MEX IMA calibration.
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Contents

1 Introduction: Design and objectives definition

IMA is a rather complex mass analyzer. Figure 1 introduces the principal design of the sensor. It consists of the electrostatic scanner, spherical top-hat electrostatic analyzer, followed by the magnet mass analyzer. Between electrostatic analyzer and magnet section ions can be accelerated. Magnetic analyzer consists of 16 azimuthal sections followed by 16 sectors of MCP position sensitive detector. Detector can register the section which incident particle is striking on and and its (particle) radial position.

Thus The instrument has a $360°$ field-of-view divided into 16 azimuthal sectors. Azimuth angle Φ is counted from the center of "0" sector. Positive direction is toward the sector "1". Polar angle Θ is counted from *XY* plane toward the top of the analyzer. Position of *X, Y, Z* axis is shown in Figure 1. The origin is the center of the spherical analyzer. Position of the particle on the detector surface is defined by sector number *S* and radial position R_M (from 0 to 32). The instant instrument properties depends on:

1. U_{def} = **EAC_U - EAC_L** scanner voltage
2. U_{an} = **ESC_H - ESC_L** analyzer voltage
3. U_{PAC} = **PAC** post acceleration voltage
4. E/Q particle energy per charge
5. M/Q particle mass per charge

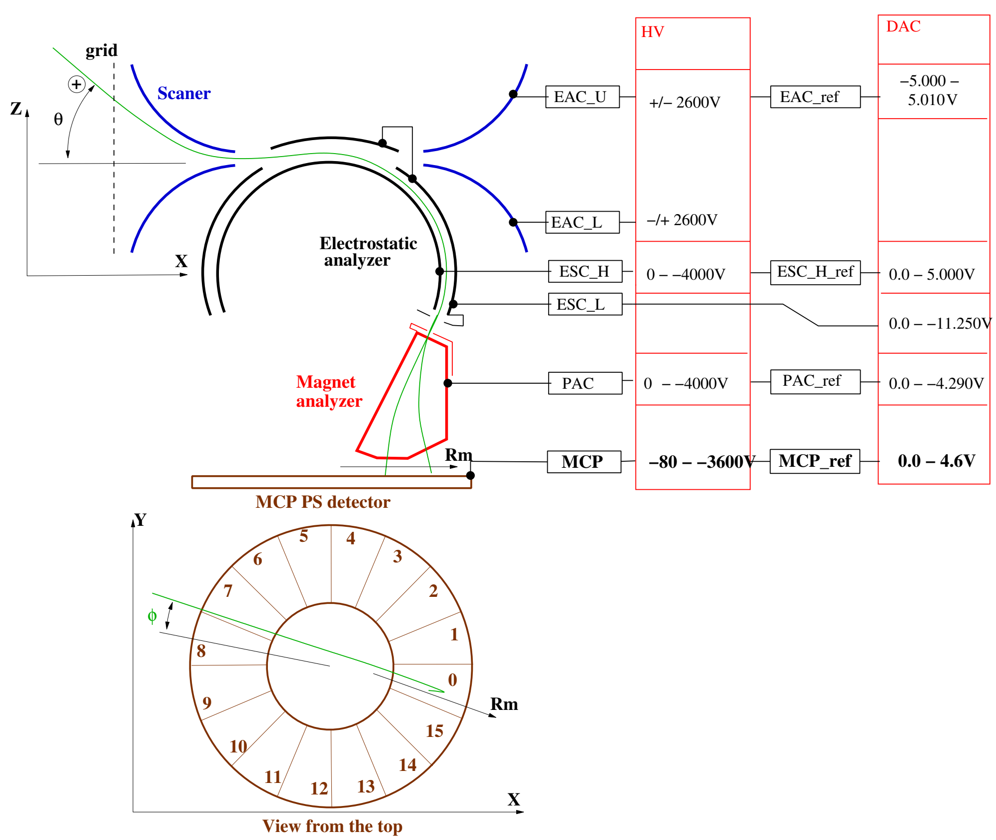


Figure 1: The principal diagram of the IMA mass analyzer. Terms and coordinate system introduction.

The subjects of calibration is as follows:

1. Function $\Theta(D)$, where $D = U_{def}/(E/Q)$. Useful function $\Theta(D_{ref})$ where $D_{ref} = EAC\_ref/(E/Q)$ is defined as well.

2. $K = (E/Q)/U_{an}$ and K_{ref} = (E/Q)/ESC_H_ref

3. $\Delta E/E$ - energy resolution of the sensor

4. $\Delta\Theta$ - elevation resolution of the sensor

5. R_M as a function of M/Q,E/Q and U_{PAC}.

6. $G_L(\Phi)$ as function of Θ, U_{PAC}, E/Q, and M/Q. Here G_L is the differential geometrical factor measured for given Φ, $cm^2\ rad\ eV/eV$

7. GF the total geometrical factor of each azimuthal sector $cm^2\ sr\ eV/eV$. Note that the last value is useless is the most of cases. The point is that the temperature of the measured ions is usually small, and angular distribution of the ion flow is narrow in comparison with the width of the azimuthal sector $22.5°$.

2 Numerical simulation and theoretical geometrical factor

2.1 Rough estimation of the geometrical factor

The standard field of view of the sensor is $22.5° \times 4° = 0.027sr$. The aperture of the instrument is defined by slit in the acceleration lens between the spherical analyzer and the magnet. For one azimuthal sector it is $1mm \times 10mm = 0.1cm^2$. $\Delta E/E = 0.04$. In this case very rough estimation of the geometrical factor of one sector is

$$GF_{estim} = 1.0 \cdot 10^{-4}\ cm^2\ sr\ eV/eV \tag{1}$$

2.2 Numerical model and examples of the instrument responses

Numerical model of the IMA sensor was made by the code **TRACE** (Fedorov, 1998, 2004). All mechanical dimensions and magnet properties has been set as close to the real device as it was possible. Since U_{PAC} values and M/Q values were different in the laboratory calibration and in the flight (see appropriate sections), two sets of simulations were made:

Table 1

	M/Q				U_{PAC}		
Laboratory	1	2	14	28	-0.0	-2000.0	-4000.0
Flight		2	16	32	-90.0	-2433.0	-4216.0

Figure 2 shows 3-D cat of the numerical mode with the ion trajectories example. Figure 3 shows several examples of the differential geometrical factor of the sensor versus several key variables calculated for flight setup.

2.3 Numerical simulation results

Figures 4 show the ion peak trajectory on the detector surface versus E/Q for laboratory and flight setup. One can see that in both cases the simulation gives something very close to the reality and hence we can use simulation results as a background for processing of the laboratory calibration data.

As it was mentioned the total geometrical factor of one sector is almost useless for the data analysis. To describe instrument property we use azimuthal differential geometrical factor $G_L(\Phi)$. The

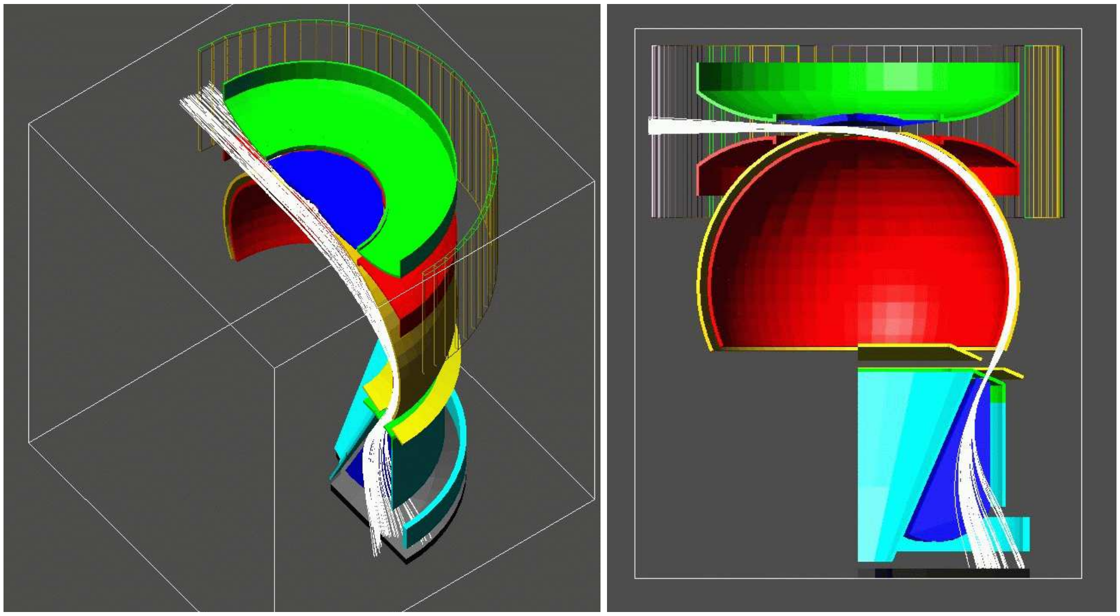


Figure 2: Cut of the IMA numerical model with ray-tracing examples. 1000 eV H^+ trajectories are shown when the post-acceleration is about 2400V. Electrostatic scanner is off.

azimuthal profile of G_L of the one azimuthal sector is shown in Figure 5. Anchor values are defined in Table 2.

Table 2 Flight configuration

PAC	En	mass	KKL	KKC	KKR
0	96.6	2	0.00e-07	4.25e-07	0.00e-07
0	97.6	4	00.0e-07	3.71e-07	00.0e-07
0	97.5	16	9.38e-05	2.17e-04	1.11e-04
0	97.5	32	1.11e-04	2.18e-04	1.18e-04
0	97.4	44	1.15e-04	2.17e-04	1.15e-04
0	241.2	2	00.0e-07	0.00e-07	0.00e-08
0	242.6	4	8.87e-06	6.85e-05	1.03e-05
0	244.2	16	8.24e-05	1.68e-04	9.37e-05
0	244.0	32	8.83e-05	1.59e-04	9.16e-05
0	243.9	44	8.89e-05	1.52e-04	9.21e-05
0	480.0	2	00.0e-07	9.96e-06	0.00e-07
0	488.6	4	4.95e-05	1.26e-04	5.96e-05
0	488.2	16	7.92e-05	1.41e-04	8.53e-05
0	487.8	32	7.58e-05	1.28e-04	8.05e-05
0	487.6	44	7.29e-05	1.20e-04	7.52e-05
0	976.3	2	3.38e-05	1.14e-04	4.60e-05
0	977.7	4	6.61e-05	1.39e-04	8.35e-05
0	975.6	16	6.84e-05	1.21e-04	6.98e-05
0	974.5	32	6.09e-05	1.04e-04	6.12e-05
0	974.3	44	5.76e-05	9.67e-05	5.94e-05
0	1955.6	2	6.01e-05	1.34e-04	8.01e-05

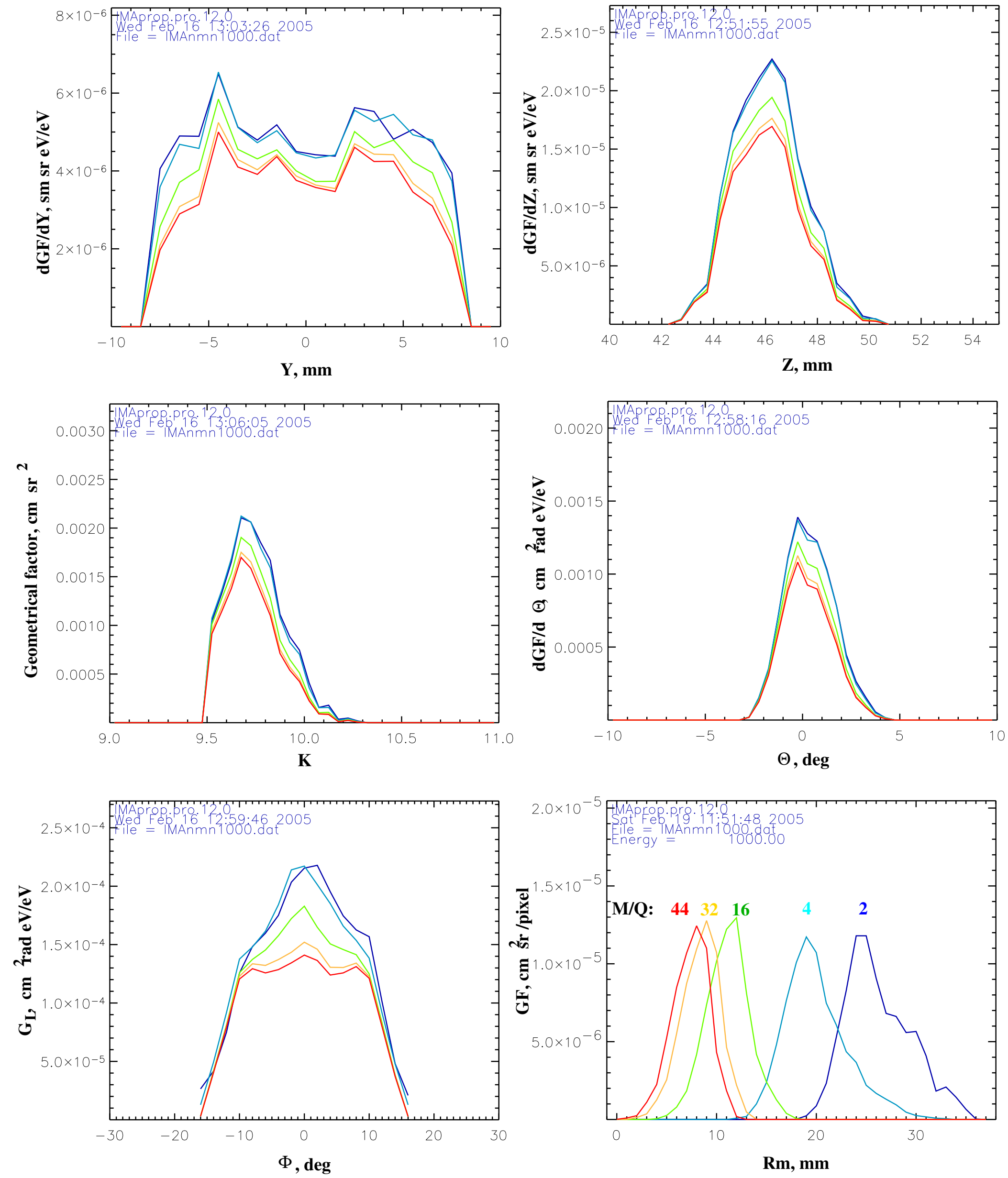


Figure 3: Examples of simulation results for PAC1 (2430V) and ion energy about 1000eV. Different colors mark different M/Q indicated in the low right panel. Two top panels show aperture of the instrument. Two middle panels show the K response and elevation response of the sensor. Low panels show azimuthal response and the mass peaks. Note that the azimuthal response changes significantly with M/Q.

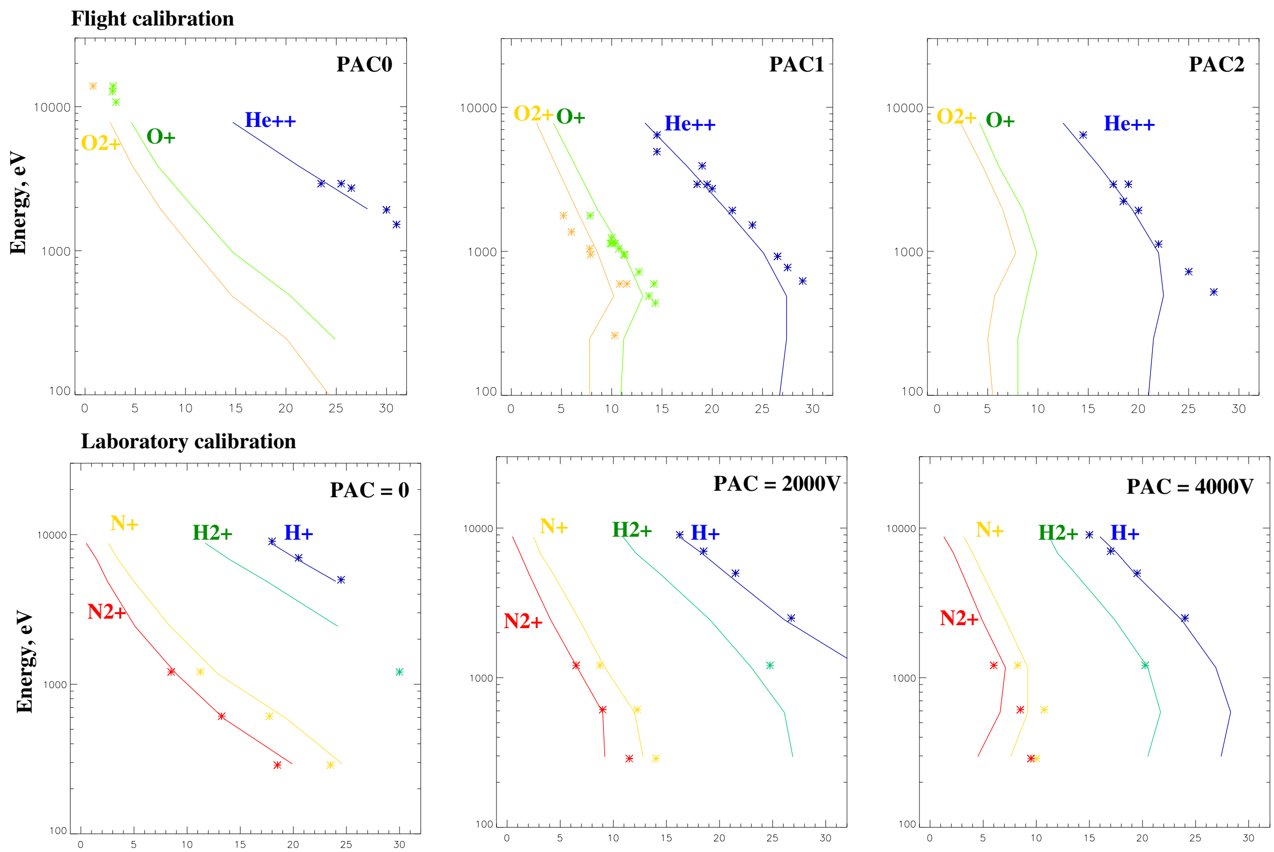


Figure 4: Position of the mass peak R_M versus E/Q for different M/Q. Top panels show the results for flight setup and low panels show the results for laboratory setup. Real positions measured in the flight (see section 4) and in laboratory (see section 3) are shown by asterisks.

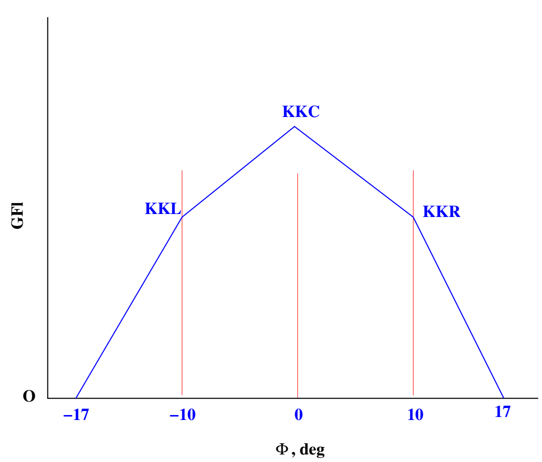


Figure 5: Simplified azimuthal response of the instrument. (Compare with Figure 3.) The function is 0 at $-17°$ and at $17°$. At $\pm 10°$ and at $0°$ the geometrical file values is defined in the Table 2and Table 3.

0	1953.5	4	6.81e-05	1.30e-04	7.58e-05
0	1948.8	16	5.30e-05	1.02e-04	5.43e-05
0	1948.0	32	4.85e-05	8.45e-05	5.05e-05
0	1947.9	44	4.74e-05	7.64e-05	5.09e-05
0	3906.7	2	6.35e-05	1.29e-04	7.23e-05
0	3900.2	4	5.61e-05	1.17e-04	5.61e-05
0	3895.2	16	4.39e-05	8.21e-05	4.71e-05
0	3895.0	32	4.37e-05	6.61e-05	4.58e-05
0	3895.5	44	4.31e-05	5.98e-05	4.49e-05
0	7799.4	2	5.21e-05	1.17e-04	5.30e-05
0	7791.5	4	4.45e-05	9.99e-05	4.63e-05
0	7789.7	16	4.07e-05	6.48e-05	4.19e-05
0	7793.4	32	3.85e-05	5.06e-05	3.97e-05
0	7795.0	44	3.74e-05	4.49e-05	3.86e-05
1	99.3	2	1.39e-04	3.55e-04	1.74e-04
1	99.3	4	1.41e-04	3.55e-04	1.53e-04
1	99.4	16	1.22e-04	3.43e-04	1.30e-04
1	99.3	32	1.19e-04	3.12e-04	1.23e-04
1	99.3	44	1.16e-04	2.95e-04	1.22e-04
1	247.3	2	1.82e-04	3.89e-04	2.24e-04
1	247.2	4	1.82e-04	3.82e-04	2.01e-04
1	247.1	16	1.60e-04	3.43e-04	1.72e-04
1	247.1	32	1.55e-04	3.20e-04	1.66e-04
1	246.9	44	1.53e-04	3.04e-04	1.63e-04
1	489.2	2	1.81e-04	2.99e-04	2.10e-04
1	488.8	4	1.73e-04	2.90e-04	1.80e-04
1	488.1	16	1.50e-04	2.54e-04	1.52e-04
1	487.9	32	1.46e-04	2.31e-04	1.47e-04
1	487.7	44	1.45e-04	2.17e-04	1.45e-04
1	975.1	2	1.42e-04	2.27e-04	1.55e-04
1	974.6	4	1.32e-04	2.21e-04	1.32e-04
1	973.5	16	1.21e-04	1.82e-04	1.20e-04
1	973.2	32	1.19e-04	1.51e-04	1.18e-04
1	973.1	44	1.17e-04	1.40e-04	1.17e-04
1	1949.1	2	1.12e-04	2.08e-04	1.16e-04
1	1947.7	4	1.12e-04	1.84e-04	1.14e-04
1	1945.1	16	9.96e-05	1.33e-04	9.81e-05
1	1944.7	32	9.36e-05	1.09e-04	9.24e-05
1	1944.7	44	9.05e-05	9.95e-05	9.00e-05
1	3898.3	2	8.84e-05	1.66e-04	9.19e-05
1	3893.2	4	7.82e-05	1.52e-04	7.76e-05
1	3889.5	16	6.48e-05	1.02e-04	6.67e-05
1	3889.4	32	6.10e-05	8.26e-05	6.31e-05
1	3889.6	44	6.02e-05	7.57e-05	6.24e-05
1	7790.7	2	6.02e-05	1.35e-04	6.09e-05
1	7784.3	4	5.16e-05	1.14e-04	5.48e-05
1	7782.0	16	4.56e-05	7.39e-05	4.73e-05
1	7784.6	32	4.40e-05	5.88e-05	4.52e-05
1	7786.0	44	4.29e-05	5.20e-05	4.45e-05

2	99.3	2	1.23e-04	3.41e-04	1.47e-04
2	99.3	4	1.13e-04	3.43e-04	1.28e-04
2	99.3	16	1.06e-04	3.12e-04	1.17e-04
2	99.2	32	1.06e-04	2.76e-04	1.19e-04
2	99.2	44	1.05e-04	2.57e-04	1.19e-04
2	248.0	2	1.40e-04	3.52e-04	1.61e-04
2	248.1	4	1.28e-04	3.51e-04	1.39e-04
2	248.0	16	1.14e-04	3.13e-04	1.24e-04
2	247.8	32	1.15e-04	2.67e-04	1.22e-04
2	247.7	44	1.14e-04	2.45e-04	1.23e-04
2	493.2	2	1.89e-04	3.88e-04	2.17e-04
2	492.7	4	1.81e-04	3.59e-04	1.94e-04
2	492.0	16	1.61e-04	3.08e-04	1.66e-04
2	491.3	32	1.58e-04	2.58e-04	1.58e-04
2	490.9	44	1.55e-04	2.29e-04	1.58e-04
2	976.4	2	1.73e-04	2.67e-04	1.79e-04
2	975.7	4	1.58e-04	2.47e-04	1.62e-04
2	974.5	16	1.39e-04	2.05e-04	1.37e-04
2	973.9	32	1.33e-04	1.74e-04	1.31e-04
2	973.8	44	1.30e-04	1.61e-04	1.28e-04
2	1948.9	2	1.30e-04	2.15e-04	1.30e-04
2	1947.7	4	1.22e-04	1.93e-04	1.22e-04
2	1945.0	16	1.07e-04	1.41e-04	1.06e-04
2	1944.6	32	9.94e-05	1.16e-04	9.93e-05
2	1944.6	44	9.66e-05	1.07e-04	9.71e-05
2	3895.1	2	1.01e-04	1.80e-04	1.03e-04
2	3889.9	4	9.07e-05	1.62e-04	8.71e-05
2	3886.5	16	7.46e-05	1.06e-04	7.54e-05
2	3886.7	32	7.12e-05	8.60e-05	7.21e-05
2	3886.7	44	7.02e-05	7.94e-05	7.06e-05
2	7783.6	2	6.70e-05	1.50e-04	6.47e-05
2	7777.4	4	5.83e-05	1.24e-04	5.94e-05
2	7776.9	16	5.20e-05	7.98e-05	5.23e-05
2	7777.3	32	5.07e-05	6.50e-05	5.18e-05
2	7779.2	44	4.95e-05	5.95e-05	5.04e-05

The same for laboratory configuration:

Table 3 Laboratory configuration

PAC	En	mass	KKL	KKC	KKR
0000	294.0	1	0.00e+00	0.00e+00	0.00e+00
0000	294.0	2	0.00e+00	0.00e+00	0.00e+00
0000	293.4	14	6.87e-05	1.33e-04	8.29e-05
0000	293.1	28	7.56e-05	1.28e-04	8.05e-05
0000	588.0	1	0.00e+00	0.00e+00	0.00e+00
0000	577.5	2	2.46e-06	1.25e-05	0.00e-06
0000	586.3	14	7.15e-05	1.24e-04	7.81e-05
0000	585.6	28	6.76e-05	1.13e-04	6.90e-05
0000	1154.0	1	4.07e-06	6.71e-06	0.00e-06
0000	1172.2	2	3.70e-05	1.13e-04	4.96e-05

0000	1170.7	14	6.25e-05	1.13e-04	6.32e-05
0000	1169.7	28	5.46e-05	9.90e-05	5.54e-05
0000	2441.1	1	3.13e-05	1.16e-04	4.74e-05
0000	2444.0	2	6.13e-05	1.31e-04	7.52e-05
0000	2435.8	14	4.93e-05	9.76e-05	5.04e-05
0000	2434.9	28	4.45e-05	7.94e-05	4.75e-05
0000	4886.7	1	5.65e-05	1.32e-04	7.23e-05
0000	4881.6	2	5.99e-05	1.23e-04	6.51e-05
0000	4868.7	14	4.28e-05	7.83e-05	4.51e-05
0000	4869.0	28	4.23e-05	6.28e-05	4.39e-05
0000	6837.2	1	5.87e-05	1.31e-04	6.93e-05
0000	6826.6	2	5.35e-05	1.19e-04	5.47e-05
0000	6816.2	14	4.15e-05	7.06e-05	4.33e-05
0000	6818.1	28	4.00e-05	5.55e-05	4.07e-05
0000	8786.8	1	5.86e-05	1.25e-04	6.56e-05
0000	8771.9	2	4.93e-05	1.13e-04	5.04e-05
0000	8763.1	14	3.95e-05	6.46e-05	4.07e-05
0000	8767.1	28	3.79e-05	5.04e-05	3.89e-05
2000	295.7	1	1.23e-04	2.93e-04	1.39e-04
2000	295.2	2	1.92e-04	3.63e-04	2.33e-04
2000	294.1	14	1.77e-04	3.27e-04	1.79e-04
2000	293.9	28	1.72e-04	3.01e-04	1.74e-04
2000	585.9	1	1.25e-04	1.97e-04	1.34e-04
2000	585.5	2	1.61e-04	2.47e-04	1.94e-04
2000	584.8	14	1.31e-04	2.20e-04	1.33e-04
2000	584.5	28	1.28e-04	1.97e-04	1.28e-04
2000	1169.8	1	1.16e-04	1.89e-04	1.29e-04
2000	1169.9	2	1.25e-04	2.13e-04	1.37e-04
2000	1167.8	14	1.15e-04	1.69e-04	1.14e-04
2000	1167.3	28	1.11e-04	1.39e-04	1.09e-04
2000	2439.6	1	8.51e-05	1.89e-04	1.10e-04
2000	2437.1	2	9.98e-05	1.89e-04	1.03e-04
2000	2431.4	14	8.27e-05	1.25e-04	8.25e-05
2000	2431.2	28	7.81e-05	1.02e-04	7.94e-05
2000	4880.5	1	7.62e-05	1.66e-04	8.61e-05
2000	4874.5	2	7.57e-05	1.51e-04	7.73e-05
2000	4863.5	14	5.51e-05	9.32e-05	5.75e-05
2000	4863.7	28	5.32e-05	7.54e-05	5.45e-05
2000	6830.2	1	6.93e-05	1.51e-04	7.87e-05
2000	6819.8	2	6.21e-05	1.37e-04	6.43e-05
2000	6810.6	14	4.68e-05	8.00e-05	4.97e-05
2000	6811.4	28	4.54e-05	6.44e-05	4.66e-05
2000	8778.7	1	6.52e-05	1.41e-04	7.20e-05
2000	8764.5	2	5.60e-05	1.27e-04	5.63e-05
2000	8757.4	14	4.32e-05	7.21e-05	4.52e-05
2000	8760.1	28	4.07e-05	5.66e-05	4.28e-05
4000	297.5	1	1.36e-04	3.60e-04	1.91e-04
4000	297.4	2	1.52e-04	3.70e-04	1.73e-04
4000	297.4	14	1.27e-04	3.32e-04	1.37e-04

4000	297.1	28	1.26e-04	2.88e-04	1.33e-04
4000	590.8	1	1.80e-04	3.53e-04	2.31e-04
4000	589.7	2	1.93e-04	3.66e-04	2.15e-04
4000	588.0	14	1.68e-04	2.94e-04	1.66e-04
4000	587.1	28	1.64e-04	2.51e-04	1.58e-04
4000	1171.0	1	1.63e-04	2.43e-04	2.01e-04
4000	1170.6	2	1.62e-04	2.43e-04	1.65e-04
4000	1168.6	14	1.30e-04	1.89e-04	1.27e-04
4000	1168.0	28	1.24e-04	1.58e-04	1.22e-04
4000	2437.2	1	1.26e-04	2.10e-04	1.38e-04
4000	2435.0	2	1.19e-04	2.03e-04	1.23e-04
4000	2430.3	14	9.67e-05	1.33e-04	9.64e-05
4000	2430.0	28	9.10e-05	1.08e-04	9.08e-05
4000	4872.9	1	9.27e-05	1.93e-04	1.00e-04
4000	4867.8	2	8.92e-05	1.71e-04	8.99e-05
4000	4858.6	14	6.56e-05	1.00e-04	6.78e-05
4000	4859.0	28	6.34e-05	8.13e-05	6.51e-05
4000	6821.8	1	8.01e-05	1.73e-04	8.78e-05
4000	6811.1	2	7.17e-05	1.57e-04	7.03e-05
4000	6803.4	14	5.54e-05	8.78e-05	5.63e-05
4000	6803.7	28	5.40e-05	7.09e-05	5.47e-05
4000	8771.6	1	7.36e-05	1.57e-04	7.61e-05
4000	8756.0	2	6.20e-05	1.43e-04	6.04e-05
4000	8750.6	14	4.95e-05	7.92e-05	5.00e-05
4000	8751.1	28	4.83e-05	6.34e-05	4.91e-05

Note that all values are calculated for polar angle $\Theta = 0$.
To be completed for different polar angles

3 Brief description of calibration facilities

3.1 Mechanical setup

The mechanical set up is shown in Figure 6. The sensor is located at about 2.5 m from the ion source. The center of sensor rotation is shifted from central axis of sensor dependence of entrance beam position on the elevation angle. The elevation angle can turn

The turnable platform allows to change azimuth in $\pm 15°$ range, so the IMA sensor is located on the support, which allows setup azimuth of the sensor with step 22.5^o manually. The elevation angle is controlled completely by remote way. Both azimuthal and elevation angle relative accuracy is $0.01°$.

Ion gun allows chose He^+, N^{++}, N_2^+ ions. In energy range 500eV - 30 keV. The energy on ions is programmed. To monitor the ion flux one CEM is mounted on the periphery of the beam.

3.2 Ion gun properties

Quick look of the ion gun properties are shown in Figure 7. **To be completed**

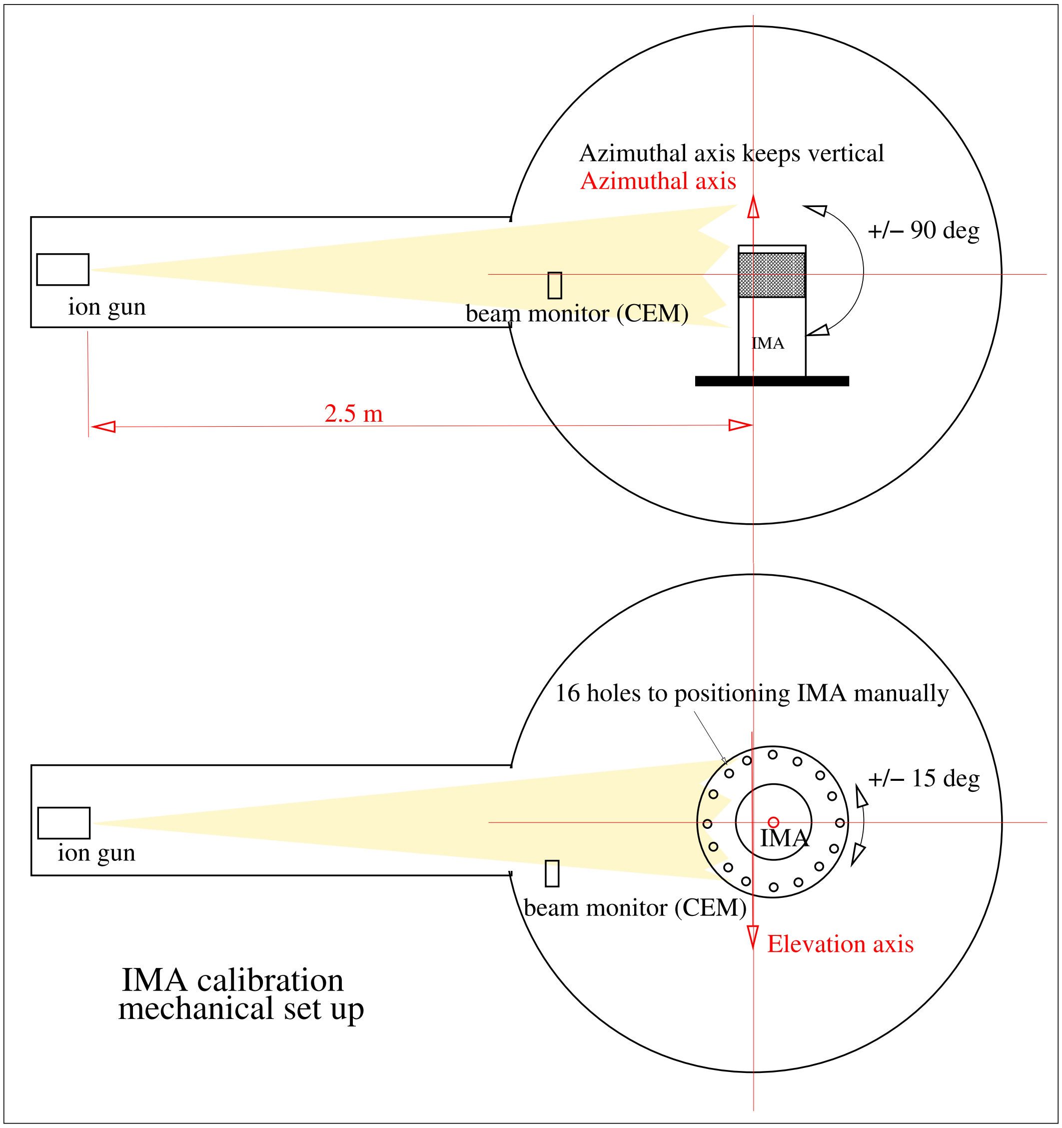


Figure 6: The mechanical set up of IMA in the vacuum chamber

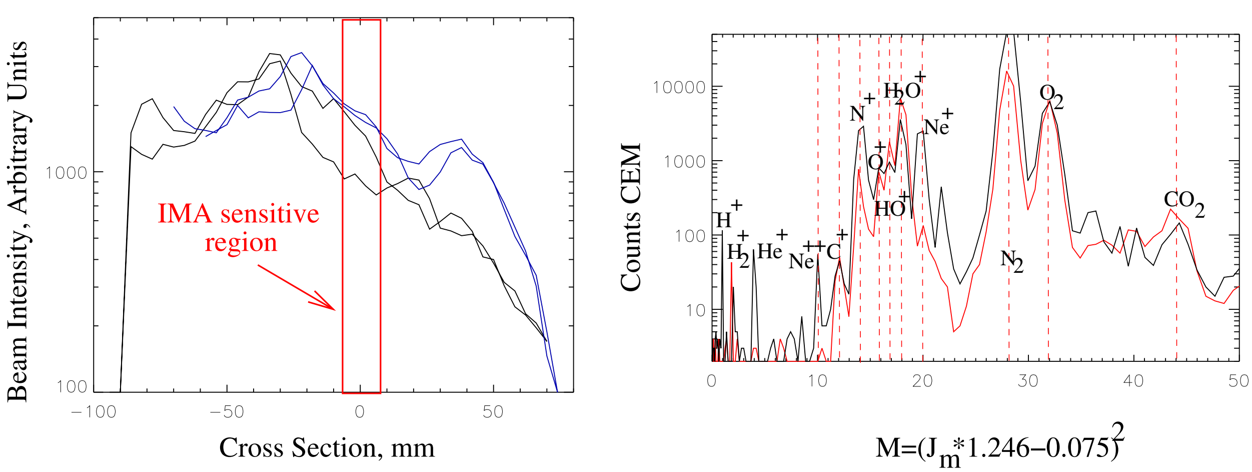


Figure 7: Left: Beam intensity distribution for different ions. Right: Beam contents versus magnet current.

3.3 High voltage setup

High voltage control is shown in Figure 8. All reference voltages for IMA HV units and for Ion Gun HV supply are provided by DAC as follows:

$$U_{ref}[mV] = -6.7 + 3.0329 \cdot NDAC$$

Here $NDAC$ is the 12 bit control word. Thus the reference values were defined with about 3mV resolution.

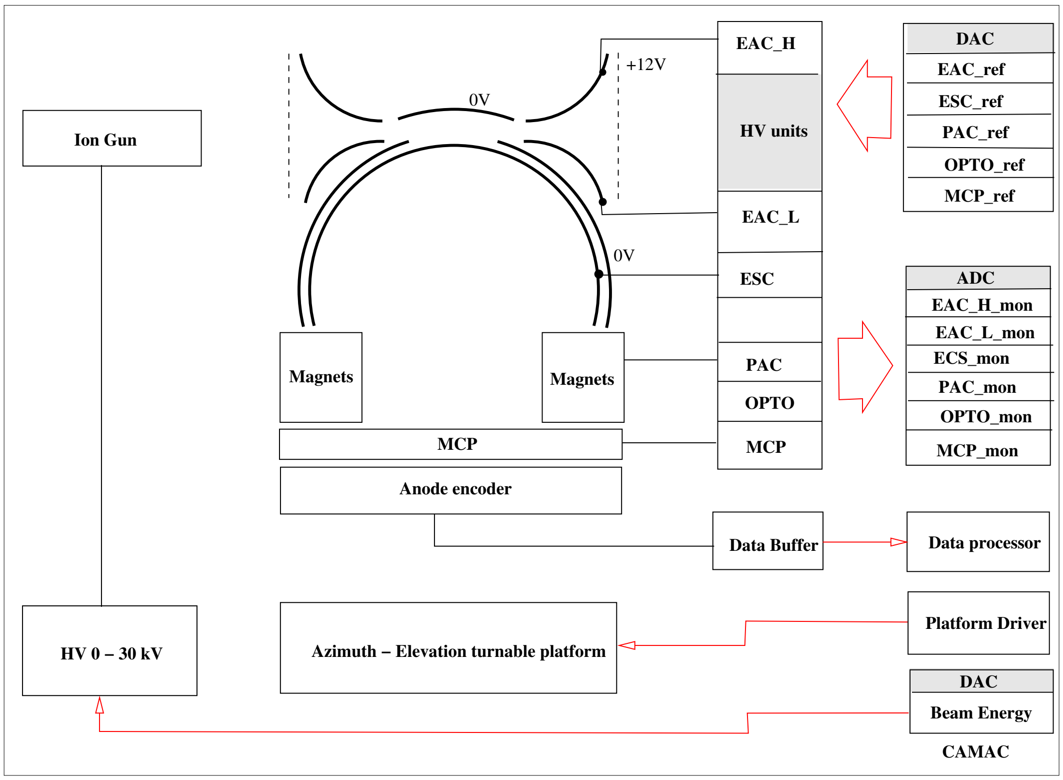


Figure 8: The electrical diagram of IMA calibration

The multichannel ADC provides measurements of HV monitor values as follows:

$$U_{mon}[mV] = NADC \cdot K_{ch} + U0_{ch}$$

Here $NADC$ is 12 bits output word and ch is channel number. The proper values of K_{ch} and $U0_{ch}$ are given in Table:

Item	Channel	K[mV/bit]	U0[mV]
MCP_{mon}	4	4.777	4.8
$OPTO_{mon}$	5	4.473	4.9
PAC_{mon}	6	5.270	5.1
EAC_L_{mon}	7	5.179	4.6
EAC_H_{mon}	8	5.214	4.8
ESC_{mon}	9	5.193	5.2

For conversion factors from the reference values to the real HV values see in "IMA flight tables V.3.0 (March 2002)"

4 MCP and detector properties

4.1 MCP integral properties

To be completed

4.2 Anode resolution properties, and ghost counts

For each azimuthal sector several R_M pixels completely broken and should be removed from the analysis. Other pixels lack inter-calibration. After analysis of laboratory and flight data we formed the following table.

Table 3 R_M pixels intercoefficiens

```
ScalePnt = [-1.0, 1.0,-1.0, 1.0,-1.0, 0.8, 1.0, 0.9,
             1.0, 1.1,-1.0, 1.0, 0.9, 1.0,-1.0, 1.0,
            -1.0, 1.0, 1.0, 1.0,-1.0, 1.0, 0.9, 1.3,
            -1.0, 1.4, 1.0, 1.2, 1.0,-1.0, 1.0,-1.0]
;              0    1    2    3    4    5    6    7
;              8    9   10   11   12   13   14   15
;             16   17   18   19   20   21   22   23
;             24   25   26   27   28   29   30   31
```

This is IDL code part. Top part of the table shows the inter-calibration coefficients and the bottom part is the pixel numbers. -1 forces to skip this pixel. Geometrical factor of the instrument is calculated **after** application of these coefficients.

To be completed

5 Measurement scheme,instrument response and geometrical factor calculation.

IMA calibration is a relatively difficult task. The main simplification of this problem is coming from the statement, that electrostatic scanner — top-hat analyzer part defines relative angular - E/Q response of the instrument, while the magnet mass-analyzer defines the real geometrical factor of the sensor depending on energy and M/Q of incident particles. This approach leads to the calibration programmer as follows:

1. MCP and detector relative response.
2. $E/Q - \Theta - D$ response of top-hat analyzer is measured for all possible values of the scanner voltage and for all possible azimuthal angles, but for one M/Q value and one energy. This procedure also gives only relative values. There are two important note to this item:
   (a) Later experiments are shown, that elevation and azimuthal response of the instrument slightly depend on U_{PAC} and M/Q. Thus we have to use simulation results (Table 2 and Table 3) to expand electrostatic part calibration data to entire energy and mass range
   (b) This calibration was made **before** we have changed the slit in the post acceleration. Hence to apply theses data with a precaution.

3. Position and form of the mass peaks is measured for set of the mass and energies of incident particles (see Table 1). It is made for zero elevation and azimuthal beam incident angles, and just for one azimuthal direction. (Data for each sector also easies, but they we obtained **before** the slit change.)

4. Absolute values of geometrical factor for one sector and set of masses and energies were defined from the last experiment and then it was expanded for all sectors and all polka angles.

5. Geometrical factor values has been interpolated to the flight configuration (other U_{PAC} and M/Q).

6 D-Elevation and Azimuthal properties of the sensor.

See "IMA flight tables V.3.0 (March 2002)" for $E/Q - \Theta - D$ properties.

To be completed

Azimuthal response of one sector is shown in Figure 9. Some difference between simulated profile and measured one is explained by Shadow from the grid support. Good consistent of two profiles allows to use simulation results to interpolate the calibration data.

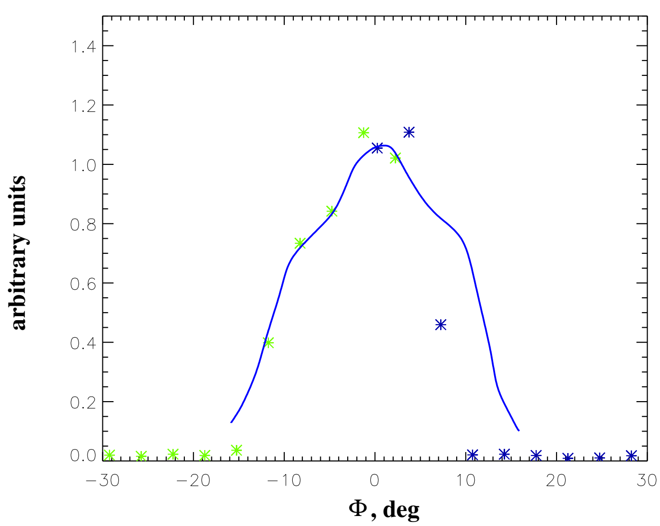


Figure 9: Relative azimuth response fro 2nd detector sector.Calibration data are shown by asterisks and simulation results are shown by solid line.

To be completed

7 Mass position and geometrical factor for different masses.

Absolute measurements were made for each energy and each masses given in Table 1 for detector sector 5. Each R_M profile has been inter-calibrated and the peak was fitted by Gaussian. Results in the absolute GF_L values is shown in Figures 10,11,12,13. Appropriate absolute profiles versus E/Q and Θ are shown in Figures 14,15,16,17 and Figures 18,19,20,21.

The summary of the measurements is shown given in Table 4. **Mpos** indicate central position of the mass peak, and **Mwidth** shows the peak width. negative value means absence of information or if

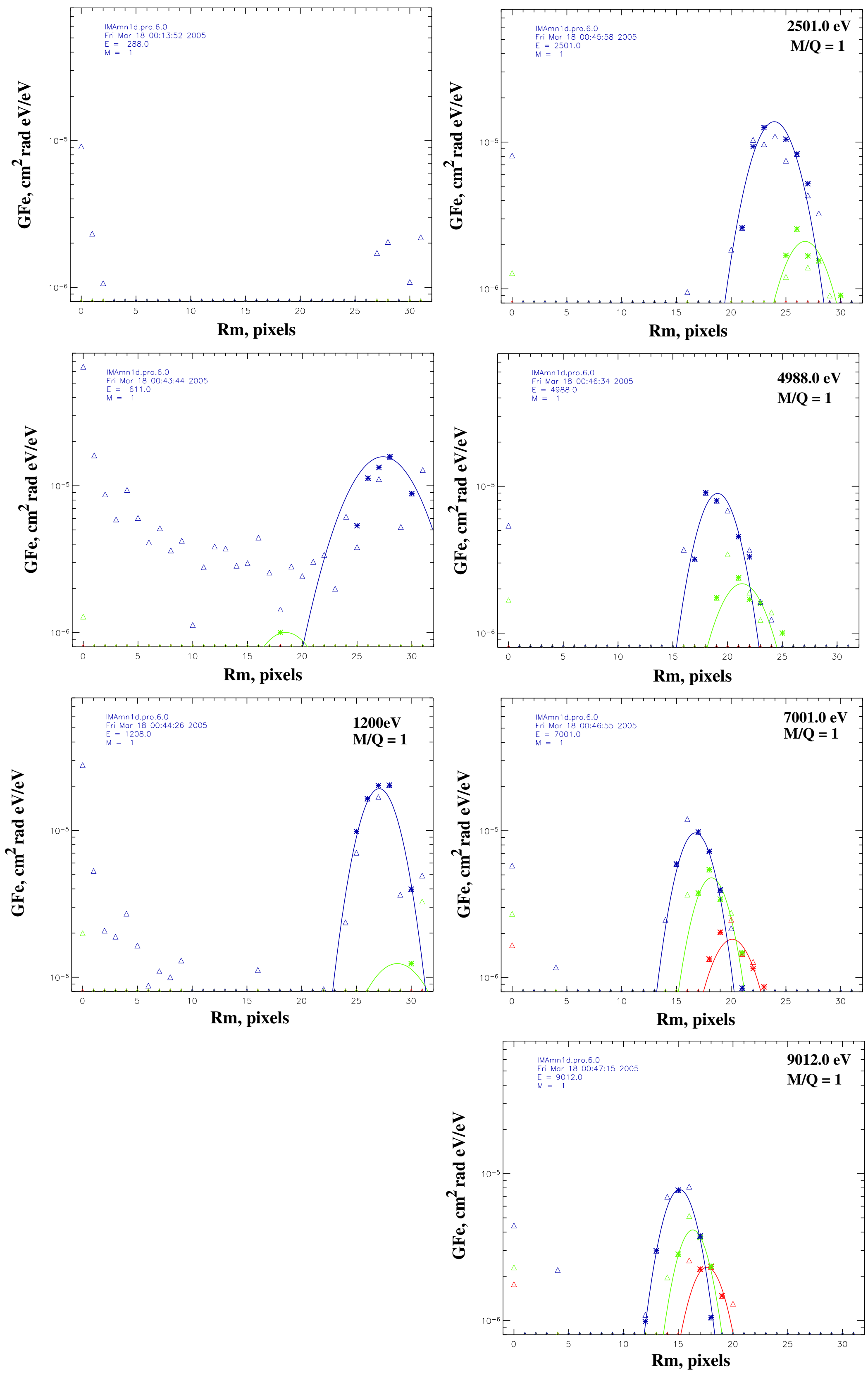


Figure 10: Mass peak of H^+ in absolute GF_L values.

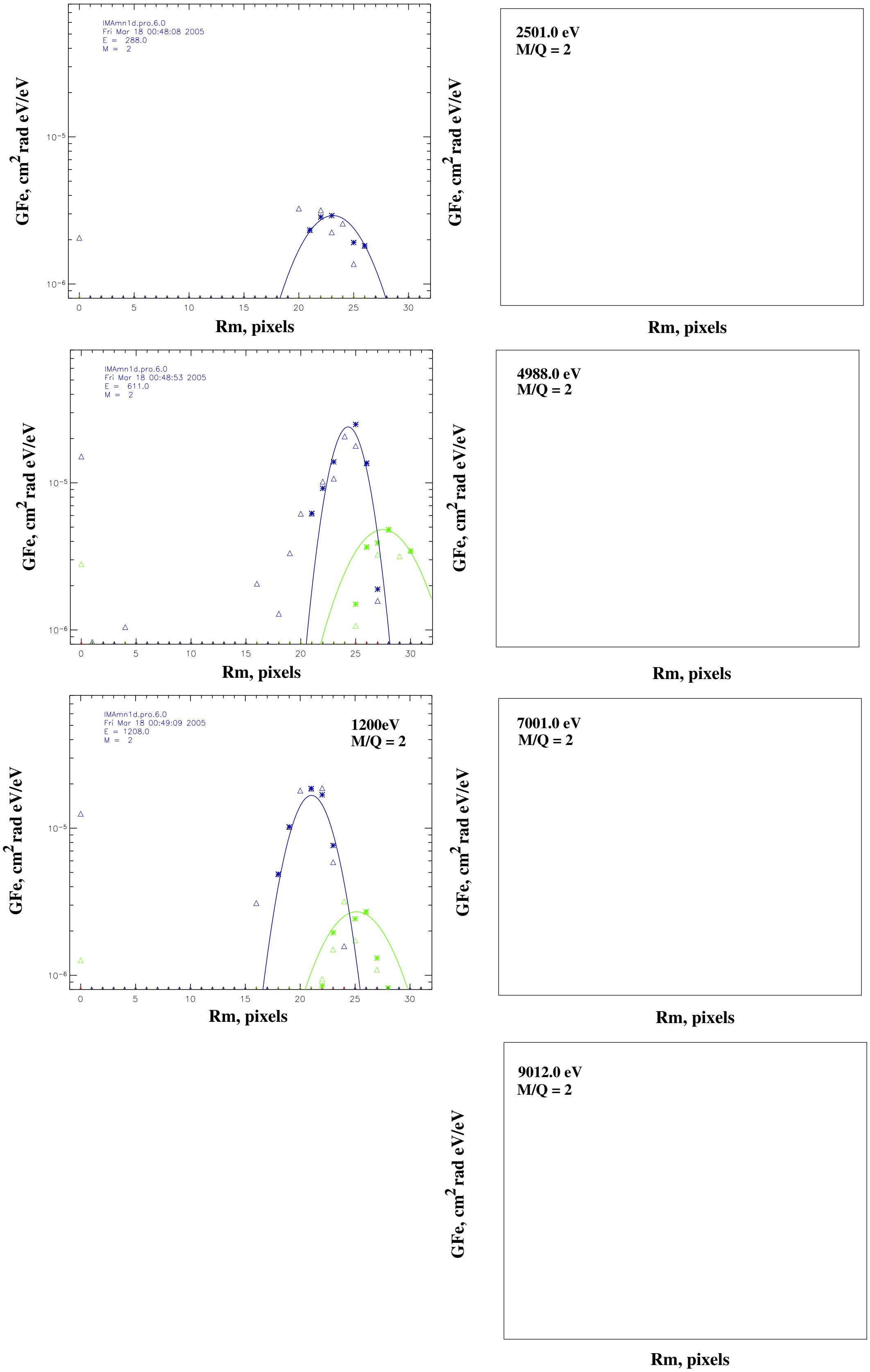


Figure 11: Mass peak of H_2^{++} in absolute GF_L values.

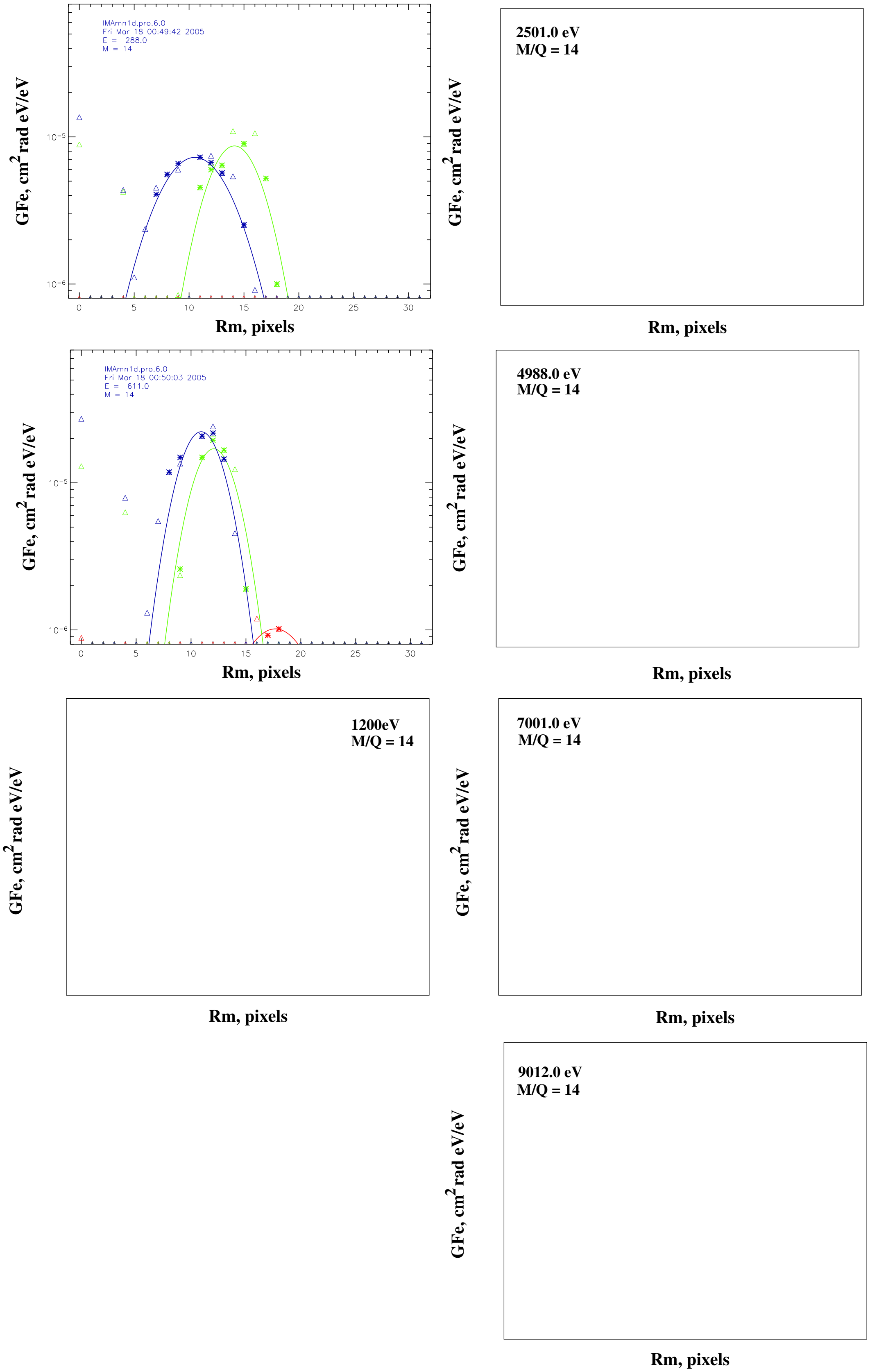


Figure 12: Mass peak of N^{+} in absolute GF_L values.

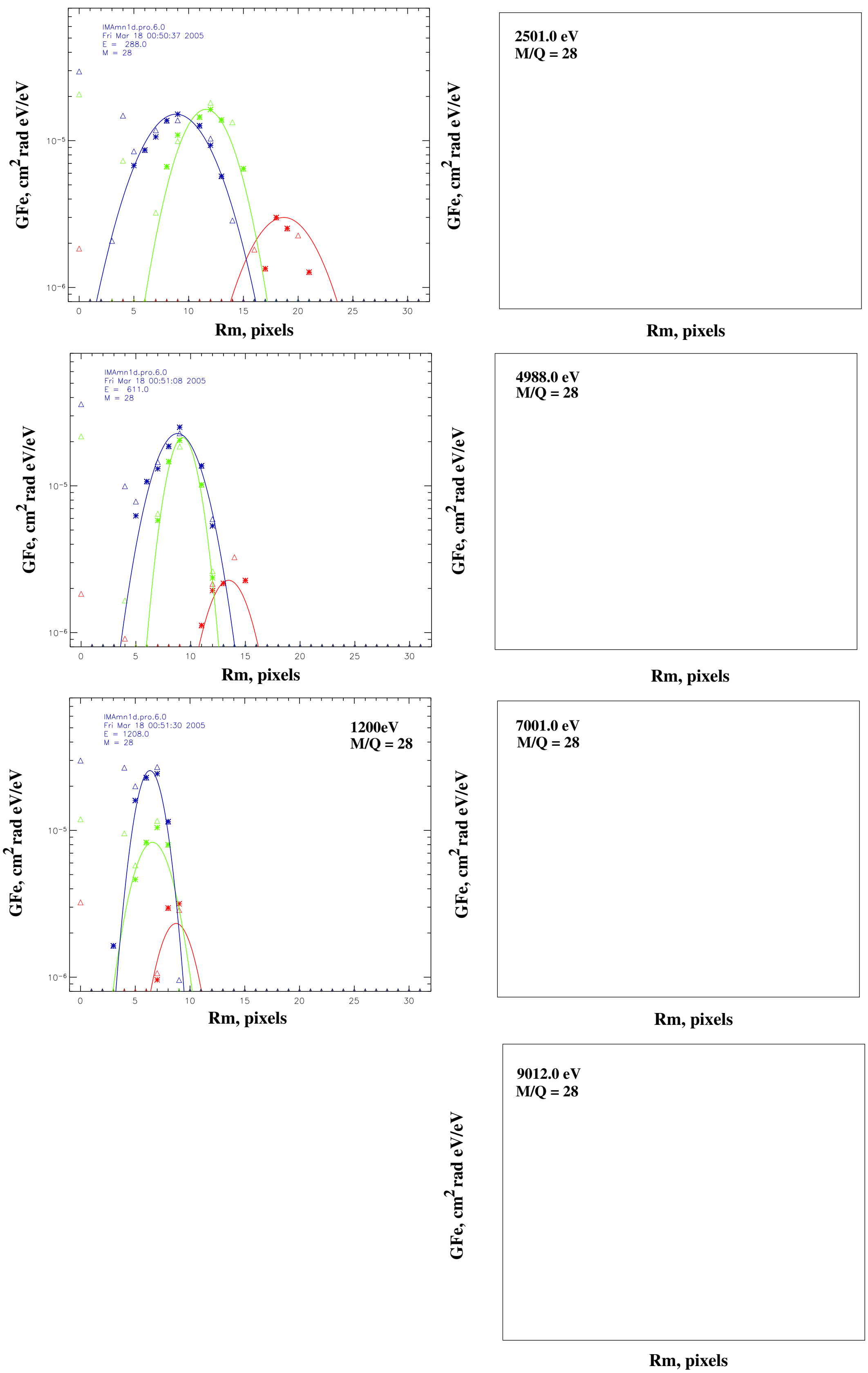


Figure 13: Mass peak of N_2^+ in absolute GF_L values.

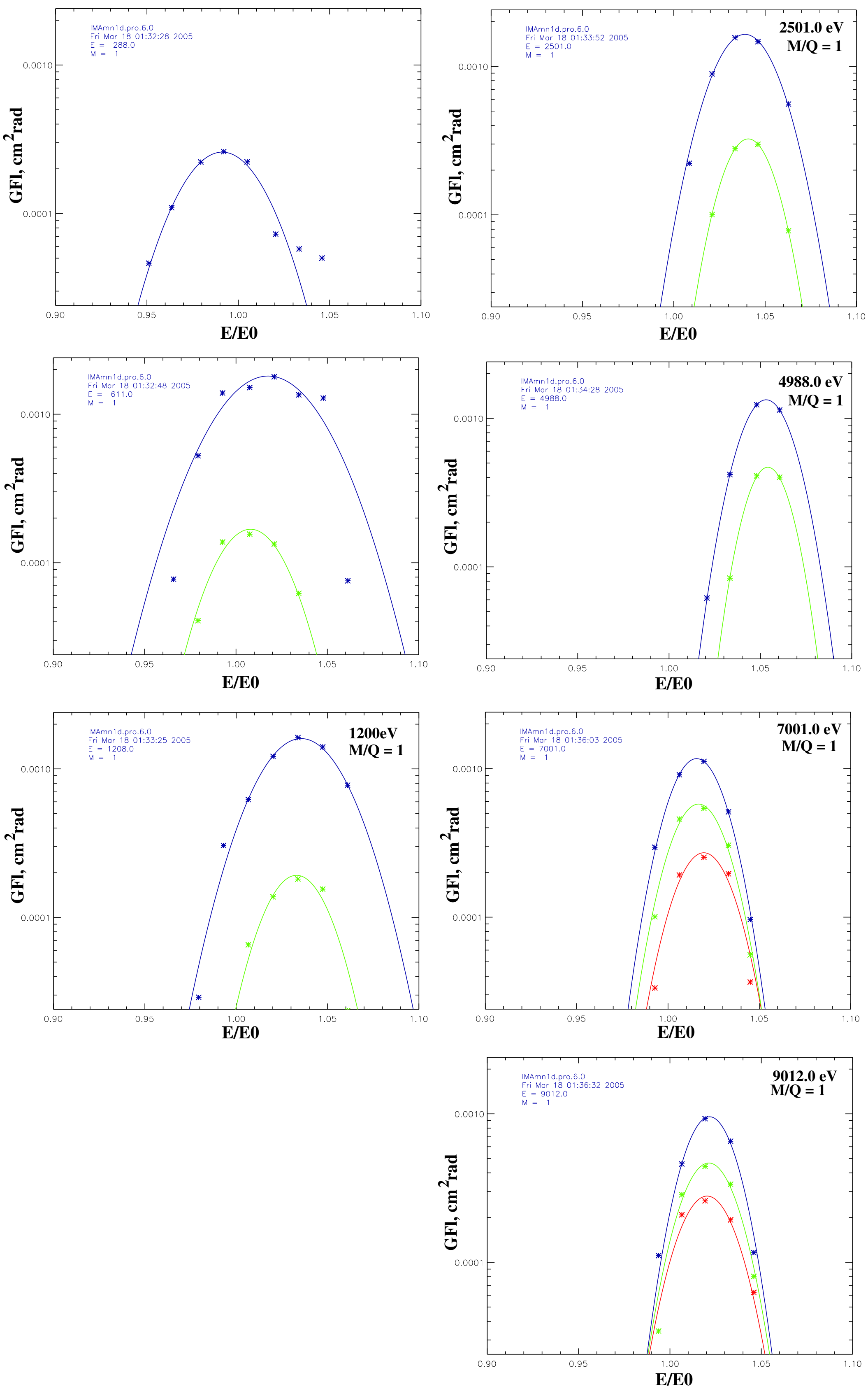


Figure 14: Differential GF_L versus E/Q for H^+.

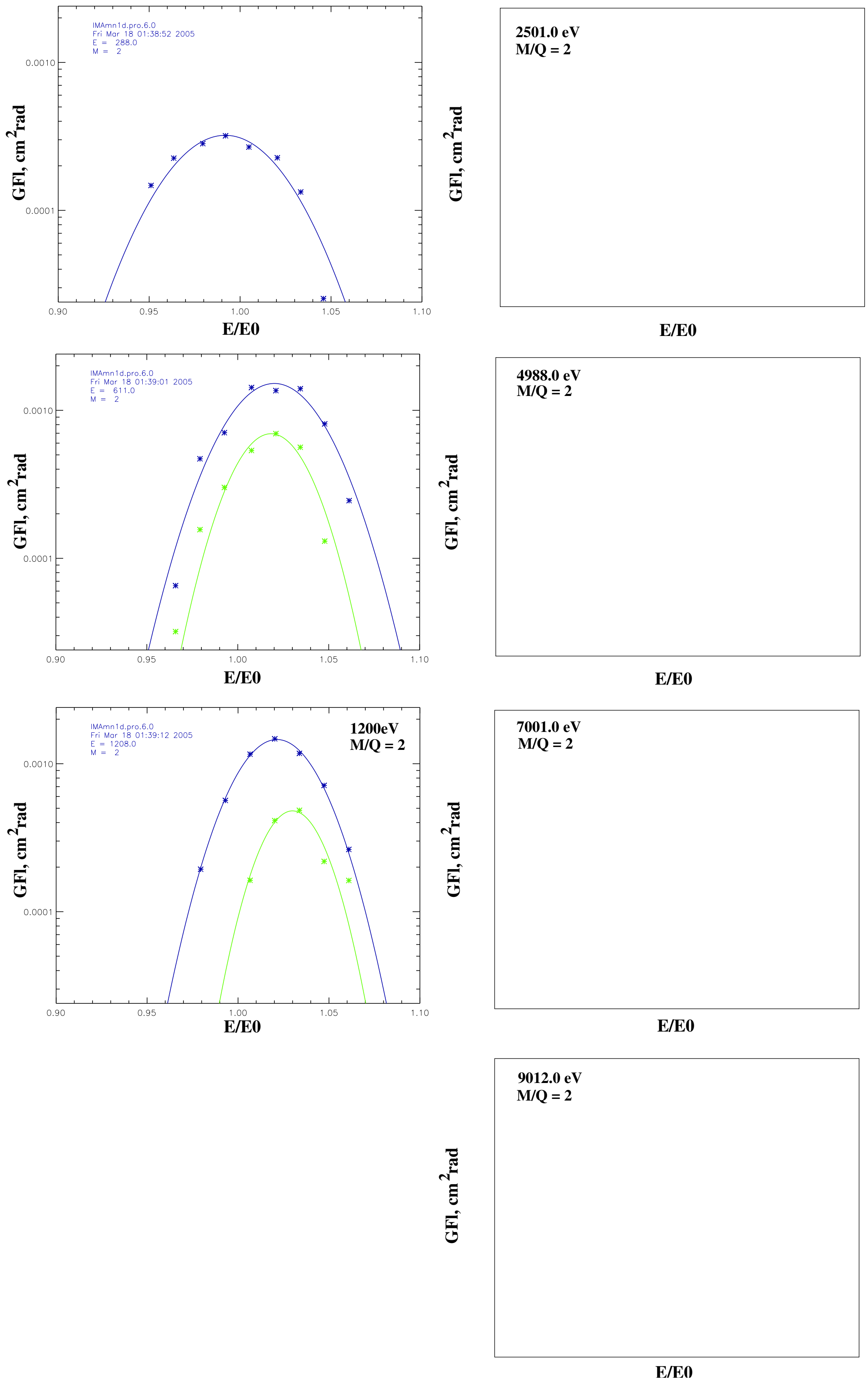


Figure 15: Differential GF_L versus E/Q for H_2^{++}.

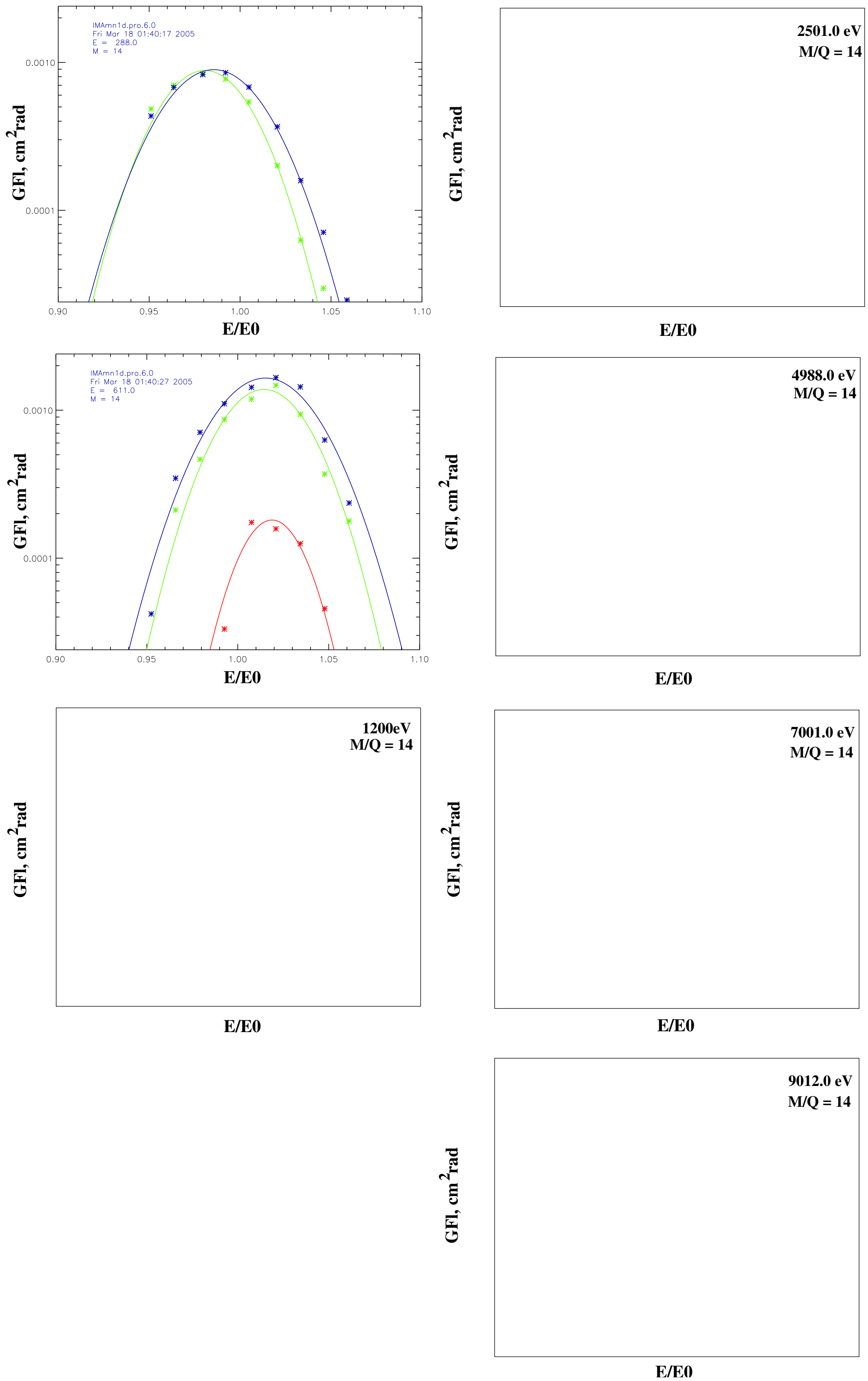


Figure 16: Differential GF_L versus E/Q for N^+.

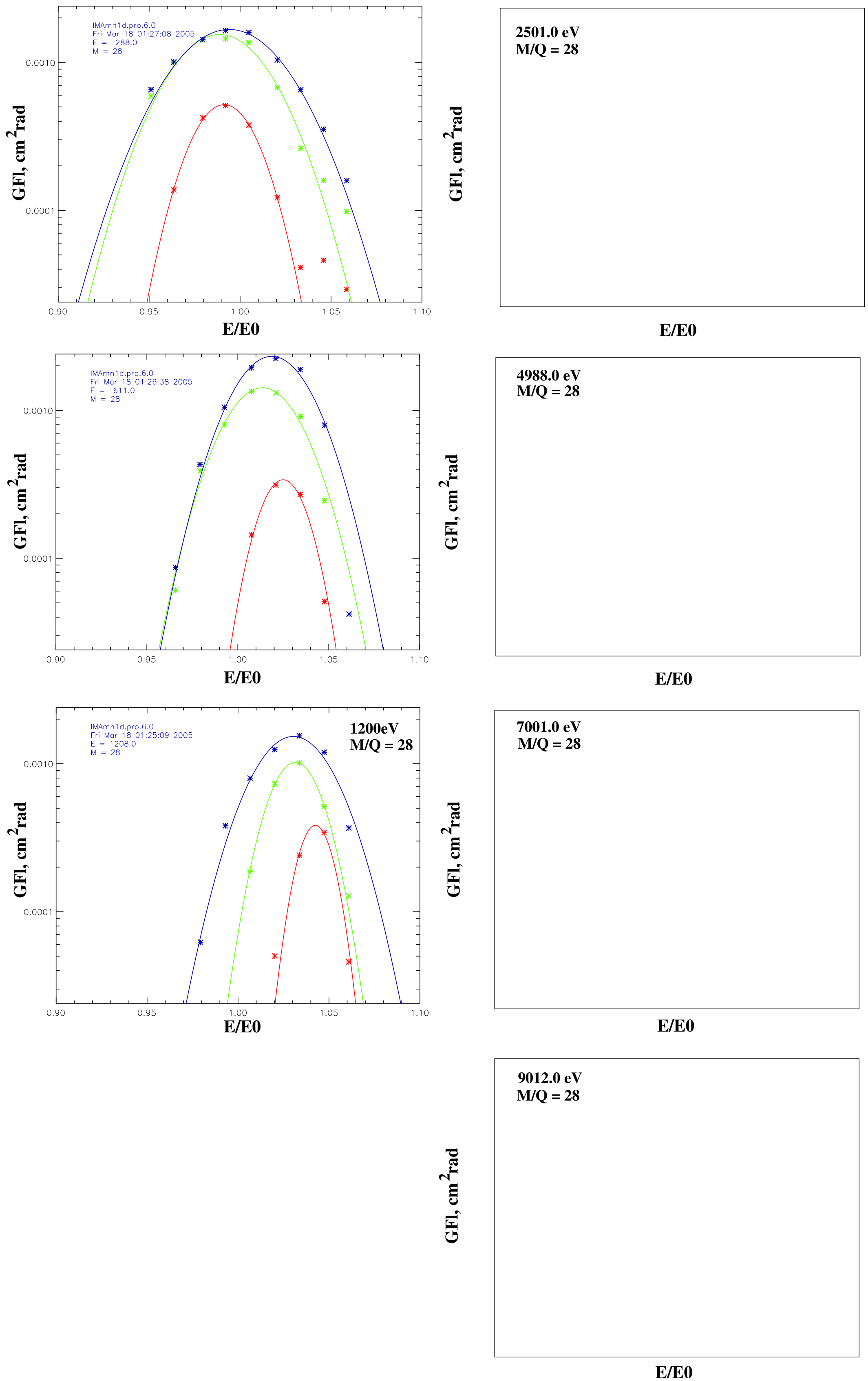


Figure 17: Differential GF_L versus E/Q for N_2^+.

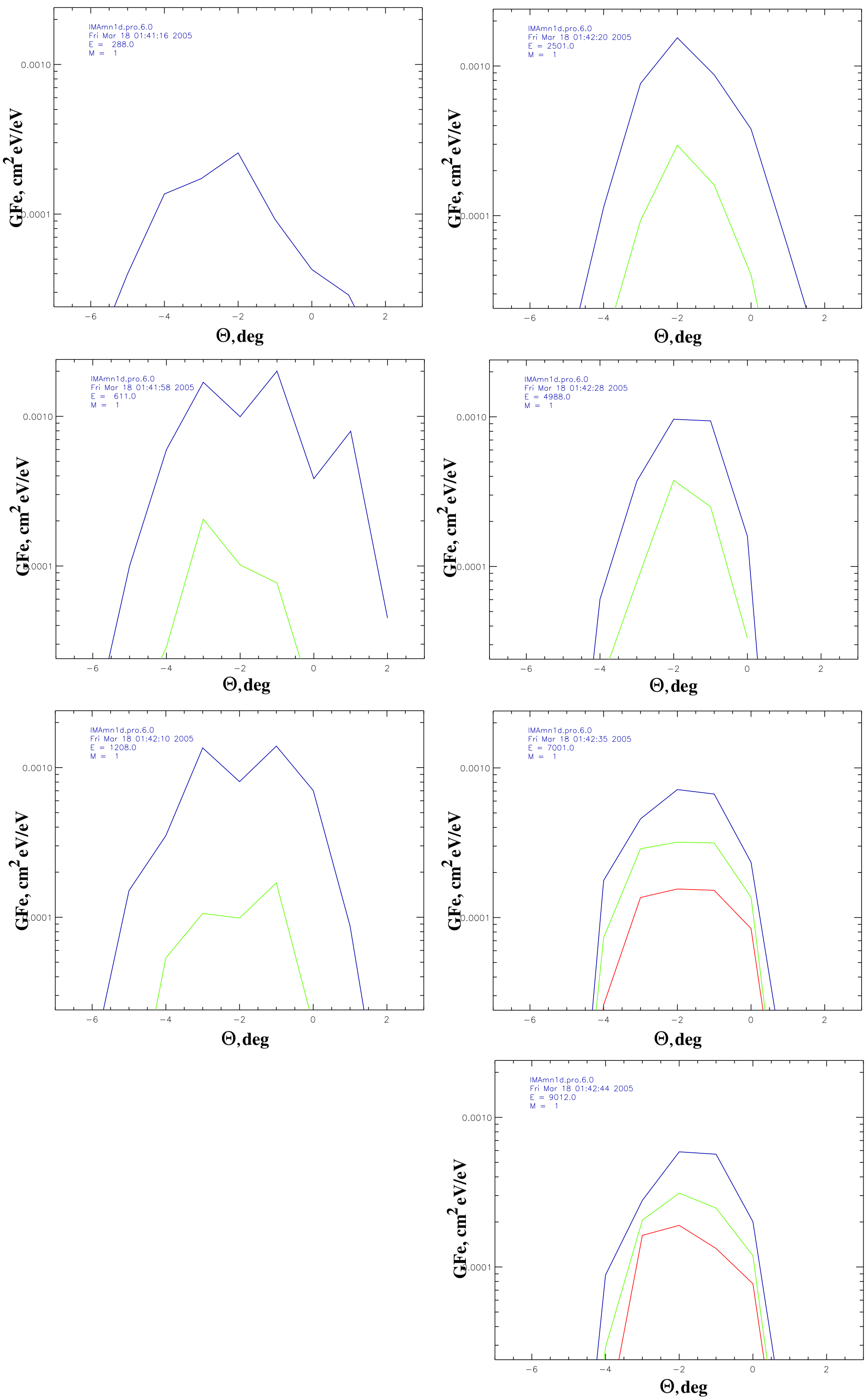


Figure 18: Differential GF_L versus Θ for H^+.

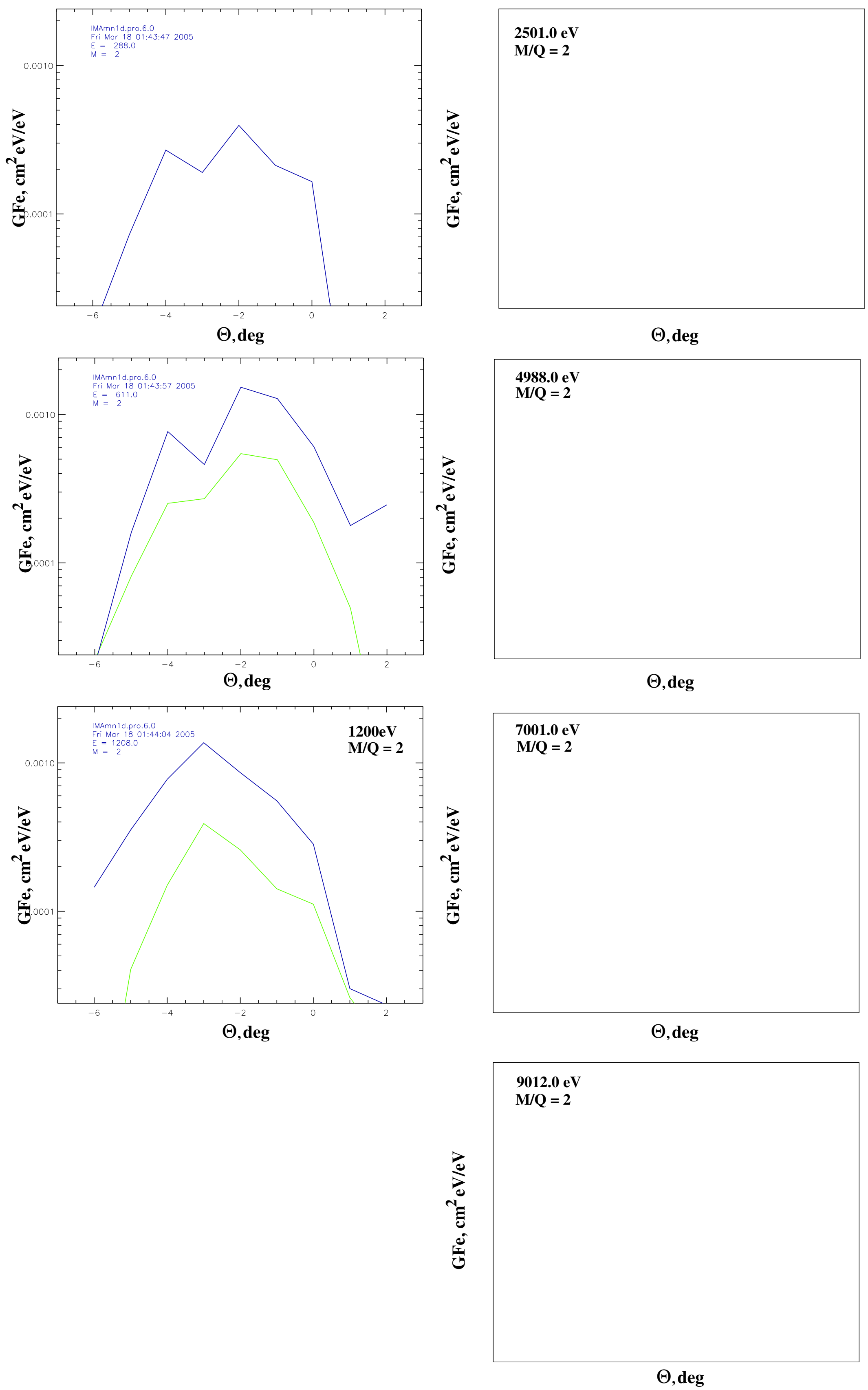


Figure 19: Differential GF_L versus Θ for H_2^{++}.

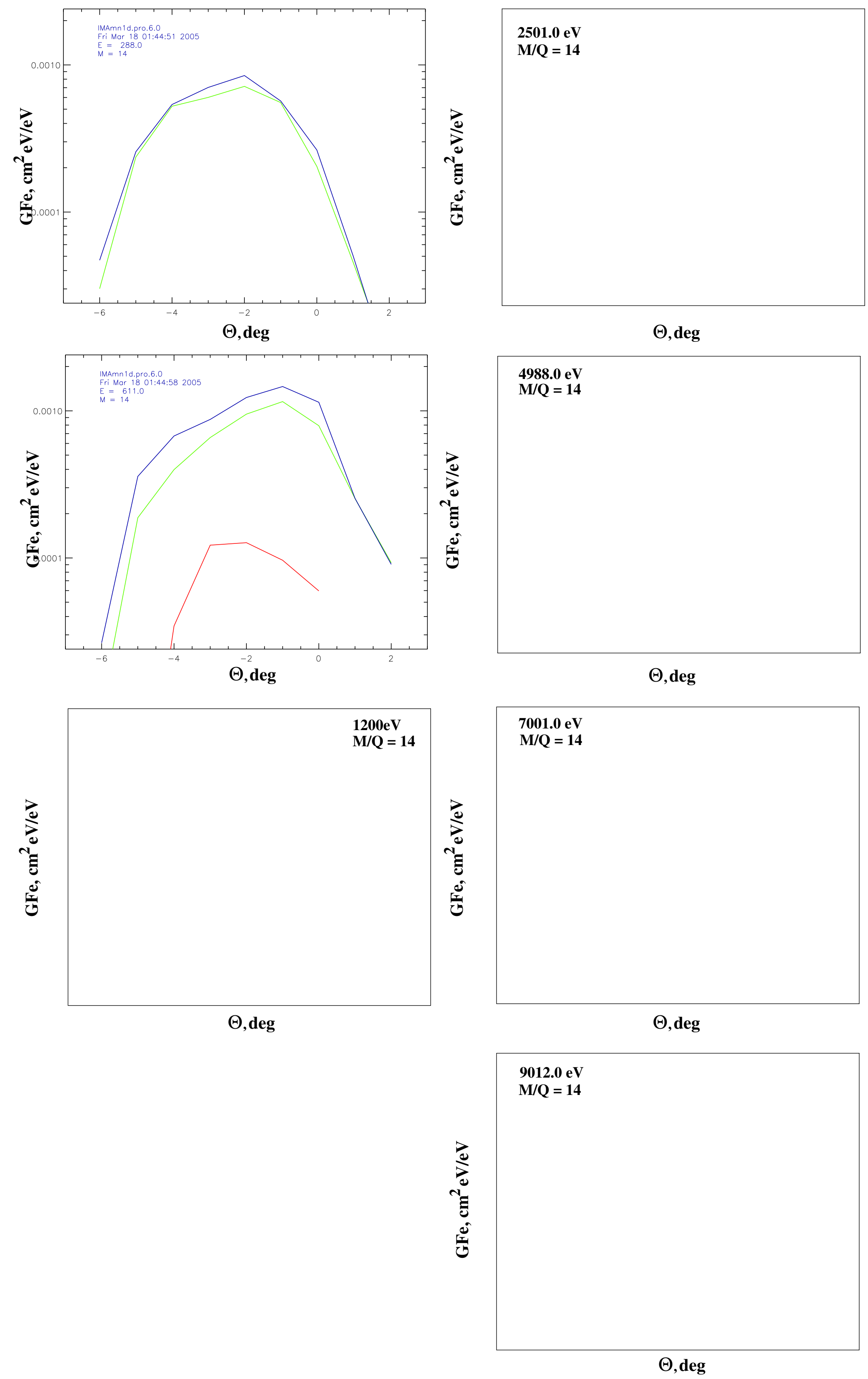


Figure 20: Differential GF_L versus Θ for N^+.

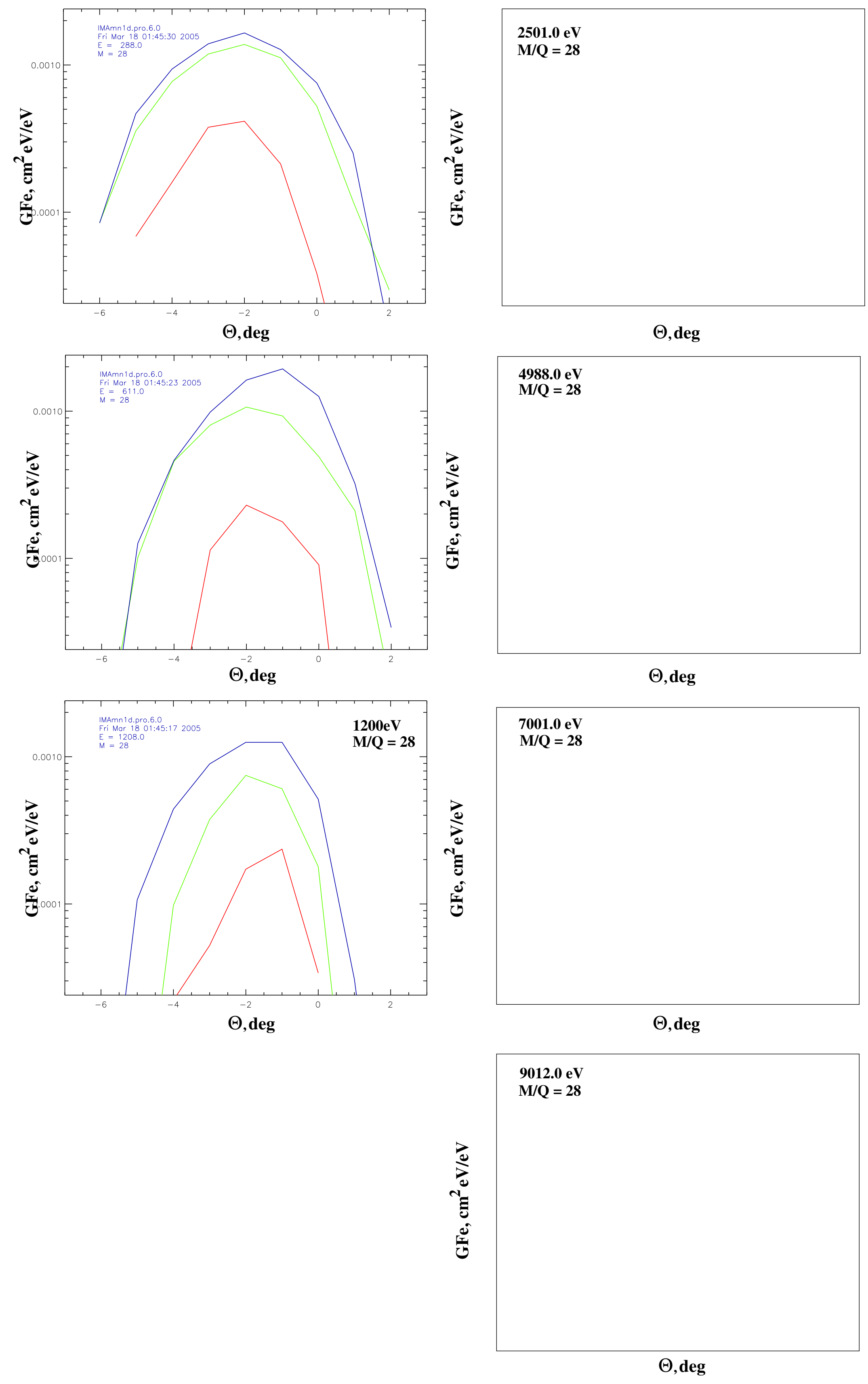


Figure 21: Differential GF_L versus Θ for N_2^+.

peak is out of detector. Note that shown valise corresponds to the center of the azimuthal profile. I.e it is KKC value.

Table 4 Measured GF_L

PAC	Eion	Mass	GFl	Tech.Value	Mpos	Mwidth
0.3	288.0	1	0.0e+00	7.23e+04	-1.0	0.0
2000.1	288.0	1	0.0e+00	7.38e+04	-1.0	0.0
3999.8	288.0	1	0.0e+00	7.24e+04	-1.0	0.0
0.3	288.0	2	0.0e+00	9.28e+04	-1.0	0.0
2000.1	288.0	2	0.0e+00	8.96e+04	-1.0	0.0
3999.8	288.0	2	0.0e+00	8.90e+04	-1.0	0.0
0.3	288.0	14	0.0e+00	1.16e+05	-1.0	0.0
2000.1	288.0	14	6.4e-06	1.16e+05	14.1	2.2
3999.8	288.0	14	7.2e-06	1.15e+05	10.5	3.0
0.3	288.0	28	0.0e+00	3.24e+04	-1.0	0.0
2000.1	288.0	28	1.2e-05	3.25e+04	11.6	2.3
3999.8	288.0	28	1.5e-05	3.10e+04	8.9	3.0
0.3	611.0	1	0.0e+00	1.07e+05	-1.0	0.0
2000.1	611.0	1	0.0e+00	1.07e+05	-1.0	0.0
3999.8	611.0	1	0.0e+00	1.07e+05	-1.0	0.0
0.3	611.0	2	0.0e+00	2.86e+05	-1.0	0.0
2000.1	611.0	2	2.8e-06	2.78e+05	27.5	3.0
3999.8	611.0	2	7.6e-06	2.77e+05	24.3	1.5
0.3	611.0	14	9.6e-07	1.65e+05	17.7	3.0
2000.1	611.0	14	9.8e-06	1.63e+05	12.1	1.8
3999.8	611.0	14	1.3e-05	1.64e+05	10.9	1.8
0.3	611.0	28	3.4e-06	2.81e+04	13.5	1.9
2000.1	611.0	28	2.2e-05	2.81e+04	9.3	1.3
3999.8	611.0	28	3.7e-05	3.07e+04	8.8	2.0
0.3	1208.0	1	0.0e+00	4.07e+05	-1.0	0.0
2000.1	1208.0	1	2.5e-07	3.28e+05	28.7	3.0
3999.8	1208.0	1	2.6e-06	3.17e+05	27.1	1.7
0.3	1208.0	2	0.0e+00	1.70e+05	-1.0	0.0
2000.1	1208.0	2	1.6e-06	1.62e+05	25.1	3.0
3999.8	1208.0	2	6.4e-06	1.61e+05	21.0	1.8
0.3	1208.0	14	0.0e+00	1.65e+04	-1.0	0.0
2000.1	1208.0	14	0.0e+00	1.69e+04	-1.0	0.0
3999.8	1208.0	14	0.0e+00	1.70e+04	-1.0	0.0
0.3	1208.0	28	1.1e-06	2.11e+05	8.7	1.6
2000.1	1208.0	28	4.4e-06	2.04e+05	6.6	1.7
3999.8	1208.0	28	9.8e-06	2.43e+05	6.3	1.2
0.3	2501.0	1	0.0e+00	1.39e+05	-1.0	0.0
2000.1	2501.0	1	6.6e-06	1.32e+05	26.8	2.1
3999.8	2501.0	1	4.1e-05	1.32e+05	23.9	1.9
0.3	2500.0	2	-1.0e+00	-1.00e+00	-1.0	-1.0
2000.1	2500.0	2	-1.0e+00	-1.00e+00	-1.0	-1.0
3999.8	2500.0	2	-1.0e+00	-1.00e+00	-1.0	-1.0
0.3	2500.0	14	-1.0e+00	-1.00e+00	-1.0	-1.0
2000.1	2500.0	14	-1.0e+00	-1.00e+00	-1.0	-1.0

3999.8	2500.0	14	-1.0e+00	-1.00e+00	-1.0	-1.0
0.3	2500.0	28	-1.0e+00	-1.00e+00	-1.0	-1.0
2000.1	2500.0	28	-1.0e+00	-1.00e+00	-1.0	-1.0
3999.8	2500.0	28	-1.0e+00	-1.00e+00	-1.0	-1.0
0.3	4988.0	1	0.0e+00	9.56e+04	-1.0	0.0
2000.1	4988.0	1	8.2e-06	9.48e+04	21.3	2.3
3999.8	4988.0	1	2.7e-05	9.49e+04	19.1	1.7
0.3	5000.0	2	-1.0e+00	-1.00e+00	-1.0	-1.0
2000.1	5000.0	2	-1.0e+00	-1.00e+00	-1.0	-1.0
3999.8	5000.0	2	-1.0e+00	-1.00e+00	-1.0	-1.0
0.3	5000.0	14	-1.0e+00	-1.00e+00	-1.0	-1.0
2000.1	5000.0	14	-1.0e+00	-1.00e+00	-1.0	-1.0
3999.8	5000.0	14	-1.0e+00	-1.00e+00	-1.0	-1.0
0.3	5000.0	28	-1.0e+00	-1.00e+00	-1.0	-1.0
2000.1	5000.0	28	-1.0e+00	-1.00e+00	-1.0	-1.0
3999.8	5000.0	28	-1.0e+00	-1.00e+00	-1.0	-1.0
0.3	7001.0	1	6.1e-06	6.22e+04	20.1	2.0
2000.1	7001.0	1	1.2e-05	6.29e+04	18.2	1.6
3999.8	7001.0	1	2.5e-05	6.31e+04	16.7	1.6
0.3	7000.0	2	-1.0e+00	-1.00e+00	-1.0	-1.0
2000.1	7000.0	2	-1.0e+00	-1.00e+00	-1.0	-1.0
3999.8	7000.0	2	-1.0e+00	-1.00e+00	-1.0	-1.0
0.3	7000.0	14	-1.0e+00	-1.00e+00	-1.0	-1.0
2000.1	7000.0	14	-1.0e+00	-1.00e+00	-1.0	-1.0
3999.8	7000.0	14	-1.0e+00	-1.00e+00	-1.0	-1.0
0.3	7000.0	28	-1.0e+00	-1.00e+00	-1.0	-1.0
2000.1	7000.0	28	-1.0e+00	-1.00e+00	-1.0	-1.0
3999.8	7000.0	28	-1.0e+00	-1.00e+00	-1.0	-1.0
0.3	9012.0	1	3.8e-05	7.79e+04	17.6	1.6
2000.1	9012.0	1	6.1e-05	7.87e+04	16.3	1.5
3999.8	9012.0	1	1.1e-04	7.87e+04	15.1	1.5
0.3	9000.0	2	-1.0e+00	-1.00e+00	-1.0	-1.0
2000.1	9000.0	2	-1.0e+00	-1.00e+00	-1.0	-1.0
3999.8	9000.0	2	-1.0e+00	-1.00e+00	-1.0	-1.0
0.3	9000.0	14	-1.0e+00	-1.00e+00	-1.0	-1.0
2000.1	9000.0	14	-1.0e+00	-1.00e+00	-1.0	-1.0
3999.8	9000.0	14	-1.0e+00	-1.00e+00	-1.0	-1.0
0.3	9000.0	28	-1.0e+00	-1.00e+00	-1.0	-1.0
2000.1	9000.0	28	-1.0e+00	-1.00e+00	-1.0	-1.0
3999.8	9000.0	28	-1.0e+00	-1.00e+00	-1.0	-1.0

The combined profile of GF_L versus energy is shown in Figure 22. We interpolated the raw data manually to get some similar behavior with simulation results.

8 In-flight calibration

To be completed

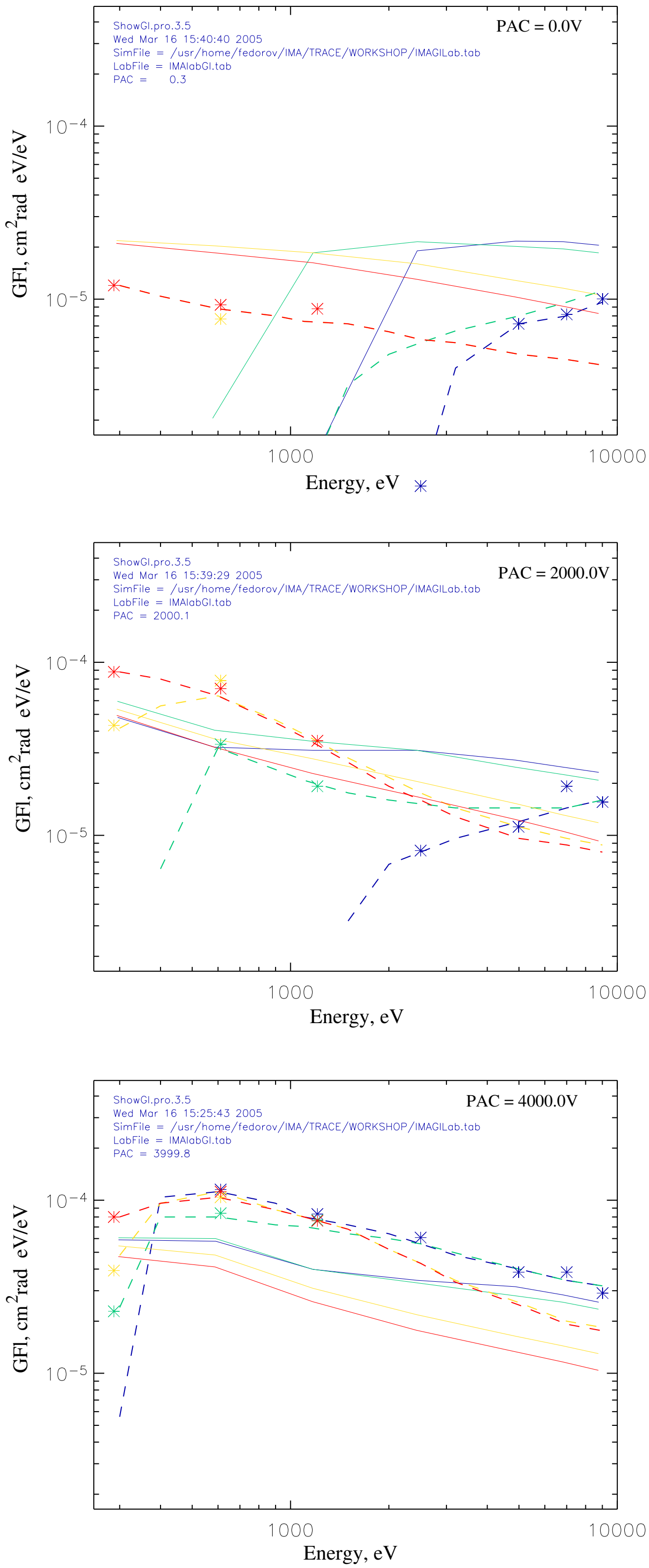


Figure 22: Measured GF_L versus E/Q for different M/Q. Measured values are shown by asterisks. Simulation values are shown by solid lines and interpolation is shown by dashed lines. Blue - H^+, Green - He_2^+, Yellow - N^+, and Red is N_2^+

9 Resulting tables

To transfer the laboratory data to the GF_L in the fight configuration we have made as follows:

1. Calculated ratio between measured (interpolated) an simulated values.
2. These ratio values were used to recover the flight GF_L from the simulation data in the flight conditions.
3. Then obtained values have been interpolated for real IMA energy steps.

Result of such processing is shown in Figure 23. The final GF_L one can see in Tabls 5,6,7. Note again that the values of these tables correspond to **KKC** in Table 2.

Table 5 Interpolated flight $GF_L$for PAC = 0

Estep	Energy	Gfl He++	GFl O+	GFl O2+
0	29992.6	-1.0e+00	-1.0e+00	-1.0e+00
1	27575.3	-1.0e+00	-1.0e+00	-1.0e+00
2	25345.4	-1.0e+00	-1.0e+00	-1.0e+00
3	23292.7	-1.0e+00	-1.0e+00	-1.0e+00
4	21406.8	-1.0e+00	-1.0e+00	-1.0e+00
5	19677.1	-1.0e+00	-1.0e+00	-1.0e+00
6	18082.8	-1.0e+00	-1.0e+00	-1.0e+00
7	16624.1	-1.0e+00	-1.0e+00	-1.0e+00
8	15279.9	-1.0e+00	-1.0e+00	-1.0e+00
9	14050.4	-1.0e+00	-1.0e+00	-1.0e+00
10	12914.6	-1.0e+00	-1.0e+00	-1.0e+00
11	11862.2	-1.0e+00	-1.0e+00	-1.0e+00
12	10903.6	-1.0e+00	-1.0e+00	-1.0e+00
13	10028.4	1.2e-05	3.9e-06	3.8e-06
14	9215.6	1.2e-05	4.0e-06	3.9e-06
15	8465.4	1.1e-05	4.1e-06	4.1e-06
16	7788.1	1.0e-05	4.2e-06	4.2e-06
17	7152.5	9.8e-06	4.3e-06	4.3e-06
18	6579.4	9.3e-06	4.4e-06	4.4e-06
19	6048.0	8.9e-06	4.5e-06	4.5e-06
20	5558.3	8.5e-06	4.6e-06	4.5e-06
21	5110.2	8.2e-06	4.6e-06	4.6e-06
22	4693.4	7.9e-06	4.8e-06	4.7e-06
23	4307.9	7.6e-06	4.9e-06	4.9e-06
24	3964.1	7.3e-06	5.1e-06	5.0e-06
25	3641.0	7.0e-06	5.2e-06	5.2e-06
26	3349.3	6.8e-06	5.4e-06	5.4e-06
27	3078.4	6.5e-06	5.5e-06	5.5e-06
28	2828.3	6.1e-06	5.6e-06	5.6e-06
29	2599.1	5.8e-06	5.6e-06	5.7e-06
30	2390.7	5.6e-06	5.8e-06	5.9e-06
31	2192.7	5.3e-06	6.1e-06	6.1e-06
32	2015.6	5.1e-06	6.4e-06	6.4e-06
33	1848.8	4.6e-06	6.7e-06	6.6e-06
34	1703.0	4.1e-06	6.9e-06	6.8e-06

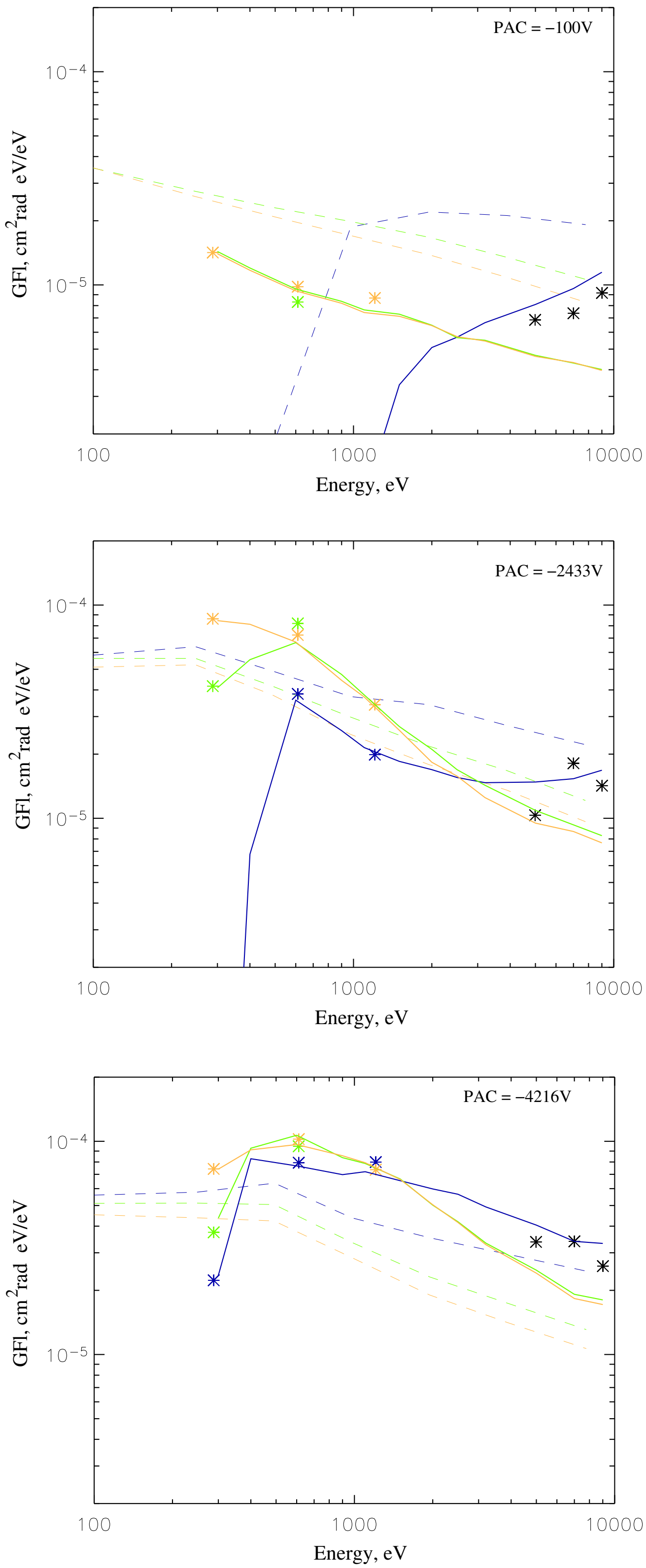


Figure 23: Interpolated flight GF_L versus E/Q for different M/Q. For reference the measured values shown by asterisks. Simulation values are shown by dashed lines and the final interpolation is shown by solid lines. Blue - He^{++}, Green - O^{+}, Yellow - O_2^{+}, Black is measured H^{+}

35	1567.5	3.6e-06	7.2e-06	7.0e-06
36	1442.5	2.9e-06	7.3e-06	7.2e-06
37	1317.4	2.0e-06	7.4e-06	7.2e-06
38	1213.2	1.5e-06	7.5e-06	7.3e-06
39	1119.5	1.1e-06	7.6e-06	7.4e-06
40	1025.7	2.0e-07	7.9e-06	7.7e-06
41	942.3	2.9e-08	8.2e-06	8.0e-06
42	869.4	1.0e-08	8.5e-06	8.3e-06
43	796.4	1.0e-08	8.7e-06	8.5e-06
44	733.9	1.0e-08	9.0e-06	8.8e-06
45	671.4	1.0e-08	9.2e-06	9.0e-06
46	619.3	1.0e-08	9.5e-06	9.3e-06
47	567.2	1.0e-08	9.9e-06	9.7e-06
48	515.1	1.0e-08	1.0e-05	1.0e-05
49	473.4	1.0e-08	1.1e-05	1.1e-05
50	442.2	1.0e-08	1.1e-05	1.1e-05
51	400.5	1.0e-08	1.2e-05	1.2e-05
52	369.2	1.0e-08	1.3e-05	1.2e-05
53	338.0	1.0e-08	1.3e-05	1.3e-05
54	306.7	1.0e-08	1.4e-05	1.4e-05
55	285.9	1.0e-08	1.5e-05	1.4e-05
56	265.0	1.0e-08	1.5e-05	1.5e-05
57	244.2	-1.0e+00	-1.0e+00	-1.0e+00
58	223.4	-1.0e+00	-1.0e+00	-1.0e+00
59	202.5	-1.0e+00	-1.0e+00	-1.0e+00
60	181.7	-1.0e+00	-1.0e+00	-1.0e+00
61	171.3	-1.0e+00	-1.0e+00	-1.0e+00
62	160.8	-1.0e+00	-1.0e+00	-1.0e+00
63	140.0	-1.0e+00	-1.0e+00	-1.0e+00
64	129.6	-1.0e+00	-1.0e+00	-1.0e+00
65	119.2	-1.0e+00	-1.0e+00	-1.0e+00
66	115.3	-1.0e+00	-1.0e+00	-1.0e+00
67	106.0	-1.0e+00	-1.0e+00	-1.0e+00
68	97.4	-1.0e+00	-1.0e+00	-1.0e+00
69	89.5	-1.0e+00	-1.0e+00	-1.0e+00
70	82.3	-1.0e+00	-1.0e+00	-1.0e+00
71	75.7	-1.0e+00	-1.0e+00	-1.0e+00
72	69.5	-1.0e+00	-1.0e+00	-1.0e+00
73	63.9	-1.0e+00	-1.0e+00	-1.0e+00
74	58.8	-1.0e+00	-1.0e+00	-1.0e+00
75	54.0	-1.0e+00	-1.0e+00	-1.0e+00
76	49.7	-1.0e+00	-1.0e+00	-1.0e+00
77	45.7	-1.0e+00	-1.0e+00	-1.0e+00
78	42.0	-1.0e+00	-1.0e+00	-1.0e+00
79	38.6	-1.0e+00	-1.0e+00	-1.0e+00
80	35.5	-1.0e+00	-1.0e+00	-1.0e+00
81	32.6	-1.0e+00	-1.0e+00	-1.0e+00
82	30.0	-1.0e+00	-1.0e+00	-1.0e+00
83	27.6	-1.0e+00	-1.0e+00	-1.0e+00

84	25.4	-1.0e+00	-1.0e+00	-1.0e+00
85	23.3	-1.0e+00	-1.0e+00	-1.0e+00
86	21.4	-1.0e+00	-1.0e+00	-1.0e+00
87	19.7	-1.0e+00	-1.0e+00	-1.0e+00
88	18.1	-1.0e+00	-1.0e+00	-1.0e+00
89	16.7	-1.0e+00	-1.0e+00	-1.0e+00
90	15.3	-1.0e+00	-1.0e+00	-1.0e+00
91	14.1	-1.0e+00	-1.0e+00	-1.0e+00
92	13.0	-1.0e+00	-1.0e+00	-1.0e+00
93	11.9	-1.0e+00	-1.0e+00	-1.0e+00
94	11.0	-1.0e+00	-1.0e+00	-1.0e+00
95	10.1	-1.0e+00	-1.0e+00	-1.0e+00

Table 6 Interpolated flight GF_L for PAC = 1

Estep	Energy	Gfl He++	GFl O+	GFl O2+
0	29992.6	-1.0e+00	-1.0e+00	-1.0e+00
1	27575.3	-1.0e+00	-1.0e+00	-1.0e+00
2	25345.4	-1.0e+00	-1.0e+00	-1.0e+00
3	23292.7	-1.0e+00	-1.0e+00	-1.0e+00
4	21406.8	-1.0e+00	-1.0e+00	-1.0e+00
5	19677.1	-1.0e+00	-1.0e+00	-1.0e+00
6	18082.8	-1.0e+00	-1.0e+00	-1.0e+00
7	16624.1	-1.0e+00	-1.0e+00	-1.0e+00
8	15279.9	-1.0e+00	-1.0e+00	-1.0e+00
9	14050.4	-1.0e+00	-1.0e+00	-1.0e+00
10	12914.6	-1.0e+00	-1.0e+00	-1.0e+00
11	11862.2	-1.0e+00	-1.0e+00	-1.0e+00
12	10903.6	-1.0e+00	-1.0e+00	-1.0e+00
13	10028.4	1.7e-05	7.9e-06	7.3e-06
14	9215.6	1.7e-05	8.2e-06	7.6e-06
15	8465.4	1.6e-05	8.5e-06	7.9e-06
16	7788.1	1.6e-05	8.9e-06	8.2e-06
17	7152.5	1.5e-05	9.2e-06	8.6e-06
18	6579.4	1.5e-05	9.6e-06	8.8e-06
19	6048.0	1.5e-05	1.0e-05	9.0e-06
20	5558.3	1.5e-05	1.0e-05	9.2e-06
21	5110.2	1.5e-05	1.1e-05	9.4e-06
22	4693.4	1.5e-05	1.1e-05	9.9e-06
23	4307.9	1.5e-05	1.2e-05	1.0e-05
24	3964.1	1.5e-05	1.3e-05	1.1e-05
25	3641.0	1.5e-05	1.3e-05	1.2e-05
26	3349.3	1.5e-05	1.4e-05	1.2e-05
27	3078.4	1.5e-05	1.5e-05	1.3e-05
28	2828.3	1.5e-05	1.6e-05	1.4e-05
29	2599.1	1.5e-05	1.6e-05	1.5e-05
30	2390.7	1.6e-05	1.8e-05	1.6e-05
31	2192.7	1.6e-05	1.9e-05	1.7e-05
32	2015.6	1.7e-05	2.1e-05	1.8e-05
33	1848.8	1.7e-05	2.3e-05	2.0e-05

34	1703.0	1.8e-05	2.4e-05	2.2e-05
35	1567.5	1.8e-05	2.6e-05	2.5e-05
36	1442.5	1.9e-05	2.8e-05	2.7e-05
37	1317.4	2.0e-05	3.1e-05	3.0e-05
38	1213.2	2.0e-05	3.4e-05	3.3e-05
39	1119.5	2.1e-05	3.7e-05	3.6e-05
40	1025.7	2.3e-05	4.1e-05	3.9e-05
41	942.3	2.5e-05	4.5e-05	4.3e-05
42	869.4	2.7e-05	4.9e-05	4.6e-05
43	796.4	2.8e-05	5.2e-05	5.0e-05
44	733.9	3.0e-05	5.6e-05	5.5e-05
45	671.4	3.3e-05	6.1e-05	6.0e-05
46	619.3	3.5e-05	6.5e-05	6.5e-05
47	567.2	2.8e-05	6.5e-05	6.9e-05
48	515.1	1.9e-05	6.2e-05	7.2e-05
49	473.4	1.4e-05	6.0e-05	7.5e-05
50	442.2	1.0e-05	5.8e-05	7.8e-05
51	400.5	6.8e-06	5.5e-05	8.1e-05
52	369.2	1.1e-06	5.1e-05	8.2e-05
53	338.0	1.5e-07	4.6e-05	8.3e-05
54	306.7	1.7e-08	4.2e-05	8.4e-05
55	285.9	3.4e-09	3.9e-05	8.5e-05
56	265.0	6.0e-10	3.6e-05	8.6e-05
57	244.2	-1.0e+00	-1.0e+00	-1.0e+00
58	223.4	-1.0e+00	-1.0e+00	-1.0e+00
59	202.5	-1.0e+00	-1.0e+00	-1.0e+00
60	181.7	-1.0e+00	-1.0e+00	-1.0e+00
61	171.3	-1.0e+00	-1.0e+00	-1.0e+00
62	160.8	-1.0e+00	-1.0e+00	-1.0e+00
63	140.0	-1.0e+00	-1.0e+00	-1.0e+00
64	129.6	-1.0e+00	-1.0e+00	-1.0e+00
65	119.2	-1.0e+00	-1.0e+00	-1.0e+00
66	115.3	-1.0e+00	-1.0e+00	-1.0e+00
67	106.0	-1.0e+00	-1.0e+00	-1.0e+00
68	97.4	-1.0e+00	-1.0e+00	-1.0e+00
69	89.5	-1.0e+00	-1.0e+00	-1.0e+00
70	82.3	-1.0e+00	-1.0e+00	-1.0e+00
71	75.7	-1.0e+00	-1.0e+00	-1.0e+00
72	69.5	-1.0e+00	-1.0e+00	-1.0e+00
73	63.9	-1.0e+00	-1.0e+00	-1.0e+00
74	58.8	-1.0e+00	-1.0e+00	-1.0e+00
75	54.0	-1.0e+00	-1.0e+00	-1.0e+00
76	49.7	-1.0e+00	-1.0e+00	-1.0e+00
77	45.7	-1.0e+00	-1.0e+00	-1.0e+00
78	42.0	-1.0e+00	-1.0e+00	-1.0e+00
79	38.6	-1.0e+00	-1.0e+00	-1.0e+00
80	35.5	-1.0e+00	-1.0e+00	-1.0e+00
81	32.6	-1.0e+00	-1.0e+00	-1.0e+00
82	30.0	-1.0e+00	-1.0e+00	-1.0e+00

83	27.6	-1.0e+00	-1.0e+00	-1.0e+00
84	25.4	-1.0e+00	-1.0e+00	-1.0e+00
85	23.3	-1.0e+00	-1.0e+00	-1.0e+00
86	21.4	-1.0e+00	-1.0e+00	-1.0e+00
87	19.7	-1.0e+00	-1.0e+00	-1.0e+00
88	18.1	-1.0e+00	-1.0e+00	-1.0e+00
89	16.7	-1.0e+00	-1.0e+00	-1.0e+00
90	15.3	-1.0e+00	-1.0e+00	-1.0e+00
91	14.1	-1.0e+00	-1.0e+00	-1.0e+00
92	13.0	-1.0e+00	-1.0e+00	-1.0e+00
93	11.9	-1.0e+00	-1.0e+00	-1.0e+00
94	11.0	-1.0e+00	-1.0e+00	-1.0e+00
95	10.1	-1.0e+00	-1.0e+00	-1.0e+00

Table 7 Interpolated flight GF_L for PAC = 2

Estep	Energy	Gfl He++	GFl O+	GFl O2+
0	29992.6	-1.0e+00	-1.0e+00	-1.0e+00
1	27575.3	-1.0e+00	-1.0e+00	-1.0e+00
2	25345.4	-1.0e+00	-1.0e+00	-1.0e+00
3	23292.7	-1.0e+00	-1.0e+00	-1.0e+00
4	21406.8	-1.0e+00	-1.0e+00	-1.0e+00
5	19677.1	-1.0e+00	-1.0e+00	-1.0e+00
6	18082.8	-1.0e+00	-1.0e+00	-1.0e+00
7	16624.1	-1.0e+00	-1.0e+00	-1.0e+00
8	15279.9	-1.0e+00	-1.0e+00	-1.0e+00
9	14050.4	-1.0e+00	-1.0e+00	-1.0e+00
10	12914.6	-1.0e+00	-1.0e+00	-1.0e+00
11	11862.2	-1.0e+00	-1.0e+00	-1.0e+00
12	10903.6	-1.0e+00	-1.0e+00	-1.0e+00
13	10028.4	3.3e-05	1.8e-05	1.7e-05
14	9215.6	3.3e-05	1.8e-05	1.7e-05
15	8465.4	3.3e-05	1.8e-05	1.7e-05
16	7788.1	3.4e-05	1.9e-05	1.8e-05
17	7152.5	3.4e-05	1.9e-05	1.8e-05
18	6579.4	3.5e-05	2.0e-05	1.9e-05
19	6048.0	3.7e-05	2.1e-05	2.1e-05
20	5558.3	3.8e-05	2.3e-05	2.2e-05
21	5110.2	4.0e-05	2.4e-05	2.4e-05
22	4693.4	4.2e-05	2.6e-05	2.5e-05
23	4307.9	4.3e-05	2.7e-05	2.7e-05
24	3964.1	4.5e-05	2.9e-05	2.8e-05
25	3641.0	4.7e-05	3.1e-05	3.0e-05
26	3349.3	4.8e-05	3.2e-05	3.2e-05
27	3078.4	5.0e-05	3.5e-05	3.4e-05
28	2828.3	5.3e-05	3.7e-05	3.7e-05
29	2599.1	5.5e-05	4.0e-05	4.0e-05
30	2390.7	5.7e-05	4.3e-05	4.3e-05
31	2192.7	5.8e-05	4.7e-05	4.7e-05
32	2015.6	6.0e-05	5.0e-05	5.0e-05

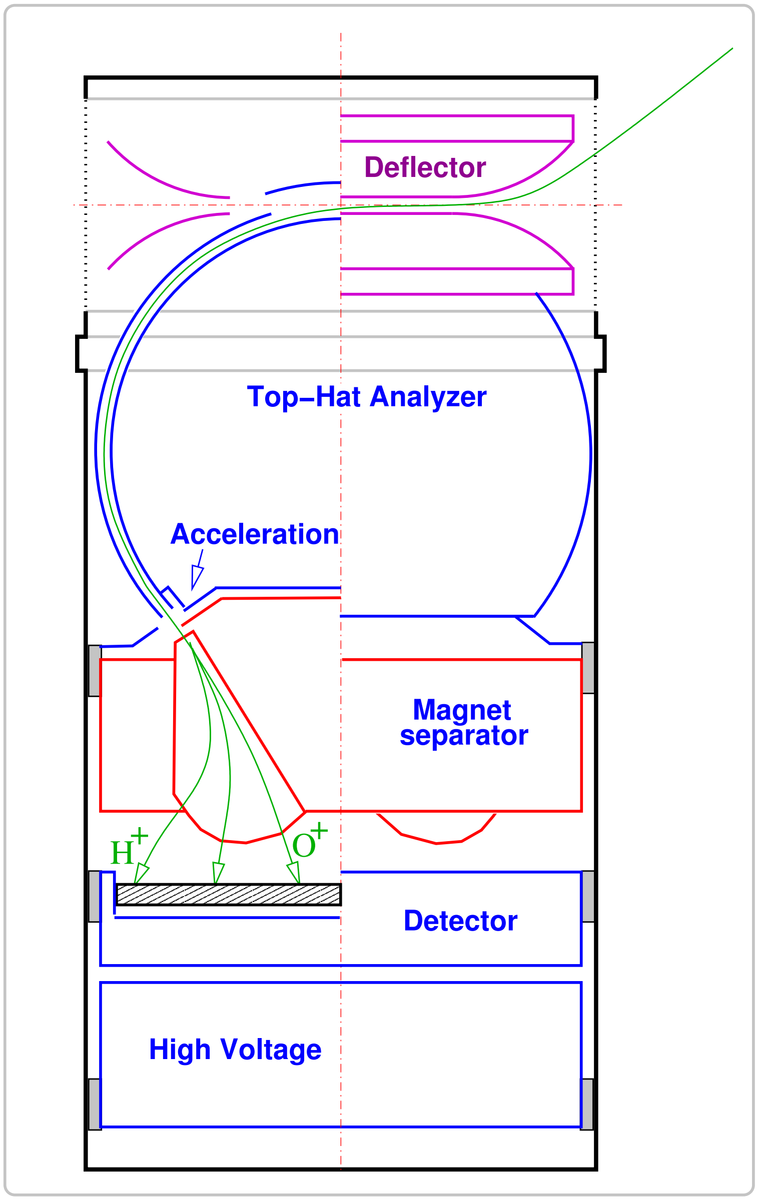
33	1848.8	6.1e-05	5.4e-05	5.4e-05
34	1703.0	6.3e-05	5.9e-05	5.9e-05
35	1567.5	6.4e-05	6.4e-05	6.3e-05
36	1442.5	6.6e-05	6.8e-05	6.8e-05
37	1317.4	6.8e-05	7.1e-05	7.1e-05
38	1213.2	7.0e-05	7.5e-05	7.5e-05
39	1119.5	7.2e-05	7.8e-05	7.9e-05
40	1025.7	7.1e-05	8.0e-05	8.1e-05
41	942.3	7.0e-05	8.3e-05	8.4e-05
42	869.4	7.0e-05	8.6e-05	8.6e-05
43	796.4	7.2e-05	9.0e-05	8.9e-05
44	733.9	7.3e-05	9.5e-05	9.1e-05
45	671.4	7.5e-05	1.0e-04	9.3e-05
46	619.3	7.6e-05	1.0e-04	9.6e-05
47	567.2	7.8e-05	1.0e-04	9.6e-05
48	515.1	7.9e-05	1.0e-04	9.5e-05
49	473.4	8.0e-05	9.8e-05	9.3e-05
50	442.2	8.1e-05	9.6e-05	9.3e-05
51	400.5	8.3e-05	9.3e-05	9.1e-05
52	369.2	5.8e-05	7.5e-05	8.6e-05
53	338.0	4.0e-05	6.0e-05	8.1e-05
54	306.7	2.6e-05	4.6e-05	7.5e-05
55	285.9	1.9e-05	3.8e-05	7.2e-05
56	265.0	1.4e-05	3.2e-05	6.8e-05
57	244.2	-1.0e+00	-1.0e+00	-1.0e+00
58	223.4	-1.0e+00	-1.0e+00	-1.0e+00
59	202.5	-1.0e+00	-1.0e+00	-1.0e+00
60	181.7	-1.0e+00	-1.0e+00	-1.0e+00
61	171.3	-1.0e+00	-1.0e+00	-1.0e+00
62	160.8	-1.0e+00	-1.0e+00	-1.0e+00
63	140.0	-1.0e+00	-1.0e+00	-1.0e+00
64	129.6	-1.0e+00	-1.0e+00	-1.0e+00
65	119.2	-1.0e+00	-1.0e+00	-1.0e+00
66	115.3	-1.0e+00	-1.0e+00	-1.0e+00
67	106.0	-1.0e+00	-1.0e+00	-1.0e+00
68	97.4	-1.0e+00	-1.0e+00	-1.0e+00
69	89.5	-1.0e+00	-1.0e+00	-1.0e+00
70	82.3	-1.0e+00	-1.0e+00	-1.0e+00
71	75.7	-1.0e+00	-1.0e+00	-1.0e+00
72	69.5	-1.0e+00	-1.0e+00	-1.0e+00
73	63.9	-1.0e+00	-1.0e+00	-1.0e+00
74	58.8	-1.0e+00	-1.0e+00	-1.0e+00
75	54.0	-1.0e+00	-1.0e+00	-1.0e+00
76	49.7	-1.0e+00	-1.0e+00	-1.0e+00
77	45.7	-1.0e+00	-1.0e+00	-1.0e+00
78	42.0	-1.0e+00	-1.0e+00	-1.0e+00
79	38.6	-1.0e+00	-1.0e+00	-1.0e+00
80	35.5	-1.0e+00	-1.0e+00	-1.0e+00
81	32.6	-1.0e+00	-1.0e+00	-1.0e+00

```
82      30.0 -1.0e+00 -1.0e+00 -1.0e+00
83      27.6 -1.0e+00 -1.0e+00 -1.0e+00
84      25.4 -1.0e+00 -1.0e+00 -1.0e+00
85      23.3 -1.0e+00 -1.0e+00 -1.0e+00
86      21.4 -1.0e+00 -1.0e+00 -1.0e+00
87      19.7 -1.0e+00 -1.0e+00 -1.0e+00
88      18.1 -1.0e+00 -1.0e+00 -1.0e+00
89      16.7 -1.0e+00 -1.0e+00 -1.0e+00
90      15.3 -1.0e+00 -1.0e+00 -1.0e+00
91      14.1 -1.0e+00 -1.0e+00 -1.0e+00
92      13.0 -1.0e+00 -1.0e+00 -1.0e+00
93      11.9 -1.0e+00 -1.0e+00 -1.0e+00
94      11.0 -1.0e+00 -1.0e+00 -1.0e+00
95      10.1 -1.0e+00 -1.0e+00 -1.0e+00
```

To be completed

Mars Express
ASPERA-3
IMA FLIGHT TABLES
V.5.2

March 27, 2007



Andrei Fedorov

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1 IMPORTANT NOTE

This text is a part of the "IMA Bible". It is supplied with a number of files that are the generic parts of "Flight Tables" or "The Bible".

2 Energy table.

Energy table establish relation between E/Q of the ion and $EnIndex$ value. This table is in `TABLES/EnTable.txt` file. The format of this file is described in the file header. Negative values indicate that IMA cannot measure the positive ions on the given energy step. The resume of IMA energy steps is given in Table 1.

Table 1: MEX IMA Energy table, V.4.0, Mar 13 2006

EnI	E/Q	EnI	E/Q	EnI	E/Q	EnI	E/Q	EnI	E/Q	EnI	E/Q	EnI	E/Q	EnI	E/Q
0	32288.7	1	29659.4	2	27234.1	3	25001.5	4	22950.2	5	21068.8	6	19334.8	7	17748.2
8	16286.2	9	14948.9	10	13713.6	11	12568.9	12	11526.2	13	10574.3	14	9690.3	15	8874.3
16	8137.6	17	7446.3	18	6823.0	19	6245.0	20	5712.3	21	5225.0	22	4771.6	23	4352.3
24	3978.3	25	3627.0	26	3309.7	27	3015.0	28	2743.0	29	2493.7	30	2267.0	31	2051.7
32	1859.0	33	1677.7	34	1519.0	35	1371.7	36	1235.7	37	1099.7	38	986.3	39	884.3
40	782.3	41	691.7	42	612.3	43	533.0	44	465.0	45	397.0	46	340.3	47	283.7
48	227.0	49	181.7	50	147.7	51	102.3	52	68.3	53	34.3	54	0.3	55	-1.0
56	-1.0	57	-1.0	58	-1.0	59	-1.0	60	-1.0	61	-1.0	62	-1.0	63	-1.0
64	-1.0	65	-1.0	66	-1.0	67	-1.0	68	-1.0	69	-1.0	70	-1.0	71	-1.0
72	-1.0	73	-1.0	74	-1.0	75	-1.0	76	-1.0	77	-1.0	78	-1.0	79	-1.0
80	-1.0	81	-1.0	82	-1.0	83	-1.0	84	-1.0	85	-1.0	86	-1.0	87	-1.0
88	-1.0	89	-1.0	90	-1.0	91	-1.0	92	-1.0	93	-1.0	94	-1.0	95	-1.0

Attention! To reach low energies, a new energy table is installed aboard of ASPERA-3. You can find this table in `TABLES/IMAMEXETable50.txt`. Apply new table for time intervals:

start	stop
2007-03-21T18:20	2007-03-21T19:20
2007-03-29T18:18	2007-03-30T18:20
TBD	end of mission

new table is given in Table 2. See also Section 6 for additional information.

Table 2: MEX IMA Energy table, V.5.0, Apr 23 2006

EnI	E/Q	EnI	E/Q	EnI	E/Q	EnI	E/Q	EnI	E/Q	EnI	E/Q	EnI	E/Q	EnI	E/Q
0	25001.5	1	23018.1	2	21204.8	3	19527.5	4	17986.2	5	16558.2	6	15254.9	7	14042.2
8	12931.6	9	11911.6	10	10970.9	11	10109.6	12	9304.9	13	8568.3	14	7888.3	15	7265.0
16	6698.3	17	6165.6	18	5678.3	19	5225.0	20	4817.0	21	4431.6	22	4080.3	23	3763.0
24	3468.3	25	3185.0	26	2935.7	27	2709.0	28	2493.7	29	2289.7	30	2108.3	31	1949.7
32	1791.0	33	1655.0	34	1519.0	35	1394.3	36	1292.3	37	1190.3	38	1088.3	39	1009.0
40	929.7	41	850.3	42	782.3	43	725.7	44	669.0	45	612.3	46	567.0	47	521.7
48	476.3	49	442.3	50	408.3	51	374.3	52	340.3	53	317.7	54	295.0	55	272.3
56	249.7	57	227.0	58	215.7	59	193.0	60	181.7	61	159.0	62	147.7	63	136.3
64	125.0	65	113.7	66	113.7	67	102.3	68	92.4	69	85.1	70	78.4	71	72.2
72	66.5	73	61.2	74	56.4	75	51.9	76	47.8	77	44.0	78	40.6	79	37.4
80	34.4	81	31.7	82	29.2	83	26.9	84	24.7	85	22.8	86	21.0	87	19.3
88	17.8	89	16.4	90	15.1	91	13.9	92	12.8	93	11.8	94	10.9	95	10.0

3 Elevation table.

Elevation table gives correspondence between Θ and $EnIndex$ and $ElIndex$. Appropriate file is `TABLES/EnTable.txt`. The format of the file is described in its header. The summary of IMA elevation table is shown in Table 3. Value less than -50.0 means that given **IMA_Energy_Spectrum**is not valid and should be excluded from data analysis.

Table 3: MEX IMA Elevation table, V.4.0, 13 Mar 2006

ElIndex EnIndex	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

0	27.6	32.0	-26.9	-22.1	-17.2	-12.3	-7.4	-2.5	2.3	7.2	12.1	17.1	22.0	26.9	31.6	-27.8
1	33.7	-31.7	-27.0	-22.1	-17.2	-12.3	-7.4	-2.5	2.3	7.2	12.1	17.1	22.0	26.9	31.6	-33.9
2	-36.2	-31.7	-27.0	-22.2	-17.2	-12.3	-7.4	-2.6	2.3	7.2	12.1	17.1	22.1	27.0	31.6	36.0
3	-36.2	-31.8	-27.1	-22.2	-17.3	-12.4	-7.5	-2.6	2.3	7.2	12.1	17.1	22.1	27.0	31.7	36.1
4	-36.3	-31.8	-27.1	-22.2	-17.3	-12.4	-7.5	-2.6	2.3	7.2	12.2	17.1	22.1	27.0	31.7	36.1
5	-36.4	-31.9	-27.2	-22.3	-17.4	-12.4	-7.5	-2.6	2.3	7.2	12.1	17.1	22.1	27.0	31.7	36.1
6	-36.4	-32.0	-27.2	-22.3	-17.4	-12.4	-7.5	-2.6	2.3	7.2	12.2	17.1	22.1	27.0	31.8	36.2
7	-36.5	-32.0	-27.3	-22.4	-17.4	-12.5	-7.5	-2.6	2.3	7.2	12.2	17.2	22.2	27.1	31.8	36.2
8	-36.6	-32.1	-27.4	-22.4	-17.5	-12.5	-7.6	-2.7	2.3	7.2	12.2	17.2	22.2	27.1	31.8	36.3
9	-36.7	-32.2	-27.4	-22.5	-17.5	-12.6	-7.6	-2.7	2.3	7.2	12.2	17.2	22.2	27.1	31.9	36.3
10	-36.8	-32.3	-27.5	-22.6	-17.6	-12.6	-7.6	-2.7	2.2	7.2	12.2	17.2	22.2	27.2	31.9	36.4
11	-36.9	-32.4	-27.6	-22.6	-17.6	-12.6	-7.7	-2.7	2.2	7.2	12.2	17.2	22.2	27.2	32.0	36.5
12	-37.0	-32.5	-27.7	-22.7	-17.7	-12.7	-7.7	-2.8	2.2	7.2	12.2	17.3	22.3	27.3	32.0	36.5
13	-37.2	-32.6	-27.8	-22.8	-17.8	-12.7	-7.7	-2.8	2.2	7.2	12.2	17.2	22.3	27.3	32.1	36.6
14	-37.3	-32.7	-27.9	-22.9	-17.9	-12.8	-7.8	-2.8	2.2	7.2	12.2	17.3	22.3	27.3	32.2	36.7
15	-37.5	-32.9	-28.0	-23.0	-18.0	-12.9	-7.9	-2.9	2.2	7.2	12.2	17.3	22.4	27.4	32.3	36.8
16	-37.7	-33.1	-28.2	-23.1	-18.0	-12.9	-7.9	-2.9	2.1	7.2	12.2	17.3	22.4	27.5	32.3	36.9
17	-37.9	-33.3	-28.3	-23.3	-18.1	-13.1	-8.0	-3.0	2.1	7.2	12.2	17.3	22.5	27.5	32.4	37.0
18	-38.1	-33.4	-28.5	-23.4	-18.3	-13.1	-8.1	-3.0	2.1	7.1	12.2	17.4	22.5	27.6	32.5	37.1
19	-38.3	-33.6	-28.6	-23.5	-18.3	-13.3	-8.1	-3.0	2.1	7.1	12.3	17.5	22.6	27.7	32.7	37.2
20	-38.6	-33.9	-28.9	-23.7	-18.5	-13.3	-8.2	-3.1	2.0	7.1	12.3	17.5	22.7	27.8	32.7	37.4
21	-38.9	-34.2	-29.1	-23.9	-18.7	-13.4	-8.3	-3.1	2.0	7.1	12.2	17.5	22.8	27.9	32.9	37.5
22	-39.1	-34.4	-29.3	-24.1	-18.8	-13.6	-8.4	-3.2	1.9	7.1	12.3	17.6	22.8	28.0	33.0	37.7
23	-39.5	-34.7	-29.6	-24.3	-19.0	-13.8	-8.6	-3.3	1.9	7.0	12.3	17.6	22.9	28.1	33.3	37.9
24	-39.9	-35.1	-29.9	-24.6	-19.2	-13.9	-8.6	-3.4	1.8	7.0	12.3	17.7	22.9	28.2	33.4	38.2
25	-40.4	-35.4	-30.1	-24.8	-19.5	-14.0	-8.8	-3.5	1.8	7.0	12.4	17.8	23.1	28.4	33.5	38.3
26	-40.8	-35.8	-30.6	-25.2	-19.7	-14.3	-8.9	-3.6	1.8	7.1	12.3	17.8	23.1	28.5	33.8	38.7
27	-41.4	-36.3	-31.0	-25.5	-19.9	-14.5	-9.0	-3.7	1.6	7.1	12.4	17.9	23.4	28.8	34.0	38.9
28	-42.1	-36.9	-31.5	-25.8	-20.2	-14.8	-9.3	-3.8	1.5	7.0	12.5	18.0	23.5	29.1	34.4	39.4
29	-42.8	-37.4	-32.0	-26.3	-20.6	-15.0	-9.5	-4.0	1.4	6.9	12.5	18.0	23.6	29.3	34.5	39.8
30	-43.3	-38.2	-32.4	-26.6	-21.1	-15.3	-9.7	-4.1	1.3	6.9	12.5	18.2	23.8	29.5	35.0	40.1
31	-44.3	-38.9	-33.0	-27.4	-21.5	-15.6	-9.9	-4.3	1.4	6.9	12.5	18.2	24.1	29.6	35.4	40.5
32	-100.0	-39.5	-33.9	-27.9	-22.0	-16.0	-10.2	-4.6	1.2	6.8	12.5	18.4	24.4	30.0	35.8	41.1
33	-100.0	-40.7	-34.8	-28.4	-22.4	-16.4	-10.6	-4.6	1.0	6.9	12.6	18.6	24.6	30.5	36.3	41.5
34	-100.0	-41.8	-35.6	-29.3	-22.9	-16.9	-10.8	-4.9	1.0	6.9	12.6	18.6	24.9	30.7	36.7	42.4
35	-100.0	-42.7	-36.6	-30.0	-23.8	-17.4	-11.3	-5.4	0.7	6.9	12.9	18.8	24.9	31.4	37.2	42.8
36	-100.0	-44.4	-37.6	-31.1	-24.5	-17.9	-11.9	-5.7	0.4	6.8	12.7	19.2	25.7	32.0	38.0	43.8
37	-100.0	-100.0	-39.3	-32.5	-25.5	-18.9	-12.2	-6.1	0.3	6.7	12.9	19.3	26.1	32.2	39.1	-100.0
38	-100.0	-100.0	-40.4	-33.3	-26.6	-19.7	-12.7	-6.4	-0.2	6.5	12.9	19.5	26.5	33.4	39.9	-100.0
39	-100.0	-100.0	-42.6	-35.2	-27.6	-20.5	-13.7	-6.7	-0.3	6.6	13.2	20.1	26.7	33.7	41.1	-100.0
40	-100.0	-100.0	-44.6	-36.8	-28.9	-21.4	-14.4	-7.6	-0.4	6.2	13.0	20.1	27.7	34.9	41.8	-100.0
41	-100.0	-100.0	-100.0	-39.1	-30.8	-23.0	-15.7	-8.0	-1.2	6.2	13.2	20.6	28.4	35.8	43.7	-100.0
42	-100.0	-100.0	-100.0	-41.3	-32.6	-24.6	-16.3	-9.1	-1.4	6.2	13.3	21.6	28.7	37.2	-100.0	-100.0
43	-100.0	-100.0	-100.0	-44.1	-35.0	-26.7	-18.0	-9.7	-1.7	6.1	13.4	22.0	30.3	39.1	-100.0	-100.0
44	-100.0	-100.0	-100.0	-100.0	-38.5	-28.7	-19.7	-11.3	-3.1	5.9	14.3	23.1	31.5	40.4	-100.0	-100.0
45	-100.0	-100.0	-100.0	-100.0	-41.9	-31.6	-22.1	-12.1	-3.7	5.8	14.2	23.3	33.1	43.8	-100.0	-100.0
46	-100.0	-100.0	-100.0	-100.0	-100.0	-34.3	-24.7	-14.3	-4.4	5.3	15.1	24.2	35.9	-100.0	-100.0	-100.0
47	-100.0	-100.0	-100.0	-100.0	-100.0	-40.4	-28.3	-17.4	-5.4	4.6	14.6	25.6	37.7	-100.0	-100.0	-100.0
48	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-34.0	-19.9	-7.0	3.5	16.0	27.6	43.4	-100.0	-100.0	-100.0
49	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-40.8	-25.3	-11.5	4.2	17.2	32.1	-100.0	-100.0	-100.0	-100.0
50	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-31.9	-14.4	1.8	17.8	36.5	-100.0	-100.0	-100.0	-100.0
51	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-43.2	-21.3	2.4	21.8	43.4	-100.0	-100.0	-100.0	-100.0
52	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-33.3	-3.6	25.5	-100.0	-100.0	-100.0	-100.0	-100.0
53	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-7.7	37.1	-100.0	-100.0	-100.0	-100.0	-100.0
54	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0
55	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0
56	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0
57	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0
58	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0
59	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0
60	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0
61	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0
62	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0
63	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0
64	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0
65	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0
66	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0
67	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0
68	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0
69	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0
70	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0
71	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0
72	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0
73	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0
74	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0
75	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0
76	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0
77	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0
78	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0
79	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0
80	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0
81	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0
82	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0
83	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0
84	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0
85	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0
86	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0
87	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0
88	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0
89	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0
90	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0
91	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0
92	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0
93	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0
94	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0

95	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0

Attention! To reach low energies, a new elevation table is installed aboard of ASPERA-3. You can find this table in 4. Apply the new table for time intervals:

start	stop
2007-03-21T18:20	2007-03-21T19:20
2007-03-29T18:18	2007-03-30T18:20
TBD	end of mission

new table is given in Table 4. Note that the is no elevation scan below $E = 50eV$. See also Section 6 for additional information.

Table 4: MEX IMA Elevation table, V.4.0, 13 Mar 2006

ElIndex EnIndex	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	24.1	20.8	17.6	14.5	11.4	8.3	5.3	2.3	-0.7	-3.7	-6.7	-9.7	-12.7	-15.8	-18.9	-22.1
1	26.3	22.7	19.1	15.7	12.3	9.0	5.7	2.4	-0.8	-4.0	-7.3	-10.6	-13.9	-17.3	-20.7	-24.3
2	28.7	24.7	20.8	17.0	13.3	9.7	6.1	2.6	-0.9	-4.4	-8.0	-11.6	-15.2	-18.9	-22.7	-26.6
3	31.4	27.0	22.6	18.5	14.4	10.5	6.6	2.7	-1.1	-4.9	-8.7	-12.6	-16.6	-20.6	-24.8	-29.1
4	34.4	29.5	24.7	20.1	15.7	11.3	7.1	2.9	-1.2	-5.4	-9.5	-13.8	-18.1	-22.6	-27.2	-32.0
5	37.8	32.2	26.9	21.9	17.0	12.3	7.7	3.1	-1.4	-5.9	-10.4	-15.1	-19.8	-24.7	-29.8	-35.2
6	41.5	35.3	29.4	23.8	18.5	13.3	8.3	3.3	-1.6	-6.5	-11.4	-16.5	-21.7	-27.1	-32.7	-38.7
7	-42.1	-36.5	-30.9	-25.2	-19.6	-14.0	-8.4	-2.8	2.8	8.3	13.9	19.6	25.3	31.0	36.6	42.1
8	-42.1	-36.5	-30.9	-25.2	-19.5	-13.9	-8.3	-2.8	2.8	8.3	13.9	19.6	25.3	30.9	36.6	42.1
9	-42.0	-36.5	-30.9	-25.2	-19.6	-14.0	-8.4	-2.8	2.8	8.3	13.9	19.6	25.3	30.9	36.6	42.1
10	-42.1	-36.5	-30.9	-25.2	-19.6	-13.9	-8.3	-2.8	2.7	8.3	13.9	19.6	25.2	30.9	36.6	42.1
11	-42.0	-36.5	-30.9	-25.2	-19.6	-13.9	-8.4	-2.8	2.8	8.3	13.9	19.6	25.2	30.9	36.6	42.1
12	-42.1	-36.5	-30.9	-25.2	-19.5	-13.9	-8.4	-2.8	2.7	8.3	13.9	19.6	25.3	30.9	36.6	42.1
13	-42.0	-36.5	-30.9	-25.2	-19.6	-13.9	-8.3	-2.8	2.7	8.3	13.9	19.6	25.3	31.0	36.6	42.1
14	-42.1	-36.5	-30.9	-25.2	-19.6	-14.0	-8.3	-2.8	2.8	8.3	13.9	19.6	25.2	31.0	36.6	42.1
15	-42.1	-36.6	-30.9	-25.2	-19.5	-14.0	-8.3	-2.8	2.8	8.3	13.9	19.6	25.2	31.0	36.6	42.1
16	-42.1	-36.5	-30.9	-25.2	-19.5	-13.9	-8.3	-2.8	2.8	8.3	13.9	19.6	25.3	31.0	36.6	42.1
17	-42.1	-36.5	-30.9	-25.3	-19.5	-13.9	-8.4	-2.8	2.7	8.3	13.9	19.6	25.2	30.9	36.6	42.2
18	-42.0	-36.5	-30.9	-25.2	-19.5	-13.9	-8.4	-2.8	2.8	8.3	14.0	19.6	25.3	31.0	36.5	42.2
19	-42.0	-36.5	-30.8	-25.2	-19.6	-13.9	-8.4	-2.8	2.8	8.4	13.9	19.6	25.3	30.9	36.6	42.1
20	-42.1	-36.5	-30.9	-25.2	-19.6	-14.0	-8.4	-2.8	2.8	8.4	13.9	19.6	25.3	30.9	36.5	42.1
21	-42.1	-36.6	-30.8	-25.2	-19.5	-14.0	-8.4	-2.8	2.7	8.3	13.9	19.6	25.3	31.0	36.6	42.1
22	-42.1	-36.5	-31.0	-25.1	-19.6	-14.0	-8.4	-2.8	2.8	8.4	13.9	19.5	25.3	30.9	36.5	42.1
23	-42.0	-36.6	-30.9	-25.2	-19.5	-13.9	-8.4	-2.8	2.8	8.4	13.9	19.6	25.3	30.9	36.6	42.2
24	-42.1	-36.4	-30.8	-25.2	-19.6	-13.9	-8.4	-2.8	2.7	8.3	14.0	19.6	25.2	31.0	36.5	42.1
25	-42.1	-36.5	-30.8	-25.2	-19.6	-13.9	-8.4	-2.8	2.7	8.3	13.9	19.6	25.2	31.0	36.6	42.1
26	-42.0	-36.5	-30.9	-25.2	-19.6	-14.0	-8.3	-2.8	2.7	8.3	13.9	19.6	25.2	31.0	36.7	42.2
27	-42.1	-36.4	-30.8	-25.3	-19.6	-13.9	-8.3	-2.7	2.7	8.3	13.9	19.7	25.3	30.9	36.6	42.1
28	-42.0	-36.6	-31.0	-25.2	-19.7	-13.9	-8.3	-2.8	2.9	8.4	14.0	19.6	25.3	30.9	36.6	42.1
29	-42.2	-36.6	-30.8	-25.2	-19.7	-13.9	-8.4	-2.9	2.8	8.4	13.9	19.5	25.4	31.0	36.7	42.1
30	-42.2	-36.4	-31.0	-25.2	-19.4	-13.9	-8.3	-2.7	2.8	8.3	14.0	19.6	25.2	31.1	36.7	42.2
31	-42.0	-36.4	-30.8	-25.2	-19.5	-14.0	-8.5	-2.7	2.7	8.4	14.1	19.6	25.3	31.1	36.4	42.1
32	-42.0	-36.7	-30.9	-25.1	-19.6	-13.9	-8.4	-2.7	2.9	8.3	13.8	19.5	25.1	31.0	36.6	42.0
33	-42.2	-36.4	-30.9	-25.3	-19.7	-13.9	-8.3	-2.7	2.7	8.3	13.9	19.5	25.2	30.9	36.5	42.0
34	-42.0	-36.6	-31.0	-25.3	-19.4	-13.8	-8.4	-2.7	2.3	8.3	13.8	19.4	25.3	30.7	36.4	42.0
35	-41.8	-36.4	-30.7	-25.3	-19.4	-14.0	-8.5	-2.6	2.4	8.2	13.8	19.6	25.3	31.2	36.5	42.1
36	-42.3	-36.3	-30.7	-25.3	-19.4	-14.0	-8.4	-2.9	2.6	8.4	14.1	19.5	25.1	31.0	36.8	42.3
37	-42.2	-36.3	-30.7	-25.4	-19.3	-14.0	-8.3	-2.8	2.7	8.2	13.9	19.4	25.5	30.9	36.6	42.1
38	-42.2	-36.3	-30.7	-25.4	-19.3	-14.0	-8.2	-2.6	2.9	8.5	13.7	19.7	25.4	30.7	36.4	42.4
39	-42.2	-36.5	-31.1	-25.4	-19.4	-14.1	-8.5	-2.9	2.6	8.1	13.8	19.6	25.2	31.0	36.5	42.3
40	-42.3	-36.8	-30.9	-25.3	-19.4	-13.7	-8.1	-2.7	2.8	8.2	13.8	19.6	25.0	30.6	36.6	42.2
41	-41.7	-36.4	-30.7	-25.3	-19.5	-13.8	-8.4	-3.0	3.0	8.3	13.8	19.5	25.4	30.9	36.8	42.1
42	-41.9	-36.2	-30.8	-24.9	-19.2	-13.8	-8.5	-2.7	2.5	8.3	13.6	19.8	25.5	30.8	36.3	42.1
43	-42.2	-36.9	-31.0	-25.5	-19.4	-14.2	-8.5	-2.9	2.7	8.2	13.9	19.8	25.3	30.9	36.9	42.3
44	-41.6	-36.8	-30.5	-25.3	-19.5	-14.0	-8.5	-2.5	2.8	8.0	14.3	19.9	24.9	31.1	36.6	42.5
45	-42.0	-36.7	-30.8	-25.1	-19.7	-13.6	-8.6	-2.8	3.0	8.7	13.8	20.0	25.5	31.3	36.3	41.6
46	-42.5	-36.9	-30.4	-25.4	-19.5	-13.9	-8.4	-3.0	2.3	8.5	14.0	19.7	25.6	30.8	36.2	42.0
47	-41.9	-37.0	-31.2	-25.6	-19.3	-14.2	-8.2	-2.4	2.5	8.2	14.2	19.3	25.8	31.4	36.2	42.4
48	-42.6	-35.9	-30.8	-24.8	-19.0	-13.4	-8.0	-2.7	2.6	7.8	14.4	20.0	24.7	30.9	36.1	41.5
49	-42.1	-36.3	-30.8	-25.6	-19.4	-13.4	-8.7	-2.9	2.8	8.3	14.2	19.1	25.4	30.8	36.3	42.2
50	-41.5	-36.8	-30.9	-25.2	-19.8	-14.6	-8.2	-3.2	3.0	6.7	14.1	19.4	24.9	30.6	36.6	41.4
51	-42.5	-35.7	-30.9	-24.7	-18.8	-14.6	-9.0	-2.2	3.2	7.3	14.0	19.7	25.7	30.4	37.0	42.3
52	-41.9	-36.2	-30.9	-25.8	-19.3	-14.6	-8.5	-2.5	3.4	7.9	13.8	20.1	25.0	30.2	37.5	41.3
53	-41.3	-37.3	-31.5	-26.0	-19.1	-14.1	-7.6	-2.8	2.0	8.4	14.7	19.8	25.1	30.7	36.5	42.6
54	-42.9	-36.4	-30.3	-24.4	-18.8	-13.5	-8.2	-3.0	2.1	9.1	14.0	19.5	25.2	31.2	37.5	41.9
55	-42.4	-35.4	-31.0	-24.6	-20.6	-14.7	-8.9	-3.3	2.2	7.9	13.2	19.1	25.3	31.8	36.4	41.1
56	-41.8	-36.7	-31.8	-24.8	-20.4	-14.0	-7.8	-3.7	2.4	8.5	14.4	18.7	25.4	30.1	37.6	42.8
57	-41.0	-35.5	-30.2	-25.1	-20.2	-13.2	-8.6	-1.9	2.5	9.3	11.6	20.6	25.6	30.8	36.2	41.9
58	-40.6	-37.7	-32.0	-23.9	-18.9	-13.9	-9.1	-2.1	2.6	7.4	12.2	19.2	24.3	29.7	35.4	41.4
59	-43.0	-36.3	-30.1	-24.1	-18.5	-13.0	-7.6	-2.4	2.9	8.2	13.6	18.6	24.4	30.4	36.8	43.6
60	-42.6	-35.6	-32.2	-25.8	-19.7	-13.9	-8.2	-2.6	3.0	8.6	14.4	19.8	26.0	32.5	35.9	43.1
61	-41.6	-37.6	-30.0	-26.3	-19.3	-12.7	-9.4	-3.0	3.3	9.8	13.1	16.4	26.3	30.0	37.8	41.9
62	-41.0	-36.7	-32.6	-24.7	-21.0	-13.7	-6.8	-3.3	3.5	7.0	14.1	17.7	24.5	32.5	36.7	41.1
63	-40.4	-35.7	-31.3	-27.0	-18.9	-15.0	-7.4	-3.6	3.8	7.5	15.2	19.2	19.2	31.0	35.5	40.2
64	-39.6	-34.6	-29.8	-25.2	-20.7	-12.2	-8.1	-4.0	4.1	8.2	12.3	20.9	20.9	29.3	34.1	44.5
65	-44.4	-38.6	-33.2	-23.0	-18.2	-13.5	-9.0	-4.5	4.4	8.9	13.5	18.2	23.1	32.5	38.0	43.8
66	-44.4	-38.6	-33.2	-23.0	-18.2	-13.5	-9.0	-4.5	4.4	8.9	13.5	18.2	23.1	32.5	38.0	43.8
67	-43.8	-37.5	-31.5	-25.8	-20.4	-15.2	-10.1	-5.1	4.8	9.8	15.0	20.3	25.8	25.8	36.5	42.9
68	-42.3	-35.4	-28.9	-22.8	-16.9	-11.3	-5.7	-0.2	5.3	10.8	16.6	22.5	22.5	28.7	28.7	41.0
69	-39.0	-39.0	-31.8	-25.0	-18.5	-12.3	-6.3	-0.3	5.7	5.7	11.7	18.0	24.5	31.4	31.4	31.4
70	-43.0	-34.9	-27.4	-27.4	-20.2	-13.4	-6.9	-0.4	-0.4	6.1	12.7	19.5	26.8	34.4	34.4	34.4

71	-38.5	-38.5	-30.0	-22.1	-22.1	-14.7	-7.5	-0.5	-0.5	6.6	13.8	21.3	29.2	29.2	37.8	37.8
72	-42.4	-33.0	-33.0	-24.2	-16.0	-16.0	-8.2	-0.6	-0.6	7.1	14.9	23.1	23.1	32.0	32.0	41.5
73	-46.9	-36.2	-26.5	-26.5	-17.5	-17.5	-9.0	-0.7	-0.7	7.6	16.2	16.2	25.2	35.0	35.0	45.8
74	-40.0	-40.0	-29.1	-29.1	-19.2	-9.8	-9.8	-0.8	-0.8	8.2	17.6	17.6	27.5	27.5	38.5	38.5
75	-44.1	-31.9	-31.9	-21.0	-21.0	-10.8	-10.8	-0.9	-0.9	8.9	19.1	19.1	30.1	30.1	42.3	42.3
76	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1
77	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2
78	-1.4	-1.4	-1.4	-1.4	-1.4	-1.4	-1.4	-1.4	-1.4	-1.4	-1.4	-1.4	-1.4	-1.4	-1.4	-1.4
79	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6
80	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8
81	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0
82	-2.2	-2.2	-2.2	-2.2	-2.2	-2.2	-2.2	-2.2	-2.2	-2.2	-2.2	-2.2	-2.2	-2.2	-2.2	-2.2
83	-2.5	-2.5	-2.5	-2.5	-2.5	-2.5	-2.5	-2.5	-2.5	-2.5	-2.5	-2.5	-2.5	-2.5	-2.5	-2.5
84	-2.8	-2.8	-2.8	-2.8	-2.8	-2.8	-2.8	-2.8	-2.8	-2.8	-2.8	-2.8	-2.8	-2.8	-2.8	-2.8
85	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0
86	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4
87	-3.7	-3.7	-3.7	-3.7	-3.7	-3.7	-3.7	-3.7	-3.7	-3.7	-3.7	-3.7	-3.7	-3.7	-3.7	-3.7
88	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1
89	-4.5	-4.5	-4.5	-4.5	-4.5	-4.5	-4.5	-4.5	-4.5	-4.5	-4.5	-4.5	-4.5	-4.5	-4.5	-4.5
90	-5.0	-5.0	-5.0	-5.0	-5.0	-5.0	-5.0	-5.0	-5.0	-5.0	-5.0	-5.0	-5.0	-5.0	-5.0	-5.0
91	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4
92	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0
93	-6.6	-6.6	-6.6	-6.6	-6.6	-6.6	-6.6	-6.6	-6.6	-6.6	-6.6	-6.6	-6.6	-6.6	-6.6	-6.6
94	-7.2	-7.2	-7.2	-7.2	-7.2	-7.2	-7.2	-7.2	-7.2	-7.2	-7.2	-7.2	-7.2	-7.2	-7.2	-7.2
95	-7.8	-7.8	-7.8	-7.8	-7.8	-7.8	-7.8	-7.8	-7.8	-7.8	-7.8	-7.8	-7.8	-7.8	-7.8	-7.8

4 Azimuth table.

Azimuth table (file `TABLES/AzimTable.txt`) shows central directions of each azimuthal sector $\Phi(AzIndex)$. This table also shown in Table 5. Angles in degrees are counted from X_{SC} to Z_{SC}. here XYZ_{SC} are Venus Express spacecraft axis.

Table 5: MEX IMA Azimuthal table, V.1.0, 13 Mar 2006

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
168.8	191.3	213.8	236.3	258.8	281.3	303.8	326.3	348.8	11.3	33.8	56.3	78.8	101.3	123.8	146.3

Thus the unit vector corresponding to the central direction of the azimuthal sector if $\Theta = 0$ $XY_{sect}(AzIndex)$is:

$$X_{sect} = cos(\Phi(AzIndex))$$
$$Z_{sect} = sin(\Phi(AzIndex))$$

And the unit vector corresponding to the **real** direction of the corresponding sector $XYZ(AzIndex, EnIndex, ElIndex)$ is:

$$X = cos(\Phi(AzIndex)) \cdot cos(\Theta(EnIndex, ElIndex))$$
$$Y = -sin(\Theta(EnIndex, ElIndex))$$
$$Z = sin(\Phi(AzIndex)) \cdot cos(\Theta(EnIndex, ElIndex))$$

5 Mass table.

Ions of the given mass and the given energy creates a Gaussian peak distributed along the radius of the azimuthal sector of the instrument. Figure 1 clarifies this statement and defines the properties of the mass peak. The figure shows one column of **IMA_Image** corresponding to fixed $AzIndex$. Counts are distributed around central position Rm as follows:

$$Counts(RmIndex) = Cmax \cdot e^{-0.5\frac{(RmIndex-Rm)^2}{Dm^2}}$$

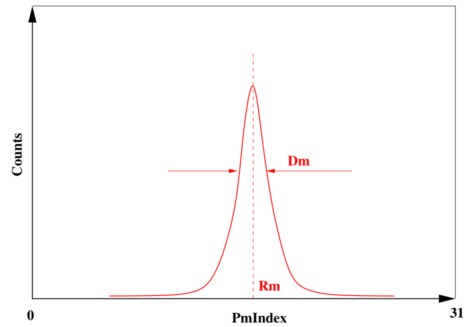


Figure 1: Definition of Rm and Dm values

Here $Cmax$ is the counts at the Rm point, and Dm represents a width of the distribution.

Table 6: MEX IMA Mass table, V.6.0, 03 Dec 2006

$PaccIndex$	$Pacc$	$Elimit$	#	GfitP0	GfitP1	GfitD0	GfitD1	Kpacc	Kmass	Dmass	Omass
0	300.	200.	0	1.913E+01	-2.389E+00	1.200E+00	1.200E+00	2.737E-01	1.000E+00	-5.000E+01	1.000E+00
0	300.	200.	1	2.479E-01	2.392E+00	5.416E-16	-1.203E-16	1.517E+00	2.000E+00	-5.000E+01	2.000E+00
0	300.	200.	2	-1.246E-02	-2.307E-02	-2.604E-17	-4.879E-19	-7.909E-01	1.700E+01	-4.900E+00	1.600E+01
0	300.	200.	3	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.800E+01	0.000E+00	3.200E+01
0	300.	200.	4	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.900E+01	1.500E+00	5.000E+01
1	2433.	340.	0	1.945E+01	-3.707E+00	1.200E+00	1.200E+00	1.067E-01	1.000E+00	-4.000E+01	1.000E+00
1	2433.	340.	1	-1.134E+00	2.117E+00	-2.996E-16	8.844E-17	1.957E+00	2.000E+00	-2.500E+01	2.000E+00
1	2433.	340.	2	8.625E-03	1.202E-02	1.765E-17	-1.240E-17	-9.828E-01	1.700E+01	-3.500E+00	1.600E+01
1	2433.	340.	3	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.600E+01	0.000E+00	3.200E+01
1	2433.	340.	4	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.300E+01	1.500E+00	5.000E+01
0	4216.	499.	0	1.132E+01	-1.500E+00	1.200E+00	1.200E+00	3.594E-02	1.000E+00	-3.000E+01	1.000E+00
0	4216.	499.	1	-4.321E-01	1.647E+00	-1.451E-16	4.208E-17	3.741E-01	1.800E+00	-2.200E+01	2.000E+00
0	4216.	499.	2	1.041E-02	-1.065E-02	2.290E-17	1.632E-17	-1.731E-01	1.700E+01	-3.600E+00	1.600E+01
0	4216.	499.	3	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.200E+01	0.000E+00	3.200E+01
0	4216.	499.	4	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.500E+01	1.500E+00	5.000E+01

Table 6 and corresponding file `TABLES/MassTable.txt` provide information of about Rm and Dm as functions of $PaccIndex$ and $EnIndex$. $PaccIndex$ is an internal IMA constant defined by telecommand. $PaccIndex$ can be 0, 1,... 7. But calibration information exists for $PaccIndex = 0,\ 4,\ 7$ only. Rm and Dm are calculated as follows ($PI = PaccIndex$):

$$
\begin{aligned}
M_{eff} &= Lin(M/Q, Kmass_i(PI), (Omass_i(PI)) \\
Pacc_{eff} &= Pacc(PI) \cdot (Kpacc_0(PI) + Kpacc_1(PI)/M_{eff} + Kpacc_2(PI)/M_{eff}^2) \\
G_{eff} &= 10^3/\sqrt{(E/Q(EnIndex) + Pacc_{eff}) \cdot M_{eff}} \\
G_{lim} &= 10^3/\sqrt{(Elimit(PI) + Pacc_{eff}) \cdot M_{eff}} \\
&\quad if\ E/Q < Elimit(PI)\ then \\
dM &= (GfitP0_0(PI) + GfitP0_1(PI) \cdot G_{lim} + GfitP0_2(PI) \cdot G_{lim}^2) - \\
&\quad (GfitP1_0(PI) + GfitP1_1(PI) \cdot G_{lim} + GfitP1_2(PI) \cdot G_{lim}^2) \\
Rm &= GfitP0_0(PI) + GfitP0_1(PI) \cdot G_{eff} + GfitP0_2(PI) \cdot G_{eff}^2 - dM \\
Dm &= GfitD0_0(PI) + GfitD0_1(PI) \cdot G_{eff} + GfitD0_2(PI) \cdot G_{eff}^2 \\
&\quad else \\
Rm &= GfitP1_0(PI) + GfitP1_1(PI) \cdot G_{eff} + GfitP01_2(PI) \cdot G_{eff}^2 \\
Dm &= GfitD1_0(PI) + GfitD1_1(PI) \cdot G_{eff} + GfitD1_2(PI) \cdot G_{eff}^2
\end{aligned}
$$

Here M/Q is Mass per a Charge of the ion (1 for H^+, and 44 for $C0_2^+$ for instance), and $E/Q(EnIndex)$ is an Energy per Charge of the ion (see **Energy table** section). $Lin(X, Y_{tab}, X_{tab})$ is the linear interpolation of X on the tabulated X_{tab} and Y_{tab}. See the next section for corresponding program example. Note that $Dpos$ in the mass table is an "atavism" and is not used in moden algorith of mass calculation position.

6 Common NetCDF file.

You can find all information described above in the common file **ima_info.nc**. This file is written in NetCDF standard. Format of this file is the same for IMA MEX and IMA VEX. One can found NetCDF standard in `http://www.unidata.ucar.edu/software/netcdf/`. IDL provides a set of functions to manipulate with NetCDF files. The header of **ima_info.nc** is as follows:

```
netcdf ima_info {
dimensions:
        ImaModeDim = 40 ;
        ImaParDim = 4 ;
        ImaEnerDim = 96 ;
        ImaElevDim = 16 ;
        ImaAzimDim = 16 ;
        ImaAzimSize = 2 ;
        ImaPacDim = 8 ;
        ImaKFSize = 7 ;
        ImaKFN = 8 ;
        ImaRmSize = 32 ;
variables:
        short ImaModes(ImaModeDim, ImaParDim) ;
        float ImaEner(ImaEnerDim) ;
        float ImaElev(ImaEnerDim, ImaElevDim) ;
        float ImaAzim(ImaAzimDim, ImaAzimSize) ;
        float ImaMassKF(ImaPacDim, ImaKFN, ImaKFSize) ;
        float ImaRevMass(ImaPacDim, ImaEnerDim, ImaRmSize) ;
// global attributes:
                :DateOfCreation = "XXXXXXXX" ;
                :Mission = "MEX" ;
                :Experiment = "ASPERA-3" ;
                :Instrument = "IMA" ;
                :EnVersion = "X.X" ;
                :ElVersion = "X.X" ;
                :AzVersion = "X.X" ;
                :MassVersion = "X.X" ;
                :ProgVersion = "X.X" ;
                :Program = "ima_info.pro" ;
                :Author = "Fedorov" ;
```

Names of arrays in this file are self described. Contents of each array is as follows:

1. Each line of **ImaModes**, corresponding to fixed telemetry mode (see **Operational Modes** section) is: $TRmIndex$ size, $TAzIndex$ size, $TEnIndex$ size, $TElIndex$ size.

2. Format of **ImaEner** array is obvious.

3. **ImaElev** gives the $Y = sin(\Theta(EnIndex, ElIndex))$ values. Value "-1000.0" means that this point is skipped in the telemetry array.

4. **ImaElev** contains X_{sect} and Z_{sect}.

5. Each line of **ImaMassKF** corresponding to fixed $PaccIndex = ImaPacDim$ and fixed $ImaKFN$ is $Pacc$, $Elim$, A_0, A_1, A_2, A_3, A_4. For $ImaKFN = 0$, $A = GfitP0$, for $ImaKFN = 1$, $A = GfitP1$, for $ImaKFN = 2$, $A = GfitD0$, for $ImaKFN = 3$, $A = GfitD1$, for $ImaKFN = 4$, $A = Kpacc$, for $ImaKFN = 5$, $A = Kmass$, for $ImaKFN = 6$, $A = Dmass$, for $ImaKFN = 7$, $A = Omass$.

Since now there are two alternative tables for Energies and for Elevations (see Sections 2 and 3), there are two corresponding NetCDF files: `ima_info.nc.V4.4.1.6.11` (old tables) and `ima_info.nc.V5.5.1.6.12` (new tables). The IDL program which reads those files and prints a "mass line" is given in the file `NetCDFDecoder.pro`. Note that it is just an example of code. To reach the best result you have to use provided "C" library.

The ICA-IMA-VIA TC/TM data formats

and related software aspects.

Issue 1.7

2004-10-28 Hans Borg. IRF- Kiruna.

Document history.

Date	Issue	By	Changes
2002-04-07	Draft	HB	Composed and edited from several partial documents.
2002-04-20	1.2	HB	Added: Related documents. Important NOTE for HK-data change. Corrected standard header status bit.
2002-05-08	1.3	HB	Added: Mass order for table look up. Command status coding.
2003-05-16	1.4	HB	Corrected parameter orders (§5.2.1,§5.2.3) Timing and time tagging. (8.0)
2003-09-07	1.5	HB	Added header (§5.5.1) & HK (§6.1) parameters descriptions. Extra to timing (§8.2)
2004-05-08	1.6	HB	Added VIA specific definitions. Updated some ICA default settings.
2004-10-28	1.7	HB	Parameter order (§5.2.3 and §5.4).

Related documents.

1) ICA – RPC : the Ion Composition Analyser in the Rosetta Plasma Consortium. O Norberg et. al.
Note: "The ICA –RPC: … should basically be applicable on the IMA - MU configuration"

2) ICA command description. Issue 1.5. H Borg.

3) IMA command description. Issue 1.4. H Borg.

4) CCSDS 120.0-B-1.

5) Basics of ICA/IMA embedded software. Issue: 1.3 H Borg

6) ICMA_ADC_CAL_yymmdd.doc (Current: yymmdd=030910 by HB)

Table of contents.

1.0 Scope.
As the ICA (RPC/Rosetta), the IMA (Aspera/Mars Express) and VIA (Aspera/Venus Express) experiments are essentially the same this document treats all three. Differences are explicitly noted. It only briefly describes the operation of the experiments.
It is assumed that the reader has a basic knowledge of the experiments.

The document tries to describe in some detail the tm data return from the experiments.

2.0 Terminology.
If not otherwise stated a byte denotes an 8-bit item and a word a 16-bit item. A nibble is a 4-bit item. Bits are labeled in the power of 2, i.e. 0 (zero) is the least significant bit.
Precaution: ESA uses “octets” for an 8-bit item and “word” for a 16-bit item. ESA also uses 0 as the MS-bit (Mil Std. 1750 convention. Item size dependent).
F8 denotes an experiment 8-bit hybrid floating code used to reduce 32/16 bit parameters to 8 bits.

3.0 Experiment basic operation.
The basic operation consists of stepping through 32 or 96 energy HV deflection steps for each of 16 entrance HV deflection steps (polar angles). A complete cycle (scan) takes 64 seconds (32 levels) or 192 seconds (96 levels) respectively. The sampling time is 120.9 milliseconds. Each sample produces an imager matrix of 32 mass bins times 16 sectors (azimuth angles).

The data acquisition and transmission is synchronized to an acquisition (start) pulse. For ICA that pulse is received once per 32 seconds and for IMA once per 16 seconds.

All data to and from the experiment is transmitted over a serial 1355-link from/to a central unit that in turn interfaces to the spacecraft systems.

Each format starts with a 16-byte long standard header with a 3-byte long synchronization pattern.

Except for the header and some data in the special modes all data is by default converted to an 8-bit hybrid floating code (F8) followed by a loss less bit data compression.
Thus, most ICA-IMA data formats will float in the ESA telemetry packets. Some may, however, be synchronized (see §5.4).

For a more detailed description of the experiment see ICA – RPC : the Ion Composition Analyser in the Rosetta Plasma Consortium. (Norberg,O. et al.).

4.0 The commanding system.

4.1 General

With a few exceptions all experiment commands consists of a 16-bit word.
The word is subdivided into 4 nibbles n3-n0.

n3	n2	n1	n0

The commands are divided into 3(4) classes (types) as:

Type 3	n3 ∴ 0	n2,n1,n0 represents a 12-bit variable parameter.
	Capacity: 15 sets. n3=1-15.	
Type 2	n3=0 n2∴0	n1,n0 represents an 8-bit variable parameter.
	Capacity: 15 sets. n2=1-15.	
Type 1/0	n3=n2=0	n1,n0 is dynamically used for variable length parameters like 4-bit, 1-bit or no parameter commands.
	Capacity: 256 sets. n1,n0=0-255.	

Note: The combined command words = 0xFFFF or 0x0000 are not used for safety.

The basic experiment internal interpretation of the 16-bit word is given below (§4.2).

For further details about commanding, see ICA/IMA Command Description. Issue 1.4. (H Borg).

4.2 Detailed command list.

The list below gives all the commands in terms of a short description, type, fixed part, parameter mask, acceptable parameter range and when applicable the default value. Note that this is the internal interpretation.

Prm: below stands for parameter. A “-“ below indicates not applicable or not defined.

Short description	Type	Fixed part	Prm. mask	Prm. range	Default
Main +28 volt switch	1/0	0x0002	0x0001	0-1	0
Opto +28 volt switch	1/0	0x0004	0x0001	0-1	0
Mcp +28 volt switch	1/0	0x0006	0x0001	0-1	0
Post acc. HV switch	1/0	0x0008	0x0001	0-1	1
Grid LV switch	1/0	0x000A	0x0001	0-1	1
Entrance HV switch	1/0	0x000C	0x0001	0-1	1
Deflection LV switch	1/0	0x000E	0x0001	0-1	1
Deflection HV switch	1/0	0x0010	0x0001	0-1	1
Direct command switch	1/0	0x0012	0x0001	0-1	0
Watch dog enable/disable	1/0	0x0014	0x0001	0-1	1
Gas pressure HV control. **ICAonly**	1/0	0x0016	0x0001	0-1	0
Thruster firing HV control. **ICA only**	1/0	0x0018	0x0001	0-1	0
Compression enable/disable	1/0	0x001C	0x0001	0-1	1
Alternating post acc. enb/dis	1/0	0x001E	0x0001	0-1	0
Post acc. level high/low	1/0	0x0020	0x0001	0-1	1
Auto reduction change enb/dis	1/0	0x0022	0x0001	0-1	1
Shadow masking enb/dis	1/0	0x0024	0x0001	0-1	1
Bad HV masking enb/dis	1/0	0x0026	0x0001	0-1	1
Bad mass clearing enb/dis. **VIA only**	1/0	0x0028	0x0001	0-1	0
Next command direct	1/0	0x0040	-	-	-
Energy deflection stepping	1/0	0x0041	-	-	-
Entrance deflection stepping	1/0	0x0042	-	-	-
Release V-cal format	1/0	0x0043	-	-	-
Activate debugger. Bench only	1/0	0x0046	-	-	-
Gas-HV timeout test. **ICA only**	1/0	0x0047	-	-	-
Trigger machine error. Bench only	1/0	0x0048	-	-	-
Test Watch dog reset.	1/0	0x004A	-	-	-
Empty TM fifo	1/0	0x004B	-	-	-
Flush TM fifo	1/0	0x004C	-	-	-
Boot PROM	1/0	0x004D	-	-	-
Imager test	1/0	0x004E	-	-	-
Dummy command	1/0	0x004F	-	-	-
Set HV ref. Range bits. **VIA only.**	1/0	0x0050	0x0003	0-3	-
Set bad mass index bit MS. **VIA only**	1/0	0x0060	+ 2:nd wrd	0-0xFFFF	0
Set bad mass index bit LS. **VIA only**	1/0	0x0070	+ 2:nd wrd	0-0xFFFF	0
Boot EEPROM incl. Context	1/0	0x00B0	0x000F	0-15	-
Set imager test pattern	1/0	0x00C0	0x000F	0-15	-
Boot EEPROM excl. Context	1/0	0x00D0	0x000F	0-15	-
Set **ICA/IMA-VIA** SID number	1/0	0x00E0	0x000F	0-5/0-6	5
Set EEPROM default boot section	1/0	0x00F0	0x000F	0-15	0

Short description	Type	Fixed part	Prm. mask	Prm. Range	Default
Set energy deflection level	2	0x0100	0x00FF	0-95	-
Set entrance deflection level	2	0x0200	0x00FF	0-15	-
Set **ICA/IMA/VIA** solar wind start index	2	0x0300	0x00FF	0-64	29/24/22
Set Gas pressure low level. **ICA only**	2	0x0400	0x00FF	0-255	0x16
Set Gas pressure high level. **ICA only**	2	0x0500	0x00FF	0-255	0x15
Set data reduction mode	2	0x0A00	0x00FF	0-39	0
Reprog. all EEPROM sections *)	2	0x0C00	0x00FF	0-16	-
Reprog. EEPROM section *)	2	0x0D00	0x00FF	0-255	-
Set **ICA/IMA/VIA** Opto reference	3	0x1000	0x0FFF	0-7	7/6/6
Set **ICA/IMA/VIA** Mcp reference	3	0x2000	0x0FFF	0-15	12/13/12
Set **ICA/IMA** Grid reference	3	0x3000	0x0FFF	0-7	7/7
Set **ICA/IMA/VIA** post acc. low reference	3	0x4000	0x0FFF	0-7	3/4/3
Set **ICA/IMA/VIA** post acc. hgh reference	3	0x5000	0x0FFF	0-7	6/7/6
Set energy defl. LV reference	3	0x6000	0x0FFF	0-4095	-
Set energy defl. HV reference	3	0x7000	0x0FFF	0-4095	-
Set entrance defl. HV reference	3	0x8000	0x0FFF	0-4095	-
Set noise reduction level	3	0x9000	0x0FFF	0-4095	0
Set **ICA/IMA-VIA** Fifo low (min) water mark	3	0xA000	0x0FFF	0-4095	40/20
Set **ICA/IMA-VIA** Fifo high (max) water mark	3	0xB000	0x0FFF	0-4095	80/40
Set **ICA/IMA-VIA** Fifo force water mark	3	0xC000	0x0FFF	0-4095	120/60
Set **ICA/IMA-VIA** Fifo clear water mark	3	0xD000	0x0FFF	0-4095	320/320
Set IMA Tm scaling factor. **IMA-VIA only**	3	0xE000	0x0FFF	0-4095	180
Start command (combined)	3	0xF000	0x0FFF	0-4095	-

*) Requires a second word reading 0xFEED (security lock key).

5.0 Telemetry/Science modes.

5.1 Telemetry modes.

The experiments have to their disposal a number of telemetry modes (here named Sid, Science ID). The Sid defines the TM rate available. The Sid numbers below are the internal ICA-IMA numbers that is also used in commanding. Note that direct (near real time) TM is mostly not available. The TM data is buffered onboard the S/C. The TM rate below then describes the reasonable amount to create to stay within the buffer allowance allocated for the planned S/C session before tapping to a ground S/C tracking station.

Telemetry modes (Sid+HK).

Sid	**Mnemonic**	**Exp. Pkt. size in bytes**	**ICA rate**	**IMA rate**
0	Min (Minimum)	618	5.15 bps	10.3 bps
1	Nrm (Normal)	2478	103.25 bps	206.5 bps
2	Bst (Burst)	4092	1023 bps	2046 bps
3	Cal (Calibration)	1074	268.5 bps	537 bps
4	Spc (Special)	3198	799.5 bps	1599 bps
5	Tst (Test)	600	75 bps	150 bps
6	Ima (Ima)	3996 *	NA	3996 bps
HK	Housekeeping	24	6 bps	12 bps

*) For IMA-VIA 2 such packets are sent every acquisition period.

5.2 Data reduction modes general.

The H/W operation of the experiment is always the same but for the 32 or 96 energy level step modes. The number of energy levels is strictly tied to the science mode selected. The experiment produces too much data to be transmitted (~ 80 000 bps). The parametric space measured are 32 mass bins (not true M/q) for 16 azimuths, 16 polar angles and 96 (32) energy levels. To cope with the high production rate versus the available Tm rate capacity the data is first reduced by integrations in the measured parametric space. The resulting (32/16 bit parameters) are then converted to a hybrid 8 bit floating code (F8). The size of the data set (format) is after this mostly still too big. The data therefore passed via a loss less bit compression routine before feeding it to the tm output FIFO.

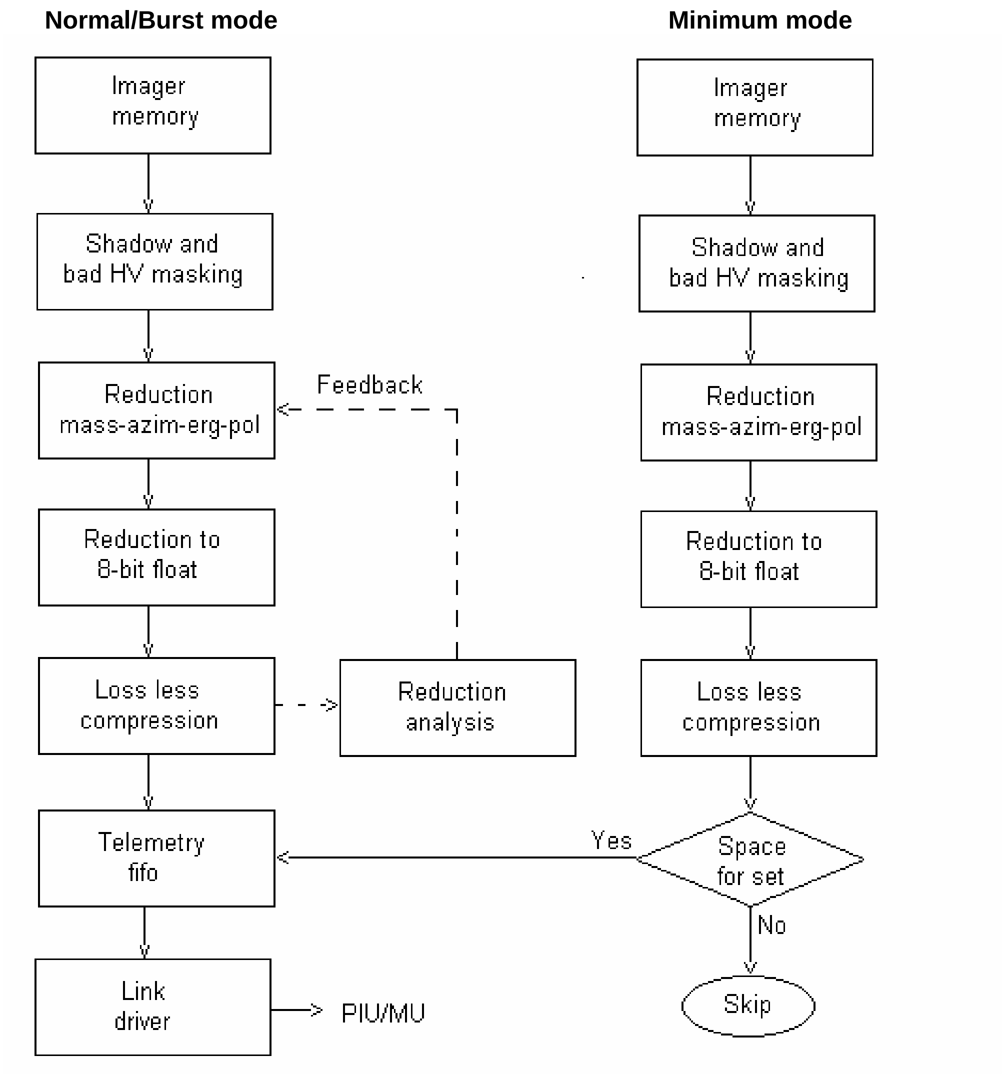
The tm FIFO can take a certain backlog of data due to its size. The backlog is watched by low and high watermarks. When appropriate, the S/W will change the reduction scheme such as to stay (on average) within the allocated tm rate. Thus the watermarks are scaled against the current telemetry mode. A more detailed description is given in § 5.2.1

5.2.1 Science data processing.

The data is read from the imager memory, shadow masked and fed to a data reduction module. The reduction is performed by integrations in the parametric space azimuth*mass*energy*polar-angles. When a full data set is acquired a 32/16 bit to a hybrid 8 bit floating code further reduces the data. The resulting data set is then compressed by a loss less method and fed to the telemetry FIFO for transmission. The TM-FIFO can take a certain backlog with respect to the current TM-rate (SID). The size of the compressed data will vary due to the characteristics of the actual data. For the *Normal* and *Burst* modes the TM-FIFO filling is controlled by analyzing the data set size with respect to the TM-FIFO filling and the actual TM-rate. When appropriate, a feedback is made to the reduction module to change the reduction scheme. The TM-FIFO filling is guided by watermarks. For the *Minimum* modes that create several data sets during the duration of a format, the reduction is fixed but instead the number of sets to transmit is adjusted to match, on the average, the TM-rate (SID).

The automatic data reduction change and data compression can be disabled by commands. It affects both *Minimu*m and *Normal/Burst* modes.

Principle data flow.



5.2.2 Shadow and bad HV masking.
It is just the fact that the anticipated field of view of the experiments is not clean. Due to the mounting there are other S/C obstacles in the field of view. The current S/W has built in tables to simply clear out (set to 0) imager sectors that are more or less obscured. This has a two-folded motivation.

a) A clear knowledge of what data is included (partly obscured may give “funny” effects).
b) Zeroing out may (not for sure) give a better compression efficiency.

Like wise, due to HV limitations (capacity or accuracy) all polar angles cannot be reached for all energies. They are treated as for shadowed sectors above.

5.2.3 Parameter orders.
Apart from the Special modes (5.4), Science data are always delivered as a matrix azimuth*mass*energy*polar, where azimuth (the first) is the fastest varying one.
For masses above or equal to 8, the integration is simply done by adding adjacent mass bins. E.g. 8 mass bins integrate them 4 by 4 from the 32 available.
Note that the Imager addressing is such that the heavier masses comes first and the lighter ones last.
For masses below 8 (i.e.<= 6), the mass bins are integrated according to lookup tables and supposed to represent true M/q. The transmission order of the M/q masses is defined by the lookup tables.
The mass order for ICA and IMA is: H+ >O+ O+ He+ He++ O++
and for VIA: H+ O+ He+ >O+ He++ O++
If less than 6 masses, masses at the end are skipped.

Azimuth, energy and polar angles always come in the same order.

5.3 The data modes.
The data modes are divided into 5 groups: Min, Nrm, Har, Exm and Special.

5.3.1 The minimum modes.
The duration of the Minimum mode data formats is 16 minutes.

Mode	Index	Masses	Azimuth angles	Energies	Polar angles	Max sets
Idle *	0					
Void	1					
Mspo	2	2	1	32	1	15
Void	3					
Msis	4	6	1	96	1	5
Mexm	5	32	1	96	1	5
Void	6					
Void	7					

*) The Idle mode produces no scientific data and is described under the Special modes.

5.3.1.1 Minimum spectra only (Mspo).
The energy deflection is stepped through 32 levels starting at the solar wind start index.
For each scan all data for the two masses protons and alpha (table look up) are integrated over the sunward facing sectors. This produces a maximum of 15 sets of 2 masses * 32 E-levels spectra. As many as can be fitted (on the average to stay within the TM capacity) in the current SID block size are transmitted**.**

Layout: 1 header
n 2*32 spectra (Compressed F8)

5.3.1.2 Minimum selected ion species (Msis).
The energy deflection is stepped through all 96 levels for each of the 16 entrance steps.

For each scan all data for 6 selected ion species (table look up) are integrated over all angles (azimuth and polar). This produces a maximum of 5 sets of 6 masses * 96 E-levels spectra. As many as can be fitted (on the average to stay within the TM capacity) in the current SID block size are transmitted**.**

Layout: 1 header
n 6*96 spectra (Compressed F8)

5.3.1.3 Minimum energy-mass matrix (Mexm).
The energy deflection is stepped through all 96 levels for each of the 16 entrance steps.

For each scan all data for 32 mass bins are integrated over all angles (azimuth and polar). This produces a maximum of 5 sets of 32 mass-bins * 96 E-levels spectra. As many as can be fitted (on the average to stay within the TM capacity) in the current SID block size are transmitted**.**

Layout: 1 header
n 32*96 spectra (Compressed F8)

5.3.2 The normal modes (Nrm).
The duration of the Normal mode format is 192 seconds.
The energy deflection is stepped through all 96 steps for each of the 16 entrance steps.

The normal mode (group) is subjected to an automatic change of the data reduction scheme (if enabled) in order to adapt to the current TM capacity (SID).
The order of the reduced data matrix is always Mass-Azimuth-Energy-Polar with Mass being the fastest varying index. The masses are integrated by means of energy dependent lookup tables.

The reduction scheme.

Mode	Index	Masses	Azimuth angles	Energies	Polar angles
Nrm-0	8	6	16	96	16
Nrm-1	9	6	16	96	8
Nrm-2	10	6	16	96	4
Nrm-3	11	6	16	96	2
Nrm-4	12	6	8	96	2
Nrm-5	13	6	4	96	2
Nrm-6	14	3	4	96	2
Nrm-7	15	3	4	96	1

Layout: 1 header
1 data set (Compressed F8)

5.3.3 The burst high angular resolution modes (Har).
The duration of the burst high angular resolution mode format is 192 seconds.
The energy deflection is stepped through all 96 steps for each of the 16 entrance steps.

The burst high angular resolution mode (group) is subjected to an automatic change of the data reduction scheme (if enabled) in order to adapt to the current TM capacity (SID).
The order of the reduced data matrix is always Mass-Azimuth-Energy-Polar with Mass being the fastest varying index.

The reduction scheme.

Mode	Index	Masses	Azimuth angles	Energies	Polar angles
Har-0	16	16	16	96	16
Har-1	17	16	16	96	8
Har-2	18	16	16	96	4
Har-3	19	8	16	96	4
Har-4	20	4	16	96	4
Har-5	21	2	16	96	4
Har-6	22	2	8	96	4
Har-7	23	2	8	96	2

Layout: 1 header
1 data set (Compressed F8)

5.3.4 The burst energy-mass matrix modes (Exm).

The duration of the burst energy-mass matrix mode format is 192 seconds.
The energy deflection is stepped through all 96 steps for each of the 16 entrance steps.

The burst energy-mass matrix mode (group) is subjected to an automatic change of the data reduction scheme (if enabled) in order to adapt to the current TM capacity (SID).
The order of the reduced data matrix is always Mass-Azimuth-Energy-Polar with Mass being the fastest varying index.

The reduction scheme.

Mode	Index	Masses	Azimuth angles	Energies	Polar angles
Exm-0	24	32	16	96	16
Exm-1	25	32	16	96	8
Exm-2	26	32	16	96	4
Exm-3	27	32	16	96	2
Exm-4	28	32	8	96	2
Exm-5	29	32	4	96	2
Exm-6	30	32	2	96	2
Exm-7	31	32	2	96	1

Layout: 1 header
1 data set (Compressed F8)

5.4 The special modes.

The special modes are mainly aimed for ground testing and calibration, but may well be used also when in orbit. Typically "Test" for commissioning.
As opposed to the science modes, the special modes do not allow any Tm FIFO backlogging.
The Test and the Cal1 mode will be synchronized to the ESA packets provided they run in combination with the Telemetry modes Tst and Cal respectively. The Fake mode is always synchronized to the ESA packets.
The order of the imager data transmitted are of type imager dump (snap shot), i.e. in the order as seen from the imager memory.
For Test,Cal1 modes that is mass*azimuth and for Cal2 mass*azimuth*energy.

Mode	Index	Content
Test	32	H/W close information and an Imager snapshot
Cal1	33	HV information and one Imager in 16-bit uncompressed words
Cal2	34	HV information and 96 Imagers (one per Energy level) in compressed F8
Fake	35	An incremental (by one) 16-bit counter in 16-bit uncompressed words
Void	36	
Void	37	
Void	38	
Void	39	

5.4.1 The test mode (Test).
The test mode delivers “hard ware close” information and do not contain any compressed data. It is 600 bytes long and will be synchronized to the ESA TM packets if SID=Tst (ICA-IMA nr 5) is used.

It contains the following data:

Byte offset	Length in bytes	Bits	Content
0	16		Standard header. See §5.4.6
16	2		Command word 0 return
18	2		Command word 1 return
20	20		10 16-bit AD monitor values. See &5.4.7
40	1		Void
41	1		Nos. 1355-link forced resets
42	1		Nos. 1355-link resets seen
43	1		Nos. 1355-link credit failures
44	2		EEPROM programming result
		15-10	Reprogramming counter
		9-8	Failure bits
		7-4	Destination EEP section
		3-0	Source EEP section
46	1		Nos. Watch dog resets
47	1		Nos. machine error resets
48	1		Void
49	3		24-bits S/W switch status. See §5.4.7
52	1		Noise reduction level
53	1		The gas pressure as seen from ROSINA. **ICA only**
54	2		Copy from HK format
		15	Direct command switch
		14-12	Pacc. low reference level
		11-0	Energy deflection HV reference
56	2		Copy from HK format
		15	Tm overflow flag
		14-12	Pacc. high reference level
		11-0	Energy deflection LV reference
58	2		Copy from HK format
		15	Pacc. current level (high=1 or low=0).
		14-12	Grid LV reference
		11-0	Entrance HV reference
60	2		CPU fault register
62	2		CPU fault address
64	1		Gas pressure low level. **ICA only**
65	1		Gas pressure high level. **ICA only**
66	2		CPU BIT result
68	2		Current program version running
70	1		Nos. sample overruns
71	1		Nos. sweep overruns
72	1		Nos. post overruns
73	1		Void
74	2		+28V monitor.
76	2		Fifo low water mark (Fmin)
78	2		Fifo high water mark (Fmax)
80	2		Fifo force limit (Ffrc)
82	2		Fifo clear limit (Fclr)
84	2		IMA Tm scaling factor. **IMA-VIA only**
86	1		Image memory test result
		7-6	Test counter.
		5-3	Memory half 1 test result
		2-0	Memory half 0 test result
87	1		E-level for Image snapshot
88	512		Imager snapshot in F8 code

5.4.2 The calibration-1 mode (Cal1).

The calibration-1 mode is specially designed for Imager calibration. It is 1074 bytes long and will be synchronized to the ESA TM packets if SID=Cal (ICA-IMA nr 3) is used.

Byte offset	Length in bytes	Bits	Content
0	16		Standard header. See §5.4.6
16	2		The digital deflection HV reference
18	2		The digital deflection LV reference
20	2		The digital entrance HV reference
22	1	7-4 3-0	The Opto. HV digital reference The Mcp. HV digital reference
23	1	7-4 3-0	The digital Post acc. HV reference The Grid LV digital reference
24	20		10 16-bit AD monitors. See §5.4.7
44	2		+28V monitor
46	1		Entrance angle index
47	1		Energy level index
48	2		Void
50	1024		Full Imager in 16-bit words

5.4.3 The calibration-2 mode (Cal2).

The calibration-2 mode is specially designed for Imager calibration. It delivers Imagers for a full 96 E-level sweep. The data is in compressed F8 code.

Byte offset	Length in bytes	Bits	Content
0	16		Standard header. See §5.4.6
16	2		The digital deflection HV reference
18	2		The digital deflection LV reference
20	2		The digital entrance HV reference
22	1	7-4 3-0	The Opto. HV digital reference The Mcp. HV digital reference
23	1	7-4 3-0	The digital Post acc. HV reference The Grid LV digital reference
24	20		10 16-bit AD monitors. See §5.4.7
44	2		+28V monitor
46	1		Entrance angle index
47	1		Energy level index
48	2		Void
50	nn		96 energy levels of full Imager in compressed F8

5.4.4 The faked data mode (Fake).

The Fake mode is specially designed to test the 1355-link for transmissions from the experiment to the PIU/MAIN-unit. It simply delivers a header followed by a word sequential counter as uncompressed data. It automatically adjusts the data size to match the current SID and will therefore always be synchronized to the ESA TM packets. Except for the header missing data can easily be detected.

Layout: 1 header.
An incremental counter to fill the current Sid packet.

5.4.5 The Idle mode.
The mode index refers it to the Minimum group, but may as well be regarded as a special mode. This mode does not produce any science data.

The Idle mode may be entered in two ways.

1) By command.
If entered by command the Opto and Mcp HV are regulated down to 0 reference, but the +28V Main switch stays ON. Also all science tm output are inhibited. Data in the tm FIFO are kept for later transmission. Commanding the experiment into the idle mode opens up for memory management activities (patch, dump or check).

2) Automatic (**ICA only**).
The experiment will enter Idle mode if the gas pressure as delivered by ROSINA excides a predefined upper limit or the experiment receives a thruster fire warning. When entered this way the +28V main switch to the HV supplies is switched off. Data in the tm FIFO, however, will continue to be transmitted.

5.4.6 The 16-bit AD monitors.
The AD monitors are stored in the following order.

Byte offset	Length in bytes	Content
0	2	Opto. HV
2	2	Mcp. HV
4	2	Upper entrance HV
6	2	Lower entrance HV
8	2	Post acceleration HV
10	2	Energy deflection HV
12	2	Energy deflection LV
14	2	Sensor unit temperature
16	2	Grid LV
18	2	DPU temperature

Actual calibration constants will be specified in the ICMA_ADC_CAL document.

5.4.7 The switch status bits.
The switch bits are coded as 0=Off and 1=On.

Bit	Content	Type
0	Mcp. +28V	H/W
1	Opto. +28V	H/W
2	Main +28V	H/W
3	Post acceleration HV	S/W
4	Grid LV	S/W
5	Entrance HV	S/W
6	Energy deflection LV	S/W
7	Energy deflection HV	S/W
8	Direct command	S/W
9	Watchdog	H/W
10	Gas HV control	S/W **ICA only**
11	Thruster firing HV control	S/W **ICA only**
12	Void	
13	Compression	S/W
14	Alternating post acceleration	S/W
15	Post acceleration level	S/W. Not really a switch
16	Auto reduction changes	S/W
17	Shadow masking	S/W
18	Bad HV masking	S/W
19	Void	
20	Void	
21	Void	
22	Test flag	S/W
23	Internal. Not commandable	

5.5 The standard header.
Each data format starts with a standard header containing the following information

Byte offset	Length in bytes	Bits	Content
0	3		Sync. Pattern. 0xE3 0x31 0xCA
3	1	7-6 5-0	Unit (1=ICA 2=IMA) Mode (index)
4	1		Experiment data format counter (Edf)
5	1	7 6 5 4 3-0	HV ramping in progress Tm Fifo emptied Checksum 0 failure Checksum 1 failure Number of sets in Minimum modes
6	1	7 6 5 4 3-0	Compression switch Auto reduction change switch Alternating post acceleration switch Post acceleration level Test pattern
7	1		Fifo filling. Number of 3-wrd packets in F8
8	1	7 6 5 4-0	Post processing overrun Sweep processing overrun Sample processing overrun PROM(0)/EEPROM section(1-16) loaded
9	1	7 6-0	Reset due to Watchdog or Machine error. Solar wind energy start index
10	3		Format start time in units of 31.25 msec. *
13	1	7 6 5-4	Bad HV masking switch Shadow masking switch The mass lookup table nr. VIA only
14	3	19-0	Format length in words

*) As the Format start time only consists of 24 bits, the MSB part should be taken from the ESA packet time. The 24 bits covers about 6 days.

5.5.1 Header parameters description.

Sync. Pattern.
The 3 bytes 0xE3 0x31 0xCA marks the start of a new EDF (Experiment Data Format). A search for this is required as the EDF's floats in the tm data stream.

Unit.
This parameter (2 bits) defines the experiment unit as follows:

0 Undefined
1 ICA
2 IMA
3 VIA

Mode.
This is the data reduction mode index used for the data in this EDF. The corresponding mode acronyms are given in &5.3 and §5.4.

Experiment data format counter.
This is an 8-bit running counter incremented by 1 for each released EDF. It swaps over to 0 after 255.

HV ramping in progress.
This bit will set if HV ramping has been performed during the data taking for this EDF.

Tm Fifo emptied.
This bit will set if the tm fifo is emptied before the start of this EDF. Always forced to and from special EDF's

Checksum 0,1 failures.
These bits will set if the corresponding checksum (0 or 1) fails during RAM booting. Sets from both PROM and EEPROM booting.

Number of sets in Minimum modes.
This parameter (4 bits) gives the number of data sets in this EDF for the minimum modes.

Compression switch.
This bit indicates whether data compression is enabled or not. 0=Disabled 1=Enabled.

Auto reduction change switch.
This bit indicates whether automatic data reduction change is enabled or not. 0=Disabled 1=Enabled.

Alternating post acceleration switch.
This bit indicates the post acceleration mode. If set (1) it is alternating else it is fixed.

Post acceleration level.
This bit gives the post acceleration level used for this format. 0=Low 1=High.

Test pattern.
For testing purposes a number of imager test patterns can be commanded. This parameter (4 bits) gives the actual test pattern number used. Ensure it is 0 for real scientific data.

Fifo filling
This gives the approximate number of 1355 link packets in the tm fifo. To convert to words, unpack the F8 code and multiply by 3.

Post,Sweep,Sample processing overrun.
These bits are set if a process overruns, i.e. the current data processing is not finished when a new is requested.

PROM(0)/EEPROM(1-16) loaded.
This parameter (5 bits) gives the program code currently loaded and running in RAM. It is coded as:
0=PROM   1-16=EEPROM section 0-15.

Reset due to Watchdog or Machine error.
This bit will set if the experiment has rebooted due to a watchdog or machine error reset.

Solar wind energy start index.
This parameter (7 bits) gives the energy start index when in the 32 level energy mode.

Format start time in units of 31.25 msec.
These 3 bytes is the starting time of this EDF. Note that more significant bits must be taken from the ESA packet time. Some attention should be paid close in time when this 3 bytes counter swaps around. That happens at about once per 6 days.

Bad HV masking switch.
This bit indicates if imager data is masked (set to zero) or not for angles/energies that can not be reached due to insufficient or too inaccurate HV. 0=Disabled   1=Enabled.

Shadow masking switch.
This bit indicates if imager data is masked (set to zero) or not for angles that are regarded as obscured by other S/C items. 0=Disabled   1=Enabled.

Mass lookup table nr.
This nr (0-2) indicates the actual mass lookup table used for this format.

Format length in words.
This parameter (20 bits) gives the total length of the format (EDF) in words.

5.6 Telemetry/Data reduction mode combinations.
In principle any Data reduction mode can be combined with any Telemetry mode. All combinations will, however, not optimize the use of the telemetry capacity. There are no precautions or restrictions built into the S/W to refuse some combinations. In the worst case (like a burst mode in the Minimum Sid) no science data at all will be delivered due to Tm FIFO clearing, provided the Auto reduction change is enabled.
The table below gives the anticipated combinations. Other combinations may, however, be used as a result of experiences from in orbit operation. Likewise the Fifo controlling limits may be trimmed.

Telemetry mode	Data reduction modes
Minimum (0)	Minimum modes
Normal (1)	Normal modes
Burst (2)	Burst modes (Har, Exm)
Calibration (3)	Calibration 1. Tailored
Special (4)	Calibration 2
Test (5)	Test. Tailored
Ima (6). IMA only	Burst modes (Har, Exm)

The Fake and Idle modes are applicable in all Telemetry modes.

6.0 The Housekeeping format.
The housekeeping format consists of 24 bytes delivered once per acquisition period. This rate is independent of the current Telemetry mode (Sid) in effect.
The ICA-IMA housekeeping format contains the following parameters:

Byte offset	Length in bytes	Bits	Content
0	1	7-2 1-0	Current data reduction mode. For index see §5.3 & 5.4 Last command status where: 0=Ok 1=Parameter out of range 2=Invalid 3=Erroneous opcode
1	1		HV switch status. The first 8 switches. See §5.4.7
2	1	7 6-4 3 2 1 0	The new command received toggle bit The current Sid number Post acceleration mode (Fixed/Alternating). +28V Main HV present * +28V Opto HV present * +28V Mcp HV present *
3	1		Fifo filling in terms of internal packets (words/3) in F8
4	2		The first word command return.
6	1		The Opto. HV monitor
7	1		The Mcp. HV monitor
8	1		The Energy deflection HV monitor
9	1		The Energy deflection LV monitor
10	1		The Post acceleration HV monitor
11	1		The Grid LV monitor
12	1		The Sensor unit temperature
13	1		The DPU Temperature
14	2	15 14-12 11-0	The direct command switch Post acceleration low level reference Energy deflection HV reference
16	2	15 14-12 11-0	Tm Fifo overflow Post acceleration high level reference Energy deflection LV reference
18	2	15 14-12 13	Post acceleration level (high or low) Grid LV reference. ICA-IMA only. The Dfl. HV range bit. VIA only.

		12 11-0	The Ent. HV range bit. VIA only. Entrance HV reference
20	2	15-13 12-9 8-0	Opto. HV default reference Mcp. HV default reference Entrance upper HV monitor
22	2	15-13 12-9 8-0	Opto. HV current reference Mcp. HV current reference Entrance lower HV monitor

*) For an explanation of the present status, See ICA/IMA Command Description Issue 1.4.

The monitor calibration constants will be specified in the ICMA_ADC_CAL document.

Important NOTE. Byte 2, bit 3 was intended to be the HV safety plug status (HV enabled/disabled). This status had to be taken out for technical reasons. The bit is now used to indicate the post acceleration mode of operation (Fixed or Alternating).

6.1 HK parameters description.

Current data reduction mode.
This gives the data reduction mode index (6 bits) currently running. The corresponding mode acronyms are given in &5.3 and 5.4.

Last command status.
This parameter (2 bits) gives the status of the last received command. The coding is

0=Ok	1=Parameter out of range
2=Invalid in current context	3=Erroneous opcode

HV switch status.
This gives the status of the HV switches (the first 8 from the switch register), where 0=Off and 1=On. The bit and switch relations are given in §5.4.7

New command received toggle bit.
This bit will toggle 0/1 each time a new command is received and the command status and the command return is fed to the HK transmit buffer.

The current Sid number.
This parameter (3 bits) gives the currently used Sid (tm mode). The acronyms and average bit rates are given in §5.1

Post acceleration mode.
By default, the post acceleration runs on a fixed HV setting. In can, however, be commanded to alternate between the preset high and low level HV. This bit is encoded as 0=Fixed, 1=Alternating.

+28V Main,Opto,Mcp HV present.
These 3 bits indicates the actual presence of the +28V after respective switch. 0=No and 1=Yes. See §6.0 for the bit switch-relations.

Fifo filling in terms of internal packets.
This gives the approximate number of 1355 link packets in the tm fifo. To convert to words, unpack the F8 code and multiply by 3. For F8 code, see § 7.0.

The first word command return.
This holds the first word (16 bits) of the last command received.

The HV,LV and temperature monitors at offsets 6-13.
These are 8-bit unsigned ADC readings for HV,LV and temperature monitors. Calibration factors will determine the sign. See §6.0 for the relation between offset and corresponding monitor.

The direct command switch.
ICA/IMA commands are of two types, direct or synchronized. The synchronized ones are executed at the end of format only. Setting the direct command switch ON (1) will turn synchronized commands to be direct.

Post acceleration low level reference.
This is the default digital low level post acceleration reference (3 bits).

Energy deflection HV reference.
This is the digital HV reference value associated with the monitor reading in this format (12 bits).

Tm Fifo overflow.
This bit is set to one if a tm fifo overflow has occurred. That is 0=No overflow 1=Overflow.

Post acceleration level.
This bit indicates the current post acceleration level. 0=Low 1=High.

Energy deflection LV reference.
This is the digital LV reference value associated with the monitor reading in this format (12 bits).

Grid LV reference (ICA-IMA only).
This is the digital grid LV reference value associated with the monitor reading in this format (3 bits).

The Dfl. And Ent. Range bits (VIA only).
This gives the HV range bit settings at the time of the monitor sampling.

Entrance HV reference.
This is the digital HV reference value associated with the monitor reading in this format (12 bits).

Opto. HV default reference.
This is the default digital Opto. HV reference value. That is the target value for ramping (3 bits).

Mcp. HV default reference.
This is the default digital Mcp. HV reference value. That is the target value for ramping (3 bits).

Entrance upper HV monitor.
This is a 9-bit unsigned ADC reading for the upper entrance HV monitor. Calibration factors will determine the sign.

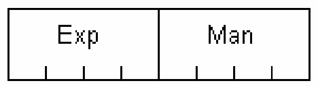
Opto. HV current reference.
This is the current digital Opto. HV reference value associated with the monitor reading in this format (3 bits).

Mcp. HV current reference.
This is the current digital Mcp. HV reference value associated with the monitor reading in this format (3 bits).

Entrance lower HV monitor.
This is an 9-bit unsigned ADC reading for the lower entrance HV monitor. Calibration factors will determine the sign.

7.0 Special data characteristics.
The experiment uses some special tools to handle data. They are briefly described below.

7.1 The F8 code.
In order to reduce the number of bits to transmit, the S/W normally converts 32/16 bit items into a hybrid 8-bit floating code. The maximum capacity is numbers up to 507903. If greater (32-bits only) the number is set to the maximum. It is regarded as a hybrid due to the fact that numbers less or equal to 32 are transmitted as integers. The layout is:



where Exp is the Exponent and Man the Mantissa. Numbers less or equal to 32 are used as is, that is they will be coded as 0x00 – 0x20. If greater the real mantissa part will be used with the MSB stripped of (always a one, not transmitted) and the next four MSB bits set into “Man”. The Exp part will be the real exponent adjusted for the new bias (32) and set into Exp.

This is a simple C routine to unpack the F8 coded data:

```
int unpack_f 8(int acc)
{    int exp;

     exp=(acc >> 4) & 0x0F;
      if(exp > 1)
        { acc=(acc & 0x0F) | 0x10;
          acc=acc << (exp-1);
       }

     return acc;
}
```

7.2 Data compression.
The ICA-IMA compression consists of two functional parts: a preprocessor and an adaptive entropy coder.

The preprocessor first converts a 16 or 32 bit word to a hybrid floating 8-bit byte (F8-code). It then uses the delayed predictor technique (to calculate δ’s) for the mapping process.

The bit compression uses Rice’s adaptive coding (CCSDS 121.0-B-1). From above (F8-code) the implemented compression software works with 8 bit length data only (Types=0-7).

7.2.1 Compressed data layout.

The compressed data layout consists of records subdivided into blocks. With exception for type 0, sub 1 each record holds compressed data for 128 bytes. The layout is a variant of the CCSDS 121.0-B-1 recommendation.

The differences are:

1) A Record always starts with a record length in bytes and if required a bit padding field at the end to ensure whole bytes. This way the next record may me located (except for some special situations) if the decompression fails in a record.

2) The order of Fundamental sequences (Fs) and Split bits (Sb) are Fs+Sb,Fs+Sb….. instead of Fs,Fs…. ,Sb,Sb… Again if a decompression fails in a block, the already decompressed bytes may be correct. This also allows for short blocks, short records at the end of a fully compressed data area.

3) The number of zero run blocks is given as a fixed binary 3 bit field instead of a Fs code.

4) The type 0 second extension (sub=1) do not use the CCDS one. Instead a special zero run record is introduced for the ICA-IMA experiments. The reason is that both experiment have large areas in shadow. When in shadow all data are zeroed out giving rise to long sequences of records with zero run blocks. Instead of counting zero run blocks, zero run records are counted. Example record: 0x03,0x00,0x17 would decompress to 128*8=1024 bytes of 0x00.

For details see CCSDS-121.0-B-1.

Record.

Length	Reference	Block 0	Block 1	……..	Block N	Pad

Block (Type 0.0)**.**

Type = 0	Sub=0	Block count-1

Block (Type 0.1)**.**

Type = 0	Sub=1	Record count-1

Block (Type 1-6)**.**

Type=1-6	Fs0+Sb0	Fs1+Sb1	………	FsN+SbN

Block (Type 7)**.**

Type = 7	Byte 0	Byte 1	………	Byte N

Fields

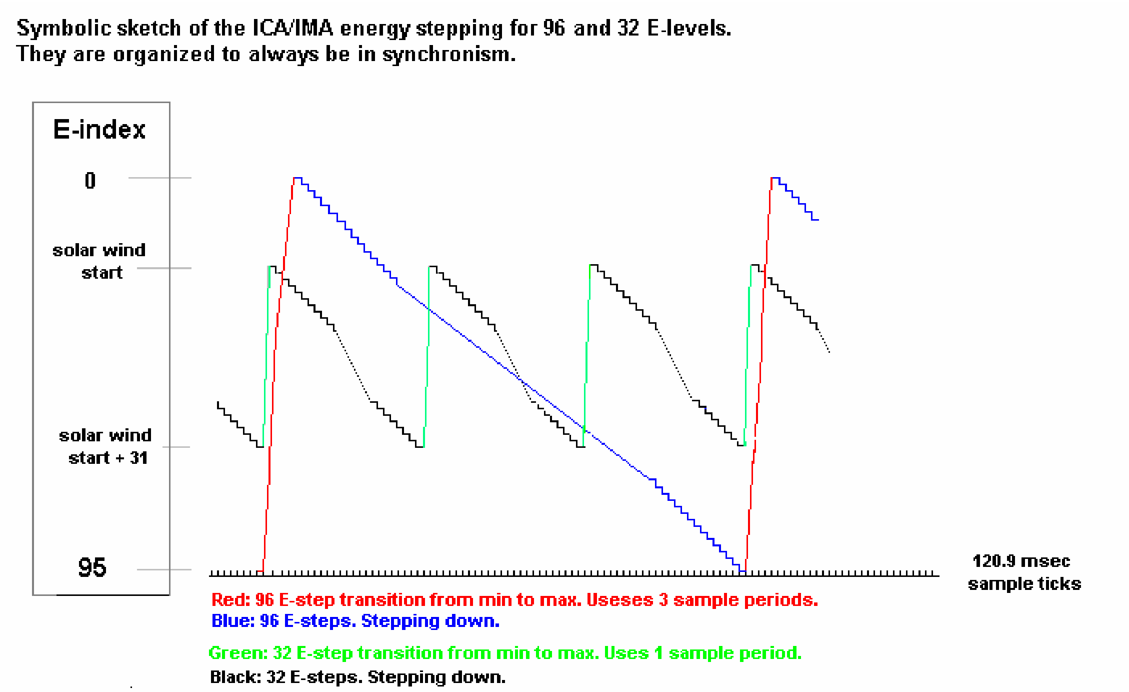
Name	**Bits**	**Short description**
Length	8	The total length in bytes of the record
Reference	8	The uncompressed reference value for the record
Block	Variable	A block of bits holding compressed data for 16 bytes *)
Pad	Variable	Bit padding to ensure whole bytes for a record
Type	3	The compression type (0-7)
Sub	1	The type 0 subtype extension (0-1)
Block count-1	3	Number of zero run blocks –1
Record count-1	4	Number of zero run records – 1
FsN+SbN	Variable	The Fundamental sequence + the Split bits for byte N
Byte	8	Un uncompressed byte

*) Block 0 only holds data for 15 bytes. The Reference gives the 16:th byte.

8.0 Timing and time tagging.

8.1 General.

Disregarding any clocks like DPU master, the experiment operation (measurement) is governed by the imager sampling time (120.9 msec). The imager supplies a mass * azimuth matrix for a given energy and elevation (polar angle) per sample. The energy and elevation is controlled by changing electro-static HV deflection systems. The energy cycle always starts at the maximum energy and is then stepped down to the minimum level. The cycle is then repeated by forcing the HV to its maximum. The change from low to high is allocated one sample period to ensure proper HV relaxing. The maximum number of energy levels are 96. There are, however, modes that use 32 consecutive levels only out of the 96. They also require a sample period for HV relaxation. Thus for a proper coherent operation, the 32 level mode requires 33 sampling periods leading to 99 sampling periods for the 96 level energy modes. The “dead” HV transition period is always placed in front of each energy scan (1 sample for 32 energy levels and 3 for 96 energy levels). The figure below shows the principles.



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8.2 Time tagging.

The term time tagging here refers to the ICA/IMA science format (EDF=Experiment Data Format) time transmitted in the header of each EDF. This time always refer to the start of the first sample in the data collection scheme for the current format. That is, any HV relaxing period is NOT included, but may have to be taking into account for subsequent cycles (energy and/or elevations). The EDF time is composed of the time delivered by S/C and an internal timer. What ever, the accuracy of the S/C timer the ICA/IMA is scaled down to 31.5 msec accuracy. Also note that the ICA/IMA EDF time is 3 bytes wide only. More significant bits must be taken from tm packet times. All times are with respect to S/C time. Any correlation/correction to UTC should be done after the ICA/IMA 3 byte time has been complemented with more significant bits from the ESA packet time. Bee observant that when the 3 byte ICA/IMA timer swaps around, the packet MSB may already have been updated by one prior to be applicable for the ICA/IMA time. This is due to the ICA/IMA tm fifo saving of tm data. This will not happen very often and can always be corrected for. The reason for only 3 bytes of ICA/IMA time tagging is to reduce the overhead by the header in the low rate tm modes. The ICA/IMA timer will swap around about once per 6 days.

9.0 Data reduction considerations.

The experipents (ICA/IMA) utilizes an automatic way of adjusting the data reduction in order not to produce too much data for tm down load. This is accomplished by integrating “adjacent” samples together. There is no attempt onboard to divide down the counts by number of samples integrated Mostly not advisable for “Poission” counting statistics. The number of samples can, however, be obtained on ground by the knowledge of the onboard steering tables. This is not a subject of this manual.

2002-04-04
Stas Barabash

IMA shadow matrix
v. 2.0

Table below gives shadowing of the IMA pixels. Each pixel is presented by the elevation and sector indexes (0…15) and central directions, elevation and azimuth, given in degrees. See the following plots showing the pixel numbering and angle definition. Shadowing "1" corresponds to NO blocking and shadowing "0" to the blocked pixels.

The attached is also a sketch showing the main objects blocking the IMA field of view.

Number	Elevation	Sector	Elevation, °	Azimuth °	Shadowing
0	0	1	47,812	168,75	1
1	0	0	47,812	191,25	0
2	0	15	47,812	213,75	0
3	0	14	47,812	236,25	0
4	0	13	47,812	258,75	0
5	0	12	47,812	281,25	0
6	0	11	47,812	303,75	0
7	0	10	47,812	326,25	0
8	0	9	47,812	348,75	0
9	0	8	47,812	11,25	0
10	0	7	47,812	33,75	1
11	0	6	47,812	56,25	1
12	0	5	47,812	78,75	1
13	0	4	47,812	101,25	1
14	0	3	47,812	123,75	1
15	0	2	47,812	146,25	1
16	1	1	53,438	168,75	1
17	1	0	53,438	191,25	0
18	1	15	53,438	213,75	0
19	1	14	53,438	236,25	0
20	1	13	53,438	258,75	0
21	1	12	53,438	281,25	0
22	1	11	53,438	303,75	0
23	1	10	53,438	326,25	0
24	1	9	53,438	348,75	0
25	1	8	53,438	11,25	0
26	1	7	53,438	33,75	1
27	1	6	53,438	56,25	1

28	1	5	53,438	78,75	1
29	1	4	53,438	101,25	1
30	1	3	53,438	123,75	1
31	1	2	53,438	146,25	1
32	2	1	59,062	168,75	0
33	2	0	59,062	191,25	0
34	2	15	59,062	213,75	0
35	2	14	59,062	236,25	0
36	2	13	59,062	258,75	0
37	2	12	59,062	281,25	0
38	2	11	59,062	303,75	0
39	2	10	59,062	326,25	0
40	2	9	59,062	348,75	0
41	2	8	59,062	11,25	1
42	2	7	59,062	33,75	1
43	2	6	59,062	56,25	1
44	2	5	59,062	78,75	1
45	2	4	59,062	101,25	1
46	2	3	59,062	123,75	1
47	2	2	59,062	146,25	1
48	3	1	64,688	168,75	0
49	3	0	64,688	191,25	0
50	3	15	64,688	213,75	0
51	3	14	64,688	236,25	0
52	3	13	64,688	258,75	0
53	3	12	64,688	281,25	0
54	3	11	64,688	303,75	0
55	3	10	64,688	326,25	0
56	3	9	64,688	348,75	0
57	3	8	64,688	11,25	1
58	3	7	64,688	33,75	1
59	3	6	64,688	56,25	1
60	3	5	64,688	78,75	1
61	3	4	64,688	101,25	1
62	3	3	64,688	123,75	1
63	3	2	64,688	146,25	1
64	4	1	70,312	168,75	0
65	4	0	70,312	191,25	0
66	4	15	70,312	213,75	0
67	4	14	70,312	236,25	0
68	4	13	70,312	258,75	0
69	4	12	70,312	281,25	0
70	4	11	70,312	303,75	0

71	4	10	70,312	326,25	0
72	4	9	70,312	348,75	0
73	4	8	70,312	11,25	1
74	4	7	70,312	33,75	1
75	4	6	70,312	56,25	1
76	4	5	70,312	78,75	1
77	4	4	70,312	101,25	1
78	4	3	70,312	123,75	1
79	4	2	70,312	146,25	1
80	5	1	75,938	168,75	0
81	5	0	75,938	191,25	0
82	5	15	75,938	213,75	0
83	5	14	75,938	236,25	0
84	5	13	75,938	258,75	0
85	5	12	75,938	281,25	0
86	5	11	75,938	303,75	0
87	5	10	75,938	326,25	0
88	5	9	75,938	348,75	0
89	5	8	75,938	11,25	1
90	5	7	75,938	33,75	1
91	5	6	75,938	56,25	1
92	5	5	75,938	78,75	1
93	5	4	75,938	101,25	1
94	5	3	75,938	123,75	1
95	5	2	75,938	146,25	1
96	6	1	81,562	168,75	0
97	6	0	81,562	191,25	0
98	6	15	81,562	213,75	0
99	6	14	81,562	236,25	0
100	6	13	81,562	258,75	0
101	6	12	81,562	281,25	0
102	6	11	81,562	303,75	0
103	6	10	81,562	326,25	0
104	6	9	81,562	348,75	0
105	6	8	81,562	11,25	1
106	6	7	81,562	33,75	1
107	6	6	81,562	56,25	1
108	6	5	81,562	78,75	1
109	6	4	81,562	101,25	1
110	6	3	81,562	123,75	1
111	6	2	81,562	146,25	1
112	7	1	87,188	168,75	1
113	7	0	87,188	191,25	1

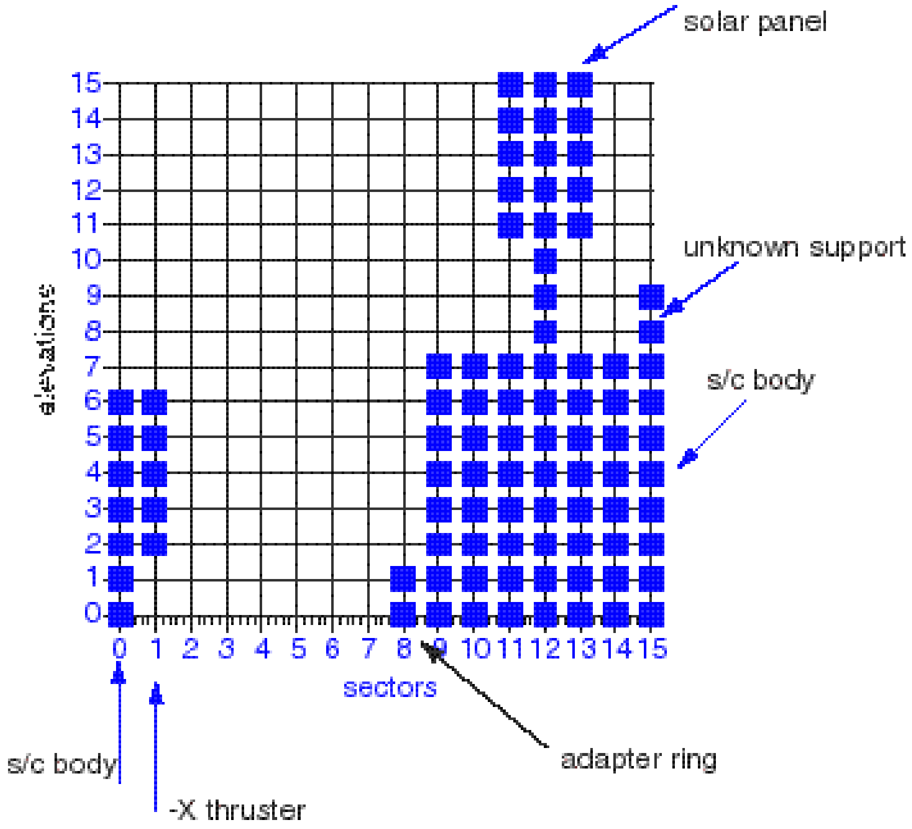
114	7	15	87,188	213,75	0
115	7	14	87,188	236,25	0
116	7	13	87,188	258,75	0
117	7	12	87,188	281,25	0
118	7	11	87,188	303,75	0
119	7	10	87,188	326,25	0
120	7	9	87,188	348,75	0
121	7	8	87,188	11,25	1
122	7	7	87,188	33,75	1
123	7	6	87,188	56,25	1
124	7	5	87,188	78,75	1
125	7	4	87,188	101,25	1
126	7	3	87,188	123,75	1
127	7	2	87,188	146,25	1
128	8	1	92,812	168,75	1
129	8	0	92,812	191,25	1
130	8	15	92,812	213,75	0
131	8	14	92,812	236,25	1
132	8	13	92,812	258,75	1
133	8	12	92,812	281,25	0
134	8	11	92,812	303,75	1
135	8	10	92,812	326,25	1
136	8	9	92,812	348,75	1
137	8	8	92,812	11,25	1
138	8	7	92,812	33,75	1
139	8	6	92,812	56,25	1
140	8	5	92,812	78,75	1
141	8	4	92,812	101,25	1
142	8	3	92,812	123,75	1
143	8	2	92,812	146,25	1
144	9	1	98,438	168,75	1
145	9	0	98,438	191,25	1
146	9	15	98,438	213,75	0
147	9	14	98,438	236,25	1
148	9	13	98,438	258,75	1
149	9	12	98,438	281,25	0
150	9	11	98,438	303,75	1
151	9	10	98,438	326,25	1
152	9	9	98,438	348,75	1
153	9	8	98,438	11,25	1
154	9	7	98,438	33,75	1
155	9	6	98,438	56,25	1
156	9	5	98,438	78,75	1

157	9	4	98,438	101,25	1
158	9	3	98,438	123,75	1
159	9	2	98,438	146,25	1
160	10	1	104,062	168,75	1
161	10	0	104,062	191,25	1
162	10	15	104,062	213,75	1
163	10	14	104,062	236,25	1
164	10	13	104,062	258,75	1
165	10	12	104,062	281,25	0
166	10	11	104,062	303,75	1
167	10	10	104,062	326,25	1
168	10	9	104,062	348,75	1
169	10	8	104,062	11,25	1
170	10	7	104,062	33,75	1
171	10	6	104,062	56,25	1
172	10	5	104,062	78,75	1
173	10	4	104,062	101,25	1
174	10	3	104,062	123,75	1
175	10	2	104,062	146,25	1
176	11	1	109,688	168,75	1
177	11	0	109,688	191,25	1
178	11	15	109,688	213,75	1
179	11	14	109,688	236,25	1
180	11	13	109,688	258,75	0
181	11	12	109,688	281,25	0
182	11	11	109,688	303,75	0
183	11	10	109,688	326,25	1
184	11	9	109,688	348,75	1
185	11	8	109,688	11,25	1
186	11	7	109,688	33,75	1
187	11	6	109,688	56,25	1
188	11	5	109,688	78,75	1
189	11	4	109,688	101,25	1
190	11	3	109,688	123,75	1
191	11	2	109,688	146,25	1
192	12	1	115,312	168,75	1
193	12	0	115,312	191,25	1
194	12	15	115,312	213,75	1
195	12	14	115,312	236,25	1
196	12	13	115,312	258,75	0
197	12	12	115,312	281,25	0
198	12	11	115,312	303,75	0
199	12	10	115,312	326,25	1

200	12	9	115,312	348,75	1
201	12	8	115,312	11,25	1
202	12	7	115,312	33,75	1
203	12	6	115,312	56,25	1
204	12	5	115,312	78,75	1
205	12	4	115,312	101,25	1
206	12	3	115,312	123,75	1
207	12	2	115,312	146,25	1
208	13	1	120,938	168,75	1
209	13	0	120,938	191,25	1
210	13	15	120,938	213,75	1
211	13	14	120,938	236,25	1
212	13	13	120,938	258,75	0
213	13	12	120,938	281,25	0
214	13	11	120,938	303,75	0
215	13	10	120,938	326,25	1
216	13	9	120,938	348,75	1
217	13	8	120,938	11,25	1
218	13	7	120,938	33,75	1
219	13	6	120,938	56,25	1
220	13	5	120,938	78,75	1
221	13	4	120,938	101,25	1
222	13	3	120,938	123,75	1
223	13	2	120,938	146,25	1
224	14	1	126,562	168,75	1
225	14	0	126,562	191,25	1
226	14	15	126,562	213,75	1
227	14	14	126,562	236,25	1
228	14	13	126,562	258,75	0
229	14	12	126,562	281,25	0
230	14	11	126,562	303,75	0
231	14	10	126,562	326,25	1
232	14	9	126,562	348,75	1
233	14	8	126,562	11,25	1
234	14	7	126,562	33,75	1
235	14	6	126,562	56,25	1
236	14	5	126,562	78,75	1
237	14	4	126,562	101,25	1
238	14	3	126,562	123,75	1
239	14	2	126,562	146,25	1
240	15	1	132,188	168,75	1
241	15	0	132,188	191,25	1
242	15	15	132,188	213,75	1

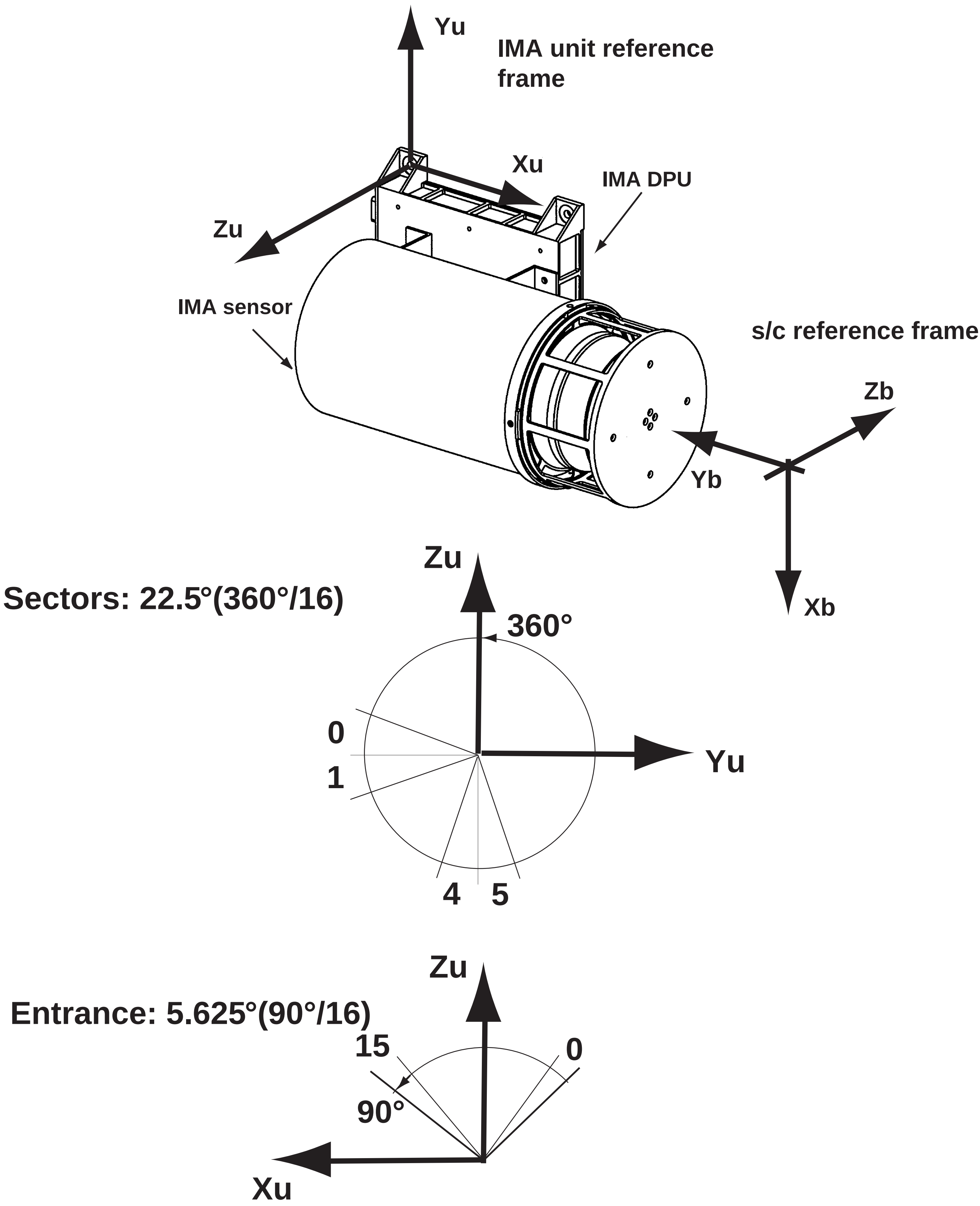
243	15	14	132,188	236,25	1
244	15	13	132,188	258,75	0
245	15	12	132,188	281,25	0
246	15	11	132,188	303,75	0
247	15	10	132,188	326,25	1
248	15	9	132,188	348,75	1
249	15	8	132,188	11,25	1
250	15	7	132,188	33,75	1
251	15	6	132,188	56,25	1
252	15	5	132,188	78,75	1
253	15	4	132,188	101,25	1
254	15	3	132,188	123,75	1
255	15	2	132,188	146,25	1

The figure below is the shadowing matrix for elevation and azimuth converted to the sector and entrance (elevation) indexes. The 180° shift between directional azimuth and the sector which sees this direction is introduced.

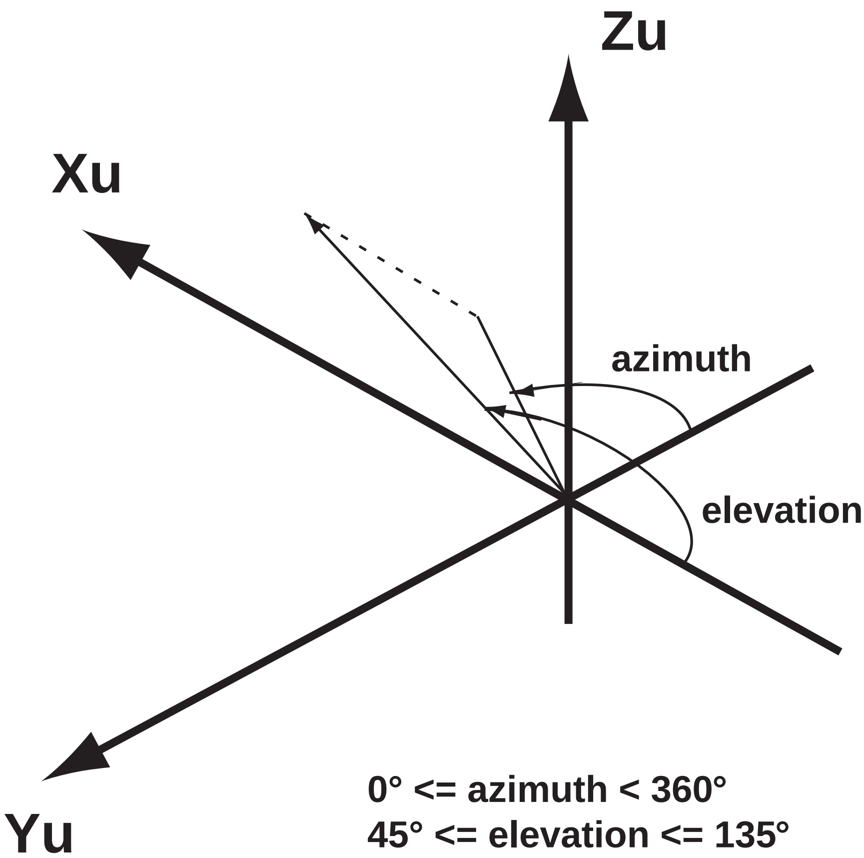


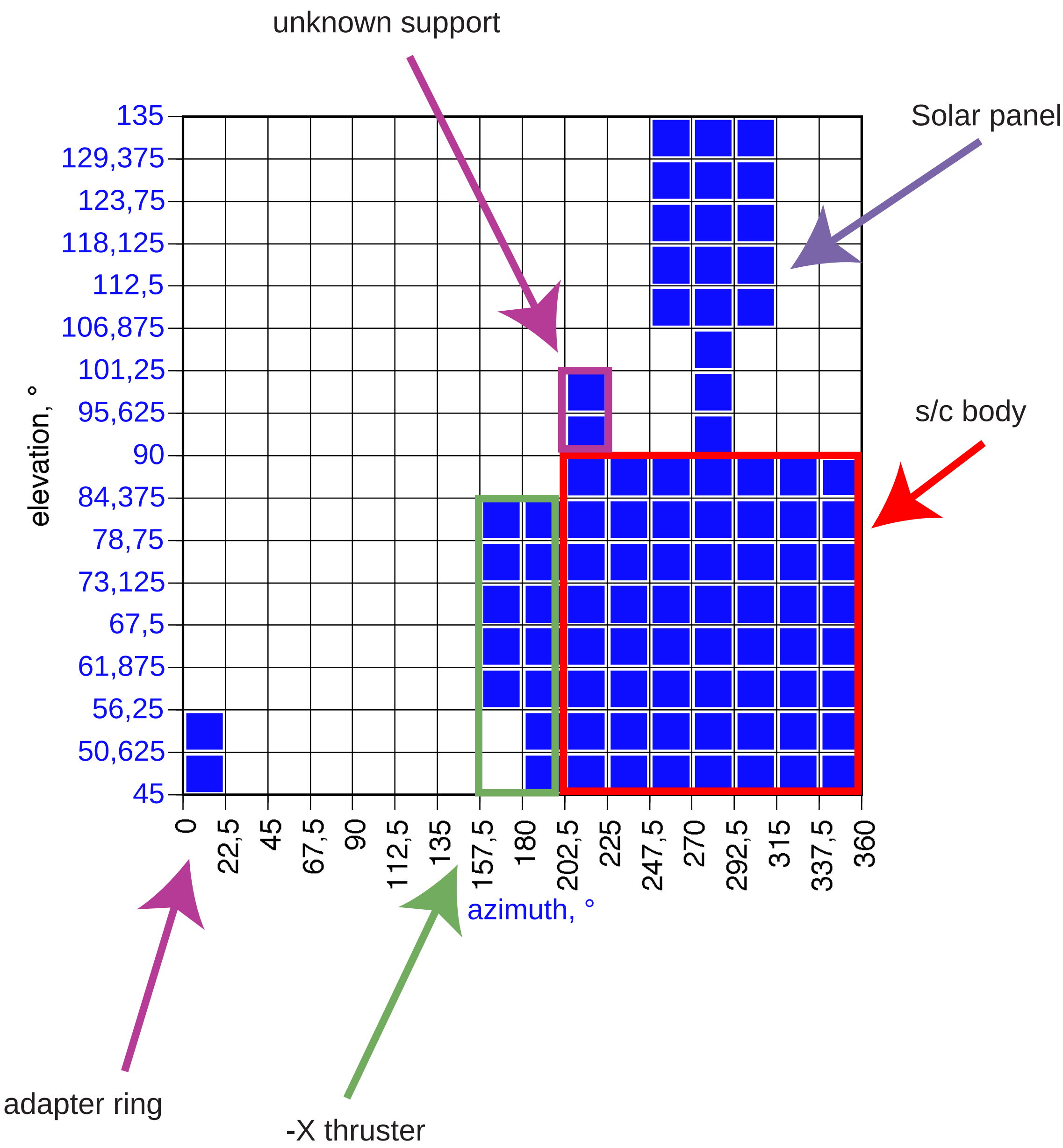
Following Hans definition this matrix is converted to the array

Shadow	Entrance index
0x008F	0
0x008F	1
0x019F	2
0x019F	3
0x019F	4
0x019F	5
0x019F	6
0x9F00	7
0xCCFF	8
0xCCFF	9
0xCC00	10
0xBD00	11
0xBD00	12
0xBD00	13
0xBD00	14
0xBD00	15


Yu
IMA unit reference frame
Xu
IMA DPU
Zu
IMA sensor
s/c reference frame
Zb
Yb
Xb
Zu
Sectors: 22.5°(360°/16)
360°
0
1
Yu
4
5
Zu
Entrance: 5.625°(90°/16)
15
0
90°
Xu

Angle definition





unknown support
Solar panel
s/c body
adapter ring
-X thruster
elevation, °
135
129,375
123,75
118,125
112,5
106,875
101,25
95,625
90
84,375
78,75
73,125
67,5
61,875
56,25
50,625
45
0
22,5
45
67,5
90
112,5
135
157,5
180
202,5
225
247,5
270
292,5
315
337,5
360
azimuth, °