
Presentations to the SPIRE Consortium Meeting
IFSI, Rome, 16/17 July 2002
SPIRE-UCF-MHO-001370

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Contents

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SPIRE Consortium Meeting
IFSI, Rome
16, 17 July 2002

Aims of the Meeting

Matt Griffin

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Main Aims of the Meeting

- Update on status of SPIRE and Herschel
- Consortium disucssion (presentations today and workshops tomorrow) of
  - AIV Facility and Instrument Test Plan
  - Instrument Calibration
- ICC management and planning
- Meetings of
  - SPIRE Steering Group
  - ICC Steering Group

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Attendance

Philippe Andre‘
Jean-PaulBaluteau
Milena Benedettini, IFSI
Riccardo Cerulli
Patrick Collins
Pierre Cox
Anna Di Giorgio
Roger Emery
Matthew Fox
Alberto Franceschini, Padova
Walter Gear
Matthew Graham
Matt Griffin
Steve Guest
Peter Hargrave
Maohai Huang
Ken King
Tanya Lim
Sergio Molinari
Hien Nguyen
Goran Olofsson
Seb Oliver
Renato Orfei
Matthew Page
Ismael Perez
Timo Prusti, ESTEC
Marc Sauvage
Paolo Saraceno
Bernhard Schulz, IPAC
John Liu Scige‘
(Rome)Steve Serjeant
Sunil Sidher
Jason Stevens
Bruce Swinyard
Toshi Takagi
Mattia Vaccari
Gillian Wright

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Agenda: Today

9:30	9:35	Welcome and logistics	Saraceno
9:35	9:40	Aims of the meeting	Griffin
9:40	9:45	Logo competition result	Griffin
9:45	10:00	**Coffee**	
10:00	10:40	SPIRE and Herschel status; IBDR report	Griffin
10:40	11:00	Instrument System/Subsystem design status/upd	Swinyard
11:00	11:30	AIV facility and instrument test plan overview	Swinyard
11:30	12:00	Instrument performance modelling and simulati	Griffin
12:00	12:40	SPIRE calibration overview	Gear
12:40	13:00	Envisaged SPIRE data products	Griffin
13:00	14:30	**Lunch**	
14:30	14:45	ICC Development Plan	King
14:45	15:15	Overview of the Ground Segment	Sidher
15:15	15:30	**Coffee**	
15:30	16:00	SPIRE ICC scenarios	Lim
16:00	16:30	ICC design	Sauvage
16:30	17:00	**ICC major workpackage overview**	King (Deferred)
17:00	17:15	**Report on the ICC review**	Griffin (Deferred)
17:15	18:30	**SPIRE Steering Group meeting**	Griffin

Agenda: Tomorrow

9:00	10:30	Workshop on the AIV facility, the Instrument Test Plan and QLA	Swinyard
10:30	10:45	Coffee	
10:45	12:15	Workshop on Calibraton Requirements Document	Swinyard
12:15	12:40	Herschel Observing Time: HST status	Griffin
12:40	13:00	Ground-based preparatory science/calibration	Lim
13:00	14:30	Lunch	
14:30	17:30	ICC Steering Group Meeting	Oliver

SPIRE Steering Group Meeting Today 17:15

- **SPIRE Steering Group**

Gary Davis, Canada	N
Jean-Paul Baluteau, France	Y
Laurent Vigroux, France	N (Philippe André)
Gianni Tofani, Italy	N (Paolo Saraceno)
Ismael Perez-Fournon, Spain	Y
Göran Olofsson, Sweden	Y
Michael Rowan-Robinson, UK	Y
Andrew Lange, USA	N

- **All Co-Investigators are invited to attend the Steering Group meeting**

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SPIRE Steering Group Meeting Agenda

1. Minutes of last meeting (July 2001)
2. Statements
3. Report to the Steering Group (presentation by MJG)
4. Canadian participation in SPIRE following shutter deletion
5. Report on June 19 Herschel/Planck payload funding meeting
6. Reports from Co-Is on funding status in each country
7. SPIRE Steering Group position on international funding status
8. Proposed change to Canadian Co-Investigator
9. Nomination of Associate Scientists
10. SPIRE management at system and subsystem level
11. Any other business

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ICC Steering Group Meeting Tomorrow 14:30

- ICC Steering Group

Seb Oliver ICC Scientist (Chair)	Y
Matt Griffin PI	Y
Laurent Vigroux Co-PI and SAp Co-I	N
Bruce Swinyard Instrument Scientist	Y
Ken King ICC Development Manager	Y
Matt Fox ICSTM DAPSAS Centre Manager	Y
Rene Gastaud SAp DAPSAS Centre Manager	N
Michael Rowan-Robinson ICSTM Co-I	N

- All Co-Investigators are invited to attend the Steering Group meeting
- Expected to report on resources/funding status
  - Jean-Paul Baluteau
  - Paolo Saraceno
  - Göran Olofsson
  - Ismael Perez-Fournon

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ICC Steering Group Meeting Agenda

- Summary of reports from Co-Is contributing to the ICC
- Agreement of total ICC staff effort available from within the consortium for the ICC Development Phase.
- Proposed ICC Management Structure and workpackage definition
- Incorporating key instrumental expertise into the ICC
- Proposed ICC Development work plan and schedule

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Logo Competition Result

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Winning Logo

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Winning Logo

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SPIRE and Herschel Status

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- INSTRUMENT DESIGN UPDATE
- IBDR REPORT
- ICC DEVELOPMENT
- FUNDING AND PROGRAMMATICS

ESA/Industry Programme and Schedule

- Launch date is still 15 February 2007 (but see later . . .)
- Industry PDR to be completed by September (documentation to be submitted by end June)
- IID-B nearly agreed (thermal interfaces still TBD)
- IID-A being updated prior to PDR
- Telescope:
  - On track: successful CDR expected
  - Change from Ni to Al coating (not easy to clean)
    - Industry proposal to add extra 3% to emissivity budget for contamination (SPIRE and PACS reject this.)

ESA/Industry Programme and Schedule

- Revised Instrument Delivery Dates (announced by ESA to Industry on 2 June)
- Industry schedule for PDR will be based on these dates

	Previous	New	SPIRE (at IBDR)
AVM	Apr. 2003	Oct. 2003	June 2003
CQM	Apr. 2003	Oct. 2003	Oct. 2003
PFM	July 2004	Jan. 2005	Oct. 2004
FS	July 2005	Jan. 2006	Jan. 2006

ESA/Industry Programme and Schedule

- New ESA *Cosmic Vision 2020* plan approved by SPC
- Eddington to be implemented in conjunction with Herschel/Planck
- Herschel/Planck instruments generally have payload schedule and funding problems
- Meeting involving DSci, ESA Executive, PI teams, major agencies took place on June 19

Programmatic Summary

- SPIRE is (barely) compatible with the new instrument delivery dates
- Main schedule problems:
  - US: Detector array delivery
  - France: Delays on warm electronics and optics
- CPP payment scheme (over)solves French and Italian problems but no effect on UK

Instrument Design

- Only significant changes since last the IBDR in April: Deletion of the Shutter
- Major design issues:
  - 300-mK thermal strap system
  - FTS mechanism design
  - DRCU grounding scheme
  - ^{3}He cooler vibration qualification
  - Beam Steering Mechanism programme

Shutter Deletion

- Purpose of Shutter: Allow detector sensitivity to be verified in the Herschel cryostat by replicating the correct photon background.
- PACS did not have a shutter but have concluded that they need the same capability
- Industry are now required to provide a Cryogenic Test Adapter (CTA) for both the EQM tests and the PFM (flight) cryostat
- Performance not likely to be as good as the SPIRE Shutter – but good enough
- Shutter therefore deleted. Alternative Canadian participation through substantial AIV and ICC support is being discussed

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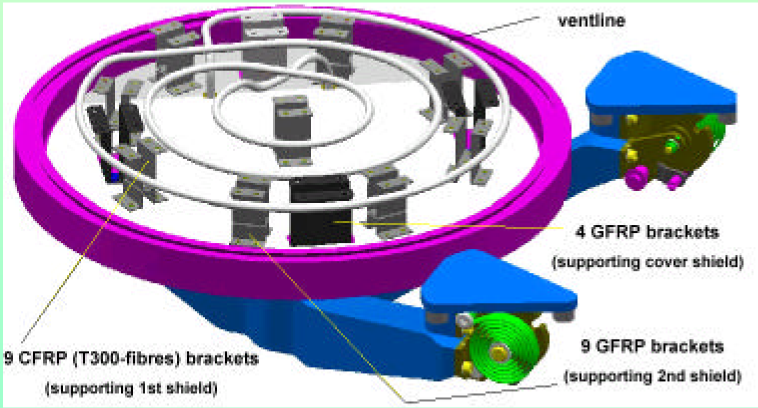
CTA Design – Flight Cryostat



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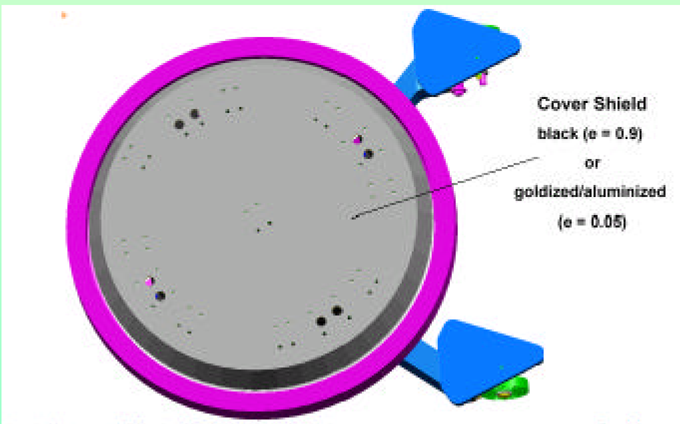
CTA Design – Flight Cryostat



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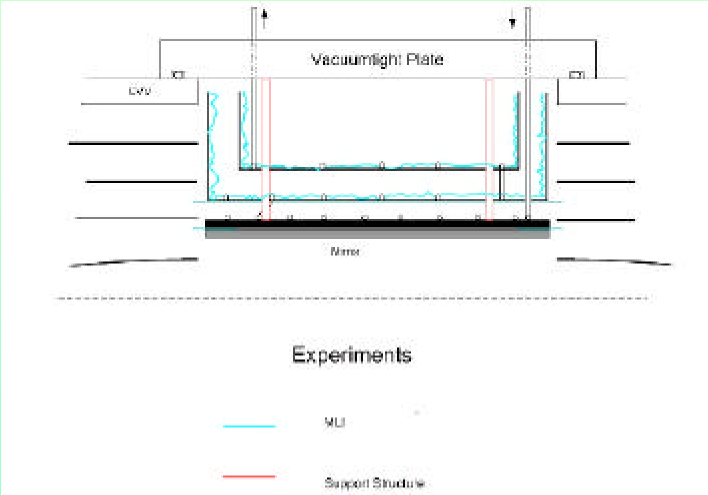
CTA Design – EQM Cryostat



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CTA Design – EQM Cryostat

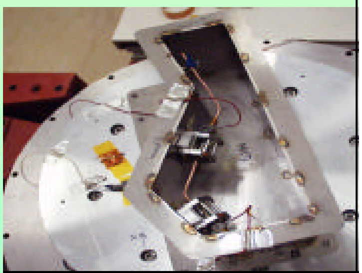
Mathcad results

300-mK Thermal Straps

- Working Team (MSSL, RAL, Cardiff) led by Doug Griffin set up in October 2001:
  - Devise and evaluate thermal strap support concepts (thermal and mechanical modelling)
  - Build and test prototypes (cryogenic thermal and room-temp. vibration testing)
  - Select optimum design
  - Formulate implementation plan
- Three designs were evaluated
- Review in February selected concept for implementation
- Working Group continues to operate
  - Design and fabrication: Cardiff and MSSL
  - Coordination, management, and System Engineering: RAL
- DDR held July 10

300-mK Thermal Straps Requirements and Constraints

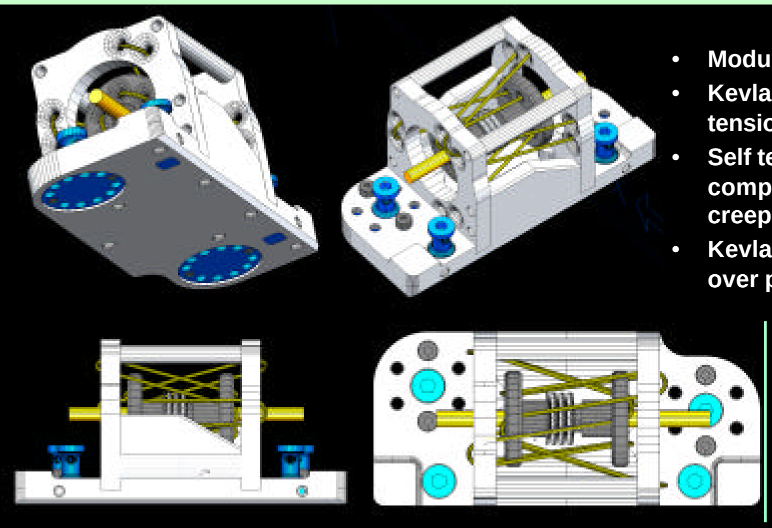
- 2mW thermal budget for whole system
- Two light-tight entry points to 2-K detector boxes
- Compliant links to BDAs and cooler tip
- DT between cooler tip and BDAs < 20 mK
- Small space envelope (20x60x60 mm^3 for each support)



Thermal strap system mock-up

- Electrical break between photometer and Spectrometer BDAs (separate grounds)
- Minimal deformation of the detector box
- Low mass
- Simple integration
- Modularity
- Accommodation of thermal control hardware if needed

300-mK Support Module MK3



- Modular units
- Kevlar under tension
- Self tensioning compensates for creep/expansion
- Kevlar passes over polished radii

Thermal Analysis

- 2 supports in photometer box – 2 x 12 wires
- 2 light baffles – 2 x 12 wires
- 30 mm Kevlar thread length

Tex	44	167	790
Strands	0.018x120	0.012x1000	0.012x5000
Load from 2 K	0.4mW	1.2 mW	6.5 mW

- Some margin on 2-K thermal budget – may change to braided Kevlar for ease of assembly

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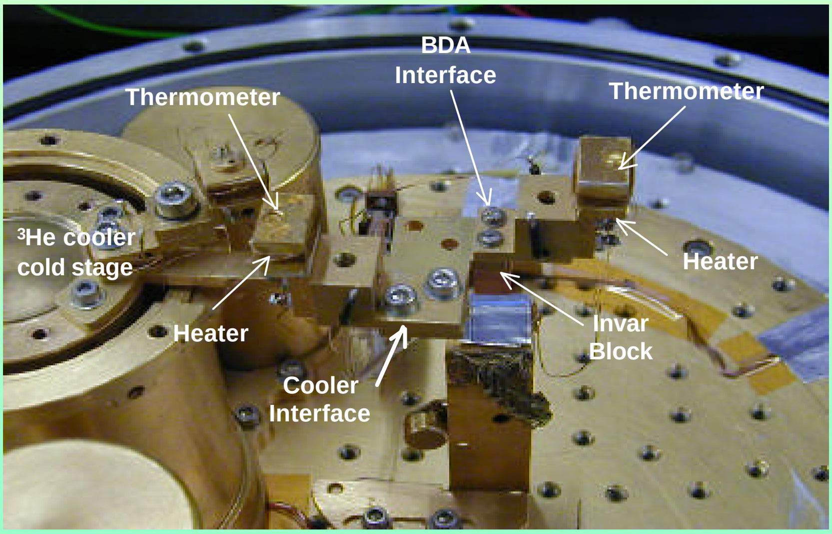
Thermal Interface Testing



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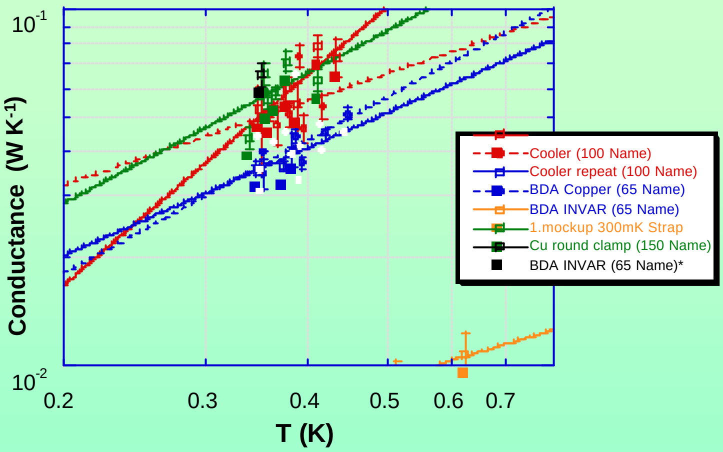
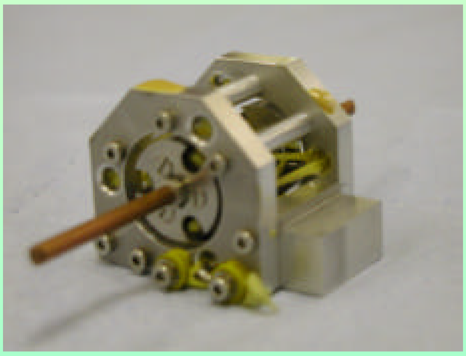
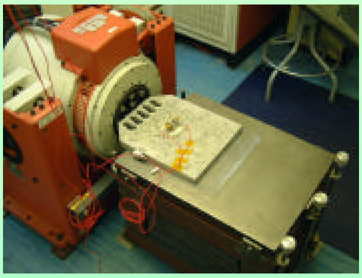
Thermal Interface Conductance

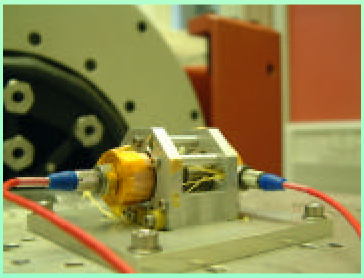


- Thermal strap and cooler interface: typ 25 mW K^{-1}
- BDA interface typ. 40 mW K^{-1}
- Envisaged ΔT from cooler to BDA interface ~ 2 mK

Thermal Strap Support Module MK2



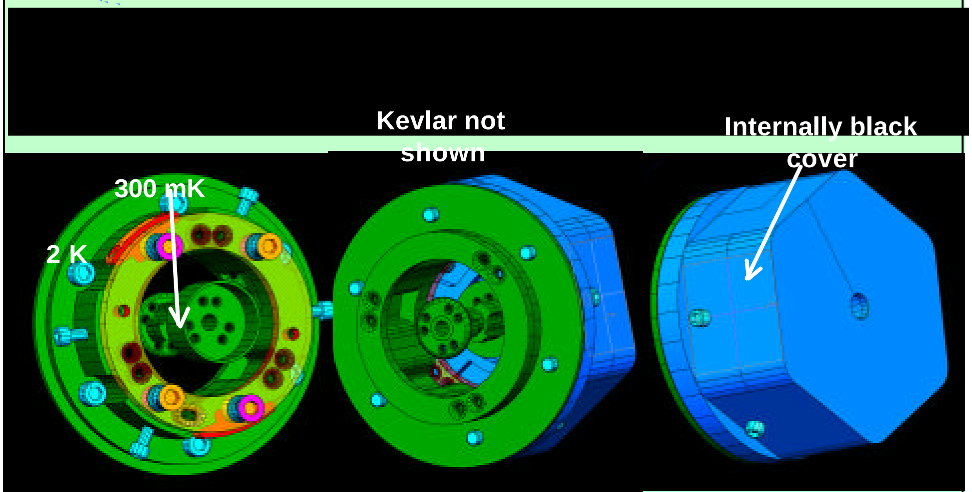




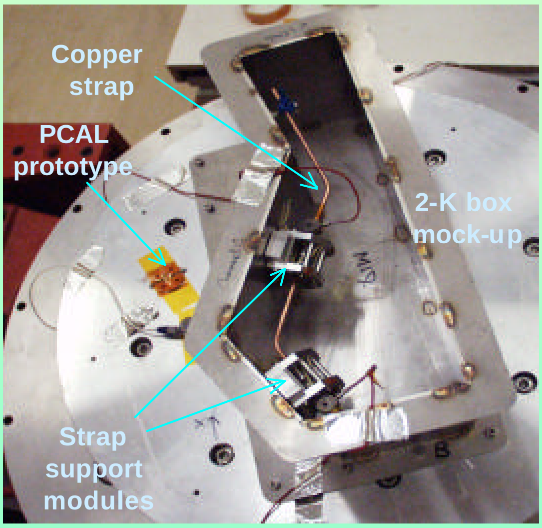
Resonant frequencies:

Axial	1120 Hz
Transverse	365 Hz

300-mK Strap Support/2-K Box Light Baffle



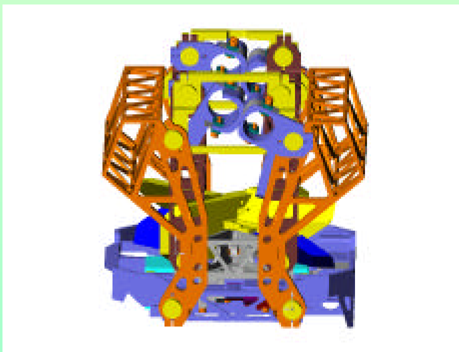
Thermal Strap System MK2 Vibration Tests



- Test sequence:
  - Sine sweep
    40g, 5 Hz - 110 Hz
  - Random
    18g rms, 5 Hz - 2 kHz
- Failure under random test – but due to Kevlar fraying at a machining burr

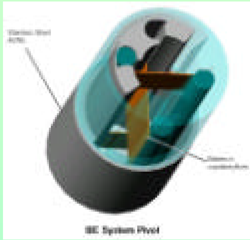
SMEC status

- SMECm STM and CQM structures being built
- Actuator prototypes built and tested
- Launch latch being built. To be tested in July.
- MCU development model built and tests nearly completed



SMEC Flex Pivots

- Problem with random vibrations levels has arisen after IBDR
- Design levels (66g peak) are 4 times higher than the level the pivots can bear.
- Proposed LAM approach



1- Measure real levels, frequencies, damping factors with dummy SMEC in the STM

2- Negotiate notches with ESA depending on these results

3- Design a way to protect the pivots during launch: sleeves to limit displacement (but small allowable clearance (10µm) before irreversible buckling of the pivot blades)

SMEC: Other Technical Issues

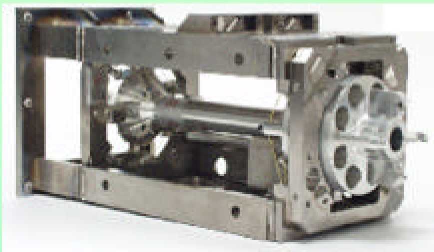
- Launch latch
  - Thermal contraction between 300 K and 4 K: same small clearance as for the pivots sleeves. Careful choice of materials and possible adjustments. Will be checked on the SMECm CQM.
- Warm electronics thermal dissipation:
  - DRCU/MCU interface qualification temperature level is approx. 75°C => internal component temperature above 105°C (85 °C is max acceptable).
  - Cooling or revision of interfaces between MCU board and DRCU or between DRCU and satellite.

Grounding Scheme

- Requirement: system design with single point ground at either warm or cold end - to be selected after EMC analysis and CQM tests
- Current SAp DRCU design forces ground point to be at the warm end
- Design changes would be needed in DRCU to make cold-end grounding possible
- JPL/CEA/Project Team currently studying the options with regular telecons
- Technical agreement not yet achieved
- Solution to be be decided in preparation for DRCU Technical DDR (to be completed by end of July)
- DRCU DDR Phase-2 (development plan and schedule) to be completed in September

STM/CQM ^{3}He Cooler Vibration Tests

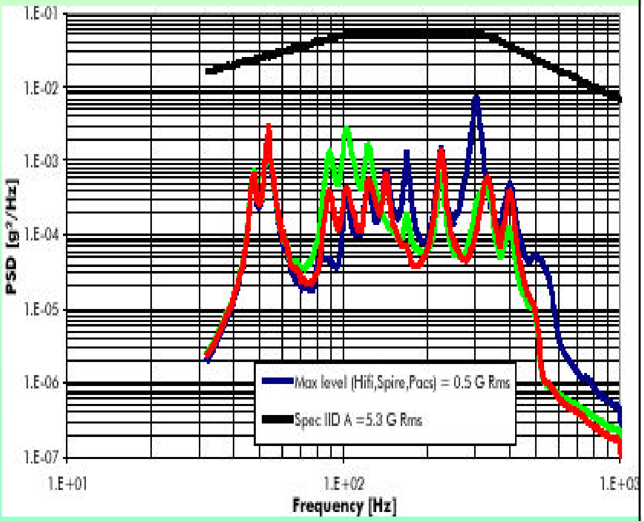
- Kevlar cords diameter for the evaporator support changed in late 2000 from 0.5 mm dia. to to 0.3 mm dia. to increase the margins and net heat lift
- Modelled performance acceptable, but assumes no slipping on pulleys



- Warm vibration tests: sine (40 g 0-100 Hz); random (14 g rms)
- Cooler survived but inspection showed some damage to a Kevlar cord due to slipping on a pully
- 40 g acceleration was enough to move the evaporator slightly and induce rubbing between the cord and the pulleys
- Impact on cooler hold time to be studied
  - Preliminary conclusion: may use up most margin wrt 48-hr requirement and/or BDA thermal load on 300 mK
  - Depends strongly on the Level-1 temperature

Random Vibration Levels

- Alcatel analysis shows factor of 10 margin between modelled levels at FPU and qualification levels specified in IID-A
- Design, cost, risk, schedule of several SPIRE subsystems is currently driven by the mechanical/thermal trade-off
  - –^{3}He cooler
  - –300-mK thermal straps
  - –SMEC
  - –Detector Arrays
- SPIRE is preparing formal request for reduction in the levels



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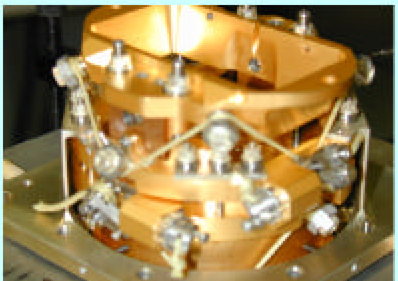
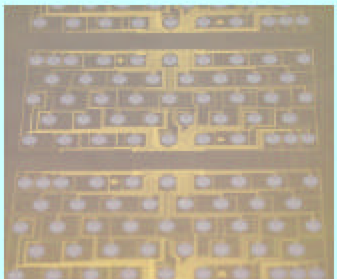
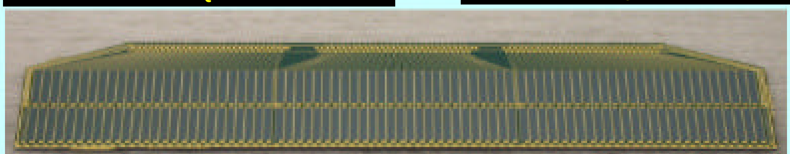
Bolometer Arrays



BDA Mechanical Qualification unit



P/LW CQM wafer



CQM Bolometer Load Resistor Array

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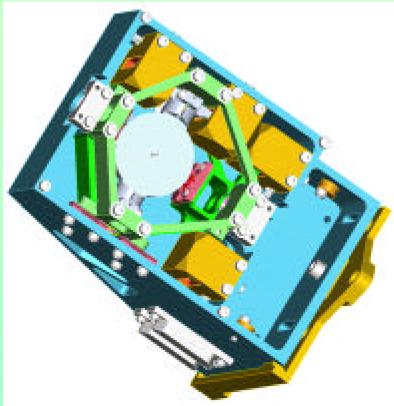
Beam Steering Mechanism

- De-scope of BSM development model philosophy already being implemented (dev. model 1 will be delivered for STM)
- Proposal not to integrate FS (not accepted by SPIRE Project)
- Descope to single axis will save very little at this stage
- No margin for any setbacks
- De-scope of the test programme or deletion of the mechanism are high risks

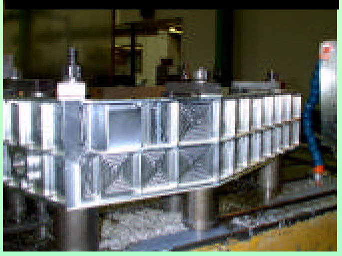


- Observing modes that allow degraded operation without the BSM exist – but major penalty to science

STM/CQM Structure

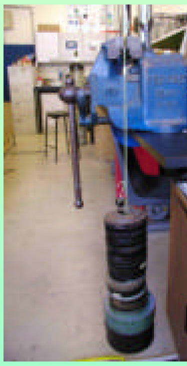
Photometer 2-K enclosure

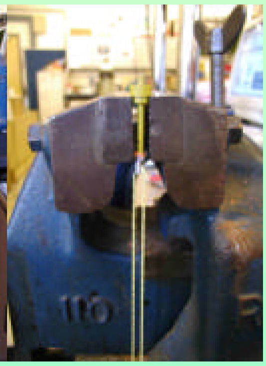
FTS-Side FPU Cover



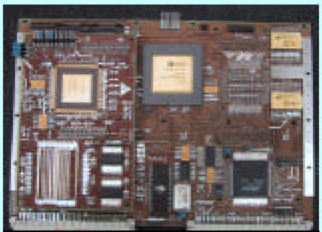
2-K Enclosure Covers

STM SCAL Source

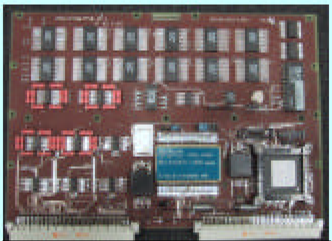




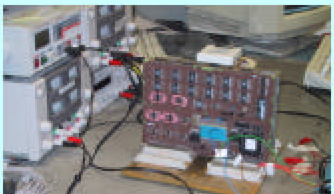
DPU Boards



CPU Board



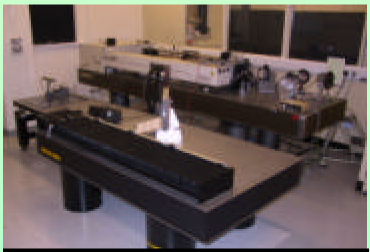
I/F Board



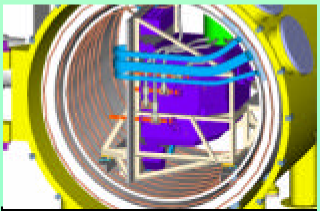
CPU + I/F + Motherboard Testing

SPIRE AIV Facility

Instrument Test Cryostat



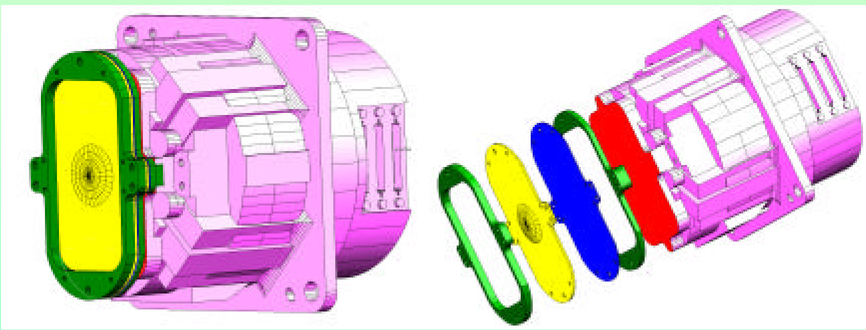
FIR laser and telescope simulator



Instrument in cryostat

Vacuum system

FTS BDA with Lens and Filter Stack



IBDR Review Board Report
Progress, Overall Status, Programmatics

- Good progress made since the IIDR, visible from documentation, presentations and recent test results
- Most issues raised at IIDR closed or close to being solved

Major concerns

- Funding situation for SPIRE
  - Reduction of Project Team to very low level of manpower, while the resources are stretched already.
  - Some activities reported to be on hold, although they need to be addressed urgently.
- Schedule
  - Main driver for all SPIRE activities; de-scoping in the AIV programme has already taken place.
  - Absence of appropriate margins

IBDR Review Board Report
Product Assurance and System Engineering

Other Concerns

- Lack of planning and coordination of future PA activities
- Lack of configuration control, especially at Subsystem level
- Full system-level FMECA is still lacking.
- Delay in completing FDIR and H/W-S/W Interaction analyses due to lack of manpower at RAL

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IBDR Review Board Report
Instrument Design and Subsystems

- System and subsystem design and definition of internal interfaces are well advanced.
- Clear way forward on mitigating microvibration risk

- Lack of visibility of Bolometers status (ITAR problems noted)
- 300-mK thermal strap status
- Harness routing to and from the BDAs still open
- FTS mechanism design not fully consolidated; lifetime tests are late in the programme
- DRCU design is not yet mature
- Too many tests being pushed into FM programme

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IBDR Review Board Report
Recommendations

1. Extreme concern that funding-driven slow-down of SPIRE Project Team activities seems to be unavoidable: impacts should be assessed and priorities proposed
2. Schedule must be urgently consolidated. Clarify planning of DRCU, Thermal straps, AIV/AIT plan.
3. Advance the status of the DRCU and thermal straps to a level equivalent with the rest of the instrument
4. Freeze the outstanding interfaces with the spacecraft, both thermal and stray light
5. PA activities need appropriate planning and resources

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IBDR Review Board Report Recommendations

6. Configuration control must be improved at system and subsystem levels.
7. Special care shall be given to early testing of high-risk items, such as the SMEC, the BDA, microphonics.
8. A software development and verification plan shall be made available.

Critical Issues Listed by SPIRE at IBDR

1. Spacecraft interfaces (IID-A & IID-B)
2. BDAs - Development Plan
   - BDA vibration levels
3. 300-mK thermal straps
4. FPU Structure schedule
5. Microvibrations
6. DRCU Dev. Plan and Schedule
7. DRCU mass
8. EMC
9. BSM Development Plan
10. UK Project Team Costs
11. OBS effort at IFSI
12. Shutter programme
13. AIV Facility
14. FMECA/FDIR

RED: More concerned

Blue: Less concerned

Black: Same

New ones . . .

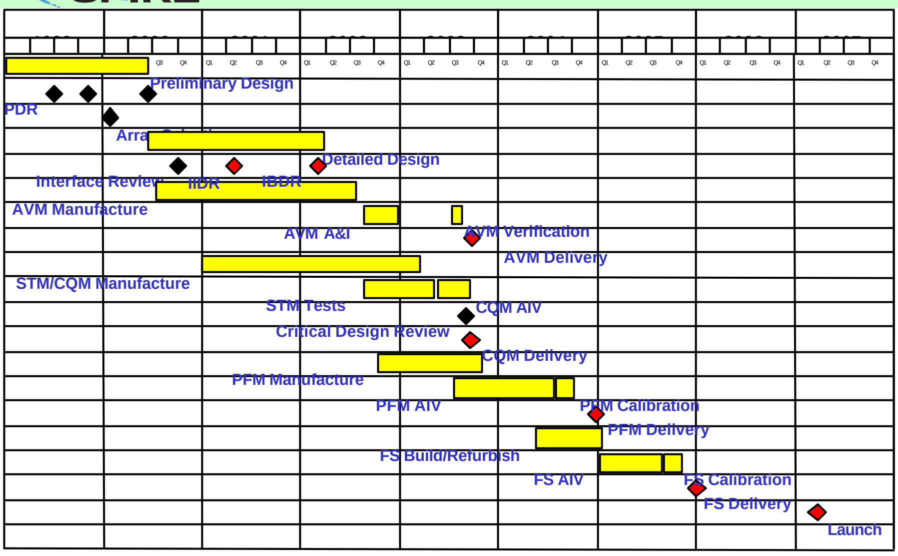
- DRCU design and overall grounding scheme
- DRCU delay
- Optics delay
- SMEC pivots vibration survival
- ^{3}He Cooler Kevlar supports

IID-B and IID-A Definition

- Considerable progress made on both
- IID-B: Thermal interfaces still need to be clarified
- IID-A: Major issue is overall emissivity budget

  IID-A consolidation meeting in Cannes at end of June

Schedule Overview (new instrument delivery dates)



CQM and PFM Critical Paths

CQM

- Detector deliveries and DRCU
  - CQM AIV programme has been adapted to accommodate SAp and JPL constraints
- FPU structure (required first)

PFM

- BDA delivery schedule:
  - JPL's desired phased delivery is non-compliant with PFM instrument-level schedule – Project Team/JPL are discussing possible solutions
- DRCU delivery

Major Risks

- Squeezed ILT programme (time and resource)
- Overlap of CQM and PFM programmes: no feedback
- FTS mechanism vibration qualification
- Parallel manufacture of PFM and CQM hardware
- Possible deletion of BSM

Instrument/System Design

Bruce Swinyard

Instrument/System Design

- Not a great deal of change since last consortium meeting.
- Most of the detailed changes were presented at the IBDR (apologies to all who were there…)
- Changes/updates since last July
  - Detailed changes to spectrometer optical design
  - Inclusion of step-and-look as real FTS operating mode
  - Alignment of BDAs
  - 300 mK straps
  - Electronics and grounding
  - Straylight modelling
  - Thermal design
  - The shutter (see Matt)
  - Vibration testing
  - Microvibration

Issues from last time

- BDA/JFETs and instrument thermal design
- Mechanisms – especially SMEC
- Electronics design not complete
- System level interfaces with PLM and SVM
- Sub-system DDRs not complete

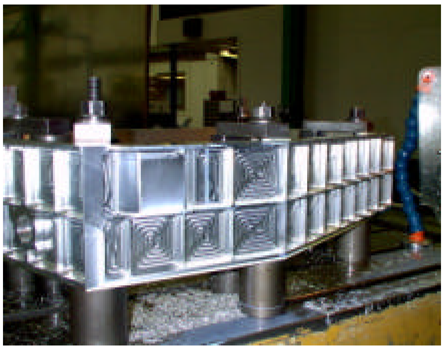
Issues to discuss this time

- Update to optical design
- BDA/JFETs and instrument thermal design
- 300 mK straps
- Mechanisms – especially SMEC
- Electronics design not complete – grounding scheme is problematic
- System level interfaces with PLM
  - Thermal design is concerning
  - Vibration levels are a problem
- Sub-system DDRs not complete – well nearly actually
- Microvibration

DDRs

- All sub-system Detailed Design Reviews have been completed except for the DRCU and DPU/OBS
- DRCU design review is underway
- Essentially all internal interfaces are closed now – structure is being built
- STMs/EMs are underway for (almost) all sub-systems
- PSU and FCU are not yet started – grounding issue
- DCU engineering model is being built between Caltech and CEA

Struture



Spectrometer Optical Design

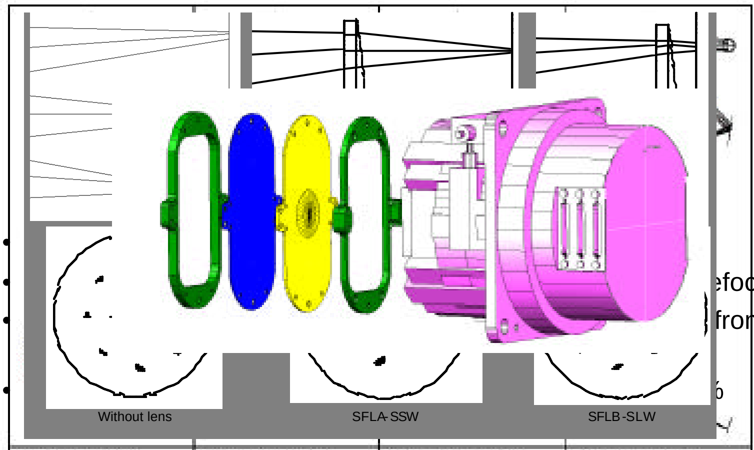
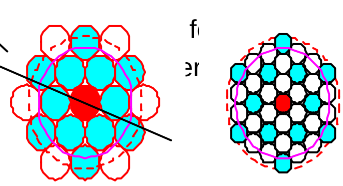


Fig. 9. Upper edge detector, long stroke	Fig. 10. Upper edge detector, short stroke	Fig. 11. Lower edge detector, long stroke	Fig. 12. Lower edge detector, short stroke

Spectrometer Optical Design again

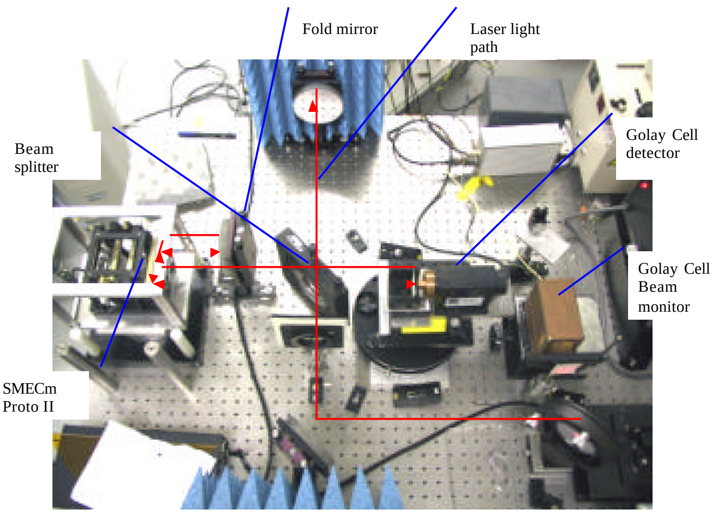
- Evaluation of the detector alignment w.r.t chop axis showed an anomaly
- Traced to using roof tops in SMEC in model rather than corner cubes
- Interfaces already agreed for detectors – major rework required to rotate the detectors
- Changing to roof tops makes the instrument vulnerable to tilt in the SMEC movement
- P this f
- W to re er problem with the SMEC



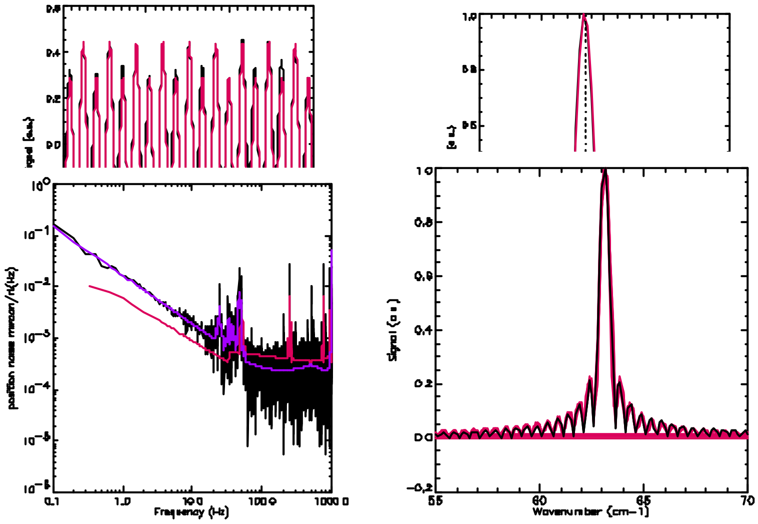
SMEC Design/Performance

- SMECm STM and CQM structures being built
- SMECm actuator prototypes built and tested
- SMECm launch latch being built (3 models). First model to be tested before 14/07/2002
- MCU development model built and tests nearly completed
- MCU call for tender to be issued at end of week (QM2, PFM and FS)
- **The flexible pivots** ***=> random vibrations levels***
- The specified design levels (66 g peak) are 4x higher than the one the pivots can bear.

SMEC Prototype Test



SMEC Test Results



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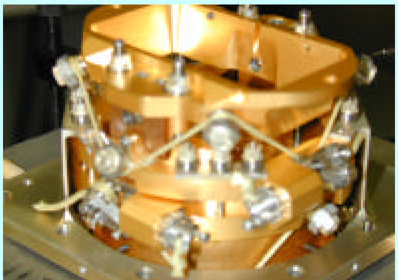
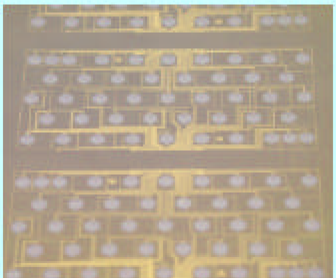
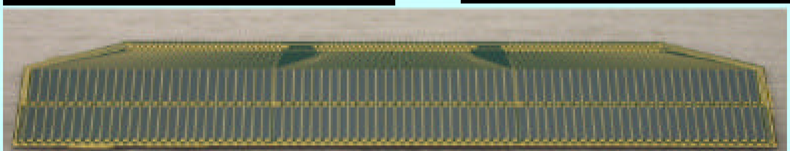
BDAs



BDA Mechanical Qualification unit



P/LW CQM wafer



CQM Bolometer Load Resistor Array

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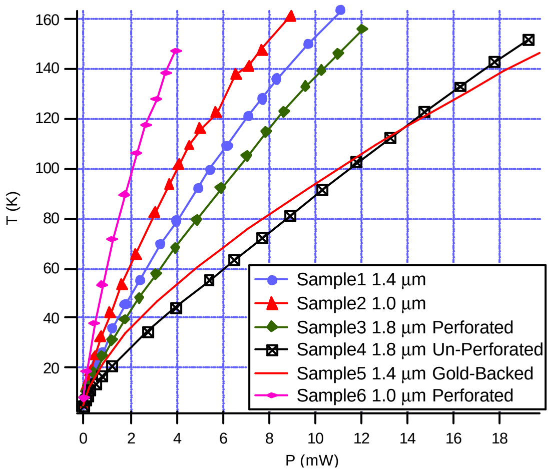
JFETs



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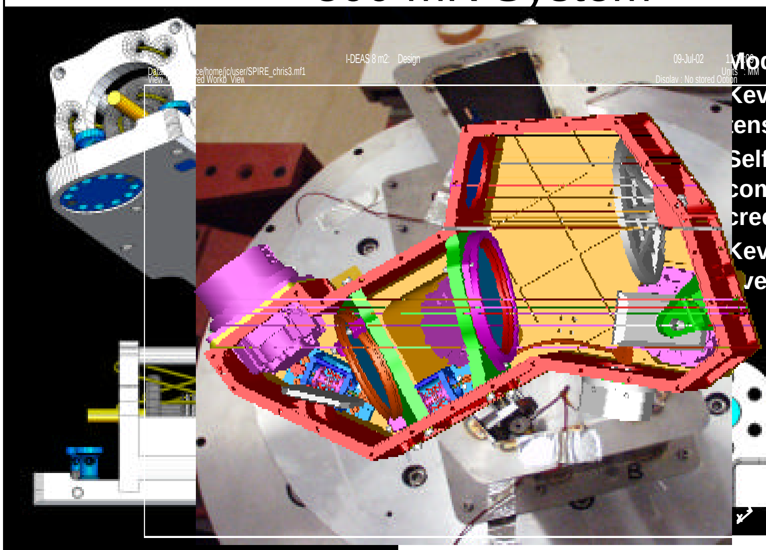
300 mK System



- Modular units
- Kevlar under tension
- Self tensioning compensates for creep/expansion
- Kevlar passes over polished radii

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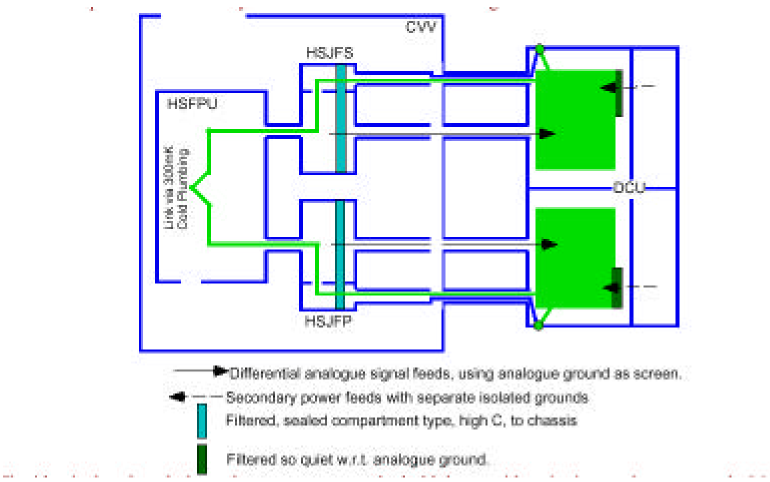
Electronics – grounding



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Vibration

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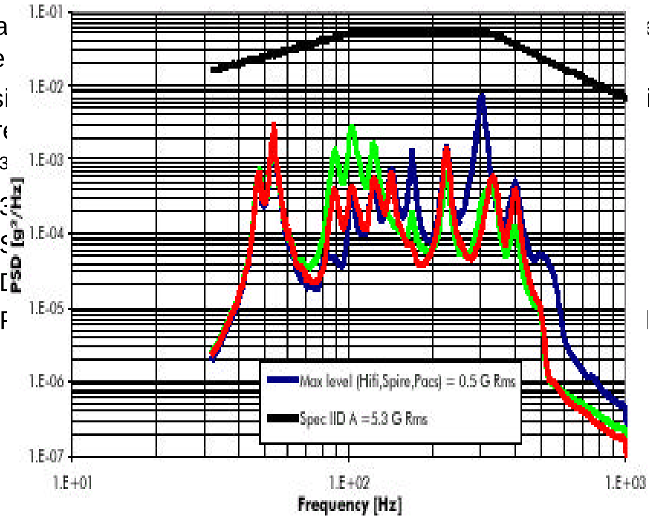

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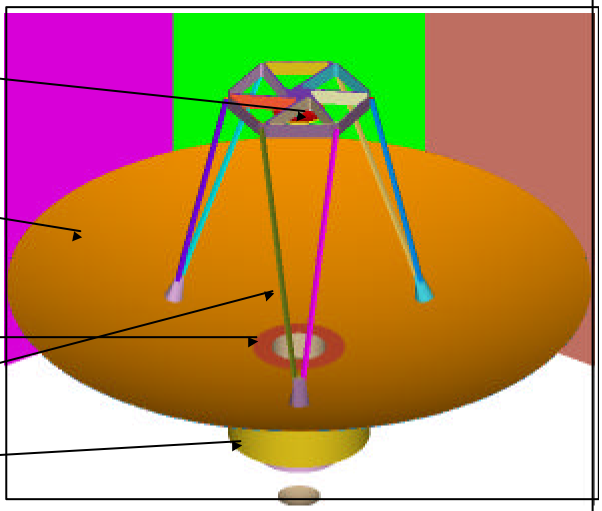
System level straylight model (i)

- M2
  - Chamfers
  - Anti-narcissus
  - Rim
- M1
  - Chamfers
  - Rim
  - Flat
  - Fixation I/F
- Baffle
  - Corr. dimensions
- Hexapod
  - MLI on fixations
- CVV
  - Corr. dimensions



System level straylight model (ii)

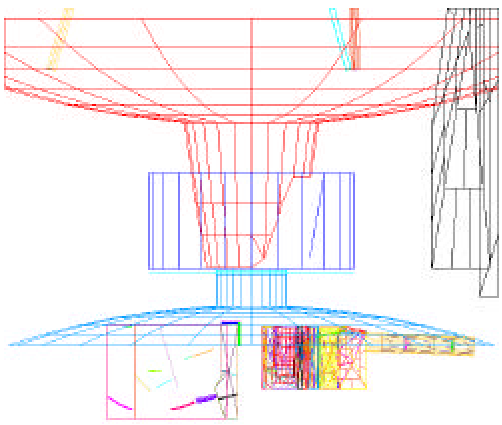


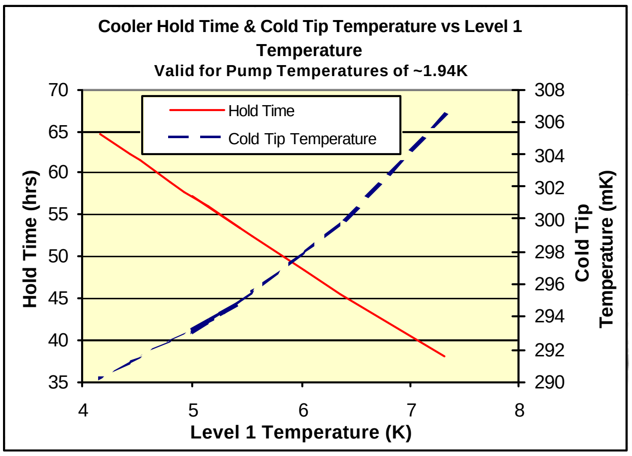
Figure 1-5:
Cone baffle

System level straylight model (iii)

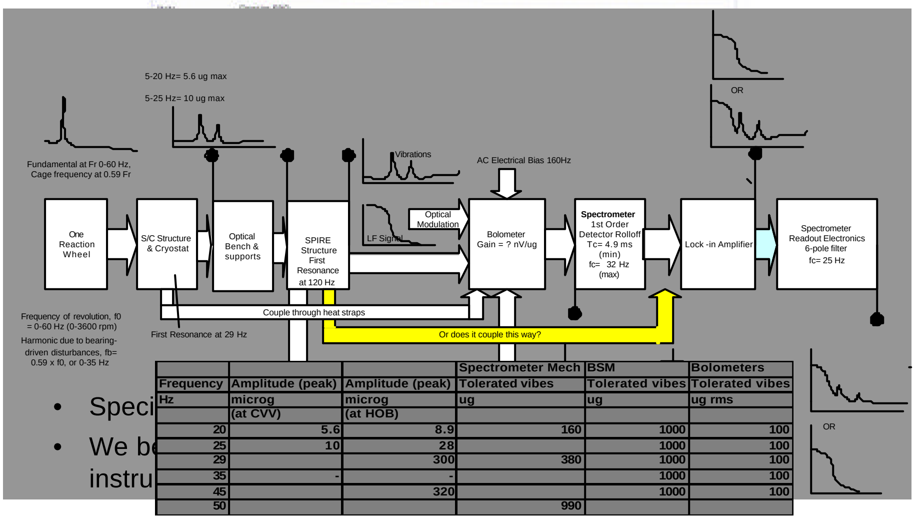
emitting object	PACS DETECTOR flux	SPIRE DETECTOR flux
sunshade (204 K, emissivity 0.05)	0.468	0.264
gap between sunshade and primary (204 K, emissivity 0.90)	1.563	1.019
Hexapod of telescope (from ASEF analysis)	3.06	3.06
Anti-narcissus (from ASEF analysis)	2.6	2.6*
gap between primary mirror and cylinder baffle (75 K, emissivity 0.90)	4.180	2.586
cylinder baffle directly towards experiments (75 K, emissivity 0.05)	0.000	0.000
inner cavity objects (75 K, emissivity 0.90),	3.806	3.494
radiation shield 2 via secondary towards experiments (43 K, emissivity 0.80)	0.001	0.002
radiation shield 2 directly towards experiments (43 K, emissivity 0.80)	0.000	0.000
sum for cylinder baffle	18.251	13.312
sum without both 'gaps'	12.508	9.707
sum without both 'gaps' and inner cavity objects	8.702	6.213

System level thermal model

- We don't have it yet……….



Microvibration



- Speci
- We be
  instru

			Spectrometer Mech	BSM	Bolometers
Frequency	Amplitude (peak)	Amplitude (peak)	Tolerated vibes	Tolerated vibes	Tolerated vibes
Hz	microg	microg	ug	ug	ug rms
	(at CVV)	(at HOB)			
20	5.6	8.9	160	1000	100
25	10	28		1000	100
29		300	380	1000	100
35	-	-		1000	100
45		320		1000	100
50			990		

Facility Requirements (i)

- A cryostat is required that will house the instrument and provide the same mechanical; electrical and thermal interfaces as presented by the Herschel cryostat
- A telescope simulator is required to present the instrument with a beam that is optically identical to that of the Herschel telescope.
- A continuum or monochromatic point like source placed at the input focus of the telescope shall be well focussed at the SPIRE image plane
- The telescope beam should be capable of being placed and focussed correctly on each pixel within the SPIRE FOV.
- It is desirable that the input FOV of the telescope simulator is large enough that an extended source that instantaneously fills the beam of a single pixel may be used.
- The telescope simulator must be capable of scanning stepwise the image of a point like coherent source across the beam of any pixel in the SPIRE FOV.
- It is desirable that the beam from the telescope can be scanned continuously across the beam of single pixel in the SPIRE FOV.

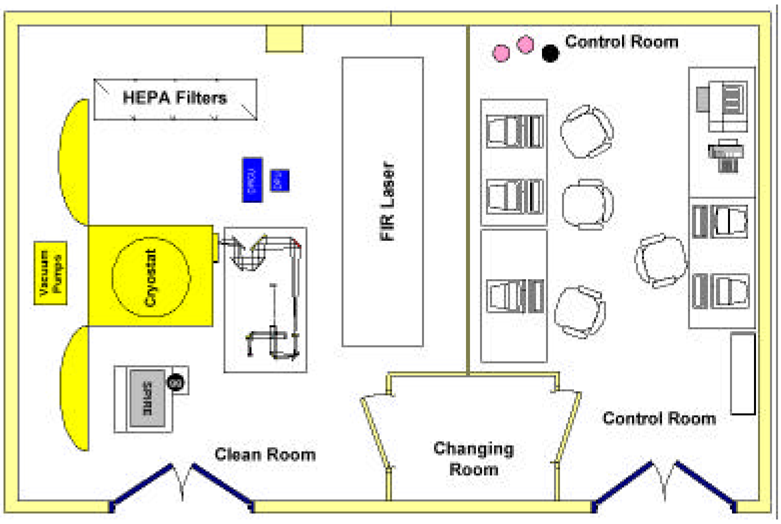
Facility Requirements (ii)

- The photon background falling onto the entrance aperture of the instrument shall be no greater than that expected from an 80-K 4% emissive surface during any measurement set up
- It shall be possible to have the instrument operate in a low background environment – i.e. dark.
- A source shall be provided that instantaneously illuminates the entire SPIRE FOV. This source shall be highly emissive in the FIR and Sub-mm and shall be of known, controllable temperature, and known emissivity. It is not necessary to feed this source to the instrument through the telescope simulator.

Facility Requirements (iii)

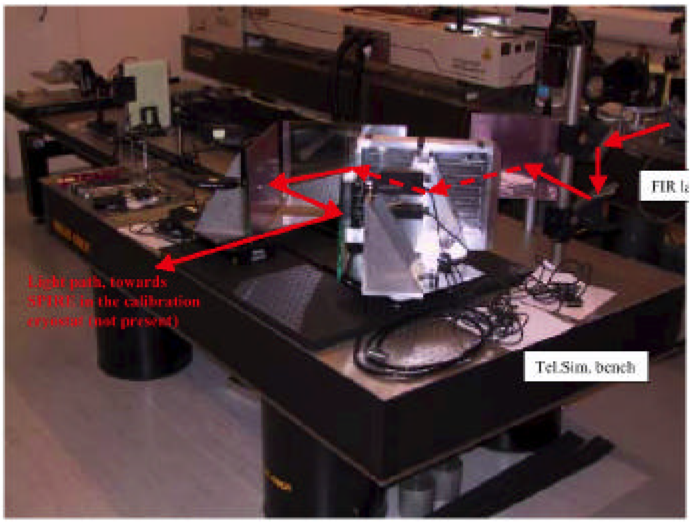
- An image of the entrance pupil of the telescope simulator shall be made accessible to allow a point like source to be scanned across the pupil location.
- A spectrometer shall be provided external to the instrument and fed to the instrument through the telescope simulator. This spectrometer shall have a resolution of at least 500 at 250 mm;
- A method of measuring the out of band rejection of the instrument shall be provided.
- A method of evaluating the off axis straylight rejection of the instrument shall be provided.
- A mono-chromatic source with a line width very much narrower than 0.04 cm^{-1} (at least 1/100) shall be provided that shall be fed to the instrument through the telescope simulator. A chopper shall be available that can modulate the signal entering the telescope simulator.
- A method of commanding and receiving data from the instrument that accurately mimics the in-flight command and data management system shall be provided.

Facility Overview



Test Cryostat

Telescope Simulator



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Architecture for a S/W Simulator for the SPIRE Photometer

Matt Griffin

Existing SPIRE Performance Simulators

- Mathcad sensitivity models for Photometer and Spectrometer (Griffin)
- Some IDL code for FTS performance analysis (Swinyard)
- Photometer deep survey simulations (various)
- For ILT, AOT definition and optimisation, problem solving, time estimation, etc., we need a simulator that will accurately mimic the performance of the system and subsystems.

Purpose of Photometer S/W Simulator

- Produce simulated Photometer data timelines (science data and housekeeping)
- Based on
  - Models of
    - The sky (in operation)
    - The CTA (in the Herschel cryostat)
    - The AIV facility CBB (during ILT)
  - Physical models of the photometer and its subsystems
  - Standard observing modes
- Results should be compatible with the existing Mathcad sensitivity model

Purpose of Photometer S/W Simulator

- But the simulator will be more versatile tool for
  - Evaluating photometer scientific performance
  - Testing observing modes and optimisation of POF parameters
  - Modelling and understanding instrument behaviour during ILT and in operation
  - Comparing simulated data analysed using Photometer data reduction S/W with the input sky
- The simulator can form the basis of time estimator to be used to plan SPIRE observations

SPIRE Time Estimators

- Proposal preparation:
  - "Cookbook" to allow rough estimation of time needed for proposed observations
  - Simple rules for sensitivity vs. observing time observing overheads
  - Could be simple S/W or just tables and charts
- Observation planning
  - Much more detailed representation of the instrument operation and performance, inc. commanding, data sampling, mechanism operation etc.

Proposed Simulator Architecture

- Separate modules defined with specific inputs and outputs
- Each parameter is defined by one particular module, and may be used by other modules
- Internal operation/sophistication of the modules can be modified without affecting other modules
- Timeline outputs:
  - All commanded parameters
  - All sampled science and H/K data channels
  - Other parameters
    - Stage temperature noise
    - Bacground and signal power levels on detectors
    - Actual positions (mechanisms, telescope pointing)
    - Etc.

Proposed Simulator Architecture

- All timeline generators based on a single master clock
- All samples and start of all mechanism movements are at clock ticks
- Noise contributions to timelines:
  - Noise power spectrum for each parameter used to generate a noisy time series

Simulator Modules

No.	Module	Abbrev.	Description
0	Astronomical Observation Template	AOT	Specifies the observation in "astronomer's terms"
1	Observatory Function	OBSFN	Specifies observing node to be simulated in terms of the appropriate Observatory Function and its parameters, as defined in the OMD.
2	Sky Simulator	SKYSIM	Produces a simulation of the area of sky to be observed, with a resolution finer than the beam.

Simulator Modules

No.	Module	Abbrev.	Description
3	Optical System	OPSYS	Main optical properties and parameters of the telescope and the SPIRE photometer (excluding the filters), and the positional mapping of the detectors on the sky.
4	Photometer Spectral Response Function	PSRF	Represents the overall spectral transmission profile of the photometer.
5	Thermal System	THERM	Contains all information on the temperatures of the instrument and the telescope, and their temporal fluctuations.

Simulator Modules

No.	Module	Abbrev.	Description
6	Telescope Pointing Timeline Generator	TPTG	Produces timelines of the commanded and actual telescope boresight pointing for the period of the observation, so that each detector sample can be associated with a particular point on the sky.
7	Beam Steering Mirror	BSM	Produces the BSM timeline in the form of an additional pointing timeline to be superimposed on that of the telescope.
8	Incident Background Power Timeline Generator	BPTG	Produces a timeline for the background power incident on each detector, due to all contributions from the telescope and instrument and their thermal fluctuations.

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Simulator Modules

No.	Module	Abbrev.	Description
9	Astronomical Power Timeline Generator	APTG	Generates a timeline for the power on each detector from the astronomical sky
10	Detector Voltage Timeline Generator	DVTG	Produces an output voltage timeline for each detector channel at the ADC input based on the inputs from 8 and 9 and an appropriate model of the detector and its analogue electronics chain.
11	Science Data Timeline Generator	SDTG	Produces digitied timelines for each detector channel and all mechanisms

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Simulator Modules

No.	Module	Abbrev.	Description
12	Housekeeping Data Timeline Generator	HKTG	Produces timelines for all instrument temperatures
13	Calibrator Power Timeline Generator	CPTG	Produces a timeline of the power incident on each detector from PCAL.

Example: Optical System (OPSYS)

Inputs from	None
Internal parameters	1. Telescope effective diameter 2. Telescope obscuration 3. Telescope focal ratio 4. Telescope effective emissivity 5. Reflectivity of each SPIRE photometer mirror 6. Emissivity of each SPIRE photometer mirror 7. Focal ratio of photometer final optics 8. Position of centre of each array focal plane (angular offset on the sky wrt telescope boresight) 9. Detector position matrices in the focal plane (y,z linear coordinate distances from centre of the nominal centre of each array focal plane) 10. Strehl ratio matrices for the three arrays 11. Beam FWHM matrices (of beams on the sky) for the three arrays 12. Feedhorn efficiency matrices for the three arrays 13. Feedhorn throughput matrices for the three arrays

Example: Optical System (OPSYS)

Outputs to	APTG	Beam profile matrices (normalised impulse response on the sky for each pixel, including characterisation of the beam shape and the position on the sky wrt the telescope boresignt. Simplest beam shape is Gaussian with a certain FWHM)
	APTG	Diffraction loss matrix
	BPTG	Emissivities of all mirrors
	ISRF	Instrument optical transmission matrix

Example: Telescope Pointing Timeline Generator (TPTG)

Inputs from	OBSFN	1. Source coordinates 2. POF 3. Selected detector set (if appropriate) 4. Jiggle parameters (if appropriate) 5. Chop freq (if appropriate) 6. Chop/Nod direction (if appropriate) 7. No. of chop cycles per nod position (if appropriate) 8. Scan map parameters 9. Nod period (if appropriate) 10. Total length of observation
Internal parameters		1. RPE 2. APE 3. Telescope transient waveform templates (accelerating, decelerating, turning around, etc.)
Internal products		1. Pointing noise power spectral density
Outputs to	Analysis	Commanded boresight position on the sky (RA, Dec.) timeline
	BPTG APTG	Actual boresight position on the sky (RA, Dec.) timeline

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Example: Thermal System (THERM)

Inputs from	OBSFN	1. POF 2. Duration for timeline computation
	BSM	BSM power dissipation
	BPTG	Incident background power on each filter
Internal parameters		1. All temperatures and their dependance on operating modes (telescope, Level-1, He-3) 2. Thermal filtering of detectors wrt cold tip 3. Telescope temperature gradient 4. JFET power dissipation 5. Filter thermal properties: filter temperature profile vs. radiant power input
Internal products		1. He-3 cold tip thermal noise power spectrum 2. He-3 cold tip temperature drift rate 3. Level-1 thermal noise power spectrum 4. Level-1 temperature drift rate 5. Filter thermal profile

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Example: Thermal System (THERM)

Outputs to	DVTG	Operating temperature timeline for each bolometer array
	BPTG	Telescope temperature
	PBTG	Telescope temperature gradient
	PBTG	Level-1 temperature timeline
	PBTG	Filter effective temperatures
	HKTG	All temperature timelines

Future Plan

- Further elaboration of architecture and parameters
- Workshop on simulator to be held (September)
- Definition of modules in detail
- Identification of team responsible for its implementation
- Plan for production of version 1 (probably a simple version)
- Coding (Java or IDL?) and verification needed by start of CQM testing (April 2003)
- Similar process needed for FTS simulator

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Envisaged SPIRE Data Products

Matt Griffin

SPIRE ICC and Data Processing

- SPIRE users
- SPIRE Data Processing and outputs
- Additional Processing for ICC
- Additional Processing for Science Analysis
- Commonality
- SPIRE Consortium constraints

User A: The General Astronomer

- **Competent and knowledgeable observational astronomer**
- **Familiar with:**
  - **Basic design and capabilities and parameters of Herschel and SPIRE**
  - **Basic SPIRE observing modes**
- **Not necessarily familiar with**
  - **Detailed instrument design**
  - **Details of the observing modes or how to optimise them for a given scientifically expressed purpose**

User A: The General Astronomer

- **Will have a user-friendly time estimator to assess feasibility and devise observing programmes**
- **Will specify observational parameters in generic astronomical terms (e.g., coordinates, wavelengths, area to be mapped, spectral resolution, basic observing mode, total integration time, rms sensitivity, etc.)**
- **Not required to specify instrument parameters (e.g. chop throw/frequency, nod frequency, telescope scan rate, integration time per scan, number of scans, mirror speed/travel etc.) - these have to be selected by the instrument experts.**

User A: The General Astronomer

- Will receive data already reduced and calibrated to a fairly mature and scientifically usable level via the "standard processing"
- Expected to know and understand the basics of how the data were processed and calibrated but not all the details.
- Will receive documentation giving description of data processing steps and essential system/instrument properties and their spectral dependence:
  - Beam profiles, Filter profiles, FTS instrument response function, Noise estimates, Flux calibration scheme
- Will receive (or have access to) the raw data plus the latest standard processing S/W, full IA software, calibration files, with long and detailed manuals, and will therefore have the opportunity to further enhance the data if desired.

User B: The Specialist

- Typically a consortium member or someone associated with big survey programmes
- Competent and knowledgeable observational astronomer
- Familiar with SPIRE and Herschel at a more detailed level (has studied the manuals in more detail than User A)
- Not necessarily as knowledgeable as ICC experts, but works with them to optimise and plan the survey observations for best efficiency and scientific return through selection of the detailed observing modes and parameters.
- Expected to work with the ICC experts on detailed data analysis,and to assist in optimising the data processing and calibration for the science to be extracted.

Standard SPIRE data processing

- Processing will be Java-based to avoid reliance on commercial or platform-dependent systems which could restrict the ability of astronomers to have full access to and control over the data
- Standard Processing will be built up from "IA" routines
- The Standard Processing will run automatically and provide scientifically usable outputs such as:
  - Point source source flux densities , positions, uncertainties
  - Calibrated spatial map with rectangular grid in standard format that can be further processed using standard packages
  - Spectrum in terms of flux density vs. wavelength
- Standard Processing will be updated at regular (e.g. six monthly) intervals

Standard Processing

- Standard Processing results are of good, but not necessarily the best quality:
  - Will be out-of-date wrt the very latest algorithms that instrument experts have devised
  - Will not implement sophisticated interactive routines that can allow astronomers' skill and judgement to enhance data quality
- But the Standard Processing will provide the general user with a good enough product to do science
- The user will have the option to read the manuals and use the full IA software to improve the results (maybe at the 10% level).

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Standard Processing

- Deglitching
- Flat fielding
- Drift compensation
- Baseline subtraction
- Averaging and co-addition
- Re-gridding
- Noise estimation
- Flux calibration
- Astrometry
- Fourier transformation (FTS)

Standard Processing Outputs

1. Chopped point source photometry
   - Calibrated flux density with statistical and pointing uncertainties
   - If seven-point used, then individual map points and details of the fit
   - All S/W for this is SPIRE-specific
   - Routines may be adapted from existing ground-based telescopes

2. Jiggle-map
   - Calibrated map (set of positions with values of flux in beam and uncertainties)
   - SPIRE specific S/W
   - Will be based on SCUBA jiggle-map routines

Standard Processing Outputs

3. Scan map
   - Regular grid of pixels (map points) already co-added with values of flux density in beam and associated uncertainties
   - SPIRE-specific
   - Some commonality with Planck
   - Commonality with PACS on format of output

4. FTS
   - Calibrated spectrum (flux density in beam vs. wavelength
   - Highly SPIRE-specific

Additional processing for internal SPIRE ICC needs

- The ICC will maintain trial versions of the Standard Processing prior to their public release, allowing
  - Scrutiny and parameter choice at all steps of the analysis
  - Replacement of routines with different or updated versions
  - Analysis of data taken in special engineering modes
- The ICC will have S/W for trend analysis, calibration analysis, instrument diagnostics, study of systematics, observation optimisation (e.g., more sophisticated time estimator, simulators, etc.)

Additional processing for SPIRE Science Analysis

- Working/development versions of Standard Processing as described above
- Any S/W that the consortium or ICC develops that is potentially useful should be developed in a manner that could allow it to be incorporated into IA at a later stage
- Examples:
  - Point source extraction from crowded fields
  - Advanced FTS data processing S/W for line identification and parameter estimation
- Archive browser S/W allowing rapid assessment of whether the observation contains data of interest.
- Quality Control product allowing HSC to asses the observation (simpler version of SP) but with additional processing to generate 'goodness' scores

Commonality

- Several elements of the Standard Processing above could be generic across the ICCs
  - GUIs and "look and feel”
  - Data input/output routines
  - Libraries of routines (statistical, graphical, curve fitting, astrometry, etc.)
  - Generic trend analysis
  - Definitions, terminology, and documentation standards
- SPIRE and PACS mapping photometers will both be used for many programmes
  - Data products and should be as similar as possible in format and calibration methods
  - Interactive S/W available to analyse data should be same for both if possible

SPIRE Consortium Constraints

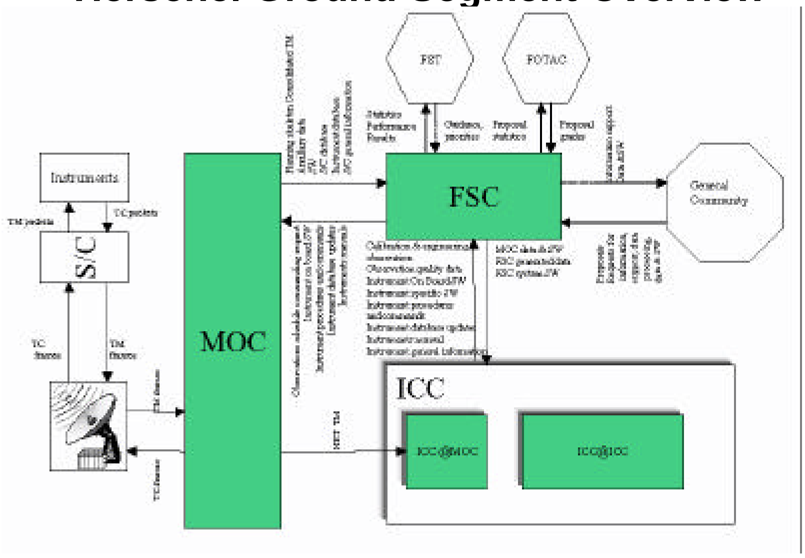
- SPIRE ICC funding is inadequate to provide what we feel is necessary in the development phase
- No funding has yet been allocated in the UK for the operations phase (and is likely to be very limited when it is)
- Following the initial HCSS development effort, SPIRE ICC resources must now be devoted largely to the development of the SPIRE-specific elements of the ICC
- Strong support will be given to common developments, but on a best efforts basis

SPIRE
ICC Development Plan

Ken King

RAL

Herschel Ground Segment Overview



ICC Development Tasks - Requirements

- **Details the Science Implementation Plan (SIP) for the development phase**
  - **Written in response to the Science Implementation Requirements Document (SIRD)**
  - **Derived from Operations Scenario Document and other HGS documentation**
  - **Plus additional requirements, mostly arising from the use of the ICC systems within the consortium:**
    - Use during ILT, including provision of QLA
    - Processing of auxilliary modes
    - Support to consortium members
    - Support for consortium to support the ICC!!
    - Publicity and Outreach
    - Support for local astronomers (TBD)

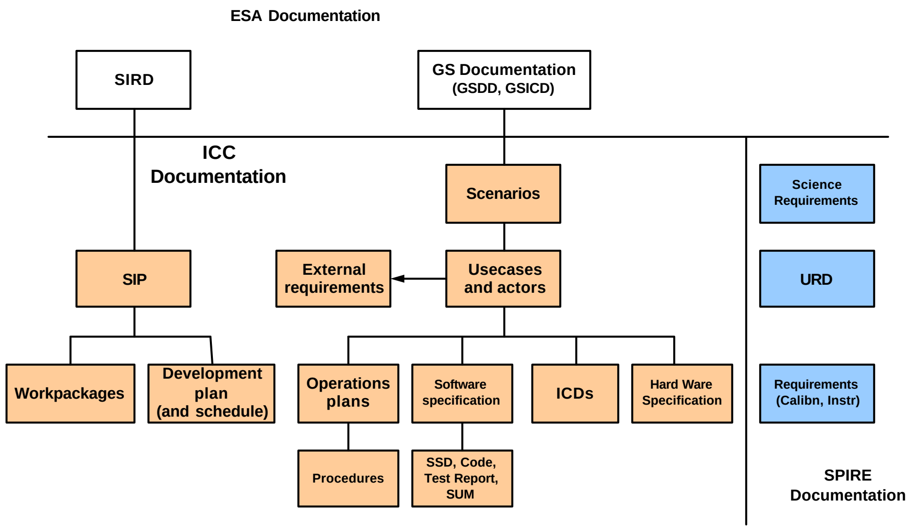
ICC Development Tasks – Common Development

- **The ICC has to fit into the Operational Scenario, which provides for smooth transition between mission phases**
- **This has been developed into a Ground Segment Description and Interface Requirements**
- **A core set of functionality and services has been identified which is being developed as a joint effort between HSC and ICCs. This is called the Herschel Common Science System (HCSS).**
- **It is used in all phases of the mission**
  - **Development and commissioning**
  - **Performance Verification and Routine Operations**
  - **Post Operations**
  - **Archive**

ICC Development Tasks - Overview

- ICC Development:
  - Management,
  - Software Development (HCSS, QLA, IA),
  - Provision of Instrument Information (databases, IUM)
  - Training
- Support to Instrument Team Activities
  - Provision of ILT and IST Systems,
  - Calibration and Observing modes testing,
  - Calibration planning,
  - Science Verification
- Preparation for Operations
  - Facilities,
  - Operations Planning,
  - Integration and Test of ICC and Ground Segment,
  - Commissioning Phase

ICC Documentation Tree



ICC Development Phases

- **Development can be divided into 5 phases based mostly on deliveries of hardware.**

- **Definition Phase (July 01 – Aug 02)**
  - **Definition of ICC and its relationship to the rest of the Herschel Ground segment**
    - Inputs: Science Requirements, SIRD,
    - Outputs: Use Cases, Scenarios
      SIP, Development Plan, workpackages
      HGS Documentation: Design Doc., ICDs
  - **Contribution to HCSS development for ILT**

ICC Development Phases (AVM)

- **Dates: June 02 – Dec 02**
- **Tasks**
  - **Development of initial versions of ICC databases and software for testing (with) the ‘AVM’**
    - Mutual test of ICC systems and DPU/OBS and DRCU Simulator (not the AVM verification)
    - Concentrates on verifying interfaces to instrument and between ICC systems
  - **Provision of test plans and procedures for ‘AVM’ integration**
  - **Execution of ‘AVM’ tests**
    - Development of OBS/ICC databases
- **Inputs:**
  - **HCSS (ILT), Instrument Data ICD, Use Cases, S/W Specs.**
- **Outputs:**
  - **Test plans, procedures and reports, Spec. for ICC database and S/W updates**

ICC Development Phases (CQM)

- **Dates: Jan 03 – Oct 03**
- **Tasks:**
  - **Update of ICC Databases and S/W for AVM/CQM Testing**
    - Includes definition of building blocks for AOTs and Calibration
  - **Definition of Calibration Tests for the CQM**
    - Conversion of Cal. Req to Cal. Plan
    - Creation of Cal Database
    - Provision of test plans, procedures, scripts
  - **Definition of tests for Observing Mode verification**
    - Conversion of Obs Modes to instr. operations
    - Provision of test plans, procedures, scripts
  - **Execution of Calibration and Observing mode tests on the CQM (as part of the test team)**
- **Inputs**
  - **Cal. Reqs, Obs Modes, AVM/CQM Test Plan, HCSS (IST)**
- **Outputs**
  - **Cal. Plan, AOT definition, Calibration database, IUM v1**

ICC Development Phases (PFM)

- **Dates: Nov 03 – Dec 04**
- **Tasks:**
  - **Update of Observing Mode definition**
    - Based on results of CQM testing
  - **Update of ICC Databases and S/W for PFM Testing**
  - **Definition of Calibration Tests for the PFM**
    - Provision of test plans, procedures, scripts
  - **Definition of tests for Observing Mode verification**
    - Provision of test plans, procedures, scripts
  - **Execution of Calibration and Observing mode tests on the PFM (as part of the test team)**
- **Inputs**
  - **CQM test results, PFM Test plans**
- **Outputs**
  - **PFM calibration database, IUM v2**

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ICC Development Phases: Operations Preparation

- **Dates: Dec 04 – Mar 07**
- **Tasks:**
  - **Provision of ICC infrastructure**
    - h/w integration, s/w integration
  - **Operations Planning**
    - Provision of plans, procedures, training of staff
  - **Testing**
    - ICC internal testing, HGS testing incl. End-to-End testing with Satellite
  - **Development of ICC software**
    - Based on results from PFM Testing and further analysis of ILT/IST data
  - **Commissioning Phase**
    - Provision of ICC@MOC systems, test procedures, support
- **Inputs**
  - **PFM Test Results, Calibration database**
- **Outputs**
  - **Instrument Simulator, Observers manual**

ICC Development Plan Ken King, RAL 11

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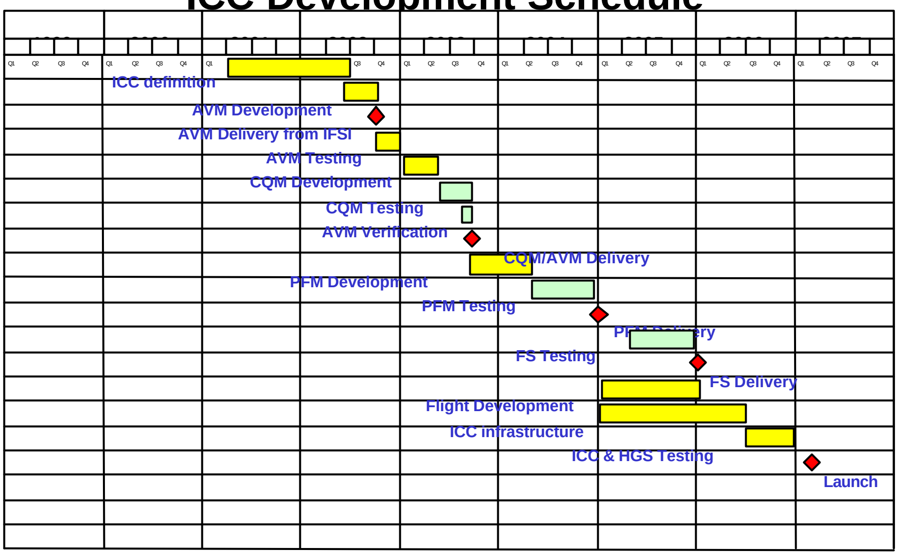
ICC Development Schedule



ICC Development Plan Ken King, RAL 12

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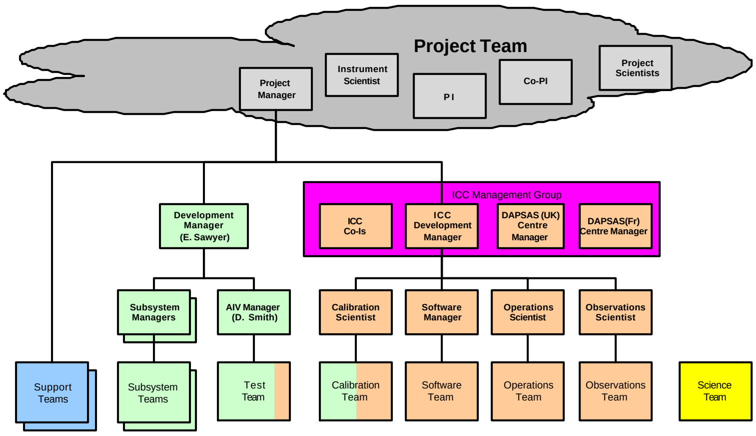
SPIRE Organisation



SPIRE Organisation during Development

ICC Development Plan Ken King, RAL 13

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Calibration Team

- **This team is responsible for defining the calibration plan for the instrument and for obtaining the required data. Its tasks are:**
  - **Definition of the SPIRE Calibration Plan**
  - **Specification of calibration ground tests**
  - **Provision of test scripts for calibration tests (done as part of the Test Team)**
  - **Analysis of data from ground calibration tests held at instrument-level**
  - **Definition of the calibration database**
  - **Population of the calibration database from ground testing and other facilities (subsystem tests, other telescopes, literature)**
  - **Specification of IA data processing modules for calibration data processing**
  - **Definition of calibration processing procedures**
- ***Note: the ICC does not provide all the resources for this activity – this team requires input from the instrument hardware teams***

ICC Development Plan Ken King, RAL 14

Observations Team

- This team is responsible for defining and verifying the astronomical observing modes of the instrument. Its tasks are:
  - Definition of the observing modes of SPIRE
  - Provision of a Science Verification Plan
  - Specification of ground tests necessary to verify the Observing Modes (including tests to validate different operational modes and tests to validate data processing software)
  - Specification of the Commissioning Phase and PV Phase observations to be made to verify the Observing modes
  - Provision of test scripts for observing mode checkout (done as part of the Test Team)
  - Analysis of test results to verify the correct processing of observations to the standard data products
  - Specification of algorithms for IA data processing modules
  - Provision of initial data processing procedures ('pipeline') for reduction of scientific observations data
  - Provision of the SPIRE Observers Manual and additional documentation required for informed scientific use of the instrument

Operations Team (Instrument Ops.)

- This team is responsible for defining and verifying the instrument operational modes and providing the instrument database(s) necessary to implement these modes. The tasks are:
  - Definition of instrument operational modes as required for calibration, engineering and scientific observations.
  - Provision of MIB, CUS, and other instrument databases necessary to implement the operational modes
  - Specification of tests (on ground and during the Commissioning Phase) to verify the correct operation of the instrument in all its operational modes
  - Analysis of data from tests to verify the correct operation of the instrument in all its operational modes
  - Specification of software and algorithms for software to process instrument data to monitor the continuing health and performance of the instrument.
  - Specification of data processing procedures for instrument monitoring during the Operations Phase
  - Provision of the Instrument Users Manual

Operations Team (ICC Ops)

- This team is also responsible for the setup and integration of the ICC for Operations. the tasks are:
  - Provision of an Operations Plan and definition of operating procedures
  - Installation and test of the OBS Maintenance facility.
  - Installation and test of externally provided systems (SCOS2000, MIB editor etc). This includes training of users.
  - Definition and execution of the ICC Integration tests and Herschel Ground Segment tests
  - Provision of all ICC infrastructure (hardware) and installation of software for use by ICC teams for analysis of test data and for use during the Operations Phase
  - Provision of training for users of ICC Systems
  - Provision, verification and delivery of the Instrument Simulator to MOC
  - Take delivery of the instrument Cryogenic Test Facility for use during Operations
  - Setup and Training of the Operations Team for the Operations Phase
  - Training of ICC-external users in ICC software and systems
  - Setup and execution of a Configuration Control system

Software Team

- This team is responsible for providing the software identified and specified by the other ICC teams. This includes both software to be provided to the Herschel Ground Segment and software for the ICC. Its tasks are:
  - Setup of an infrastructure (hardware and software) for development of software (including version control, configuration control, sandboxes)
  - Provision of HCSS software to the Herschel Ground Segment
  - Provision of IA, calibration and monitoring software as specified by other ICC groups
  - Provision of ICC software infrastructure (HCSS, Access Control, Information Handling, Problem Reporting) for use during development and Operations

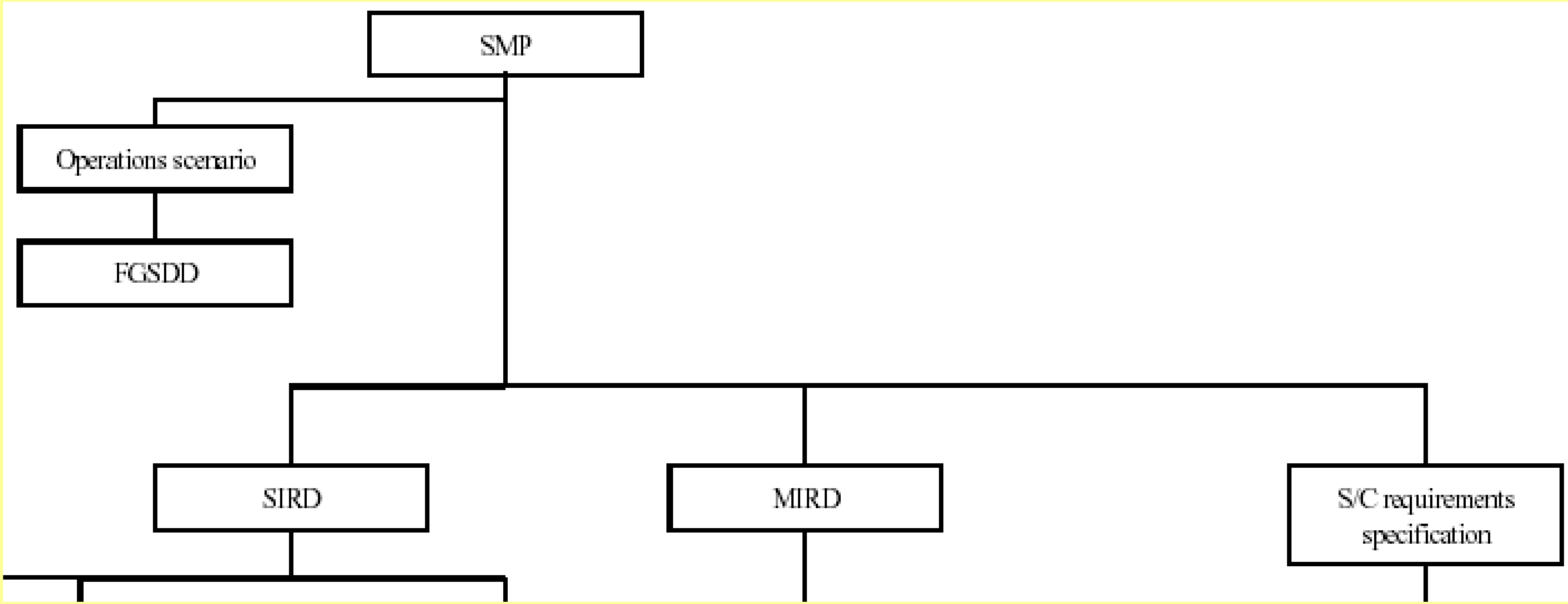
Herschel Ground Segment

Sunil Sidher (RAL)

Operations Concepts

- Minimise total overall operations effort
- Maximise the utilisation of expertise
- Address instrument operations and data processing requirements early on
- Minimise overheads and the need for dedicated infrastructure
- Exploit commonality between instruments (commanding and telemetry)
- Geographical distribution of the ground segment

Top Level Ground Segment Documents



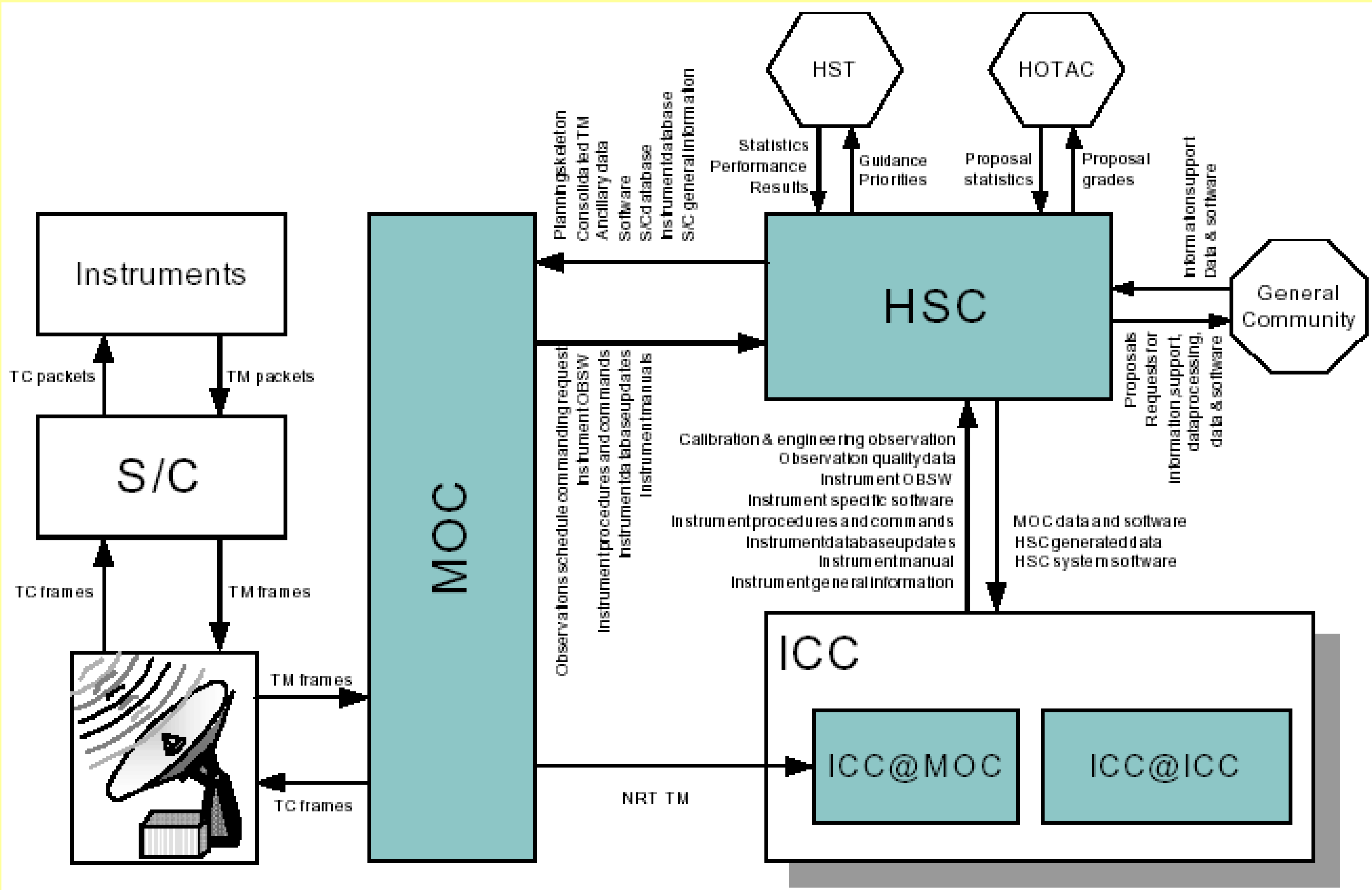
Herschel GS System Engineering (HGSSE) Group

- Consists of GS system engineers from ESA (HSC+MOC) and the three ICCs.
- Regular meetings every 6-8 weeks
- Three key GS documents produced by the HGSSE:
  - ➢ HGS Design Description (HGSDD)
  - ➢ HGS Interface Requirements Document (HGS IRD)
  - ➢ HGS List of ICDs
- The HGSDD and the HGS IRD were formally signed off last January.
- The Herschel Ground Segment End-to-End Test Plan is currently under review within the HGSSE

Herschel Ground Segment Centres

- **Mission Operations Centre (MOC) -** responsible for S/C operation and instrument safety during in-orbit phase. Assumed to be located at ESOC (Germany).
- **Herschel Science Centre (HSC)** - general astronomical community's interface with the Herschel Observatory (issuing of AOs, proposal handling, etc). Assumed to be located at Vilspa (Spain).
- **Instrument Control Centres (ICCs)** - responsible for operation of their instrument and data processing software. Located at (or near) the PI institutes.

Overview of the Herschel Ground Segment



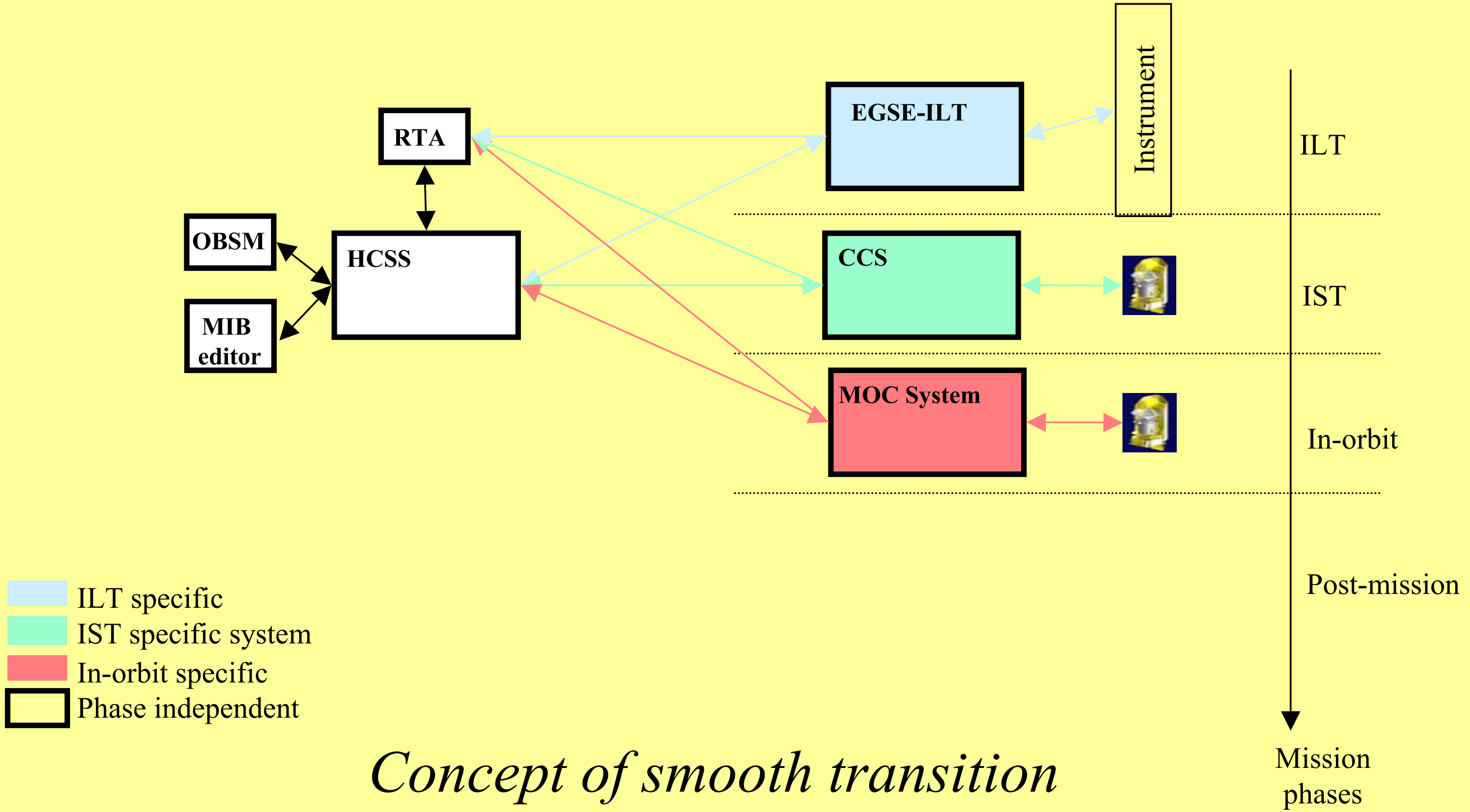
Herschel Common Science System (HCSS)

- Introduction: Why the HCSS?
- What is the HCSS?
- How does the HCSS work (main relevant concepts for observations)?
- How is it supporting ILT and interfacing with the EGSE-ILT?
- How is it meant to support IST and to interface with the Central Checkout System (CCS)?
- Who is developing the HCSS?
- When is the HCSS to be delivered?

Introduction: Why the HCSS? (1)

- In all mission phases (ILT, IST, in orbit operation) there is need for a system to:
  - generate instrument command sequences (vs.. individual commands)
  - archive instrument TM for science or instrument test purpose
  - analyse instrument TM.
- Traditionally the system supporting these functions in operation (Science Operation Centre) is developed separately from the system supporting instrument tests (instrument EGSE)
- For Herschel it has been decided (1999-2000) to support these common functions with a common system : the common science system (HCSS). This is known as the ***smooth transition*** concept
- Advantages:
  - reduce overall development effort
  - allow smooth transfer of data from one phase to another
  - validate system at an early stage

Introduction: Why the HCSS? (2)



Concept of smooth transition

Principal HCSS Components

CUS – definition of observation templates and command generation

PHS – definition of proposals and observations

MPS – scheduling of observations

CC – configuration control of SW, data and documentation

IA – interactive analysis SW for an instrument

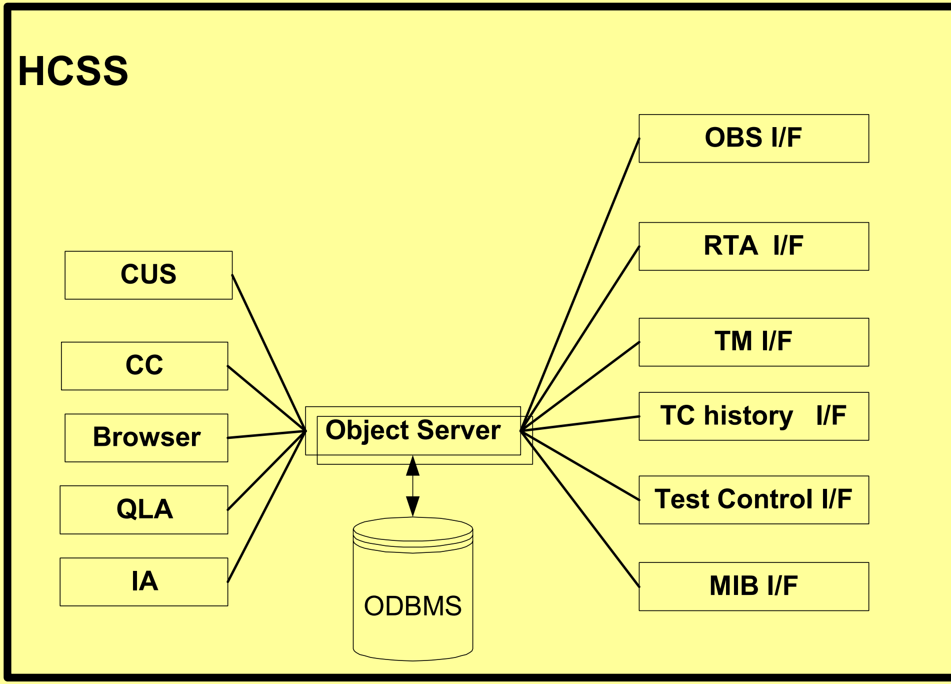
QLA – Quick Look S/W for assessment of test data and science observations (Not strictly part of HCSS but uses HCSS infrastructure).

SPG/QCP – S/W for producing standard data products and for assessing quality of data from observations. Built from IA modules.

Browsers

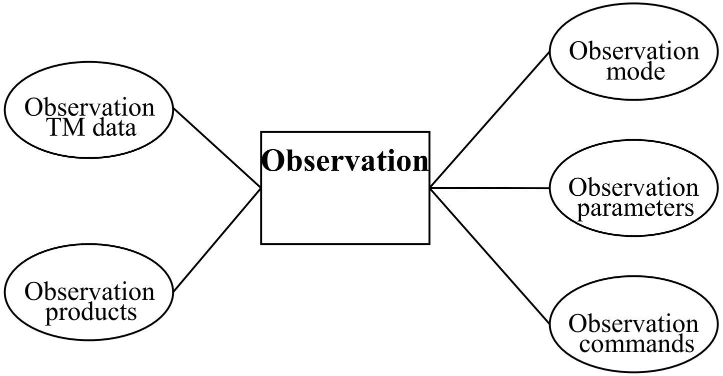
What is the HCSS? (1)

- **HCSS architecture**:
  - The HCSS is an OO client/server system written in JAVA with an ODBMS (Versant)
  - Implements mission phase independent core services (object servers)
  - Implements a set of applications mission phase independent or dependent
  - Implements a set of I/F to external systems



How does the HCSS work for observations? (1)

- **Concept of observation**
  - extension of the concept of astronomical observation to cover test "observation"
  - define the generation of instrument and Test Execution command sequences
  - relate uplink and downlink data



How does the HCSS work for observations? (2)

- **Generation of commands sequence (1):**
  - An observing mode is defined as a logical structure (script) of commands. An observing mode can be instantiated to define an observation by supplying parameter values. In particular running the script with parameters will yield the sequence of commands corresponding to the observation.
  - The HCSS supports the definition of observing mode (CUS), the instantiation of an observation mode into an observation and the generation of the corresponding commands

How does the HCSS work for observations? (3)

Generation of commands sequence (2):

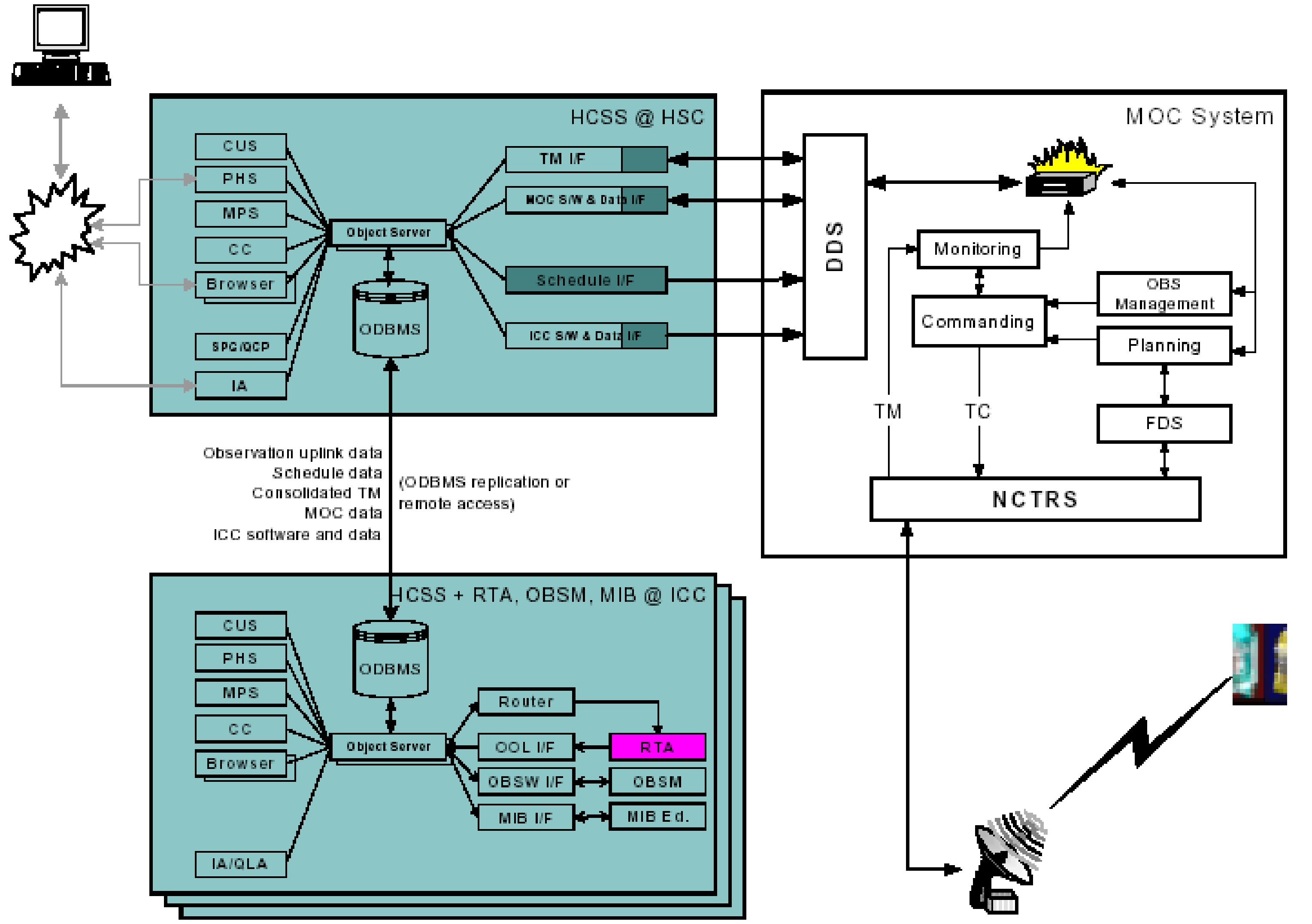
- Observing modes, e.g.:
  - Point source photometry
  - Fully sampled spectral map: continuous scan
- Observing mode parameters, e.g.:
  - integration time
  - wavelength band (spectroscopy)
  - chopper throw
  - resolution (spectroscopy)

- Instrument command sequences, e.g.:
  - T_0: Initiate_Observation (ObsId), $CmdId_0$
  - ΔT_1: Configure (), $CmdId_1$
  - ΔT_2: Calibrate (), $CmdId_2$
  - ΔT_3: Start_spec_map(), $CmdId_3$
  - ΔT_4: Measure(), $CmdId_4$
  - ΔT_5: Configure(), $CmdId_5$

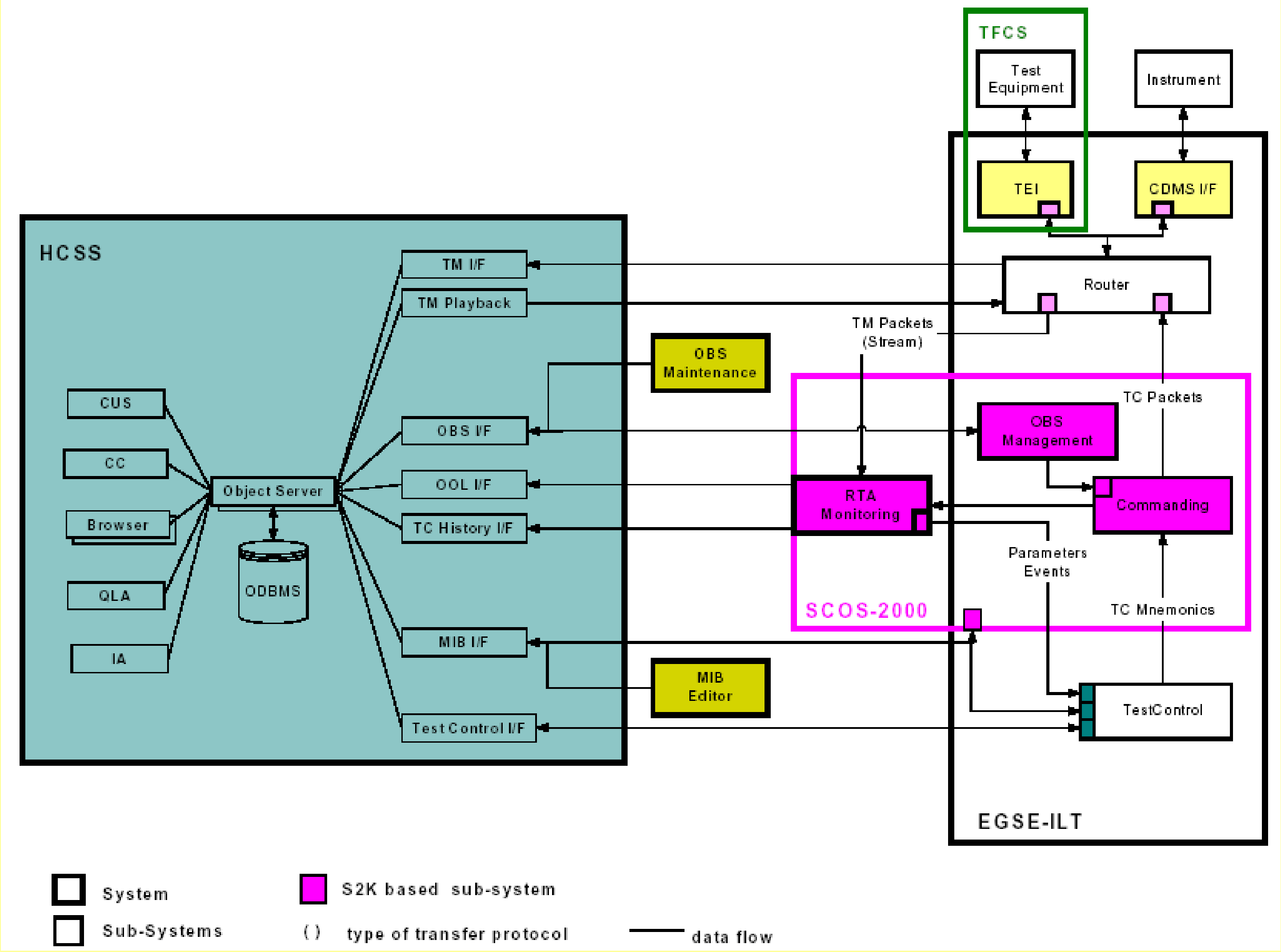
How does the HCSS work for observations (4)?

- **Relating Downlink to Uplink:**
  - needed for archiving purposes
  - needed for data analysis and calibration
  - done at observation level for TM data
    - using a unique identifier (ObsId) per (execution of an) observation
  - done at command level for command verification
    - using a unique id (TC Id) per instrument command to be appended to the TC history as generated by SCOS-2000 (2.3e)
  - for ObsId the following has been agreed with the instrument teams:
    - each command sequence for a given observation will start with a specific instrument command (service 8) to set the ObsId
    - The ObsId will be reflected in the following instrument TM packets:
      - HK & diagnostic (service 3)
      - Event (service 5)
      - Science (service 21)

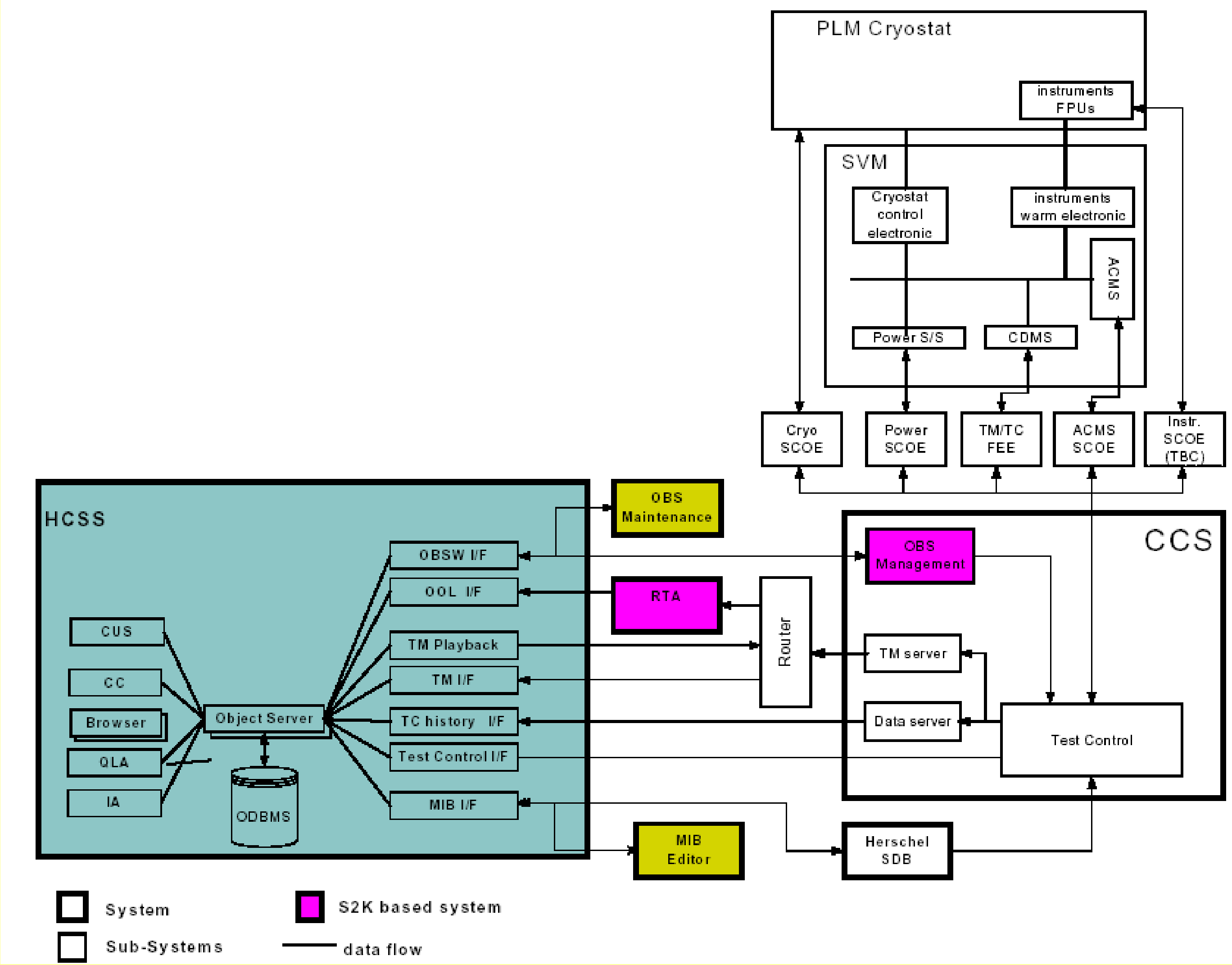
Herschel GS in Routine Phase



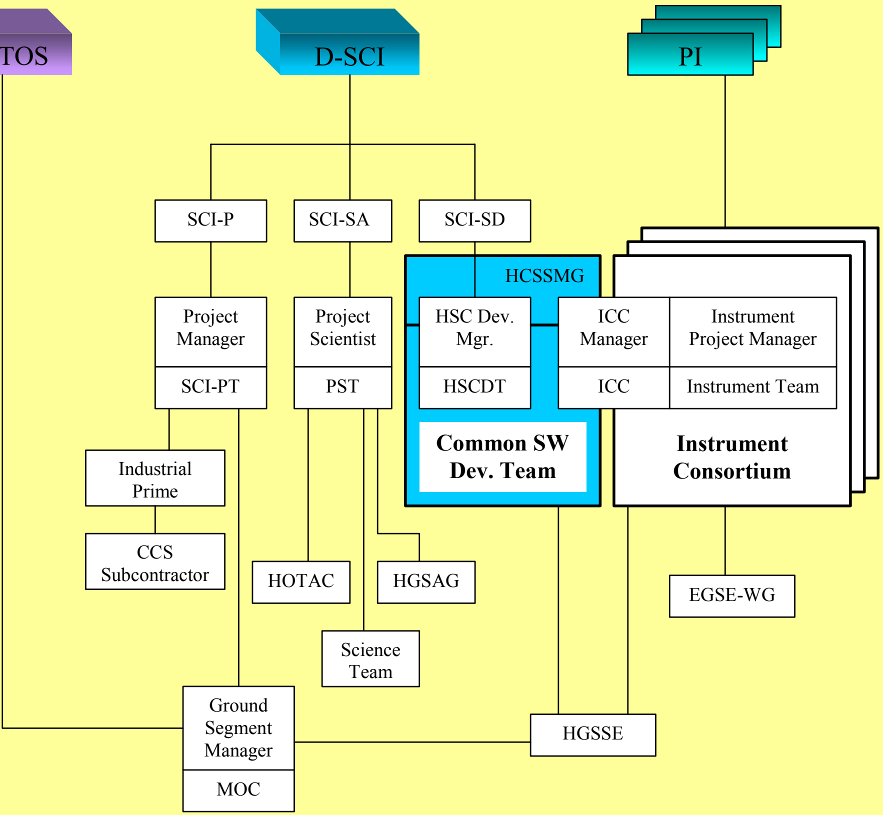
Herschel GS in ILT



HGS in IST (extrapolation from ILT)



Who is developing the HCSS?



The Common SW Development Team (CSDT) is comprised of :

- 7 f.t.e. in ESTEC
- 3+ f.t.e. in ICCs
- Some IPAC involvement

When is the HCSS to be delivered?

- **HCSS v0.1**
  - to support ILT
  - was delivered in June 2002
  - CUS, TM ingestion and extraction, MIB ingestion, etc are all prototyped
- **HCSS v0.2**
  - to support ILT & IST
  - to be delivered in December 2002
- ….
- **HCSS v1.0**
  - to support operation
  - to be delivered in December 2006

SPIRE ICC Contribution to HCSS v0.1

- TM Data Extractor: On demand retrieves TM packets and data frames from the HCSS database (Steve Guest).
- TC history ingestor: Reads TC history records from SCOS-2000 and ingests them into the HCSS database as objects (Matthew Graham).
- Out Of Limit (OOL) data ingestor: Retrieves OOL packets from SCOS-2000 and ingests them into the HCSS database as objects (Matthew Graham).

Instrument Simulator in the Ground Segment (1)

- In the Ground Segment an Instrument Simulator is a software simulator of the whole instrument.

It will used by the MOC to:

- train operations staff (by simulating typical housekeeping and *science telemetry*, providing anomalous situations e.g. out of limits in housekeeping data etc.)
- allow the Ground Segment procedures to be exercised
- test new command sequences and observation
- test updates to OBSW
- perform End-to-End test dry runs

Instrument Simulator in the Ground Segment (2)

This simulator will be delivered to ESOC for integration into their S/C s simulator.

The run-time environment for the S/C simulator and the simulation model interface (SMI) are defined at the following URL:

http://www.estec.esa.nl/smp/

Instrument Simulator Requirements

- A draft document outlining the requirements on the Instrument Simulator has been prepared by ESOC and circulated to the three ICCs for comments.
- The HGSSE will take all comments from the ICCs (due date: End July 2002) and provide a consolidated input to ESOC (due date: End August 2002).
- ESOC will then issue a revised version of the requirements document (due date: 13th September 2002).

SPIRE ICC

ICC Scenarios

Tanya Lim, RAL

16/17th July 2002 SPIRE Consortium Meeting, Rome

Contents

SPIRE ICC

- Why Scenarios?
- Some Scenarios
  - ILT
  - Calibration
  - Data Processing

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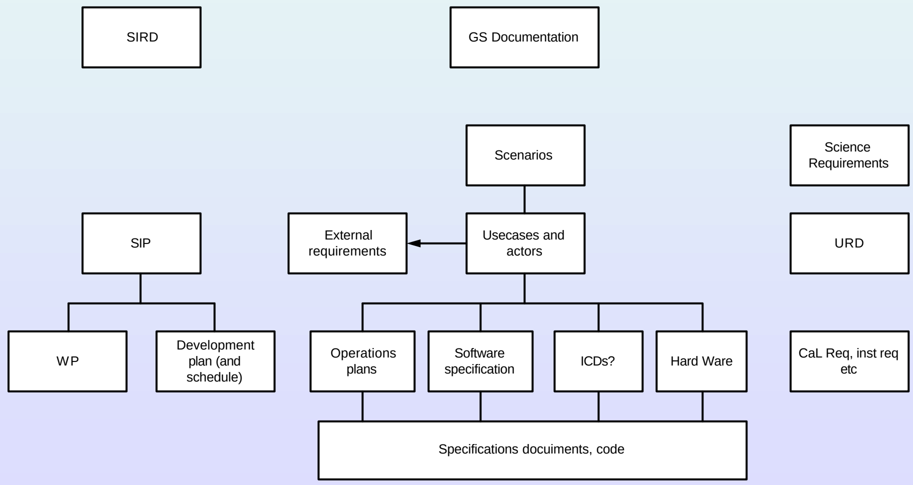
Why Scenarios?

SPIRE ICC



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ILT Scenario - I

SPIRE ICC

Main ICC Activities during ILT

- Development and maintenance of QLA
- Development of the MIB (Instrument database)
- Development of command verification software
- Assisting with testing
  - *Generating test scripts*
  - *Running test control*
  - *Monitoring NRT output (RTA and QLA)*
  - *Analysing some of the test data*

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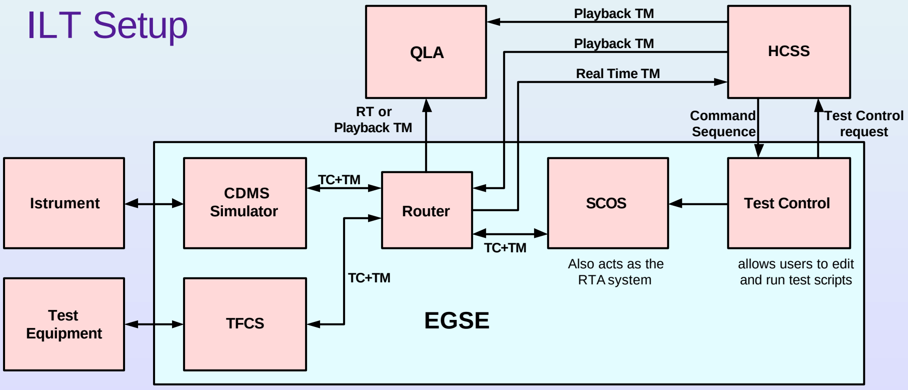
ILT Scenario - II

SPIRE ICC

ILT Setup



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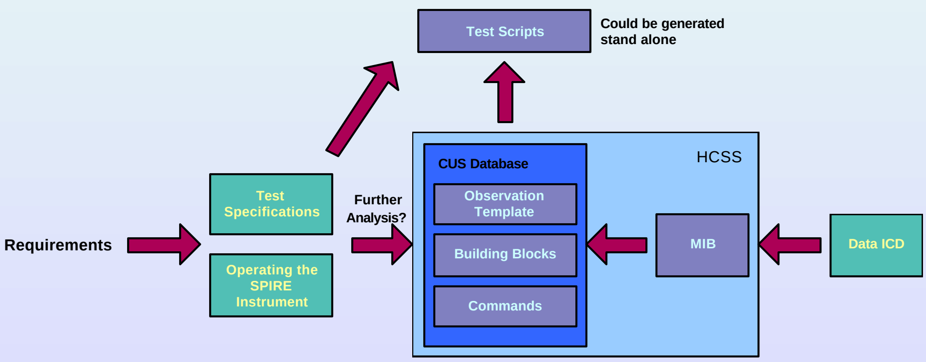
ILT Scenario - IV

SPIRE ICC



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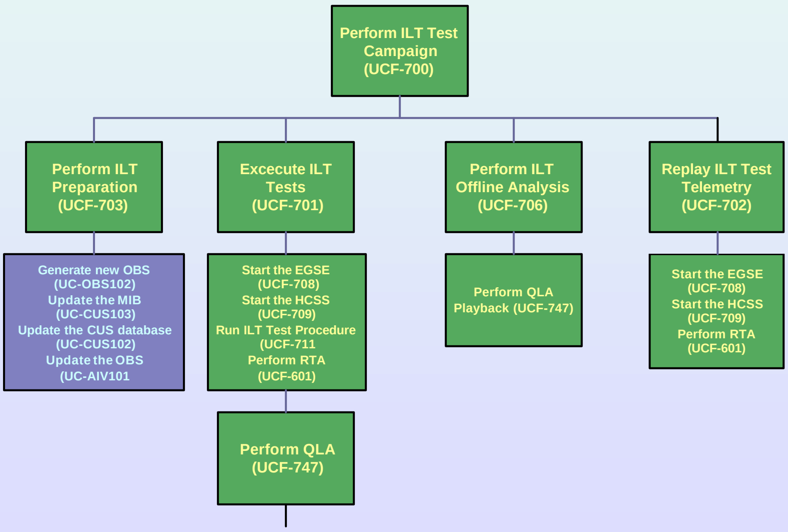
ILT Scenario - III

SPIRE ICC



ICC QLA Use cases

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Calibration Scenario - I

SPIRE ICC

Main ICC Calibration Activities

- Defining the calibration plan – *joint activity with the instrument team up to routine ops*
- In ILT analysing the test data in terms of calibration
- In operations…
  - ➢ *Updating the calibration plan*
  - ➢ *Scheduling observations*
  - ➢ *Analysing in-flight data*
  - ➢ *Refining uplink/downlink/time estimator files*
  - ➢ *Documenting calibration status*

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Calibration Scenario - III

SPIRE ICC

What is the calibration plan?

- The calibration plan will contain the list of all measurements and observations necessary to calibrate and characterise SPIRE.
- It will also contain the dependencies of these measurements and observations.
- It should how the data will be used to generate the files needed.
- It should also contain the list of calibration and performance parameters that need to be supplied to the ICC by various subsystem groups.

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Calibration Scenario - I

SPIRE ICC

The ICC use cases on calibration are encompassed under two summary level use cases

- Prepare the calibration plan (UC-CAL002)

  This deals with the preparation of the plan

- Calibrate SPIRE (UC-CAL001)

  This deals with the act of calibration, consulting the plan, scheduling observations, analysis if the data etc

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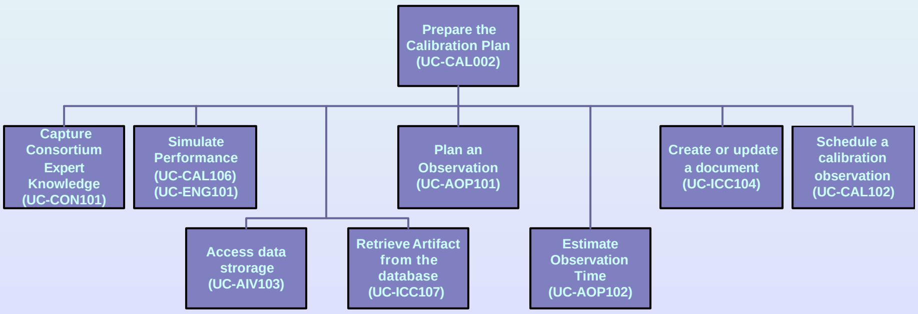
Calibration Scenario

SPIRE ICC



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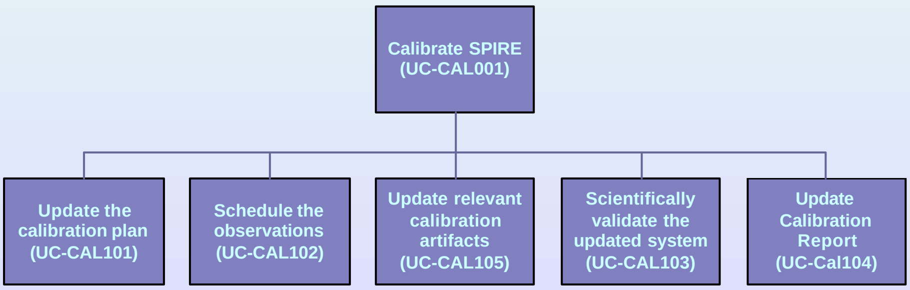
Calibration Scenario

SPIRE ICC



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Calibration Scenario

SPIRE ICC

The calibration plan is an evolving official ICC document

It has to be officially created and maintained

UC-ICC104 [create or update a document]

It can be modified to reflect our evolving knowledge of SPIRE:

UC-CAL101 [update calibration plan]

Some areas of it can be discussed/planned with the other ICCs and the HSC:

UC-OTH001 [Interface for joint ICC/HSC areas of commonality

Data Processing Scenario - I

SPIRE ICC

Standard data reduction

- IA using standard product generation
- Quality Control Pipeline
- IA used interactively

Other processing

- QLA
- Calibration analysis (‘expert IA’)
- Trend analysis
- Diagnostics

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Data Processing Scenario - II

SPIRE ICC

Standard Processing

HSC Responsibilities

- Running IA for standard product generation
- Running the quality control pipeline and quality checking the output.

ICC Responsibilities

- Development and maintenance of all data processing software
- Development and maintenance of associated instrument calibration
- Scientific validation of the products

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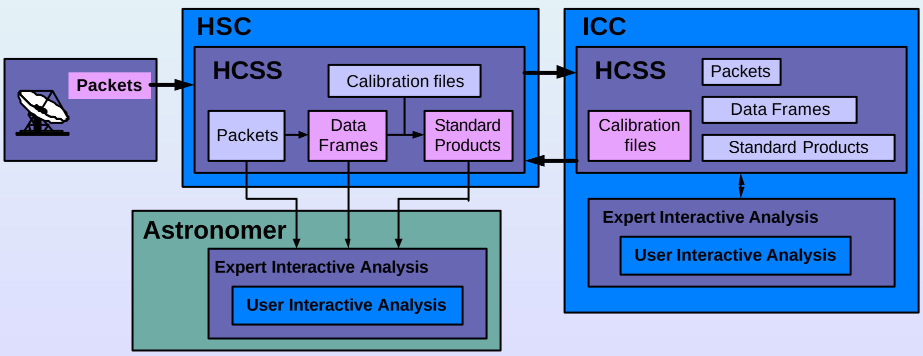
Data Processing Scenario - III

SPIRE ICC



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Data Processing Scenario - IV

SPIRE ICC

Expected ICC use of data processing

Standard Processing

- Development and testing of improvements to the code (algorithms) and calibration files
- Investigating quality control failures
- Investigating instrument/SW problems

Other Processing

- Using QLA to support tests or validate updates
- Using calibration analysis to generate new cal files
- Trend analysis
- Running diagnostic software

Data Processing Scenario - V

SPIRE ICC

Development of QLA

- This will do low level processing
- Data will be stored in the database and accessible via a user interface
- Test data will be used to generate first generation of calibration files externally to the QLA system

Development of IA

- Will build slowly on experience gained with QLA
- We could re-use QLA code
- Calibration analysis will build on ‘first generation’ experience

Data Processing Scenario - VI

SPIRE ICC

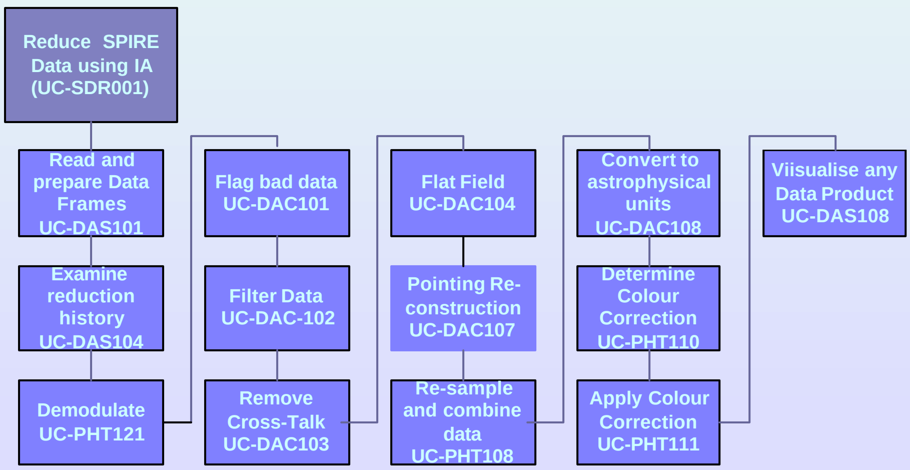
How does our use case approach describe this?

- User-level use case describing running QLA
  - ➢ User-level use cases describing interactive steps
- Summary level use-case describing running IA
  - ➢ Sub-function use cases describing IA processing steps
- More work still needed on calibration analysis, QCP and trend analysis

Data Processing Scenario - VII

SPIRE ICC

Interactive Analysis



Summary

SPIRE ICC

- The ICC activities can be described by a series of scenarios
- These act as a 'cover note' for the use cases and show how the use cases fit into the ICC system
- Much of this ICC definition work has now been done and we are moving into the next stage of development

SPIRE

SPIRE ICC Design

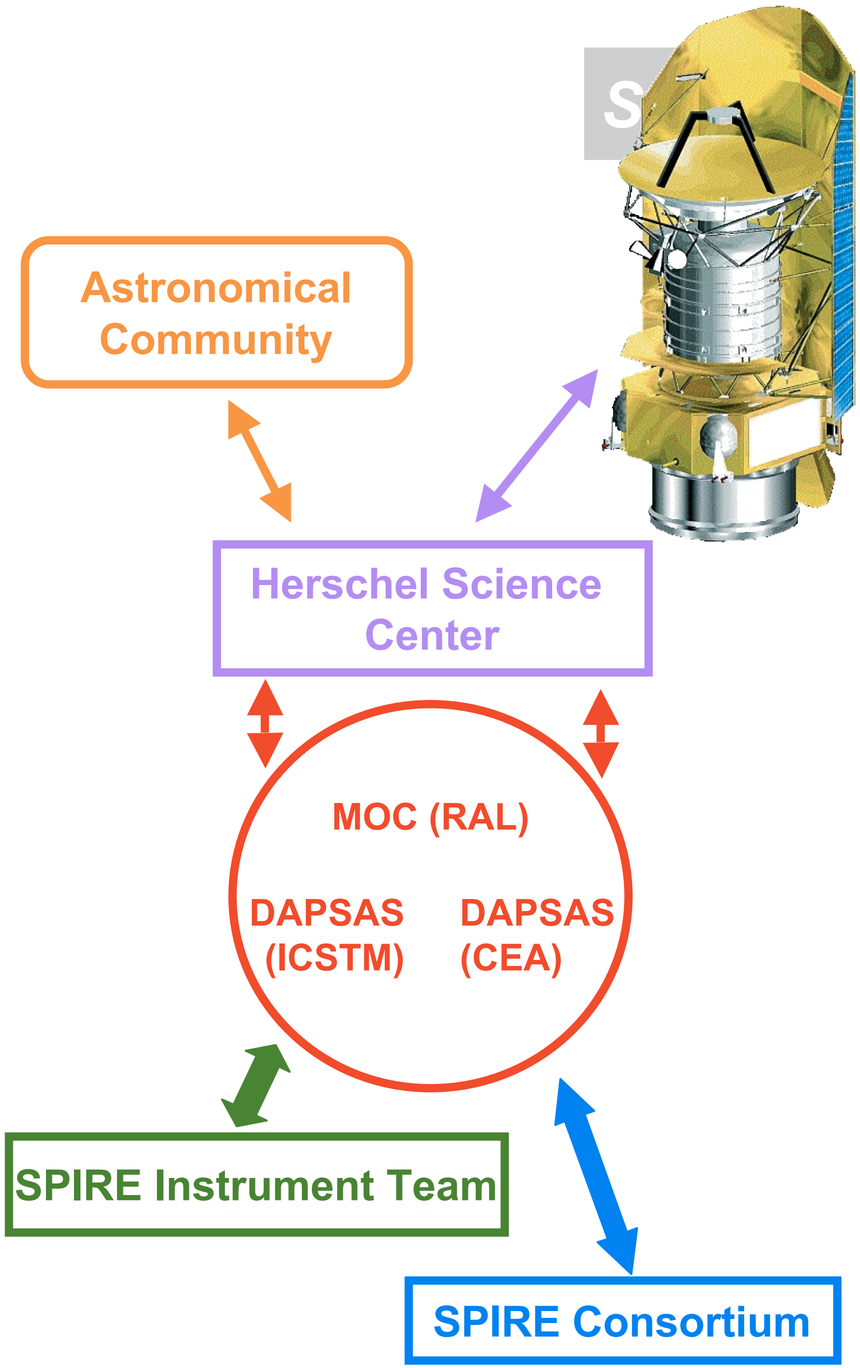
Marc Sauvage, on behalf of the ICC definition team

COMMISSARIAT A L'ENERGIE ATOMIQUE

What will the ICC be?

- **The Instrument Control Center has a number of missions:**
  - Provide the community with a fully calibrated instrument
  - Provide the community with the tools to prepare SPIRE observations
  - Provide the community with the tools to analyze SPIRE data
  - The ICC doesn't "do science"

- **In order to fulfill these missions, the ICC is also involved in**
  - Preparing the tests to be performed on the instrument models
  - Providing the tools to analyze those test



ICC design methodology

SPIRE

- **One aim of the Herschel mission is to present a consistent ground-segment.**
  - the Herschel Science Center and the three ICCs have used a common approach to the design: the use-case methodology
- **What is this methodology?**
  - Define the missions of the system under design
  - List the people/actors who are going to play a part in the system
  - List the groups/actors that are external to the system but expected to be important for the system
  - Imagine the system performing its functions and describe them from a high level ("Scenarios") to a low-level ("sub-functions")
- **How do you make sure the system does what it was supposed to do?**
  - Review the high-level use-case against the system's missions
  - Review the use-cases, scenarios, and actors against expectations of the external actors and users of the system.

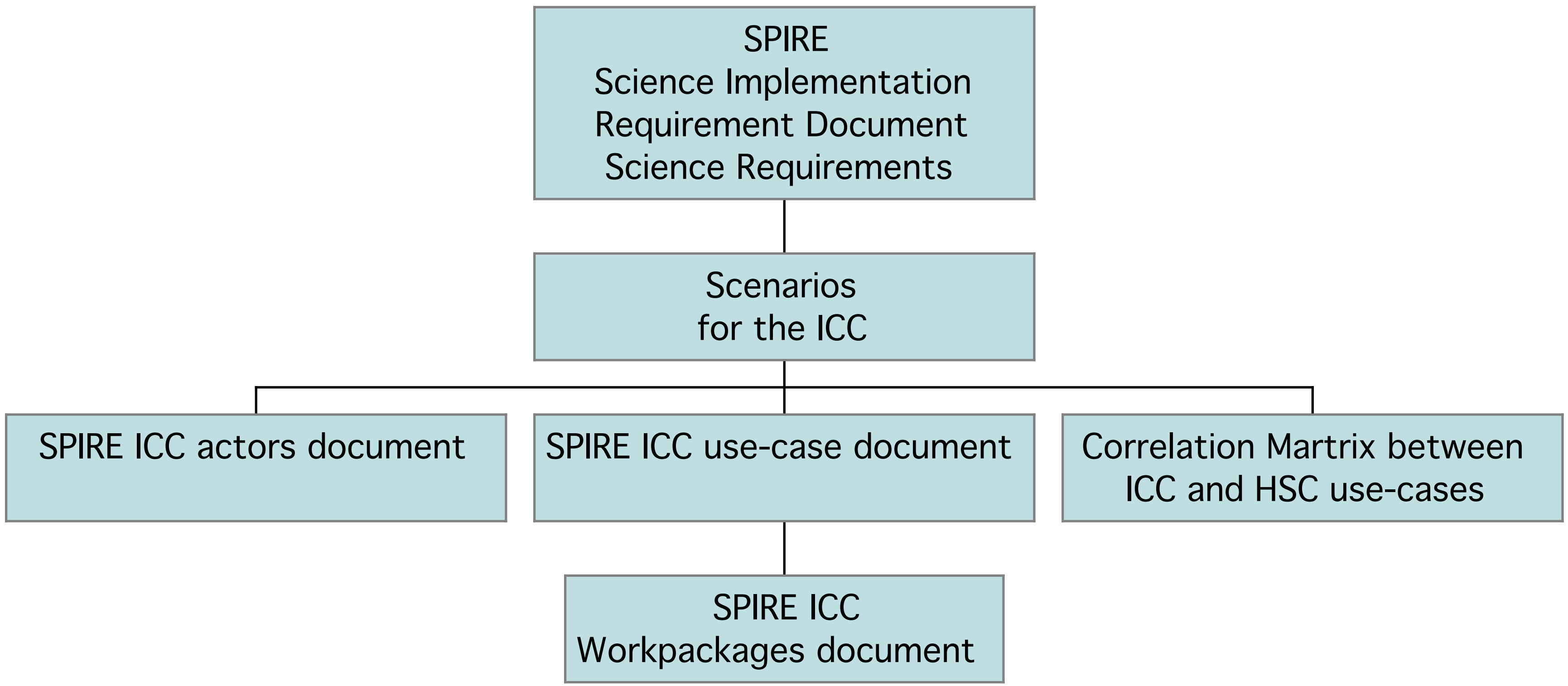
Use-cases for the SPIRE ICC

SPIRE

- **We have identified three levels of use-cases**
  - Summary-level
  - User-level
  - Sub-function level
- **Summary-level use-case:**
  - A summary-level use-case describes a top-level scenario of ICC use. "Calibrate SPIRE" is typically a summary-level use-case.
- **User-level use-case:**
  - A user-level use-case is one which satisfies an immediate goal of the primary actor. Such a use-case does not make sense on its own, but is part of a larger "mission" or "scenario". "determine calibration value" would be user-level use-cases.
- **Sub-function use-case:**
  - A use-case describing a single action with an almost immediate result. Examples are: "fit a curve", "display data", "access data storage".

the ICC design process

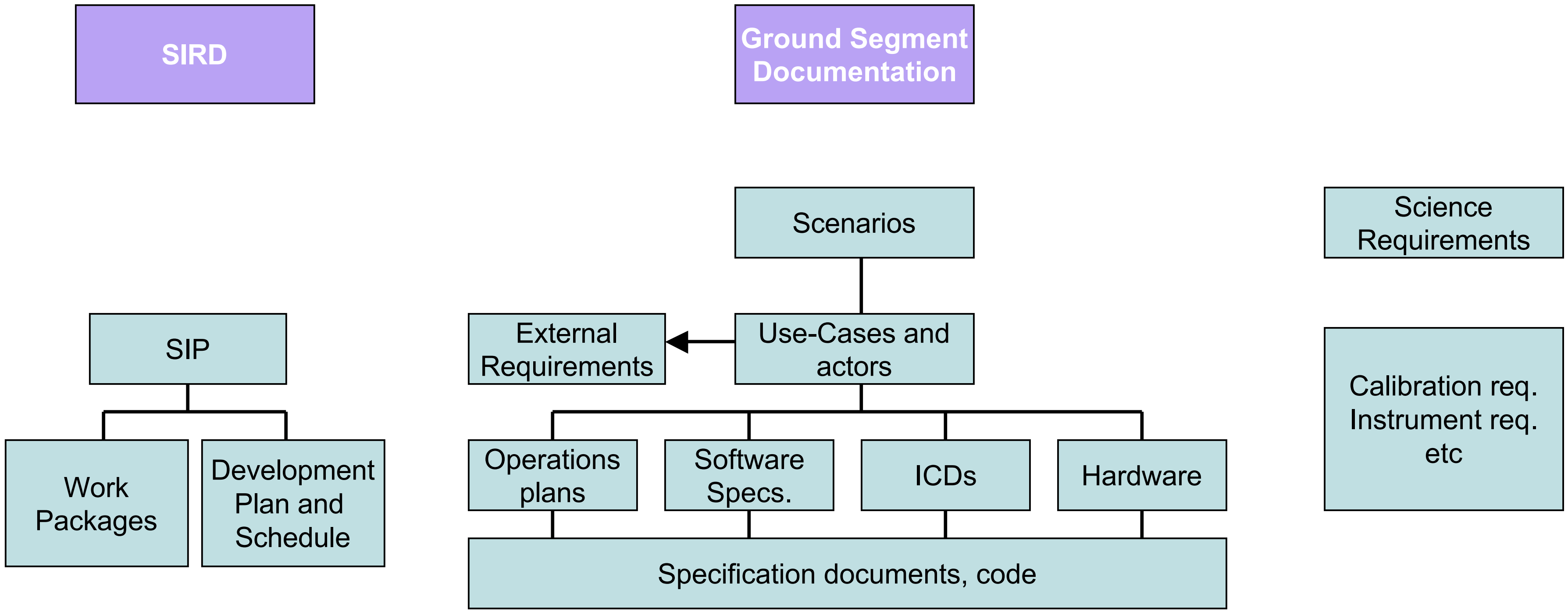
This is how we proceeded to design the ICC:



Other documents used in the process are:

- **HCSS use-cases**
- **Calibration requirement document**
- **SPIRE test plans**

Documents describing the ICC design



How should one read these documents?

SPIRE

- **If you want to check that the ICC we are designing will fulfill your needs:**
  - Check the list of actors. This is not the ICC personnel, but rather the list of competences required to make the ICC work.
  - Check the list of summary level use-cases: this should show all of the main functions of the ICC and describe operational processes.
  - Check the schedule of the principal work-packages to see in which order the functions of the ICC will be implemented.

- **Lower-level use-cases are here to define more precisely the processes for the development phase.**

Where are we now?

SPIRE

- **A first version of the design has been reviewed. It identified the need for:**
  - More clarity in the use-cases
  - Better schedule
  - Better interfaces
- **Some work has already begun**
  - Instrument Engineering Simulator
  - QLA
  - All parts common with the Herschel Science Center (HCSS)
- **Work-packages have been costed and scheduled**
  - Need agreement for the repartition and go-ahead on work-packages
- **We need to define our interfaces with the various sub-groups of the instrument team**
  - Through dedicated working groups?

Presentation of the ICC design

SPIRE

- **First list the actors**
  - Should give you an idea of the competences in the ICC.
  - Note that actors can play a bigger part than their names suggest (e.g. an instrument tester may do much more than simply apply procedures)

- **Then show the summary-level use-cases**
  - The complete list defines the ICC
  - Their process will be shown for some prototypical ones

- **Finally identify the interfaces of the ICC**
  - Some responsibilities are shared (e.g. calibration)
  - Some are unclear (participation of the ICC in instrument tests, science)

ICC actors

SPIRE

Management

- ICC Manager
- Materials Review Board

Instrument use

- Instrument Engineer
- Instrument Tester
- Operations Engineer

Instrument problems

- Problem Analyst
- Problem Reporter

Science

- Data Processor
- Calibration Scientist
- Expert Knowledge System
- ICC Scientist
- Scientific Product Analyst

Interfaces

- External User
- Herschel Science Center

System managment

- Computer System Manager
- Configuration Controller
- Database System Manager

Information flow

- Documenter
- ICC Helpdesk
- Information Handler

Software development

- Infrastructure Software Developer
- On-Board Software Maintenance Team
- Scientific Software Developer
- Software Tester

Example: the Scientific Software developer

SPIRE

- **Description:**
  - computer engineering and astronomical data reduction background.
  - understands the instrument characteristics and its operation modes.
  - designs, codes, tests and implements software for scientific data analysis and reduction.
- **Responsibilities:**
  - Design, code, test and integrate scientific parts of the ICC software.
  - Write documentation (User Manuals etc.).
- **Interests:**
  - Easy access to all data (uplink and downlink) associated with an observation.
  - Navigation and queries down to the functional unit resolution element
  - Smooth maintenance / development of the software system independent of the physical location (test environment available, etc)
  - ICC configuration control integrated with HSC configuration control
  - Notifications of new SCRs etc.

Example: Calibration Scientist (1)

SPIRE

- **Description:**
  - strong astronomical background and an in-depth knowledge of the properties and operations of the instrument.
  - plan the necessary calibration observations to characterize the instrument, determine and verify the calibration parameters of the instrument and specify how these parameters have to be applied.
  - When analyzing the calibration observation data the calibration scientist will check that the model of the instrument’s behavior is still valid.
  - may determine that a change in the observation strategy is needed or that a new type of calibration observation template is required.

Example: Calibration Scientist (2)

SPIRE

- **Responsibilities:**
  - Write and maintain the overall calibration plan
  - Implement the calibration plan
  - Determine the instrument calibration parameters
  - Validate the instrument calibration parameters
  - Monitor the trends in instrument characteristics
  - Propose improvements in standard product generation software
  - Propose improvements in on-board reduction & compression
  - Propose improvements in observing modes
  - Document the instrument performance/calibration to the astronomer
- **Interests:**
  - Simple, readable code of the standard processing software
  - Easy plugging-in of code into standard product generation software in private sandbox
  - Easy access to all uplink, observation science and ancillary data from functional units
  - Same access to in-orbit as to ILT data.
  - Availability of calibration reference data from other facilities
  - Availability of satellite observing time for calibration

The ICC summary-level use-cases

SPIRE

- **These use-cases capture the main processes of the ICC:**

Manage the ICC	Manage ICC knowledge base
Perform ILT test campaign	Perform instrument test
Prepare the calibration plan	Calibrate SPIRE
Investigate instrument problem	Investigate external SC/instrument effect on SPIRE instrument
Test, validate and verify observing modes	Reduce SPIRE data using IA
Support HSC query	Handle problem report
Maintain computing environment	Plan and deliver a new user release
Evaluate ICC-external algorithm	Collaborate with other ICCs or HSC

Use-case processes

SPIRE

Prepare the Calibration Plan

- Obtain Cal. Req. from Instrument team
- *CON101: Capture consortium expert knowledge*
  Interact with IT to clarify Cal. Req
- *CAL106: Simulate science performance*
  ENG101: Simulate instrument behavior
  Investigate consequence of artefacts on calibration strategy
- *AIV103: Access data storage*
  ICC107: Retrieve artefact from the database
  Collects test phase results and consolidate into Cal. Measurements. EXT
- *AOP101: Plan an observation*
  Create calibration observation. EXT
- *AOP102: Estimate observation time*
  Budget the calibration observation
- *ICC104: Create or update a document*
  Compile all observations into the Calibration Plan
- *CAL102: Schedule a calibration obs.*
  Check that all calibration obs. can be Scheduled. EXT
- Validate and verify the plan with IT
- *ICC105: place an item into CC*
  Place the calibration plan into CC

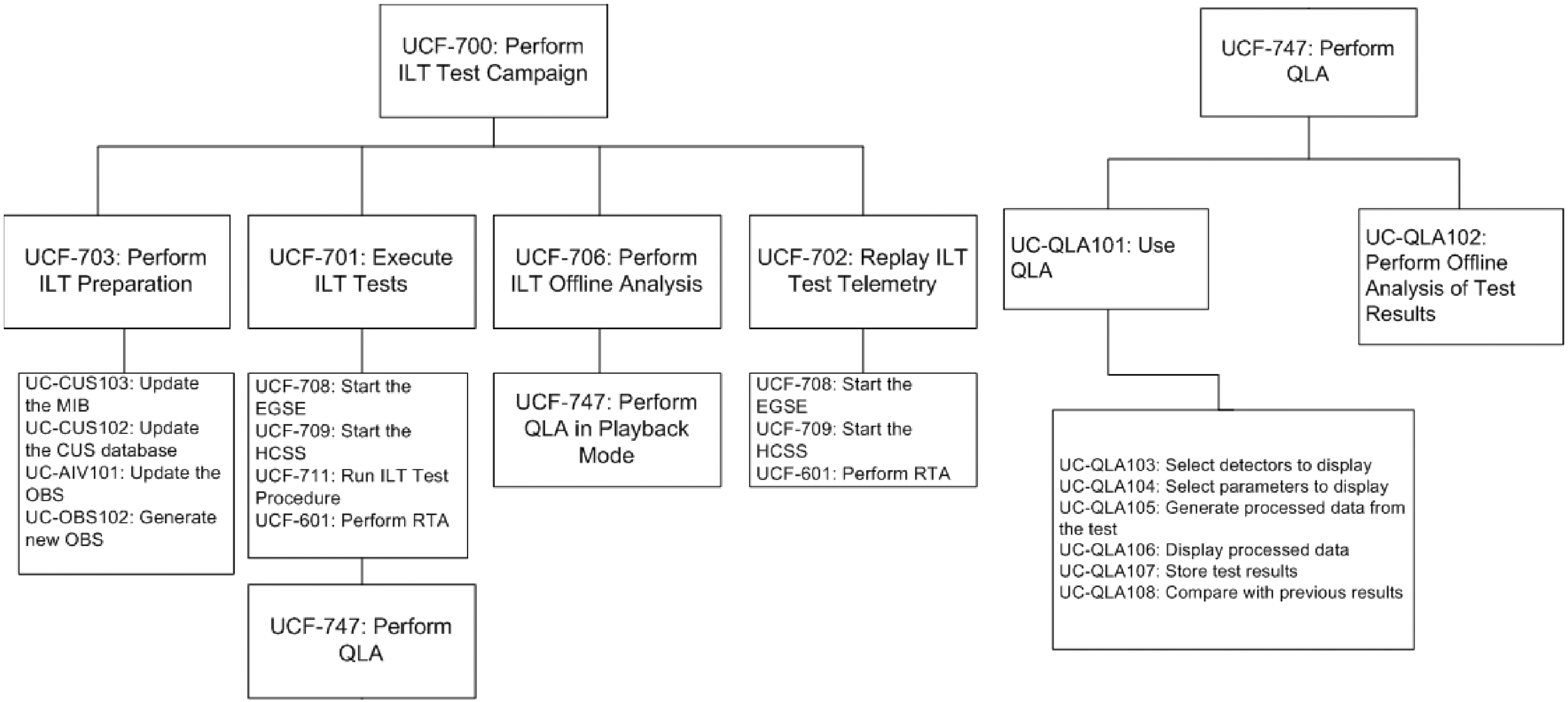
Requires an interface

CAL004: extensions

SPIRE

- Other instruments may place request on SPIRE calibration plan
  - *OTH001: Collaborate with other ICCs or HSC*
    Get requests from other instruments
  - Go to step 5
- Calibration cannot be implemented with the observing templates
  - *ICC104: Create or update a document*
    Specify how the observation should be done
  - *AIV102: Generate, validate and verify scripts and observation requests*
    Generate new observing sequence
  - Go to step 6
- Some calibration observations cannot be scheduled
  - Interact with IT to modify observations
    - Obs. can be modified
      - Go to step 8
    - Obs. cannot be modified
      - Inform PI to plea for more Cal. time

ILT seen through the use-cases



ICC Interfaces

SPIRE

- **The main interface to be defined is with the instrument team**
  - Participation of ICC personnel to tests
  - Participation to the definition of instrument tests
  - Deliverables to the instrument team (e.g. simulators)
  - Deliverables from the instrument team (e.g. calibrators)
- **Interface with the HSC**
  - A large number of systems are common (e.g. problem reporting system, databases, IA)
  - Well covered by a number of documents
- **Interface with the consortium**
  - Large expertise in observing strategy, data reduction methods
  - Require inputs from our side regarding instrument performance and observing templates.

ICC structure

SPIRE

- **In the MOC+DAPSAS scheme:**
  - The MOC is responsible for the interaction with the HSC and for the operation of SPIRE
  - The DAPSAS work more off-line, and are responsible for the production of the analysis tools for SPIRE data
  - What about calibration?
- **Both the DAPSAS and MOC will participate in calibration**
- **Teams will be organized around calibration issues involving members of the MOC and DAPSAS (with a leader in MOC or DAPSAS)**
  - We expect that themes requiring in-depth and long-term analysis will be under DAPSAS responsibility, while those that are more critical for the instrument will be under MOC responsibility.
- **Members will circulate between MOC and DAPSAS according to the state of their theme.**

SPIRE
ICC Work packages

Ken King

RAL

Scope of the Work Packages

Some of the WPs cover tasks which overlap with the work of teams external to the ICC. We have assumed the following:

- Calibration
  - A Calibration Team (composed of Instrument Team and ICC members) is responsible for producing the calibration plan and for the ground calibration of the instrument.
  - The ICC is responsible for creating the calibration database and populating it with the results of calibration.
  - Calibration Team personnel will support execution of the calibration tests (as part of the Test Team)
- Commissioning Phase
  - Handled by instrument Test Team at MOC, with the ICC 'at home' ready to support in the event of problems.
  - ICC will provide systems for use in the MOC
- Project Office and other support activities
  - Handled by SPIRE Project Office, PA resources and system management at no cost to the ICC

Scope (continued)

- Support to the Instrument (Development) Team - allows instrument expertise to be gained
  - provision of ICC systems for ILT, IST, Commissioning e.g. QLA, HCSS, Other Tools (e.g. Command Validator)
  - Definition of instrument command/telemetry database, CUS Database, Observations Templates, Operations Procedures
  - Support to Testing: writing scripts, processing test data – particularly for calibration and observing mode tests
- Processing of auxiliary mode (serendipity) data - parallel mode is a standard mode, covered by IA
- Support to consortium members
  - Training in use of ICC tools
  - Provision of instrument information to aid observation selection
  - Provision of facilities for consortium to support the ICC in software development
- Publicity and Outreach activities
- Support for local astronomers – TBD

ICC Work Packages

- Development Phase
  - ICC Development:
    - Management, Software Development, Provision of Instrument Information, Training
  - Support to Instrument Team Activities
    - Provision of ILT and IST Systems, Support to testing, Calibration, Science Verification
  - Preparation for Operations
    - Facilities, Operations Planning, Integration and Test of ICC and Ground Segment, Commissioning Phase
- Operations Phase
  - Routine Operations
    - Instrument Monitoring, Calibration processing, Quality control
  - Non-Routine Operations
    - Performance Verification, Key Programmes, Problem handling
  - Maintenance
    - Software Evolution, Facilities maintenance

Software Development

- Software shall be developed following ESA standards e.g.:
  - ECSS-E-40, for software engineering process (possibly modified for small projects and o-o s/w development) (SPMP, SVVP, URD, SSD, Test Plan, Transfer Doc)
  - ECSS-M-40 for configuration control
- Joint Software (HCSS, Time Estimator (TBD))
  - Joint effort with ESA and other ICCs, requiring regular meetings and telecons
  - SPIRE responsible for TM I/F, T/C History and OOL ingestion, IA framework (part), plus others TBD
  - Dates: v0.1 (ILT) Aug 02, v0.2 (IST) Dec 02, v0.3 Dec03, v0.4 Dec04, v0.5 Dec 05, V1.0 Dec 06
  - Continued Maintenance
- Infrastructure Software
  - For: Problem reporting, Configuration Control, Access Control, Sandbox environment for testing
  - May be setup and use of HCSS functionality or SPIRE systems (off-the-shelf or in-house)
- Tools
  - Diagnostic tools
  - Simulators

Software Development (cont.)

- QLA: Prototype IA, used for ILT and IST, provides display and processing (in real time) of science telemetry
  - Functionality for AVM:
    - **Activities:** System Level Analysis, Requirements, Systems Analysis, Domain modelling
    - **Architecture:** System Design, Interface Definition, Framework
    - **Data Interfaces:** Data acquisition, Interface to display/plot tools, Data storage and retrieval, Data import/export
    - **User Interfaces:** Data selection and control, Parameter display, Tables, (visualisation and update), Detector selection, Display management
    - **Image Displays:** Visualisation of detector arrays, Plotting, Timeline
    - **Data Analysis:** Timeline reconstruction – instrument packets
  - Functionality for CQM:
    - **Image Displays:** Interactivity, Colour Table Manipulation
    - **Plotting:** general 2-D
    - **Data Analysis:** Timeline reconstruction – test equipment, Conversion to Volts, Frequency/response, Crosstalk, Curve fitting, Statistics, FFT, Demodulation – basic subtraction, Deglitching – manual
    - **Specific Test Support:** Peak-up, Load curves, Noise level, Time constant, Beam steering, Filtering OOB rejection?, VI monitoring
  - Functionality for PFM
    - **User Interfaces:** Comparison of current and stored data, Scripting, Integrated printing
    - **Plotting:** 3-D
    - **Data Analysis:** Demodulation – Fourier, Deglitching – algorithmic, SMEC processing, Spectrum conversion, RSRF determination, Calibrate interferogram, Combine interferograms, Data cube construction for spectrometer

Software Development (cont.)

- **Interactive Analysis (IA)**
  - Consists of IA Framework (developed jointly with ESA and other ICCs, plus
  - Data processing modules (for processing science data from all observing modes:
  - Plus Modules for Calibration Analysis, Trend Analysis, Quality Control pipeline

Data Processing Modules (i)

- **Common Modules:**
  - **Remove Bolometer to Bolometer Sensitivity Variations**
  - **Filter Data on any Criteria**
  - **Visualize any Data Product**
  - **Identify and Flag Data on any criteria**
  - **Import and Export Data**
  - **Transform Spacecraft Coordinates to Sky Position**
  - **Remove instrument Crosstalk**
  - **Background Subtraction**
  - **Resample and combine data spatially and temporally**
  - **Data reduction History**
  - **Apodise and Transform Interferogram**
  - **Remove Instrument Signature**
  - **Detect and Identify Lines**

Data Processing Modules (ii)

- Photometry Modules:
  - Determine and Apply Colour Correction
  - Detect Sources
- Spectrometry Modules:
  - Reconstruct Interferogram
  - Convert Position Counter to mechanical Mirror Position
  - Phase Correction
  - Regrid
  - Responsivity Correction
  - Correct for Time-Dependant Flux
  - Correct for Position-Dependent variation in flux
  - Apodise and Transform Interferogram
  - Remove Instrument Signature
  - Detect and Identify Lines

Calibration

- **Calibration team is responsible for defining the calibration plan for the instrument and for obtaining the required data. In particular, they will be responsible for specifying and analysing the data from tests carried out on the ground. Its tasks are:**
  - Definition of the SPIRE Calibration Plan
  - Specification of calibration ground tests
  - Provision of test scripts for calibration tests (done as part of the Test Team)
  - Analysis of data from ground calibration tests held at instrument-level
  - Definition of the calibration database
  - Population of the calibration database from ground testing and other facilities (subsystem tests, other telescopes, literature)
  - Specification of IA data processing modules for calibration data processing
  - Definition of calibration processing procedures

Science Verification

- **Verification of SPIRE Observing Modes**
- **Tasks are:**
  - **Provision of a Science Verification Plan**
  - **Specification of ground tests necessary to verify the Observing Modes (including tests to validate different operational modes and tests to validate data processing software)**
  - **Specification of the Commissioning Phase and PV Phase observations to be made to verify the Observing modes**
  - **Provision of test scripts for observing mode checkout (done as part of the Test Team)**
  - **Analysis of test results to verify the correct processing of observations to the standard data products**
  - **Specification of algorithms for IA data processing modules used for reduction of scientific observations data (including Serendipity and parallel modes)**
  - **Provision of initial data processing procedures ('pipeline') for reduction of scientific observations data (including key programmes)**

The SPIRE Quick Look Analysis System

Tanya Lim

16/17 July 2002 SPIRE Consortium Meeting, Rome

Requirements

- Quick Look Analysis is a system that allows near real time scientific assessment of the instrument data
- The requirements were initially set via a URD and this has now been superseded by use cases
- There are two user level use cases one dealing with running QLA and one with the offline analysis
- Below this are a set of interactive steps
- The test are referenced directly in one of these two use cases

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Main QLA Use Case

1. TS: Select detector(s) to display **(UC-QLA103**)
2. TS: Select parameters to display **(UC-QLA104)**
3. TS: Select displays while the test is running
4. TS: De-select displays during the test.
5. TS: Change speed of data stream (only in playback mode)
6. QLA: Generate processed data from the test **(UC-QLA105)**.
7. QLA: Display processed data **(UC-QLA106)**
8. QLA/TS: Store test results **(UC-QLA107)**
9. TS: Compare with previous results**.(UC-QLA108)**

Models

For SPIRE the QLA system is being developed by the ICC on the basis of the needs of each instrument model

- **AVM -** Basic functionality,
  – selection of data, time series plots, lists, RTA type displays, raw images, packet dumping,
- **CQM** - Test specific support,
  – e.g. load curves, noise plots, spectra?, plotting two parameters against each other, scripting
- **PFM -** More sophisticated data processing

Data will be stored in an OO database, the user interface is an AVM/CQM work package

Detector Selector AVM Work Package

Inputs

Interface to QLA controller
Parameter list
A list of default sets of detectors per array

Activities:

- Produce graphical displays showing the photometer and FTS detector arrays, with the detector numbers overlaid.
- Add a set of buttons or a pull down menu for the default sets.
- Add detector selection by mouse click on the displays.
- Make displays respond to input data i.e. change colour e.g. raw detector signal values.
- Make selectable GUI listing all possible parameters.

Load Curve CQM Work Package

Inputs:

Time series plotting, 2-D plotting, Product saving tool, Voltage conversion, Statistics

Activities:

Produce tool to:

Construct load curves, Display load curves, Display default parameters Save and restore output products to/from database and/or disk

Define load curve product

Outputs:

GUI component
Load curve product

Performance Test Specifications

Sunil Sidher

- The performance test specification document expands on the test plan
- There are about 120 instrument requirements identified in the AIV plan to be performance requirements
- These requirements have been analysed along with the calibration requirements and the set of performance tests were identified.
- As much as possible the tests were formulated to cover as many requirements as possible.

The tests have been split up under headings

- Detector tests
- Optical tests
- BSM
- SMEC
- Calibrators
- OOB tests

About 30 tests have been identified

ILT-PERF-CPC - Photometer Calibrator Characterisation
ILT-PERF-CSC - Spectrometer Calibrator Characterisation
ILT-PERF-CSR - Room temperature nulling

Method

1. At the start of the test the internal blackbody is in the instrument beam and the entire array is illuminated. The detectors are switched off, the JFETs are set to nominal bias

2. Set the blackbody to power setting to give an equivalent input power to the telescope.

3. Take a long time series of output offset and voltage from the instrument.

4. Repeat for a range of JFET biases by taking a shorter time series.

Test Setup:

EGSE JPL

Source Internal cold black body

Facility FTS Not Used

Flip mirror Pointing to internal black body

Telescope simulator Not used

External chopper Not used

PCAL Off

SCAL Off

BSM Off

SMEC Off

Output Parameters:

Voltage output from all possible channels for active sub-instrument

Detector biases

TBD temperatures

Analysis

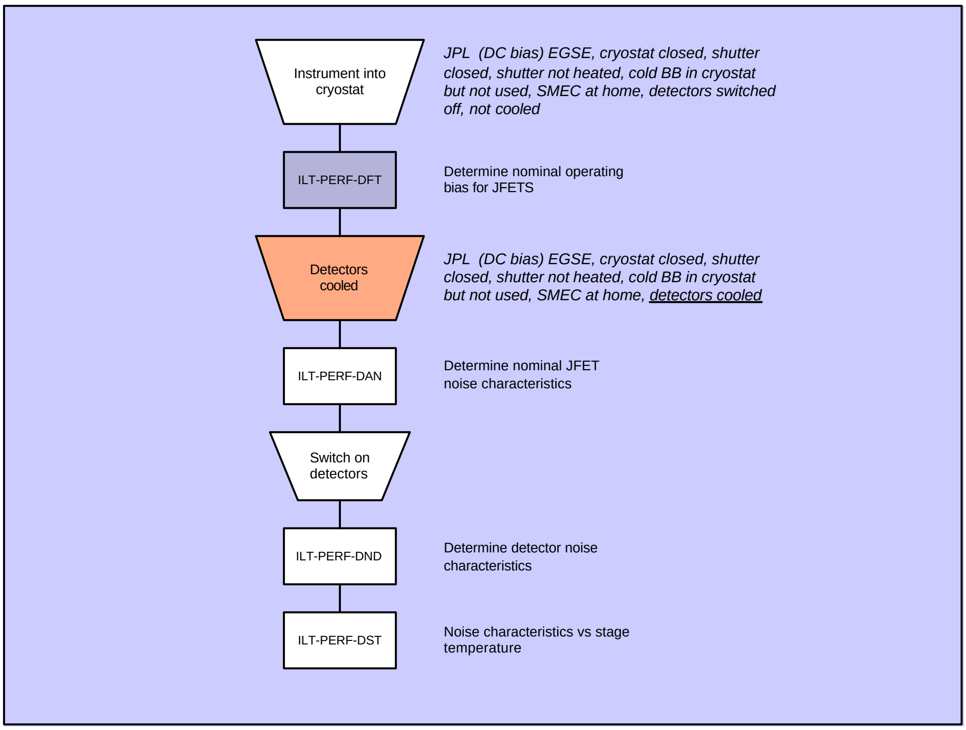
Recover the output offset voltage of each channel by removing instrument gains

Fourier transform time series

Check for microphonics

Determine position of 1/f knee

Compare with expected values.


Instrument into cryostat
JPL (DC bias) EGSE, cryostat closed, shutter closed, shutter not heated, cold BB in cryostat but not used, SMEC at home, detectors switched off, not cooled
ILT-PERF-DFT
Determine nominal operating bias for JFETS
Detectors cooled
JPL (DC bias) EGSE, cryostat closed, shutter closed, shutter not heated, cold BB in cryostat but not used, SMEC at home, detectors cooled
ILT-PERF-DAN
Determine nominal JFET noise characteristics
Switch on detectors
ILT-PERF-DND
Determine detector noise characteristics
ILT-PERF-DST
Noise characteristics vs stage temperature

SPIRE CALIBRATION REQUIREMENTS

Walter Gear
(presented by Bruce Swinyard)

Documentation

- Requirements laid out in detail in document SPIRE-RAL-PRJ-1064 by Bruce Swinyard
- All interested parties should refer to this document, and there will be a workshop tomorrow morning
- This talk briefly summarises some key issues

Origins….and work still to be done

- Calibration requirements are all derived from the science requirements….
- However, there is also considerable technical input from the instrument team in terms of the practicalities of making measurements
- The loop is not yet fully closed in taking these back through a scientific analysis to a final set of calibration requirements...

From SRD to CRD

- There are 25 requirements listed in the SRD, of which 14 are identified as directly driving calibration requirements
- The CRD also identifies an additional 5 calibration requirements implicit in the SRD making a total of 19 calibration requirements so far identified
- NOT going to list them all here one by one (you'll be glad to here !!)
- BUT these do need to be reviewed in detail and approved as they define much of instrument testing plan, so please read the document ….!!

Key science requirements (1)

- SRD-R5 requires that *“psf shall be neasured to very high accuracy”*
- input is required on what exactly “very high” means….
- Simulation is probably required to determing effect of sidelobes on e.g. detecting faint point sources in surveys, and extracting morphologies of marginally extended sources.

Key science requirements (2)

- SRD-R8 requires that *“Xtalk <1% (0.5% goal) for nearest neighbours & 0.1% (0.05% goal) for all other pixels”*
- This is a very complex and time-sonsuming requirement to check. Can it be redefined or simplified in some way to make testing easier (without relaxing basic science requirement) ?

Key science requirements (3)

- SRD-R11 requires “*absolute photometric accuracy 15% or better at all l with a goal of 10%*”
- Is this too conservative ?? LWS now claims 5%….(several years post-mission though!)
- SRD-R19 makes same requirement for FTS, is this appropriate ?

Key science requirements (4)

- SRD-R13 requires “*relative photometric accuracy at all l of 10% or better with a goal of 5%.*
- Depending on answer to (3) is this also too conservative ?
- Is it too conservative even if (3) is not ?

Additional requirements not explicit in SRD (1)

- CRD-SR1: *"photometer and spectrometer relative responses across an individual array shall be known to TBC%"*
- *What is TBC ?*
- *Needs simulations of effect of varying response when co-adding signals from different detectors to obtain spectrum in case of spectrometer and when chopping between pixels in case of photometer*

Additional requiremnents ..(2)

- CRD-SR2: *"Relative response of the spectrometer at <u>any</u> wavelength shall be known to TBC%"*
- TBC = ??
- Should this requirement be any less stringent than the previous one ?

Additional requirements ..(3)

- CRD-SR3: *"relative response of the photometer as a function of l shall be known to TBC%"*
- May seem odd at first but is needed for colour corrections (e.g. planet vs. Synchrotron source)
- modelling required, consistent with SRD-R8 and SRD-R11 ??

- These requirements should define everything a non-instrumentally minded astronomer needs to know.
- If anyone identifies anything missing that does not fulfill their scientific needs, speak now (or tomorrow morning) or forever hold your peace ...

- The CRD also goes on to define ways in which the requirements can be met
- again comments very welcome now, in tomorrow session or by email (to Bruce and/or Tanya)

Ground Based Preparatory Science/Calibration

Tanya Lim

Contents

- The ESA context - The HCalSG
- Planned activities of the HSC
- What is available and what is needed…
  - Spectral Calibration
  - Photometric Calibration

The Herschel Calibration Steering Group

- This group was set up under the leadership of Ana Heras from the Hershel Project Scientist Team
- This group will oversee instrument calibration and cross-calibration activities
- Each instrument has two representatives (Pete and Tanya for SPIRE), plus there are two PST members, and two mission scientists
- Other experts will attend as invited
- First meeting was held on 09/07/02 where broad agreement was reached on common requirements

Calibration Activities of the HSC

Instrument Calibration and Cross Calibration

- Aim is to learn from ISO and get co-located specialists employed early
- There should be one expert per instrument employed in a six month time frame

Specialist Activities

- Radiation modelling, discussion about putting a radiation monitor on Herschel
- Pointing re-construction, focal plane mapping

Spectral Preparation

We have…

An FTS which extends from 447-1500 GHz (200 - 670 µm) with a variable resolution between 20 - 1000

Basic Calibration Issues

- Wavelength calibration is not needed with an FTS!
- The FTS linearity is limited by source brightness
- Understanding the nulling in terms of telescope behaviour
- It is working is a spectral domain partially covered by other instruments – these are mainly heterodyne
- It is optimised to work below 450 µm

Spectral Preparation

For calibration we require:

- A set of point-like sources with lines of known brightness.
- These must be distributed around the sky for ease of observation and availability.

We expect to use:

- Existing observations
- Predicted lines from models

Spectral Preparation

Current and pre-Herschel instruments

- **SWAS** 5 lines between 487 GHz (626 µm) and 557 GHz (538 µm)
- **Odin**, receivers operating between 486 and 503 GHz and between 541 and 580 GHz
- **JCMT** Heterodyne receivers capable of reaching 810 GHz (370 µm), currently…
  - no standard spectra at higher frequency than 609 µm
  - no representative spectra higher than 433 µm

16/17 July 2002 SPIRE Consortium Meeting, Rome

Spectral Preparation

Current and pre-Herschel instruments

- **CSO**
  - Heterodyne receivers capable of reaching 850 GHz
  - An FTS with filters down to 350 µm
- **SOFIA CASMIR**, a heterodyne receiver aiming to operate between 500 and 2100 GHz
- **SOFIA SAFIRE**, an imaging Fabry-Perot spectrometer, operating between 458 GHz to 2067 GHz
- **ISO** LWS Fabry-Perot and grating operating up to ~190 µm

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Spectral Preparation

As neither space nor ground-based line observations reach above

~ 850 GHz (below ~350 µm)

and ISO did not reach below

~ 1500 GHz (above ~200 µm)

We would like line modelling using

- line fluxes from ISO i.e. above 1500 GHz (< 200 µm)
- line fluxes in the sub-mm < 850 GHz (> 350 µm)

Continuum Preparation

Requirements

- SPIRE absolute photometric accuracy is required to be 15% or better at all wavelengths with a goal of 10%
- The relative photometric accuracy is required to be better that 10% with a goal of 5%
- SPIRE photometry must be linear over a dynamic range of 4000 for astronomical signals (confusion limit ~15 mJy - ~ few 10's Jy)

Continuum Preparation

Expectations

- We expect to achieve a highly stable calibration
- The expectation is that there will be significant improvements on the 10-20% currently achieved by ground-based facilities

Continuum Preparation

Planets

Expected to be the primary calibrators

- Uranus might be too bright for the photometer (200 Jy at 350 µm, 857 GHz) so we may rely on Neptune
- Both Uranus and Neptune can be used for FTS calibration
- The ISO LWS and PHOT Calibration is very good up to 200 µm
- We are able to tie the Neptune calibration in with the Uranus and Mars model through the LWS data

Continuum Preparation

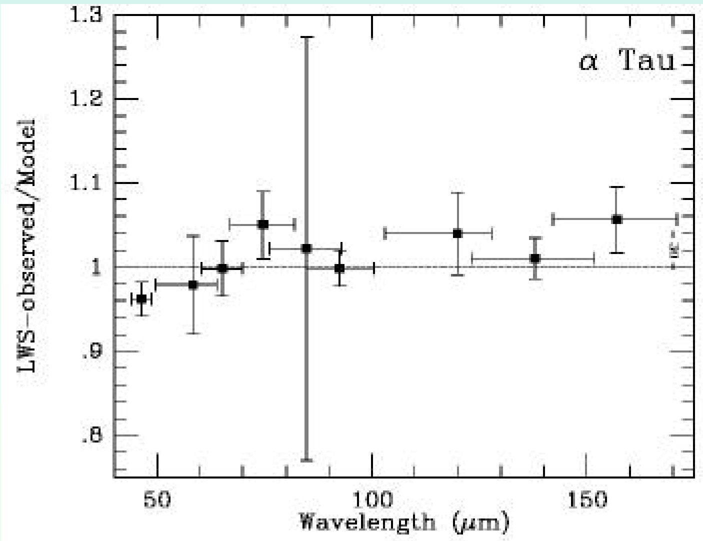
Major asteroids

- ISO PHOT used 5 asteroids as primary calibrators, models accuracy currently ~ 10% in FIR
- ISO LWS data based on Uranus shows consistency with both PHOT and the models in the FIR

Stars

- Well defined photospheric models can be tied in with ISO, MSX and ground-based observations (~5% in FIR)
- Suitable candidates must be > 10 mJy at 250 µm
- We are currently looking at extending K-M templates used for ISO PHOT to the SPIRE wavelength range.

Continuum Preparation



Continuum Preparation

Star	250 flux (W/cm2/µm)	250 flux (mJy)	350 flux (W/cm2/ µm)	350 flux (mJy)	500 flux (W/cm2/µm)	500 flux (mJy)
Alpha Ari	6.220E-22	130	1.619E-22	66	3.888E-23	32
Alpha Boo	5.627E-21	1170	1.465E-21	598	3.517E-22	293
Alpha Hya	1.050E-21	219	2.733E-22	112	6.563E-23	55
Alpha Tau	5.130E-21	1070	1.335E-21	545	3.206E-22	267
Beta And	2.138E-21	445	5.565E-22	227	1.336E-22	111
Beta Gem	8.778E-22	183	2.285E-22	93	5.486E-23	46
Beta Peq	3.003E-21	626	7.817E-22	319	1.877E-22	156
Eps Lep	4.321E-22	90	1.125E-22	46	2.701E-23	23
Gamma Cru	7.219E-21	1500	1.879E-21	767	4.512E-22	376
Gamma Dra	1.220E-21	254	3.176E-22	130	7.625E-23	64
Delta Dra	1.533E-22	32	3.991E-22	16	9.581E-23	8
Ome Cap	3.134E-22	65	8.158E-23	33	1.959E-23	16
HR 1699	4.340E-23	9	1.130E-23	5	2.713E-24	2
HR 2131	7.150E-23	11	1.861E-23	8	4.469E-24	4
HR 5442	5.097E-23	11	1.327E-23	5	3.186E-24	3
HR 5826	1.046E-22	22	2.723E-23	11	6.538E-24	5
HR 8685	4.981E-23	10	1.297E-23	5	3.113E-24	3

Continuum Preparation

We plan to have a set of secondary calibrators:

- Fainter asteroids
- Galilean satellites (e.g. Callisto)

We also need faint calibrators (<200 Jy at 250 µm) as visibility limited by the solar aspect angle (~60°)

- Ultra-Compact HII regions – small enough?
- Protoplanetary nebulae – non-variable enough?
- Galaxies – bright enough?

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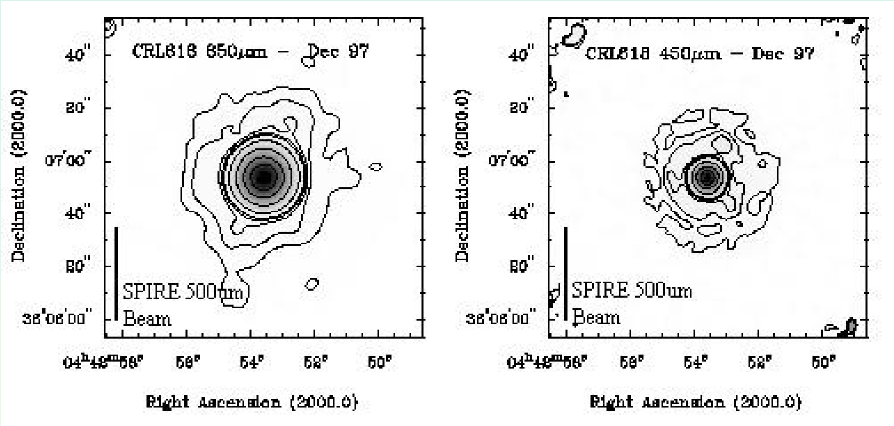
Continuum Preparation



JCMT Secondary calibrator CRL 618 with the SPIRE 500 µm beam for comparison.

Continuum Preparation

What we would like – archive and literature raiding

- SED models of galactic sources (emissivity wavelength dependence)
- SCUBA or similar archived observations of stable point sources
- SED models and observations of dusty galaxies (critical for photometric redshifts and source count interpretation) using data from JCMT, BOLOCAM, SIRTF, ASTRO-F

Continuum Preparation

What we would like – observations and modelling

- Improved planetary models
- Improved asteroid thermal models, asteroid monitoring in the sub-mm
- Stellar photospheric models or SED templates
- Sub-mm (SCUBA) observations of the brightest stars
- SED models and observations of dusty galaxies (critical for photometric redshifts and source count interpretation) using data from JCMT, BOLOCAM, SIRTF, ASTRO-F

Summary

Needs for astronomical preparation identified

- *Further work on raiding archives*
- *Preparatory observations*
- *Models*

No resources funded

Possible help from

- *Activities of the SPIRE consortium*
- *Activities of the other instruments*
- *The HCalSG*

Ground Testing: Summary
Bruce Swinyard

- Data will pour from the instrument during testing (100 kb/s)
- The functional and basic performance tests can (only) be analysed using sub-system/system expertise
- For those tests where there is a direct impact on the scientific performance/calibration we expect assistance in analysis of the data and any S/W modules required for QLA
- We need to plan in verification of instrument operating modes (even if we don't have time to do the testing)
- We need to strictly pare down the test plan to only essential tests
- Please read the the Test Plan(s) and test specifications – the CQM tests are representative of what we will do on the PFM
- We will suggest a minimum set of tests – but we need affirmation that this set is o.k.

Participants

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