CURRENT SYSTEM DESIGN FOR THE CEA FILLED ARRAYS OPTION

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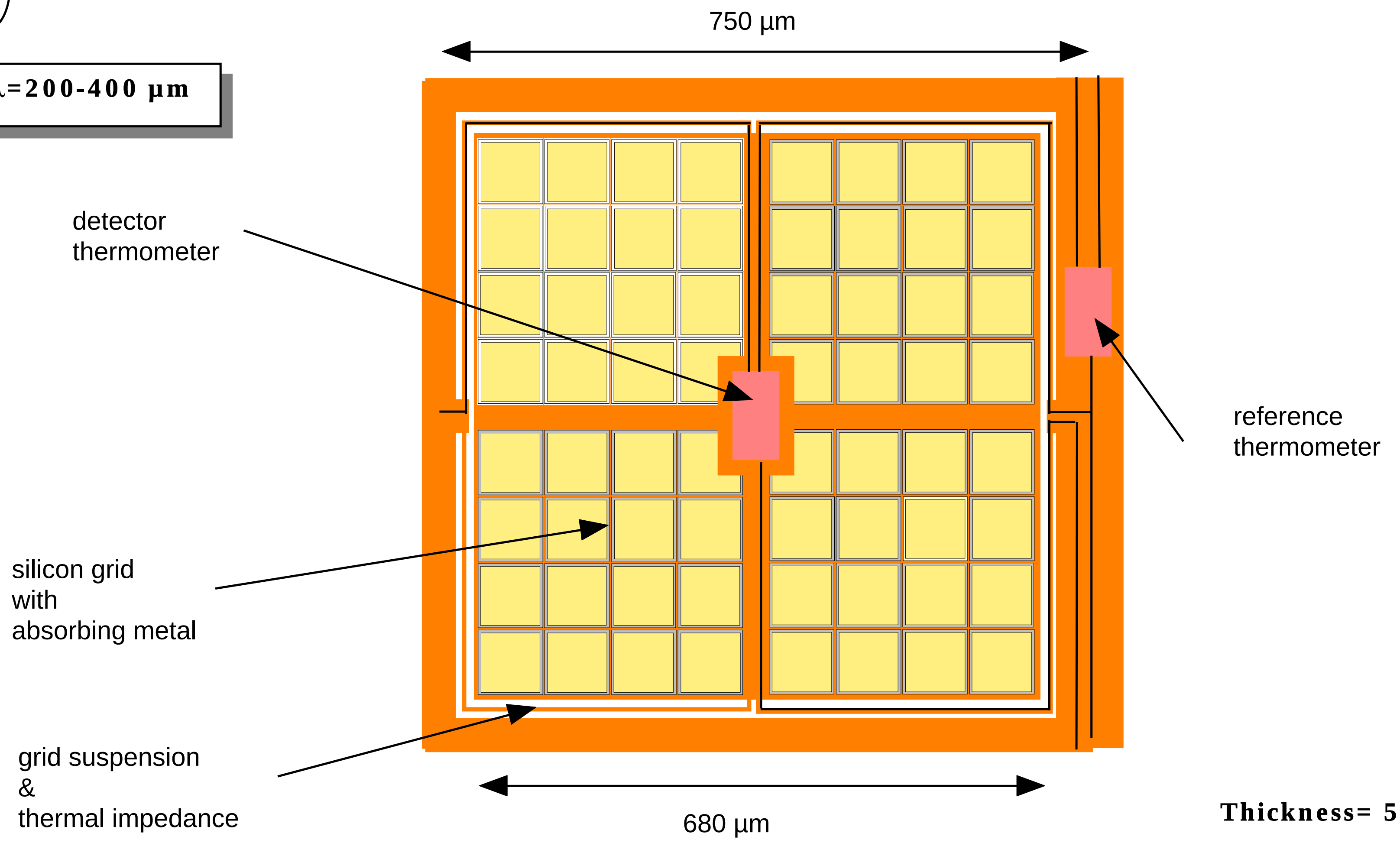
THE NEW PIXEL DESIGN

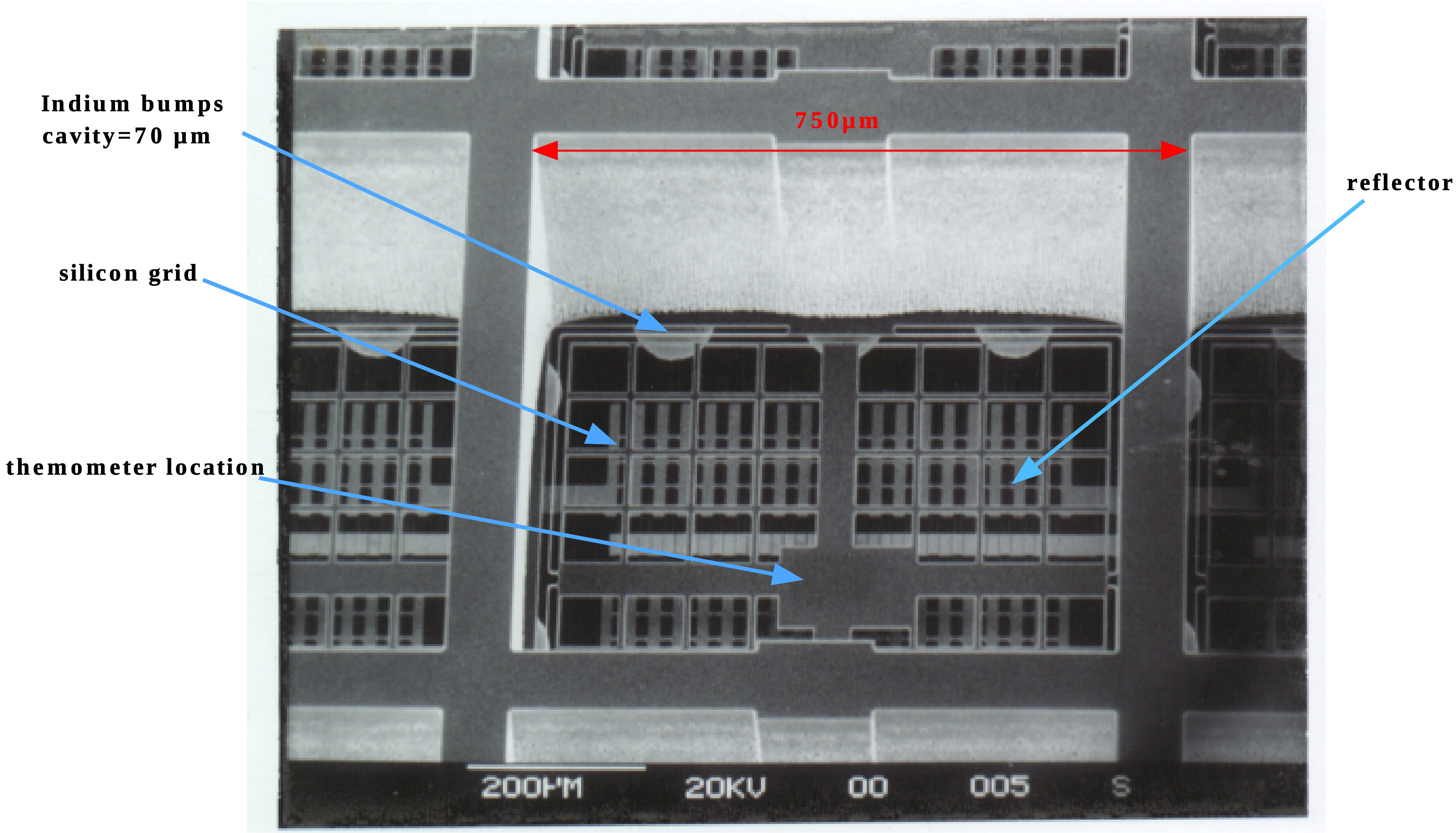
λ=200-400 μm



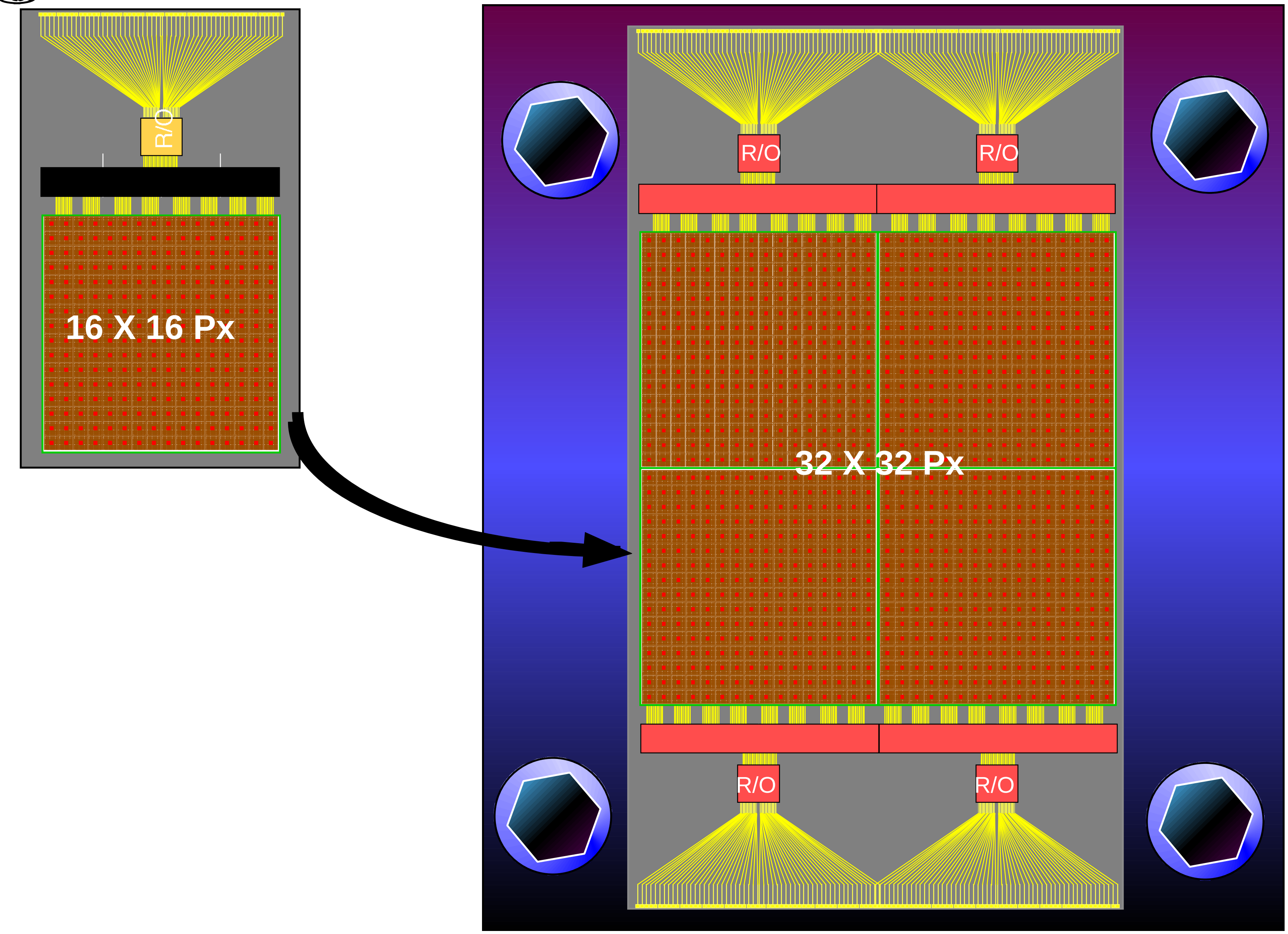
Thickness= 5μm

Main changes:
- **Pattern step size reduction 900->750 μm**
- **Slim grid to lower heat capacity**
- **Smaller suspension beams to decrease τ_{ther}**
- **Stripped reflector to lower electrical Capacitance**

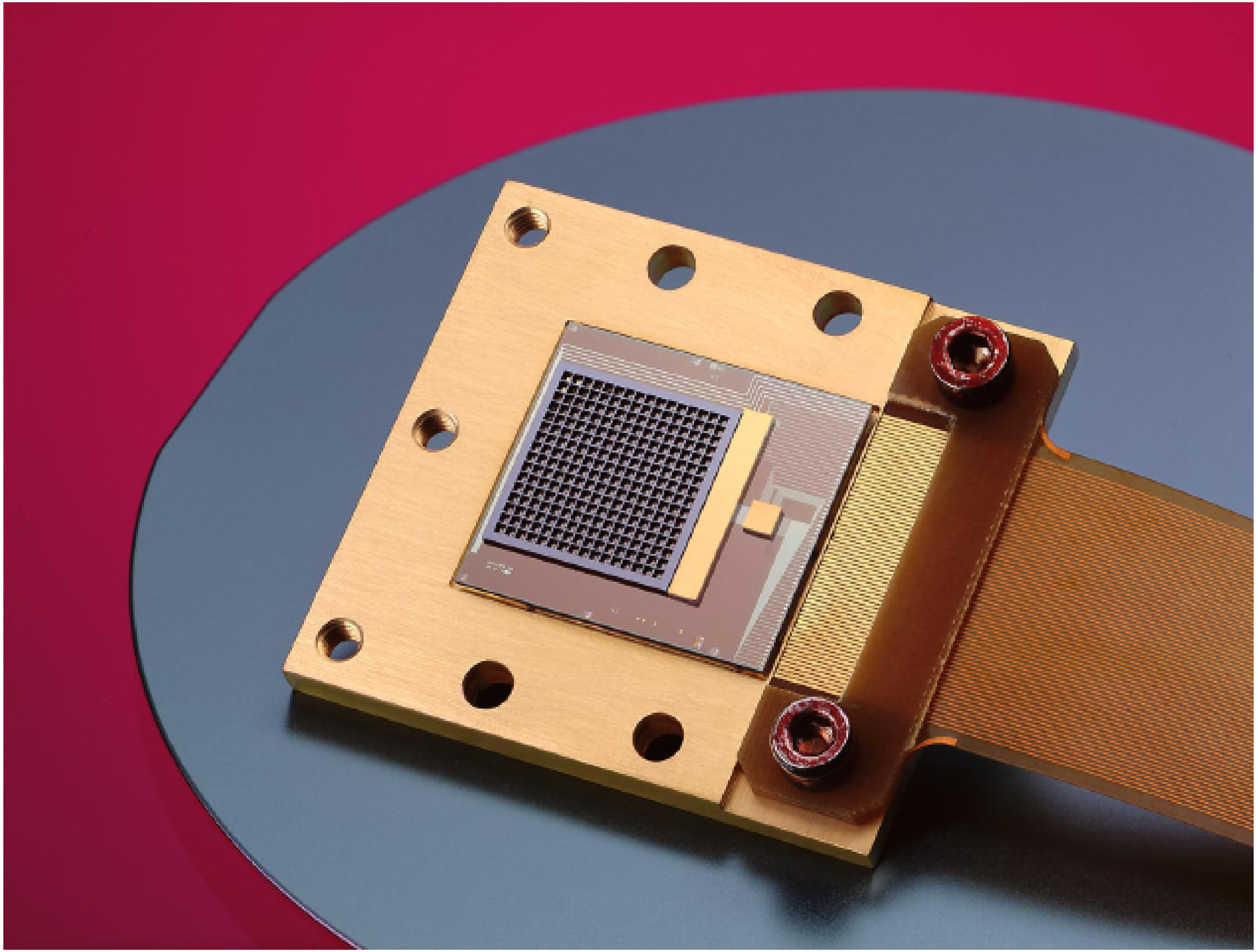
THE NEW PIXEL DESIGN



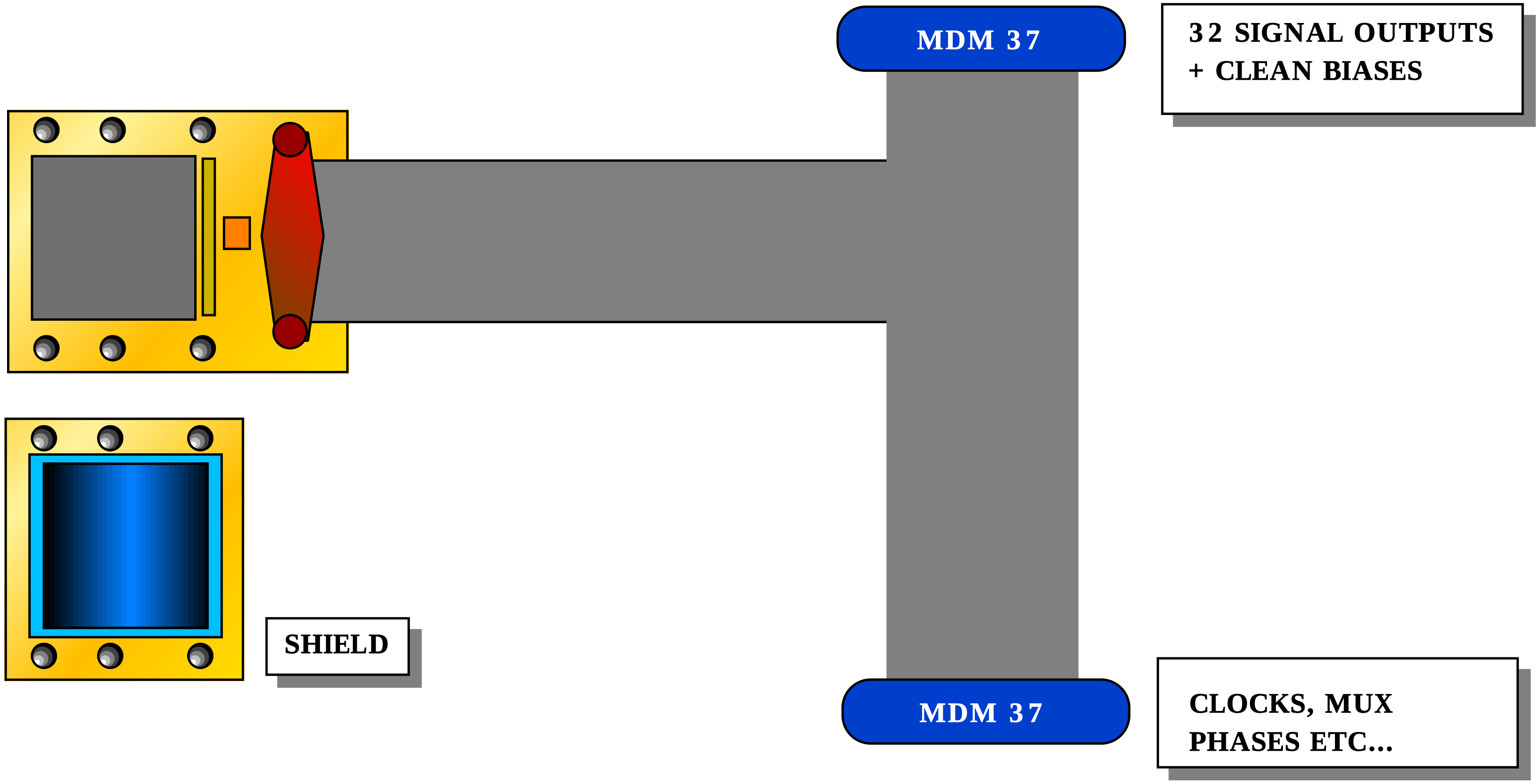
THE ARRAY CONCEPT



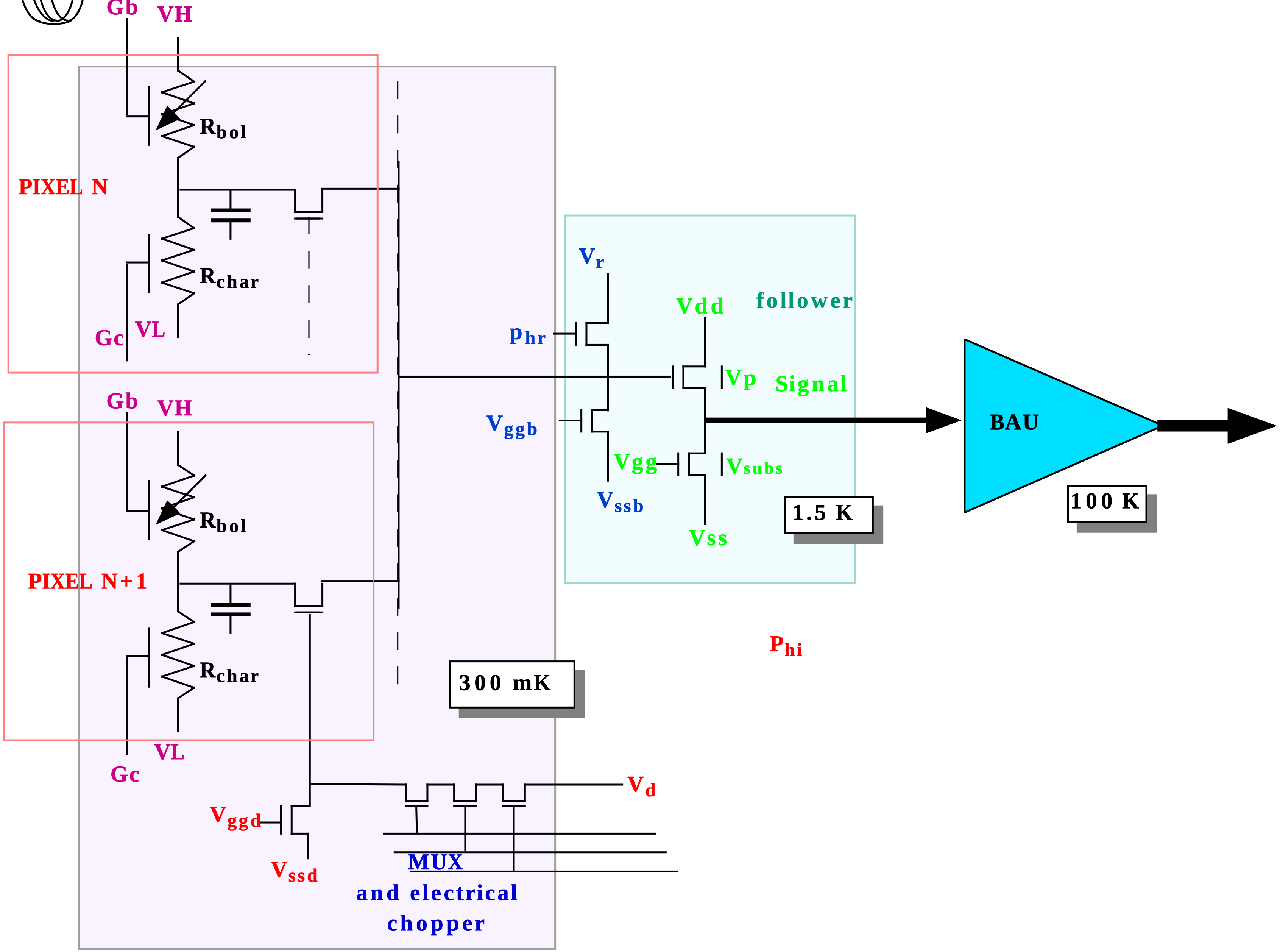
THE ARRAY CONCEPT



WIRING


MDM 37
32 SIGNAL OUTPUTS
+ CLEAN BIASES
SHIELD
MDM 37
CLOCKS, MUX
PHASES ETC...

WIRING


Gb
VH
R_{bol}
PIXEL N
R_{char}
Gc
VL
Gb
VH
R_{bol}
PIXEL N+1
R_{char}
Gc
VL
V_r
p_{hr}
Vdd
follower
Vp
Signal
V_{ggb}
Vgg
V_{subs}
V_{ssb}
Vss
1.5 K
BAU
100 K
WARM ELECTRONICS
300 K
300 mK
P_{hi}
V_d
V_{ggd}
V_{ssd}
MUX
and electrical
chopper

WIRING 4 X 4 ARCMIN 8->1 MUX

IMAGER

3 ARRAYS

	32 X32	24 X 24	16 X 16
ADDRESS	5 wires	5 wires	5 wires
DC i/o	2 "	2 "	2 "
bias	1 "	1 "	1 "
bus bias	1 "	1 "	1 "
DC bias	1 "	1 "	1 "
ref bias	1 "	1 "	1 "
bias	1 "	1 "	1 "
outputs +2 ref	132 "	132 "	36 "
main bias	2 "	2 "	2 "
followers bias	1 "	1 "	1 "
substrate bias	1 "	1 "	1 "
frame bias	2 "	2 "	2 "
ground ref	1 "	1 "	1 "
bridge bias	2 "	2 "	2 "
heater bias	2 "	2 "	2 "
TOTAL	155	155	59 wires

SPECTROMETER

2 ARRAYS

16 X 16	12 X 12
5 wires	5 wires
2 "	2 "
1 "	1 "
1 "	1 "
1 "	1 "
1 "	1 "
1 "	1 "
36 "	36 "
2 "	2 "
1 "	1 "
1 "	1 "
2 "	2 "
1 "	1 "
2 "	2 "
2 "	2 "
59	59 wires

GRAND TOTAL = 487 WIRES

WIRING FOR 8 X 4 ARCMIN 8->1 MUX

IMAGER

3 ARRAYS

	64 X32	48 X 24	32 X 16
ADDRESS	6 wires	6 wires	5 wires
DC i/o	2 “	2 “	2 “
bias	1 “	1 “	1 “
bus bias	1 “	1 “	1 “
DC bias	1 “	1 “	1 “
ref bias	1 “	1 “	1 “
bias	1 “	1 “	1 “
outputs +2 ref	262 ”	262 “	70 “
main bias	2 “	2 “	2 “
followers bias	1 “	1 “	1 “
substrate bias	1 “	1 “	1 “
frame bias	2 “	2 “	2 “
ground ref	1 “	1 “	1 “
bridge bias	2 “	2 “	2 “
heater bias	2 “	2 “	2 “
TOTAL	286	286	93 wires

SPECTROMETER

2 ARRAYS

32 X 16	24 X 12
5 wires	5 wires
2 “	2 “
1 “	1 “
1 “	1 “
1 “	1 “
1 “	1 “
1 “	1 “
70 “	70 “
2 “	2 “
1 “	1 “
1 “	1 “
2 “	2 “
1 “	1 “
2 “	2 “
2 “	2 “
93	93 wires

GRAND TOTAL = 851 WIRES

OPERATION

OPERATING TEMPERATURE :

Designed to work at 0.3 K under a 1 pW optical flux.

POWER DISSIPATION AT 2 K STAGE (per array) :

-Heat load oN ^{3}He Fridge by conduction 5µW/array --> 1.25 mW total
(assuming a 1/50 ^{3}He fridge efficiency).

-Bias on read out circuit --> 1->2 mW,

IONISING RADIATION EFFECT :

To be determined on a accelerator device on prototype bolometer. From ISOCAM a thumb rule gives 1 proton/minute /pixel and the deposited energy is around 150 eV (2.4 E-11 µJ).

PIXEL ANGULAR RESPONSE :

Large ± 40 °. Necessity of efficient baffling, but small size array.

CROSS TALK:

N/A to the nearest pixel if sampling the PSF. Important for electrical crosstalk between distant pixels.

ACHIEVABLE ARRAY SIZE :

64 X 32 Pixels (3 x 3 cm^2).

TELEMETRY :

TBD

SPIRE Requirements Issue

Important inputs for requirements are still missing :

➔ **FTS operation**

➔ **Chopper operation**

• **Scan Mode with AOCS**

• **On-board datation : resolution/accuracy**

➔ **On-board processing : instrument data rate / telemetry data rate**

• **Operating modes**

• **Degraded modes**

• **Temperature regulation (He^3)**

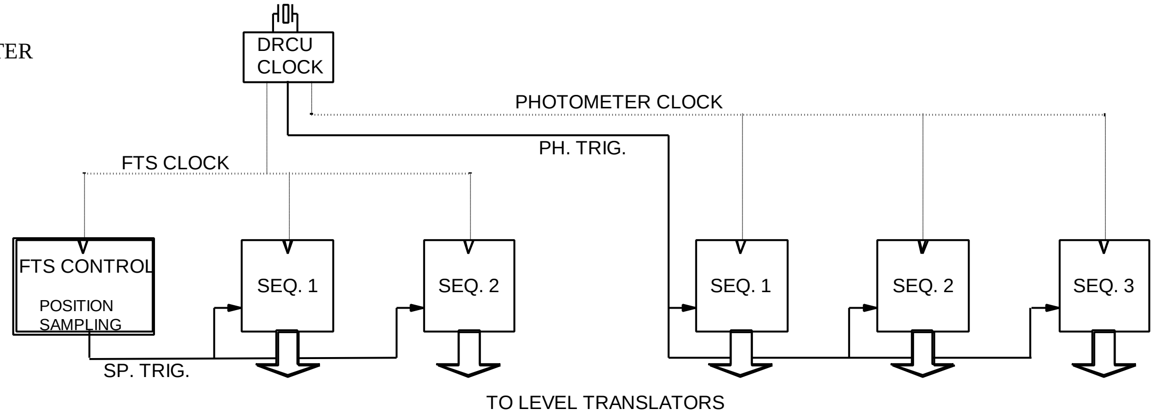
• **H/K specification (temperature, else) : how many/accuracy/rate**

FIRST/SPIRE

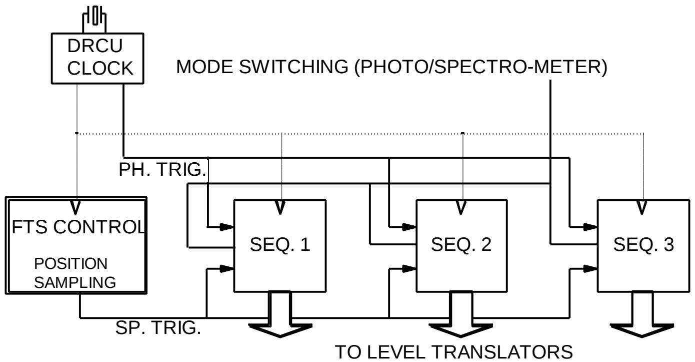
DRCU SYNCHRONIZATION TREE vs FPU CONFIGURATIONS

❶ BOLOMETER ARRAYS FOR PHOTOMETER AND SPECTROMETER ARE DIFFERENT (BASELINE)

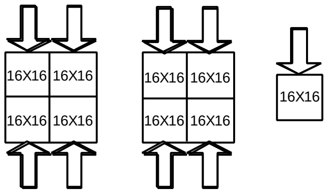
NOTE : FTS & PHOTOMETER CLOCKS MAY BE IDENTICAL

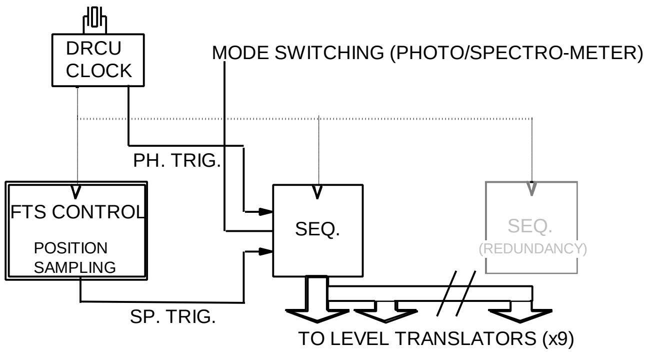


❷ PHOTOMETER AND SPECTROMETER SHARE THE 3 BOLOMETER ARRAYS (DIFFERENT ARRAY SIZES)



❸ PHOTOMETER AND SPECTROMETER SHARE THE 3 BOLOMETER ARRAYS (BASED ON MULTIPLE 16x16 ELEMENTARY ARRAYS). CEA + TES (?) OPTIONS

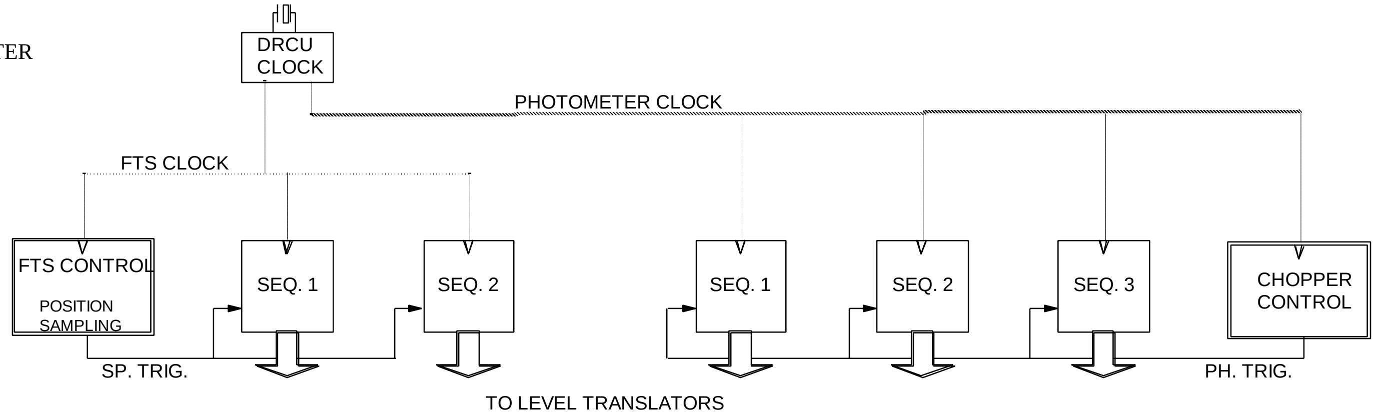




DRCU SYNCHRONIZATION TREE vs FPU CONFIGURATIONS WITH CHOPPER SYNC.

1. BOLOMETER ARRAYS FOR PHOTOMETER AND SPECTROMETER ARE DIFFERENT (BASELINE)

NOTE : FTS & PHOTOMETER CLOCKS MAY BE IDENTICAL



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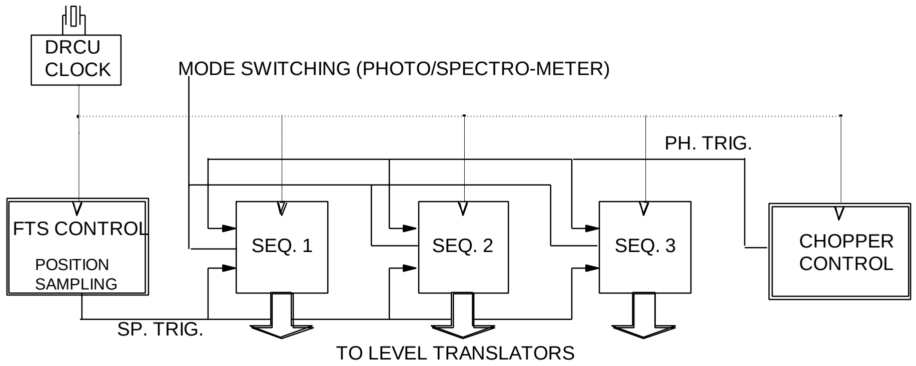

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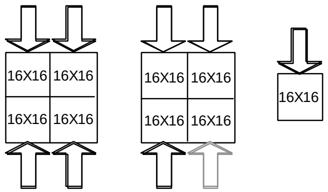
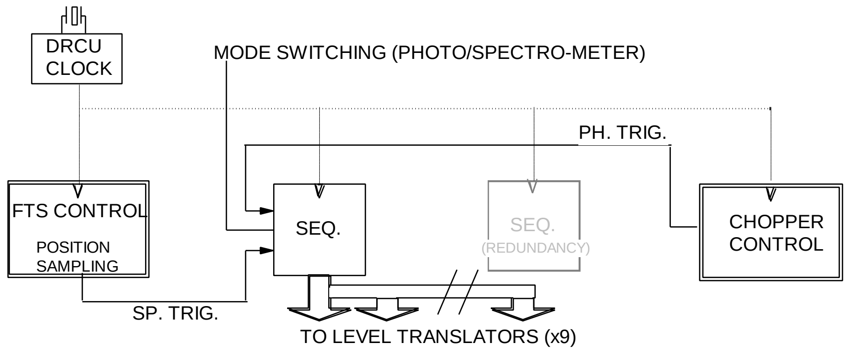




1/03/99

SPIRE Acquisition Rates

Photometer

Central Wavelength µm	Theorical array sizes	Practical array sizes	Number of pixel	Acquisition rate rate Hz [1]	Number of acq. /s	Number of bits	Data rate bits/s
250	**32x32**	32x32	1024	40	40960	14	573440
350	**24x24**	32x32	576	40	23040	14	322560
500	**16x16**	16x16	256	40	10240	14	143360
						Total (average) :	1039360

1 : Assuming a 2 time oversampling

Minimum compression factor compared to **40 kbits/s** (200 kbits/s-TBC) : **26** (5) → **Image rate = 1.5 /s**
Real compression factor will take into account data format (i.e. 3 bytes / pixel)

Spectrometer

Wavelength µm	Theorical array sizes	Practical array sizes	Number of pixel	Acquisition rate rate Hz [1]	Number of acq. /s	Number of bits	Data rate bits/s
200-300	**16x16**	16x16	256	40	10240	14	143360
300-600	**12x12**	16x16	144	40	5760	14	80640
						Total (average) :	224000

1 : Assuming a 2 time oversampling

Minimum compression factor compared to **40 kbits/s** (200 kbits/s-TBC) : **6** (1.12 !) → **Interferogram rate = 1 / 240 s**
Real compression factor will take into account data format (i.e. 3 bytes / pixel)

SPIRE Acquisition Rates

• **Dominated by the SPECTROMETER high resolution mode memory requirements (if full spectrum co-addition).**

• **Assuming a 40 second scanning duration the amount required to store one scan is :**

Number of arrays	Number of acq. /s	Quantization in bytes	Memory size in bytes
2	10240+5760	2	1280000

• **Total Memory required includes :**

- **currently acquired spectrum : 2 bytes**
- **sum of the spectra (6) : 3 bytes**
- **deglitching table : 1 bytes**

Total : 3.84 Mbytes

• **Oversampling (factor of 1.5) may be required ➔ Total with margin : 6 Mbytes**

➔ **Memory could be saved if data reduction is based on error-free data compression algorithm insteed of performing co-additions : no more need for “sum of spectro” & “deglitching” buffers.**

<u>Assumption</u> : microprocessor running at 20 MHz (clock period = 50 ns)

- **CEA Option : 125824 16-bit words /s or one pixel every 8 µs**

➔ **1 data acquisition every 160 microprocessor cycles**
➔ **DMA in not mandatory**

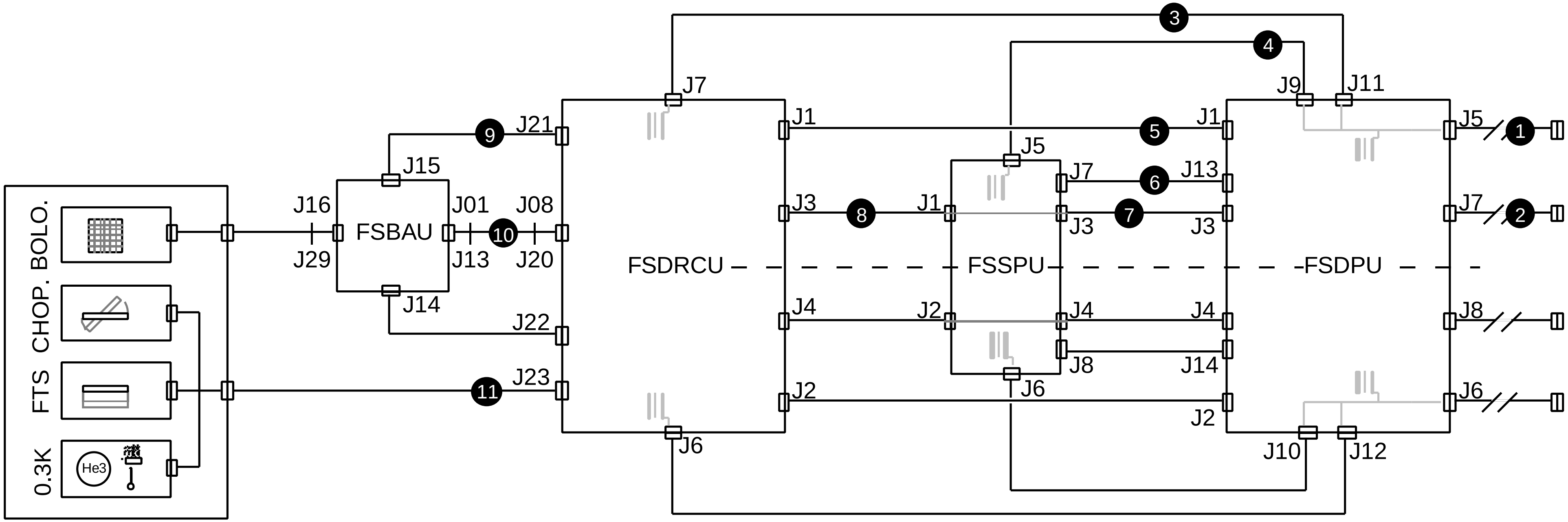
- **JPL (Feed-Horn) Option : modulated and oversampled data gives 4 Mwords/s or one pixel every 238 ns**

➔ **1 data acquisition every 4-5 microprocessor cycles**
➔ **requires DMA in the Signal Processing Unit**

- **GSFC (T.E.S.) Option : oversampled data gives 64 Mwords/s or one pixel every 15 ns**

➔ **incompatible with 50 ns clock period.**
➔ **requires data pre-processing (using hardwired electronics) in the DRCU to reduce Signal Processing input data rate (i.e. factor of 10).**
➔ **requires DMA in the Signal Processing Unit.**

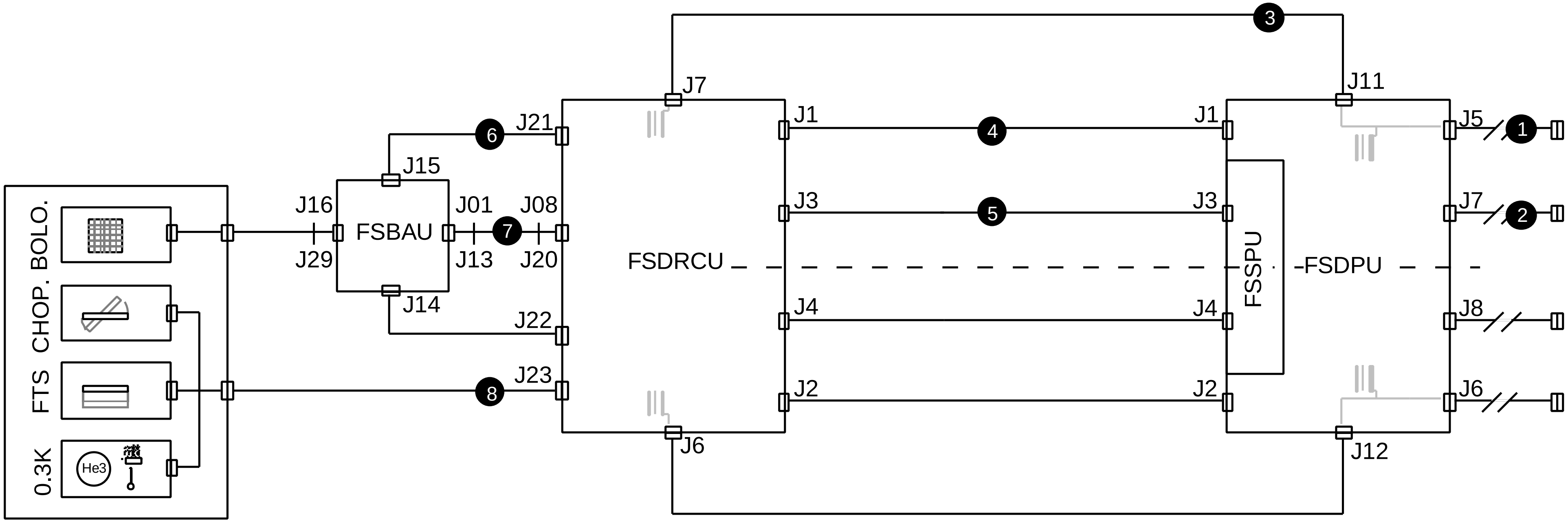
SPIRE ELECTRICAL CONFIGURATION
SPU H/W & S/W OPTION



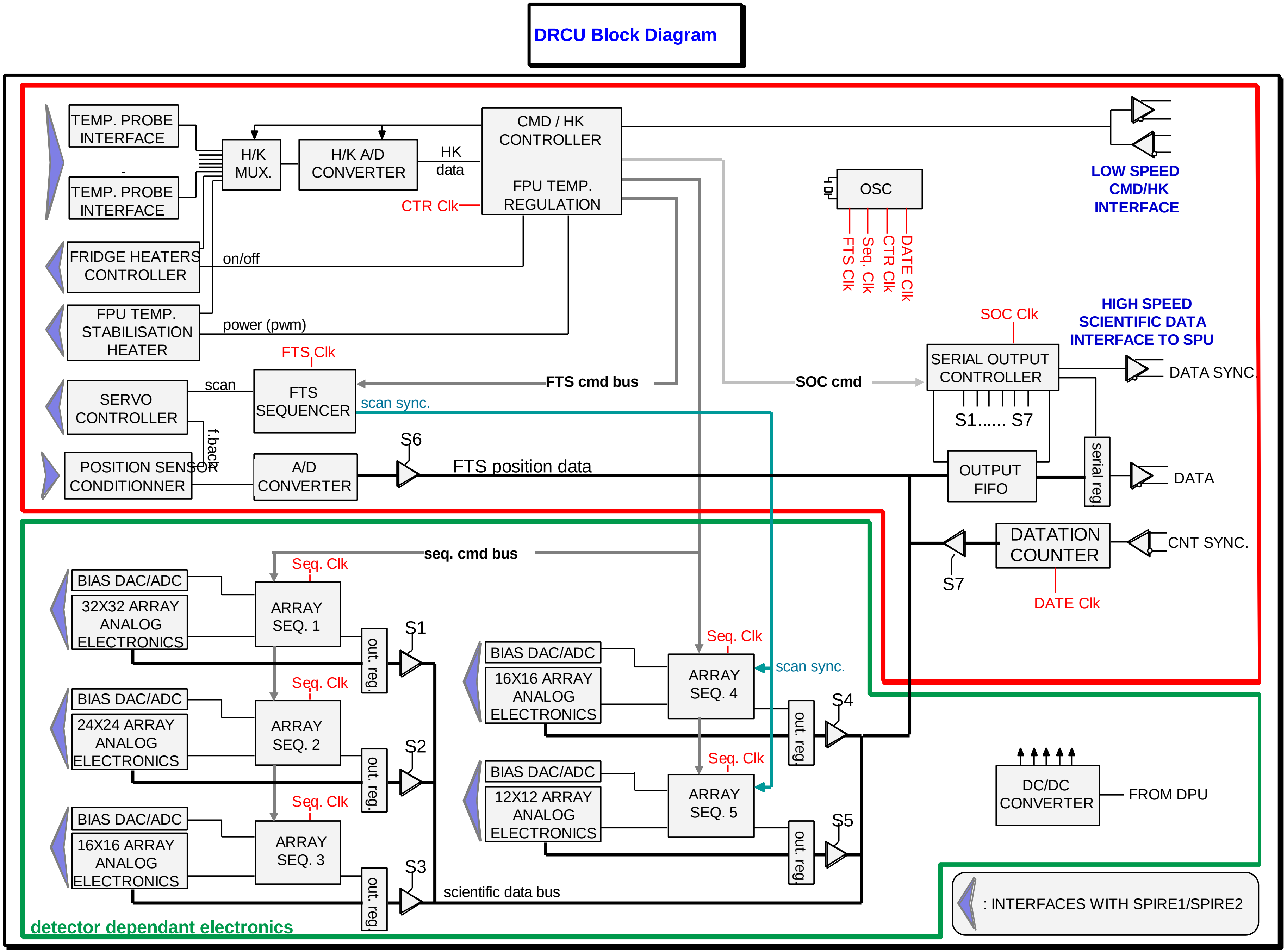
HARNESS TYPES :

1. SPIRE CMD/HK
2. SPIRE PPWR
3. DRCU PPWR
4. SPU PPWR
5. DRCU CMD/HK
6. SPU CMD/HK
7. SPU DATA
8. DRCU DATA
9. BAU SPWR
10. BAU SIGNAL
11. MECHANISMS CONTROL + HK

SPIRE ELECTRICAL CONFIGURATION
SPU S/W ONLY OPTION



1 SPIRE CMD/HK
2 SPIRE PPWR
3 DRCU PPWR
4 DRCU CMD/HK
5 DRCU DATA
6 BAU SPWR
7 BAU SIGNAL
8 MECHANISM CONTROL + HK


DRCU Block Diagram
TEMP. PROBE INTERFACE
TEMP. PROBE INTERFACE
H/K MUX.
H/K A/D CONVERTER
HK data
CMD / HK CONTROLLER
FPU TEMP. REGULATION
CTR Clk
LOW SPEED CMD/HK INTERFACE
OSC
FTS Clk
Seq. Clk
CTR Clk
DATE Clk
FRIDGE HEATERS CONTROLLER
on/off
FPU TEMP. STABILISATION HEATER
power (pwm)
HIGH SPEED SCIENTIFIC DATA INTERFACE TO SPU
SOC Clk
SERIAL OUTPUT CONTROLLER
DATA SYNC.
FTS Clk
SERVO CONTROLLER
scan
FTS SEQUENCER
FTS cmd bus
SOC cmd
scan sync.
S1...... S7
f.back
S6
POSITION SENSOR CONDITIONNER
A/D CONVERTER
FTS position data
OUTPUT FIFO
serial reg.
DATA
DATATION COUNTER
CNT SYNC.
S7
DATE Clk
seq. cmd bus
Seq. Clk
BIAS DAC/ADC
32X32 ARRAY ANALOG ELECTRONICS
ARRAY SEQ. 1
out. reg.
S1
BIAS DAC/ADC
24X24 ARRAY ANALOG ELECTRONICS
ARRAY SEQ. 2
S2
BIAS DAC/ADC
16X16 ARRAY ANALOG ELECTRONICS
ARRAY SEQ. 3
S3
scientific data bus
BIAS DAC/ADC
16X16 ARRAY ANALOG ELECTRONICS
ARRAY SEQ. 4
scan sync.
S4
BIAS DAC/ADC
12X12 ARRAY ANALOG ELECTRONICS
ARRAY SEQ. 5
S5
DC/DC CONVERTER
FROM DPU
: INTERFACES WITH SPIRE1/SPIRE2
detector dependant electronics

System Trade-offs for number of detectors

What are the limiting factors which determine how far we could extend the effective field of view of SPIRE?

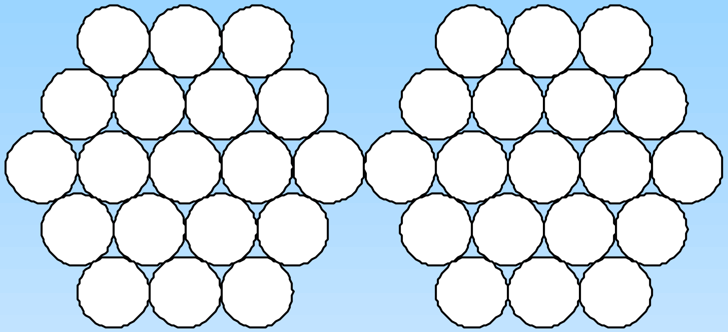
See scientific requirements -

- in summary, a 4'x8' field of view using 2Fλ horns should be given serious consideration for optimum mapping speed, if the horn option is chosen

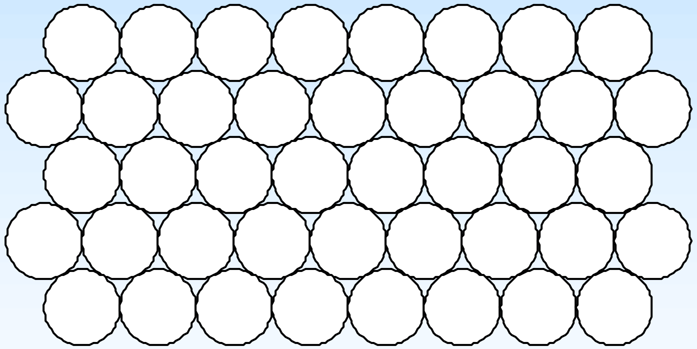
- Same applies with filled arrays, so that ideally 2 sets of 32x32, 16x16 and 12x12 arrays would be needed

SPIRE

Horn arrays: filling 4' x 8' field:



2x19 arrays= 38 detectors



42 detectors

We will need just over twice as many detectors, and conductors, amplifiers….

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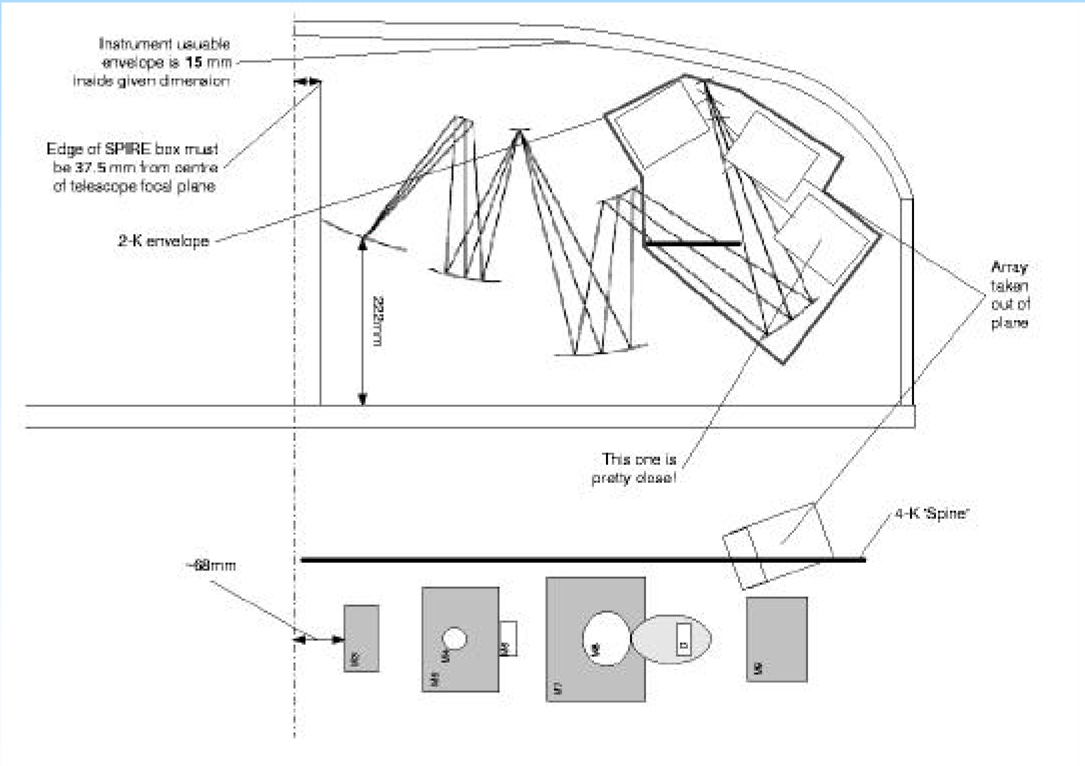
SPIRE

Optics:

It looks like 4 by 8 arcminutes is possible in the space envelope without the mirrors becoming too large, but there may be problems with space for the photometer arrays



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Signal wiring issues:

- **Inside FPU**
  - **Connectors- 37, 51 or 100 way ?**
  - **Ribbon cables - Kapton or Woven?**
- **Cold Interconnect Harness: FPU to BAU, BAU to DRC and FPU to DRC (ESA responsible)**
  - **Connectors- 37, 51 or 100 way ?**
  - **Conventional wire bundles or Ribbon cables - Kapton or Woven?**

Inside FPU

0.3-4K	4'x4' Option	4'x8' Option		
Description	Conductors	Conductors	Shields	Type
P250Signal	195	390	0/TBC	Kapton
P350Signal	123	246	0/TBC	Kapton
P500Signal	69	138	0/TBC	Kapton
S350Signal	72	144	0/TBC	Kapton
S600Signal	48	96	0/TBC	Kapton
TCBIAS	8	8	4/TBC	SST
TCSIG	8	8	4/TBC	SST
TOTAL	523	1030		

Using twisted pairs separated by ground wires.
Detector bias on Kapton ribbons

SPIRE

Cold Interconnect Harness

15-300K	4'x4' Option	4'x8' Option		
Description	Conductors	Conductors	Shields	Type
P250Signal	183	366	0/TBC	Kapton
P350Signal	111	222	0/TBC	Kapton
P500Signal	57	114	0/TBC	Kapton
S350Signal	60	120	0/TBC	Kapton
S600Signal	36	72	0/TBC	Kapton
Det Bias	20	40	10	SST
TCBIAS	8	8	4/TBC	SST
TCSIG	8	8	4/TBC	SST
TOTAL	483	950		

Using twisted pairs separated by ground wires, which may not be necessary, post JFET

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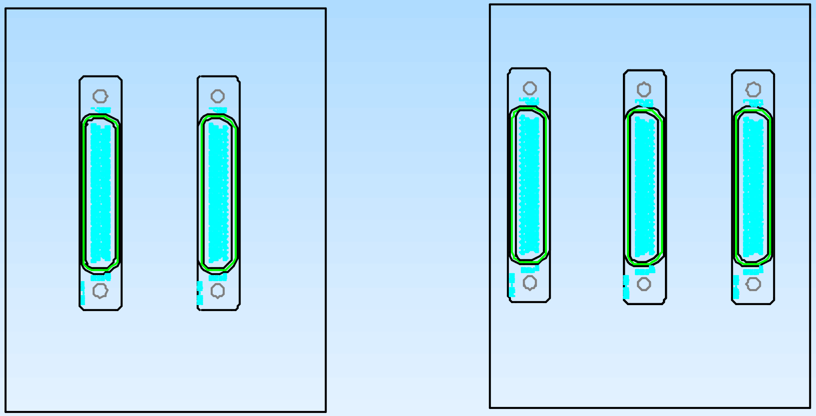
Connector options:

61 detector array: 130 pins
2 x 100w MDM

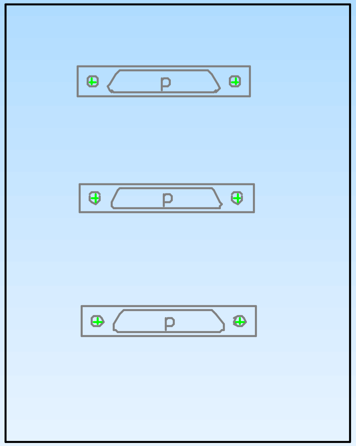
122 detector array: 255 pins
3 x 100w MDM



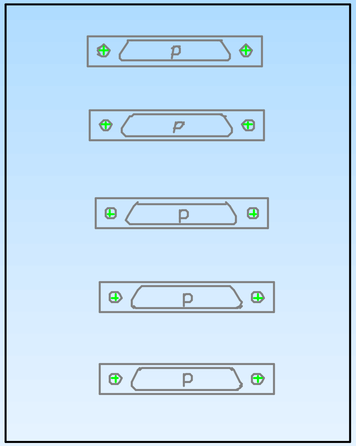
Typical space available: 95 x 75 mm

Connector options:

61 detector array: 130 pins
3 x 51w MDM



122 detector array: 255 pins
5 x 51w MDM



Using ESA-approved 37w MDMs will be even worse!

Data Rate

- **Whether we can use a higher data rate depends on the availability of x-band transponders**
- **Moving to 4'x 8' may be possible even with the current down-link: at present we assume factor 3 compression to get 25 kbps data rate.**
- **PACS assume factor 80 compression to give 40 kbps!**

SPIRE

Mass of array assemblies

- Array Mass will double
- Optics mass will increase
- BAU mass will increase
- JFET or cold electronics will increase in mass

Thermal loads

- **0.3K load due to supports will double:**

$$Q(F, M, Ey, ki) \equiv \frac{3 \cdot (M \cdot ki) \cdot (2 \cdot \pi \cdot F)^2}{Ey}$$

- **loads due to wiring will also double**

Power consumption of cold & warm electronics

SPIRE

- **Will double**
- **DRC 25 W budget is already tight for TES and horn options**
- **-but ESA say there is some room for manoeuvre - we could push towards 100W?**

Increased Costs:

- Manufacture:
  - Horns
  - Arrays
  - Cables
  - Load resistors
  - Read-out electronics
- Integration Time
- Testing Time