ALCATEL SPACE	HERSCHEL/PLANCK	REF. : H-P-ASPI-MN-534	
		DATE : 06/11/01	PAGE : / 1
COMPTE RENDU DE REUNION / *MINUTES OF MEETING*		LIEU / *PLACE* : *Cannes*	

OBJET / *PURPOSE* :

CLASSIFICATION :

EMC/POWER WORKING GROUP MEETING #12

PARTICIPANTS *ATTENDEES*	SOCIETE *FIRM*	SIGNATURE *SIGNATURE*	PARTICIPANTS *ATTENDEES*	SOCIETE *FIRM*	SIGNATURE *SIGNATURE*
SEE NEXT PAGE FOR A COMPLETE LIST					
REDACTEUR / *WRITTEN BY* :					

CONCLUSION :

DISTRIBUTION : PARTICIPANTS / *ATTENDEES*	POUR ACTION : *FOR FURTHER ACTION*
	POUR INFORMATION : *FOR INFORMATION*

APPROUVE PAR / *APPROVED BY*

NOM / *NAME*				
SIGNATURE / *SIGNATURE*				

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M052-1

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Terence BAX	—"—	—"—
Dominique YVON 6/11/2001	CEA/Saclay	33 1 69 08 3625

(*) AGENDA : SEE ANNEX I - ALCATEL TO PRESENT LCL CHARACTERISTICS TOMORROW TO ALL PARTICIPANTS

PLANCK REQUEST A DEDICATED PLANCK EMC MEETING TO DISCUSS & DEFINE PLANCK RELATED EMC MODELS. PLANCK INSTRUMENTS ARE REQUESTED TO PROVIDE THE AGENDA TOPICS. THE DATE FOR THIS MEETING IS 17TH JANUARY 2002.

(*) REVIEW OF ACTIONS. - SEE ANNEX I FOR ACTIONS SUMMARY

AI1 : LCL ALLOCATION & SIZING: THE INSTRUMENTS ARE REQUESTED AGAIN TO PROVIDE COMPLETE DATA REGARDING LCLS, (LONG PEAK / SHORT PEAK / AVERAGE). THIS DATA TO BE PROVIDED BY 15/11/2001.

AI2 : PROVIDE EMC CONTROL PLAN,

SPIRE - CLOSED
PACS - TO BE PROVIDED 15/11/01
HIFI - ALREADY PROVIDED.
LFI - TO BE PROVIDED * 15/11/01
HFI -

* SEE ANNEX II FOR A SUMMARY OF TESTS.

AI3 : LFi presents extracts of draft EMC Control Plan (to be issued soon)

ESA recalls that for RE testing, most of the RE is from the harness → test at Instrument level would be more significant than just at unit level + analysis at Instrument level.

Advice : combine tests at unit level (+) test at Instrument level.

ALCATEL & ESA REMIND THE INSTRUMENTS TO DEFINE HOW THE CS TESTS WILL BE PERFORMED AT CYRO TEMPERATURES WITHIN THE EMC CONTROL PLAN.

AI1: PROVIDE DC RESISTANCE OF WAVEGUIDES: HIFI STATE THAT THIS DEPENDS UPON THE MATERIAL USED WHICH IS PROVIDED BY ASTRIUM. – ESTIMATED BY HIFI AS 100mΩ UNLESS A DC BLOCKED WAVEGUIDE IS USED.

AI2: PROVIDE ESTIMATE NEEDS FOR SVM-CVV IMPEDANCE, FOR 4 COAX IN PARALLEL. – DC RESISTANCE = 50mΩ
IMPEDANCE VALUE TO BE PROVIDED

AI 4 TO 7: PROVIDE FREQUENCY PLAN: ASTRIUM – CLOSED
ASPI/ALENIA – CLOSED.
SPIRE – WILL BE PROVIDED 16/11/01
PACS – WILL BE PROVIDED 15/11/01

IN ADDITION LFI WILL PROVIDE A FREQUENCY PLAN — AI 1 LFI 15/11/01

HFI TO PROVIDE A FREQUENCY PLAN — AI 2 HFI 15/11/01

AI8 EXPLAIN HOW BOLA IS GROUNDED
PACS – ACTION STILL OPEN. (EMAIL HAS ALREADY BEEN SENT BUT NOT RECEIVED WILL BE RESENT 7/11/01)

AI11 IDENTIFY & PROVIDE ELECTRICAL MODELS FOR CRYO HARNESS,
ASTRIUM HAVE PROVIDED THE INFORMATION
SEE EMC/ESD ANALYSIS REPORT FOR SDR ISO.AS.1400.TN.0434
ISSUE 1 8.3.89

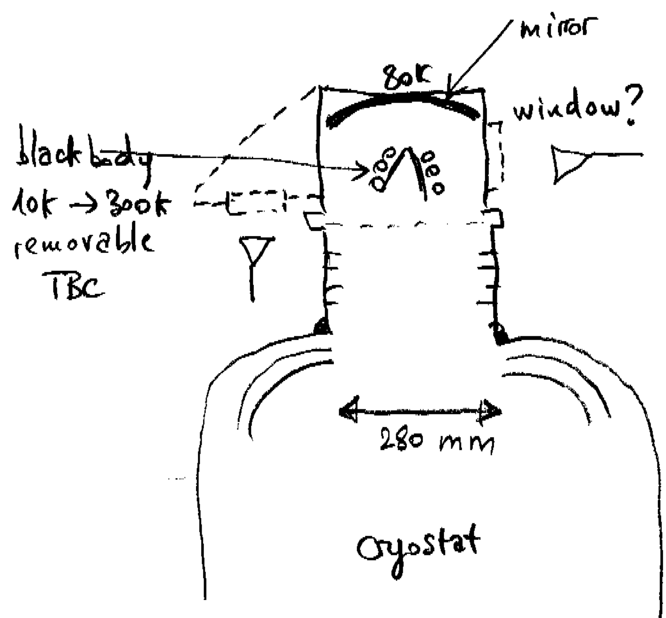
AI12 PROVIDE OVERALL GROUNDING DIAGRAM,
ALCATEL IS PREPARING THIS DIAGRAM.

(*) EMC

- NEED & DEFINITION OF RADIATED EMC TESTING AT HERSCHEL "EQM" LEVEL. - SEE ANNEX FOR EXTRACT OF SPIRE, HIFI & PACS NEEDS.

- Test can be done at room T° for HIFI (RATIONALE WILL BE PROVIDED) Not for SPIRE & PACS (need of cryogenic T°)
- SPIRE concern: very difficult to do representative RS at Instrument level.

Presentation of the foreseen "cryogenic test set up" by C. Kalde from Astrium and discussion about the way to radiate inside the "test cavity".



windows for field injection may pose straylight problems.

Nick (SRON) suggestion is to have rather radiating antenna inside.

HIFI will not use all mixers → coaxial feedthrought will be available to connected internal radiating field and internal probe.
(or it would be possible to create a need feedthrough)
Calibration would be done with cryostat open, at room temperature with standard external radiating antenna.

Not the whole frequency band from 14 kHz to 18 GHz is interesting to test in this RS configuration. (Coupling through cables, not apertures, dominates up to a certain frequency)

ASPI suggests [200 MHz (TBC) – 18 GHz].

For lower frequencies [14 kHz → 200 MHz (TBC)] RS will be done with an external antenna, in a standard way, with 2V/m.

ASTRIUM PRESENTED THEIR UNDERSTANDING OF THE EMC TEST CAMPAIGNS, SEE ANNEX III. ASTRIUM IS CONCERNED ABOUT THE ANTENNA WHICH COULD BE USED IN CRYO, WHAT WOULD BE THE REQUIREMENTS FOR THESE ANTENNA?

ESA ENCOURAGE THAT EMC RS TESTING IS PERFORMED AT EQM LEVEL.

ALL INSTRUMENTS WILL DEFINE THE REPRESENTIVITY OF THEIR EQM INSTRUMENT WITH RESPECT TO ELECTRICAL/EMC ISSUES.

AI 3 — ALL INSTRUMENTS — 15/11/01

ASPI/ASTRIUM WILL START DEFINING THE REQUIREMENTS FOR THE TEST ANTENNA TO IDENTIFY ANY PARTICULAR NEEDS FOR THE CRYO TESTS.

(*) Power

- Presentation on paper board by Bob Hibberd of LCL characteristics.

  clarifications on :

  - I_{CLASS}
  - I_{TRIP}
  - I_{LIMIT}
  - $I_{overshoot}$

  THE GOIR WILL BE UPDATED TO REFLECT THESE CLARIFICATIONS.

GROUNDING DIAGRAM

LFI PRESENTED THEIR GROUNDING DIAGRAM. SEE ANNEX IV

HFI PRESENTED THEIR GROUNDING CONCEPTS, THE DETECTION CHAIN WILL BE ELECTRICALLY INSULATED FROM STRUCTURE, (SEE ANNEX V) FROM THE 4k BOX TO THE PAU, THE GROUNDING REFERENCE BEING IN THE REU.

NEXT EMC/WORKING GROUP MEETING - WEDNESDAY 16TH JAN 2002 AT ALCATEL 09:00

PLANCK EMC WORKING GROUP MEETING - THURSDAY 17TH JAN 2002 AT ALCATEL 09:00

SUITE / *CONTINUED* :

ACTION

Presentation of Cryo-harness electric requirements by LFI. ANNEX # VIII (to be sent by email)
+ management of associated thermal constraints.
→ optimisation.

EMC aspects of cryo harness also presented:
Sensitive to external magnetic field because no twisting! Concern is HFI 4K cooler H field emission.

DY mentions that SST is less fragile for their cryo cables.

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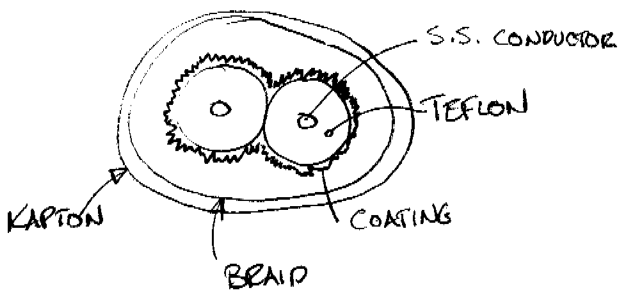
SUITE / CONTINUED : | ACTION

- HFI PRESENTED MEASUREMENT RESULTS* FOR NOISE AS MEASURED ON TWO TYPES OF CABLES WHICH WERE USED BETWEEN THE BOLOMETER AND JFET INPUTS.

  * NOT PART OF THE PLANCK PROGRAM, IT IS NOT INTENDED TO USE EITHER OF THE CABLES FOR PLANCK.

  A STAINLESS STEEL CABLE (0.1mm DIA) WITH A TEFLON INSULATOR + LOW NOISE COATING, WILL BE USED (PROVIDED BY HABIA)



- SPIRE GAVE THEIR UPDATED GROUNDING DIAGRAM, ANNEX VI

- PACS WILL PREPARE AN UPDATED GROUNDING DIAGRAM WHICH WILL BE READY BY END DECEMBER 2001 AN INITIAL DIAGRAM WAS PRESENTED, ANNEX VII

SHIELD CONNECTIONS

ESA/ALCATEL RECOMMEND THAT BOTH ENDS OF SHIELDS ARE GROUNDED ON THE SBDL CONNECTIONS. ESA/ALCATEL ALSO STATE THAT OVERSHIELDING ON SBDL CONNECTIONS IS NOT NECESSARY

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ALCATEL SPACE	**LISTE D'ACTIONS** / *ACTION ITEM LIST*	REF. : H-P-ASPI-MN-534
	OBJET / *PURPOSE* : **EMC/POWER WORKING GROUP MEETING #12**	DATE : 06/11/2001
	HERSCHEL/PLANCK	PAGE :

Origine	ACTION			DATE
	N°	Description	Responsable / *Responsible*	Echéance / *Due*
ALCATEL	1	PROVIDE FREQUENCY PLAN	LFI	15/11/01
"	2	" " "	HFI	15/11/01
"	3	DEFINE REPRESENTIVITY OF EQM INSTRUMENTS WRT ELECTRICAL/EMC	ALL INSTRUMENTS	15/11/01

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EMC/Power WG meeting #12

Cannes, 5-6 November 2001

AGENDA

- Review of actions
- Power :
  - Clarification on LCL characteristics
  - Inrush current (IID-A section 5.9.5.6.4)
- EMC :
  - Need and definition of radiated EMC testing at Herschel "EQM" level (AI H-P-ASPI-MN-406/10)
  - HIFI RS in 4-8 GHz IF band
  - Types of signals exchanged between Instrument units and shielding/overshielding/shieldings connection strategies (backshells, etc.).
    - ➔ Shield connection in balanced digital links
    - ➔ How to calculate SMA shielding?
    - ➔ Cryo-harness shields connections
  - Grounding diagrams

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EMC/Power WG meeting #12 : actions review

		Action to	Status	Closure reference
Power EMC WG meeting #11 (H-P-ASPI-MN-306)				
AI1 :	Review LCL allocation and complete/correct	(Instruments)	**OPEN** / Partially CLOSED for HIFI	email from A. Naber
AI2 :	Provide EMC Control Plan	(SPIRE/PACS)	CLOSED for SPIRE	SPIRE-RAL-DOC-???
AI3 :	Provide EMC Control Plan	(LFI/HFI)	**OPEN**	
AI4 :	Comment HIFI EMC test results	(ASPI)	CLOSED	H-P-ASPI-LT-447
EMC WG meeting Herschel/Cryostat (H-P-ASPI-N-311)				
AI1 :	Provide details of DC resistance of waveguides	(HIFI)	**OPEN**	
AI2 :	Provide estimate of needs for SVM-CVV impedance	(HIFI)	**OPEN**	
AI3 :	Provide estimate of the electrical resistance of cryo harness	(Astrium)	CLOSED	HP-2-ASED-0090/01
AI4 to 7 :	Provide frequency plan	(SPIRE, PACS, ASPI+Alenia, Astrium)	CLOSED for Alenia and Astrium	HP-2-ASED-0090/01 email from E. Ciancetta
AI8 :	Explain how BOLA chassis is grounded	(PACS)	**OPEN**	
AI9 :	Evaluate ISO model for internal cryostat grounding	(Astrium)	CLOSED	HP-2-ASED-0090/01
AI10 :	Identify (& provide) samples of ISO cryo cables	(ESA + Astrium)	Partially CLOSED for Astrium CLOSED for ESA (no samples)	HP-2-ASED-0090/01 email from B. Jackson
AI11 :	Identify (& provide) electrical models for cryo harness	(ESA + Astrium + ASPI)	Partially CLOSED	HP-2-ASED-0090/01
AI12 :	Provide overall grounding diagram	(ASPI)	**OPEN**	
Herschel EQM AIV meeting (H-P-ASPI-MN-406)				
AI11 :	To perform and circulate an evaluation of the EMC level inside cryostat"	(ASPI)	CLOSED	H-P-ASPI-LT-512

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EMC/Power WG meeting #12 : Power

- Clarification on LCL characteristics (Bob Hibberd)
- Inrush current
  - IID-A 2/0 section 5.9.5.6.4 : *"Inrush current is limited by the spacecraft PDU LCL to a maximum of 1.5 times the short peak value. At LCL switch-on, the inrush current is limited by PDU LCL as well as the inductance in the user input circuit.*
    Inrush current is limited by the PDU LCL to a value between the instantaneous peak value and 1.5 times the instantaneous short peak value.
    *Inrush current duration is set [by?] the PDU LCL. To prevent LCL trip-off, users shall limit the inrush current duration to a maximum change [charge?] of 5A*msec (TBC).*
    LCL users shall limit the rate of change of inrush current to 1A/µs."
  - Comments :
    - ➔ Text to be updated :
      - limitation of current slope to 1A/µs ensured by the LCL, not necessarily by the user alone
      - 5A*msec = 5 mC too high
    - ➔ Requirements on user inrush current at switch ON to be introduced in the § 5.14 EMC :
      - "plug-in" current specification (switch ON by an external relay)
      - inrush current specification (switch ON by an external LCL)

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EMC/Power WG meeting #12 : Power

Inrush current (cont'd)

- **Plug-in current specification** (switch ON with an external bounce-free relay set between the LISN and the user on the positive power line) :
  - The recorded inrush current shall show the following 2 distinct aspects :
    - A plug-in current transient corresponding to the charge of the primary filter capacitors
    - A DC/DC converter start current transient
  - Plug-in current transient requirements :
    - S(I*dt) < **2 mC**
    - dI/dt < **2 A/µs**
    - I peak < **30 A**
  - DC/DC converter start current transient requirements **(TBC)** :
    - shall not exceed the user line LCL current limitation value for a total time higher than (trip-off time / 2)
    - shall comply with : S(I*dt) < (LCL current limitation value)*(trip-off time / 2)

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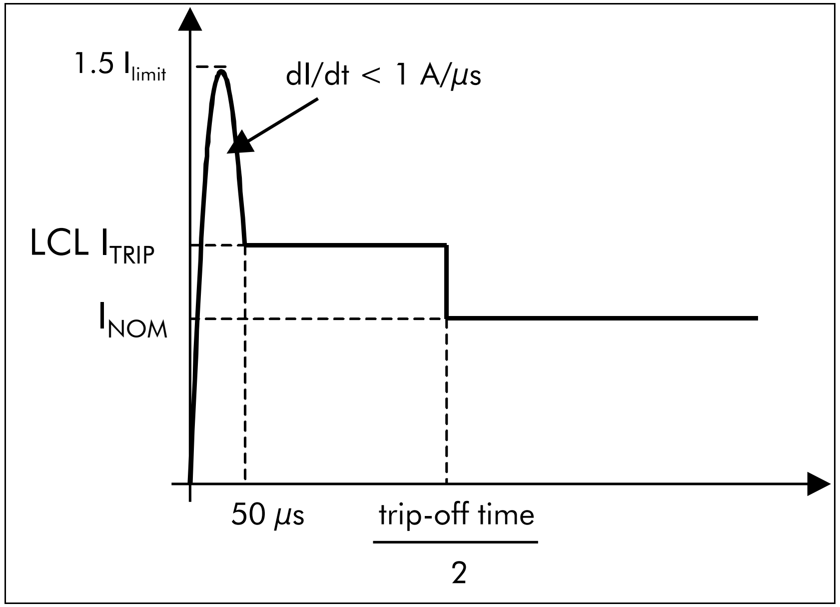
EMC/Power WG meeting #12 : Power

Inrush current (cont'd)

- **Inrush current specification** (switch ON with an external LCL set between the LISN and the user) :



A trip-off time / 2 = **5 ms** (TBC) shall be assumed.

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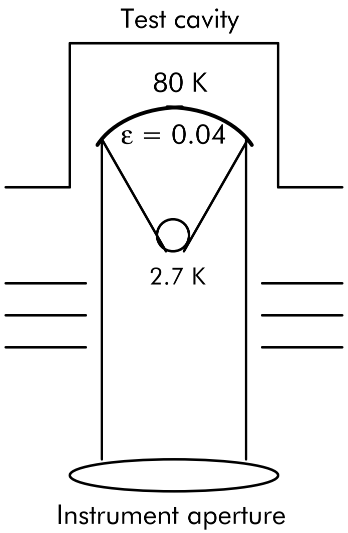
EMC/Power WG meeting #12 : EMC

- Need and definition of radiated EMC testing at Herschel "EQM" level (AI H-P-ASPI-MN-406/10)
  - Extracts of Herschel EQM AIV meeting (1&2/10/2001) :



➔ **SPIRE** : **(slides)** “An analysis of SPIRE verification requirements […] has shown that we can do all the required testing at Instrument level, with the exception of […] System level EMC testing - most especially **radiative susceptibility tests** […] We would like therefore to carry out system tests in the **EQM cryostat** to complete the instrument verification for […] EMC”.

➔ “The EMC environment in the cryostat has to be fully representative of the Herschel cryostat and demonstrated to be so by modelling or analysis”.

➔ “SPIRE is far more concerned about RFI corrupting the detection and readout circuit than in the more routine units on the SVM, Bolometers are sensitive to 1pW, RFI currents cause ohmic heating to the bolometers which becomes indistinguishabble to the readout circuit”.

➔ **(minutes)** “If needed, the RF source shall be installed in the Herschel test cavity for RS testing”.

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EMC/Power WG meeting #12 : EMC

- Need and definition of radiated EMC testing at Herschel "EQM" level (AI H-P-ASPI-MN-406/10) (cont'd)
  - Extracts of Herschel EQM AIV meeting (1&2/10/2001) :
    - ➔ **HIFI** : **(slides)** "HIFI viewpoint regarding cQM tests […] Test of conducted & radiated **EMC is THE most useful aspect** […] **Radiated most important** […]".
    - ➔ "Alcatel EQM objectives reviewed […] **THE** most critical aspect for HIFI, **radiated susceptibility**, is not tested.
      This will not be tested until Herschel FM is assembled. A problem discovered at that stage will be an **unmitigated disaster**.".
    - ➔ "Proposed RS EMC Strategy : […] either full RS EMC test of representative S/C […] or
      - test/calculate shielding efficiency of cryostat" - can be at room temp
      - determine RS sensitivity of HIFI FPU - can be at room temp, HIFI AIV
      - combine the above to determine allowed EM field at the SVM
      - compare result with expected/measured EM field at the SVM
    - ➔ **(minutes) "EMC […] can be evaluated at room temperature => HIFI position = STM seems Ok !"** (if no RS at EQM level is foreseen).

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EMC/Power WG meeting #12 : EMC

- Need and definition of radiated EMC testing at Herschel "EQM" level (AI H-P-ASPI-MN-406/10) (cont'd)
  - Extracts of Herschel EQM AIV meeting (1&2/10/2001) :
    - → **PACS** : **(slides)** "During ILT, two specific test sequences required for certain EMC measurements will be developed. During EQM, performance of these sequences will allow verification of certain EMC requirements.
      Note : EQM EMC testing might very likely require both types, conductive and **radiative** measurement (details TBC)".
    - → **Conclusion/Discussion** : **(minutes)**
      "The main open point are : Representativeness of the test set-up regarding EMC testing […]".
      "The baseline is to perform only CE and CS due to the expected shielding of the cryostat w.r.t. radiative environment […] in bandwidth [10 kHz - 10 MHz]".
      "**Regarding radiated testing, the need and the definition shall be an outcome of the EMC working group**".
      "**The implementation of this test shall be addressed by Astrium after the EMC WG decision**".

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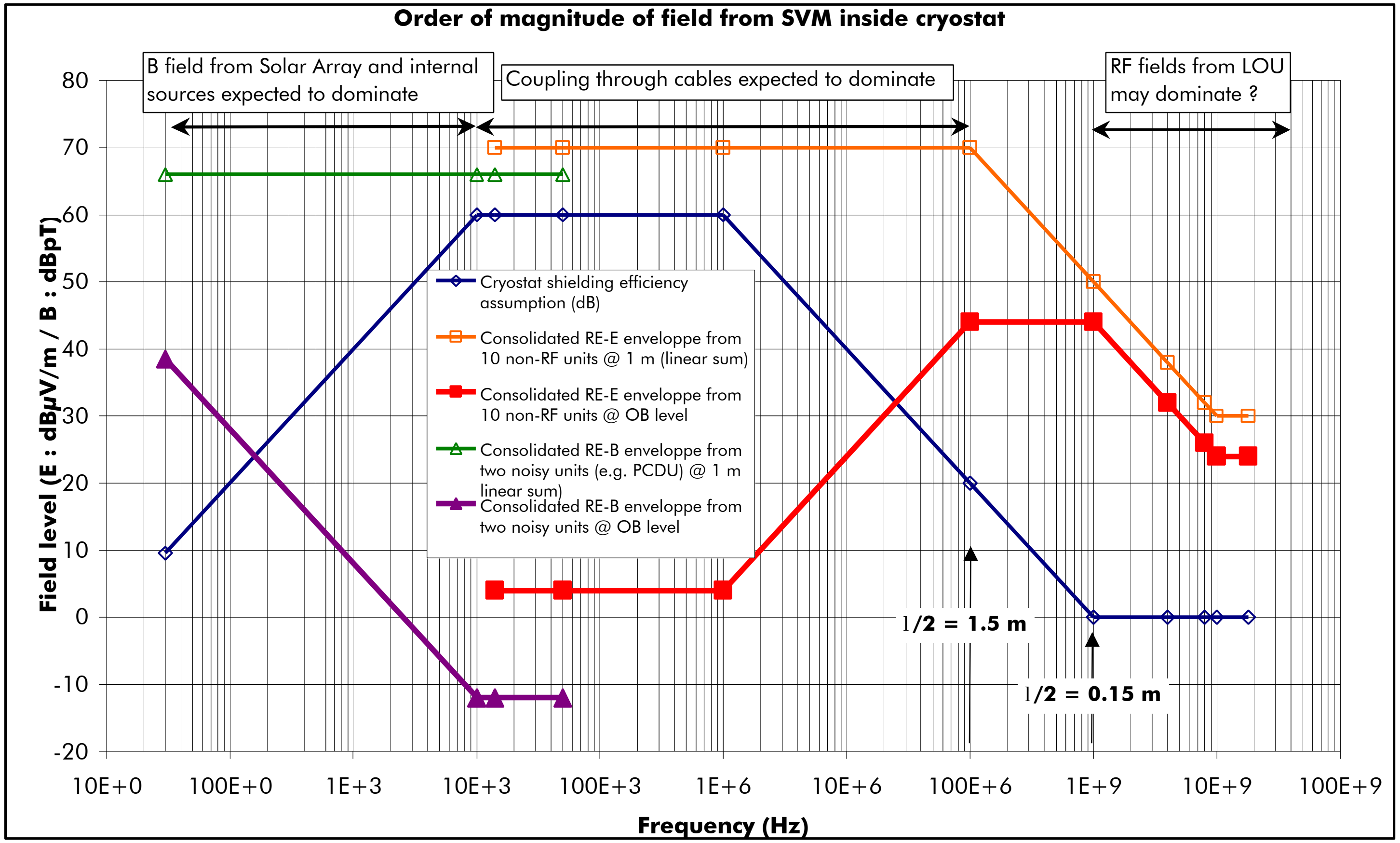
EMC/Power WG meeting #12 : EMC

- AI H-P-ASPI-MN-406/11 (Herschel EQM AIV Meeting) :
  "to perform and circulate an evaluation of "EMC" level inside cryostat"



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EMC/Power WG meeting #12 : EMC

HIFI RS in 4-8 GHz IF band

- Principle of **RS relaxation from 2V/m to 2mV/m (66 dBµV/m) in IF band [3.5 - 9 GHz]** agreed by ASPI and ESA, provided that the actual susceptibility thresholds are measured, should they be higher than 2mV/m.
- Outcomes of EMC Implementation Assessment meeting (29-30/10/01, SRON-U) :
  - ➔ Relaxation sufficient for HRS
  - ➔ Relaxation sufficient for WBS
  - ➔ Relaxation may not be sufficient for FPU (IF signal susceptibility threshold = **-160 dBm**), from B.J. v L. / P.J. d G. synthesis :
    - Negligible S.E. of cryostat
    - MSA S.E. limited by Optical and LO hole : S.E. ~5 dB
    - Mixer unit : tested AF ~ 67 dBm^{-1} (for a particular mixer unit)
      Give me a favor, use S.E. ! → S.E. (dB) = AF(dBm-1) + 20logλ - 19.76 ~ 21 dB
    - P_R(dBm) = E(dBµV/m) - SE(dB) + 10log($\lambda^2/4\pi$) -115.76 =
      = 66 - 26 - 33.5 -115.76 ~ **-109 dBm** : **roughly 50 dB are missing**

➔ **HIFI to go on considering possible improvements (+10 dB? +20 dB? +30 dB?)**

➔ **ASPI and ESA to consider further relaxation and/or system margin reduction and/or analyses refinement**

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EMC/Power WG meeting #12 : EMC

- Types of signals exchanged between Instrument units and shielding/overshielding/shieldings connection strategies (backshells, etc.).
  - Shield connection in balanced digital links :
    - Alcatel advice :
      - connection of the STP shields to chassis at both ends
      - overshield not necessarily useful
    - Standard practice on Alcatel Spacecraft's
    - Limits radiated emission
    - Limits impedance mismatching
  - How to calculate SMA shielding?
    (question from HIFI EMC Implementation Assessment meeting)
  - Cryo-harness shields connections
    - Technology ?
    - Backshells ?

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EMC/Power WG meeting #12 : EMC

Grounding diagrams

Reminder : Instruments were requested to use standard symbols presented at the last EMC WG meeting. Although it is understood that some more may be necessary (e.g. "analogue ground"), they should be limited to the minimum.

Problem common to all Instruments is protection of sensitive lines (detectors signals or bias lines) against common mode noise.

- **LFI** : draft was handed over by M. Miccolis at "LFI / HFI Satellite interfaces meeting" and commented
- **HFI** : the grounding diagram from IID-B does not include
  FPU ➔ JFET ➔ PAU ➔ Analogue REU grounding (but presented in Instrument meeting).
  Bolometer detectors : possible synergy with Herschel/SPIRE ?
- **HIFI** :
  - ➔ Clear grounding diagrams are available from IID-B
  - ➔ Note "Filtering of FCU - IF amplifiers interface", SRON-U/FCU/TN/2000-003, about to be updated with frequency dependant noise criterion

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EMC/Power WG meeting #12 : EMC

Grounding diagrams (cont'd)

- **SPIRE** :
  - ➔ Grounding diagram from IID-B 2.0 very dense and presenting dark zones (especially at DCU level) …
  - ➔ "Grounding and screening philosophy" described in document from J. Delderfield, dated 3/04/2001: trade-off for bolometer "analogue ground" connection to chassis :
    - at BDA ? (via 300mK cold plumbing and sorption cooler straps)
    - at DCU ? ("analogue ground" at BDA isolated by sapphire)

  (avoid ground loop to ensure low frequency common mode rejection)

  "Computer grounding model" + test verifications expected to resolve trade-off

- **PACS** :
  - ➔ Grounding diagrams in "System Grounding Diagrams", PACS-ME-LI-006, Issue 1, 19/02/01 (to be annexed to IID-B), but does not include FPU grounding diagrams
  - ➔ Photoconductor (spectroscopy) FEE ➔ DEC interconnection/grounding proposal presented at last meeting with lots of question marks.Also presented by Terence Bax on paper board. To be completed/confirmed and included in IID-B.
  - ➔ Bolometer (photometry) grounding diagram ?

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EMC / POWER WORKING GROUP. ANNEX II

1.1.1 Conducted Tests

Test Name	LFI	RAA	DAE	REBA	Note
Conducted Emission					
Power lines Diff. Mode NB	A	T	T	T	
Power lines Comm. Mode NB	A	T	T	T	
Power lines Diff. Mode Ripple Ampl.	A	T	T	T	
Conducted Susceptibility					
Power lines Diff. Mode steady state	T	T	T	T	
Power lines Comm. Mode steady state	T	T	T	T	
Signal lines Comm. Mode	T	T	T	T	
Signal Ref. Comm. Mode steady state	T	T	T	T	
Signal lines Comm. Mode transient	T	T	T	T	
Power lines transient	T	T	T	T	

1.1.2 Radiated Tests

Test Name	LFI	RAA	DAE	REBA	Note
Radiated Emission					
E-Field NB	A	T	A	T	
H-Field NB	A	T	A	T	
Radiated Susceptibility					
E-Field NB	A	A	T	T	
H-Field NB	A	A	T	T	

1.1.3 ESD Tests

Test Name	LFI	RAA	DAE	REBA	Note
Arc discharge Susceptibility					
ESD	A	A	T	T	

3. Testing Approach

3.1 Configuration and Environments

	EQM Integrated Module	PFM Integrated Module	PFM Herschel
Configs:	• ISO Cryostat • Flight Optical Bench • Flight spare FPUs/Outer CVV electronic and CVV instrumentation • CVV inner cryo harness, el. representative • CVV outer testharness, el. representative • CVV Cover closed • Avionics Modules (no SVM) • No telescope, no sunshield/sunshade	• Full flight configuration except: • - CVV cover closed • - No Telescope • - No sunshield/sunshade	• Full flight configuration except: • - CVV cover closed
Facility:	• Cleanroom 100000	• Cleanroom 100000	• Cleanroom • Anechoic Chamber **Cleanliness and impacts to be clarified for RS/RE tests**
Operats:	• Reference RF/IR sources **(tbd/tbc by INSTRUMENTS) ?**	• Reference RF/IR sources **(tbd/tbc by INSTRUMENTS) ?**	•

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3.2 Testing Baseline Proposal for EQM and PFM

	EQM Integrated Module	PFM Integrated Module	PFM Herschel
Tests:	Conducted Tests: • PLM CE (no test limits) on PLM units, primary power and secondary power • PLM CS on PLM units, primary power	Conducted Tests: • PLM CE (no test limits) on PLM units, primary power and secondary power • PLM CS on PLM units, primary power	Conducted Tests: • CE in general, inside satellite (no test limits)
	Radiated Tests: • none (X)	Radiated Tests: • none	Radiated Tests: • RE E- and H-field, 14 kHz to 18 GHz • RS (tbd PLM configurations)

(X): ASPI Requested to perform a "CS simulated RS" test or RS test

ASG :

1. **RS test not in baseline proposal**
2. **"CS simulating RS" level prediction analysis not covered by baseline proposal (EMC spec was not issued/applicable for ASG proposal)**
3. **"CS simulating RS" test could be done (if the effort is in the frame expected for a standard CS test).**

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Discussion "CS simulating RS" Level Analysis vs. Standard RS Test for EQM Integrated Module

"CS simulating RS" Level Analysis:

- Based on specified radiated environment, both for H-and E-field. ☹
  6 dB margin to real field?
- Based on geometrical architecture/structure model (coupling loop length, height) for the prediction of induced voltage Vi. 12 dB uncertainty ? ☹
- Electrical modelling of harness, interfaces and structure: 12 dB uncertainty? ☹
- Easy and quick performance of test! ☺
- And, when the test fails? ☹

Standard Module RS test

- FPUs somehow shielded from the CVV outer environment (H and E-field): 😐
  Attenuation of CVV Structure (flight representative)
  Attenuation of Apertures (flight representative)
  Harness Couplings into CVV (flight representative)
  CVV cover closed (non-representative ----------------**see "option"**-----

Avionics modules not flight representative with impact on RE (to be minimised not to influence the module RS results). 😐

- Anechoic chamber or specifically prepared integration site needed (absorbers, shields) -feasibility tbc/tbd ☹

 © Astrium

"Option": Specific Cryogenic Test Adapter

- can be put on a specific "MGSE" provided by the supplier of the cryostat cover (tbc) to test e.g. the opening and closing of the cryostat cover under vacuum conditions". This specific "MGSE" can be seen as EMC/electrical equivalent to the "straylight-trap" between telescope and CVV opening of HERSCHEL PFM.

- can be used on EQM only. The PFM will be equipped with the "straylight-trap" on which the adapter cannot be used due to mechanical reasons.

- contains a background cold mirror of (e.g.) solid Al, not to overdrive the FPUs during testing
- contains a "tuneable" blackbody (10K ... 300K) that could be removed (tbc/tbd) to increase the

free-space in order to place a RF RS antenna or make the optical path to external antenna free (tbd).

The **Cryogenic Test Adapter** can/could be modified and/or re-built to fulfil the objectives of an RS test on the CVV interiors (FPUs and correlating CVV internal cryo harness)

 © Astrium

Ideas:

- use" of the a specific **Cryogenic Test Adapter** as needed for the Dark Background measurement, to
  - replace the black body by an antenna?
    - area available too small for a standard antenna
    - other types of quite small antennas operating in tbd Hz to tbd Hz?
  - remove the black body and use an specifically optical aperture in the adapter to couple RF in?
    - aperture diameter?
    - specific geometry of the cover for RF coupling purposes?
    - requirements on the cover from instruments side (field of view at tbc K)?
- "New" specific **Cryogenic Test Adapter** just for RS tests ?
  - place antenna in?
    - same points as from above
  - aperture in adapter
    - same points as above

- "Definitions" of environments and test
  - RS test levels (E-field, H-field, tbc) and frequencies
  - Fail/pass criteria and corresponding means necessary for calibration, alignment, data processing (quick-look)
  - specific CVV operations tbc
  - any restrictions

-DISCUSSION-

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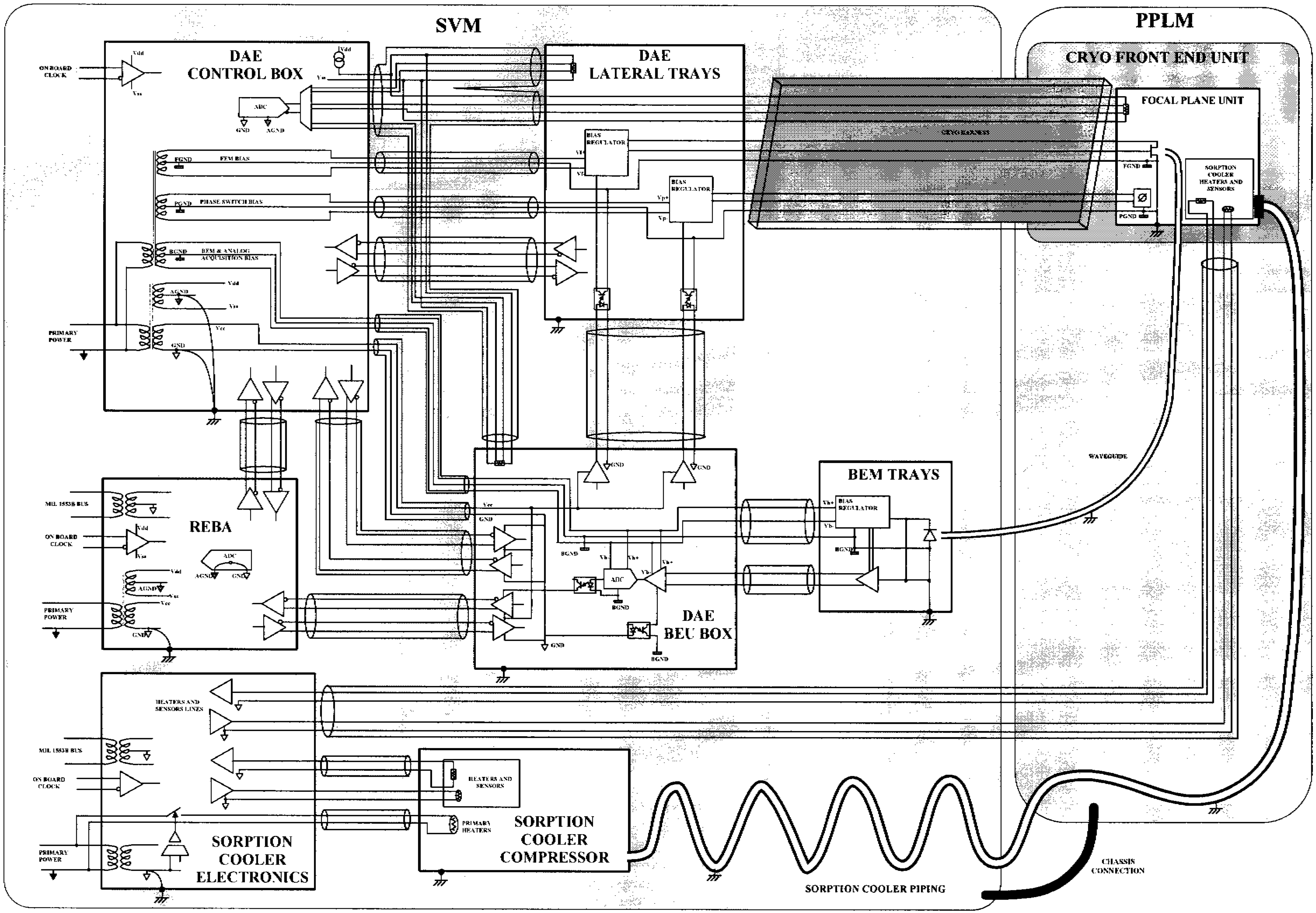
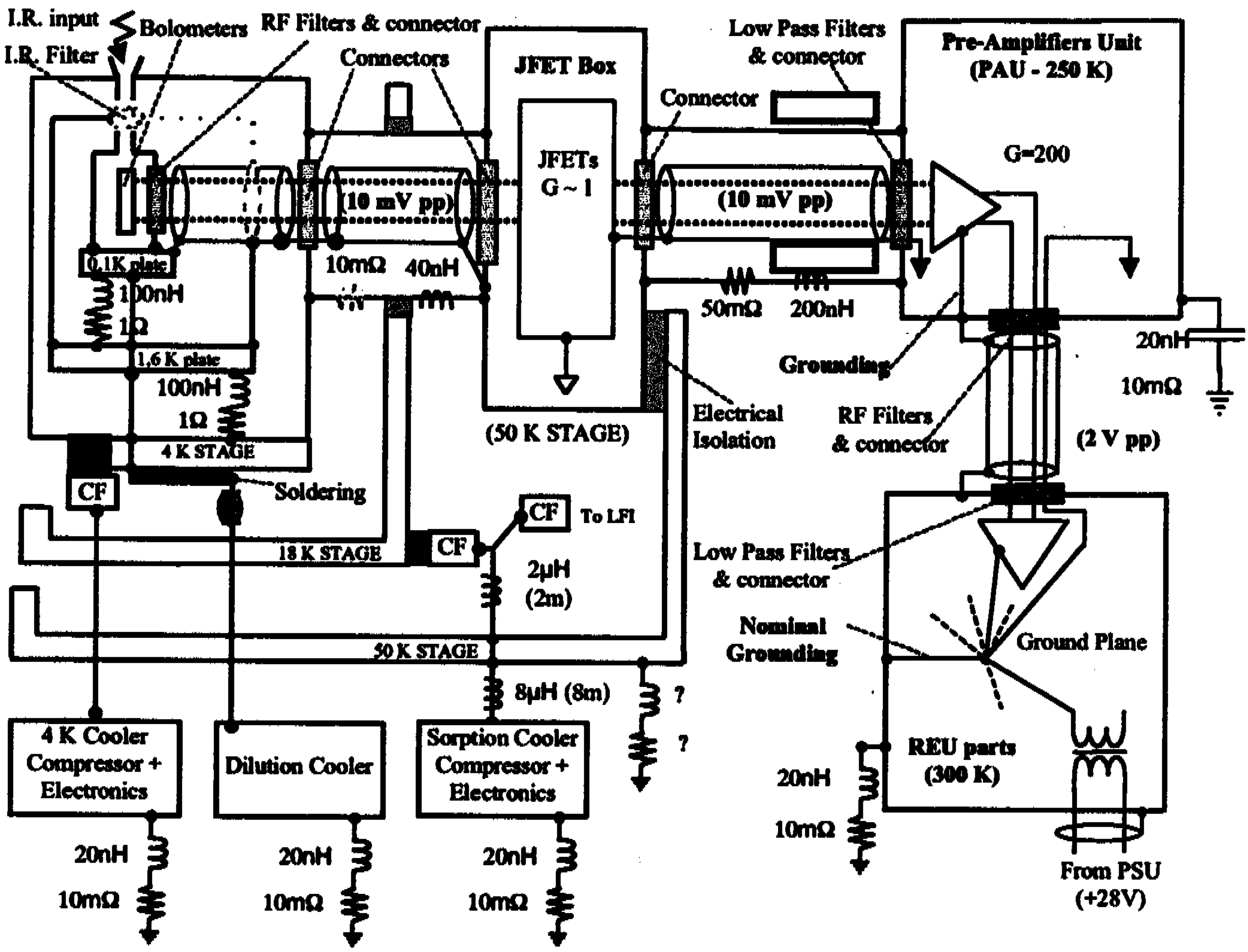
ANNEX IV


SVM
PPLM
DAE
CONTROL BOX
DAE
LATERAL TRAYS
CRYO FRONT END UNIT
FOCAL PLANE UNIT
ON BOARD CLOCK
PRIMARY POWER
FEM BIAS
PHASE SWITCH BIAS
BEM & ANALOG ACQUISITION BIAS
BIAS REGULATOR
CRYO HARNESS
SORPTION COOLER HEATERS AND SENSORS
WAVEGUIDE
REBA
MIL 1553B BUS
DAE
BEU BOX
BEM TRAYS
HEATERS AND SENSORS LINES
HEATERS AND SENSORS
PRIMARY HEATERS
SORPTION COOLER ELECTRONICS
SORPTION COOLER COMPRESSOR
SORPTION COOLER PIPING
CHASSIS CONNECTION

ANNEX V

UPDATE REQUIRED



Satellite Structure

Local Electrical Ground

Local Electrical Ground for each channel

CF Cold Finger

Electrical IsolationLow capacity

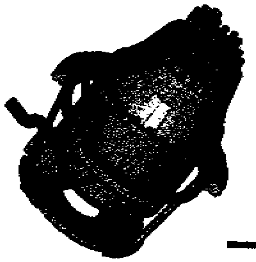
Sapphire Isolation (30pF) for Sorption Cooler at 18K stage

Feedthrough Isolation at 18K stage or 300K stage for 4K cooler

Ferrite Toroid

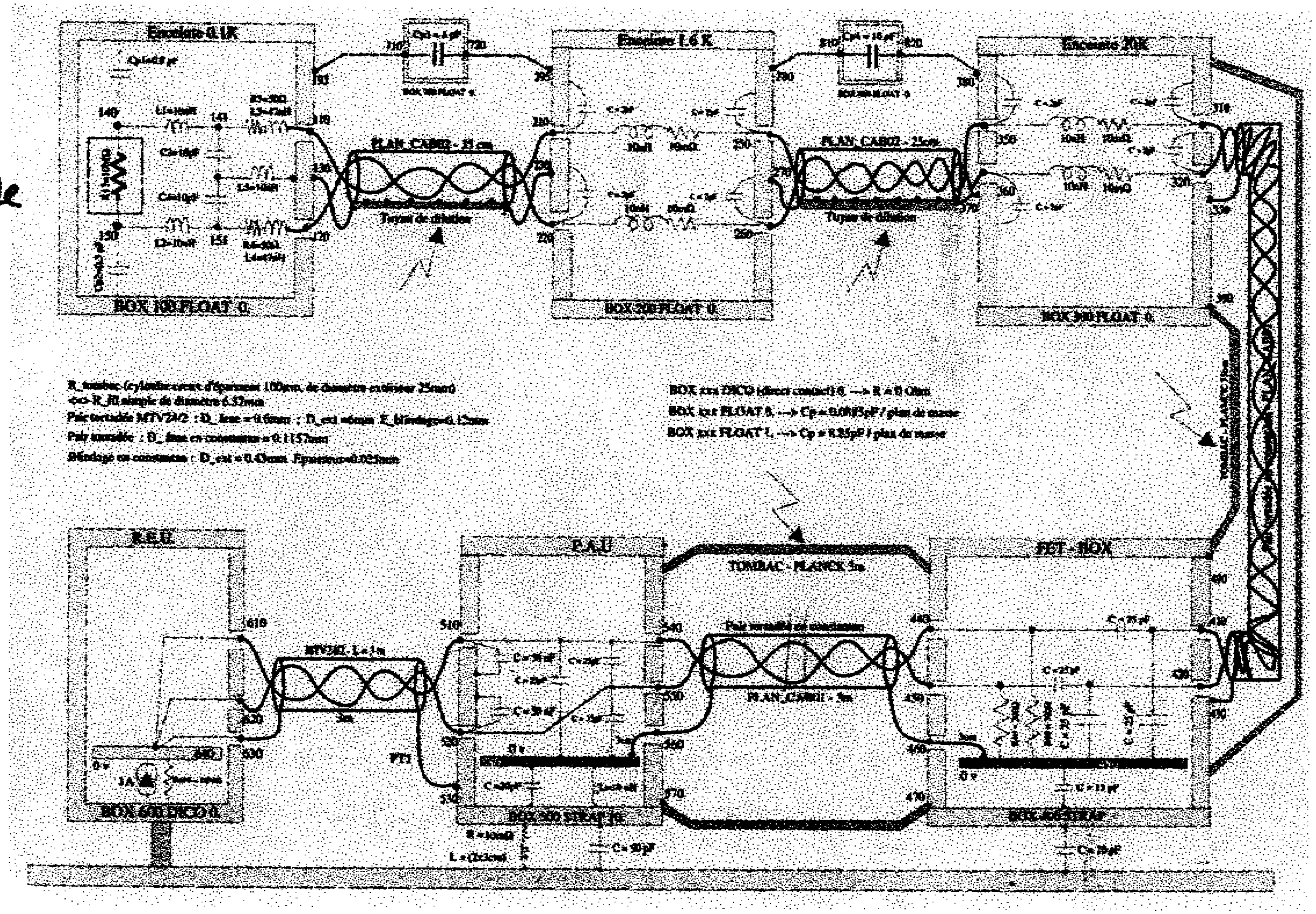
FPU-REU GROUNDING PHILOSOPHY

UPDATE REQUIRED

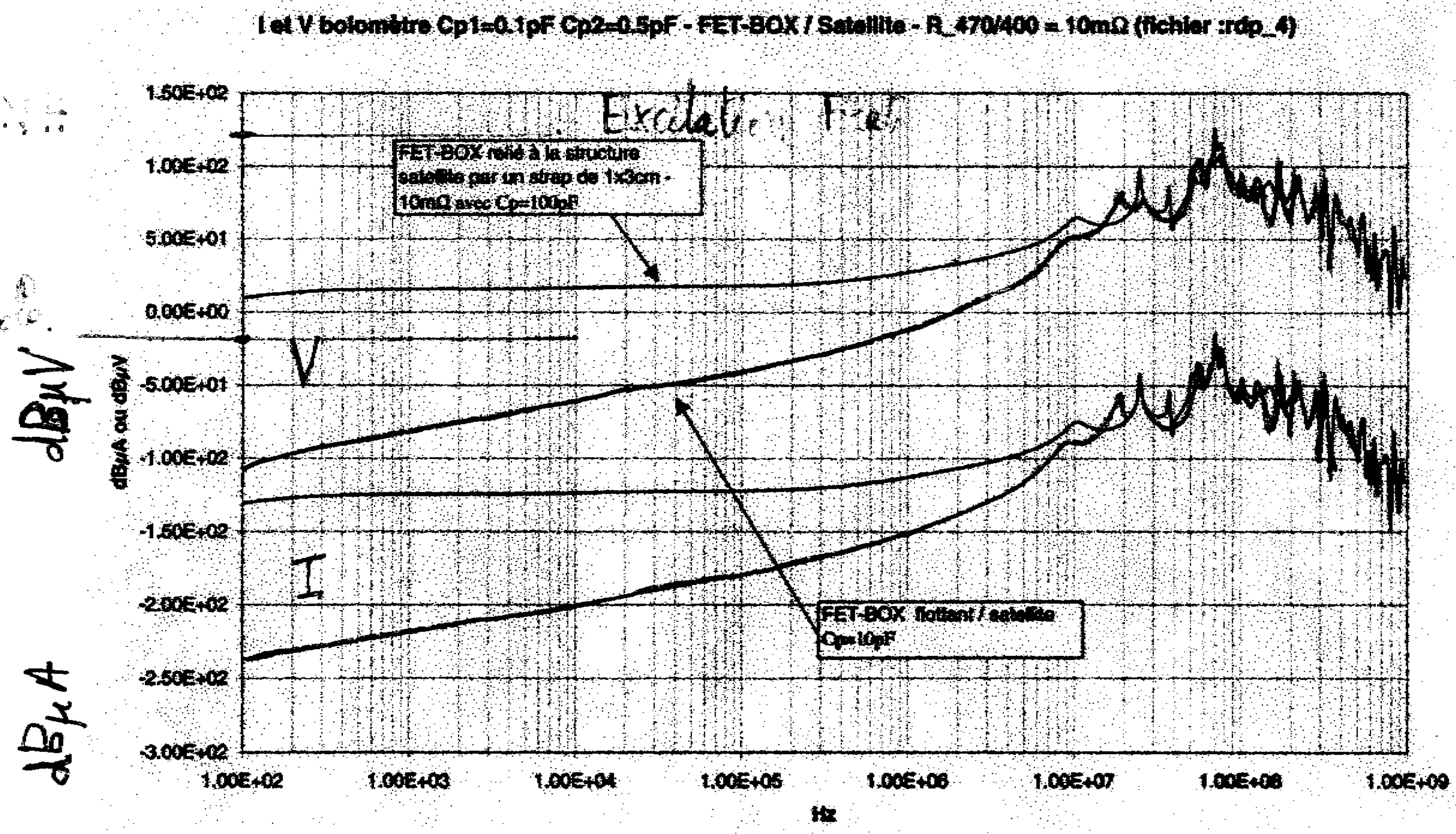


Simulation Work - From bolometer to REU .

Johan Pahn
CNES Toulouse



EMC Modelling: Asymmetric Stray capacitance FET-BOX Grounding



Next Work in line:

- Optimise HFI instrument grounding / Wiring Design vs satellite EMI Model.

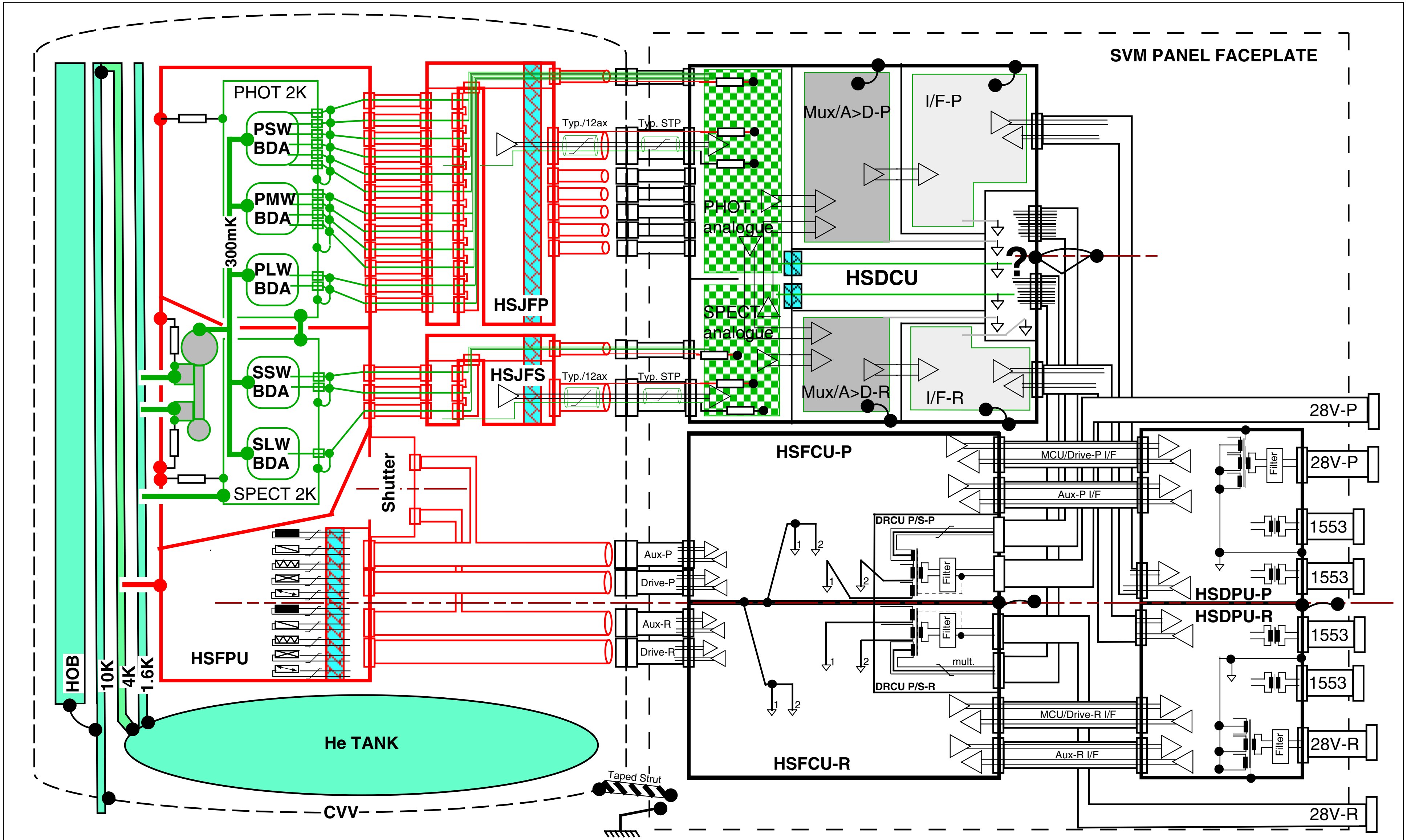
⟹ Obtain Satellite EMI Model (preferred)

~~Obtain~~ or build one from mechanical design of SVM

- Then using simulations as a guide.

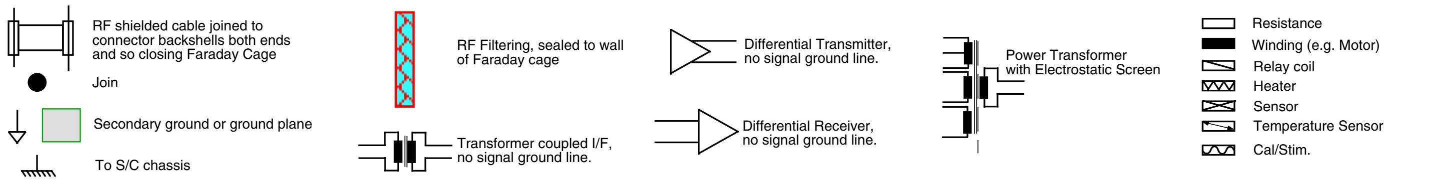
  Compromise with cryogenics –

  Update design –

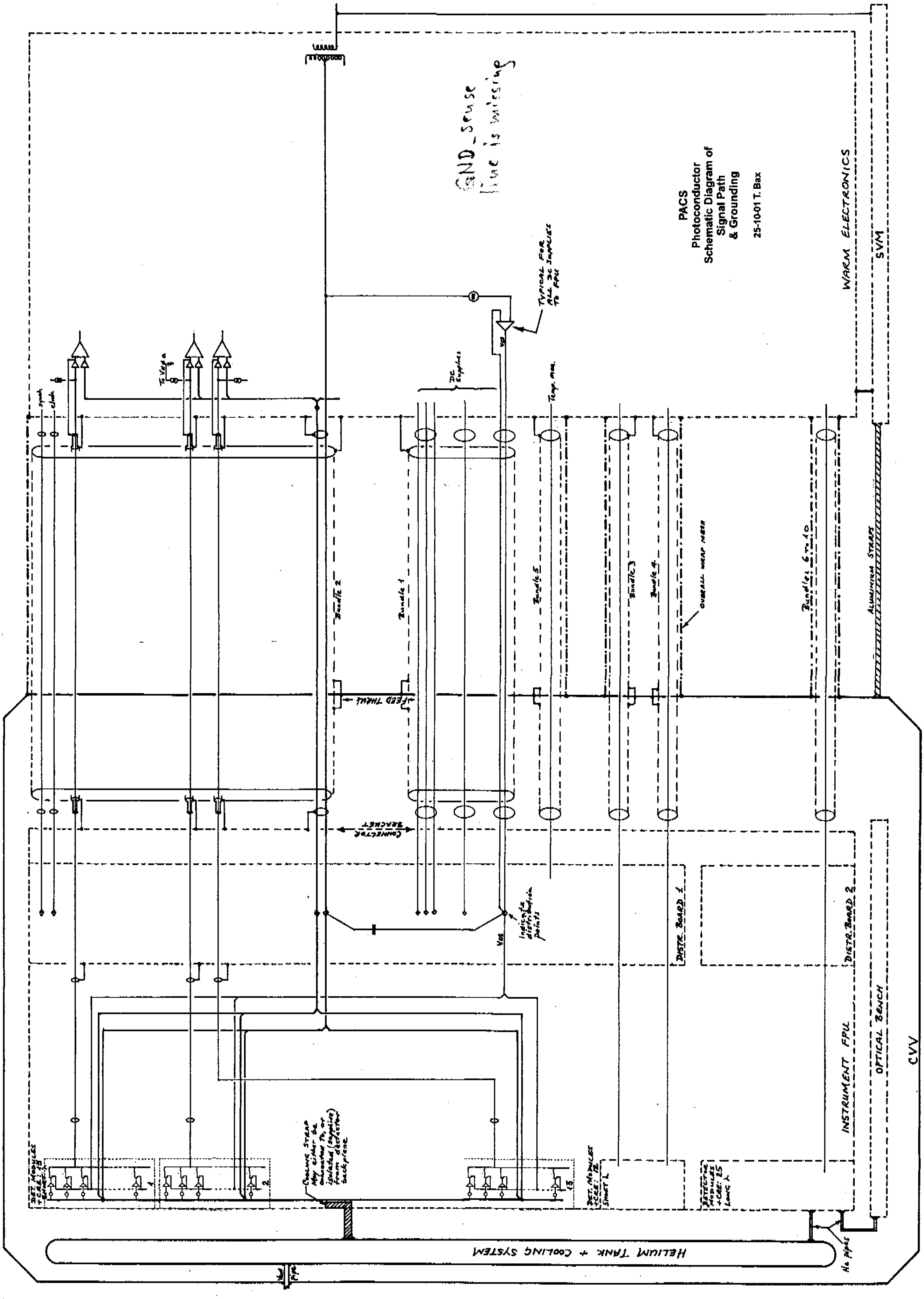


HERSCHEL SPIRE GROUNDING SCHEME

JD 10th September 2001



ANNEX VII



PACS
Photoconductor
Schematic Diagram of
Signal Path
& Grounding
25-10-01 T. Bax
GND_sense line is missing
WARM ELECTRONICS
SVM
CVV
OPTICAL BENCH
INSTRUMENT FPU
HELIUM TANK + COOLING SYSTEM
DISTR. BOARD 1
DISTR. BOARD 2
Bundle 1
Bundle 2
Bundle 3
Bundle 4
Bundle 5
Bundles 6 to 10
ALUMINIUM STRAPS
OVERALL WRAP MESH
FEED THRU
CONNECTOR BRACKET
DC Supplies
Temp. mon.
TYPICAL FOR ALL DC SUPPLIES TO FPU
He pipes

PLANCK LFI - Cryo-harness
Thermal requirements

Source: Sorption Cooler Interface Control Document, Issue 3.3

VG3 @	50K	60K
FPU	7 + 14 mW	9 mW

Source: Herschel/Planck Instrument Interface Document, IID PART A, Issue 2.0

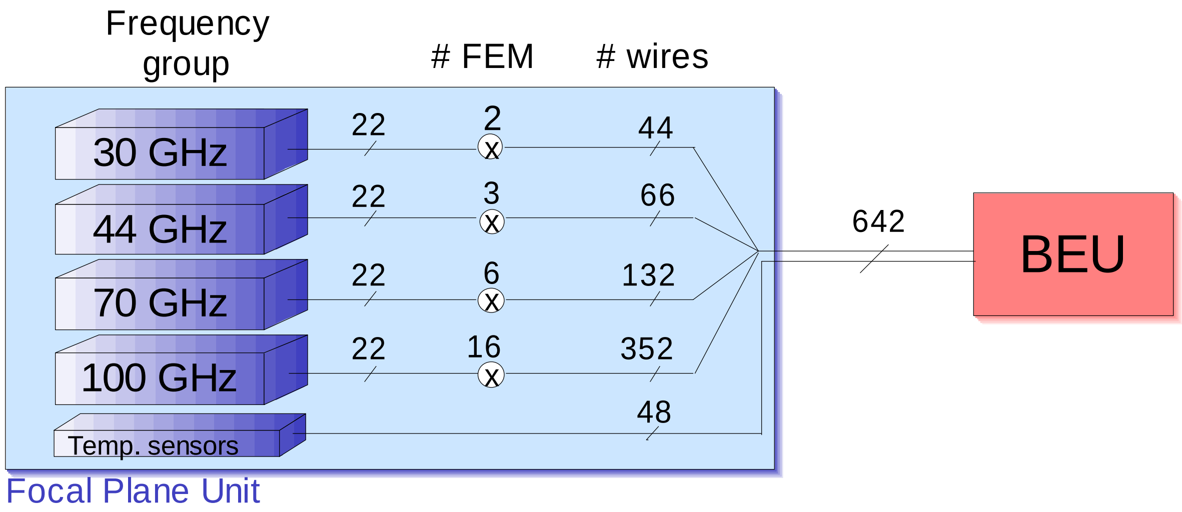
	Thermal load [mW]	Temperature [K]	Range [K]	Comments
VG3	100*	49	46 - 52	mean value
VG2	60*	98	56 - 101	worse case
VG1	730*	149	90 - 150	worse case

**: Values include 20% margin*

PLANCK LFI - Cryo-harness

Electric requirements (TBC)

FEM Connections	# wires
HEMT Drain	4 x 1 = 4
HEMT Gate 1	4 x 1 = 4
HEMT Gate 2	4 x 1 = 4
ϕ switch	4 x 2 = 8
ϕ switch GND	1
HEMT GND	1
TOTAL	**22**



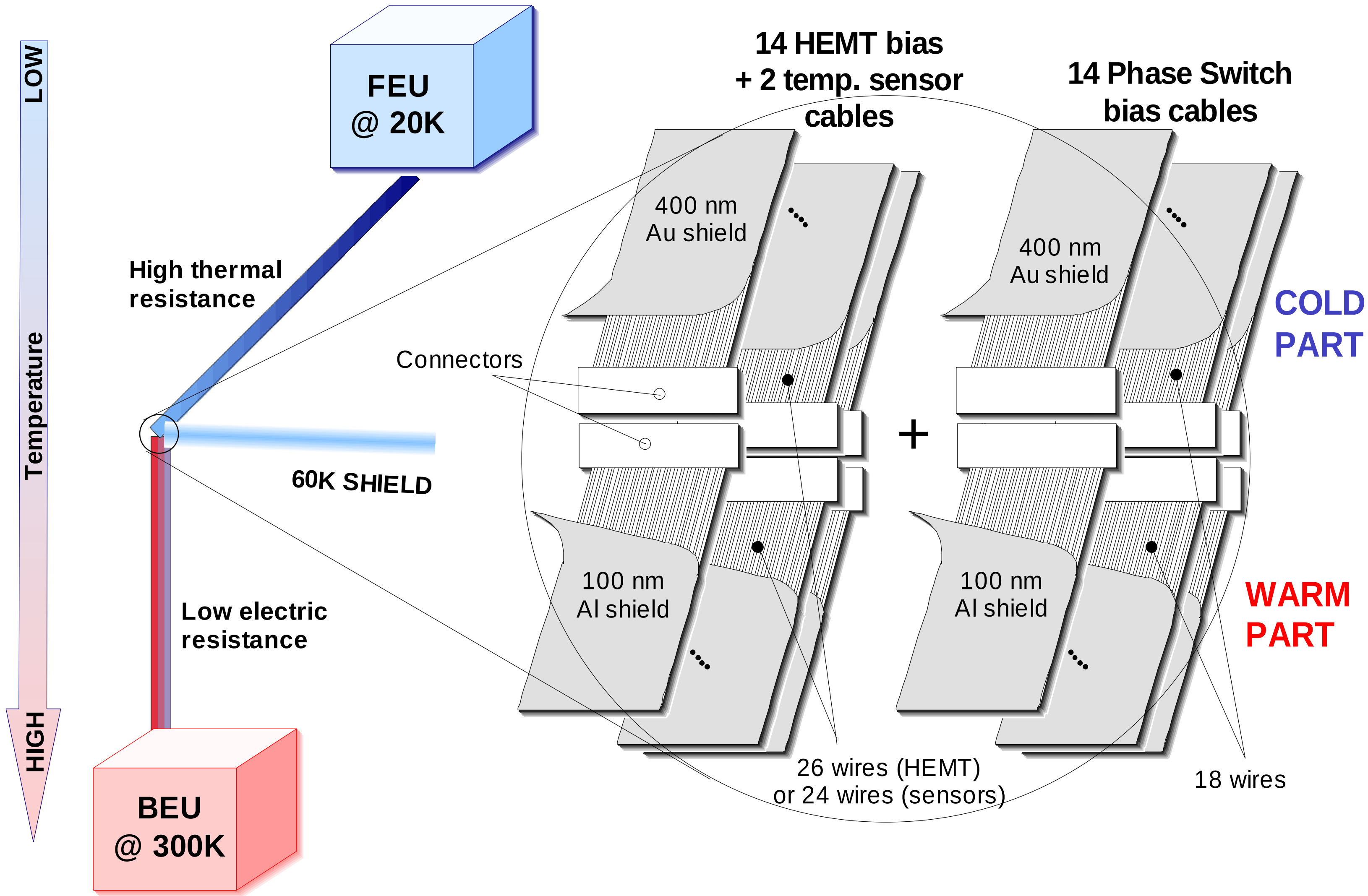
Wire	I max @ 20K	I max @ 300K	El. res. (W)	Total # wires
HEMT GND	40 mA	200 mA	< 1 Ω	27
HEMT Drain	10 mA	50 mA	< 5 Ω	108
ϕ switch	1 mA	1 mA	< 50 Ω	216
ϕ switch GND	4 mA	4 mA	< 10 Ω	27
HEMT Gate 1	100 μA	100 μA	< 1000 Ω	108
HEMT Gate 2	40 μA	40 μA	< 1000 Ω	108
Temp sensors	10 μA	10 μA	< 1000 Ω	48
TOTAL				**642**

PLANCK LFI - Cryo-harness
Routing philosophy

642 total wires to route from the BEU to the FEU:

- **Separation of the different EMC classes**
- **30 total cables:**
  - 14 HEMT LNAs
  - 14 Phase Switches
  - 2 Temperature sensors
- **HEMT LNAs and Phase Switch cables:**
  - 2 FEMs per cable, each 4 channels
  - minimization of current paths
  - trade-off: thermal and electric properties

PLANCK LFI - Cryo-Harness Routing Principle



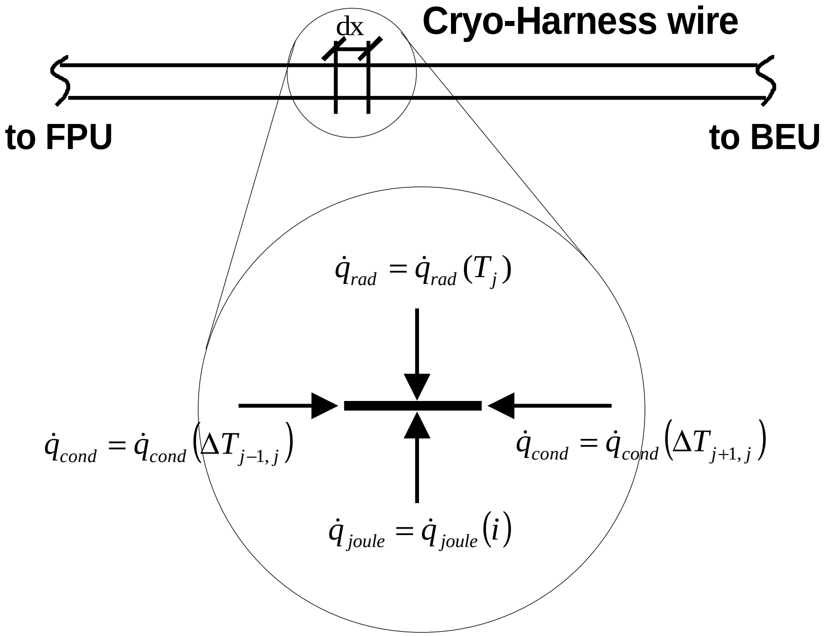
PLANCK LFI - Cryo-harness
Material selection for wires and shields

Materials for shielding	Thickness
Aluminium (Al)	100 nm
Gold (Au)	400 nm
Copper (Co)	250 nm

Materials for wires	Diameter
Aluminium (Al)	30 AWG … 40 AWG
Gold (Au)	30 AWG … 40 AWG
Phosphor-Bronze	30 AWG … 40 AWG
Copper (Cu)	30 AWG … 40 AWG
Nickel (Ni)	30 AWG … 40 AWG
Platinum (Pt)	30 AWG … 40 AWG
Titanium (Ti)	30 AWG … 40 AWG
Constantan	30 AWG … 40 AWG
Manganin	30 AWG … 40 AWG

PLANCK LFI - Cryo-harness

Mathematical model for the heat transfer estimation



$$dx = \frac{length\ of\ wire}{number\ of\ nodes} = \frac{l}{n}$$

$$T(1) = T(FPU) = 20K$$

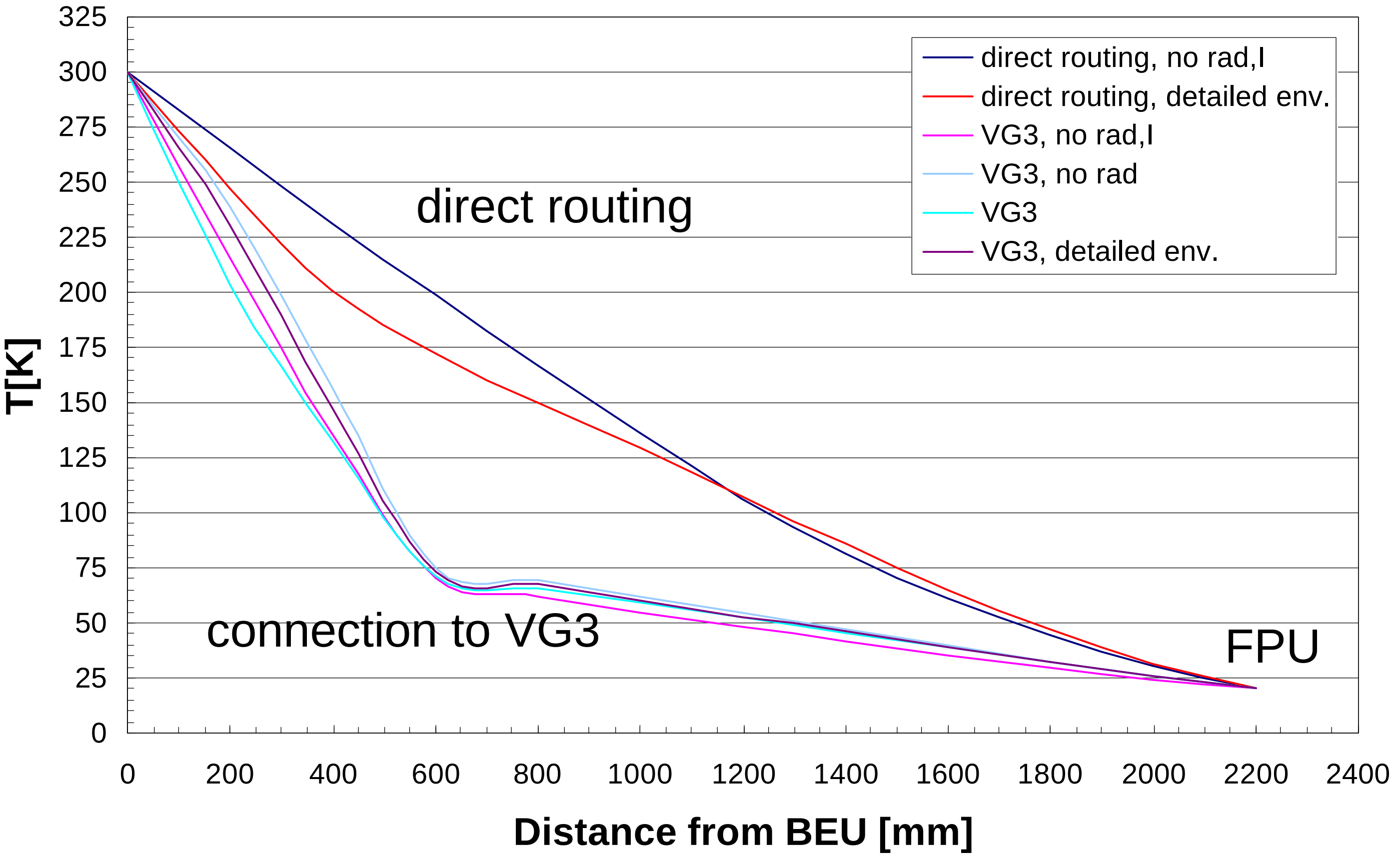
$$T(n) = T(BEU) = 60K$$

$$\sum \dot{q}(T_j) = 0$$

$$(T_{j-1} - T_j) \cdot k(T_{j,j-1}) \cdot \frac{Sec}{dx} + (T_{j+1} - T_j) \cdot k(T_{j,j+1}) \cdot \frac{Sec}{dx} + r(T_j) \cdot \frac{dx}{S} i^2 + s \cdot a \cdot (T_{env}^4 - T_j^4) = 0$$

PLANCK LFI - Cryo-harness
Estimated temperature distribution

direct routing vs. VG3 interconnection



PLANCK LFI - Cryo-harness
Thermal Optimum

Length (20-60K, 60-300K):	1.6m, 0.6m
Emissivity:	0.04
Coeff. of view (1=4PI):	0.6
Tenvironment (20-60K, 60-300K):	60K, 180K

			COLD PART: 20-60K			WARM PART: 60-300K		
Wire	**Current [A]**	**R_{TOT} [Ohm]**	**Material**	**AWG**	**P FPU**	**Material**	**AWG**	**P VG3**
HEMT Drain	0.010000	5.0	Au	40	-7.40	Ni	40	-42.89
HEMT Gate	0.000100	194.5	Manganin	40	-0.76	Manganin	40	-14.29
Phase Switch	0.001000	63.0	Ti	38	-2.85	Manganin	40	-16.74
Phase Switch GND	0.004000	14.1	Pt	40	-1.06	PhBronze	40	-4.47
HEMT GND	0.040000	1.4	Au	34	-7.21	Al	38	-40.16
Temp. Sensors	0.000040	194.4	Manganin	40	-0.15	Manganin	40	-3.17
TOTAL					**-19.44**			**-121.73**
TOTAL WITH SHIELD CONTRIBUTION			Au	400 nm	**-20.16**	Au	400 nm	**-131.44**
			Al	100 nm	**-20.39**	Al	100 nm	**-123.92**
			Cu	250 nm	**-21.19**	Cu	250 nm	**-130.14**

- **Best possible thermal behavior in terms of heat transfer on FPU and VG3**
- **Thermal requirements are not satisfied for the case VG3 @ 60K**
- **Electric requirements are not satisfied**
- **Room temperature operation not allowed**

PLANCK LFI - Cryo-harness
Trade-Off Solution

Length (20-60K, 60-300K):	1.6m, 0.6m
Emissivity:	0.04
Coeff. of view (1=4PI):	0.6
Tenvironment (20-60K, 60-300K):	60K, 180K

			COLD PART: 20-60K			WARM PART: 60-300K		
Wire	**Current [A]**	**R_{TOT} [Ohm]**	**Material**	**AWG**	**P_{FPU} [mW]**	**Material**	**AWG**	**P_{VG3} [mW]**
HEMT Drain	0.010000	2.71	Ni	38	-9.98	Ni	38	-57.43
HEMT Gate	0.000100	194.65	Manganin	40	-0.85	Manganin	40	-16.37
Phase Switch	0.001000	24.02	Ti	38	-3.07	Ti	38	-35.17
Phase Switch GND	0.004000	5.95	Ti	32	-1.31	Ti	32	-13.65
HEMT GND	0.040000	0.82	Cu	38	-9.29	Cu	38	-48.71
Temp. Sensors	0.000040	194.50	Manganin	40	-0.17	Manganin	40	-3.63
TOTAL					**-24.67**			**-174.96**
TOTAL WITH SHIELD CONTRIBUTION			Au	400 nm	**-25.39**	Au	400 nm	**-184.67**
			Al	100 nm	**-25.62**	Al	100 nm	**-177.15**
			Cu	250 nm	**-26.42**	Cu	250 nm	**-183.37**

- **Fulfillment of electrical requirements**
- **Room temperature operation allowed with additional high-emissivity coating**
- **Slight increase of the heat transfer on the FPU**

PLANCK LFI - Cryo-harness
Interconnection to VG's

Routing method	P_{FPU} [mW]	P_{VG3} [mW]	P_{VG2} [mW]	P_{VG1} [mW]
ID1: direct routing, no rad,I	50	-	-	-
ID6: direct routing, detailed env.	54	-	-	-
ID2: VG3, no rad,I	21	104	-	-
ID3: VG3, no rad	27	145	-	-
ID4: VG3	26	112	-	-
ID5: VG3 (60K), detailed env.	**26**	**133**	**-**	**-**
ID9: VG3, detailed env. (Alcatel: vg1=149K, vg2=98K, vg3=49K)	**23**	**146**	**-**	**-**
ID10: VG1, VG2, VG3, detailed env. (Alcatel: vg1=149K, vg2=98K, vg3=49K)	**21**	**91**	**31**	**182**
ID11: VG1, VG3, detailed env. (Alcatel: vg1=149K, vg2=98K, vg3=49K)	**22**	**105**		**196**

Estimated results without margin

A 20% margin should be foreseen due to the high sensitivity of the thermal model to the boundary conditions.

PLANCK LFI - Cryo-harness

Proposed technology for cryo-harness manufacturing

- 2.2 m cable length, 30 total cables.
- Selection of proper materials/gauges for the wires (trade-off thermal and electrical characteristics), according to the current flowing in the wires.
- Separation of the wires in two EMC classes (HEMT bias and Phase switch bias).
- Realisation of a thin shield (good conductor) through chemical vapor deposition.
- High-robustness Kapton coating of the cables for mechanical stability of the shield.

PLANCK LFI - Cryo-harness
Summary of EMC aspects

Problems	Comments
Influence of external magnetic fields	Wire twisting not possible due to bias supply architecture and cable complexity
limited shielding effect	Need of trade-off thermal and electrical characteristics
reduced wire gauges, selected on the base of the flowing current	Current limitation on the voltage regulators (higher complexity)
possible charging effects of the Kapton coating (to be investigated)	Evaluation of discharge mechanisms and their influence on the wires