Background simulations and shielding implementation

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Outline

- Background Work Package organization
- Status of the activities
- Work Breakdown Structure
- Relevant activities for the Demonstration Model
- Shielding implementation

L2 environment characterization

Aim	Responsible	Task	Interfaces
Solar environment characterization: • Quiet solar environment • SEP occurrence • SEP parameterization • $t(F > F^*)$	IAPS Roma/INAF	Coordination, model development	Collaboration with: • IASF Milano • Toulouse GPPS Delivery to: • IAPS Roma • IASF Palermo
SEP conditions background: • High energy particles • Focalized low energy particles	IAPS Roma/INAF	Geant4 simulations	Input from: • IAPS Roma
	IASF Palermo/INAF	Ray-tracing simulations	
Low energy protons (<100 keV): • Stationary conditions • Soft protons • Satellites data comparison to derive the scaling to L2	IASF Milano/INAF	XMM data analysis	Collaboration with: • IAPS Roma Delivery to: • IASF Palermo
	Toulouse GPPS/IRAP	GEOTAIL, ACE, WIND data analysis	
Focalized particle flux at focal plane	IASF Palermo/INAF	Ray-tracing simulations	Input from: • IASF Milano • IAPS Roma • Toulouse GPPS
	IAPS Roma/INAF	Geant4 simulations from the optics to the focal plane	

Geant4 simulations

Aim	Responsible	Task	Interfaces
FPA improvement & system design definition	IAPS Roma/INAF	Different FPA design tests Electron shield optimization	Input from: SRON Delivery to: SRON, IAPS Roma
Cryostat model implementation	IAPS Roma/INAF	Definition of a geometry file for the X-IFU cryostat	Input: SRON Collaboration with: IAPS Roma Delivery to: CEA-Toulouse/APC, IASF Bologna, CNES
Satellite model definition	CEA-Paris/APC	Definition of a reasonable geometrical model for the satellite	Delivery to: IAPS Roma, IASF Bologna
Geant4 versions validation	CEA-Paris /APC	Version 9.3, 9.5 tests	Collaboration with: IAPS Roma (9.4, 9.2)
	IASF Bologna/INAF	Version 9.1, 9.6, 9.10 tests	
RMF definition	IAPS Roma/INAF	Definition of a response matrix for X-IFU	Input from: IASF Palermo Delivery to: OAR Roma, OA Palermo, IASF Bologna

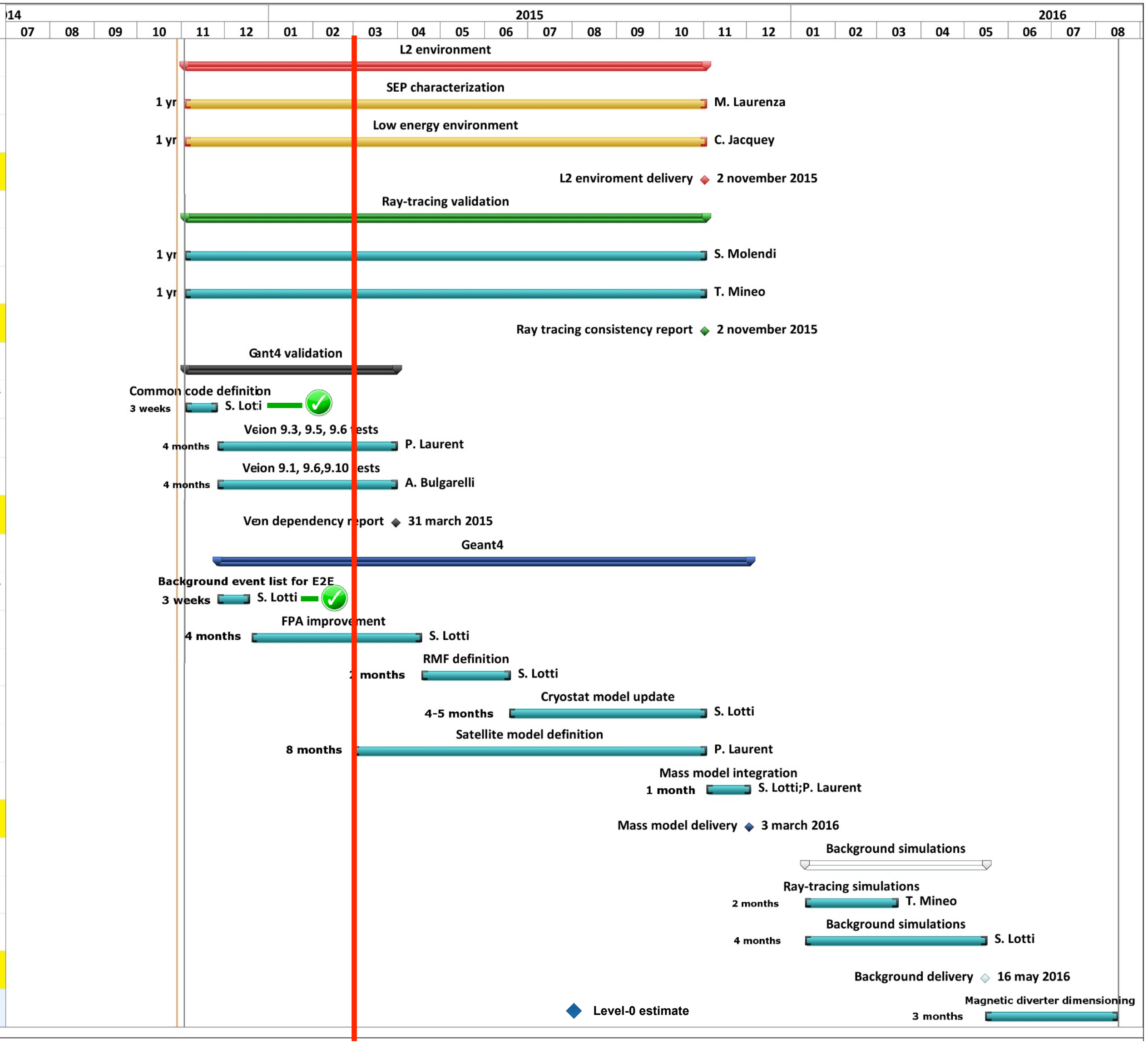
Interfaces

The WP activities affect and are affected by the activities of several other groups:

- **FPA (SRON):**
  - → starting FPA design.
  - ← indications on how to optimize the design to reduce the background (iterative process)
- **Magnetic diverter (CNES/ESA):**
  - ← integrated flux and the spectrum of the particles focalized by the mirrors, both for “standard” conditions and for a “worst” case.
  - ↔ discuss with ESA the specifications of the magnetic diverter.
- **Cryostat mass model (CNES):**
  - → cryostat mass model as close as possible to the flight one.
- **Satellite mass model (CNES):**
  - → information on the satellite that are needed to produce a reasonable mass model
- **X-IFU Science team:**
  - ← background spectrum and integrated flux (1^{st} order)
  - ← Residual fluorescences background (2nd order)
  - ← Time stability (2nd order)
  - ← Spatial homogeneity across the detector (2nd order)
  - ← Fraction of the detector assigned to particle background characterization (2nd order)
- **E2E simulations:**
  - ← background event lists needed for the E2E simulations
- **WFI background (WFI team):**
  - ↔ compare results
- **Filters (Unipa):**
  - → information on the thermal filters

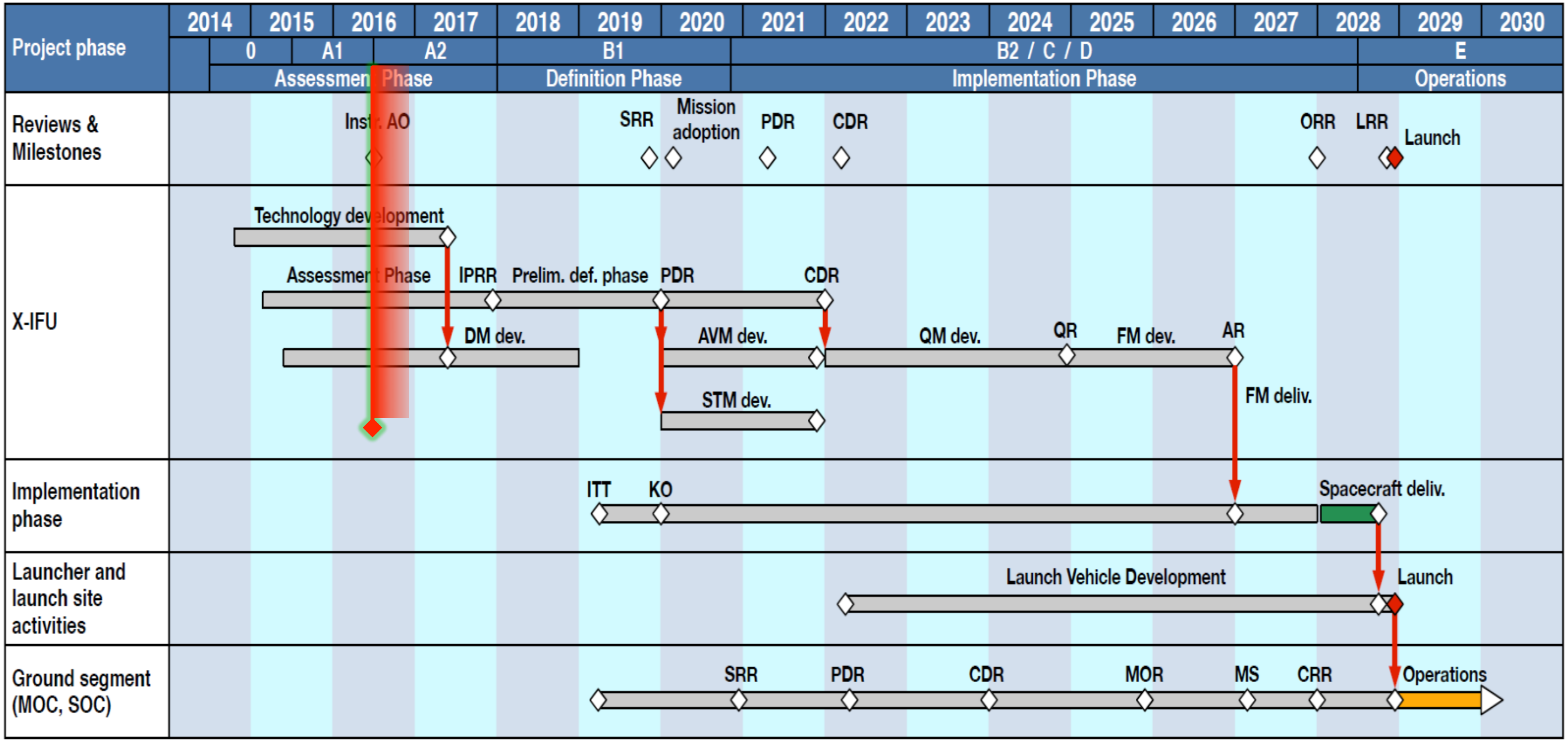
Status of the activities

ID	Activity	Start	End
1	L2 environment	lun 03/11/14	lun 02/11/15
2	SEP characterization	lun 03/11/14	lun 02/11/15
3	Low energy environment	lun 03/11/14	lun 02/11/15
4	L2 enviroment delivery	lun 02/11/15	lun 02/11/15
5	Ray-tracing validation	lun 03/11/14	lun 02/11/15
6	XMM data analysis	lun 03/11/14	lun 02/11/15
7	Reflectivity test	lun 03/11/14	lun 02/11/15
8	Ray tracing consistency report	lun 02/11/15	lun 02/11/15
9	Geant4 validation	lun 03/11/14	mar 31/03/15
10	Common code definition	lun 03/11/14	dom 23/11/14
11	Version 9.3, 9.5, 9.6 tests	lun 24/11/14	mar 31/03/15
12	Version 9.1, 9.6,9.10 tests	lun 24/11/14	mar 31/03/15
13	Version dependency report	mar 31/03/15	mar 31/03/15
14	Geant4	lun 24/11/14	gio 03/12/15
15	Background event list for E2E	lun 24/11/14	dom 14/12/14
16	FPA improvement	mar 16/12/14	ven 17/04/15
17	RMF definition	sab 18/04/15	gio 18/06/15
18	Cryostat model update	gio 18/06/15	lun 02/11/15
19	Satellite model definition	dom 01/03/15	lun 02/11/15
20	Mass model integration	mar 03/11/15	gio 03/12/15
21	Mass model delivery	gio 03/12/15	gio 03/12/15
22	Background simulations	lun 11/01/16	lun 16/05/16
23	Ray-tracing simulations	lun 11/01/16	mar 15/03/16
24	Background simulations	lun 11/01/16	lun 16/05/16
25	Background delivery	lun 16/05/16	lun 16/05/16
26	Magnetic diverter dimensioning	lun 16/05/16	mar 16/08/16



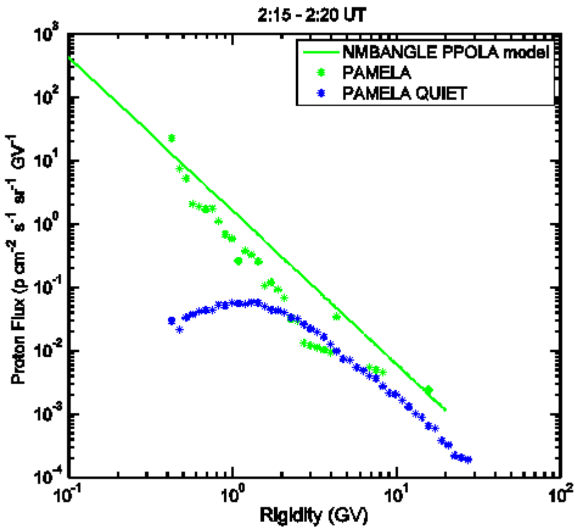
Status of the activities

X-IFU timeline (V1.1.0)



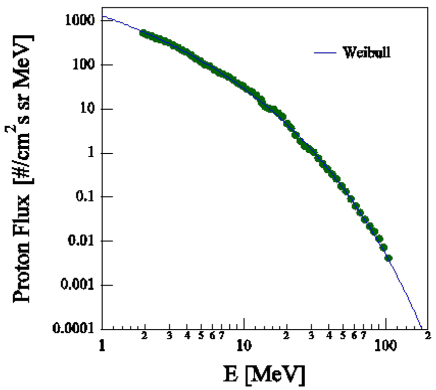
Status of the activities: SEP characterization

IAPS/INAF Rome

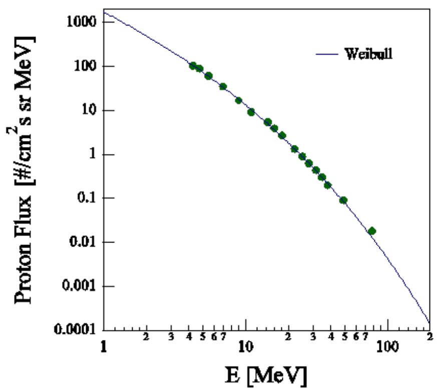


- Aims
  - Assess the SEP influence on the particle background
- Means
  - satellite data analysis (ACE, SOHO-ERNE, STEREO, PAMELA), and model development
- Present:
  - Weibull distribution found to be the best spectral shape for SEP events
  - NMBANGLE PPOLA model to obtain high energy data
- Next:
  - Define typical/worst case spectrum
  - Occurrence statistic
  - Improve the model, expand the SEP events database

26 December 2001 event (SOHO - L1)

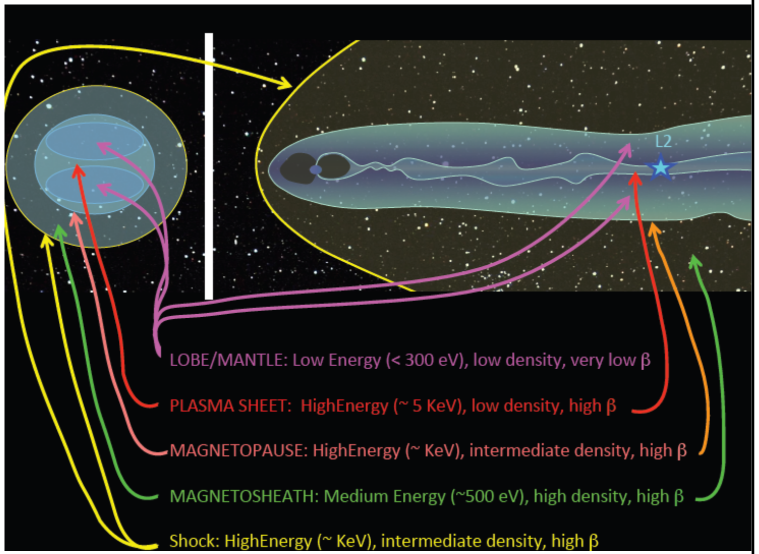


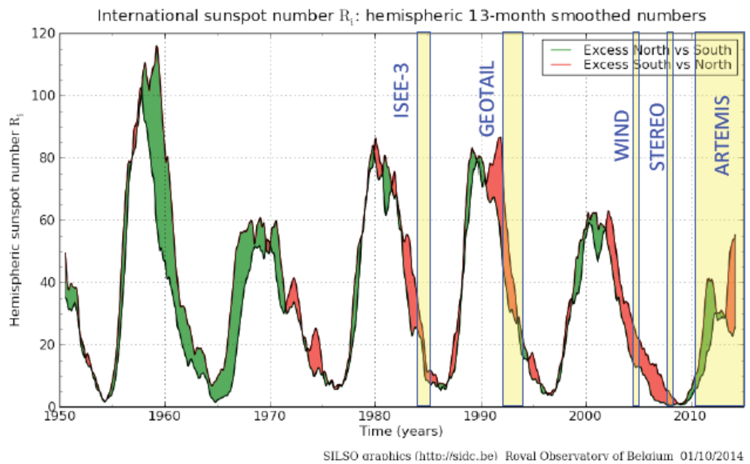
21 March 2011 event (STEREO - 1 AU)



Status of the activities: LE environment GPPS/IRAP Toulouse

- Aims
  - define a “best case” and a “worst case” for proton flux in L2
  - Provide a separate analysis for each kind of particle
- Means:
  - GEOTAIL, ARTEMIS, STEREO, and WIND data analysis
- Present:
  - analyzed the whole GEOTAIL dataset
- Next:
  - mean proton fluxes in different spatial sectors of the magnetotail





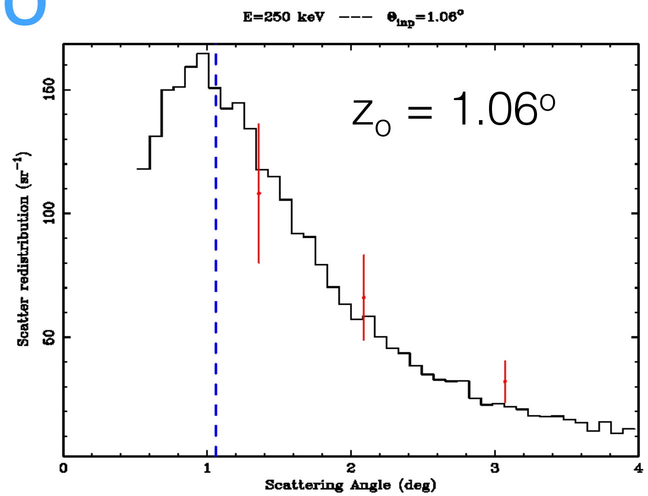
Status of the activities: XMM data analysis IASF/INAF Milano

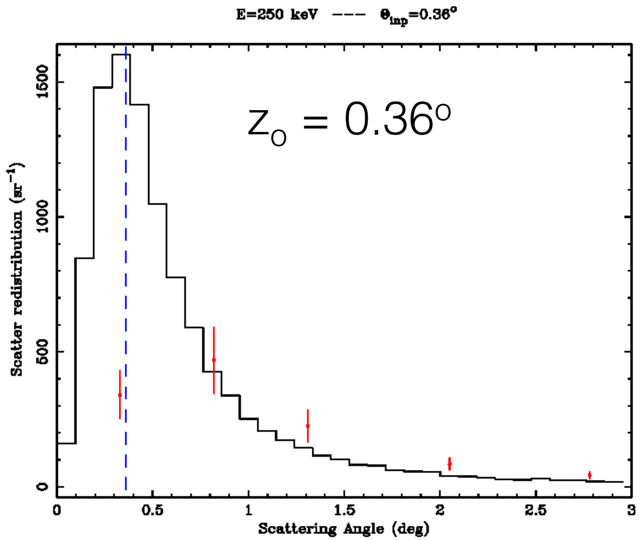
- Aims
  - Characterization of Soft Proton flux in XMM-Newton orbit
- Means
  - re-analysis of the soft protons data for the entire EPIC archive, in different points of the orbit
- Present:
  - Localization of XMM wrt Earth Magnetosphere (Ghizzardi & Gastaldello) done for all orbits up to 2009
  - Definition of EPIC products necessary for SP characterization done ~80% (Gastaldello, De Luca, Tiengo & Belfiore)
  - Exploratory run on small subsample of observations in progress (De Luca Tiengo, Belfiore & Marelli)
  - First estimate of the focused proton flux for ATHENA (doc available - Molendi, Gastaldello, Rossetti, Spiga, Tiengo)

Status of the activities: reflectivity tests

IASF/INAF Palermo

- Aims
  - Estimate the focused proton flux
- Means
  - Raytracing simulations of the optics reflectivity
- Present:
  - Comparison with lab data (Firsov model):
    - >> Similar results for all energies (agreement with theory)
    - >> model works well at incident angles >~1 deg
- Next:
  - Include other theoretical models that can be extrapolated at low incident angles
  - include the results in the optics ray-tracing code





Status of the activities: Geant4 validation

APC Paris + IASF/INAF Bologna + IAPS/INAF Roma

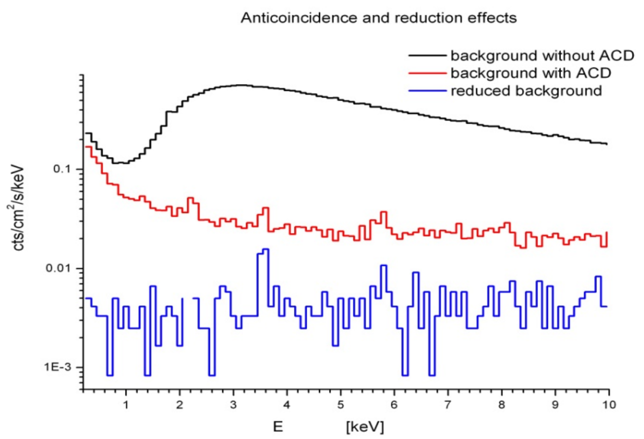
- Aim:
  - validate and optimize the Monte Carlo code results
- Means:
  - comparison of different Geant4 versions
  - Code cross-check and optimization
- Present:
  - Common code distributed
  - Simulations ongoing
- Next
  - Satellite model definition
  - Code cross-check and optimization

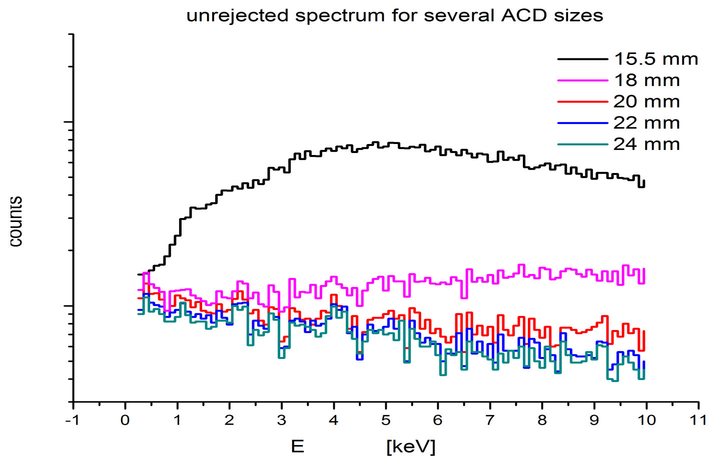
Status of the activities: FPA improvement
IAPS/INAF Roma

- Aim: optimize the passive shield and cryo-AC efficience

- Present:
  - studying the electron production as function of the material and its thickness
  - cryoAC size scaling in the new FPA

- Future:
  - Complete and consolidate the study results
  - Produce definitive passive shield design
  - Optimize CryoAC performaces related to design



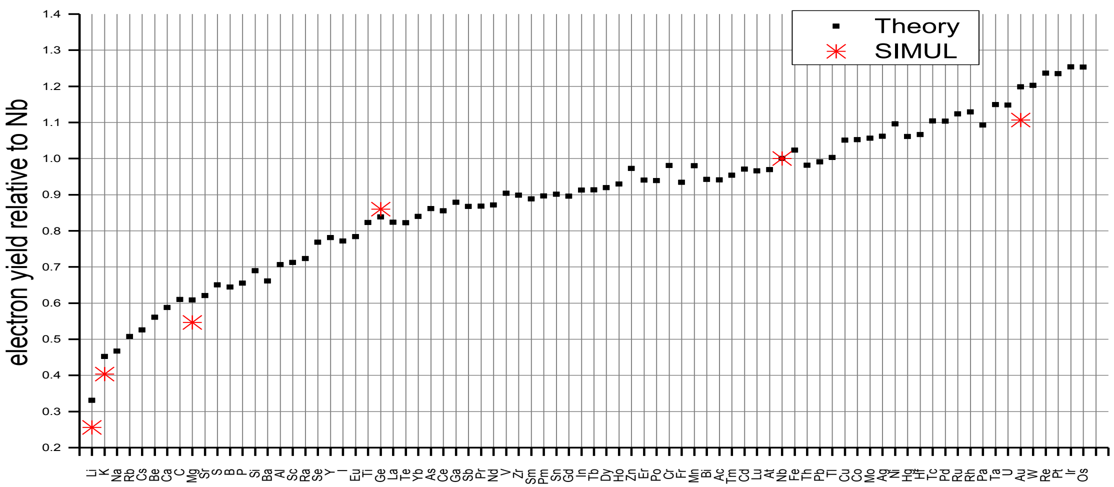


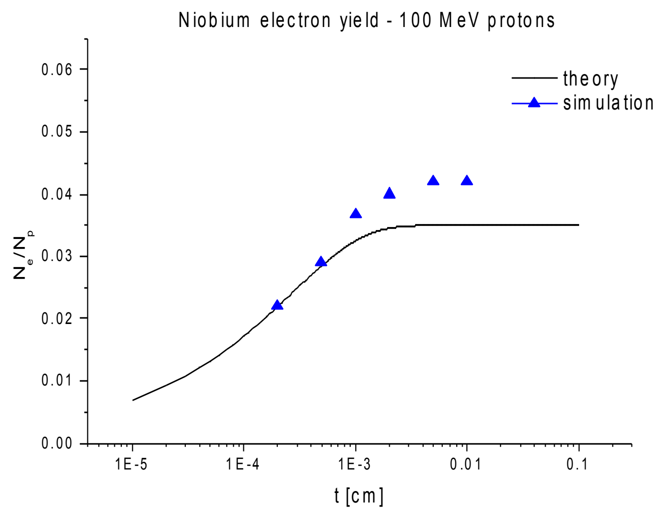
Status of the activities: FPA improvement

IAPS/INAF Roma

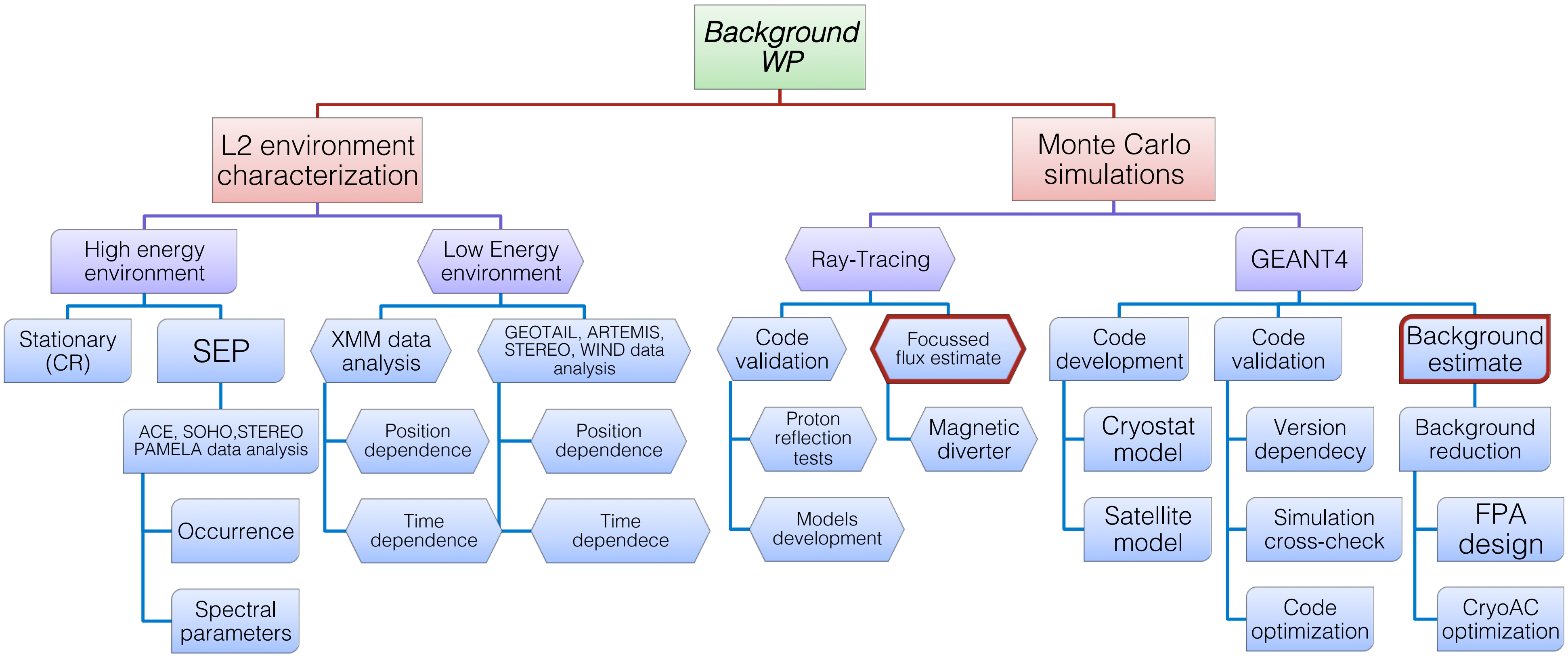
- We studied the secondary electrons production as function of the material
  - Good agreement for low thicknesses, yield grows approximately as $\sqrt{\rho}$
  - Magnesium viable as alternative to kapton
- Also probed production as function of the thickness
  - The production increases as function of the material thickness
  - It could be useful to reduce the shield thickness (TBC)

Results are preliminary: need to validate and extend the model to different energies/materials





Work Breakdown Structure

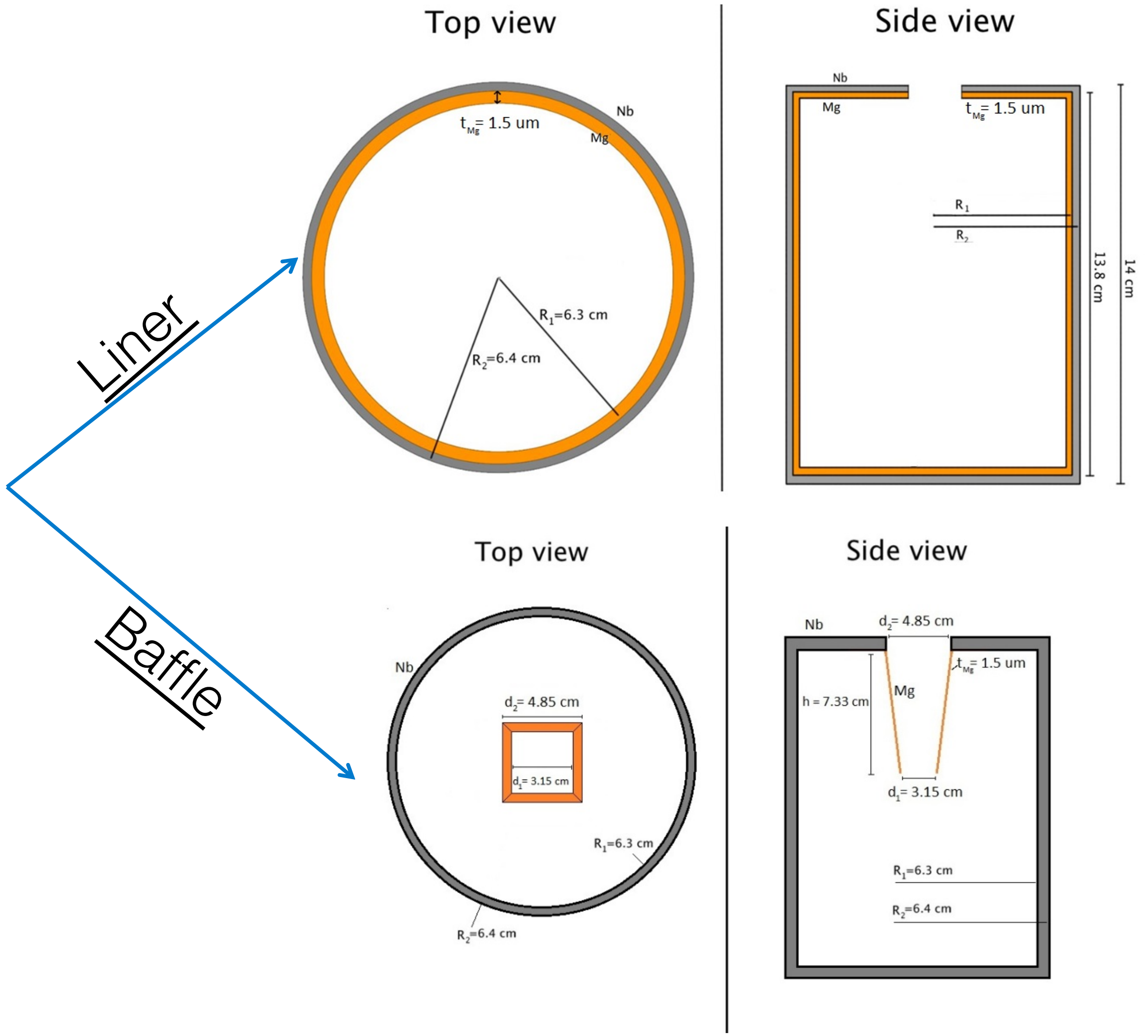


Acitivities in the study phase

- Define the relevant components in L2 environment and their impact on the instr. Bkg
- Assess the XIFU non–residual bkg (all components)
- Optimize the above
- Deliver inputs for instrument design (w.p.r.t. secondary electron shielding and CryoAC)
- Requirements for magnetic diverter

SHIELDING IMPLEMENTATION

From GEANT4 simulations
Geometries



Materials, masses, cooling capability

Posta :: RE: Tech note about thermal assessment of the ATHENA X-IFU passive shielding. - Google Chrome

https://webmail.sic.rm.cnr.it/horde/imp/dynamic.php?page=message&buid=5&mailbox=SU5CT1gvQVRIRU5BL0NyeW9BQy9CS0dfc2hpZWxkaW5n&token:

Rispondi | Inoltra | Elimina

RE: Tech note about thermal assessment of the ATHENA X-IFU passive shielding. Salva

Data: 27/11/2014 (11:31:18 CET)
Da: CHARLES Ivan 159464
A: claudio.macculi@iaps.inaf.it
Cc: Didier Barret, Rodolphe Cledassou, Thierry Carlier, den Herder Jan Willem, Luigi Piro, Simone Lotti, Brian Jackson, van Weers Henk, DUBAND Lionel 142947, DUVAL Jean-Marc, Daniel Christophe

Hai risposto a tutti i destinatari di questo messaggio il 27/11/2014 11:54:58.

Testo (7 KB)

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Dear Claudio,

Thinking a little bit more about your request to validate that your under study design is compatible with the
cooling capability, I realize that the impact could be larger on the sorption stage than on the ADR stage. The
enthalpy of your layers should have a dependence with the temperature with a power factor higher than the one
of the cooling power available at the different temperature stages (ADR and sorption).
Cooling spec (to be consolidated)
1.26 uW at 50 mK
13.2 uW at 300 mK
This gives a cooling power law = aT^b with b = 1.3

So I propose that you also check the energy given to the sorption cooler for further evaluation. To do so, if
we take an allocation of 1% , this gives around 10 mJ (10 times more cooling power at 300 mK than at 50 mK)
and you can take a temperature decrease from 2 K to 400 mK (to be a little bit conservative). Obviously we
will be very sensitive to the 2 K temperature level.
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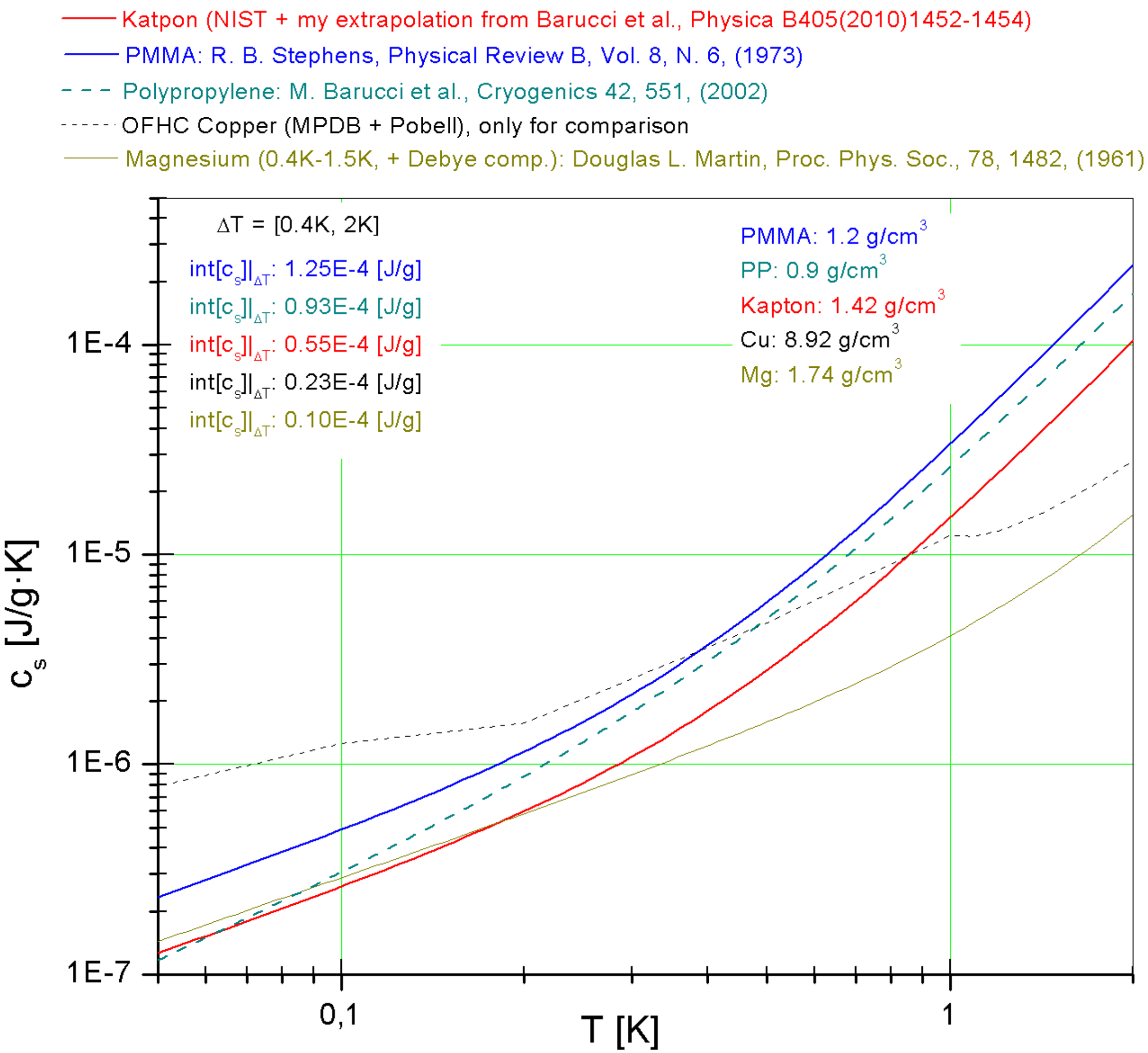

There is a lot of margin

$$\Delta Q = m \cdot \int_{0.4}^{2} c_s(T)dT < 10\ \mathrm{mJ}$$

Material	Density [g/cm³]	Maximum Mass [g]
PMMA	1.2	80
PP	0.9	107
Kapton	1.42	180
Magnesium	1.74	1000

$$\Delta Q = m \cdot \int_{0.05}^{0.4} c_s(T)dT < 1\ \mathrm{mJ}$$

Material	ΔQ/m [J/g]	Maximum Mass [g]
PMMA	5.5 E-7	1800

Mg(250 um) < 35 g
PP(250 um) < 19 g