Exploring the Hot and Energetic Universe: The second scientific conference dedicated to the Athena X-ray observatory 24-27 September 2018, Palermo, Real Teatro Santa Cecilia, Italy

The EXACRAD and AREMBES projects: towards a better knowledge and assessment of particle background environment for the ATHENA mission

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on behalf of the bkg/CryoAC working group and AREMBES

Outline

- AREMBES
- EXACRAD
- Conclusions

List of posters exploiting results from both the CTPs

AMATO ROBERTA - A theoretical model for the soft protons scattering on X-ray optics.

D'ANDREA MATTEO - The Cryogenic AntiCoincidence detector for ATHENA X-IFU: preliminary test of the Demonstration Model.

FIORETTI VALENTINA - Soft proton scattering with ATHENA mirrors and the WFI induced background as case study

FIORETTI VALENTINA - Background simulation of the HITOMI/SXS instrument: preliminary results

GASTALDELLO FABIO - The variability of the XMM cosmic-ray induced particle background and lessons learned from Athena

MARELLI MARTINO - Evaluation of the XMM-Newton background as a prediction for the Athena background

MINERVINI GABRIELE - Assessment of the Galactic Cosmic Ray (GCR) proton spectrum and its uncertainty at L2 during the ATHENA mission lifetime (2031-2034).

AREMBES

Name	Institute
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S. Molendi	INAF
S. Lotti	INAF
A. Argan	INAF
M. Laurenza	INAF
M. Rossi	INAF
D. Martella	INAF
T. Mineo	INAF
A. Bulgarelli	INAF
V. Fioretti	INAF
V. Génot	IRAP
F. Pajot	IRAP
C. Jacquey	IRAP
F. Lei	Radmod Research
V. Ivanchenko	CERN

Name	Institute
P. Truscott	Kallisto Consultancy
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B. Gianesin	SWHARD
P. Dondero	SWHARD
S.A. Ibarmia Huete	INTA
P. Laurent	CEA
T. Eraerds	MPE
A. von Kienlin	MPE
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C. de Vries	SRON
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I. A. Daglis	NOA/IAASARS

Due to the quite stringent ATHENA bkg requirements AREMBES has put around a table different skills. It has been clear since the beginning of the proposal that for ATHENA it was necessary to change the approach to the bkg issues opening to a larger community.

AREMBES (expected to be closed by 2019)

- **Part 1)** - Athena particle environment characterization; physical processes tuning in Geant4; AREMBES Simulator Framework Requirements → **Closed**.

  Main results:
  - Environment mainly related to low energy component, see next slides. HE GCR L1 vs L2 behave the same way (S. Molendi's talk).
  - The Space Physics List developed for Athena, endorsed by ESA for X-IFU (officially adopted and currently used)

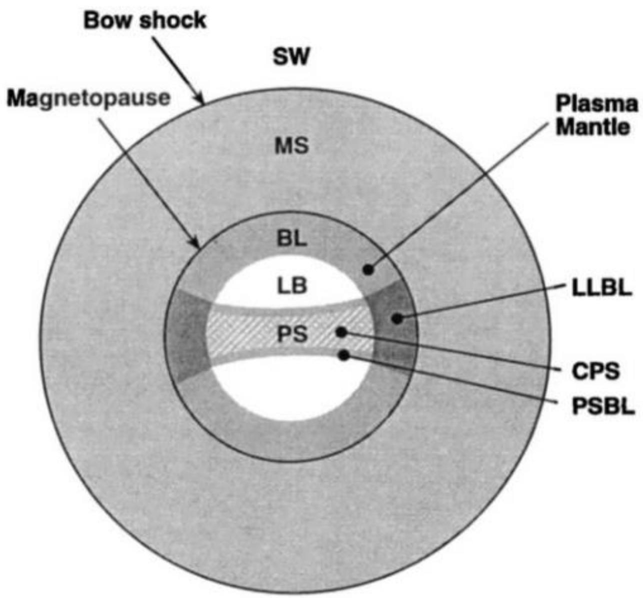
  CCN1: activity on L1 Vs L2 particle environment under completion (see next slides)
  - Task CCN1-1: Characterization L1 of particles environment (INAF, IRAP) → closed
    TN1.4 Issue 3 «AREMBES - L1 Particle Environment» delivered to the ESA ASST (M. Guainazzi)
  - Task CCN1-2: L1 effect on Athena (X-IFU INAF and WFI MPE) → on-going

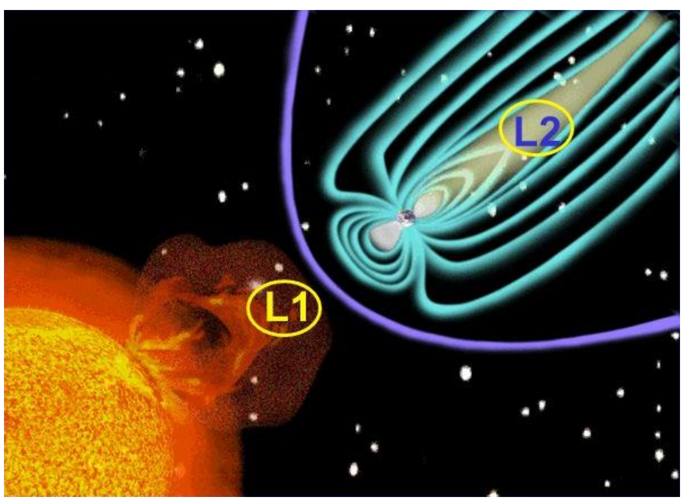
- **Part 2)** - Construction of a user friendly simulator based on Geant4 → **on-going**

  Status:
  - Requirements collected from the AREMBES users and the Athena community implemented
  - Implementation, Verification and Validation on-going
  - ASF still under finalization
  - Solved several technical issues

- **Part 3) -** Update and Mainteinance

Low energy particles: L1 vs L2 (quiet case, no SEP)





Study of SP environment in L1 and L2
(C. Jacquey IRAP, M. Laurenza INAF)

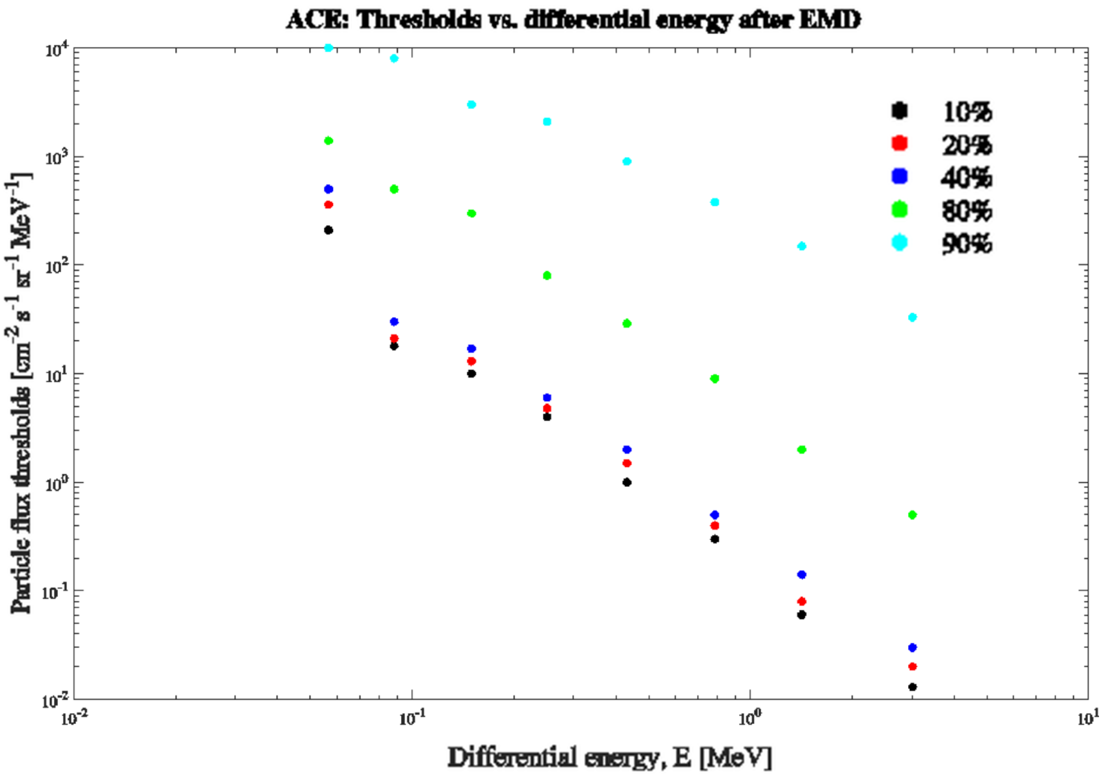
L1 and L2 distance from Earth	1.5×10^6 km
Sun to Earth 100x	150×10^6 km

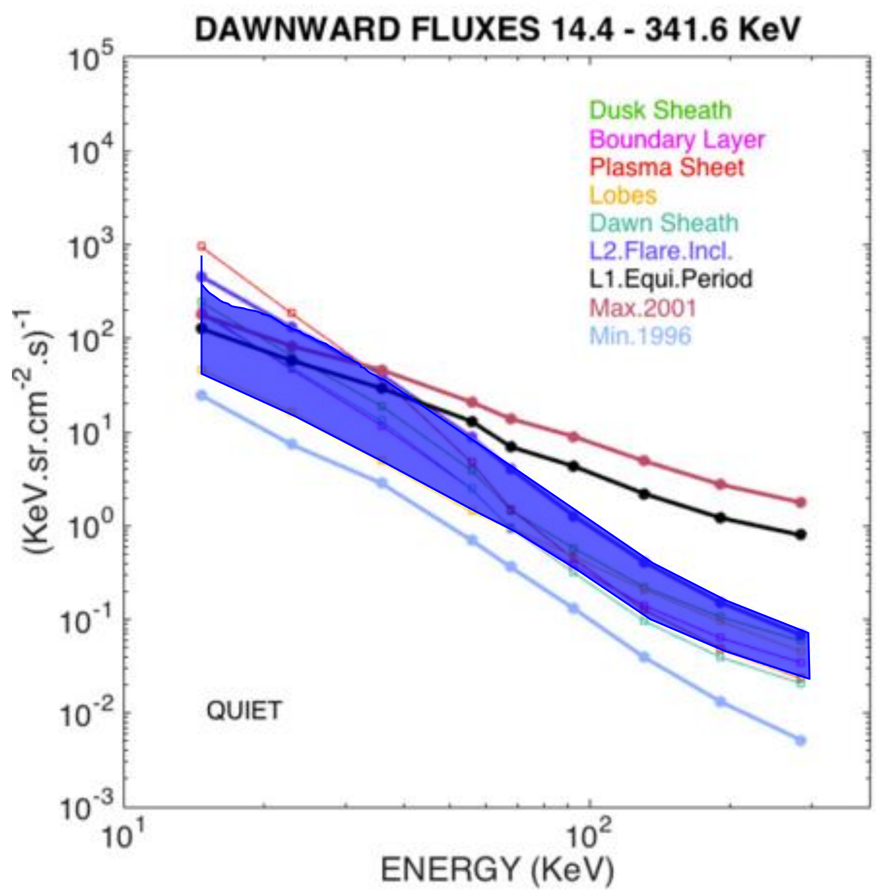
L1 in solar wind
L2 "in" distant tail region

L1 → high data coverage: 1.5 solar cycles
L2 → few months over 2 yrs, close to L2

Making predictions for L1 is WAY easier

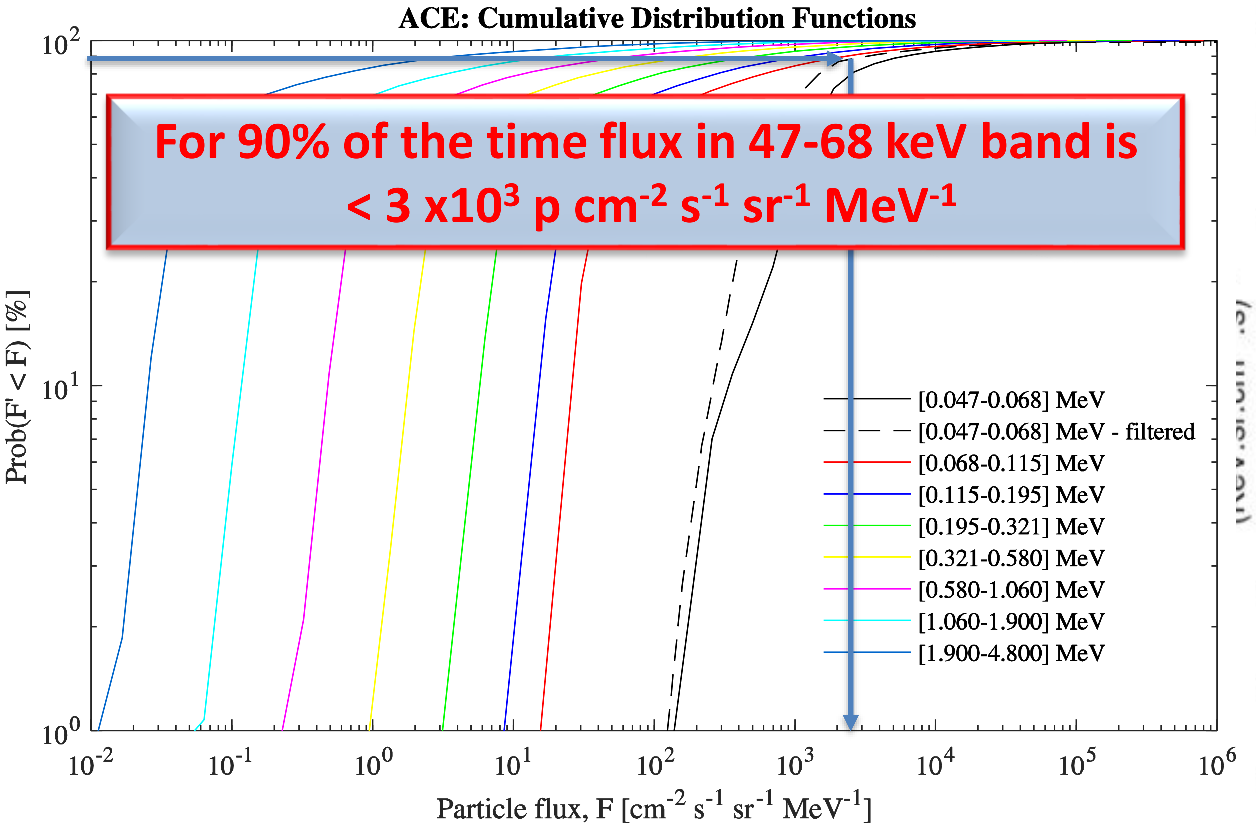
Low energy particles: L1 Vs L2



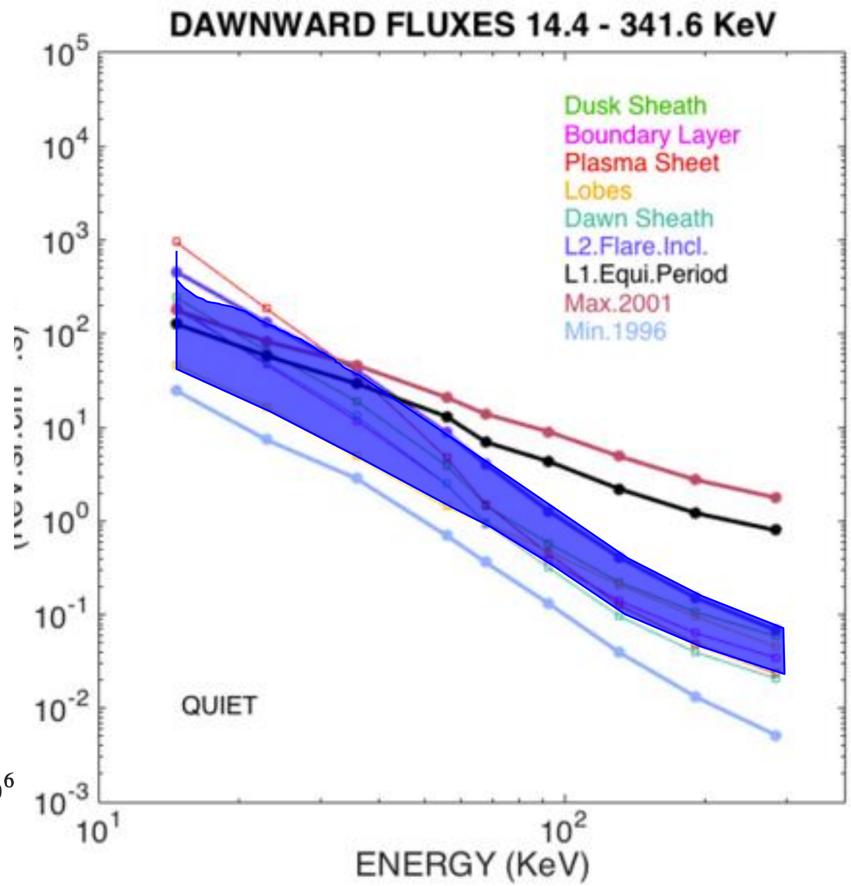


L1 representativity is infinitely higher

Low energy particles: L1 Vs L2



For 90% of the time flux in 47-68 keV band is $< 3 \times 10^3$ p cm^{-2} s^{-1} sr^{-1} MeV^{-1}



L1 representativity is infinitely higher

Summary L1 vs L2 (low energy)

Both environments studied in detail with available data

L2 highly structured environment, few months of coverage over a period of 2yrs and no coverage at L2 → **No reliable prediction of SP flux at L2 possbile**

L1 less complicated environment, data for more than 1 solar cycle → **Reasonable prediction can be made for L1, major source of uncertainty is cycle to cycle variability**

The ASF core to be implemented for the ESA-SQR

1) batch mode (scripts, data-card from the GUI)

→ present, not yet tested

2) Physics list management

→present, tested and working

3) particle environment loading: as data table, formula entry, connection with SPENVIS and OMERE.

→ present, tested and working

4) data output: FITS and ASCII. The output is in ROOT. External tools convert ROOT→FITS and ROOT→ASCII

5) post processing: present in the form of external tools to be customized (on-going)

6) filtering to reduce the output data size: only track sampling inside the volume is present (on-going)

7) Operational environment: Linux, Windows (MacOS not yet tested, TBC).

8) TNID, TID, DD: already present in CIRSOS

9) Geometry (simulator loads only GDML, not CAD files as required). ASF can:

→ Change or to assign materials

→ Check solid overlaps

→ mass model viewer

10) production cuts implemented volume by volume, region by region

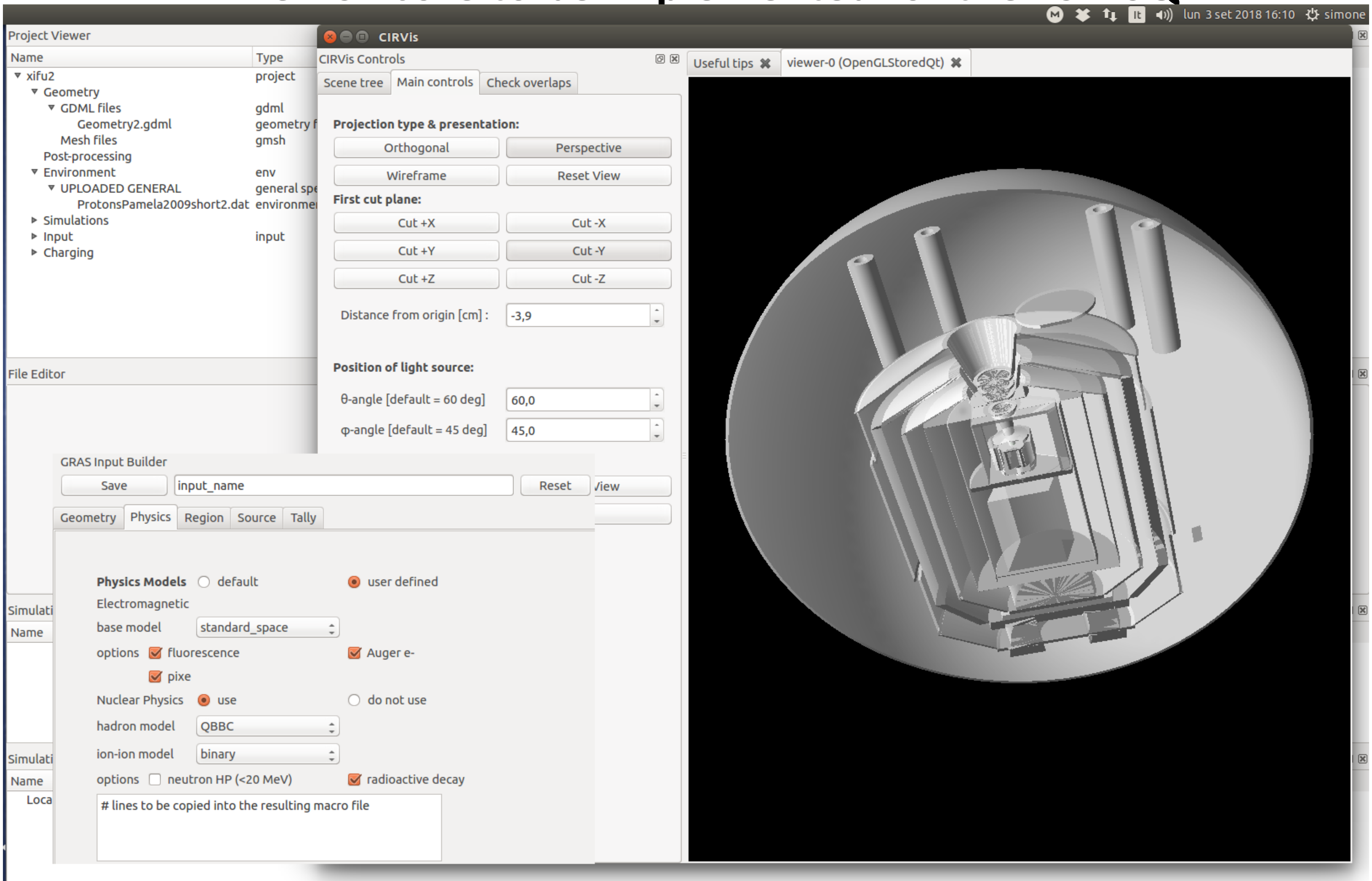
→present, tested and working for regions

11) full distribution of Linux virtual machine delivered (ASF-INS-0050)

→ Ok and tested.

The ASF simulation of proton scattering by X-ray optics, using a single row of the ATHENA/SPO mass model, has been successfully validated by comparison with independent Geant4 simulations.

The ASF core to be implemented for the ESA-SQR



AREMBES – SIMPOSiUM synergy

- A synergy has been put in place between these CTP projects to provide to ESA a feedback on MD design. The instrument teams provide to ESA Emax and deflection efficiency at Emax.
- Both these CTPs have commitments on MD issues: SP flux, tools for magnetic deflection, etc…
  - At present in the context of this synergy the AREMBES team has validated by Geant4 a MD design provided by SIMPOSiUM. SIMPOSiUM has in turn validated its IDL code with measurements.
  - By using Geant4 we can
    - take into account the generation of secondaries from primaries interacting with the MD
    - evaluate the SP scattering by SPO: energy and angular distribution of protons emerging from the SPO to be provided as input to the SIMPOSiUM team to perform a cross-check of the MD deflection efficiency
- ESA has kicked-off with a Czeck company (FrenTECH) an activity on MD design
  - On June, 12th, 2018 we have had a telecon with ESA to better frame our efforts towards this topic
  - Yesterday attended the MD Baseline Selection Review (ESA-FrenTECH). ESA has provided us a design to run some simulation on both the platforms, thus providing feedback to the TDA if possible

EXACRAD

EXACRAD experimental activities

Exacrad kicked off on October 6th 2017

Goal: validation of the SPL in regard of physical processes relevant to ATHENA

WP3

Low energy particles scattering off SPO samples

parameter (p,He)	range (essential)
energy, E	0.1-1 MeV
incidence angle,α	0.3°- 2° (in dense sampling)
scatter polar angle,ϑ	0.1°- n·α n>4
scatter azimuthal angle,φ	±2°

5 weeks campaign between May and December 2018

Tuebingen University (E. Perinati)

WP4

High energy secondary particles generation

Function	Value	Comments
Initial proton energy	250 MeV	GCR max
Material to be tested	6+1	Al, Ti, Cu, Nb, Kapton, C, Si
Thickness of materials	3	
Angle from beam axis	3	10, 45, 70°

October-November 2018

CEA-Saclay (P. Laurent)

WP5

Backscattered electrons yield and spectrum

Function	Value	Comments
Energy range	10-100 keV	30 keV, 60 keV, 100 keV
Angular range	θ~10°	1 measurement
Materials	Au, Bi, Si	Micro-validation
Materials	Composite sample (X-IFU)	Macro-validation

e^- yield: February-March 2018
e^- spectrum: September 2018

ONERA – Toulouse (T. Paulmier)

Expected project closure in mid 2019

EXACRAD experimental activities

- Experimental irradiation requirements defined
- Samples chosen and procured
- Detector configurations selected and prepared
- Accelerator facilities identified and booked

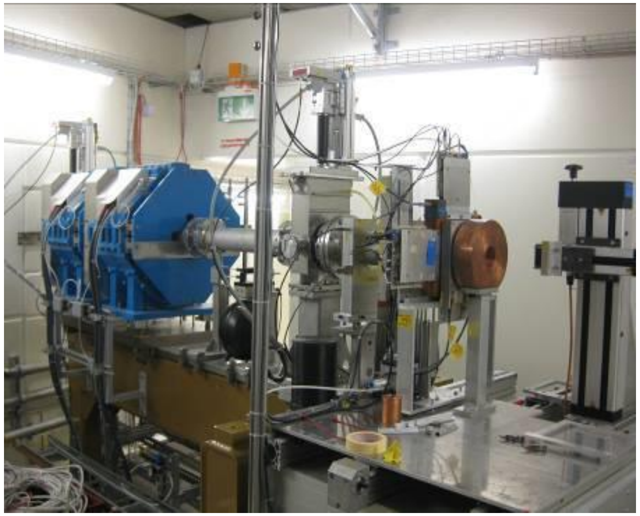
WP3

Low energy particles scattering off SPO samples

Frankfurt setup

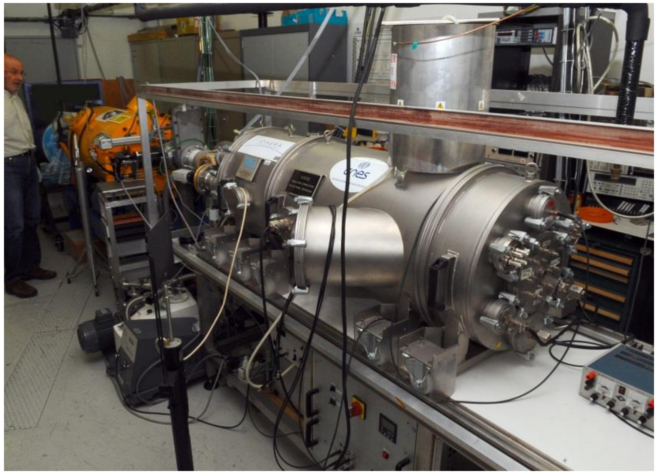
WP4

High energy secondary particles generation



WP5

Backscattered electrons yield and spectrum



WP3 Status (Low energy particles scattering off SPO samples)

WP3 test plan and timeline (tentative, NEW)

Phase	Mar/Apr	May/Jun	Jul/Aug	Sep/Oct	Nov/Dec
0	X		X		
1		X	X	X	
2				X	X

Phase 0 = completion of setup transfer to the facility in Frankfurt and setup commissioning

Phase 1 = 2 campaigns (2.5-week per campaign) for essential measurements

Phase 2 = 2 campaigns (2.5-week per campaign) for goal measurements

Essential: 100 keV - 1MeV; incidence angle = 0.3 – 2 deg
Goal: < 100 keV; incidence angle = 2 – 20 deg

WP4 Status (High energy secondary particles generation)

Detector Hardware

4 different kind of detectors: gas, scintillator+PM, solid state (Si and BGO, Bismuth germanium oxide) all have been procured.

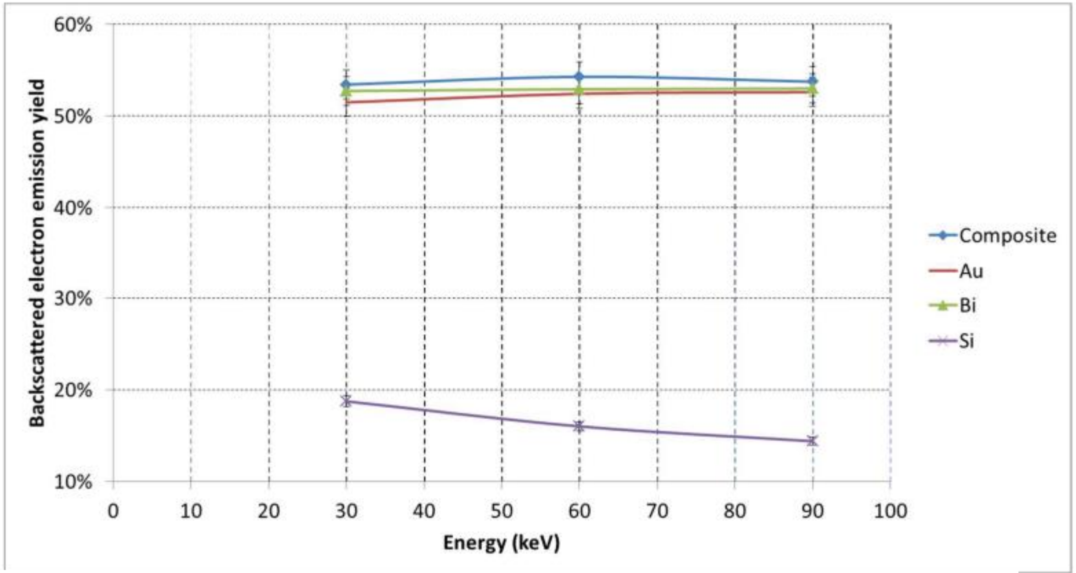
Pre-tests

- A successful pre-test has been made with gas and plastic detectors at the accelerator facility in Orsay (CSNSM/ARAMIS) from April 9th to 11th.
- Gas detectors were calibrated with a ^{207}Bi beta source.
- Another pre-test with all the components is foreseen at CSNSM (Orsay) end of September 2018.

Beam line

- The PIF line at PSI is booked for October 26th – 28th.
- The test plan is completed.
- We have a contact point at PSI who help us in preparing and running the test.

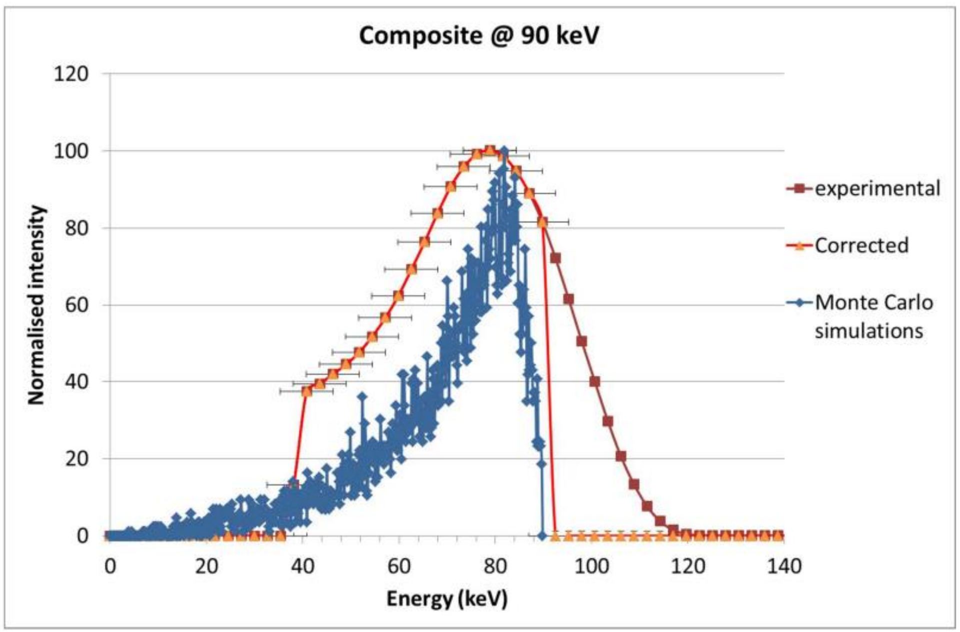
WP5 Status: Experimental plan carried out



Backscattered electrons yield and spectrum

Measurement of backscattered electron yield

- As expected, high Z material feature a higher yield than low Z material.
- Negligible differences between different high Z materials
- Compound provided by GSFC team



Measurement of BSE energy spectrum

- Corrections needed for pile-up
- Significant evolution with the incident energy

Conclusions

- AREMBES
  - Framework Simulator: validation activity on-going
  - L1 Vs L2 particle environment work concluded
  - The L1 environment is much more well known wrt the L2 (highly structured, poor knowledge)
  - In place a collaboration with the SIMPOSiUM team and ESA on MD design

- EXACRAD
  - Experimental setups defined and prepared, facilities booked
  - Experimental WPs in good shape:
    - electron backscattering measurements performed, first results available
    - Ion forward scattering and secondary particles yield measurements during 2018