The Athena background

Luigi Piro (INAF/IAPS)

inputs: Simone Lotti (IAPS/INAF), Tanja Eraerds (MPE), Silvano Molendi (INAF/IASF-Mi), Philippe Laurent (CEA), Claudio Macculi (IAPS/INAF)

Summary

- Impact of bkg
- Background components
- The environment
- Propagation of particle to instruments
- XIFU & WFI
- Organization: instruments, WG & ESA tender

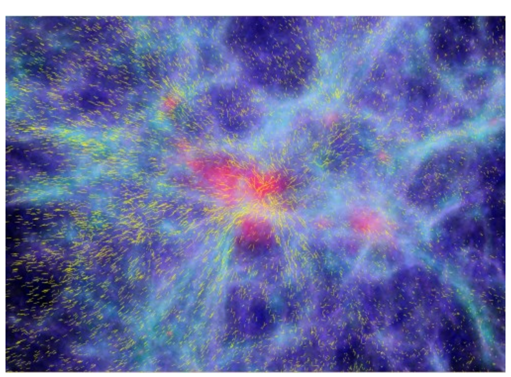
Background: why it matters

Particles component

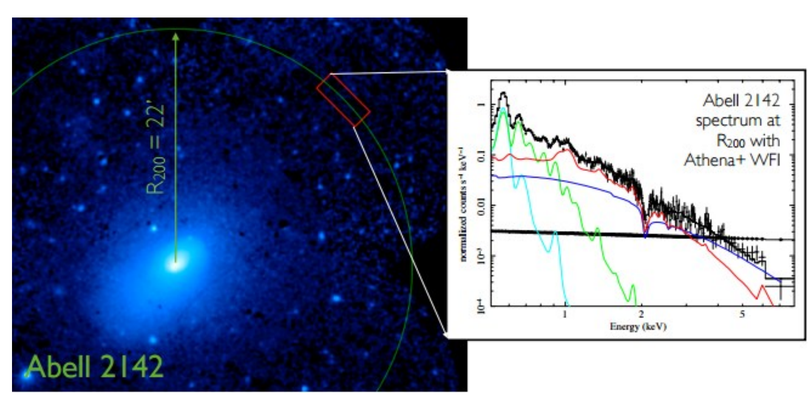
$$F_{\min} = \frac{n_\sigma}{QA_s}\sqrt{\frac{B_i A_d + B_d Q\Omega A_s}{t\Delta E}}$$

Diffuse component

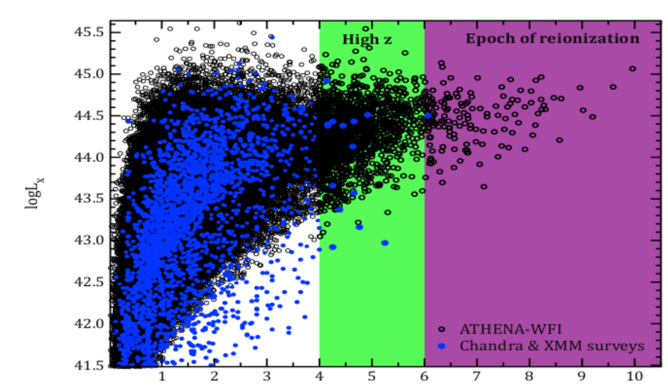
- Observation of diffuse/faint/distant objects
- Level & Reproducibility



WHIM in emission



Cluster outskirts



Distant AGNs

Components

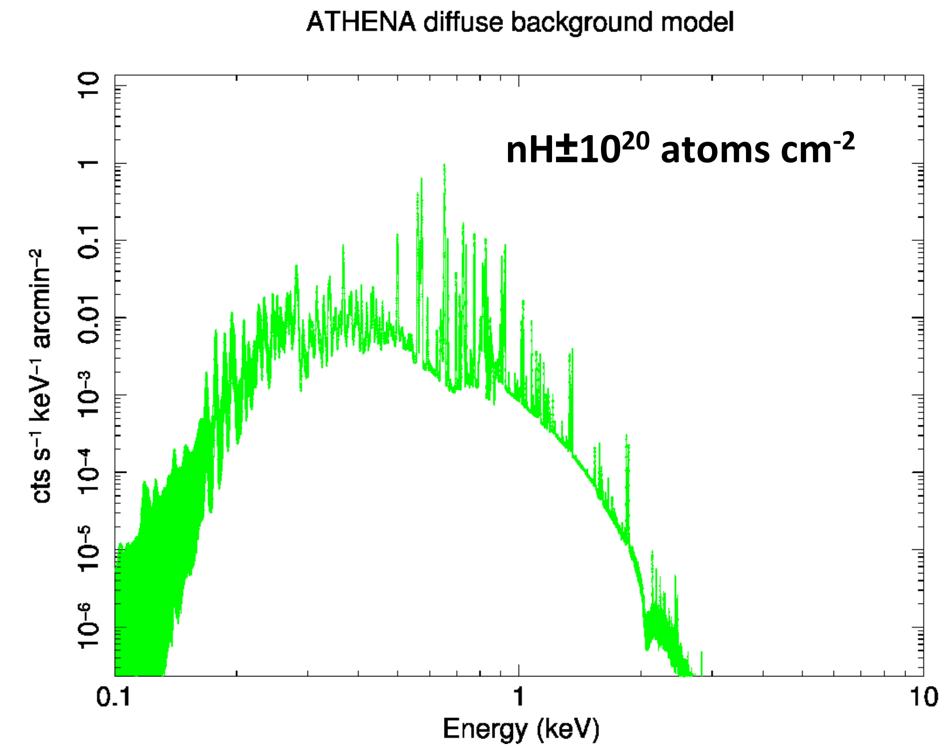
- X-ray
  - XRB
  - Stray light
- Particle bkg
  - Throughout (mostly high energy particles)
  - Focussed by mirrors (soft protons & ions)
  - Activation (delayed component)

The soft X-ray Background

$$F_{\min} = \frac{n_\sigma}{QA_s}\sqrt{\frac{B_i A_d + B_d Q\Omega A_s}{t\Delta E}}$$

Several components:

- Above 1 keV: absorbed powerlaw
  - Extragalactic origin (unresolved AGNs)
- Below 1 keV: lines from hot diffuse gas
  1. Anticorrelates with interstellar medium nH
     - Galactic halo
       - T=2x10^6 K
       - Uniform emission, not uniform absorption
  2. Not anticorrelates with nH
     - Local Hot Bubble (d=100 pc, T=10^6 K)
     - Solar Wind Charge Exchange
       - 80% of ¾ keV emission
     - Geocoronal emission
       (same process as SWCX, not important in L2)



apec + wabs (apec + powerlaw)
(LHB&SWCX) + nH (GalHalo+AGNs)

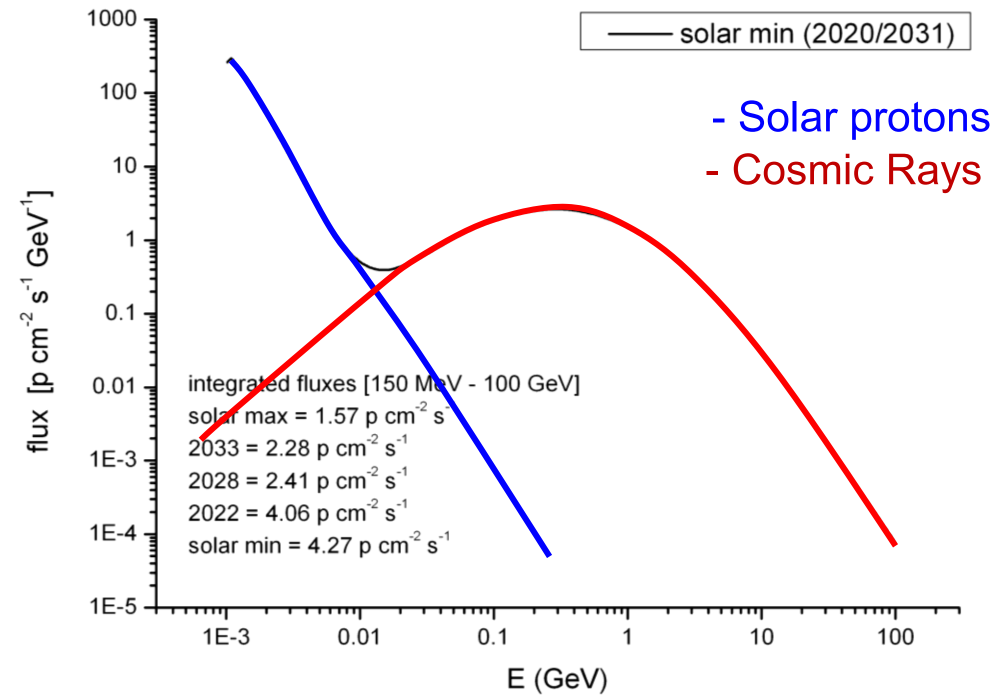
Only high spectral resolution can separate lines fr expected nH variations $\approx 10^{20}$ $atoms \cdot cm^{-2}$ / deg

The particle background

$$F_{\min} = \frac{n_\sigma}{QA_s}\sqrt{\frac{B_i A_d + B_d Q\Omega A_s}{t\Delta E}}$$

No experimental data for this background **in L2.**

Induced by 2 populations of charged particles able to reach the focal plane, depositing part or all of their energy



- High energy (>100 MeV)
  - CR dominated in stationary conditions
  - Solar Energetic Particle (flares)

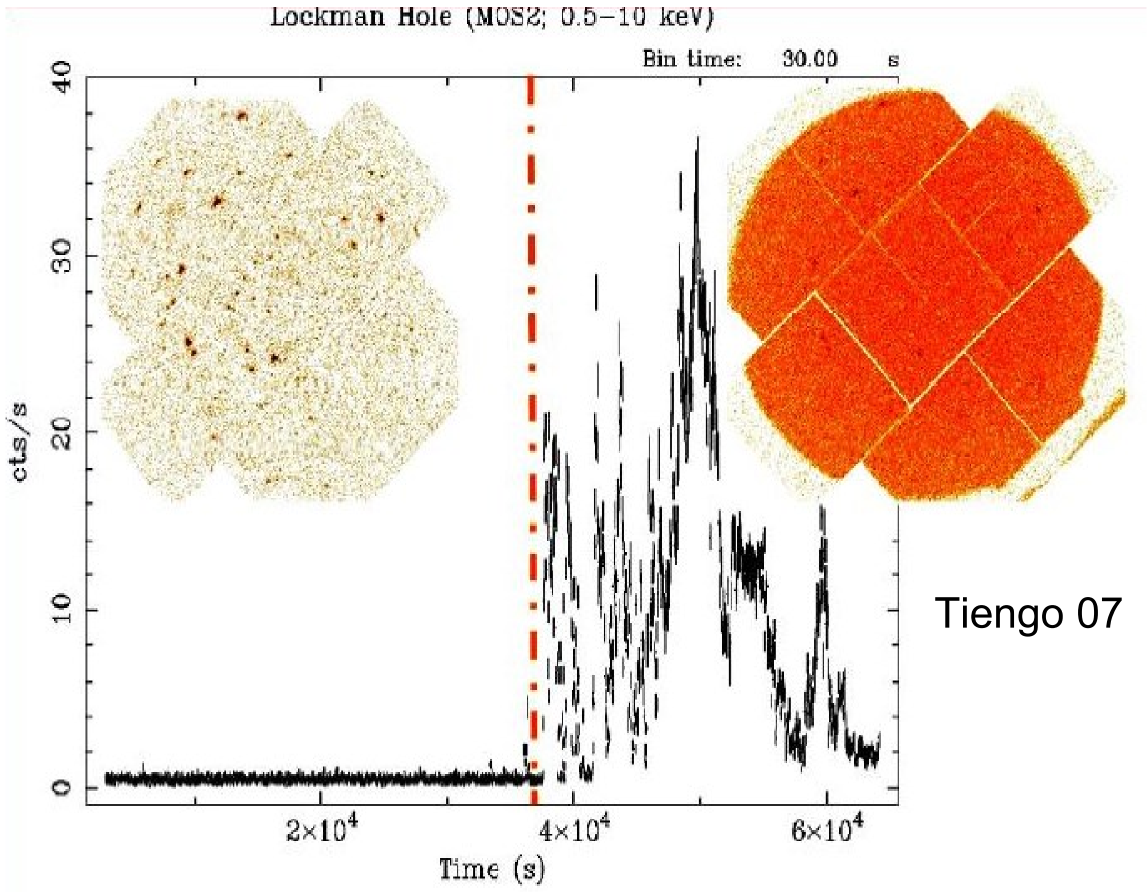
- Low energy (<100s keV)
  - Soft solar protons (& ions)

Both components depend on the solar cycle, and they are anticorrelated.

Low Energy Particles

The process is analogous to the one experienced by photons

- Soft protons
- Focussed by the optics, as XMM and Chandra experience has shown
  - In XMM compromised up to 30% of obs. Time



Tiengo 07

- Low energy external fluxes in L2 are poorly known
- Focalization efficiency determined with MC/ray tracing simulations, different treatments, preliminary assessment
- Several data from existing satellites
- New experimental data to validate simulator
- Heritage from already flown X-ray missions

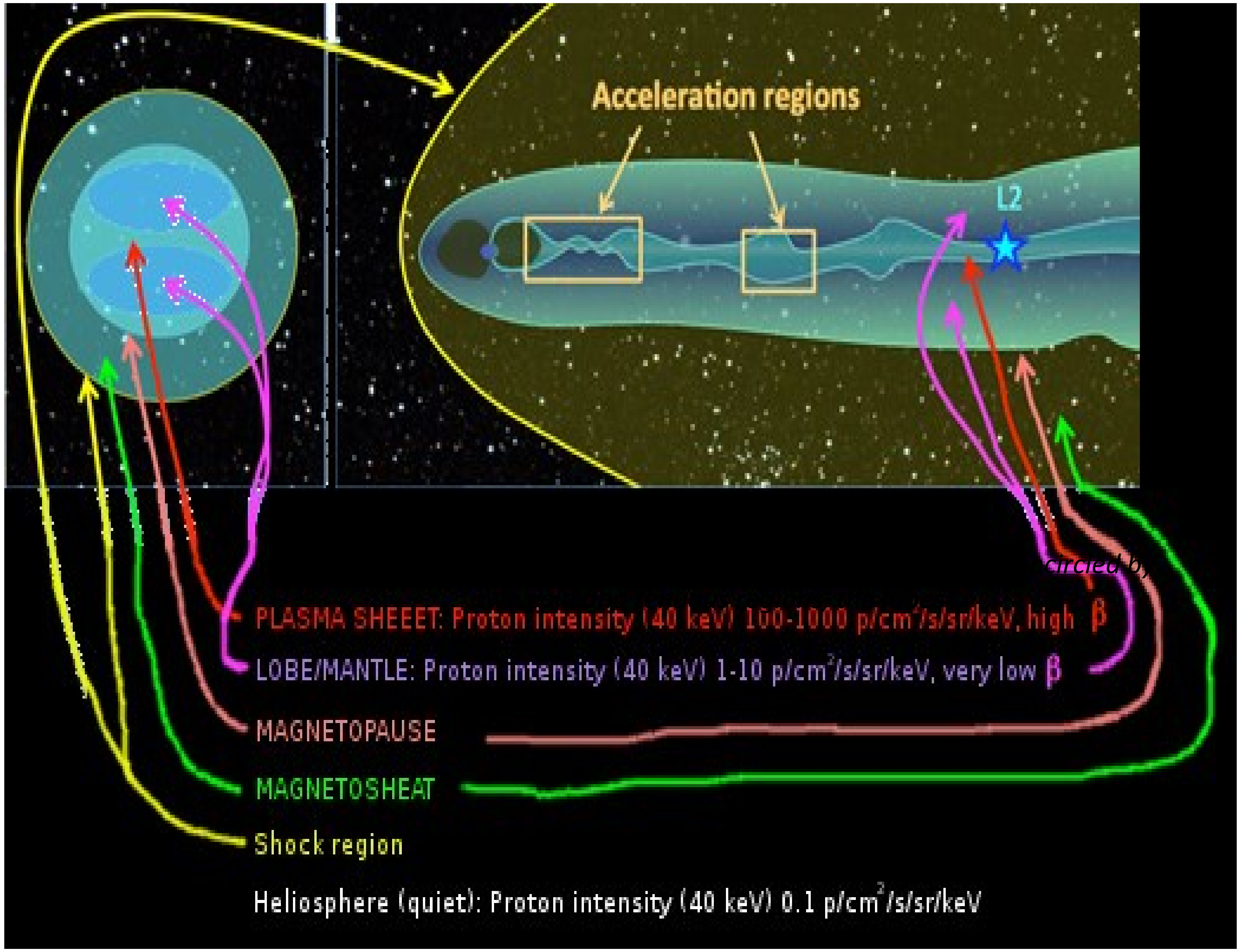
Low energy environment

Magnetotail

Highly dynamic system controlled by:

- highly variable solar wind
- geomagnetic activity
- Particles locally accelerated

- No precise model and sparse data
- An L2 halo orbit may meet all these zones



XIFU background activities

- L2 environment activities (INAF/IAPS,IASF-MI,Pa & IRAP):
  - High energy (>100 MeV) SEP events occurrence
  - Solar soft proton level enhancements (SPLE?) occurrence and interaction with the magnetotail up to L2
  - XMM-Newton data analysis
  - Satellite data analysis for L2 environment characterization (*GEOTAIL*, *Planck/SREM*, *WIND*, *IMP-8*, ARTEMIS, ACE, STEREO, SOHO)
- GEANT4 (& ray tracing) simulations
  - Geant4 simulations & validations (versions/models) (IAPS, IASF-Bo, CEA)
  - Soft protons mirror ray tracing & models (IASF-Pa)
- Design: CyoAC & Passive shield improvement (IAPS)
  - Cryostat + Satellite mass model definition in GEANT4 (IAPS, SRON, CEA)

First SP estimates & Magnetic Diverter Req.s

IASF-Milano and IASF-Palermo

The fluxes for the different zones of the magnetotail are (O.M.E.):

- Heliosphere: I_{sp}(51 keV)=0.07 p/cm^2/s/sr/keV
- Lobes: heliosphere x 10 – x 100
- Plasma sheet: heliosphere x 10^4 – x 10^5

F_{sp}(1 keV)< 10^{-3} p/cm^2/s/keV

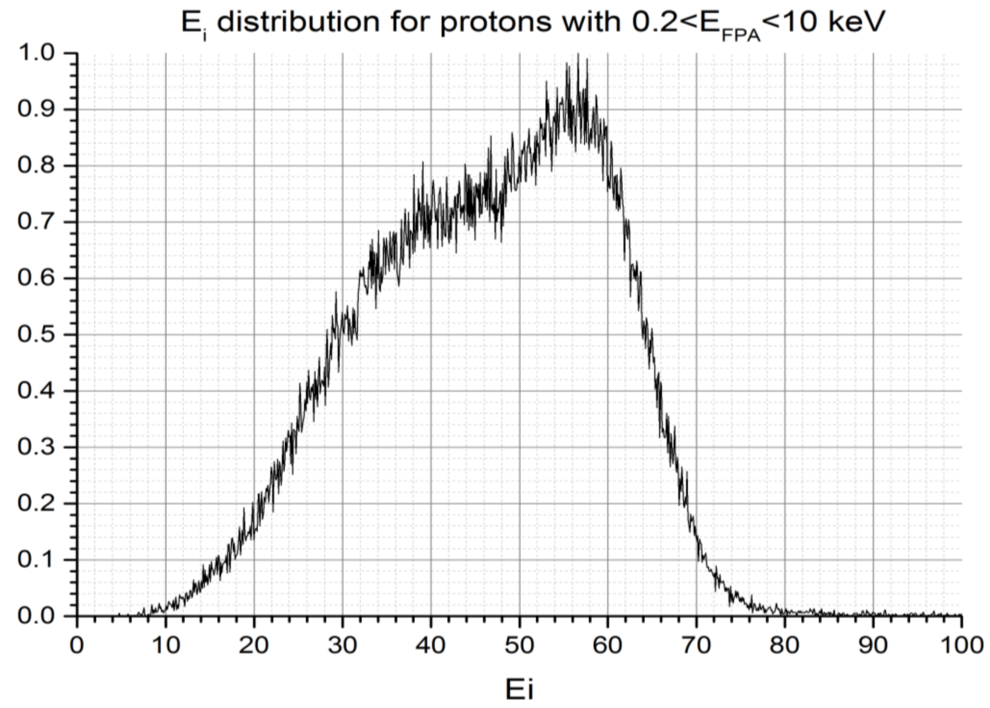
(heliosphere)

=20% nominal particle bkg

In first approximation the thermal filters block protons up to 50 keV, but straggling requires >80keV

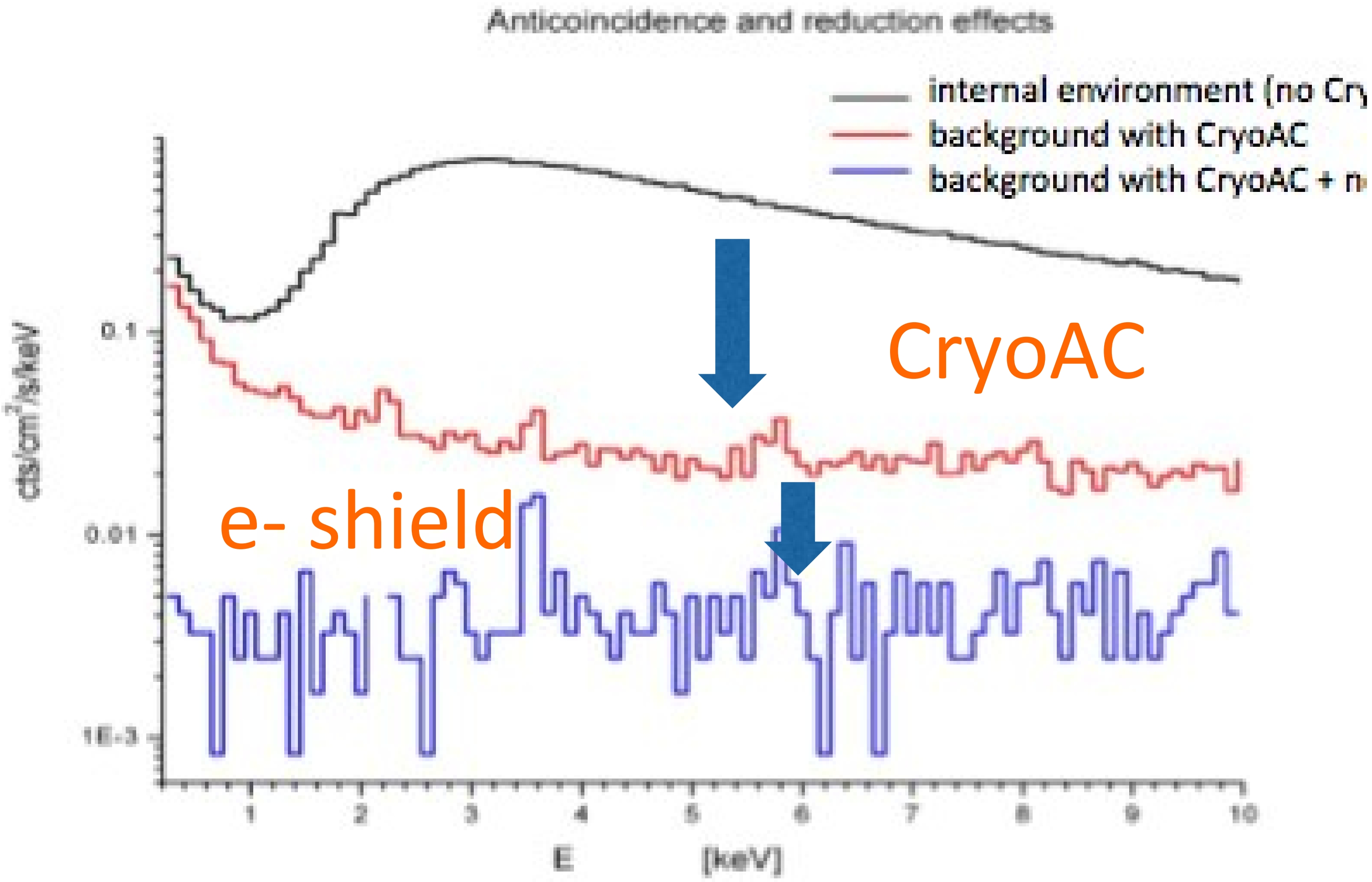
These are just first order estimates:

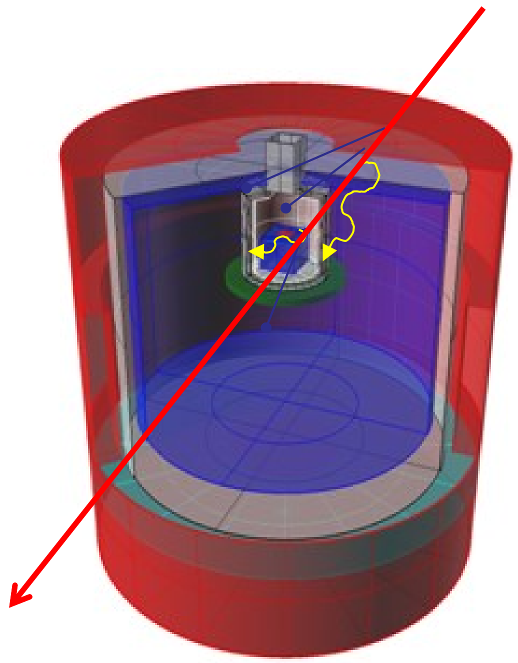
- In lobes and plasma regions this component can exceed the required bkg by orders of magnitude, thus requiring an **high efficiency magnetic diverter** ~1/10^4)
- Assess the soft proton distribution probability



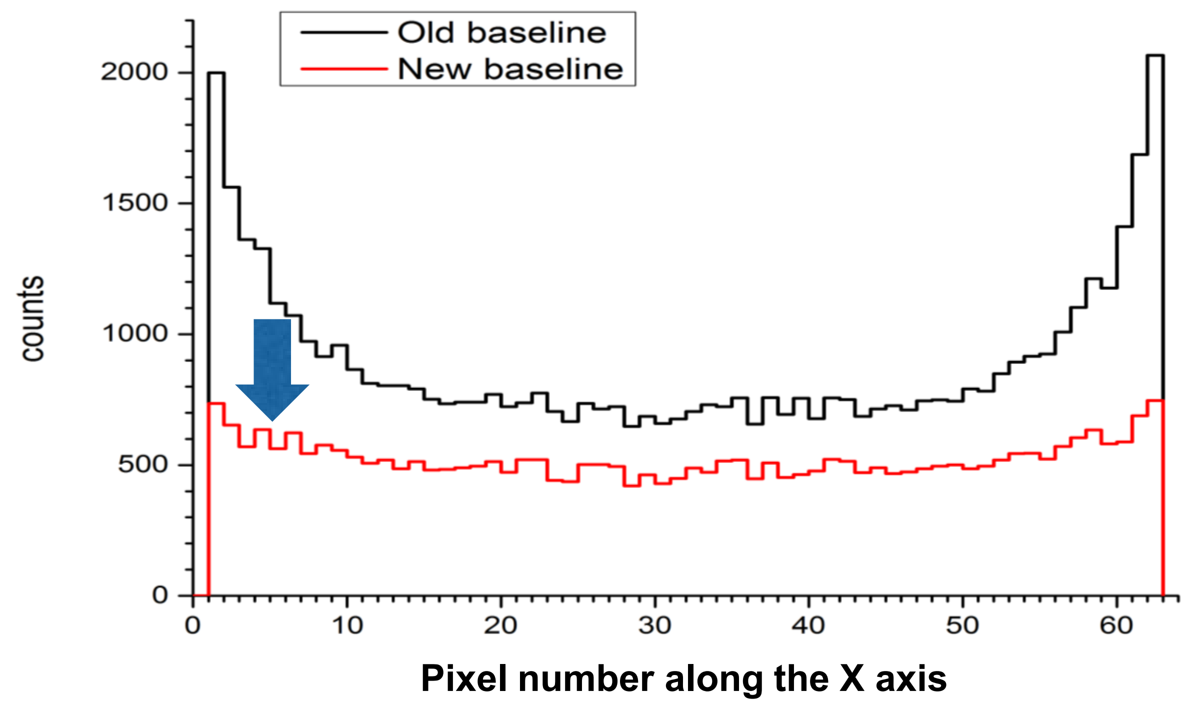
Background estimates and design

IAPS Roma





CryoAC improvement

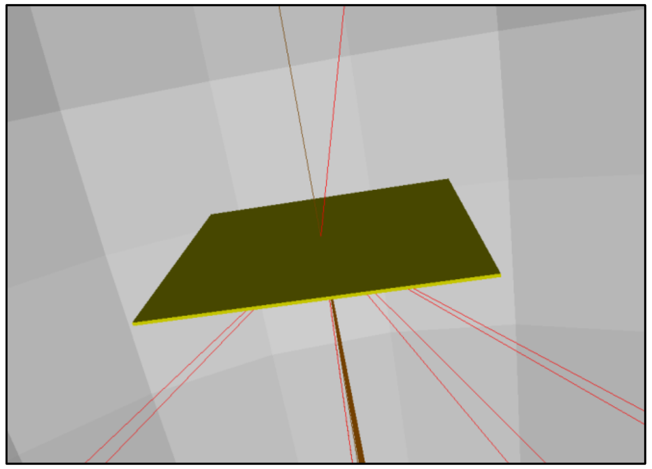


Comparison of Low Energy EM Physics Lists

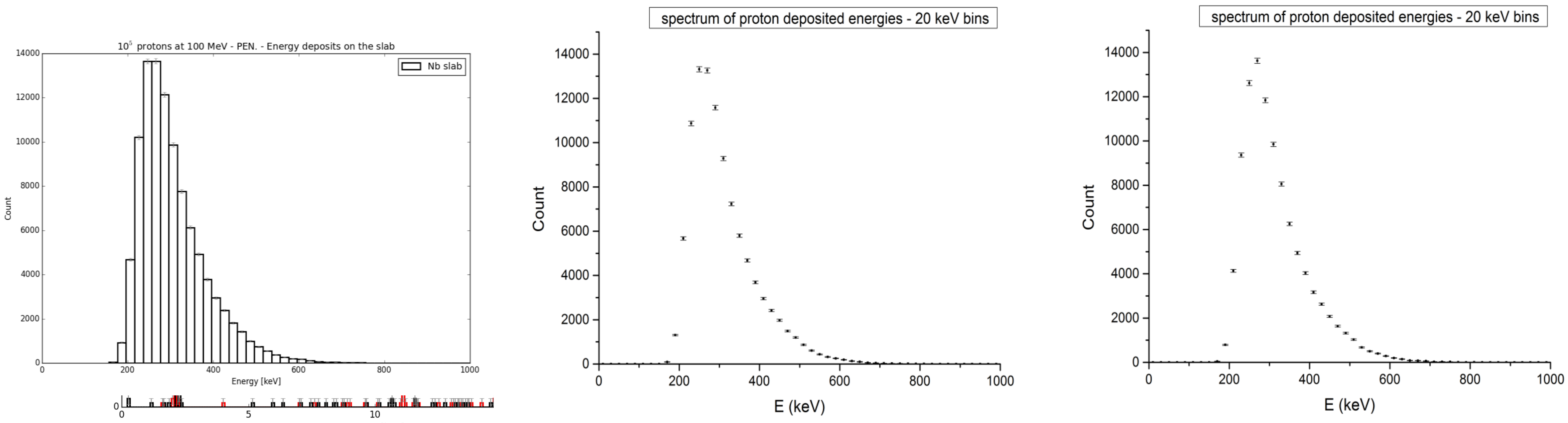
IASF Bologna, IAPS Roma, CEA Paris

- Geometry: Nb slab (1 cm × 1 cm × 100 µm)
- Input particles: 10^5 protons from a point src
- Direction: normal to the detector surface

- Geant4 9.1, 9.4 and 9.6 LowE EM Physics List tested:
  - LIVERMORE
  - PENELOPE



Different versions and Physicslists reported results in agreement for the proton energy deposit:



Energy spectrum deposited in the slab by protons left 9.1, center 9.4, right 9.6

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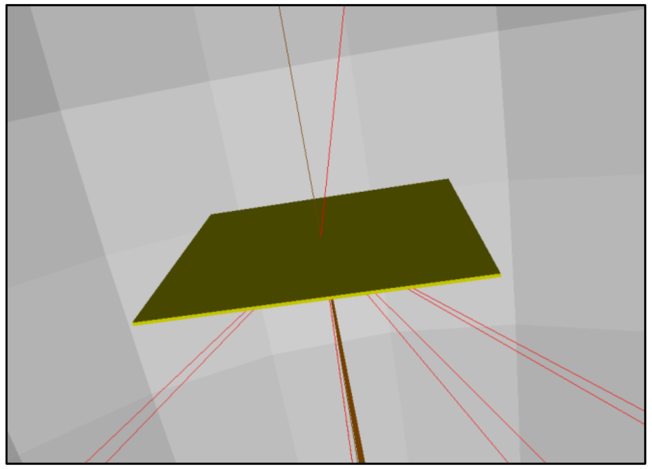

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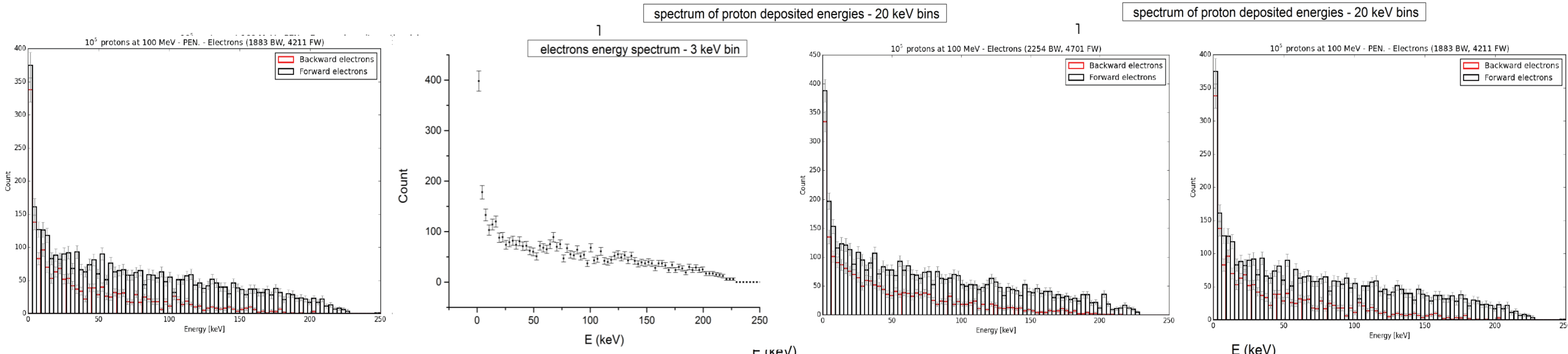
And for the spectrum of secondary electrons generated



Spectrum of the electrons emerging from the slab, from left to right Geant4 9.1, 9.4, 9.6 (Livermore), 9.6 (Penelope)

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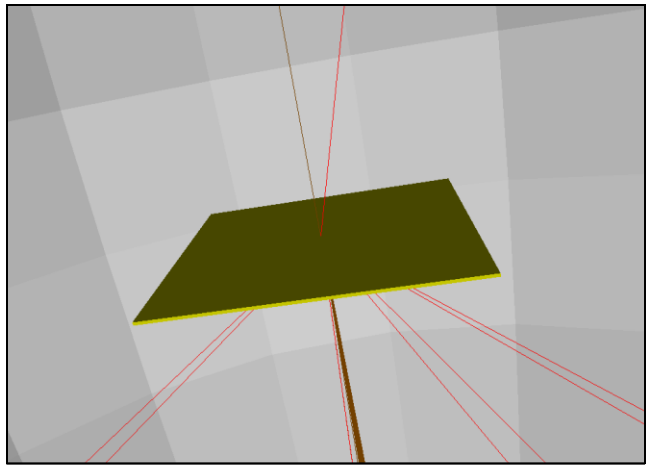
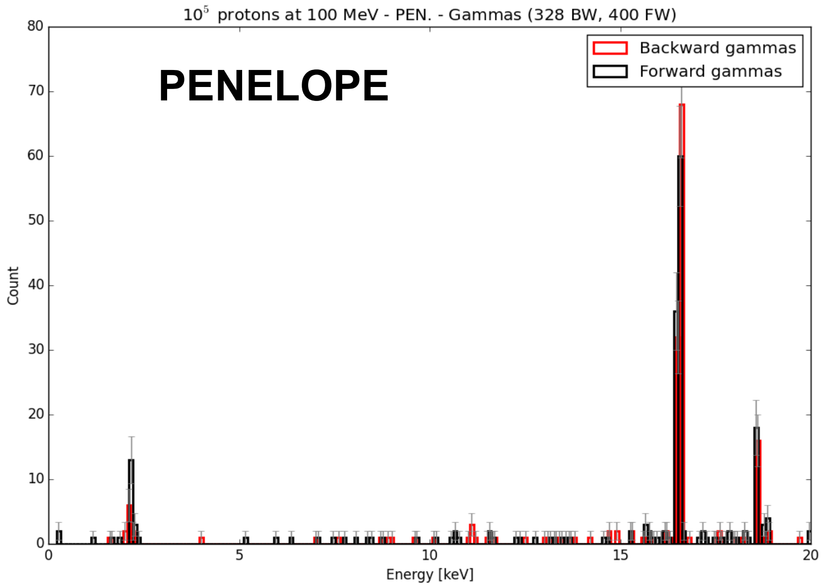
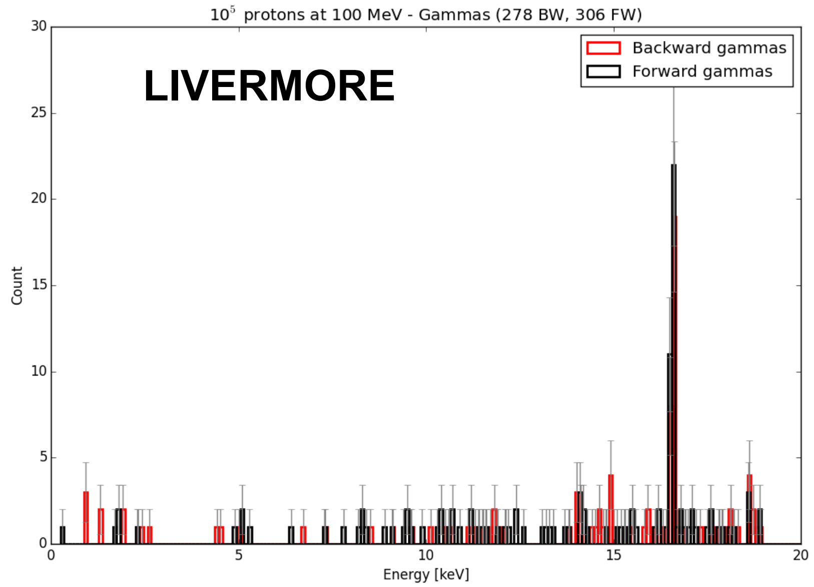


Most relevant discrepancy is that the use of the different physics lists results in different distributions of secondary photons: If PENELOPE is used, the number of photons is 3 times higher at the fluorescence energy





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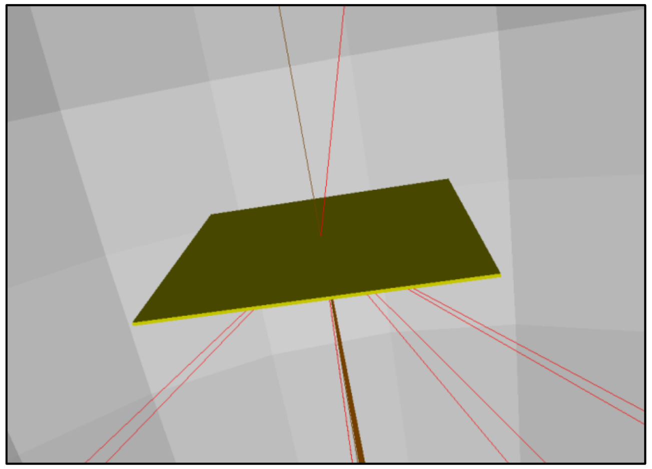


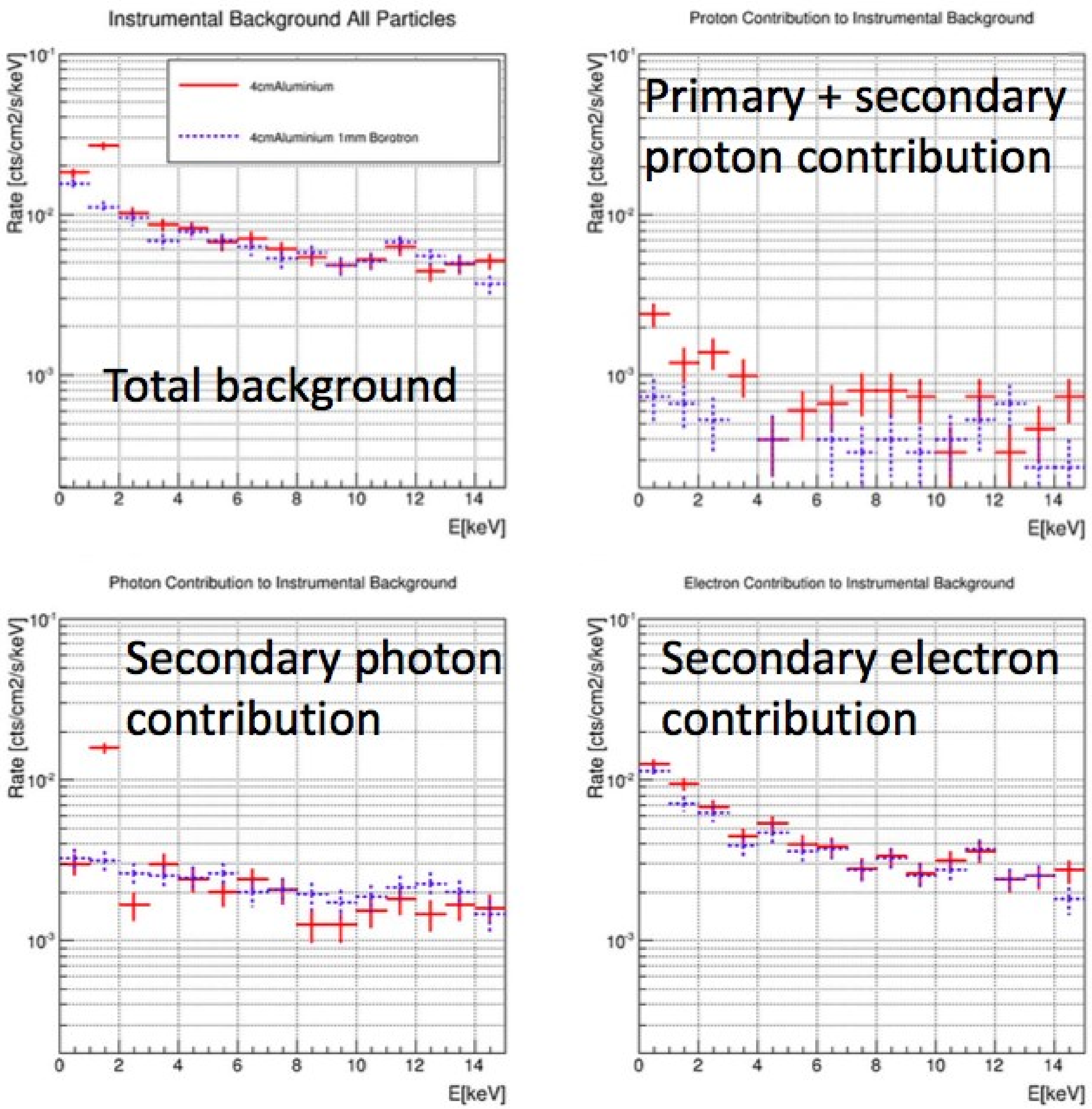
e- scattering to be validated (but sparse exp. data)

WFI activities

- MPE, IAAT, OU, CEA, INAF
- Optimization of graded z-shield to suppress fluorescence lines and continuum ongoing
- Background estimation becoming more and more complete
  - Inclusion of cr electrons and cr ions ongoing
  - Geometry is becoming more realistic
  - High Energy Input spectra follow now ESA recommondations
  - Study of different possibilities to suppress background ongoing
- First estimation of delayed radiaction induced background show that it is likely to be negligible
- New work task about estimation of background from data (i.e. from small detector, dark edges etc.)

WFI bkg simulations

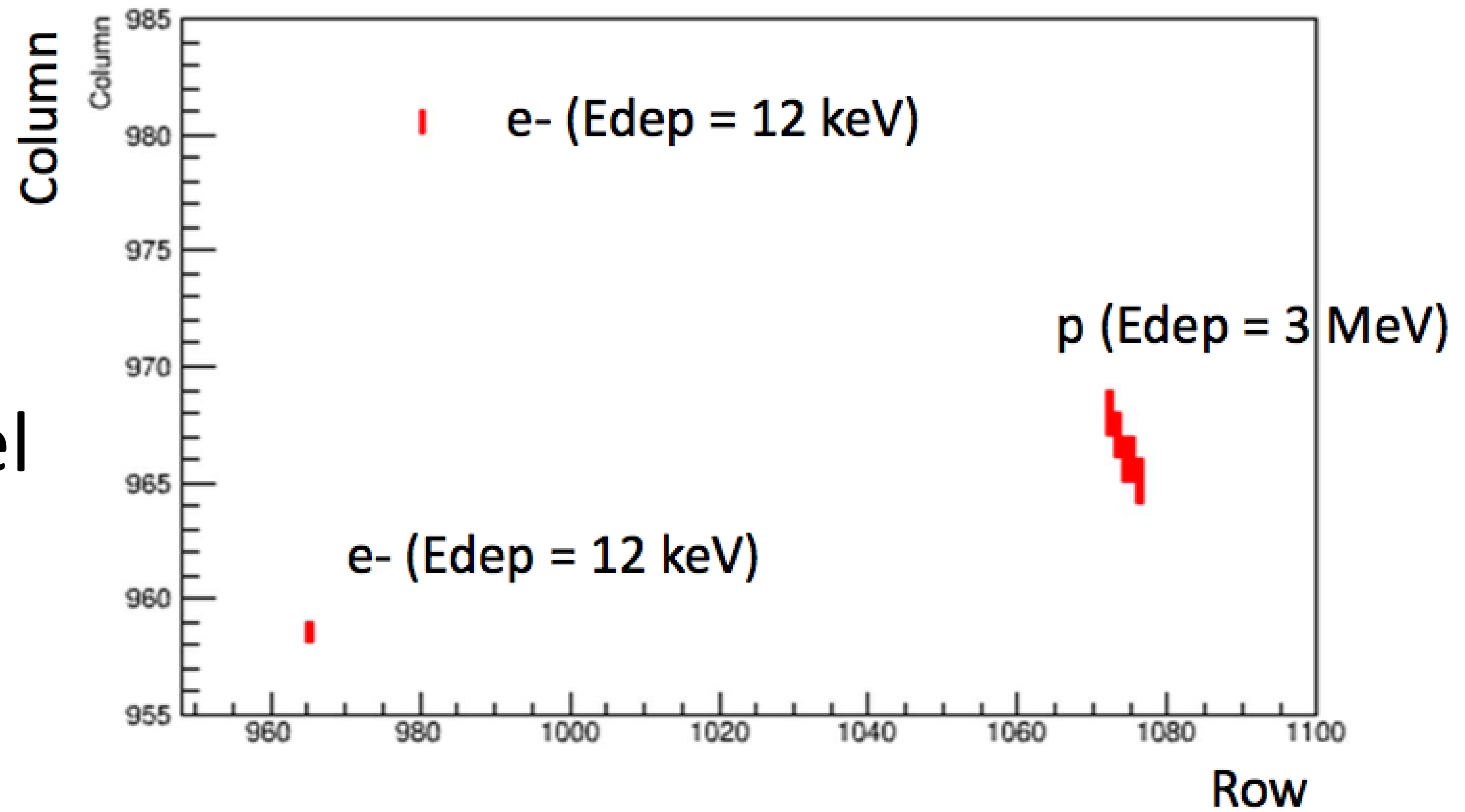
- Very simple geometry for these comparisons:
- Closed boxes around detector
- - 4cm of Al shield
- – low z material graded shield (Beryllium, Borcarbid Borotron)



Further WFI studies on bkg suppression

- Patter recognition possibly effective to further reduce bkg
  - distance of fake signal pattern in this case 100 pixel
  - Background reduction plays against downtime, computing power and bandwidth

Pattern produced by an incoming 390 MeV proton



AREMBES: Athena Radiation Environment Models and X-Ray Background Effects Simulators.

- ESA tender relevant for the planned activities on Athena bkg

- **Part 1 (30%, 9 Month):** Analyses of radiation effects data and experience from previous X-ray missions, consolidation of user requirements, **improvement of L2 radiation environment** models, and **improvement of the relevant GEANT 4 physics models** to treat propagation of charged particles, photons and radiation background in X-ray mirrors and surrounding spacecraft structures
- Part 2 (60%, 9 Month): Development of a user-friendly radiation background simulator framework incorporating Part 1 output and considering the specific technologies used in the ATHENA telescope and foreseen instruments, verification of all software elements, construction of a **representative ATHENA geometry model, and validation of the simulator performance**

- **Part 3 (10%, 12 Month)**: This part covers the maintenance and upgrades of the developed software
- An Athena-based proposal is being submitted

Bkg WG

- Share Commonalities and Maximize synergies for WFI and XIFU
- Geant 4 some overlap:
  - For a relative comparison adopt the same version & physics list
  - Agree on the particle environment (easy for cr)
  - Shielding
  - Activation
- Environment some overlap:
  - Reflectivity
  - Diverter
- Results, w.p.r.t those that have impact on both instruments will be shared by the two instruments teams