

PIXE Simulation With Geant4

Maria Grazia Pia, Georg Weidenspointner, Mauro Augelli, Lina Quintieri, Paolo Saracco, Manju Sudhakar, and Andreas Zoglauer

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Abstract—Particle induced X-ray emission (PIXE) is an important physical effect that is not yet adequately modelled in Geant4. This paper provides a critical analysis of the problem domain associated with PIXE simulation; it evaluates the conceptual approach, design and implementations of PIXE modelling so far available in Geant4, and describes a set of software developments to improve PIXE simulation with Geant4. The capabilities of the developed software prototype are illustrated and applied to a study of the passive shielding of the X-ray detectors of the German eROSITA telescope on the upcoming Russian *Spectrum-X-Gamma* space mission.

Index Terms—Geant4, ionization, Monte Carlo, PIXE.

Max-Planck-Institut für extraterrestrische
Physik and Halbleiterlabor, Germany
Space Sciences Lab., UC Berkeley, USA
CNES, Toulouse, France
INFN Genova and INFN LNF, Italy

Developed in response to experimental requirements of
the astronomy/astrophysics community

PIXE component

+

(existing) Geant4
Atomic Relaxation

+

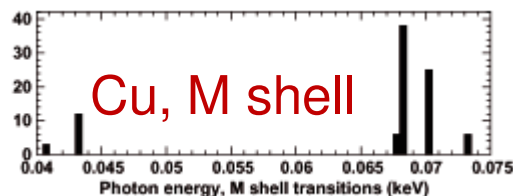
Ionisation client

Compliant with

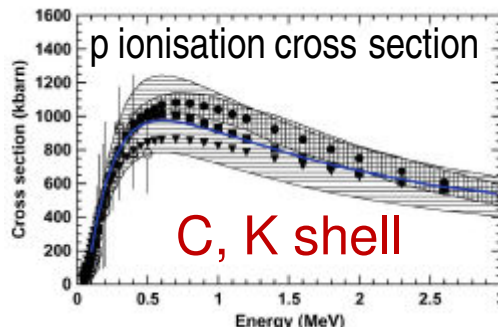
G4VContinuousDiscreteProcess

State-of-the-art p and α ionization cross sections
(theoretical and empirical models) for **K, L, M** shell

Thorough V&V



X-ray emission

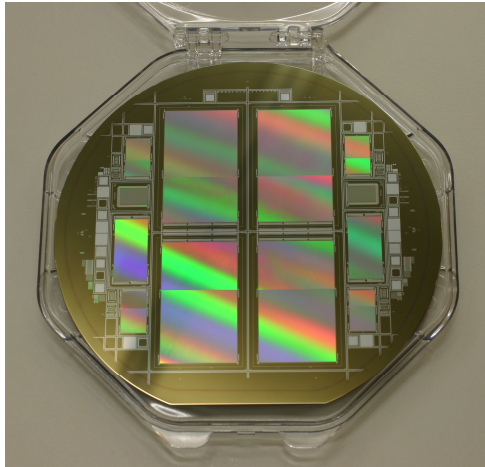


Further technical
details in the paper

eROSITA PIXE application

Software applied to a real-life problem

Astronomical X-ray full-sky survey mission eROSITA
on-board the Spectrum-X-Gamma space mission
launch planned for end of 2012



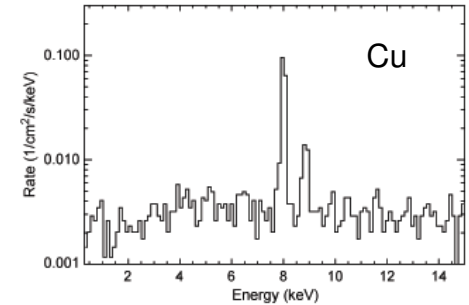
Wafer including 4 eROSITA PNCCDs

Detectors sensitive to 0.1-15 keV

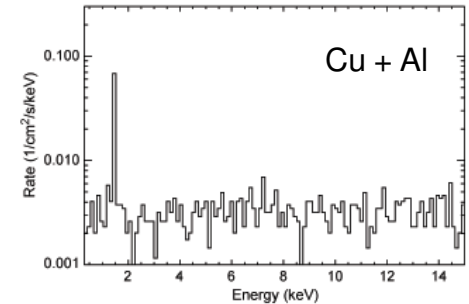
Is a graded shield Cu-Al-B₄C really necessary?

Constraints for a satellite:

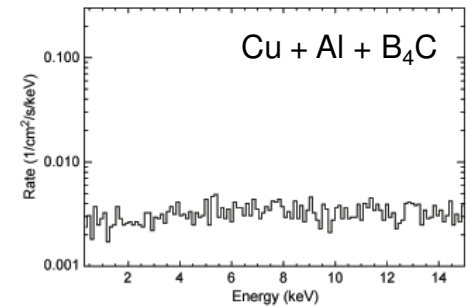
- background noise
- very limited telemetry
- manufacturing effort
- mass limits



(a)



(b)



(c)

Fig. 12. A comparison of the fluorescence background due to ionization by cosmic-ray protons in an L2 orbit for three different graded Z shield designs for the eROSITA X-ray detectors. (a) Cu shield; (b) Cu-Al shield; (c) Cu - Al - B₄C shield.

To emphasize

- **Significant investment of the astro-community** in the whole software development process
- Fruitful **collaboration** between experimental community and Geant4 members
 - An example to follow!
- **Critical requirement** of the astro-community
- Software **already in use** by the astro-community (MPI-MPE etc.), need it in Geant4
 - Geant4 **toolkit**, multiple options, the **astro-community wants this one**
- Need **high quality software** for **critical applications** (detector shielding in space)
- **Outlook:** further extensions/improvements related to experimental issues