

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 requirements of the experimental community

PIXE component

+

(existing) Geant4
Atomic Relaxation

+

Ionisation client

Compliant with

G4VContinuousDiscreteProcess

30 March 2010: requested its release at Geant4 Technical Forum

17 June 2010: contacted for a “technical evaluation” of our code

too late for June 2010 Geant4 9.4-beta release

28 June 2010: we provided material for evaluation and clarifications

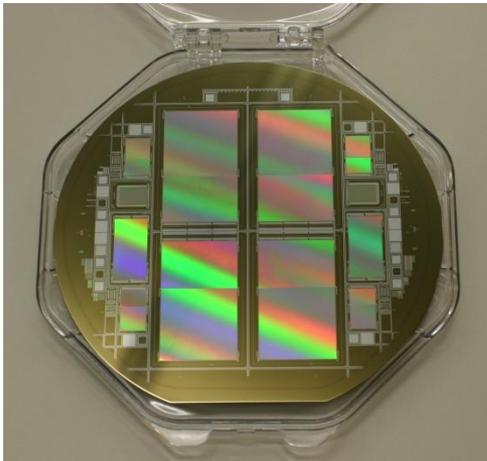
In September 2010 we are still talking about releasing code
developed, validated and used in real-life in 2008,

needed by experimentalists (who **invested resources** into its development)

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



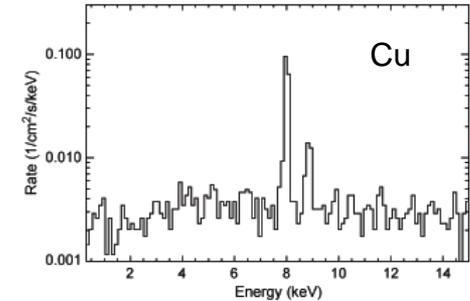
Wafer including 4 eROSITA PNCCDs

Detectors sensitive to 0.1-15 keV
Is a graded shield Cu-Al-B₄C really
necessary?

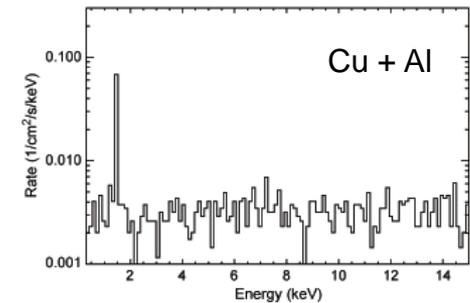
Constraints for a satellite:

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

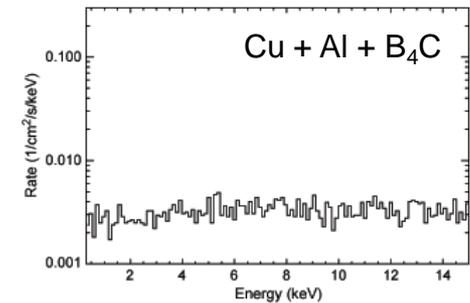
The same holds for IXO and similar X-ray missions.



(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.

Other developments in the meantime

- **Improved accuracy of XRF generation**
 - Resulting from significant investment in a large-scale validation project
 - Geant4 accuracy compared to other Monte Carlo codes (*not the best!*)
- New developments and large-scale validation for accurate simulation of **low energy electrons**
 - Relevant background for future missions
 - By-product: estimated accuracy of current Geant4 (*not the best!*)
- Significant **performance improvement** in physics data management

We request all these developments to be released in a dedicated package (along with PIXE developments)

We also request to **maintain the original “Livermore” processes** and related software in future Geant4 releases

- We gratefully acknowledge CERN’s support in this R&D

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