12th Geant4 Space Users Workshop, Surrey, Apr 2017

Geant4 in CAS

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Li Gang

Zhang Juan

Preface

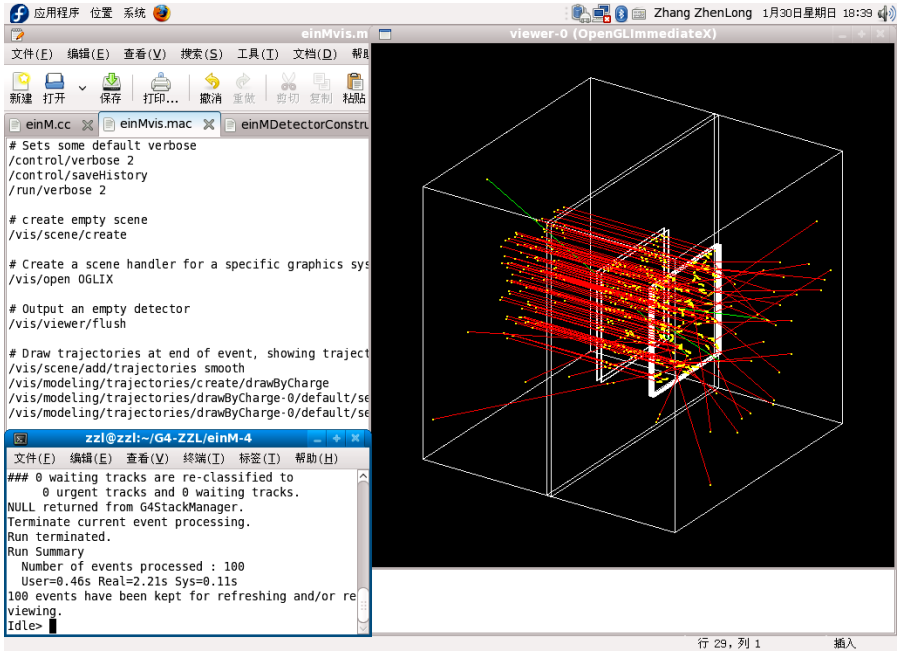
- **Chinese Academy of Science is a so big organization (more than 100 Institutions all over the China), and many institutions are engaged in space science or space technology, so it's difficult to make a presentation about *Geant4 in CAS*.**
- **Whit the assistance by several friends and my limited knowlodge, this presentation will focus on two aspects :**
  - **Space radiation effects (including internal charging) analysis**
  - **Space science missions**

Space Environment Effects Laboratory, NSSC

- **Fields : Study space environment interact with satellite materials and electronic devices by ground testing & computer calculation.**
  - **radiation damage**
  - **Single event effects**
  - **Spacecraft charging**
  - **Debris impact**
  - **……**

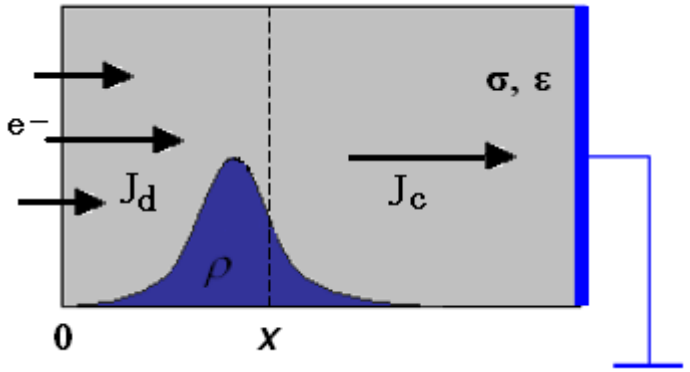
Application to Radiation Effects Analysis

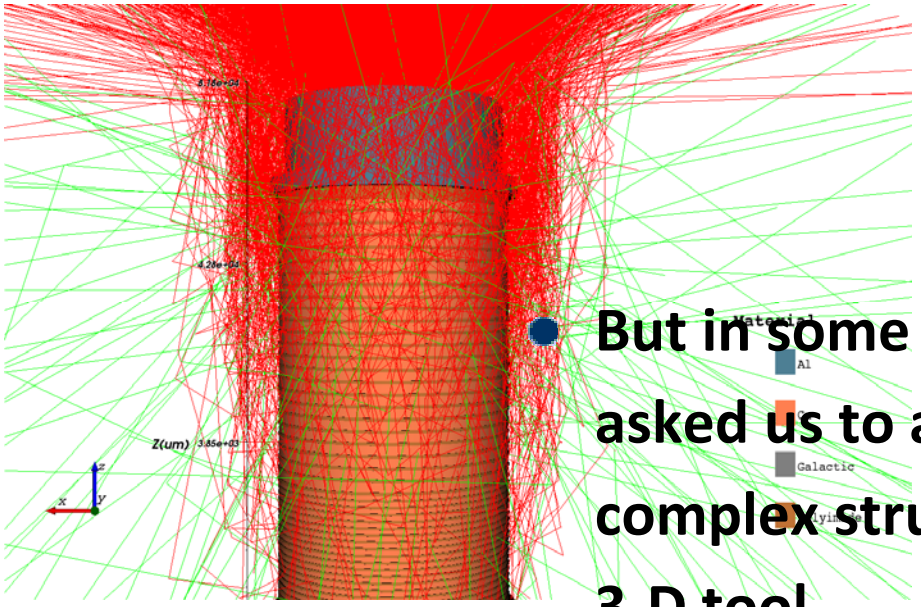
- In NSSC, Geant4 has been a Important tool for space radiation effects analysis.
  - Internal Charging
  - Single Event Effects
  - Total Ionizing Dose



Internal Charging Analysis

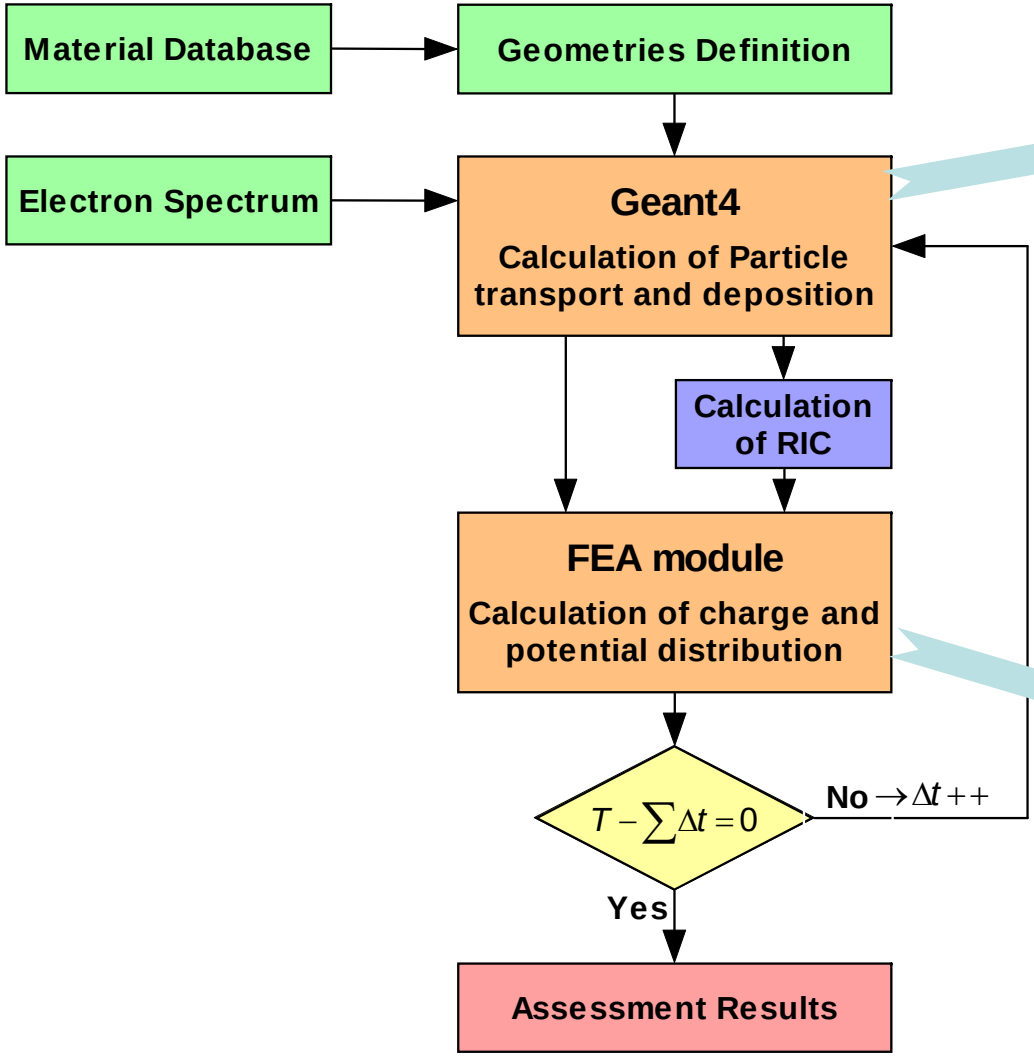
- Before 2008, we used 1-D model (similar to DICTAT) to analyze the risk of internal charging.

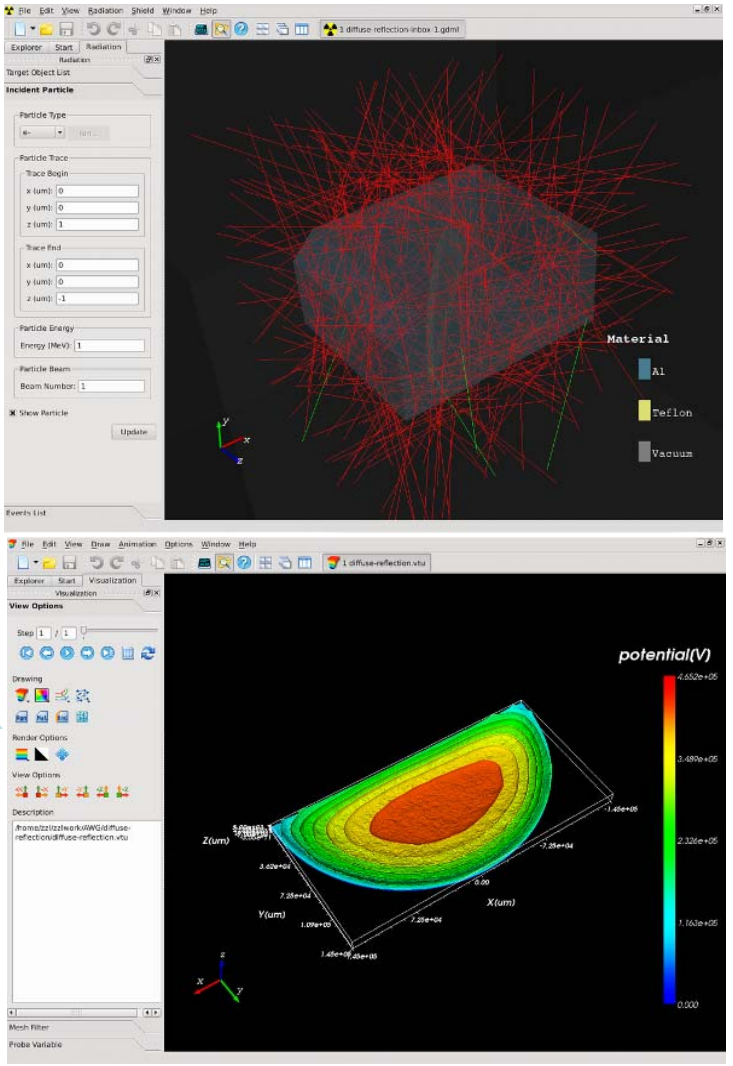




- But in some missions, satellite engineers asked us to assess the realistic parts with complex structures, we had to develop a 3-D tool.

SIC3D — NSSC's 3-D Internal Charging simulation tool

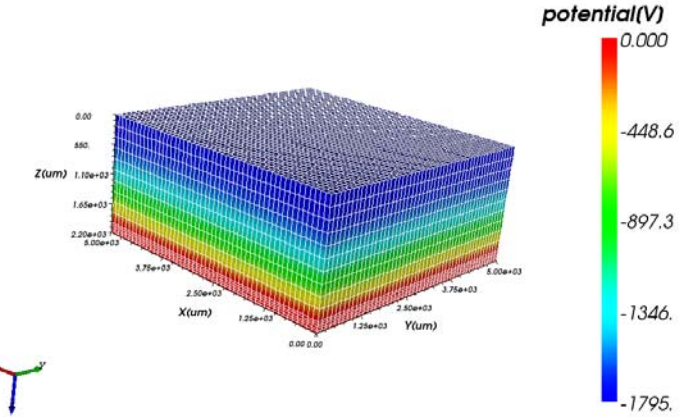




The Interface of SIC3D

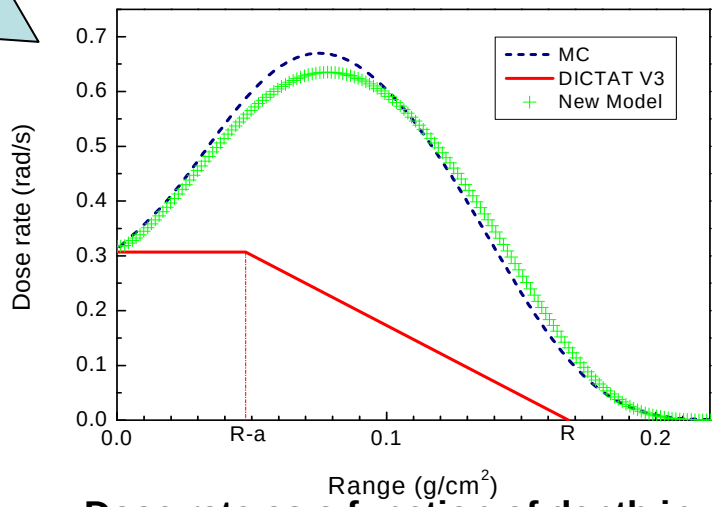
Comparison with DICTAT

- The results is similar when the slab is thicker.
- But difference is observed when the slab is thinner
  - The reason is “energy loss” of DICTAT



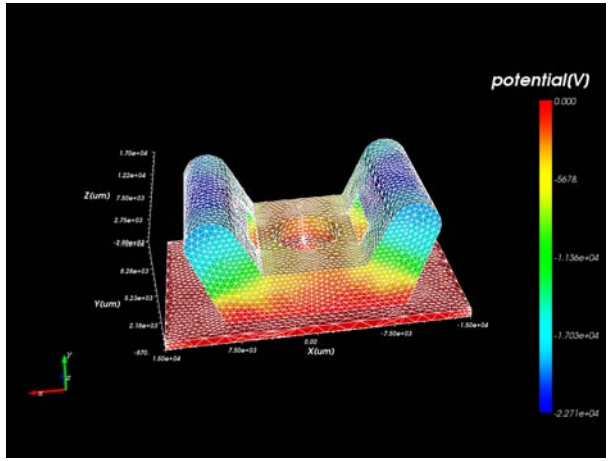
Comparison of the charging results with different PI thickness

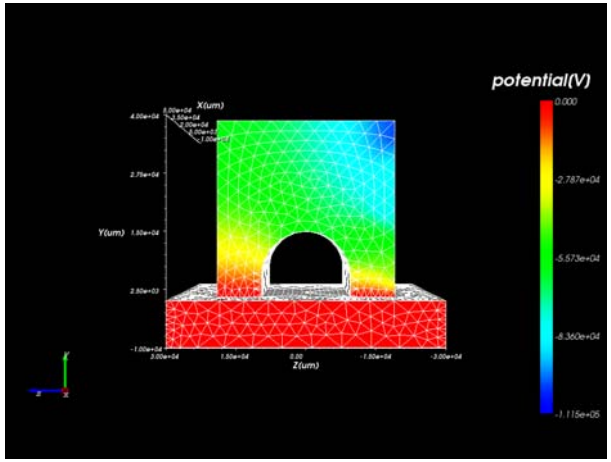
thickness（mm）	Emax（V/m）	
	DCITAT V3	SIC3D
0.5	1.4E+05	6.1E+04
1.0	8.1E+05	3.6E+05
1.2	7.4E+06	7.5E+05
1.5	7.4E+06	5.3E+06
2.0	7.4E+06	7.2E+06
3.0	7.4E+06	7.2E+06

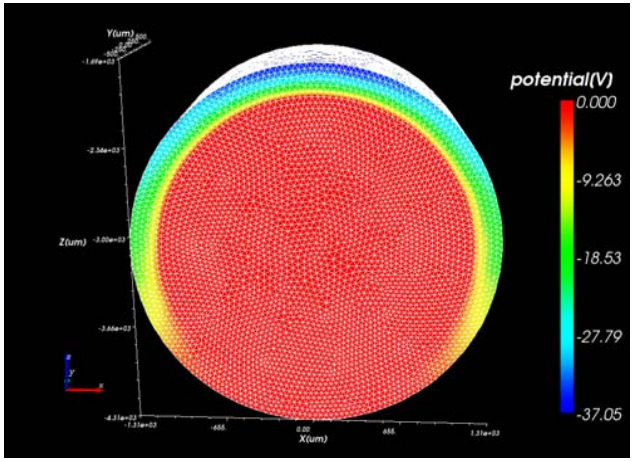


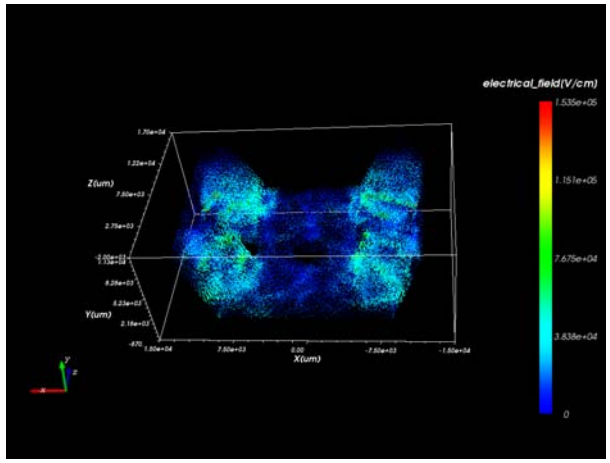
Dose rate as a function of depth in polyimide for a normally incident 0.5 MeV electron beam

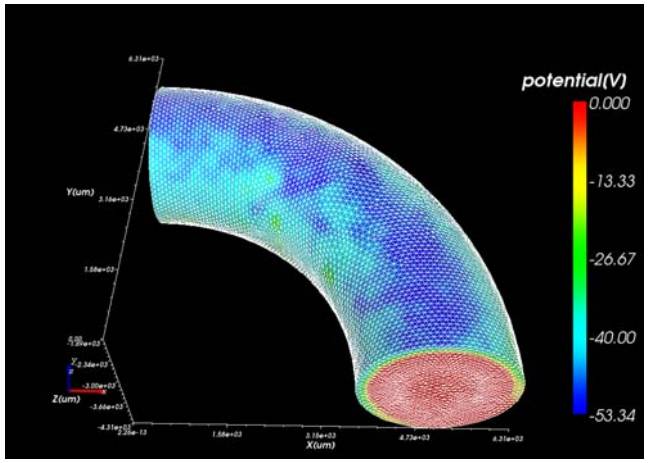
Some calculation results

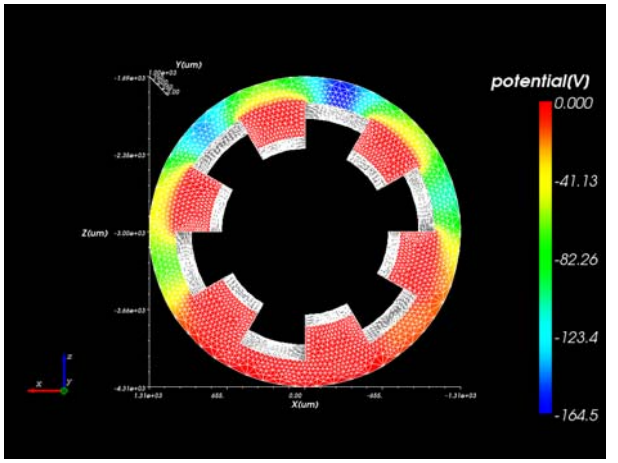






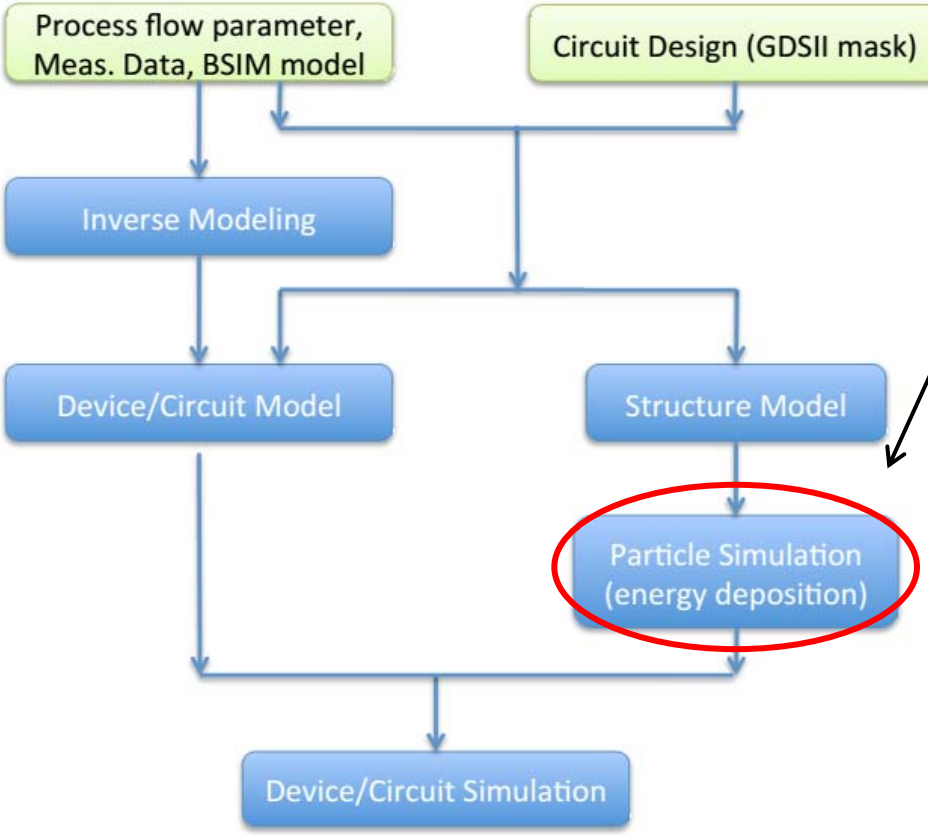


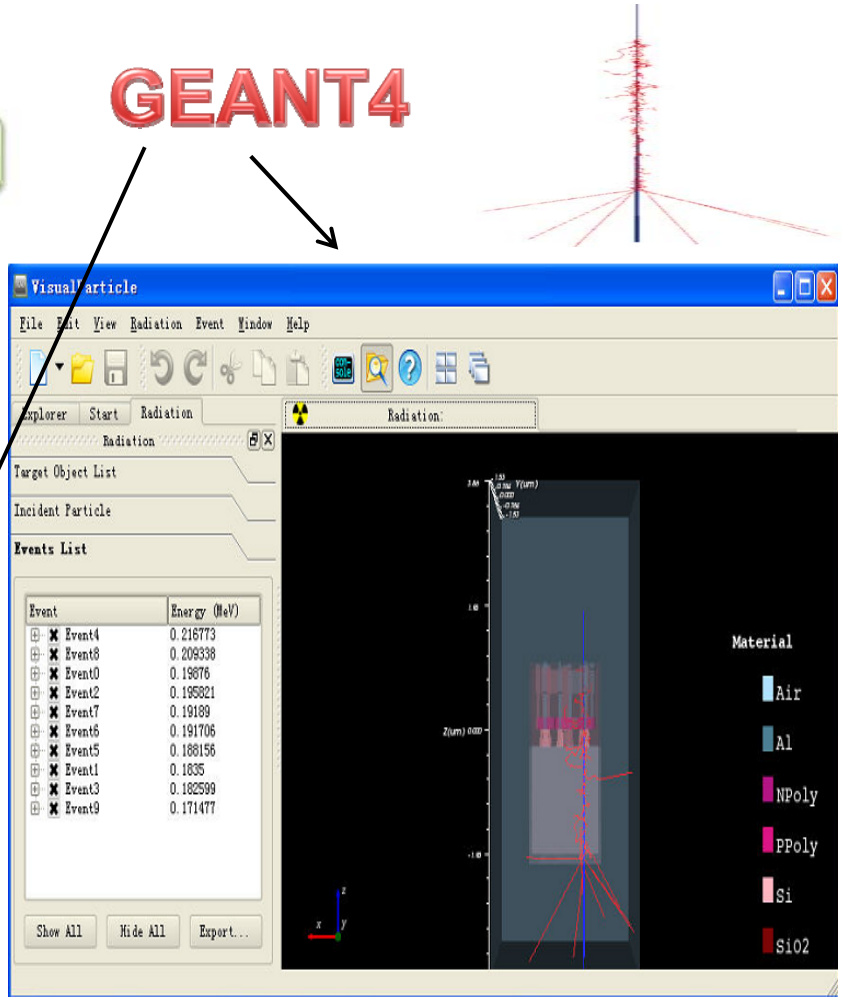




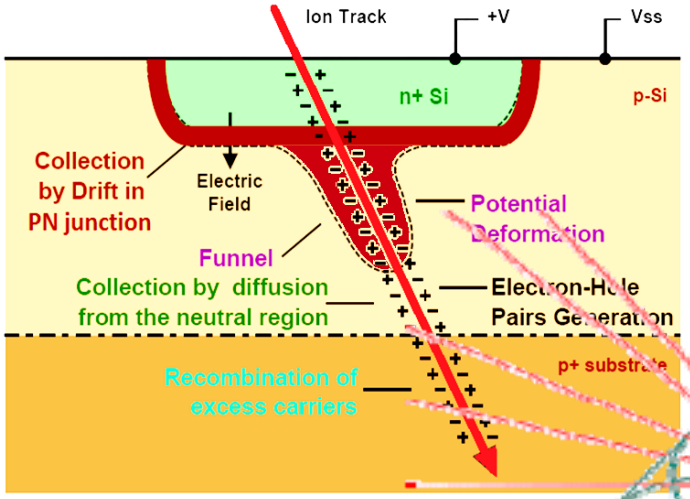
Single Event Effects Simulation

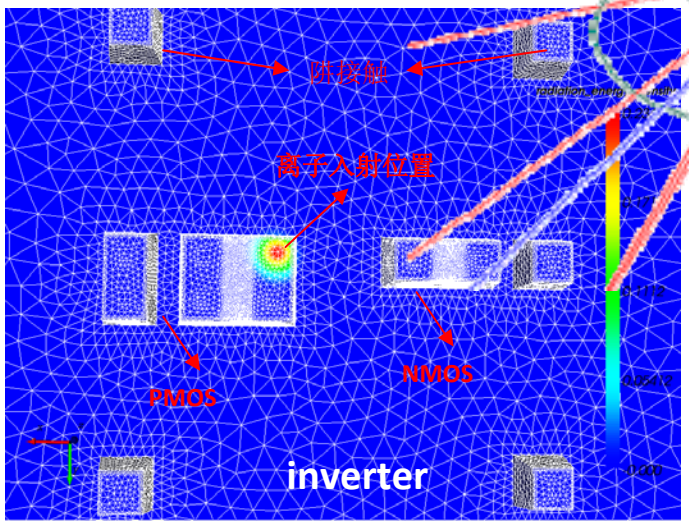
- For SEE Simulation, a commercial software, COGENDA/TCAD has been used in NSSC.



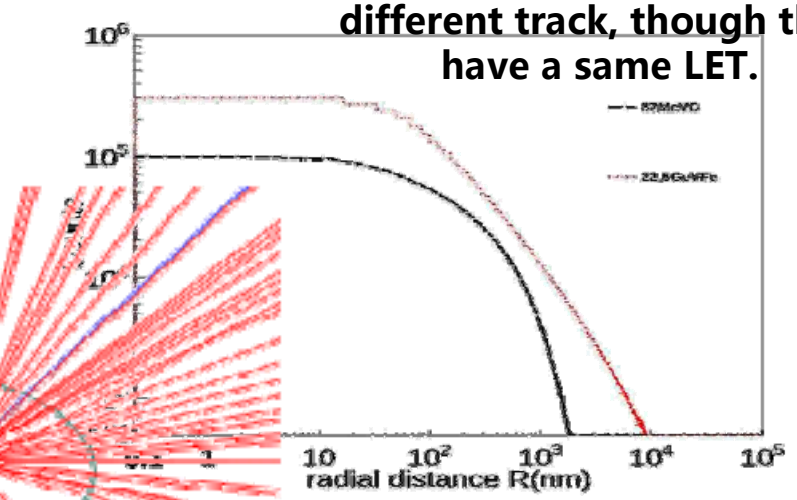


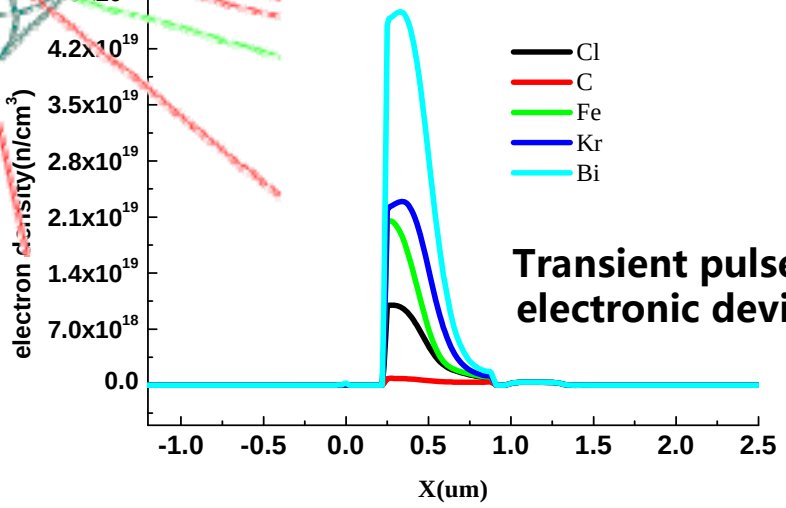
One of simulation results





Different kinds of ions have different track, though they have a same LET.

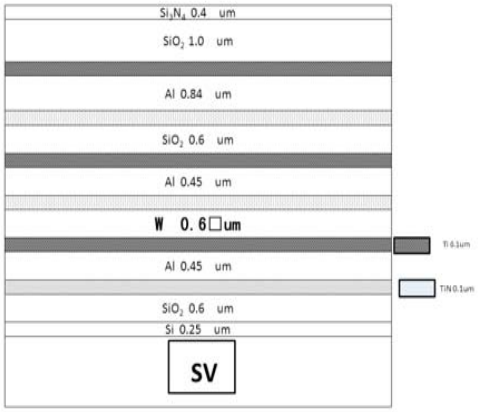


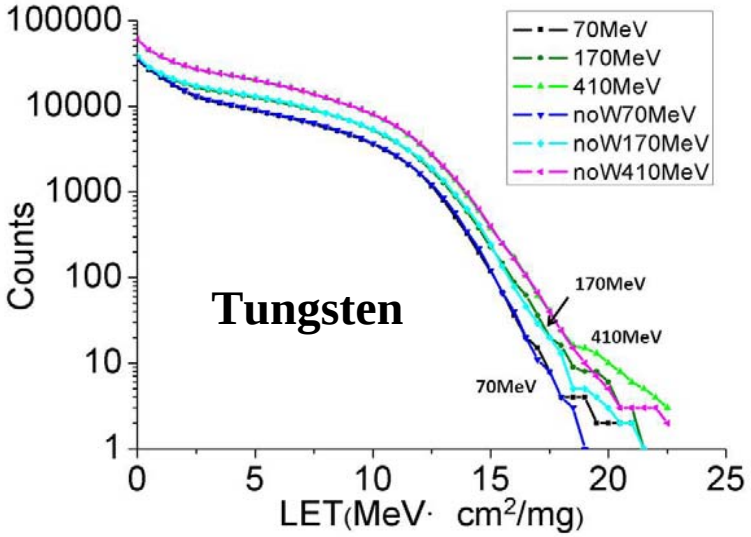


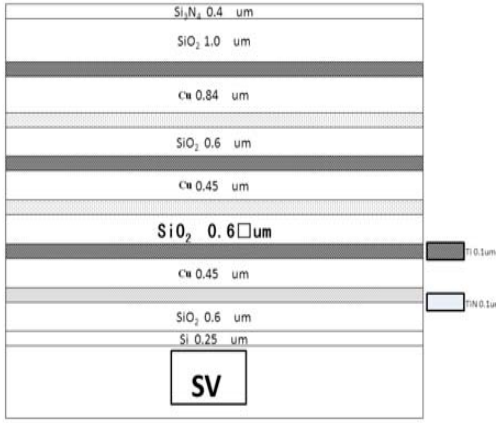
Transient pulse in electronic device.

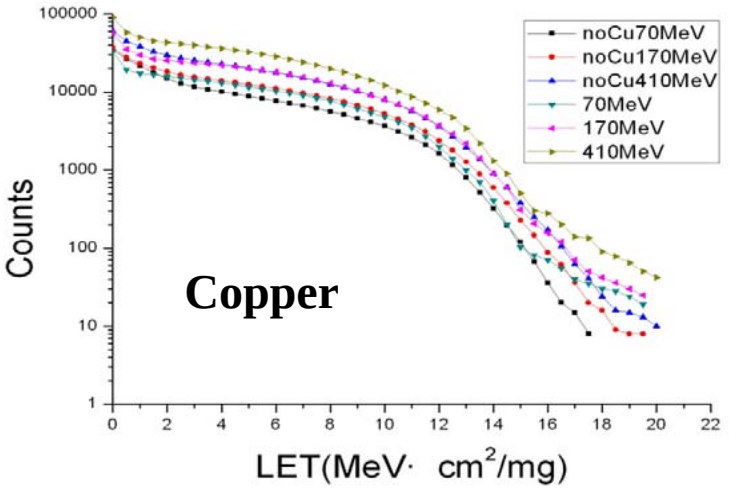
Another result

The influence of metal lines material : A device will have more higher upset ratio while its metal lines contain high Z elements.



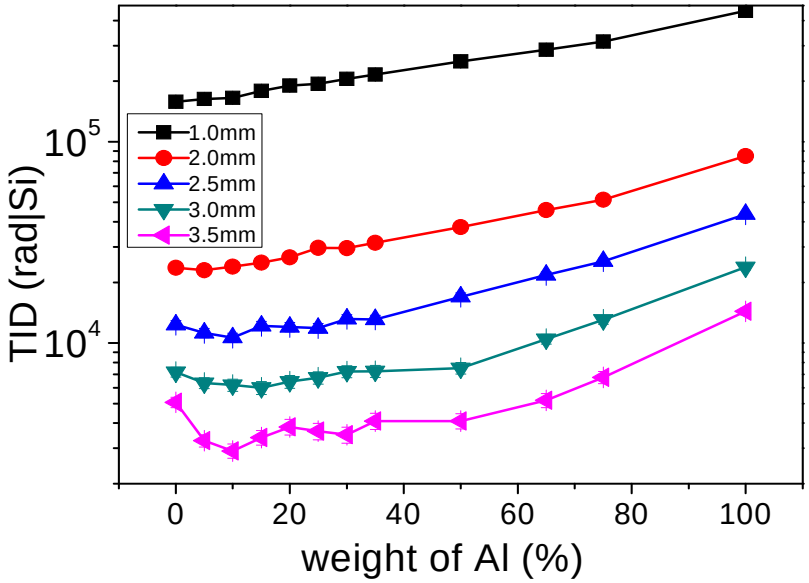


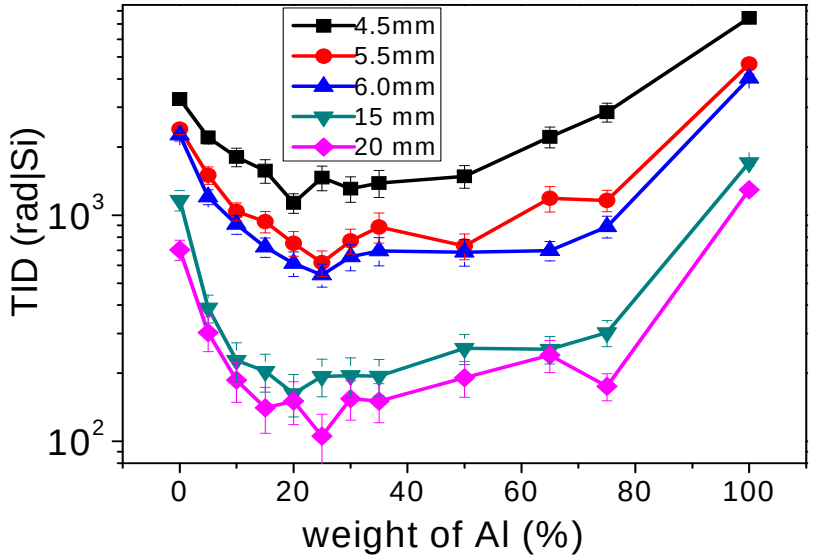




Total Ionizing Dose Analysis

- **Tantalum-aluminum multiple shield calculation by Geant4**



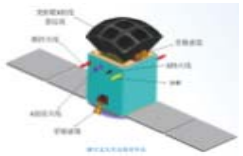


Application to Space science missions

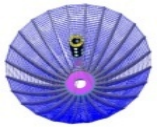
- Since 2011, the Strategic Priority Program on Space Science has been carried out.
- Main Goal : Through independent and co-operational science missions, dedicating to deepen our understanding of universe and planet earth
- Geant4 has been widely used in this program.

Strategic Priority Program on Space Science

HXMT

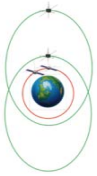


EP

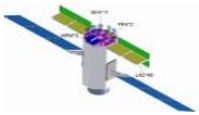


S-VLBI

QUESS



MIT

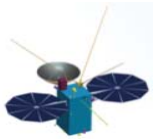


XTP

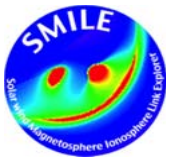
SVOM

SJ-10

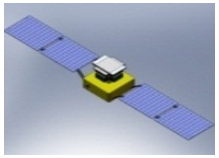
WCOM



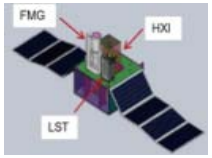
SPORT



SMILE



DAMPE



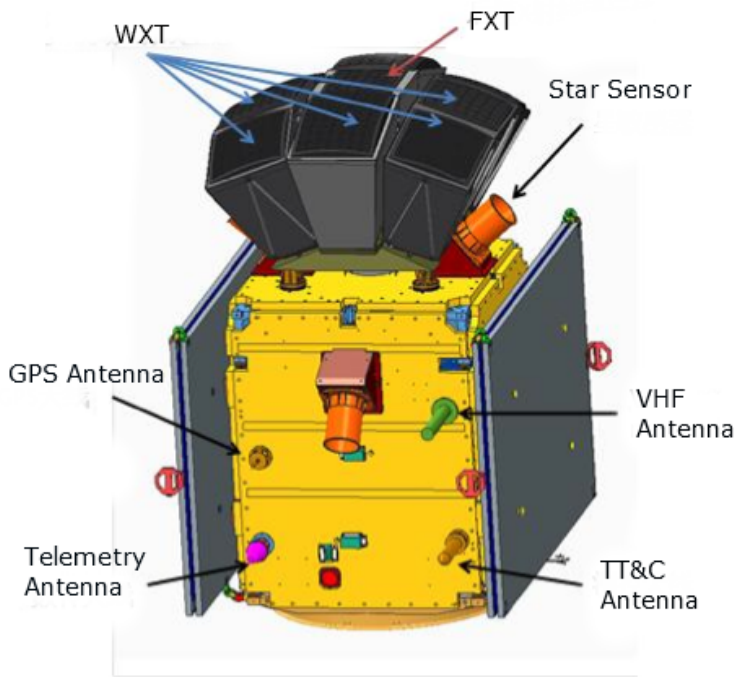
ASO-S

STEP

2015 2016 2017 2018 2019 2020 2025 2030

Carrying out this program is the most important duty of NSSC

CASE 1 : Einstein Probe



Launch Time: 2021

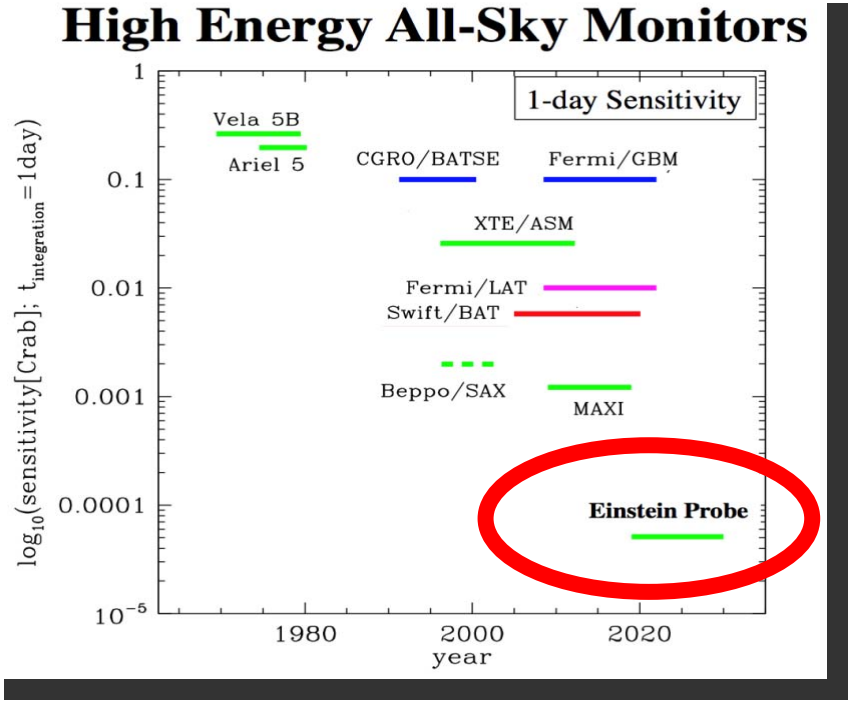
Key Scientific Objectives:

Black Holes and Gravitational Waves

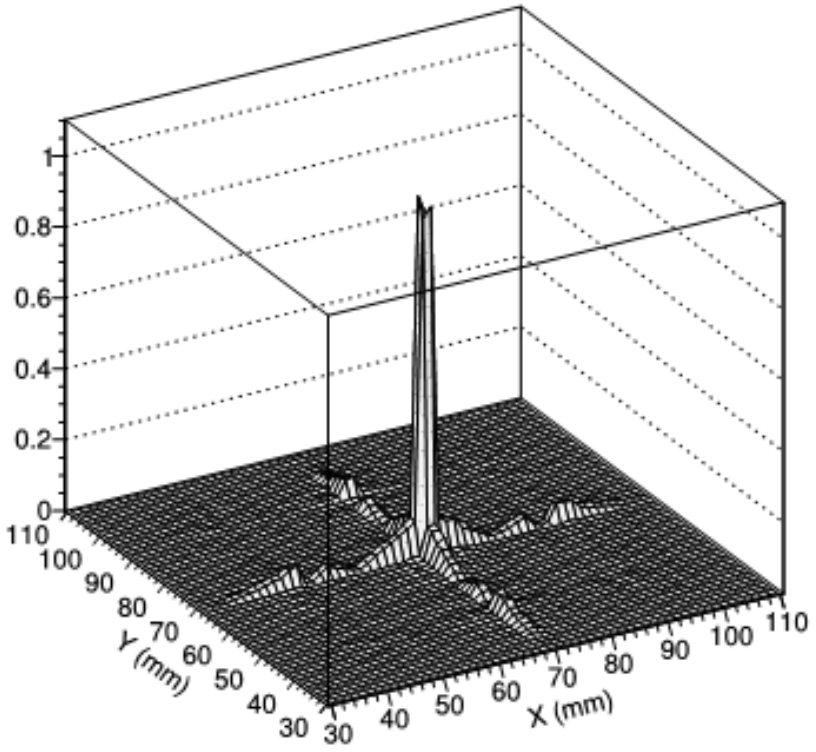
Energy Range: **0.5-4 keV**

Filed of View: **60° X 60°**

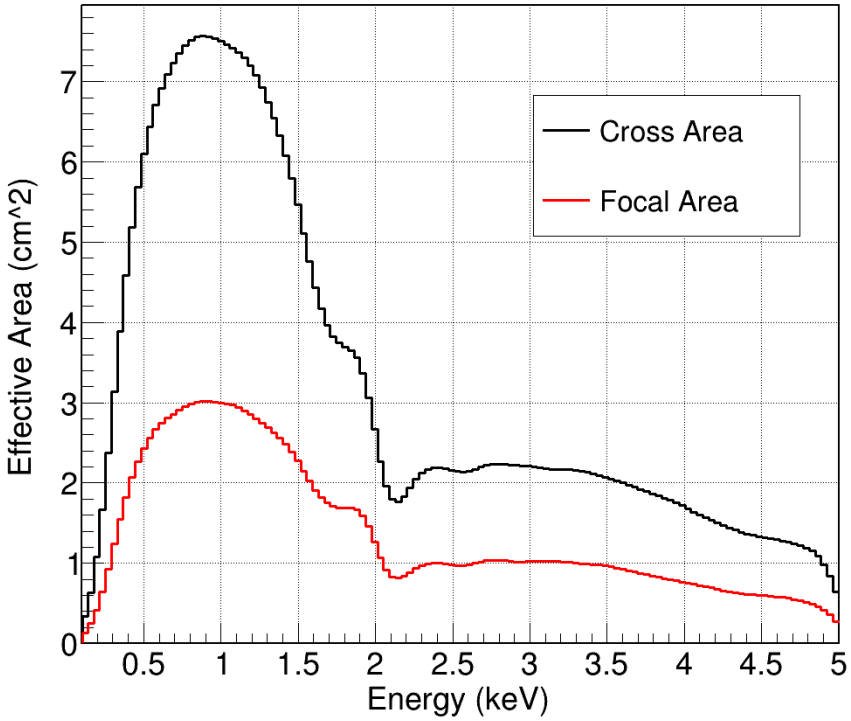
EP will be the **most sensitive** all-sky monitor



Performance estimated with Geant4

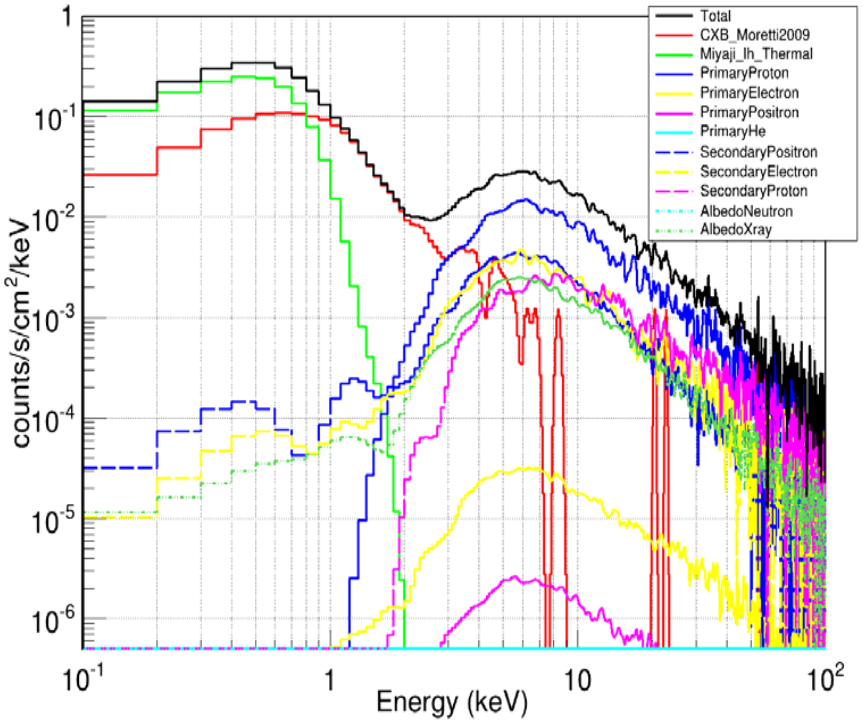


Point Spread Function

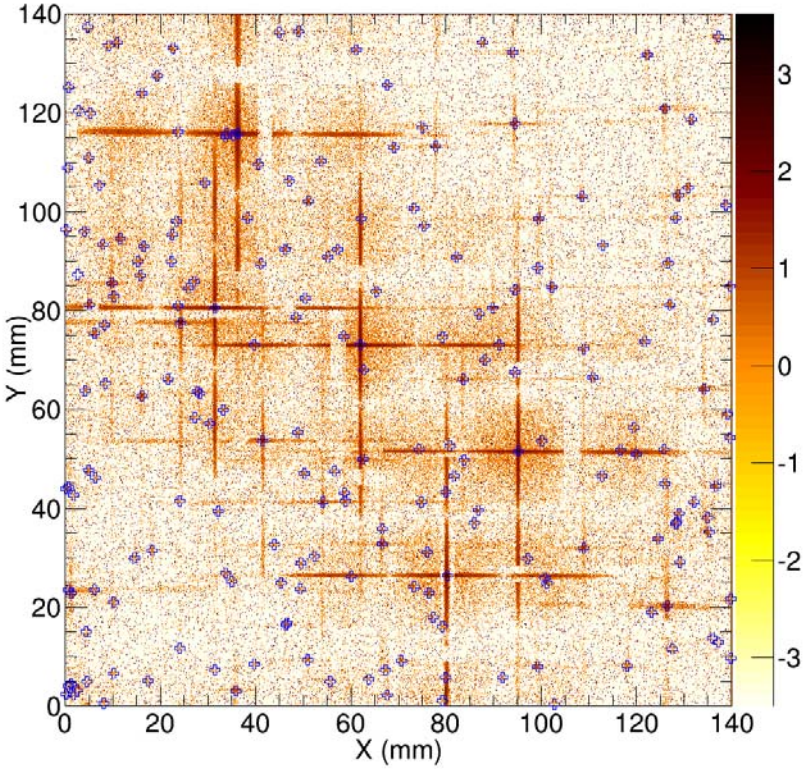


Effective Area

Performance estimated with Geant4



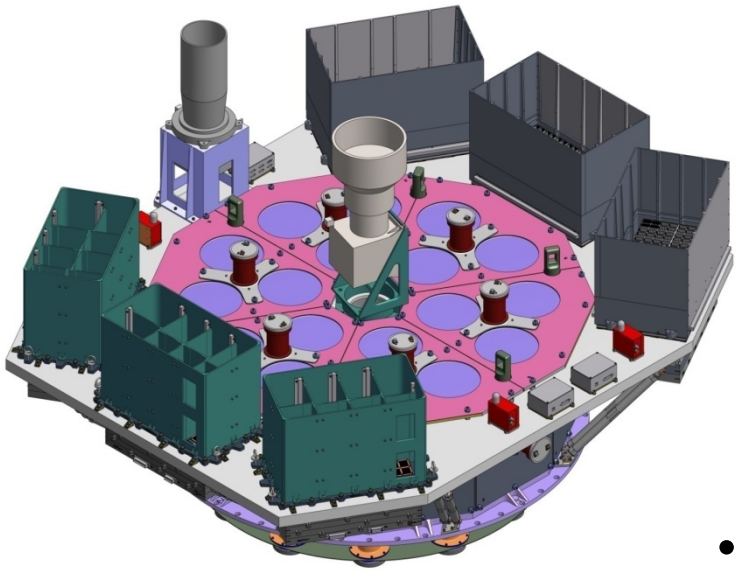
Instrumental Background due to the space environment



Observations of a piece of the X-ray sky with point sources

Detail： Zhao Donghua’s report

CASE 2 : Hard X-Ray Modulation Telescope



Key Scientific Objectives:

- **Large area X-ray survey**
- **Broad band (1-250keV) and large collection area (5000cm2@100keV) pointed observations of high energy objects.**

Launch Time: 2017

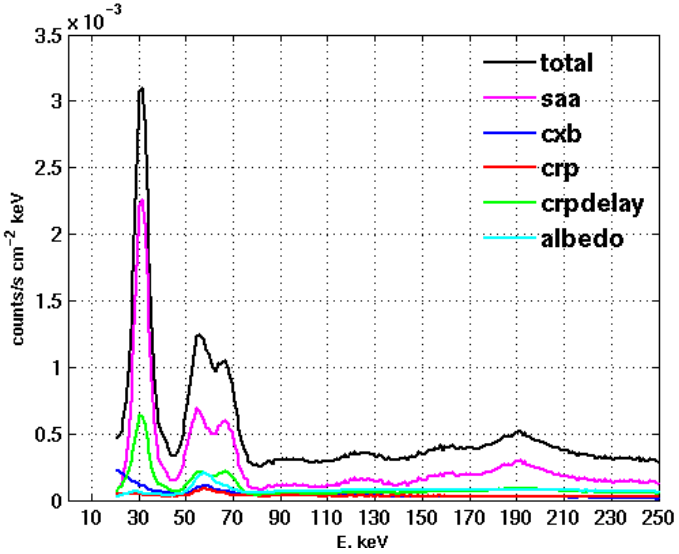
- **Payloads:**
  - **HE(NaI/CsI, 20-250keV)**
  - **ME(Si-Pin,5-30keV)**
  - **LE(SCD,1-15keV)**
  - **SEM(space environment monitor)**
  - **Particle Monitors**

Geant4 simulation on HXMT Payloads

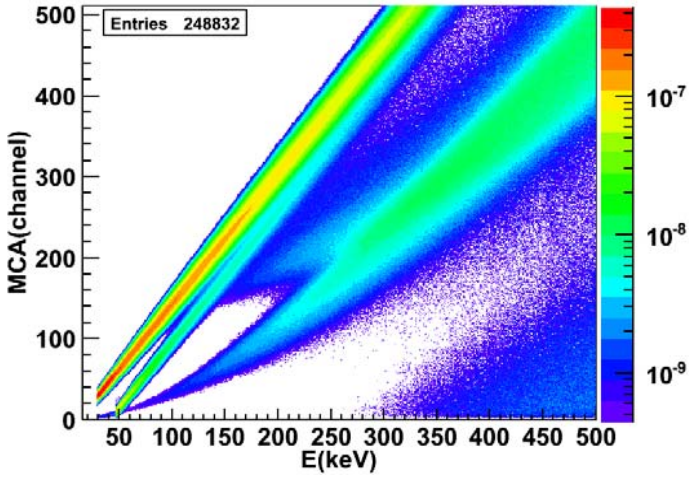
- In-orbit background simulation to
  - estimate background level, help to make observation plan
  - background characteristic, help to analysis and reduction of the in-orbit background
  - The line feature in background spectrum helps to supplement in-orbit calibration

- Simulation of on-Ground calibration experiments

Detail： Zhang Juan's report



HE background spectrum



HE response matrix

Summary

- **Geant4 is an important tool for space radiation effects analysis and Space science detector simulation.**

Thank you!