Space Application of Geant4 for Wideband All-sky Monitor onborad X-ray Satellite Suzaku

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and the Suzaku HXD-II team

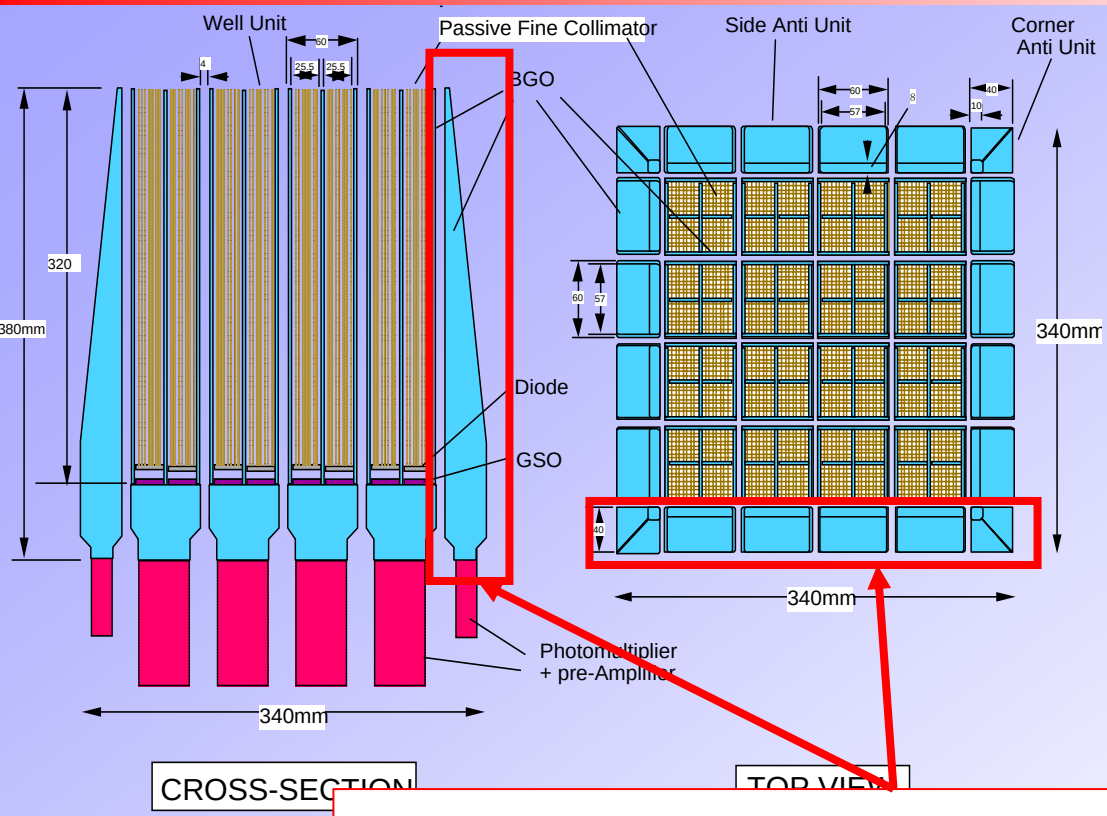
Successful launch of Astro-E2

The fifth Japanese X-ray satellite Astro-E2 launched successfully on 10 July, 2005, and named as “Suzaku”

Suzaku
XIS (CCD : 0.3 – 12 keV)
HXD(PIN+GSO : 10–600 keV)

Wideband+ low background observation

Hard X-ray Detector(HXD-II) onboard Suzaku

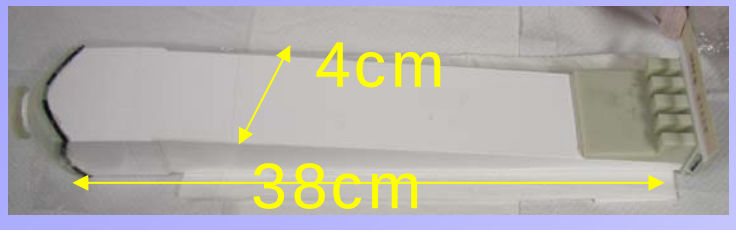


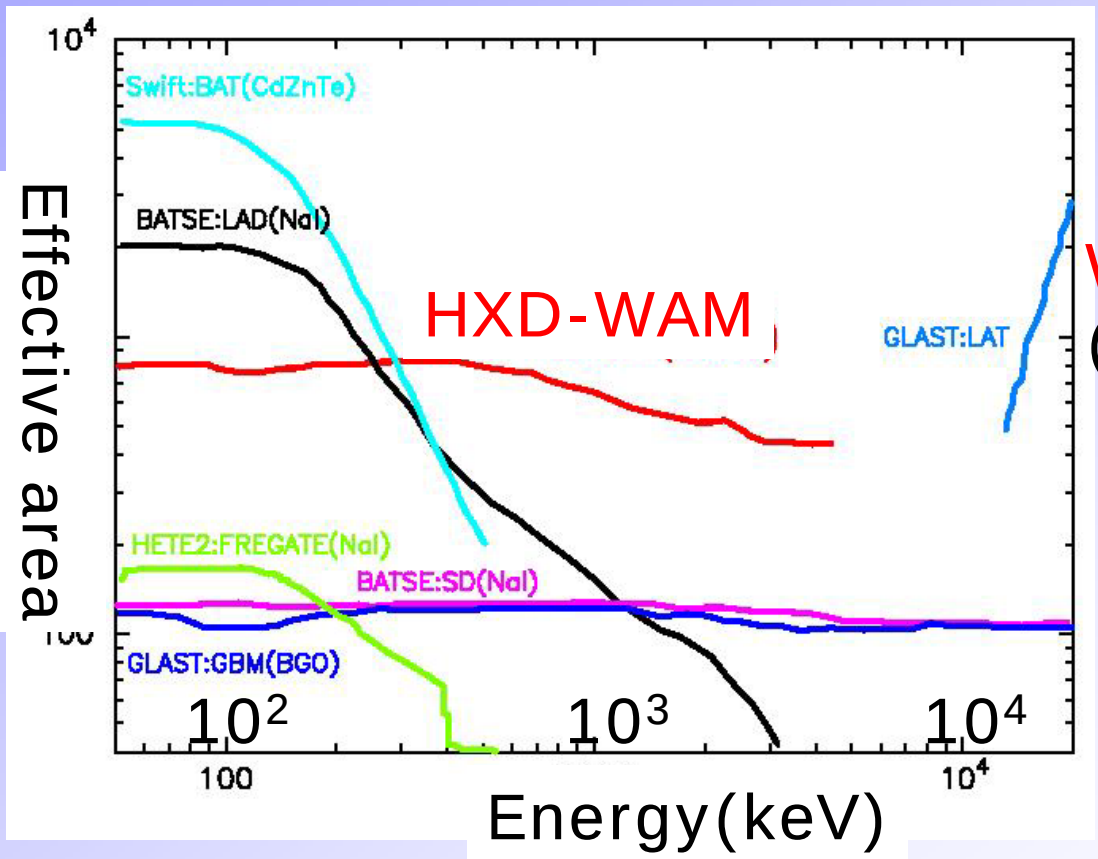
- Wide energy band
  - PIN photodiode
    - -> 10 – 60 keV
  - GSO crystal
    - -> 30 – 600 keV
- Very low background
  - 16 Well-type GSO/BGO phoswitch counters
  - 20 BGO active shield

We can use the shield as the all-sky monitor in hard X-ray band

Today's talk is *NOT* about the main PIN/GSO detectors but BGO active shield as the all-sky monitor

HXD-II Wideband All-sky Monitor (HXD-WAM)





HXD-II is surrounded by thick (4cm) large (38cm) 20 BGO crystals

- Large detector area
- Wide field of view

Wideband All-sky Monitor (HXD-WAM)

energy band :
50 – 5000 keV

Targets

- -Gamma-ray Bursts
- -Solar Flare
- -other transient src

Why Geant4 for HXD-WAM?

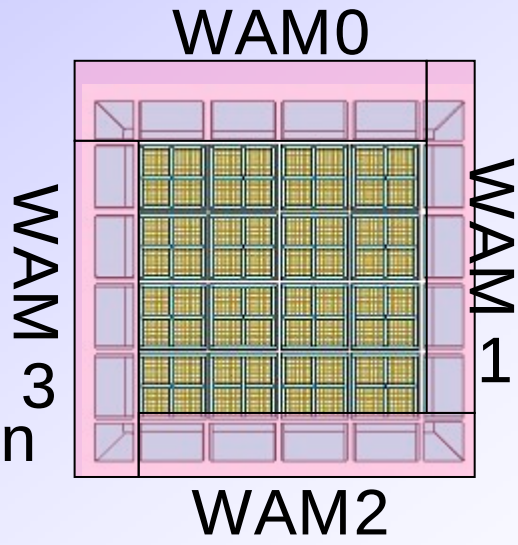
We need Monte Carlo simulation for calculation of the detector response of HXD-WAM.

1. Importance of the Angular Response

HXD-WAM : four side-facing detector

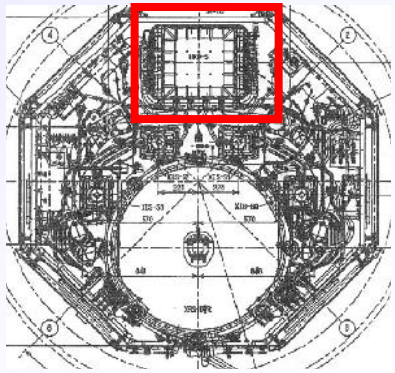
Counting ratio for each side

→ Incident photon direction



HXD-WAM : located into the satellite body

Effective area varies with direction



Satellite topview

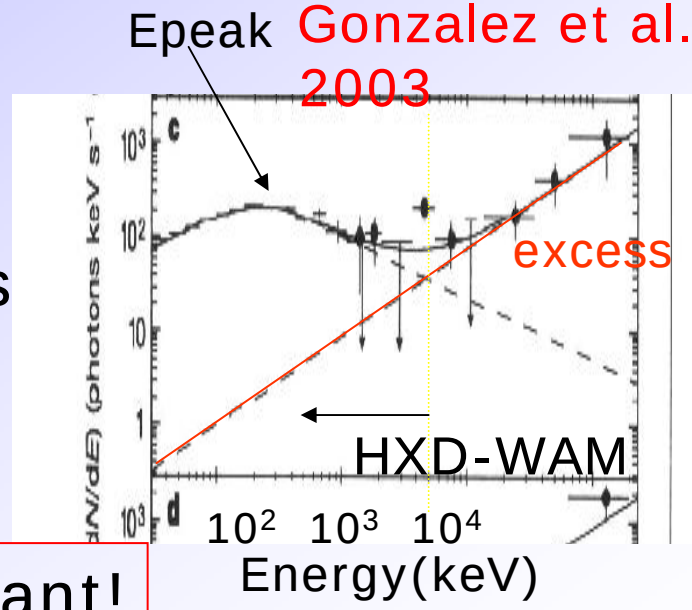
Absorption feature by the satellite body is very very important !

Why Geant4 for HXD-WAM?

We need Monte Carlo simulation for calculation of the detector response of HXD-WAM

2. Need the accurate Energy Response
   The Key for GRBs sicence
   A. Determine spectral shape
      ->obtain Ep in wide band
   B. Detection of the MeV-GeV excess
      ->another emission in GRB ?

   HXD-WAM only do these now !



Accurate Energy Response is important!

- Compton scattering
- Large geometrical effects
- all energy, all direction

Monte Carlo simulation with Geant4

Step by Step calibration

We construct WAM simulator in four comparison steps

1. simple piece of BGO

   Check the validity of physical process of Geant4

2. single unit of HXD-WAM

   Measure the detector characteristics of HXD-WAM
   and include into HXD-WAM simulator

3. Assembly of the HXD-WAM

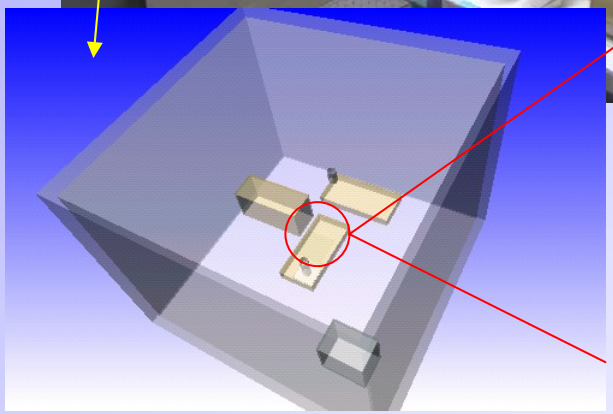
   Measure the angular response of HXD-WAM
   to comparison with the absorption by the satellite

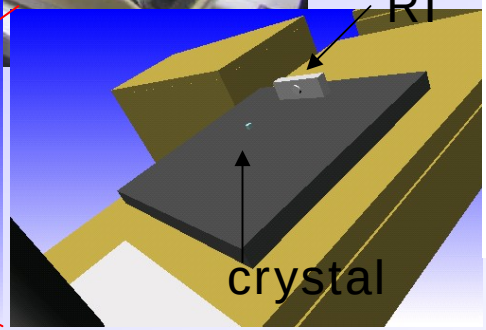
4. Installation on the Suzaku satellite

   Construct Suzaku Mass Model for HXD-WAM

Comparison with the pre-flight calibration(I)

Step 1: Simple BGO piece



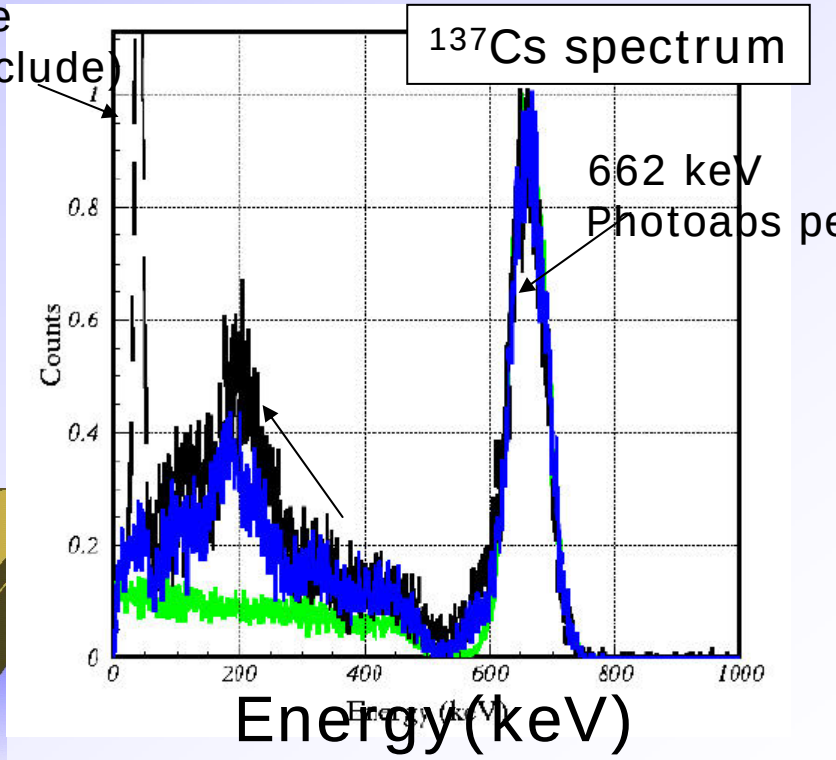


Black : Experiment

Green : simulation (crystal only)

Blue : simulation (Full Geometry)

EC line
(not include)



well reproduce BGO response!

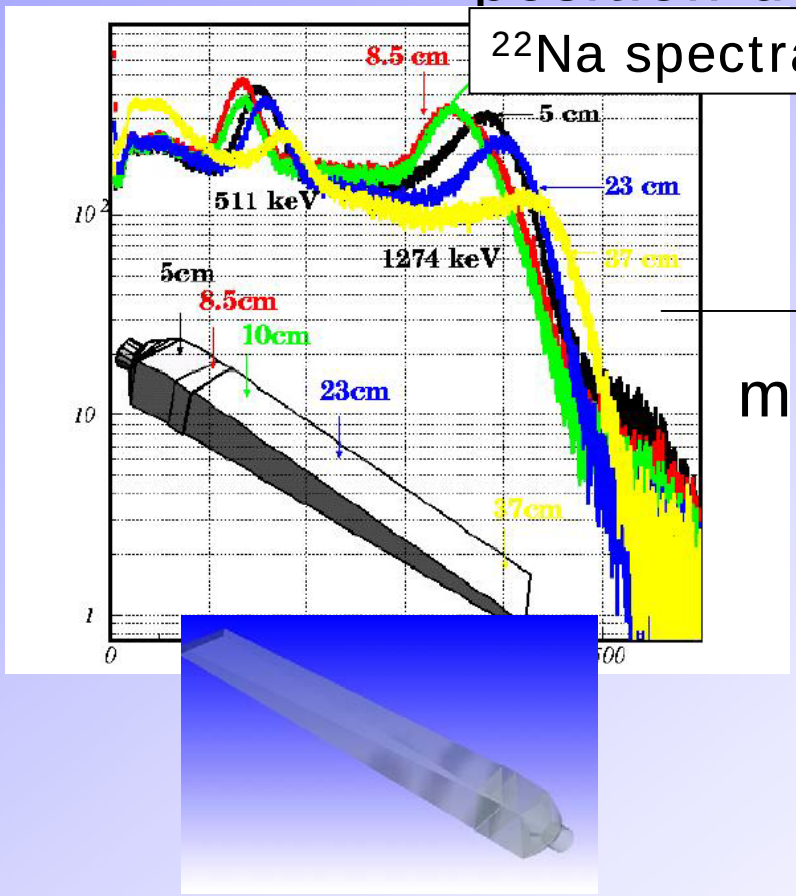
Comparison with the pre-flight calibration(II)

Step 2: single unit of HXD-WAM

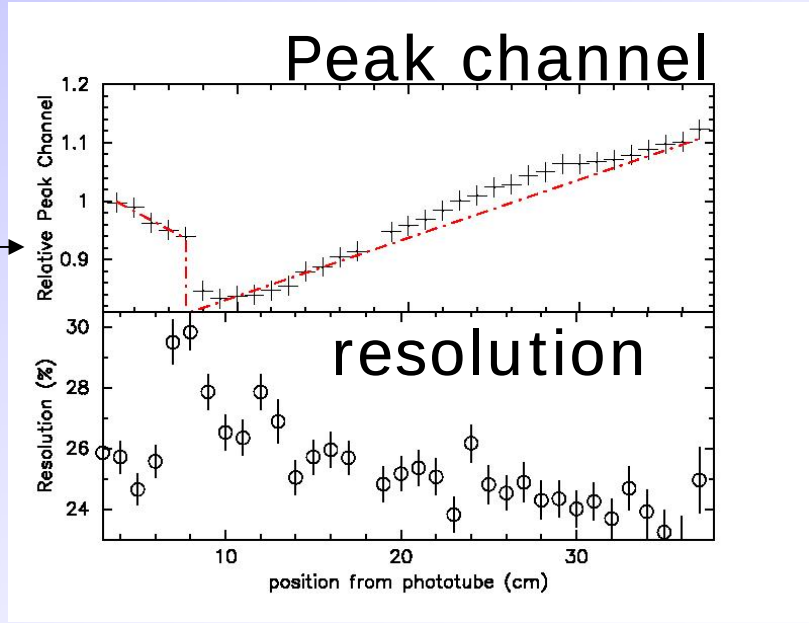
Important characteristic

⟶ position dependency of the light yield

^{22}Na spectra



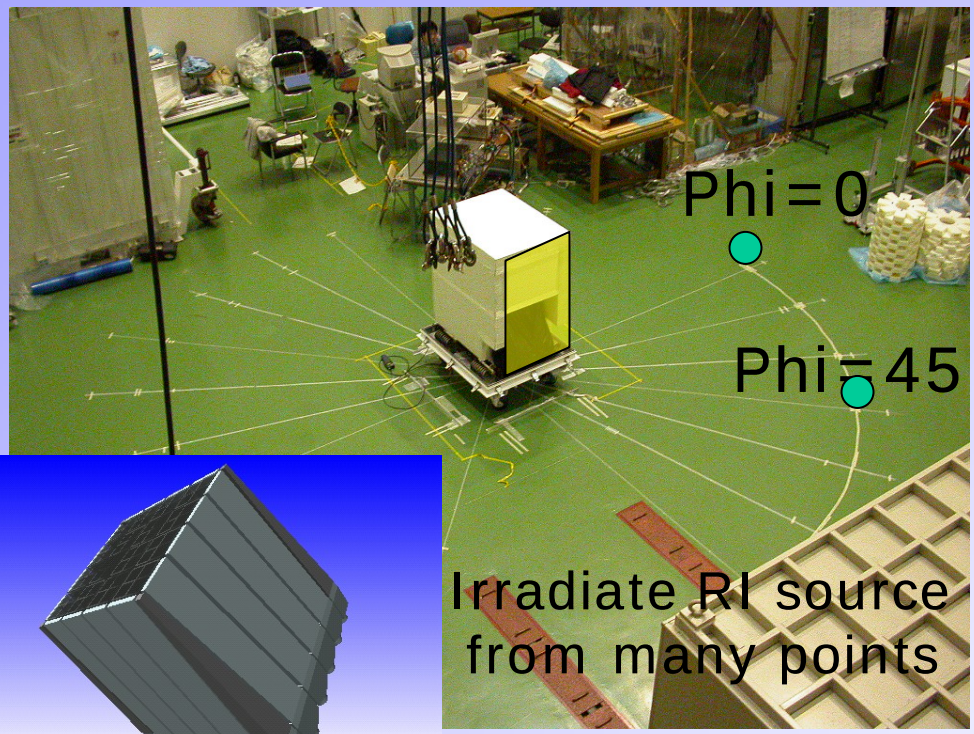
model



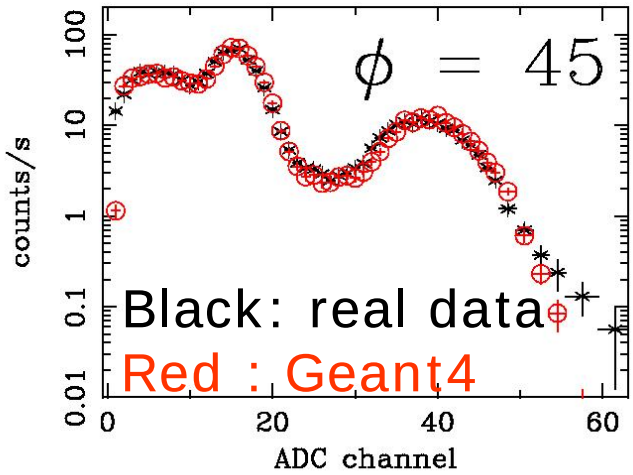
Include simulator by weighting to energy deposit in each step

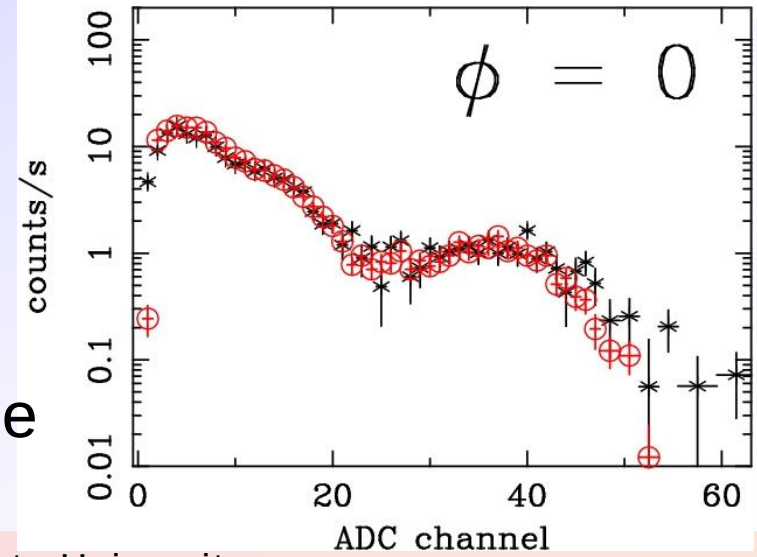
Comparison with the pre-flight calibration (III)

Step 3: Assembly of HXD-WAM



^{22}Na spectrum

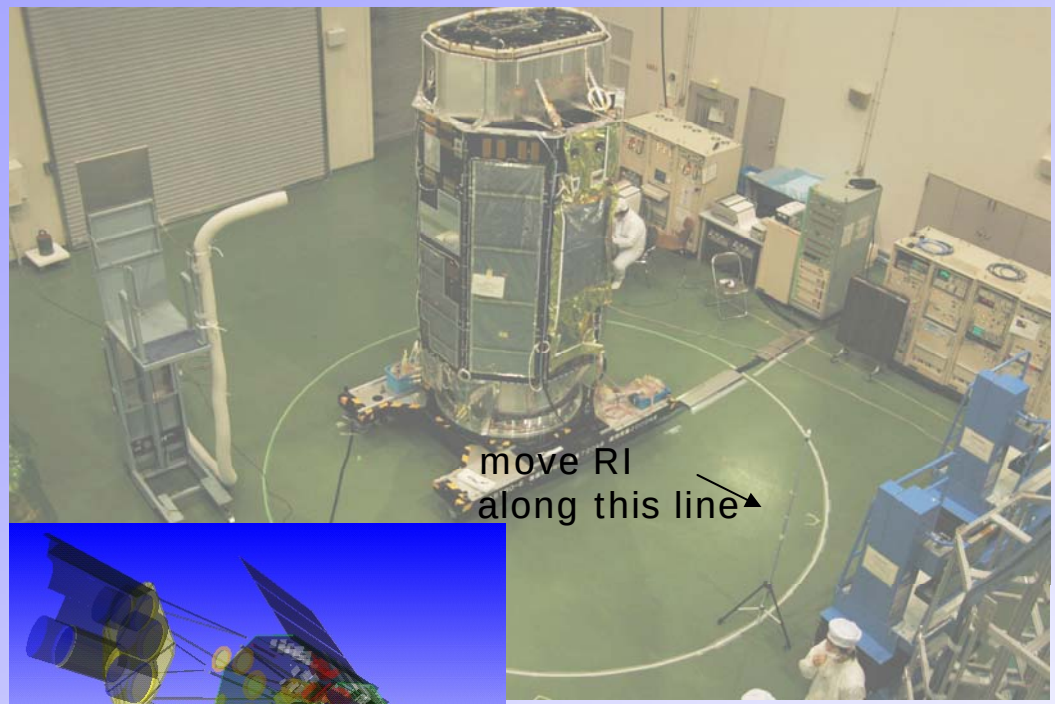




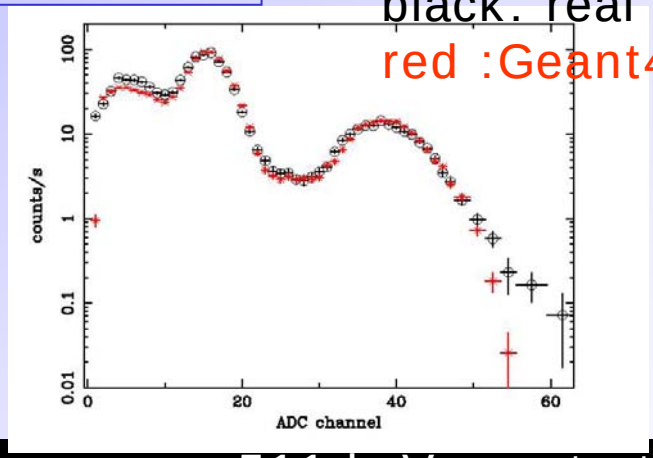
Both angle and energy response is well reproduced

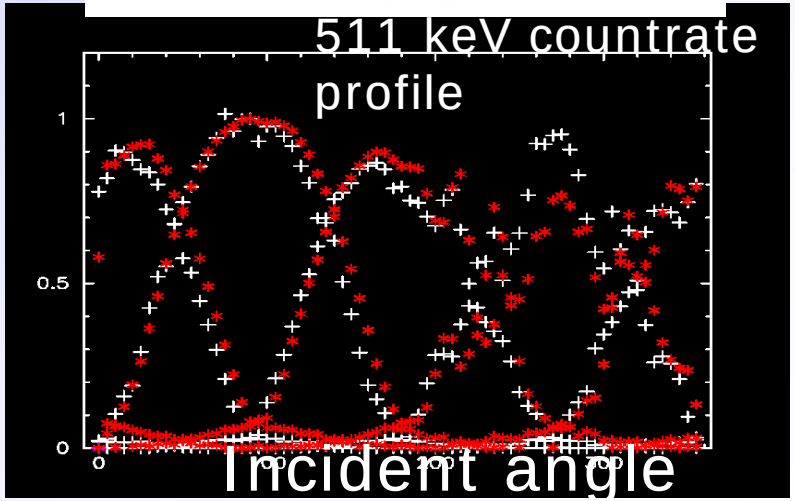
Comparison with the pre-flight calibration (IV)

Step 4: Installation on the Suzaku satellite



black: real
red :Geant4





Suzaku WAM simulator
reproduce the response within 10-20 % accuracy!

Comparison with the in-orbit data

Cross calibration with other GRB satellite

Expected spectral model

X

Detector response by Geant4

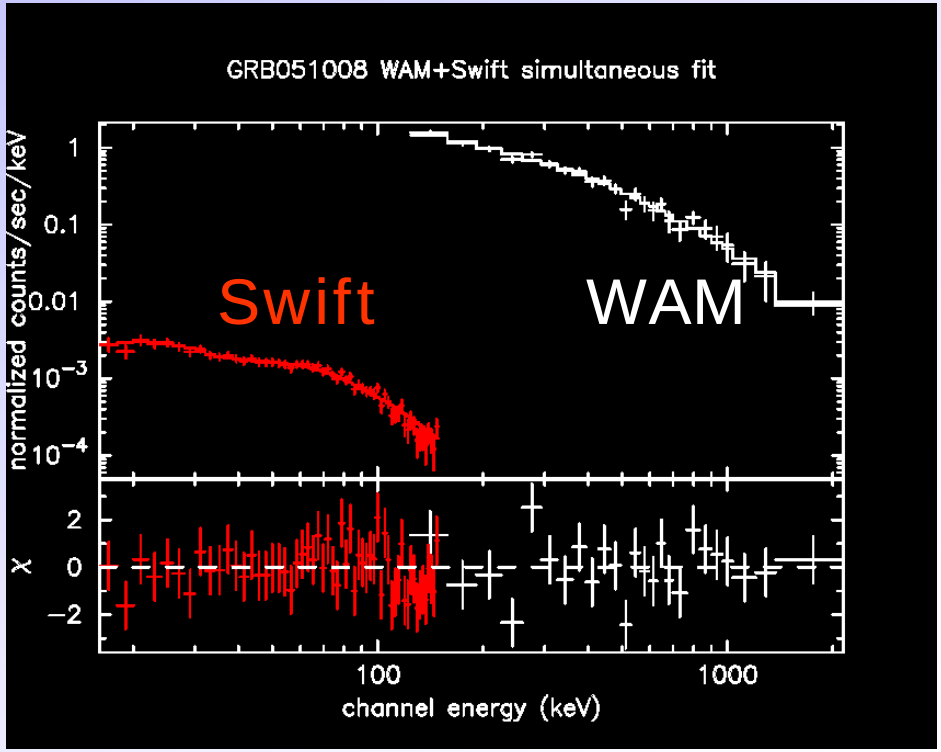
=

Expected pulse height spectrum

Compare!

Observed pulse height spectrum

GRB051008 with Swift



Same model are acceptable within 20% accuracy

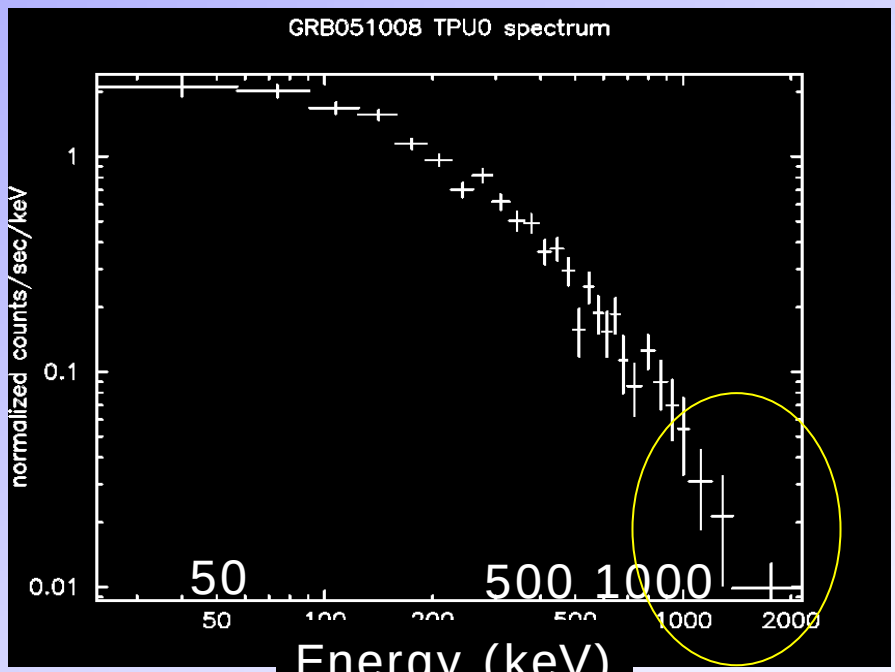
Preliminary results of HXD-WAM

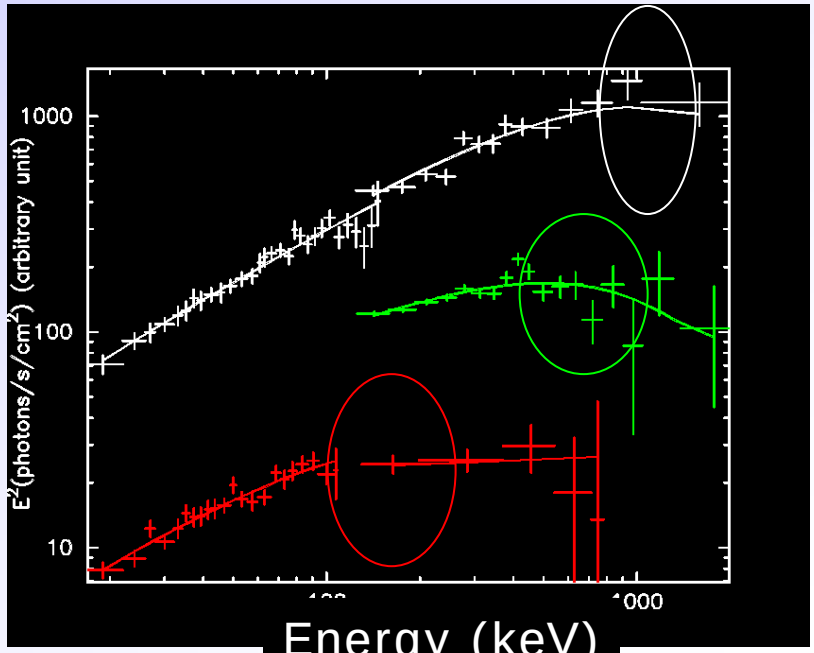
Now HXD-WAM are detecting many GRB events

Some interesting preliminary results
using HXD-WAM response with Geant4

-emission above 1 MeV
from some GRBs !

- Epeak is seen
from some GRBs





Summary

- We have developed Geant4 simulator for HXD-WAM onboard Japanese X-ray satellite Suzaku.
- Geant4 HXD-WAM simulator reproduce pre/in-flight calibration within 10-20 % accuracy.
- Now we can use Geant4 HXD-WAM simulator for calculation of the energy spectra from astronomical objects such as GRBs, solar flare, and so on.
- Now we are modifying the Suzaku Mass Model.
  - improving of the accuracy of the response
  - extend the response in low energy band