A new Si array for CAT-M

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Presentation Outline

Giant Resonances

- The Isoscalar Giant Monopole Resonance

Research Topic

Active Targets

- Active Targets for the ISGMR

Method

Development of the Experimental Setup

- Dipole Magnet
  - Delta Rays Reduction
- A new Si array for CAT-M lateral flanges
  - Position Sensitivity

Developments

ISGMR (Isoscalar Giant Monopole Resonance)

Giant Resonances are Nuclear Collective Excitation

The ISGMR is a Compression Modes

- in-phase compression and expansion of the nucleus

The resonance energy relates to the Nuclear Incompressibility

K_A = Nuclear Incompressibility

ISGMR (L=0)
Breathing Mode

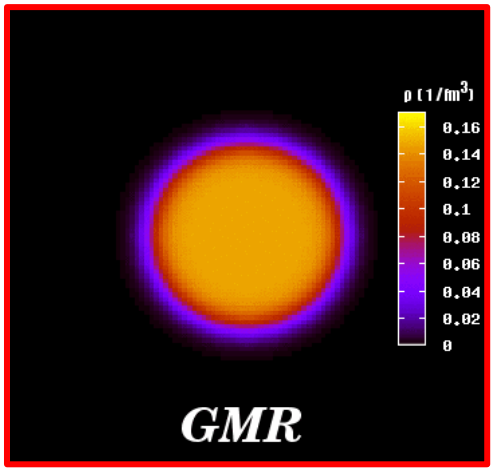


Figure credits: M. N. Harakeh

What we measure!

$$E_{ISGMR} = \hbar \sqrt{\frac{K_A}{m\langle r^2 \rangle}}$$

Motivations

Through theoretical models, we can relate K_A with K_∞ (Incompressibility of the nuclear matter), an ingredient of the Nuclear Equation of State (EoS).

Key Concept:

The ISGMR is a compression mode, and its energy can be used to constrain K_∞

Active Target for ISGMR

Nuclear Reaction

Inelastic scattering: Maximum cross section at very forward angles

Reaction Kinematics

Inverse kinematics: Very low energy of recoil nucleus (difficult to measure!)

Phys. Rev. C 92, 024316 (2015)

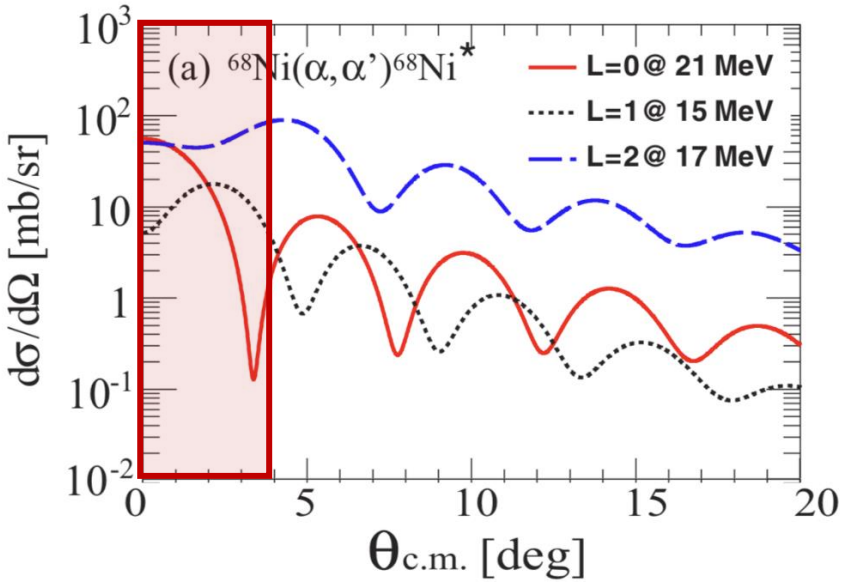
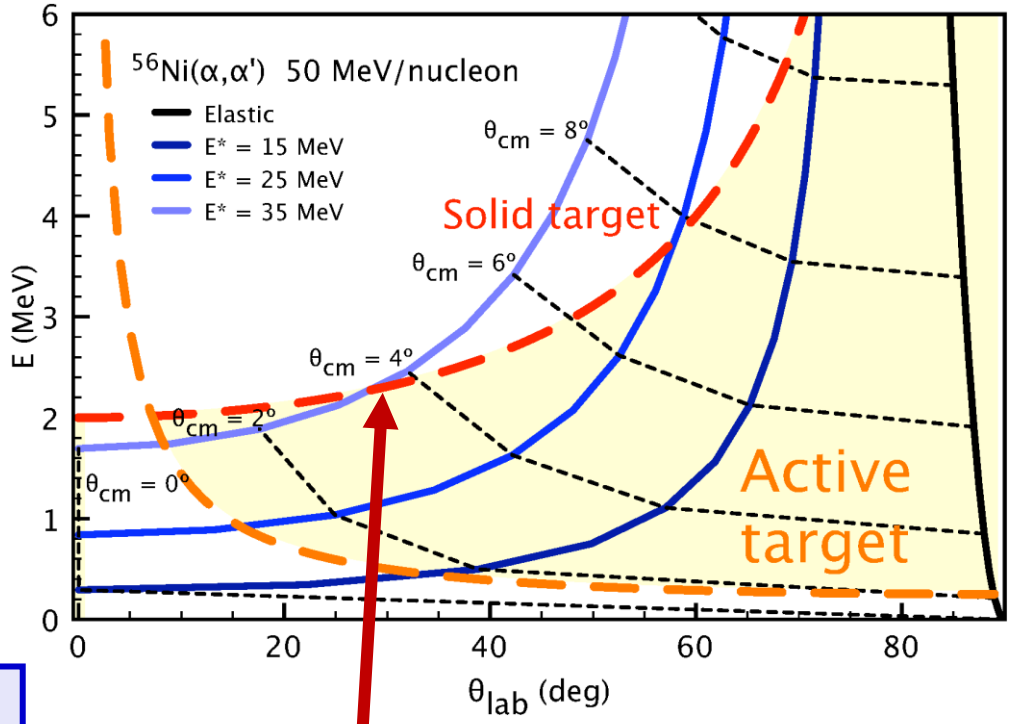


Figure credits: Riccardo Raabe



Active Targets:

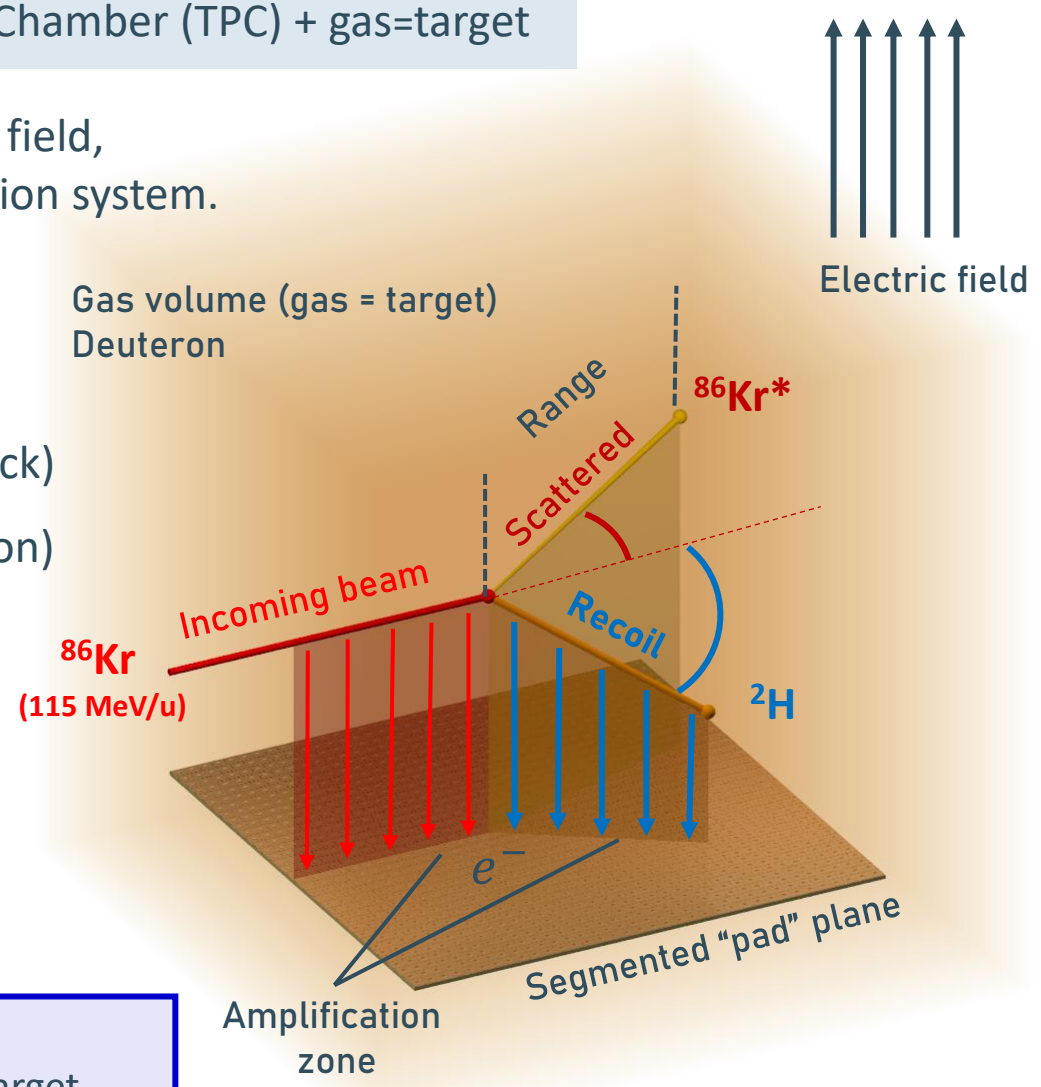
Active Targets are well suited for the study of the ISGMR

Solid Target: Hgh Energy Threshold!

What is an Active Target?

Time-Projection Chamber (TPC) + gas=target

Gas-filled detector volume in an electric field,
with a position sensitive electron collection system.



3D Track reconstruction:

- "pad" plane signal (2d image of the track)
- drift time of the electrons (3rd dimension)

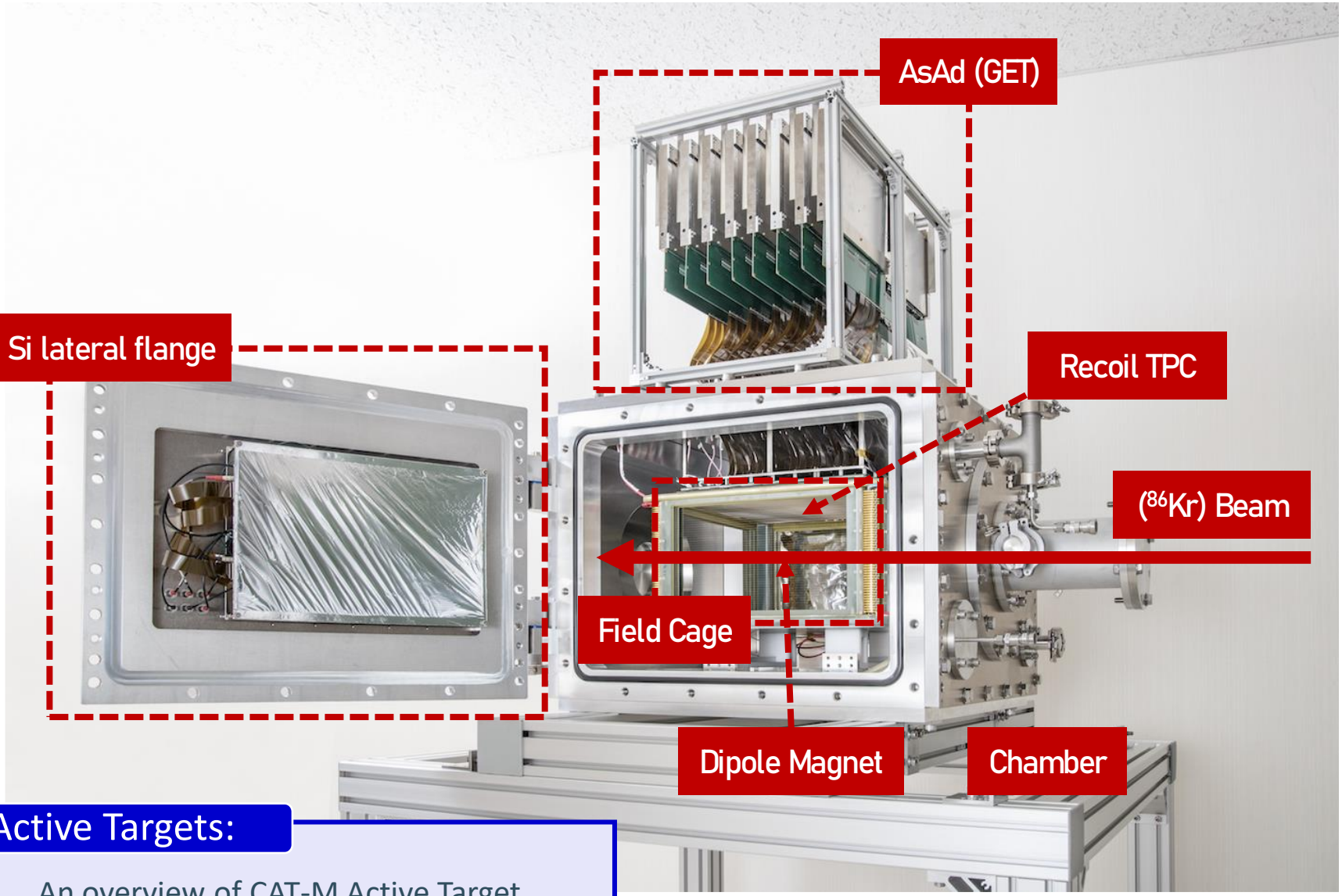
- Study the excitation of the nucleus, measuring the light recoiling particle.

Active Targets:

The basics working principle of an Active Target

Let's meet CAT-M!

CNS Active Target – Medium/Manul



Active Targets:

An overview of CAT-M Active Target

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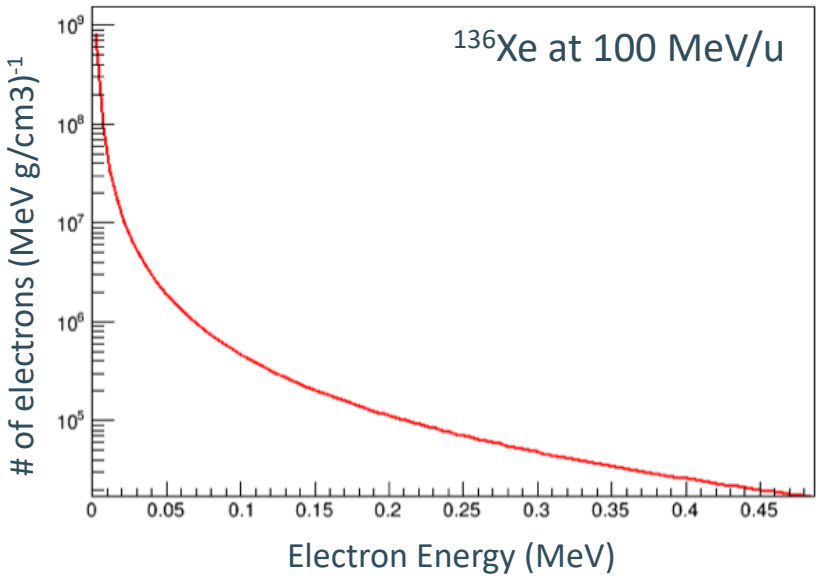
Development

Delta Rays produce a large background

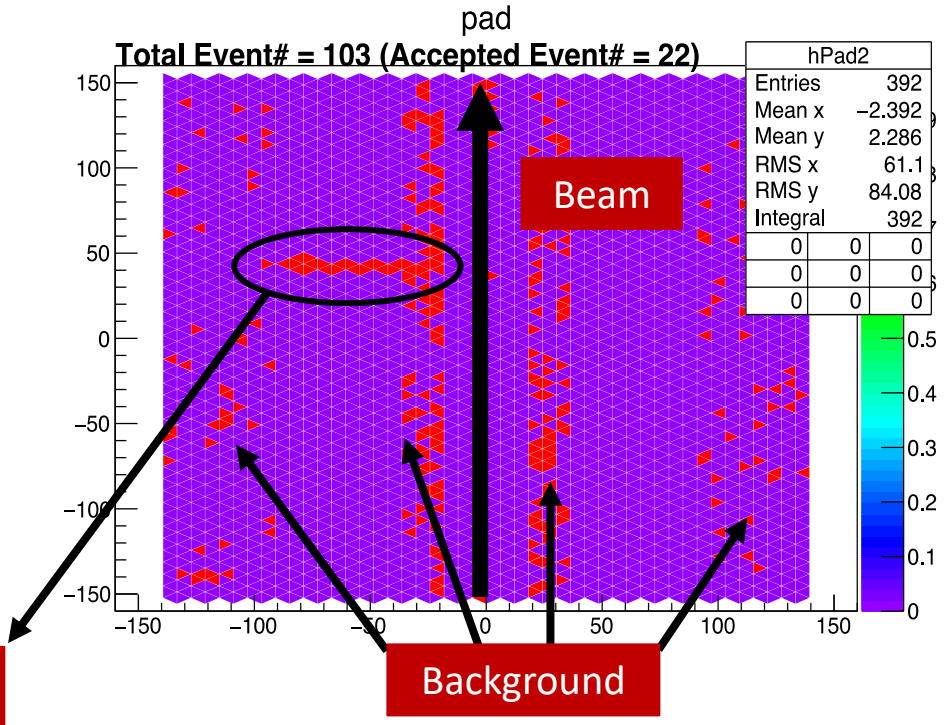
Figure Credits: Shinsuke Ota (RCNP, Osaka)

Delta Rays are generated from the interaction with the beam

Delta Rays energy distribution



A typical event recorded on the recoil TPC



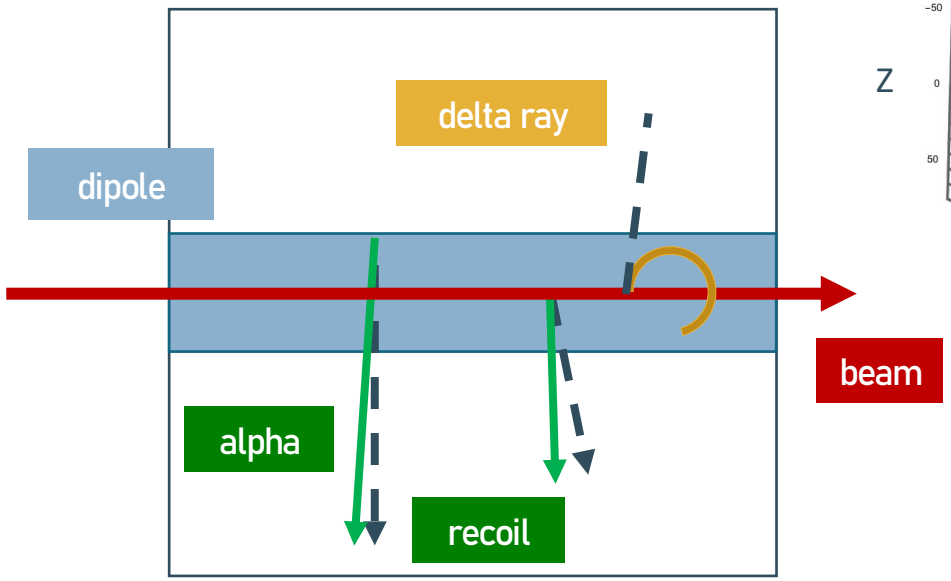
Delta Rays:

Noise from the delta rays triggers the DAQ

The high background triggers the acquisition system

Magnet Design

Delta Rays are confined in a region along the beam



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Magnet Design

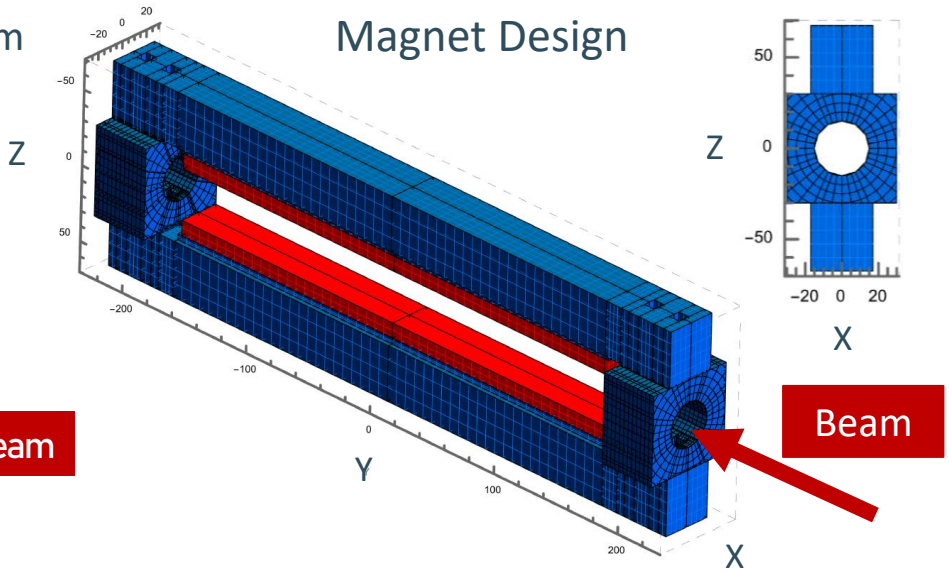
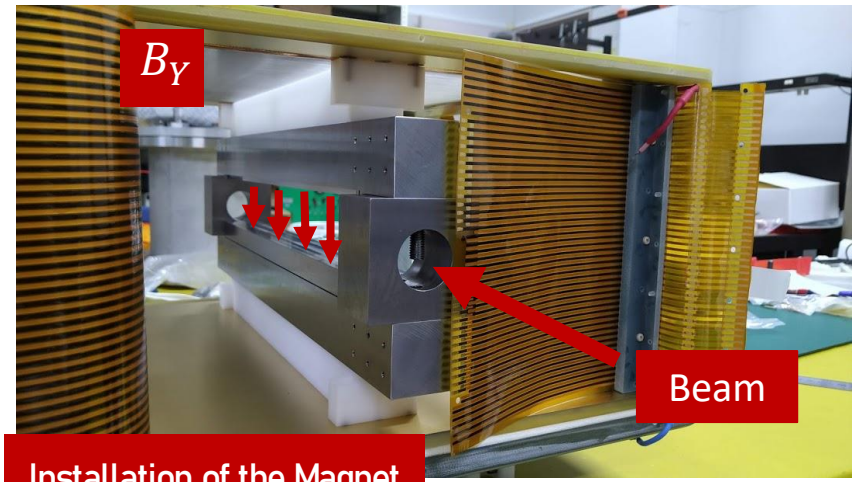


Figure credits: Reiko Kojima (CNS, Tokyo)

First time a magnet in the field cage!
Noise Reduction ~ 600



Installation of the Magnet

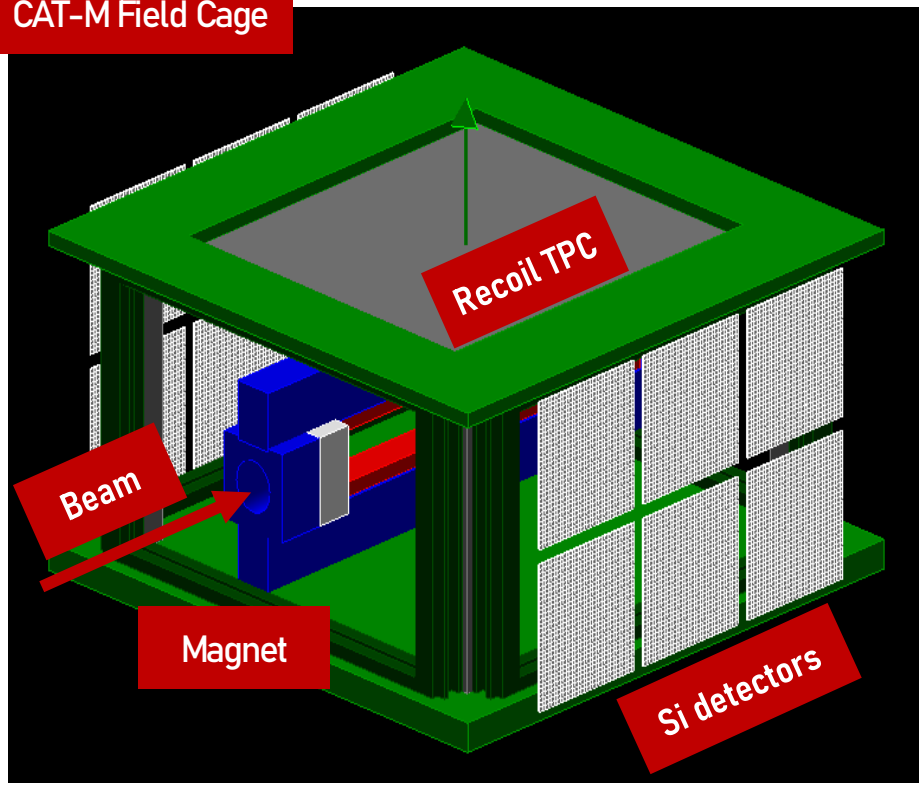
Dipole Magnet:

Magnet working principle and design

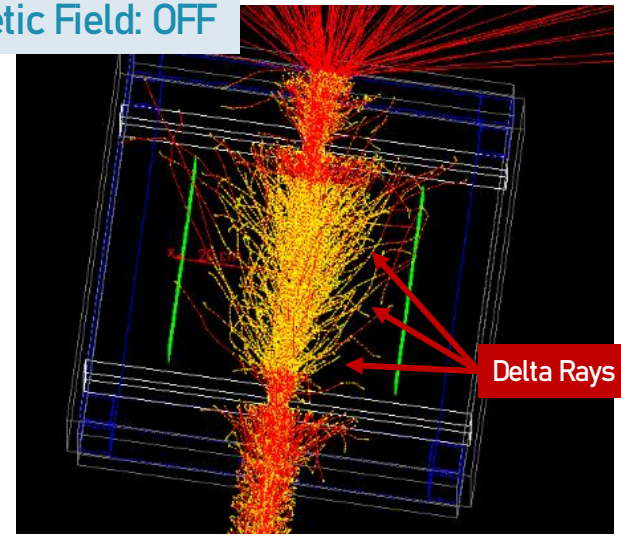
G4 Simulation for Delta Rays

Recoil TPC Event

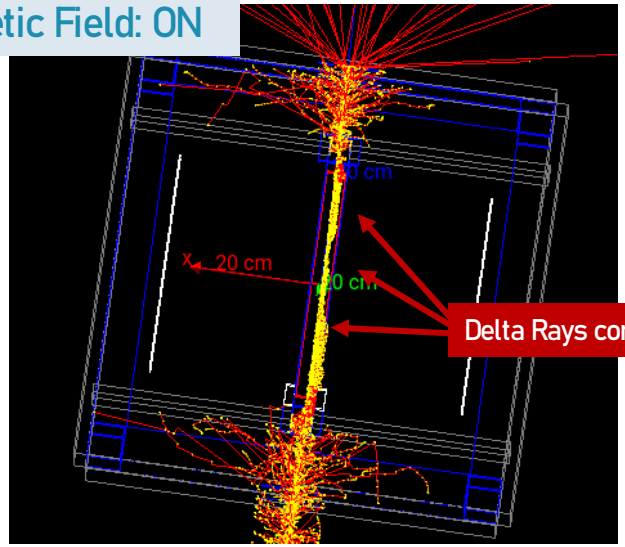
Geant4: Geometry Visualization



Magnetic Field: OFF



Magnetic Field: ON



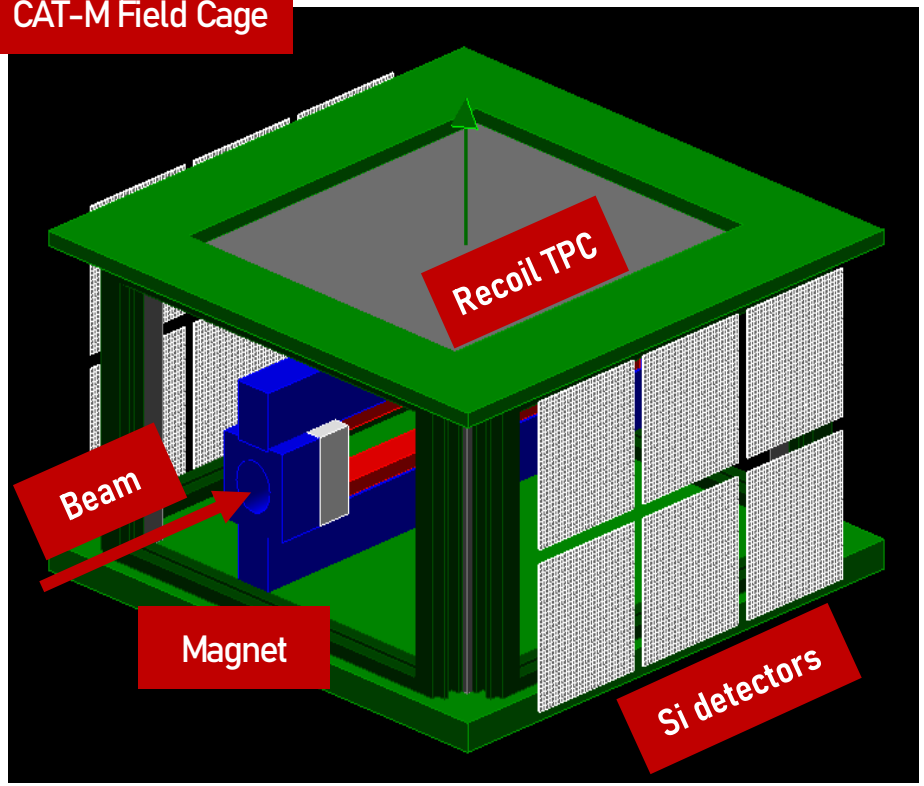
G4 Simulations:

CAT-M geometry in Geant4:
Delta Rays reduction with Magnetic field

G4 Simulation for Delta Rays

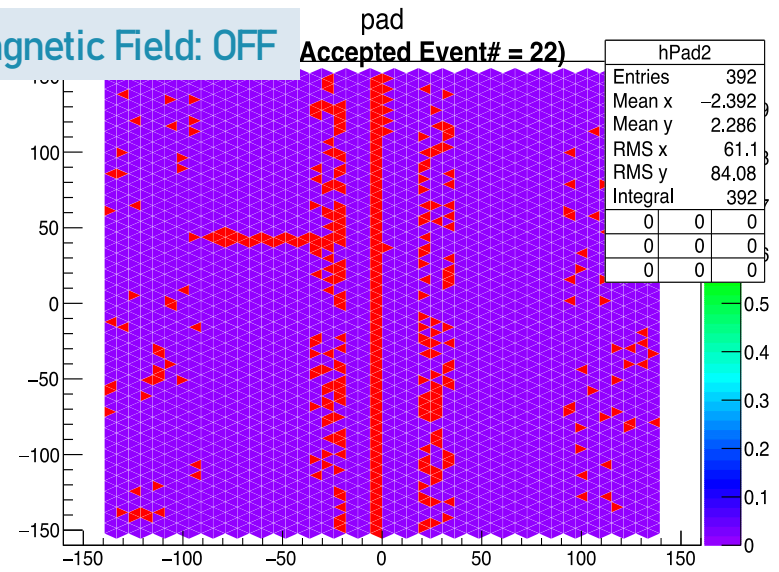
Geant4: Geometry Visualization

CAT-M Field Cage

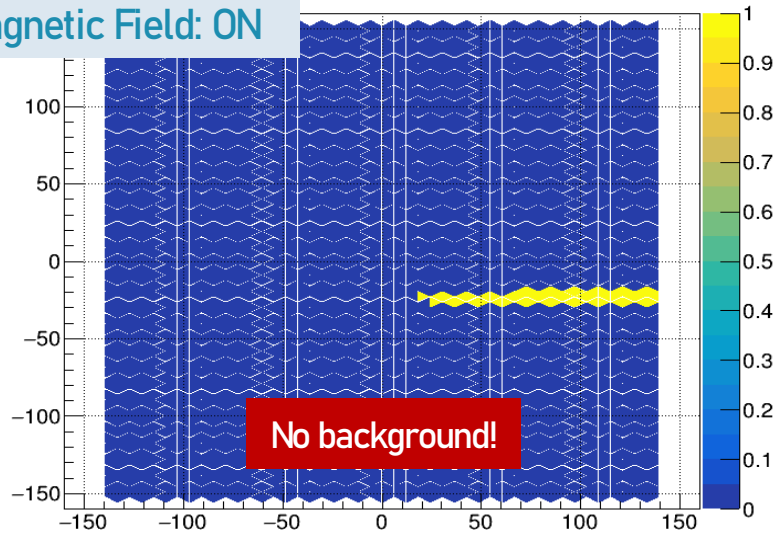


Recoil TPC Event

Magnetic Field: OFF



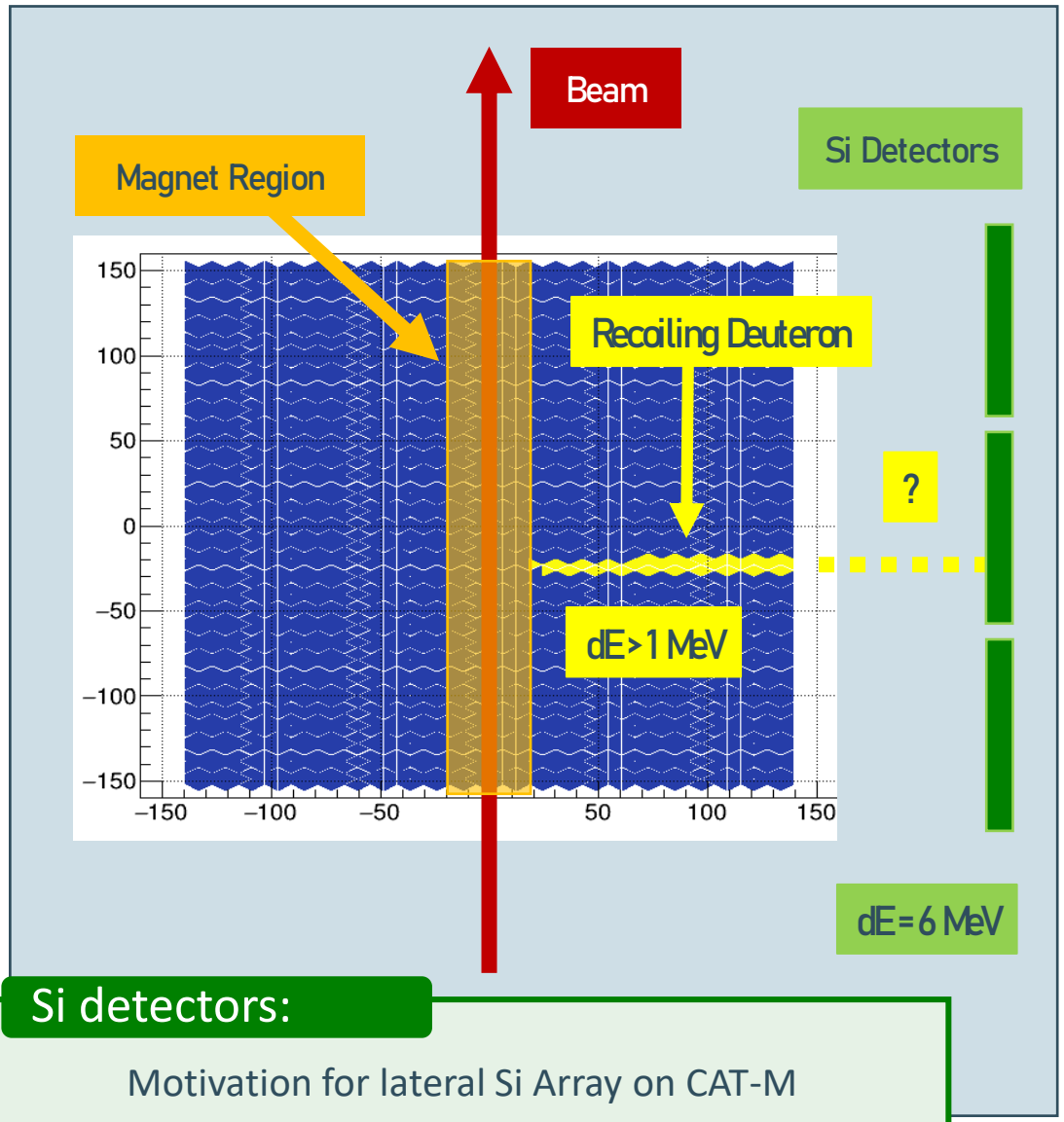
Magnetic Field: ON



G4 Simulations:

CAT-M geometry in Geant4:
Delta Rays reduction with Magnetic field

Lateral Si detectors



Si detectors:

Motivation for lateral Si Array on CAT-M

Event Reconstruction

The event is lost anytime the particle has enough energy to leave the Recoil TPC.

- The particle can be fully stopped, and its energy can be determined.

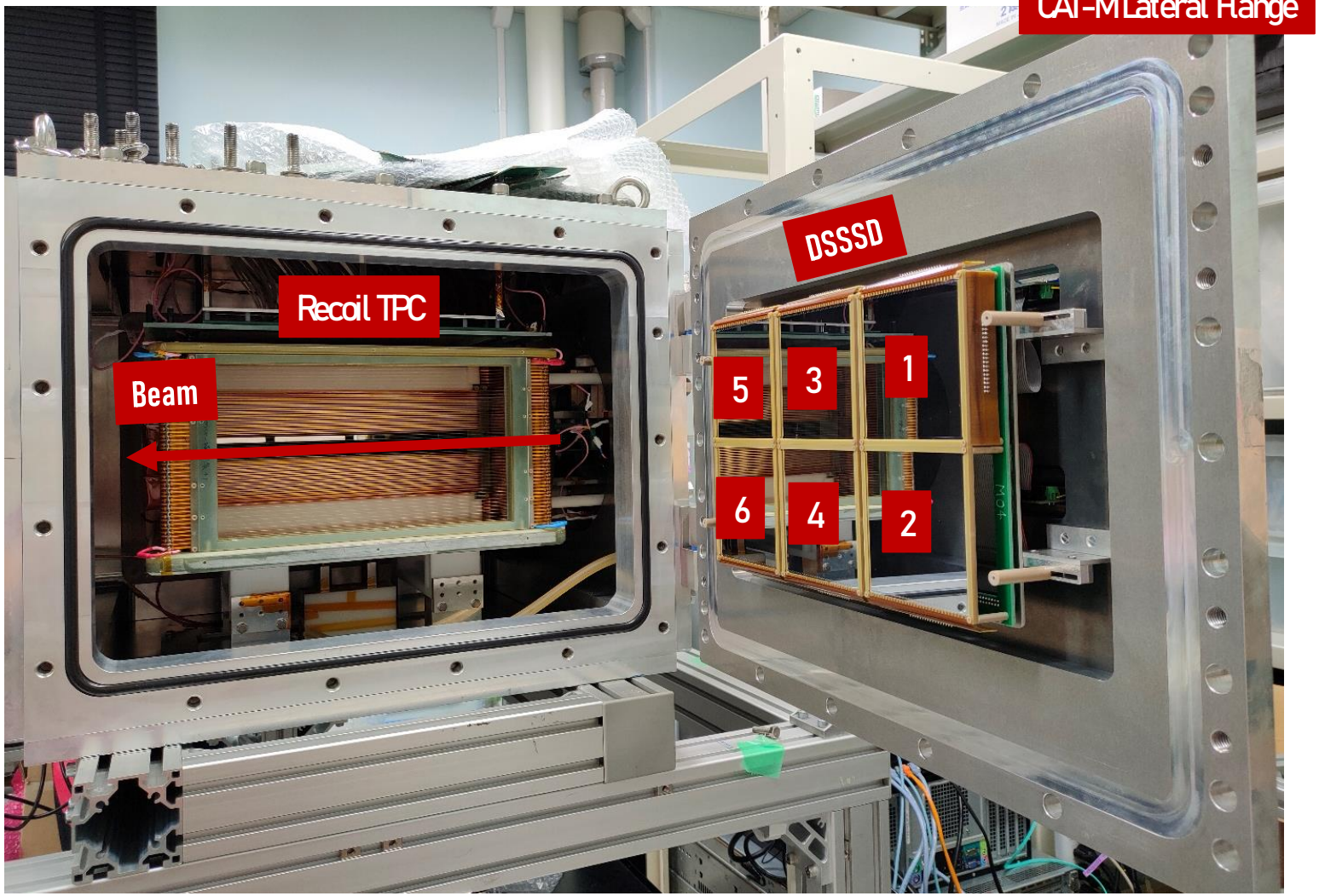
In addition…

- High coverage of solid angle to maximize efficiency.
- Position sensitivity in order to obtain information on scattering angle.

A new Si Array

DSSSD (Double-Sided Silicon Strip Detector)

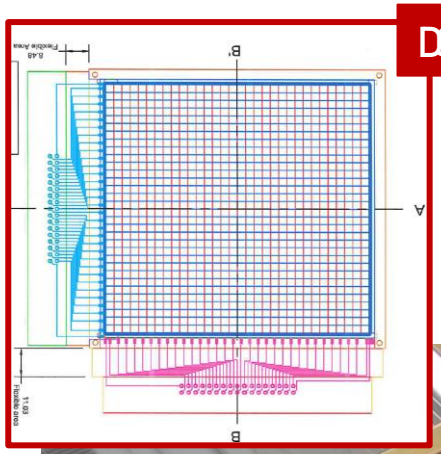
CAT-M with the Silicon Array (lateral flange)



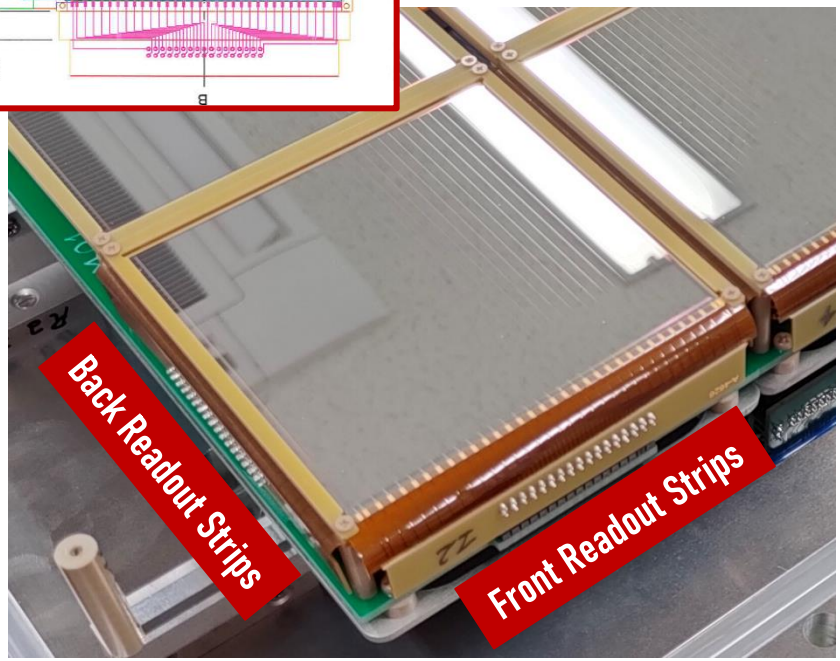
A new Si Array

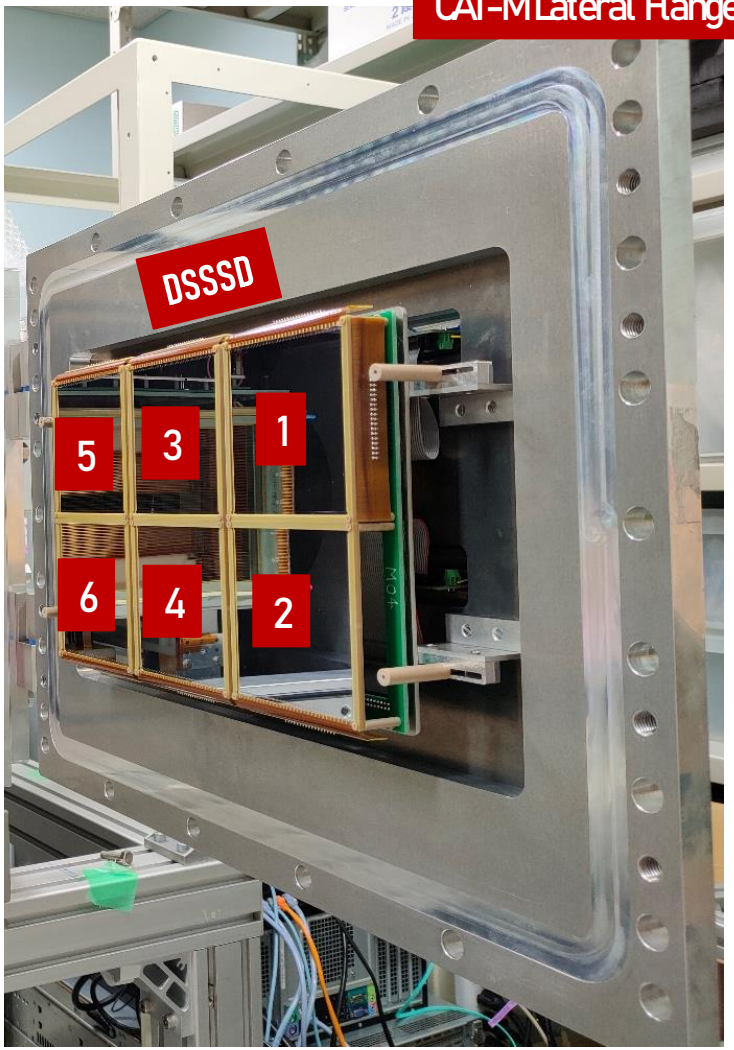
DSSSD (Double-Sided Silicon Strip Detector)

CAT-M with the Silicon Array (lateral flange)



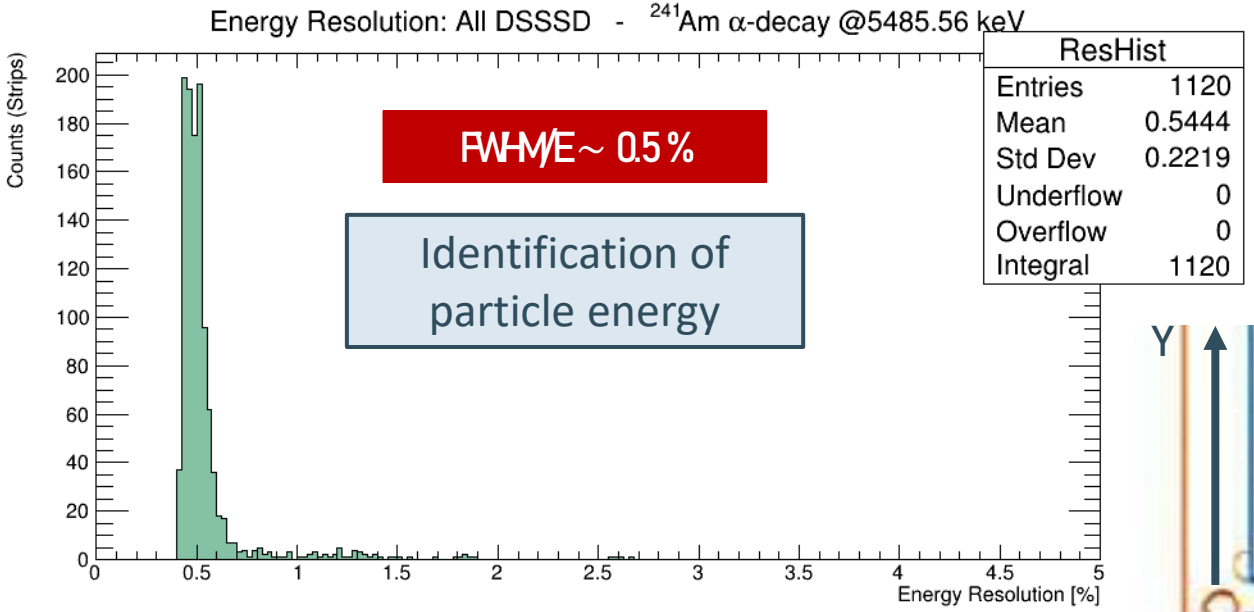
- Surface 10 cm x 10 cm
- 64 readout strips
- Thickness: 1000 µm





DSSSD Array: What to expect?

- Energy Resolution (for the whole array: 18 detectors)

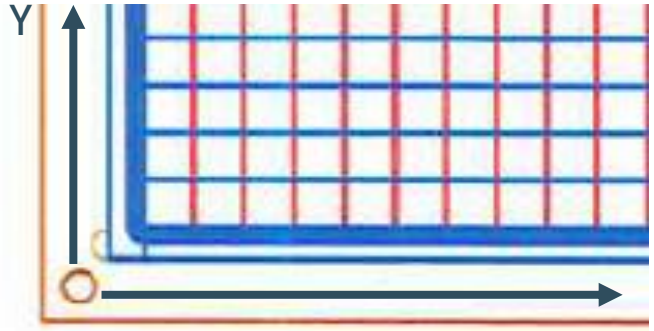


FWHM/E ~ 0.5 %

Identification of particle energy

12 DSSSD - 10 cm x 10 cm

Good coverage of Solid Angle



- Position Sensitivity
  - 32 front strips - horizontal
  - 32 back strips - vertical

Information on Recoil Angle

dx ~ 0.3 mm
dy ~ 0.3 mm

- Detector Thickness

Thickness ~ 1000 μm

Stopping Power:
Deuteron (0.4 atm) up to 16 MeV

DSSSD Summary:

Performance of the DSSSD array

Summary:

- Physics: The Isoscalar Giant Monopole Resonances
- Description of Active Target & CAT-M
- Development of the experimental setup
- ➢ Next experiment : HIMAC (Chiba), September 2022

Thank you for your attention

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