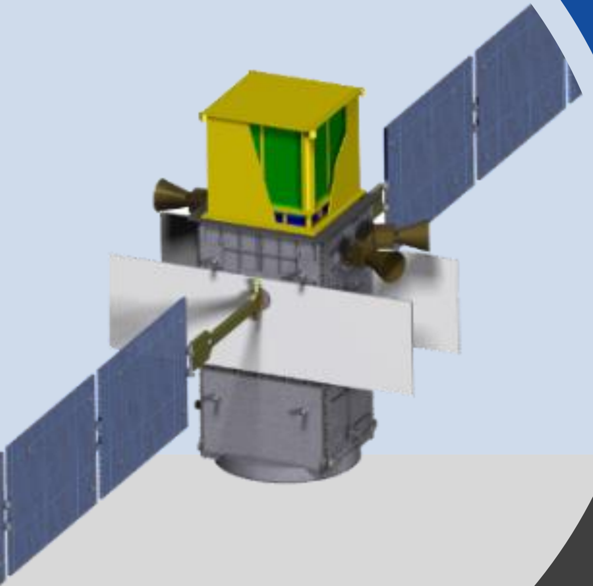
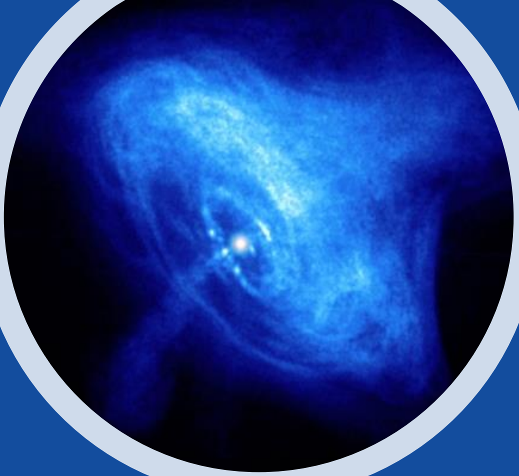
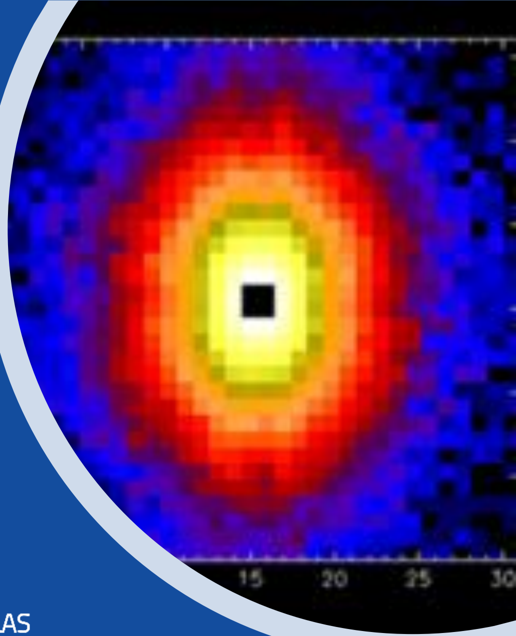






LABORATÓRIO DE INSTRUMENTAÇÃO
E FÍSICA EXPERIMENTAL DE PARTÍCULAS
partículas e tecnologia

e-ASTROGAM Tracker and Calorimeter Polarimetry

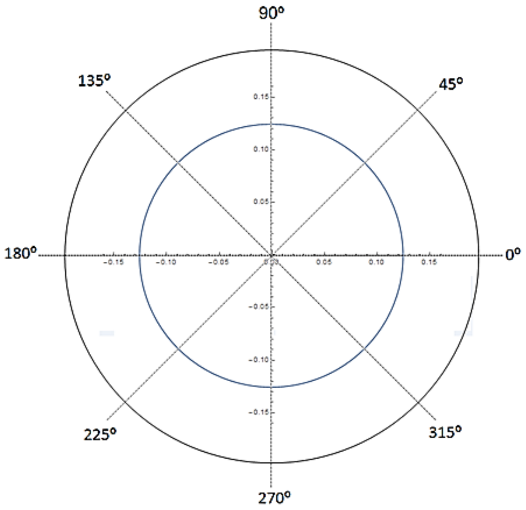
A.F.V. Cortez, R. M. Curado Silva, J. Maia, F. P. Santos, A. De Angelis

1.
A Few Polarimetry Concepts

Compton Polarimetry

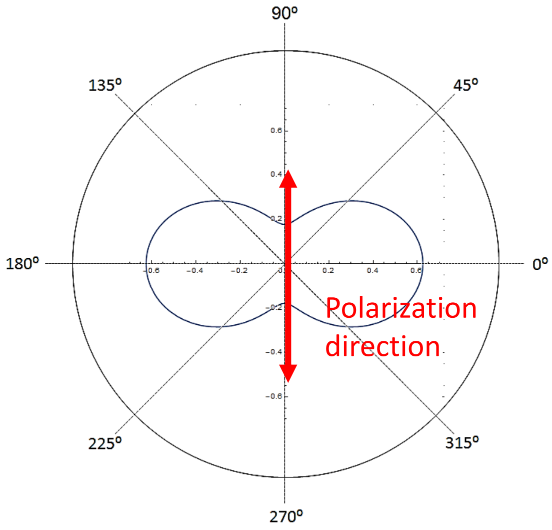
Unpolarized Beam

$$\frac{d\sigma_{KN,U}}{d\Omega} = \frac{1}{2} r_0^2 \varepsilon^2 [\varepsilon + \varepsilon^{-1} - \sin^2\theta]$$



Polarized Beam

$$\frac{d\sigma_{KN,P}}{d\Omega} = \frac{1}{2} r_0^2 \varepsilon^2 [\varepsilon + \varepsilon^{-1} - 2\sin^2\theta \cos^2\eta]$$

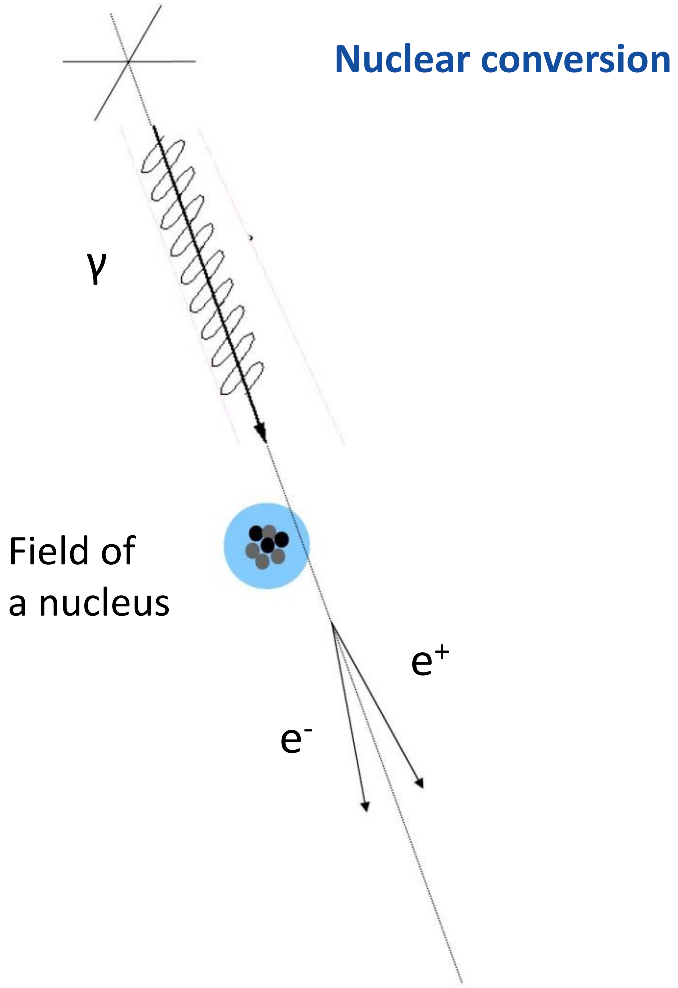


100%

Pair Production Polarimetry

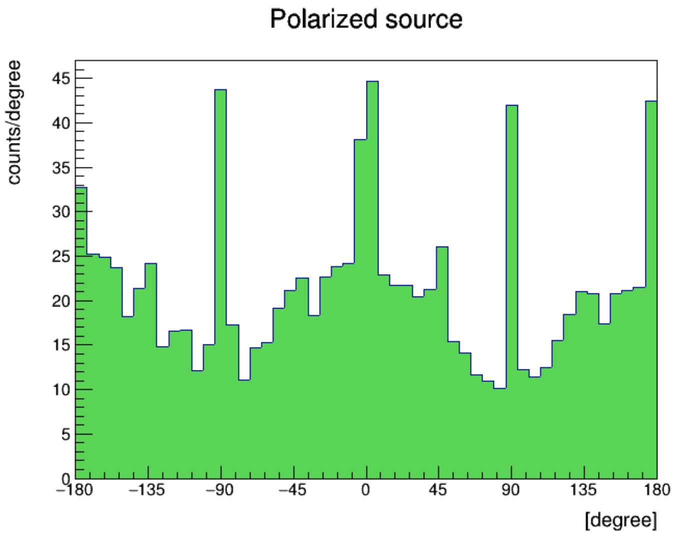
- e-/e+ pair is emitted in the plane of polarization of the photon;
- The pair distribution modulation amplitude and maxima phase depend on polarization degree and angle, respectively;

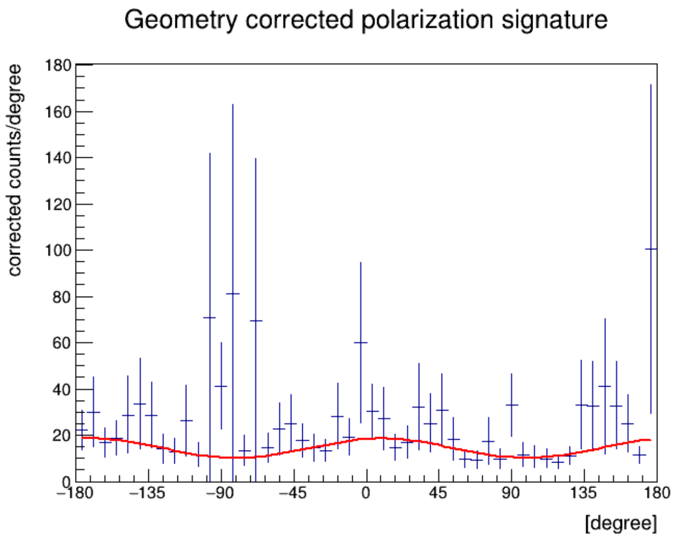
- Simulation code based on MEGAlib and BoGEMMS (Bologna Geant4 Multi-Mission Simulator) for pair production regime;
- Experimental: MEGA prototype data analysis.



Pair Production
Polarimetry with e-ASTROGAM

1) MEGA prototype at Duke University (100% polarized beam)





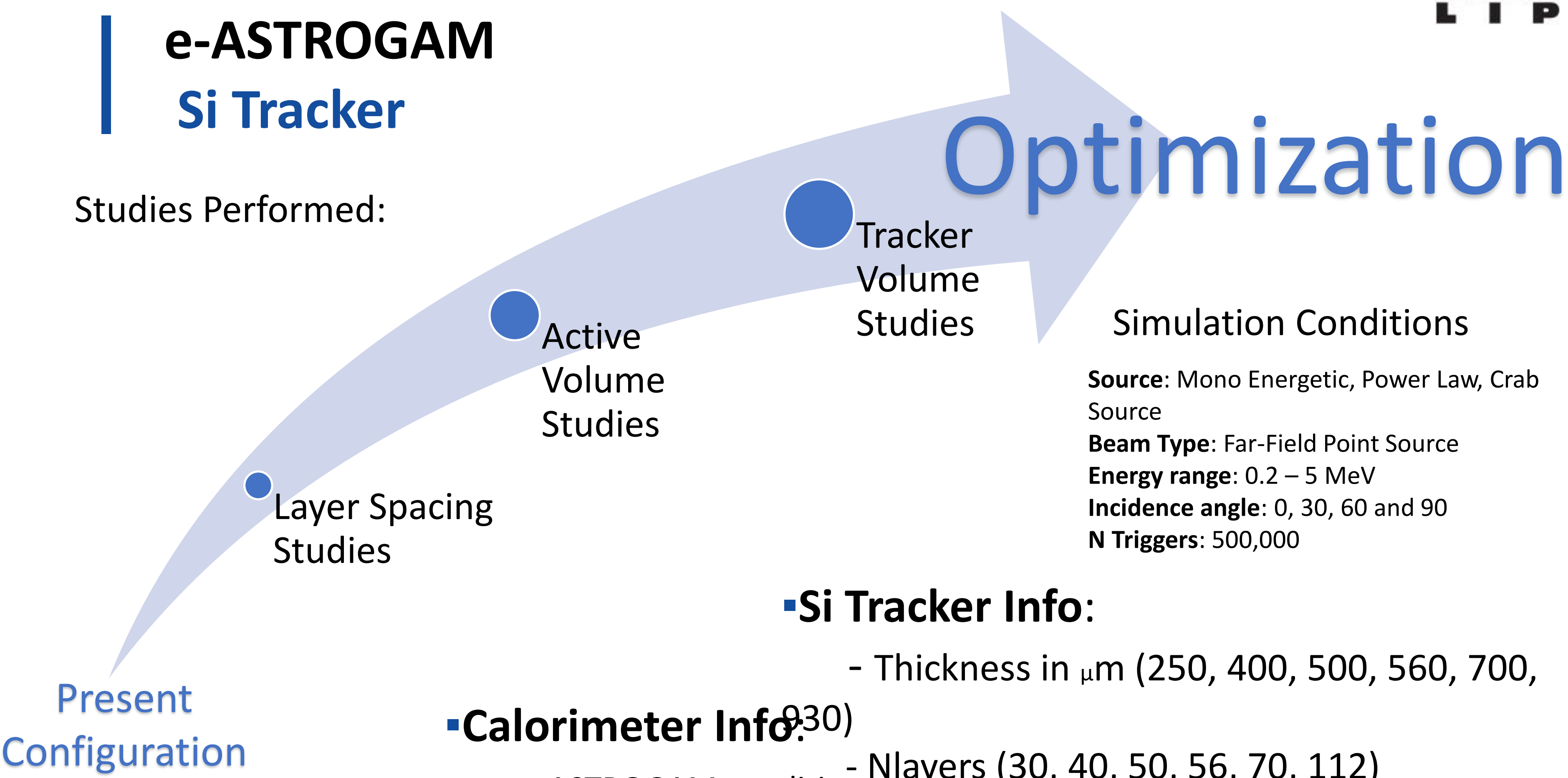
2.
Polarimetric Studies of the eASTROGAM Si Tracker

LIP

e-ASTROGAM

Si Tracker

Studies Performed:



Simulation Conditions

Source: Mono Energetic, Power Law, Crab Source
Beam Type: Far-Field Point Source
Energy range: 0.2 – 5 MeV
Incidence angle: 0, 30, 60 and 90
N Triggers: 500,000

- **Si Tracker Info**:
  - Thickness in μm (250, 400, 500, 560, 700, 930)
  - Nlayers (30, 40, 50, 56, 70, 112)
  - Spacing in cm (0.50, 0.75, 1.00, 1.10, 1.40

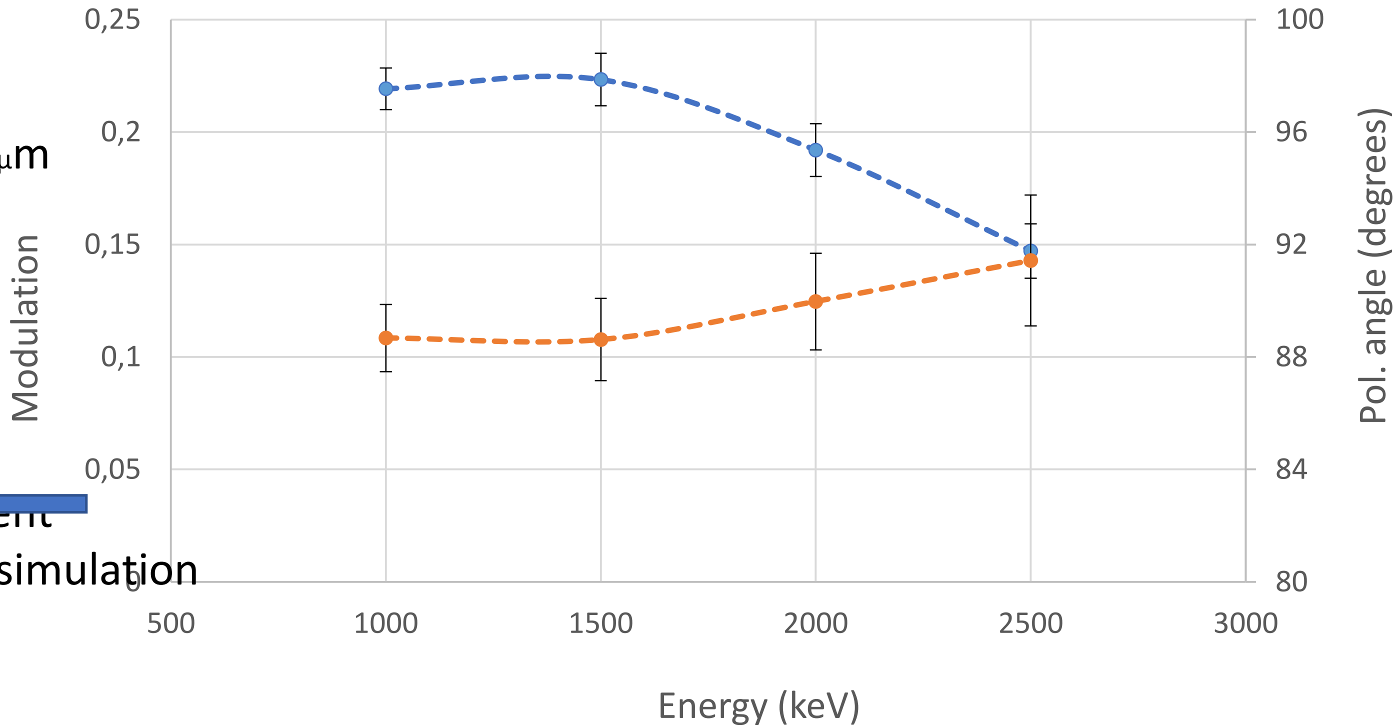
- **Calorimeter Info**:
  - eASTROGAM conditions

e-ASTROGAM
Si Tracker - Monoe

Simulation Conditions

Source: Monoenergetic
Beam Type: Far-Field Point Source
Incidence angle: Normal
Energy range: 1 – 3 MeV
N Triggers: 500,000

- **Si Tracker Info**:
  - Thickness - 500 μm
  - Nlayers - 56
  - Spacing 1.00 cm



Results in agreement with the previous simulation

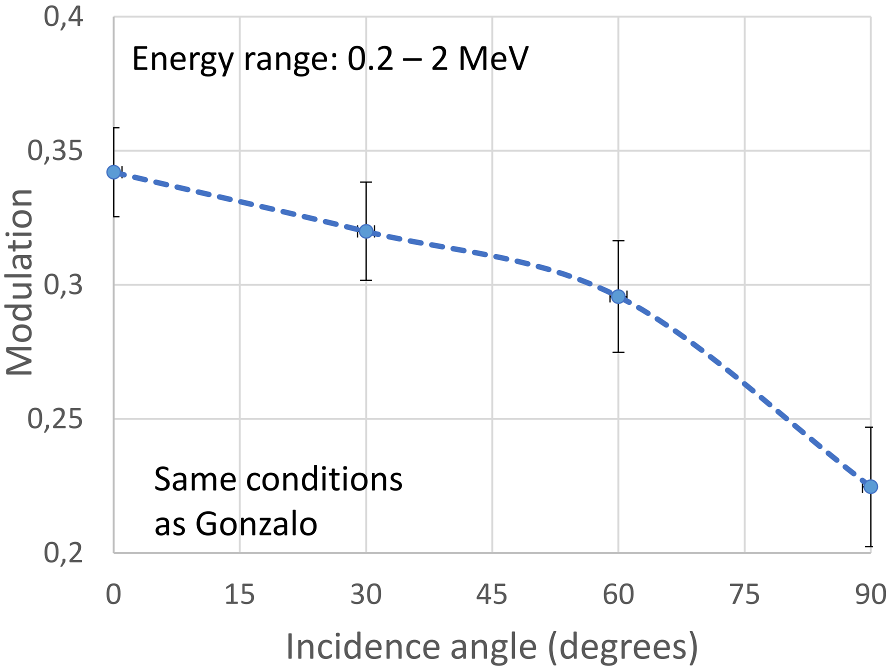
Simulation Conditions

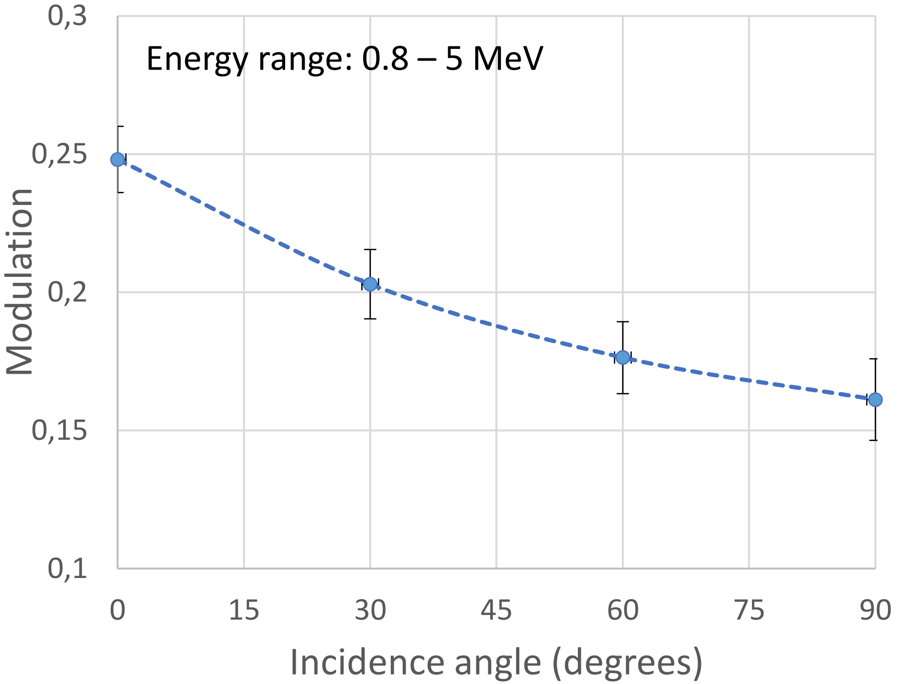
e-ASTROGAM

Si Tracker - Crab Source

- **Source Info**: Power Law (2.0)
  Far-Field Point Source
  500,000 Triggers

- **Si Tracker Info**: Thickness - 500 μm
  Nlayers - 56
  Spacing 1.00 cm





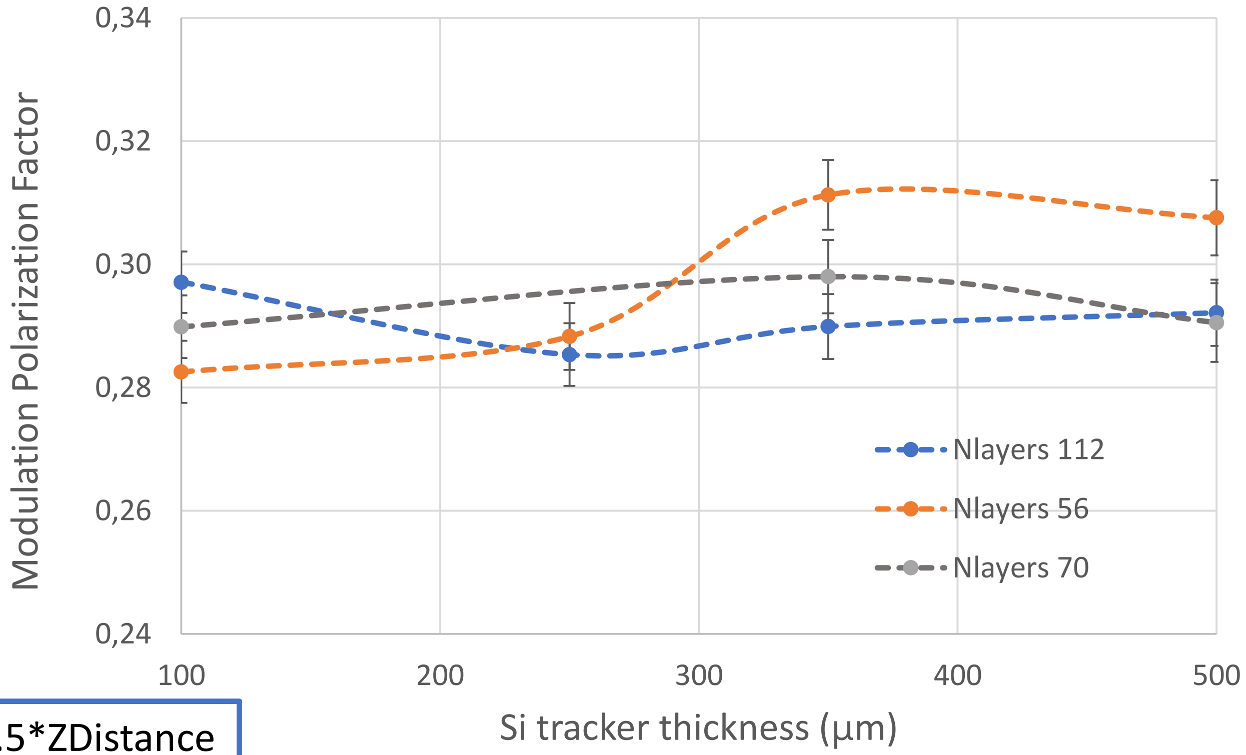
e-ASTROGAM

Si Tracker - Total Volume Studies

Simulation Conditions

Source: Power Law (2.0)
Beam Type: Far-Field Point Source
Energy range: 0.5 – 2 MeV
N Triggers: 500,000

- Variable Sensitive volume
- Constant Interlayer spacing
- Variable Number of layers
- Variable Total Tracker volume



TotVol = Const*(Nlayers – 1)*0.5*ZDistance

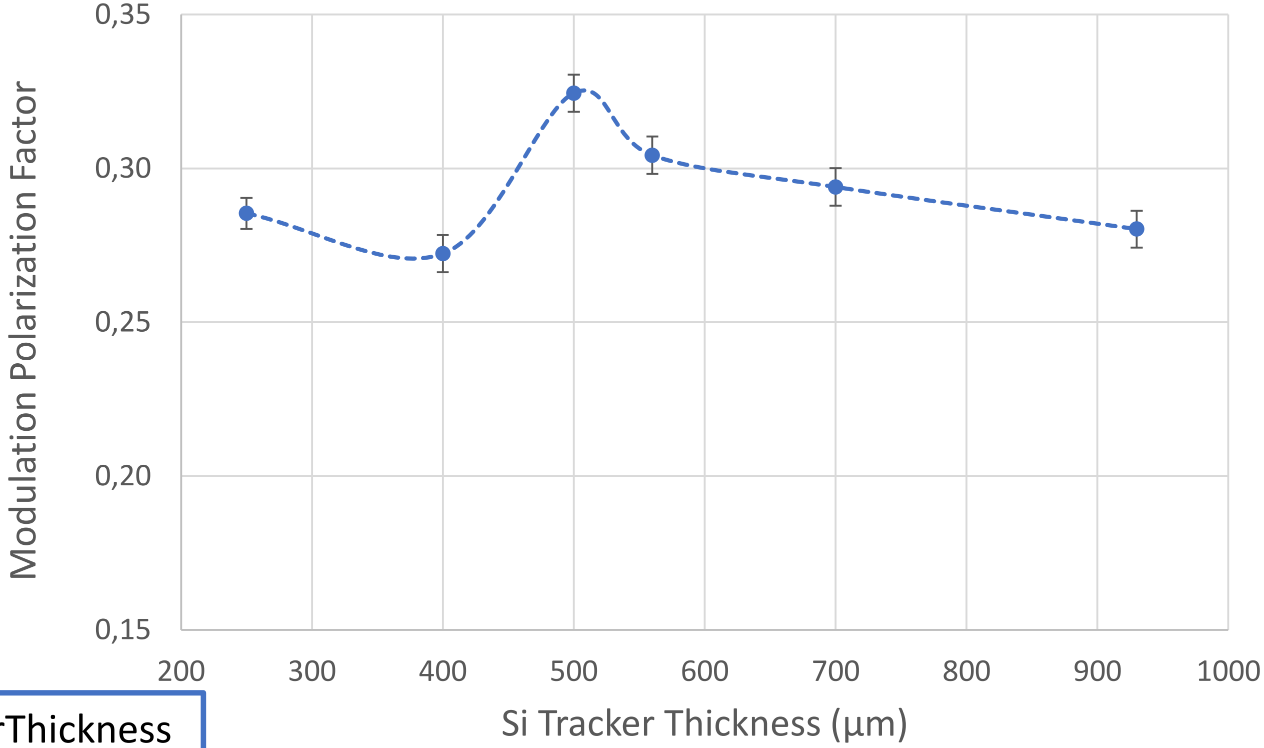
e-ASTROGAM

Si Tracker - Active Volume Studies

Simulation Conditions

Source: Power Law (2.0)
Beam Type: Far-Field Point Source
Energy range: 0.5 – 2 MeV
N Triggers: 500,000

- Constant Sensitive volume
- VariableInterlayer spacing
- Variable Number of layers
- Variable Total Tracker volume



ActVol = Const* (Nlayers)*LayerThickness

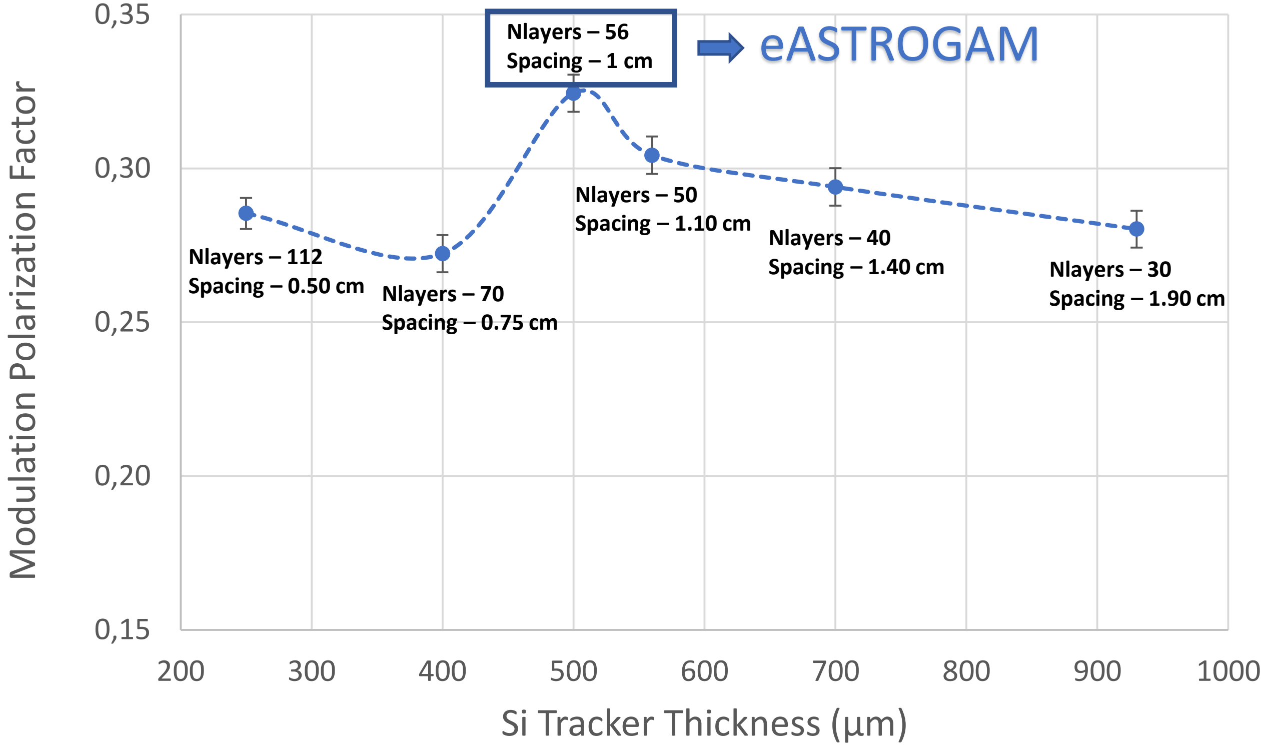
e-ASTROGAM

Si Tracker - Active Volume Studies

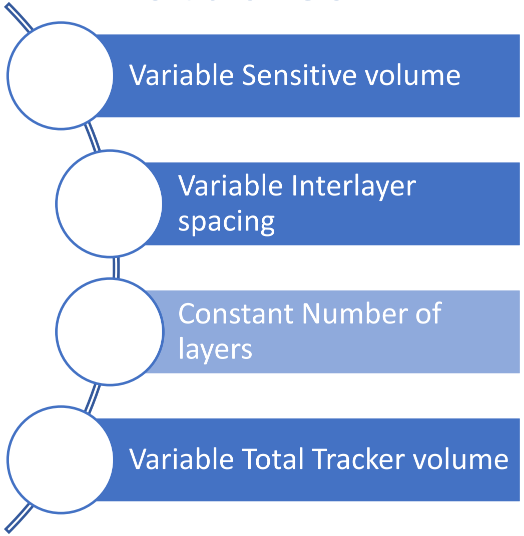
Simulation Conditions

Source: Power Law (2.0)
Beam Type: Far-Field Point Source
Energy range: 0.5 – 2 MeV
N Triggers: 500,000

- Constant Sensitive volume
- VariableInterlayer spacing
- Variable Number of layers
- Variable Total Tracker volume

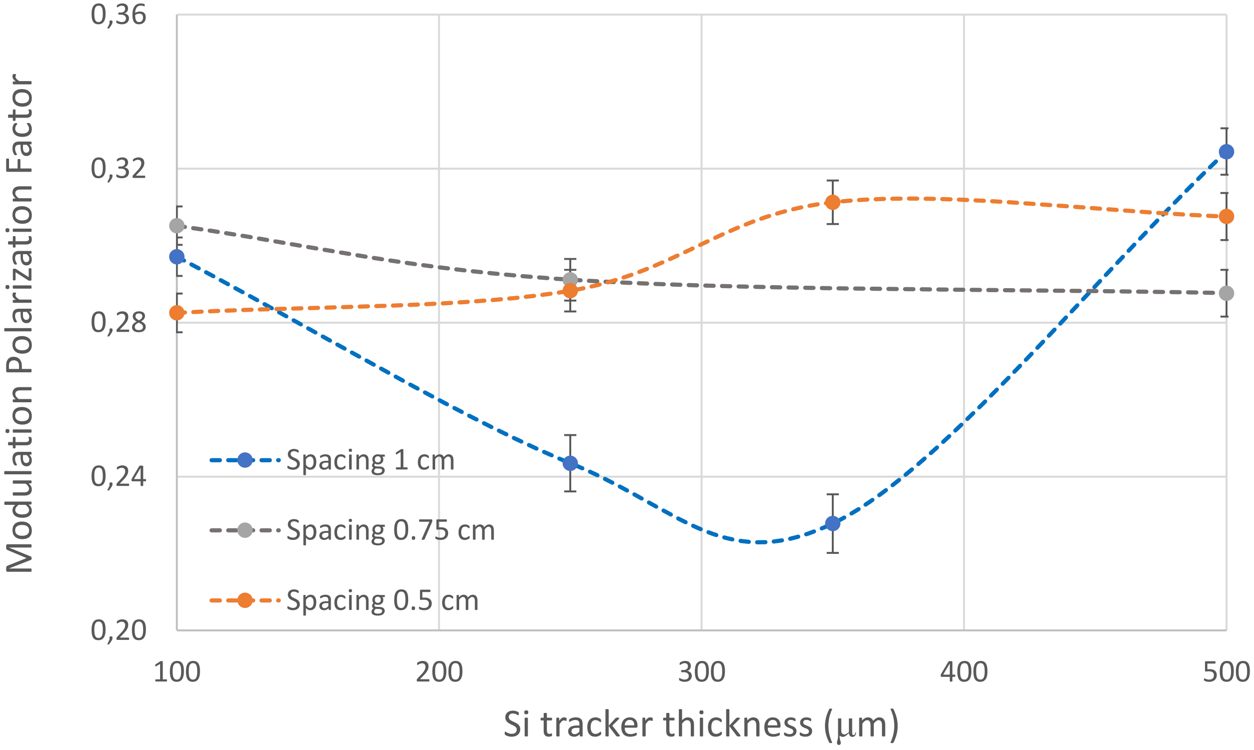


e-ASTROGAM
Si Tracker - Spacing Studies



Simulation Conditions

Source: Power Law (2.0)
Beam Type: Far-Field Point Source
Energy range: 0.5 – 2 MeV
N Triggers: 500,000



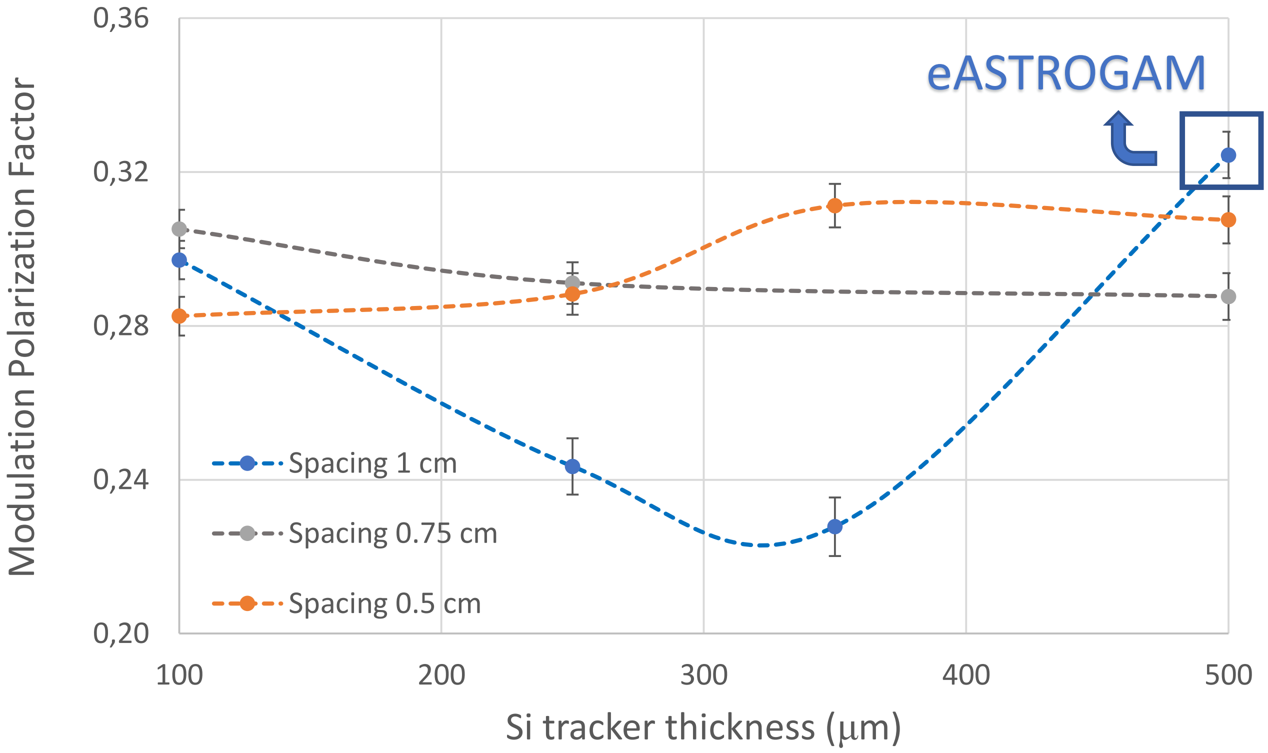
e-ASTROGAM

Si Tracker - Spacing Studies

Simulation Conditions

Source: Power Law (2.0)
Beam Type: Far-Field Point Source
Energy range: 0.5 – 2 MeV
N Triggers: 500,000

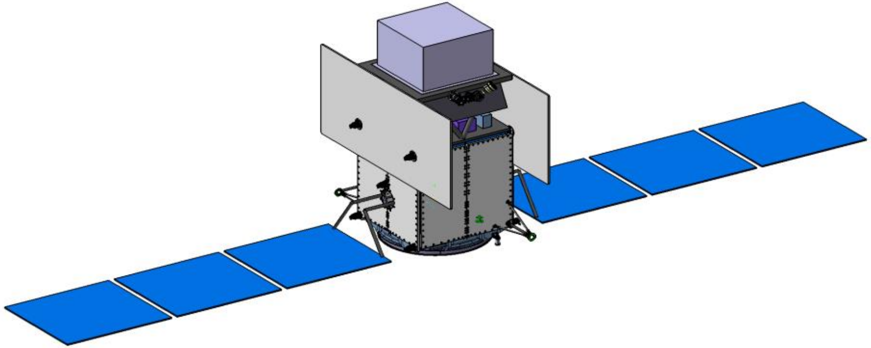
- Variable Sensitive volume
- Variable Interlayer spacing
- Constant Number of layers
- Variable Total Tracker volume



And tables to compare data

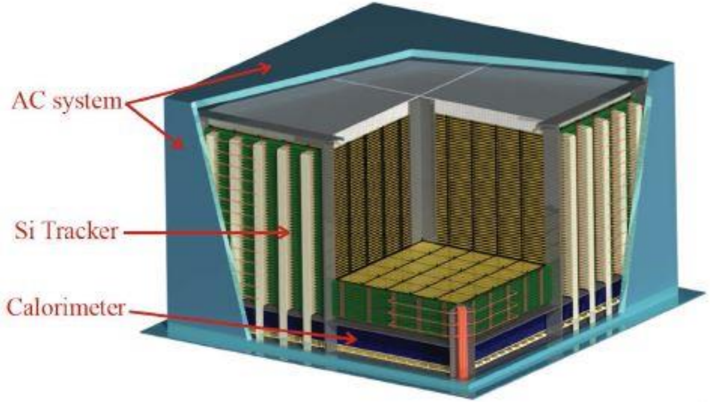
MDP Requirements	eASTROGAM paper MDP	Simulated MDP
< 20 % 10 mCrab, 0.3-2.0 MeV, 1 year obs. time	0.7% Crab, 0.2-2.0 MeV, 1 Ms obs. time	**0.65%** Crab, 0.2-2.0 MeV, 1 Ms obs. time
	Galactic Center, 10% 10 mCrab, 0.2-2.0 MeV, 1 year obs. Time	Galactic Center, **10.8%** 10 mCrab, 0.2-2.0 MeV, 1 year obs. Time

eASTROGAM
Si Tracker Polarization Summary



So far what have we learned?

- Si Tracker seem to be close to be optimized;
- There is a small dependence on the geometry parameters;
- Although not shown results similar to Gonzalo’s were obtained (energy resolution and angular resolution);

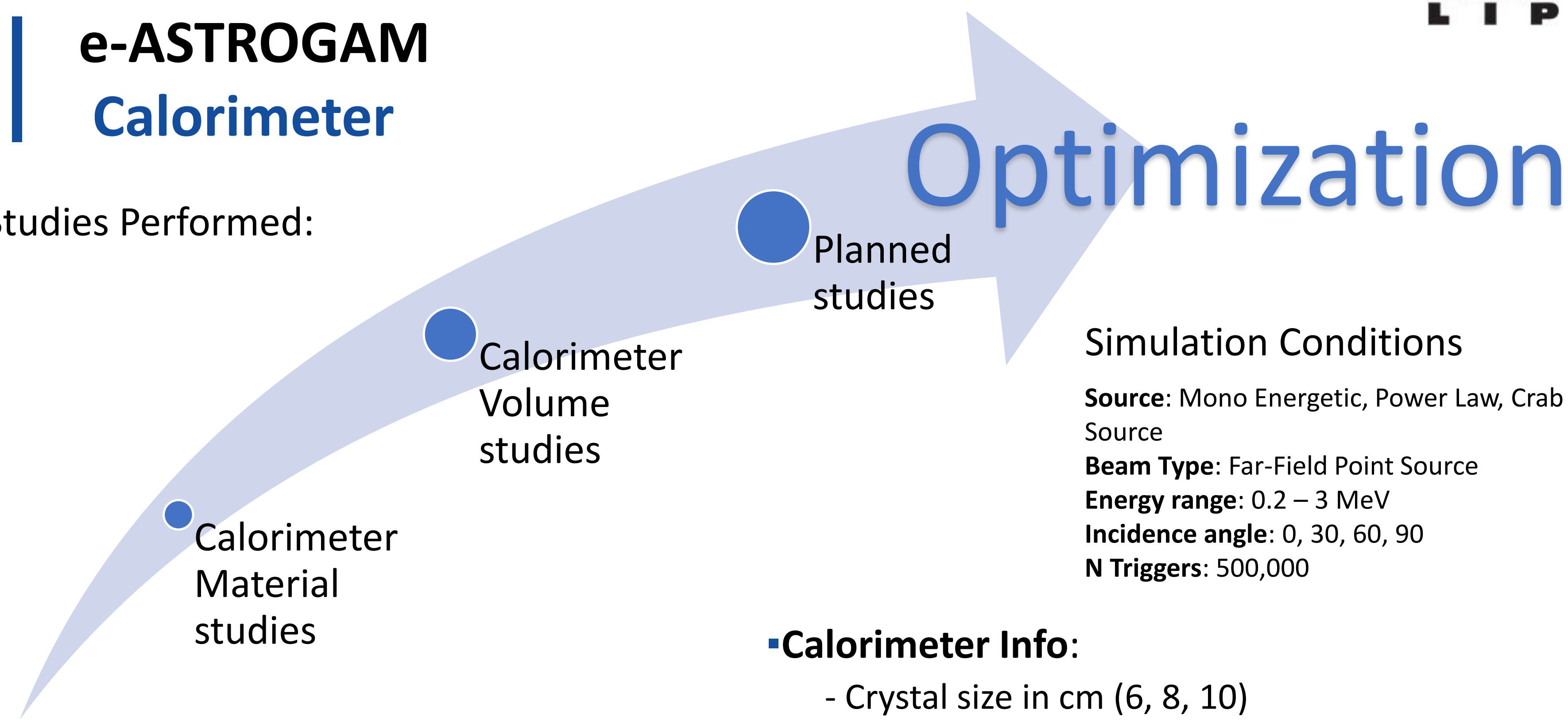


3.
Polarimetric Studies of the eASTROGAM Calorimeter

L I P

e-ASTROGAM
Calorimeter

Studies Performed:



Present Configuration

Simulation Conditions

Source: Mono Energetic, Power Law, Crab Source
Beam Type: Far-Field Point Source
Energy range: 0.2 – 3 MeV
Incidence angle: 0, 30, 60, 90
N Triggers: 500,000

- **Calorimeter Info**:
  - Crystal size in cm (6, 8, 10)
  - Material (CsI, CdTe, CZT)
- **Si Tracker Info**:
  - eASTROGAM conditions

e-ASTROGAM

Calorimeter - Monoenergetic Source

Simulation Conditions

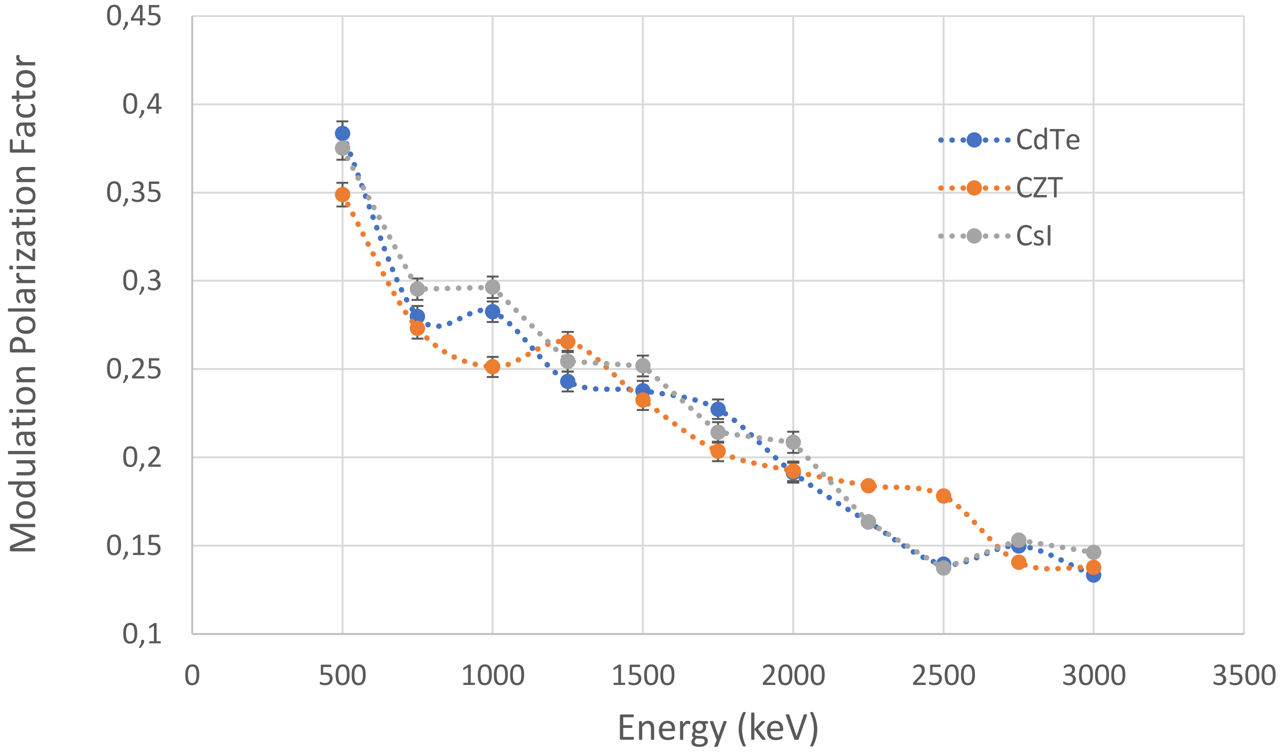
Source: Monoenergetic
Beam Type: Far-Field Point Source
Incidence angle: Normal
Energy range: 0.5 – 3 MeV
N Triggers: 500,000

Calorimeter info:

- Material – CsI, CdTe, CZT
- Crystal size – 8 cm

Si Tracker info:

- Thickness – 500 µm
- Nlayers - 56
- Spacing 1.00 cm



e-ASTROGAM
Calorimeter – Non-Monoenergetic

Simulation Conditions

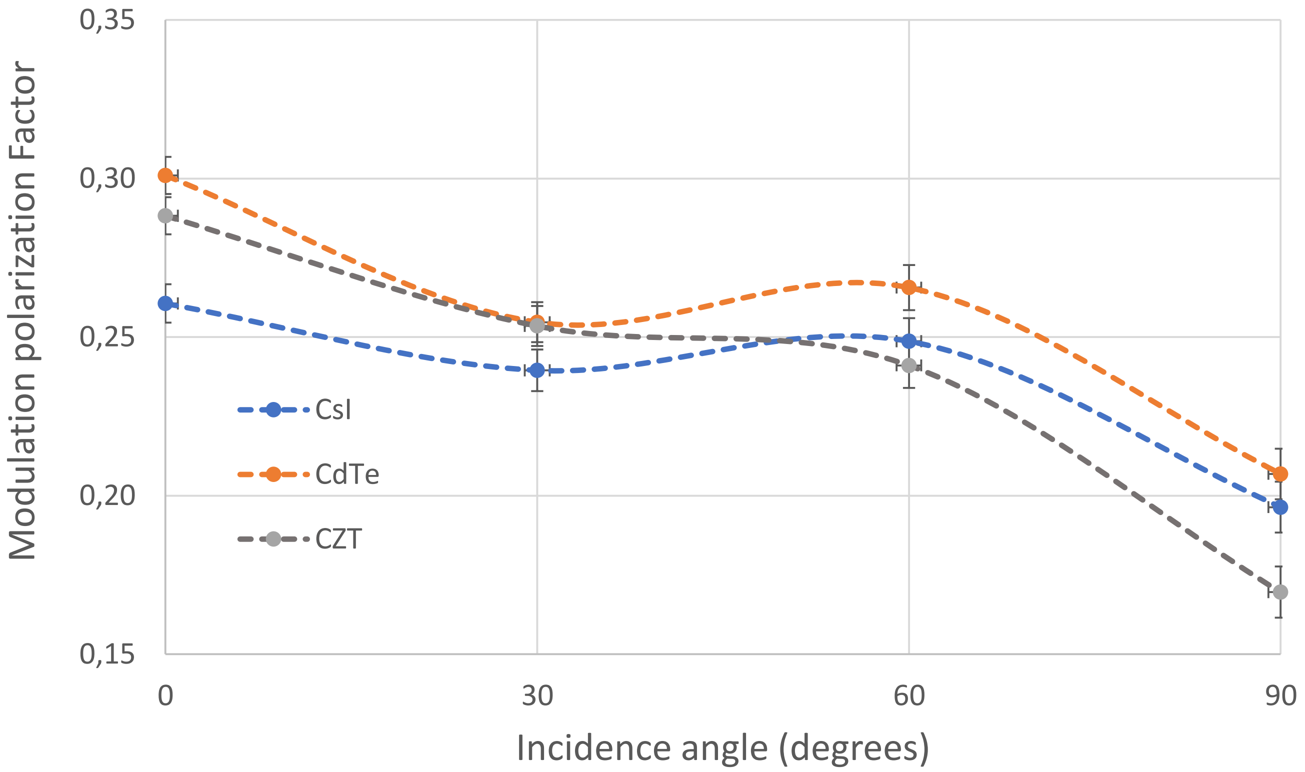
Source: Power Law (2.0)
Beam Type: Far-Field Point Source
Incidence angle: 0, 30, 60, 90
Energy range: 0.5 – 2 MeV
N Triggers: 500,000

Calorimeter info:

- Material – CsI, CdTe, CZT
- Crystal size – 8 cm

Si Tracker info:

- Thickness – 500 µm
- Nlayers - 56
- Spacing 1.00 cm



e-ASTROGAM

Calorimeter – Crab Source

Simulation Conditions

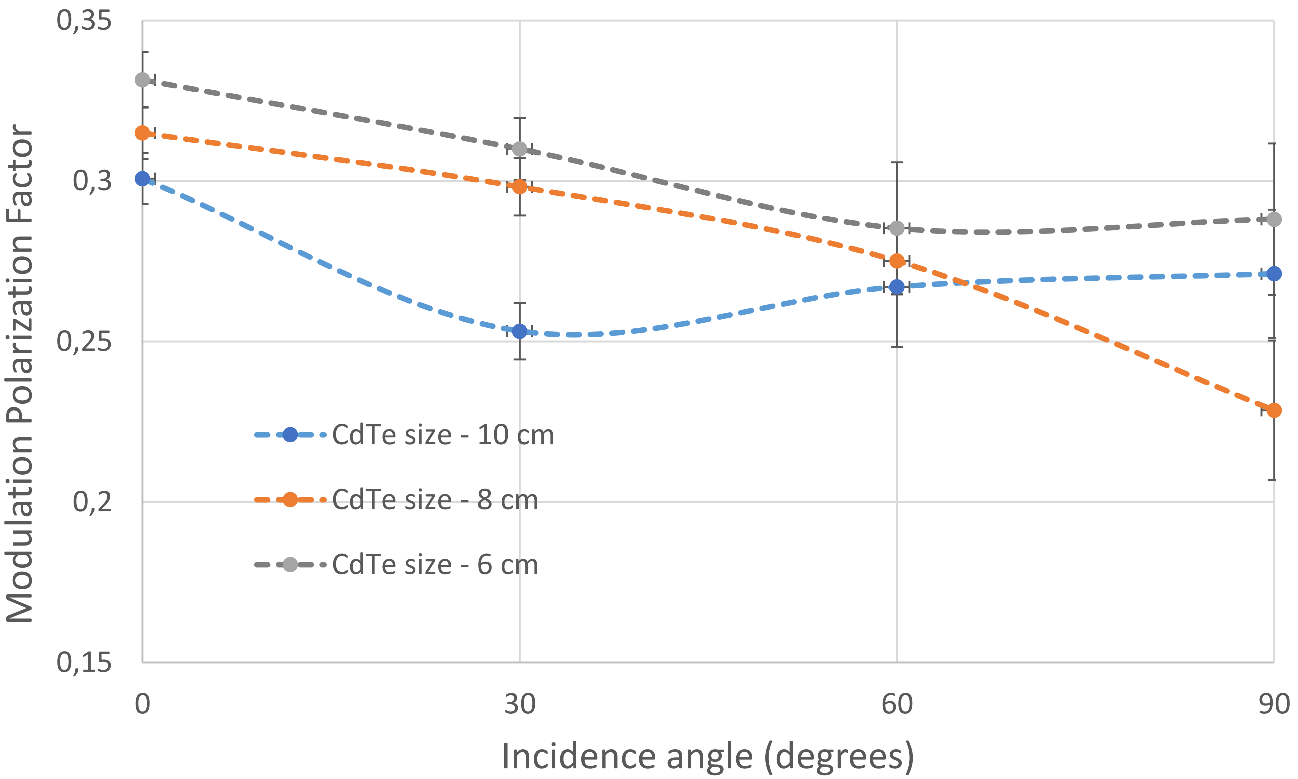
Source: Power Law (2.0)
Beam Type: Far-Field Point Source
Energy range: 0.5 – 2 MeV
N Triggers: 500,000

Calorimeter info:

- Material – CdTe
- Crystal size – 6, 8, 10 cm

Si Tracker info:

- Thickness – 500 µm
- Nlayers - 56
- Spacing 1.00 cm



e-ASTROGAM
Calorimeter – Crab Source

Simulation Conditions

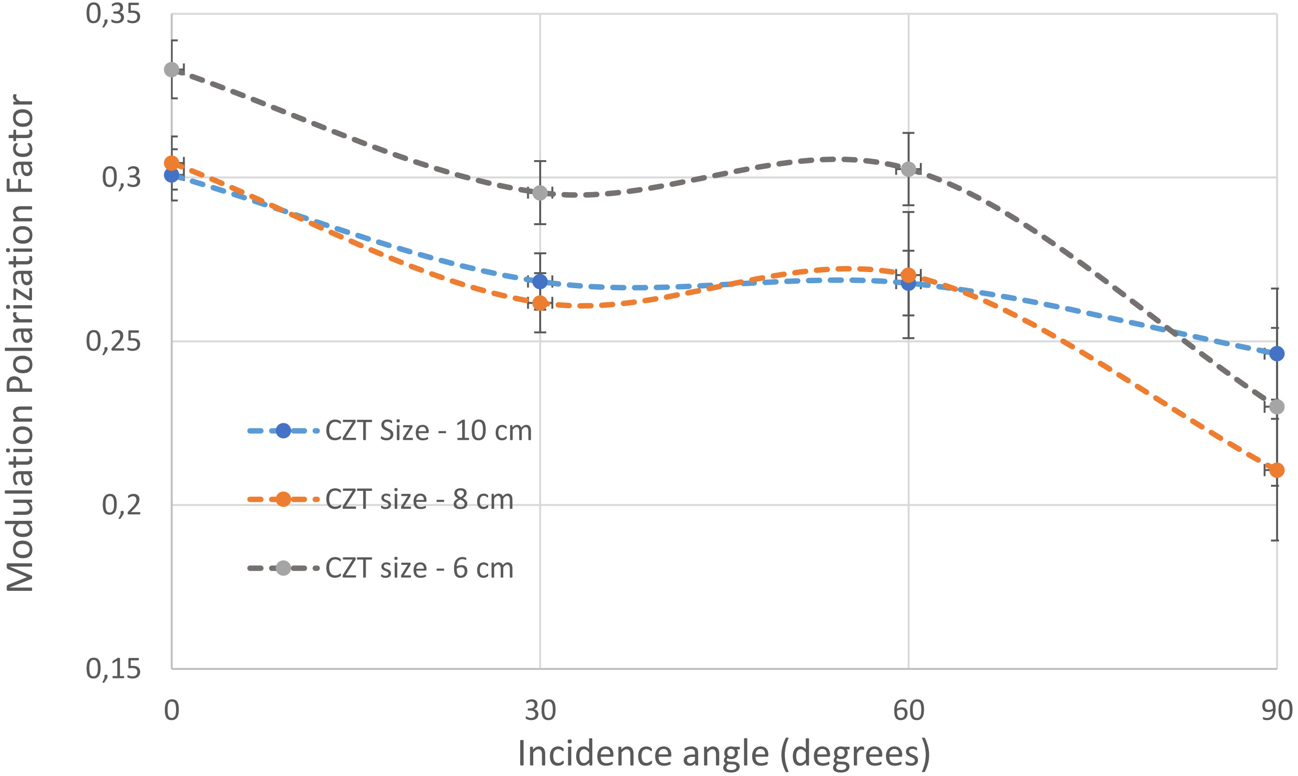
Source: Power Law (2.0)
Beam Type: Far-Field Point Source
Energy range: 0.2 – 2 MeV
N Triggers: 500,000

Calorimeter info:

- Material – CZT
- Crystal size – 6, 8, 10 cm

Si Tracker info:

- Thickness – 500 µm
- Nlayers - 56
- Spacing 1.00 cm



e-ASTROGAM
Calorimeter – Crab Source

Simulation Conditions

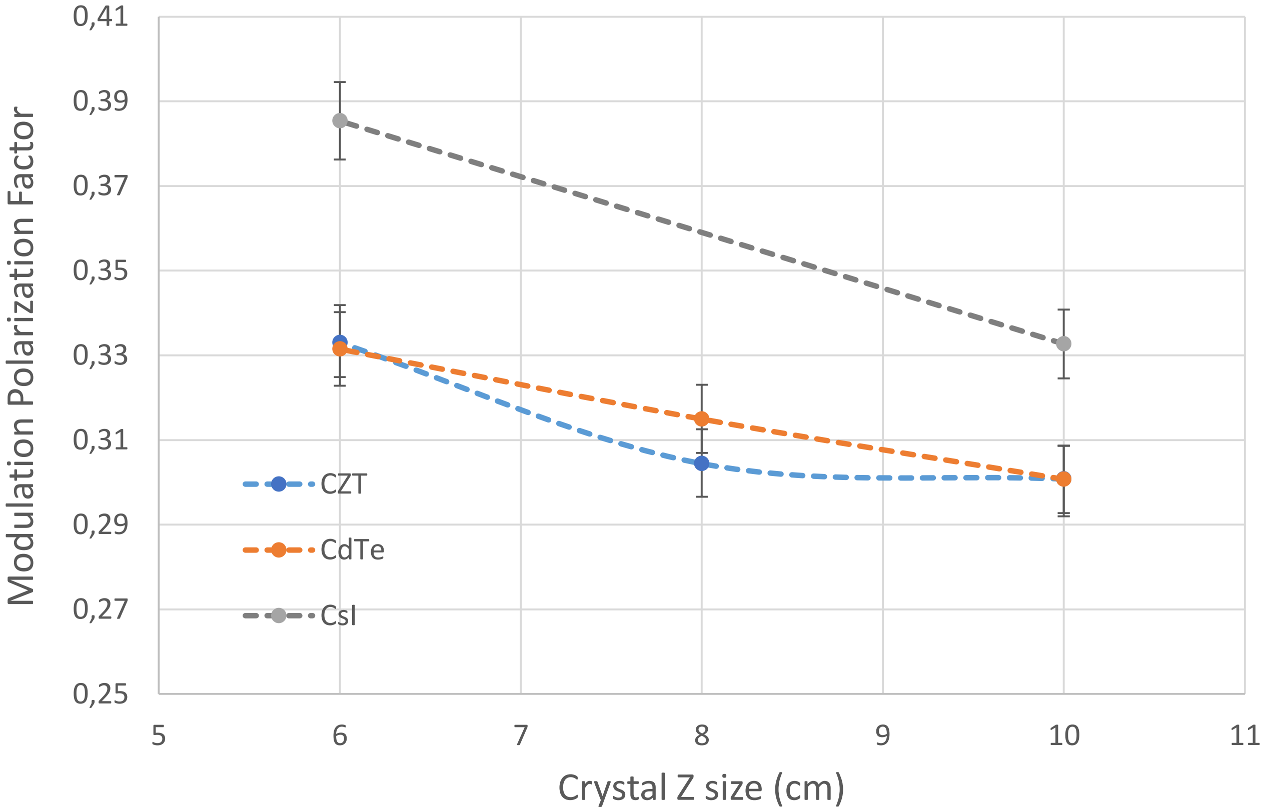
Source: Power Law (2.0)
Beam Type: Far-Field Point Source
Energy range: 0.2 – 2 MeV
N Triggers: 500,000

Calorimeter info:

- Material – CZT, CdTe, CsI
- Crystal size – 6, 8, 10 cm

Si Tracker info:

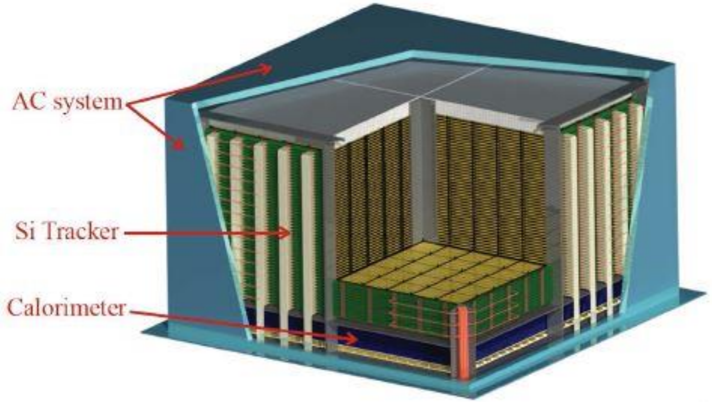
- Thickness – 500 µm
- Nlayers - 56
- Spacing 1.00 cm

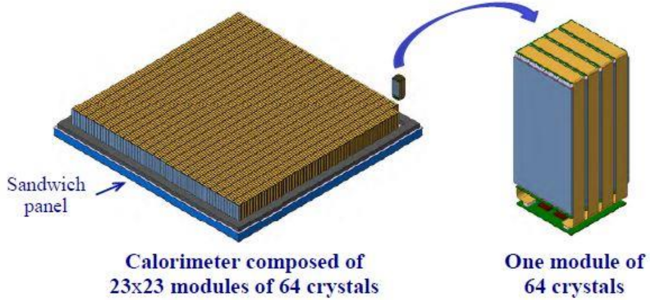


eASTROGAM Calorimeter Polarization Summary

So far what have we learned?

- CsI crystals have the best modulation factor for normal incidence;
- Smaller crystals improve the modulation factor (6 cm);
- Other crystals should be explored;





Summary & Conclusions

- Using Geant4/MEGALib we have simulated the mass model for eASTROGAM telescope
- The main objective was to understand how the different geometry parameters are related

  - **Si Tracker**
    - Thickness
    - Number of Layers
    - Distance between Layers
    - Active volume
    - Total volume
  - **Calorimeter**
    - Material (CsI, CZT, CdTE)
    - Crystal size (6, 8 and 10 cm)

→ Study the Polarization Response

Next steps...

- Change other parameters of the calorimeter geometry
  - Crystals Size Z (with more detail)
  - Crystals Size XY
  - GAP around Crystals (Pitch)
  - Closer to realistic dimensions of the CdTe crystals.
- Perform the polarimetric study in the pair production regime
- Although not mentioned, we intend to explore the AC System changing slightly its configuration.

Thank you!

Compton Polarimetry

A pixel/voxel detector is a good candidate to perform measurements on all the standard observable parameters (spectroscopy, timing, imaging);

Efficient use of the detector: each unit acts both as a scattering and as detection elements.