

Characterising the response to high energy photons of the R3B/FAIR electromagnetic calorimeter CALIFA

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5th IDPASC and LIP
PhD student workshop

U LISBOA | UNIVERSIDADE
DE LISBOA

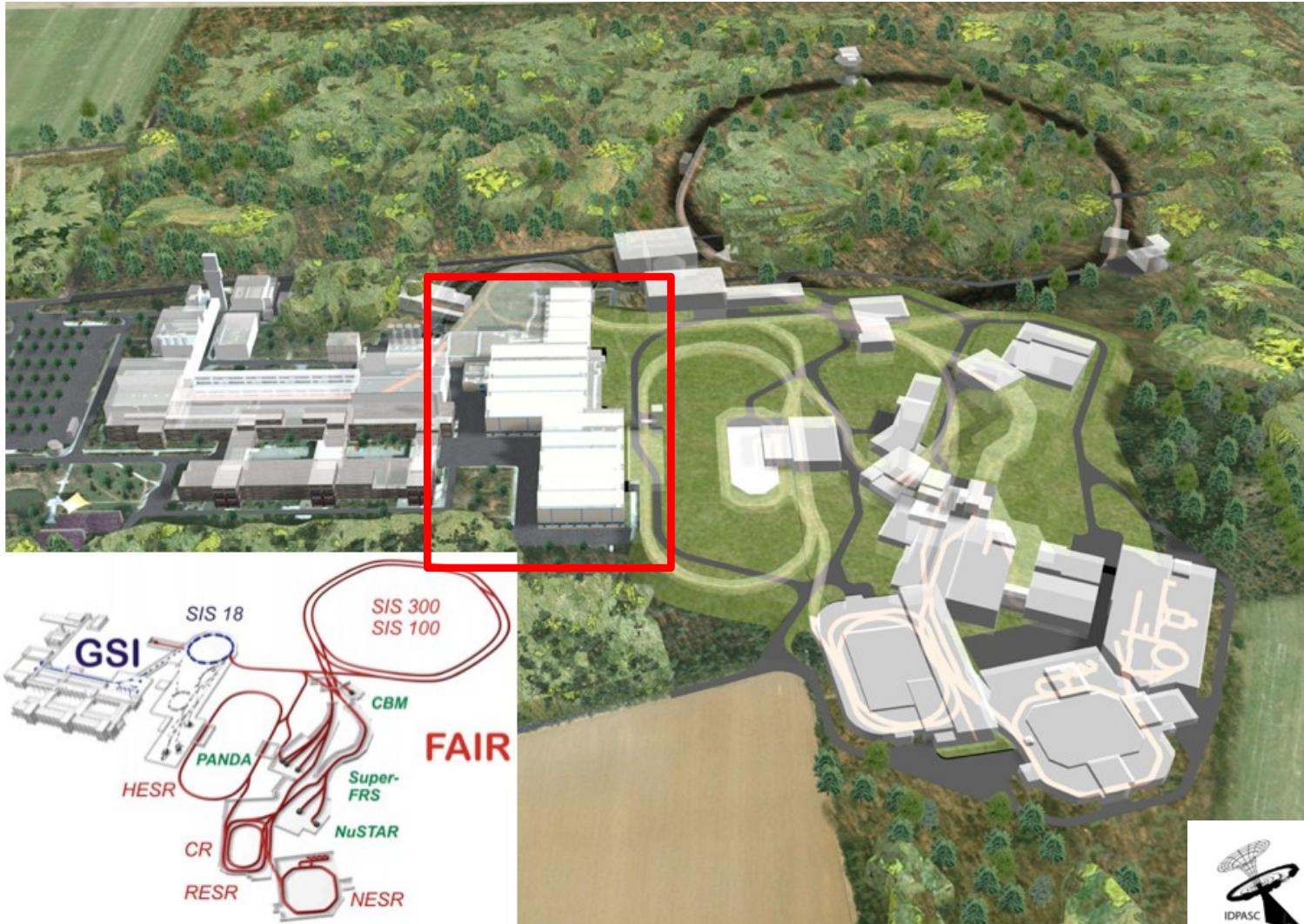


Aim

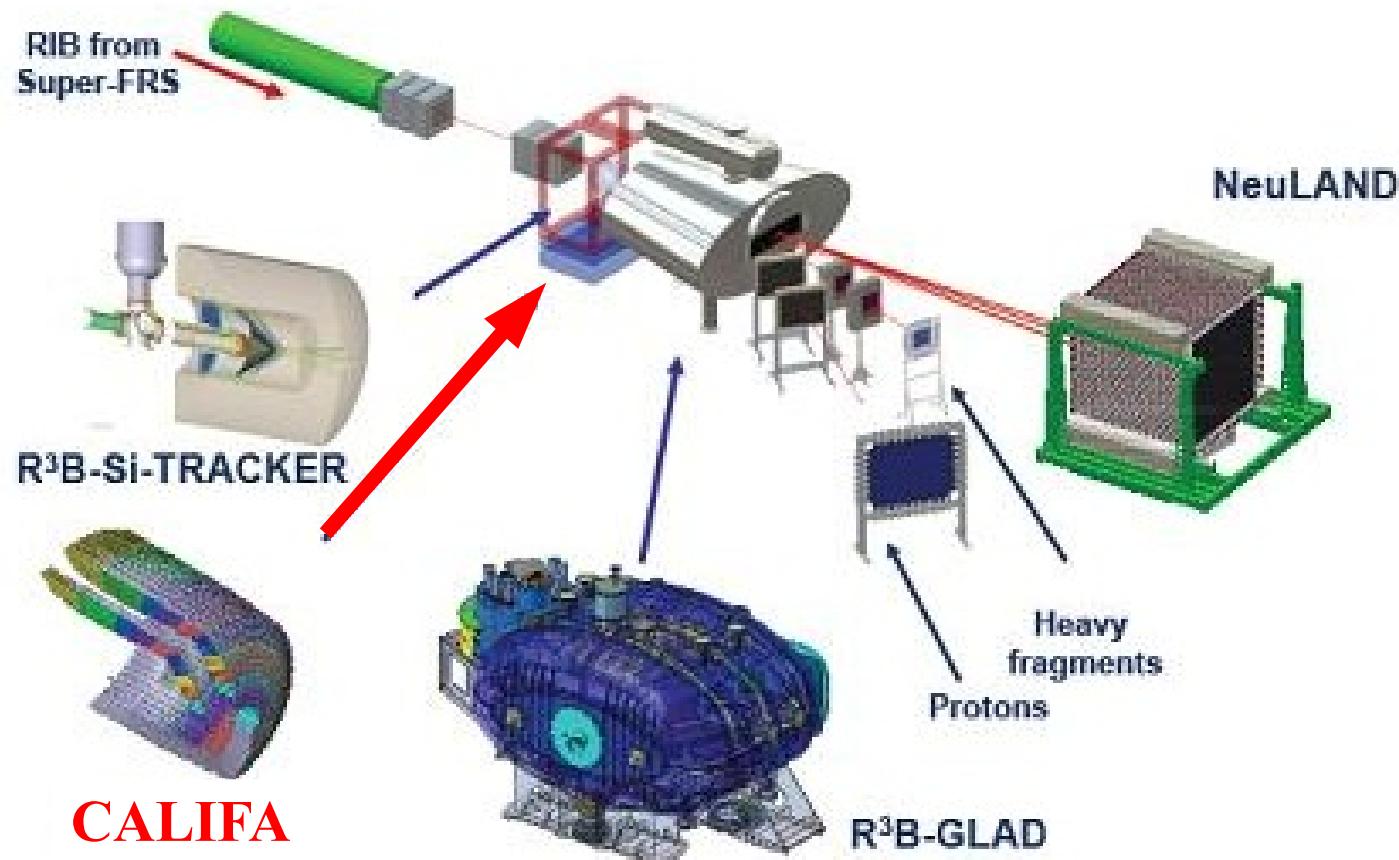
- ★ **Motivation:** Contribute to the characterization of CsI(Tl) crystals using high energy γ -rays
- ★ **Measurement of direct decay to ground or first excited state** from resonances of light nuclei produced in a high Q-value radiation reactions



Facility for Antiproton and Ion Research



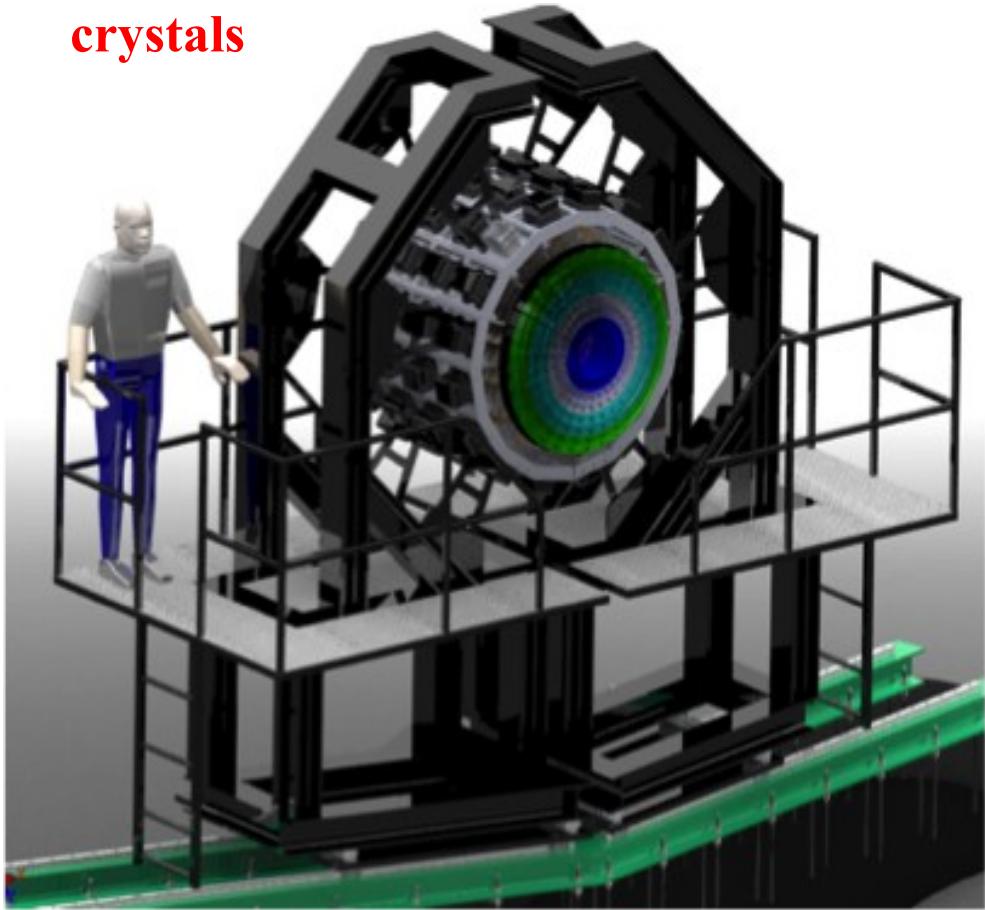
Reactions with Relativistic Radioactive Beams





CALorimeter for the In-Flight detection of gamma rays and light charged pArticles

~ 1952 CsI(Tl)
crystals



Extensive energy range
photons: 0 – 20 MeV
protons: 0 – 300 MeV

High energy resolution
1 – 10 %

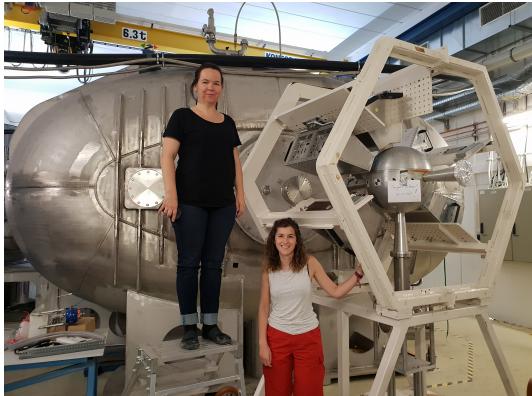
Working conditions
γ-ray spectrometer
γ-ray calorimeter
Hybrid detector



Nowadays...



Phase-Zero: 2018



Benchmarking:

Protons
Beam
Photons



<https://fair-center.eu>

B. Pietras, *et al.* First testing of the CALIFA Barrel demonstrator. NIMB (2016) 814:56-64.

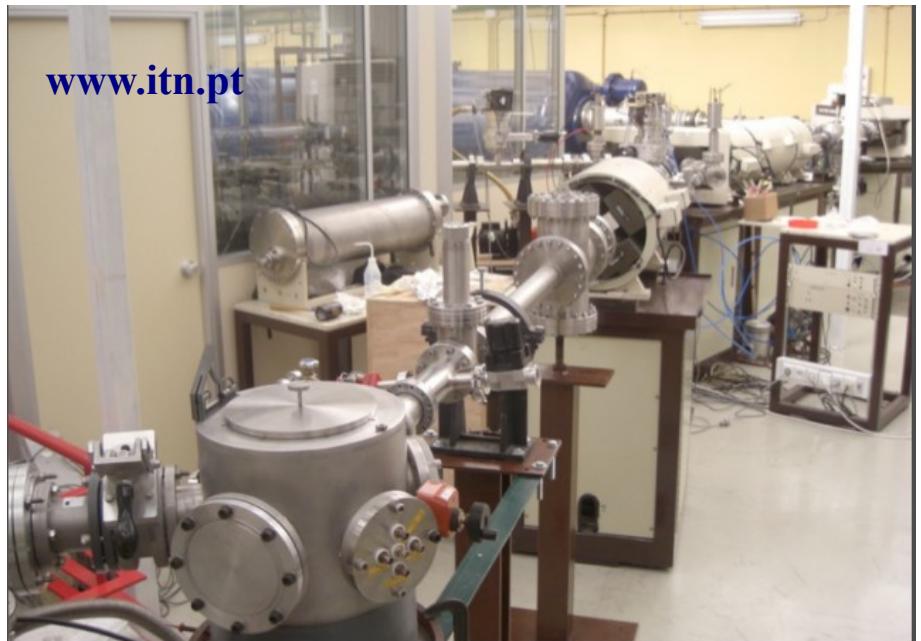


Particle Induced Gamma Emission (PIGE): as a tool



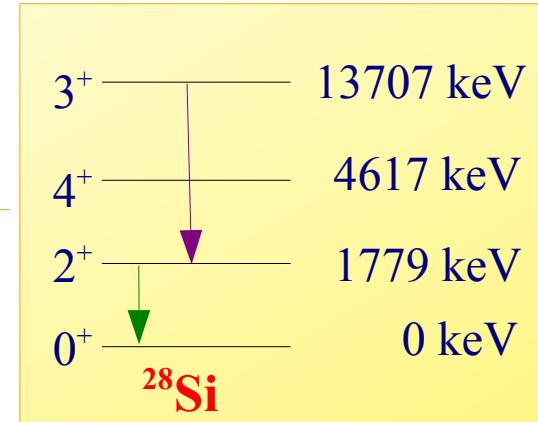
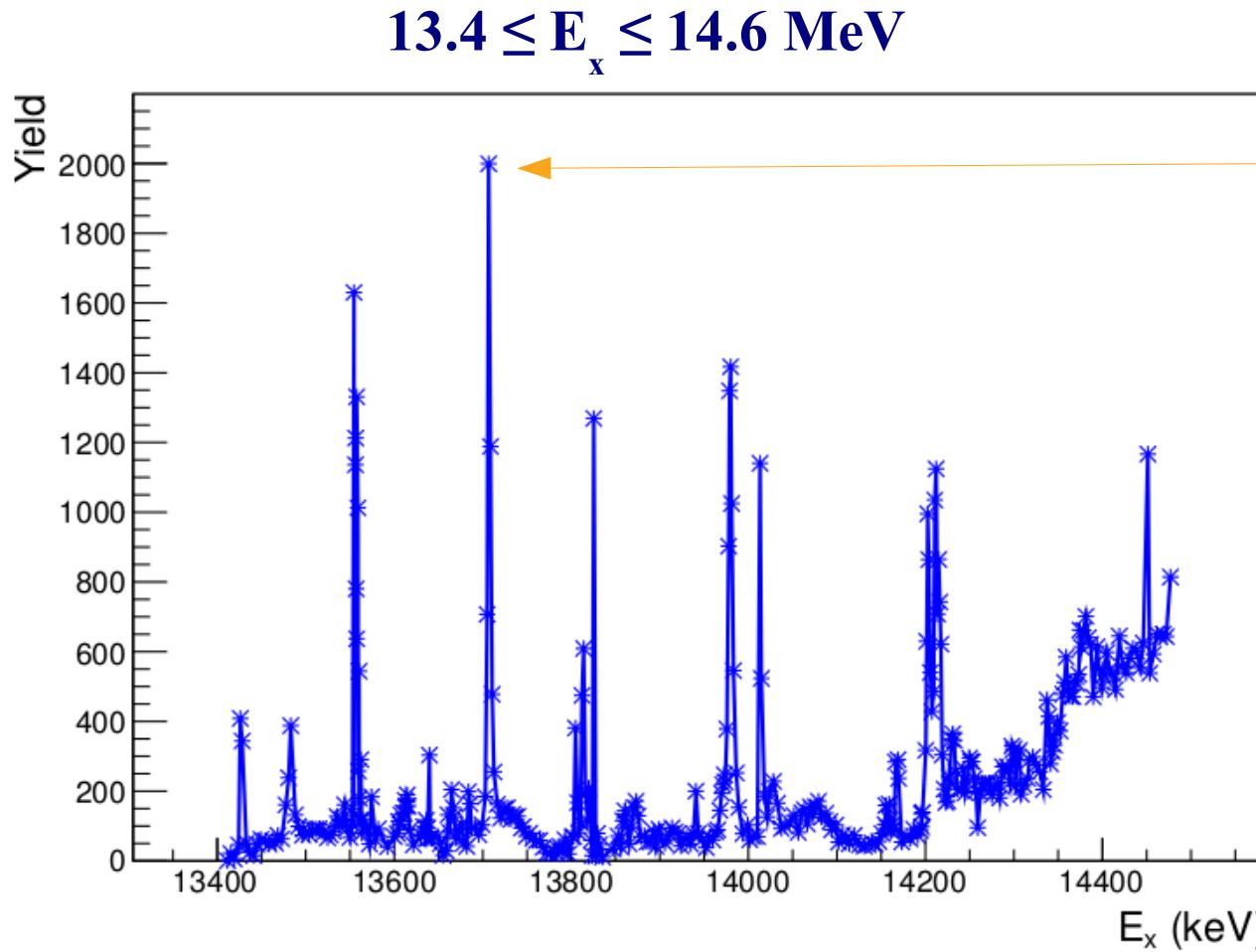
to produce $\gamma > 10 \text{ MeV}$
to challenge
**CALIFA barrel
segments**

Q-value: 11.59 MeV



Nuclear reaction line @ tandem
accelerator at LATR-CTN

Resonance picture of ^{28}Si determined by the yield of first excited state



Thin target Exp.

Integral of photopeak:

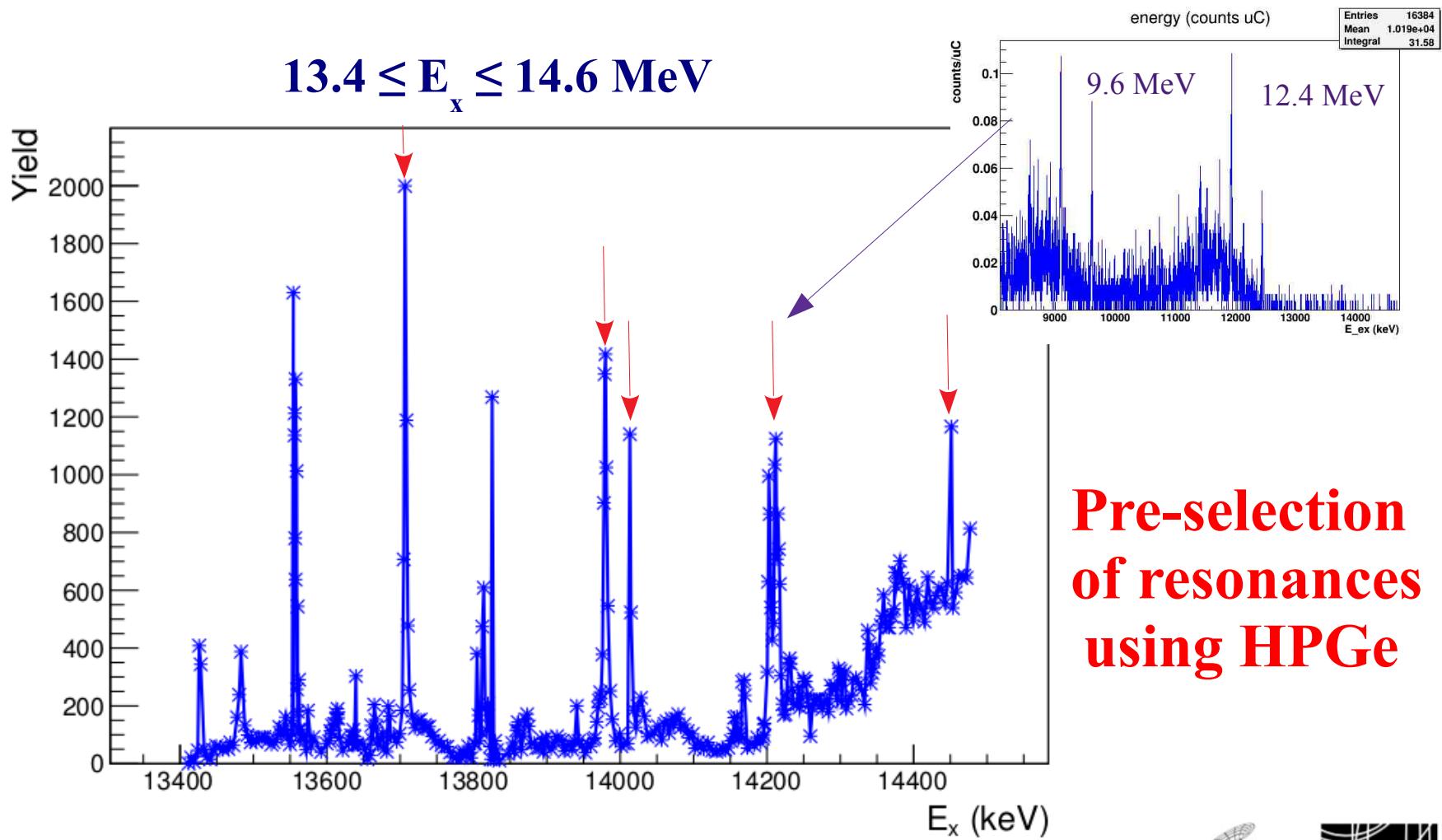
Yield

Files analysed > 300

E_p steps: 2 keV

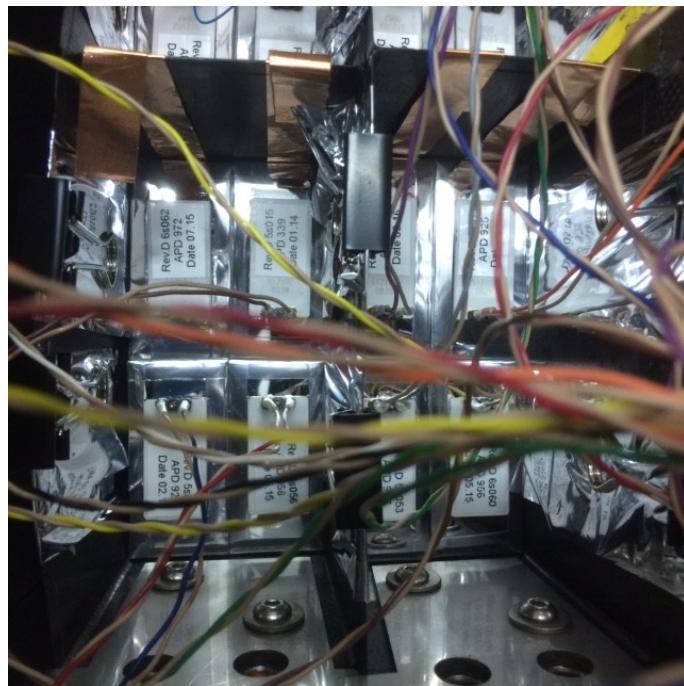
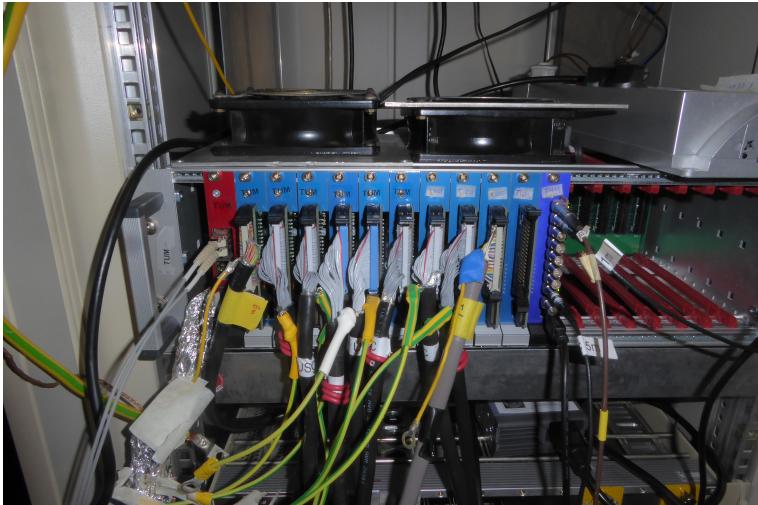


Resonance picture of ^{28}Si determined by the yield of first excited state

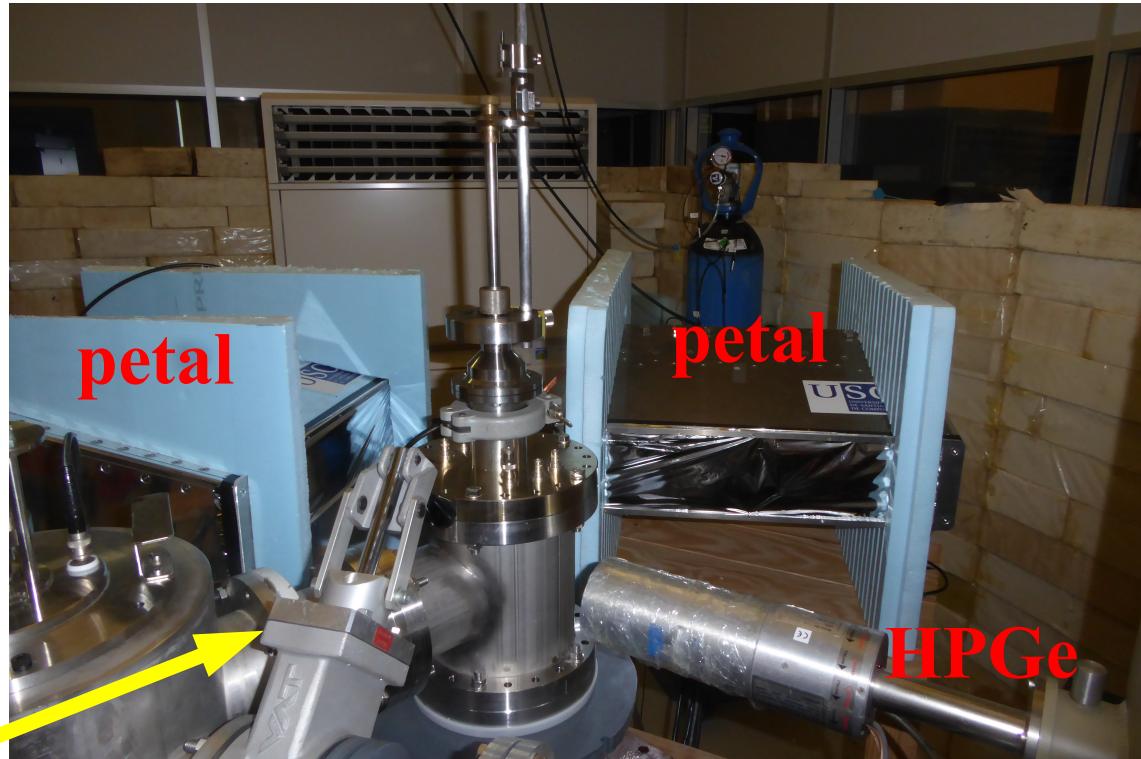


Pre-selection
of resonances
using HPGe

CALIFA petal



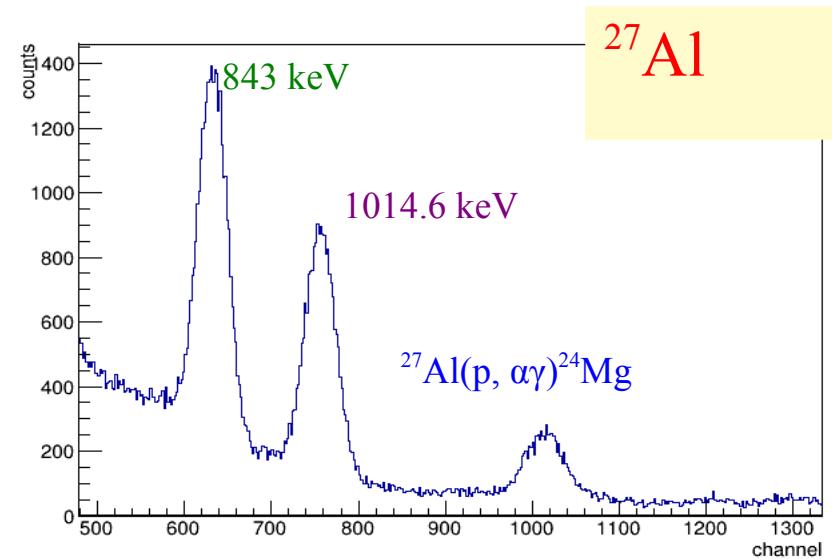
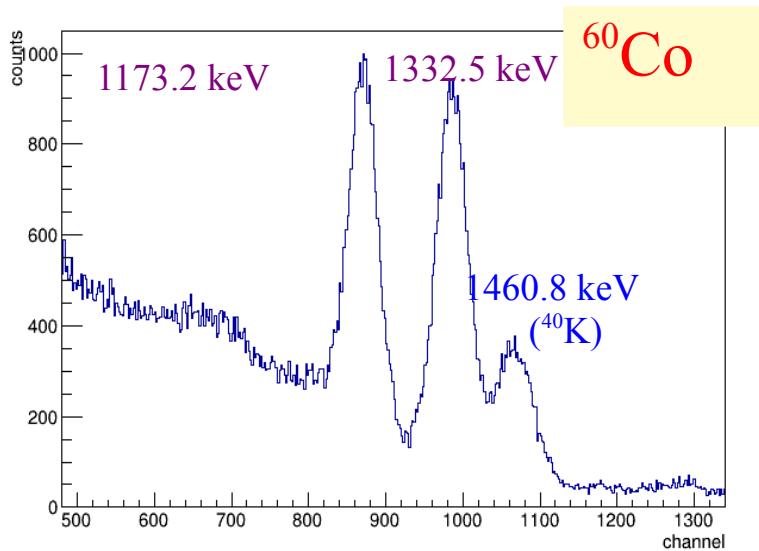
Experimental setup @ LATR-CTN



Beam line

Calibration Procedure

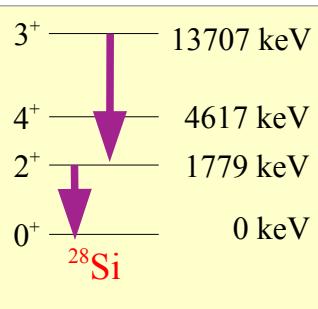
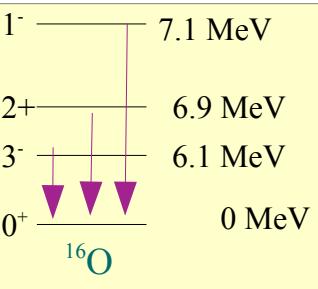
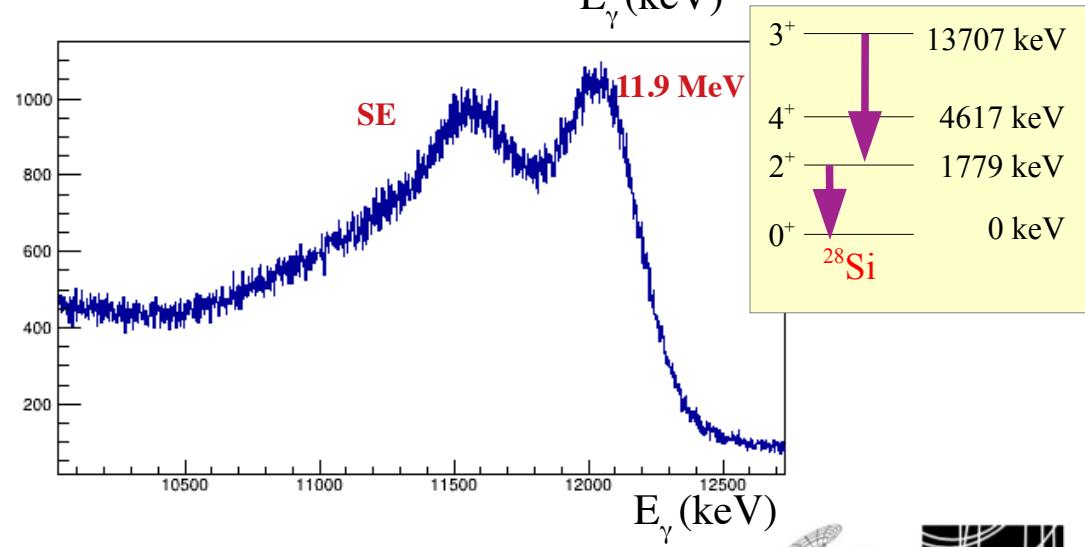
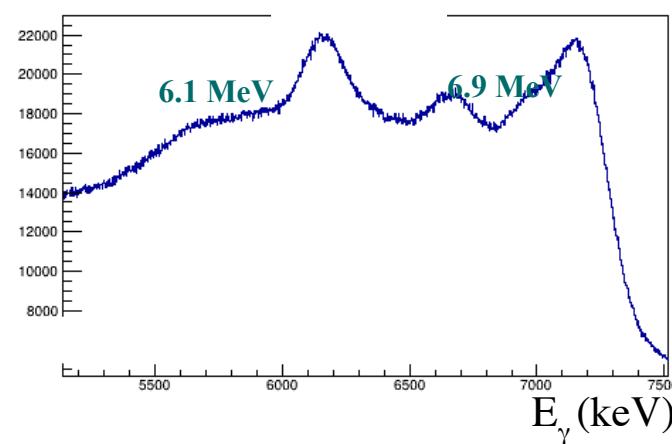
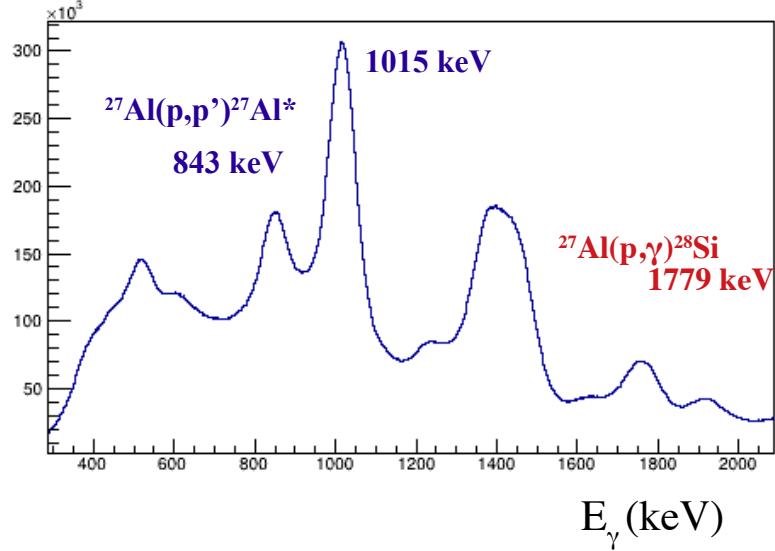
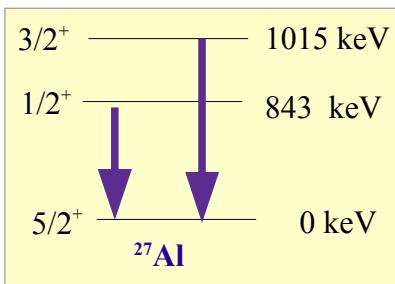
- ★ Data efficiently unpacked using R3BRoot unpacker



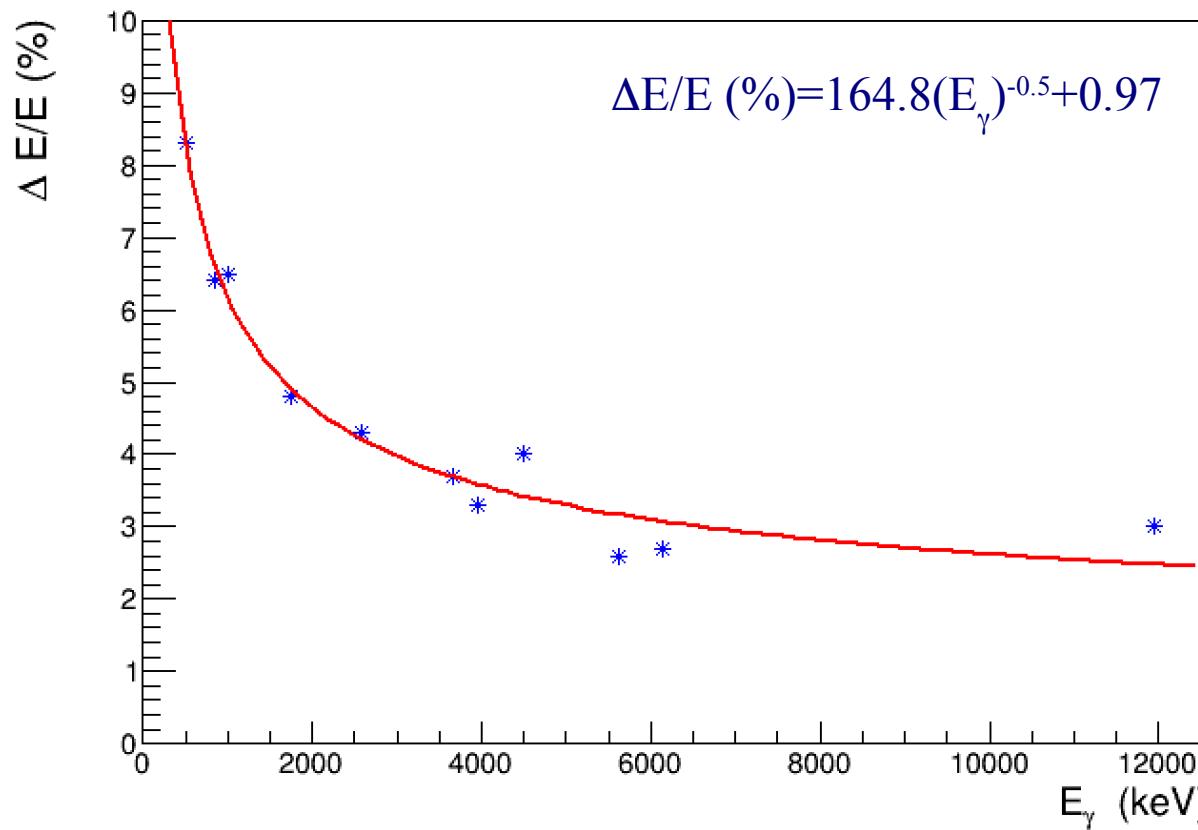
- ★ A flavour of CALIFA barrel response:
- ★ Source: ^{60}Co
- ★ Continuous monitoring:
 $^{27}\text{Al}(\text{p}, \text{p}'\gamma)^{27}\text{Al}$

Intrinsic petal response:

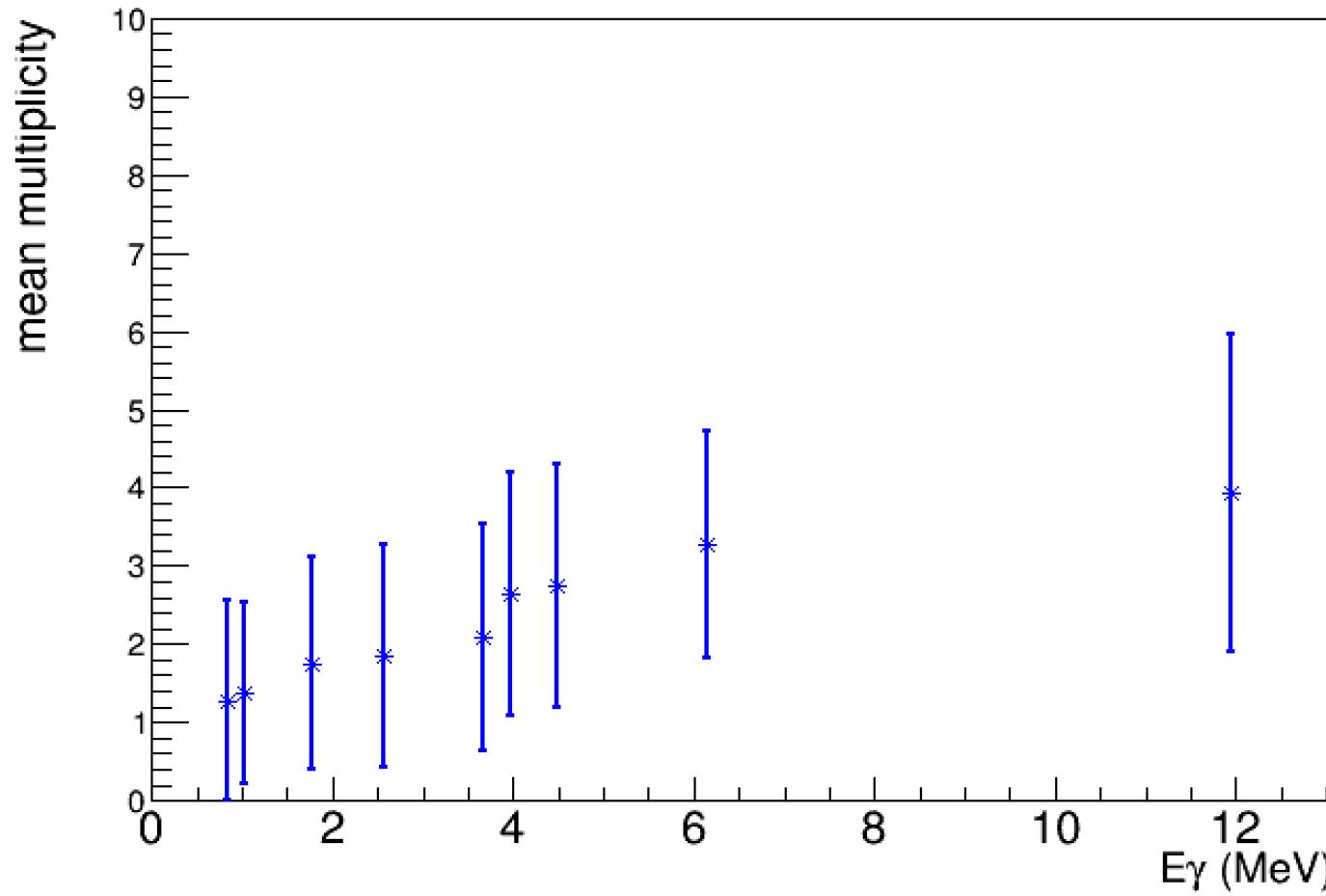
$E_p = 2210$ keV



Petal Integral response: Energy Resolution

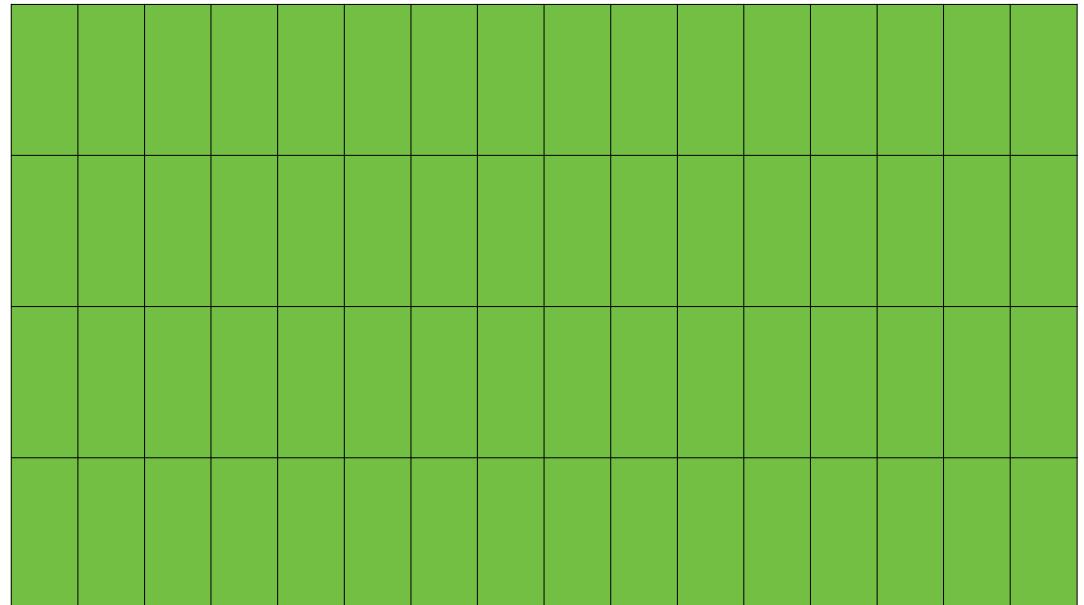


Petal Integral response: Mean crystal multiplicity

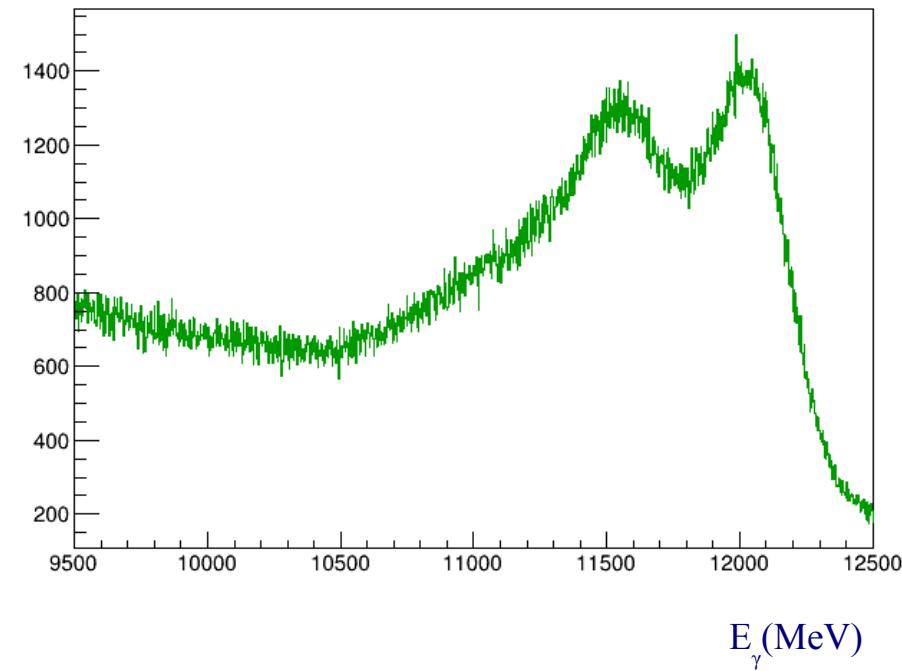
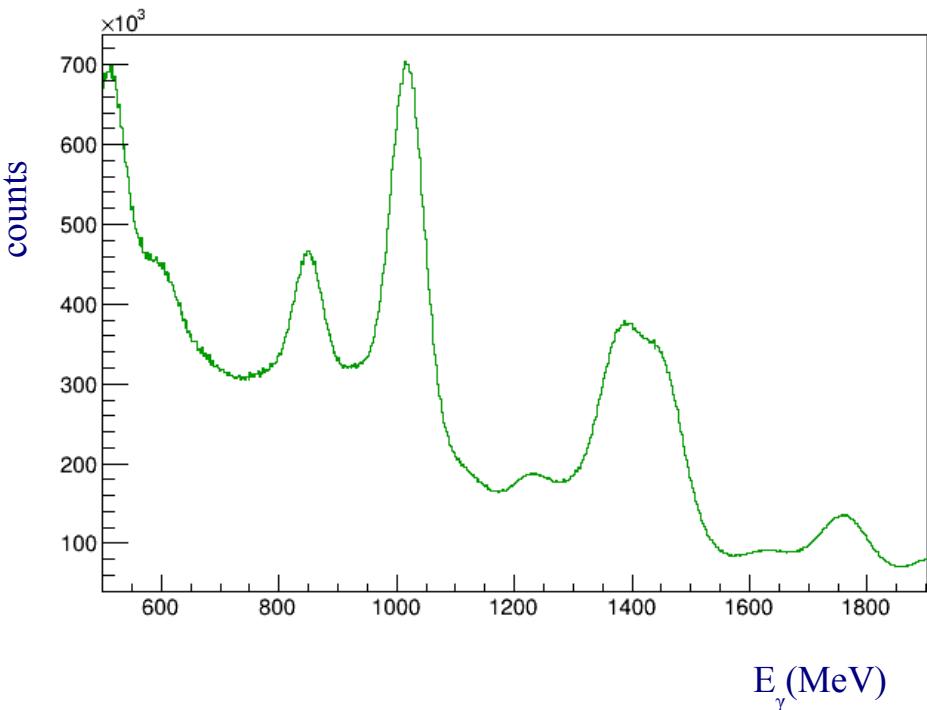
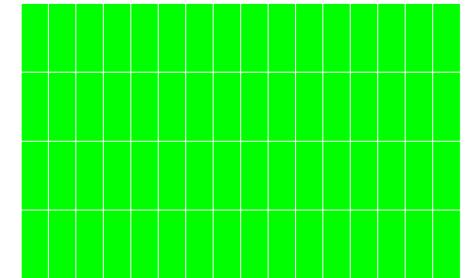


Reconstruction approaches (1 petal)

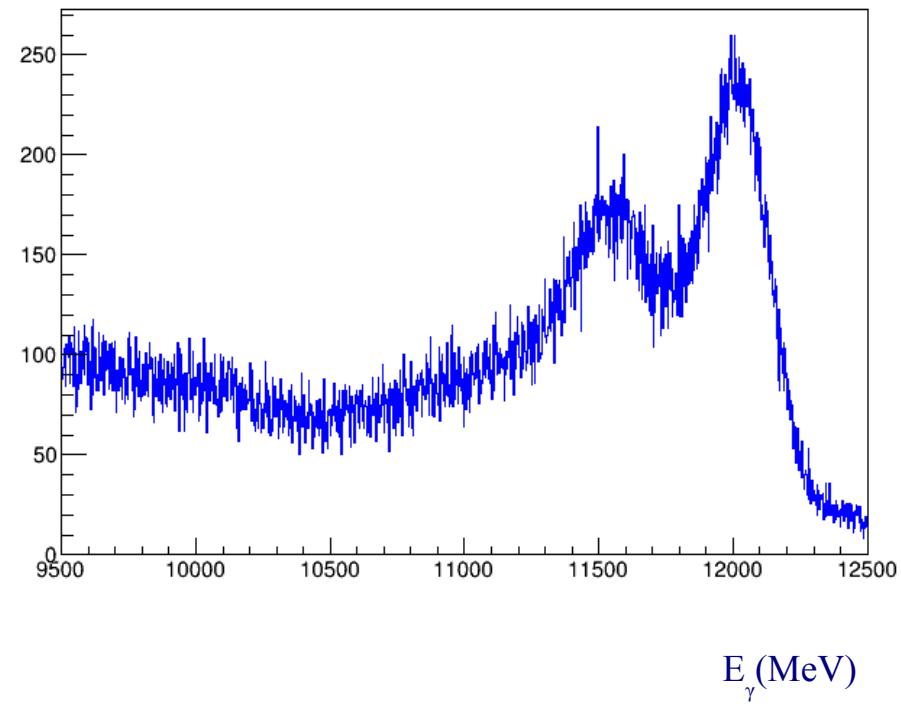
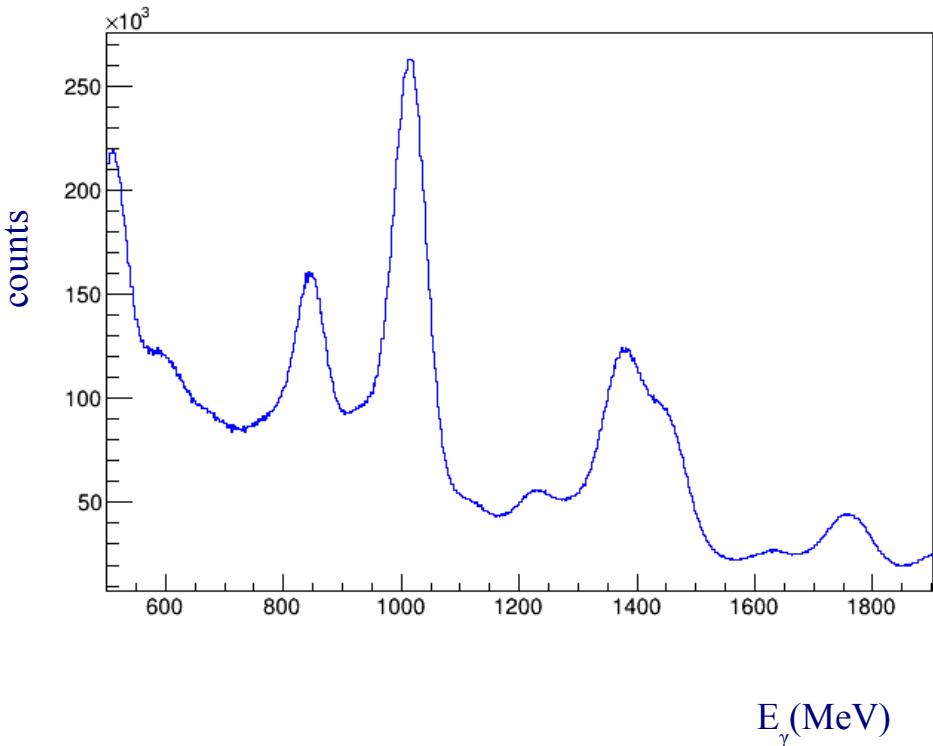
- ★ Calorimeter
- ★ Active shield
- ★ E_{\max} dependent
- ★ Distance dependent



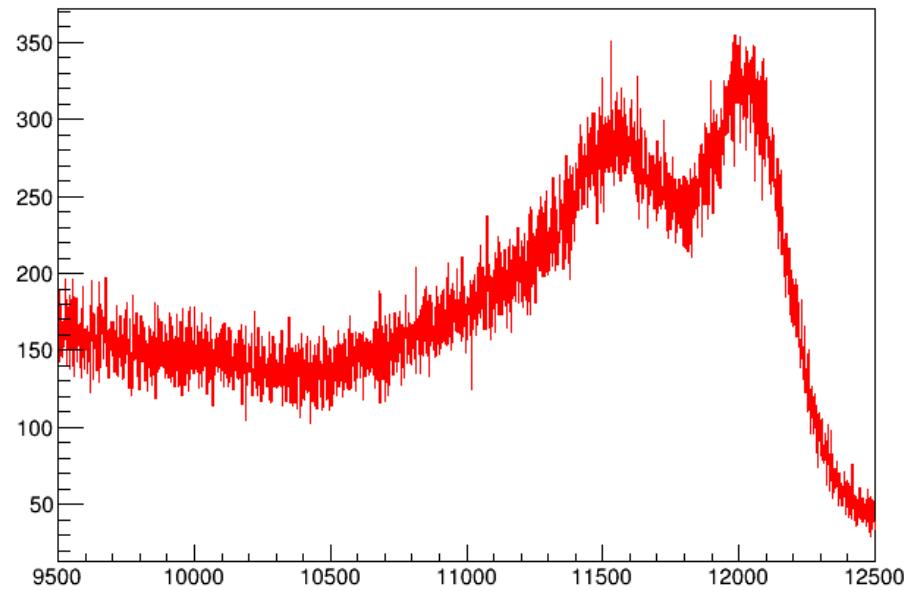
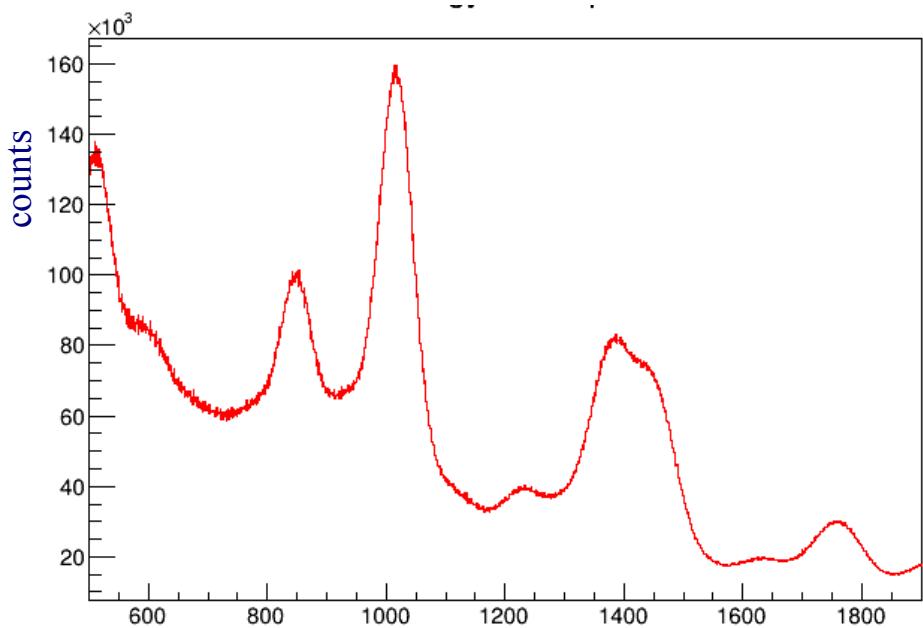
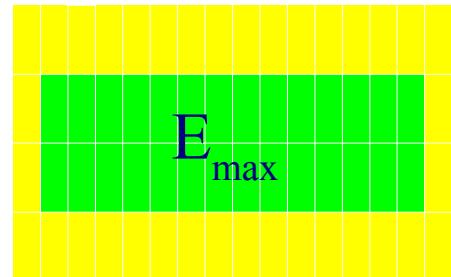
Reconstruction approach: calorimeter



Reconstruction approach: Active Compton shield



Reconstruction approach: Highest energy core



Reconstruction approach: Distance constrained

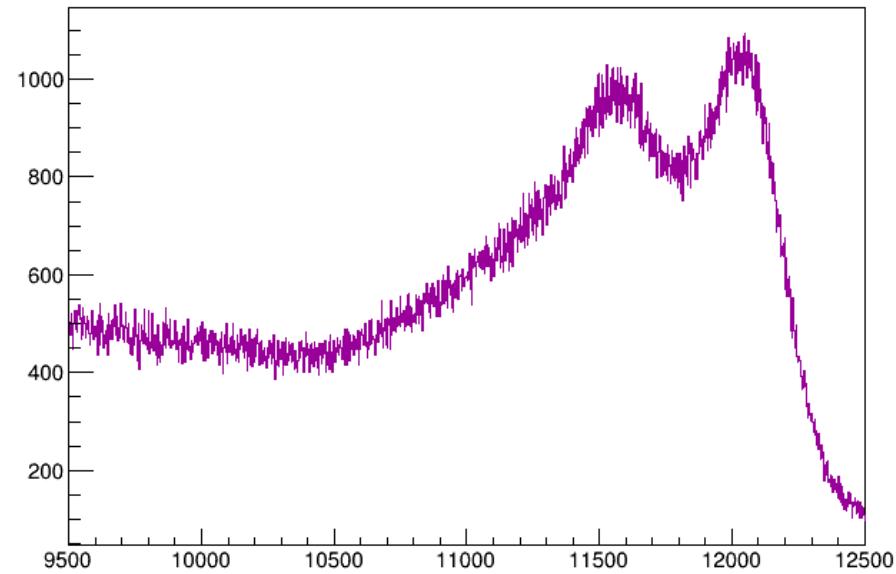
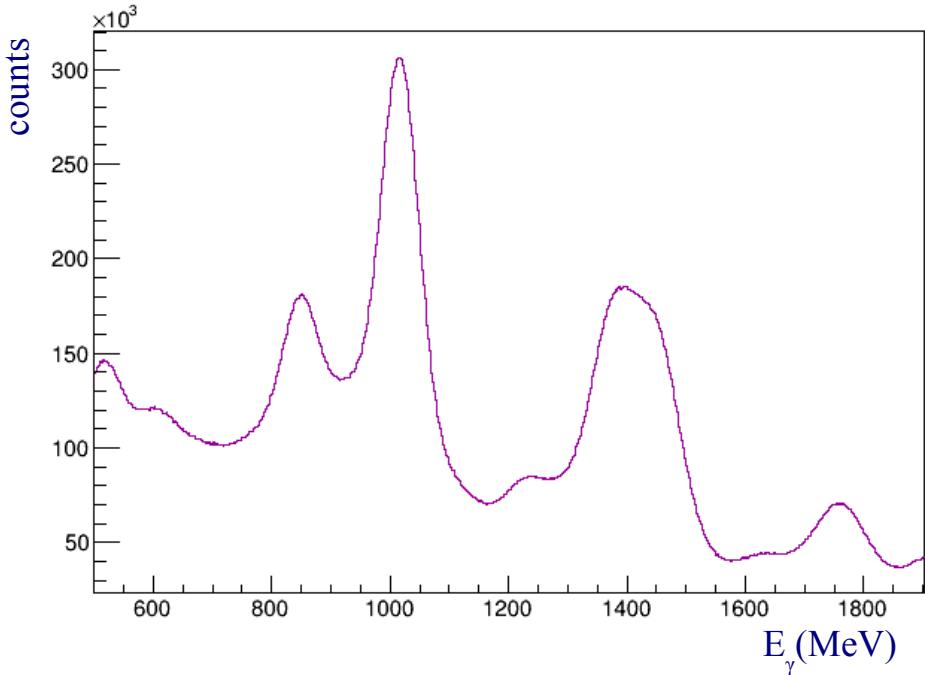
Distance
condition
applied!

$$d_i = \sqrt{(x_i - x_{max})^2 + (y_i - y_{max})^2}$$

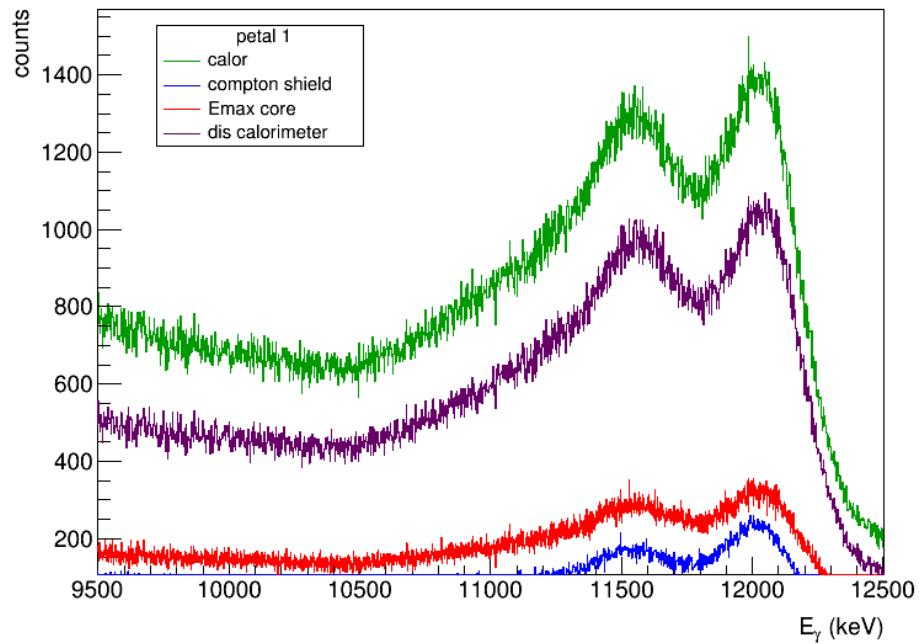
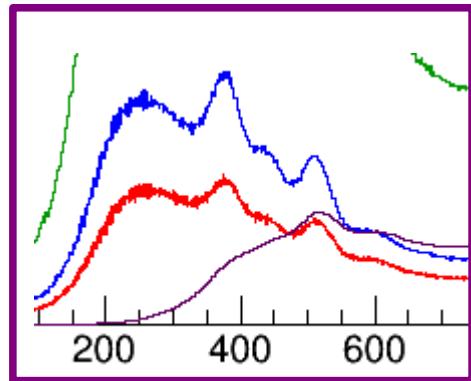
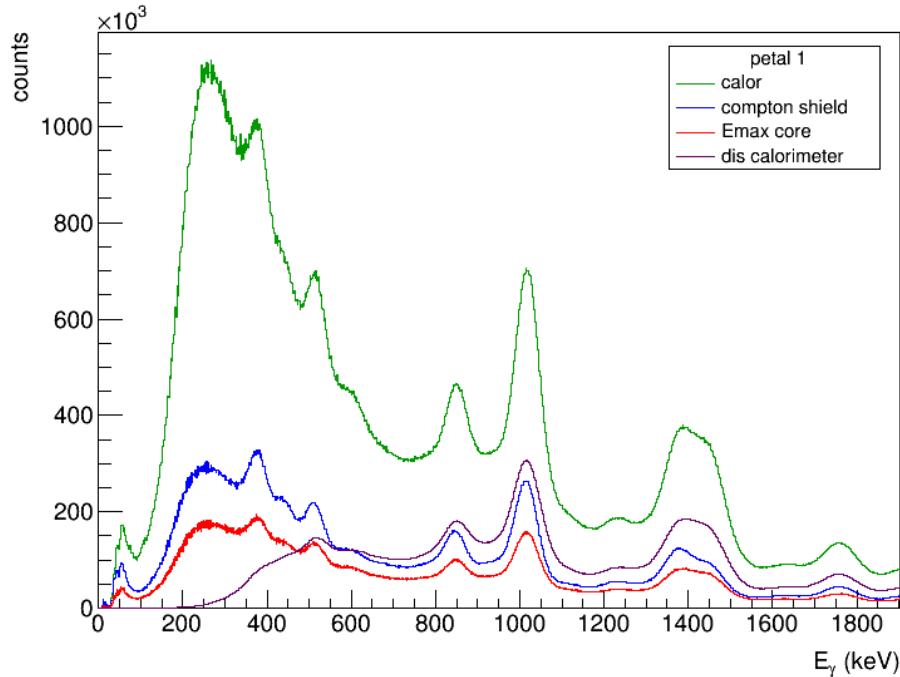
d_i in crystal units

$$\sum_i d_i < d_{max}$$

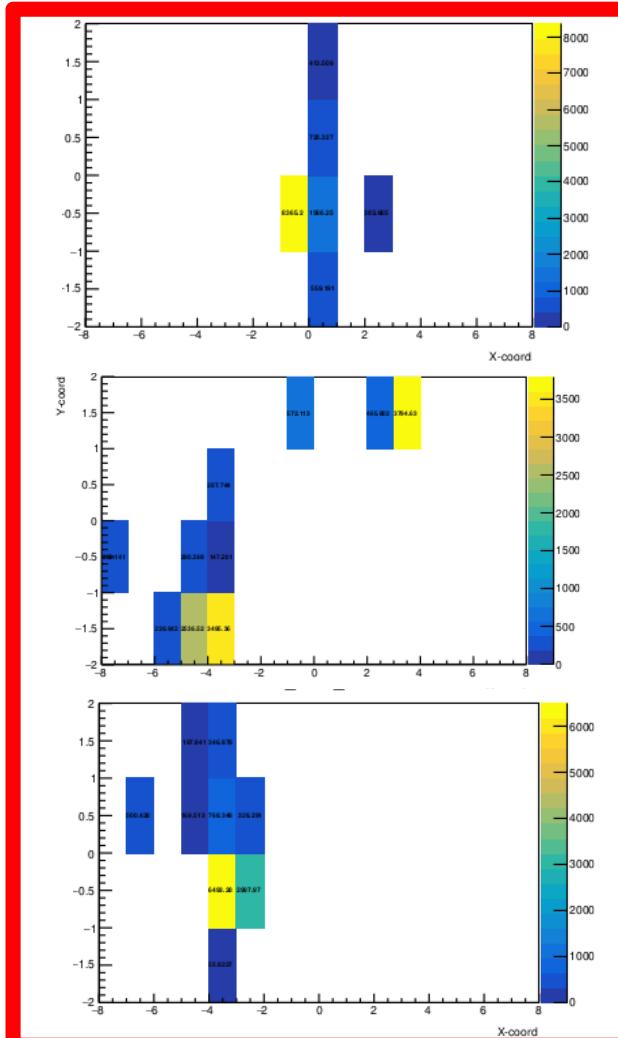
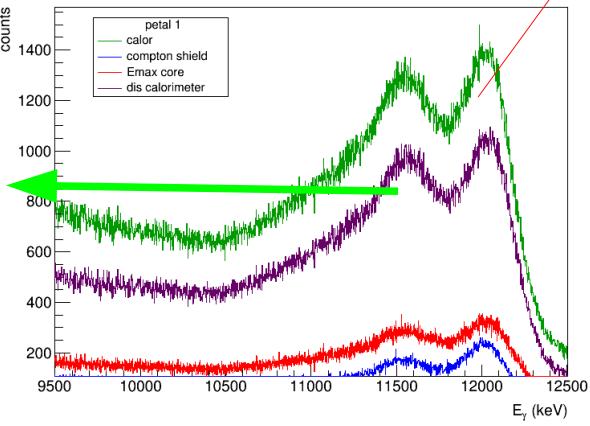
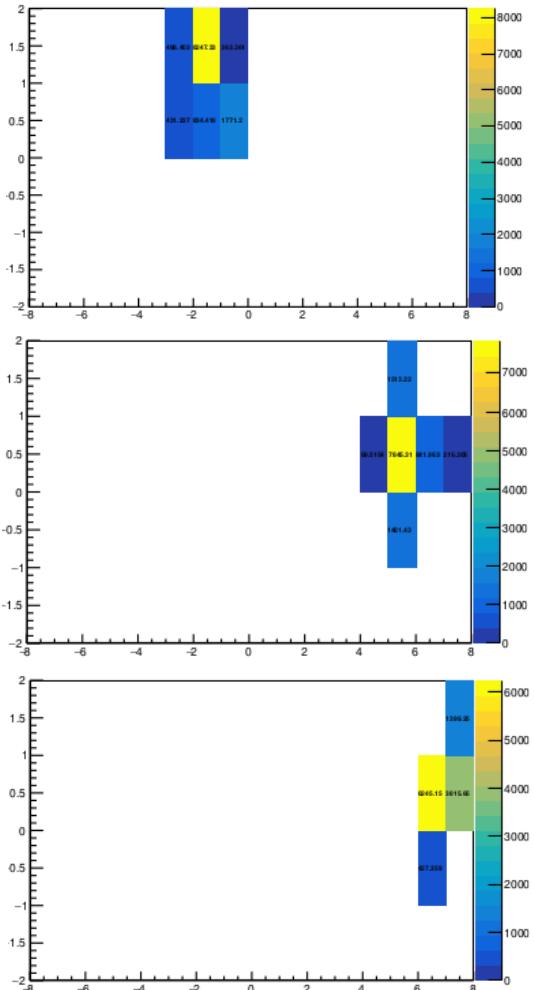
$$d_{max} = \text{mult} \cdot \sqrt{2}$$



Comparison of Reconstruction approaches:



Possible source for ANN approaches:



Collaborators



D. Galaviz
L. Peralta
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E. Galiana
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E. Galiana

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P. Klenze



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H. Silva



E. Alves
R. Coelho da Silva
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J. Rocha



A. Sánchez-Benítez



