Nuclear level density and gamma-ray strength function of ^{240}Pu and ^{243}Pu (Part I)

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Lawrence Livermore National Laboratory

5th Workshop on Nuclear Level Density and Gamma Strength

Oslo, May 18–22, 2015

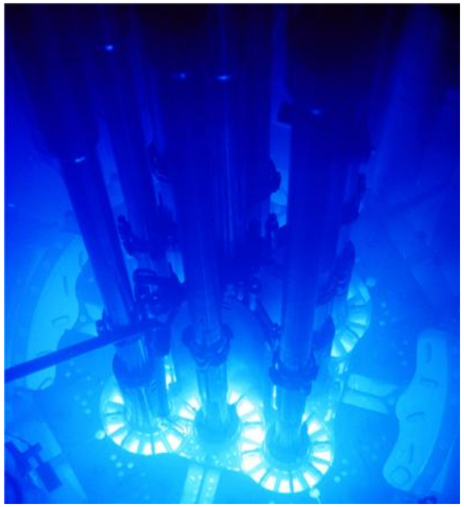
This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract DE-AC52-07NA27344. Lawrence Livermore National Security, LLC

Motivation

- Fundamental nuclear structure
- Enables Cross Sections calculations via Hauser-Feshbach formalism ➔ advanced nuclear reactors

  ➔ waste management

  ➔ nuclear security



Previous work with actinides

PHYSICAL I

Constant-temperature level densit

M. Guttormsen,[1,*] B. Jurado,[2] J. N. Wilson,[3] M. Aiche,[2]
T. W. Hagen,[1] A. C. Larsen,[1] M. Lebois,[3] E
G. M. Tve

PRL **109,** 162503 (2012) PHYSICAL

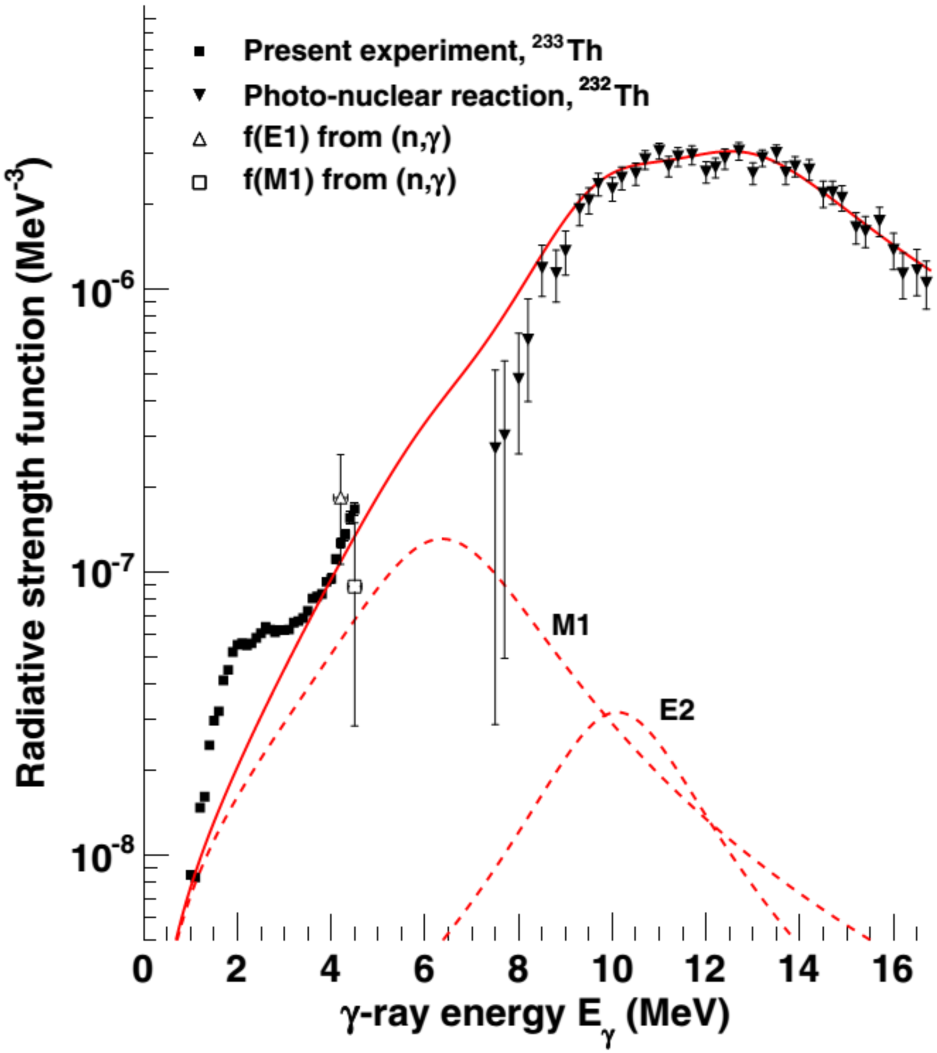
Observation of Large Scis

M. Guttormsen,[1,*] L. A. Bernstein,[2] A. Bürg
T. Renstrøm,[1] S. Siem

PHYSICAL RE

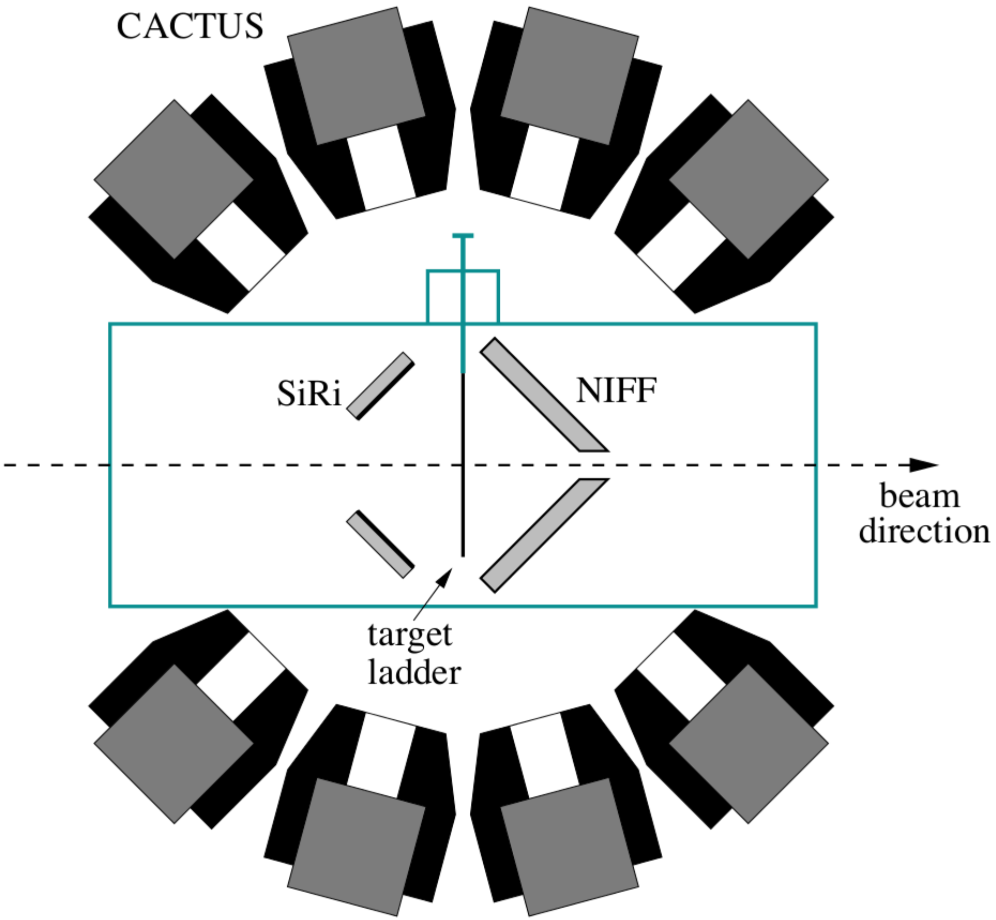
Level density and γ-ray strengt

T. G. Tornyi,[1,2,*] M. Guttormsen,[1] T. K. Eriksen,[1] A
A. C. Larsen,[1] T. Renstrøm,[1] S



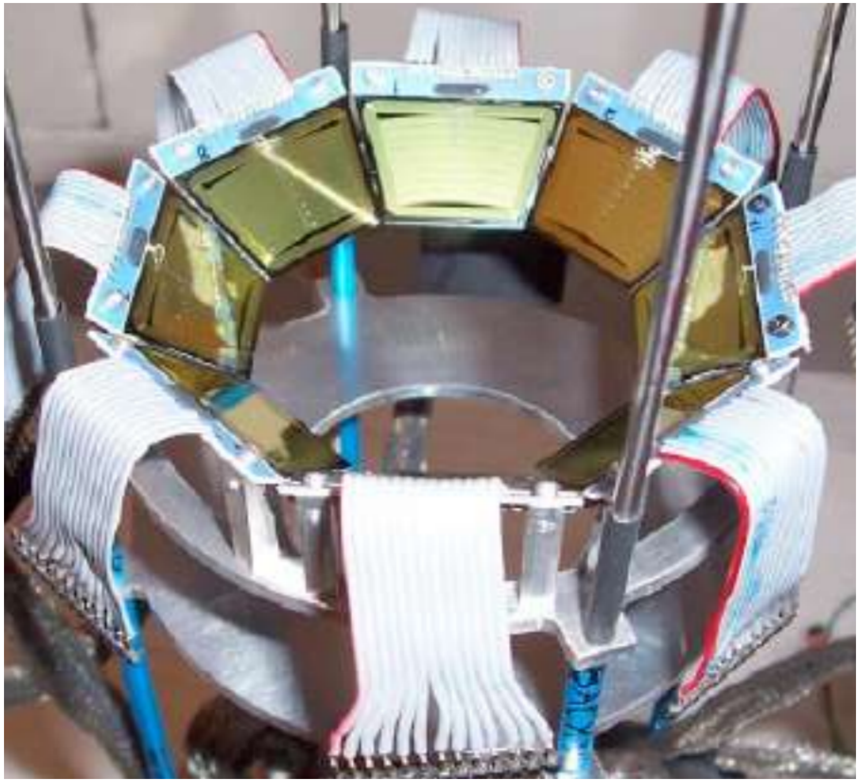
Experimental Setup

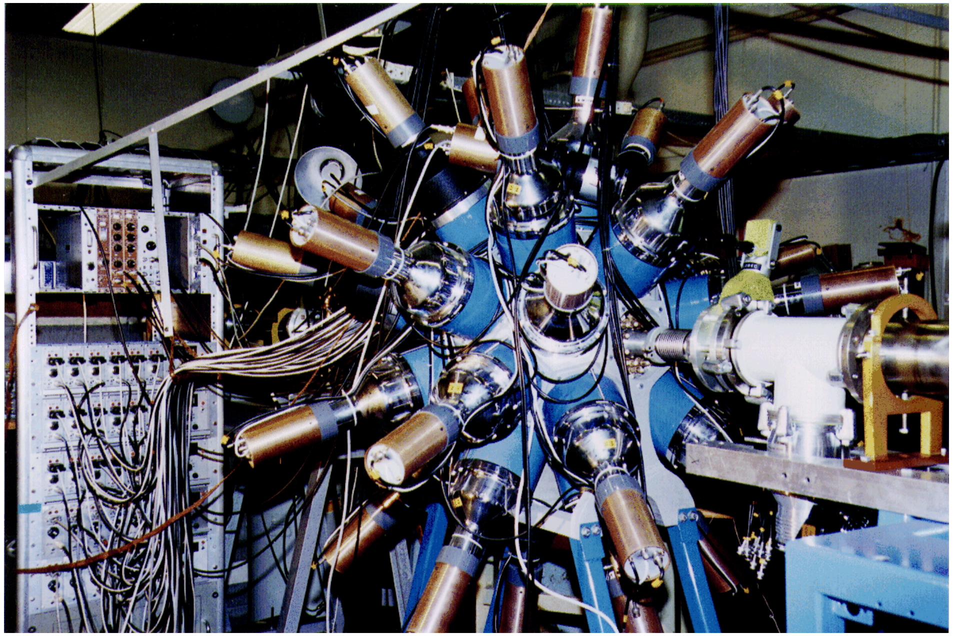
- Beam time: June 2014
- 12 MeV deuteron beam on ^{239}Pu and ^{242}Pu targets (0.400 mg/cm^2 on 1.8 mg/cm^2 Be backing)
- p, γ coincidence with SiRi
- Fission, γ coincidence with NIFF



Tornyi et al. NIM A 738 (2014)

Experimental Setup





Siri 8x8 ΔE–E particle telescope

At 126° to 140° with respect to the beam

Cactus: 28 5”x5” NaI γ detectors

Experimental Setup

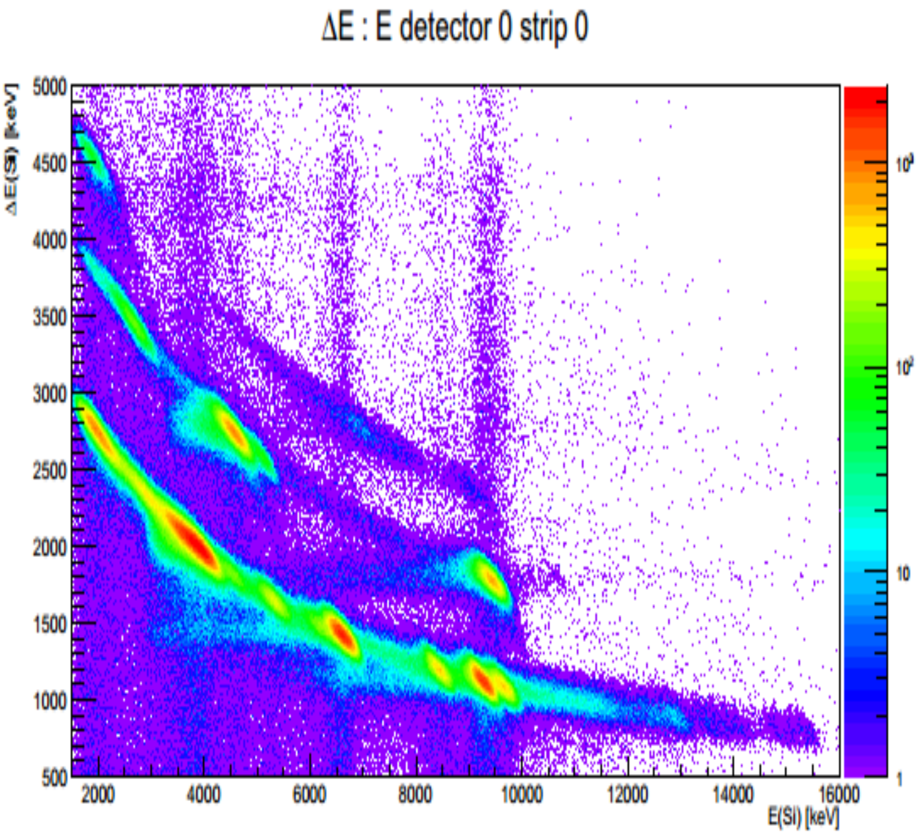
- NIFF: low pressure gas filled PPACs
  ➔ insensitive to light ions

Allows veto of fission events

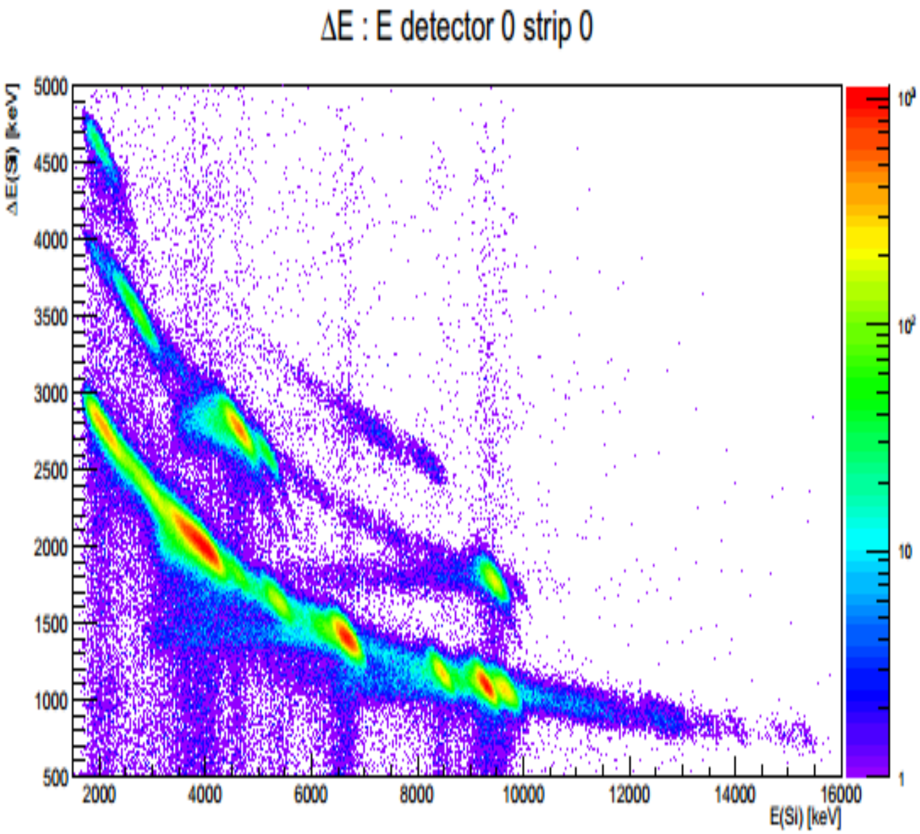
Tornyi et al. NIM A 738 (2014)

SiRi calibration

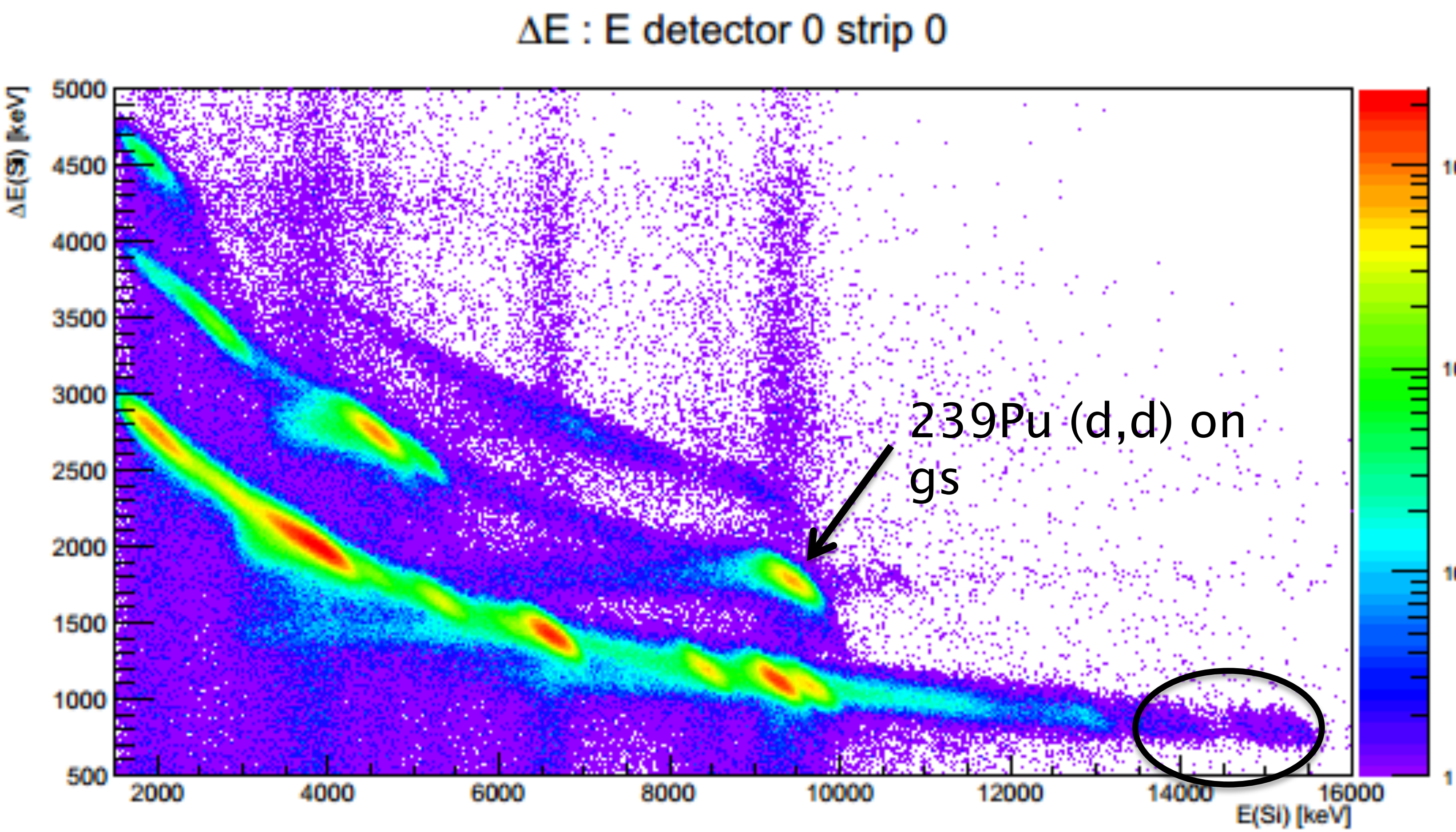
^{239}Pu target



^{242}Pu target

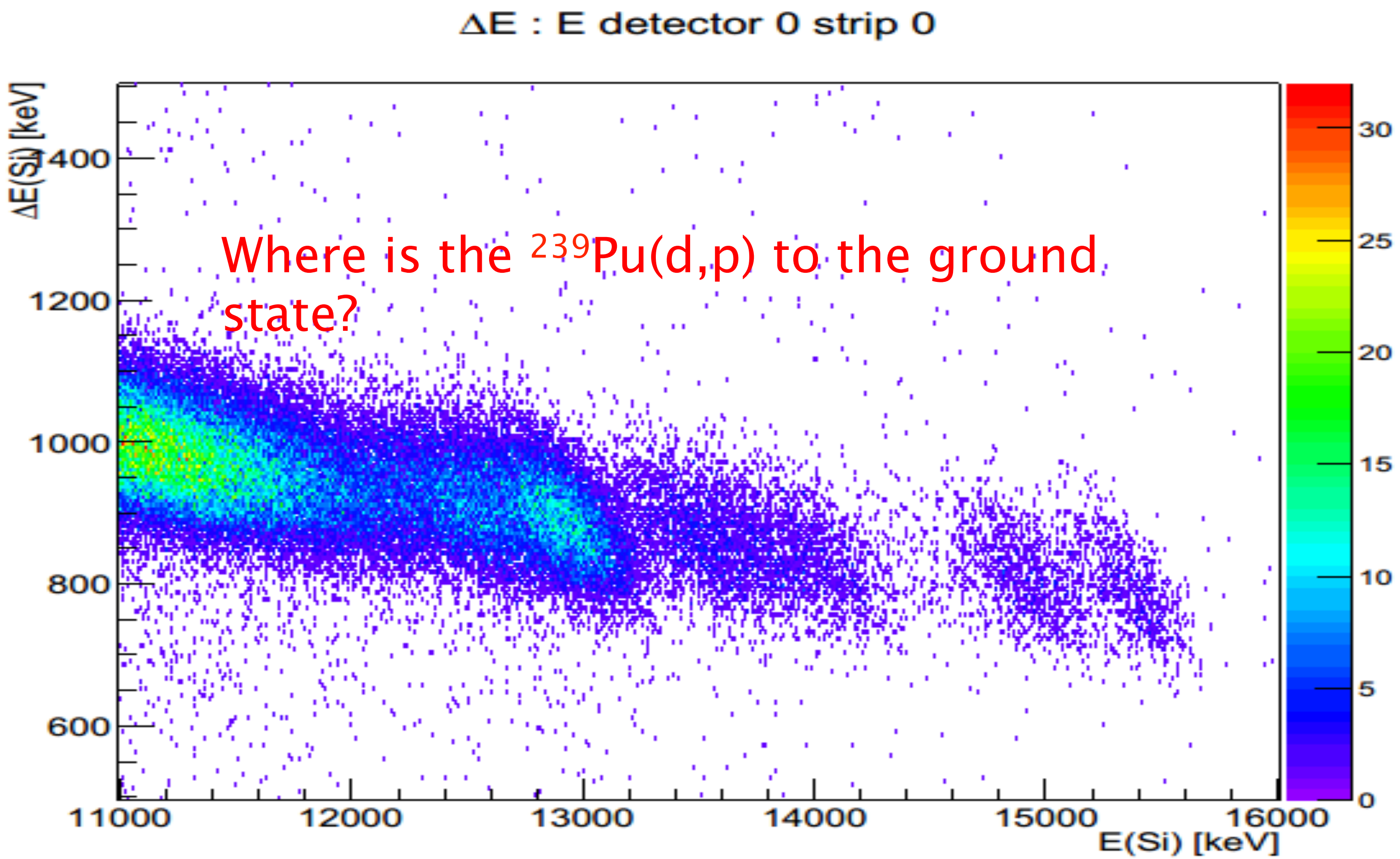


SiRi Calibration



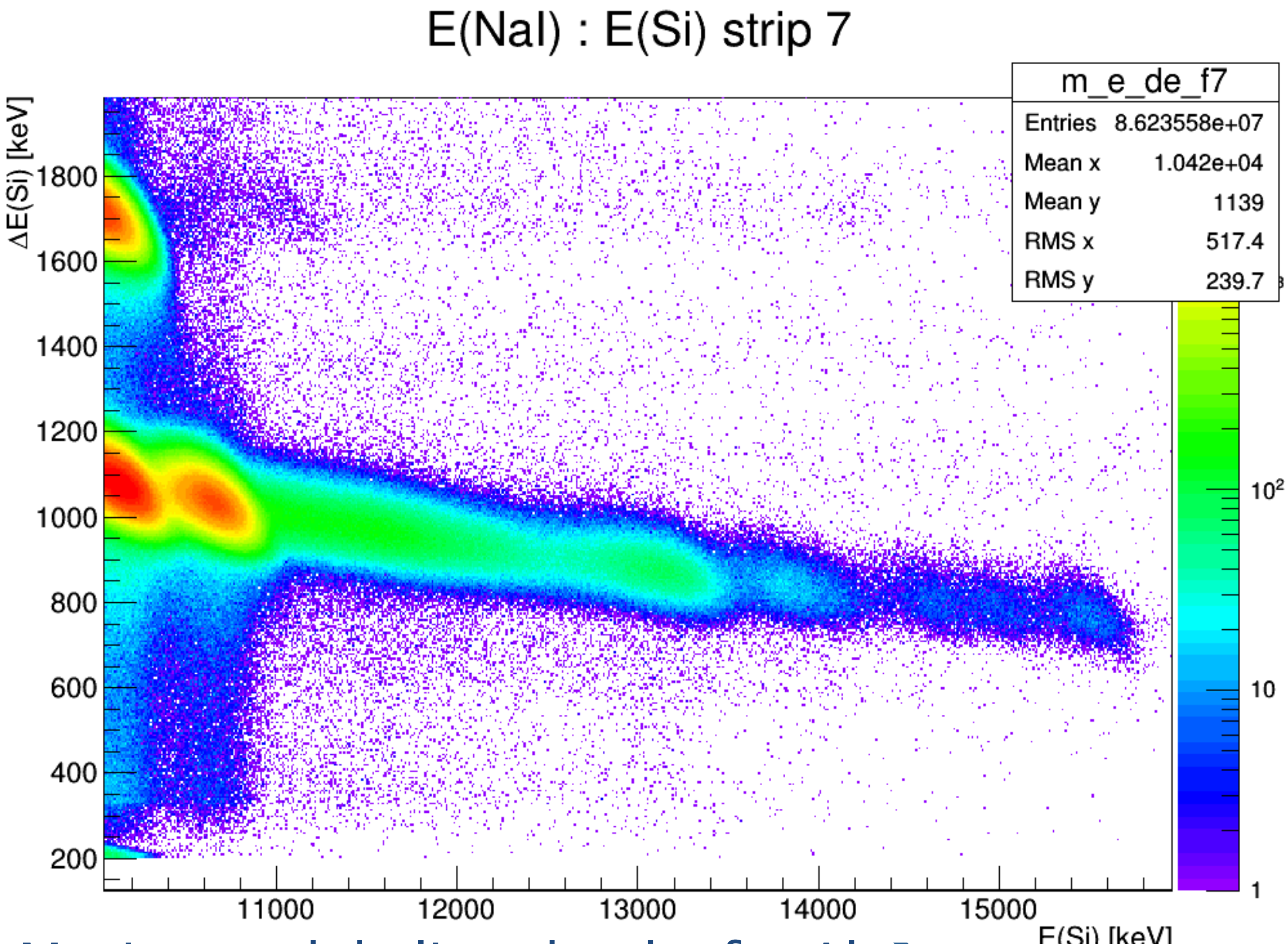
Second calibration point needed

SiRi Calibration



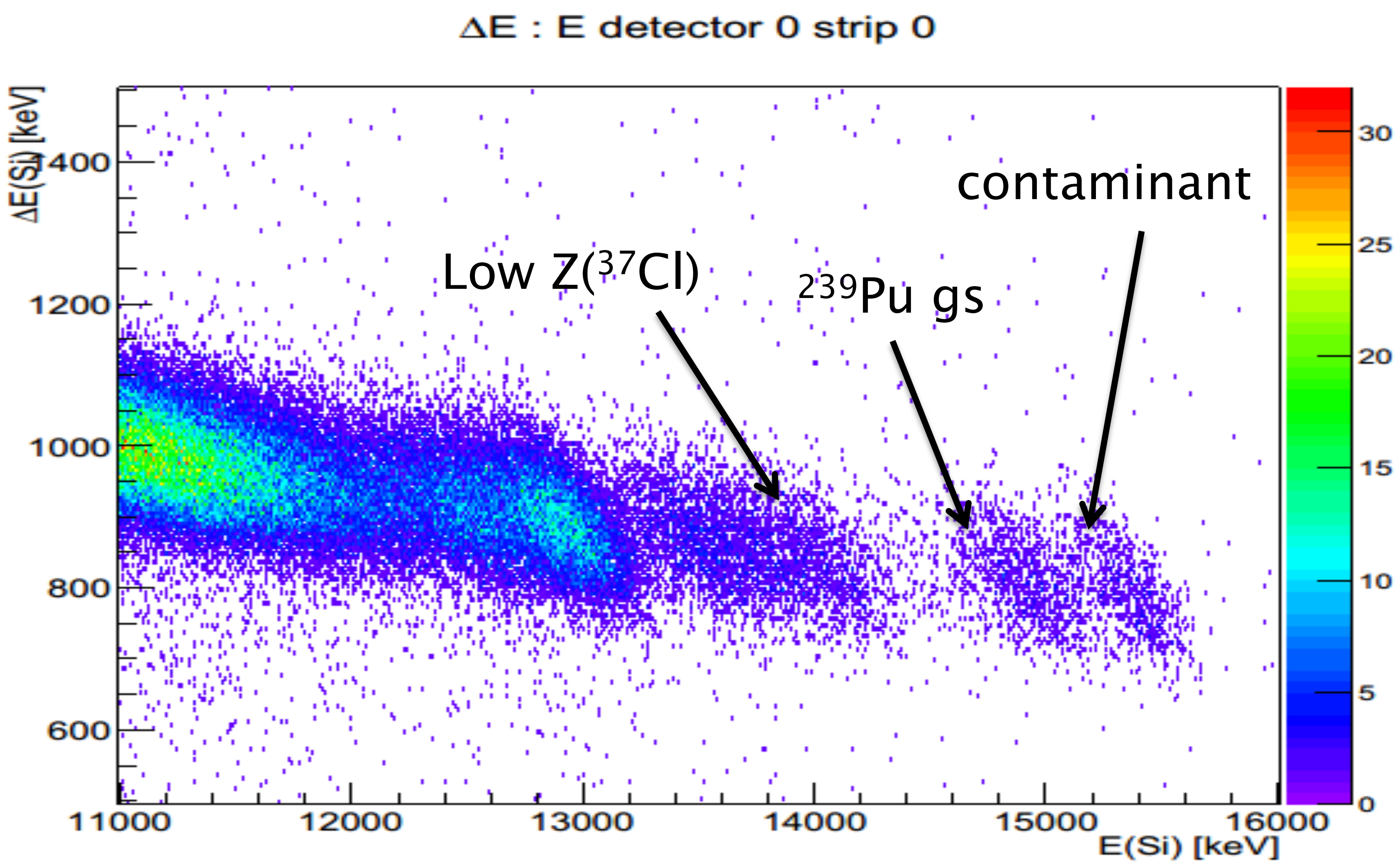
Heavy or light?

Different strips correspond to different angle of the detector in respect to the incident beam
➔Light nuclei are more sensitive than heavy nuclei



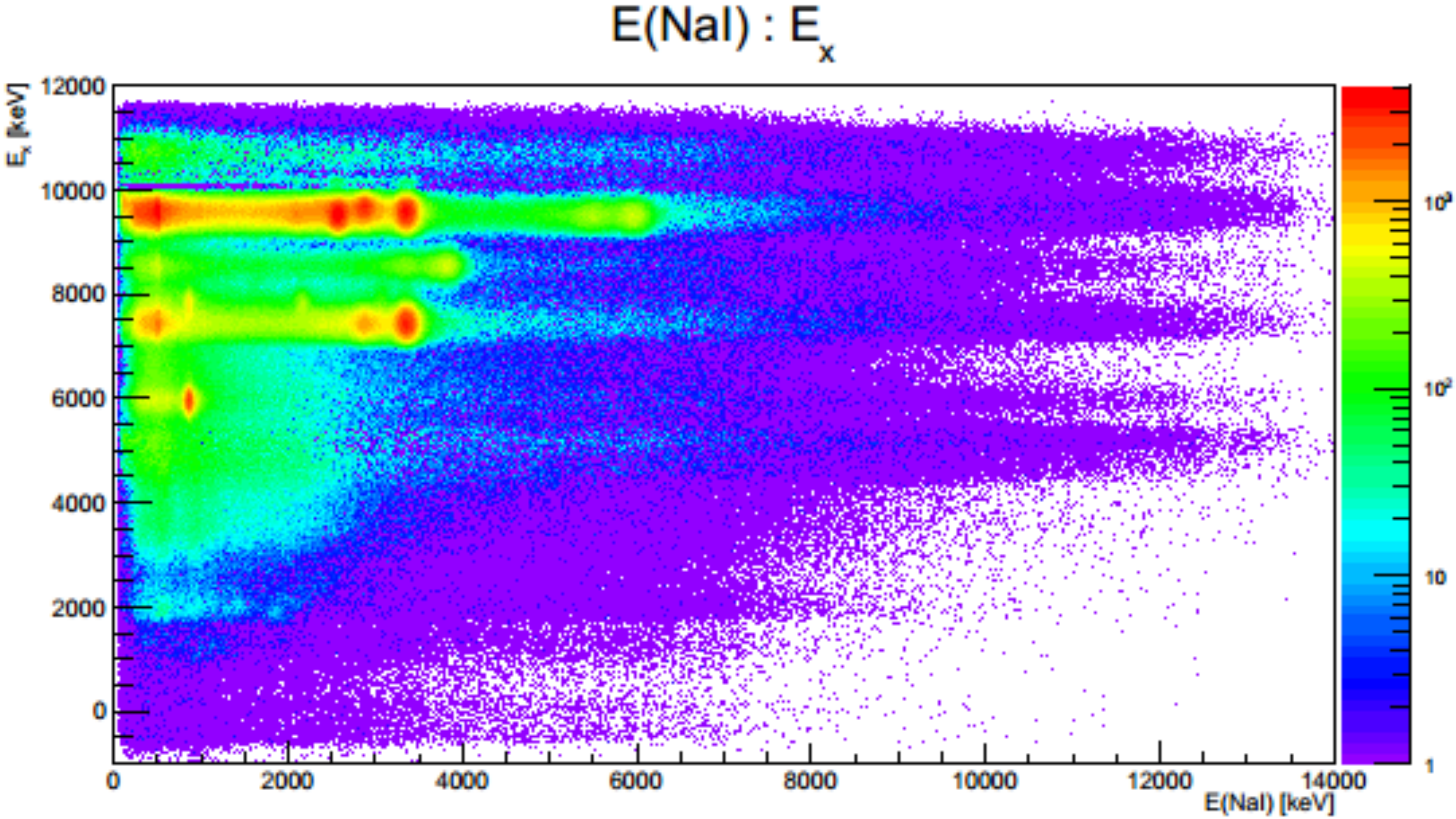
Moving peak believed to be for Al ➔ experiment with just the Al frame

SiRi Calibration

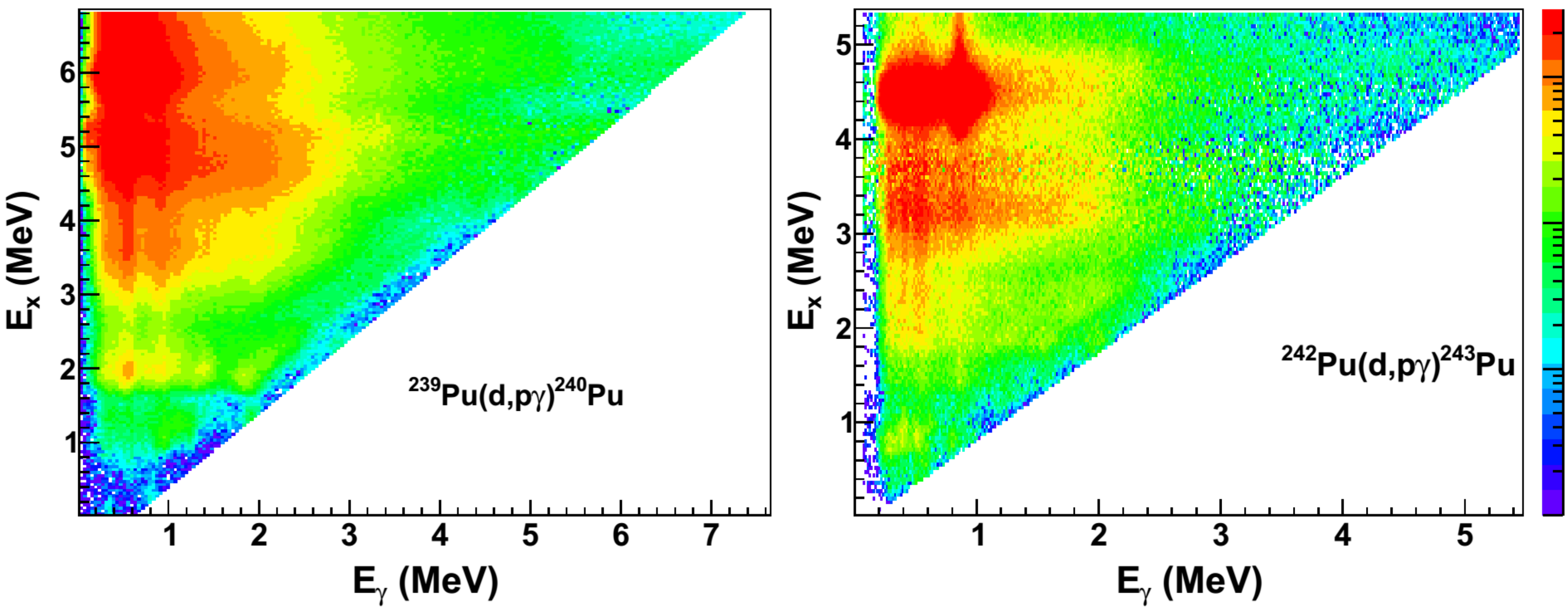


Low Z contaminant from target fabrication process

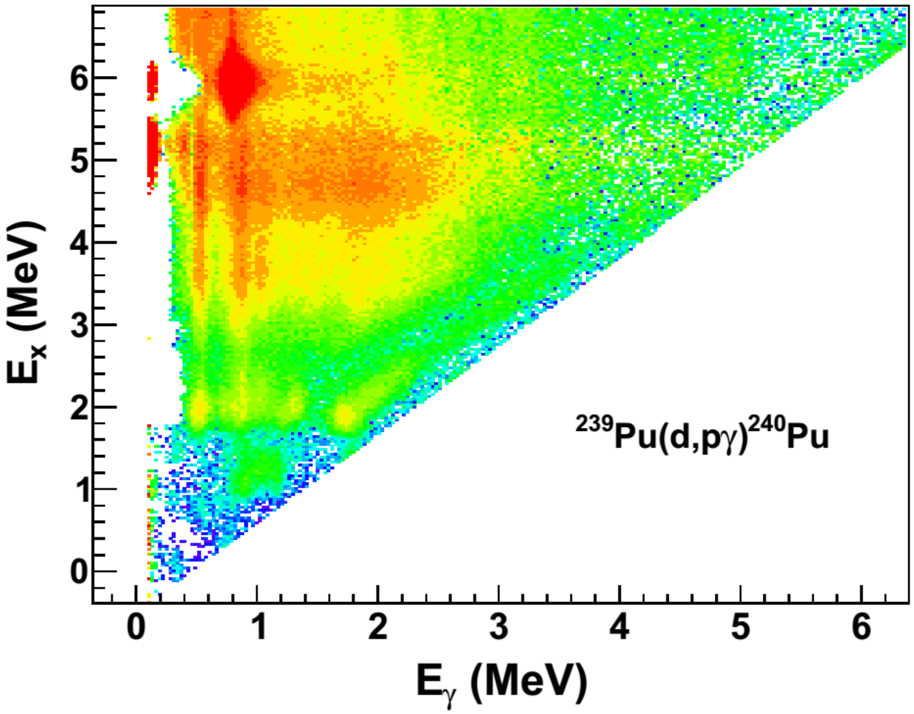
Particle-γ coincidence matrix

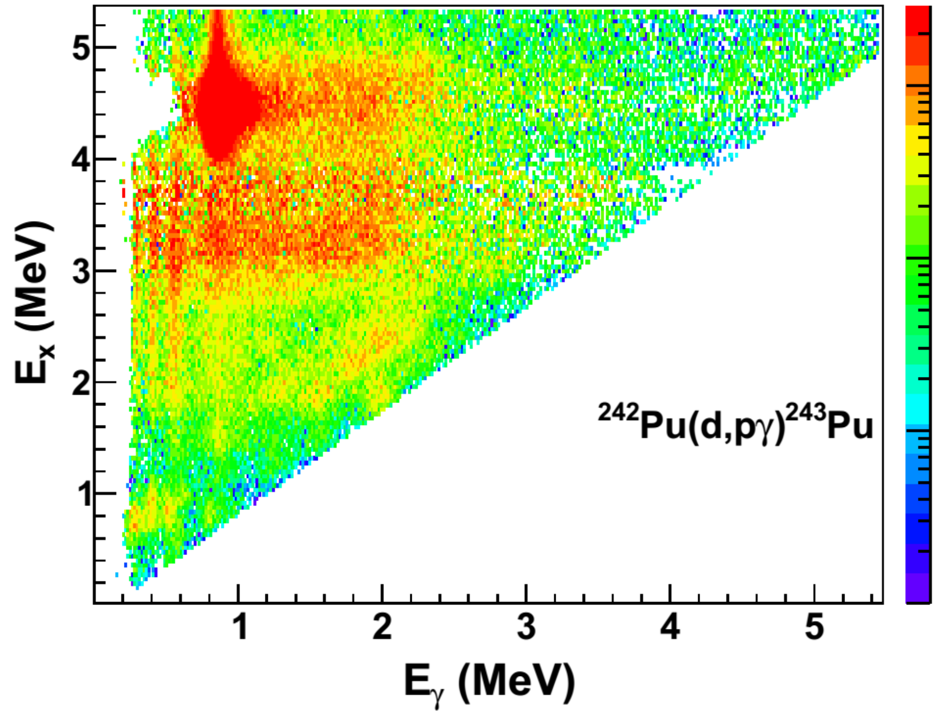


Particle-γ coincidence matrix



Unfolding procedure

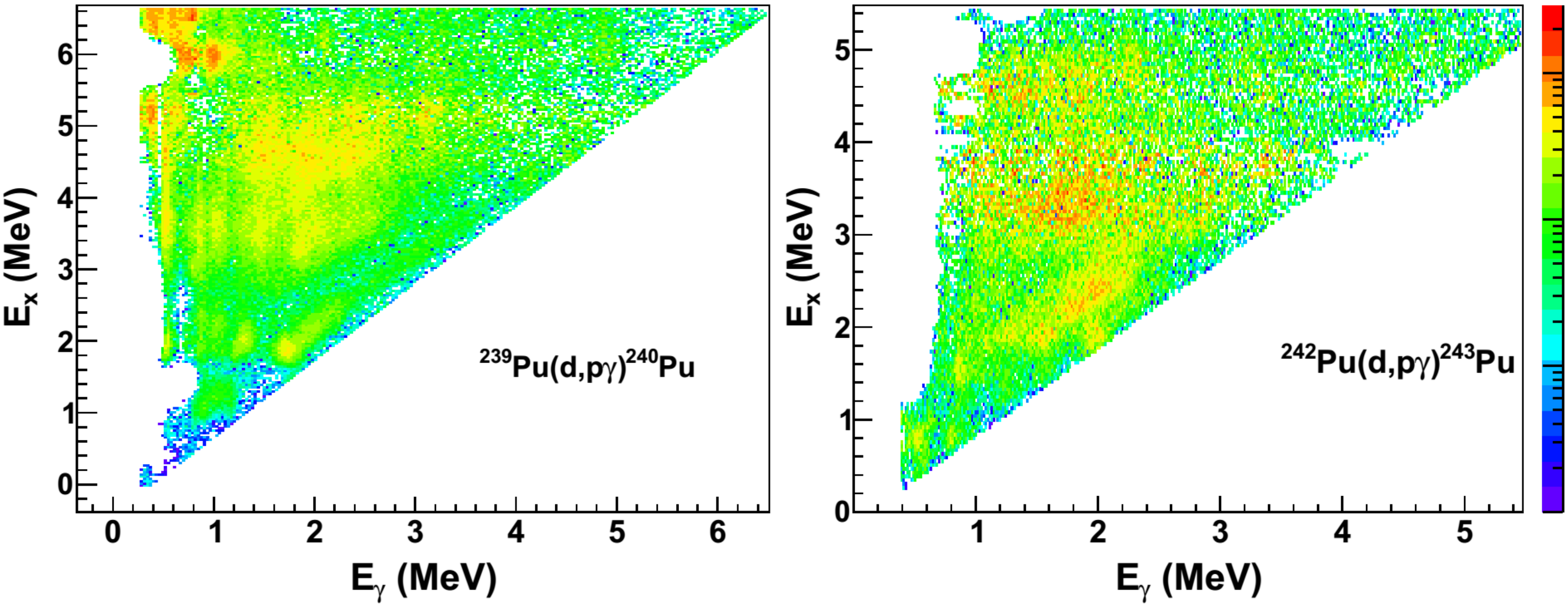




Unfolding: Correct γ spectra with known detector response
See: M. Guttorsen et al., NIM A 374,371 (1996)

Huge ^{17}O contamination peak at 870 keV

First generation extraction



First generation: Extract primary γ from the total γ spectra
See: M. Guttorsen et al., NIM A 255,518 (1987)

Partial conclusion

Important contamination with light (O, Be) and heavy nuclei causing some pile-up

For first generation matrix extraction, we had to remove an O peak (only important peak in the excitation energy range of interest

Following in Fabio's talk:
Nuclear level density, γ-ray strength function and cross section calculation with Talys

Many thanks

- Oslo Cyclotron Laboratory
- F. Zeiser, M. Guttormsen, A.C. Larsen, D.L. Bleuel, B.L. Goldblum, L.A. Bernstein, J.A. Brown, F. Bello, L. Crespo, T. Eriksen, F. Giacoppo, A. Görgen, K. Hadynska-Klek, M.Klintefjord, M. Lebois, T. Renstrøm, S. Rose, E. Sahin, S. Siem, T. Tornyi, A. Voinov, M. Wiedeking, J. Wilson

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University of Oslo

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Laboratory for Accelerator Based Sciences

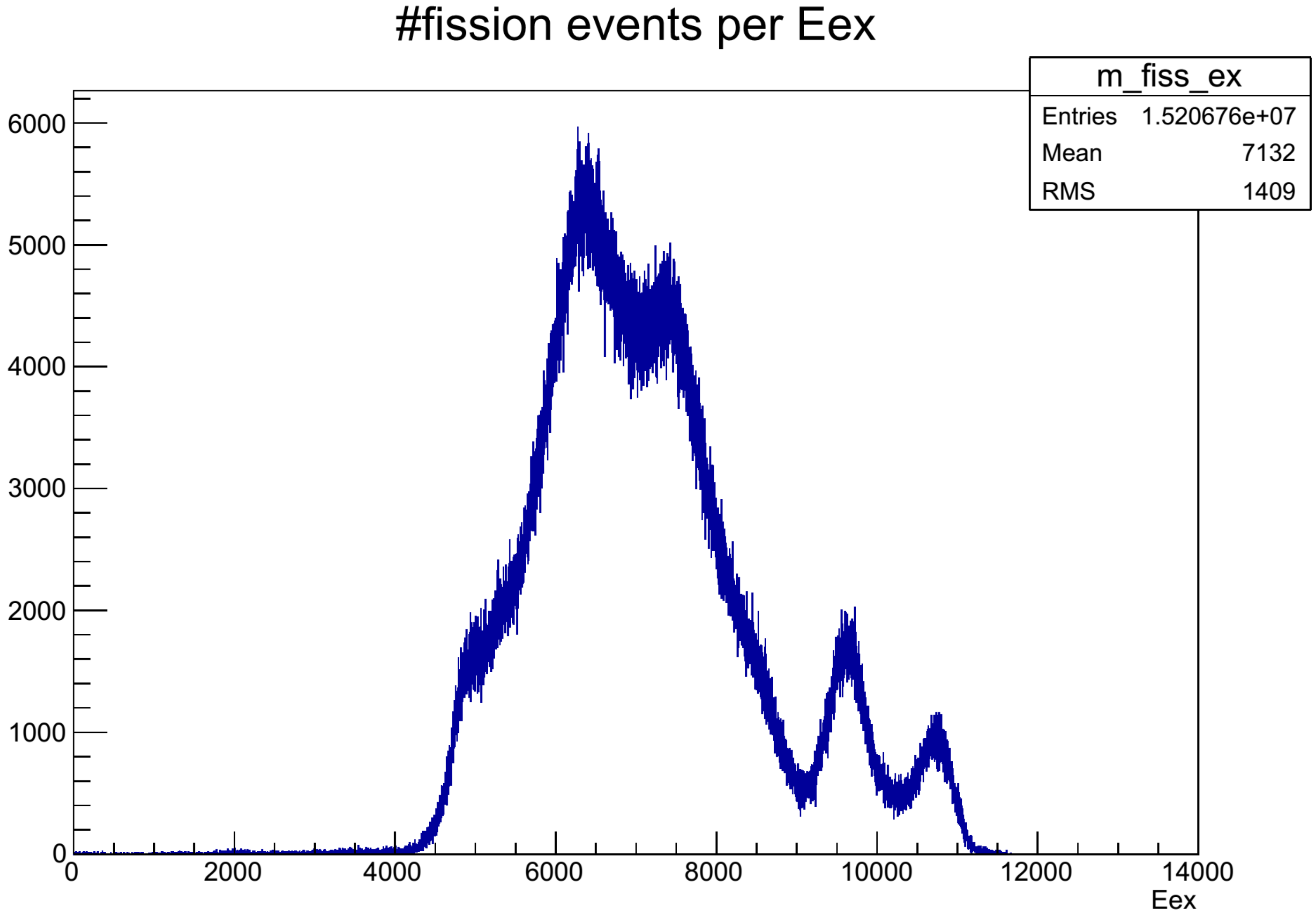
Target contamination

Nuclide	Number of atoms	% error
U237	2.2E6	14.1
Pu238	3.5E13	9.5
Pu241	6.9E13	32.7
Pu242	1.5E18	2.7
Am241	1.5E11	6.5

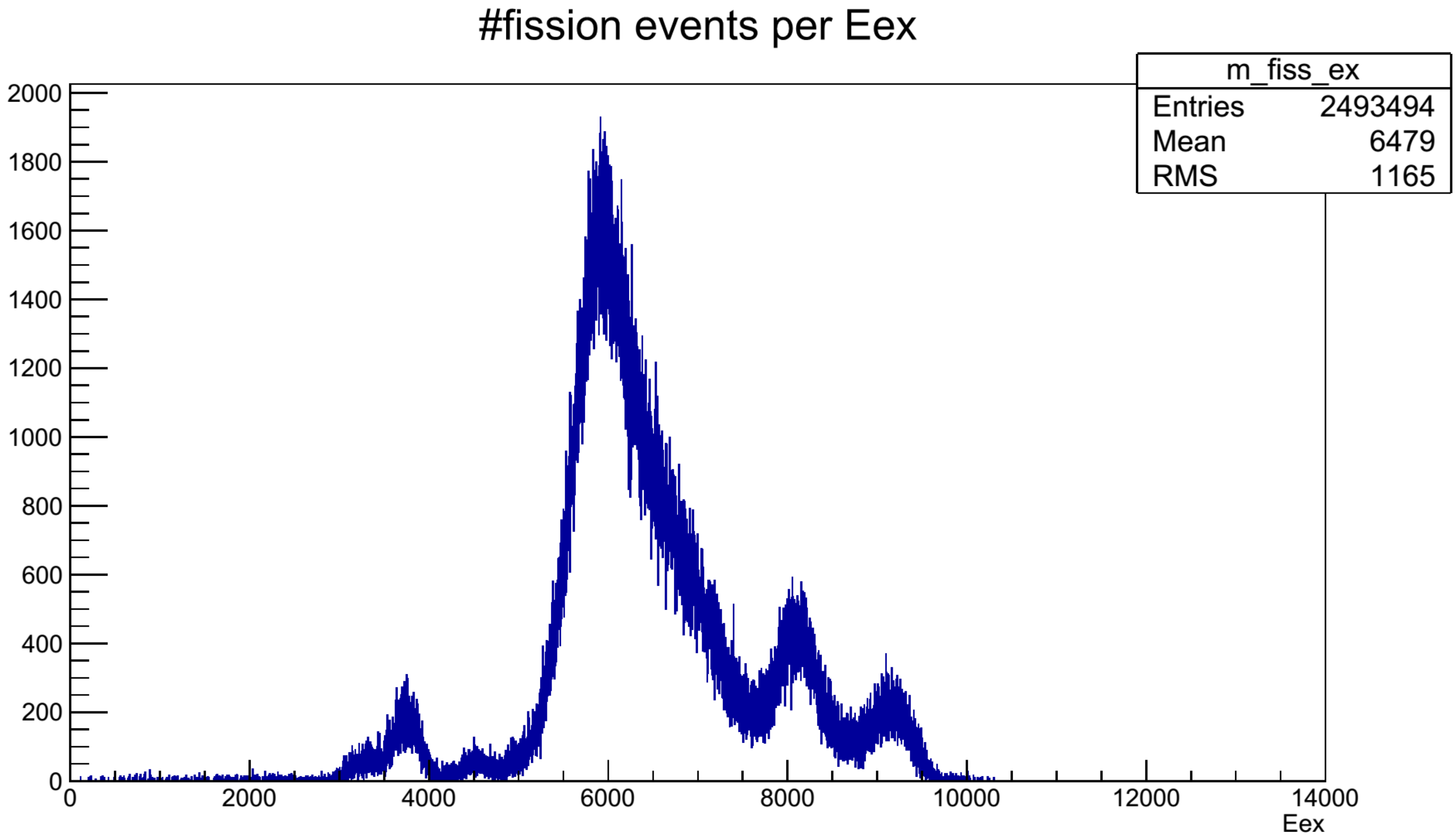
Other possible contamination

Nuclide	Qvalue (MeV)	T1/2
Pu239	4.3	
Pu237	4.8	46 d
Np234	4.8	4 d
U233	4.6	1.6E5 y
Am239	4.9	11.9 h

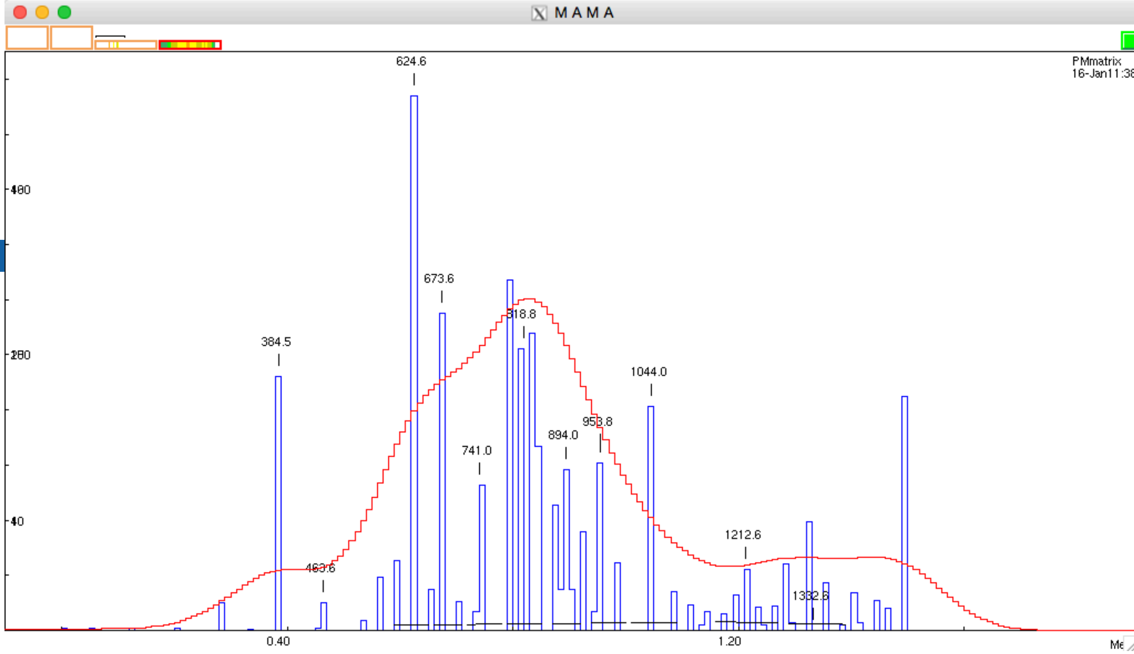
Fission following $^{239}Pu(d,p)$



Fission following $^{242}Pu(d,p)$

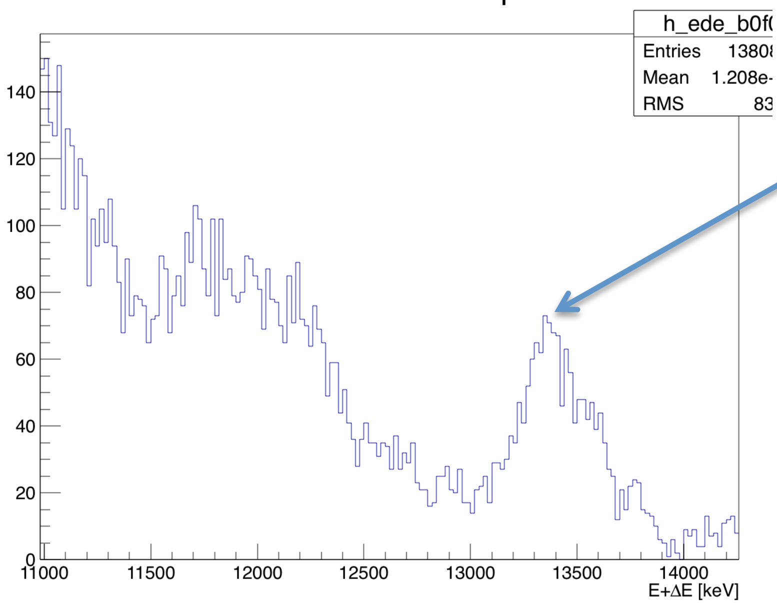


Magne Guttormsen,
Private communication



Particle group:
Ex = 835 +/-10 keV

E+ΔE detector 0 strip 0



ΔE : E detector 0 strip 0