Study of highly-excited states in ^{140}Ce *via* inelastic scattering of ^{17}O

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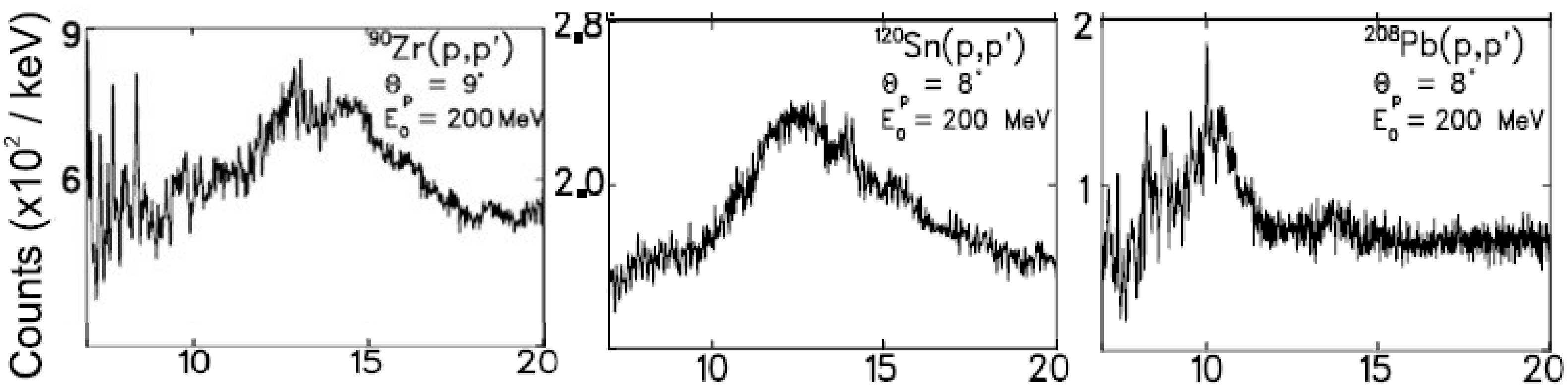
- Physics motivation
  - *Giant quadrupole resonance*
  - *Pygmy structures*
- Experimental setup
  - *Inelastic scattering*
  - *Gamma and ion detection*
- Data analysis + preliminary results
  - *Selection of ^{17}O channel*
  - *Doppler correction*
  - *E_{gamma} vs E* coincidence matrix*
- Conclusions and Plans

Giant Quadrupole Resonance (GQR)

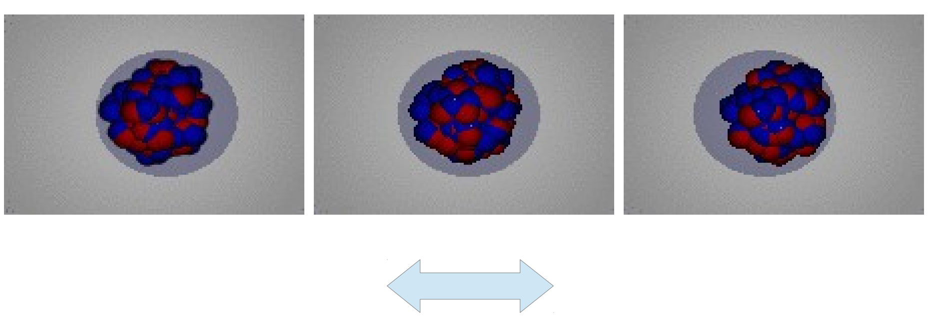
(p,p') reactions at 200 MeV



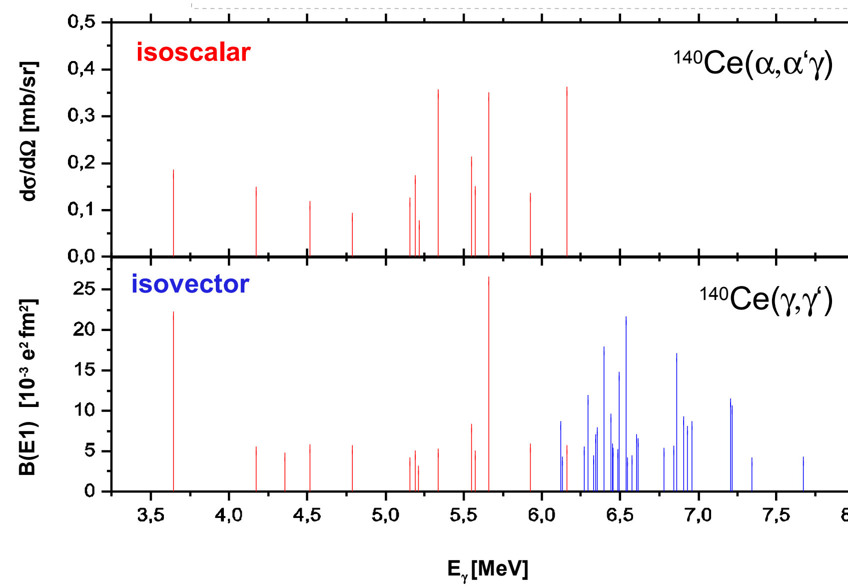
Shevchenko, PRL93(2004)122501-1

Pygmy structures (PDR)

motion of the neutron skin against the proton-neutron core



Splitting of PDR into two components



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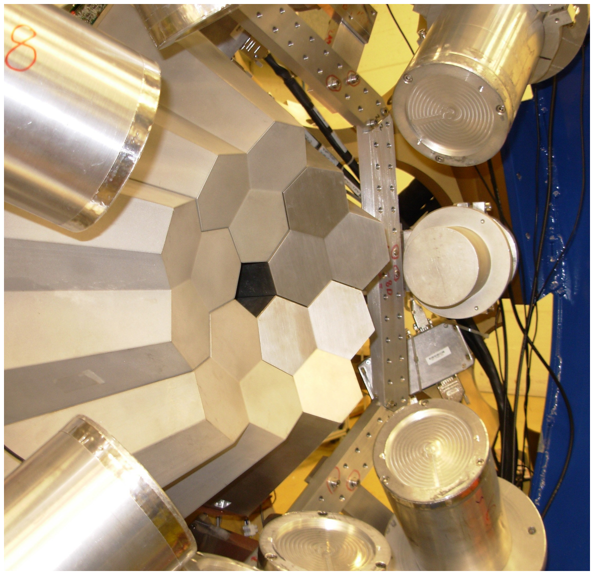
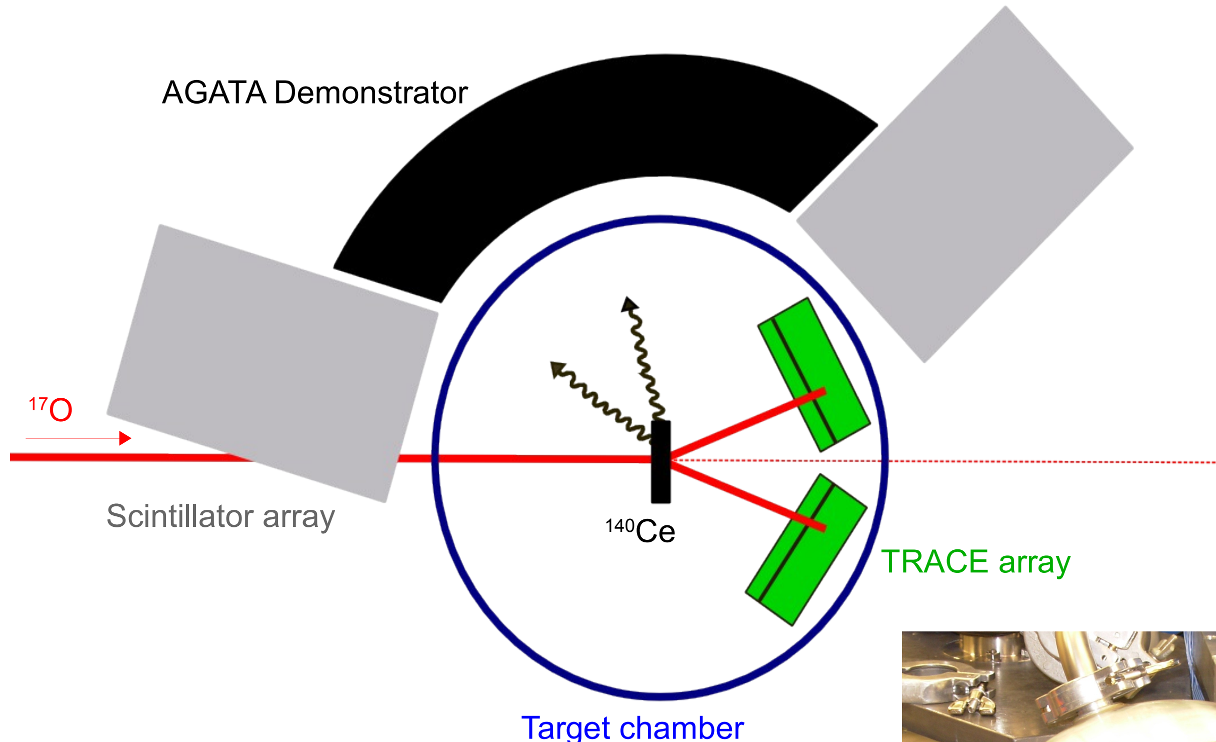
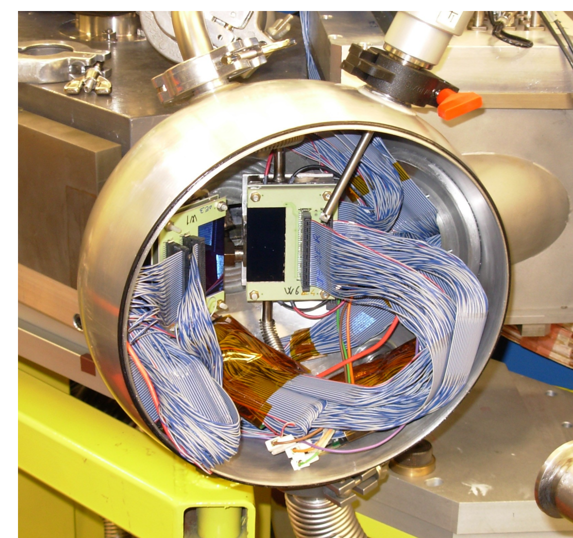
Inelastic scattering of ^{17}O @ 20 MeV/u on ^{140}Ce target



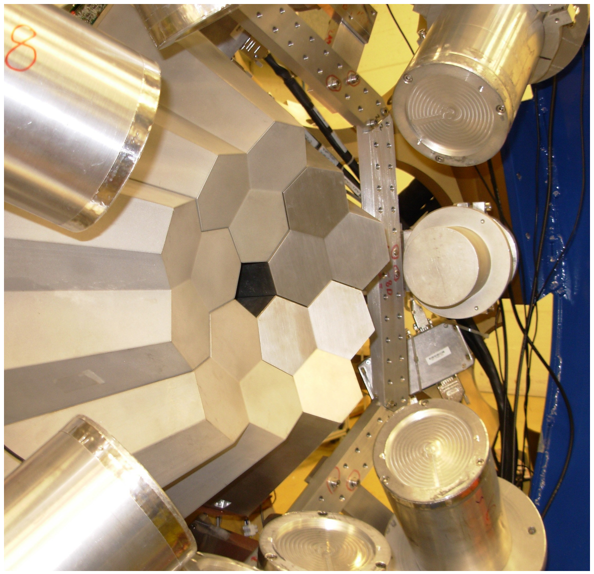




Properties:

- ^{17}**O** is lightly bound (4.1 MeV) – no excitation of projectile
- beam energy 20 MeV/A – highest possible in LNL-Legnaro
- target thickness of 2.5 mg/cm^2
- high cross-section for population of GQR

Inelastic scattering of ^{17}O @ 20 MeV/u on ^{140}Ce target



AGATA Demonstrator: 5 triple clusters of HPGe detectors

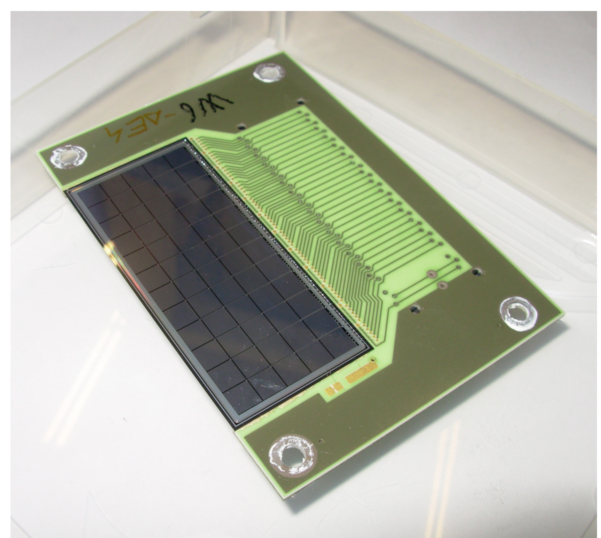
Pulse Shape Analysis
Tracking Algorithm

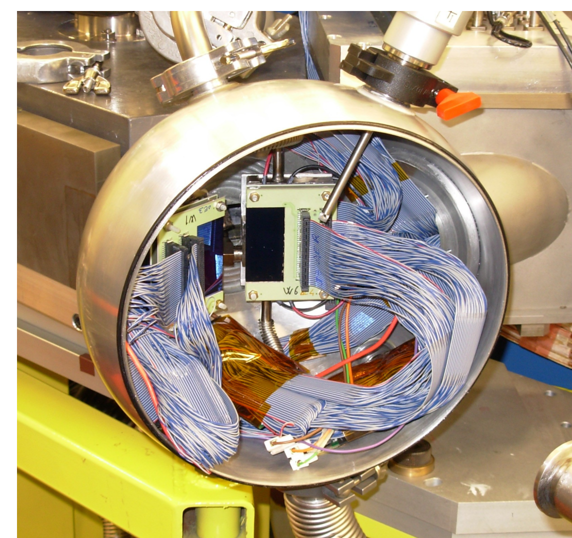
Scintillator array: 9 Large volume $LaBr_3$: Ce

High efficiency (30% more than HPGe)
Cylindrical shape, volume up to 9 x 20 cm
energy resolution ~20 keV FWHM at 662 keV

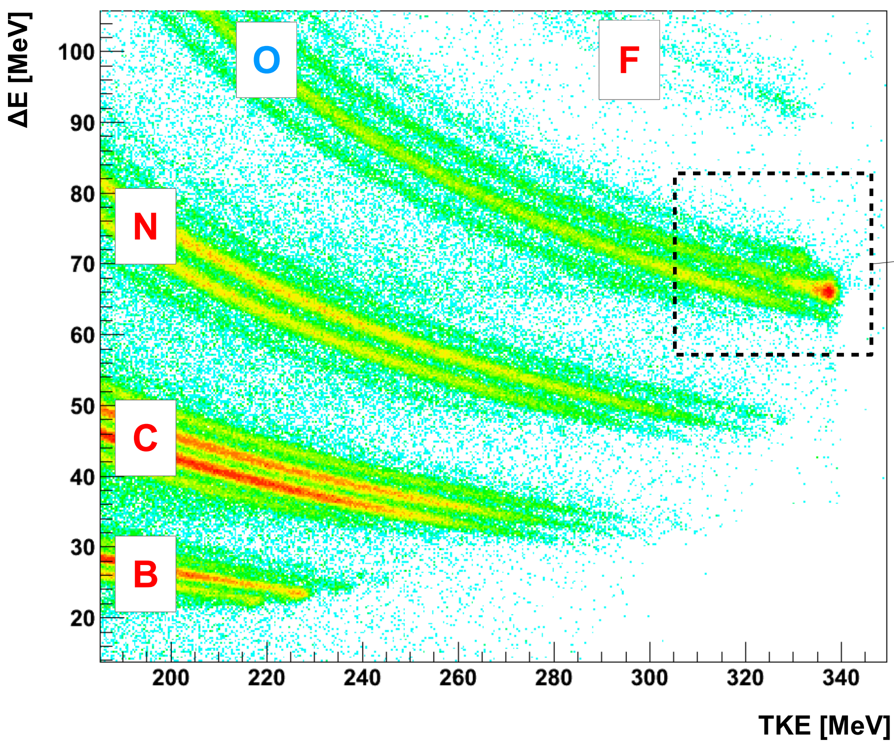
TRACE array: 2 ΔE-E telescopes

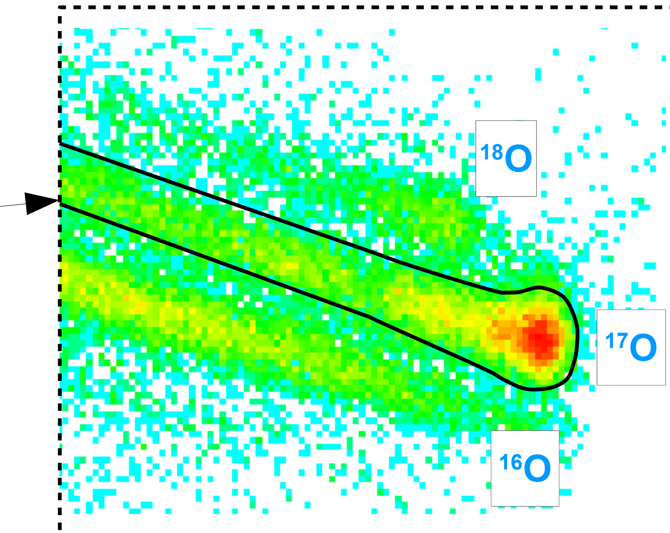
Si-pad technology (5 x 12 pixels)
Pixel area: 4x4 mm^2
Active area: 20 x 50 mm^2
Thickness: ΔE detector – 200 μm
E detector – 1 mm

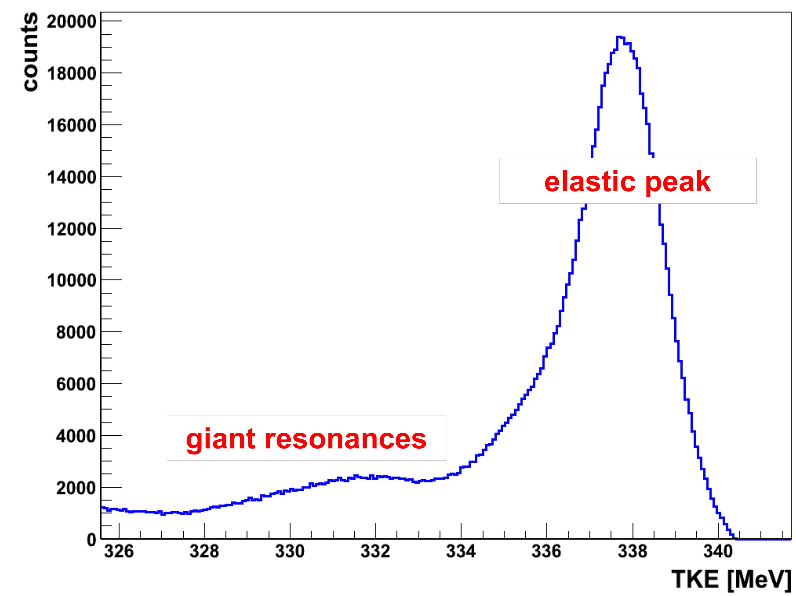




ΔE-TKE matrices for each pad of Si detectors



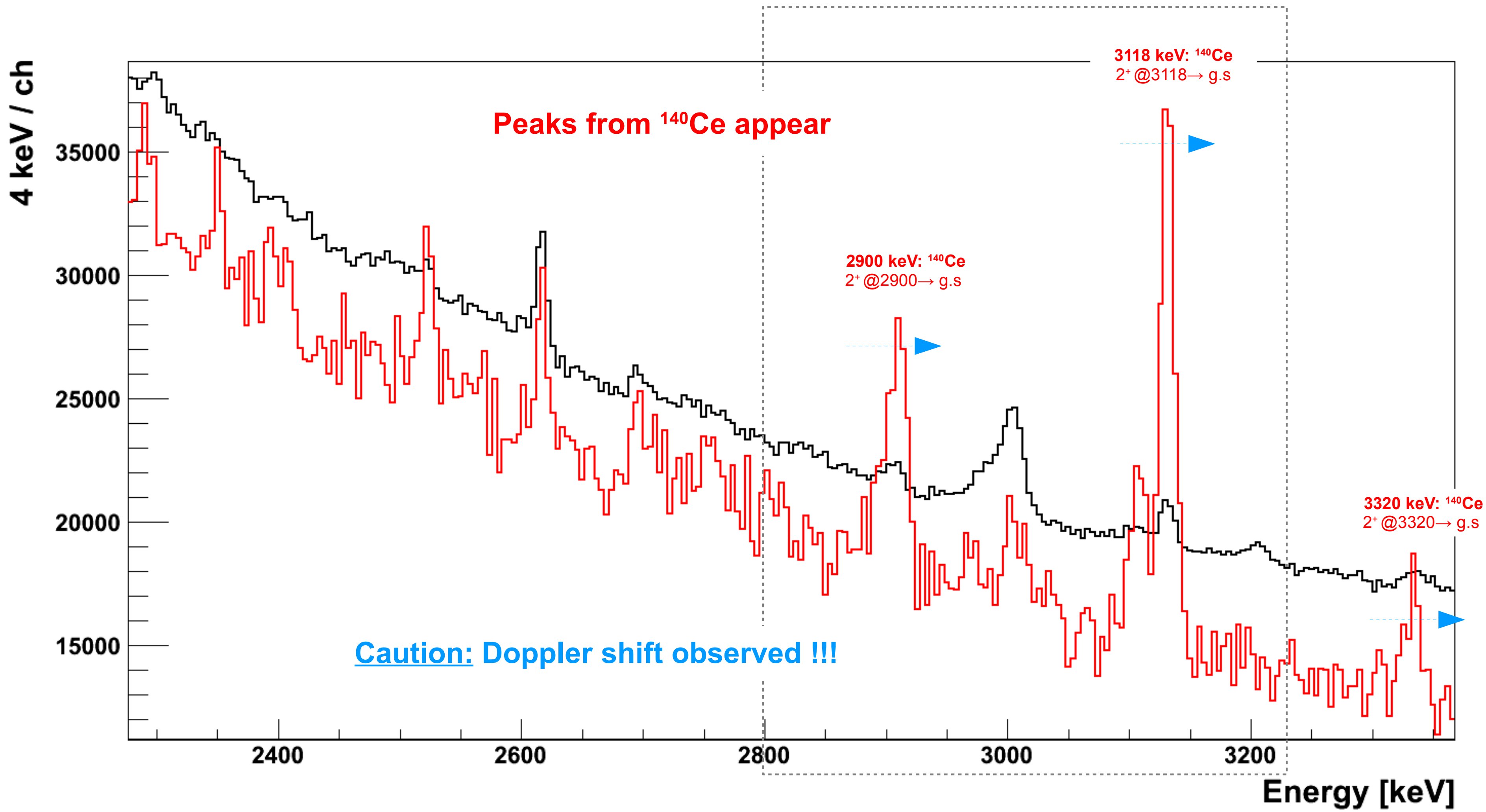




Spectrum of total kinetic energy deposited by ^{17}O in both ΔE-E layers of Si detectors.

Data analysis – selection of ^{17}O channel

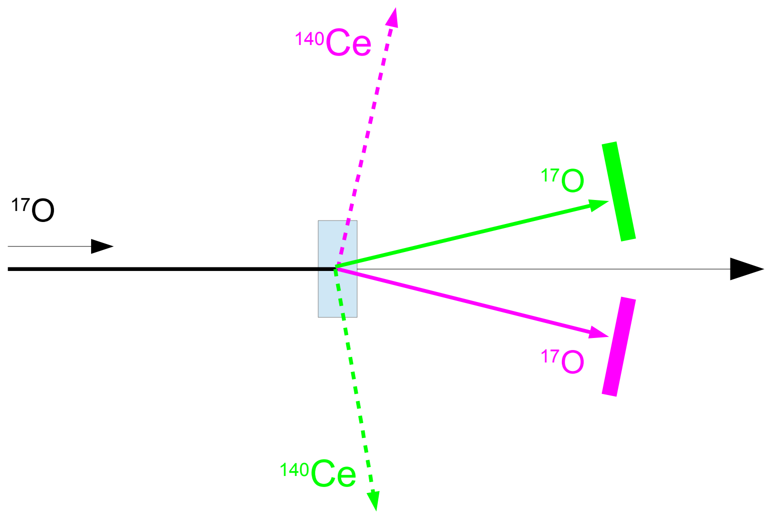
gate on time coincidence peak
time gate + ^{17}O selection

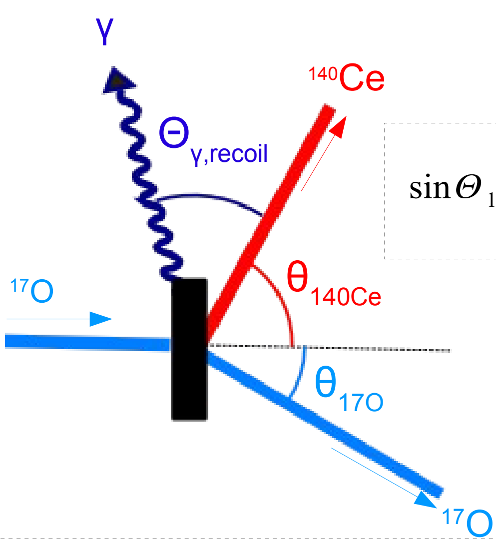


1) AGATA Demonstrator algorithm: PSA + tracking

2) Target-like recoils

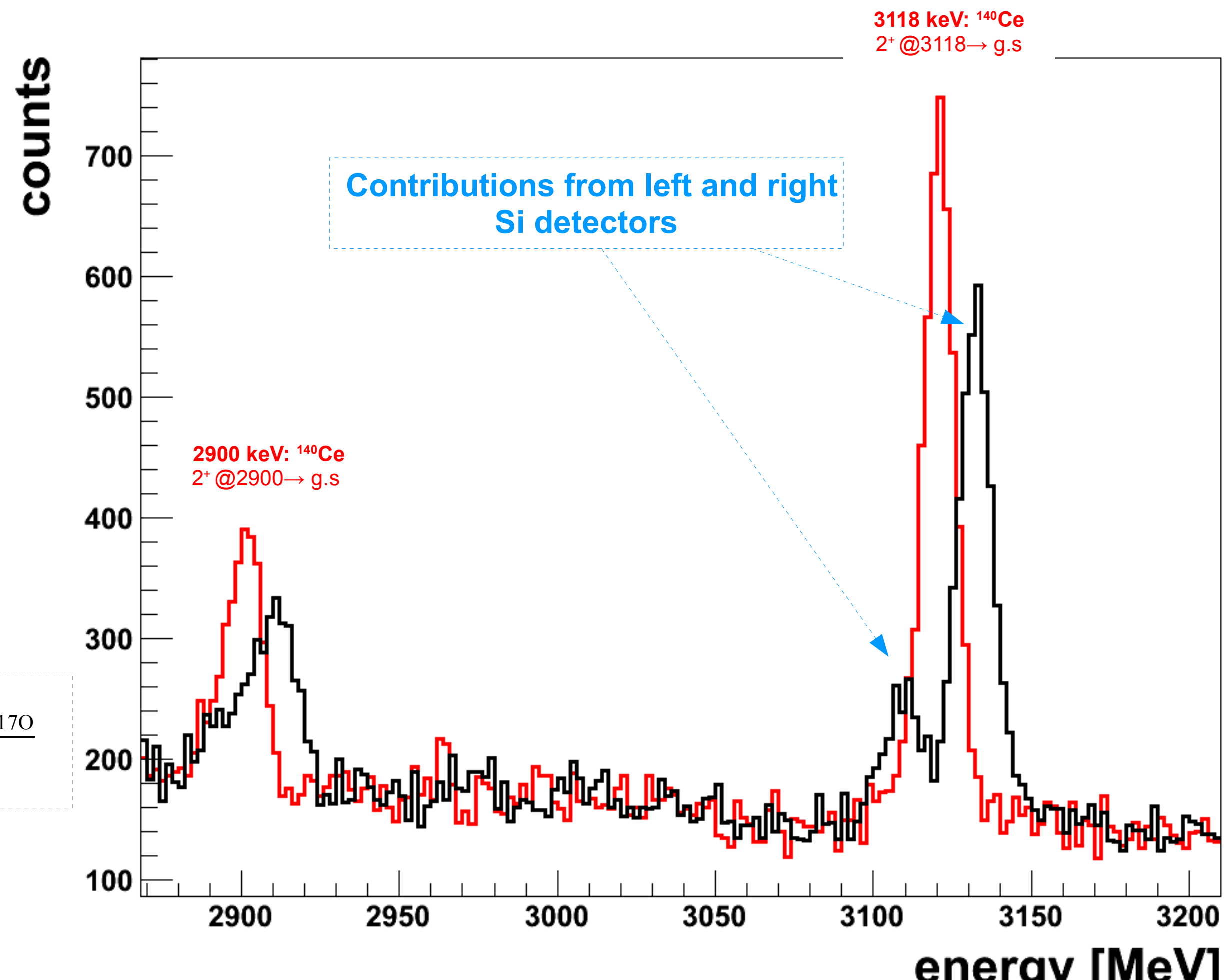
v/c ~ 0.5%





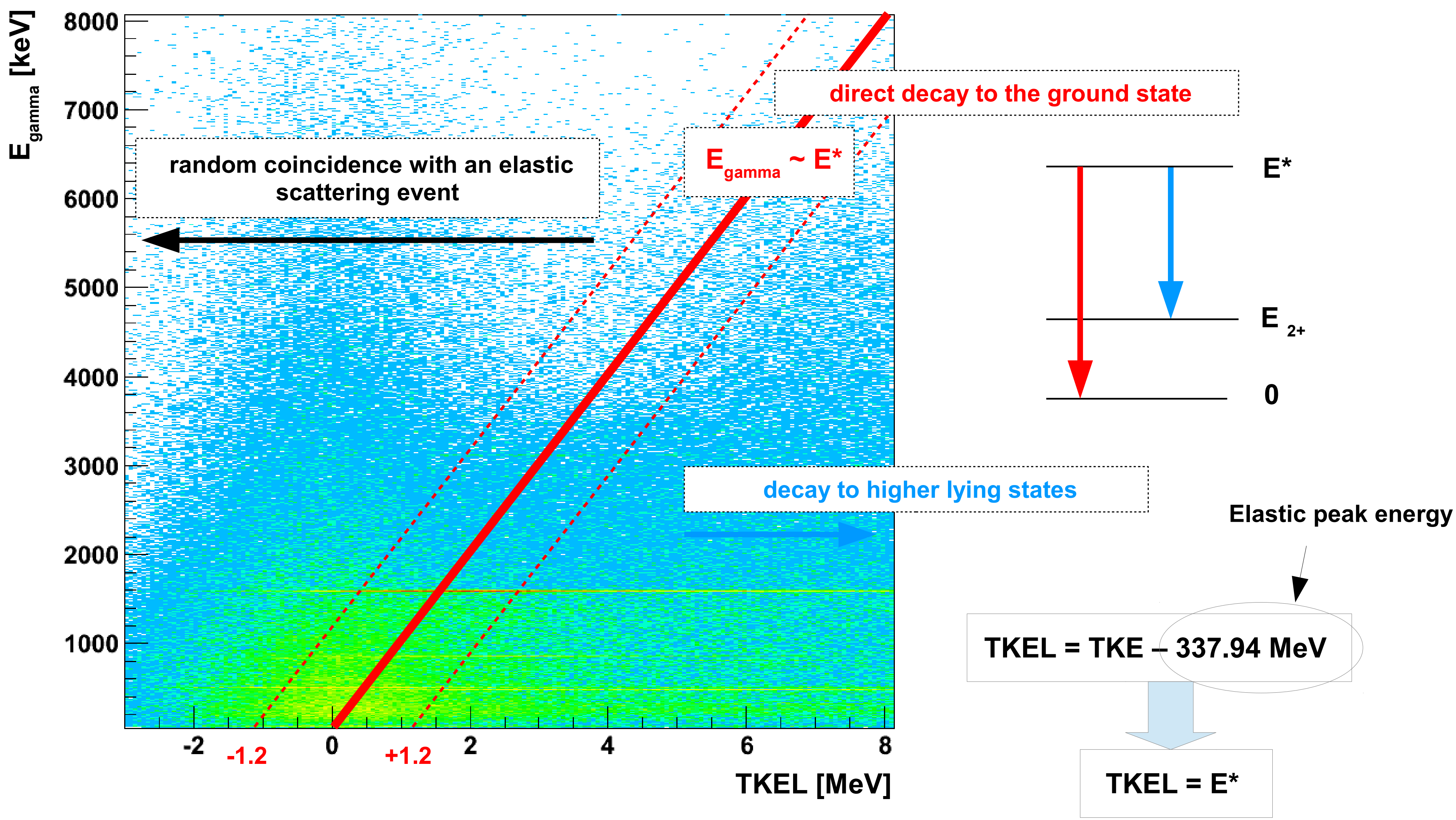
$$\sin\Theta_{140Ce} = \frac{v_{17O}\, m_{17O} \cdot \sin\Theta_{17O}}{m_{140Ce} \cdot v_{140Ce}}$$

σ = 19.16keV
σ = 6.14 keV

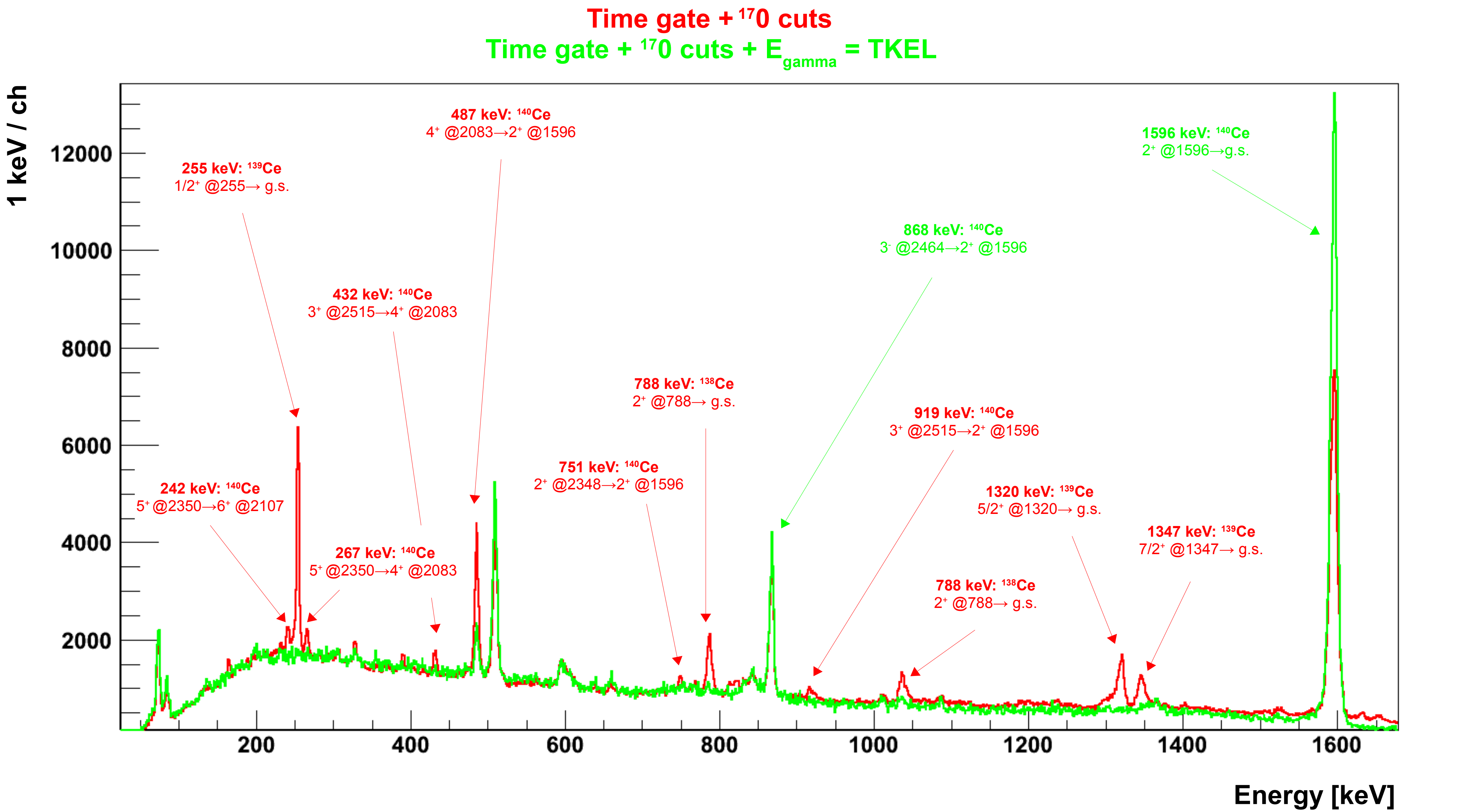


Velocities of target nucleus and projectile is set constant and simulated using LISE

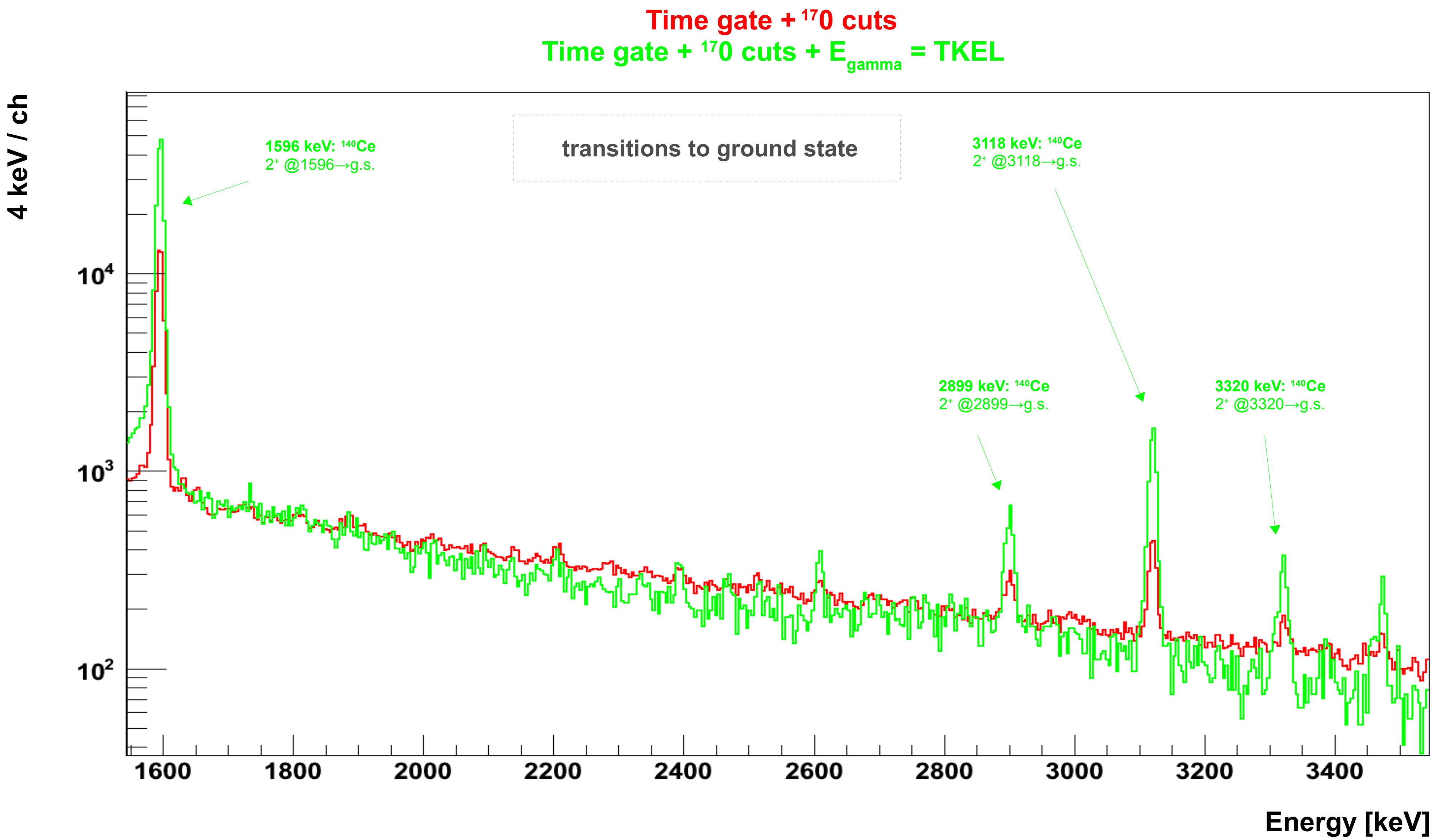
$^{140}Ce(^{17}O, ^{17}O'\gamma)$ – coincidence matrix



Examples of identified gamma lines for lower energies..

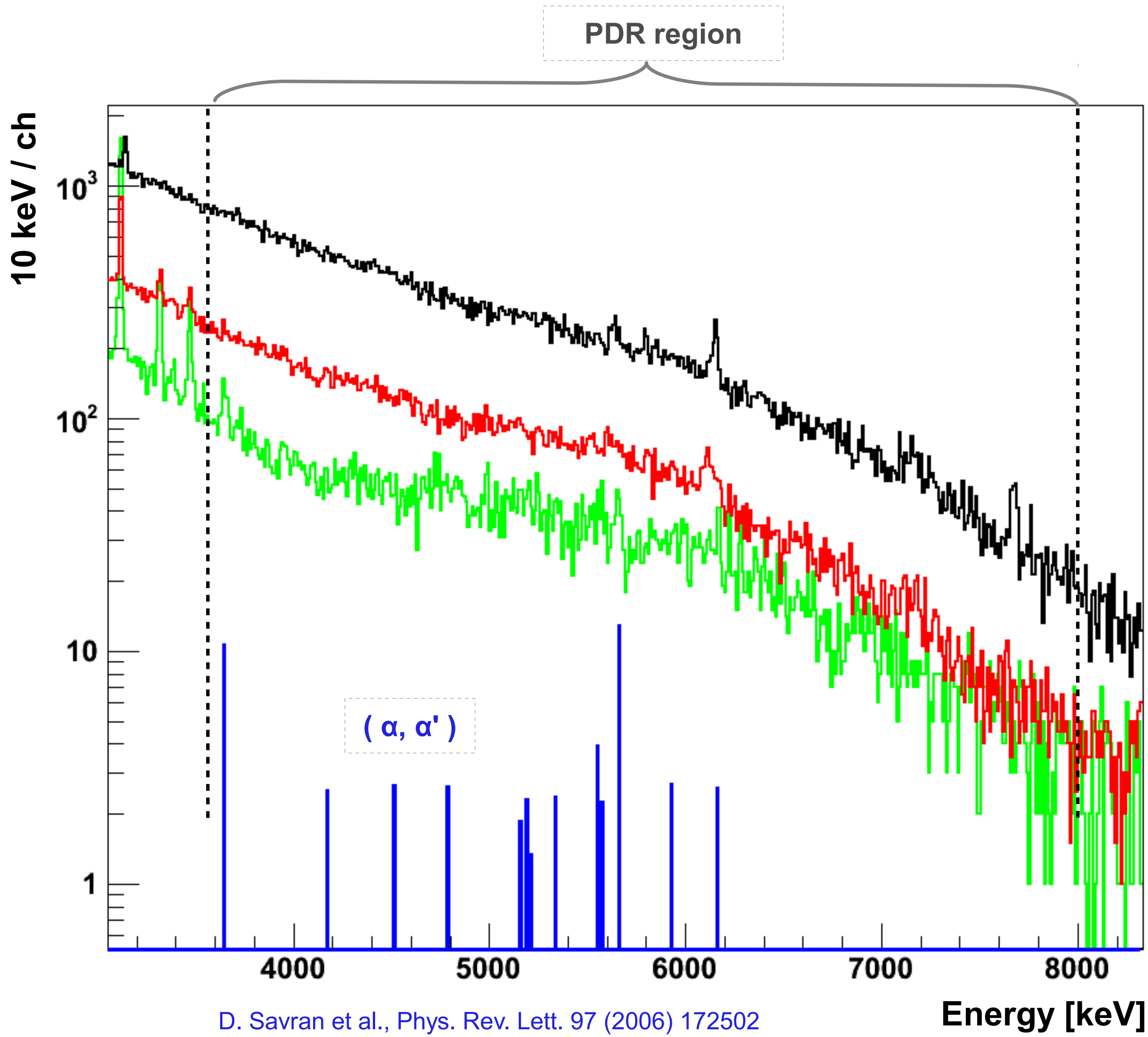


...and higher energies



In order to see the PDR:

- gate on coincidence peak
- inelastic scattering channel
- transitions directly to the g.s.
- E1 - not yet selected



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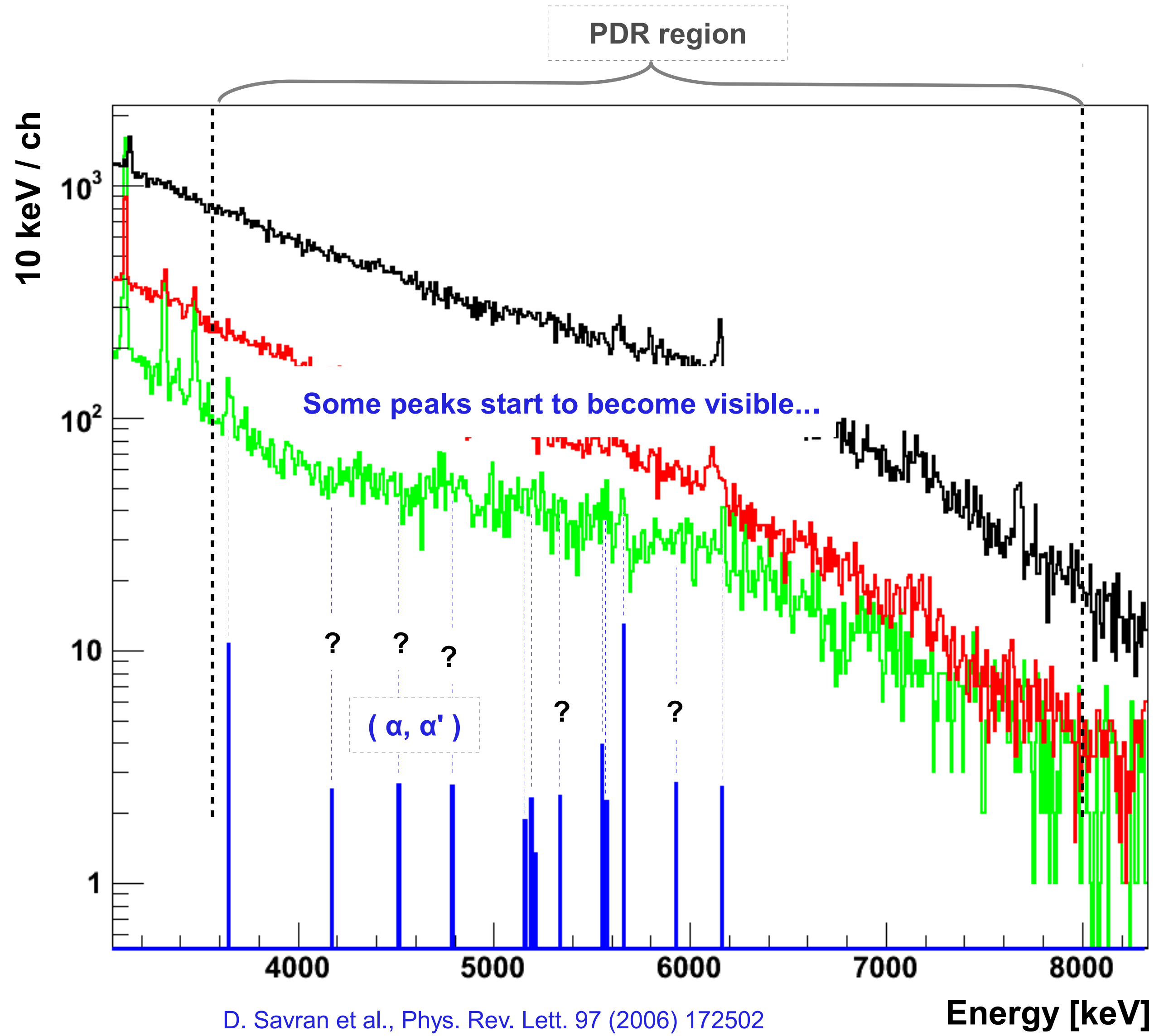
Angular distributions

in order to distinguish between E1 and E2



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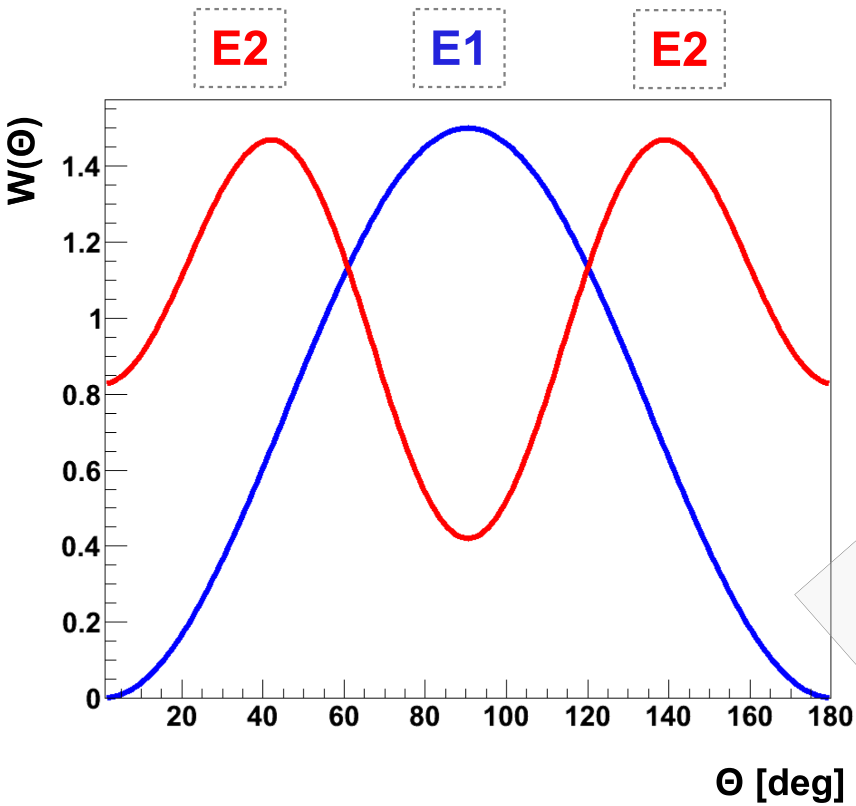
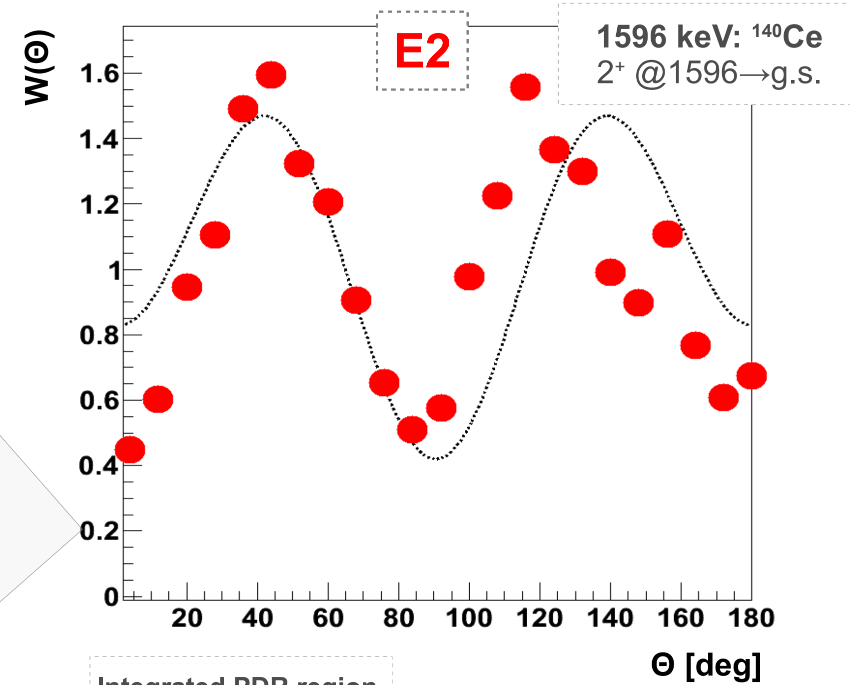
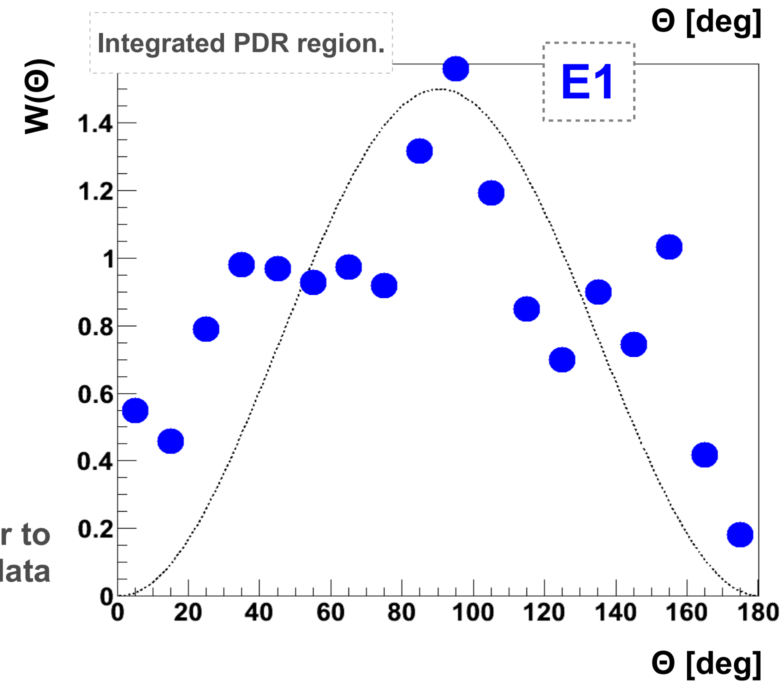
Results – Angular distributions

Expected angular distributions for E1 and E2 transitions



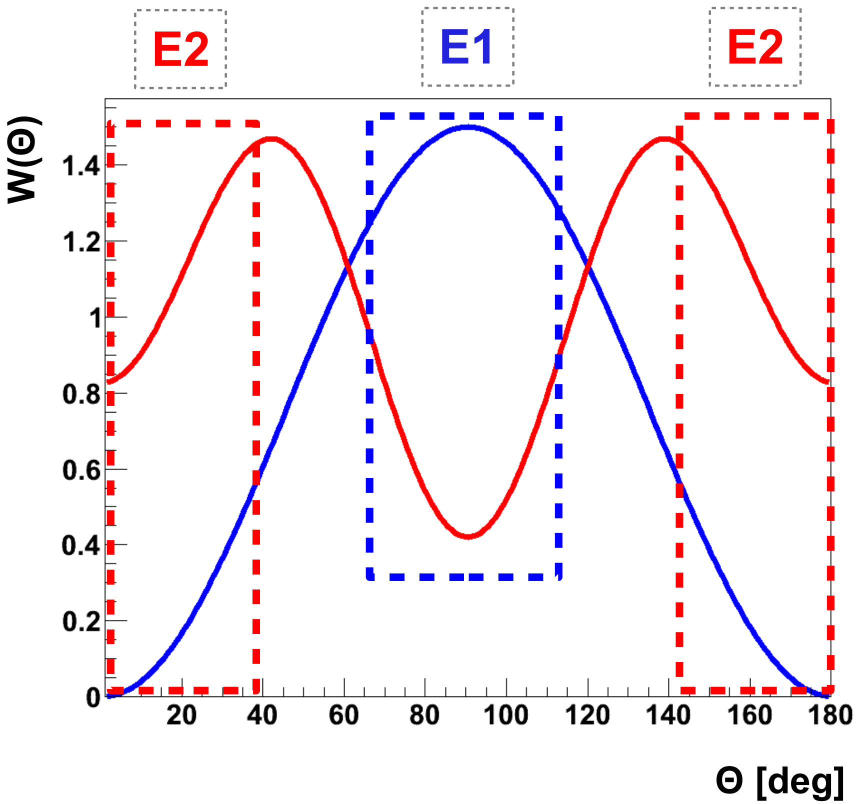
Very preliminary !!!





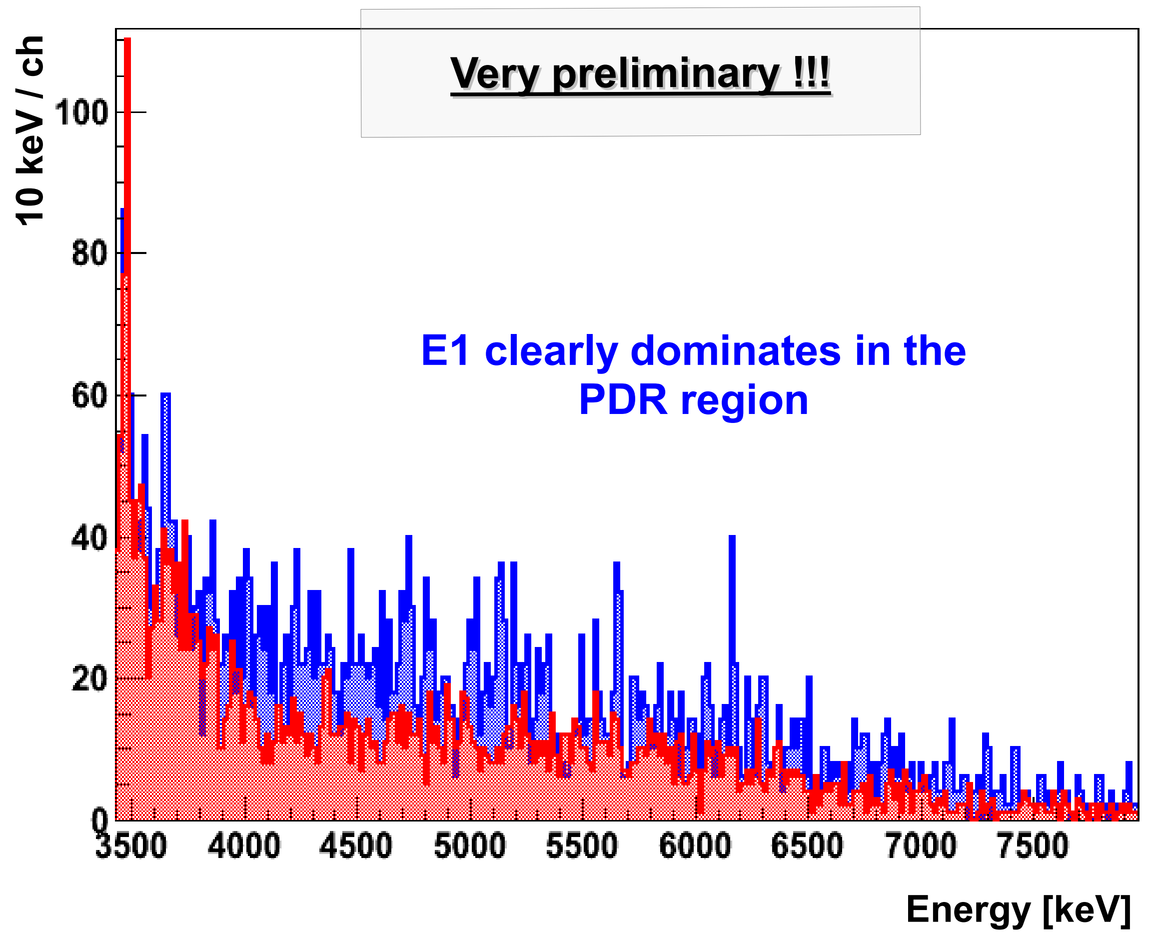
AGATA angular efficiency simulated with Geant4 in order to normalize the experimentally obtained data

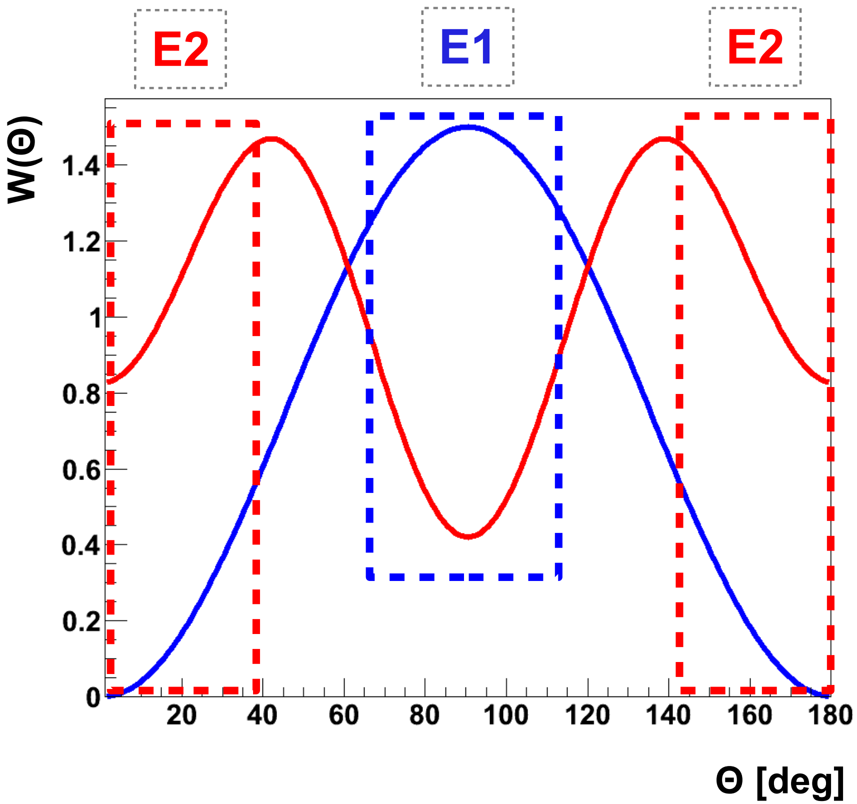
We can extract E1/E2 like spectra...

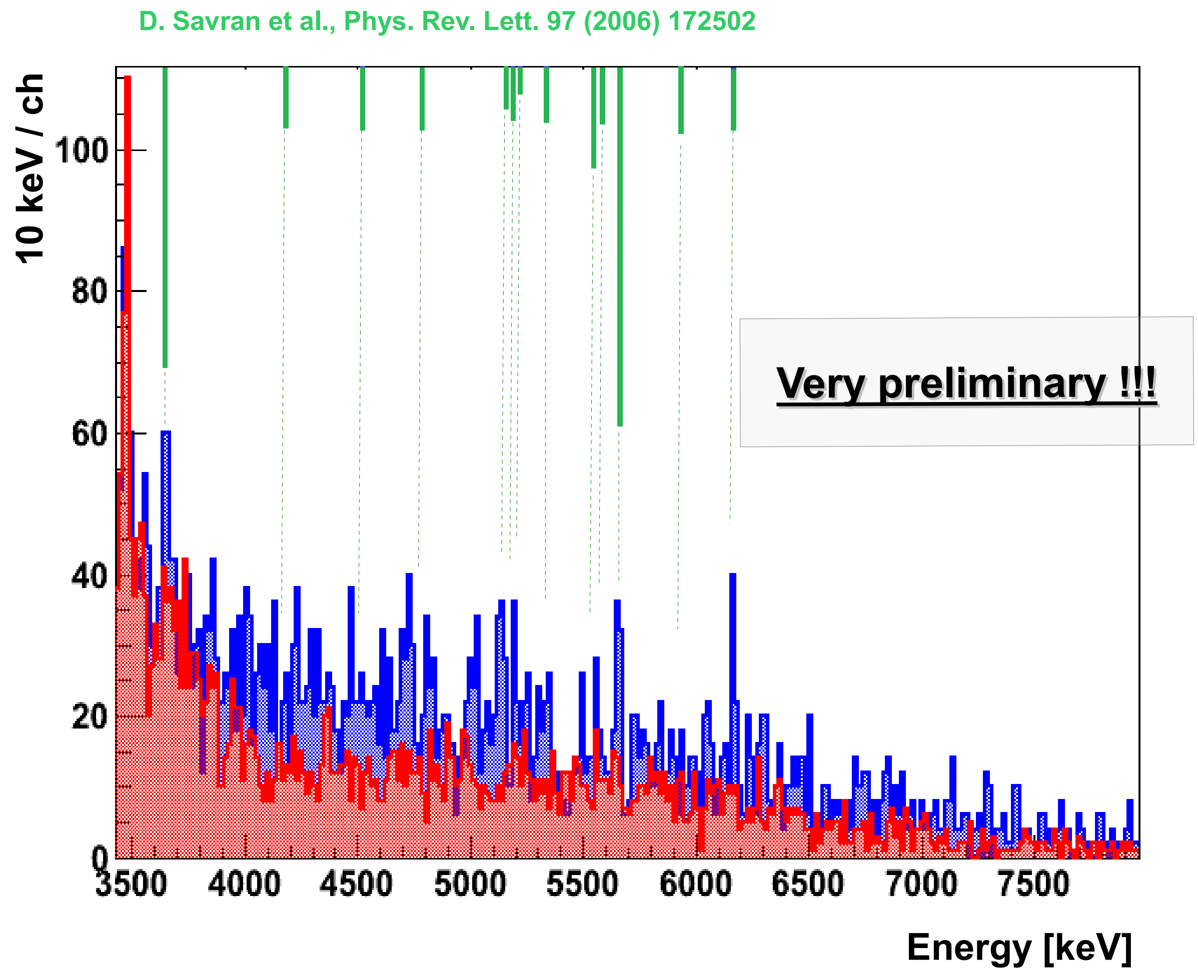


..by selecting appropriate angular range

E1 and E2 spectra normalized to the first excited state 2^+




E2
E1
E2
W(Θ)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
20
40
60
80
100
120
140
160
180
Θ [deg]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10 keV / ch
100
80
60
40
20
0
3500
4000
4500
5000
5500
6000
6500
7000
7500
Energy [keV]
Very preliminary !!!

- Position sensitivity for gamma rays and recoils resulted in:
  - precised Doppler correction,
  - reduction of background
  - high sensitivity to multipolarity – angular distribution

Very preliminary results shows E1 strength enhancement in the region of PDR with isoscalar character

- On-going and future work
  - analysis of scintillator data
  - estimation of cross sections
  - study of gamma rays from decay of GQR in ^{140}Ce

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