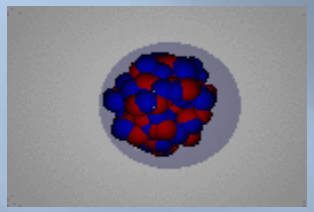
Study of High-Lying States in ^{208}Pb and ^{90}Zr with the AGATA Demonstrator (28/05 to 05/06 2010)

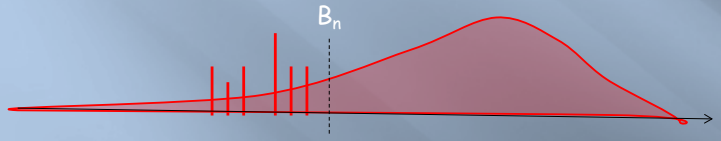
Outline:

- Physics motivation
- Experimental setup
- Preliminary results
  - Si detectors
  - Gamma decay from “pygmy” states
  - Doppler correction with the AD

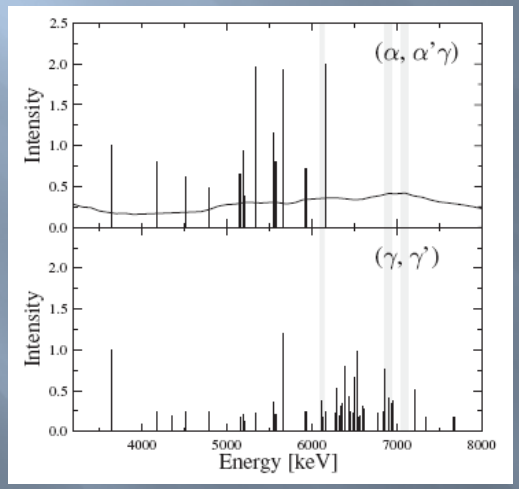
Physics motivation

Pygmy Dipole Resonance



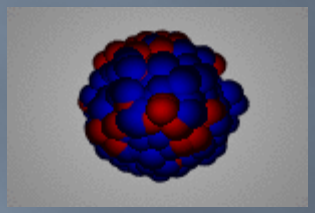


Different population with (γ,γ'), $(\alpha,\alpha'\gamma)$

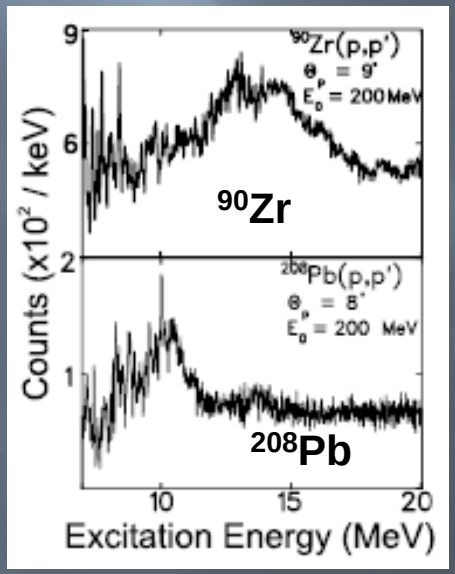


D. Savran et al., PRL97(2006)172502

Giant Quadrupole Resonance

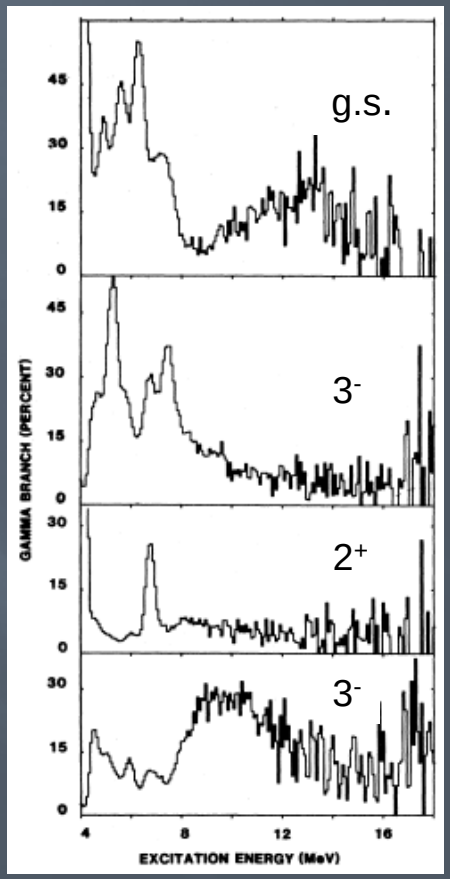


Fine structure



Shevchenko PRL93(2004)

Branching ratios

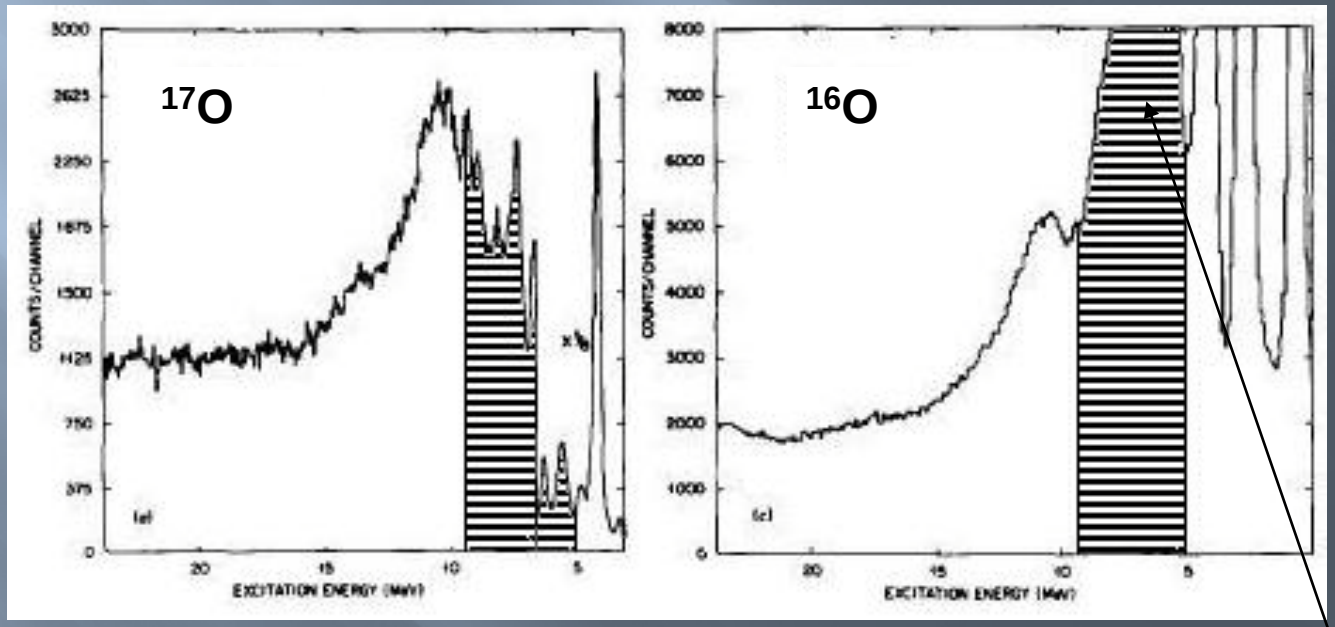


J. Beene et al PRC39(1989)

Experimental technique

Inelastic scattering ^{17}O @ 20 MeV/u on ^{90}Zr, ^{208}Pb, ... targets
+ γ-ray coincidence measurement

Heavy-ion scattering can populate giant resonances with large cross-sections
^{17}O is loosely bound (S_n = 4.1 MeV)
We can eliminate projectile excitation above 4 MeV



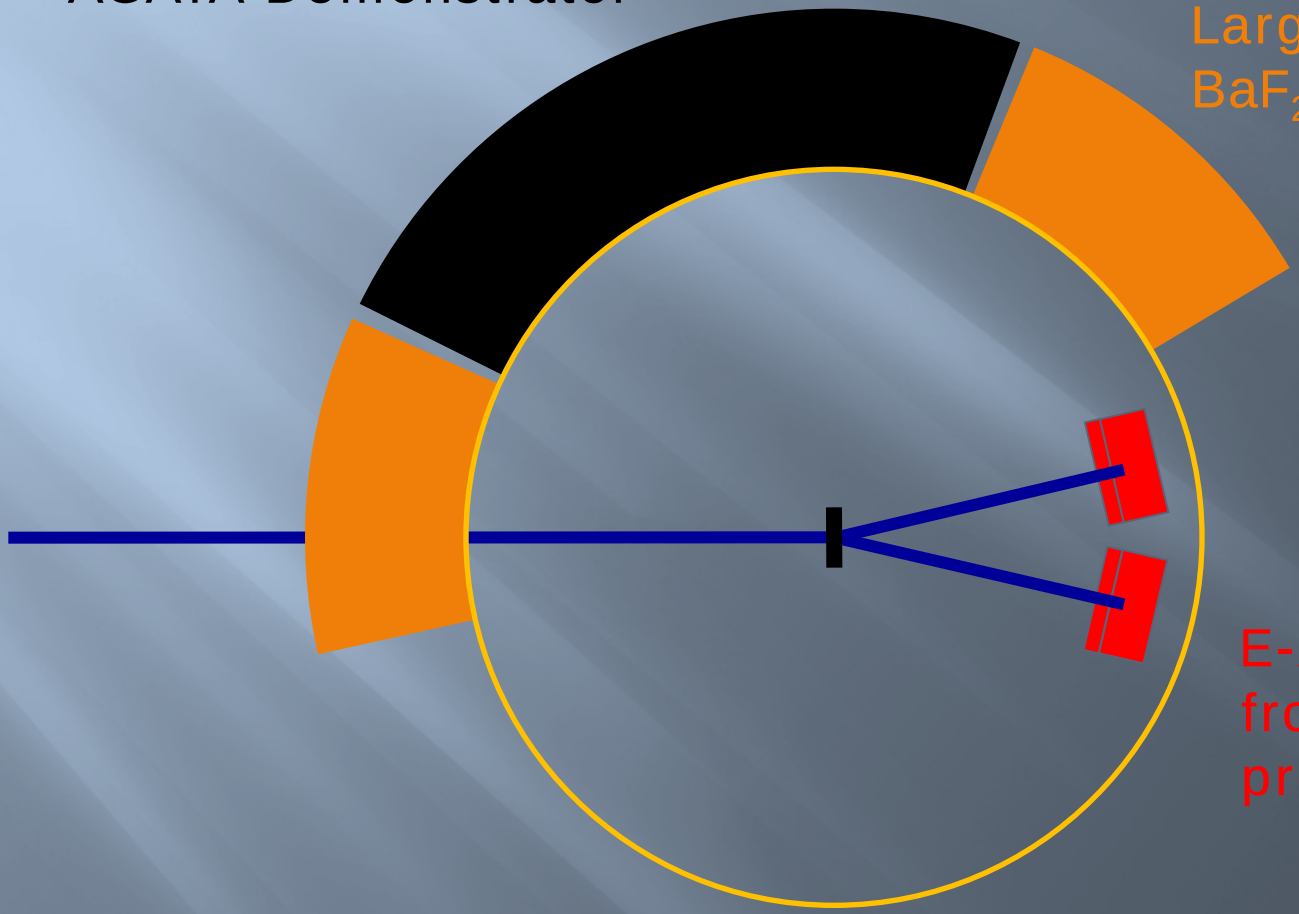
F. E. Bertrand et al NPA 482(1988)287c

Projectile excitation

Experimental setup

AGATA Demonstrator

Scintillator array
Large volume $LaBr_3$:Ce,
BaF_2



E-ΔE Telescopes from the TRACE project

Ejectile detection

Constraints on E^*-E_γ allow to greatly suppress background and select decay branches to g.s. or excited states

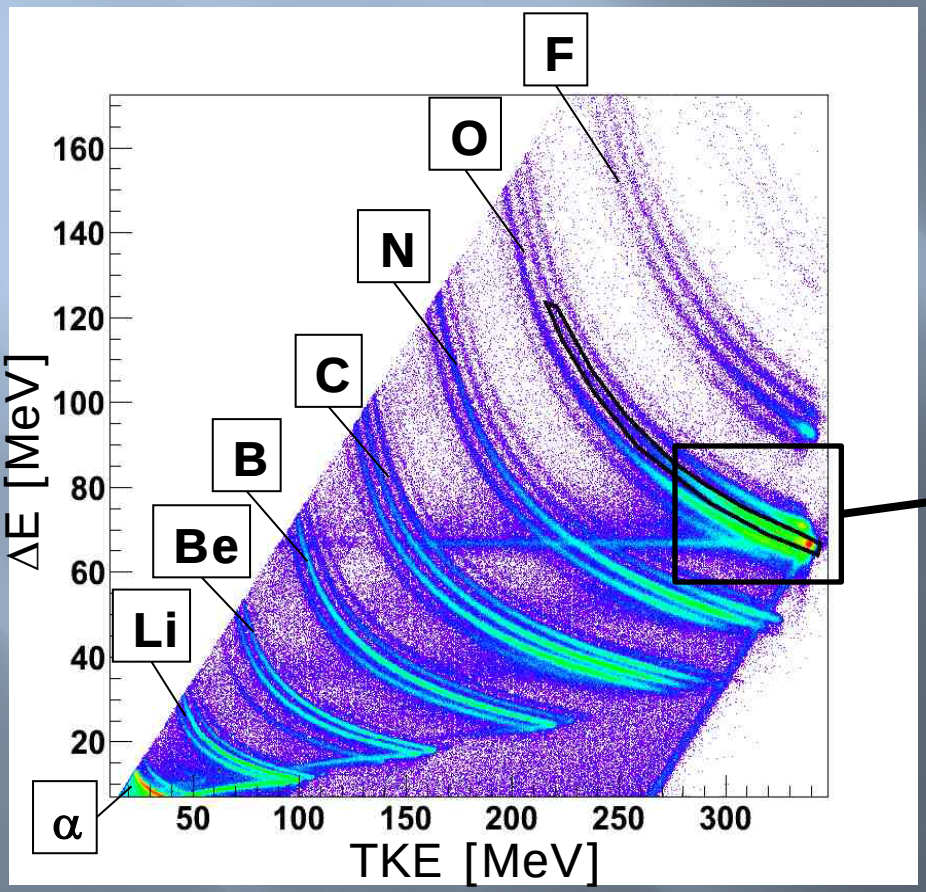
E-ΔE detector must have a high energy resolution for selection of excitation energy (<1%) but also a large solid angle to increase efficiency

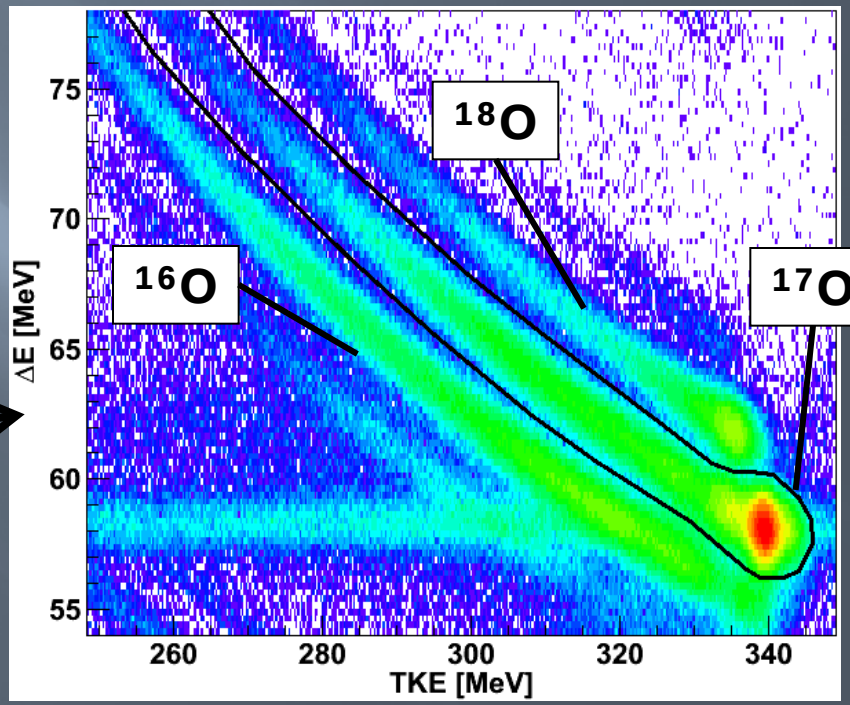
Segmented E-ΔE detector from the TRACE project (D. Mengoni)

- Si-pad technology, 60 (5x12) pixels
- Large number of channels
- Active area of 20x50 mm^2
- Pixel area of 4x4 mm^2
- Cooled to -30 °C
- E detector: 1 mm thick
- ΔE detector: 200 μm thick

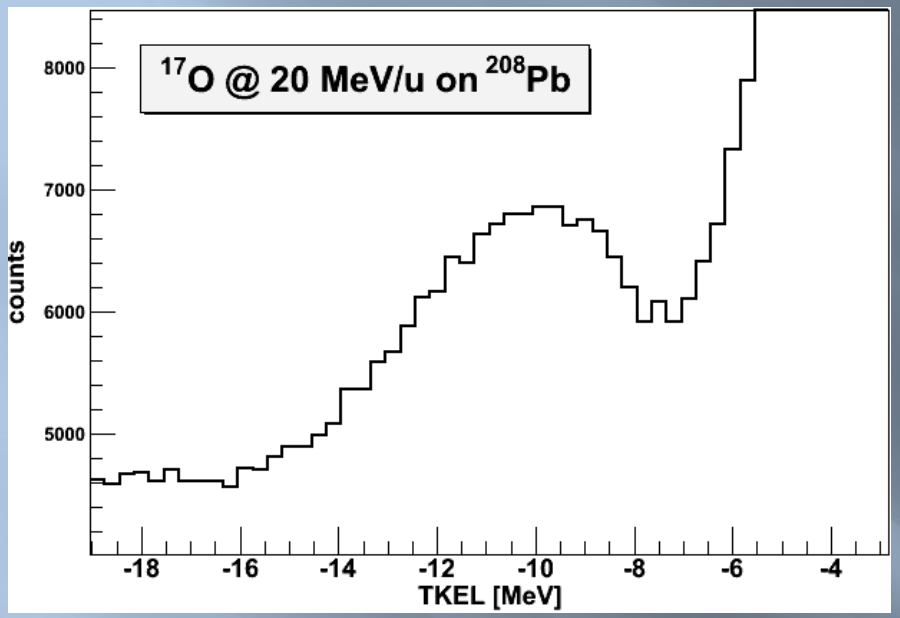
Preliminary results: ejectile identification

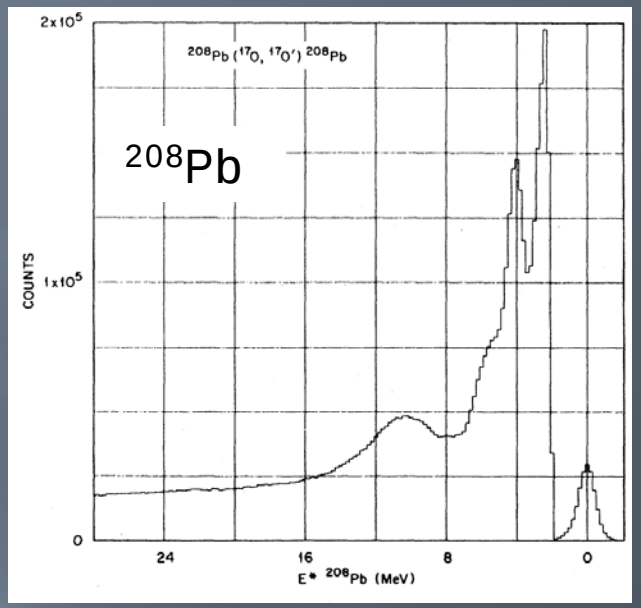
Good charge and mass identification up to Z = 9



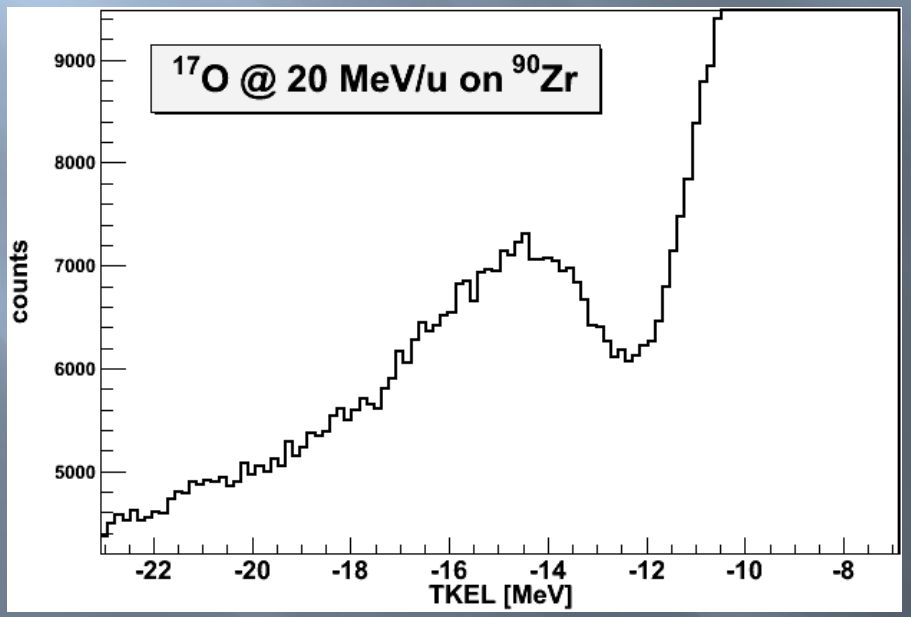


Preliminary results: GQR spectrum





J. Beene et al PRC39(1989)1307

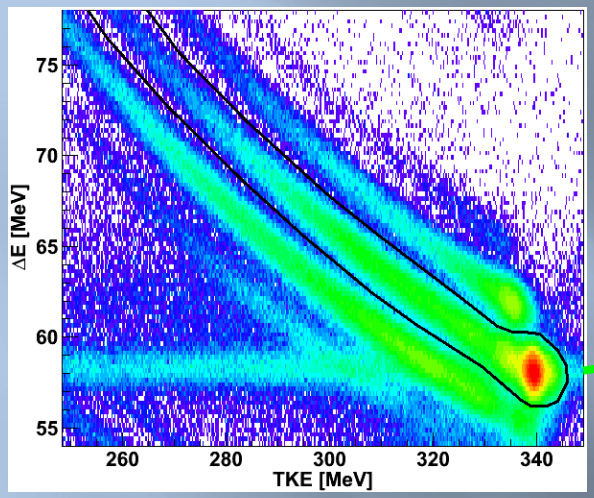


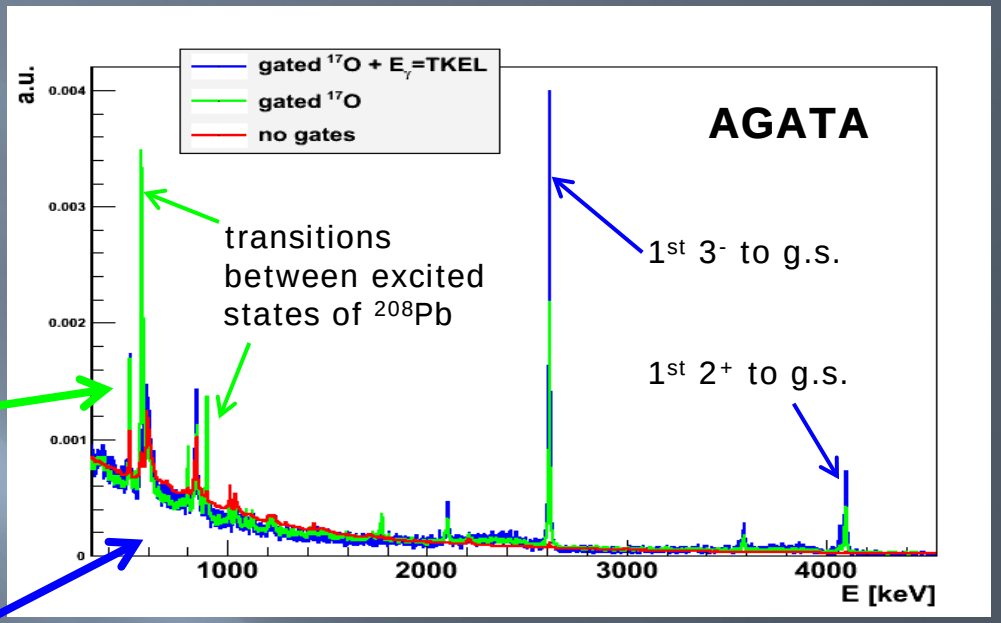
Giant Resonance bump

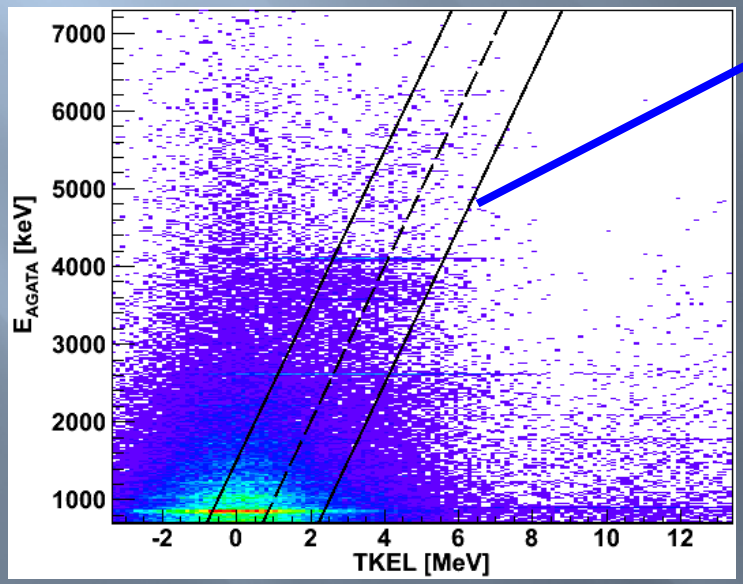
^{208}Pb: E_{GQR} ~ 10 MeV

^{90}Zr: E_{GQR} ~ 14 MeV

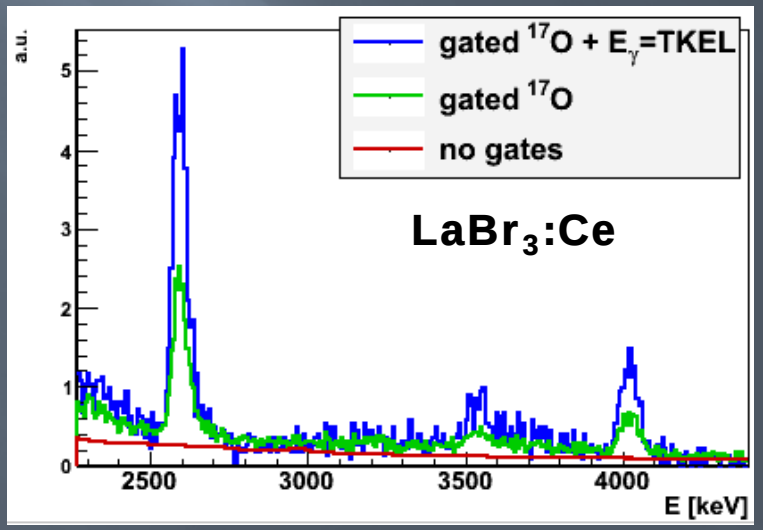
Preliminary results: selectivity







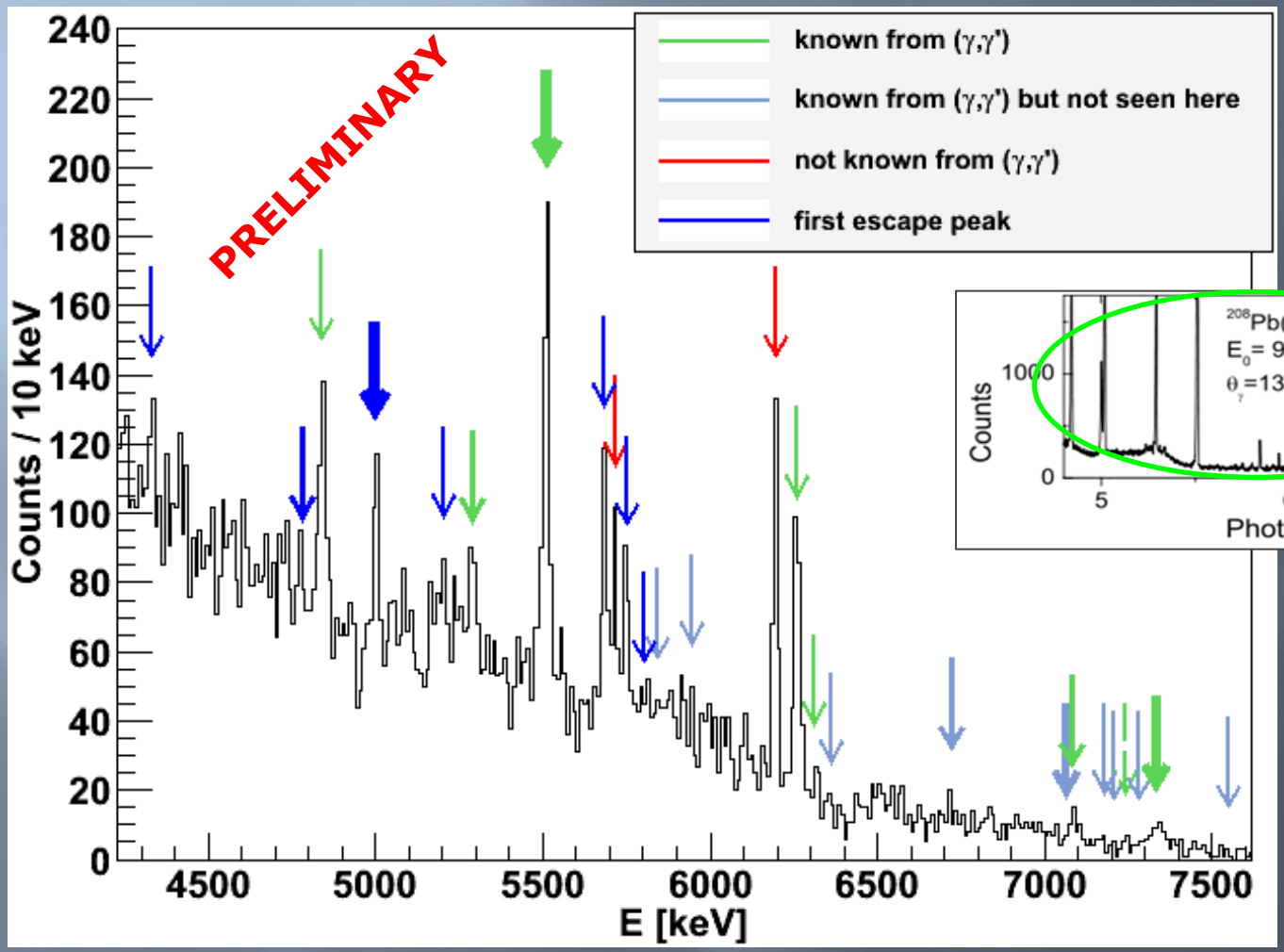
All spectra are normalized to the total number of counts

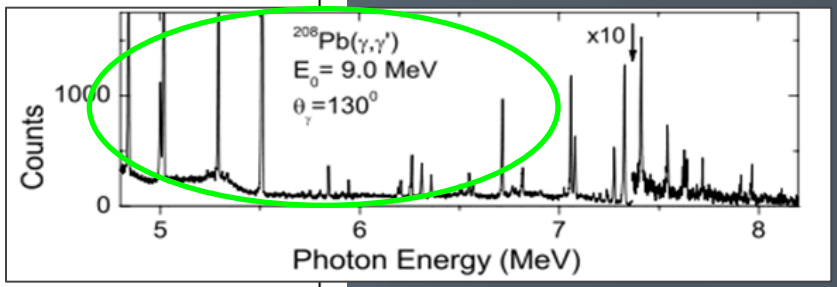


Preliminary results: pygmy states in ^{208}Pb

- Select ^{17}O scattering
- Apply Doppler correction for recoil motion of target
- Select E_γ = TKEL

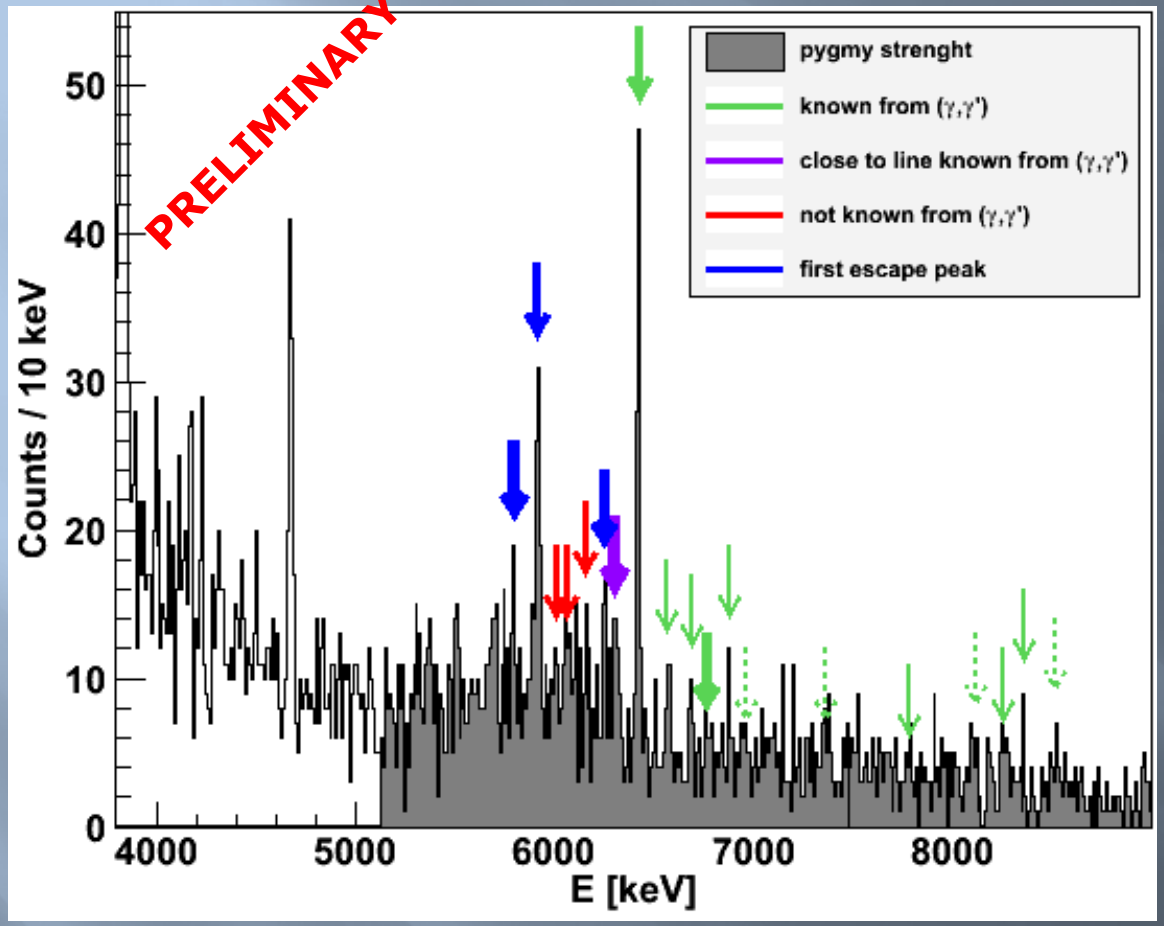
Comparison with NFR:
some known lines are visible, mostly at lower energy
possible new lines

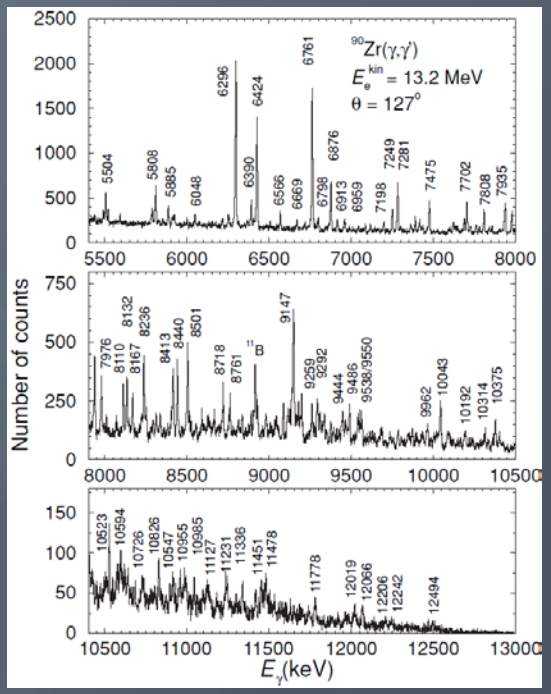




N. Ryezayeva et al.,
PRL 89, 27 (2002)

Preliminary results: pygmy states in ^{90}Zr





R. Schwengner et al.,
PRC 78, 064314 (2008)

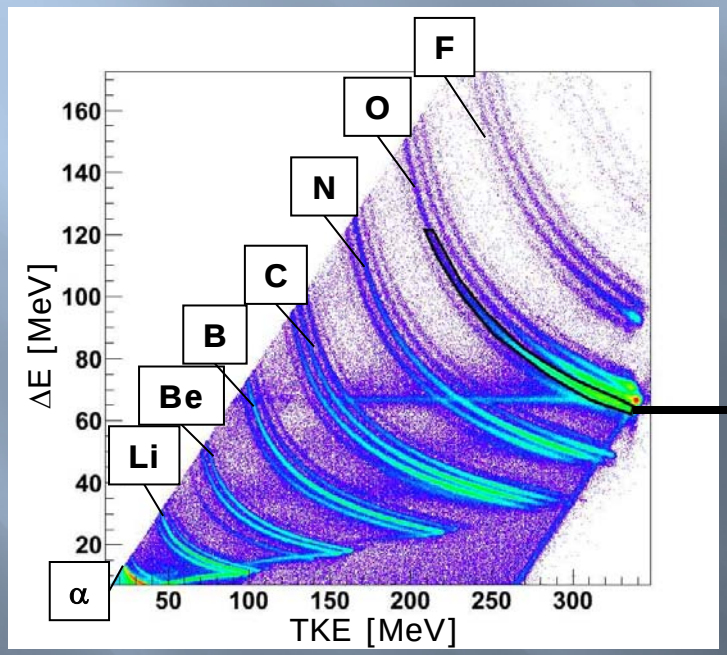
Many lines measured with NFR
Arrows show only the ones seen also in our spectrum
Low statistics at high energy

Preliminary results: Doppler correction

Gamma-rays emitted in-flight

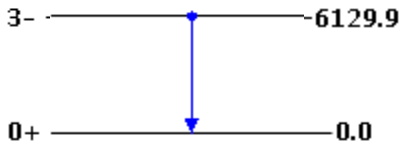
v/c ~ 20%

γ



^{16}O channel: high energy γ-ray low background from target

^{16}O



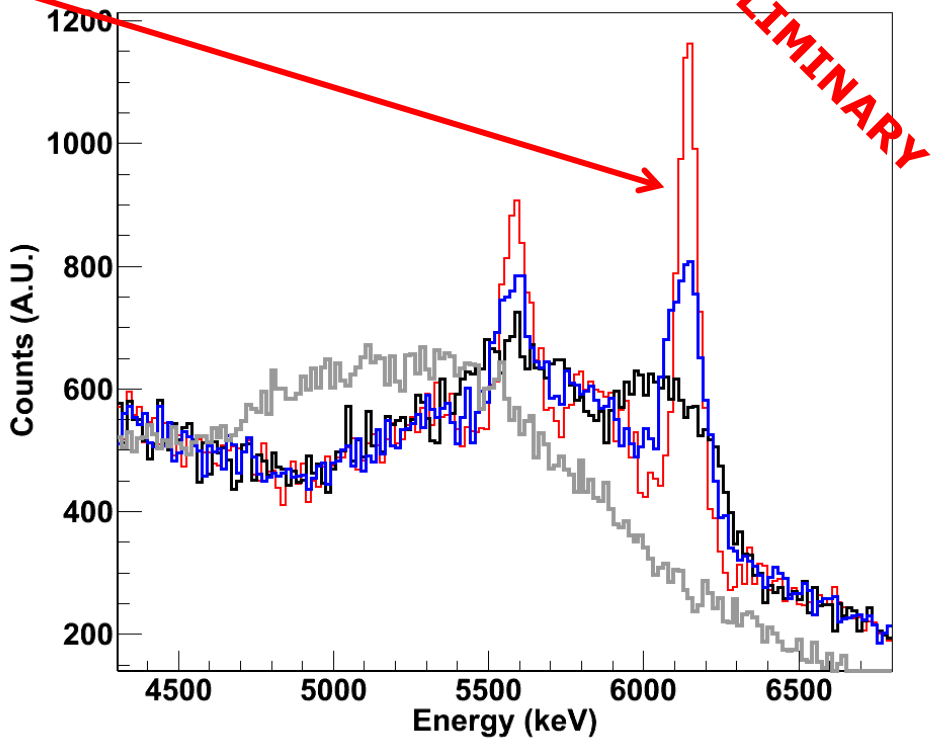
No Dopp Corr

Crystal Centers

Segment Centers

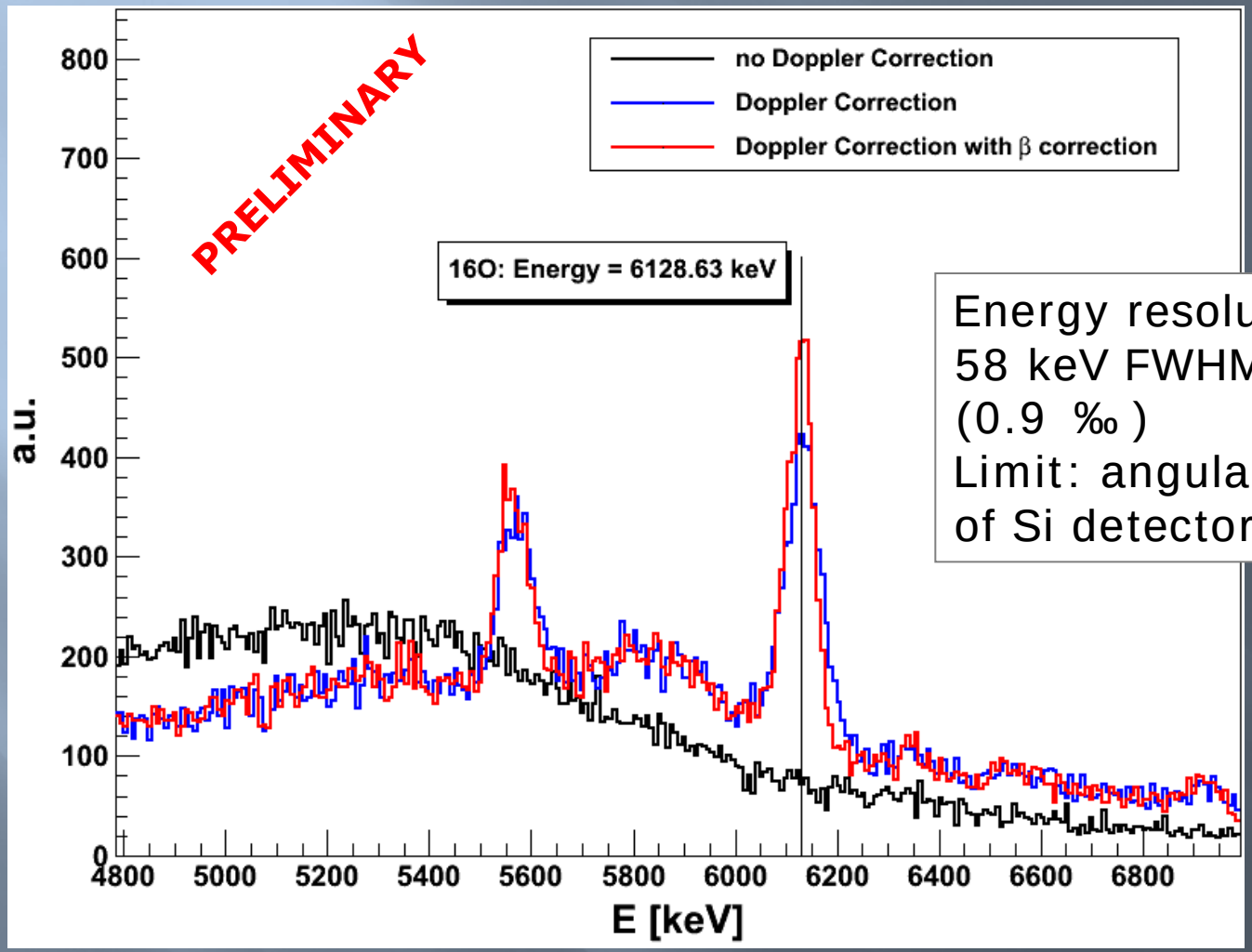
PSA+Tracking

PRELIMINARY



Preliminary results: Doppler correction

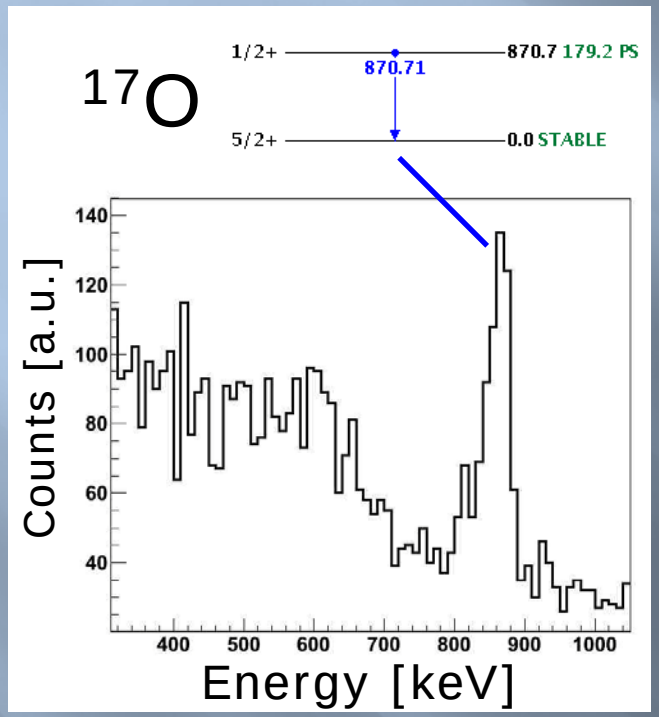
Further improvement in resolution with event-by-event beta calculation from measured TKE

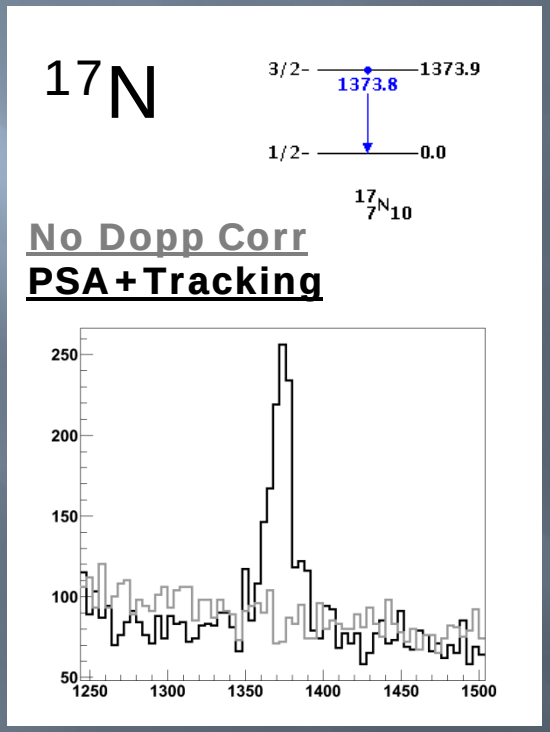


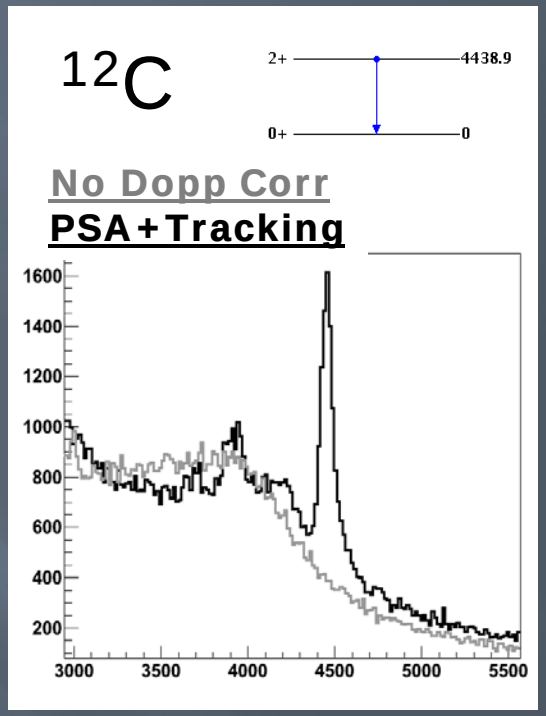
Energy resolution:
58 keV FWHM at 6.1 MeV
(0.9 ‰)
Limit: angular resolution
of Si detectors (~ 3°)

Preliminary results: Doppler correction

^{16}O data were used to optimize the position of Si detectors
Validated with other reaction channels







Si position information was used to calculate the direction of the recoil for target nucleus in an inelastic scattering event

Summary

- Measurement of gamma decay from highly excited states populated with inelastic scattering of heavy ions
- Reactions:

^{208}Pb(^{17}O,^{17}O')^{208}Pb @ 20 MeV/u

^{90}Zr(^{17}O,^{17}O') ^{90}Zr @ 20 MeV/u

- Preliminary results for "pygmy" states in ^{208}Pb and ^{90}Zr
  - confirmed some states known from (γ,γ') experiments, mostly at low energy
  - possible new states
- Doppler correction for ^{16}O: resolution of 58 keV at 6.1 MeV (limit: Si angular resolution)

To- do list

- Response function (GEANT4, Radware)
- Extraction of B(E1) values
- Estimate the sensitivity limit

- Scintillator spectra (integrated strength)

- GQR decay and branching

Collaboration

R. Nicolini[a], D. Mengoni[c,h], A. Bracco[a], S. Leoni[a], F. Camera[a], D. Bazzacco[c], E. Farnea[c], A. Gadea[b,d], G. Benzoni[a], F. Birocchi[a], N. Blasi[a], C. Boiano[a], S. Brambilla[a], A. Camplani[a], A. Corsi[a], F.C.L. Crespi[a], A. Giaz[a], B. Million[a], L. Pellegri[a], S. Riboldi[a], V. Vandone[a], O. Wieland[a], G. De Angelis[b], P. Molini[b], D. R. Napoli[b], F. Recchia[b], E. Sahin[b], J.J. Valiente-Dobon[b], A. Gottardo[c], C. Michelagnoli[c], D. Montanari[c], C. Ur[c], A. Maj[e], M. Kimiecik[e], M. Ciemala[e], R. Kempley[f], A. Bürger[g]

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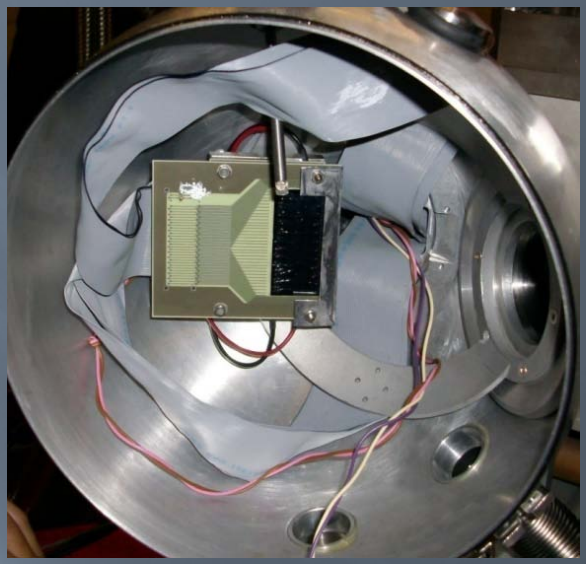
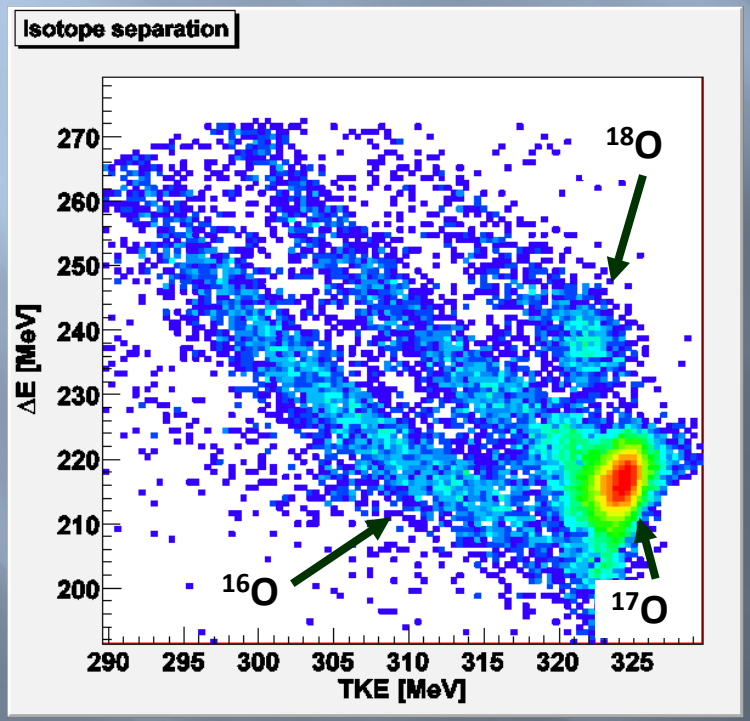
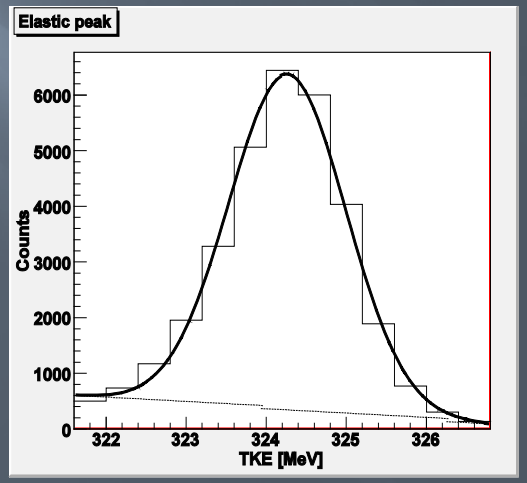
Thank you for the attention

^{17}O @ 19 MeV/u
^{208}Pb target 2 mg/cm^2

- 1 telescope at 13°
- ΔE detector – 500 μm
- E detector – 1 mm

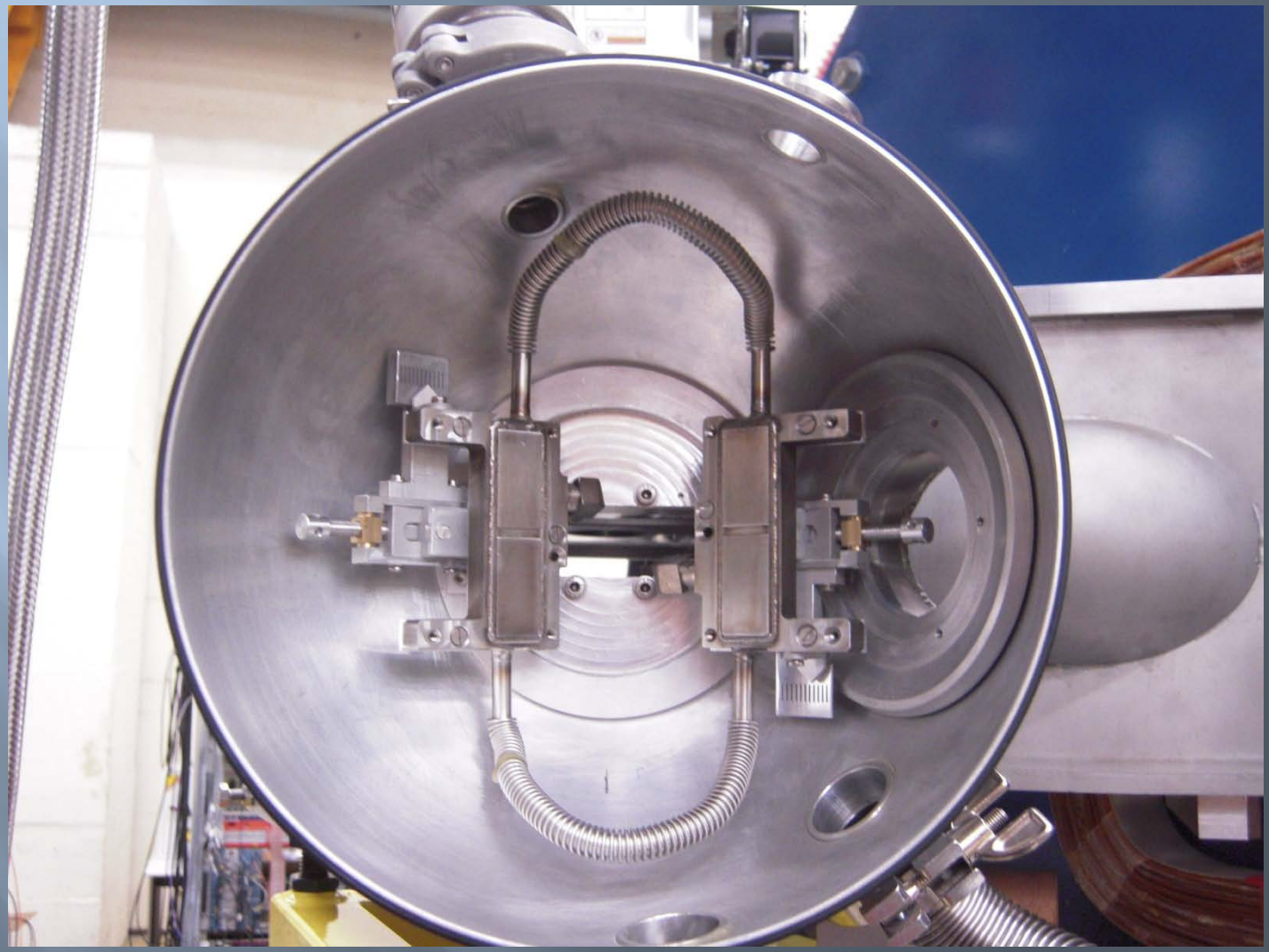


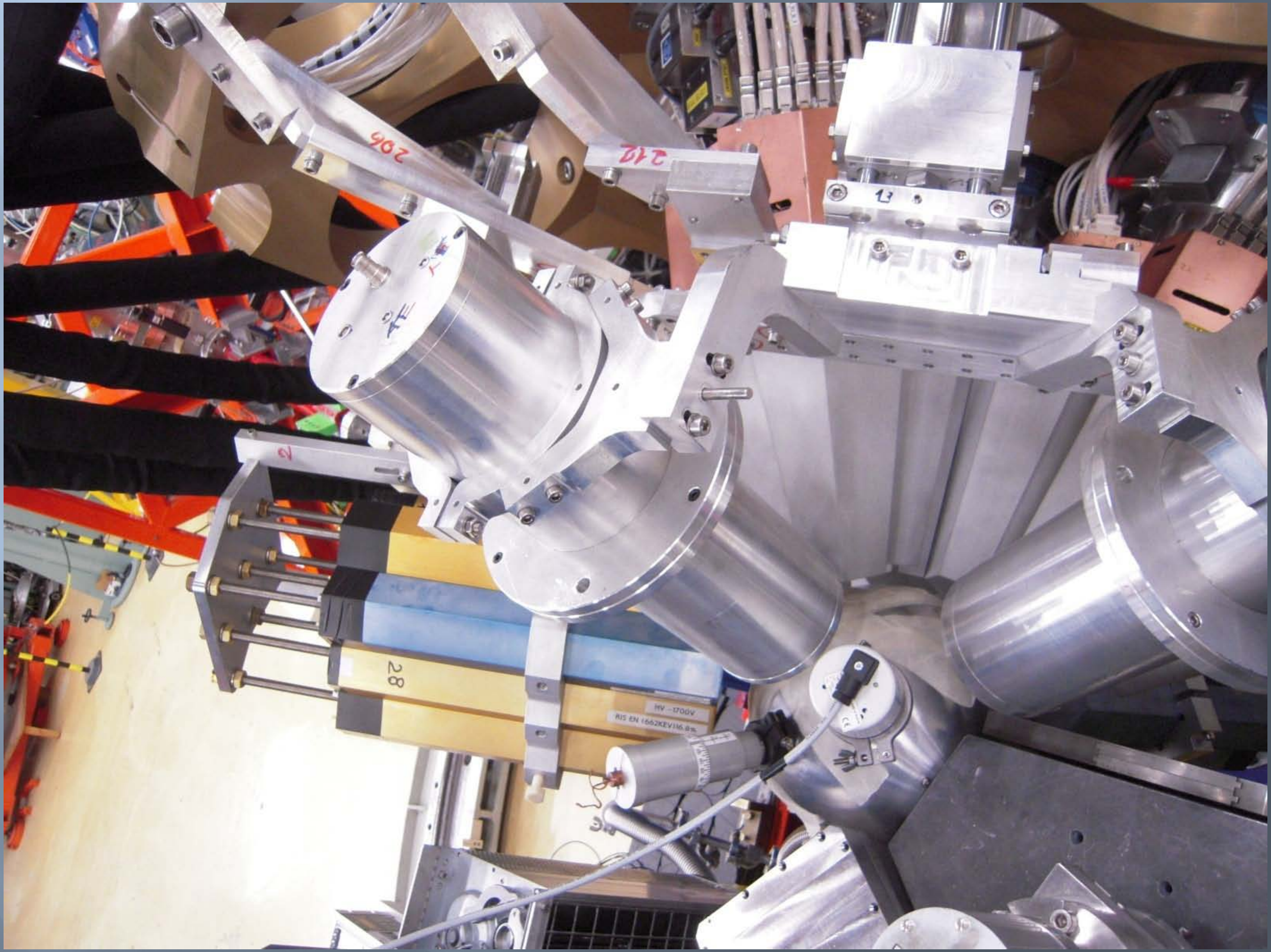




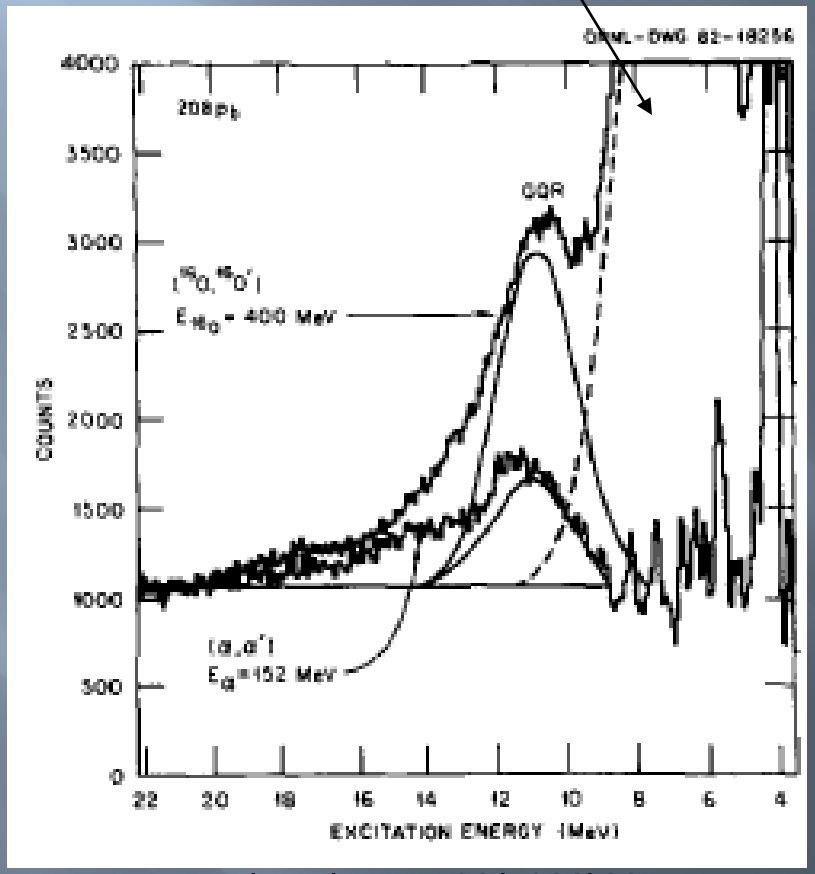
Clean separation of isotopes

FWHM = 1.5 MeV (5 ‰)

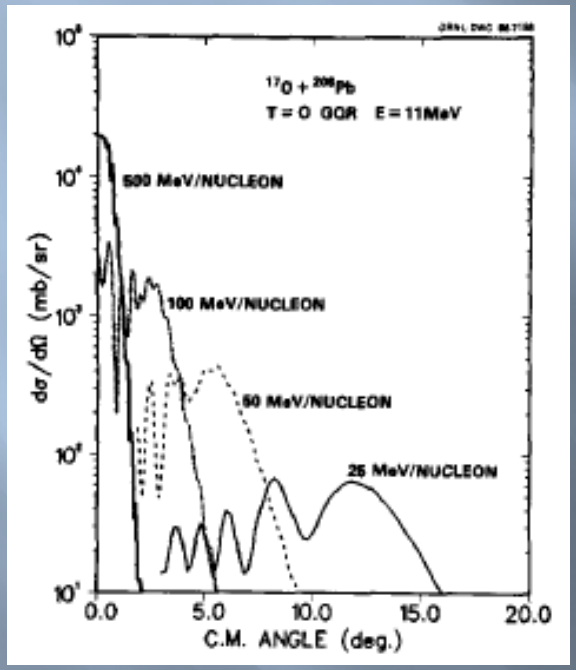




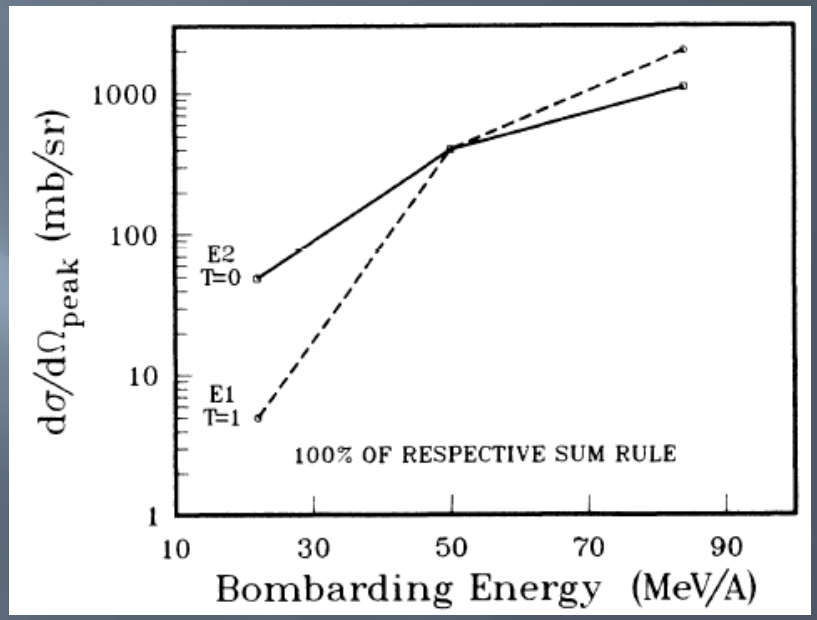
Projectile excitation



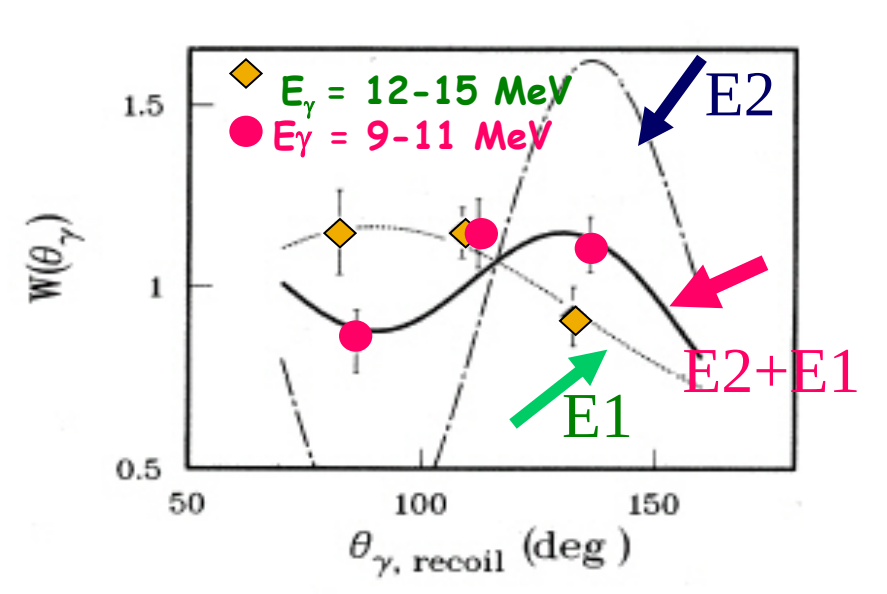
F.E.Bertrand et al NPA 482(1988)287c



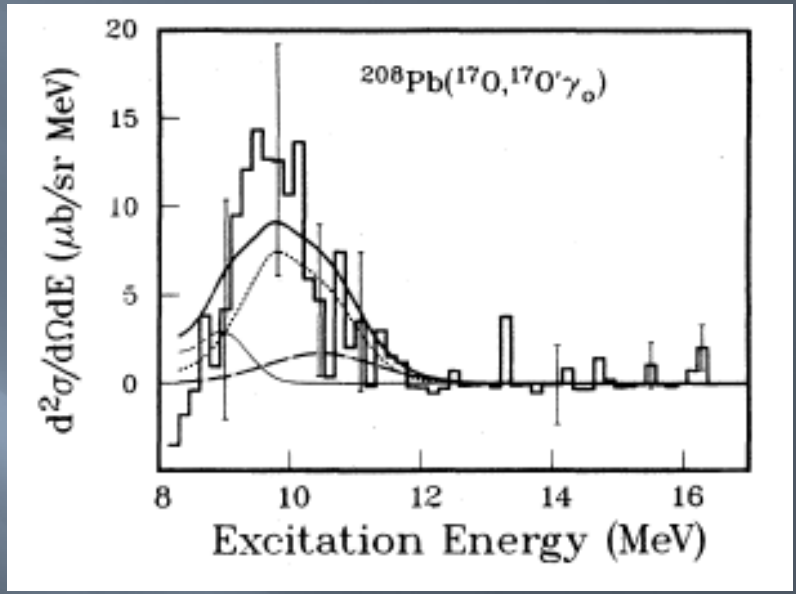
F.E.Bertrand et al NPA 482(1988)287c



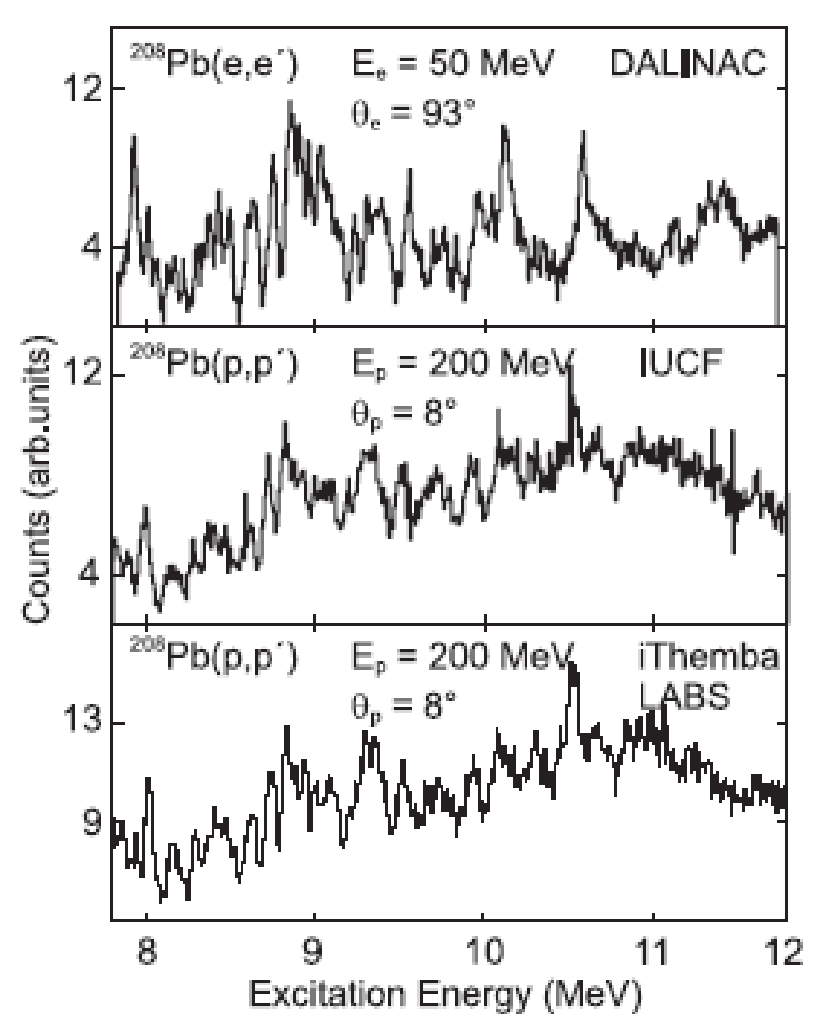
J. Beene et al. PRC41(1990)929

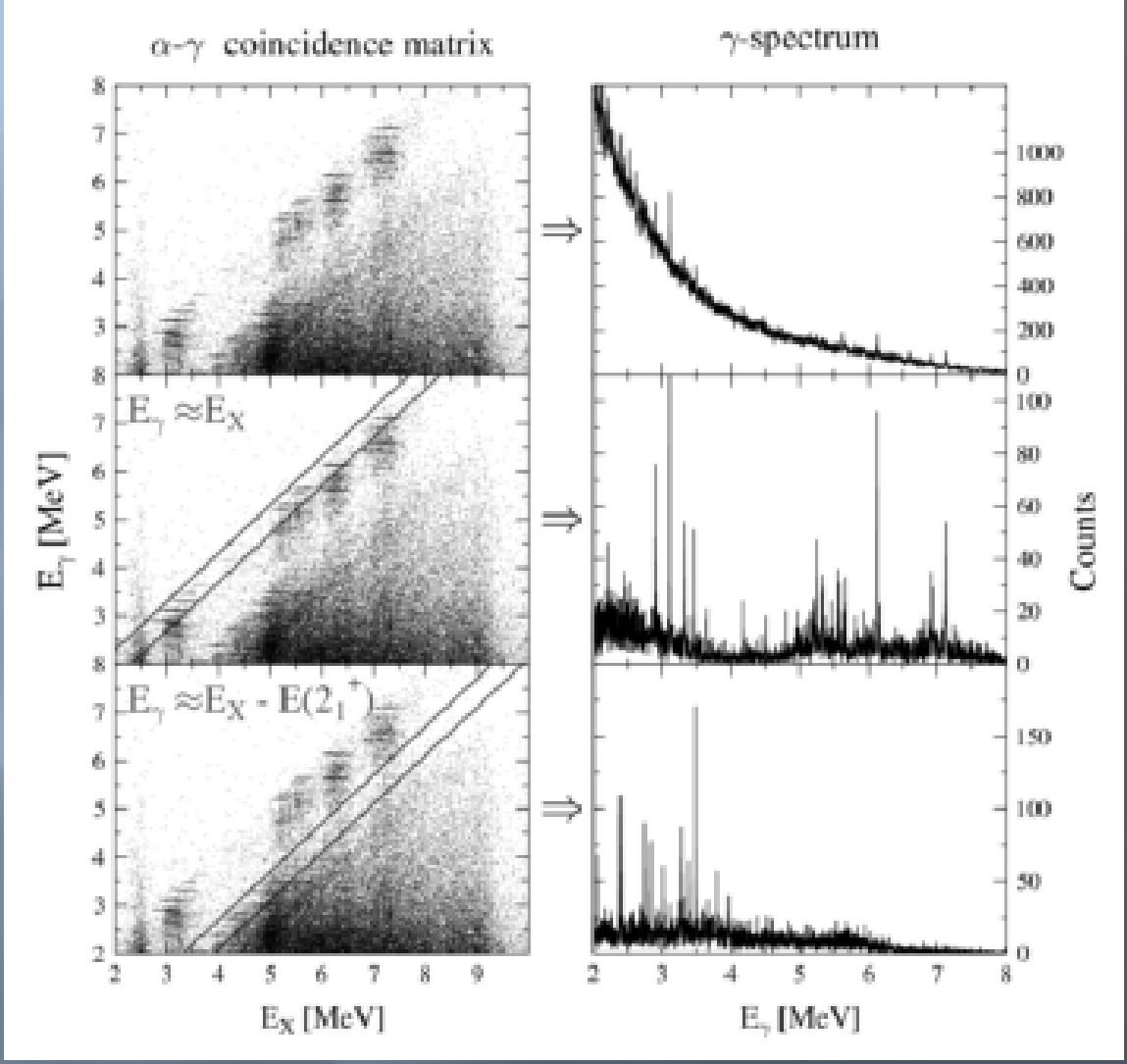


J. Beene et al PRC39(1989)1307



J. Beene et al PRC39(1989)1307


^{208}Pb(e,e´)
E_e = 50 MeV
θ_e = 93°
DALINAC
^{208}Pb(p,p´)
E_p = 200 MeV
θ_p = 8°
IUCF
^{208}Pb(p,p´)
E_p = 200 MeV
θ_p = 8°
iThemba LABS
Counts (arb.units)
Excitation Energy (MeV)



D. Savran et al., PRL97(2006)172502