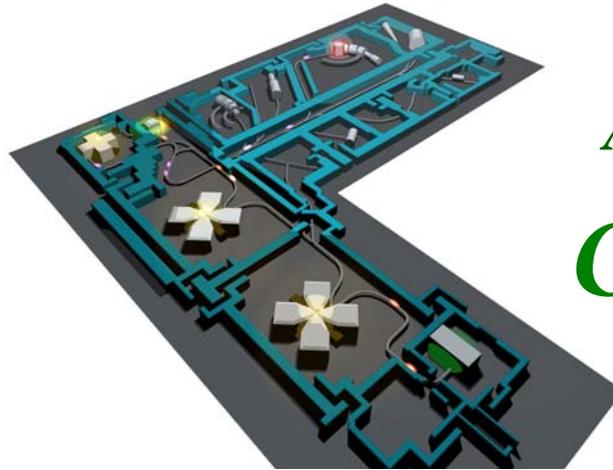


Exogam+ Vamos +

Towards a new era



A. Navin

GANIL

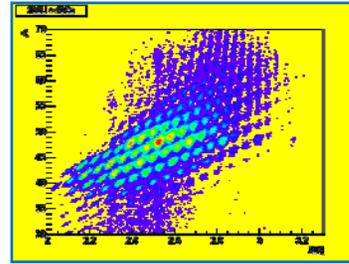
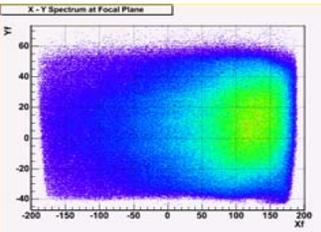
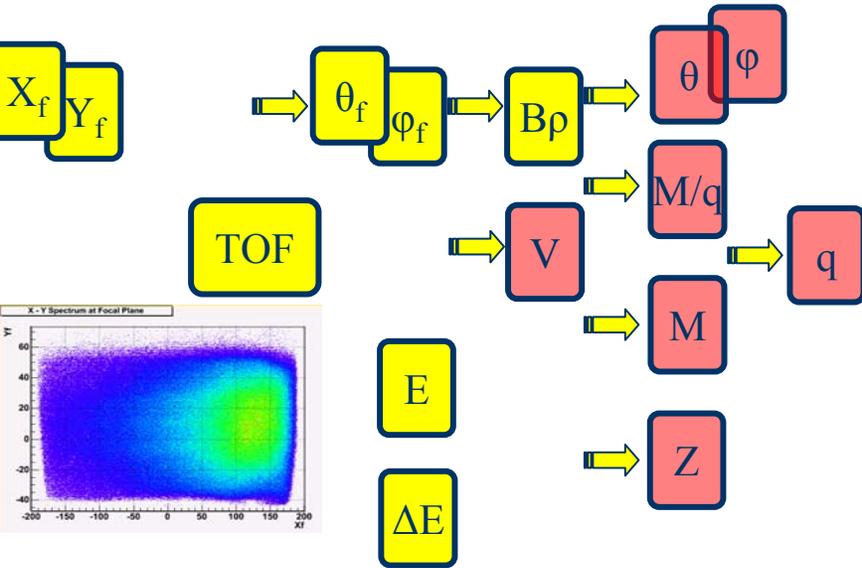
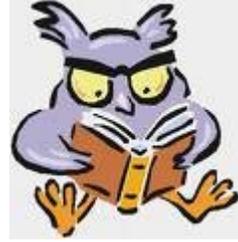
Plan: Brief overview E+V

Stable Heavy beams: Deep inelastic scattering E+V

ISOL Radioactive beams: E+V+T+M2 Power of Direct reactions

Future plans: Increased sensitivity

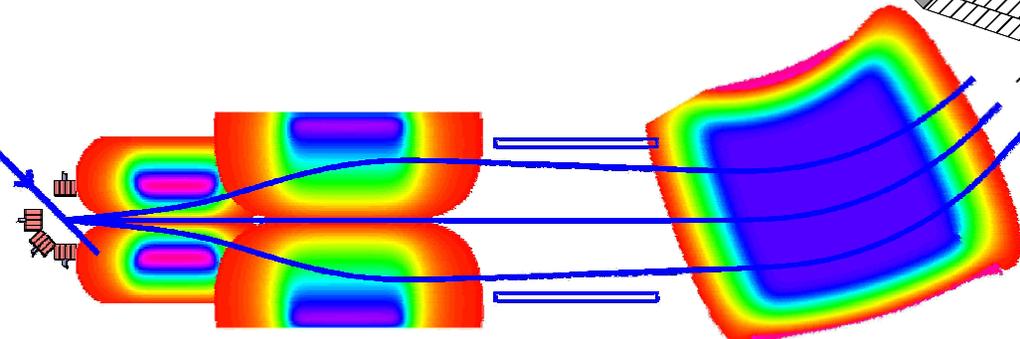
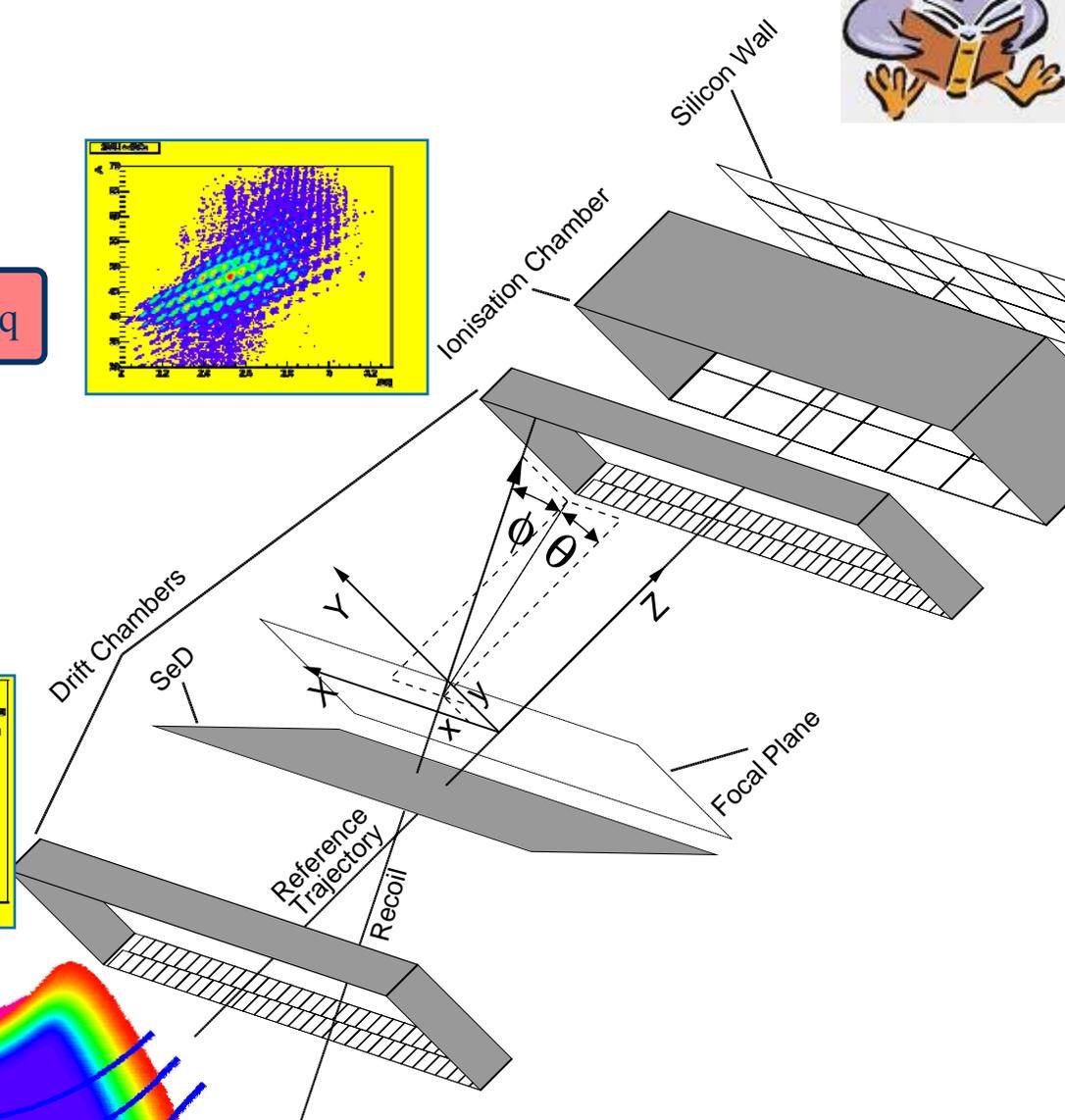
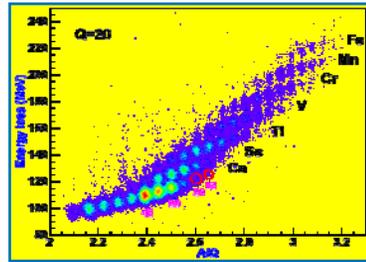
Software spectrometer



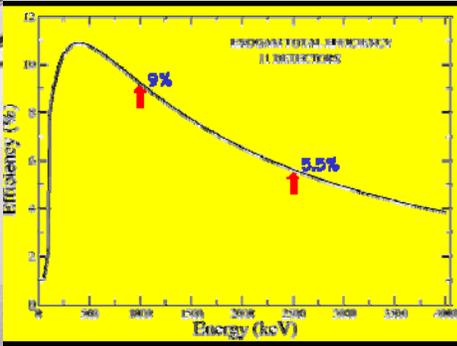
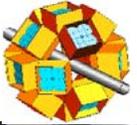
$$M/q \sim B\rho \times \text{TOF}$$

$$M \sim E \times \text{TOF}^2$$

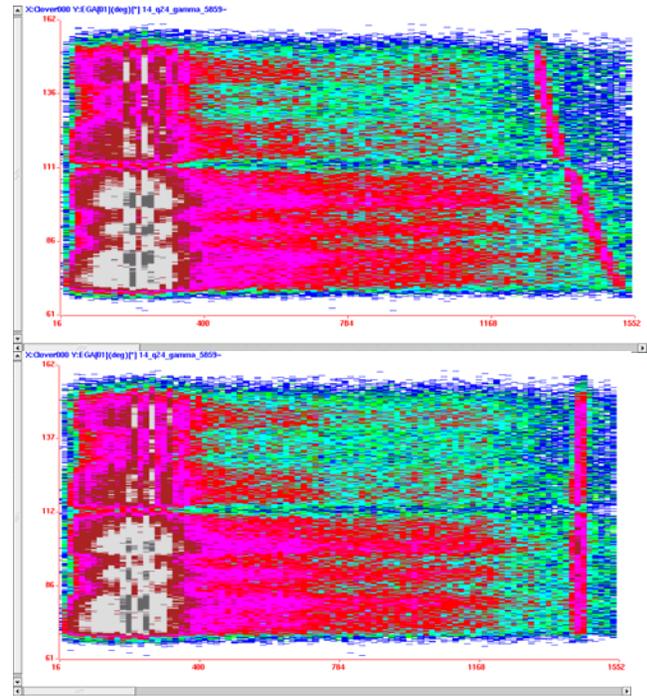
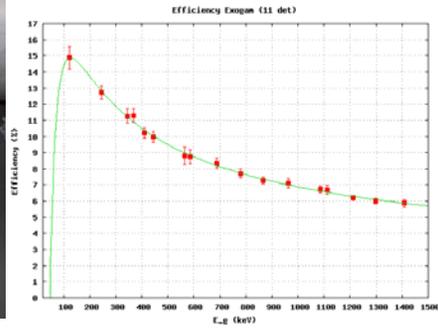
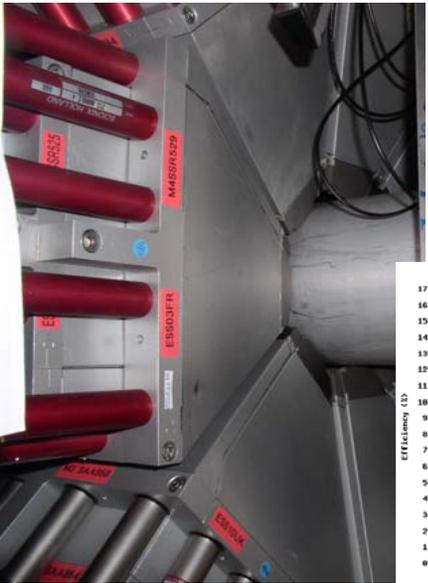
$$Z \sim E \times \Delta E$$



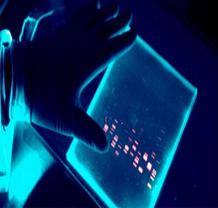
Performance of the VAMOS for reactions near the Coulomb barrier NIM A (in press)



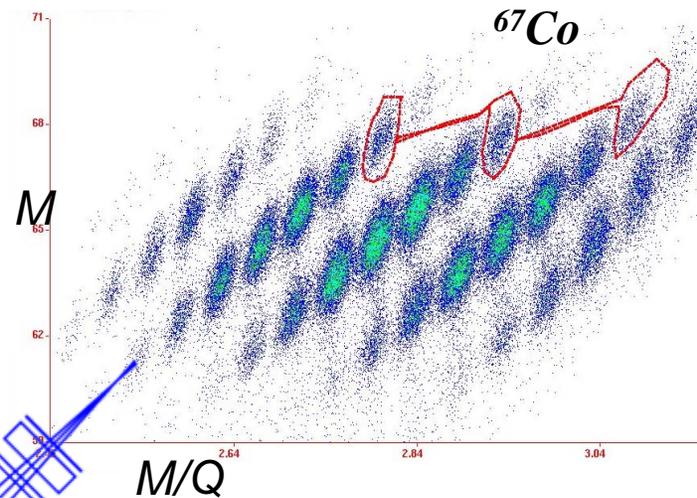
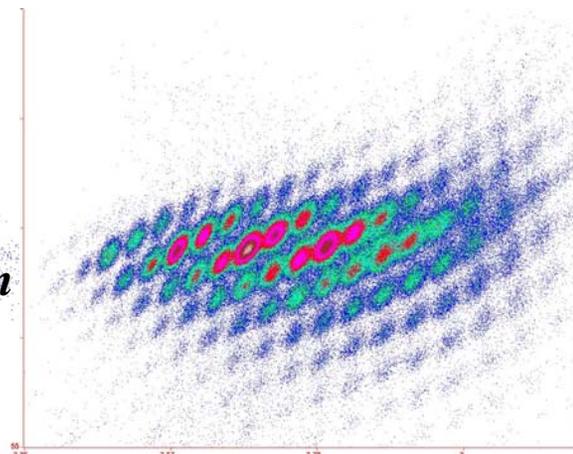
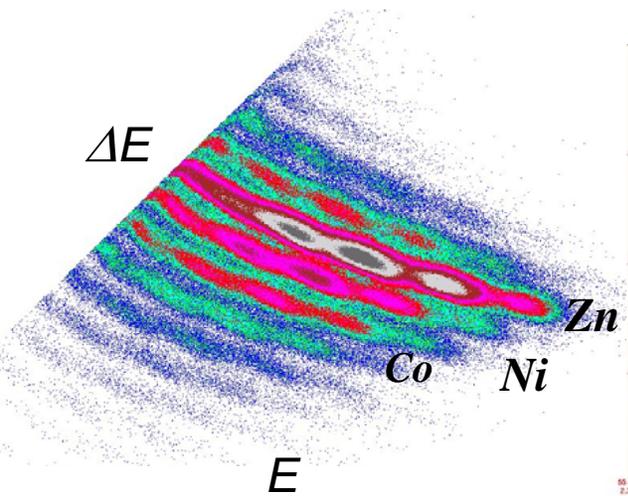
4K triggers 25 % deadtime



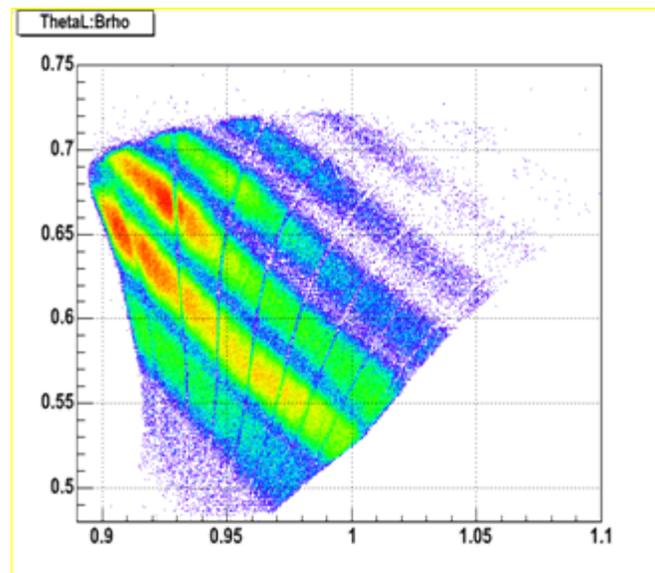
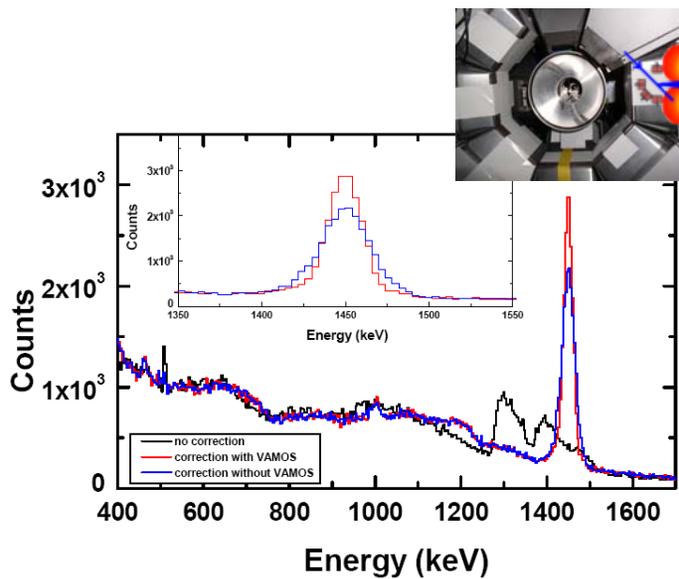
Correlations



Who am I



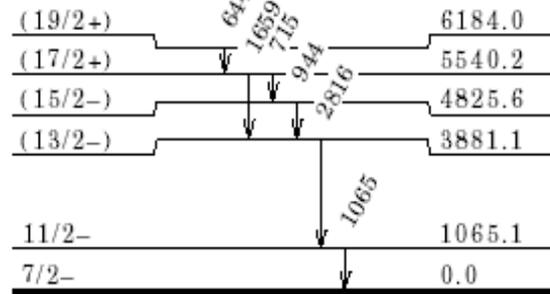
Z resolution verified ~ 50



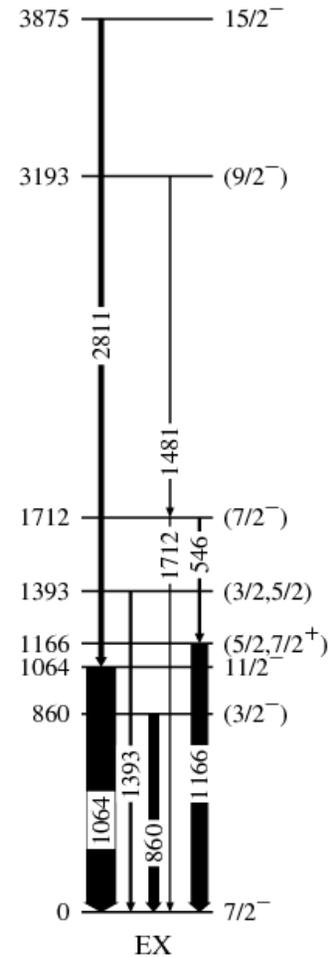
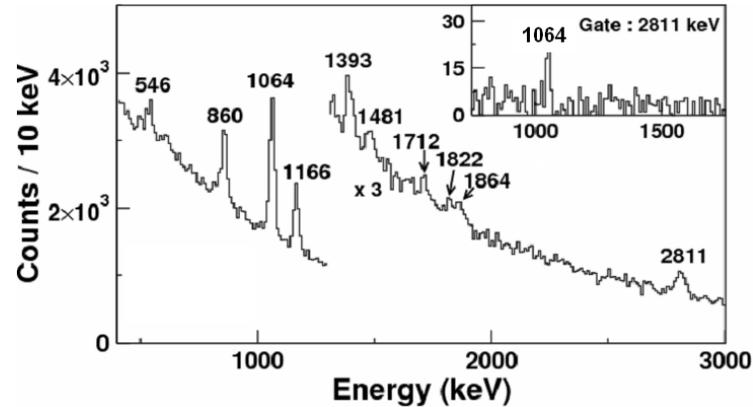
What more can $E+V$ do

(I) Unbiased spectra!

DIC (Thick target)

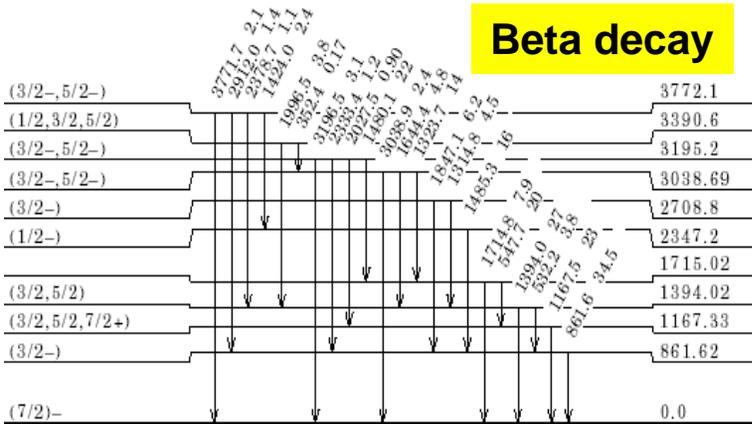


$^{51}_{21}\text{Sc}_{30}$



$^{51}_{21}\text{Sc}_{30}$

Beta decay



$^{51}_{21}\text{Sc}_{30}$

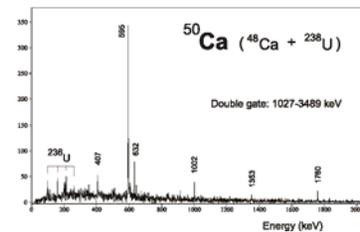
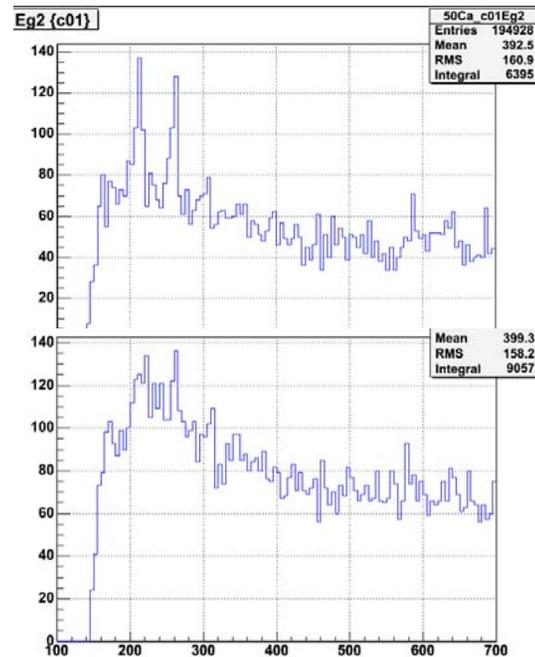
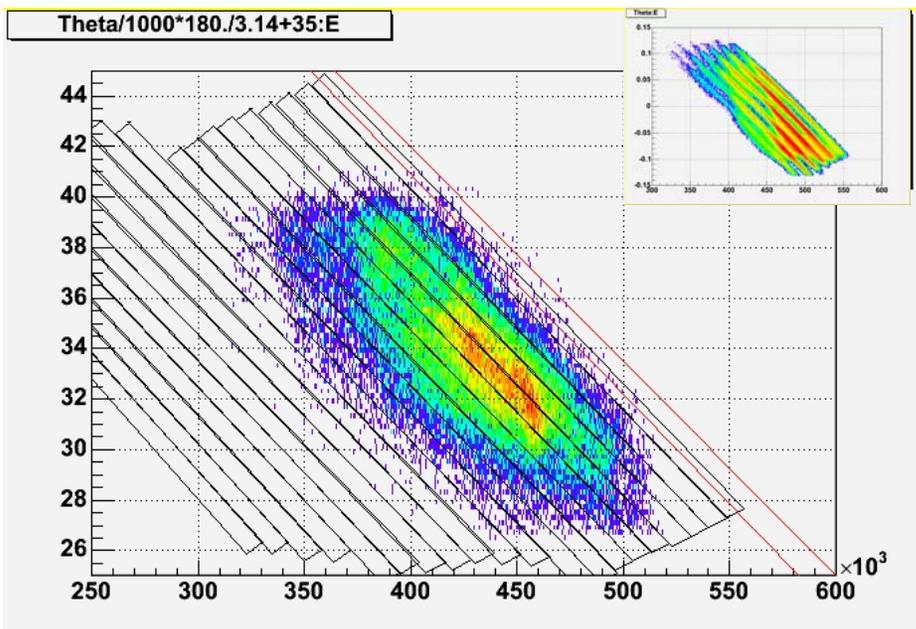
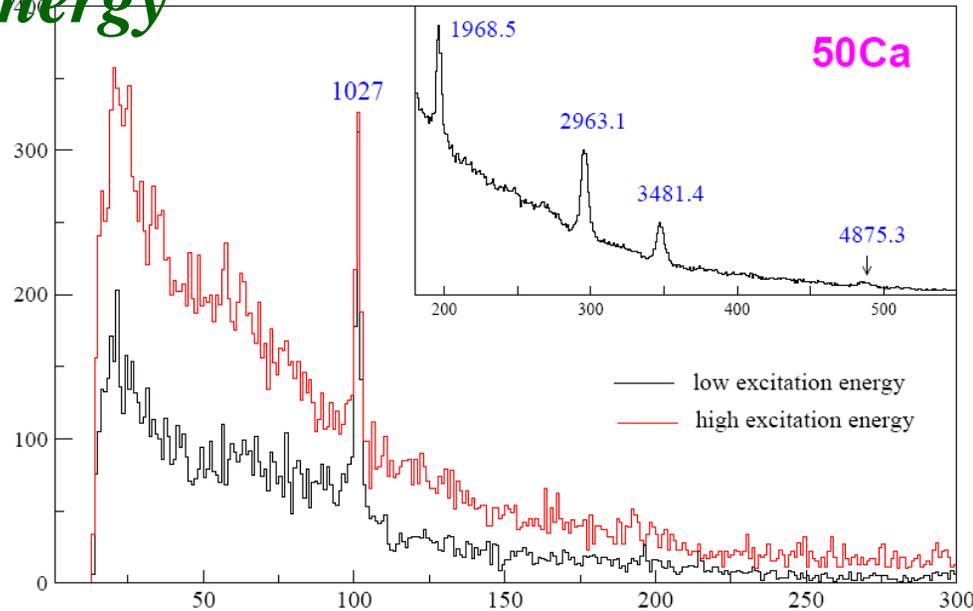
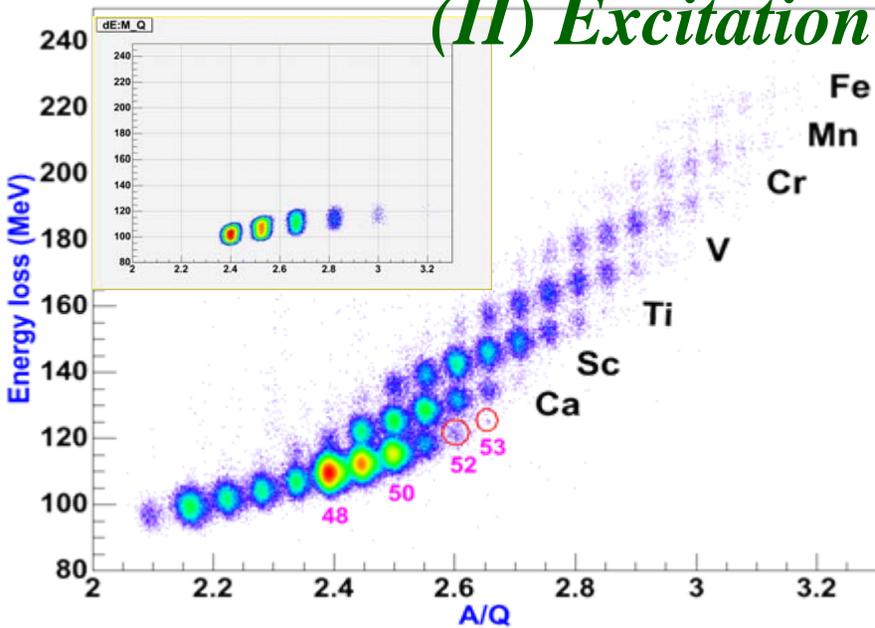
Yrast and non yrast states
Populated in DIT

Present work (EXOGAM + VAMOS)

Man in prep

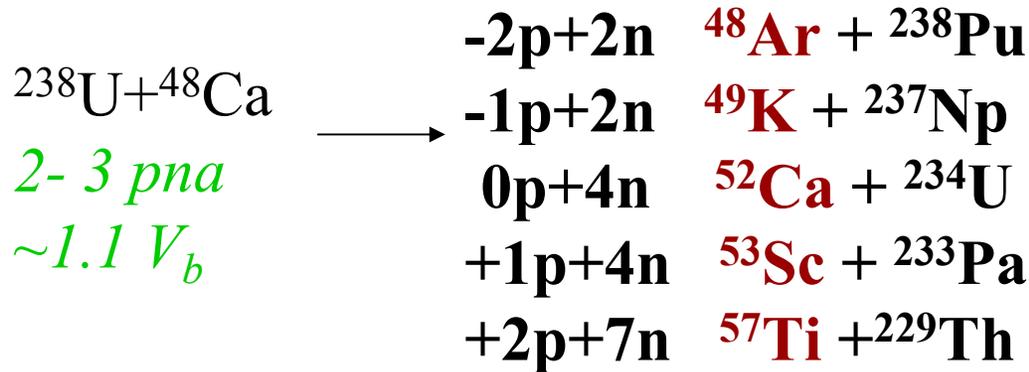
What more can $E+V$ do

(II) Excitation energy



Reaching new frontiers with Deep inelastic reactions at GANIL

Been there done it Cracow-ANL-MSU, Legnaro



We do it our way
Inverse kinematics

Si to Ni

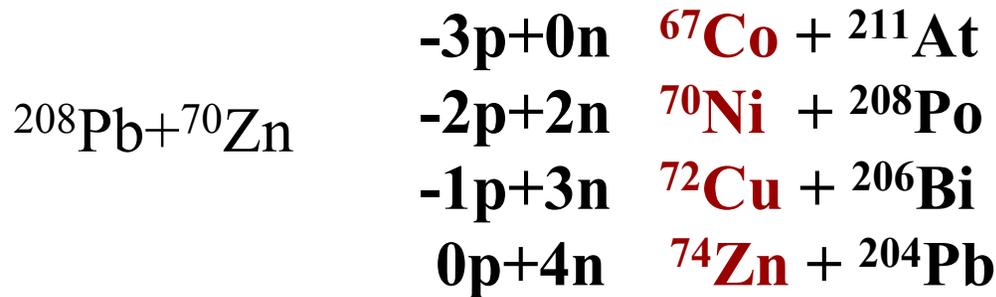
PRC 76 021304R (07)

PRL submitted

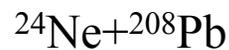
Man in preparation



(NIM A in press)



γ - γE^* gated



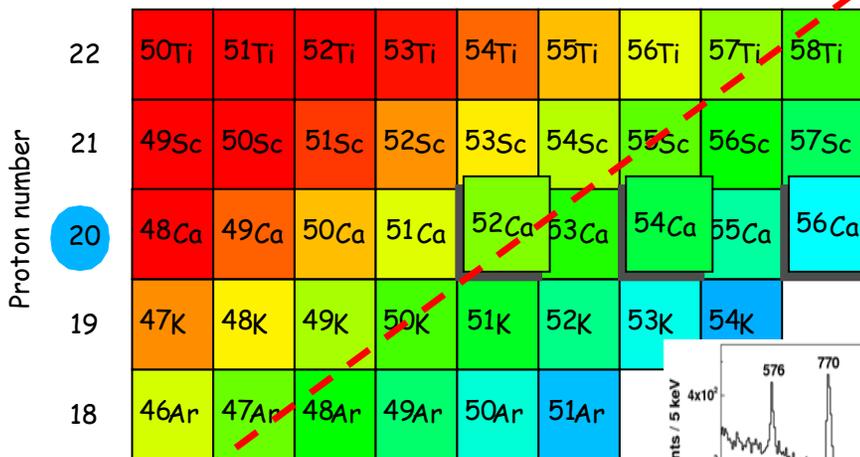
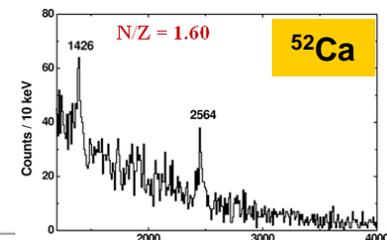
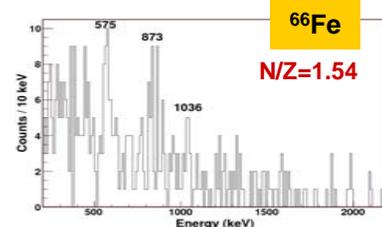
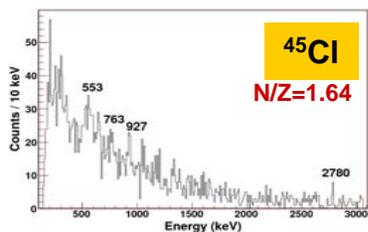
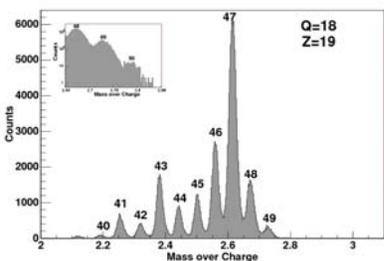
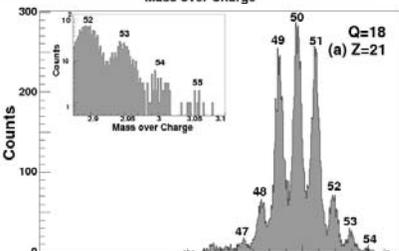
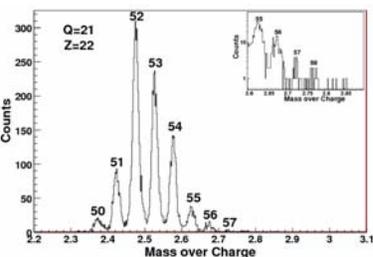
$10^5/\text{sec}$



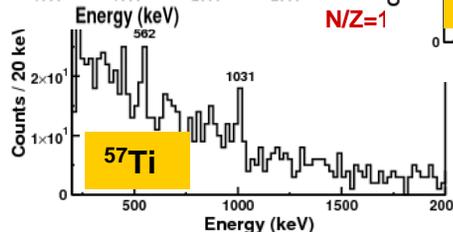
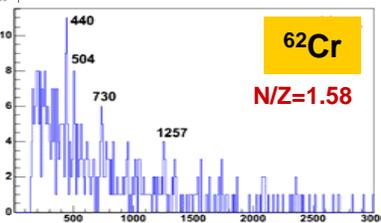
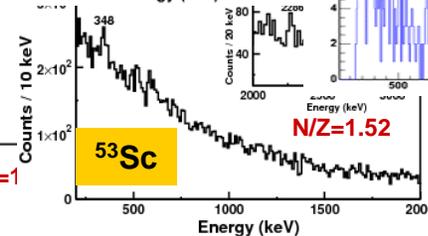
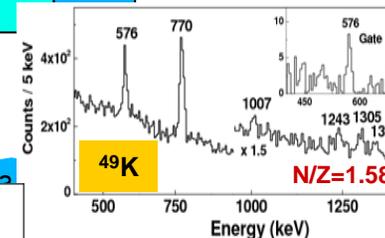
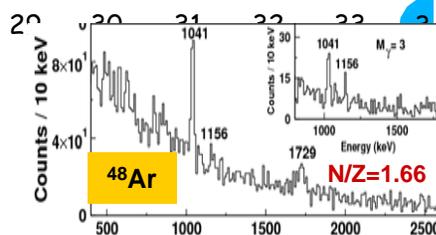
Use RIB's

Large acceptance Spectrometer and high efficiency Gamma-array

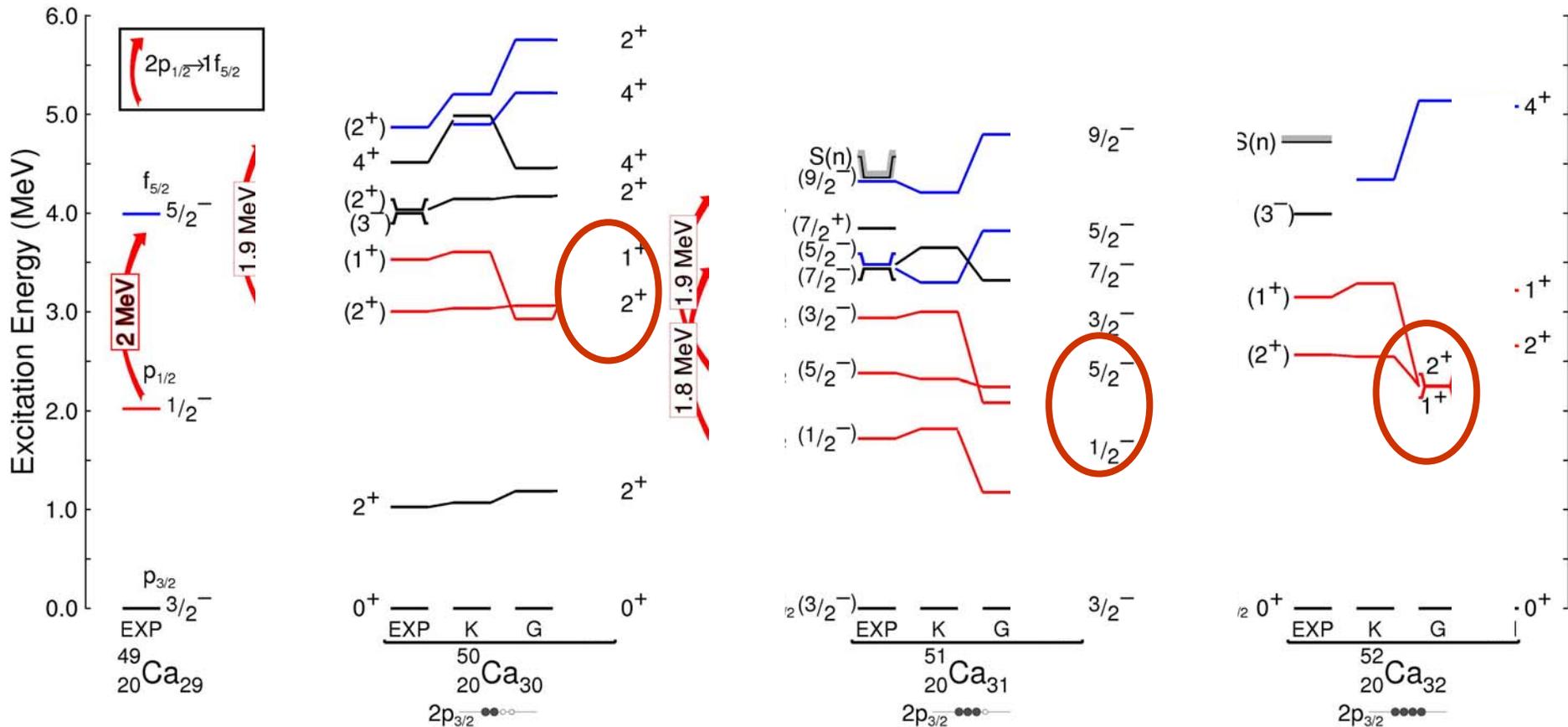
Direct identification of nuclei at the limit and population of excited states



28



Evolution of shell structure with Isospin in Ca isotopes



Is N=34 a new 'shell closure' in Ca ? Subjective



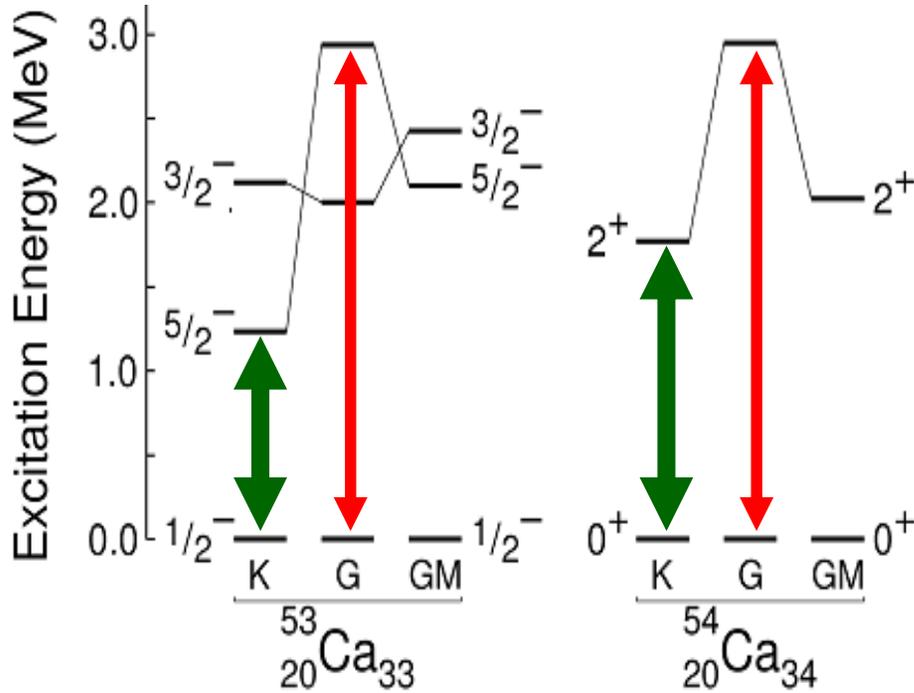
K KB3Gm Yes



G GXPF1A No

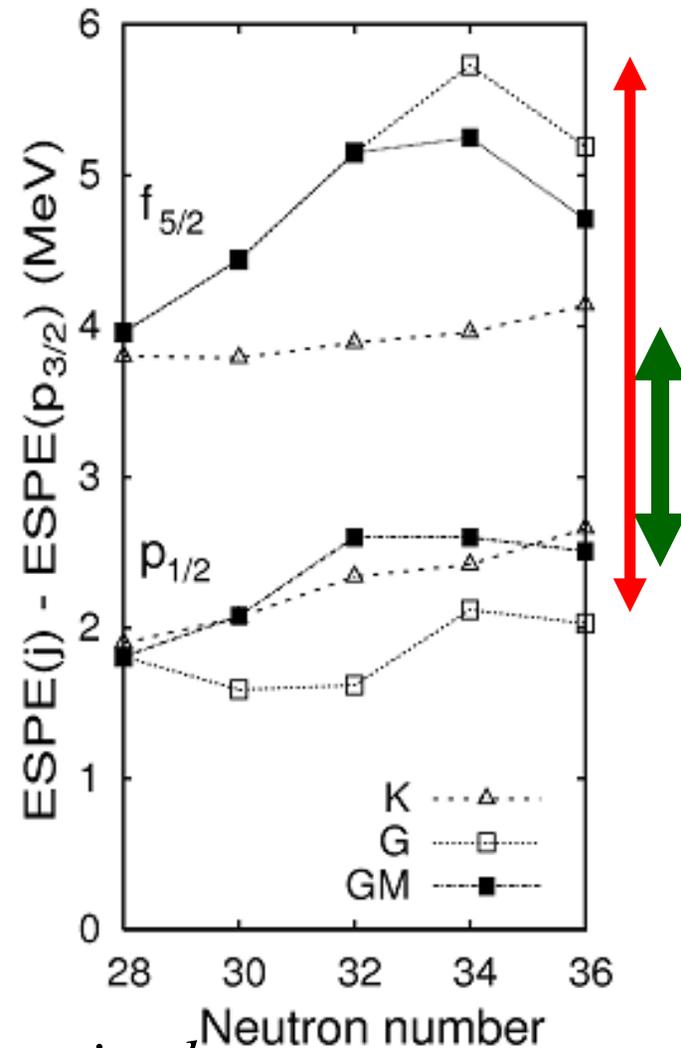
GM G modified $\langle p_{3/2} p_{3/2}, 1^+ | V | p_{3/2} p_{3/2}, 1^+ \rangle$

On(nO) shell closure of N=34



No Shell closure at N=34

Beyond mean field PRL 99, 062501 (2007)

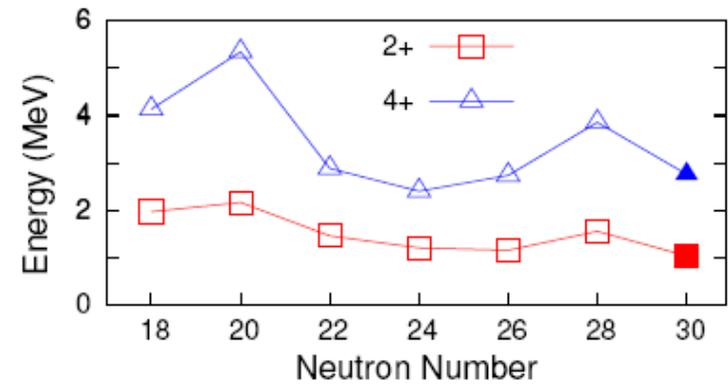
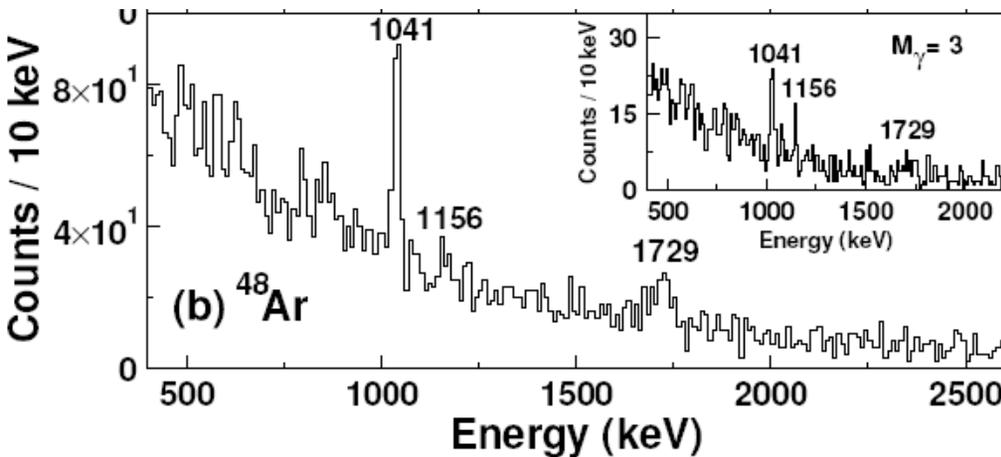
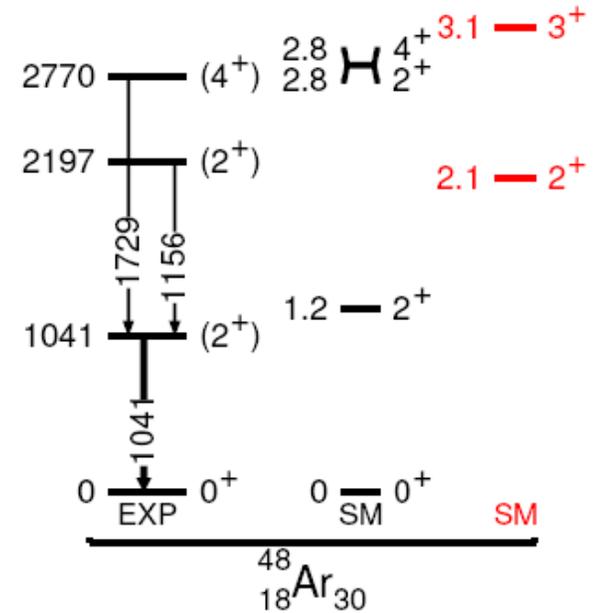
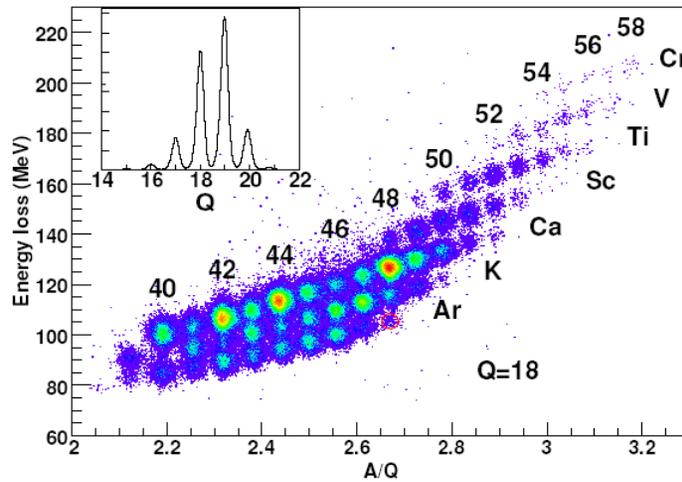


$\langle p_{3/2} p_{3/2}, 1^+ | V | p_{3/2} p_{3/2}, 1^+ \rangle$ *Not well determined*

^{48}Ar yet another nucleus far from stability Or..

Most exotic nucleus produced in DIT $N/Z=1.67$,

Mass not yet measured BUT

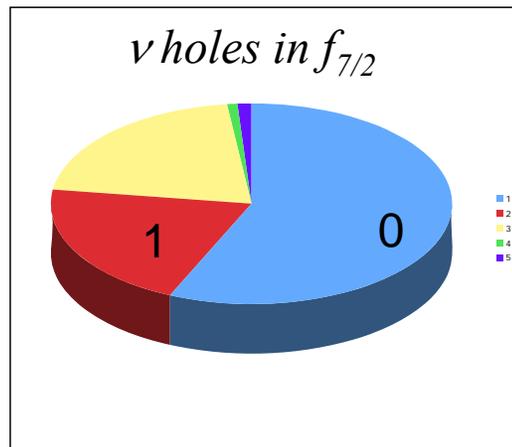


Deformations near classical closed shells

Shell model calculations

Alfredo Poves, Fredrick Nowascki

E. Caurier



Breakdown of $N=28$ shell closure

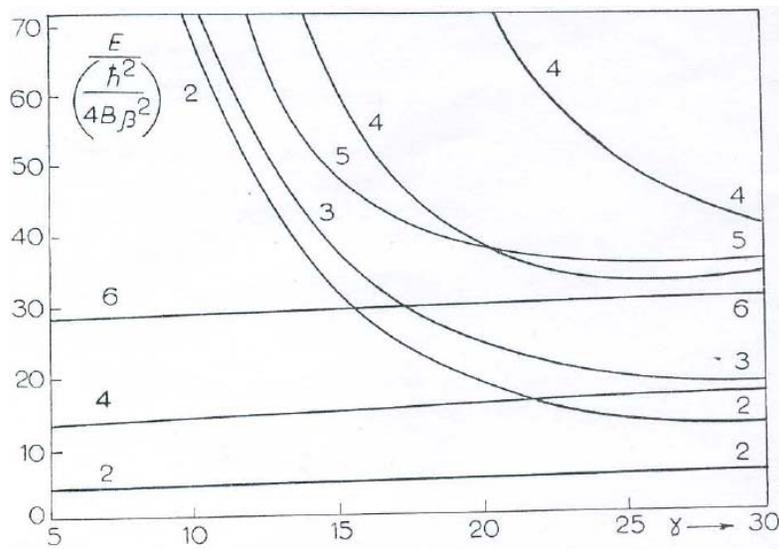
Presence of correlations, cross shell excitations.

Existence of deformed shapes $N \sim 28$, ^{42}Si

Signatures of triaxial shapes

Davydov et al NPA 8 (1958) 237,

Davydov et al NPA 20 (1960) 499



Rotational spectra only slightly effected by violation of axial symmetry

Appearance of new rotational states 2,3,4,....

Lowering of these states with increase in deviation from axial symmetry.



Existance of Triaxial shape in ^{48}Ar

Shell model calculations

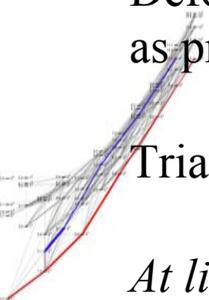
(using the same interaction PRL 99 099202 which explained the structure of ^{42}Si , ^{47}Ar)

Shell model calculations show band structure characterized with a constant Q

Macroscopic description predicted by Davydov *et al.*

Band structure can be charerterized with $\gamma=40$ deg, $\beta=0.25$

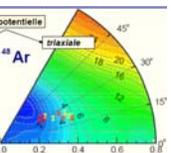
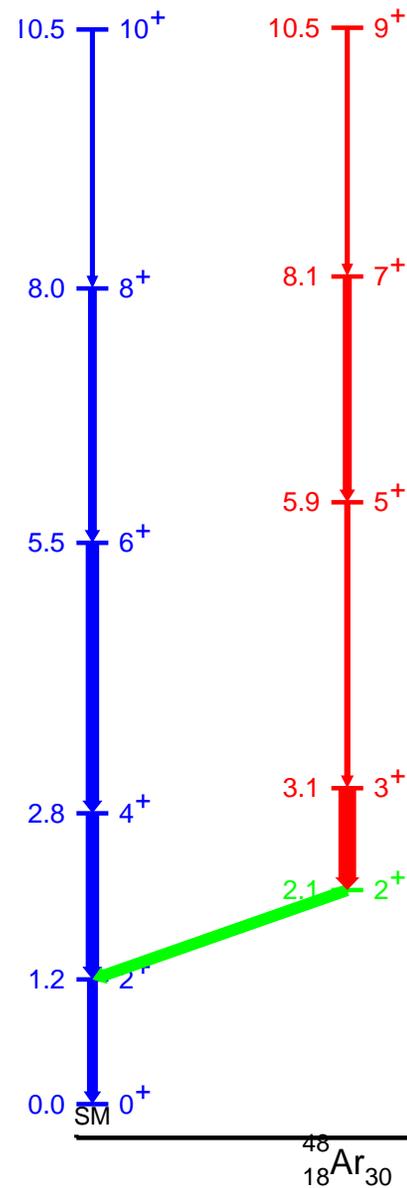
Deformed structures with the shell model as predicted by Davydov et al. energies, BE2



Triaxial shape at low spin

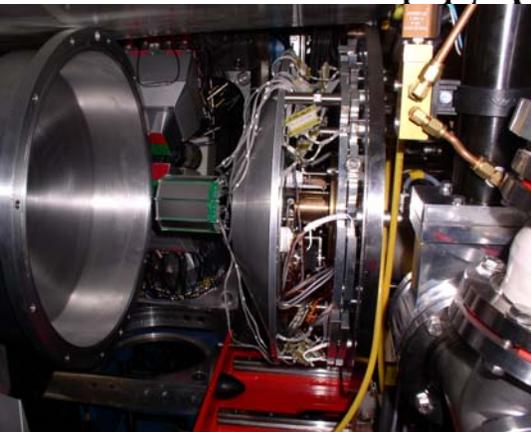
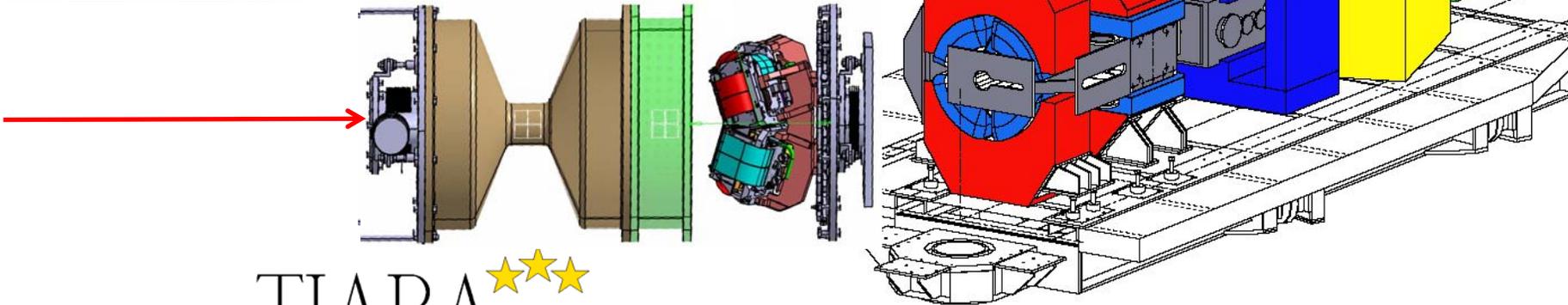
At limit of measurements, but tomorrow is another day.

Degeneracy of the sd orbits maximizes the quadrupole correlations energy of the configuration with open neutron orbits



Spectroscopy of Bound-Unbound states

Ex, Jp, Spectroscopic Factors (SF) using (d,p), (d,t)



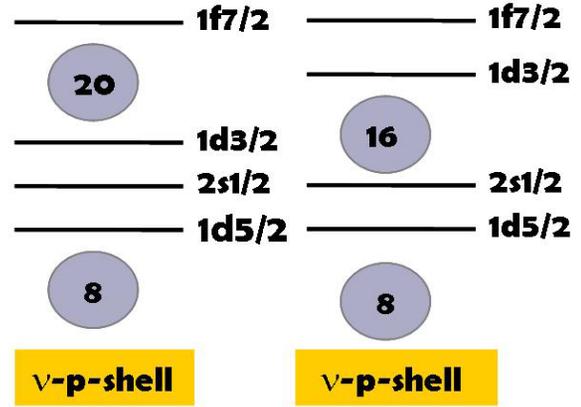
MUST2



Triple coincidences:
Target-like particles -
TIARA/MUST2
Beam-like particles - VAMOS
Gamma - EXOGAM
Trigger: hit in Si-detector

Campaign

Search the $d_{3/2}$ single-particle orbital in n-rich oxygen isotopes
 $^{20}\text{O}(d,p)^{21}\text{O}$



Quenching of Spectroscopic factors
 $^{26}\text{Ne}(d,t)^{25}\text{Ne}$ to compare with n-knockout

The $d_{3/2}$ level responsible for the N=16 shell gap

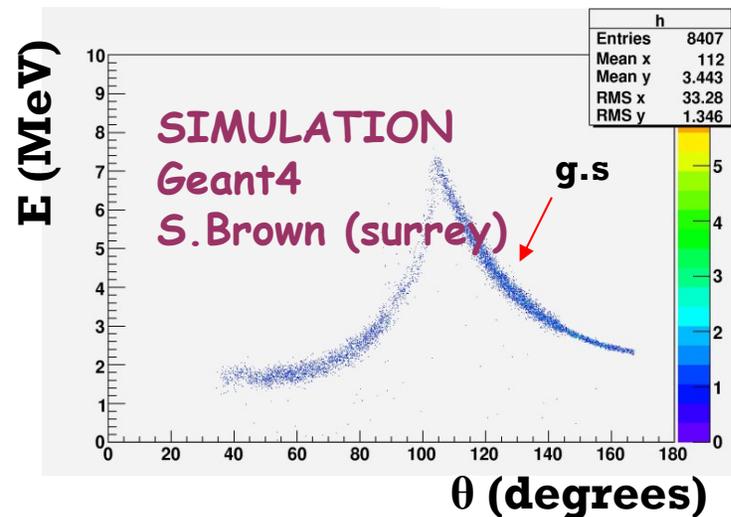
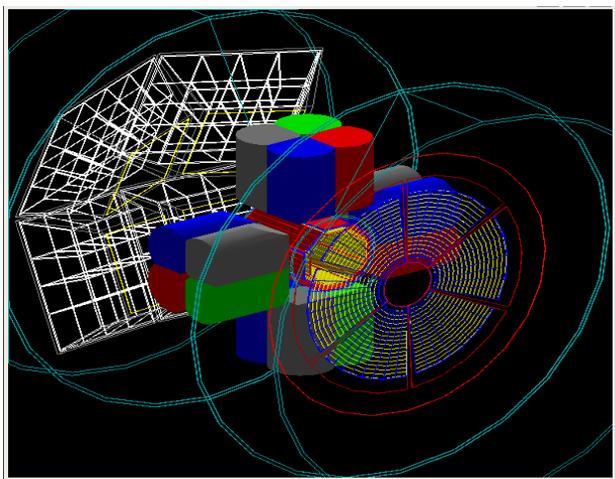
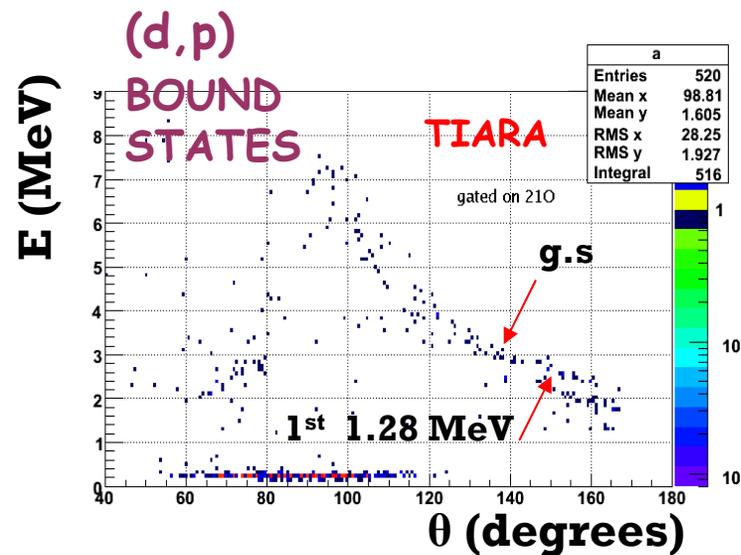
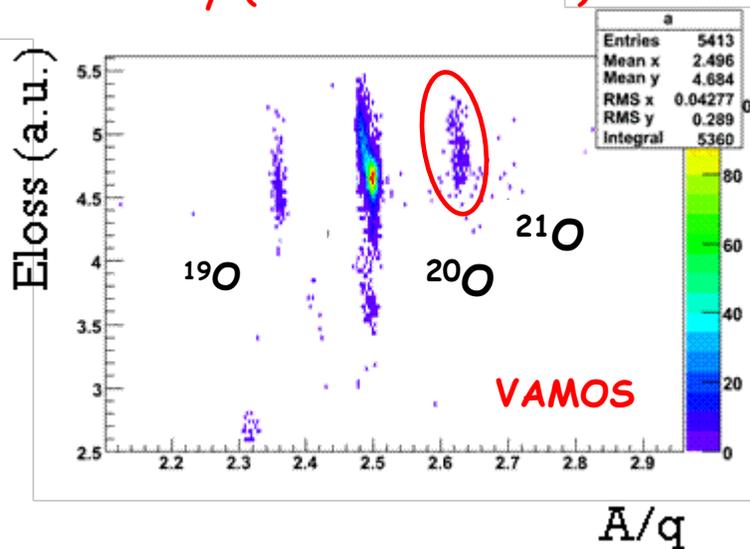
SPIRAL
 10^4 $^{20}\text{O}/\text{s}$
 $2 \cdot 10^3$ $^{26}\text{Ne}/\text{s}$

TIARA MUST2 Exogam VAMOS
GANIL

B. Fernandez*, J.S Thomas*, W. Catford* + collbⁿ

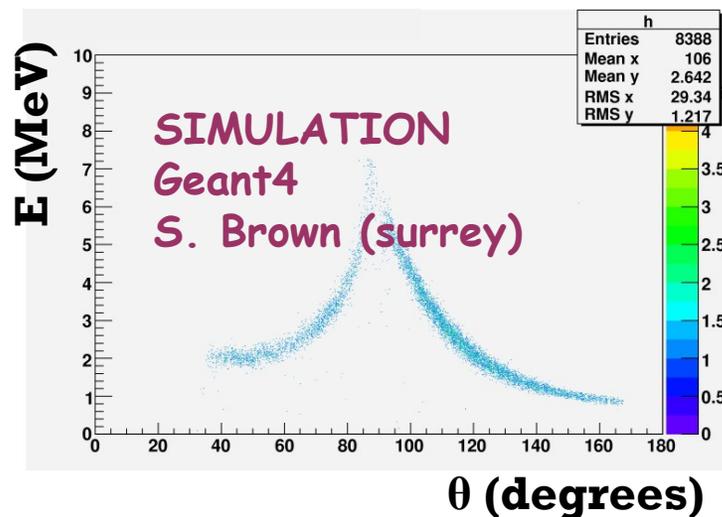
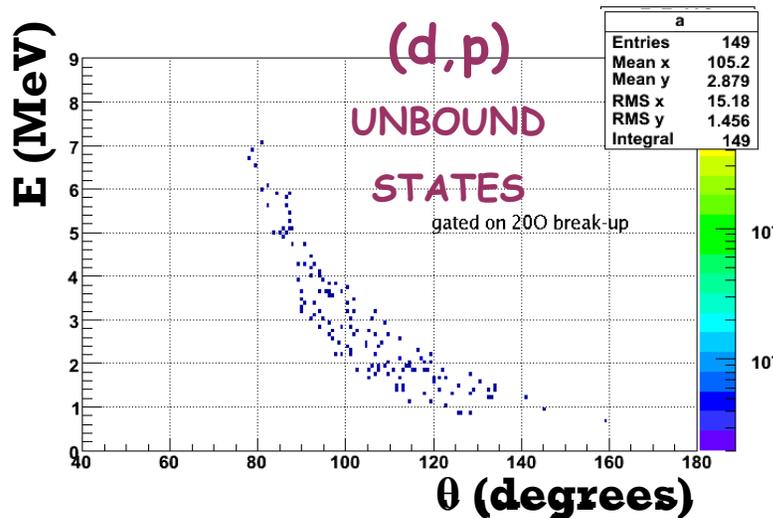
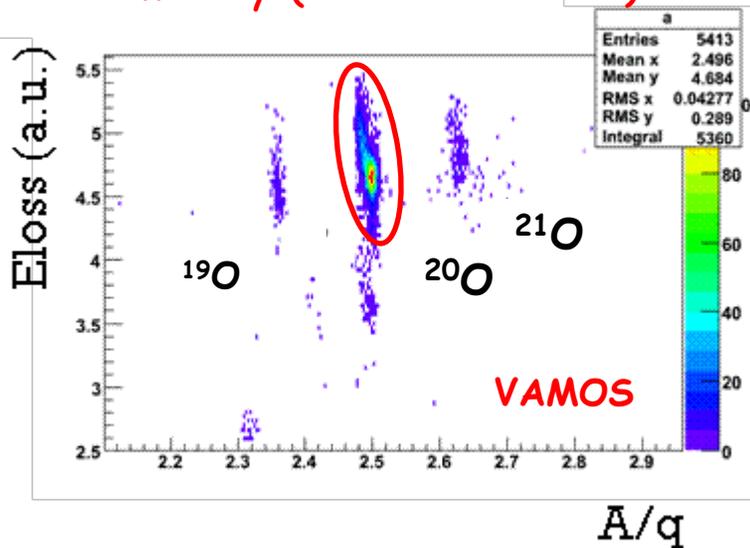
ON-LINE ANALYSIS: $d(^{20}\text{O}, p)^{21}\text{O} \rightarrow ^{21}\text{O} + \gamma$ (bound states)

Preliminary (on-line results) 40% data



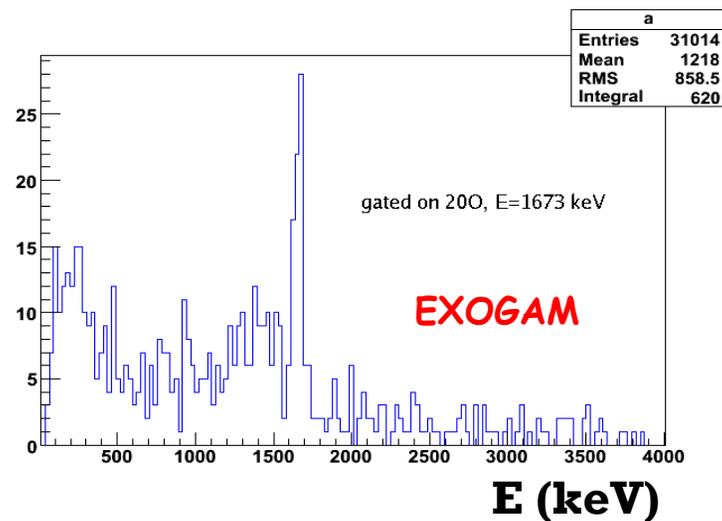
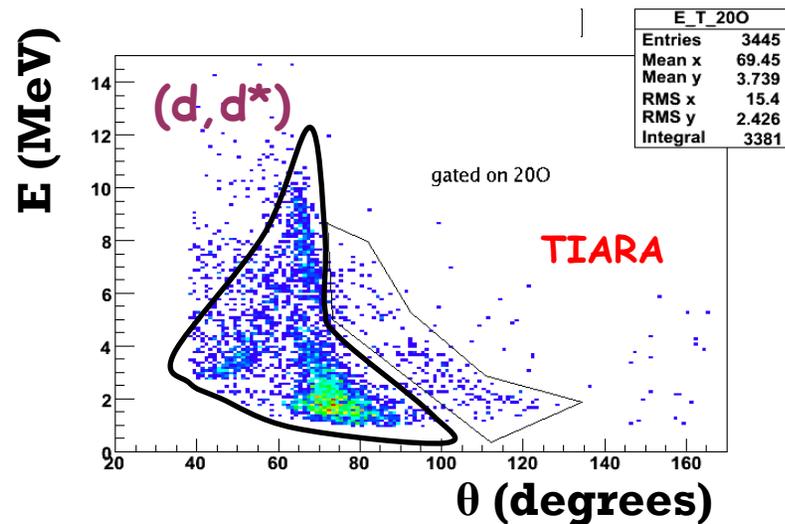
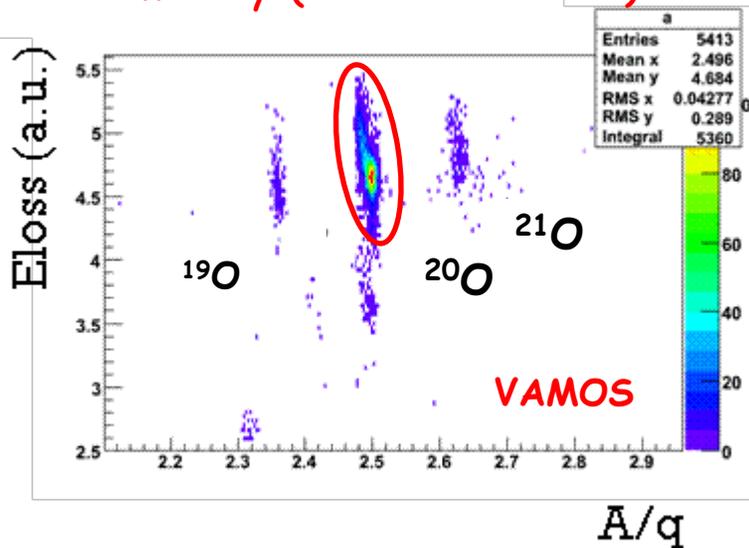
ON-LINE ANALYSIS: $d(^{20}\text{O}, p)^{21}\text{O} \rightarrow ^{20}\text{O} + n$ (unbound state)

Preliminary (on-line results)

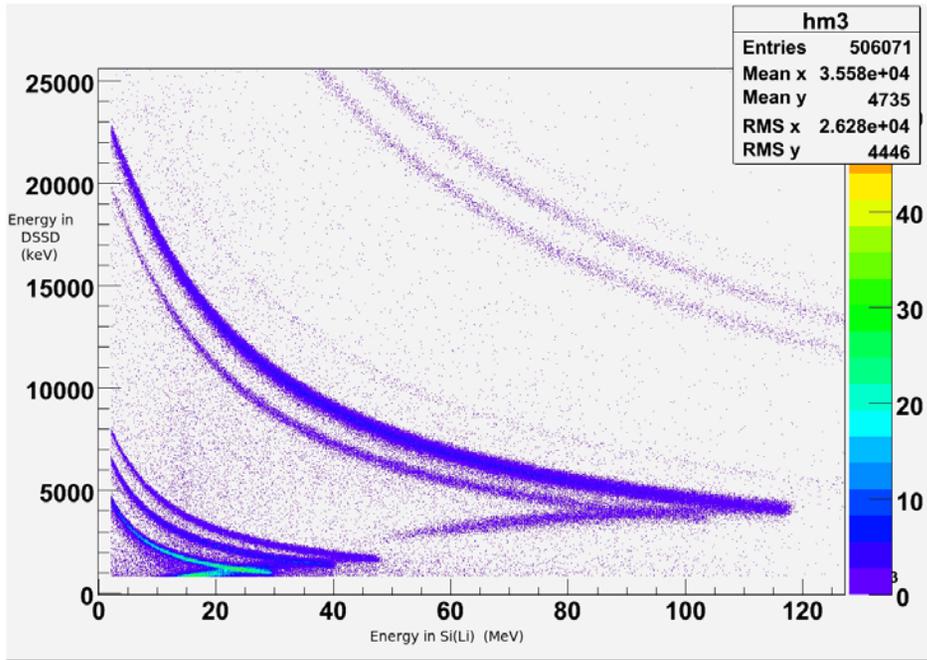


ON-LINE ANALYSIS: $d(^{20}\text{O}, d^*)^{20}\text{O} \rightarrow ^{20}\text{O}^* + d$

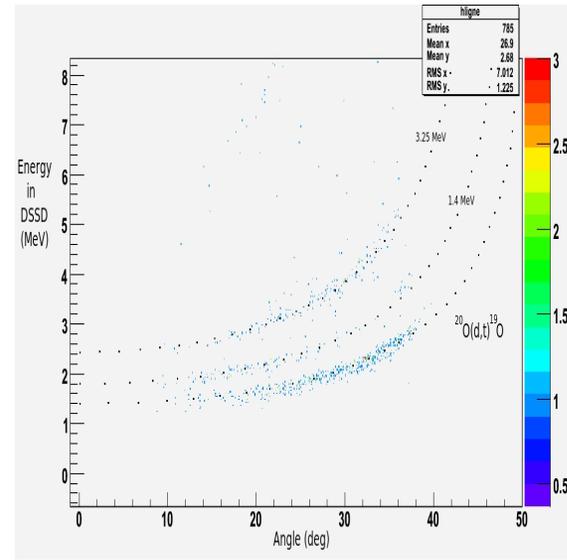
Preliminary (on-line results)



MUST2

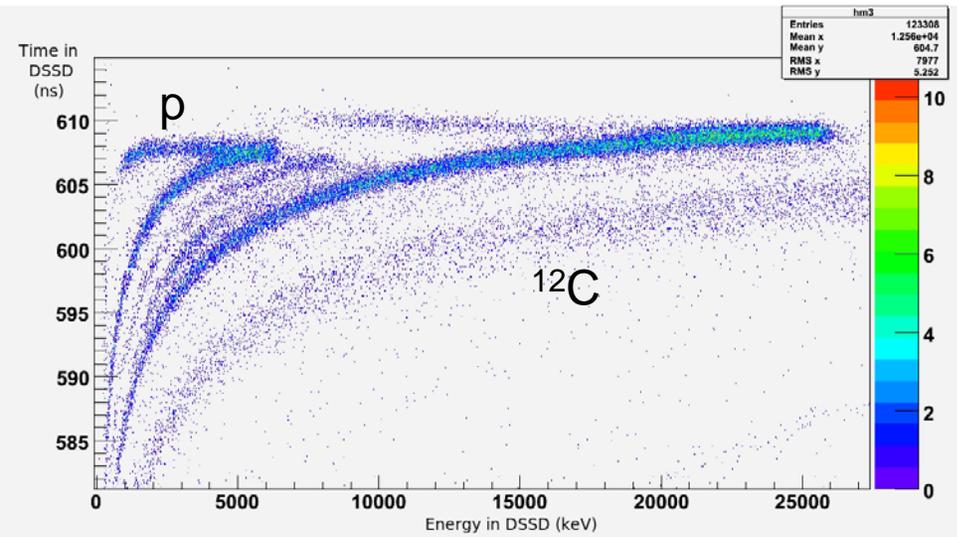


$^{20}\text{O}(d,t)^{19}\text{O}$
10A MeV



A Ramus et al

*Great oppurtunities for the future
p+γ correlations*



Improvements of sensitivity I

Exogam upgrade

- *Goals*
- *Full digital electronics for Inner , Outer and shield signals*
- *Implementation of PSA to improve the angular sensitivity*
- *High counting rate > 50 kHz/crystal*
- *Compatibility with digital ancillary (AD, AGATA, VAMOS)*
(Replace ageing electronics)

★GANIL proposition: AGATA-like, Thanks to the hard work of the Expert committee

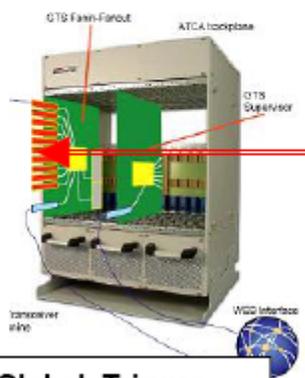
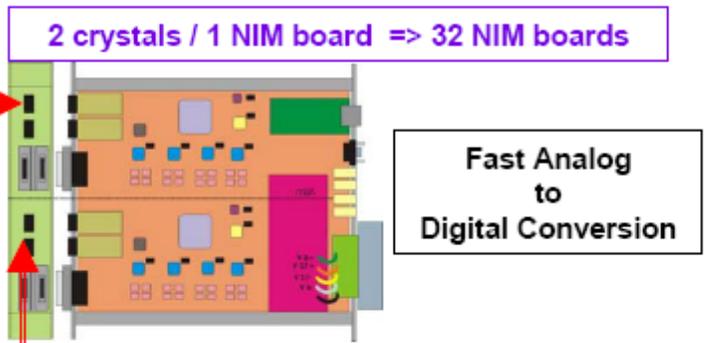
★ Development time: 3 years. Manpower available after spring 2008.

EXOAM2

General architecture



7 differential analog signals per crystal
ICR < 100kHz per crystal



Global Trigger and Synchronization

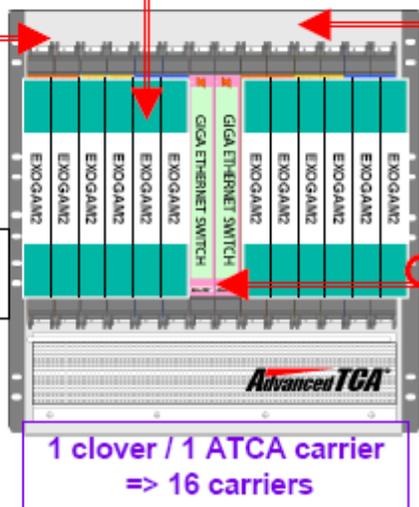
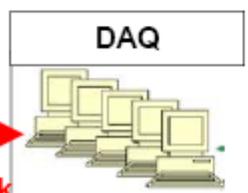
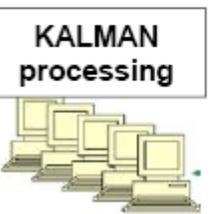
1 GTS supervisor and 16 GTS mezzanines

8 links per ATCA carrier
(1.4 Gb/s per ADC channel)

1 link per ATCA carrier

1 link per ATCA carrier
(2 Gb/s)

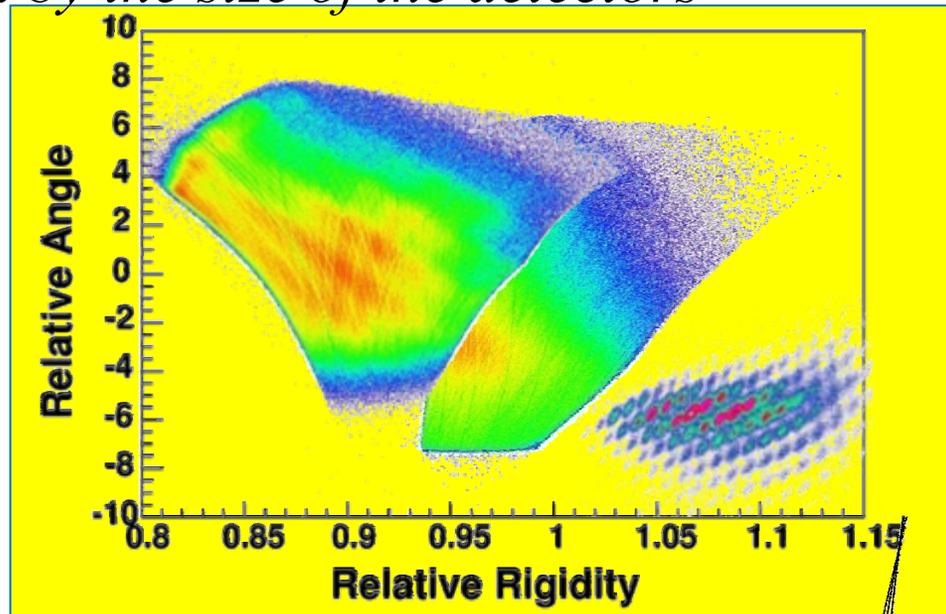
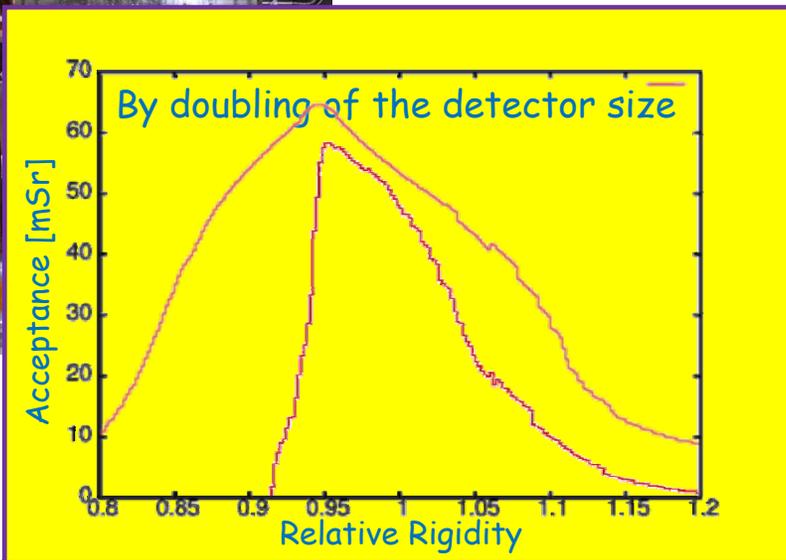
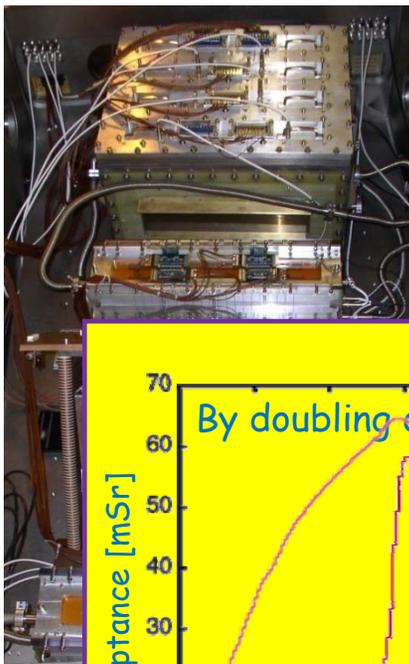
Digital Processing



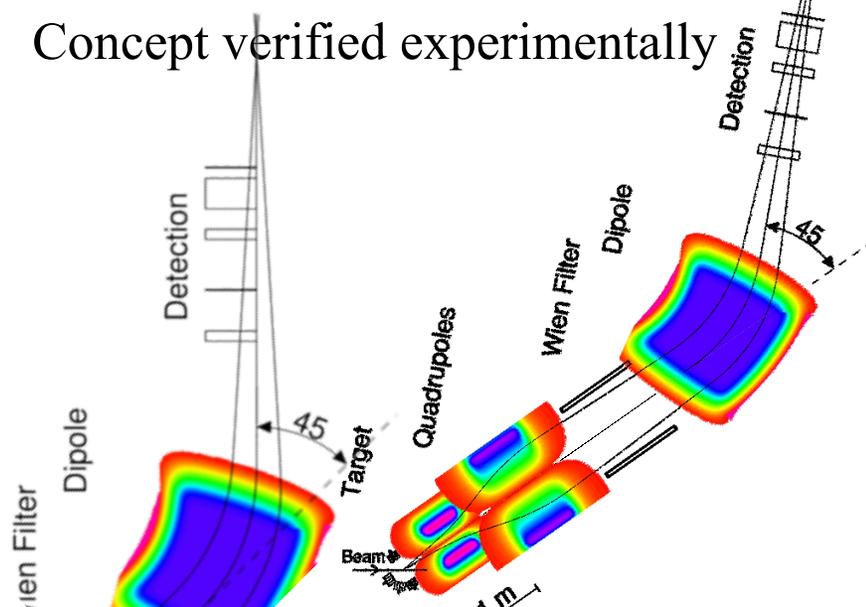
1 link per hub
(3 MB/s per crystal)

Improvements of sensitivity II

Acceptance limited by the size of the detectors



Concept verified experimentally



Coming soon

Plunger slow (Kohn) and fast

beams (Bucarest),

rotating target

MUSETT Si array Saclay RDT

Gas filling of VAMOS 2009 test

A bright Future

*Improvements in
the efficiency and resolving power EXOGAM and VAMOS
should allow us to attack more challenging problems.*

*Coupling with a large array of detectors
INDRA, MUST2, TIARA, AGATA +++*

*Physics of exotic phenomenon with reactions ranging from
transfer to multi fragmentation.*

Towards SPIRAL2 FF

A collaborative effort thanks to the team

Conclusions

*The woods are lovely dark and deep,
But I have miles to go before I sleep,
Miles to go before I sleep.....*

Robert Frost