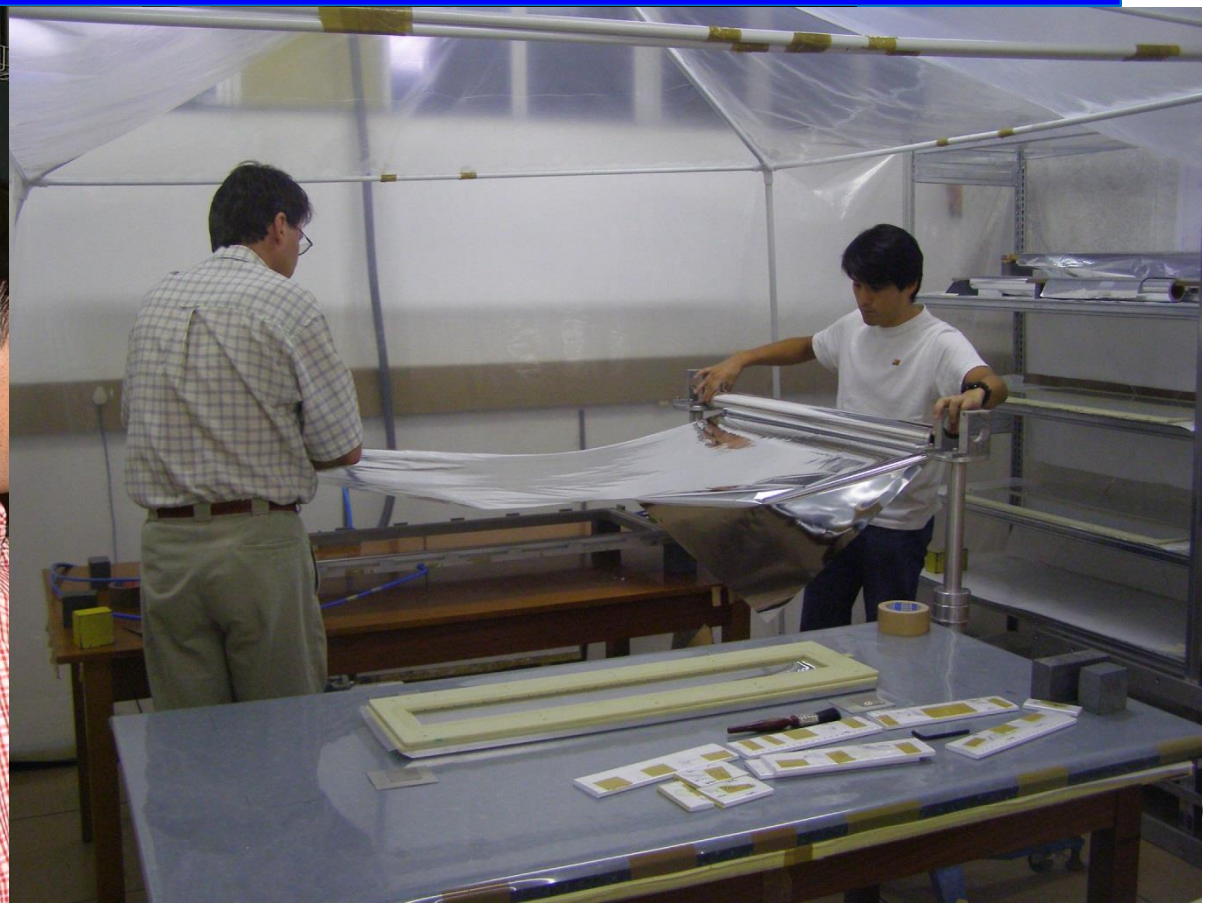
High energy resolution spectroscopy with K600 magnetic spectrometer at iThemba LABS – FD Smit

Beginning of 0˚ mode for K600 at iTL

- Invitation by Peter von Neumann-Cosel to take part in an RCNP experiment
- Meet Yoshi at RCNP in May 2002
- Yoshi strongly advises that 0˚ at iTL is possible
- Biggest worry is that weekends only beam time would make it impossible
- Return home to considering

Work commences with Japanese help (2003)

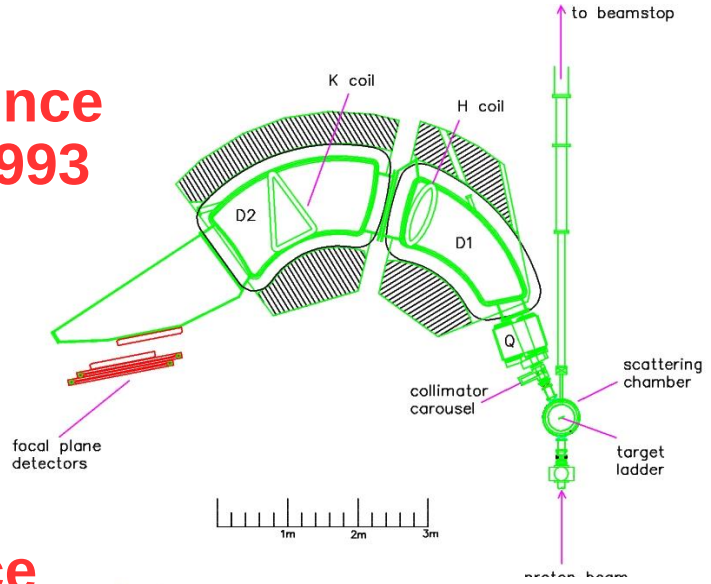


Oct' 2006 – First beam in new 0˚ beam dump

The K600 at iThemba LABS

A kinematically corrected QDD magnetic spectrometer for light ions

Since 1993



Indiana University Cyclotron Facility design

Finite angle measurements (θ_{scat}>5°)

Medium dispersion focal plane B(D1)=B(D2)

Large momentum range: p_{max}/p_{min}=1.097

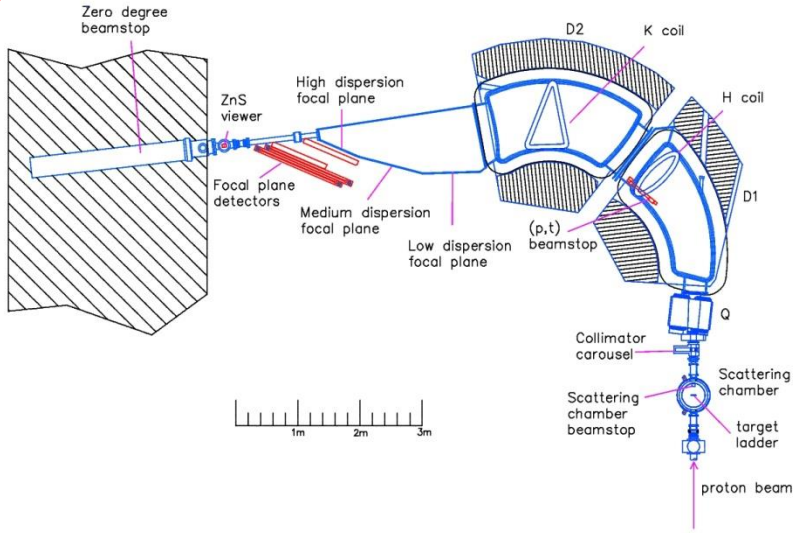
Resolving power: $\Delta p/p$ = 1/28000

Horizontal magnification M_x =-0.52

Vertical magnification M_y =-5.5

Dispersion: 8.4 cm/%

Since 2009



Zero degree measurements (θ_{scat}<2°)

High dispersion focal plane B(D1)/B(D2)=1.49

Momentum range: p_{max}/p_{min}=1.05

Horizontal magnification M_x =-0.74

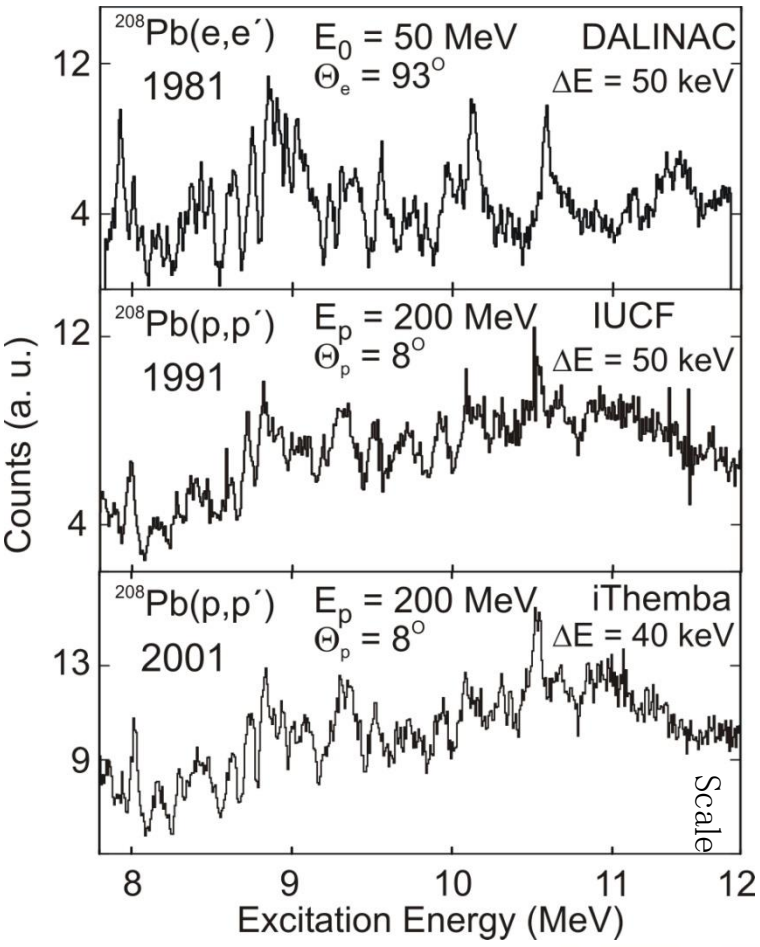
Vertical magnification M_y =-7.05

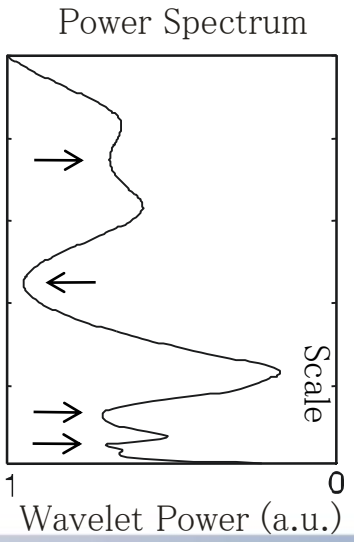
Dispersion: 10.9 cm/%

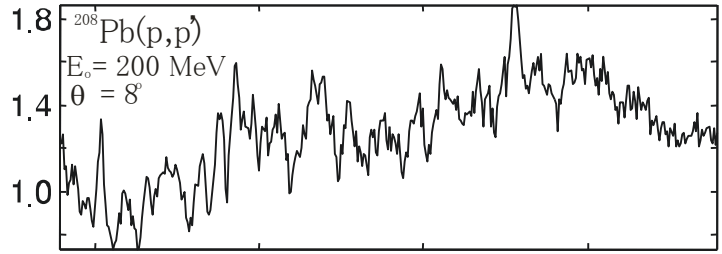
Solid angle: 3.5 msr

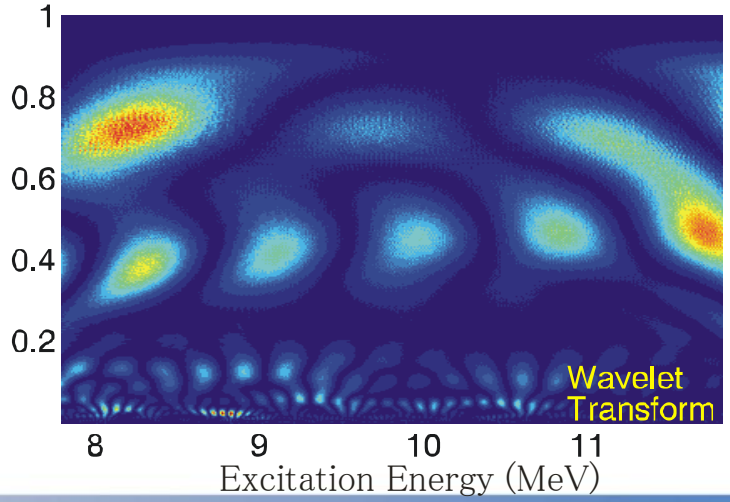
ISGQR & IVGDR fine structure

- Fine structure seems to be global phenomenon: different targets, different resonances
- Wavelet analysis: scales characterize the fine structure
- Use scales to study dissipative mechanisms of GR









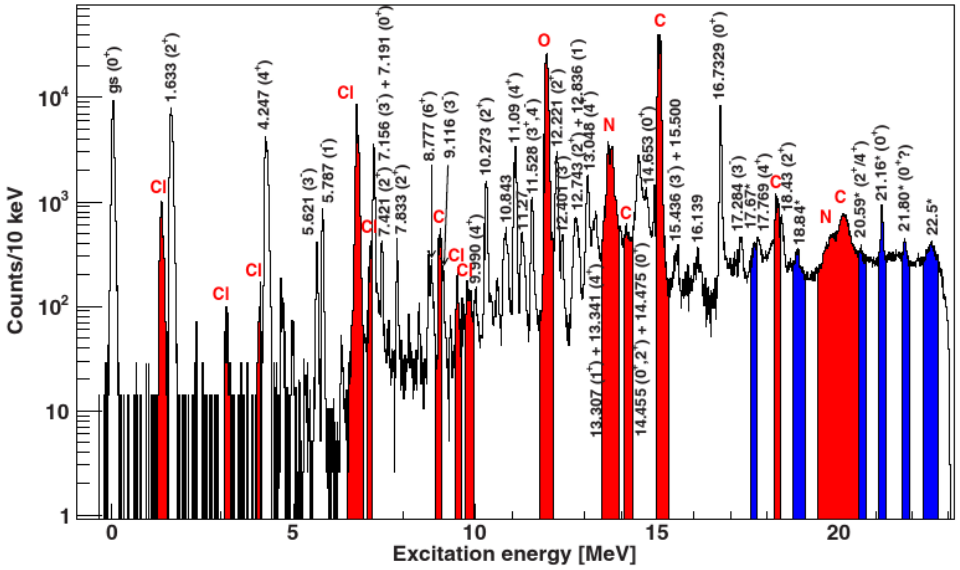
A. Shevchenko et al., Phys. Rev. Lett. 93, 122501 (2004)

iTL K600 zero degrees

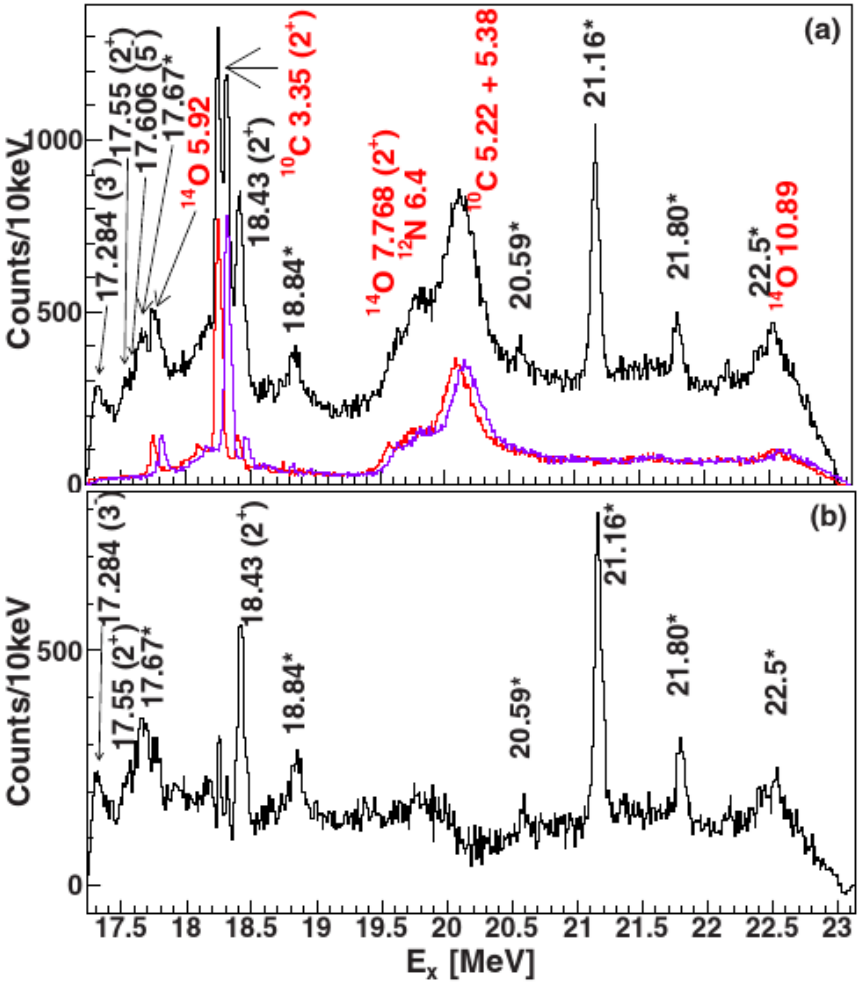
Special thanks :
Y Fujita
H Fujita
K Hatanaka
G Berg

Clustering - Recent ^{20}Ne results from iThemba LABS

- ^{22}Ne(p,t)^{20}Ne at 60 MeV
- 0° , 7° ,16° ,27° , gas target
- Discovered 6 new, narrow, states in E_x=17–23 MeV
- 17.67, 18.84, 20.59, 21.16, 21.80, 22.5 MeV
- Low spin values: J=0–2
- Only state at 22.5 MeV could not be interpreted by shell–model calculations



Physical Review C 91 (2015) 034317



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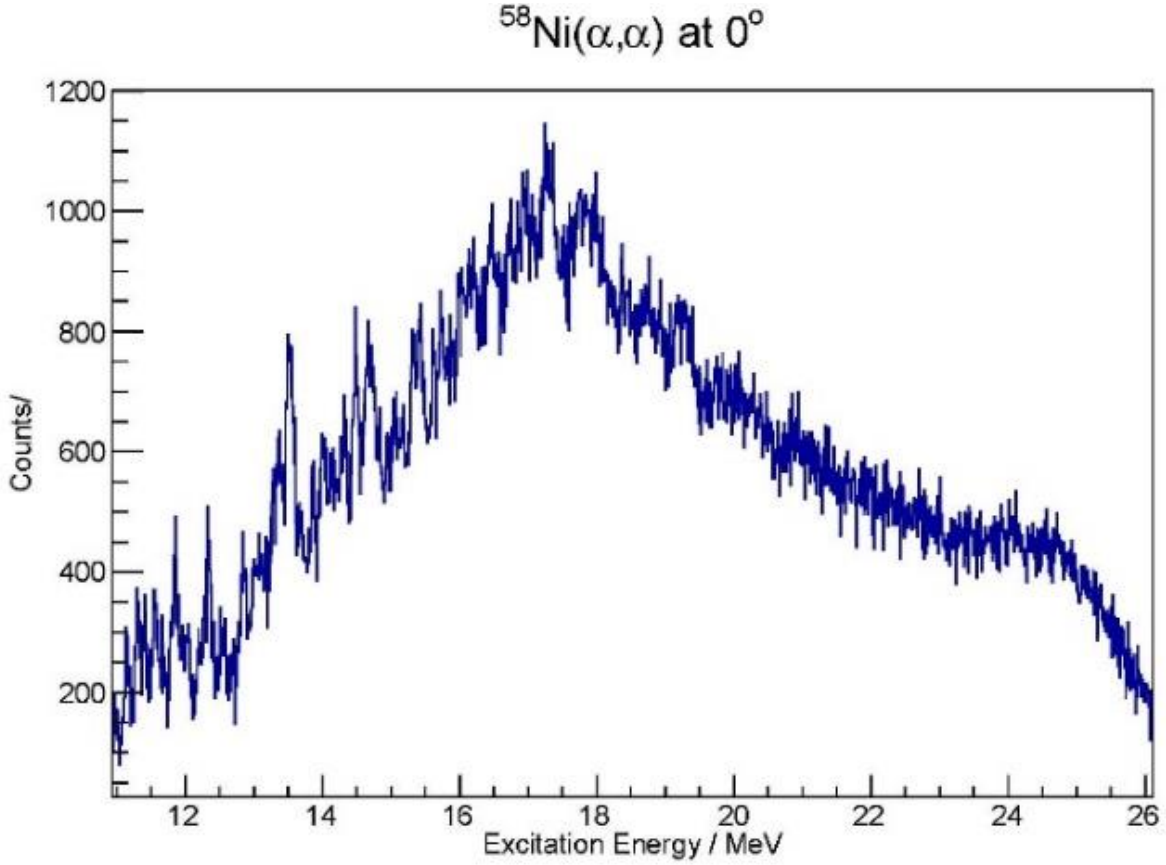
Do as well or better than RCNP at (α,α')

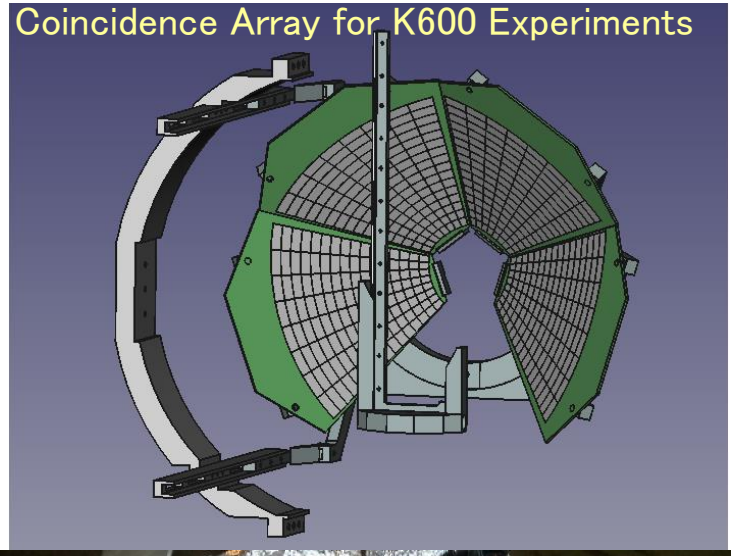
ISGMR Data -- Spin Dependence of Level Densities

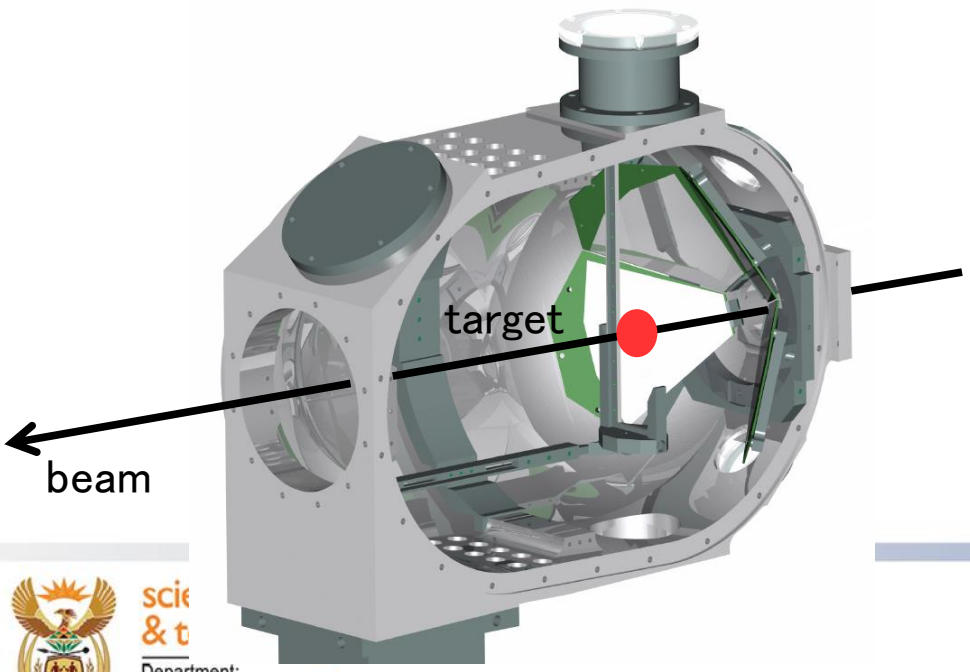


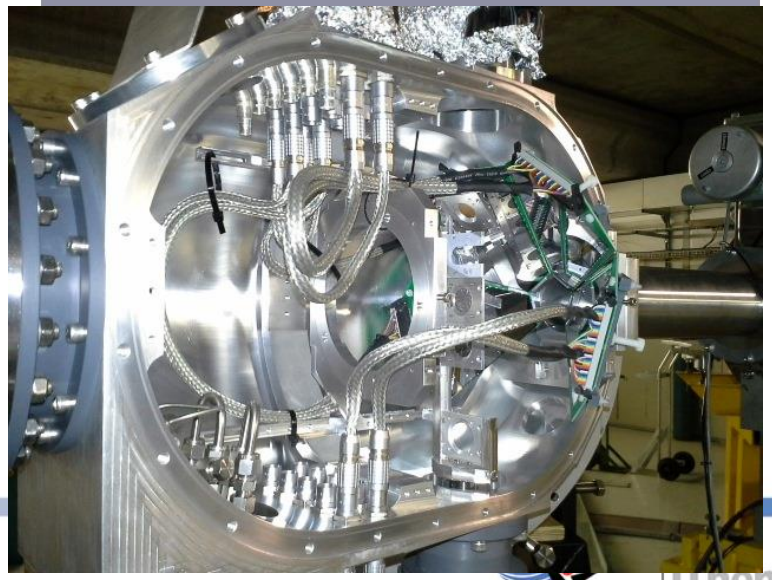
Being Analyzed – 75 keV

Add a Coincidence DSSSD array: CAKE

- 4× MMM-400 Double Sided Silicon Strip Detectors (DSSSD)
- Lampshade configuration
- 400 μm thick (7 MeV p, 28 MeV α)
- 16 rings, 8 sectors
- θ range: 114° – 166°
- total solid angle: 21% of 4π; 0.66 msr/DSSSD
- target to detector separation: 100–110 mm
- rates during experiment <5kHz/DSSSD







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NRF NEP funding UID 86052

National Research Foundation
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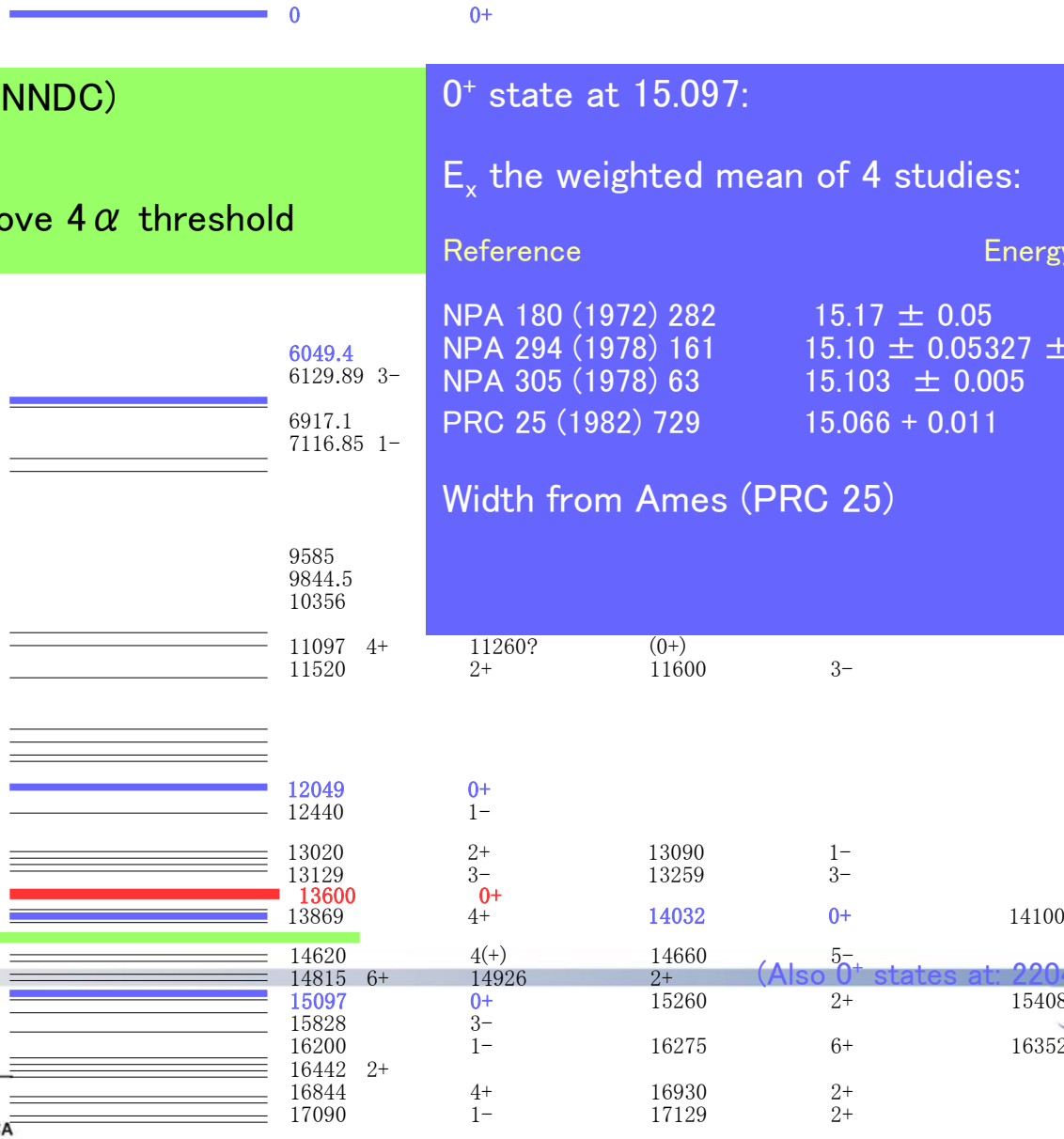
Laboratory for Accelerator Based Sciences

Clustering: the ^{16}O nucleus



Natural parity states (NNDC)

0^+ state at 15.097:
- few hundred keV above 4 α threshold

0^+ state at 15.097:

E_x the weighted mean of 4 studies:

Reference	Energy	Width (MeV)	
NPA 180 (1972) 282	15.17 ± 0.05	190 ± 30	$^{12}C(\alpha$
NPA 294 (1978) 161	15.10 ± 0.05327 ± 100	$^{15}N(p,\alpha_i),(p,p_0)$	
NPA 305 (1978) 63	15.103 ± 0.005	–	
PRC 25 (1982) 729	15.066 + 0.011	166 ± 30	$^{12}C(\alpha$

Width from Ames (PRC 25)

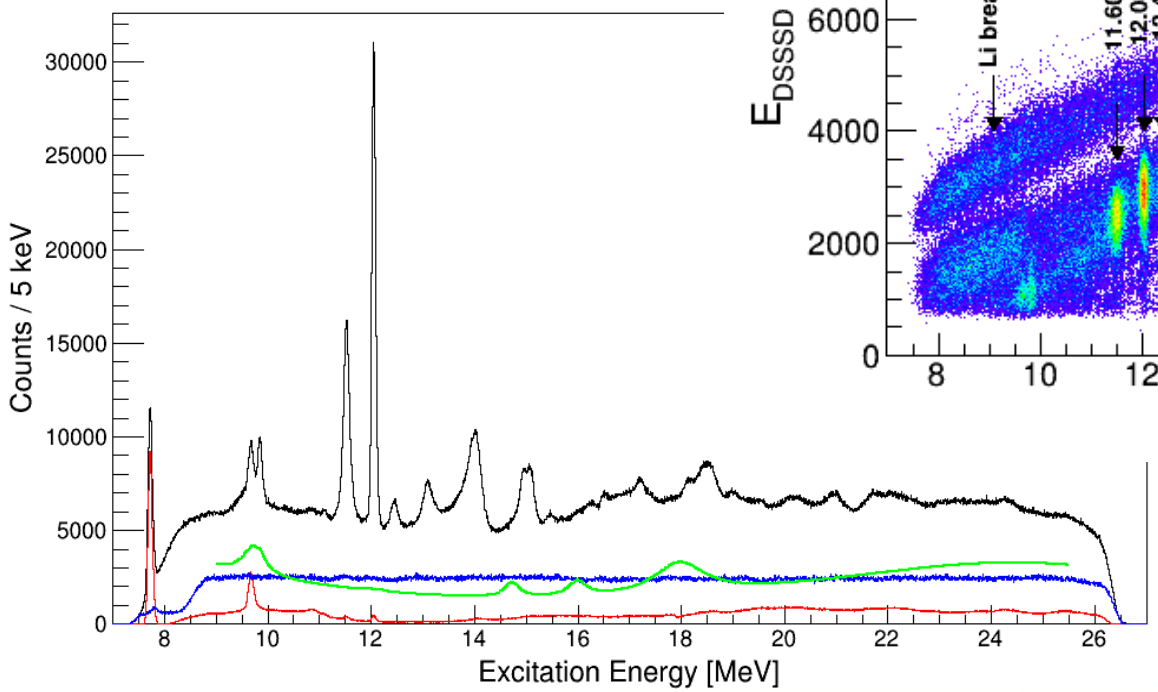
$S_{4\alpha}$ = 14437 keV

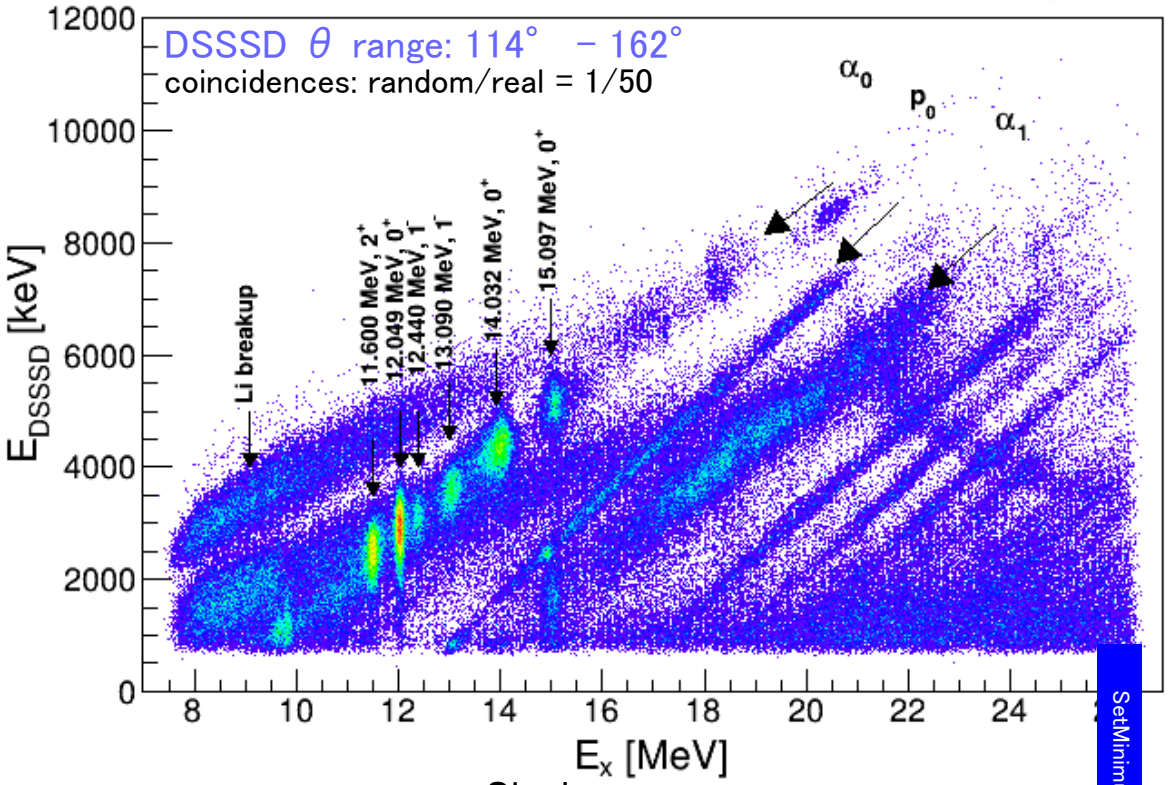
(Also 0^+ states at: 22040 keV & 22721 keV)

$Li_2CO_3(\alpha,\alpha')$ coincidence results @ 200 MeV, 0

Search for Hoyle-like state in ^{16}O

Characterize decay of 0^+_6 at 15.097 MeV



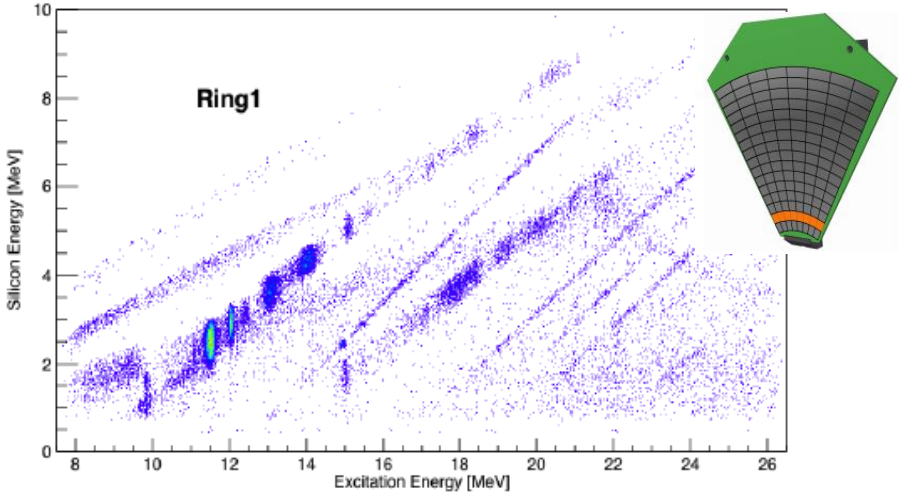


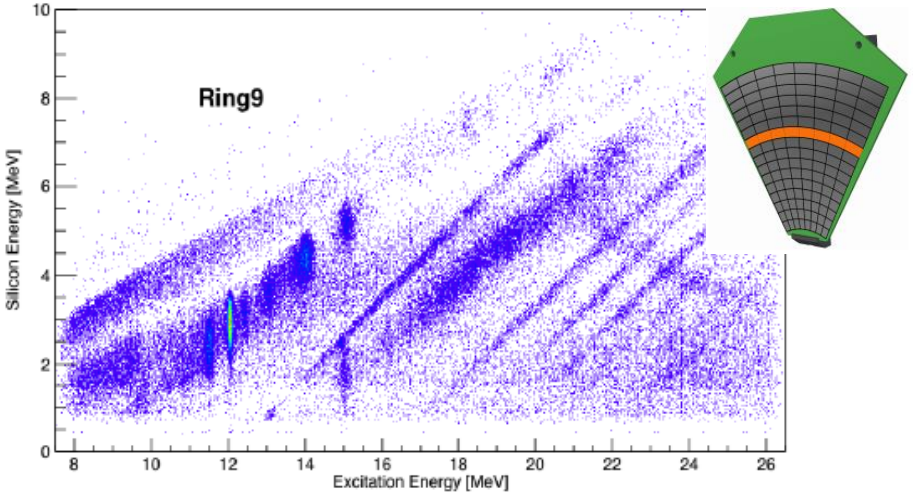
Singles spectrum components:

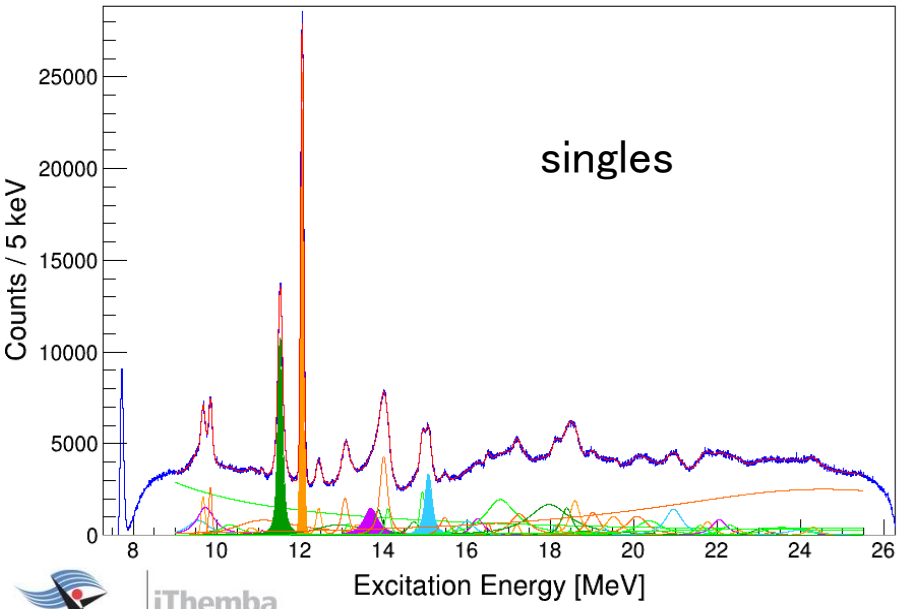
- total yield
- fitted Li background
- experimental backgrond
- measured ^{12}C

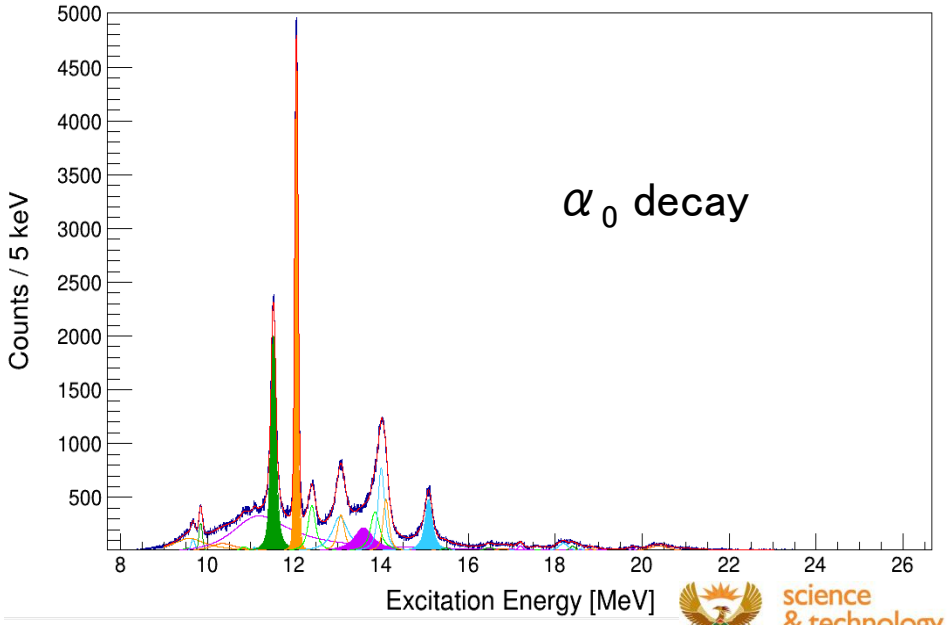
SetMinimum(3)

$Li_2CO_3(\alpha, \alpha')$ coincidence results @ 200 MeV









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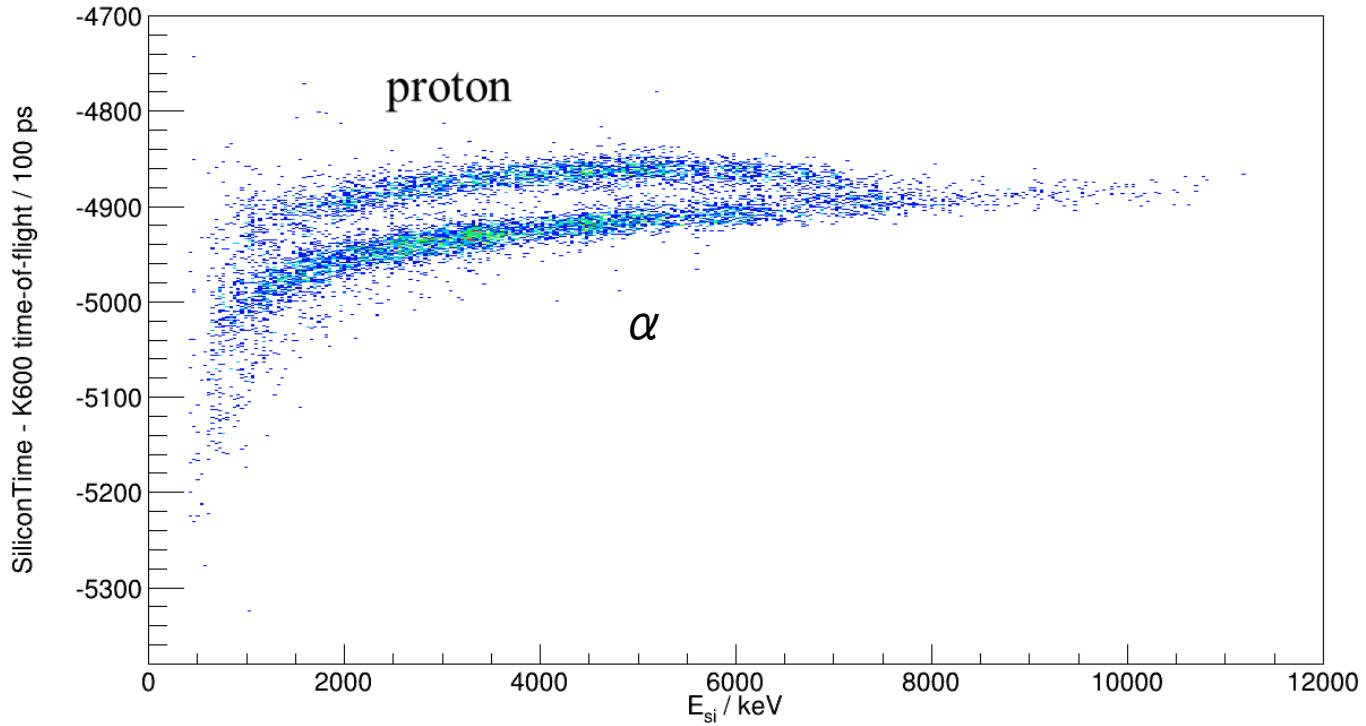
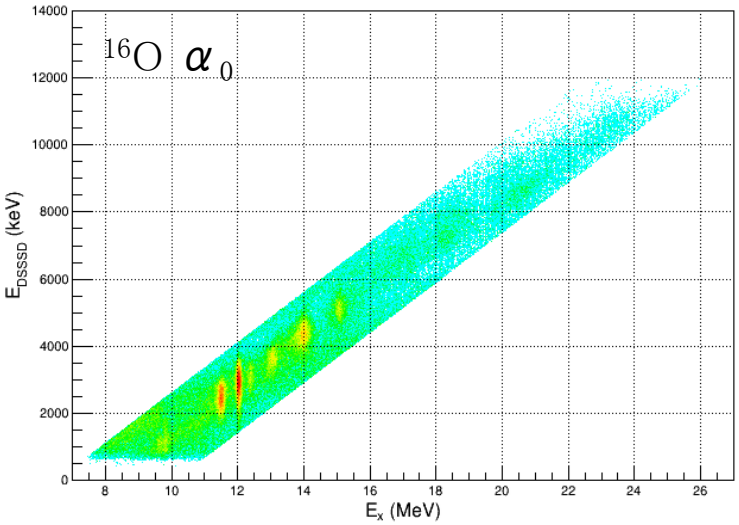
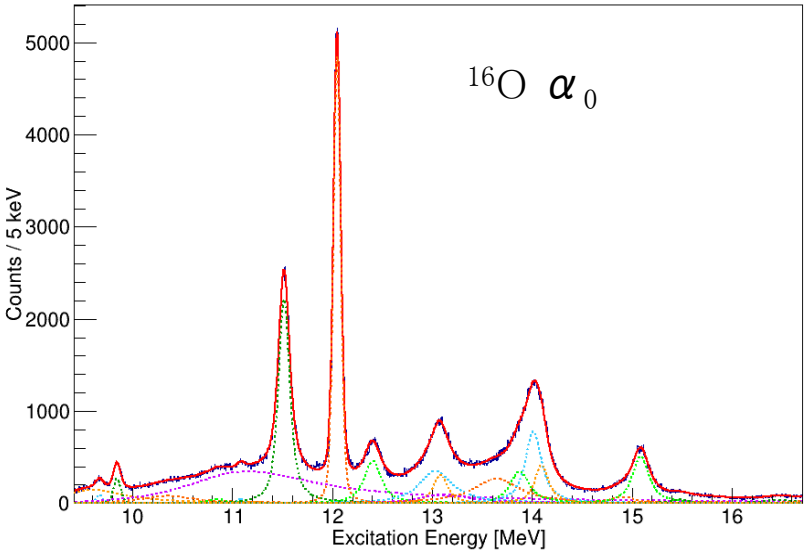
Particle Separation via Time-of-Flight to Si detectors

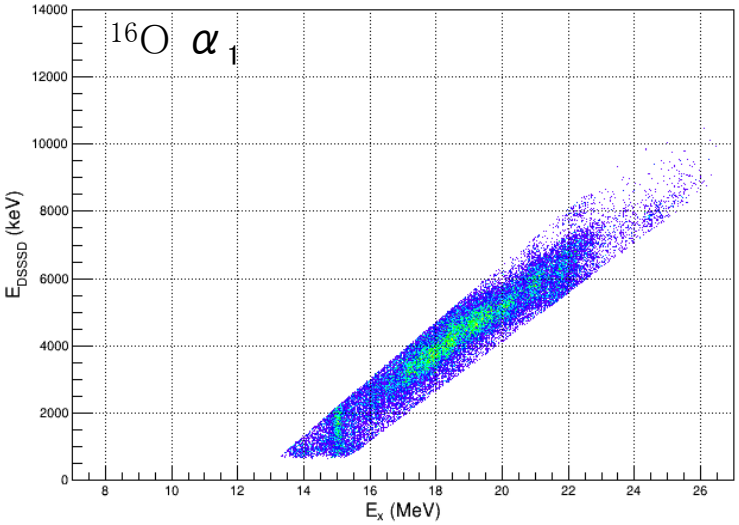
DSSSD PID：

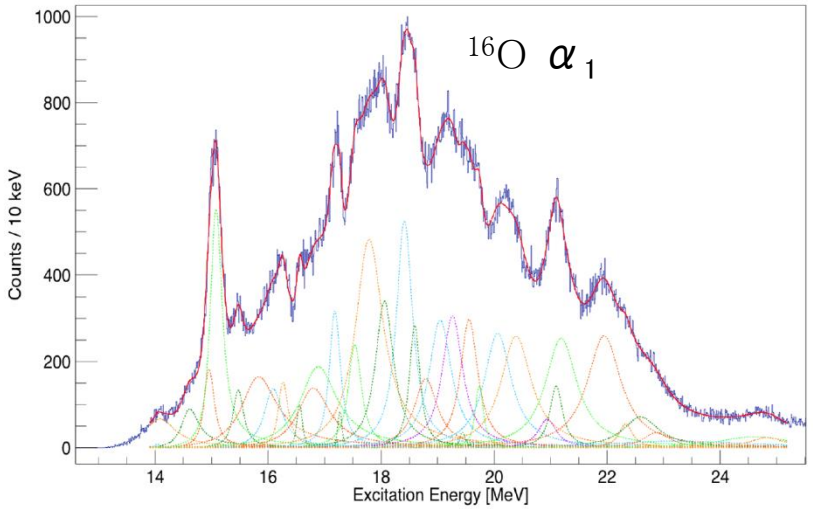


Coincidence results: Li_2CO_3

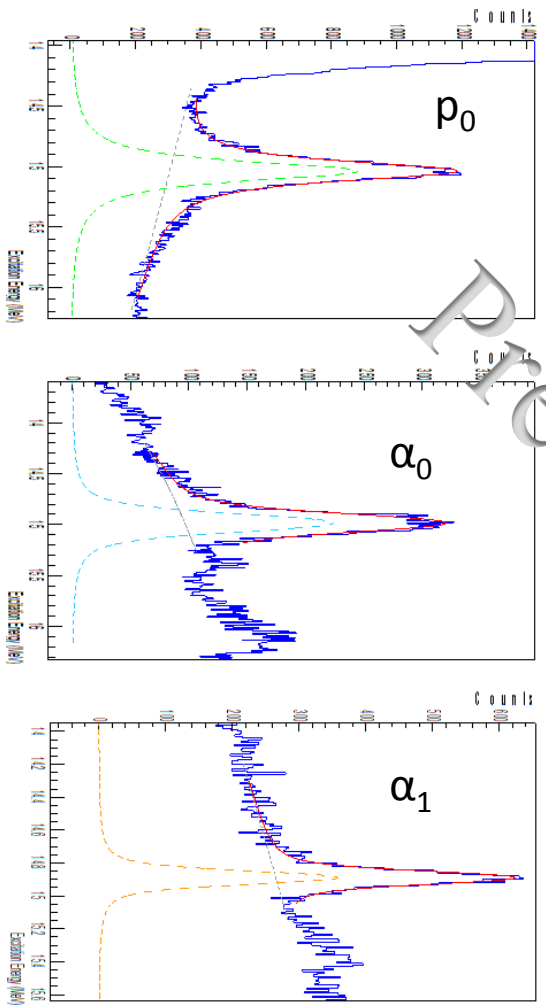


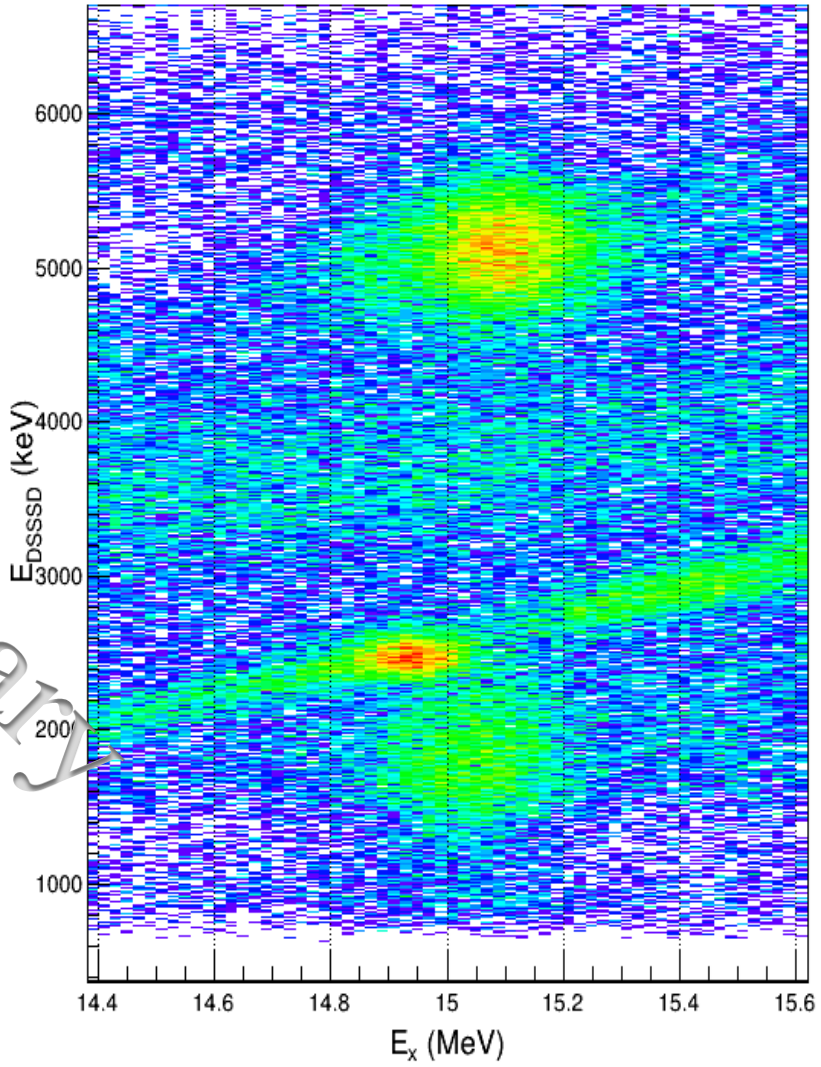






15.097 MeV not one state?



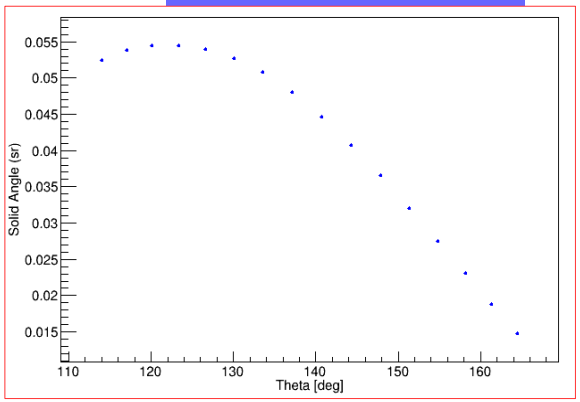


Set Minimum(2)

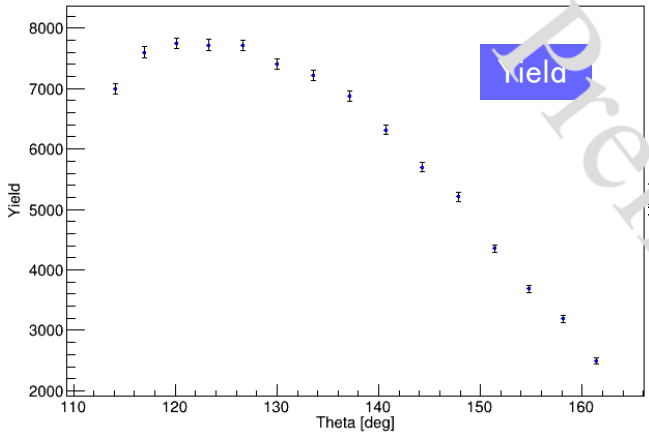
Test cases: 2^+ 11.52 MeV & 0^+ 12.049 MeV

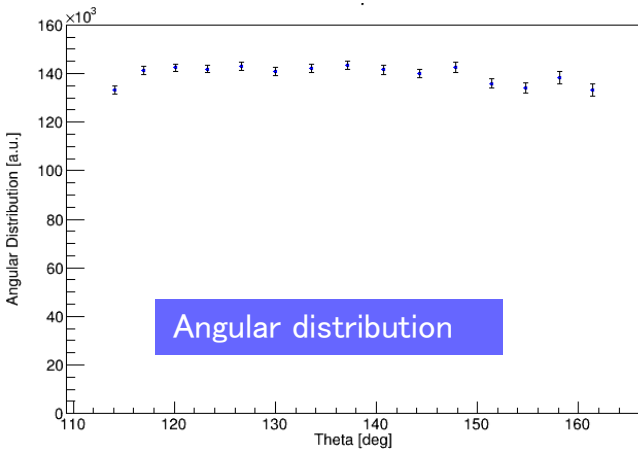
0^+ 12.049 α_0 extracted branching ratio: 97%

solid angle / ring

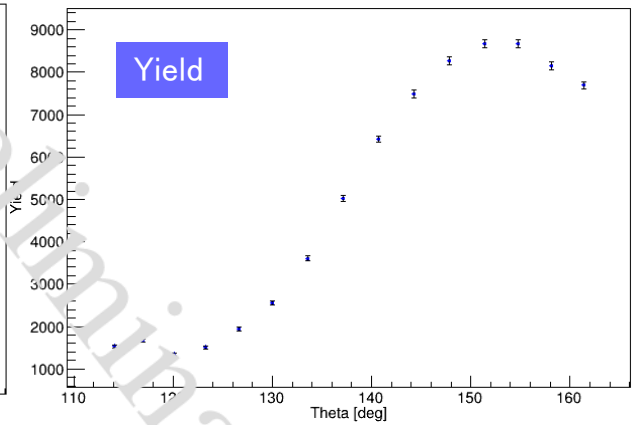


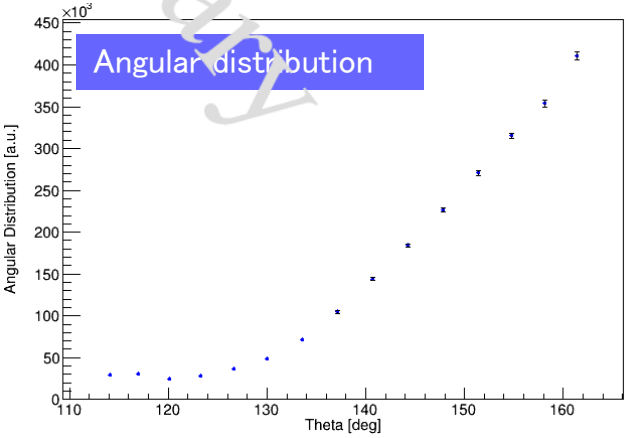
0^+ 12.049 α_0

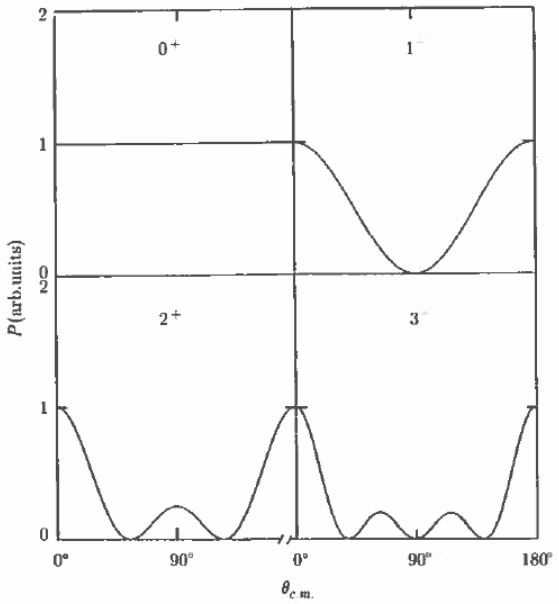




2^+ 11.52 α_0

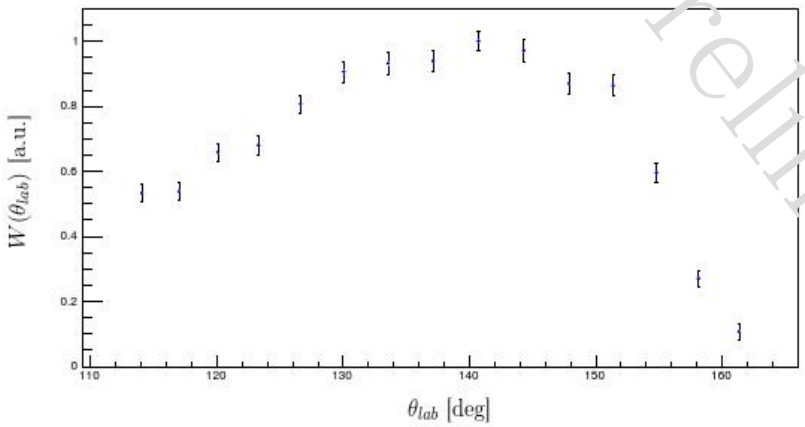




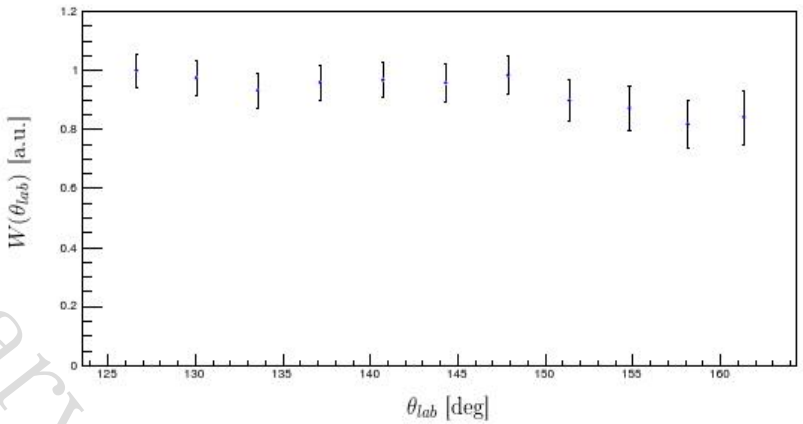


15.097 MeV results

0^+ 15.097 α_0 angular distribution



0^+ 15.097 α_1 angular distribution



If isotropic distribution assumed …

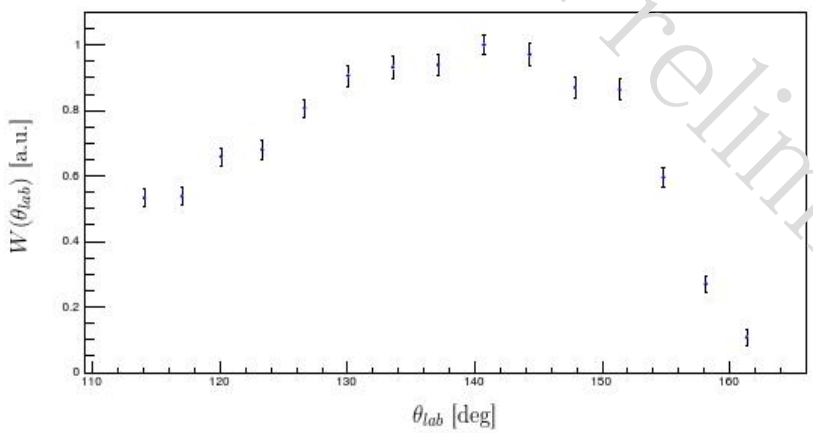
0^+ 15.097 α_0 branching ratio
counts(α_0)/counts(singles)*SA = 0.89 ± 0.06

0^+ 15.097 α_1 branching ratio
counts(α_1)/counts(singles)*SA = 0.35 ± 0.05

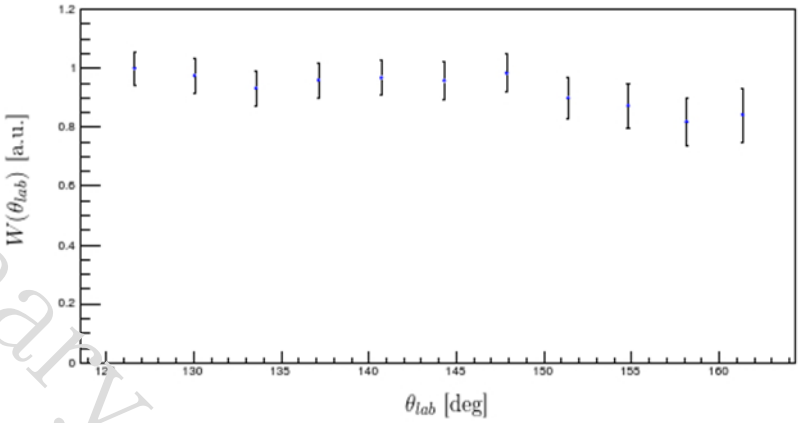
X

15.097 MeV results

0^+ 15.097 α_0 angular distribution



0^+ 15.097 α_1 angular distribution



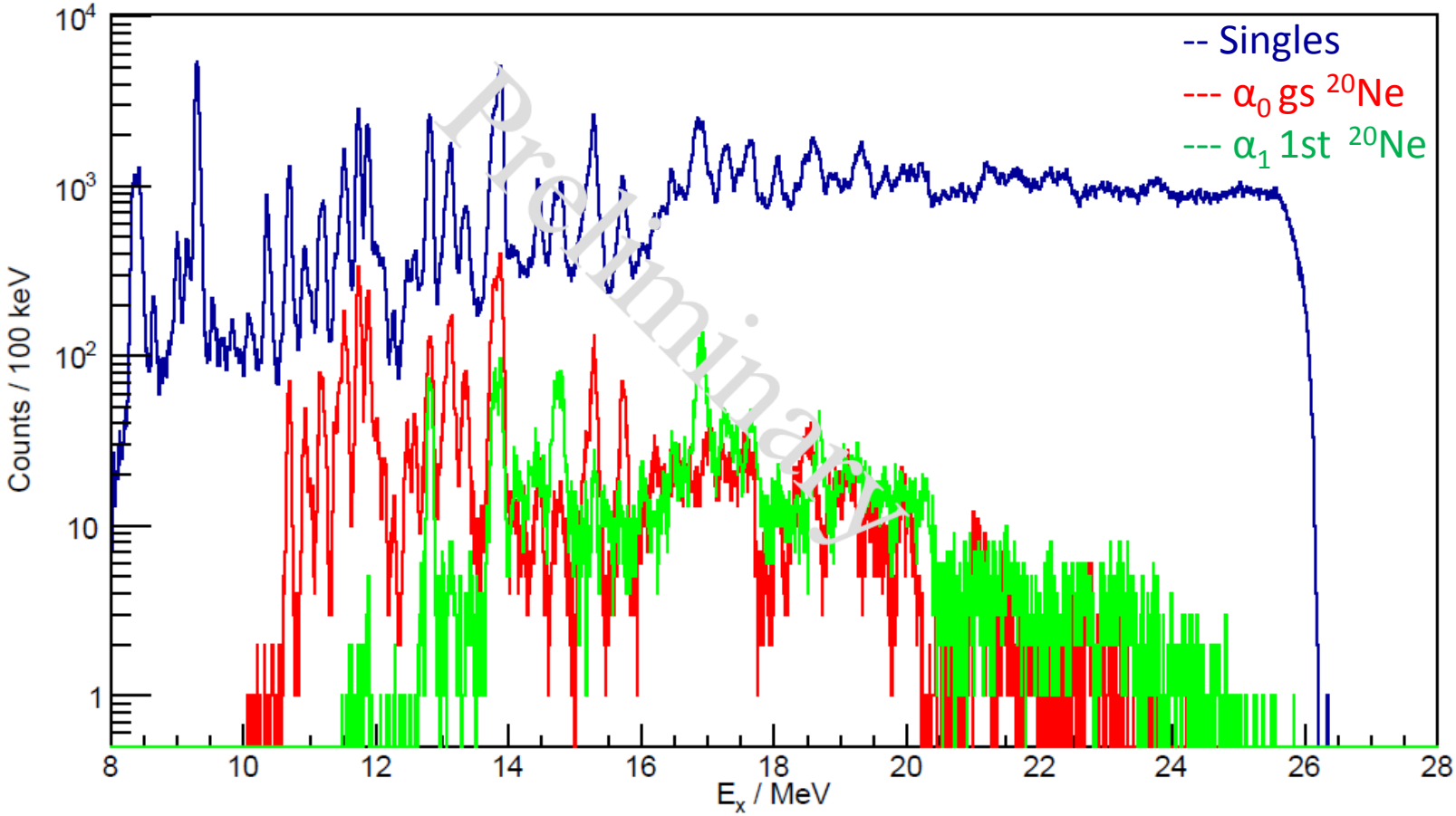
This work

?? 15.090(1) α_0 – Width 164 ± 5 keV

0^+ 15.046(3) α_1 – Width 216 ±10 keV

Prospect of benefit for fine structure Giant Resonance

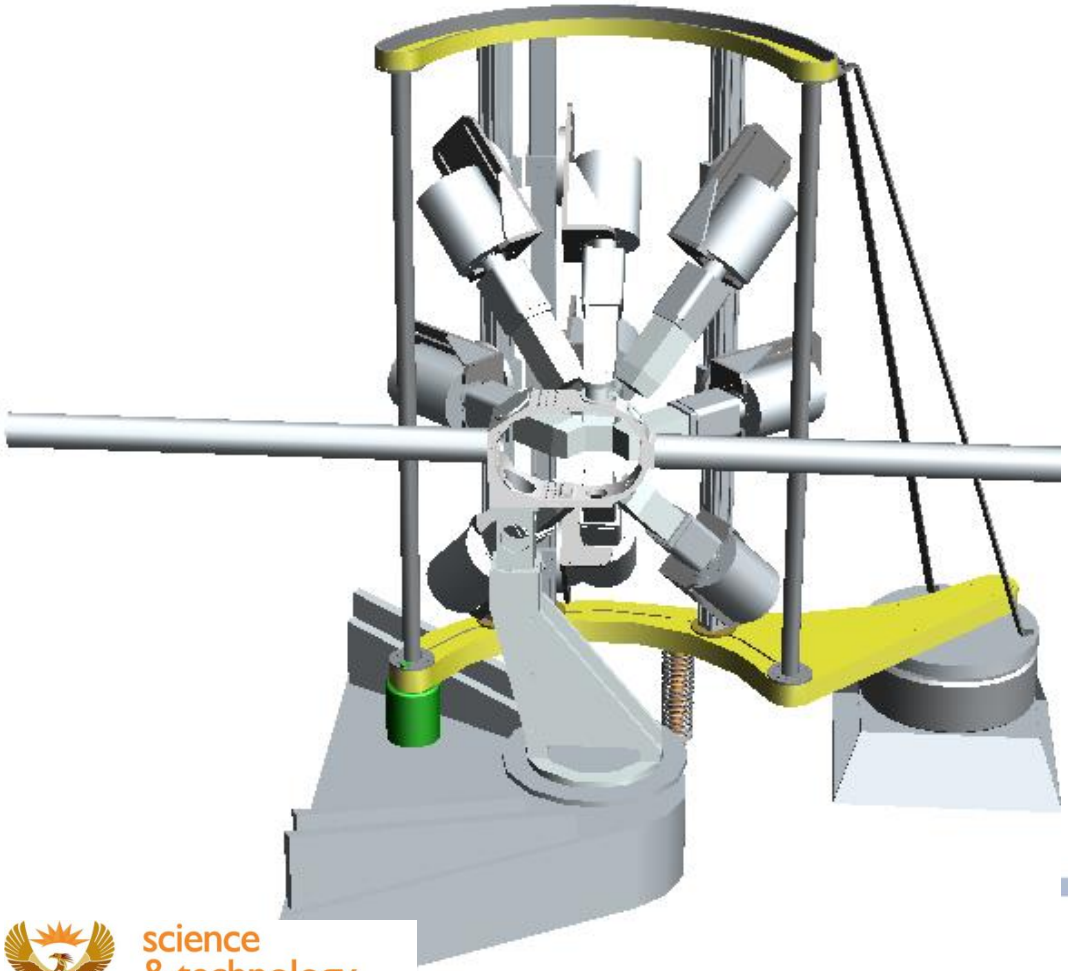
^{24}Mg(α,α') at 0˚ with K600 and CAKE

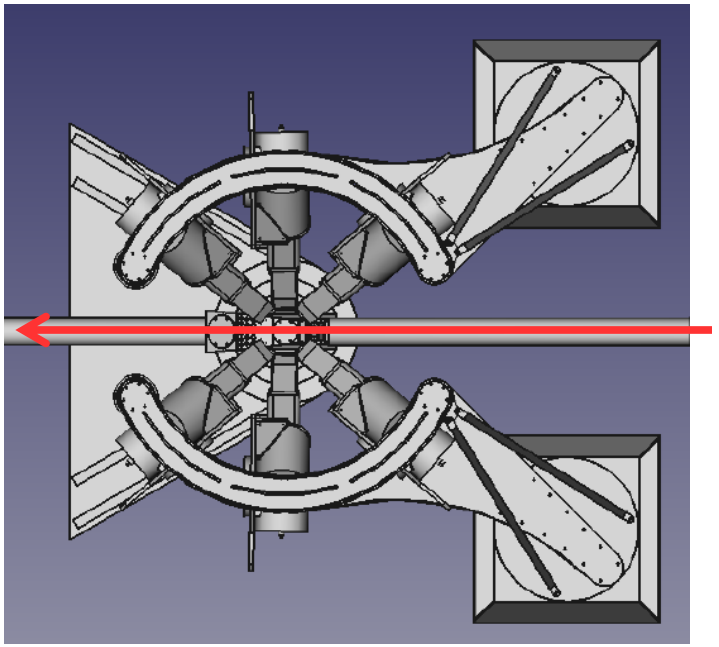


Being Analyzed

Add a Coincidence HPGe array: BAGEL

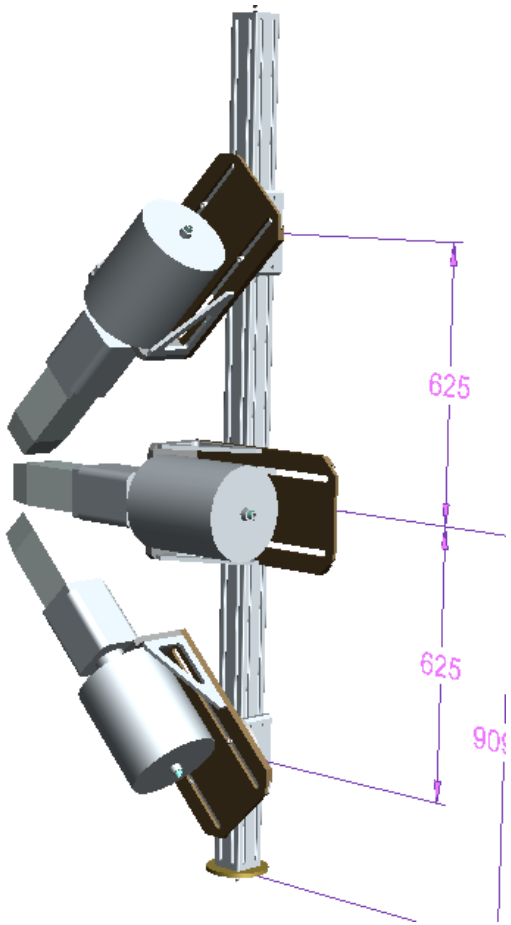
Beautiful Array of GErmaniums for L-value determination

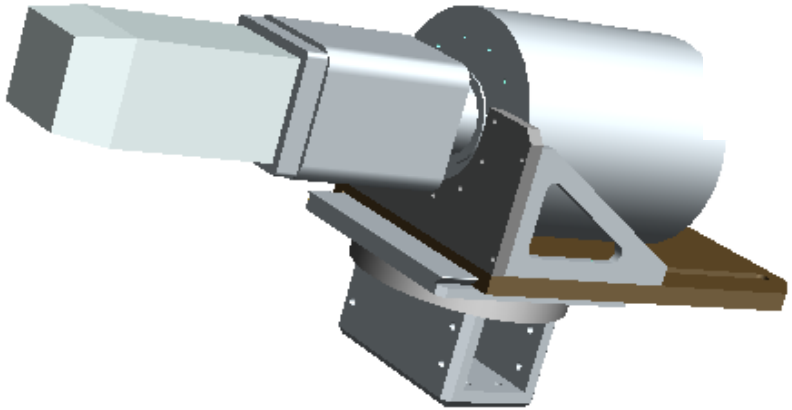




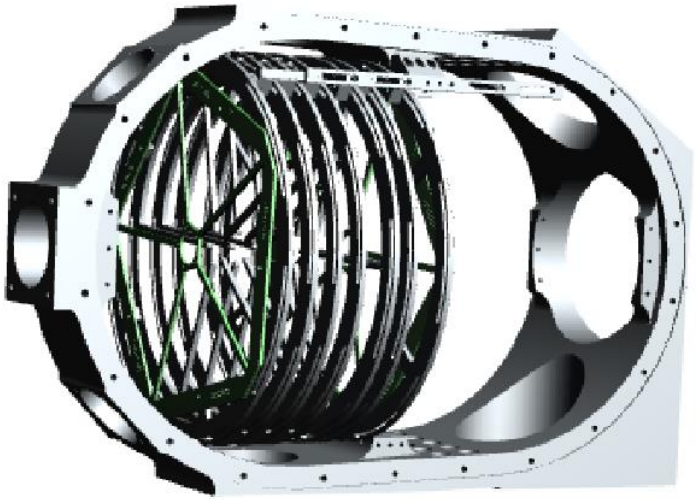
BAGEL array: soon to be assembled

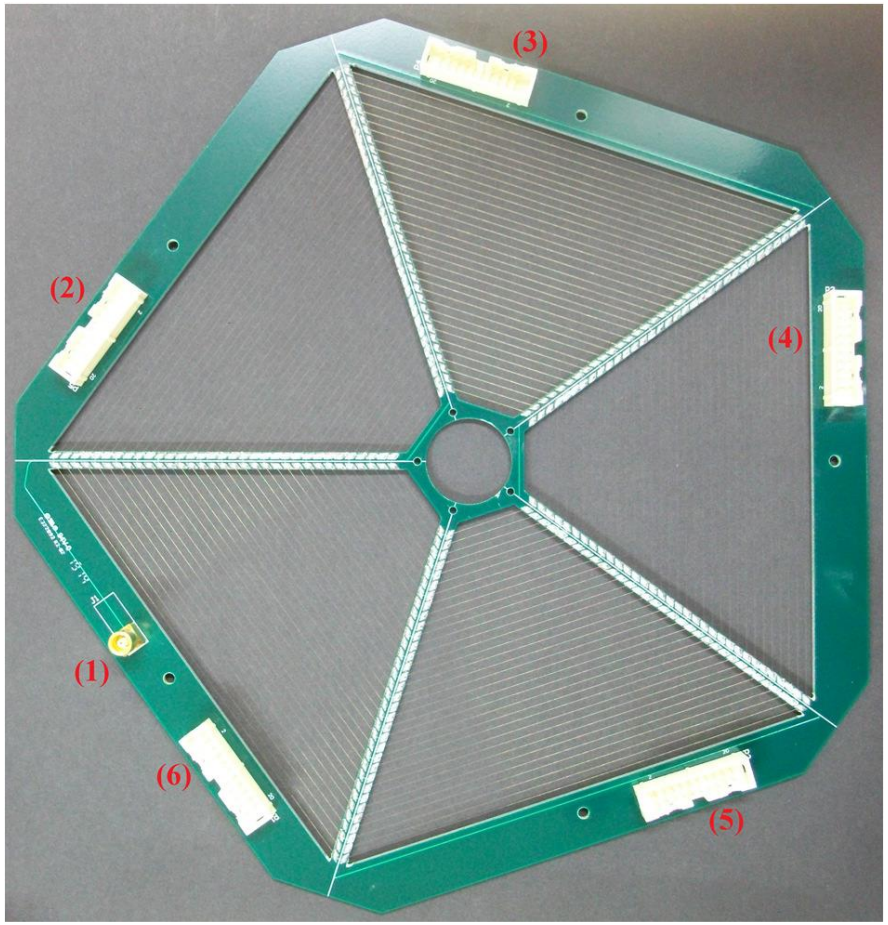
Assembly start
February 2016





GATEAU – Gaseous Active-TargEt Ancilliary Unit





Contributors and support

- Y Fujita, H Fujita, K Hatanaka, A Tamii
- A Richter, P von Neumann-Cosel
- J Carter, E Sideras-Haddad, I Usman
- G Berg
- P Papka R Fearick
- R Neveling, G Steyn, S Frötsch, L Conradie, D Fourie
- Deutsche Forschungsgemeinschaft
- National Research Foundation

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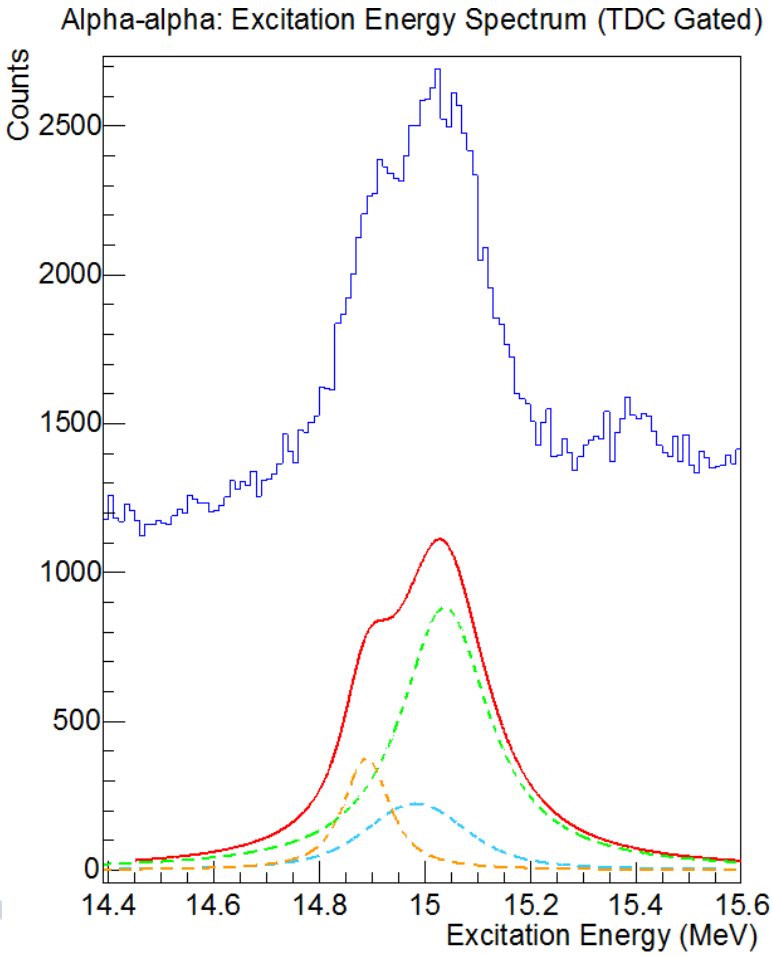
New Post Docs

- P Adsley – Stell. Univ. & iTL
- L Pellegri – Wits Univ. & iTL
- D Marin-Lambarri – Univ. West. Cape & iTL
- V Pesudo – Univ. West. Cape & iTL

Students MSc work

^{16}O – KCW Li – Univ. Stellenbosch
GATEAU – JW Brümmer – Univ. Stellenbosch

Thank You


Alpha-alpha: Excitation Energy Spectrum (TDC Gated)
Counts
2500
2000
1500
1000
500
0
14.4
14.6
14.8
15
15.2
15.4
15.6
Excitation Energy (MeV)