Shell inversion toward the Island of Inversion with ^{29}Mg

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University Of Surrey

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15th July 2016

Shell evolution toward the island of inversion

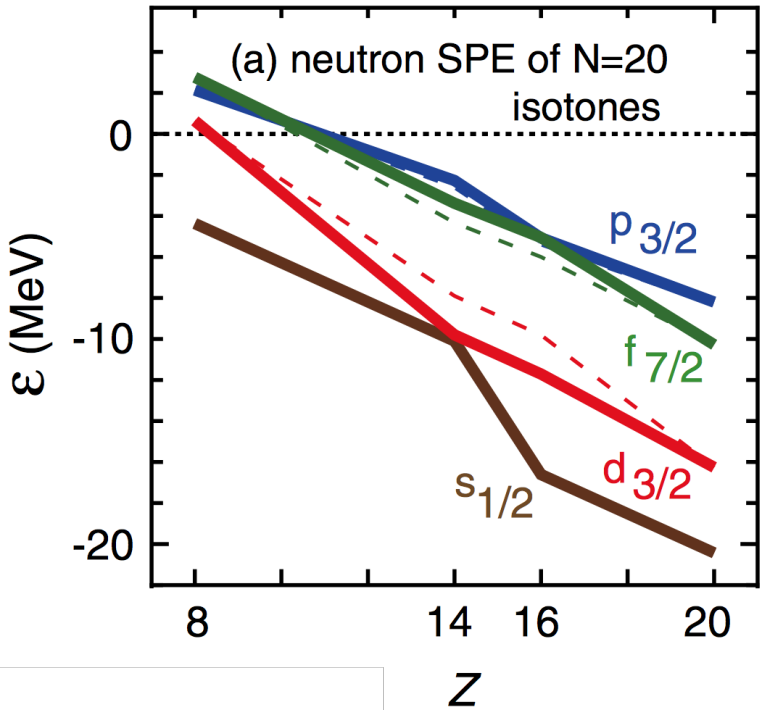
^{27}P	^{28}P	^{29}P	^{30}P	^{31}P	^{32}P	^{33}P	^{34}P	^{35}P	^{36}P	^{37}P	^{38}P
^{26}Si	^{27}Si	^{28}Si	^{29}Si	^{30}Si	^{31}Si	^{32}Si	^{33}Si	^{34}Si	^{35}Si	^{36}Si	^{37}Si
^{25}Al	^{26}Al	^{27}Al	^{28}Al	^{29}Al	^{30}Al	^{31}Al	^{32}Al	^{33}Al	^{34}Al	^{35}Al	^{36}Al
^{24}Mg	^{25}Mg	^{26}Mg	^{27}Mg	^{28}Mg	^{29}Mg	^{30}Mg	^{31}Mg	^{32}Mg	^{33}Mg	^{34}Mg	^{35}Mg
^{23}Na	^{24}Na	^{25}Na	^{26}Na	^{27}Na	^{28}Na	^{29}Na	^{30}Na	^{31}Na	^{32}Na	^{33}Na	^{34}Na
^{22}Ne	^{23}Ne	^{24}Ne	^{25}Ne	^{26}Ne	^{27}Ne	^{28}Ne	^{29}Ne	^{30}Ne	^{31}Ne	^{32}Ne	^{33}Ne
^{21}F	^{22}F	^{23}F	^{24}F	^{25}F	^{26}F	^{27}F	^{28}F	^{29}F	^{30}F	^{31}F	

- Intruder State
- low laying excited state
- shell study using (d,p) selectivity
- track the N=20 shell gap

^{29}Mg status unclear $\rightarrow$ assign spin and parity

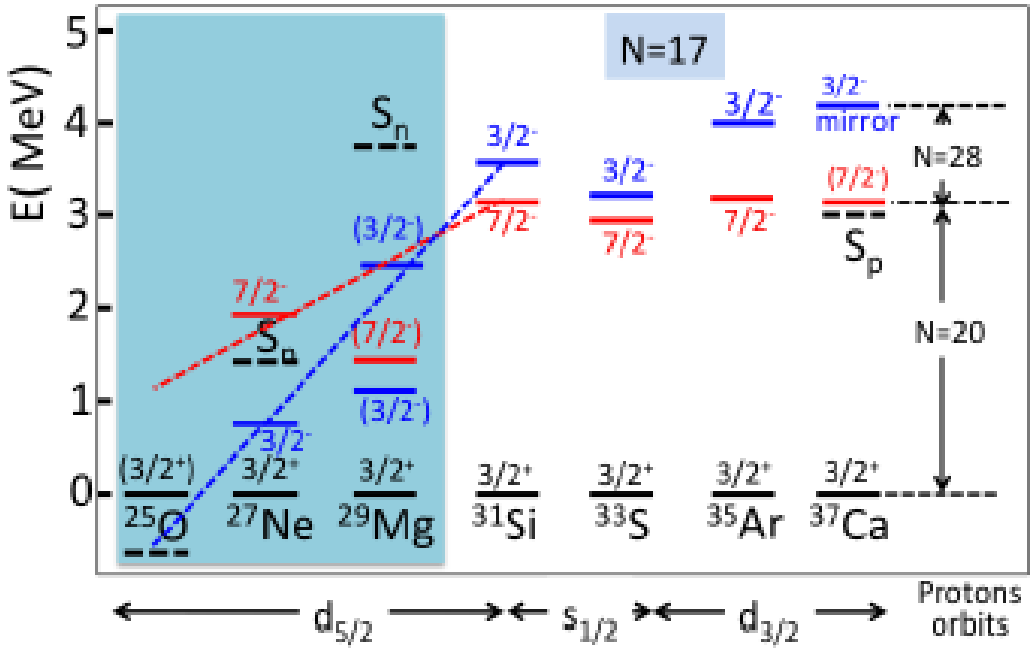
The $N = 20$ Shell Gap

SPE for N=20



Otsuka *et al* PRL 104, 012501 (2010)

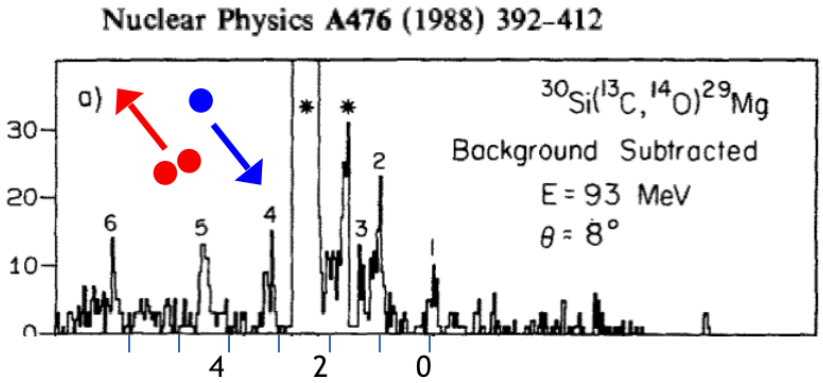
Energy of the lowest state of each spin

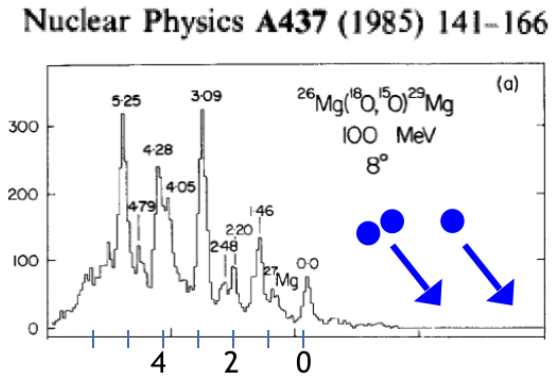


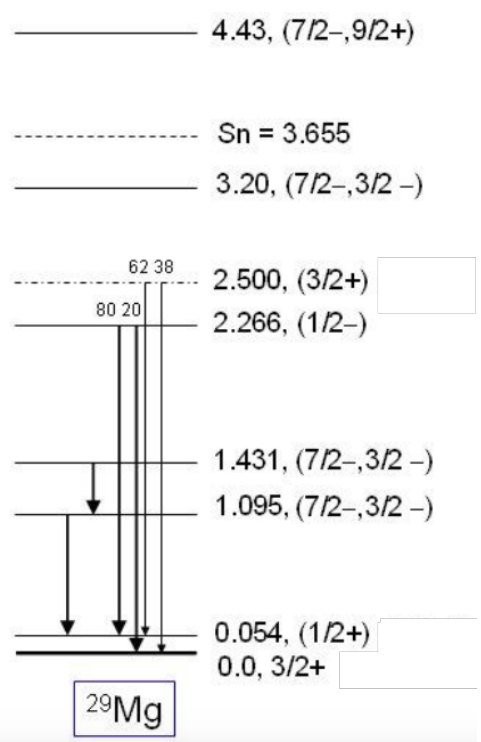
Sorlin, INPC 2013 proceedings.

- $Z = 8$ to $Z = 14$ filling $d_{5/2}$
- Neutron orbital are shifted
- $N = 20$ is weakening
- $N = 16$ is strengthening

Previous Experiments







(^{13}C,^{14}O):

- Poor selectivity
- Contaminant in region of interest

(^{18}O,^{15}O):

- Less selectivity

Overall:

- Few state identified
- Tentative spin
- only one SF

Beam Production: ISAC-II at Triumf

Primary proton beam

- 50 MeV
- 100 μA
- Silicon Carbide target

  $\rightarrow$ Do not hold HV

Secondary Beam

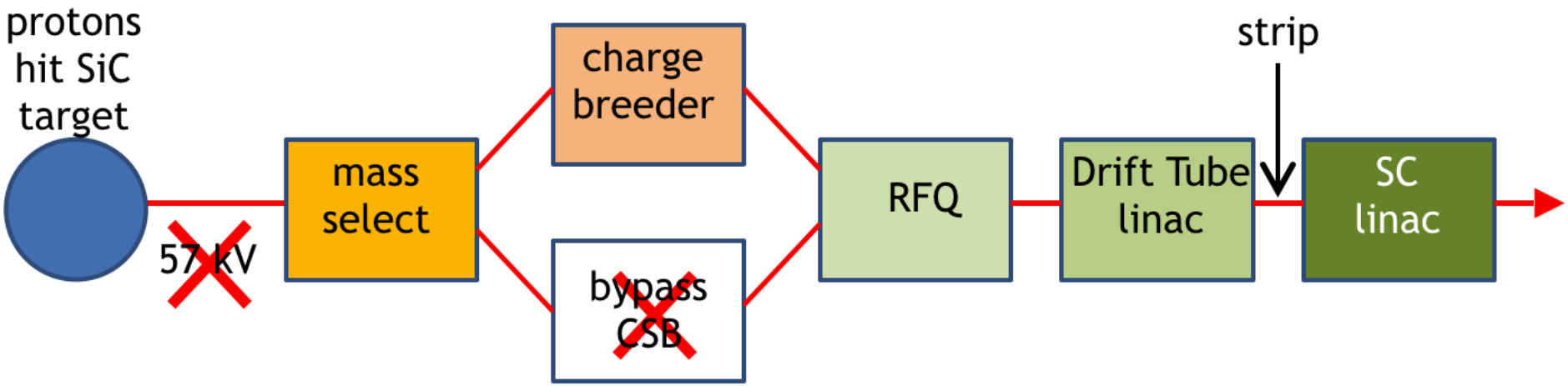
- ^{28}Mg beam 3000 pps at 8 AMeV

  $\rightarrow$ With strong contamination

  ^{28}Si cont. (3. 10^5 pps)

  ^{28}Al cont. (300 pps)

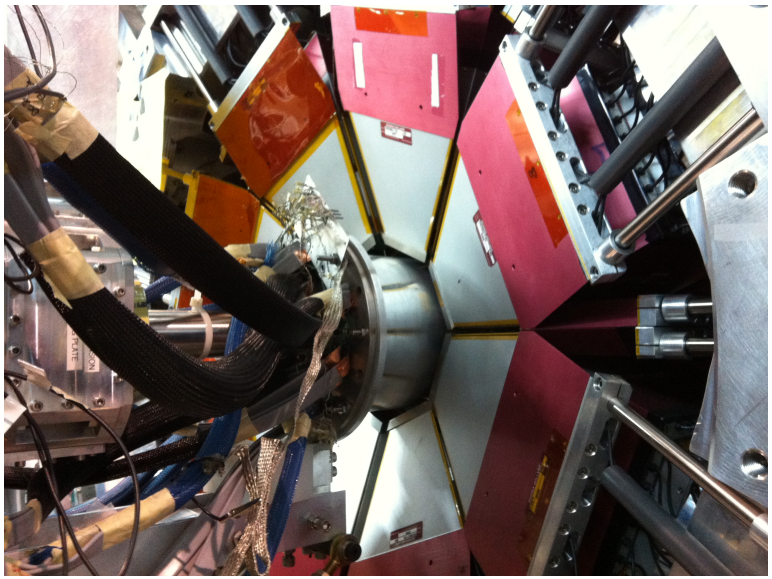
ISACII beam line

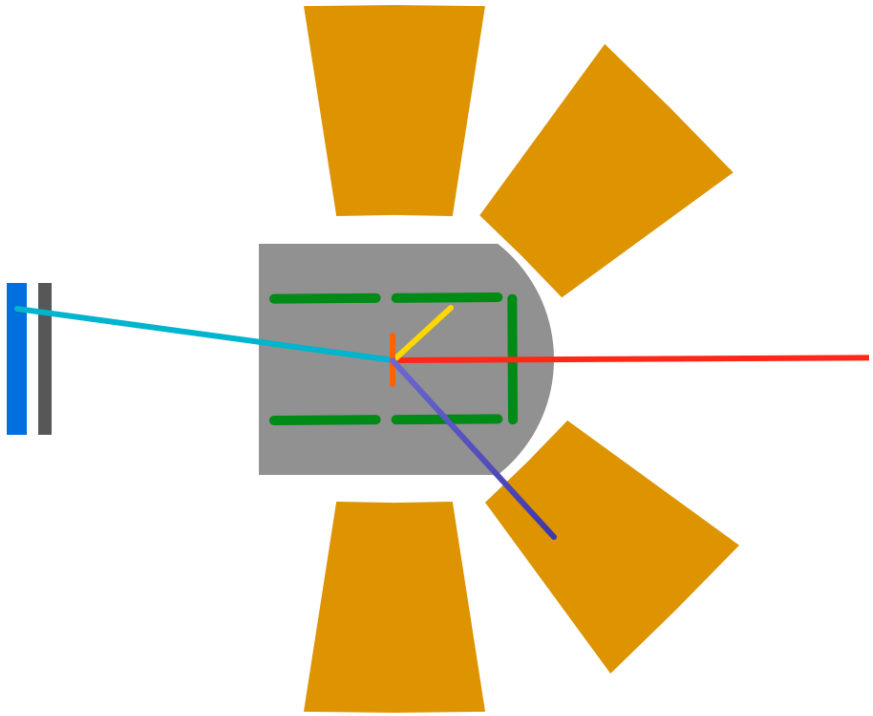


Tigress and Sharc: γ-particle coincidences

Setup around the target

- CD_2 0.5 mg.cm^{-2}
- 12 Sharc DSSD detector
- 12 Tigress Ge clover
- Trifoil detector at 0 deg.





Sharc (University of York)

Silicon Highly-segmented Array for Reactions and Coulex

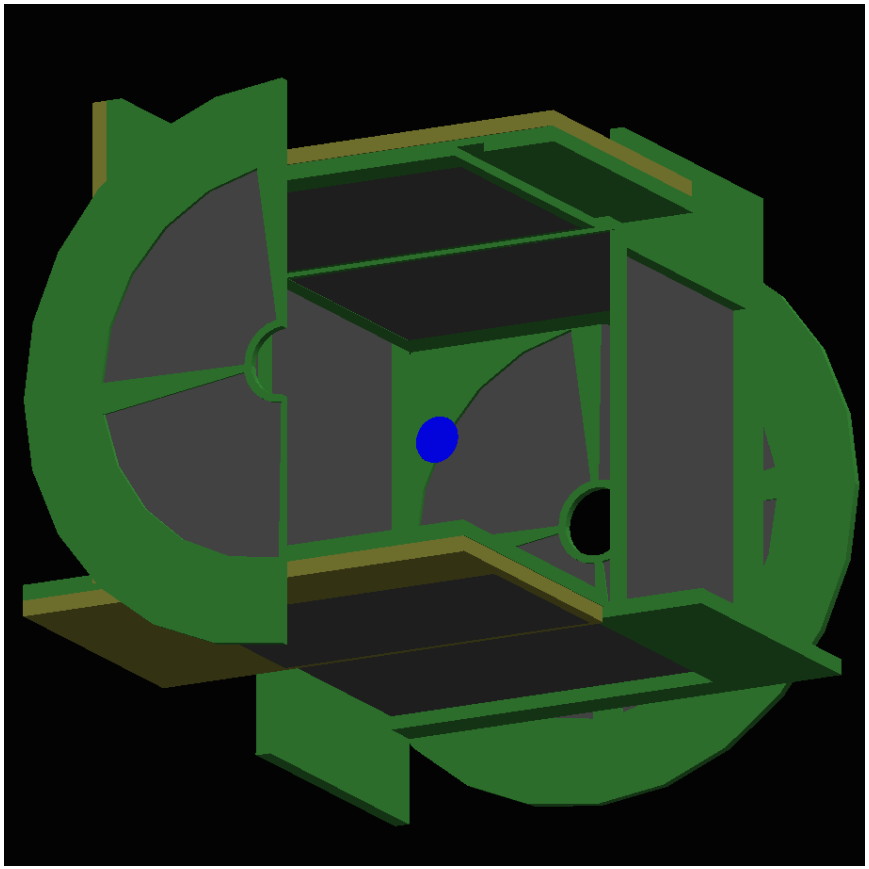
Compact Design

less than 75 mm from target:

- Upstream Single layer Annular
- Upstream Single layer Box
- Downstream Double layer Box
- Downstream Double layer Annular

Limitations

- No TOF Id
- E-ΔE only downstream
- Not suited for (d,t) $(d,^3\mathrm{He})$



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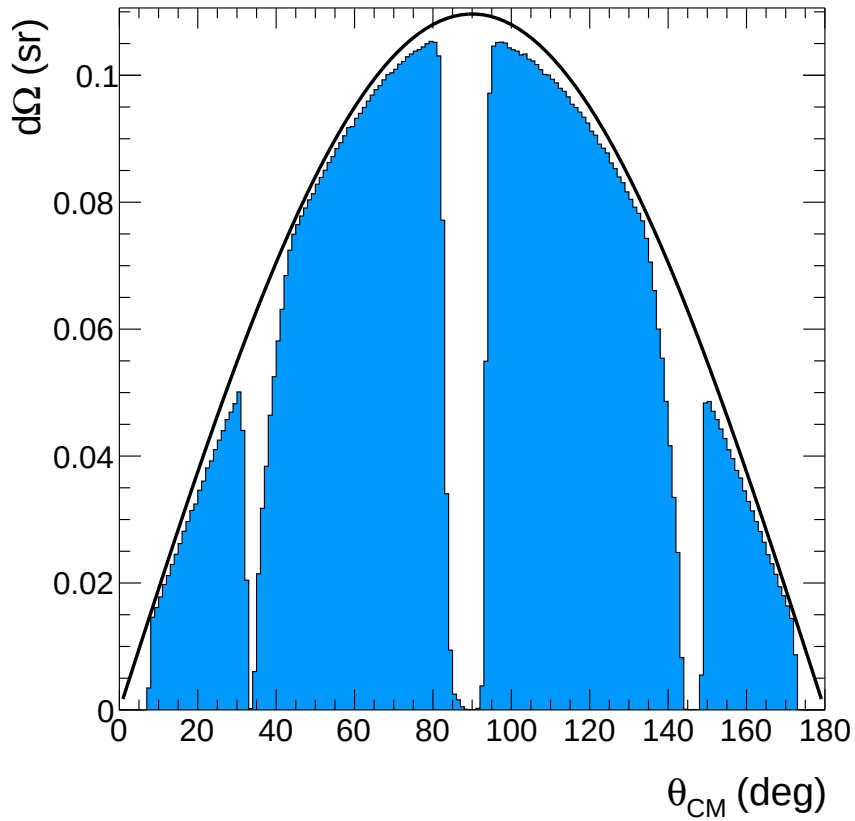


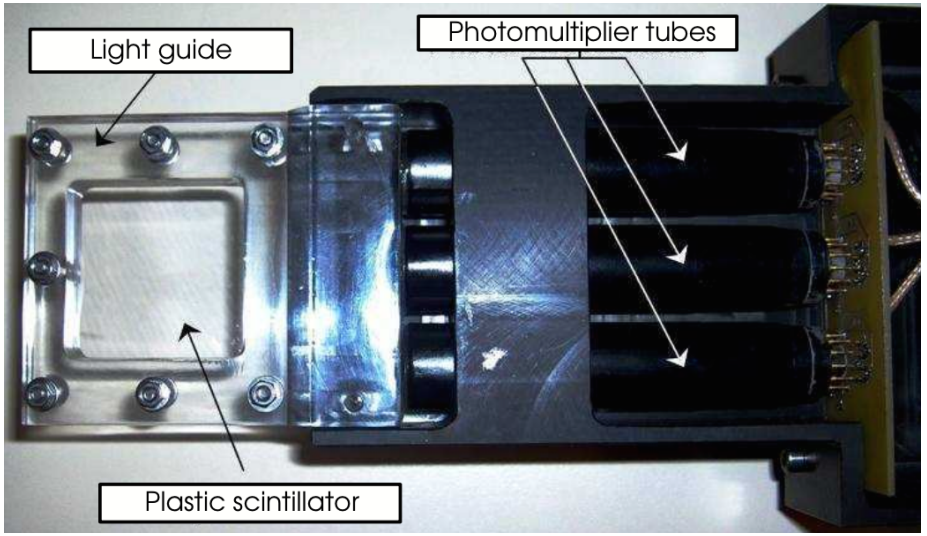
Trifoil (LPC Caen)

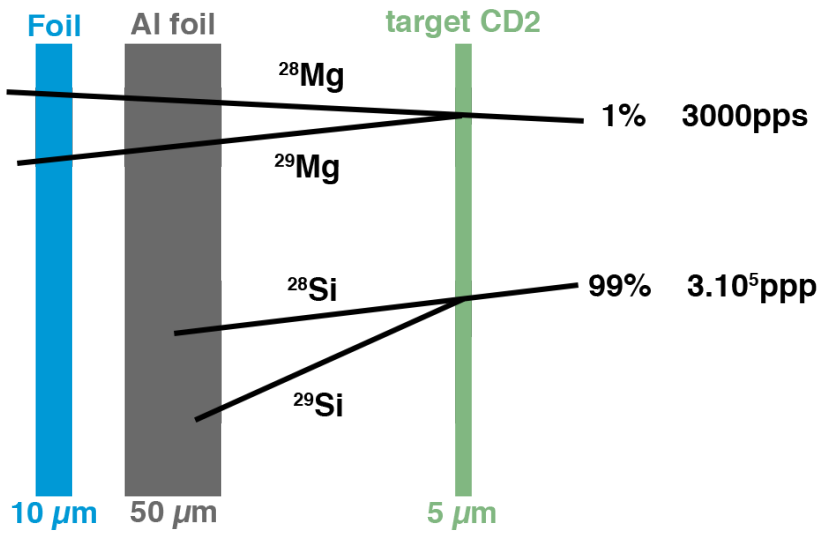
Design

- Passive Al foil
  - → 30 μm for ^{26}Na
  - → 50 μm for ^{29}Mg
  - → 40 μm for ^{94}Sr
- Active BC400 foil 100 μm
- 3 PMT
- 40 mm^2
- 40 cm from target

Logic

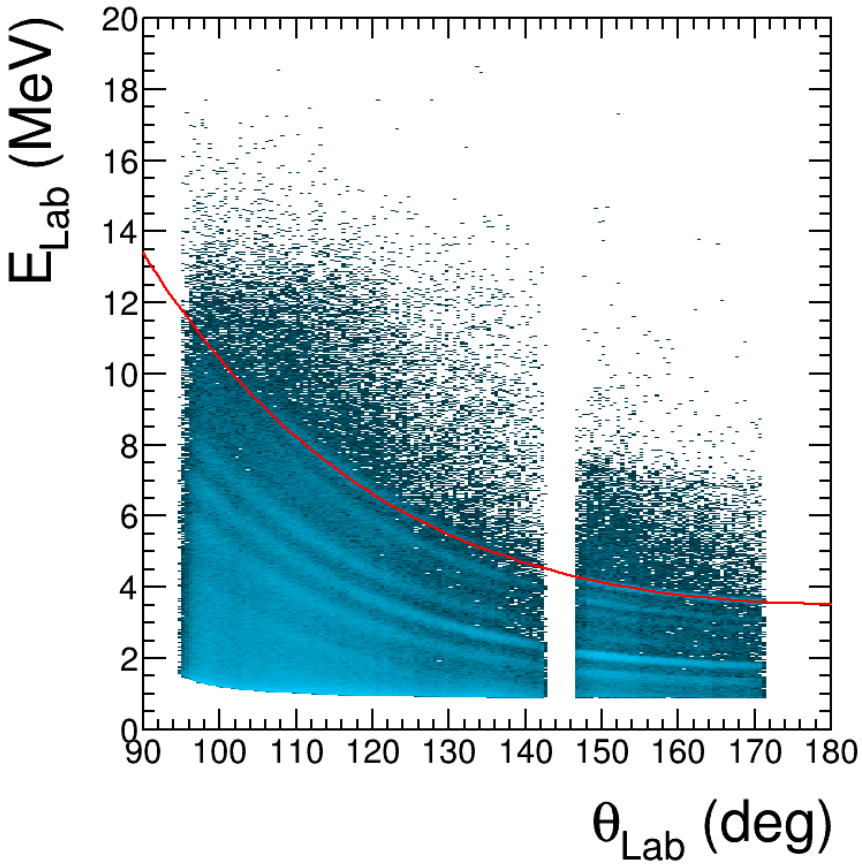
- Direct beam : no Si trigger
- Direct Reaction: Trifoil
- Compound Nucleus: Stopped in Al
- **Contaminant: Stopped in Al**



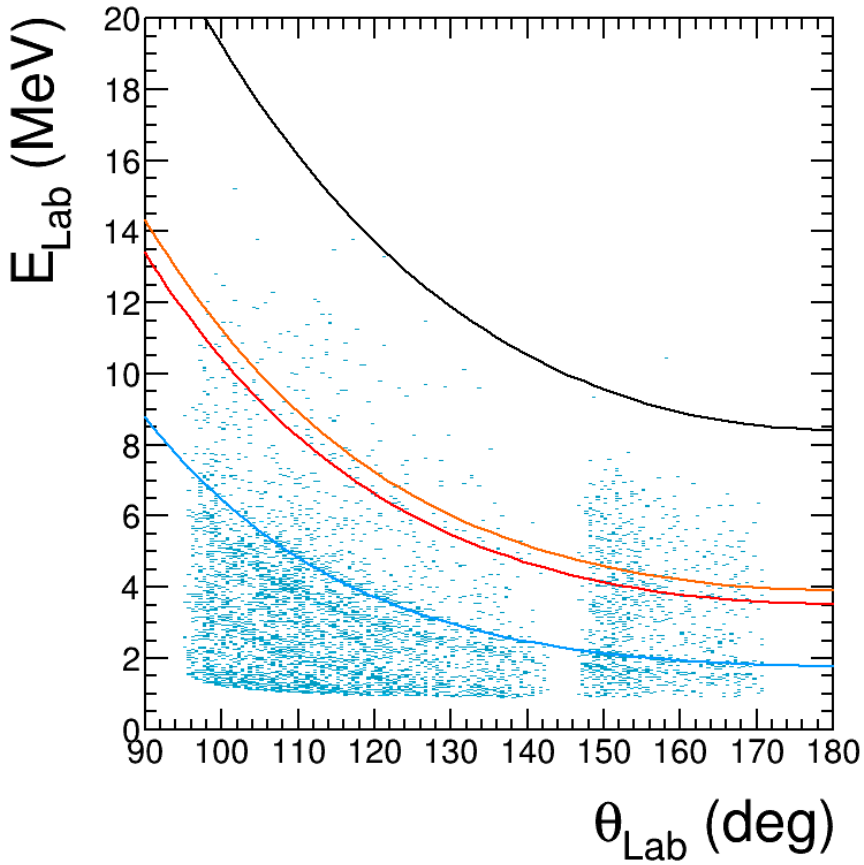


Removing Contaminant

No Trifoil Gate



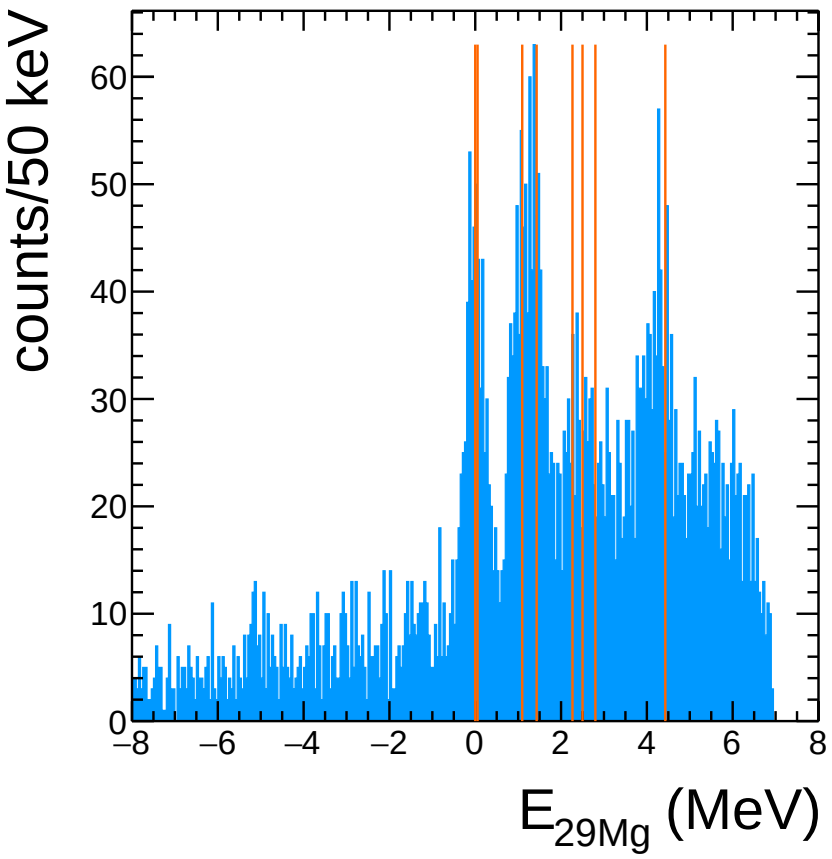
Trifoil Gate



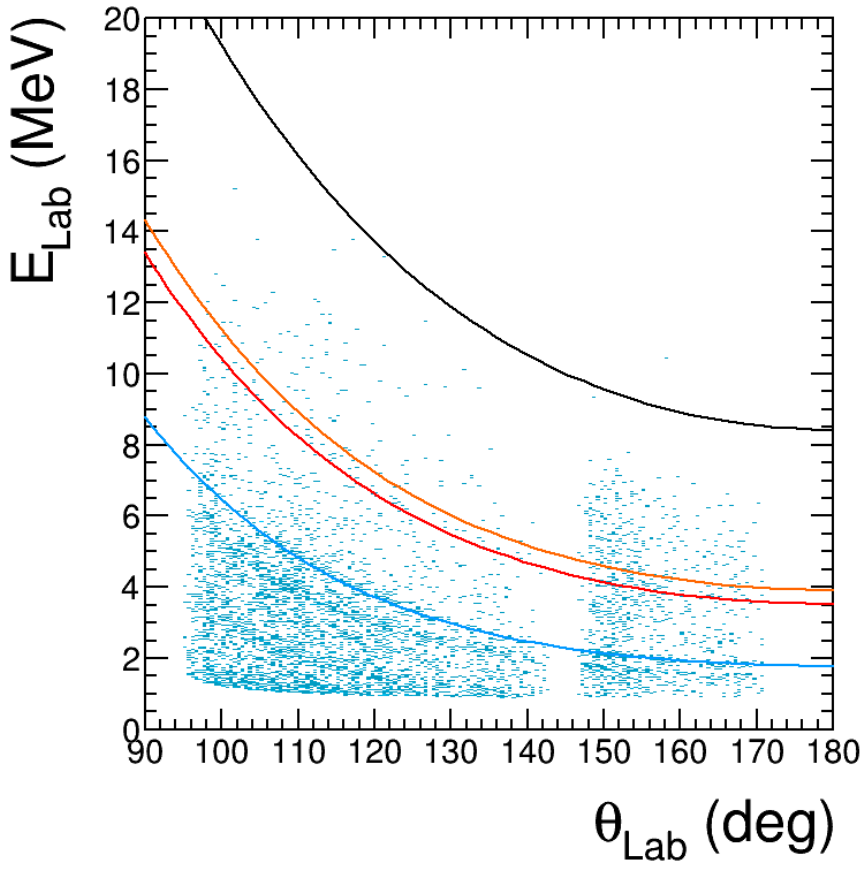
Trifoil gate Remove ^{28}Si(d,p) ^{29}Si successfully

Removing Contaminant

Gated Excitation Energy



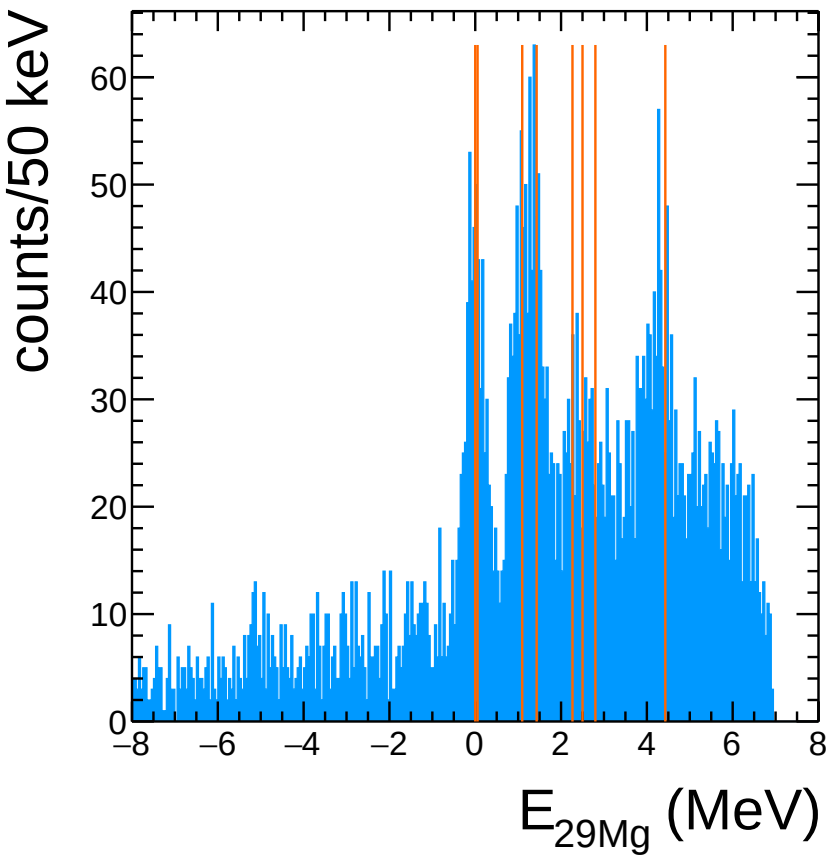
Trifoil Gate



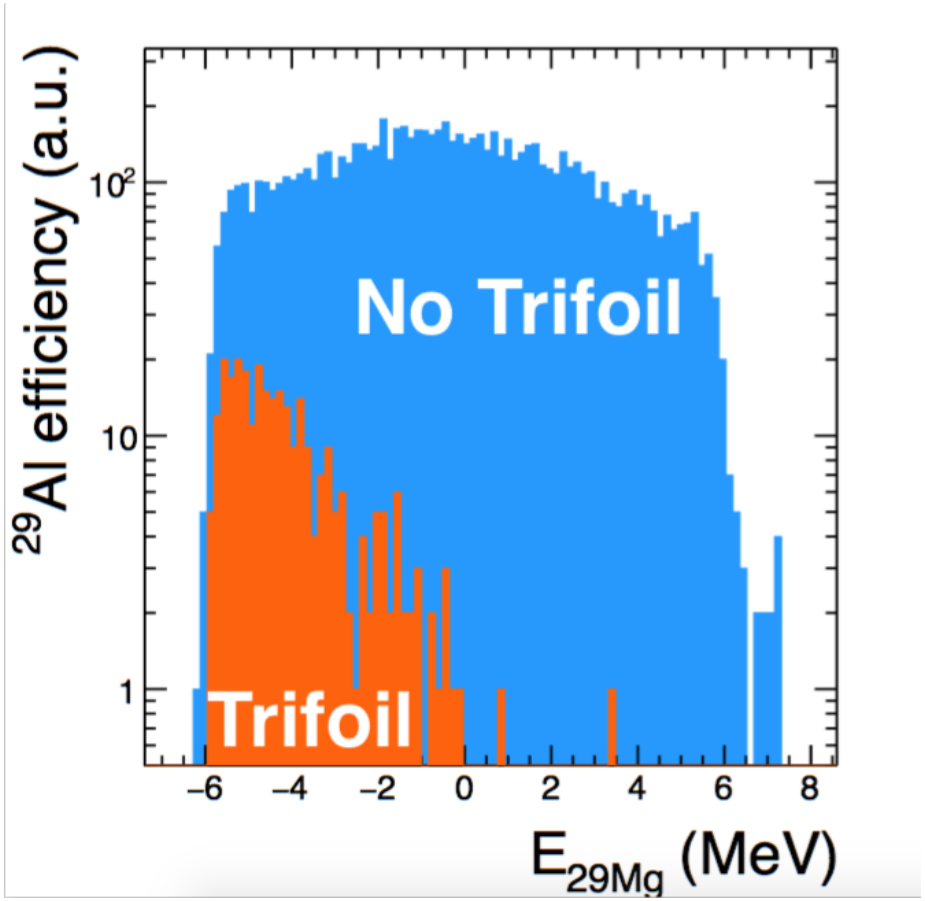
^{28}Al(d,p) ^{29}Al present at Neg. Excitation

Removing Contaminant

Gated Excitation Energy



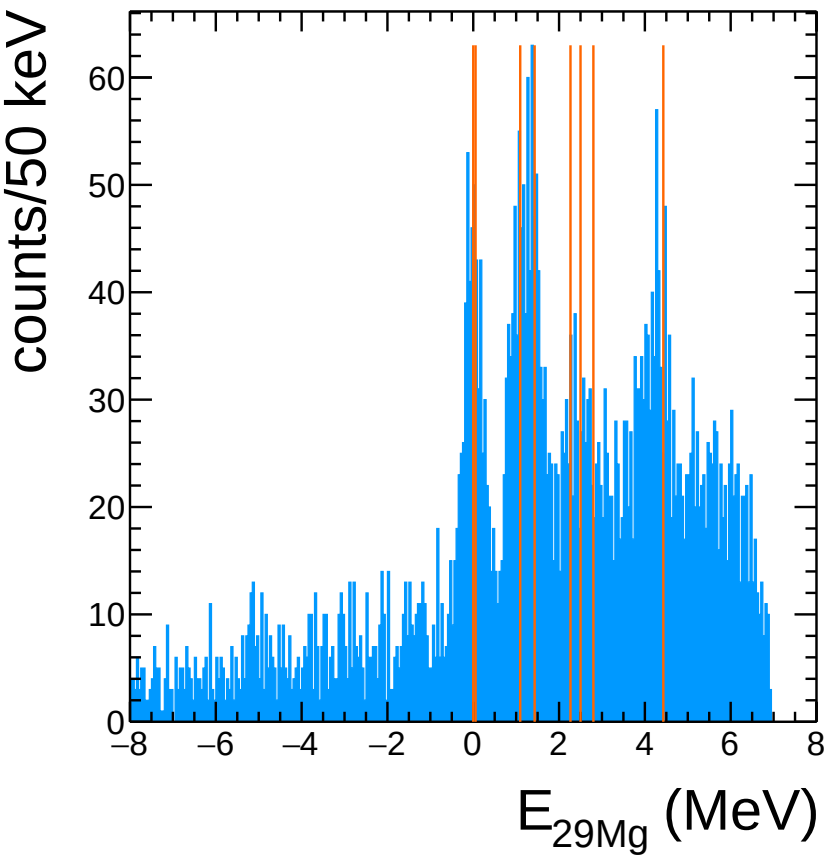
Trifoil gated ^{29}Al efficiency



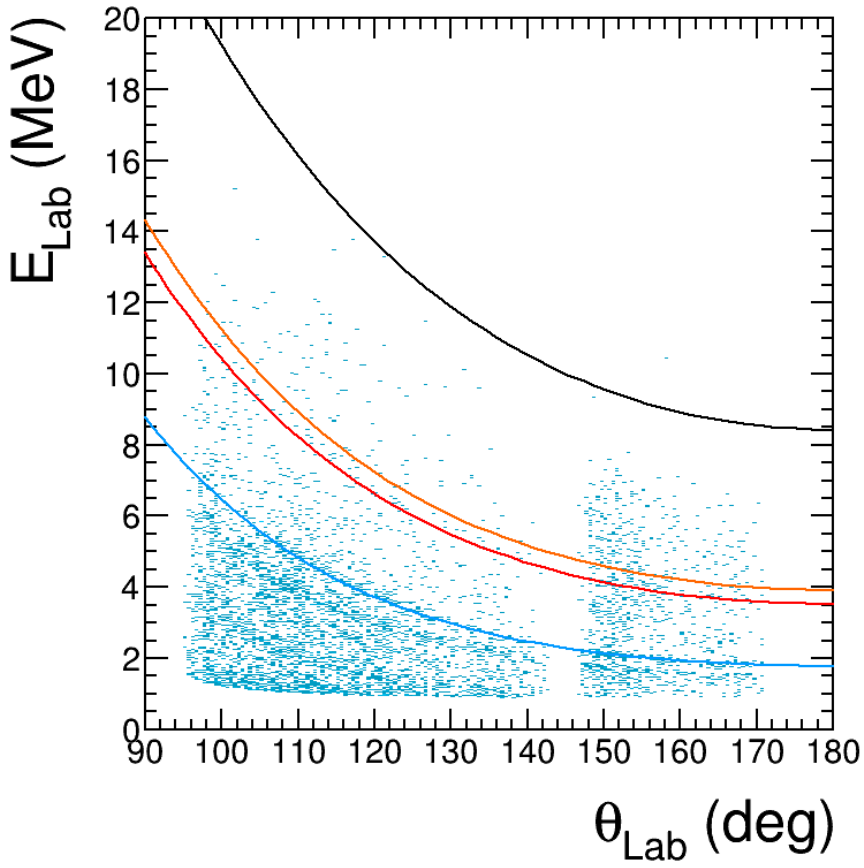
Trifoil gate Remove ^{28}Al(d,p) ^{29}Al successfully

Removing Contaminant

Gated Excitation Energy



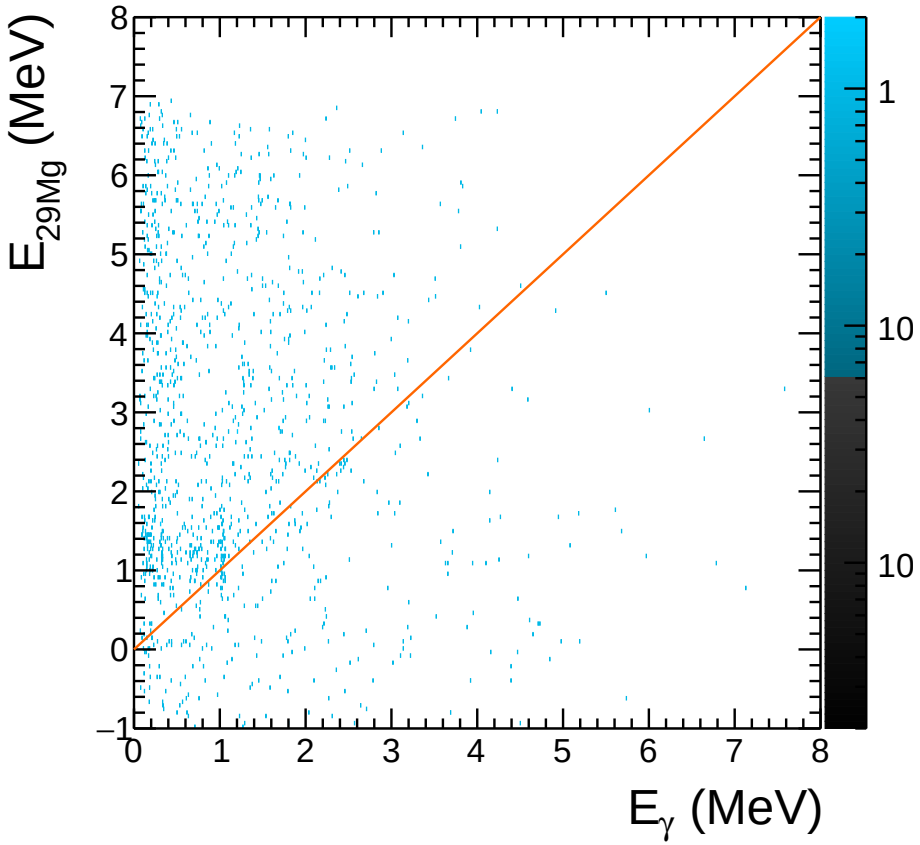
Trifoil Gate



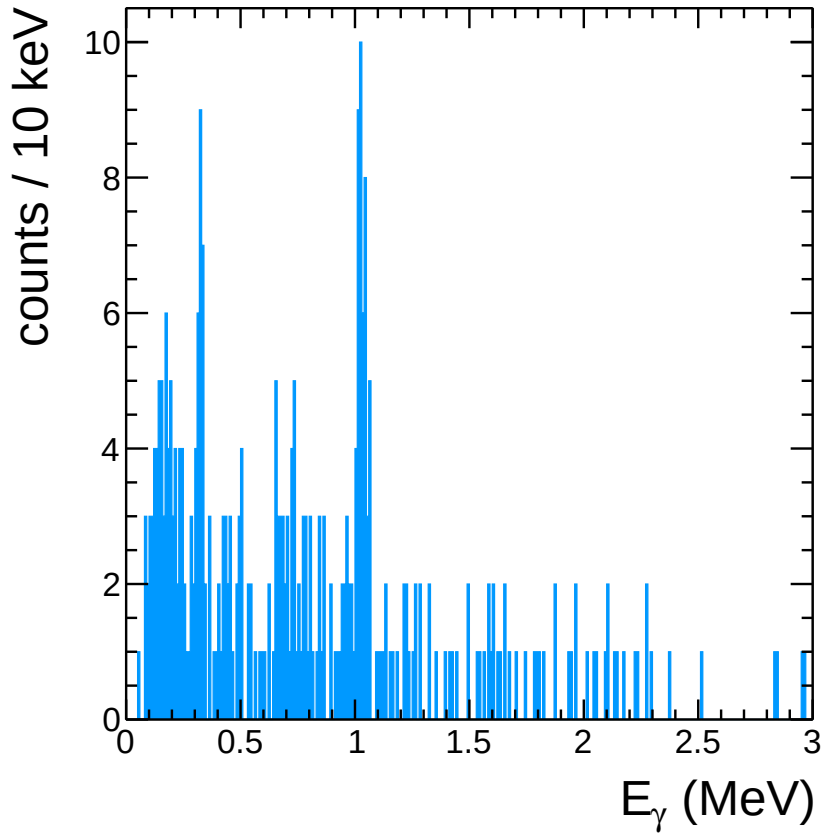
Still important background below -6 MeV → Open issue!

γ-ray spectroscopy

E_{Mg}-E_γ



Gated E_γ



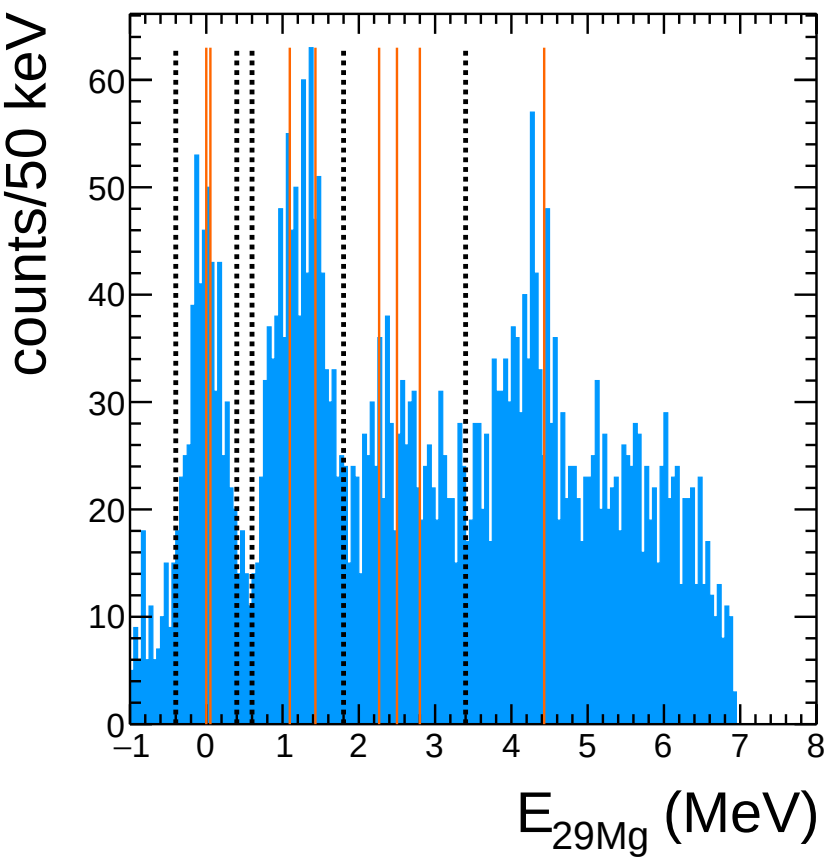
336 keV and 1041 keV in coincidence with 1-1.5 MeV doublet

✓ Validate analysis

✗ Not enough stat for γ-gating

(Not so preliminary) Differential cross-sections

Excitation Gating



CS Calulation

Reaction theory:

- TWOFNR calculation
- ZR ADWA (Johnson-Sopper)
- CH89 Potential

Overlap:

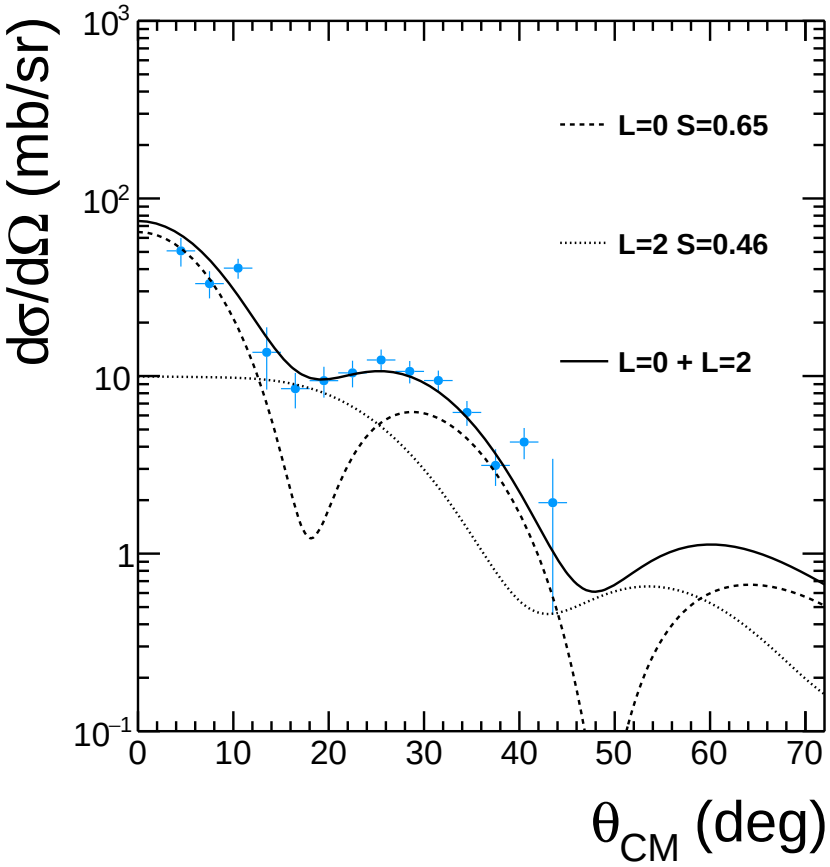
- WS fixed geometry
- r_0=1.25 fm a_0=0.65 fm
- Binding energy prescription

SM Calculations

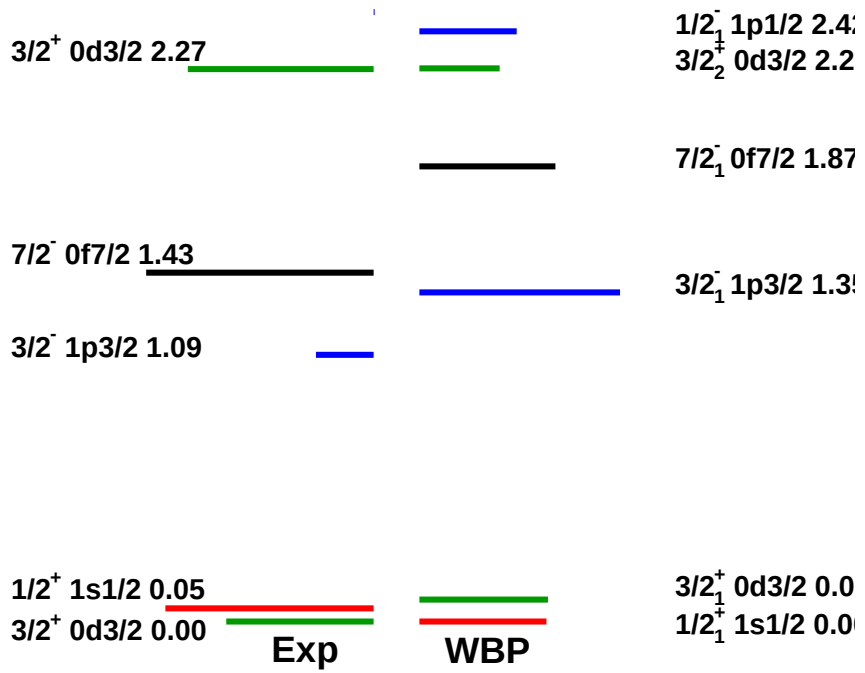
- Nushell X
- WBP interaction
- full $1\hbar\omega$
- *spsdpf* model space

(Not so preliminary) Differential cross-sections

Ground State Doublet

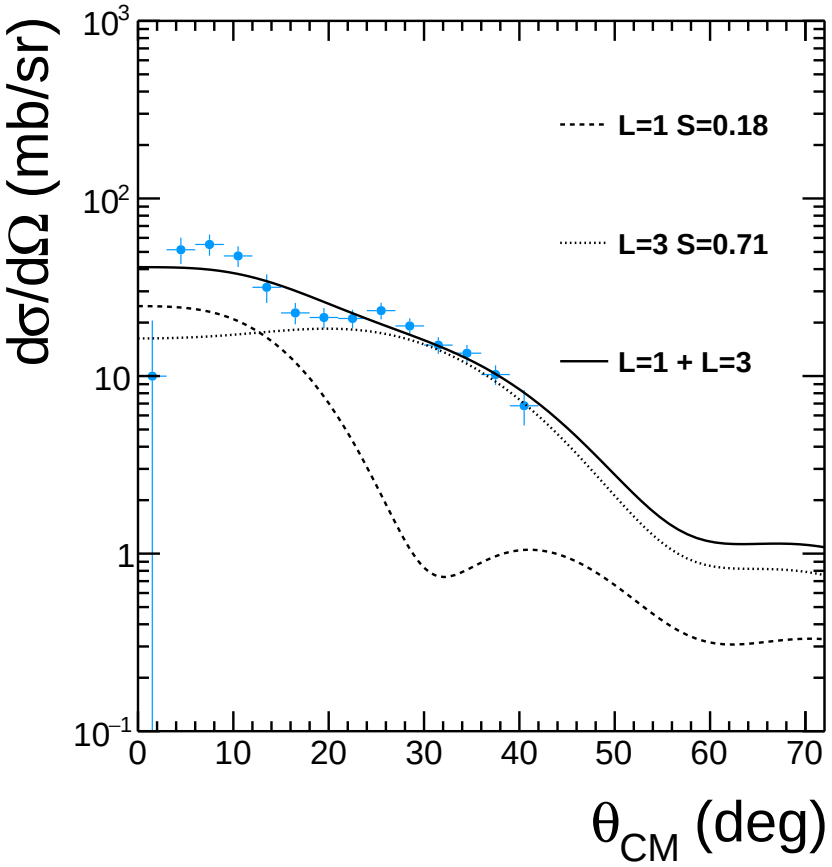


SM Calculations

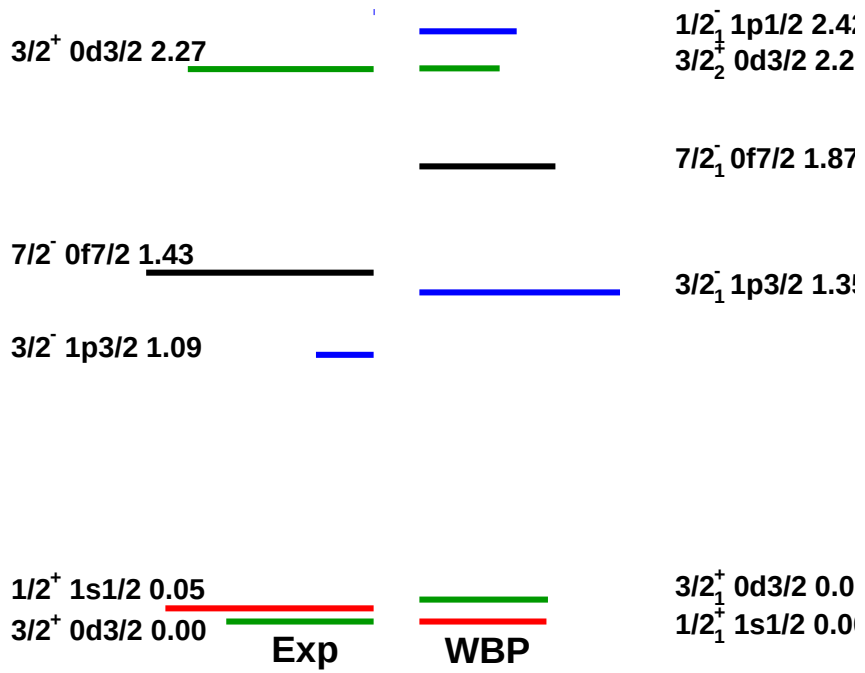


(Not so preliminary) Differential cross-sections

1 MeV Doublet

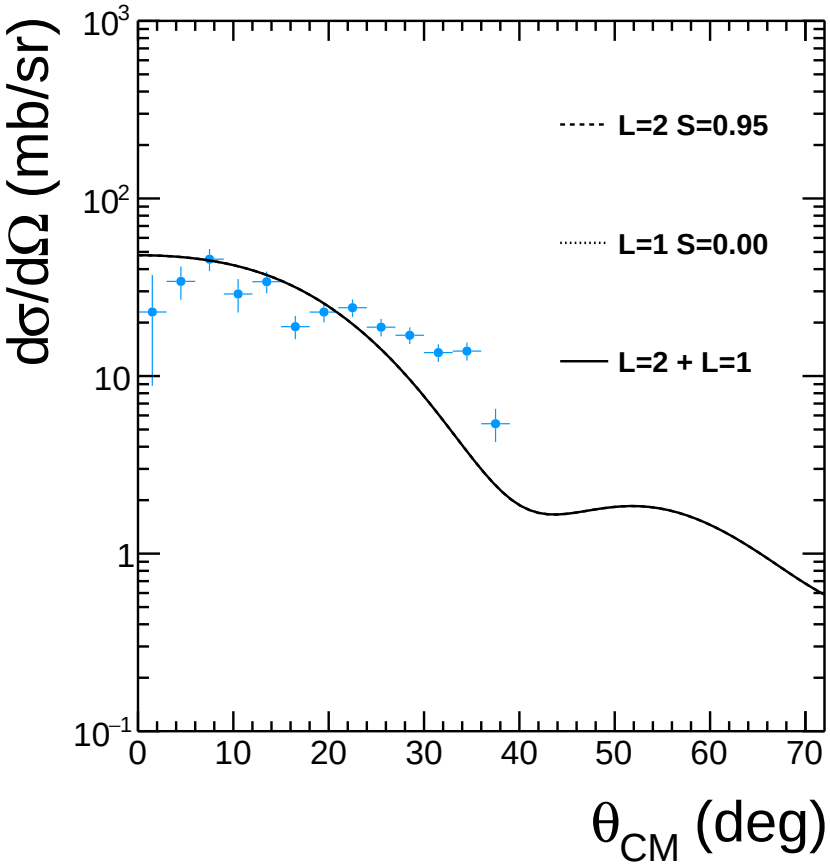


SM Calculations

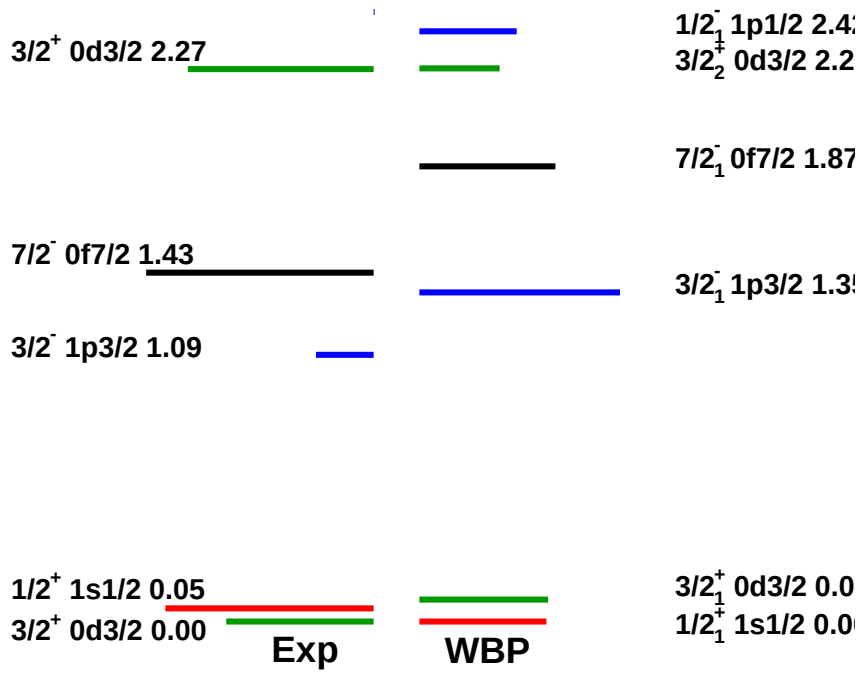


(Not so preliminary) Differential cross-sections

2 MeV Doublet



SM Calculations



Conclusion

Conclusion

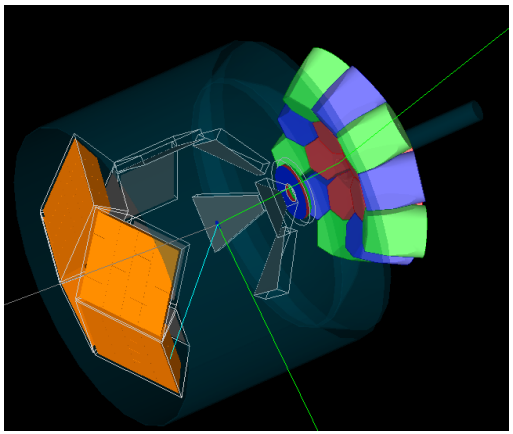
Key Points:

- Work in progress for CS
- Background to be understood

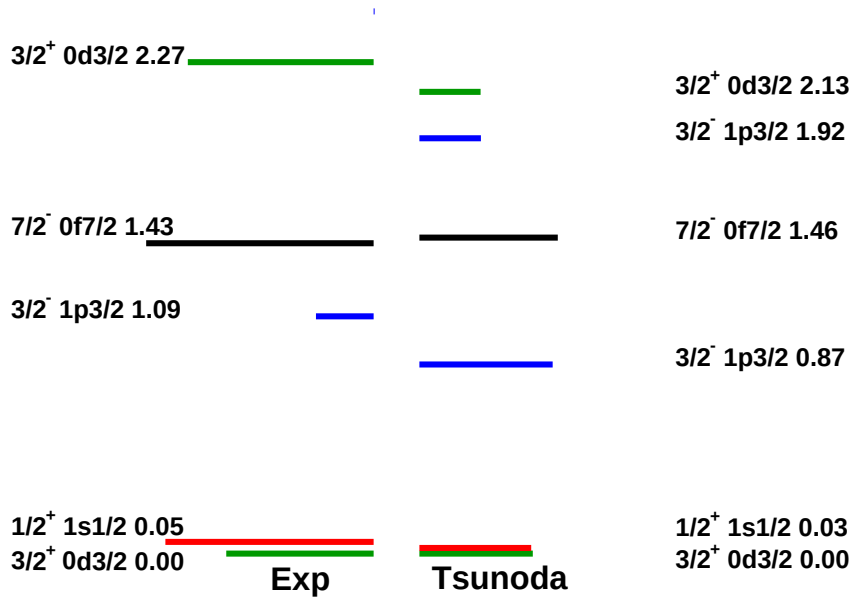
Perspective:

- Re-do the experiment
- MUGAST+SPIRAL1^{+} @ GANIL

MUGAST+AGATA+VAMOS



Microscopic Shell Model



Thank you

Collaborators

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