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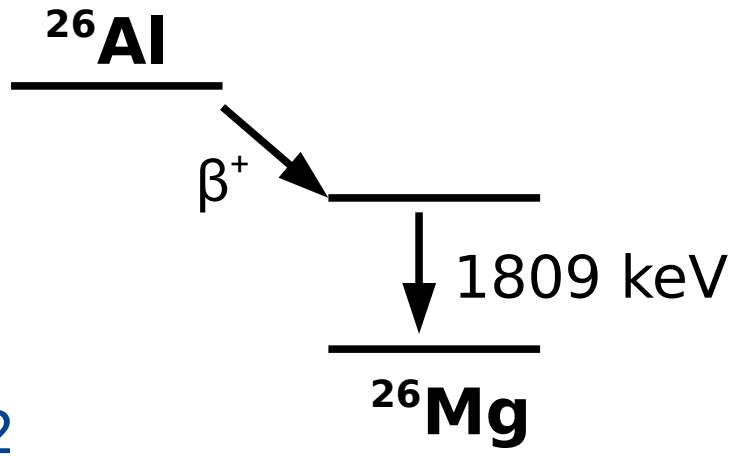
1. March 2016

The ^{23}Na(α,*p*) cross section at astrophysically relevant energies

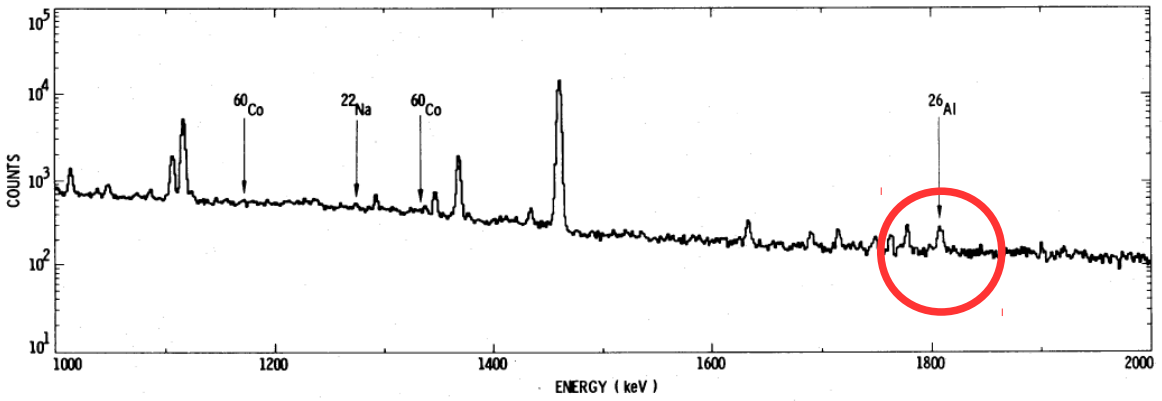
Alan Howard

Galactic ^{26}Al



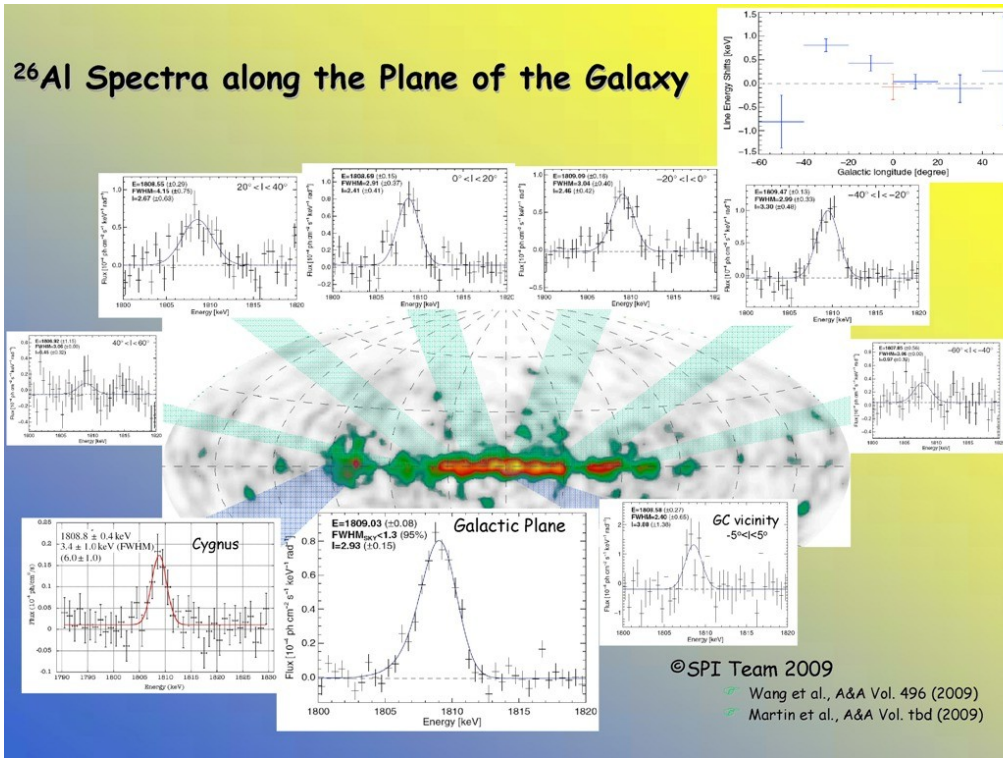
- Decays with $t_{1/2}=7.2\times10^5$ years
- First observation by HEAO 3 in 1982
- Direct evidence of ongoing nucleosythesis in the galaxy!

W. Mahoney *et. al.*, Astrophys. J. **262**, 742 (1982)



Galactic ^{26}Al

- New data from e.g. COMPTEL and SPI
- ^{26}Al observed along the galactic plane
- Co-rotates with galaxy
- Massive stars are prime candidates for production



→ Prantzos, N. & Diehl, R., Phys. Rep. **267**(1), 1–69 (1996)

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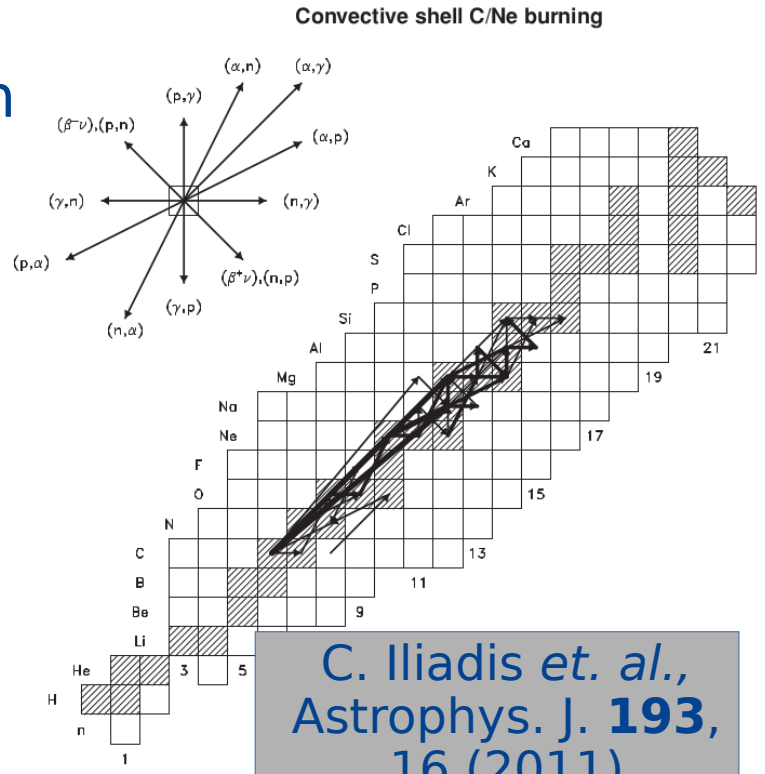
Sensitivity of ^{26}Al production

- Post-processing calculations to assess sensitivity of ^{26}Al production to reaction cross sections

"Particularly important reactions are ^{26}Al(n,p)^{26}Mg, ^{25}Mg(α,n)^{28}Si, ^{24}Mg(n,γ)^{25}Mg, and ^{23}Na(α,p)^{26}Mg. These reactions should be prime targets for future measurements."

- ^{23}Na(α,p)^{26}Mg acts as a proton source for ^{25}Mg(p,γ)^{26}Al

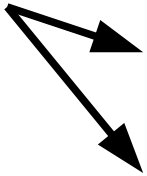
- Factor of 3 in ^{26}Al production for a cross section change of a factor 10



C. Iliadis *et. al.*, Astrophys. J. **193**, 16 (2011)

Existing knowledge (2014)

- Direct measurements performed in 1960s/70s



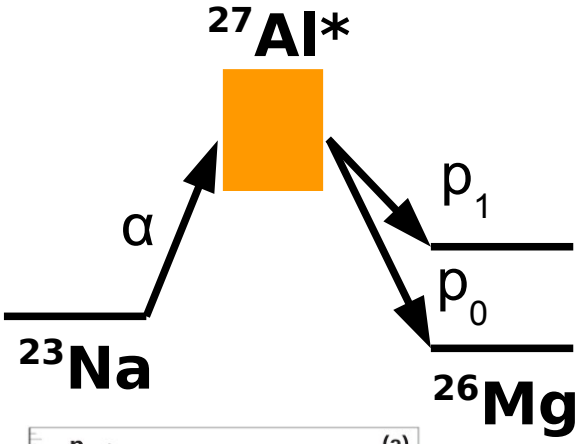
J. Kuperus, Physica 30, 2253 (1964)

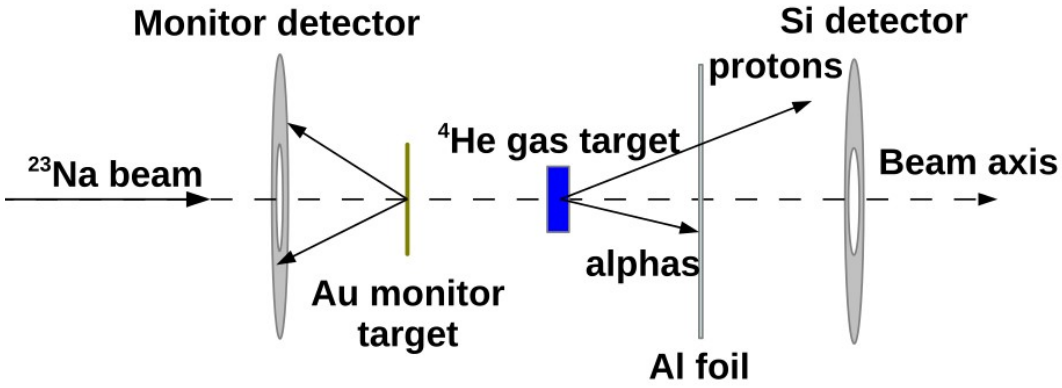
D. P. Whitmire *et. al.*, Phys. Rev. C **9**, 996 (1974)

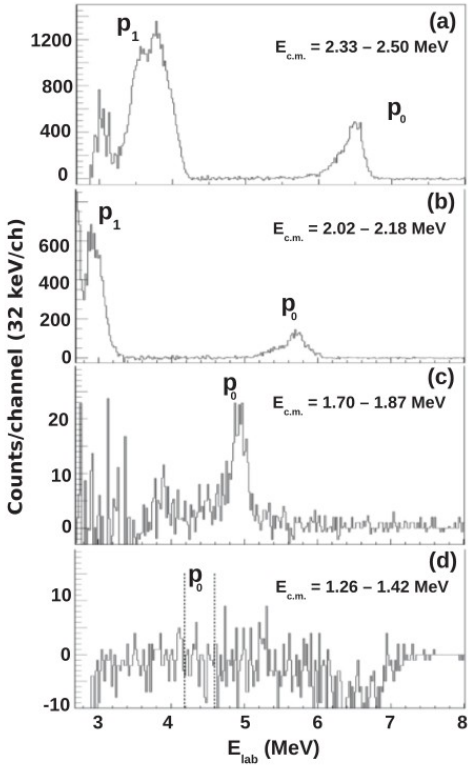
- NaCl target properties not well understood during bombardment (changes in thickness/stoichiometry)
- Data missing in low-energy region of interest for stellar production
- Statistical model results are recommended - robust experimental data desired

A new measurement

- Direct measurement in inverse kinematics at ANL



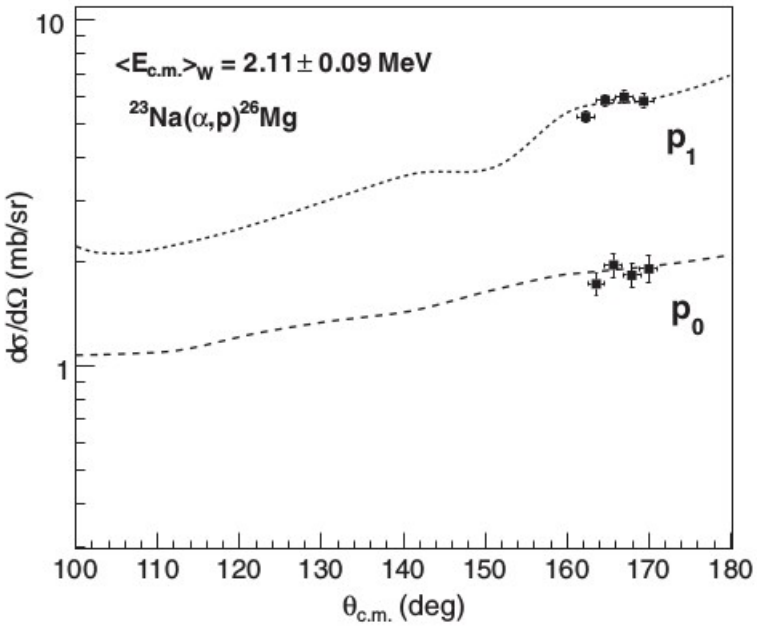


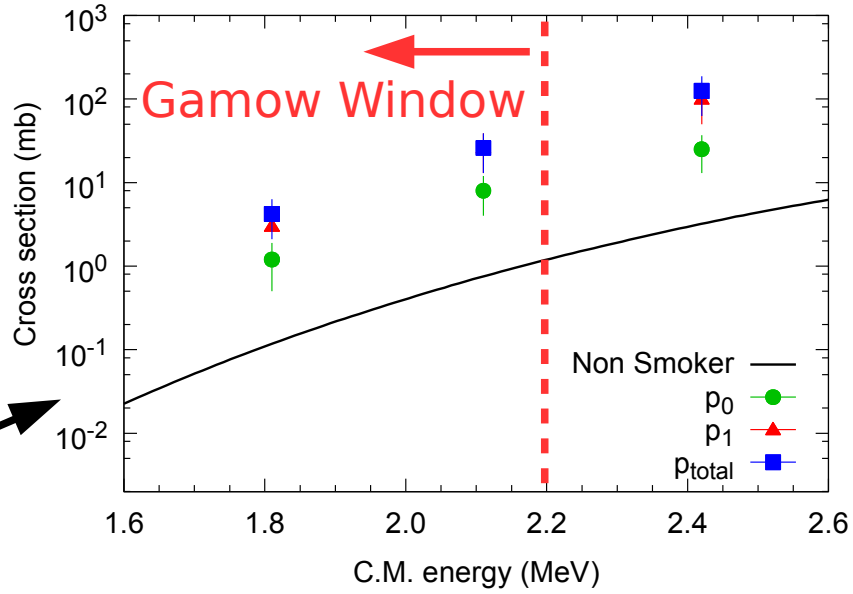


S. Almaraz-Calderon *et. al.*, Phys. Rev. Lett. **112**, 152701 (2014)

Results

Cross section 40x larger than statistical model calculations!





Narrow angular coverage - distributions adopted from ^{27}Al(α,p)

More than required to change ^{26}Al production by a factor of 3

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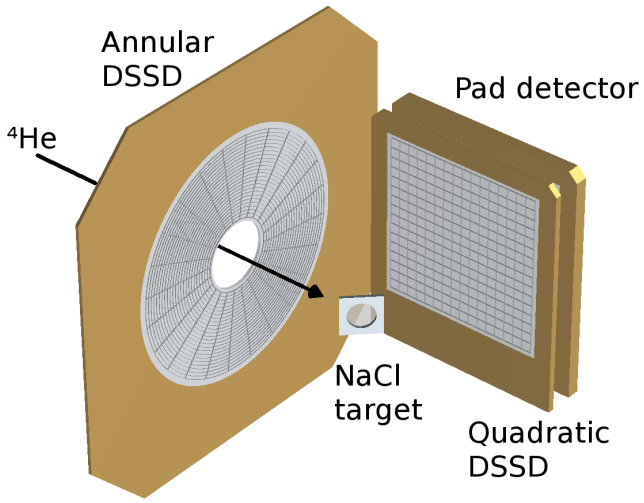
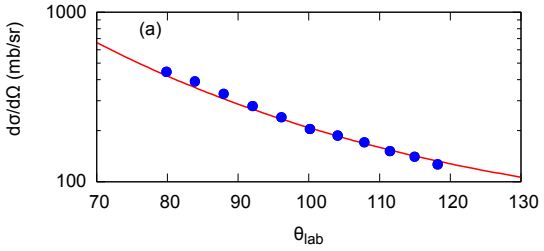
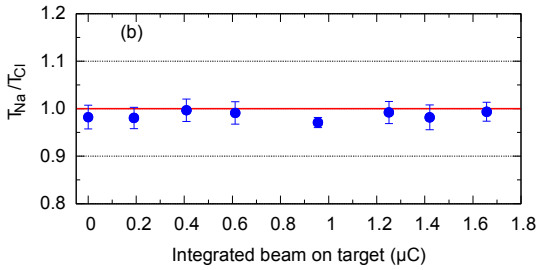
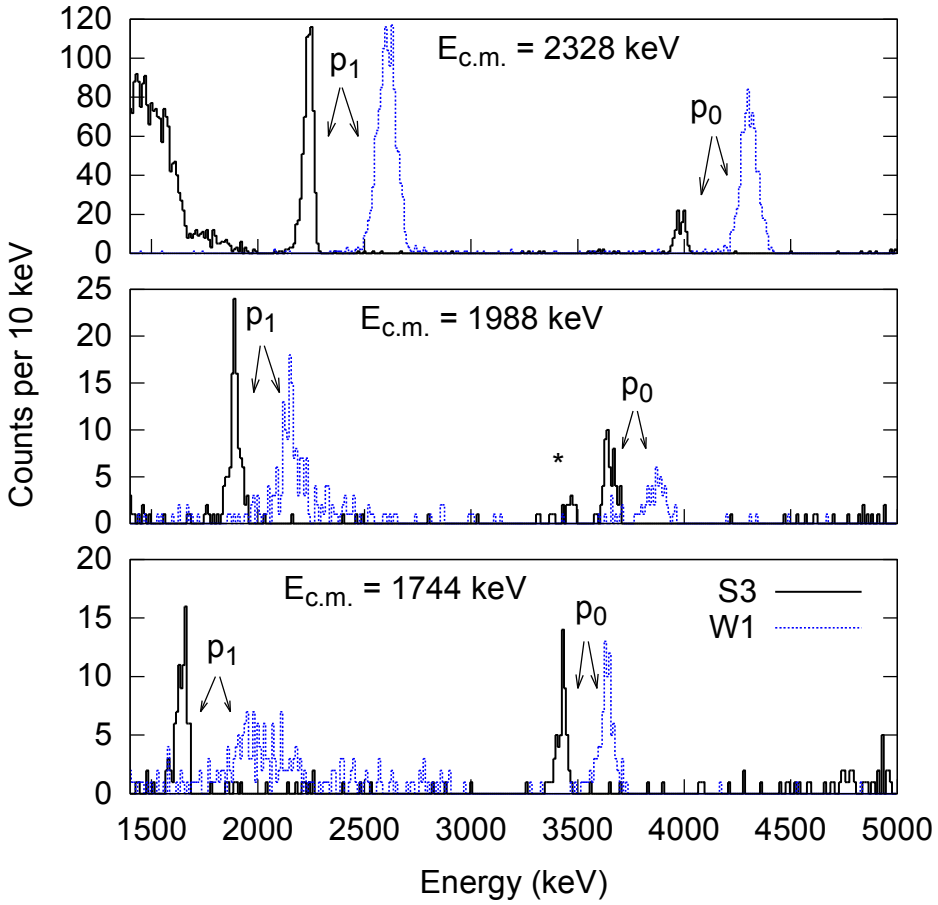
Our tool box ...

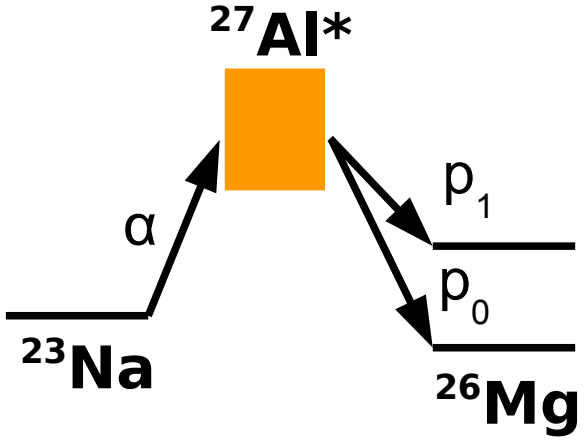


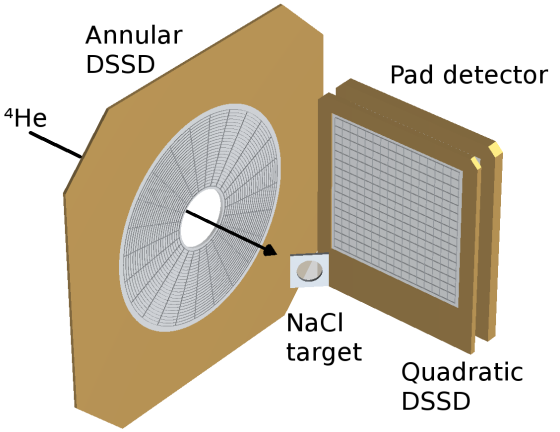
- Measure in normal kinematics
- Two DSSDs covering θ_{lab}=60°-165°
- large Solid permits beam currents ~300 pA
- $E_{beam(c.m.)}$ = 2.0 – 2.9 (1.7 – 2.5) MeV
- No degrader foils – measure elastically scattered beam
- Removes uncertainties in foil thickness, beam integration, detector solid angle







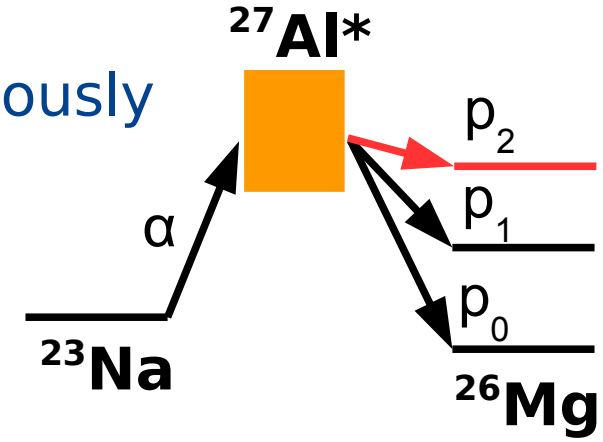




Effective energies: account for energy losses within target

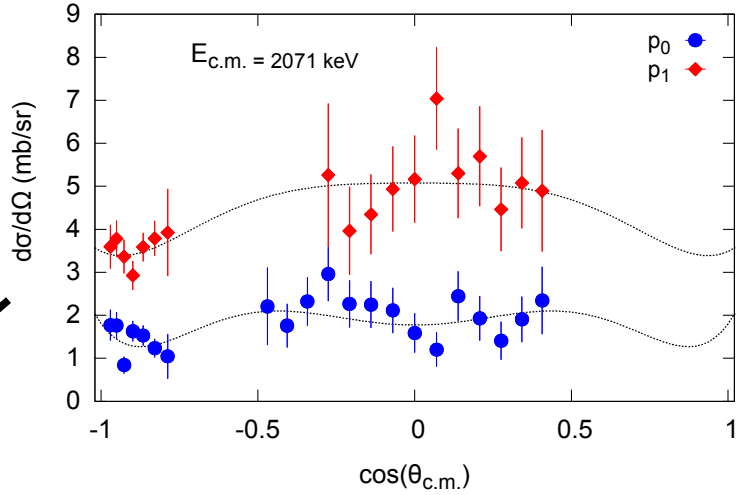
Constraining the p_2 contribution

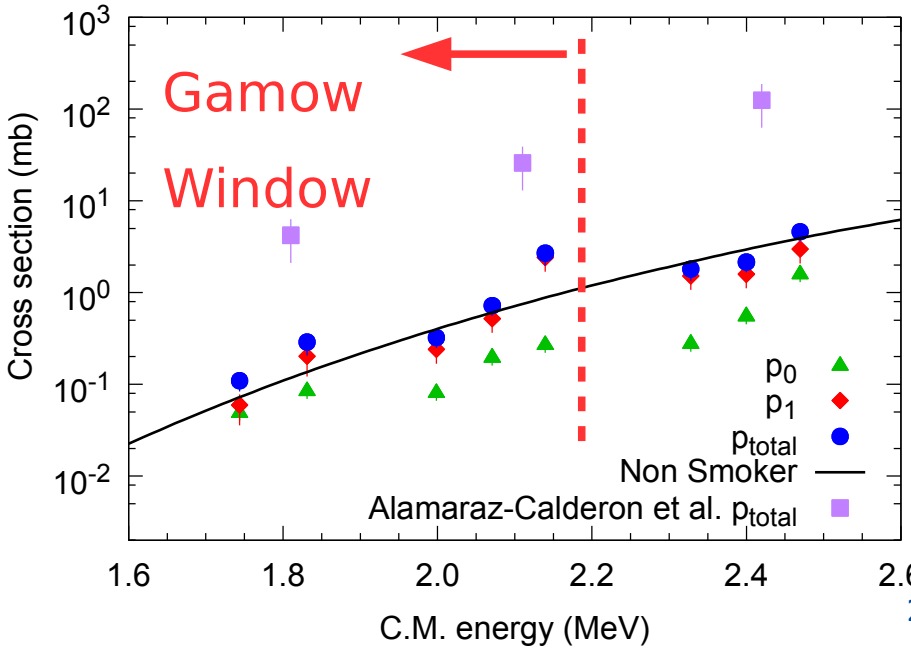
- It has been assumed that the p2 contribution becomes negligible at low energies – should be confirmed
- p_2 energies too low to use a telescope – instead rely on degrader method
- Normalise to p_0 and p_1 measured previously
- Additionally, obtain near complete angular measurement, including forward angles



Results – cross sections

- Cross sections consistent with statistical model calculations

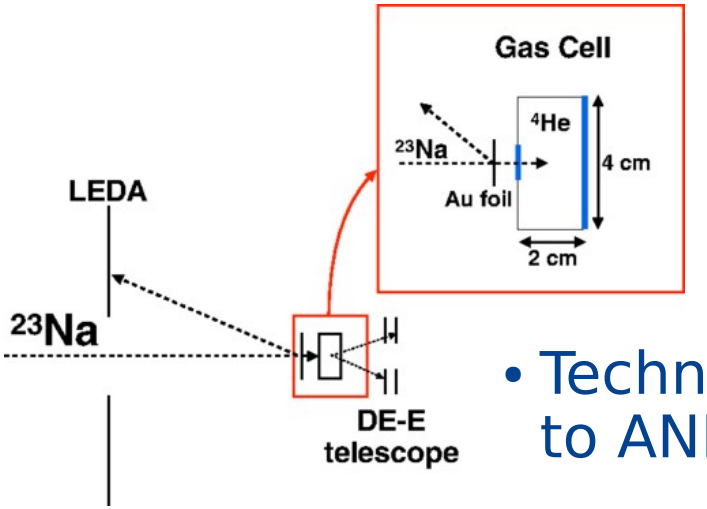




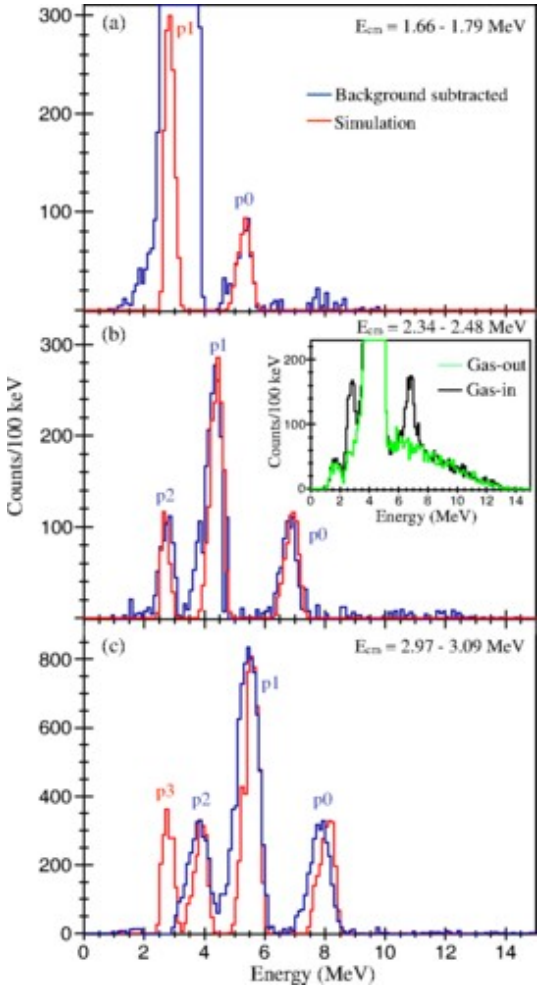
- Uncertainties are ~30%
- Clearly inconsistent with results from ANL

TRIUMPH measurement

- Independent direct measurement in inverse kinematics at TRIUMPH



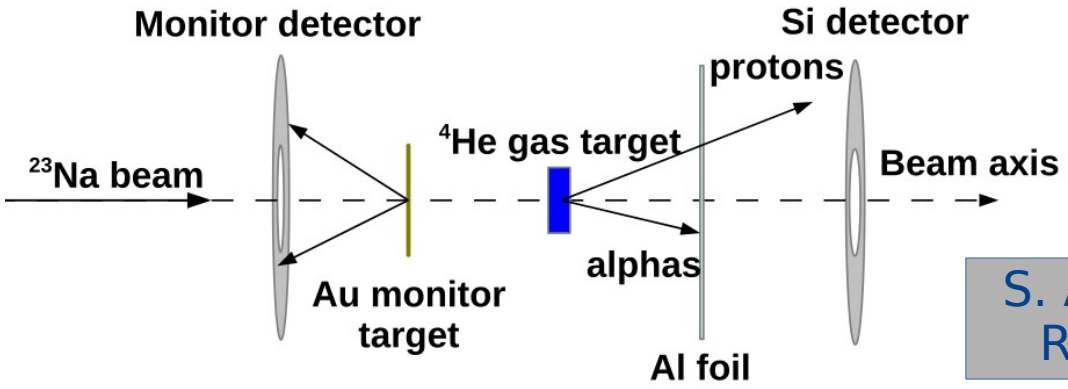
- Technique very similar to ANL measurement



J.R. Tomlinson *et. al.*, Phys. Rev. Lett. **115**, 052702 (2015)

ANL measurement - update

- Problem in the analysis related to downscaling of monitor
- Results now consistent with Aarhus and Triumph data



- New measurement with active target performed – results coming soon

S. Almaraz-Calderon *et. al.*, Phys. Rev. Lett. **115**, 179901 (2015)

Conclusions

- Results consistent with statistical model calculations
- Given 30% uncertainty on cross sections, ^{26}Al production uncertainty is around 10% (based on sensitivity study)
- A review of the combined data sets is under way at York/Aarhus
- Results promise to be suitable for use in future comparisons of expected and measured ^{26}Al yields

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Acknowledgements

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