The first direct measurement of $^{17}O(\alpha,\gamma)^{21}Ne$ and its impact upon s-process abundances

M. Taggart for the DRAGON collaboration

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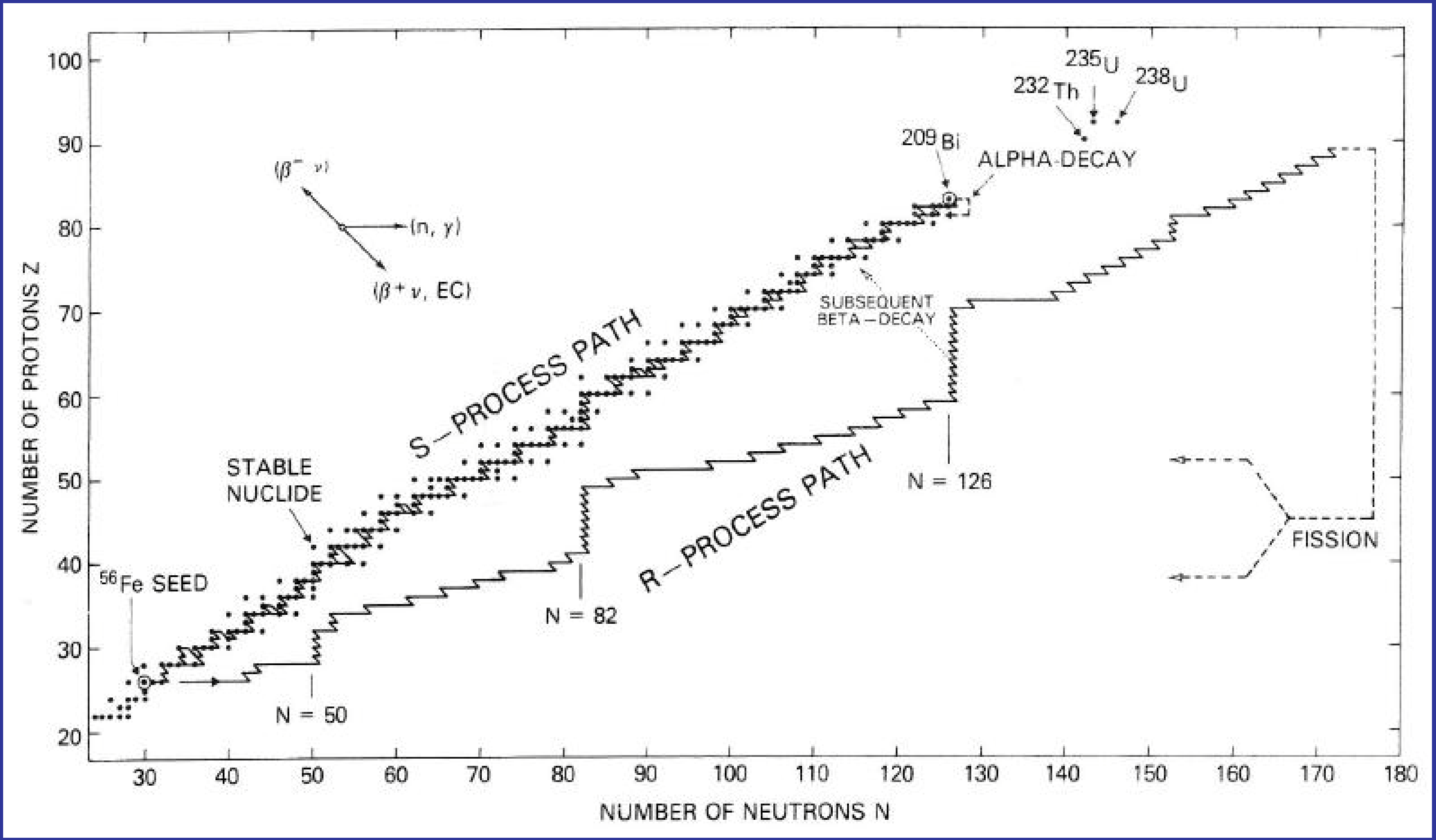
Introduction

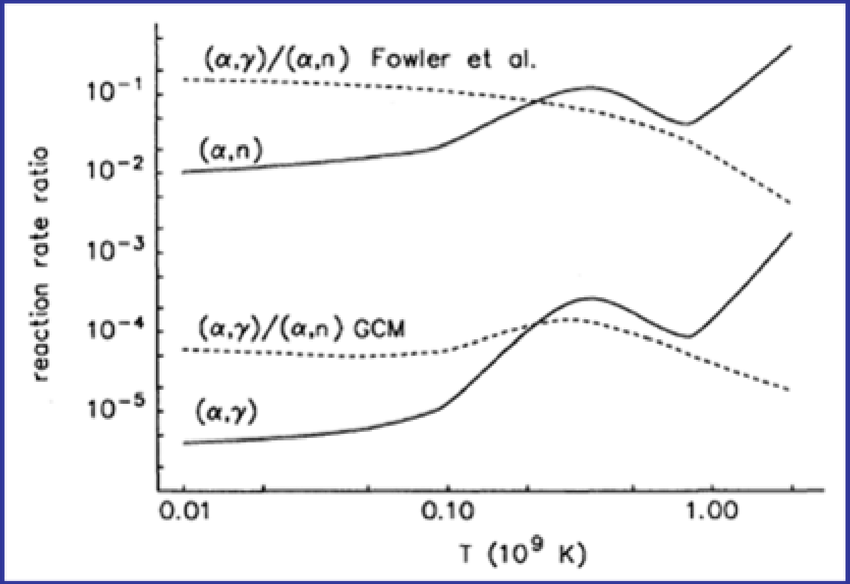
- Astrophysics motivation
  - How $^{17}O(\alpha,\gamma)^{21}Ne$ relates to the s-process
- The DRAGON facility
- Experimental analysis

ASTROPHYSICAL MOTIVATION

The Astrophysical s-Process



^{16}O – Neutron Poison or Absorber?



Phys. Rev. C, 48, 2746 (1993)

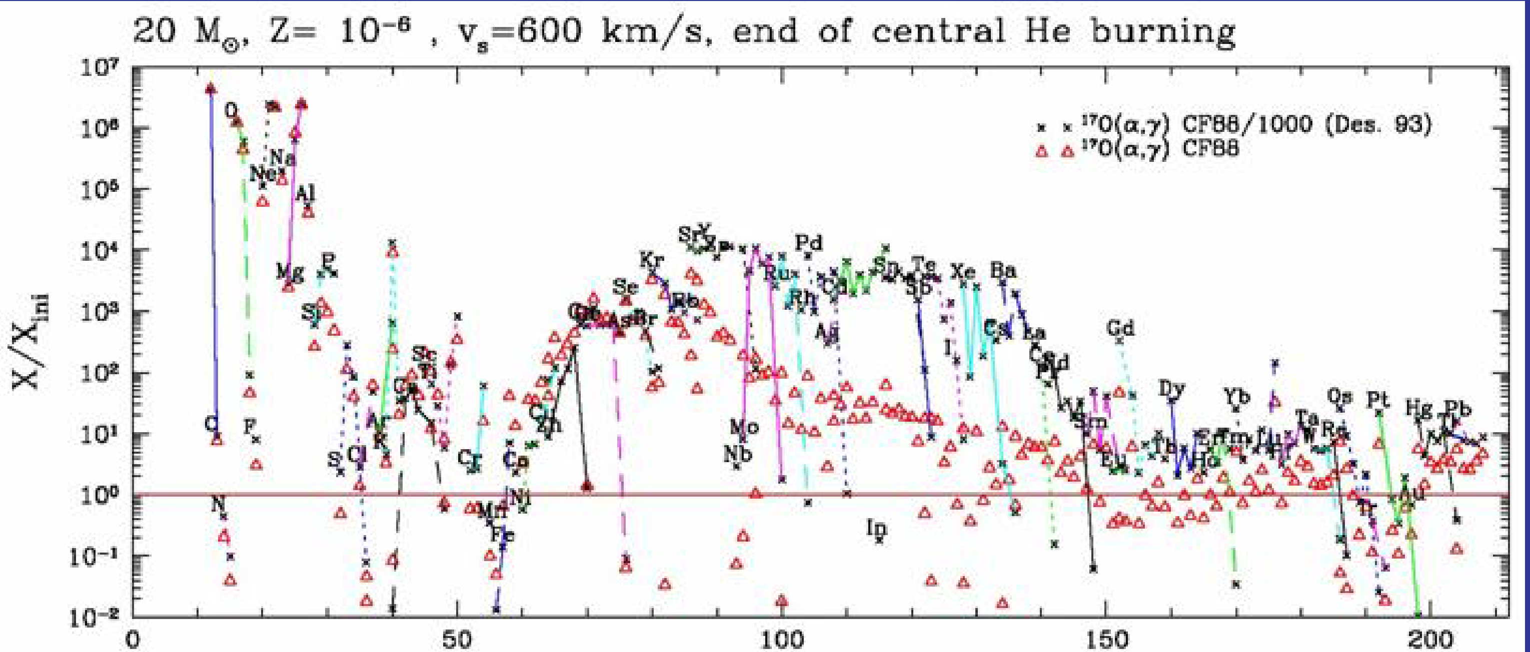
- Light isotopes (^{16}O, $^{20,22}Ne$, $^{25,26}Mg$,) can remove neutrons available to the s-process
- Abundance of ^{16}O is independent of metallicity – "primary n-poison"
- ^{17}O has competing reactions:

  (α,n)

  (α,γ)
- (α,n) dominates, but by how much?
- If (α,γ) is too strong...
  - recycling by (α,n) is incomplete
- Up to a factor of 10^4 variation in predictions

Impact of $^{17}O(\alpha,\gamma)^{21}Ne$

- Fast rotating massive stars at low metallicity may produce high s-process abundances between Sr and Ba, due to primary ^{22}Ne in the He core, with a potential impact on the GCE of the heavy elements (Pignatari et al. 2008, Hirschi et al. 2008)..
- Nucleosynthesis calculations using different rates for $^{17}O(\alpha,\gamma)^{21}Ne$, produce vastly different abundances, due to the large rate existing uncertainty.



Hirschi *et al*, NIC-X 083 (2008)

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THE DRAGON FACILITY

See also:

J. Fallis - NIC_XI_325

A. Parikh - NIC_XI_065

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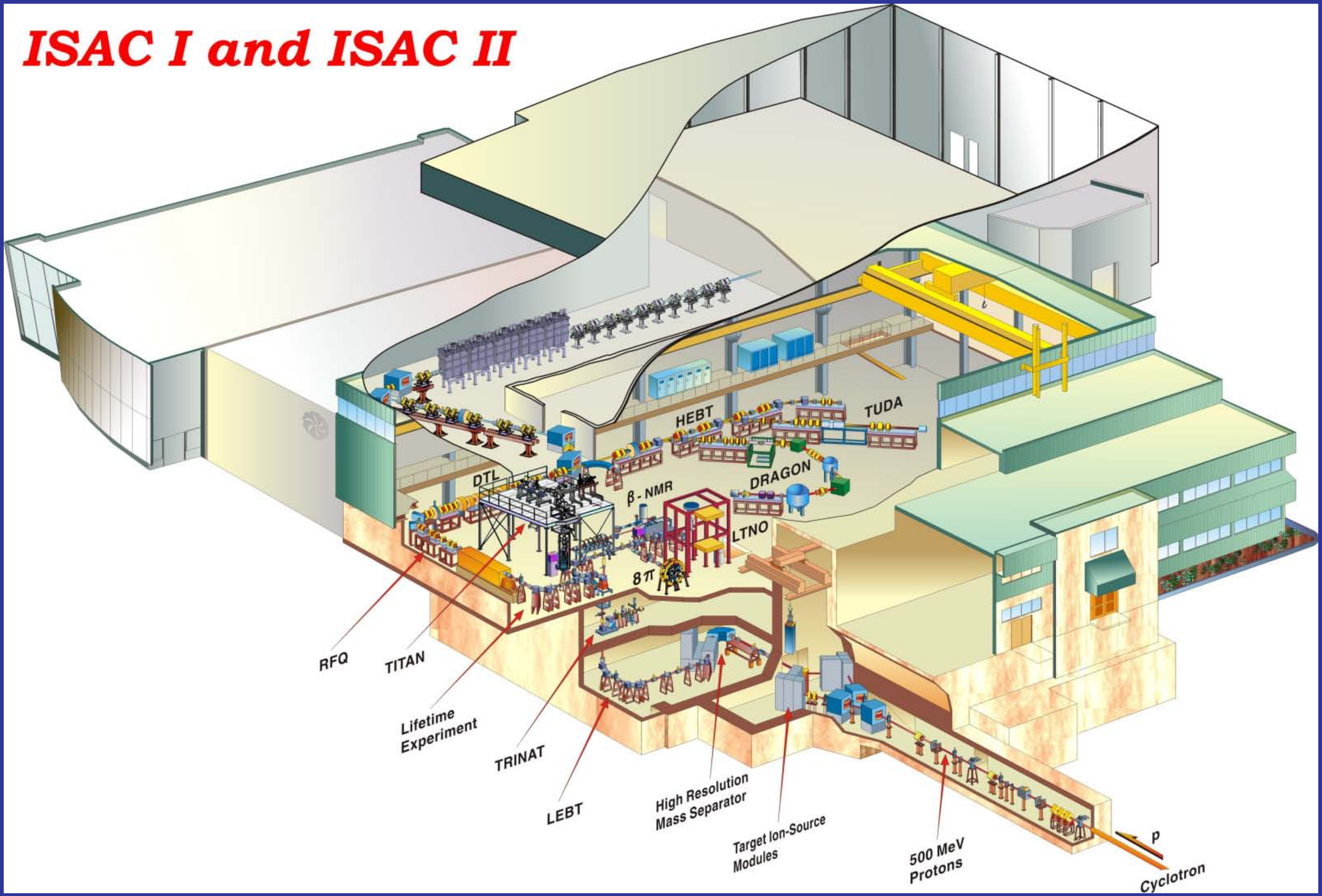
ISAC I & II, TRIUMF, Vancouver



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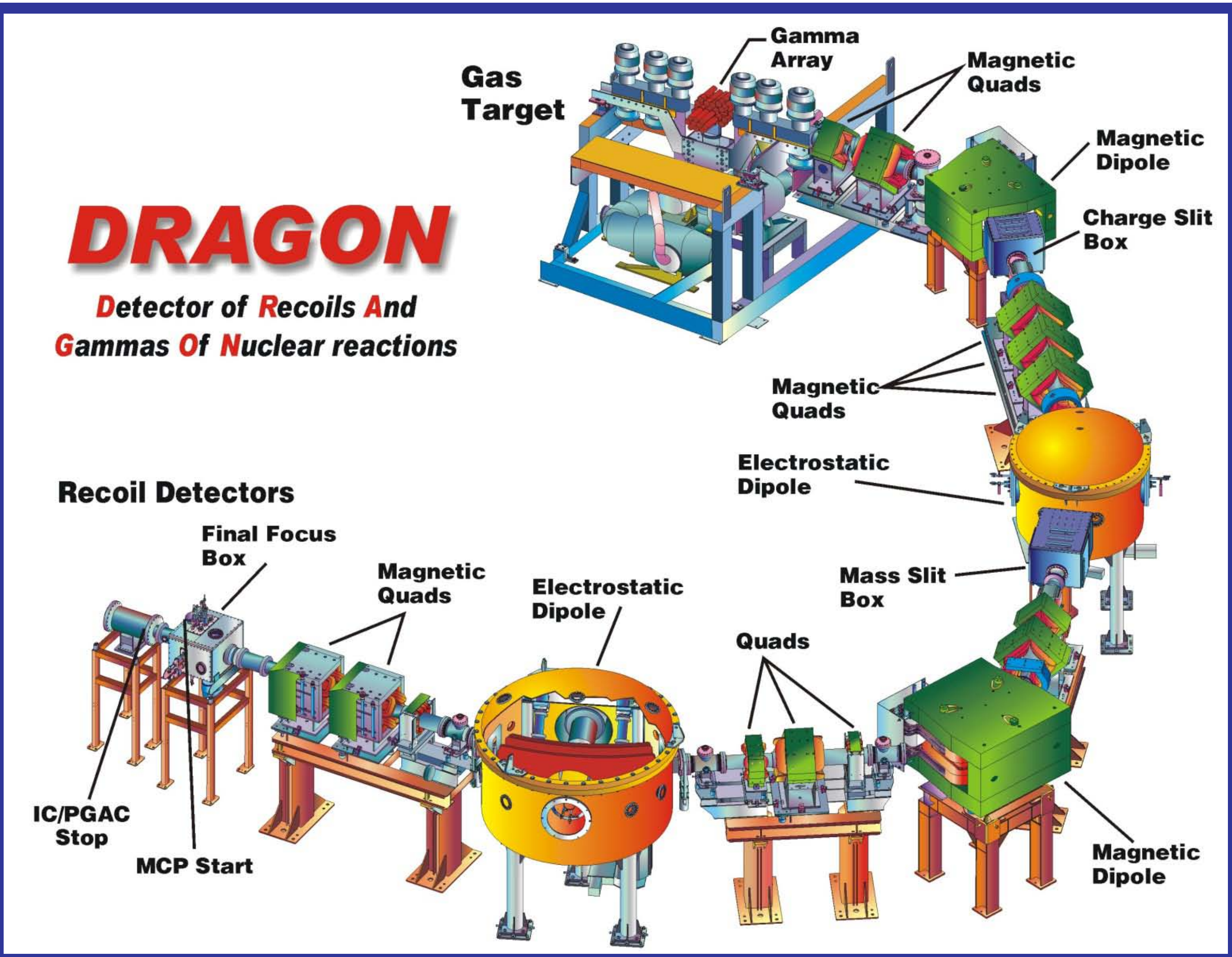
DRAGON recoil separator



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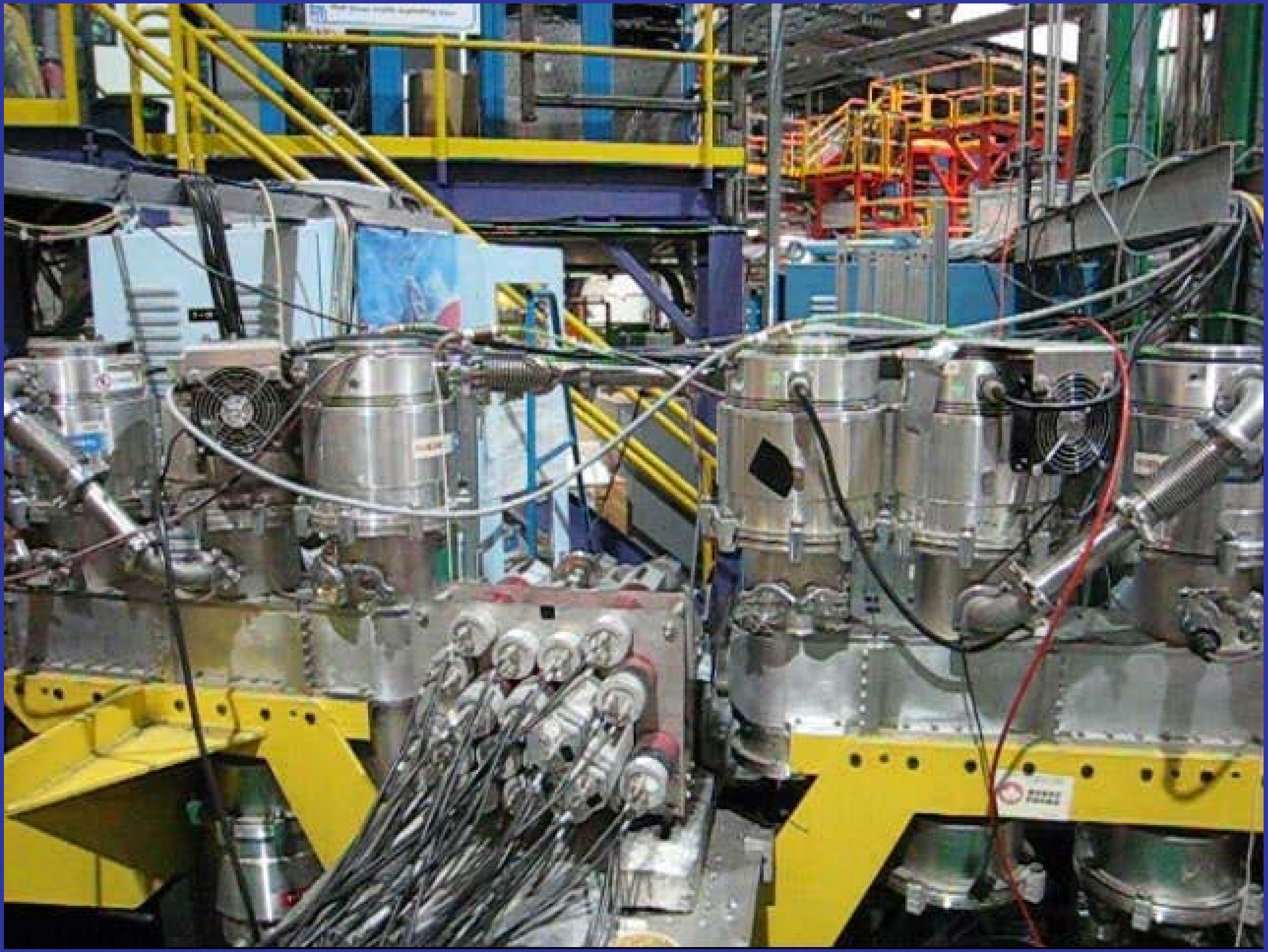
DRAGON Guided Tour…



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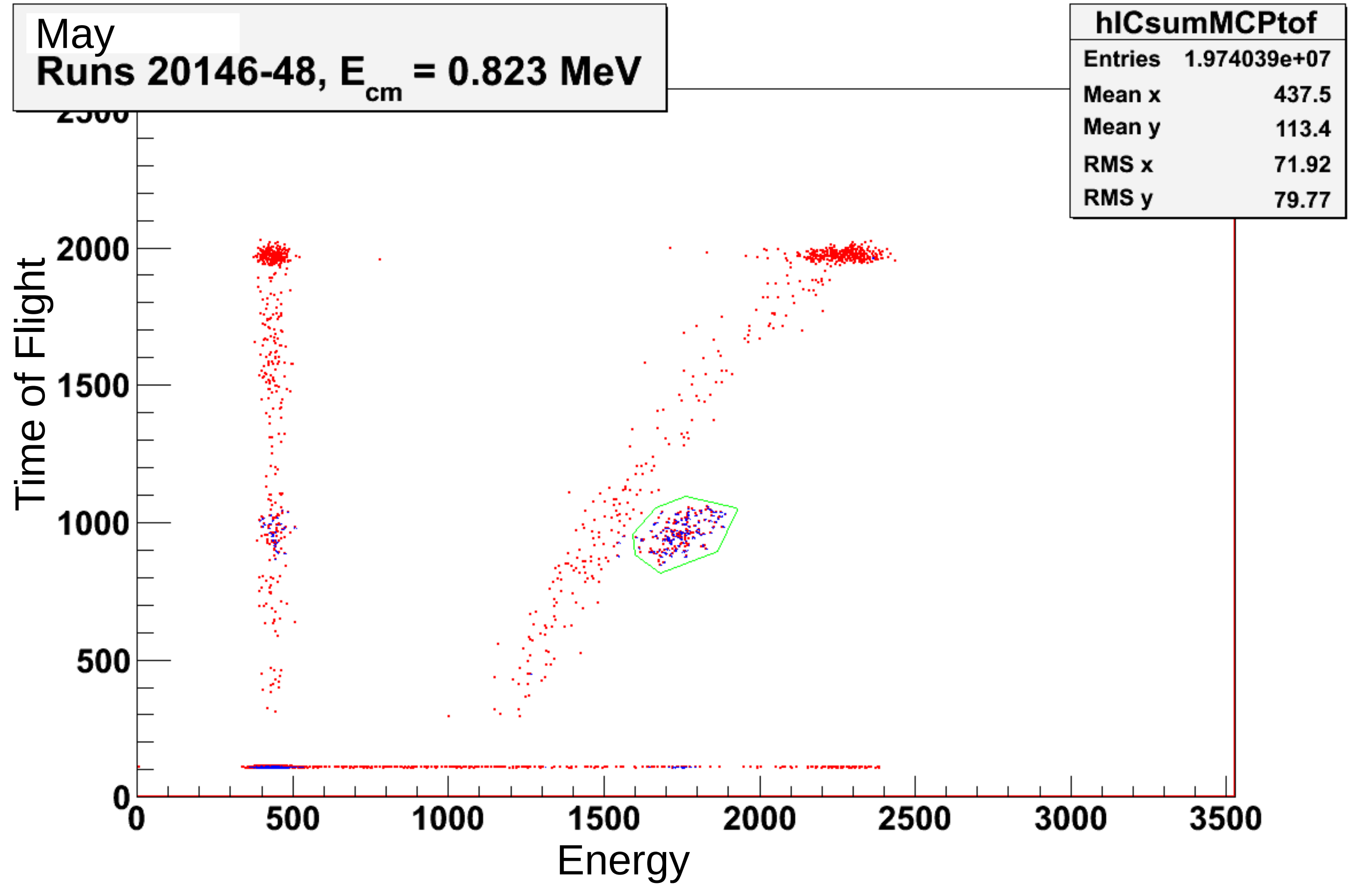
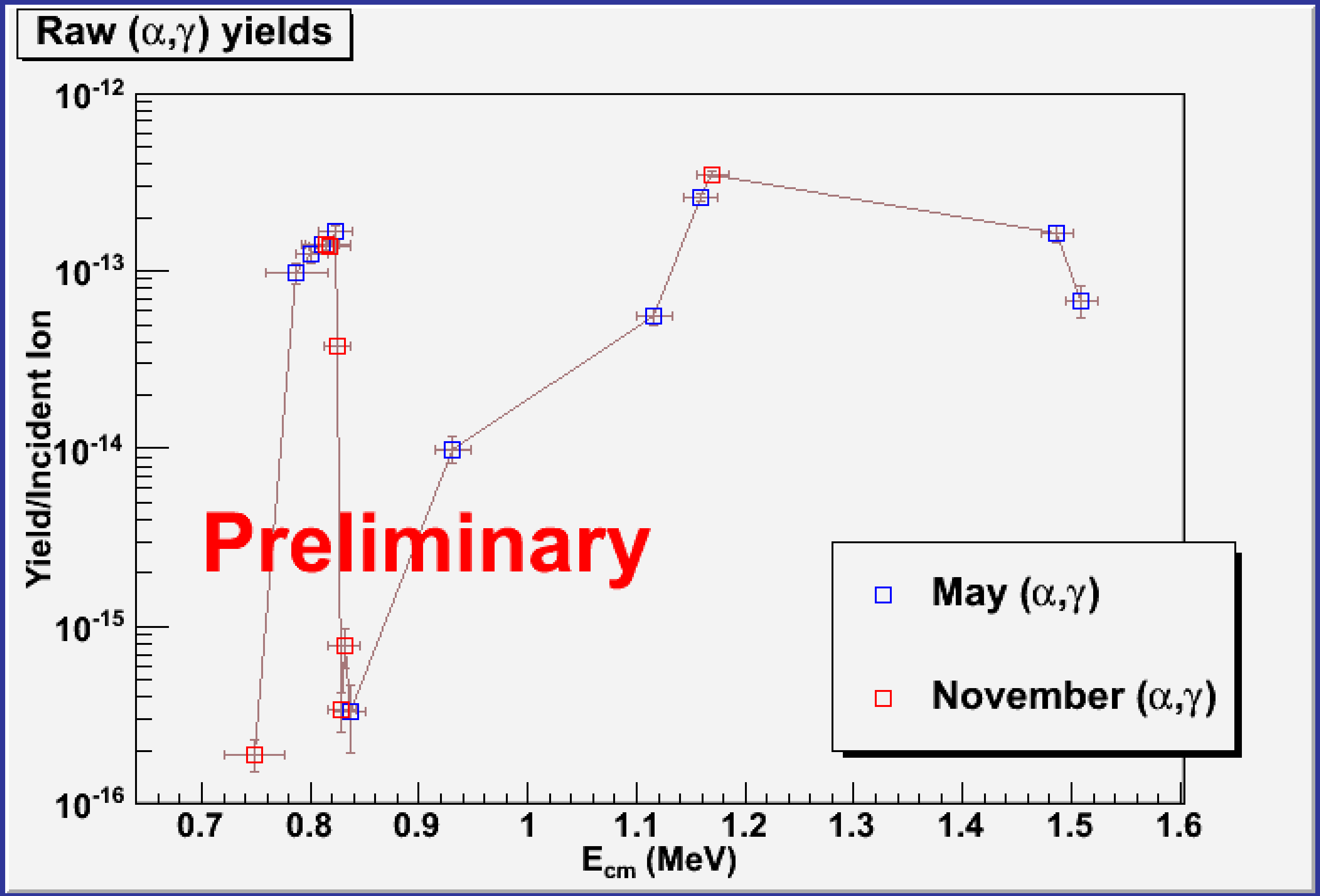
EXPERIMENTAL ANALYSIS

Recoil Event Selection



Raw Yield Data



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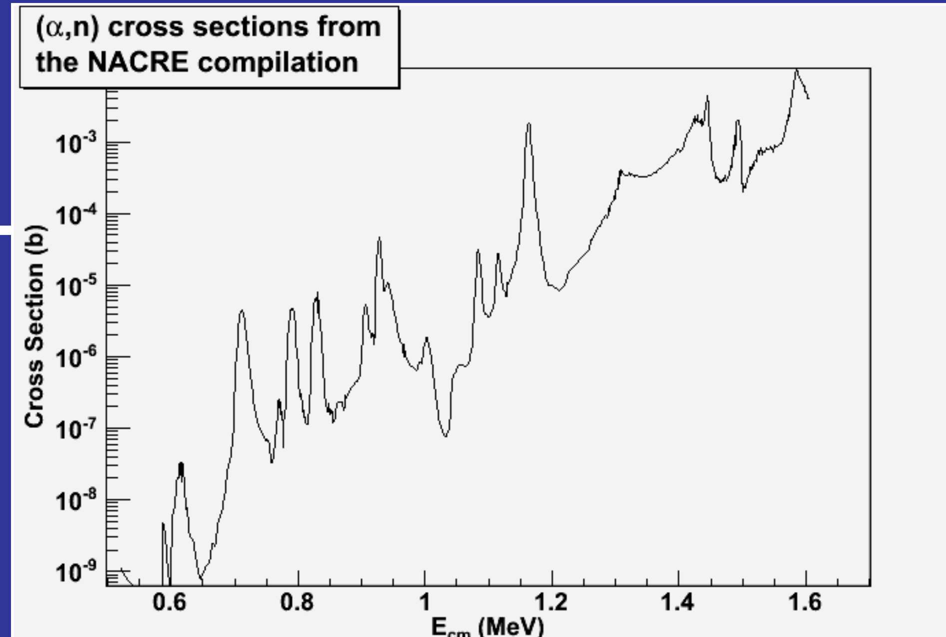
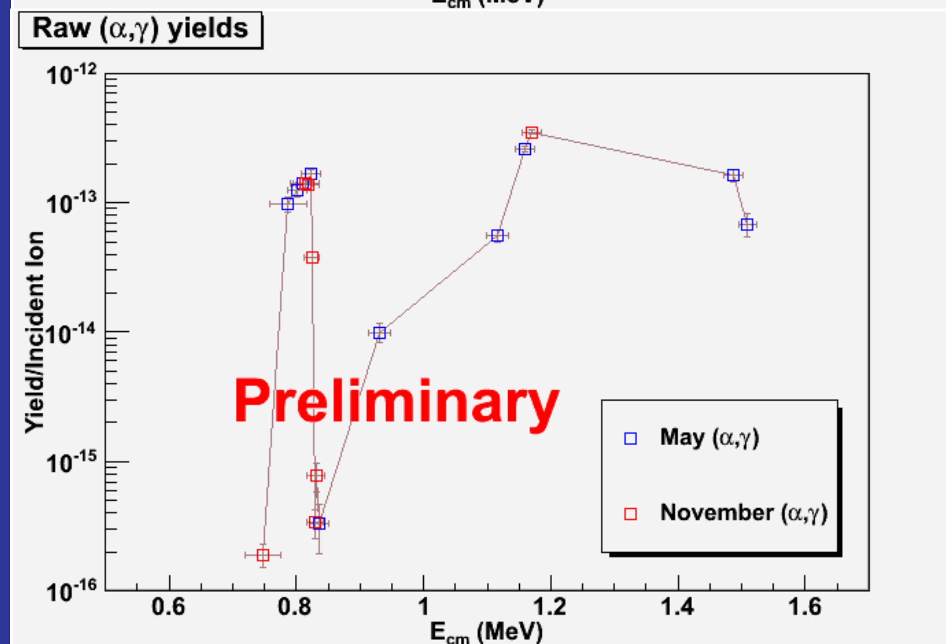
Comparison with NACRE data

- Limited data available at planning stages
- Experiment planned to select energies based on Denker *et al.* $^{17}O(\alpha,n)^{20}Ne$ data
- Recent work by Notre Dame group:

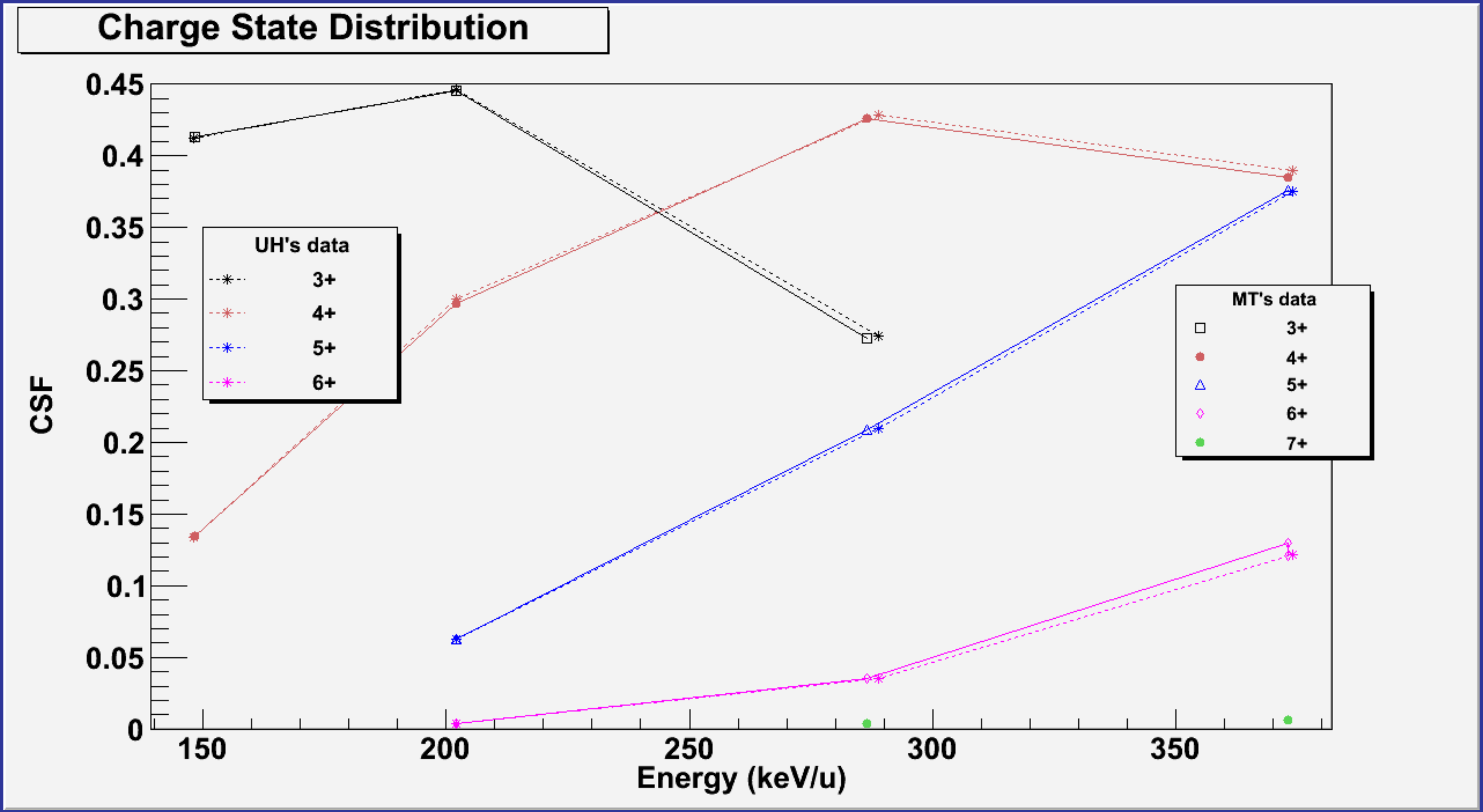
  A.Best, NIC_XI_159

- "Region of unexpectedly high yield" becomes apparent in comparison with the (α, n) data
- E_{cm} ~ 0.8 MeV
- Repeated during November experimental run





Charge State Distributions



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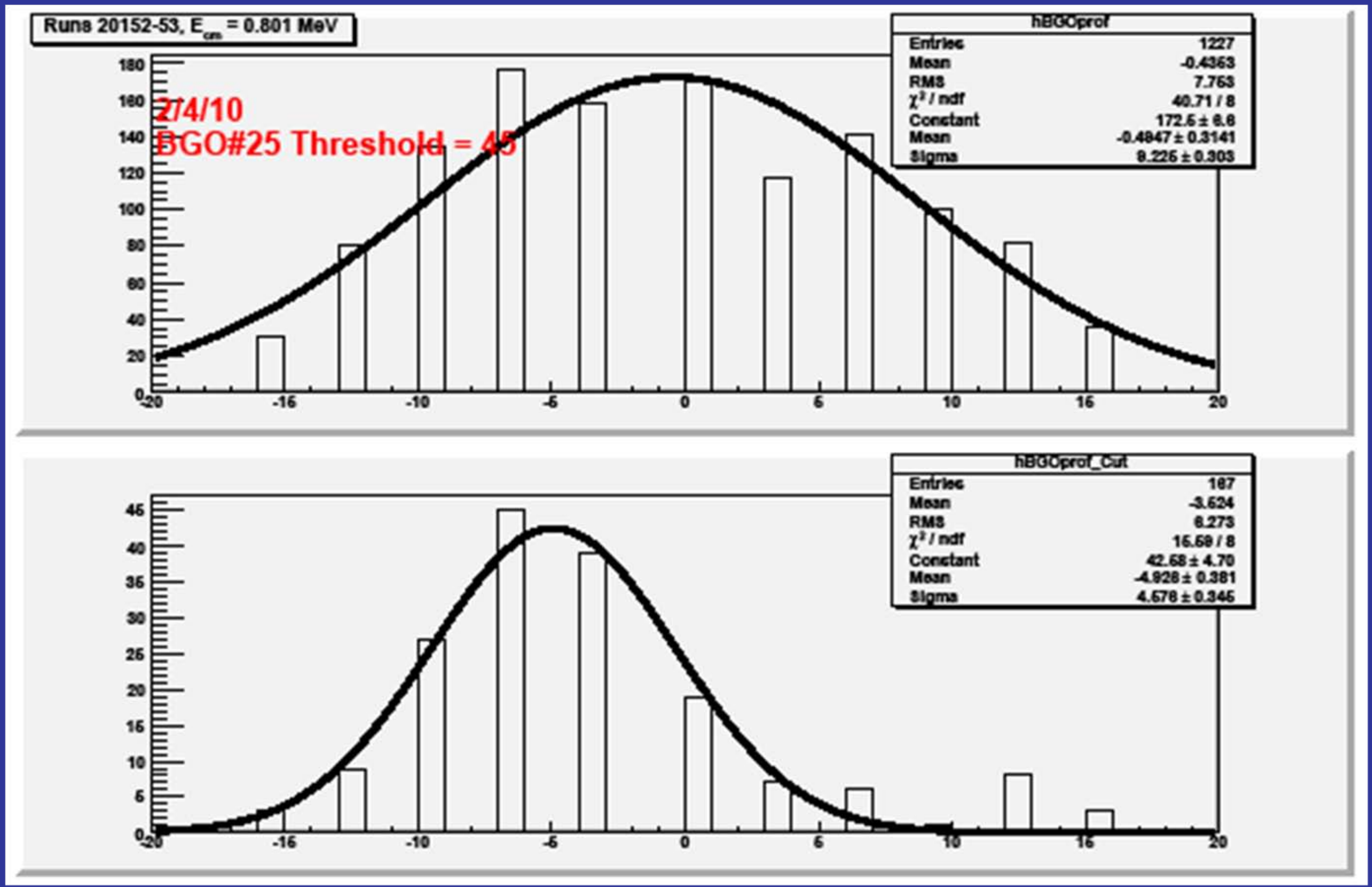
Hunting Resonances



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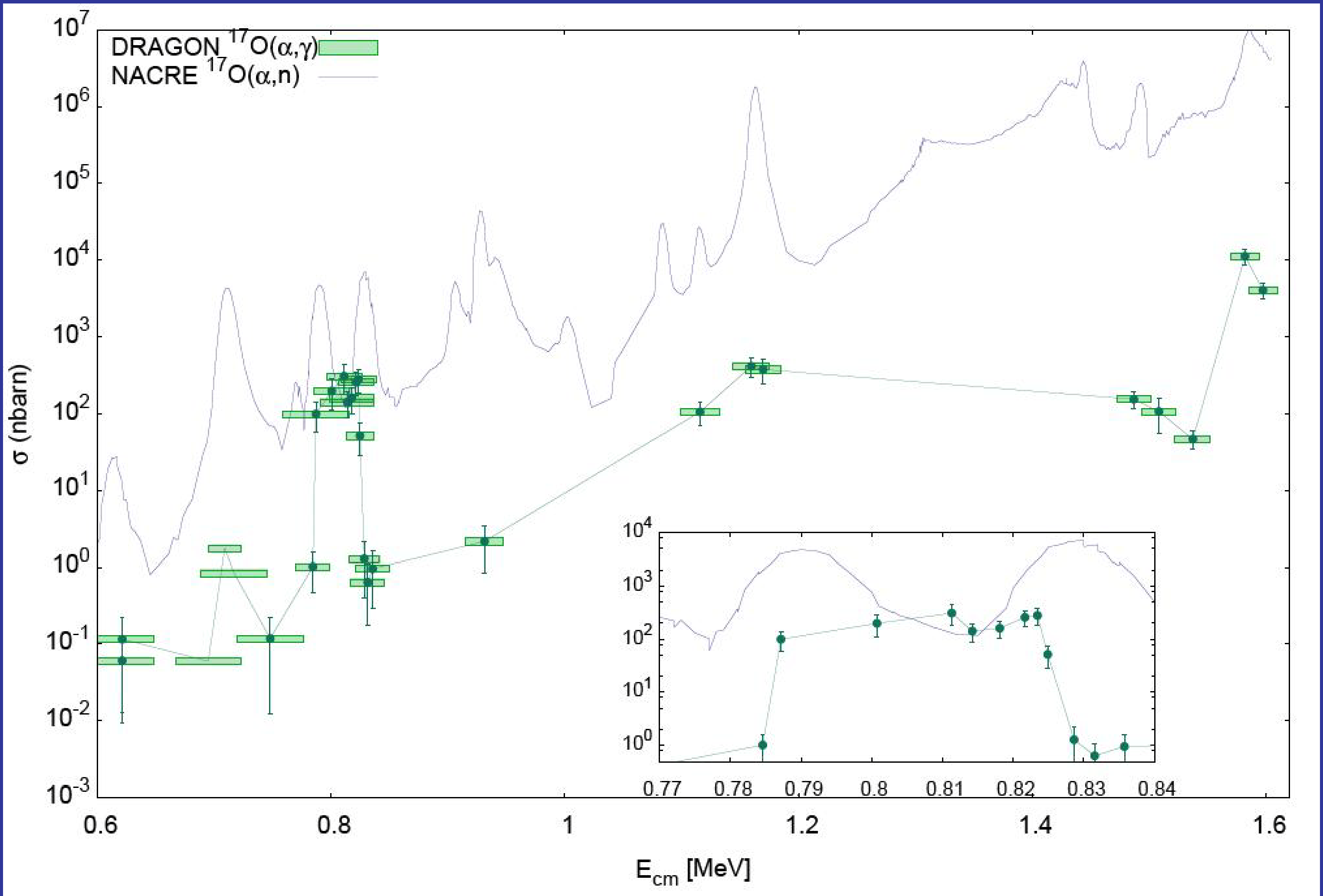
(α,γ) cross sections – courtesy U. Hager



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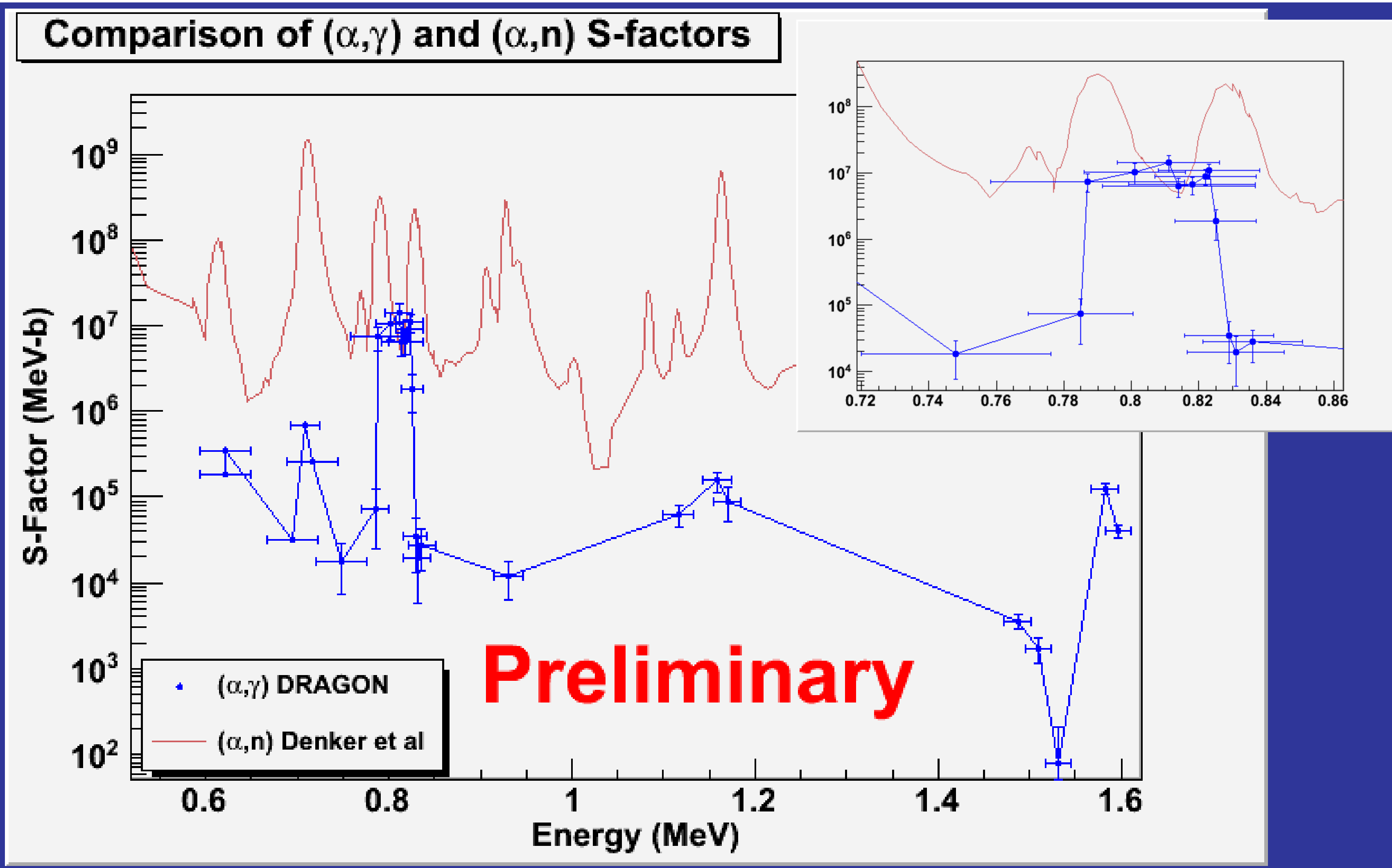
S-factors



Comparison of (α,γ) and (α,n) S-factors
S-Factor (MeV-b)
Energy (MeV)
(α,γ) DRAGON
(α,n) Denker et al
Preliminary

Remaining work

- Conversion of raw yields to cross sections
  - Efficiencies
  - CSD
  - Beam intensity
  - Deadtime
  - Angular Distribution
- Extrapolation to required energy range
- Implementation of astrophysical codes with latest cross section data – U. Victoria, U. Keele

Collaborators

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  - A. M. Laird, S. Fox, M. Bentley, B. Fulton, C. Diget, K. Chipps, J. Brown
- TRIUMF
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- University of Edinburgh
  - A. Murphy, D. Mountford
- McMaster University
  - A. Chen
- University of Victoria
  - F. Herwig, M. Pignatari
- University of Keele
  - R. Hirschi