TACTIC: A new detector for nuclear astrophysics

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Experimental Nuclear Astrophysics at low energies

- Studying directly key nuclear reactions for nucleosynthesis and energy generation in explosive sites - novae, supernovae and X-ray bursters

- Experimental conditions
  - Beam energies: about 0.1 – 2 MeV/u (up to few $10^9$ K)
  - Charged particle energies of few MeV down to ~ 100 keV
  - Radioactive beams - high background, low intensity
  - Cross sections can be low - << mbarn

- Need high efficiency, large solid angle detector arrays with low detection threshold
TRIUMF Annular Chamber for Tracking and Identification of Charged particles

MOTIVATION: study the $^8\text{Li}(\alpha,n)^{11}\text{B}$ reaction

Recent (rapid neutron capture) r-process network calculations of core collapse supernovae have included light nuclei and shown that for particular models, two nuclear reaction chains

\[
\alpha(\alpha n,\gamma)^9\text{Be}(n,\gamma)^{10}\text{Be}(\alpha,\gamma)^{14}\text{C} \quad \text{and} \\
\alpha(t,\gamma)^7\text{Li}(n,\gamma)^8\text{Li}(\alpha,n)^{11}\text{B}
\]

can significantly affect the final abundances of certain heavy nuclei

Much experimental effort has gone into studying this reaction………. 
Last $^8$Li($\alpha,n)^{11}$B measurement
by means of a Multiple Sampling and Tracking Proportional Chamber (MSTPC)


Figure 1. Schematic illustration of the detector system.

+ Helium as target gas and counter gas
+ Threedimensional tracking plus energy loss
- $^8$Li beam directly into the chamber
- Beam stopped in chamber
- Low beam intensity
- Broad energy spectrum of the beam
Each anode strip provides energy loss and timing information:
- Total energy
- Trajectory
- Particle i.d.

48 channel Flash ADC
VME board

48 x amp
Current status

• Fabrication of prototype complete
• Assembly of outer casing and internal support structures complete
• Assembly of cathode complete
• Assembly of anode and GEM – today!

• Source testing in York – May to June 2007
• Ship to TRIUMF – July 2007
• Install TACTIC on TUDA beamline – July 2007
  (construction and installation of stand and GHS ongoing at TRIUMF)
• Initial stable beam tests – 29th August to 3rd September
• Stable (α,n) tests late 2007
• First radioactive beam experiment spring 2008
Summary

• Detection of low energy charged particles for direct measurements of astrophysically interesting reactions with large solid angle coverage
• Measure dE/dx, E and timing to reconstruct track and identify particle
• Target and detector gas can be same or separate as determined by experimental constraints
• Intrinsically radiation hard
• Surrounded by gamma array (BGO?)
• Install in DRAGON windowless gas target?

Design versatile enough to optimise configuration for other studies:

- $^{12}$C+$^{12}$C low energy fusion
- $^{18}$Ne($\alpha$,p)$^{21}$Na
- Other ($\alpha$,n) and ($\alpha$,p)?

Future opportunities for TACTIC in Europe? If interested, please contact me!
Many thanks to G. Ruprecht for most of these slides!

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