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 $^{8}Li(\alpha,n)^{11}B$ 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

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

can significantly affect the final abundances of certain heavy nuclei

Much experimental effort has gone into studying this reaction…….

Last ^{8}Li(α,n)^{11}B measurement
by means of a Multiple Sampling and Tracking Proportional Chamber (MSTPC)

T. Hasimoto, Nuc. Phys. A **764** (2004)330

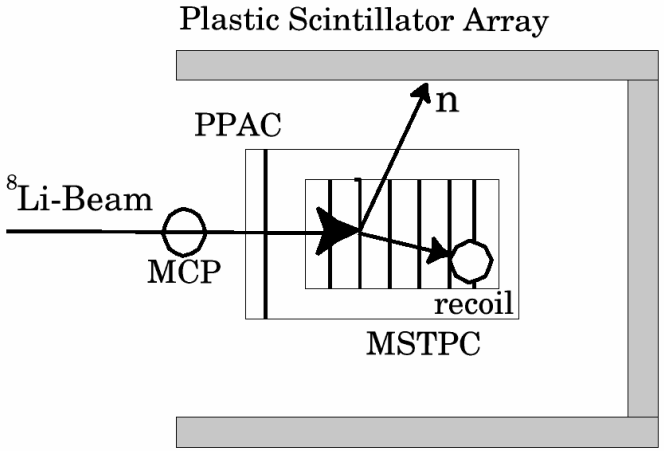
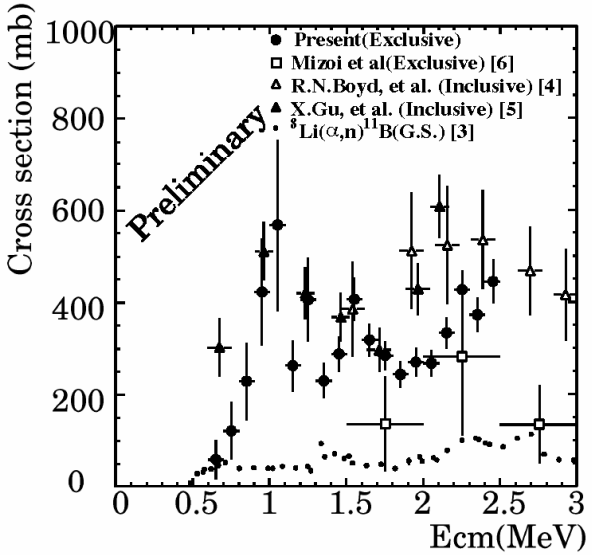
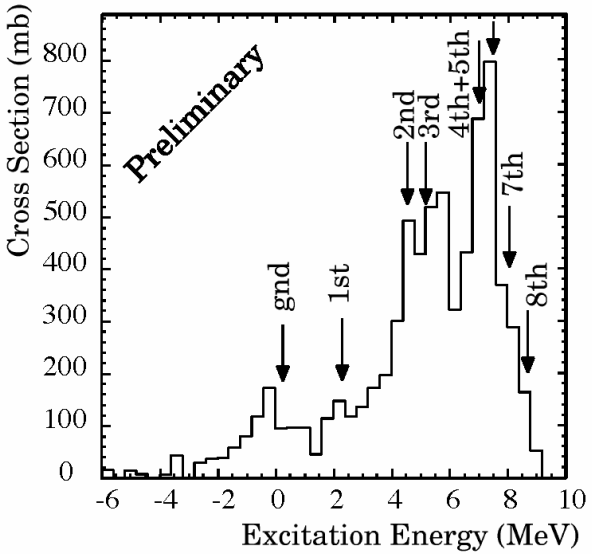


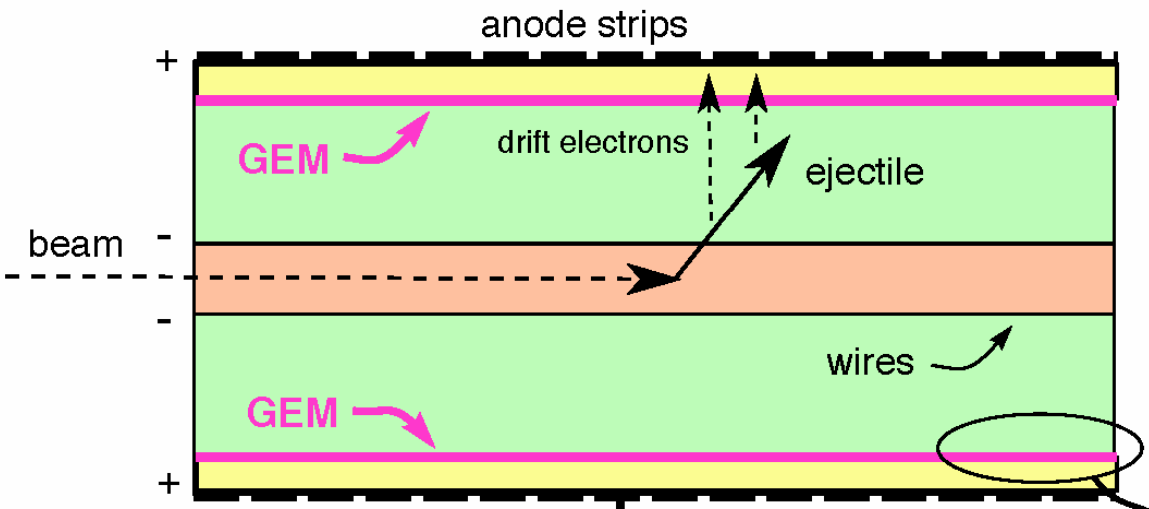
Figure 1. Schematic illustration of the detector system.

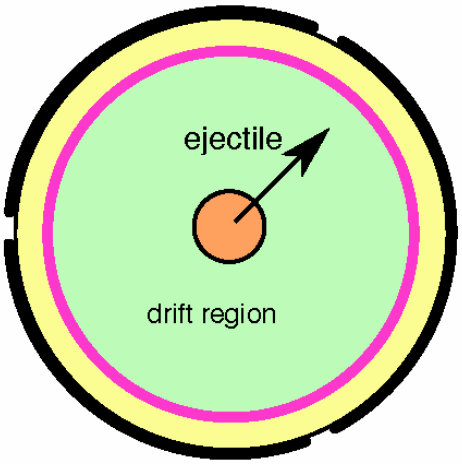
+ Helium as target gas and counter gas
+ Threedimensional tracking plus energy loss
- ^{8}Li beam directly into the chamber
- Beam stopped in chamber
- Low beam intensity
- Broad energy spectrum of the beam

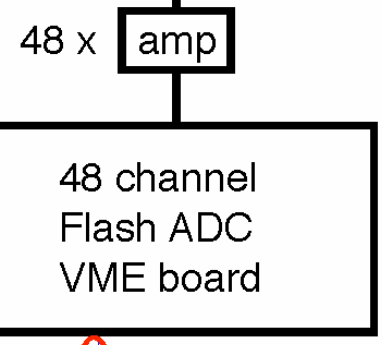


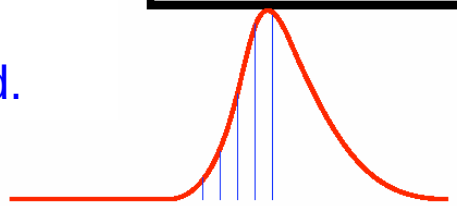


TACTIC: TRIUMF Annular Chamber for Tracking and Identification of Charged particles



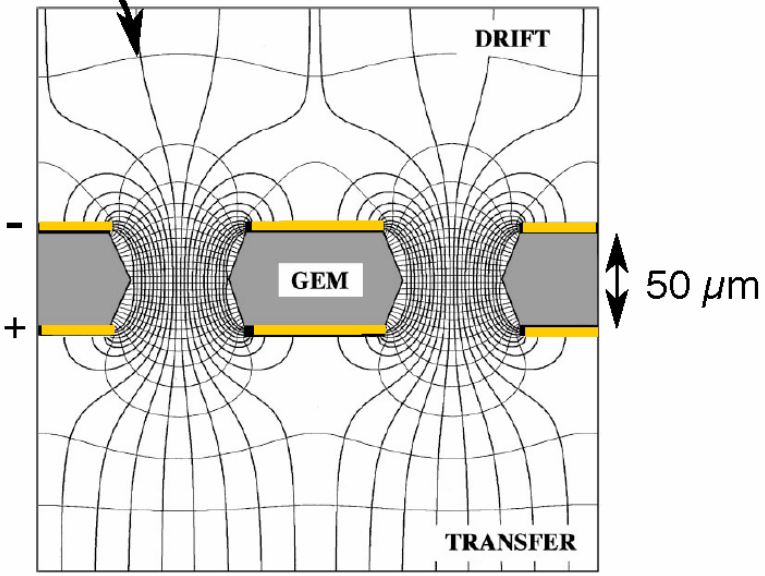


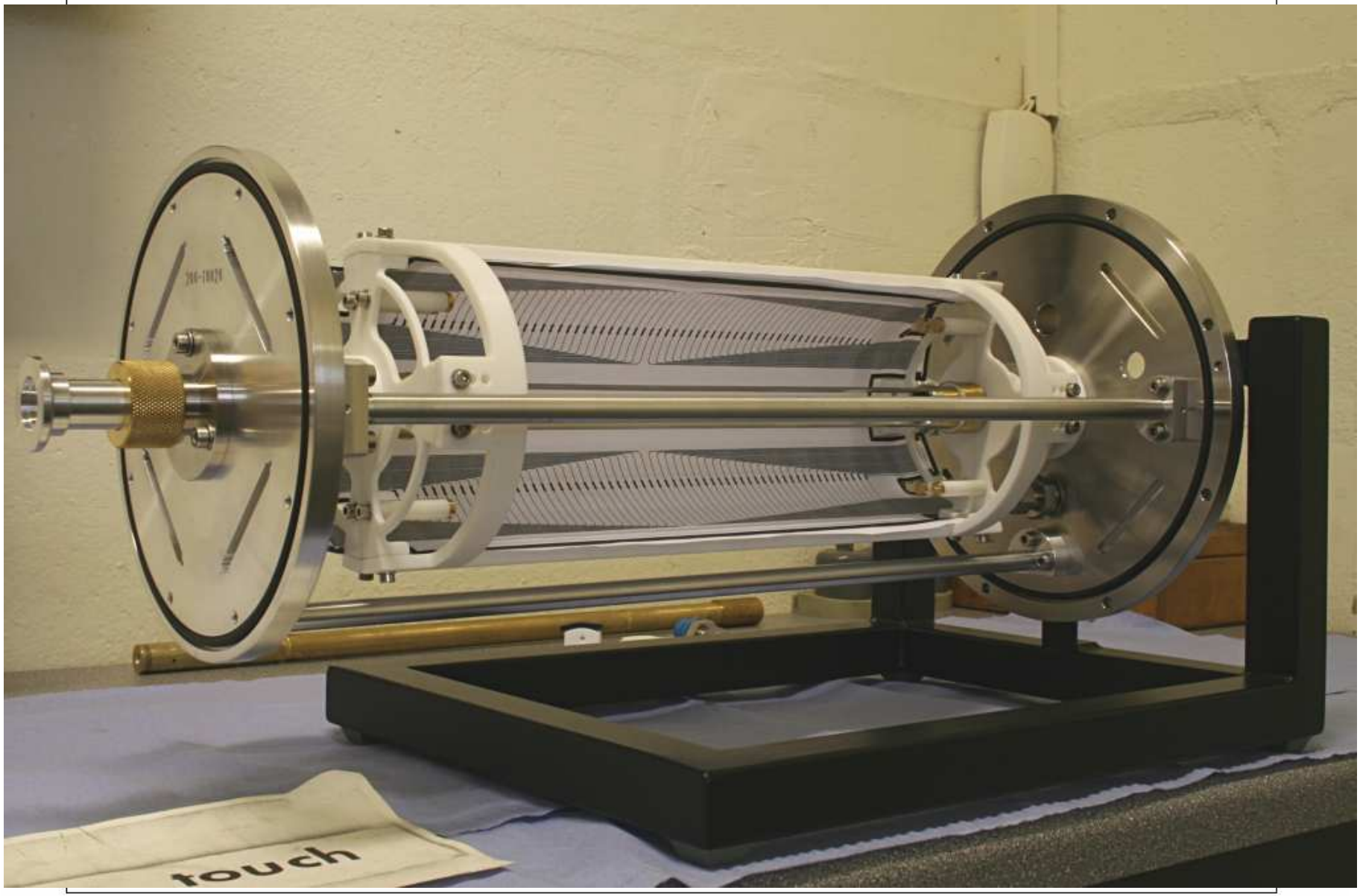




Each anode strip provides energy loss and timing information

- total energy
- trajectory
- particle i.d.

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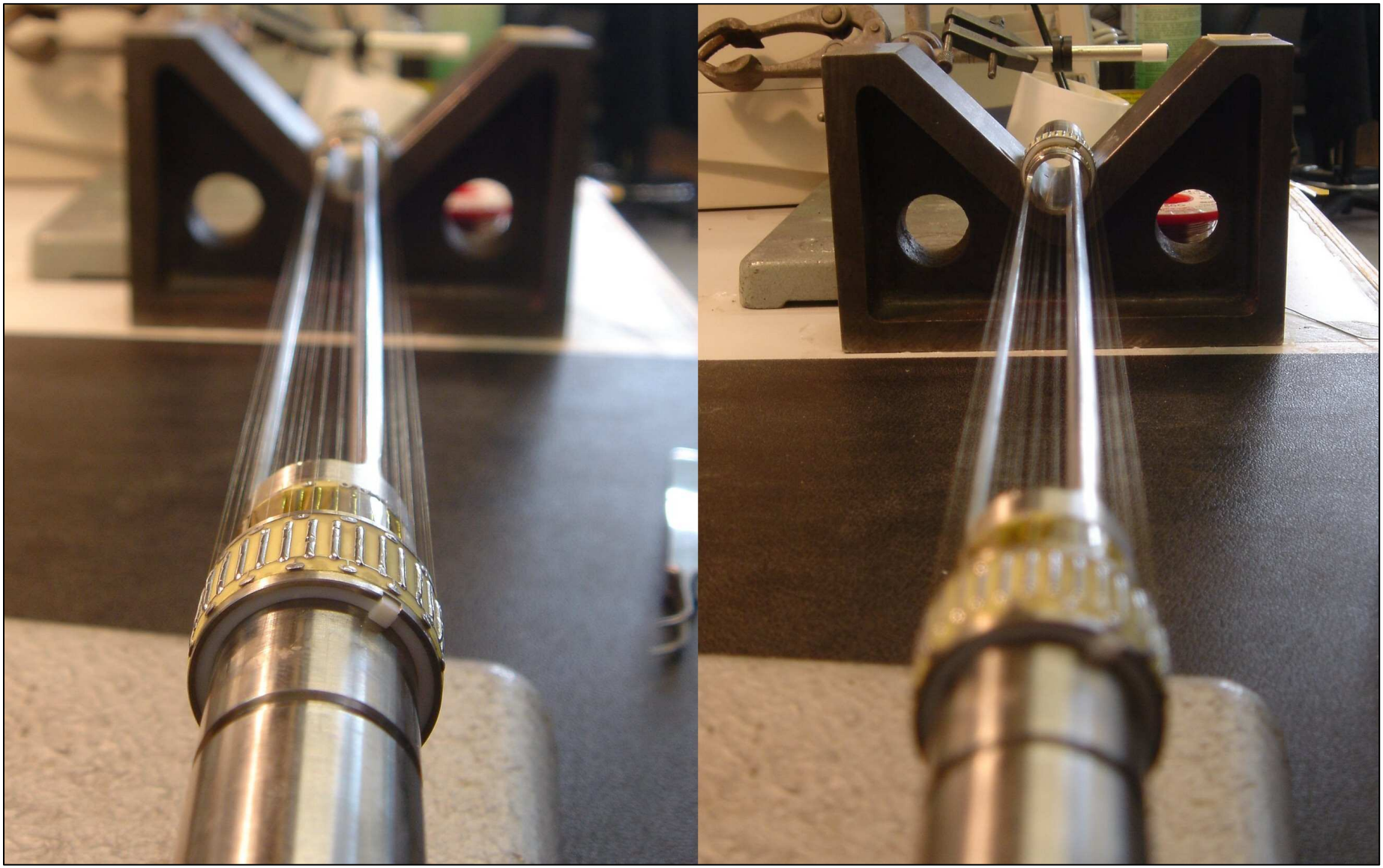

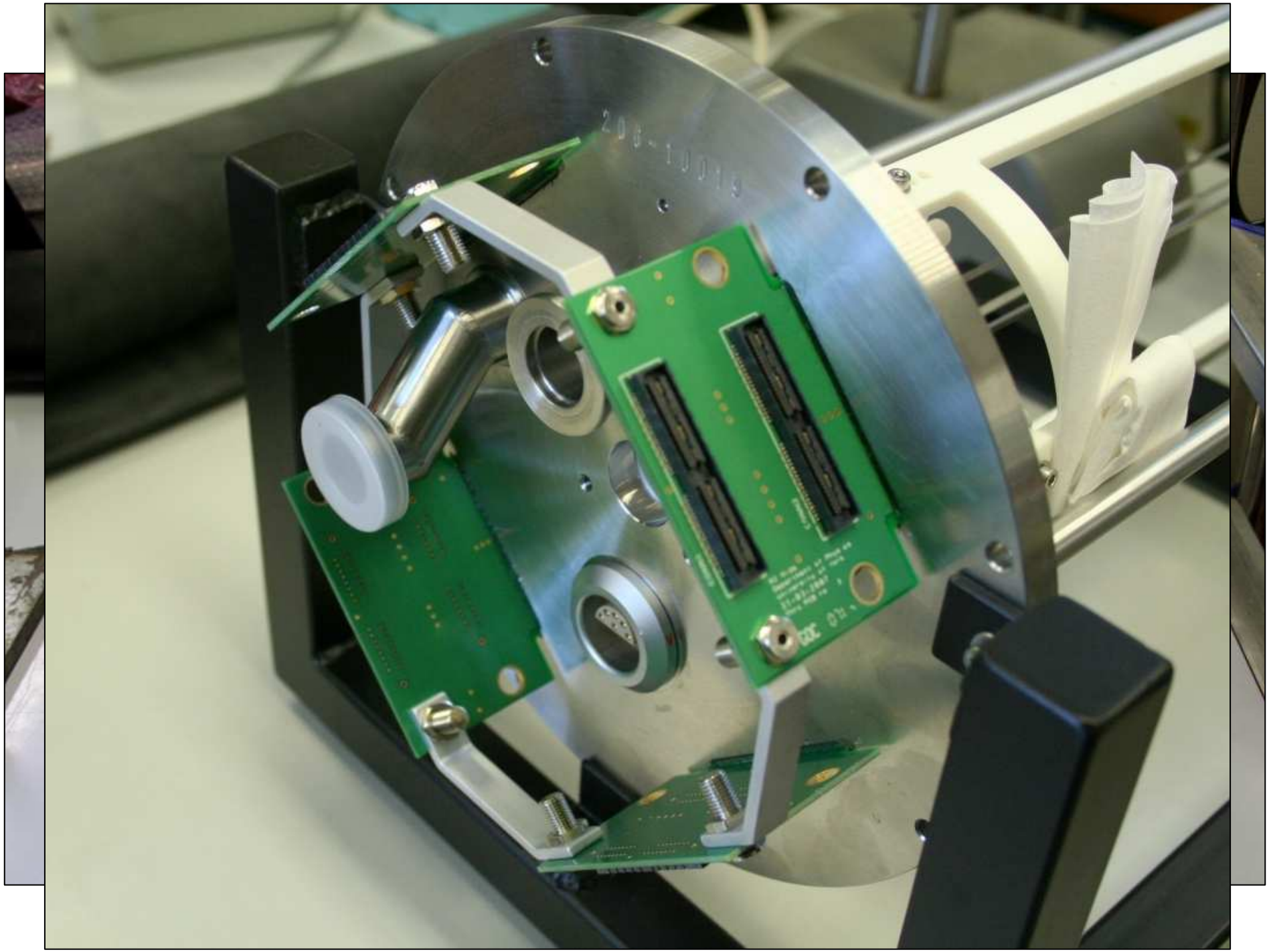

Current status

- 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 (α,n) and (α,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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