Study of O-14 using resonant alpha scattering

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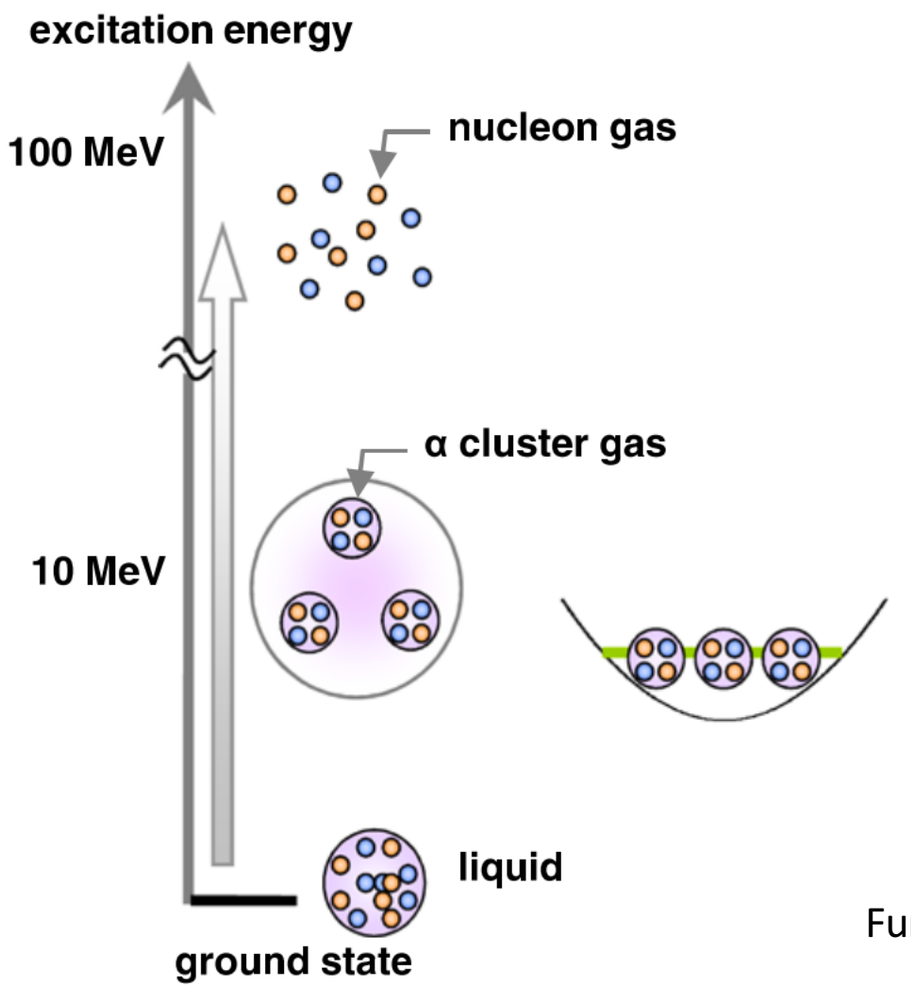
R-matrix Workshop
June 28, 2016

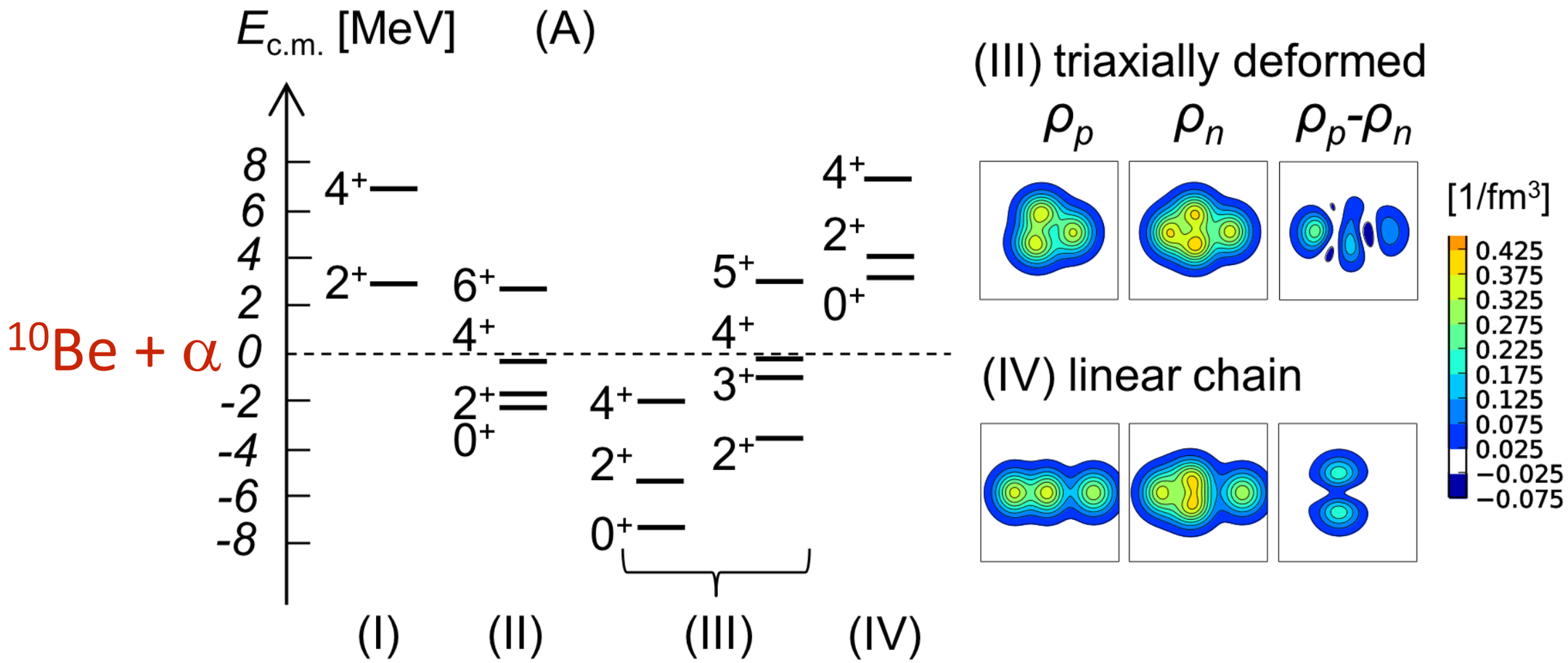
Clustering in Nuclei



Funaki et al. Prog. Nucl. Part. Phys. 82, 78 (2015)

- What causes nuclei to cluster?
- Nuclear theory: Important paradigm
- Important for nucleosynthesis: He burning, cyclic cycles, *rp*-process

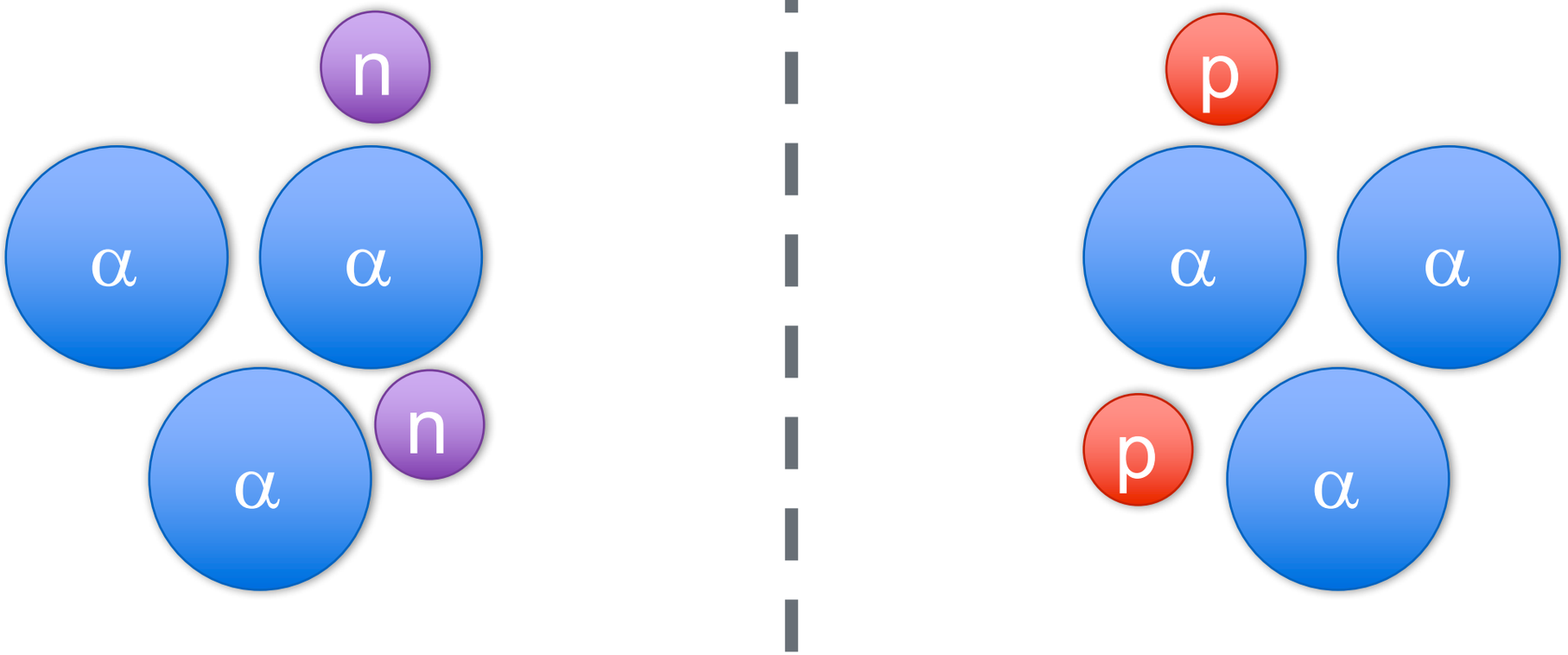
Linear chain in ^{14}C



- Anti-symmetrized Molecular Dynamics (Suhara and Kanada-Enyo PRC 82, 044301 (2010)
- Triaxial and linear chain rotational bands (III) + (IV)
- Freer et al. PRC 90 054324 (2014), Fristch et al. PRC 93 014321 (2016)

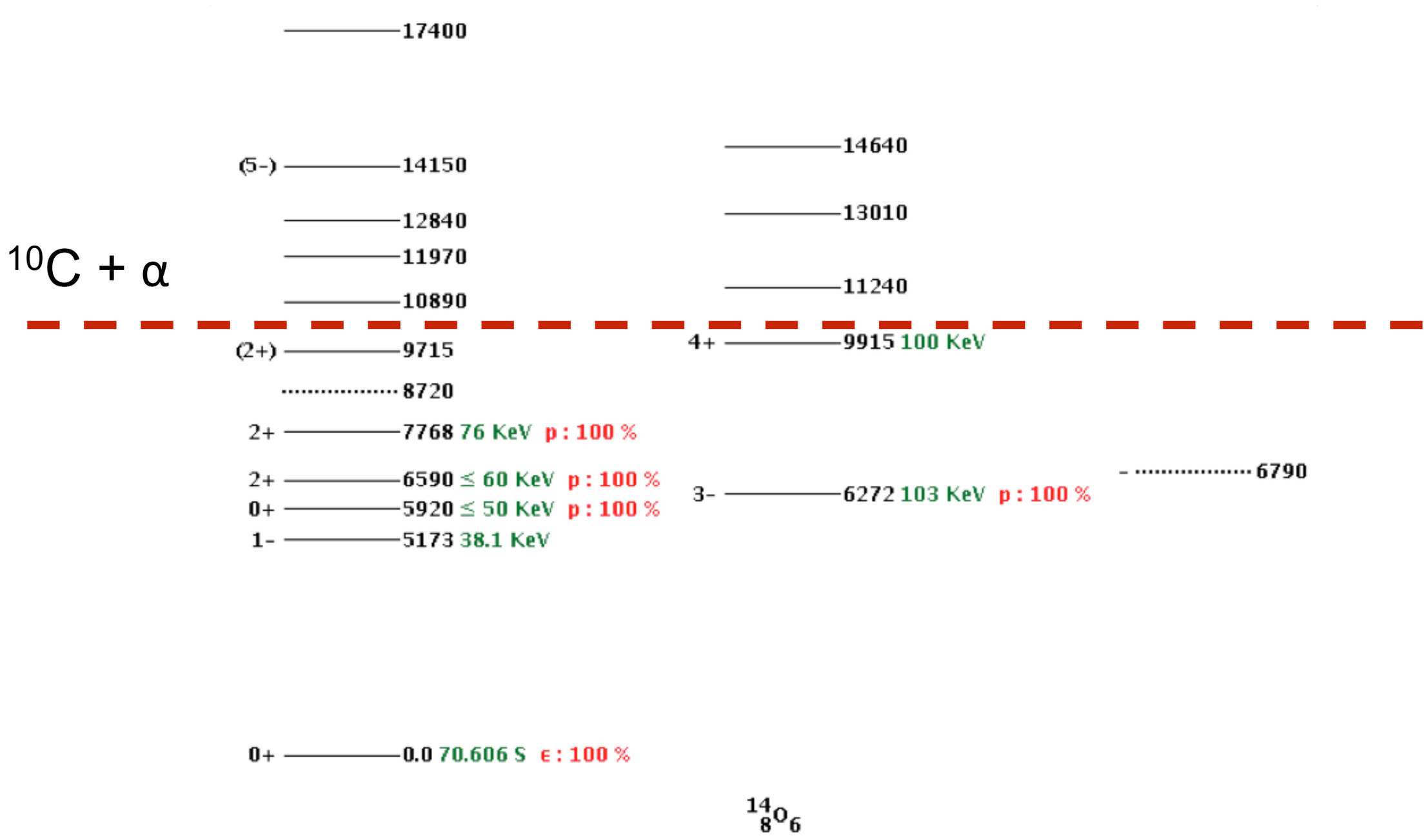
Isospin symmetry: $^{14}C/^{14}O$

?



- Exchange neutrons for protons
- ^{10}C + α experiment; ^{14}O

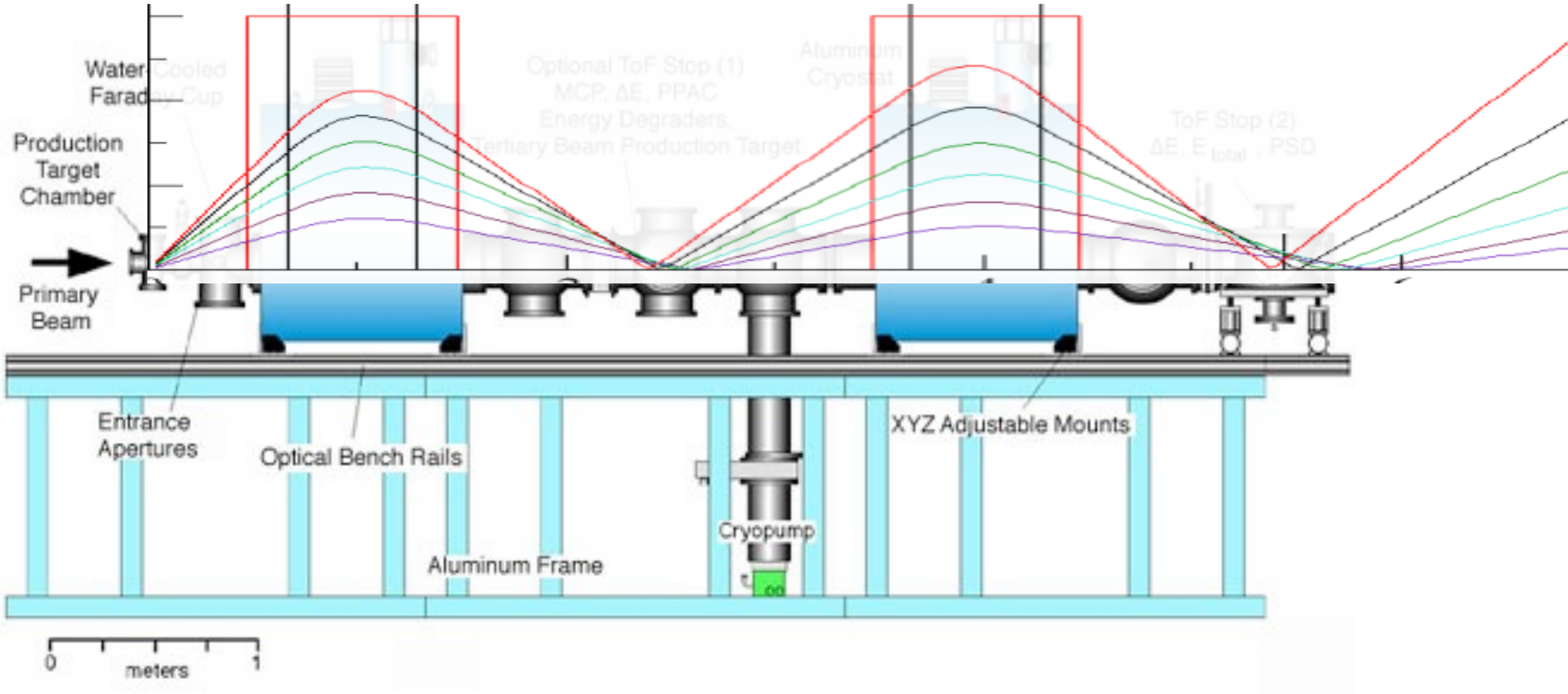
^{14}O cluster structure?



^{10}C + α

- Spins and parities for levels above alpha threshold
- Crucial for interpreting structure

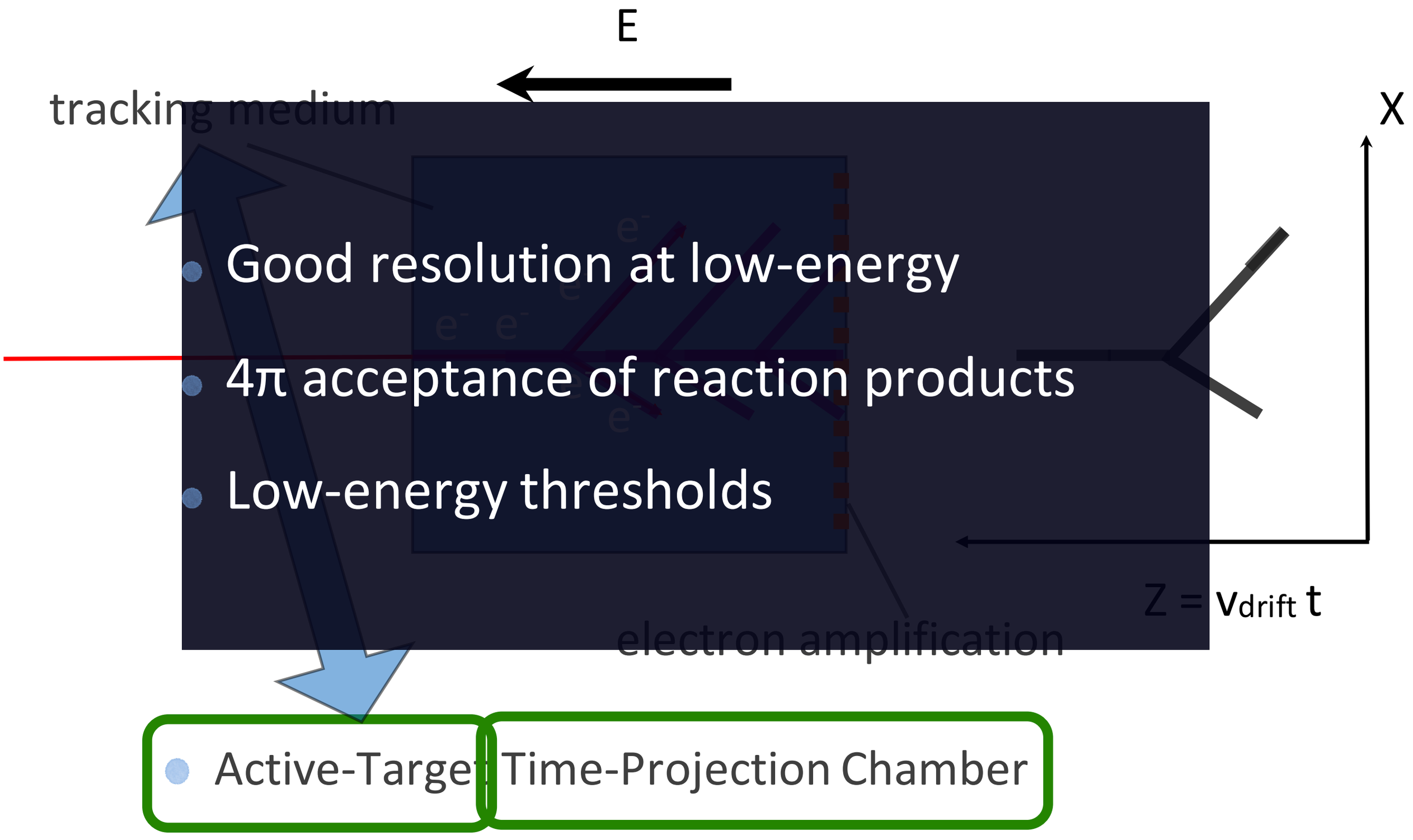
TwinSol at Notre Dame



- Light radioactive-ion beams produced in flight
- charge exchange ^{3}He(^{10}B,*t*)^{10}C*, 52.5 MeV, 34.8 MeV

F. Bechetti et al., NIM A 505, 377-380 (2003)

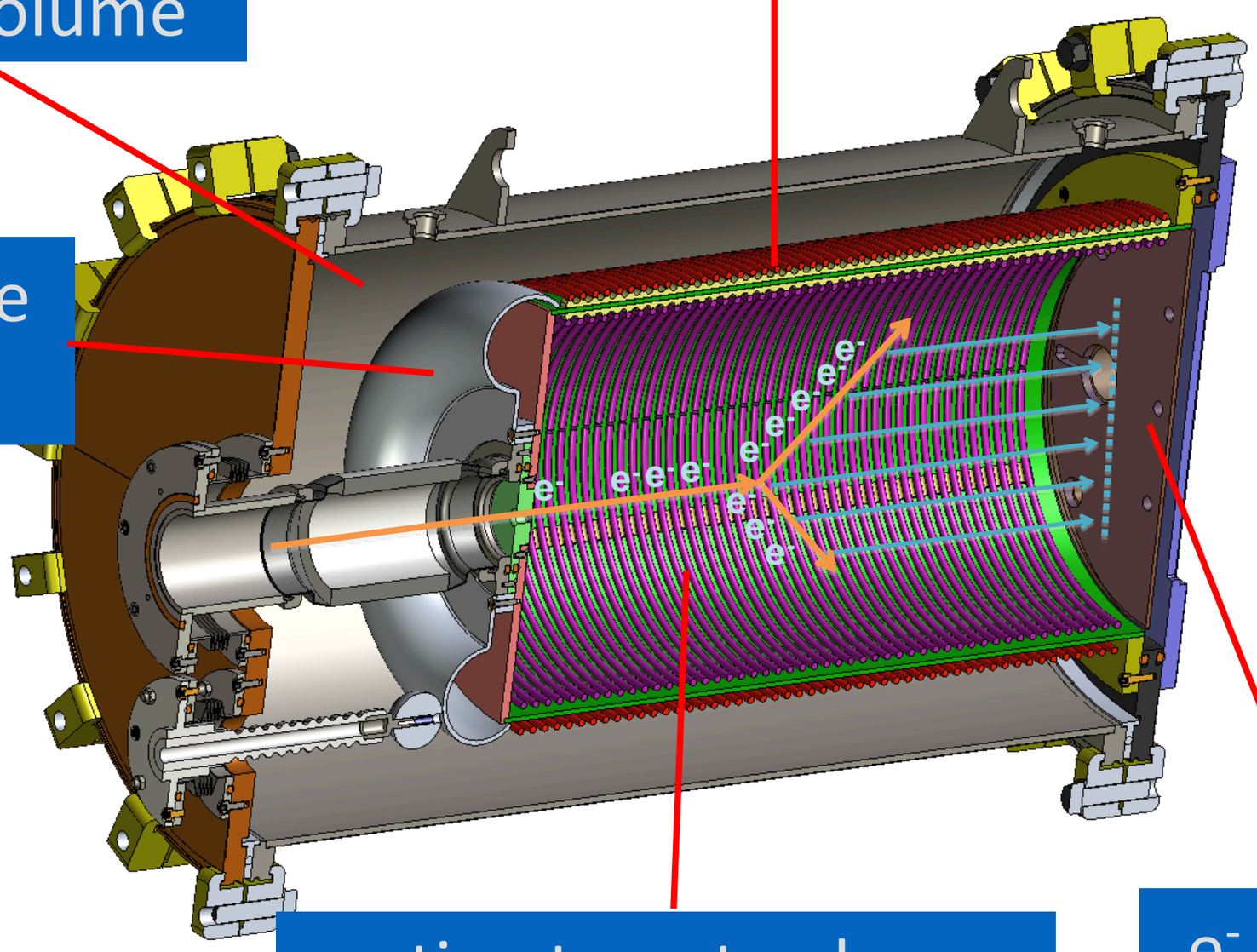
Active-target Concept



- Good resolution at low-energy
- 4π acceptance of reaction products
- Low-energy thresholds

- Active-Target Time-Projection Chamber

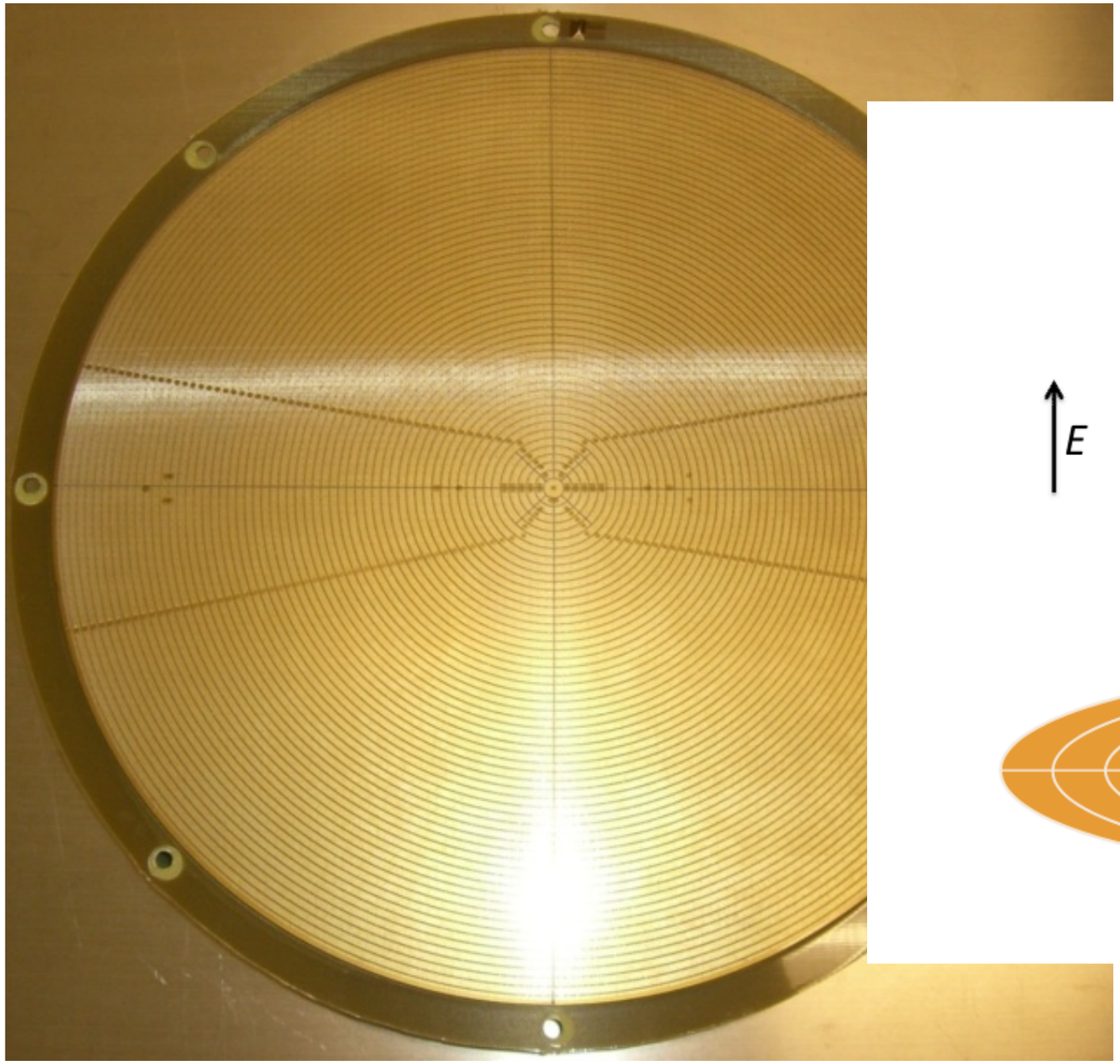
Prototype AT-TPC

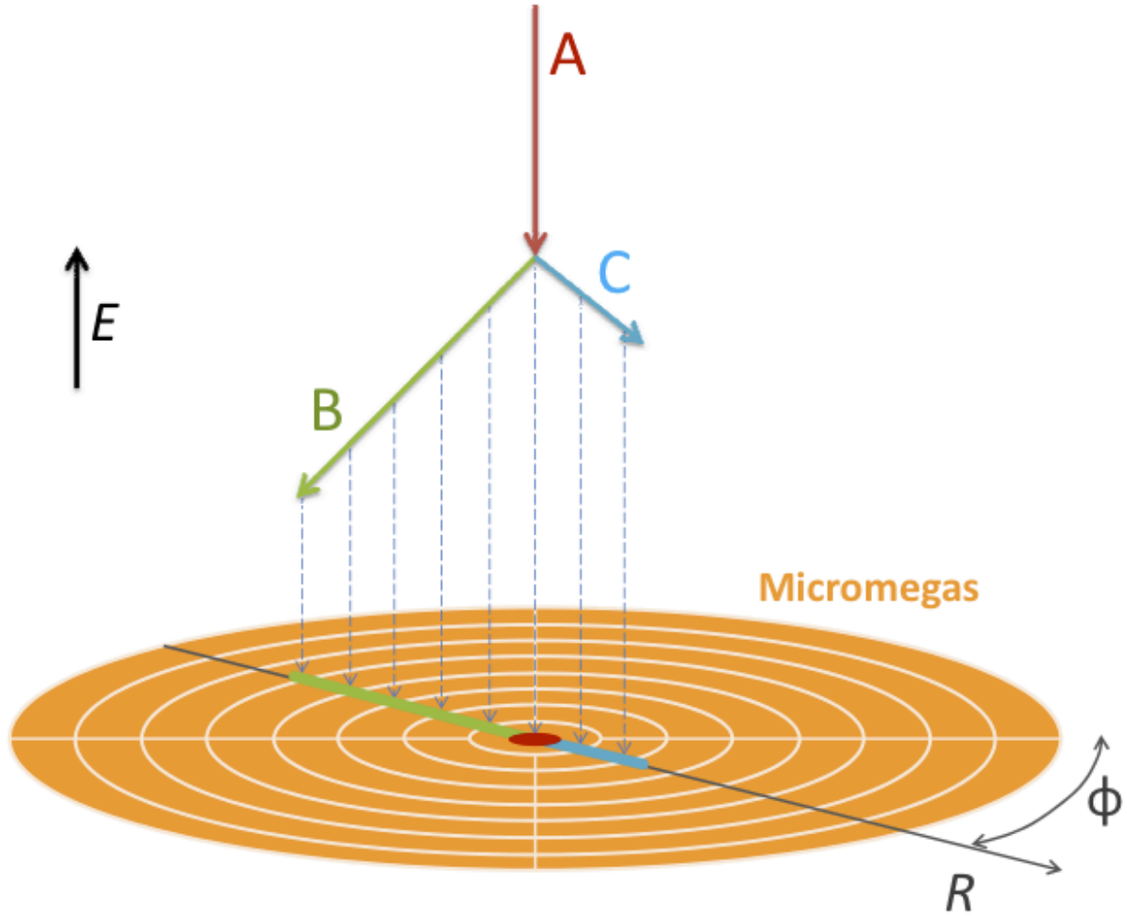


- 50 cm length, 25 cm diameter

D. Suzuki et al., NIM A, 691 39 (2012)

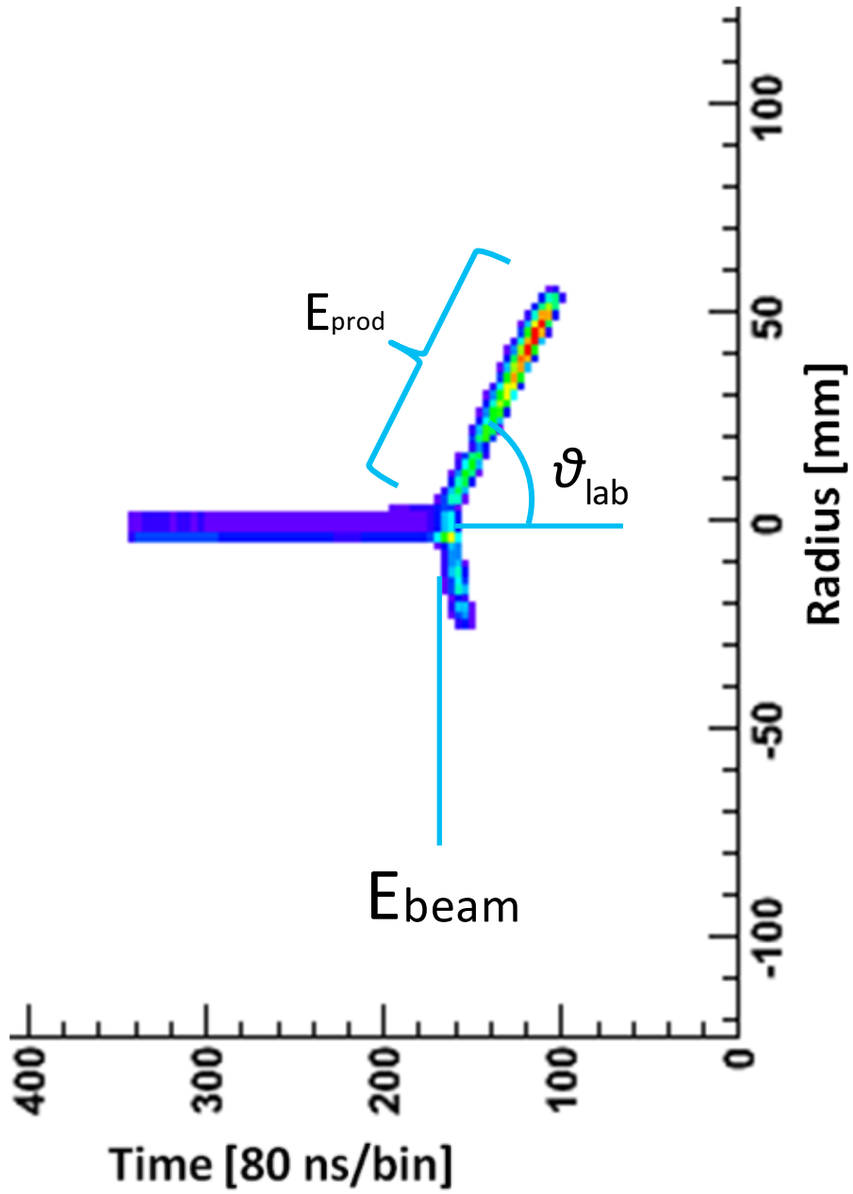
Prototype Micromegas



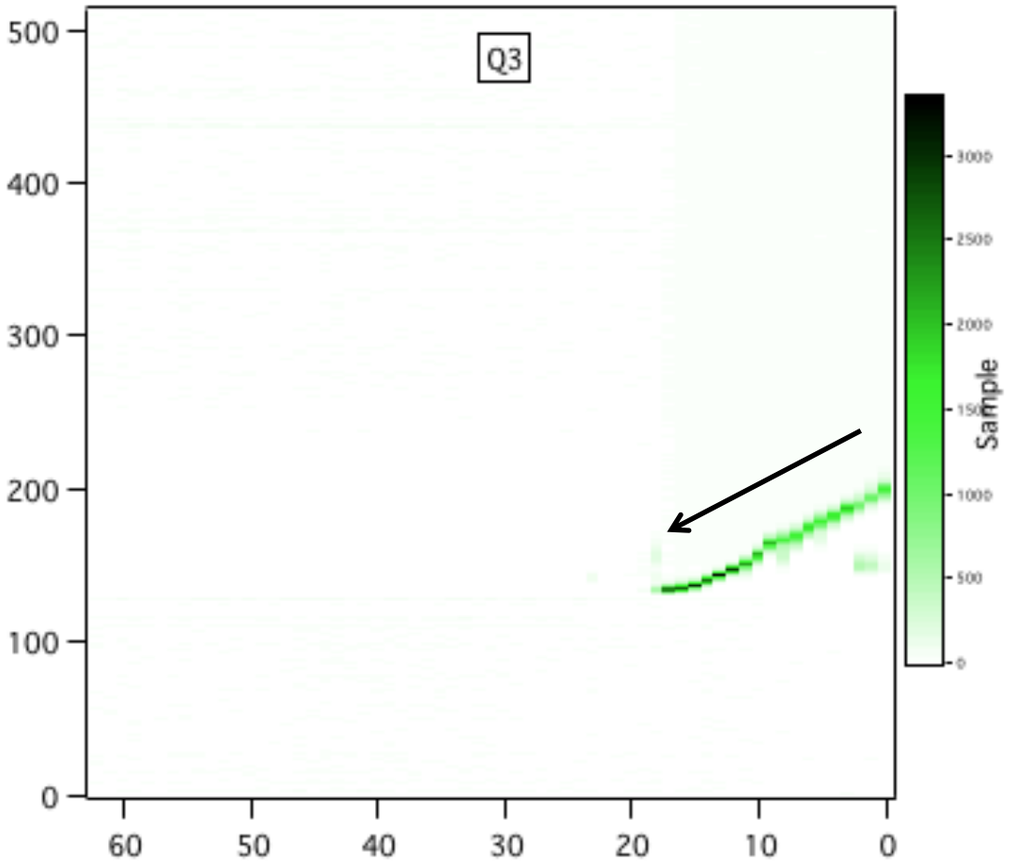


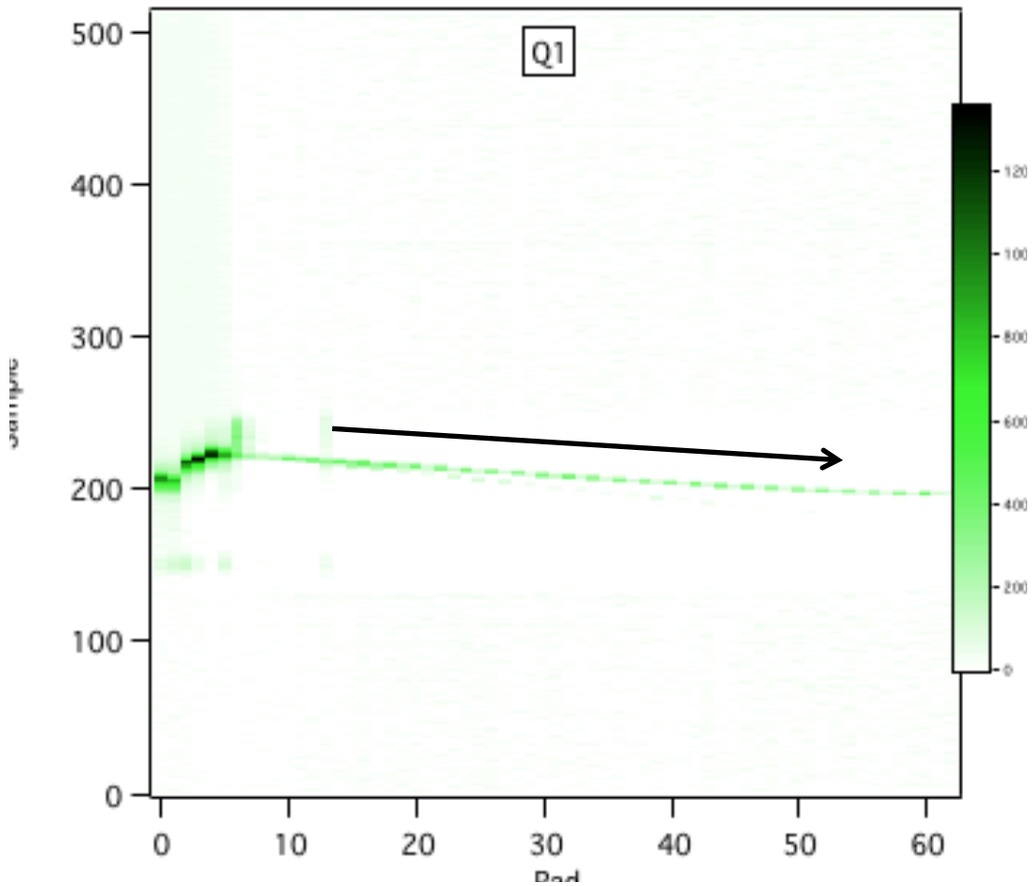
What we measure

- Energy of beam, E_{beam}
  - position
- Angle, θ_{lab}
- Ebeam, E_{prod}
  - Bragg curve
- Cross Sections: $d\sigma/d\Omega(E,\theta)$



$^{10}C + \alpha$ experiment

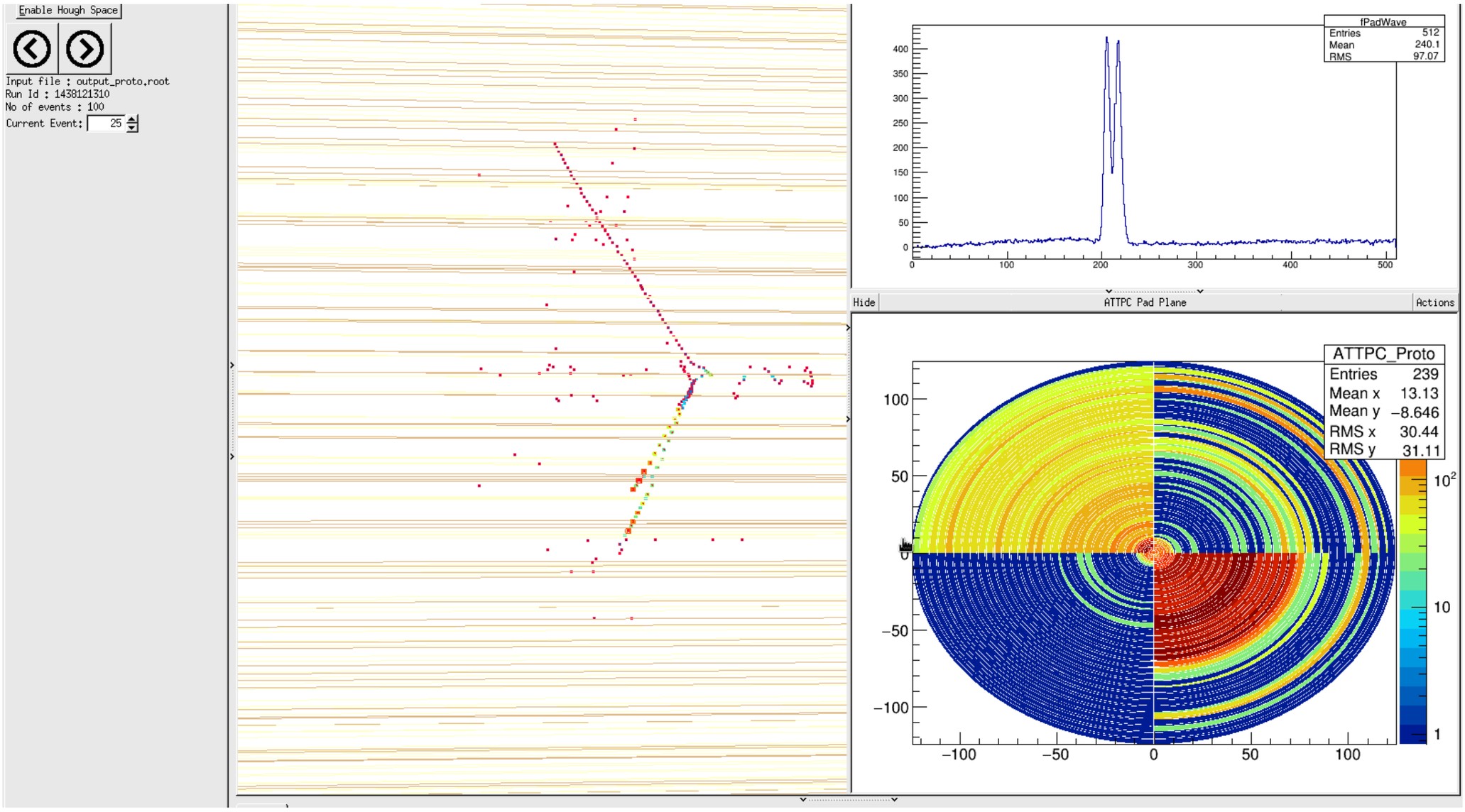




- Several possible reactions
  - $^{10}C + {}^{4}He$
  - Heavy + light
  - $^{10}C + {}^{12}C$, $^{10}C + {}^{16}O$

- 4.9×10^{6} events, 5 days
- 8.4×10^{8} ions in chamber

ATTPC ROOT: Track visualization

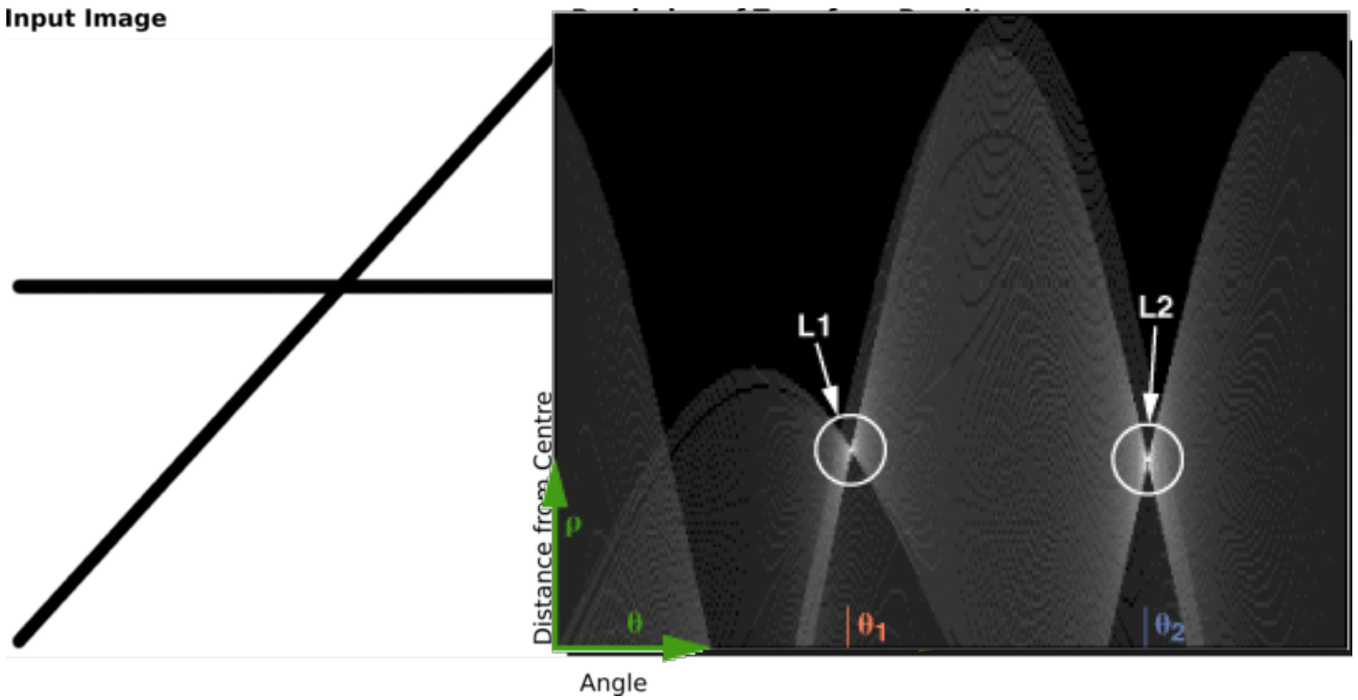


- Use of azimuthal angle: 3D track

Y. Ayyad et al., NSCL

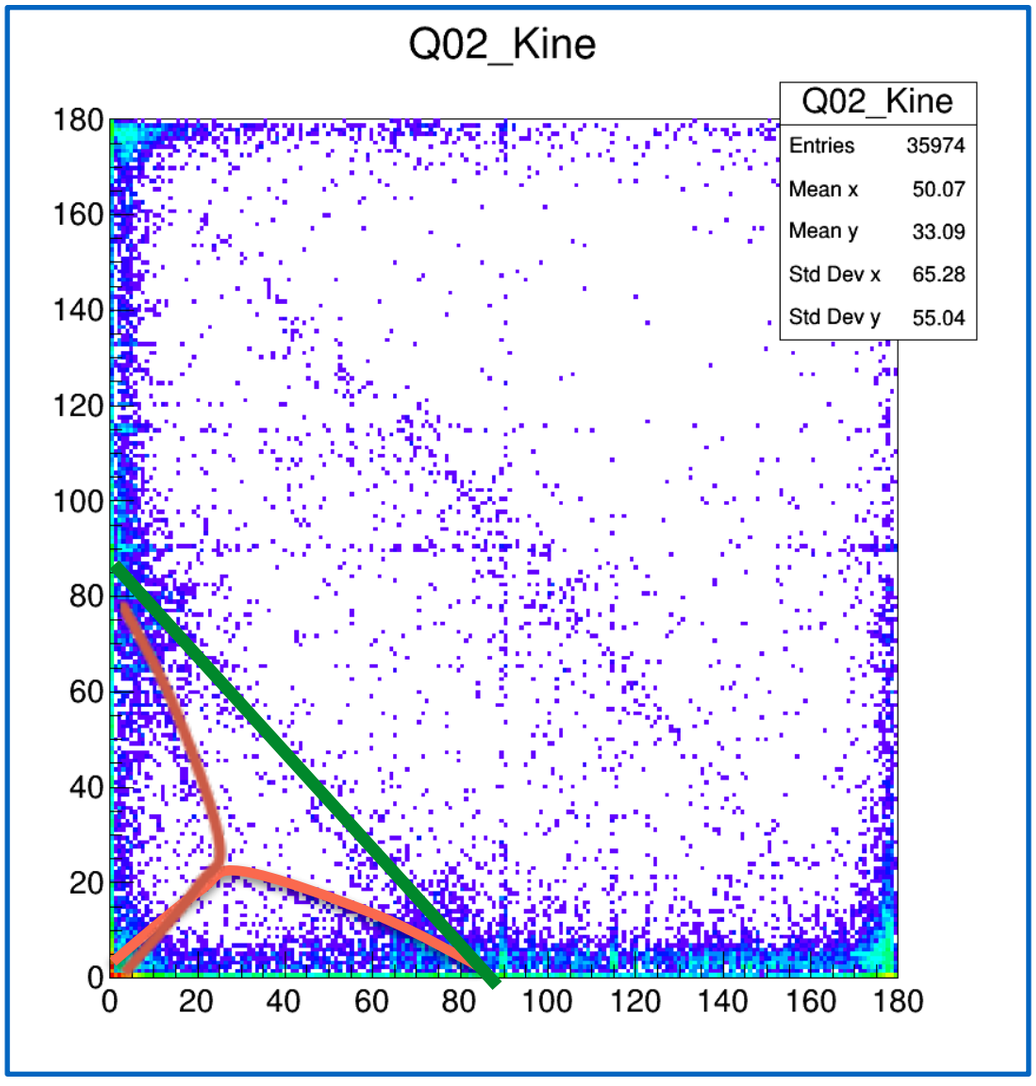
- Visualization, tracking, analysis

Next steps: Tracking



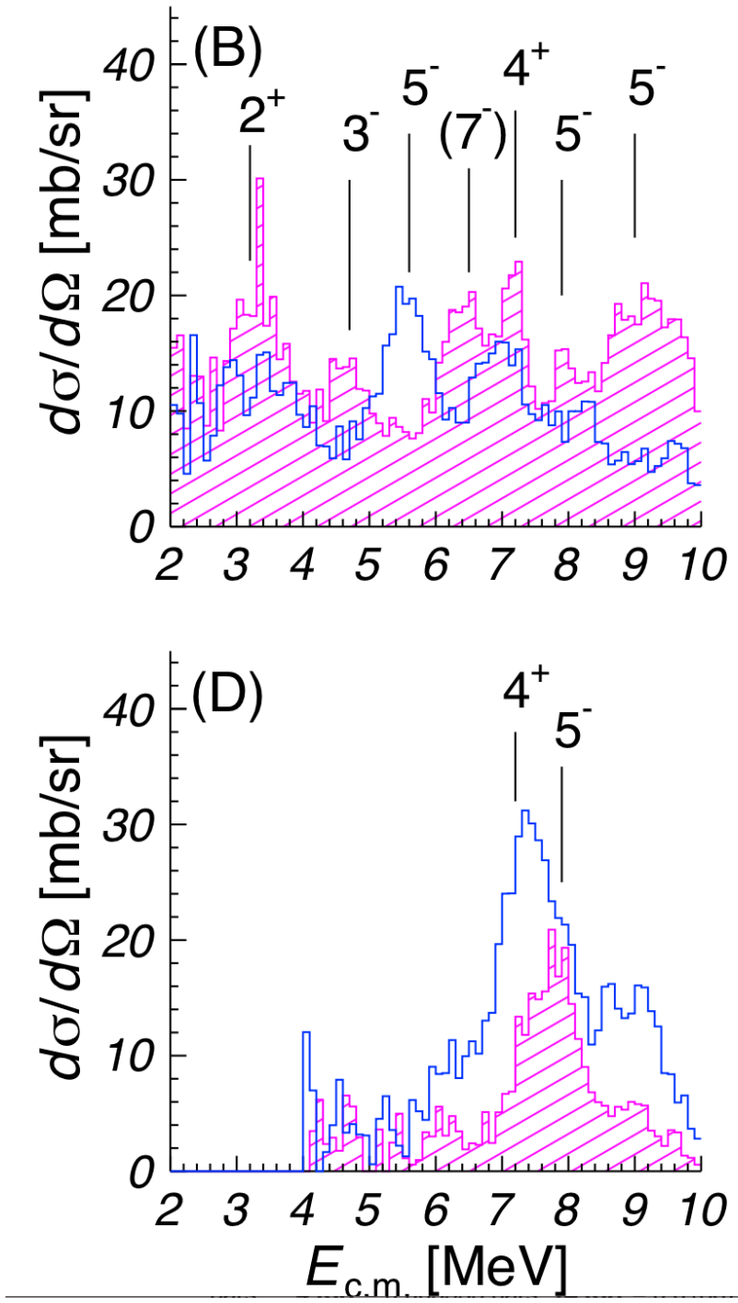
- Tracking algorithm
  - Find peaks quickly: *Tspectrum, Wavelet transform*
  - Construct tracks robustly: *Hough transform*
- Excitation functions; angular distributions

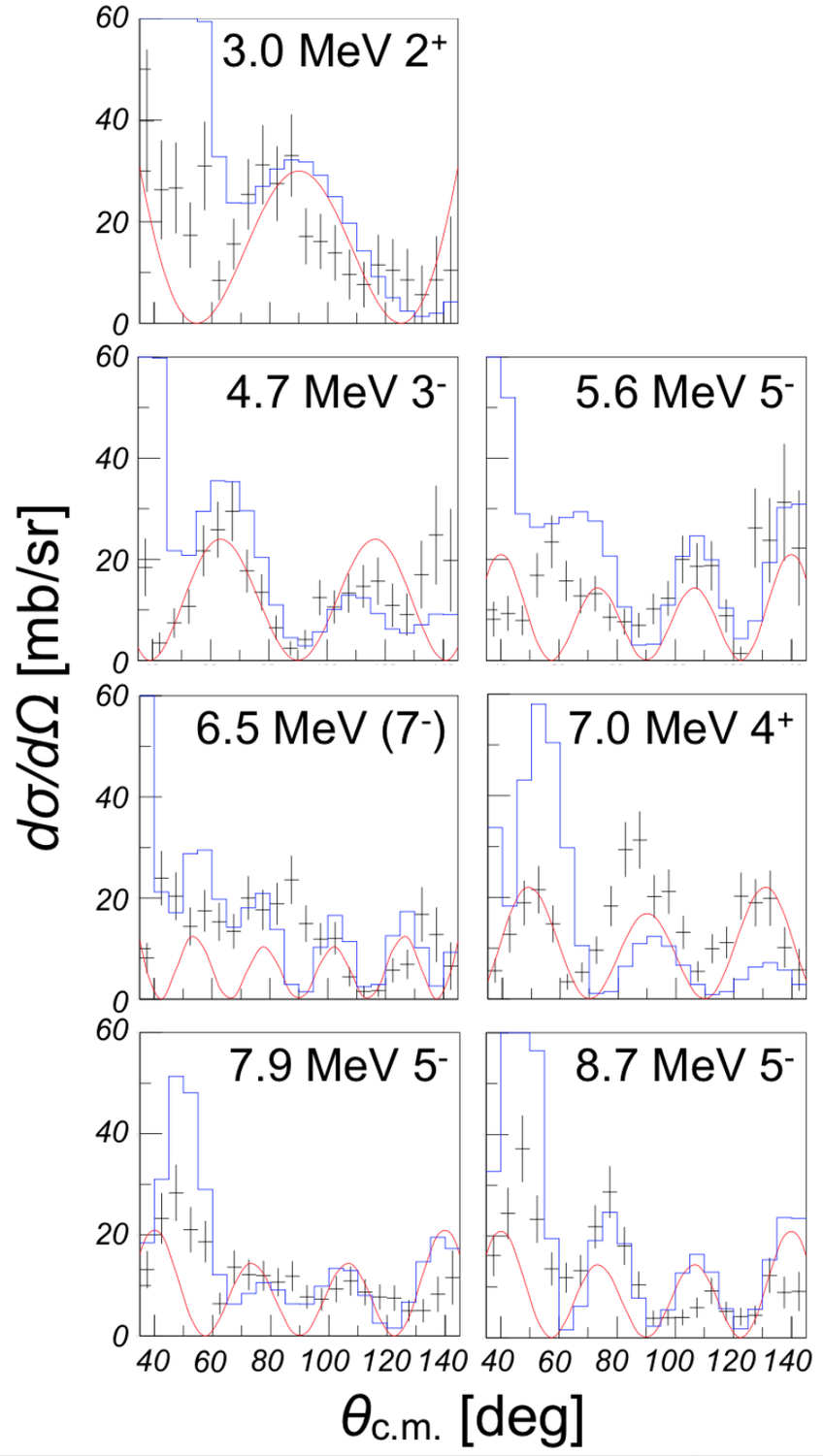
^{10}C-α angle-angle correlations



- 1 run (run 190) , 10 files, 17000 events.
- ^{10}C and ^{4}He scattering
- Programming issues

^{14}C: Cross Sections and Angular Distributions

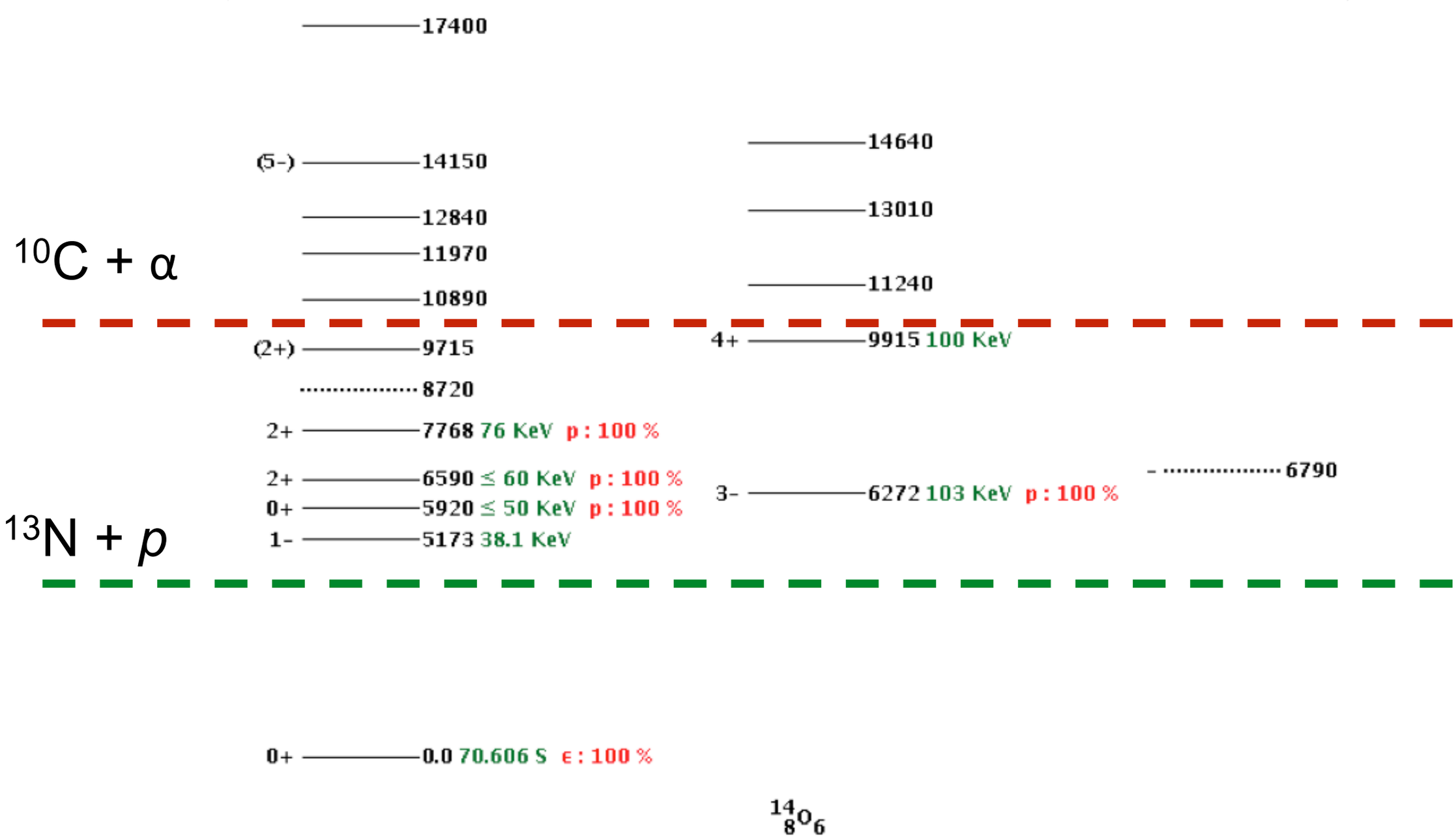




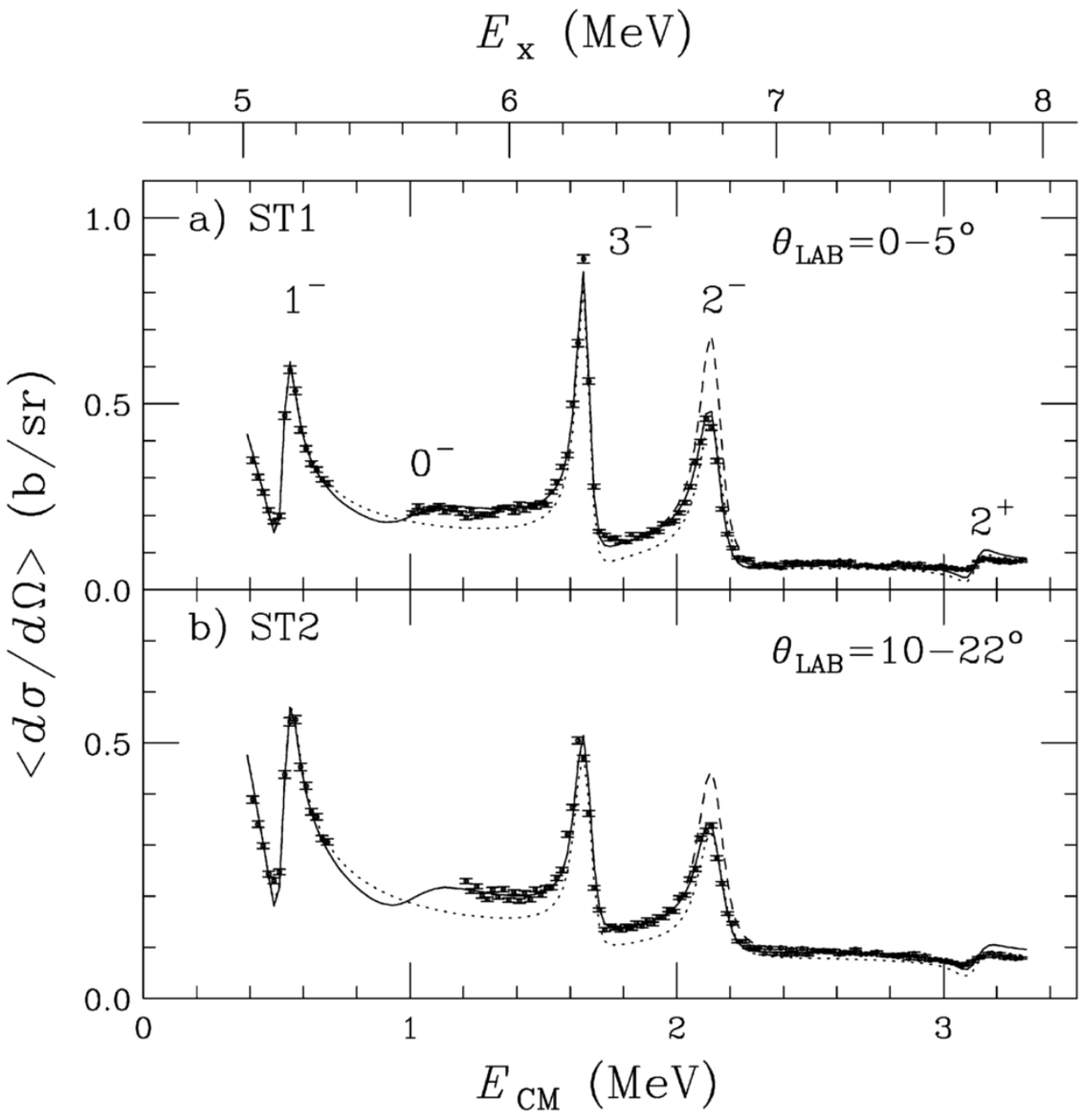
A. Fritsch et al. PRC 93, 014321 (2016)

- Example from ^{14}C

^{14}O levels above *p* threshold



$^{13}N + p; ^{14}O$



- Teranishi et al. Phys. Lett. B 650, 129 (2007)

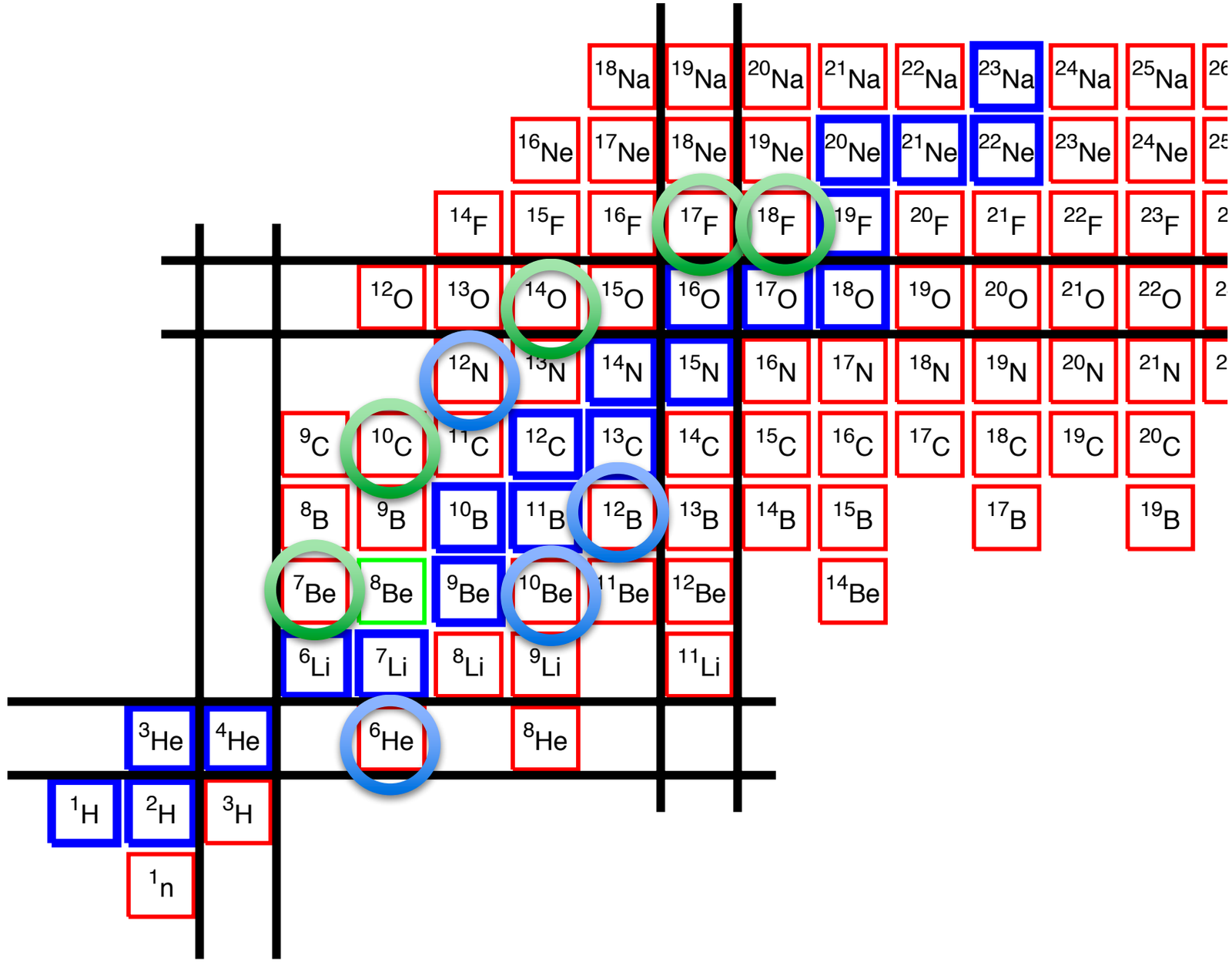
- Use of Dsigma IV code
  - Hongwei Wang
- AZURE2
- Documentation
- Community of users
- Validated

Summary

- Investigation of states above $^{10}C + \alpha$ threshold
  - TwinSol and PAT-TPC
- Analysis is ongoing
- Goal is precise measurements of differential cross sections
  - Elastic and inelastic
- Describe nuclear scattering: R-matrix analysis
  - Large alpha widths in ^{14}O?

- Future work…

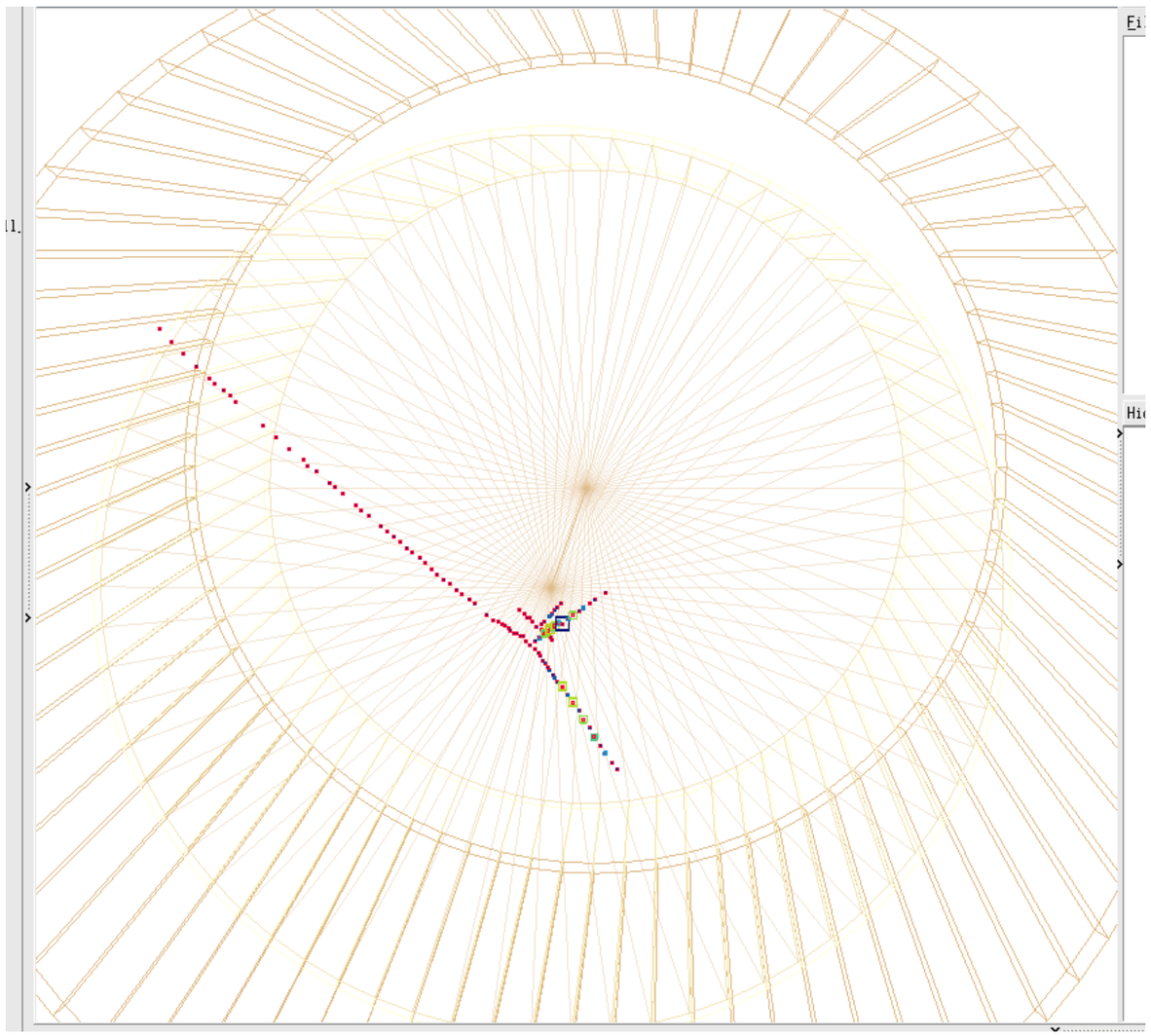
Present and Future TwinSol Beams



- 10^2- 10^5 pps
- Program for studying novel alpha-cluster structure in light nuclei

Future explorations

- Cross section measurement at low energy
  - Gas target
  - 3- and 4-body breakup
  - Coulomb dissociation



Acknowledgements

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