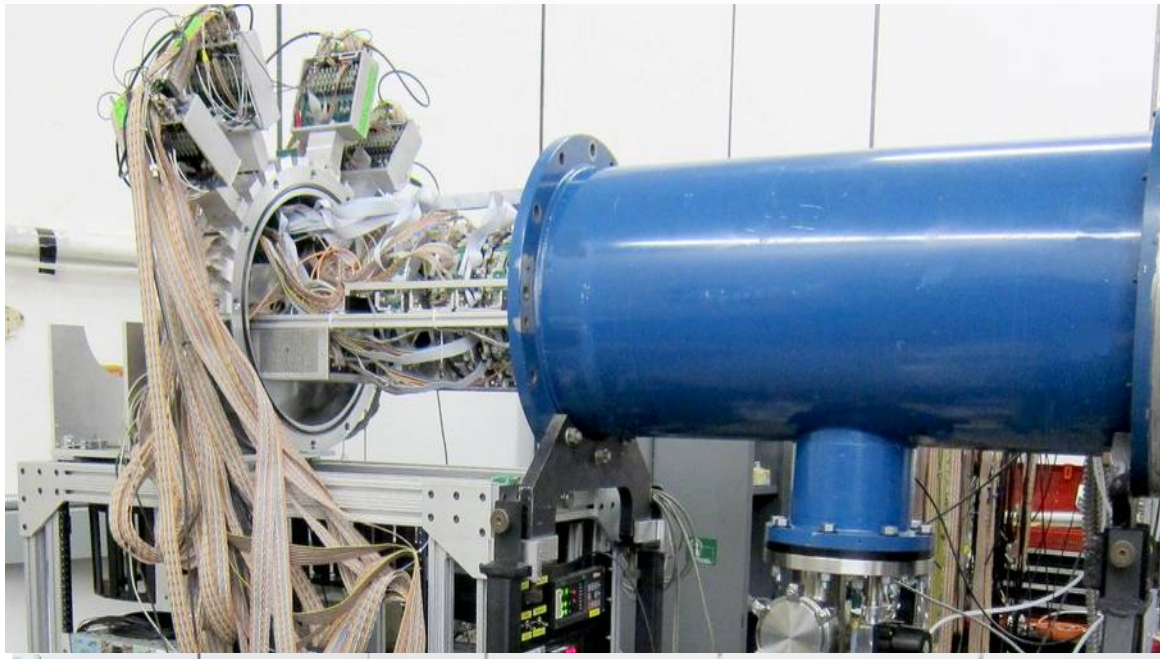
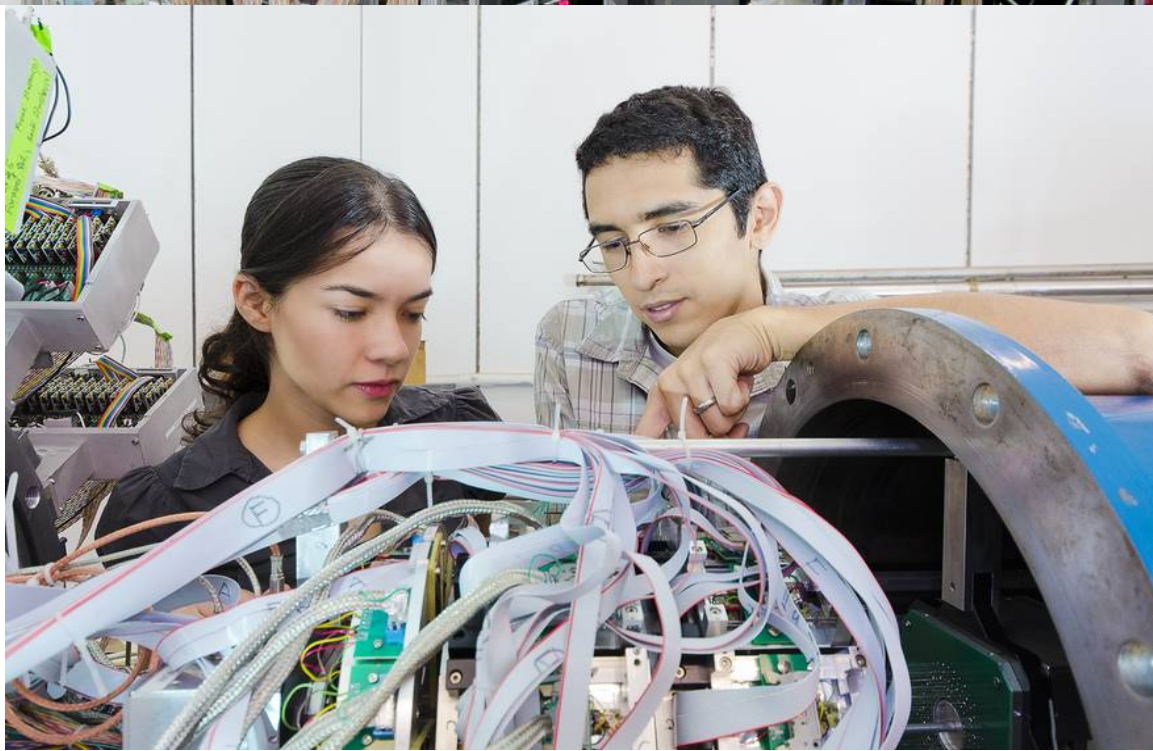
Instrument Development: ANASEN

- Active-target detector for (p,p), (α,p) and (d,p) reactions with exotic beams
- 2009 NSF-MRI grant
  J. Blackmon (LSU),
  G. Rogachev (now TAMU),
  I. Wiedenhöver (FSU)
- To be used at FSU's RESOLUT facility and MSU's ReA 3 facility
- Developed, built and commissioned at FSU with ~12 weeks of beam time during 2011,2012
- RIB experiments (FSU)
  He-6 beam (March 2012)
  B-8 beam (July 2012)
  O-19 beam (Sept. 2012)
  Ne-18 beam (Feb 2013)
- ReA3: K-37 (Aug2013)





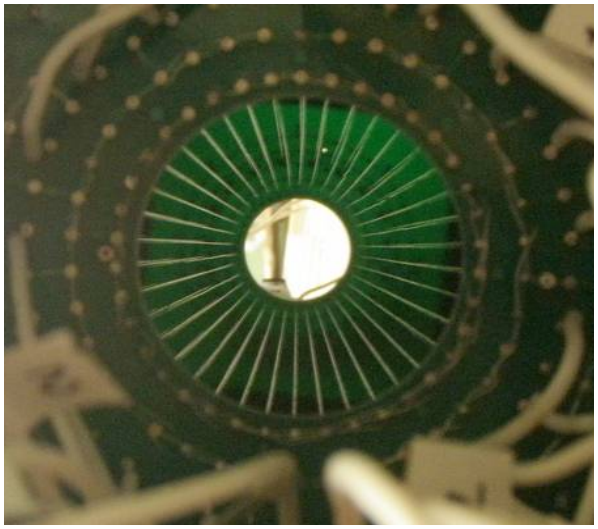
ANASEN Concept

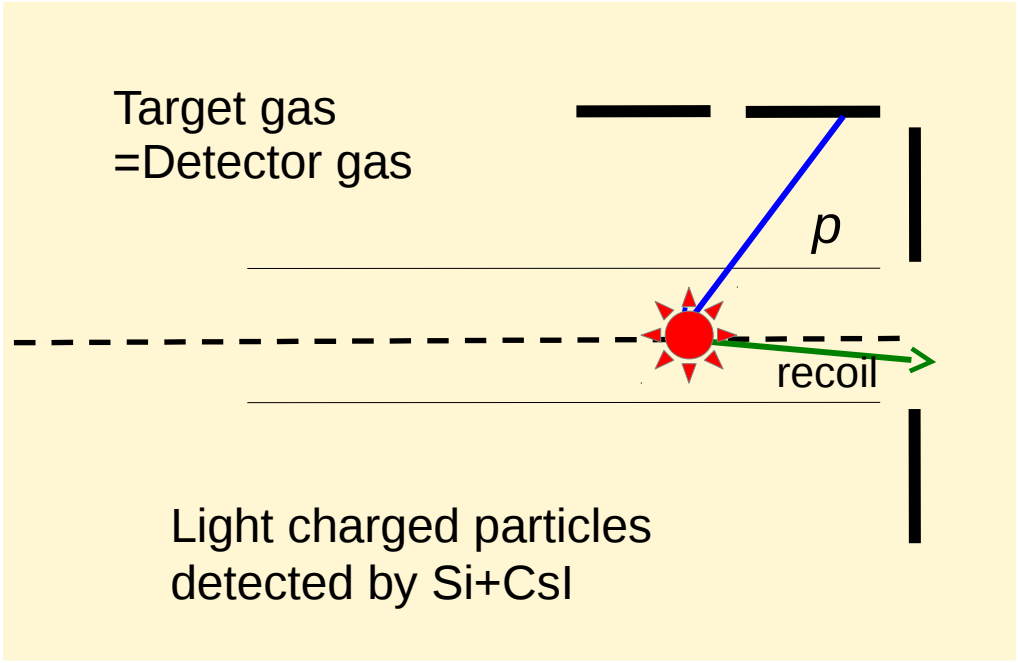
Array for Nuclear Astrophysics Studies with Exotic Nuclei

Extended active gas target/detector

Cylindrical proportional counter surrounding beam axis

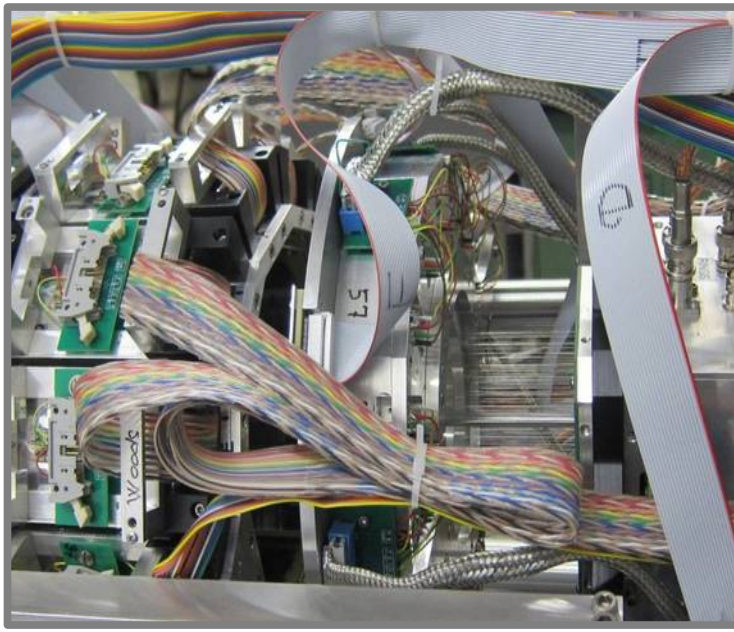
19 anodes 7μm diam carbon fiber → High Gain



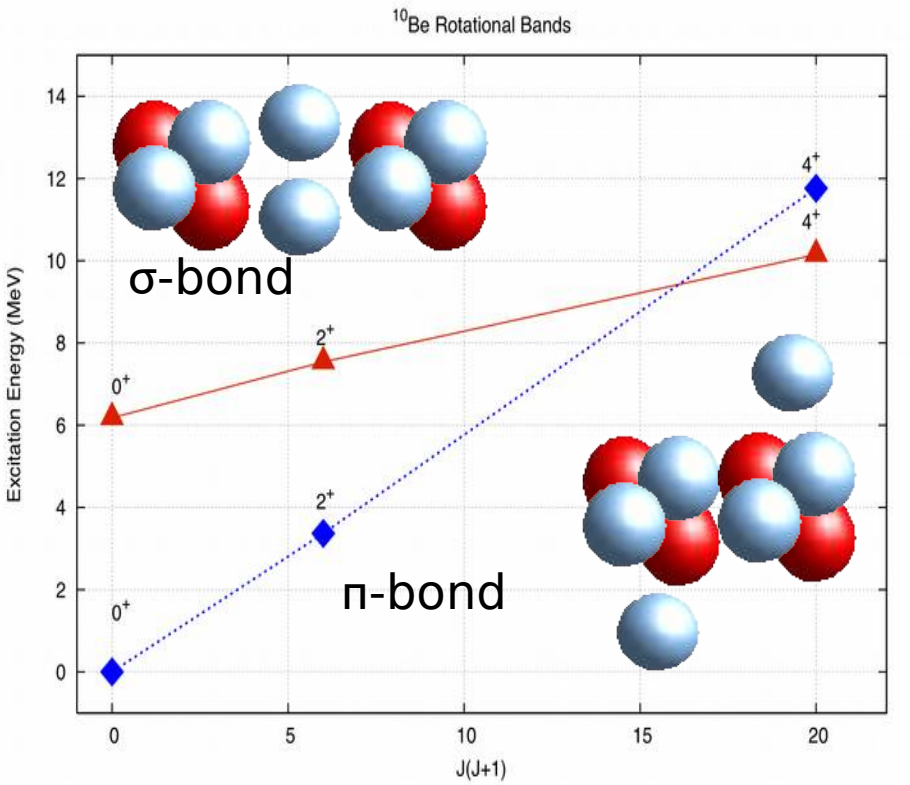


1. ΔE in PC → particle identification
2. Position Si + Position PC → θ_{lab}
3. Energy Si + θ_{lab} → E_{cm}

Entire excitation function simultaneously measured



First ANASEN RIB-experiment: Cluster states in ^{10}Be



W. von Oertzen ZPA354 (1996)
A. Dote, et al., PRC 56, 1844 (1997).
N. Itagaki and S. Okabe, PRC 61, 044306 (2000).
Y. Ogawa, et al., NPA (2000).
Kanada-En'yo & Horiuchi, Prog.Th.Phys. (2001).

- Rotational band with high moment of inertia built on 0+ at 6.18 MeV.
- 10.15 MeV state reported to be extremely clustered.
- Believed to be associated with α-2n-α molecular rotational band.
- Disagreement in spin-parity assignment for 10.15 MeV
  - ✓ 4+ Freer, et al., PRL (2006) Milin, et al., NPA (2005)
  - ✓ 3- Curtis, et al., PRC (2001).

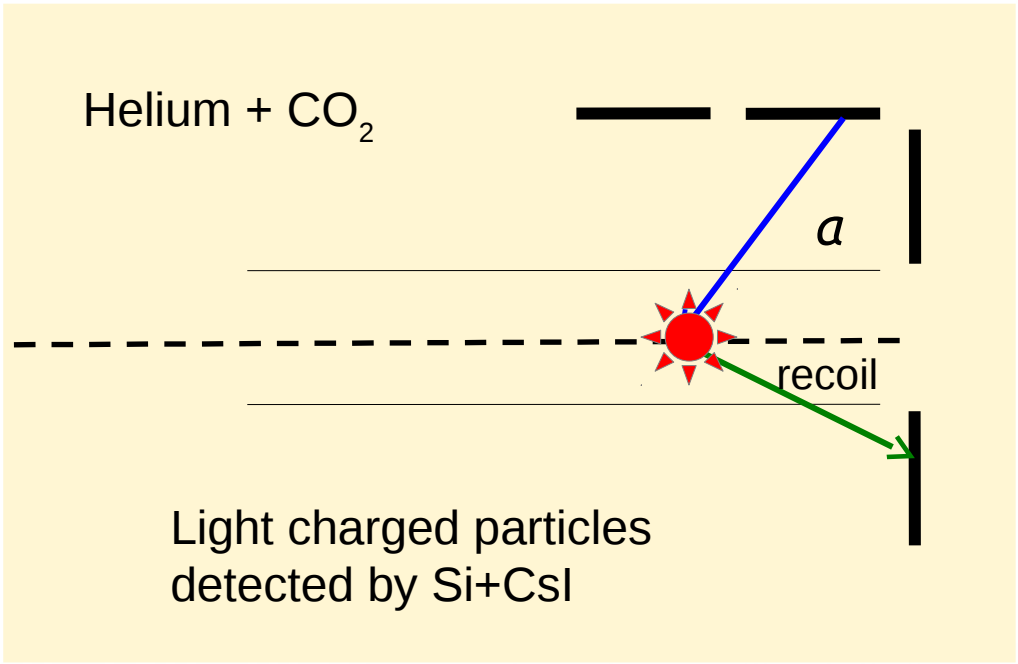
ANASEN: ^{6}He+α scattering

FSU Grad.Student A. Kuchera

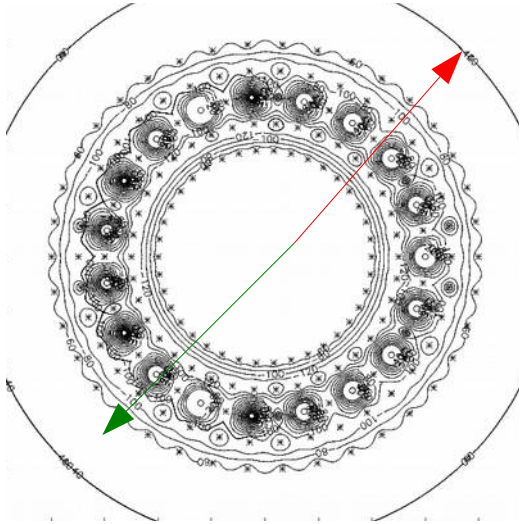
With TAMU & INFN-Canania

^{6}He beam from RESOLUT

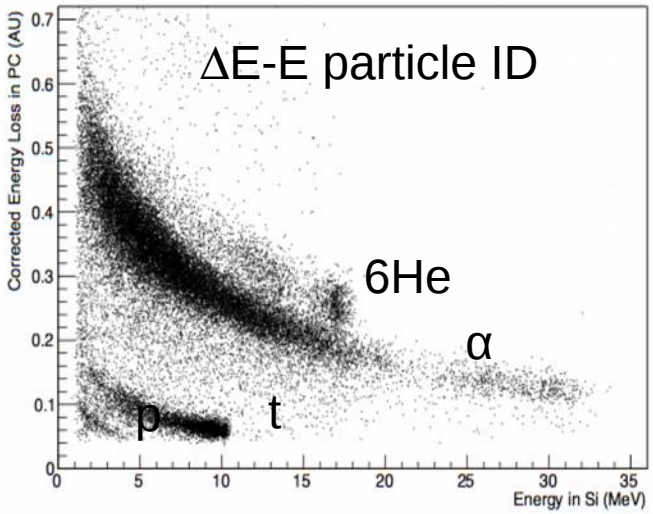
7 bombarding ^{6}He energies used to map between Ex=9.1-17 MeV in ^{10}Be

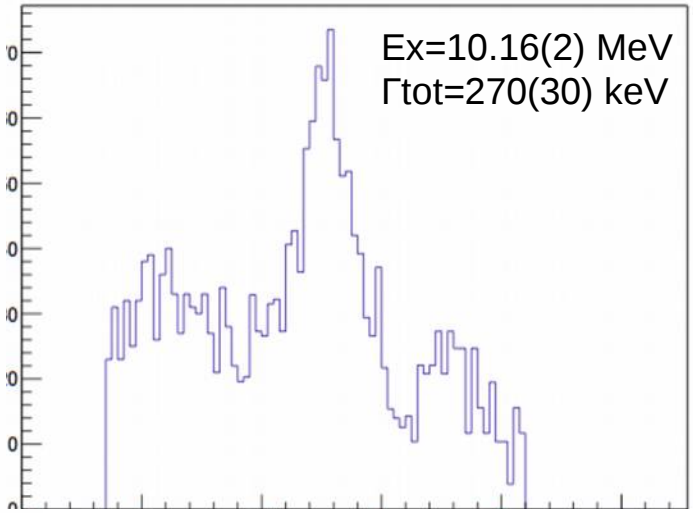


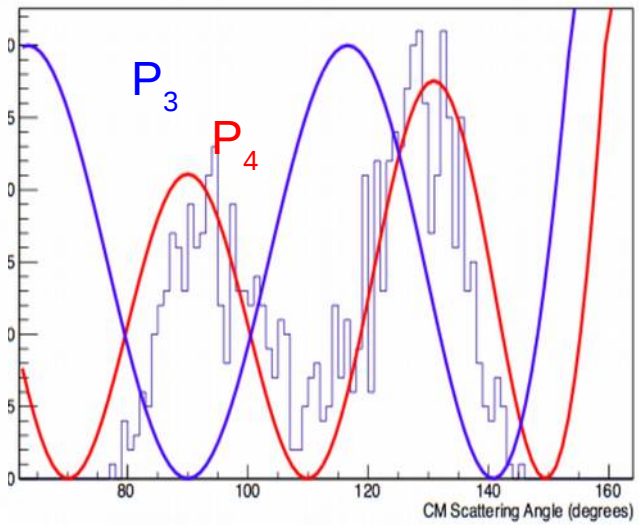
^{6}He (enters through Window)



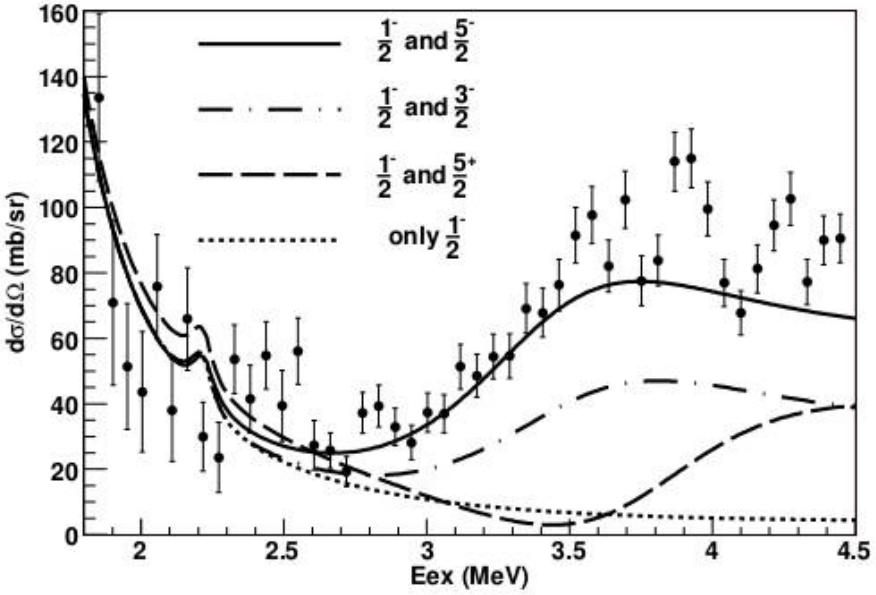
Angular distribution => **4^{+}**



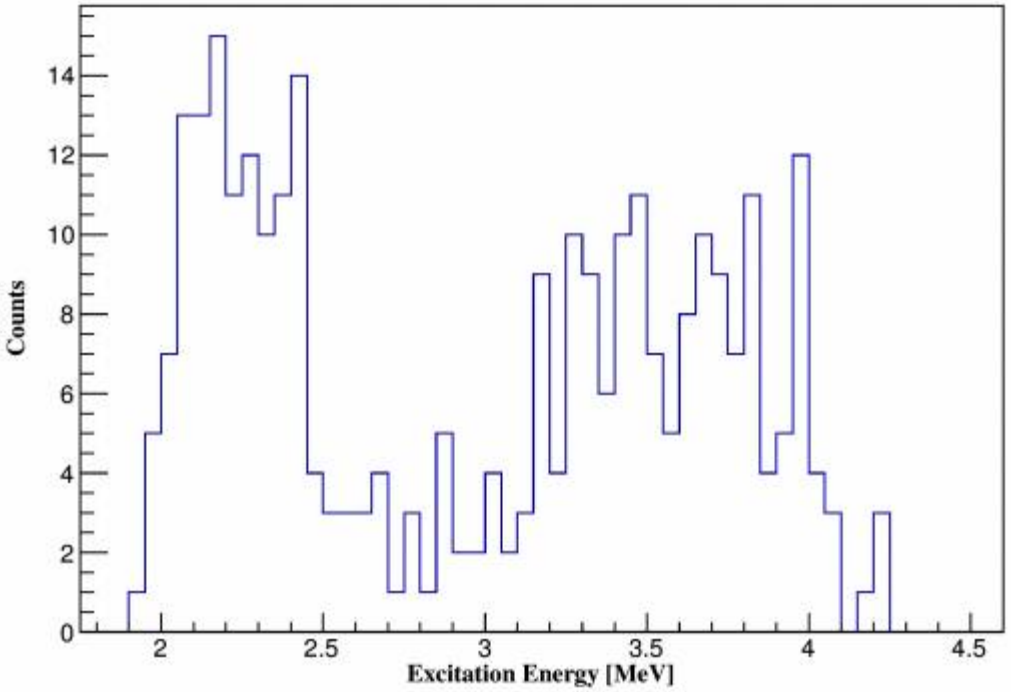




Proton Scattering: ^{8}B Grad. Student Joe Belarge



G. V. Rogachev et al. PRC **75**, 014603 (2007)



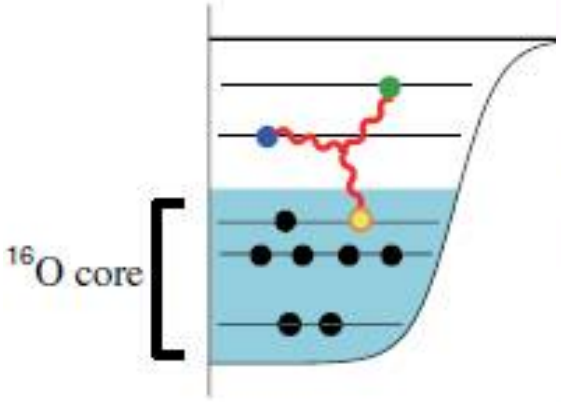
- Beam 1*10^{4} pps, 10% purity, 10 h of data
- Experiment cut short because of cryogenics problems in May 2012
- Results consistent with previous experiment, but could not improve on it.

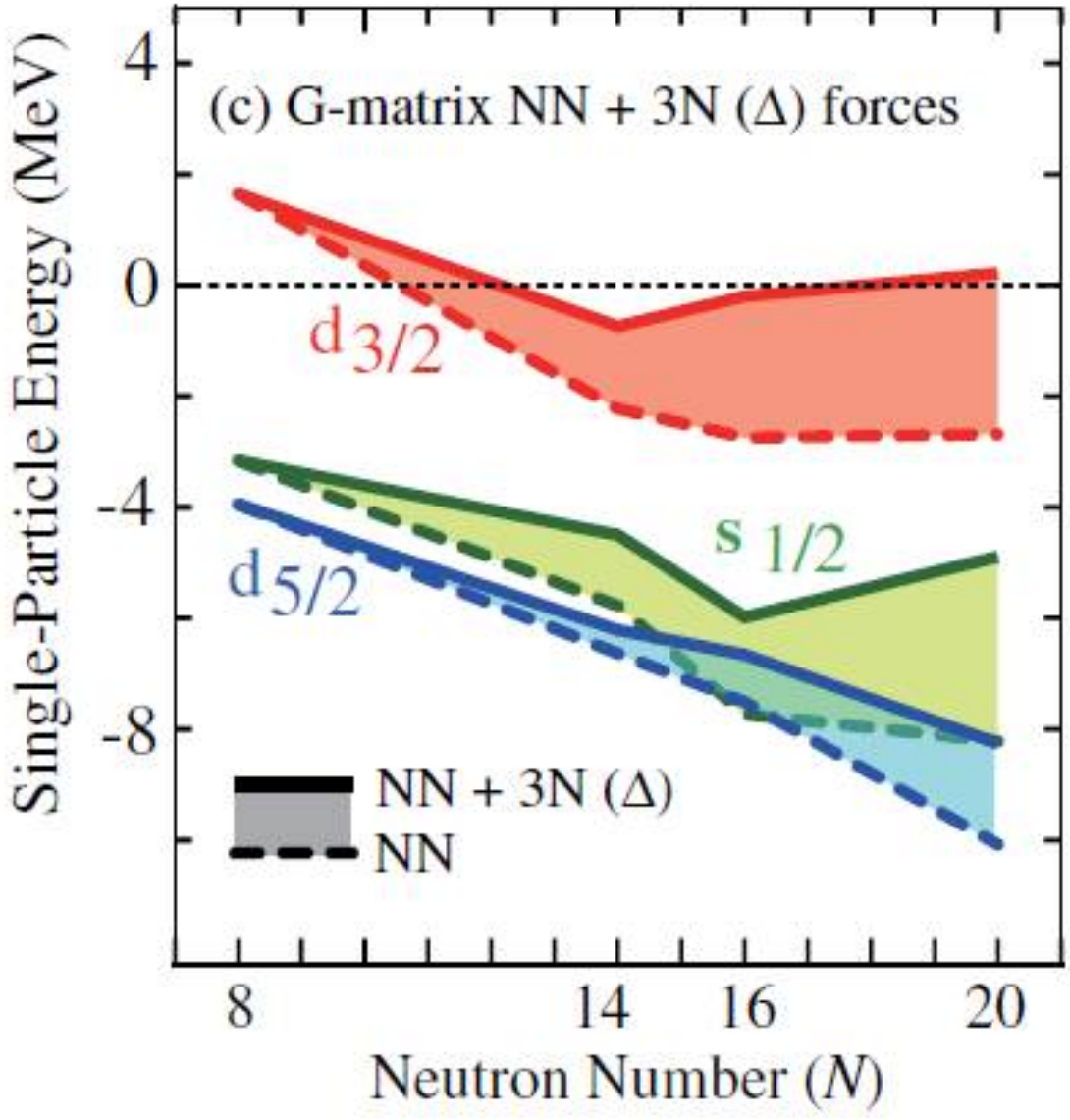
Evidence for Three-body Forces in Oxygen-isotopes

T. Otsuka, T. Suzuki, J. Holt, A. Schwenk, and Y. Akaishi,
Three-Body Forces and the Limit of Oxygen Isotopes, PRL 105, 032501 (2010)

Three-body forces are needed to explain location of n-drip-line in Oxygen isotopes, ^{28}O unbound

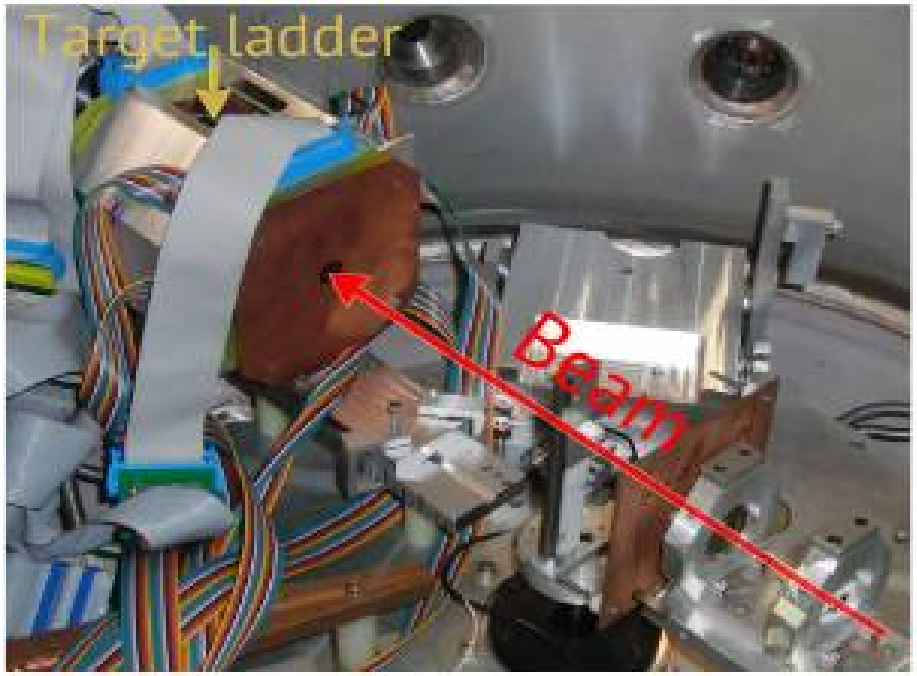
Mechanism:
2p-1h interaction

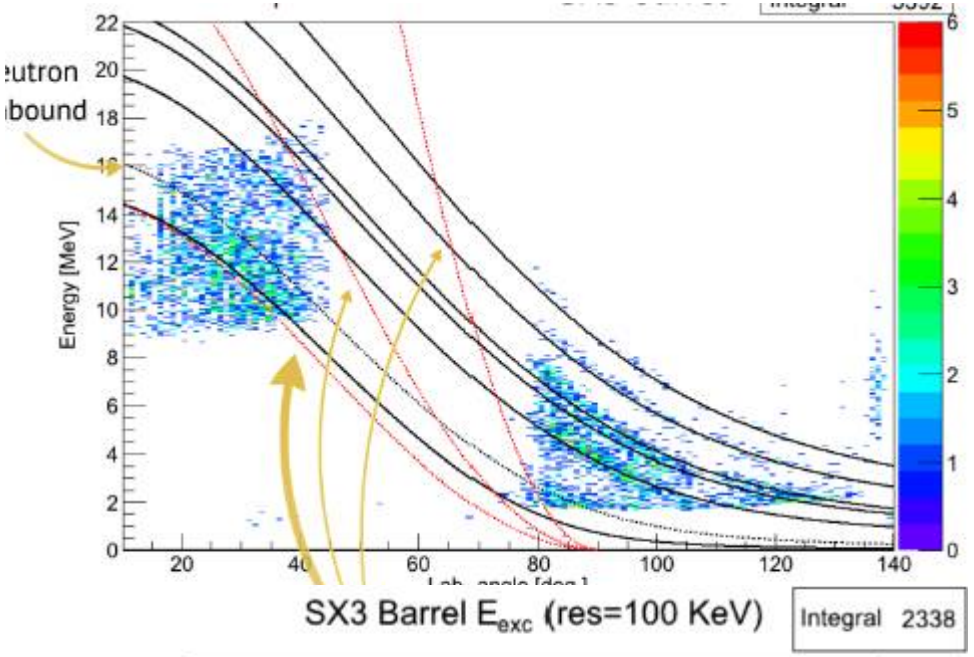


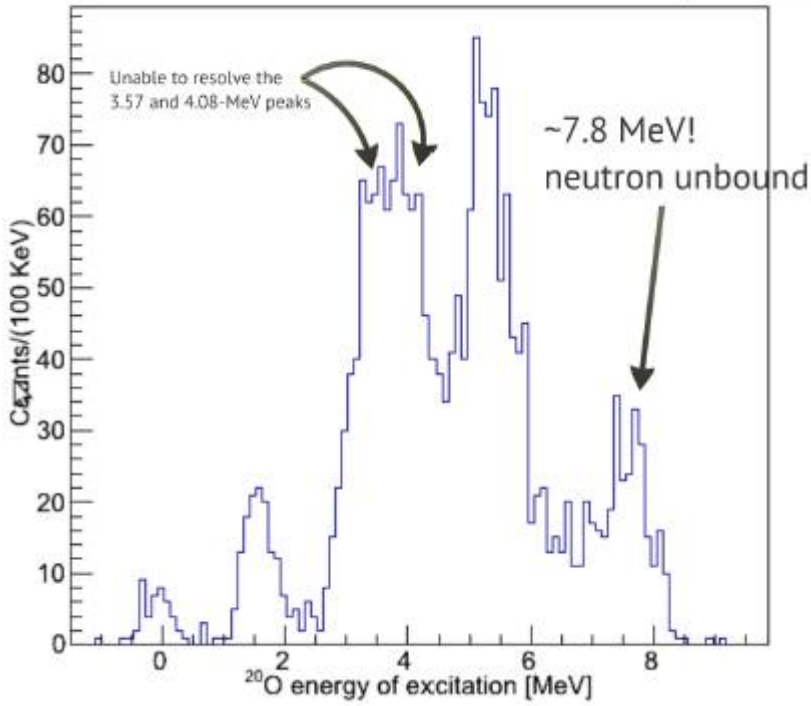


Is there evidence for this mechanism in lighter Oxygen isotopes ?

ANASEN early implementation: $^{19}O(d,p)^{20}O$



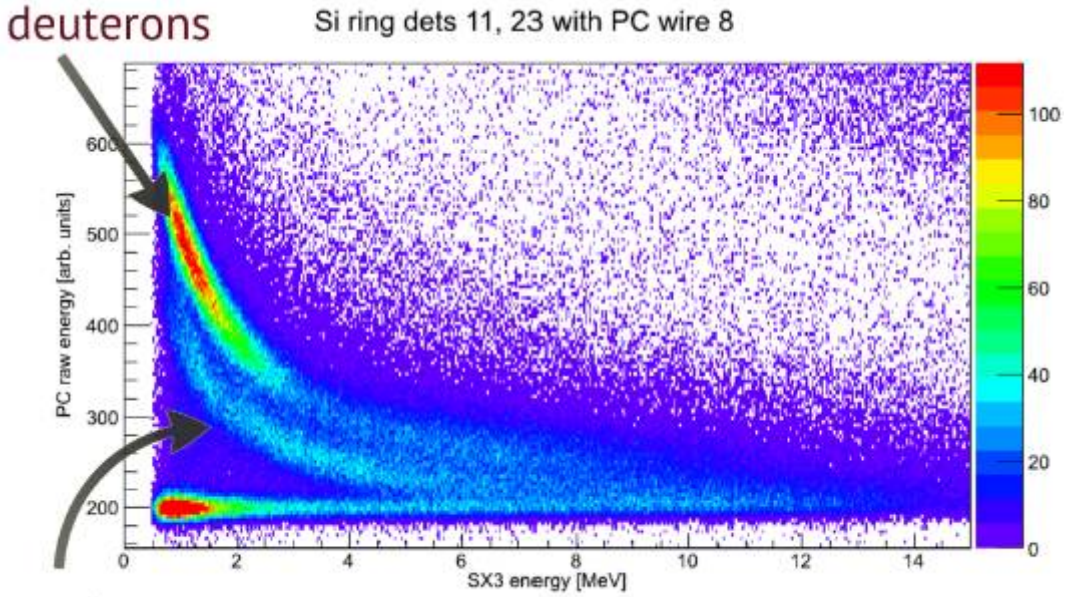


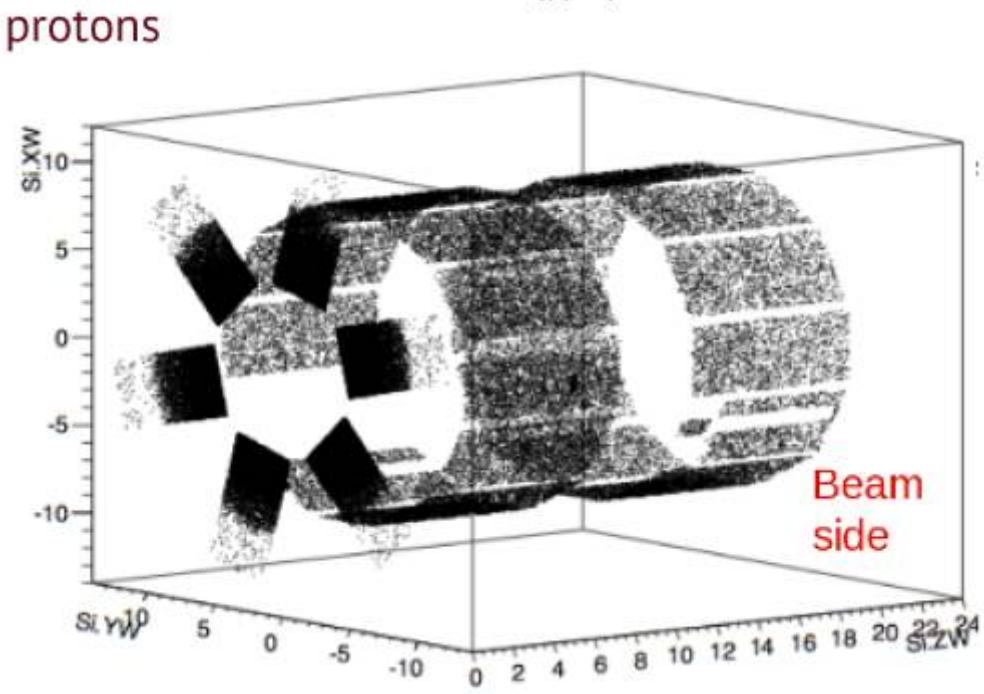


- Compact setup of ANASEN detectors
- CD_2 fixed target
- Found 7.8 MeV $d_{3/2}$ resonant state

D_2 gas in full ANASEN

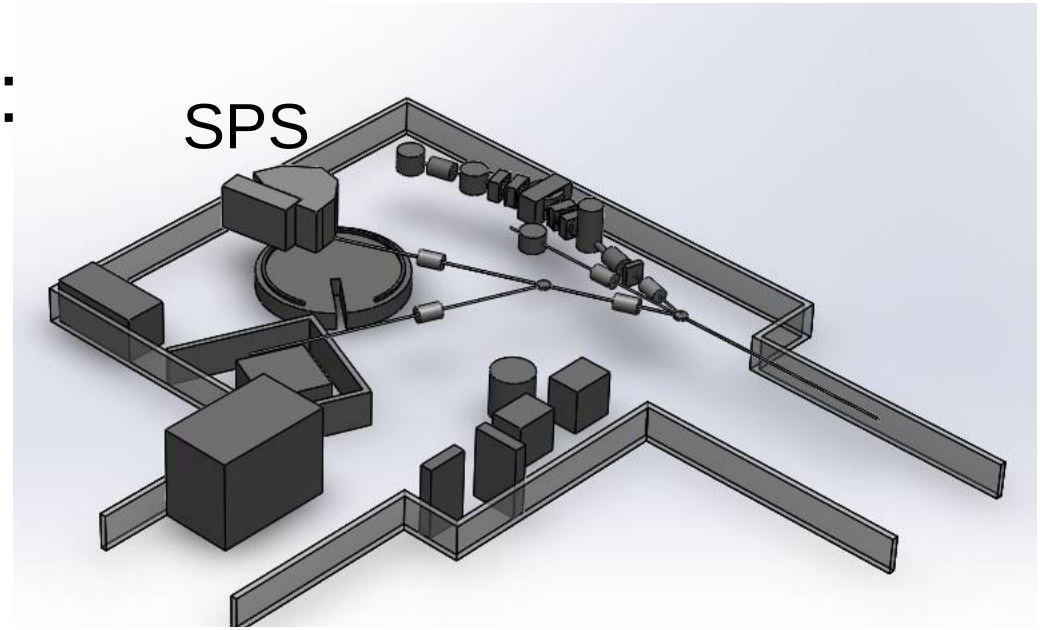
- Active (thick) target : ~2 mg/cm^2 pure D_2
- Proportional counter allows p discrimination
- ~90 degree sensitivity no target ladder
- Experiment finished September 2012
- Analysis in progress: (D. Santiago-Gonzales) Joe Belarge





Split-pole Spectrograph

- (Yale) SPS is at FSU: Installation 2014-2015
- Program in Nuclear Astrophysics (see talk be C. Deibel)
- Physics of open systems: “Hyperradiance”
- Orbital strength in resonances



Nuclear Structure Research at FSU

- Split-pole spectrograph will be new work-horse program, once operational (2016).
- Gamma-array: Spectroscopy of light exotic nuclei and stable beams, ^{14}C, now digitized (XIA)
- Program tightly connected to Atlas / Gammasphere / Gretina
- Investigating future connection to Split-Pole Spectrograph
- ANASEN is being developed into (d,p) exotic beam detector for use at FSU, ReA-10
- Close connection to programs at NSCL / FRIB: orbital structure in exotic nuclei