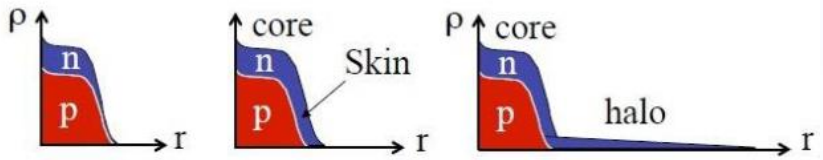
Study of the neutron skin and soft dipole resonance in ^{8}He

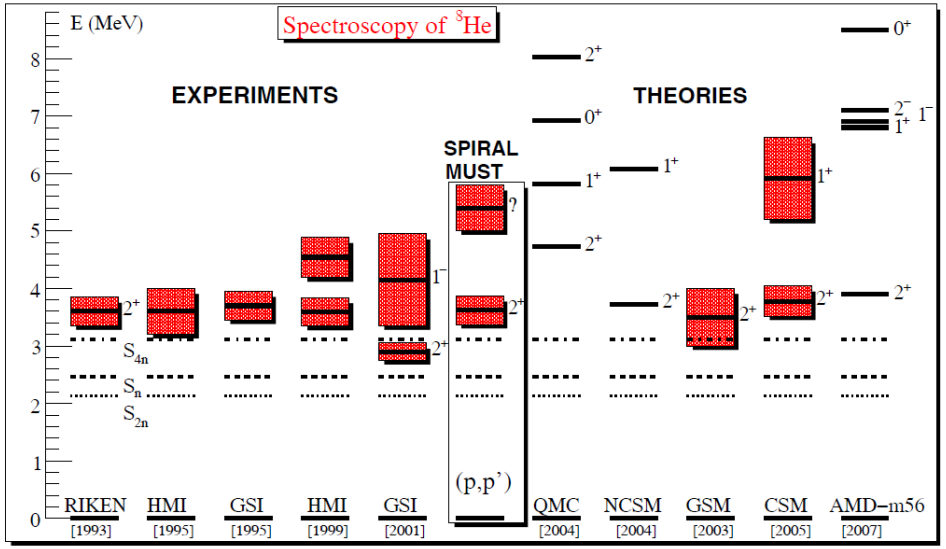
Yassid Ayyad (IGFAE/FRIB), Ben Kay (ANL) and Jie Chen (ANL) and the ISS Collaboration

- ^{8}He has the largest N/Z= 3 of all known bound isotopes.
- ^{8}He has a four neutron-skin structure around a ^{4}He core.
- Larger two-neutron separation energy and smaller radius than ^{6}He: N=6 subshell closure.
- Density distribution consistently determined by elastic scattering and reaction cross section.
- ^{8}He has no bound excited states
- Experimental information from transfer reactions is rather scarce…

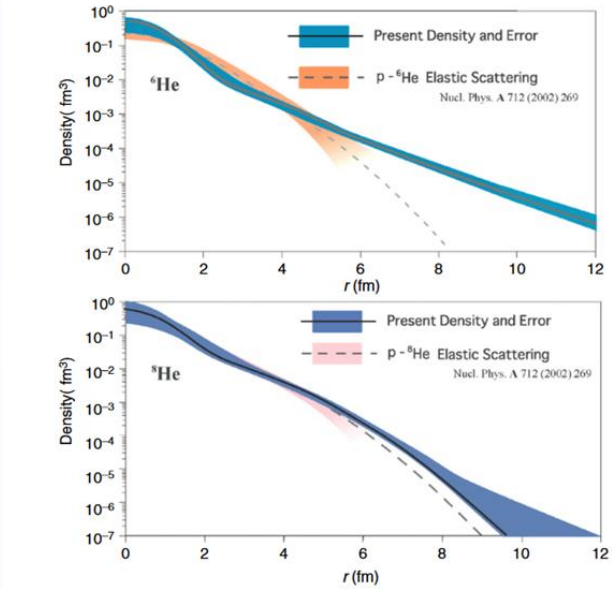
neutron skin thickness

$$\Delta r_{np} = \langle r_n \rangle - \langle r_p \rangle$$



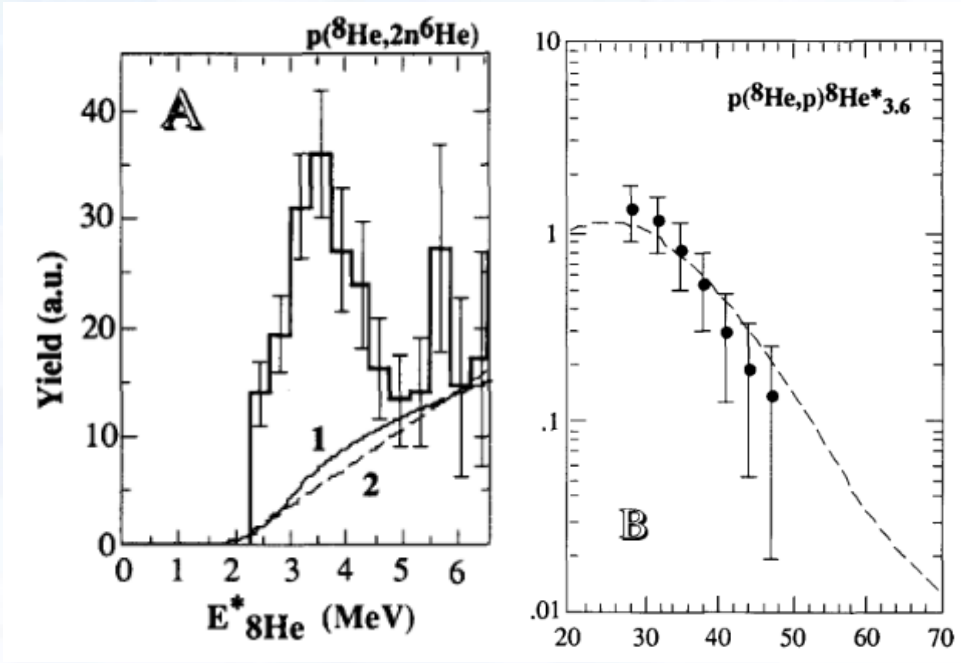


Eur. Phys. J. A (2015) **51**: 91



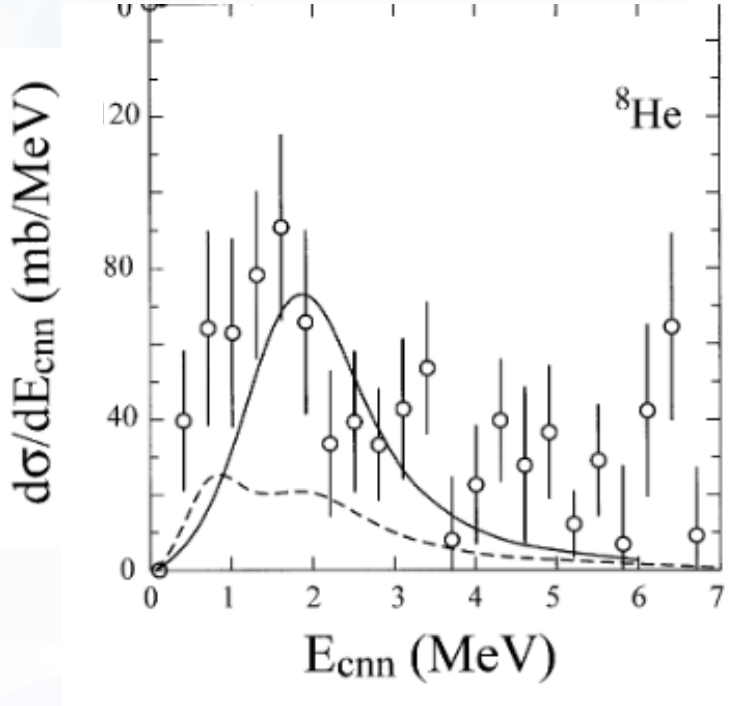
Progress in Particle and Nuclear Physics 68 (2013) 215–313

^{8}He+p 72A MeV
3.6 MeV 2^{+}

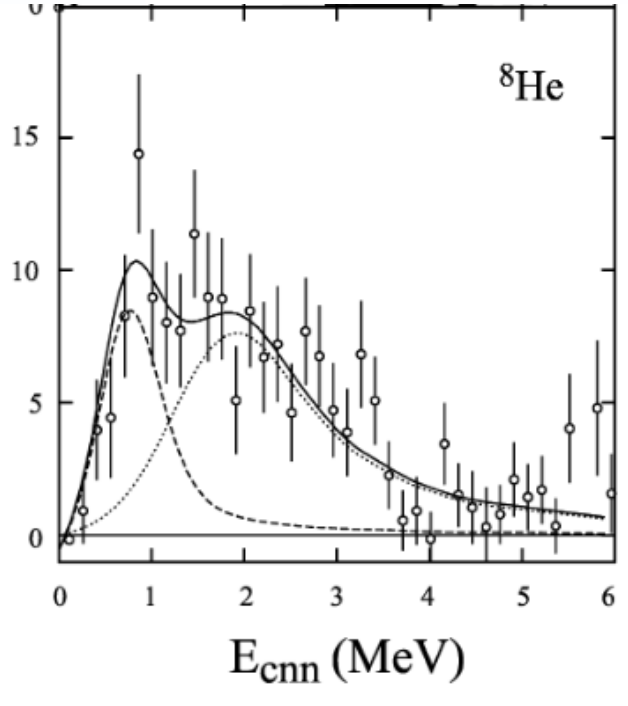


Physics Letters B 316 (1993) 38-44

227A MeV ^{8}He+Pb (Coulomb)
Below 2 MeV 2^{+}, 4.15 MeV 1^{-}



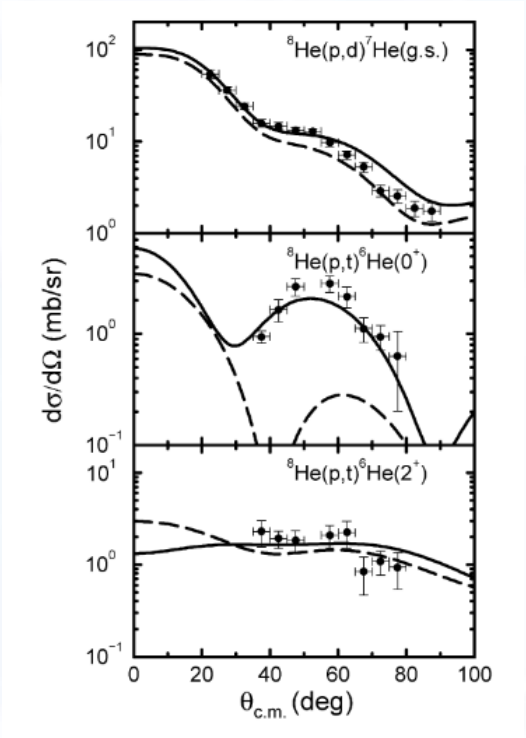
227A MeV ^{8}He+C
2.9 MeV 2^{+}, 4.15 MeV 1^{-}



Nuclear Physics A 679 (2001) 462–480

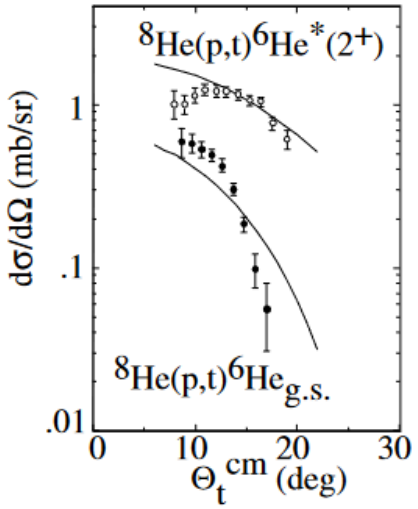
Physics Letters B 646 (2007) 222–226

- **^{8}He(p, t)^{6}He at 15.7A MeV**
- Significant probability of finding the "valence" neutrons in other configurations: as $(1p_{3/2})^2(1p_{1/2})^2$
- ^{8}He(p, t)^{6}He reaction is a rather more sensitive probe of the ^{8}He ground state than the ^{8}He(p, d)^{7}He neutron pickup.
- SF of ^{6}He(0^{+})+2n and 6He(2^{+})+2n 1.0 and 0.014. Very small contribution of the ^{6}He(2^{+}) state in ^{8}He



Phys. Rev. Lett. 90, 082501 (2003)

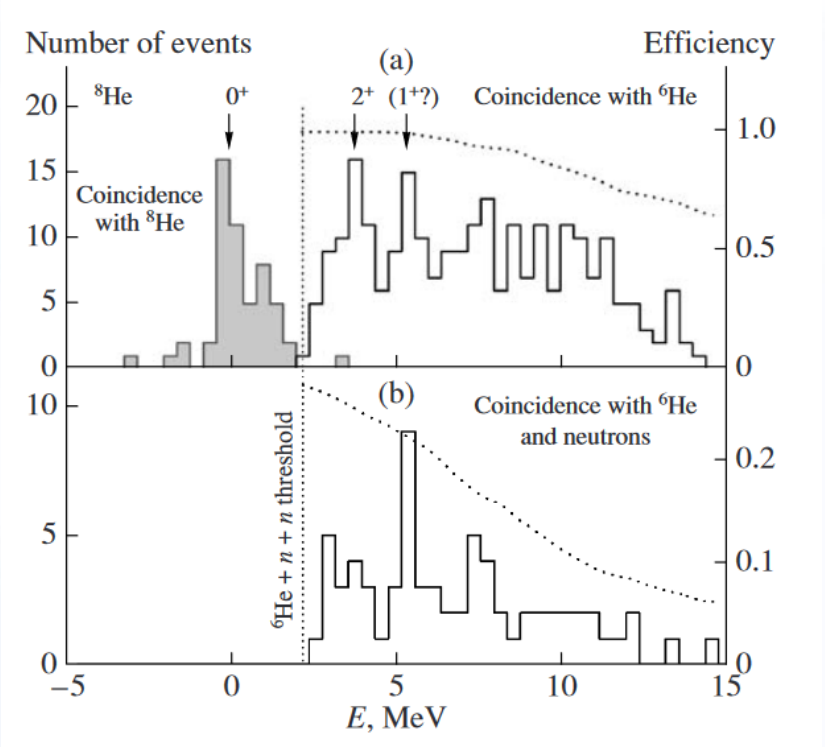
- **^{8}He(p, t)^{6}He at 61.3AMeVA MeV**
- Ground state and the 2^{+} excited state of ^{6}He were populated.
- Cross section for p(^{8}He,t)^{6}He(2^{+}) larger than ^{6}He(0^{+}).
- ^{6}He(2^{+}) configuration dominates in the ^{8}He g.s.

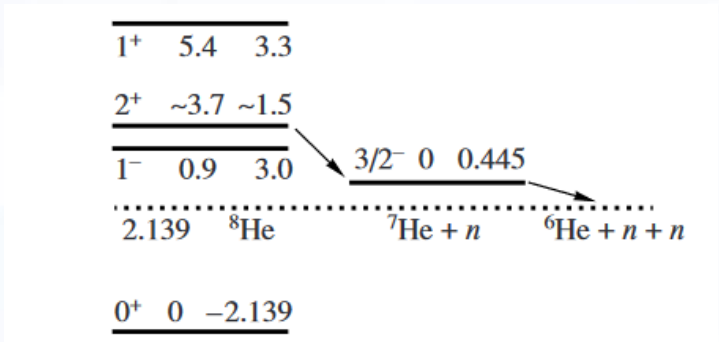


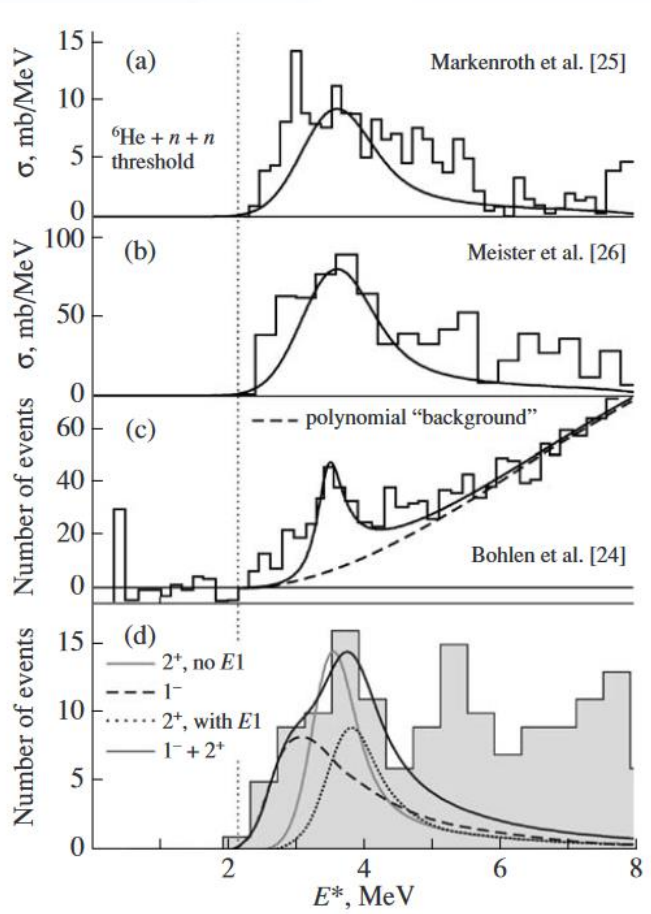
Physics Letters B 672 (2009) 22–29

Physics of Particles and Nuclei Letters, 2009, Vol. 6,. 118

- ^{6}He(t,p)^{8}He at 25A MeV observed clear resonance structures.
- Spectroscopic factor of 0.8–1.1 for the ^{6}He(gs)/^{8}He(gs) overlap.
- ^{6}He(gs) and the ^{6}He(2^{+})state is not strongly dependent in the $(1p_{3/2})^4$ and $(1p_{3/2})^2(1p_{1/2})^2$ mixing.
- Evidence of a near-threshold low-lying dipole mode 1^{-}

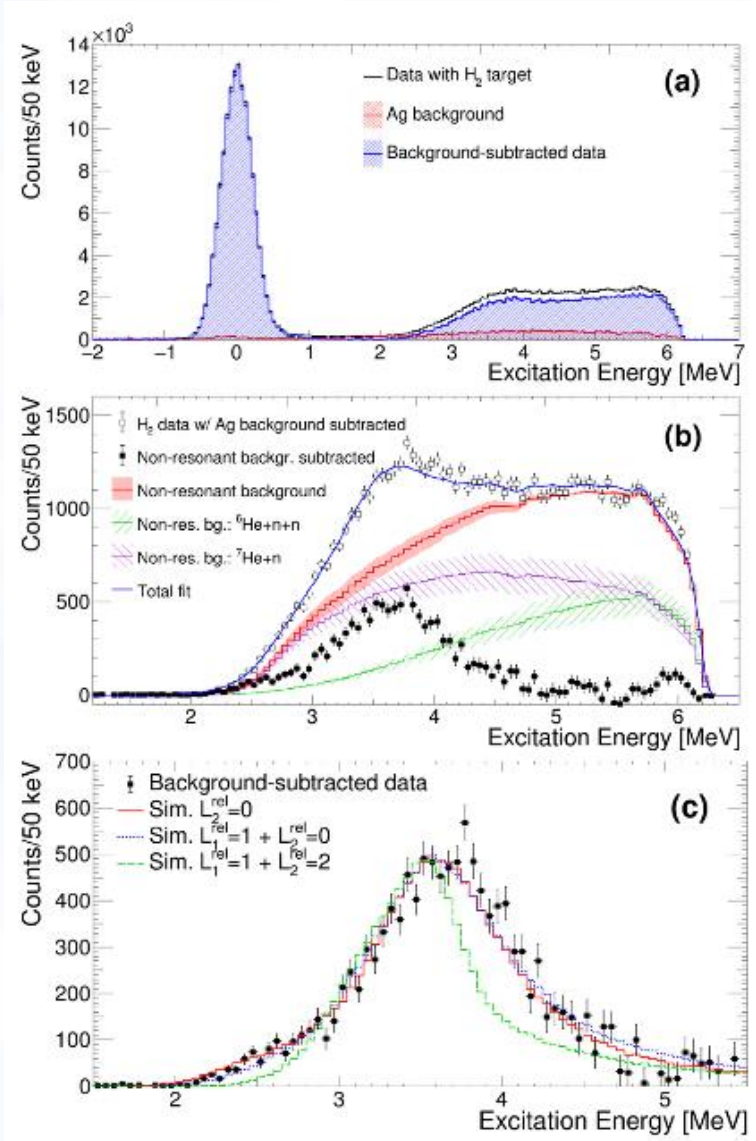


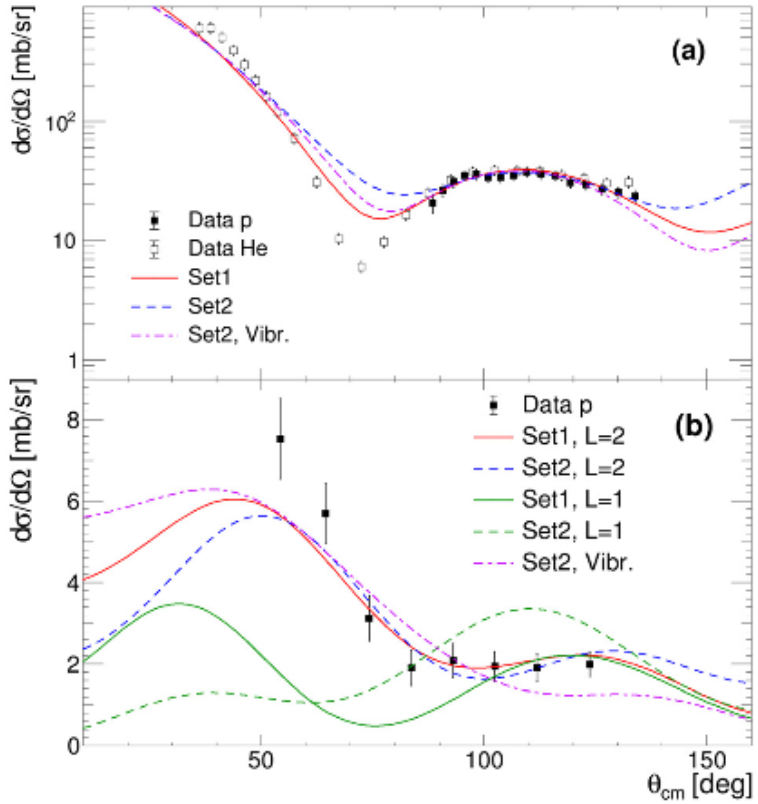




Physics Letters B 822 (2021) 136710

- ^{8}He(p,p') at 8.25A MeV observed a L=2 resonance at 3.54 MeV (0.89 MeV FWHM).
- Microscopic coupled reaction channels with structure inputs from no-core shell model (NCSM).
- Quadrupole deformation parameter of β_2= 0.40(3), large deformation.
- No evidence of a low-energy dipole resonance or any E1 strength.





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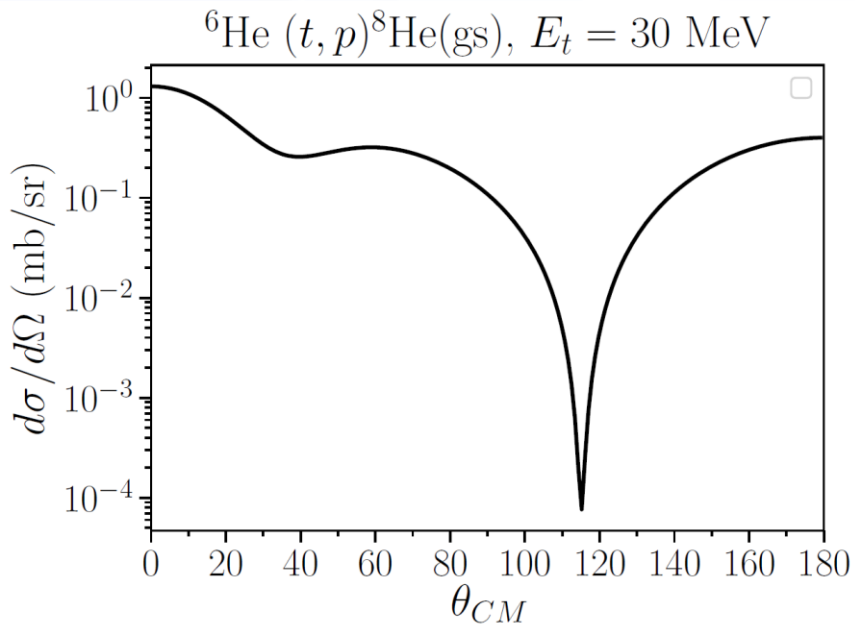
- Particle-particle correlations might be a distinctive feature of dipole resonances where halo neutrons act as a nucleon Copper pair around an inert core.
- Two-neutron transfer is a powerful tool to investigate low-energy dipole modes where pairing plays a key role (Eur. Phys. J. A, 55:243, 2019).
- Absolute differential cross sections: two neutron transfer on second order DWBA (G. Potel, E. Vigezzi, F. Barranco, R. Broglia).
- ^{8}He wave function with $(1p_{3/2})^4$ configuration with 34.9% and of the $(1p_{3/2})^2(p_{1/2})^2$ with 23.7% (Phys. Rev. C 77, 054317 (2008)) and calculated potentials.
- Estimates are consistent with the reported cross sections of Golokov et al (Physics Letters B 672 (2009) 22–29).
- **Objectives of the experiment: Investigate the ^{8}He gs and possible resonance structures with high-resolution. Determine the role of the configuration mixing in the ^{8}He shape configuration. Elucidate the existence of a possible E1 soft-dipole resonance.**



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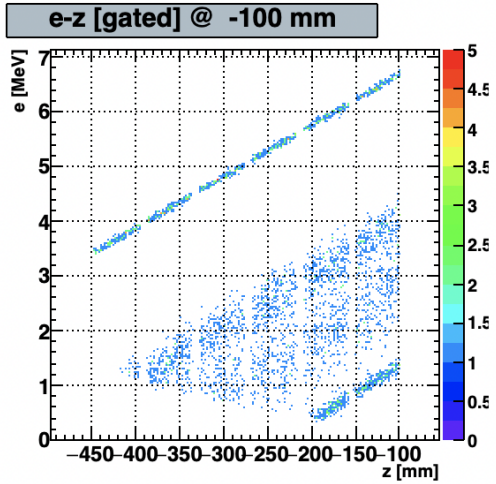
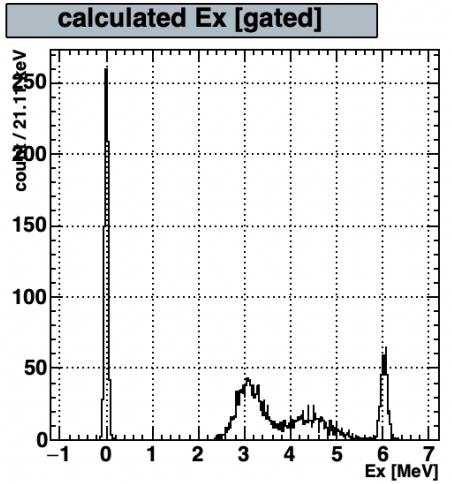
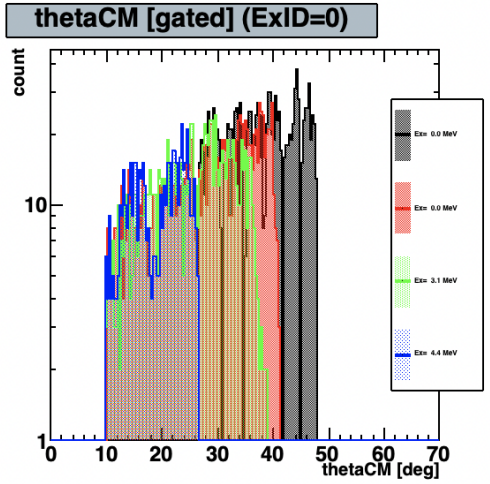
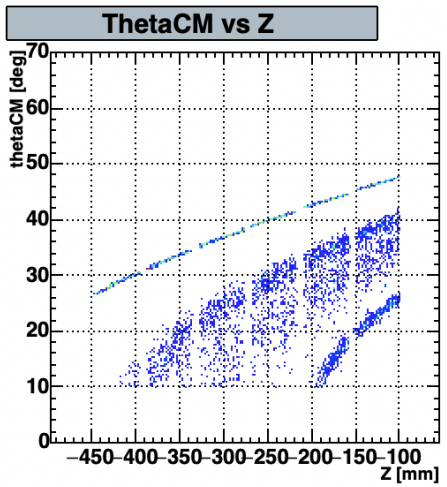
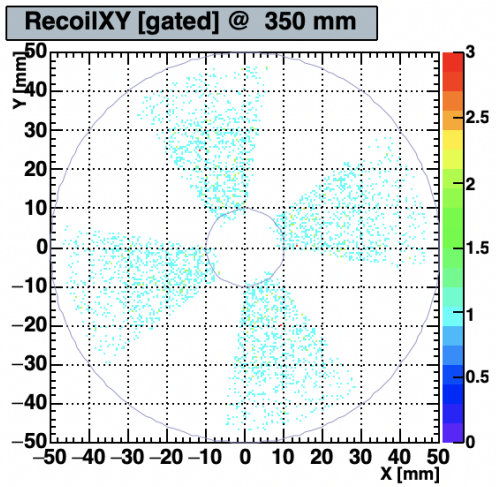
- (t,p) reaction on ^{6}He at 10 MeV/u using the Isolde Solenoidal Spectrometer (ISS).
- Si array placed at 100 mm upstream of the target.
- Recoil detector placed at 350 mm downstream of the target.
- Magnetic field of 2 T.
- Angular coverage 10 – 45 deg CM.
- Titanium tritide target ~45 μg/cm² (450 μg/cm² of titanium). To be used in IS696 (Wimmer, Macchiavelli) and IS695 (Ayyad, Vigezzi).
- Expected resolution of 150 keV (FWHM).












```
6He(t,p)8He @ 10.00 MeV/u

field = -2.00 T, into plan

gate:

hit == 1
& loop <= 1
& thetaCM > 10
& rhoRecoil > 5
```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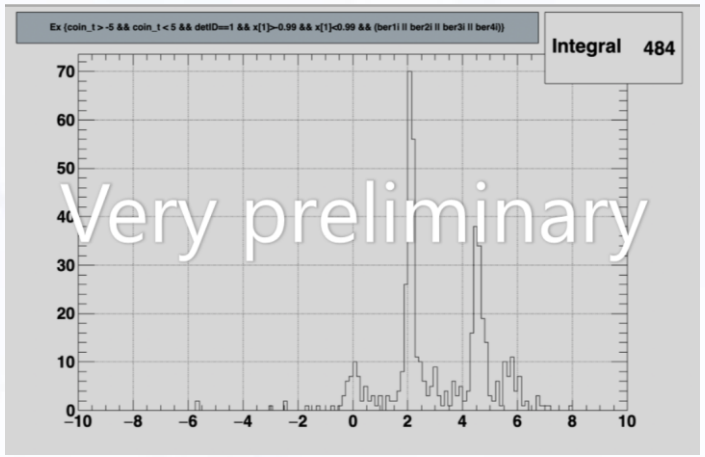

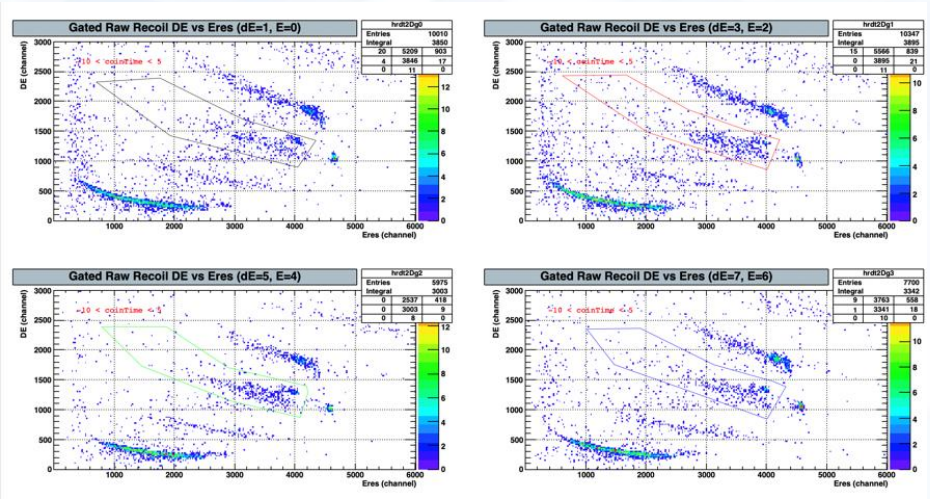

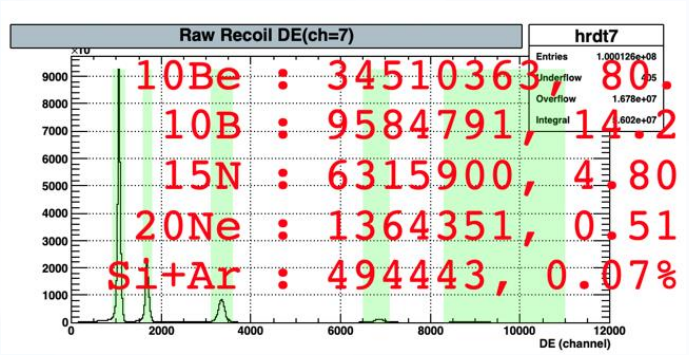

- SOLARIS experiment at ReA6 (FRIB): ^{10}Be(t,p)^{12}Be at 10A MeV.
- Performed with a 10^5 pps beam (10^6 instantaneous rate).
- Titanium tritide target of arounf 20 μg/cm^2
- Clear identification of the ^{12}Be levels with a preliminary resolution better tan 200 keV (FWHM).

Excellent background rejection capabilities.

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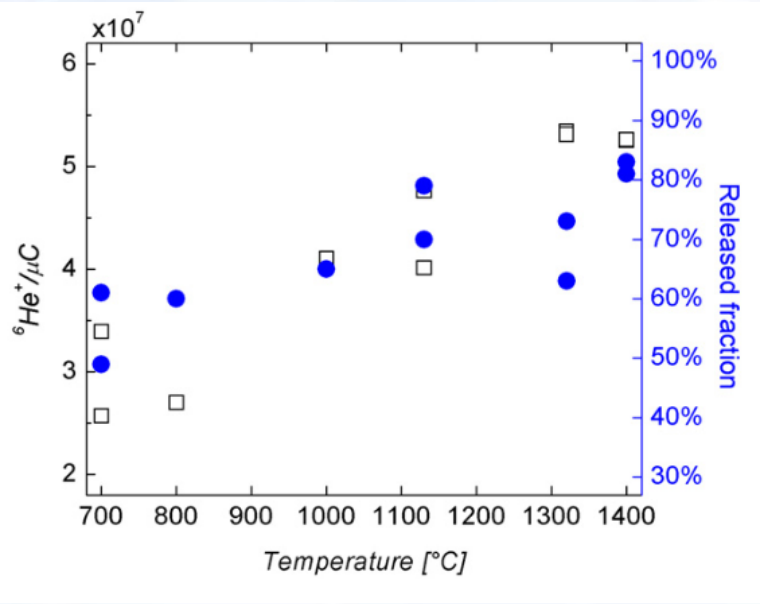
Beam time request



- 21 shifts of beam time to study the (t,p) reaction on ^{6}He at 10 MeV/u.
- 3 shift of stable ^{4}He.
- Beam intensity of around 10^{6} pps, based on previous experimental data (4.70×10^{7} Yield/μC).
- INTC TAC Comments: The TAC has identified one serious issue with this proposal. The transmission through the machine appears to be quite significantly over-estimated if previous experience can be used as a guide. The shift evaluation needs to be re-considered for an estimation of 0.1-0.03% rather than 5%. If approved, this experiment would benefit from development time to optimise the transmission of such beams to HIE ISOLDE. Possible hot spots along the machine could also complicate scheduling.

Thank you!

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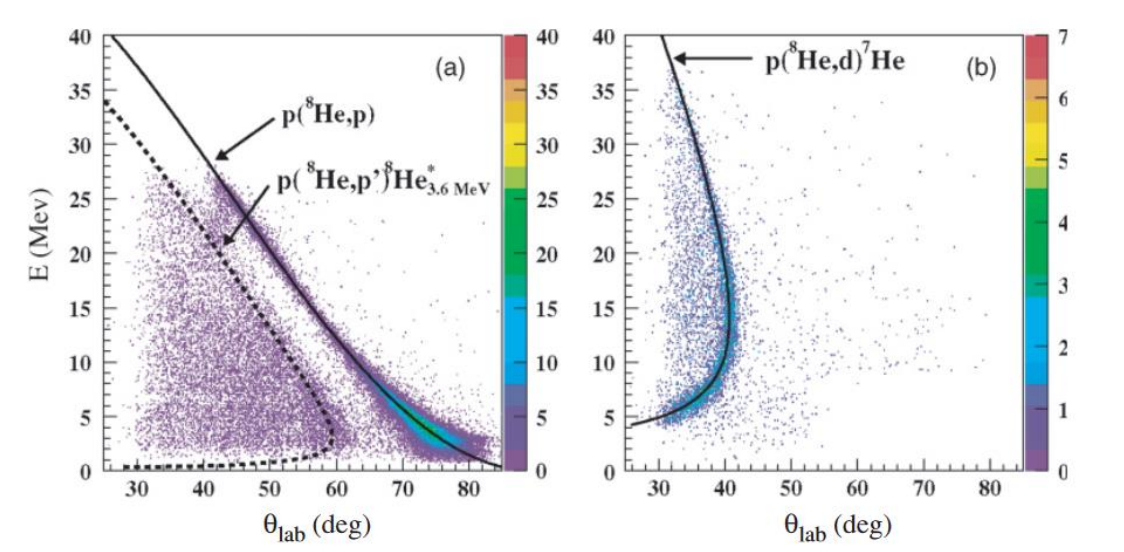

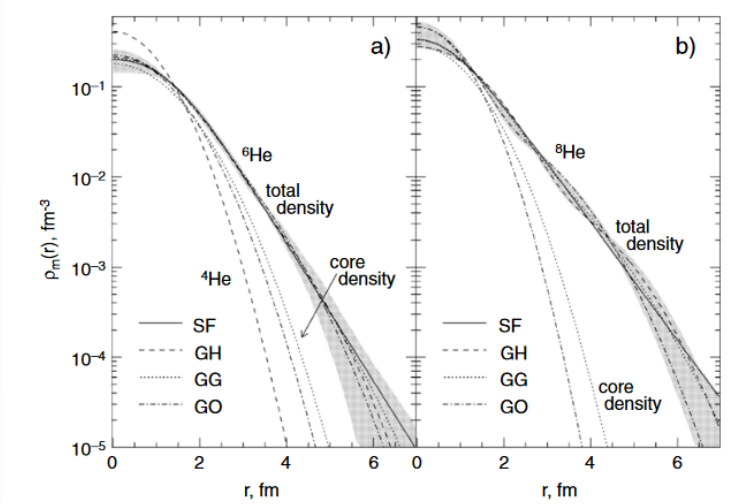

Phys. Rev. C 73 (2006) 044301

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