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Study of the scattering of ^{15}C at energies around the Coulomb barrier

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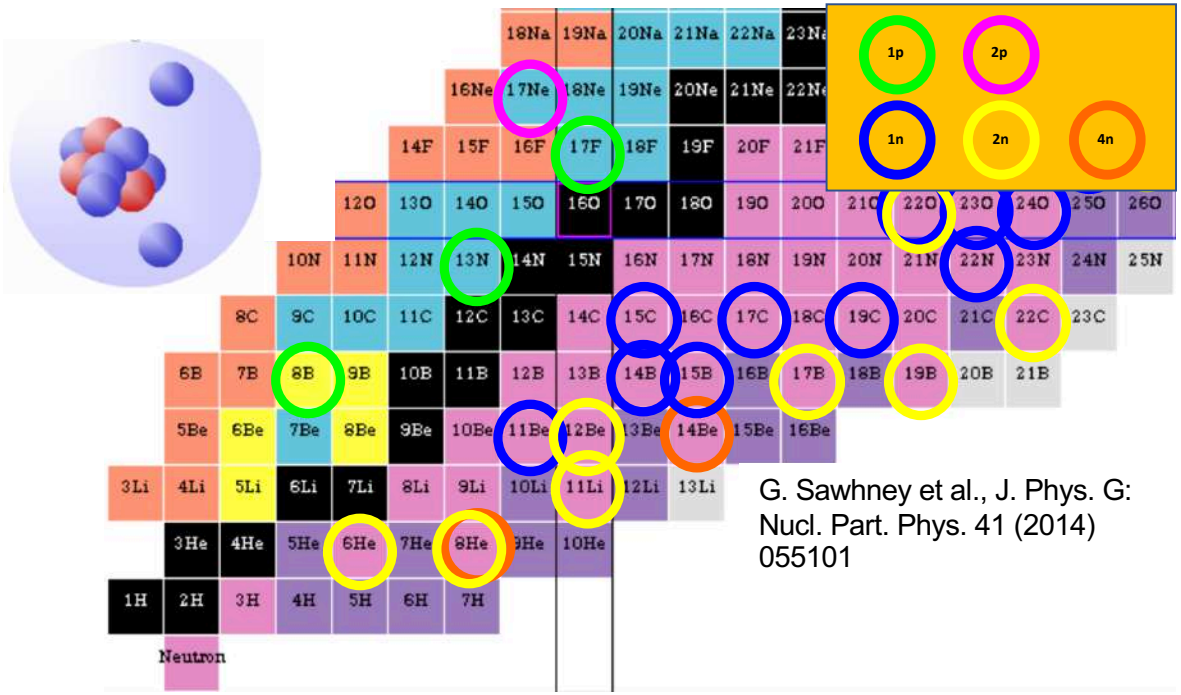
Halo nuclei

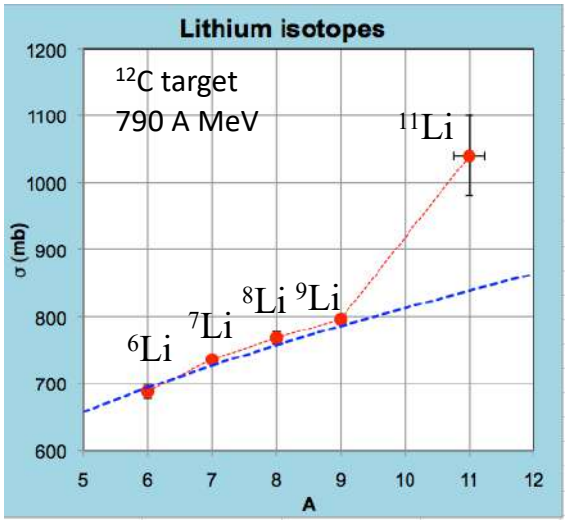
Formed by a core and weakly bound valence nucleons:

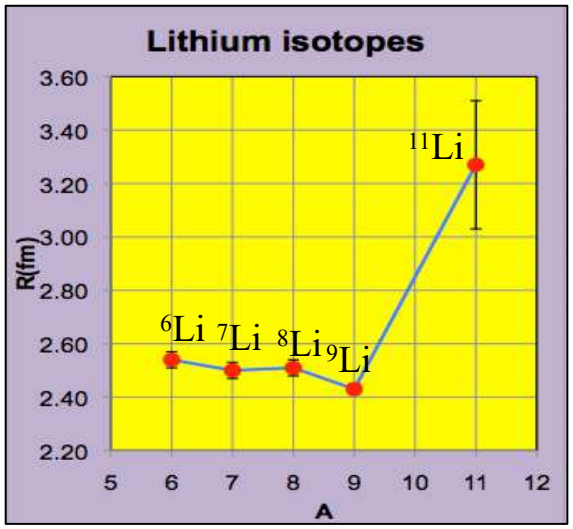
- Extended mass distribution
- Large rms matter radius ~ “halo”
- Large reaction cross sections
- Narrow momentum distributions following fast fragmentation
- Concentration of B(E1) close to BU threshold



G. Sawhney et al., J. Phys. G: Nucl. Part. Phys. 41 (2014) 055101

I. Tanihata et al., Phys. Rev. Lett. 55, 2676 (1985).





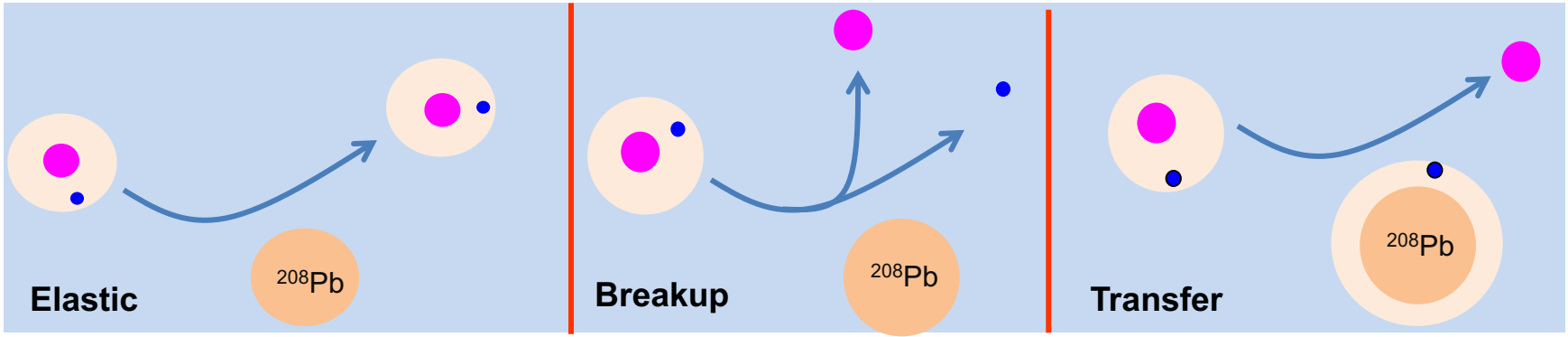
Neutron haloes

Provide an ideal test bench to study few-body correlations by measuring elastic, neutron transfer and breakup.

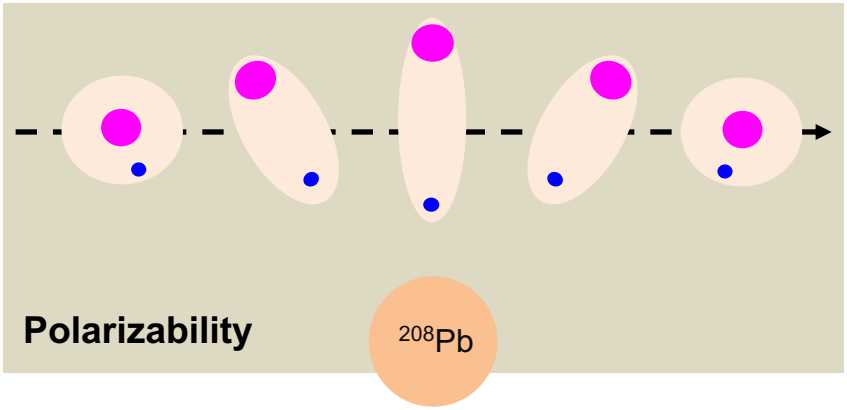
Coulomb barrier scattering of halo nuclei

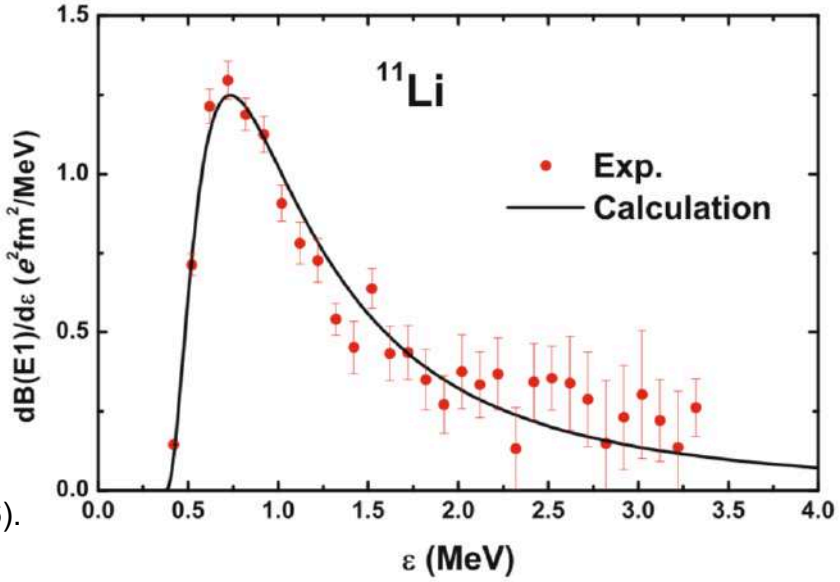
- Coupling between relative motion and internal degrees of freedom

  elastic – inelastic – transfer – breakup – fusion + effects of the continuum
- Strong absorption in elastic channel
- Large cross section for fragmentation



- They are easily polarizable: distortion of structure in the vicinity of target → Coulomb dip. polarizability



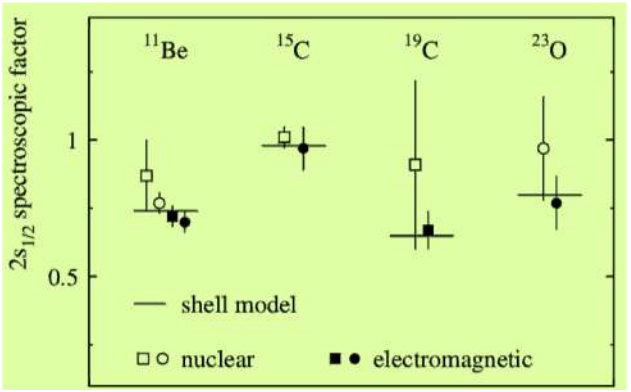


T. Nakamura et al., Phys. Rev. Lett. 96, 252502 (2006).
T. H. Kim et al., Jour. Kor. Phys. Soc. 73 (2018) 553.

What makes 15C (τ =2.45s) interesting?

- Weakly bound: S_{1n}=1.2 MeV and S_{2n}= 9.4 MeV.
- Narrow momentum distributions of breakup ($^{14}C + n$).
- Large interaction cross sections and radius.
- First excited state (E= 740 keV).
- Ground state characterized by $2s_{1/2}$ single-particle configuration.

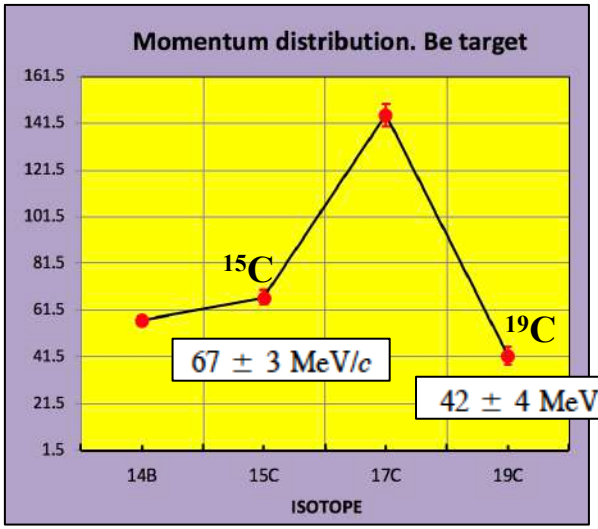
15C			
E(level)	Jπ	$T_{1/2}$	Decay Modes
0.0	1/2+	2.449 s *5*	β⁻ : 100.00 %

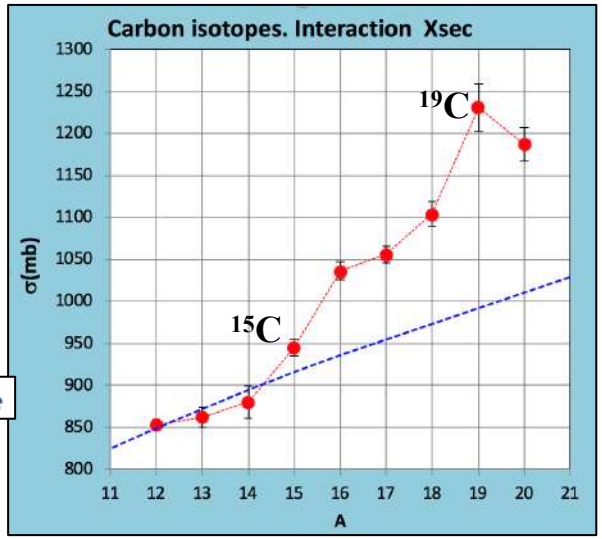


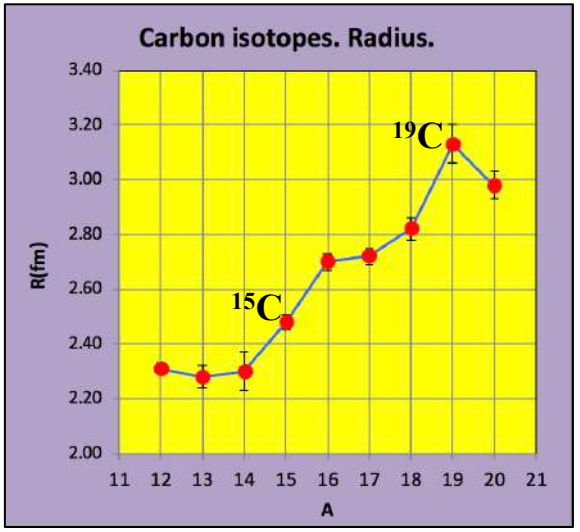
T. Aumann, Eur. Phys. J. A 26, 441 (2005).

→ **Candidate for a very extended 1n nuclear halo**

→ **First case of a pure $s_{1/2}$ halo**







D. Bazin et al. PRC 57(1998) 2156

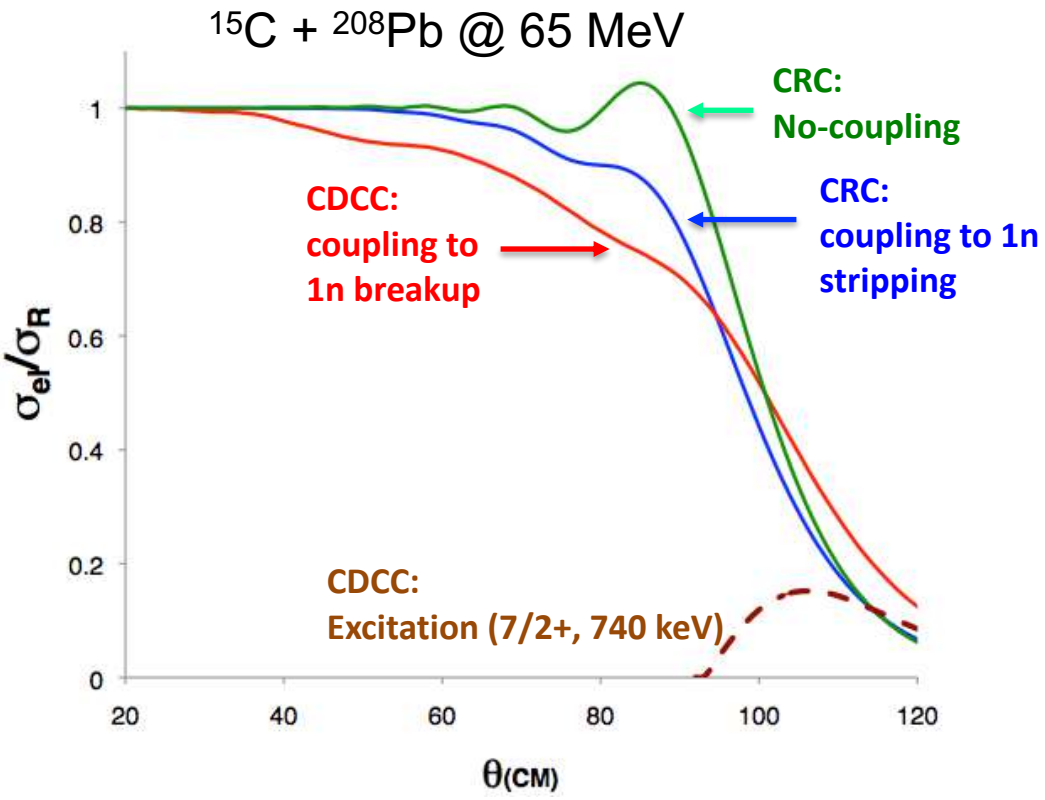
A. Ozawa et al. Nuclear Physics A 691 (2001) 599–617

Coulomb barrier scattering of ^{15}C + ^{208}Pb

Theoretical studies for the system ^{15}C+^{208}Pb at Coulomb barrier ~ E= 65 MeV.

- 1n-stripping channel: Coupled Reaction Channel calculations (CRC).
- 1n-breakup: Continuum Discretized Coupled Channel Calculations (CDCC).
- Inelastic (7/2+, 740 keV): CDCC.

N. Keeley et al., Phys. Rev. C 75 (2007) 054610
N. Keeley et al., Eur. Phys. J. A 50 (2014) 145.



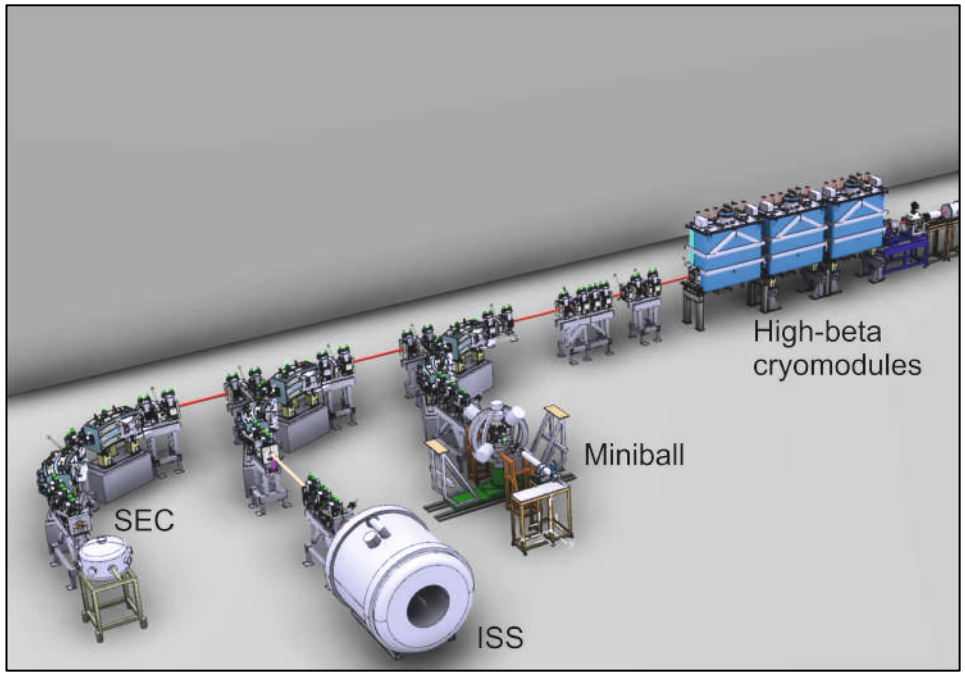
Scattering dominated by the competition of one-neutron stripping and breakup.

CRC/ 1n stripping		CDCC/ direct breakup	
Total reaction (mb)	927	Total reaction (mb)	1379
1-n stripping (mb)	265	Breakup (mb)	462
		Excitation(5/2+,740keV) (mb)	45

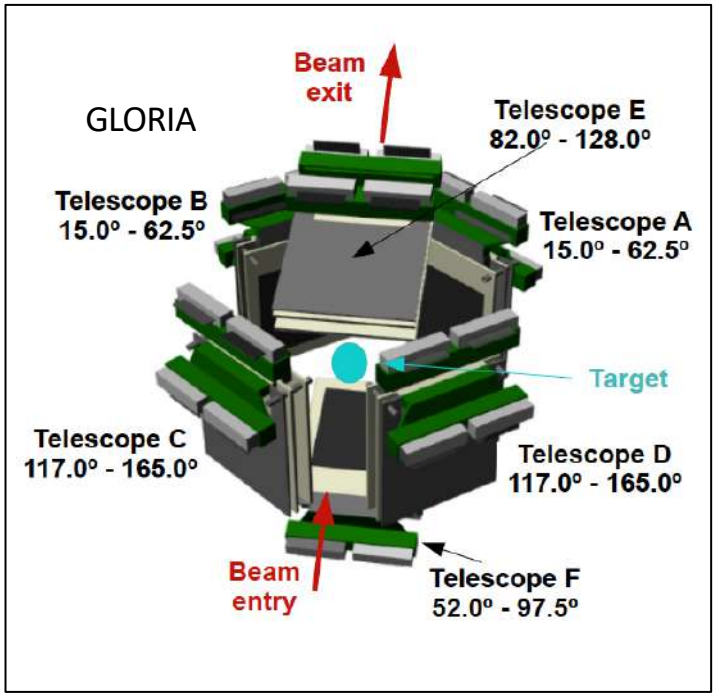
Coulomb barrier scattering of ^{15}C + ^{208}Pb

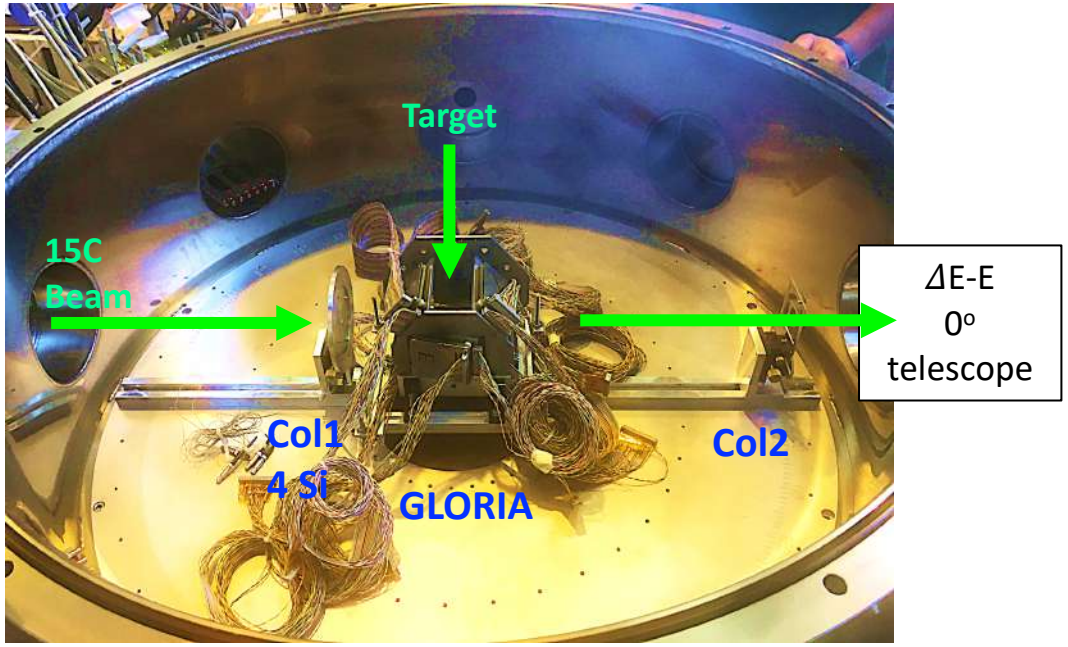
Experiment IS699 at HIE-ISOLDE (CERN) Spokespersons : I. Martel & O. Tengblad

- ^{15}C at E= 65 MeV
- 2 x 10^3 pps at the reaction target
- Cocktail beam of ^{15}N + ^{15}C
  - ✓ ^{15}N tightly bound and E << Coulomb barrier → no reactions expected → use for monitoring and normalisation



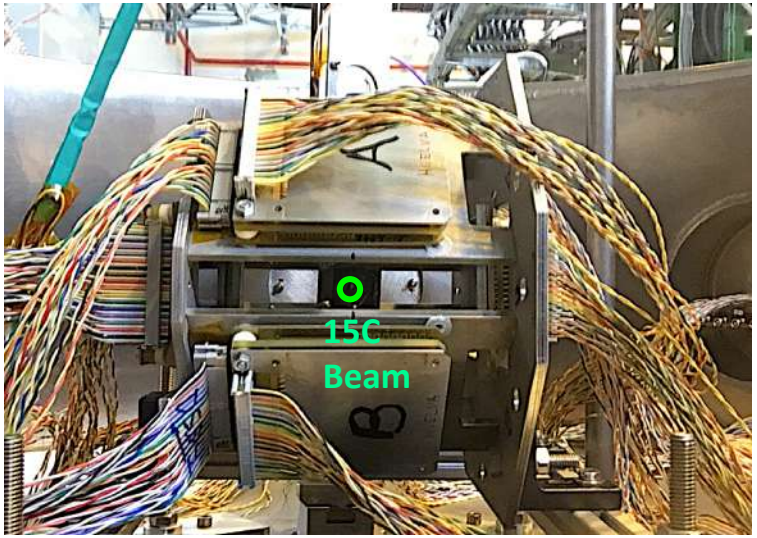
GLORIA detector array





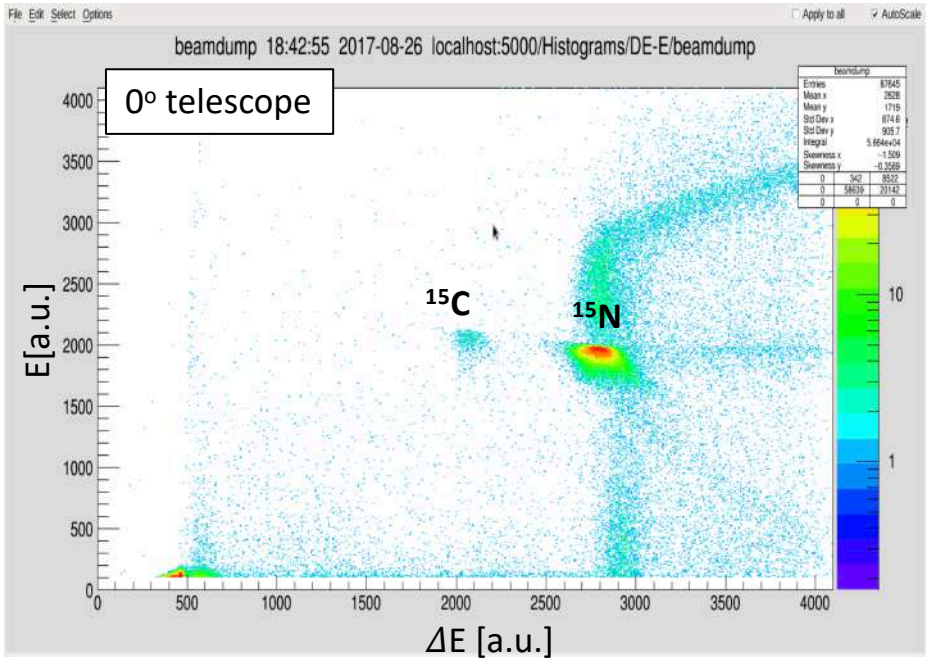
- 6 DSSSD particle telescopes (40mm, 1mm).
- Total solid angle 26 %.
- Tilted target ~ 30°
  → Full angular distribution 15°-165° Lab.
- E_{res} ~30 keV.

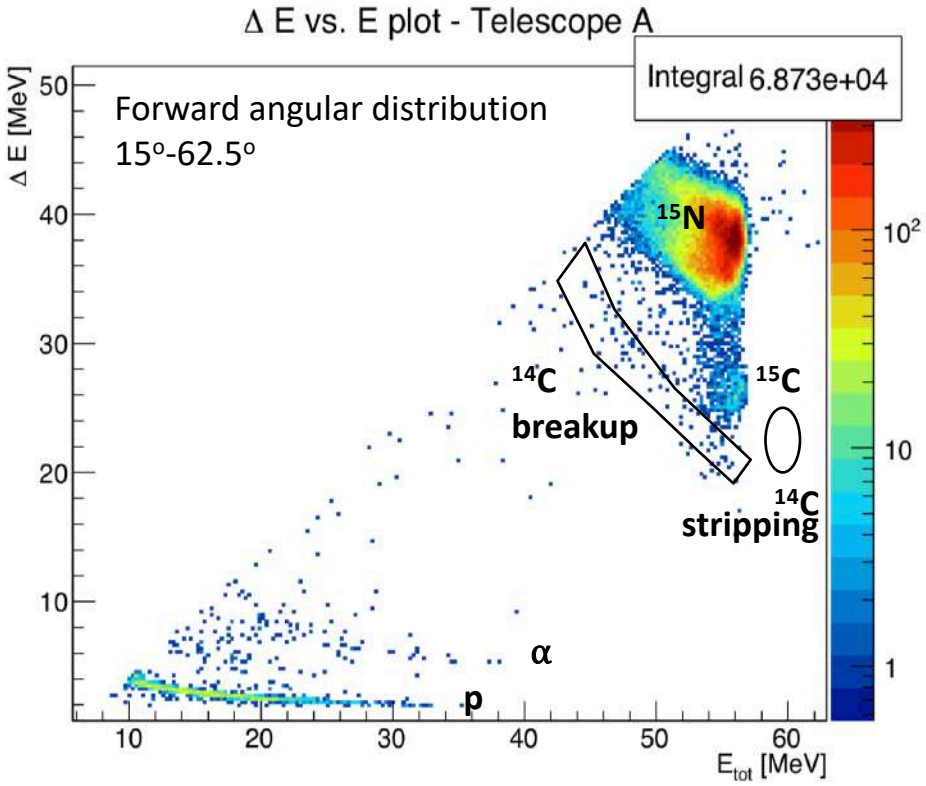
G. Marquínez-Durán, Nucl. Inst. Meth. A755 (2014)69.



PRELIMINARY RESULTS

- Reaction target ^{208}Pb, 1.5 and 2.1 mg/cm^2.
- Monitoring using ^{15}C/^{15}N ratio at 0^o telescope (~ 3%).
- Average ^{15}C beam intensity ~ 2 x 10^3 pps on target.





SUMMARY AND CONCLUSIONS

- Study the dynamics of ^{15}C at energies around the Coulomb barrier at HIE-ISOLDE (CERN).
- GLORIA detector system and the SEC reaction chamber.
- Measured the angular distribution of ^{15}C (elastic/quasielastic scattering).
- Preliminary results:
  - ✓ Strong absorption in the elastic channel
  - ✓ Large reaction cross sections
  - ✓ Dynamics seems to be dominated by the breakup channel
- Data analysis in progress

PhD students

- ✓ Javier Díaz Ovejas (Supervisor: O. Tengblad, CSIC- Madrid, Spain)
- ✓ Alexander Knyazev (Supervisor: J. Cederkäll, Lund University, Sweden)

IS699 Collaboration

CERN – Huelva (Spain) – Madrid (Spain) – Warsaw (Poland) – Belfast (UK) – Leuven (Belgium) – Catania (Italy) –Zagreb (Croatia) – Ioannina (Greece) – Mexico (Mexico) – Cracow (Poland) – Aarhus (Denmark)

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THANKS !