



R³B



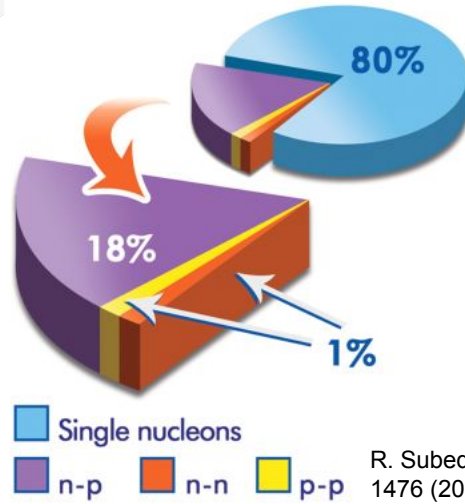
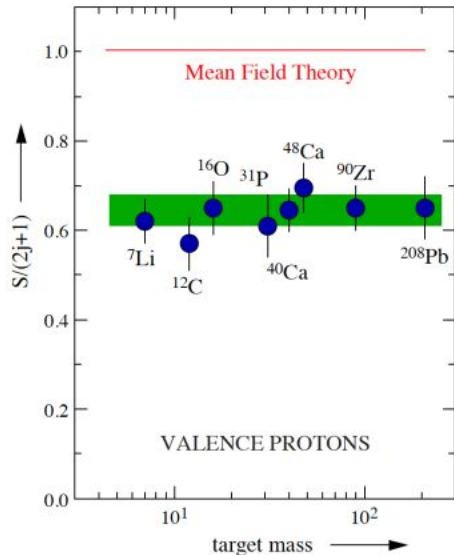
Probing Short Range Correlations via (p,pd) Quasi-Free Scattering reactions

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STFC Summer School 2024

Short Range Correlations

- The independent particle model does not account for all interactions between the nucleons.
- Observed experimentally through the reduction in spectroscopic factors

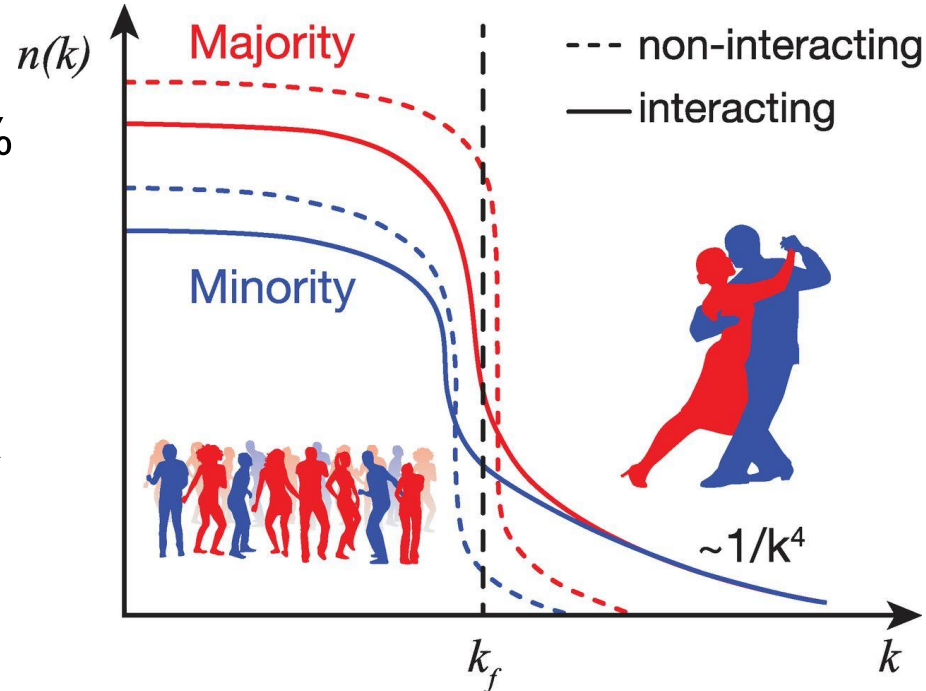


Attributed to **Short Range Correlations (SRCs)**, dominated by neutron-proton interactions.

R. Subedi et al., *Science* **320**, 1476 (2008).

Short Range Correlations

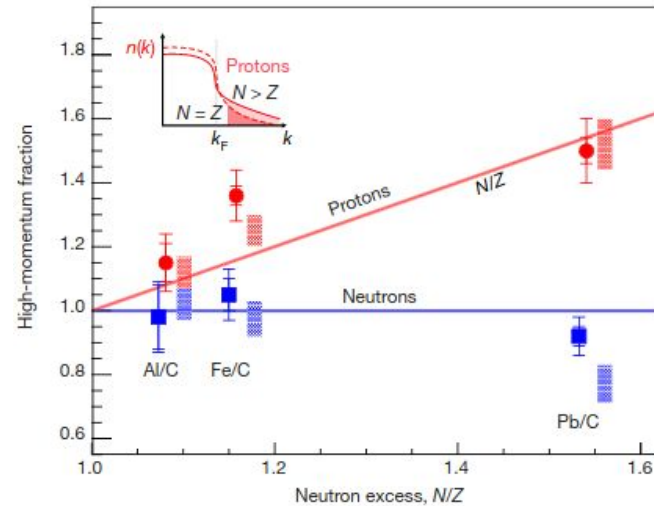
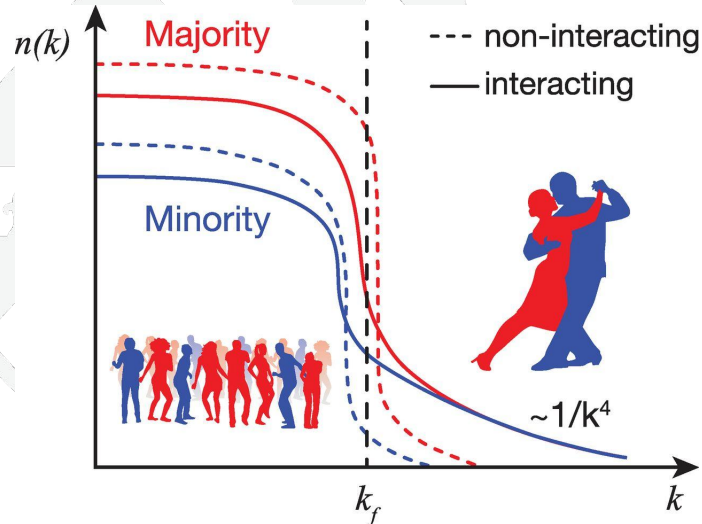
- Short range correlations deplete 30-40% of single particle states.
- These nucleons instead populate a high momentum tail, well above the Fermi momentum.
- Dominated by neutron-proton pairs, or a “quasi-deuteron”.



O. Hen et al., Science **346**, 614 (2014).

Isospin dependence on SRCs

- For $k < k_F$ the number of majority fermions should be greater than the minority.
Intuitive: neutron rich should have more neutrons.
- For $k > k_F$ each majority fermion has a minority pair - number of high momentum protons and neutrons are the same.
- This means a greater fraction of high momentum minority fermions in more neutron or proton rich nuclei.
- Observed at JLAB with $(e,e'p)$ and $(e,e'n)$ scattering experiments.

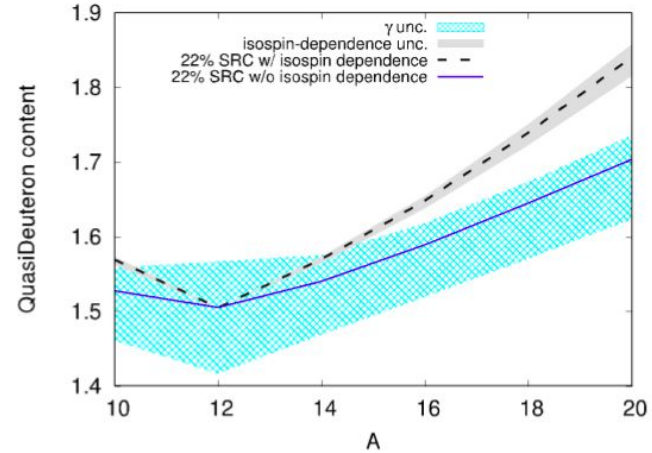
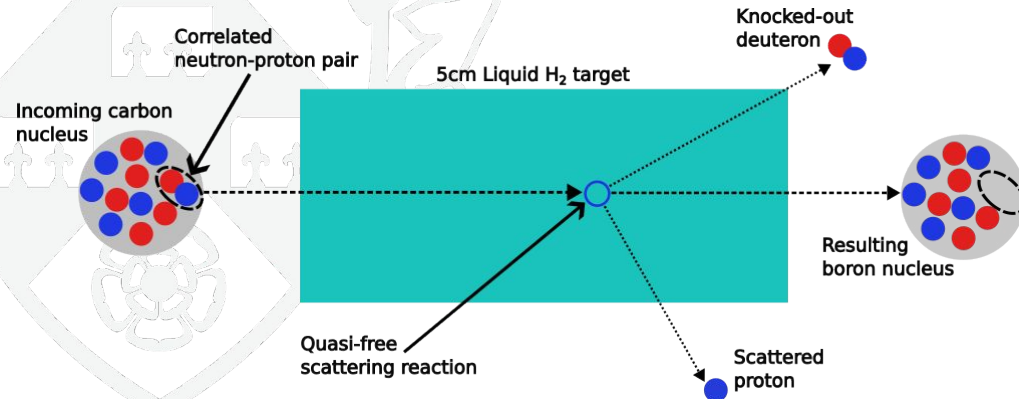


M. Duer et al., Nature
560, 617 (2018).

Probing Short Range correlations via (p,pd) Quasi Free Scattering reactions

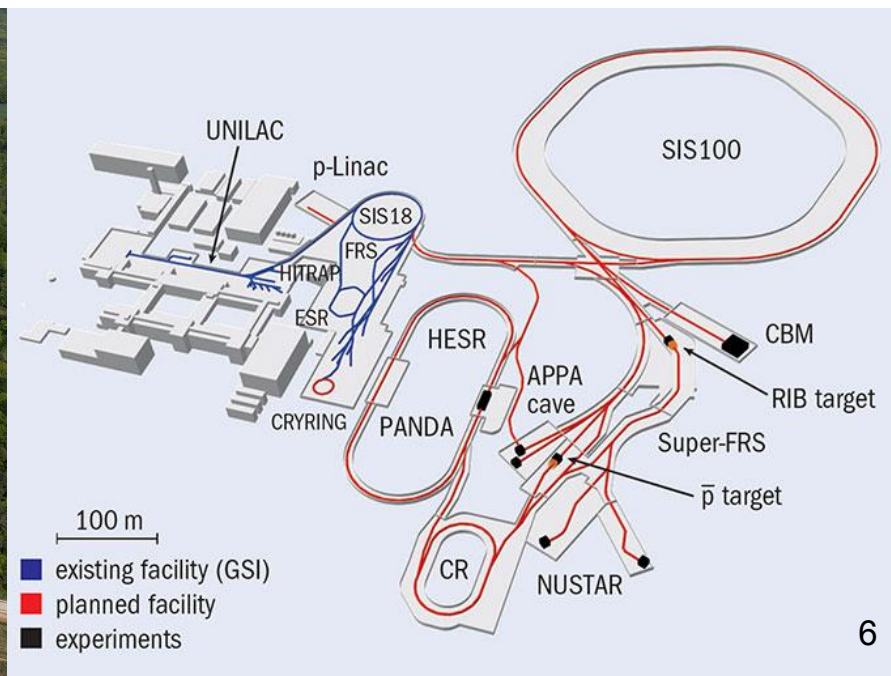
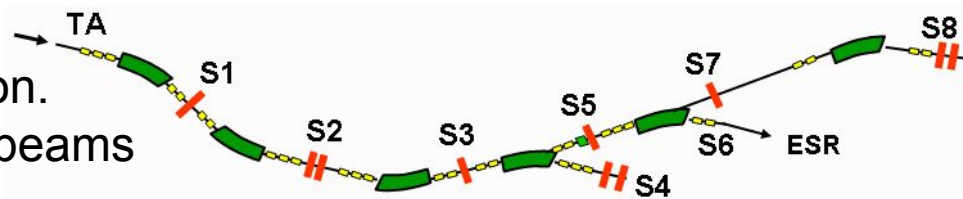
Aims

- Investigate the SRC dependence on isospin.
- Measure (p,pd) Quasi-Free Scattering cross sections of $^{10,14,16}\text{C}$ relative to ^{12}C at 400MeV/u.

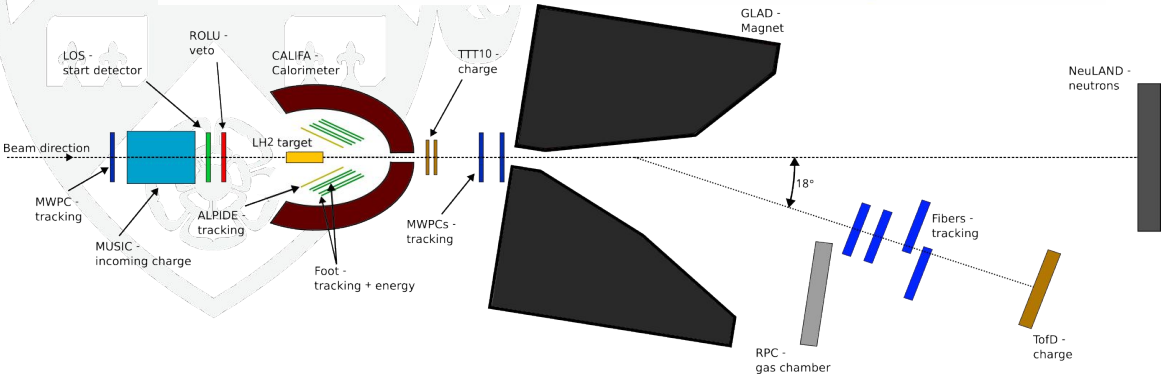
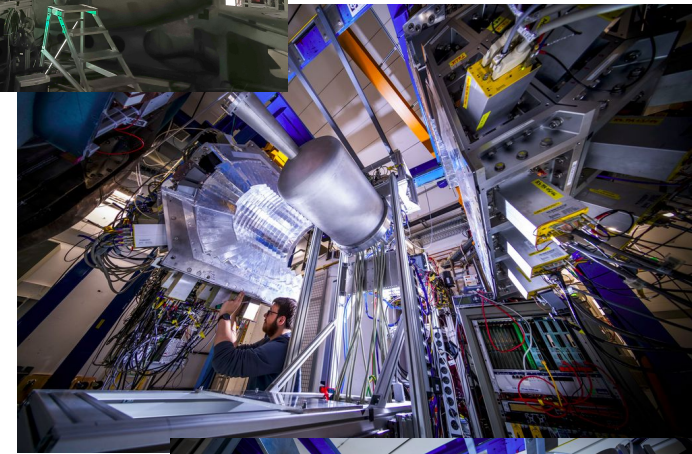
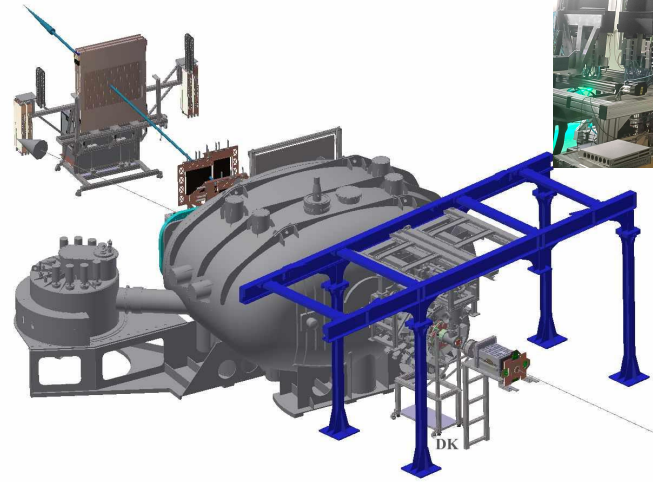
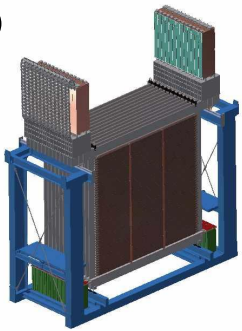


Where do we do this?

R3B Setup at GSI-FAIR for complete kinematical reconstruction of nuclear reaction.
Fragment Separator (FRS) provides exotic beams to R3B

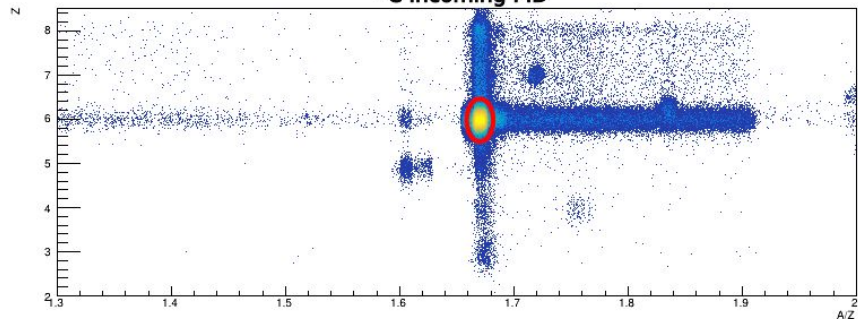


Setup

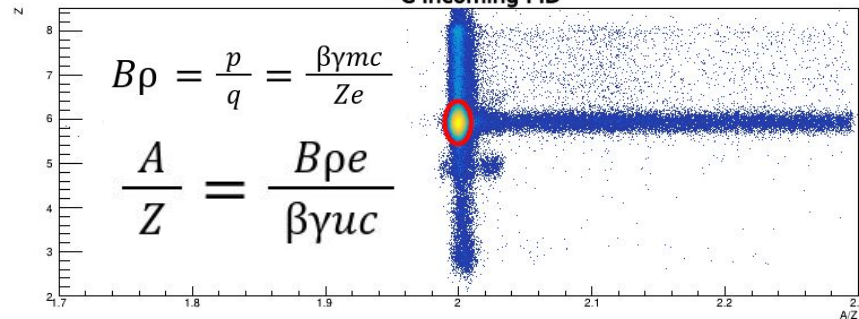


Incoming PID

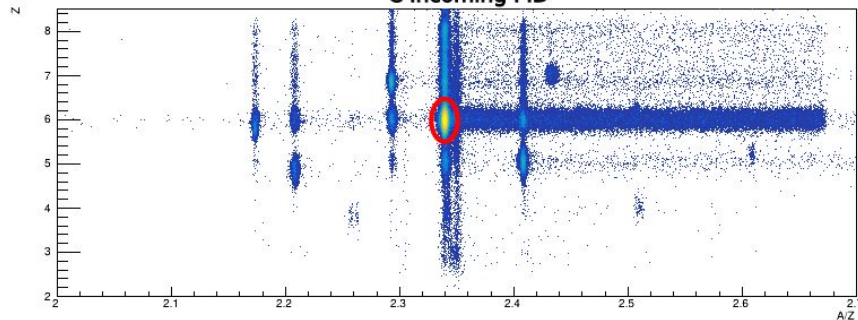
¹⁰C Incoming PID



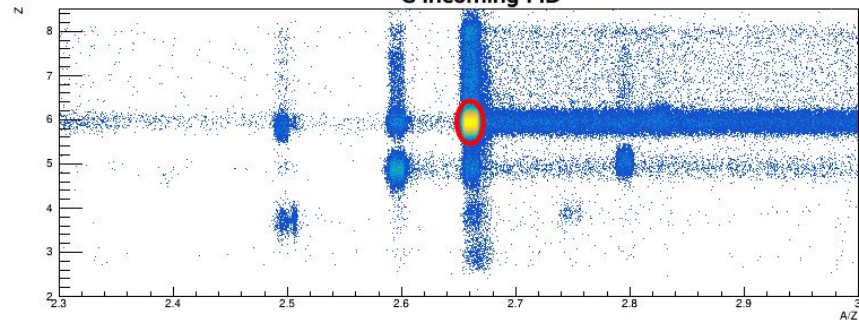
¹²C Incoming PID



¹⁴C Incoming PID



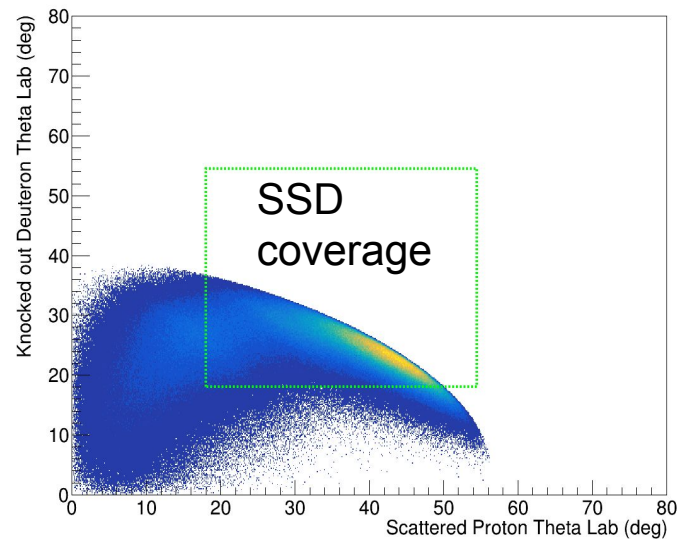
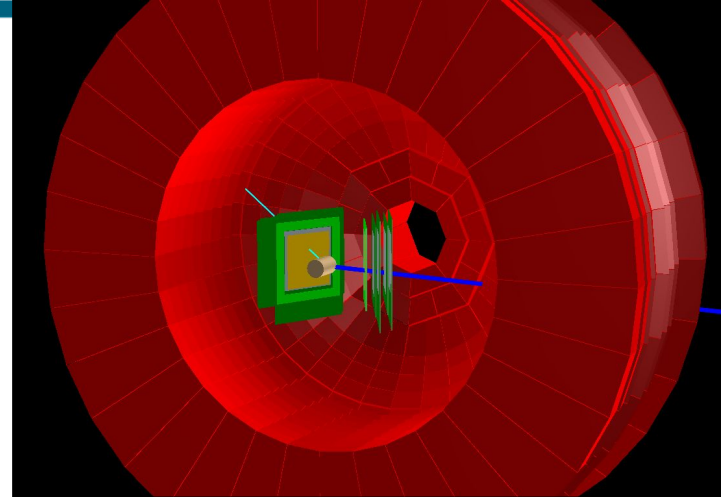
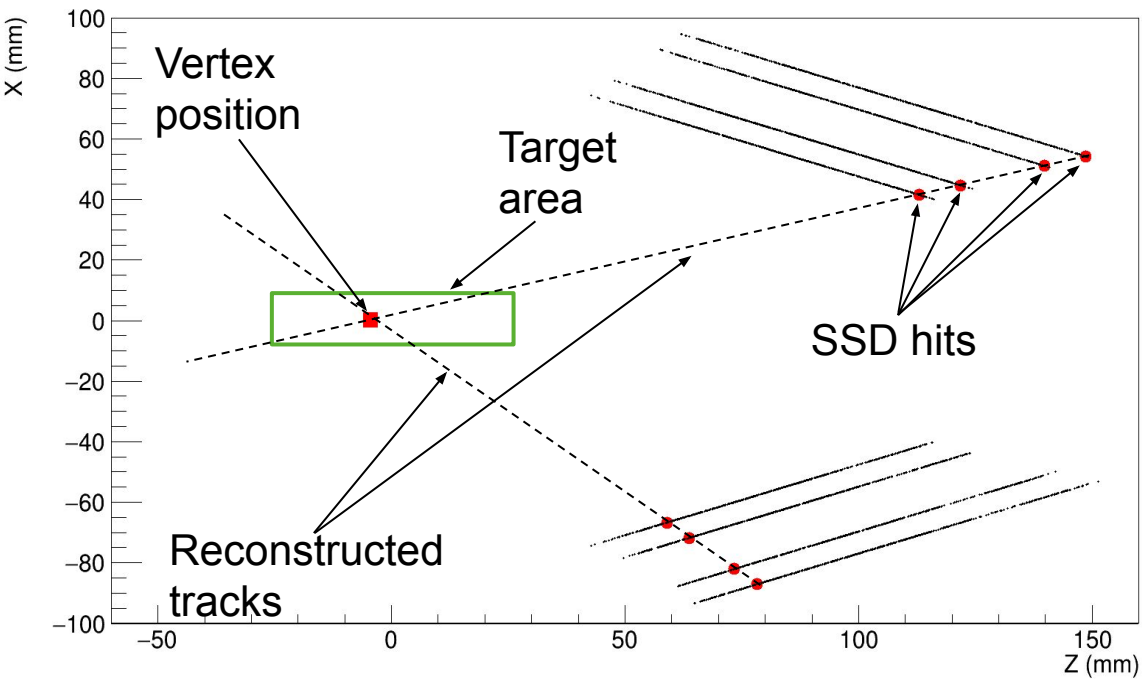
¹⁶C Incoming PID



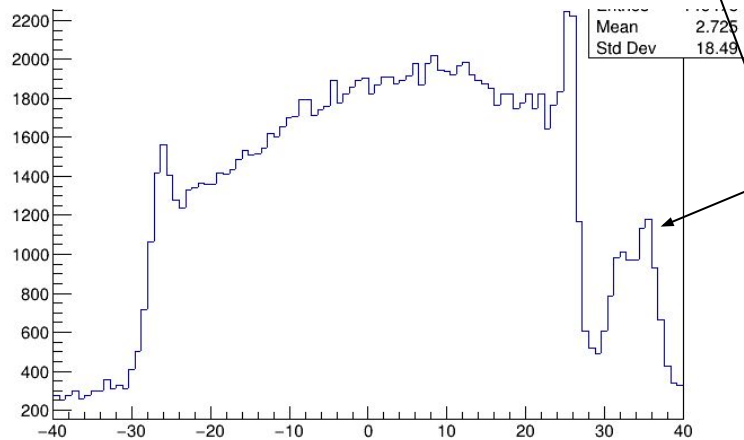
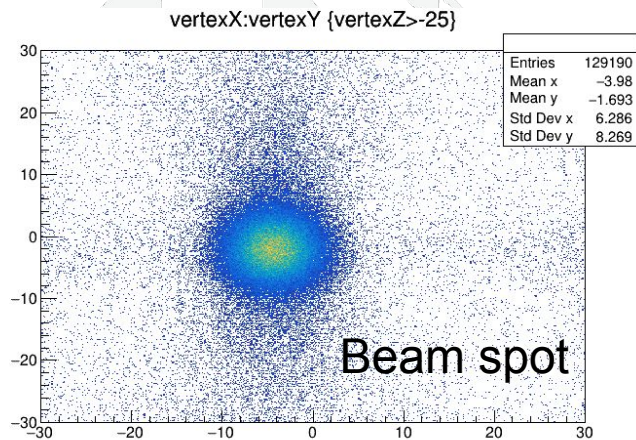
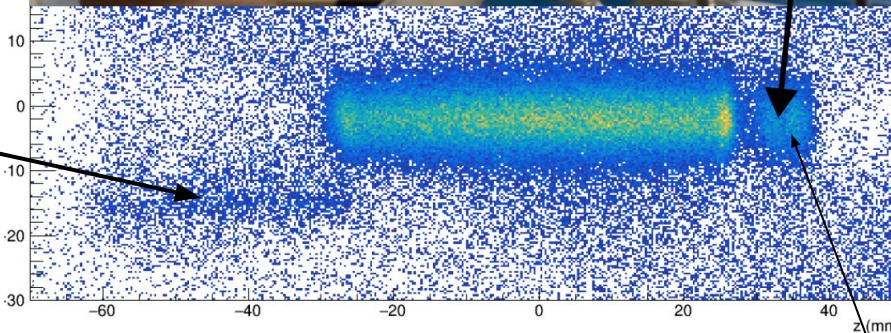
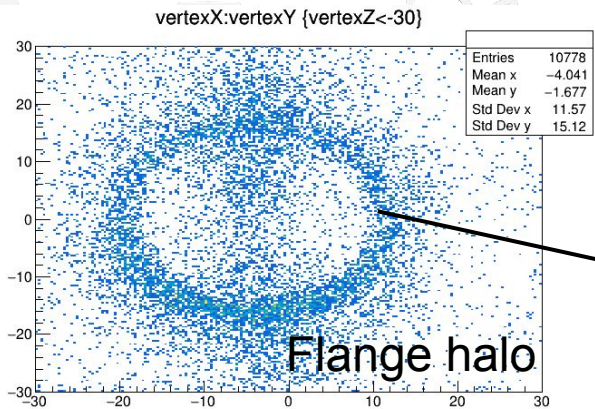
Greater contamination as expected in exotic nuclei, these can be removed in analysis by gating on carbon nucleus

Vertex reconstruction

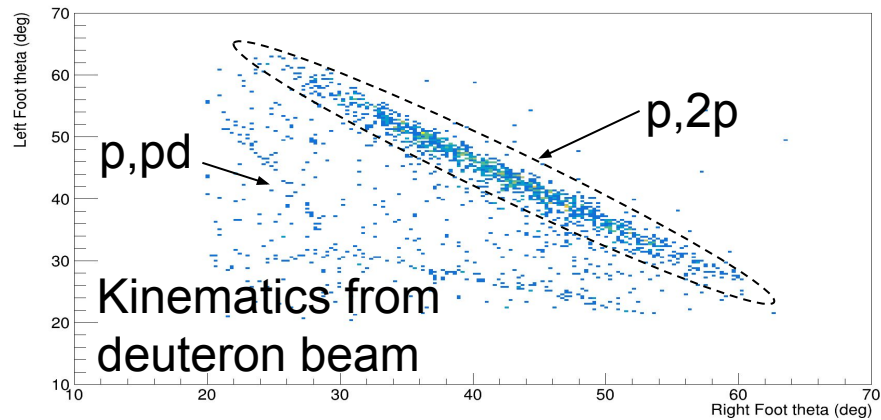
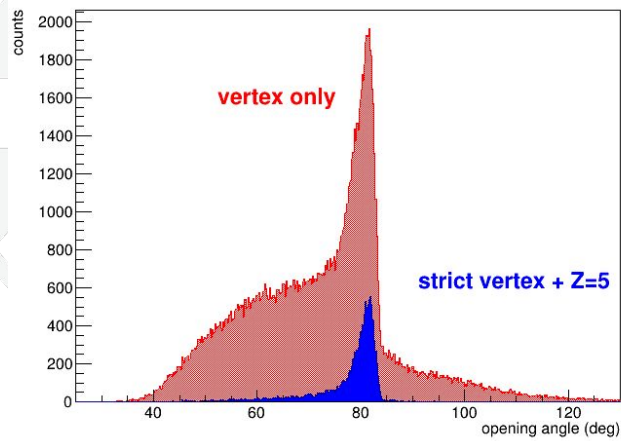
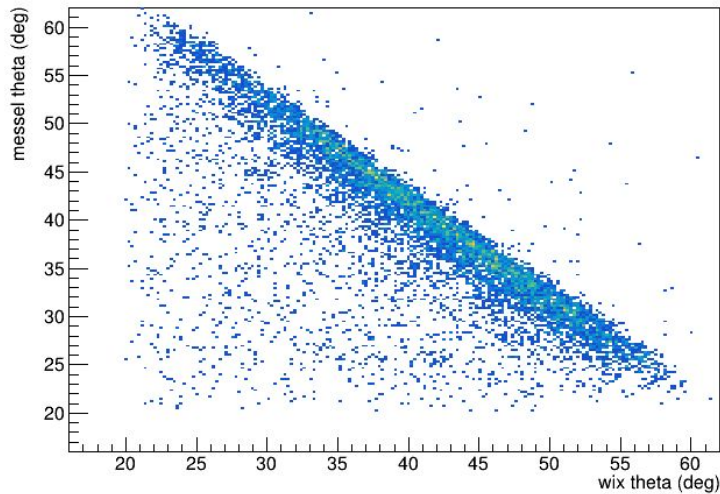
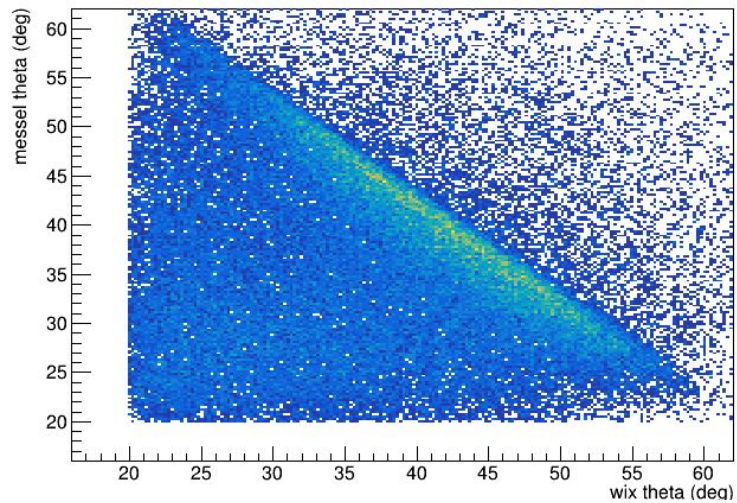
Example vertex reconstruction



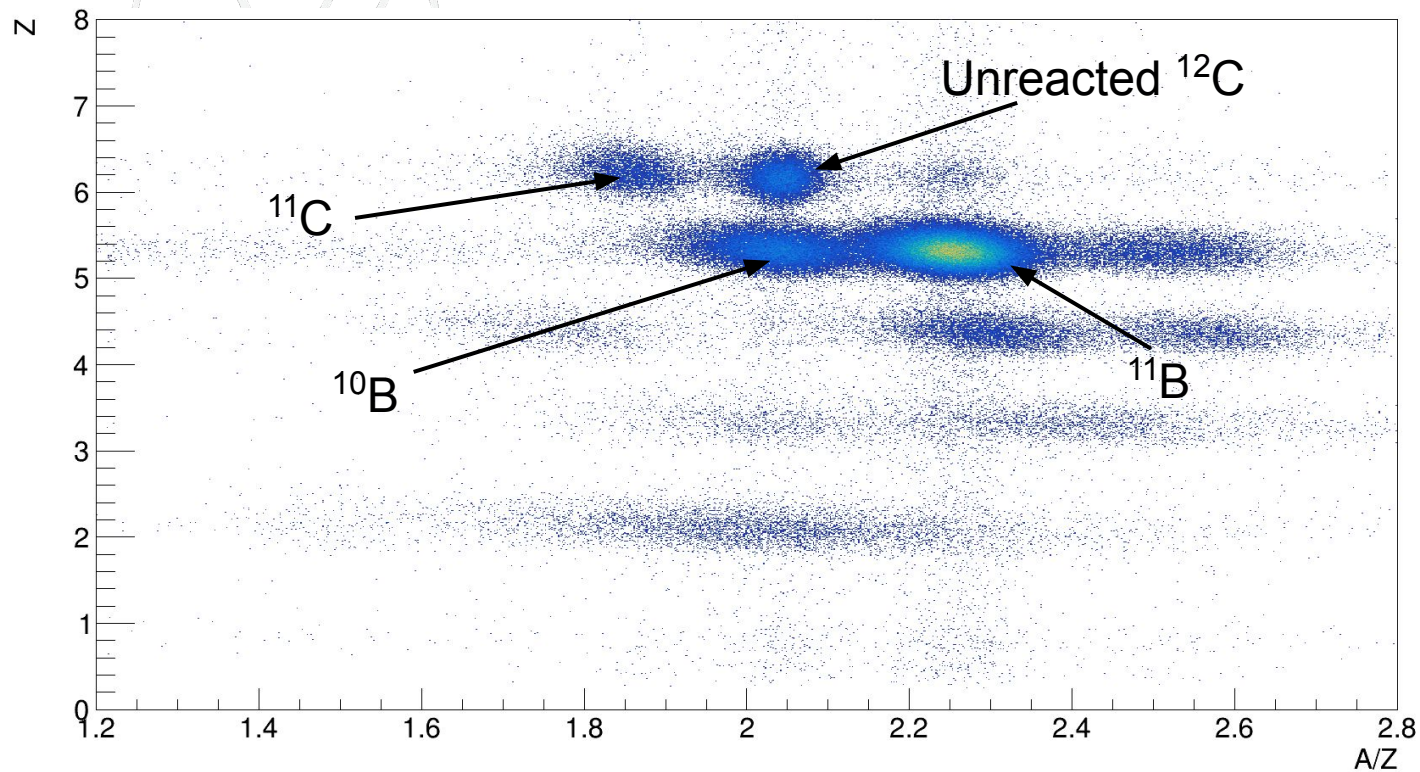
Vertex



Knockout kinematics



Fragment PID



Summary

- Introduced the motivation to investigate SRCs and their isospin dependence.
- Explained why (p, pd) QFS reactions is a useful tool to probe SRCs.
- Introduced the R3B setup.
- Presented initial results from this experiment.



Thank you for your attention!

Backup

4 Foot dE Sum vs Califa E

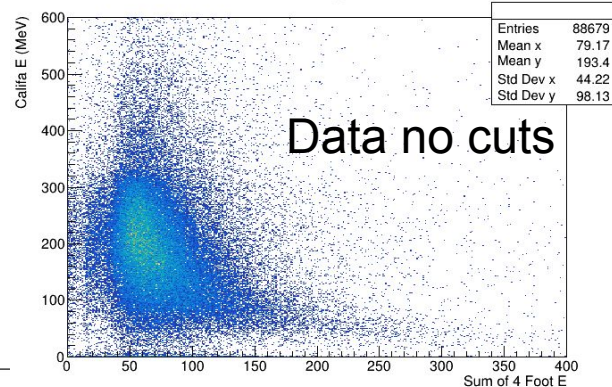
P,2p simulation

h_p2p_energy	
Entries	255720
Mean x	0.6618
Mean y	167.3
Std Dev x	0.2738
Std Dev y	69.75

Can we use Foot dE vs Califa E for PID?



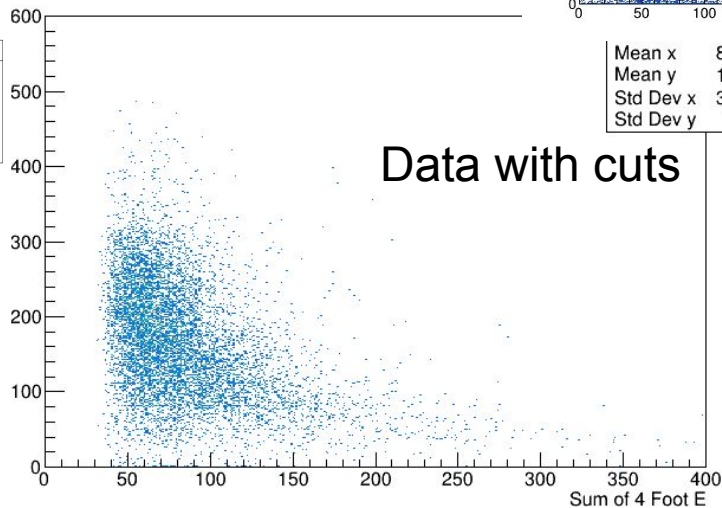
EL:Foot_EL



Sum of 4 Foot E vs Califa E

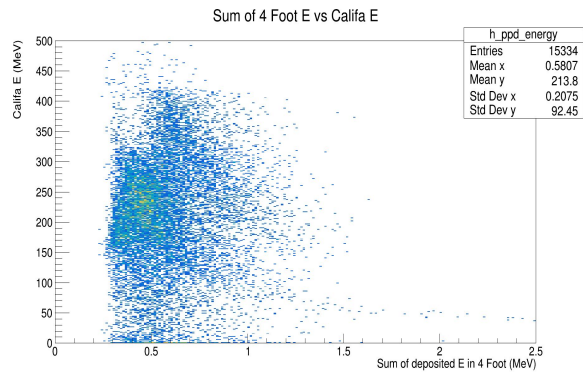
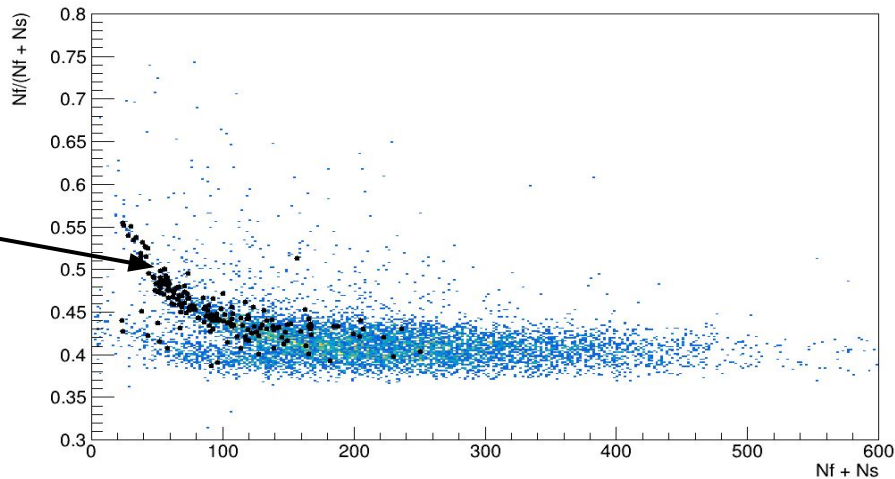
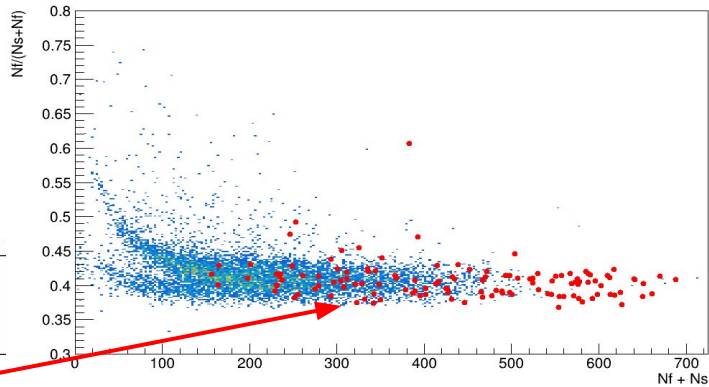
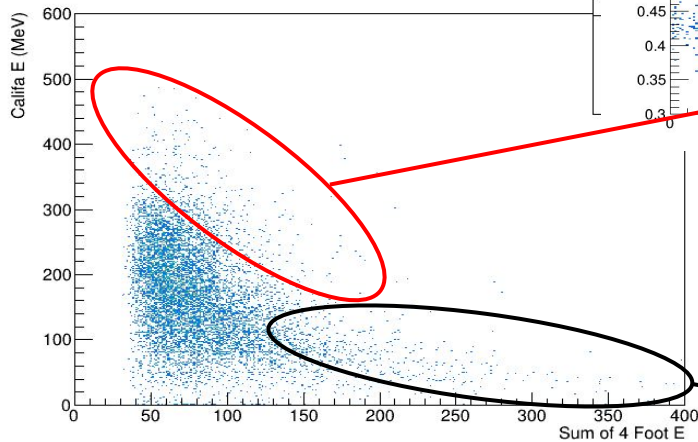
p, pd simulation

h_ppd_energy	
Entries	15334
Mean x	0.5807
Mean y	213.8
Std Dev x	0.2075
Std Dev y	92.45



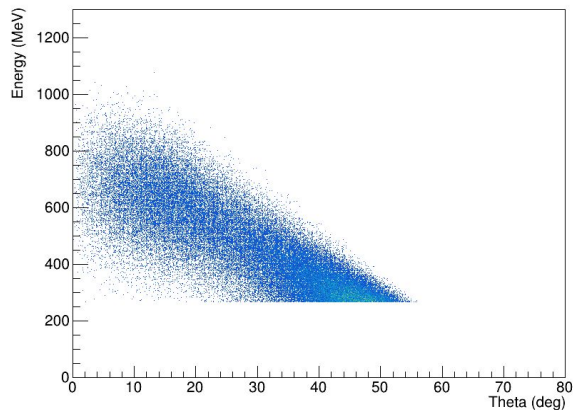
Backup

QPID

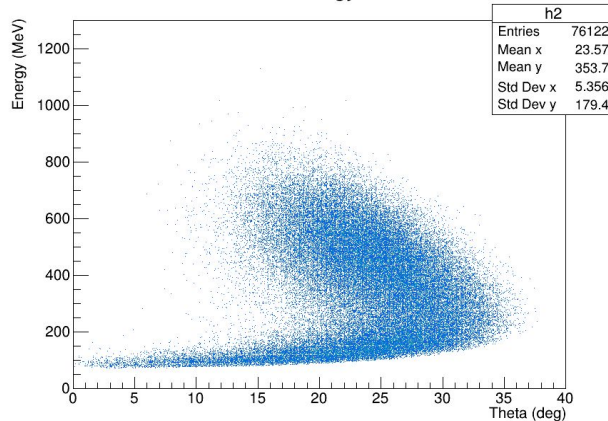


Backup

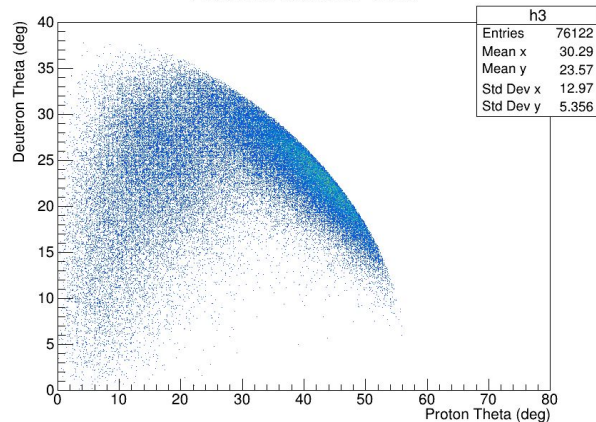
Proton Energy vs Theta



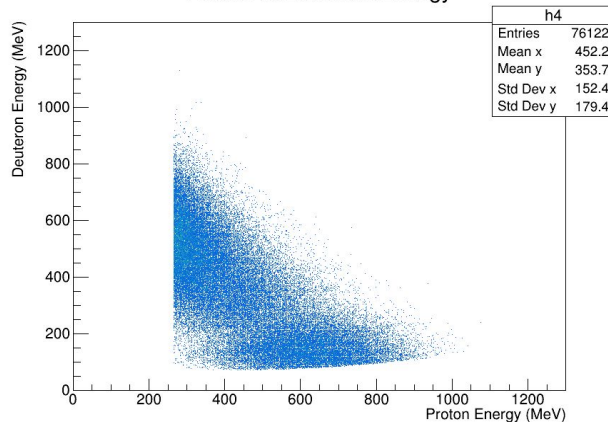
Deuteron Energy vs Theta



Proton vs Deuteron Theta



Proton vs Deuteron Energy



400 MeV/u
sims

Mandelstam_t cut
< -500000