QFS cross sections along calcium isotopes

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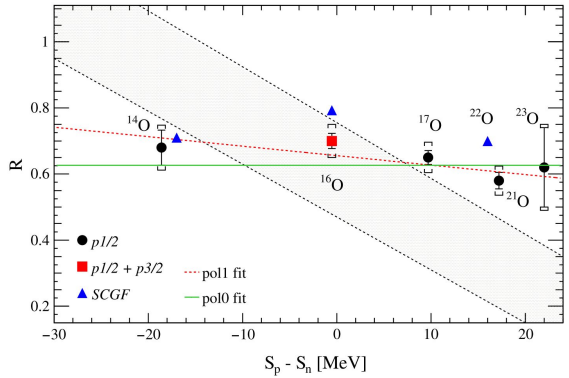
Towards wider isospin regions

Reduction factor: $R = \sigma_{exp} / \sigma_{th}$

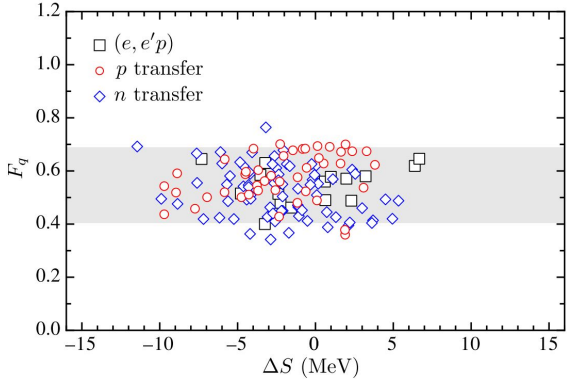
Quasi-free scattering (QFS) and **transfer reactions** show small isospin dependencies.
Knockout reactions with nuclear targets show a strong dependency which could be attributed to reaction mechanisms.
QFS is a cleaner reaction and can access wider isospin regions.

(p,2p) Quasi-free scatterings



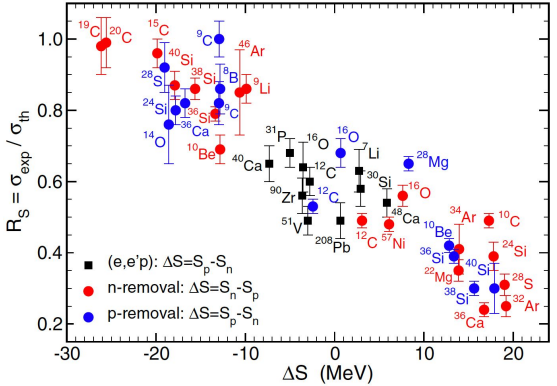
L. Atar et al., PRL **120**, 052501 (2018)

Transfer reactions



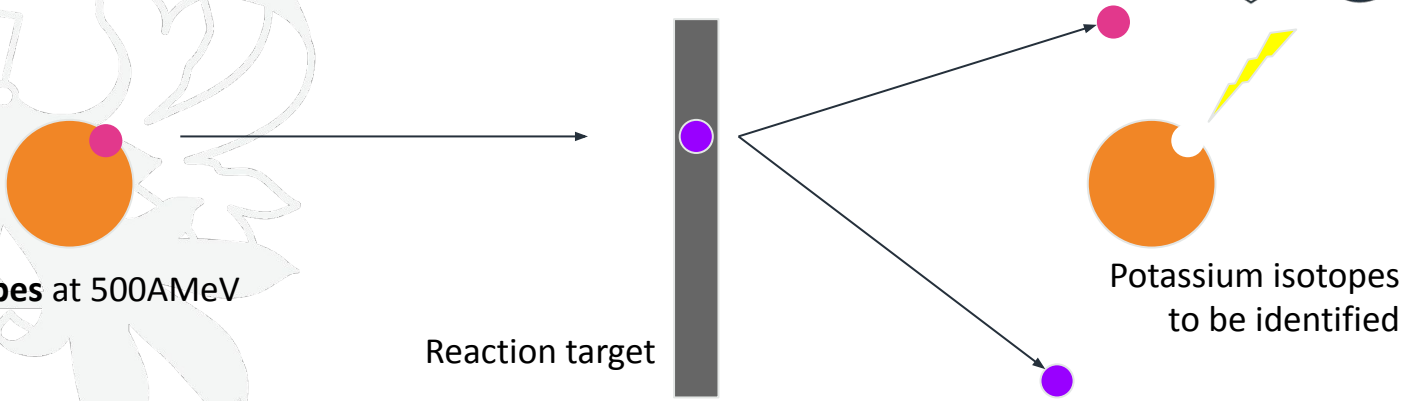
B. P. Kay et al., PRL **111**, 042502 (2013)

Knockout reactions



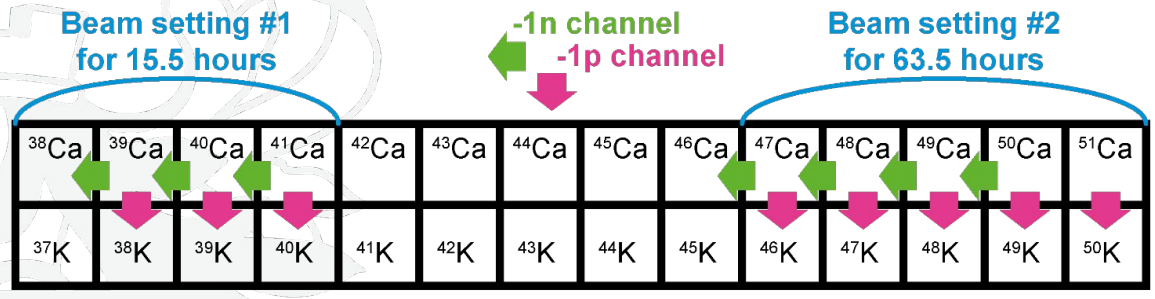
J. A. Tostevin and A. Gade, PRC **90**, 057602 (2014)

Quasi-free scattering of Ca isotopes

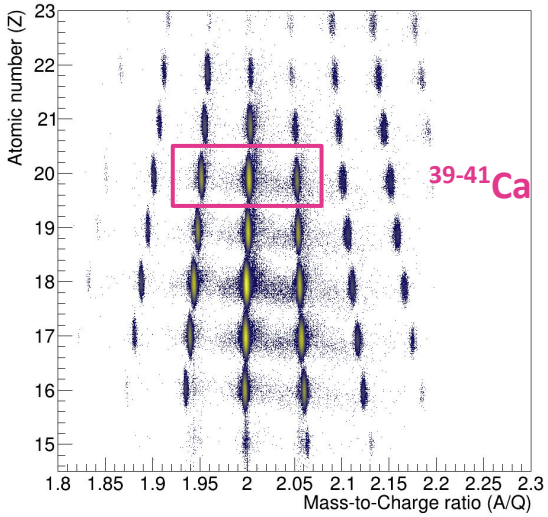


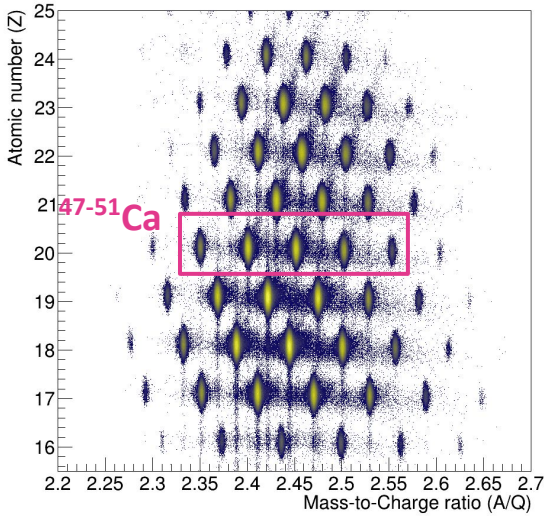
- Calcium isotopes have protons in the closed shell (Z=20)
- QFS reactions can be employed in inverse kinematics
- Minimised final-state interactions at around 500AMeV
- Deduce experimental cross sections for identifying the reactions

The s467 experiment



Colour scales are logarithmic



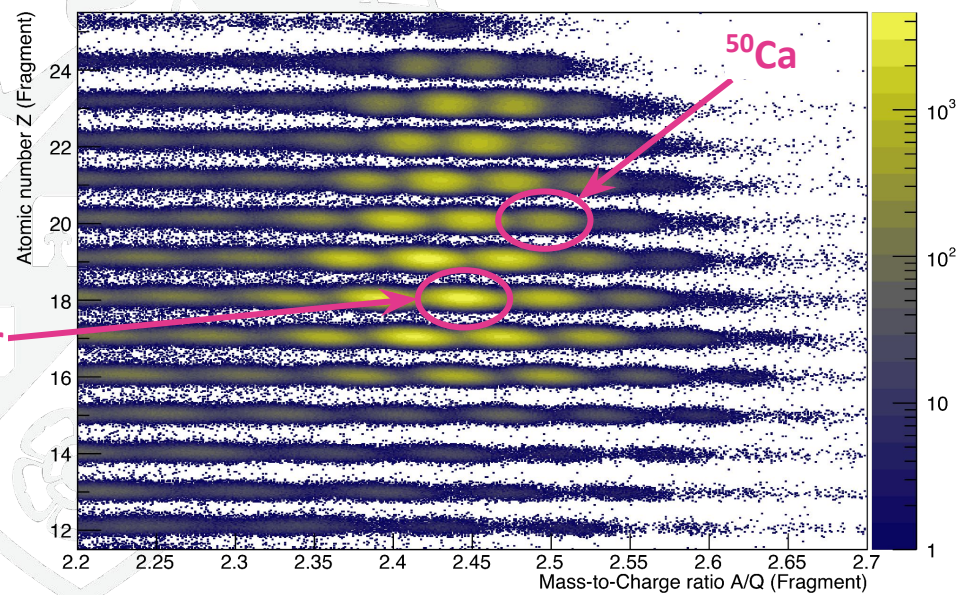


Fragment PIDs

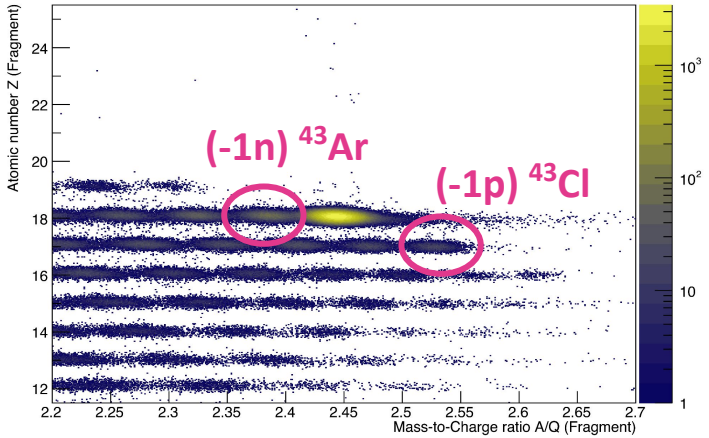
PID plots for ^{50}Ca setting with CH_2 target runs.

ToF, ΔE, $B\rho$ used for the reconstruction.

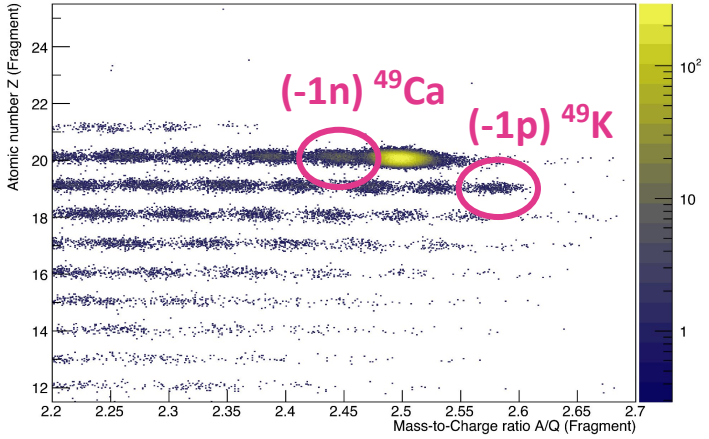
Fragment PID with CH2 target



Fragment PID with CH2 target (44Ar gated incoming)



Fragment PID with CH2 target (50Ca gated incoming)



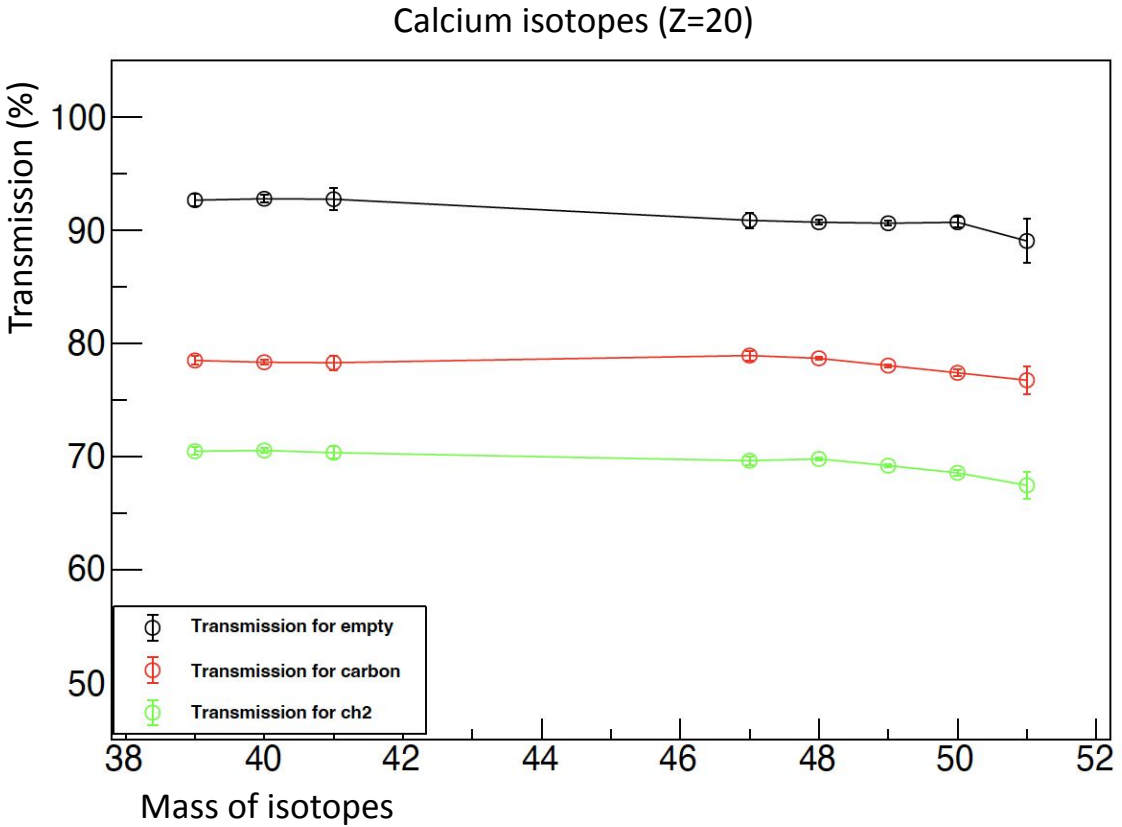
Beam transmissions

Total reaction σ_{tot} is deduced as:

$$\sigma_{tot} = - \log_e(N_{out}/N_{in}) / N_{targ}$$

The systematic trend of σ_{tot} is a good test for the acceptance of the fragment arm:

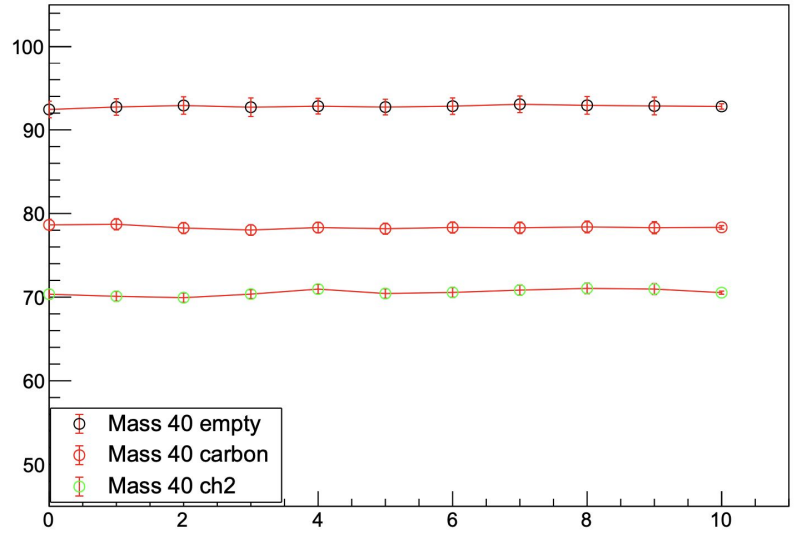
- Is the acceptance stable over the measurement?
- Any dependencies with the momentum?

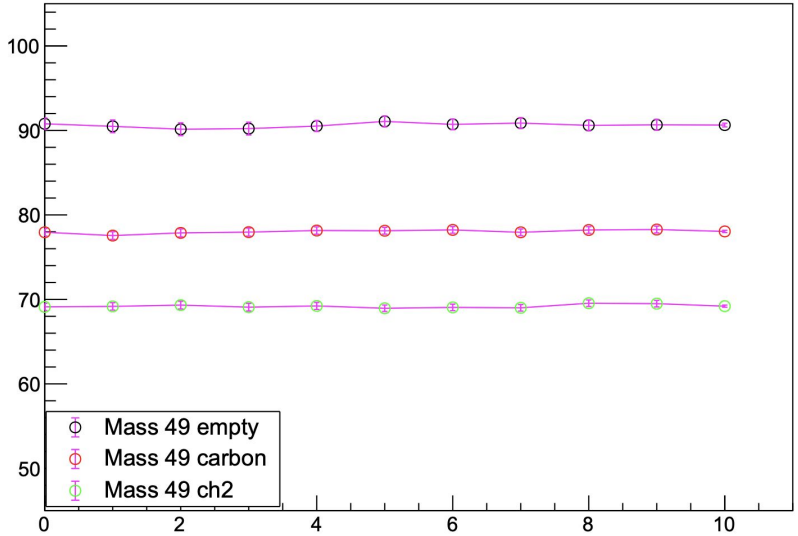


Transmission over the time

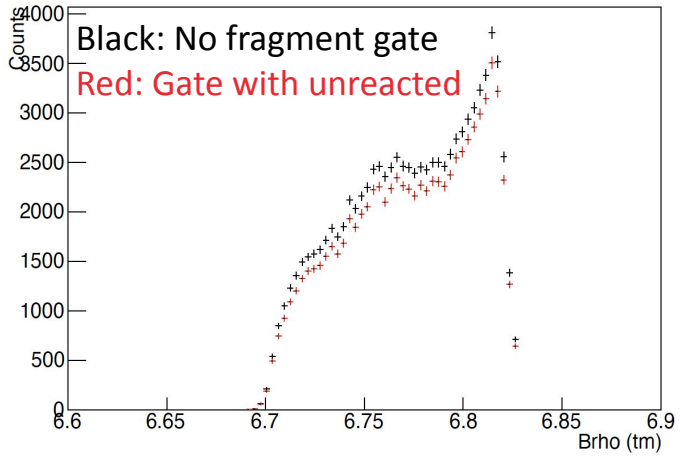
Divide into 10 subsets of the full statistics.

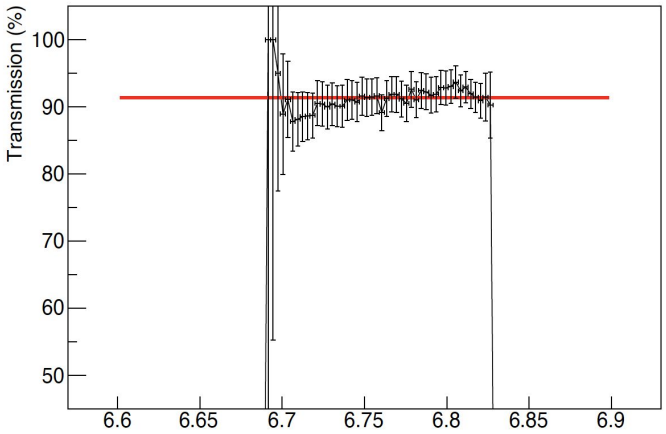
✓ The transmissions are constant within the statistical fluctuations.



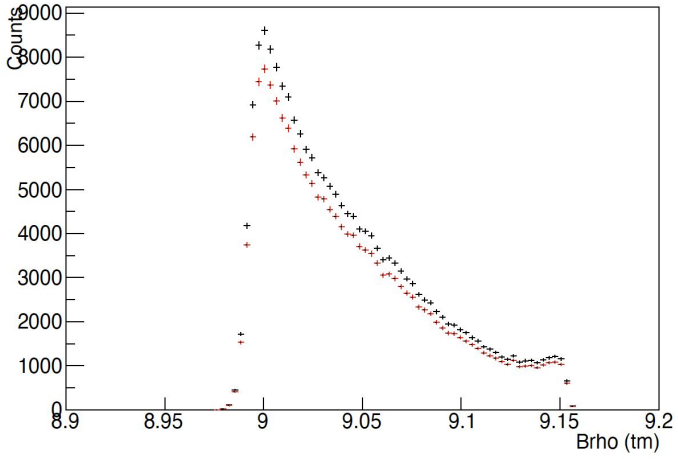


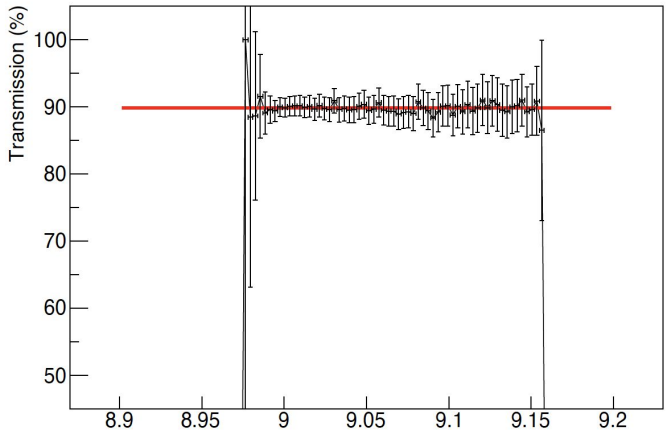
Beam transmission of ^{40}Ca





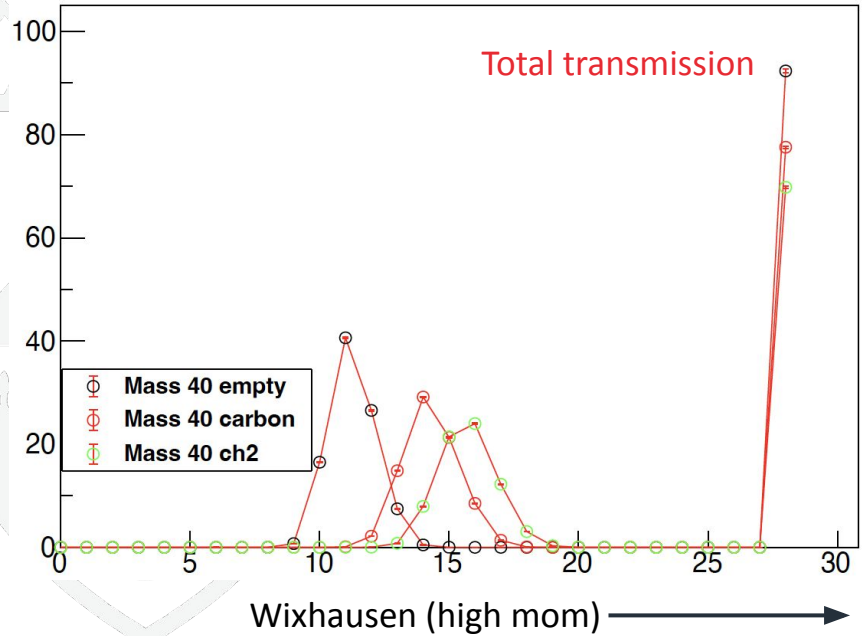
Beam transmission of ^{48}Ca

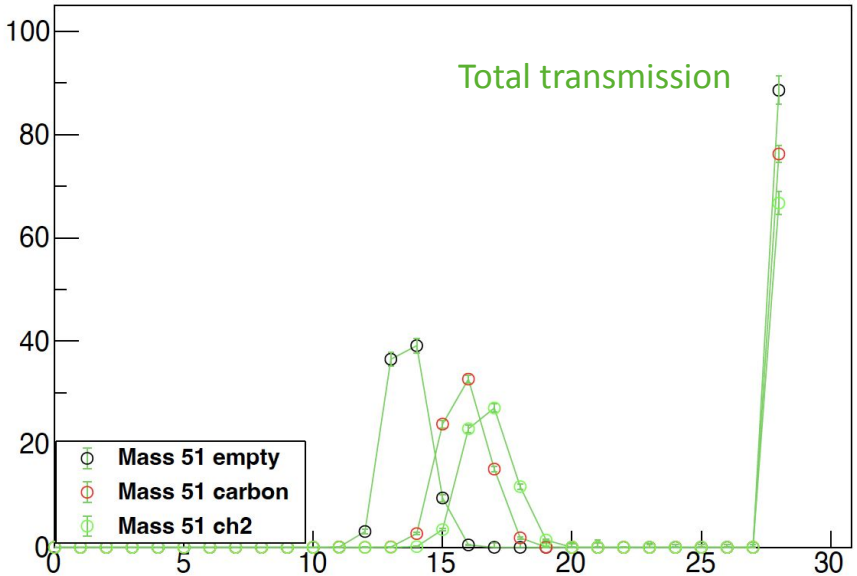




Beam distributions

SofiaTofW: 28 paddles for the Time-of-Flight





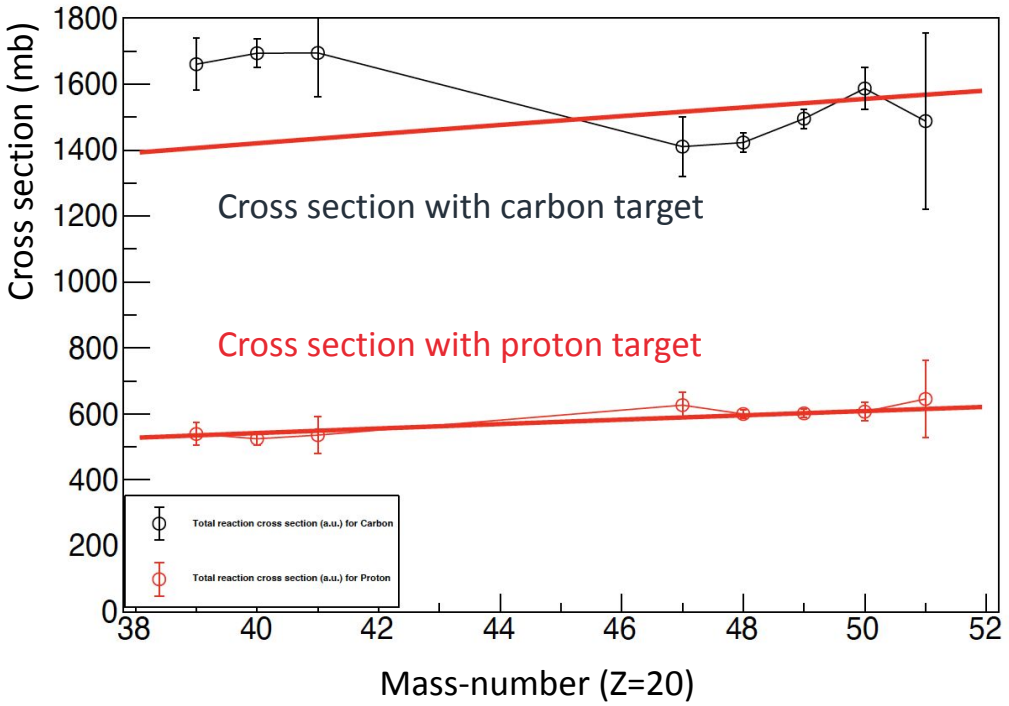
Total reaction cross sections

Total reaction σ_{tot} is deduced as:

$$\sigma_{tot} = - \log_e(N_{out}/N_{in}) / N_{targ}$$

Cross section would follow the matter size $r^2 \sim A^{2/3}$.

Data points are fitted with $f(A) = k(A_{projectile}^{1/3} + A_{targ}^{1/3})^2$.

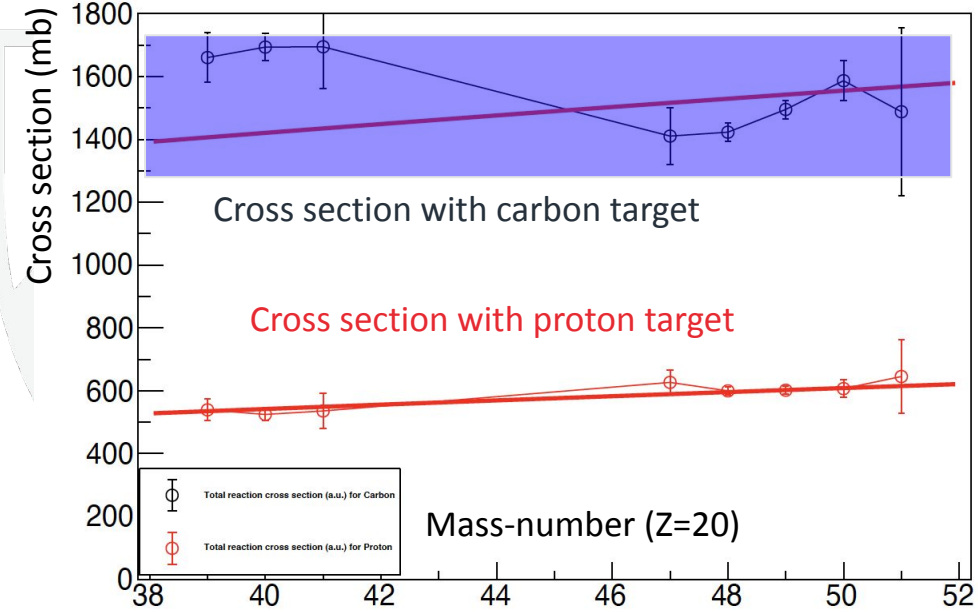


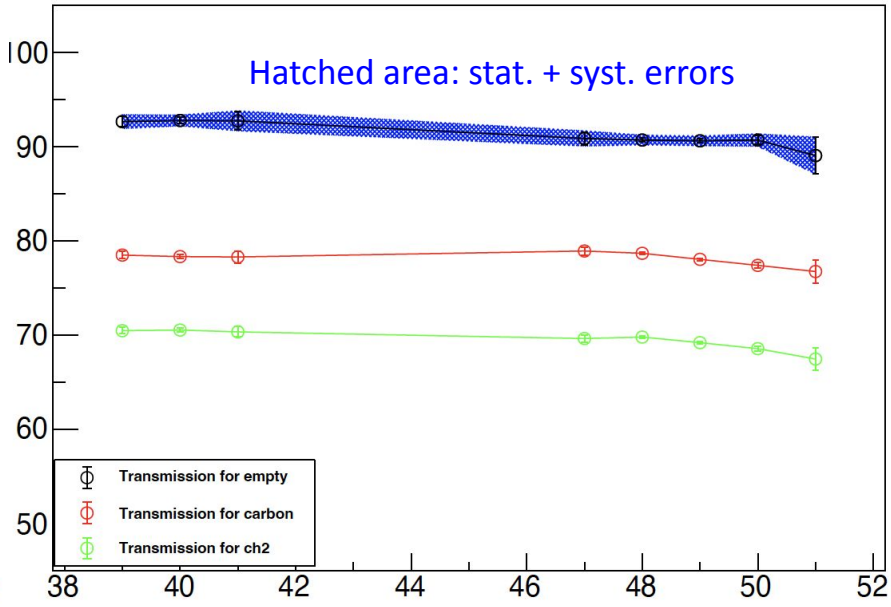
Transmission and cross sections

σ_{tot} for carbon target deviates from the trend line more than stat. error.

→ Calculate the deviation back to the uncertainty of transmission of empty runs.

Possible systematic uncertainty of transmission thru. GLAD





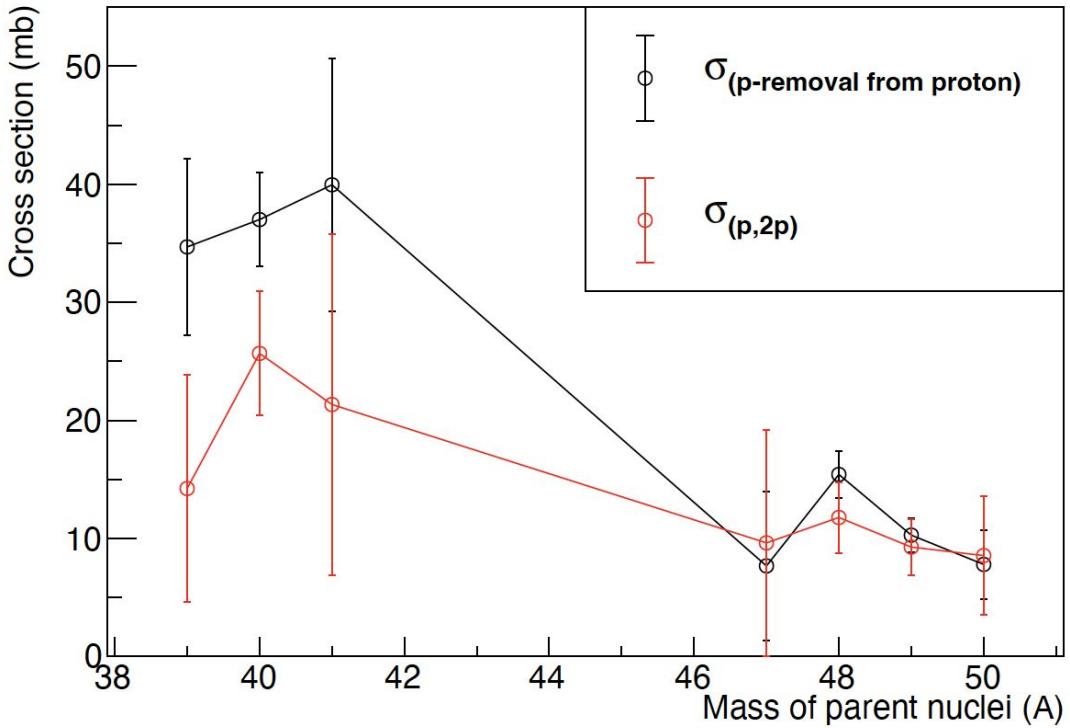
QFS conditions in CALIFA

Analysis and Simulation are performed by Luke Rose

Conditions

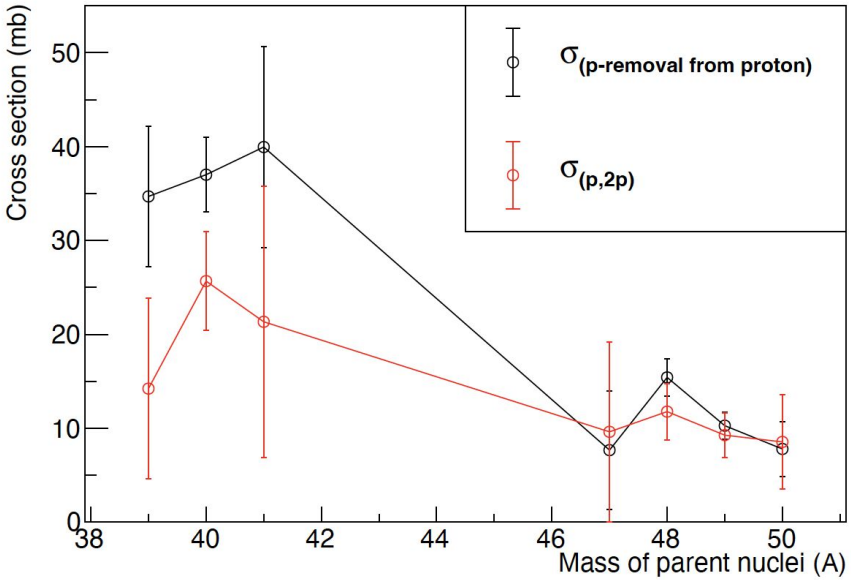
- Two protons: $E > 10$ MeV
- One in Wixhausen, another in Messel sides.
- Opening angle $\theta_{\pi\pi}$
- Carbon contributions subtracted

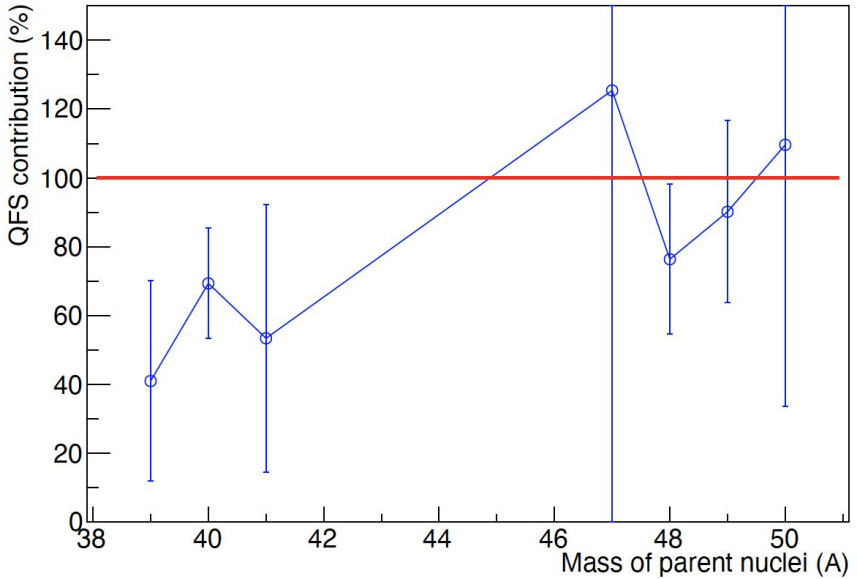
Some discrepancy is seen in neutron-deficient side



Contributions from other reactions

The ratios btw. (total) inclusive σ_{-1p} and $\sigma_{p,2p}$ indicate contribution of inelastic channels.





Summary and Outlook

- Possible systematic uncertainties from the transmission are investigated
  - A few % of uncertainty in empty target run was seen, but others are within the statistical error bars.
  - Contribution from the uncertainty of the target thickness/density is < 5%.
- QFS condition in CALIFA applied to obtain the QFS cross sections
  - Contribution from inelastic channel in neutron deficient isotopes?
- Extending the study to other isotopic chains and the -1n channel.
- Single particle cross sections of QFS reaction (σ_{sp}) are ready.
  Waiting for the nuclear structure calculations for spectroscopic factors (C^2S)

Science and Technology Facilities Council

FAIR Phase 0 Research Program

Thank you for listening!