POSSIBLE NEW PHYSICS CASE STUDIES FOR FOOT

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APPLICATION OF FOOT TO NUCLEAR PHYSYCS STUDIES

Main application, as we know, is the measurements of cross sections for proton and ion therapy.

For which other physic cases can the FOOT detector be used?

The FOOT referees suggested to investigate:

- Connections between the measurement of **charge changing cross section** to equation of state (EOS) characteristics.
- Measurement of **neutron removal cross section** in neutron rich nuclei

Usually these experiments are more sensitive at higher energy and not really at the FOOT energies.

SOME REFERENCES

Charge-changing-cross-section measurements of $^{12-16}$C at around $45A$ MeV and development of a Glauber model for incident energies $10A - 2100A$ MeV

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We have measured for the first time the charge-changing cross sections (σ_{CC}) of $^{12-16}$C on a ^{12}C target at energies below $100A$ MeV. To analyze these low-energy data, we have developed a finite-range Glauber model with a global parameter set within the optical-limit approximation which is applicable to reaction cross section (σ_R) and σ_{CC} measurements at incident energies from $10A$ to $2100A$ MeV. Adopting the proton-density distribution of ^{12}C known from the electron-scattering data, as well as the bare total nucleon-nucleon cross sections, and the real-to-imaginary-part ratios of the forward proton-proton elastic scattering amplitude available in the literatures, we determine the energy-dependent slope parameter β_{pn} of the proton-neutron elastic differential cross section so as to reproduce the existing σ_R and interaction-cross-section data for ^{12}C+^{12}C over a wide range of incident energies. The Glauber model thus formulated is applied to calculate the σ_R's of ^{12}C on a ^{9}Be and ^{27}Al targets at various incident energies. Our calculations show excellent agreement with the experimental data. Applying our model to the σ_R and σ_{CC} for the "neutron-skin" ^{16}C nucleus, we reconfirm the importance of measurements at incident energies below $100A$ MeV. The proton root-mean-square radii of $^{12-16}$C are extracted using the measured σ_{CC}'s and the existing σ_R data. The results for $^{12-14}$C are consistent with the values from the electron scatterings, demonstrating the feasibility, usefulness of the σ_{CC} measurement and the present Glauber model.

Peeling Off Neutron Skins from Neutron-Rich Nuclei: Constraints on the Symmetry Energy from Neutron-Removal Cross Sections

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An experimentally constrained equation of state of neutron-rich matter is fundamental for the physics of nuclei and the astrophysics of neutron stars, mergers, core-collapse supernova explosions, and the synthesis of heavy elements. To this end, we investigate the potential of constraining the density dependence of the symmetry energy close to saturation density through measurements of neutron-removal cross sections in high-energy nuclear collisions of 0.4 to 1 GeV/nucleon. We show that the sensitivity of the total neutron-removal cross section is high enough so that the required accuracy can be reached experimentally with the recent developments of new detection techniques. We quantify two crucial points to minimize the model dependence of the approach and to reach the required accuracy: the contribution to the cross section from inelastic scattering has to be measured separately in order to allow a direct comparison of experimental cross sections to theoretical cross sections based on density functional theory and eikonal theory. The accuracy of the reaction model should be investigated and quantified by the energy and target dependence of various nucleon-removal cross sections. Our calculations explore the dependence of neutron-removal cross sections on the neutron skin of medium-heavy neutron-rich nuclei, and we demonstrate that the slope parameter L of the symmetry energy could be constrained down to ± 10 MeV by such a measurement, with a 2% accuracy of the measured and calculated cross sections.

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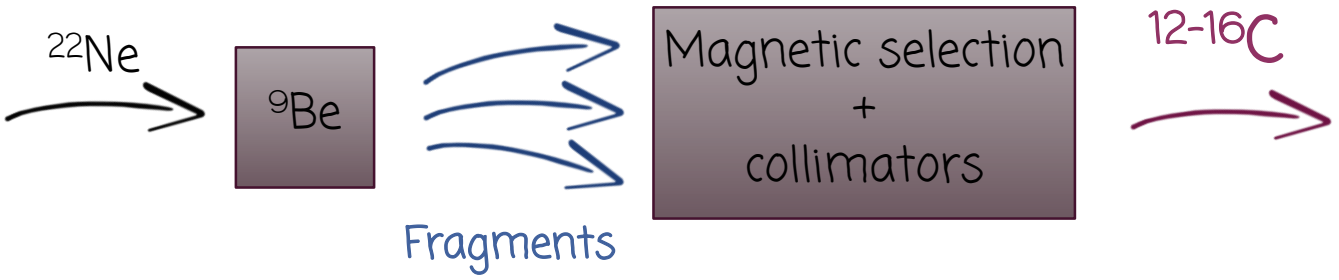
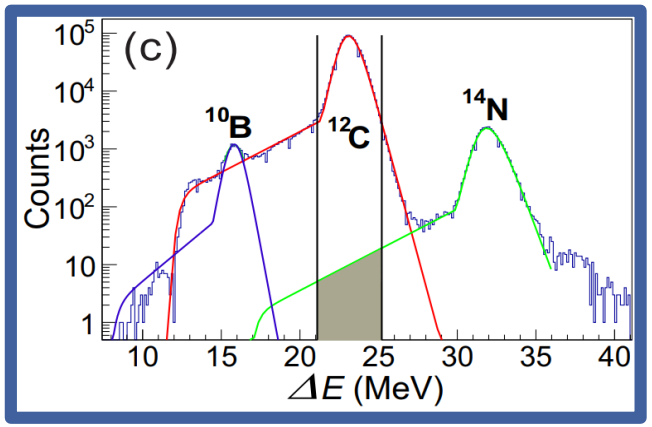
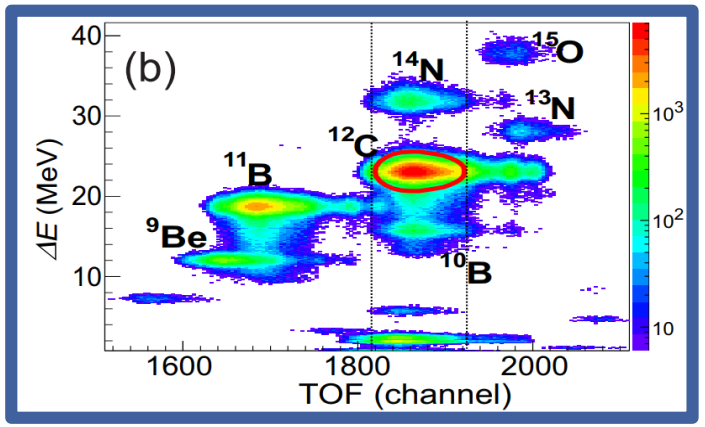
EXAMPLE OF EXPERIMENT

Charge-changing-cross-section measurements of $^{12-16}$C at around 45A MeV and development of a Glauber model for incident energies 10A – 2100A MeV







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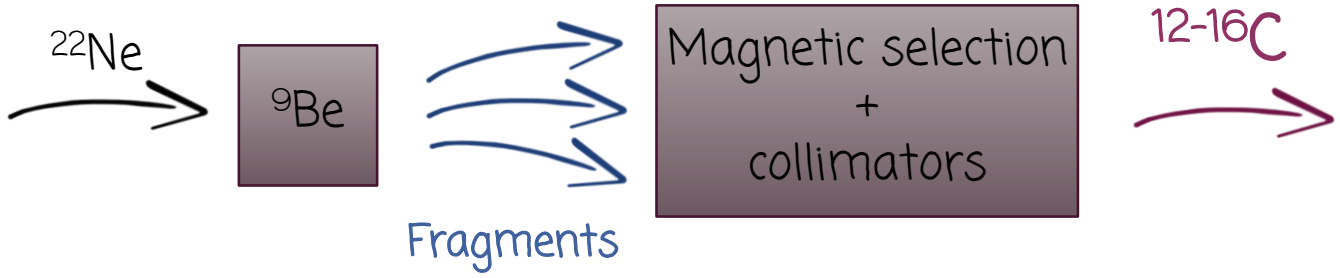
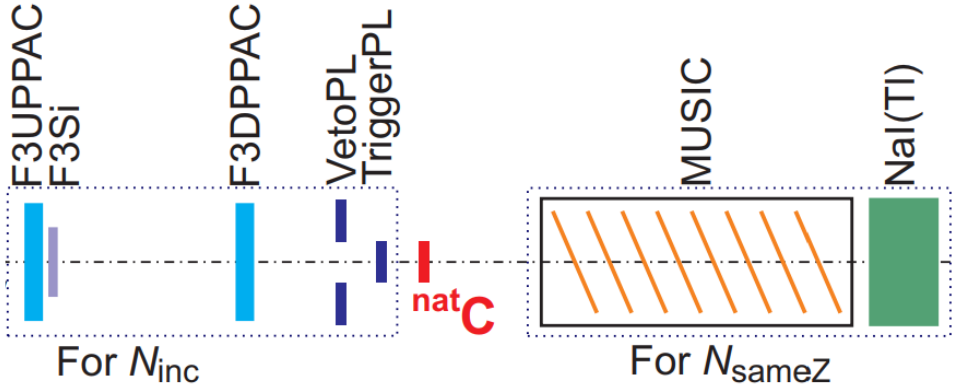
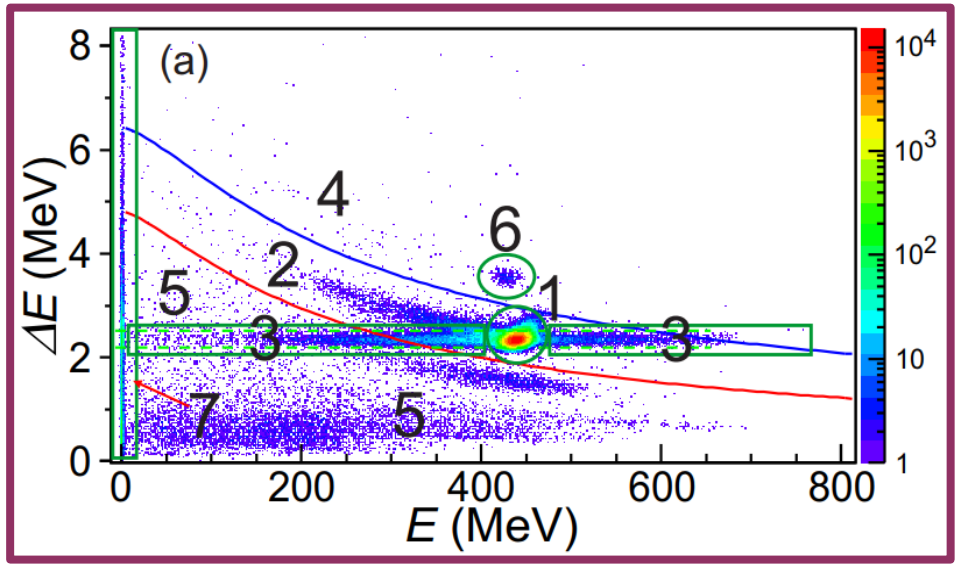




The particles are classified by 7 regions:

(1) beam-like particles
(2) elastic and inelastically scattered beam-like particles
(3) particles that reacted in the NaI(Tl) scintillator
(4) proton-picked-up particles
(5) proton-removed particles
(6) beam contaminants
(7) "out-of-acceptance" particles, which were not detected by the NaI(Tl) detector



NEW JOB FOR THE FOOT COLLABORATION

Dedicated studies are needed to explore the FOOT detector capabilities for this kinds of measurements

WHO VOLUNTEERS?