Polarimetry for Swift Light Ions

Nigel Buttimore – Trinity College Dublin – Ireland

Compare elastic $^3\text{He}^\uparrow$–A to elastic A – $^3\text{He}^\uparrow$ (known polarization)

The beam and target ion A can consist of proton, D, or ^{3}He ions

An intermittant cluster jet target may allow ToF study of recoils

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TIME REVERSED HELIUM-3 PROCESS

- Compare the elastic $^3He^\uparrow$–p to elastic p–$^3He^\uparrow$ with known ^{3}He-Jet polarization

- A 42–276 GeV proton beam colliding with a $^3He^\uparrow$ Jet of known polarization provides calibration of $^3He^\uparrow$–p scattering over the energy/3 range 42–184 GeV

- A 28–184 GeV/3 ^{3}He beam scattering on a $^3He^\uparrow$ Jet of known polarization provides calibration of $^3He^\uparrow$–^{3}He collisions over full energy/3 range 28–184 GeV

- A 21–138 GeV/N D or α beam colliding with a $^3He^\uparrow$ Jet of known polarization provides calibration of $^3He^\uparrow$–D (α) scattering over energy/3 range 28–138 GeV

- George Igo and I. Tanihata, AIP Conference Proc. 675 (2003) no.1, 836-840, "Absolute calibration of the RHIC CNI polarimeters using 125-GeV/A C ions" doi:10.1063/1.1607251

TIME REVERSED DEUTERON PROCESS

- Compare elastic D – p reaction to elastic p – $D^{\uparrow}$ with known $D^{\uparrow}$-Jet polarization

- A 42–276 GeV proton beam colliding with a $D^{\uparrow}$ Jet of known polarization provides calibration of $D^{\uparrow}$–p scattering over the energy/2 range of 42–138 GeV

- A 21–138 GeV/2 Deuteron beam scattering on a $D^{\uparrow}$ Jet of known polarization provides calibration of $D^{\uparrow}$– D collisions over full energy/2 range of 21–138 GeV

- The unpolarized Deuteron here could be replaced by a ^{12}C or α particle without altering the energy/N ranges as the ratio Z/M remains approximately the same

- When a heavier nucleus is used as a target it should be light enough to have a recoil velocity above the threshold for detection and such that background effects are not too great. A A Poblaguev et al, PRL 123, 162001 (2019)

JET TARGET OF PELLETS

- A pellet target may offer a way of using time-of-flight information on the recoils to facilitate a study of beam profiles and polarization profiles P Thieberger

- A pellet of size 30 μm moving at a velocity 70 m/s across a 1 mm beam will traverse the beam in 15 μs https://panda.gsi.de/publication/re-tdr-2012-002

- The cluster jet group have indicated that pellets of light atoms can be generated at a frequency of (as low as) 40 kHz so that they may be generated every 25 μs

- There is about 10 μs before the next pellet arrives at the beam by which time many recoil ions will have been detected and pile-up hopefully may be controlled

- Pellets of density 10^{15} atoms/cm^2 can be optically tracked to indicate the location of the source of the recoil ion as the pellet of atoms traverses the beam

CONCLUSIONS

- Absolute polarimetry for deuteron or helion beams on a nuclear target can be secured via the time reversed process of the same nuclear beam scattering on polarized D or ^{3}He Jet targets provided inelastic backgrounds can be controlled

  –> A nucleus available as beam and target is useful for absolute polarimetry
  –> The nuclei could be protons, deuterons, helions, alphas, carbon, neon . . .
  –> Nuclei should be light enough to facilitate detection above the noise level

- The ^{3}He$^\uparrow$–C analyzing power is $\approx -70\%$ of the $A_{\rm N}$ for p$^\uparrow$–C in the CNI region

  –> $A_{\rm N}$ for vector polarized D$^\uparrow$–C is $\approx 10\%$ of $A_{\rm N}$ for CNI ^{3}He$^\uparrow$–C scattering

- A cluster jet target of appropriate atoms may provide a method of measuring beam profiles and of accessing polarization profiles via studies of the recoil ions

The word "proton" (Ancient Greek $\pi\rho\tilde{\omega}\tau o\nu$, neuter of $\pi\rho\tilde{\omega}\tau o\varsigma$, "first") appeared in print on September 17, 1920, and in the journal Nature on November 11, 1920.