# e-$^3$He Scattering Study

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# Physics Motivation – Neutron Structure

- Nucleon structure measurements for understanding QCD
  - Origin of nucleon spin (using **polarized $^3He$ beam**)
  - Use light nuclei to probe neutron ($^2H/^3He$ as effective neutron target)
- Experimental method: **double tagging** sample $e^3He\ (e, e', p_{1S}, p_{2s})$
  - **Measure scattered electron** in central for $x$, $Q^2$
  - **Measure two spectator protons** in far-forward (B0 tracker, Off-momentum, and Roman Pots)
- Impact
  - Provides valuable input for **polarized parton distribution global fit and flavor separation**
  - Tests nuclear correction by comparing to existing fixed target data

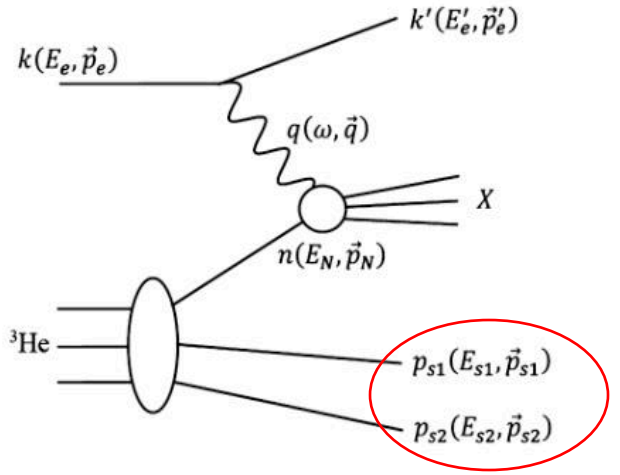


**Fig. 2.** A diagram of Deep Inelastic $e$+$^3$He scattering with double spectator tagging. The channel shown here is electron scattering off a neutron in $^3$He; the two spectator nucleons are the protons in the process $^3\mathrm{He}(e, e' p_{s1} p_{s2})X$.

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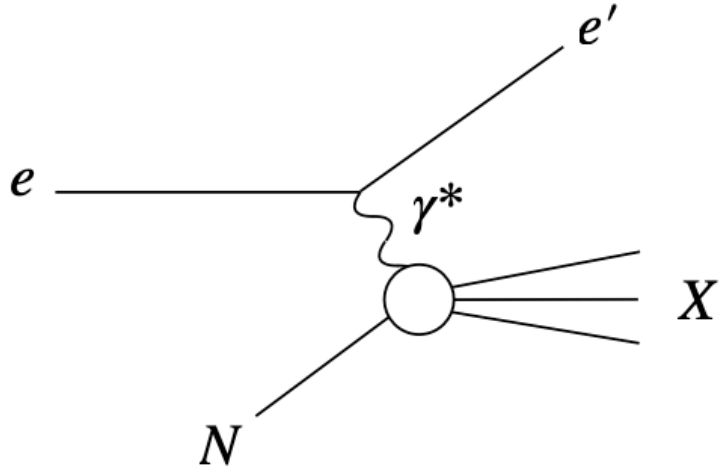
# Event Generator – DIS Event Sample

**CLASDIS** generator

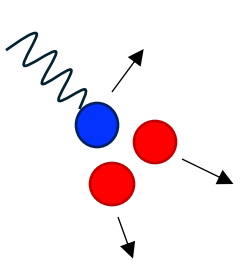
- Fixed target frame
- Polarized and unpolarized targets
- DIS events from free proton/neutron
- No Fermi motion of nucleons and No kinematics of spectators



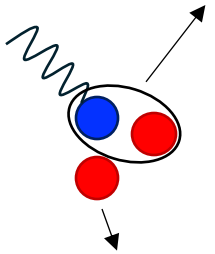

**Separate procedure**

- Add Fermi motion
- Add kinematics of spectators

**Breakup models of $^3He$**



Mean-field 3-body breakup



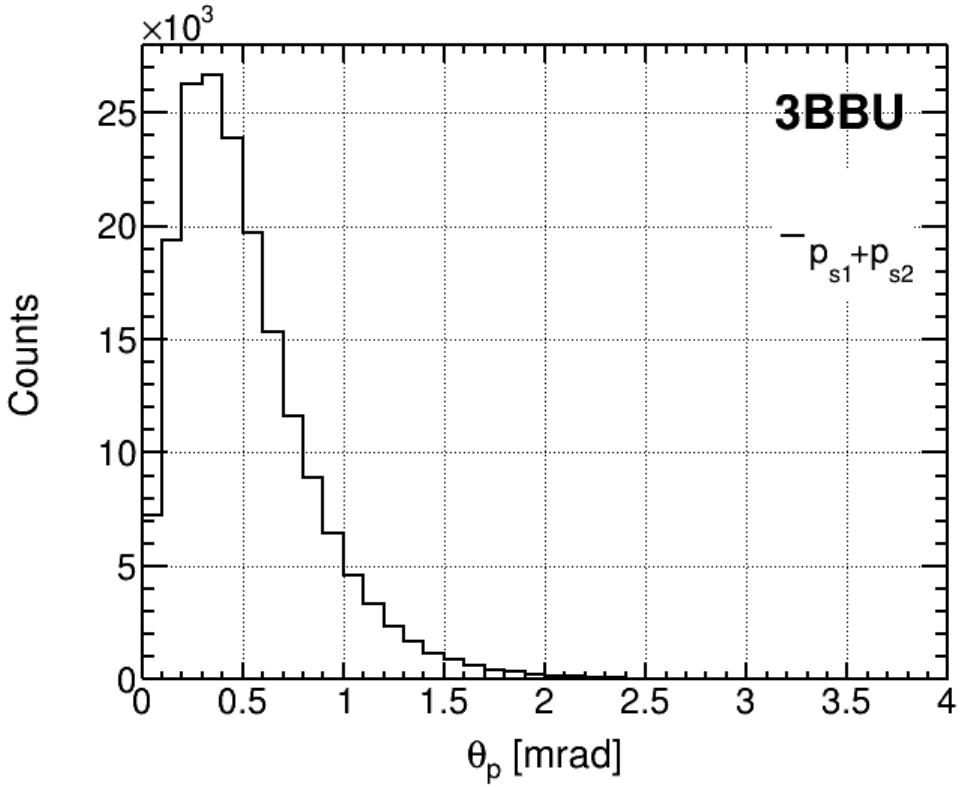
Short-range correlation breakup

# Event Generator – DIS Event Sample

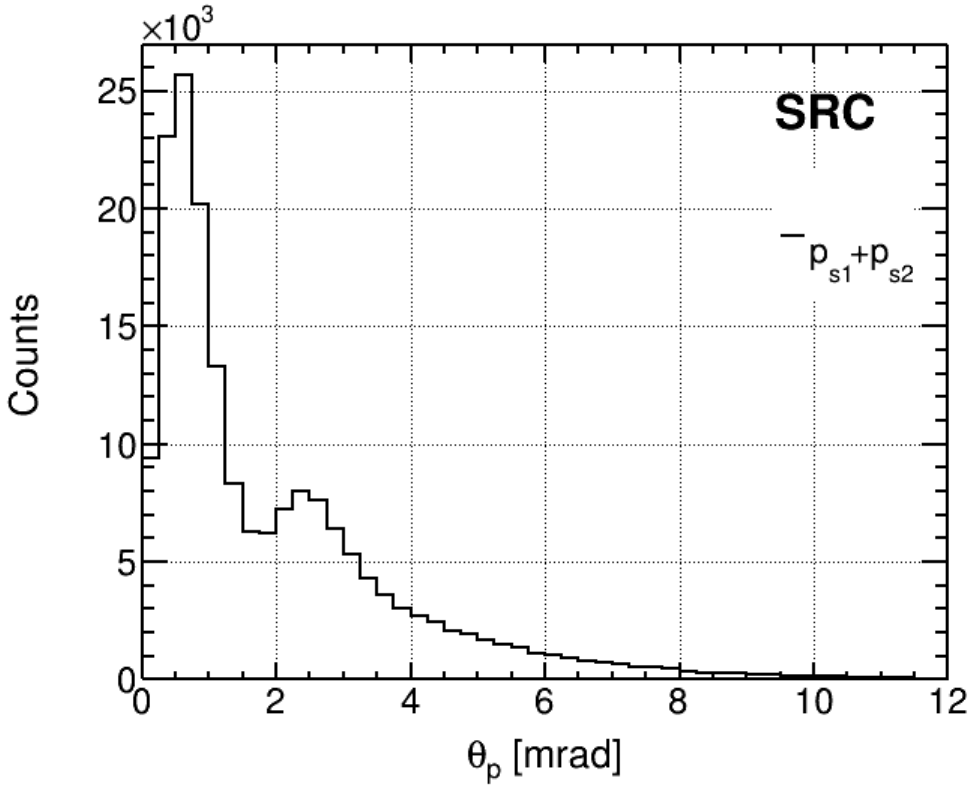
- Obtained two samples (3BBU-MF and SRC) from Alex Jentsch
  - $e^3He$ 18×110 GeV² unpolarized SIDIS samples in PYTHIA format
  - Converted to HepMC format for DD4hep simulation via eic-smear
    - Some issue occurs when parsing events – too few vertices (vertices info missing)
  - 200k events per sample, but 45.5 % of events having two spectator protons

# Kinematics of Two Spectator Protons

Mean-Field 3-body Breakup




Short-range Correlation Breakup



# Kinematics of Two Spectator Protons

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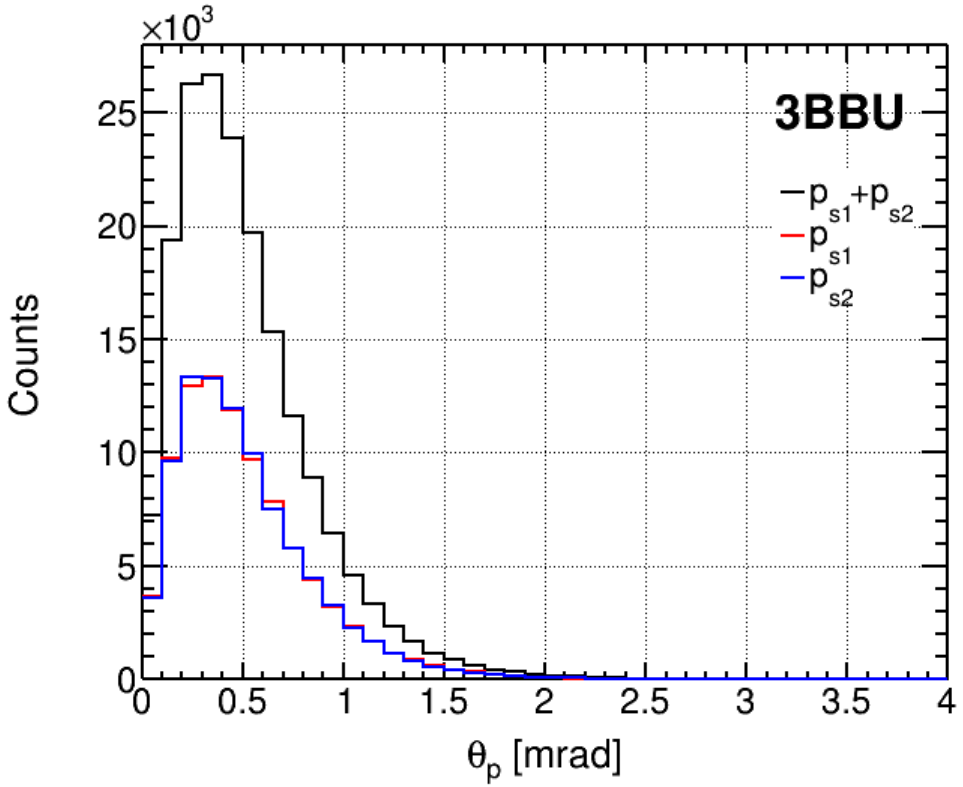
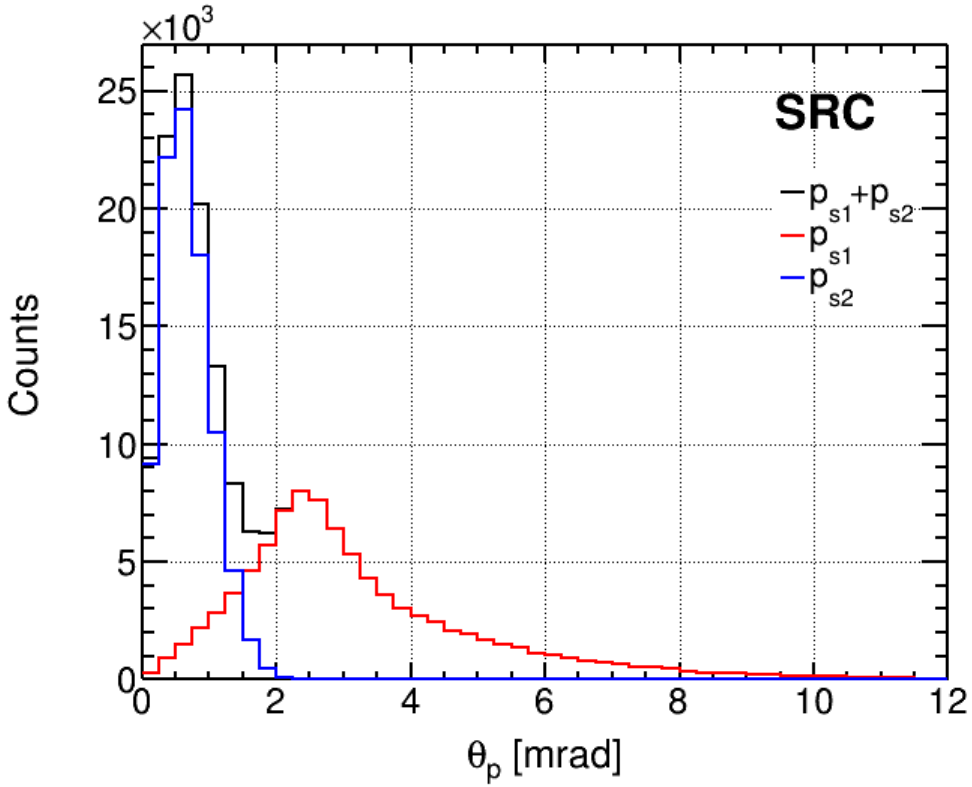



Short-range Correlation Breakup



# Angular Distribution of Tagged Protons

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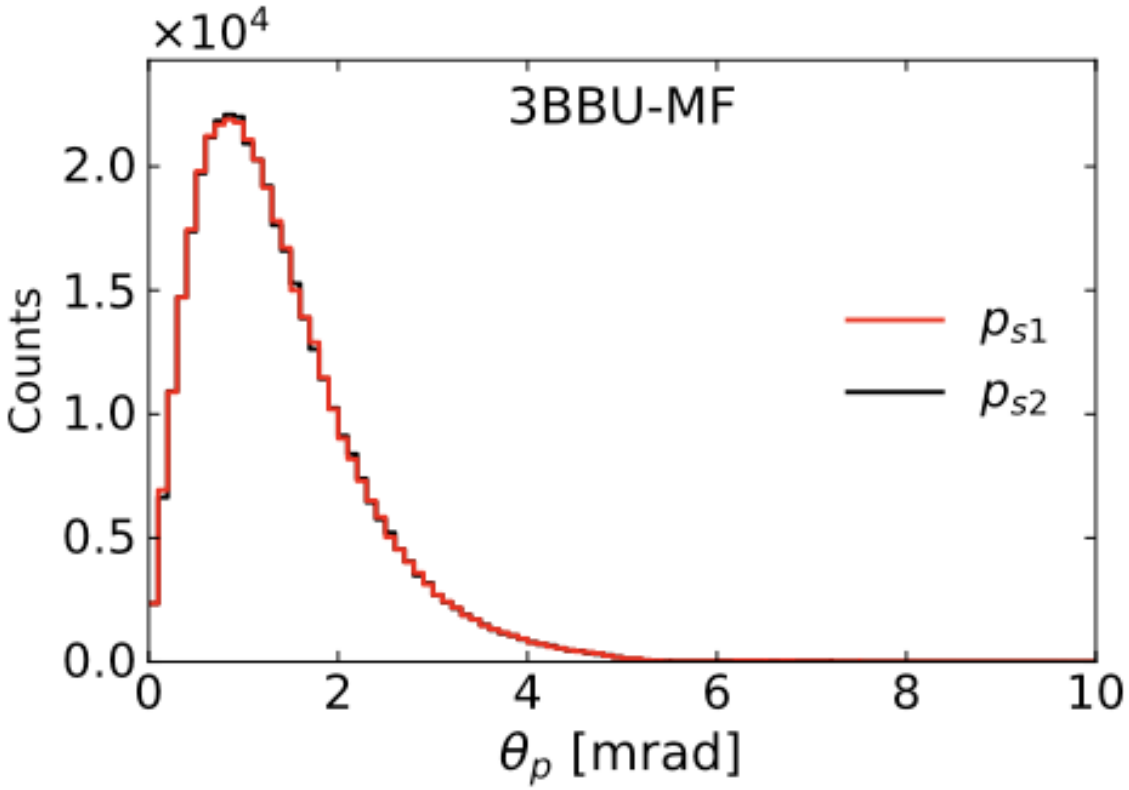
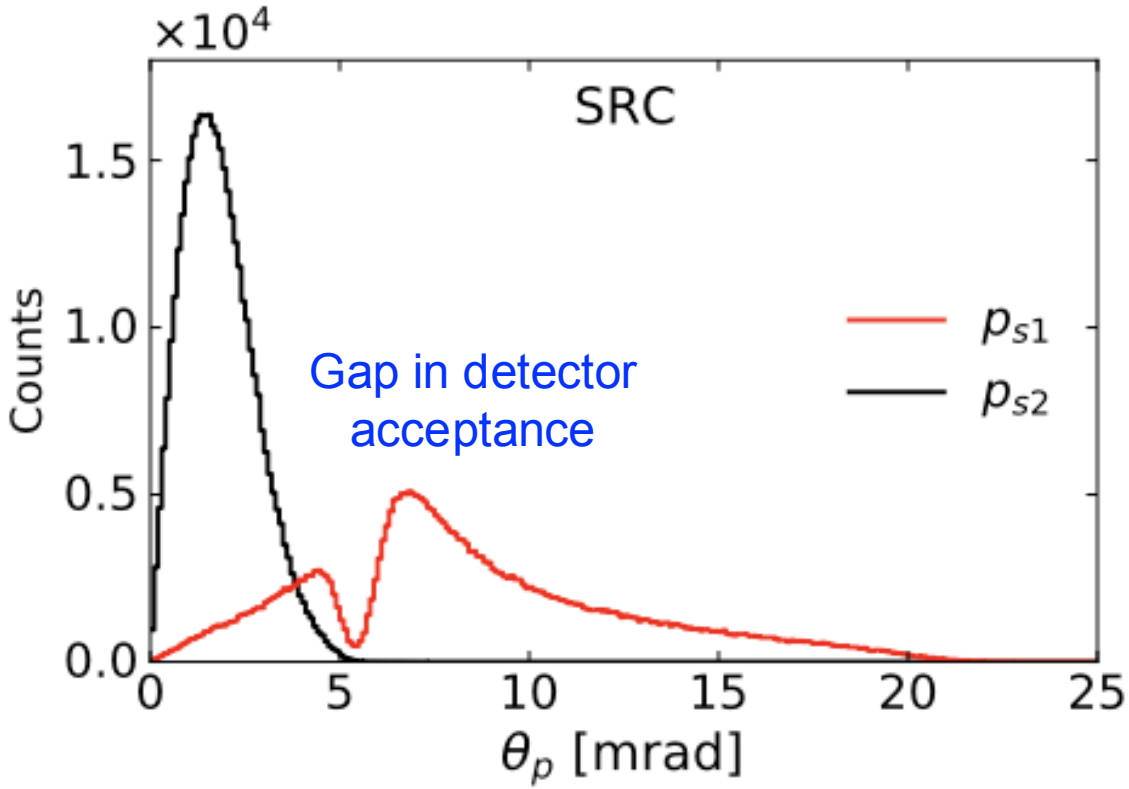
Mean-Field 3-body Breakup




Short-range Correlation Breakup




Comparing to previous figure, beam effects are included
(beam crossing angle + angular divergence/momentum spread)?
And this is tagged spectator protons by far-forward detectors (detector acceptance included)

# Next Steps

- Understand $e^3He$ event generator(s) better
  - CLASDIS and DJANGOH
  - Follow up with CLASDIS on additional procedure with Fermi motion and kinematics of spectators
- Pass through Afterburner to run IR-8 DD4hep simulation
  - Check tagged distributions
  - Look at hit information from OMD/Roman Pot and total momentum reconstruction ($|\vec{p}_{1s} + \vec{p}_{2s}|$)
- Given current pre-conceptual IR-8 design, explore capability to tag two spectators and it may provide opportunity on baseline optimization with far-forward detectors (complementarity)

# Backup Slides