



Hadron polarimetry for the Electron-Ion Collider

Ana Sofia Nunes



BROOKHAVEN
NATIONAL LABORATORY

DIS 2021

12-16 April 2021

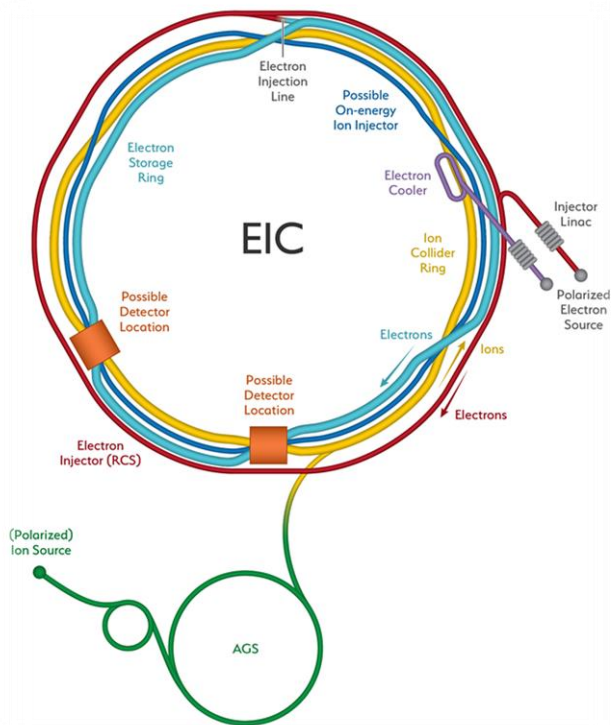
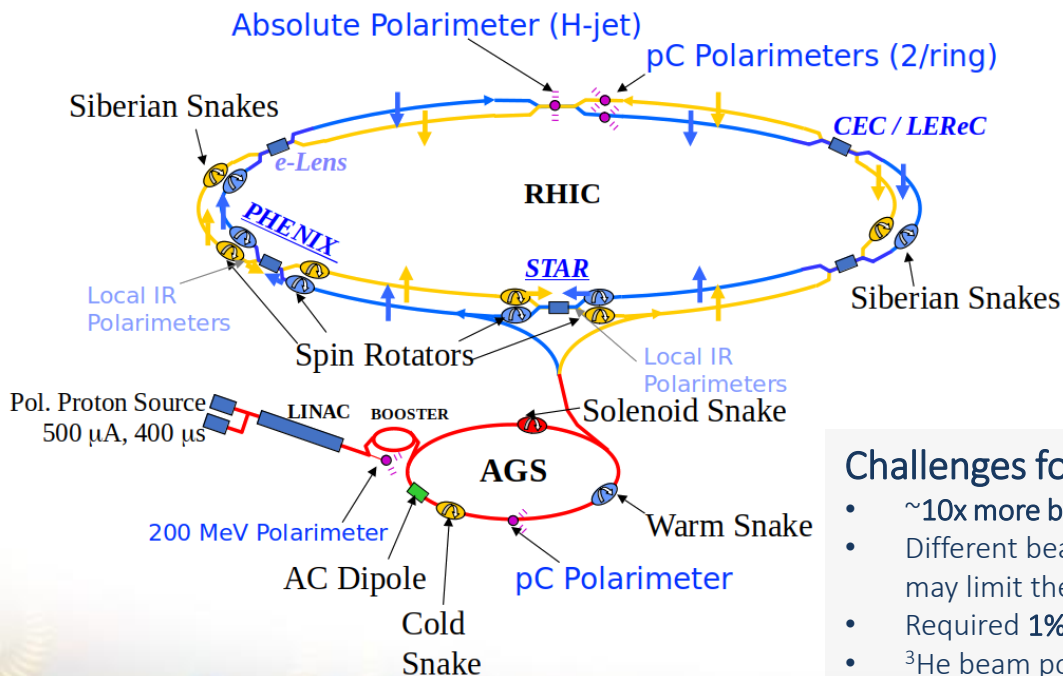
(virtual @ Stony Brook University, USA)



From RHIC to the EIC

Hadron polarimetry at RHIC:

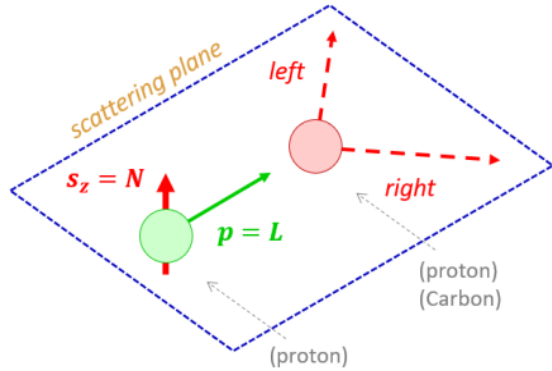
- Difficult because there is no process that allows from first principles to relate beam polarization and an observable
- Achieved $\sim 1.5\%$ systematic uncertainty in polarization measurement, polarization profile and life time, bunch by bunch



Challenges for hadron polarimetry at the EIC:

- $\sim 10\times$ more beam bunches \Rightarrow Bunches closer in time
- Different beam conditions \Rightarrow **Higher temperatures** at C wires in pC polarimeters, may limit their lifetime
- Required **1% systematic uncertainty** polarization measurement, **bunch by bunch**
- ^3He beam polarization to be measured for the first time

Hadron polarimetry method



Basis:

Elastic scattering in CNL-region

→ left-right asymmetry of recoil particles:

$$\epsilon = \frac{N_L - N_R}{N_L + N_R}$$

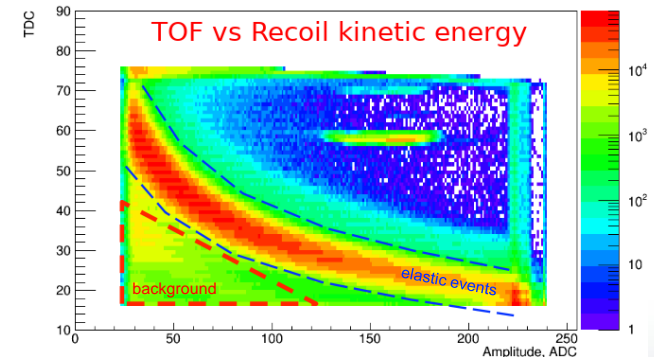
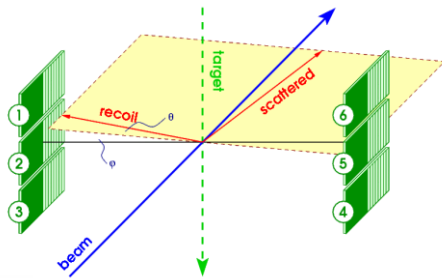
Asymmetry and polarization are related through **analyzing power**: $\epsilon = A_N P$

When one can polarize the target and measure its polarization → absolute beam polarization (as in the HJet):

$$P_{\text{beam}} = \frac{\epsilon_{\text{beam}}}{A_N} = \frac{\epsilon_{\text{beam}}}{\epsilon_{\text{target}}} P_{\text{target}}$$

Two-tier measurement @ RHIC:

- HJet to measure absolute polarization with limited statistical power
- pC polarimeters with high statistical power, to measure online polarization, polarization profile, polarization lifetime and bunch by bunch polarization



Data from pC polarimeters at RHIC, before calibration

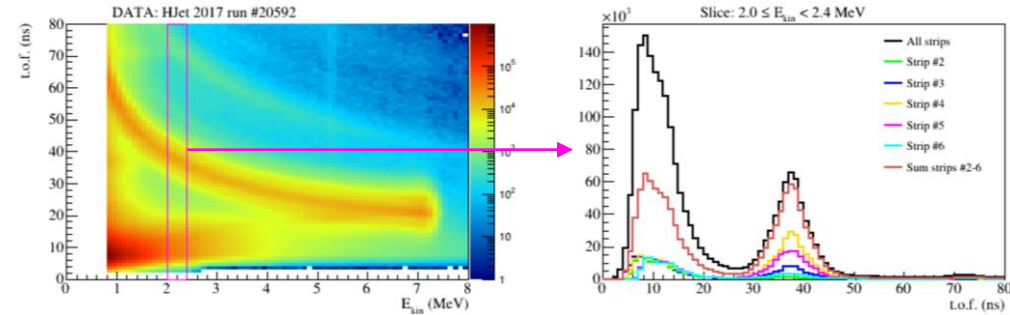
Simulations

2017 HJet Data

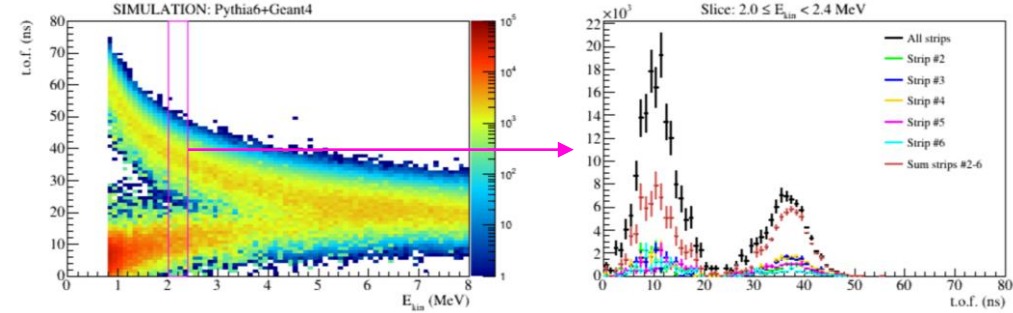
Run #20592

Simulation (Pythia6+Geant4)

1Bevents. Includes: $\sigma=3.5$ ns long bunches,
material around interaction (HJetSim, by O. Eysler)

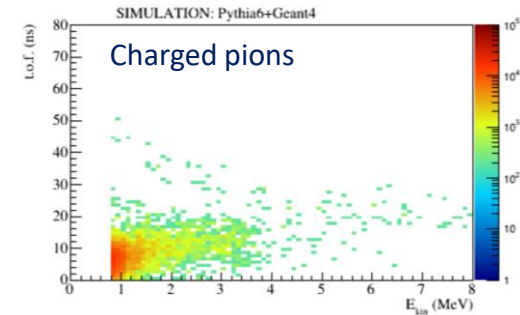


T.o.f., $2.0 < E < 2.4$ MeV, by silicon strip



T.o.f., $2.0 < E < 2.4$ MeV, by silicon strip

- Main data features are reproduced by the simulation
- Low energy, low time of flight background consist of results from charged pions, charged kaons, and a few photons and electron-positron pairs
- Pion background => motivation for their detection/vetoing with a second layer of silicon sensors
- There is still room for improvement in the background description



Summary and outlook

- The EIC will be the first collider using polarized electrons and light ion beams (protons and ^3He)
- **Challenges for the EIC:**
 - require 1% systematic uncertainty and bunch-by-bunch polarization
 - ^3He polarization measurement never done in a high energy collider
 - high bunch frequency
 - increased background sensitivity \rightarrow vetoing under investigation
 - increased beam heating of carbon targets \rightarrow new materials to be considered
- **Tests can be done at RHIC (APEX) AND AGS in the next few years:**
 - ^3He beam, unpolarized and polarized, together with ZDCs @ 18 m from HJet

pC polarimeter RHIC proton beam scan



- **Acknowledgements:**

Elke Aschenauer, Bill Schmidke, Oleg Eyser, Haixin Huang, Andrei Poblaguev, Anatoli Zelenski