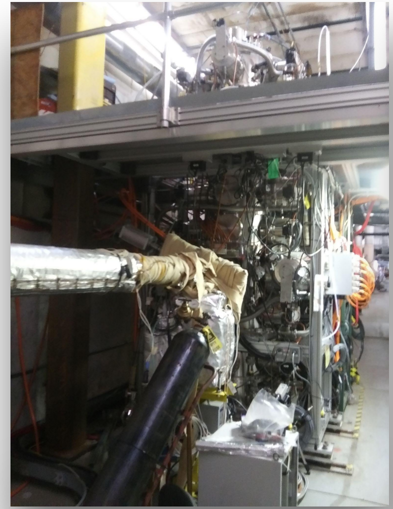
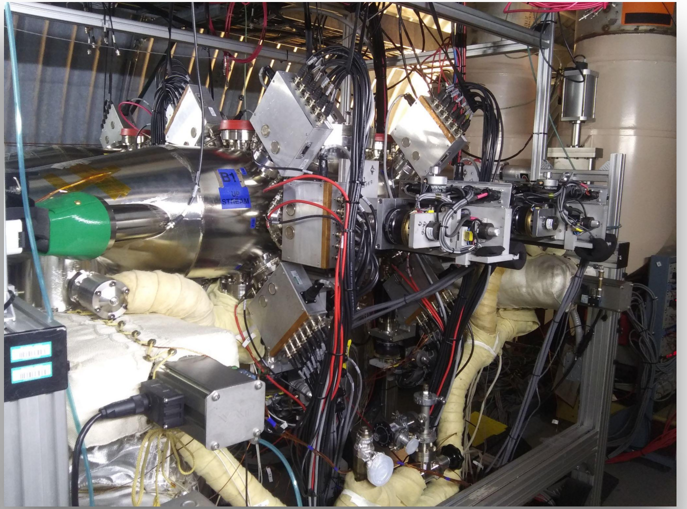
 

Simulations of hadron polarimetry: impact of second layer of silicon detectors

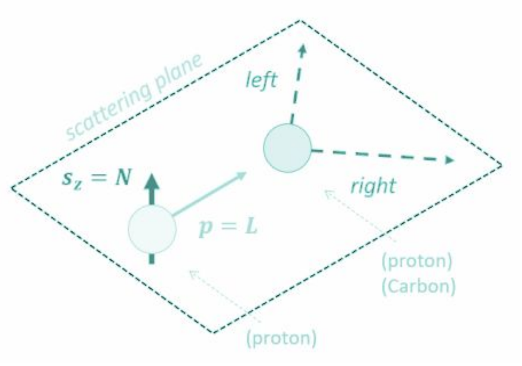
Ana S. Nunes

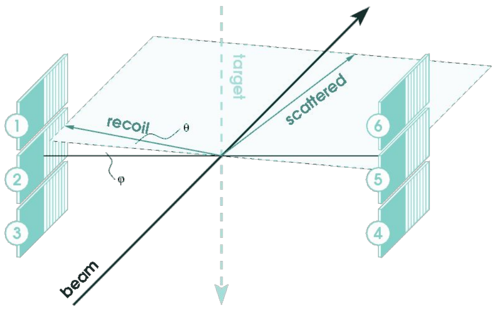
BNL/EIC Weekly Meeting

September 27th, 2021

Brookhaven National Laboratory

Hadron polarimetry: method and data



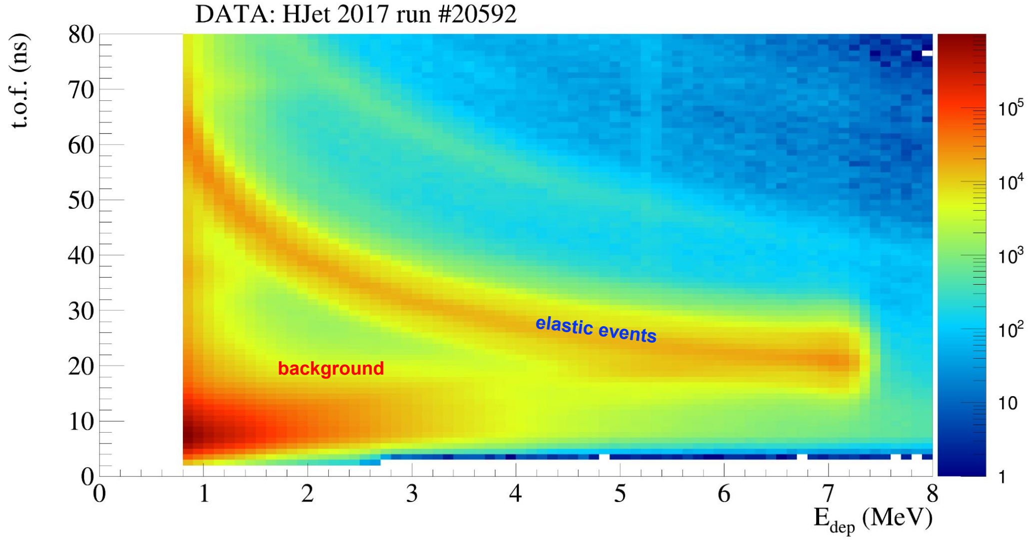


Basis:

Elastic scattering in CNI-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**: $\epsilon = A_N P$



Introduction to the HJet

Hadron polarimetry method at the HJet: based on elastic scattering pp->pp events (in the CNI interference region), selected based on t.o.f., E_{dep} and angle of recoil particle

To be understood:

Sources of background

Conditions of tests

Used in MC simulations:

Pythia6, “minimum bias” processes (11, 12, 13, 28, 53, 68, 91, 92, 93, 94, 95), E_{beam} = 255 GeV, 1B events

HjetSim (by Oleg Eyser), based on Geant4, with:

HJet width σ=26 mm

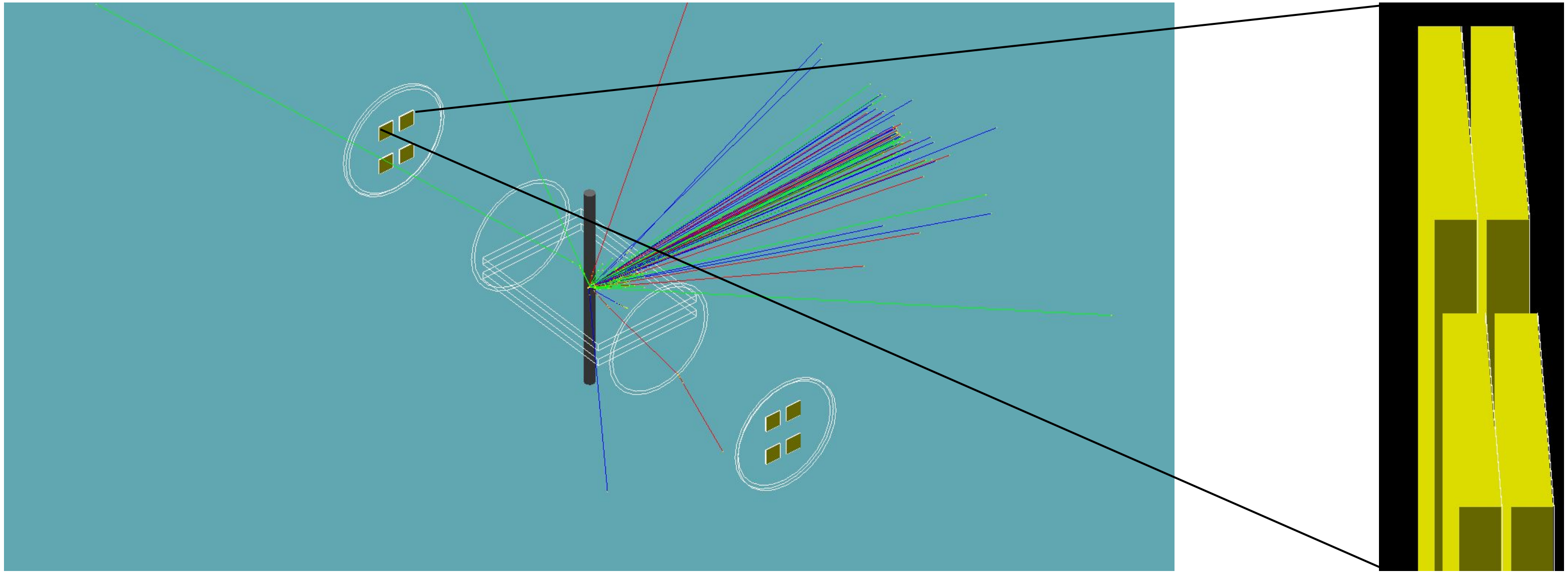
Beam bunches longitudinal extension σ=3.5 ns

Surrounding material: flanges behind the detectors, cylindrical detector chambers, “target chamber”

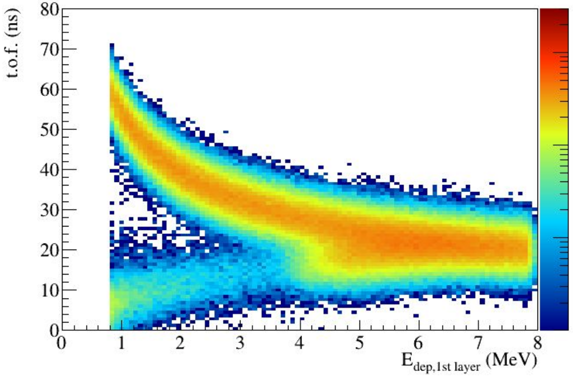
* 2 layers of silicon detectors, w/ dead layers

* W/o and w/ ceramic layer (1.6 mm of alumina)

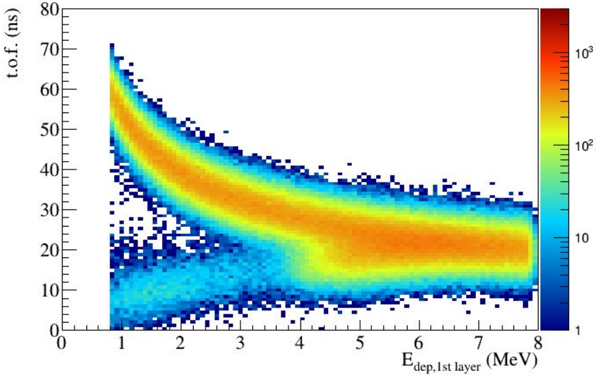
HJet: setup for simulations



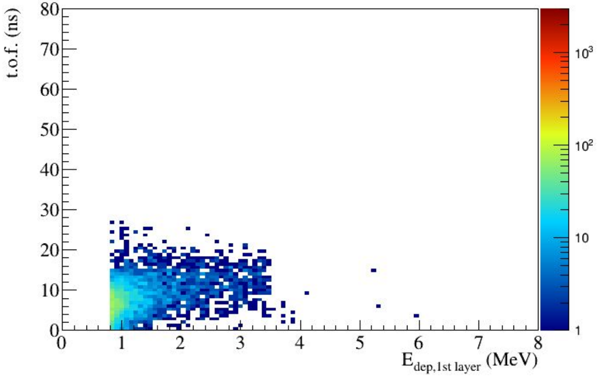
Simulation results: t.o.f. vs E_{dep}



All particles



Protons

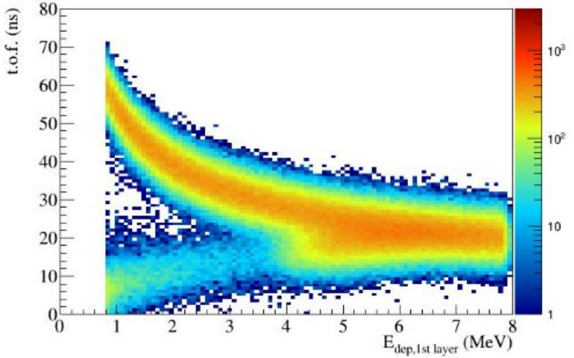


Charged pions

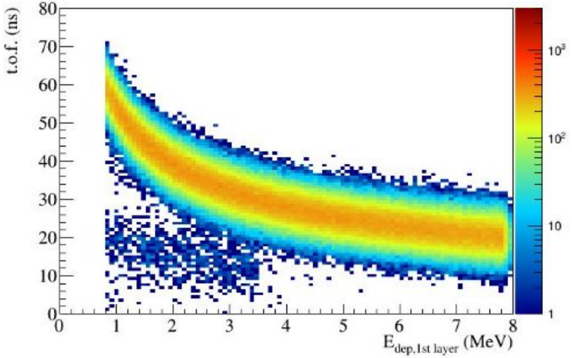
- Punch-through protons and charged pions are identified as sources of background to the elastic event selection

Using second Si layer to veto background

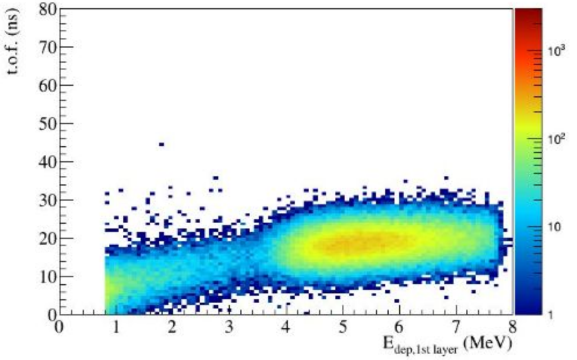
Without ceramic layer



All particles



Particles w/o hits in 2nd layer



Particles w/ hits in second layer

- **Vetoing particles that reach the second Si layer** allows to clean the sample to be used for the polarimetry measurement, by **removing both punch-through protons** and **low t.o.f. and low E_{dep} particles (charged pions)**

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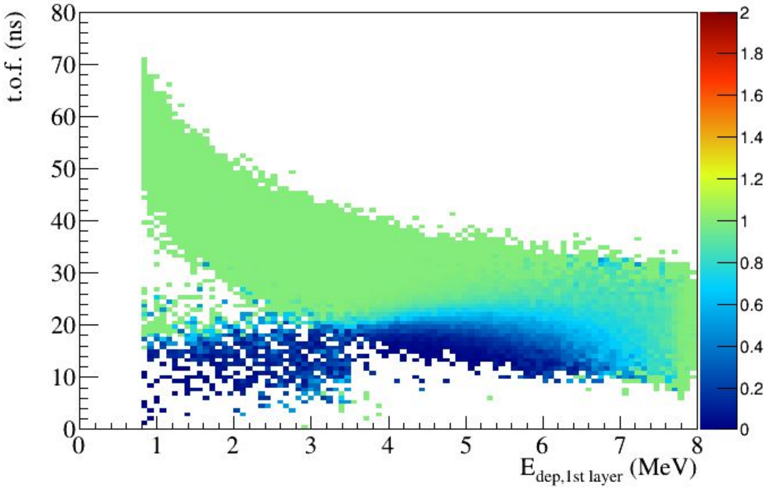
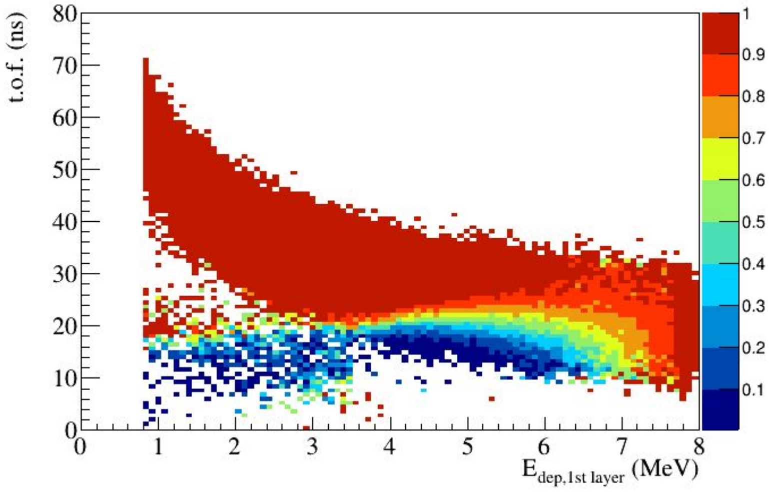
Fraction of particles surviving after veto





- **Vetoing particles that reach the second Si layer** allows to clean the sample to be used for the polarimetry measurement, by **removing both punch-through protons** and **low t.o.f. and low E_{dep} particles (charged pions)**

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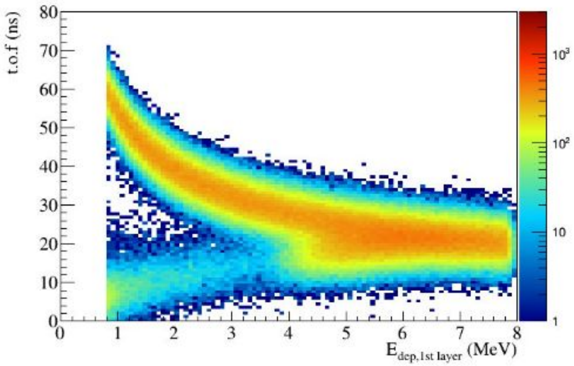
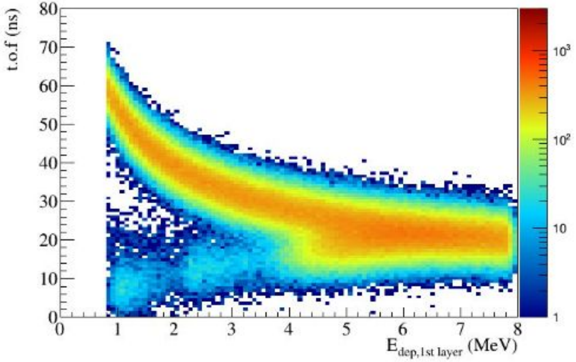
Including a ceramic layer in between Si

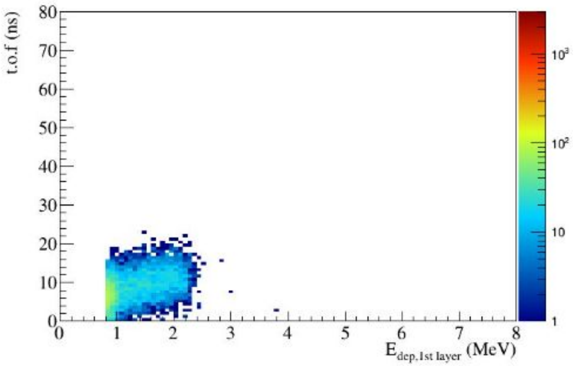
With ceramic layer, 1.6 mm thickness



All particles



Particles w/o hits in 2nd layer



Particles w/ hits in second layer

- The **presence of a ceramic layer**, as was used in previous tests, limits the particles that reach the second layer of Si, thereby **limiting the effectiveness** of its use for sample cleanup

Introduction to the pC polarimeters

Hadron polarimetry method at the pC polarimeters: based on elastic scattering pC->pC events (in the CNI interference region), selected based on t.o.f. and E_{dep} of recoil particle

To be understood:

Sources of background

Conditions of tests

Used in MC simulations:

Dpmjet3, “minimum bias” processes except elastic scattering, E_{beam} = 255 GeV, 1M events

Adapted **HjetSim** (by Oleg Eyser), based on Geant4, with:

Thin carbon ribbon as target

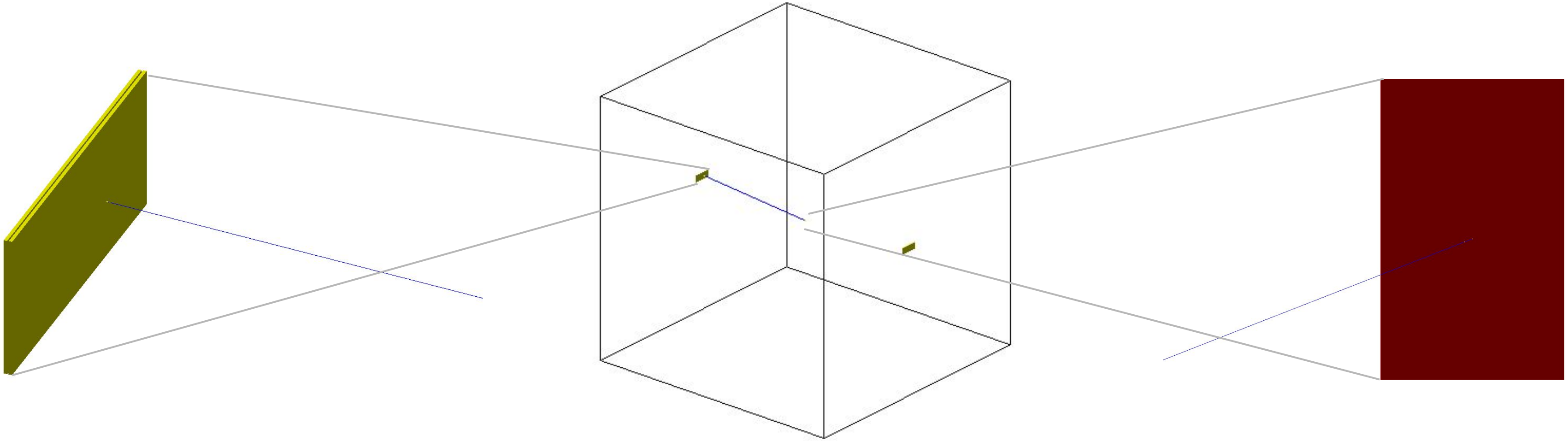
Beam bunches longitudinal extension σ=3.5 ns

Surrounding material

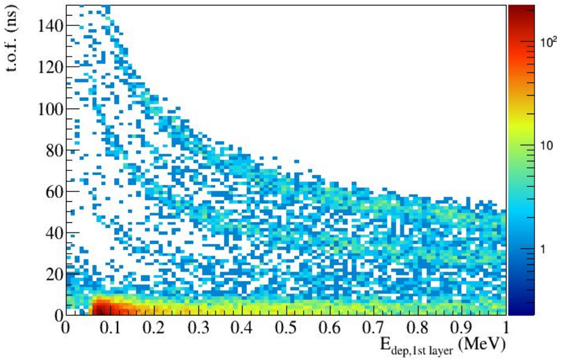
* 2 layers of silicon detectors

Also thanks to Jaroslav Adam who adapted hepevt class to also read nuclei

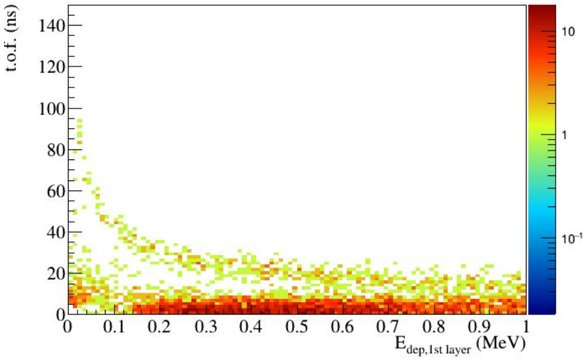
pC polarimeters: (simplified) setup used for simulations



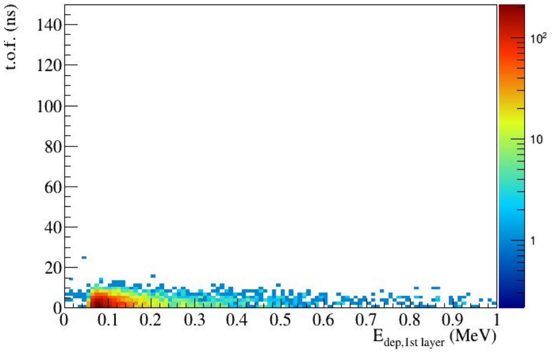
Simulation results: t.o.f. vs E_{dep}



All particles



Protons

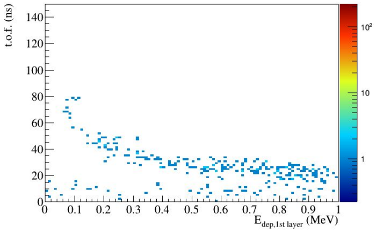


Charged pions

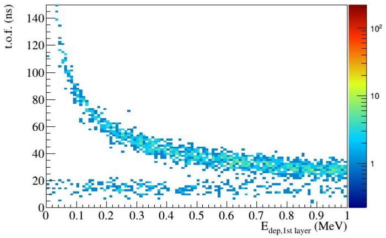
Simulation results: t.o.f. vs E_{dep}

Generator: Dpmjet3 (not including elastic scattering; simulating the background to the elastic pC→pC events)

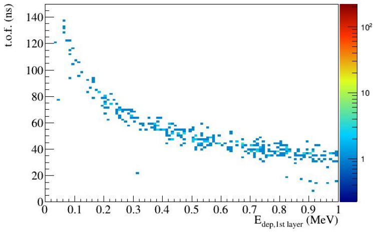
H



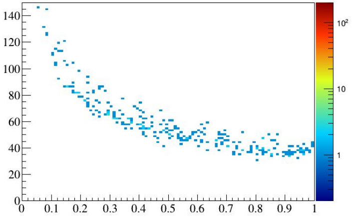
He



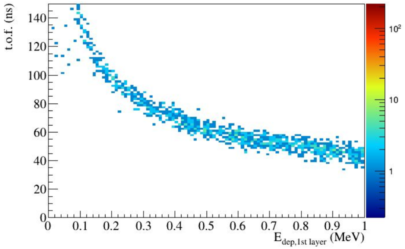
Li



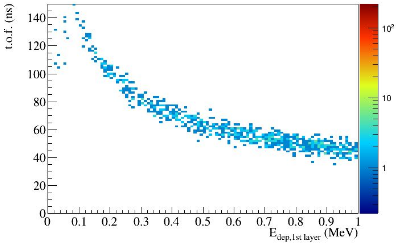
Be



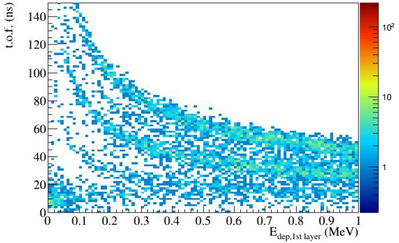
B



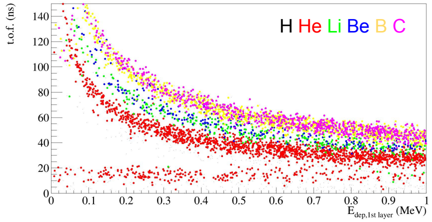
C



all nuclei (A>=1)

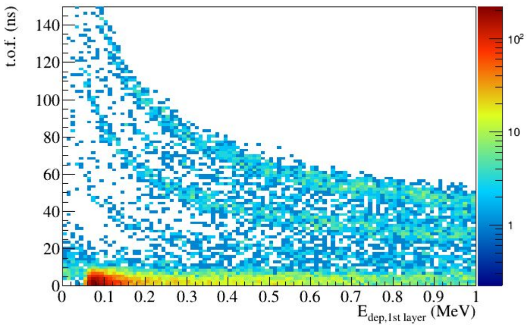


all isotopes (A>=1)

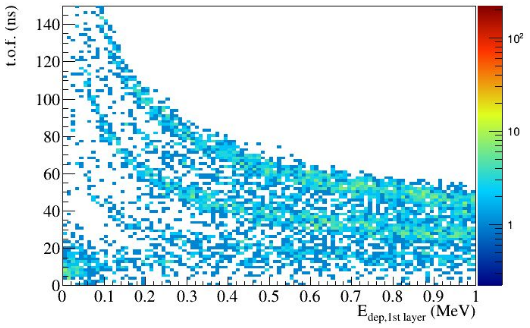


pC polarimeters: impact of Si second layer

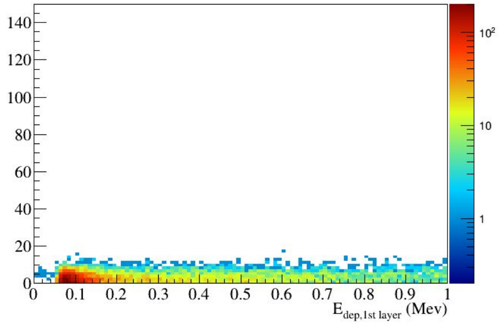
Generator: Dpmjet3 (not including elastic scattering; simulating the background to the elastic pC→pC events)



All particles



Particles w/o hits in 2nd layer



Particles w/ hits in 2nd layer

- The second layer of silicon allows to **veto particles of very low t.o.f.**

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Summary

For the HJet:

The background at low t.o.f. and low E_{dep} is composed of charged pions

A second layer of Si detectors can in principle be used to veto punch-though protons and background charged pions

The presence of a ceramic layer reduced the effectiveness of the veto

For pC polarimeters:

A double layer of silicon can veto particles only at very low t.o.f., below ~10 ns

Backup

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HJet Simulation

Event generator: Pythia 6, "minimum bias" process mix

$11: f_i f_j \to f_i f_j$

$12: f_i \bar{f}_i \to f_k \bar{f}_k$

$13: f_i \bar{f}_i \to f_k \bar{f}_k$

$28: f_i g \to f_i g$

$53: gg \to f_k \bar{f}_k$

$68: gg \to gg$

91 : elastic scattering

92 : single scattering ($AB \to XB$)

93 : single scattering ($AB \to XA$)

94 : double diffraction

95 : low $p_\perp$ production

E_{beam} = 255 GeV

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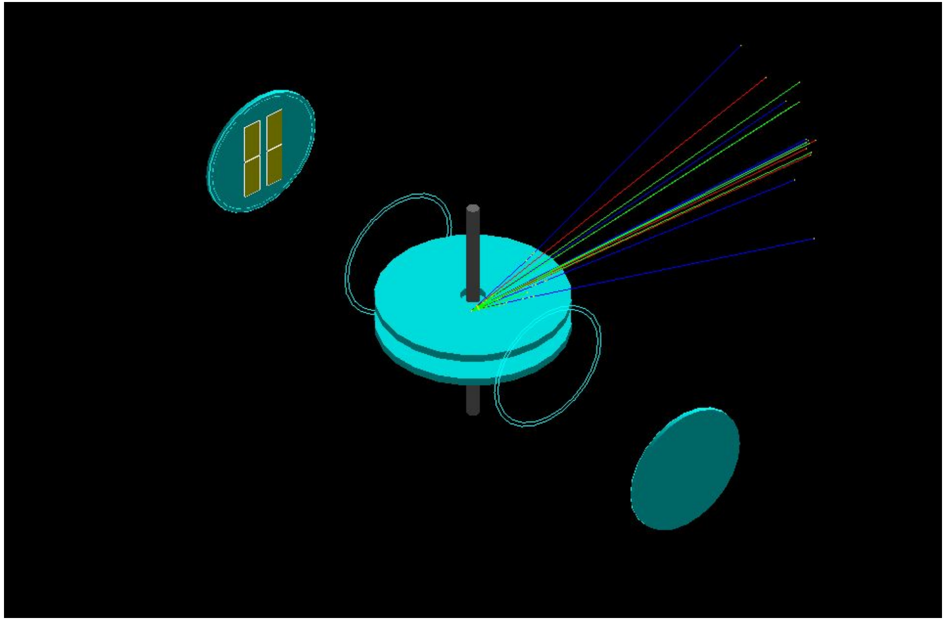
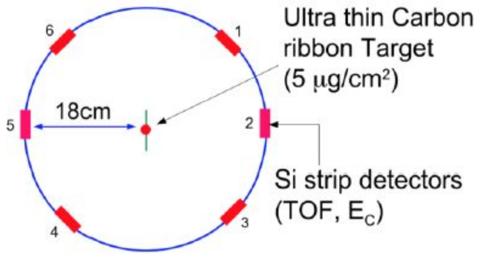
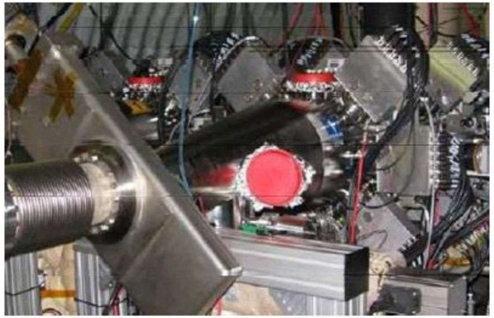
Passage through matter: Geant 4 (HJetSim, by Oleg Eyser)



Local Hadron Polarimetry

- Measurement of the polarization vector at the interaction point (IP-6)
  - Inside spin rotators and crab cavities
  - Ensure longitudinal polarization orientation
- Non-destructive with minimal impact on beam lifetime
- Rapid, quasi-online analysis for fast feedback during accelerator setup
- Elastic recoil from ultra-thin Carbon target
- Silicon strip detectors
  - Measure energy and time-of-flight
- Move part of the setup from RHIC IP-12 to EIC IP-6
  - Vacuum chamber, target station, detector chambers
- Modify detector setup for improved inelastic background rejection
- Modify readout for reduced bunch spacing
- Identify adequate target material for EIC conditions
  - Target heating from beam





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