Polarimetry

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LHCspin Kickoff Meeting

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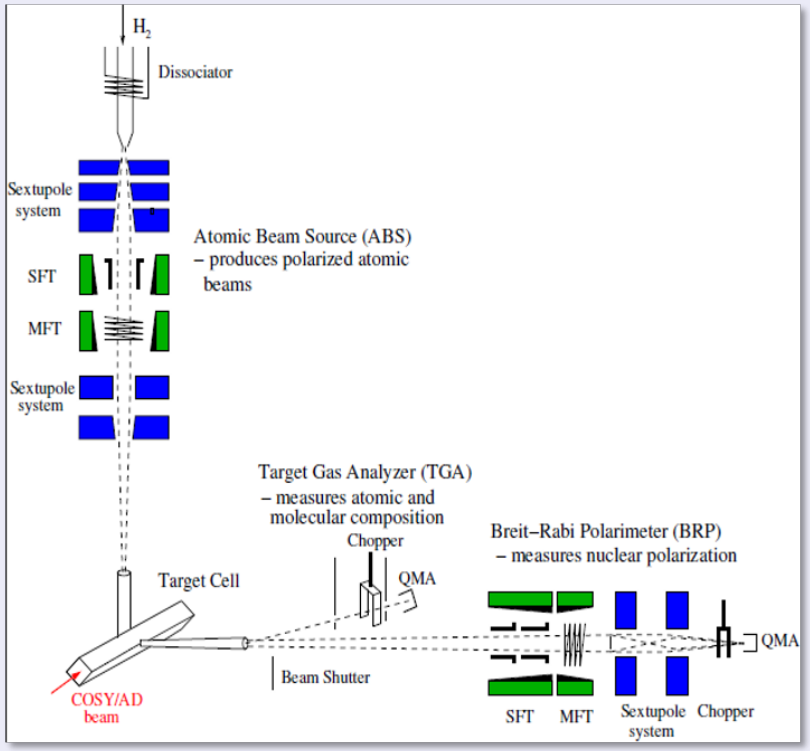
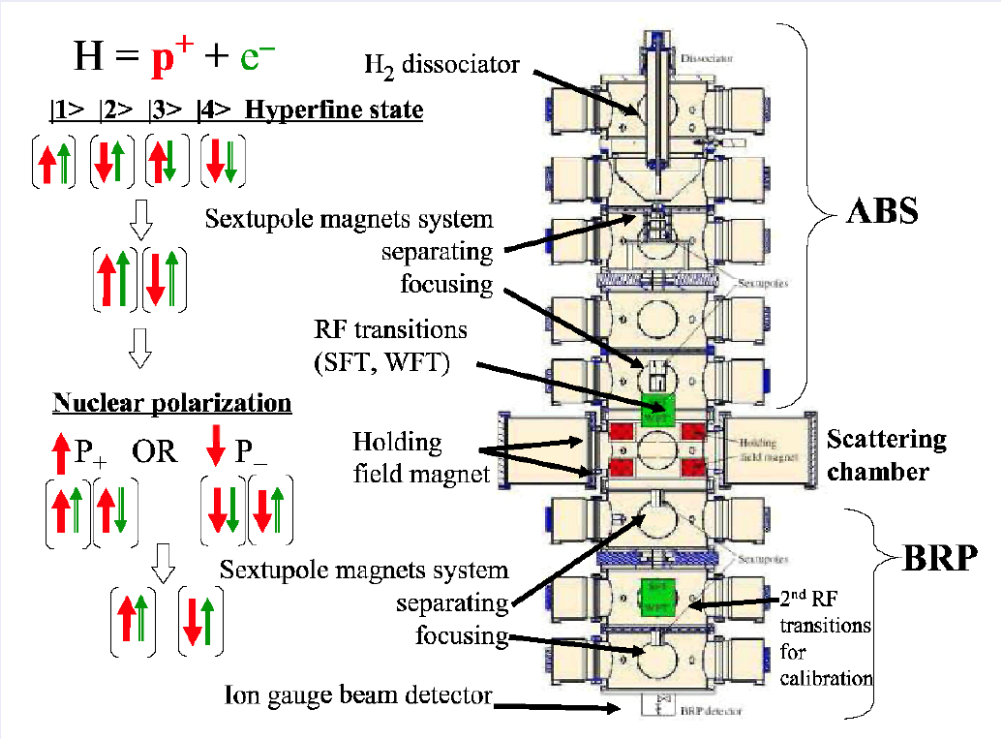
Atomic beam source with Breit-Rabi polarimeter (BRP)

Storage cell vs free jet





Breit-Rabi polarimeter

- Stern-Gerlach effect + RF-transition to determine HFS occupation number
- Only sensitive to atomic polarization (no information on molecules)
- Viable solution for free-get target ($\rightarrow$ A. Nass' talk)
  - Measured polarization at RHIC: $P_{target} = 92.4\ \% \pm 1.8\ \%$

Polarization measurement with BRP as Sampling Polarimeter

Polarization in a Storage Cell

$$P_T = \alpha_0 \alpha_r P_a + \alpha_0 (1 - \alpha_r) P_m$$

- $P_T \equiv$ total target polarization
- $\alpha_0 \equiv$ atomic fraction in absence of recombination
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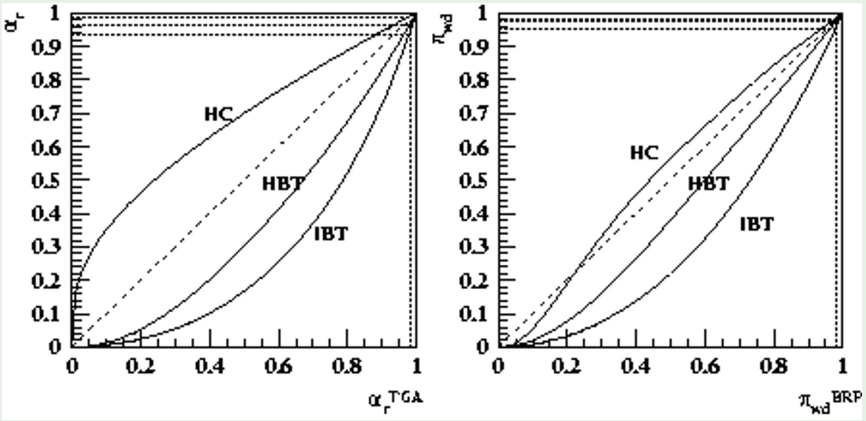
- $\alpha_r = c_\alpha \alpha_r^{TGA}$
- $P_a = c_P P_a^{BRP}$



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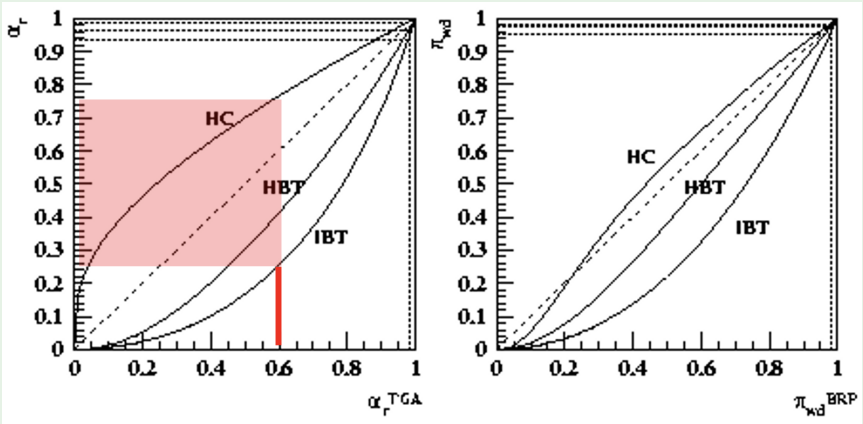

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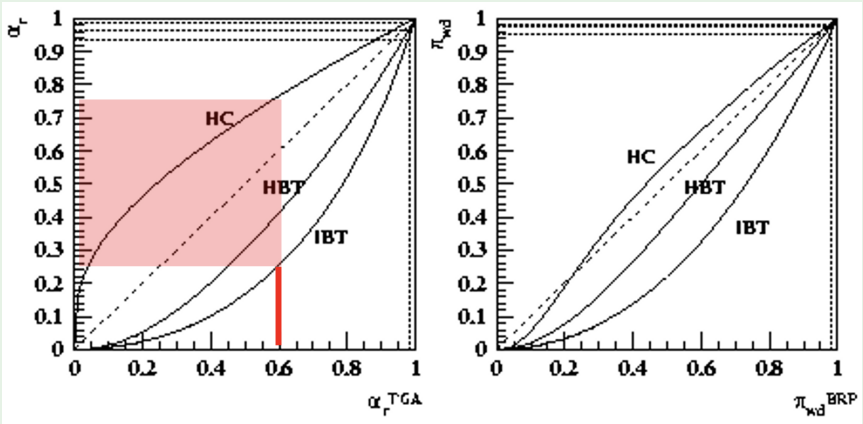
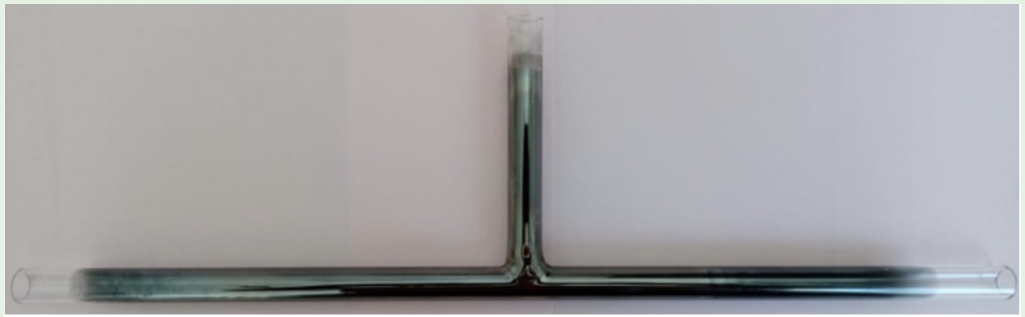


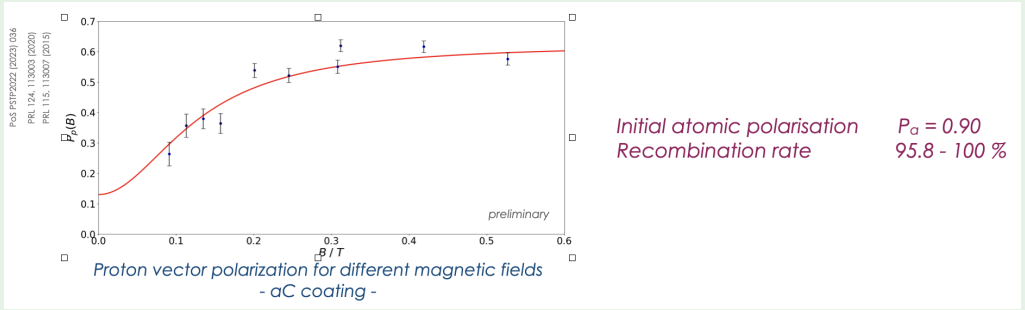
Limits of sampling polarimetry with BRP

- Systematic error increases with recombination and depolarization
- Not able to measure molecular polarization

Measurement at FZ-Jülich and Perspectives

Quartz cell coated with amorphous carbon





- Result: recombined molecules preserve polarization! → talk by R. Engels
- Option for a polarized molecular target
  - →Note: polarization at 100 K constitutes a lower limit from 300 K

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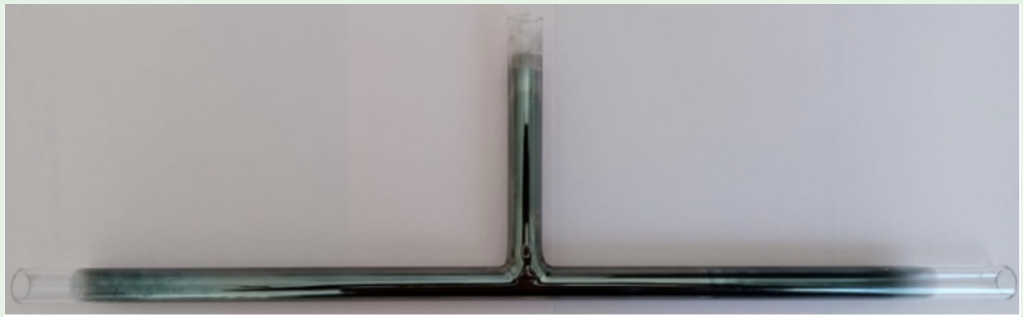

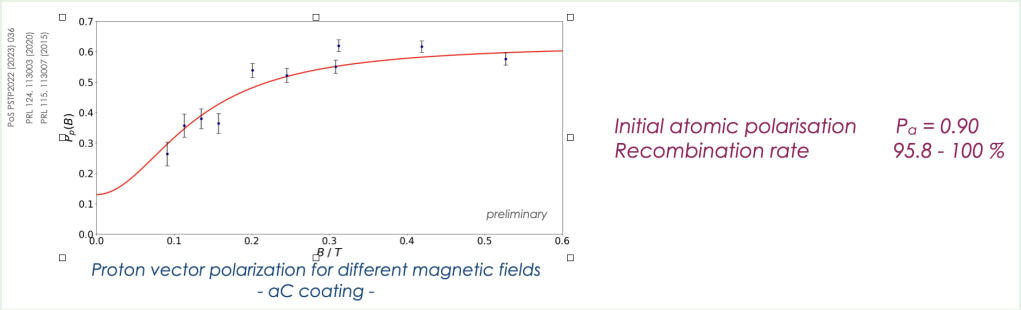

Proton vector polarization for different magnetic fields
- aC coating -

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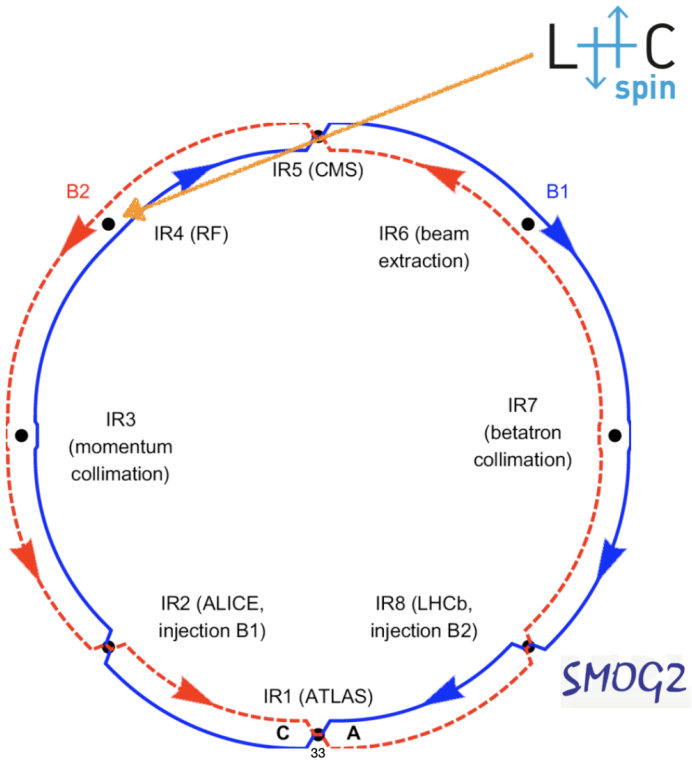
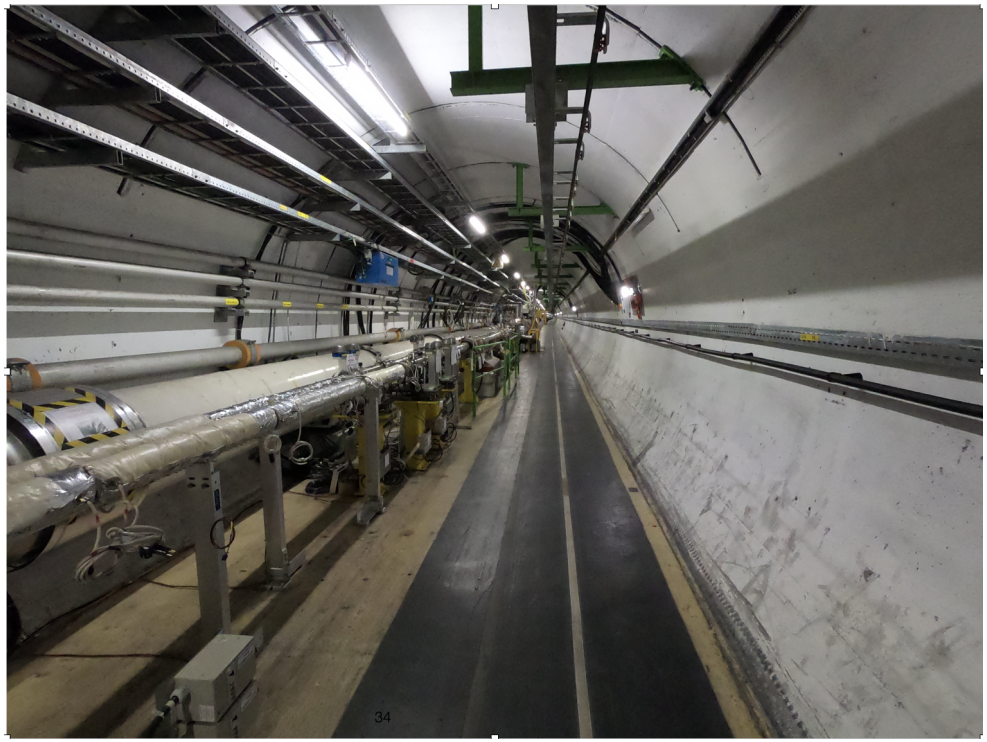
  - →Note: polarization at 100 K constitutes a lower limit from 300 K

1 - Investigations at Ferrara setup

- Measurement not repeatable at FZJ
- Option at Ferrara setup: installation of an amorphous carbon coated cell
  - Measurement of recombination (TGA)
  - Measurement of residual atomic polarization (BRP)

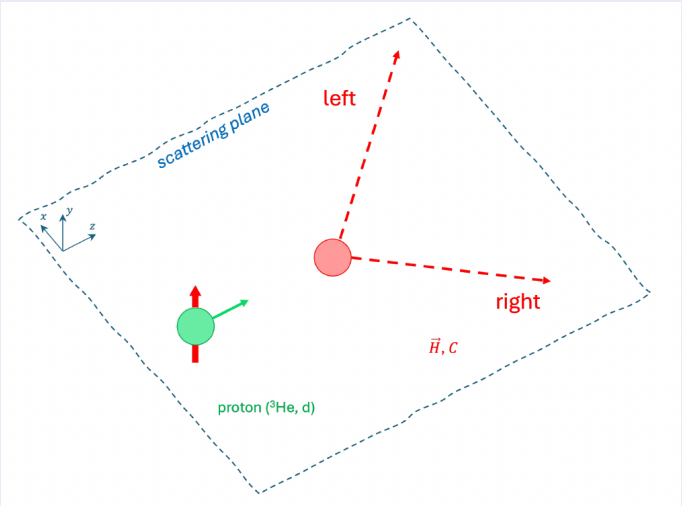
Polarized jet target at LHC Interaction Region 4





Polarization Measurement by Scattering Asymmetry

Spin-dependent cross section



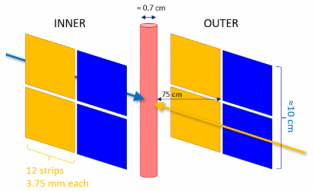
- $\sigma = \sigma_0(1 + A_y P_y cos\phi)$
  - σ_0 : unpol. cross section
  - P_y: target polarization
  - A_y: analyzing power
  - ϕ: azimuth of scattered particle

Coulomb Nuclear Interference (CNI)

- A_y: polarization sensitivity of the scattering process
- Interference of EM and strong interaction $\Rightarrow$ sizable A_y for elastic pp scattering

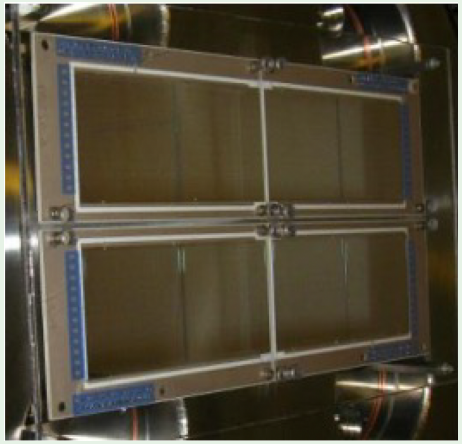
Polarimetry with CNI at RHIC

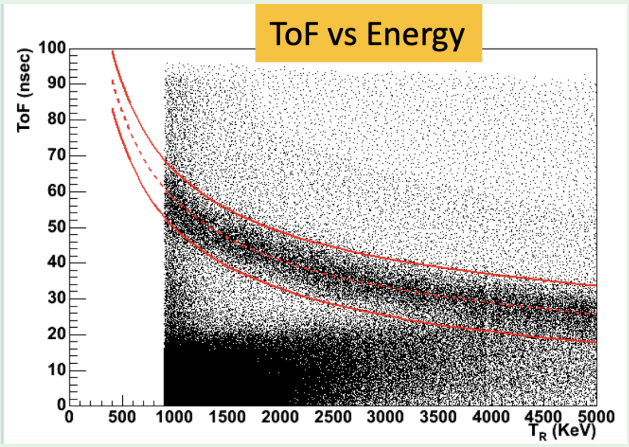
Recoil spectrometer at RHIC

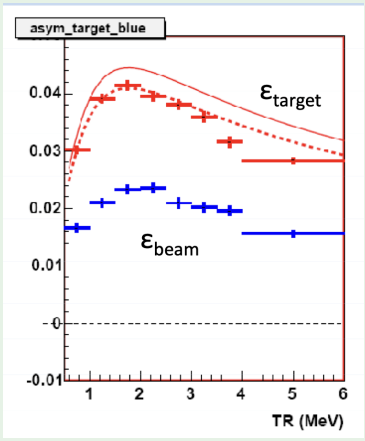


Eight Si strip detect.

- 12 vertical strips
- 3.75 mm pitch
- 500 µm thickness





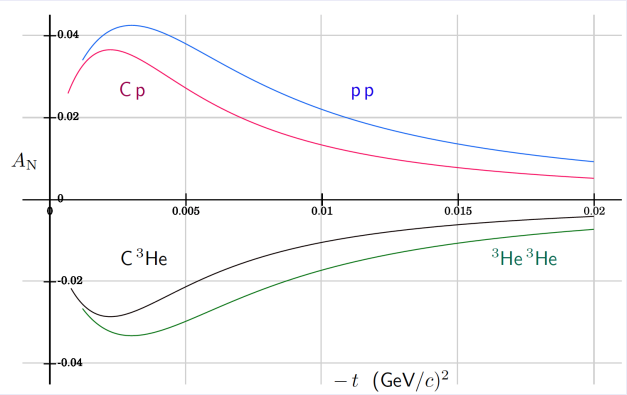


- Si detectors measure T_R & ToF of recoil proton.
- Correlations (T_R & ToF) and (T_R & θ_R) $\rightarrow$ elastic process
- Asymmetry: $\epsilon = \frac{L-R}{L+R} = A_y \cdot P_y cos\phi \Rightarrow$ derivation of P_y
- Note: sign of P_y periodically reversed to minimize systematic effects

Test of absolute polarimetry at IR4

Theoretical predictions (N. Buttimore, Ferrara - 16.07.19)

- Analyzing power:



- Cross section at 7 TeV: σ_{tot} = 47 mb (255 GeV: σ_{tot} = 39.2 mb).
- Recoil energies at 7 TeV: 1.7 MeV $< T_R <$4.6 MeV
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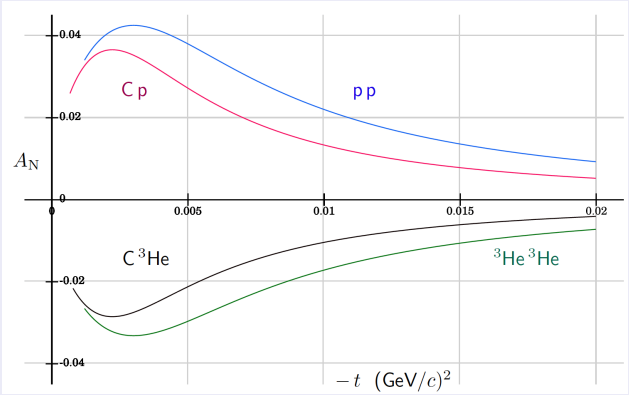

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- ABS (jet target) + BRP + recoil detector ($\geq$ 500 μm Si stop 5 MeV protons)
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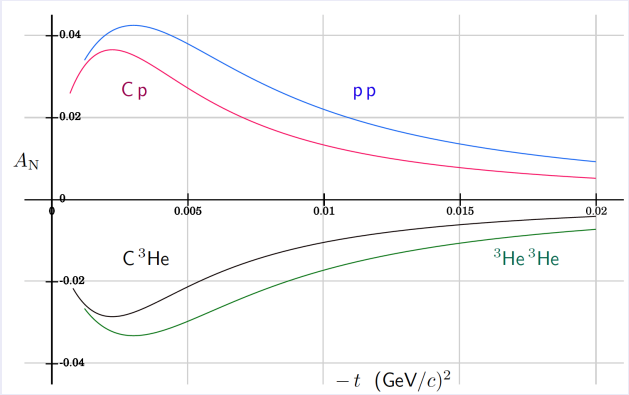

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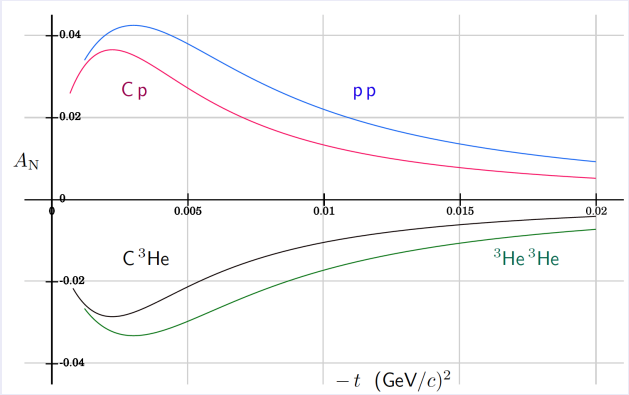

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- Chamber design and wake fields' simulation ($\rightarrow$ Anna's talk)

Perspectives for polarimetry at LHCb

Stage 1 at IR4: ABS (jet target) + BRP + recoil detector (RD)

- BRP + RD
  - Validation of theoretical predictions of analysing power at 7 TeV

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Stage 2 at LHCb: ABS + storage cell + BRP + RD

- Option1: implementation of RD at the end of the cell ($\rightarrow$ Dima's talk)
- Option 2: implementation of the RD in the middle of the a cell with "windows"
  - $\rightarrow$ Cell with two sample tubes in the center with geometrical projection?
- Additional requirements:
  - BRP in front of ABS for tuning of RF transitions
    - $\rightarrow$ might depend on the measurements at Ferrara setup
  - Unpolarized gas for absolute calibration of target density

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- Magnetic holding field and homogeneity
- Beam induced depolarization in a molecular polarized target

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Fallback solution

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