Central PAX Physics Case:

Transversity distribution of the nucleon in Drell-Yan:

→ FAIR as successor of DIS physics

- last leading-twist missing piece of the QCD description of the partonic structure of the nucleon

- observation of $h_1^q (x,Q^2)$ of the proton for valence quarks ($A_{TT}$ in Drell-Yan >0.2)
  - transversely polarized proton beam or target (√)
  - transversely polarized antiproton beam (✗)
Principle of Spin Filtering

\[ \sigma_{\text{tot}} = \sigma_0 + \sigma_\perp \cdot \vec{P} \cdot \vec{Q} + \sigma_\parallel (\vec{P} \cdot \vec{k})(\vec{Q} \cdot \vec{k}) \]

- \( \sigma_0 \) is the unpolarized fraction.
- \( \sigma_\perp \) and \( \sigma_\parallel \) are the polarized fractions along perpendicular and parallel directions, respectively.
- \( \vec{P} \cdot \vec{k} \) and \( \vec{Q} \cdot \vec{k} \) are the polarization vectors.

P beam polarization:
Q target polarization:
k \parallel beam direction

For initially equally populated spin states: \( \uparrow (m=+\frac{1}{2}) \) and \( \downarrow (m=-\frac{1}{2}) \)

**transverse case:**
\[ \sigma_{\text{tot} \pm} = \sigma_0 \pm \sigma_\perp \cdot Q \]

**longitudinal case:**
\[ \sigma_{\text{tot} \pm} = \sigma_0 \pm (\sigma_\perp + \sigma_\parallel) \cdot Q \]
Principle of Spin Filtering

\[ \sigma_{\text{tot}} = \sigma_0 + \sigma_\perp \cdot \vec{P} \cdot \vec{Q} + \sigma_\parallel \cdot (\vec{P} \cdot \vec{k})(\vec{Q} \cdot \vec{k}) \]

P beam polarization
Q target polarization
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Spin Filtering Tests at TSR (MPI Heidelberg)

Experimental Setup

Results

F. Rathmann. et al., PRL 71, 1379 (1993)
Interpretations of the result

- Observed polarization cross section: \( \sigma_{\perp} = 72.5 \pm 5.8 \text{ mb} \)
- 1994, Meyer and Horowitz: scattering off polarized nuclei and spin transfer from polarized electrons \( \Rightarrow \sigma_{\perp} = 65 \text{ mb} \)
- 2001, Milstein and Strakhovenko + Nikolaev and Pavlov: only selective removal through scattering off nuclei beyond the acceptance angle \( \Rightarrow \sigma_{\perp} = 85.6 \text{ mb} \)

\( \Rightarrow \) Further experimental tests necessary to disentangle the effects of electrons and nuclei \( \Rightarrow \) experiments with protons at COSY (Jülich):
  - Depolarization measurements
  - Spin Filtering experiments with polarized target

No data to predict polarization for filtering antiprotons
\( \Rightarrow \) Spin Filtering measurements with antiprotons at AD (CERN)
Requirements for Spin Filtering

- High polarization of an internal gaseous target with areal densities up to $10^{15}$ atoms/cm$^2$ using a storage cell
- Low beta section to be able to pass the stored p/p beam through the cell (see talk of A. Garishvili)
- Ability to produce and measure electron and nuclear polarization of the H and D target gas with variable target holding fields
- Implementation of a siberian snake for longitudinal spin filtering
Setup of the Polarized Target

- Production of a polarized atomic beam by an atomic beam source (ABS)
- Increase of the target density by means of a storage cell
- Analysis of target polarization by a so-called Breit-Rabi polarimeter (BRP) and a target gas analyzer (TGA)
- Calibration of the BRP by means of pp-scattering data
The Polarized Atomic Beam Source

- Former HERMES ABS rebuilt with modified vacuum system (cryo pumps replaced by turbo-molecular pumps and new forevacuum system) on a new support
- New cabling for fast installation and removal and new interlock system
- Vacuum system with the microwave dissociator is running
- Construction of an analysis chamber with QMS and compression tube
- First intensity measurements done (intensities up to $6 \times 10^{16}$ atoms/s)
Performance of the new Vacuum System

<table>
<thead>
<tr>
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<th>Forevacuum</th>
<th>Chamber pressures</th>
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<tr>
<td></td>
<td>PIR 1 (mbar)</td>
<td>PIR 2 (mbar)</td>
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<tr>
<td>base pressure</td>
<td>5x10^{-4}</td>
<td>1x10^{-3}</td>
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<tr>
<td>H\textsubscript{2} part. pressure with 90 sccm H\textsubscript{2} gasinlet</td>
<td>2x10^{-2}</td>
<td>3x10^{-2}</td>
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<tr>
<td>MW-dissociator running</td>
<td>2x10^{-2}</td>
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Sufficient pumping speed of new forevacuum system
Storage Cell and Holding field

- Filtering requires $10^{15}$ atoms/cm$^2$ therefore use of storage cell
- Use of Teflon foil to detect recoils and suppress depolarization and recombination
- Openable cell to allow injected uncooled AD beam to pass
- Weak holding field coils included in cell design to define spin axis
- Additional superconducting Helmholtz coil to provide a strong longitudinal holding field
The Breit-Rabi Polarimeter

- Former HERMES BRP rebuilt on a new support with modifications due to new configuration with the ABS
- Tracking calculations lead to modified sextupole magnet configuration for 300 K effusive hydrogen / deuterium beam
- New strong field transition cavity for hydrogen and deuterium
- New cabling and interlock system are currently installed
New dual cavity for the BRP

- 2 different frequencies needed for hydrogen and deuterium transitions without mechanical changeover
- Construction of a dual cavity with 2 pairs of resonator rods and trim capacitors for tuning
- Tuning using a Spectrum Analyzer successful
- Test with atomic beam to be done in 2008
Flow limiters to reduce gas flow into the adjacent sections

Pump with cold surfaces of the superconducting quadrupoles
Silicon Detectors

- Measurements of beam polarization using pp (\(\bar{p}p\))-elastic scattering at COSY (AD)
- Good azimuthal resolution (up/down asymmetries)
- Low energy recoils (<8 MeV) detected by silicon telescopes
Transverse & Longitudinal Filtering

- Use of the WASA and electron cooler solenoid to form a Siberian snake at COSY for long. filtering

- Implementation of a Siberian snake into AD
Planned measurements

- Depolarization measurements with unpolarized helium and deuterium target and initially polarized proton beam in 2007/08
- Filtering measurements with pure electron polarized hydrogen target and pure nuclear polarized hydrogen in a strong magnetic holding field at COSY using a proton beam to determine the effect of electrons and nuclei separately in 2009/10
- Filtering measurements at AD with nuclear polarized hydrogen and deuterium target in a weak magnetic holding field and an antiproton beam to show the ability of the method to produce polarized antiprotons in 2010/11
Summary

Experimental tests necessary:

• needs substantial funding!
• new collaborators welcome!