Acceleration, Storage and Polarimetry

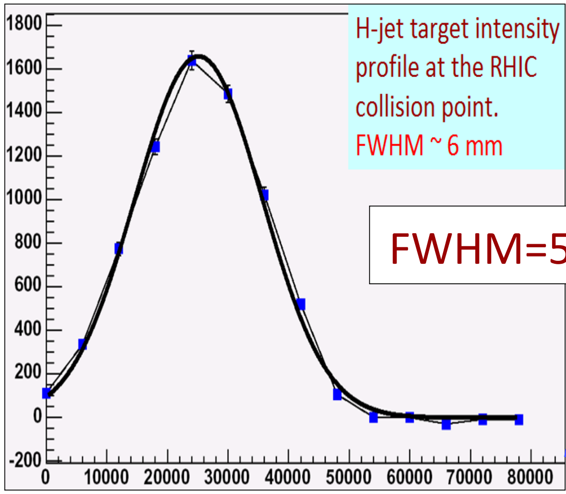
Conveners: V.Ptitsyn, E.Stephenson

Total of 17 talks presented in parallel sessions

Major areas covered:

- ❖RHIC polarimetry and spin flipper (4 talks)
- ❖NICA polarimetry developments (3 talks)
- ❖EDM developments (3 talks)
- ❖Electron polarimetry (MESA and others) (3 talks)
- ❖EIC polarization designs and simulations (4 talks)

H -jet polarimeter



FWHM=5.5 mm

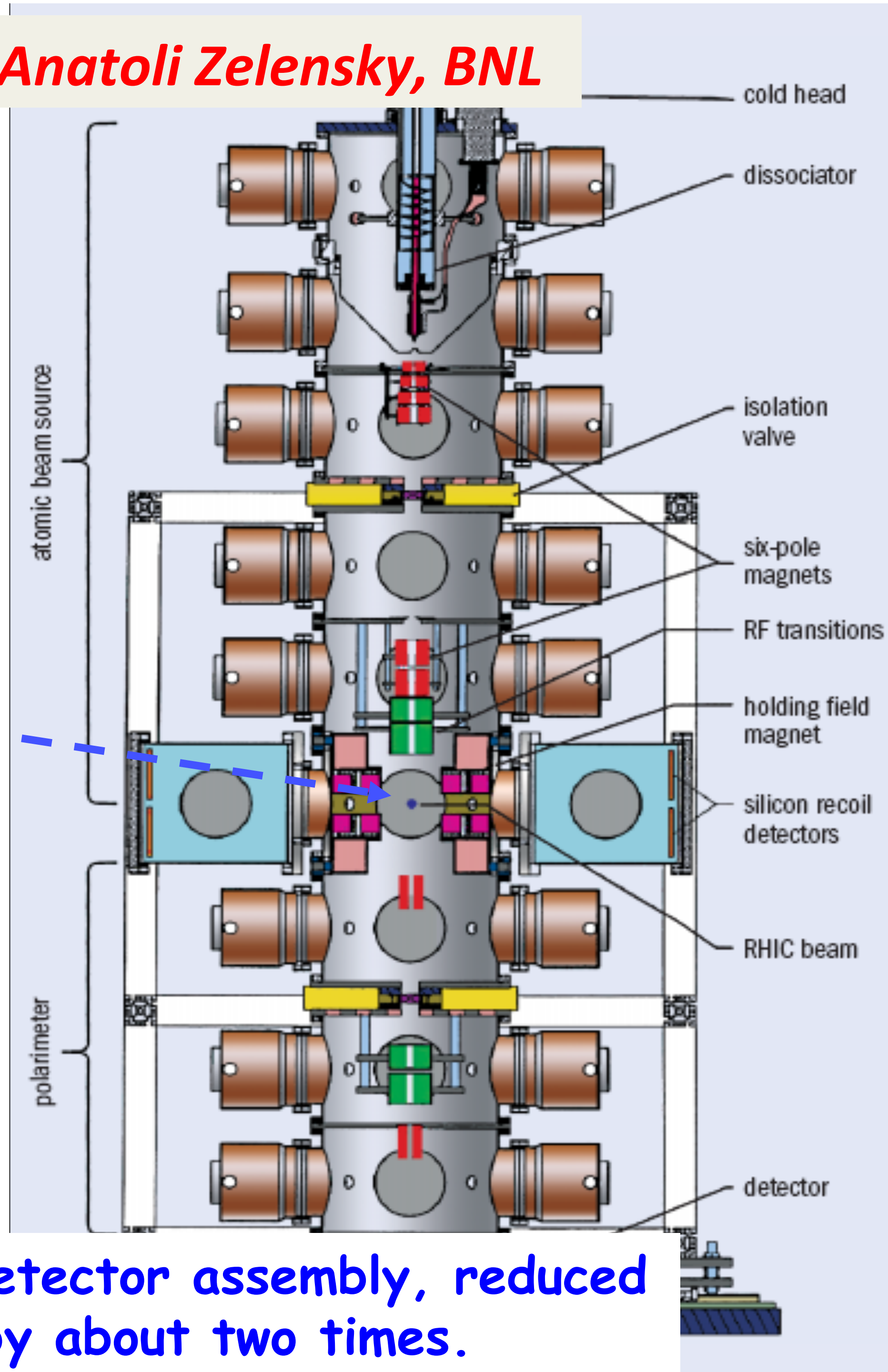
The distance from the nozzle
To collision point is 127 cm

Record $12.6 \cdot 10^{16}$ atoms/s Atomic Beam intensity.

Atomic beam velocity ~ 1800 m/s

H-jet thickness at the collision point-$1.2 \cdot 10^{12}$ atoms /cm^2

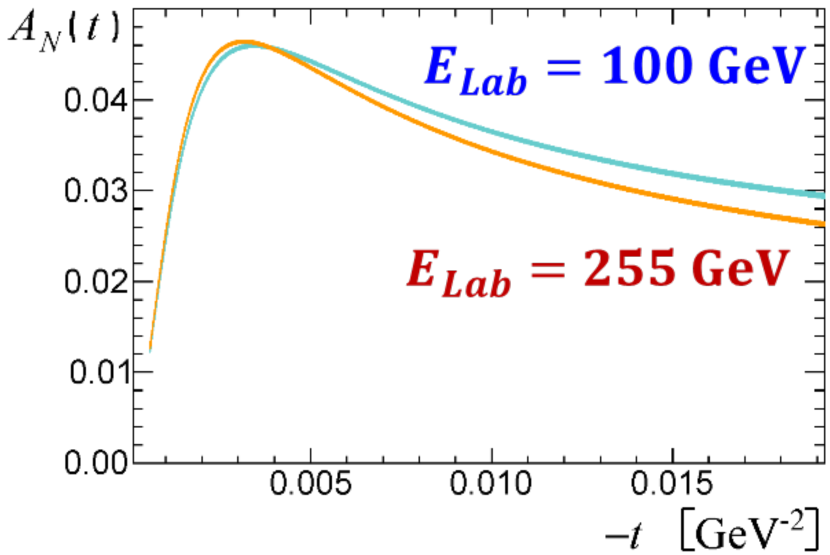
Anatoli Zelensky, BNL

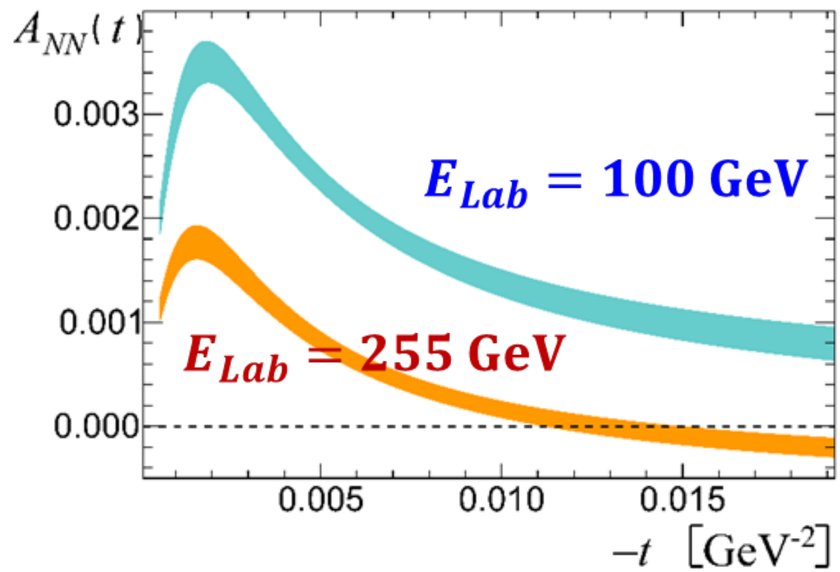


Latest upgrade, new Si-strips detector assembly, reduced measurement statistical errors by about two times.

Andrey Poblaguev, BNL

Analyzing powers were measured with very high precision in CNI region





- **Single and double spin-flip analyzing powers for elastic pp scattering were measured with high precision for two beam energies:**

  $\sigma_{A_N}(t)/A_N(t) < 1\%$ $\quad\quad$ $\sigma_{A_{NN}}(t) < 0.0002$
- **The measurements at two energies can be extrapolated to a wide range of E_{Lab}**

The un-polarized high thickness (10^{14}-10^{15} $H2/cm^2$) H-jet can be used for the precision (~1 % in 1hour) polarization measurements in eRHIC, using these A_n –analyzing power values.

Nigel Buttimore, Trinity College Dublin

A theoretical study of elastic collisions with spin at momentum transfers in the CNI region in the context of proton and ^{3}He polarimetry. Major points:

- ✧ Proton polarimetry is mature now and polarized 3He may be forthcoming.
- ✧ The ^{3}He–C analyzing power is ≈ −78% of A_N for p-C in the CNI region.
- ✧ A polarized ^{3}He jet and beam would enable an absolute ^{3}He polarimeter
- ✧ Single and double helicity flip pp amplitudes are known at many energies
- ✧ Extrapolation of amplitudes to other high energies is becoming possible

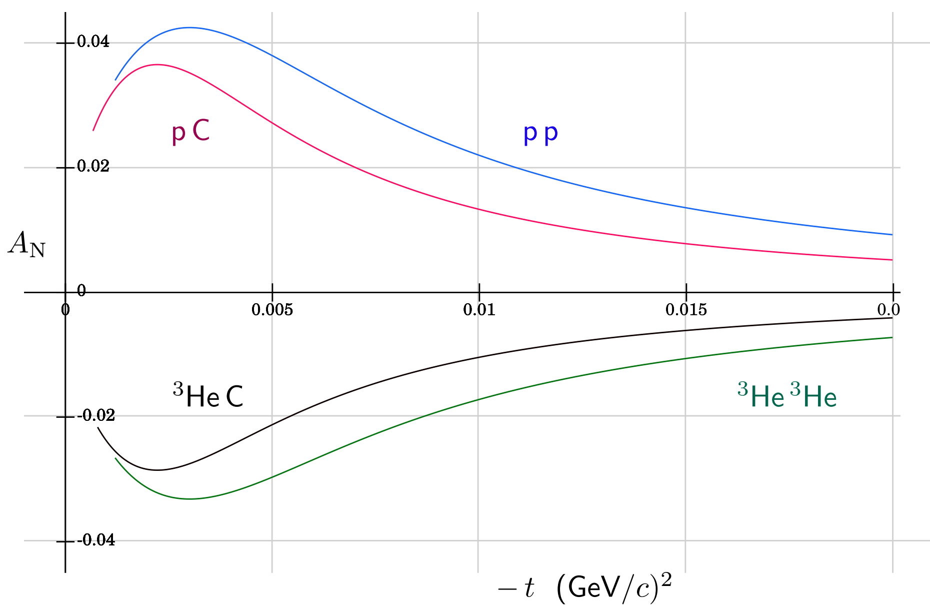


Figure 1: Analyzing power A_{N} versus invariant momentum transfer (-t) in (GeV/c)^2 for (1) p p and p h scattering, (2) p C scattering, (3) h C scattering, (4) h h and h p scattering

The optimum value of 3% to 4 % varies slowly with energy s as $1/\sqrt{\sigma_{\mathrm{tot}}(s)}$

It is either a maximum or minimum depending on the sign of constant κ

$$A_{\mathrm{N}}^{\mathrm{opt}} = \frac{\kappa}{4m_{\mathrm{p}}}\sqrt{-3\,t_{\mathrm{e}}}\,, \qquad \kappa = \frac{\mu}{Z} - \frac{m_{\mathrm{p}}}{m}$$

The value of κ is 1.793 (anomalous μ) for protons and -1.398 for helions.

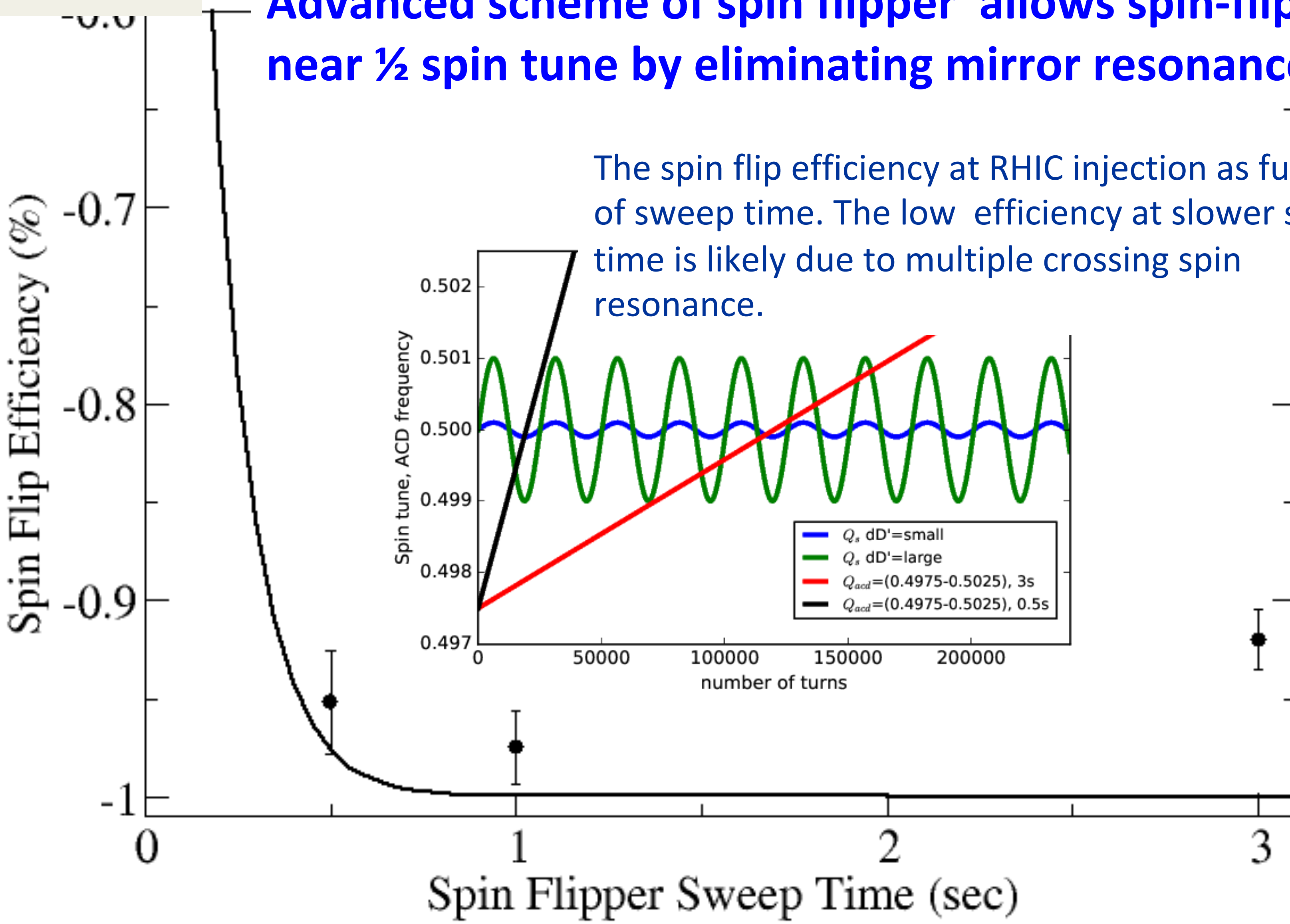
Hadronic helicity flip amplitudes and two photon exchange are ignored here.

H. Huang, BNL

Demonstration of successful spin-flip at RHIC at 24 GeV and 255 GeV.

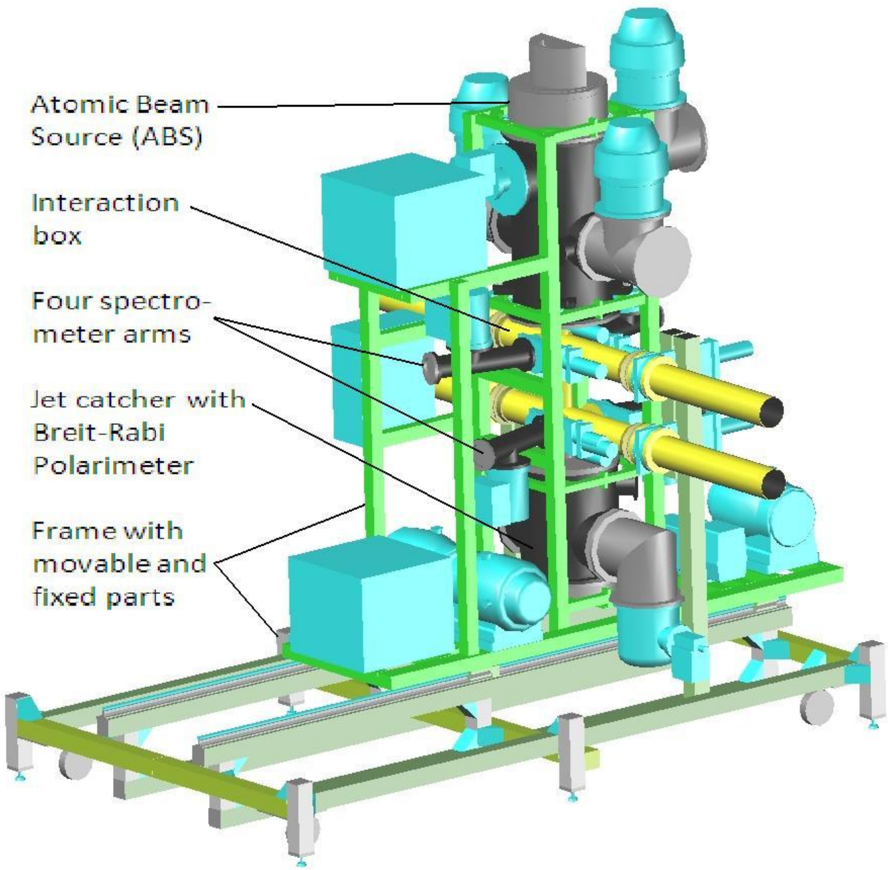
Advanced scheme of spin flipper allows spin-flip near ½ spin tune by eliminating mirror resonance

The spin flip efficiency at RHIC injection as function of sweep time. The low efficiency at slower sweep time is likely due to multiple crossing spin resonance.



Mikhail Kulikov, JINR

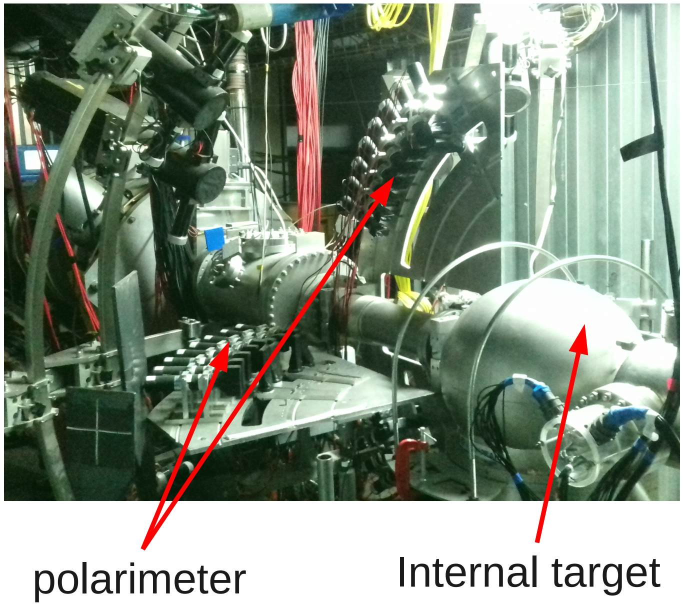
Well advanced design of Jet polarimeter for NICA was described



- The polarimeter APol allows to make fast (few minutes) measurements of absolute values and signs of proton and deuteron accelerated beams polarization.
- The measurements can be made simultaneously on both NICA beams using a single polarized jet target.

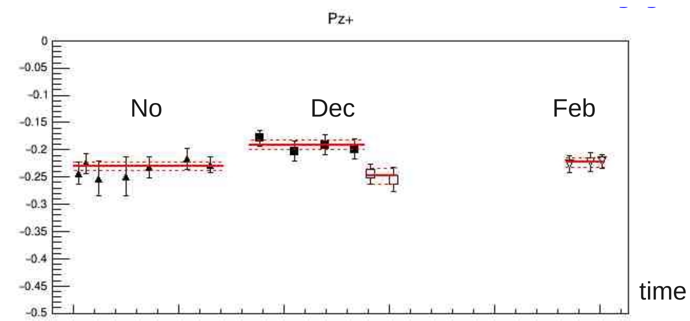
Vladimir Ladygin (JINR)

Polarimetry with internal target in JINR Nuclotron

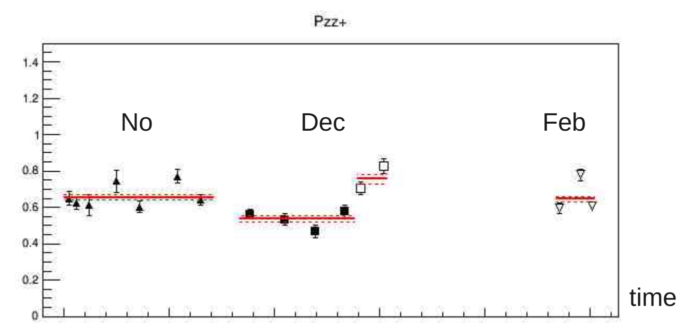


Internal beam and thin CH2 target
(C for background estimation).

- The upgraded version of the deuteron beam polarimeter has been used to obtain the vector and tensor polarizations using dp-elastic scattering at 270 MeV during 2016/2017 runs.
- The current polarimeter has been also used to measure the proton beam polarization at 500 MeV using pp- (quasi)elastic scattering. The obtained value of the vertical proton polarization is -0.354 ±0.022.



Deutrons
Pz+, Pzz+ - polarization for spin mode: (-1/3,+1)

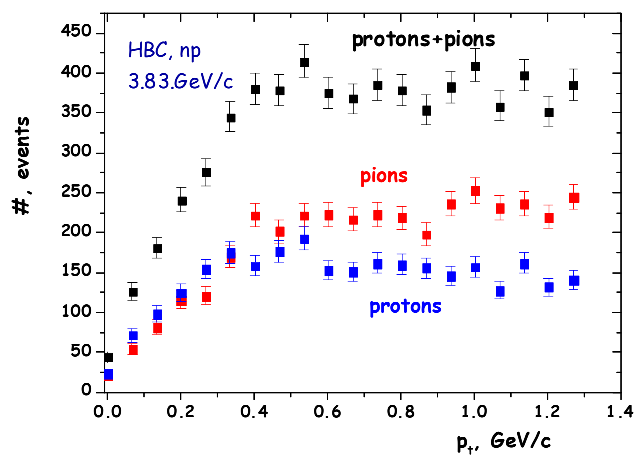


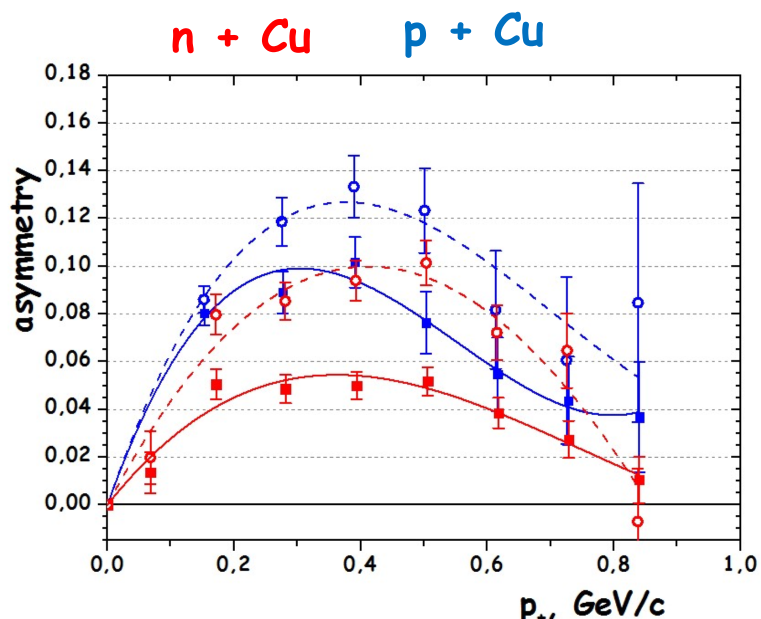
Nikolai Piskunov, JINR

Data of measurements of analyzing powers for neutrons and protons at ALPOM2 experiment were presented.
The data include scattering on different targets (CH2, CH, C, Cu) at the momenta 3.0, 3.75 and 4.2 GeV/c

n(p)↑ + Cu ⟹ one charge particle + X

3.75 GeV/c





Full squares – no cut;
open circles – energy deposit cut, 6000.

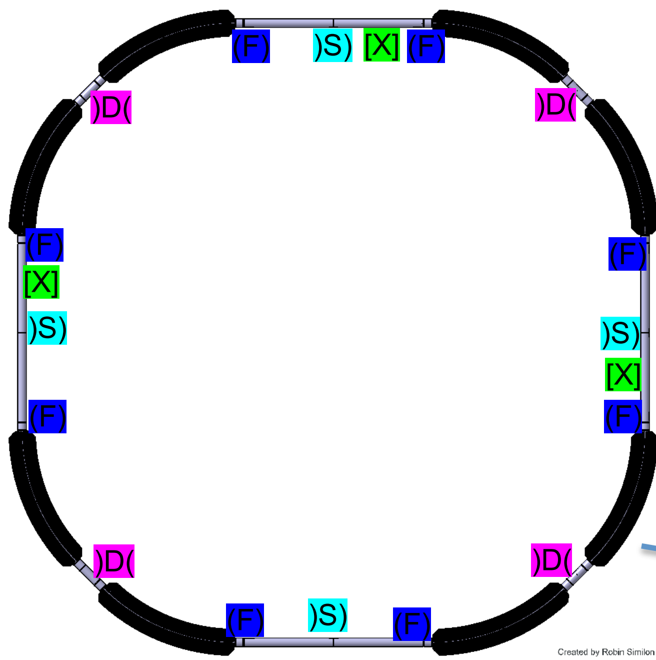
Based on the available (and ancient) charge exchange analyzing power data for np->pn, the expectation was that the same reaction channel for the complex target available (C, CH, CH2 and Cu) would be significantly larger than for the forward process, np->np.
The new data fully support this expectation.

Sig Martin, FZ-Julich

JEDI (JÜLICH ELECTRIC DIPOLE MOMENT INVESTIGATIONS)

Prototype EDM storage ring design was presented

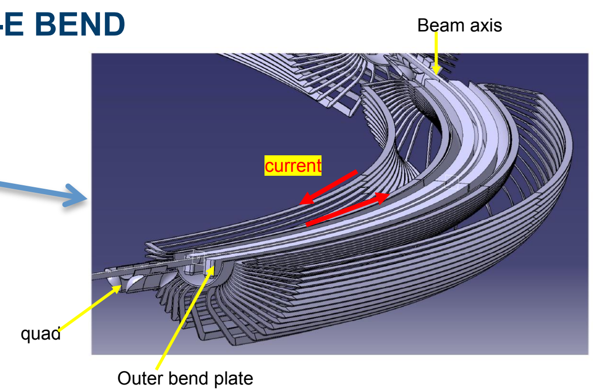
- Storage time
- CW/CCW operation
- Spin coherence time
- Polarimetry
- μ-moment effects
- (pEDM measurement)
- Stochastic cooling



✧ All electric at 30 MeV or less

✧ Frozen spin at 45 MeV

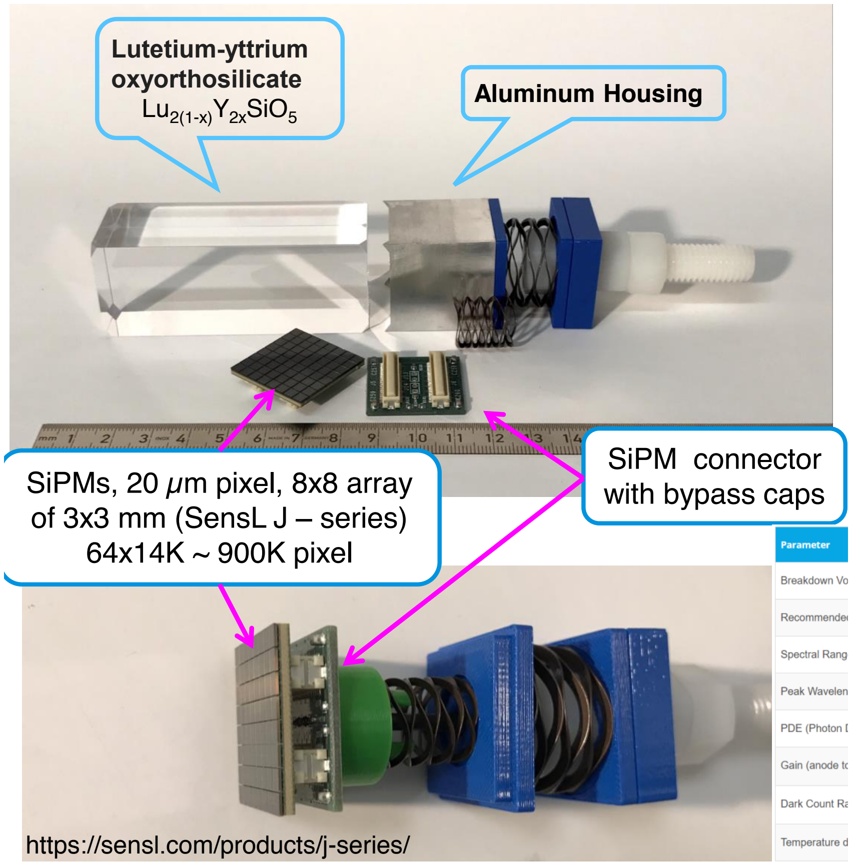
B-E BEND

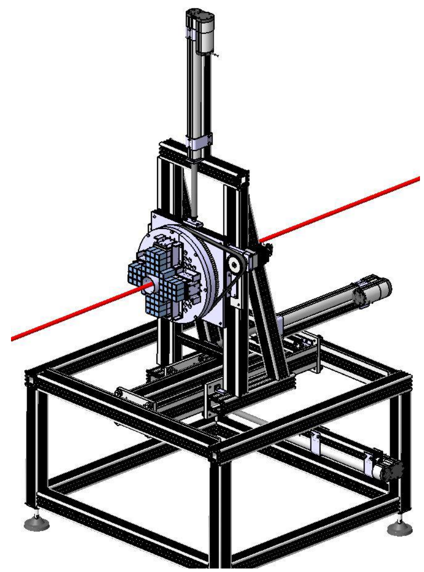


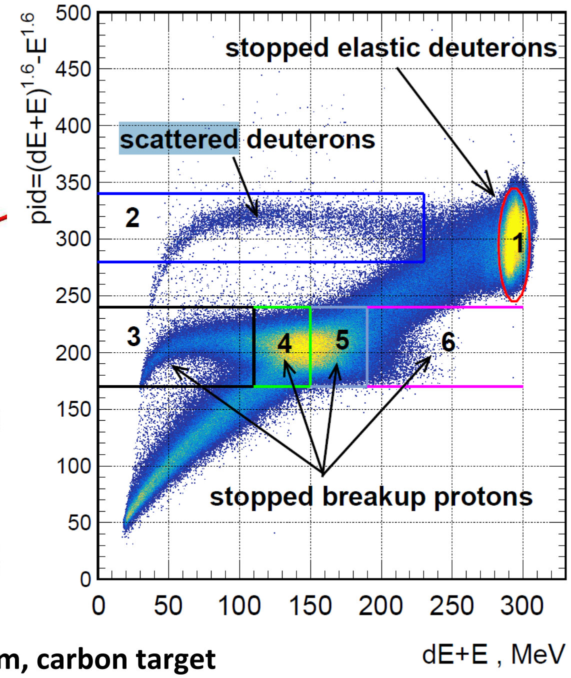
PBC (CERN) and ESPP-Update; possible host sites: COSY (see above) or CERN

Dito Shergelashvili, Tbilisi SU

Progress with assembly and testing of LYSO modules for charge-particle EDM polarimeter was reported







Deuteron beam, carbon target

Several beam tests done on extracted beam
Installing the polarimeter in the COSY ring in 2019

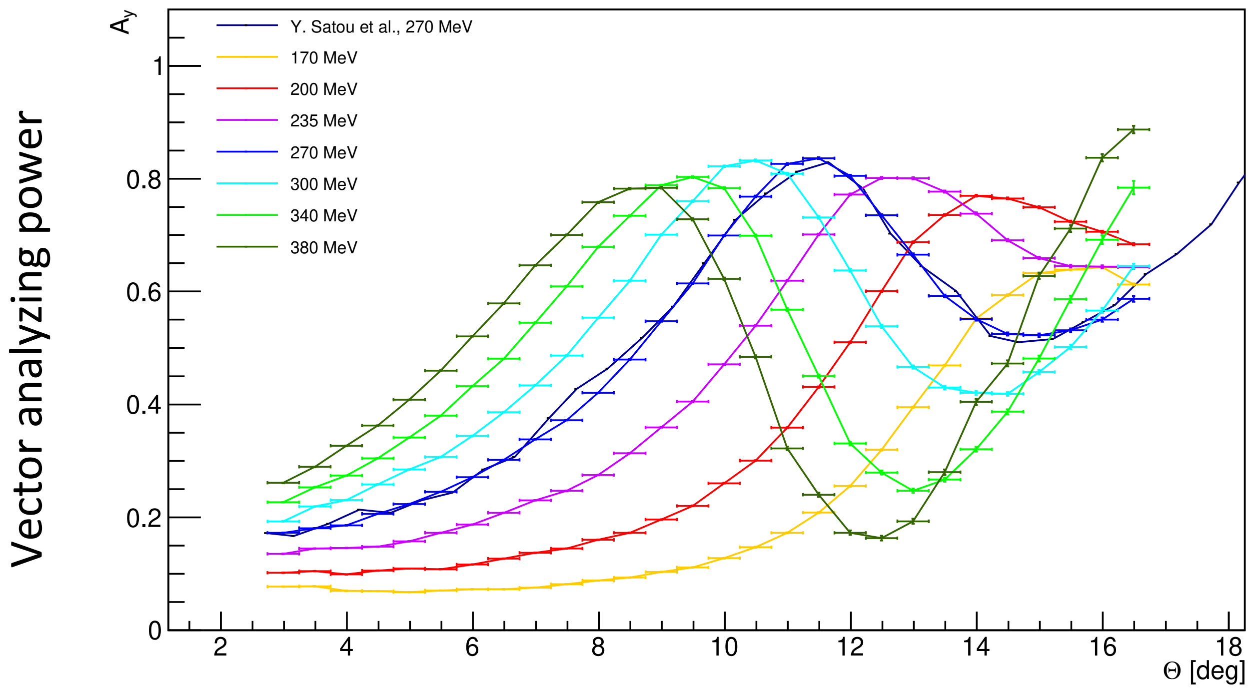
Fabian Muller, RWTH Aachen University

Results of precision measurements of dC analyzing power and elastic dC cross section were presented.

Important for EDM polarimetry.

Done in COSY on remnants of WASA detector

Results



← Statistical errors shown

← Results will be used for an optimal EDM polarimeter development

good agreement with published references

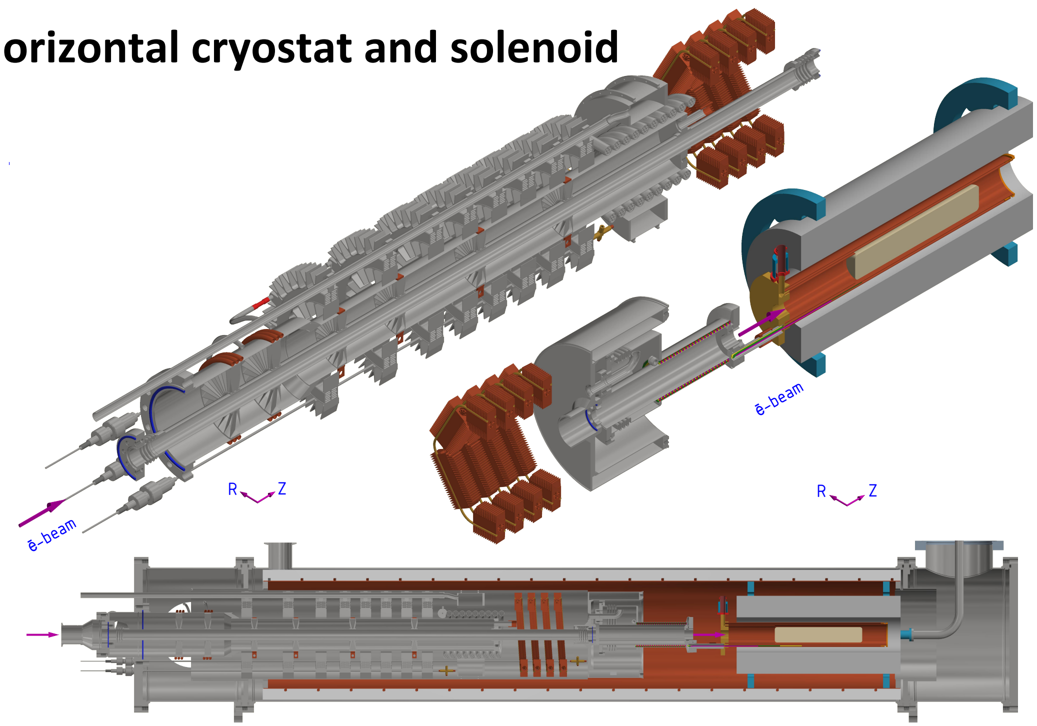
Extracting the analyzing power from the asymmetries:

1. Absolute beam polarization was not known → using reference A_y from Satou et al
2. Fitting asymmetry for 270 MeV to reference → got polarization value of 0.434
3. Using this polarization to scale asymmetries for other energies (assuming same polarization)

Valery Tioukin, INP, JGU Mainz

Report on development of Møller polarimeter at 50−150 MeV for MESA based on Polarized Atomic Hydrogen Target.

Horizontal cryostat and solenoid



✧ Superconducting magnet B=8.0 T provides trapping in longiutdinal direction

✧ Coated cell wall with 50 nm film of superfluid ^{4}He provides radial trapping (T wall =0.25−0.30K)

$\rho_H = 3.0\times10^{15}$ cm^{-3}

- Some design issues still have to be solved (e.g. FX-HX, Target "clearing")
- Hardware in fabrication
- Cooling down in 2019

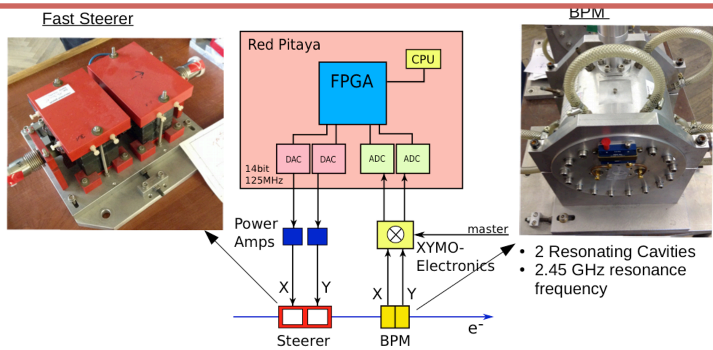
Ruth Kempt, Mainz

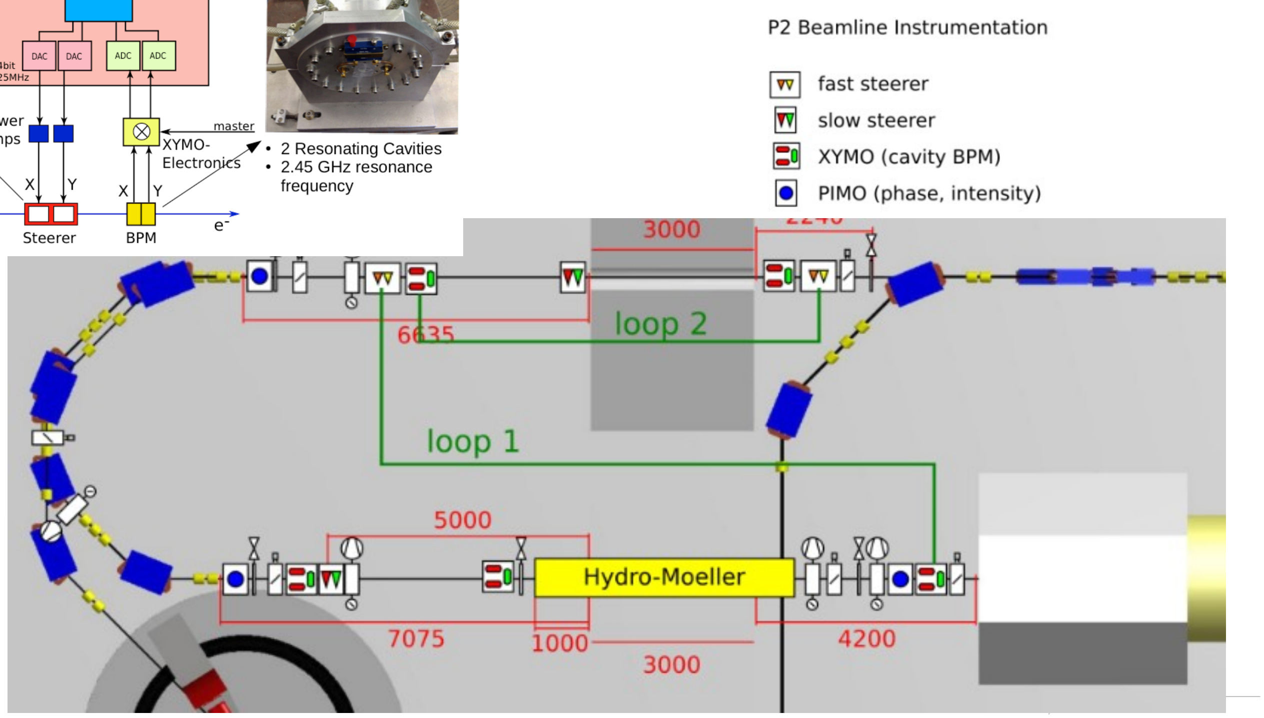
- ✧ P2 in MESA plans to measure the weak mixing angle with record high precision.
- ✧ The apparatus’ asymmetry, produced by helicity correlated fluctuations of the beam parameters (position, angle, intensity and energy) contributes to measured assymetry..
- ✧ High precision measurements/control of the parameters position, angle and intensity has to be realized

Beam position control system satisfying the experiment requirement has been developed

$$\Delta A^{\mathrm{app}} = \frac{\sigma}{\sqrt{9 \times 10^{9}}} \stackrel{!}{=} 0.1\,\mathrm{ppb}$$

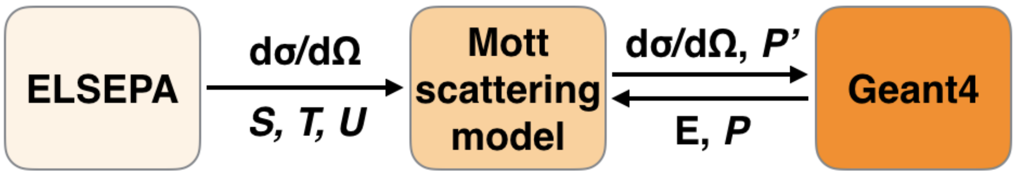
$$\sigma = \Delta A^{\mathrm{app}}(STA) \stackrel{!}{=} 9.5\,\mathrm{ppm}$$





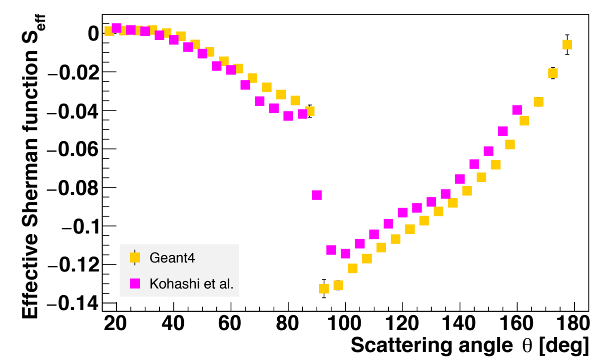
Michal Dragowski (University of Warsaw)

Improved model for MC simulation of polarized electrons interaction with matter in the MeV range was presented



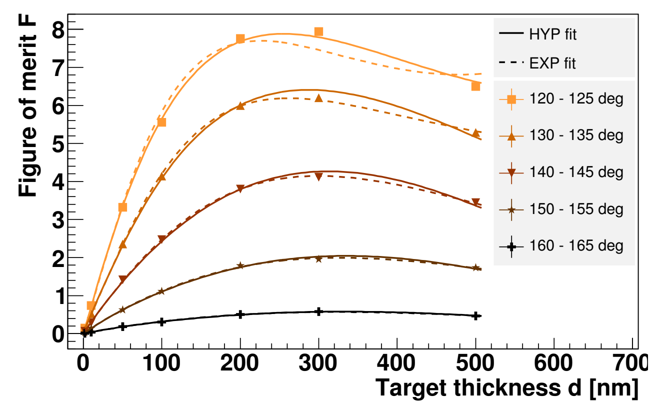
Possible applications:

- computation of the effective Sherman function
- experiment optimization
- depolarization of electron beams passing through matter



100 keV, 500 nm Au

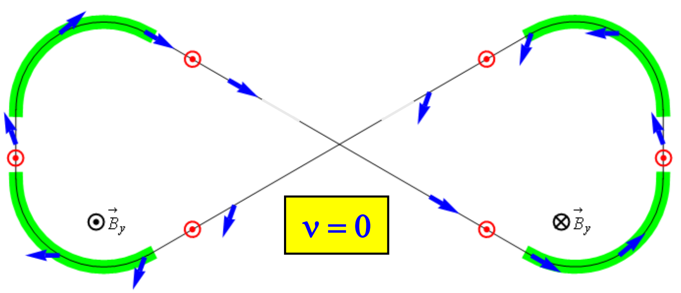
T. Kohashi, M. Konoto and K. Koike, Jpn. J. Appl. Phys. 45, 6468 (2006)

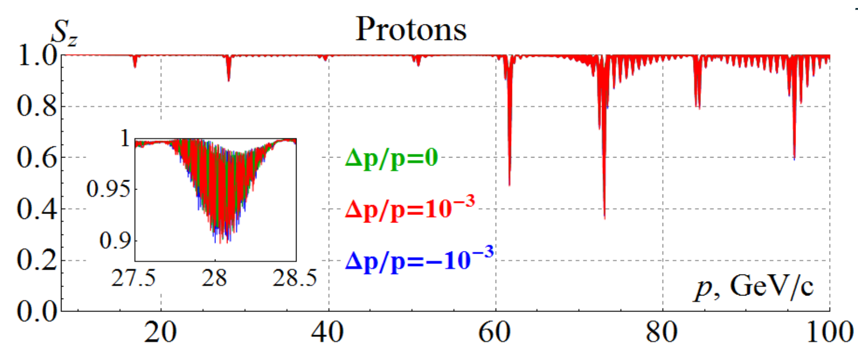


100 keV, 2 – 500 nm Au

Fanglei Lin (JLab)

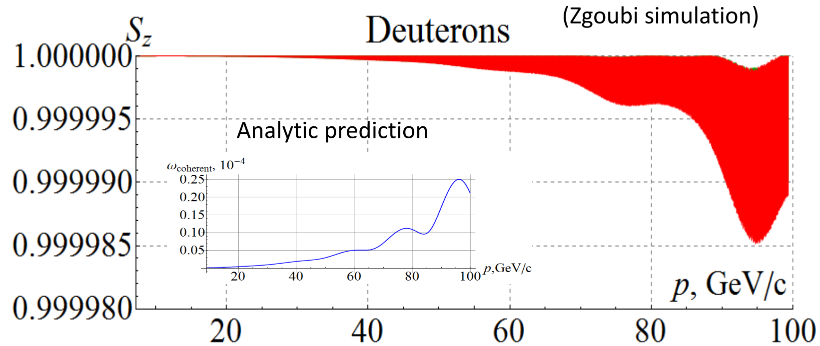
- JLEIC rings adopt a figure-8 shape to preserve and control polarization in a spin transparency mode
- Designs for ion and electron polarization schemes have been presented as well as results of recent simulation studies





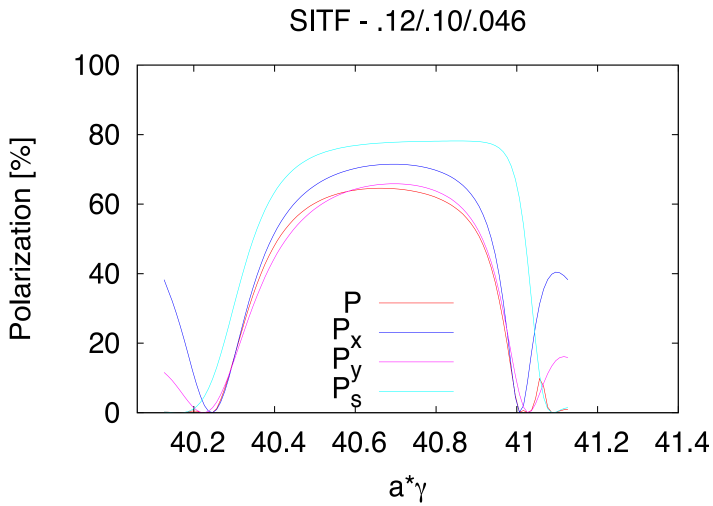
Zgoubi simulation

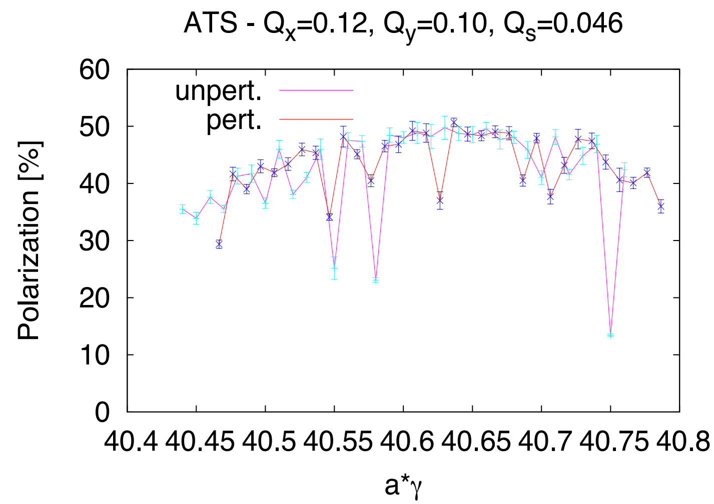
On-going preparation for Spin transparency mode experiment in the RHIC (using a specific configuration of two RHIC Siberian Snakes)



Eliana Gianfelice (Fermilab)

Results of recent polarization simulation studies for eRHIC electron storage ring. With various types of misalignments and machine errors.



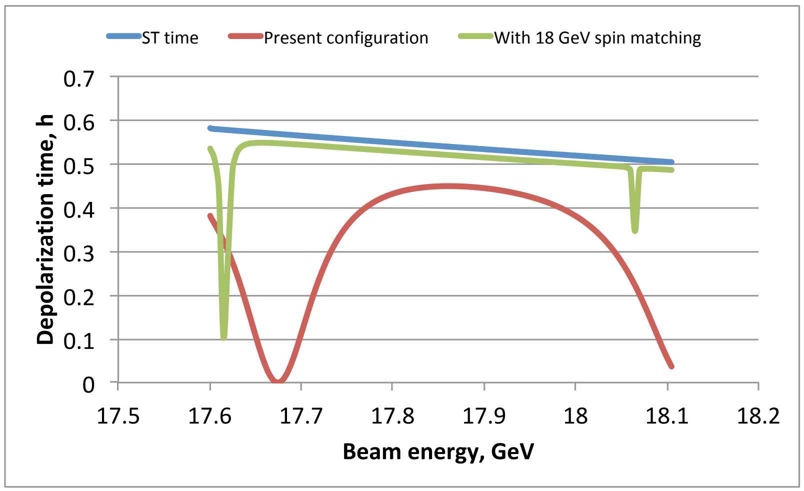


At 18 GeV P∞ ≈ 50% seems within reach:
– for upwards polarized bunches (anti-parallel to the guiding field), <P >≈ 80%., over 5 minutes if P (0)=85%;
– for bunches polarized downwards the average polarization is ~67%.

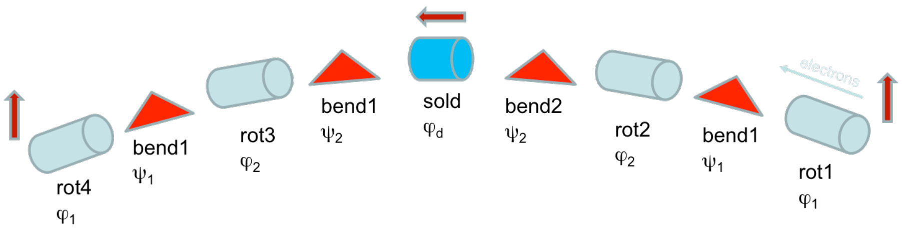
Vadim Ptitsyn (BNL)

- **Spin matching conditions for spin rotators used in EIC designs (eRHIC and JLEIC) have been derived.**
- **The ways to satisfy these condition by a rotator layout and optics design were shown.**

Realizing the spin matching condition the depolarization time can be maximized in both EIC design



eRHIC spin rotator
C-type bending configuration



$$\sum_{rot:j=1,4} H_j\left(f_I\right)=0\,; \quad \sum_{rot:j=1,4} H_j\left(f_I^*\right)=0\,;$$

betatron motion conditions

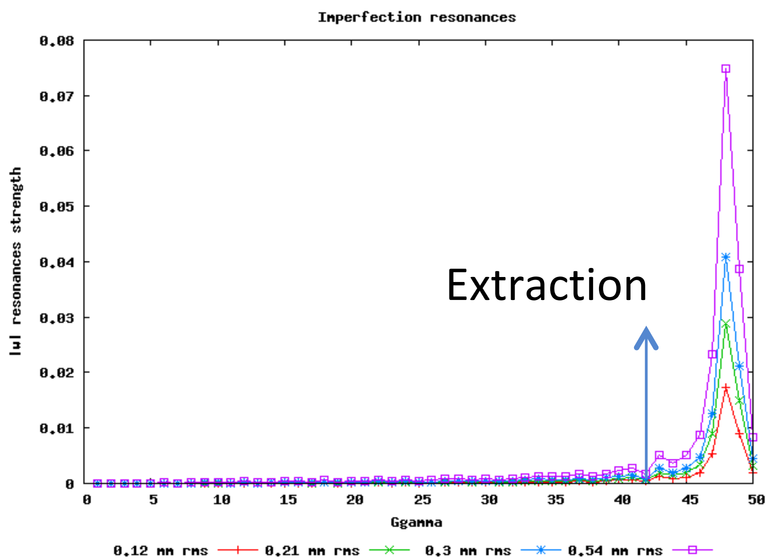
$$a\gamma \sum_{rot:j=1,4} H_j\left(D\right)+\sum_{rot:j=1,4}\varphi_j k_{sj}-\sum_{bends:i=1,4}\psi_j k_{yi}=0$$

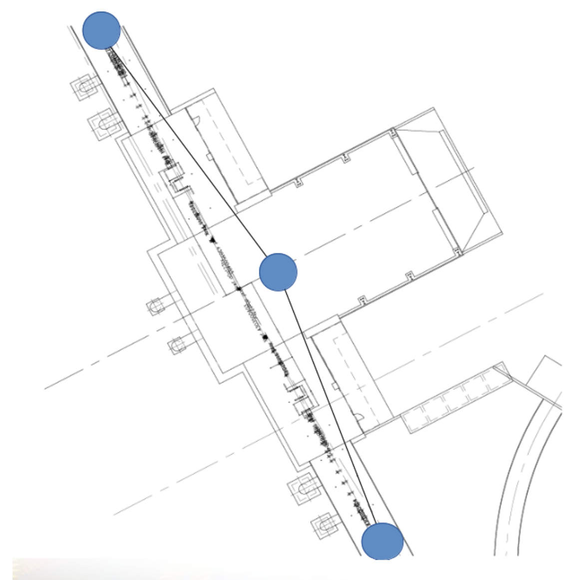
longitudinal motion condition

Vahid Ranjbar (BNL)

Design status of eRHIC polarized electron injector, Rapid Cycling Synchrotron, was presented.

- **High periodicity lattice eliminates intrinsic spin resonances as well as strong imperfection resonance (Spin Resonance Free lattice)**
- **High acceleration rate: 100-200 ms**
- **Repetition rate: 1 Hz**





Spin transparent bypass of experimental detectors has been worked out

Thank you for your attention !