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Measurement of $p^{\uparrow}\mathrm{Au}$ and $p^{\uparrow}d$ analyzing power

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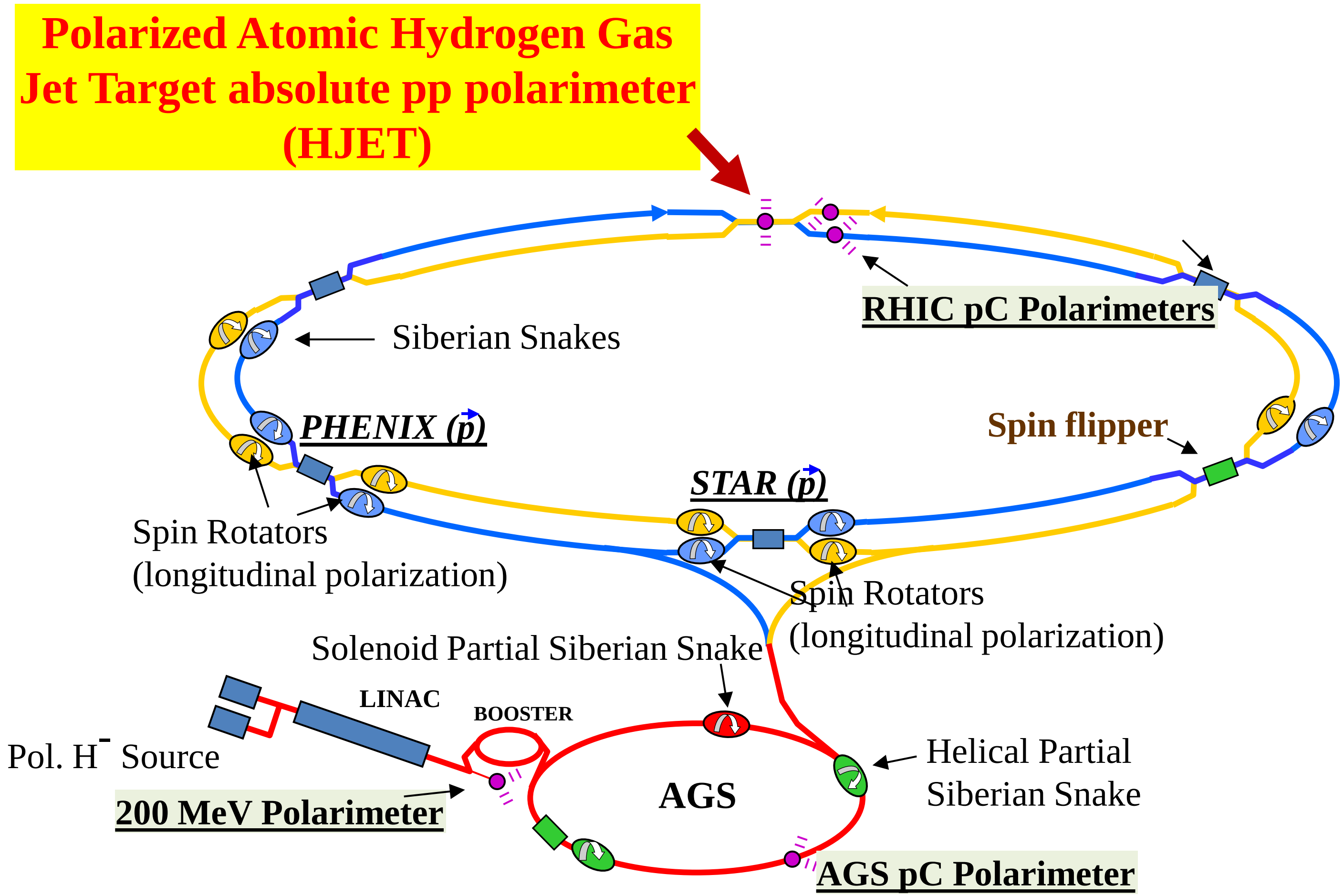
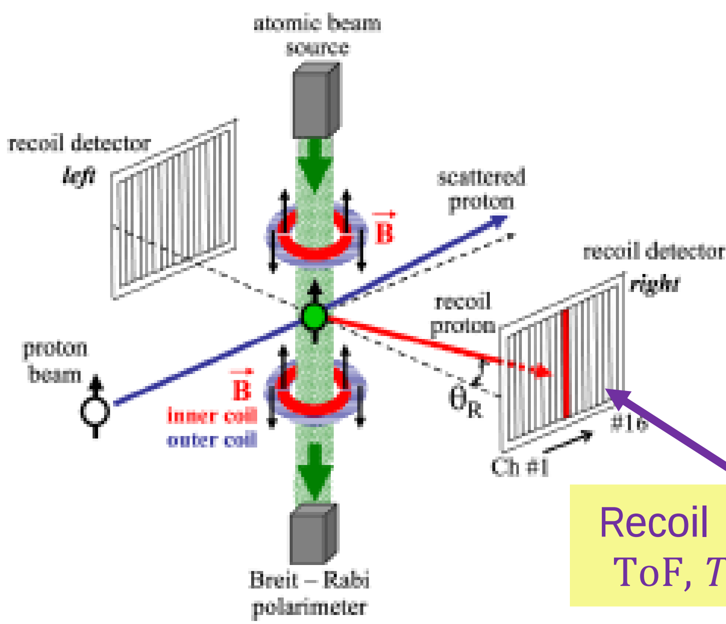
Polarized Proton Beams at RHIC

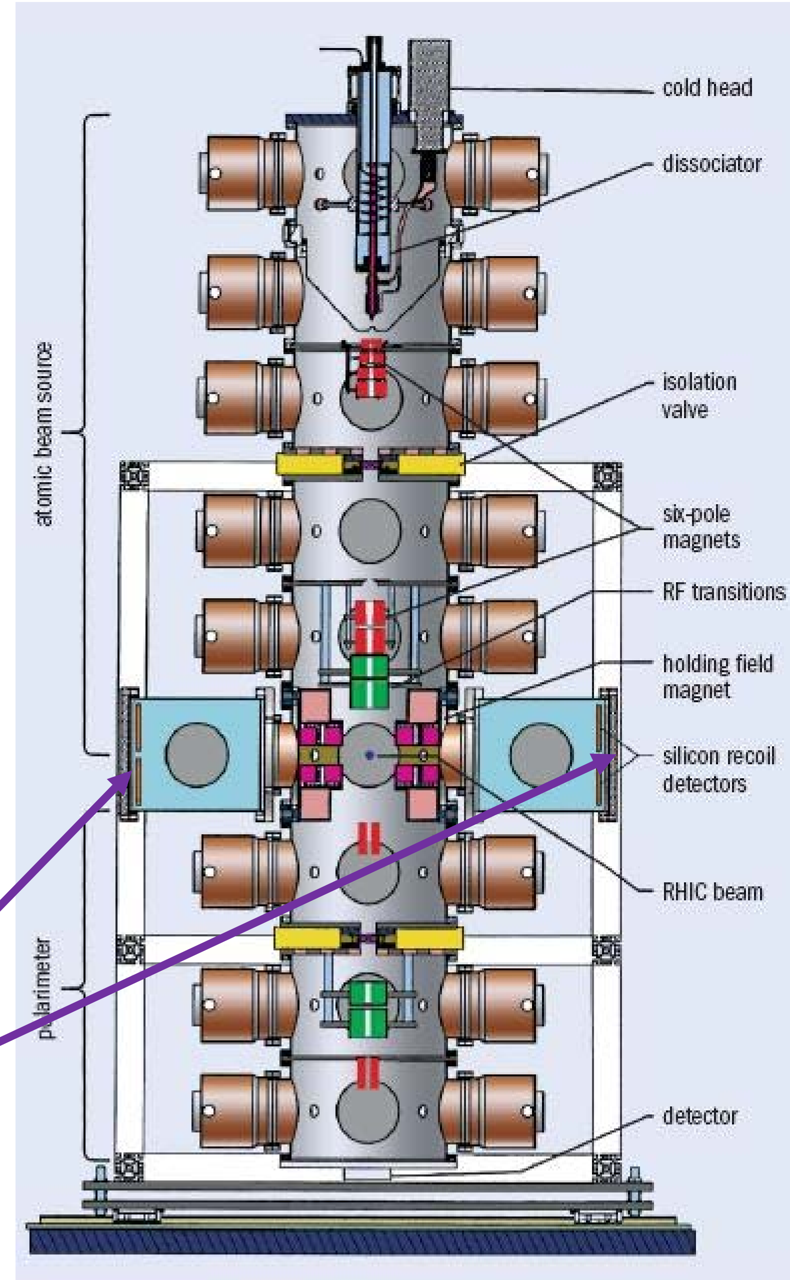


Polarized Atomic Hydrogen Gas Jet Target (HJET)

- The HJET polarimeter was commissioned in 2004.
- It was designed to measure absolute polarization of 24-250 GeV/c proton beams with systematic errors better than $\Delta P/P \leq 0.05$
- The atomic hydrogen polarization in the Jet is ~96%
- Jet intensity 12.6×10^{16} atoms/sec
- Jet density 1.2×10^{12} atoms/cm^2
- The Jet polarization is flipped every 5 min.



Recoil detectors
ToF, T_{REC}, θ_{REC}



HJET in RHIC Run16

In 2016, the RHIC scientific program included:

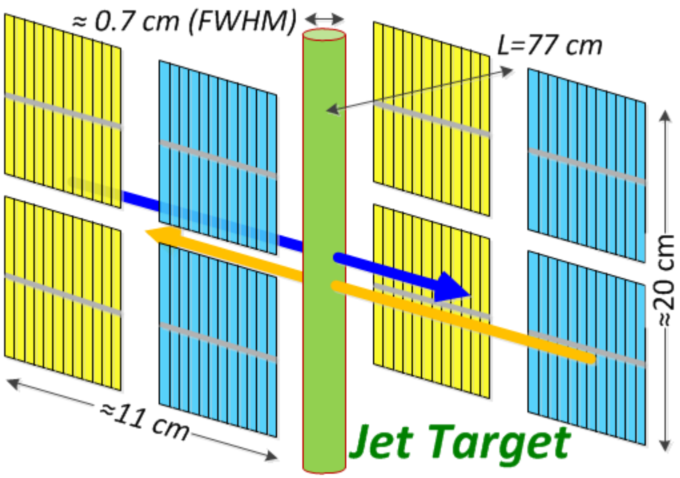
- 100 GeV/n Au+Au Operation - 10 weeks
- d-Au Energy Scan (10, 20,31, and 100 GeV/n) - 5 weeks

HJET operation was not supposed in Run16.

Motivation to turn on HJET and perform the measurements

- We had an opportunity to make first measurements of $p^{\uparrow}\mathrm{Au}$ and $p^{\uparrow}d$ analyzing power in the 10-100 GeV proton energy range.
    - The measurements were performed in a background mode, i.e. with no disturbance of the main RHIC program.
    - Results of measurements may be helpful to improve parameterization of proton-nucleus elastic scattering.
- We used a chance for additional tests of the HJET performance and study of systematic errors in polarization measurements at Jet
    - Since the background conditions were significantly different from the pp run, the obtained data (including special tests) may help to study the sources of systematic errors for proton beam polarization measurements.
    - Important goal of this study is an investigation of a possibility of absolute proton beam polarization measurement with accuracy $\Delta P/P < 2\%$.

HJET detector configuration



Both RHIC beams (Blue and Yellow) are measured simultaneously

Silicon Detectors

(Hamamatsu Photonics K.K. *S10938-3627*)

8 paired detectors (12 strips per detector)

Detector size	$45 \times 45\ mm^2$
Gap between detectors	$\approx 19\ mm$
Strip size	$3.7\ \times 45\ mm^2$
Gap between strips	$50\ \mu m$
Depletion region	$470\ \mu m$
Uniform Dead-layer	$\sim\ 0.37\ mg/cm^2$
Distance to the beam	$769\ mm$
Bias Voltage	$150\ V$

Kinematics of the $A_{beam}p^{\uparrow}$ scattering:

$$t = (p_R - p_t)^2 = -2m_pT_R$$

For elastic scattering:

$$\tan\theta_R = \frac{z_{det} - z_{jet}}{L} = \sqrt{\frac{T_R}{2m_p}\frac{E_{beam} + m_p^2/M_{beam}}{E_{beam} - m_p + T_R}}$$

Effective polarized proton energy:

$$E_p^{(eff)} = E_{beam}\frac{Nm_p}{M_{beam}} \approx E_{beam}$$

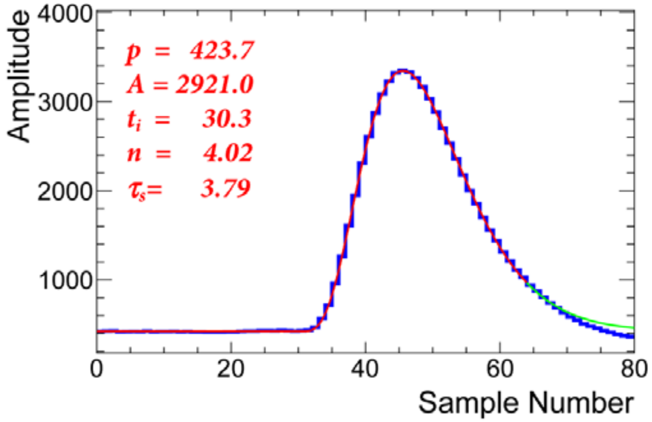
(E_{beam} is given in GeV/nucleon units)

- ***The detector geometry allows to detect recoil protons (elastic pp) with kinetic energy up to $11\ MeV$ ($-t \lesssim 0.02\ GeV^2$).***
- ***Protons with energy above $7.8\ MeV$ punch through the detector (only part of kinetic energy is detected).***
- ***Analyzing power can be measured as a function of momentum transfer $A_N(t)$***

DAQ

The HDAQ DAQ is based on VME 12 bit 250 MHz FADC250 (Jlab)

Full waveform (80 samples) was recorded for every signal above threshold (~0.5 MeV).



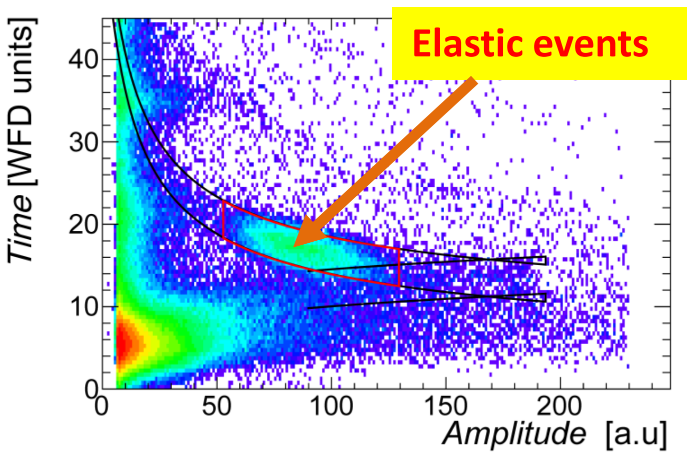
Signal parametrization:

$$W(t) = p + A\,(t - t_i)^n \exp\left(-\frac{t-t_i}{\tau_s}\right)$$

$$t_m = t_i + n\tau_s$$

t_i is proton input time to the detector.
t_m is time of the signal maximum.
t_m is more stable in the fit.

- blue line: ***measured waveform***
- red line: ***fit function W(t)***
- green line: ***continuation of the fit function***



For every event signal time and amplitude (and waveform shape parameters) are measured

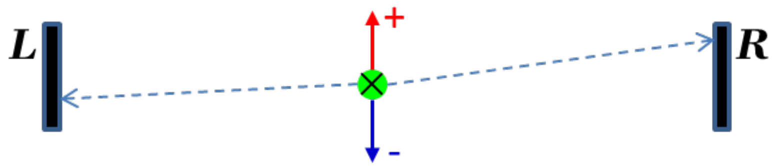
The single spin correlated asymmetry may be calculated as function of momentum transfer t:

$$a_{jet}(t) = \frac{N_L^+ - N_R^+}{N_L^+ - N_R^+} = \frac{N_L^+ - N_L^-}{N_L^+ - N_L^-} = A_N(t)P_{jet}, \quad |a| \lesssim 0.05$$

For polarized proton beam, the same events may be used to measure the beam polarization:

$$P_{beam} = \frac{-a_{beam}}{A_N} = -P_{jet}\frac{a_{beam}}{a_{jet}}$$

Determination of Spin Correlated asymmetry



In the spin-flip measurements with left/right symmetric detectors, systematic errors for the spin correlated asymmetry $\boldsymbol{a = PA_N}$ may be strongly suppressed. $\boldsymbol{P}$ is beam or target vertical polarization and $\boldsymbol{A_N(t)}$ is analyzing power.

$$\begin{cases} N_L^+ = N_0(1+a)(1+\epsilon)(1+\lambda) \\ N_L^- = N_0(1-a)(1+\epsilon)(1-\lambda) \\ N_R^+ = N_0(1-a)(1-\epsilon)(1+\lambda) \\ N_R^- = N_0(1+a)(1-\epsilon)(1-\lambda) \end{cases} \Rightarrow \quad a = \frac{\sqrt{N_L^+ N_R^-} - \sqrt{N_R^+ N_L^-}}{\sqrt{N_L^+ N_R^-} + \sqrt{N_R^+ N_L^-}}$$

and similar for ϵ and λ

$\boldsymbol{N_{LR}^{+-}}$ is number of detected events depending on detector side and spin direction. $\boldsymbol{\epsilon}$ and $\boldsymbol{\lambda}$ are acceptance and intensity asymmetries, respectively.

The "*square root formula*" gives exact and, thus, systematic error free solution if asymmetries a, ϵ, λ are uncorrelated.

It should be understood that actually an effective analyzing power is measured

$$a = PA_N^{(eff)} = P\left\langle \frac{A_N(t) - 2m_p \frac{dA_N(t)}{dt}\delta T}{1+b(T)} \right\rangle_T, \qquad t = -2m_p T$$

Generally, background fraction $b(T)$ and error in energy δT depend on recoil proton energy T and are different for left and right detectors.

Corrections to the "square root formula"

First order corrections:

$A_N \to A_N^{(L,R)} = A_N + \delta A_N^{(L,R)}$ Mainly associated with errors in background evaluation. Significant for blue (deuterium beam) detectors.

$\epsilon \to \epsilon_{L,R}^{\pm} = \epsilon \pm (-1)^{LR} \delta\epsilon_{L,R}$ Related to electronic noise correlation with RF transition state in two down blue detectors. In Run16, suppressed but still exist

$P \to P^{\pm} = P \pm \delta P$ For the HJET $P = 95.8 \pm 0.1\%$, $\delta P < 0.15\%$

Systematic errors in asymmetry measurements:

$$P\delta A_N = P\frac{\delta A_N^{(L)} + \delta A_N^{(R)}}{2} + \frac{\delta\epsilon_L - \delta\epsilon_R}{2}$$

$$\delta\lambda = P\frac{\delta A_N^{(L)} - \delta A_N^{(R)}}{2} + \frac{\delta\epsilon_L + \delta\epsilon_R}{2}$$

$$\delta\epsilon = \delta P A_N$$

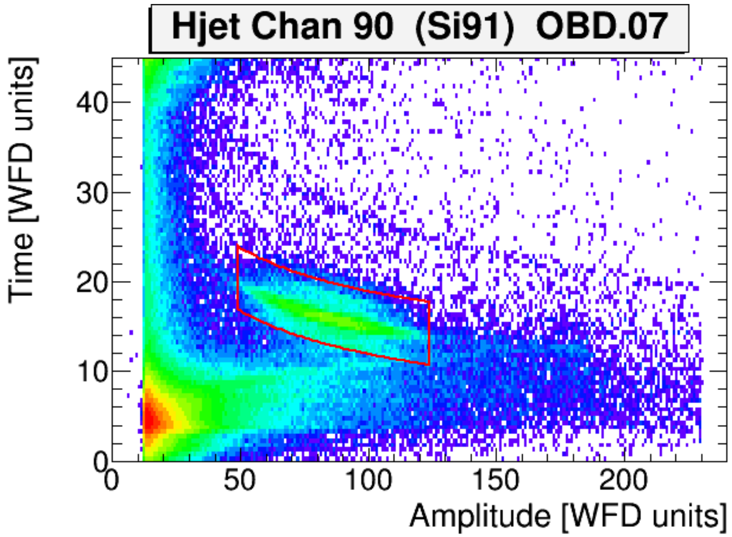
- Systematic errors in $A_N(t)$ and $\lambda(t)$ may be correlated or anti-correlated
- Since intensity asymmetry $\lambda(t)$ is recoil proton energy (or t) independent, possible variation in measured $\lambda_{meas}(t)$ is an indication of systematic errors in A_N

For the systematic error free measurement we need:

- Good energy calibration of the detectors
- Reliable subtraction of the background
- Control the electronic noise dependence on RF transition state (Jet polarization sign)

The "square root formula" will take care about anything else.

Event Selection: Recoil proton mass cut

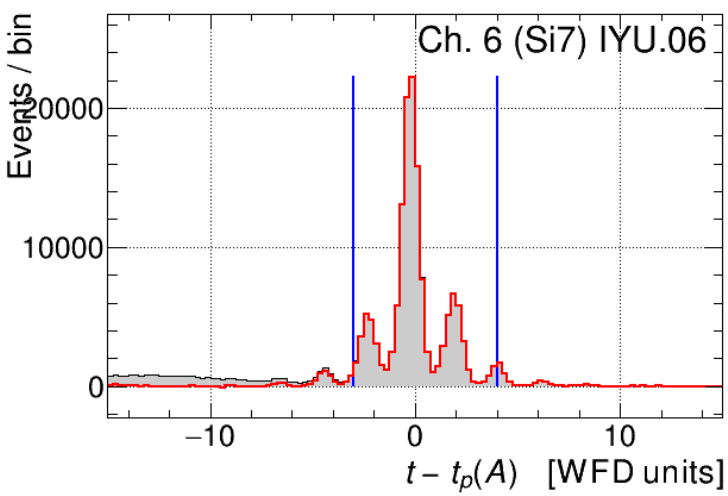


For recoil protons, the measured time t_m and amplitude A_m are linked by proton mass via the equation:

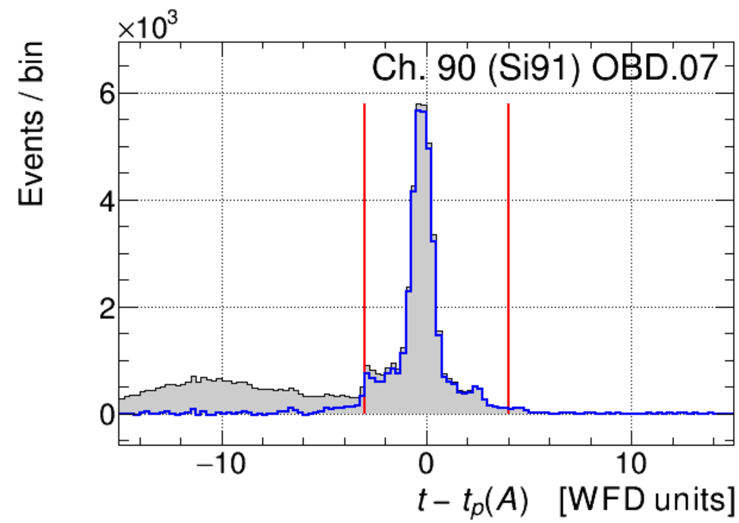
$$t_m = t_p(A_m) \equiv t_0 + \mathrm{TOF}(E_{kin}(A_m, g, x_{DL}))$$

The distribution of $\delta t = t_m - t_p(A_m)$ is dominated by the longitudinal beam profile and, thus is the same for all Si strips.

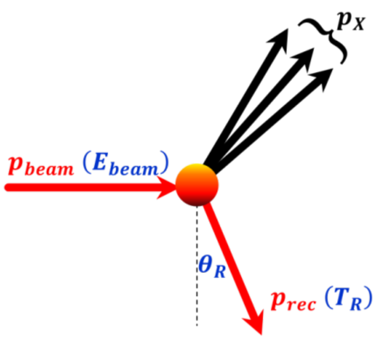
Yellow (Gold) beam, 31 GeV/n



Blue (deuterium) beam, 31 GeV/n



Event Selection: Missing Mass Cut



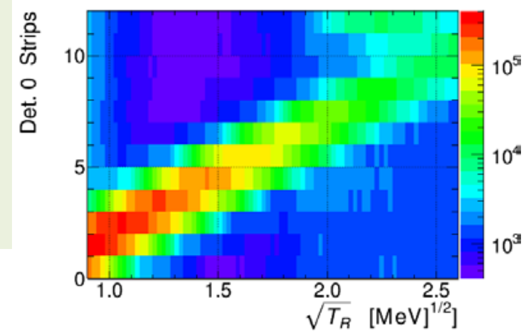
For elastic scattering, $p_X^2 = (p_b + p_t - p_R)^2 = m_p^2$

$$z_{det} - z_{jet} = L\sqrt{\frac{T_R}{2m_p}\frac{E_{beam} + m_p^2/M_{beam}}{E_{beam} - m_p + T_R}} \rightarrow \kappa\sqrt{T_R} + \frac{c_{MF}}{\sqrt{T_R}}$$

$$\frac{dN}{d\sqrt{T}} \propto \sqrt{T}\frac{d\sigma}{dt} f\left(\kappa\sqrt{T} - \kappa\sqrt{T_{str}}\right), \qquad \sqrt{T_{str}} = \frac{\langle z_{str} - z_{jet}\rangle}{\kappa}$$

$f(z_{jet})$ is the jet density profile

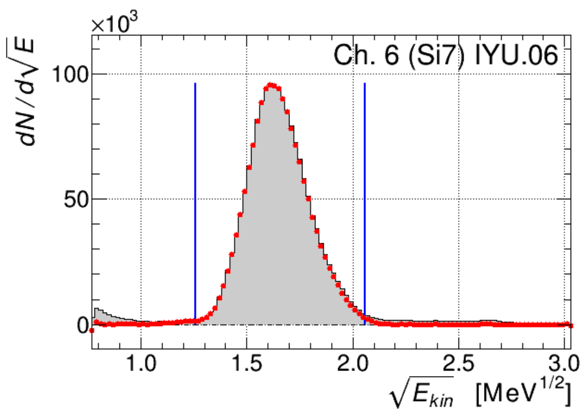
Magnetic field corrrection

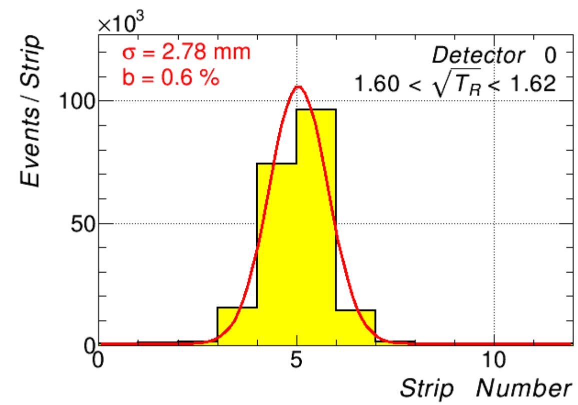


For elastic scattering, energy distribution in a strip is an image of proton distribution in the target

For elastic scattering, number of events distribution distribution in the strips is a histogram of proton distribution in the target

dAu 31 GeV
Gold beam



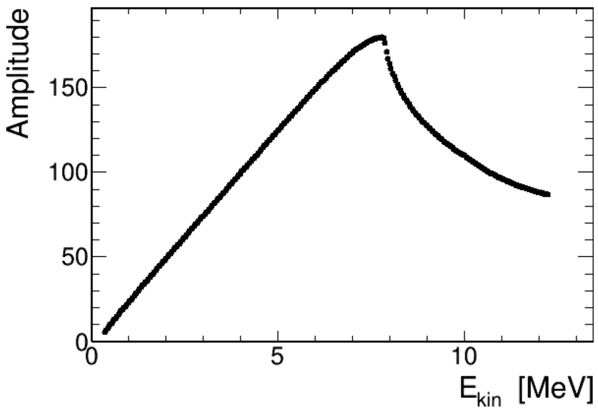


For variable $\zeta = \sqrt{T} - \sqrt{T_{str}}$ we can use the same cut in all 96 strips to select elastic events.

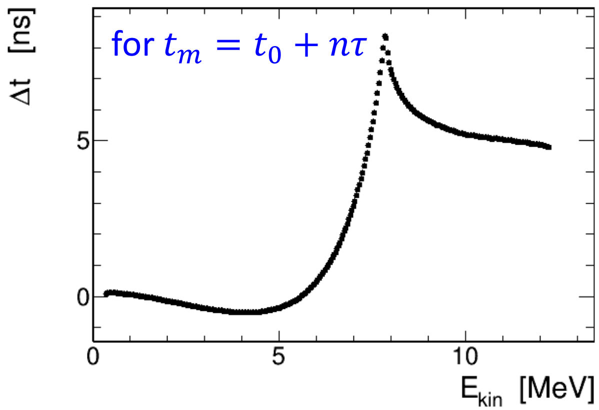
Separation of the stopped and punched through protons

To separate stopped and punched through protons we employed the waveform shape dependence on proton kinetic energy E_{kin}: $W(t) \propto A(E)\,(t-t_0)^{n(E)}\ \exp\left(-\frac{t-t_o}{\tau(E)}\right)$

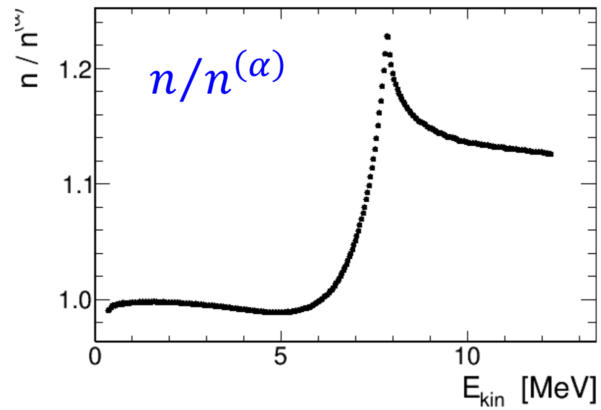
Amplitude



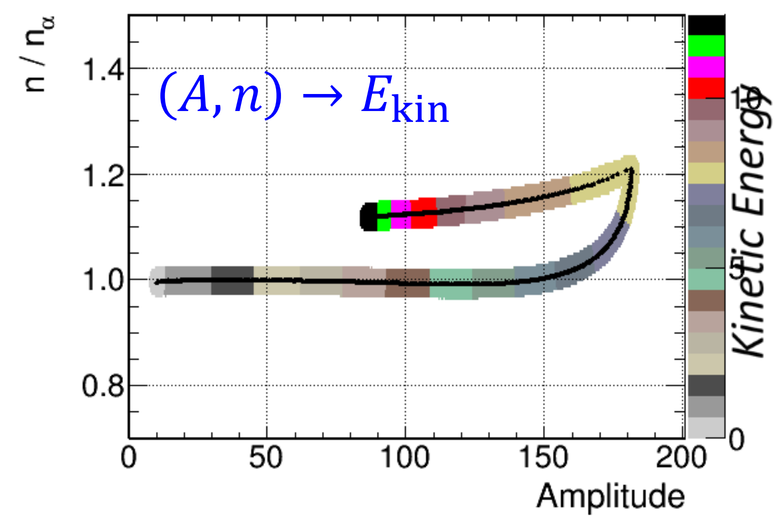
Correction to measured time



Waveform shape parameter

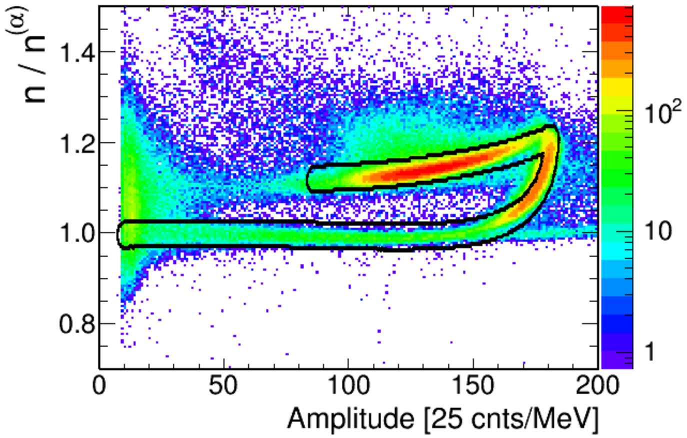


- The signal waveform dependence on kinetic energy was found in a simulation.
- Calibration measurements were used to adjust the simulation.
- Every pair of measured values of amplitude A and waveform shape parameter n was related to the proton kinetic energy E_{kin}.

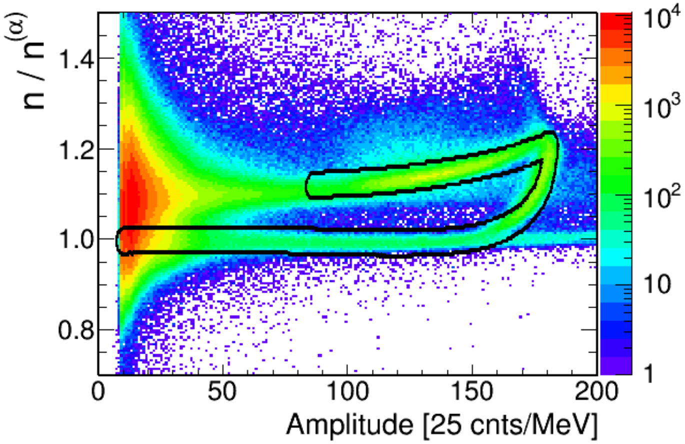


Separation of the stopped and punched through protons

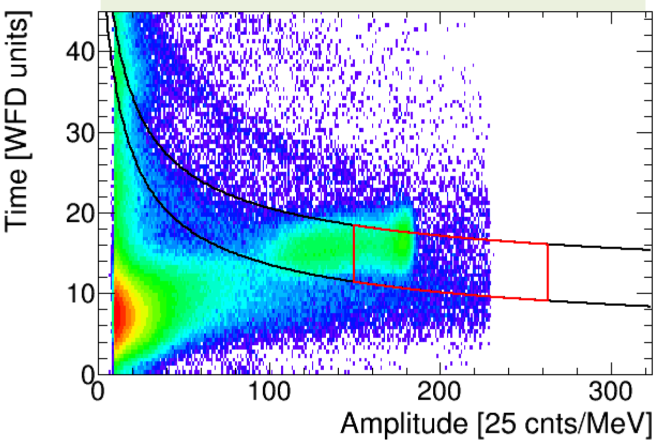
For events within $t - t_p(A)$



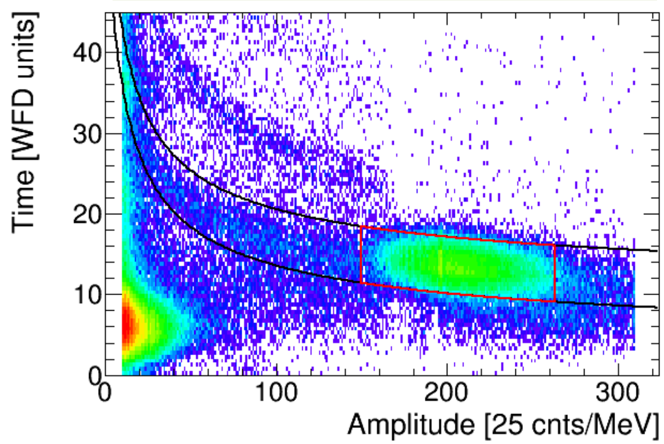
For other events



Raw data

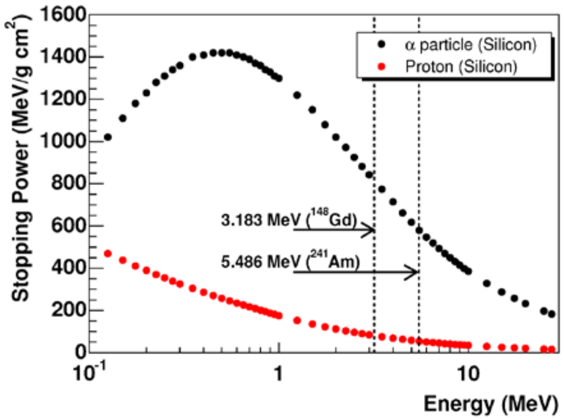


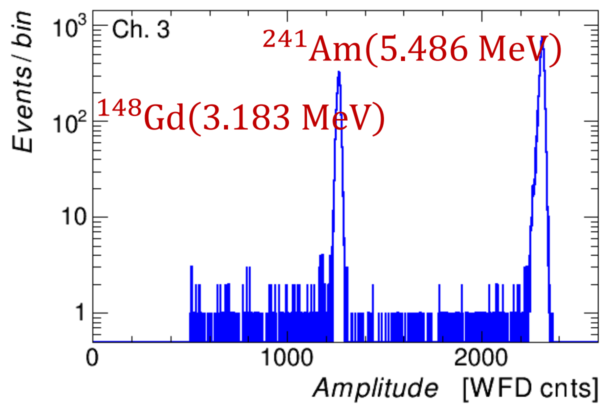
After energy correction



- Waveform simulation is not perfect but acceptable to begin with
- More work is needed.
- The background was partially eliminated

Energy calibration using alpha-sources





$$E_{kin} = gA + E_{loss}(gA, x_{DL})$$

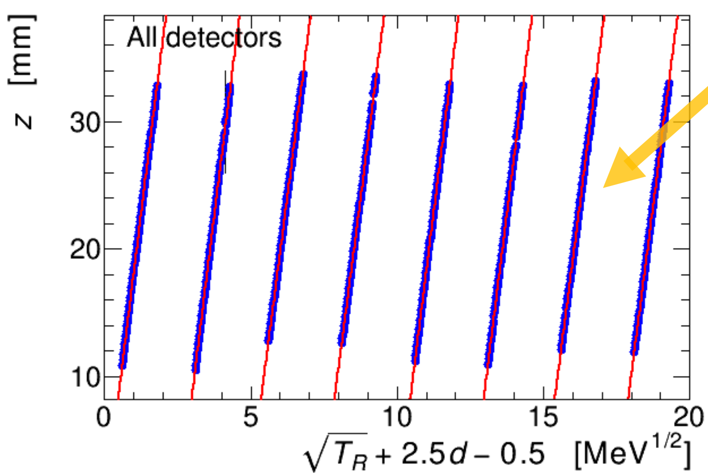
$g \sim 2.5\ keV/cnt$

$x_{DL} \sim 0.37\ mg/cm^2$

$\sigma_E \sim 20\ keV$

- **Energy losses in dead-layer has to be accounted**
- **Two alpha-sources allows us to determine both gain g and dead-layer thickness x_{DL}.**

Verification of the calibration using recoil protons from elastic scattering:



$$\langle z_{det} - z_{jet} \rangle = \kappa\sqrt{T_R}, \qquad \kappa = 18\ \mathrm{mm}/MeV^{1/2}$$

A discrepancy is being observed:

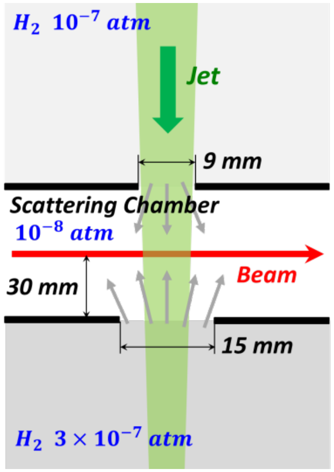
$$\delta\sqrt{T_R} \approx 0.035 + 0.009\sqrt{T_R}$$

$\Rightarrow$ $\langle \Delta T/T \rangle \approx 3\%$ **and** $\langle \Delta T \rangle = 180\ \mathrm{keV}$

After corrections: $\langle \sigma_T^{syst}/T \rangle \approx 0.9\%$ **and** $\langle \sigma_T^{syst} \rangle \approx 20\ \mathrm{keV}$

Since the source of discrepancy (calibration?, geometry?, magnetic field corrections?, …?) is not proved yet, the corrections are not validated. The study is being continued.

Background



Molecular hydrogen background:

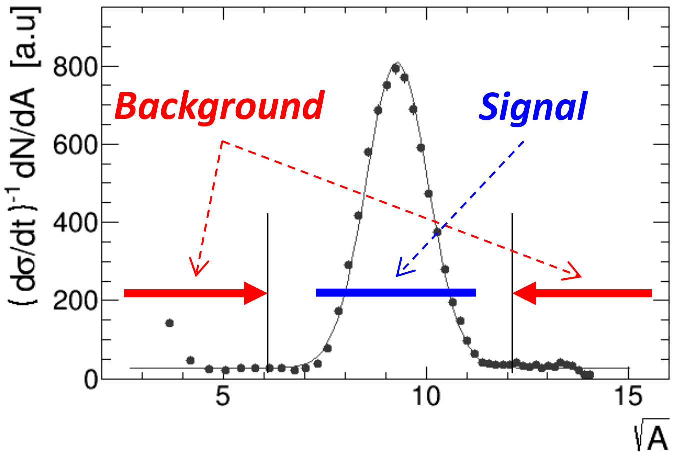
- Atomic hydrogen polarization in the Jet is $95.8 \pm 0.1\%$
- Molecular hydrogen is un-polarized and ,thus, reduce the average polarization of the Jet
- Since molecular hydrogen has much wider distribution than the jet, it potentially could be normalized and subtracted. (The background rate as a function of recoil proton energy is expected to be the same for all Si strips in a detector)

Inelastic background (beam scattering on the HJET frame and non-hydrogen atoms in the Jet)

$$A_{beam} + A_{target} \to p + X$$

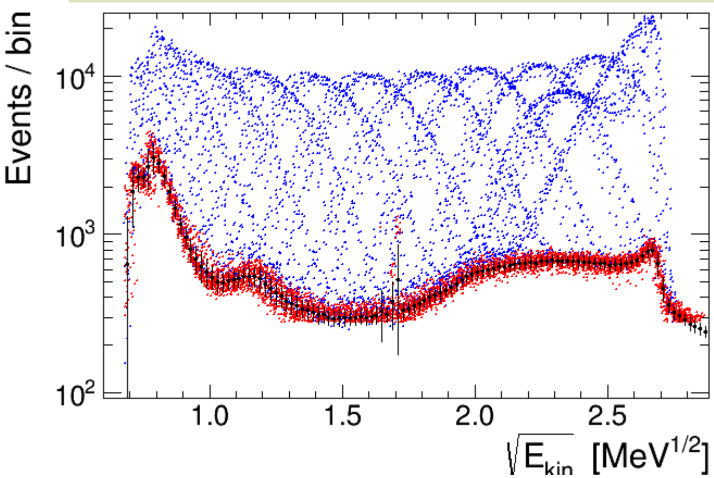
For such processes, since there is no strict correlation between proton energy and angle (within detector acceptance) the background rate is expected to be the same in all Si strips of the detector.

Background subtraction

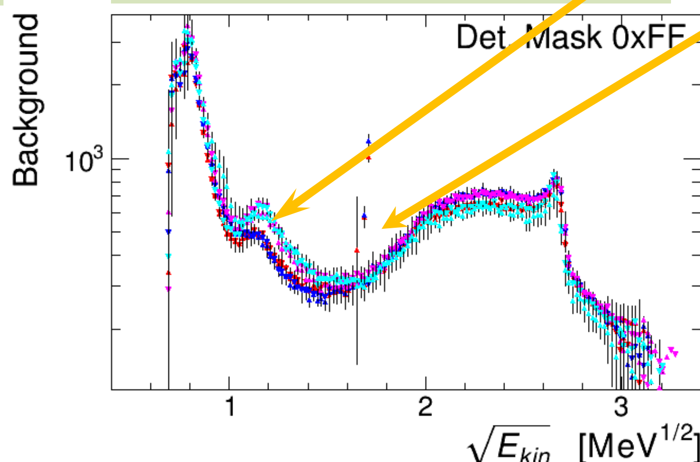


- For all Si strips, the (Gaussian) elastic pp signal is expected to have the same height and width but different position depending on z-coordinate of the strip
- **The molecular hydrogen contribution is expected to be flat and, thus, the same for all strips.**
- **The distributions for inelastic background is expected to be the same for all strips, because the acceptance angle is small and there is no strong correlation between energy and angle.**
- **Selecting events $\pm 4\sigma\ (0.6\ MeV^{1/2})$ outside the elastic peak we can determine the background contribution as a function of energy (amplitude).** ***This could be done independently for all time bins***

Superposition of $\sqrt{E}$ distributions for all Si strips. Points selected for background evaluation are marked red



Background distributions determined for each detector separately.

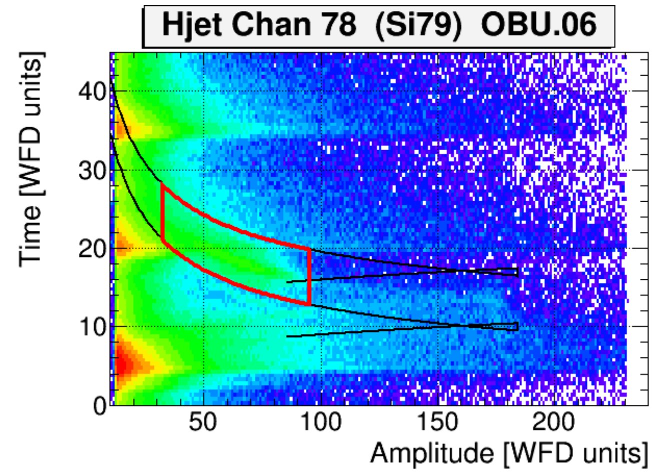


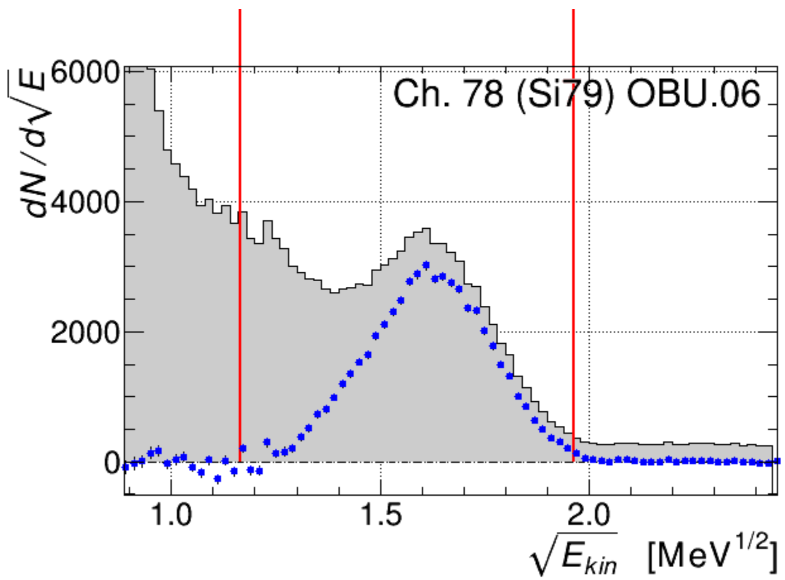
- Beam halo is not the same for inner and outer detectors.
- Some alpha source particles in the data
- Background is slightly detector dependent.

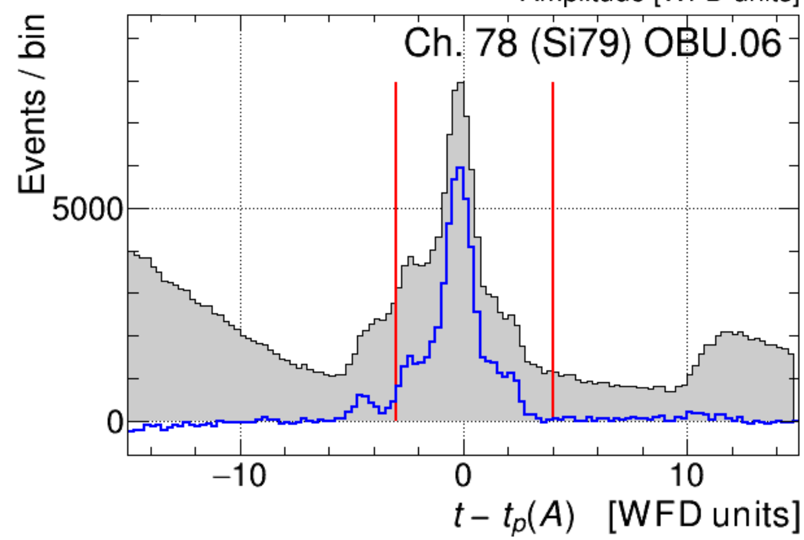
Background should be measured separately for every detector and every beam / jet polarization

How background subtraction works

The example is given for blue detector in 100 GeV dAu Run
(*The worse background/signal ratio*)

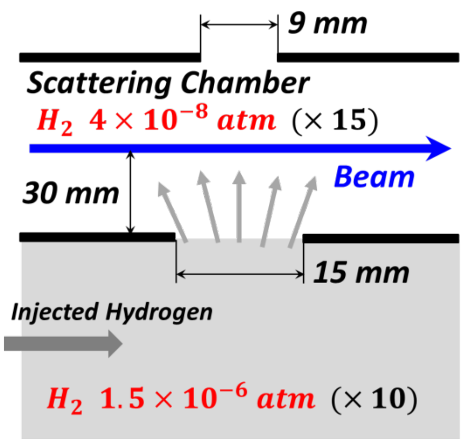






- The method works reasonably well even in this extremal case
- Usually, the accuracy of background subtraction is $\lesssim (5 \div 10)\%$.
- If the background level $< 10\%$ the background related systematic errors might be $< 1\%$.

Evaluation of the molecular hydrogen background

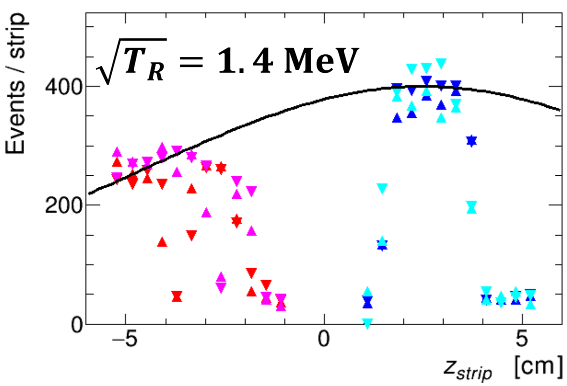


Molecular hydrogen (MH) distribution was tested in Run 16:

- 20 min run with single (blue) 9.8 GeV/n Au beam.
- Jet off. Hydrogen was injected to Chamber 7
- The distribution was found flat

$$\sigma_{MH} \approx 7.5\ cm \gg \sigma_{jet} \approx 2.6\ mm$$

- but it was strongly modified by the jet collimators
- Only a small part ($\sim$20%) of MH was accounted by background subtraction

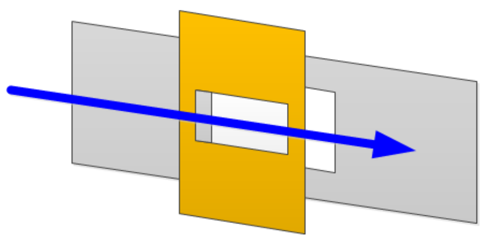


The observed structure of molecular hydrogen distribution in opposite (yellow) detectors was found in a regular run data, which allows us to normalize atoms density in the **flat** MH background:

$$n_{MH}^{f}/n_{jet}^{peak} = 0.5 \pm 0.2\%$$

Similarly the MH hydrogen in the jet was evaluated as

$$n_{MH}^{f}/n_{jet}^{peak} = 0.3 \pm 0.1\%$$



The MH contribution to the *effective* Jet polarization:

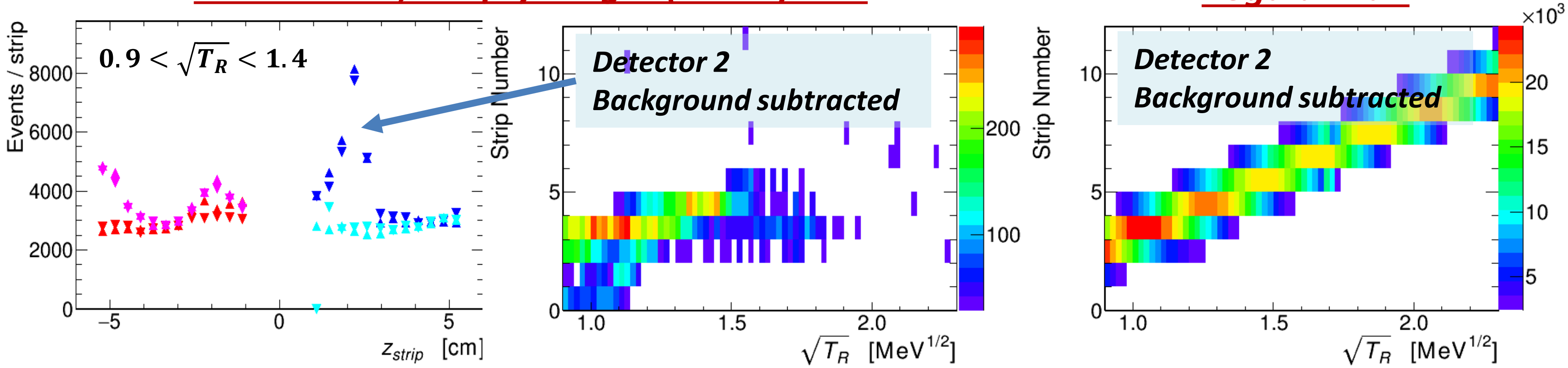
$$\Delta P/P = -1.5 \pm 0.5\%$$

Only about 0.3% are accounted by background subtraction.

Non-uniformity of inelastic background

dAu 9.8 GeV, Empty Target (no Jet) Run

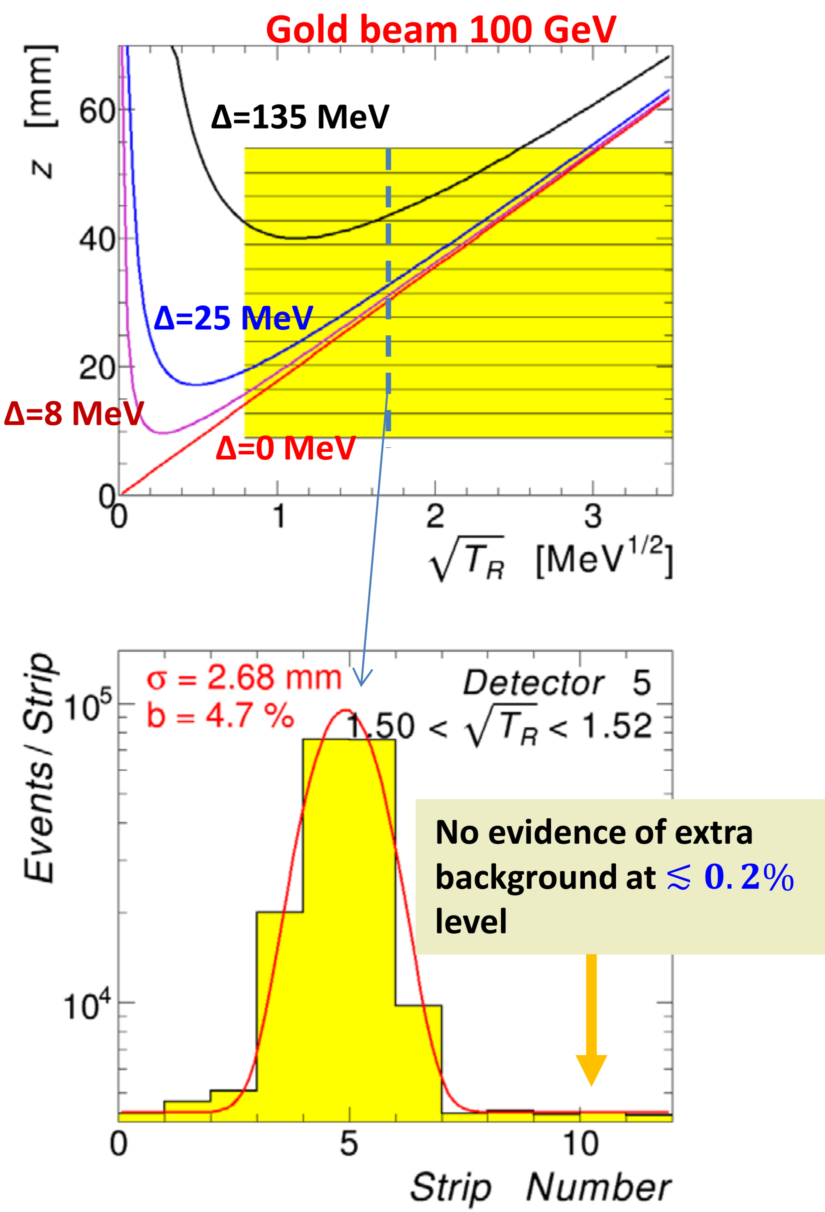
Regular Run



- Flat distributions were expected in empty target (Jet off) runs.
- Strong non-flatness is seen in **inner blue** and **outer yellow** detectors at $0.9 < \sqrt{T_R} < 1.9$
- For inner (right) blue detectors the background is not properly subtracted. The remaining background is well overlapped with the elastic signal.
- As result, for blue beam $\delta A_N^{(R)} < 0$ if $T_R \lesssim 3$ MeV.
- If this is the only systematic error then the measured analyzing power $A_N^{(m)}(t)$ may be corrected using the deviation in the intensity asymmetry measurement $\boldsymbol{\delta A_N^{(m)}(t) = \delta\lambda^{(m)}(t)}$

For blue (deuterium) beam we have to expect a significant systematic error at low $(-t < 0.005\ \mathrm{GeV}^2)$ momentum transfer which, however, may be corrected. We plan to remove the HJET collimators in Run 17.

Beam inelastic scattering on the Jet hydrogen



$$\mathbf{Au} + \boldsymbol{p}^{\uparrow} \rightarrow \boldsymbol{p_R} + \boldsymbol{X}$$

$$z/L \approx \sqrt{\frac{T_R}{2m_p}} + \sqrt{\frac{2m_p}{T_R}}\frac{\Delta}{E_{\mathrm{Au}}} \qquad (\Delta = M_X - M_{Au})$$

No evidence of the discussed background is being observed

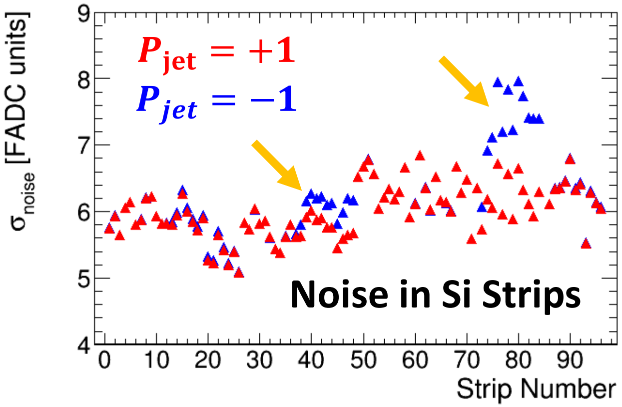
- We can exclude the $\boldsymbol{Au \rightarrow X_1 + X_2} \quad (\Delta > \Delta_M = \boldsymbol{M_1 + M_2 - M_{Au}})$ at $\sim 0.2\%$ level
- *More study is needed to evaluate possible contribution of the following processes:*
  - $\mathbf{Au} \rightarrow \boldsymbol{Au^*}$ (excitation)
  - $\mathbf{Au} \rightarrow \boldsymbol{Au + \gamma}$ (bremsstrahlung)
- If any, such a background will not be subtracted by the method discussed above.

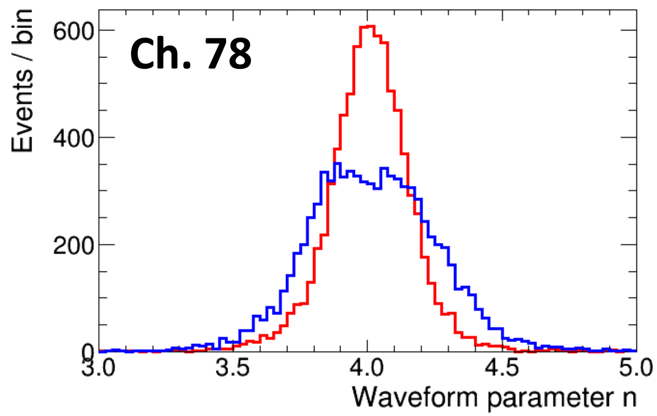
Detector acceptance correlation with the Jet polarity

<u>The Jet RF transition cavity can induce noise in the Jet Si detectors:</u>

$$P\delta A_N = \frac{\delta\epsilon_L - \delta\epsilon_R}{2} \qquad \delta\epsilon_{l,R} = \frac{\Omega^+_{L,R} - \Omega^-_{L,R}}{\Omega_L + \Omega_R}$$

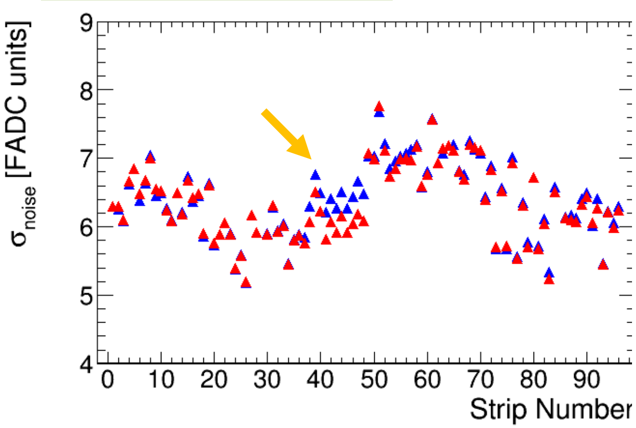
Run 2015

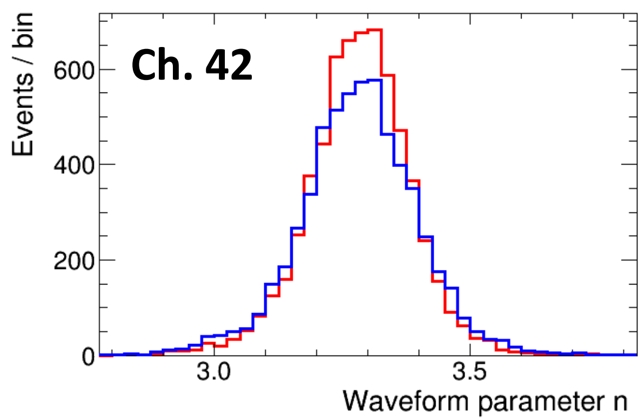




- **For a tight cut the acceptance may be change by up to a factor 2, which strongly affects the polarization measurement**
  $P\delta A_N = \delta\epsilon_L/2 \approx -0.15$
  (300 % error !)
- **For a loose cut, e.g 4±0.7, the problem is strongly suppressed.**

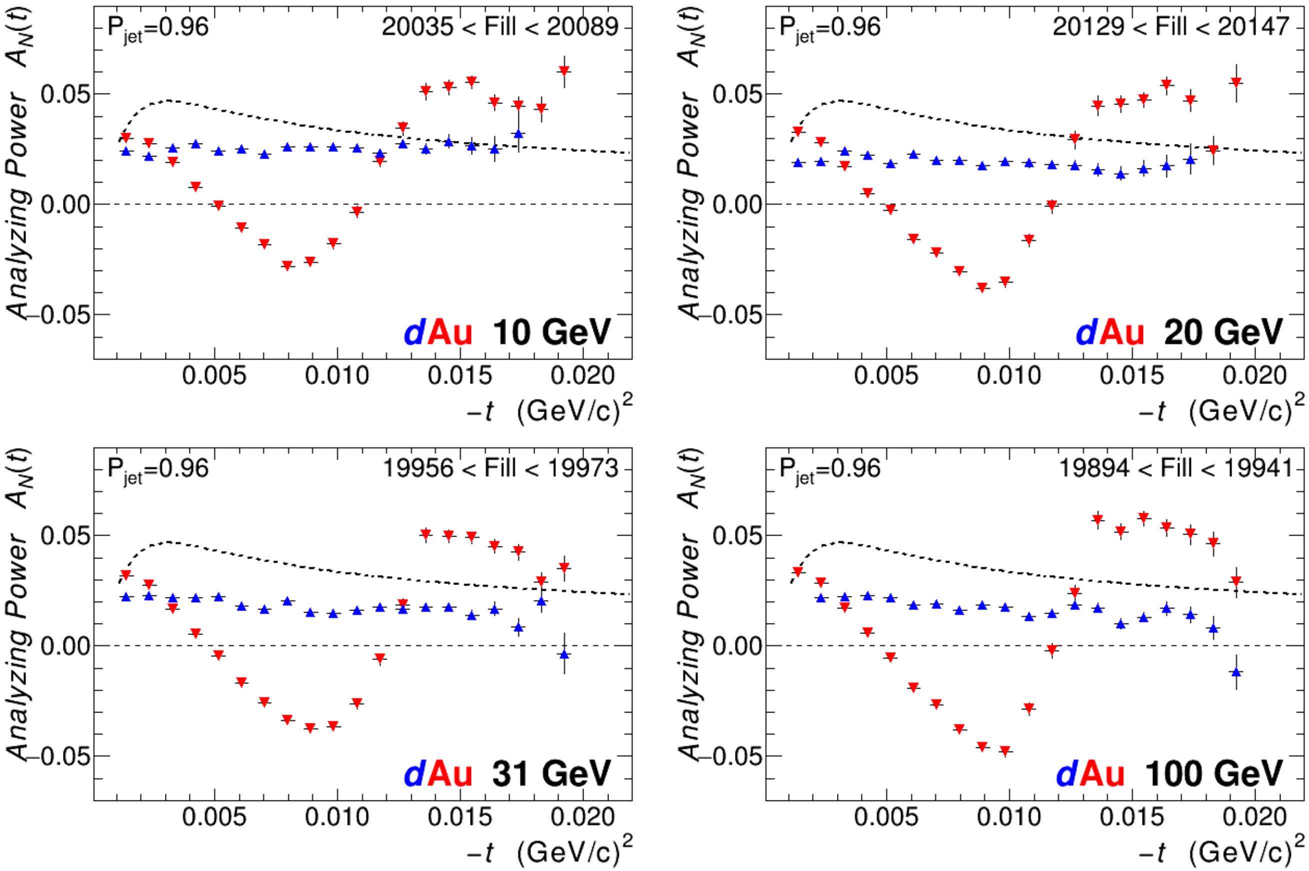
Run 2016





- **Situation was strongly improved but not eliminated.**
- **The RF induced noise is still seen in one inner blue detector**

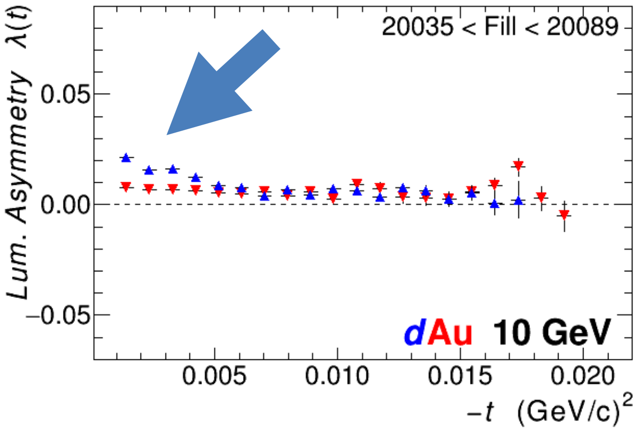
***PRELIMINARY* results for $p^{\uparrow}d$ and $p^{\uparrow}\mathrm{Au}$ analyzing power (Run 2016)**

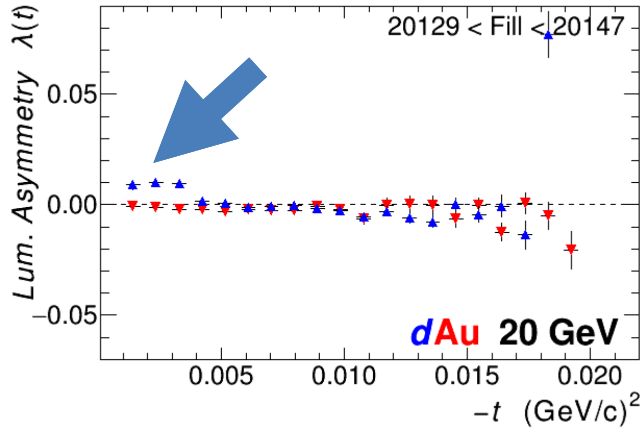


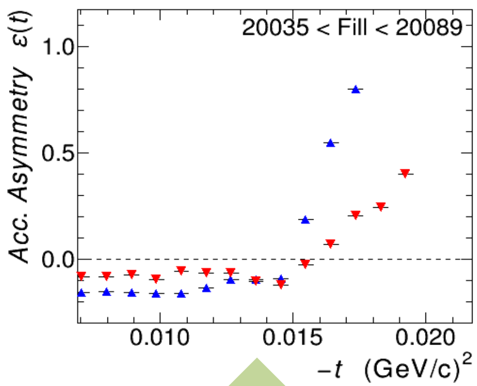
***Dashed black line shows a theoretical prediction for $p^{\uparrow}p$ (with no hadronic spin-flip amplitude, $r_5 = 0$)**

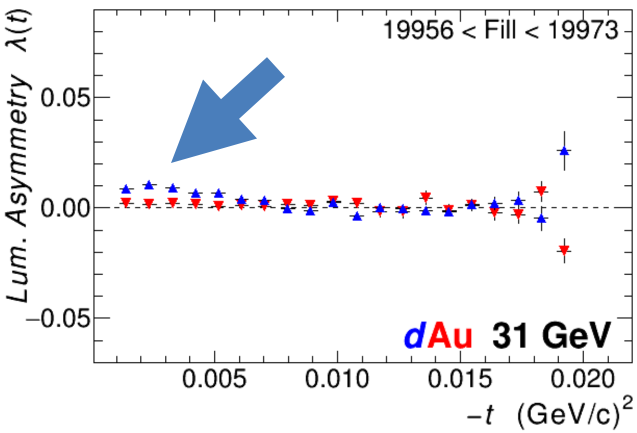
- Background was subtracted.
- Statistical errors were underestimated ($\sigma_N = \sqrt{N_{meas} - N_{bgr}}$) for points with large background contribution.
- Systematic errors were not corrected.

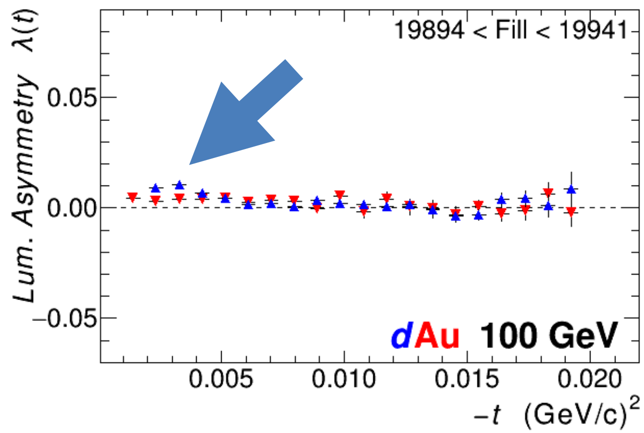
Luminosity (intensity) asymmetry $p^{\uparrow}d$ and $p^{\uparrow}\mathrm{Au}$ measurements







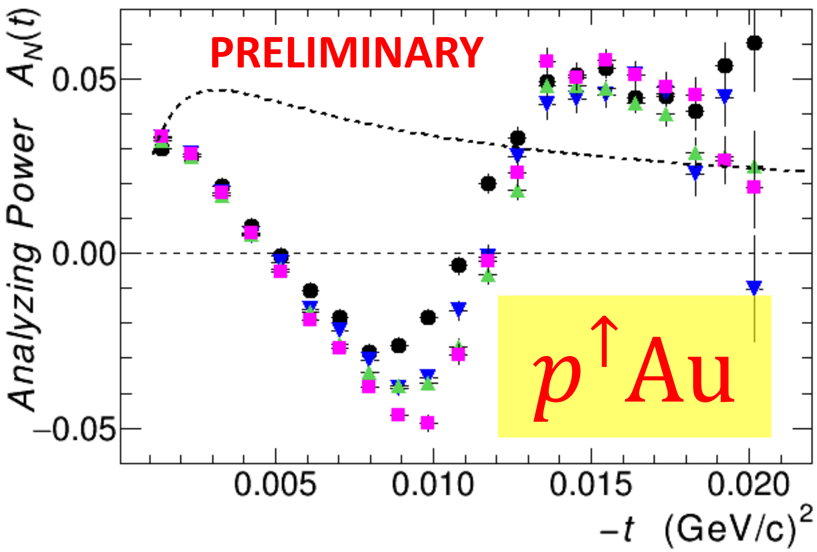


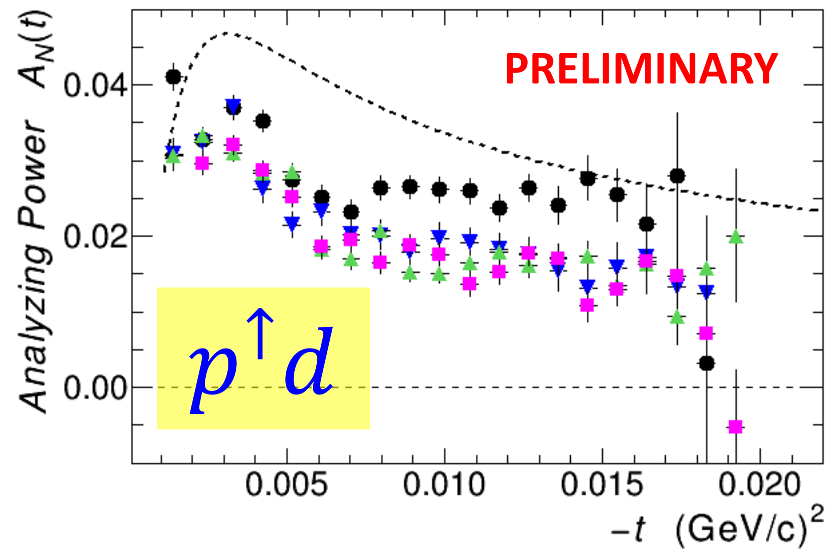


For large recoil angles (large $-t$), the left/right detector acceptances may be significantly different.

- The $\lambda(t)$ has to be t independent
- For blue (deuterium) beam Improperly subtracted background is expected to be the main source of discrepancy at low t.
- Fluctuations of $\lambda(t)$ may be used for rough estimate of the systematic errors.
- Systematic errors are expected to be small at $0.006 < -\mathrm{t} < 0.012\ (\mathrm{GeV}/c)^2$

$A_N(t)$ dependence on beam energy





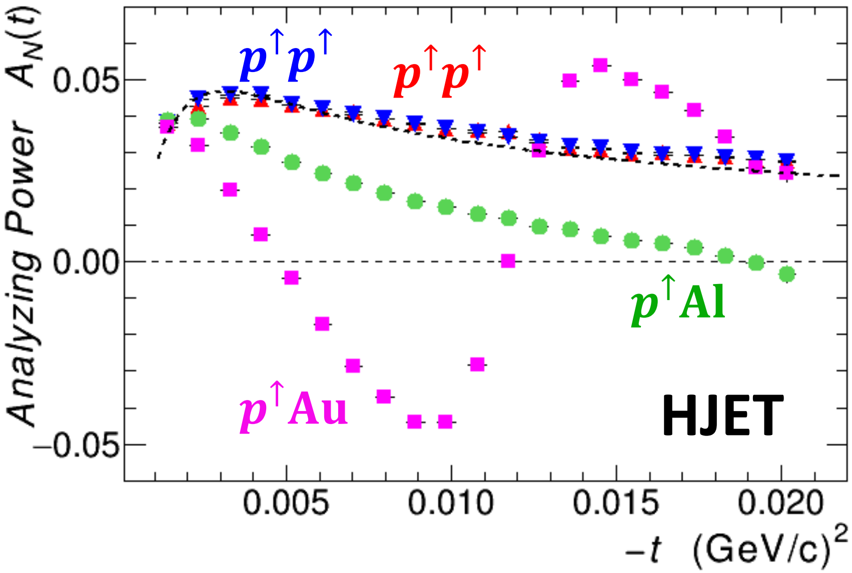
- ● 10 GeV
- ▼ 20 GeV
- ▲ 31 GeV
- ■ 100 GeV

Partial correction of systematic errors:

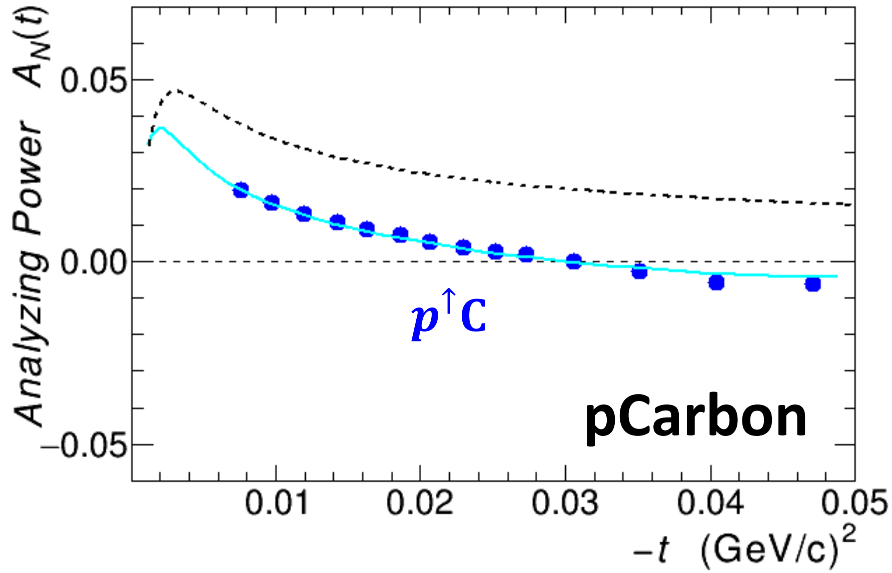
- To account for un-subtracted molecular hydrogen, $P_{jet} = 95\%$.
- To account for un-subtracted inelastic background in inner blue detectors, for blue (deuterium) beam $A_N(t) \to A_N(t) + \frac{\lambda(t) - \langle\lambda\rangle}{P_{jet}}$ if $-t < 0.006$. The average value of intensity asymmetry $\langle\lambda\rangle$ was calculated at $0.006 < -t < 0.012$. *The method does not work well for the 10 GeV data.*
- For $-t > 0.012$, the analyzing power was calculated using fixed intensity asymmetry $\langle\lambda\rangle$.

Other results from RHIC

Run 2015, 100 GeV (preliminary)



Run 2006, 100 GeV (unpublished)



- Systematic errors were **partially** corrected (similar to 2016 data)
- $p^\uparrow p^\uparrow$ results are given separately for blue and yellow beams.
- $p^\uparrow\mathrm{Au}$ results are in a reasonable consistence with new (2016) measurements
- Momentum transfer range may be extended to $-t \lesssim 0.023$.

- Proton beam polarization was measured using HJET
- For $0.002 - t < 0.010$ the measured $p\mathrm{C}$ analyzing power (including theoretical extension) is very similar to the $p\mathrm{Al}$ one
- It might be interesting to make $p\mathrm{C}$ measurements at HJET using Carbon beam

Elastic $p^\uparrow p^\uparrow$ scattering

Helicity amplitudes describing elastic $p^\uparrow p^\uparrow$ scattering:

spin non-flip $\phi_1(s,t) = \langle + + | + + \rangle$, $\phi_3(s,t) = \langle + - | + - \rangle$

double spin flip $\phi_2(s,t) = \langle + + | - - \rangle$, $\phi_4(s,t) = \langle + - | - + \rangle$

single spin flip $\phi_5(s,t) = \langle + + | + - \rangle$

$$\phi_i(s,t) = \phi_i^{had}(s,t) + \phi_i^{em}(s,t) e^{\delta_C(s,t)}$$

$$\frac{d\sigma}{dt} = \frac{2\pi}{s^2}\left(|\phi_1|^2 + |\phi_2|^2 + |\phi_3|^2 + |\phi_4|^2 + 4|\phi_5|^2\right)$$

$$A_N \frac{d\sigma}{dt} = -\frac{4\pi}{s^2} Im[(\phi_1 + \phi_2 + \phi_3 - \phi_4)\phi_5^*]$$

Electromagnetic amplitudes are known from QED.
For small t (CNI region) the A_N is dominated by interference of hadronic and electromagnetic amplitudes

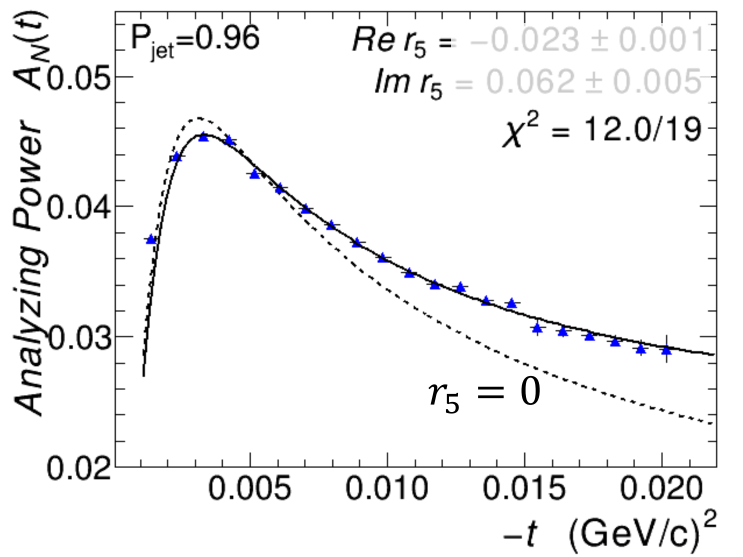
$$\frac{16}{\sigma_{tot}^2}\frac{d\sigma}{dt}e^{-Bt} = \left(\frac{t_c}{t}\right)^2 - 2(\rho + \delta_C)\frac{t_c}{t} + (1 + \rho^2)$$

$$\frac{m_p A_N}{\sqrt{-t}}\frac{16}{\sigma_{tot}^2}\frac{d\sigma}{dt}e^{-Bt} = \kappa(1 - \rho\delta_C)\frac{t_c}{t} - 2(\mathrm{Im}\, r_5 - \delta_C \mathrm{Re}\, r_5)\frac{t_c}{t} - 2(\mathrm{Re}\, r_5 + \rho \mathrm{Im}\, r_5)$$

$$|t_c| = \frac{8\pi\alpha}{\sigma_{tot}(mb)} \qquad \kappa = \mu_p - 1 = 1.79 \qquad r_5 = \frac{m_p \phi_5^{had}(s,t)}{\sqrt{-t}\ \mathrm{Im}\,(\phi_1 + \phi_3)^{had}/2}$$

$$\sigma_{tot} = 38.4\ \mathrm{mb},\ \rho = -0.08,\ \delta_C = 0.02,\ B = 12\ \mathrm{GeV}^2\quad (E_{beam} = 100\ \mathrm{GeV})$$

Run15: $p^\uparrow p^\uparrow$ 100 GeV
(preliminary)



The determination of r_5 is very sensitive to the systematic errors.

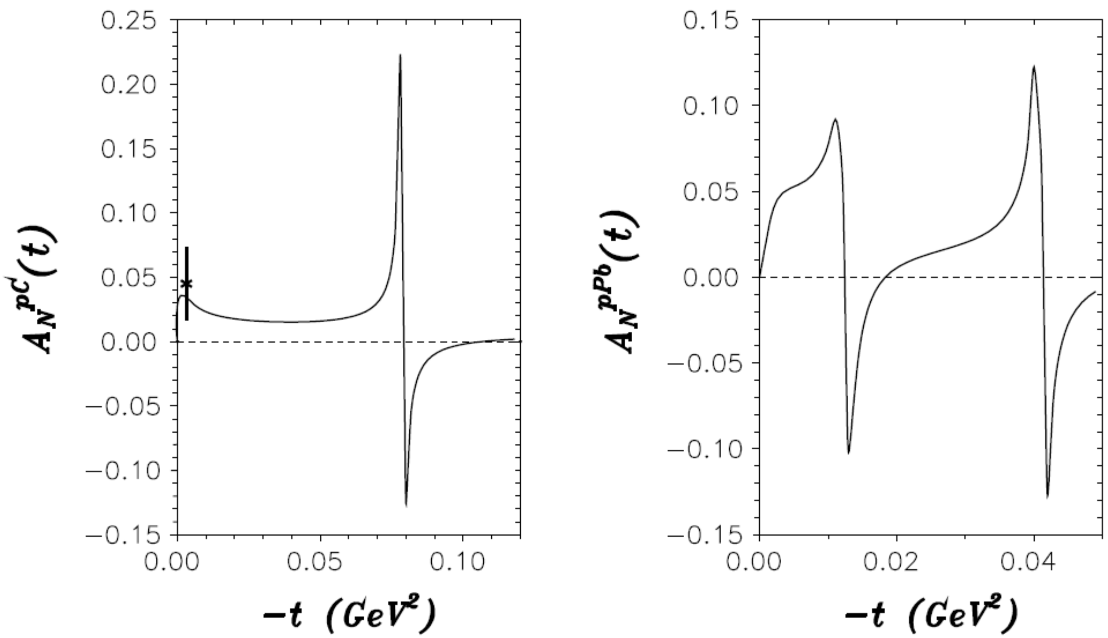
Polarized proton-nucleus scattering

Theoretical description of the single spin asymmetry in proton-nucleus elastic scattering is similar to the proton-proton scattering, however it is much more complicated because "the diffractive structures in elastic pA are extremely sensitive to the chosen nuclear parameters, and to the corrections from the real part of the amplitude, Coulomb phase etc".

Theoretical calculations done **almost 20 years ago** with actually no available experimental data are not in a good agreement with recent measurements.

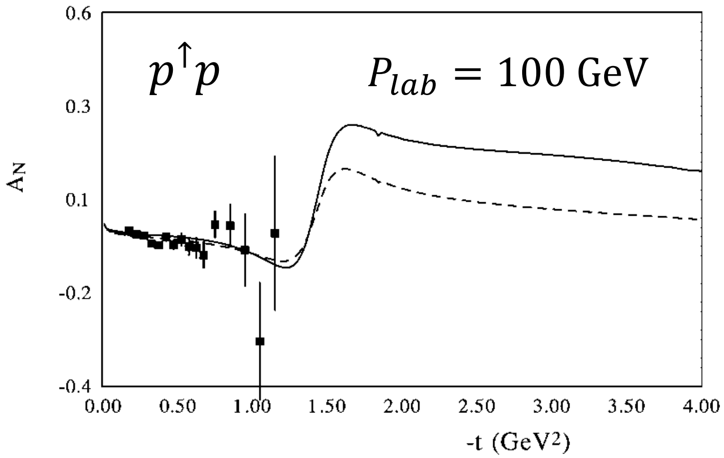
Experimental study of the spin correlated asymmetry is an important entry for parameterization of proton-nucleus scattering amplitudes.

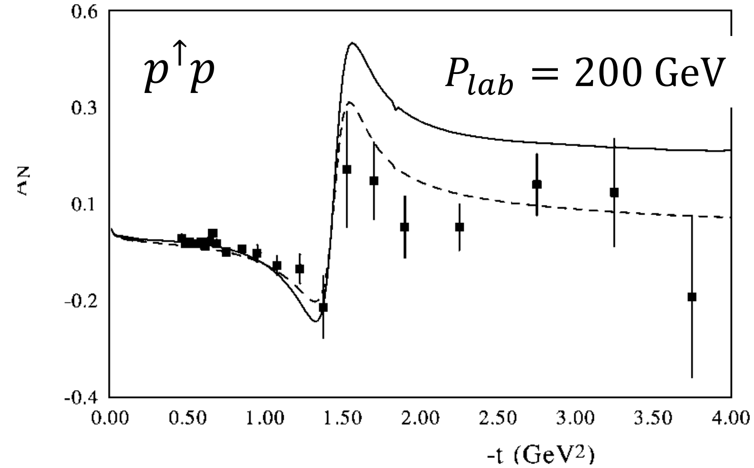
B. Kopeliovich, arXiv:hep-ph/9801414, **1998**



$p^{\uparrow}$Au *vs* $p^{\uparrow}p$

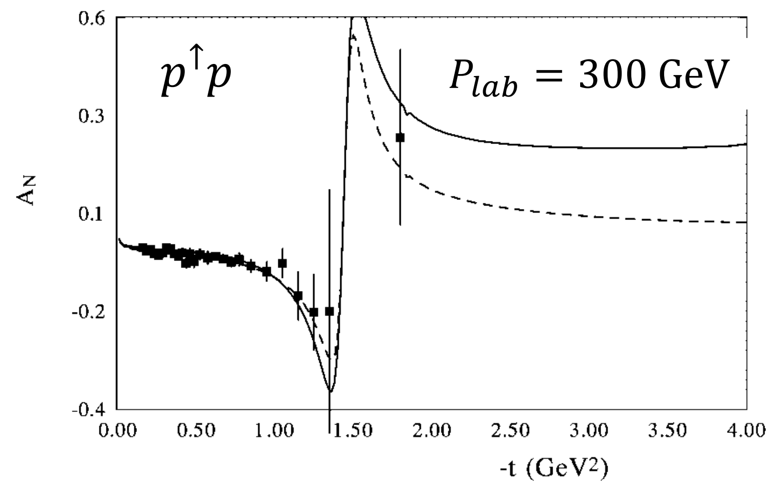
O. Selyugin, arXiv:1512.05130 (**2015**)





- The Analyzing power dependence on t looks very similar for pp and pAu.
- The difference in the t-scale may be related to the diffractive angle difference:

$$\theta_{\mathrm{dif}} \sim \lambda / d \quad \Rightarrow \quad t \sim A^{-2/3}$$



Summary

- Preliminary results for $p^{\uparrow}d$ and $p^{\uparrow}\mathrm{Au}$ analyzing power at measurements at RHIC HJET where reported. The measurements were done at four energies 10, 20, 31, and 100 GeV. The analyzing power was measured for $0.002 < -t < 0.020\ (\mathrm{GeV}/c)^2$
- Some systematic errors were evaluated and results of measurements were corrected
- There is understanding of the main sources of systematic errors but more study is still needed for
  - Energy Calibration
  - Separation of stopped and punched through protons
  - Noise correlation with the Jet polarization state
  - Inelastic background dependence on the Jet collimators
  - The beam inelastic scattering on Jet protons.
- A precise accounting for gain variations and possible instability in Si detectors, magnetic field corrections, the detector geometry stability has to be done