RHIC Polarimetry: Status and Plans

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on behalf of the
polarimetry group

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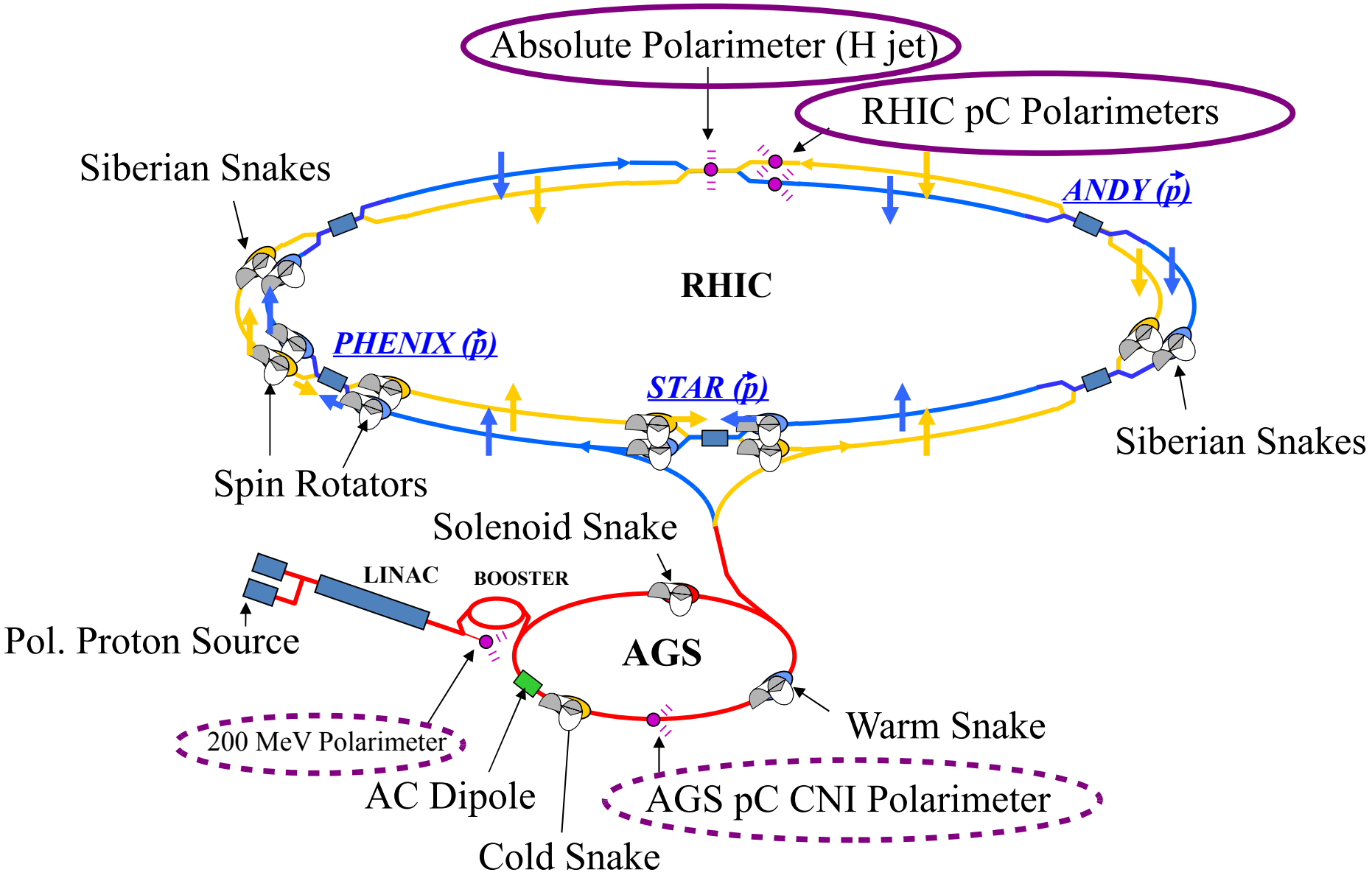
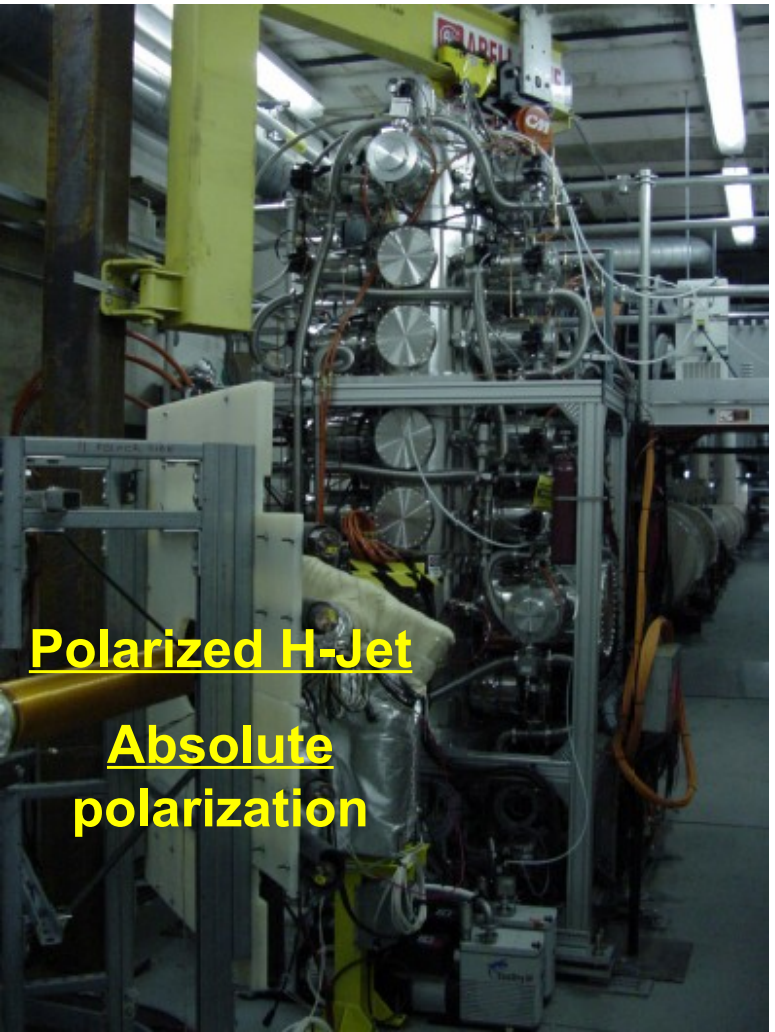
RHIC and Polarimetry

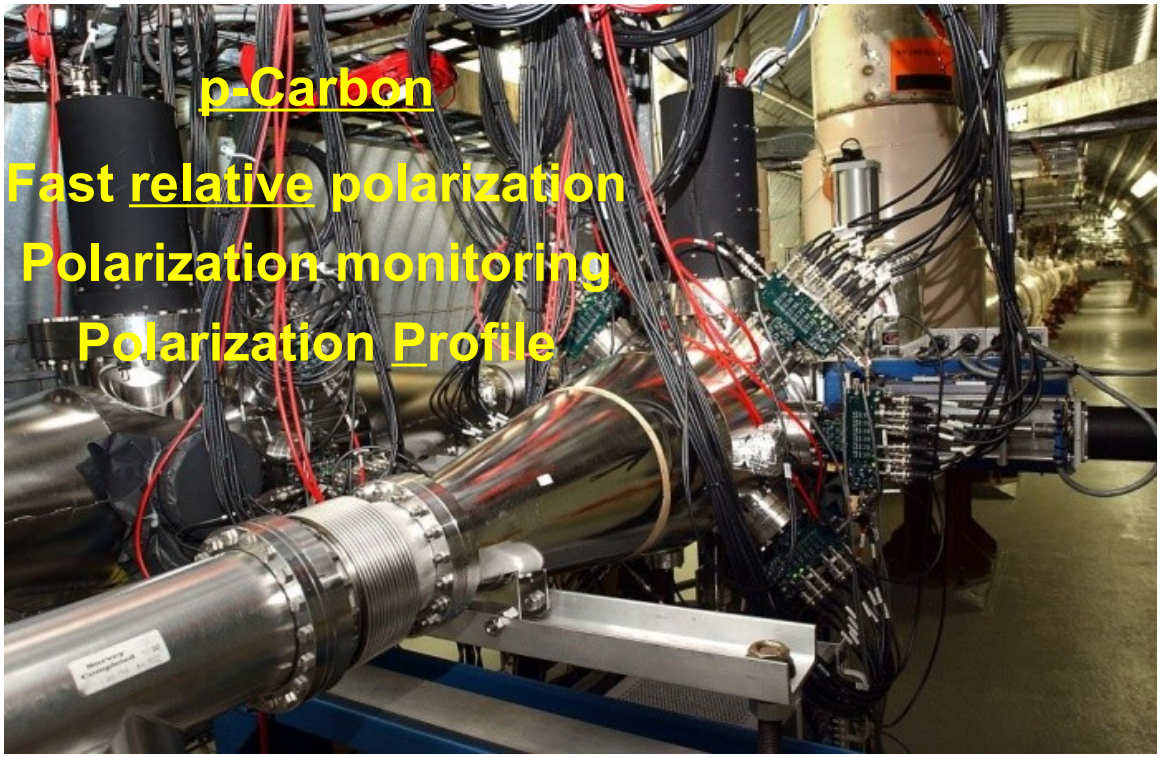


RHIC Polarimeters

"CNI" polarimetry
Left-right asymmetry in elastic scattering: Interference between electromagnetic and hadronic amplitudes in the Coulomb-Nuclear Interference (CNI) region

- Fast feedback for polarized beam setup, tune and development
- Precise beam polarization measurements for RHIC, experiments

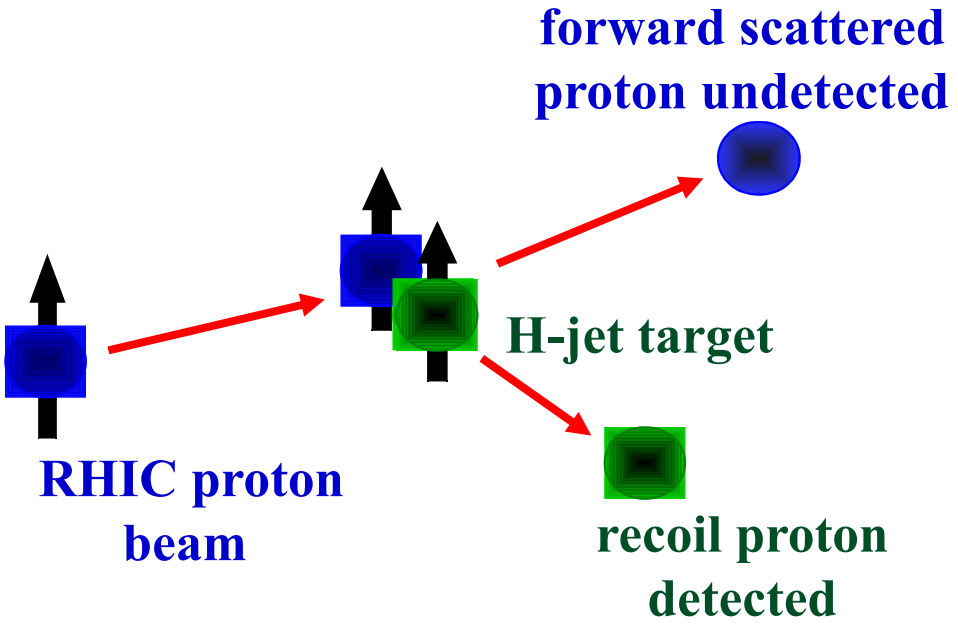




Polarized H-Jet Polarimeter

- Polarization P
- L/R asymmetry ϵ
- analyzing power A_N

$$A_N = \frac{1}{P}\frac{N_L - N_R}{N_L + N_R} = \frac{\epsilon}{P}$$



"beam", "target" identical, same A_N:

$$A_N(t) = -\frac{\epsilon_{\text{target}}}{P_{\text{target}}} = \frac{\epsilon_{\text{beam}}}{P_{\text{beam}}}$$

measured:

"unpol. beam" avg. ⇑ & ⇓

"unpol. target" avg. ⇑ & ⇓

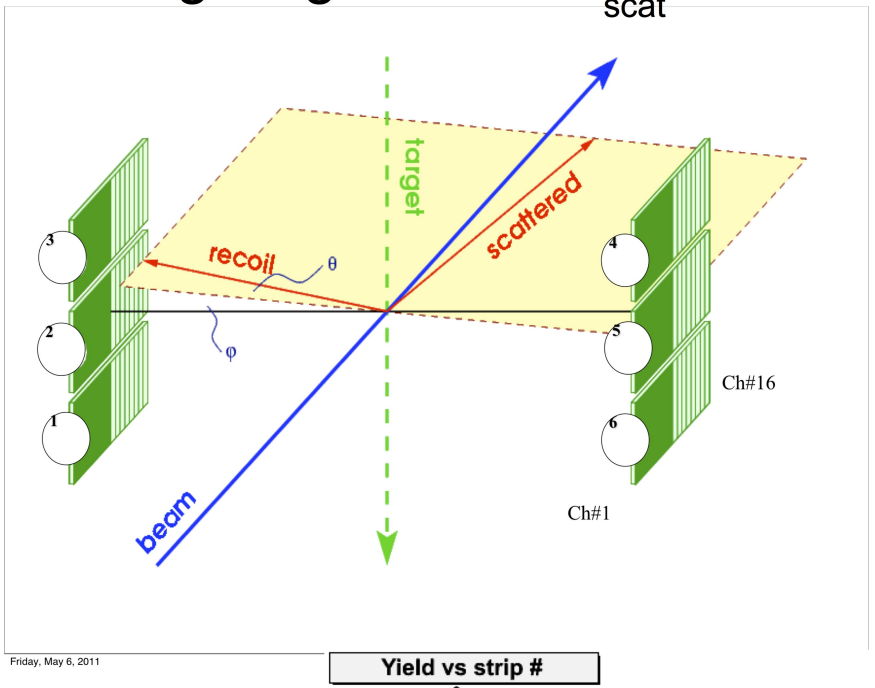
$$P_{\text{beam}} = -P_{\text{target}}\frac{\epsilon_{\text{beam}}}{\epsilon_{\text{target}}}$$

P_{target} ~96% measured by Breit Rabi Polarimeter

H-Jet: elastic event selection

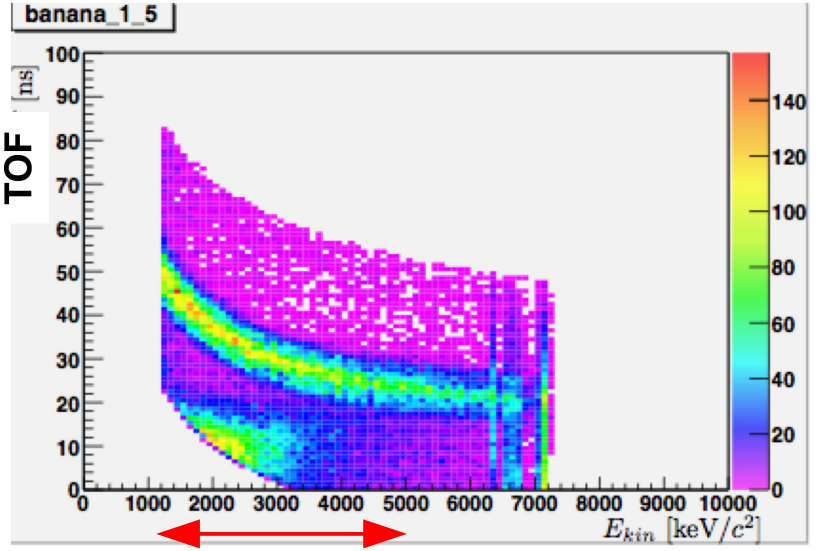
Si det.:

- E, TOF measure
- Long. segment. $\Rightarrow \theta_{scat}$

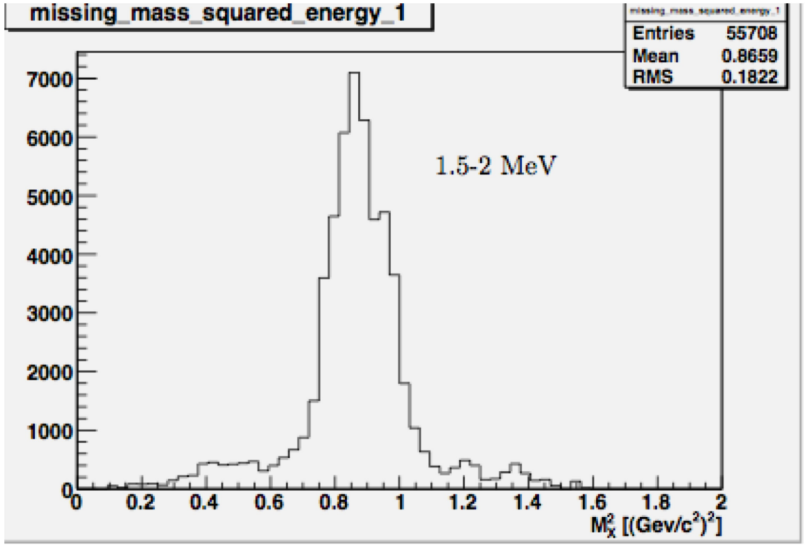


TOF select scattered protons: $t = \cdot\sqrt{\frac{m_p}{2E_{kin}}}$

polar. in range 1<Ep<5 MeV

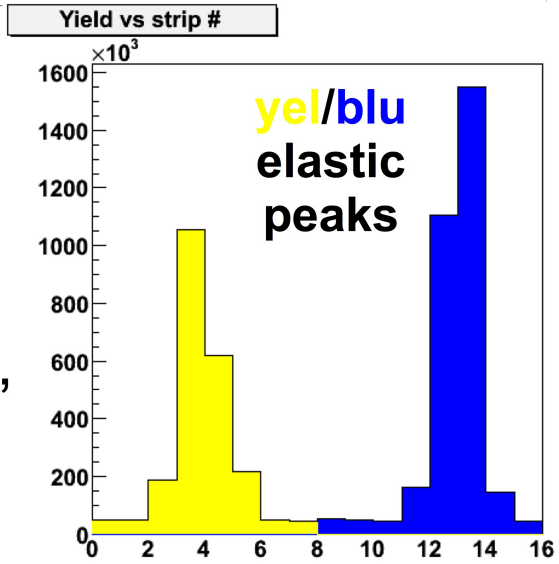


select elastic pp→pp: $M_X^2(E_p,\theta_{scat}) \approx m_p^2$



fixed Ep:

- Strip# ∝ θ_{scat}
- blue forward, yellow back.



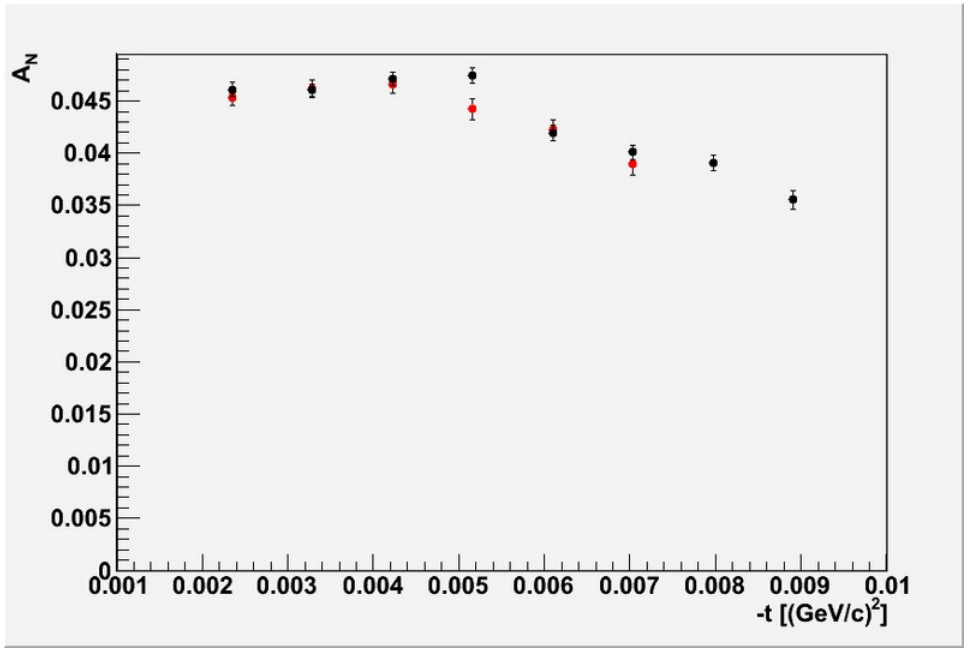
H-Jet: A_N & polarization

A_N vs. t (sum all Run11):

- Consistent w/ Run9
- Relatively flat in

$$t = -2M_p \cdot E_{kin}$$

⇒ weak sensitivity to Ekin scale

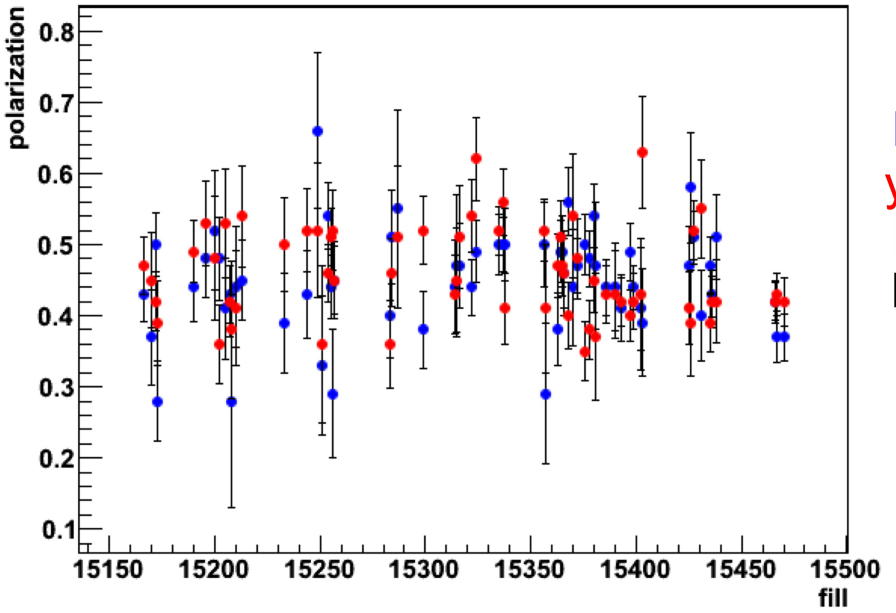


$$t = (p_{in} - p_{out})^2 < 0$$

Polarization vs fill:

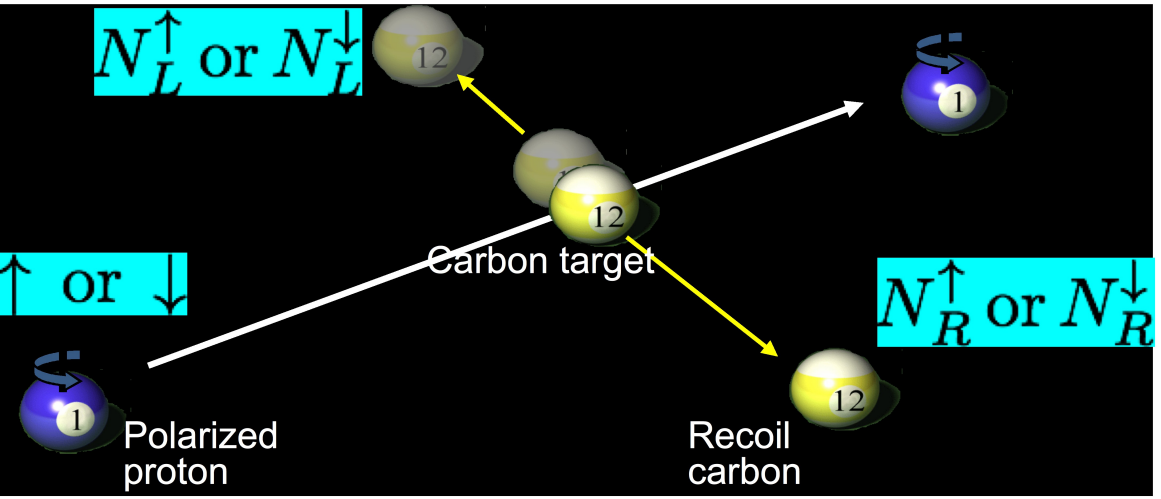
- Low rate ~20 Hz

⇒ statistics limited, 10-15% rel. uncert. / fill

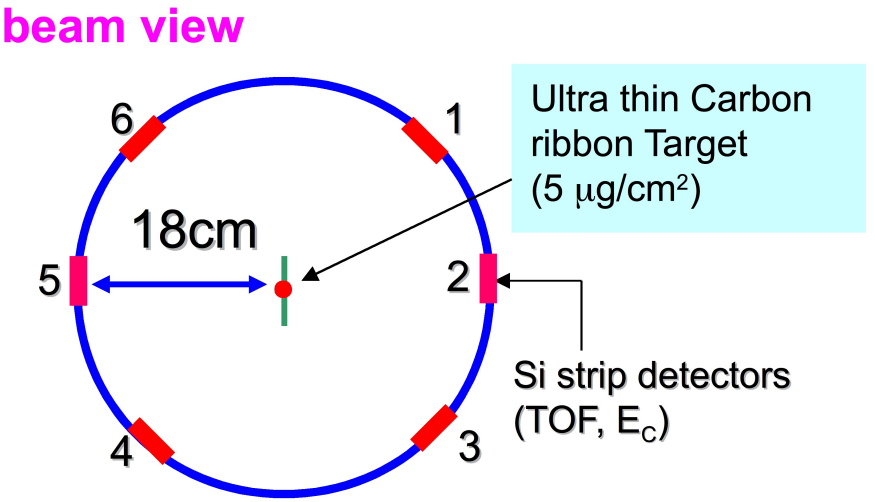


blue / yellow RHIC beam

P-Carbon Polarimeter



2 polarim. / RHIC ring:

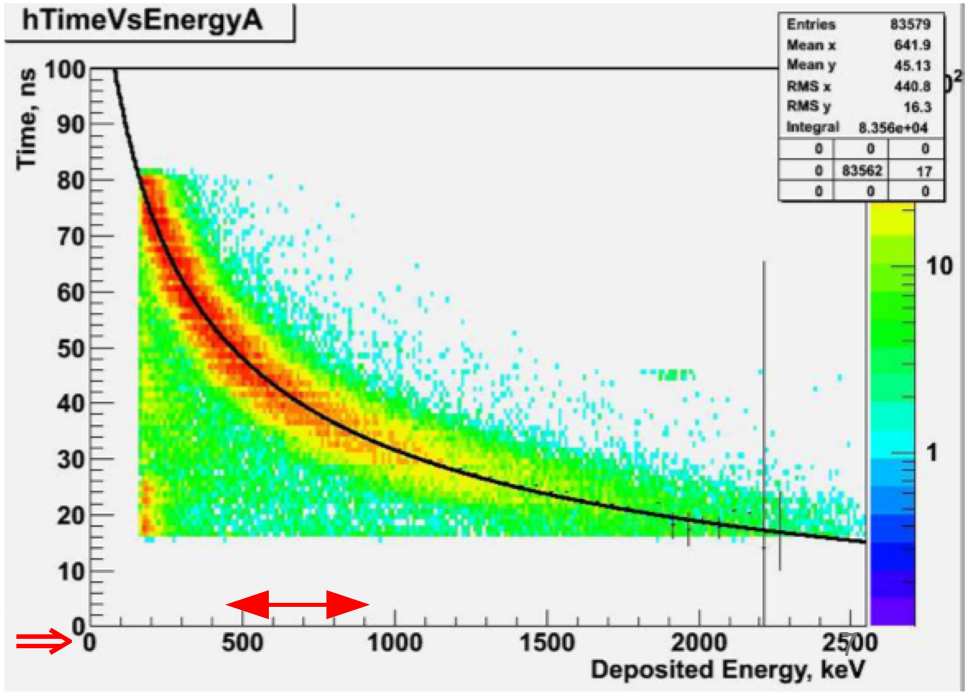


Target Scan mode (~30 sec/measurement)

- Rate 10's MHz ⇒ rel. stat. uncert. 2-3%
- 4-5 measurements per fill:

  injection, ramp before/after rotators,

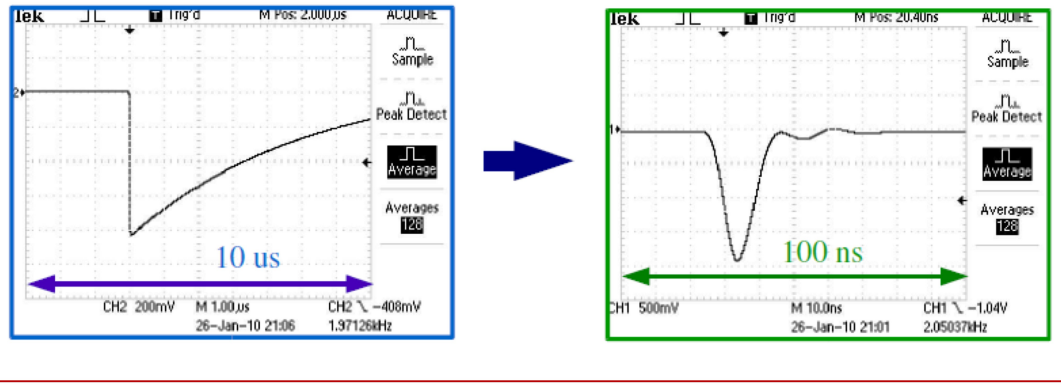
  @ store every 2-3 hours
- Vertical & horizontal profiles each beam
- Normalized to H-Jet over many fills



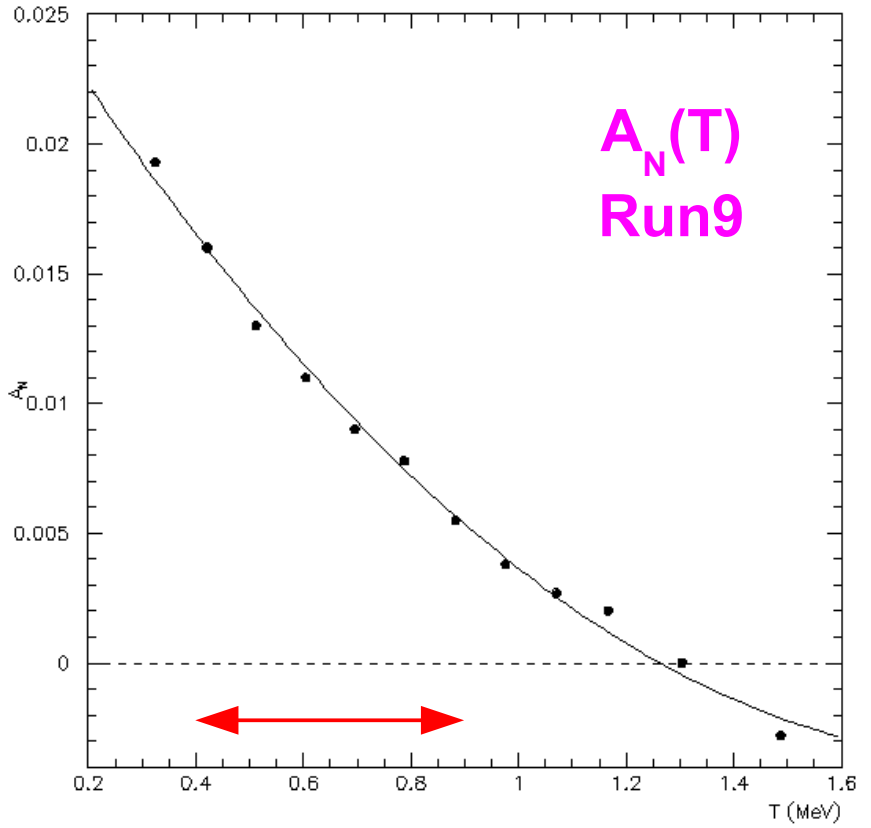
TOF select scattered ^{12}C $0.4<E_c<0.9$ MeV ⇒

pC: improvements, challenges

- Through Run9, rate effects observed: pileup/signal loss, calibration, ...
- Run11: replaced preamps Q→I sensitive; pulse 10's nS→~10 nS
- Run11: no significant rate effects observed



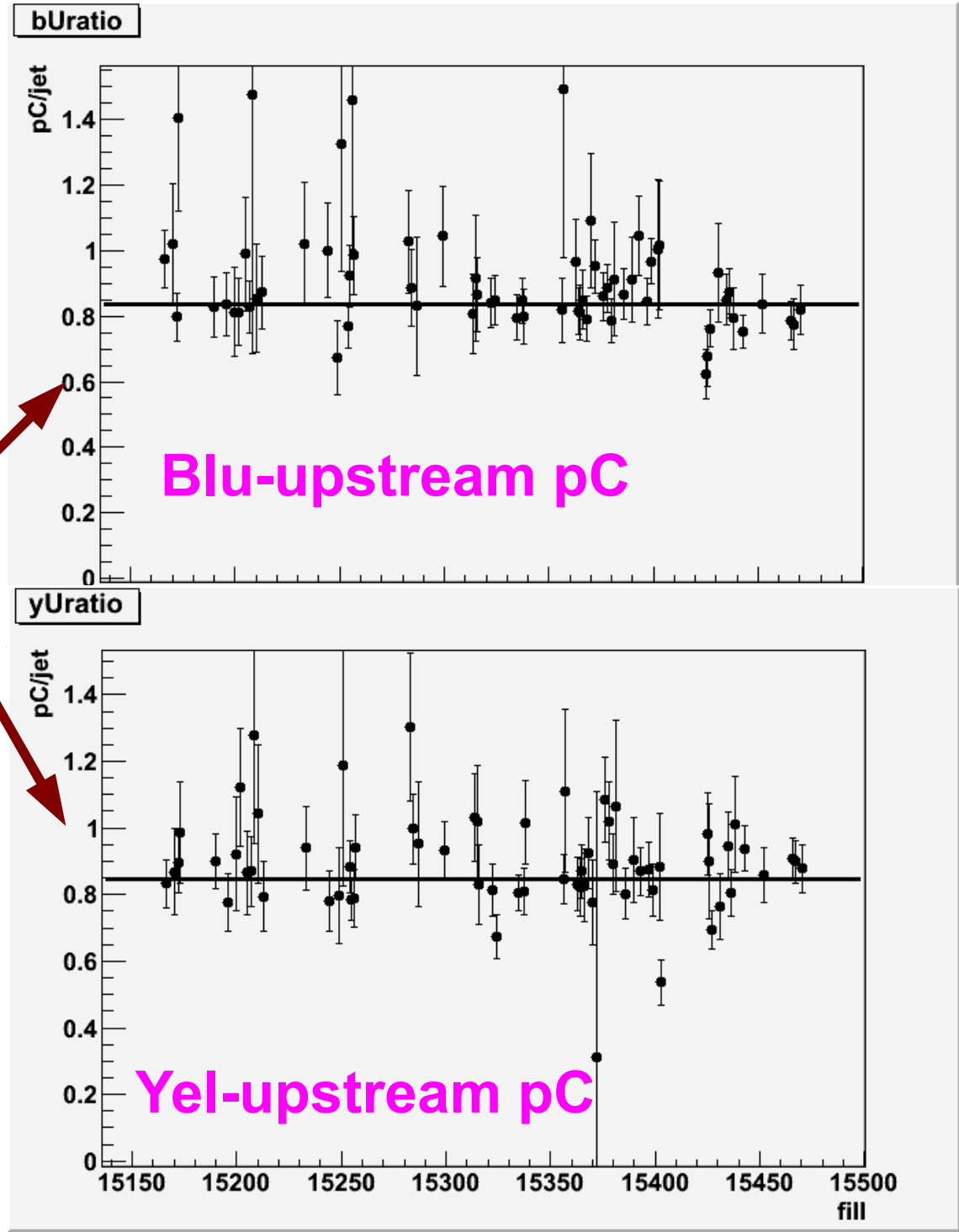
- Analyzing power $A_N(T)$ very steep dependence on ^{12}C k.e. T
- Measure in 0.4<T<0.9 MeV;
- effective A_N from pC/H-jet ratio
- Sensitive to ^{12}C energy scale: e.g. $\Delta T = 25$ keV $\Rightarrow \Delta A_N = 5\%$ relative
- Improvement: normalize pC/H-jet separately each pC polarimeter
- **Remaining: ^{12}C E-scale uncert. major source of A_N, P uncertainty**



1 tick=50keV

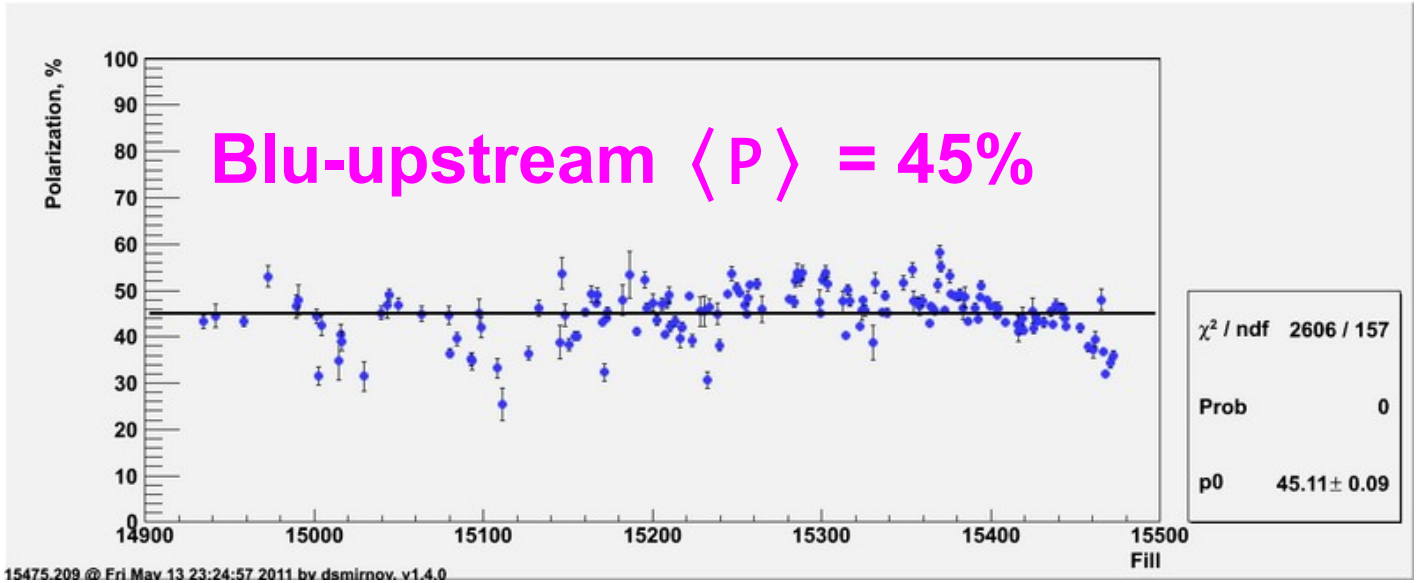
pC/H-jet normalization

- Normalize each pC to H-jet values for ring blue/yellow
- pC/H-jet ratio vs. RHIC store (compared to 'default' A_N, absolute value arbitrary)
- Uncert. dominantly H-jet stat.
- Should be constant in time
- Fluctuations (other than stat.) indicative of sys. variations

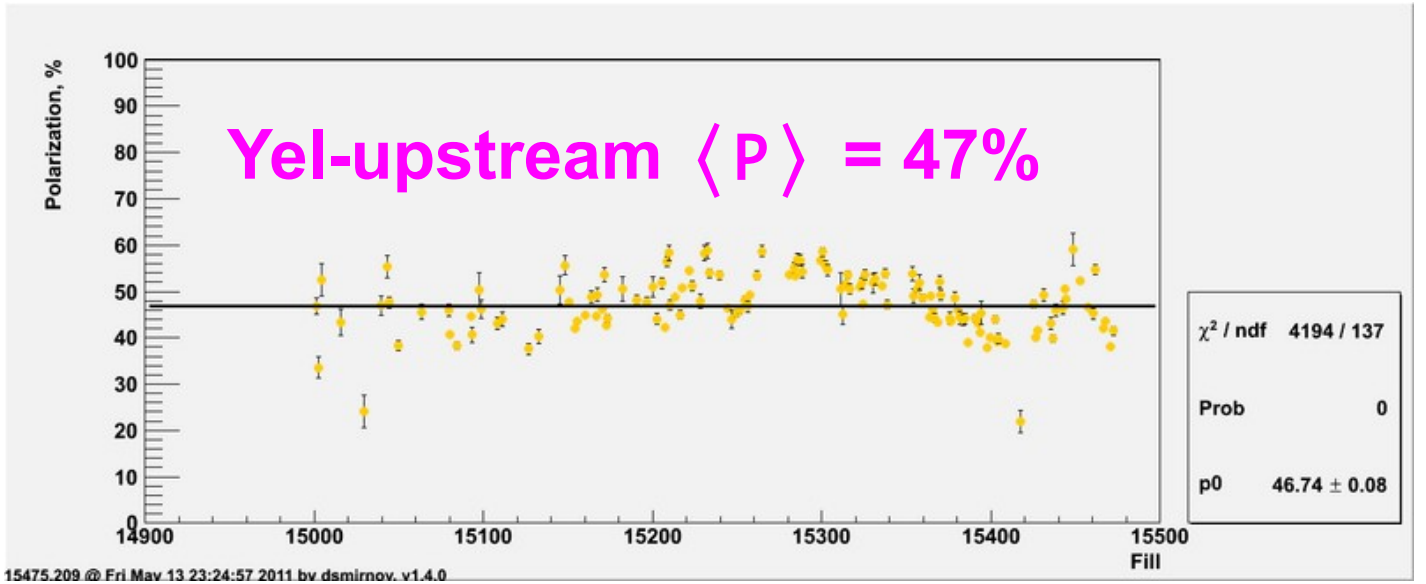


pC Polarization

- Values per fill through Run11, upstream pC polarimeters
- Downstream values consistent (next ↘)

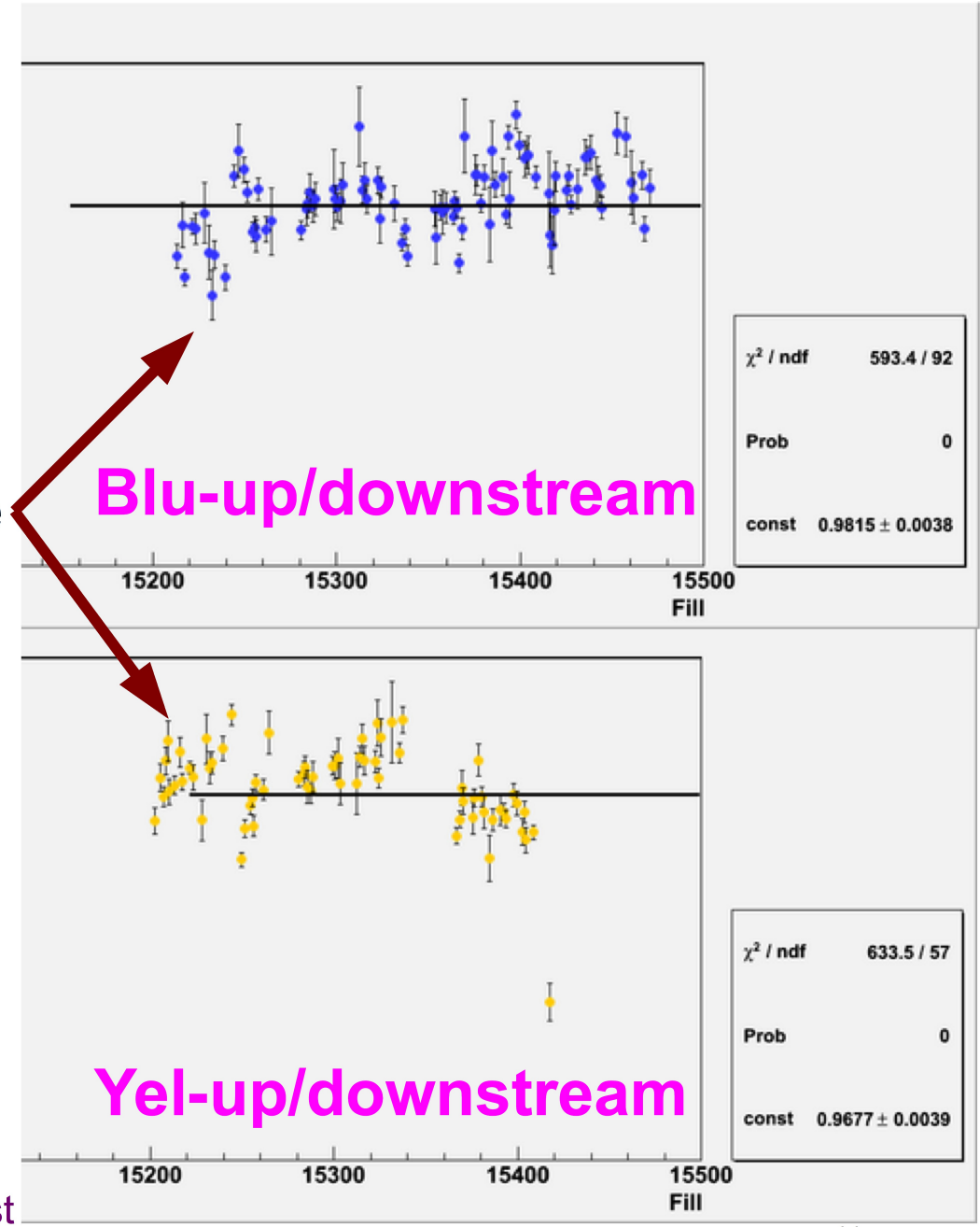


- Lines to guide eye; variations show real RHIC polar. trends, e.g. intensity ↑ polarization ↓



pC Polarization cross-check

- Two polar. each ring
  - upstream/downstream
  - usually vertical/horizontal target sweeps
- Mean P of H/V sweep should be equal
- Up/downstream ratio vs. RHIC store
- Uncert. dominantly pC stat.
- Should be constant in time
- Fluctuations (other than stat.) indicative of sys. variations

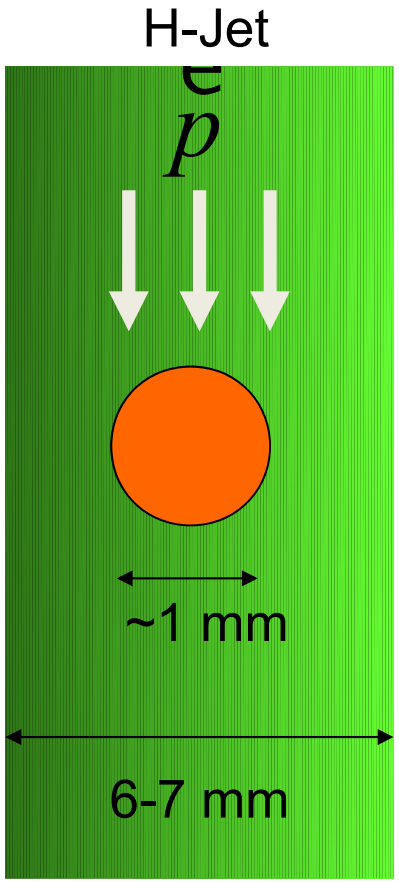


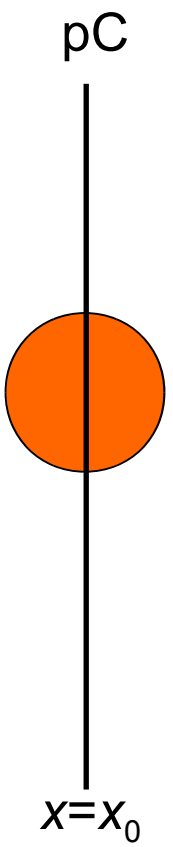
(downstream polar. not available earliest part Run11)

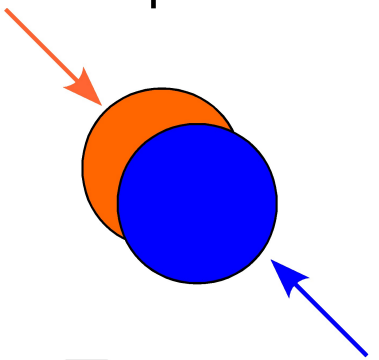
Polarization Profile

If polarization changes across the beam, the average polarization seen by Polarimeters and Experiments (in beam collision) is different

$P_{1,2}(x,y)$ – polarization profile, $I_{1,2}(x,y)$ – intensity profile, for beam #1 and #2







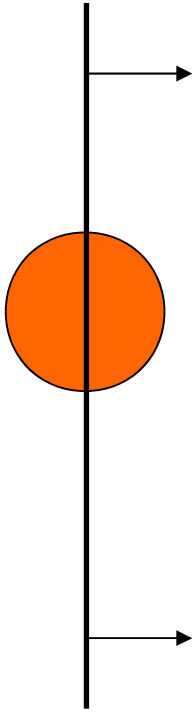
$$\langle P_1 \rangle_{\mathrm{exp}} = P_1(x,y) \otimes I_1(x,y) \otimes I_2(x,y)$$

(for single-spin-asym.)

$$\langle P_1 \rangle_{\mathrm{H-jet}} = P_1(x,y) \otimes I_1(x,y) \quad \langle P_1 \rangle_{\mathrm{pC-fixed}} = P_1(x_0,y) \otimes I_1(x_0,y)$$

Sweep of carbon target averages over x_0 $\Rightarrow$ $\langle P_1 \rangle_{\mathrm{pC-sweep}} = \langle P_1 \rangle_{\mathrm{H-jet}}$

Pol. Profile and collider exp. Polarization

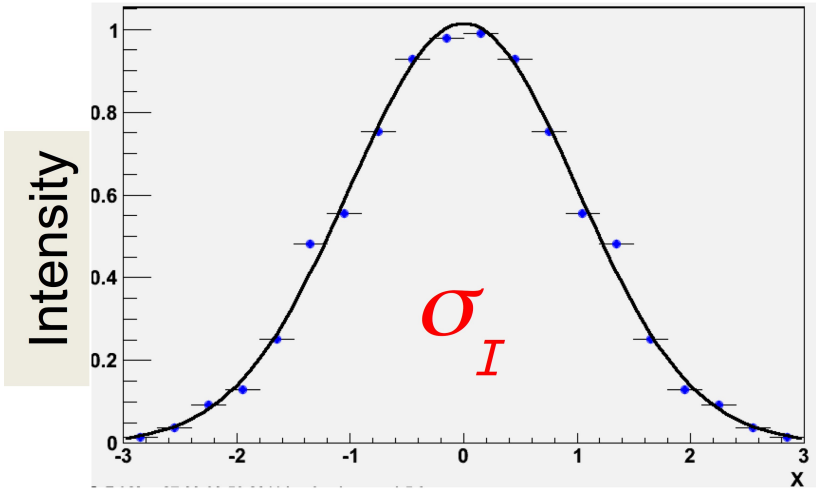


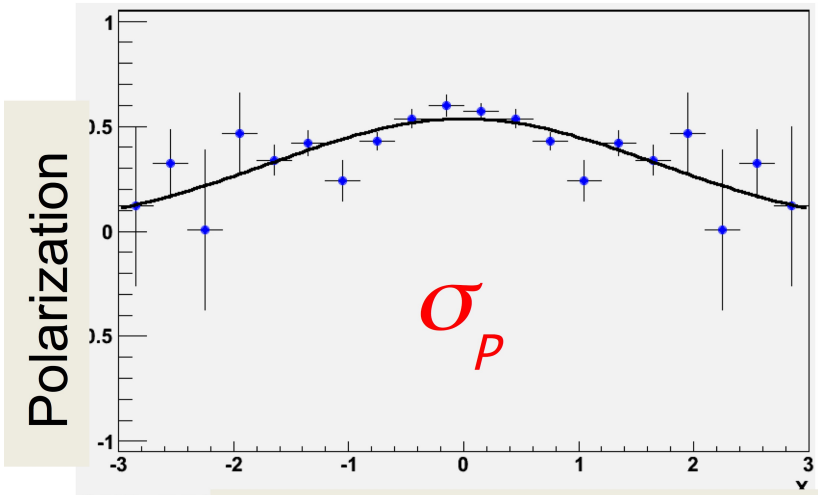
Scan C target across beam
both X, Y directions

$$R = \left(\frac{\sigma_I}{\sigma_P}\right)^2$$

For gaussian profiles,
pC-sweep → collider exp.:

$$\langle P\rangle_{\mathrm{exp}} \approx \langle P\rangle_{\mathrm{pC-sweep}} \cdot \sqrt{1+\frac{1}{2}R_x} \cdot \sqrt{1+\frac{1}{2}R_y}$$





Target Position (arb. units)

Ideal case: flat pol. Profile ($\sigma_P=\infty \Rightarrow R=0$)
no correction

Run11 pol. for collider exp.:

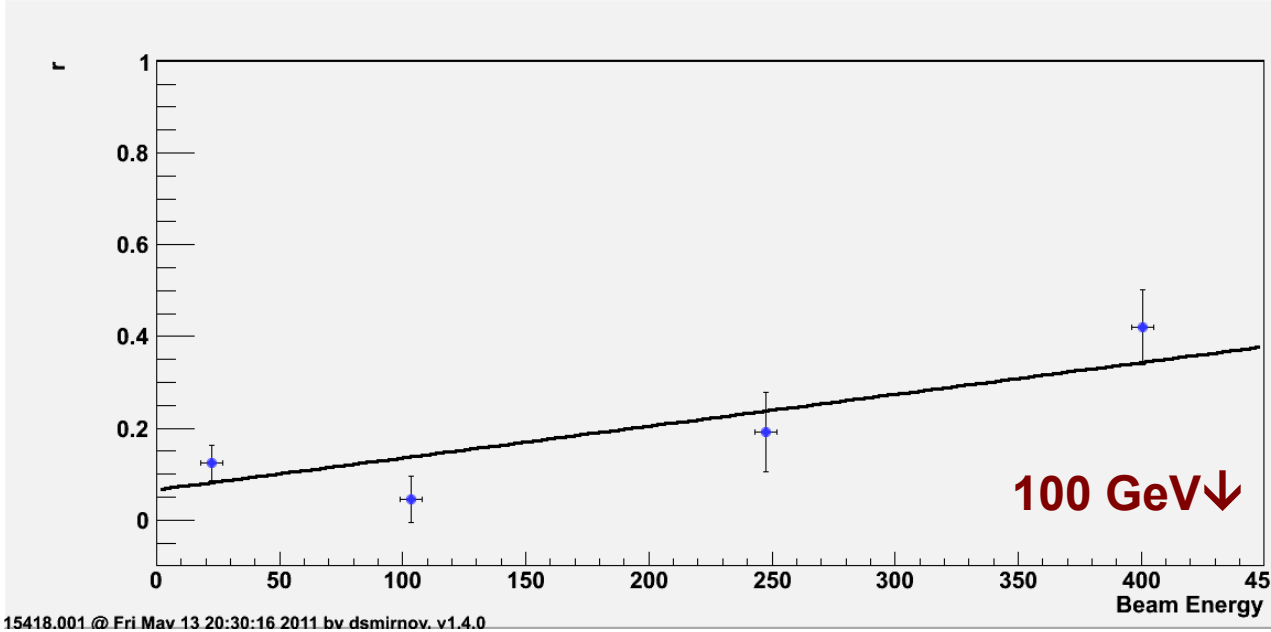
- $R_x \approx R_y$

$$\langle P\rangle_{\mathrm{exp}} \approx \langle P\rangle_{\mathrm{pC-sweep}} \times \left(1+\frac{1}{2}R\right)$$

- $R \approx 0.18$
- ~9% (relative) correction

depolarization ↔ pol. profile

- Run11 ramp up/down study:
  24 GeV → 100 GeV → 250 GeV → 100 GeV
- With stops at each energy for polar. measurements
- Direct comparison P(100 Gev↓)/P(100 GeV↑)
- Profile growth through ramps:
  R monotonically increasing
  each ramp step



- Decrease in ⟨P⟩ has ~constant core peak P_0,
  loss of poalrization at edges of beam (profile growth)
- Consistent with model for polar. loss from intrinsic resonances

good example: detailed polar. measurements improve understanding, development RHIC poalrization

Summary

- RHIC polarimetry has continued to improve
  as RHIC polarization had improved

- Significant improvements Run11:
  - faster front end electronics, rate effects vanquished
  - increased use pC/H-jet normalization
- Evident in 'cleaner' data

- Incomplete list next improvements:
  - continue study alternative detectors
  - improve target operation & robustness
    (Run11 targets nearly depleted)

- Continue interaction w/ RHIC,
  improving polarization operations