pC (CNI) polarimeters

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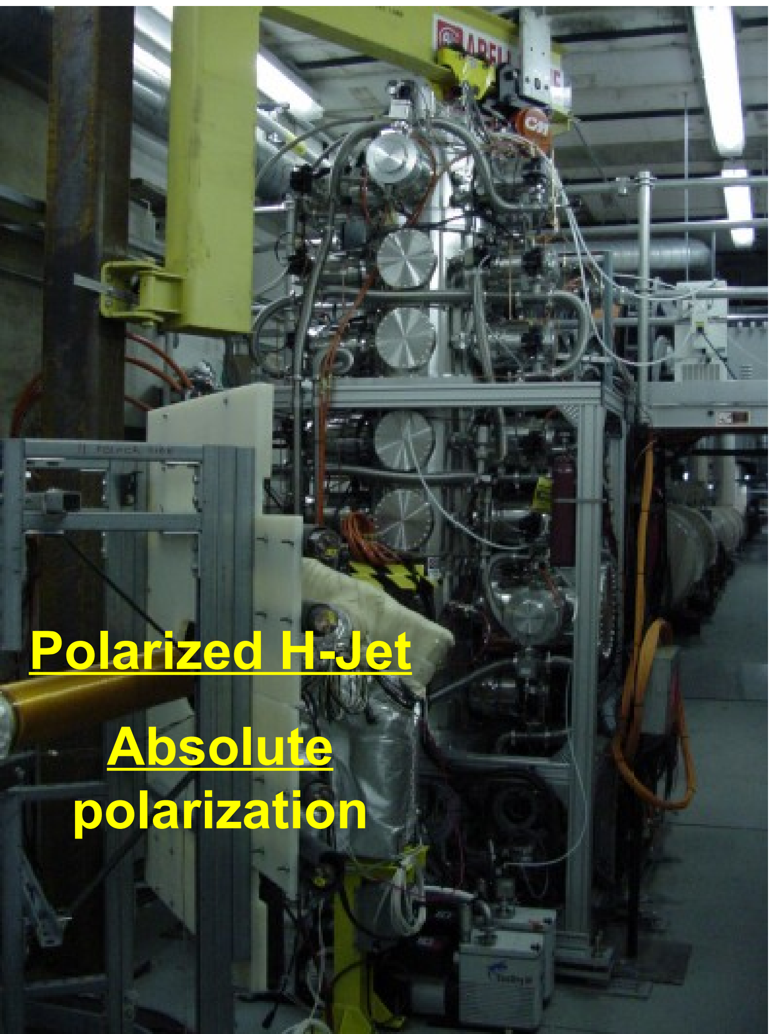
RSC mtg. 13.01.12

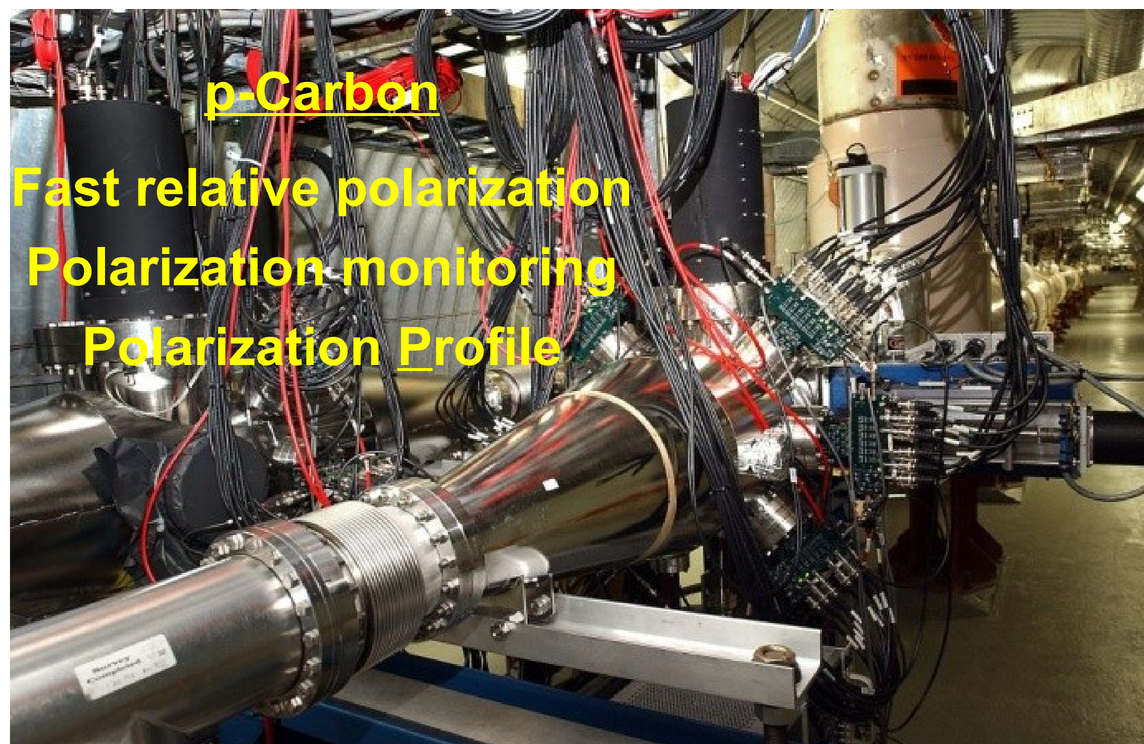
- CNI & p-Carbon polarimeters: brief overview
- pC systematic uncertainties:
  - A_N^{pC} energy dependence
  - energy loss in targets, target instability
- Steps to address in Run12:
  - target selection, construction
  - monitor w/ long. seg. detectors
- Run12 pC overview
- Special runs for polarimetry studies
- Advertisement: Run11 results

RHIC CNI polarimeters

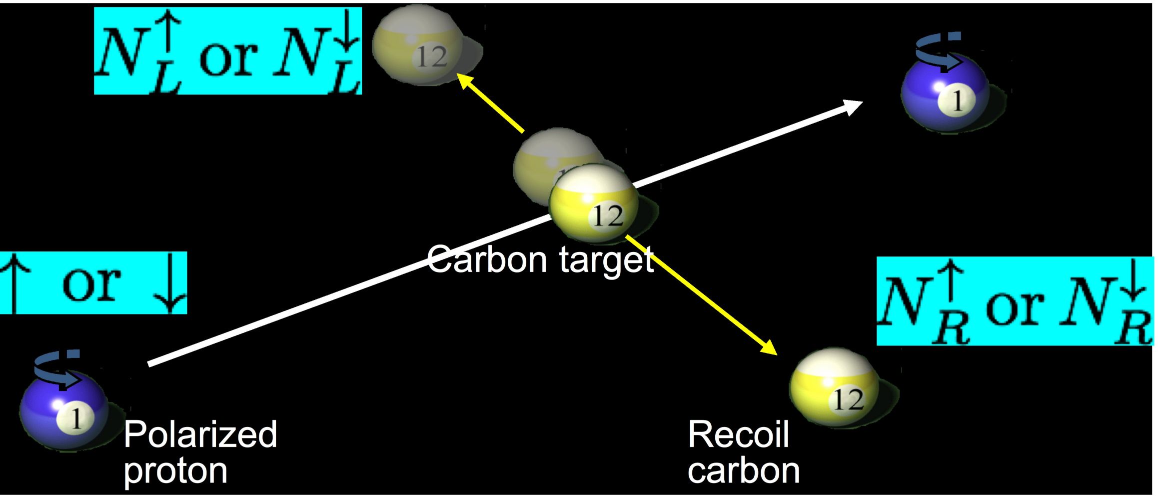
"CNI" polarimetry
Left-right asymmetry in elastic scattering:
Interference between electromagnetic and hadronic amplitudes in the Coulomb-Nuclear Interference (CNI) region

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



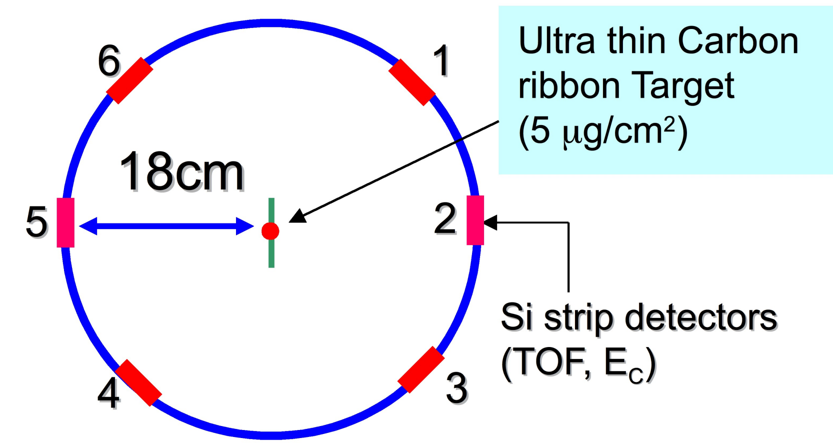


p-Carbon polarimeter



2 polarim. / RHIC ring:

beam view



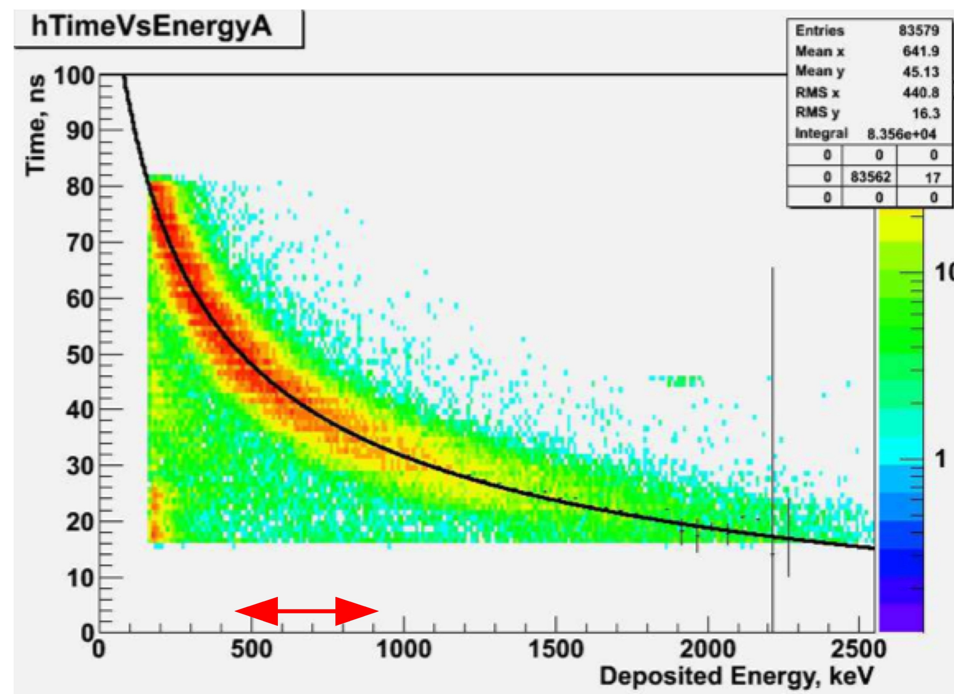
Target Scan mode (~30 sec/measurement)

- 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,

  determine $$A_N^{pC} = \frac{\epsilon^{pC}}{P_{H-jet}}$$



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

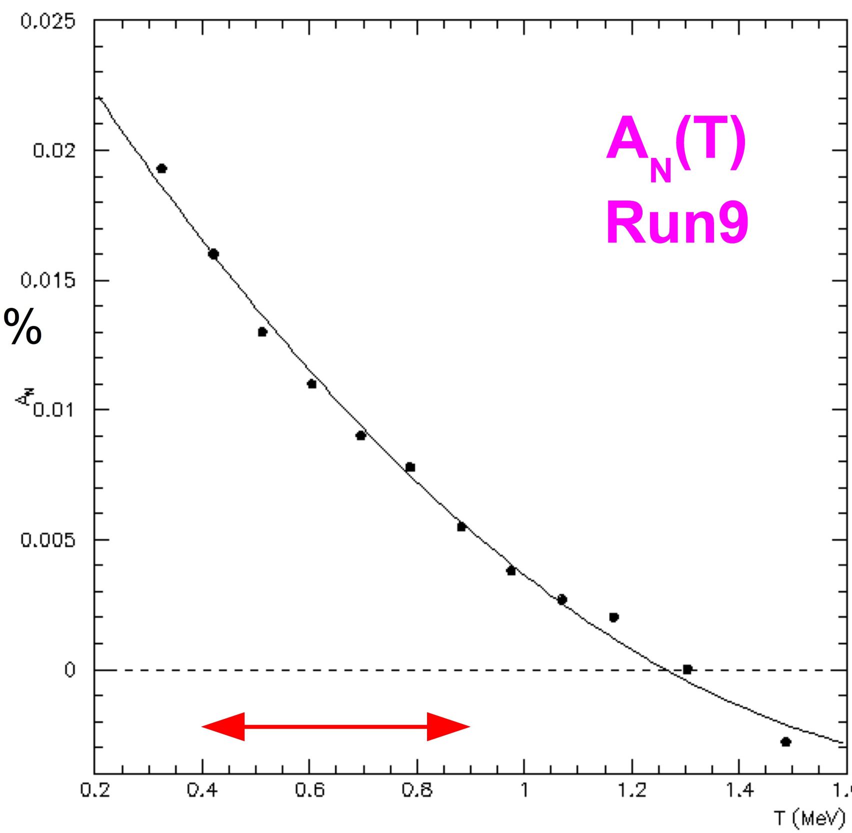
pC polarization: A_N^{pC}

- An average (assumed constant) analyzing power determined *per fill* from H-jet polarizations: $$A_N^{pC} = \frac{\epsilon^{pC}}{P_{H-jet}}$$
  (H-jet stat. limited)
- Then used for finer grained (e.g. several per fill) pC polarizations: $$P_{pC} = A_N^{pC} \cdot \epsilon^{pC}$$
- L/R asymmetry ϵ^{pC} measured with “square root” or “cross ratio” formula;
  cancellations: acceptances, luminosities, many systematics
- Main contributions to pC P systematics:
  measurement-to-measurement variations of actual A_N^{pC} away from assumed constant

$A_N^{pC} \leftrightarrow$ energy scale

- Analyzing power $A_N(T)$ very steep dependence on ^{12}C kinetic energy T:
- Measure in 0.4<T<0.9 MeV; effective A_N from pC/H-jet ratio

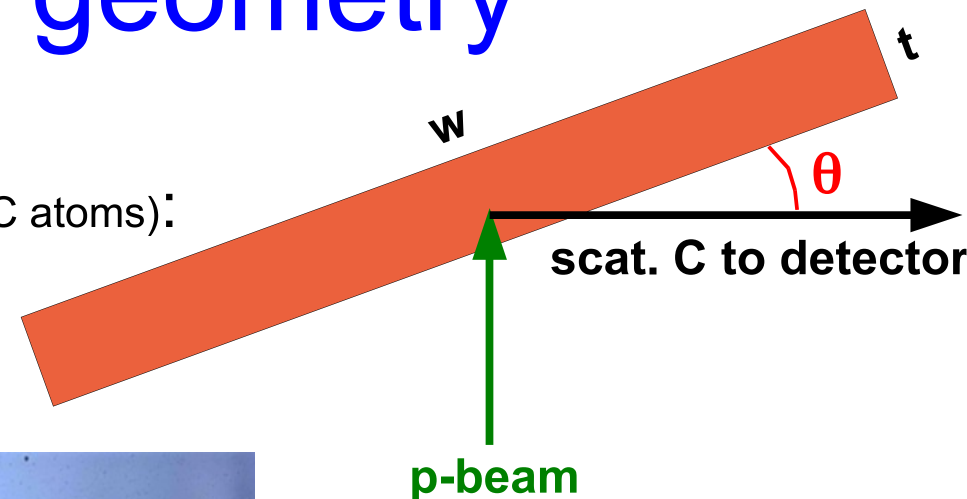
A_N^{pC}~1%



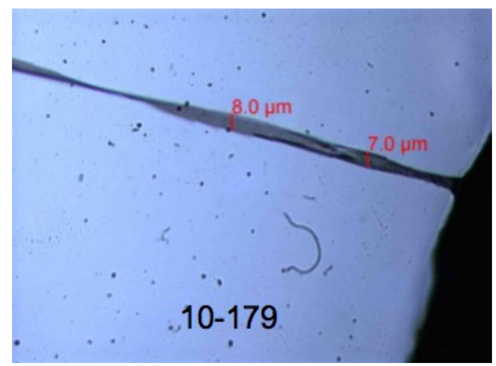
1 tick=50keV

- Sensitive to ^{12}C energy scale: e.g. ΔT = 25 keV $\Rightarrow \delta A_N$ = 5% relative
- **Energy scale of scattered ^{12}C major source of A_N, P uncertainty**
- 1st point: the energy scale uncertainty of the Si detectors introduces uncertainty on A_N, P
- e.g. - estimated dead layer in Si ~60 $\mu g/cm^2$
  - ^{12}C in T range lose ~200 keV in dead layer
  - uncertainty of ~10% on dead layer $\Rightarrow$ 5% uncertainty on A_N

Ribbon target geometry

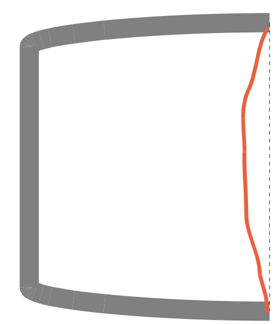


- Top view of vertical ribbon target, width $w \approx 7\mu$, thickness $t \approx 25$nm (~110 C atoms):
- Angle θ flat w-side w.r.t. detector
- Entire ribbon (w,t) is bathed in beam (beam $\sigma_{x,y}$ = 0.5-1 mm)



- Target may be twisted:
  length scale of twists $\approx 150\ \mu$
  a few twists across beam

- Beam-eye view of target on frame:
- Target may be loose, up to 2-3 mm play

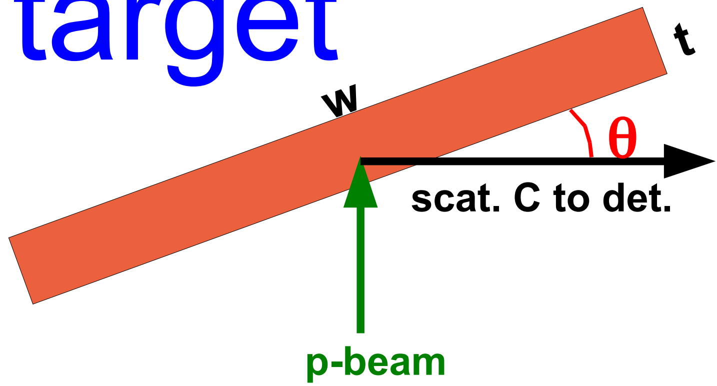


ribbon length
~2.5 cm

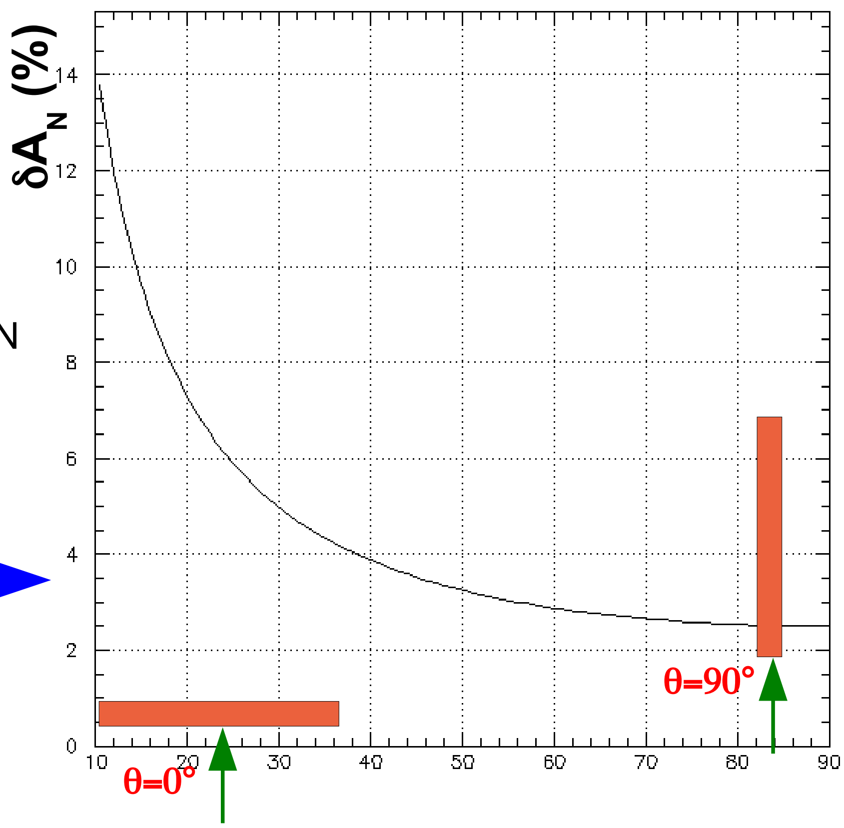
<u>As target sways in the $\vec{p}$ breeze, may:</u>

- Rotate about vertical axis, changing θ
  & path length L through target en route to detector: $L \propto t/\sin(\theta)$
- May move along beam direction, changing
  range of scattering angles covered by detector

^{12}C energy loss in target



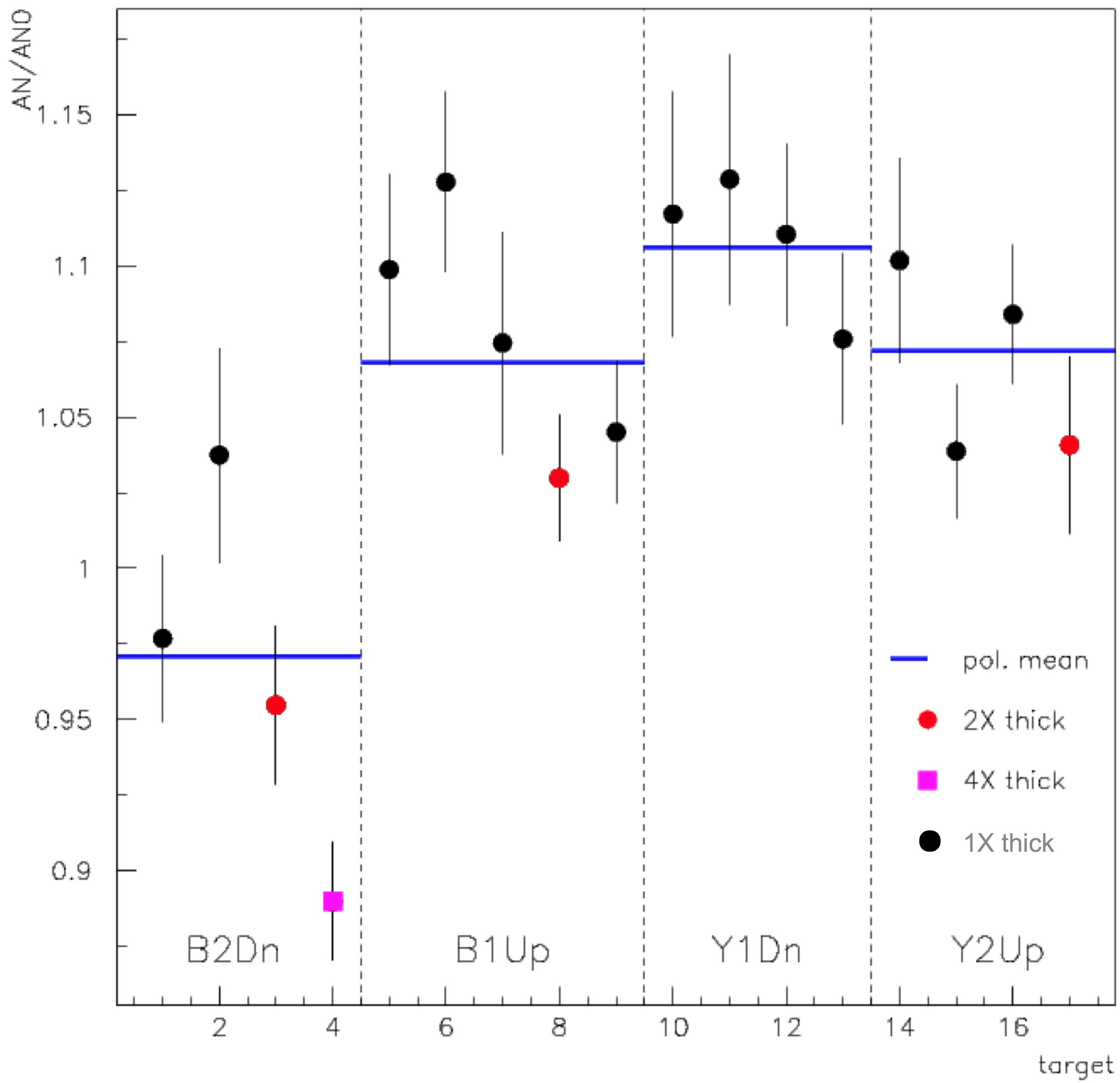
- Scattered ^{12}C nuclei lose energy in ^{12}C target en route to Si detectors
- Measured T_{meas} down-shifted from scattered T_{scat}
- We measure over a fixed T_{meas} range
- If θ changes path length changes given T_{meas} corresponds to different T_{scat}, A_N
- $L = t/(2 \cdot \sin\theta) \Rightarrow$ steep change A_N as $\rightarrow 0°$
- Put in #'s for C-C dE/dz, A_N(T):



Loose targets ⇒ unstable orientation
⇒ unstable effective A_N

Data: A_N^{pC} per pC target

- Run11 had nominal 25 nm thick targets, & a few 2×,4× thick.
- A_N each target determined from pC/H-jet normalization
- Relative to fixed A_{N0} (error bars statistical):



- Blue lines are mean A_N each polar.

Clear trend:

- Thick targets lower A_N
- Consistent with more E-loss in target, lower A_N
- 1×⟶4× consistent with expectation from E-loss

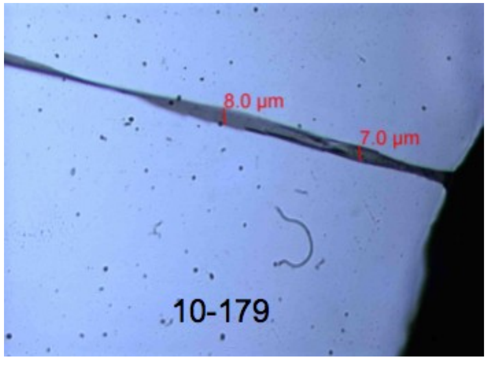
⇒ Target thickness significant effect on A_N

Run12: target strategy

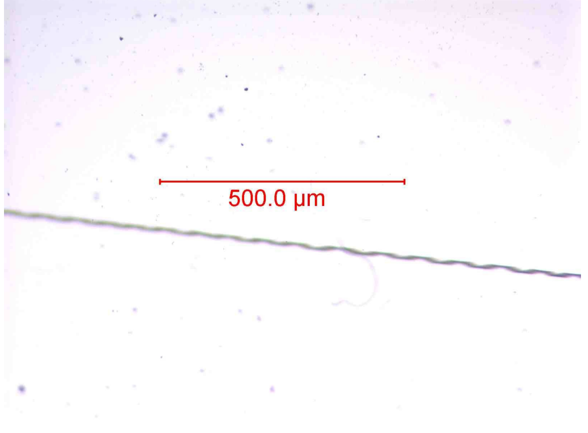
- Energy loss in targets, instabilities ⇒ significant variations of A_N^{pC}
- Strategy: minimize energy loss, use thinnest possible targets:

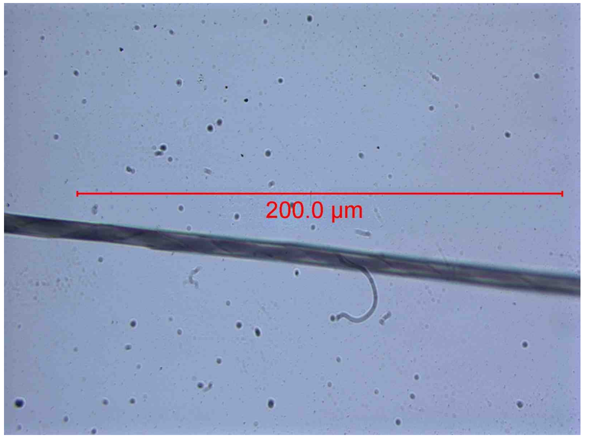
  ⇒ all targets 25 nm thick

- Rotation / twisting of targets varies E-loss en route to detectors
- Usual targets are slightly twisted:



- Highly twisted targets were produced:





- Many twists across beam, orientation effects average out

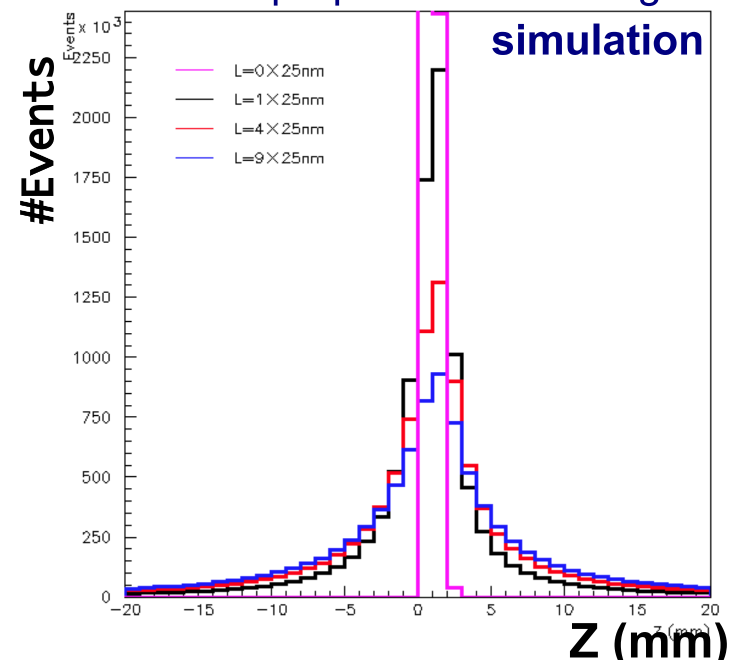
  ⇒ several highly twisted targets installed

^{12}C multiple scattering in target

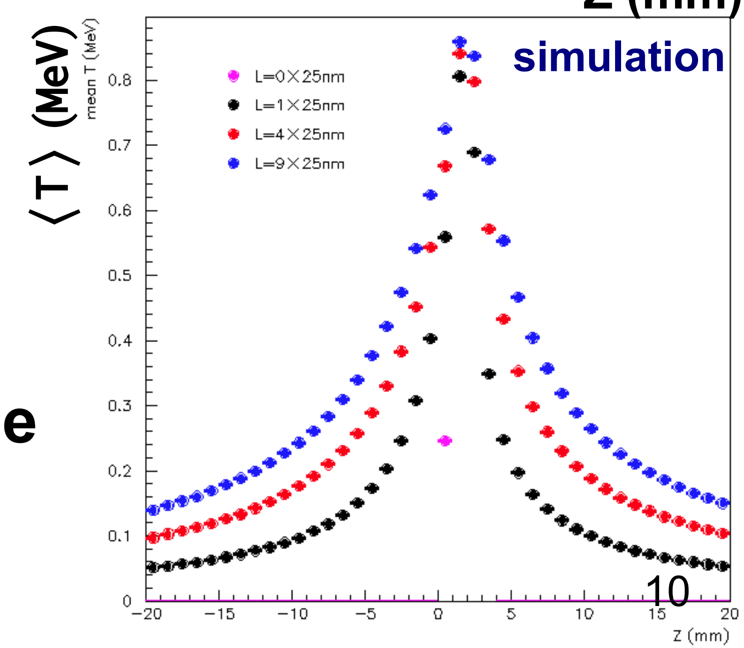
- The recoil ^{12}C also undergo multiple Coulomb scattering, RMS angle $\theta_{RMS} \propto \sqrt{L/T}$ (L=path length, T=kinetic E)

- Distributions (nearly) azimuthally uniform, but for Z (along beam) distributions:
- No mult. scat. ~all perpendicular to beam
- More material $\Rightarrow$ more events larger θ, Z: shown here (0,1,4,9) $\times$ 25 nm:

Z = direction along beam
Z = 0 perpendicular to target



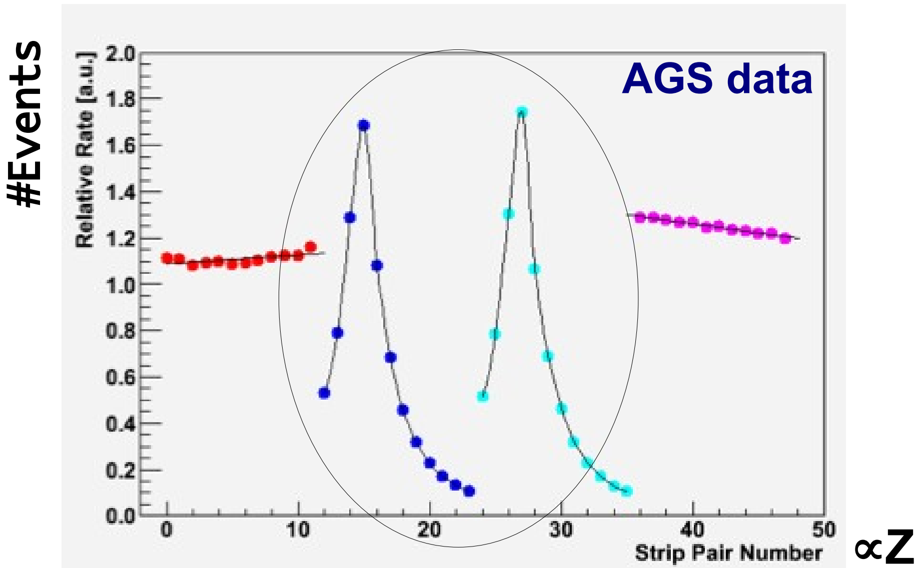
Also:
- Lower energy $\Rightarrow$ larger mult. scat. angles
- Mean energy drops at larger θ, Z:

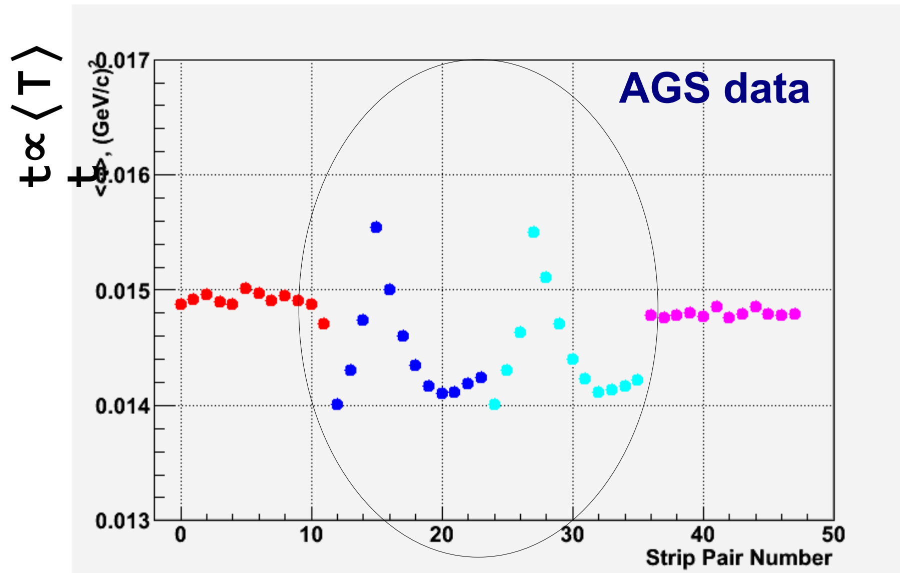


- **Widths of #event, T distributions increase with amount of target material crossed**

Longitudinal det. segment.

- Previously: all RHIC pC detectors segmented azimuthally
- AGS pC polar. has some longitudinally (Z) segmented detectors:

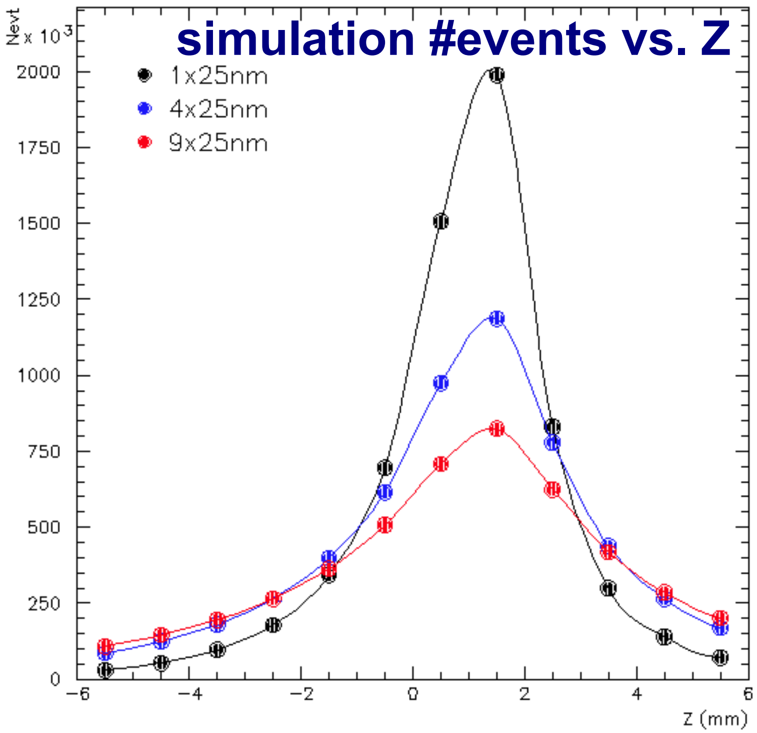


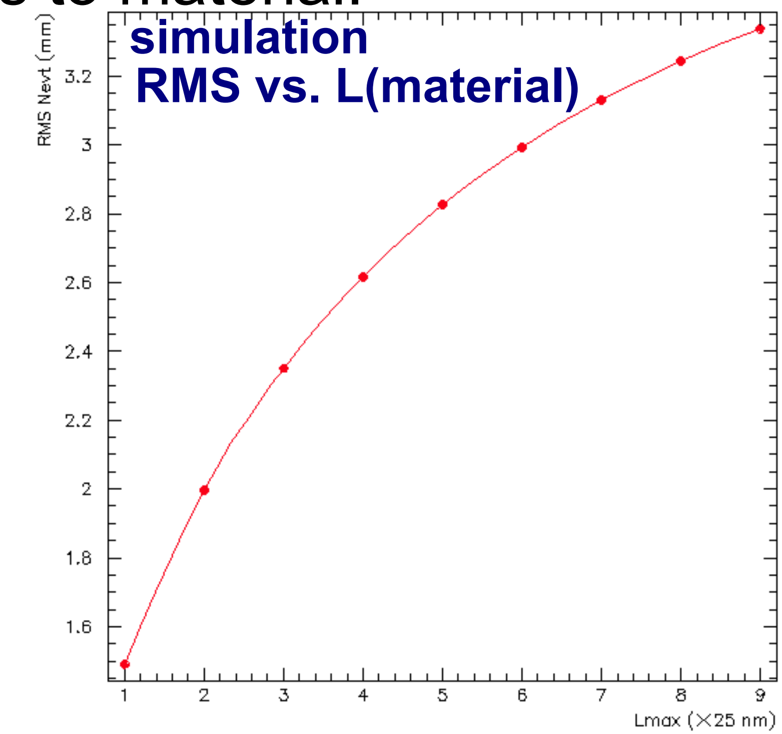


- Peak of distributions ~ Z of target w.r.t. detector
- Widths of these distributions ~ path length in target material (compare plots previous slide)

Run 12: long. det. segmentation

- To gain info on target material traversed en route to detectors:
  ⇒ **one pair detectors rotated for longitudinal segmentation**
- e.g. width of event distribution relates to material:





- Perhaps can e.g. relate A_N^{pC} to RMS...

Improvements Run12

- Those were main points to address systematics, instabilities of P meas.
- Here list all features / improvements for Run12:

Targets (thin ^{12}C ribbons):

- ✓ Varying E-loss of scattered ^{12}C in target ⇒ instability P measurement
  targets not rigid, twisting varies path length in target, E-loss
- ✓ Use thinnest possible targets (25 nm), minimal E-loss
- ✓ Test: highly twisted targets, average effects of twisting
- Test: shorter targets, may allow increase 6→8 targets / ladder (lifetime)
  also: shorter target more stable, less flexing

Detectors (Si strips):

- Continue tests of commercially available Hamamatsu;
  migrate towards in future runs
- ✓ One pair detectors longitudinal segmentation:
  - width of event distribution ~ target material traversed by scattered ^{12}C (multiple scattering)
  - monitor, compare expected E-loss effects on P measurement

Improvements Run12

DAQ (2 independent systems):

- Run11 numerous glitches switching RHIC clocks within system
- Reconfigured so each ½ has Blu or Yel polarimeters, 1 clock each DAQ

α-sources (calibration):

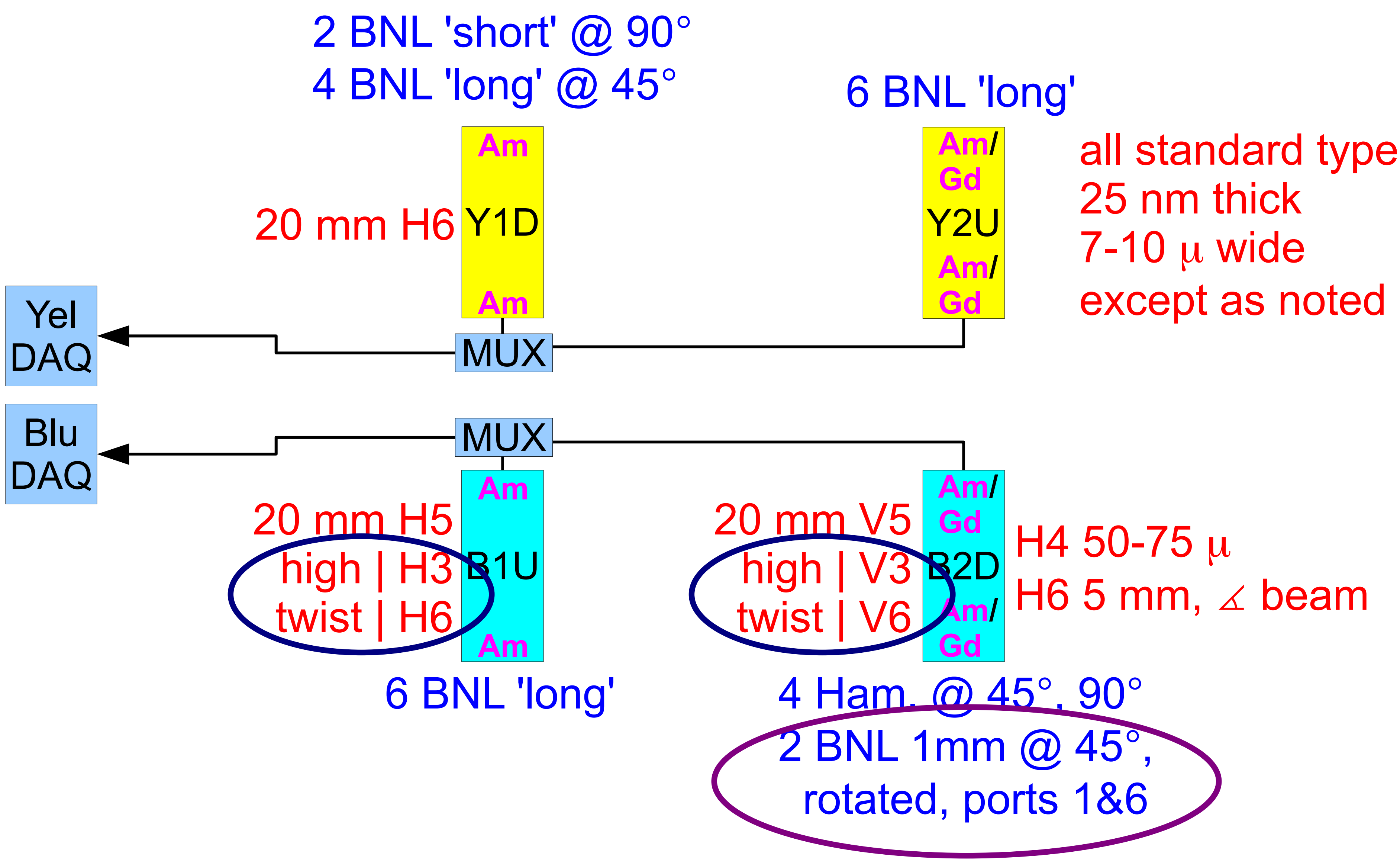
- Previously only ^{241}Am sources, 1 E-point, rough calibration
- Added some ^{148}Gd sources, 2 E-points: calibration & Si dead layer

- Status:
- Detectors, targets installed ~end November, under vacuum since
- Reconfigured DAQ tested, mostly debugged, continuing
- Tests with α-sources starting, preliminary results OK

- System overview next slide ↘
- Blu2(dn) most "experimental" polarimeter

Run12 RHIC pC polarimeters

DAQ, detectors, targets, sources



Special runs (H-jet also)

- Backgrounds in H-jet measurement not understood,
  need more info to estimate, gauge related uncertainties
- 1- vs. 2-beam background has puzzling aspects
- Can run with one beam separated from jet target, get 1-beam data
- Can be done in normal running, will definitely do

- A_N^{pC} varies with beam energy
- This year will have much data 100, 250 GeV beams
  with same polarimeter configuration, reduced syst. in comparing
- Maybe also want H-jet running long 24 GeV fills**?**
  (Done hurriedly end Run11, inconclusive results)
  Critical to compare P at injection, store

- Alternatively: Ramp up/down studies**?** (also done end Run11)
- Also requires dedicated running time...

Run11 results?

So much for the future, what about the past?

- Run11 polarization results near ready for distribution
- Will provide:
  - mean P for each store
  - mean P for each measurement, 3-4 per store
    for experiments that turned on late
  - corrections mean P → P for colliding experiments
    (polarization profile, not discussed here)
- Systematics uncertainties mostly evaluated, final steps under way
  results appear promisingly good

Run11 results & systematic studies will presented soon...