



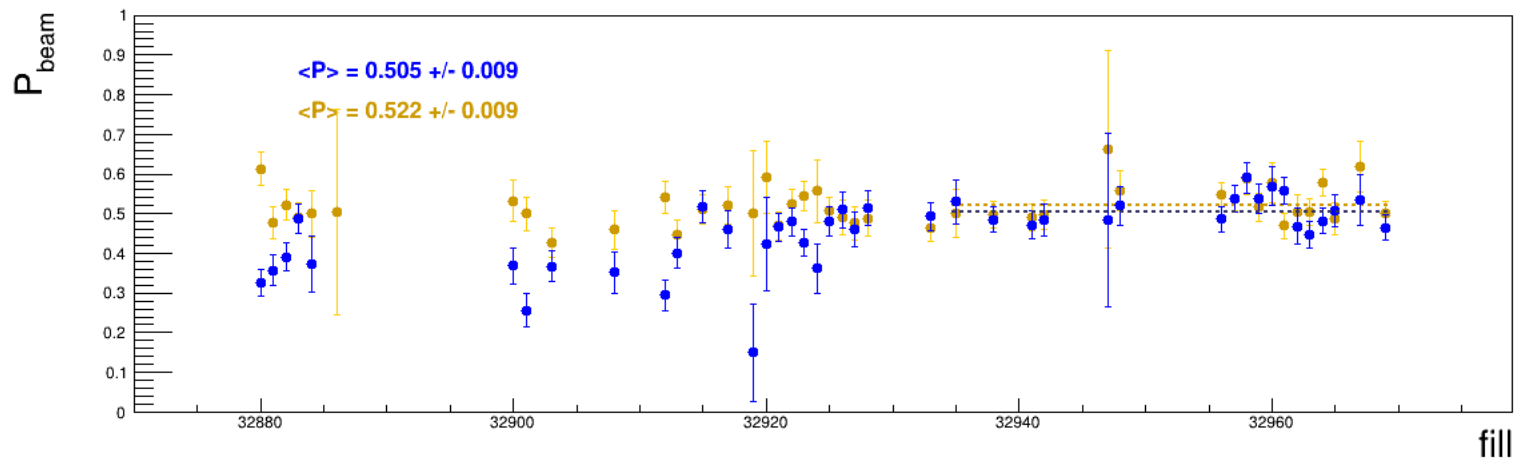
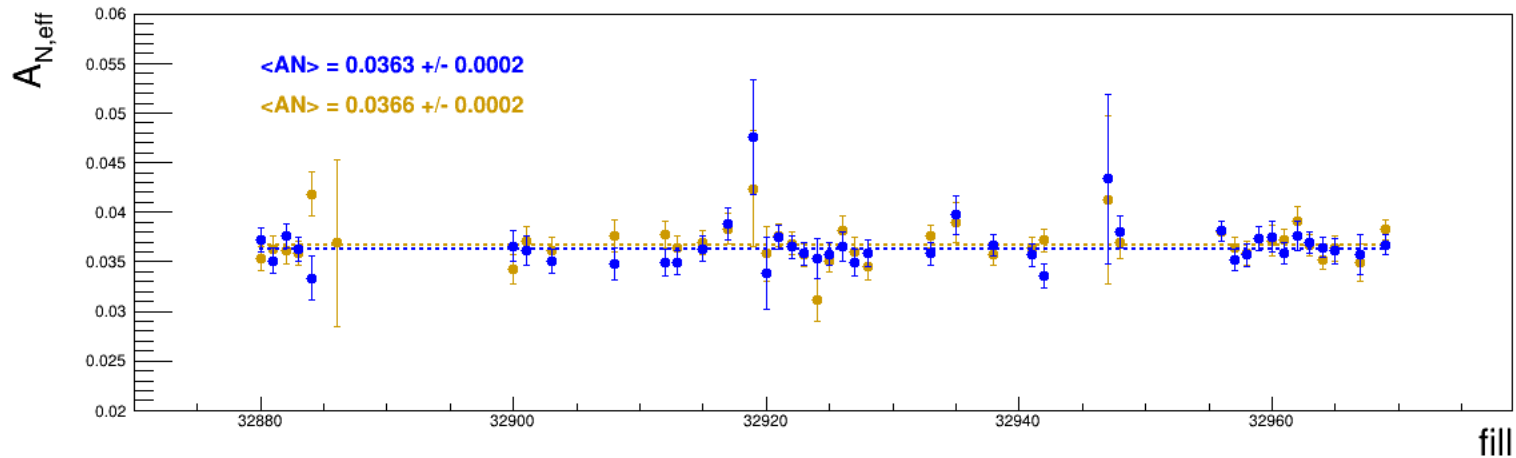
# Polarization Status at pC and STAR after Energy Change

E.C. Aschenauer

Info available at  
<https://www.cnipol.bnl.gov>

Electron-Ion Collider

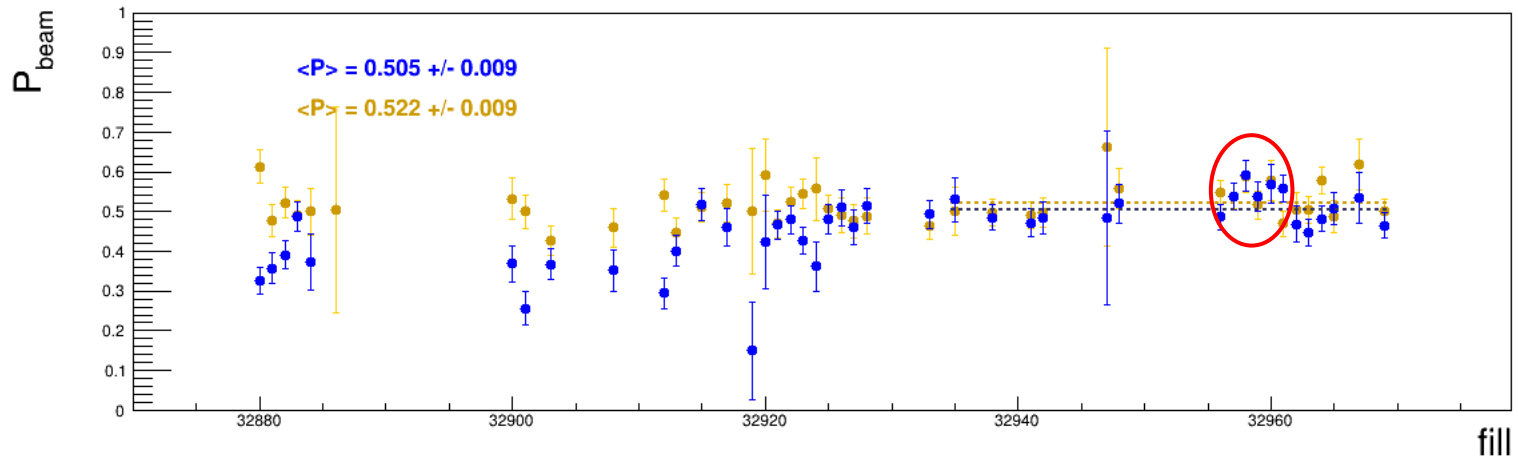
# Measurements by H-Jet



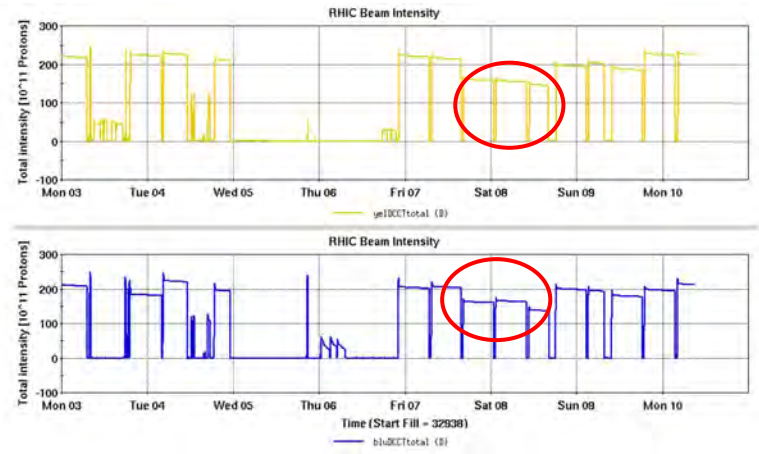
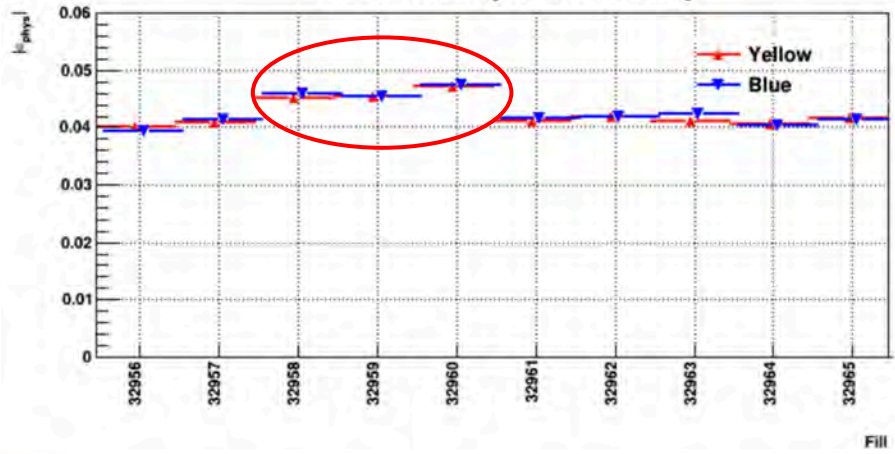
→ Yellow and Blue very similar, both lower than 2017

→ 2017 – values: Blue: 54.7 Yellow: 55.8

# Measurements by H-Jet



ZDC local polarimetry

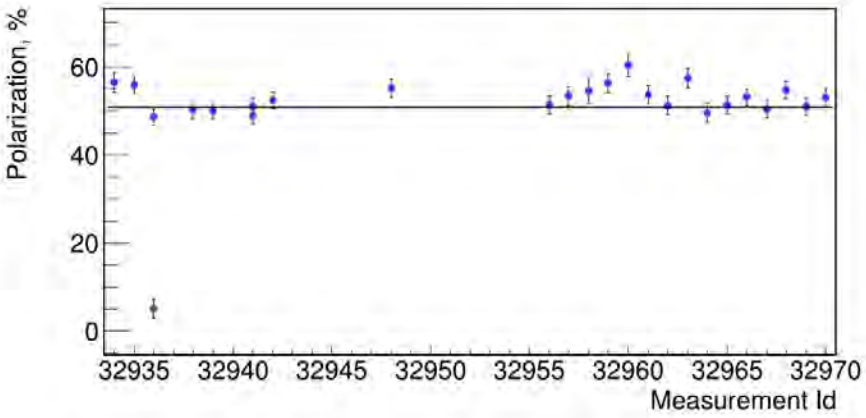


- See strong dependence of polarization on luminosity
- going from 55% to 50% polarization equivalent to a loss of 20% in Luminosity → FOM  $P^2L$



# Polarization at Injection

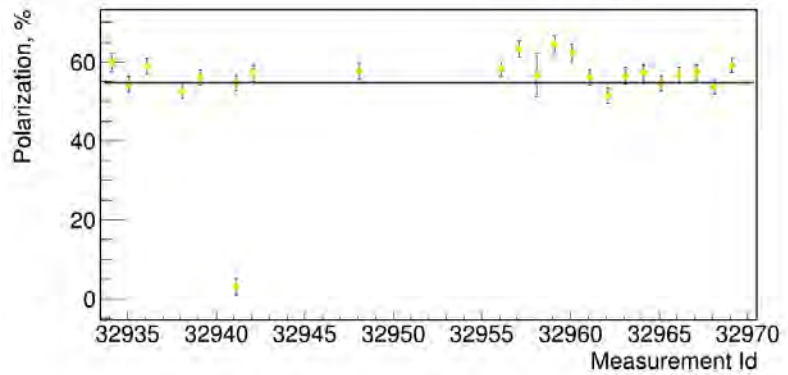
Fills 32934-32970, Analyzed Tue Jan 11 11:01:26 2022, Version v2.2.10M, zchang



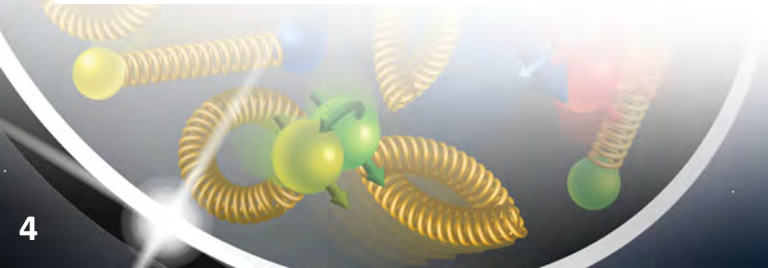
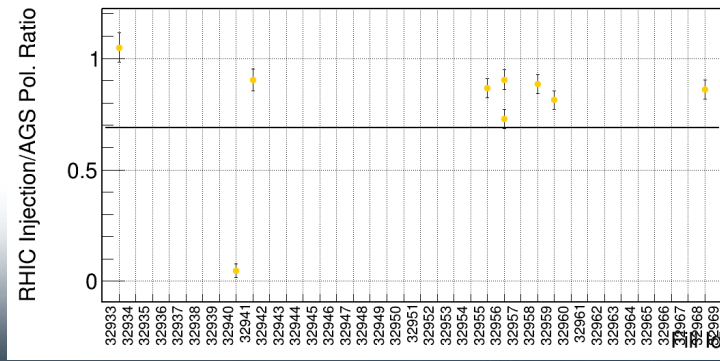
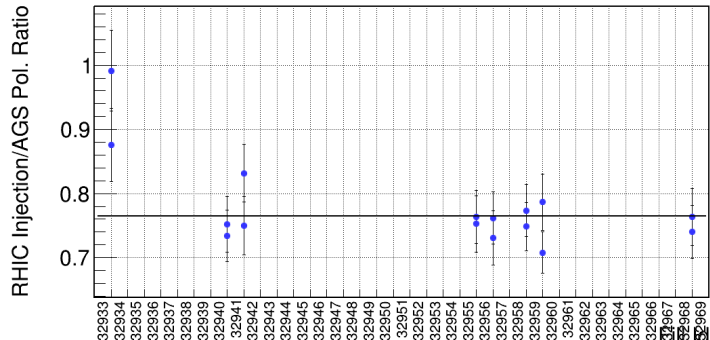
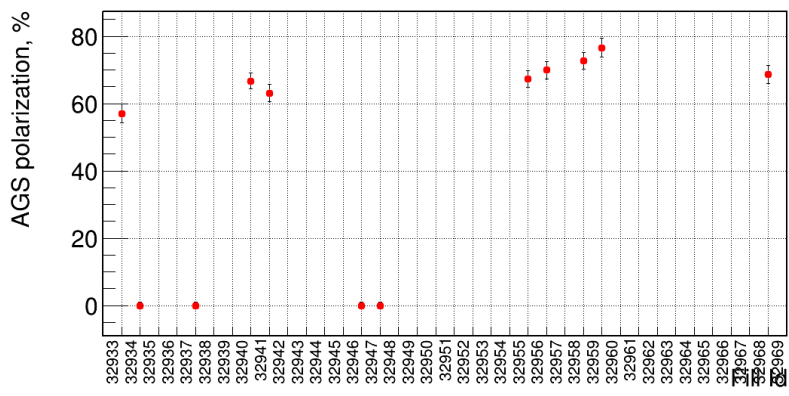
$\chi^2 / \text{ndf}$	537.2 / 24
Prob	0
$p0$	$50.79 \pm 0.4121$

# Polarization@24 GeV

Fills 32934-32970, Analyzed Tue Jan 11 11:01:26 2022, Version v2.2.10M, zchang

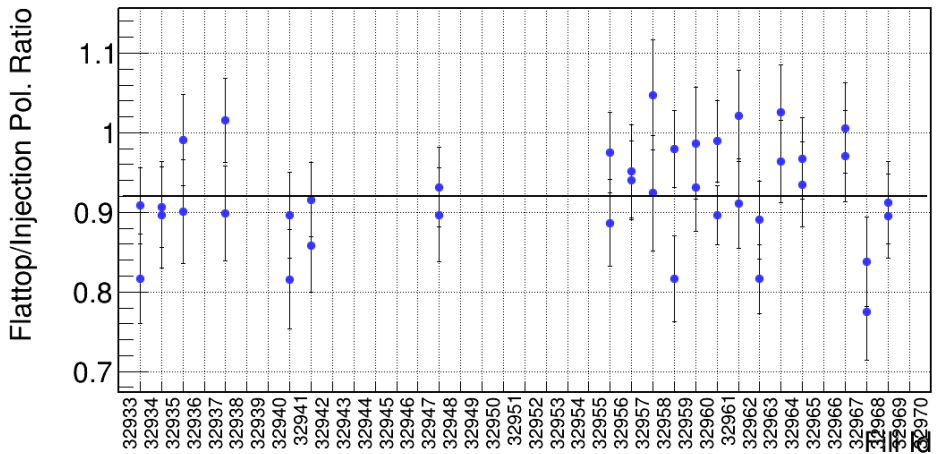


$\chi^2 / \text{ndf}$	707.6 / 22
Prob	0
$p0$	$54.73 \pm 0.4254$



# Polarization: Ramp Efficiency

Fills 32934--32971, Analyzed Tue Jan 11 12:01:26 2022, Version v2.2.10M;, zchang

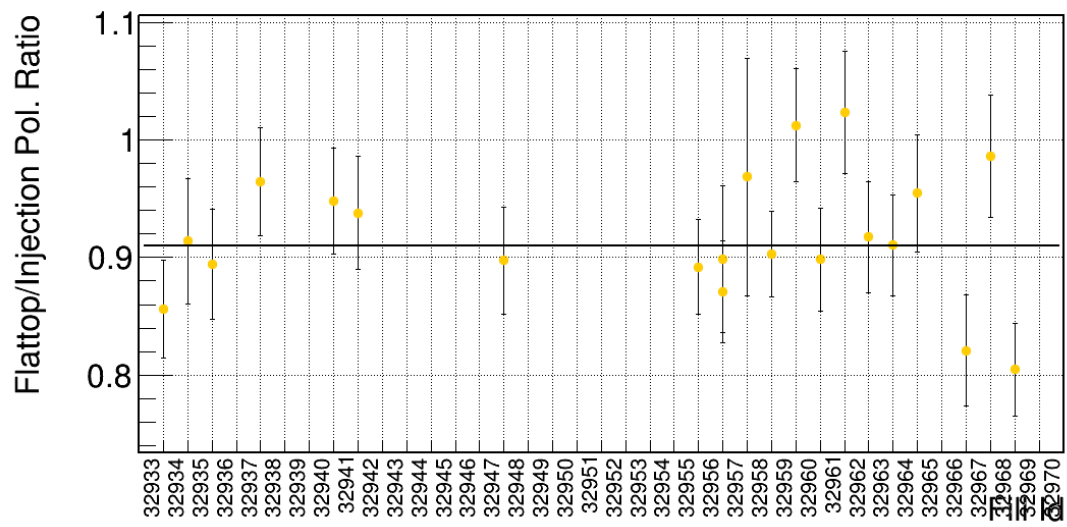


$\chi^2 / \text{ndf}$	51.99 / 39
Prob	0.07966
const	$0.9205 \pm 0.008537$
$\sigma_y$	$0.06406 \pm 0$

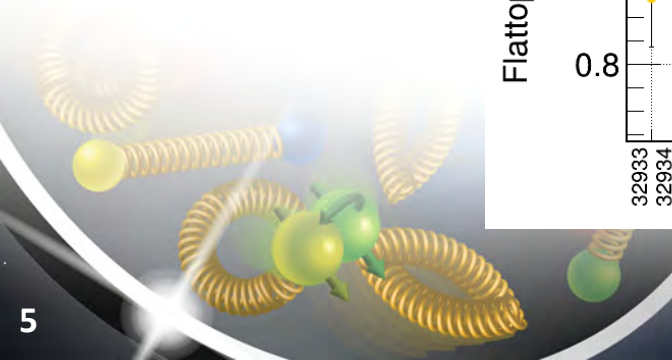
## Polarization after Ramp

depends on pC Analyzing Power at 24 GeV

Fills 32934--32971, Analyzed Tue Jan 11 12:01:26 2022, Version v2.2.10M;, zchang

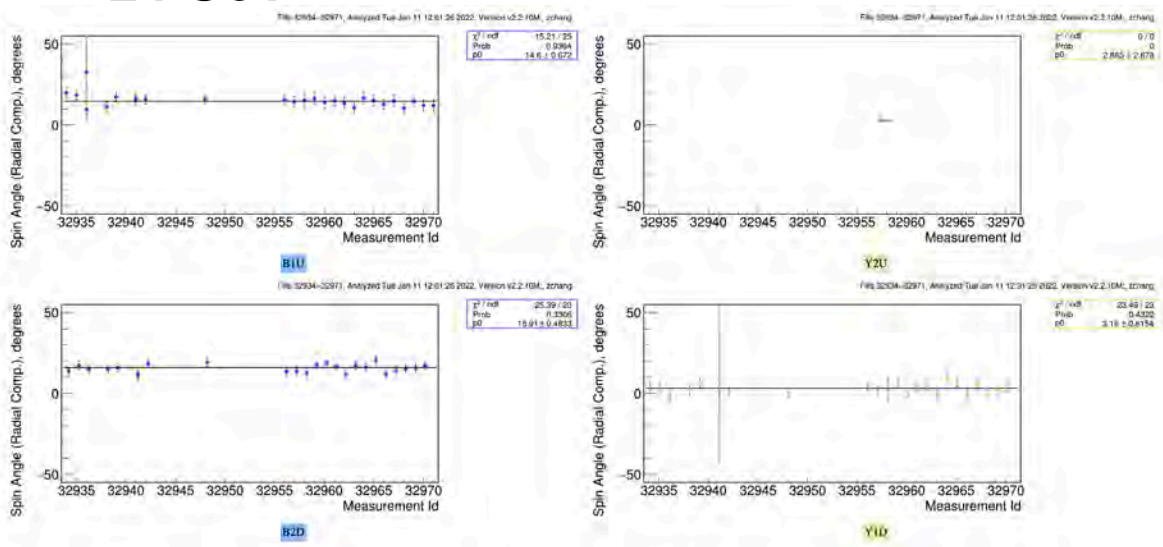


$\chi^2 / \text{ndf}$	28.73 / 20
Prob	0.09323
const	$0.9102 \pm 0.01017$
$\sigma_y$	$0.05488 \pm 0$

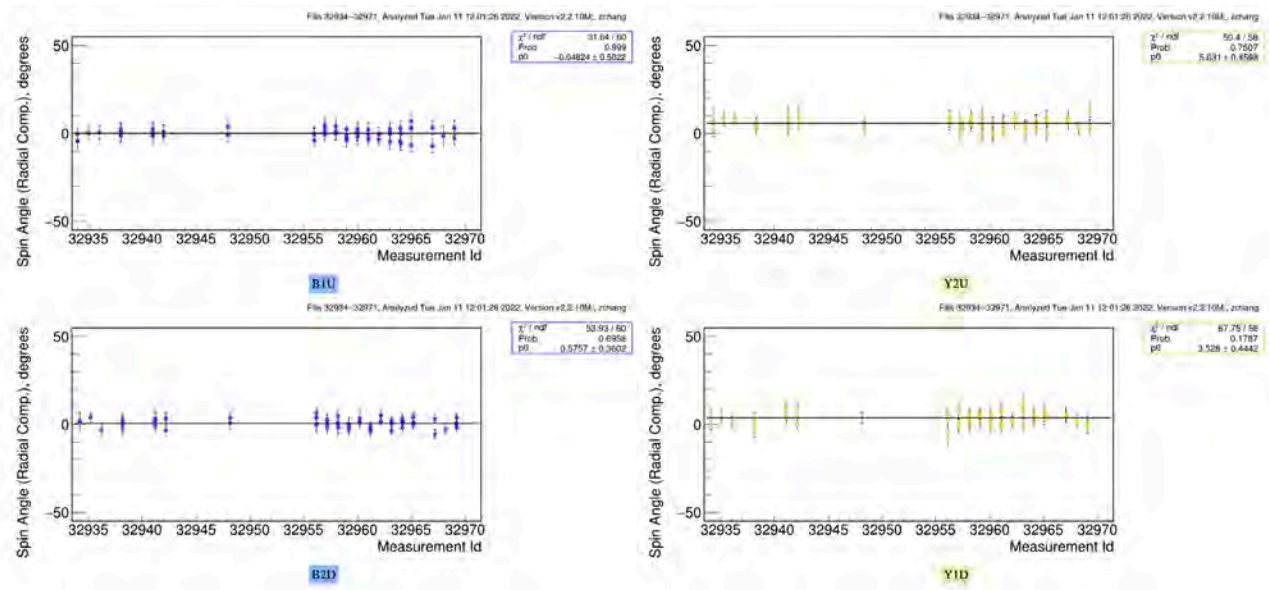


# Polarization direction at pC

## 24 GeV



## 255 GeV



spin tilts @ store

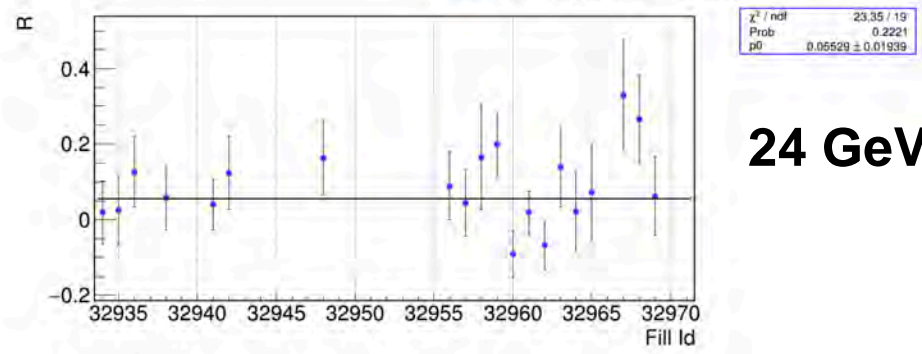
$\phi_{pC} (^{\circ})$	Blu	Yel
Run9-100	6	5
Run11-250	3	1
Run12-100	3	3
Run12-255	11	7
Run13-255	16	9
Run15-100 pp	3	2
Run15-104 pAu	0	-
Run15-104 pAl	1	-
Run17-255	12	8

**Blue:**  
 $+\phi_{pC}$ : spin tilted  
 towards ring - inside

2022: longitudinal component at IP12?

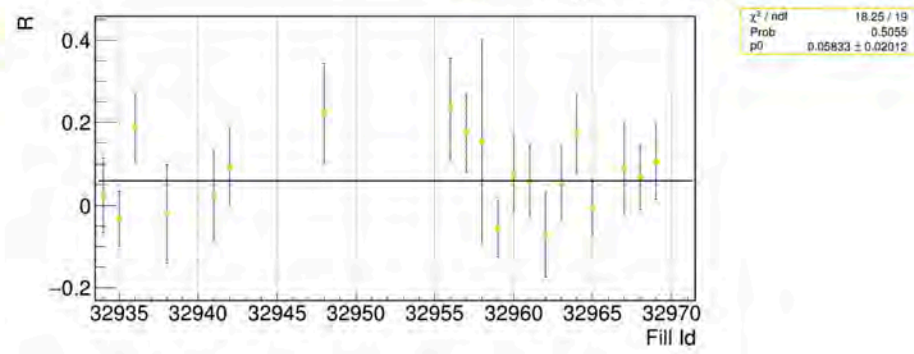
# Polarization Profile and Decay

**BIU**  
 Fills 32934-32971, Analyzed Tue Jan 11 12:01:26 2022, Version v2.2.10M, zchang

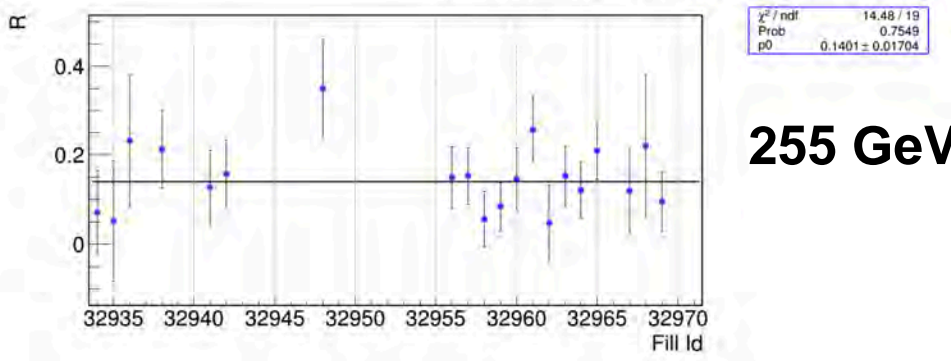


**24 GeV**

**Y2U**  
 Fills 32934-32971, Analyzed Tue Jan 11 12:01:26 2022, Version v2.2.10M, zchang

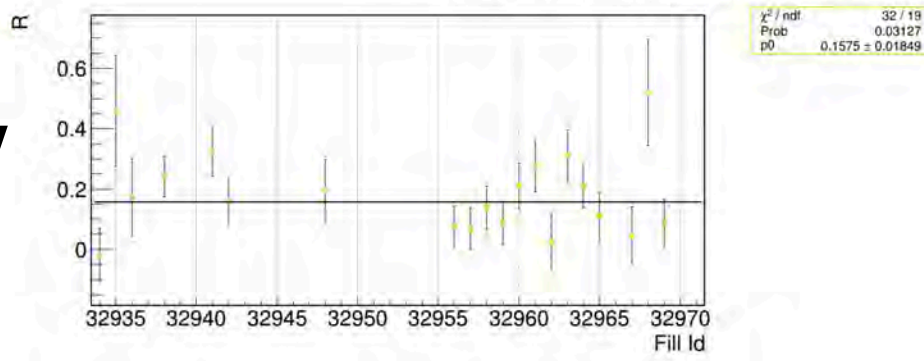


Fills 32934-32971, Analyzed Tue Jan 11 12:01:26 2022, Version v2.2.10M, zchang



**255 GeV**

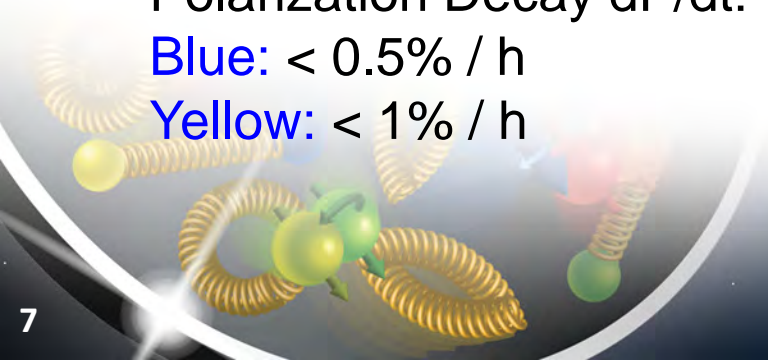
Fills 32934-32971, Analyzed Tue Jan 11 12:01:26 2022, Version v2.2.10M, zchang



Polarization Decay dP/dt:

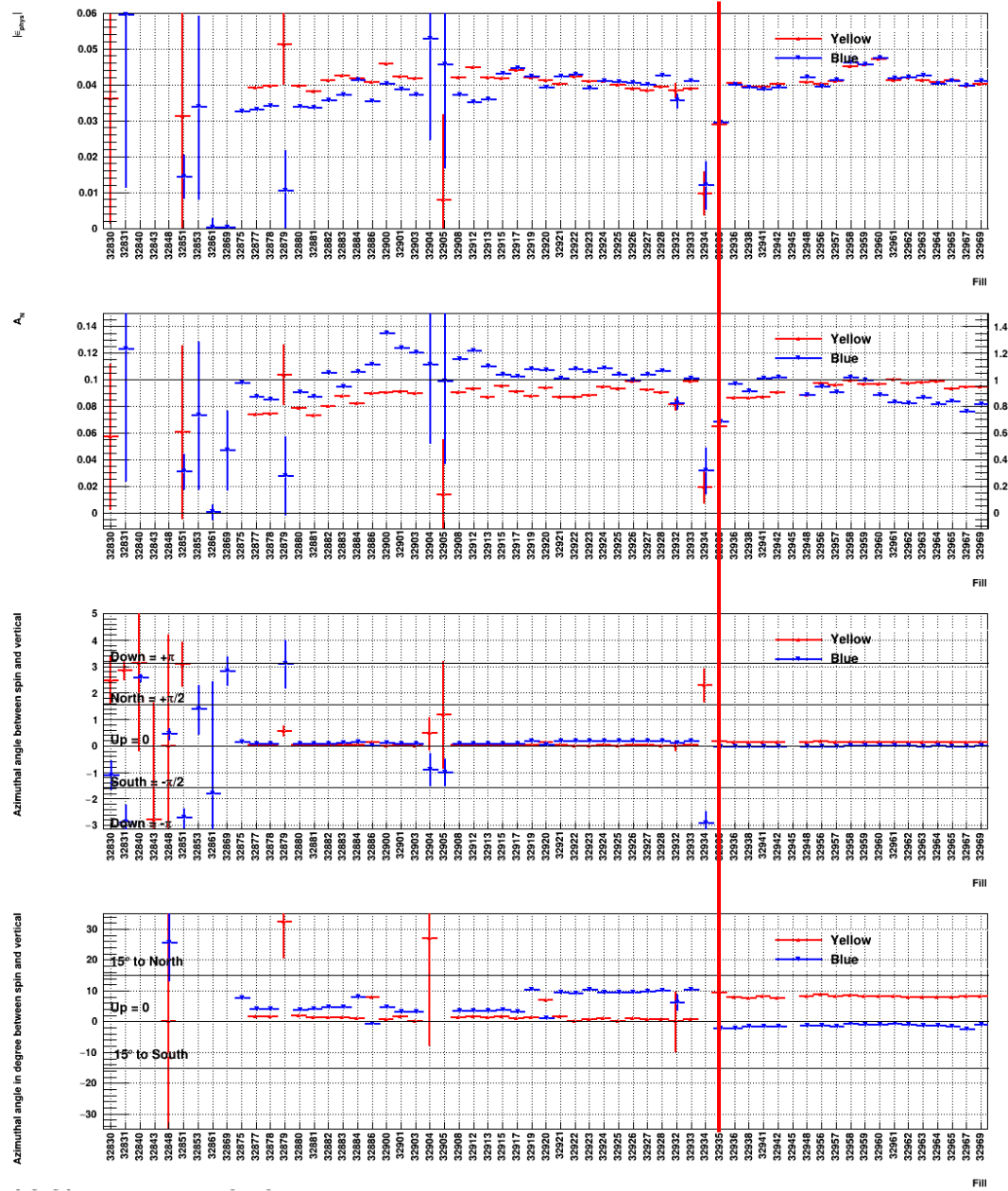
Blue: < 0.5% / h

Yellow: < 1% / h





# STAR Local Polarimeter



No more spin tilt in **Blue**  
 → same as at pC  
 ~10° spin tilt in **Yellow**  
 → larger than at pC

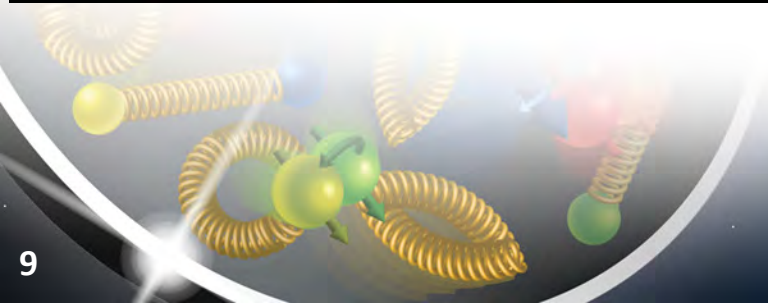
### Wish list:

- would like to do rotator ramp to study longitudinal component
- would like to do snake scan in **Yellow** to reduce spin tilt

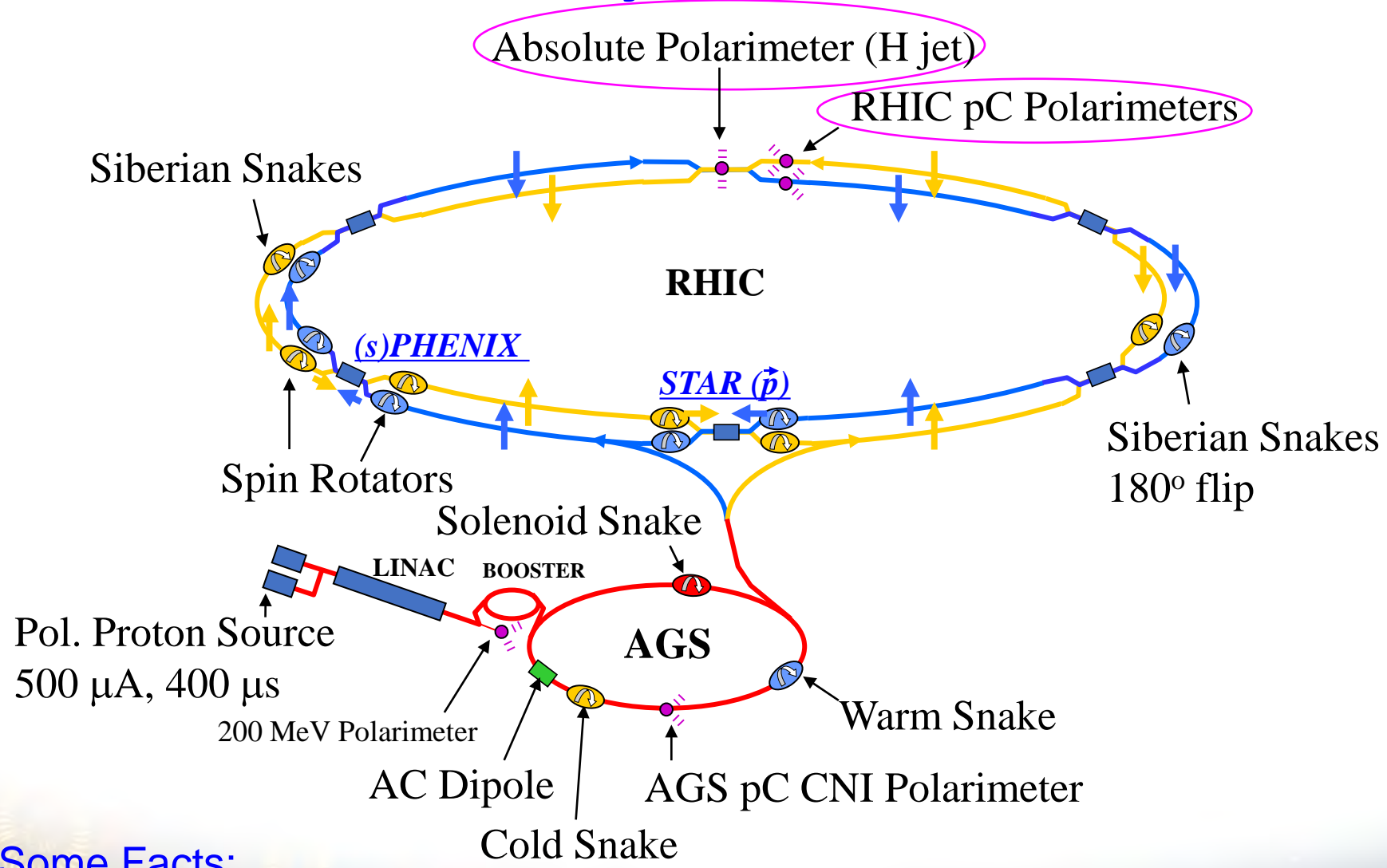




**BACK UP**



# RHIC and Polarimetry

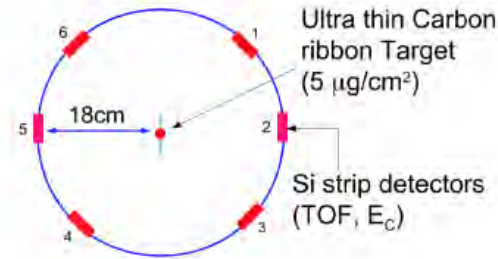
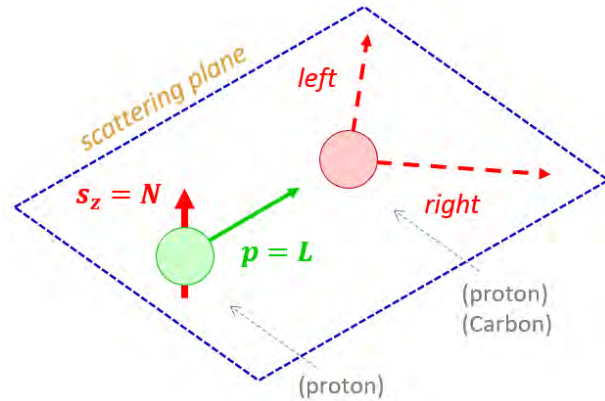
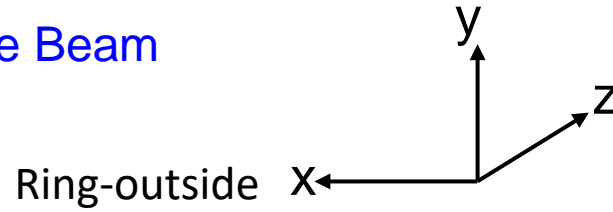


## Some Facts:

CDEV spin direction the one at the source, id even spin flips source to RHIC  
 IP-12 spin direction and source are the same  $\rightarrow$  IP-6 spin direction == **-IP-12**

# pC Polarimetry

Coordinate System: → Blue Beam



Note:

$$\Phi = 0 = +y$$

For yellow beam x-axis is flipped  
+x points ring-inside

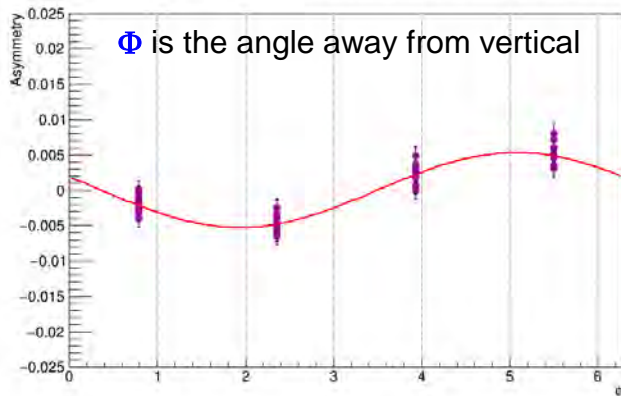
## spin tilts @ store

$\phi_{pC} (^{\circ})$	Blu	Yel
Run9-100	6	5
Run11-250	3	1
Run12-100	3	3
Run12-255	11	7
Run13-255	16	9
Run15-100 pp	3	2
Run15-104 pAu	0	-
Run15-104 pAl	1	-
Run17-255	12	8

Blue:

+ $\phi_{pC}$ : spin tilted  
towards ring - inside

32877.202: Recorded Mon Dec 20 20:27:03 2021, Analyzed Mon Dec 20 21:17:50 2021, Version v2.2.10M, zchang



$\chi^2 / \text{ndf}$  57.37 / 45  
Prob 0.1021  
Asym 0.005593 ± 0.0002583  
 $\phi$  0.365 ± 0.04764

B2D

Run22 24 GeV 8-10 0  
Run22 255 GeV 20 0

Polarimeter-Info: <https://www.cnipol.bnl.gov/rundb/>



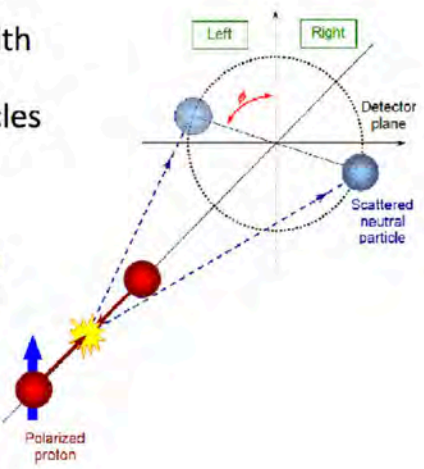
# STAR Local Polarimetry

## Single-spin asymmetry at zero angle

Hadronic calorimeter equipped with Shower Maximum Detector detects very forward neutral particles

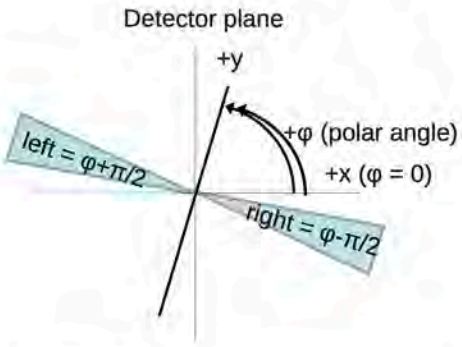
$$p^\uparrow + p \rightarrow n + X$$

Large asymmetry  $A_N$  of neutron production enables its use as a local polarimeter

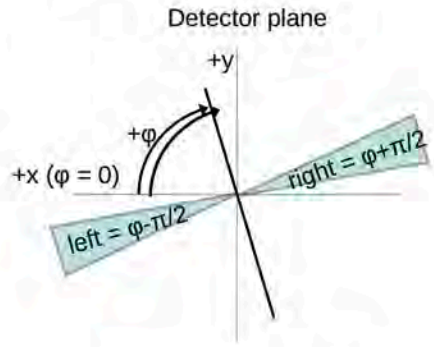


Local polarimeter normally used to ensure beam is longitudinal if spin rotators are used  
 →  $A_N$  disappears if spin is longitudinal

## Geometry definition

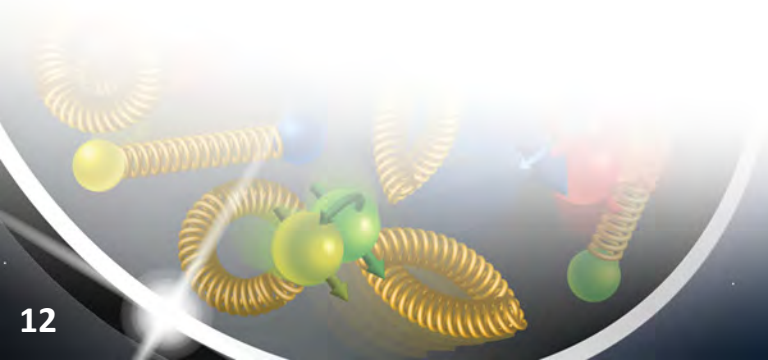


Looking along yellow beam



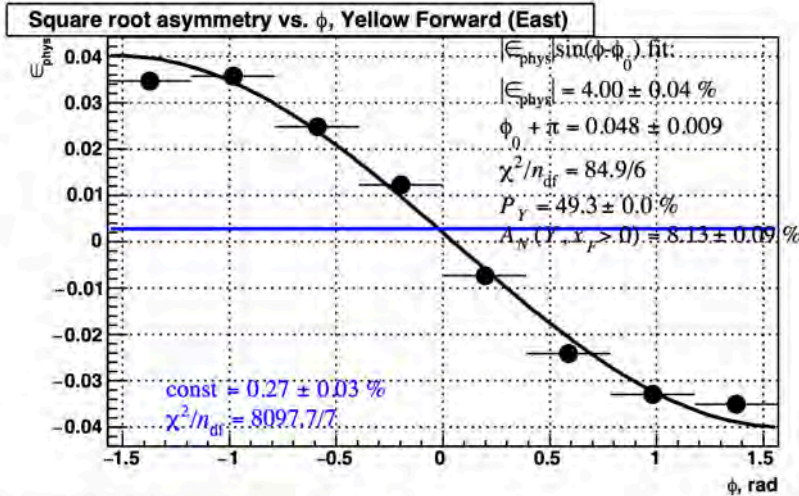
Looking along blue beam

$\epsilon_{phys}$  is a left-right asymmetry with respect to  $\phi = \text{const}$  plane, looking along the incident beam



# STAR Local Polarimetry

## Run-17

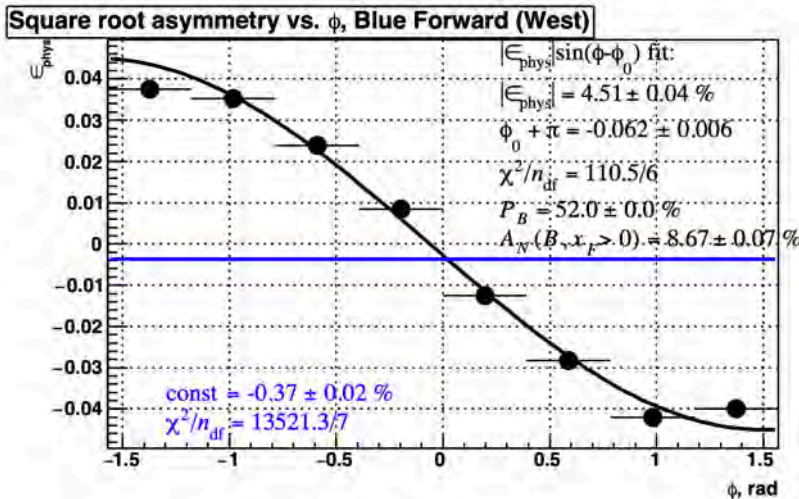


**Note:**

$$1/P \times \epsilon_{\text{phys}} = A_N$$

$$A_N \text{ Yellow} = A_N \text{ Blue}$$

$$\frac{e_{\text{Phys}}^{\text{Blue}}}{e_{\text{Phys}}^{\text{Yellow}}} = \frac{P_B}{P_Y}$$



**All worked out in Run-17**

ZDC Single Spin Asymmetry (run 18074020)

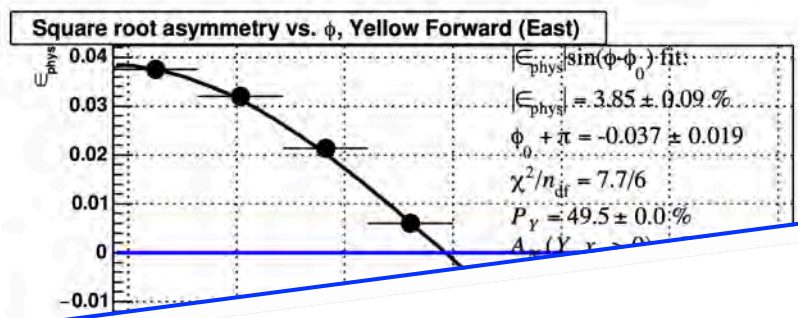
Wed Mar 15 09:34:01 2017

# STAR Local Polarimetry

## Run-22 – Result from last Tuesday

**Note:**  
 $1/P \times \epsilon_{\text{phys}} = A_N$

$A_N \text{ Yellow} = A_N \text{ Blue}$

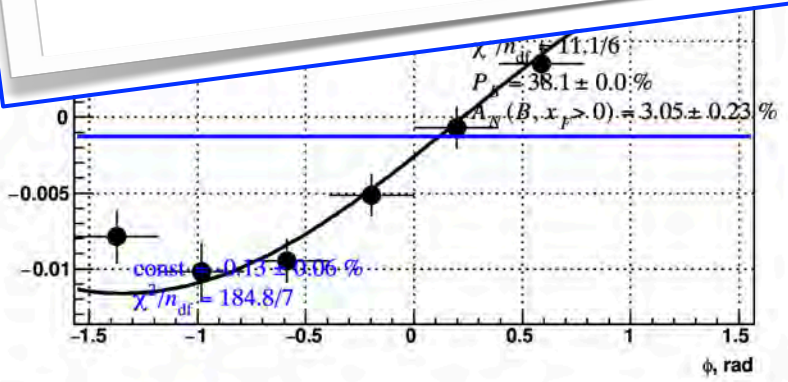


**BUT**

can the difference in spin direction between IP-6 and IP-12 be soo big

Result also inconsistent with spin tracking simulations

→ let's dig a bit deeper



side do not agree  
 still different by 2.55

this would need  $P_{\text{Blue}}$  to be significantly higher

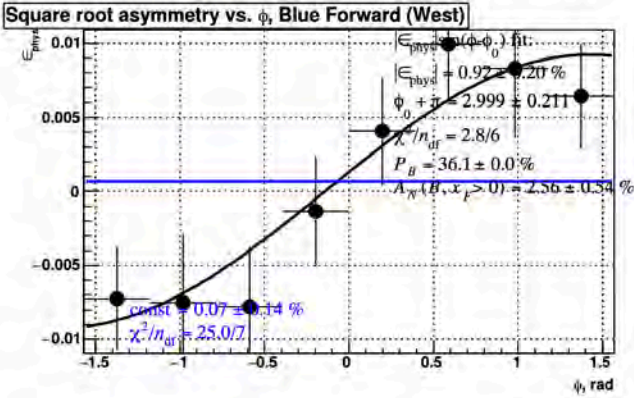
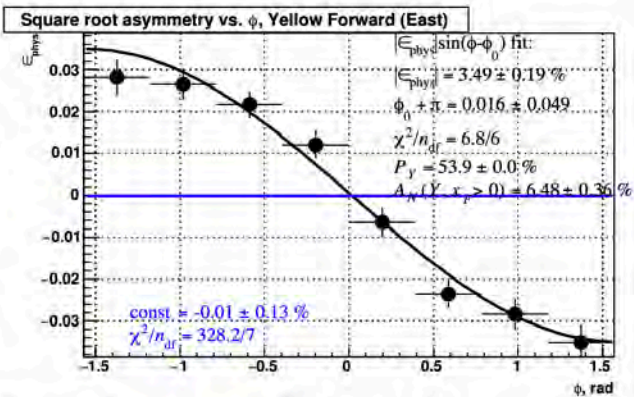
→ only explanation  
 significant longitudinal component at STAR

ZDC Single Spin Asymmetry (run 22355037)



# STAR Local Polarimetry

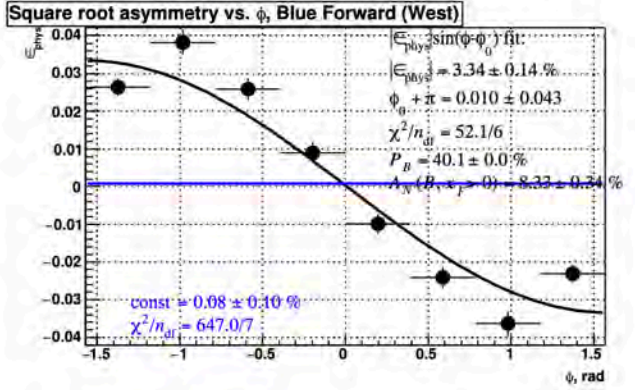
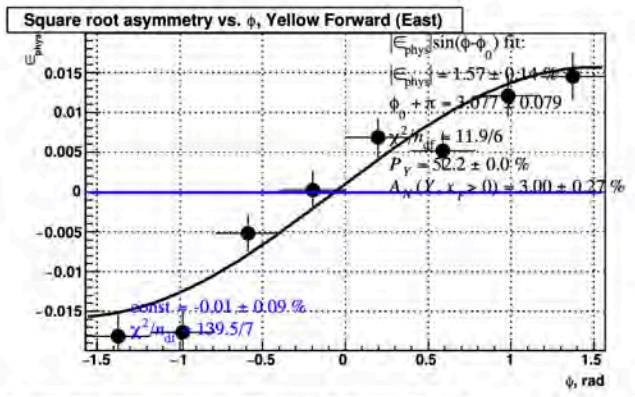
Fill 32881



ZDC Single Spin Asymmetry (run 22356039)

Wed Dec 22 18:58:12 2021

Fill 32882

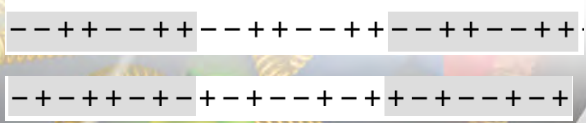


ZDC Single Spin Asymmetry (run 22356048)

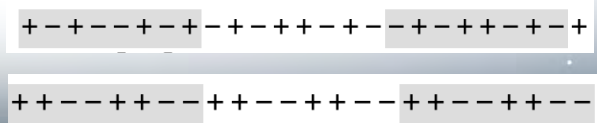
Wed Dec 22 19:14:02 2021



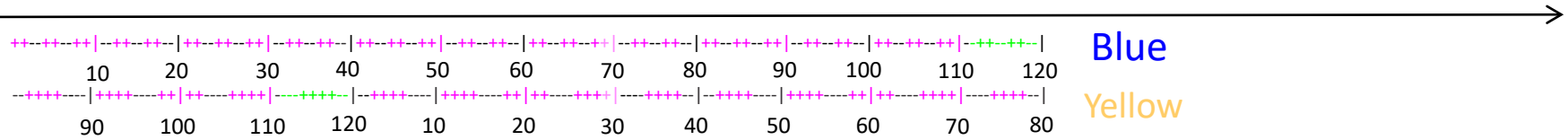
Only change between fills the spin pattern



Yellow  
Blue



# STAR Local Polarimetry



green bunches: empty bunches → abort gaps

For local polarimetry it is critical to have bunch – id and spin direction at STAR correctly correlated

→ Till 2017: reference was blue beam

Somewhen this was switched to yellow beam, maybe during BES fixed target running

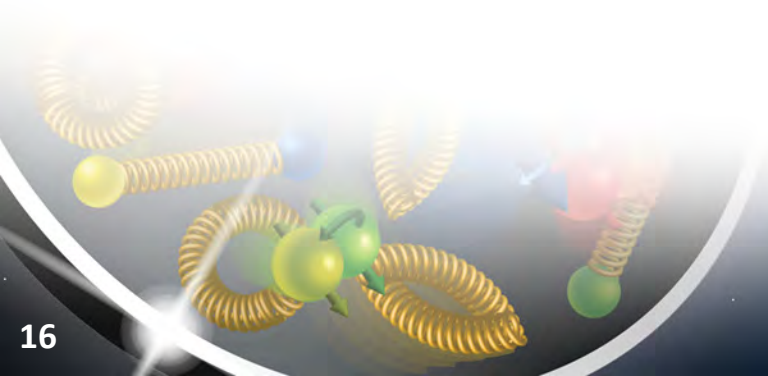
→ Local Polarimeter code was not modified



## Fun Facts:

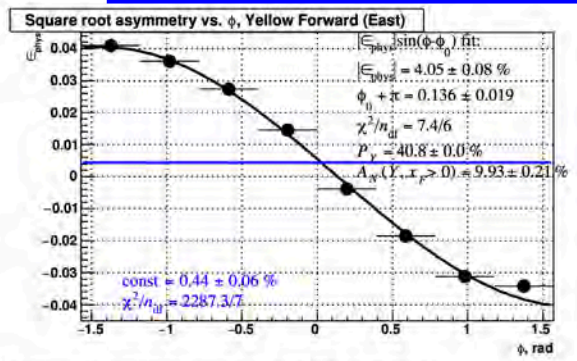
does not matter a lot for `---+---+---+---+---+---+---+---+` spin patterns

→ Therefore, Yellow agreed between 2017 and 2022 and Blue was screwed up

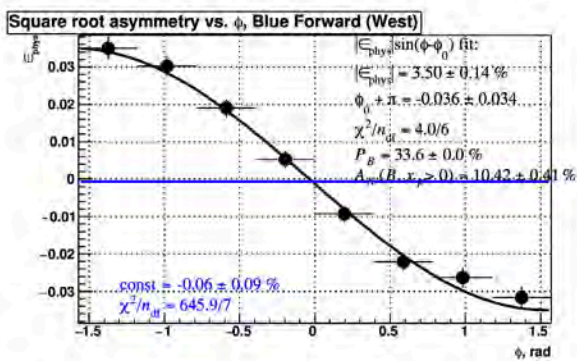
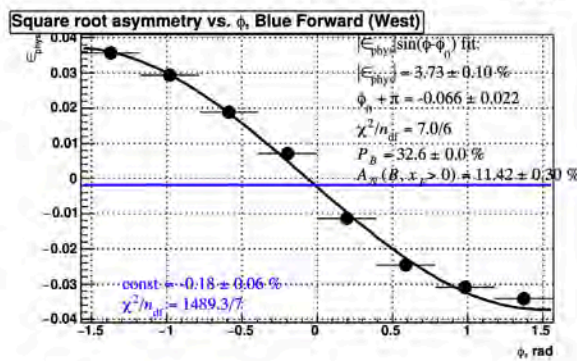
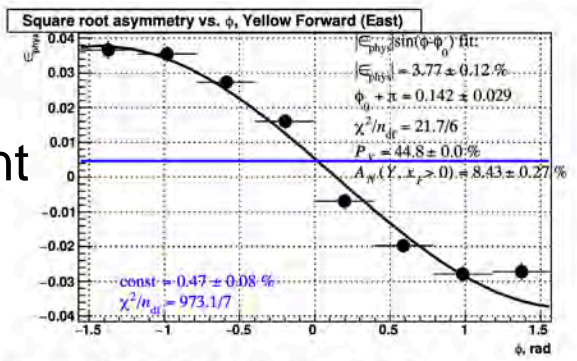


# STAR Local Polarimetry Energy Scan

Ggamma	485	485.5	486	486.5	487
Brho [Tm]	846.6492256	847.5220718	848.3949179	849.2677641	850.1405896
pc [GeV]	253.8190524	254.0807251	254.3423978	254.6040705	254.865737



radial component  
in Yellow



ZDC Single Spin Asymmetry (run 22357034)  
Thu Dec 23 13:31:14 2021

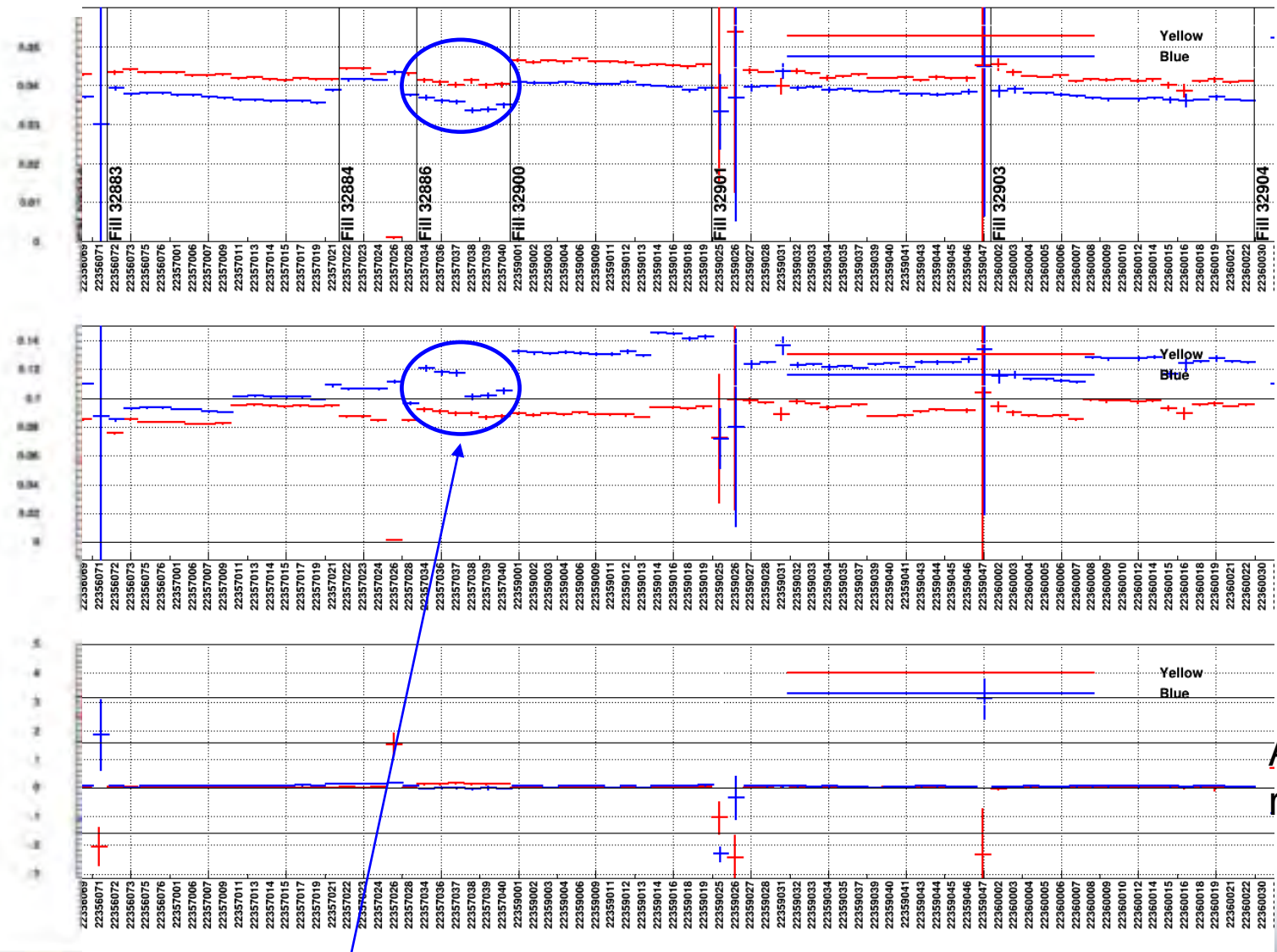
ZDC Single Spin Asymmetry (run 22357039)  
Thu Dec 23 14:55:49 2021

very small radial component  
in Blue  
transverse component at pC < STAR

no radial component  
in Blue  
transverse component at pC & STAR  
agree a bit better



# STAR Local Polarimetry Energy Scan



$\epsilon_{\text{phys}}$

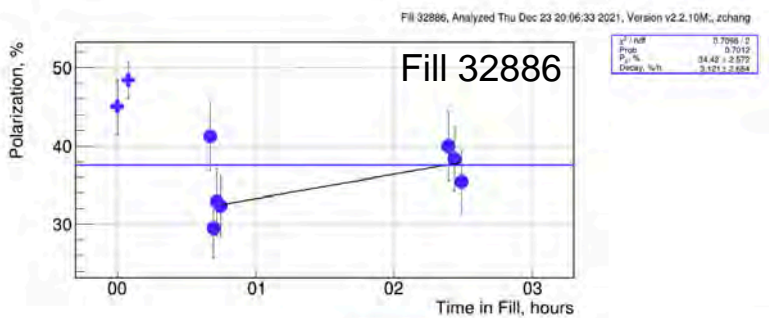
$1/P \times \epsilon_{\text{phys}} = A_N$

Angle showing radial component

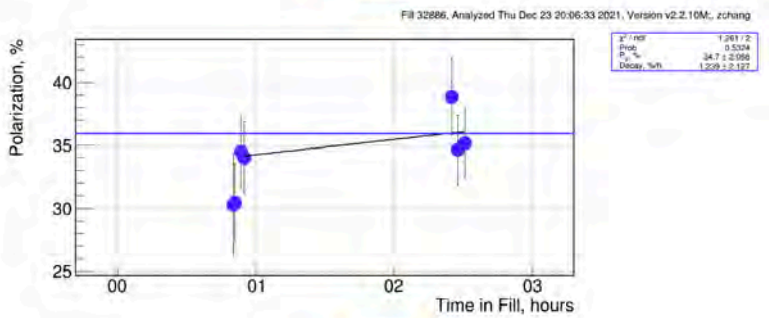
Change in  $A_N$  indicates longitudinal component at pC moved to transverse

# Beam Energy Scan

Ggamma	485	485.5	486	486.5	487
Brho [Tm]	846.6492256	847.5220718	848.3949179	849.2677641	850.1405896
pc [GeV]	253.8190524	254.0807251	254.3423978	254.6040705	254.865737



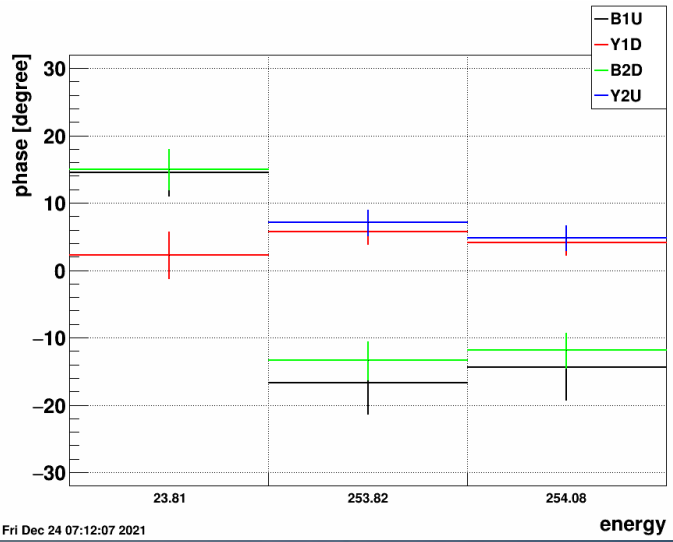
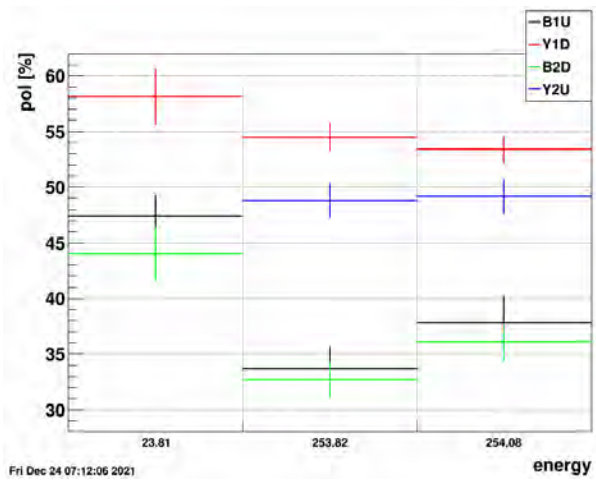
B1U



B2D

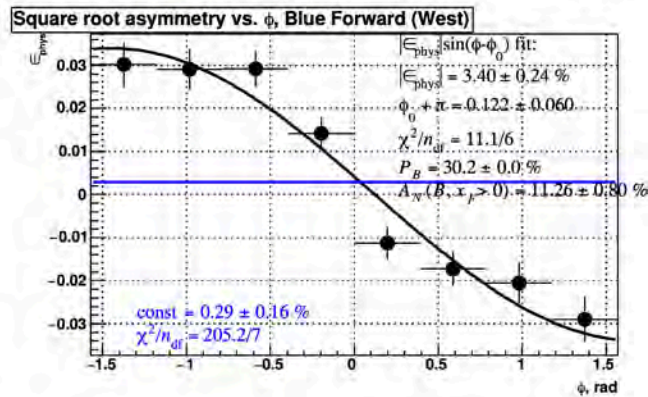
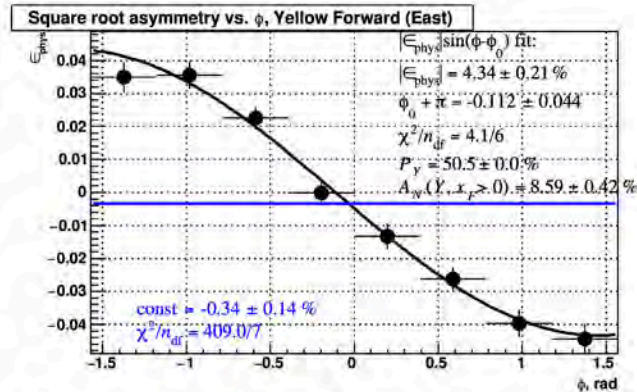
Change in Blue polarization moving longitudinal spin into transverse direction

Yellow remained in statistics the same



# STAR Local Polarimetry

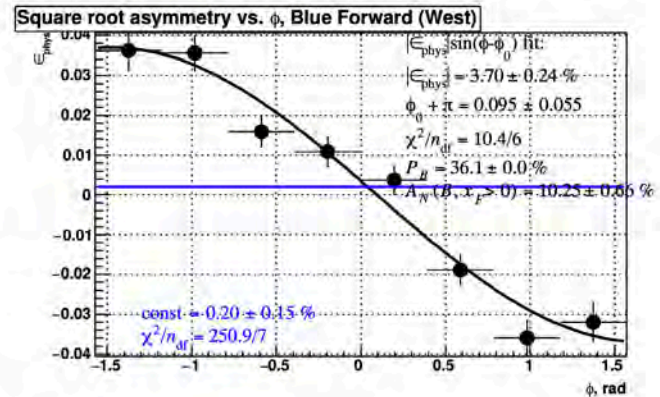
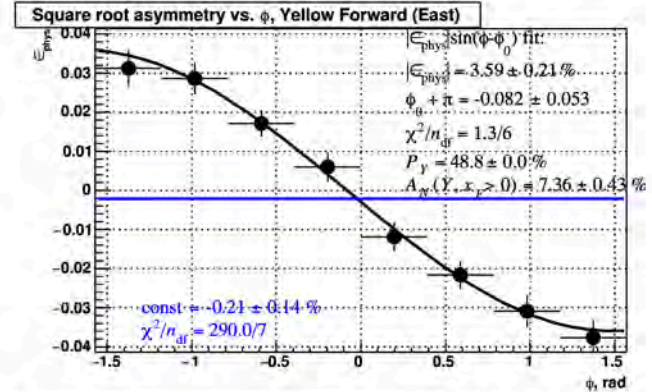
Fill 32912



ZDC Single Spin Asymmetry (run 22361028)

Mon Dec 27 18:53:55 2021

Fill 32913



ZDC Single Spin Asymmetry (run 22362007)

Tue Dec 28 02:58:52 2021

- Small radial component both in Yellow and Blue
- pC significant radial component
- Blue: transverse component at IP6 and pC are different
- $A_N$  Yellow  $\neq$   $A_N$  Blue

longitudinal component at IP-6 and pC need to be determined through machine studies

Electron-Ion Collider