» Recent Results from Proton Polarimetry at RHIC«

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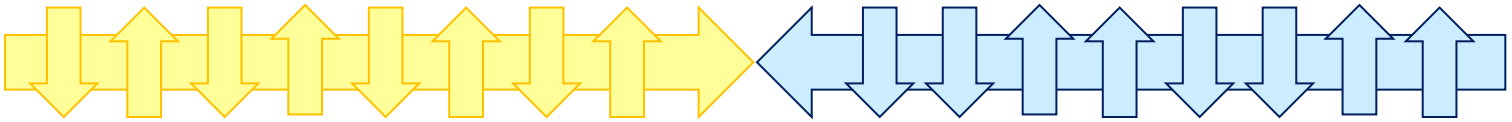
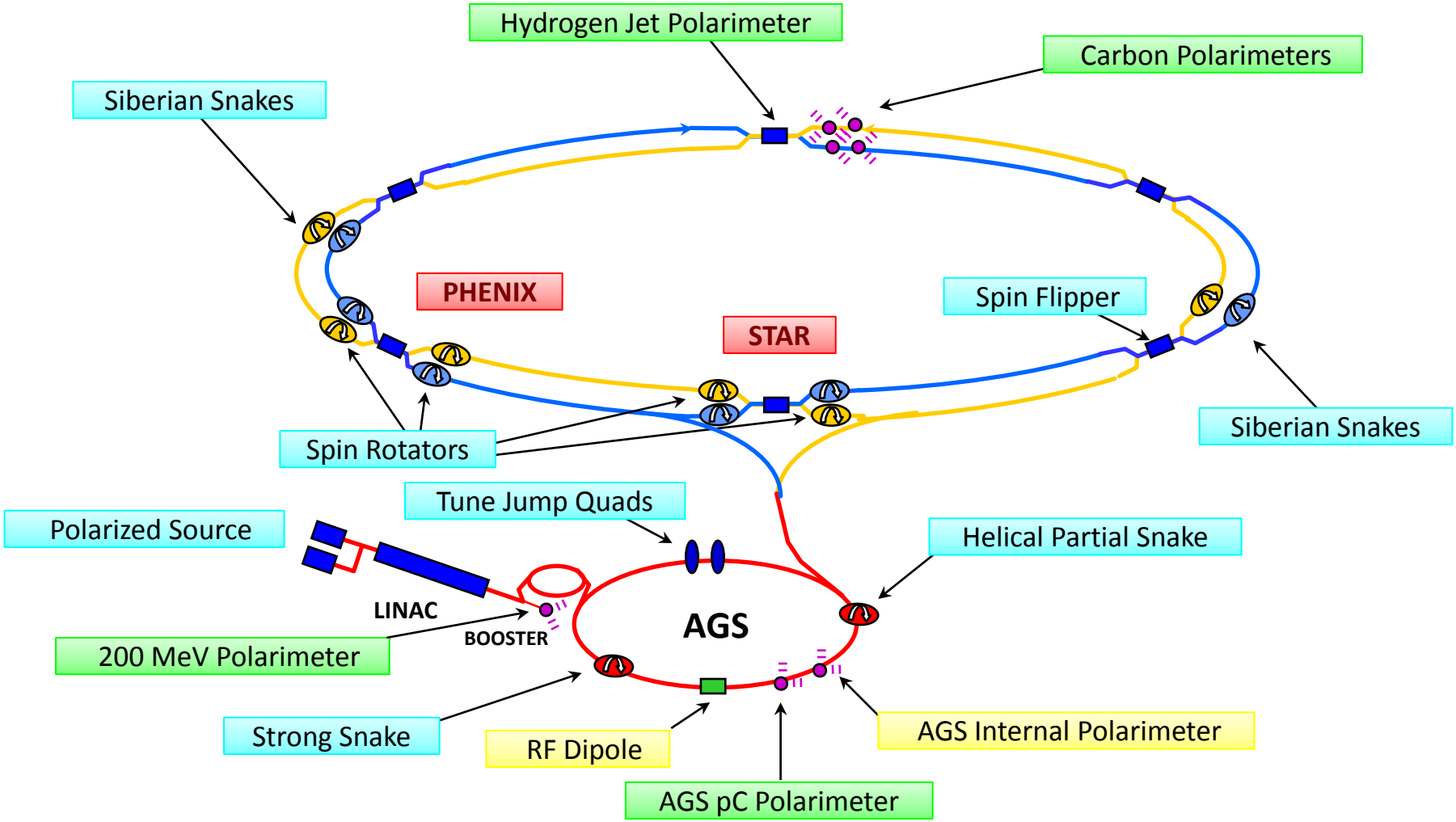
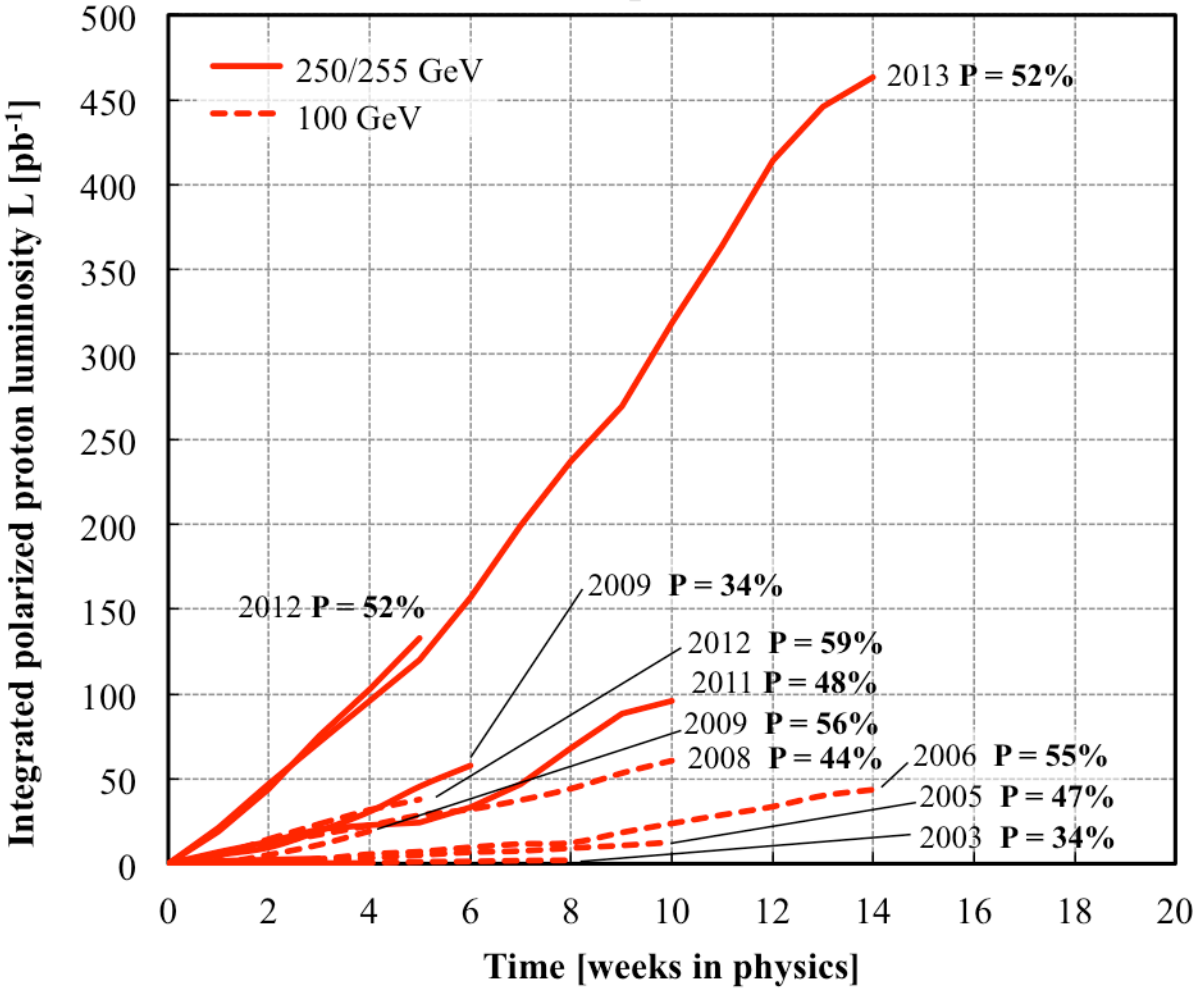
for the RHIC Polarimetry Group

DNP Meeting, October 2014, Waikoloa, HI

BROOKHAVEN
NATIONAL LABORATORY




Hydrogen Jet Polarimeter
Carbon Polarimeters
Siberian Snakes
PHENIX
STAR
Spin Flipper
Siberian Snakes
Spin Rotators
Tune Jump Quads
Polarized Source
Helical Partial Snake
LINAC
BOOSTER
AGS
200 MeV Polarimeter
Strong Snake
RF Dipole
AGS Internal Polarimeter
AGS pC Polarimeter



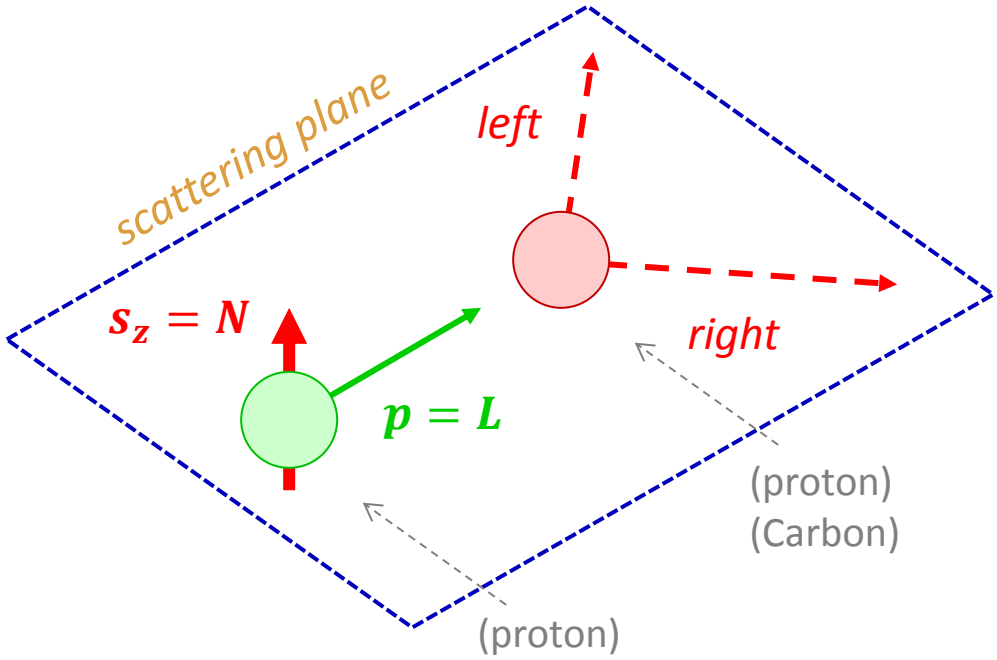
Consistent improvement in delivered luminosity and beam polarization at 100/255 GeV.

Polarization

$$P = \frac{n^{\uparrow} - n^{\downarrow}}{n^{\uparrow} + n^{\downarrow}}$$

$$s_z = \pm \frac{1}{2}\hbar$$

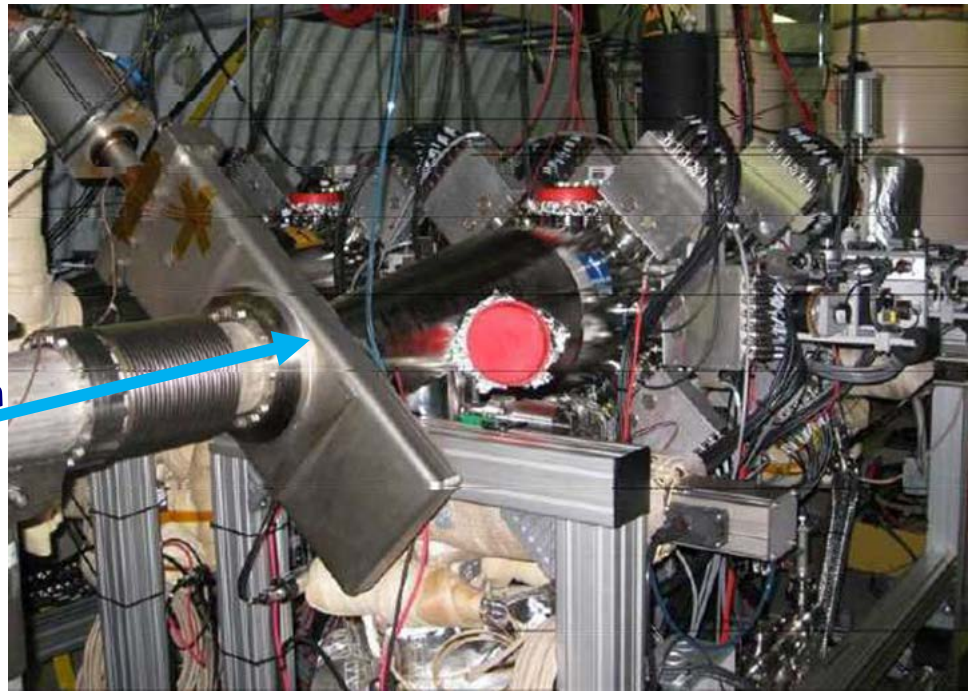
Asymmetry

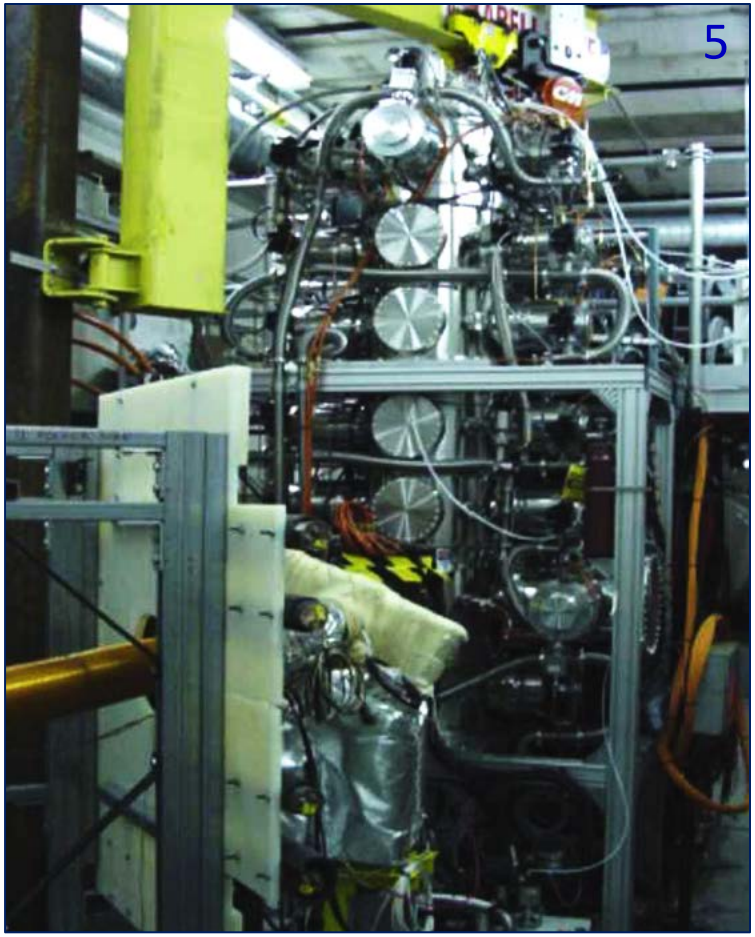


$$A_N = \frac{d\sigma_{left} - d\sigma_{right}}{d\sigma_{left} + d\sigma_{right}}$$

$$\varepsilon = A_N \cdot P = \frac{N_L - N_R}{N_L + N_R}$$

(*) perpendicular to polarization vector





Carbon polarimeters

Two per ring

Fast measurement

$\sigma \approx 4\%$

Beam polarization profile

Polarization decay (time dependence)

normalization

Hydrogen jet polarimeter

Polarized target

Continuous operation

$\sigma \approx 5 - 8\%$ per fill

atomic jet target

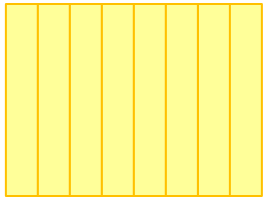
scattered proton

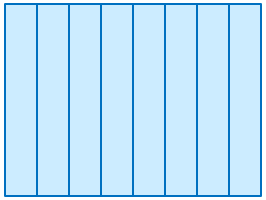
proton beam
100/250 GeV

recoil proton from
elastic scattering

5 MeV

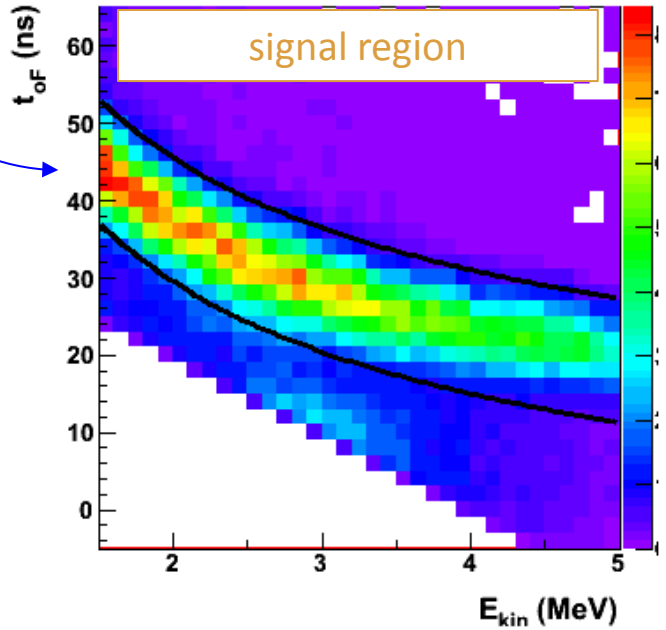
1 MeV

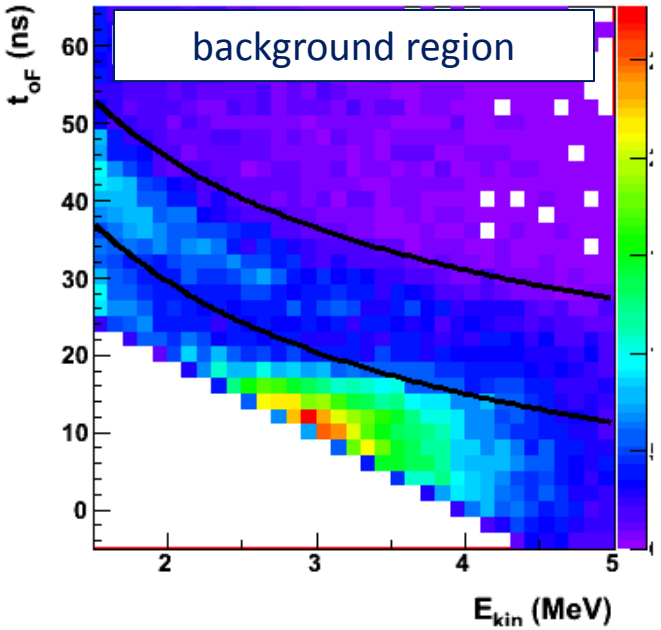




Si strip detectors
≈ 4 mm wide
75 cm from interaction point

$$E_{kin} = \frac{1}{2}mv^2$$





$$P_{Beam} = -\frac{\varepsilon_{Beam}}{\varepsilon_{Target}} P_{Target}$$

from Breit-Rabi measurement

$$\varepsilon = \frac{N^{\uparrow} - N^{\downarrow}}{N^{\uparrow} + N^{\downarrow}}$$

1

Polarization independent background

$$\varepsilon = \frac{N^{\uparrow} - N^{\downarrow}}{N^{\uparrow} + N^{\downarrow} + 2 \cdot N_{bg}} \Rightarrow \frac{\varepsilon_B}{\varepsilon_T} = \frac{N_B^{\uparrow} - N_B^{\downarrow}}{N_T^{\uparrow} - N_T^{\downarrow}}$$

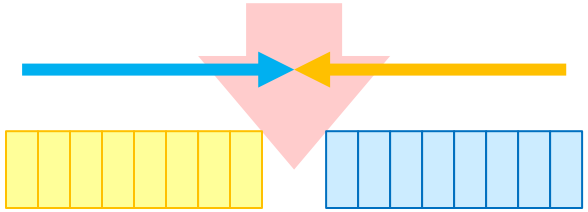
2

Polarization dependent background

$$\varepsilon = \frac{\varepsilon_{inc} - r \cdot \varepsilon_{bg}}{1 - r}$$

background fraction $r = N_{bg}/N$

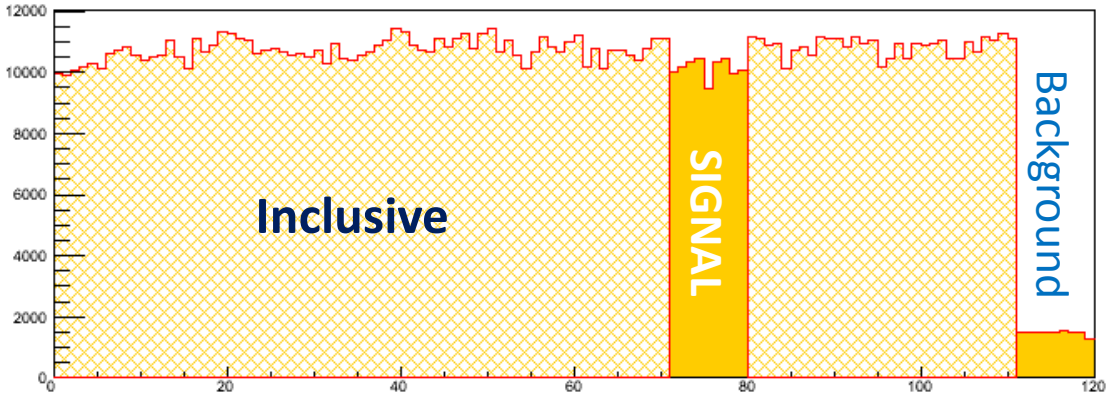
What if $[\varepsilon_{bg}]_T \neq [\varepsilon_{bg}]_B$?

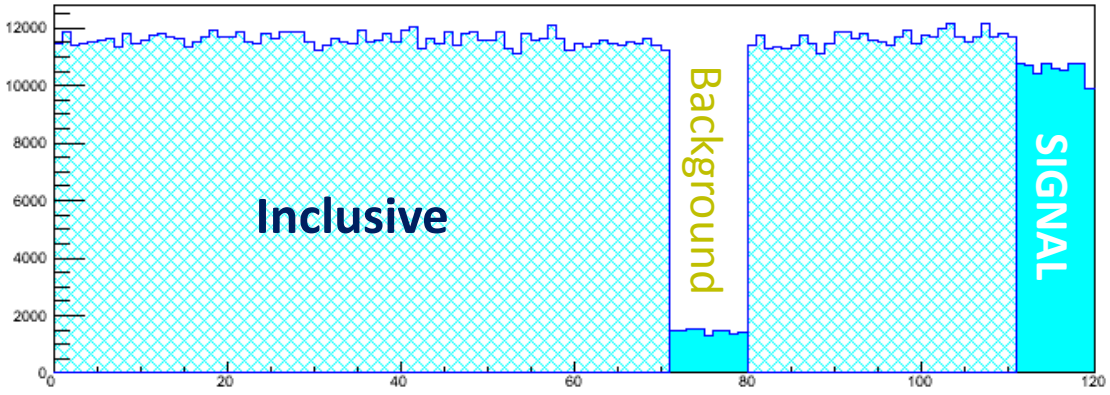


$$P_Y = -\frac{\varepsilon_Y}{\varepsilon_T} P_T \qquad P_B = -\frac{\varepsilon_B}{\varepsilon_T} P_T$$

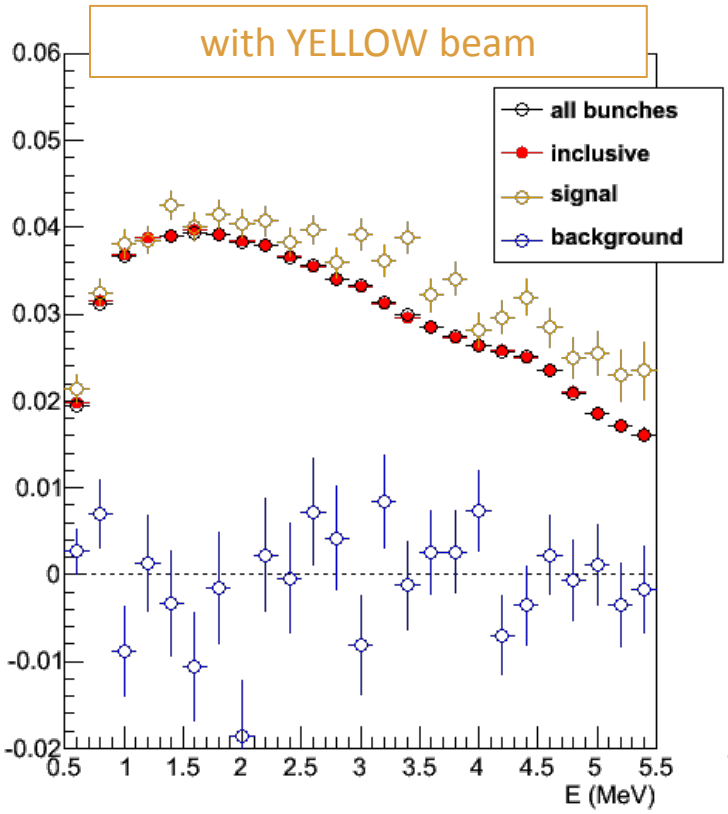
$$\varepsilon_S = \frac{\varepsilon - r \cdot \varepsilon_B}{1 - r}$$

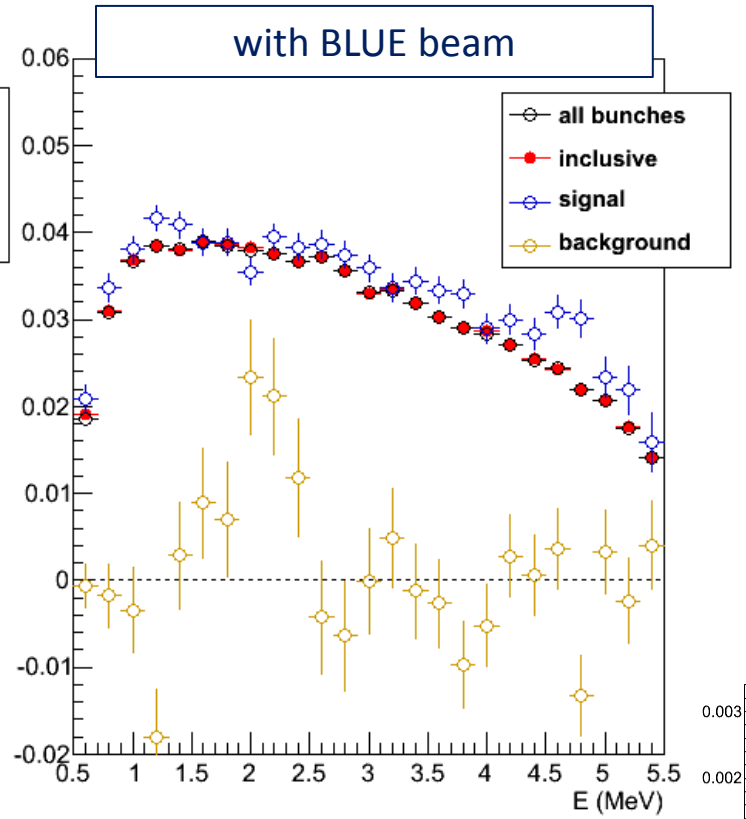
signal: ε_S
background: ε_B
inclusive: ε
background fraction: r



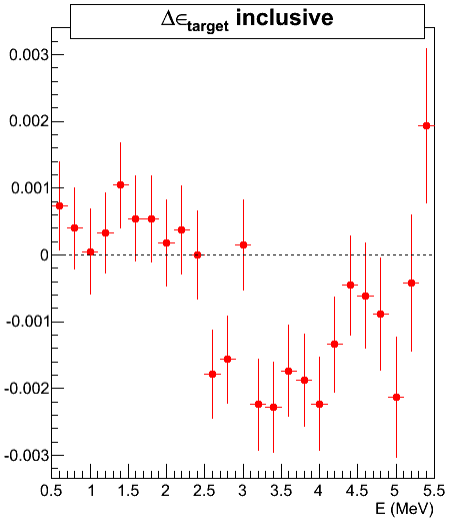


Target Asymmetries





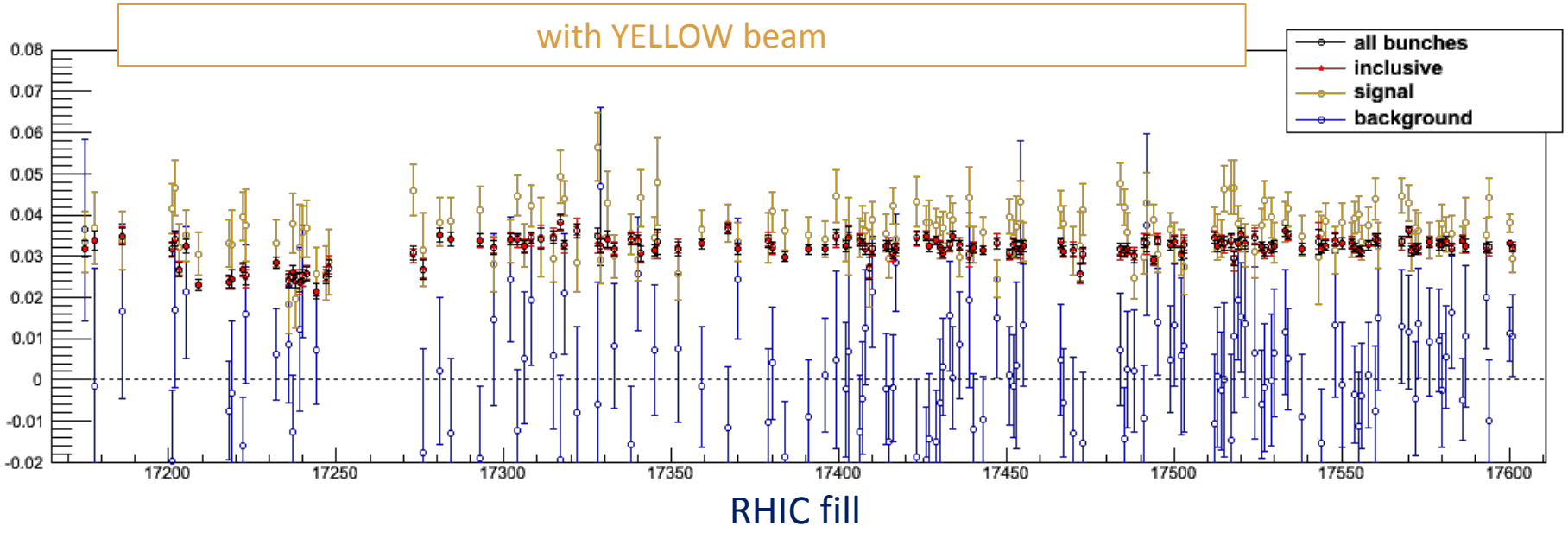
120 bunches
102 bunches
9 bunches
9 bunches

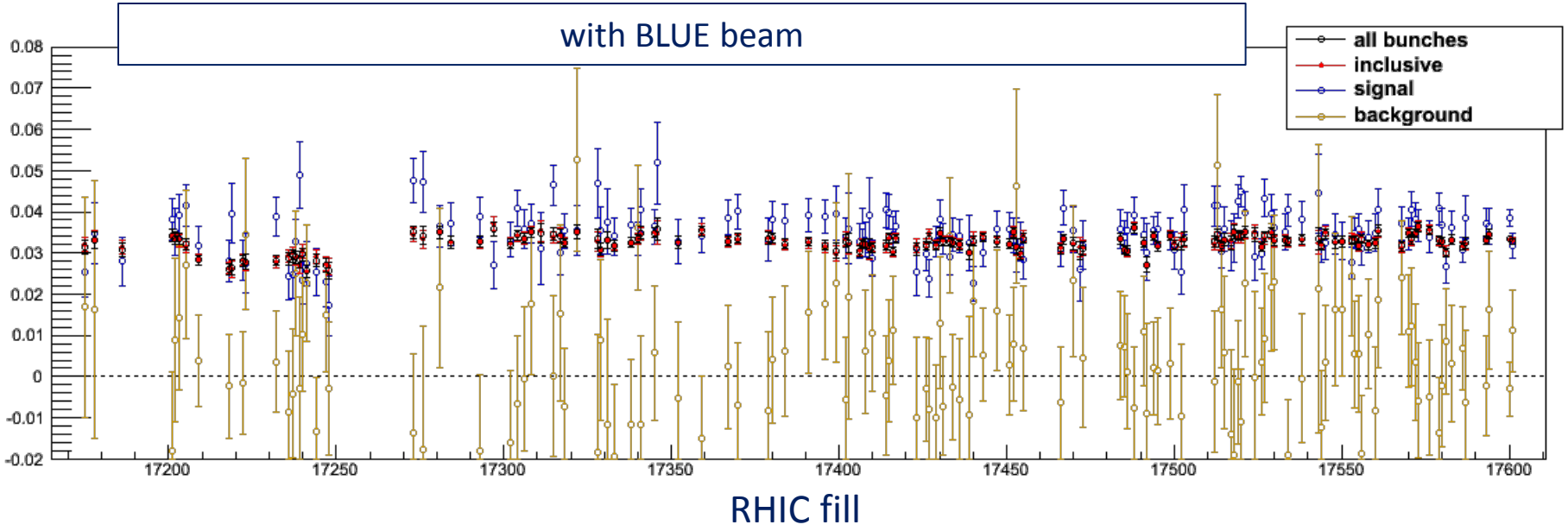


Full 2013 statistics!

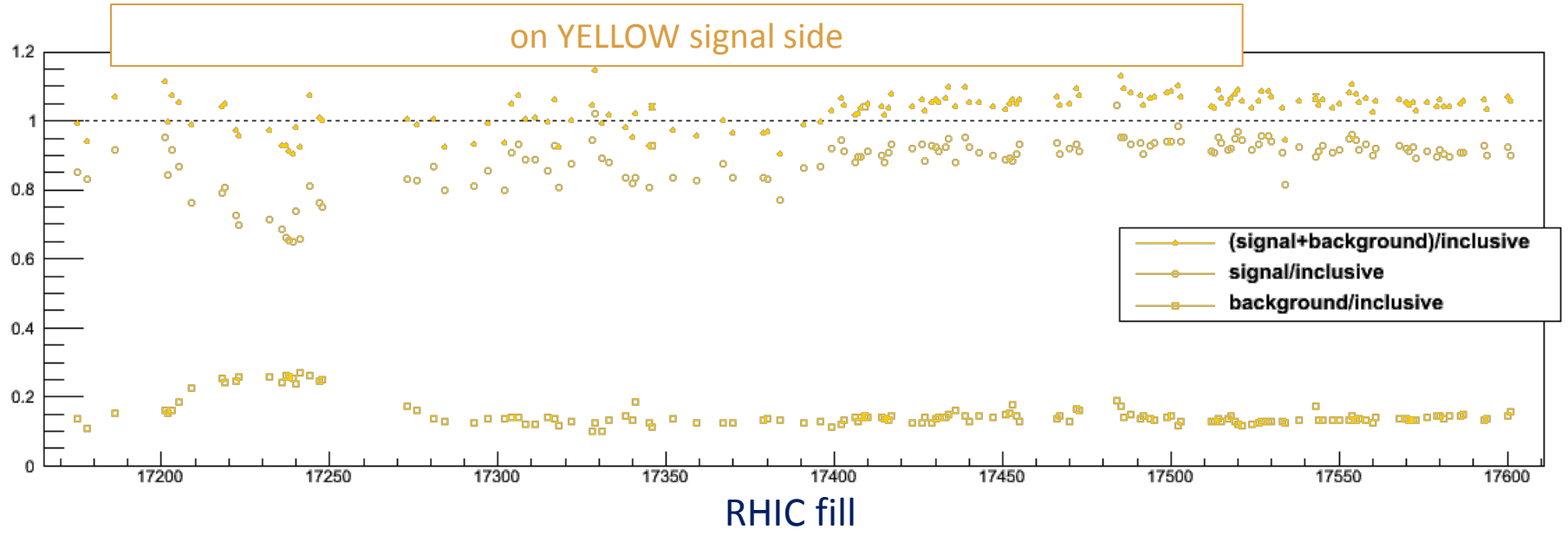
Normalize with known target polarization

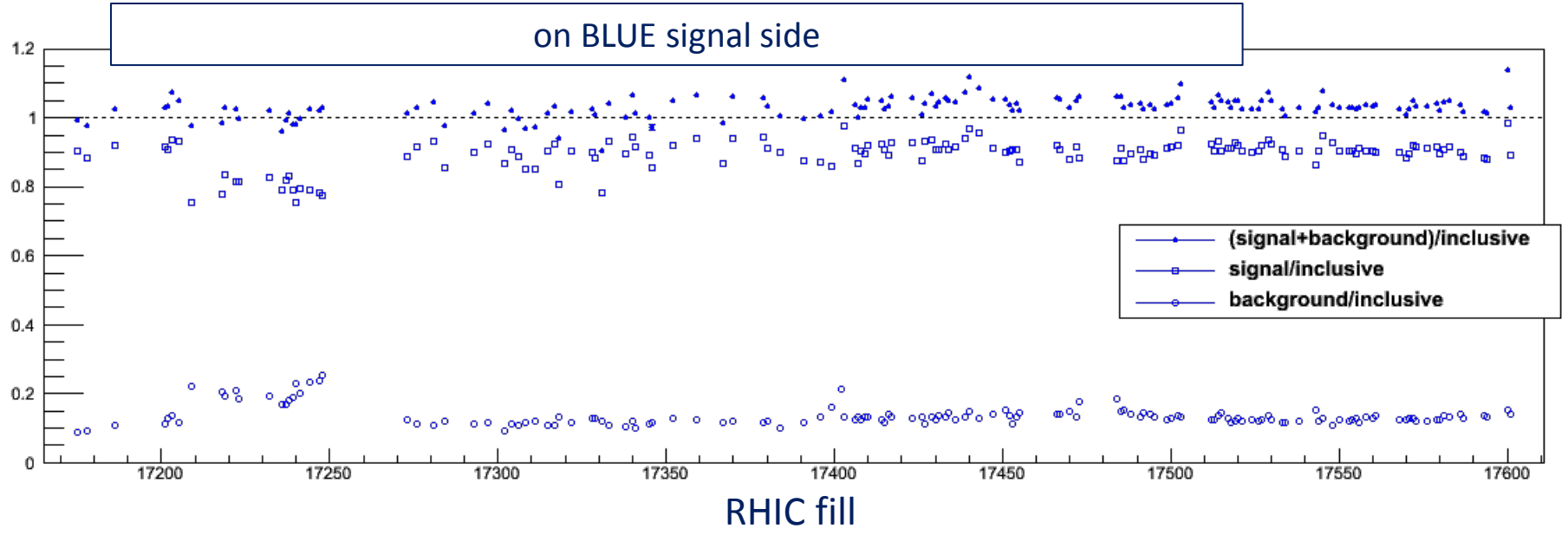
Target Asymmetries



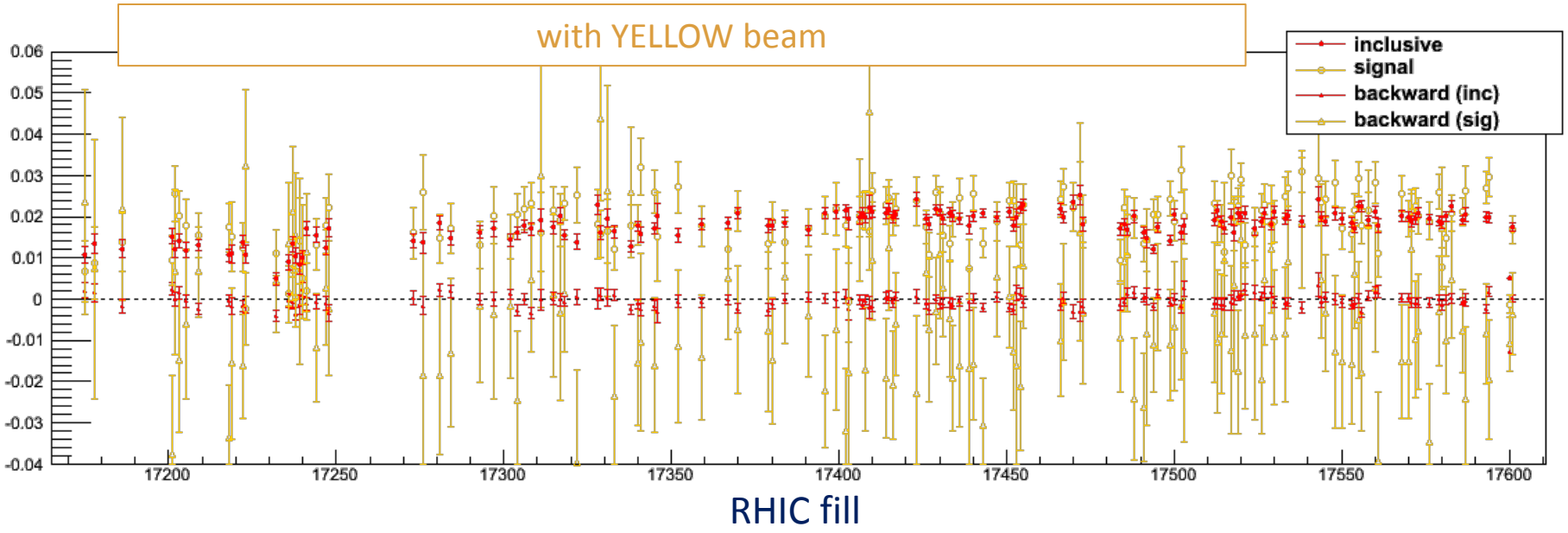


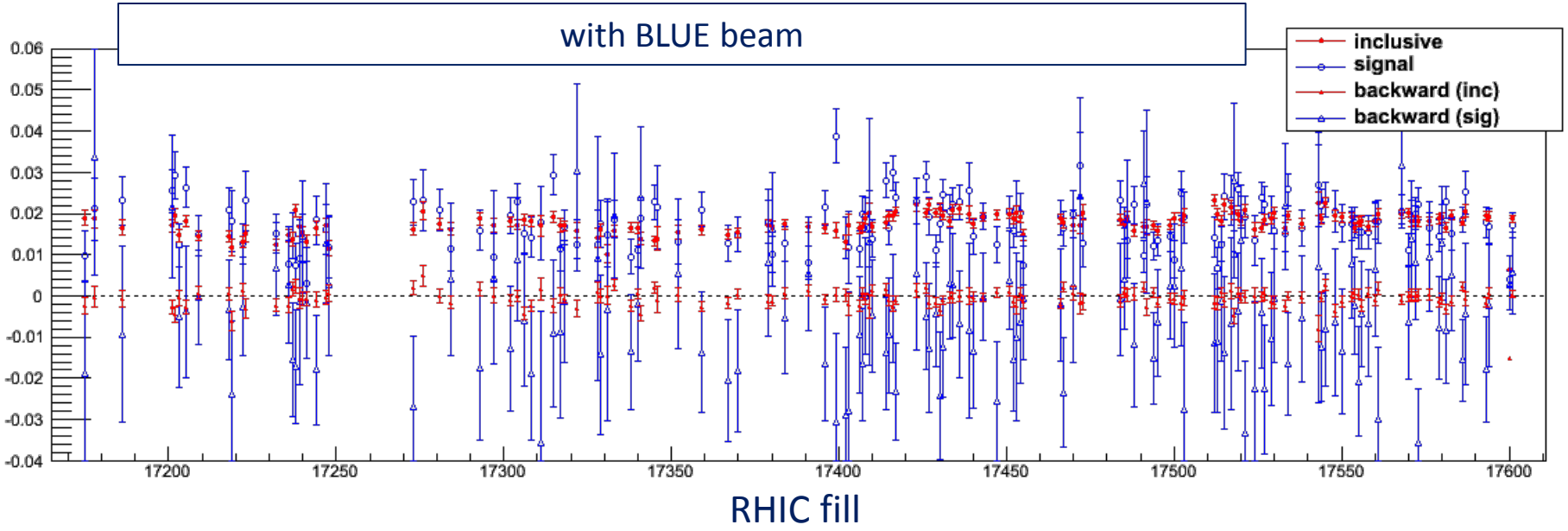
Background Fraction





Beam Asymmetries





$$\varphi(s,t) = \langle \lambda_C \lambda_D | \varphi | \lambda_A \lambda_B \rangle$$

$$\varphi_1(s,t) = \left\langle +\frac{1}{2} +\frac{1}{2} | \varphi | +\frac{1}{2} +\frac{1}{2} \right\rangle$$

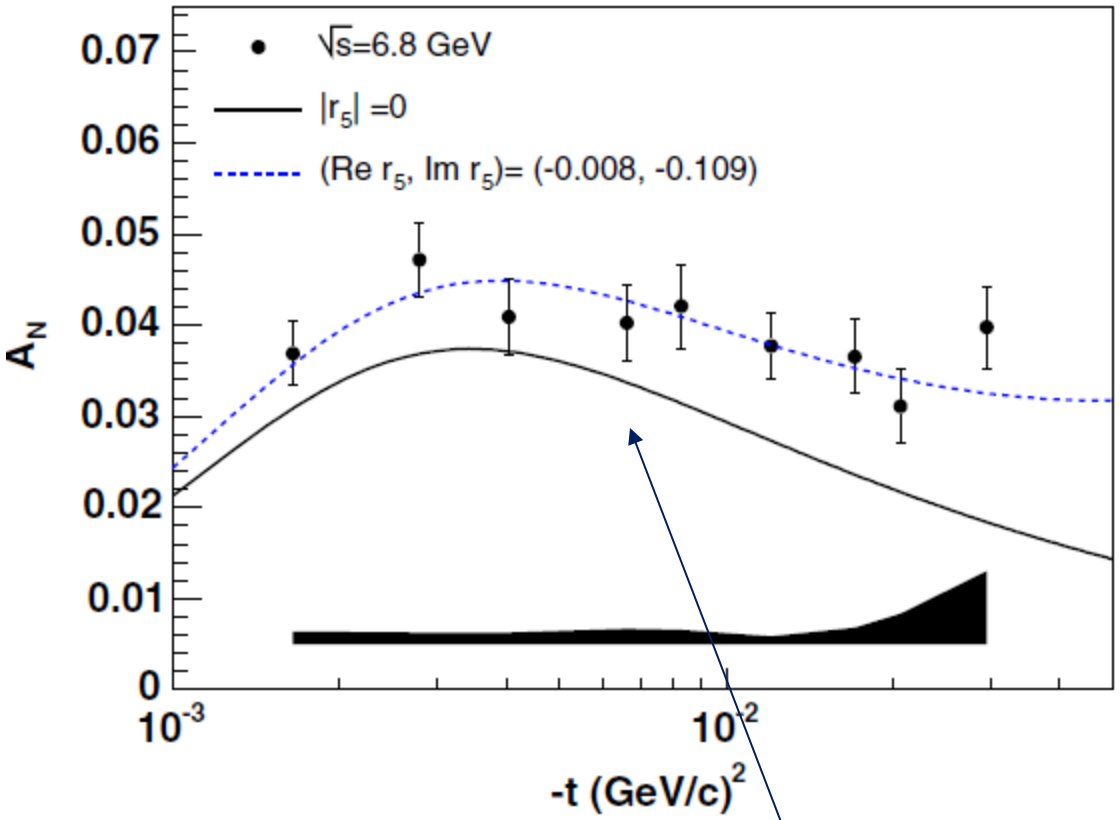
$$\varphi_2(s,t) = \left\langle +\frac{1}{2} +\frac{1}{2} | \varphi | -\frac{1}{2} -\frac{1}{2} \right\rangle$$

$$\varphi_3(s,t) = \left\langle +\frac{1}{2} -\frac{1}{2} | \varphi | +\frac{1}{2} -\frac{1}{2} \right\rangle$$

$$\varphi_4(s,t) = \left\langle +\frac{1}{2} -\frac{1}{2} | \varphi | -\frac{1}{2} +\frac{1}{2} \right\rangle$$

$$\varphi_5(s,t) = \left\langle +\frac{1}{2} +\frac{1}{2} | \varphi | +\frac{1}{2} -\frac{1}{2} \right\rangle$$

Phys. Rev. D 79, 094014 (2009)



$$A_N \frac{ds}{dt} = -\frac{4\pi}{s^2} \mathrm{Im}\left[\varphi_5^{em*}(s,t)\varphi_+^{had}(s,t) + \varphi_5^{had*}(s,t)\varphi_+^{em}(s,t)\right]$$

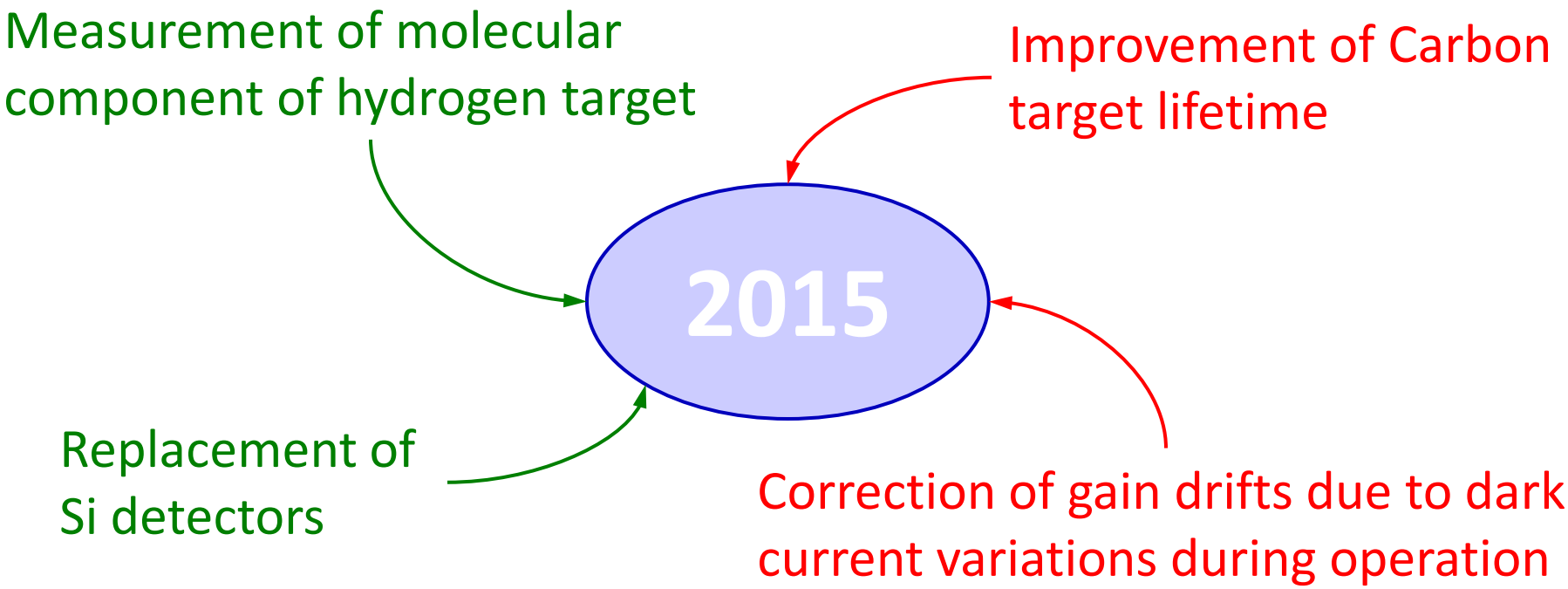
First data from 100 GeV beam (2004)

o Polarimetry at RHIC

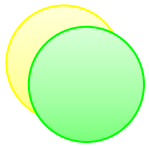
- Essential input for experiments
- Fast feedback during collider operation

Fast polarization measurement with Carbon targets

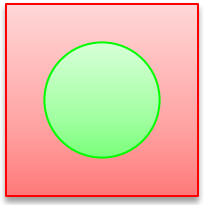
Absolute normalization with polarized hydrogen jet target



Polarization Profile

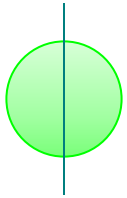


$$P_{coll} = \frac{\int dxdyP(x,y)I_B(x,y)I_Y(x,y)}{\int dxdyI_B(x,y)I_Y(x,y)}$$



$$P_{jet} = \frac{\int dxdyP(x,y)I_B(x,y)}{\int dxdyI_B(x,y)}$$

jet target polarization is flat



$$P_{sweep} = \frac{\int dyP(y)I_B(y)}{\int dyI_B(y)}$$

vertical and horizontal Carbon targets available

For Gaussian profiles

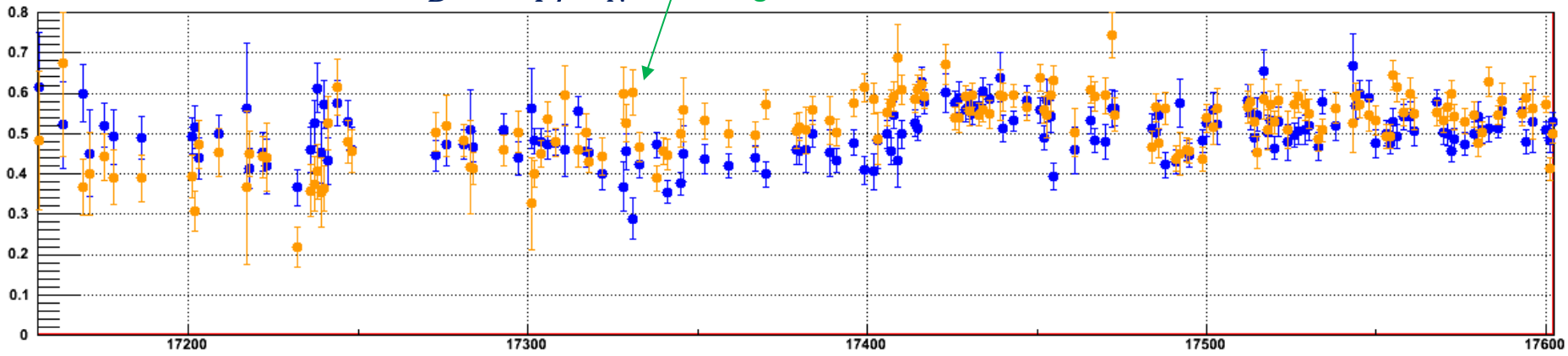
$$I = I_{peak} \cdot e^{-i\vec{r}^2/\sigma_I^2}$$

$$P = P_{peak} \cdot e^{-i\vec{r}^2/\sigma_P^2}$$

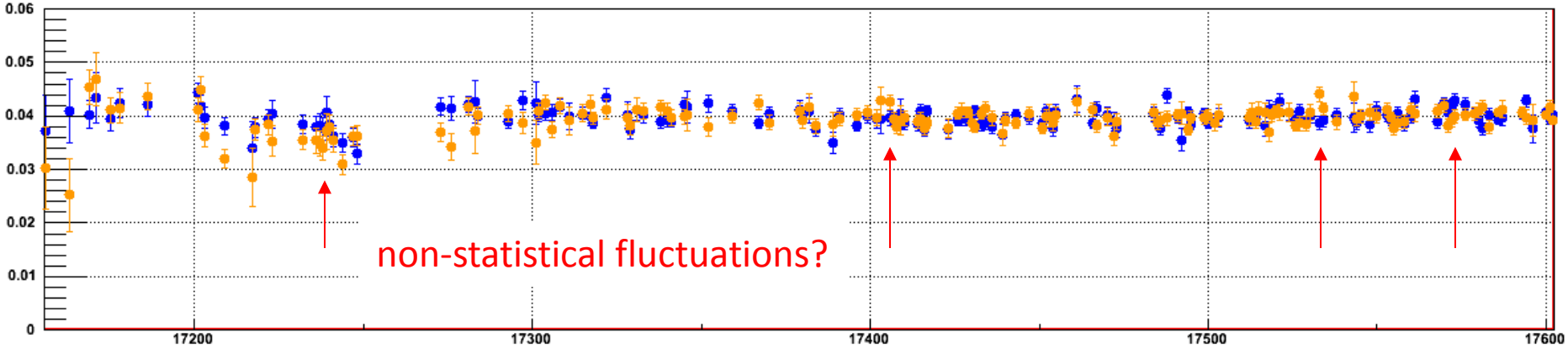
Profile parameter $R = \frac{\sigma_I^2}{\sigma_P^2}$

Online Results 2013 (HJET)

Beam Polarizations $P_B = \varepsilon_T / A_N$

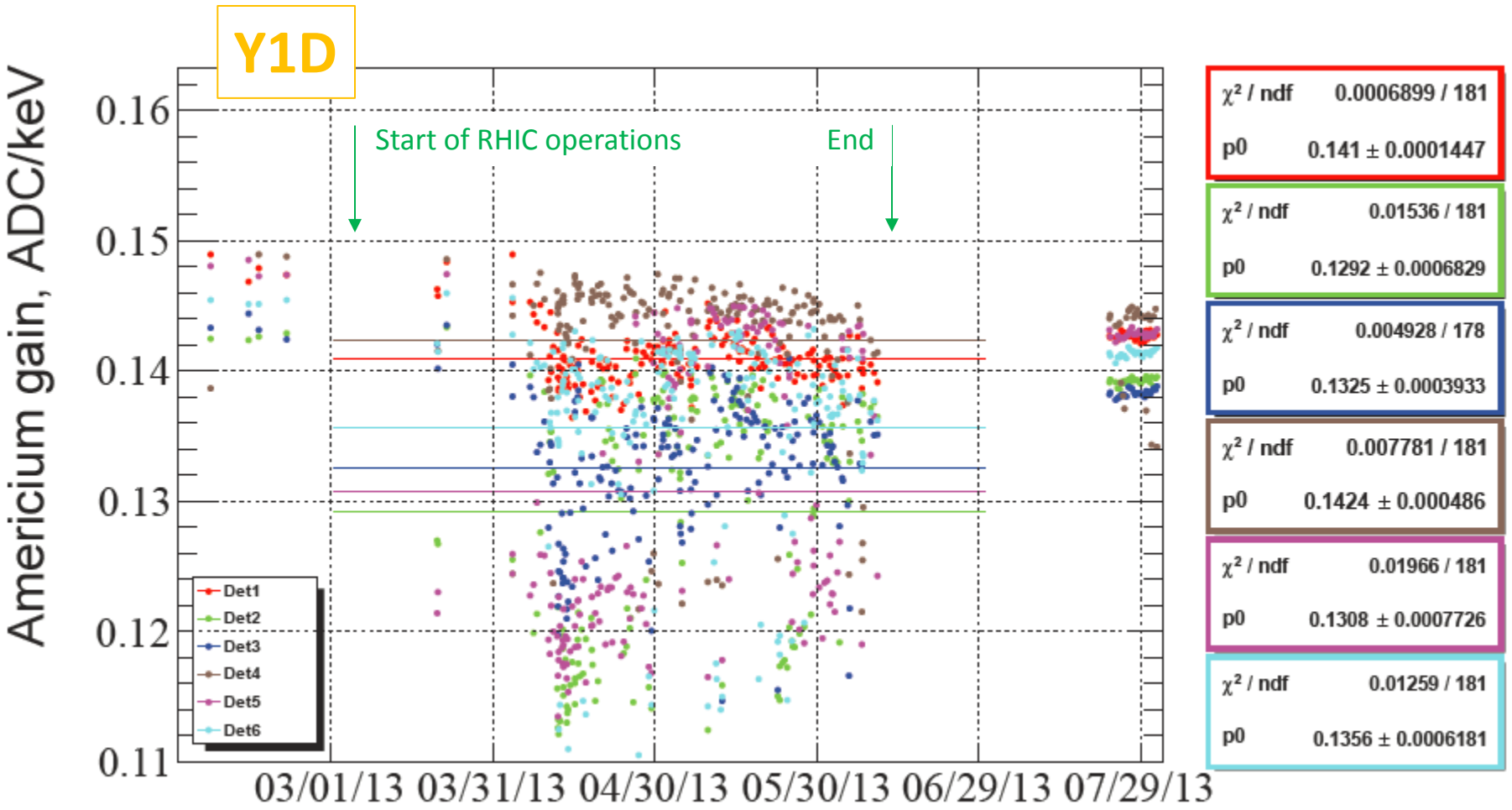


Analyzing Power $A_N = \varepsilon_T / P_T$



Concern about correlations with beam parameters

α-Calibrations (pC Polarimeters)



Large fluctuations observed in all pC detectors