

# Conclusions about RHIC Polarimetry for Run-02

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Based on the Spin2002 contribution article,  
*“RHIC pC CNI Polarimeter: Status and Performance  
from the First Collider Run”*

# Systematic error estimation

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## □ List of error sources

### ■ False asymmetry distribution

- Distribution of null asymmetry measurement (Y, Cross)
- Difference of two independent detector set (X90-X45)

### ■ Bunch fluctuation ( $\chi^2$ /ndf distribution)

### ■ Bunch dependent effect (mixing spin pattern)

### ■ Other sources

- Backgrounds, pile-up
- Si dead-layer, E950 ...

# False asymmetries

- The width of distribution includes both *systematic* and *statistical* contributions in the form of quadratic sum
- Systematic error can be unfolded from the distribution with equation,

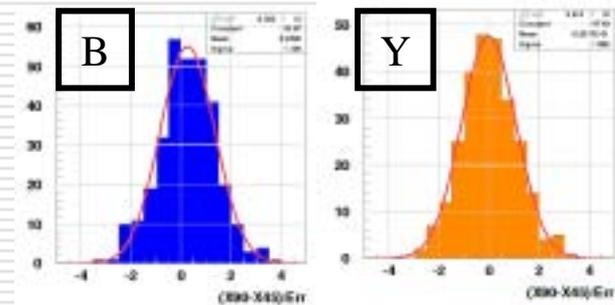
$$\sigma_{\text{systematic}} = \sqrt{\sigma_{\text{observed}}^2 - \sigma_{\text{statistics}}^2}$$

## • Independent measurement

<b>(X90-X45)/Err</b> Mean 0.25(B) / -0.02(Y) Sigma 1.11(B)/ 1.10(Y)	→	$\sigma_{\text{syst}} = \text{B: } 0.5\sigma_{\text{stat}}$ $\text{Y: } 0.5\sigma_{\text{stat}}$
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## • Null asymmetry measurement

<b>Y45/Err</b> Mean 0.16(B) / -0.30(Y) Sigma 1.11(B)/ 1.43(Y)	→	$\sigma_{\text{syst}} = \text{B: } 0.5\sigma_{\text{stat}}$ $\text{Y: } 1.0\sigma_{\text{stat}}$
<b>Cross/Err</b> Mean -0.17(B) / -0.32(Y) Sigma 1.30(B)/ 1.26(Y)	→	$\sigma_{\text{syst}} = \text{B: } 0.8\sigma_{\text{stat}}$ $\text{Y: } 0.8\sigma_{\text{stat}}$



(X90-X45)/Stat.Err

- Dec.22th-End, no energy correction
- bunch selection level-2 (tight cut)

The systematic error for each measurement is estimated as,

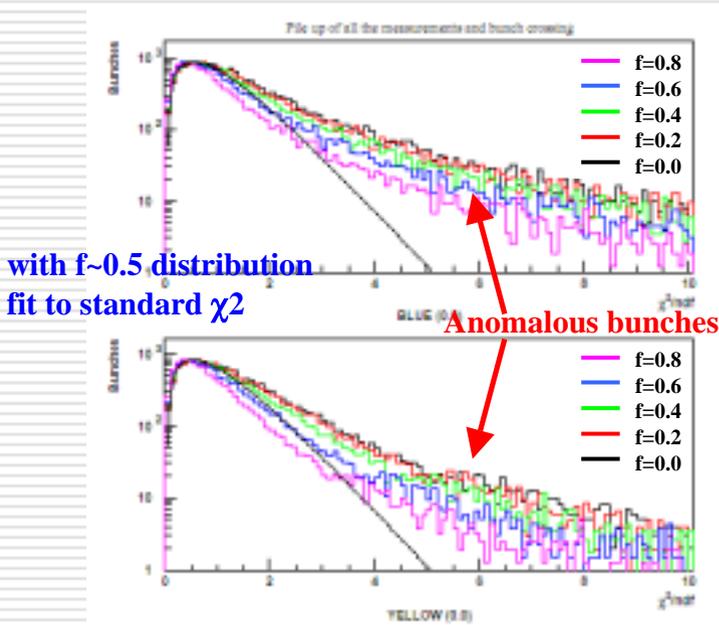
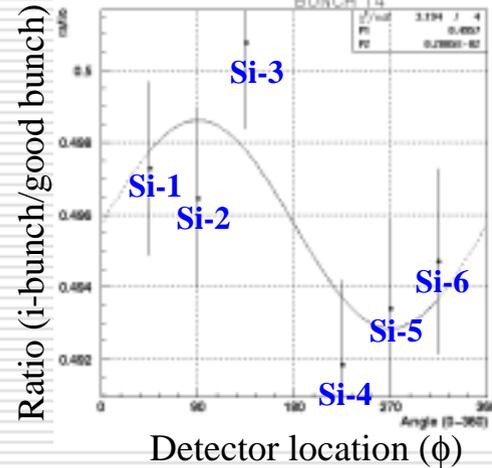
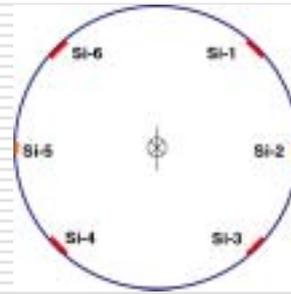
$$\sigma_{\text{syst}} = (0.5-1.0) \sigma_{\text{stat}}$$

- Each regular measurement contains 20M events (including both 45+90 degree detectors)
- $1/\sqrt{20 \times 10^6} = 2.2 \times 10^{-4}$  but actually is  $2.8 \times 10^{-4}$  (due to analyzing power difference)

# $\chi^2$ /ndf distribution

## □ Bunch by bunch check

- Event counts in 6 detectors of certain bunch are compared with the standard (or good) bunch
- The ratios are fit with  $\sin\phi$  function and yield the fitting  $\chi^2$ /ndf



$$\chi^2 = \sum_{\text{detector}} \left( \frac{(x_i - \bar{x}_i)^2}{\sigma_{\text{stat}}^2 + \sigma_{\text{sys}}^2} \right)$$

$$= \frac{1}{(1 + f^2)} \sum_{\text{detector}} \left( \frac{(x_i - \bar{x}_i)^2}{\sigma_{\text{stat}}^2} \right)$$

- The distribution ( $f=0.0$ ) is broader than standard  $\chi^2$
- Accountable with  $f \sim 0.5$ , this means

$$\sigma_{\text{sys}} = 0.5 \sigma_{\text{stat}}$$

- Distributions are normalized with the maximum contents
- Anomalous bunches are removed from analysis

# Randomly mixed spin pattern

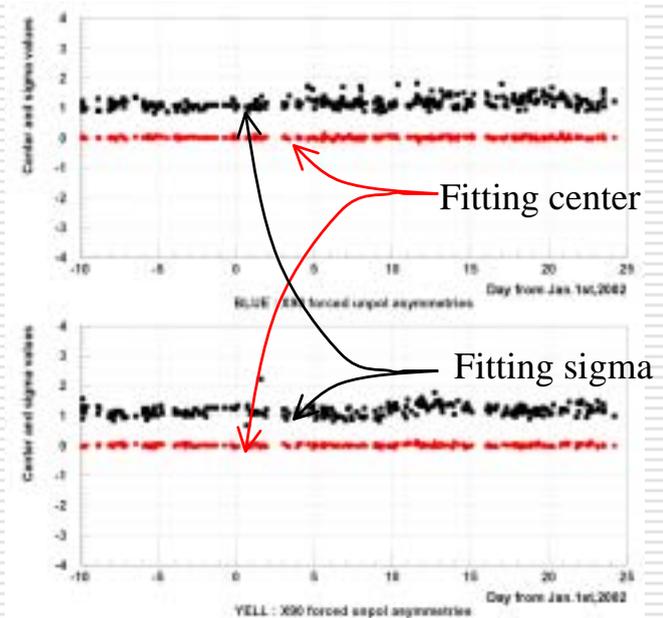
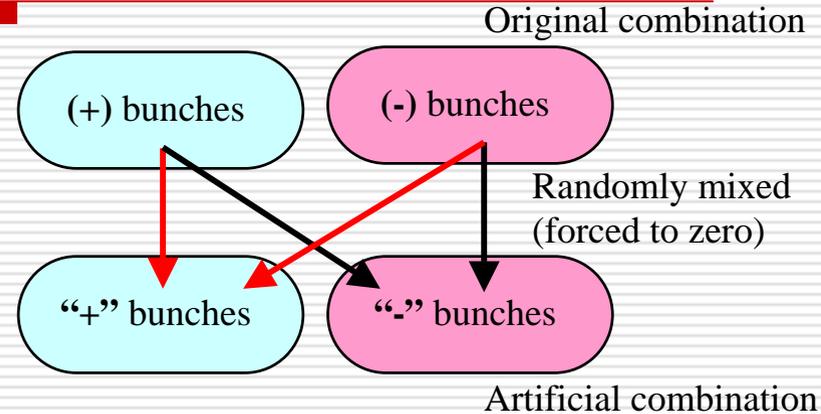
- Mixing (+) and (-) bunches randomly into artificial “+” and “-” groups, and recalculate the asymmetry for enough times (x1000 for each run)
- Distribution is Gaussian shape. The deviation from statistical fluctuation represents the systematic error

$$\sigma_{\text{false}}(\text{BLUE}) = 1.12$$

$$\sigma_{\text{false}}(\text{YELLOW}) = 1.11$$

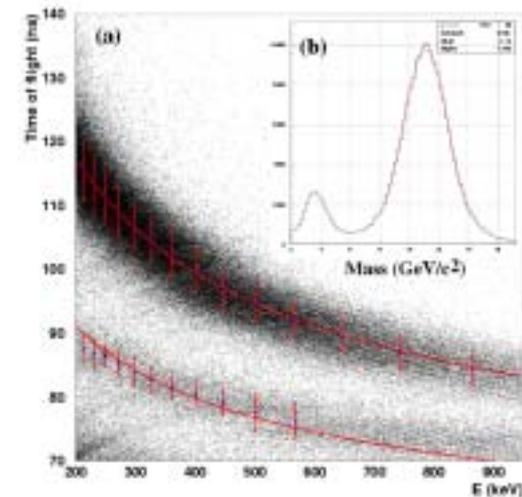
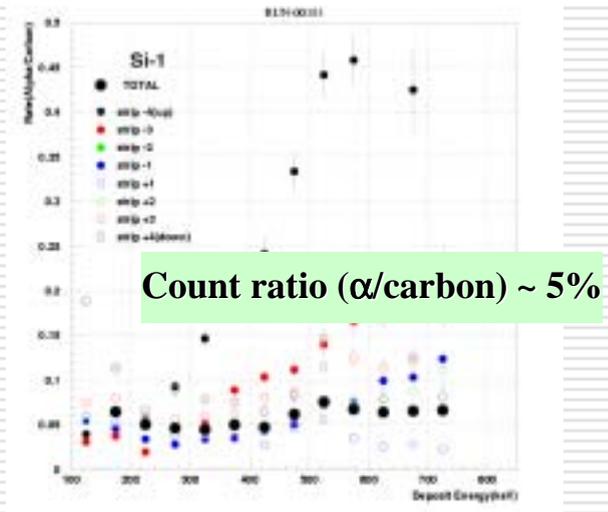
⇒  $\sigma_{\text{syst}} = \text{BLUE: } 0.5\sigma_{\text{stat}}$   
 $\text{YELLOW: } 0.5\sigma_{\text{stat}}$

These studies are not independent, each study indicates the size of systematic error of  $(0.5-1.0) \times \sigma_{\text{stat}}$ . Conservatively we decided to use  $1.0 \times \sigma_{\text{stat}}$  in order to reflect our uncertainty on the origin of systematics



# Other contributions...(1)

- Background events under Carbon locus
  - inelastic reactions (from carbon mass peak) under 1% level is expected (count ratio is 5%)
  - De-bunched beam effect can be evaluated using the counts in abort gap. Usually well under 1%, and a few % for bad cases
  
- Pile-up events
  - Estimated well under 1% from dedicated run data



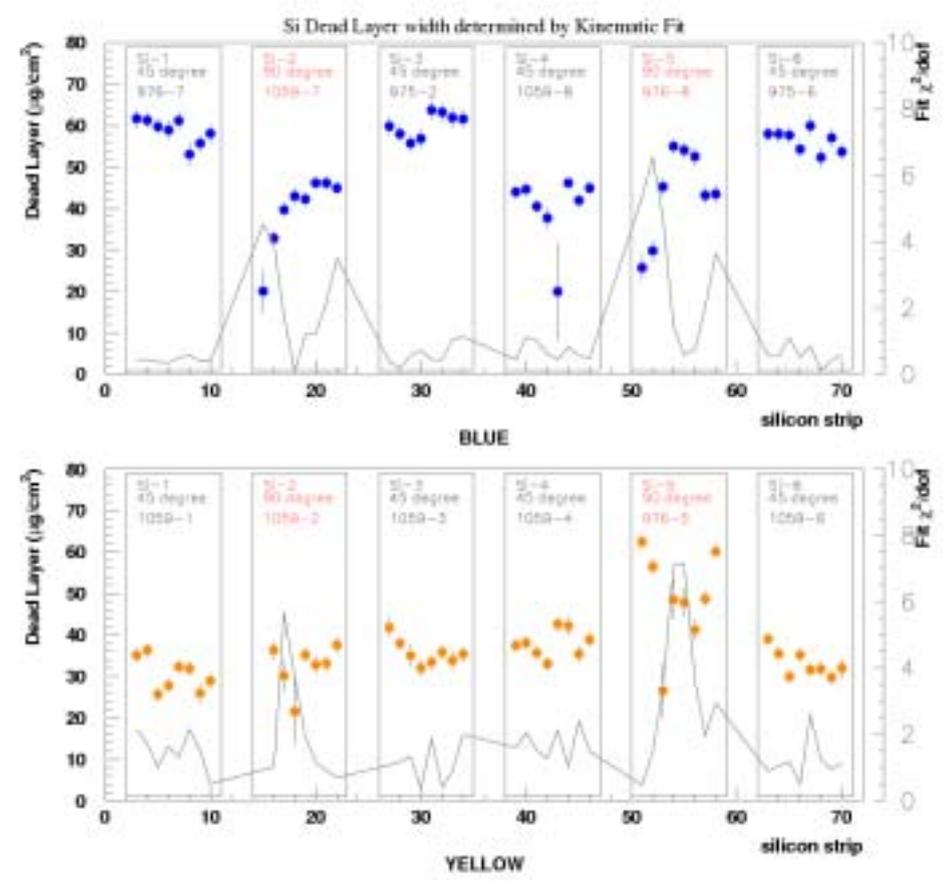
# Other contributions...(2)

## □ Si dead layer

- thickness can be determined by kinetic fit to carbon band
- $\pm 10\%$  determination power
- This will propagate to  $A_N$  uncertainty of  $\pm 4\%$

## □ E950 error propagation

- The  $\pm 31\%$  total error is expected, where it is a linear sum of
  - The statistical
  - Raw asymmetry systematic
  - Beam polarization systematic



# Measured polarization

- ❑ Fills with > 4 hours long and most stringent bunch selection are applied
- ❑ Significance of our measurements are huge
- ❑ From the mean values,

At injection energy (24GeV/c).

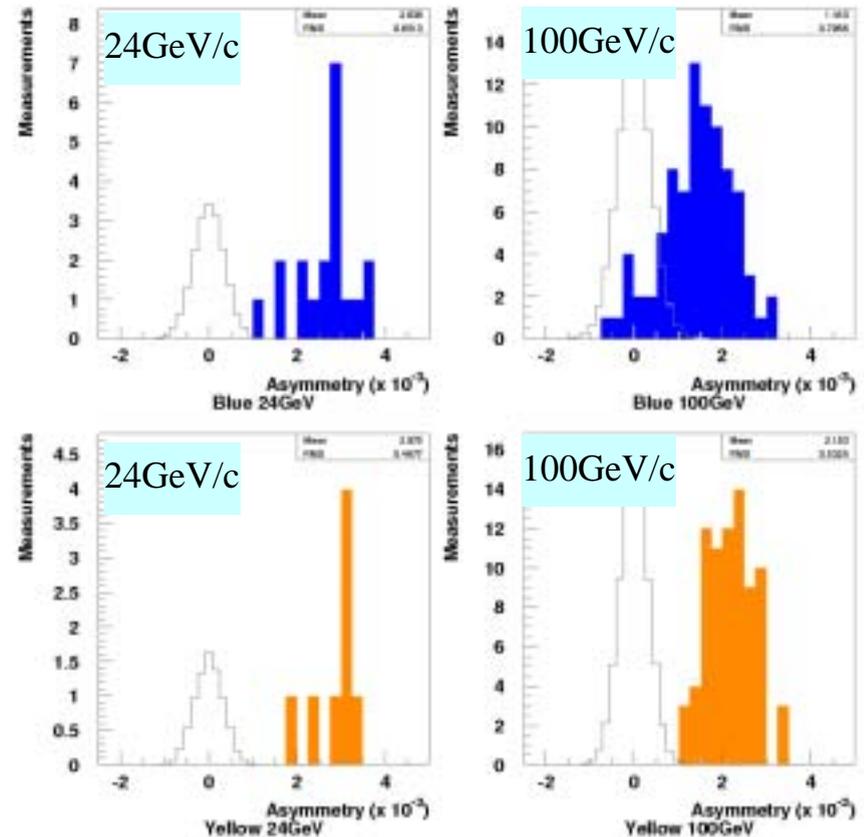
$$\overline{P_{blue}(24\text{GeV}/c)} = 0.21 \pm 0.005(\text{stat.}) \pm 0.02(\text{sys.}) \pm 0.07(\text{scale})$$

$$\overline{P_{yellow}(24\text{GeV}/c)} = 0.22 \pm 0.007(\text{stat.}) \pm 0.02(\text{sys.}) \pm 0.07(\text{scale})$$

If we assume the same analyzing power at 100GeV/c,

$$\overline{P_{blue}(100\text{GeV}/c)} = 0.11 \pm 0.002(\text{stat.}) \pm 0.02(\text{sys.}) \pm 0.03(\text{scale})$$

$$\overline{P_{yellow}(100\text{GeV}/c)} = 0.16 \pm 0.002(\text{stat.}) \pm 0.02(\text{sys.}) \pm 0.05(\text{scale})$$



Open : Asymmetries with random spin pattern  
 Closed: Asymmetries with actual spin pattern

# Run-02 polarization for each run

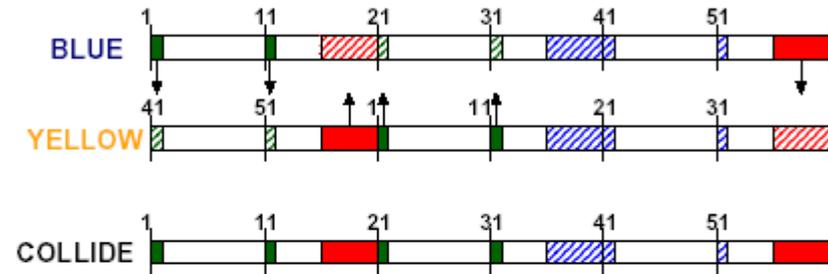
For a practical use, run-by-run results had been also distributed to experiments at [http://spin.riken.bnl.gov/~jinnai3/polarimeter/FY2002/bunch\\_sel/index.html](http://spin.riken.bnl.gov/~jinnai3/polarimeter/FY2002/bunch_sel/index.html)

In the page above, three types of bunch selection conditions are provided to fit with experiments

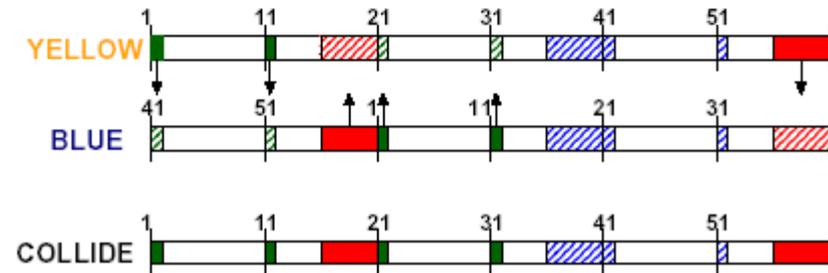
- Condition 0
  - counter bunches for abort gaps
- Condition 1
  - 1<sup>st</sup>, 11<sup>th</sup>, condition 0
  - Anomaly bunches for specific luminosity
  - $\chi^2/\text{ndf} > 5$
- Condition 2
  - Condition 1
  - Influence from the other IP



## PHENIX



## STAR



# Conclusion and outlook

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- Average polarization values are obtained with full systematic error estimations
  - $P_{\text{blue}}(24\text{GeV}) = 0.21 \pm 0.005(\text{stat.}) \pm 0.02(\text{sys.}) \pm 0.07(\text{scale})$
  - $P_{\text{yellow}}(24\text{GeV}) = 0.22 \pm 0.007(\text{stat.}) \pm 0.02(\text{sys.}) \pm 0.07(\text{scale})$
- The point-to-point systematic error was 10% level for 20% polarization
- Major contribution propagated from E950 error
- In next run, recalibration measurement for pC CNI process using a new AGS polarimeter (with other internal polarimeter, E880) is planned