

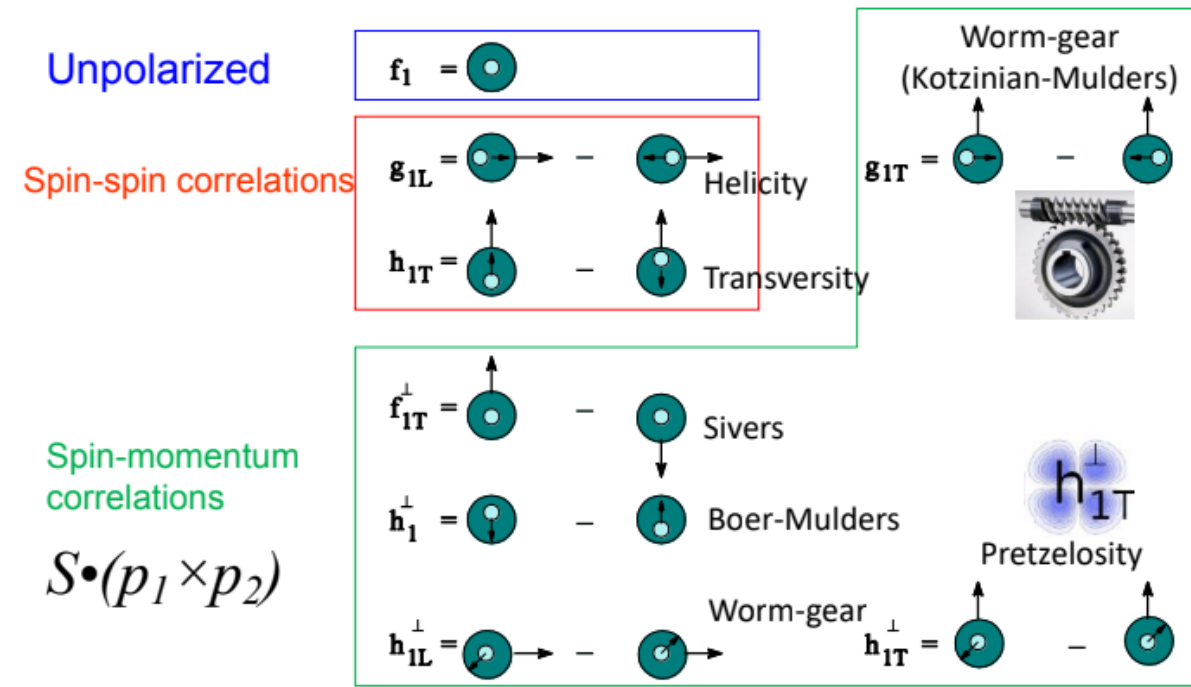
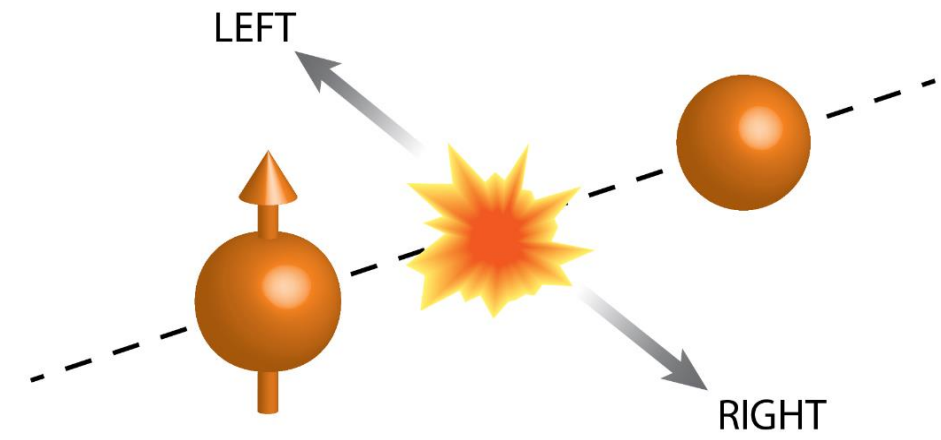
Preparations for spin physics at sPHENIX

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Motivation

- Transverse momentum dependent (TMD) PDFs and FFs encode spin-momentum correlations between hadrons and constituent partons
 - Needed to describe large transverse single spin asymmetries, A_N
 - Accessed in p+p observables with hard and soft scale

$$A_N = \frac{\sigma_L - \sigma_R}{\sigma_L + \sigma_R}$$

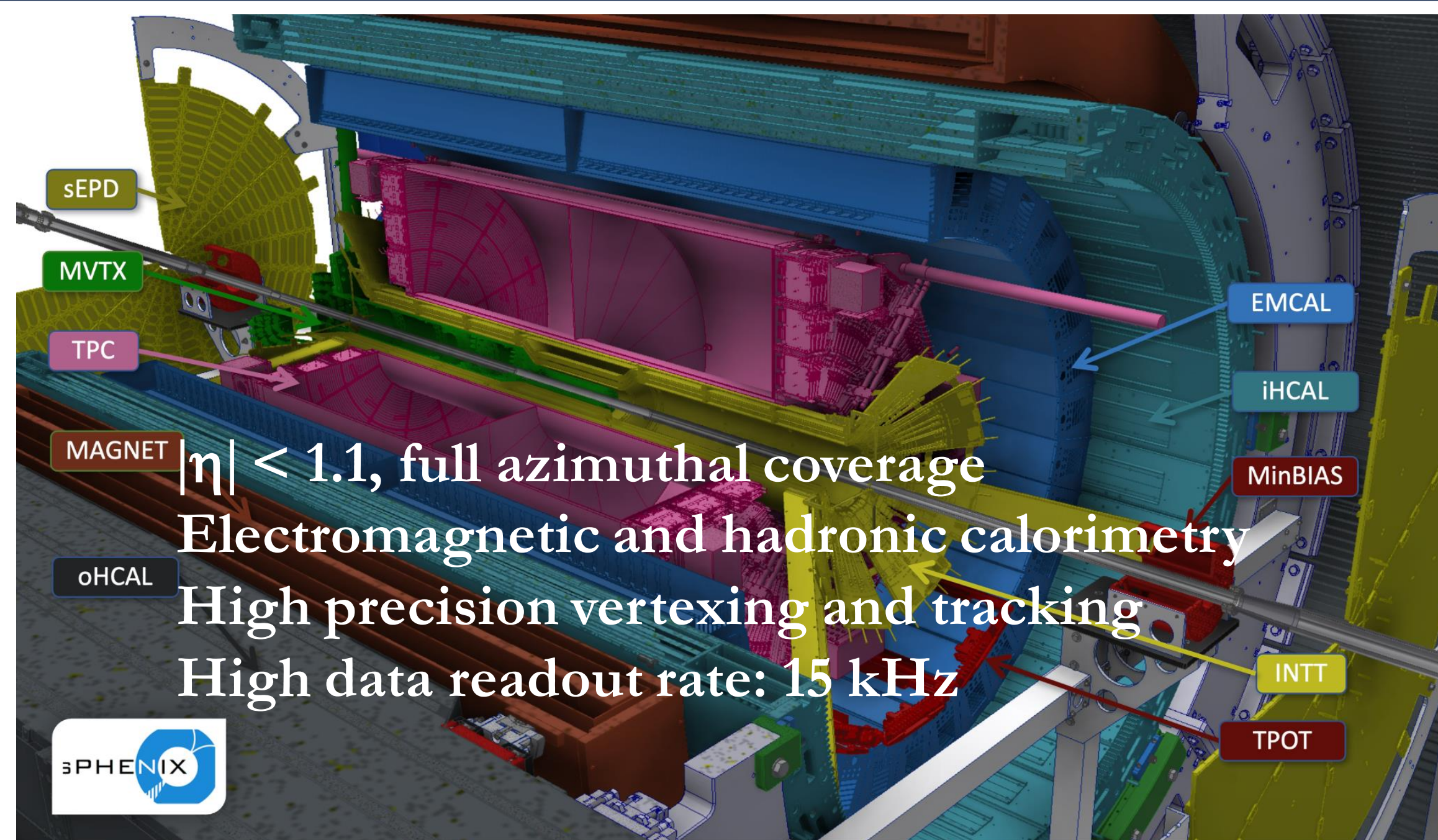


- TMDs are related to the collinear twist-3 correlation functions
 - Directly accessed in p+p processes with hard scale

$$A_N \propto \sum_{a,b,c} \phi_{a/A}^{(3)}(x_1, x_2, \vec{s}_\perp) \otimes \phi_{b/B}(x') \otimes \hat{\sigma} \otimes D_{c \rightarrow C}(z) + \sum_{a,b,c} \delta q_{a/A}(x, \vec{s}_\perp) \otimes \phi_{b/B}^{(3)}(x'_1, x'_2) \otimes \hat{\sigma}' \otimes D_{c \rightarrow C}(z) + \sum_{a,b,c} \delta q_{a/A}(x, \vec{s}_\perp) \otimes \phi_{b/B}(x') \otimes \hat{\sigma}'' \otimes D_{c \rightarrow C}^{(3)}(z_1, z_2)$$

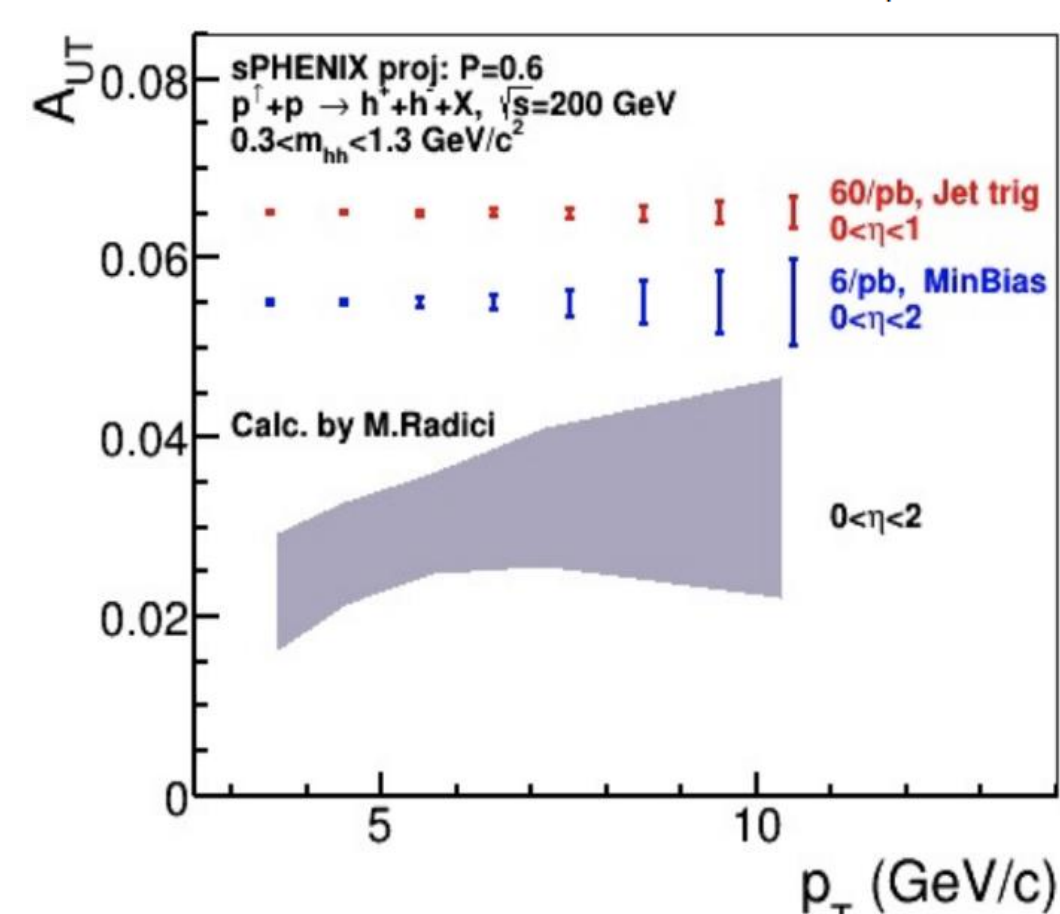
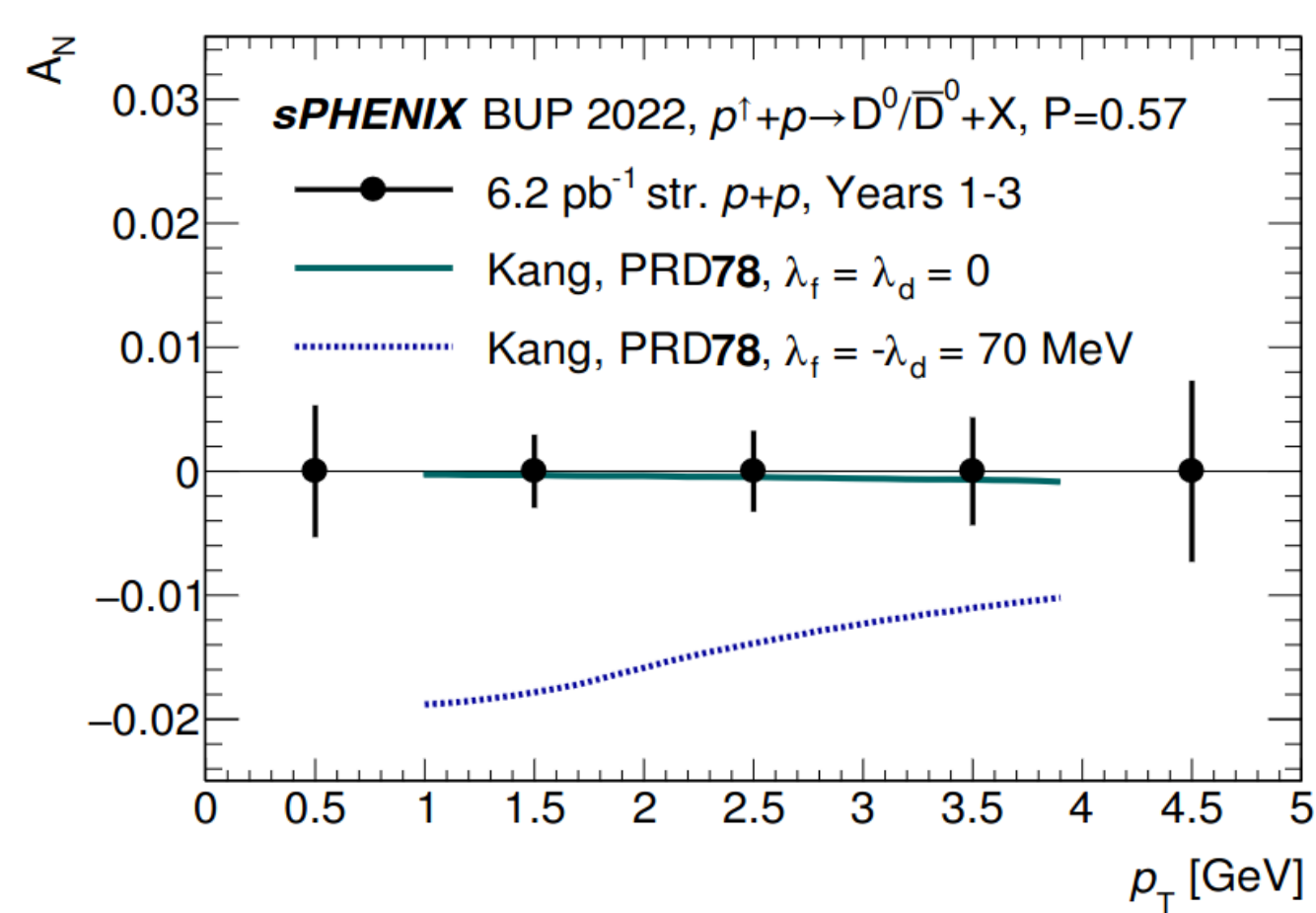
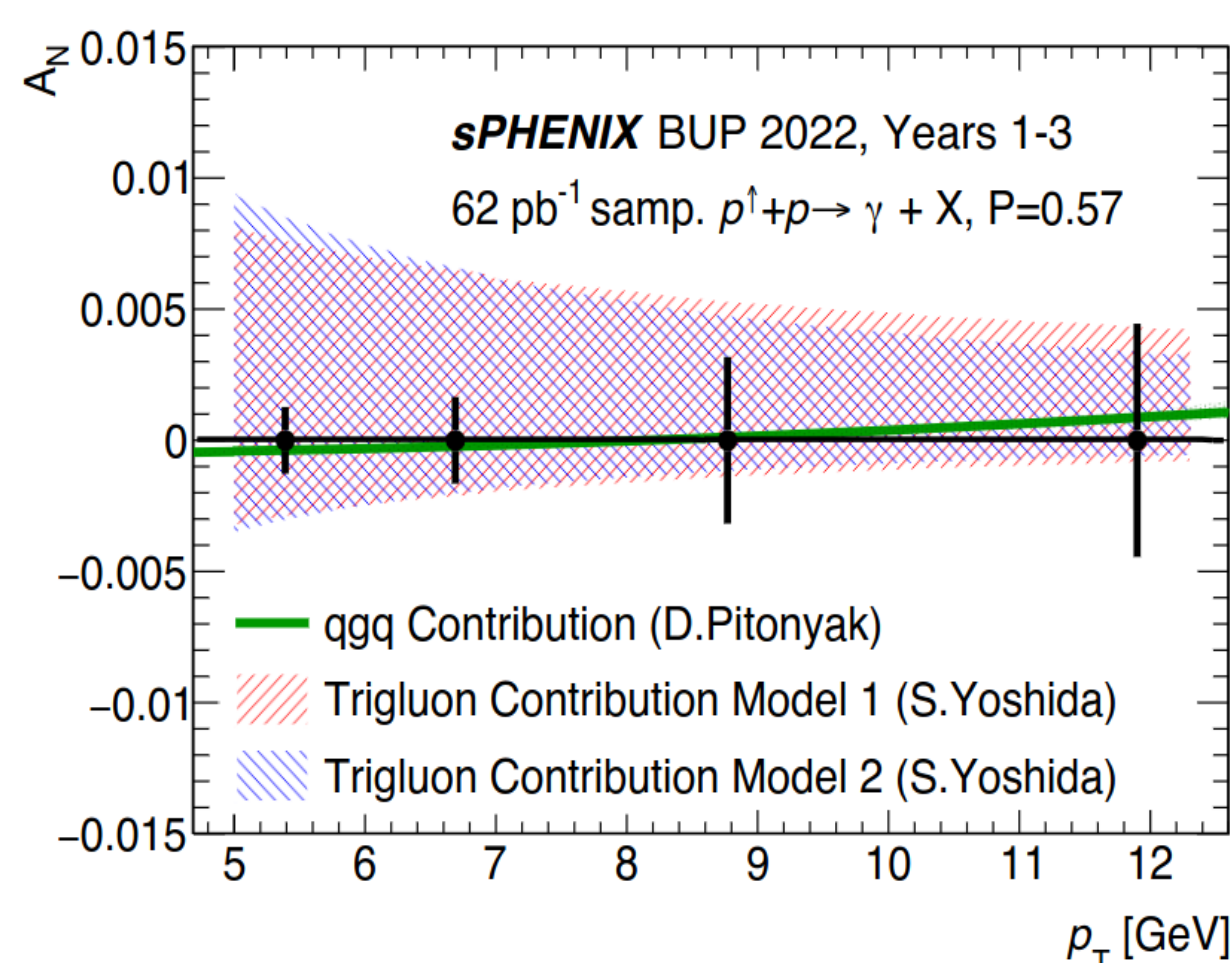
Twist 3 correlation function of polarized proton
Twist 3 correlation function of unpolarized proton
Twist 3 fragmentation function
Transversity Distribution

sPHENIX Detector



Transverse Spin at sPHENIX

- Direct photon and heavy flavor A_N
 - Clean probe of tri-gluon correlation function

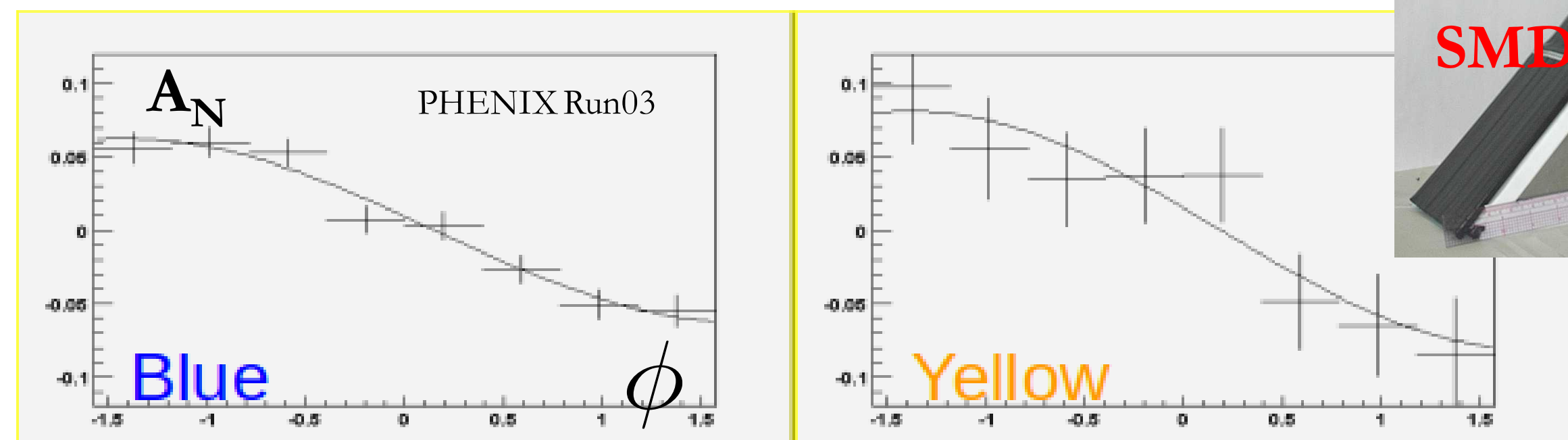


- γ -jet and dijet A_N
 - Gluon and u/d flavor-dependent
 - Sivers TMD PDF
- Charged particle Interference Fragmentation Function (IFF) and Collins asymmetry
 - Constrain transversity distribution

Spin Hardware

Local Polarimetry

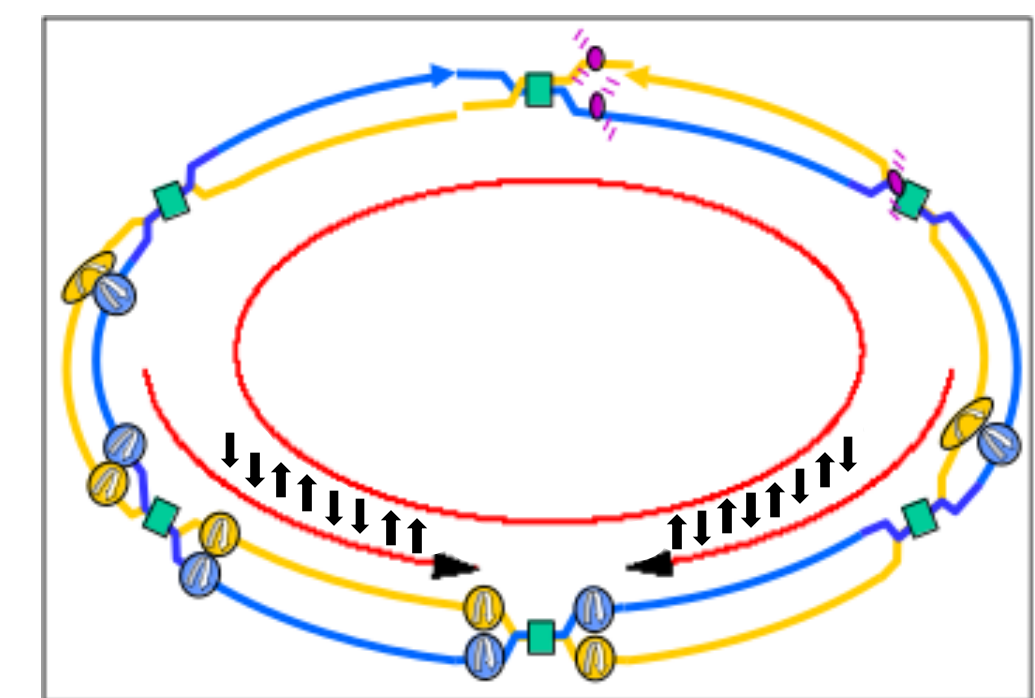
- Monitor blue (CW) and yellow (CCW) beam polarization at sPHENIX
- Zero degree calorimeter (ZDC) and Shower Max Detector (SMD) hodoscope measure known forward neutron A_N



Relative Luminosity

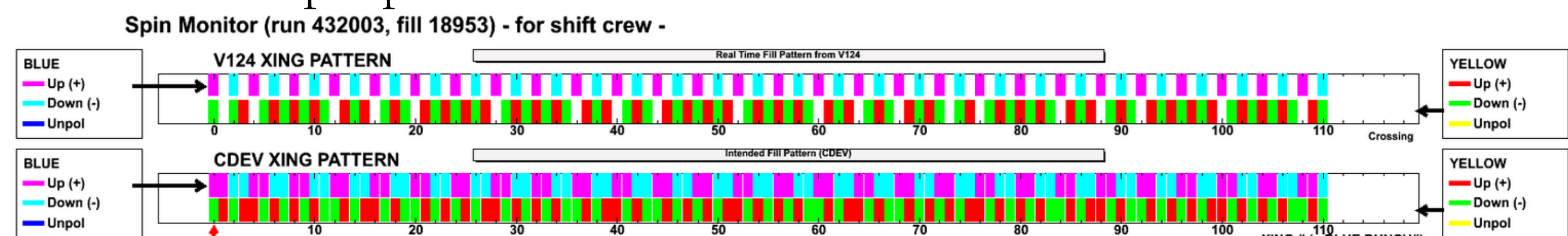
- Correction for differences in luminosity between $p + p^\uparrow$, $p + p^\downarrow$
- In each fill, proton polarizations alternate up/down per beam crossing according to spin patterns for each beam
- Scaler boards in MBD and ZDC count number of triggers in each bunch crossing

$$R = \frac{\mathcal{L}^\uparrow}{\mathcal{L}^\downarrow}$$

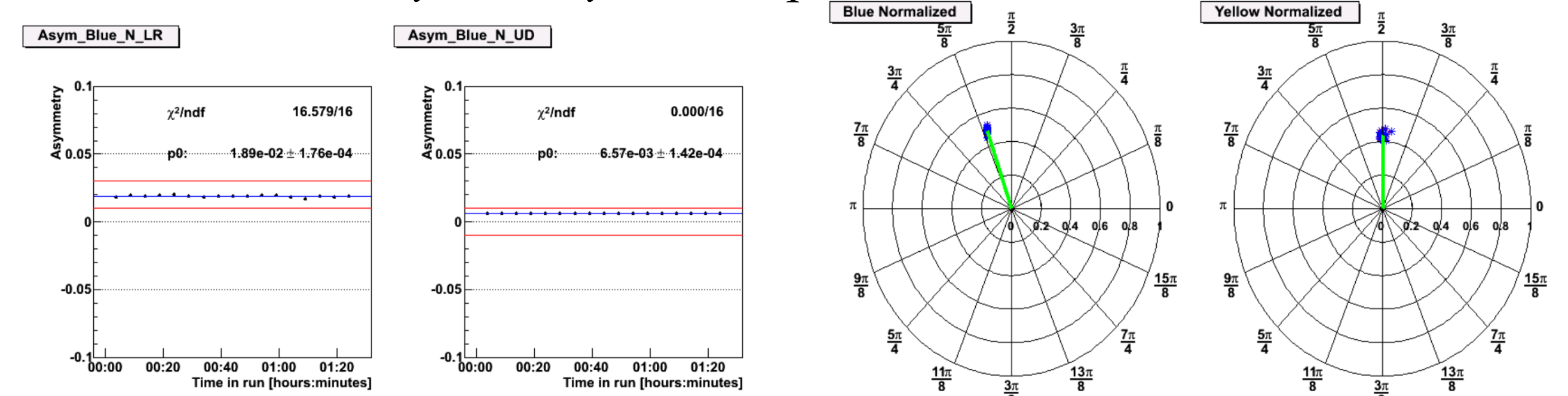


Online Monitoring

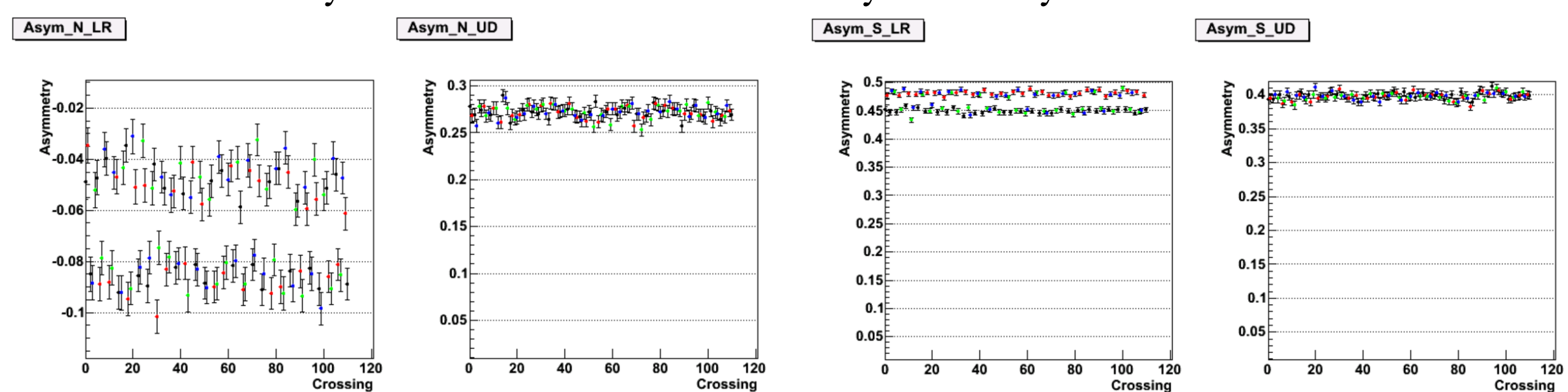
- Monitor spin patterns received from Main Control Room



- Online local polarimetry from ZDC/SMD
 - Neutron asymmetry from square root formula



- Bunch-by-bunch raw neutron asymmetry from SMD scaler counts



*Plots from PHENIX Run15

References

- SPHENIX Beam Use Proposal 2023.
- E. Umaka. "sPHENIX Detector". RHIC & AGS AUM 2023.
- PHENIX online monitoring, Run15.
- S. Park. "PHENIX Local Polarimeter". PHENIX Spinfest 2013.
- C. Aidala. "Spin-Momentum Correlations, Aharonov-Bohm, and Color Entanglement in Quantum Chromodynamics, KIT, 2019.