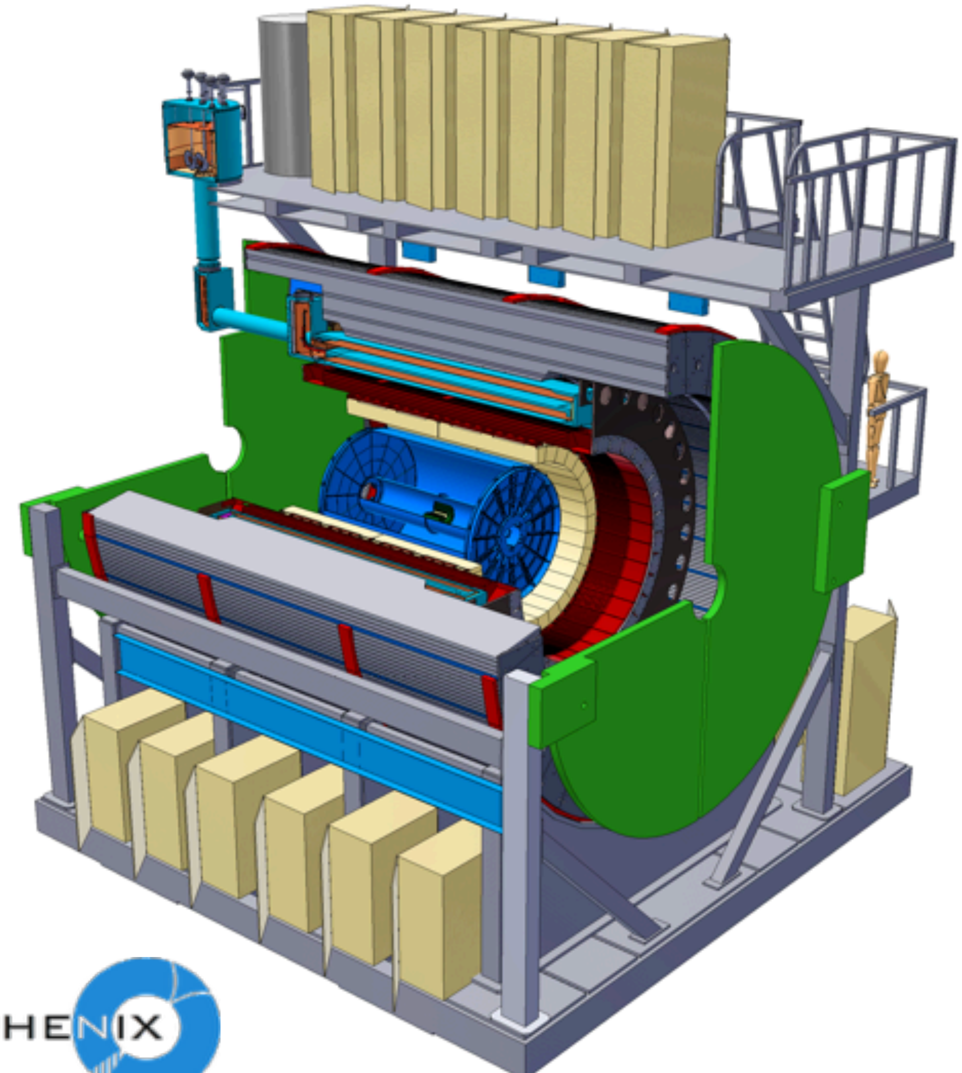
Spin Physics with sPHENIX Detector

A.Bazilevsky (BNL)

For sPHENIX Collaboration

sPHENIX



New detector for the RHIC facility at BNL (USA)

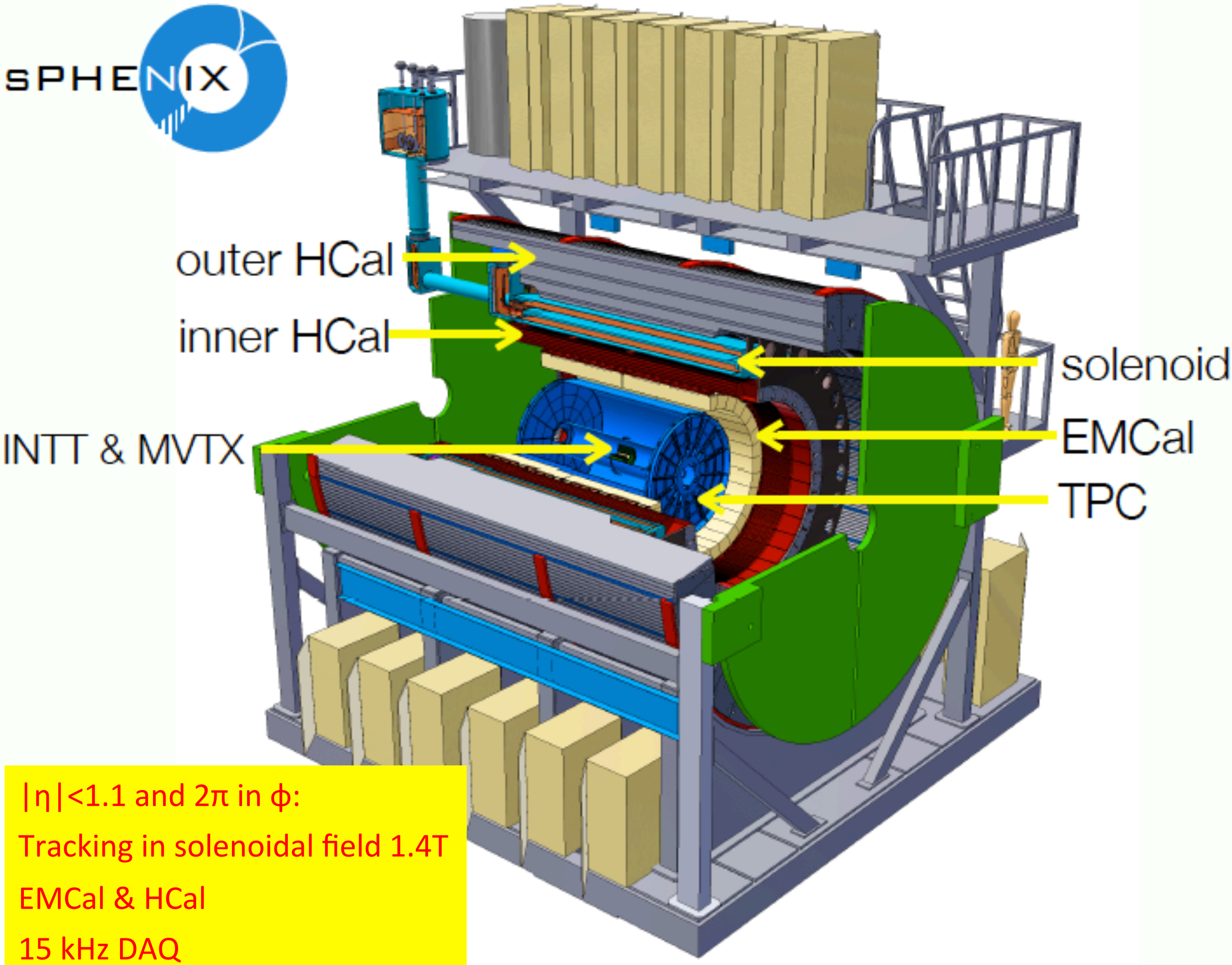
- New Collaboration formed
- >70 institutions and counting

For studies of the strongly interacting quark-gluon plasma using jet, photon and heavy-flavor observables.

Time line:

- CD0 Review - Sep 2016
- CD1/3a Review - May 2018
- Installation complete - 2022
- Running – 2023

RHIC with polarized proton beams plus sPHENIX => strong capabilities for Spin Physics measurements sPHENIX



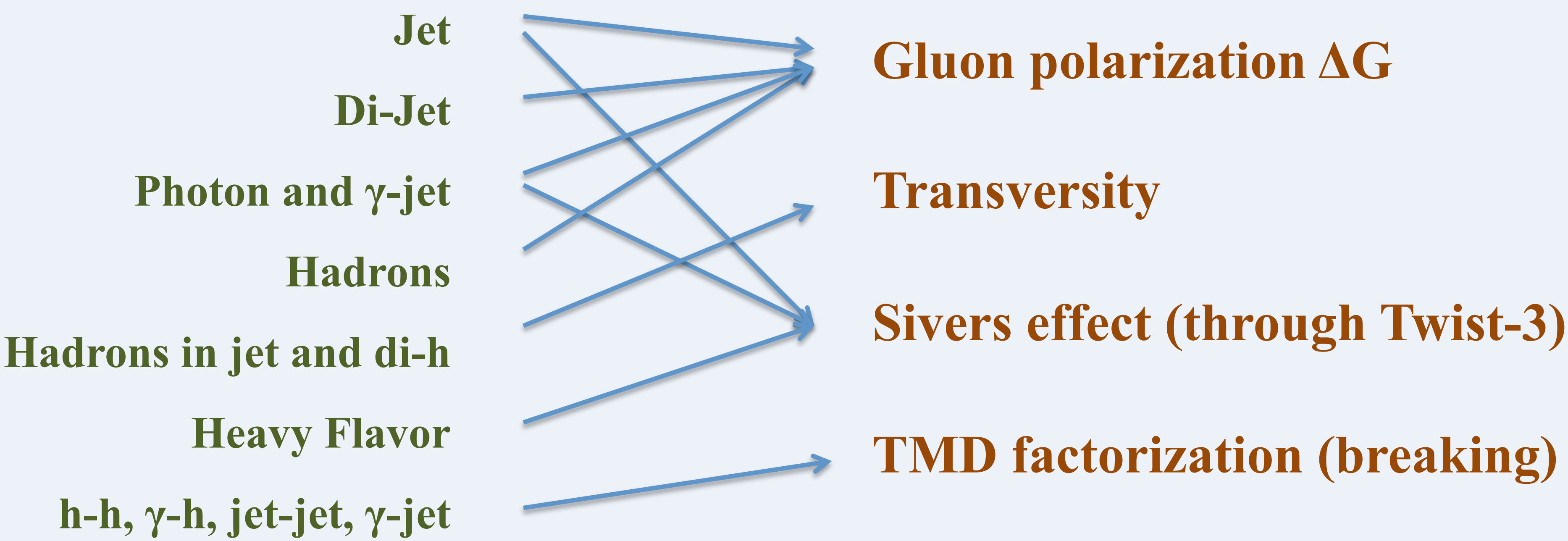
|η|<1.1 and 2π in ϕ:

Tracking in solenoidal field 1.4T

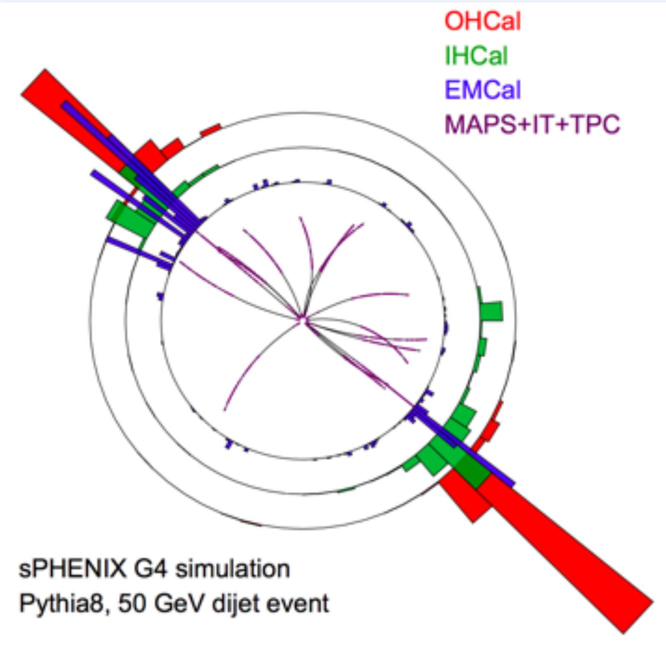
EMCal & HCal

15 kHz DAQ

Spin Physics with sPHENIX



Jet and h±



Good Calorimetry:

EMCal: $$\frac{\sigma_E}{E} \approx \frac{15\%}{\sqrt{E}}$$

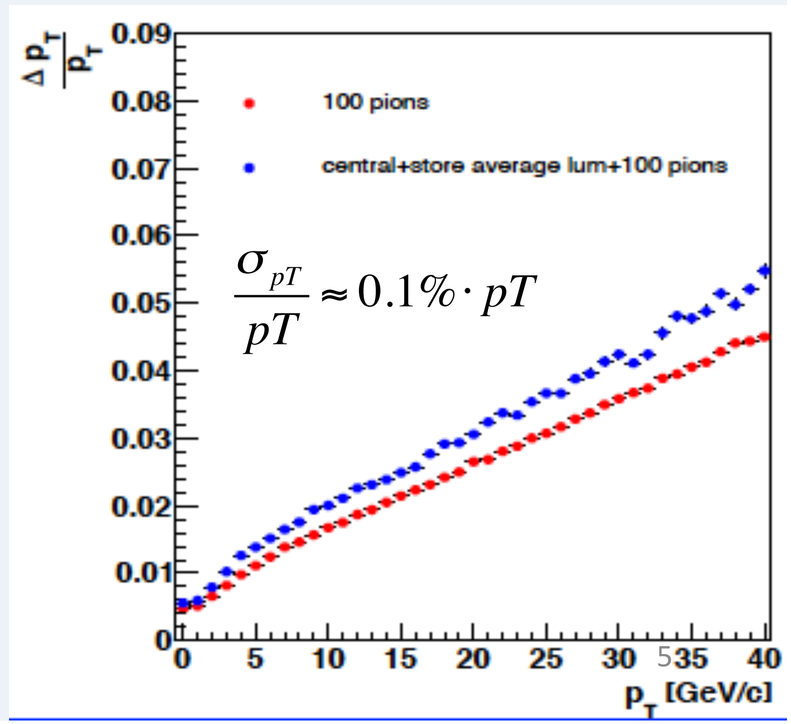
HCal: $$\frac{\sigma_E}{E} \approx \frac{100\%}{\sqrt{E}}$$

Excellent tracking:

TPC: momentum measurements

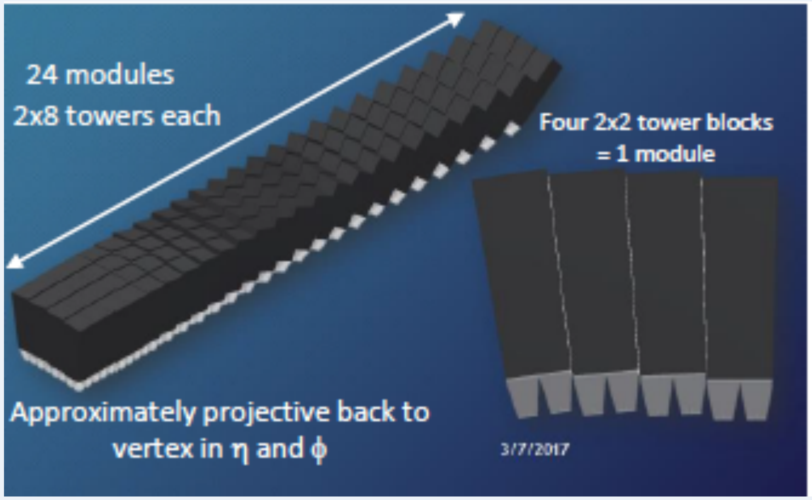
INTT: timing and pattern recognition

MVTX: collision vertex



Photon / π0

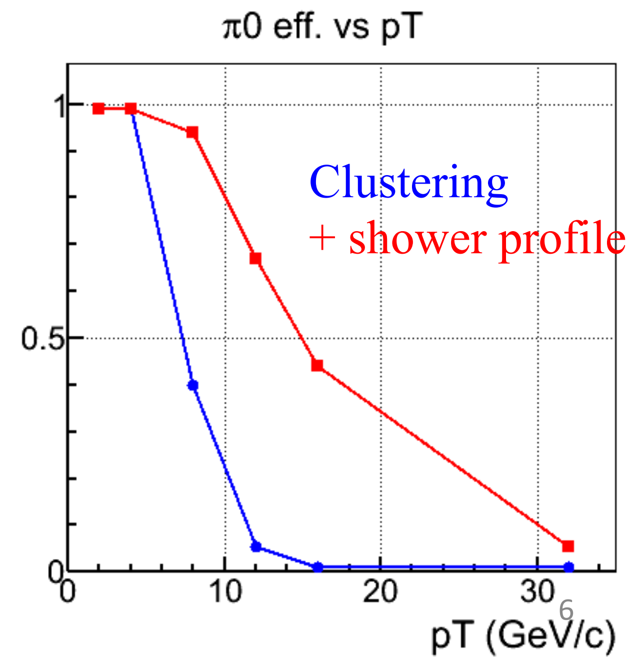
EMCal sector



Tungsten-scintillating fiber sampling EMCal:

- Approx. projective in η and φ
- 18 X_0, 1 λ
- $\Delta\eta\times\Delta\varphi = 0.025\times0.025$
- $\sigma_E/E \approx 15\%/\sqrt{E}$

π0→γγ merging in EMCal



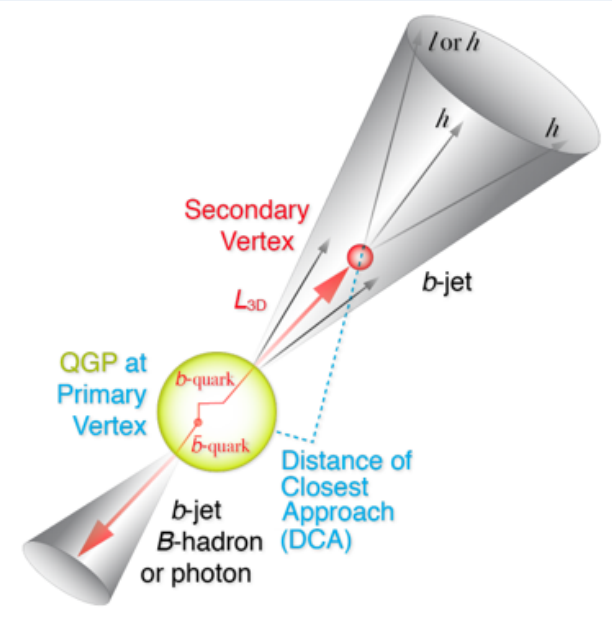
Allows for γ/π0 discrimination up to ~20 GeV/c

- The range of statistically significant measurements

Direct γ: S/B ~ 2 for pT=7-25 GeV/c

- The main source of bg – merged π0

Heavy Flavor



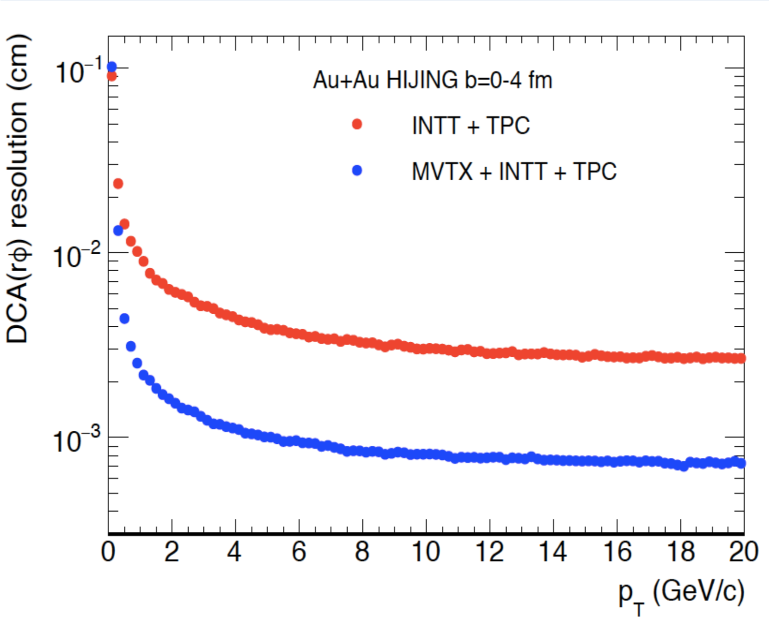
DCA

Counts tracks with DCA outside a cut relative to event vertex

Secondary Vertex

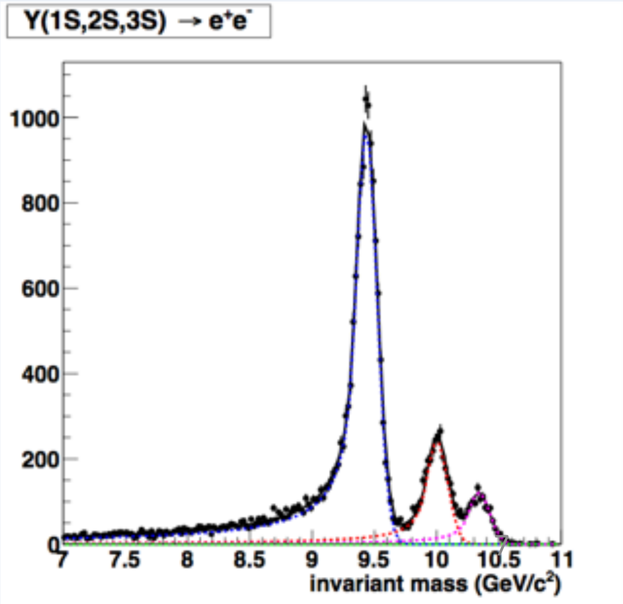
Secondary vertex within jet

Direct reco of heavy meson decays



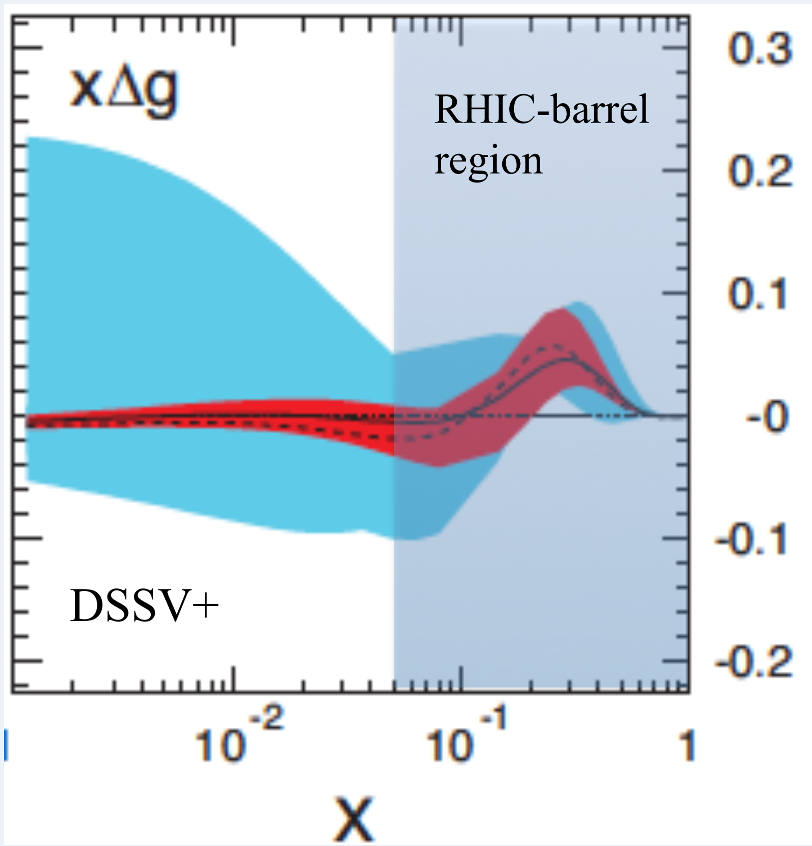
Excellent DCA resolution (10 μm at high pT)

Excellent mass resolution for quarkonia states



Gluon polarization ΔG

EIC White paper: arXiv:1212.1701



DIS+RHIC(≤2009)
+EIC

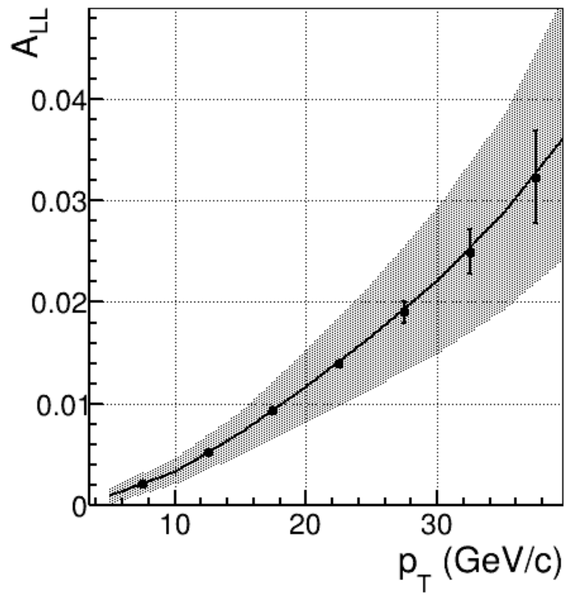
With EIC data the dominant uncertainty to ΔG-integral will be coming from "RHIC region"

⇒ We should do our best to improve it before RHIC stops pp running

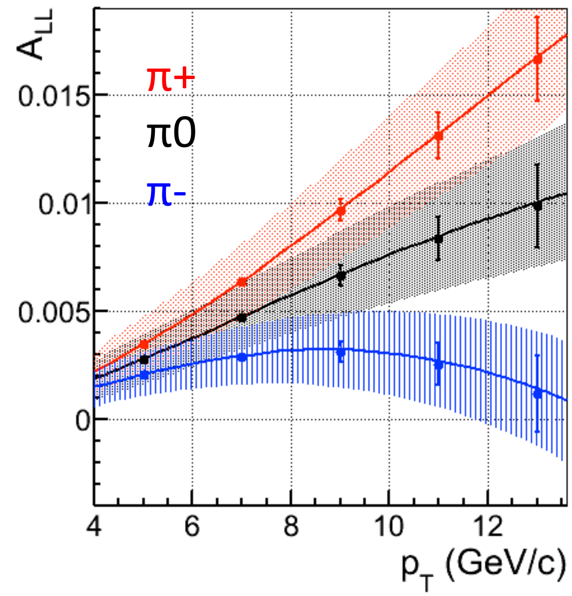
ΔG projection

$\sqrt{s}$=200 GeV |η|<1.1
L=700 pb^{-1} P=0.6
Theory curve and band: NNPDF

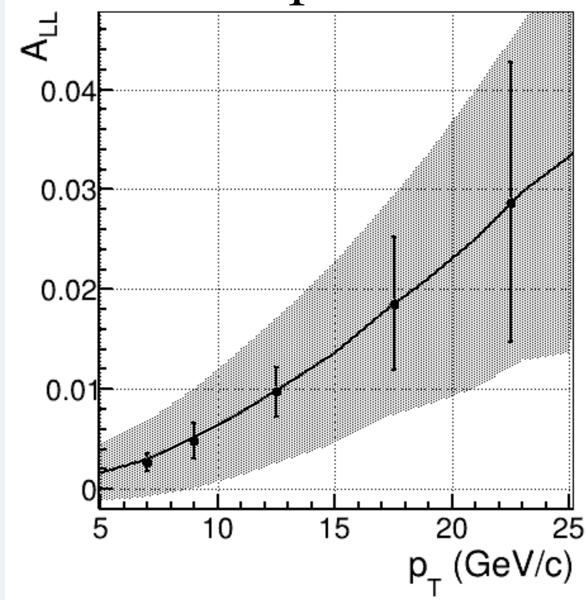
Jet



Pions



Dir. photons



Brings us to era of high precision ΔG measurements:

Will crucially improve ΔG constraint at x>0.05

- ΔGdx-integral at x>0.05 expected to be improved by a factor >4

Multiple channels with different theoretical and exp. uncertainites

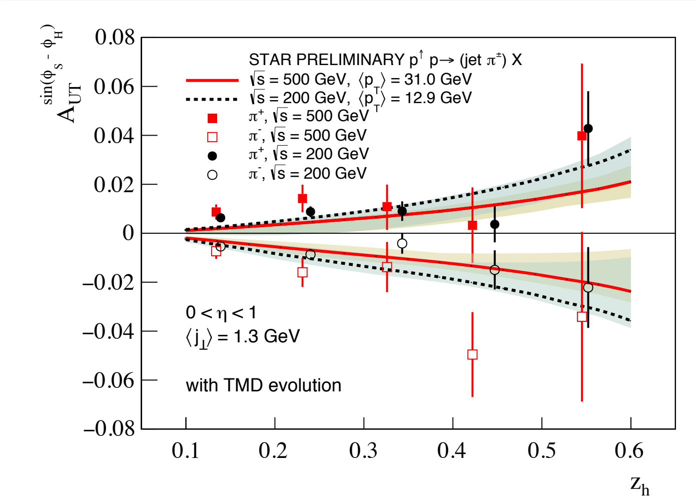
- Crucial syst. cross check

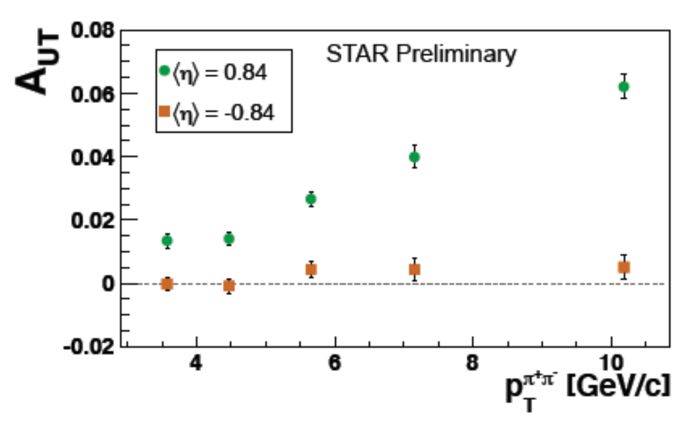
Complementary to the future EIC

- Crucial universality test in the overlapping x-range

Transversity

STAR:





First measurements in pp to access transversity:

Collins asymmetry (hadron within jet)

TMD approach

IFF asymmetry (di-hadron)

Collinear approach

sPHENIX expects to contribute high precision data for these

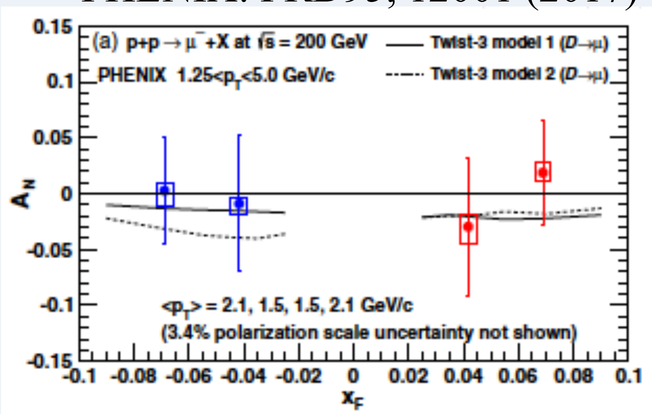
As a dedicated jet detector with excellent tracking resolution and high DAQ bandwidth

Will allow for multi-dim binning

Will provide crucial tests for factorization and universality of distr. functions

Other measurements

PHENIX: PRD95, 12001 (2017)



Open HF A_N:

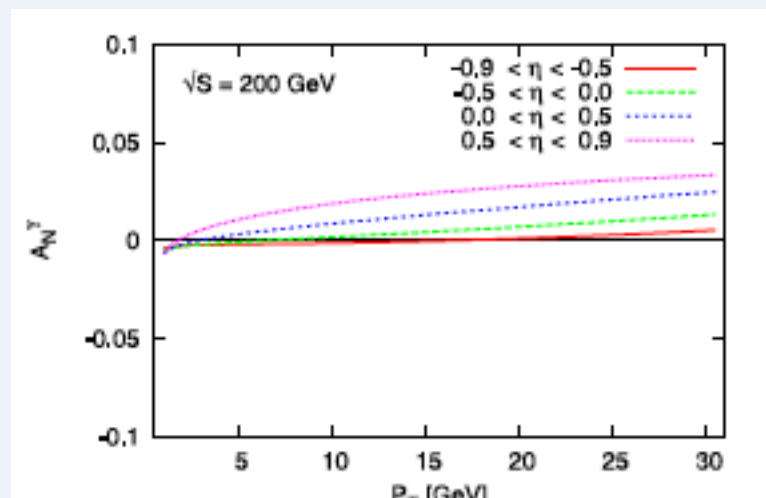
Sensitive to Twist-3 tri-gluon correlation fnct.

sPHENIX will considerably improve it

Decay electron + DCA

Or D reconstruction

K.Konazawa and Y.Koike: Phys. Lett. B 720, 161



Direct γ A_N:

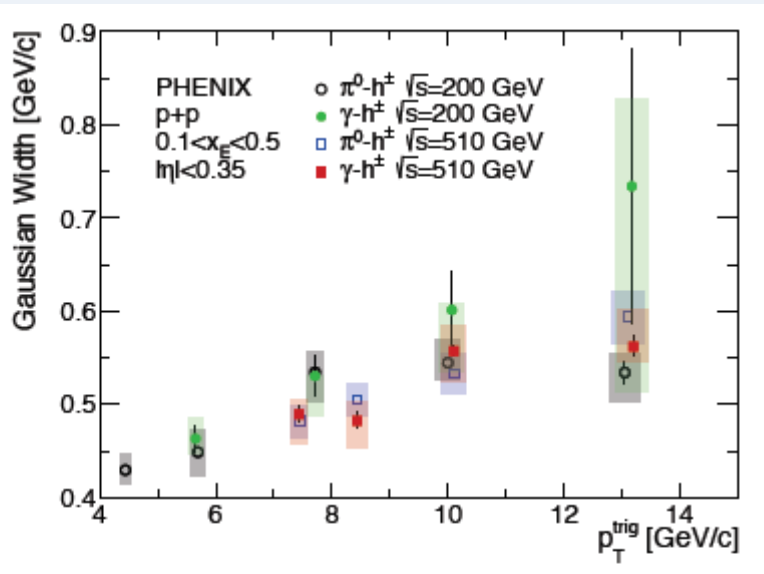
Sensitive to Twist-3 quark-gluon correlation fnct.

Nobody yet measured it

sPHENIX will do it!

Other measurements II

PHENIX: 1805.02450

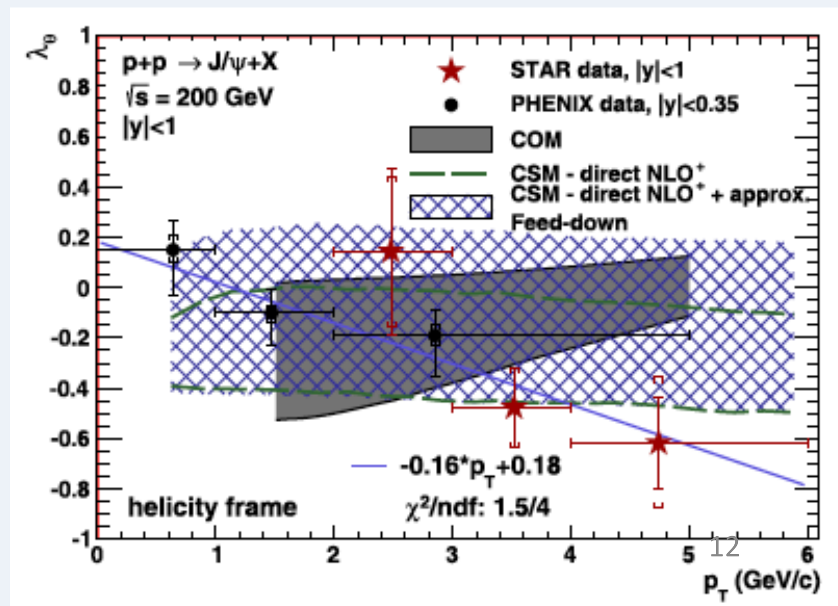


Evolution of non-perturbative kT and jT through correlation measurements

Sensitive to TMD factorization breaking

sPHENIX will provide high precision measurements from jet-jet, γ-jet, h-h, γ-h, including correlations with spin

STAR: PLB 739, 180; PHENIX: PRD 82, 012001



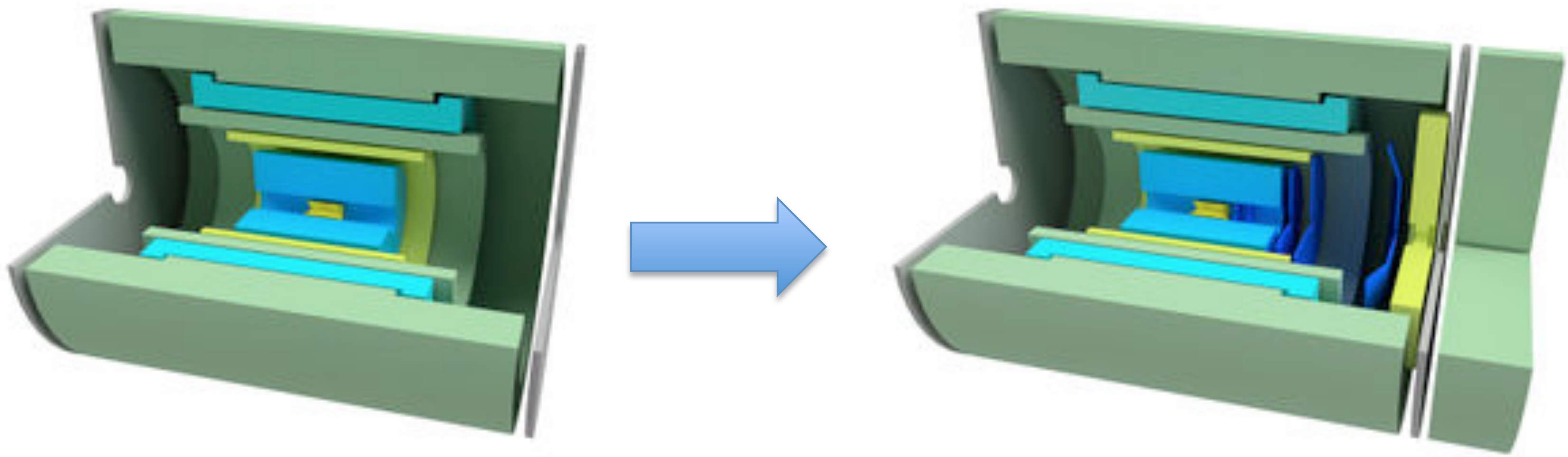
Quarkonia polarization

Sensitive to production mechanism

J/ψ photoproduction in UPC

Access to GPD from pp!

Forward Upgrade Proposal

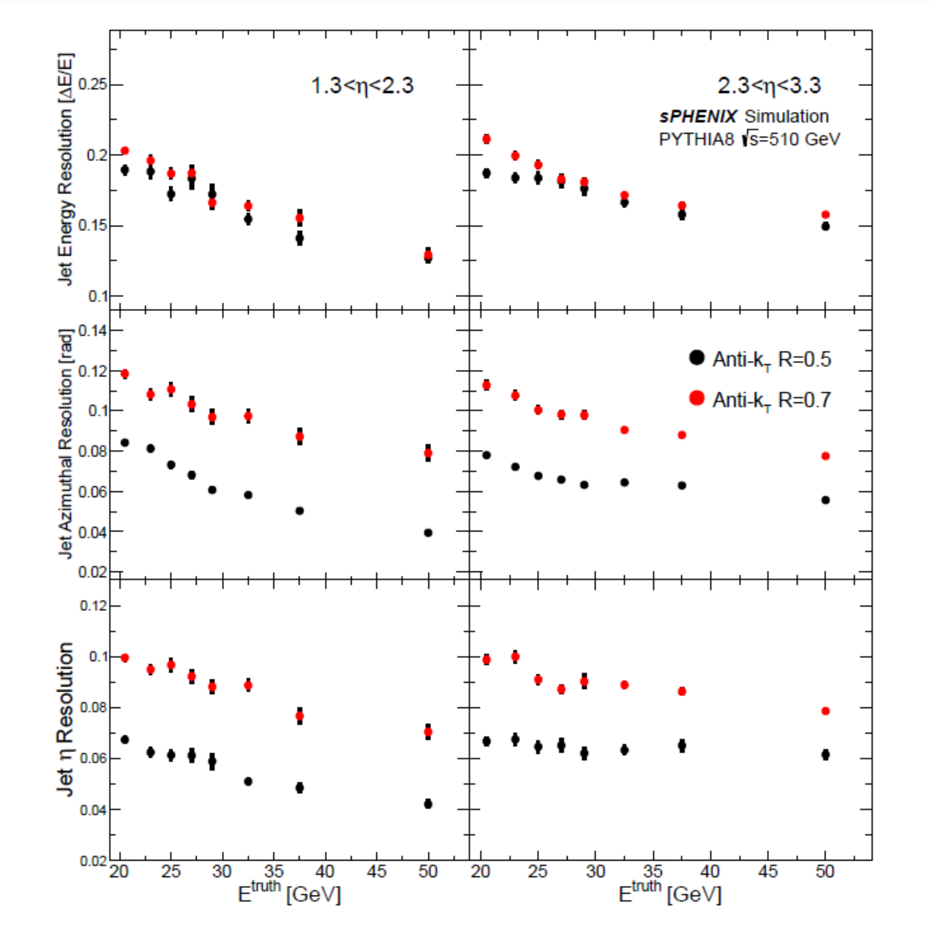


Solenoid 1.4T
EMCal & HCal
Tracking

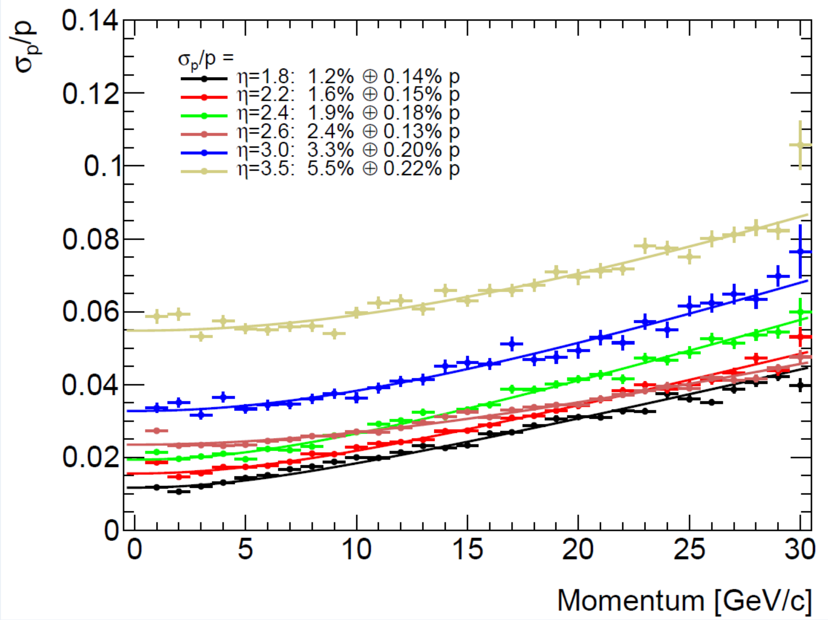
+ Forward EMCal & Hcal
+ Forward tracking

Forward Jet and h±

Good jet resolution for E, η, φ

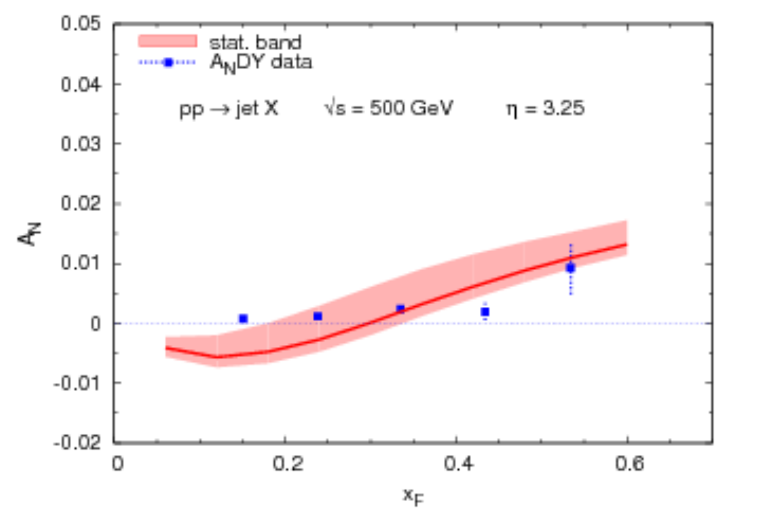


Excellent charged track momentum resolution even in forward region



Jet A_N

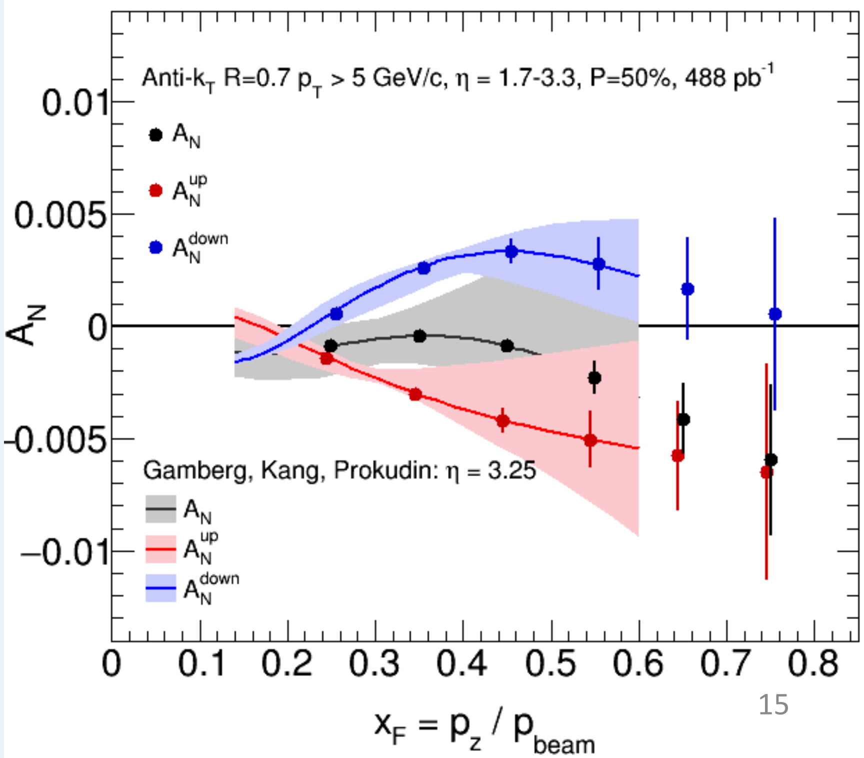
A_NDY: PLB 750, 660



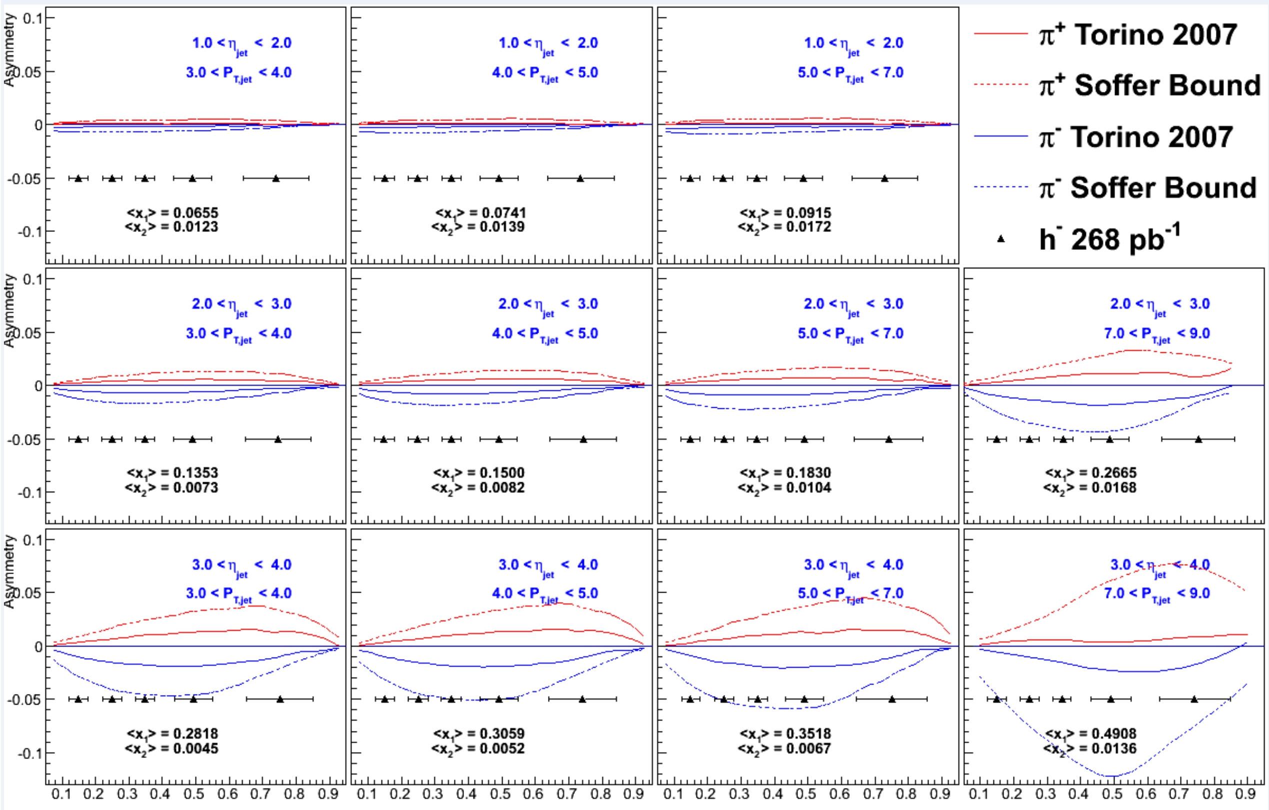
Sensitive to Sivers fnct.

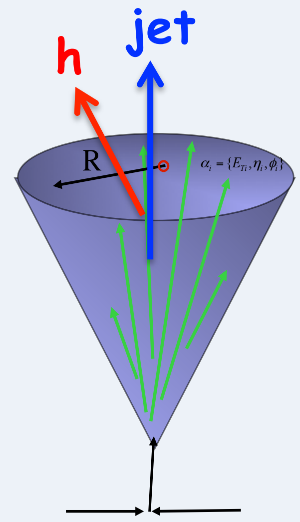
Jet A_N~0 => cancellation from u&d?

Tagging jets with the charge of leading hadron changes jet composition
=> ability to separate effects from u and d



Hadron in Jet: Collins Asymmetry





Gives access to transversity
Expands x-range to higher values => necessary for tensor charge

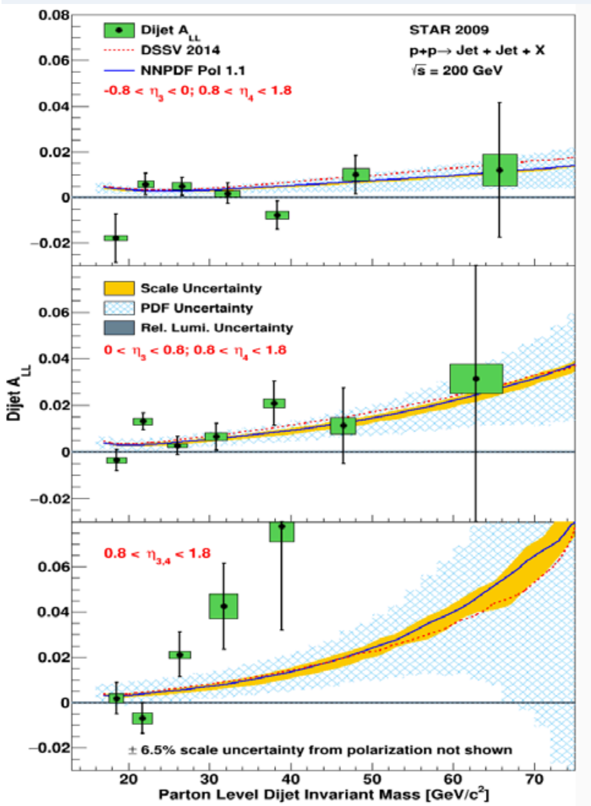
$$\delta q^a = \int_0^1 \left(\delta q^a(x) - \delta \bar{q}^a(x)\right) dx$$

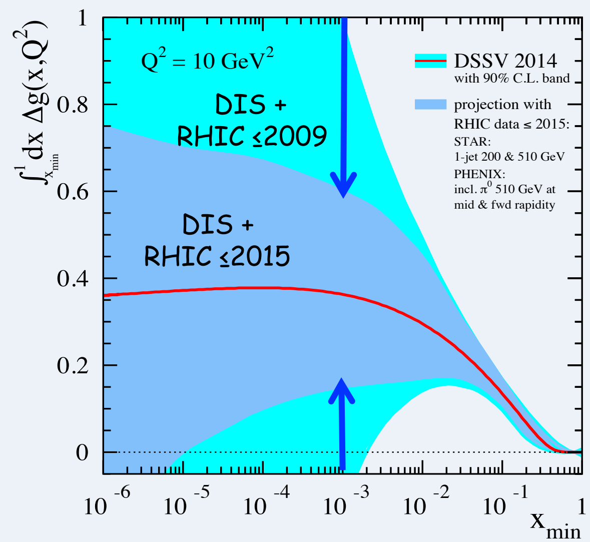
Calculable on lattice

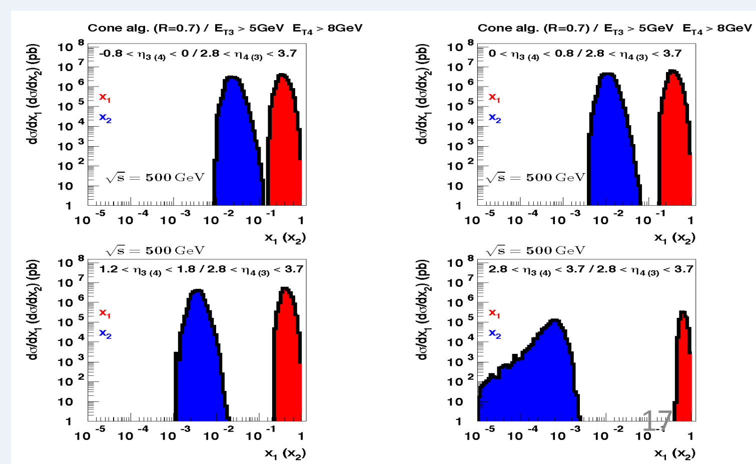
Di-jet A_{LL}: $\Delta G(x)$ to lower x

If we run at $\sqrt{s}$=500 GeV

STAR: 1805.09742







fsPHENIX will considerably improve it

Effective jet triggering and high DAQ rate

Higher rapidity => Lower x (down to ~10^{-3})

Summary

Wide range of **high precision** spin measurements to be addressed by sPHENIX

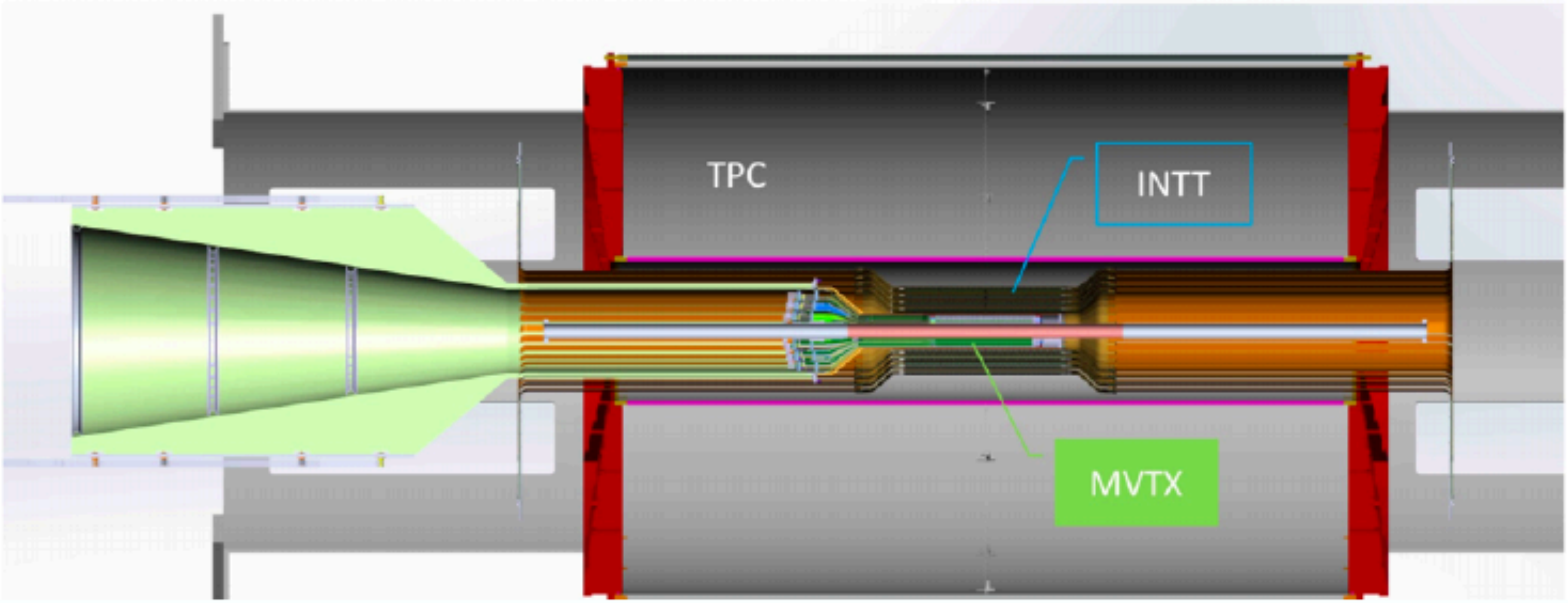
sPHENIX – new collaboration with >70 institutions and is growing

Invite new collaborators:

- New physics ideas
- New instrumentation
- The possibility to evolve sPHENIX to a DIS detector at future EIC

Backup

The Tracking detectors

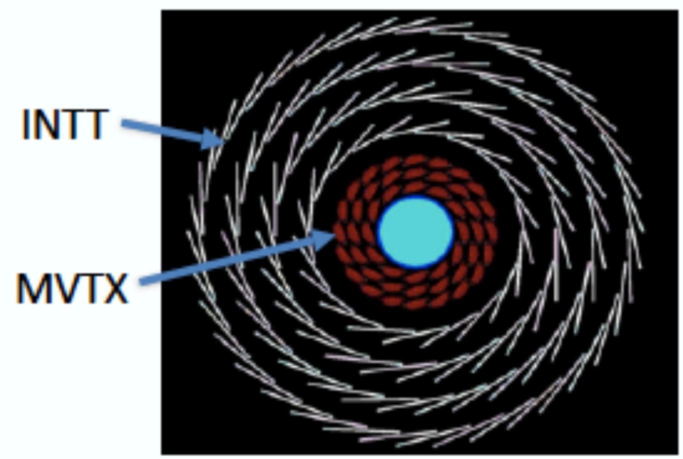


Functions:

TPC - momentum measurement

MVTX - precise track vertex

INTT - timing & pattern recognition



The Tracking Detectors (in GEANT 4)

TPC - Gateless, continuous readout
- 90:10 Ne-CF4 gas - low diffusion + high ion mobility
- Electron drift velocity 8 cm/μs - 13.2 μs maximum drift time
- Quad GEM electron multiplier + chevron readout pads
- 48 layer readout covering 30 - 78 cm radius
- R-ϕ resolution ~ 150 μm
- Δp/p ~ 1% at 5 GeV/c

INTT - Silicon strips
- 4 layers 7 < R < 13 cm
- Pitch 78 μm, Z length 1.6-2 mm
- Fast - can resolve one beam crossing

MVTX - 30 μm x 30 μm MAPS pixels
- 3 layers 2.3 < R < 3.9 cm
- Readout time window ± 5 μs
- ~ 5 μm space point precision

Average mass budget of inner detectors

MVTX ~ 0.3% / layer
(1% total)

INTT ~ 1% / layer
(4% total)

Calorimeters

EMCal

Tungsten-scintillating fiber sampling calorimeter

18 X_0, 1 λ

$\Delta\eta \times \Delta\phi = 0.025 \times 0.025$

Read out by silicon photomultipliers

2D projective geometry

Small Moliere Radius, short radiation length

Energy resolution $\leq 16\%/\sqrt{E}$ @ 5%

HCal

Sampling calorimeter

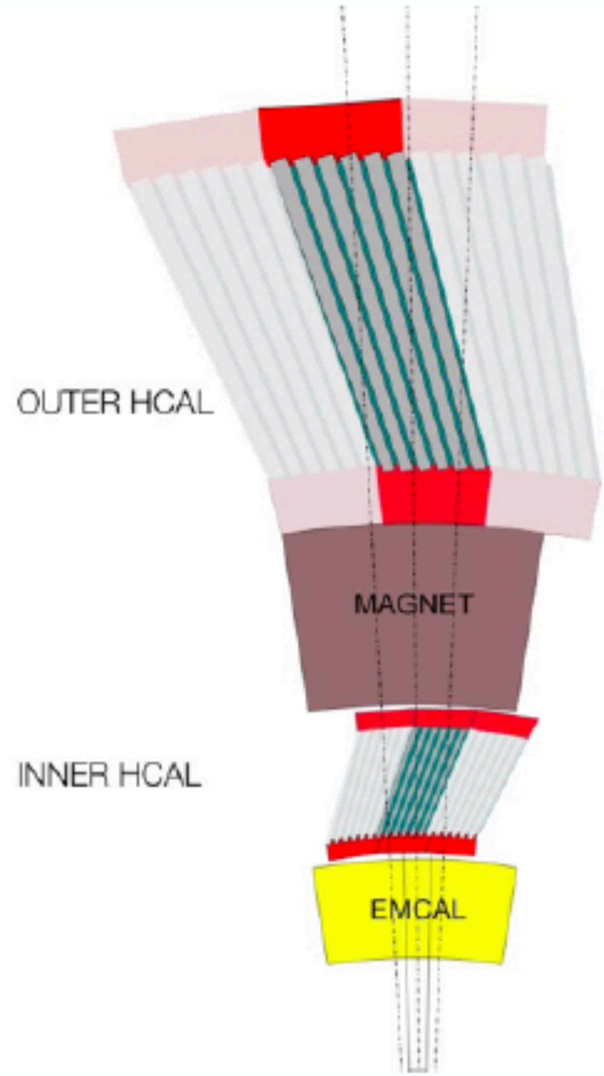
Magnet steel plates / scintillator tiles

3.8 λ

$\Delta\eta \times \Delta\phi = 0.1 \times 0.1$

Read out by silicon photomultipliers

Doubles as the flux return for the solenoid



Aschenauer, Sassot, Stratmann, PRD 92, 094030