Forward Di-Muon Spin Asymmetries in PHENIX with the FVTX Detector

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For the PHENIX Collaboration

PHENIX

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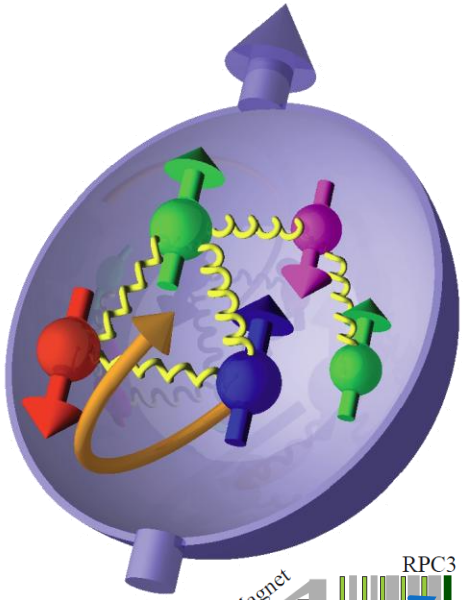
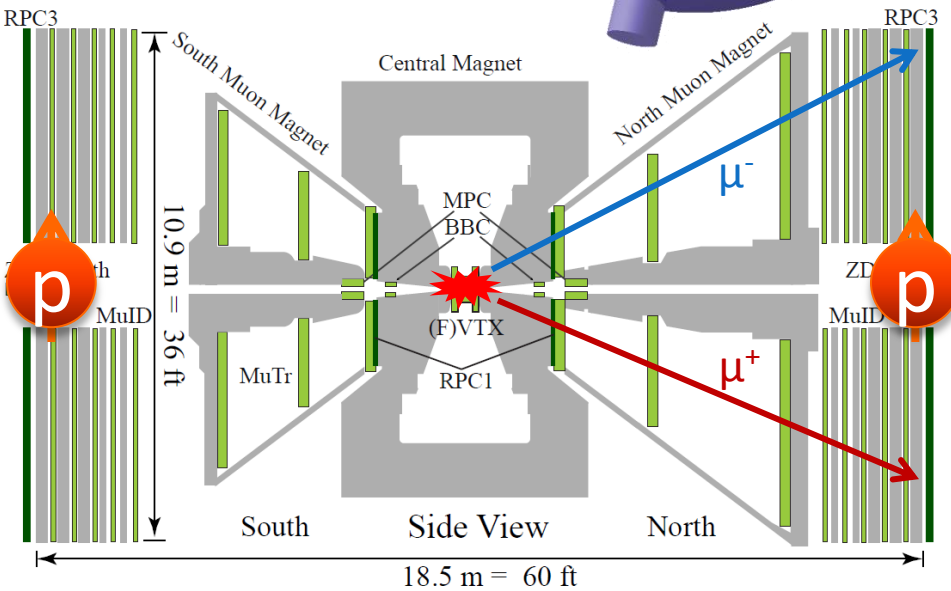
PHENIX Forward Di-Muon spin asymmetries

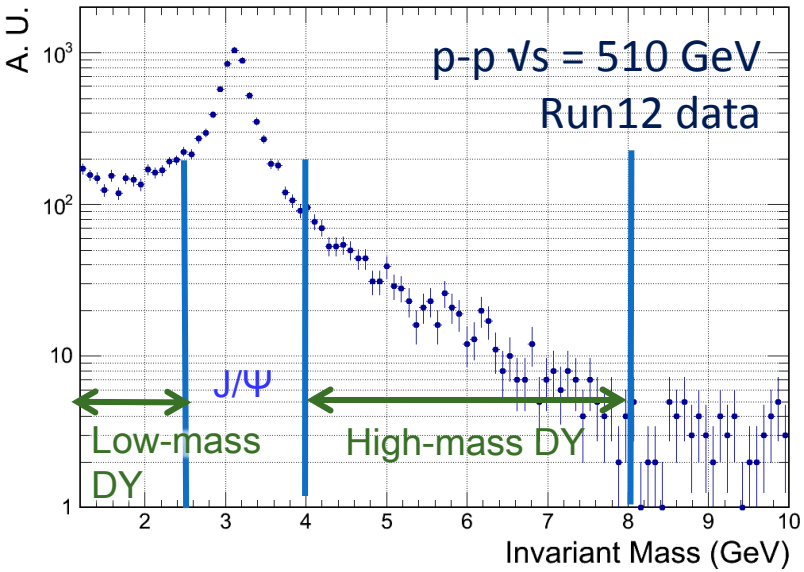
- Nucleon is a complex system of spinning and orbiting partons
- Di-muon production in polarized p-p collisions provides unique access to nucleon structures through spin asymmetry measurements
  - (gg→) J/ψ → $\mu^{\pm}$ access to gluon helicity and Sivers effect
  - ($u\bar{u}$ →) Υ* → $\mu^{\pm}$ Drell-Yan provides clean access to
    - Δ ū / ū thr. longitudinal DSA
    - Quark Sivers effect thr. transverse SSA
- PHENIX experiment provides excellent detection for di-muon in the forward region (1.2<|η|<2.4) through Muon Spectrometers
  - x_1=0.02-0.06, x_2 = 5×10^{-4}-2×10^{-3} For di-muons detected in same arm
- New vertex detector (FVTX) of matching η -acceptance provides new capability in differentiating signal to background

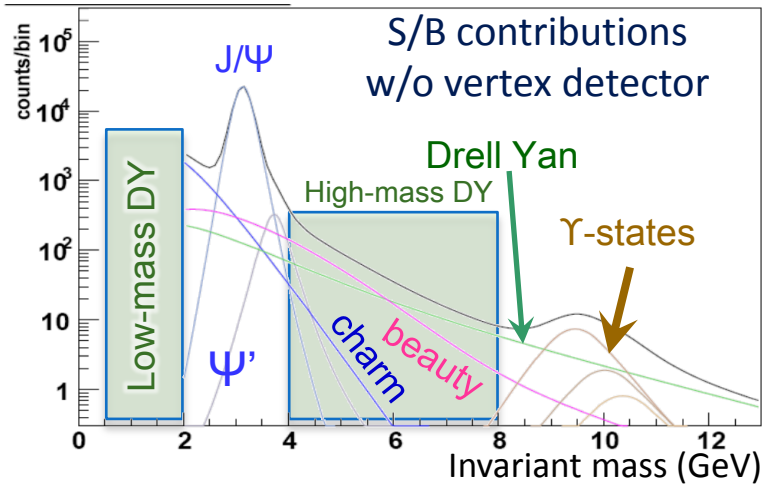




Measuring forward di-muon pairs

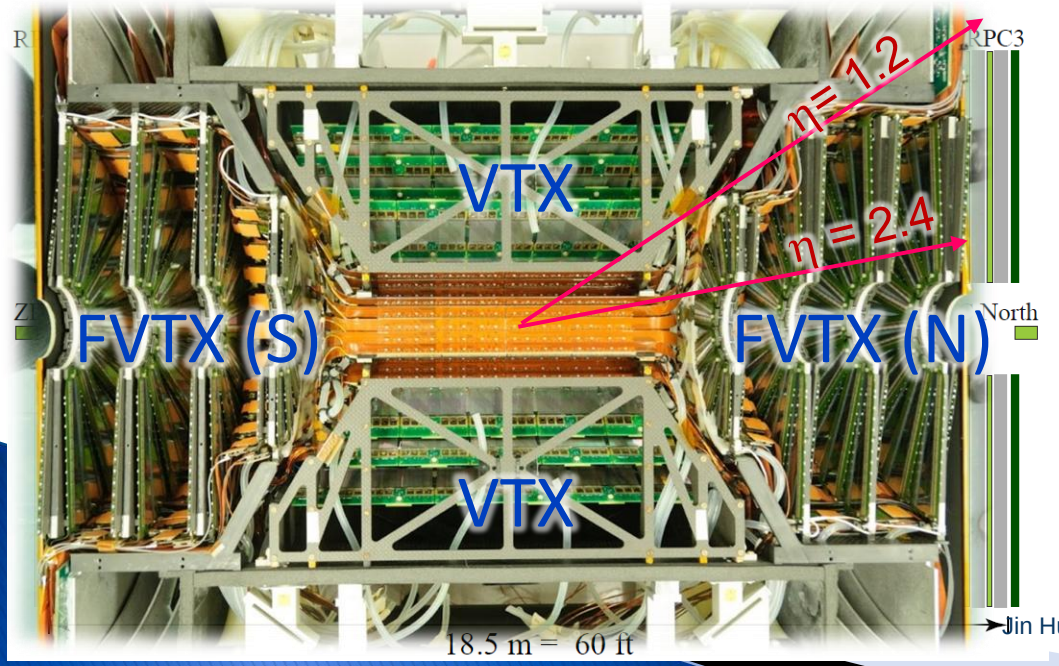
- Signal divided into three regions
- High-mass DY
  - 4 GeV < M < 8 GeV
  - Dominated by beauty decay background if w/o FVTX
- J/Ψ
  - Mass resolution ~ 150 MeV
  - Relatively clean signal ~10:1 s/b
- Low-mass DY
  - M < 2.5 GeV
  - Dominated by combinatorial and charm background if w/o FVTX

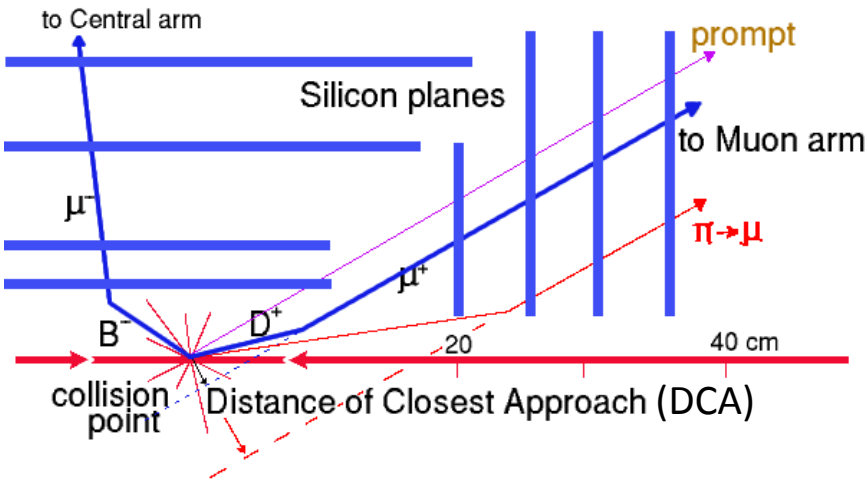




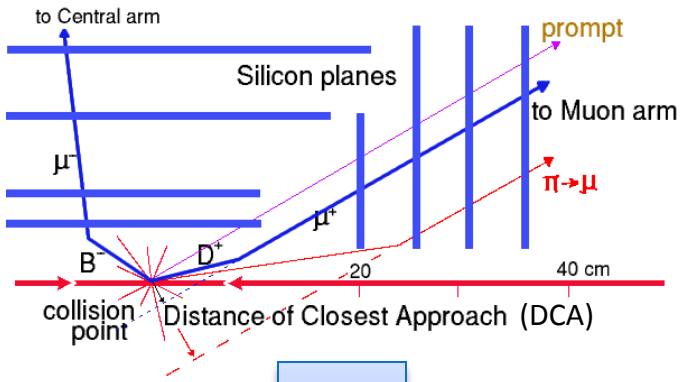
Forward vertex detector (FVTX)

- FVTX – forward silicon vertex detector
  with 1M strips along azimuthal direction and 75 μm pitch
- Differentiate primary vertex / secondary decay using DCA
  - Very important to separating Drell-Yan from heavy flavor decay background
- Precisely measure di-muon opening angle : J/ψ mass
  - Improves J/ψ mass resolution by 40%
- Joint tracking with Muon Tracker : suppress decay-in-flight and mis-reconstruction
- Track isolation : suppress hadrons from jet for W measurement
  - Back-referring to A. Meles' talk (Hadron II)
- The rest of talk will focus on discussing the Drell-Yan measurement

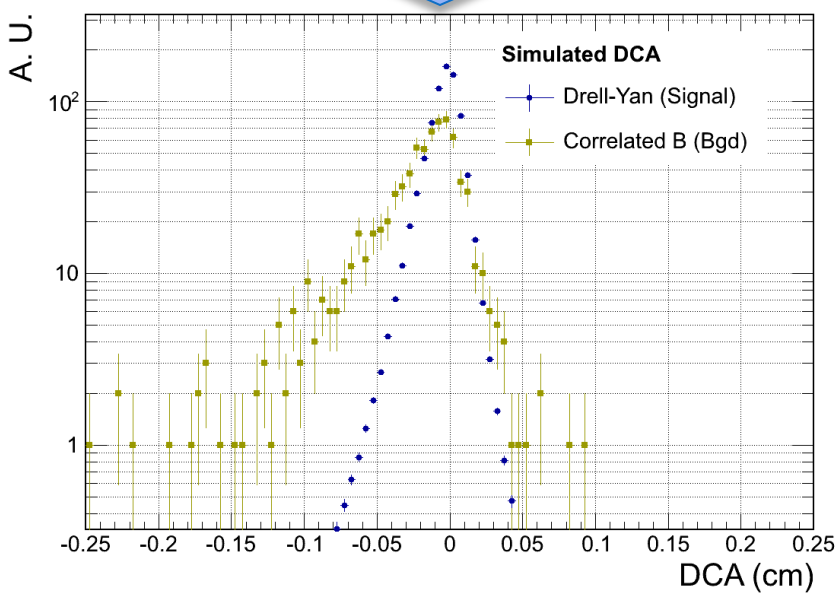


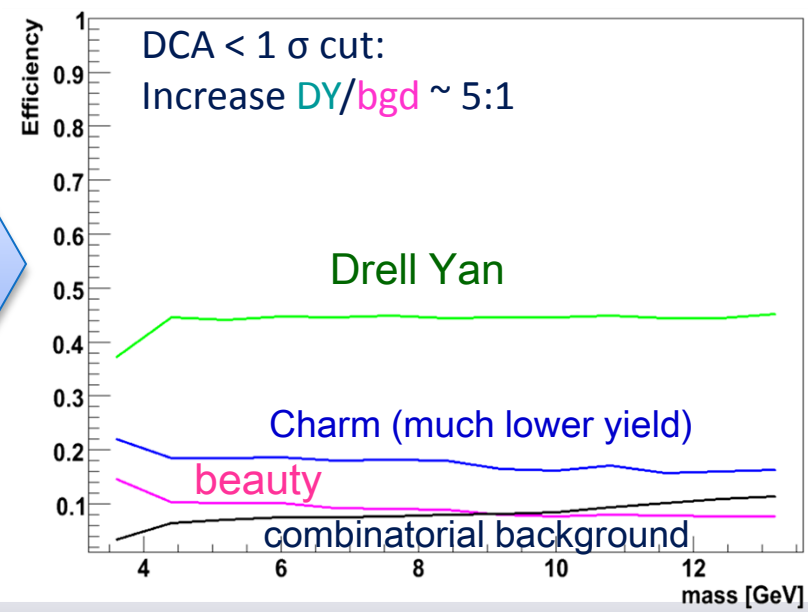


Extracting DY signal with FVTX-DCA cuts



- DCA cuts improve DY signal-to-background (dominated by beauty) ratio from 1:1 to 5:1 for high mass region
- Expect first polarized DY measurement!
- Studies on low-mass DY also suggest promising signal





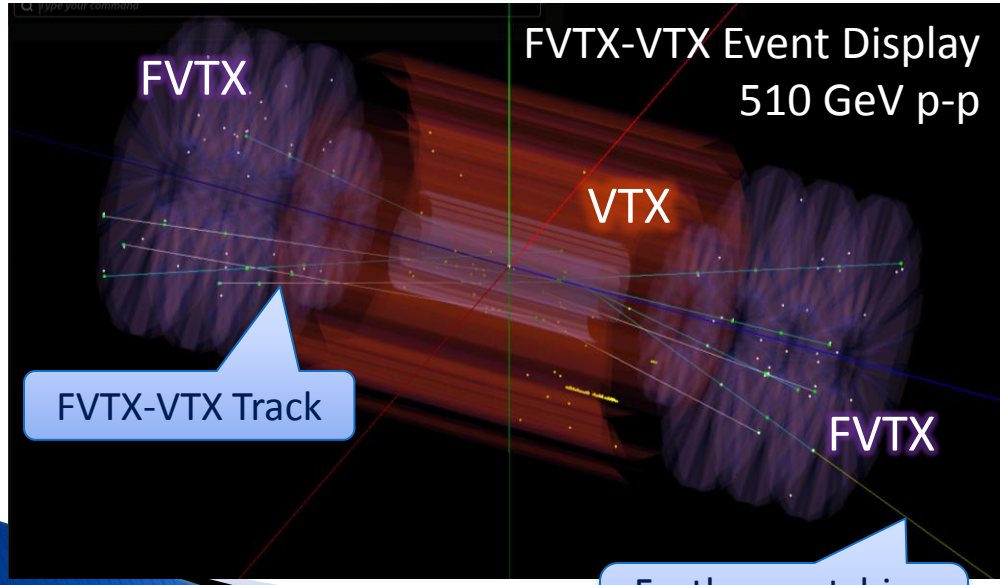
More discussion on FVTX-DCA: J. Bok's talk – Instrumentation VI

FVTX Commissioning in Run12

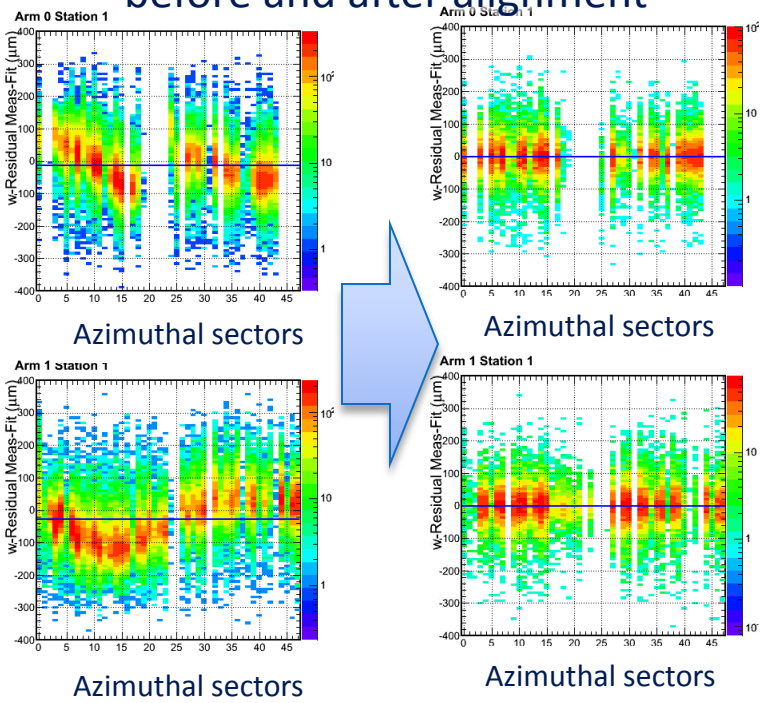
	Oct-Dec 2011	– Detector final assembly and test Quality check on all wedges
FVTX → IR	Late Dec 2011	– First data from PHENIX IR
	Late Jan 2012	– First full detector readout from IR
200 GeV p-p transversely pol.	Feb 8 2012	– First data (self-triggered) with beam, shortly after stable run 12 collision were established
	Feb 24 2012	– First physics data with 1/6 acceptance
510 GeV p-p longitudinal pol.	Mid March 2012	– Detector operational for p-p with ~90% of acceptance ON Have taken all 510 GeV p-p data
Heavy ion	Late March 2012	– Detector operation by shift workers
	Mid Apr 2012	– Commissioning and production for Heavy ion running

Analysis highlights

- Finalizing reconstruction and simulation software
- Detector self-alignment performed
  Global alignment work in progress
- On-going QA for Run12 data



FVTX Residual (μm)
before and after alignment

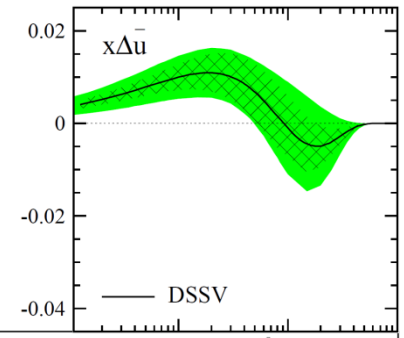


DY longitudinal DSA (A_{LL})

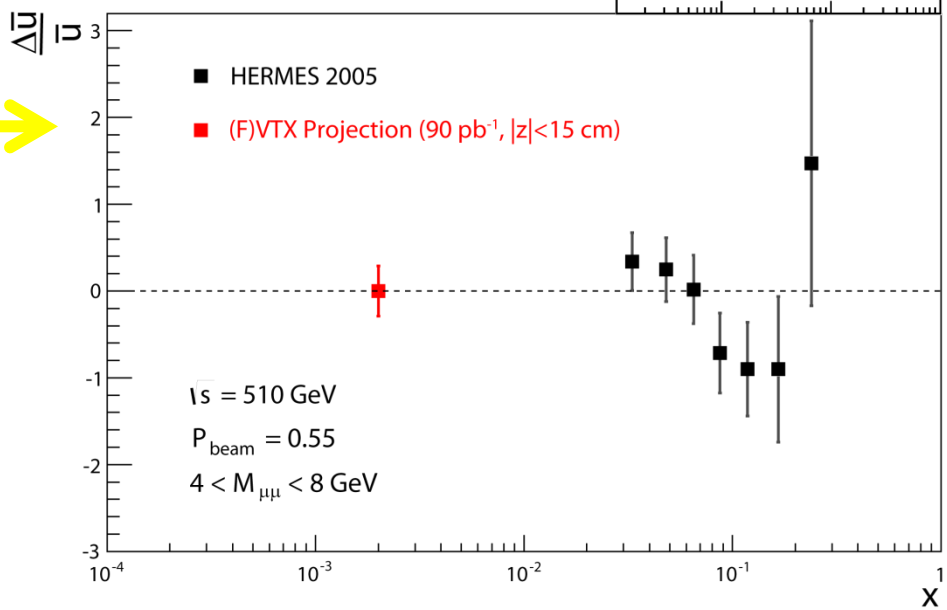
- Drell-Yan A_{LL} can cleanly access $\Delta \bar{u} / \bar{u}$
- Compared with RHIC-W, access smaller x_2
- Comparing with previous measurement (DIS), no fragmentation process is involved, high Q^2
- provides unique check on global fits

$$A_{LL}^{DY} = -\frac{\sum_q e_q^2\{\Delta q(x_1)\Delta\bar{q}(x_2) + \Delta\bar{q}(x_1)\Delta q(x_2)\}}{\sum_q e_q^2\{q(x_1)\bar{q}(x_2) + \bar{q}(x_1)q(x_2)\}}$$

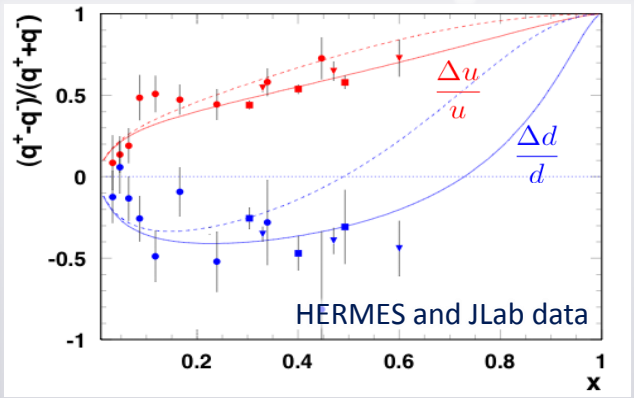
$$\approx -\frac{\Delta u(x_1)}{u(x_1)} \cdot \frac{\Delta\bar{u}(x_2)}{\bar{u}(x_2)}$$



Run12+13 projection



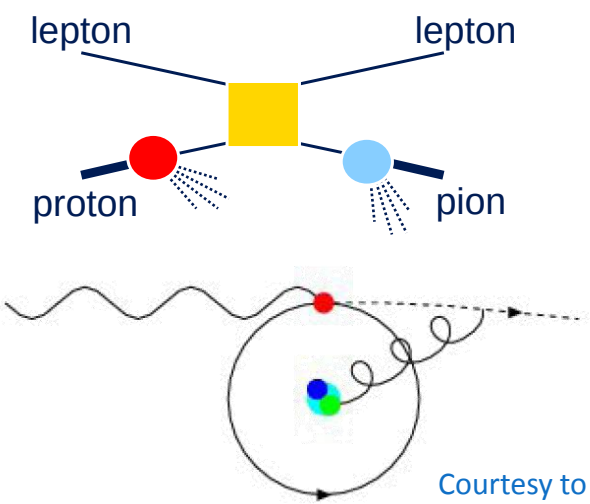
$\Delta u / u$ ~0.2 for our x_1~0.06



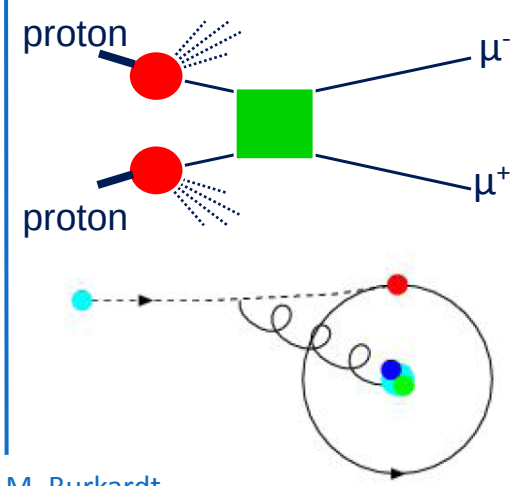
DY Transverse SSA (A_N)

- DY SSA (A_N) gives access to quark Sivers effect ($f_{1T}^{\perp}$) in proton
- Good handle on background
- $f_{1T}^{\perp}$ expected to reverse in sign from SIDIS to DY measurement
  An important test for TMD framework

Semi-inclusive DIS (SIDIS)

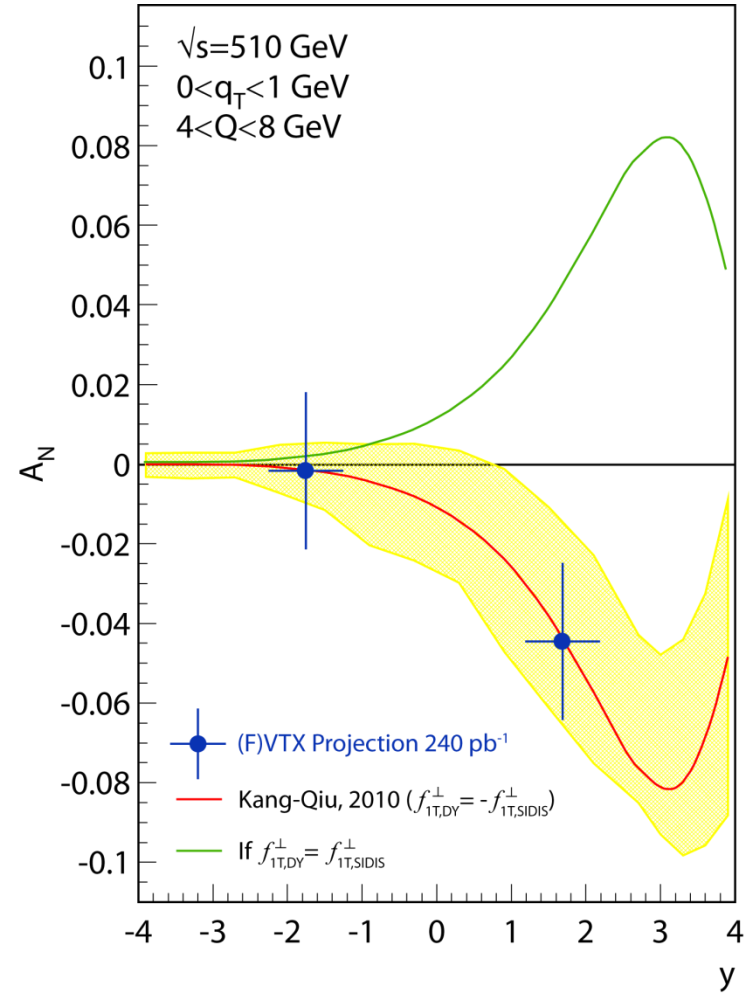


Drell-Yan



Courtesy to M. Burkardt

3-year running projection



Conclusion

- PHENIX experiment provides excellent di-muon detection in ($1.2<|\eta|<2.4$)
- First capability for polarized Drell-Yan measurement provided by new FVTX detector
  - Longitudinal DSA (A_{LL}) provides unique clean check on $\Delta \bar{u} / \bar{u}$
  - Transverse SSA (A_N) probes Sivers effect and test of TMD framework with clean control of background
  - FVTX commissioned in Run12, first data on disk
- J/ψ mass resolution improved 40% by FVTX
  - Run12 longitudinal and transverse data on disk
  - Analysis on-going