Transverse Single Spin Asymmetry in J/ψ Production in $p\vec{p}$ Interactions at SpinQuest

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Outline

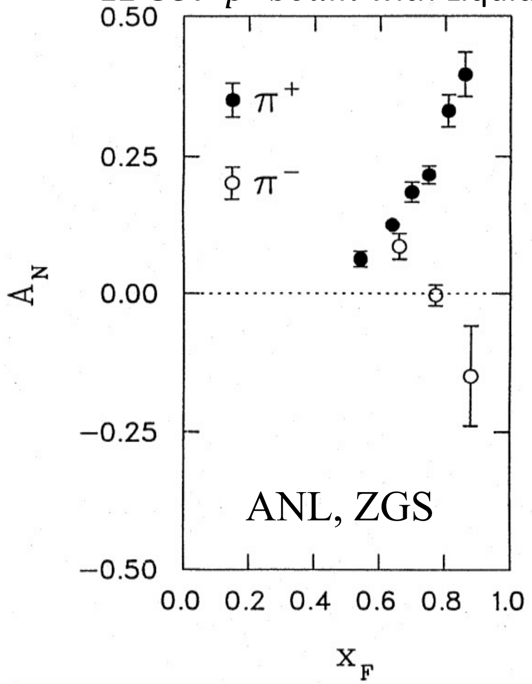
1. Transverse Single-Spin Asymmetry and Sivers Effect.
2. SpinQuest Motivation.
3. J/psi TSSA from SpinQuest.
4. Optimizing the Magnetic Fields for J/Psi Production.
5. Summary and Conclusions.

Transverse Single-Spin Asymmetry and Sivers Effect

How it all started?

W.H. Dragoset et al., PRL36, 929 (**1976**)

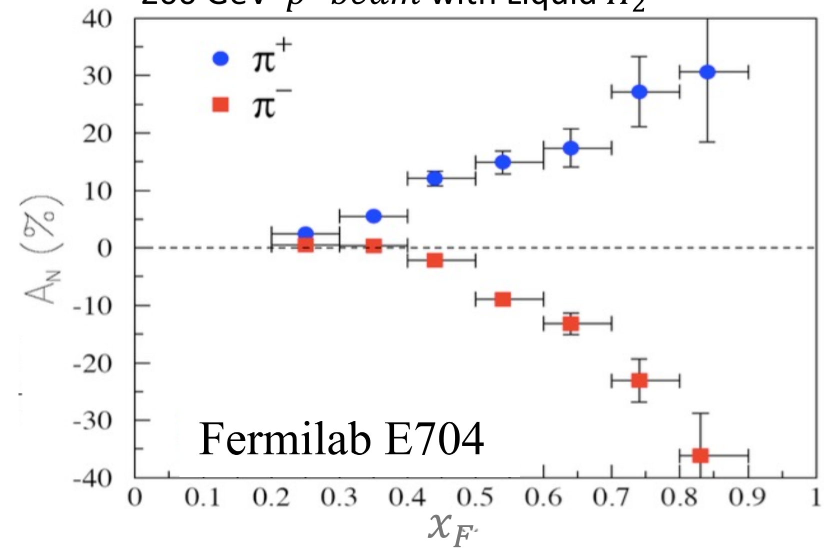
12 GeV $p^{\uparrow}$ *beam* with Liquid H_2

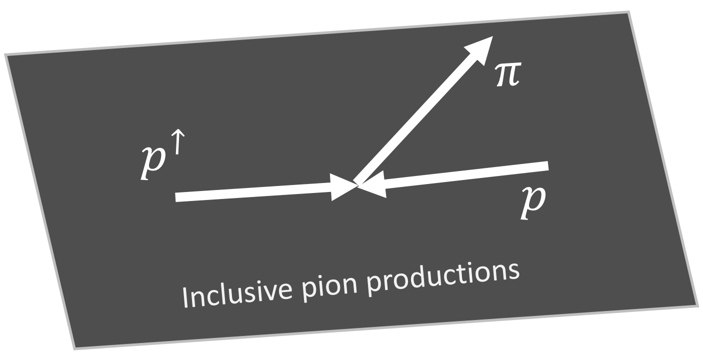


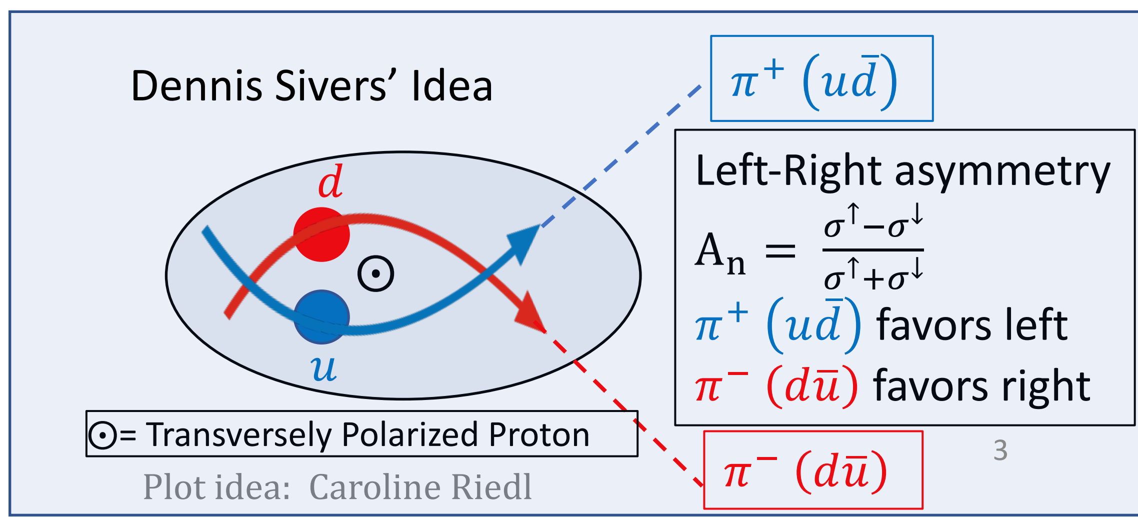
Phys. Lett. B, 268(**1991**),Pages 462-466

Plot credit: M. Anselmino

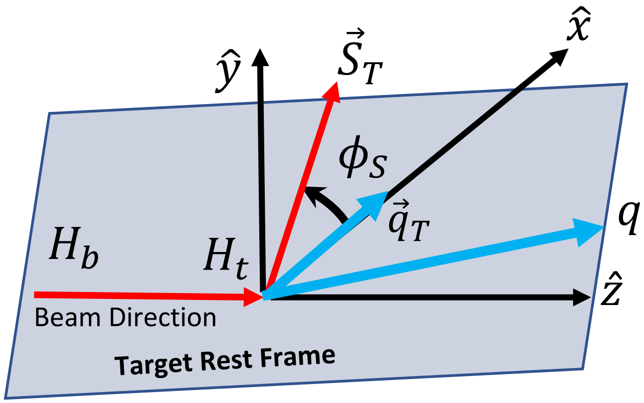
200 GeV $p^{\uparrow}$ *beam* with Liquid H_2







SpinQuest Motivation



$$p + p^{\uparrow} \rightarrow \mu^{+} \mu^{-} + X$$

Drell-Yan

$$p + p^{\uparrow} \rightarrow J/\psi + X$$

$J/\psi \rightarrow \mu^{+} \mu^{-}$

J/ψ Production

$\vec{S}_T$ = Target spin vector
$\hat{x}, \hat{y}, \hat{z}$, is target rest frame = TF; $\hat{x} = \hat{q}_T, \hat{y} = \hat{z} \times \hat{q}_T$
$\vec{q}_T$ = Dimuon's transverse momentum.
H_b = Unpolarized proton beam.
H_t = Polarized target.

$$A(\phi_S) = \frac{1}{|S_T|} \frac{\sigma^{\uparrow} - \sigma^{\downarrow}}{\sigma^{\uparrow} + \sigma^{\downarrow}} = \sin\phi_S \, A_T^{\sin\phi_S}$$

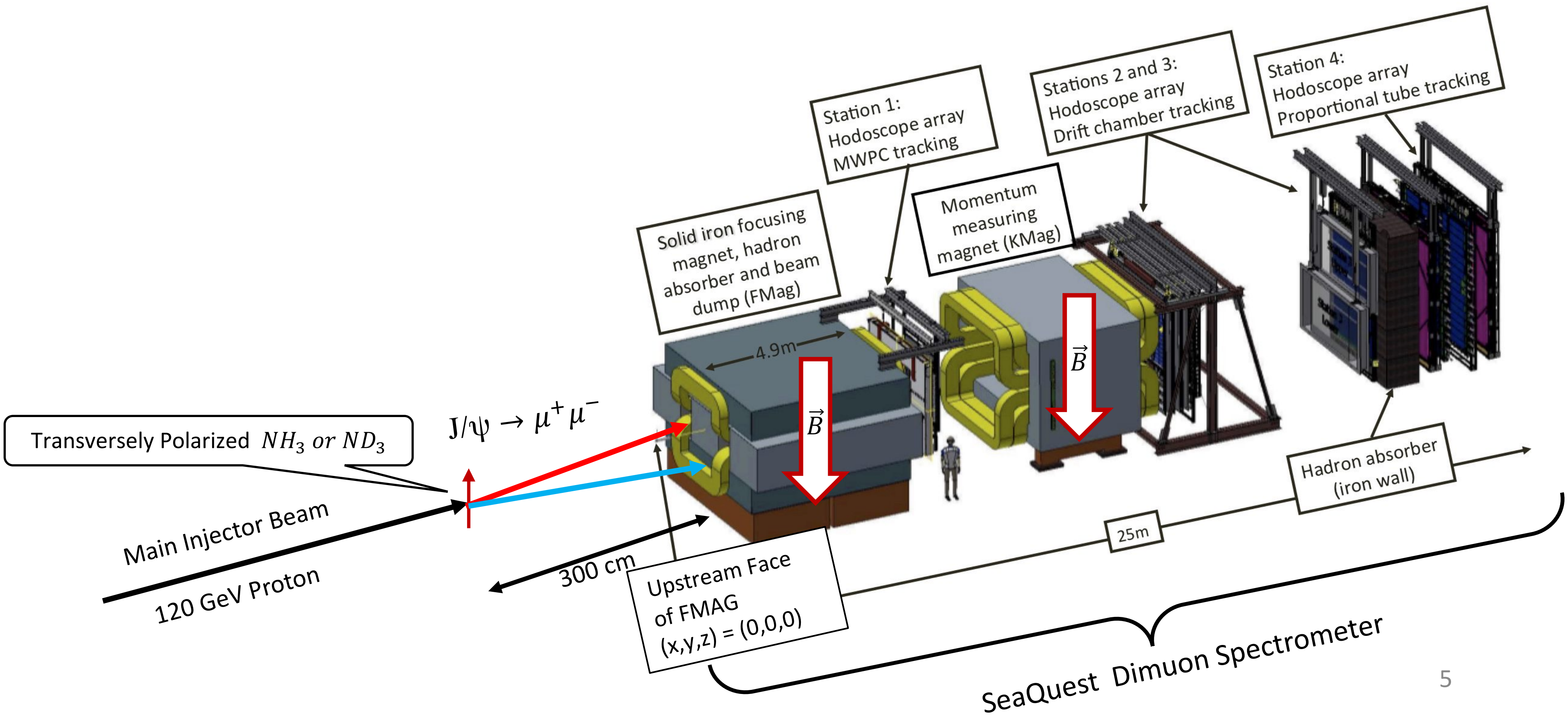
1. $\sigma^{\uparrow(\downarrow)}$ is the cross section in up (down) spin state, and $A_T^{\sin\phi_S}$ is the Sivers asymmetry.
2. We can extract the asymmetry from the $\sin\phi_S$ modulation in the azimuthal yield.

J/ψ TSSA from SpinQuest

SpinQuest Apparatus and Simulation Info

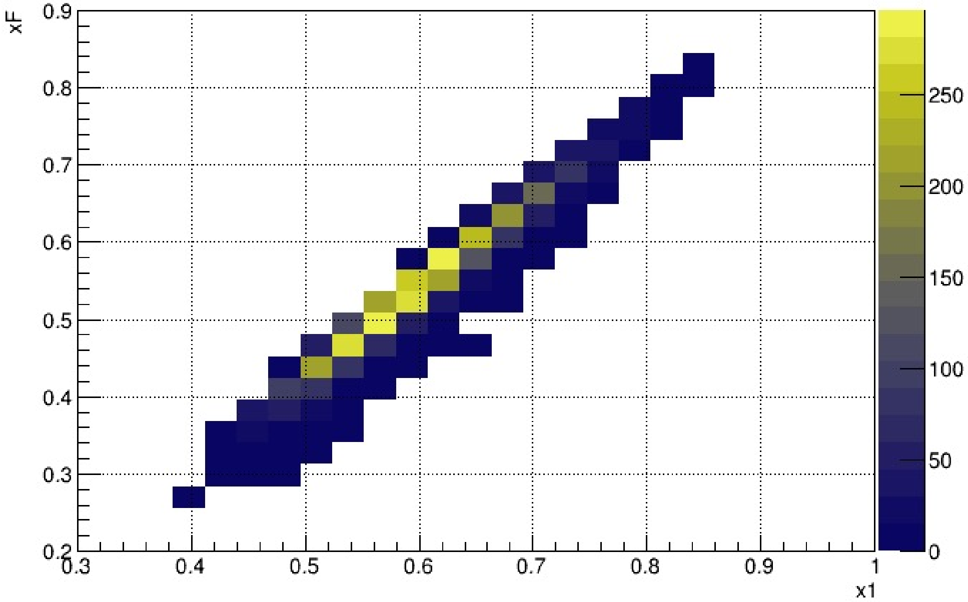
In the simulation study for next slides using Pythia8:

1. Magnetic fields are parallel.
2. “Accepted muons” mean they pass through the drift chambers and hodoscopes.
3. Trigger and reconstruction effects aren’t included in the study.

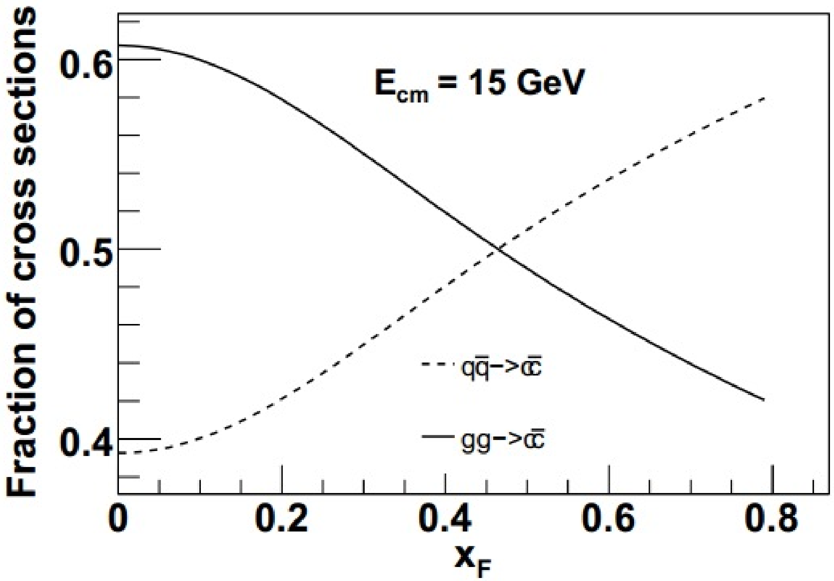


J/ψ TSSA from SpinQuest: J/ψ Production is Sensitive to the Sea Quarks.

Using SpinQuest Acceptance



Prediction from P. P. Bhaduri et al



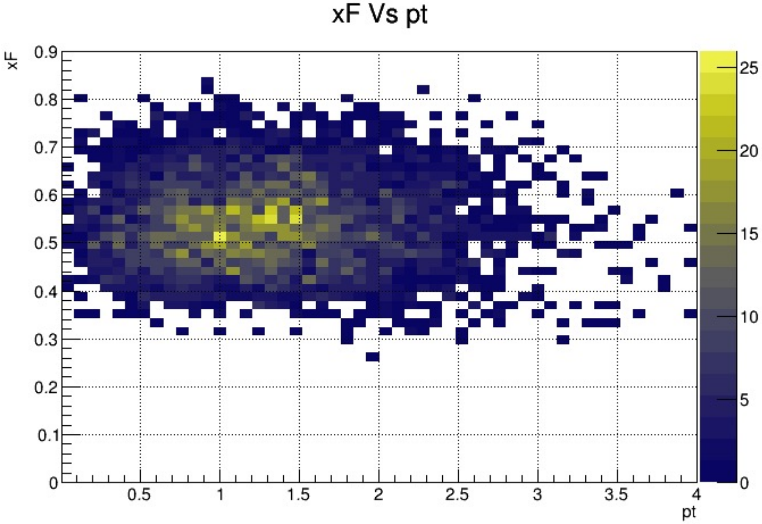
Source: arXiv:1110.4268.

1. $c\bar{c}$ production from quark annihilation becomes important at higher xF.
2. According to the model at right, at higher x_F, J/ψ Production at SpinQuest is sensitive to the the $q\bar{q}$ annihilation.

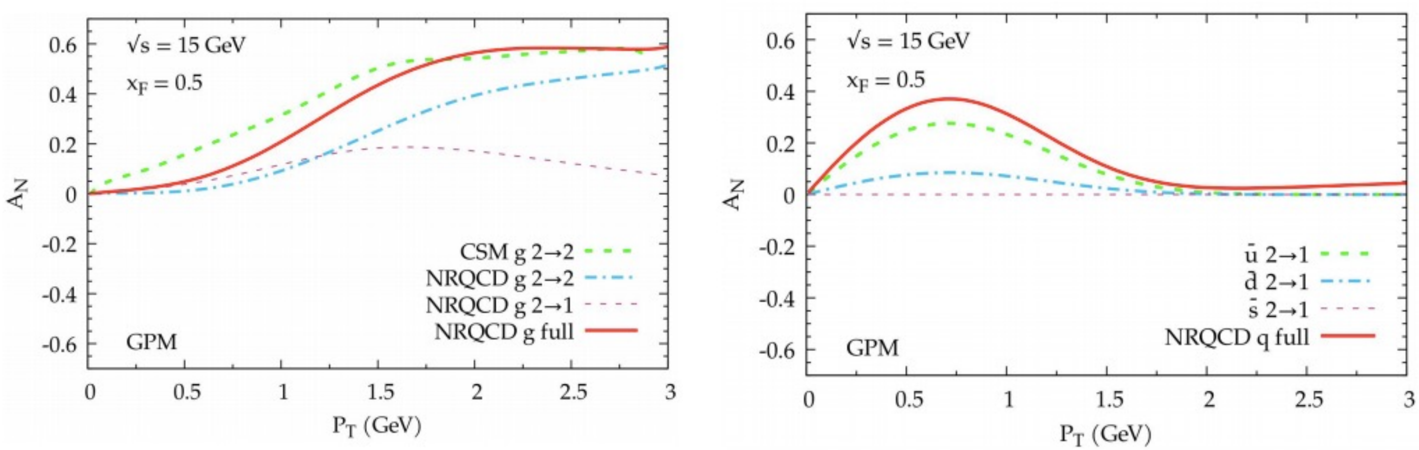
J/ψ TSSA from SpinQuest: Anticipated Asymmetry Prediction from U. D'Alesio et al

1. The top right plot shows SpinQuest acceptance for the J/ψ, and we can see that most accepted dimuons at SpinQuest will be at $p_T \sim$ 0-2 GeV and $x_F \sim$ 0.4-0.7.
2. When $x_F = 0.5$, the prediction (see below) from U. D'Alesio et al. shows that at lower p_T the asymmetry is dominated by $q\bar{q}$ interactions while at higher p_T the gg interactions are dominant.

SpinQuest Acceptance



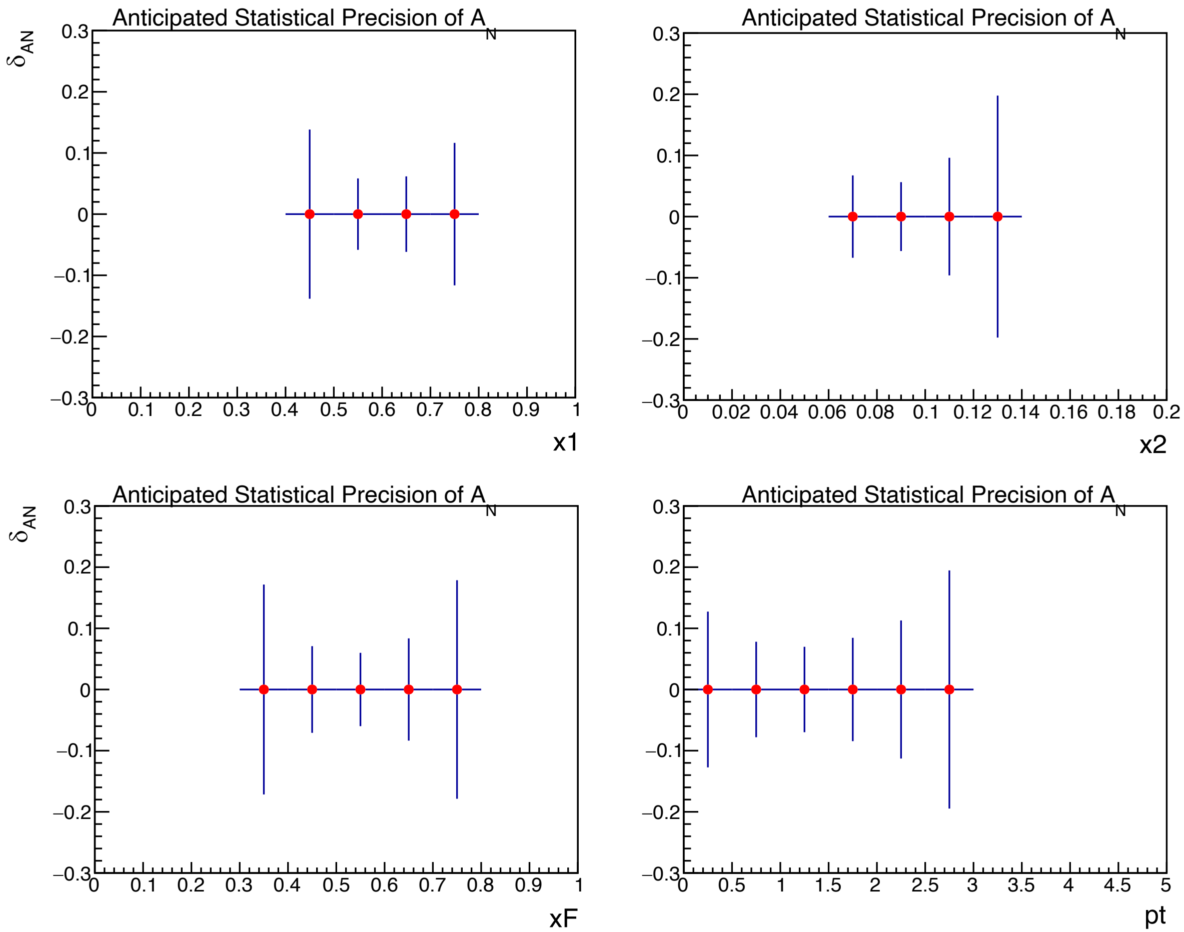
$\sqrt{s}$ = 15 GeV @ SpinQuest



Phys. Rev. D 102, 094011

J/ψ TSSA from SpinQuest: Anticipated Precision

For one week's data-taking, anticipated Precision of J/ψ TSSA in terms of total dimuon yields.



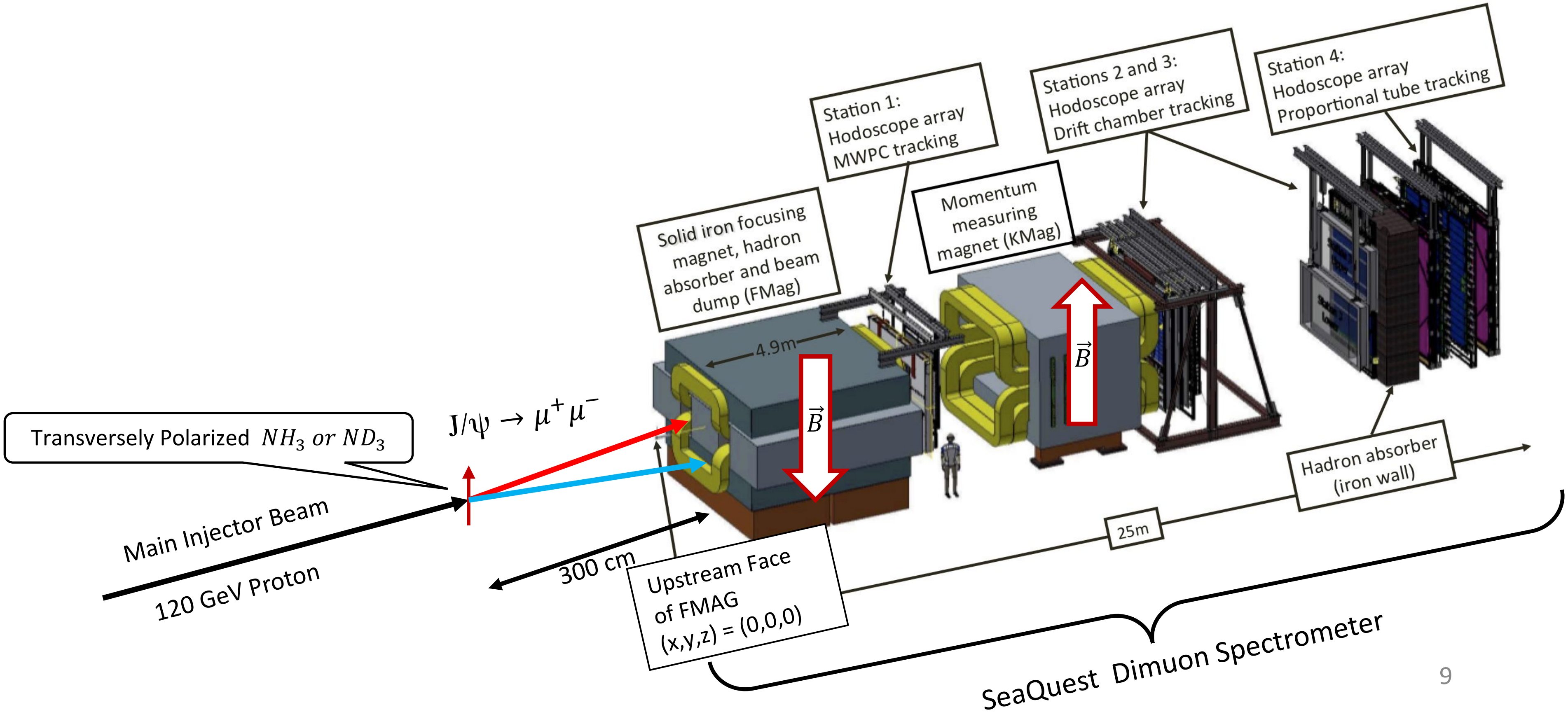
$$\delta_{AN} = \delta_{AN}^{sim} / (\mathrm{f_{dil}} \cdot \mathrm{P_{pol}} \cdot \sqrt{\mathcal{L}^{1w}/\mathcal{L}^{sim}}) = 1/(\mathrm{f_{dil}} \cdot \mathrm{P_{pol}} \cdot \sqrt{N_{j/\psi}^{1w}})$$

Integrated Luminosity $\mathcal{L}^{sim}$ = 8414.86 pb^{-1} and $\mathcal{L}^{1w} = 7 \times 10^{4}$ pb^{-1}

Target polarization : $P_{pol} = 0.8$; Dilution factor NH_3: $f_{dil} = 0.176$;

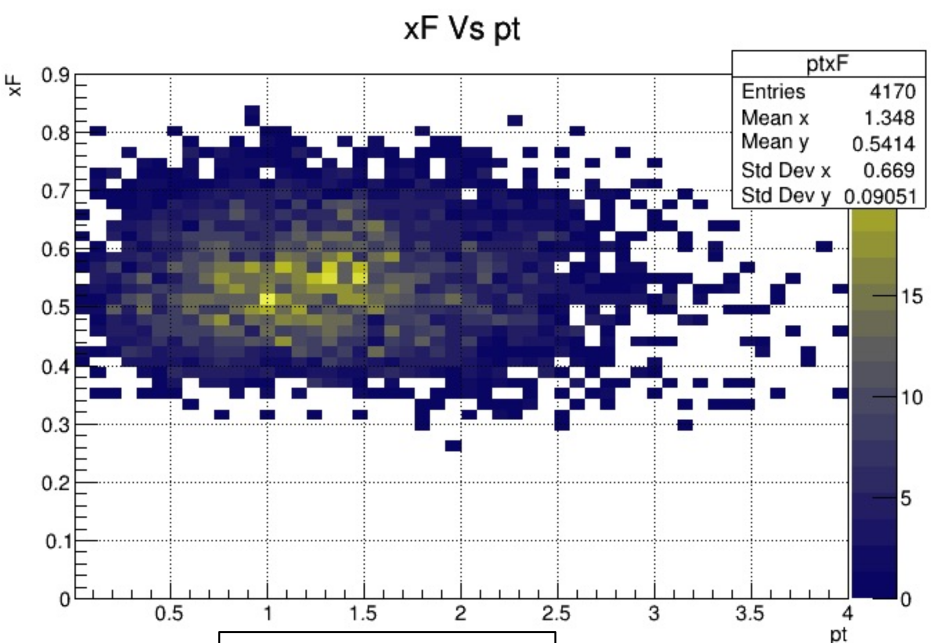
Optimizing the Magnetic Fields for J/ψ Production.

- In normal beam running conditions, both FMag and KMag bend muons in the same direction. Let's call that field configuration **"Parallel"** B Fields.
- To attain higher yield, we will change the polarity of the KMag. Let's call that field configuration "**Antiparallel**" B Fields.

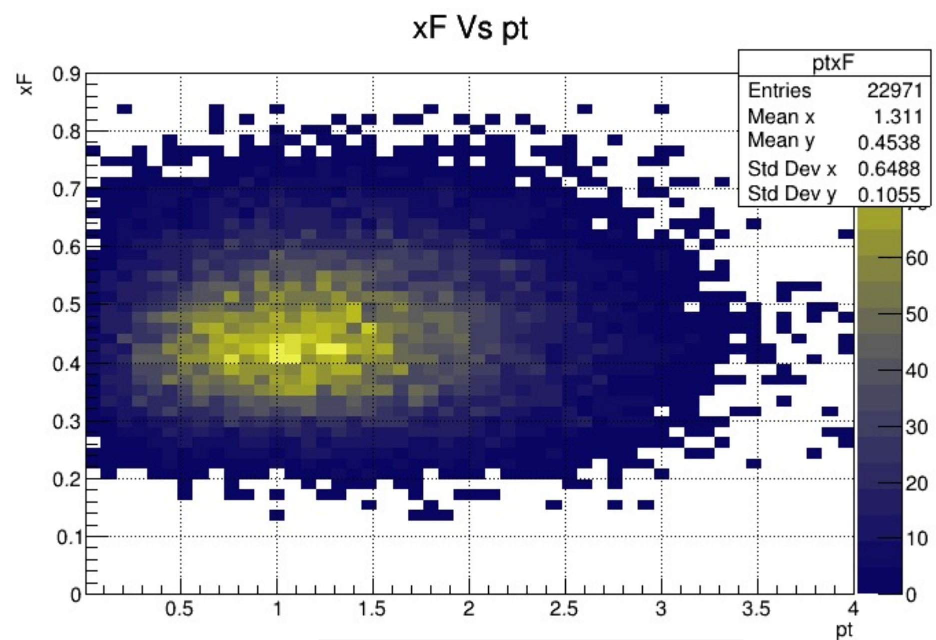


Optimizing the Magnetic Fields for J/ψ Production.

With antiparallel field polarities we have about ~6 times more dimuons.



Parallel Fields



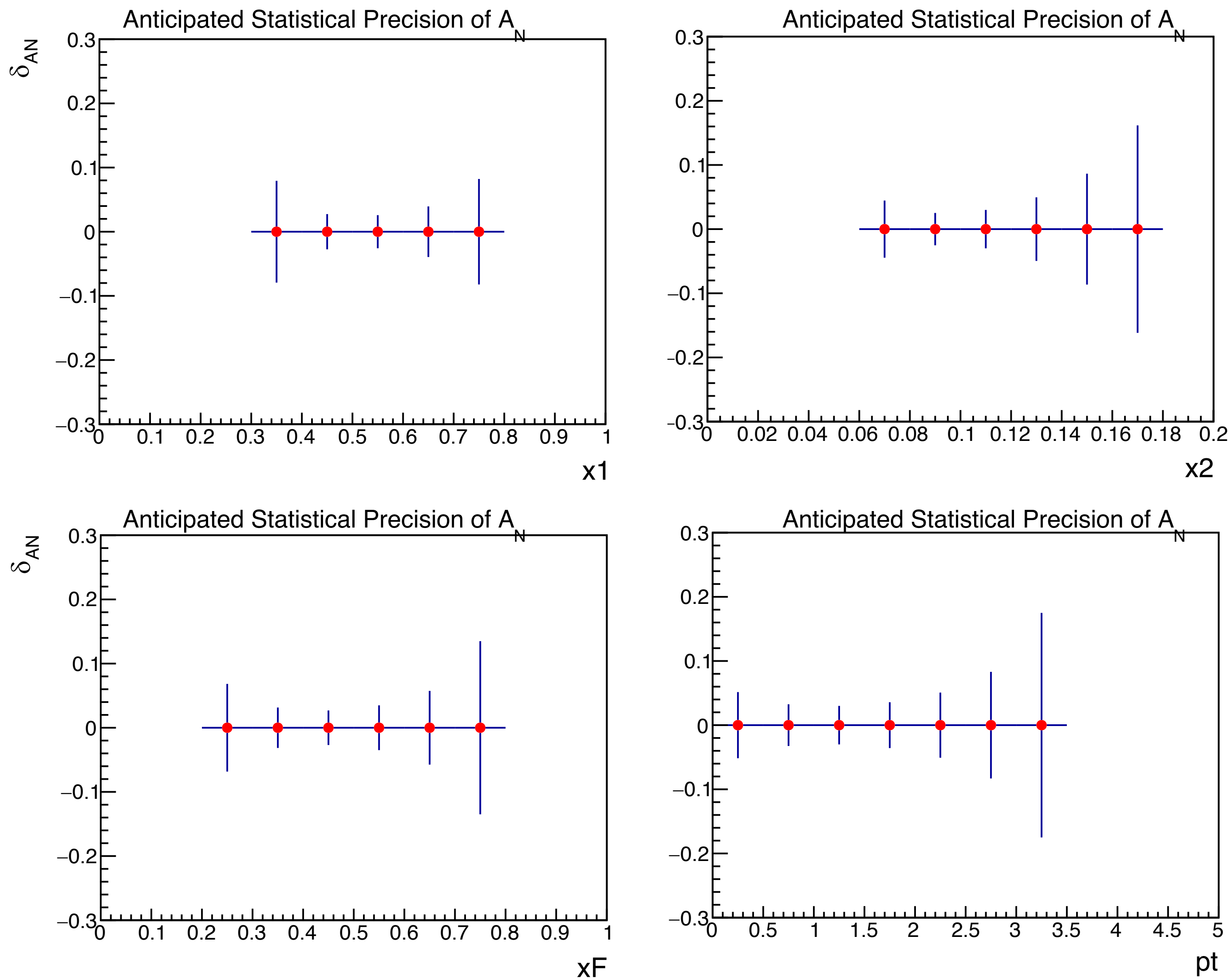
Antiparallel Fields

We are working on the combinatorial background contributions in each configuration.

Anticipated Precision for J/ψ TSSA

$\delta_{AN} = 1/(\mathrm{f_{dil}} \cdot \mathrm{P_{pol}} \cdot \sqrt{\boldsymbol{N_{j/\psi}}})$

Antiparallel B Fields



For one week's data-taking, anticipated Precision of J/ψ TSSA will be improved by the **factor** $\frac{\mathbf{1}}{\sqrt{\mathbf{6}}}$.

Summary and Conclusions

- We have done a simulation study for a SpinQuest measurement of the transverse single-spin asymmetry (TSSA) in J/ψ production. At this point we have only included acceptance effects, but not yet trigger and reconstruction.
- We found that using antiparallel spectrometer fields greatly increases our J/ψ yield. A background study will give us a proper understanding of what setup would be more favorable for data-taking.
- From different model we also understand that at the lower p_T regions, the SpinQuest experiment will be more sensitive to the sea quarks.
- A SpinQuest measurement of the TSSA in J/ψ production, combined with the only other measurement (by PHENIX at RHIC), will shed light on the little-known gluon Sivers function.