The STAR W Physics Program

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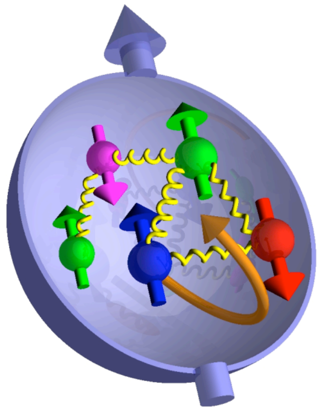
STAR Collaboration

APS April Meeting

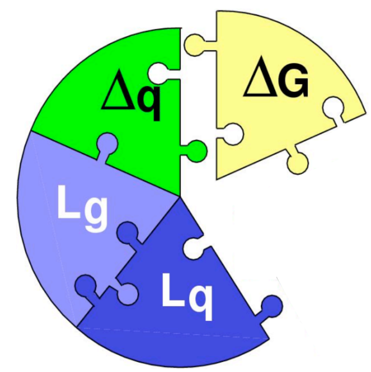
The Spin Puzzle



The proton is viewed as being a "bag" of bound quarks and gluons interacting via QCD

Spins + orbital angular momentum need to give the observed spin 1/2 of proton

$$\frac{1}{2} = \frac{1}{2}\Delta\Sigma + L_q^z + \Delta G + L_g^z$$



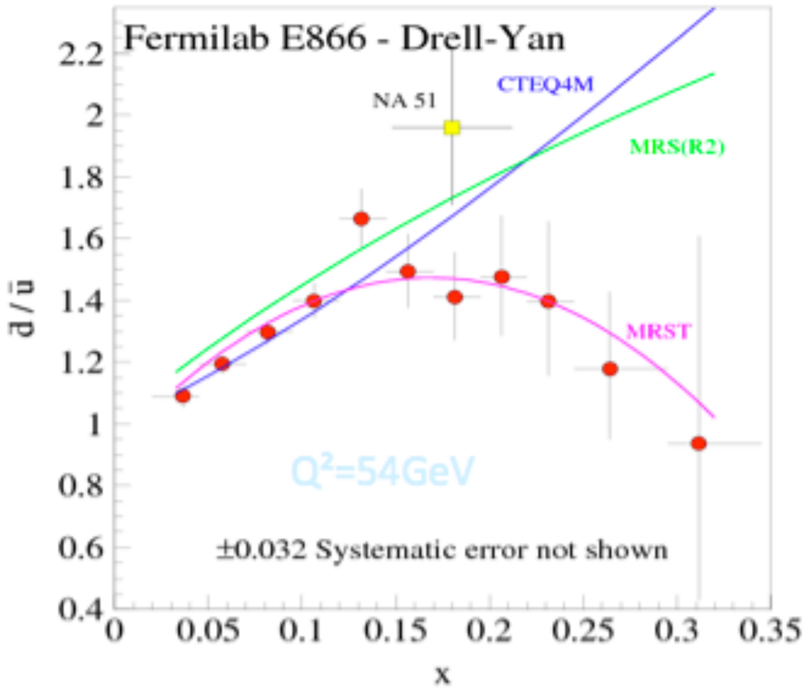
Fairly well measured only ~30% of spin

Being measured at RHIC

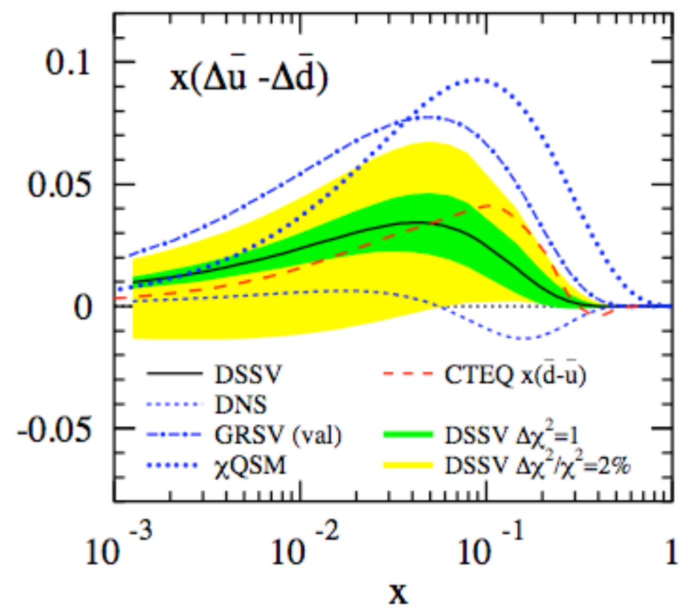
A future challenge

$$\Delta\Sigma = \int (\Delta u + \Delta d + \Delta s + \Delta\bar{u} + \Delta\bar{d} + \Delta\bar{s} + \cdots)dx \qquad \Delta G = \int \Delta g dx$$

Flavor Asymmetry in the Sea



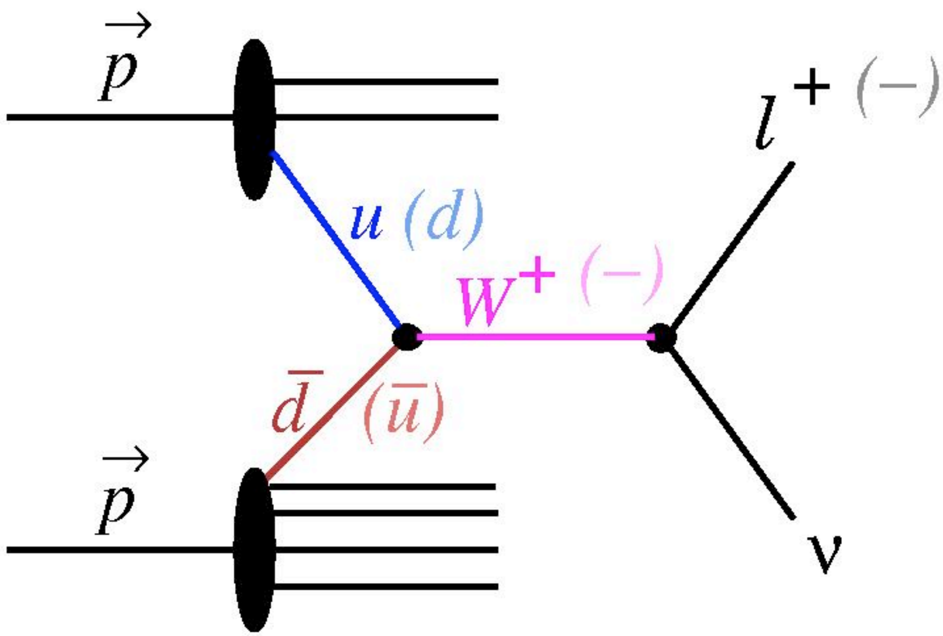
- Pauli blocking should contribute to the observed signal, but how much is currently debated
- Non-perturbative processes may be needed in generating the sea



arXiv:0904.3821

- E866 results are qualitatively consistent with pion cloud models, instanton models, chiral quark soliton models, etc.

Probing the Sea through Ws



$$u + \bar{d} \rightarrow W^{+} \rightarrow e^{+} + \nu$$

$$\bar{u} + d \rightarrow W^{-} \rightarrow e^{-} + \bar{\nu}$$

- Reconstruct Ws through e^+ and e^- decay channels
- V-A coupling leads to perfect spin separation
- Neutrino helicity gives preferred direction in decay

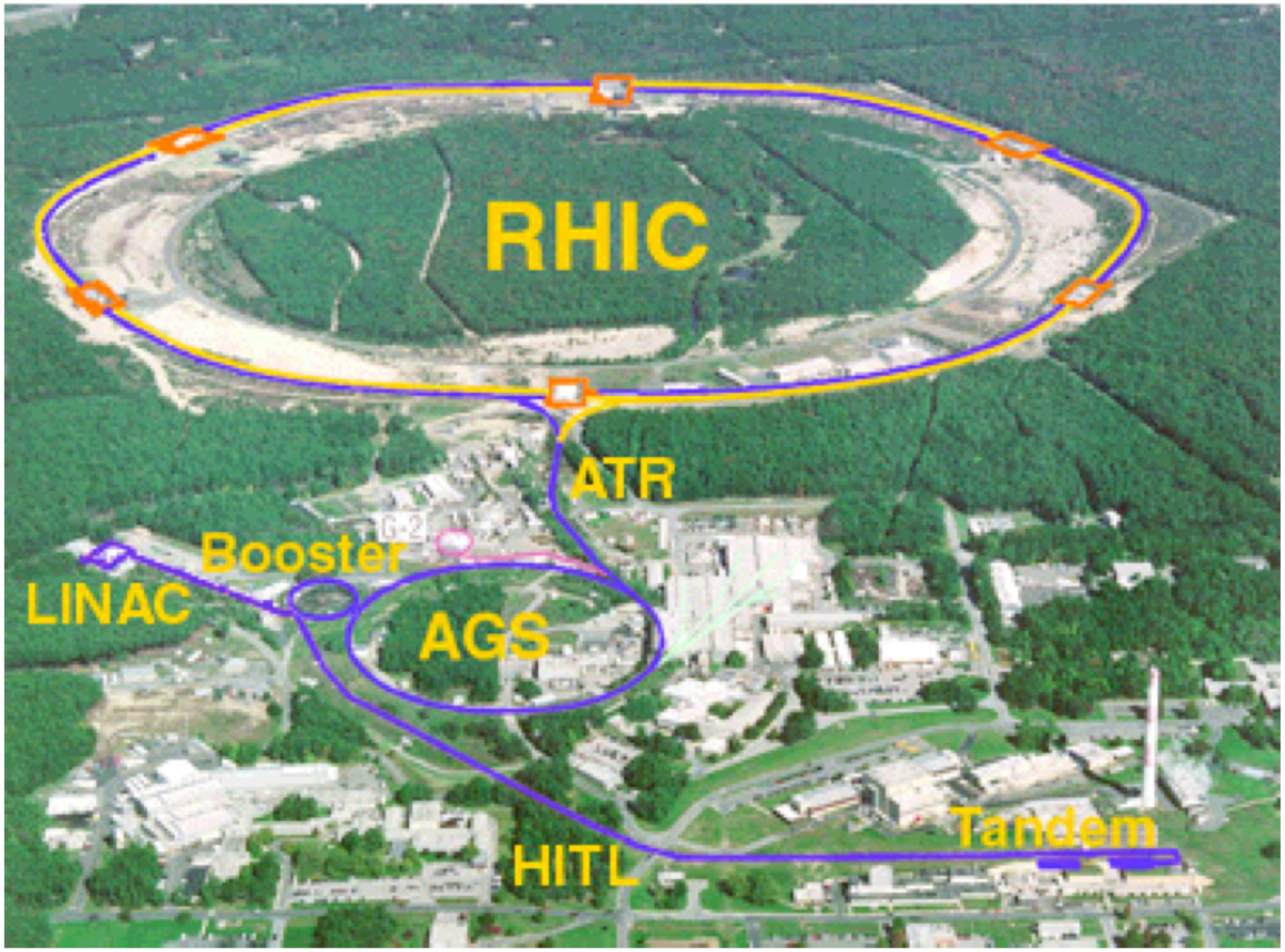
Measure parity violating single helicity asymmetry A_L

(Helicity flip in one beam while averaging over the other)

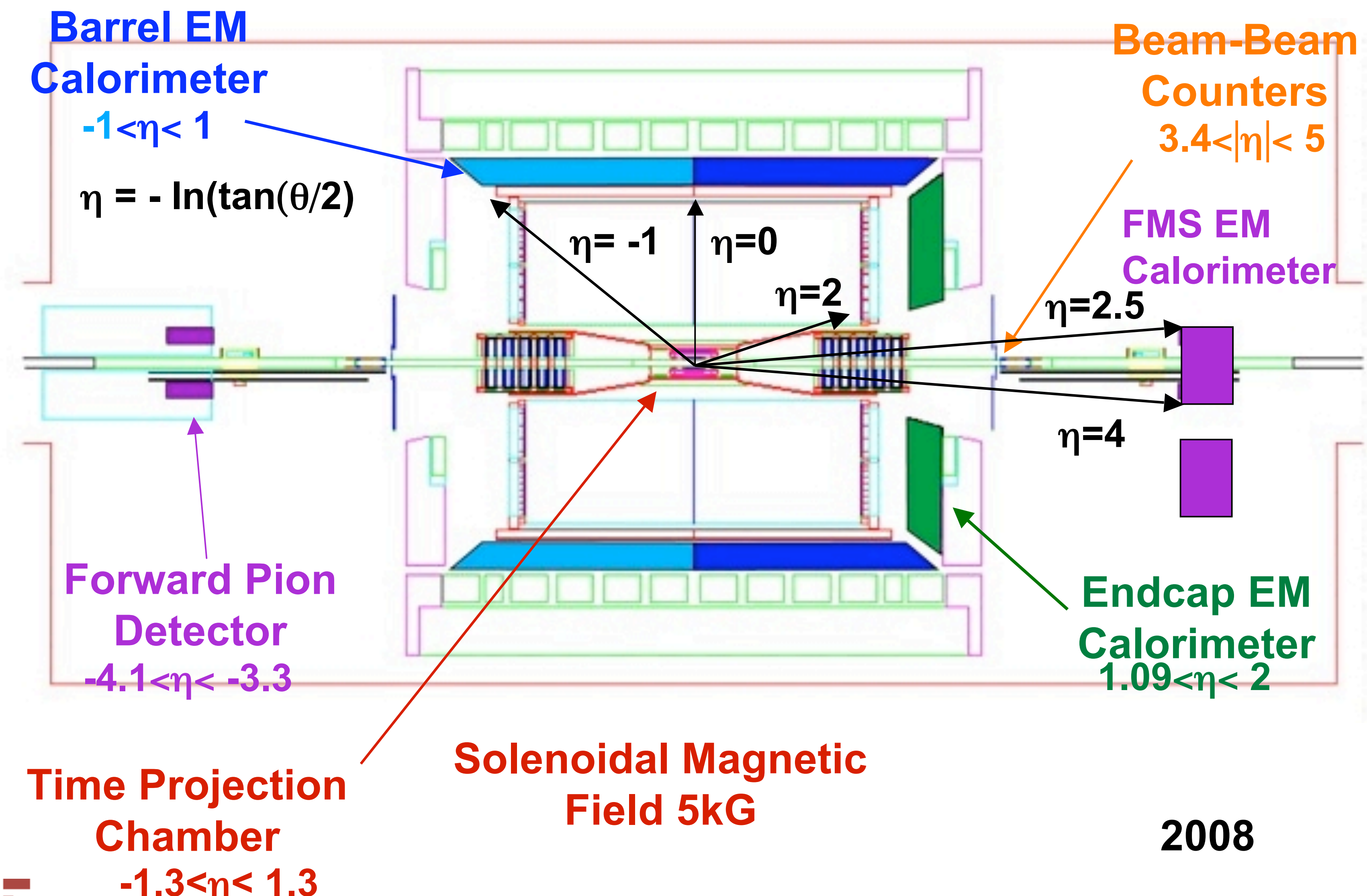
$$A_L^{W-} \propto \Delta d(x_1)\bar{u}(x_2) - \Delta\bar{u}(x_1)d(x_2) \qquad A_L^{W^+} \propto \Delta u(x_1)\bar{d}(x_2) - \Delta\bar{d}(x_1)u(x_2)$$

RHIC

The world's first polarized proton collider



STAR



Solenoidal Magnetic Field 5kG

2008

Two Regions for Ws

There are two different kinematical regimes in which STAR can reconstruct the W

Forward/Backward Rapidity

At forward or backward rapidity (defined by polarized proton), the formulas for the single helicity asymmetries simplify to

$$A_L^{W^+}(y_W >> 0) \approx \frac{\Delta u(x)}{u(x)} \qquad A_L^{W^-}(y_W >> 0) \approx \frac{\Delta d(x)}{d(x)}$$

$$A_L^{W^+}(y_W << 0) \approx -\frac{\Delta \bar{d}(x)}{\bar{d}(x)} \qquad A_L^{W^-}(y_W << 0) \approx -\frac{\Delta \bar{u}(x)}{\bar{u}(x)}$$

Mid Rapidity

At mid-rapidity, interpretation is mired by large q_T dependent resummation effects

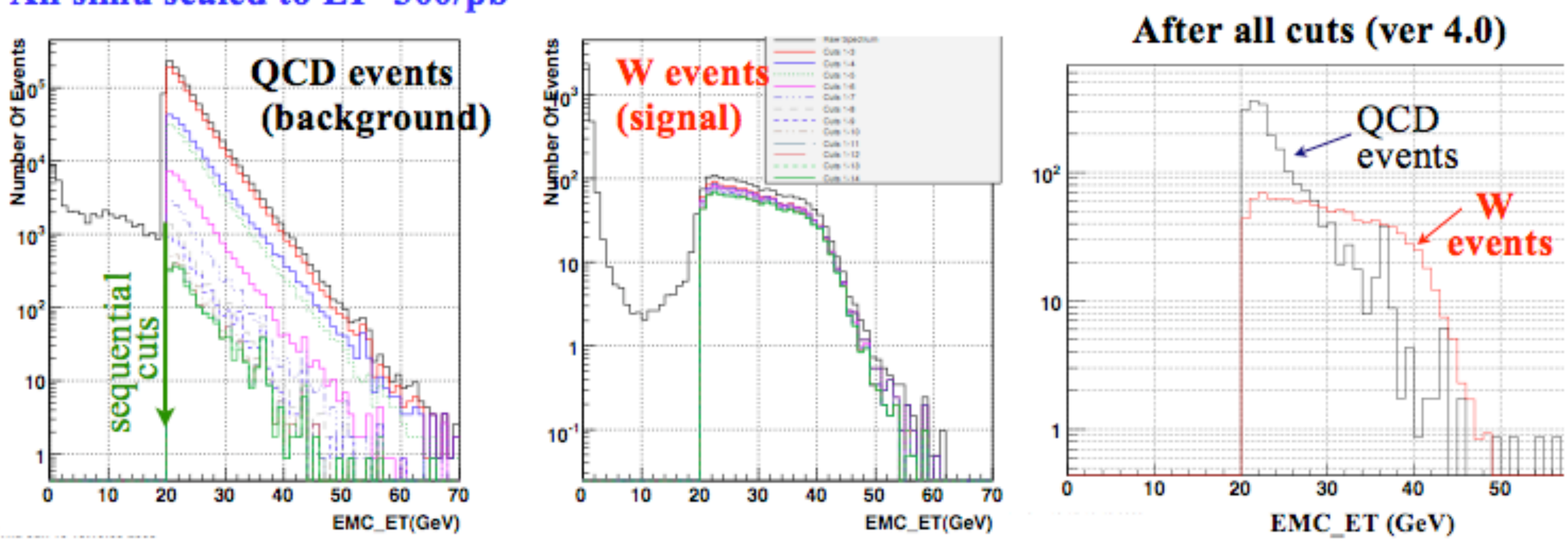
$$A_L^{W^+} \approx \frac{\Delta u(x_1)\bar{d}(x_2) - \Delta \bar{d}(x_1)u(x_2)}{u(x_1)\bar{d}(x_2) + \bar{d}(x_1)u(x_2)}$$

$$A_L^{W-} \approx \frac{\Delta d(x_1)\bar{u}(x_2) - \Delta \bar{u}(x_1)d(x_2)}{d(x_1)\bar{u}(x_2) + \bar{u}(x_1)d(x_2)}$$

Ws at forward rapidity - I

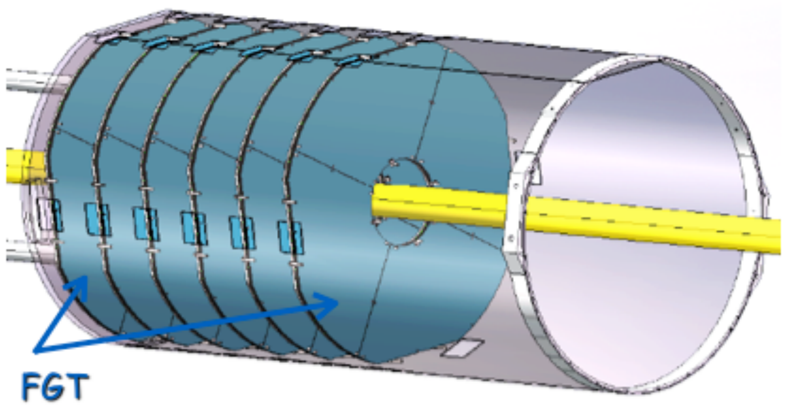
- Generated 10e10 pythia QCD events with full detector response
- e/h separation based on isolation style, missing E_T, and EEMC specific PID cuts
- With current algorithm S/B>1 for E_T > 30 GeV
- Assumes good tracking at forward rapidity

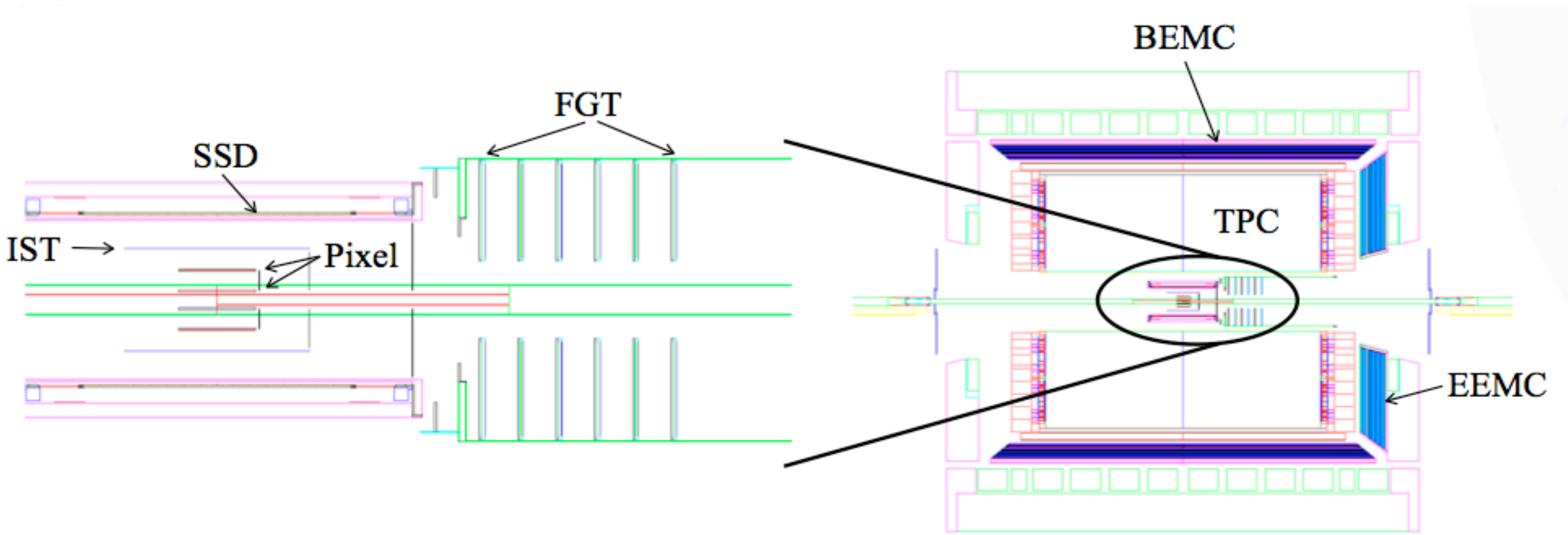
All simu scaled to LT=300/pb



Forward Triple GEM Tracker

An upgrade is in preparation at STAR at forward rapidity that will be able to handle the rates/number of tracks at sqrt(s)=500 GeV



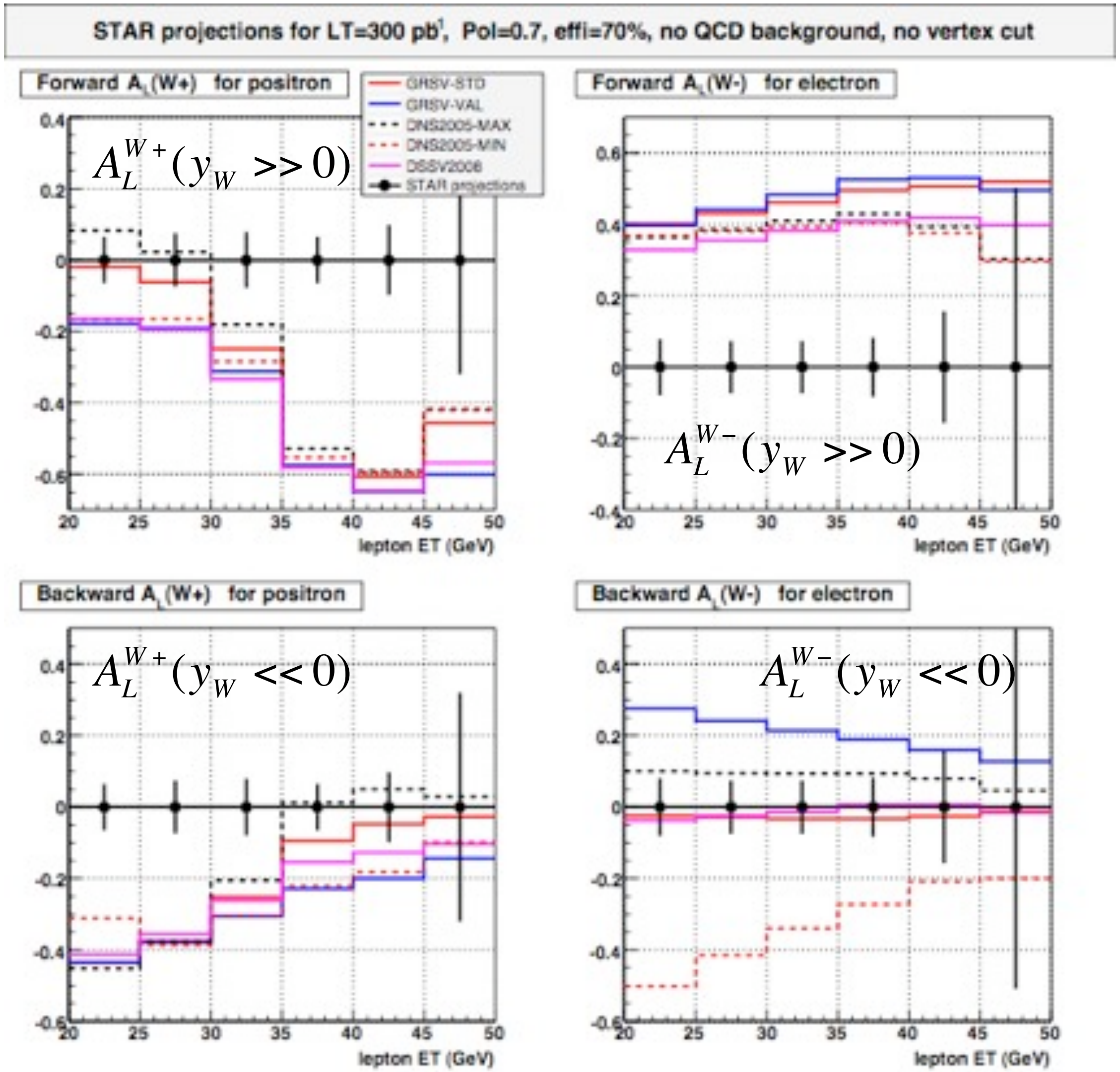


Ws at forward rapidity - II

The 500 GeV Program at RHIC should take about $300pb^{-1}$ of data.

The expected uncertainties as a function of the decay lepton E_T is shown to the right

Assumes the sensitivities from the simulations and an installed FGT

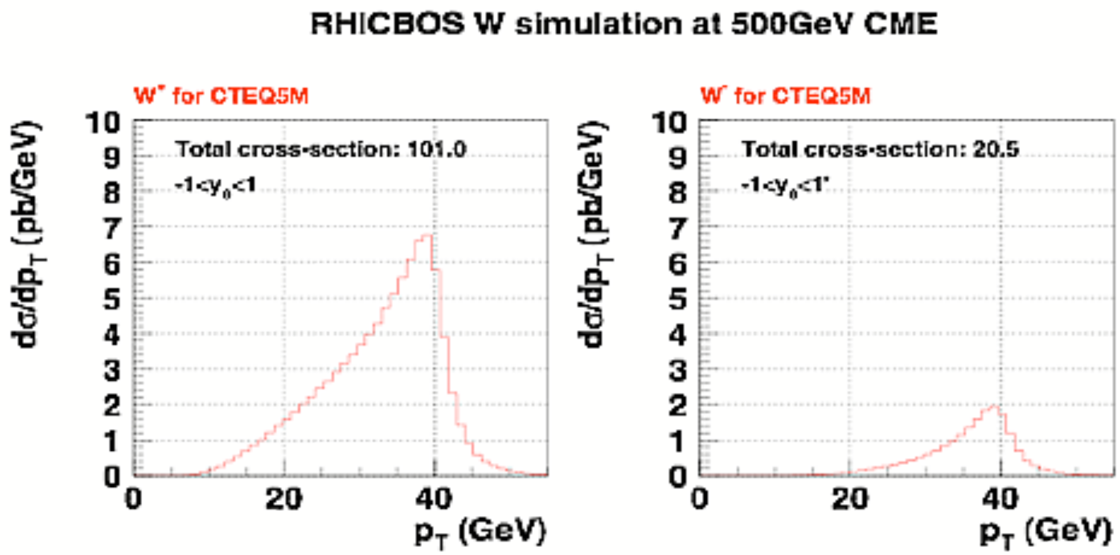


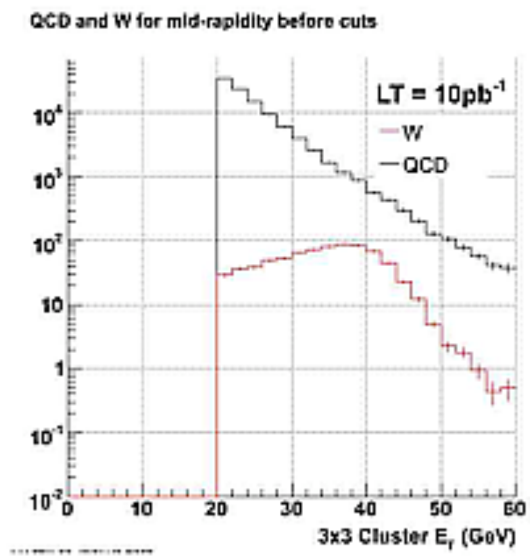
Ws at mid-rapidity - I

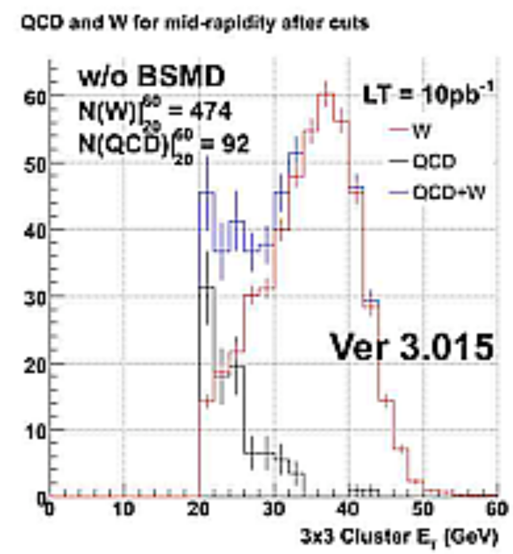
The cross section for mid-rapidity W production is ~3x larger than at forward rapidity

STAR has the capabilities in place to reconstruct the W at mid-rapidity.

An algorithm was developed to reconstruct the W at mid-rapidity and simulations were performed using pythia+full detector response.



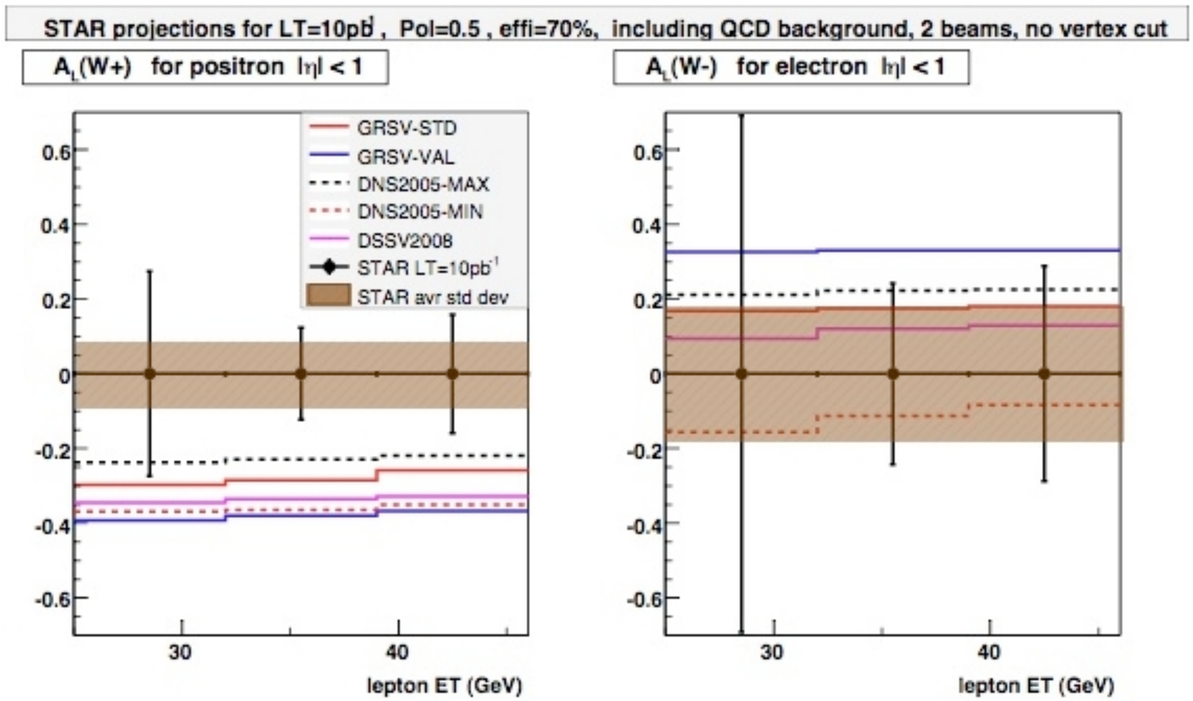




Ws at mid-rapidity - II

RHIC just completed its first sqrt(s) = 500 GeV running period

During this running STAR collected 10pb^{-1} with an average polarization of ~35%



With current implementation of algorithm, STAR expects to reconstruct ~350 Ws

A goal is a first measurement of A_L for W production

Conclusions

- W production in polarized proton-proton collisions at RHIC will constrain polarized ubar/dbar distributions in the proton
- Construction and installation of the FGT will allow tracking and charge sign discrimination at forward rapidity.
- STAR has collected its first data sample at sqrt(s)=500 GeV (~10pb^{-1}) and is working to reconstruct its first W signal.