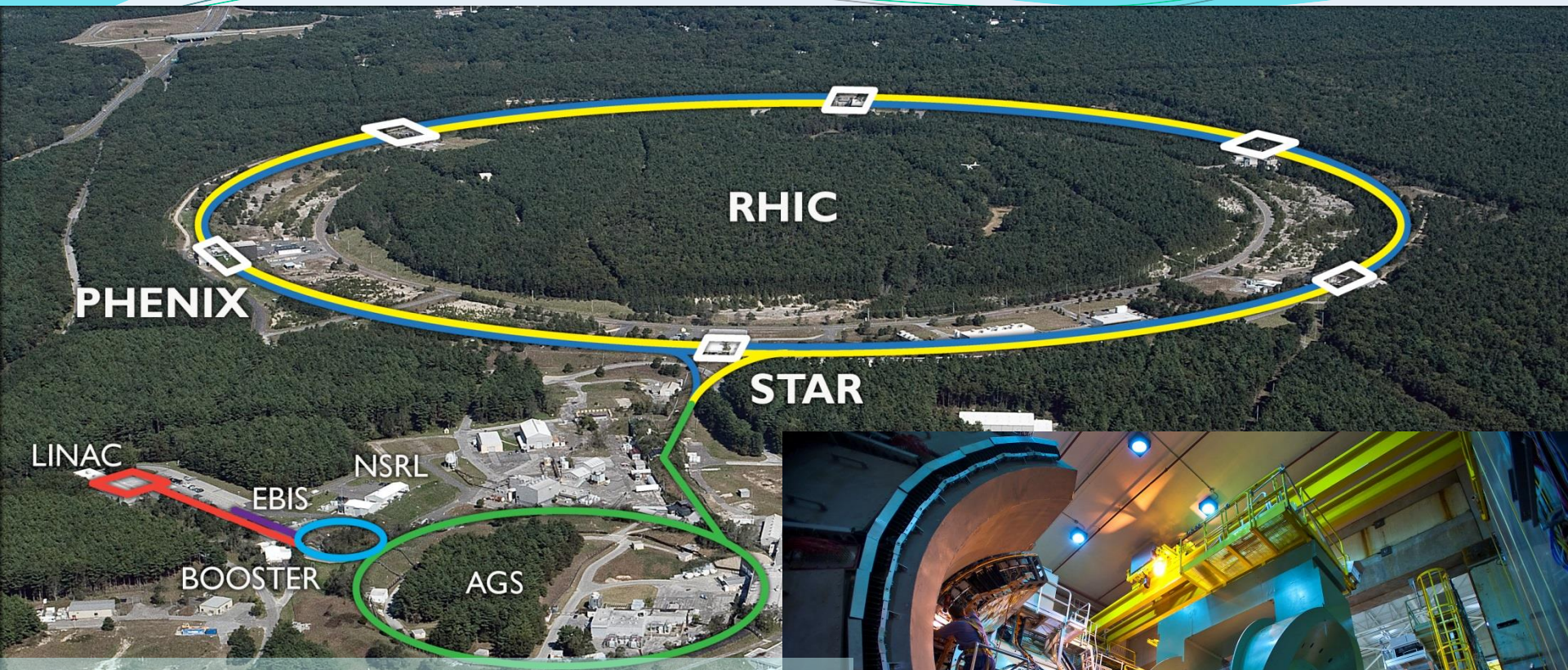
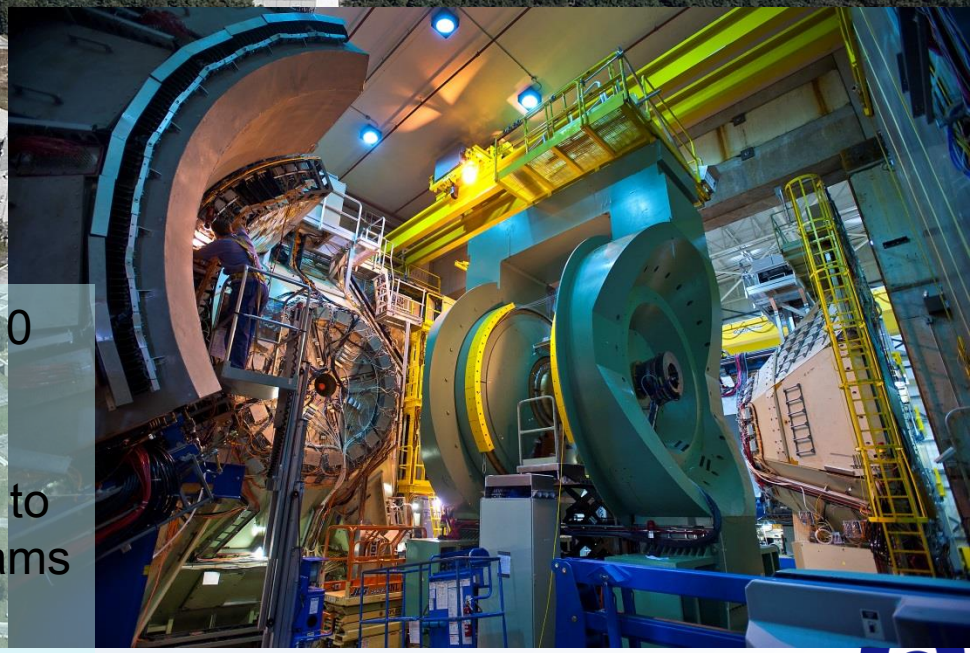
A_{LL} measurements

DIS 2016, April 11-15,
DESY, Hamburg
Taebong Moon (Yonsei/RIKEN),
Ralf Seidl
(RIKEN)
For the PHENIX collaboration

RIKEN

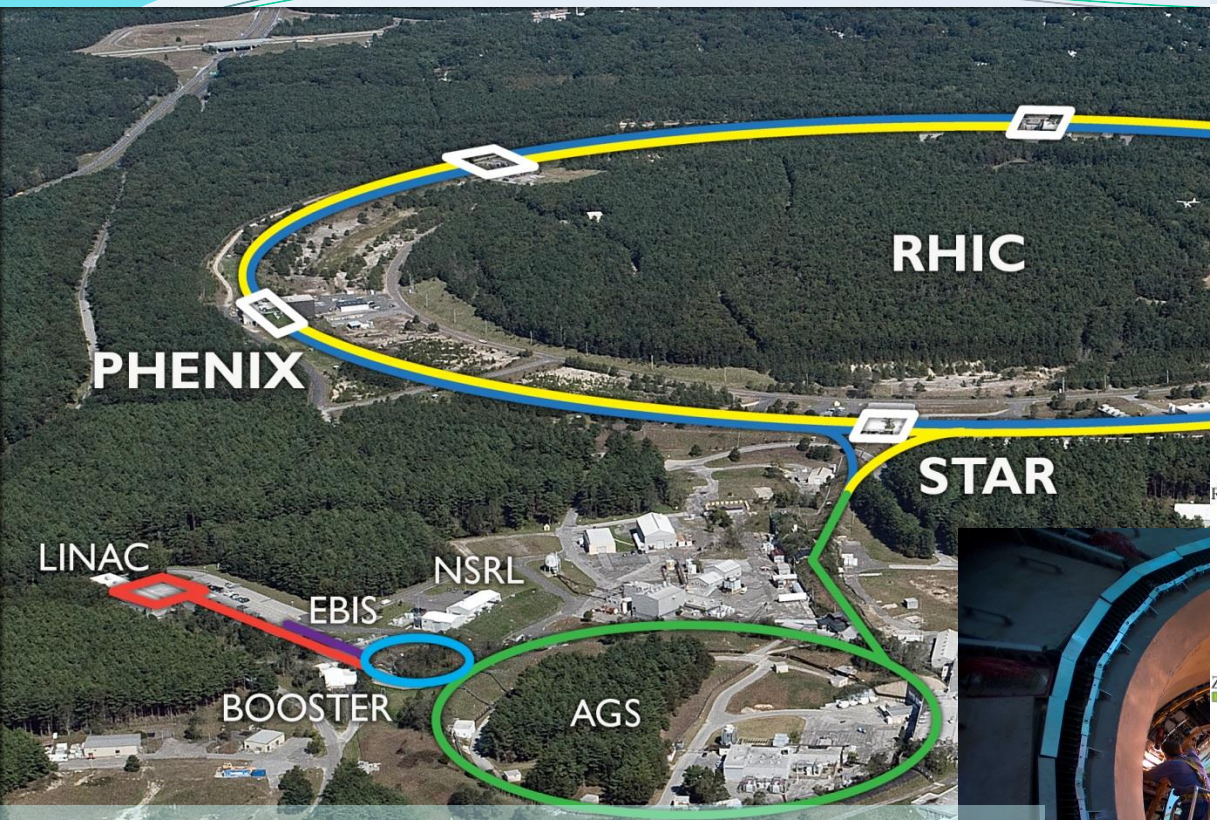
RHIC and PHENIX

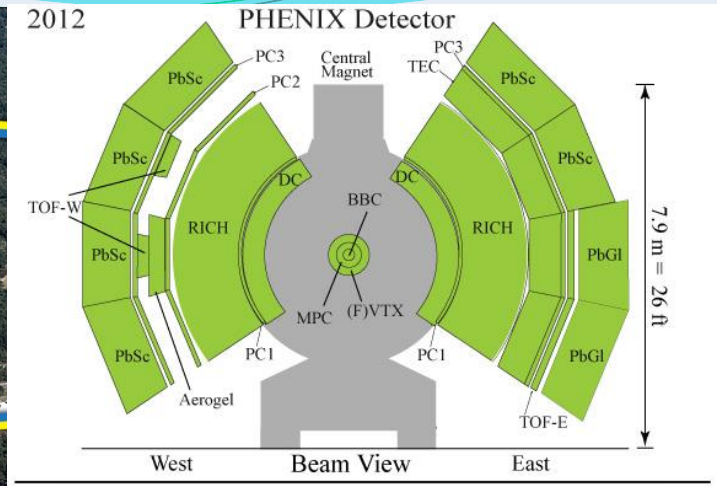


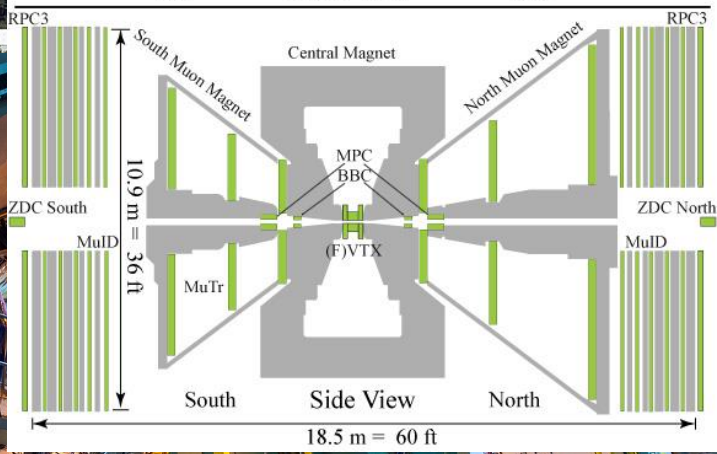


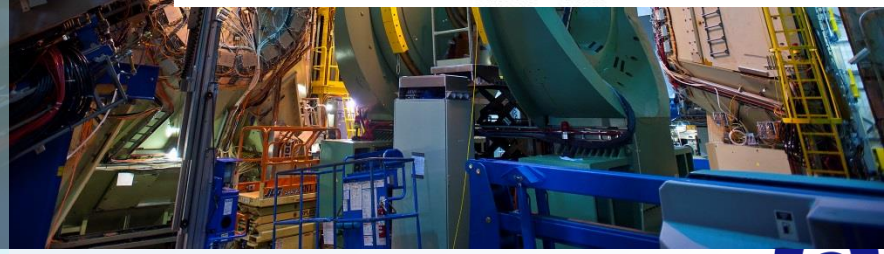
- Polarized proton beams from $\sqrt{s}$ of 62-510 GeV
- pA, AA collisions up to 200 GeV
- Spin rotators around PHENIX and STAR to select long. or transversely polarized beams
- Global and local polarimetry

RHIC and PHENIX



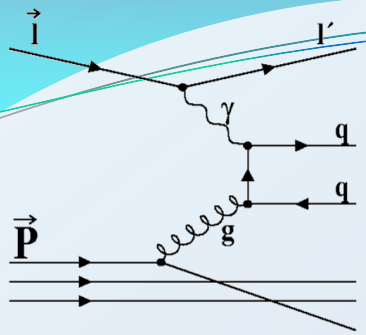




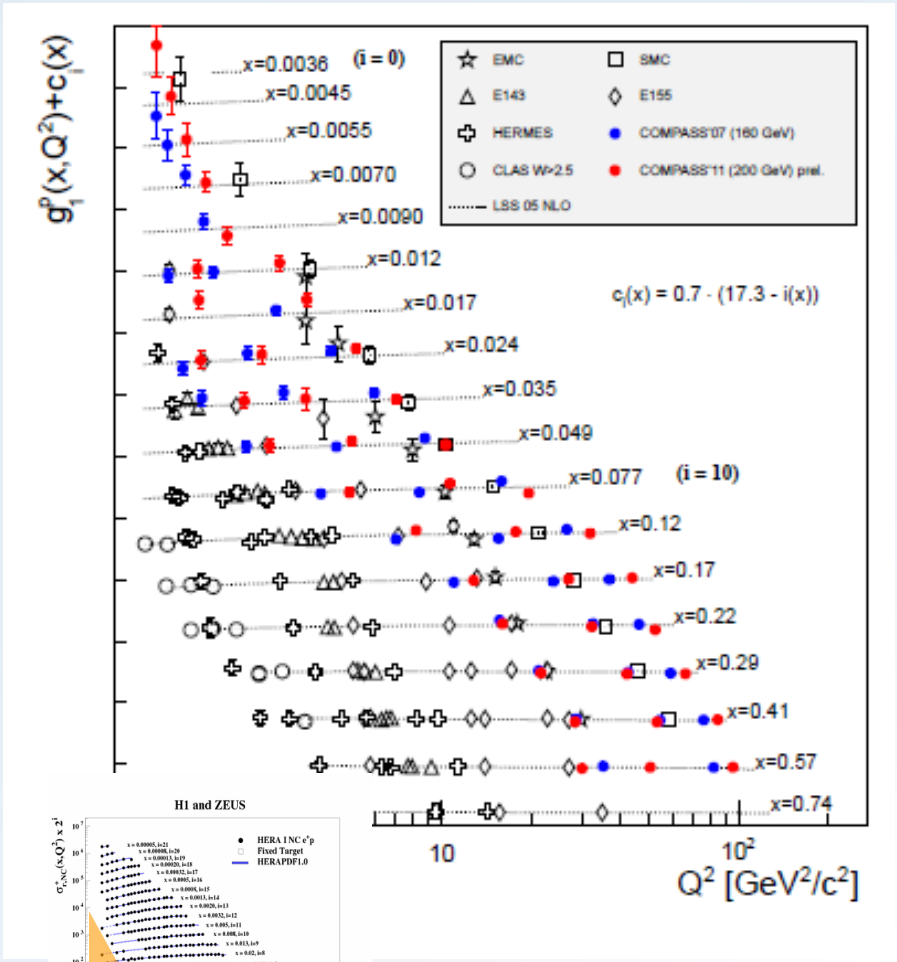


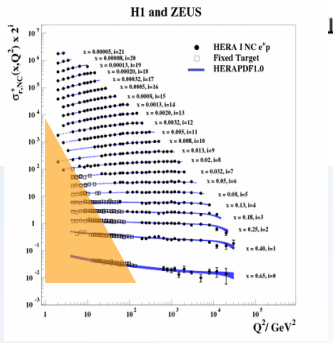
- Polarized proton beams from $\sqrt{s}$ of 62-510 GeV
- pA, AA collisions up to 200 GeV
- Spin rotators around PHENIX and STAR to select long. or transversely polarized beams
- Global and local polarimetry

Gluon polarization



- Barely access via DIS data through DGLAP evolution (no large Q^2 lever arm)
- Some access in SIDIS through high Pt hadrons and charmed mesons

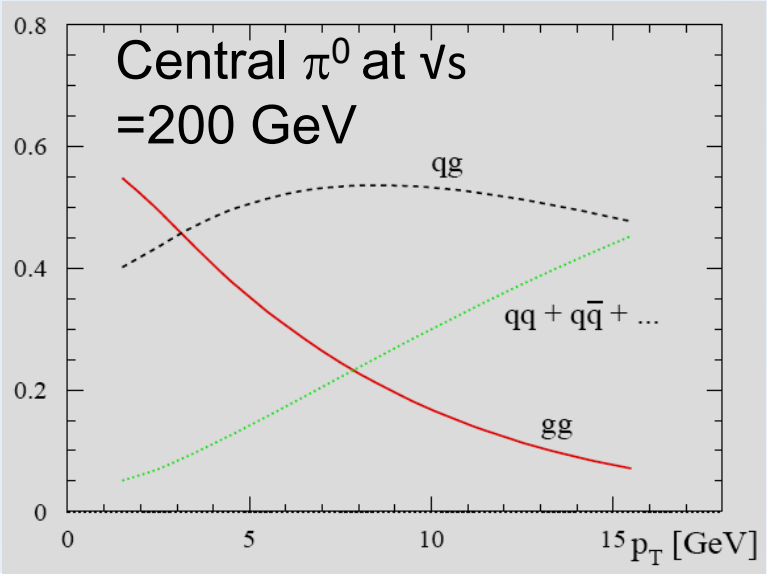


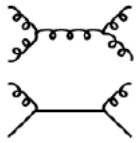
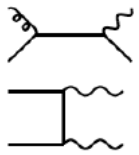
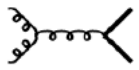


Gluon polarization

- Barely access via DIS data through DGLAP evolution (no large Q^2 lever arm)
- Some access in SIDIS through high Pt hadrons and charmed mesons
- Polarized pp collisions at LO in α_S sensitive to gluons

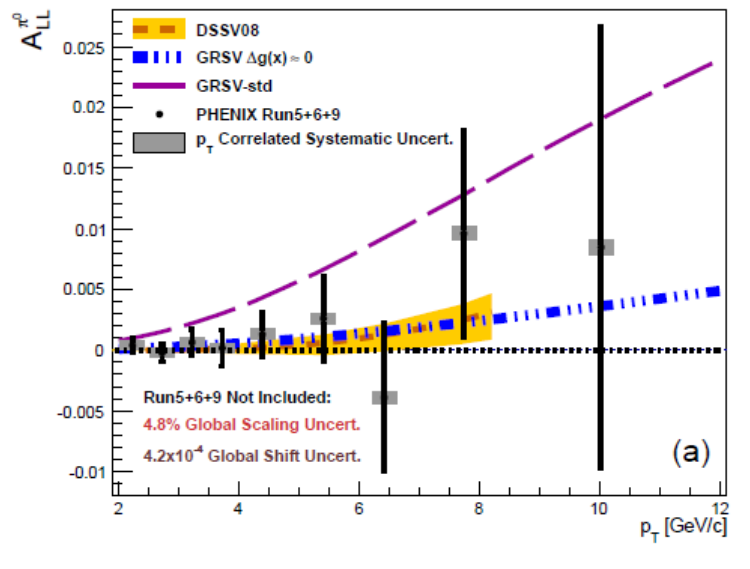
➔long. double spin asymmetries A_{LL} access Δg



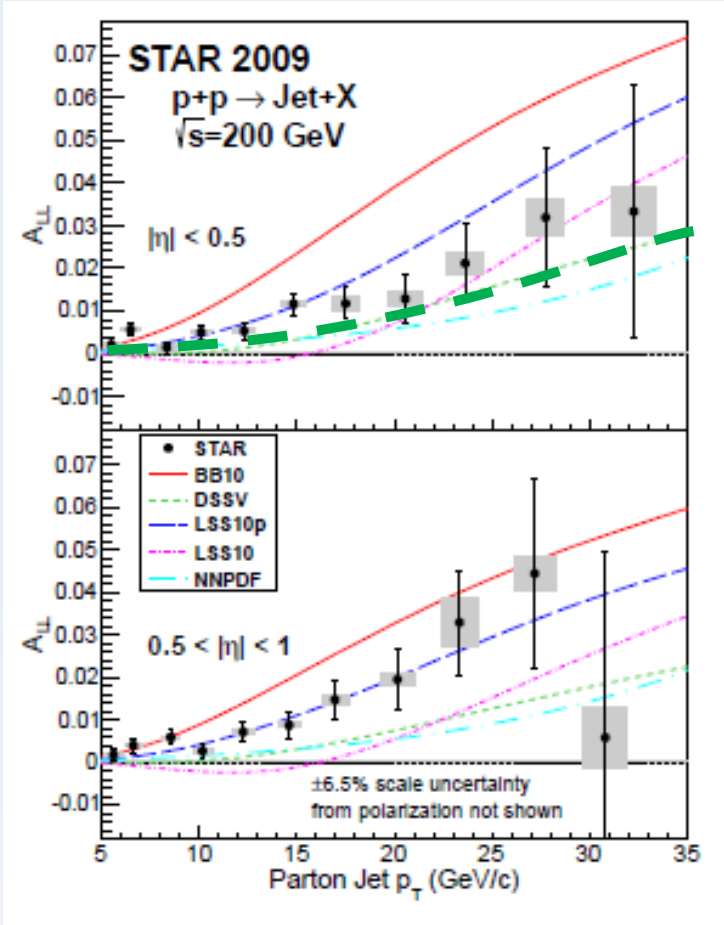
Reaction	Dom. partonic process	probes	LO Feynman diagram
$\vec{p}\vec{p} \to \pi + X$	$\vec{g}\vec{g} \to gg$ $\vec{q}\vec{g} \to qg$	Δg	
$\vec{p}\vec{p} \to \text{jet(s)} + X$	$\vec{g}\vec{g} \to gg$ $\vec{q}\vec{g} \to qg$	Δg	(as above)
$\vec{p}\vec{p} \to \gamma + X$ $\vec{p}\vec{p} \to \gamma + \text{jet} + X$	$\vec{q}\vec{g} \to \gamma q$ $\vec{q}\vec{g} \to \gamma q$	Δg Δg	
$\vec{p}\vec{p} \to \gamma\gamma + X$	$\vec{q}\vec{\bar{q}} \to \gamma\gamma$	$\Delta q, \Delta\bar{q}$	
$\vec{p}\vec{p} \to DX, BX$	$\vec{g}\vec{g} \to c\bar{c}, b\bar{b}$	Δg	

Current highlights: gluon helicities

PHENIX: Phys.Rev. D90 (2014) 012007



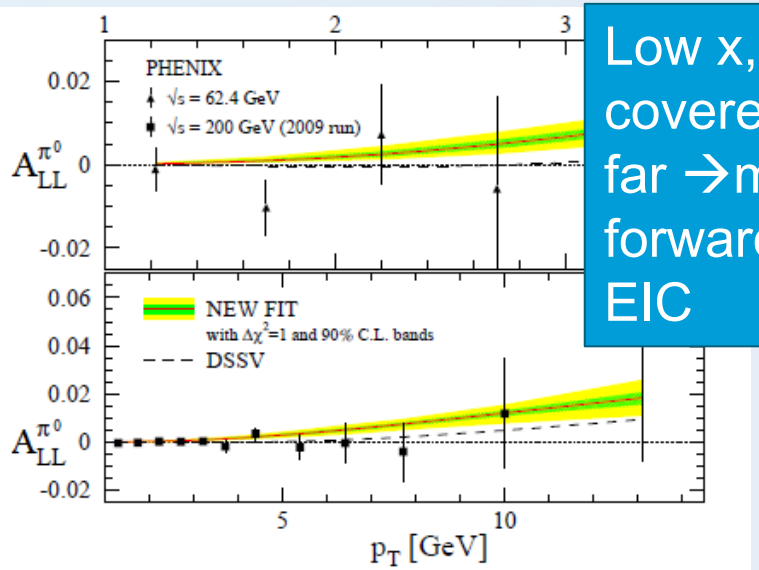
STAR: arXiv:1405.5134



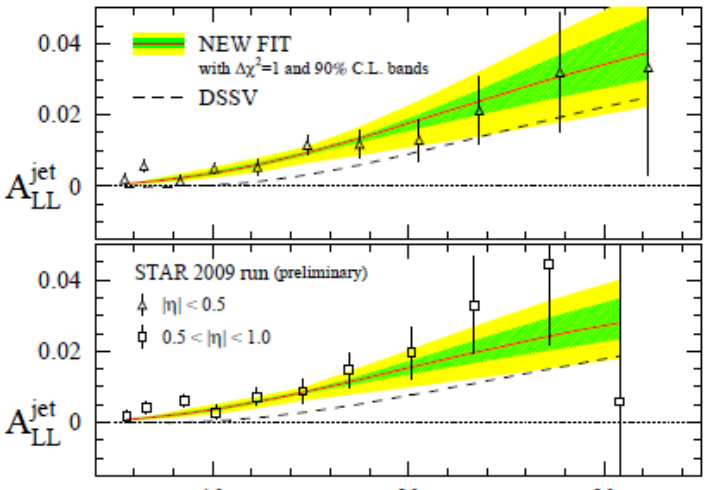
- 200 GeV up to 2009 did not show any large A_{LL}
- First indications of nonzero gluons in 2009 data, especially Star's jet A_{LL}s

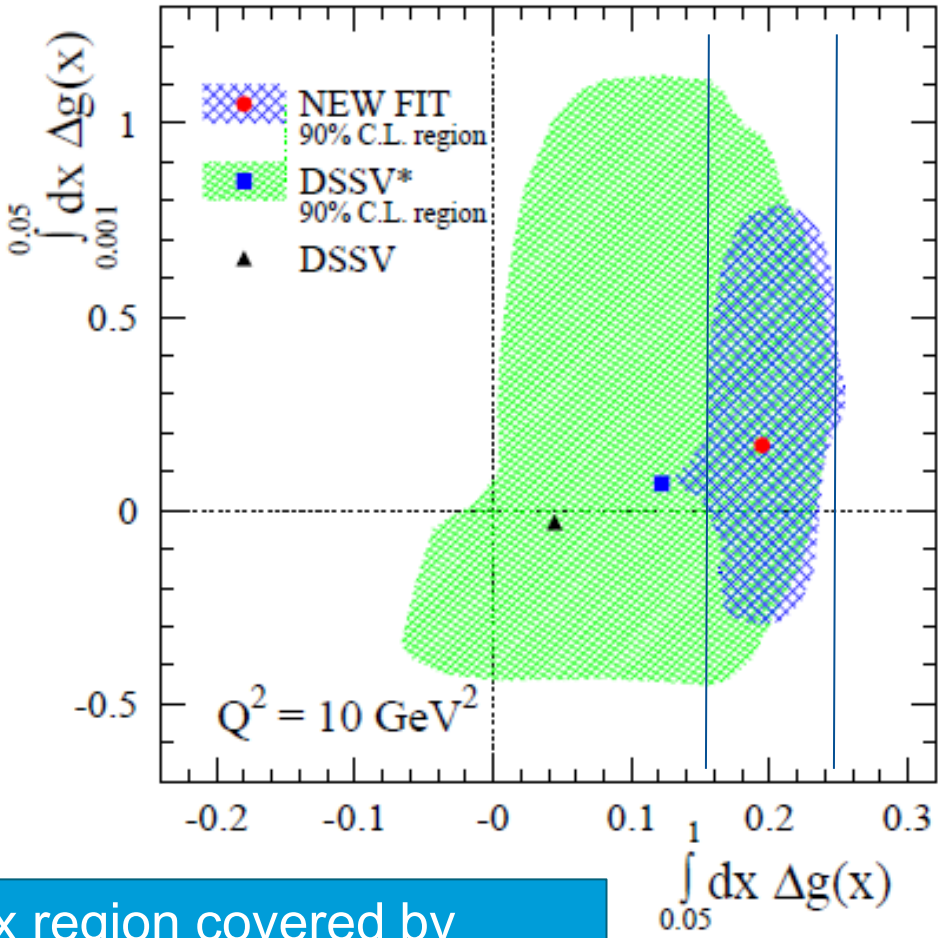
First nonzero gluon spin indication

- DSSV:Phys.Rev.Lett. 113 (2014) 012001



Low x, not covered so far →more forward pp, EIC

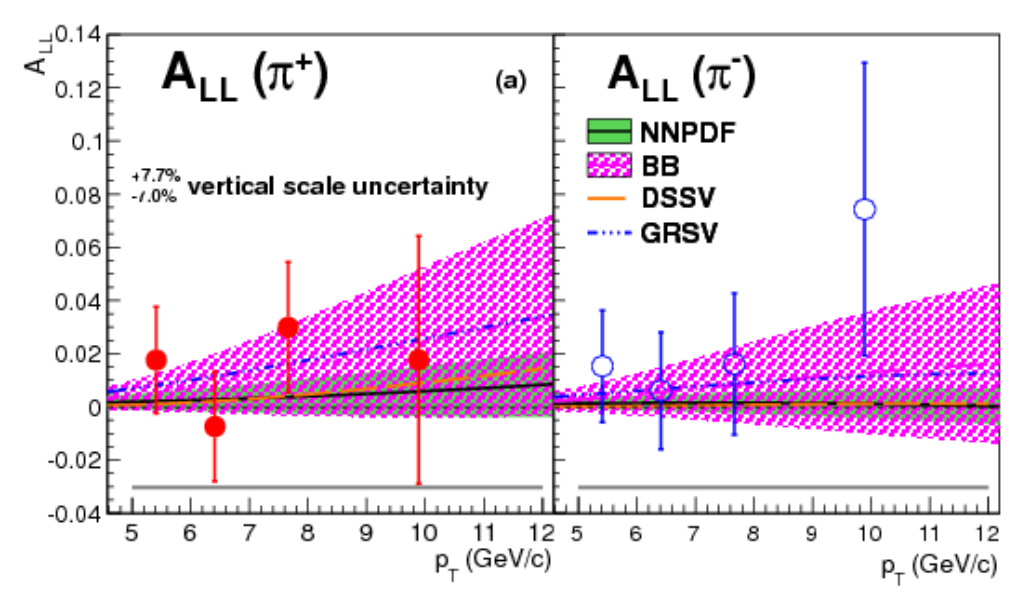




x region covered by current RHIC and DIS results

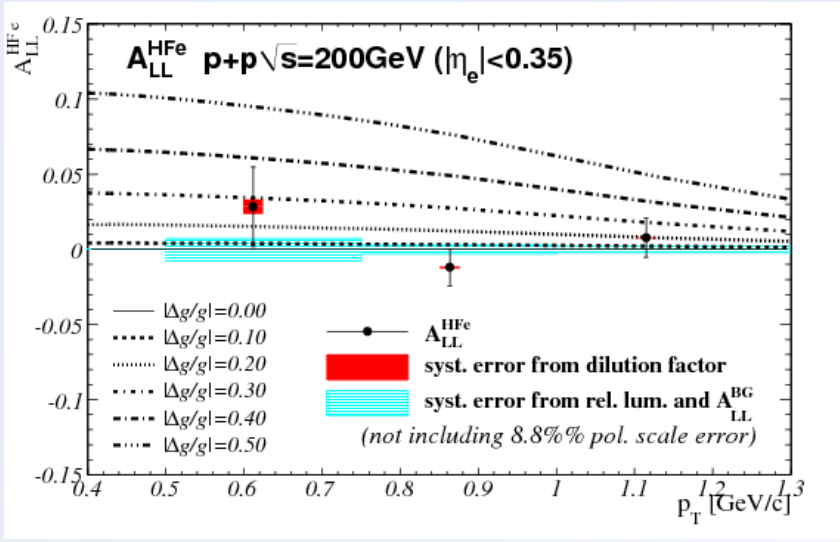
Other 200 GeV results not yet used in global fit

Phys.Rev. D91 (2015) 3, 032001



- Charged pions as potential direct indicator for sign of Δg via pion A_{LL} ordering
- 500 GeV analysis ongoing
- Reduced statistics compared to π^0 due to triggering
- Also central η

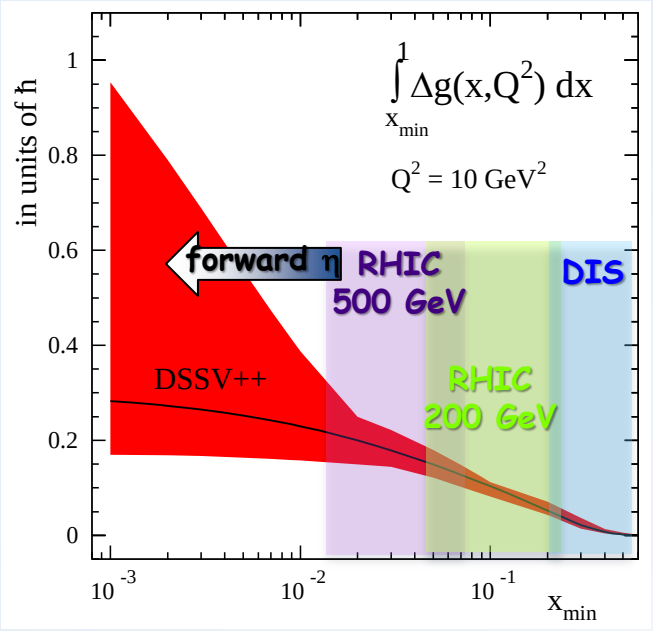
Phys.Rev. D87 (2013) 012011



- Single electrons at central rapidity from heavy flavor production directly sensitive to gluon helicity
- Large scale given by the HF quark masses

Next steps: extend gluon x range

- Higher beam energies at 510 GeV in 2011-2013 increase sensitivity towards lower x for workhorse measurements (central pions and Jets)
- Forward measurements will access more asymmetric collisions and even lower x to below $x=10^{-2}$ in forward pion and jet measurements
- Improved precision in central jet and pion measurements
- Later: Forward jet and Di-jets to scan x range

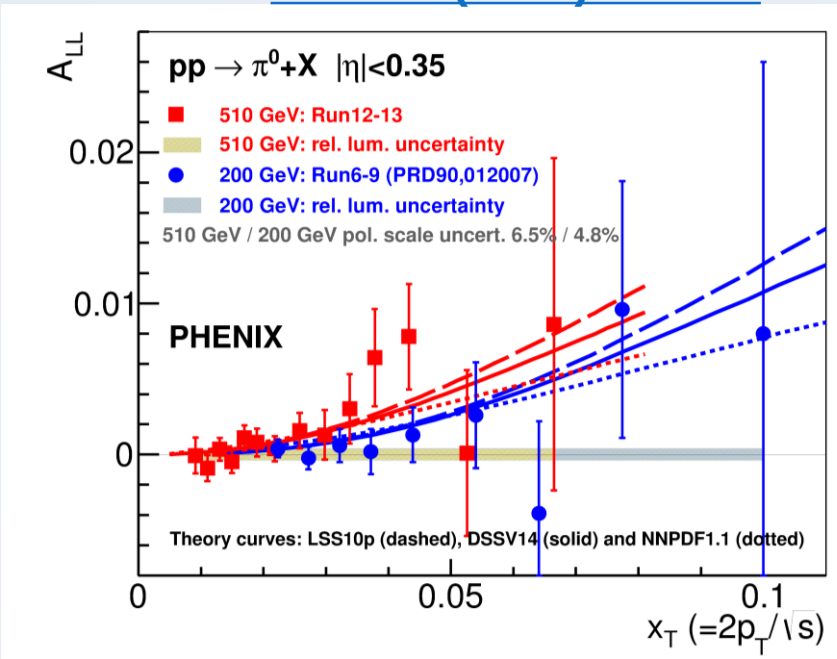


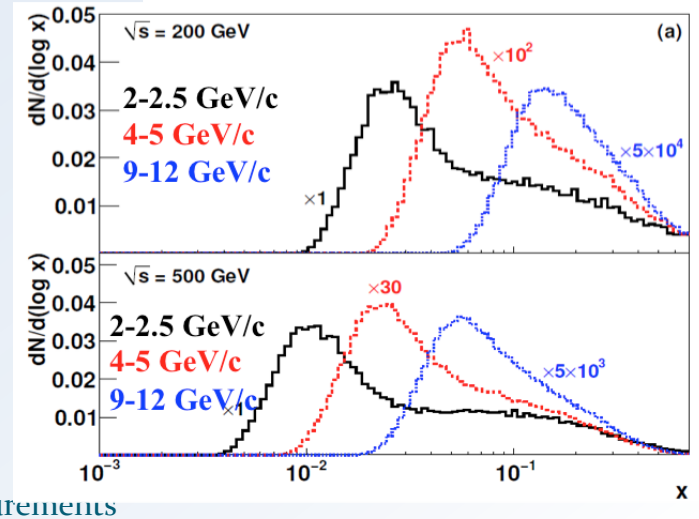
Even lower x accessible eventually at EIC

higher energies at central rapidity

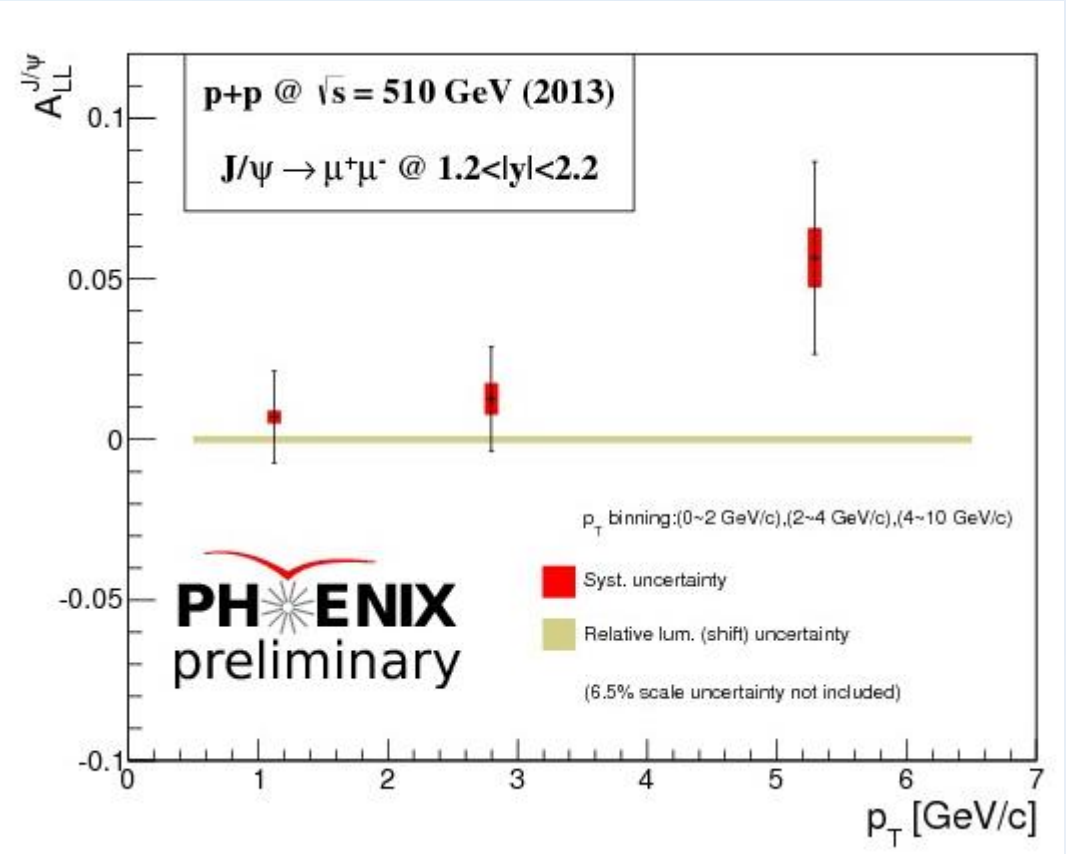
PHENIX PRD 93 (2016) 011501

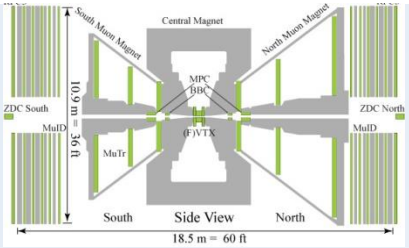
- Nonzero gluon polarization established with RHIC √s = 200 GeV data
- RHIC 510 GeV data (>2011) now confirms it in workhorse measurement
- Extend access to lower x by higher energy
- Charged pion analysis at 510 GeV ongoing

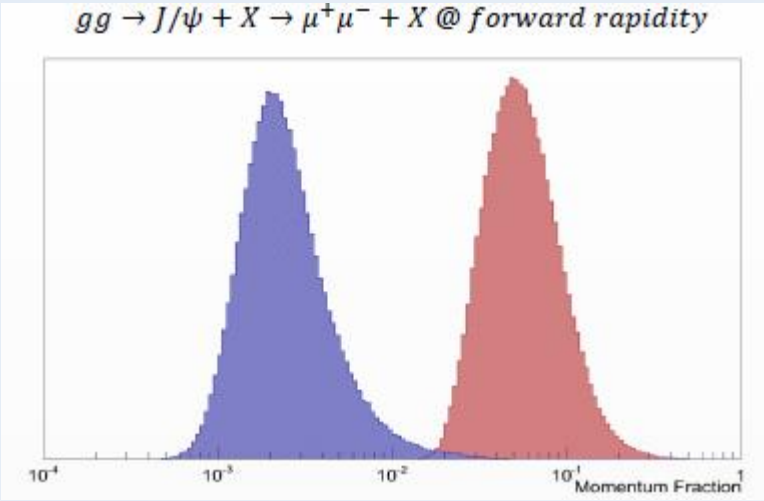




Forward J/Psi asymmetries @ 510 GeV





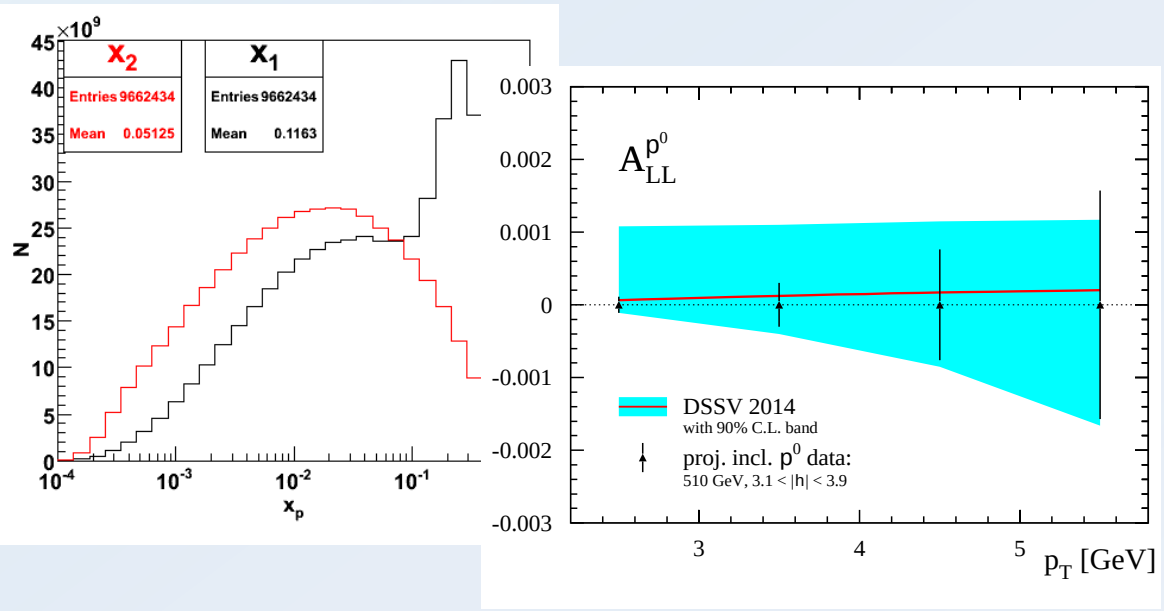


- J/Psi predominantly produced via gluon-gluon scattering
- Access to x_g~2-3 10^{-3}
- production mechanism still not entirely clear
- Feed down with similar gluon dependence

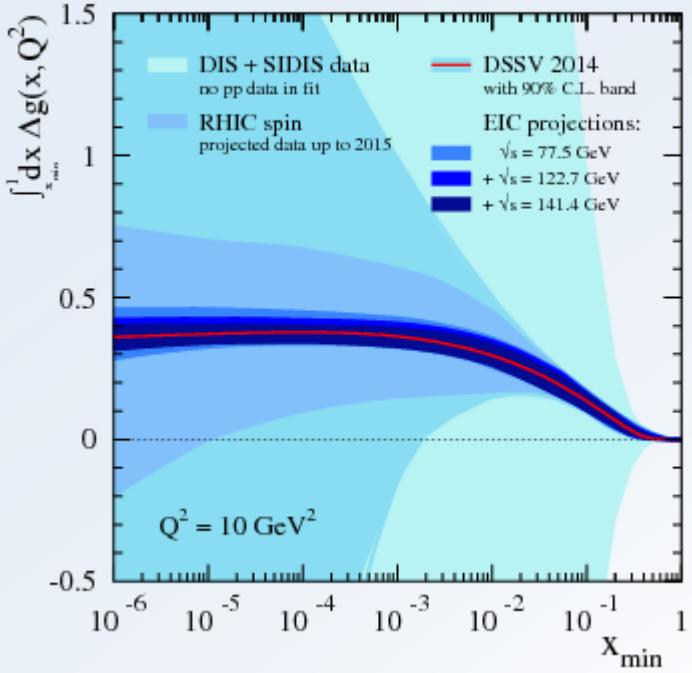
Expected impact of existing RHIC data

Forward π^0 in $3.1<\eta<3.9$, $p_T>1$GeV

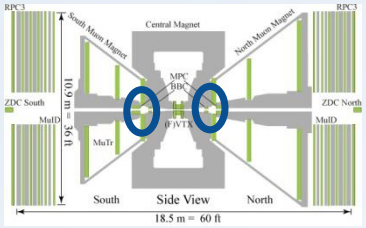
RHIC Spin LRP white paper: http://arxiv.org/abs/arXiv:1501.01220
and CNM plan: http://arxiv.org/abs/arXiv:1602.03922



RPD 92 (2015) 094030



- 2013 data analysis of forward po/clusters sensitive to lower x
- Analysis ongoing



- Running integral of the total gluon helicity

Summary

- First nonzero pion double spin asymmetries confirm sizeable gluon spin contribution to the proton spin
- Sensitivity extended with central pions at 510 GeV to ~0.01
- Forward J/Psi asymmetries reach down to 0.001 with slightly positive asymmetry
  - Potential strong impact if production mechanism known
- More forward neutral pion and central charged pion measurements ongoing