Overview of SoLID

Solenoidal **L**arge **I**ntensity **D**evice

- **Full exploitation of JLab 12 GeV Upgrade**

  → A **Large Acceptance** Detector **AND** Can Handle **High Luminosity** (10^{37}-10^{39})

  Take advantage of latest development in detectors , data acquisitions and simulations

  Reach ultimate precision for SIDIS (TMDs), PVDIS in high-*x* region and threshold J/ψ

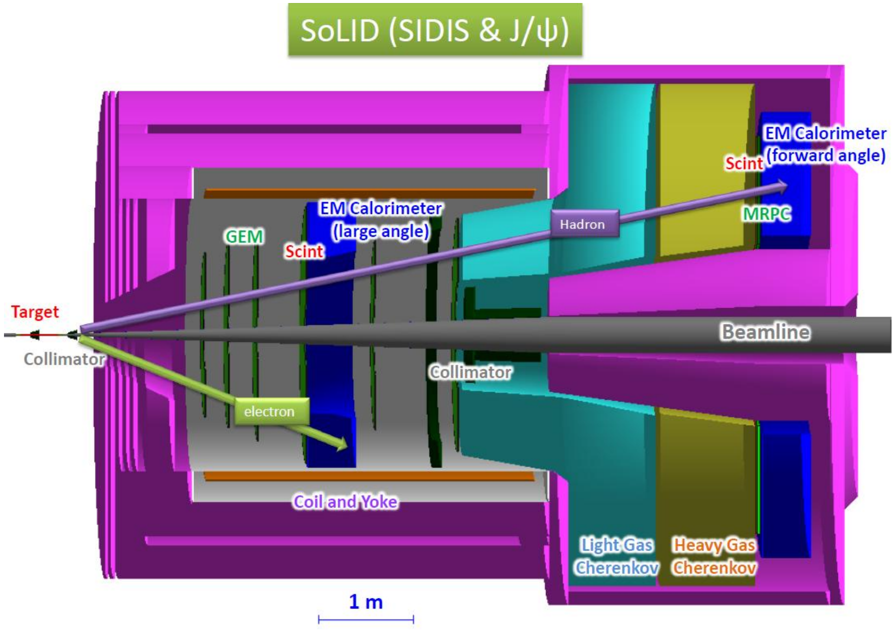
- **5 highly rated experiments approved**

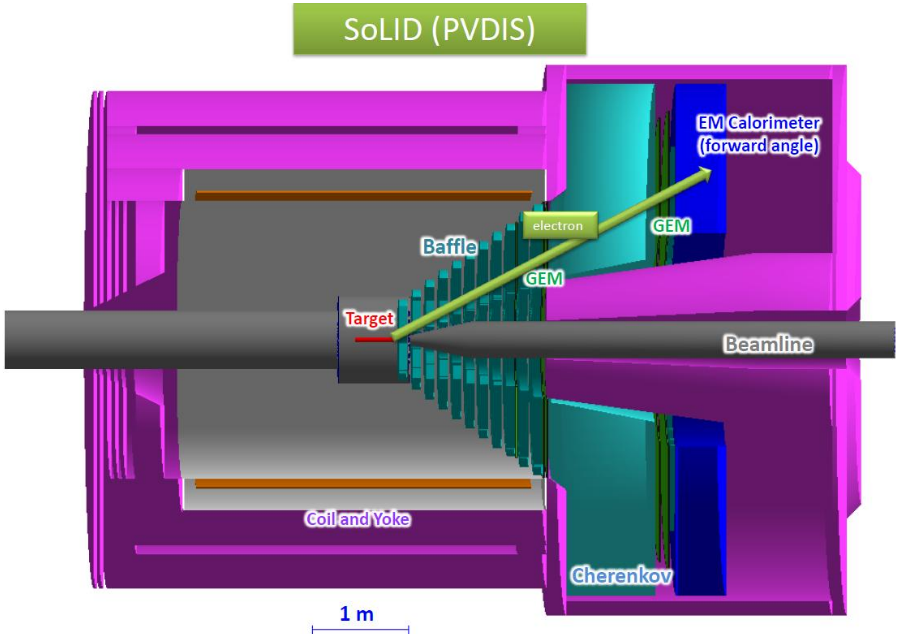
  Three SIDIS experiments, one PVDIS, one J/ψ production

  Bonus: di-hadron, Inclusive-SSA, and much more …

- **Strong collaboration** (200+ collaborators from 50+ institutes, 11 countries)

  Significant international contributions



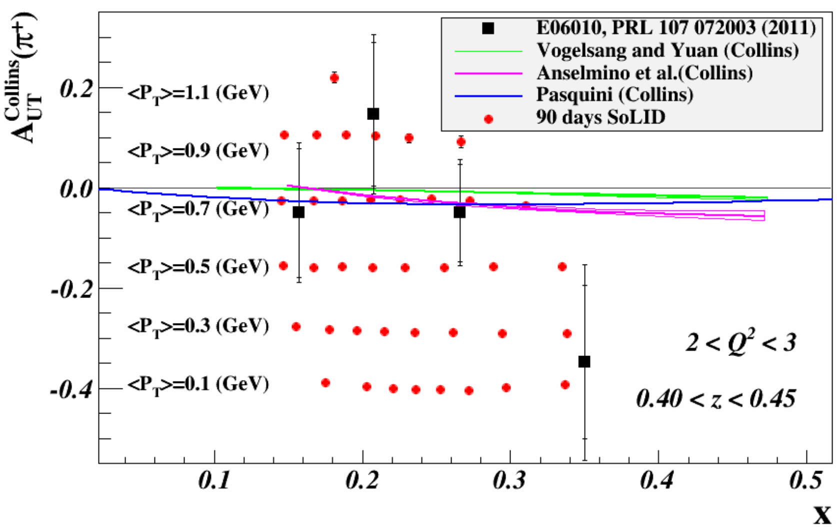


Nucleon Structure with SoLID-SIDIS

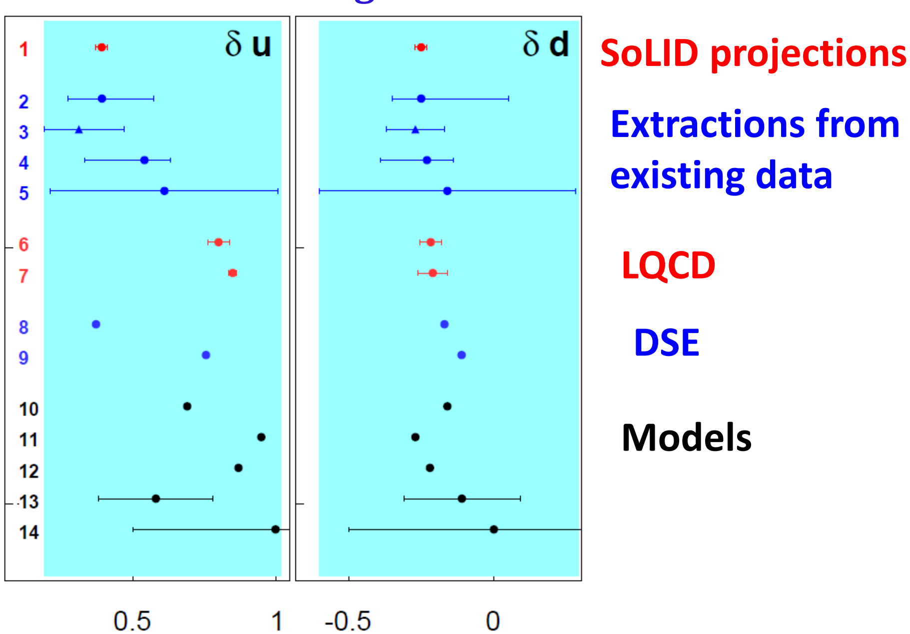
Semi-inclusive Deep Inelastic Scattering *program*:
Large Acceptance + High Luminosity
+ Polarized targets
→ **4-D** mapping of **Collins**, Sivers, and pretzelocity asymmetries,…
→ Tensor charge of quarks, **transversity** distributions, **TMDs**…
→Benchmark test of Lattice QCD, probe QCD Dynamics and quark orbital motion

Collins Asymmetry

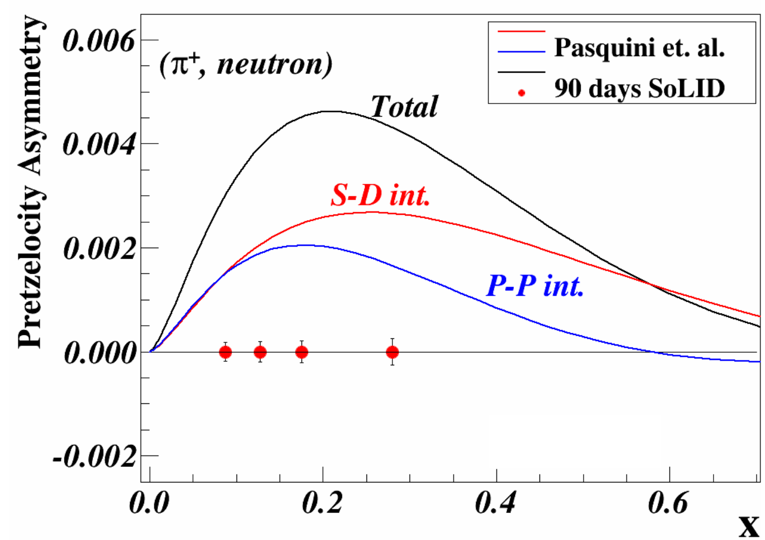
Total > 1400 points



Tensor Charges



Pretzelosity → information on OAM

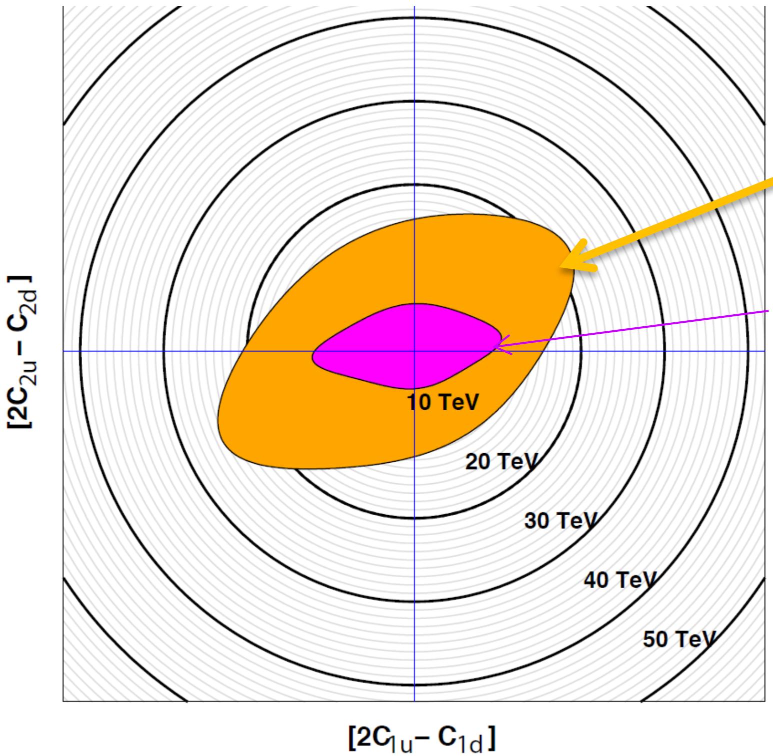


Parity Violation with SoLID

Parity-violating Deep Inelastic Scattering:

- High Luminosity on LD2 and LH2
- Better than 1% errors for small bins over large range kinematics
- Test of Standard Model
- Quark structure of nucleon:
  - **charge symmetry violation**
  - **d/u at large x**
  - **quark-gluon correlations**

Presentation by P. Souder and K. Kumar



PVDIS asymmetry has two terms:

1) C_{2q} weak couplings, test of Standard Model

2) Unique precision information on **quark structure of nucleon**

Mass reach in a composite model SoLID-PVDIS ~ 20 TeV (LHC scale)

SoLID-J/ψ: Study Non-Perturbative Gluons

Presentation by Z. Zhao

J/ψ: ideal probe of non-perturbative gluon

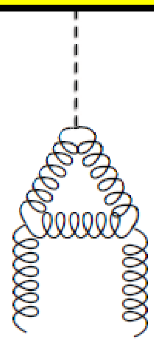
The <u>high luminosity & large acceptance</u> capability of SoLID enables a <u>unique</u> "precision" measurement near threshold

- **Shed light on the low energy J/ψ-nucleon interaction (color Van der Waals force)**
- **Shed light on the 'conformal anomaly' an important piece in the proton mass budget:**

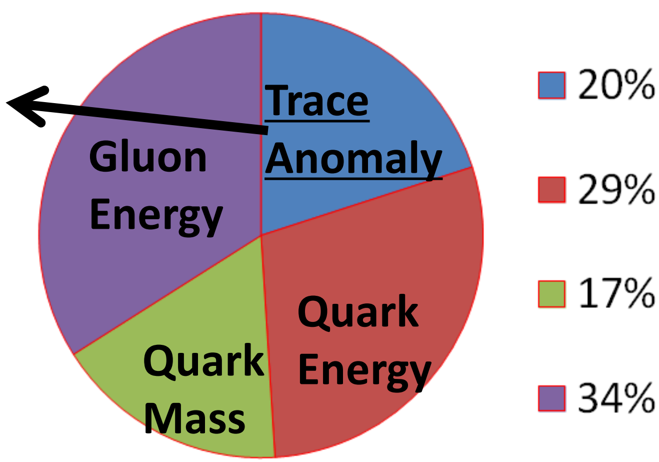
Models relate J/ψ enhancement to trace anomaly

$$\gamma^* + N \rightarrow N + J/\psi$$

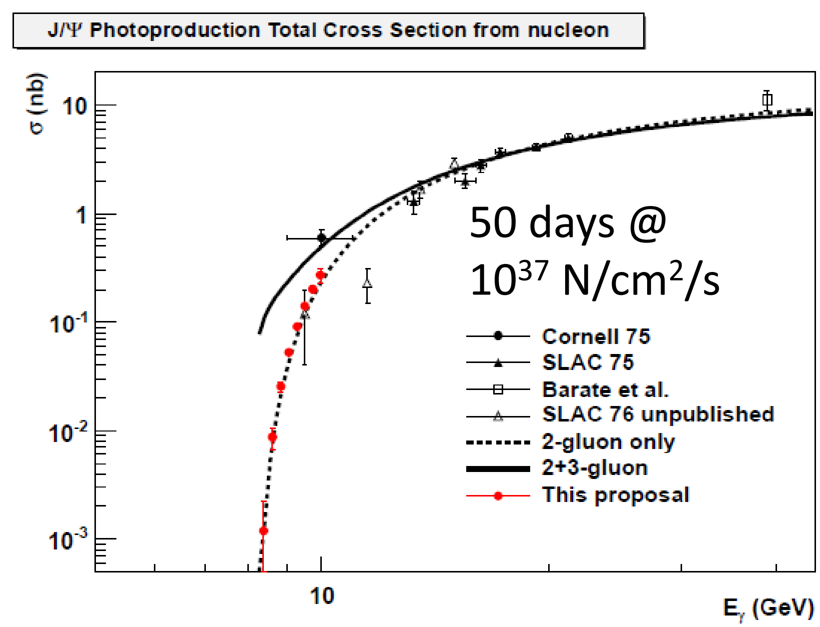
$$G^{\alpha\beta\gamma} G^{\gamma}_{\alpha\beta}$$



Proton Mass Budget



X. Ji PRL 74 1071 (1995)

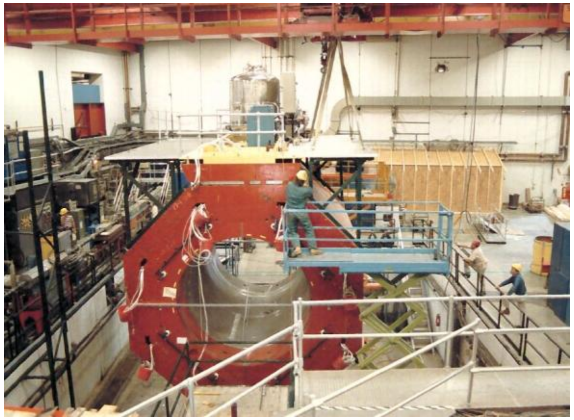


SoLID Timeline and Status

- 2010-2012 Five SoLID experiments approved by PAC (4 A, 1 A- rating)
  3 SIDIS with polarized ^{3}He/p target, 1 **PVDIS**, 1 **threshold J/ψ**
- 2013: **CLEO-II magnet formally requested and agreed**
- 2014: Site visit, plan transportation to JLab (2016)

2010-2014: Progress
  - **Spectrometer magnet, modifications**
  - **Detailed simulations**
  - **Detector pre-R&D**
  - **DAQ**

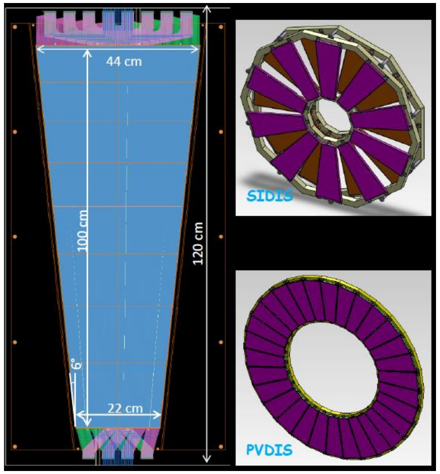
✓ 2014: **pre-CDR submitted** for JLab Director's Review



CLEO-II magnet

Active collaboration,
200+ physicists from 50+ international institutions

Draft funding profile includes significant international contributions (China)



GEM R&D
China/UVa

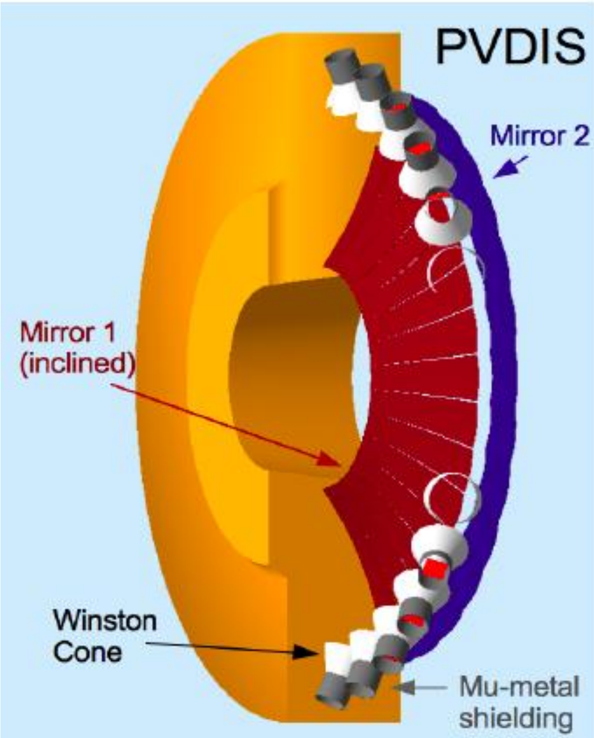
Backup

Progress in Detectors

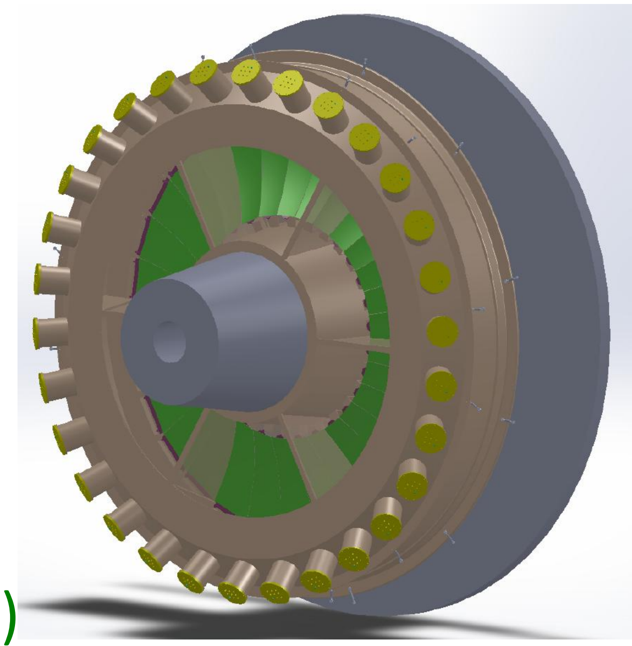
SIDIS/TMD Program

SoLID Detector Development

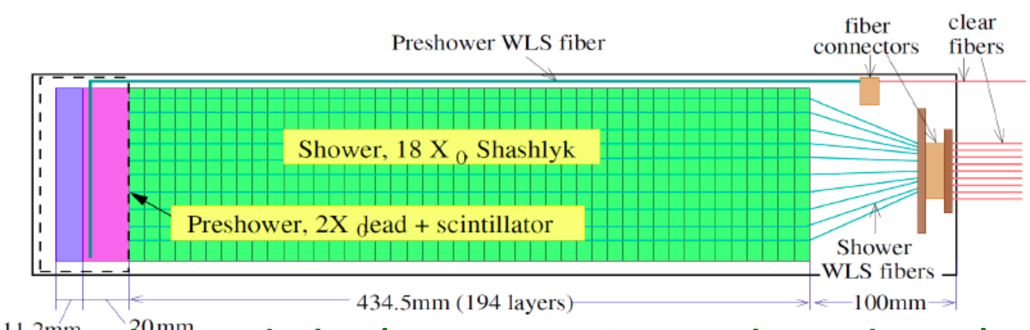
Simulations now with realistic backgrounds



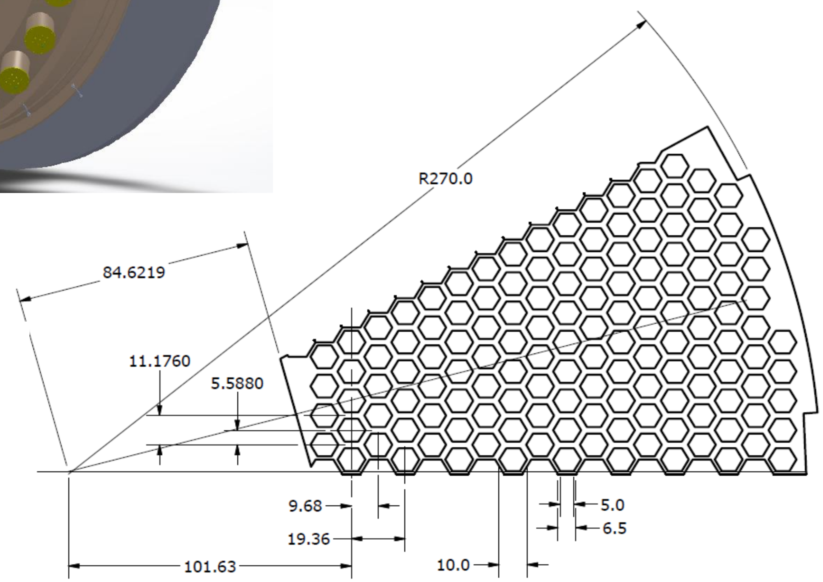
Light Gas Cerenkov (Temple)



Heavy Gas Cerenkov (Duke)



ECal Module (UVA, W&M, Shandong)

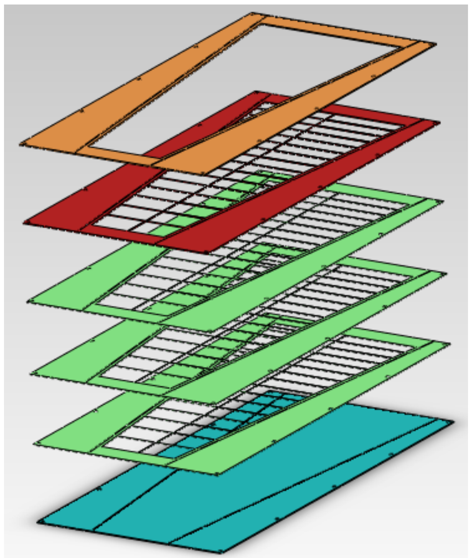


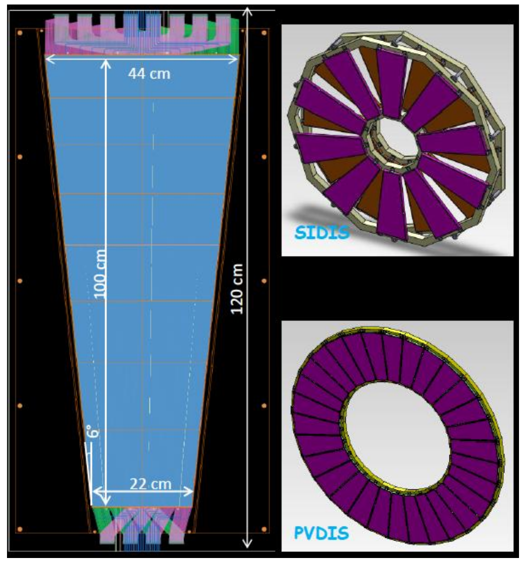
ECal Mounting Design (ANL)

GEM Progress

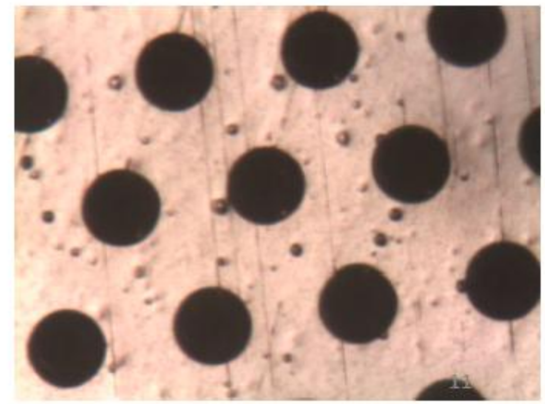
Chinese Collaboration

- First full size prototype assembled at **UVA**, tested in beam (Fermi Lab)
- 30x30 cm prototype constructed, readout tested (**CIAE/USTC/Tsinghua/Lanzhou**)
- GEM foil production facility under development at **CIAE** (China)





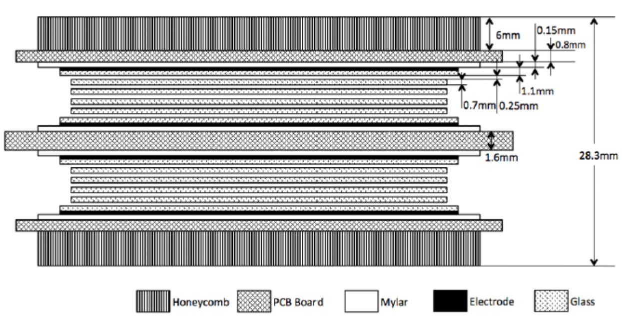
GEM foils made at CIAE

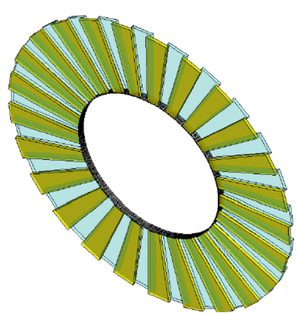


MRPC – High Resolution TOF

> 95 % efficiency

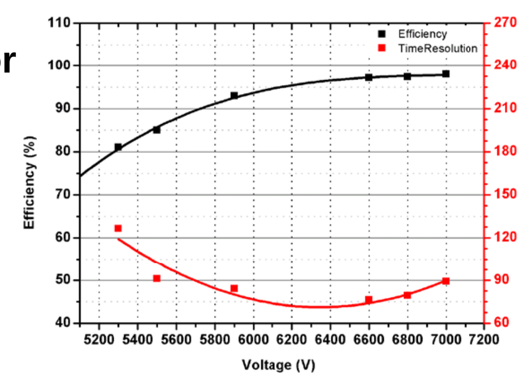
Timing resolution ~ 85 ps





A MRPC prototype for SOLID-TOF in JLab
Y. Wang, *et al.* **JINST 8 (2013) P03003**

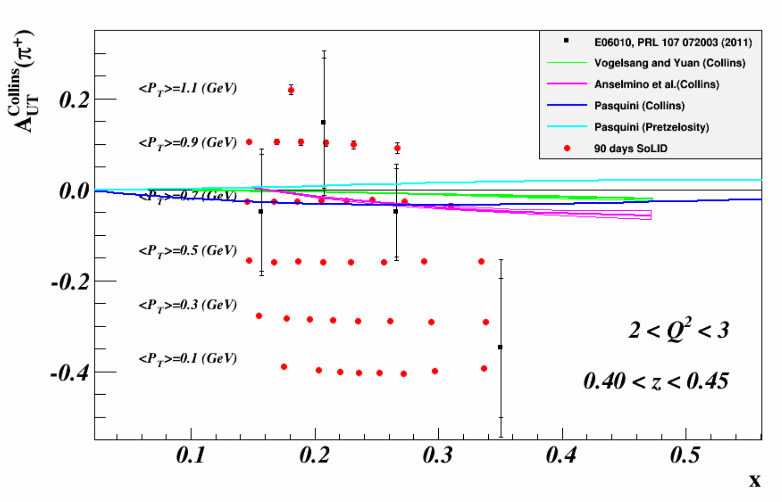
(Tsinghua)



Transversity and Tensor Charge

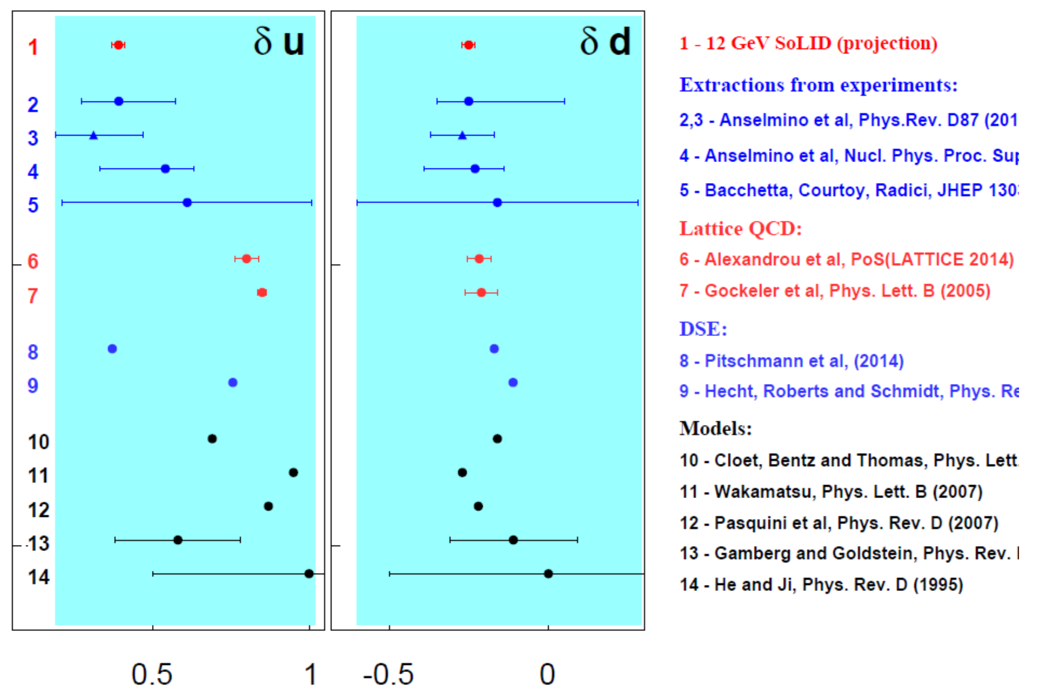
- Collins Asymmetries ~ Transversity (x) Collin Function
- **Transversity**: chiral-odd, not couple to gluons, **valence behavior**, largely unknown
- **Tensor charge (0th moment of transversity): fundamental property**
  Lattice QCD, Bound-State QCD (Dyson-Schwinger) , Light-cone Quark Models, …
- Global model fits to experiments (SIDIS and e+e-)
- SoLID with **trans polarized n & p** → determination of tensor charges for **d & u**

Collins Asymmetries



P_T vs. x for one (Q^2, z) bin
Total > 1400 data points

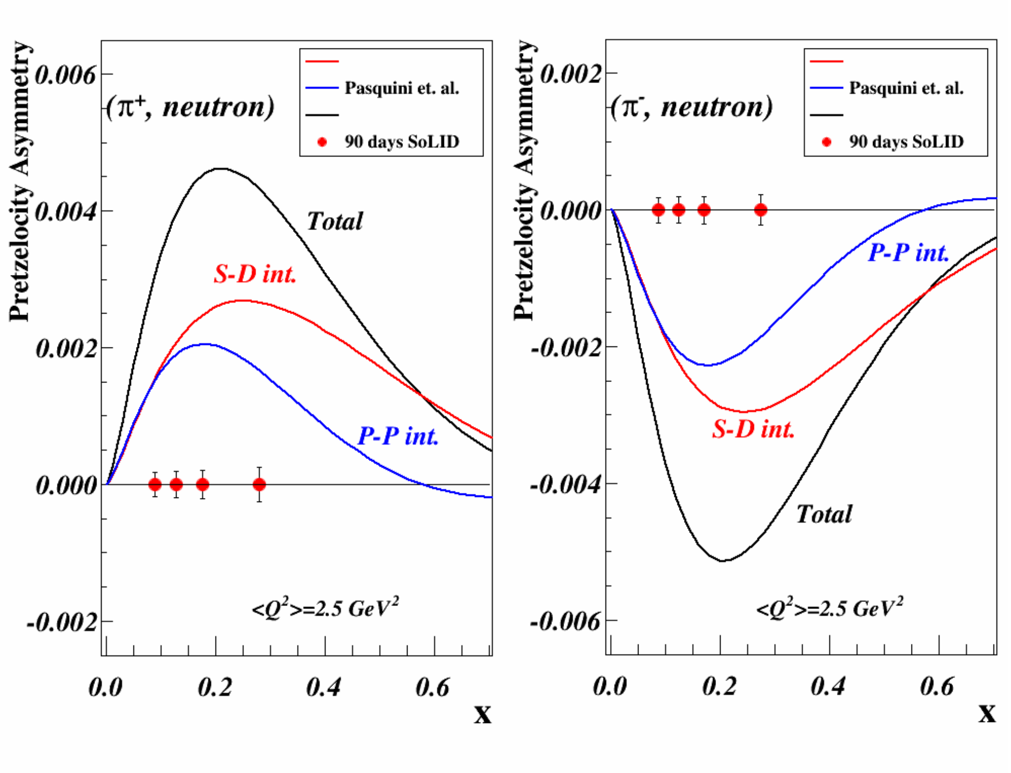
Tensor Charges



- *Projections with a model*
- *There are un-measured regions*
- *QCD evolutions being worked*

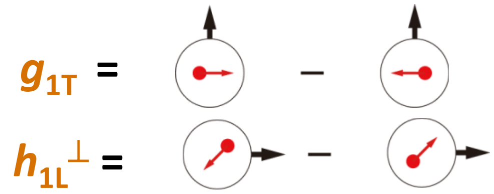
TMDs: 3-d Structure, Quark Orbital Motion

- TMDs : Correlations of transverse motion with quark spin and orbital motion
- **Without OAM, off-diagonal TMDs=0,**
  no direct model-independent relation to the OAM in spin sum rule yet
- Sivers Function: QCD lensing effects
- In a large class of models, such as light-cone quark models
  Pretzelosity: ΔL=2 (L=0 and L=2 interference , L=1 and -1 interference)
  Worm-Gear: ΔL=1 (L=0 and L=1 interference)
- **SoLID with trans polarized n/p → quantitative knowledge of OAM**



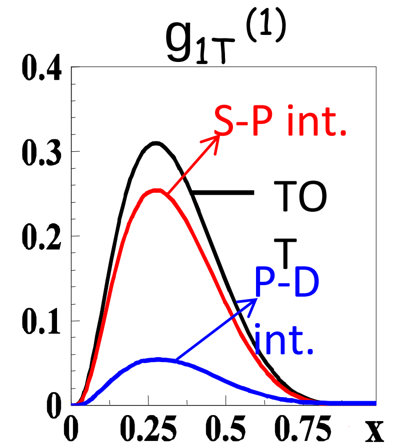
Pretzelosity

Worm-gear Functions



- Dominated by real part of interference between L=0 (S) and L=1 (P) states
- No GPD correspondence
- Exploratory lattice QCD calculation:

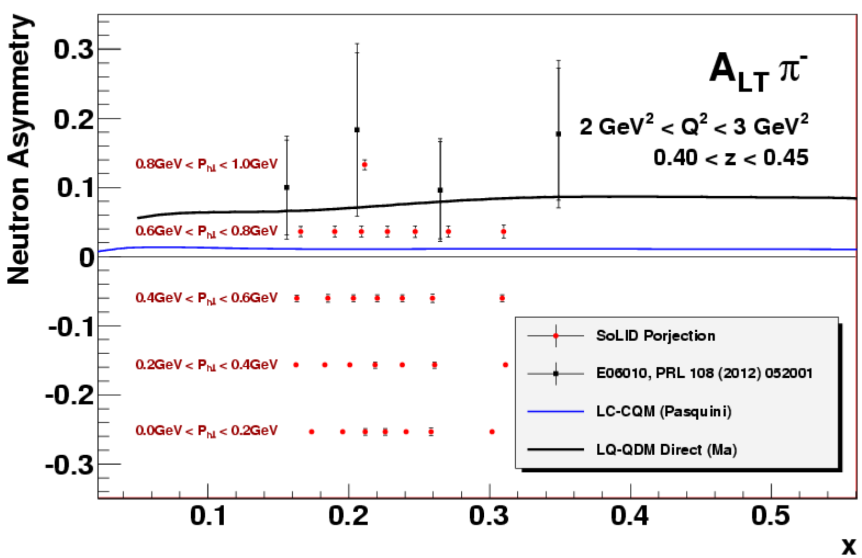
  Ph. Hägler et al, EPL 88, 61001 (2009)

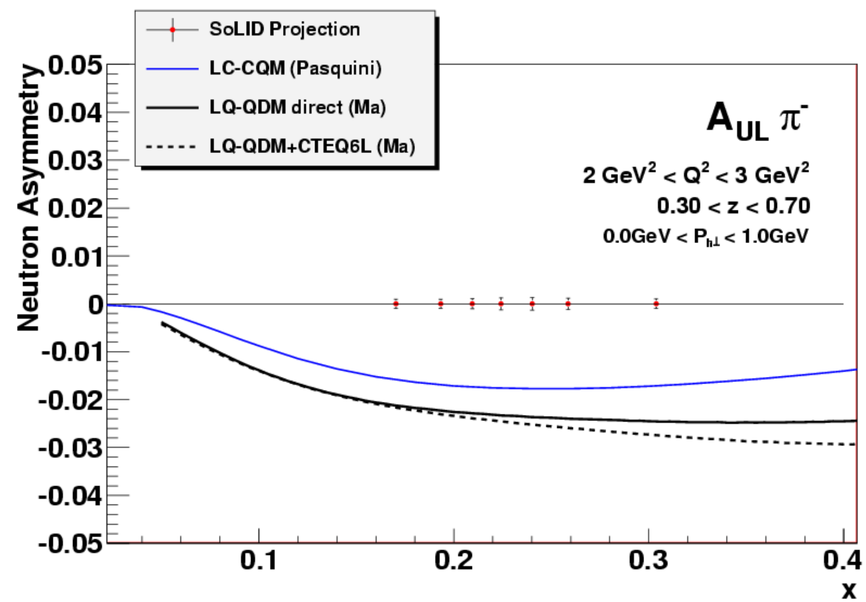


Light-Cone CQM by B. Pasquini

B.P., Cazzaniga, Boffi, PRD78, 2008

Neutron Projections,





$$A_{LT} \sim g_{1T}(x) D_1(z)$$

$$A_{UL} \sim h_{1L}^{\perp}(x) \otimes H^{\perp}{}_1(z)$$