The Spin Program at STAR:

Using polarized quarks to probe the structure of hadrons

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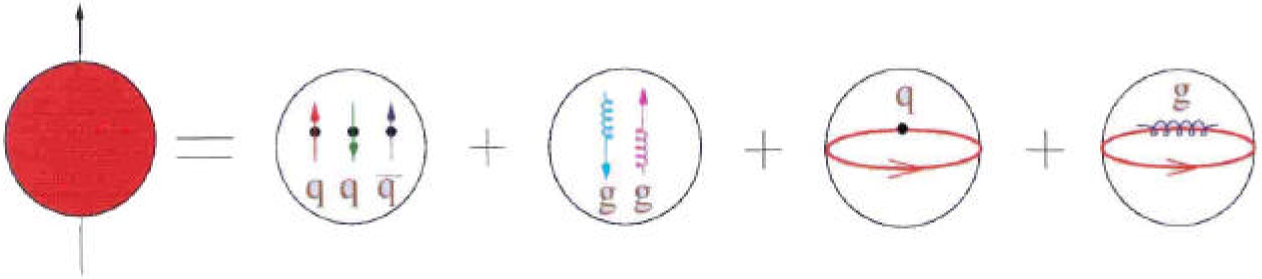
Where Does the Proton Get Its Spin ?



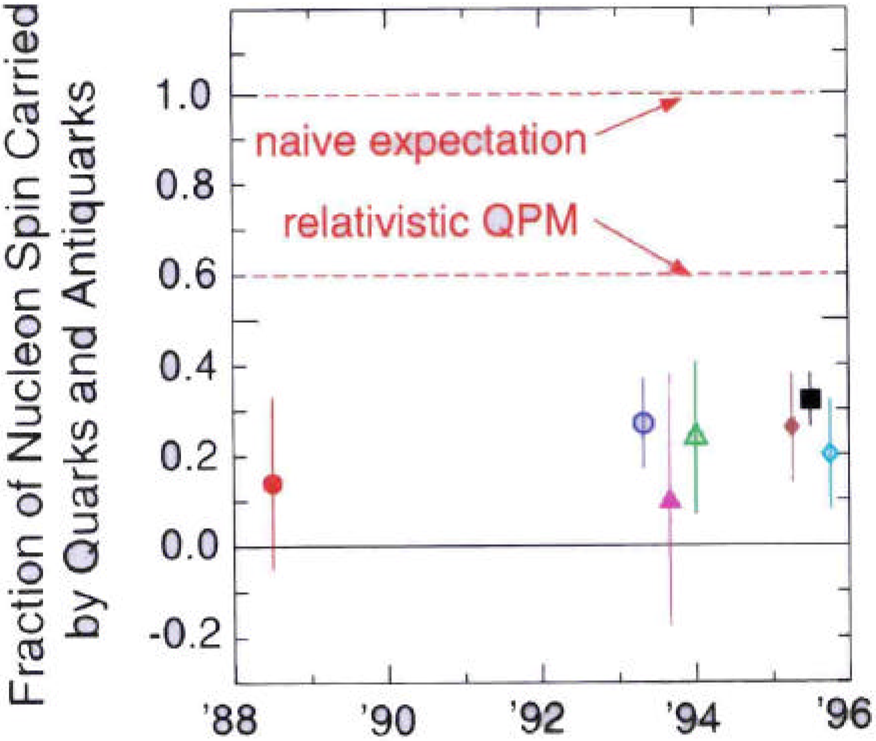
Proton Spin = Quark Spin + Gluon Spin + Quark Orbital + Gluon Orbital

$$\langle S_{p_z} \rangle = \frac{1}{2} = \frac{1}{2}\Delta\Sigma + \Delta G + \langle L_{q_z} \rangle + \langle L_{G_z} \rangle$$

$$\Delta\Sigma(Q^2) \equiv \sum_{i=u,d,s,\ldots} \int_0^1 dx\, \Delta f_i\,(x,Q^2)\,; \quad \Delta G(Q^2) \equiv \int_0^1 dx\,[G^+(x,Q^2) - G^-(x,Q^2)]\,;$$

where parton helicity distribution

$$\Delta f_i\,(x,Q^2) \equiv f_i^+(x,Q^2) + \bar{f}_i^+(x,Q^2) - f_i^-(x,Q^2) - \bar{f}_i^-(x,Q^2)$$



The Proton Spin Puzzle

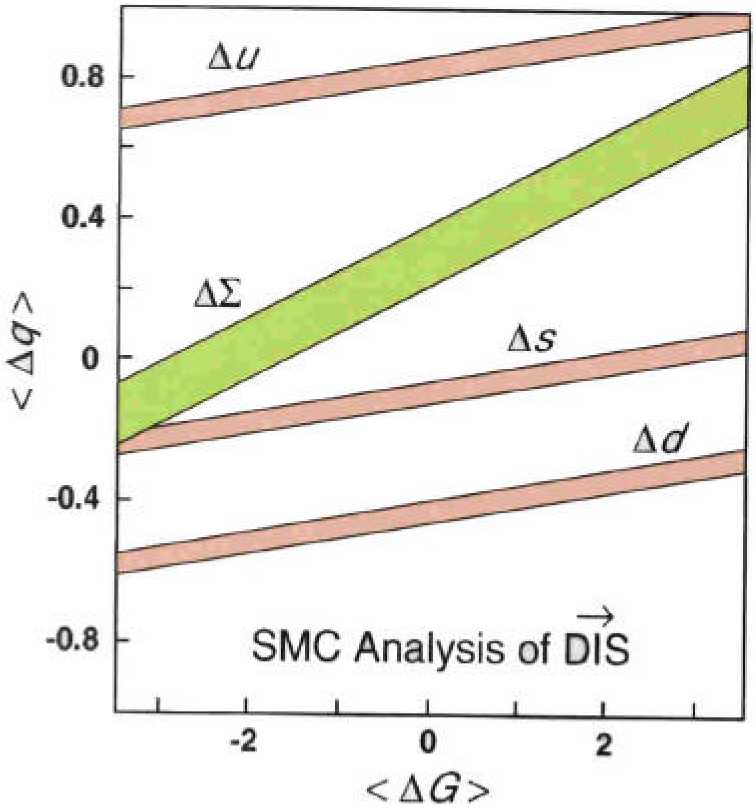
"Standard" inference of

$\Delta\Sigma$ ($Q^2 \approx 5$ GeV^2)

from $\overrightarrow{\text{DIS}}$:

$\vec{e}\,(\text{or}\,\vec{\mu}) + \vec{p} \rightarrow e'\,(\text{or}\,\mu') + X$

$\Delta G(x,Q^2)$ is the **next essential piece** of the nucleon spin puzzle:



Axial anomaly of QCD introduces gluon contributions to polarized DIS ⇒

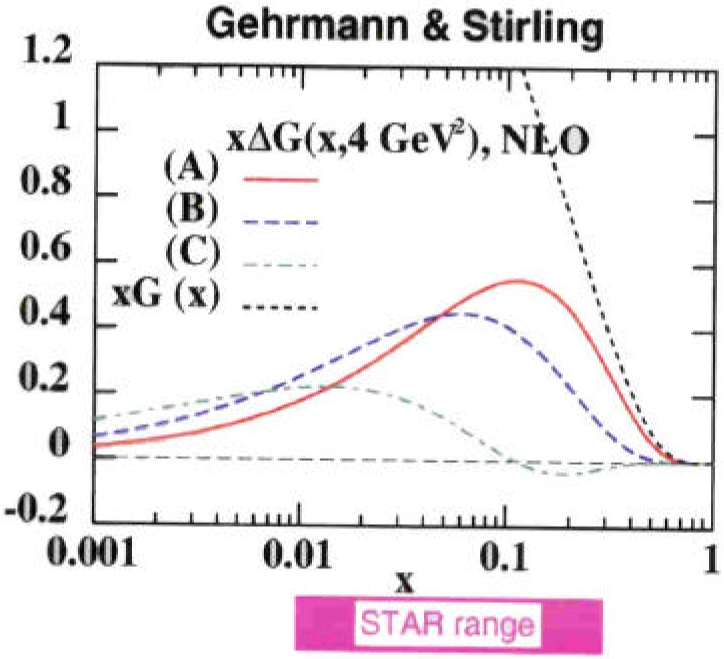
the integrated quark contribution to a proton's helicity can be extracted unambiguously from DIS **only if there is an independent determination of**

$$\Delta G(Q^2) = \int_0^1 \Delta G(x,Q^2)\, dx$$

to a precision of ± 0.5 or better.

Presently have only **very loose constraints** on $\Delta G(x)$, from observed scaling violations in polarized DIS.

All models ⇒ expect dominant contributions to $\int \Delta G(x,Q^2)\, dx$ from $x_{gluon} < 0.1$ because that is where **most of the gluons reside!**

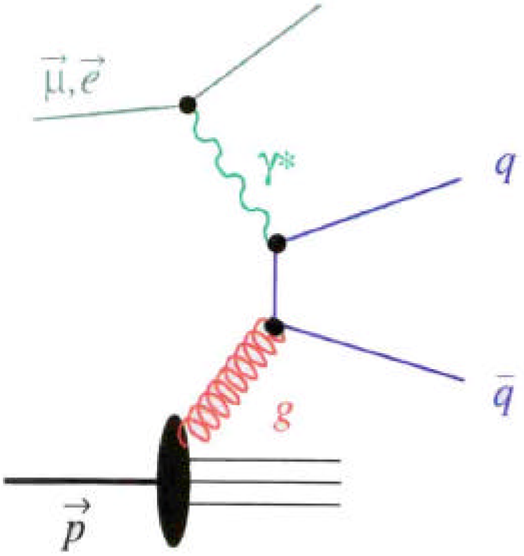


Using pQCD to probe the gluons

Best information on ΔG can be obtained by:

- using a probe that interacts directly (via color force) with the gluon
- using a highly polarized probe so that spin *correlations* can be studied
- working at $\sqrt{s}$ and p_T values where pQCD can be reliably applied

One possibility: use virtual photons as a probe



"Photon-gluon fusion," leading to
- *- open charm*
- *- dijets*
- *- high p_T (leading) hadron pairs*

Primary technique for HERMES, COMPASS, and polarized HERA

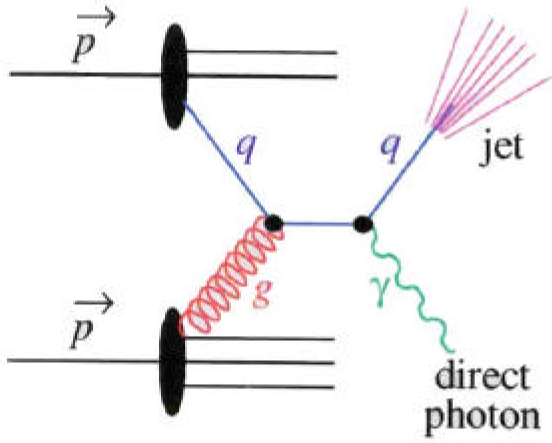
Limitations of these studies:

★ HERMES and COMPASS are fixed-target experiments
- most sensitive to ΔG for $x_g > 0.1$
- larger ambiguities in interpretation due to inverse Compton scattering and competing soft (e.g., VMD) hadron production processes

★ fate of polarized HERA still to be determined ...

Another possibility: use direct photons as a signature,
⇒ use polarized quarks as the probe

$\vec{p}$ beam can be viewed as incoherent ensemble of $\vec{q}, \vec{\bar{q}}, \vec{g}$:



"Quark-gluon Compton scattering" with detection of
- high p_T photon
- γ + jet coincidence

Primary technique to be used in *pp* collisions at RHIC

Basic idea: study the reaction $\vec{p} + \vec{p} \to \gamma(+jet) + X$

Note: in **collider** frame, p beams have momentum = $\sqrt{s}/2$; colliding **parton** momenta are then $x_1\sqrt{s}/2$ and $x_2\sqrt{s}/2$, with

colliding parton luminosity = $f_1(x_1,Q^2)\, f_2(x_2,Q^2) \bullet$ (pp luminosity)

parton polarization = $\dfrac{\Delta f(x,Q^2)}{f(x,Q^2)} \bullet$ (proton polarization)

Then: measure spin correlation asymmetry with longitudinally polarized protons for $\vec{p} + \vec{p} \to \gamma(+jet) + X$

$$A_{LL} = \frac{1}{P_{b1} P_{b2}} \bullet \frac{N_{++} - N_{+-}}{N_{++} + N_{+-}}$$

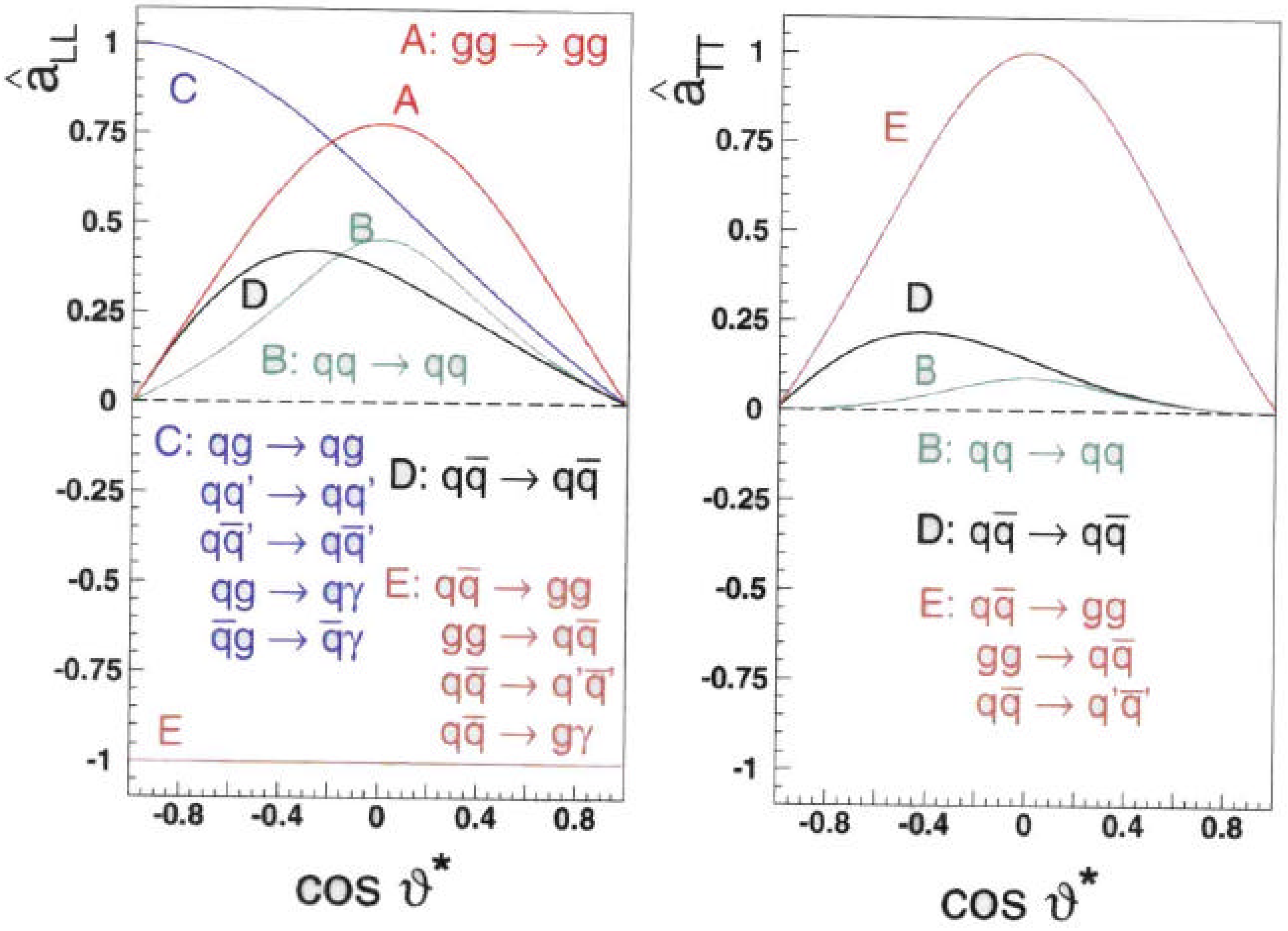
$P_{b1(2)}$ — beam pol'n (~70%)

N_{++} — equal helicity yield

N_{+-} — opposite helicity yield

Spin Sensitivity in Leading-Order pQCD Parton Collisions

$\hat{a}_{LL} \equiv \dfrac{\sigma_{++} - \sigma_{+-}}{\sigma_{++} + \sigma_{+-}}$, *where subscripts give parton helicity*



NEED: *g in initial state; highly polarized collision partner; large $\hat{a}_{LL}$; minimal competing processes.*

BEST CHOICES *are half-strong, half EM ($\Rightarrow \sigma \sim \alpha\alpha_s$)*:

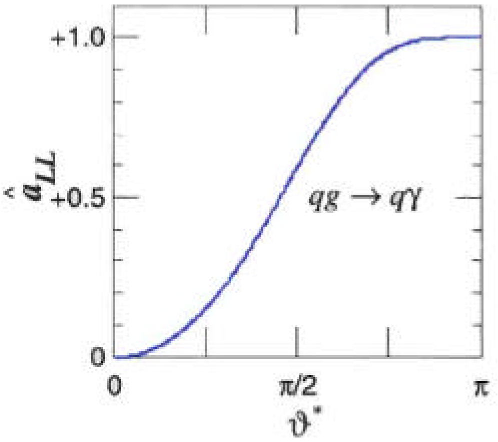
	SIGNAL	LEADING BKGRD	ACCEL.	DETECT
1)	$\vec{q} + \vec{g} \to q + \gamma$	$\vec{q} + \vec{\bar{q}} \to g + \gamma$	$\vec{p}$-$\vec{p}$ collider	γ + jet
2)	$\vec{\gamma} + \vec{g} \to q + \bar{q}$	$\vec{\gamma} + \vec{q} \to g + q$	$\vec{e}$-$\vec{p}$ collider	jet + jet

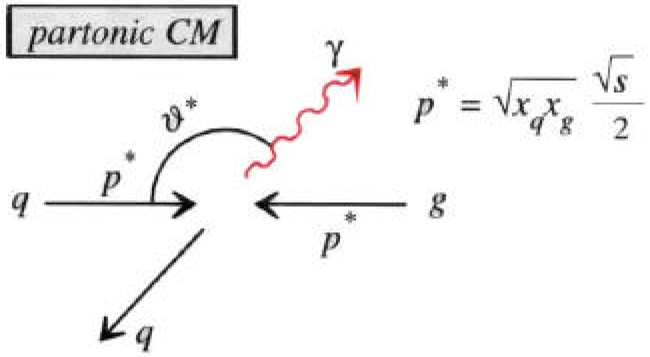
Advantages of $\vec{p} + \vec{p} \to \gamma + jet + X$ with STAR for Determining $\Delta G(x,Q^2)$

1) Dominance of a single LO pQCD process: $qg \to q\gamma$

- *$q + \bar{q} \to \gamma + g$ contributes only ~10% to direct photon yield in STAR*
- *NLO predictions ⇒ no qualitative changes (enhanced sensitivity to ΔG)*
- *higher-twist effects are small at $p_T \gtrsim 10$ GeV/c*

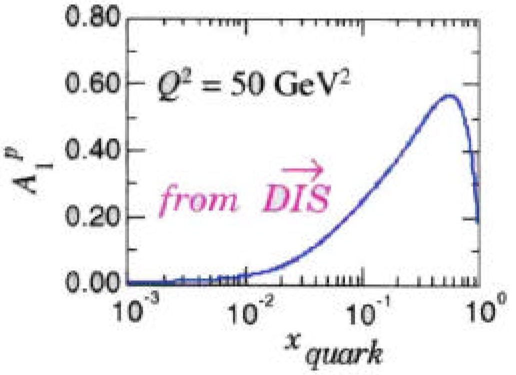
2) Large spin correlation for gluon Compton scattering when γ is detected in direction of incident quark:





3) Large quark polarization for $x_q \geq 0.2$

- *Asymmetric partonic collisions (e.g., $x_q \geq 0.2 \oplus x_g < 0.1$) ⇒ products boosted forward in lab ⇒ Endcap EMC required*



4) Kinematic reconstruction of x_q and x_g from γ-jet coincidence:

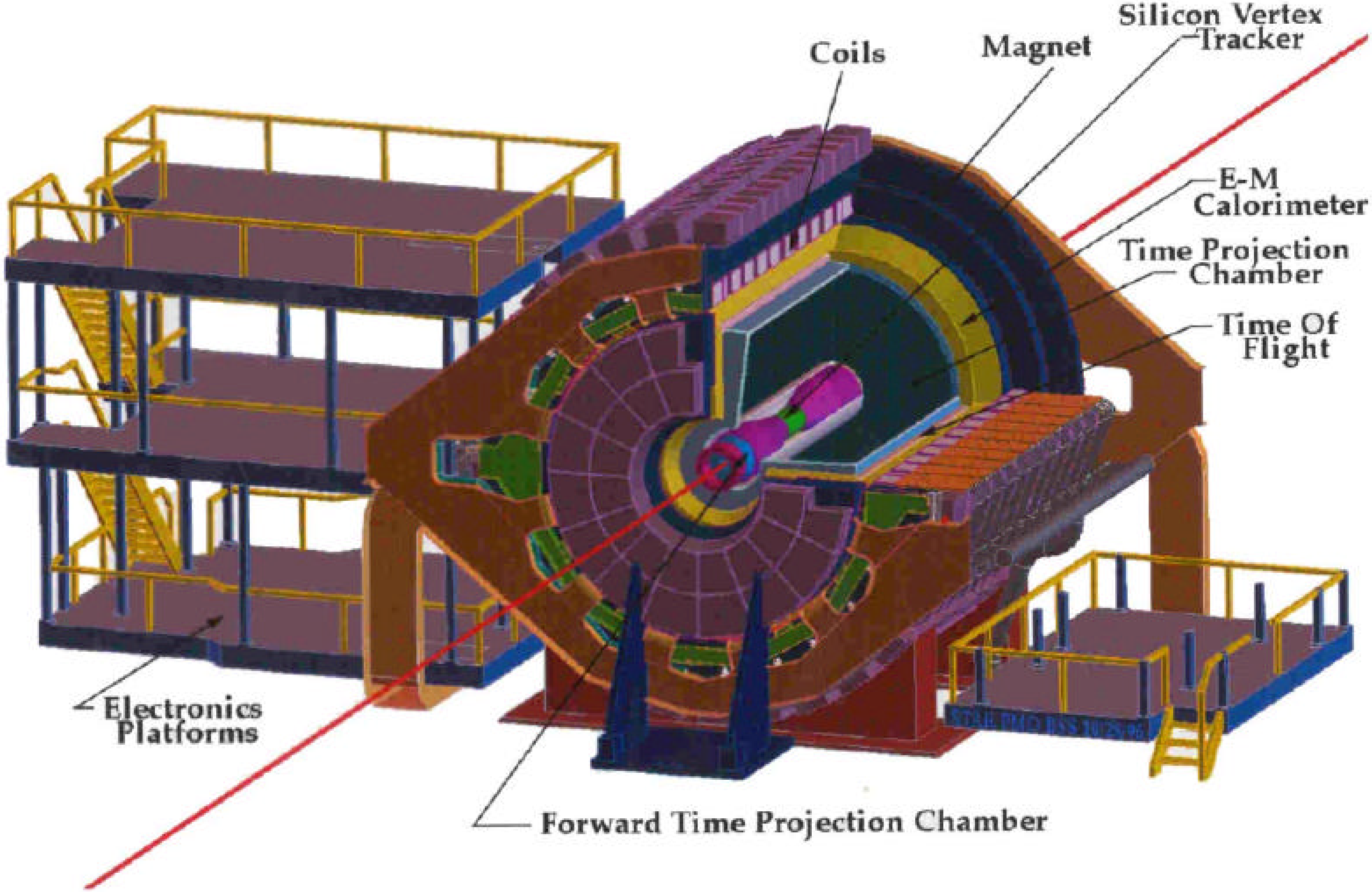
- *requires large acceptance of STAR + EEMC for jet identification*
- *facilitates direct extraction of $\Delta G(x)$*
- *combined with pol'n meas'ment, reduces sensitivity to k_T-smearing*

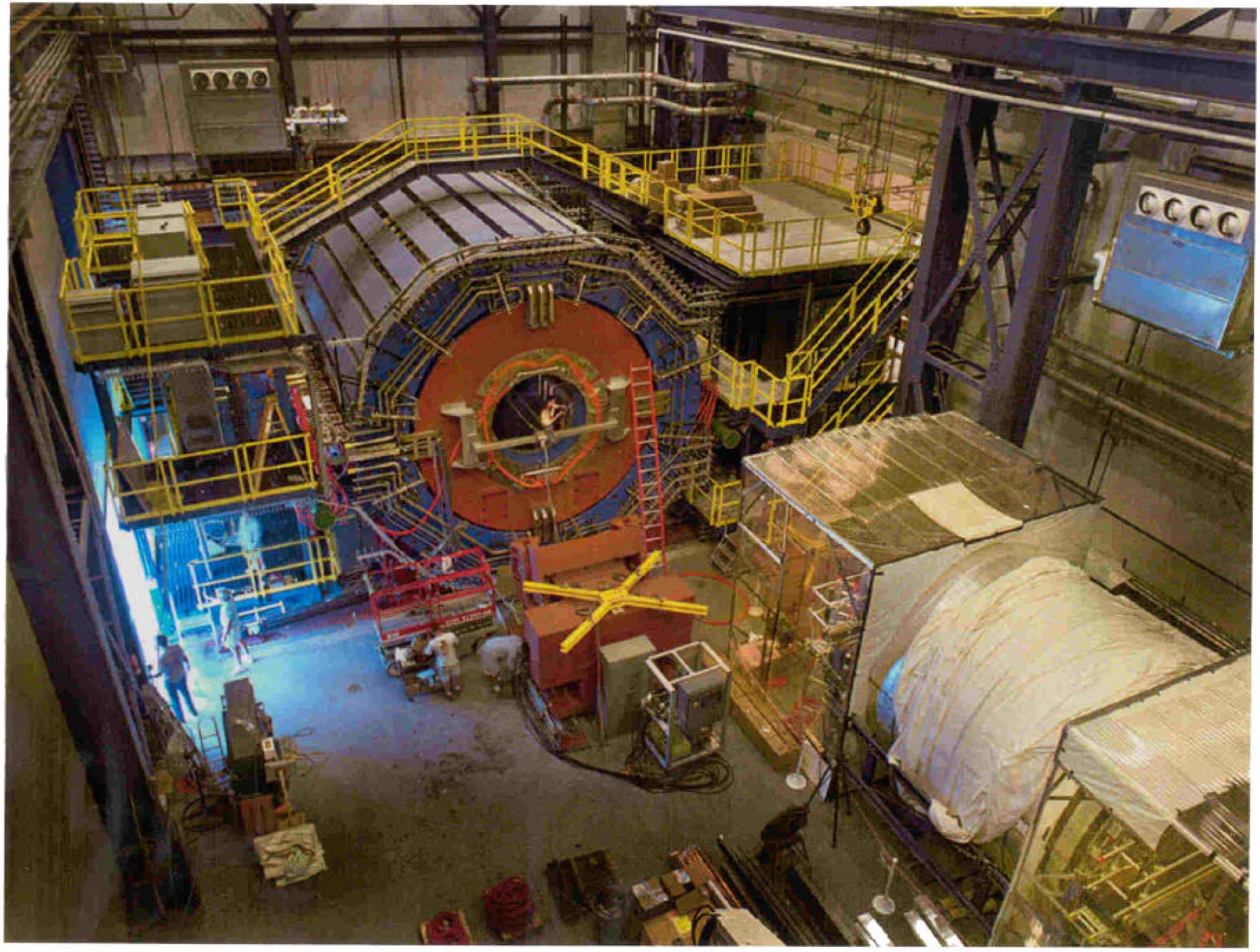
5) Broad coverage over range $0.01 \leqslant x_g \leqslant 0.3$:

- *need 10-week measurements at both $\sqrt{s} = 200$ and 500 GeV*
- *allows direct determinagtion of $\int \Delta G(x)\,dx$ to better than ±0.5*

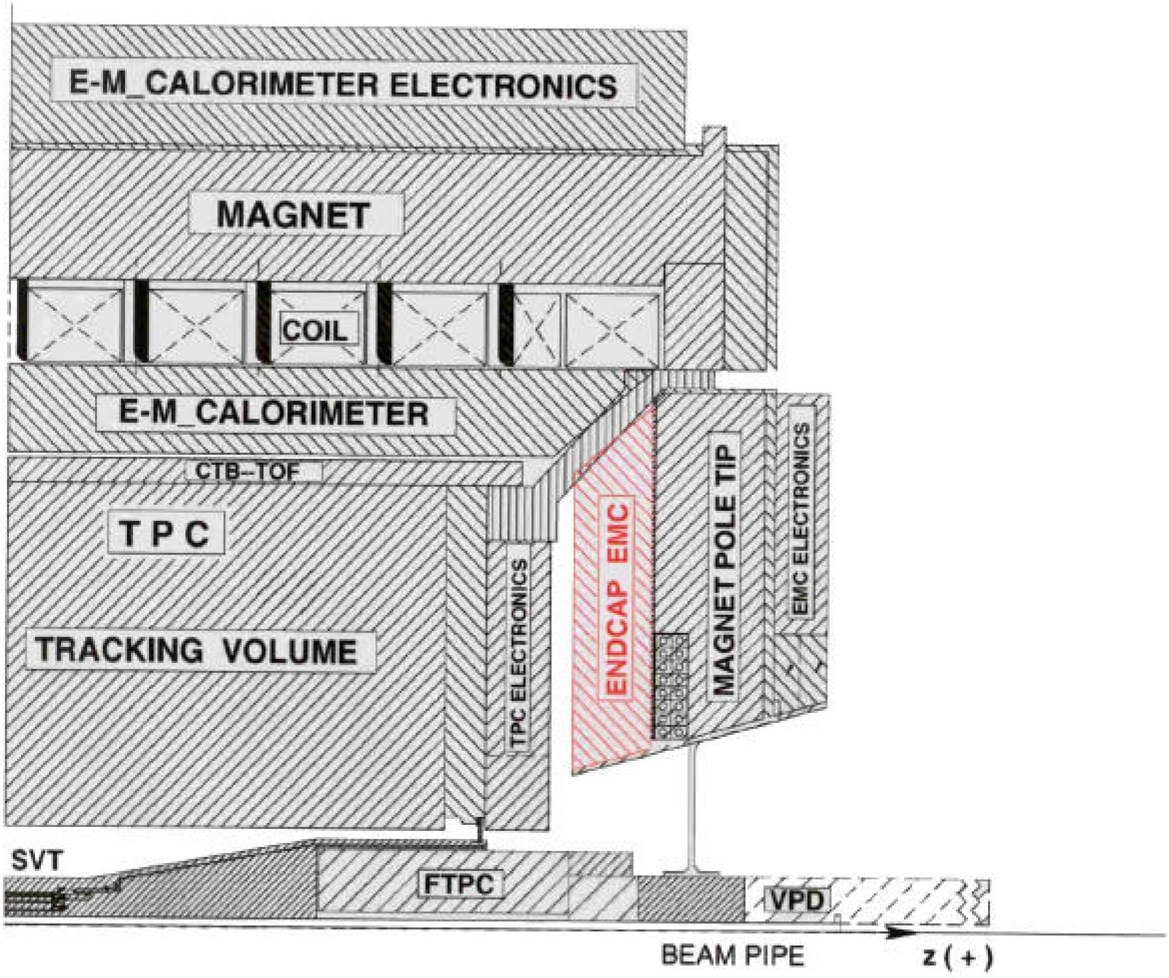
BNL from the air – the AGS / RHIC Complex

Main components of the STAR detector





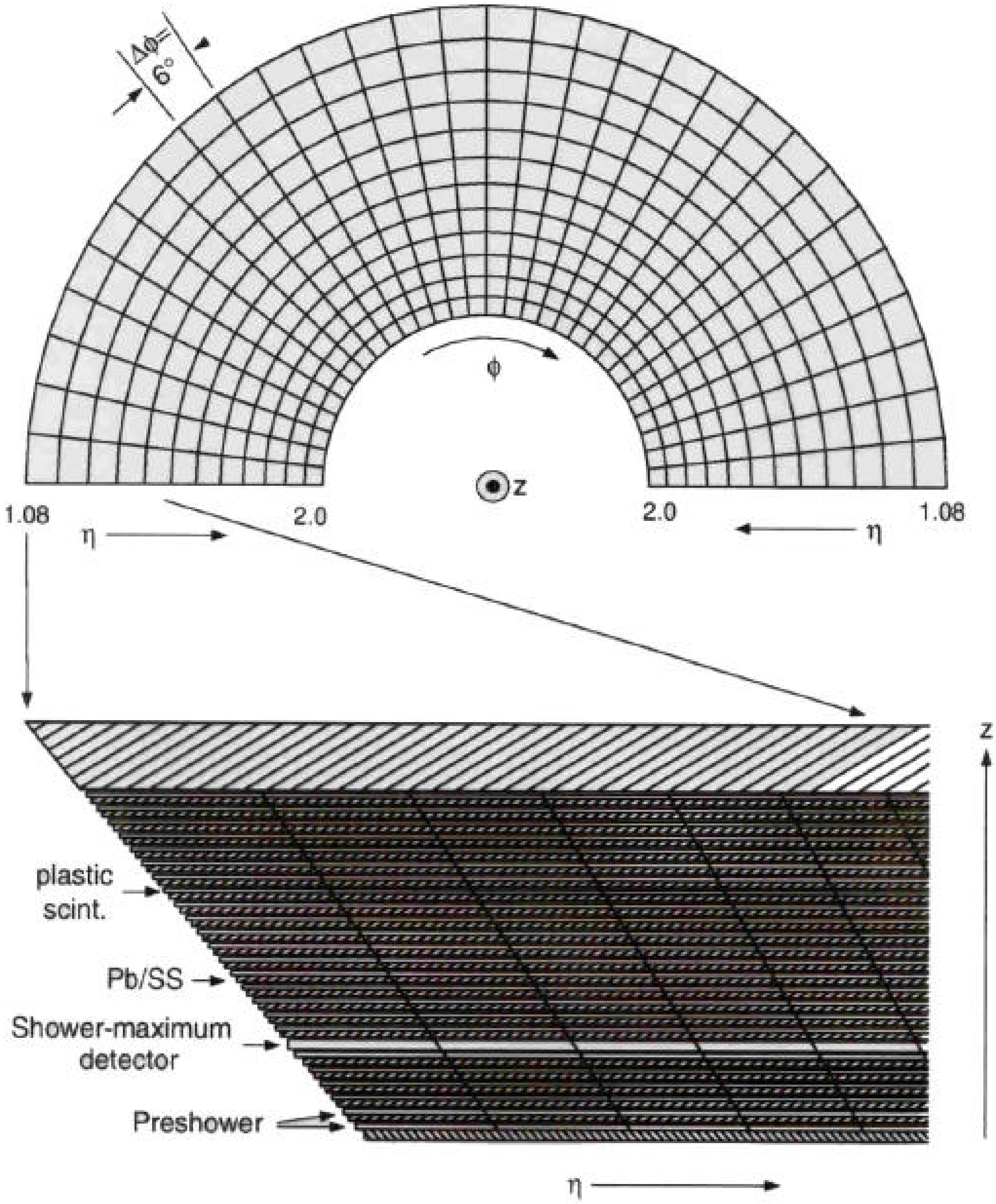
An Endcap EMC for STAR:



The Endcap EMC will provide access to:

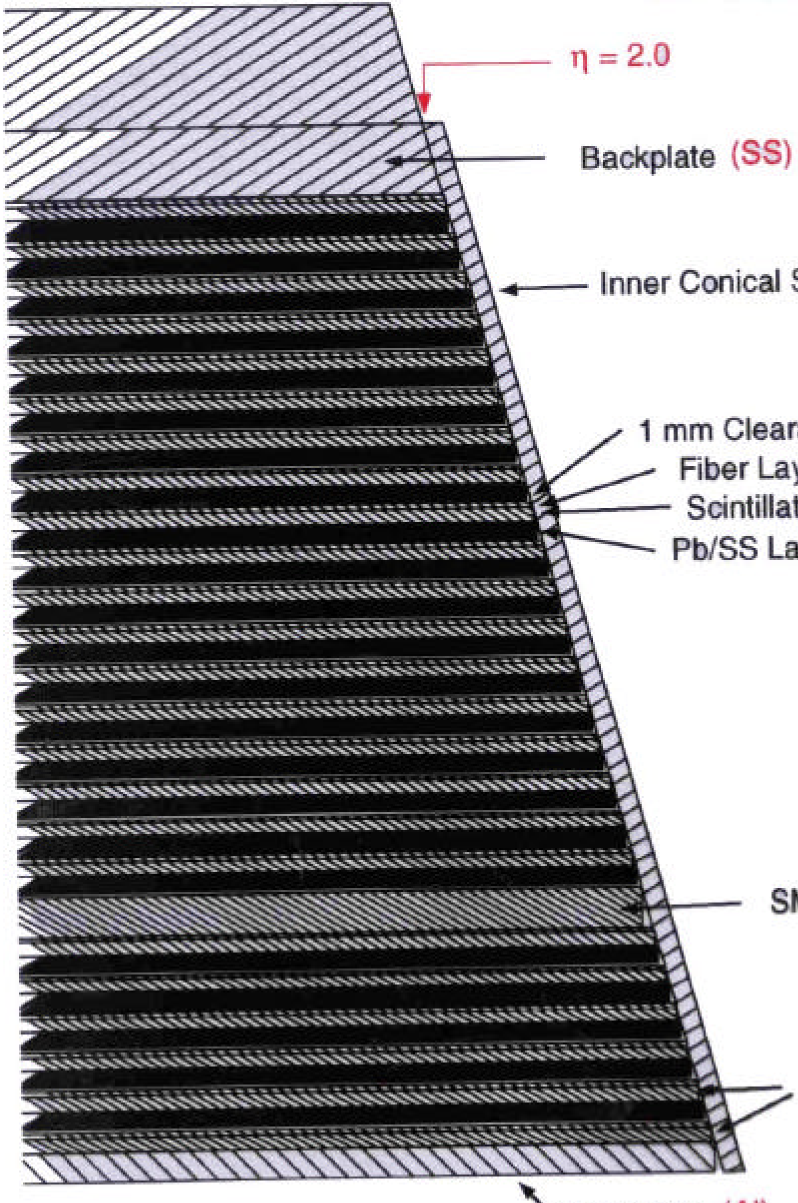
- *highly asymmetric partonic collisions*, so highly polarized quarks at $x_q \geq 0.2$ can probe gluon polarizations at $x_g < 0.1$
- *back-angle (in parton c.m. frame) calorimetric information*, where partonic σ *and* a_{LL} have high FOM for $\Delta G(x) / G(x)$
- *greatly enhanced coverage for jets*, compared to use of STAR EMC barrel ($|\eta| \leq 1$) alone

Main Design Features of the STAR EEMC:



- 720 projective towers, contained in two halves
- full azimuthal coverage for pseudorapidities $1.08 \leq \eta \leq 2.00$
- 23 layers of lead with 24 layers of 4 mm plastic scintillator for 6.7% sampling fraction and 21 radiation lengths depth

EEMC Depth Budget



$\eta = 2.0$

Backplate (SS)

Inner Conical Support (SS)

1 mm Clearance

Fiber Layer (1.6 mm plastic guide)

Scintillator (4 mm)

Pb/SS Laminate (4.7 mm Pb + 2 * 0.5 mm SS)

SMD (depth not yet optimized)

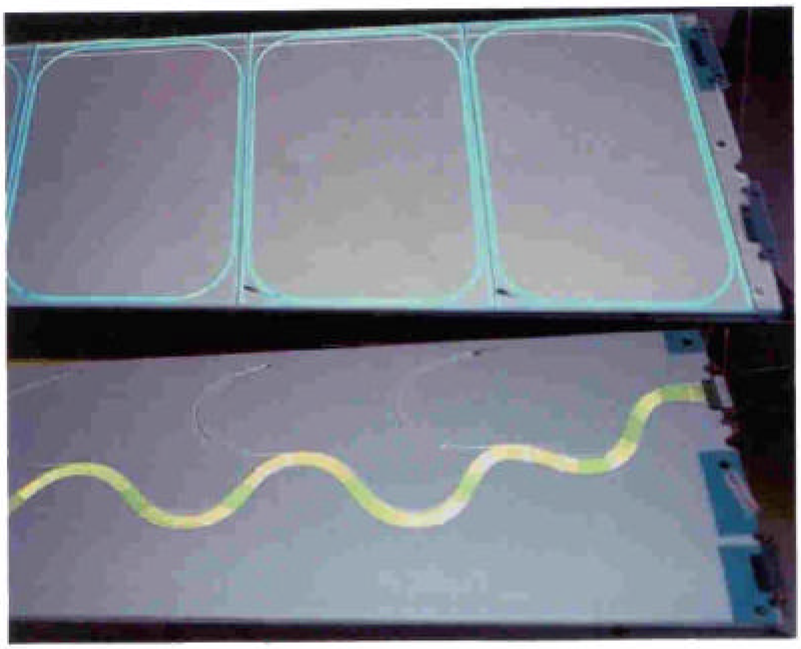
Preshower (2 * 5 mm scint. layers)

Frontplate (Al)

Basic mechanical structure similar to CDF plug upgrade:

SS plugs through Pb/SS layers + SS spacers + tie rods from front to rear plates ⇒ self-supporting structure into which megatiles, SMD inserted without compression.

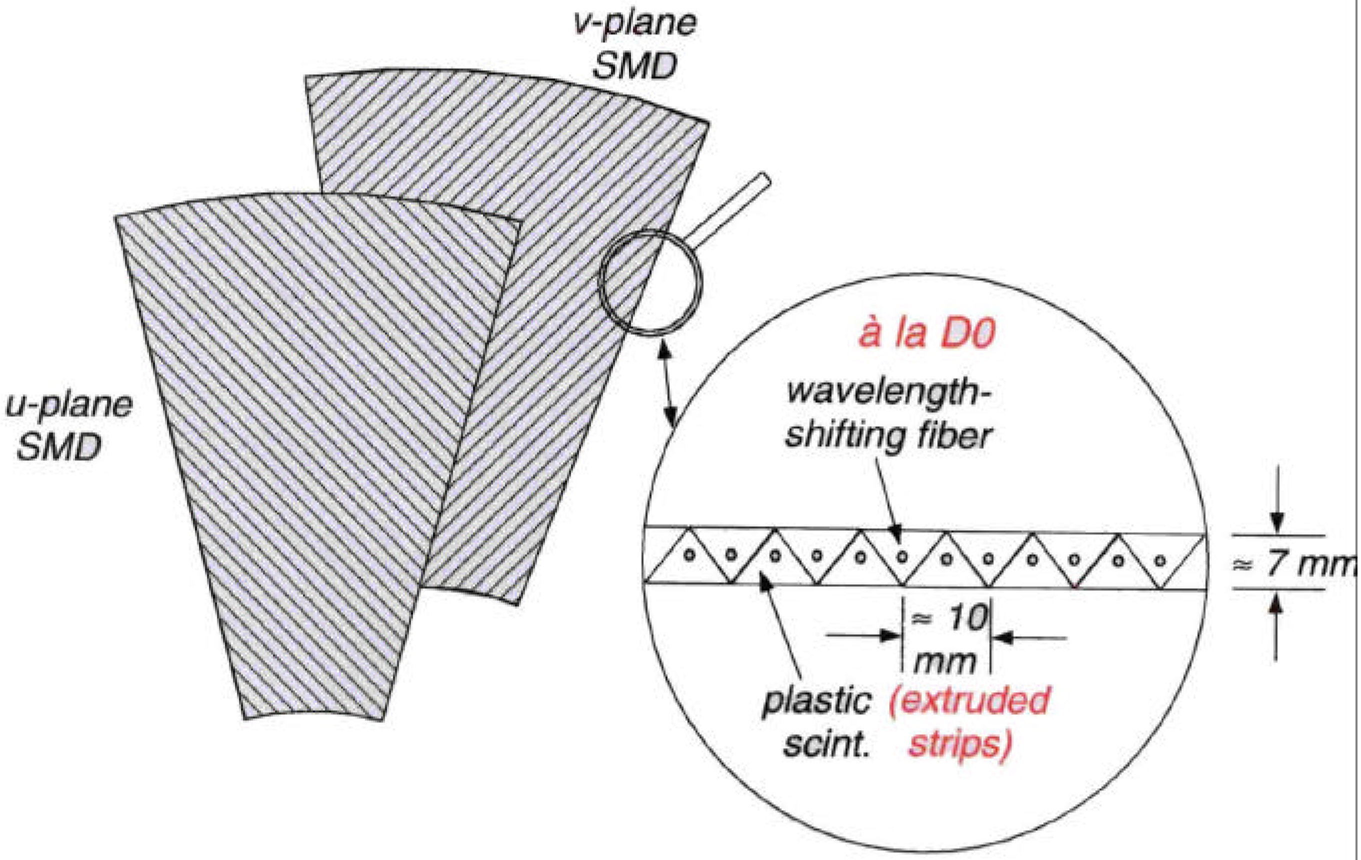
A few EEMC construction pictures …



Close-up of $\eta=1$ edge of a 6-deg megatile. Light from each of the 12 tiles is carried via WLS fiber to the outer edge, then transported in clear fiber to the tower PMT's.

One of the 24 Pb and stainless steel radiator layers being assembled. The SS plates are laminated to the top and bottom of the ~4mm thick lead plate.

Proposed Endcap Shower-Maximum Detector



Purpose: distinguish single-γ from di-photon events via transverse EM shower profile

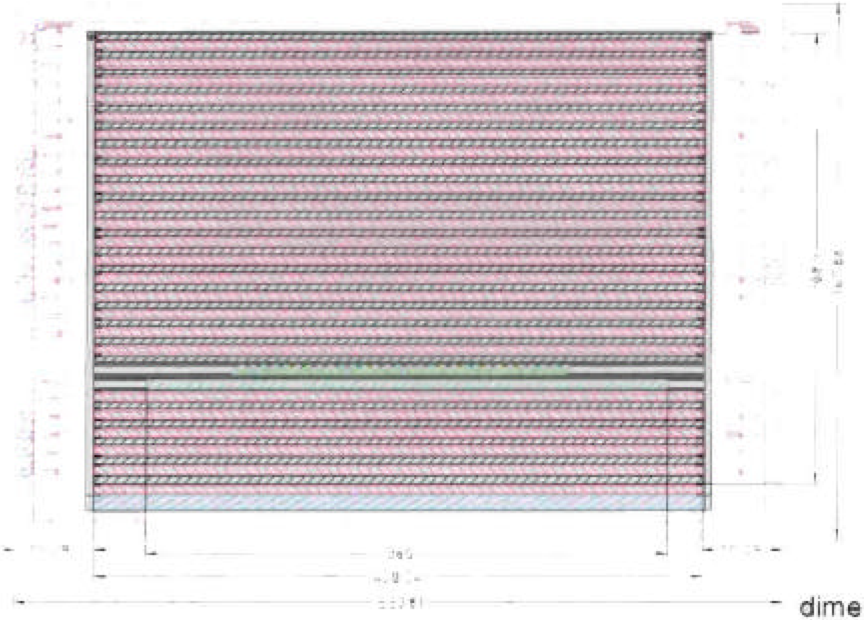
Features:

- stabilization of energy-sharing among neighboring strips ⇒ improved γ / π^0 discrimination vs. gaseous SMD or rectangular scint. strips
- good spatial resolution (~ 2.5 mm for shower centroid) aids matching of $e^\pm$ showers to TPC tracks
- ≈ 300 strips/layer/30° sector ⇒ 7200 SMD fibers in all
- alternating depth offset between layers in adjacent sectors simplifies fiber routing
- multi-anode PMT readout
- initial prototyping tests under way
- tested at SLAC (10/99)

Prototype Objectives

- Do measured SMD electromagnetic shower profiles agree with simulations?
- Does GEANT properly account for event-to-event fluctuations in the shower profiles?
- How effective is a gain-matching procedure for the SMD strips?
- What is the tower resolution and how linear is the tower response?

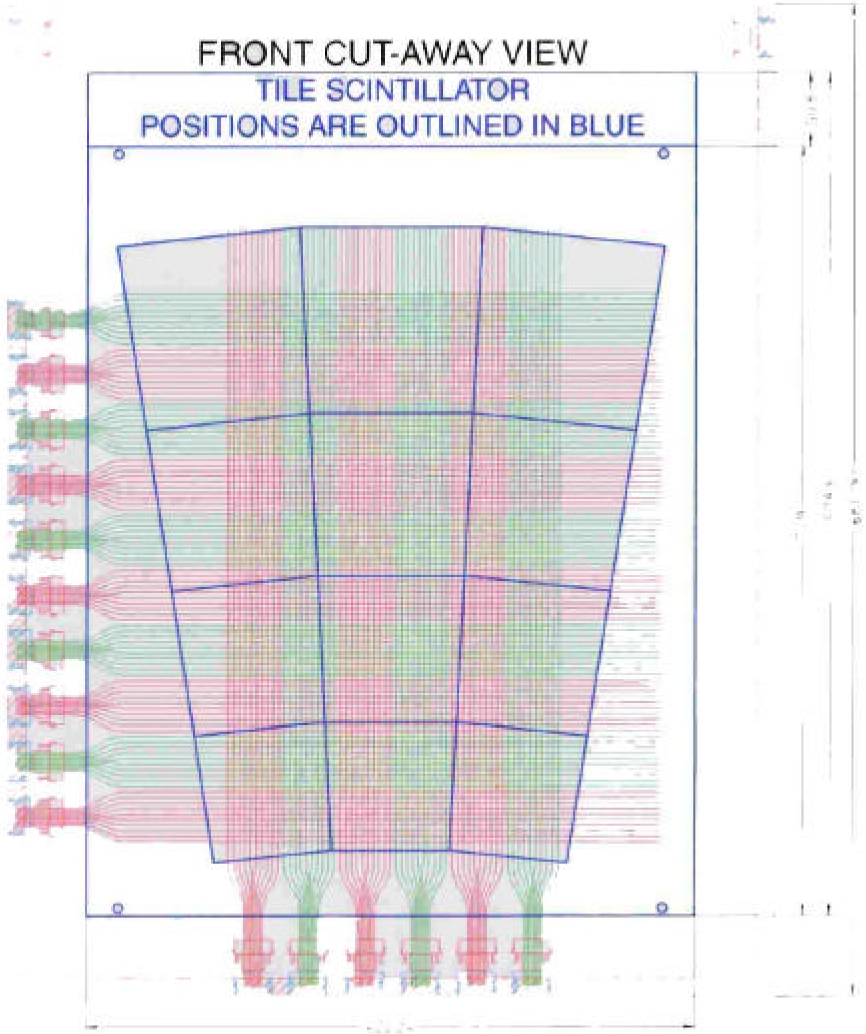
TOP VIEW



Prototype EEMC + SMD Design

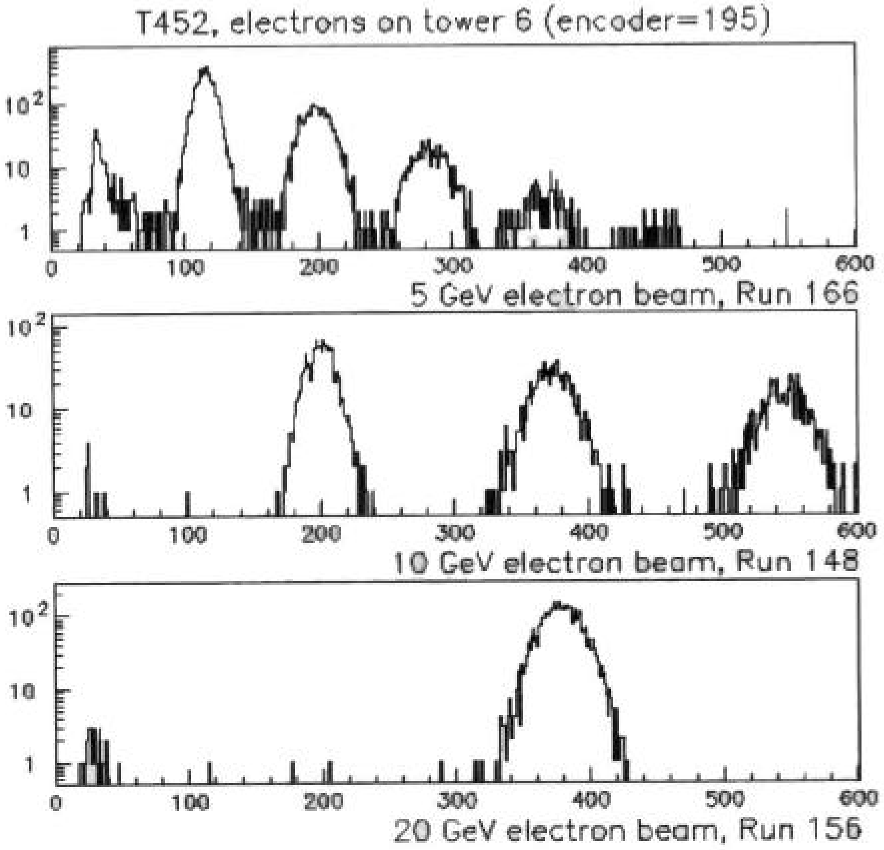
- *24-layer sampling calorimeter, 4(5)-mm thick SCSN-81.*
- *12 projective towers, resembling EEMC near $\eta=2$.*
- *SMD — two orthogonal planes of triangular strips:*
  100-strip 'y' plane
  60-strip 'x' plane

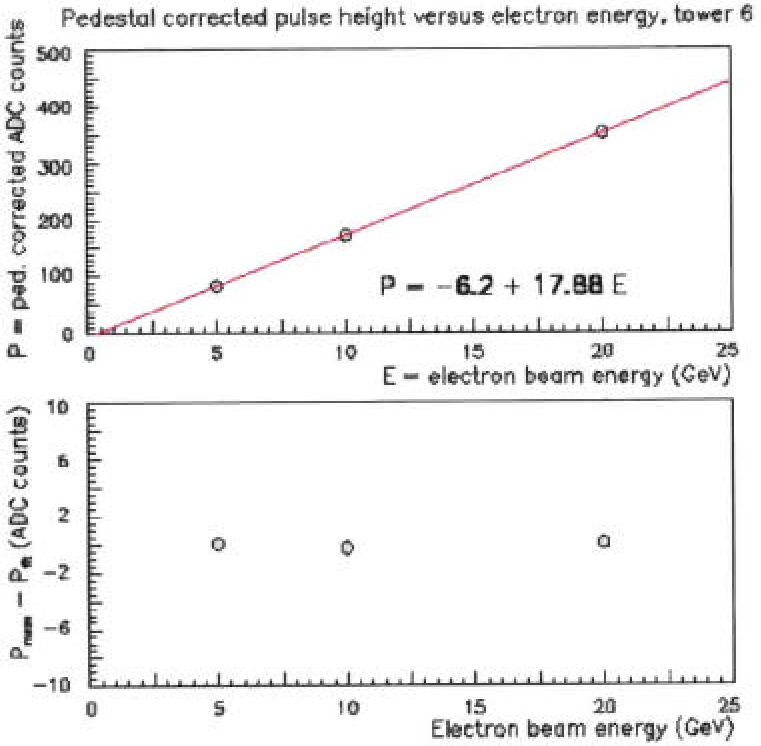
FRONT CUT-AWAY VIEW



dimensions in mm

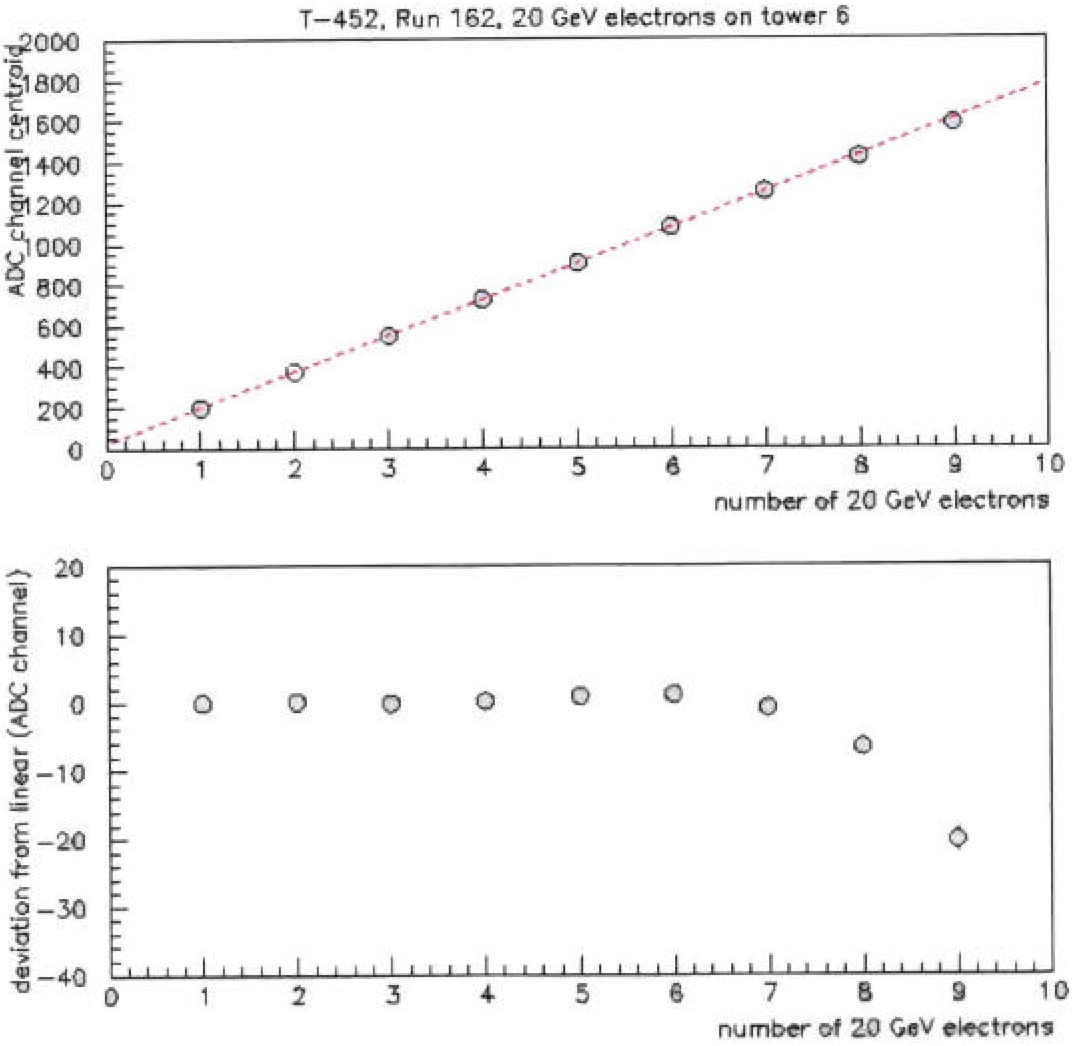
Results from SLAC FFTB Expt. T-452





Can use the 5 GeV data (for example) to check linearity of the PMT response, then compare single electron pulse heights at several different energies to test linearity of the calorimeter response to electromagnetic showers.

PMT response from SLAC T-452



Raw ADC peak centroids *vs.* # of 20 GeV electrons incident on a single pEEMC tower in a single pulse (< 1ns). Bottom plot shows deviations from linearity, suggesting a less than *1% fall-off* at PMT outputs equivalent to *160 GeV* of light.

Using cosmic-ray muons for 'pre-beam' gain adjustment

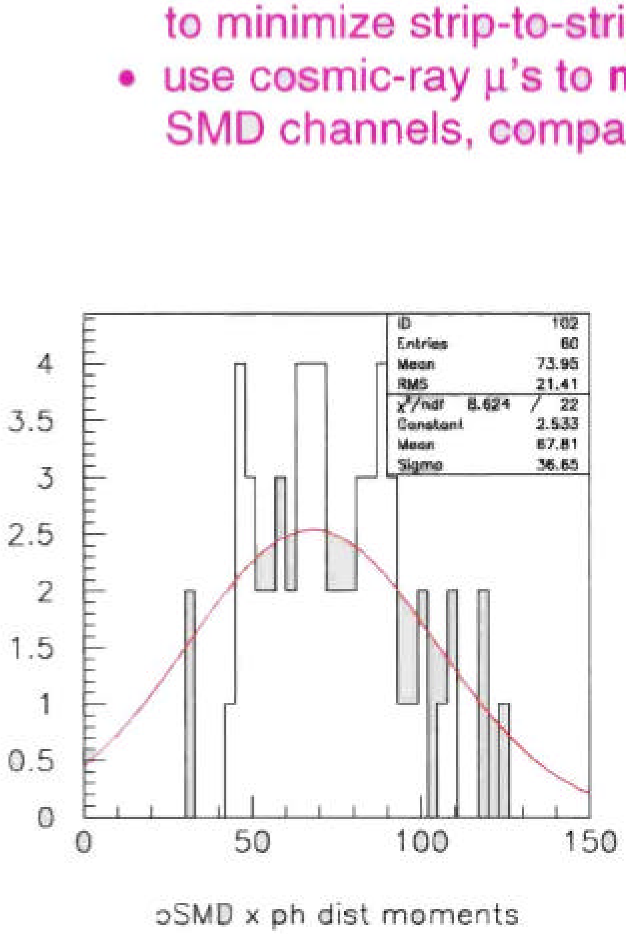
Validity of technique established for pSMD with SLAC test beam
⇒ gains not set in hardware, but compensated for in software

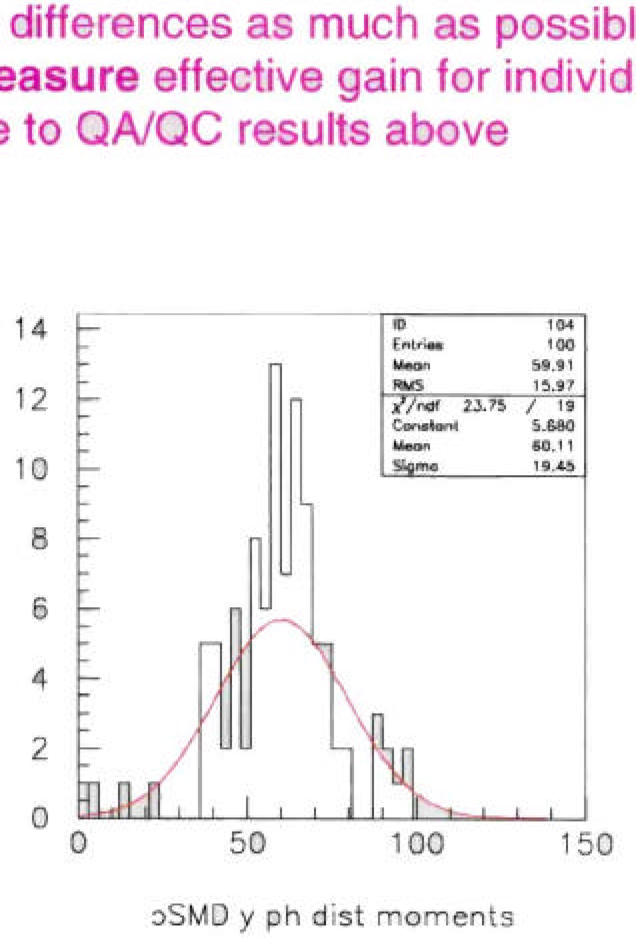
"Effective gain" for each channel product of :

- pixel-to-pixel variations in MAPMT gain
- strip-to-strip variations in light collection efficiency

Technique:

- (QA/QC) — use LED's to **measure** relative gain of each anode signal for each MAPMT
- (QA/QC) — develop procedures (wrapping, polishing, etc.) to minimize strip-to-strip differences as much as possible
- use cosmic-ray μ's to **measure** effective gain for individual SMD channels, compare to QA/QC results above

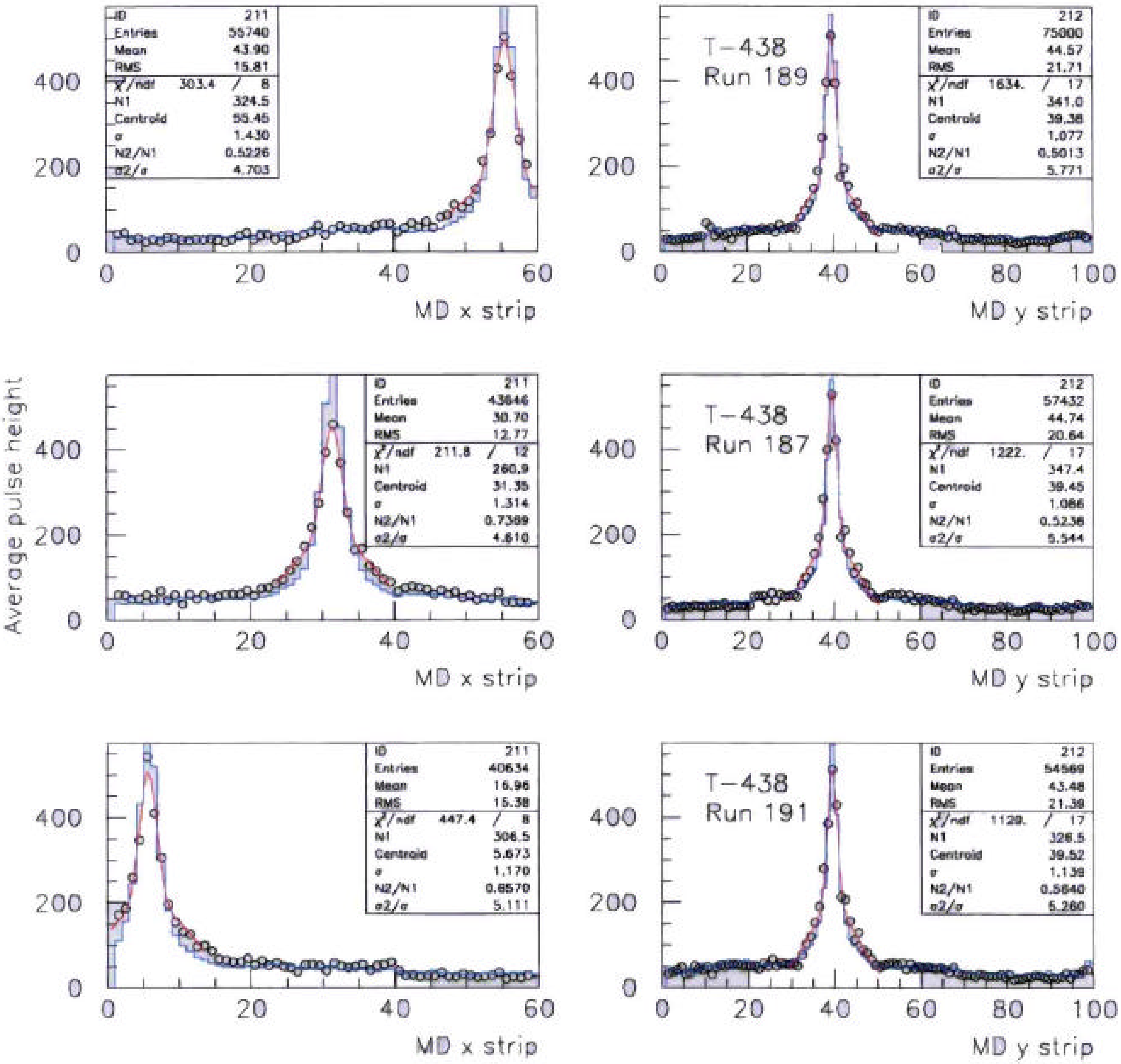




By then correcting in software for the ‘gain’ of each channel

- * obtain uniform response at ~10% level or better
  ⇒ *already sufficient for excellent γ / π° discrimination*

- * agreement with simulations indicates that <u>absolute</u> gains also determined to needed level of precision

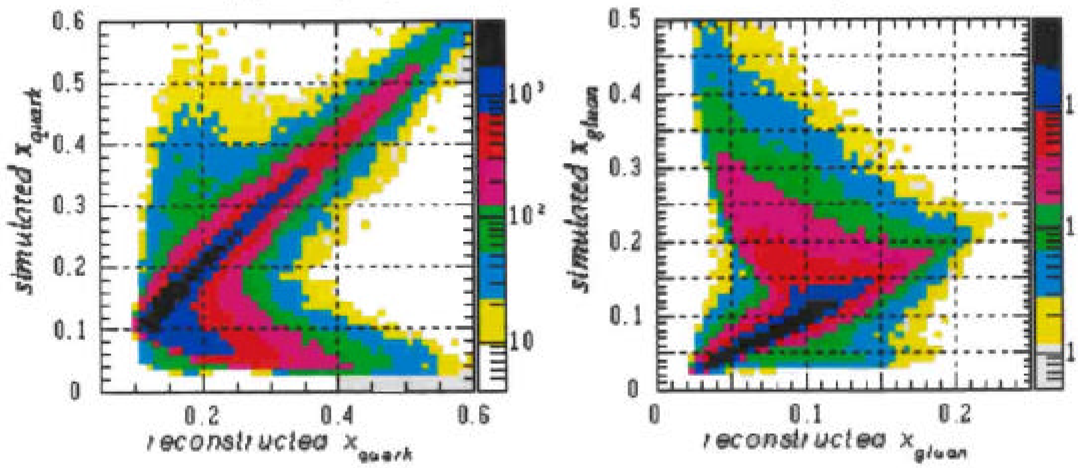


Simulation studies for the EEMC

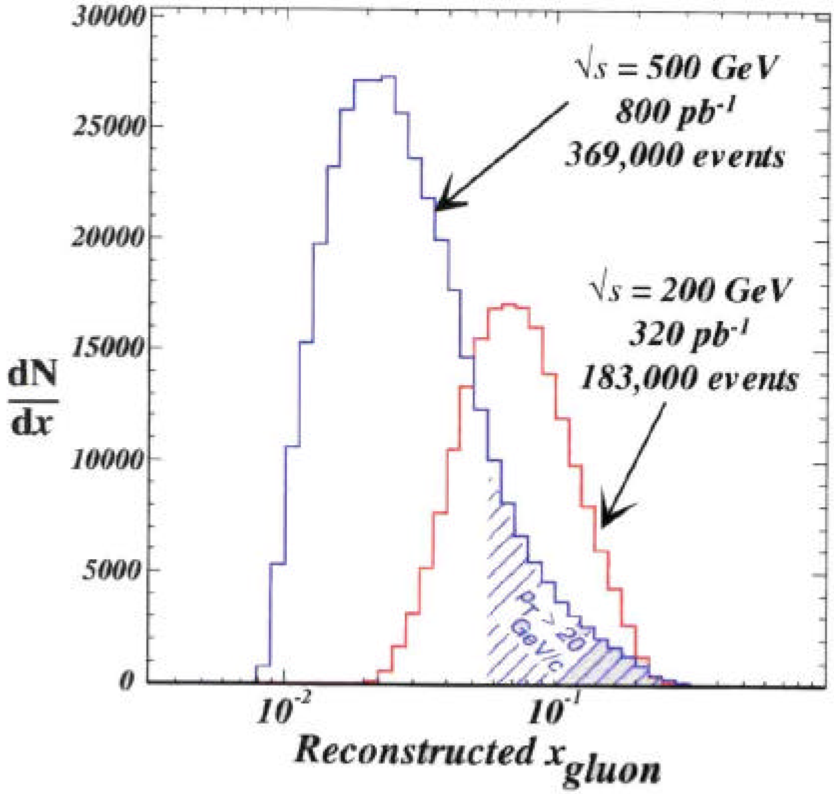
1. Use PYTHIA 5.7 for QCD event generator, to describe relevant features of “hard” processes
2. Use parton helicity distributions (including ΔG) from the analysis of Gehrmann and Stirling, after evolving observables to $Q^2 = p_T^2/2$
3. Put pQCD-predicted spin dependence in ‘by hand’
4. Then: run simulated events through the same analysis (software cuts) to be used in real data analysis, to determine the ‘measured’ spin asymmetries
5. Use asymmetries to reconstruct quantities of interest, assuming that all ‘observed’ γ + jet events are due to quark-gluon collisions in which $x_q > x_g$

First test: compare reconstructed values of initial-state parton x values to those generated in simulations

$p\,p \rightarrow \gamma + jet + X$, $\sqrt{s} = 200$ GeV 320 pb^{-1}

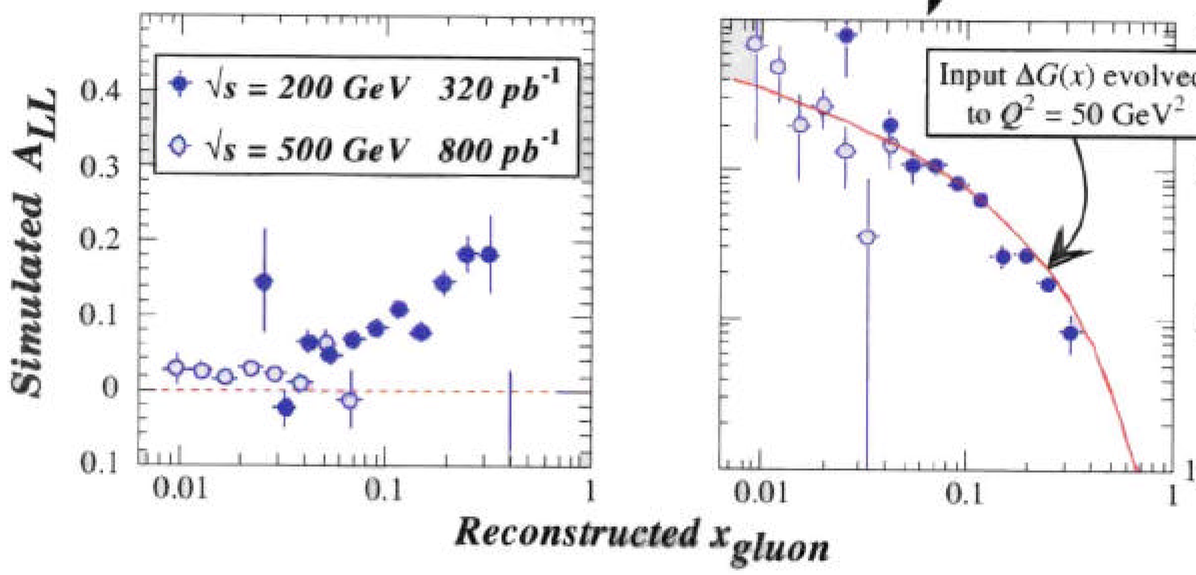


$\vec{p}\,\vec{p} \to \gamma + jet + X$ **with STAR + EEMC**



By combining measurements at $\sqrt{s} = 200$ GeV and $\sqrt{s} = 500$ GeV, STAR γ + jet data will allow a direct determination of $\int \Delta G(x,Q^2)\,dx$ to a precision better than ±0.5.

Addition of the $\sqrt{s} = 500$ GeV results should reduce the $x_g \to 0$ extrapolation uncertainty by a factor ≈ 6.



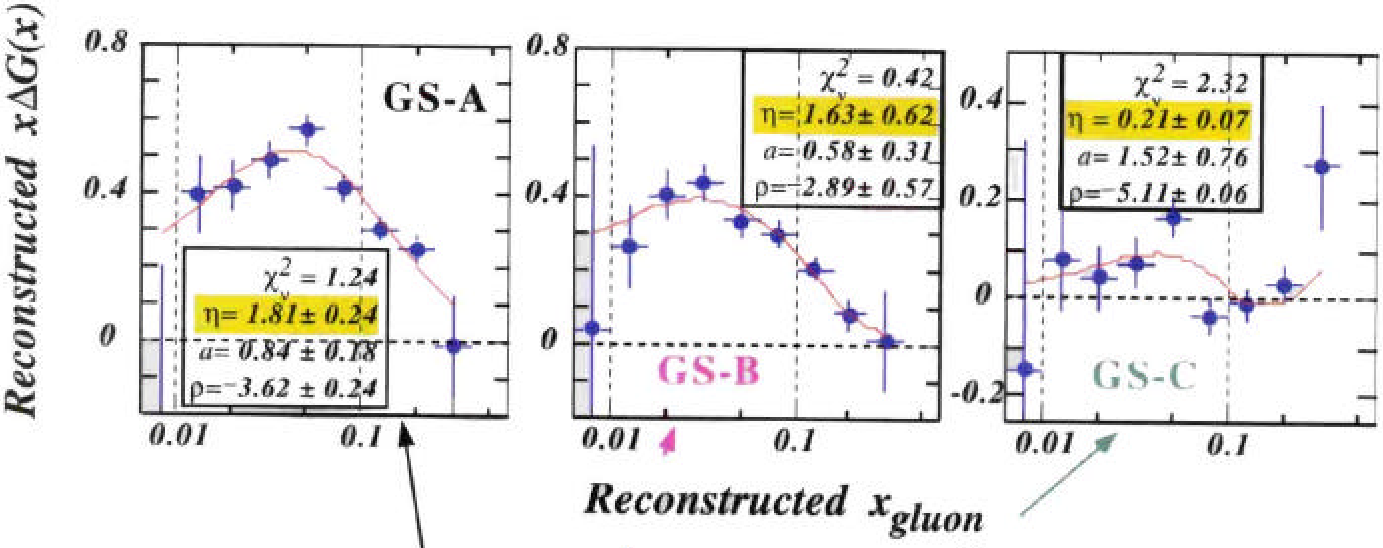
$$A_{LL} = \frac{\Delta G(x,Q^2)}{G(x,Q^2)} \cdot A_1^p(x_q,Q^2) \cdot \hat{a}_{LL}^c(\theta^*)$$

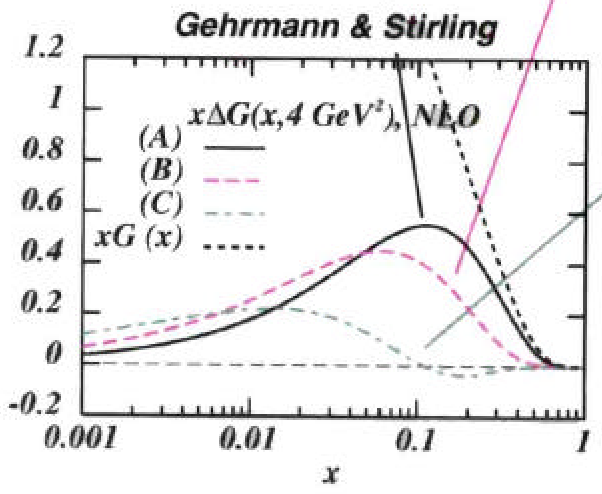
Recent simulations, incorporating several different $\Delta G(x,Q^2)$ models and proper DGLAP evolution show that STAR BEMC + EEMC + 200 GeV + 500 GeV are all essential to cover sufficient x_{gluon} range ($0.01 \leq x_{gluon} \leq 0.30$) to constrain the extrapolation to $x \to 0$, needed to determine the first moment (η in fits below) to a precision ≈ ± 0.5.

⇒ Likely time scale for full γ-jet coincidence measurements is 2003-4

$\vec{p} + \vec{p} \to \gamma + jet + X$ *with STAR + EEMC at*

$\sqrt{s}$ *= 200 GeV (320 pb^{-1}) + $\sqrt{s}$ = 500 GeV (800 pb^{-1})*





There are small systematic errors that arise from simplifying assumptions made in a direct reconstruction of ΔG from the measured asymmetries. These errors depend on $\Delta G(x,Q^2)$, but can be corrected in an iterative analysis with the aid of simulations. Analysis of STAR's coincidence data with varying kinematic cuts is important to test the simulations.

Theoretical and Technical Challenges

Theoretical Backgrounds (higher-order contributions):

1) *Next-to-Leading Order pQCD diagrams: about 25% of detected photons will be fragmentation photons from jets*
   ⇒ only small quantitative changes to $A_{LL}(\gamma)$ -- though difficult to estimate effects of supression via isolation cuts

2) *Multiple soft gluon radiation prior to hard scattering may ⇒ up to few GeV/c transverse momenta of colliding partons ⇒ systematic errors in reconstructed $x_{1,2}$:*
   ⇒ kinematic effects of such k_T-smearing are included in the simulations, and are not too serious for coincidence polarization experiments;
   ⇒ furthermore, simulations by Regensburg group (A. Schäfer, et al.) indicate that multiple gluon radiation does not affect the gluon helicity distribution appreciably.

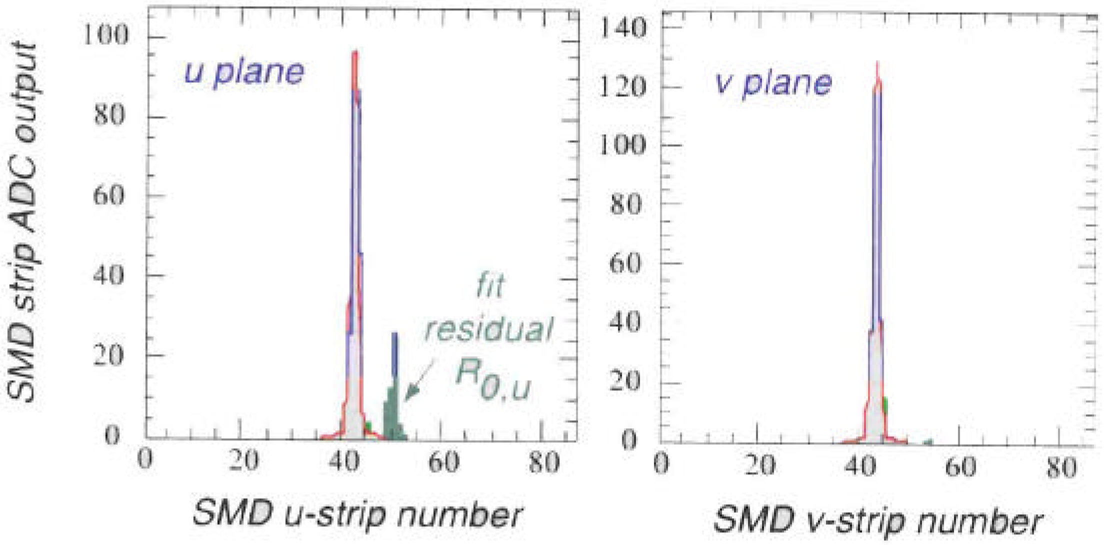
Experimental Backgrounds:

1) *Abundant high-p_T π^0, $\eta^0 \rightarrow \gamma\gamma$ at very small ($\gtrsim$ 10 mrad) opening angles:*
   ⇒ combination of isolation cuts and SMD shower profile cuts provide adequate suppression in simulations (see next frame) -- simulated shower profiles agree well with measured profiles in prototype SMD beam test.

2) *40 μs TPC drift time + high $\vec{p}$-$\vec{p}$ luminosity ⇒ many spurious track segments from earlier or later beam crossings:*
   ⇒ challenging, but feasible, to reject pileup tracks via matching to fast detectors and correct vertex location -- requires Level 3 trigger event "filtering".

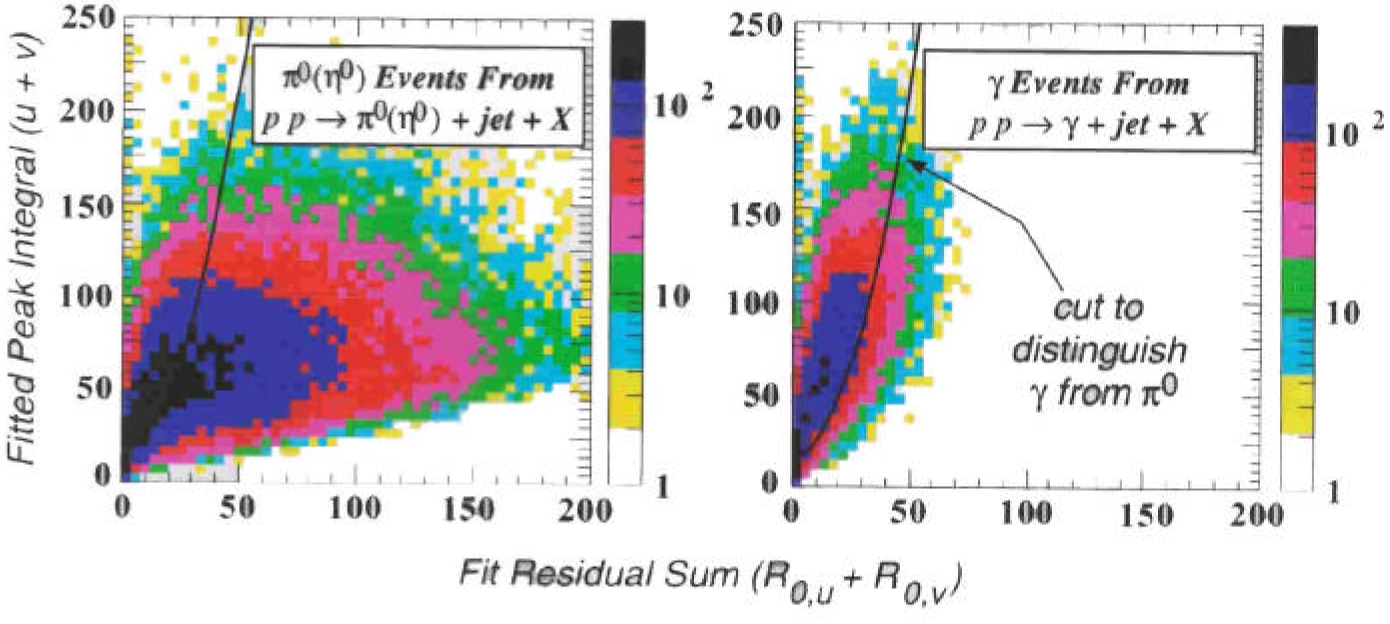
SMD γ / π^0 Discrimination Algorithm

SMD transverse shower profile for 30 GeV π^0 event



- ***fit transverse SMD profile with peak shape characteristic of average response to single*** γ

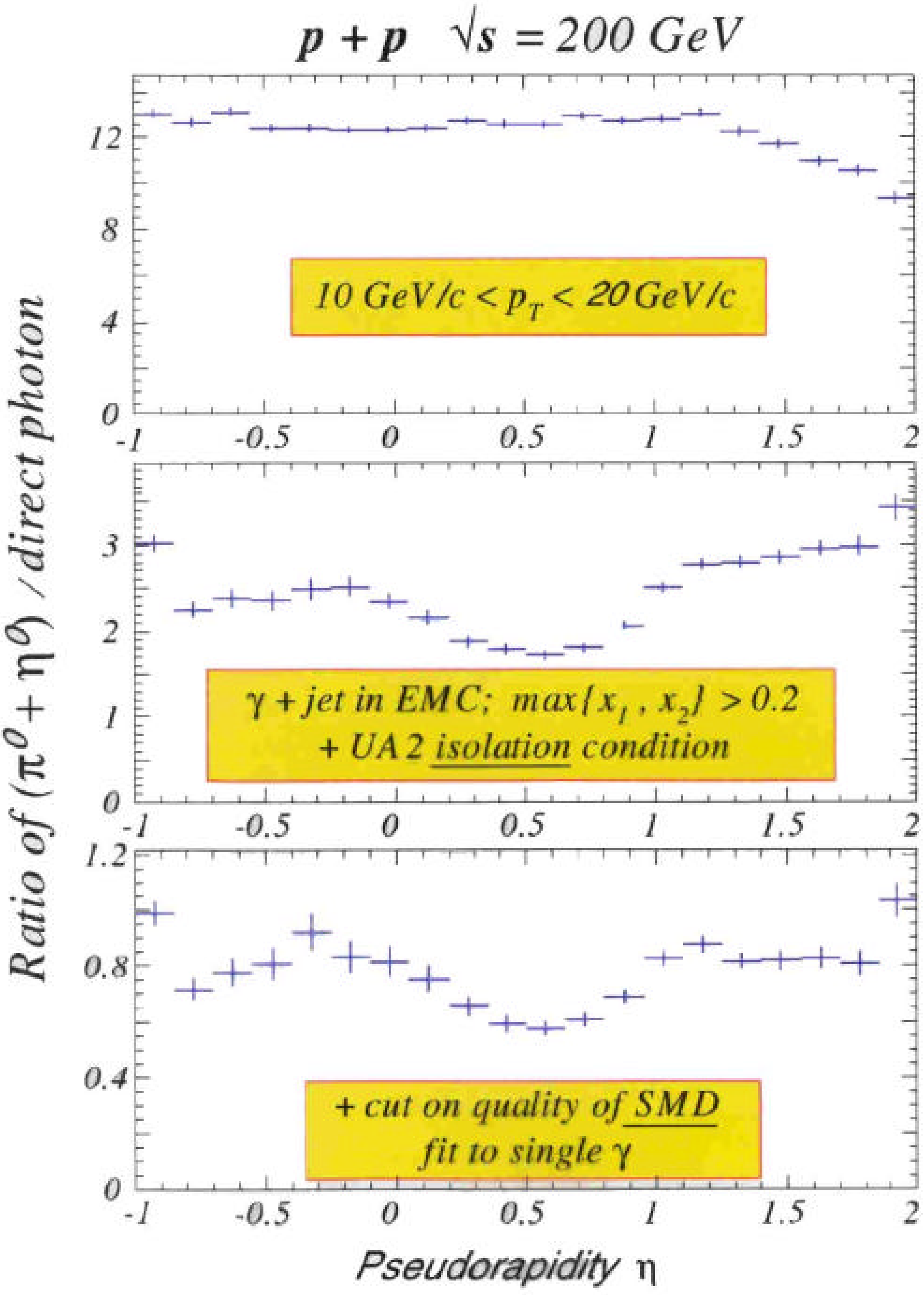
- ***determine peak integral and "worst-side" fit residual for each plane of SMD***



⇒ ≈80% π^0 (η^0) rejection ⊕ ≈80% γ retention up to E ≈ 50 GeV

$\pi^0 + \eta^0$ Background Suppression for $\vec{p} + \vec{p} \rightarrow \gamma + jet + X$

(PYTHIA 5.7 simulations)



Remaining background to be subtracted by measuring A_{LL} for samples that pass and fail SMD cut

⇒ increased errors on $\Delta G(x)$ by factor 1.5 - 2.0

Complementary Sensitivity to $\Delta G(x,Q^2)$ from Other $\vec{p}+\vec{p}$ Reaction Channels

1) *Inclusive Prompt Photon Production* $\vec{p}+\vec{p}\rightarrow\gamma+X$ *:*

- *free from possible biases introduced by jet identification*
- *cannot measure* x_q *and* x_g *event-by-event (use* $x_T \equiv 2p_T/\sqrt{s}$ *)* $\Rightarrow$ *more averaging over kinematic ranges*

2) *Inclusive Jet or Leading Hadron Production :*

- *Abundant events* $\Rightarrow$ *high statistics early in RHIC Spin program*
- *Competing contributions from q+g, g+g, q+q complicate interpretation*

3) *Open Heavy Flavor Production :*

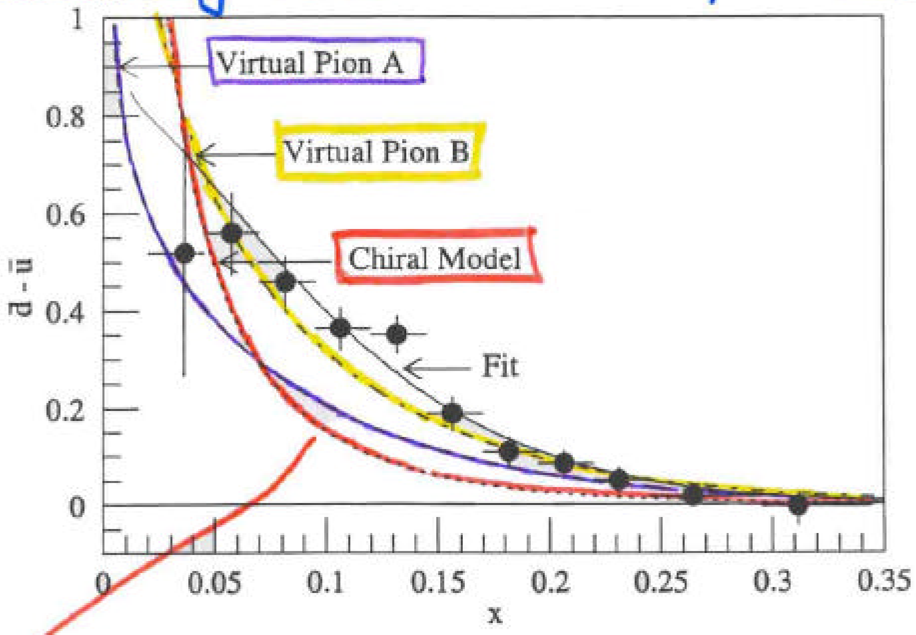
- *Is mechanism dominated by gluon-gluon fusion:* $g+g \rightarrow c\bar{c}, b\bar{b}$ *?*
- *If so, sensitive to product of gluon polarizations at two different x-values* $\Rightarrow$ *most useful if* $\Delta G/G$ *relatively large*
- *Positive ID of charm (e.g.,* D^0 *decay)* $\Rightarrow$ *low statistics; detection via inclusive lepton decay* $\Rightarrow$ *large background to discriminate*

4) *High-*p_T *Drell-Yan Dilepton Production :*

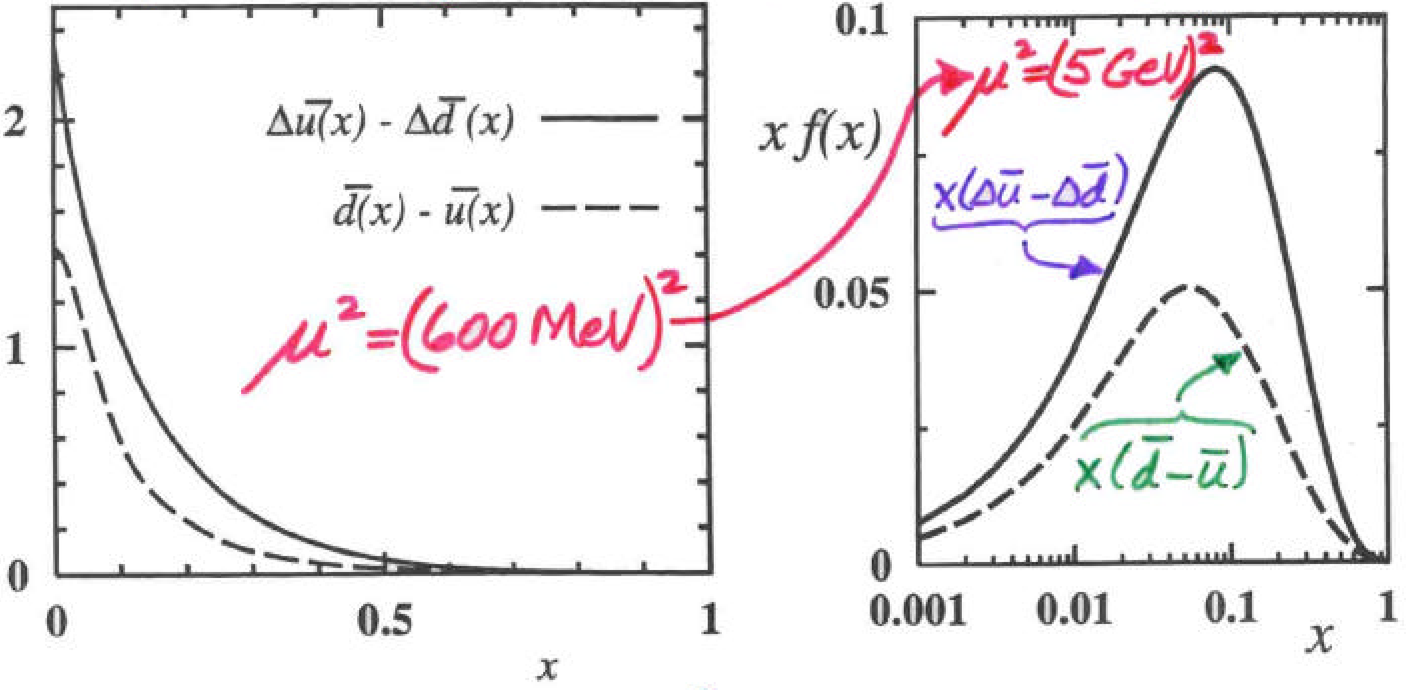
- *At* $p_T > M/2$*, should be dominated by* $q+g \rightarrow q+\gamma^* \rightarrow q+l^+l^-$
- *Reduced sensitivity to isolation cut, fragmentation ambiguities*
- *Small cross section, triggering* $\Rightarrow$ *experimental challenges*

Credibility of final results will rest on simultaneous account for data in several sensitive channels, plus consistency with results from photon-gluon fusion.

Large $\bar{d}-\bar{u}$ asymmetry mapped in FNAL E866 is qualitatively consistent with pion cloud models

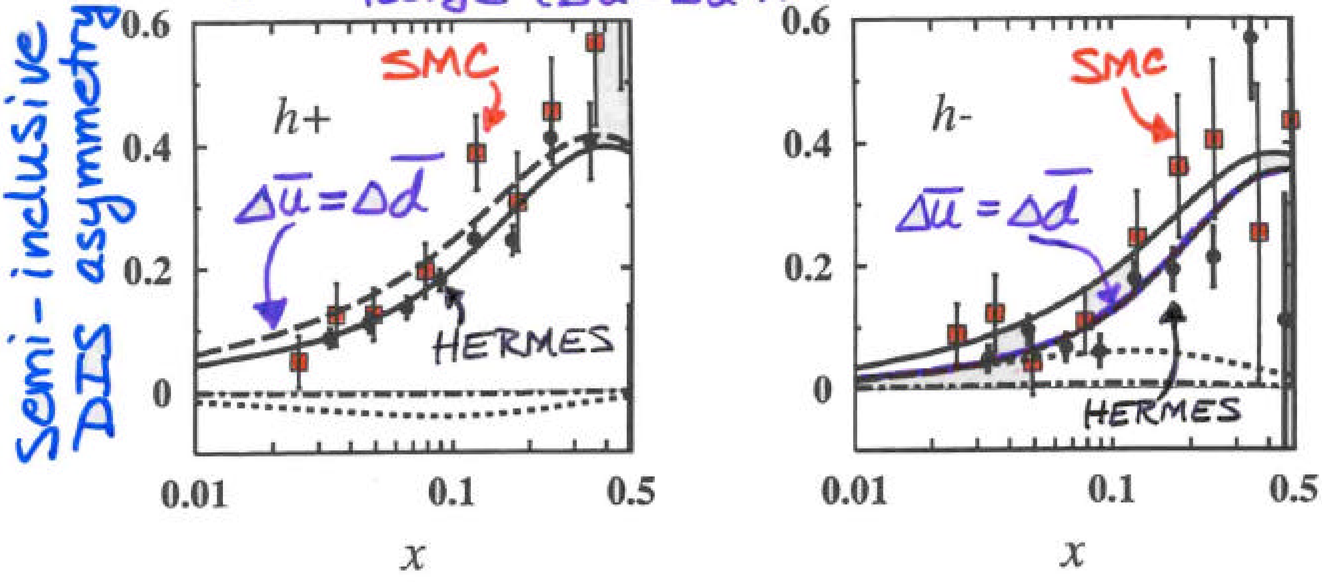


and with Chiral Soliton model, appropriate in large-N_c limit of QCD: quarks bound by collective pion field ⇒ χSB



⇒ is there a large flavor-dependence of $\bar{q}$ polarizations in the proton?

SMC + HERMES semi-inclusive $\overrightarrow{\text{DIS}}$ data are not very sensitive to, but also not inconsistent with, large $(\Delta\bar u - \Delta\bar d)$.

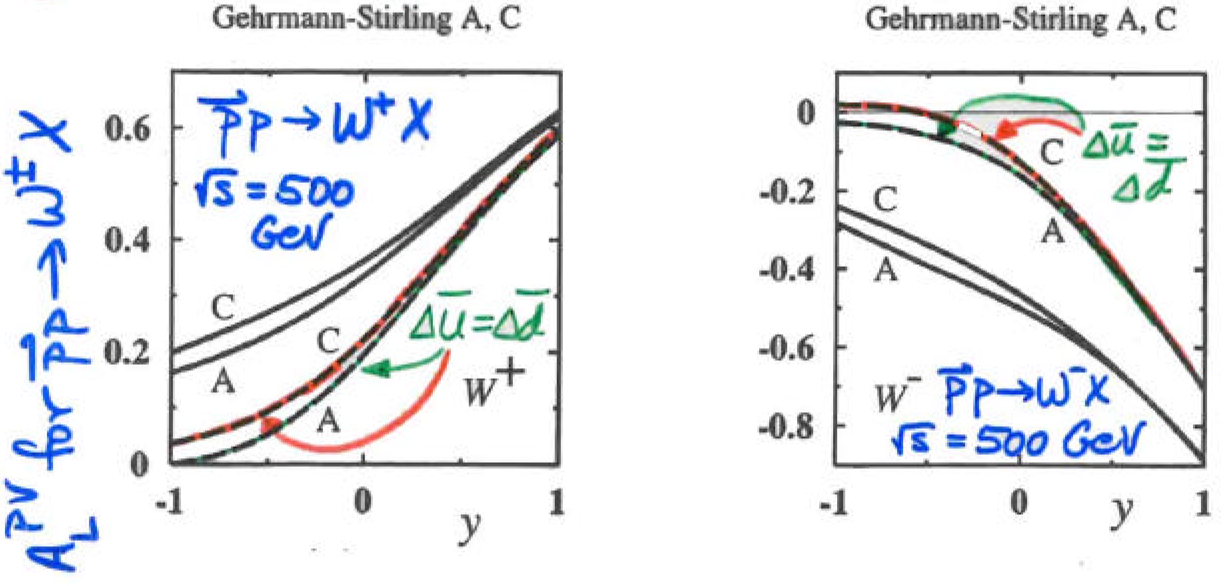


$W^\pm$ prod'n in $\vec p + \vec p$ collisions ⇒ strong sensitivity:

e.g., $$A_L^{W^+}(\text{beam } \underline{a}) = \frac{\Delta u(x_a)\bar d(x_b) - \Delta\bar d(x_a)u(x_b)}{u(x_a)\bar d(x_b) + \bar d(x_a)u(x_b) + hfc}$$

$x_a \gg x_b$ ⇒ simplifications:

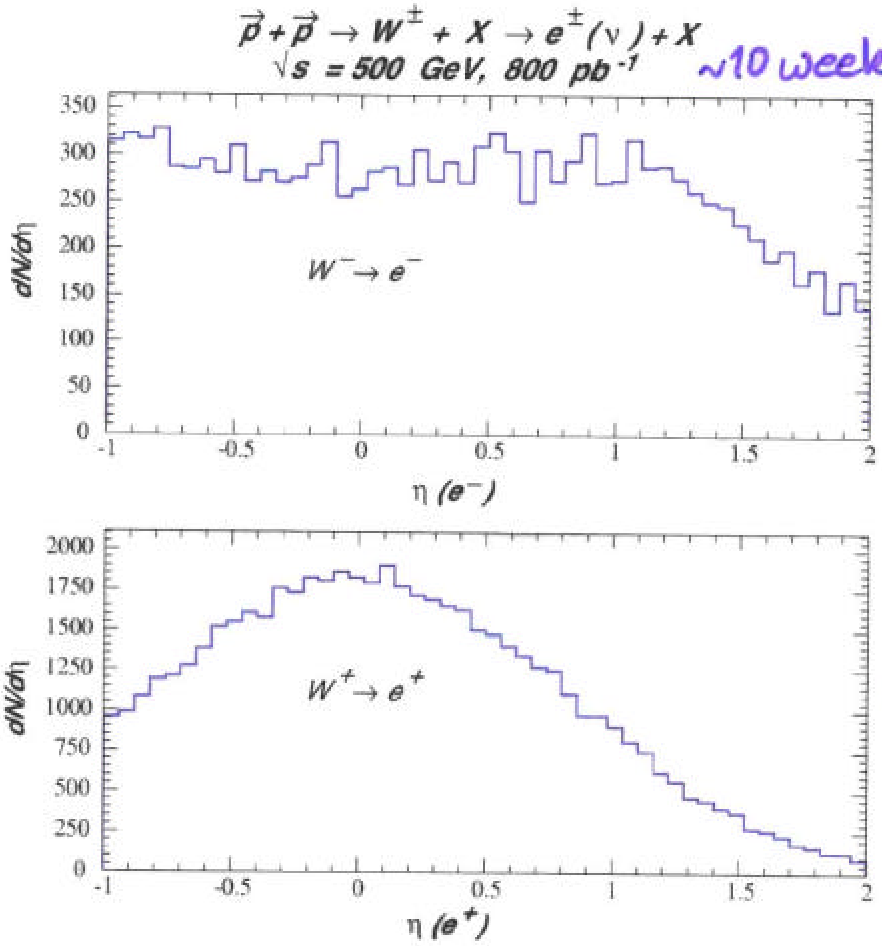
$$A_L^{W^+}(\text{beam } a) \rightarrow \frac{\Delta u}{u}(x_a);\quad A_L^{W^+}(\text{beam } b) \rightarrow +\frac{\Delta\bar d}{\bar d}(x_b);\ \ldots$$


Gehrmann-Stirling A, C

Gehrmann-Stirling A, C

$W^\pm$ Production / Decay Kinematics

- $W^\pm$ has momentum in dir'n of higher-x parton (usually q)
- $W^\pm$ produced left-handed
- PV decay ⇒ in W rest frame, e^+ emitted preferentially **along** dir'n of W^+ spin
  CP ⇒ e^- emitted preferentially **opposite** W^- spin
- ⇒ e^- focused in q direction; e^+ more spread out
- ⇒ for W^- production, e^- in endcap preferentially probes $d_{toward}\ \bar{u}_{away}$ **collisions**


$\vec{p}+\vec{p} \rightarrow W^\pm + X \rightarrow e^\pm(\nu)+X$
$\sqrt{s}$ = 500 GeV, 800 pb^{-1}

~10 weeks @ $\mathcal{L}$ = $2\times10^{32}\ cm^{-2}s^{-1}$

~14 K W^- events

~57 K W^+ events

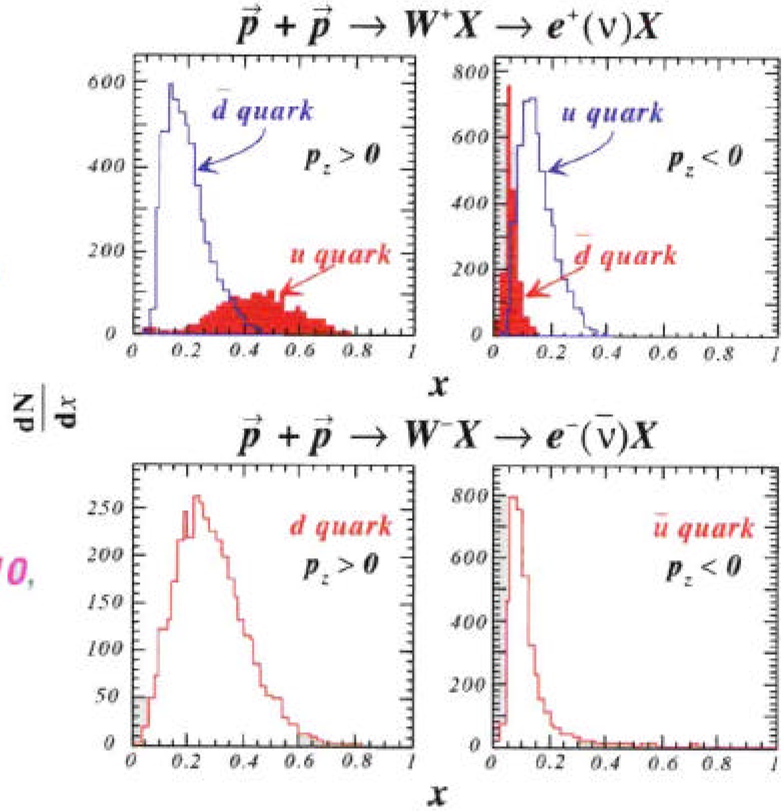
For $e^{\pm}$ detected in the endcap region ($1 \le \eta \le 2$), we probe either:

asymmetric $q_{toward}\,\bar{q}_{away}$

or reasonably symmetric

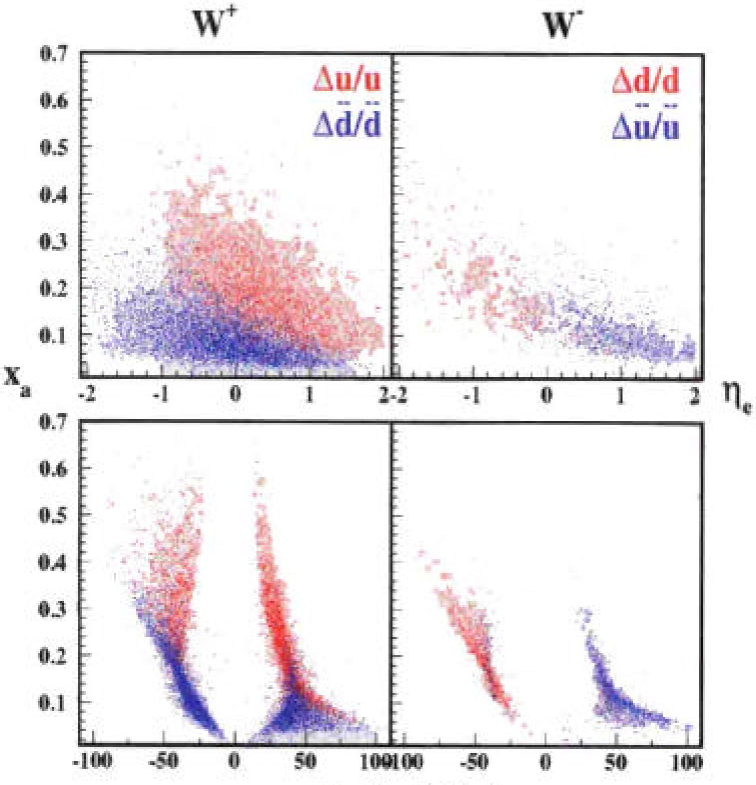
$\bar{d}_{toward}\,u_{away}$ collisions.

The asymmetric collisions in particular probe $x_{\bar{q}} < 0.10$, where chiral soliton model predicts large flavor-dep. antiquark polarizations.



assume:

Unpol. Beam → ← Polarized Beam



The detected electron energies and pseudo-rapidities provide event-by-event information by which we can constrain the Bjorken x-values of the colliding partons and the assignment of the x-values to quark vs. antiquark.

Approximate Reconstruction of $x_{1,2}$ for W Production Events

*Neglecting the **transverse** momentum q_T with which the W is produced, and the width of the W, two-body fusion + 2-body decay kinematics ⇒*

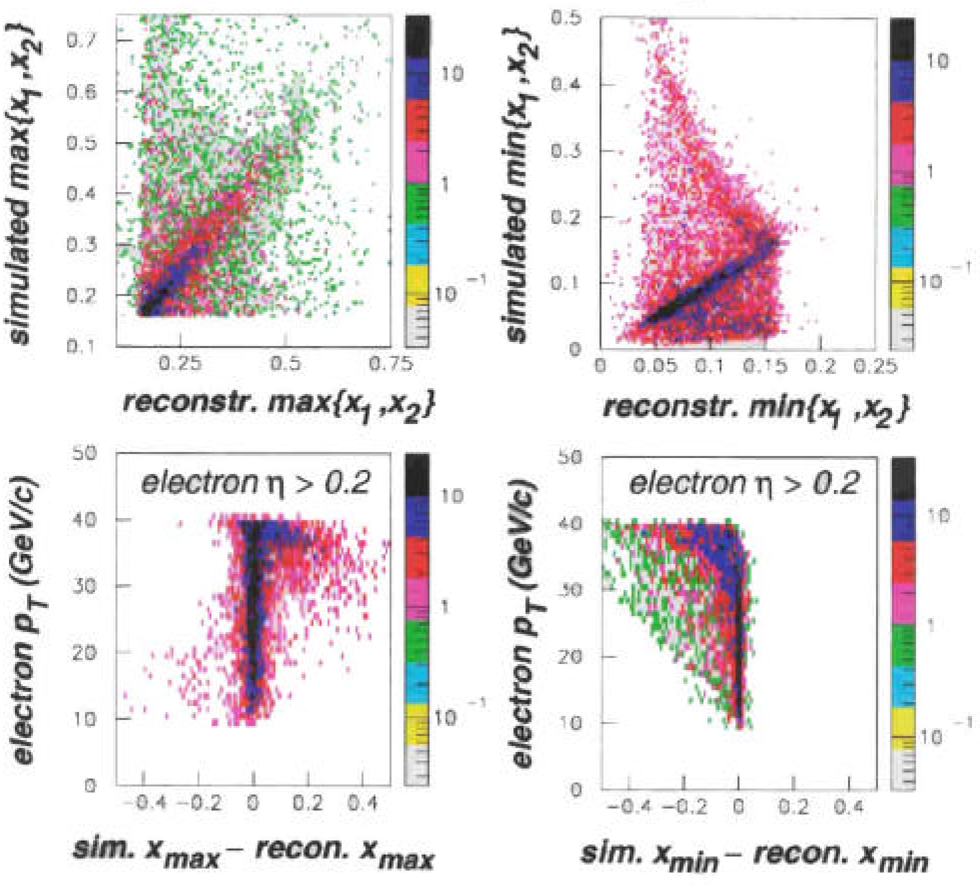
$$\sqrt{x_1 x_2} = \frac{M_W}{\sqrt{s}} = 0.16 \text{ at } \sqrt{s} = 500 \text{ GeV};$$

$$\beta_W = \frac{x_1 - x_2}{x_1 + x_2} = \tanh\,[\,\eta_e^{meas} - \eta_e^{rest}\,]$$

$$= \tanh\,[\,\eta_e^{meas} - \cosh^{-1}(M_W/2p_{T_e}^{meas})]$$

This permits extraction of $x_{1,2}$ *with good resolution* ($\sigma_{x\text{-}min} \approx 0.01$, $\sigma_{x\text{-}max} \approx 0.02$) *from* η **and** p_T *measurements for the daughter* $e^{\pm}$, *except at mid-rapidity or for the highest electron* p_T *(where the W has small longitudinal momentum in the collider frame, so that neglect of* q_T *is a poor approximation). The assignment of* x_{max} *to the quark and* x_{min} *to the antiquark is most reliable for the most asymmetric partonic collisions.*

$p+p \rightarrow W^{\pm}X,\ \sqrt{s} = 500$ GeV, 78 pb^{-1}

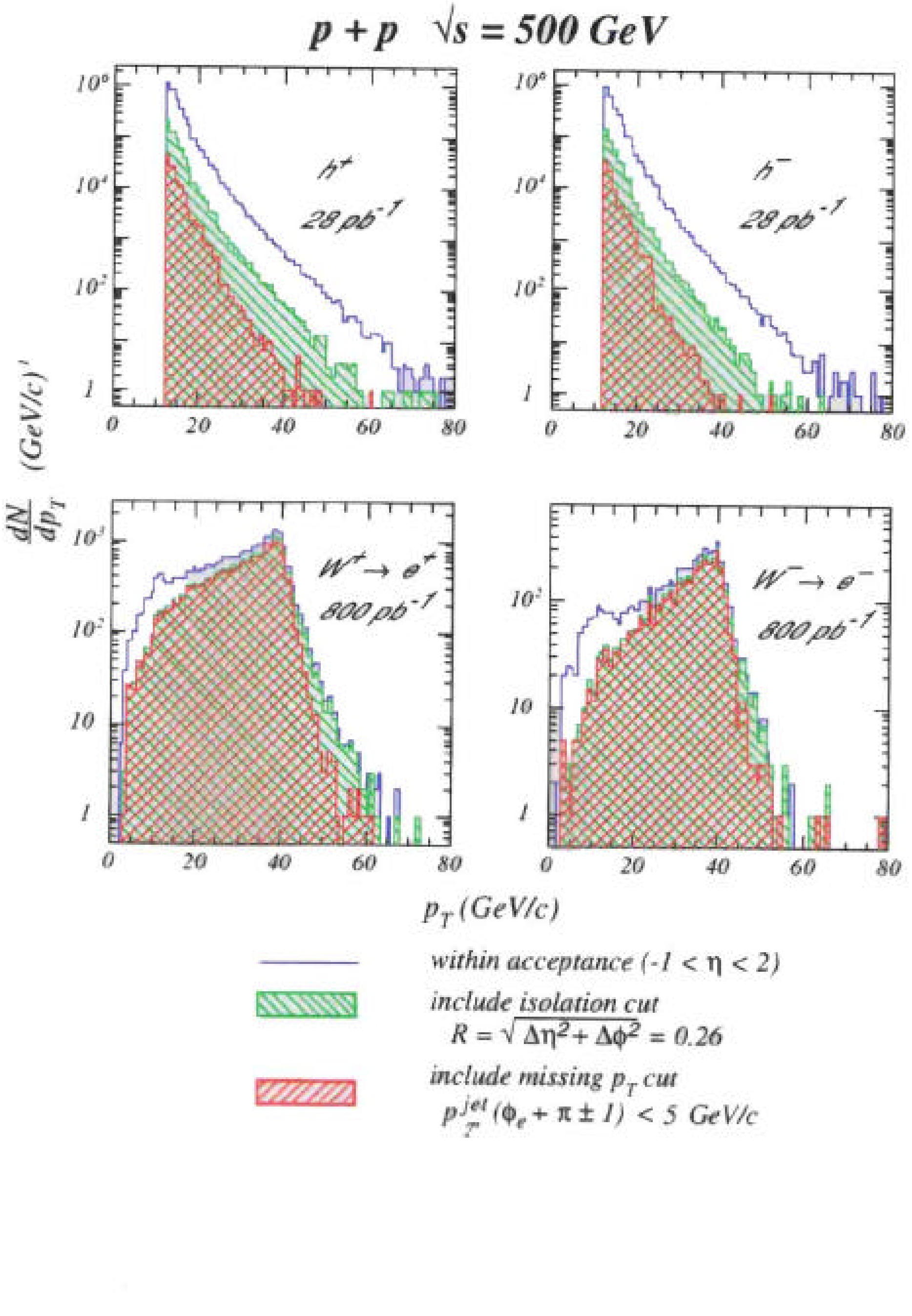


Hadron / Electron Discrimination

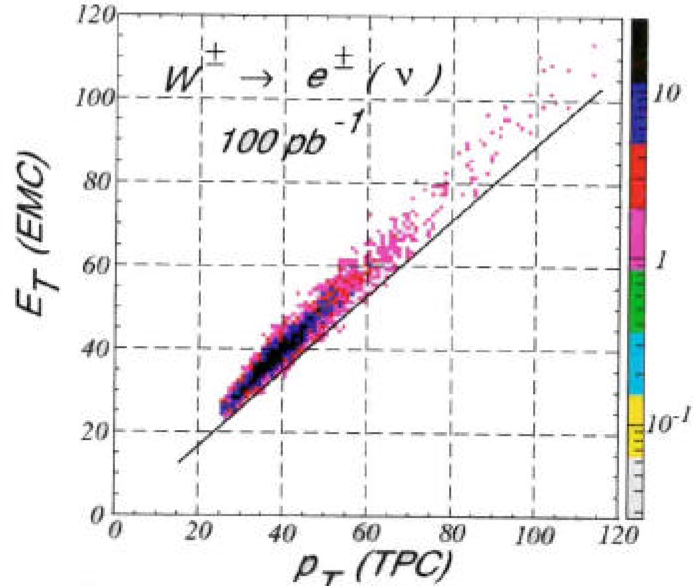
is provided by a combination of cuts on:

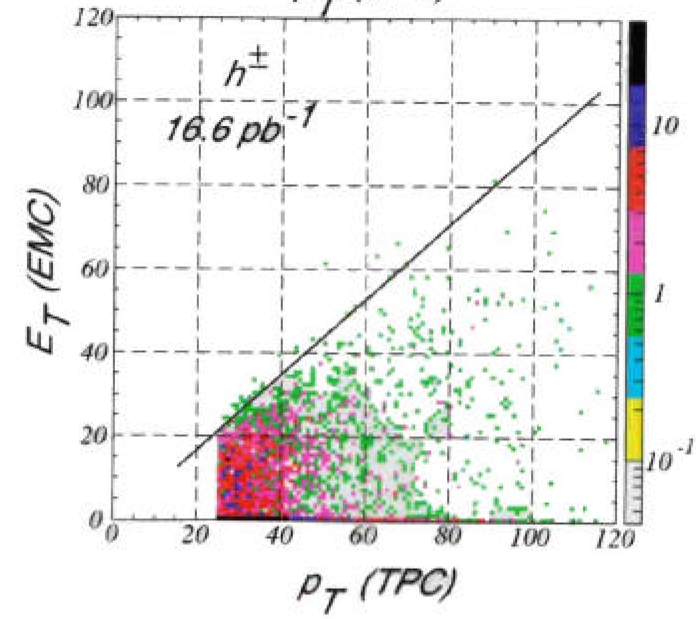
- isolation of detected particle from other jet fragments
- absence of accompanying jet at opposite azimuth
- calorimeter response: E_T (in EMC) vs. p_T (in TPC) and/or $E_{preshower}$, $E_{post\text{-}shower}$, E_{SMD} vs. E_{tot} (in EMC)

Each cut provides hadron suppression by about an order of magnitude, yielding W signal/ hadron bkgd. > 1 at $p_T^e \geq 20$ GeV/c



EM Calorimeter Response: > 20 radiation lengths, but ~1 hadron interaction length ⇒ strong hadron background suppression via reduced EMC energy deposition:





In the endcap region, where p_T resolution from TPC deteriorates, and at high E_T , where jets often give a charged and a neutral (e.g., π^0) hadron in the same EMC tower, e/h discrimination relies increasingly on EMC response alone:

comparison of energy depositions in preshower layers, SMD, and post-shower layer with EMC tower, + analysis of shower profile in SMD ⇒ order of magnitude suppression of $h^{\pm}$ vs. $e^{\pm}$.

Status and Timescales

RHIC: just completed first successful *pp* run (3 wks dev, 5 wks data)!

- ✓ Lots of new devices – new polarized source, many polarimeters, four Siberian snakes, spin flippers, CNI polarimetry at top energy
- ✓ p beams ramped to 100 GeV in each ring
- ✓ Peak luminosities of ~ 2 x 10^{30} cm^{-2} s^{-1} achieved at end of run
- ➢ Average polarization only ~15% (?) at top of ramp (lost in AGS)
- ➢ No reliable means of determining absolute polarization at 100 GeV
- ➢ Run schedule for 2003-2004 very uncertain due to funding situation

STAR: all baseline detectors / subsystems now up and running reliably

- ✓ TPC track reconstruction working even for central Au-Au collisions (L3 provides color display of all reconstructed tracks in real-time!)
- ✓ Should have ½ of Barrel EMC installed by October 2002
- ✓ Full complement of luminosity monitors, scalers, triggers operational including 'high-tower' trigger for BEMC patch
- ✓ Wrote 20M minimum-bias *pp* events to tape for HI data set

EEMC: all production lines underway, but much remains to be done ...

- ✓ Mechanical structure for lower half to be installed on poletip June '02
- ✓ Should have sufficient megatiles, SMD planes, PMT boxes, and front-end electronics for four 30° sectors by October '02
- ✓ Several calibration and monitoring systems (involving UV lasers, LED's, radioactive sources) prototyped and ready for use
- ➢ Behind schedule for readout electronics and slow controls
- ➢ Lots of acquisition and analysis software still to be written
- ➢ Have a small crew of people doing a large number of jobs, ***BUT ...***

... all test results and extensive simulations indicate that STAR at RHIC, when equipped with the full EEMC, will provide a direct measurement of $\Delta G(x)$ and its integral to an accuracy of ±0.5, and a robust separation of the nucleon anti-quark polarization into its flavor components.

CONCLUSIONS

1) STAR well equipped for $W^{\pm}$ production via detection of isolated $e^{\pm}$ daughters over $-1 < \eta \lesssim +1.7$, unaccompanied by jet at opposite azimuth. Easy triggering via high E deposition in single EMC tower.

2) Measurement of four single-spin PV asymmetries for $W^{\pm}X$, in 10-week run @ $\sqrt{s} = 500$ GeV $\vec{p} + \vec{p}$, allows determination of $\Delta\bar{u}/\bar{u}$ vs. $\Delta\bar{d}/\bar{d}$ with typical uncertainties $\sim \pm 0.05$ in bins of width $\delta x_{\bar{q}} \approx 0.02$, over range $0.05 \lesssim x_{\bar{q}} \lesssim 0.15$, where $1/N_c$ expansion suggests large, flavor-dependent antiquark pol'ns.

3) Simultaneous determination of $\Delta u/u$ and $\Delta d/d$ allows crosscheck against $\overrightarrow{\text{DIS}}$.

4) Still need <u>complete</u> simulation, incorporating W prod'n + bkgd., full TPC response (incl. deteriorating resolution at $\eta > 1$, pileup), and full EMC response (incl. preshower, SMD and post-shower), on which to tune $W^{\pm}$ identification and reconstruction algorithms, as well as extraction of $\Delta q/q\ (x_q)$ and $\Delta\bar{q}/\bar{q}\ (x_{\bar{q}})$.

5) Future improvements possible:

enhanced luminosity ⇒ look for forward baryon in coincidence to "get in touch with proton's inner Goldstone boson" -- e.g., e^+ - n (ZDC) coinc. to isolate inter'n with $\bar{d}$ from pion cloud

enhanced fwd. calorim. ⇒ map $\Delta u/u$, $\Delta d/d$ at $x_q > 0.6$, where quark polarizations are presently poorly known.