OVERVIEW OF E159, E160, E161

S.O.C. Review April 11, 2001

P. Bosted

- A cohesive program of three fixed target photoproduction experiments.
- Significant overlaps in beam, target, and detectors; maximizes physics output for investment needed.
- Approved at Nov. 2000 EPAC meeting.
- Plan to run several calendar months each.

  2003: E160 A-dependence of J/ψ

  2004: E161 $\Delta G(x)$ from Open Charm

  2005: E159 GDH Sum Rule
- Experiments joined together to form Real Photon Collaboration

REAL PHOTON COLLABORATION

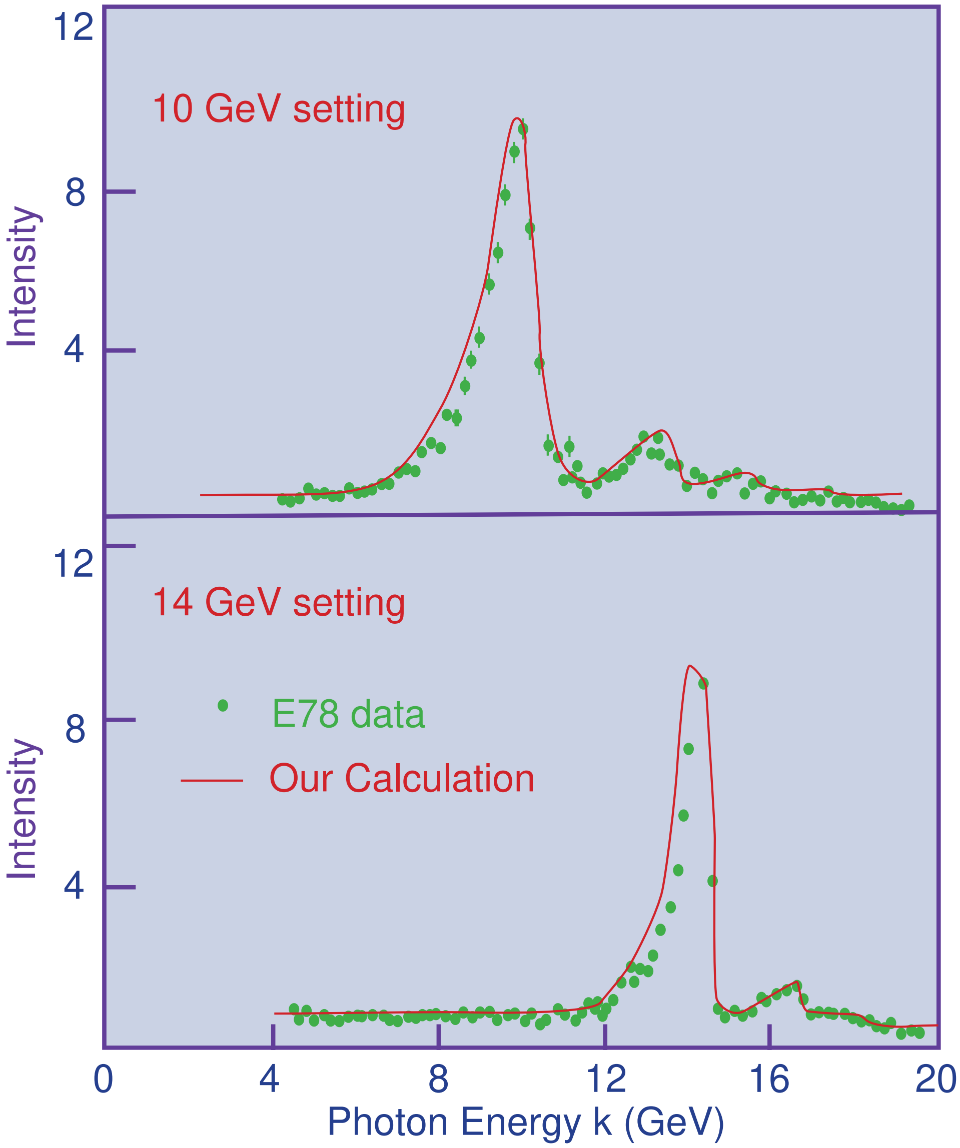
- **UCLA**
- **INFN Frascati, Italy**
- **Jefferson Lab**
- **University of Liverpool**
- **Los Alamos**
- **University of Massachusetts**
- **Saclay, France**
- **Institut fur Kernphysik, Mainz**
- **Old Dominion University**
- **Ruhr-UniversitB̑ochum, Germany**
- **Smith College**
- **SLAC**
- **University of Virginia**
- **College of William and Mary**
- **Yerevan Physics Institute, Yerevan, Armenia**

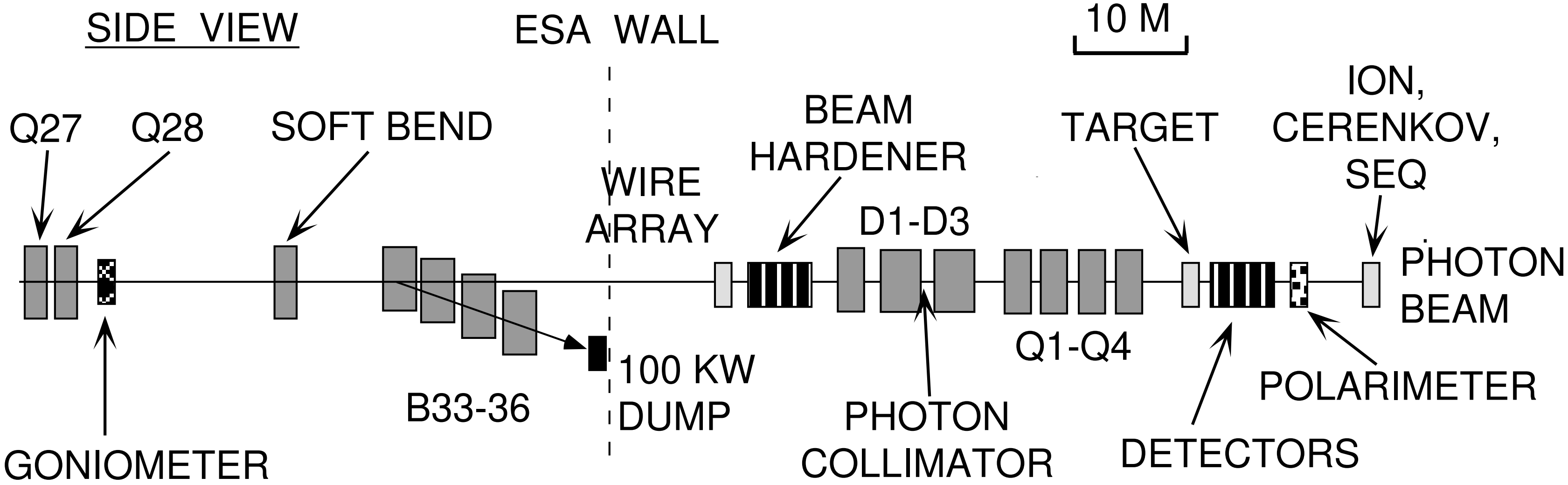
Overview Of Coherent Bremsstrahlung

- Normal bremsstrahlung radiation of photons from electrons passing through a material gives flux proportional to $(dk/k)(L/X_0)$
- Coherent bremsstrahlung occurs when material is a crystal. A set of high intensity spikes at discrete energies occurs.
- Energy of spikes depends on angle between electron and crystal
- Intensity increases with beam energy E, and ratio E/k_0
- Diamond is best crystal.
- We propose to re-establish old SLAC setup, and upgrade from 20 to 50 GeV capability.

COMPARISON OF OUR CALCULATIONS WITH E78 MEASURED SPECTRA

Electron beam energy was 19.7 GeV.




SIDE VIEW
ESA WALL
10 M
Q27
Q28
SOFT BEND
WIRE ARRAY
BEAM HARDENER
D1-D3
TARGET
ION, CERENKOV, SEQ
PHOTON BEAM
GONIOMETER
B33-36
100 KW DUMP
PHOTON COLLIMATOR
Q1-Q4
DETECTORS
POLARIMETER

E160: MEASUREMENT OF THE A-DEPENDENCE OF J/ψ AND ψ' PHOTOPRODUCTION

K Griffioen, P. Bosted, D. Crabb co-spokespersons

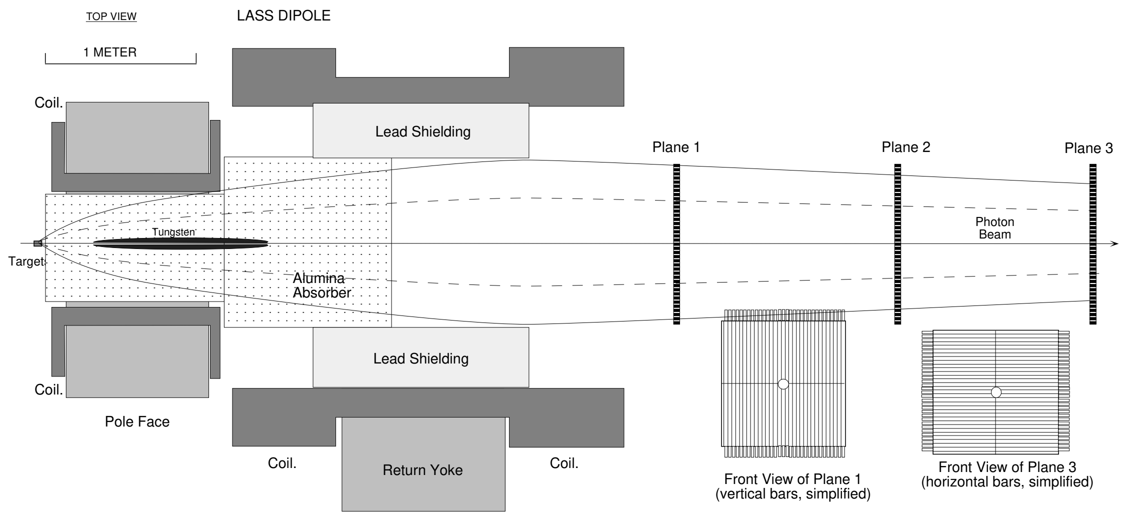
Planned to run in 2003

http:www.slac.stanford.edu/exp/e160/

- Goals:
  - Learn about creation and interaction of J/ψ and ψ' in nuclei.
  - Understand why VMD and geometrical expectations for $\sigma_{\rm tot}^{\psi N}$ are at odds.
  - Constrain causes for J/ψ suppression in relativistic heavy-ion collisions. by using simpler probe in same energy region.

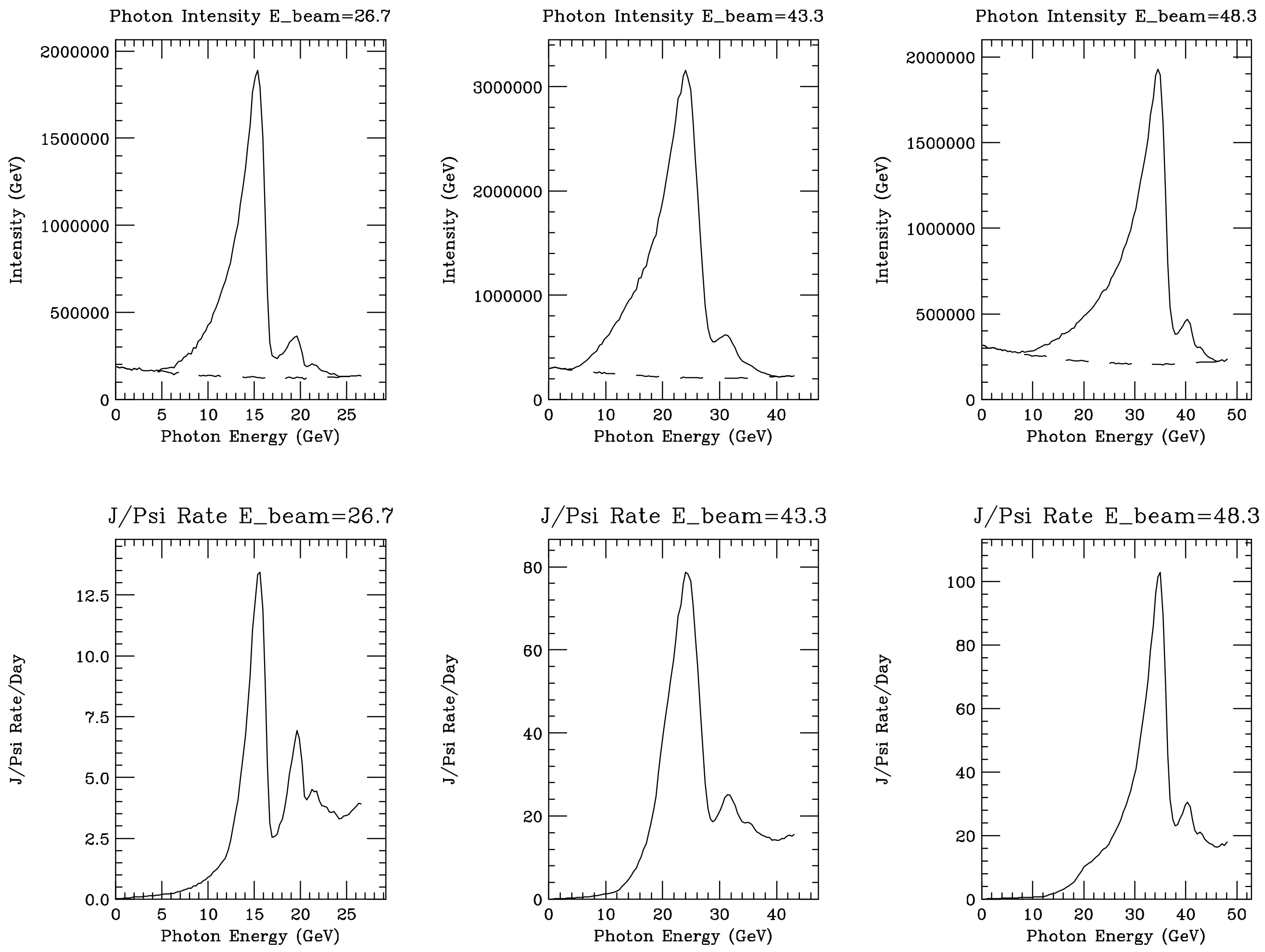
- **Measurement:**
  - Reconstruct J/ψ from $\mu^+\mu^-$ pairs.
  - Identify quasi-elastic events with fit to p_t-distribution
  - Use Be, Al, Cu, Pb targets
  - Use 15, 25, and 35 GeV photons
- **Anticipated Results:**
  - t-distributions
  - α from $\sigma_A \propto A^\alpha$ at 15, 25, 35 GeV
  - ψ-nucleon cross section $\sigma_{\rm tot}^{\psi N}$ at 15, 25, 35 GeV with much smaller errors than previous experiments.
  - First look at ψ'-nucleon cross section $\sigma_{\rm tot}^{\psi N}$

E160 Spectrometer

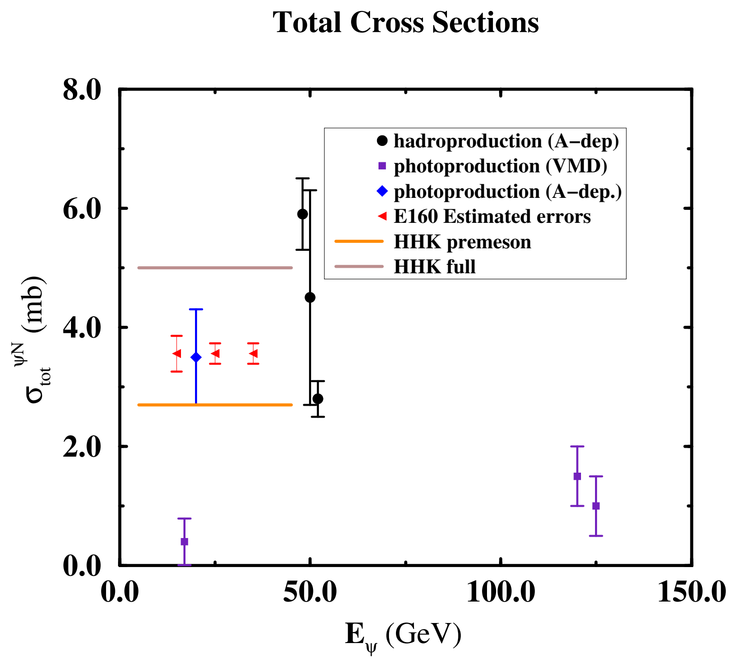


- **29D32 Dipole Magnet $\int B \cdot d\ell = 22$ kG-m**
- **70D43 LASS Dipole Magnet $\int B \cdot d\ell = 25$ kG-m.**
- **2.2 m alumina (Al_2O_3) absorber with tungsten core.**
- **3 planes of scintillator hodoscopes.**

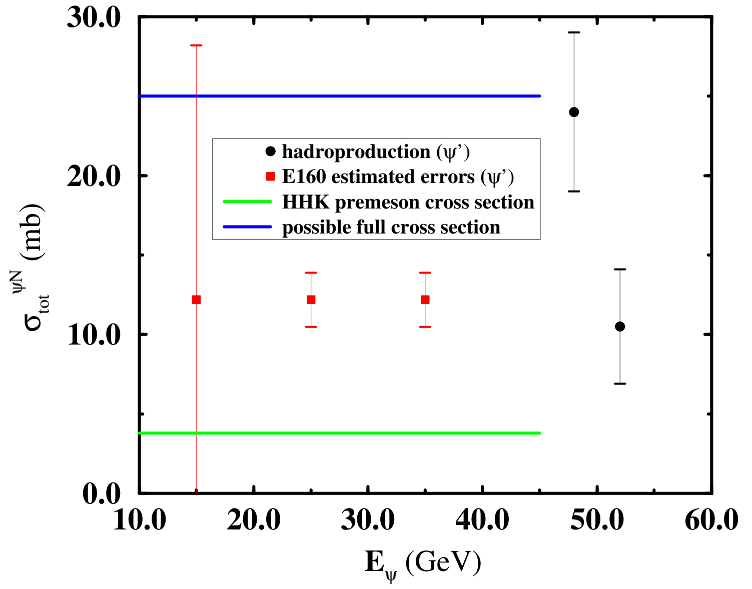
Photon Intensity (Energy Weighted Flux) and Acceptance-Weighted J/ψ Rate Versus Photon Energy for 3 Settings



Error Estimates on $\sigma_{\text{tot}}^{\psi N}$



Error Estimates on $\sigma_{\text{tot}}^{\psi N}$



E161

MEASUREMENT OF

GLUON SPIN DISTRIBUTION IN NUCLEONS USING POLARIZED OPEN CHARM PHOTOPRODUCTION

S. Rock, D. Crabb, P. Bosted co-spokespersons

Planned to run in 2004

http:www.slac.stanford.edu/exp/e161/

WHAT WE KNOW

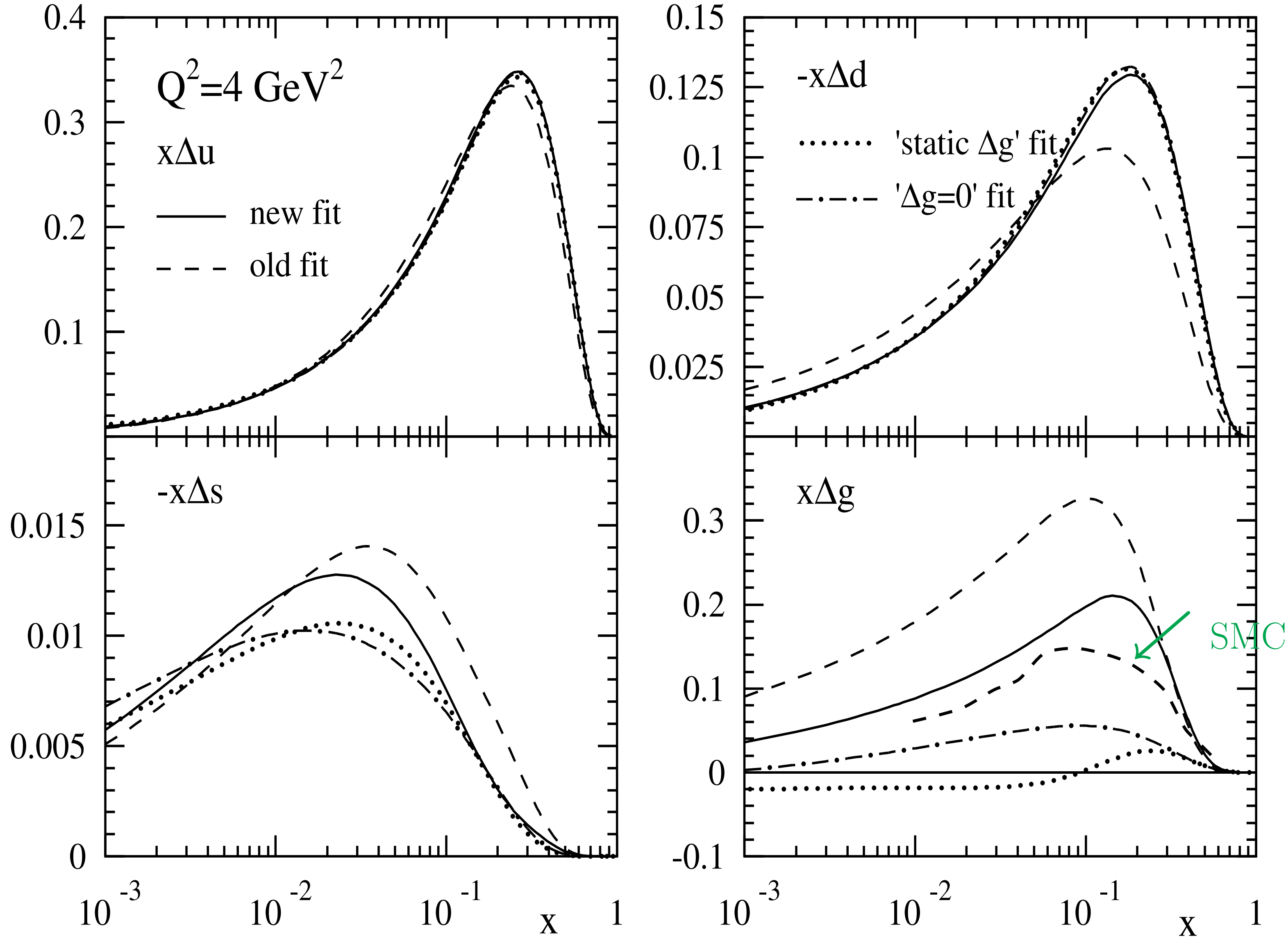
POLARIZED PARTON DISTRIBUTIONS FROM pQCD EVOLUTION EQUATIONS.

THE FIT OF

Gluck, Reya, Stratmann and Vogelsang (1999)

$$\Delta q(x,Q^2) = q_i^{\uparrow}(x,Q^2) - q_i^{\downarrow}(x,Q^2)$$

Δg ONLY APPEARS in NLO, and is poorly known

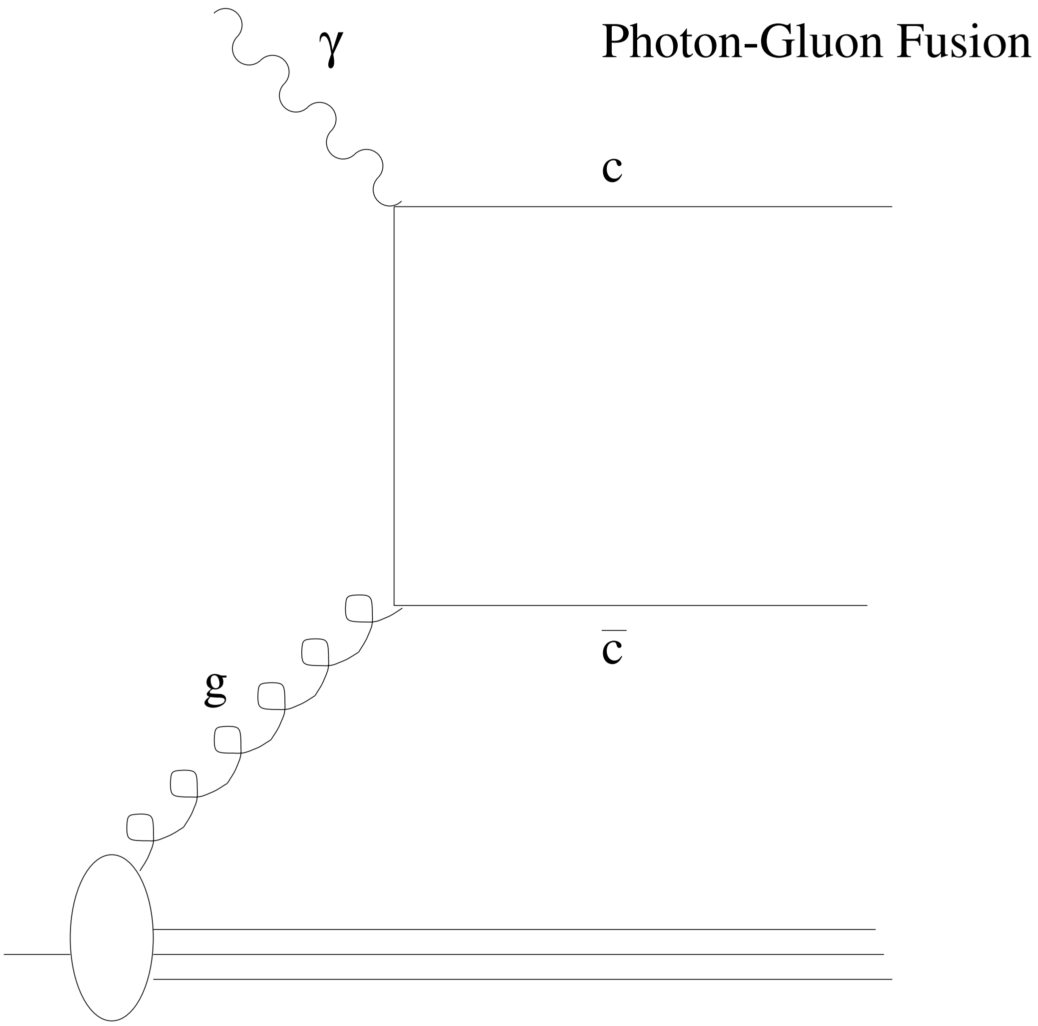


HOW TO MEASURE $\Delta g(x, Q^2)$ DIRECTLY

POLARIZED PHOTON BEAM

POLARIZED LiD TARGET

PHOTON-GLUON FUSION



EXPERIMENTAL STRATEGY

Tag Charm With Single Decay μ

	D^+	D^0	D_s^+	Λ_c^+
produced(%)	19	63	8	8
Branching Ratio(%)	17	7	8	4
fraction of μ^+(%)	37	47	8	4
	D^-	$\bar{D}^0$	D_s^-	Λ_c^-
produced(%)	21	71	6	2
fraction of μ^-(%)	40	53	5	1

BACKGROUNDS

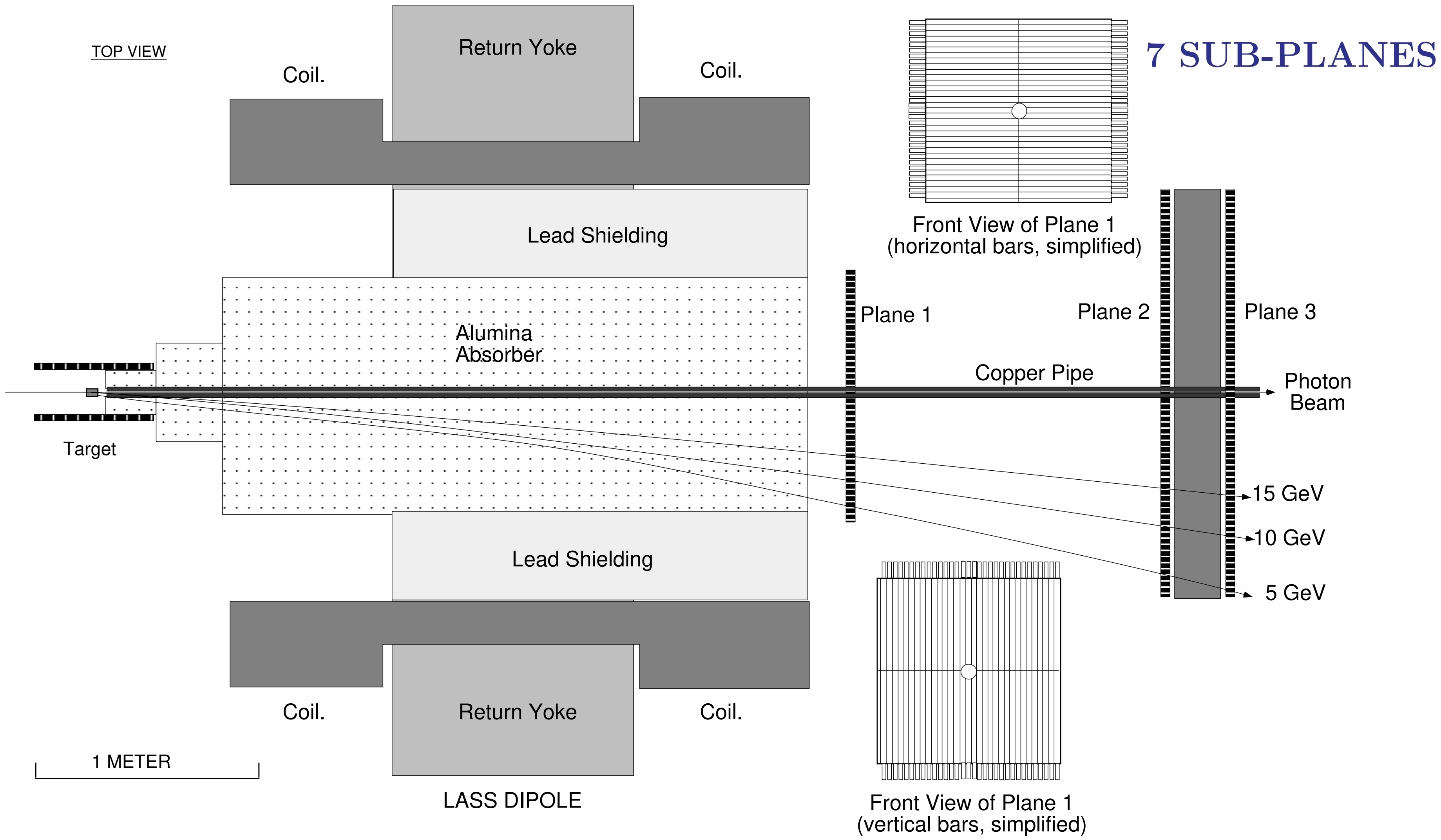
- μ FROM K and π DECAY (Long Lifetime)
- Bethe-Heitler μ PAIRS
- J/ψ DECAY (Small)
- VECTOR MESON DECAYS (Small)
- ASSOCIATED PRODUCTION (Small)
- FINAL STATE INTERACTIONS (Small)
- DIFFRACTIVE PRODUCTION (Small)

EXPERIMENTAL STRATEGY

- **HIGH POLARIZATION TARGET**
- **HIGH POLARIZATION BEAM**
- **MEASURE MOMENTUM of μ**
  - High Field Magnet
  - Fine Grain Hodoscopes
  - Good Time Resolution
- **ABSORB K and π BEFORE DECAY**
  - $\sim$ 10 Interaction Lengths (38 R.L.)
  - Monte Carlo Predicts Rates
  - Asymmetry Very Small (E155)
  - Two Absorber Setups
    75% and 25% of Time
  - Multiple Scattering of μ Almost the Same
- **VETO $\mu^+\mu^-$ PAIRS**
  (B-H, J/ψ, VECTOR MESONS)
  - Some Singles Remain (Acceptance)
  - Calculate Based on Pairs and Known σ

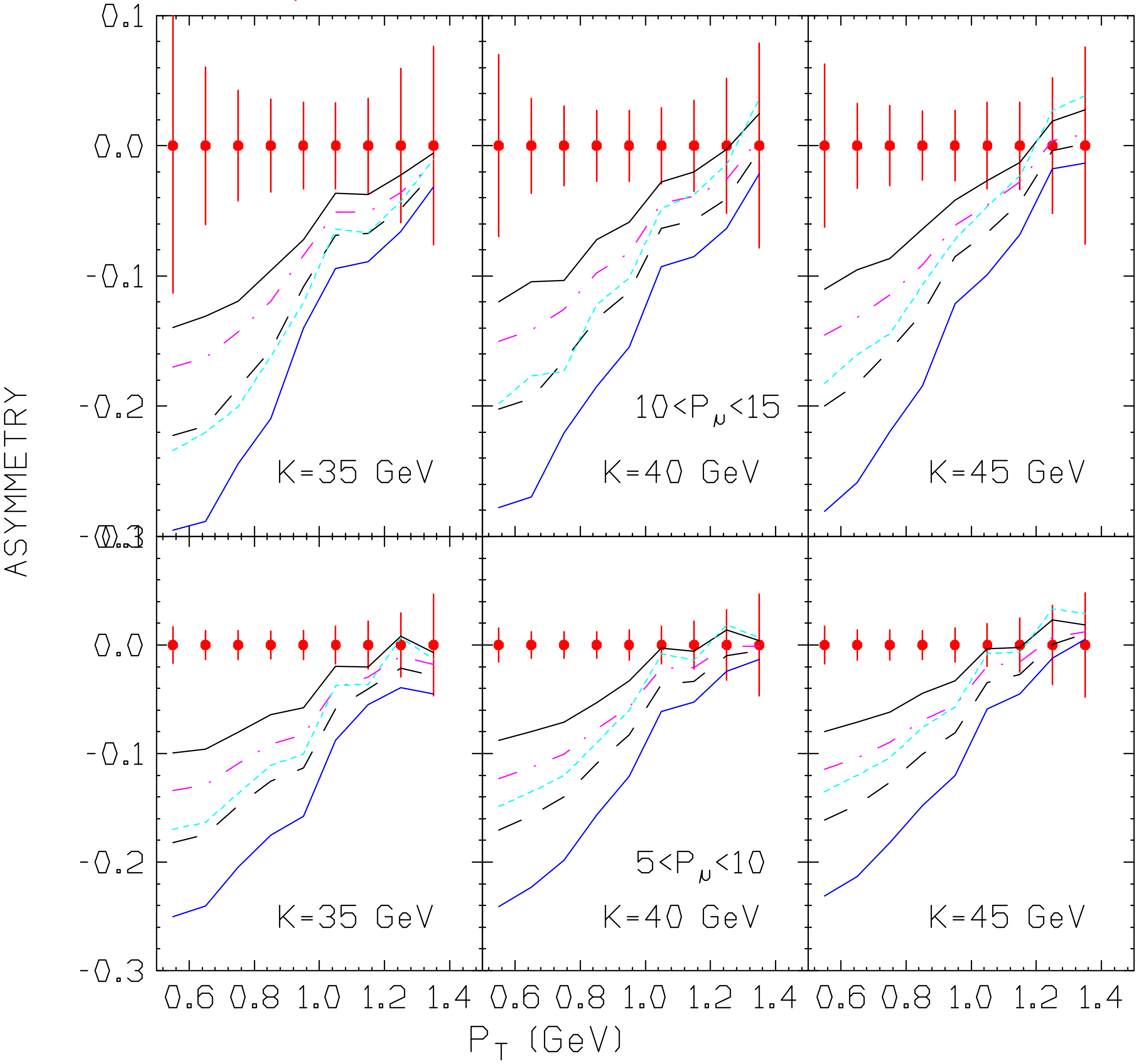
μ SPECTROMETER

NORMAL MODE

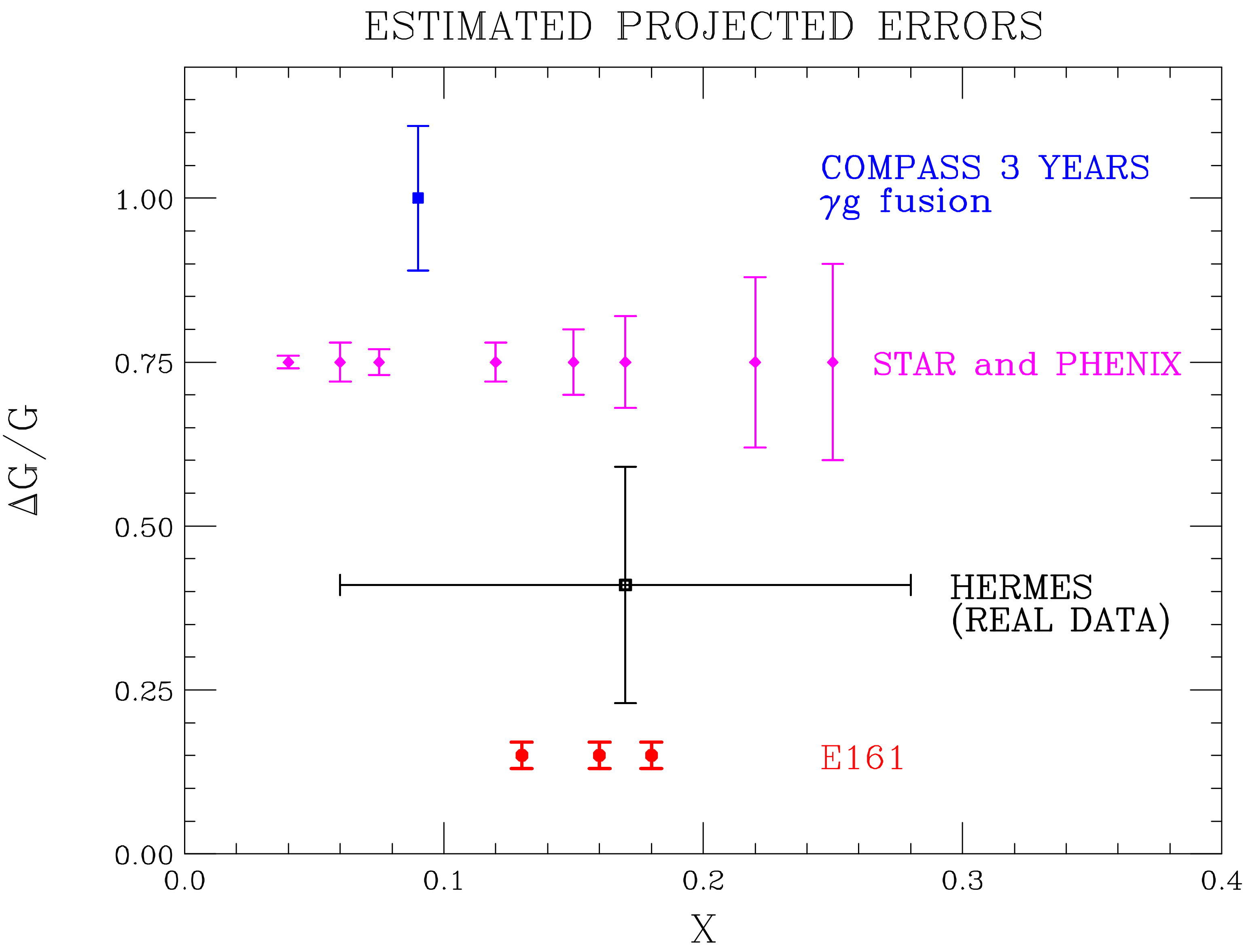


EXPECTED RESULTS

for Asymmetry in Cross Sections with photon/nucleon Spins parallel or anti-parallel



COMPARISON OF EXPERIMENTS



SLAC-PROPOSAL-E159

Proposal to Measure $\Delta\sigma^{\gamma N}(k)$ and the High Energy Contribution to the Gerasimov-Drell-Hearn Sum Rule

P. Bosted, D. Crabb co-spokespersons

Planned to run in 2005

http:www.slac.stanford.edu/exp/e159/

INTRODUCTION

- Total photo-absorption cross section $\sigma^{\gamma N}(k)$ depends only on photon energy k for real photons.
- Can be decomposed into spin 1/2 and 3/2 final states $\sigma_{3/2}$ and $\sigma_{1/2}$, corresponding to helicity of photon aligned or anti-aligned with spin of nucleon.
- Spin-averaged $\sigma^{\gamma N}(k) = (\sigma_{1/2} + \sigma_{3/2})/2$ well-measured (including SLAC early 1970's). Roughly constant at 120 μb.
- We propose to measure

$$\Delta\sigma^{\gamma N}(k) = \sigma_{3/2} - \sigma_{1/2}$$

using circularly polarized photons and longitudinally polarized nucleons.

The GDH SUM RULE

- Relates integral over $\Delta\sigma(k)$ to anomalous magnetic moment κ of target with spin S (composite or elementary).

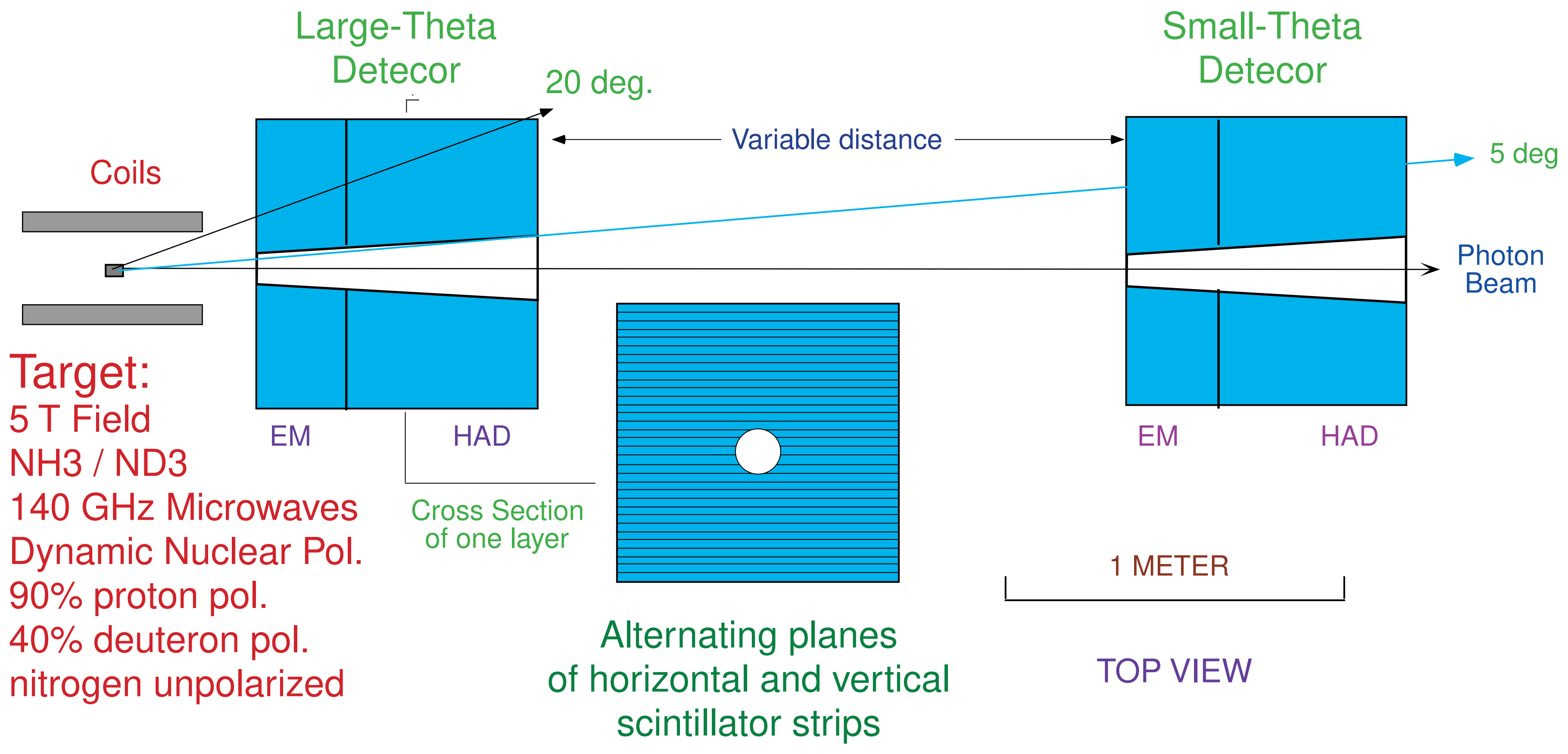
$$\int_{k_\pi}^{\infty} \frac{dk}{k} \Delta\sigma^{\gamma N}(k) = \frac{2\pi^2 \alpha \kappa^2}{M^2} \tag{1}$$

- Follows from general principles of causality, universality, Lorentz and electromagnetic gauge invariance.
- One assumption: that un-subtracted dispersion relation can be used for $f_2(\nu)$.
- Scale of convergence gives scale of highest spin-flip excitations of target.
- $\Delta\sigma^{\gamma N}(k)$ must decrease with k at high k for integral to converge. Contrast to $\sigma^{\gamma N}(k)$, known to increase with k at high energies.

EXPERIMENTAL OVERVIEW

- Coherent bremsstrahlung provides circularly polarized photons $4 < k < 40$ GeV.
- Subtract incoherent contributions to obtain $\Delta\sigma(k)$ at discrete values of k.
- Longitudinally polarized NH_3 and ND_3 targets.
- Measure total cross section asymmetry with large calorimeters.
- Reject E.M. backgrounds with cuts, longitudinal segmentation of detector, and/or calculations
- Measure in Counting Mode for lower systematic error (each hadronic interaction is individually counted)
- Use Flux Integration Mode for smaller statistical errors (total hadronic energy summed over many interactions).

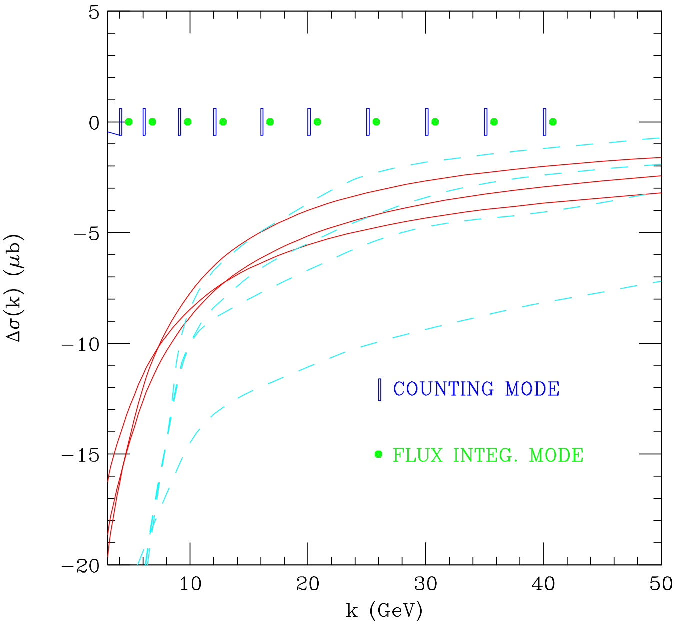
Target and Detectors



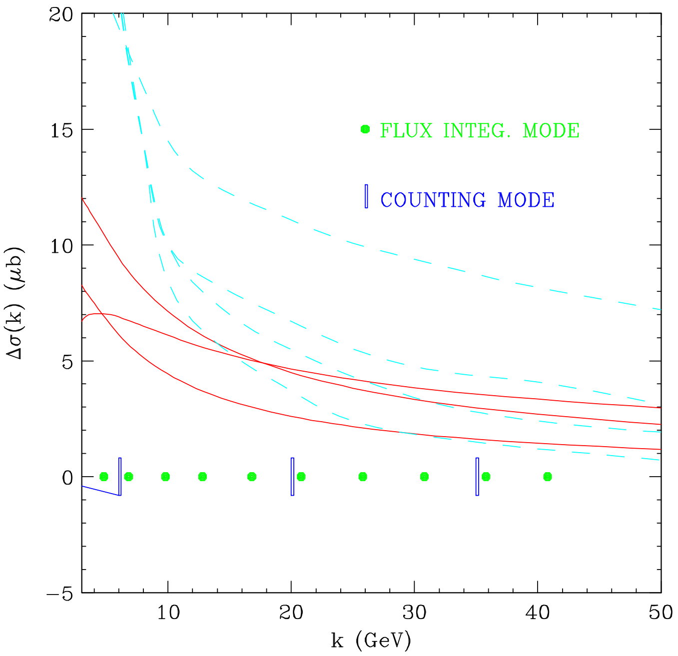
27 EM and 53 Had layers summed
with longitudinal wave-shifter bars

EXPECTED ERRORS FOR PROTON

Systematic errors (not shown) expected to be 6% to 8% (relative).



EXPECTED ERRORS FOR NEUTRON



SUMMARY OF REAL PHOTON EXPERIMENTS

- Unique opportunity: experiments cannot be done elsewhere (even if Jlab 12 GeV upgrade happens).
- Cost effective, using much existing equipment.
- Simultaneous operation with PEP-II will be possible.
- Interesting physics shedding light on charm, quark-gluon plasma, and spin structure of the nucleon.