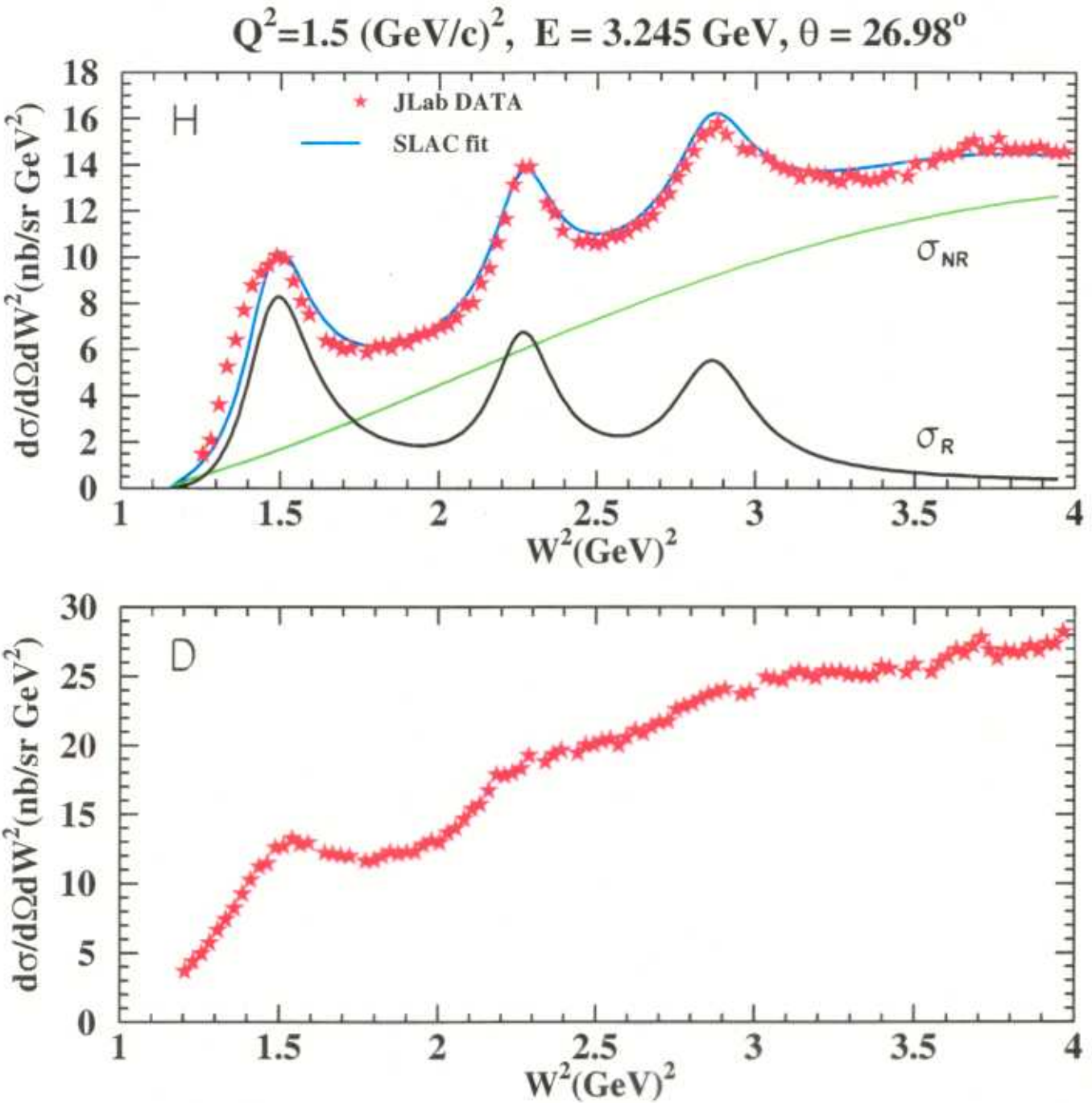
Outline

- Physics
  - Structure Function Ratios at Large x
  - Resonance Production
- History
  - Previous Proposal and PAC Comments
- New Concept
  - Rates and Backgrounds
  - Detector
- Discussion

FREE NEUTRON TARGET

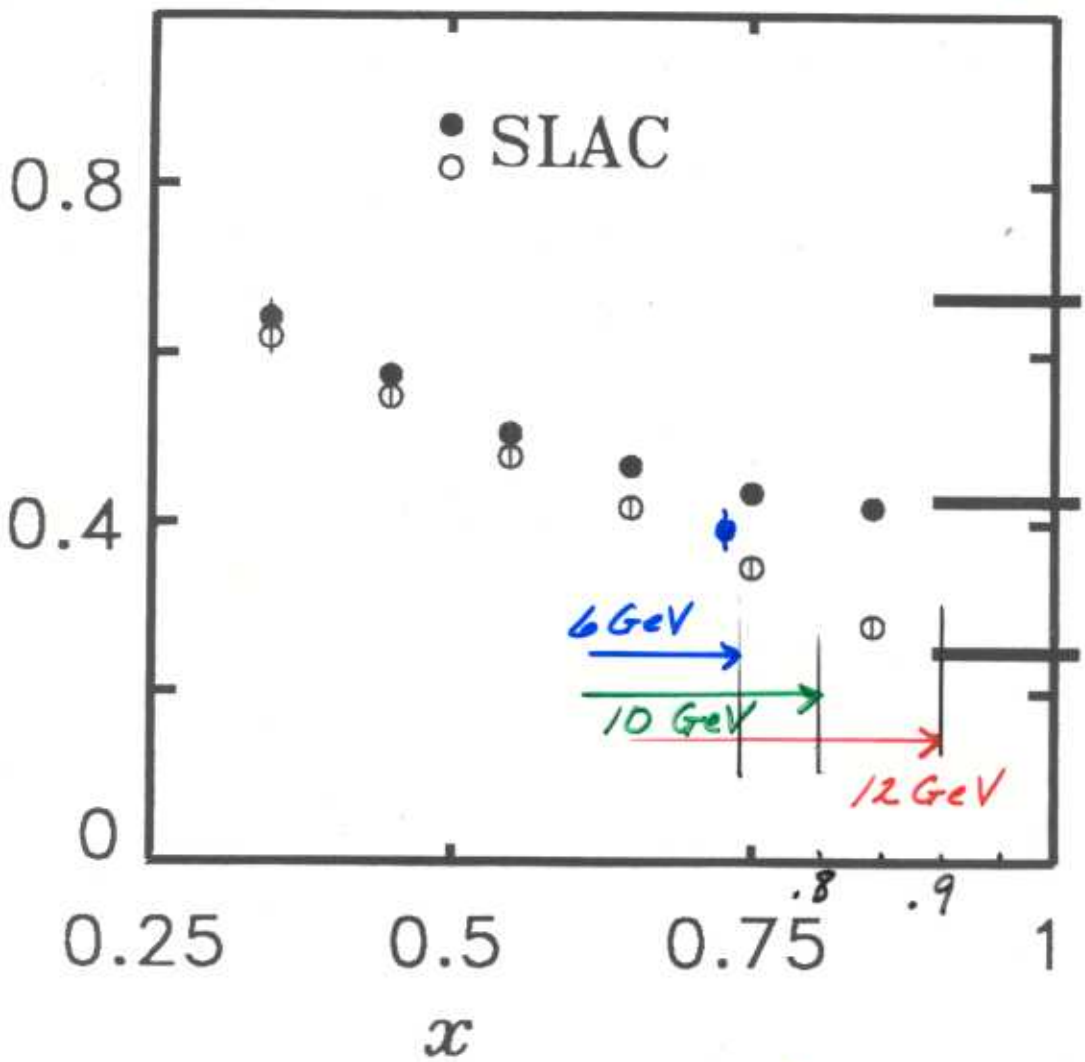
Physics

- No Free Neutrons
  - Measure Proton
  - Measure Deuteron
    - Smear Proton and Subtract
    - Iterative Deconvolution to get "Neutron"
- Process can Lead to Large Uncertainties
  - Yang and Bodek, Phys. Rev. Lett. 82, 2467 (1999)
  - Melnitchouk and Thomas, Phys. Lett. B 377, 11 (1996)


Q^2=1.5 (GeV/c)^2, E = 3.245 GeV, θ = 26.98°
H
JLab DATA
SLAC fit
σ_{NR}
σ_R
$d\sigma/d\Omega dW^2$(nb/sr GeV^2)
W^2(GeV)^2
D
$d\sigma/d\Omega dW^2$(nb/sr GeV^2)
W^2(GeV)^2

F_2^n / F_2^p

("TAGGED" NEUTRON TARGET)



● with corrections for off-shell effects

○ without " " " " "

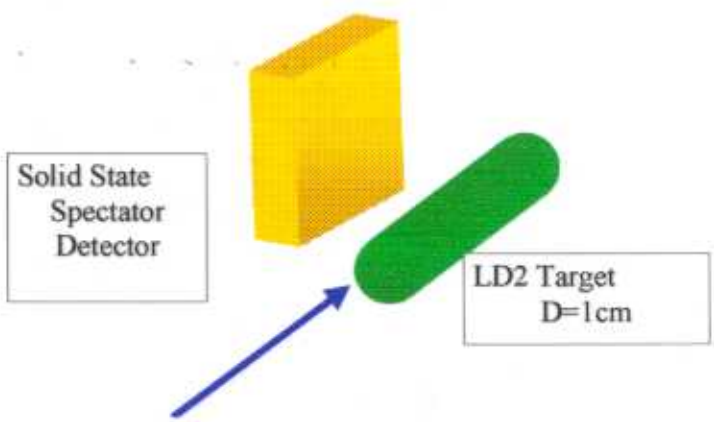
A "tagged" neutron target measurement at JLab could solve this discrepancy.

W. Melnitchouk and A.W. Thomas, Phys. Lett B 377 (1996)

FREE NEUTRON TARGET

LENT

- Thin: D =1 cm LD2 Target
  - Detectors Outside
  - Relatively Low Tech
  - min $P_m \approx$ 150 MeV
- No Way to Get Much Lower in This Scheme



Proposal:	PR-97-107
Scientific Rating:	None
Spokesperson(s):	C.E. Keppel, R. Ent, J. H. Mitchell
Title:	Study of Neutron Resonances by Low-Energy Neutron Tagging (LENT)

Motivation:

This is a proposal to measure the inclusive virtual photon neutron cross section over the Q^2 range $1< Q^2 <3.5$ (GeV/c) ^{2} and the hadronic recoil mass range 1 - 2 GeV. The experiment consists of using a 6-GeV electron beam incident on a deuterium target and detecting the scattered electron in coincidence with the low energy recoil proton.

Measurements and Feasibility:

The PAC believes this is an interesting and useful program. However, there were several subjects that should be investigated before approval. The background rates test that was described in the proposal was performed with the 2.65 inch diameter Hall C LD2 target. There was strong recommendation to make more tests, for example by studying the change in background rates induced by moving the beam closer to the wall (say within 0.5 cm) in the existing Hall C LD2 target.

Issues:

The PAC was not convinced that measurements focusing on missing momentum between 150 MeV/c and 200 MeV/c would yield reliable information on neutron structure due to issues such as final state interactions. It was felt that if an experiment could be designed that would allow measurements with a minimum missing energy ~80 MeV/c, this proposal would be considerably strengthened.

The PAC was also concerned that (even at low-missing momentum) the reaction mechanism assumed in the proposal may not lead directly to information on neutron structure. For example, the virtual photon may be absorbed by the deuteron and then the excited deuteron decays into two baryons (and possibly a few pions). The collaboration may want to consider a "calibration" experiment where the neutron is measured and the proton is tagged in order to compare with the known proton structure.

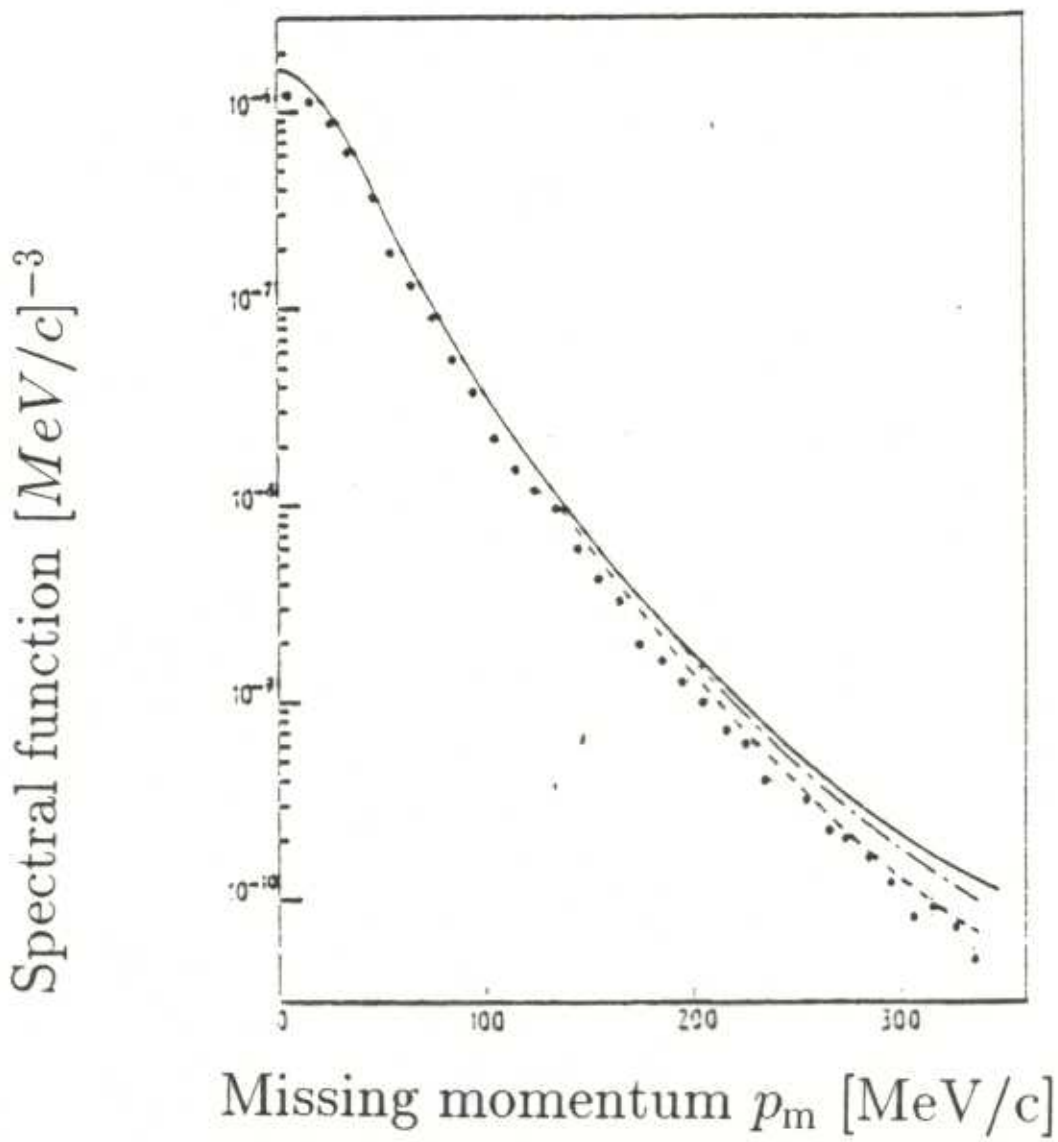
PAC views this proposal as a promising technique to provide important information on neutron structure but would need to see the above issues addressed before a new proposal could be approved.

Recommendation:

Defer.

FREE NEUTRON TARGET

Momentum Distribution



- Very Steep

FREE NEUTRON TARGET

Rescattering And Other Sources of Slow Protons

or how "free" is it ?

$$\int_{60}^{200} \rho(p_m) p_m^2 dp_m \approx 0.5 \Leftrightarrow \int_{0}^{60} \rho(p_m) p_m^2 dp_m \approx 0.4$$

- In DIS Soft Pions May Alter Spectator Momentum
  - Simula Estimates:Rescattering Decreases Rapidly for $Q^2>2$
- Other Slow Protons
  - Resonance Decay
    - Backward is Better
    - $Q^2>0.5$ Irrelevant in Backward Hemisphere
- Spectator Spectrum is Isotropic !!

FREE NEUTRON TARGET

Rates

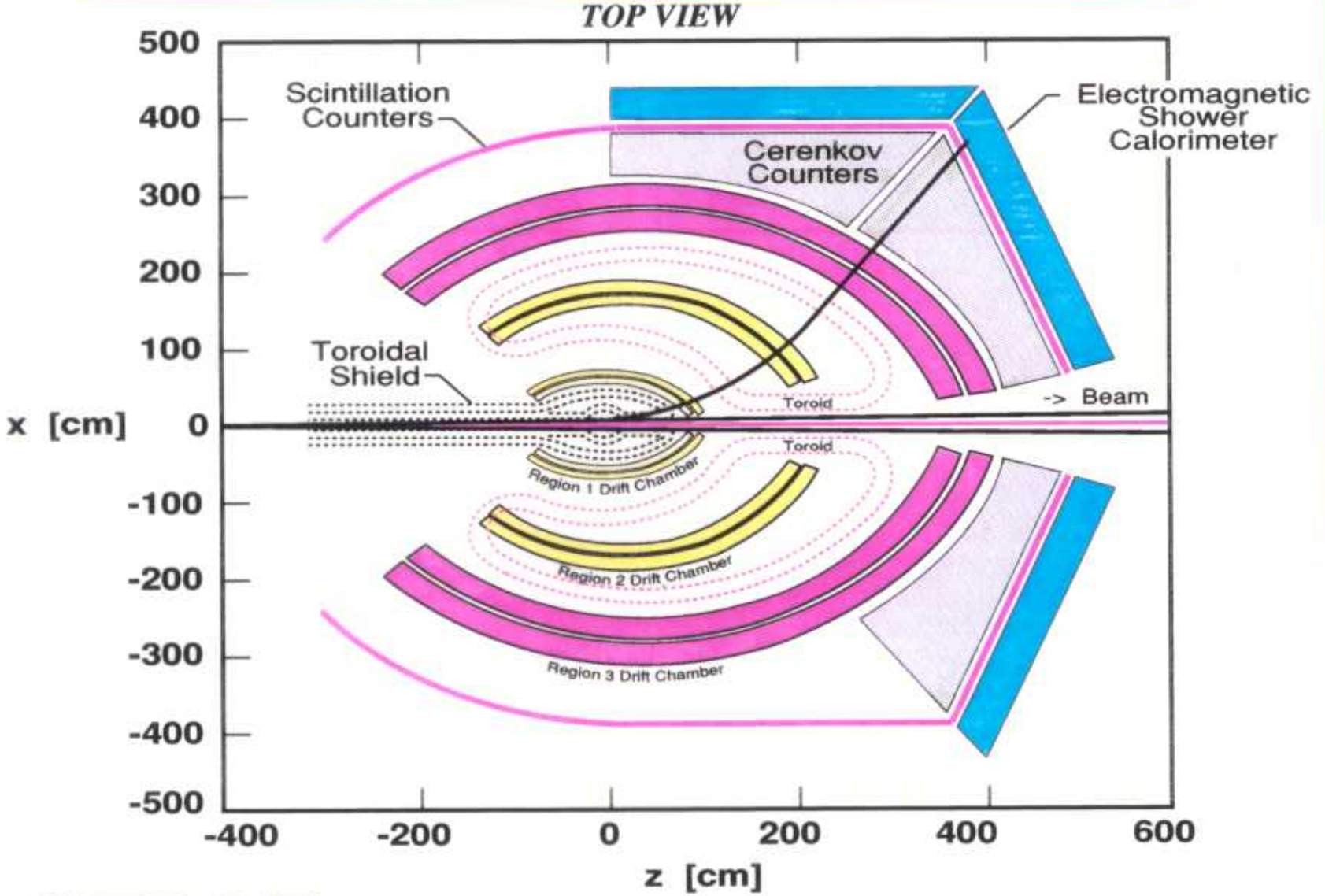
- Proton Singles
  - Simple Estimate of γD -- Gives 20 MHz of Protons into 2π
  - EPC 6 MHz
  - Hall C Test Gave Less
  - At 6 MHz R/A of 1 to 1 with Δt of 10 ns
- Mollers
  - Huge: Need to Eliminate Mollers with P less than 1 MeV (10 is better)
  - Sweeping Field
  - Solenoid has Simple Geometry
  - B > 0.1 T

FREE NEUTRON TARGET

Active Target

- 30 cm of ~~10~~ 5 Atm Deuterium Gas
  - 100 nA $\longrightarrow$ L=10^{34} 2*
- Sweeping Magnetic Field to Bottle Up Mollers
- Need Good Timing to Reduce Randoms - 10 ns
- GEM - Gas Electron Multiplier
  - Fast
  - Low Density
  - Developed at CERN
  - Good Resolution

LARGE ACCEPTANCE SPECTROMETER



CEBAF

The Continuous Electron Beam Accelerator Facility

hallB/largeaccspectrVG6C 6/16/92

5 The Gas Electron Multiplier GEM

5.1. Introduction

The Gas Electron Multiplier (GEM) is a thin multilayer foil, incorporated into the drift gap of a gas detector. It works as a proportional gas amplifier

The GEM sheet consists of a thin insulation foil, metal clad on both sides and perforated with a regular matrix of holes. The holes are very closely spaced and have a diameter less than 100µm. Due to the manufacturing process, chemical etching after photo-lithography, they have a double conical profile, with the narrower diameter in the centre of the insulator. [26], [28]

Upon application of a potential difference between the insulating electrodes, an electric field develops in the holes, and external drift field lines are focused inside. Charge produced by the primary ionisation follows the drift field lines to the GEM grid. On approaching the GEM holes, electrons it reach a region of high field and acquiring energy and multiplying in avalanche. Amplification factors of several hundred provided from a standard GEM grid are safe to achieve, thus GEM can be used as a internal pre amplifier in many gaseous detector applications.

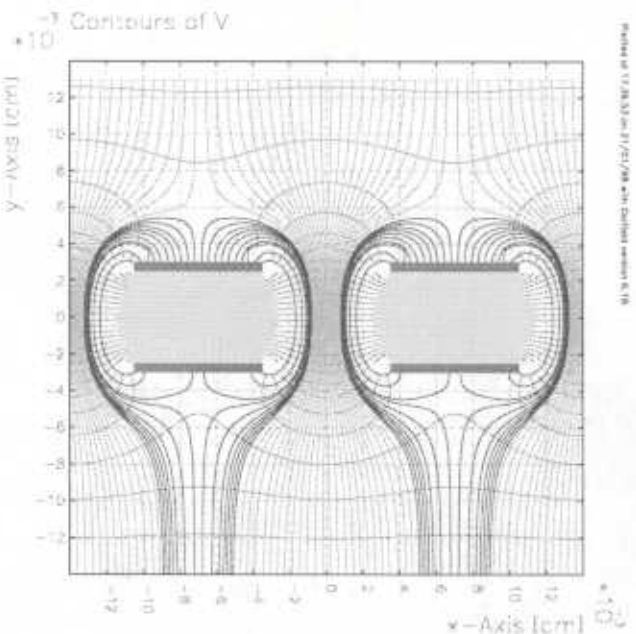
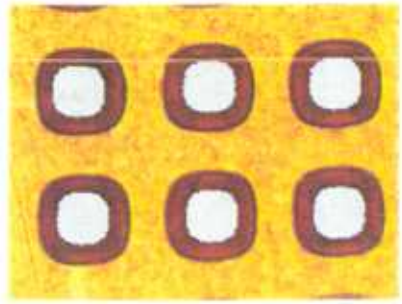
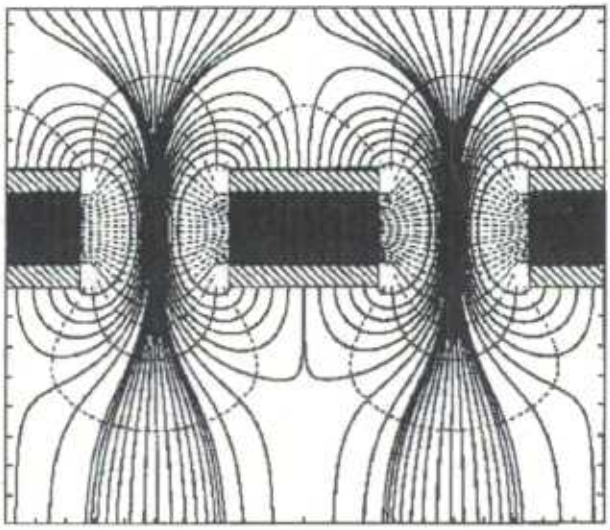
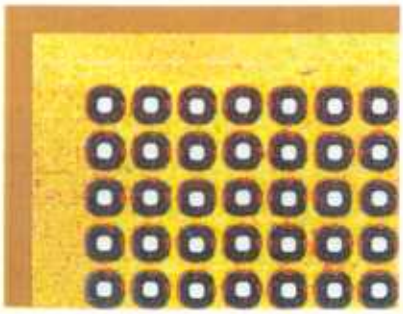


Fig. 5.1: Calculation of the developed field lines after applying potential difference to both GEM electrodes and the drift electrode. This plot is a simulation, realized with a program called MAXWELL. More details about field calculations on GEM see chapter 5.7..







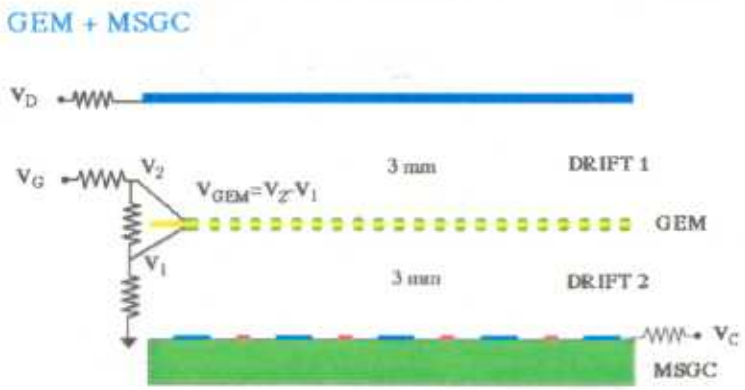


Figure 2. Left top: the basic structure of a GEM mesh consists of a thin insulating sheet with two metal layers separated by a thin insulator. Regular matrix of holes is made by chemical etching on both sides with photolithographic patterning. Typical parameters are: 50 μm thick Kapton foil with 5 μm Copper layer, 140 μm hole spacing, 80 μm hole diameter.

Right top: the difference of potential between the two electrodes of the GEM structure produces a dipole field within the channels. The field calculations are made with MAXWELL Electric Field Simulator. The potental across GEM is assumed 500V, while the external fields are 1kV/cm above and 2kV/cm below the GEM structure.

Bottom: The GEM+ microstrip (MSGC) structure as a potential two-stage amplifying and readout structure to employ in the detector. The strip electrode will be also placed on a plastic support foil to minimize the amount of material.

- 5 atm D_2 gas target region
  2 × 30 cm long
  5 cm radius
- Thin aluminized Mylar Foil
  + differential pressure system
  w. expansion vessels
- 6 layers of GEM detectors
  operating at 5 atm Ar
  - 0.2 mm of Al before 6th layer
    $\Rightarrow p_{max} \approx 200$ MeV/c
  - need gain of ≈ 10 to collect
    sufficient charge in integration time
    Sachi: gain ~ 100 @ 7 bar
- $\sigma \leq 6$ MeV/c

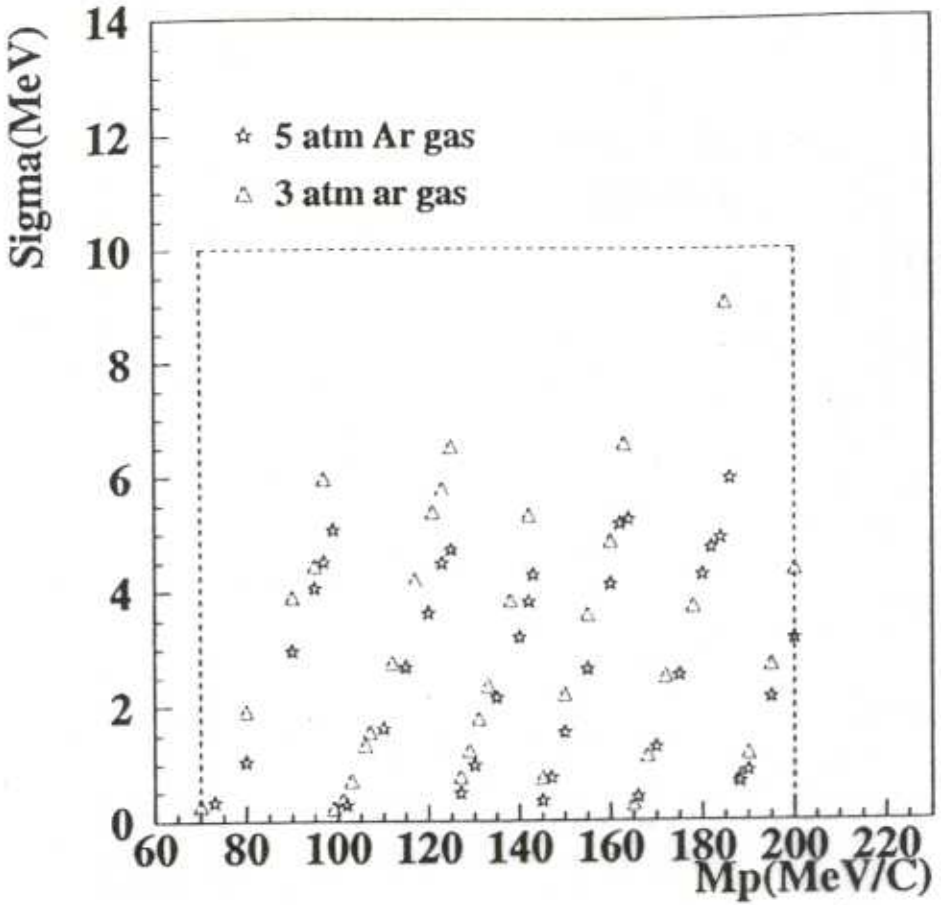
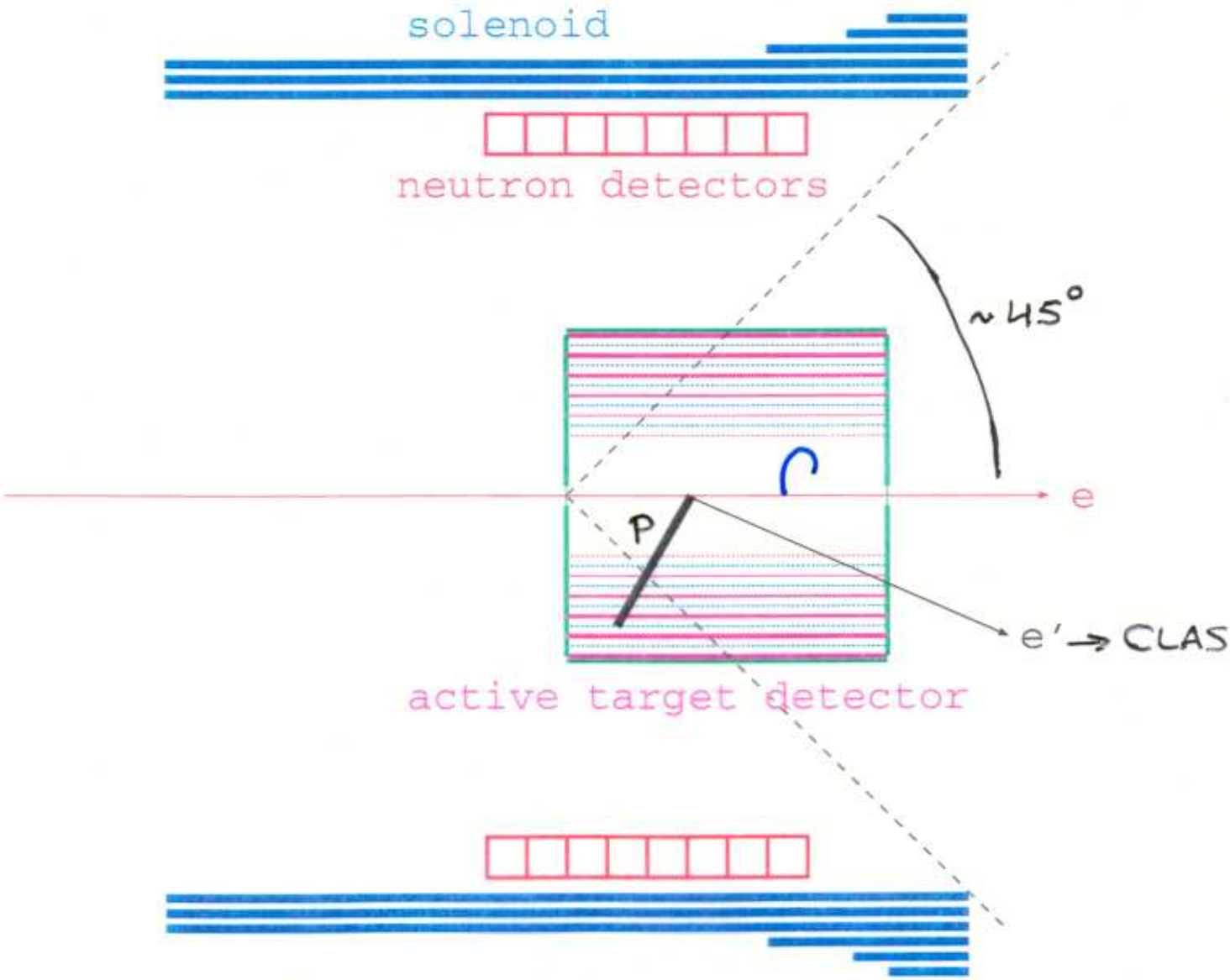

Sigma(MeV)
14
12
10
8
6
4
2
0
5 atm Ar gas
3 atm ar gas
60
80
100
120
140
160
180
200
220
Mp(MeV/C)

Table 1: EXAMPLE – 6 GeV Kinematics and Rates for a 10 Day Experiment

W^2	Q^2	Θ	rate
$(GeV/c)^2$	$(GeV/c)^2$	deg	**10 days**
1.50	2.95	20	41K
2.90	2.57		110K
4.00	2.25		120K
1.50	3.95	25	30K
2.90	3.45		115K
4.00	3.03		155K
1.50	4.90	30	11K
2.90	4.26		57K
4.00	3.73		83K
1.50	5.70	35	3.4K
2.90	4.95		25K
4.00	4.36		41K
1.50	6.40	40	1.3K
2.90	5.53		10K
4.00	4.87		19K
1.50	6.90	45	0.7K
2.90	6.00		5.2K
4.00	5.30		9.5K

SPECTATOR !

$D(e,e'p)$



SOLENOID

1 MeV MOLLERS

CONFINED

D_2, 10 ATM.

60 MeV/c < p

< 200 MeV/c

FREE NEUTRON TARGET

Conclusions

- Low Energy Proton in Backward Hemisphere Should Provide a Good Tag
- P_m Down to ≈ 60 or70 MeV/c Possible
- Experts (Sauli, Stan, etc) Think its Technically Feasible with GEM Technology
- Lots of Things to Measure
- Lots of Work to be Done
  - Collaborators Wanted, Needed and Welcomed !!