

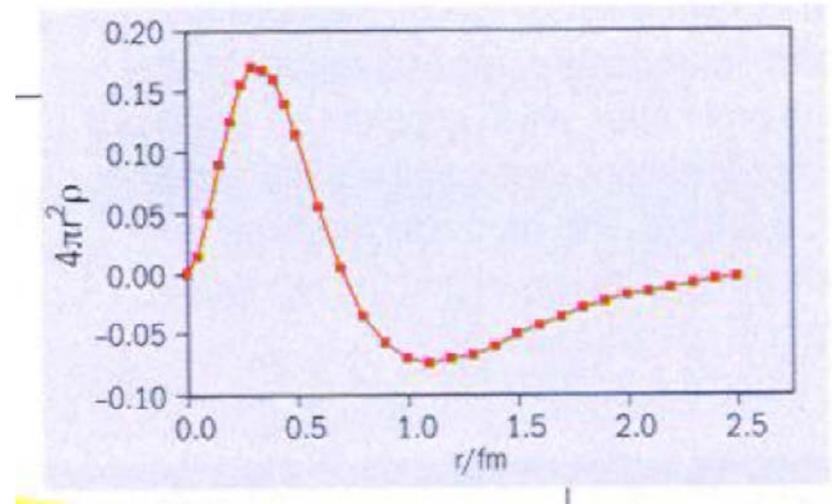
# *Electric Form Factor of the Neutron*

*Experiment E04-110*

*Jefferson National Accelerator  
Facility*

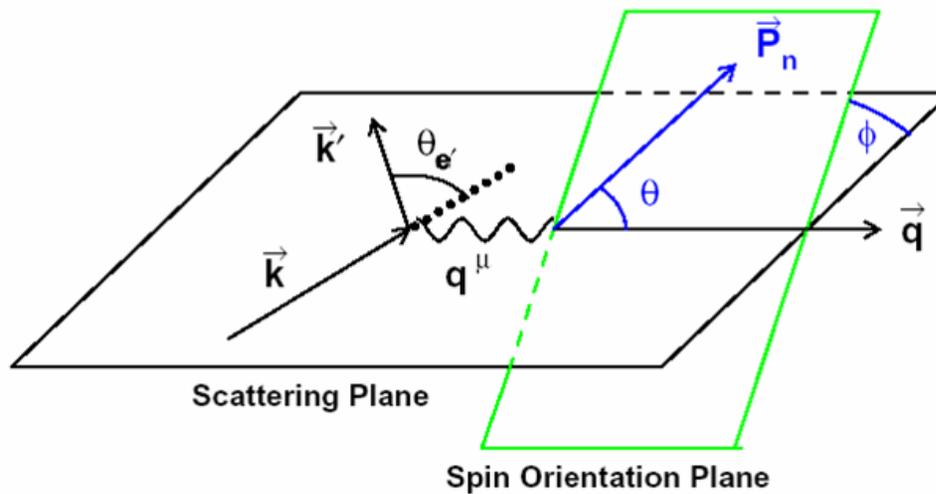
# Scientific Motivation

- *Fundamental quantity for neutron*
- *Important for understanding internal structure of nucleon*
- *Provides sensitive test of models of the nucleon*
- *Crucial for calculation of nuclear charge form factors*



In PWIA, the cross-section asymmetry with respect to helicity reversal of the electron is:

$$A(\theta, \phi) = P_e P_n f_D \frac{K_1 \sin\theta \cos\phi G_{En} G_{Mn} + K_2 \cos\theta G_{Mn}^2}{G_{En}^2 + K_3 G_{Mn}^2}$$



## $G_E^n$ via Recoil Polarization

*In the plane-wave approximation, the recoil polarization produced by a longitudinally polarized electron beam in quasielastic electron-neutron scattering is restricted to the scattering plane. It can be shown that*

$$P_{S'} / P_L = -K_S (G_E^n G_M^n) / I_0 ,$$

$$P_{L'} / P_L = K_L (G_M^n)^2 / I_0 .$$

$G_E^n$  and  $G_M^n =$  Electric/ Magnetic form factors of the neutron

$P_{S'}$  and  $P_{L'}$  = sideways/longitudinal neutron-polarizations

$P_L$  = electron beam polarization

$$I_0 = (G_E^n)^2 + K_0 (G_M^n)^2$$

$K_S$ ,  $K_L$ , and  $K_0$  are kinematic functions of  $\theta_e$ , and  $Q^2$ .

*Measuring  $P_{S'}$  and  $P_{L'}$  and taking the ratio yields*

$$P_{S'} / P_{L'} = (-K_S / K_L) G_E^n / G_M^n .$$

*A significant advantage of this technique is that  $P_L$  and the analyzing power of the secondary reaction cancel in the ratio.*

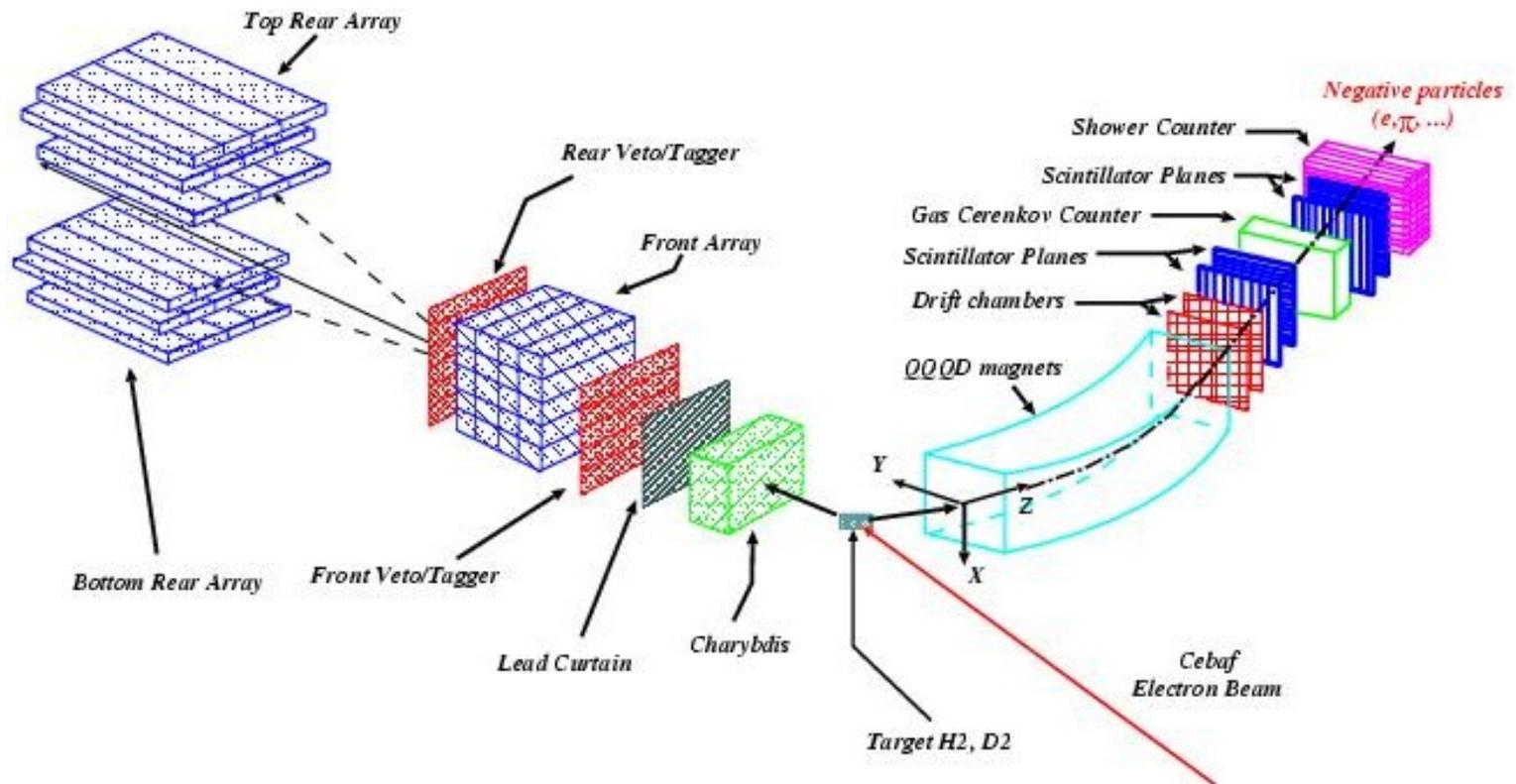
# *Experimental Technique*

- *Double-scattering experiment*
- *Longitudinally polarized electron beam*
- *Liquid deuterium target (15 cm)*
- *Scattered electron detected in magnetic spectrometer*
- *Knock-out neutron detected in neutron polarimeter*

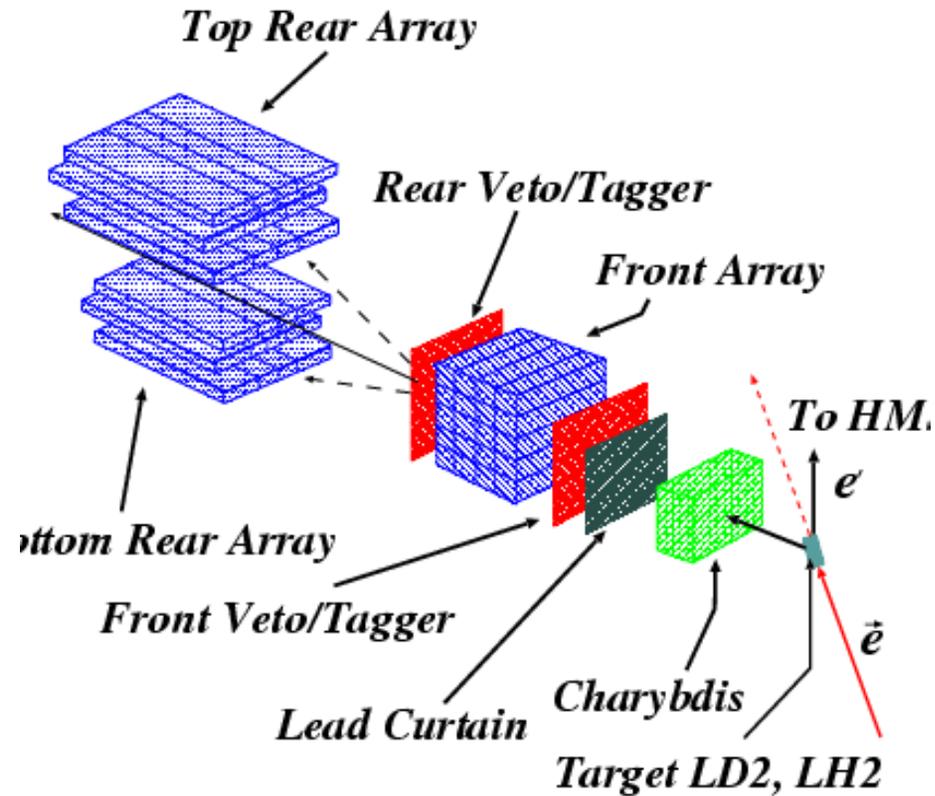
# Experimental Overview

*E93-038  
Polarimeter*

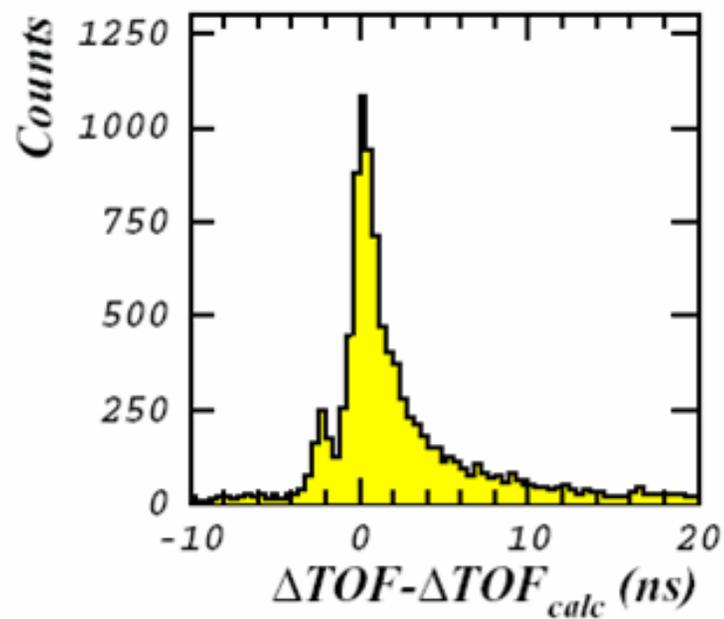
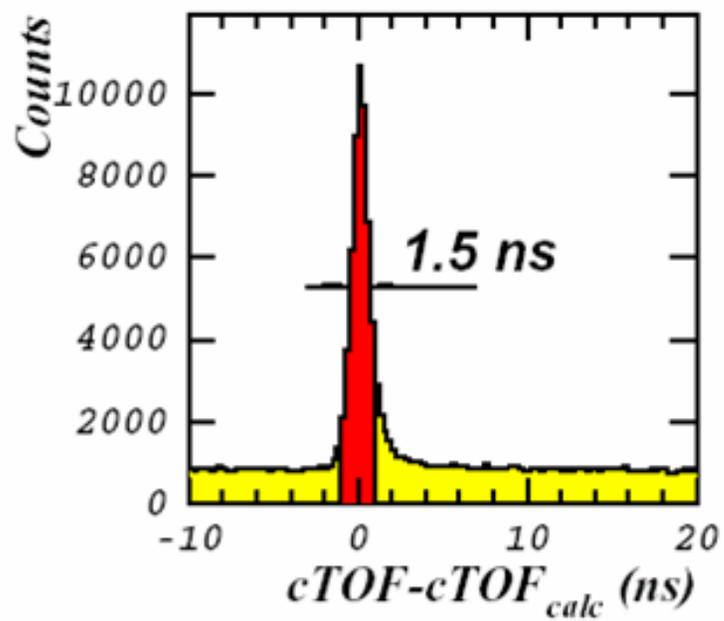
*High Momentum Spectrometer  
(HMS)*



# Neutron Arm

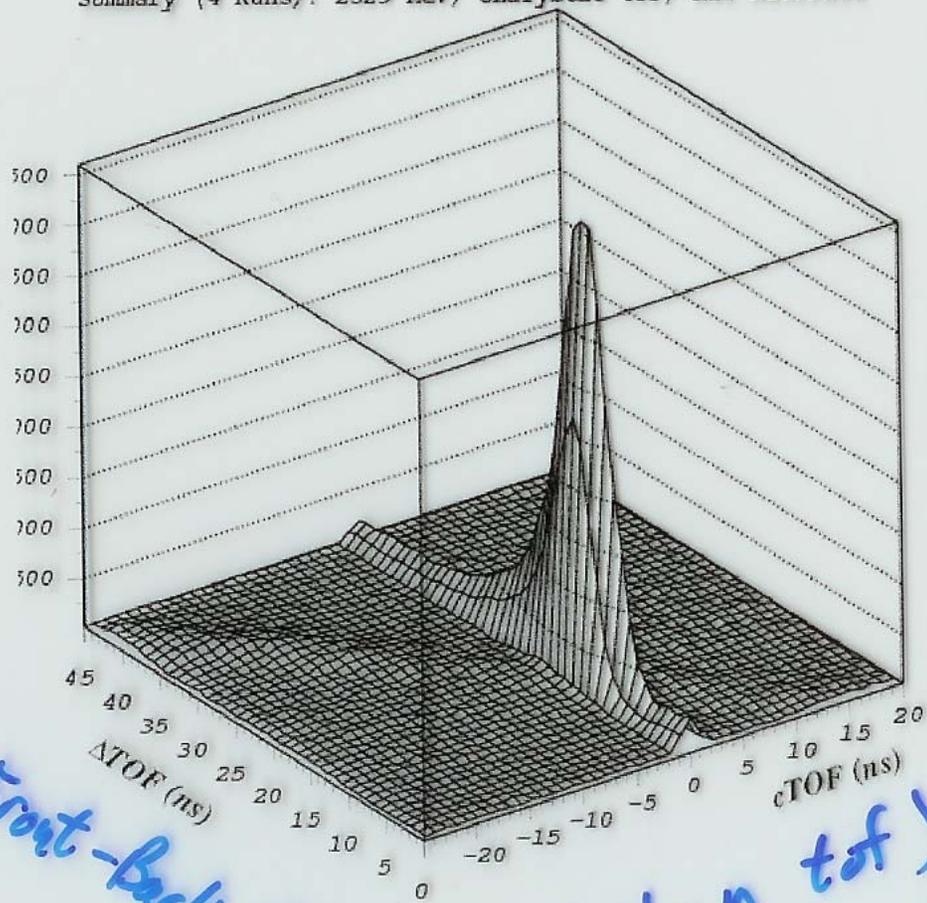






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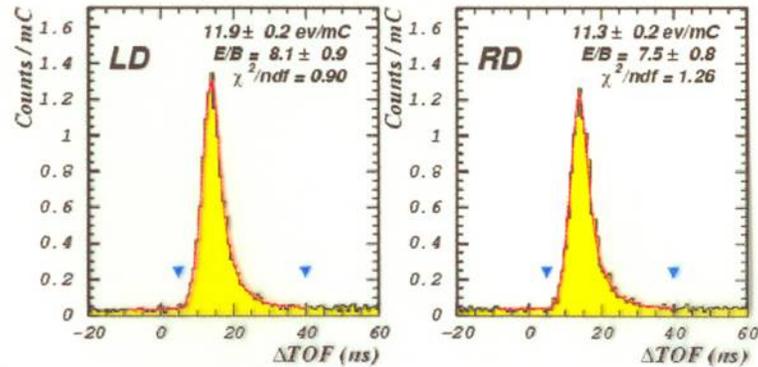
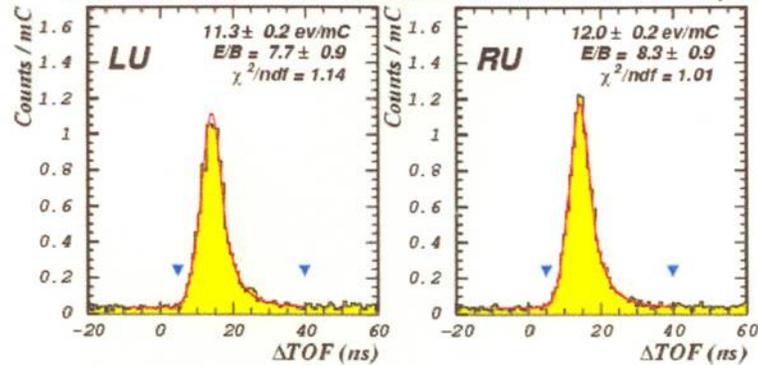
Summary (4 Runs): 2329 MeV; Charybdis OFF; All Neutrals



(Front-back tof)

(e<sup>+</sup>-n tof)  
FWHM ≈ 1.5 ns

HMS-NPOL Coinc; 448.21 mC;  $2.655 \times 10^8$  ctr; CHARY.-237 A;  $\lambda/2$  out



Beam (L/R) Asymmetry  $\xi_{LR} = -0.17 \pm 0.72 \%$   
 NPOL (U/D) Asymmetry  $\xi_{UD} = 0.00 \pm 0.72 \%$

Cross-Ratio  $r = 1.0577 \pm 0.0152$

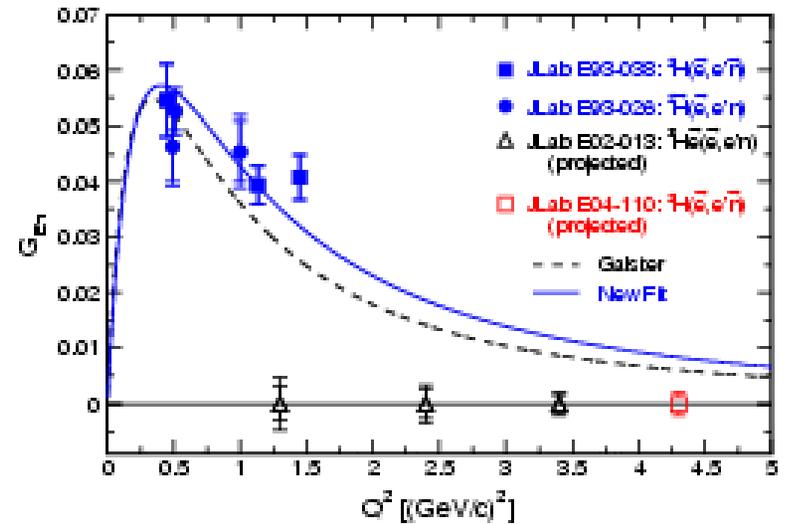
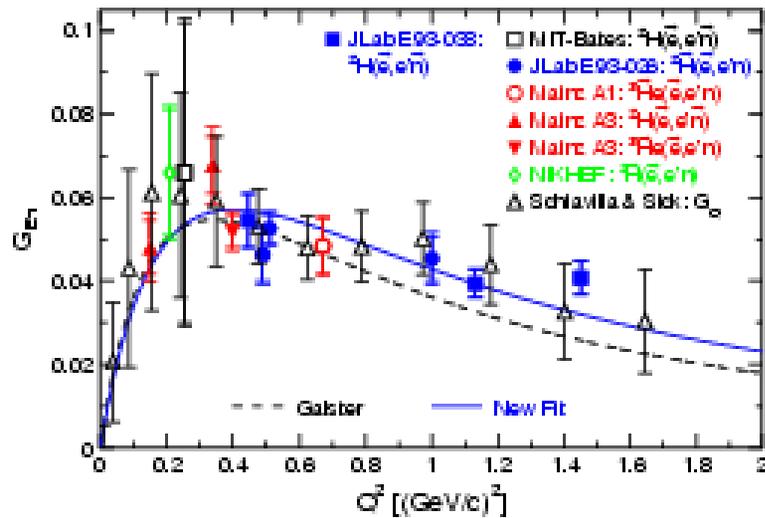
Asymmetry  $\xi = 2.80 \pm 0.72 \%$

Analysis (v2.1) done on 8/ 1/2001 by

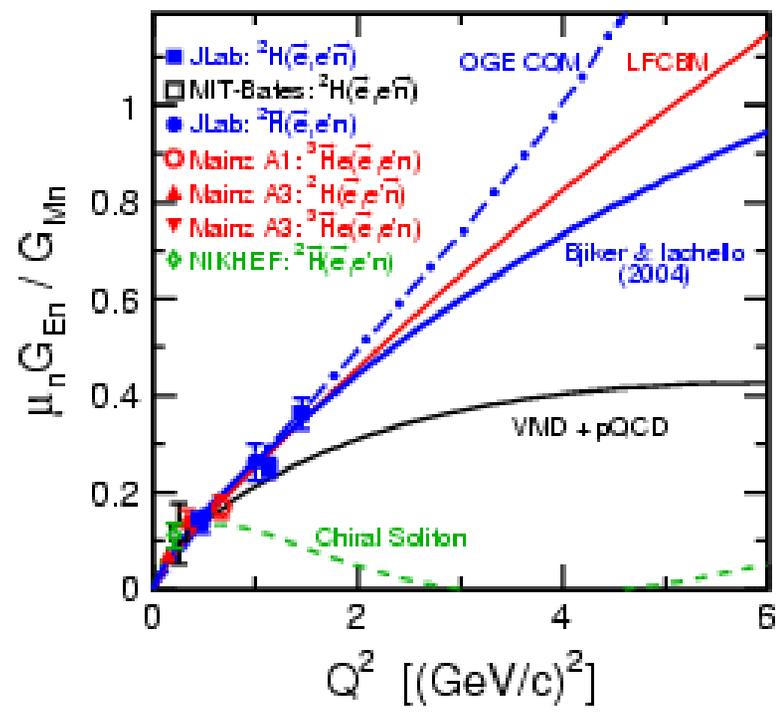
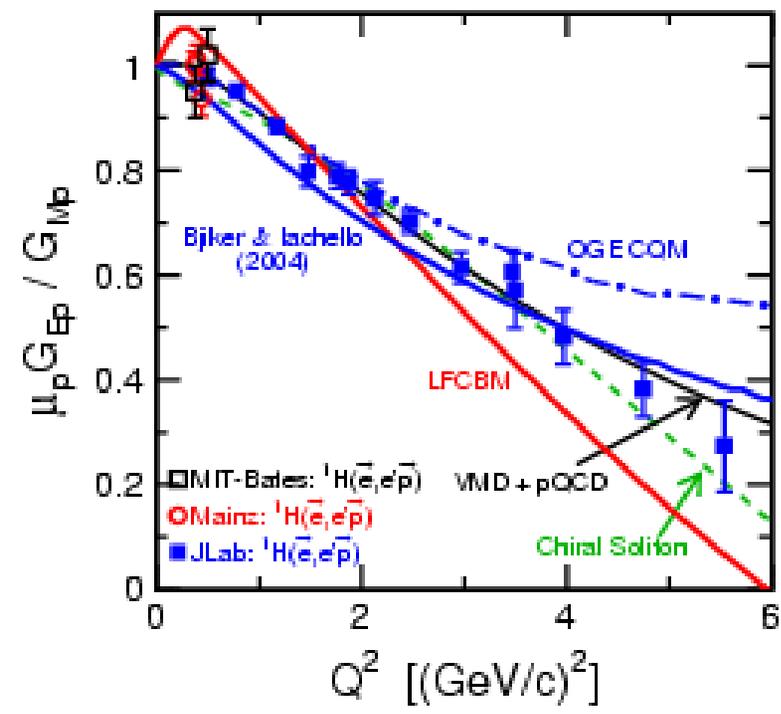
$$r = \left[ \frac{(RU \cdot LD)}{(LU \cdot RD)} \right]^{1/2}$$

$$\xi = \left[ \frac{(r - 1)}{(r + 1)} \right] / AP$$

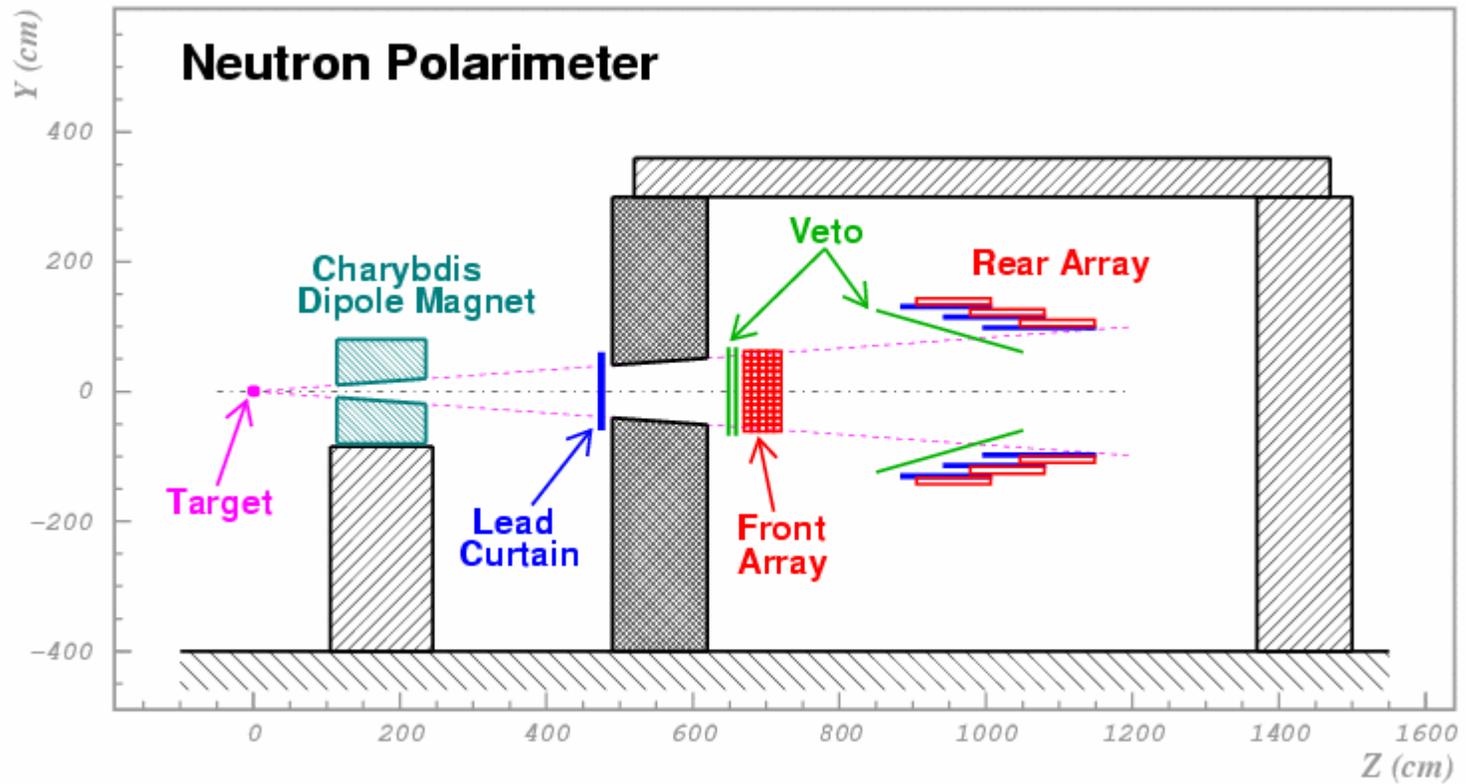
# $G_E^n$ World Data



# $G_E^p / G_E^n$ vs Theory

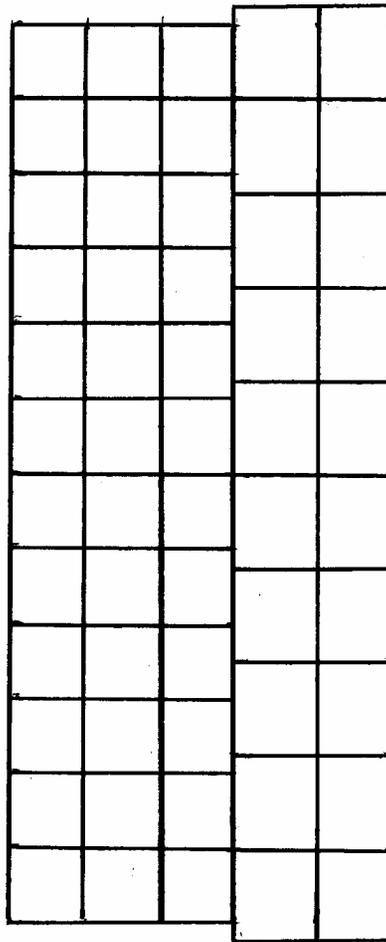


# Neutron Polarimeter



# *Front Array*

*36 10x10x100 cm  
bars*



*20 10x12.5x100 cm  
bars*

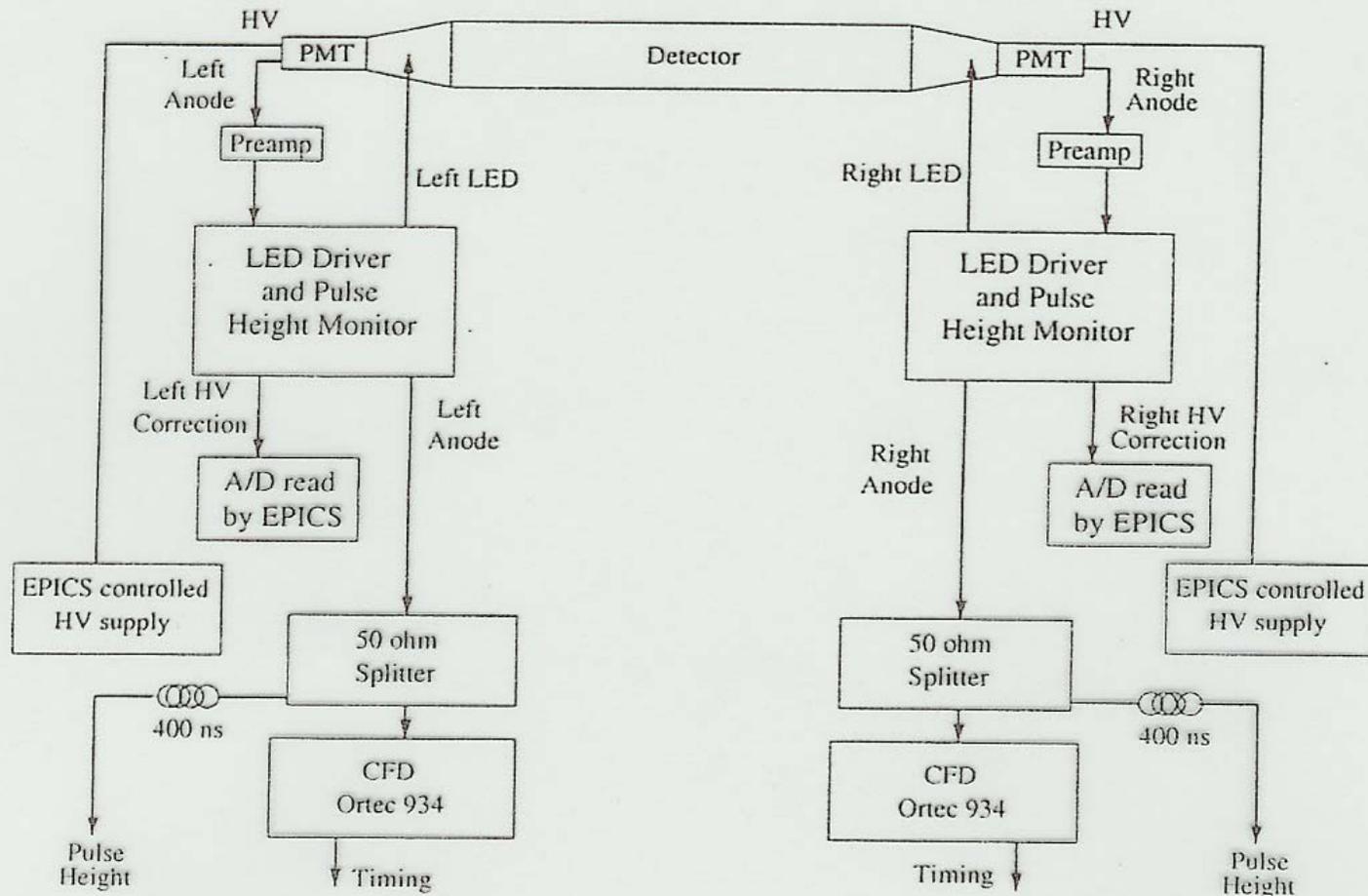


Figure 3.4: This is a schematic of the electronics used to produce the timing and pulse height signals for the 44 neutron detectors in NPOL. All electronics were installed in the NPOL detector enclosure under the detector platform.

## 1. FRONT ARRAY

36 [10cm x 10cm x 100cm] Scintillators & Light Pipes	
Have 32, need 6 more (2 spares)	\$14,000
20 [12.5cm x 10cm x 100 cm] Scintillators & Light Pipes	
Existing in Hall A array (IU detectors)	
30 [1cm x 10cm x 106 cm] Veto Scintillators & Light Pipe	27,000
All neutron detectors have PMT's & Mag Shields	
Veto detector PMT's & Mag Shields may be obtained from veto detectors in E93-038 Gen Exp. ?	
64 Replacement 2-in diam PMT's (First 3 layers)	64,000

## 2. REAR ARRAY

## OPTION 1:

Use existing neutron detector array.

Replacement PMT's for neutron detectors (10)	20,000
Rear Array Veto detectors	
20 [1cm x 25 cm x 106 cm] vetoes & light pipes	40,000
40 2-in diam PMT's & Mag Shields	46,000

## OPTION 2:

Cut all existing 20x40 detectors (12) into two 10x40 detectors.

Cutting and new Light Pipe fabrication will be performed at Kent.

24 5-in Diam PMT's & Mag Shields	52,000
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## 3. ELECTRONICS

46 Quad CF Discriminators	
Have 22 (KSU) + 10 (Tel Aviv) + 10 (MSU-Tennelec)	
Need 4 more for Option 2 @\$3K/ea	12,000
3 32-Channel Gain Stabilization Units - Have (Kent)	
10 Octal Leading-Edge Discriminators for Veto - Have/borrow	

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TOTAL:	OPTION 1	211,000
	OPTION 2	275,000