Search for N* Resonances in Photo-Induced Reactions using Double-Polarization and the CLAS Spectrometer at Jefferson Laboratory

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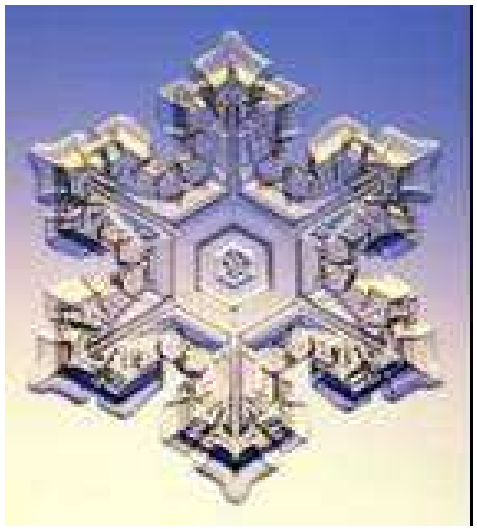
Outline



Outline

General Physical Motivation

Search for *Missing* Resonances

Quark models predict many more baryons than have been observed

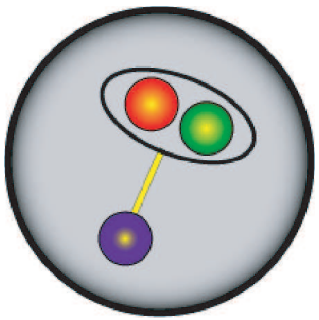
	****	***	**	*
N Spectrum	11	3	6	2
Δ Spectrum	7	3	6	6

$\Rightarrow$ according to PDG
(Phys. Rev. **D66** (2002) 010001)

$\Rightarrow$ little known
(many open questions left)

Possible Solutions:

a) Quark-Diquark Structure



one of the
internal degrees
of freedom
is frozen

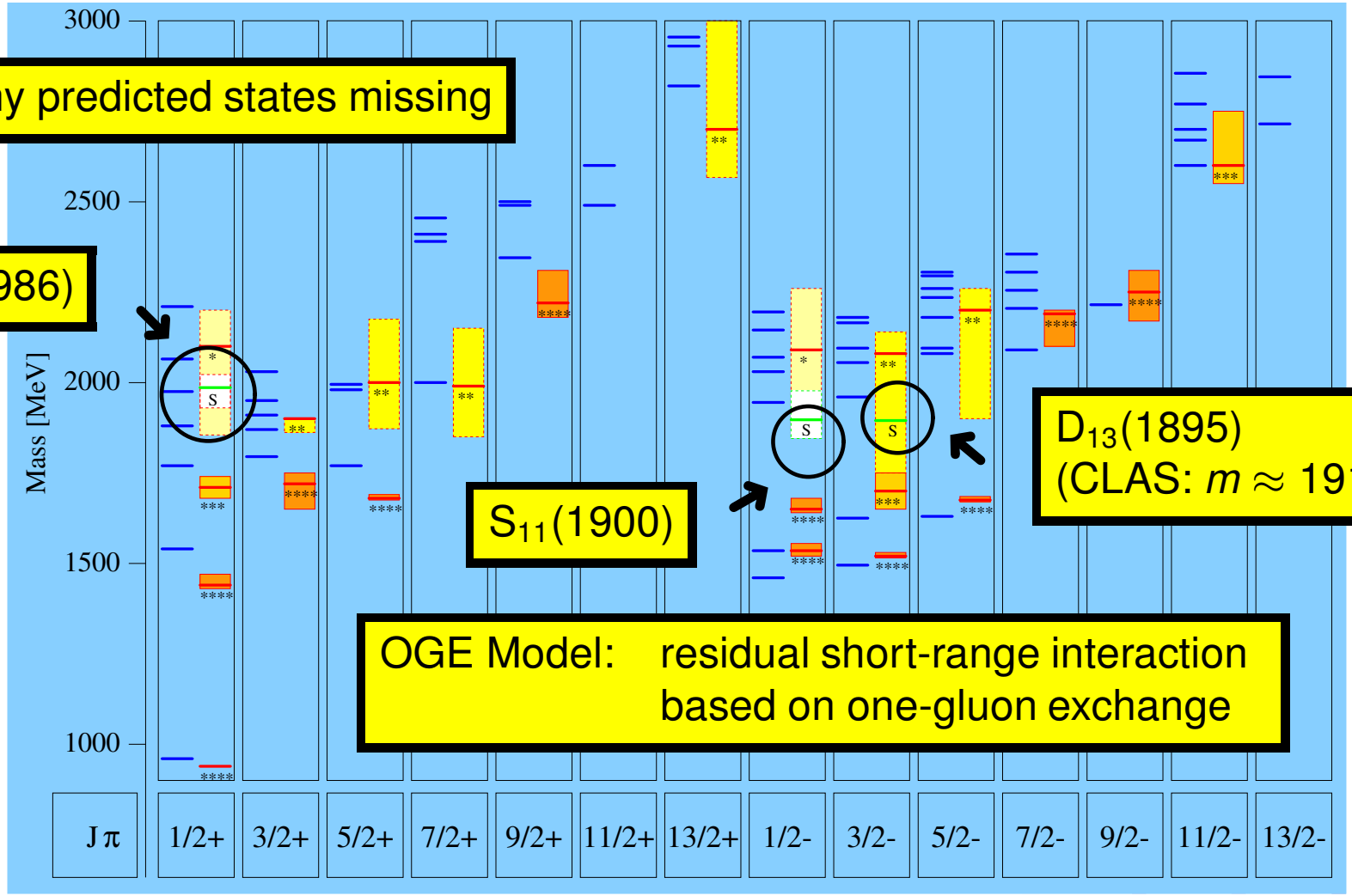
b) They have not been observed, yet

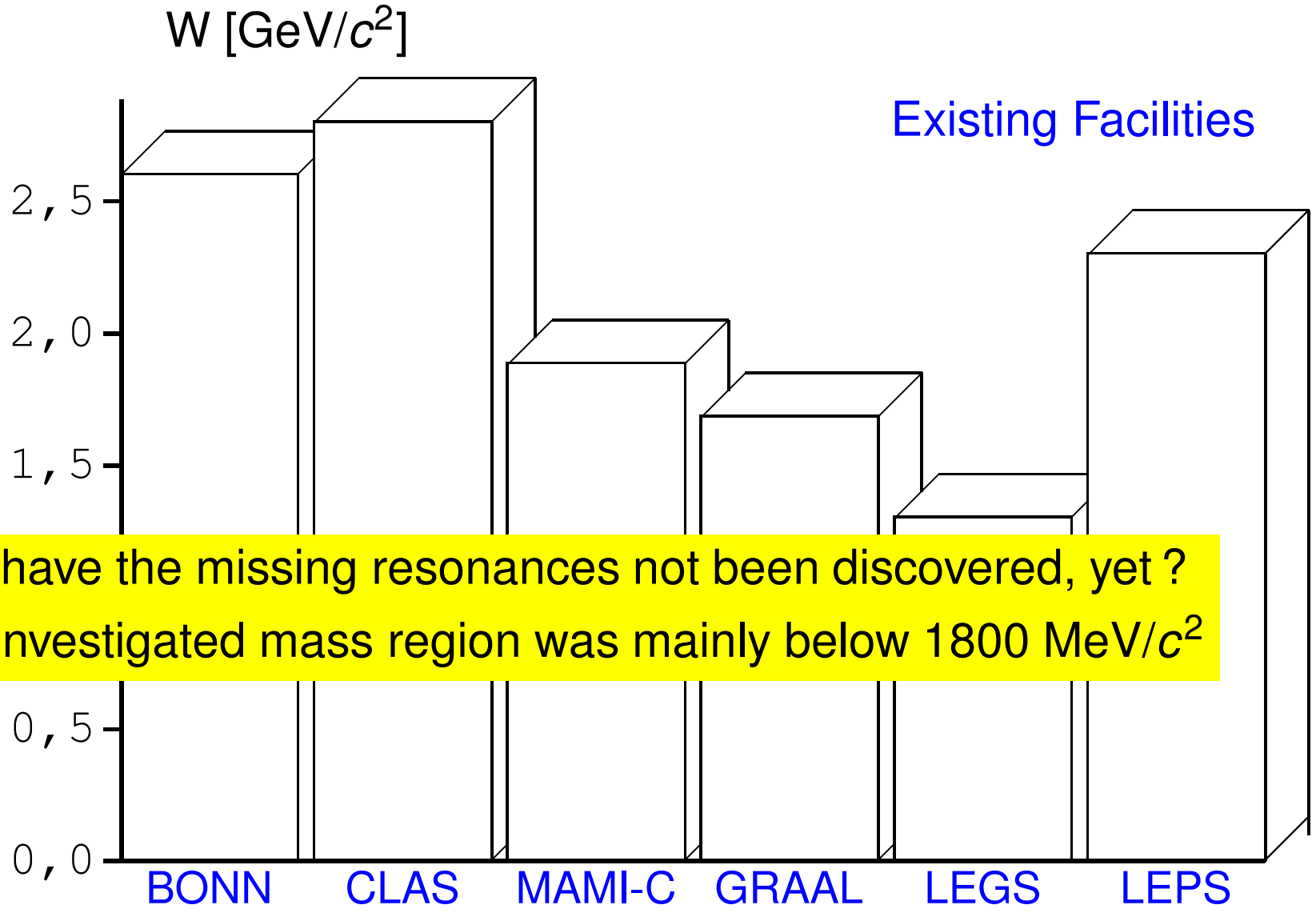
Nearly all existing data result from
πN scattering experiments

$\Rightarrow$ If the missing resonances did not couple to Nπ, they would not have been discovered!!

Nucleon Resonances: Status

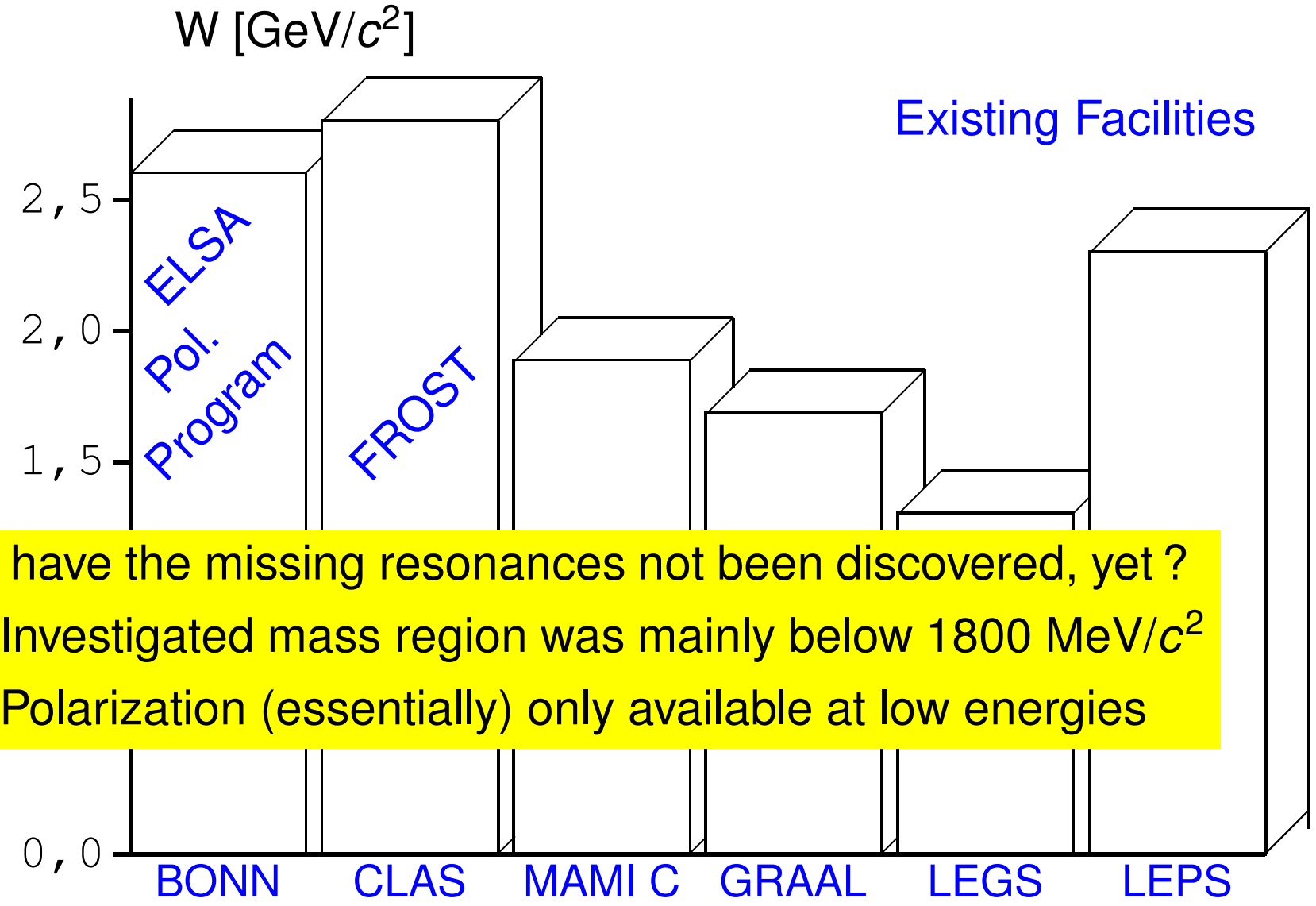
S. Capstick and N. Isgur, Phys. Rev. **D34** (1986) 2809





Why have the missing resonances not been discovered, yet ?

- Investigated mass region was mainly below 1800 MeV/c^2



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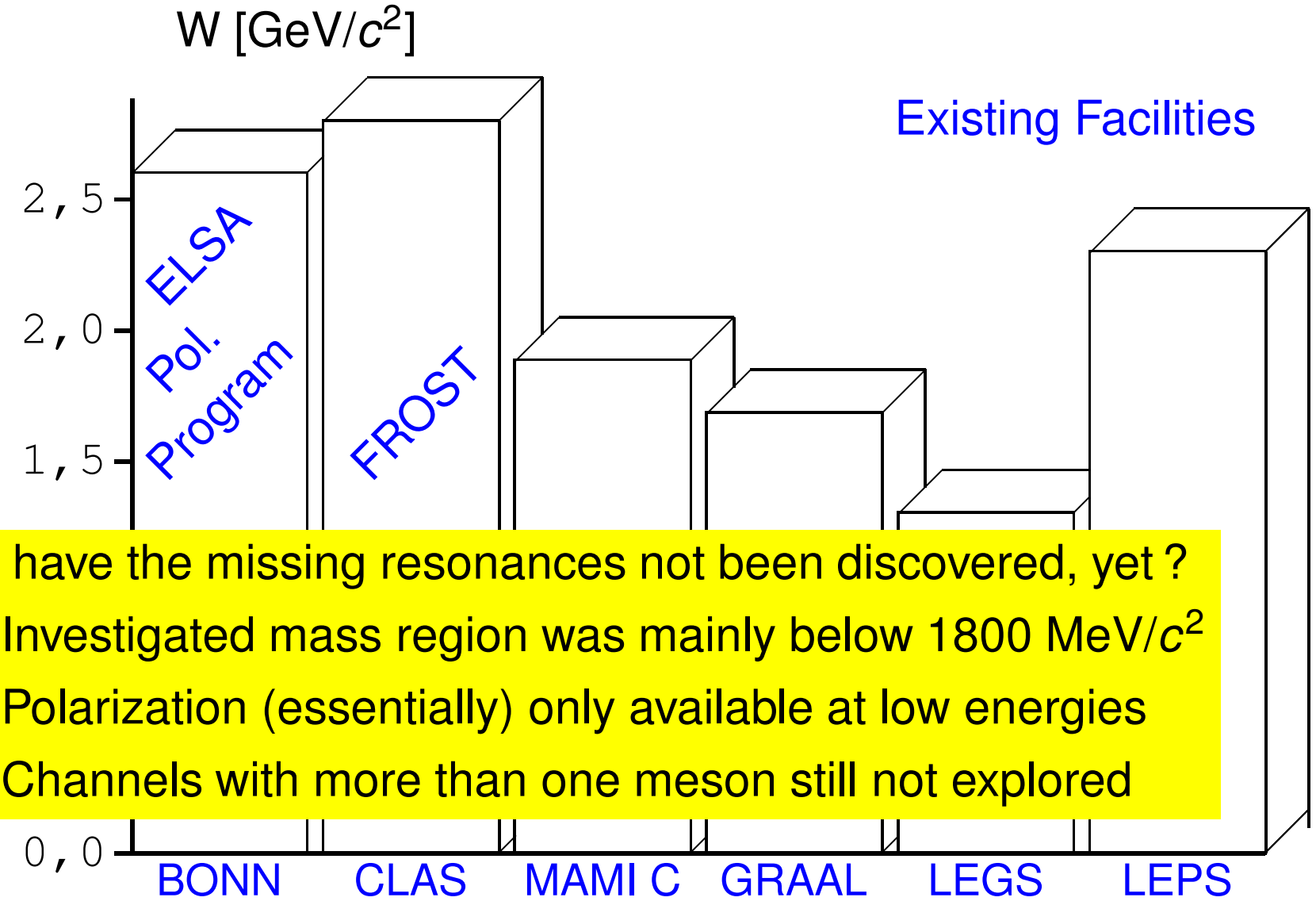

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- Investigated mass region was mainly below 1800 MeV/c^2
- Polarization (essentially) only available at low energies
- Channels with more than one meson still not explored

Outline

The Double-Polarization Program (FROST) at JLab

Approved Experiments:

- E 02-112 $\Rightarrow$ *Photoproduction of Hyperons* ($K^+\Lambda$, $K^+\Sigma^0$, $K^0\Sigma^+$)
- E 03-105 $\Rightarrow$ $\pi^0 p$, $\pi^+ n$ *Photoproduction*
  E 04-102
- E 05-012 $\Rightarrow$ η *Photoproduction*
- E 06-013 $\Rightarrow$ $\pi^+\pi^-$ *Photoproduction*
  ($W < 2.3$ MeV/c^2, $\Delta A \leq 0.05$, large angular coverage)

➜ Total of 89 PAC days approved!

Beam-Target Polarization Observables

$$\frac{d\sigma}{d\Omega} = \sigma_0 \{ 1 - \delta_l \Sigma \cos 2\phi + \Lambda_x (-\delta_l \mathbf{H} \sin 2\phi + \delta_\odot \mathbf{F}) - \Lambda_y (-\mathbf{T} + \delta_l \mathbf{P} \cos 2\phi) - \Lambda_z (-\delta_l \mathbf{G} \sin 2\phi + \delta_\odot \mathbf{E}) \}$$

$\Leftarrow$ Single-Meson Final States (7 Observables)

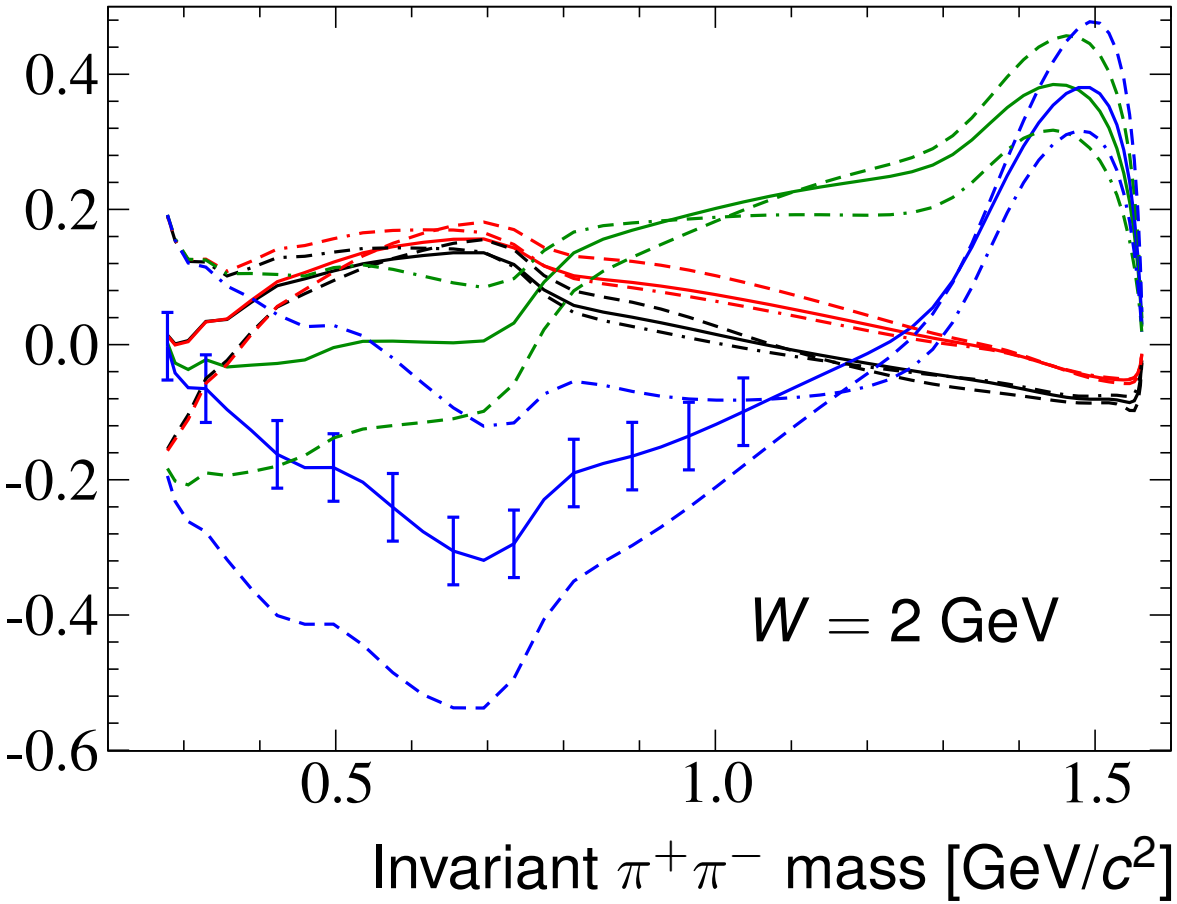
Two-Meson Final States $\Rightarrow$ (15 Observables)

$$I = I_0 \{ (1 + \vec{\Lambda}_i \cdot \vec{\mathbf{P}}) + \delta_\odot (\mathbf{I}^\odot + \vec{\Lambda}_i \cdot \vec{\mathbf{P}}^\odot) + \delta_l [\sin 2\beta (\mathbf{I}^s + \vec{\Lambda}_i \cdot \vec{\mathbf{P}}^s) \cos 2\beta (\mathbf{I}^c + \vec{\Lambda}_i \cdot \vec{\mathbf{P}}^c)] \}$$

Outline

Model Calculations of $P_x^{\odot}$ by W. Roberts

$\phi = 0.0035$ rad (almost 0), $\phi = 0.56$ rad, $\phi = 2.09$ rad, $\phi = 3.04$ rad (almost π)



Circ. Beam $\to$ Trans. Target

- Solid Line
  Full Calculation
- Dashed Line
  $S_{11}(1900)$ Omitted
- Dashed-Dotted Line
  $P_{31}(1910)$ Omitted

$\Rightarrow$ goal: $\Delta P_x^{\odot} \leq 0.05$

Model Calculations of $P_y^{\odot}$ by W. Roberts

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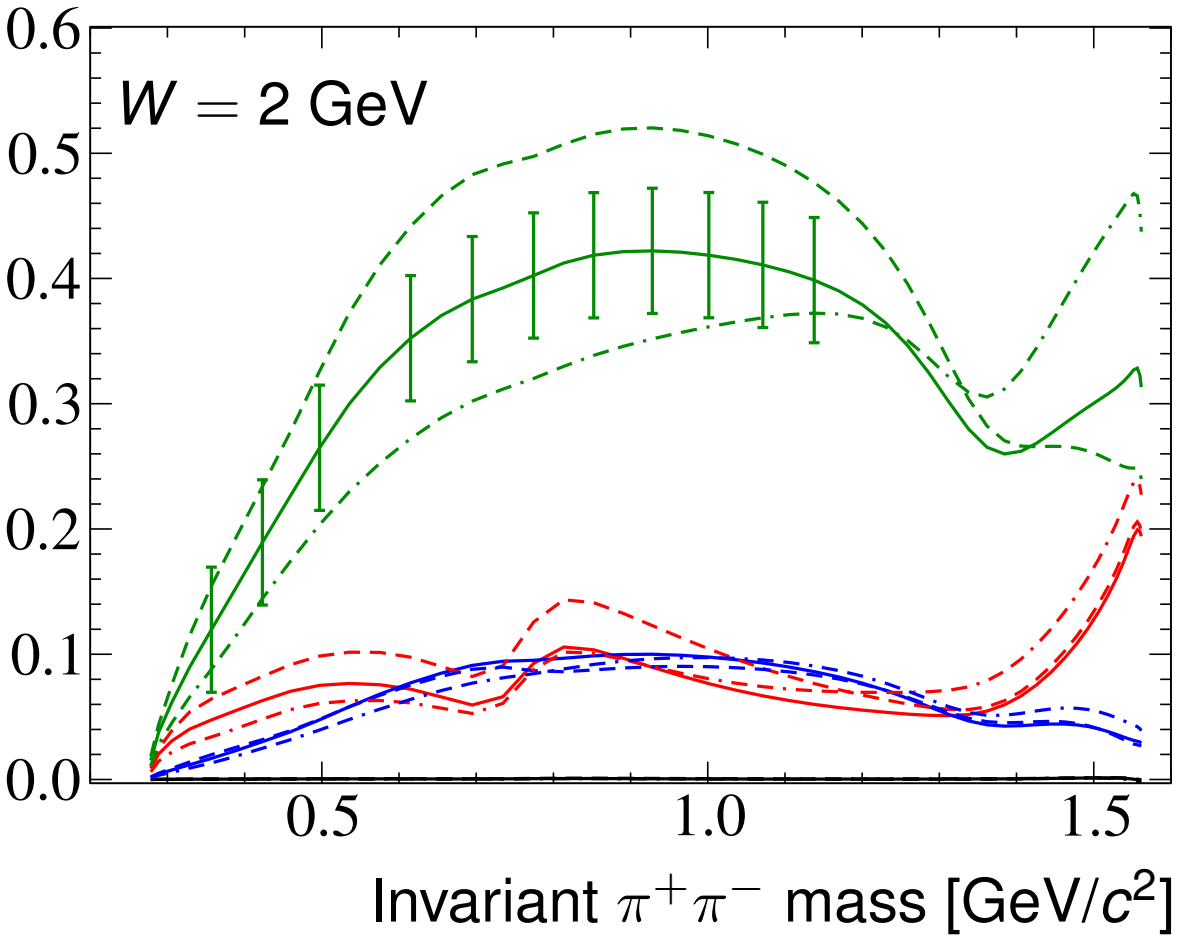

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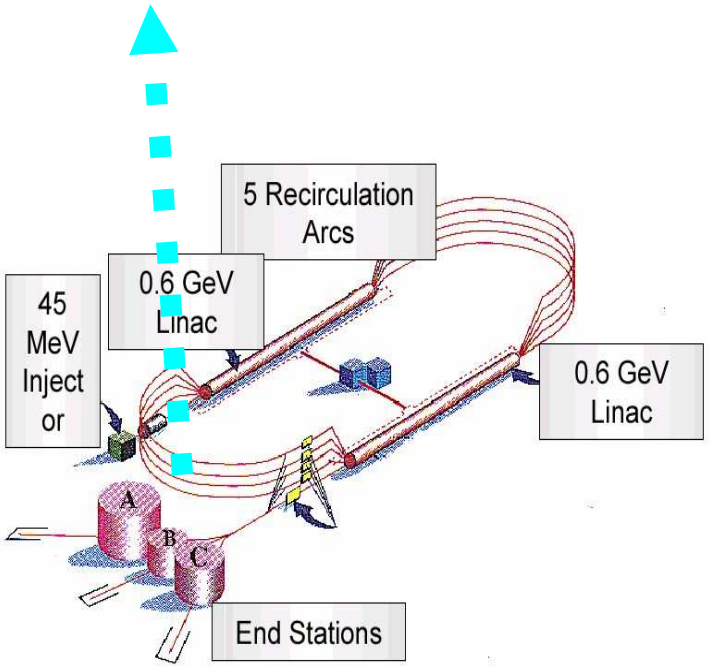
CEBAF Large Acceptance Spectrometer

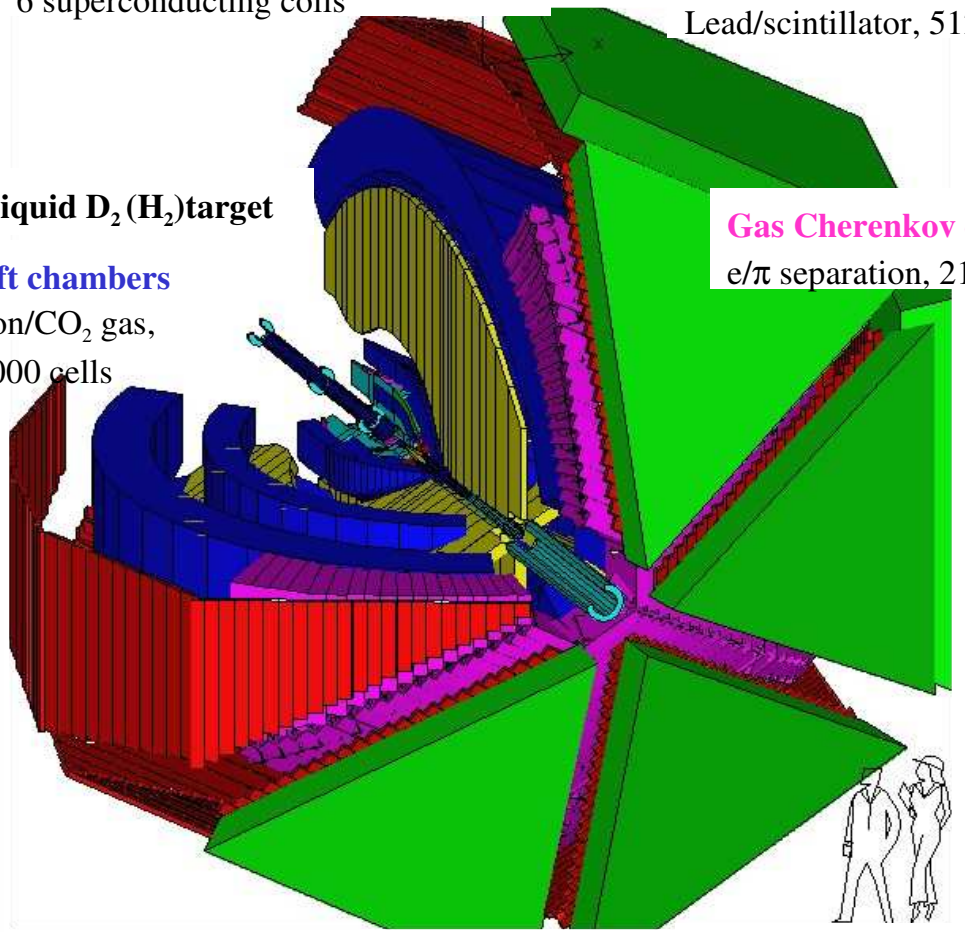
Hall B



Torus magnet
6 superconducting coils

Liquid D_2 (H_2)target

Drift chambers
argon/CO_2 gas,
35,000 cells



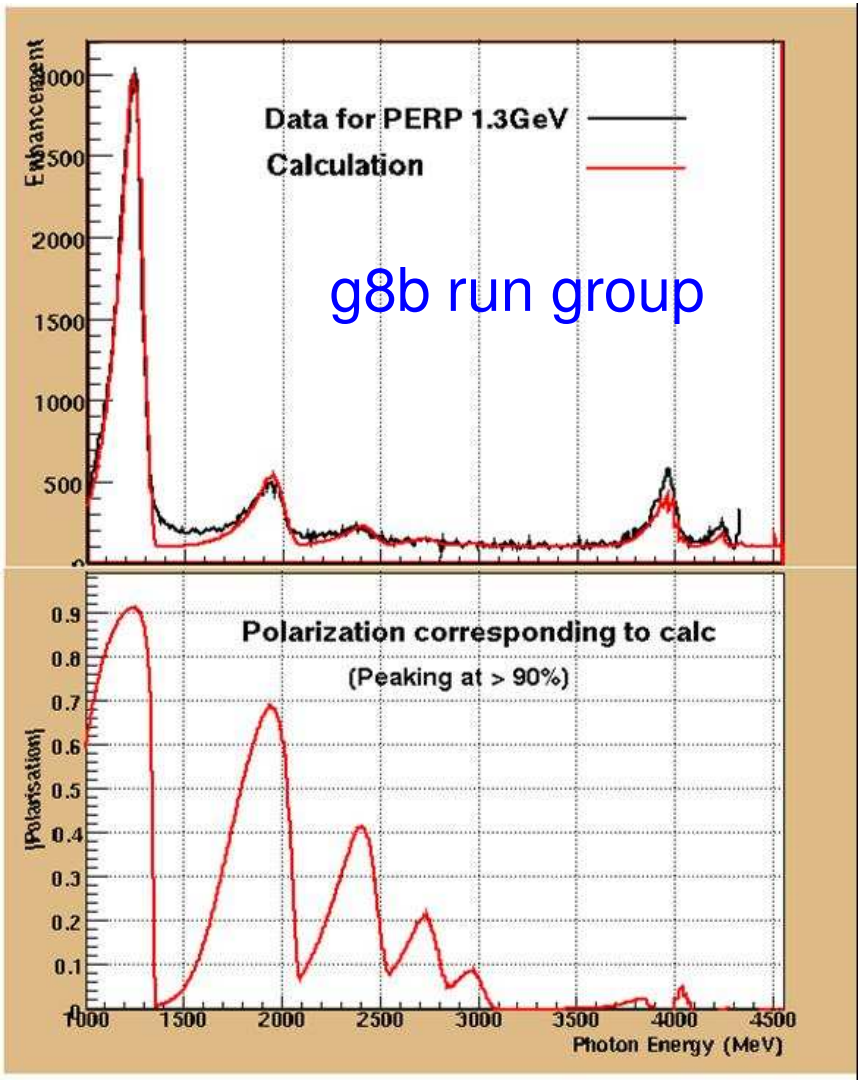
Large angle calorimeters
Lead/scintillator, 512 PMTs

Gas Cherenkov counters
e/π separation, 216 PMTs

Electromagnetic calorimeters
Lead/scintillator, 1296 PMTs

Time-of-flight counters
plastic scintillators, 684 PMTs

The Coherent Bremsstrahlung Facility at CLAS



Requirements for coherent beam:

- Low emittance, stable beam
- High-quality thin crystal
- Collimation:
  < 0.5 characteristic angle
- Polarimetry

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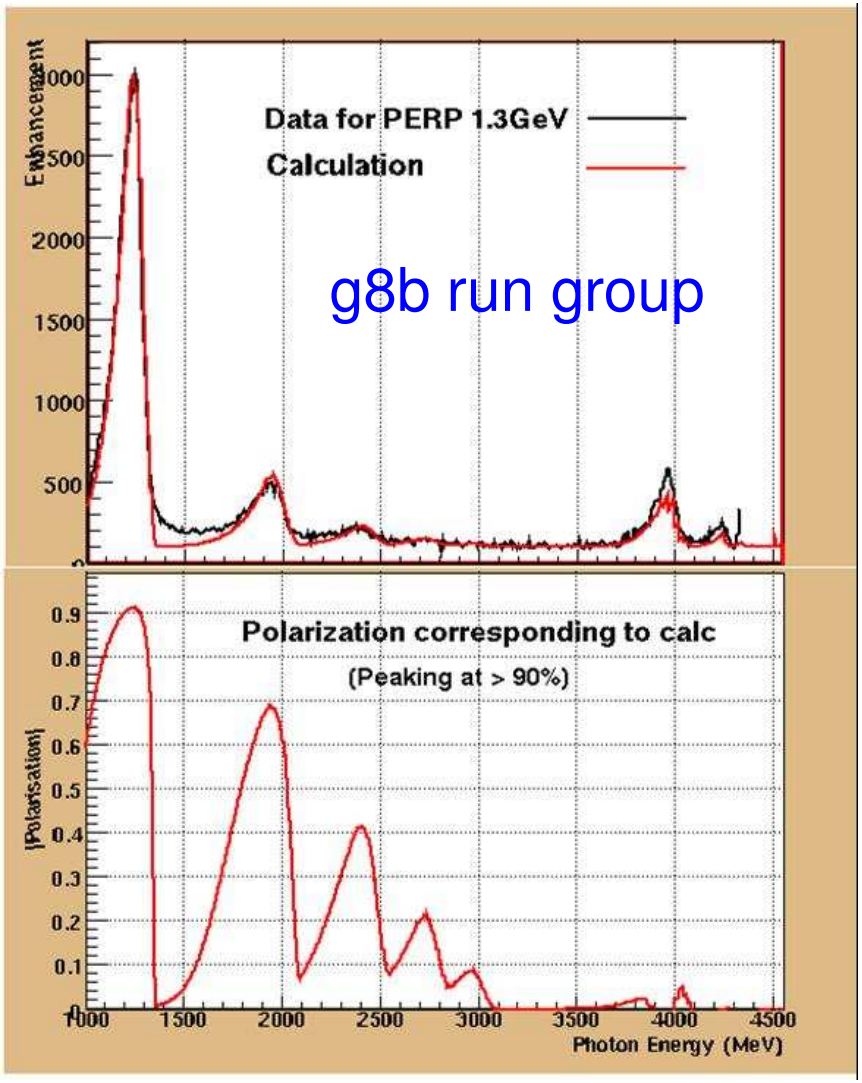

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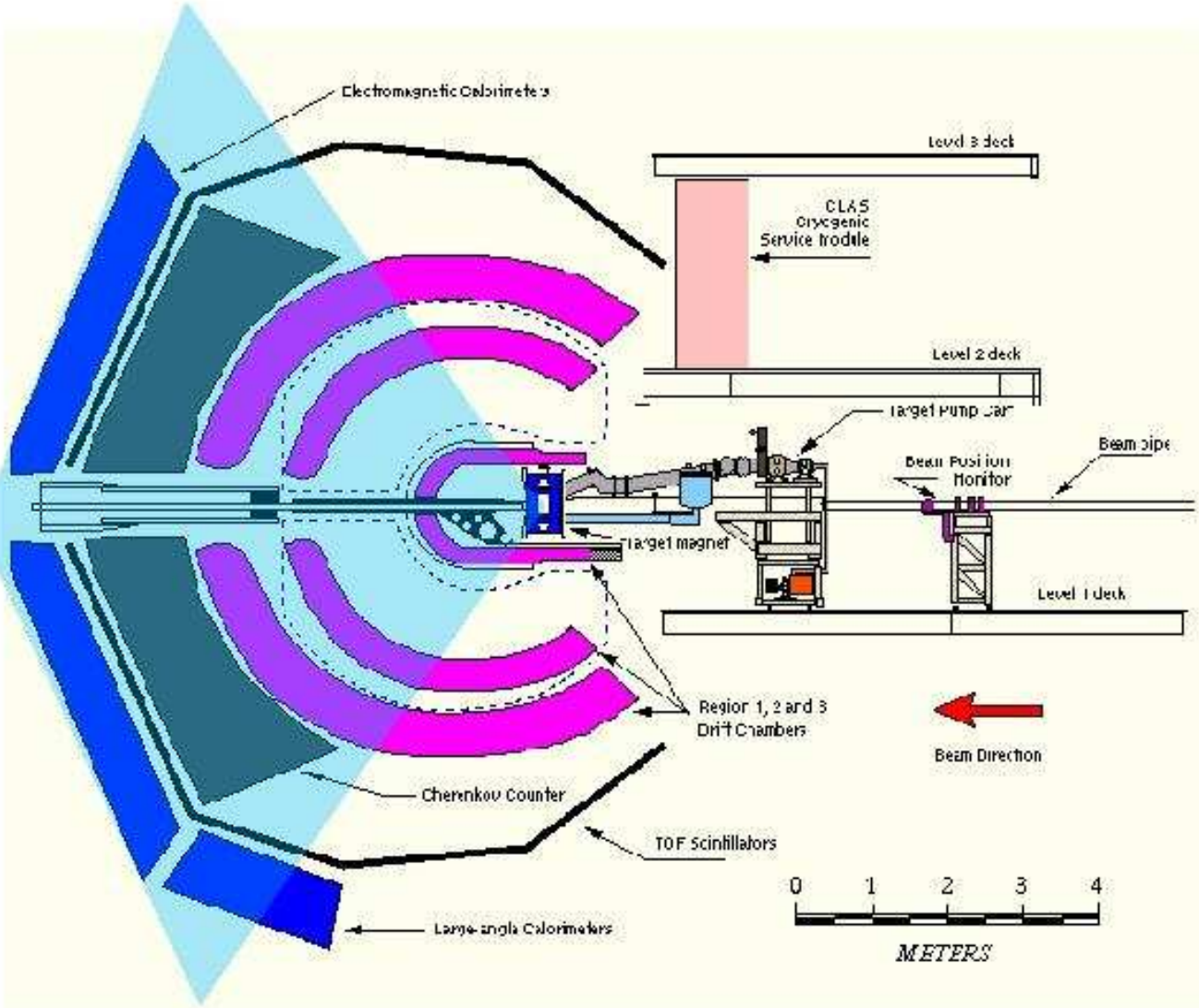
Circularly-Polarized Beam:

$$P_{\odot}(E_{\gamma} / E_{e^-}) = P_e \cdot \frac{4k - k^2}{4 - 4k + 3k^2}$$

➜ 60 % – 99 % of incident P_{e^-}

Outline

The Current Hall-B Polarized Target: $^{15}NH_3$ ($^{15}ND_3$)

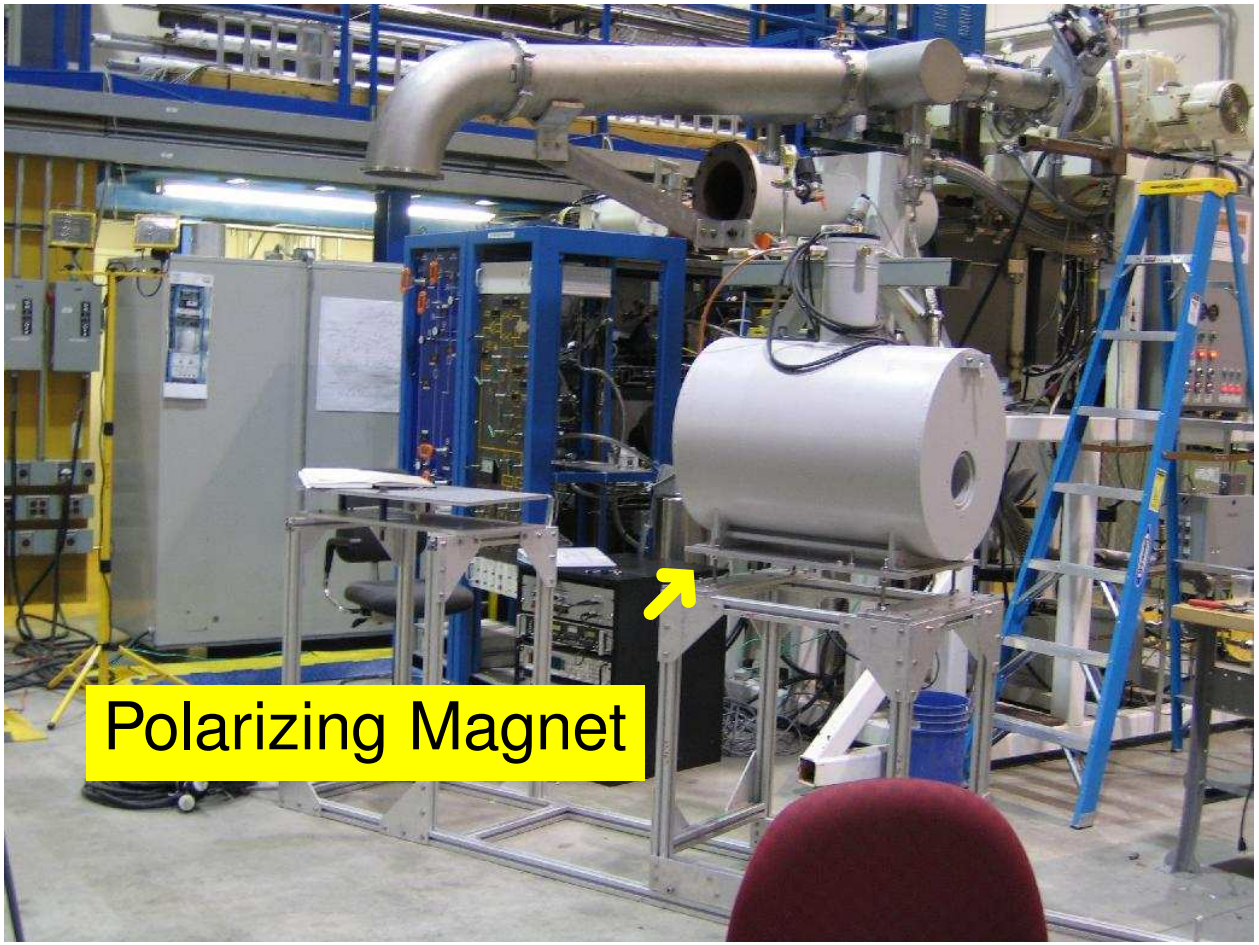


Protons (and deuterons) continuously polarized by 140 GHz microwaves at 5 T and 1 K.

- Proton polarization: $\approx 75 - 85\,\%$
- D polarization: $\approx 25 - 35\,\%$
- Limited acceptance: $\theta < 65°$

$\Rightarrow$ Need 4π target !

Polarizing Magnet

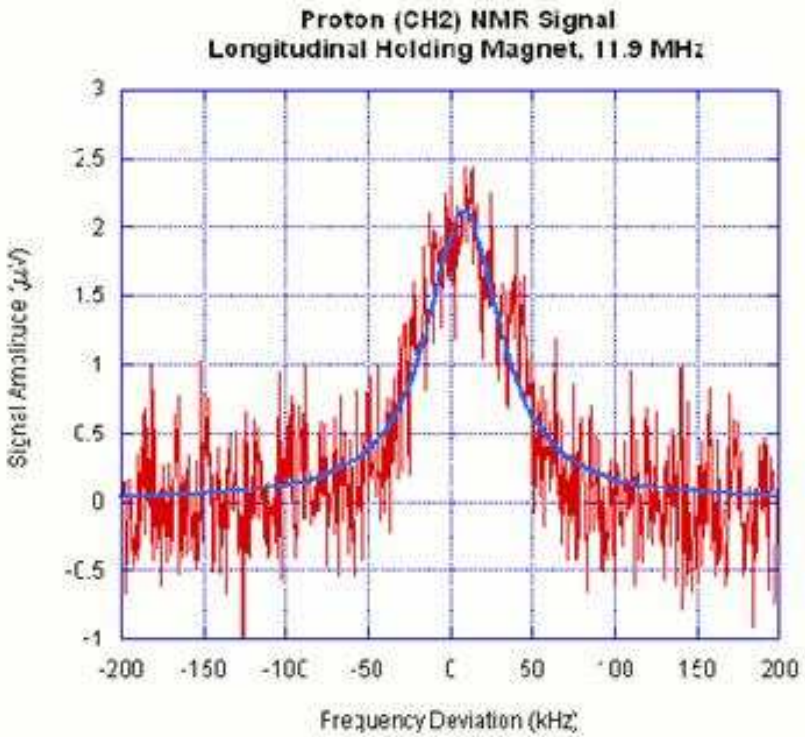


- Max. Field: 5.0 T
- Δ B/B: $< 3 \times 10^{-5}$
- Bore: 127 mmm

Cryomagnetics, Inc.
Oak Ridge, TN, USA

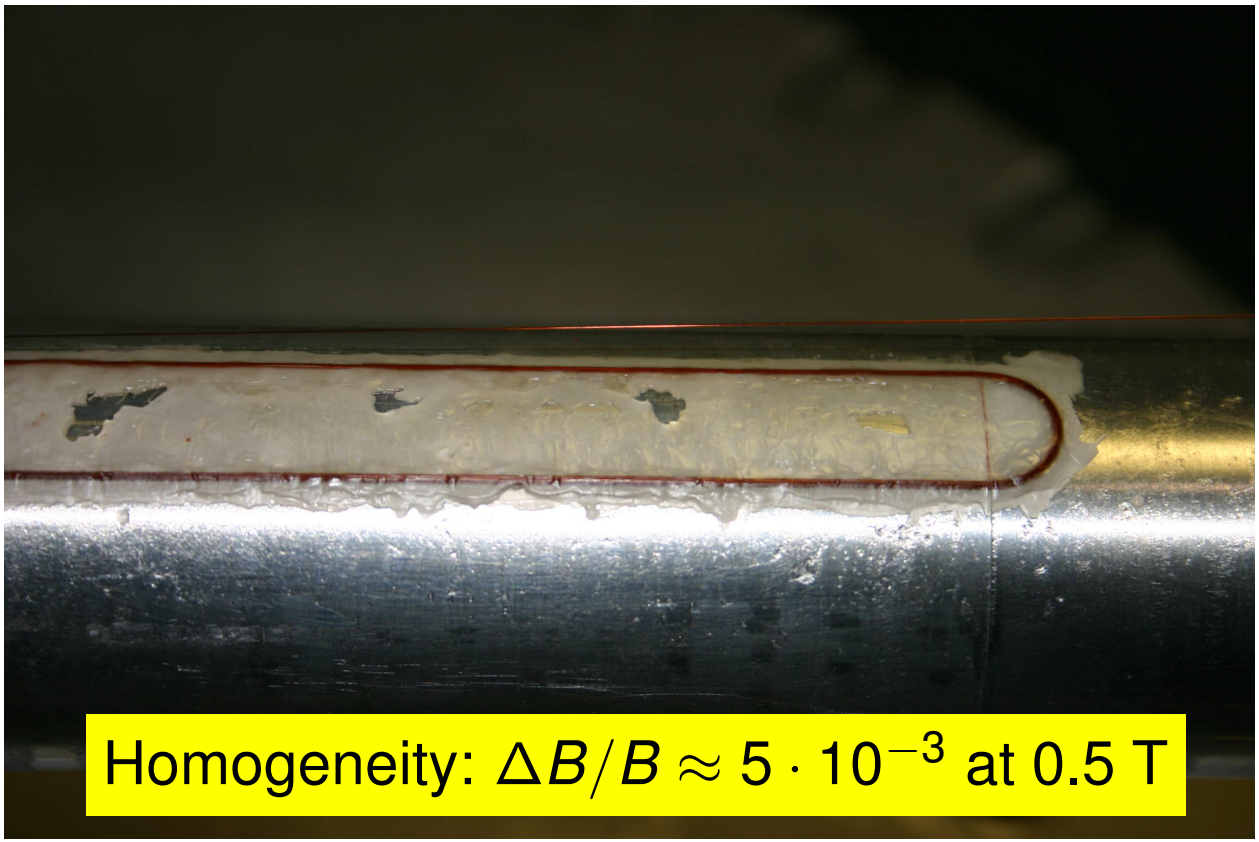
Holding Magnet: Solenoid for Longitudinal Polarization

Homogeneity: $\Delta B/B \approx 3 \cdot 10^{-3}$ at 0.5 T



Online NMR

Transverse Holding Magnet: Dipole *(Race-Track Coils)*



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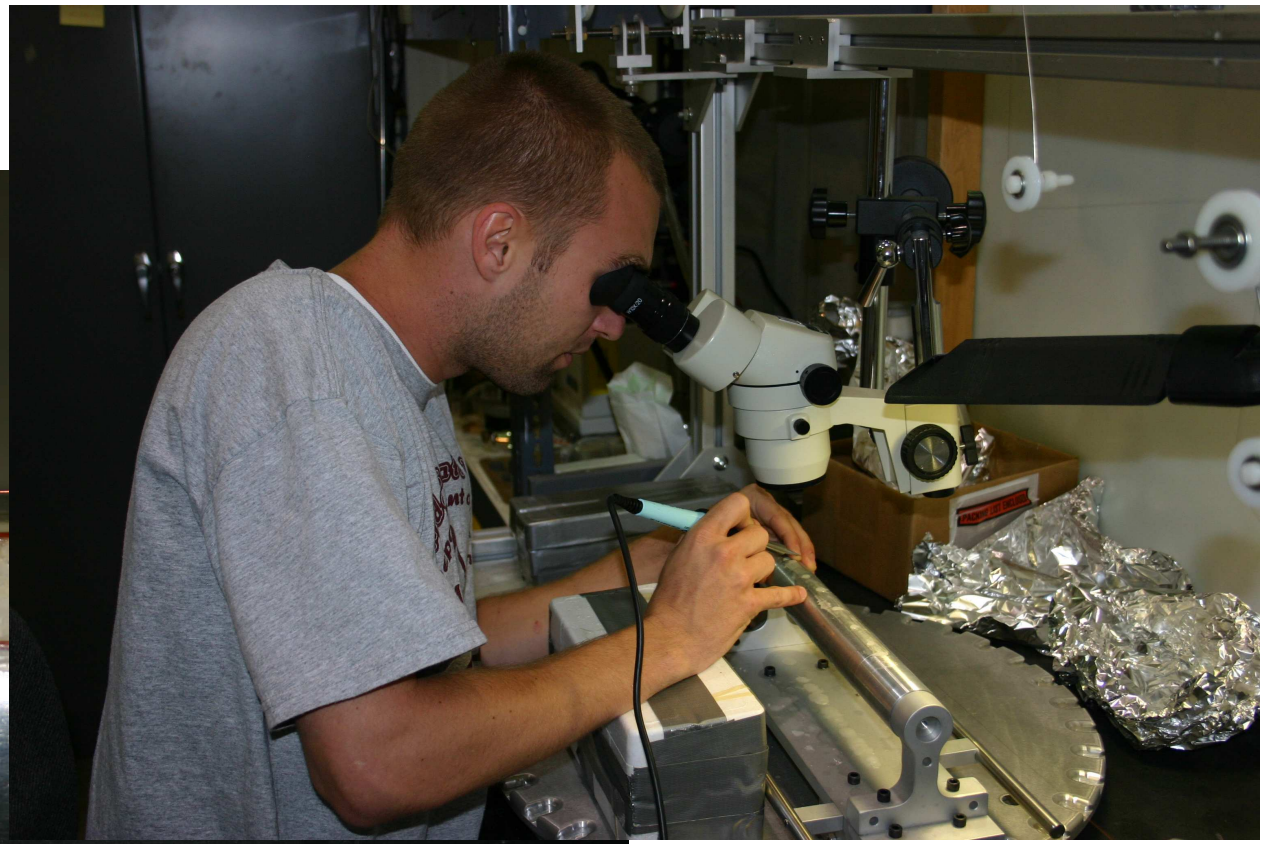
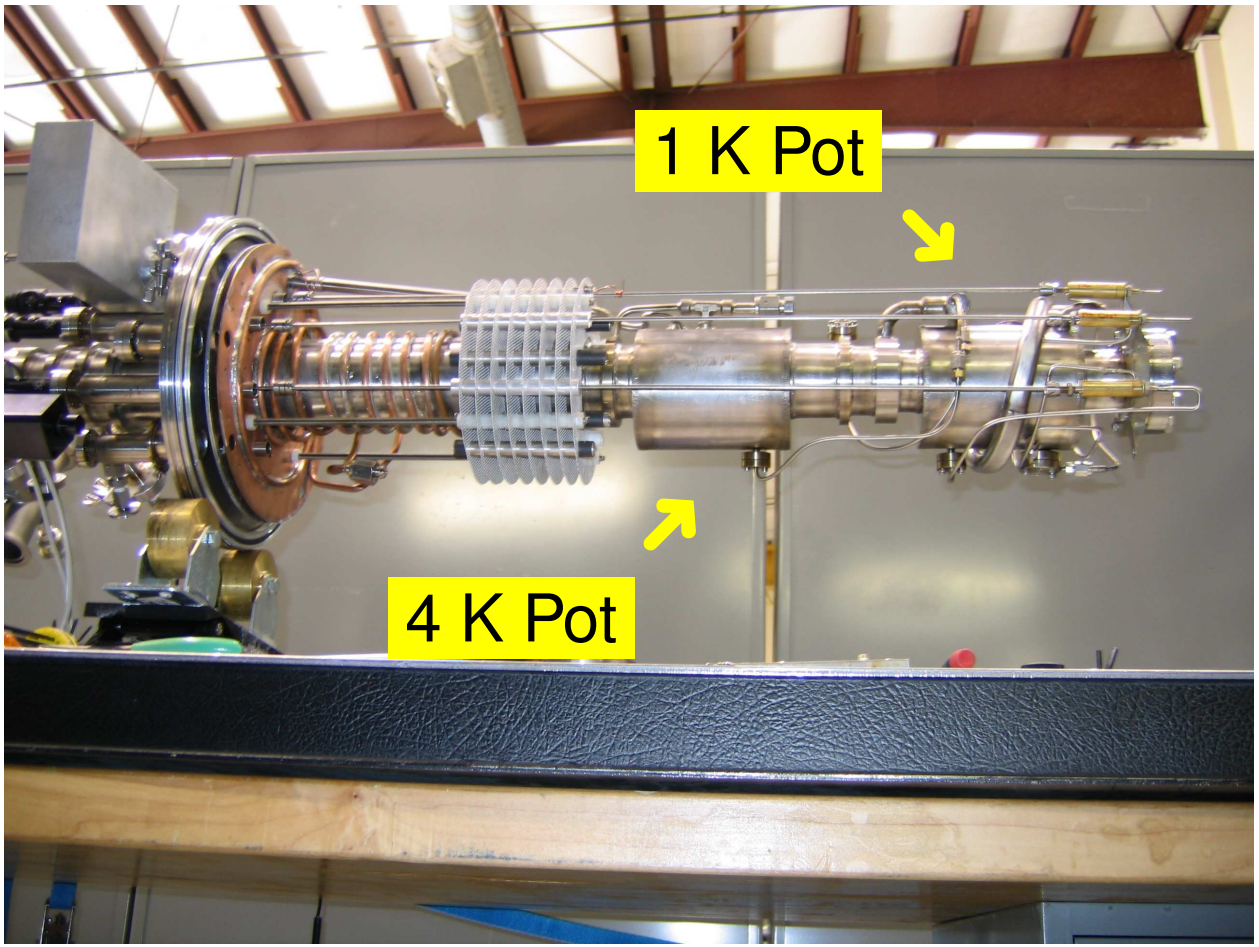


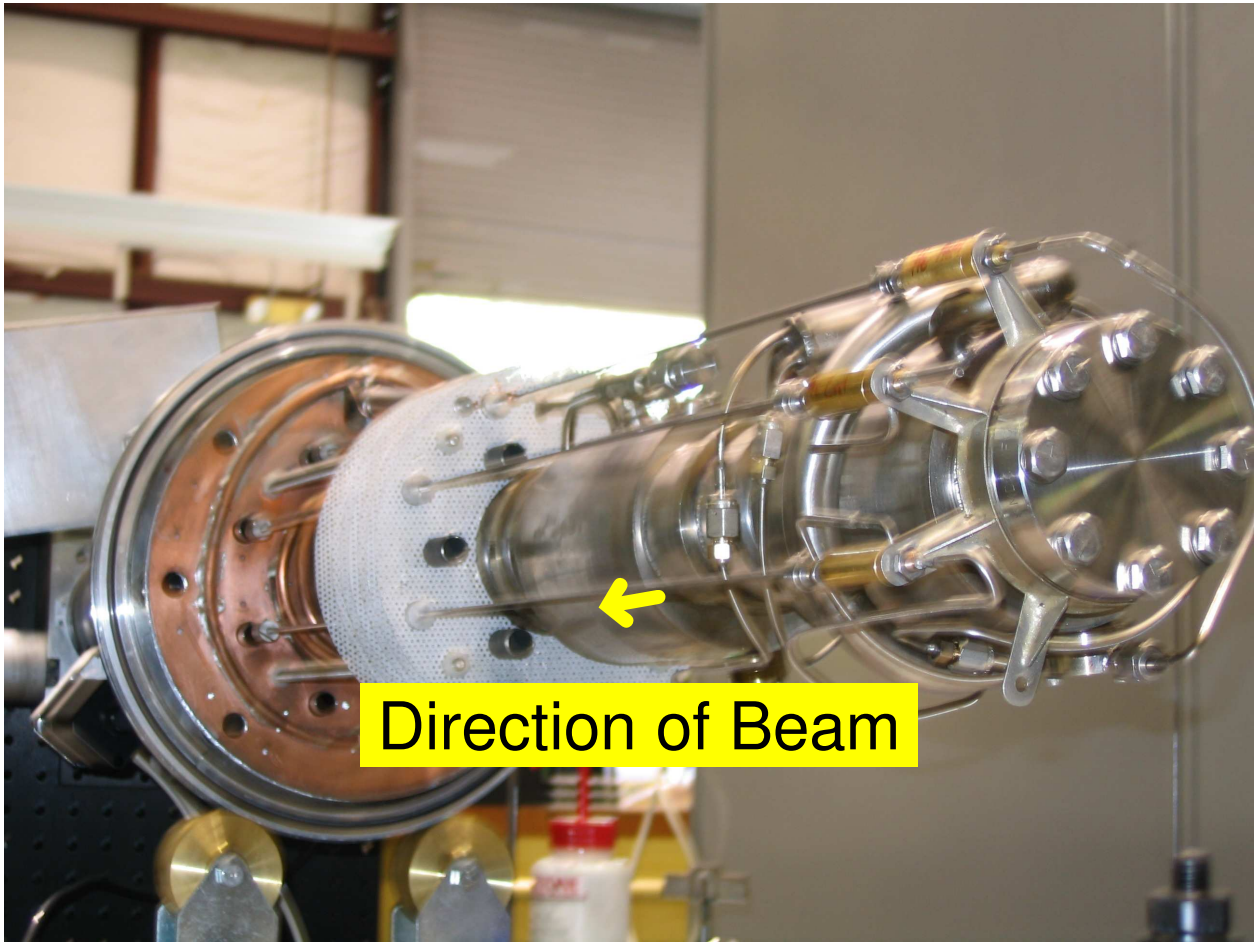
Homogeneity: $\Delta B/B \approx 5 \cdot 10^{-3}$ at 0.5 T

Precooling Coil for ^{3}He Gas



Dilution Refrigerator goes here ...

Another View of the Refrigerator ...



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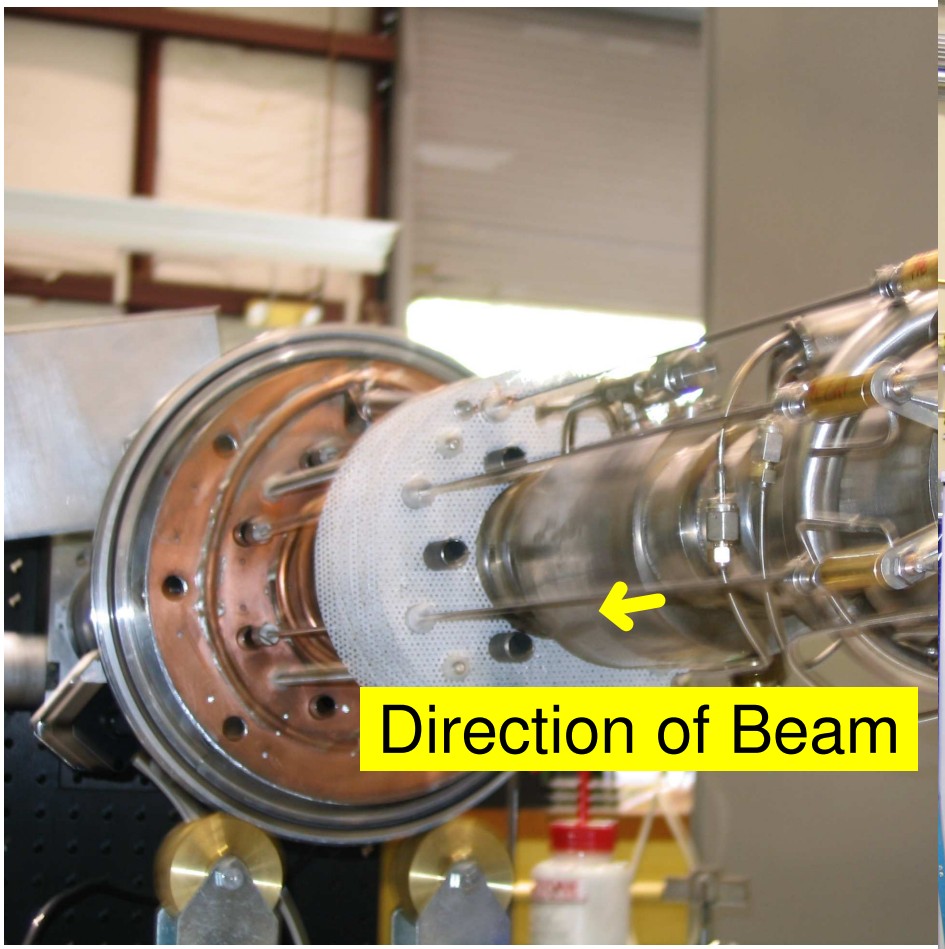
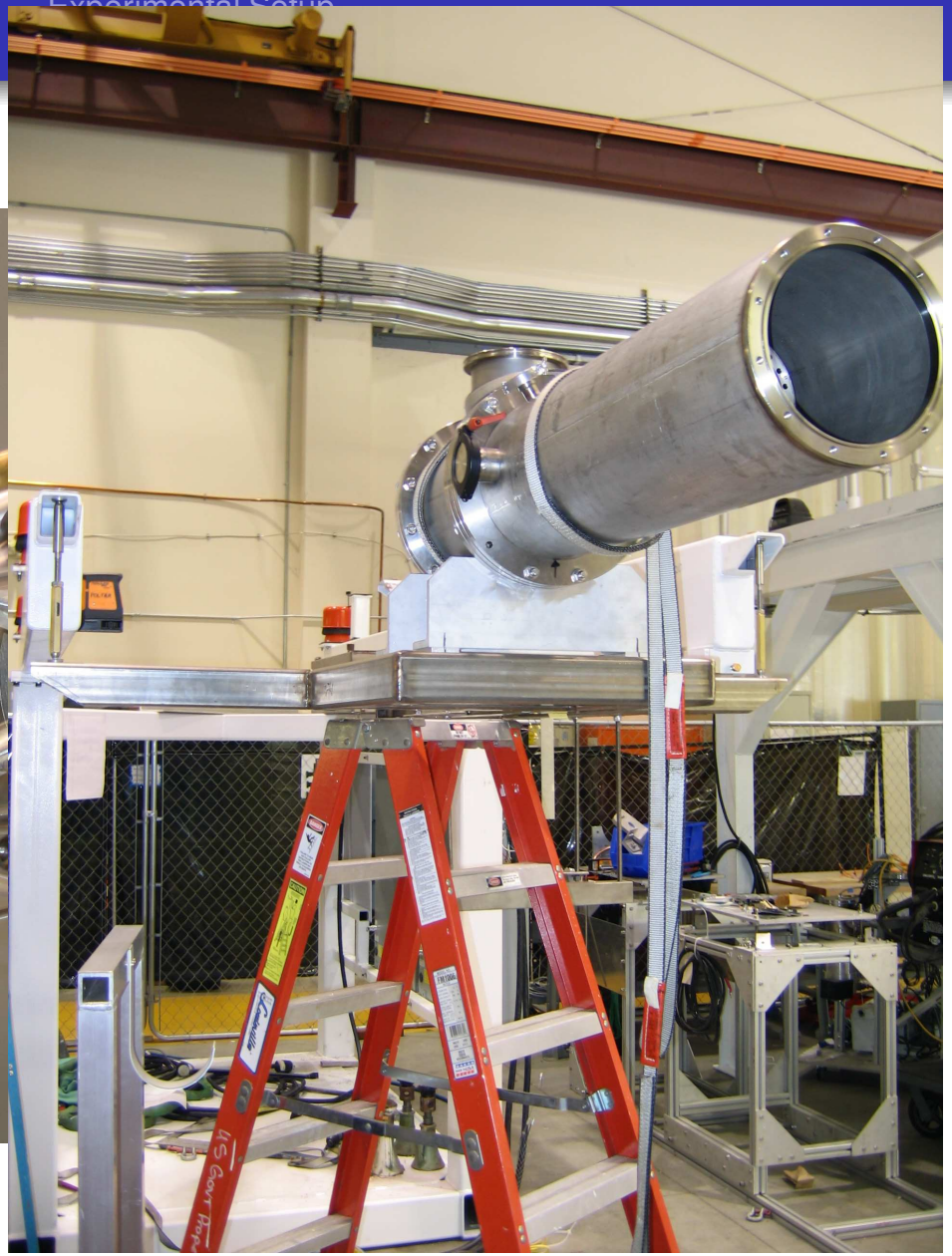

Direction of Beam



Summary

- Experiments will provide many excellent data.
- JLab: Scheduled for November 2006 – September 2007