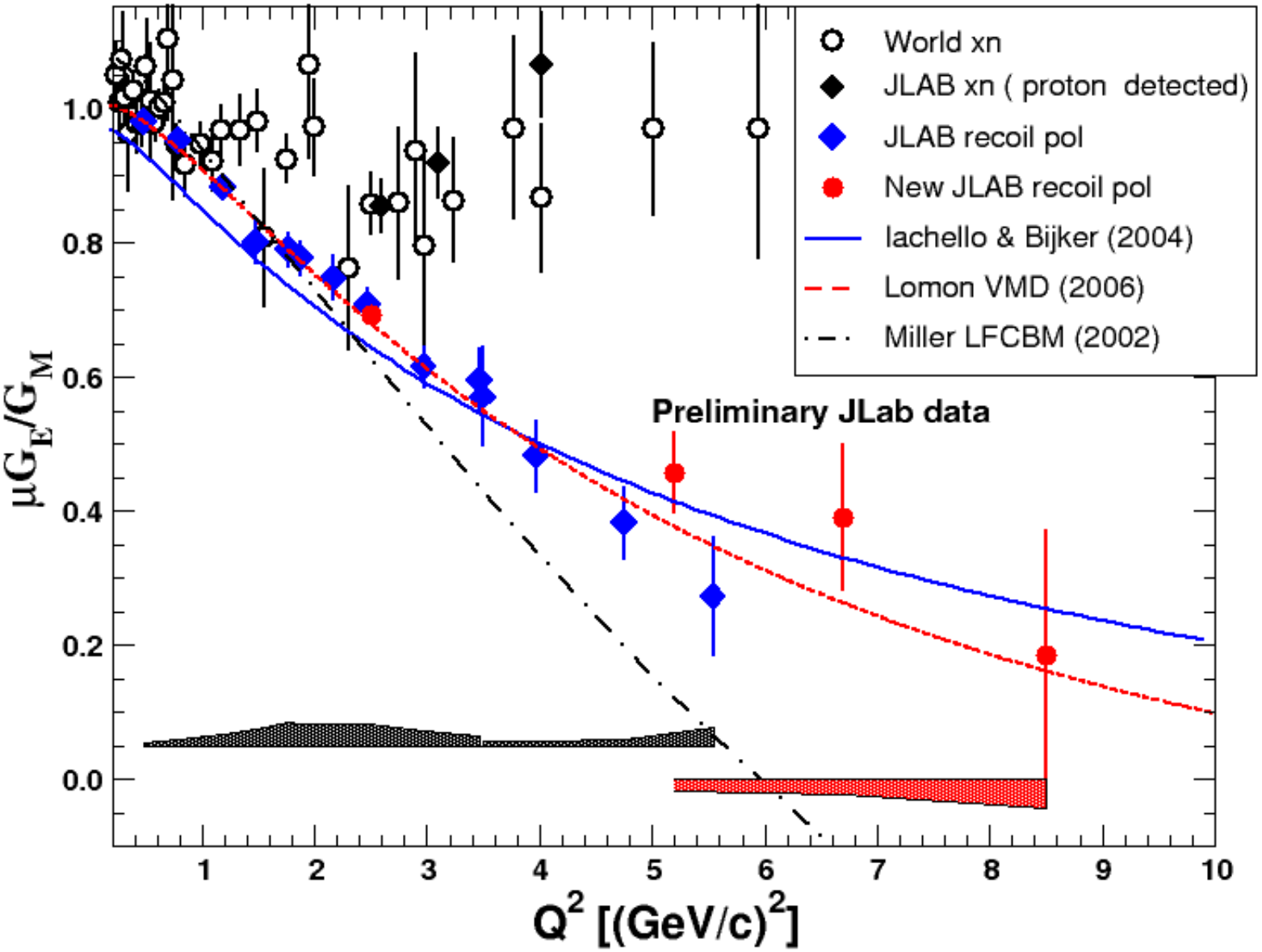
Gep5: Proton G_E/G_M to Q^2= 14.5

Mark Jones

for the Gep5 Collaboration

Status of Proton G_E/G_M



Status of Gep5

- Ed Brash (CNU) and MJ upgraded from collaborators to co-spokesperson of E12-07-109 (Gep5)

- Significant modifications in design since proposal

- Optimized detectors using GEANT MC

Challenges of high Q^2 measurements

- Low elastic cross-section $\sigma \sim E^2/Q^{12}$
- Low analyzing power $A_y \sim 1/p \sim 1/Q^2$
- Overall experimental FOM $\sim \sigma A_y^2 \sim E^2/Q^{16}$

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•Need large acceptance in both electron and proton arm

•Hall C SHMS limited to ~4msr on proton arm

•To full take advantage of CEBAF 12 GeV upgrade need new device

Challenges of high Q^2 measurements

- Increased systematics due to larger precession angles $\chi \sim \gamma_p \sim Q^2$
- Smaller angles ($\sim 1/p \sim 1/Q^2$) has to be used for polarimetry; will increase instrumental asymmetry

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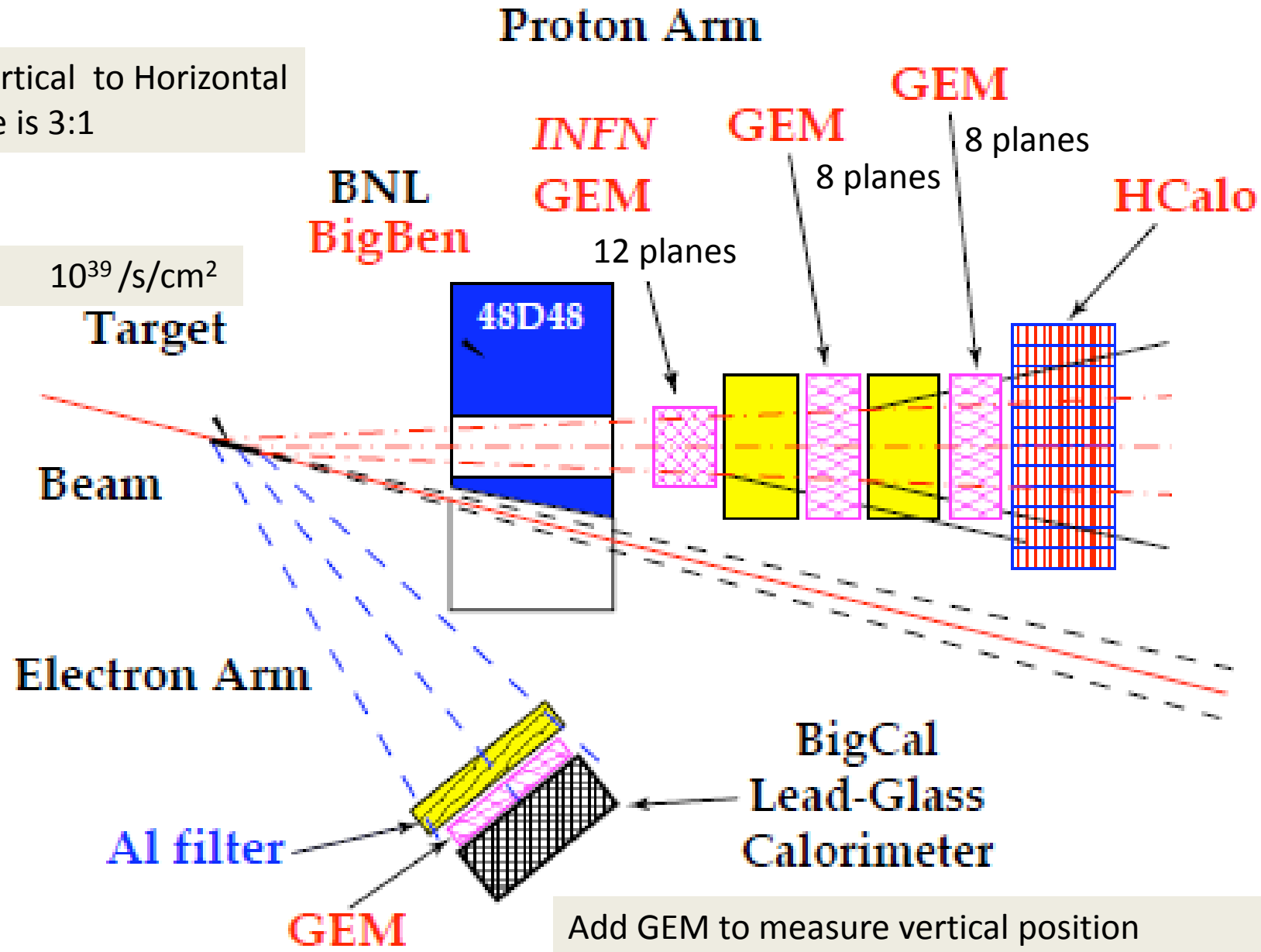
- Desirable to measure in different experimental setups.
- Reusing Bigcal and FPP detectors from recent Hall C experiment makes running an additional experiment cost effective.

Experiment Setup

Ratio of Vertical to Horizontal acceptance is 3:1

40cm LH2 10^{39} /s/cm^2



Add GEM to measure vertical position
Improve track matching

Kinematics

Q^2 $(\mathrm{GeV/c})^2$	E_{beam} GeV	beam time days	p_p GeV	θ_{SBS} deg	E_e GeV	θ_{BigCal} deg	$\Delta[\ \mu G_E/G_M]$
5.0	6.6	1	3.48	28.0	3.94	26.3	0.023
10.0	8.8	10	6.20	16.7	3.47	35.3	0.065
14.5	11.	45	8.61	12.0	3.27	39.0	0.135

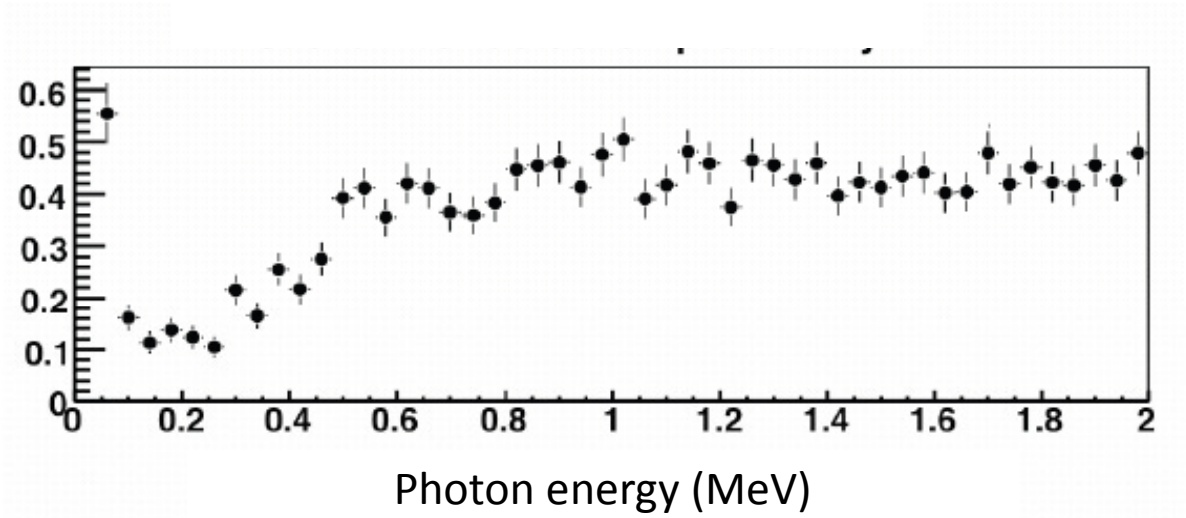
Trigger :

- High energy threshold on the hadron calorimeter
  - 3 GeV threshold gives rate of 1.5 MHz
- Electron calorimeter
  - 2.5 GeV threshold gives rate of 60KHz
- Coincidence rate is 5 KHz (50ns coincidence window)

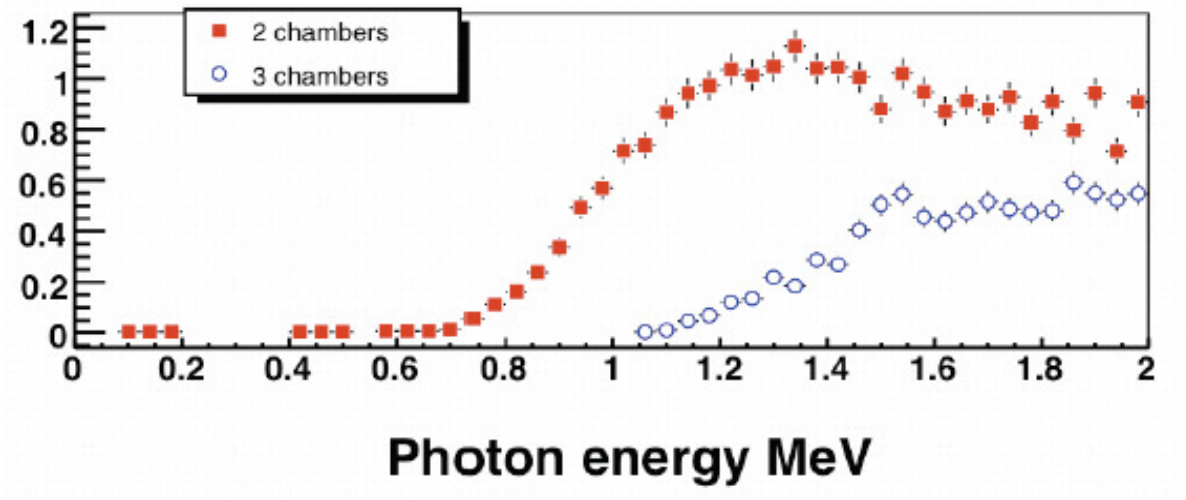
Low energy photons interactions with Front GEMs (3 chambers, 4 planes each)

- Low energy electrons swept away by magnet.
- Low energy photons dominate rates.
- Rates change from 400 KHz/cm^2 at first plane to 1MHz/cm^2 at the 12th plane

1st chamber detection Probability (%)



Multichamber Detection Probability (%)



Rates and tracking in Bigcal GEM

Tracker	Area of interest for tracking, cm^2	Rate, kHz/cm^2	Strip pitch, mm	Strip occupancy, %	Number of pseudo-tracks per event	Number of strip planes
First	0.20 x 18	400	0.4	13.5	1.65×10^{-2}	12
Second	$2\pi\ 0.35^2$	130	1.6	7.4	8.7×10^{-6}	8
Third	$\pi\ 4.8^2$	64	1.6	3.6	5.2×10^{-4}	8
BigCal	$\pi\ 1.2^2$	173	1	2.4	2.8×10^{-2}	2

- Aluminum absorber cuts rate of low energy electrons and photons. Still rate of 173 kHz/cm^2
- Use BigCal calorimeter to define position to 3σ = 1.2cm
- Number of pseudo tracks is 3%.
- BigCal GEM measures vertical position. Assume elastic scattering and predict vertical position in proton arm front tracker.

Rates and tracking in Hadron 1st GEM

Tracker	Area of interest for tracking, cm^2	Rate, kHz/cm^2	Strip pitch, mm	Strip occupancy, %	Number of pseudo-tracks per event	Number of strip planes
First	0.20 x 18	400	0.4	13.5	1.65×10^{-2}	12
Second	$2\pi\ 0.35^2$	130	1.6	7.4	8.7×10^{-6}	8
Third	$\pi\ 4.8^2$	64	1.6	3.6	5.2×10^{-4}	8
BigCal	$\pi\ 1.2^2$	173	1	2.4	2.8×10^{-2}	2

- "First" tracker of proton arm has 3 chambers each with 4 planes
- Rate dominated by low energy photons from target and produce in chambers.
- BigCal GEM measures vertical position and calorimeter to get horizontal postion. Assume elastic scattering and predict "Area of interest" in proton arm front tracker.
- Number of pseudo tracks is 2%.
    - With 12 planes sensitive to rate

Rates and tracking in Hadron 3rd GEMs

Tracker	Area of interest for tracking, cm^2	Rate, kHz/cm^2	Strip pitch, mm	Strip occupancy, %	Number of pseudo-tracks per event	Number of strip planes
First	0.20 x 18	400	0.4	13.5	1.65×10^{-2}	12
Second	$2\pi\ 0.35^2$	130	1.6	7.4	8.7×10^{-6}	8
Third	$\pi\ 4.8^2$	64	1.6	3.6	5.2×10^{-4}	8
BigCal	$\pi\ 1.2^2$	173	1	2.4	2.8×10^{-2}	2

- "Third" tracker of proton arm has 2 chambers each with 4 planes
- Rate dominated by photons interacting with analyzer
- Use position determined in hadron calorimeter to narrow the "area of interest"
- Number of pseudo tracks is 0.05%

Rates and tracking in Hadron 2nd GEM

Tracker	Area of interest for tracking, cm^2	Rate, kHz/cm^2	Strip pitch, mm	Strip occupancy, %	Number of pseudo-tracks per event	Number of strip planes
First	0.20 x 18	400	0.4	13.5	1.65×10^{-2}	12
Second	$2\pi\ 0.35^2$	130	1.6	7.4	8.7×10^{-6}	8
Third	$\pi\ 4.8^2$	64	1.6	3.6	5.2×10^{-4}	8
BigCal	$\pi\ 1.2^2$	173	1	2.4	2.8×10^{-2}	2

- "Second" tracker of proton arm has 2 chambers each with 4 planes
- Rate dominated by photons interacting with analyzer
- Use position determined in "First" and "Third" to narrow the "area of interest"
- Number of pseudo tracks is 0.0009%

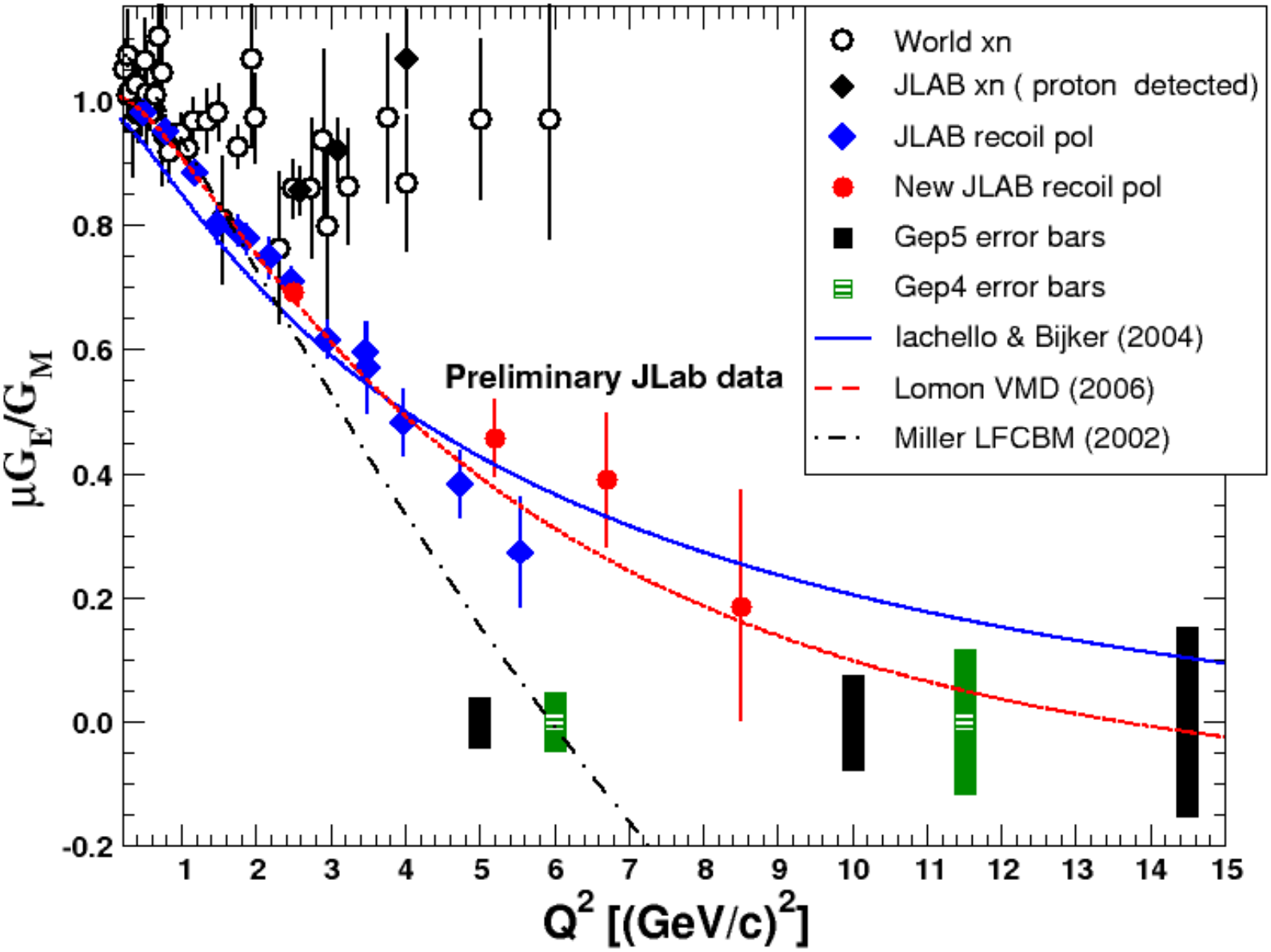
What if Rate Estimates Wrong?

- Front GEM tracker group is most sensitive to rate estimate.
- Factor of 1.5 times higher rate multiplies the number of pseudo-tracks per event by $(1.5)^{12} = 130$

Incident photon rate, kHz/cm^2	Psuedo-tracks per event		s
chamber type	standard	reduced material	reduced material
strips divided in	two chambers	two chambers	four chambers
400	1.65%	0.03%	0.00%
600	100%	3.52%	0.22%
800	100%	100%	6.95%

- Reduce material thickness by replace honeycomb by stretched films
- Further reduction by splitting the readout in the middle and doubling the number of channels.

Projected Error bars for Gep5

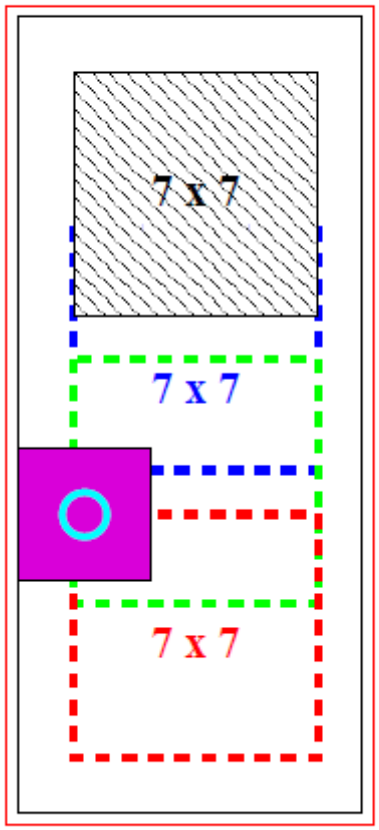


Backup slides

Trigger

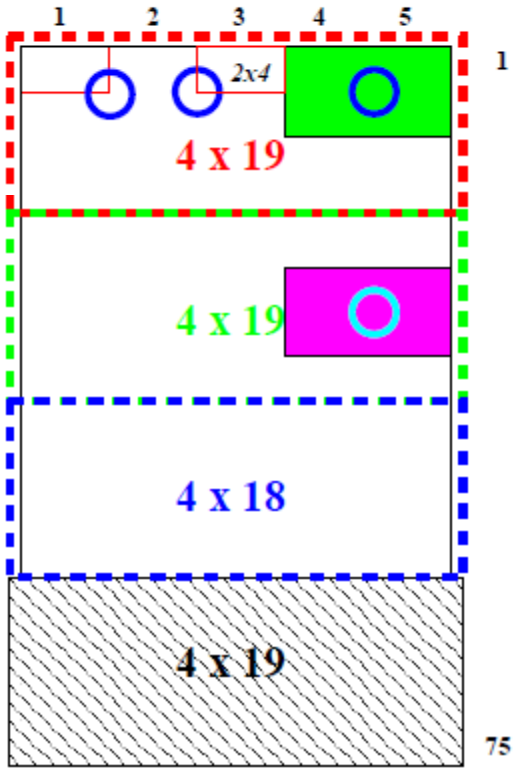
High energy threshold on the hadron (3GeV, 1.5 MHz)and electron (2 GeV, 60KHz) calorimeter reduce coincidence rate to 5 KHz (50ns coincidence window)

10 x 20 HCAL blocks



7 x 17 software sum−16

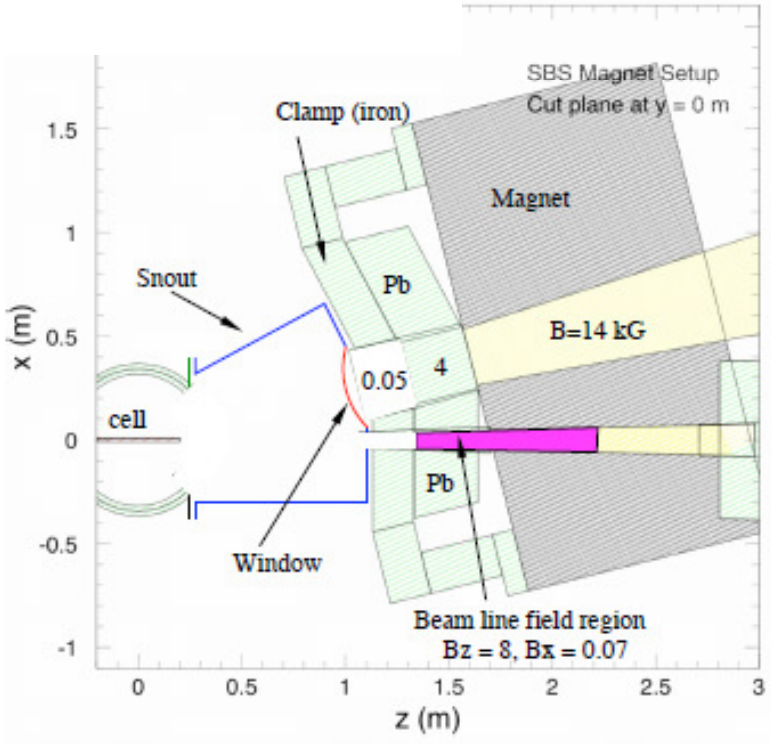
20 x 75 ECAL blocks



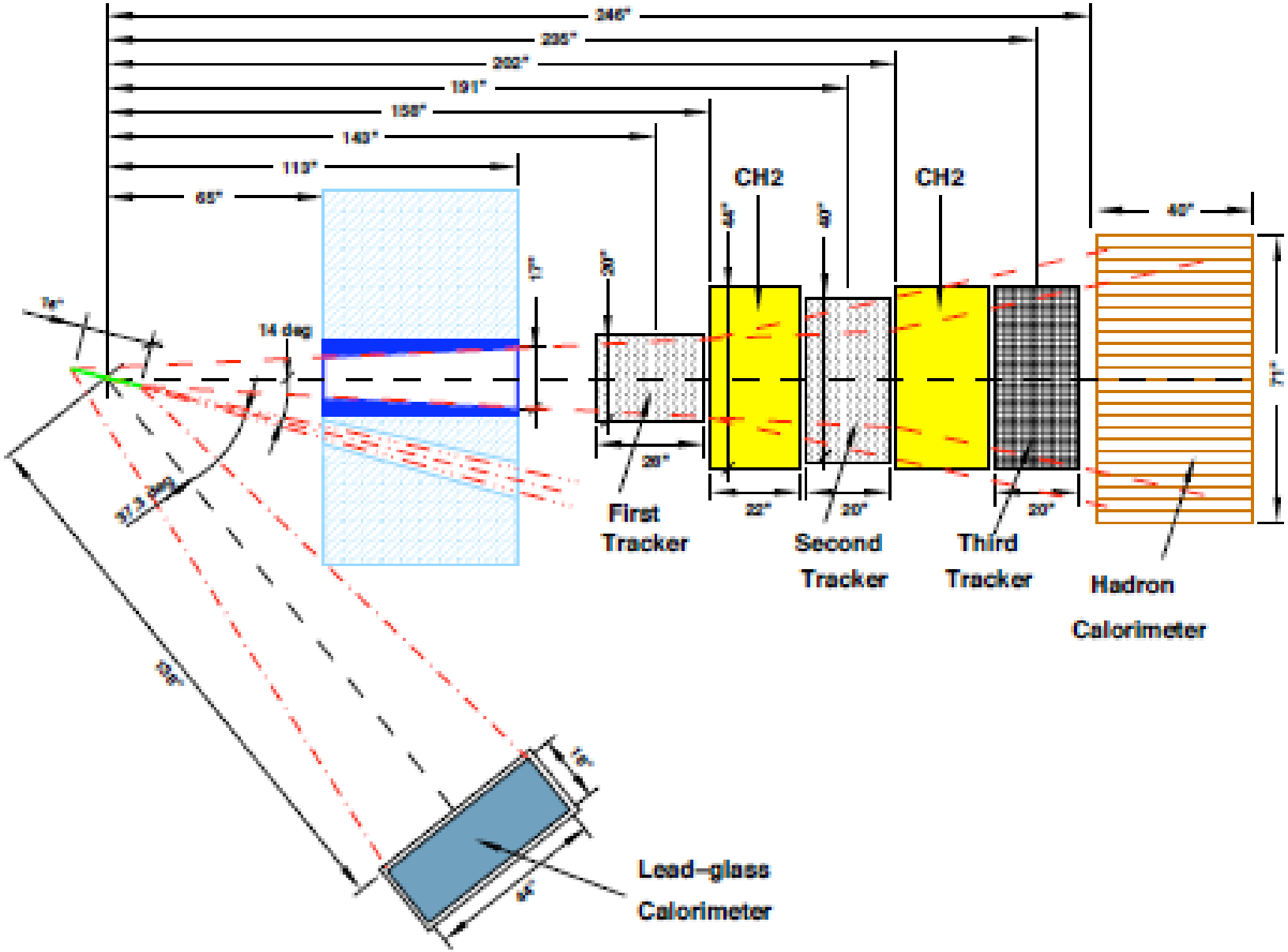
5 x 38 sum−8
4 x 37 sum−32

GEANT simulation

- a target, including Al side walls and end-caps;
- a scattering chamber with a large exit snout and a vacuum window in front of the magnetic field clamp;
- the magnet, including a field clamp, its aperture and magnetic field, and the opening for the beam line;
- the beam line lead shielding behind the magnet;
- a region with magnetic field on the beam line;
- a detector presented by a sensitive volume at 325 cm from the target (not shown in the Figure);
- a diffuser in the beam dump at 28 m from the target (not shown);



Layout of experiment



Collaboration

C.F. Perdrisat (spokesperson), L.P. Pentchev (spokesperson-contact),
D. Armstrong, T. Averett, R. Feuerbach, M. Finn, M. Meziane
College of William and Mary

E. Cisbani(spokesperson), F. Cusanno, F. Garibaldi,
S. Frullani, G. M. Urciuoli, M. Iodice, M.L. Magliozzi
INFN, Rome, Italy

V. Punjabi (spokesperson), M. Khandaker (spokesperson), F. Wesselmann
Norfolk State University

B. Wojtsekhowski (spokesperson), A. Camsonne, J.P. Chen,
E. Chudakov, C. DeJager, H. Fenker, P. Degtyarenko, M. Jones, J. Gomez,
O. Hansen, D. W. Higinbotham, J. LeRose, R. Michaels, S. Nanda, A. Saha
Thomas Jefferson National Accelerator Facility, Newport News, VA 23606

E. Brash and D. Doughty
Christopher Newport University, Newport News, VA and
Thomas Jefferson National Accelerator Facility, Newport News, VA 23606

E. Tomasi-Gustafsson
DAPNIA, Saclay, France

W. Boeglin, P. Markowitz, J. Reinhold
Florida International University, Fl

V.P. Kubarovsky, A.M. Davidenko, Yu.M. Goncharenko, V.I. Kravtsov,
Yu.M. Melnik, V.V. Mochalov, L.F. Soloviev and A.N. Vasiliev
Institut for High Energy Physics, Protvino, Russia

N. Piskunov, D. Kirillov, I. Sitnik,
O. Gavrishchuk, G. Meshcheryakov, A. Nagaytsev and I. Savin
Laboratory for High Energy, JINR, Dubna, Russia

G. Cates, D. Day, R. Lindgren, N. Liyanage,
V. Nelyubin, B. Norum, K. Paschke
University of Virginia, Charlottesville, VA 22901

S. Nedev
University of Chemical Technology, Sofia, Bulgaria

K. Aniol and D. J. Margaziotis
Cal State University, Los Angeles, CA 90032

S. Abrahamyan, A. Ketikyan, S. Mayilyan, A. Shahinyan, H. Voskanyan
Yerevan Physics Institute, Yerevan, Armenia

J. Annand, D. Ireland, R. Kaiser, K. Livingston,
I. MacGregor, B. Seitz, and G. Rosner
University of Glasgow, Glasgow, Scotland

W. Bertozzi, S. Gilad, J. Huang, B. Moffit,
P. Monaghan, N. Muangma, A. Puckett, X. Zhan
Massachusetts Institute of Technology, Cambridge, MA 02139

D. Nikolenko, I. Rachek, Yu. Shestakov
Budker Institute, Novosibirsk, Russia

G.B. Franklin, B. Quinn
Carnegie Mellon University, Pittsburgh, PA 15213

R. De Leo, L. La Gamba, S. Marrone, E. Nappi
INFN, Bari, Italy

C.E. Hyde[+] and A. Radyushkin
Old Dominion University, Norfolk, VA 23529
[+] also Laboratoire de Physique Corpusculaire,
Universit Blaise Pascal, 63177 Aubire FRANCE

E. Piasetzky, G. Ron, J. Lichtenstandt
Tel Aviv University, Israel

R. Wilson
Harvard University, Cambridge, MA 02138

A. Glamazdin
Kharkov Institute of Physics and Technology, Kharkov 310077, Ukraine

J. Calarco
University of New Hampshire, Durham, NH 03824

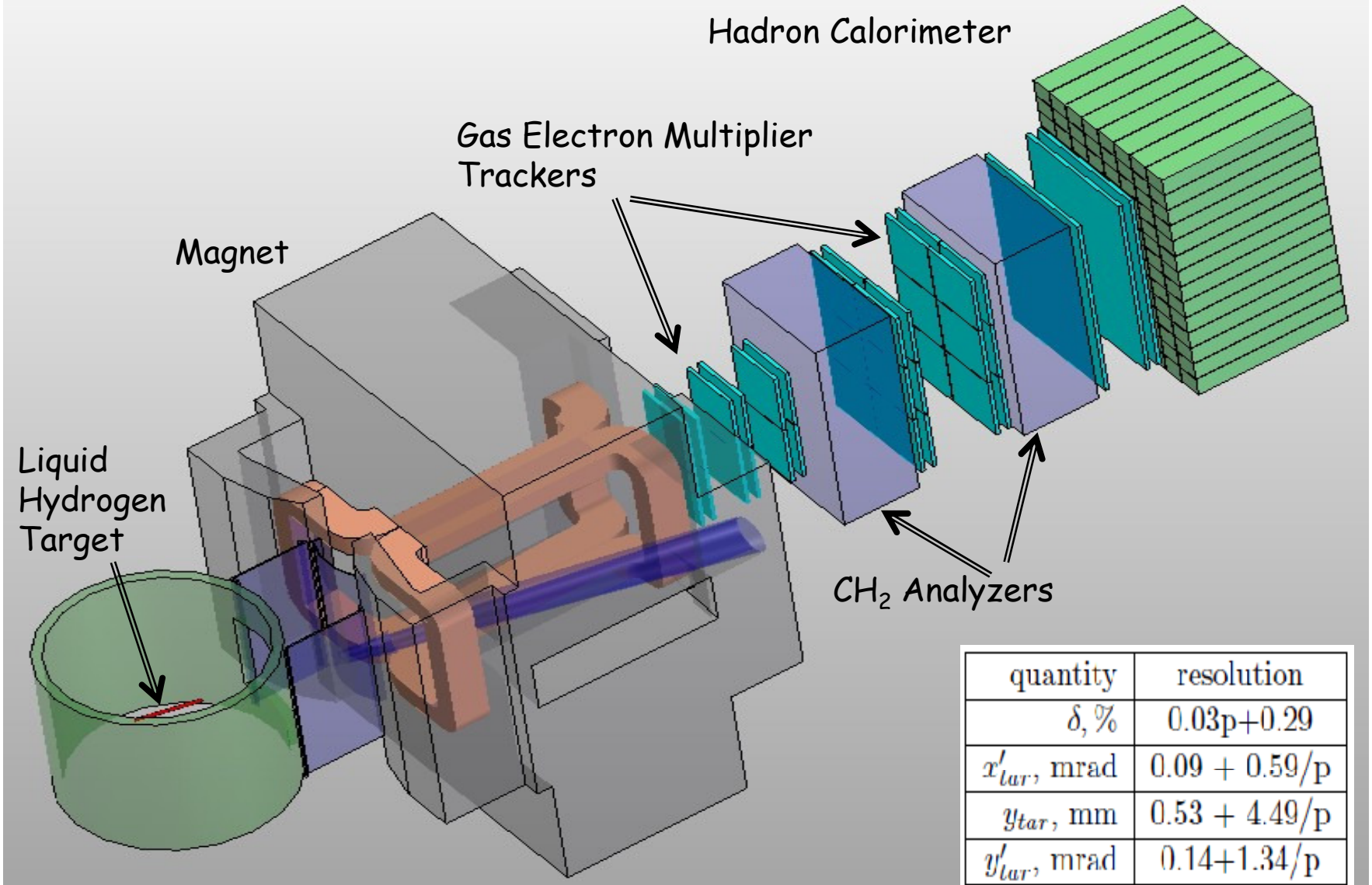
B. Vlahovic
North Carolina Central University, Durham, NC 03824

A. Sarty
Saint Mary's University, Nova Scotia, Canada B3H 3C3

G. Huber
University of Regina, Regina, Canada S4S 0A2

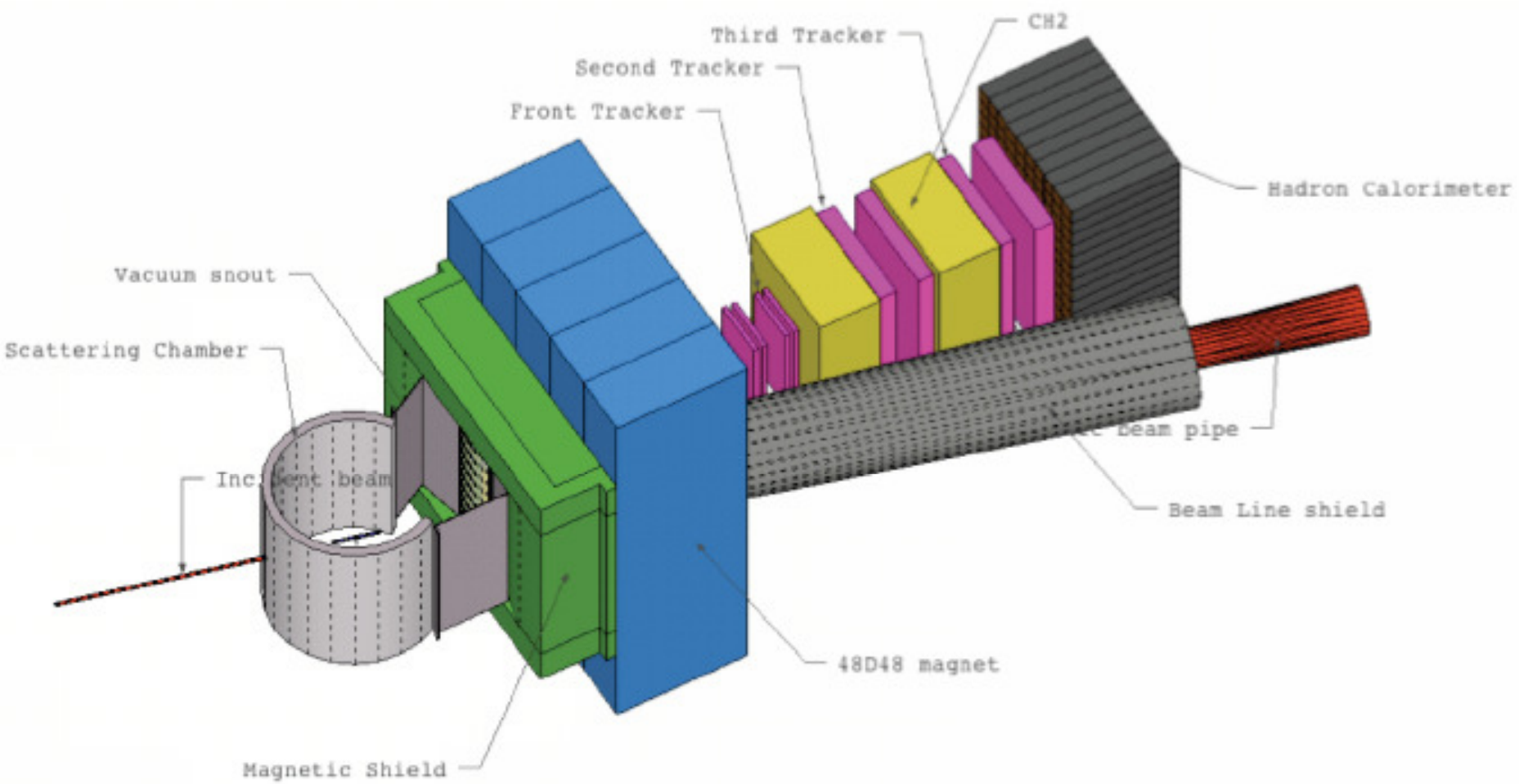
Piotr Decowski
Smith College, Northampton, MA 01063

SBS for Gep5



quantity	resolution
δ, %	0.03p+0.29
x'_{tar}, mrad	0.09 + 0.59/p
y_{tar}, mm	0.53 + 4.49/p
y'_{tar}, mrad	0.14+1.34/p

SBS for Gen5



δ, %	0.03p+0.29
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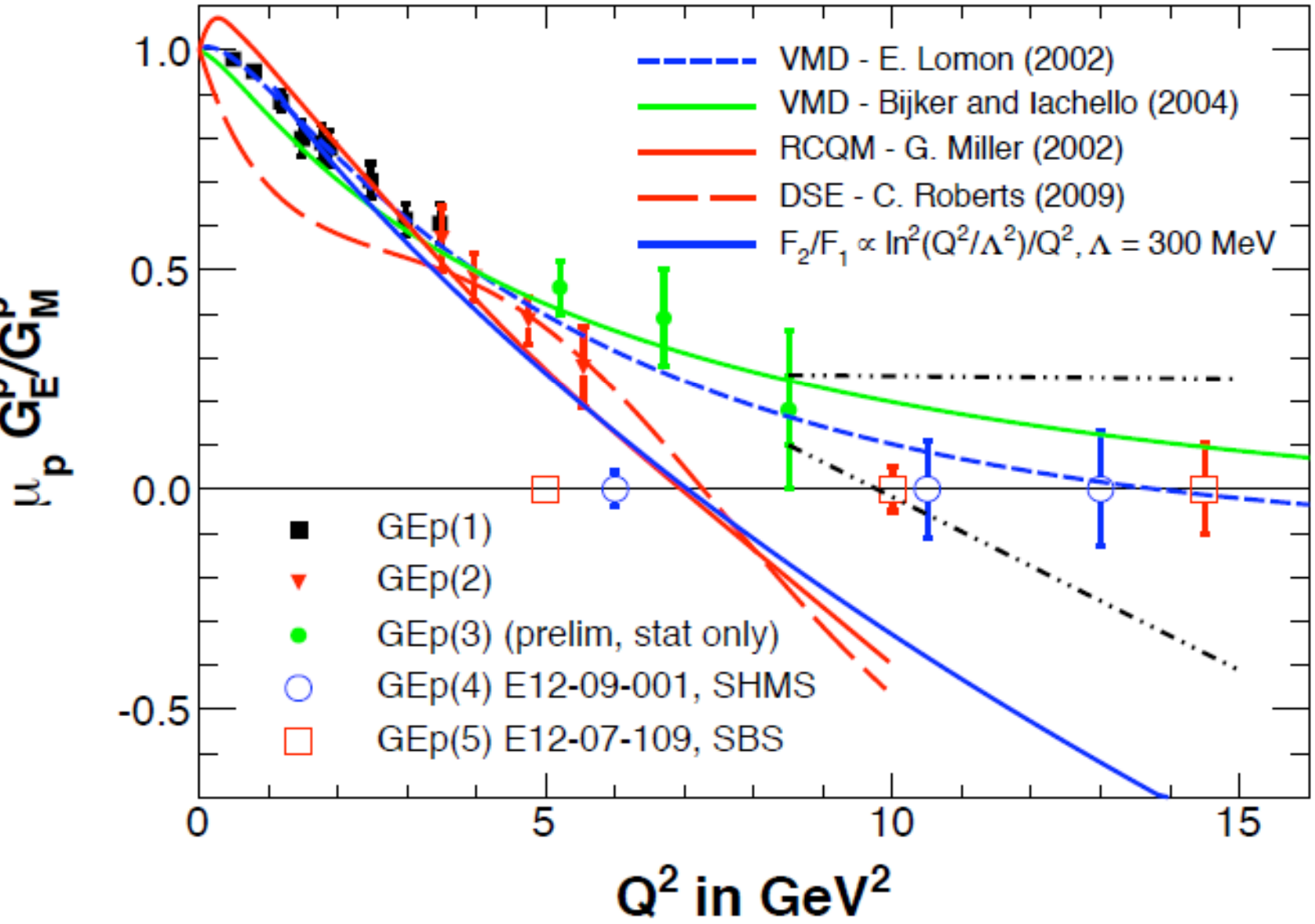
VMD - E. Lomon (2002)
VMD - Bijker and Iachello (2004)
RCQM - G. Miller (2002)
DSE - C. Roberts (2009)
F2/F1 ∝ ln2(Q2/Λ2)/Q2, Λ = 300 MeV
GEp(1)
GEp(2)
GEp(3) (prelim, stat only)
GEp(4) E12-09-001, SHMS
GEp(5) E12-07-109, SBS
μp GEp/GMp
Q2 in GeV2
1.0
0.5
0.0
-0.5
0
5
10
15