Super Bigbite Overview

Bogdan Wojtsekhowski, JLab

- Concept of the spectrometer
- Magnet and detectors
- Major Items of Equipment
- Budget profile
- The path to the SBS
- Physics program

Concept considerations

- Modern tracking and PID technology
- Vertical bending with simple optics
- At full luminosity the detector is placed behind the dipole magnetic field
- Reuse of the existing dipole magnet
- Multi-purpose application of the components

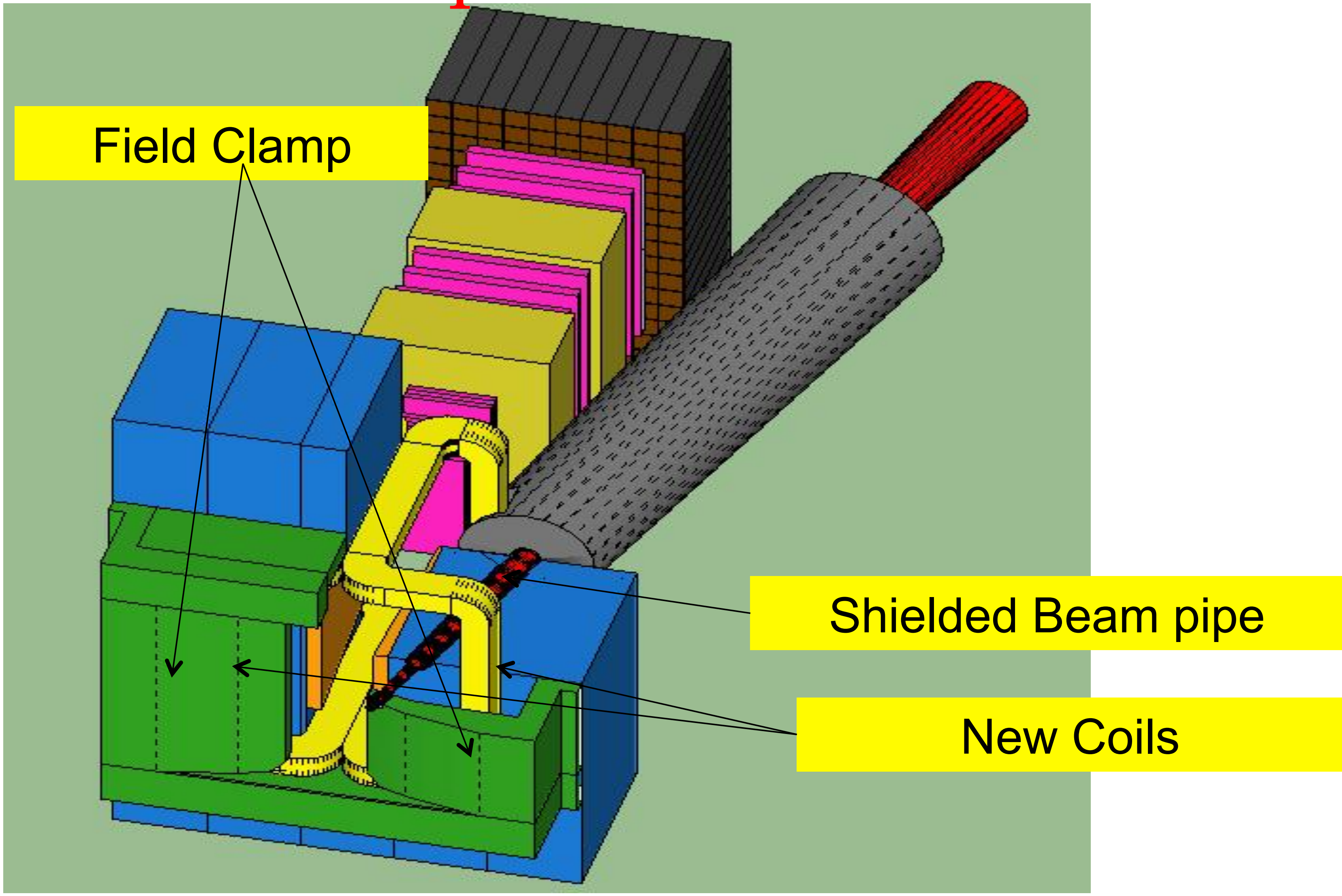
Spectrometer

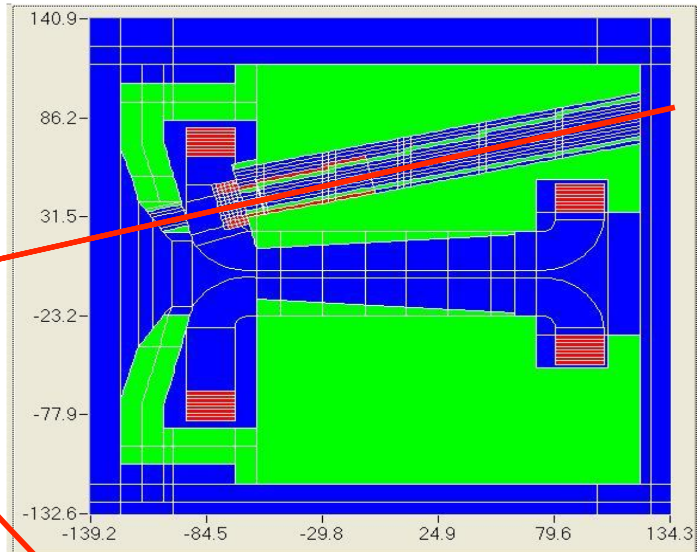
- Magnet of 100 tons with aperture of 46 cm x 122 cm;
  field integral is of 2(3) Tesla-meter
- Detector package:
  - GEM trackers resolution: 0.07 mm
  - Calorimeter based trigger > 1 GeV
  - Lead-glass PID for electron (future)
  - Fast RICH from HERMES for π,K (SIDIS)

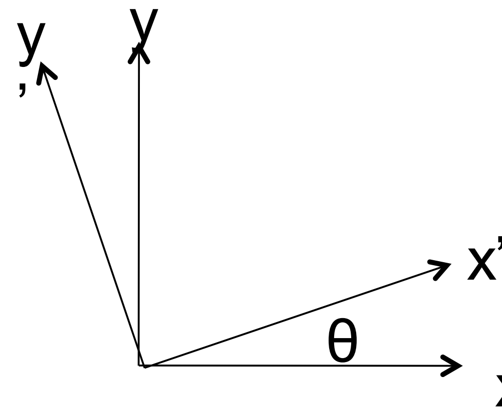
How to put a wide magnet at a 5-10^{o} angle near the target?

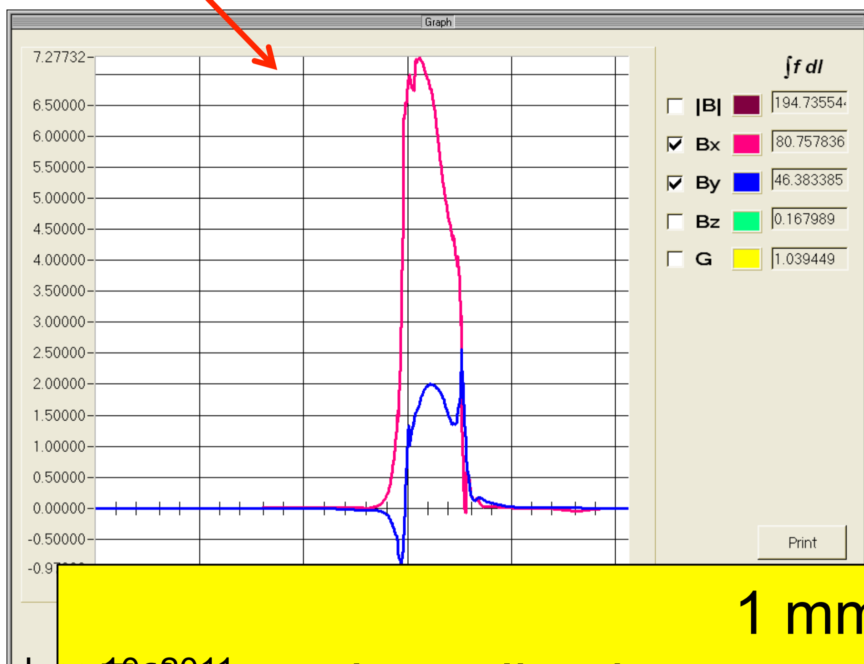
Answer: Iron yoke has a cutoff to allow for the beam pipe!

Spectrometer









$$\int B_{y'} dl = 1.3 \times 10^{-3}\ T \cdot m$$

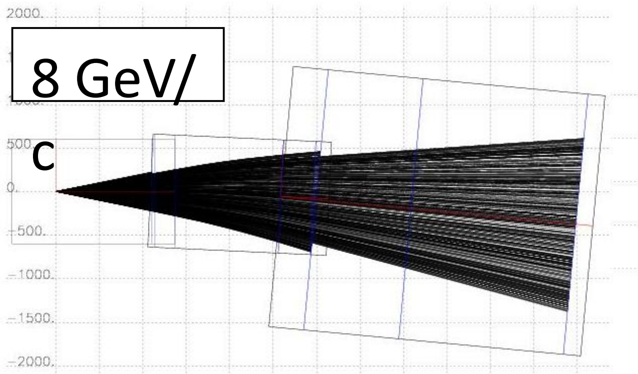
$$P = 11\, GeV/c \rightarrow B\rho = 36.69\ T \cdot m$$

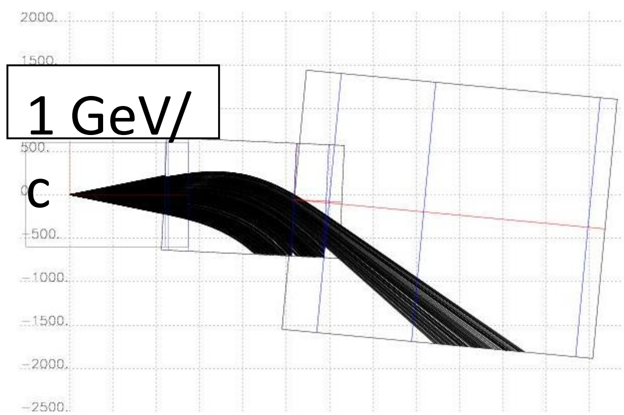
$$\alpha = \frac{\int B dl}{B\rho} \rightarrow \alpha = \frac{0.0013}{36.69} = 3.5 \times 10^{-5}$$

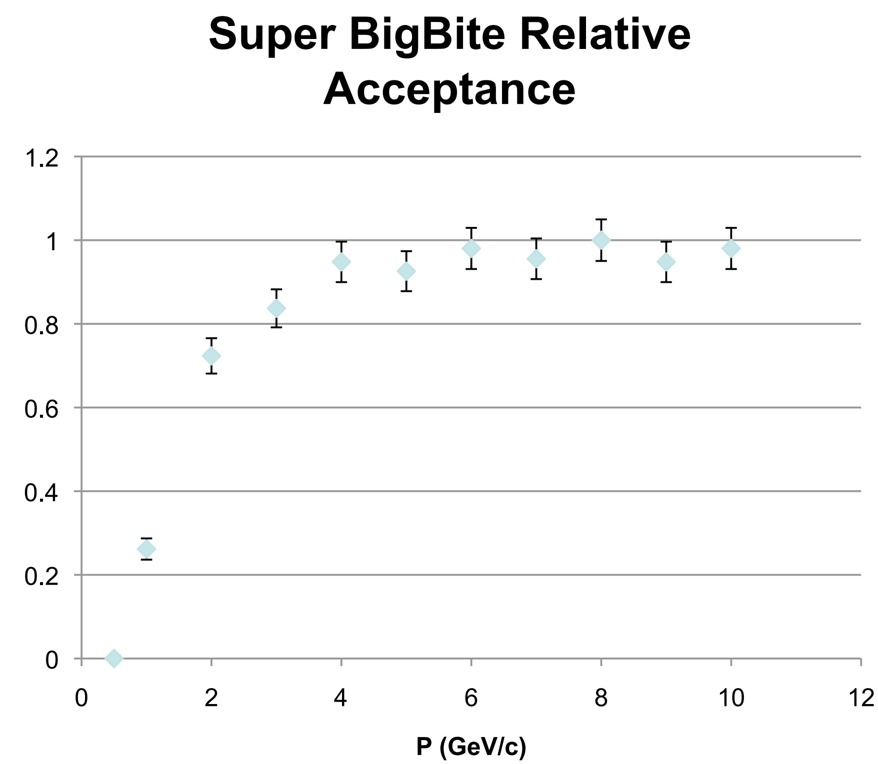
1 mm @ 30m

Effect on beamline by transverse field is effectively eliminated

Spectrometer







Spectrometer

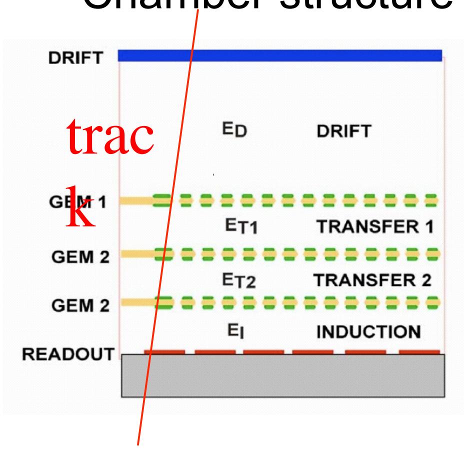
	1st Order resolution	1st Order P = 8 GeV/c	SNAKE P = 7-9 GeV/c
δ (%) (Momentum)	0.03P+0.29	0.53	0.48
θ_{tar} (mrad)	0.09 + 0.59/P	0.16	0.16
y_{tar} (mm)	0.53 + 4.49/P	1.09	0.9
φ_{tar} (mrad)	0.14+1.34/P	0.31	0.30

Solid angle

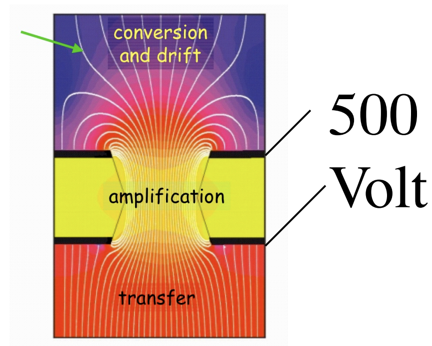
$\boldsymbol{\theta_{central}}$, degree	$\boldsymbol{\Omega}$, msr	D, meter	Hor. range, degree	Vert. range, degree
3.5	5	9.5	± 1.3	±3.3
5.0	12	5.8	± 1.9	±4.9
7.5	30	3.2	± 3	±8
15	72	1.6	± 4.8	±12.2
30	76	1.5	± 4.9	±12.5

Concept of the GEM detector

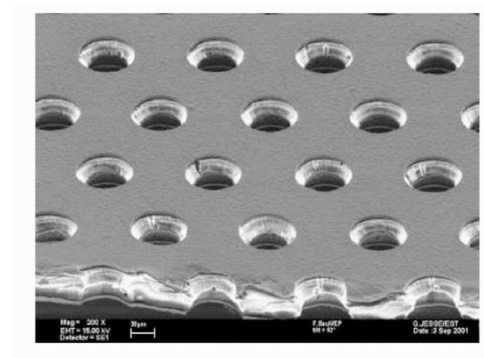
Chamber structure



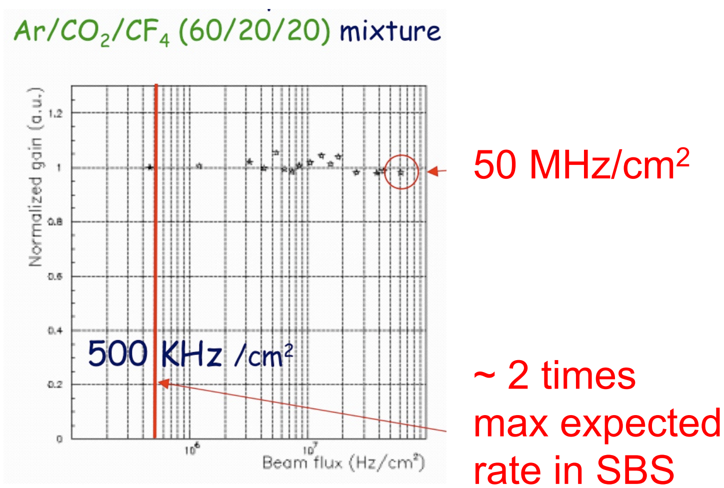
Field

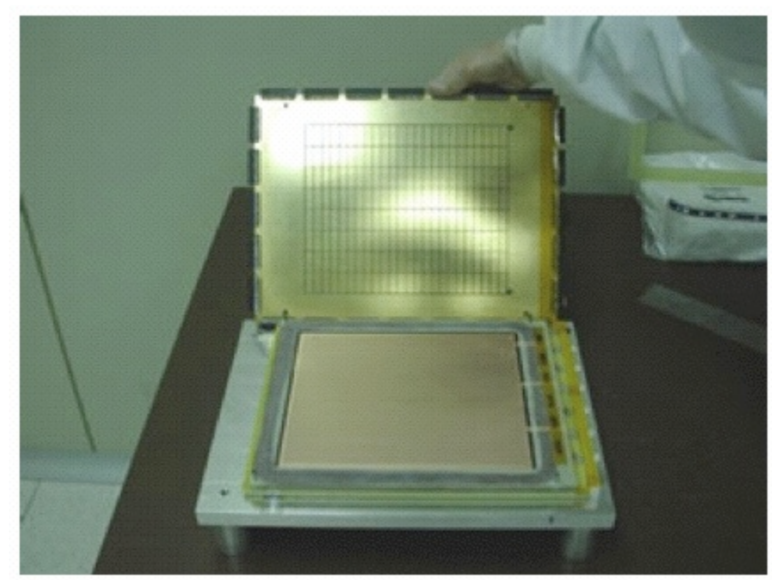


GEM foil picture

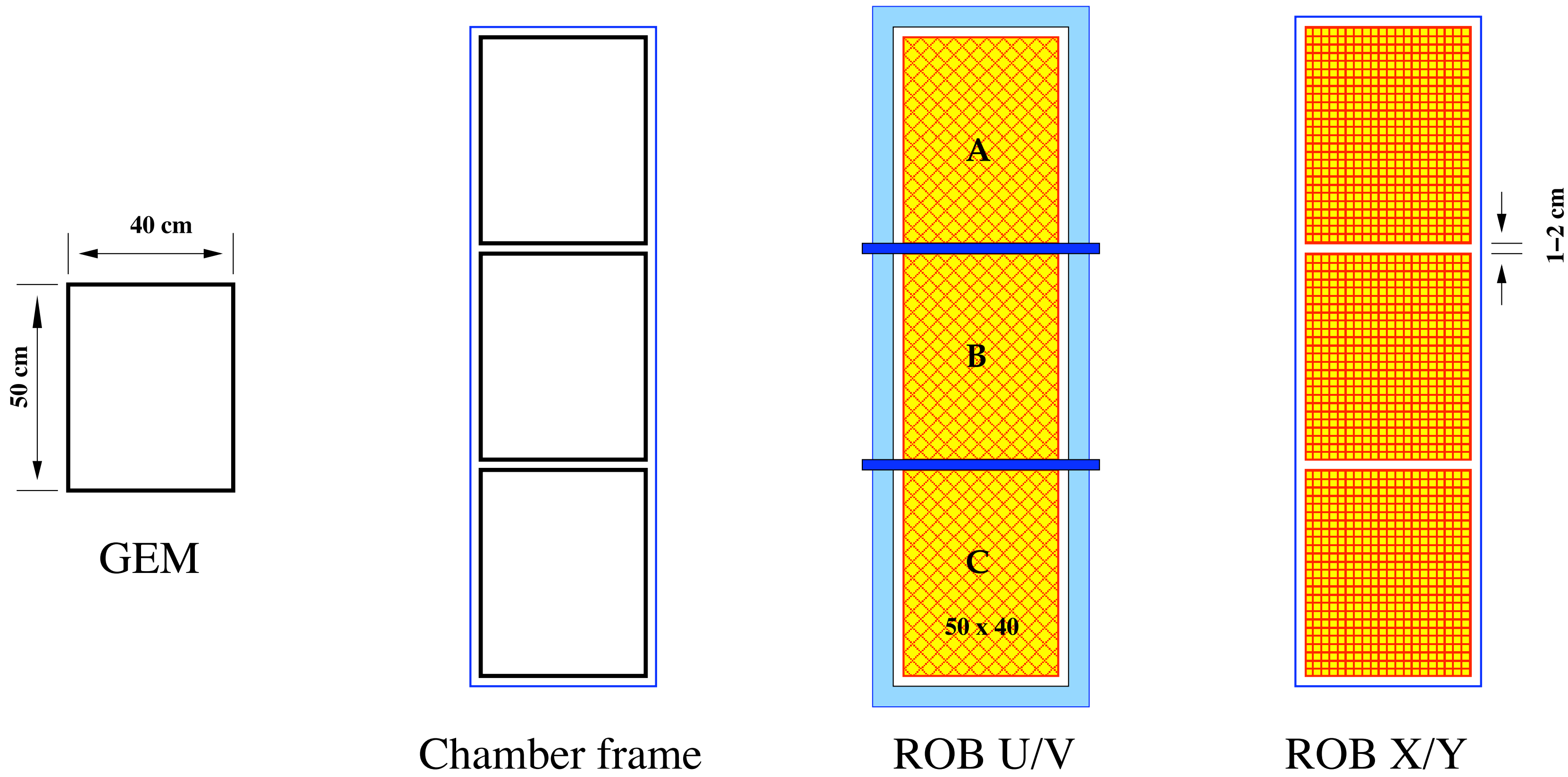


Chamber gain vs. rate for LHCb project





Concept of the Front tracker

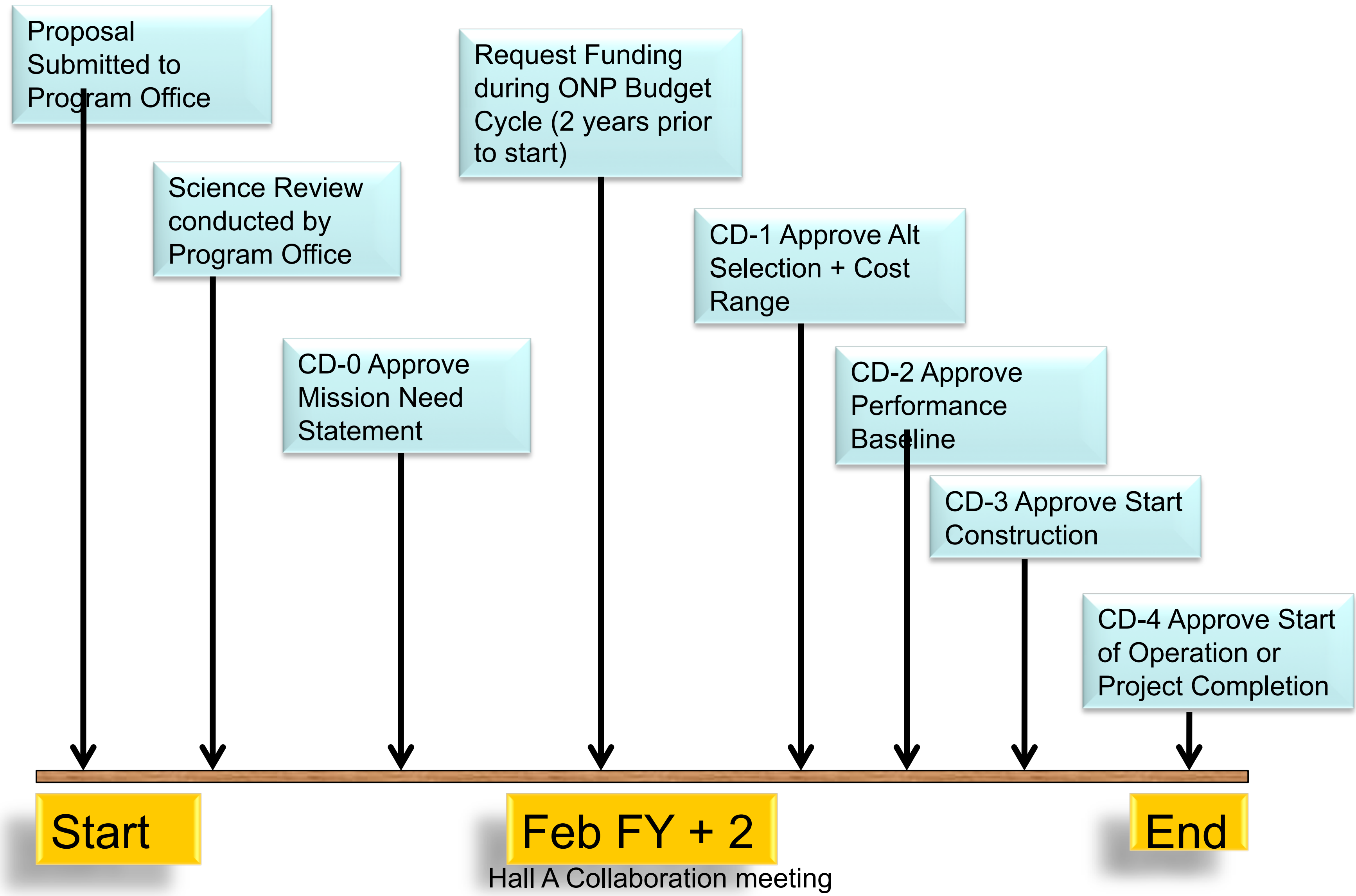


Concept of the Front tracker

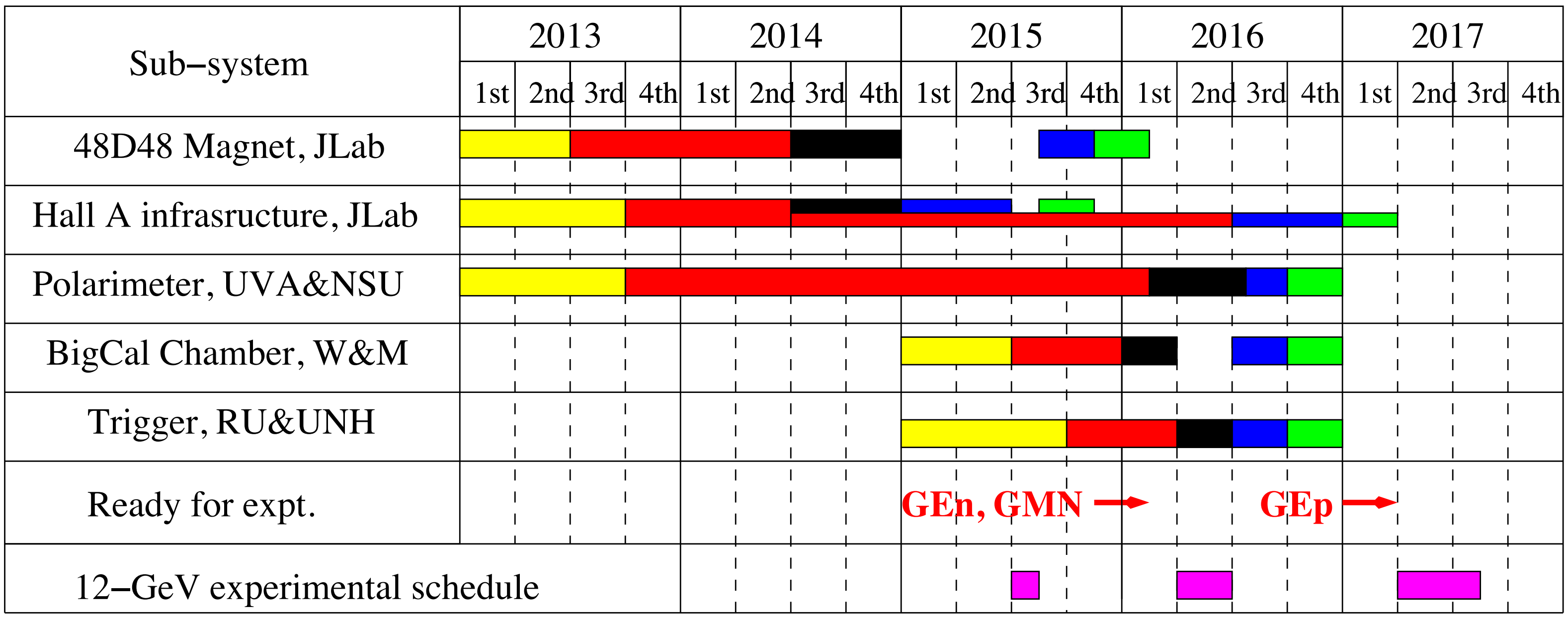
Major Items of Equipment (MIE)

- MIE is supported at National Labs only, generally by Office of Science
- "Mission Need" must be established
  - Accomplished through Peer Review
- Scope > $2M Total Estimated Cost (TEC) includes engineering and design, but does not include R&D
  - Funded with Capital Equipment (CE)
  - Identified individually in federal budget as MIE
- Scientific merit and feasibility should be completed two years prior to the proposed start of TEC funding (tied to budget submission)
- Once approved, further reviews may be required that focus on technical, cost, schedule, and management aspects
- MIEs > $5M Total Project Cost (TPC) must follow DOE O 413.3
  - Critical Decisions (CD-1 thru CD-4)
  - May be tailored based on complexity and need

MIE Timeline



MIE Timeline



Budget profile and collaboration

Table 1: Experimental equipment budget (in $1000) broken down by institute (project) and fiscal year. The overhead is included. The 3.5% per year inflation and the contingency (21% in total) are included.

Institute	FY2013	FY2014	FY2015	FY2016	FY2017	Total
JLab	401	647	683	285	85	2,100
UVA	348	419	501	281		1,548
W&M			86			86
NSU		333	240			573
Rutgers			23	198		221
year total	749	1,399	1,533	763	85	4,529

DOE Review Charge

The primary purpose of this review is to evaluate and articulate the merit and significance of the proposed scientific program for ___SBS_________. Specifically, this office would like to evaluate what important progress in scientific knowledge will occur within the first three years after the new capabilities become operational. In carrying out this charge, each panel member is asked to evaluate and comment on:

The significance of specific scientific questions identified by the community and laboratory which they believe can be addressed by data acquired during the first three years of operations;

The feasibility of the approach or method proposed to carry out the proposed program;

The impact of the planned scientific program on the advancement of nuclear physics in the context of current and planned world-wide capabilities; and

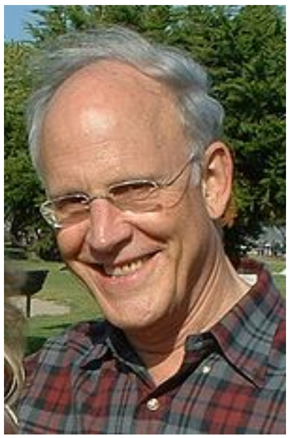
The experimental and theoretical research efforts and technical capabilities needed to accomplish the proposed scientific program.

The results of **this review should establish the scientific need for the new capabilities,** and in turn, the critical technical performance parameters necessary to assure that the science can be accomplished. The review presentations should present a plan that identifies, as specifically as possible, research groups and leaders who will support and exploit the new capabilities to address the proposed scientific program.

Scientific questions

Origin of the mass

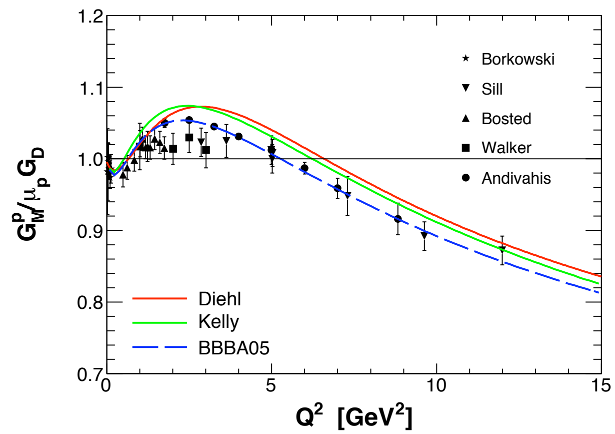
from the D. Gross Nobel Lecture:

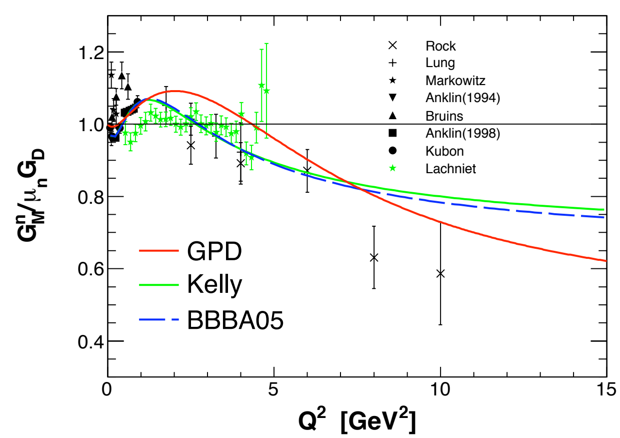


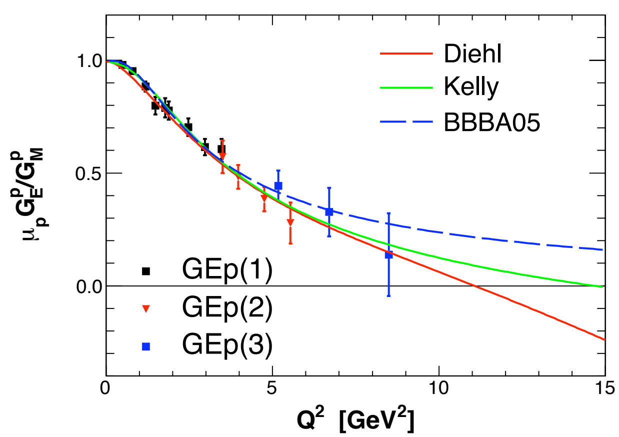
"It is sometimes claimed that the origin of mass is the Higgs mechanism that is responsible for the breaking of the electroweak symmetry that unbroken would forbid quark masses.
This is incorrect. Most, 99%, of the proton mass is due to the kinetic and potential energy of the massless gluons and the essentially massless quarks, confined within the proton."

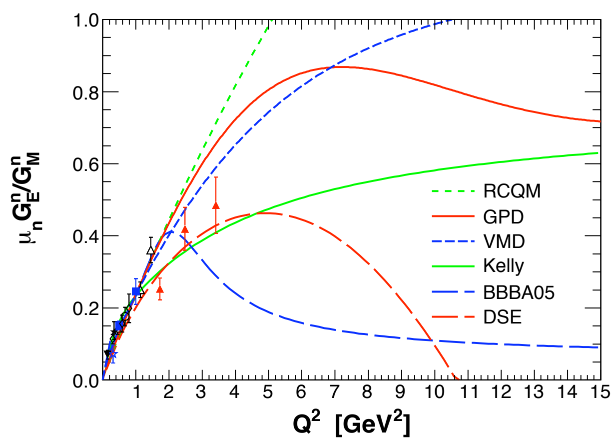
Scientific questions

Sachs Form Factors of the nucleon







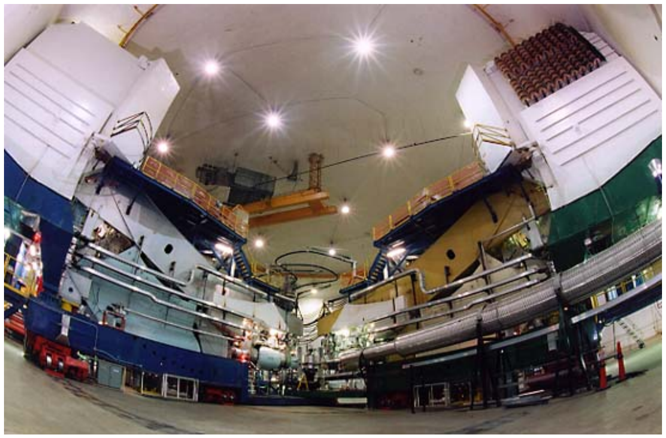


Hall A Collaboration meeting

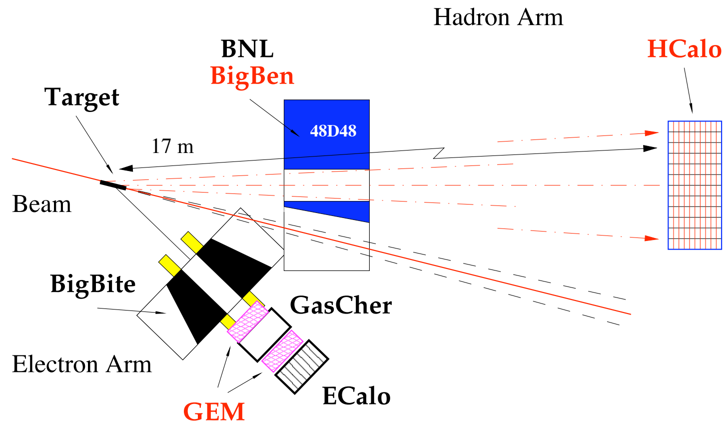
Feasibility of the approach

Proton Magnetic Form Factor

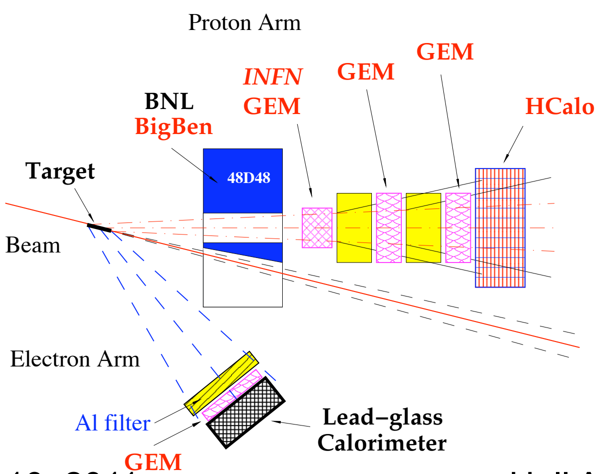
Proton magnetic form factor: E12-07-108



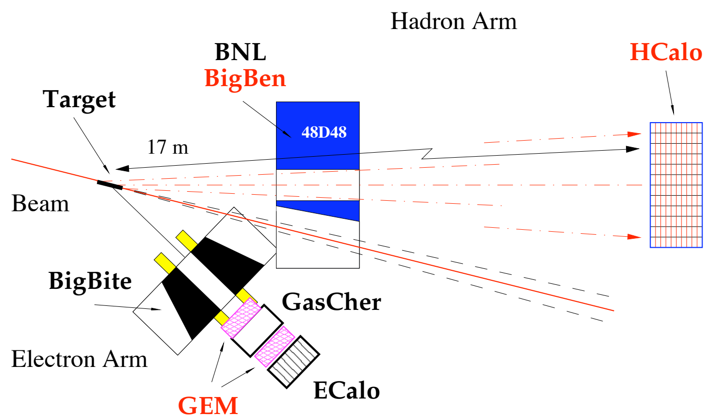
Neutron/proton form factors ratio: E12-09-019



Proton form factors ratio, GEp(5): E12–07–109

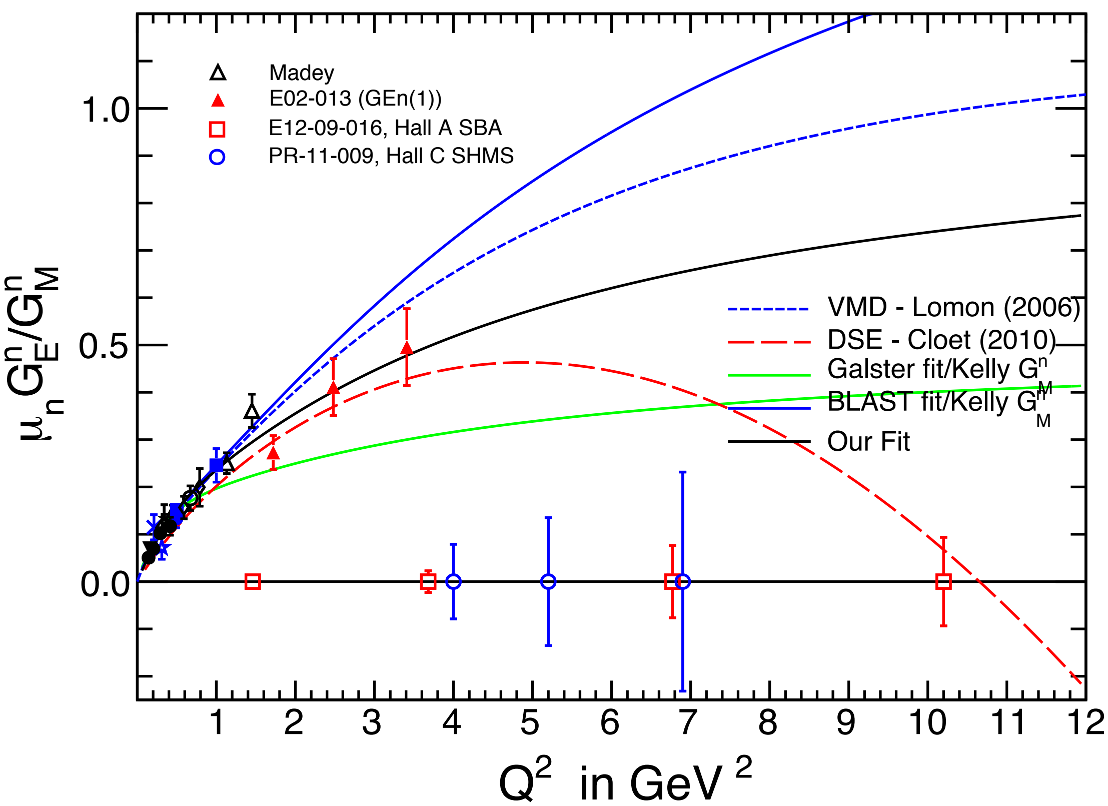


Neutron form factors ratio, GEn(2):E12-09-016



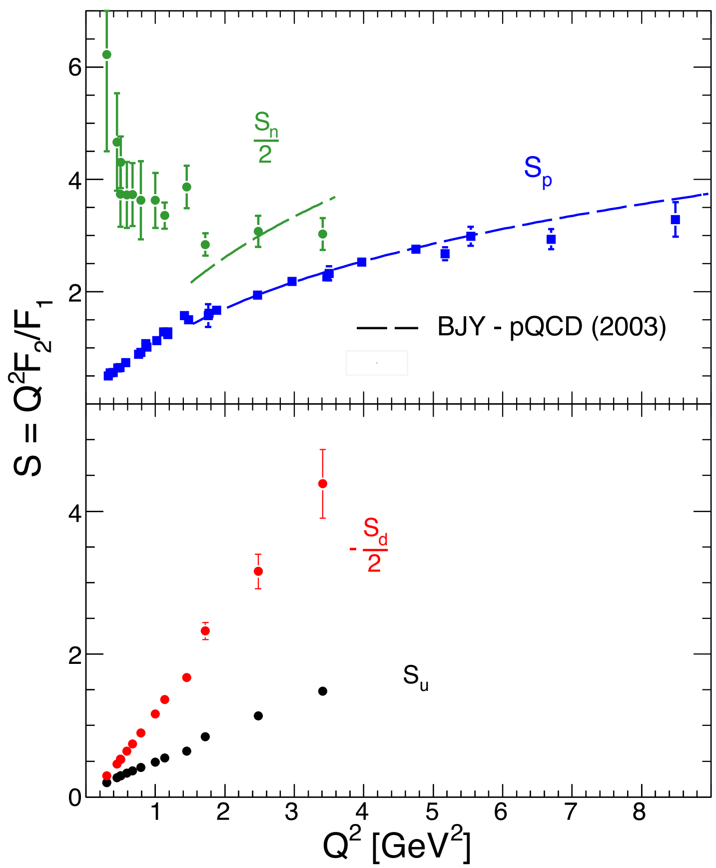
The impact of the program

12 GeV GEn experiment



Impact of the Form Factor program

Flavor decomposition of the Dirac and Pauli Form Factors



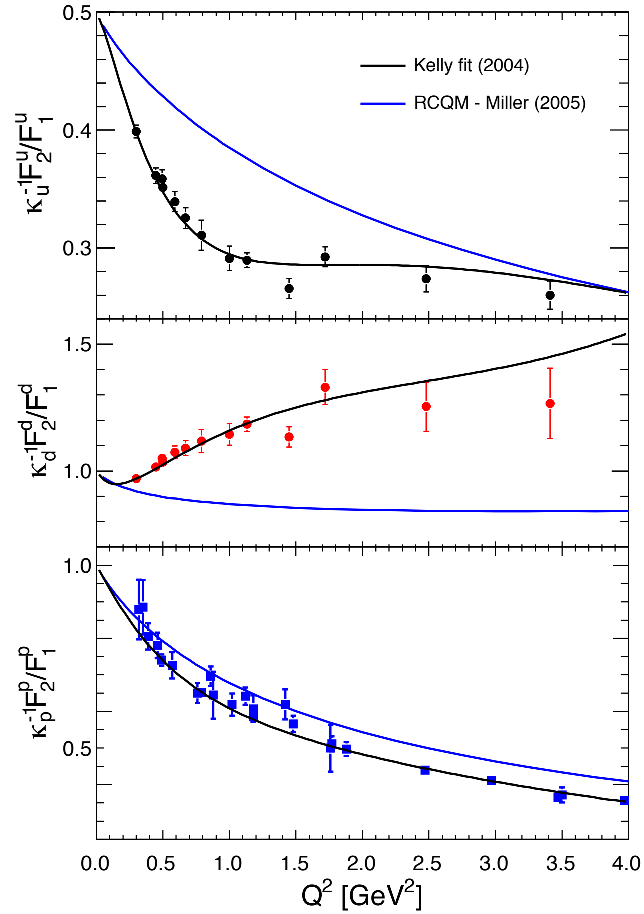
Log scaling for the proton ff ratio is “accidental”

The lines are straight!

Where will these lines be at 10 GeV^2 ?

Impact of the Form Factor program

Di-quark structure of the nucleon?



Log scaling for the proton ff ratio is “accidental”

The d-quark contributions to both F1 and F2 are strongly suppressed at high Q^2

The ff ratio for each flavor is constant for $Q^2 > 1$ GeV^2

SBS/BB physics program

- **A1n**/d2n – gain ~ 500 compared with previous results
- **GEP** : reach decisive high 14.5 GeV^2
- GMN: reach absolute max 18 GeV^2
- GEN: reach 10 GeV^2 (flight to the Moon)
- SSA in nSIDIS: 30,000 gain vs. HERMES

==================================

- A(e,e'ϕ)X – in DIS regime
- D(e,e'p) – proton FFs ratio and Resonances
- D(e,e'd) event rate gain ~ 50 at 6 GeV^2
- T/^{3}He(e,e') : 0.1 g of T in the target = 0.6% of Bates
- RCS $d\sigma/dt, K_{LL}, A_{LL}$ \ L= 4 10^{36}
- SRC: e'(HRS) + p(SBS) + N(BB)
- PVDIS – gain by 10-15 compared with two HRS
- A(e,e'p/n), A(e,e'$\pi^{+/-}$) – modification, CT

The goal is understanding of the nucleon

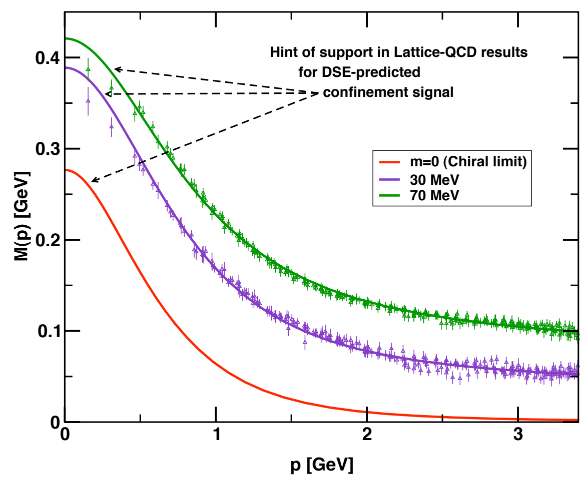
C.Roberts: the dressed-quark mass function $M(p^2)$

Frontiers of Nuclear Science: Theoretical Advances

Mass from nothing.

In QCD a quark's effective mass depends on its momentum. The function describing this can be calculated and is depicted here. Numerical simulations of lattice QCD (data, at two different bare masses) have confirmed model predictions (solid curves) that the vast bulk of the constituent mass of a light quark comes from a cloud of gluons that are dragged along by the quark as it propagates. In this way, a quark that appears to be absolutely massless at high energies ($m = 0$, red curve) acquires a large constituent mass at low energies.

$$S(p) = \frac{Z(p^2)}{i\gamma \cdot p + M(p^2)}$$



U.S. DEPARTMENT OF ENERGY
Office of Science
Office of Nuclear Physics
UChicago Argonne
Argonne NATIONAL LABORATORY

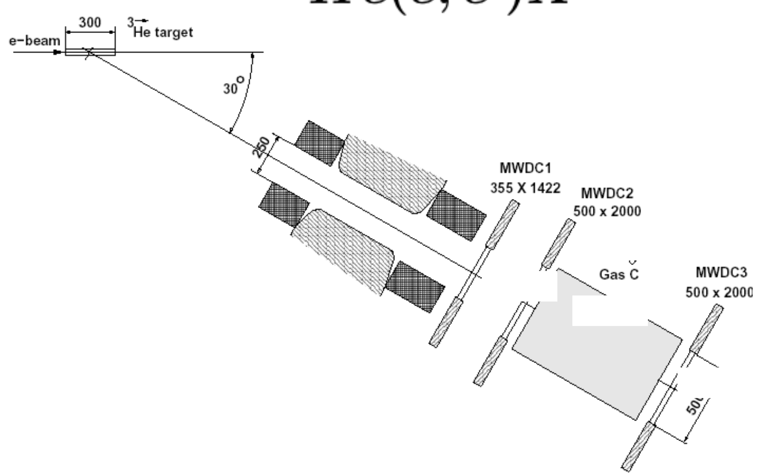
First Contents Back Conclusion

Craig Roberts – *Exposing the Dressed Quark's mass*
4th Workshop on Exclusive Reactions at High Momentum Transfer, 18-21 May 2010 . . . 27 – p. 13/28

Polarized DIS with SBS/BB

Annand, Averett, Cates, Liyanage, Rosner, Zheng, and BW

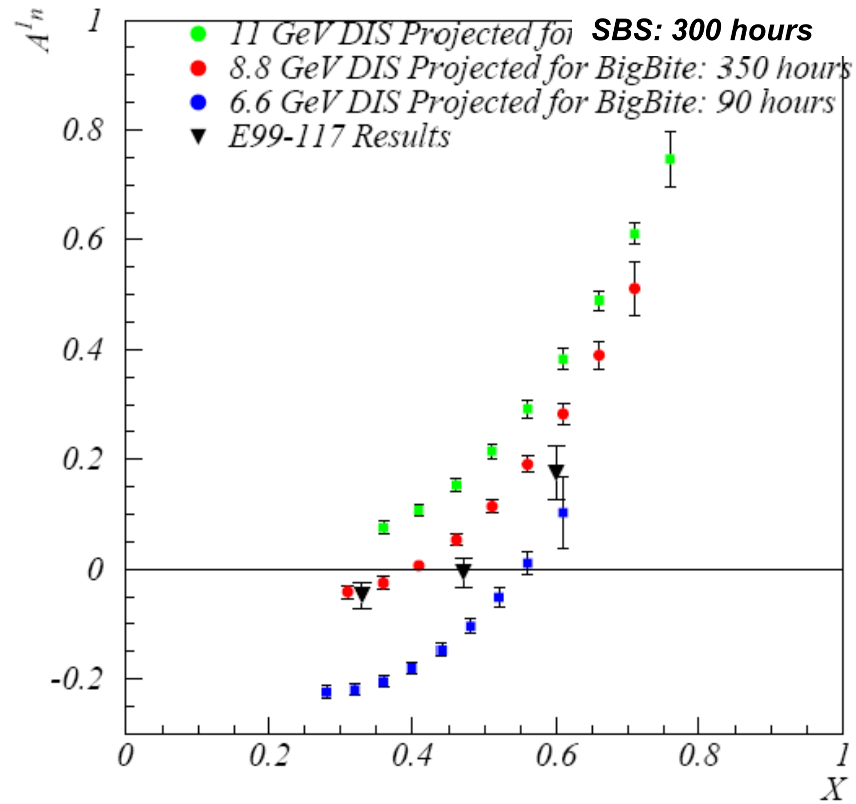
$^3\vec{He}(\vec{e}, e')X$



The value of A1n is sensitive to the spin flip!

Q^2 dependence of A1n at given x_{Bj} has a quark mass effect!

E12-06-122



very good accuracy, x up to 0.75
the study of Q^2 dependence

from Mont's report at JLab User meeting

FY12 Science and Technology Objectives

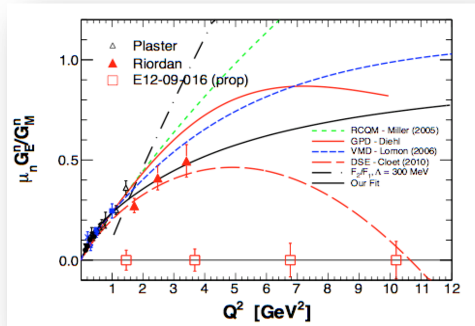
Experimental Nuclear Physics

Continued Preparation for 12 GeV Research

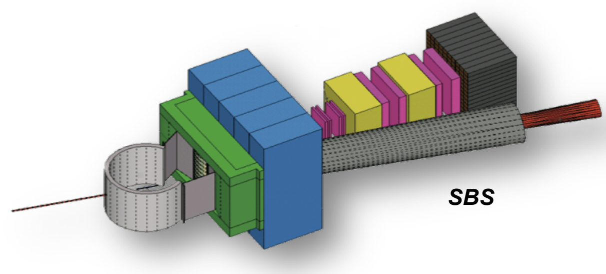
- Remove SOS from Hall C
- Remove CLAS from Hall B
- 12 GeV program planning for all four halls
  - PAC39 will continued setting priorities and reviewing new proposals
- Scientific/technical preparations for all Hall programs
  - SBS - Complete design effort
  - MOLLER - Pre-R&D in preparation for FY14 PED project start

Physics Beyond 12 GeV

- Longer-range planning through the continued development of the scientific case for a high-luminosity collider, including studies of the design of an appropriate detector and its incorporation into the ring design



Hall A Neutron Electric Form Factor



SBS