SBS project overview and status

B. Wojtsekhowski

- SBS development
- Physics program
- Collaboration
- Experiment preparation
- Hermetic photon source
- Experiment for next year's PAC

Large acceptance detectors

Before completion of the WACS (E99-114) experiment, we formulated a scheme of the GEn-1 experiment at large momentum transfer. By 2002, JLab already had several GEn proposals with polarized He-3 targets, but they all used small solid angle detectors and, as a result, were limited by 1 GeV^2, which for He-3 was disfavored by the PAC due to an FSI problem. There were several new ideas in our GEn proposal:

1) Measurement is at $Q^2 \sim 3.5$ GeV^2 where the FSI problem is greatly reduced.
2) Electron arm solid angle was up by a factor of 10-20 by using BigBite.
3) Event selection was based on the p_\perp cut instead of the p_\parallel cut.
4) Neutron arm efficiency was boosted by the modestly shielded BigHand with 250 plastic bars and 200 veto counters, a 20 MeV trigger threshold.
5) The holding field for the polarized target was created by means of an efficient custom designed magnetic box.
6) Target polarization was boosted by the K-Rb combination and high power laser system.

The PR 02-003 proposal with all detailed MC simulations of physics, detector and target components was developed for the winter 2002 PAC21.

First time "Super BigBite"

The May 2002 "High-t reactions" organizers asked me to present some new ideas about GEn perspectives. I explained our plan for the approved E02-013 and came up with a few additional considerations:

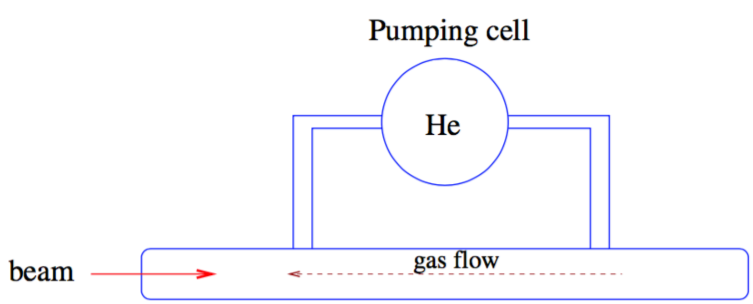


Figure 3. The target cell with two attachments to the pumping cell which allow the gas flow.

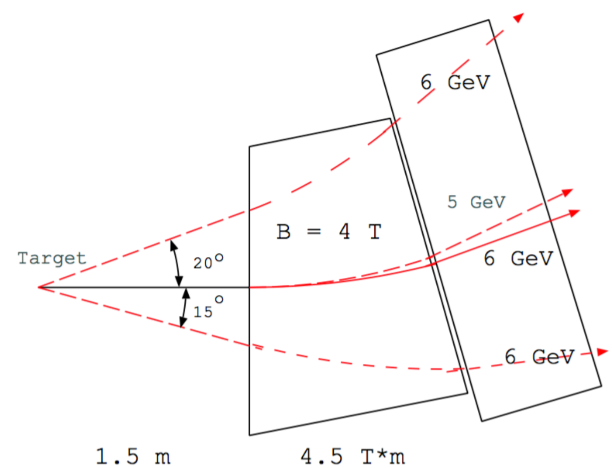


Figure 4. A side view of the Super BigBite.

The scheme in Fig. 3 is now known as a convection flow polarized He-3 target

The sketch in Fig. 4 is only remotely close to a real SBS in which the small angle capability is important.

High-Q^2 form factors

With completion of the GEn E02-013 in 2006 and experience working with a large collaboration and big scale preparation, I looked at a set of FF experiments:

GEP-15

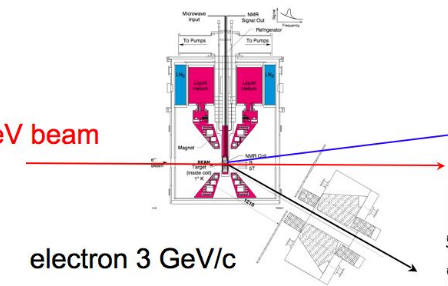
D.Day, D.Crabb, R.Lindgren and BW

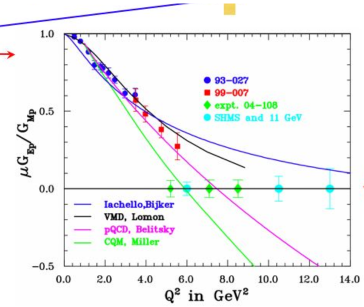
Polarized NH_3 target and BigBite + hodoscope

11 GeV beam

Proton 8 GeV/c

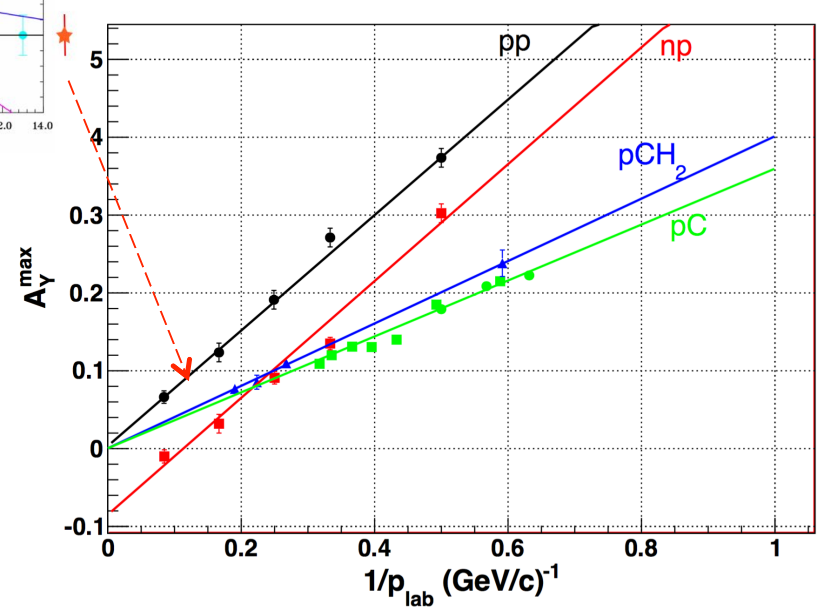
electron 3 GeV/c





May be we should do it aslo at 6 GeV for 9 GeV^2 ?

Why not a polarimeter?



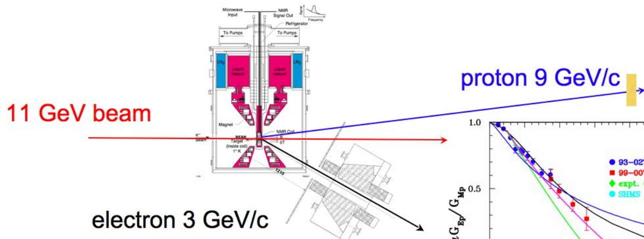
High-Q² form factors

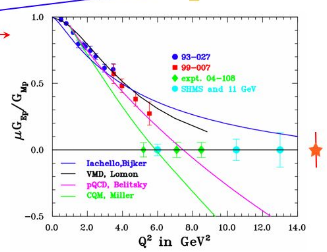
With completion of the GEn E02-013 in 2006 and experience working with a large collaboration and big scale preparation, I looked at a set of FF experiments:

GEP-15

D.Day, D.Crabb, R.Lindgren and BW

Polarized NH_3 target and BigBite + hodoscope



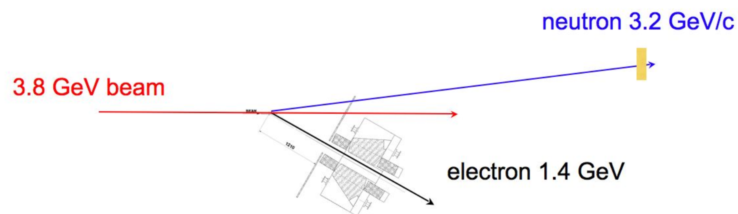


May be we should do it aslo at 6 GeV for 9 GeV² ?

GEN-4.5

G.Cates, R.Feuerbach and BW

Polarized ^{3}He target and BigBite + BigHand

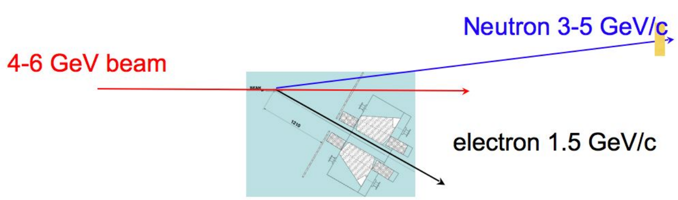


GEN at 4.5 GeV² with uncertainty of 20% Galster in 30 days

GMN-8 (15 with CEBAF12)

B.Quinn and BW

Liquid D_2 target, BigBite + hodoscope



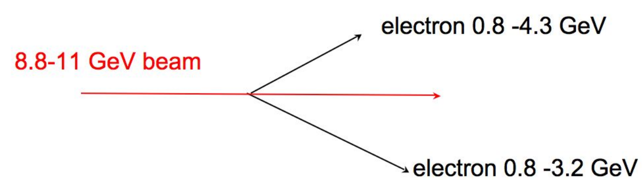
In 600h GMN at Q^2 = 3.5, 4.5, 6.0, and 8.0 GeV² with 2% uncertainties

GMP-18

W.Boeglin and BW

Liquid H_2 target and two HRS

	Q^2= ~10-12.6 GeV²	Q^2 = ~15	Q^2 = ~18
E_e	θ/t(days)/ev.	θ/time/ev.	θ/time/events
11	30/2/35k	39/5/30k	65/10/20k
8.8	33/1/32k	95/5/25k	
6.6	65/1/60k		



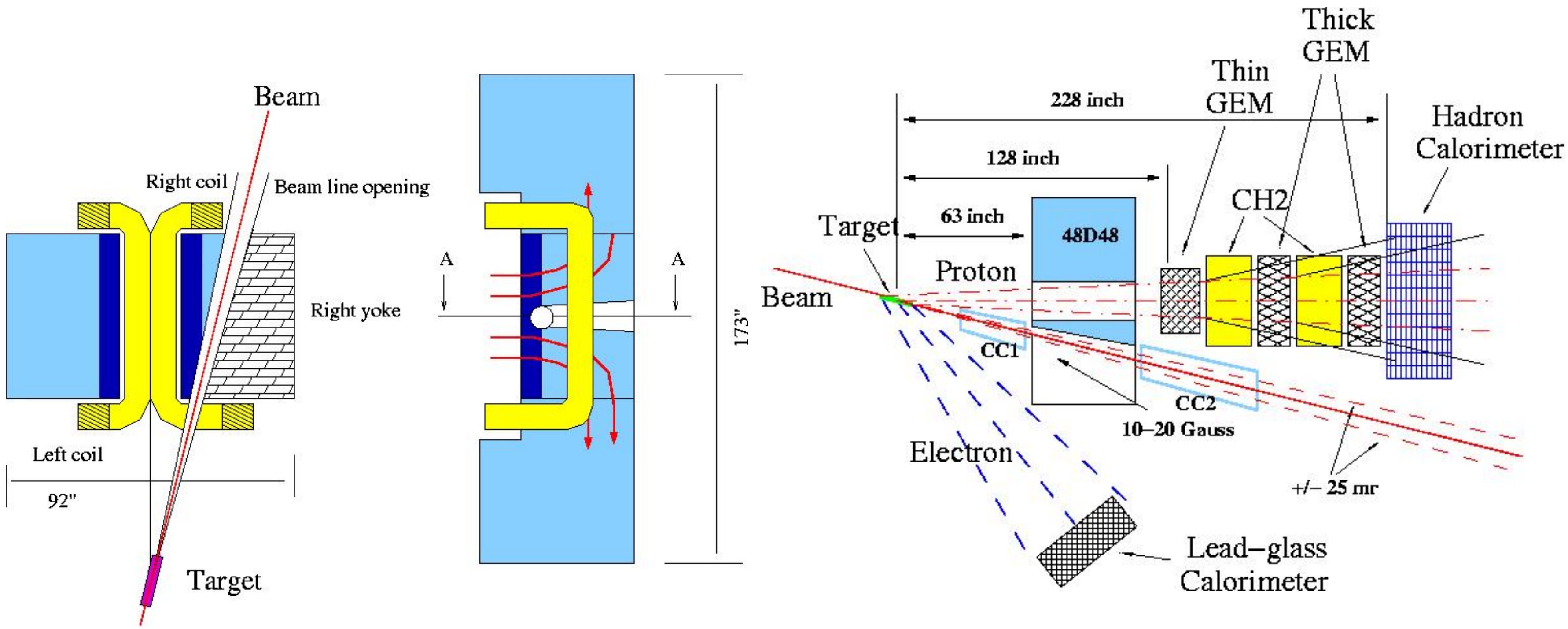
Forward angle and large acceptance

In the middle of February 2007 Lubomir stopped by and asked to revisit my old suggestion of a specialized proton arm with FPP for a GEp experiment. In about a week or two, a novel concept of the SBS with a field-free path for the beam line was formulated. I started a very wide search for an available large dipole magnet (SLAC, BNL, FNAL, …) but had a problem getting one.

In March-April the PI team was formed: JLab / W&M / NSU / INFN

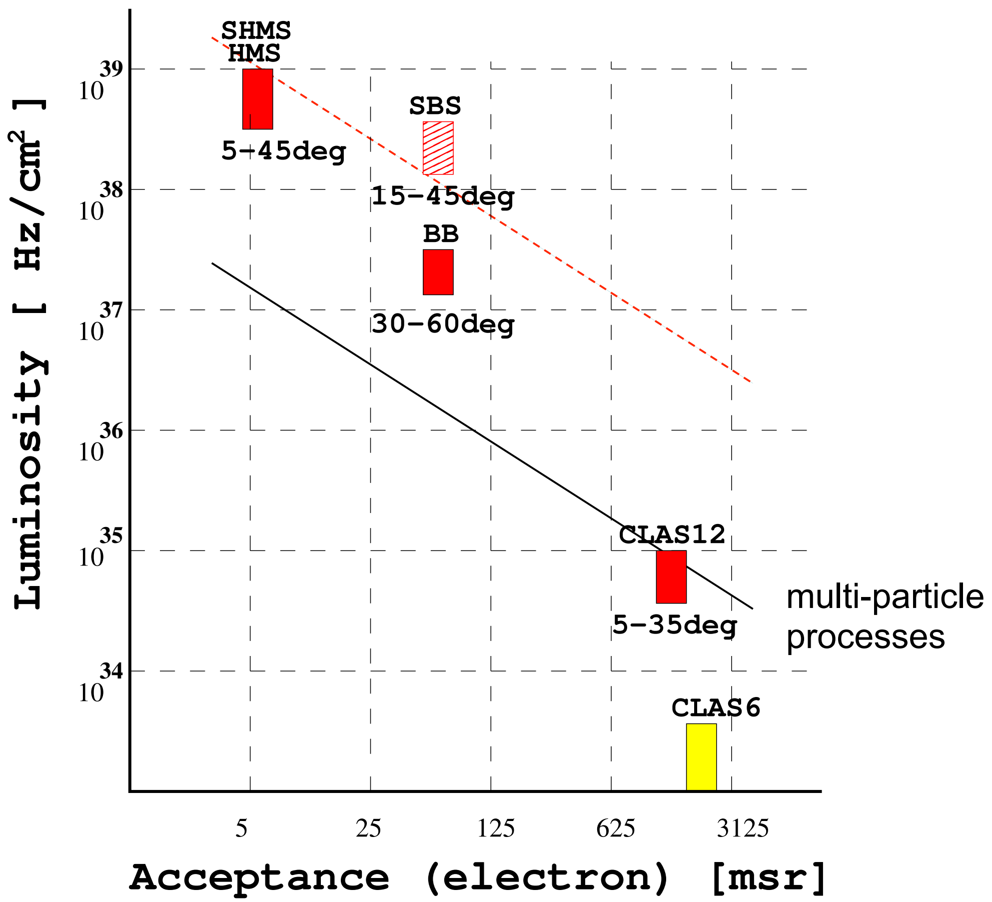
In April during a trip to BNL for the LEGS leftover detectors I saw (by chance) Bob Chrien (to thank him for his help with the BigBite wire chamber design) and got a friendly suggestion of 48D48 and a welcome ride from Phil Pile.

SBS project flagship - GEp



presented to PAC32 on Aug. 7, 2007

SBS in the JLab detector landscape



A range of 10^4 in luminosity.

A big range in solid angle:
from 5 msr (SHMS)
to about 1000 msr (CLAS12).
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The SBS is in the middle:
for a solid angle (up to 70 msr)
and high luminosity capability.

In several A-rated experiments
SBS was found to be the best
match to the physics.

GEM allows a spectrometer
with open geometry (->large
acceptance) at high L.

One- and Two-Arm experiments (O&TA)

Many productive experiments in the field belong to the category One- and Two-Arm:

Among them are DIS, SIDIS, FFs (GEP), WACS, DVCS, ...

The main advantage of these “simple” (e,e’) and (e,e’h/γ) is the simplicity of such processes for physics interpretation

The productivity of an experiment or Figure-of-Merit:

$$FOM = \mathcal{L} \times \Omega_1 (\times \Omega_2)$$

Figure-of-Merit for O&TA experiments

One-arm experiments: high $\mathcal{L}$ and large Ω ($\Delta Q^2/Q^2 \sim 0.1$) :
The Super Bigbite Spectrometer is a natural choice in the case of low luminosity experiments such as the polarized target (and Tritium) due to the large solid angle Ω = 70 msr and protected detector rate capability.

Two-arm experiments deal with elastic or “quasi”-elastic

$p_m \sim 0.2$ GeV/c for the nuclei; ~ 0.5-1 GeV/c for the nucleon

The high $Q^2/t/\nu$ experiment N(e,e’h) means $p_h \sim 2$-8 GeV/c;
70 msr of SBS acceptance: the detector captures efficiently events up to $p_m \sim p_h/5$ => one setting could be a whole experiment

$$FOM = \mathcal{L} \times \Omega_{electron} = 10^{38} \cdot 0.07 = 7 \times 10^{36}$$

$$electron/s \times nucleon/cm^2 \times sr$$

One- and Two-Arm experiments (O&TA)

$$FOM = \mathcal{L} \times \Omega_{electron} = 10^{38} \cdot 0.07 = 7 \times 10^{36}$$

$$electron/s \times nucleon/cm^2 \times sr$$

Now we can formulate a detector configuration
for productive one- and two-arm experiments

- Magnetic analysis with "vertical bend"
- Moderate solid angle
- Independent arms
- Small angle capability
- Space for segmented PID and/or polarimeter

One- and Two-Arm experiments (O&TA)

$$FOM = \mathcal{L} \times \Omega_{electron} = 10^{38} \cdot 0.07 = 7 \times 10^{36}$$

$$electron/s \times nucleon/cm^2 \times sr$$

Now we can formulate a detector configuration
for productive one- and two-arm experiments

- Magnetic analysis with “vertical bend” => protected detector
- Moderate solid angle => high luminosity
- Independent arms => full range of angles
- Small angle capability => high x, t, low x
- Space for segmented PID => RICH counter

SBS experiments

Experiments proposed/approved by year

A1n	2006	SBS project
GEP	2007	SBS project
GEN	2009	SBS project
GMN	2009	
SIDIS	2009	
TDIS-π	2015	
TDIS-K	2017	
WACS-pol	2017	
GEnRP	2017	

Welcome new experiments!

SBS physics program

- **GEP** : 12 $(GeV/c)^2$
- GMN: 13.5 $(GeV/c)^2$
- GEN: 10 $(GeV/c)^2$
- SSA in nSIDIS: 30,000 gain vs HERMES

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- **A1n**/d2n – gain ~ 20-30 compared with HMS/SHMS
- TDIS meson (π, K) DIS
- WACS-ALL, 100+ gain in productivity (Hall C/A)
- GEnRP with charge exchange
- J/Psi near threshold – hot physics
- g2p with a wide open magnet for the polarized target
- double polarized H(γ,φ p), H(γ,π^o p)

SBS physics program

- **GEP** : 12 $(GeV/c)^2$
- GMN: 13.5 $(GeV/c)^2$
- GEN: 10 $(GeV/c)^2$

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The N* form factors – a very recent email from B. Pire:

Dear Bogdan

It seems to me that the proton and neutron form factor measurements which are programmed in the SuperBigBite agenda could easily be accompanied by the measurement of the reaction

gamma^* N -> N' pi

in the kinematics near the kinematics of the nucleon form factor, i e « backward pion electroproduction » , which we proposed to describe in terms of Transition Distribution Amplitudes (TDAs) as explained for instance in

https://urldefense.proofpoint.com/v2/url?u=https-3A__arxiv.org_pdf_1112.3570.pdf&d=DwIFaQ&c=lz9TcOasaINaaC3U7FbMev2lsutwpI4--09aP8Lu18s&r=AbiN89_3ZnlN7XXGlD-Vhw&m=DqKKE_tK7x3ywmQ5RiuWvUcwZsyOF24hxvA2LSn5wG8&s=Tmmvd3aDbAZ1cpUbOhWdo1BWk916aXGgmBl6gPfSzrs&e=
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In particular the soft pion limit is particularly well described within the QCD framework that we use, but also the generic case where the pion carries a significant part of the nucleon energy but flows in the direction of the initial nucleon (in the gamma* N center of mass system). In any case, I believe that the recoil Did you consider this piece of physics ?

Did you consider this piece of physics ?

Could you please forward this remark to any interested person in the collaboration? We are ready to discuss this issue further with him(her).

With my best regards

Bernard Pire
CPhT - Ecole Polytechnique

SBS collaboration

- The weekly meetings are productive
- The organization with CC in charge works well

- More organization/suggestions:

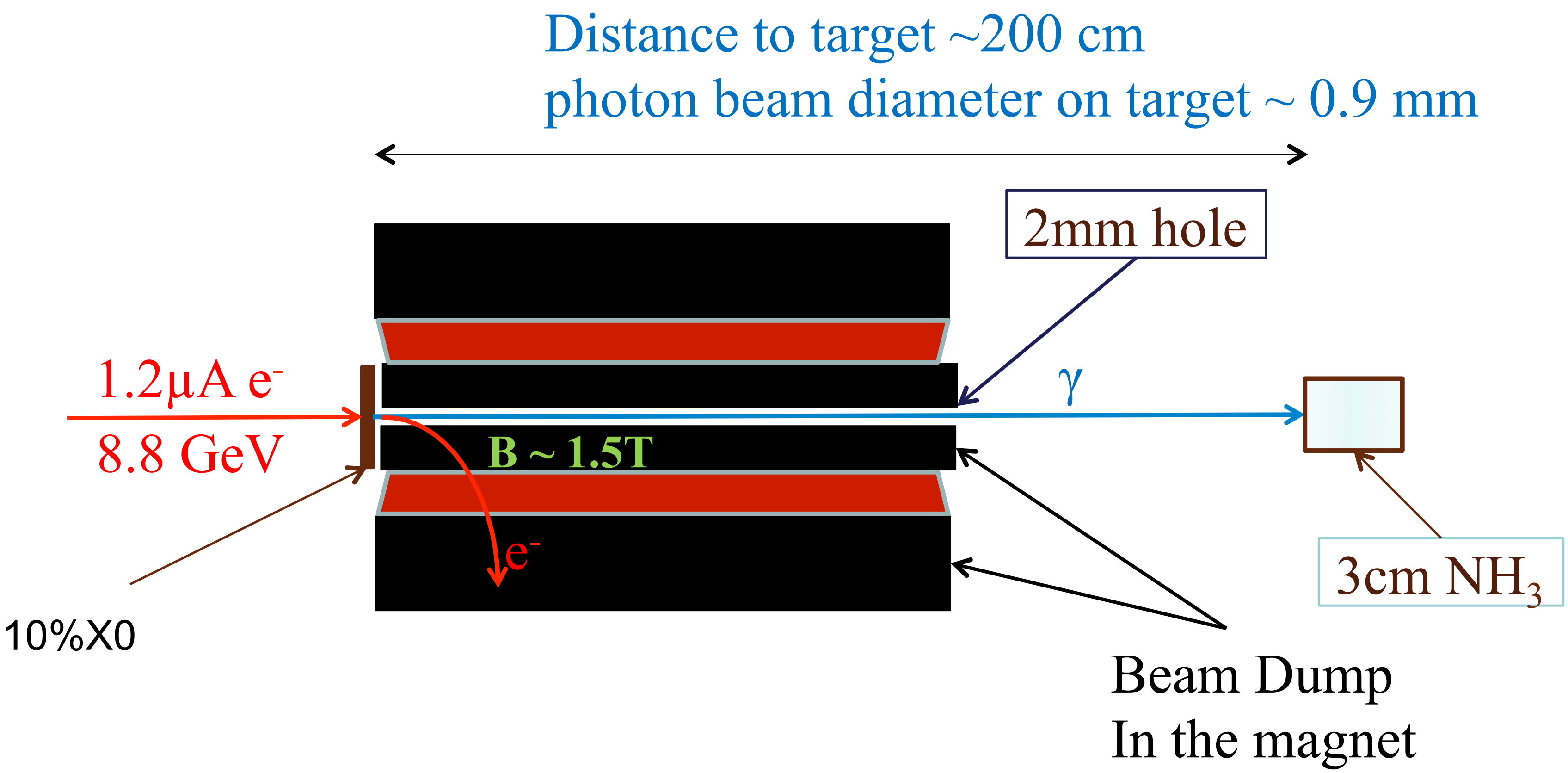
  - Experiments will benefit from an Exec. Comm. with key experts for each subsystem: MC, target, beam, detectors, manpower

  - Two collaboration meetings per year
  - Web page for each detector
  - Web page for each experiment

Status of experiment preparation

- DOE funded (SBS) projects:
  the final review on June 6, 2017; Mark
- GMn – first to run:
  the experiment readiness review on June 15, 2017; Brian
- Today and tomorrow every system will be presented

A novel γ-source for WACS

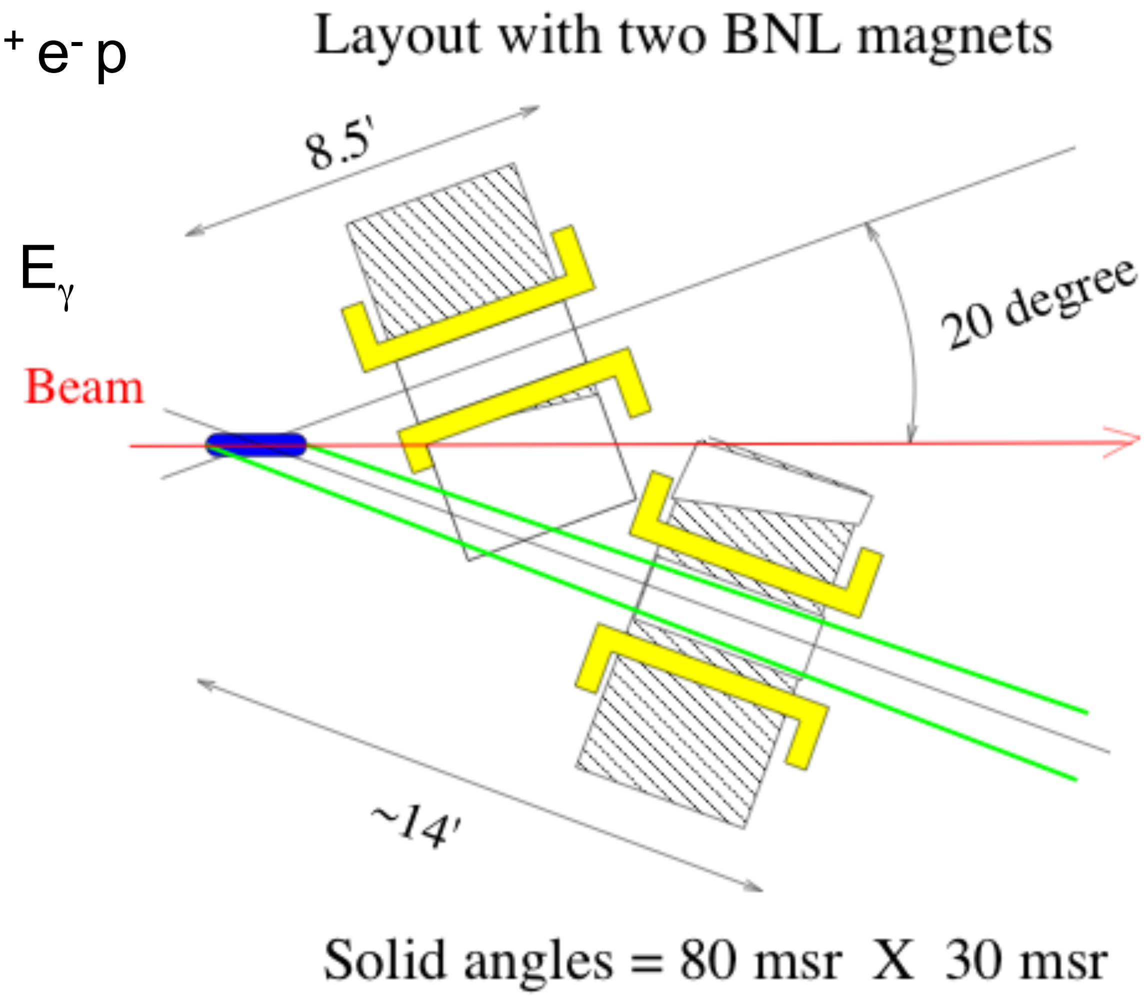


Initial MC simulation shows acceptable background rate on SBS and NPS
Detailed analyses of radiation level are in progress

Photoproduction of J/Psi from the proton

$\gamma p \rightarrow J/\Psi\, p \rightarrow e^+ e^- p$

will measure
cross section vs E_γ



PAC32 report

Motivation: This collaboration proposes to extract G_{Ep}/G_{Mp} at Q^2 =12.9 and 14.8 (GeV/c)^2 through a measurement of the polarization transfer in elastic $\vec{e}\,\vec{p}$ scattering. The estimated absolute statistical accuracy, $\Delta[\mu_p\ G_{Ep}/G_{Mp}\ ]$, will be about 0.1. This accuracy would match the precision achieved in lower momentum transfer recoil measurements at JLab. Knowledge of the proton form factors is crucial for the understanding of the structure of the nucleon, and their measurements belong to the mainstream of the scientific program of the Laboratory. The form-factors challenge phenomenological models and may be directly compared to lattice QCD calculations.

Measurement and Feasibility: The experiment will run in Hall A. BigCal will be used to detect electrons scattered off a 40 cm cryogenic target; the latter requires a special, dedicated design. A customized setup for detecting the recoil proton will include a dipole magnet, three new fast trackers (GEMs) for the determination of its momentum, interaction point and polarization, as well as a hadron calorimeter to control the trigger rate. The dipole is available from BNL, the polarimeter can be developed from the existing new polarimeter built in Hall C, and several options exit for the hadron calorimeter (e.g. using parts recovered from calorimeters existing at the collaborating institutions). A new and key part of the detector is the set of GEMs. Construction, implementation and installation of those devices will require a large, strongly coordinated organizational and financial effort. The proposal would be strengthened if the new recoil proton detector could be used by the future Hall A experiments, *e.g.* SIDIS from different polarized targets, GEN measurements, J/ψ photo-production, etc.

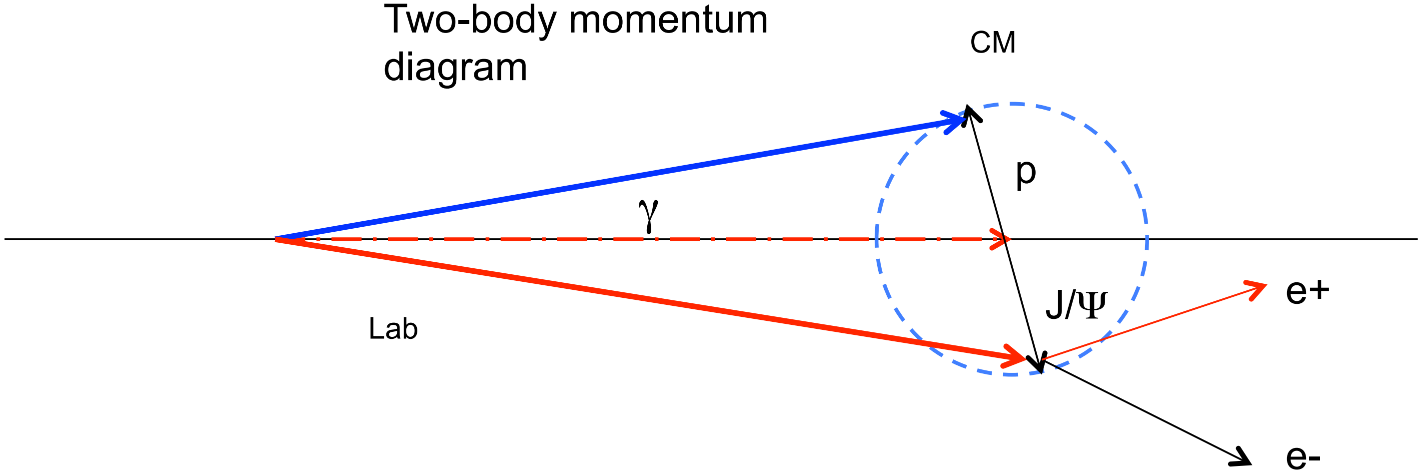
Polarization in J/Psi from the proton

C.Fanelli, L.Pentchev, BW

$\gamma_{pol} p \dashrightarrow J/\Psi\ p_{pol} \dashrightarrow e^+ e^- p_{pol}$

$\gamma_{pol} p_{pol} \dashrightarrow J/\Psi\ p \dashrightarrow e^+ e^- p$

Two-body momentum diagram



All three particles will be detected

Polarization in J/Psi from the proton

C.Fanelli, L.Pentchev, BW

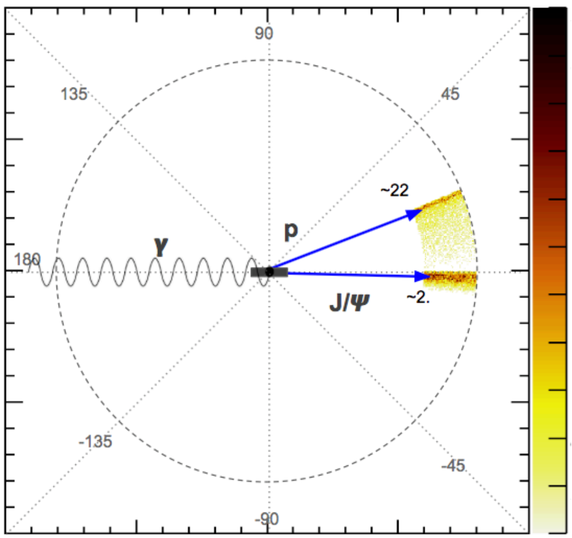
$\gamma_{pol} p \dashrightarrow J/\Psi\ p_{pol} \dashrightarrow e^+ e^- p_{pol}$

$\gamma_{pol} p_{pol} \dashrightarrow J/\Psi\ p \dashrightarrow e^+ e^- p$

Double polarization observable ALL/ALS or/and KLL/KLS;
Statistical accuracy is ~ 0.1 in a 10 day run (precision cross section data also)

All equipment from the GEp/SBS experiment

Sensitivity to the reaction mechanism and LHCb pentaquark state quantum numbers



Transversely polarized proton target

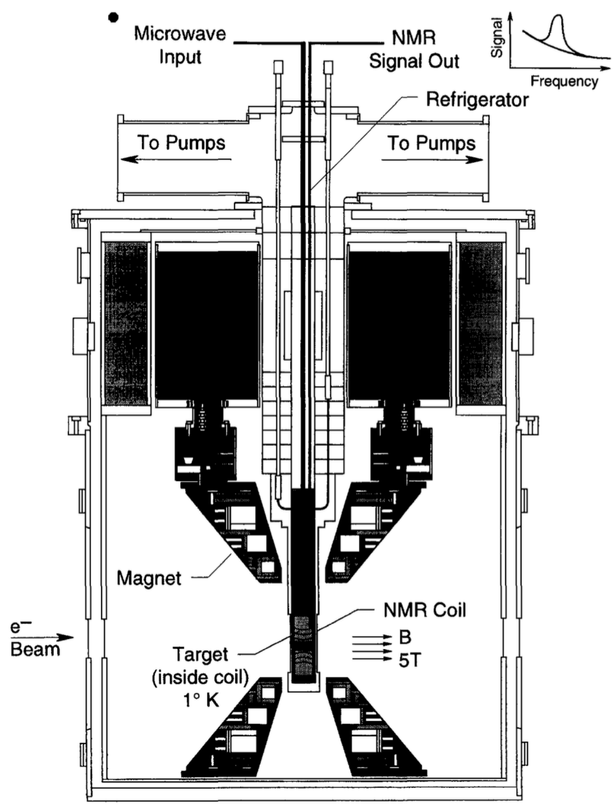


Fig. 1. Schematic of the E143 polarized target.

the coils: +/- 17^o opening
in transverse direction

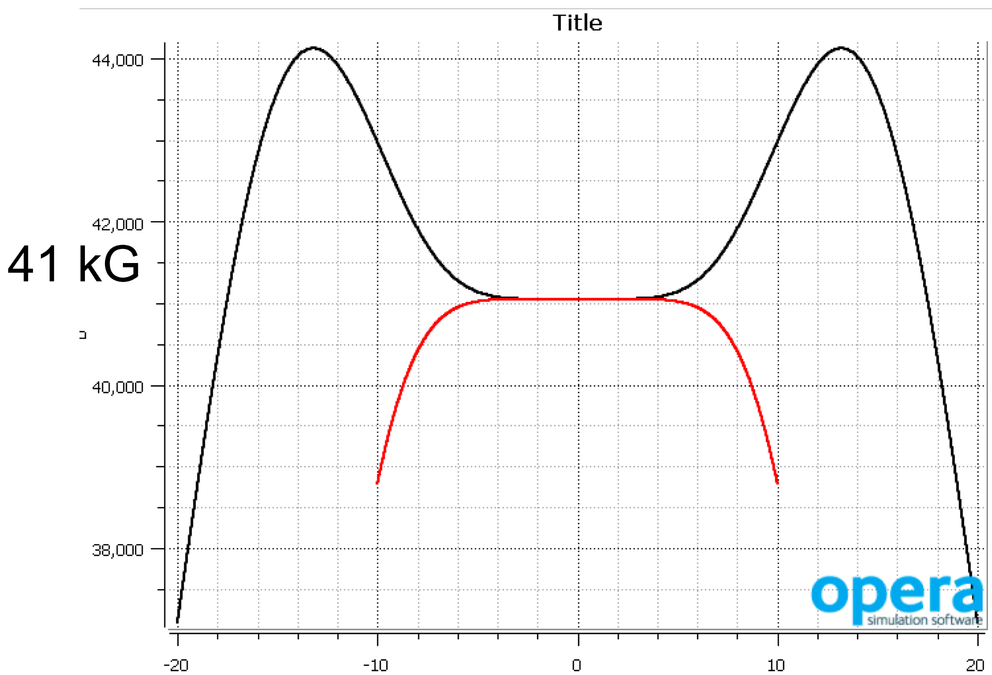
DIS data for g2 are not sufficient.

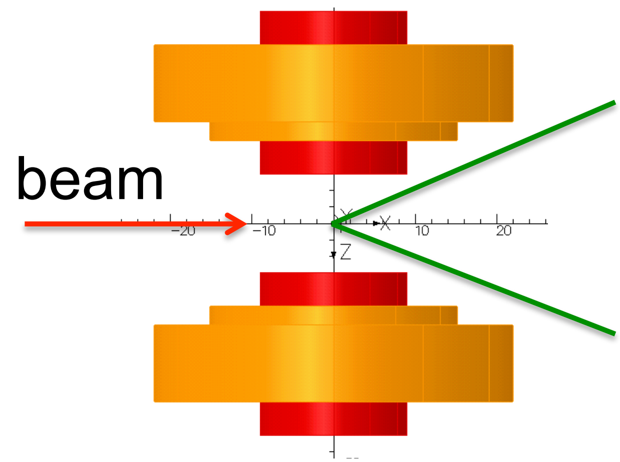
We need a 12 GeV experiment.

SBS are natural instrument but
the target opening is a problem.

Proposed solution

Double gap (+ 10 cm)
Opposite compensation coils
Opening is 50 deg.





SBS realization

Mark will present a global picture