Backward Angle Physics Opportunities with SBS

a qualitative approach

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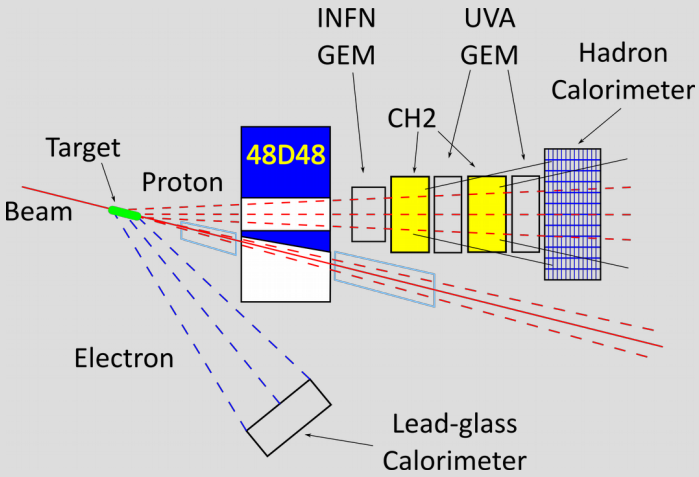
SBS Collaboration in a glimpse

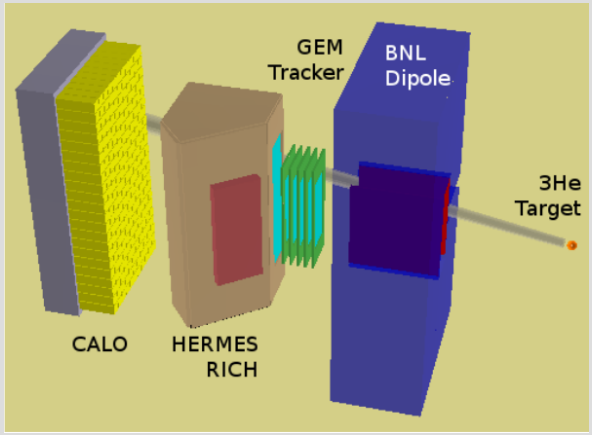
- The SuperBigBite Spectrometer (SBS) collaboration was formed to take advantage to JLab accelerator 12GeV upgrade (energy and luminosity).
- Main program was aim to the study of the EM Form Factors but now extended to other fields (i.e. nucleon and meson structure).
- The collaboration focus in the use of the new SuperBigBite Spectrometer to be used in the Hall A at JLab with other equipment.
- It is planned to start to run in September 2021.
  - Installation is planned to start immediately after the long accelerator shutdown
- Several experiments has been approved: E12-07-109(GEp), E12-09-016(GEn), E12-09-019(GMn), E12-09-018(SIDIS),E12-06-122(A1n), C12-15-006 (TDIS), and E12-17-004 (GEn-recoil) and run group addition C12-15-006A (TDIS-Kaon).
  - Two new this year: PR12-20-010 (nTPE) and PR12-20-008 (WAPP)

SuperBigBite

- SBS is a very versatile non-focusing spectrometer due to his modular design, high luminosity capability (~10^{38} electron/s-nucleon/cm^2), large solid angle (x10-15 larger than focus spectrometers), small scattering angle capability (down to 3.5deg)
- The detector package (not all included):
  - BNL 48D48 BigBen (Magnet)
  - GEM tracker
  - Hadron calorimeter
  - Coordinate detector
  - Cerenkov detector
  - Neutron polarimeter
  - Proton polarimeter

SBS configuration for GEp experiment



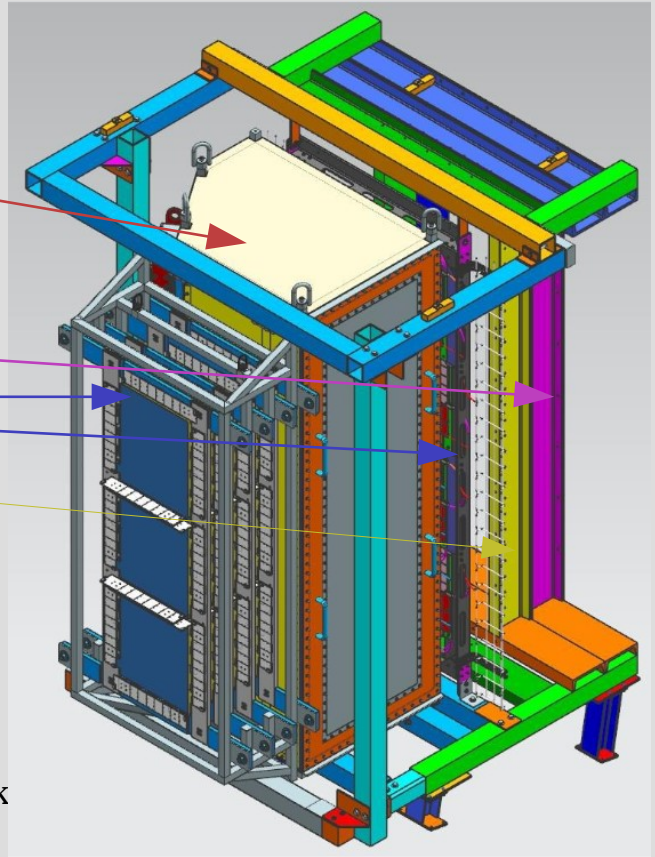


SBS configuration for SIDIS experiment

https://userweb.jlab.org/~mahbub/HallA/SBS/SBS-CDR_New.pdf

BigBite

- As SBS, BigBite is a non-focusing magnetic, large acceptance spectrometer. For the SBS program, the detector package has been upgraded with new detectors and front end electronics.
  - NIKHEF BigBite (BB) – magnet
  - Gas Ring Cherenkov (GRINCH)
    - 10^{-2} π/e separation
    - π threshold 2.7 GeV/c
  - Glasgow hodoscope
  - GEM trackers
  - Pb-glass shower counters



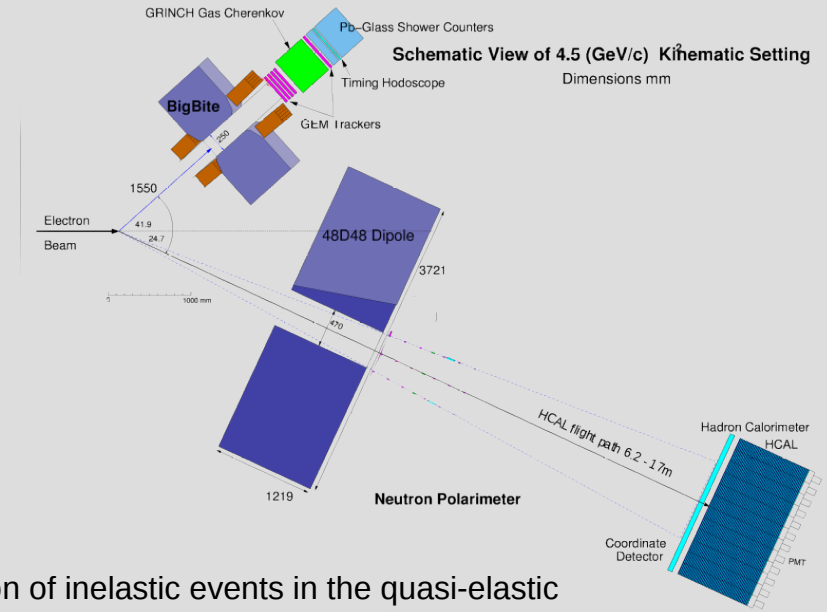
BB will be complementary as electron arm of several experiments with SBS, in particular :
E12-09-019(GMn) and E12-17-004 (GEn-recoil)

GMn E12-09-019

Precision Measurement of the Neutron Magnetic Form Factor up to Q^2=13.5 (GeV/c)^2 by the Ratio Method

The experiment will measure the neutron's magnetic form factor at nine kinetic points, from the ratio of neutron to proton -coincident quasi-elastic electron scattering from deuteron

Q^2 (GeV/c)^2	E_{beam} (GeV)	θ_e	θ_N	E′ (GeV)	P_N (GeV/c)	R_{HCal} (m)	$\int B\,dl$ (T-m)	Equiv. p_{Kick} (MeV/c)	$\mathcal{L}(\times 10^{38}/A$ (/cm^2/s)
3.5	4.4	32.5°	31.1°	2.5	2.6	6.2	1.4	270	0.7
4.5	4.4	41.9°	24.7°	2.0	3.2	6.2	1.7	350	1.4
6.	4.4	64.3°	15.6°	1.2	4.0	11	0.7	250	2.8
8.5	6.6	46.5°	16.2°	2.1	5.4	11	1.2	250	2.8
10.	8.8	33.3°	17.9°	3.5	6.2	13	1.3	340	1.4
12.	8.8	44.2°	13.3°	2.4	7.3	14	1.2	350	2.8
13.5	8.8	58.5°	9.8°	1.6	8.1	17	0.9	330	2.8



https://www.jlab.org/exp_prog/proposals/09/PR12-09-019.pdf

https://hallaweb.jlab.org/12GeV/SuperBigBite/documents/ERR2017/update10.pdf

Estimated fractional contamination of inelastic events in the quasi-elastic sample after W²and θ_{pq} cuts but before any correction is applied

Q^2 (GeV/c)^2	3.5	4.5	6.0	8.5	10.	12.	13.5	16.	18.
Max. θ_{pq} (deg.)	2.5	2.3	1.9	1.1	0.9	0.8	0.7	0.6	0.6
Max. W^2 (GeV^2)	1.1	1.2	1.3	1.3	1.4	1.4	1.6	1.6	1.7
Proton contamination (%)	5.3	5.5	8.8	13.	15.	21.	26.	28	33.
Neutron contamination (%)	13.5	11.	15.4	26.	30.	34.	43.	50.	51.

GEn-RP E12-09-019

Measurement of the ratio G_E^n/G_M^n by the double-polarized $^2H(\vec{e},e'\vec{n})$ reaction

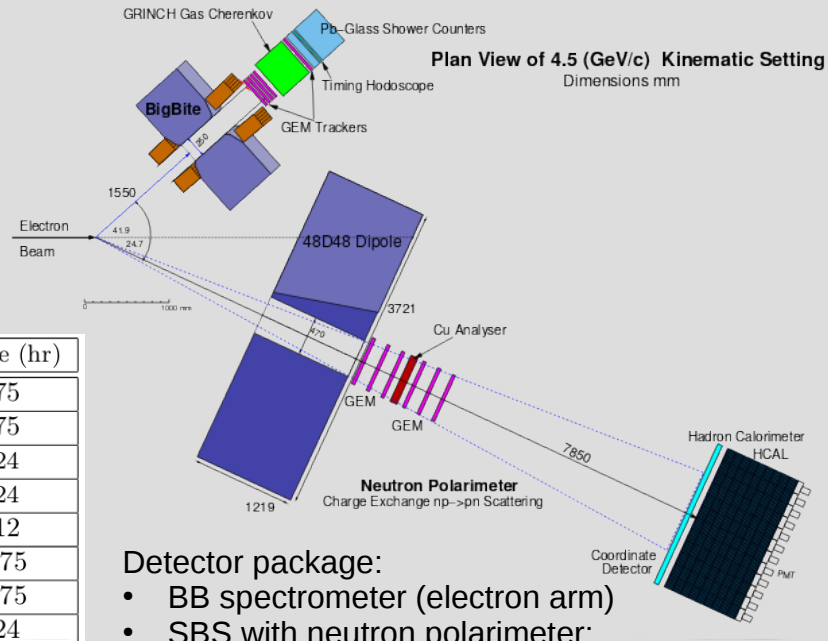
The experiment will extract the neutron form factor ratio from the ratio of transverse and longitudinal components of the spin polarization P_x/P_z. Transferred to the nucleon from polarized electron.

It is programmed to measure at Q^2 = 4.5 (GeV/c)² making use of the calibrations runs at the GMn experiment, but it is planned to request to extend to two extra kinematic points.

https://www.jlab.org/exp_prog/proposals/17/PR12-17-004.pdf

New calibrations are needed for those points

Q^2	Function	Target	Precession	Time (hr)
6.0	Production $^2H(\vec{e},e'\vec{n})$	LD_2	pos	75
6.0	Production $^2H(\vec{e},e'\vec{n})$	LD_2	neg	75
6.0	BB Optics etc.	C Foil		24
6.0	$^1H(e,e'p)$	LH_2		24
	Angle Change			12
9.3	Production $^2H(\vec{e},e'\vec{n})$	LD_2	pos	375
9.3	Production $^2H(\vec{e},e'\vec{n})$	LD_2	neg	375
9.3	BB Optics etc.	C Foil		24
9.3	$^1H(e,e'p)$	LH_2		48
Total				1032



Detector package:

- BB spectrometer (electron arm)
- SBS with neutron polarimeter:
  - Cu block
  - GEMs (charged particles)
  - Coordinate detector
  - HCAL

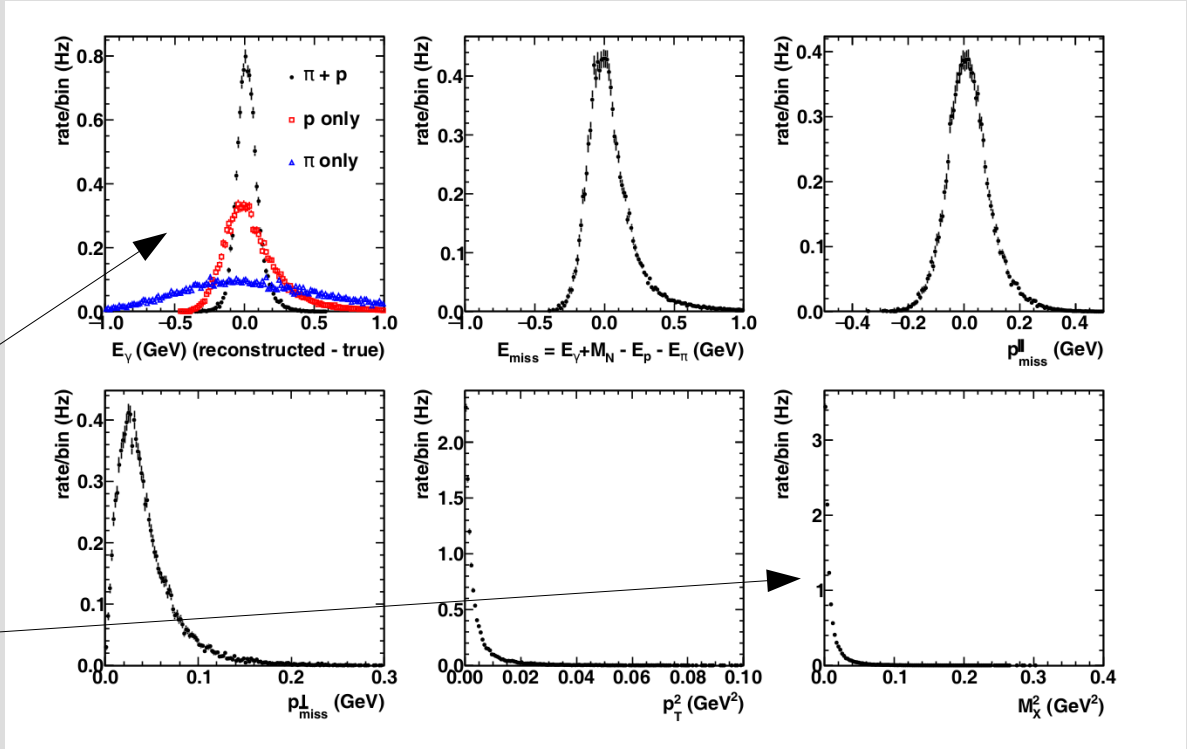
WAPP E12-20-008

Polarization Transfer in Wide-Angle Charged Pion Photoproduction

Making use of the same set up as GEn-RP, the experiment will focus in the polarization transfer asymmetry K_{LL} measurement in $\vec{\gamma} n \rightarrow \vec{p} \pi^-$ adding 6% Cu radiator upstream of the deuterium target (among other changes)

A. Puckett, PAC 48 presentation, 2020

The proposal shows how with a similar detector set up (GEn-RP) we can achieve a good resolution for the search of backward production



Why these experiments?

- They are very simple set-up
- Although they are dedicated to measure neutron form factor, they will use protons too (to be use as data or for calibration)
- GMn is the first experiment to run in the SBS collaboration and GEn-RP will make use of such experience to run
- They offer a window that allows to run parasitic

What is the catch?

- First and above all, **tons of simulations** with those configurations should be run to show the feasibility of such measurement.
- HCAL energy resolution is not so well determined
- In order to run parasitic, the trigger or coincidence time should be wider

Final remarks

- SBS is the next project to be on floor next year (for many years)
- Several experiments has been approved, besides the original FF purpose of the project.
- GMn and GEn-RP are two of the approved experiments quite attractive to try measurements in the u-channel
- For this, several **(I won't be tired to say it)** simulations must be run
  - In case of feasibility of the measurement, we should start to talk with the collaboration directly
- A full whole proposal? (besides a run group proposal)

Thank for your attention

and special thanks to Bill,
who is the heart of these potential studies