SBS in Hall C - physics to do: pol WACS

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SBS Collaboration Meeting
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Outline:

Disclaimer:

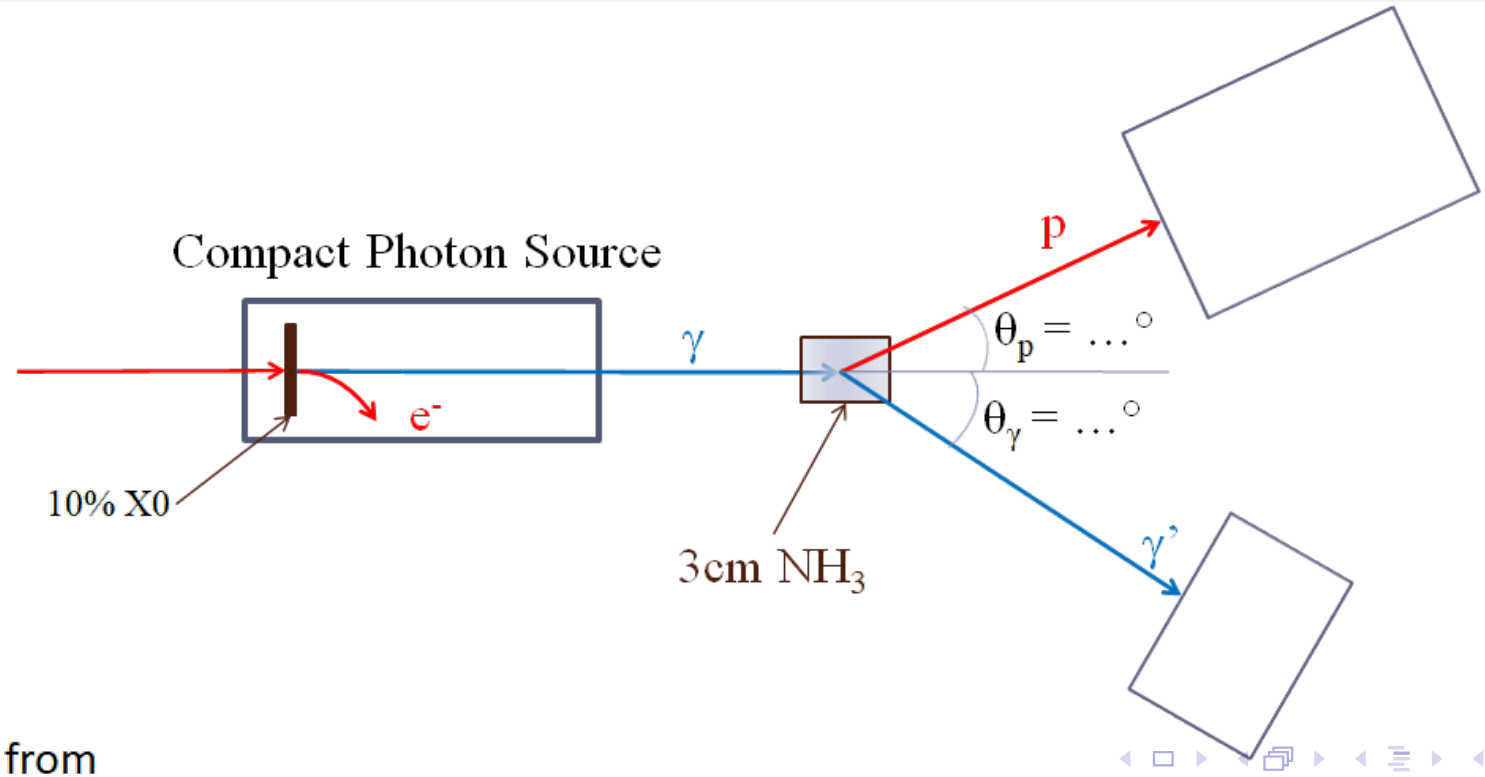
This is just GN's $0.02 worth...

- Many people contributed (directly or indirectly) to this talk (and they will hopefully be acknowledged as appropriate).
- ...and they all have done their level best! thanks!
- Therefore, all **inaccuracies, miss-statements, controversial, or just plain wrong statements** are mine alone!
- That said, onward to the: **What is this experiment about?** question...

JLab E12–17–008

WACS is...

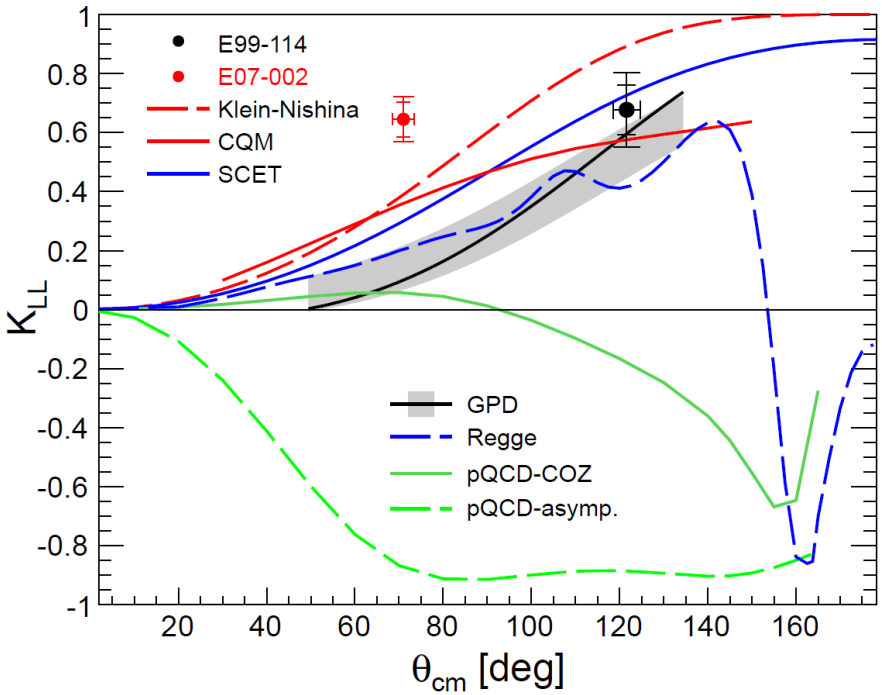
- aka **E12–17–008**, aims to "measure the initial–state helicity correlation observables A_{LL} and A_{LS} in Wide–Angle Compton Scattering".
- ...using a circularly–polarized photon beam and a polarized proton target.

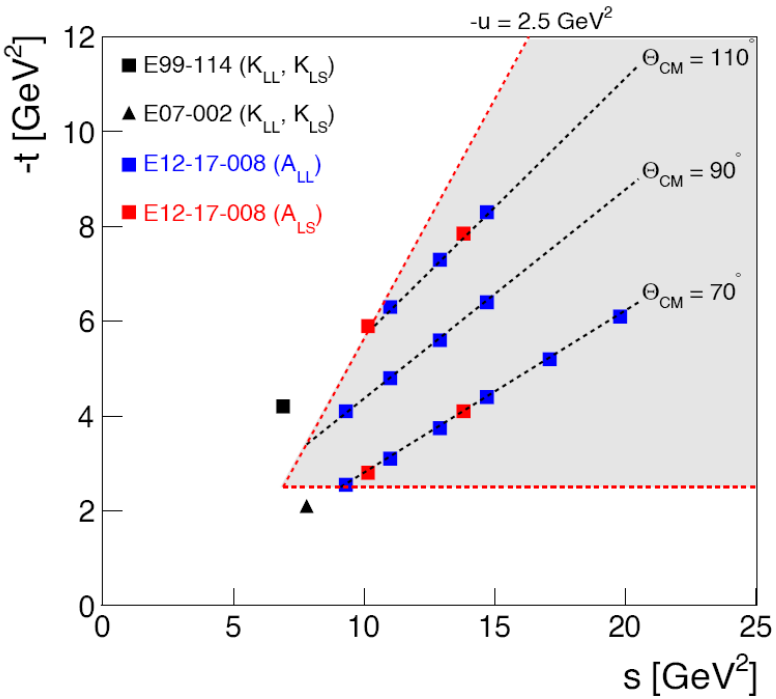


from

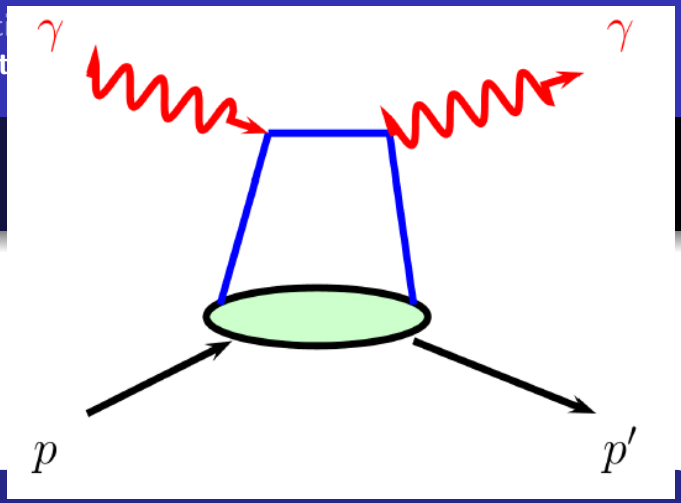
In a nut–shell..

- So: $\vec{\gamma} + \vec{p} \rightarrow \gamma' + p$ @ s: 9...20 GeV^2 ϑ_{CM}: 70°, 90°, 110°
- Hall C, 1100 hours, A^- rating.
- Co–Pi: D. Day, D. Hamilton, D. Keller, B. Wojtsekhowski, J. Zhang, GN





Polarized WACS



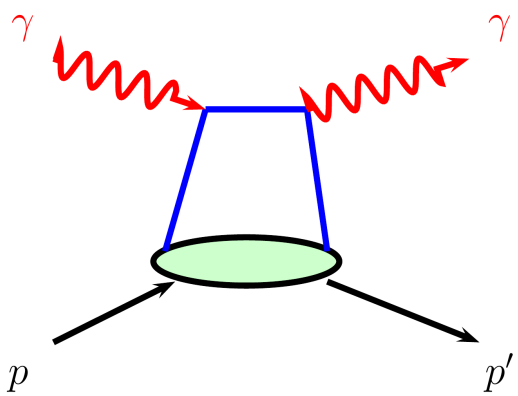
WACS goals:

- the ultimate goal is understanding the structure of the nucleon.
- pQCD expected to dominate at high energies. DIS scales at low-ish W^2.
- picture less clear for hard exclusive processes (???)
  - results, thus far, (way) above the pQCD predictions
  - a popular possible description: handbag mechanism
  - more measurements are needed!

Handbag Mechanism

Non-perturbative Proton Structure: GPD-based Approach

Radyushkin, Phys Rev D58 (1998)
Huang *et al.* EPJ C23 (2002)
Diehl & Kroll, EPJ C73 (2013)



- Provided that $s, -t, -u \gg \Lambda^2$ the handbag mechanism involves factorization of the scattering amplitude into:
  - Hard photon-parton scattering
  - Soft emission and re-absorption of parton by proton

$$\mathcal{M}_{\mu'+,\mu+} = 2\pi\alpha_{\rm em}\left\{\mathcal{H}_{\mu'+,\mu+}[R_V + R_A] + \mathcal{H}_{\mu'-,\mu-}[R_V - R_A]\right\}$$

$$\mathcal{M}_{\mu'-,\mu+} = 2\pi\alpha_{\rm em}\frac{\sqrt{-t}}{m}\left\{\mathcal{H}_{\mu'+,\mu+} + \mathcal{H}_{\mu'-,\mu-}\right\}R_T$$

Non-perturbative physics encoded in vector, axial-vector and tensor form factors which can be related to $1/x$ moments of high momentum transfer, zero skewedness GPDs $H, \tilde{H}$ and E.

Credit: D. Hamilton

A_{LL} and A_{LS} observables...

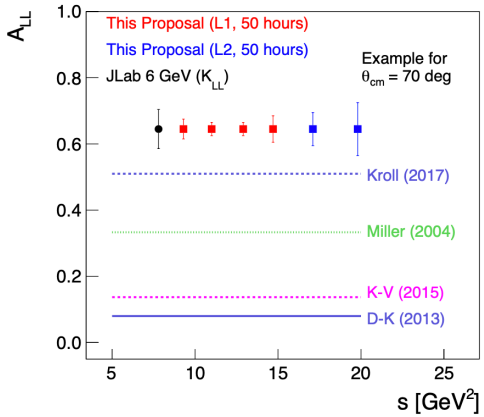
Polarized WACS, E12-17-008

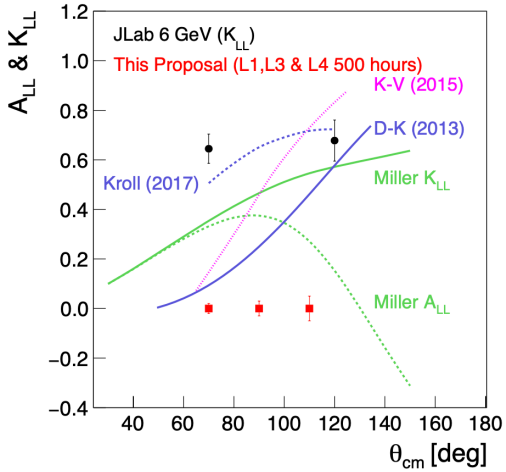
$$\frac{d\sigma}{dt} = \left(\frac{d\sigma}{dt}\right)_{\mathrm{KN}} \left\{ \frac{1}{2}\frac{(s-u)^2}{s^2+u^2}\left[R_V^2(t) + \frac{-t}{4m^2}R_T^2(t)\right] + \frac{1}{2}\frac{t^2}{s^2+u^2}R_A^2(t) \right\}$$

$$A_{LL} = K_{LL} = \frac{R_A(t)}{R_V(t)} A_{LL}^{\mathrm{KN}}$$

$$A_{LS} = -K_{LS} = A_{LL}\left[\frac{\sqrt{-t}}{2m}\frac{R_T(t)}{R_V(t)} - \beta\right]$$

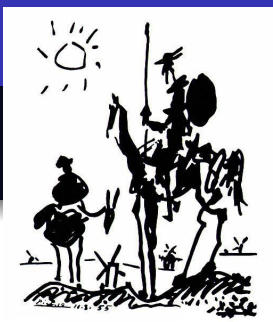
Diehl & Kroll, EPJ C73 (2013)





Slide from D. Hamilton

Credit: B. Wojtsekhowski



Questions Polarized WACS hopes to answer

WACS goals:

- Is factorization dominant at 12 GeV? Size of TM, other HT corrections?
- A_{LL} and A_{LS} constraints on GPD moments? Axial & tensor structure of the proton high $-t$?
- Nature of the quark abs/emitting photons in CS?
- How do SCET and GPD predictions* compare? Anything to learn about handbag mechanism? Hadron helicity flip role?

Experimental Setup

Experimental Technique

1. A 2.5 μA polarized electron beam incident on a 10 % radiator inside a new Compact Photon Source (CPS) produces a high-intensity untagged photon beam.
2. The proton target is the UVA/JLab solid polarized ammonia target.
3. The recoil proton is detected with the BigBite spectrometer equipped with GEM trackers and trigger detectors.
4. The highly-segmented $PbWO_4$ NPS calorimeter is used to detect the scattered photon.

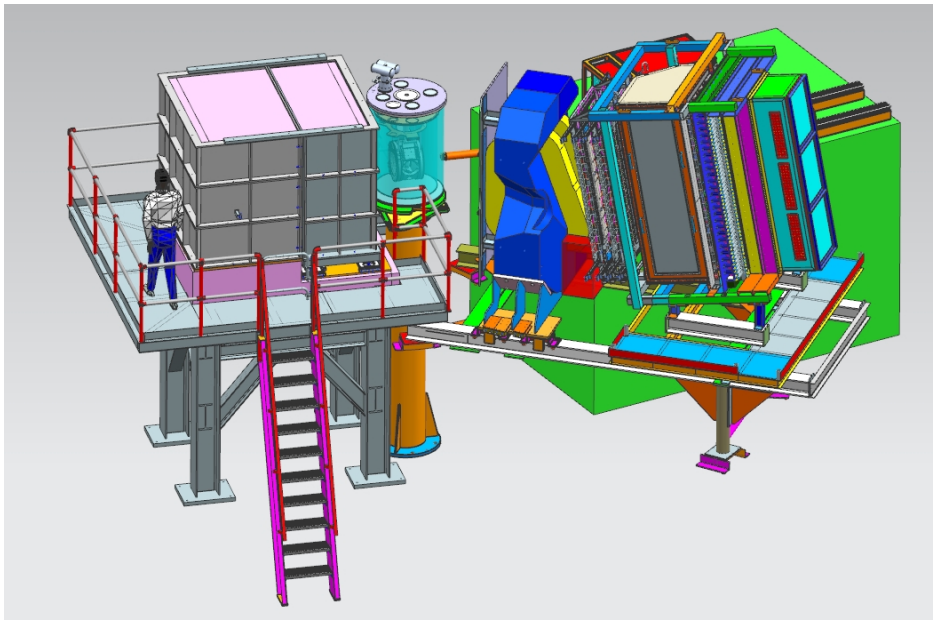


Figure from Steve Lassiter

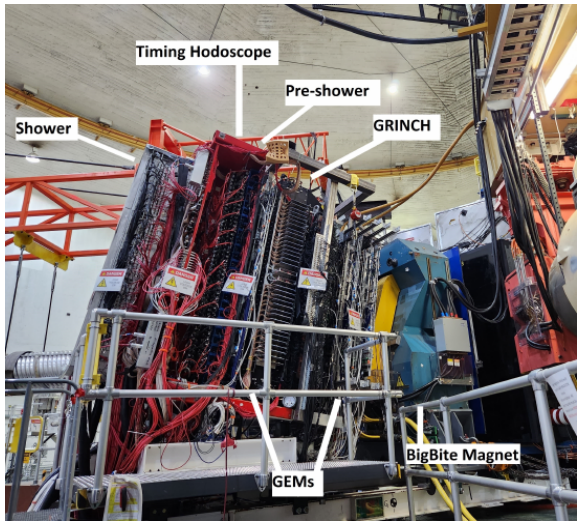
The use of the CPS and BigBite results in a factor of 30 improvement in figure-of-merit over previous experiments and opens up a new range of polarized physics opportunities at JLab.

Credit: D. Hamilton

BigBite

BigBite Spectrometer Status

- The BigBite spectrometer with the new 12 GeV detector stack was commissioned and installed in Hall A in 2021.
- Performance and data-quality during the first SBS form factor experiments (GMn and GEn) have been excellent.
- The collaboration has gained experience operating and analyzing data with large-area GEM trackers at luminosities of $10^{37} - 10^{38}$ $\mathrm{cm}^{-2}\mathrm{s}^{-1}$ (c.f. $\sim 10^{36}$ for the proposed measurements).



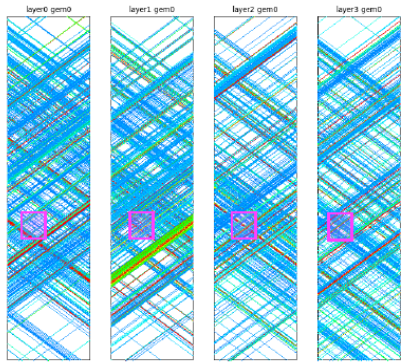


Figure from Andrew Puckett

Credit: D. Hamilton

Polarized Target

Polarized Target Status

- The polarized target is the UVA/Jlab solid ammonia DNP system.
- It will employ the new JLab magnet which provides a much higher acceptance for running with transverse polarization.
- UVA are working on a target cell motion system for beam-target rastering in order to manage heat load and radiation damage on the target material.

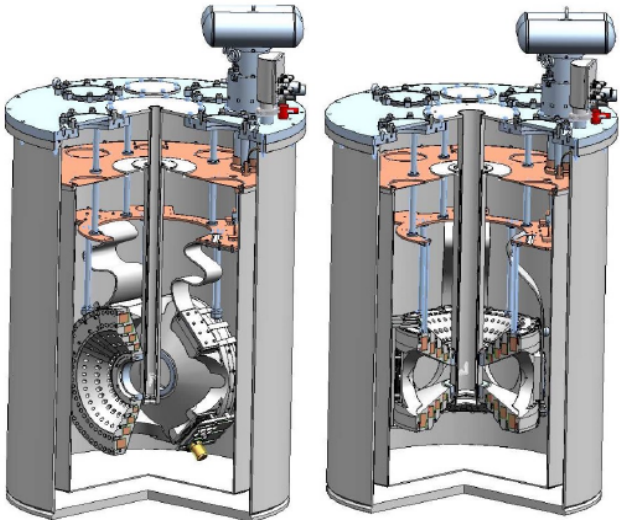


Figure from Chris Keith

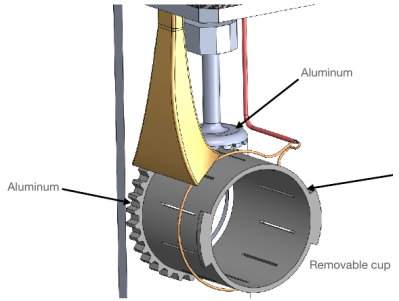


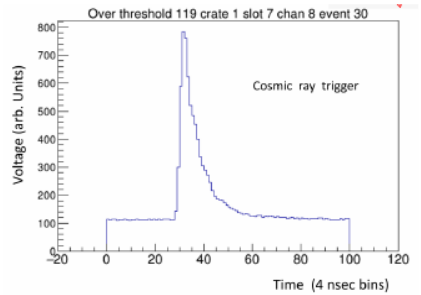
Figure from Dustin Keller

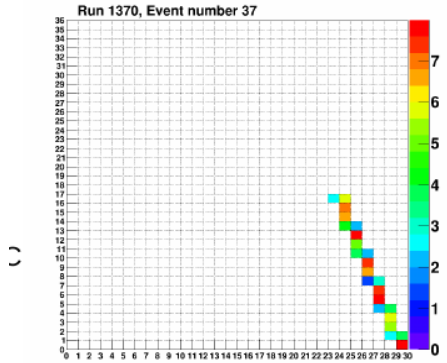
Credit: D. Hamilton

NPS

Neutral Particle Spectrometer Status

- Construction of the NPS is complete and it is currently being installed in Hall C, with first beam expected in a few months.
- DAQ, slow controls and software commissioning is near completion.





Figures from Carlos Munoz Camacho, Bob Michaels and Simona Malace

Credit: D. Hamilton

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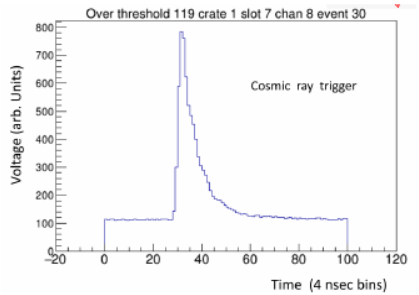
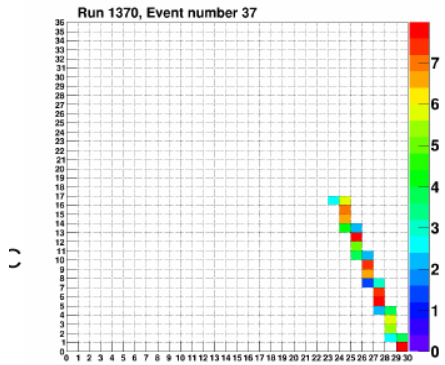
UPDATE: NPS RG1a ran from Sept. 2023 - May 2024!!



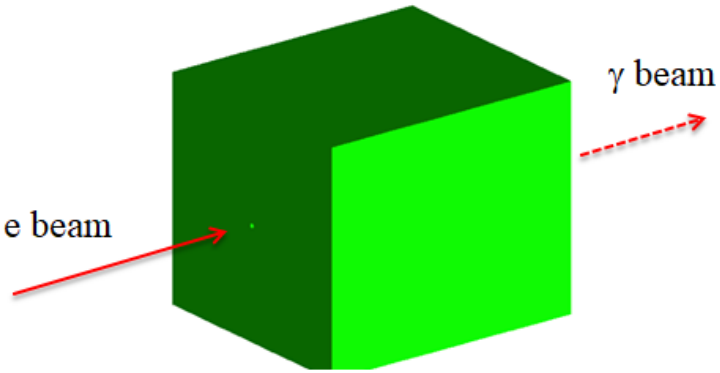


Figures from Carlos Munoz Camacho, Bob Michaels and Simona Malace

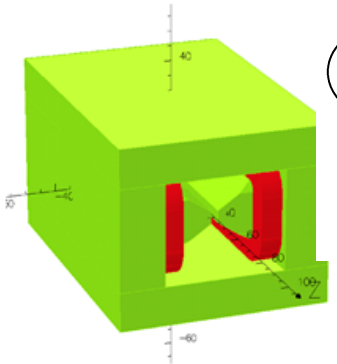
Credit: D. Hamilton

CPS (I)

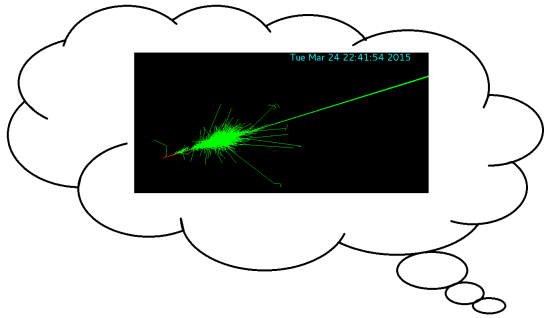
Compact Photon Source

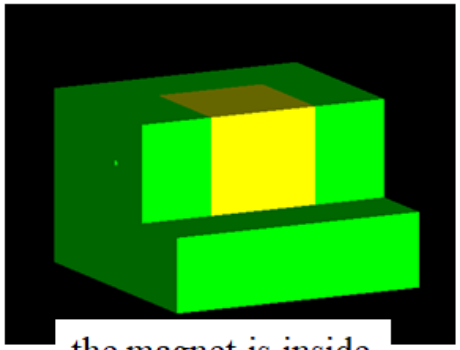


2.6 m x 2.5 m x 2.5 m structure

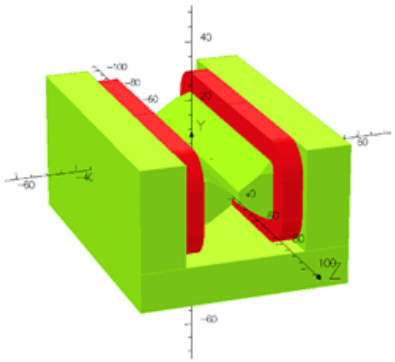


1 m x 0.6 m x 0.5 m magnet





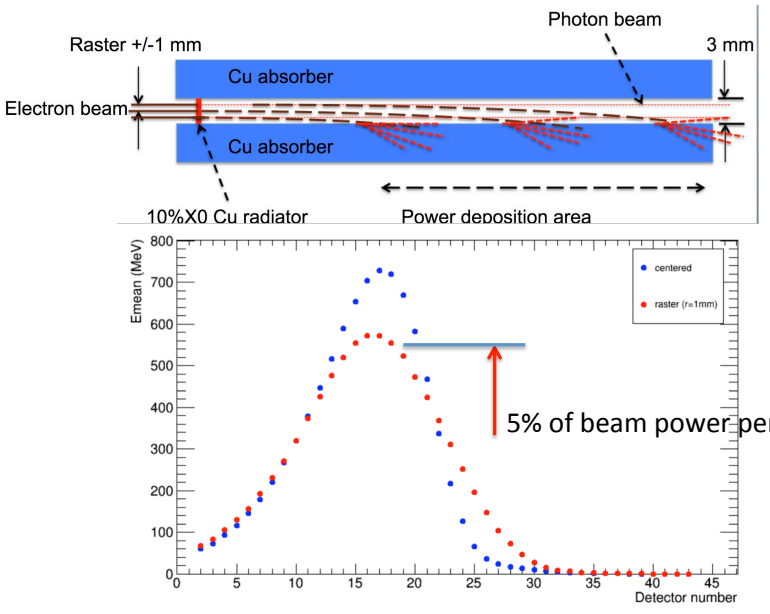
the magnet is inside

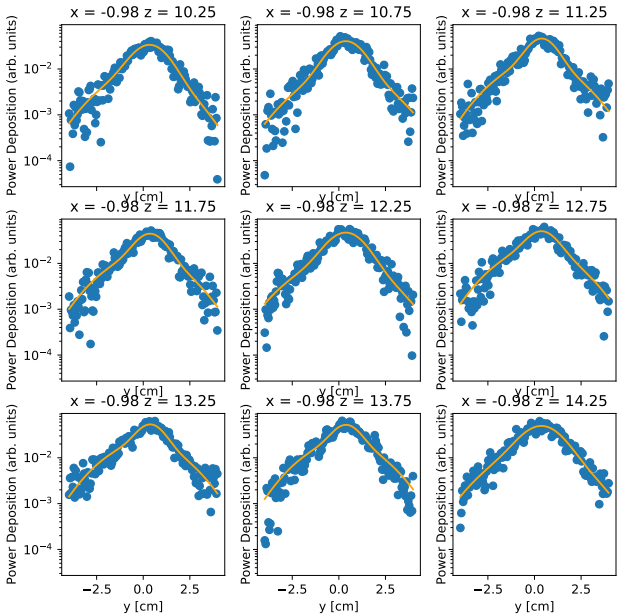


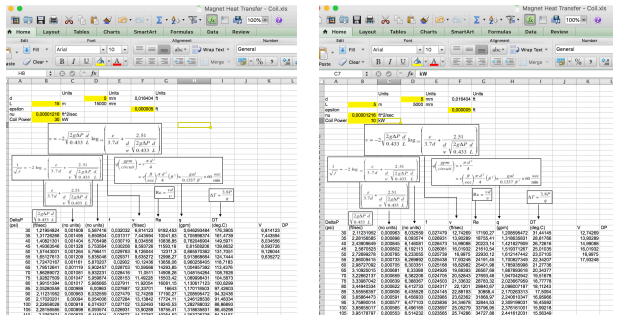
the magnet top plate is removed

CPS (II)

Longitudinal distribution of the beam power







Credit: B. Wojtsekhowski

CPS (III)

Polarized WACS, CPS

A conceptual design study of a Compact Photon Source (CPS) for Jefferson Lab NIM-A 957 (2020) 163429

D. Day [a], P. Degtiarenko [b], S. Dobbs [c], R. Ent [b], D.J. Hamilton [d], T. Horn [e,b,*], D. Keller [a], C. Keppel [b], G. Niculescu [f], P. Reid [g], I. Strakovsky [h], B. Wojtsekhowski [b], J. Zhang [a]

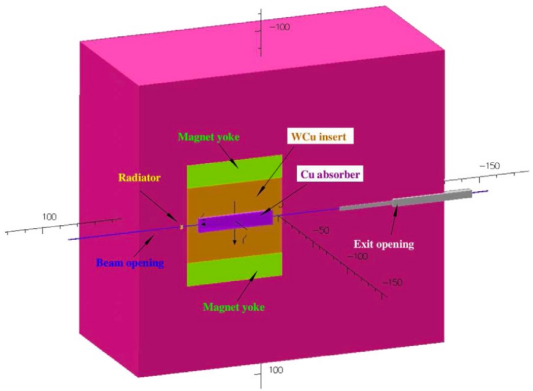


Fig. 3. The CPS cut-out side view. Deflected electrons strike a copper absorber, surrounded by a W-Cu insert inside the magnet yoke. The outer rectangular region in this view is the tungsten-powder shield.

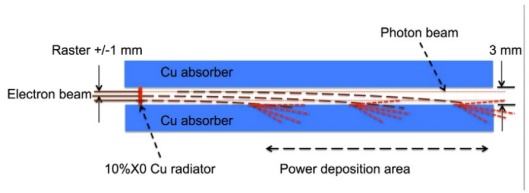


Fig. 4. The scheme of beam deflection in the magnetic field to the absorber/dump.

around the photon beam can be as narrow as the photon beam size. After passing through the radiator, the electron beam should be separated from the photon beam by means of deflection in a magnetic field. The length, aperture and field strength of the magnet are very different in the proposed source compared to in the traditional tagging technique. In the traditional source the magnet is needed to direct the electrons to the dump. Because of the large momentum spread of electrons which

Credit: B. Wojtsekhowski

CPS (IV)

Compact Photon Source Status

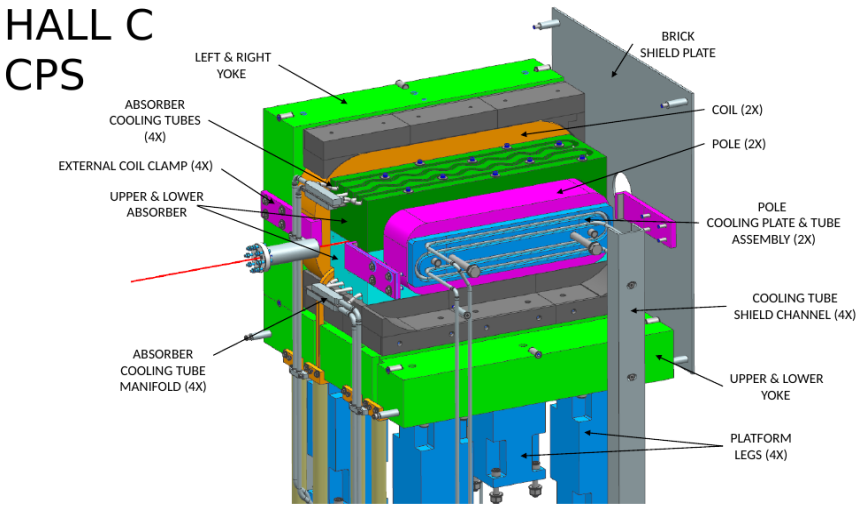


Figure from Steve Lassiter

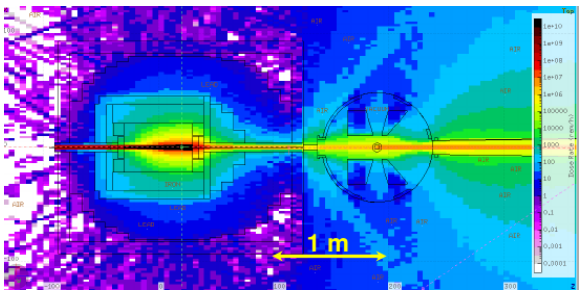
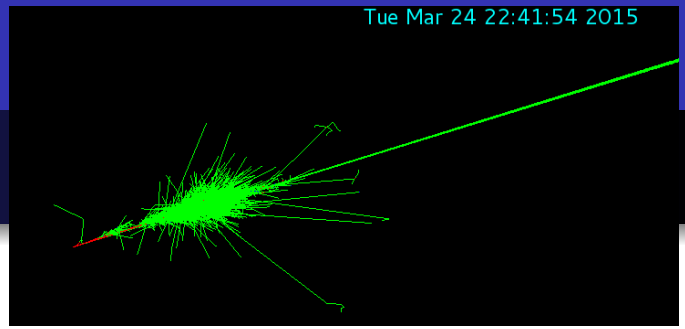


Figure from Pavel Degtiarenko

- E12-17-008 was the primary driver behind the CPS concept of a hermetic magnet-dump with an exit channel for the photon beam.
- FEA studies of the magnetic field and heat flow and FLUKA simulations of prompt and activation radiation load are complete.
- The conceptual design was published [Day *et al.* NIM A957 (2020)].
- Design of the magnet, central absorber, shield layers and support structure is complete and all components have been ordered.

Credit: D. Hamilton



Quo Vadis

I hope I convinced you that Polarized WACS...

- offers a new (and productive) way of exploring the structure of the nucleon and probing the reaction mechanism(s) prevalent at 12 GeV scale.
- nexus of several new(ish) and innovative pieces of experimental hardware.
- CPS opens a whole area of possible exploration.
- ...so join us as we seek the future of (S)BS and the progress of the field, ... in Hall C!

THANK YOU!