Physics with positron beam using SBS

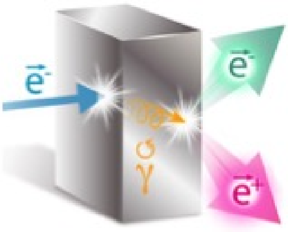
An Overview of the Positron Working Group White Paper

Axel Schmidt

SBS Collaboration Meeting

July 14, 2020

Positron Working Group at JLab



Wiki page:

- `wiki.jlab.org/pwgwiki`

Mailing list:

- Sign-up:
- pwg-request@jlab.org

Contacts:

- Eric Voutier, Orsay
- Joe Grames, JLab

PWG Recent Activities

2017:

- International Workshop on Physics with Positrons at Jefferson Lab

2018:

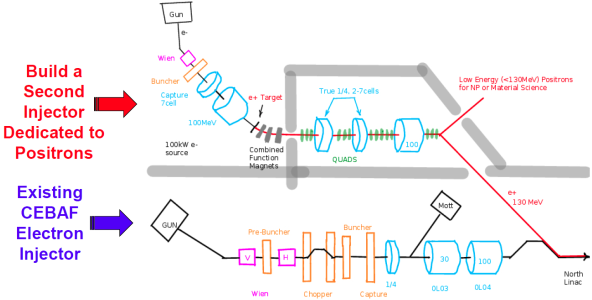
- Letter of Intent to PAC46

2020:

- 2 DVCS Proposals to PAC48
- **White Paper: An Experimental Program with Positron Beams at the Jefferson Laboratory**

Putting positrons into CEBAF

See 2020 Proposals, 2018 LOI for more details.



PEPPo Method: transfer polarization from e^- to e^+

- 1 μA unpolarized
- 100 nA with 40% polarization

2020 White Paper

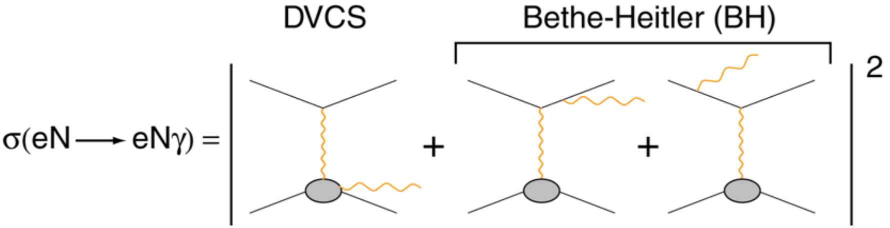
An Experimental Program with Positron Beams at the Jefferson Laboratory

Topical Areas

- Deeply-Virtual Compton Scattering
- Two-Photon Exchange (TPE)
- Tests of the Standard Model

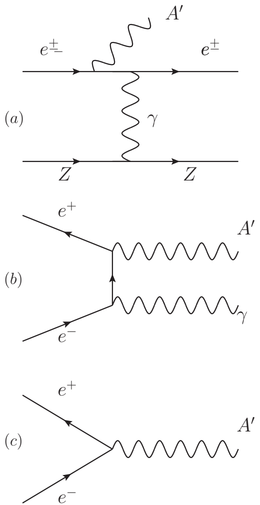
Each area has several experiment concepts.
Three TPE concepts use SBS.

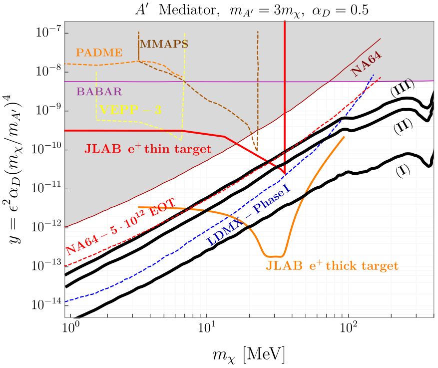
Positrons help separate DVCS from Bethe-Heitler



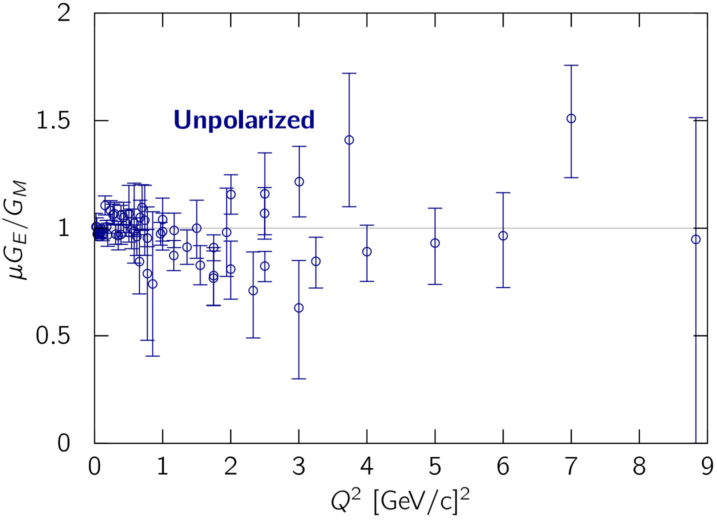
- *Beam charge asymmetries for Deeply Virtual Compton Scattering on the proton at CLAS12*
- *Deeply Virtual Compton Scattering using a positron beam in Hall C*
- 4 additional white paper concepts

Positrons can be used to search for possible dark photons.





Hard two-photon exchange may explain the proton's form factor discrepancy.



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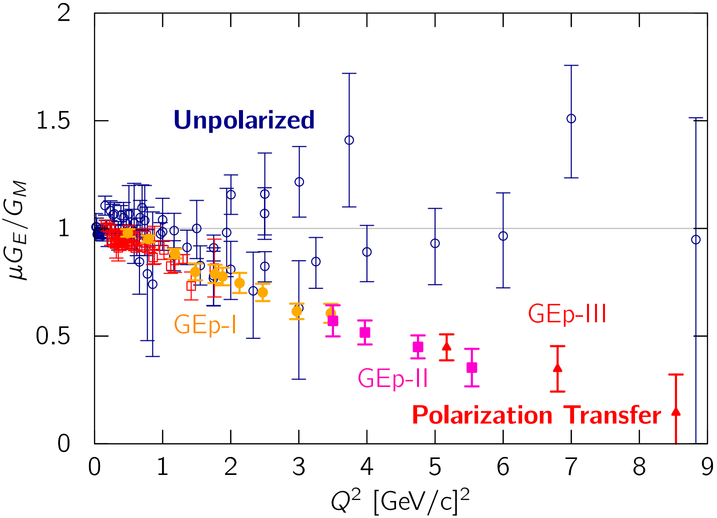

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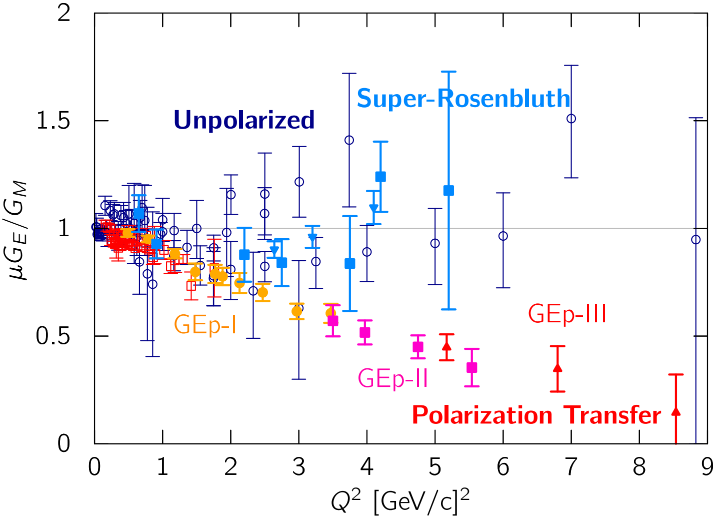
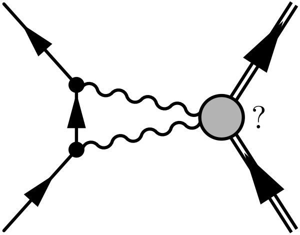


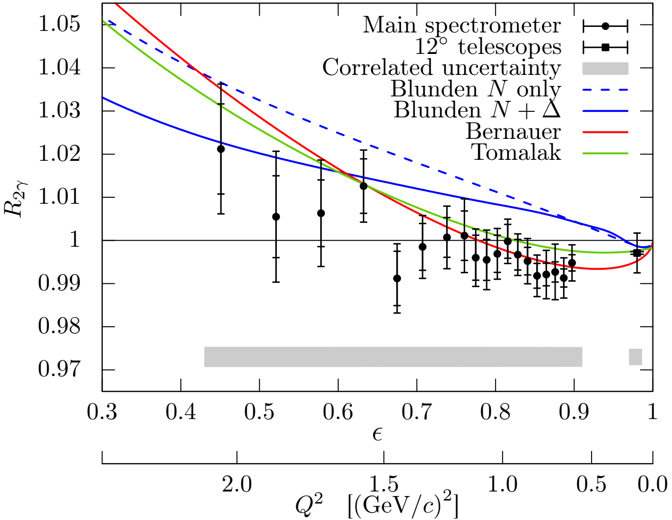
Hard TPE can be accessed through several different observables.



$$\frac{\sigma_{e^+p}}{\sigma_{e^-p}} = 1 - 4G_M \mathrm{Re}\left(\delta\tilde{G}_M + \frac{\epsilon\nu}{M^2}\tilde{F}_3\right) - \frac{4\epsilon}{\tau} G_E \mathrm{Re}\left(\delta\tilde{G}_E + \frac{\nu}{M^2}\tilde{F}_3\right) + \mathcal{O}(\alpha^4)$$

$$\frac{P_t}{P_l} = \sqrt{\frac{2\epsilon}{\tau(1+\epsilon)}}\frac{G_E}{G_M} \times \Big[1 + \mathrm{Re}\left(\frac{\delta\tilde{G_M}}{G_M}\right) + \frac{1}{G_E}\mathrm{Re}\left(\delta\tilde{G_E} + \frac{\nu}{m^2}\tilde{F}_3\right)$$
$$- \frac{2}{G_M}\mathrm{Re}\left(\delta\tilde{G_M} + \frac{\epsilon\nu}{(1+\epsilon)m^2}\tilde{F}_3\right) + \mathcal{O}(\alpha^4)\Big]$$

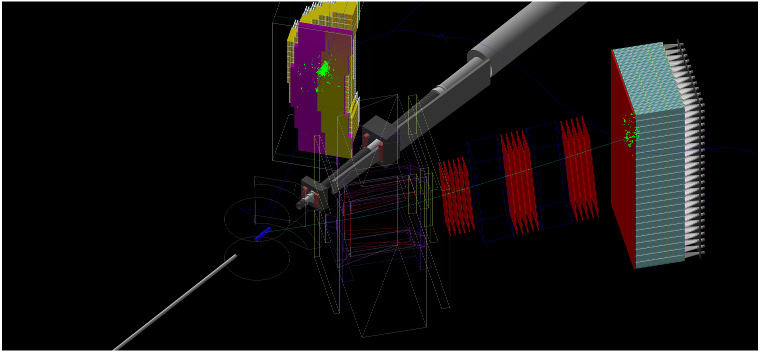
OLYMPUS, CLAS, VEPP-3 observed small TPE but only covered $Q^2 < 2$ GeV^2.



Polarization transfer in $\vec{e}^+ p \to e^+ \vec{p}$ scattering using the Super BigBite Spectrometer

A. J. R. Puckett et al.

- 4.4 GeV e^+ beam
- 40 cm liquid H_2 target
- SBS for proton polarimetry
- CDET + ECAL for electron detection



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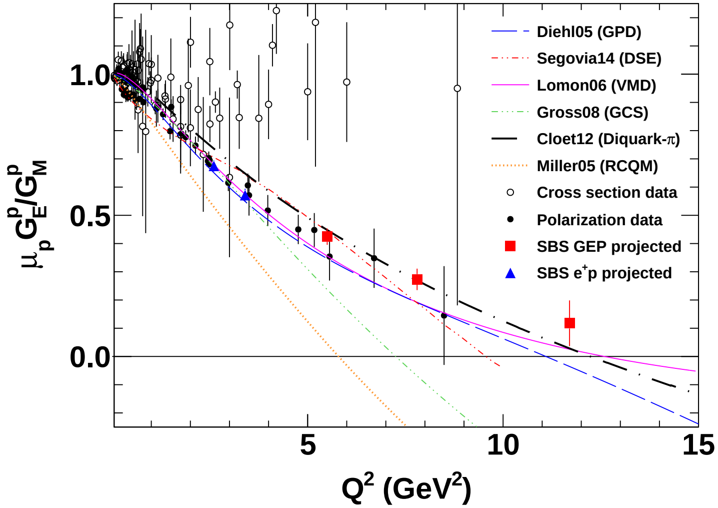
Lepton	E_e GeV	$\langle Q^2 \rangle$ GeV^2	θ_e deg.	$\langle \epsilon \rangle$	θ_p deg.	p_p GeV	Event rate Hz	Days
e^+	4.4	2.6	27.0	0.84	36.2	2.15	16	30
e^+	4.4	3.4	32.5	0.76	31.1	2.56	7	60
e^-	4.4	3.4	32.5	0.76	31.1	2.56	1,050	1

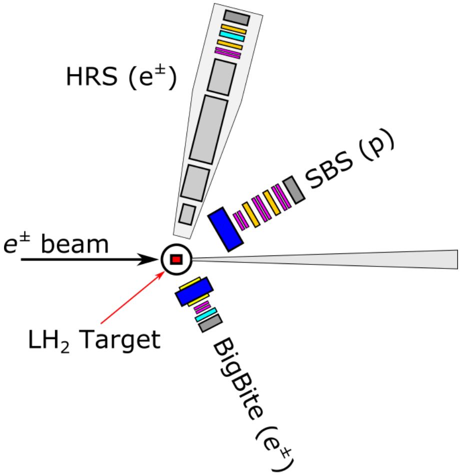
This would be mellow compared with upcoming high-rate SBS measurements.



Direct two-photon exchange measurement via e^+p/e^-p scattering at low ϵ in Hall A

E. Cline et al.

- Unpolarized inclusive elastic scattering
- SBS, BigBite, and 1 HRS to maximize acceptance
- *2 week measurement*



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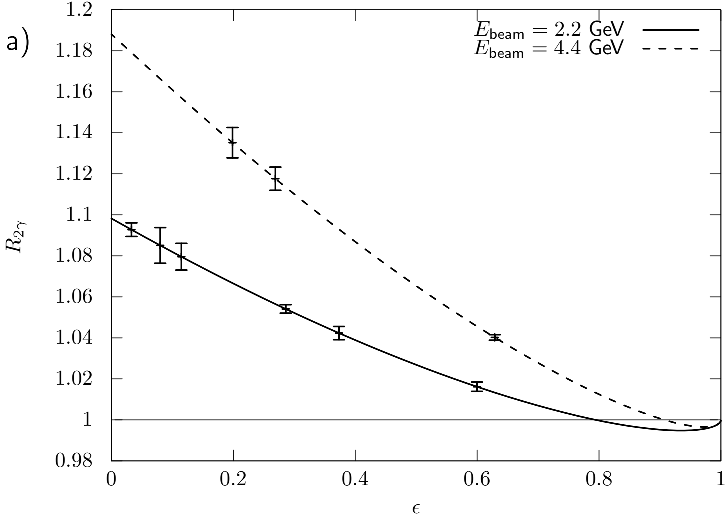
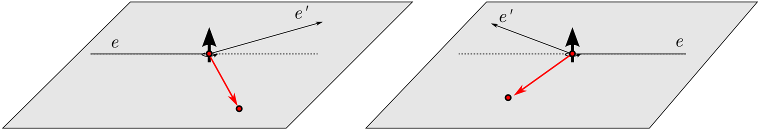


Transverse single-spin asymmetries are only possible with multi-photon exchange.

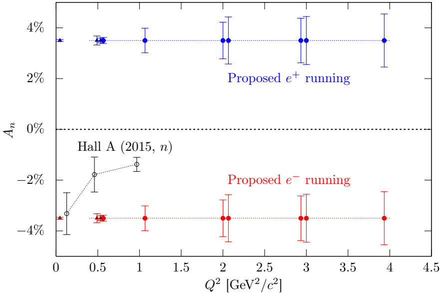


$$A_n = \frac{\sqrt{2\epsilon(1+\epsilon)}}{\sqrt{\tau}\left(G_M^2 + \frac{\epsilon}{\tau}G_E^2\right)} \times$$
$$\left[-G_M \mathrm{Im}\left(\delta\tilde{G}_E + \frac{\nu}{M^2}\tilde{F}_3\right) + G_E \mathrm{Im}\left(\delta\tilde{G}_M + \frac{2\epsilon\nu}{M^2(1+\epsilon)}\tilde{F}_3\right)\right] + \mathcal{O}(\alpha^4)$$

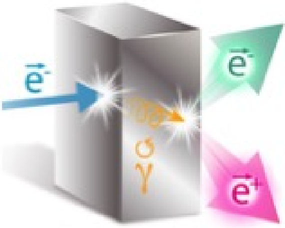
Target-Normal Single Spin Asymmetries measured with positrons

A. Schmidt et al.

- Unpolarized inclusive elastic scattering (100 nA)
- Polarized frozen spin proton target
- SBS, BigBite, and 1 HRS to maximize acceptance
- *15-day measurement*



Summary



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Check out our upcoming White Paper

- *Hopefully on arXiv in a couple weeks.*