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A Compact Photon Source For The WACS Experiment At JLab

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What is Compact Photon Source ?

It is a facility, part of the JLab proposal PR12-15-003:

"Polarization Observables in
Wide-Angle Compton Scattering
at Photon Energies up to 8 GeV"

With Spokes-persons:

Sergey Abrahamyan (YerPhI)

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Talk Outline

1. Wide Angle Compton Scattering Experiment: Physics Motivation.
2. WACS: Equipment and Scope.
3. Compact Photon Source Design: Work Plan, Key Concepts and Layout.
4. CPS Design: Advantages, Challenges and Setup.
5. Summary

1.1 WACS: Physics Motivation

PR12-15-003 is an experiment to measure the initial state helicity correlation asymmetry A_{LL} in Wide-Angle Compton Scattering (WACS) by scattering circularly polarized photons from a longitudinally polarized proton target at invariant s in the range of 8 to 16 GeV^2 for several scattering angles between $\theta_{cm} = 80^\circ$ and $\theta_{cm} = 100^\circ$.

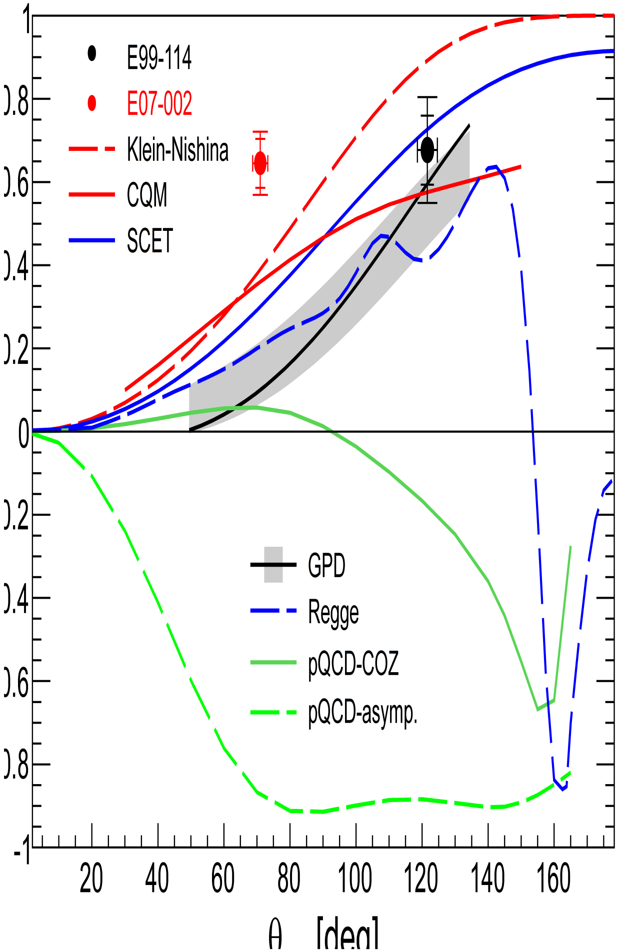
Two previous JLab experiments, E99-114 and E07-002, have already demonstrated the feasibility of the experimental real photon Compton scattering technique at JLab using an untagged photon beam of very high intensity mixed with an electron beam and have provided high accuracy results for the cross section and polarization parameter K_{LL}, admittedly at relatively low values of s, −t, −u for K_{LL}.

1.2 WACS: Physics Motivation

In the 6 GeV era there was an approved A-rated JLab experiment (E-05-101) to measure A_{LL} which did not get beam time due to a scheduling complication and polarized target failure. PAC42 recently supported experiment E12-14-006, which has a similar motivation. The analysis completed in January 2015 of the E07-002 experiment shows an unexpected result for the polarization transfer parameter K_{LL} , which was found to be three times larger than predicted by the GPD-based model at $\theta_{cm} = 70^{\circ}$.

Such news motivates the study of the polarization effect in a Wide Angle Compton Scattering experiment at significantly higher s than was done (or proposed) before.

1.3 WACS: Physics Motivation



E99-114
s=6.9, t=-4.0, u= -1.1 GeV^2

E07-002
s=7.8, t=-2.1, u= -4.0 GeV^2

PRL 115, 152001 (2015)

New measurement at large (doubled) s, t, u values is necessary to clarify the mechanism of WACS.

1.4 WACS: Physics Motivation

Moreover there are some issues that request to explore further the measurement of polarization observables in WACS at JLab:

- What is the nature of the quark which absorbs and emits photons in the WACS process in the wide angle regime? Is it a constituent or a current quark?
- What is the energy scale at which the GPD mechanism becomes dominant? WACS will explore this question at large *s*.
- If the GPD approach is correct, is it indeed true that the WACS reaction proceeds through the interaction of photons with a single quark?
- What are the constraints on the GPD integrals imposed from the proposed measurement of the A_{LL} observable?
- What is the role of a diquark *ud* correlation in WACS?

2.1 WACS: Equipment and Scope

WACS utilizes an untagged bremsstrahlung photon beam and the polarized target used in the g2p experiment with the target field oriented along the beam direction. The scattered photon will be detected in the Neutral Particle Spectrometer (NPS), while the coincident recoil proton will be detected in the Super Bigbite Spectrometer (SBS). An intense photon beam (Compact Photon Source) will be produced at a distance of 2 m from the target and cleaned from an electron beam by means of a shielded magnet-dump.

WACS will carry out its measurements at large s (8-16 GeV^2) and −t (3-7 GeV^2). These are optimal conditions for testing the applicability domain of GPDs. WACS needs about 350 hours of an electron beam with 1.2 μA at 8.8 GeV energy to measure the polarization observable A_{LL} to a statistical accuracy better than 0.09 in a wide-angle regime near $\theta_{cm} = 90^{\circ}$ at four values of s. This measurement will significantly increase our experimental confidence in the application of the GPD approach to reactions induced by real photons.

3.1 CPS Design: Work Plan.

- The WACS measurement requires a real photon source from the CEBAF electron beam that can safety operate in Hall A. One of the main tasks of our team is to consolidate the design of the photon source proposed by us, simulate the performance and then build it.
- The selected solution is an untagged bremsstrahlung gamma source consisting of a 10% radiation length radiator and a normal conducting magnet to sweep incident beam electrons out of the beam line, with proper shielding inside and around the magnet (which basically makes the magnet a sort of mini beam dump). The magnet bore, a copper cylinder with a set of small diameter (2 mm) holes, projected to be 1 m long, slowly rotating around its axis to perform as a "mechanical raster" to protect the target from overheating.

3.1 CPS Design: Key Concepts

The key parts of our approach are:

1) A dump is at the same time a sweep magnet.
2) A small opening just for the photons, which provides collimation of the radiation background (γ/n).
3) A moving hole provides the best match of #1, #2 and the desirable size of the beam spot at the target.

3.2 CPS Design: Conceptual Layout

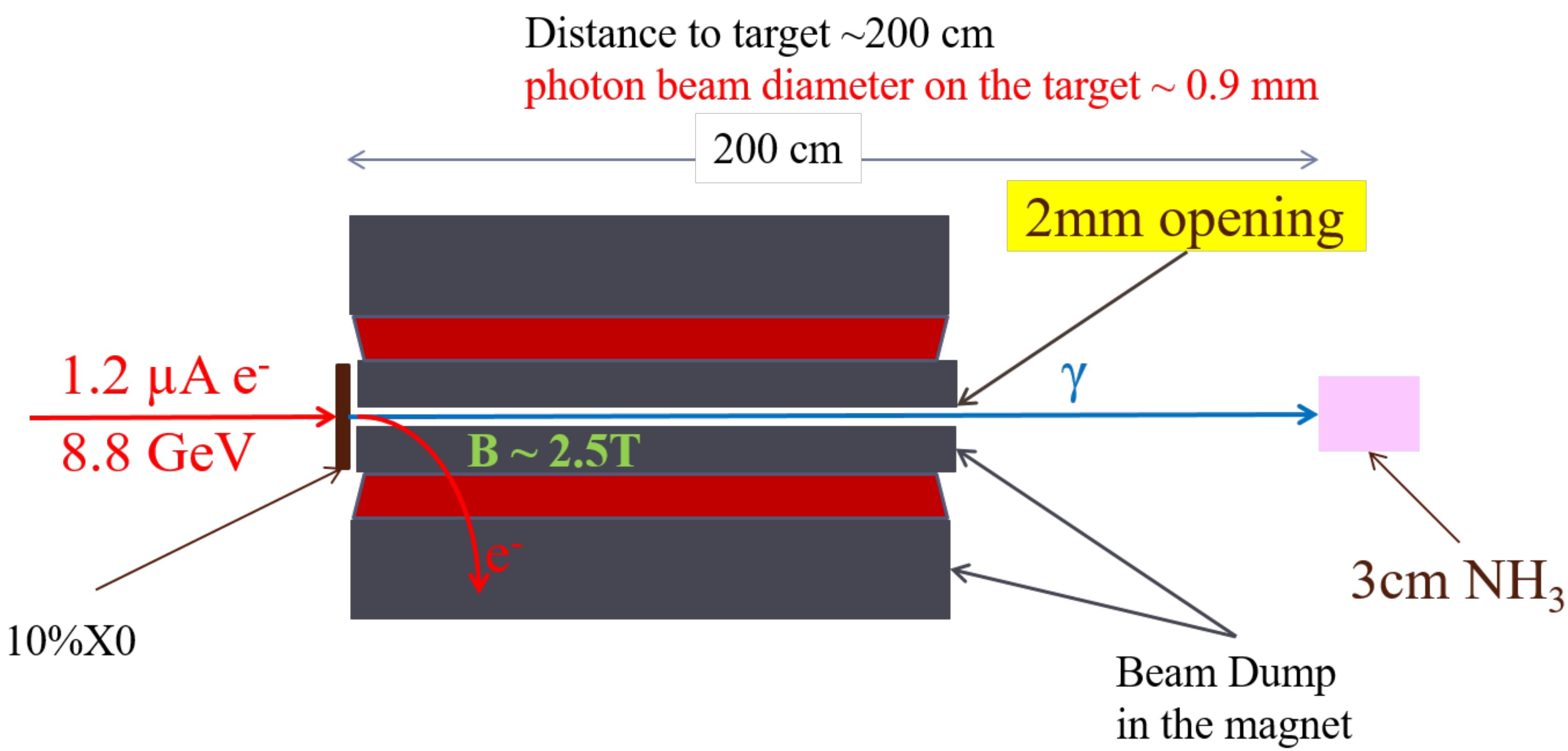


Fig. 3 Conceptual layout of the Compact Photon Source

4.1 CPS Design: Advantages

The CPS advantages, to carry out WACS measurements, are:

1) A 10 times higher beam intensity (vs. a mixed e/γ beam) with acceptable radiation level in the hall, target.

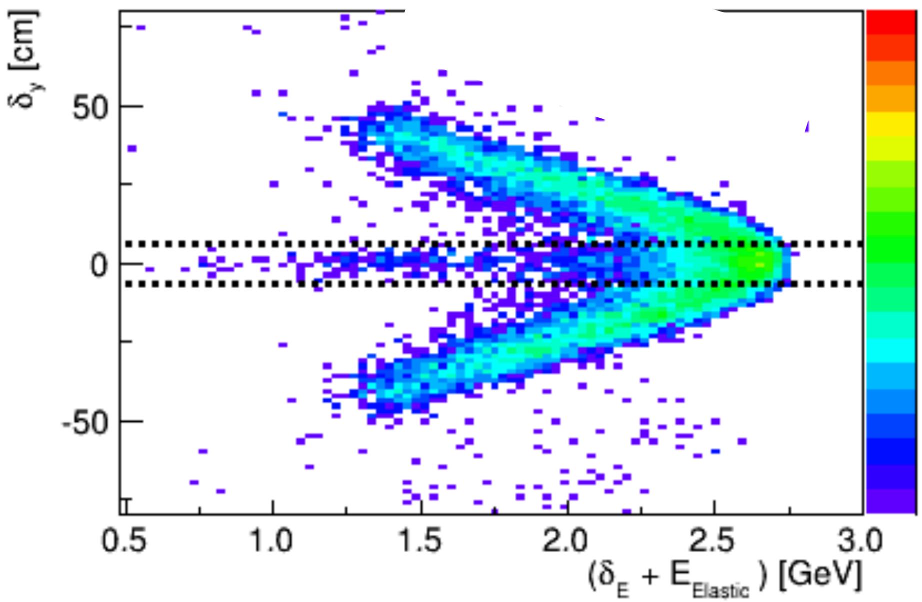
2) A 0.9 mm beam diameter on the target.

3) A simple beam line without a chicane (needed in the case of a mixed e/γ for a transversely polarized NH3 target.

4.2 CPS Design: Challenges

Small photon spot is very important:

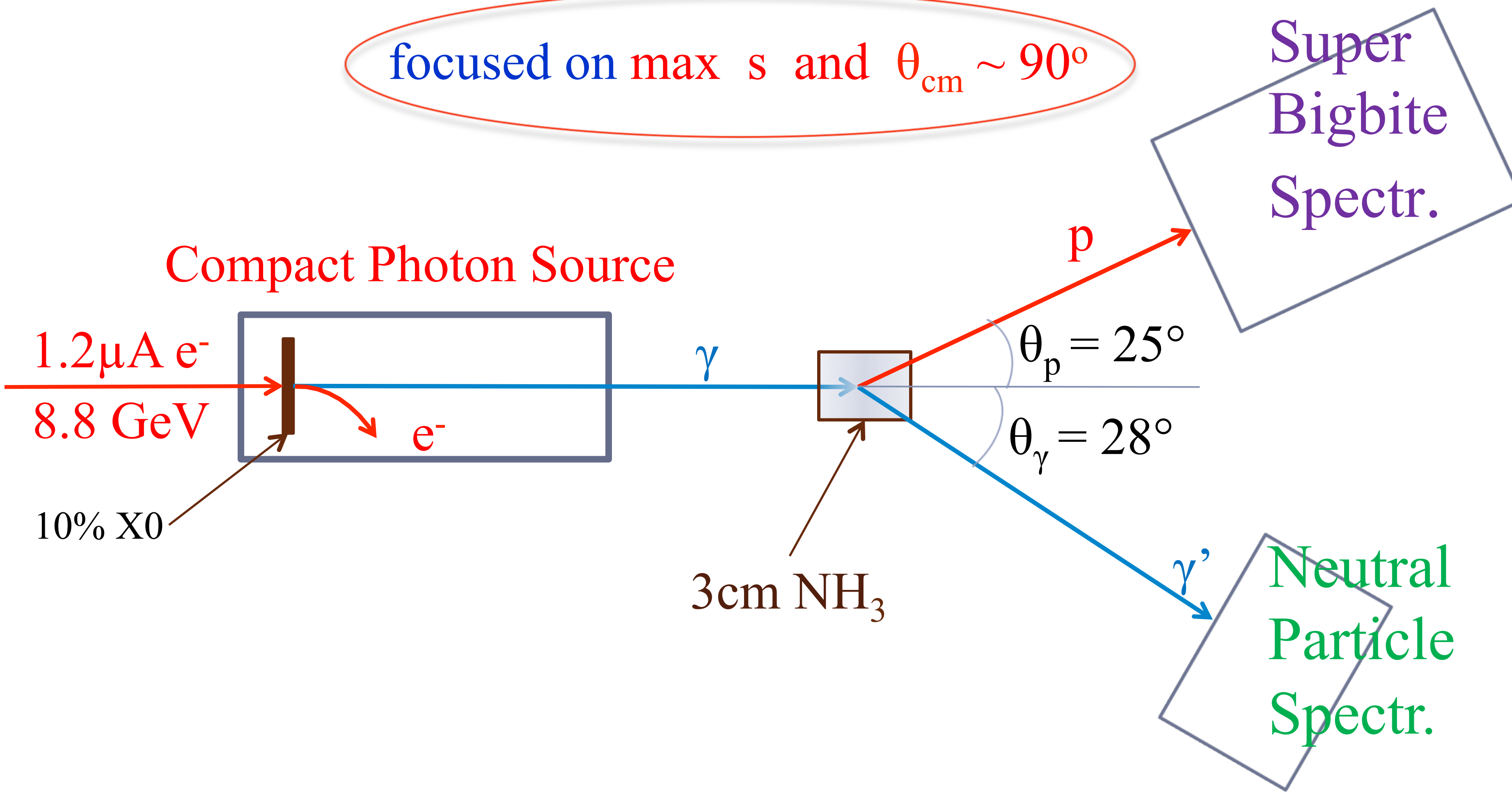
- It defines the width of the out-of-plane photon–proton angular correlation
- It contributes to the proton momentum resolution



At the $\delta y \sim 0$ point where WACS events are located the photon energy - angle correlation is “zero” and there are only angular correlations which allow to differentiate the Compton and π^0 events

4.3 CPS Design: Experimental Setup

focused on max s and $\theta_{cm} \sim 90^o$



5. Summary

Compton scattering off the nucleon is one of the simplest processes that can provide valuable information for the understanding of the nucleon structure. A Wide Angle Compton Scattering (WACS) experiment requires a secondary real photon source from the CEBAF electron beam, that can safety operate in Hall A at JLab. One of the challenging tasks for the team proposing the WACS experiment will be to consolidate the design of the Compact Photon Source, simulate its performance, and then build it.
The proposed solution is an untagged bremsstrahlung gamma source consisting of a 10% radiation length radiator and a normal conducting magnet to sweep incident beam electrons out of the beam line, with proper shielding inside and around the magnet, making it a sort of mini beam dump. The magnet bore, a copper cylinder with a set of small diameter (2 mm) holes, designed to be 1 m long, will slowly rotate around its axis to perform as a "mechanical raster", to protect the target from overheating.

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