Compact Photon Source

The NIM paper development update
based on 1/22/2019 meeting

Bogdan Wojtsekhowski for the CPS collaboration

February 1, 2019

The paper structure

Plan on CPS paper(s)

a. collection of the papers on prior art

b. physics with photon beams

c. motivations for compact photon beam and options

d. unpolarized and polarized target needs

e. radiation effect in polarized target NH3 old story from CERN, T20 at Bonn and others

f. why and how to distribute the heat and radiation load

g. CPS concept and realization option

h. physics experiments under discussion with CPS at JLab

The paper structure

This paper presents the development of a new instrument, an intense source of a narrow photon beam for use with dynamically-polarized solid-state polarized targets.

In the first section we formulate the motivation, the requirements, and perspectives for high-energy photo-production experiments.
In the second section we review the prior state-of-the-art of photon source design.

The third section presents the ideas of the concept of such a new Compact Photon Source.
The fourth section briefly analyzes the methods to distribute the power of heat and radiation load over the area of the polarized material.

The next section then describes the implementation of a CPS at Jefferson Lab in support of several experiments.
In the sixth section, we present the radiation analysis based on several methods including Fluka and Geant4.

Finally, we conclude with the initial engineering plan for the CPS.

See the full text on the NPS web page:
https://wiki.jlab.org/cuawiki/index.php/Meeting_22_January_2019

Physics motivation

Traditionally, knowledge has been gathered on the structure of protons and neutrons from studies of their static properties (mass and spin, polarizabilities, form factors) and the one-dimensional quark and gluon momentum distributions underlying them.
Yet despite decades of research, our knowledge of the microcosm of proton structure has remained elusive.

Double-polarized high s/t/u exclusive reactions provide a clean access to the nucleon structure and quark-gluon dynamics.

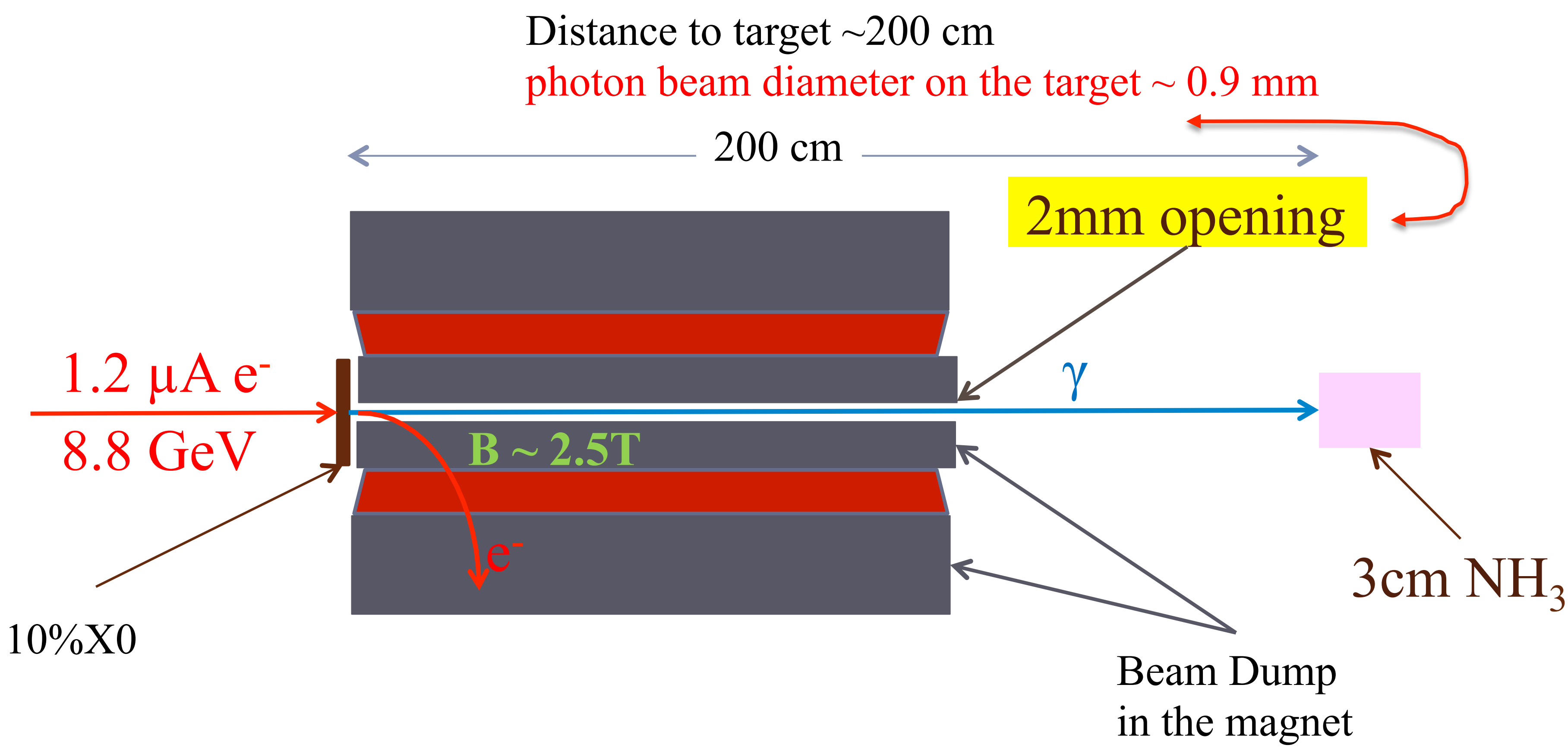
Luminosity in Double Polarized Experiments

1. NH3 target heat/damage capability is characterized by a limit on an electron beam intensity of 100 nA => $L_{eN} \sim 10^{36}$ cm^2/s which means the photon-nucleon $L_{\gamma N} \sim 5\ 10^{34}$ (eqv.-ph.) cm^2/s

2. Naturally, a pure photon beam allows to reach $L_{\gamma N} \sim 1.5\ 10^{36}$ (eqv.-ph.) cm^2/s which represents a significant gain by a factor of 30.

3. Exclusive reactions deal with very large physics backgrounds and require precision kinematical analysis which is possible for a narrow photon beam => This means a short distance between a photon radiator and the target.

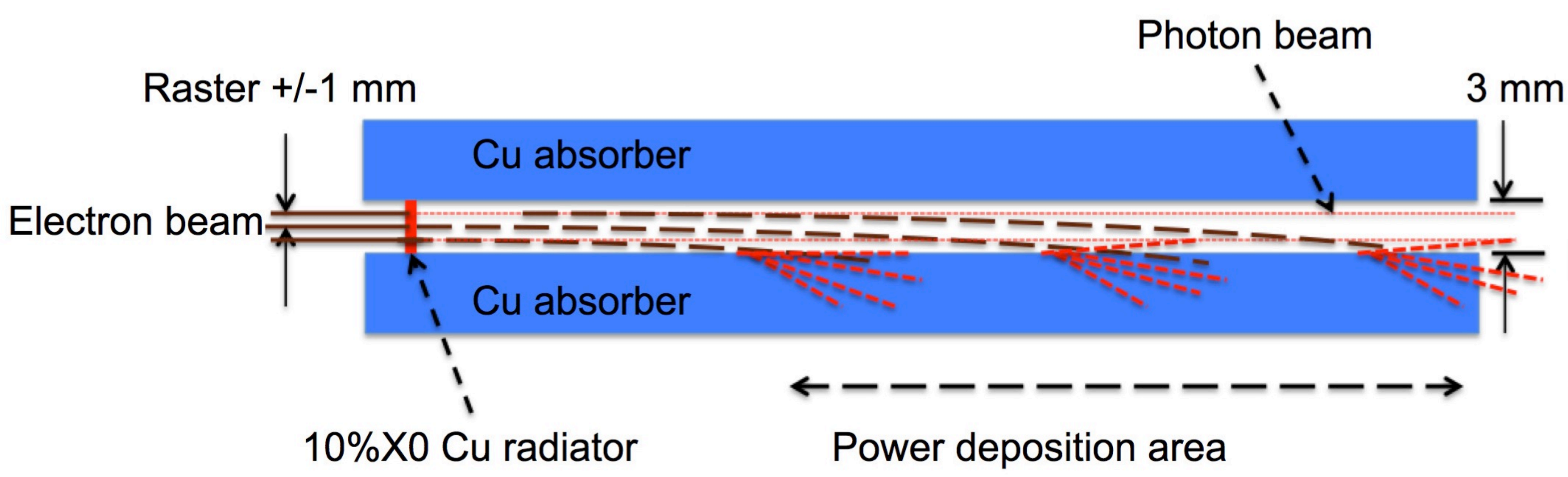
Hermetic Compact Photon Source



First presented at NPS meeting on November 19, 2014
with the Geant4 results for the WACS experimental setup

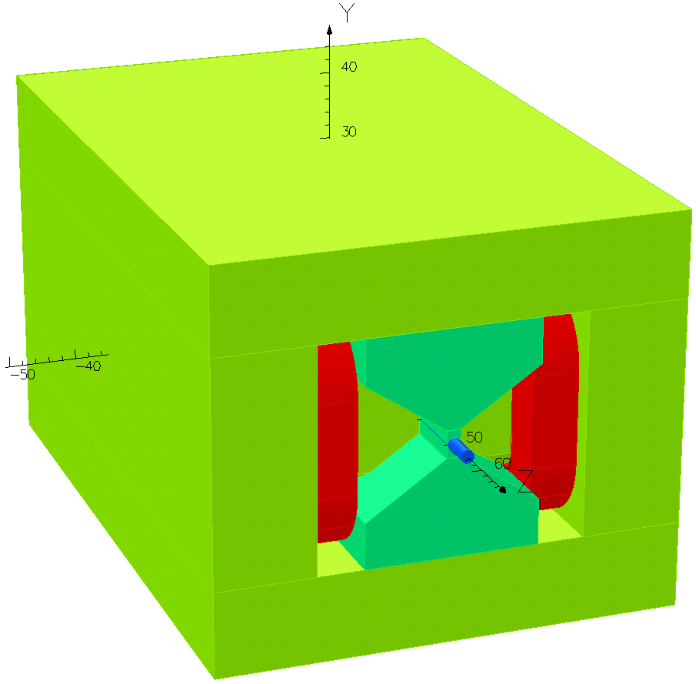
Hermetic Compact Photon Source

Longitudinal distribution of the beam power
is **a key part item** of CPS design

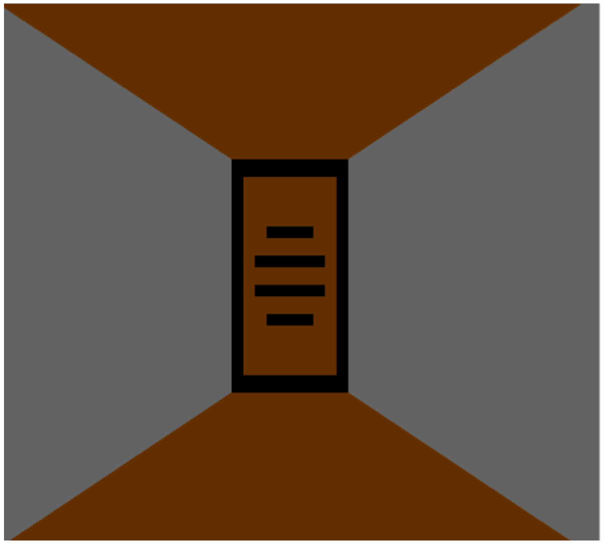


Hermetic Compact Photon Source

Magnet design



Beam rastering is difficult



From the CDR report in May-June, 2015 with
Geant4 results for a WACS experimental proposal

also a copy in arXiv:1712.06419

Hermetic Compact Photon Source

Collaboration building

Hi Everyone,

Referring to the list of action items for the NPS in 2016, I want to indicate the UVa group's support for Bogdan's conception for an intense pure photon source. It is clear to us that space limitations (and the physics of production) require the coupling of the bending magnet and the shielded dump. Bogdan's design might even be improved and it is likely we have the time to do so.

We have, since our presentation of a pure photon source to the NPS collaboration in late 2014, studied how such a device would drive the FOM for the approved experiment in Hall C - the improvement is substantial. We are excited about the other possibilities this might open up and are willing to work with everyone to make it a reality.

Zimbra 6/3/16, 12:15 PM

Unfortunately, I have a appointment at 9 am tomorrow. Please keep me apprised of your discussions.

All the best,

Donal

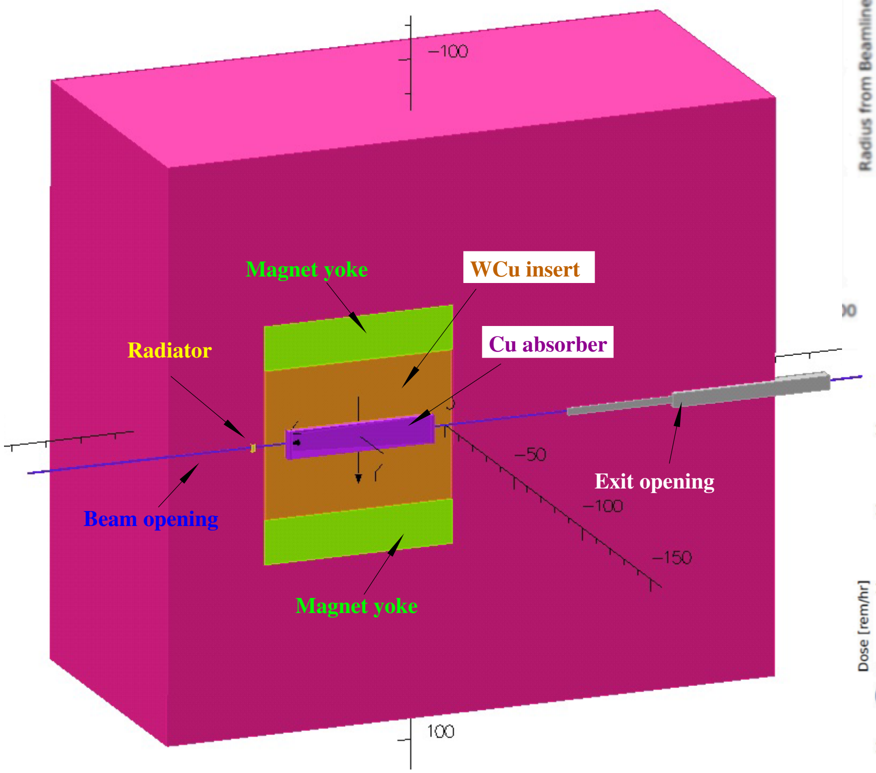
Hermetic Compact Photon Source

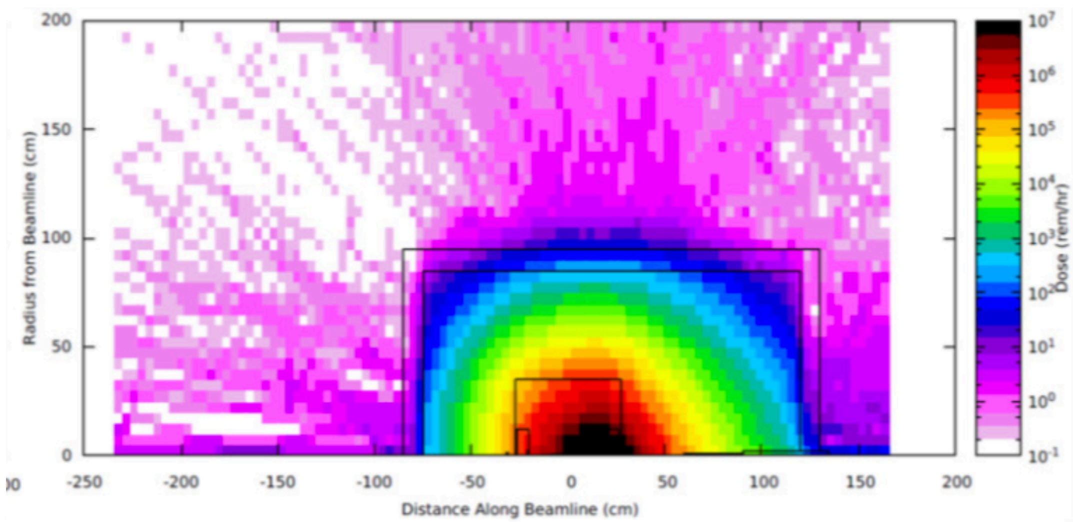
Physics case for CPS

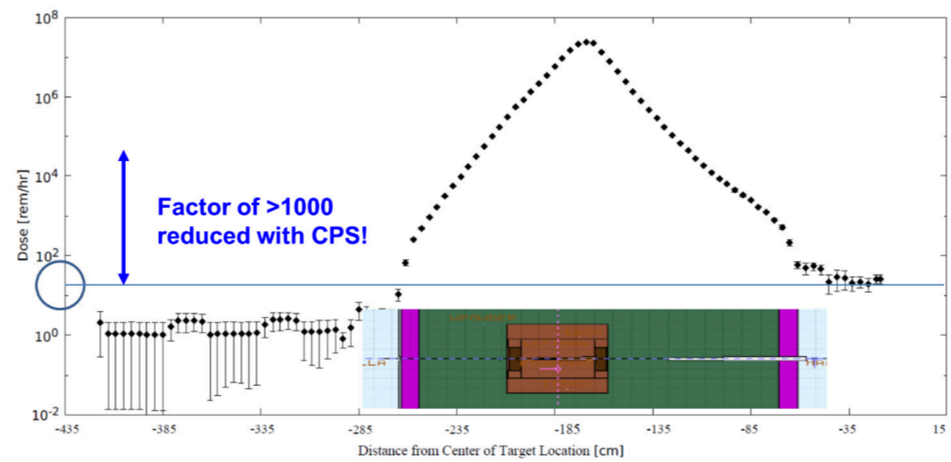
Workshop on High-Intensity Photon Sources (HIPS2017) Mini-Proceedings

6th - 7th February, 2017 Catholic University of America, Washington , DC, U.S.A.

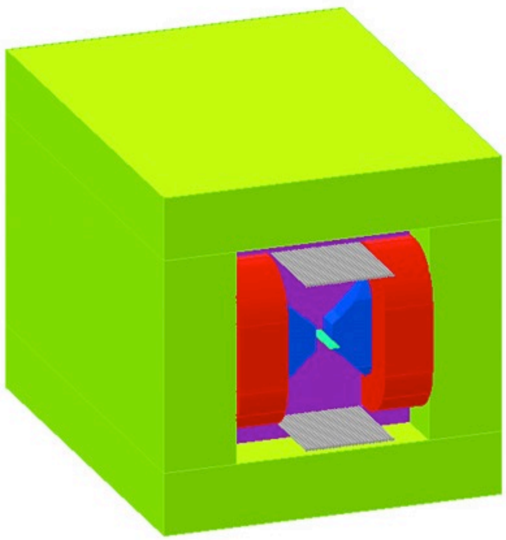
Compact Photon Source



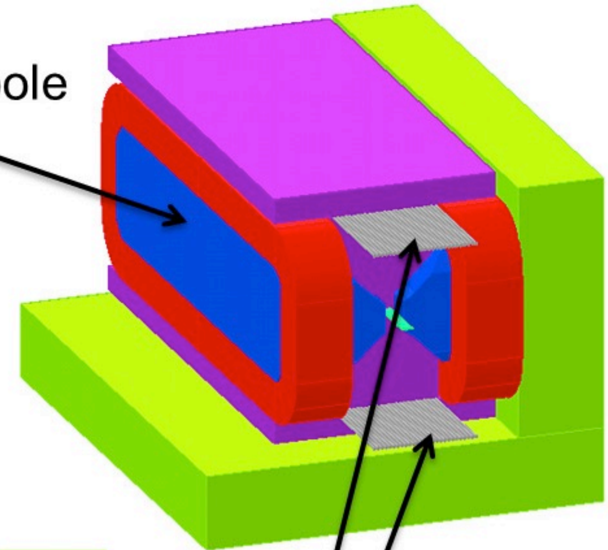




Compact Photon Source

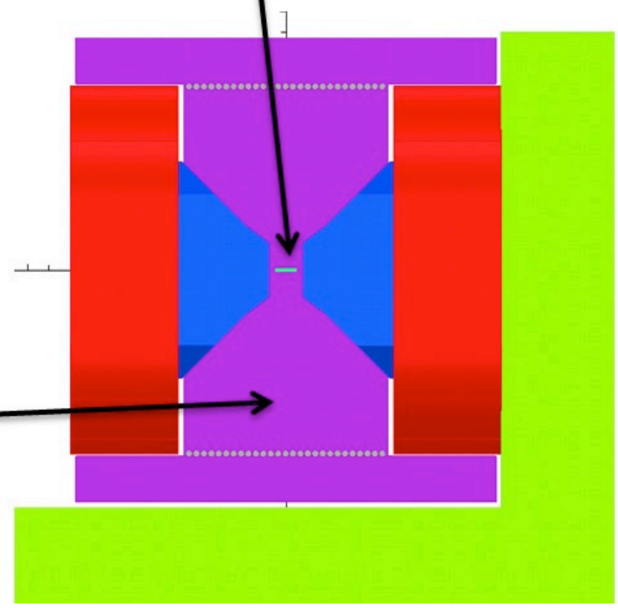


Permendur pole



2x20 mm^2 opening

Power 30 kW x 750 A
32 mm gap 2.0 Tesla



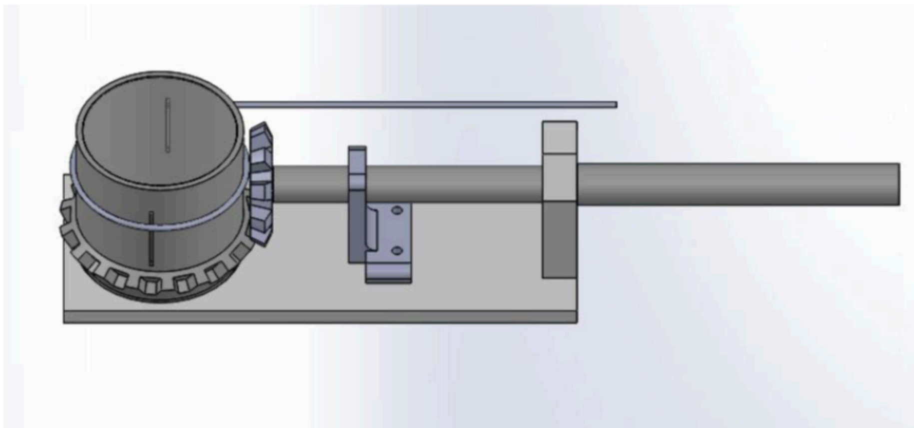
Cooling water lines

WCu power absorber and radiation shielding

A horizontal raster can be done but the vertical raster is a harder problem

Compact Photon Source

Rotation of the target is the proposed solution for rastering
(in combination with vertical movement of the ladder)



The rotating target cup driven by a gear and shaft with the NMR loop

The rate of rastering is important parameter:
Recent studies show that 1 Hz is sufficient.

The list of physics experiments

The exclusive reactions

- The double polarization RCS – APPROVED by PAC45 for 46 days

ALL in WACS at high u and t => access to the axial FF of a nucleon.

- The double polarized TCS – proposal PR12-18-005 (C2) by PAC46

ALS in TCS at high s => unique access to the GPD E of a nucleon.

- Double polarization pion photo-production: p(γ,π + N) – cross section

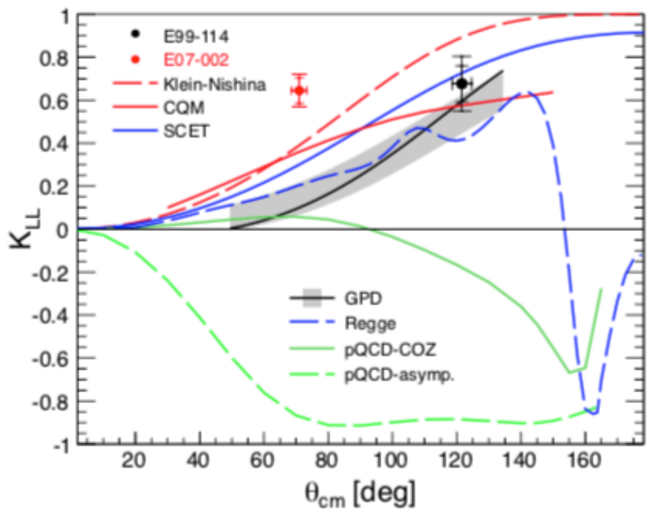
with small steps on incident photon energy and ALL, ALS – a key test of the loop-3 diagram, a puzzle of a factor 50 in the cross section value, a meson-nucleon resonance with 2.5 GeV mass.

- Double polarization deuteron disintegration D(γ,p + n)

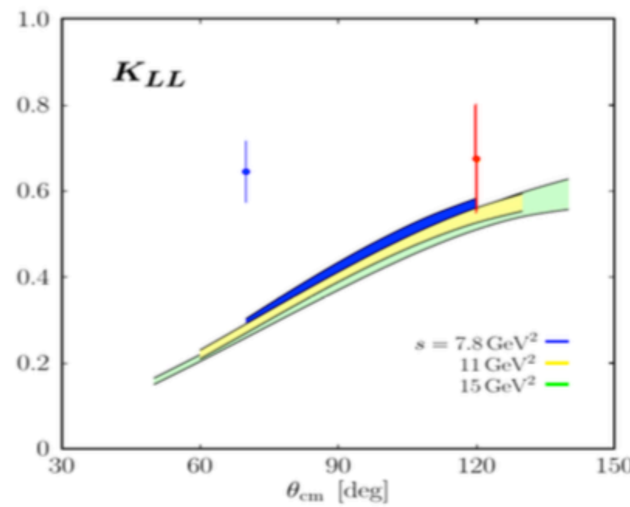
- The nature of a wide LHCb pentaquark: p(γ,J/Psi + p), LOI12-18-001

JLab approved WACS experiment

Hamilton *et al.* PRL94 (2005)
Fanelli *et al.* PRL115 (2015)



Diehl & Kroll Eur. Phys. J. C73 (2013)



- Results strongly favour leading quark (Feynman) mechanism ($x \approx 1$).
- E07-002 result is larger than all predictions including Klein-Nishina: $K_{LL} = R_A(t)/R_V(t)\,K_{LL}^{\mathrm{KN}} \implies$ large $R_A(t)$.

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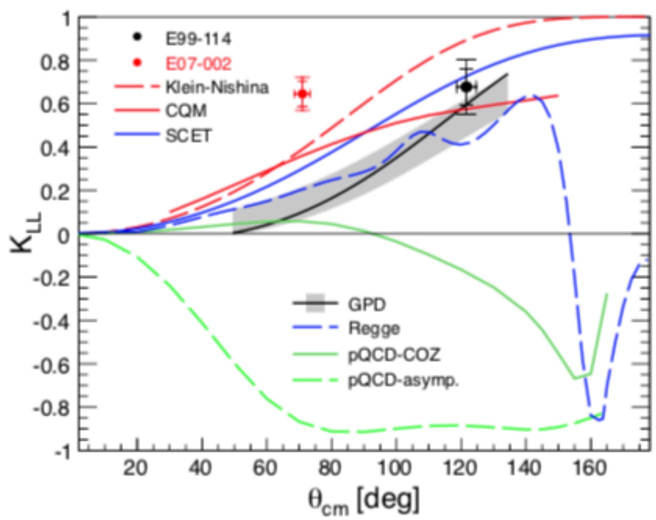
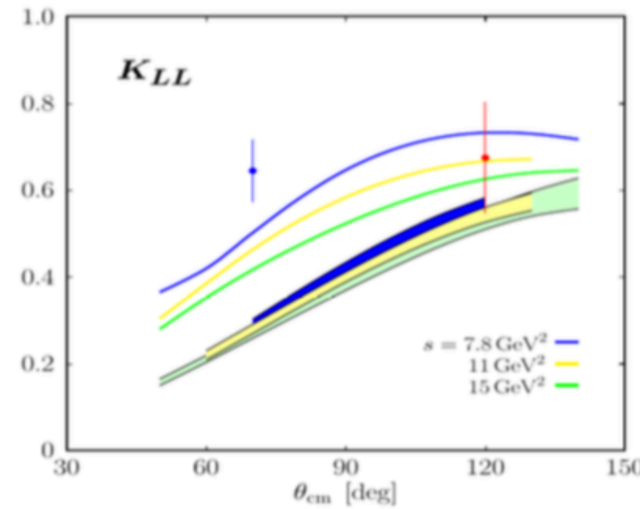


Diehl & Kroll Eur. Phys. J. C73 (2013)
Kroll arXiv:hep-ph/1703.05000 (2017)



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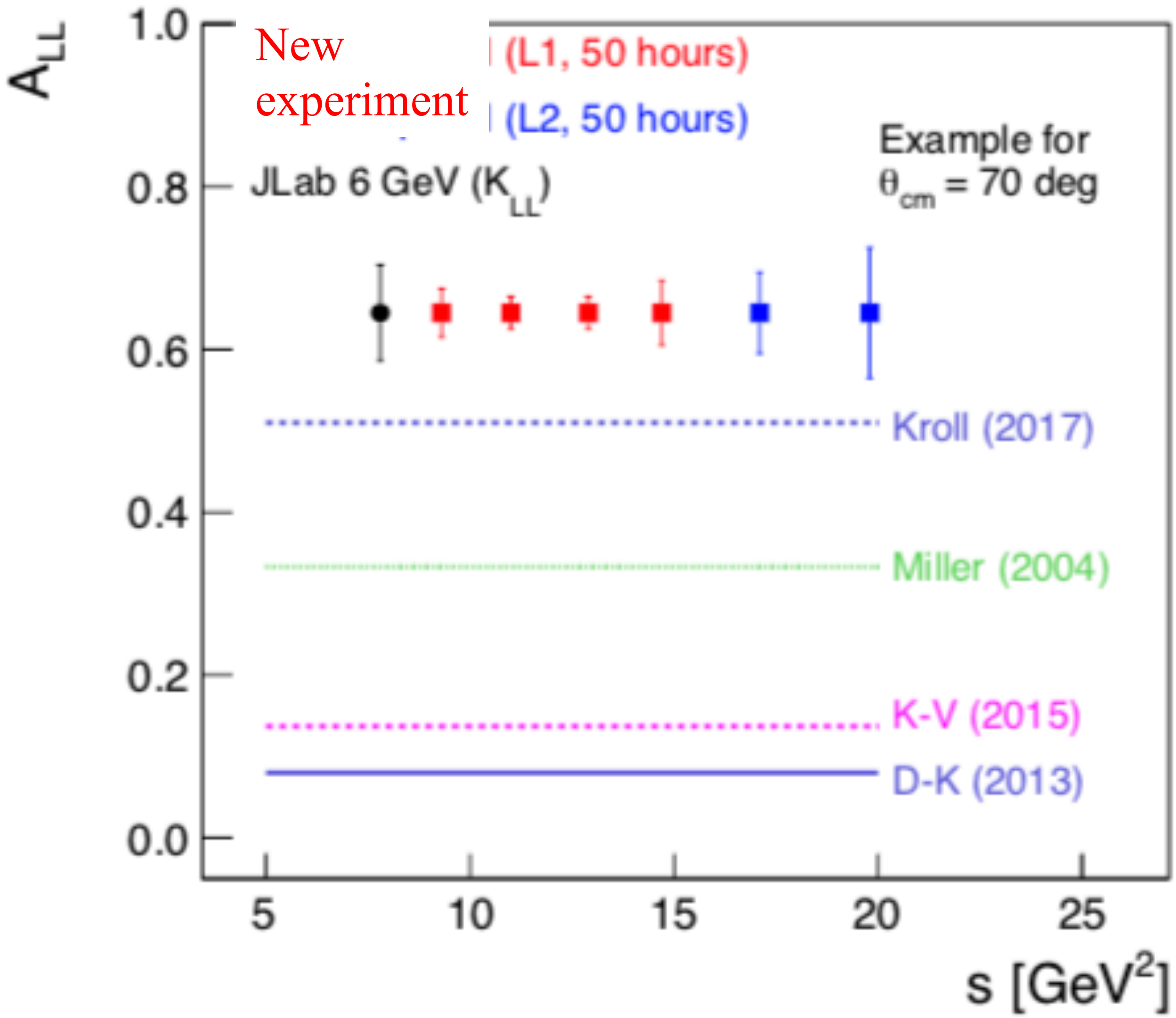
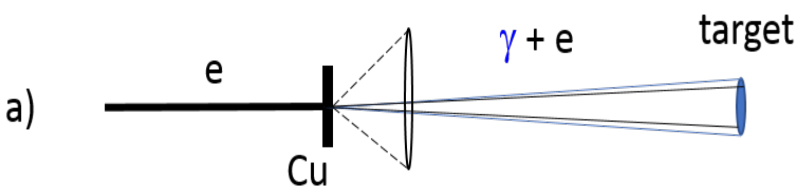
New result suggests axial nucleon current is larger that vector current at moderate $-t$, but validity of factorization and mass corrections are potentially problematic.

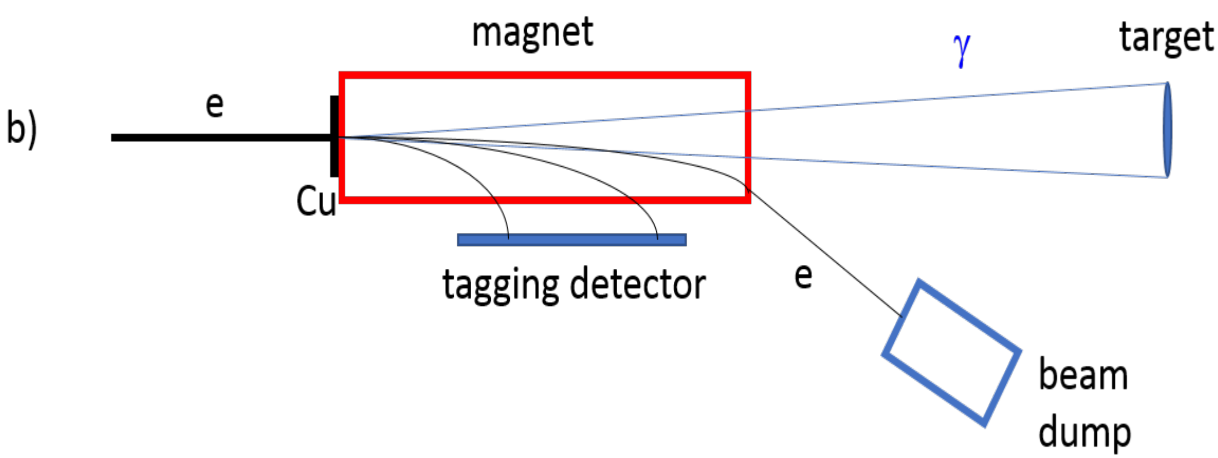
JLab approved WACS experiment



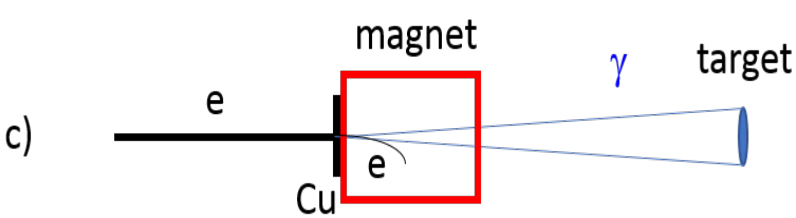
80 years history of photo-induced nuclear reactions



Mixed e-γ beam: SLAC, JLab
Heat load limits intensity



Pure γ beam (incl. tagged)
NINA, Bonn, DESY, Cornell, SLAC, Mainz, JLab
Large size and cost facility, large beam spot at the target



Novel concept: Compact Photon Source
Narrow channel for an electron beam:
15 cm long beam power deposition,
“hermetic” beam dump with a10 times shorter distance from the radiator to target

The projected time-line

The goal is to have final document completed by August and have the paper ready for submission by fall 2019.