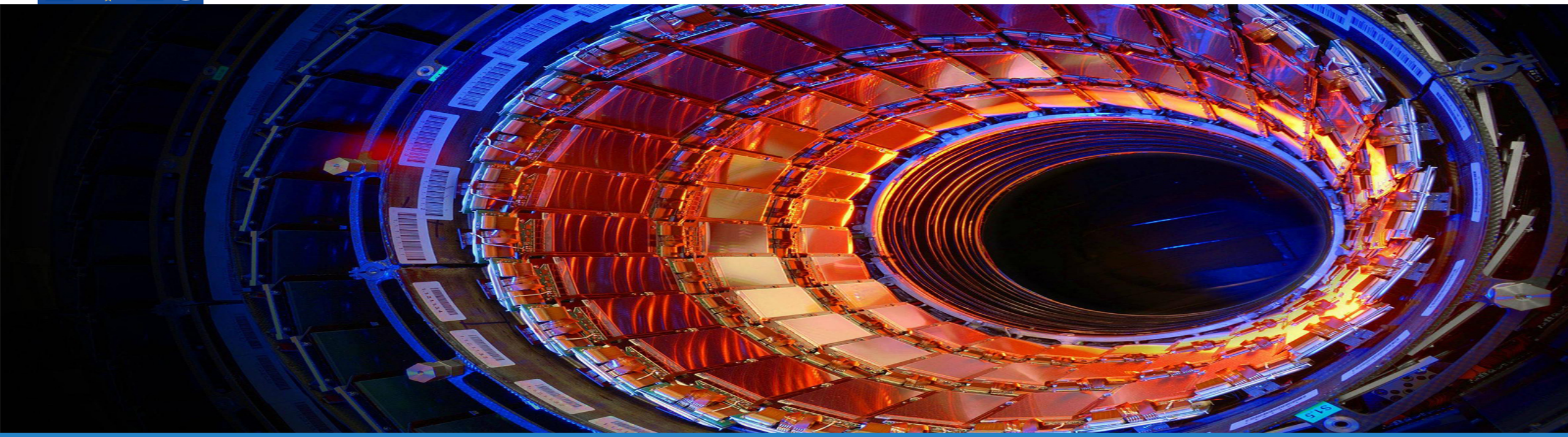


JRA 13:
Polarized Electrons, Positrons and Polarimetry (P3E)

Niklaus Berger, JGU Mainz, for JRA 13

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 824093

Polarized Electrons, Positrons and Polarimetry (P3E)

STRONG-2020 Annual Meeting, October 14-15, 2020

Pushing further

the **intensity frontier** of polarized electron sources,

the **intensity frontier** of low energy polarized positron sources,

and the **precision frontier** of electron polarimetry.

P3E-1: High Intensity Polarized Electron Source

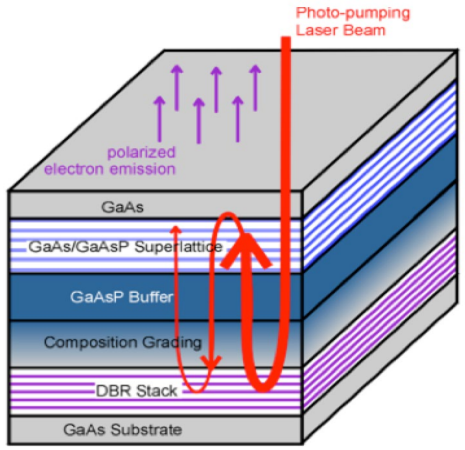
P3E-2: High Intensity Polarized Positron Source

P3E-3: High Precision Electron Polarimetry

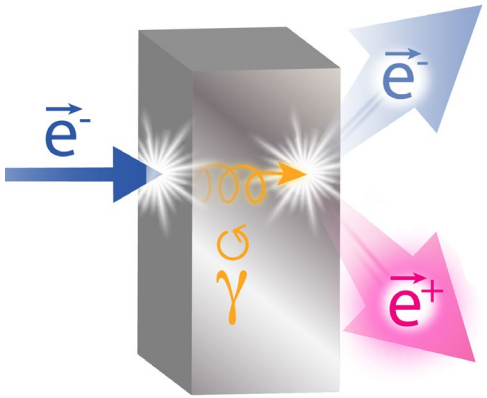
Polarized Electrons, Positrons and Polarimetry (P3E)

STRONG-2020 Annual Meeting, October 14-15, 2020

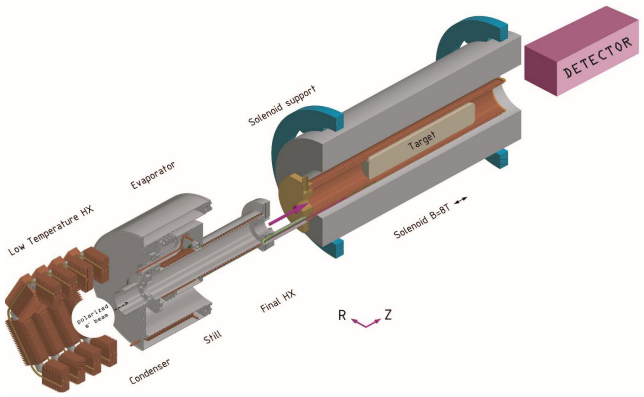
Photocathode R&D: Development of high quantum effciency and long live-time photocathodes



Polarized Positron R&D: Application of the newly demonstrated PEPPo technique to hadronic physics accelerators



Polarmieter R&D: High precision and accuracy polarimetry for low energy electron beams – detector systems



High Intensity Polarized Electron Source

TASKS/Subtasks	Year 1				Year 2				Year 3				Year 4			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
P3E-1. High Intensity Polarized Electron Source																
1.1 Modelling of photocathode quantum efficiency								MS75								
1.2 Proof-of-concept experimentation												MS76				

- No deliverable over the first Reporting Period
- Good progress towards MS75 & MS76

Completed

- Modelling and simulation of ion-bombardment in a dc-high voltage photo-gun
- Experimental evaluation of the effect of photo-gun biasing on photcathode lifetime

In progress

- Simulation of the effects of increased laser area illumination

Simulating Photocathode Ion Bombardment

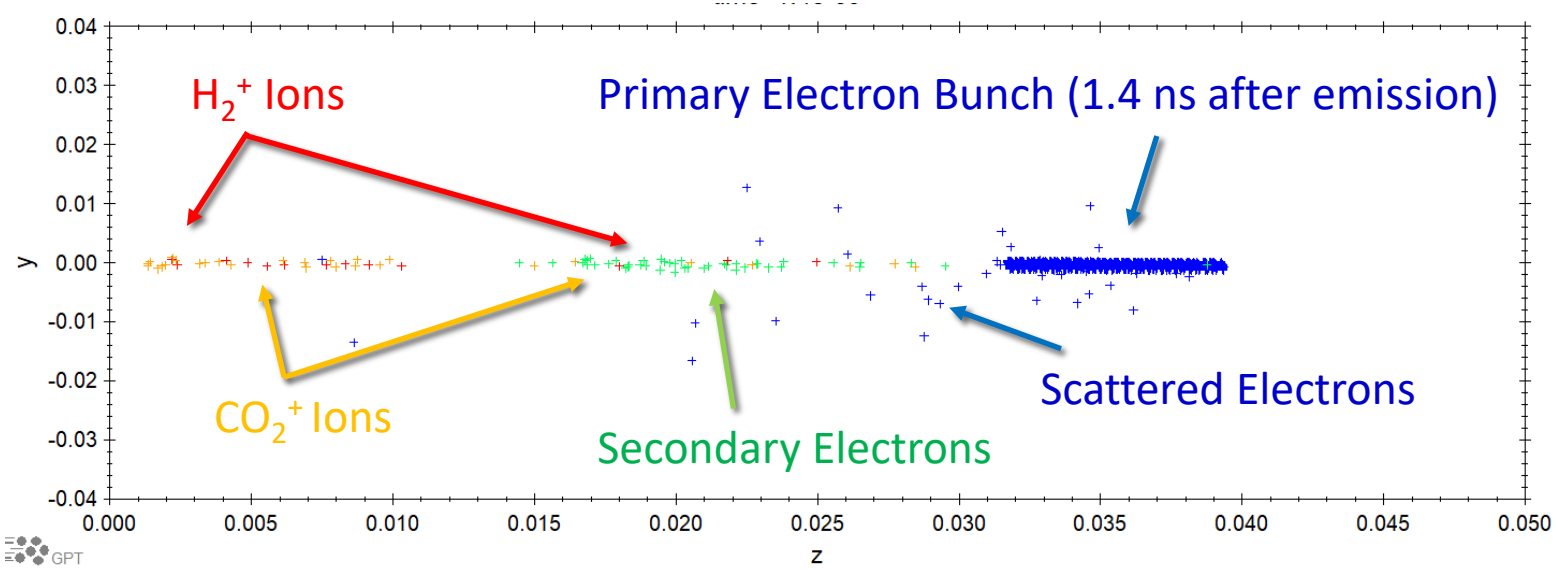
PhD Research of J. Yoskowitz (JLab/ODU)

STRONG-2020 Annual Meeting, October 14-15, 2020

Predicting the generation of ions and their secondaries in and around a dc-high voltage photo-gun to design future mitigations of ion back bombardment and to explain experimental studies.

A new custom element for the software *General Particle Tracer* was developed.

Monte Carlo algorithms sample ionization cross-sections of typical gasses (H_2, He, CO, CH_3, CH_4) to create realistic rate and energy reactions to study the dynamics of ions and secondary electrons along the primary electron beam trajectory.



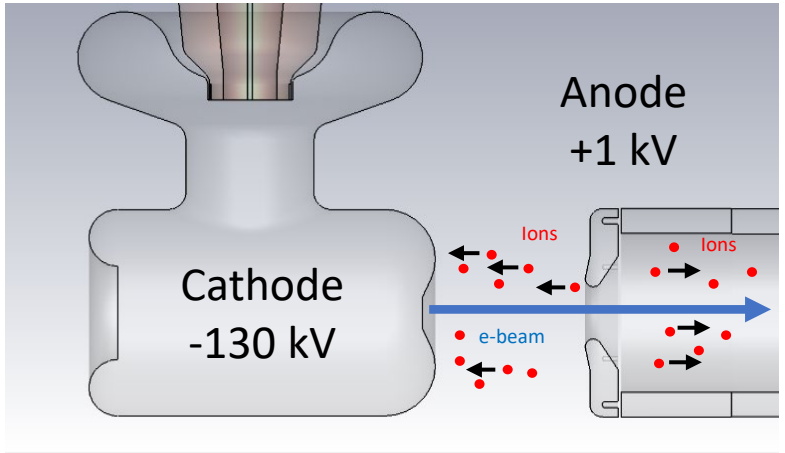
Measuring Photocathode Lifetime

PhD Research of J. Yoskowitz (JLab/ODU)

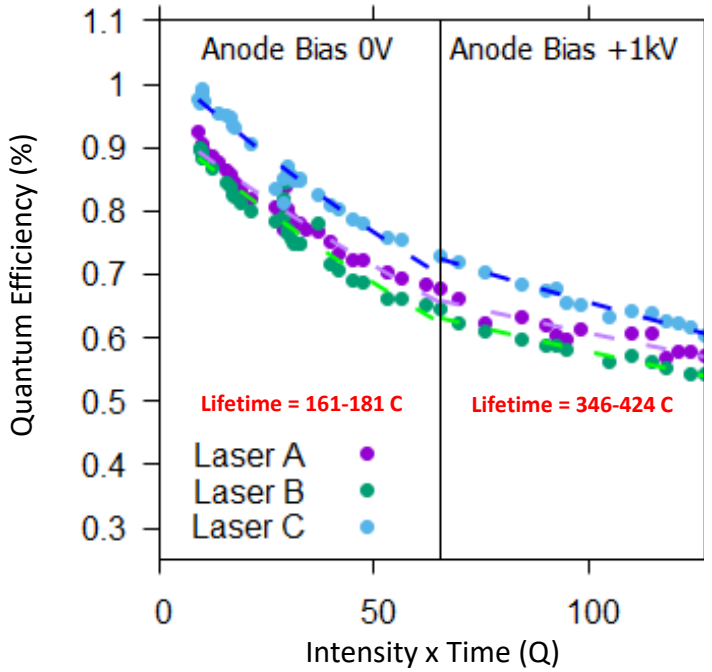
STRONG-2020 Annual Meeting, October 14-15, 2020

An electron beam in a high-voltage dc photo-gun ionizes residual gas, such as hydrogen or carbon monoxide.

Applying a modest positive bias to the anode should repel ions from entering the accelerating cathode-anode gap, limiting ions from bombarding the photocathode.



Measurements performed at the CEBAF injector in 2019 demonstrated reducing the ion damage rate by about 50%, very significant.



High Intensity Polarized Positron Source

TASKS/Subtasks	Year 1				Year 2				Year 3				Year 4			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
P3E-2. High Intensity Polarized Positron Source																
2.1 Simulation of positron production, collection, deceleration				MS77				MS77						MS77		
2.2 Target stress simulation and experimental analysis				MS78						MS78			MS78			

- No deliverable over the first Reporting Period
- Good progress towards MS77
- Some delay in MS78 progress following the postponement of the STRONG 2020 funded personnel because of the pandemic

Completed

- Implementation of the simulation framework of positron production
- Comparative study of positron collection devices

In progress

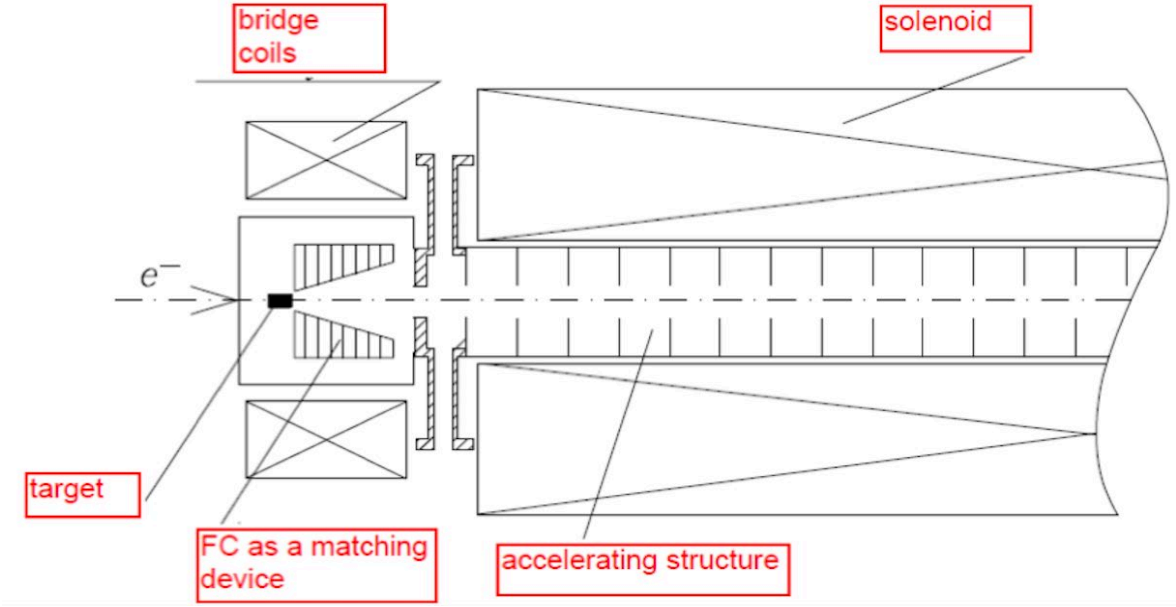
- Irradiation of targets and damage analysis via synchrotron diffraction method
- Modelling of polarization processes within Geant4
- Modelling of positron capture

Modelling a (PEPPo) Polarized Positron Source

PhD Research of S. Habet (IJCLab/JLab)

STRONG-2020 Annual Meeting, October 14-15, 2020

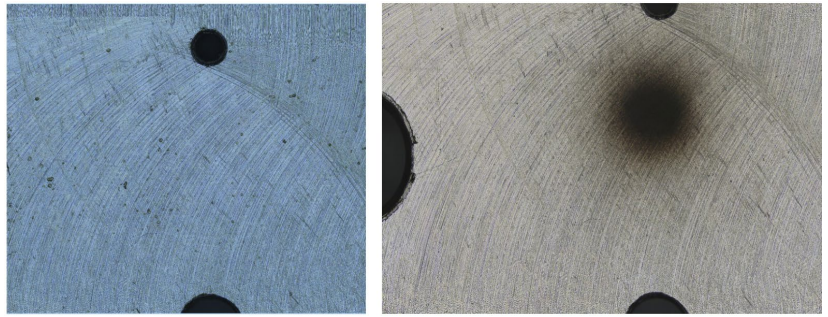
The essential components of a positron source are: an initial beam (e^- or γ), a positron production target, a positron collection device (magnet), and a positron capture system (accelerating structure). The full modelling of a high duty-cycle polarized positron source is one P3E objective.



Completed efforts concern the **production** and the **collection** of positrons.

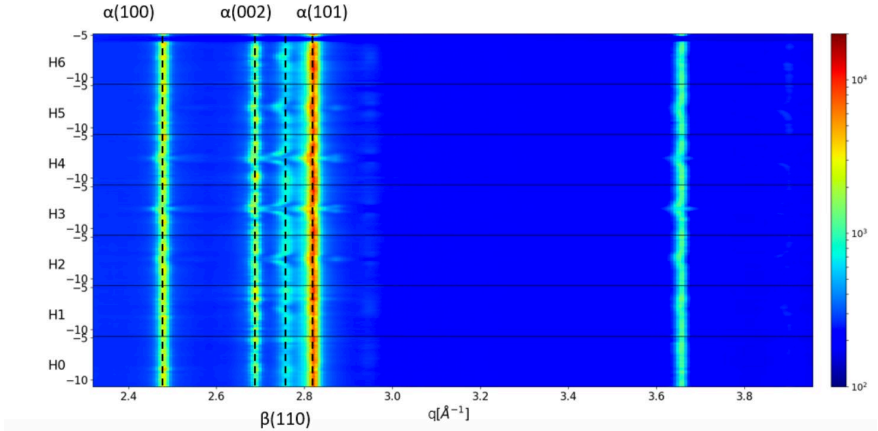
The evaluation of different target materials for the production of positrons is worked-out by irradiating materials with the MAMI electron beam at different energies, pulse lengths, and frequencies, varying the Peak Energy Deposition Density. Material damages further are characterized by synchrotron diffraction techniques at PETRA III.

Target before and after radiation



Ti-Alloy targets were irradiated with a 3.5 MeV electron beam, causing a temperature increase of 120°C

α/β phase transitions in Ti-6Al-4V



Analysis with 87.1 keV X-rays reveals phase transitions for targets irradiated in CW-mode.

Bachelor Research of T. Lengler (UH)

e⁺@JLab

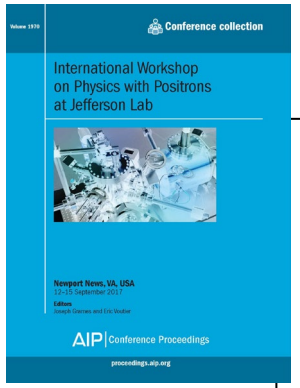
Publications

- e+@JLab White Paper, arxiv:2007:15081, JLab-PHY-20-3232 (2020).

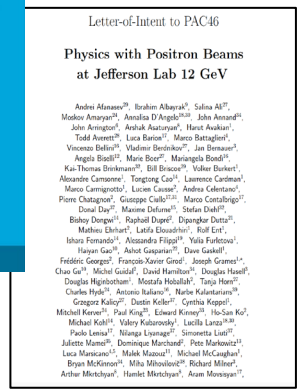
Invited presentations at the

- 2020 International Accelerator Particle Conference
- Workshop on Beam Polarization and Polarimetry at EIC

STRONG-2020 Annual Meeting, October 14-15, 2020



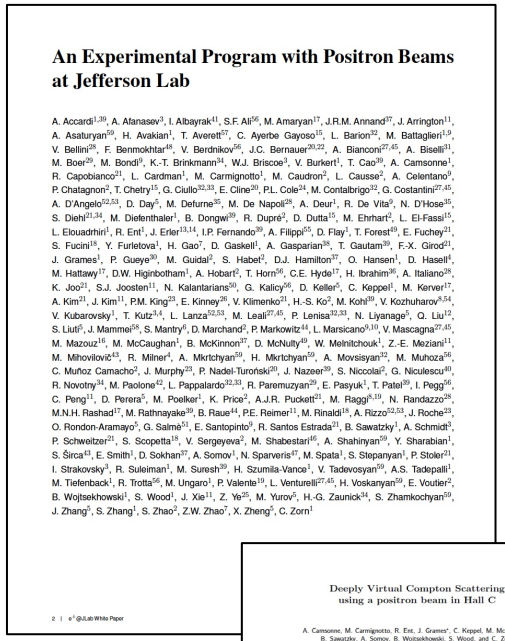
2018



Following the publication of JPos17 proceedings and a Letter-of-Intent to PAC46, P3E members drove the JLab positron effort towards a **White Paper** and the submission of **two proposals** at PC48.

e+@JLab White Paper

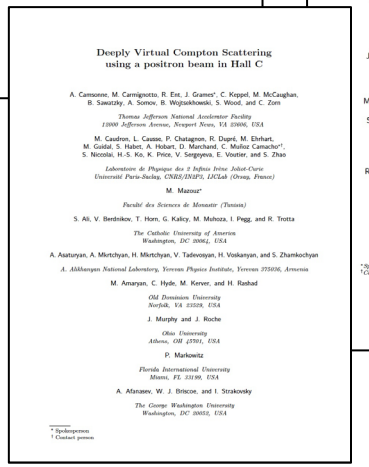
A community of 200 physicists from 59 Institutions supports a high impact experimental program with positron beams at JLab.



Proposals

- DVCS cross section on the proton (C. Muñoz Camacho et al.)
- DVCS beam charge asymmetry on the proton (E. Voutier et al.)

Conditionally approved

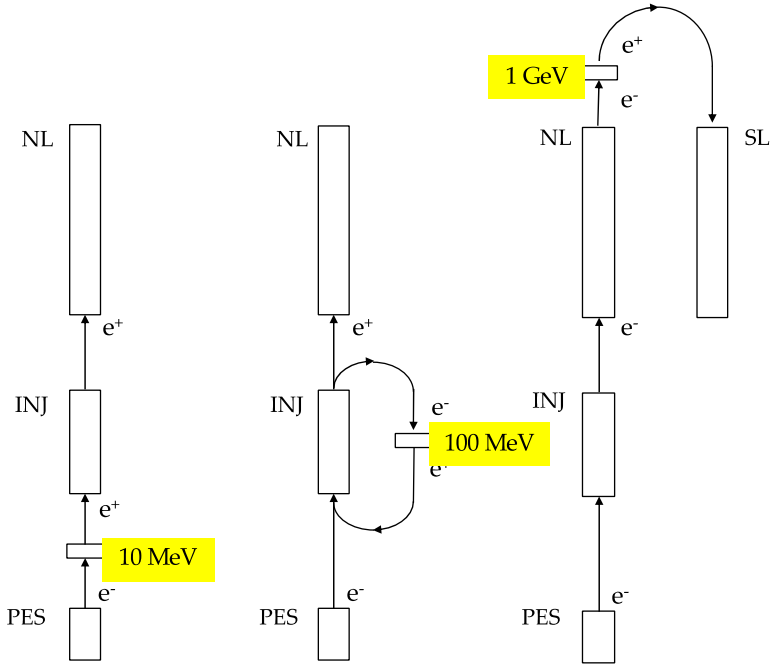


2020

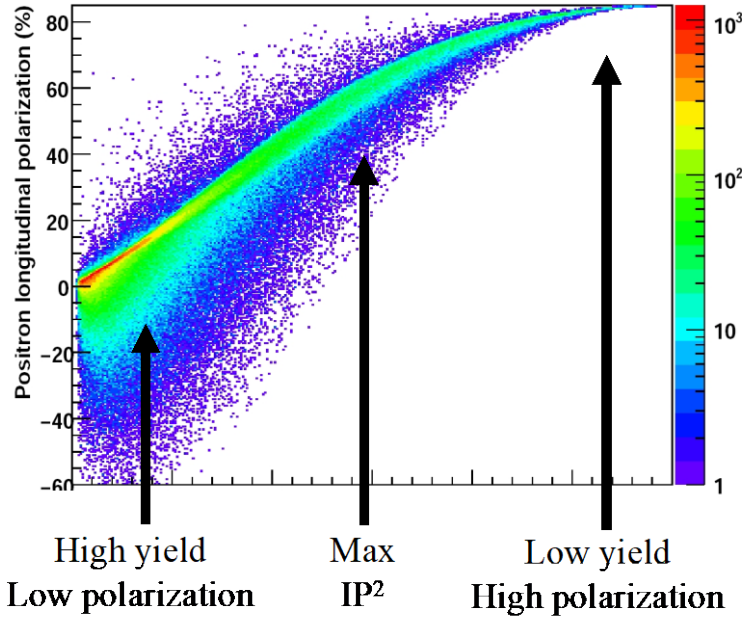
e⁺@JLab

In parallel to P3E efforts, the proposal “A positron source for our future” was awarded funding under the FY2021 Laboratory Directed Research and Development Funds. It will determine the most appropriate scheme for installing a PEPPo source at JLab, and will set the basis for a prototype.

Towards a Conceptual Design Report…



Behavior is universal for any electron beam energy:
10 MeV, 100 MeV or 1 GeV



J. Grames et al. (JLab)

STRONG-2020 Annual Meeting, October 14-15, 2020

High Precision Electron Polarimetry

TASKS/Subtasks	Year 1				Year 2				Year 3				Year 4			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
P3E-3. High Precision Electron Polarimetry																
3.1 Simulation of the polarimeter detector						MS79										
3.2 Technical design of the polarimeter detector																

- No deliverable over the first Reporting Period
- Some delay in hiring personnel because of the pandemic
- Still on target for MS79 in November

Completed

- Implementation of the simulation of the Hydro Moller target
- Implementation of the simulation of the magnetic chicane
- Implementation of the simulation of generic detector

In progress

- Simulation of monolithic pixel detector
- Characterisation measurement of high-voltage monolithic active pixel sensors

Hydro-Moller Polarimeter

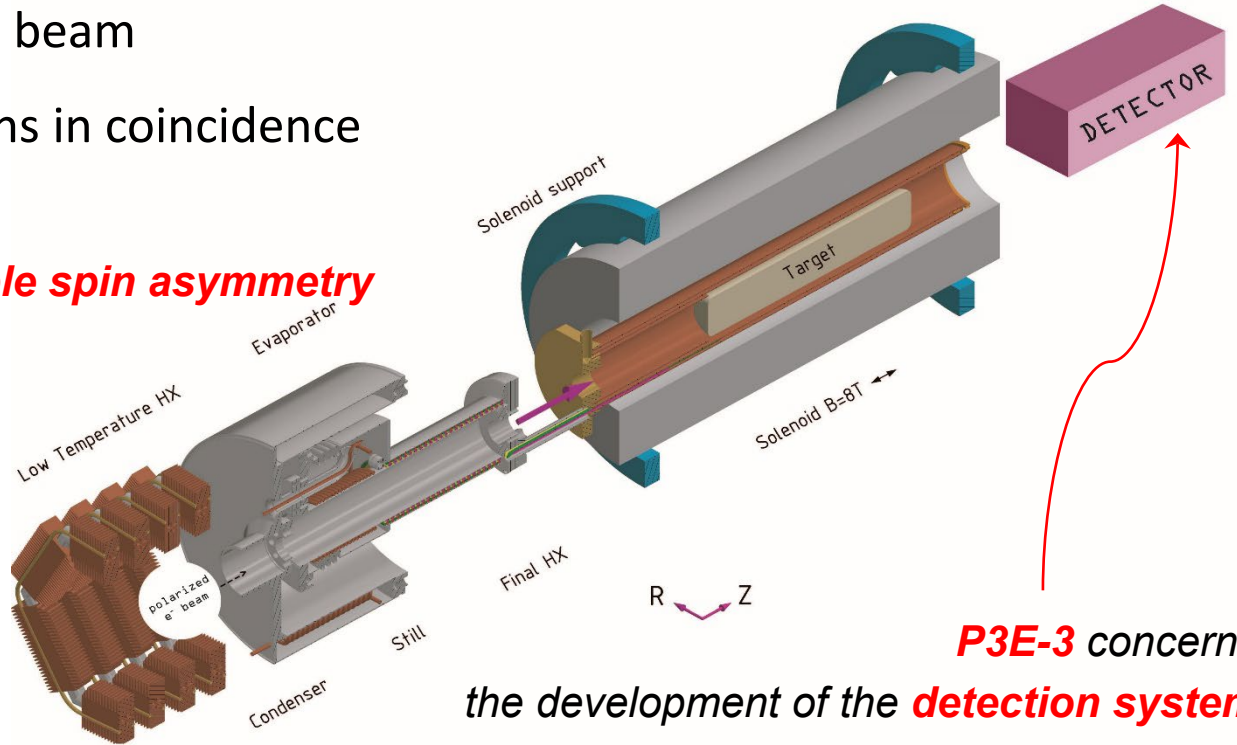
STRONG-2020 Annual Meeting, October 14-15, 2020

Reminder : Hydro-Møller polarimeter for on-line polarimetry at ~100 MeV

P2 @ MESA

- Trap and polarize atomic hydrogen in high-field solenoid at 0.3 K
- Requires dilution cryostat (under construction at Mainz)
- Magnetic chicane to separate Moller electrons from beam
- Detect electrons in coincidence

➥ ***Measure double spin asymmetry***



P3E-3 *concerns the development of the* ***detection system***

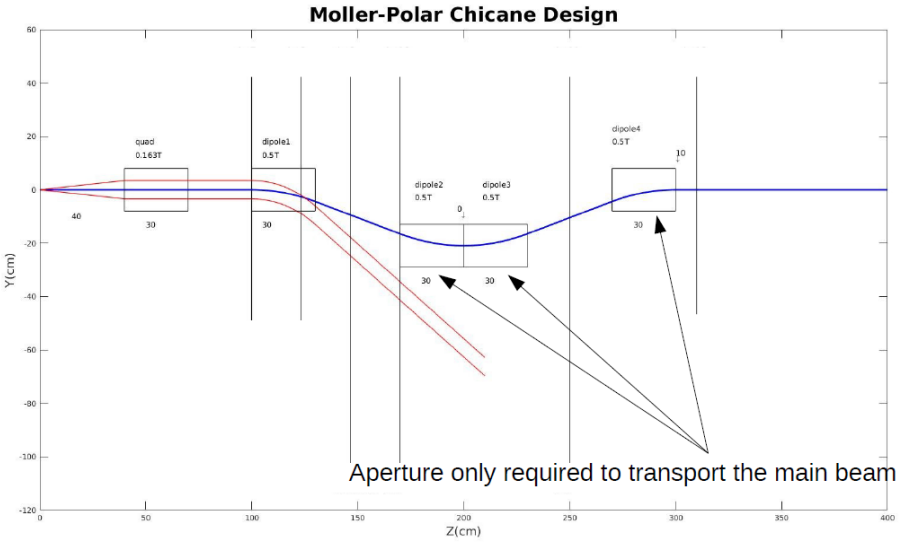
Simulating the Hydro Moller detector

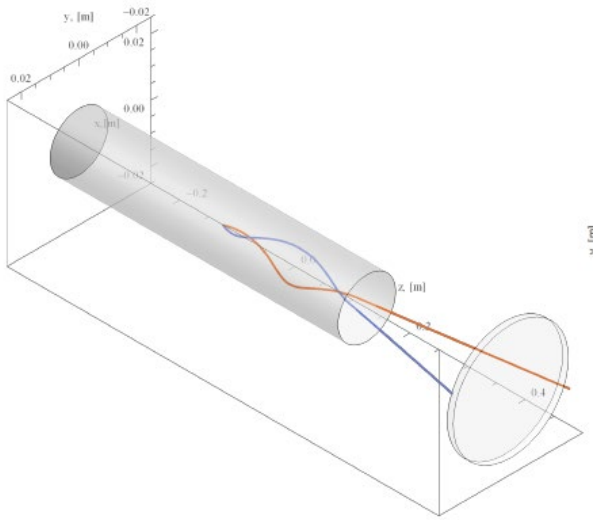
Contributions from

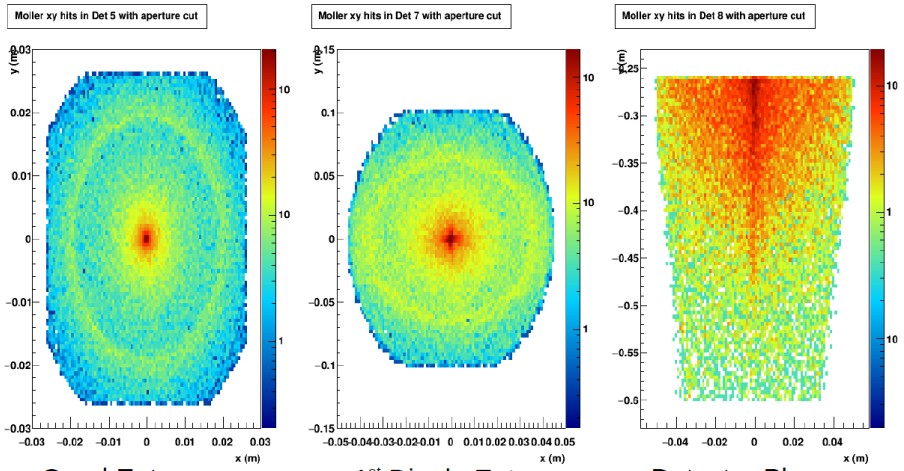
V. Tyukin, K. Kumar, R. Beminiwhatta, S. Riordan

STRONG-2020 Annual Meeting, October 14-15, 2020

- Design available for a detection chicane to separate Møller and beam electrons
- Simulation tracks electrons from hydrogen through the magnet system up to the detector
- Generic simulated detector
- Ongoing: integrate HV-MAPS sensors insimulation package (HYMOSIM)







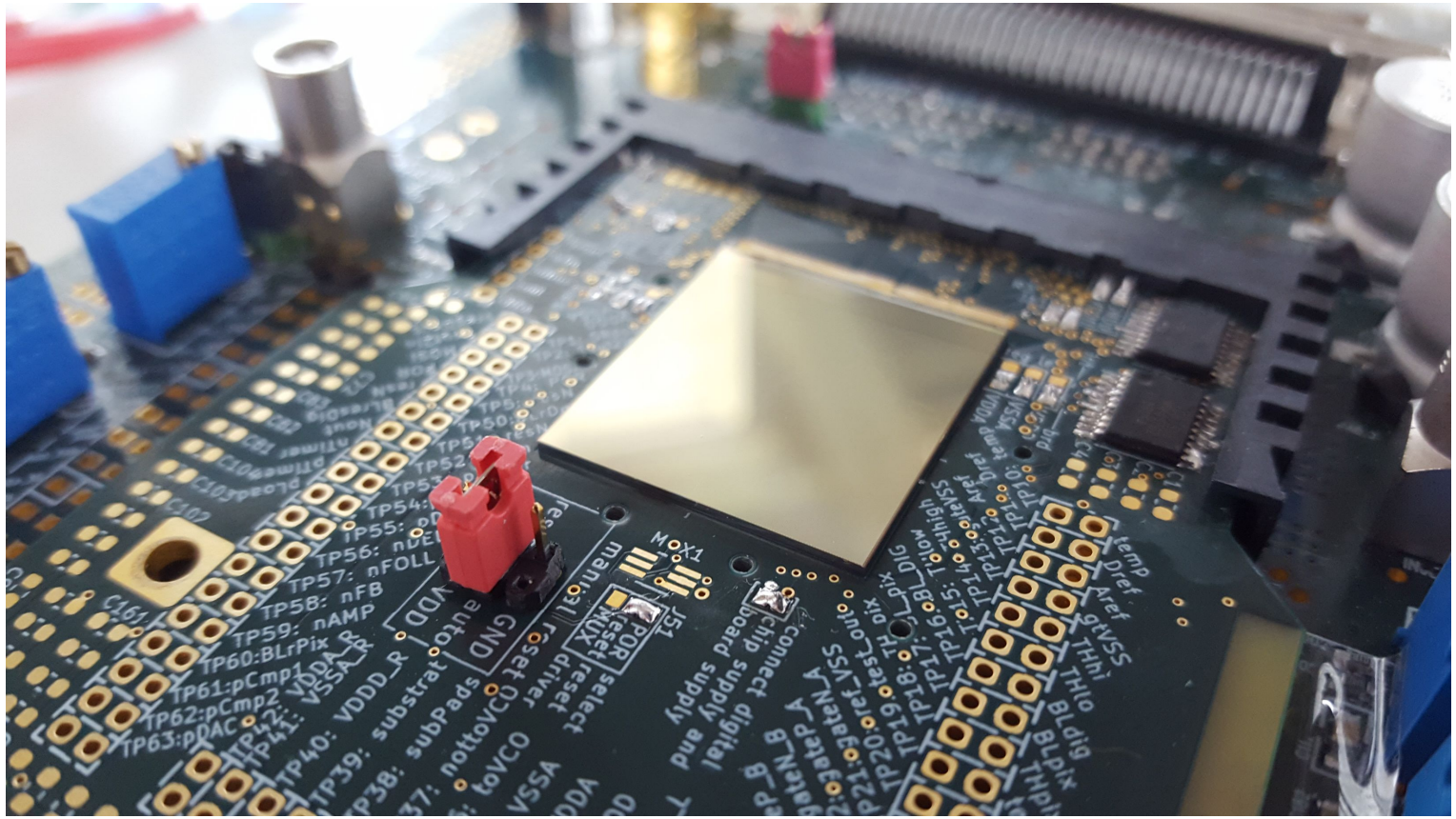
Quad Entrance | 1st Dipole Entrance | Detector Plane

Evaluating HV-MAPS Pixel senors

Full size (2cm x 2cm) sensors available

Beam tests at DESY, PSI and MAMI

First results promising



Summary

JRA P3E is on track to provide:

- High quantum efficiency, long lifetime photocathodes for high-current polarized electron beams
- Polarized positron beams obtained with the PEPPo technique
- High precision electron polarimetry using Moller scattering on atomic hydrogen in a trap and the associated electron detector