



JRA 13: Polarized Electrons, Positrons and Polarimetry (P3E) Niklaus Berger, JGU Mainz, for JRA 13





Polarized Electrons, Positrons and Polarimetry (P3E)

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

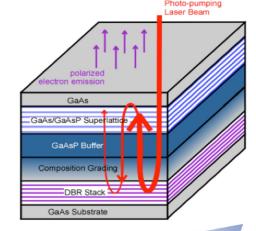
P3E-2: High Intensity Polarized Positron Source

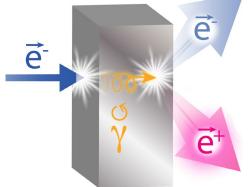
P3E-3: High Precision Electron Polarimetry



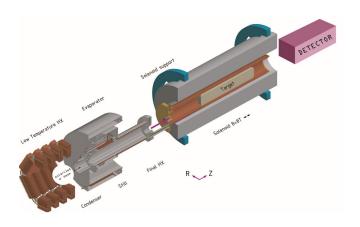
Polarized Electrons, Positrons and Polarimetry (P3E) Photocathode R&D: Development of high quantum effciency and long live-time photocathodes

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	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							ļ									
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



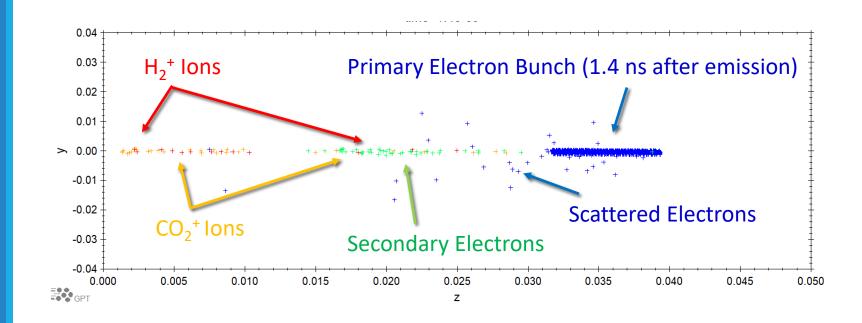
Simulating Phothocathode Ion Bombardment

PhD Research of J. Yoskowitz (JLab/ODU)

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 (H₂, He, CO, CH₃, CH₄) to create realistic rate and energy reactions to study the dynamics of ions and secondary electrons along the primary electron beam trajectory.





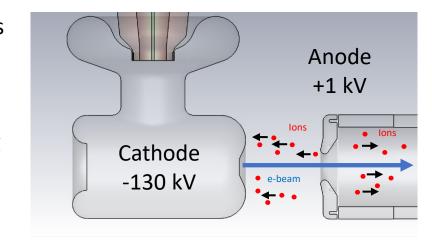
Measuring
Phothocathode
Lifetime

PhD Research of J. Yoskowitz (JLab/ODU)

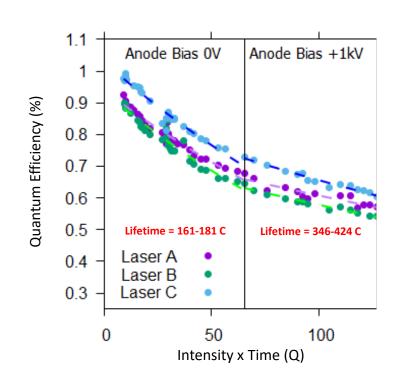
STRONG-2020 Annual Meeting, October 14-15, 2020

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 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							ļ									
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

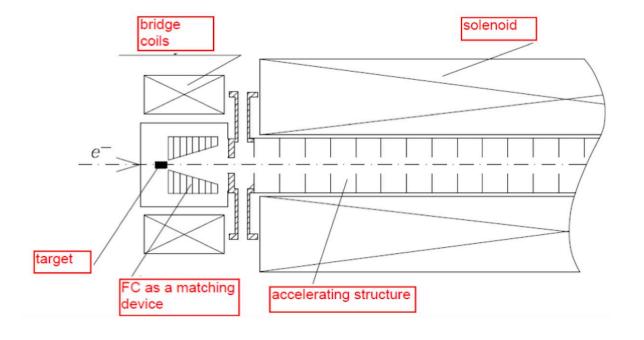
- Irradiation of targets and damage analysis via synchrotron diffraction method
- Modelling of polarization processes within Geant4
- Modelling of positron capture



Modelling a (PEPPo) Polarized Positron Source

PhD Research of S. Habet (IJCLab/JLab)

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.

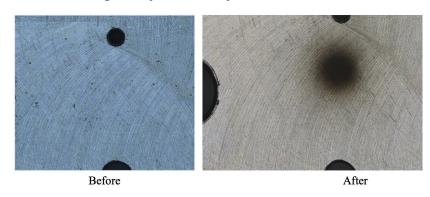


Bachelor Research of T. Lengler (UH)

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

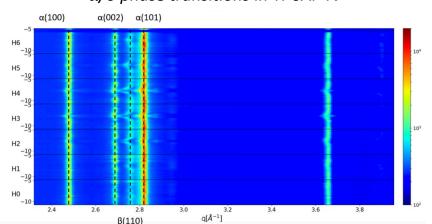
The evaluation of different target materials for the production of positrons is worked-out by irradiating materials with the MAMI electron beam at different energies, pulse lengths, and frequencies, varying the Peak Energy Deposition Density. Material damages further are characterized by synchrotron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



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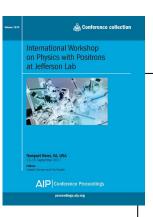
Publications

- 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

Physics with Positron Beams at Jefferson Lab 12 GeV

Andrei Altensen¹⁰. Brahm Albayrak¹. Salina All².
Molake Amayam². Anatisa D.Naghin². John Assan².
Molake Amayam². Anatisa D.Naghin². John Assan².
Told Amerit². Lose Bissen². Messe Bratispie².
Vincense Bistim². Vindense Benisham². John Bensun².
Angels Bissel². Messe Bost². Messen Bost².
Molake Bost². Messen Bost².
Molake Bost². John Bensun².
Alleanthe Carmone². Torgiese Gos². Lessen Confeller,
Molace Cemporol. Torgiese Gos². Lessen Confeller,
Peric Catagon². Georges Cale^{217.2}. Monto Contableg².
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Molace Horen². Park Rollin². Grand Komer³. Hospate Gos².
Desgies Highotsham³. Mostafrie³. Desde Komer³. Hospate Molace Michael Moren³. Post Rollin³. Grand Komer³.
Molace Michael³. Molace Michael³. Post Rollin³. Grand Komer³. Hospate Molace Michael³.
Molace Michael³. Molace Michael³.
Jalente Manne³. Desinique Marchael³. Pet Melacetal³.
Jalente Manne³. Desinique Marchael³. Pet Melacetal³.
Jalente Manne³.

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.

An Experimental Program with Positron Beams at Jefferson Lab

A. Accardi^{1,39}, A. Afanasev³, I. Albayrak⁴¹, S.F. Ali⁵⁶, M. Amaryan¹⁷, J.R.M. Annand³⁷, J. Arrington A. Asaturyan⁵⁹, H. Avakian¹, T. Averett⁵⁷, C. Ayerbe Gayoso¹⁵, L. Barion³², M. Battaglieri¹ V. Bellini²⁸, F. Benmokhtar⁴⁸, V. Berdnikov⁵⁶, J.C. Bernauer^{20,22}, A. Bianconi^{27,45}, A. Biselli³¹ M. Boer²⁹, M. Bondi⁹, K.-T. Brinkmann³⁴, W.J. Briscoe³, V. Burkert¹, T. Cao³⁹, A. Camsonne B. Capobianco²¹, L. Cardman¹, M. Carmignotto¹, M. Caudron², L. Causse², A. Celentano P. Chatagnon², T. Chetry¹⁵, G. Ciullo^{32,33}, E. Cline²⁰, P.L. Cole²⁴, M. Contalbrigo³², G. Costantini²⁷ A. D'Angelo^{52,53}, D. Day⁵, M. Defurne³⁵, M. De Napoli²⁸, A. Deur¹, R. De Vita⁹, N. D'Hose³ S. Diehl^{21,34}, M. Diefenthaler¹, B. Dongwi³⁹, R. Dupré², D. Dutta¹⁵, M. Ehrhart², L. El-Fassi¹ L. Elouadrhiri¹, R. Ent¹, J. Erler^{13,14}, I.P. Fernando³⁹, A. Filippi⁵⁵, D. Flay¹, T. Forest⁴⁹, E. Fuchey² S. Fucini18, Y. Furletova1, H. Gao7, D. Gaskell1, A. Gasparian38, T. Gautam39, F.-X. Girod2 J. Grames¹, P. Gueye³⁰, M. Guidal², S. Habet², D.J. Hamilton³⁷, O. Hansen¹, D. Hasell M. Hattawy¹⁷, D.W. Higinbotham¹, A. Hobart², T. Horn⁵⁶, C.E. Hyde¹⁷, H. Ibrahim³⁶, A. Italiano² K Jon²¹ S.I. Jonston¹¹ N Kalantarians⁵⁰ G Kalimy⁵⁶ D Keller⁵ C Kennel¹ M Kenyer A. Kim²¹, J. Kim¹¹, P.M. King²³, E. Kinney²⁶, V. Klimenko²¹, H.-S. Ko², M. Kohl³⁹, V. Kozhuharov⁸ V. Kubarovsky¹, T. Kutz^{3,4}, L. Lanza^{52,53}, M. Leali^{27,45}, P. Lenisa^{32,33}, N. Livanage⁵, Q. Liu¹ S. Liuti⁵, J. Mammei⁵⁸, S. Mantry⁶, D. Marchand², P. Markowitz⁴⁴, L. Marsicano^{9,10}, V. Mascagna²⁷ M. Mazouz16, M. McCaughan1, B. McKinnon37, D. McNulty49, W. Melnitchouk1, Z.-E. Meziani M. Mihovilovič⁴³, R. Milner⁴, A. Mkrtchvan⁵⁹, H. Mkrtchvan⁵⁹, A. Movsisvan³², M. Muhozai R. Novotny³⁴, M. Paolone⁴², L. Pappalardo^{32,33}, R. Paremuzyan²⁹, E. Pasyuk¹, T. Patel³⁹, I. Pegg⁵ C. Peng¹¹, D. Perera⁵, M. Poelker¹, K. Price², A.J.R. Puckett²¹, M. Raggi^{8,19}, N. Randazzo M.N.H. Rashad¹⁷, M. Rathnayake³⁹, B. Raue⁴⁴, P.E. Reimer¹¹, M. Rinaldi¹⁸, A. Rizzo^{52,53}, J. Roche² O. Rondon-Aramayo⁵, G. Salmè⁵¹, E. Santopinto⁹, R. Santos Estrada²¹, B. Sawatzky¹, A. Schmidt³ P. Schweitzer²¹, S. Scopetta¹⁸, V. Sergeveva², M. Shabestari⁴⁶, A. Shahinyan⁵⁹, Y. Sharabian S Širca⁽³⁾ F Smith¹ D Sokhan³⁷ A Somov¹ N Snarveris⁴⁷ M Snata¹ S Stenanyan¹ P Stoler² I. Strakovsky³, R. Suleiman¹, M. Suresh³⁹, H. Szumila-Vance¹, V. Tadevosyan⁵⁹, A.S. Tadepalli¹ M. Tiefenback¹, R. Trotta⁵⁶, M. Ungaro¹, P. Valente¹⁹, L. Venturelli^{27,45}, H. Voskanyan⁵⁹, E. Voutier² B. Wojtsekhowski¹, S. Wood¹, J. Xie¹¹, Z. Ye²⁵, M. Yurov⁵, H.-G. Zaunick³⁴, S. Zhamkochyan⁵⁹ J. Zhang⁵, S. Zhang¹, S. Zhao², Z.W. Zhao⁷, X. Zheng⁵, C. Zorn

2 | e⁺@uLab White Pape

<u>e+@JLab White Paper</u>

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

Deeply Virtual Compton Scattering using a positron beam in Hall C States of the Compton Scattering and States of the Compton Scattering States of the States of Scattering States of Scattering States of Scattering Scattering States of Scattering Scatteri

P. Markowitz

A. Afanasev, W. J. Briscoe, and I. Strakov



Proposal to PAC48

PR12-20-009

Beam Charge Asymmetries for

Deeply Virtual Compton Scattering on the Proton at CLAS12

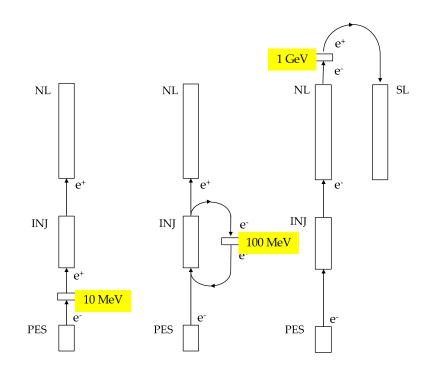


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J. Grames et al. (JLab)

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...



10 MeV, 100 MeV or 1 GeV

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Max

 IP^2

Low yield

High polarization

High yield

Low polarization

Behavior is universal for any electron beam energy:



High Precision Electron Polarimetry

TASKS/Subtasks		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						1	ļ .									
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

<u>Completed</u>

- 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

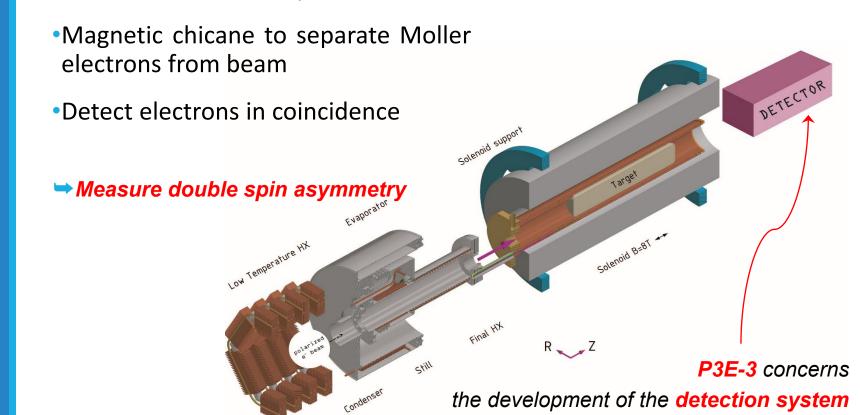


Hydro-Moller Polarimeter

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)

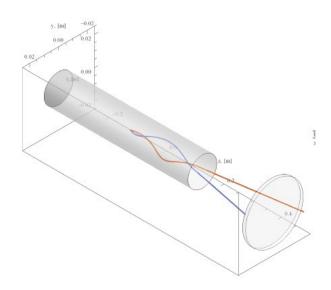


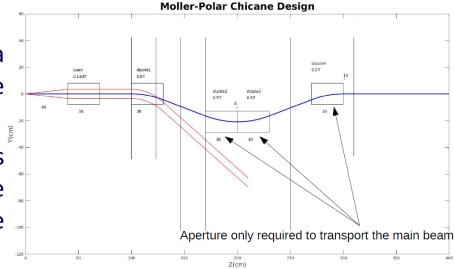


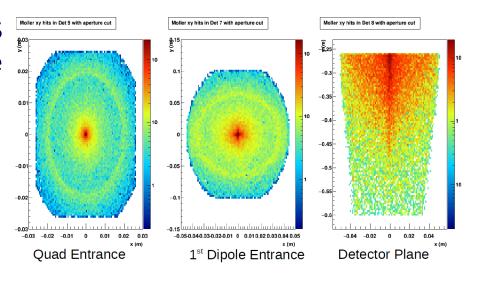
Simulating the Hydro Moller detector

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

- 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)







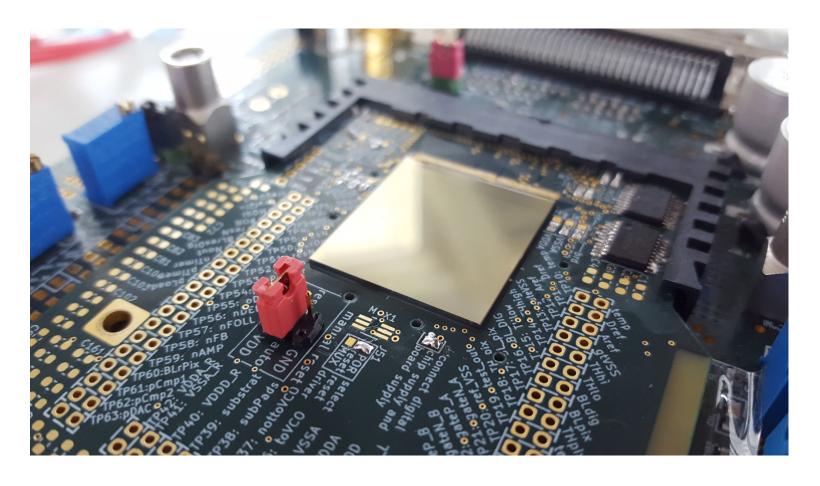


Evaluating HV-MAPS Pixel senors

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