C. Fanelli

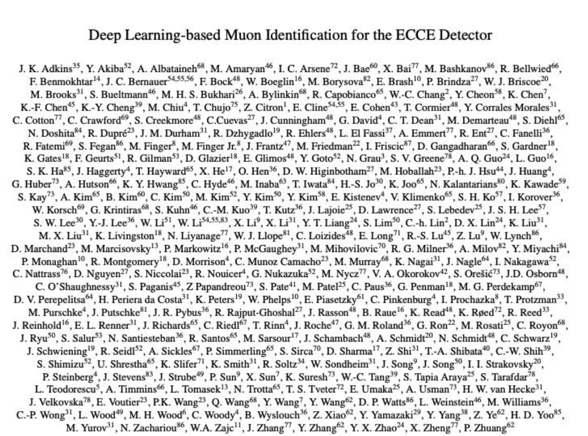
ECCE AI Working Group

Update on papers

ecceaiwg.slack.com

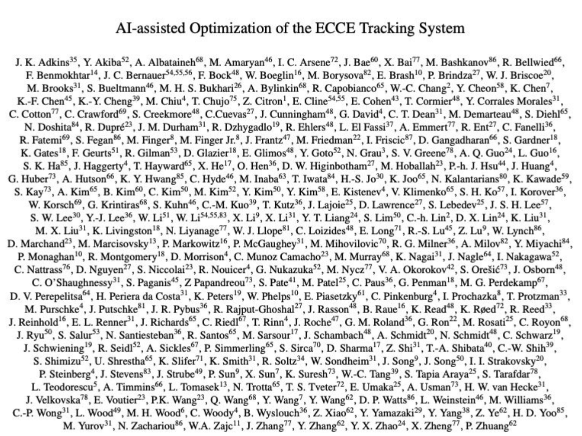
Updates from AI WG on papers

- ecce-paper-comp-2022-01
  - Deep Learning-based Muon Identification for the ECCE Detector
- ecce-paper-comp-2022-02
  - AI-assisted Optimization of the ECCE Tracking System



Deep Learning-based Muon Identification for the ECCE Detector

J. K. Adkins[35], Y. Akiba[52], A. Albataineh[68], M. Amaryan[46], I. C. Arsene[72], J. Bae[60], X. Bai[77], M. Bashkanov[86], R. Bellwied[66], F. Benmokhtar[14], J. C. Bernauer[54,55,56], F. Bock[48], W. Boeglin[16], M. Borysova[82], E. Brash[10], P. Brindza[27], W. J. Briscoe[20], M. Brooks[31], S. Bueltmann[46], M. H. S. Bukhari[26], A. Bylinkin[68], R. Capobianco[65], W.-C. Chang[2], Y. Cheon[58], K. Chen[7], K.-F. Chen[45], K.-Y. Cheng[39], M. Chiu[4], T. Chujo[75], Z. Citron[1], E. Cline[54,55], E. Cohen[43], T. Cormier[48], Y. Corrales Morales[31], C. Cotton[77], C. Crawford[69], S. Creekmore[48], C.Cuevas[27], J. Cunningham[48], G. David[4], C. T. Dean[31], M. Demarteau[48], S. Diehl[65], N. Doshita[84], R. Dupré[23], J. M. Durham[31], R. Dzhygadlo[19], R. Ehlers[48], L. El Fassi[37], A. Emmert[77], R. Ent[27], C. Fanelli[36], R. Fatemi[69], S. Fegan[86], M. Finger[8], M. Finger Jr.[8], J. Frantz[47], M. Friedman[22], I. Friscic[87], D. Gangadharan[66], S. Gardner[18], K. Gates[18], F. Geurts[51], R. Gilman[53], D. Glazier[18], E. Glimos[48], Y. Goto[52], N. Grau[3], S. V. Greene[78], A. Q. Guo[24], L. Guo[16], S. K. Ha[85], J. Haggerty[4], T. Hayward[65], X. He[17], O. Hen[36], D. W. Higinbotham[27], M. Hoballah[23], P.-h. J. Hsu[44], J. Huang[4], G. Huber[73], A. Hutson[66], K. Y. Hwang[85], C. Hyde[46], M. Inaba[63], T. Iwata[84], H.-S. Jo[30], K. Joo[65], N. Kalantarians[80], K. Kawade[59], S. Kay[73], A. Kim[65], B. Kim[60], C. Kim[50], M. Kim[52], Y. Kim[50], Y. Kim[58], E. Kistenev[4], V. Klimenko[65], S. H. Ko[57], I. Korover[36], W. Korsch[69], G. Krintiras[68], S. Kuhn[46], C.-M. Kuo[39], T. Kutz[36], J. Lajoie[25], D. Lawrence[27], S. Lebedev[25], J. S. H. Lee[57], S. W. Lee[30], Y.-J. Lee[36], W. Li[51], W. Li[54,55,83], X. Li[9], X. Li[31], Y. T. Liang[24], S. Lim[50], C.-h. Lin[2], D. X. Lin[24], K. Liu[31], M. X. Liu[31], K. Livingston[18], N. Liyanage[77], W. J. Llope[81], C. Loizides[48], E. Long[71], R.-S. Lu[45], Z. Lu[9], W. Lynch[86], D. Marchand[23], M. Marcisovsky[13], P. Markowitz[16], P. McGaughey[31], M. Mihovilovic[70], R. G. Milner[36], A. Milov[82], Y. Miyachi[84], P. Monaghan[10], R. Montgomery[18], D. Morrison[4], C. Munoz Camacho[23], M. Murray[68], K. Nagai[31], J. Nagle[64], I. Nakagawa[52], C. Nattrass[76], D. Nguyen[27], S. Niccolai[23], R. Nouicer[4], G. Nukazuka[52], M. Nycz[77], V. A. Okorokov[42], S. Orešić[73], J.D. Osborn[48], C. O'Shaughnessy[31], S. Paganis[45], Z Papandreou[73], S. Pate[41], M. Patel[25], C. Paus[36], G. Penman[18], M. G. Perdekamp[67], D. V. Perepelitsa[64], H. Periera da Costa[31], K. Peters[19], W. Phelps[10], E. Piasetzky[61], C. Pinkenburg[4], I. Prochazka[8], T. Protzman[33], M. Purschke[4], J. Putschke[81], J. R. Pybus[36], R. Rajput-Ghoshal[27], J. Rasson[48], B. Raue[16], K. Read[48], K. Røed[72], R. Reed[33], J. Reinhold[16], E. L. Renner[31], J. Richards[65], C. Riedl[67], T. Rinn[4], J. Roche[47], G. M. Roland[36], G. Ron[22], M. Rosati[25], C. Royon[68], J. Ryu[50], S. Salur[53], N. Santiesteban[36], R. Santos[65], M. Sarsour[17], J. Schambach[48], A. Schmidt[20], N. Schmidt[48], C. Schwarz[19], J. Schwiening[19], R. Seidl[52], A. Sickles[67], P. Simmerling[65], S. Sirca[70], D. Sharma[17], Z. Shi[31], T.-A. Shibata[40], C.-W. Shih[39], S. Shimizu[52], U. Shrestha[65], K. Slifer[71], K. Smith[31], R. Soltz[34], W. Sondheim[31], J. Song[9], J. Song[50], I. I. Strakovsky[20], P. Steinberg[4], J. Stevens[83], J. Strube[49], P. Sun[9], X. Sun[7], K. Suresh[73], W.-C. Tang[39], S. Tapia Araya[25], S. Tarafdar[78], L. Teodorescu[5], A. Timmins[66], L. Tomasek[13], N. Trotta[65], T. S. Tveter[72], E. Umaka[25], A. Usman[73], H. W. van Hecke[31], J. Velkovska[78], E. Voutier[23], P.K. Wang[23], Q. Wang[68], Y. Wang[7], Y. Wang[62], D. P. Watts[86], L. Weinstein[46], M. Williams[36], C.-P. Wong[31], L. Wood[49], M. H. Wood[6], C. Woody[4], B. Wyslouch[36], Z. Xiao[62], Y. Yamazaki[29], Y. Yang[38], Z. Ye[62], H. D. Yoo[85], M. Yurov[31], N. Zachariou[86], W.A. Zajc[11], J. Zhang[77], Y. Zhang[62], Y. X. Zhao[24], X. Zheng[77], P. Zhuang[62]



AI-assisted Optimization of the ECCE Tracking System

J. K. Adkins[35], Y. Akiba[52], A. Albataineh[68], M. Amaryan[46], I. C. Arsene[72], J. Bae[60], X. Bai[77], M. Bashkanov[86], R. Bellwied[66], F. Benmokhtar[14], J. C. Bernauer[54,55,56], F. Bock[48], W. Boeglin[16], M. Borysova[82], E. Brash[10], P. Brindza[27], W. J. Briscoe[20], M. Brooks[31], S. Bueltmann[46], M. H. S. Bukhari[26], A. Bylinkin[68], R. Capobianco[65], W.-C. Chang[2], Y. Cheon[58], K. Chen[7], K.-F. Chen[45], K.-Y. Cheng[39], M. Chiu[4], T. Chujo[75], Z. Citron[1], E. Cline[54,55], E. Cohen[43], T. Cormier[48], Y. Corrales Morales[31], C. Cotton[77], C. Crawford[69], S. Creekmore[48], C.Cuevas[27], J. Cunningham[48], G. David[4], C. T. Dean[31], M. Demarteau[48], S. Diehl[65], N. Doshita[84], R. Dupré[23], J. M. Durham[31], R. Dzhygadlo[19], R. Ehlers[48], L. El Fassi[37], A. Emmert[77], R. Ent[27], C. Fanelli[36], R. Fatemi[69], S. Fegan[86], M. Finger[8], M. Finger Jr.[8], J. Frantz[47], M. Friedman[22], I. Friscic[87], D. Gangadharan[66], S. Gardner[18], K. Gates[18], F. Geurts[51], R. Gilman[53], D. Glazier[18], E. Glimos[48], Y. Goto[52], N. Grau[3], S. V. Greene[78], A. Q. Guo[24], L. Guo[16], S. K. Ha[85], J. Haggerty[4], T. Hayward[65], X. He[17], O. Hen[36], D. W. Higinbotham[27], M. Hoballah[23], P.-h. J. Hsu[44], J. Huang[4], G. Huber[73], A. Hutson[66], K. Y. Hwang[85], C. Hyde[46], M. Inaba[63], T. Iwata[84], H.-S. Jo[30], K. Joo[65], N. Kalantarians[80], K. Kawade[59], S. Kay[73], A. Kim[65], B. Kim[60], C. Kim[50], M. Kim[52], Y. Kim[50], Y. Kim[58], E. Kistenev[4], V. Klimenko[65], S. H. Ko[57], I. Korover[36], W. Korsch[69], G. Krintiras[68], S. Kuhn[46], C.-M. Kuo[39], T. Kutz[36], J. Lajoie[25], D. Lawrence[27], S. Lebedev[25], J. S. H. Lee[57], S. W. Lee[30], Y.-J. Lee[36], W. Li[51], W. Li[54,55,83], X. Li[9], X. Li[31], Y. T. Liang[24], S. Lim[50], C.-h. Lin[2], D. X. Lin[24], K. Liu[31], M. X. Liu[31], K. Livingston[18], N. Liyanage[77], W. J. Llope[81], C. Loizides[48], E. Long[71], R.-S. Lu[45], Z. Lu[9], W. Lynch[86], D. Marchand[23], M. Marcisovsky[13], P. Markowitz[16], P. McGaughey[31], M. Mihovilovic[70], R. G. Milner[36], A. Milov[82], Y. Miyachi[84], P. Monaghan[10], R. Montgomery[18], D. Morrison[4], C. Munoz Camacho[23], M. Murray[68], K. Nagai[31], J. Nagle[64], I. Nakagawa[52], C. Nattrass[76], D. Nguyen[27], S. Niccolai[23], R. Nouicer[4], G. Nukazuka[52], M. Nycz[77], V. A. Okorokov[42], S. Orešić[73], J. Osborn[48], C. O'Shaughnessy[31], S. Paganis[45], Z Papandreou[73], S. Pate[41], M. Patel[25], C. Paus[36], G. Penman[18], M. G. Perdekamp[67], D. V. Perepelitsa[64], H. Periera da Costa[31], K. Peters[19], W. Phelps[10], E. Piasetzky[61], C. Pinkenburg[4], I. Prochazka[8], T. Protzman[33], M. Purschke[4], J. Putschke[81], J. R. Pybus[36], R. Rajput-Ghoshal[27], J. Rasson[48], B. Raue[16], K. Read[48], K. Røed[72], R. Reed[33], J. Reinhold[16], E. L. Renner[31], J. Richards[65], C. Riedl[67], T. Rinn[4], J. Roche[47], G. M. Roland[36], G. Ron[22], M. Rosati[25], C. Royon[68], J. Ryu[50], S. Salur[53], N. Santiesteban[36], R. Santos[65], M. Sarsour[17], J. Schambach[48], A. Schmidt[20], N. Schmidt[48], C. Schwarz[19], J. Schwiening[19], R. Seidl[52], A. Sickles[67], P. Simmerling[65], S. Sirca[70], D. Sharma[17], Z. Shi[31], T.-A. Shibata[40], C.-W. Shih[39], S. Shimizu[52], U. Shrestha[65], K. Slifer[71], K. Smith[31], R. Soltz[34], W. Sondheim[31], J. Song[9], J. Song[50], I. I. Strakovsky[20], P. Steinberg[4], J. Stevens[83], J. Strube[49], P. Sun[9], X. Sun[7], K. Suresh[73], W.-C. Tang[39], S. Tapia Araya[25], S. Tarafdar[78], L. Teodorescu[5], A. Timmins[66], L. Tomasek[13], N. Trotta[65], T. S. Tveter[72], E. Umaka[25], A. Usman[73], H. W. van Hecke[31], J. Velkovska[78], E. Voutier[23], P.K. Wang[23], Q. Wang[68], Y. Wang[7], Y. Wang[62], D. P. Watts[86], L. Weinstein[46], M. Williams[36], C.-P. Wong[31], L. Wood[49], M. H. Wood[6], C. Woody[4], B. Wyslouch[36], Z. Xiao[62], Y. Yamazaki[29], Y. Yang[38], Z. Ye[62], H. D. Yoo[85], M. Yurov[31], N. Zachariou[86], W.A. Zajc[11], J. Zhang[77], Y. Zhang[62], Y. X. Zhao[24], X. Zheng[77], P. Zhuang[62]

Status of ecce-comp-2022-01

- AI WG met on March 25
- A lot of work done on the PID and on the physics analysis of Time-like Compton scattering (TCS) in $\mu^+\mu^-$ (see reply to DPAP)
    - Analysis, results and figures available. We have not written an analysis note for that yet so we are writing the paper “from scratch”.
- Defined structure of the paper and identified key people to distribute work:
    - BNL, CNU, Glasgow, JLab, MIT, SUNY, W&M, …

Contents

Timeline of ecce-comp-2022-01

- Complete narrative in ~2 weeks

- Presentation to Biweekly meeting in 4 weeks for internal approval

Status of ecce-comp-2022-02

- Advanced state already. We started from the existing ECCE technical note and presented last year in many occasions.
- About 15-16 pages excluding references

Abstract

The Electron-Ion Collider (EIC) is a cutting-edge accelerator experiment proposed to study the nature of the "glue" that binds the building blocks of the visible matter in the universe. The proposed experiment will be realized at Brookhaven National Laboratory in approximately 10 years from now, with the detector design and R&D currently ongoing. Noticeably EIC can be one of the first facilities to leverage on Artificial Intelligence (AI) during the design and R&D phases. Optimizing the design of its tracker is

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of crucial importance for the EIC Comprehensive Chromodynamics Experiment (ECCE), a protocollaboration that is proposing a detector design based on a 1.5T solenoid. The optimization is an essential part of the design and R&D and ECCE includes in its structure a working group dedicated to AI-based applications for the EIC detector. In this note we describe an unprecedented study in the detector design of large-scale experiments using AI that has been accomplished during the detector proposal. This study required a complex parametrization of the detector system simulated with the Fun4All framework. Our approach deals with an optimization problem in a multidimensional design space driven by multiple objectives that encode the detector performance, while satisfying several mechanical constraints. We describe our strategy and show results for the ECCE tracking system. The AI-assisted design can be extended after the detector proposal to other sub-detectors or system of sub-detectors to optimize the performance of the EIC detector.

Keywords: ECCE, Electron Ion Collider, Tracking, Artificial Intelligence, Evolutionary, Bayesian Optimization.

Contents

to detect electromagnetic and hadronic showers and complete information on the particle flow which is essential for certain event topologies, *e.g.*, those containing jets. The optimization of the EIC detector is of utmost importance during the design and R&D phases planned in the EIC schedule [4].

Artificial Intelligence (AI) can provide dedicated strategies for complex combinatorial searches and can handle multi-objective problems characterized by a multidimensional design space, allowing to capture hidden correlations among design parameters. ECCE included these techniques in the design workflow during the detector proposal. This AI-assisted design strategy can be used at first to steer the design. After the technology choice is selected (based also on the important insights provided by AI), it can be further utilized to eventually fine-tune the detector parameters. During the detector proposal the design of the detector has been a continued optimization

- About 15-16 pages excluding references
- Key-people currently working on this:
  - MIT, Regina
    - Updating some plots
    - Polishing text

Timeline of ecce-comp-2022-02

- Aiming for internal review and presentation in 2 weeks at the next Bi-weekly Meeting