AI4EIC Hackathon: PID with the ePIC dRICH

https://eic.ai/

AI4EIC hackathon ‘22 documentation:
CF, J Giroux, D McSpadden, K Rajput, K Suresh
https://doi.org/10.5281/zenodo.7197023

5/9/2023

C. Fanelli for the AI4EIC
(credits: J. Giroux, K. Suresh)

26TH INTERNATIONAL CONFERENCE ON COMPUTING IN HIGH ENERGY & NUCLEAR PHYSICS

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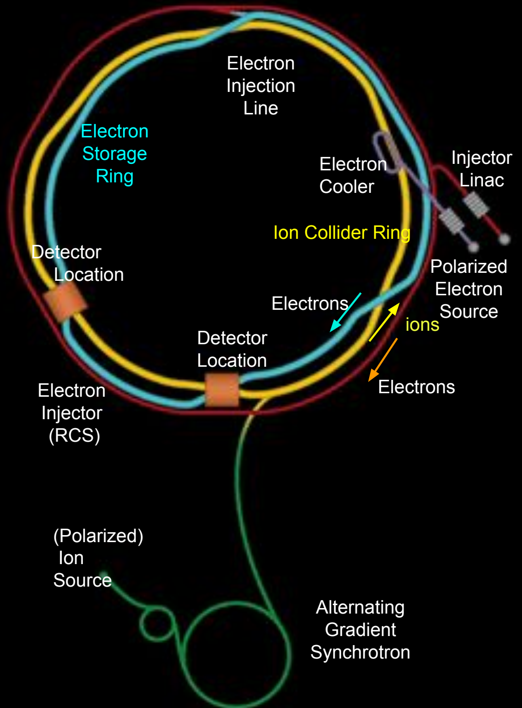
Exploring the Nature of Matter

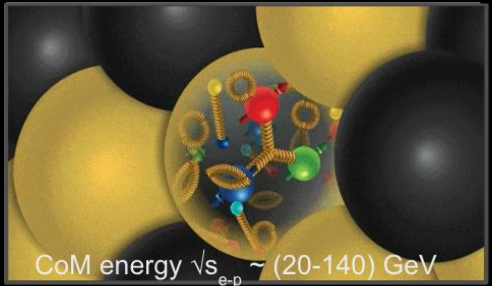
Electron Ion Collider

fundamental questions

A precision machine to study the “glue” that binds us all



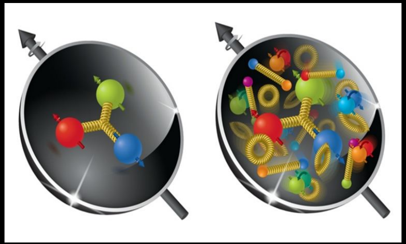
polarized electron - polarized protons/ions



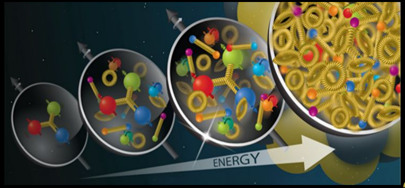
World-wide interest, thousands of users and hundreds of institutions already involved

How does the mass of the nucleon arise?

How does the spin of the nucleon arise?



What are the emergent properties of dense systems of gluons?



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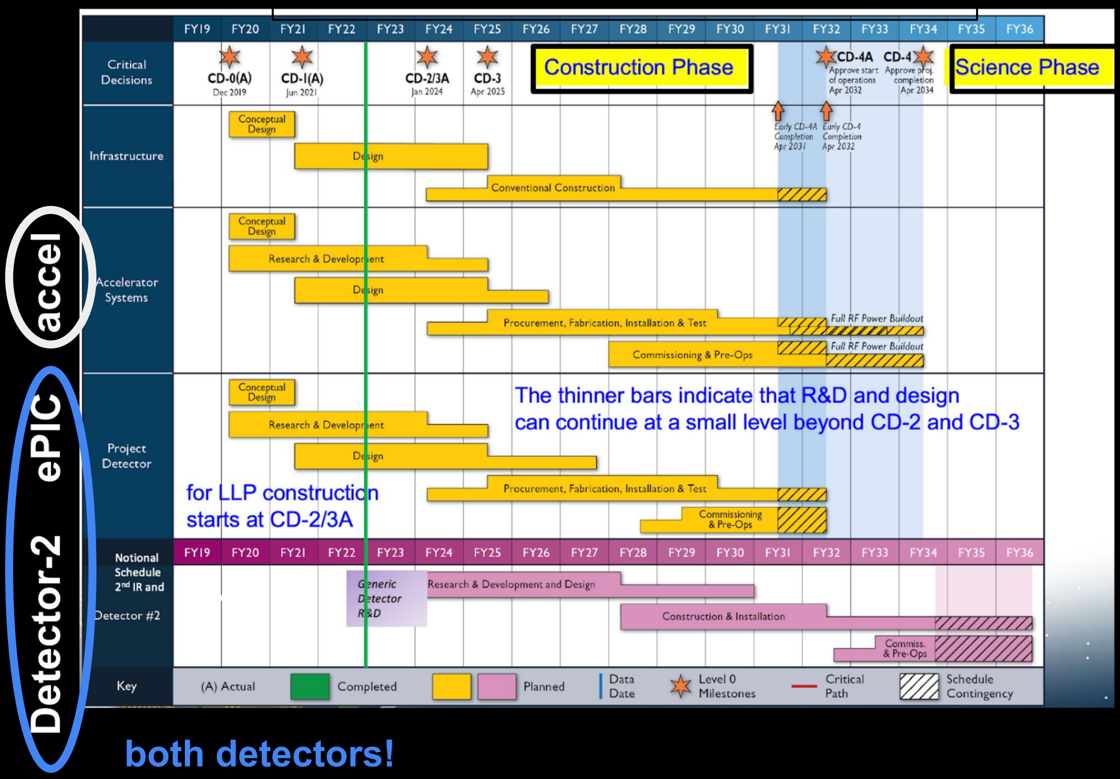
Total estimated cost ~ $1.6-2.6B

AI/ML and the EIC schedule

- EIC will integrate AI from beginning through all project phases.
- EIC can be the first experiment for QCD to be designed with the assistance of AI
- EIC will take advantage of intelligent decisions in all aspects of data processing.
- Streaming Readout (SRO) will enable AI/ML integration for seamless offline and online analysis convergence.

See also other CHEP2023 talks, e.g., D. Lawrence (EIC SW Overview) and CF (AI/ML for ePIC)

R. Ent, AI4EIC workshop, October 2022



[1] C. Fanelli, Z. Papandreou, K. Suresh et al, NIMA, Vol 1047, 2023, 167748
[2] J. Bernauer, C. Dean C. Fanelli et al., NIMA, Vol 1047, 2023, 167859
[3] F. Ameli et al., Eur. Phys. J. Plus (2022) 137: 958

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What is AI4EIC?

https://eic.ai

- AI will be an integral part of the EIC software and to work in this direction, a dedicated AI Working Group (AI4EIC) has been established within the EICUG (https://www.eicug.org)
- AI4EIC will serve as an entry point to AI applications and organizes workshops, tutorials, hackathons, Kaggle-like challenges, etc.
- AI4EIC is a vibrant community built through multiple events organized during the last two years and collaborates with the recently formed ePIC Collaboration.
- Workshops serve as a body of essential knowledge for AI4EIC, and produce proceedings, annual report, journal special issues. Educational activities and outreach are aimed at disseminating AI in the EIC community.
    - AI4EIC has already organized 2 workshops (200+ participants), several tutorials (https://eic.ai/workshops), monthly meetings (https://eic.ai/events), and an international hackathon (https://eic.ai/hackathons).
    - Hackathon events are built around specific challenges for EIC and help identify strategies, architectures and algorithms that will benefit the EIC physics program.
    - Additionally, AI4EIC is committed to establishing educational events (e.g., schools) designed to enhance AI and ML proficiency within the EIC community. For more information, https://eic.ai/community and https://eic.ai/ai-ml-references.

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AI4EIC 2022 Workshop & Hackathon

https://eic.ai/workshops

https://eic.ai

- Workshop:

  Total of 220 registered participants (also last year, >200!)

  - Very good attendance in person!

  6 sessions (15 conveners, 40+ speakers)

  - Design
  - Theory/Exp connections (morning + afternoon sessions)
  - Recon & PID
  - Infrastructure (+ Panel Discussion)
  - Streaming

Discussion from this workshop contributed to LRP WP

- Tutorials:
  - MOBO (Meta AI)
  - OmniFold
  - MLFlow
  - GNN

https://eic.ai/community

- Hackathon:

  (10 teams from North, South America, Asia, Europe)

https://eic.ai/community
https://doi.org/10.5281/zenodo.7197023

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AI4EIC Hackathon

Hackathon: Brings together communities with diverse skill sets, such as CS, DS, and physics, fostering collaboration and launching projects that align with the core objectives of the EIC.

Organized on Fri October 14, 2022 after AI4EIC workshop

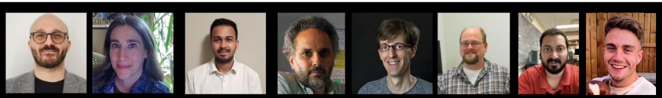
Organizers: Cris Fanelli (William & Mary/JLab), Diana McSpadden (JLab/Data Science), Kishan Rajput (JLab/Data Science)

Advisory and problem definition: Evaristo Cisbani (INFN), Wouter Deconinck (U. Manitoba)

Computing resources: Eric Walter (William & Mary, IT)

Data generation, Documentation, Validation: James Giroux (U. Regina), Karthik Suresh (U. Regina)

Technical Assistance: Eric Walter (William & Mary, IT), James Giroux (U. Regina), Karthik Suresh (U. Regina)



CF, DMcS,KR, EC,WD,EW,KS,JG

Background/Motivation: Cherenkov detectors constitute the backbone of PID at EIC

Challenges:

- Simulations are typically compute-expensive
- Reconstruction relies on pattern recognition of noisy, sparse rings of photons (with complicated topologies for the DIRC);
- Events with close tracks that can easily produce mis-identification

ML/DL ideal for a holistic event-level reconstruction and can also provide computational speed-up

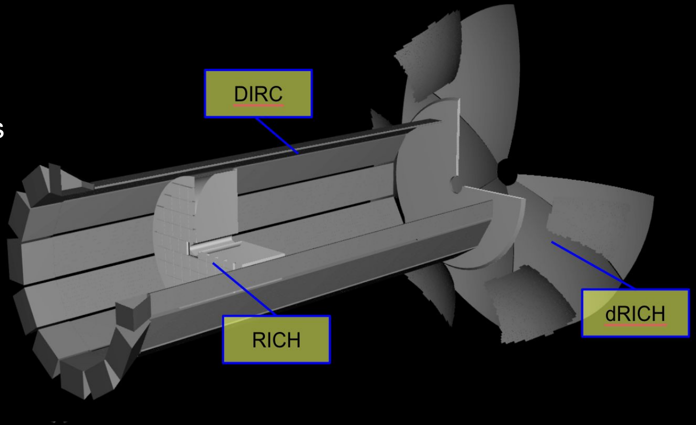


Image used for illustrative purposes

Goal: Can we begin to leverage ML/DL for PID based on low-level features from imaging Cherenkov detectors? This can be a first step towards ML/DL applications for PID with Cherenkov detectors.

“Targeted” detector: dual-RICH in ePIC is instrumental to guarantee an efficient identification of hadrons in the hadron-endcap covering a large range in momentum

https://doi.org/10.5281/zenodo.7197023

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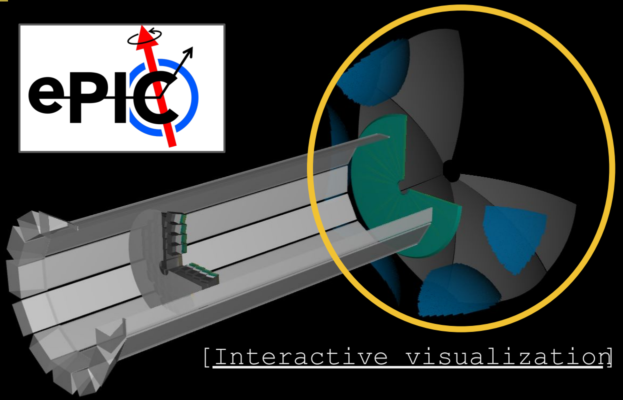
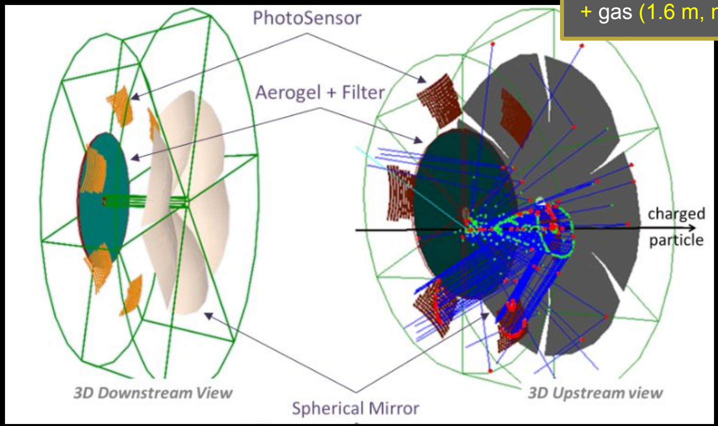
dRICH detector

[E. Cisbani, A. Del Dotto, CF, M. Williams JINST 15 P05009 *et al* 2020]

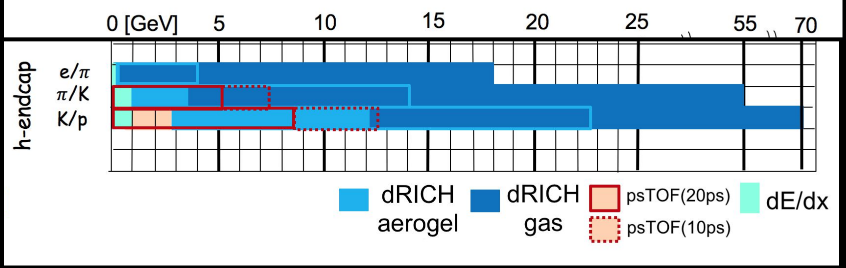
aerogel (4 cm, n(400 nm): 1.02)
+ 3 mm acrylic filter
+ gas (1.6 m, n(C_2F_6): 1.0008)

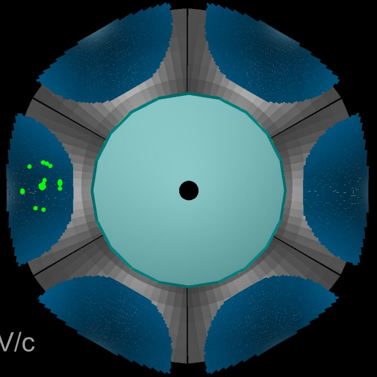


[Interactive visualization]



Two radiators with different refractive indices to provide PID with large momentum coverage





θ = 15
Φ = 0
P = 15 GeV/c

view from the electron end cap

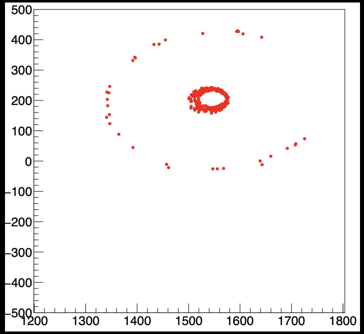
π/K classification is tackled, being the most challenging task

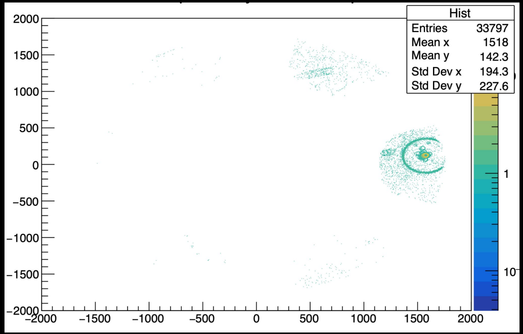
chose as working point P ~ 15 GeV where both radiators contribute to PID

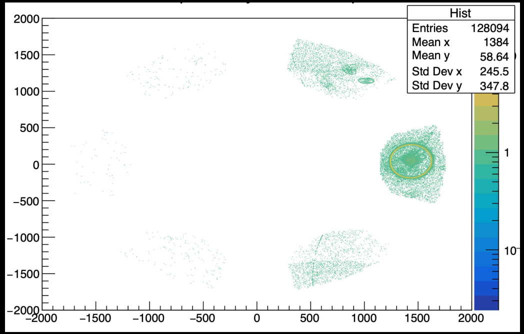
3 Problems of Increasing Complexity

Problem 1	Problem 2	Problem 3
Fixed momentum and direction (threshold accuracy 94%)	Larger phase-space (threshold accuracy 86%)	Larger phase-space + noise (threshold accuracy 80%)

π/K







$$\text{score} = 50.0 + 50.0 \times \frac{\text{(ACC - THRESHOLD)}}{100.0-\text{THRESHOLD}}$$

$$\text{ACC} = \frac{\sum_N |y_{pred} == y_{true}|}{N}$$

Problem 1

Training Events	1.5 Million Events	With Magnetic Field ($\sim$ 1.5T)
Momentum	15 GeV/c	at Interaction Point (0, 0, 0)
Theta θ	20°	at Interaction Point (0, 0, 0)
Phi ϕ	0°	at Interaction Point (0, 0, 0)

Problems 2,3

Training Events	3 Million Events	With Magnetic Field ($\sim$ 1.5T)
Momentum	$15-20GeV/c$	at Interaction Point (0, 0, 0)
Theta θ	$15-16°$	at Interaction Point (0, 0, 0)
Phi ϕ	$0-5°$	at Interaction Point (0, 0, 0)

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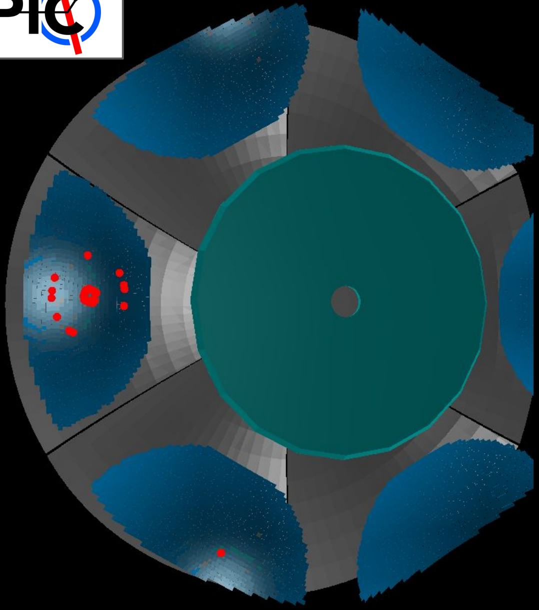
Data

https://doi.org/10.5281/zenodo.7197023



Used ePIC software stack for data generation [1] [2]

Event information (4 Cols)					3D hits of yielded optical photons (180 Cols)								
eventID	PID	P [GeV/c]	θ [deg]	Φ [deg]	X0 [mm]	…	X59	Y0	…	Y59	Z0	…	Z59
0	211	15.10	15.12	0.45	1570	1412	1660	55.3	-2.5	23.4	2365	2378	2361
1	321	16.76	15.48	1.23	1514	1525	1456	12.4	6.5	10.2	2413	2314	2154
⋮				⋮	⋮								⋮
N	211	17.89	15.67	1.26	1613	1645	1564	12.5	-75.	151.2	2376	2143	2314

The maximum # of detected optical photons is set to 60. Average detector photons are in the range of 30 -40 with noise.

Dataset:

- Publicly available on Zenodo
- Data format csv and hdf5 — flat data, accessible to colleagues from various fields

AWS Resources

- Each team was allocated an AWS instance
  - 4x Nvidia A10G 24GB GPUs
  - 48 vCPUs with total RAM allocation of 192GB and ~4TB storage
- W&M prebuilt Conda environments containing the most common ML packages
  - PyTorch
  - TensorFlow
- Full technical assistance provided throughout the event by W&M Research Computing Group
  - Accessible to both remote and in-person participants

powered by aws

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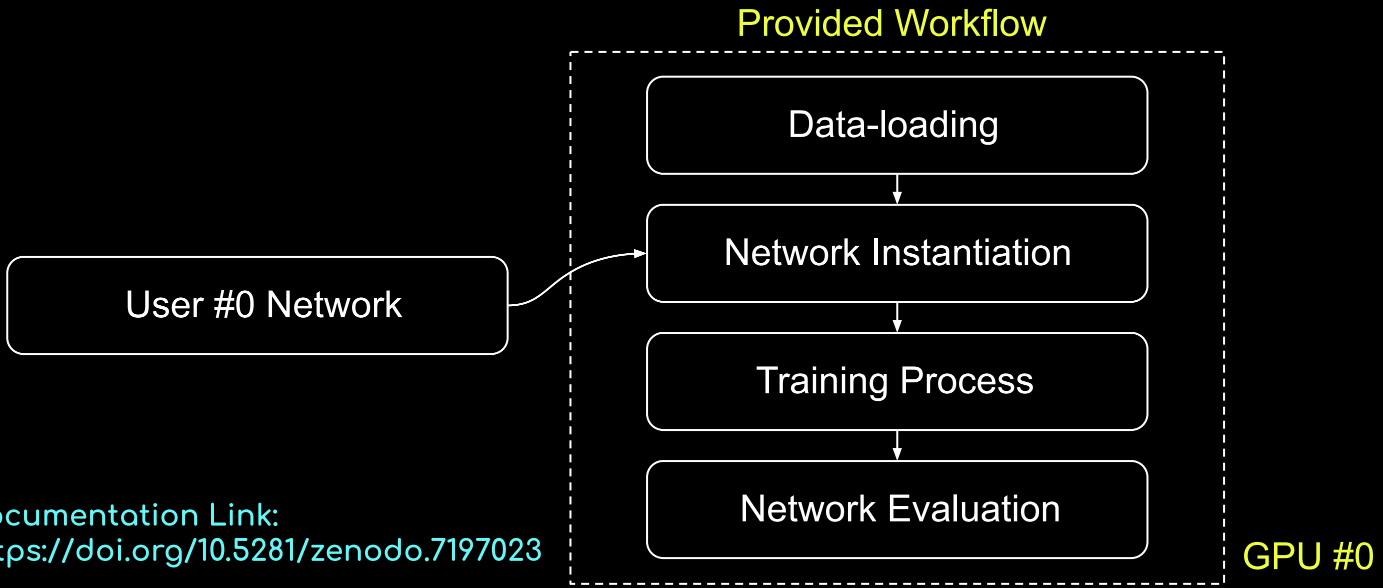
Efficient Training Workflows

- Multiple users introduce the need for efficient resource management within teams
  - Minimize memory usage during model training schemes
  - Provide full training and evaluation workflow - focus on model development
  - Instructions provided for specific GPU allocation within a group - capable of utilizing distributed training techniques across multiple GPUs

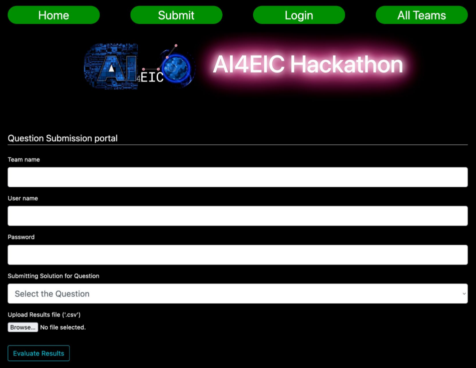


Documentation Link:
https://doi.org/10.5281/zenodo.7197023

Submission & Leaderboard

https://ai4eichackathon.pythonanywhere.com/leaderboard

- Leaderboard was made with a submission portal. Participants submit solutions to be graded in real time.
- Participants continued to submit solutions to improve their scores even after the hackathon.
- “JINR” team won the Hackathon - Used CatBoostClassifer
- “Jets” team secured 2nd place - Used Convolution Neural Nets (CNN)
- The winners are invited to give a talk at the next AI4EIC workshop



Home Submit Login All Teams

AI4EIC Hackathon

Congrats Team JINR!!!!!!!! (submission on 10-14-2022)

Hackathon Leaderboard

RANK	TEAM	SCORE	QUESTIONS ATTEMPED
1	JINR	293.896	Q1, Q2, Q3
2	Jets	293.535	Q1, Q2, Q3
3	PLYD	248.504	Q1, Q2, Q3
4	JB and EC	233.473	Q1, Q2, Q3
5	In Principle	229.323	Q1, Q2, Q3
6	Team Manitoba	177.200	Q1, Q2, Q3
7	Team WM and DK	62.075	Q1

⋮

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Conclusions

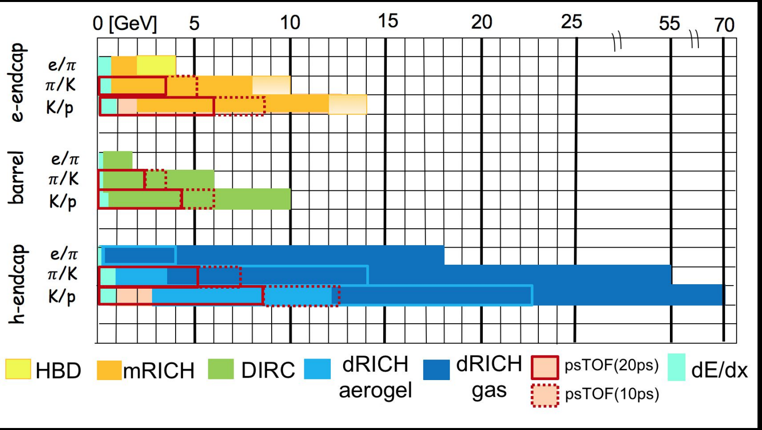
- **Hackathon useful to unveil the ML/DL potential for EIC:** During the hackathon, innovative ML/DL-based solutions outperformed traditional cut-based methods, signaling a promising initial step towards using ML/DL for PID with the dual-RICH detector.
- **Community building and collaboration:** The event fostered community building by gathering diverse individuals in collaboration, enhancing shared learning and strengthening relationships. This set a strong foundation for future joint AI + physics endeavors.
- **Igniting young minds:** The hackathon was a valuable and educational experience for the younger participants, who expressed great excitement about their involvement, nurturing their creativity and passion for AI in scientific research.
- **A launchpad for future innovations:** The hackathon kick-started the utilization of ML/DL for the ePIC dRICH, with participant enthusiasm underlining the potential for continued innovation and refinement of these approaches
- **Forthcoming 3rd AI4EIC workshop + hackathon:** winter 2023, announcement will be made soon.
    - People interested in AI4EIC activities can email support@eic.ai.
    - More info on https://eic.ai/how-to-join

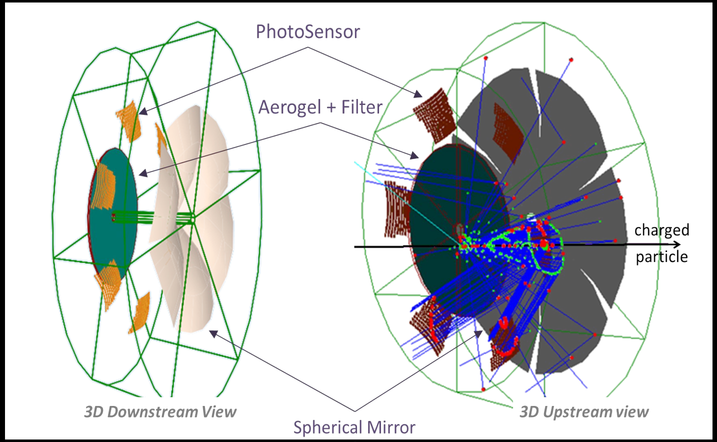
Backup

dRICH: ante-proposal

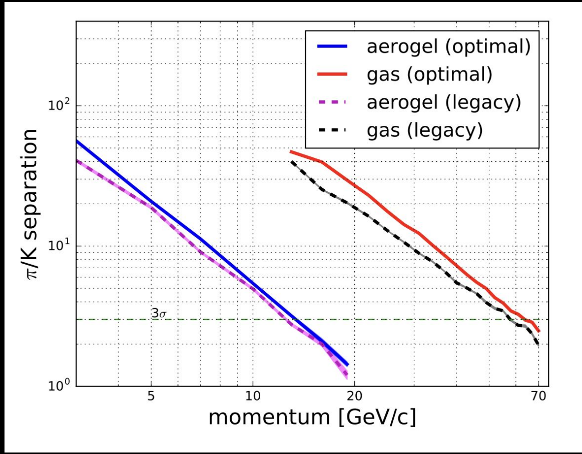
E. Cisbani, A. Del Dotto, CF*, M. Williams et al.
"AI-optimized detector design for the future Electron-Ion Collider: the dual-radiator RICH case."
Journal of Instrumentation 15.05 (2020): P05009.

aerogel (4 cm, n(400 nm): 1.02)
+ 3 mm acrylic filter
+ gas (1.6 m, n(C_2F_6): 1.0008)





- Continuous momentum coverage.
- Simple geometry and optics, cost effective.
- Legacy design from INFN, see EICUG2017

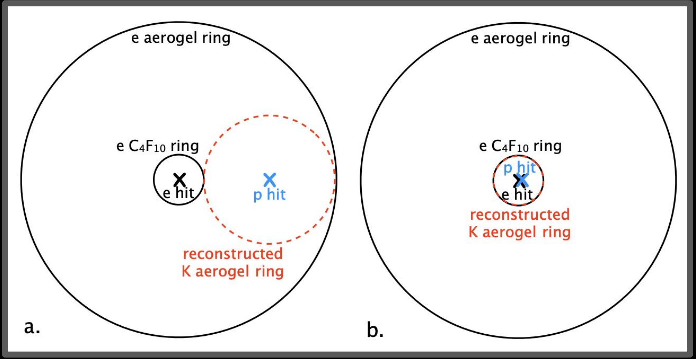


- 6 Identical open sectors (petals)
- Optical sensor elements: 8500 cm^2/sector, 3 mm pixel
- Large focusing mirror

dRICH reconstruction

* analogy with different approaches discussed for DIRC

- Indirect Ray Tracing (IRT)
  - The basic idea is that, given tracking information and RICH PMT hits, the Cherenkov-photon emission angle can be reconstructed.
  - The distribution of observed photon angles is compared to the expected angle for each particle type and the most likely particle type is determined.
  - Fast, non computationally intensive. Lowest accuracy compared to other methods in this slide.
- Direct Ray Tracing (DRT)
  - Simulates a PMT hit pattern based on the track kinematics and particle hypothesis
  - Construct likelihood by comparing “PDF” to the observed hit pattern
- Event-level algorithm (EVT)
  - Motivation: two close tracks can produce mis-identification
  - Builds upon DRT. Improvement by looking at each event as a whole rather than individual tracks
    - → sum over all tracks in the event



R. M. Lamb, PhD thesis, 2010, The Boer-Mulders and Cahn effects: Azimuthal modulations in the spin-independent SIDIS cross section at HERMES, https://inspirehep.net/literature/872161

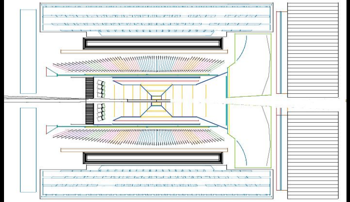
Data Generation

eic shell → Generating π/K tracks → Afterburner analysis → Apply quantum efficiency → Add Noise and save output

eic shell

Setup eic shell.

Setup geometry using dd4hep framework.



Generating π/K tracks

Use ndsim to simulate tracks.

The simulation does not include any detectors beyond the dRICH and in the electron endcap region.

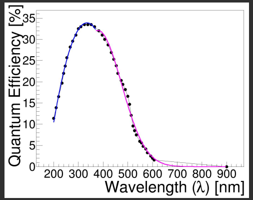
Afterburner analysis

Juggler was used to analyze the outputs from simulation

eic-recon was also explored. eic-recon was still under active development in September 2022

Apply quantum efficiency

To simulate real data, a quantum efficiency is applied to each of the optical photons based on its energy as in figure.



Add Noise and save output

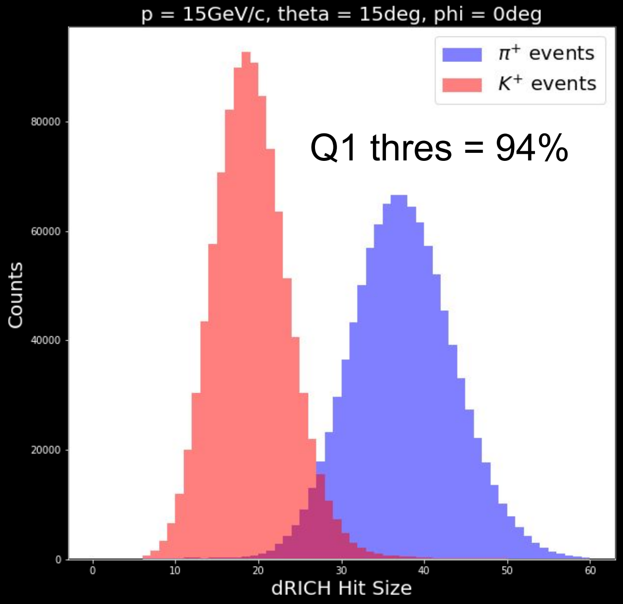
If needed, added random noise (Poisson with mean 5). Typical rates expected are between 5 optical photons per event.

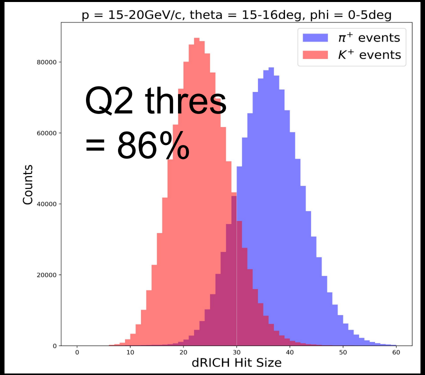
Save the output in the desired format. `csv` and `HDF5`

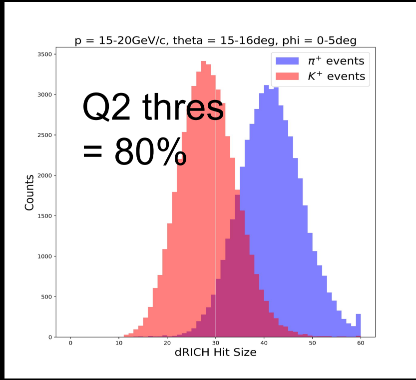
Threshold accuracy

Due to the shape of the ring in dRICH between the pions and kaons, one could place a cut on the total number of optical photons to distinguish between π/K in a given kinematic setting. This works poorly over a wide kinematic setting, though.

For judging purposes, a threshold accuracy is calculated based on this cut.







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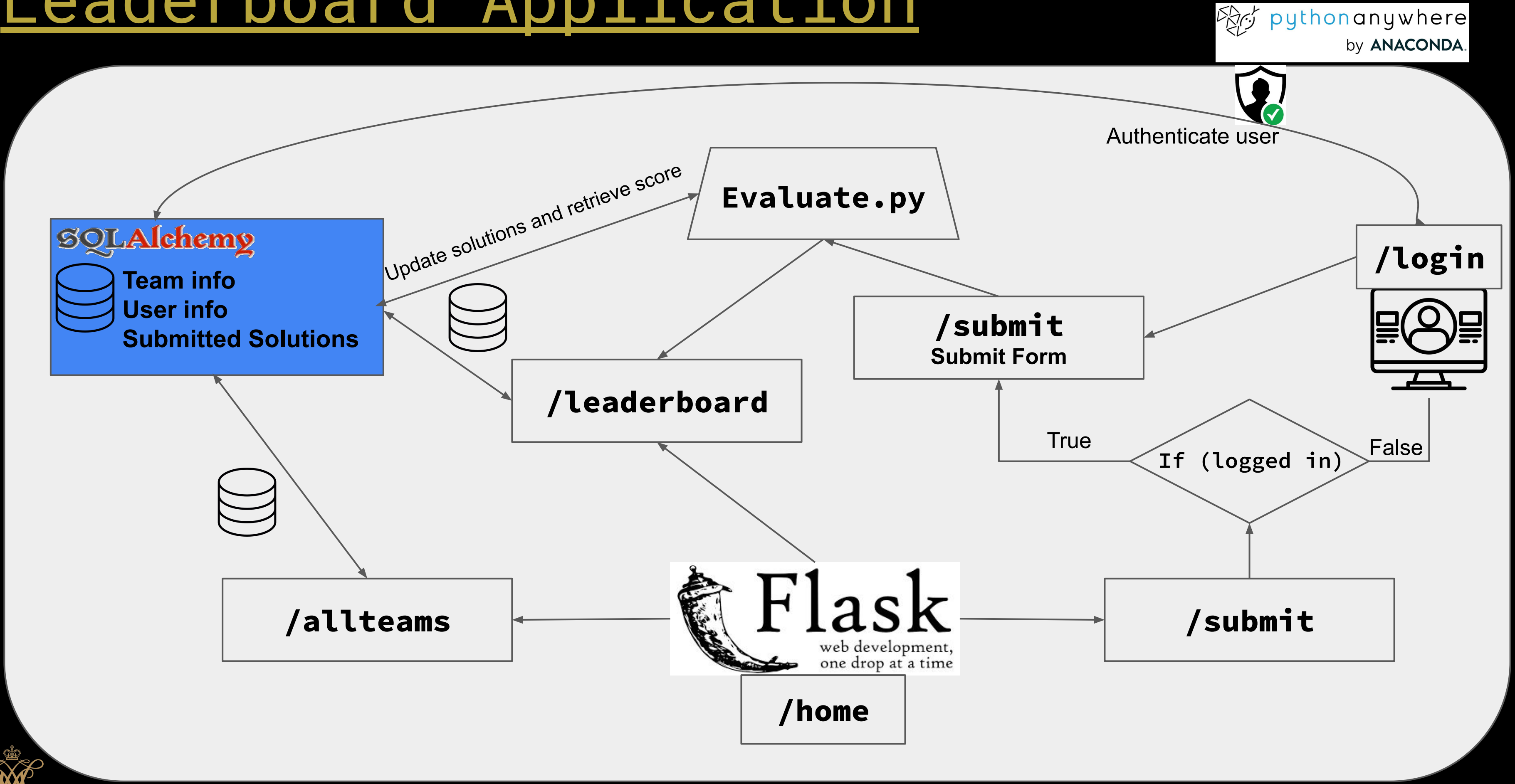
Leaderboard Application



2nd AI4EIC Live Document

https://docs.google.com/document/d/13BWnq_ywTYs__2zA0beeDob8pcuiiBiVqXNk33Kk8LY/edit

Live Document:

Artificial Intelligence for the Electron Ion Collider

Timetable

This is the live meeting notes (Q&A) document for the second workshop dedicated to Artificial Intelligence for the Electron Ion Collider, which will take place at William & Mary from **October 10 to October 14, 2022**.

This has been used during the workshop to collect questions and replies

Conveners monitored discussion/questions in the live document

Total of 26 pages

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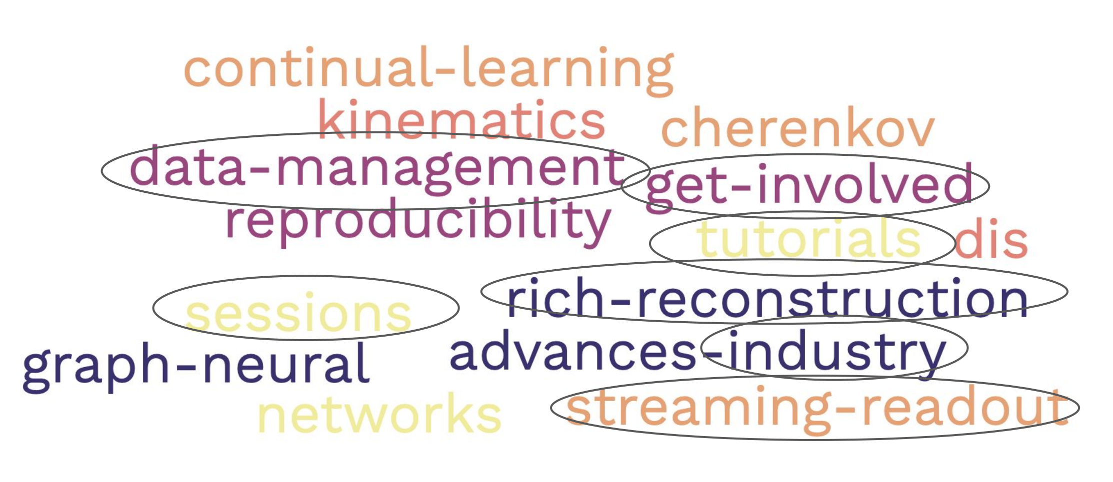
Survey (early 2022)

Hackathon: https://indico.bnl.gov/event/16586/page/435-hackathon
Tutorials: https://indico.bnl.gov/event/16586/page/426-tutorials

- A detailed survey was sent https://forms.gle/6LADKTGaX7DeTVE46
- We want to learn more about our community, and we asked for feedback on what the needs and interests are, and what potential opportunities
- Feedback and key-words:



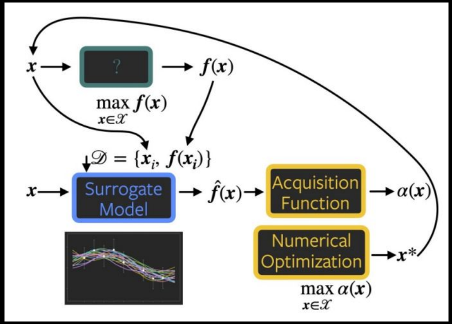
We organized our monthly meetings and workshop and hackathon taking into account this feedback

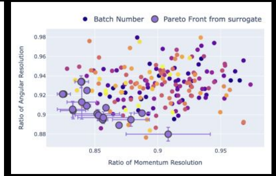
We have tutorial sessions every day of the workshop

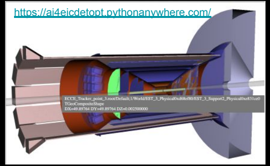
For more details on the survey, see https://indico.bnl.gov/event/15636/

AI4EIC Tutorials

M. Balandat, Meta AI



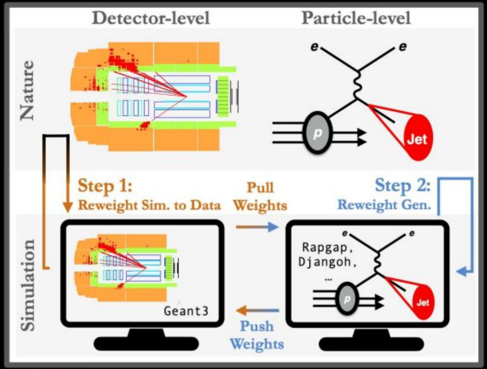




Multi-objective Optimization

F. Torales Acosta (LBNL)

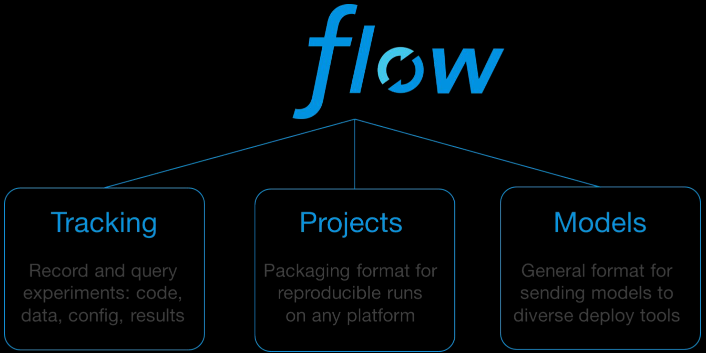
V. Mikuni (NERSC)



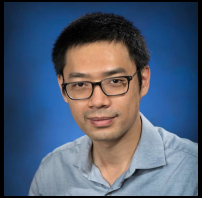
OmniFold

Unfolding

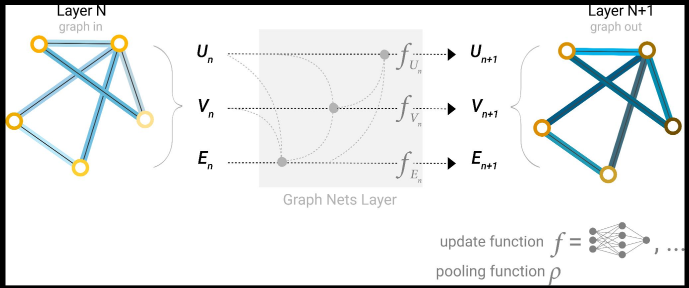
K. Rajput
JLab/DS



MLflow — ML lifecycle



Y. (Ray) Ren (BNL)



Graph Neural Network

AI4EIC Agenda

Convener list

Tutorial on Multi-objective Optimization (Meta)

Tutorial on Unfolding (LBNL, NERSC)

Mon, October 10, morning: introduction and overview

Time	Talk	Speaker	Location	Slot
10:00	Welcome & Intro to AI4EIC		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	10:00 - 10:25
	EIC schedule and overview	Elke-Caroline Aschenauer et al.	room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	10:25 - 11:05
11:00	Discussion		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	11:05 - 11:20
	Coffee break		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	11:20 - 11:40
	DOE perspective on opportunities for AI in nuclear physics	Manouchehr Farkhondeh	room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	11:40 - 12:10
12:00	Discussion		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	12:10 - 12:30
13:00	Lunch (on your own)		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	12:30 - 13:30
	NSF perspective on opportunities for AI in nuclear physics	Bogdan Mihaila	room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	13:30 - 14:00

DOE and NSF Perspectives

Mon, October 10, afternoon: Design

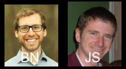
Time	Talk	Speaker	Location	Slot
14:00	Tutorial on Ax/Botorch: Multi-Objective Optimization	Max Balandat	room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	14:00 - 14:45
	Discussion		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	14:45 - 14:55
15:00	AI-assisted detector design / updates from ECCE to EPIC	karthik suresh	room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	14:55 - 15:15
	Q/A		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	15:15 - 15:20
	AI-driven detector design for the EIC	Benjamin Nachman	room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	15:20 - 15:40
	Q/A		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	15:40 - 15:45
	Coffee Break		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	15:45 - 16:00
16:00	ML application for beam optics control in the LHC	Elena Fol	room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	16:00 - 16:20
	Q/A		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	16:20 - 16:25
	AI/ML overview for accelerator design activities	Todd Satogata	room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	16:25 - 16:45
	Q/A		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	16:45 - 16:50
	Discussion		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	16:50 - 17:00

Tue, October 11, morning: theory/experiment connections

Time	Talk	Speaker	Location	Slot
10:00	ML for QCD Analysis - 3D Imaging	simonetta liuti	room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	10:00 - 10:20
	Q/A		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	10:20 - 10:25
	Modeling Hadronization Using ML and the Lund String Model	Tony Menzo	room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	10:25 - 10:45
	Q/A		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	10:45 - 10:50
11:00	Modeling Hadronization Using ML and the Cluster Model	Siodmok Andrzej	room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	10:50 - 11:10
	Q/A		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	11:10 - 11:15
	Coffee Break		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	11:15 - 11:30
	A(I)DAPT	Astrid Hiller Blin	room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	11:30 - 11:50
	Q/A		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	11:50 - 11:55
12:00	Femtoscale Imaging of Nuclei using ML and Exascale Platforms	nobuo sato	room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	11:55 - 12:15
	Q/A		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	12:15 - 12:20
	Differentiable Simulations	Benjamin Nachman	room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	12:20 - 12:40
	Q/A		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	12:40 - 12:45
	Discussion		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	12:45 - 13:00

Tue, October 11, afternoon: theory/experiment connections

Time	Talk	Speaker	Location	Slot
14:00	Reconstructing DIS and SIDIS properties	Connor Pecar	room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	14:00 - 14:20
	Q/A		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	14:20 - 14:25
	Machine Learning in Spectroscopy and Partial Wave Analysis	William Phelps	room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	14:25 - 14:45
	Q/A		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	14:45 - 14:50
15:00	Fast Detector Simulations with Machine Learning	David Shih	room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	14:50 - 15:10
	Q/A		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	15:10 - 15:15
	Coffee break		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	15:15 - 15:35
	overview talk on ML-based unfolding	Anja Butter	room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	15:35 - 15:55
	Q/A		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	15:55 - 16:00
16:00	Tutorial on Unfolding	Fernando Torales - Acosta et al.	room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	16:00 - 16:45
	Discussion		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	16:45 - 17:00
17:00				



Tutorial on MLFlow (JLab)

Wed, October 12, morning: Reconstruction & PID

Time	Talk	Speaker	Location	Slot
10:00	Interpretable Networks for Identifying Leptons	Daniel Whiteson	room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	10:00 - 10:25
	Q/A		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	10:25 - 10:30
	(tentative) Deep learning for jet tagging	Raghav Kunnawalkam Elayavalli	room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	10:30 - 10:55
	Q/A		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	10:55 - 11:00
11:00	Machine Learning in ACTS	Corentin Allaire	room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	11:00 - 11:17
	Q/A		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	11:17 - 11:20
	Coffee break		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	11:20 - 11:30
	(tentative) Muon Identification with Deep Learning at EIC	William Phelps	room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	11:30 - 11:45
	Q/A		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	11:45 - 11:48
12:00	ML particle identification with measured shower profiles from calorimetry	Chao Peng	room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	11:48 - 12:03
	Q/A		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	12:03 - 12:06
	Lambda event tagging at CLAS12	Matthew McEneaney	room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	12:06 - 12:21
	Q/A		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	12:21 - 12:24
	ML for calorimetry	Nathan Branson	room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	12:24 - 12:39
	Q/A		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	12:39 - 12:42
	Data-driven learning: Flux+Mutability	James Giroux	room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	12:42 - 12:57
	Q/A		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	12:57 - 13:00

Wed, October 12, afternoon: Infrastructure and Frontiers

Time	Talk	Speaker	Location	Slot
14:00	Tutorial on MLFlow	Diana McSpadden	room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	14:00 - 14:45
	Q/A		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	14:45 - 14:50
	Coffee break		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	14:50 - 15:00
15:00	Foundation Model Infrastructure	Svitlana Volkova	room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	15:00 - 15:13
	Q/A		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	15:13 - 15:18
	AI/ML hardware co-design	Frank Liu	room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	15:18 - 15:31
	Q/A		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	15:31 - 15:35
	Machine Learning with FPGA	Nhan Tran	room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	15:35 - 15:48
	Q/A		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	15:48 - 15:52
16:00	AI/Ml with HPC	Joo Balint	room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	15:52 - 16:05
	Q/A		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	16:05 - 16:10
	break		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	16:10 - 16:15
	Panel Discussion	Jin Huang et al.	room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	16:15 - 17:00
17:00				

Panel Discussion

Thu, October 13, morning: Streaming Readout

Time	Talk	Speaker	Location	Slot
10:00	(tentative) AI in SRO at INDRA/ASTRA	Markus Diefenthaler	room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	10:00 - 10:20
	Q/A		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	10:20 - 10:22
	Fast ML for FPGA	Sergey Furletov	room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	10:22 - 10:42
	Q/A		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	10:42 - 10:44
11:00	AI for real time applications in next generation HEP detectors	Roberto Ammendola	room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	10:44 - 11:04
	Q/A		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	11:04 - 11:06
	Coffee break		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	11:06 - 11:16
	AI-based data reduction for streaming DAQ	Jin Huang	room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	11:16 - 11:36
	Q/A		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	11:36 - 11:38
	Streaming Readout for Next Generation Electron Scattering Experiments	Mariangela Bondi	room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	11:38 - 11:58
	Q/A		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	11:58 - 12:00
12:00	ML for Heavy Flavor Identification	Cameron Dean	room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	12:00 - 12:20
	Q/A		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	12:20 - 12:22
	AI for Experimental Controls	Thomas Britton	room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	12:22 - 12:42
	Q/A		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	12:42 - 12:44
	Discussion		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	12:44 - 13:00

Tutorial on GNN (BNL)

Thu, October 13, afternoon: Summary and Future

Time	Talk	Speaker	Location	Slot
14:00	Tutorial on Graph Neural Networks	Yihui Ren	room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	14:00 - 14:45
	Q/A		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	14:45 - 14:50
15:00	Hackathon on October 14		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	14:50 - 15:15
	Coffee break		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	15:15 - 15:30
16:00	Summaries		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	15:30 - 16:12
	Q/A		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	16:12 - 16:15
	Future	Cristiano Fanelli	room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	16:15 - 16:30
	Closing		room 1019, William & Mary, Raymond A. Mason School of Business, Alan B. Miller Hall	16:30 - 16:40

AI4EIC Talks

Talks: https://indico.bnl.gov/event/16586/contributions/speakers

Design

- M. Balandat (Meta) Multi-objective Optimization Tutorial
- K. Suresh (Regina) Adaptive Experimentation in EIC
- B. Nachman (LBNL) AI-driven detector design
- E. Fol (CERN) ML Application for beam optics control in the LHC
- T. Satogata AI/ML overview for accelerator design activities

The/Exp (morn.)

- S. Liuti (UVA) ML for QCD analysis - 3D imaging
- T. Menzo (U. Cincinnati) Modeling Hadronization Using ML and the Lund String Model
- S. Andzrej (Jagiellonian U.) Modeling Hadronization Using ML and the Cluster Model
- A. Hiller Blin (U. Regensburg) A(I)DAPT
- N. Sato (JLab) Femtoscale Imaging of Nuclei using ML and Exascale Platforms
- B. Nachman (LBNL) Differentiable Simulations

Data centric analysis, UQ, modeling, analysis/preservation, event level inference

The/Exp (aftern.)

- D. Shih (Rutgers) Fast Detector Simulations with ML
- W. Phelps (CNU/JLab) ML in Spectroscopy and Partial Wave Analysis
- C. Pecar (Duke) Reconstructing DIS and SIDIS properties
- A. Butter (LPNHE CNRS) Ideas for ML based unfolding
- F. Torrales Acosta (LBNL) and V. Mikuni (NERSC) Unfolding Tutorial

Fast sim, spectroscopy, event-level reco, unfolding

Reco/PID

Particle-level, event tagging, data-driven

- D. Whiteson (UC Irvine) Interpretable Networks for Identifying Leptons
- R. Kunnawalkam Elayavalli (Vanderbilt U.) Tagging heavy flavor jets @ RHIC
- W. Phelps (CNU/JLab) Muon identification with Deep Learning at EIC
- C. Allaire (IJC-Lab) Machine Learning in ACTS
- C. Peng (ANL) ML PID with measured shower profiles from calorimetry
- M. McEneaney (Duke) Λ event tagging at CLAS12
- N. Branson (Messiah U.), ML for calorimetry
- J. Giroux (Regina), Data-driven learning : Flux + Mutability

Infrastructure

- D. McSpadden (JLab/DS) MLFlow tutorial
- S. Volkova (PNNL) Foundation Model Infrastructure
- F. Liu (ORNL) AI/ML hardware co-design
- N. Tran (FNAL) Machine Learning with FPGA
- B. Joo (ORNL) AI/ML with HPC
- J. Huang (BNL), T. Miceli (FNAL), M. Williams (MIT), Panel Discussion

SRO

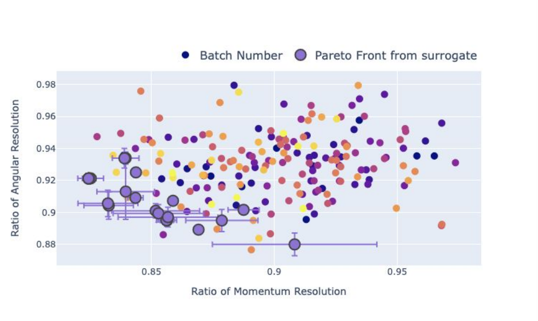
- M. Diefenthaler (JLab) INDRA-ASTRA
- S. Furletov (JLab) FastML for FPGA
- R. Ammendola (Tor Vergata, Rome) AI for streaming readout: an architectural perspective
- J. Huang (BNL) AI-based data reduction for streaming DAQ
- M. Bondi' (INFN/Catania) SRO for next generation electron scattering experiments
- C. Dean (MIT) ML for Heavy Flavor Identification
- T. Britton (JLab) AI for Experimental Controls

Jefferson Lab
Exploring the Nature of Matter

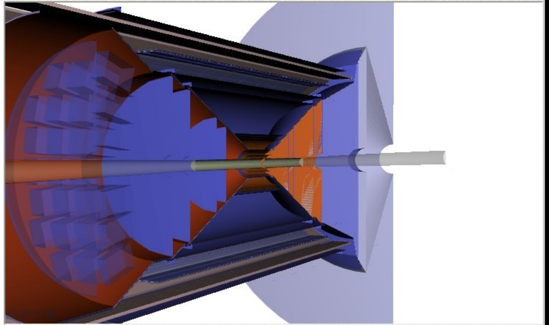
Integrate modern Data Science tools

CF et al, NIM A, 2023, 167748

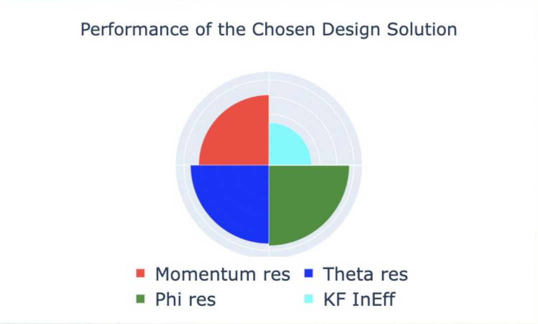
Multi Objective Bayesian Optimization



GEANT4 Visualization of the design



Click on petals for finer evaluations

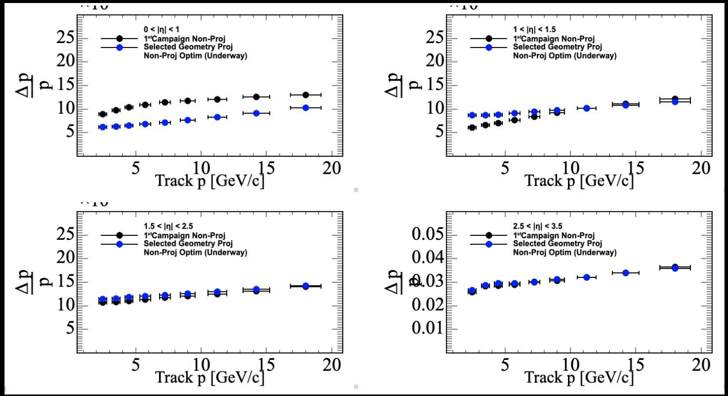


Design Parameters Table

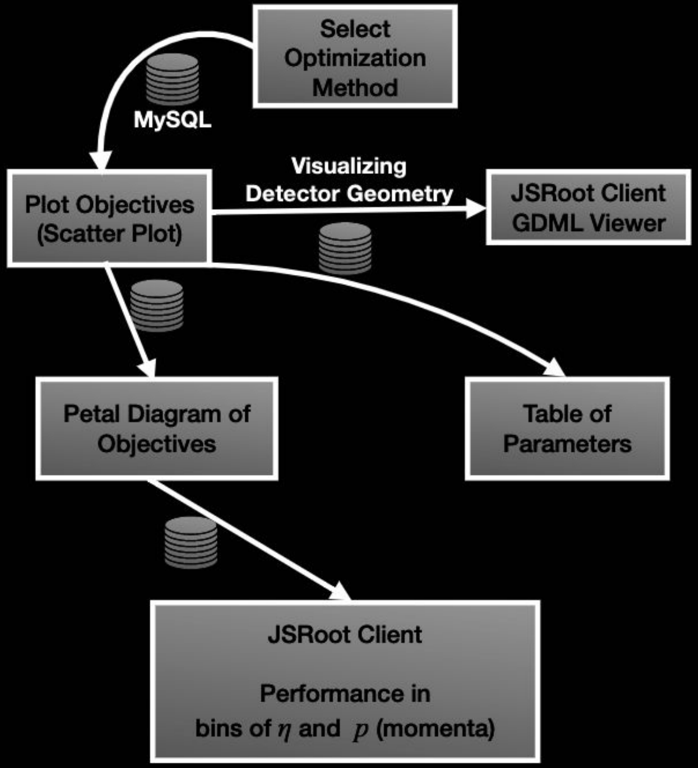
Parameter Name	Parameter Value
Angle of cone [deg]	25.00
Radius of uRwell-1 [cms]	32.47
z E-TTL [cms]	171.00
z F-TTL [cms]	157.60
z EST-1 [cms]	40.39
z EST-3 [cms]	85.09
z FST-1 [cms]	35.03
z FST-3 [cms]	83.78
z FST-5 [cms]	131.27

The whole idea of the AI-assisted design is that of determining trade-off optimal solutions in a multidimensional design driven by multiple objectives

For an interactive visualization:
https://ai4eicdetopt.pythonanywhere.com



Visualization



- The interactive visualization employs several Python and JavaScript libraries/packages to visualize the results from the optimization
  - Plotly-dash - click&play interface; interactive navigation; expanded dashboard
  - JSRoot — JSRoot project allows reading binary and JSON ROOT files in JavaScript; drawing of different ROOT classes in web browsers; reading TTree data; using node.js used to visualize the detector geometry which is stored in GDML format
  - Pandas: read source data (Pareto front solution)
  - MySQL DB: most convenient DB that is used alongside Flask based applications. Meta-data like location of Geometry files, Location of parameters file are stored in the form of a database

https://ai4eicdetopt.pythonanywhere.com