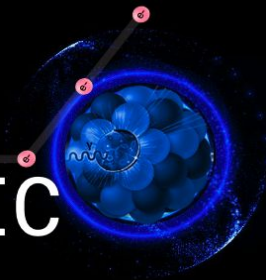




4EIC



<https://eic.ai/>

# Report from EICUG AI WG

Electron-Ion Collider User Group Meeting 2022

Cristiano Fanelli, Tanja Horn

CFNS Stony Brook University

# EICUG AIWG (aka AI4EIC) Mission

<https://eicug.github.io/content/wg.html>

- EIC has the unique opportunity to start incorporating AI from the very beginning and to systematically leverage on it during all phases of the project (see [EIC Yellow Report, Chap. 11](#)).
- AI will be an integral part of the EIC software and we will take advantage of intelligent decisions in all aspects of data processing from detector readout and control to analysis.
- To work in this direction, there is an AI Working Group (AI) as part of the SWG. The AIWG will serve as an entry point to AI applications and will organize meetings, workshops, tutorials, and Kaggle-like challenges.
- The AIWG will embrace the EIC Software Statement of Principles

## Broader scope

[Kickoff meeting of the EICUG AI WG](#)

### Cross-cutting / multidisciplinary, open data to boost AI, increase AI literacy in EIC, educational outreach

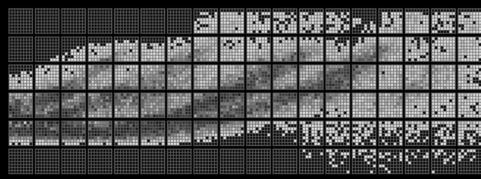
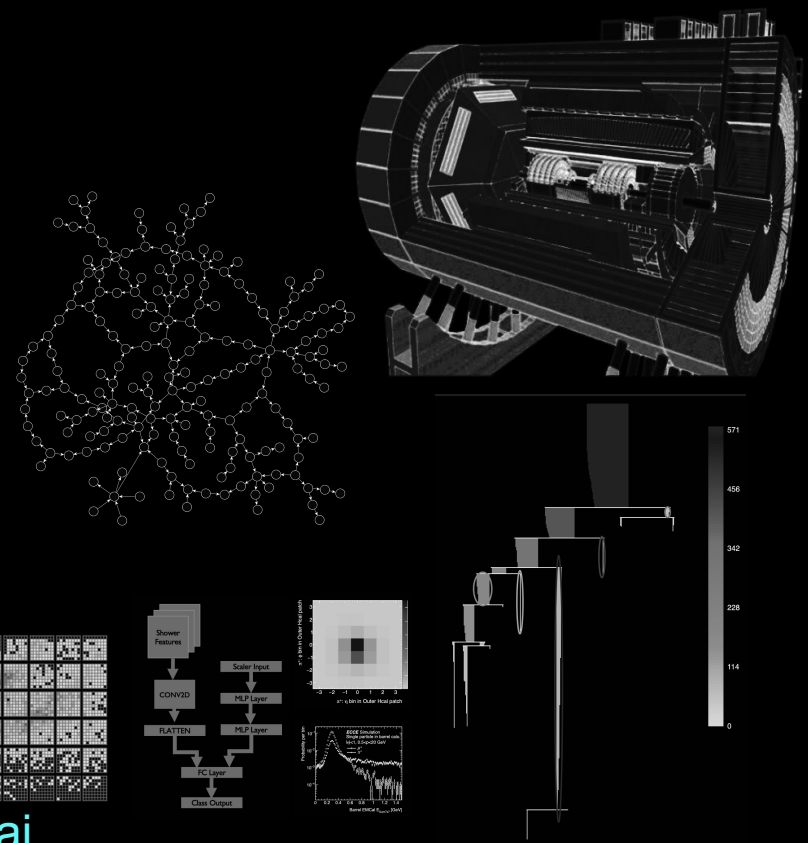
- EIC is being designed now... will be built over ~ 10 years.
- Opportunity to engage with other communities: message from AI4EIC was this should start "now!"
  - Initiatives in NP, HEP
  - Computer Science, Data Science
- Encourage participation from industry. Running theme at AI4EIC was partnership with industry. What is the most productive way going forward?
  - [Computing Frontiers, Panel Discussion at AI4EIC](#) and [Meeting\\_Live\\_Document\\_AI4EIC\\_Workshop](#)
  - [AISIS: Artificial Intelligence for Science, Industry and Society — Particle and Nuclear Physics — panel discussion](#)
- We may need to think of new data policy to make data - not necessarily real data - accessible to a broader community --- this involves hackathons, educational events) — [Open, FAIR data](#); [open-source software](#)
- Today's students might have leading role in EIC in ~10 years — We need outreach

# Forum to present AI/ML updates to EIC

Embrace accelerator, detector, theory, CS/DS

E.g., Lot of momentum due to multiple ongoing AI-efforts for the EPIC detector (and towards Detector-2):

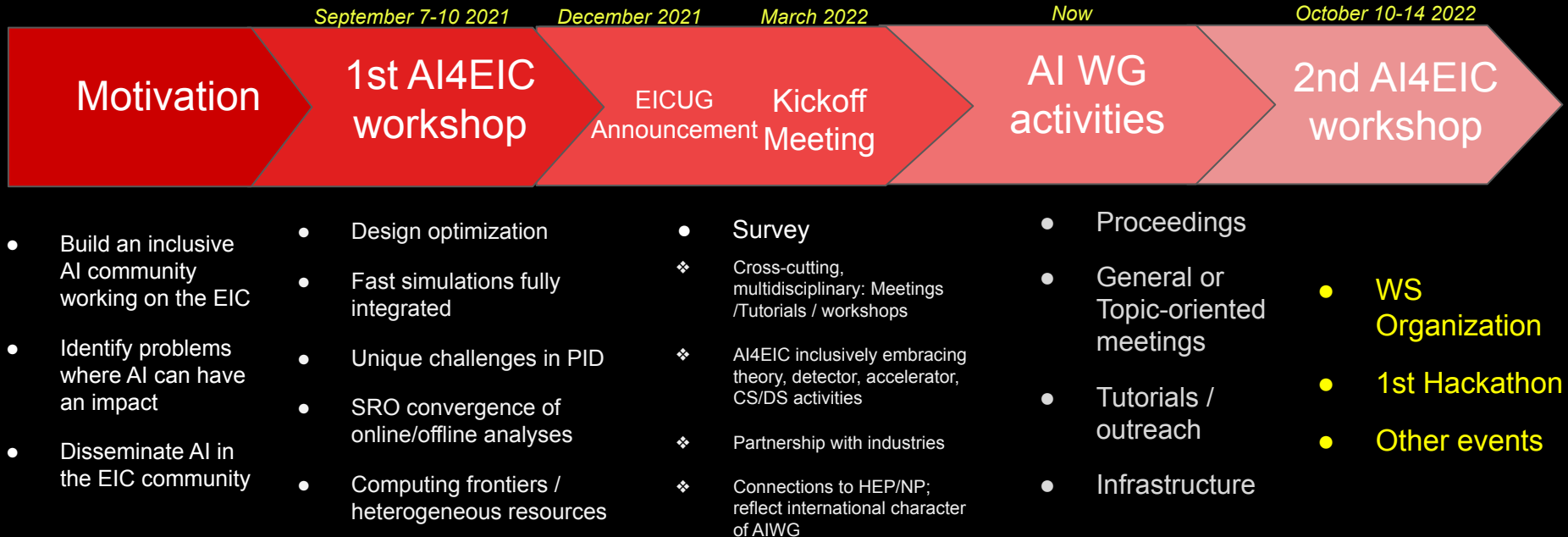
- Fast ML in Streaming Readout at EIC (ML for HF identification )
- Design optimization with AI
- PID, e.g., Muon ID with deep learning
- Deeply learning DIS
- Calo Reconstruction: multi-dimensional Clustering
- Etc ...



[support@eic.ai](mailto:support@eic.ai)

# AI4EIC Timeline

Activities rapidly evolving in the EICUG AI WG in < 1 year



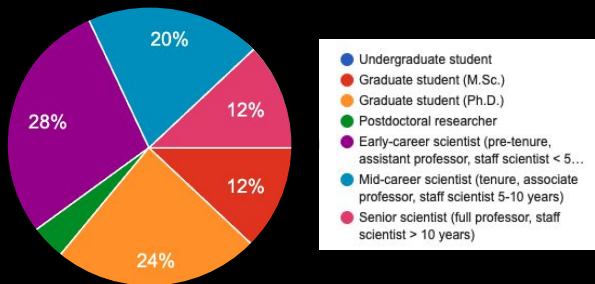
# Kickoff/Survey

- Survey
- ❖ Cross-cutting, multidisciplinary: Meetings /Tutorials / workshops
- ❖ AI4EIC inclusively embracing theory, detector, accelerator, CS/DS activities
- ❖ Partnership with industries
- ❖ Connections to HEP/NP; reflect international character of AIWG

# AI4EIC Survey

~ 30 questions / 30 participants

## Demographics



## Community-driven efforts

### Questions (short/open):

- Demographics
- Future Events (workshop, hackathon, kaggle-like, suggestions)
- Activities (how get engaged: “sub-WG”, tutorials, schools, community challenges, workshop, ...)
  - Workshop sessions, suggestions
  - Meetings, suggestions
- Open Data & Software, Information and Communication
- General

Dear AI/ML enthusiasts,

Thanks a lot for the active discussion we had at the kickoff meeting of the EICUG AIWG (AI4EIC) during which we decided to send a survey to our community. Please find the link below:

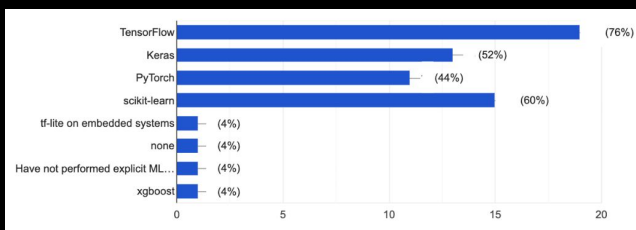
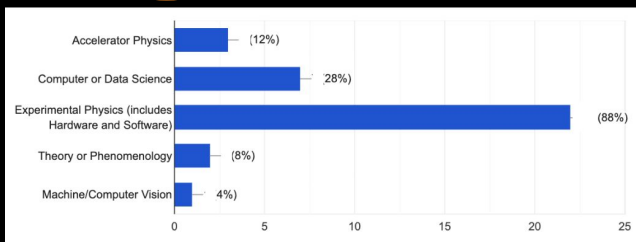
<https://forms.gle/6LADKTGaX7DeTVE46>

Kindly provide your answers before Monday, May 2.

The next AI4EIC meeting will take place on Wednesday, May 4, 11am EDT. Please find below a link to the indico webpage, where you can find the meeting coordinates:

<https://indico.bnl.gov/event/15530/>

Looking forward to seeing you at the next AI4EIC meeting.



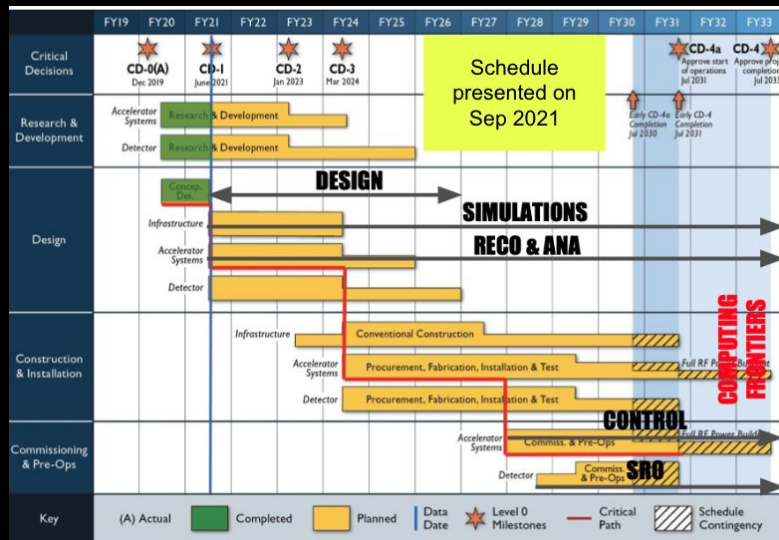
Responses presented for the first time [here](#)

# Activities

- Proceedings
- General or  
Topic-oriented  
meetings
- Tutorials /  
outreach
- Infrastructure

# [ 1<sup>st</sup> Workshop (Sep 2021) ]

[Timetable](#)  
[Live Document](#)  
[Proceedings](#)



Held (virtually) at CFNS, 243 participants

Conveners: Friederike Bock (ORNL), Malachi Schram (JLab)

### Accelerator and Detector Design

Conveners: Corey Adams (ANL), Makoto Asai (SLAC)

### Simulations

Conveners: Liliana Teodorescu (Brunel U.), Thomas Ullrich (BNL), Yulia Furletova (JLab)

### Reconstruction and Analysis

Conveners: Benjamin Nachman, Thomas Britton (JLab)

### Accelerator and Detector Control

Conveners: Jin Huang (BNL), Philip Harris (MIT)

### Detector Readout

Conveners: Gabriel Perdue (Fermilab), Olivier Pfister (U. Va.), Wouter Deconinck (U.Manitoba)

### Computing Frontiers

Invited speakers + contributions:

Corey Adams, Lucio Anderlini, Makoto Asai, Fernando Barbosa, Thomas Britton, Markus Diefenthaler, Aurelee Edelen, Rolf Ent, Farah Fahim, Abdullah Farhat, Cristiano Fanelli, Sergey Furletov, Yulia Furletova, Louis-Guillaume Gagdon, Gagik Gavalian, Sergey Gleyzer, Lukasz Graczykowski, Yue Hao, Philip Harris, Douglas Higginbotham, Jin Huang, Yi Huang, Travis Humble, Torri Jeske, Sylvester Joosten, Michelle Kuchera, Henry Lamm, Benjamin Nachman, Gabriel Perdue, William Phelps, Dylan Rankin, Kishansingh Rajput, Dmitry Romanov, Andrew Schick, Malachi Schram, Stephen Sekula, Nhan Tran, Thomas Ullrich, Tod Satogata, Mike Williams, Dantong Yu

1<sup>st</sup> AI4EIC Workshop with focus on Experimental Applications

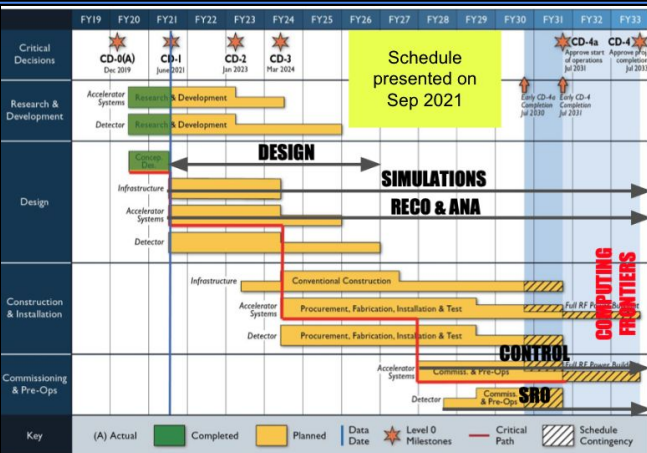
<https://eic.ai/workshops>







# AI4EIC Proceedings JINST (2022)



<https://iopscience.iop.org/journal/1748-0221/page/extraproc98>

D.W. Higinbotham, EIC Detector Overview (session: Detector Design)

C. Fanelli, Design of detectors at the EIC with AI (session: Detector Design)

L. Anderlini, Machine learning for the LHCb simulation (session: Simulations)

L. Graczykowski et al., Using machine learning for PID in ALICE (session: Reconstruction and analysis)

L.-G. Gagnon, Machine learning for track reconstruction at the LHC (session: Reconstruction and analysis)

C. Fanelli and A. Mahmood, Artificial Intelligence for imaging Cherenkov detectors at the EIC (session: Reconstruction and analysis)

T. Jeske et al., AI for Experimental Controls at Jefferson Lab (session: Accelerator and Detector Control)

T. Britton and B. Nachman, Accelerator and Detector Control for the EIC with machine learning (SUMMARY of the entire session on Accelerator and Detector Control)

T. Xuan et al., High performance FPGA embedded system for machine learning based tracking and trigger in sPHENIX and EIC (session: Streaming Readout)

S. Furletov et al., Machine Learning on FPGA for Event Selection (session: Streaming Readout)

T.S. Humble et al., Frontiers in computing for artificial intelligence (SUMMARY of the entire session on Computing Frontiers and Panel Discussion)


<https://eic.ai/ai-ml-references>

# Meetings (2022)

CALENDAR		*TBC
10/10-14/2022	<b>AI4EIC Workshop</b> 2nd workshop, hosted by College of William and Mary, Williamsburg, VA October 10-14, 2022	In presence + virtual
9/14/2022 *	<b>AI WG 6th meeting</b> 6th meeting of the EICUG AI WG	9am - 11am ET Virtual
8/17/2022 *	<b>AI WG 5th meeting</b> 5th meeting of the EICUG AI WG	9am - 11am ET Virtual
7/20/2022	<b>AI WG 4th meeting</b> 4th meeting of the EICUG AI WG topic-oriented: detector design (re-scheduled; slides uploaded)	9am - 11am ET Virtual <a href="https://indico.bnl.gov/event/16328/">https://indico.bnl.gov/event/16328/</a>
6/22/2022	<b>AI WG 3rd meeting</b> 3rd meeting of the EICUG AI WG topic-oriented: uncertainty quantification	9am - 11am ET Virtual <a href="https://indico.bnl.gov/event/16073/">https://indico.bnl.gov/event/16073/</a>
5/4/2022	<b>AI WG 2nd meeting</b> 2nd meeting of the EICUG AI WG Survey: <a href="https://forms.gle/6iADKTGaxZDeTVF46">https://forms.gle/6iADKTGaxZDeTVF46</a>	11am - 12pm ET Virtual <a href="https://indico.bnl.gov/event/15636/">https://indico.bnl.gov/event/15636/</a>
3/30/2022	<b>AI WG kickoff meeting</b> Kickoff meeting of the EICUG AI WG	11am - 12pm ET Virtual <a href="https://indico.bnl.gov/event/14923/">https://indico.bnl.gov/event/14923/</a>
9/7-10/2021	<b>AI4EIC Workshop</b> 1st workshop, hosted by CFNS/BNL September 7-10, 2021	Virtual

*April to October 2022*

## Topic-oriented Discussions (2022):

-  Uncertainty Quantification
- -> Detector Design (Aug/Sep)
- Continual Learning (Aug/Sep)
- Near real-time ML/DL (Aug/Sep)
- ML lifecycle (Sep/Oct)

*2nd workshop October 10-14 at W&M*

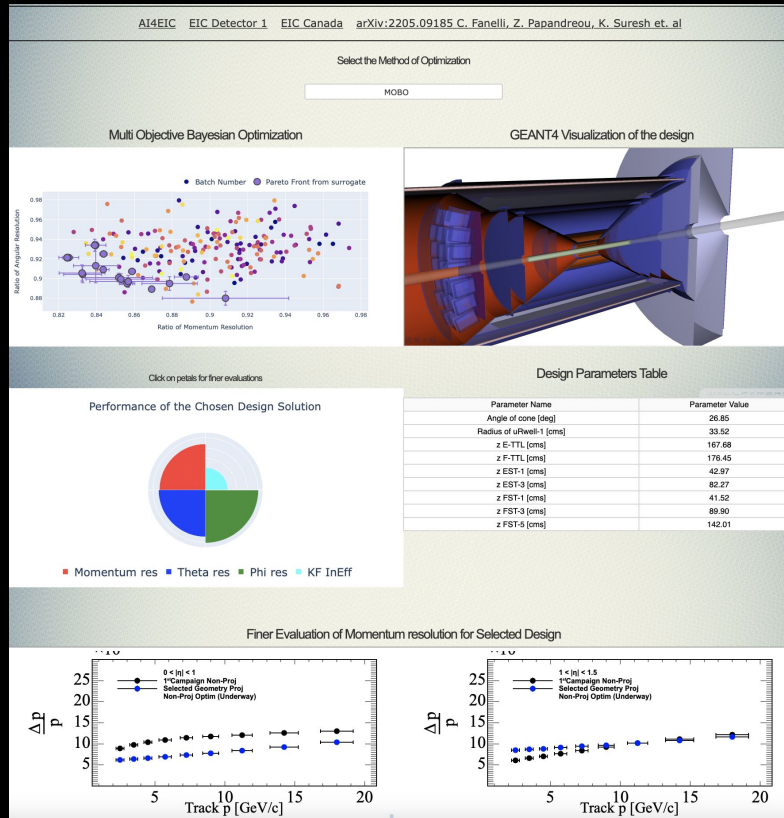
- more to come

<https://eic.ai/events>

# Tutorials for the EIC community

- “Design optimization” is probably one of the most recurrent topic of this meeting
- AI4EIC made available lectures/hands-on tutorials on how to do an optimization in a multi-dimensional space driven by multiple objectives (and constrained by multiple constraints). You can also include uncertainties in a Bayesian framework.
  - This can be coupled to full Geant4 simulations!
  - If you have competing objectives (e.g., resolution vs costs) it turns out there is no best solution, but a set of tradeoff solutions (Pareto front). AI can help determine the Pareto front.
  - Highly parallelizable, take advantage of modern methods to accelerate calculations (e.g., autodifferentiation when applicable)
  - Possible partnership with industry? E.g., support of Meta Open Source community (Facebook)
- Why not using these tools systematically when needed, i.e. when it comes to complex optimization problems, instead of brute-force (or just manual) optimization?

# Tutorials: Examples



An interactive Jupyter Book with lectures and hands-on tutorials with toy models (by C. Fanelli)  
<https://cfteach.github.io/nnpss/intro.html>

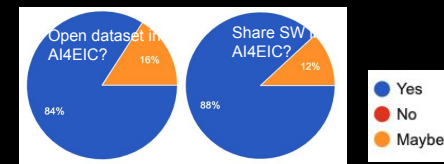
An interactive navigation of the Pareto front obtained with the ECCE baseline (by K. Suresh)  
<https://ai4eicdetopt.pythonanywhere.com/>



# AI/ML Infrastructure for EIC community

- A typical AI/ML project may be characterized by training dataset (if supervised), candidate and final models, hyperparameters, performance metrics, etc.
- We will discuss (i) how to effectively manage the lifecycle of such projects and handle experimentation, reproducibility, deployment and model registry (see, e.g., MLflow) as well as (ii) how to integrate AI/ML as production piece in a pipeline.
- This entails decisions on data format, data and analysis preservation in synergy with the ongoing discussion in the EPIC common software stack
- Creation of repository in <https://github.com/eic>; entry-point for documentation <https://eic.ai/community> (with links therein); discussion on community contribution workflow

## Open Fair Data, Open-source SW



### Based on:

- EIC Software Statement of Principles
- Monitor the ongoing discussion from EPIC software stack on DAP...
- Meetings with Computing Coordination Group

# AI4EIC Communication Platforms

- How to get in contact and get info:
  - **Support:** for issues related to <https://eic.ai> and events/collaborations [support@eic.ai](mailto:support@eic.ai)
  - **Mailing list:** [eicug-software-ai@eicug.org](mailto:eicug-software-ai@eicug.org) (general announcements)
  - **Rapid communications:** <https://ai4eic.slack.com/>
    - considering if migrating to Mattermost (if needed)

# Future

- WS  
Organization
- 1st Hackathon
- Other events

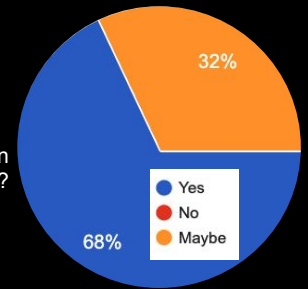
# 2<sup>nd</sup> Workshop (Oct 2022)

Emphasis on ongoing AI/ML activities for EIC

Inspiring talks in synergy with other communities

- AI for Design (EPIC / Detector-2)
- Connections to Theory
- AI/ML for analysis/reconstruction/PID
  - Connections to streaming
- AI/ML Workflow / Infrastructure
- Frontiers in AI/ML
- Tutorials!
- Hackathon event

The second annual workshop on AI4EIC will be held on October 10-14, 2022. Would this be a good option for you?



October 10-14 2022, William & Mary: in-person & virtual



with support of



Community paper on Artificial Intelligence for EIC?

<https://eic.ai/workshops>



# Conclusions

- AI WG is ramping up activities; several people are joining the efforts (we have >12 institutions on board) and more collaborators are welcome
- We had already a few meetings on cross-cutting topics (e.g., uncertainty quantification with talks from accelerator, detector, theory)
- Check out <https://eic.ai/events> for future (and past) events; next topic-oriented meetings for 2022 will be on topics like continual learning, detector design, machine learning life-cycle, near real-time applications
- Save the date: AI4EIC Workshop+hackathon October 10-14, 2022. Location: W&M
- More to come (e.g., kaggle-like challenge) — AI4E(P)IC!



# References

## References

- [1] AI4EIC Meetings and events: <https://aic.ai/events>
- [2] AI4EIC community (e.g., tutorials): <https://aic.ai/community>
- [3] AI4EIC Proceedings and literature: <https://aic.ai/ai-ml-references>
- [4] AI4EIC workshop <https://aic.ai/workshops>

# Questions?

