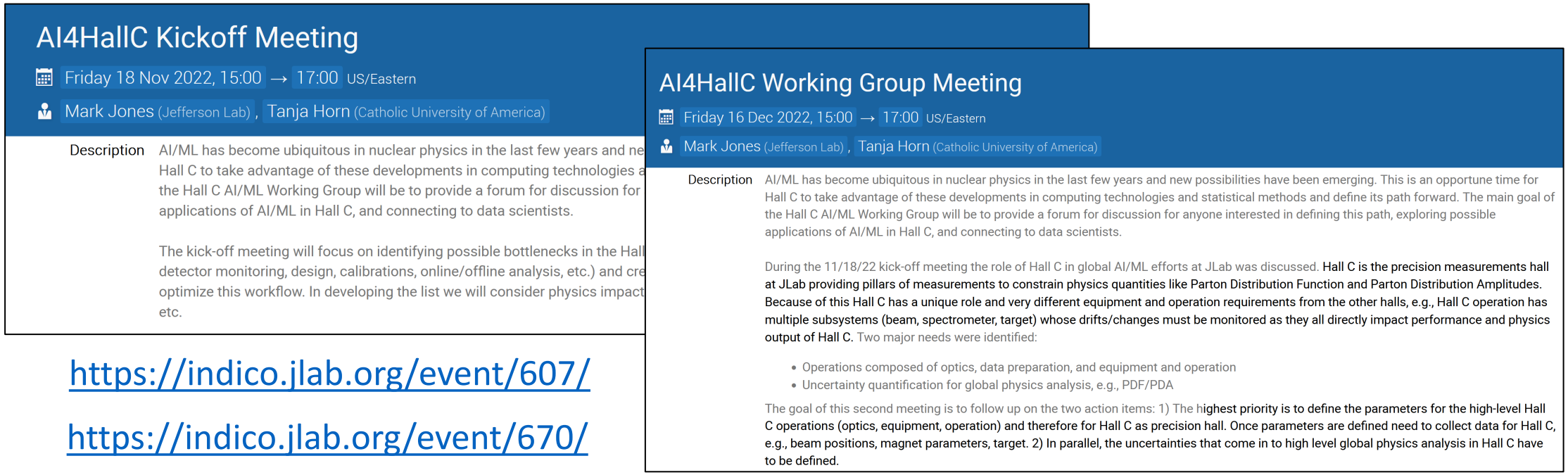
AI4HallC WG Overview

Tanja Horn, Cristiano Fanelli

AI/ML in Hall C WG

- ❑ The AI4HallC WG had a kickoff meeting on 18 November 2022
- ❑ The meetings are open to All! No experience with AI/ML required.
- ❑ Meetings are roughly every month. - Announcements through the Hall C mailing list
- ❑ Next meeting: February 2023 (stay tuned for the exact date)



AI4HallC Kickoff Meeting

Friday 18 Nov 2022, 15:00 → 17:00 US/Eastern

Mark Jones (Jefferson Lab), Tanja Horn (Catholic University of America)

Description AI/ML has become ubiquitous in nuclear physics in the last few years and ne
Hall C to take advantage of these developments in computing technologies a
the Hall C AI/ML Working Group will be to provide a forum for discussion for
applications of AI/ML in Hall C, and connecting to data scientists.

The kick-off meeting will focus on identifying possible bottlenecks in the Hall
detector monitoring, design, calibrations, online/offline analysis, etc.) and cre
optimize this workflow. In developing the list we will consider physics impact
etc.

AI4HallC Working Group Meeting

Friday 16 Dec 2022, 15:00 → 17:00 US/Eastern

Mark Jones (Jefferson Lab), Tanja Horn (Catholic University of America)

Description AI/ML has become ubiquitous in nuclear physics in the last few years and new possibilities have been emerging. This is an opportune time for Hall C to take advantage of these developments in computing technologies and statistical methods and define its path forward. The main goal of the Hall C AI/ML Working Group will be to provide a forum for discussion for anyone interested in defining this path, exploring possible applications of AI/ML in Hall C, and connecting to data scientists.

During the 11/18/22 kick-off meeting the role of Hall C in global AI/ML efforts at JLab was discussed. Hall C is the precision measurements hall at JLab providing pillars of measurements to constrain physics quantities like Parton Distribution Function and Parton Distribution Amplitudes. Because of this Hall C has a unique role and very different equipment and operation requirements from the other halls, e.g., Hall C operation has multiple subsystems (beam, spectrometer, target) whose drifts/changes must be monitored as they all directly impact performance and physics output of Hall C. Two major needs were identified:

- Operations composed of optics, data preparation, and equipment and operation
- Uncertainty quantification for global physics analysis, e.g., PDF/PDA

The goal of this second meeting is to follow up on the two action items: 1) The highest priority is to define the parameters for the high-level Hall C operations (optics, equipment, operation) and therefore for Hall C as precision hall. Once parameters are defined need to collect data for Hall C, e.g., beam positions, magnet parameters, target. 2) In parallel, the uncertainties that come in to high level global physics analysis in Hall C have to be defined.

https://indico.jlab.org/event/607/

https://indico.jlab.org/event/670/

AI/ML in Hall C WG

https://indico.jlab.org/event/607/

AI4HallC Kickoff Meeting

Friday 18 Nov 2022, 15:00 → 17:00 US/Eastern

Mark Jones (Jefferson Lab), Tanja Horn (Catholic University of America)

Description

AI/ML has become ubiquitous in nuclear physics in the last few years and new possibilities have been emerging. This is an opportune time for Hall C to take advantage of these developments in computing technologies and statistical methods and define its path forward. The main goal of the Hall C AI/ML Working Group will be to provide a forum for discussion for anyone interested in defining this path, exploring possible applications of AI/ML in Hall C, and connecting to data scientists.

The kick-off meeting will focus on identifying possible bottlenecks in the Hall C science output workflow (spectrometer setting, data acquisition, detector monitoring, design, calibrations, online/offline analysis, etc.) and creating a priority list of applications where AI/ML may assist and optimize this workflow. In developing the list we will consider physics impact for Hall C, timelines when AI/ML tools would need to be available, etc.

15:00 → 15:30 **Introduction - examples from other experimental halls**

15:30 → 16:00 **What are the needs of Hall C - experts from hall c round table**

16:00 → 16:30 **Priority list - ranking of challenges**

16:30 → 17:00 **Discussion**

AI/ML in Hall C WG

https://indico.jlab.org/event/607/

What are the needs of Hall C - experts from Hall C round table

- ❑ Hall C is the **precision measurements** hall at JLab **providing pillars of measurements to constrain physics quantities like Parton Distribution Function and Parton Distribution Amplitudes**
- ❑ Hall C has a unique role and very different equipment and operation requirements from the other halls, e.g., **multiple subsystems (beam, spectrometer, target) whose drifts/changes must be monitored as they all directly impact performance and physics output** of Hall C.
- ❑ Two major areas of needs were identified:
  - Higher level global physics analysis
    - *Uncertainty quantification* still a big topic and not well understood → **Nobuo's talk**
  - Higher level operation → composed of the three points below
    - *Equipment and Operation*: e.g., Optics parameter tuning → fish out small outliers out of a large set of optics data → affects the precision of Hall C:
    - Data Preparation → identify and *combine parameters from many different experiments* in Hall C
    - *Equipment and Operation → want to know minor changes* of magnet optics (spectrometer) and/or beam

Action items/Prioritizations/Ranking of Challenges

- ❑ **Highest priority is to define the parameters for the high-level Hall C operations** (optics, equipment, operation) and therefore for Hall C as precision hall. Once parameters are defined need to collect data for Hall C, e.g.,
- ❑ In parallel, **define uncertainties that come in to high level global physics analysis in Hall C** (PDF/PDAs - there Hall C provides pillars of measurements for their constraint)

AI/ML in Hall C WG

https://indico.jlab.org/event/670/

AI4HallC Working Group Meeting

Friday 16 Dec 2022, 15:00 → 17:00 US/Eastern

Mark Jones (Jefferson Lab), Tanja Horn (Catholic University of America)

Description

AI/ML has become ubiquitous in nuclear physics in the last few years and new possibilities have been emerging. This is an opportune time for Hall C to take advantage of these developments in computing technologies and statistical methods and define its path forward. The main goal of the Hall C AI/ML Working Group will be to provide a forum for discussion for anyone interested in defining this path, exploring possible applications of AI/ML in Hall C, and connecting to data scientists.

During the 11/18/22 kick-off meeting the role of Hall C in global AI/ML efforts at JLab was discussed. Hall C is the precision measurements hall at JLab providing pillars of measurements to constrain physics quantities like Parton Distribution Function and Parton Distribution Amplitudes. Because of this Hall C has a unique role and very different equipment and operation requirements from the other halls, e.g., Hall C operation has multiple subsystems (beam, spectrometer, target) whose drifts/changes must be monitored as they all directly impact performance and physics output of Hall C. Two major needs were identified:

- Operations composed of optics, data preparation, and equipment and operation
- Uncertainty quantification for global physics analysis, e.g., PDF/PDA

The goal of this second meeting is to follow up on the two action items: 1) The highest priority is to define the parameters for the high-level Hall C operations (optics, equipment, operation) and therefore for Hall C as precision hall. Once parameters are defined need to collect data for Hall C, e.g., beam positions, magnet parameters, target. 2) In parallel, the uncertainties that come in to high level global physics analysis in Hall C have to be defined.

AI/ML in Hall C WG

https://indico.jlab.org/event/670/

Starting to develop the Hall C parameter list for overall higher level operations:

- ❑ **Future/optimization of parameters relevant for Hall C as the precision measurement** The online spreadsheet is available here: Hall C Parameters
- ❑ **AI/ML tools for Hall C overall goal:** start with a specific case for validation using existing data
  - Action item: Compile a list of additional ideas to compare to existing data

Parameters relevant for HallC

- ➢ Overall objective: what are the observables that are most connected to Hall C precision? directly and indirectly correlated parameters.
- ➢ It seems best to separate dynamic and static parameters, as well as event stream parameters

Implementation and AI/ML tools for Hall C

- ➢ Ex 1: Brad S.: DC correlations between hits/rates and tracks.
- ➢ Ex 2: Casey M: Parameterize the background rate in single-arm experiments at small angles

Casey's talk

Hall C Parameter List						
		Correlations that impact Hall C precisi				
Type of Parameter	*Parameter*	*Beam*	*Optics/Spectrometer*	*Target*	*Data sources*	*Detector rates*
Dynamic stream (can change continously like EPICs variables; does not need events)	BPM positions	X	X			
	Magnet currents	X	X			
	Beam Energy	X	X			
	Raw data for calculating beam energy (need more details from Jay)					
	Beam current HallC (after shieldwall)	X	X			
	Incoming Beam Current (includes accelerator)					
	Detector rates					
	Synchronicity (between different systems that make the measurements)					
Static stream (changes every hour or so)	Spectrometer Angles					
	Target type					
	Target density					
Event stream	Triggers (need more details)					
	raw TDC (hits, etc.)					
	raw ADC					

Working on a more detailed matrix