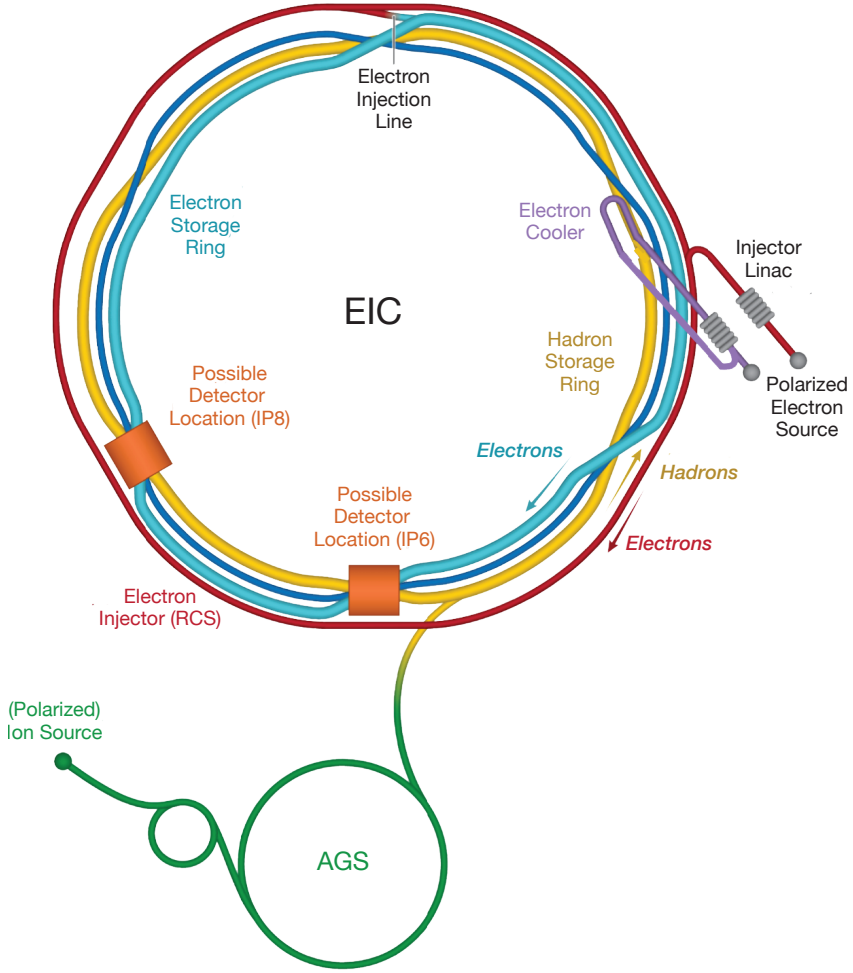
The Electron-Ion Collider (EIC)



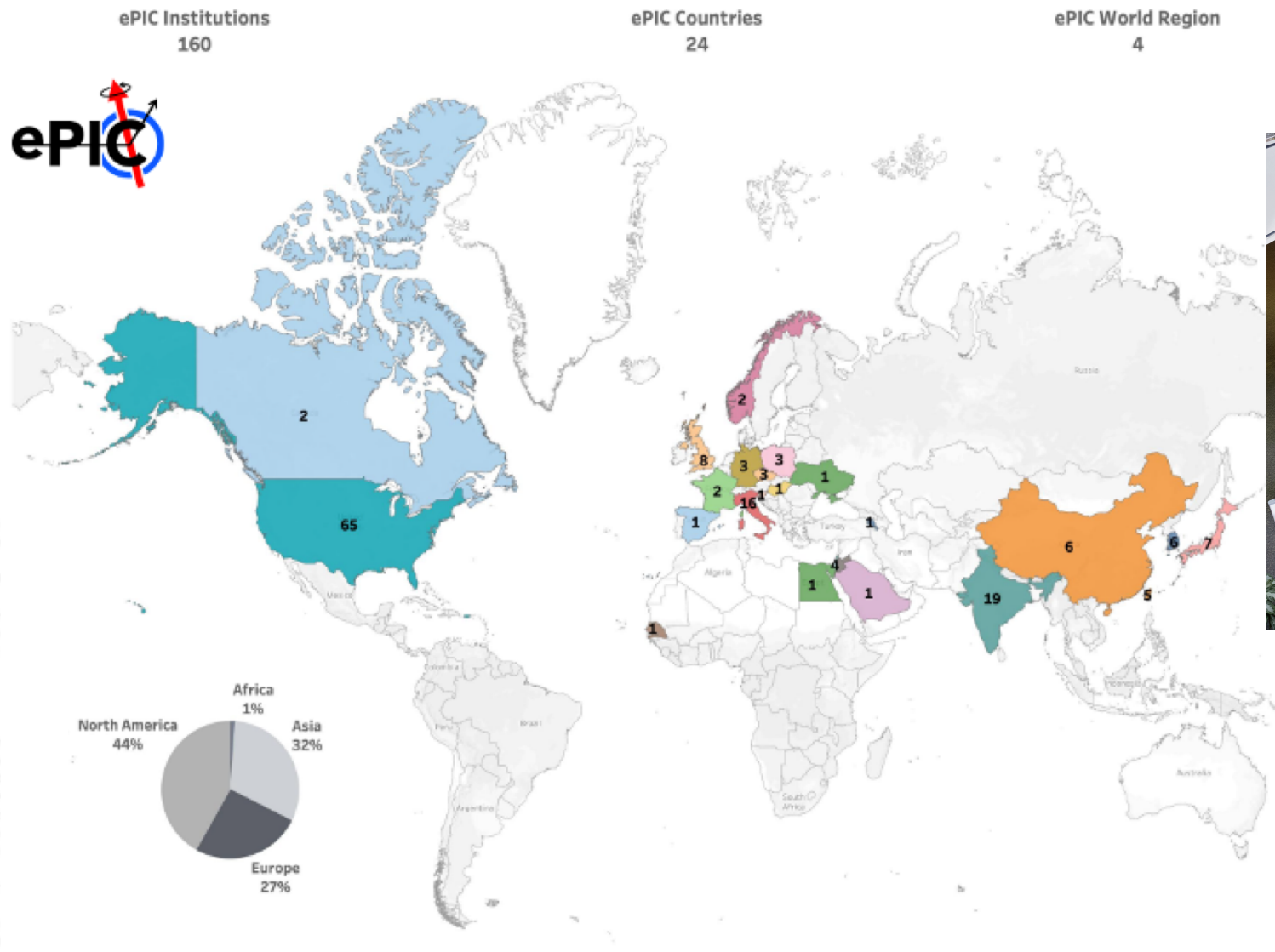
Frontier accelerator facility in the U.S.

- **World's first collider of**:
  - Polarized electrons and polarized protons,
  - Polarized electrons and light ions (d, ^{3}He),
  - Electrons and heavy ions (up to Uranium).

- The EIC will enable us to embark on a **precision study of the nucleon and the nucleus at the scale of sea quarks and gluons**, over all of the kinematic range that is relevant.
- The **EIC Yellow Report** (Nucl.Phys.A 1026 (2022) 122447) describes the physics case, the resulting detector requirements, and the evolving detector concepts for the experimental program at the EIC.

- BNL and Jefferson Lab will be host laboratories for the EIC Experimental Program. Leadership roles in the EIC project are shared.
- EIC operations will start in about a decade.

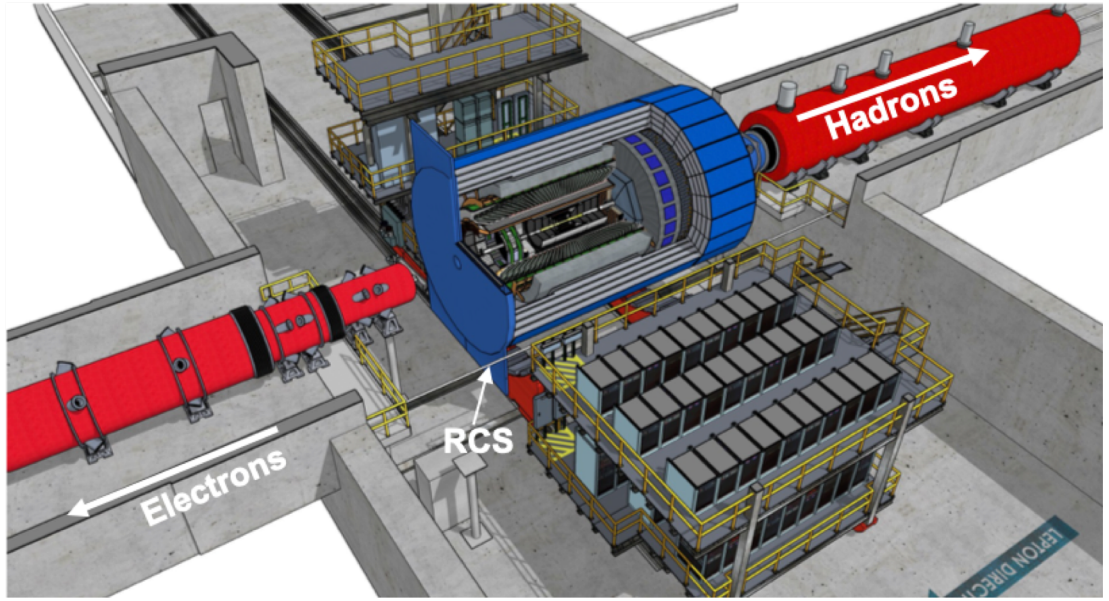
2022–2023: Formation of ePIC Collaboration



ePIC Collaboration Meeting at Jefferson Lab in January 2023

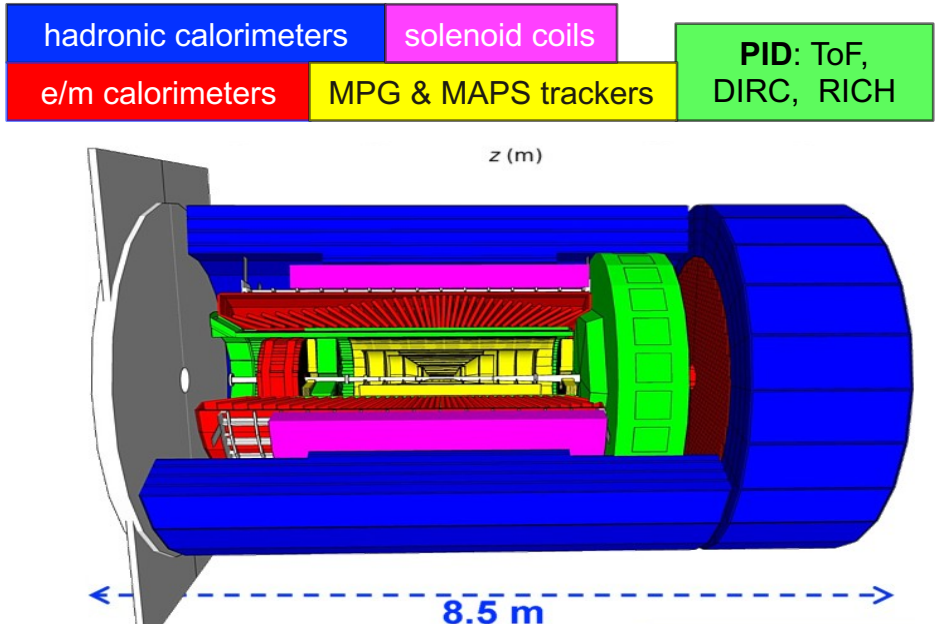
General Purpose Detector for ePIC

Integrated interaction and detector region (+/- 40 m)
to get ~100% acceptance for all final state particles, and measure them with good resolution.



Overall detector requirements:

- Large rapidity (-4 < h < 4) coverage; and far beyond in far-forward detector regions.
- Large acceptance solenoid of 1.7 T (up to 2 T).
- High control of systematics: luminosity monitor, electron and hadron polarimetry.



Examples for simulation challenges:

- Extensive use of optical photon-based detectors.
- Fine granularity detectors in calorimetry (fibers) to an extent that impacts navigation.
- Unique geometries enabled by additive manufacturing which prevents using CSG parametrized solids and needs BREP.

Priorities for Detector Design and Simulations

- Validation of Geant4 using test-beam setup and results:
  - Building up on Maurizio Ungaro's (Jefferson Lab) validation of NP experiments.
  - Makoto Asai (Jefferson Lab) has started a physics list for the EIC.

- Ease of switching between detector options: We use DD4hep for geometry description and exchange.

- Ease of **leveraging new and rapidly evolving** technologies:
  - **AI/ML** for a) fast and accurate simulations and b) detector design optimization.
  - **Heterogeneous architectures**:
    - AI/ML is the best near term prospect for using LCF/Exascale effectively.
  - Support for high concurrency heterogeneous architectures and fast simulations integrated with full detector simulations allows to leverage AI/ML in Geant4.
  - **Priority for ePIC**: Sub-event parallelism as the next phase in concurrent Geant4.

- Tight engineering integration requires CAD import in Geant4.

Since 2016, the EIC community has been collaborating with the Geant4 Collaboration through Makoto Asai as liaison, and we aim to sustain and strengthen this partnership in our ongoing work with Geant4.