Snapshot of ATHENA Proposal Effort

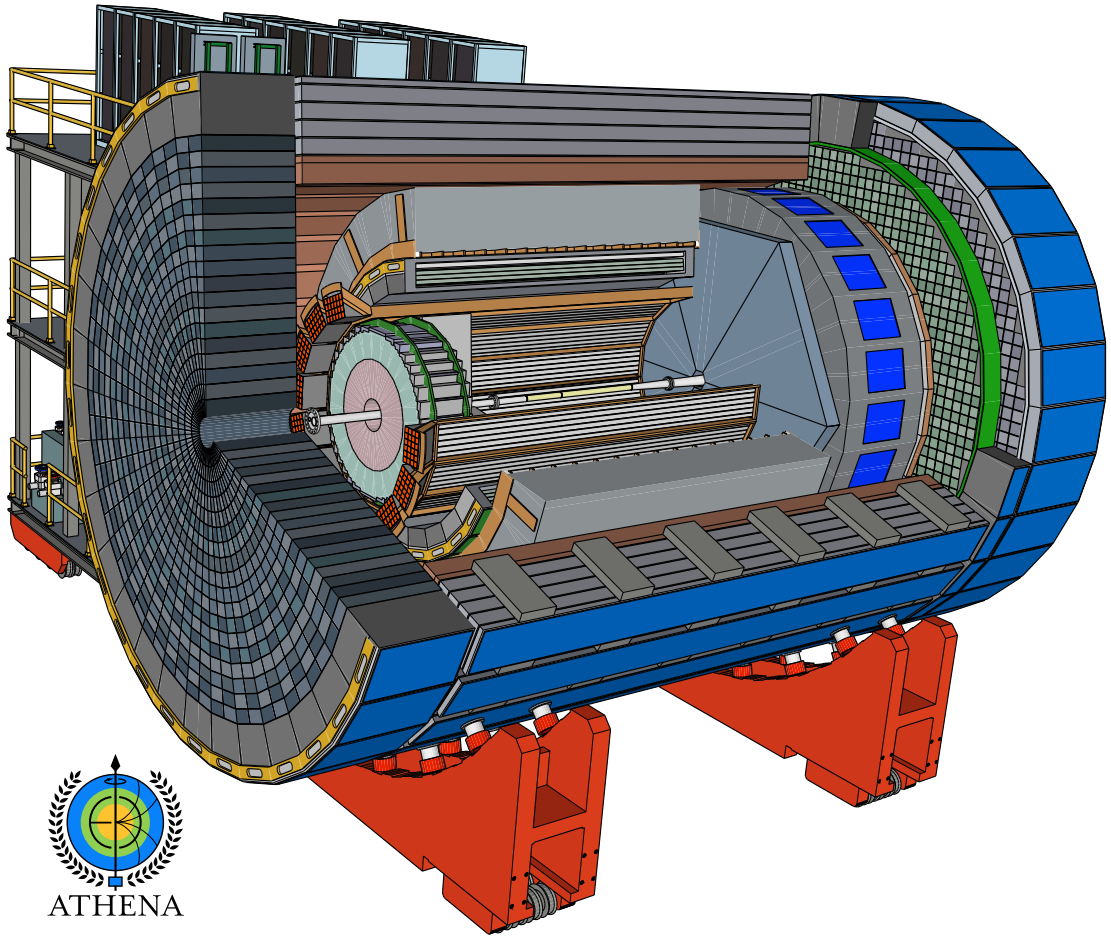
Bernd Surrow

TEMPLE UNIVERSITY

On behalf of the ATHENA Collaboration

Outline

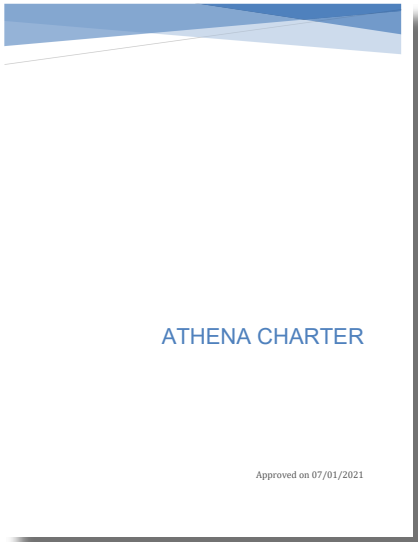
- Introduction
- ATHENA
  - Physics Highlights
  - Detector Layout
- Summary



Introduction

- Collaboration News
  - WWW-page:
    - Collaboration page: https://sites.temple.edu/eicatip6/
    - WIKI page: https://wiki.bnl.gov/athena/index.php/Main_Page=
  - Charter (Approved on 07/01/2021): https://sites.temple.edu/eicatip6/files/2021/08/ATHENA_Charter_adopted_07.01.21.pdf
  - Election of IB Chair: Ernst Sichtermann (LBL)
  - Election of Spokesperson Team: Spokesperson - Silvia Dalla Torre (INFN Trieste) and Deputy Spokesperson - Bernd Surrow (Temple University
  - Executive Board (EB) formation in very advanced state with large overlap with the previous coordination committee, which steered all ATHENA activities in the first months, ratified at IB meeting on Friday, October 29:
    - Ex-officio members
    - Members at Large
    - Member within 5 career years from obtaining his/her PhD. Ongoing process!

"This Charter describes the overall governance structure of the Collaboration, including the Institutional Board, the Executive Board, and the Spokesperson position."

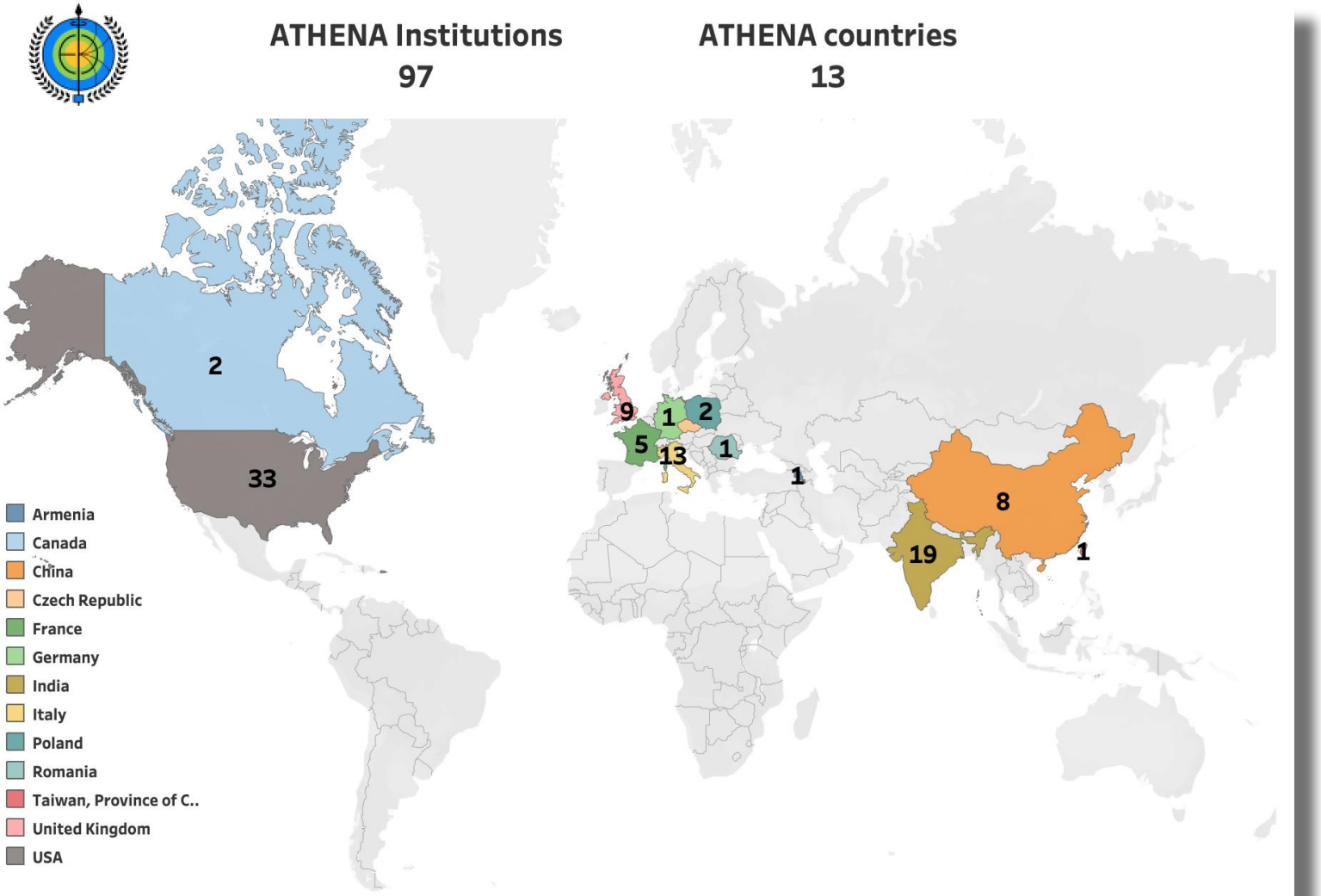


ATHENA establishes an Executive Board that advises the Spokesperson on:

- experiment construction, operations, maintenance, and upgrades,
- data management, software, and computing,
- working groups, committees, and their coordination,
- inclusion, diversity, equity, and accountability,
- any other scientific, technical, or managerial matters pertaining to the Collaboration.

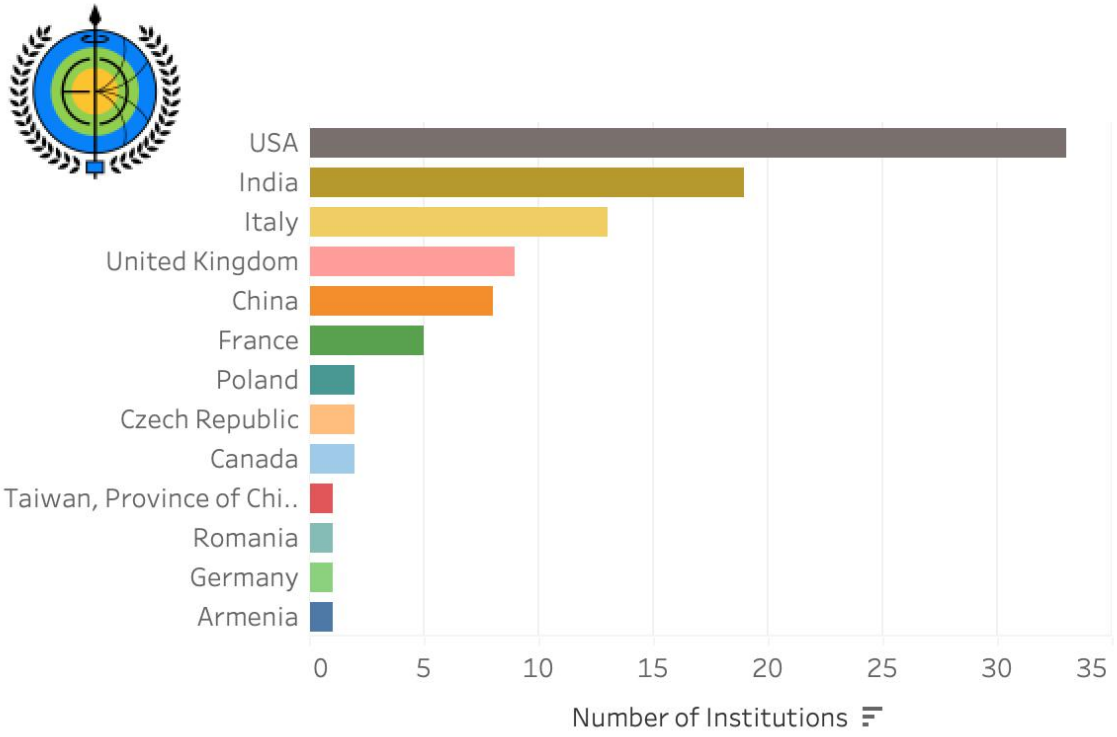
Introduction

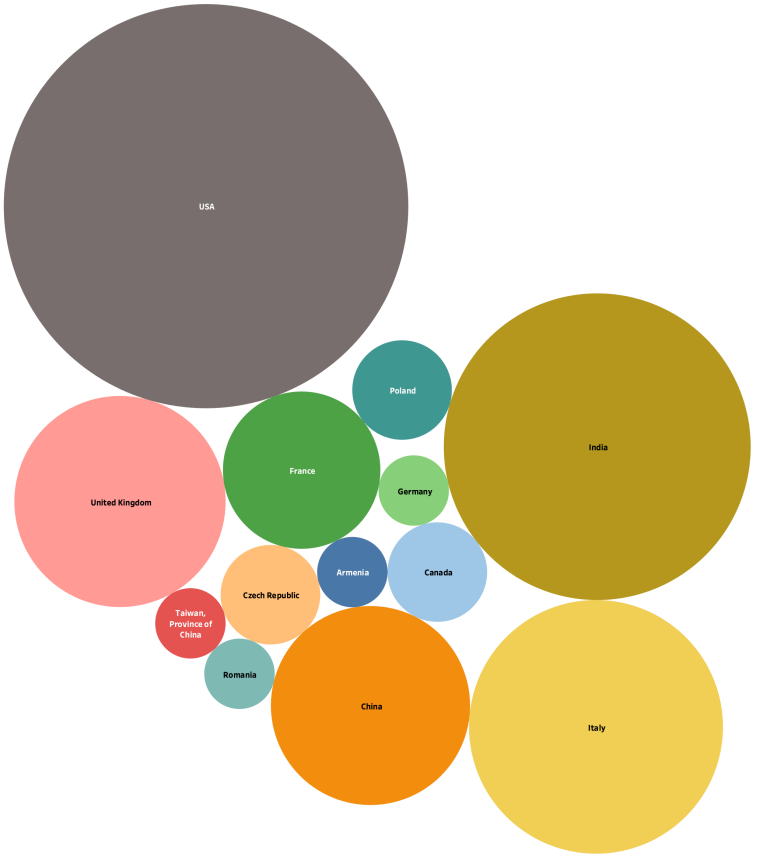
- Collaboration Overview (1)



Introduction

Collaboration Overview (2)





Introduction

- Proposal Preparation
  - A Proposal Committee was formed early on coordinating three core proposal elements for the ATHENA proposal effort: costing, integration/global design, and editing. The proposal committee provides the needed connection between detector, physics and software WGs:

- Costing: Bernd Surrow, James Symons, Olga Evdokimov, Zhangbu Xu, and Yulia Furletova
- Integration / Global Design: Bedanga Mohanty, Franck Sabatie, Alexander Kiselev, Thomas Ullrich, and Silvia Dalla Torre
- Editing: Abhay Deshpande, Barbara Jacak, Zein-Eddine Meziani, and Peter Jones

Ex-officio / Official EIC project contact: Elke Aschenauer

ATHENA - Physics Highlights

- Physics Working Groups and ATHENA Approach
  - Inclusive Working Group:
    - Barak Schmookler
    - Qinghua Xu
    - Paul Newman
  - Semi-Inclusive Working Group:
    - Marco Radici
    - Anselm Vossen
  - Jets/HF/EW-BSM Working Group:
    - Ernst Sichtermann
    - Stephen Sekula
    - Brian Page
    - Miguel Arratia
  - Exclusive/Tagging Working Group:
    - Salvatore Fazio
    - Spencer Klein
    - Daria Sokhan

- Perform complementary measurements allowing to embrace the entire EIC physics program (EIC White paper, NAS report, and Yellow Report)
- Approach is to a large extent inspired by the YR & CDR studies as a starting point and thus driven by the entire EIC community!

ATHENA - Detector Layout

Detector Working Groups and ATHENA Approach

- Tracking Working Group:
  - Laura Gonella
  - Domenico Elia
  - Francesco Bossu
  - Matt Posik
- PID Working Group:
  - Tom Hemmick
  - Roberto Preghenella
  - Franck Guerts
- Calorimetry Working Group:
  - Oleg Tsai
  - Paul Reimer
  - Vladimir Berdnikov
- Far Forward Working Group:
  - Alexander Jentsch
  - John Arrington
- Far-Backward Working Group:
  - Krzyzstof Piotrzkowski
  - Jaroslaw Adam
- DAQ Working Group:
  - Alexandre Camsonne
  - Jeffery Landgraf
- Polarimetry Working Group*:
  - Ciprian Gal
  - Oleg Eyser

ATHENA

- A new detector at IP6 with a solenoid offering a 3T field in order to better exploit various EIC potentials
- IP6 offers larger experimental hall
- New detector components profiting from state-of-the-art novel detector technology
- Taking advantage of multi-year of EIC R&D investment and intensive R&D collaborative efforts
- Strong international community, profiting from diverse experience!

*Jointly with other proto-collaborations and projects

ATHENA - Detector Layout

Software Working Groups and ATHENA Approach

Sylvester Joosten (ANL)

- Software Working Group:
  - Sylvester Joosten
  - Dmitry Romanov
  - Whitney Armstrong
  - Andrea Bressan*
  - Wouter Deconinck

*EICUG representative

ATHENA

ATHENA Software & Computing Overview

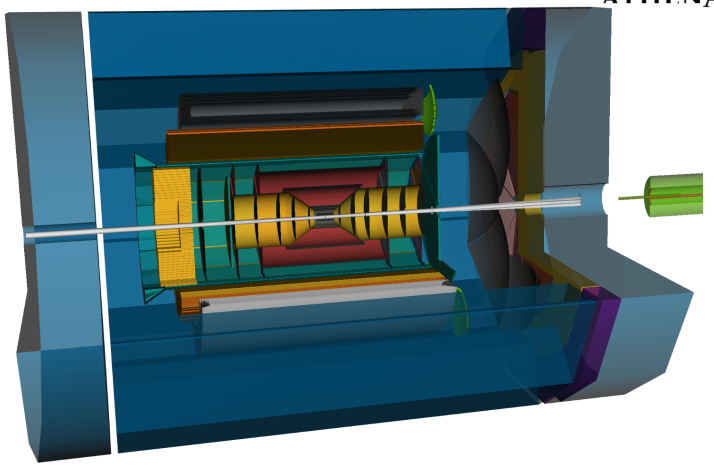
ATHENA

Philosophy

- **Build forward-looking team of software developers to ensure the long-term (decades!) success of the EIC scientific program.**
- Strong emphasis on modular, orthogonal tools
- Integrate with HTC/HPC, CI workflows, and enable use of data-science toolkits
- Build on top of a mature, well-supported, and actively developed HEP software stack.

Implementation

- Detailed detector geometry description in DD4HEP, which steers the Geant4 simulations
- Reconstruction framework (JUGGLER) built on top of GAUDI, leveraging ACTS for tracking and Tensorflow for AI.
- Modular components communicate through a robust, flat data model (EICD, implemented using PODIO).
- Leverage dedicated GitLab server (eicweb) with CI backend for reproducible container builds (using Spack), and automated tests and benchmarks.



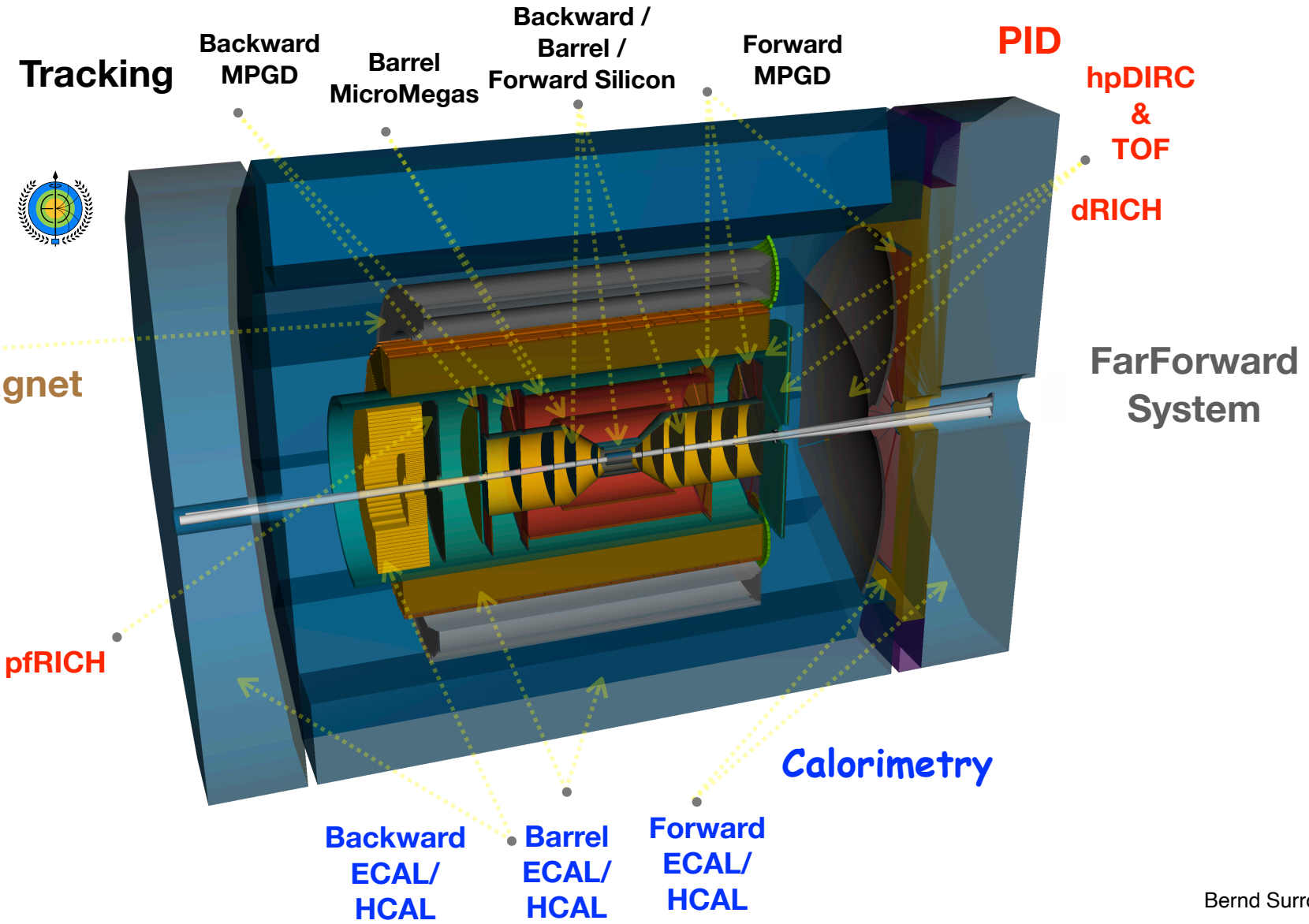
Highlights

- Performant modern simulation/reconstruction toolkit, fully operational in 4 months!
- Setup for efficient detector optimization for the proposal and beyond.

1

ATHENA - Detector Layout

- Overview



ATHENA - Detector Layout

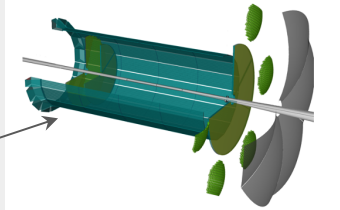
- Simulations: Software & Computing Status

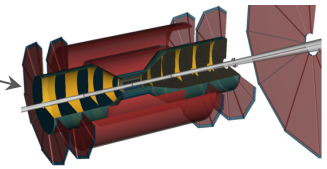
Sylvester Joosten (ANL)

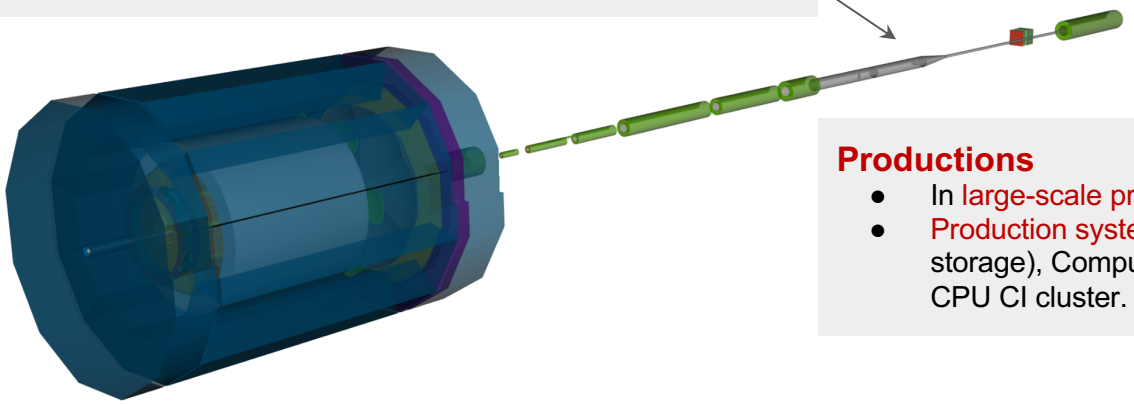
ATHENA Software & Computing Status

Detailed implementation for all subsystems

- Most simulations performed with two different baseline designs ("acadia" and "canyonlands")
- **PID**: Working implementations for all optical detectors (dRICH, pfRICH, mRICH and DIRC)
- **Tracking**: Various configurations of silicon and gaseous detector setups, including support/services
- **Calorimetry**: Barrel imaging ECAL, backward glass/quartz ECAL, forward WScFi ECAL, hermetic HCAL system
- **Far forward**: B0 tracker, Roman Pot & OMD detectors, detailed ZDC (split in ECAL and HCAL)







Reconstruction

- Tracking using ACTS, validated and performing well
- Calorimetry reconstruction algorithms (island clustering, 2+1D clustering, topological clustering and AI e/π for the barrel)
- Functional standalone RICH reconstruction (IRT), being integrated with Juggler right now.
- Special reconstruction routines for Roman Pots and OMDs

Productions

- In large-scale production mode for crisp proposal figures.
- Production systems: OSG (current main focus), JLab, BNL (for S3 storage), Compute Canada, ALCF, LCRC, and dedicated 500 CPU CI cluster.

ATHENA - Detector Layout

- Design / Optimization

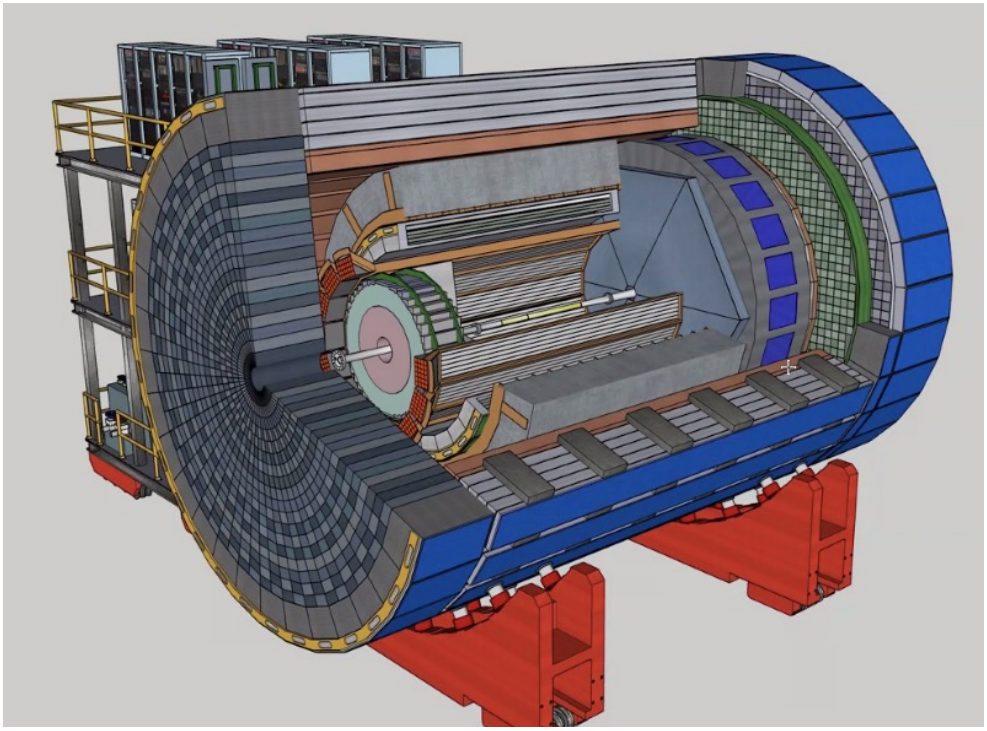
Silvia Dalla Torre (Trieste)

ATHENA

Global layout – Central Detector

COMPONENTS:

- 3T solenoid
- Hybrid tracking
  - barrel, far/backward
- Calorimetry
  - HCal, ECal
  - barrel, for/backward
- PID
  - dRICH (forward)
  - DIRC and AC-LGAD TOF (barrel)
  - eRICH (backward)



In the following: focus on what is <u>further advanced/new</u> respect to YR and resp to July report

ATHENA - Detector Layout

- Magnet

Silvia Dalla Torre (Trieste) and Valerio Calvelli (Saclay)

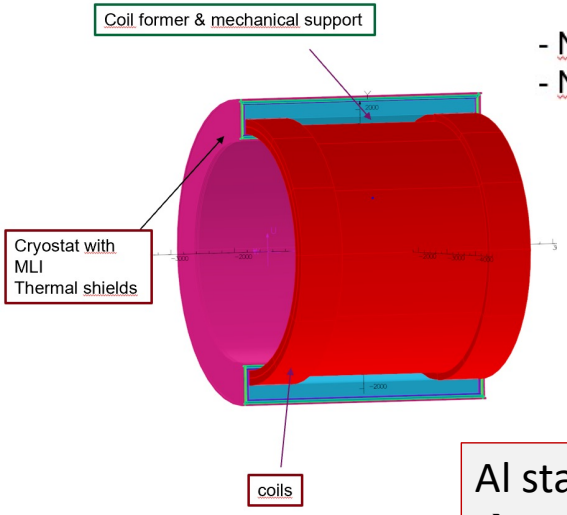
Central Detector - MAGNET

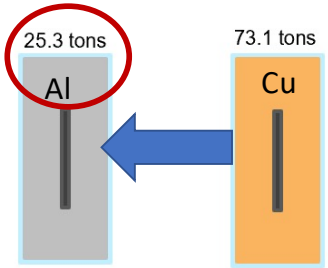
2 novel ingredients

Design progress: SOCRATE, a light solenoid!

Coil former & mechanical support

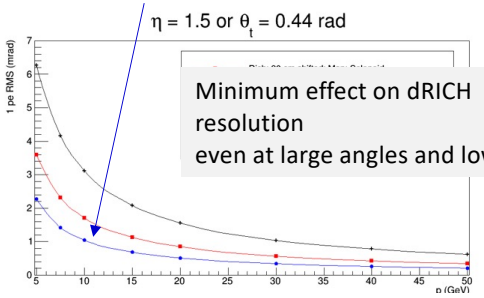
- NbTi Rutherford with Al stabilizer
- NbTi Rutherford with Cu stabilizer



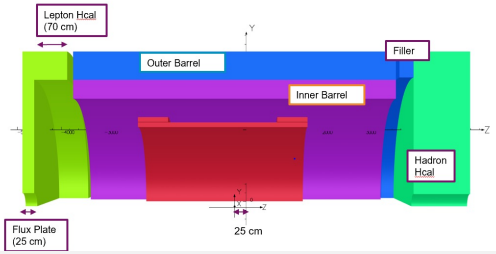


Al stabilizer & self-supporting
→
Light: ~ 1.5 interaction length
Thin: ~ 40 cm

Solenoid shifted 25 cm
towards backward endcap



Minimum effect on dRICH resolution
even at large angles and low p !



- Solenoid equidistant from backward and forward Hcals
- Tuning iron/steel in the HCals

→ Large reduction of the em forces

13500 → 37 kN

SELF-SUPPORTING SOLENOID

ATHENA - Detector Layout

- Calorimetry

Silvia Dalla Torre (Trieste) and Oleg Tsai (UCLA)

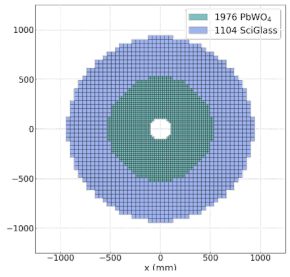
Central Detector - CALORIMETRY

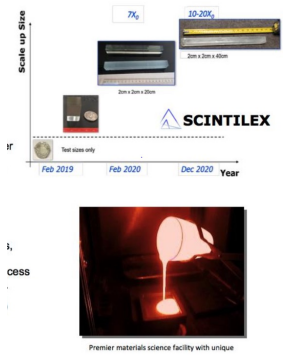
backward
- **ECAL: hybrid, PWO insert and Glass outer ring, EEEMCAL effort**
- **HCAL: Fe/SC**

forward
- **ECAL: W-powder/SciFi**
- **HCAL: Fe/SC**

barrel
- **ECAL: hybrid architecture: imaging & sampling**
- **HCAL: Fe/SC**

Backward eECAL



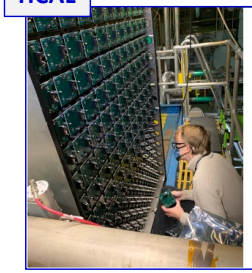


forward eECAL

sPHENIX Wpowder/SciFi Cal
Sensor: Si PMs

IEEE Transactions on Nuclear Science, Volume 65, Issue 12, pp. 2901-2919, December 2018

HCAL

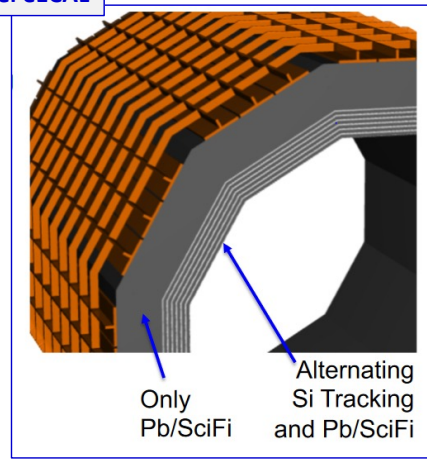


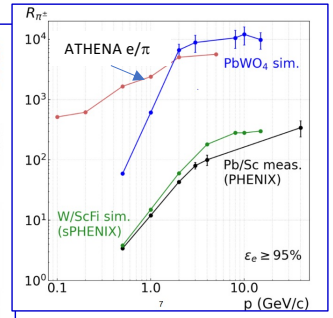
STAR Forward Calorimeter System.

Constructed in 2020 with new, very efficient method.

HCal Fe/Sc, similar technology for EIC reference detector.

Barrel eECAL





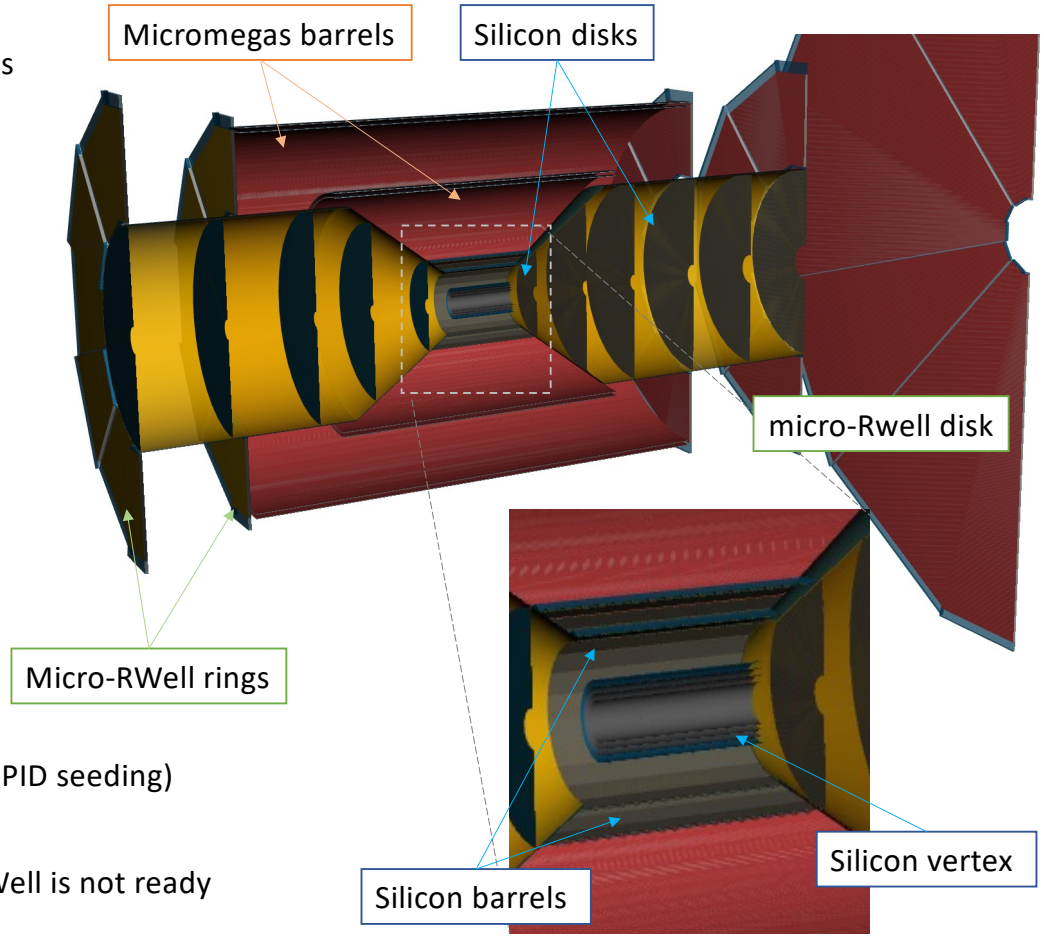
9 imaging layers based on the AtroPix sensor; also providing the needed space point downstream of the hpDIRC

ATHENA - Detector Layout

Tracking

Matt Posik (Temple University)

- ATHENA Tracker
  - Complimentary silicon and MPGD technologies to provide a cost efficient tracking solution capable of achieving excellent momentum, angular, and vertex reconstruction resolutions and large eta coverage
- Central Tracker
  - 3 Si vertex layers
  - 2 Si barrel layers
  - 4 micromegas barrel layers
- Backward Tracker
  - 5 Si disks
  - 2 micro-RWell rings
- Forward Tracker
  - 6 Si disks
  - 2 micro-RWell rings
  - Large micro-RWell tracker behind dRICH (aid PID seeding)
- GEM to be used as backup technology if micro-RWell is not ready



ATHENA - Detector Layout

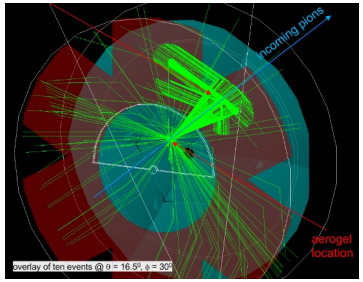
- PID

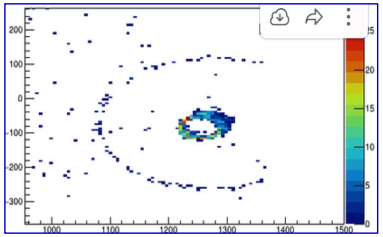
Silvia Dalla Torre (Trieste)

ATHENA

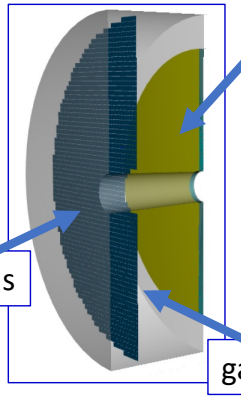
Central Detector - PID

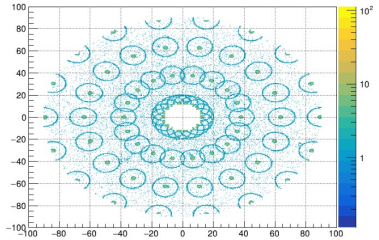
forward PID: dRICH (aerogel&gas with focalization)





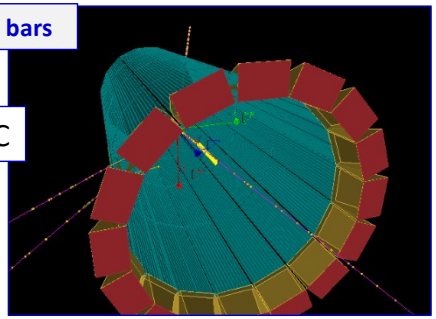
backward PID: pfRICH (aerogel&gas in proximity focusing scheme)



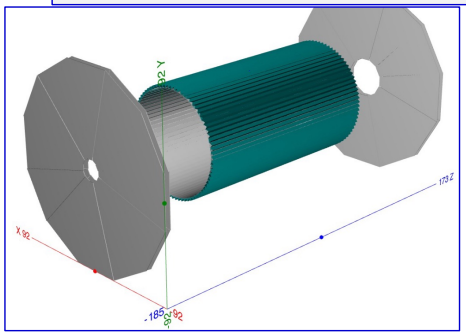


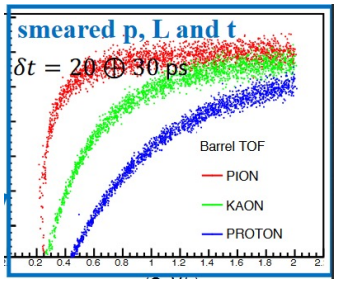
barrel PID: hpDIRC with re-use of BABAR bars

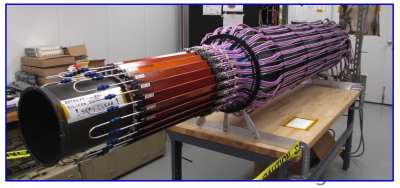
hpDIRC



barrel PID for low momentum particles: TOF by AC-LGAD





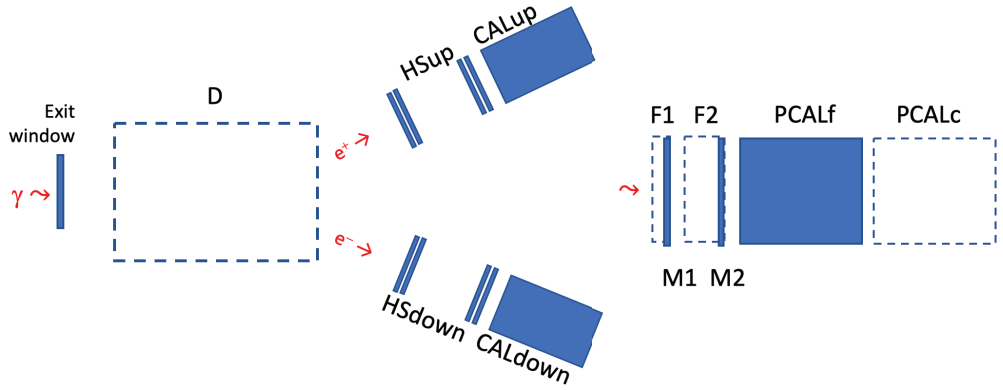


ATHENA - Detector Layout

- FarBackward

Far Backward detection system (photons)

- Detection system for Bremsstrahlung photons:



Mariusz Przybycien
(AGH University of
Science and
Technology, Krakow)

- **PCALc** – movable tungsten spaghetti calorimeter for luminosity measurement via photon counting.
- **PCALf** – movable tungsten spaghetti calorimeter for photon flow measurement (high lumi).
- **F1,2 + M1,2** – two movable tungsten/graphite filters 0.5 X_0 and 1 X_0 thick, equipped with segmented fused silica SR monitors.
- **$CAL_{up,\,down}$** – tungsten spaghetti calorimeters with hodoscopes **$HS_{up,\,down}$** to be used for luminosity measurement via photon conversion in the exit window.
- **Dipole magnet** - small spectrometer dipol magnet.

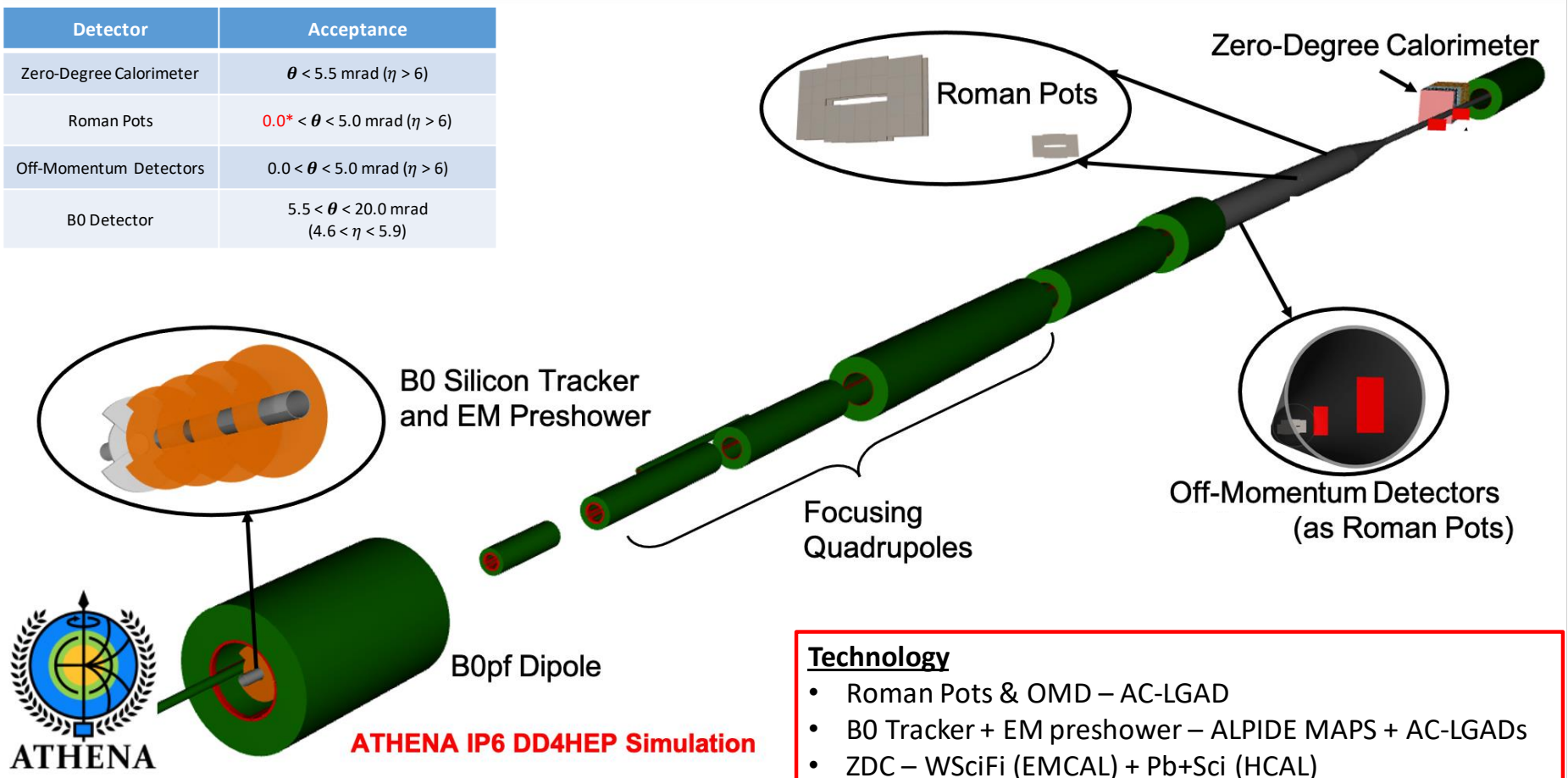
ATHENA - Detector Layout

- FarForward

Alex Jentsch (BNL)

Far-Forward IR and Detectors

Detector	Acceptance
Zero-Degree Calorimeter	θ < 5.5 mrad (η > 6)
Roman Pots	0.0* < θ < 5.0 mrad (η > 6)
Off-Momentum Detectors	0.0 < θ < 5.0 mrad (η > 6)
B0 Detector	5.5 < θ < 20.0 mrad (4.6 < η < 5.9)



Technology

- Roman Pots & OMD – AC-LGAD
- B0 Tracker + EM preshower – ALPIDE MAPS + AC-LGADs
- ZDC – WSciFi (EMCAL) + Pb+Sci (HCAL)

Summary and Next Steps

- ATHENA Proposal Detector Design completed, incl. magnet design
- Core costing (Material/Labor) of sub-systems completed
- Finalize of plots (detector / physics / collaboration / costing / schedule) and text

  ongoing —> Circulation of draft to collaboration in November —> Ready for

  submission on December 1!

Thank you to ALL who have worked

and continue to work extremely hard

to meet the ATHENA proposal

completion!