Status of the ATHENA Proposal

Silvia Dalla Torre
INFN - Trieste

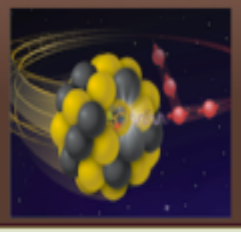
On behalf of the ATHENA Collaboration

INTRODUCTION

ATHENA first steps

Kick-off meeting for EIC@IP6

https://indico.bnl.gov/event/10825/



Kick-off Meeting for an EIC Detector at IP6 (EIC@IP6)

12-13 March 2021

US/Eastern timezone

- Overview
- Timetable
- Remote Login Instructions
- Contribution List
- My Conference
  - My Contributions
- Registration
- Participant List

Following the site selection for construction of the U.S. Electron-Ion Collider research facility by the U.S. Department of Energy (DOE) in early 2020, the EIC Users Group led a year-long Yellow Report initiative to define the detector design criteria needed to realize the EIC physics described in the EIC White Paper, supported by the National Academy of Sciences. Using the Yellow Report as input, a Reference Detector concept was presented at the recently held DOE Critical Decision-1 review of the EIC.

A Call for EIC Detector Proposals has been issued by DOE & BNL/JLab on March 6, 2021, with an expected proposal submission deadline on December 1st, 2021. The EICUG community's strong preference for two detectors has led to multiple exciting detector initiatives. We invite all interested groups and consortia to come together to plan for a detector inspired by the Yellow Report detector concept based on a new central detector magnet up to 3T, which could evolve into a concrete proposal and collaboration formation for IP6.

with 292 register participants,

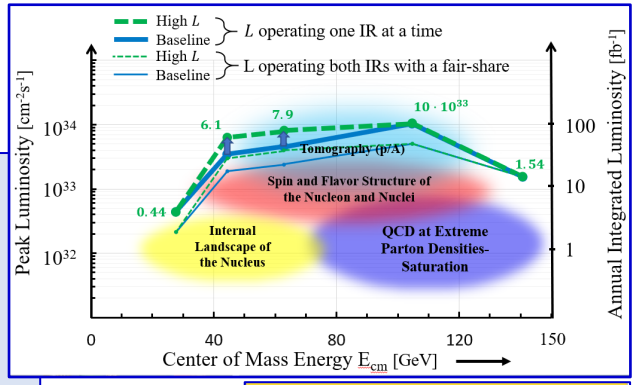
attendance peak at 197,

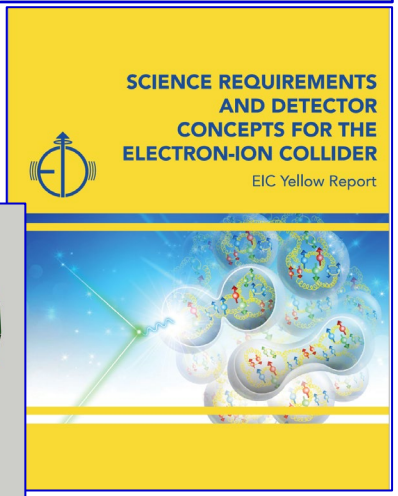
no session with less than 130 participants

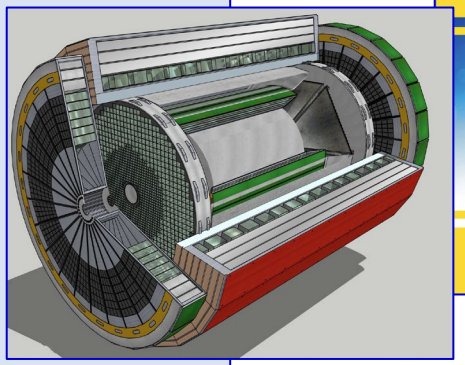
ATHENA highlights

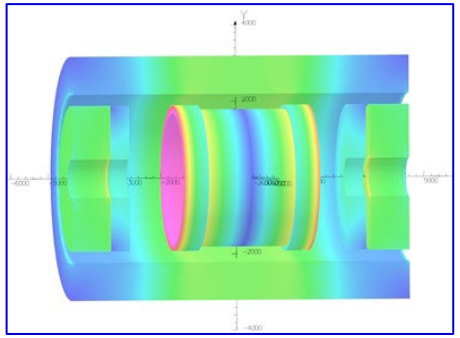
The key elements shared within our community

- A detector to cover the whole EIC physics program (EIC White Paper, NAS report and Yellow Report)
  - Helps from the efforts towards larger luminosity at small CM energies announced both for IP6 and IP8 (Joint EIC Project Management Team & EIC proposal coordination Team meeting, June 3, 2021)
- YR & CDR-inspired in order to use the YR studies as starting point going beyond whenever useful/possible
  - Starting point is therefore from the whole EIC community and we are willing to continue the collaboration with this community
- A solenoid offering a 3 T field in order to better exploit the EIC potentialities
- IP6 choice because of the advantages offered by the larger experimental hall
  - The new solenoid enhances the IP6 space potentialities thanks to its large bore diameter
  - More enhancement from the recent confirmation (Joint EIC Project Management Team & EIC proposal coordination Team meeting, July 1, 2021) of 0.5 m extra space is available for the central detector, forward region
- new detectors components to profit of the status of the art in detector technologies
- A strong international community









ATHENA challenges

Largely related to the novelty aspects

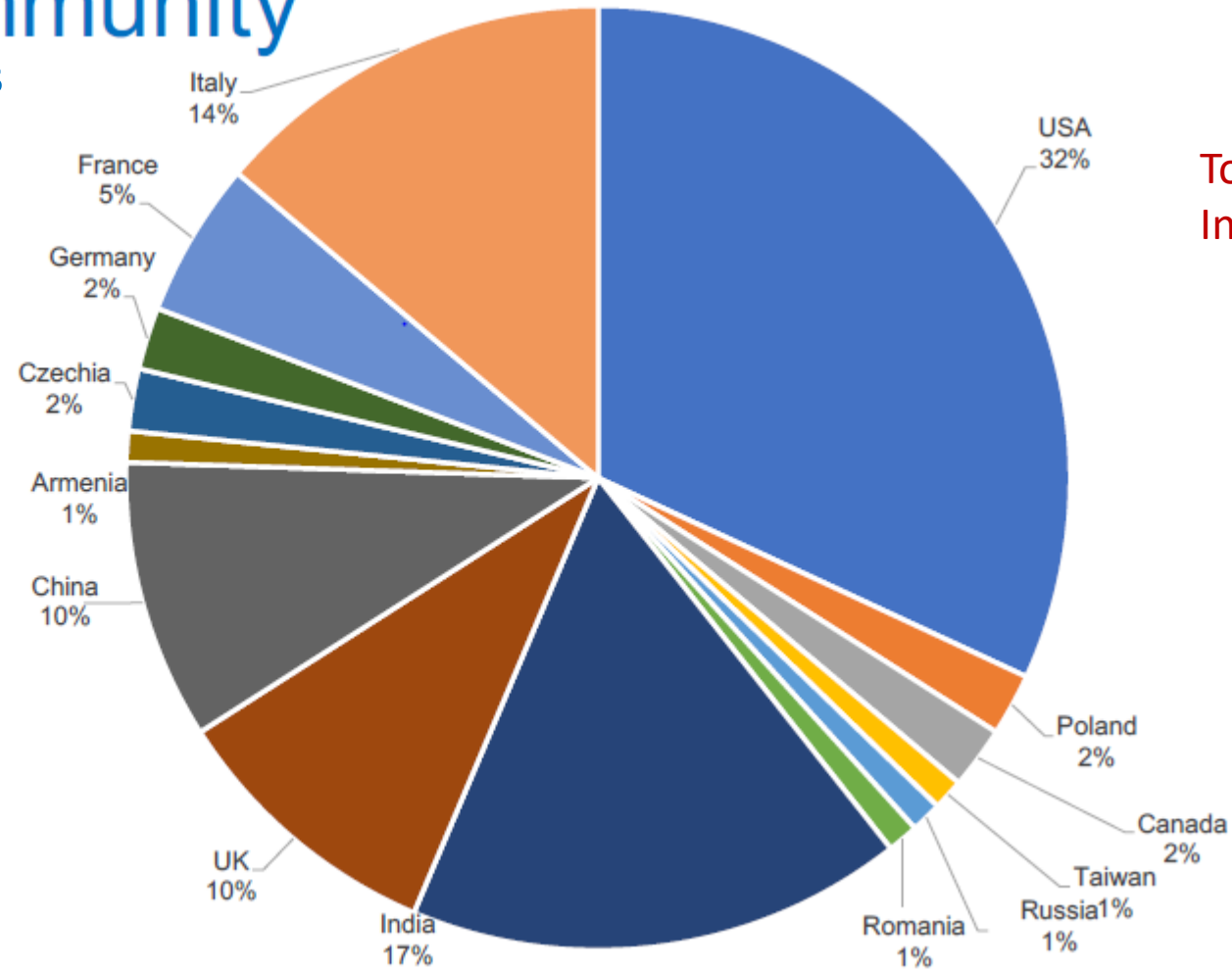
- No solenoid specifications fixed since the beginning: contribute to its definition
- Push for a new future-oriented simulation and reconstruction software framework initiated in order to attract young developers and be better prepared for the TRD phase
- Different sub-detector technology options considered within the YR: selection needed
- Build-up the coherence of a largely diversified community (different countries/continents and scientific background)
  - Even the selection of the time for a meeting is not so obvious !

MORE ABOUT US

ATHENA community

ATHENA community
by Institutions

- USA
- Poland
- Canada
- Taiwan Province of China
- Russia
- Romania
- India
- UK
- China
- Armenia
- Czechia
- Germany
- France
- Italy



Total: 95 Institutions

ATHENA, forming a COMMUNITY

a dense calendar of collaboration meetings

1. *Collaboration meetings*

- **Bi-weekly meetings: 11.00 am (EDT) – 2.00 pm (EDT)**
  mainly for US and Europe colleagues
  13 meetings so far
- **Monthly meetings: 8.00 pm (EDT) – 11.00 pm (EDT)**
  mainly for US and ASIA colleagues
  4 meetings so far

2. *OPERATIVE MEETINGS:*

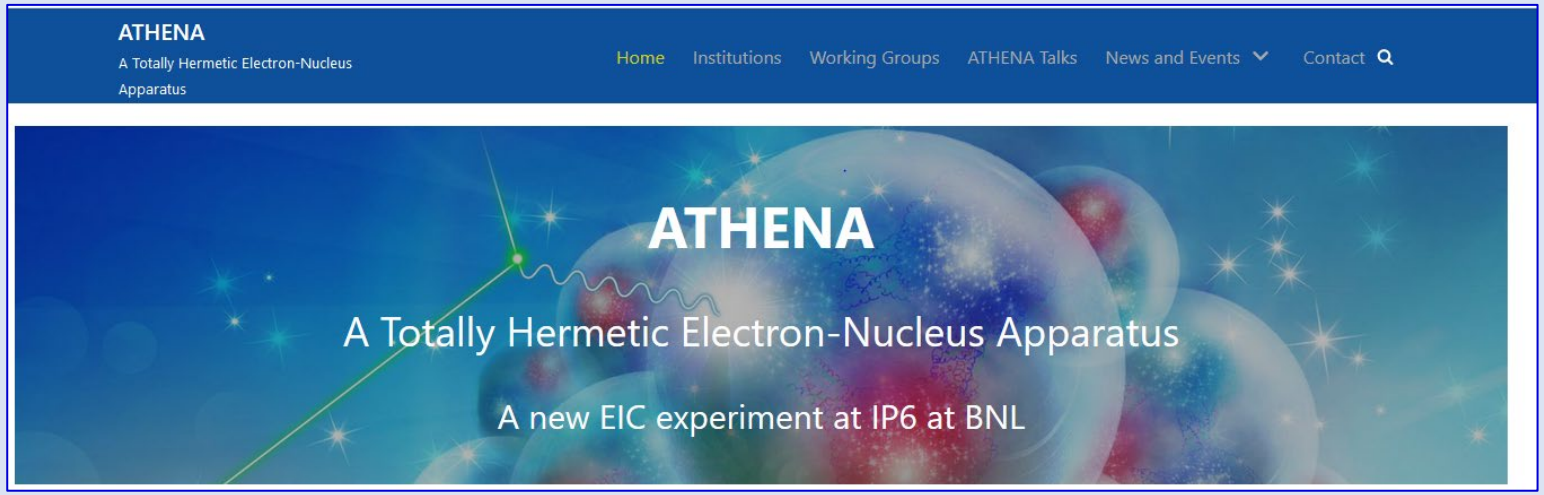
WG & Proposal committee meetings

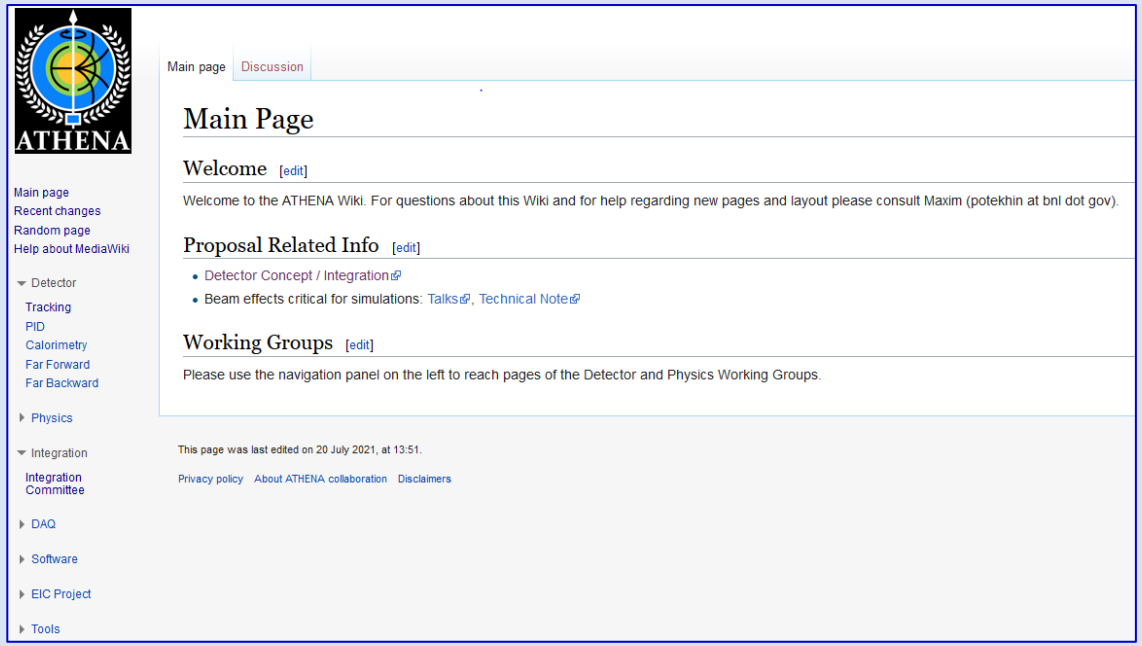
ATHENA, forming a COMMUNITY, more

Facilitating COMMUNICATION

1. ***The ATHENA web-site: https://athena-eic.org/***

2. ***The ATHENA wiki page https://wiki.bnl.gov/athena/index.php/Main_Page***





ATHENA, structuring the community

Initial structure, to start working at full speed since the very beginning

- A proto-IB (Institutional Board:
  - Governing board for the validation of all the major decisions
- A Coordination Committee for everyday coordination in the initial phase
  - ATHENA kick-off meeting organizers :

Silvia Dalla Torre (INFN Trieste, Italy)
Olga Evdokimov (University of Illinois / Chicago, USA)
Barbara Jacak (UC Berkeley, USA)
Franck Sabatie (Saclay, France)
Abhay Deshpande (SBU / CFNS & BNL, USA)
Yulia Furletova (JLab, USA)
Alexander Kiselev (BNL, USA)
Bernd Surrow (Temple University, USA)

A consolidated structure for the long-term life of the collaboration

- Writing the ATHENA CHARTER, now approved

CHARTER Committee

- Ken Barish (UC Riverside)
- Olga Evdokimov (UIC)
- David Gaskell (JLAB)
- Nicole d'Hose (CEA-Saclay)
- Tom Hemmick (Stony Brook)
- Zein-Eddine Meziani (ANL)
- Bedanga Mohanty (NISER)
- Marta Ruspa (Torino)
- Murad Sarsour (GSU)
- Ernst Sichtermann (LBNL)
- Daria Sokhan (Glasgow)
- Thomas Ullrich (BNL)
- Anselm Vossen (Duke)
- Qinghua Xu (Shandong)

- elections of IB chair and deputy, SP and deputy, process started, completed in September

Election/Nominating Committee

- Pietro Antonioli (INFN-Bologna)
- John Arrington (LBL)
- Nicole d'Hose (CEA Saclay)
- Yulia Furletova (JLAB)
- Sylvester Joosten (ANL)
- Brian Page (BNL)

Operative Bodies (approved by IB) that will remain active to ensure continuity to the on-going activities

- The Working Groups (WG)
- The Proposal Committee

ATHENA at work: the WGs

WGs and Conveners

Software & Computing Working Group

CONVENERS: Sylvester Joosten, Dmitry Romanov, Whitney Armstrong, Andrea Bressan, Wouter Deconinck

PHYSICS VALIDATION WGs

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

SUB-DETECTOR WGs

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

ATHENA at work: the PROPOSAL COMMITTEE

- Goal: Committee is tasked with coordinating three core proposal elements of the EIC@IP6 proposal effort concerning costing, integration/global design, and editing.

- The proposal committee provides the needed connection between WG's.

- Costing: Bernd Surrow, 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
ABOUT OUR DETECTOR

Why a new 3T solenoid

- **A solenoid offering a 3 T field in order to better exploit the EIC potentialities**

Layer	Length	Radial position
Layer 1	420 mm	36.4 mm
Layer 2	420 mm	44.5 mm
Layer 3	420 mm	52.6 mm
Layer 4	840 mm	133.8 mm
Layer 5	840 mm	180.0 mm
TPC start	2110 mm	200.0 mm
TPC end	2110 mm	780.0 mm

(a) Barrel region

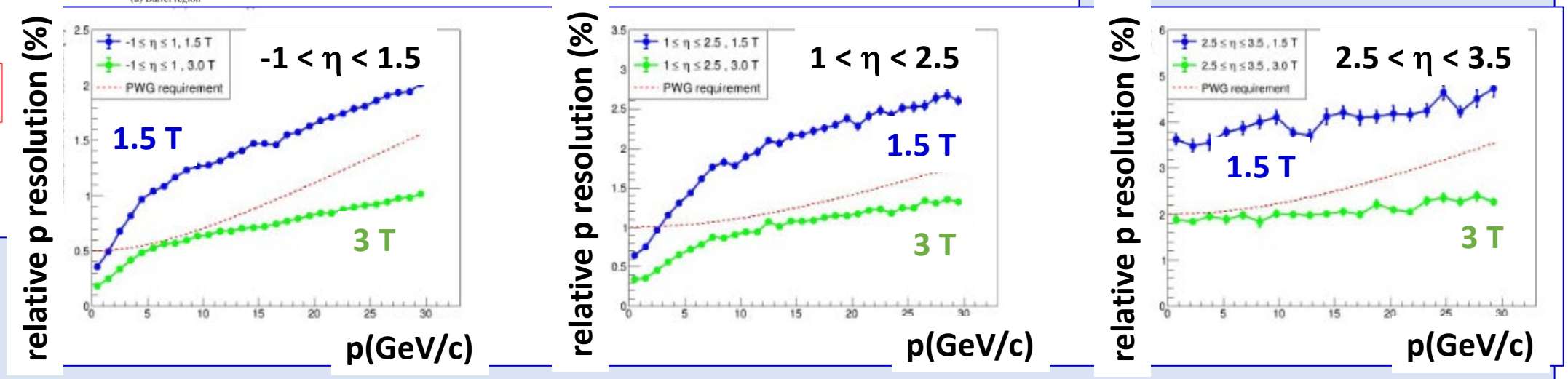
Disk	z position	Inner radius	Outer radius
Disk 1	220 mm	36.4 mm	71.3 mm
Disk 2	430 mm	36.4 mm	139.4 mm
Disk 3	586 mm	36.4 mm	190.0 mm
Disk 4	742 mm	49.9 mm	190.0 mm
Disk 5	898 mm	66.7 mm	190.0 mm
Disk 6	1054 mm	83.5 mm	190.0 mm
Disk 7	1210 mm	99.3 mm	190.0 mm

(b) Disk region

10μm pixel pitch

$x/X_0 = 0.05\%$ per vertexing layer (1 – 3)
$x/X_0 = 0.55\%$ per tracking layer (4 and 5)
$x/X_0 = 0.24\%$ per disk (1 – 7)

Simulations by H. Wennlöf, Birmingham

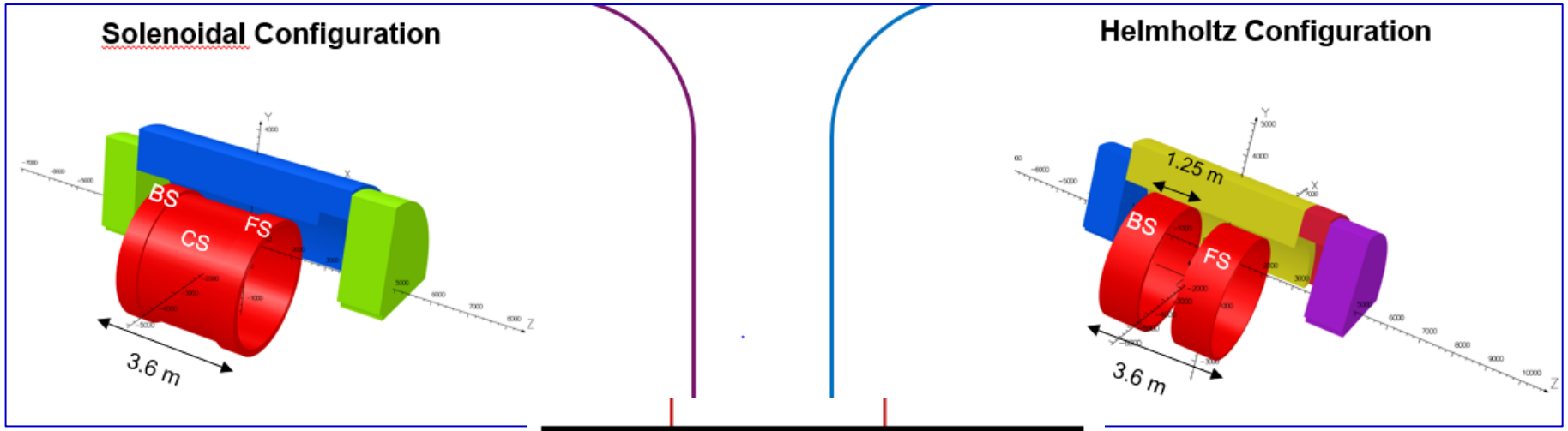


- **The new solenoid enhances the IP6 space potentialities thanks to its large bore diameter: 1.6 m**
  - **More space for the most challenging detector region: the barrel of the central detector**
- **Operation at lower field for specific measurements can be planned**

The ATHENA solenoid

New Solenoid (up to 3T)

By: V. Calvelli (CEA), R. Rajput-Ghoshal (JLAB)



Initial specifications

Parameter	Goal
B_{IP} (T)	3.00
Bore radius (mm)	1600
Coil length (mm)	3600
H TCP 2 (%)	5.0
H FLAT 1 (%)	10.0
Projectivity (T/Amm²)	min

For TPC

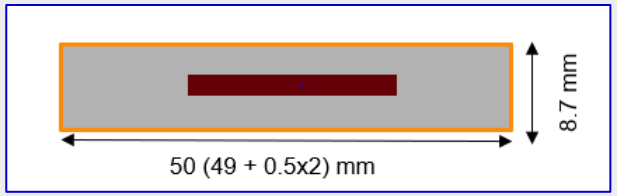
Enough Bdl at small angles

For frd RICH

New 3T solenoid, present status

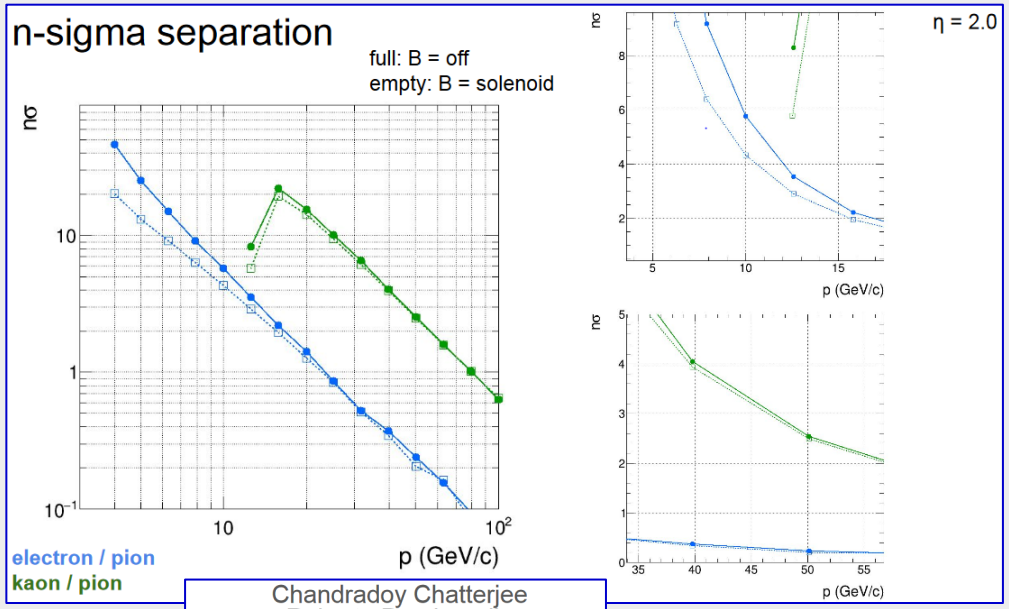
- **Magnet design, intense current activity about:**
  - **Magnetism: issue of the forces pushing the coils towards the iron in the frd and bkd Hcals**
  - **Cryogenics**
  - **Conductor design and selection of the conductor stabilizer (Al/Cu)**

V. Calvelli, 21 July 2021



- **Present assessment of the magnet configurations**

- **No TPC in ATHENA (see next slides)**
- **No substantial degradation (both configurations) from tracking studies**
- **No substantial degradation for high p particle PID (hadrons)**
- **PID degradation at small p (e-π separation issue)**



Chandradoy Chatterjee
Roberto Preghenella

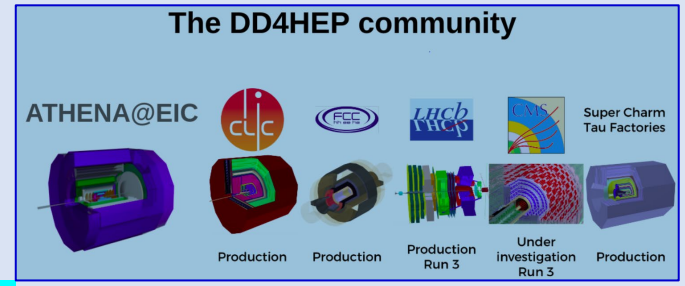
ATHENA PID working group meeting
28 June 2021

ATHENA simulation software

A non-easy choice: it affects the activity of all the WGs !

- **We have selected an integrated simulation tool within the DD4hep frame**
  - The whole set of software packages adopted includes DD4hep, Gaudi, ACTS
    - They are supported by large international collaborative efforts across experiment and lab boundaries
    - They have been validated for (HL-)LHC
  - Using world-class software, there is resource saving in term of time and effort
  - The entire software stack scales to modern heterogeneous computing architectures in use at HTC and Grid sites (current and projected) without large dedicated additional efforts
  - The modular architecture allows easy swapping in and out of new reconstruction algorithms (in isolation from the rest of the reconstruction)
    - demonstrated by the various calorimetry clustering studies already completed
  - Already a step towards up-to-date software for EIC
  - Not a minor consideration:

    A wide enthusiastic team pushing towards this option !



Software & Computing Conveners:
Whitney Armstrong, Andrea Bressan(*), Wouter Deconinck, Sylvester Joosten, Dmitry Romanov
(*)- liaison to EICUG software group

Day 0 WG support:
Kolja Kauder, Miguel Arratia, Stephen Sekula, Dmitry Romanov, Yulia Furletova, Andrea Bressan

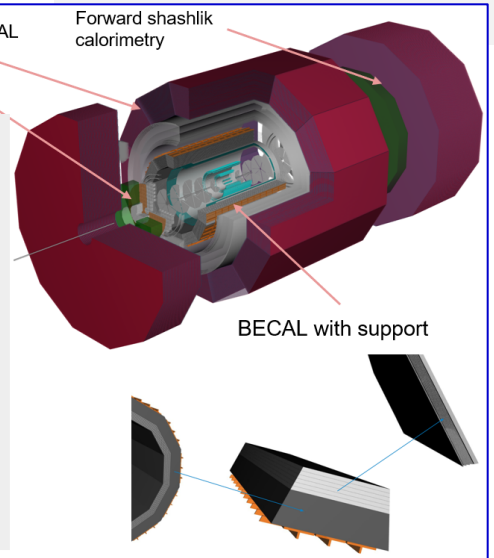
Full simulation/reconstruction team
Whitney Armstrong, Miguel Arratia, Wouter Deconinck, Sylvester Joosten, Jihee Kim, Chao Peng, Tomas Polakovic, Dmitry Romanov, Marshall Scott, Zhenyu Ye, Ziyue Zhang, Maria Żurek
...and a rapidly growing amount ATHENA collaborators!

one of the fields where ATHENA points towards up-to-date solutions

ATHENA simulation software, status

Calorimetry WG

- Ready to study impact of magnet on HCAL:
  - ✅ Realistic HCAL geometry
  - ✅ Solenoid & Helmholtz
  - ✅ HCAL clustering and energy calibration
- ECAL system well-developed:
  - Barrel ECAL:
    - ✅ Barrel SiW imaging calorimeter
    - ✅ Barrel hybrid SiW + WSciFi calorimeter
  - Electron-endcap ECAL:
    - ✅ Crystal calorimeter
    - ✅ Glass calorimeter
    - ✅ Hybrid electron endcap for baseline
      - 🚧 Optimize geometry implementation
    - 🚧 WSciFi calorimeter
- Geometry:
  - 🚧 Finalize/validate geometry for "baseline" setup



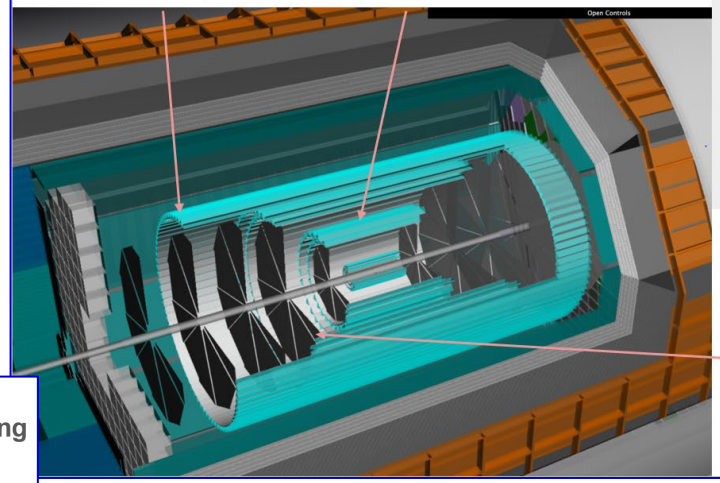
Calorimetry delegate: Vladimir Berdnikov
S&C WG contacts: Wouter Deconinck & Sylvester Joosten

ATHENA
Collaboration Meeting
SWG Update
Friday 2021-07-22

Tracking WG

Outer LGAD layer not part of the "0-0-0" setup

Barrel staves as in ITS2 TDR

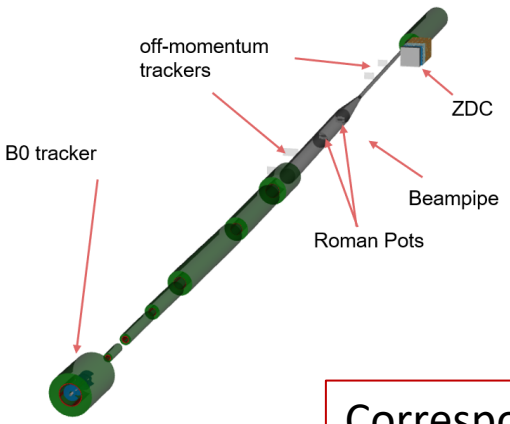


- 🚧 silicon tracker
  - 🚧 Material validation (Shujie Li)
  - 🚧 NEW Vertex layers to be changed to cylindrical geometry
  - 🚧 Validate barrel geometry
  - ❌ Support cones
- ✅ NEW barrel MMGAS (Francesco Bossu)
  - ✅ also have barrel μRWEL
- ✅ GEM

Disks are wedges with sensitive layer and average material backing. Needs better constraints from WG

Tracking delegate: Matt Posik
S&C WG contact: Sylvester Joosten

Far-forward & Far-backward WGs



- FF being worked on by Alex Jentsch
  - ✅ Magnets and detectors updated to latest design
  - 🚧 Flip IR orientation to right-handed coordinate system - **"big flip"** being prepared, right now (tentative merge before Monday)
  - ✅ NEW FF beamline elements
    - 🚧 Validate/tune materials
- FB
  - 🚧 IR implementation

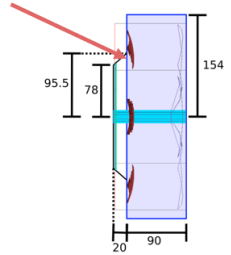
Correspondingly, event reconstruction progress well advanced

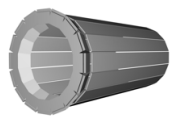
PID WG

- dRICH (Christopher Dilks, Chao Peng)
  - ✅ NEW Base geometry plugin ready
  - 🚧 mirror alignment issue being solved by Christopher
- mRICH (Murad Sarsour, Whitney Armstrong)
  - ✅ received baseline realistic geometry (implemented in fun4All) from Murad
  - ✅ implement realistic detector in DD4hep
  - 🚧 Fix issue with optical photons getting trapped in Fresnel lens
- DIRC (Grzegorz Kalicy, Dmitry Romanov)
  - ✅ Converted geometry (some polishing needed)
  - 🚧 Refactor the code for DD4hep
  - 🚧 Make initial validation benchmark
- TOF (Zhenyu Ye)
  - ✅ LGAD implementation with realistic services
- GridPix (Sanghwa Park)
  - 🚧 Initial implementation

dRICH geometry implementation in DD4Hep

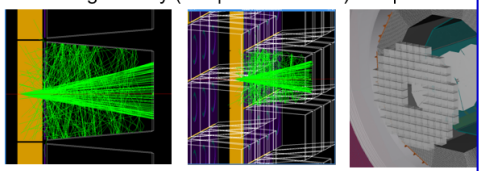
dd4hep Gaseous RICH Envelope





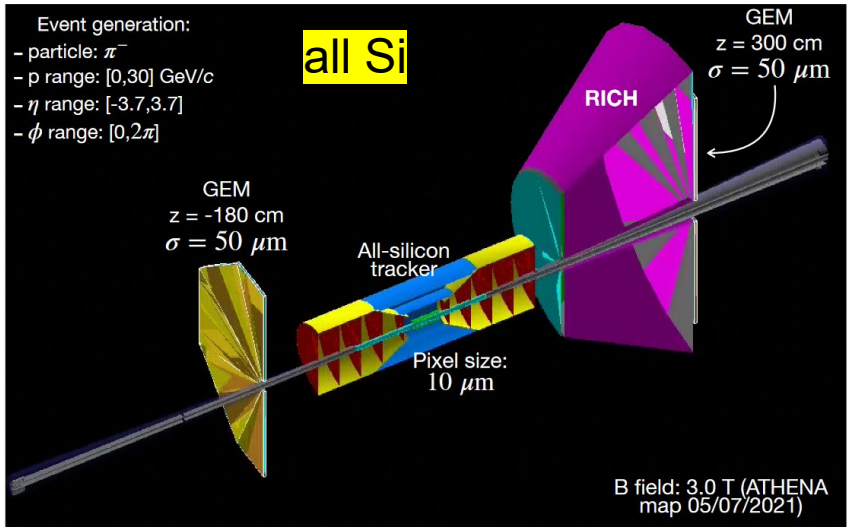
DIRC geometry ported

mRICH geometry (w/ optical surfaces) complete

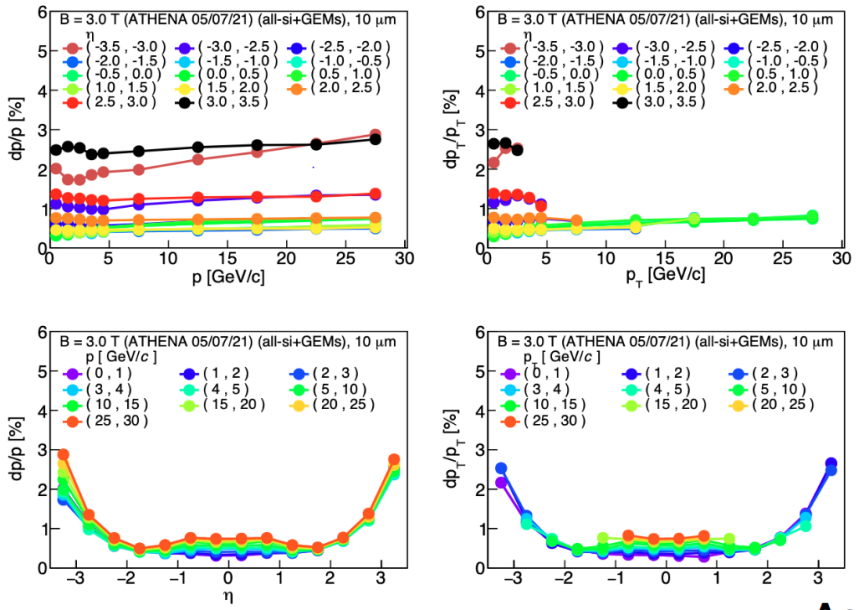


PID delegate: Zhenyu Ye
S&C WG contact: Dmitry Romanov

The two configurations of ATHENA tracking



Momentum resolutions



Rey Cruz-Torres
ATHENA Tracking Meeting
07/13/2021

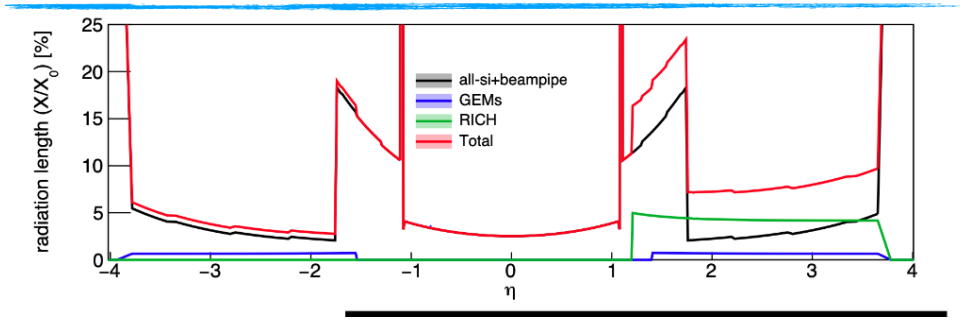
Silicon

- 2 vertex layers, 0.05% X/X_0
- 2 + 2 barrel layers, 0.55% X/X_0
- 5 disks per side, 0.24% X/X_0
- All with 10 μm pixel pitch

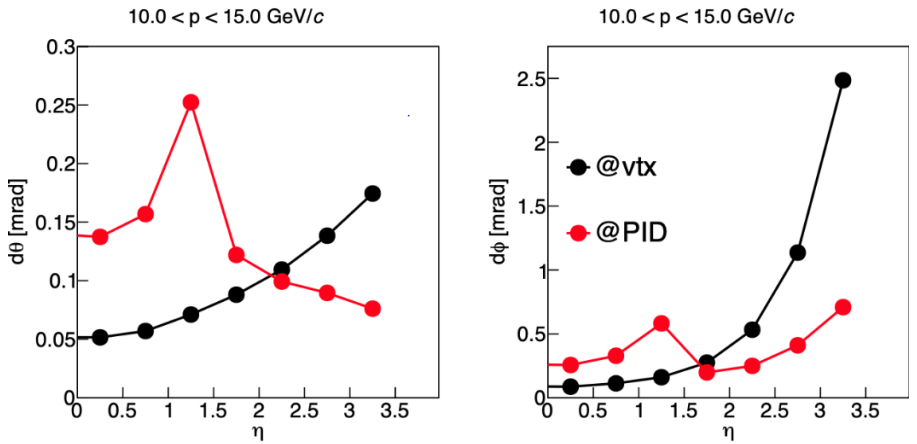
GEM

- 1 on N and 1 on P
- 0.7% X/X_0
- 250 μm in R
- 50 μm in Rϕ

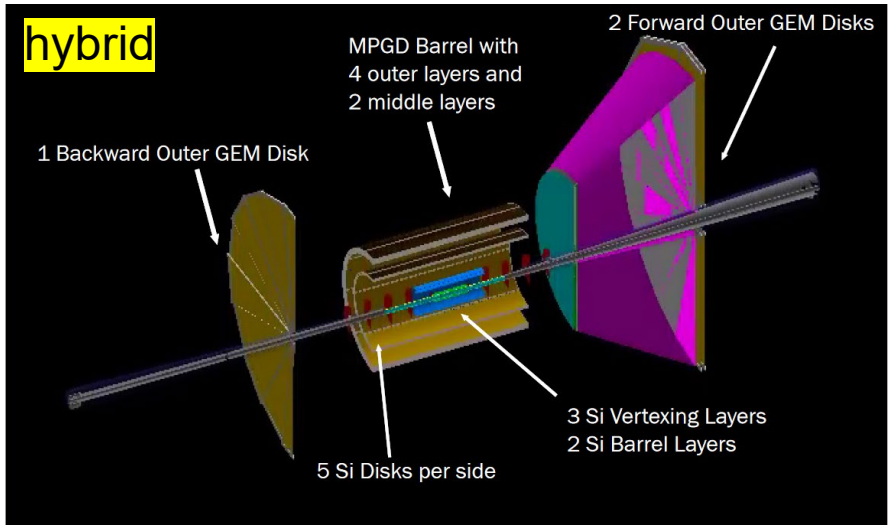
Detector Material Budget



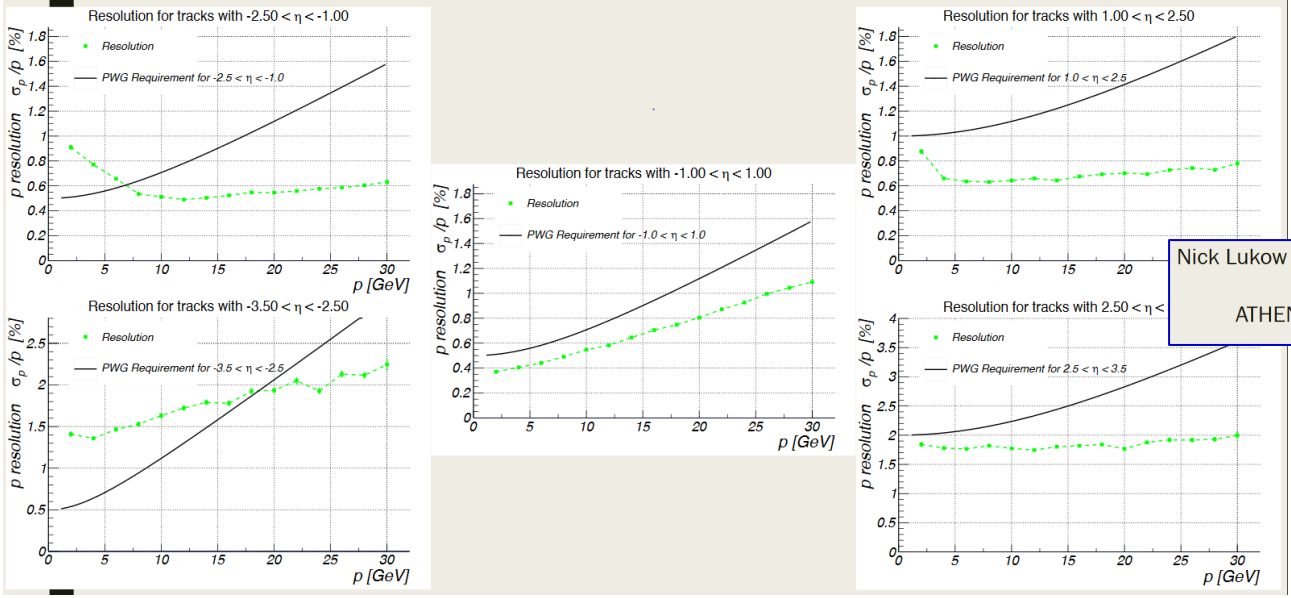
Angular Resolutions



The two configurations of ATHENA tracking



P Resolution vs P



Nick Lukow + Athira Kunnath Vijayakumar
July 13, 2021
ATHENA Tracking WG Meeting

Silicon

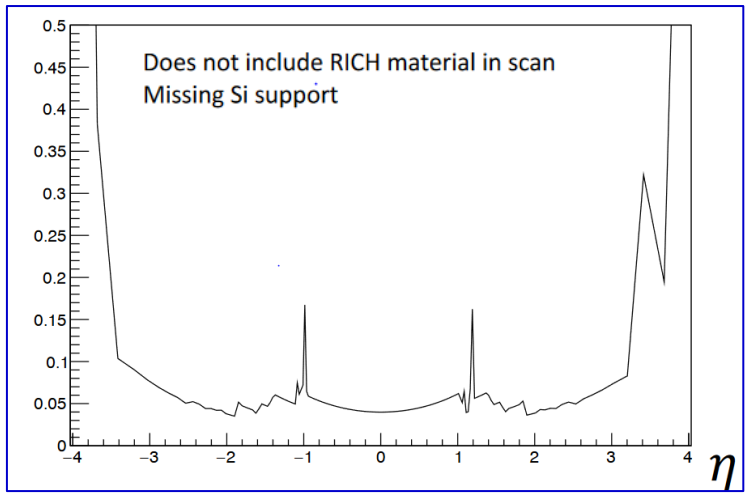
- 3 vertex layers, 0.05% X/X_0
- 2 barrel layers, 0.55% X/X_0
- 5 disks per side, 0.24% X/X_0
- All with 10 μm pixel pitch

Micromegas

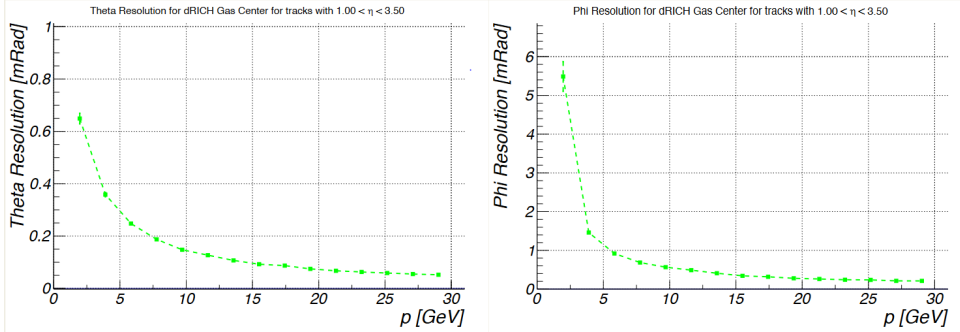
- 2+4 layers, 0.4% X/X_0
- 150 μm in z
- 150 μm in Rϕ

GEM

- 1 on N and 2 on P
- 0.4% X/X_0
- 250 μm in R
- 50 μm in Rϕ

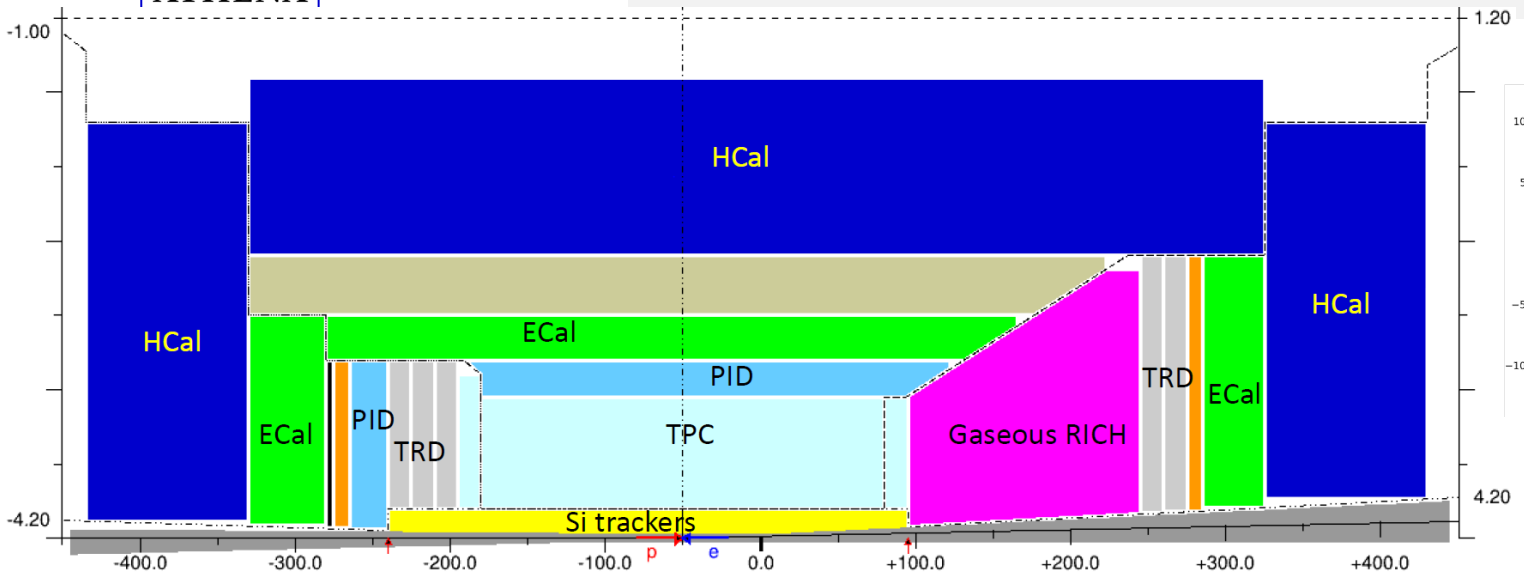


Angular Resolution at mid-gas dRICH



Measured at z = +220cm

ATHENA calorimetry



central detector, backward

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

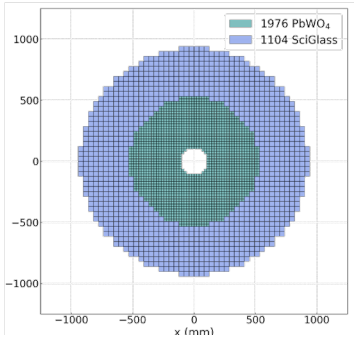
central detector, forward

- **ECAL: W-powder/SciFi**
- **HCAL: Fe/SC, ongoing detector optimization (including total depth, layer thickness and granularity)**

central detector, barrel → next slide

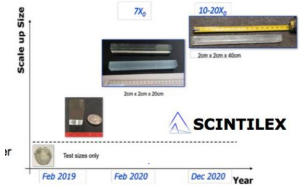
eECAL

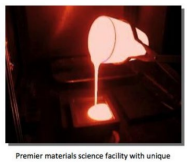
Sensor: SiPMs (TBC)



Detection – $PbWO_4$ crystals

- Up to 2010 – PWO-II production at BTCP, Russia
  - Missing funding -> bankruptcy of BTCO
- Limited availability of reliable SICCAS (China) crystals that would be compatible with experiment requirements
  - ~900 produced for JLab projects since 2017 – Q&A concerns, 30-40% rejection
- 2014 – restart of high-quality PWO-II production at CRYTUR, Czech Republic
  - ~900 produced for JLab projects since 2018 at rate of ~20-30 crystals /month
- Cost of PWO crystals ($15-25/cm^3)

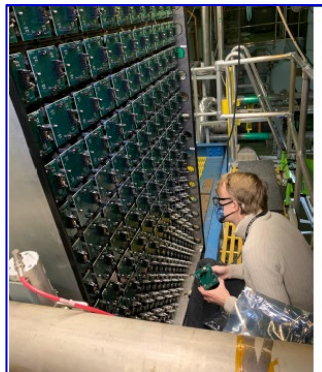




Production & cost issue

sPHENIX Wpowder/SciFi Cal
Sensor: Si PMs

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



STAR Forward Calorimeter System.

Constructed in 2020 with new, very efficient method.

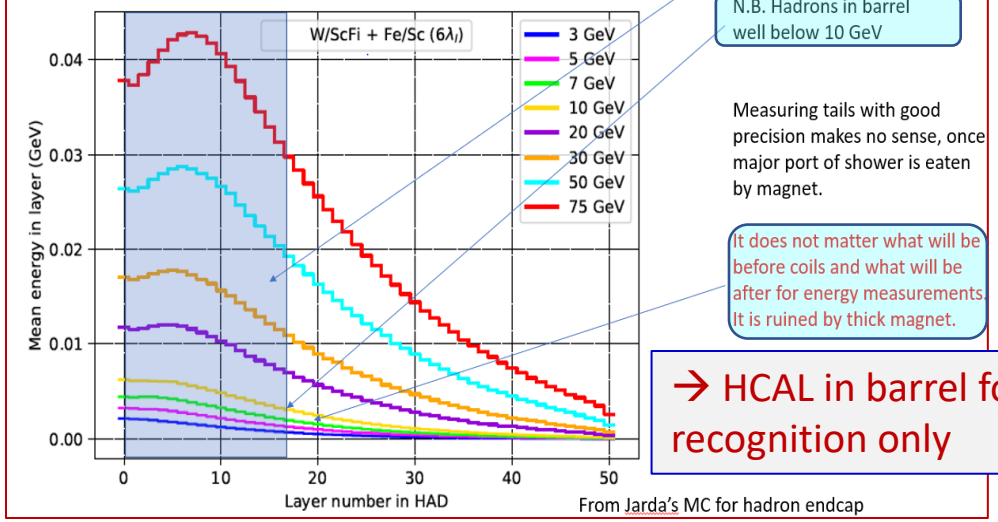
HCal Fe/Sc, similar technology for EIC reference detector.

ATHENA calorimetry

The puzzle of calorimetry in the barrel: a proposal within ATHENA

06/05/21 Coils and Bhcal, General Info for Discussion session O.Tsai

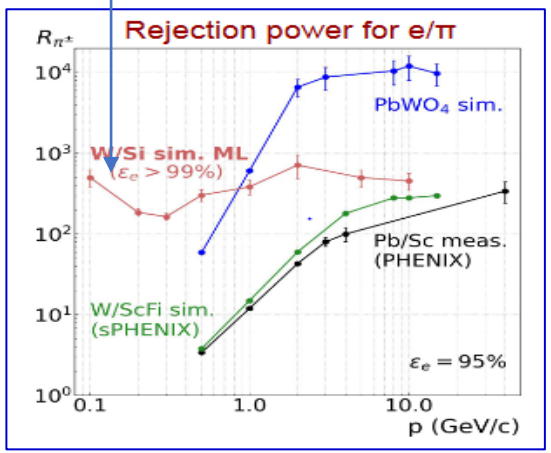
Sc Magnet is very thick ~ 2 interaction length!



From Jarda's MC for hadron endcap

→ HCAL in barrel for recognition only

This option is not in YR



Barrel ECal approach:

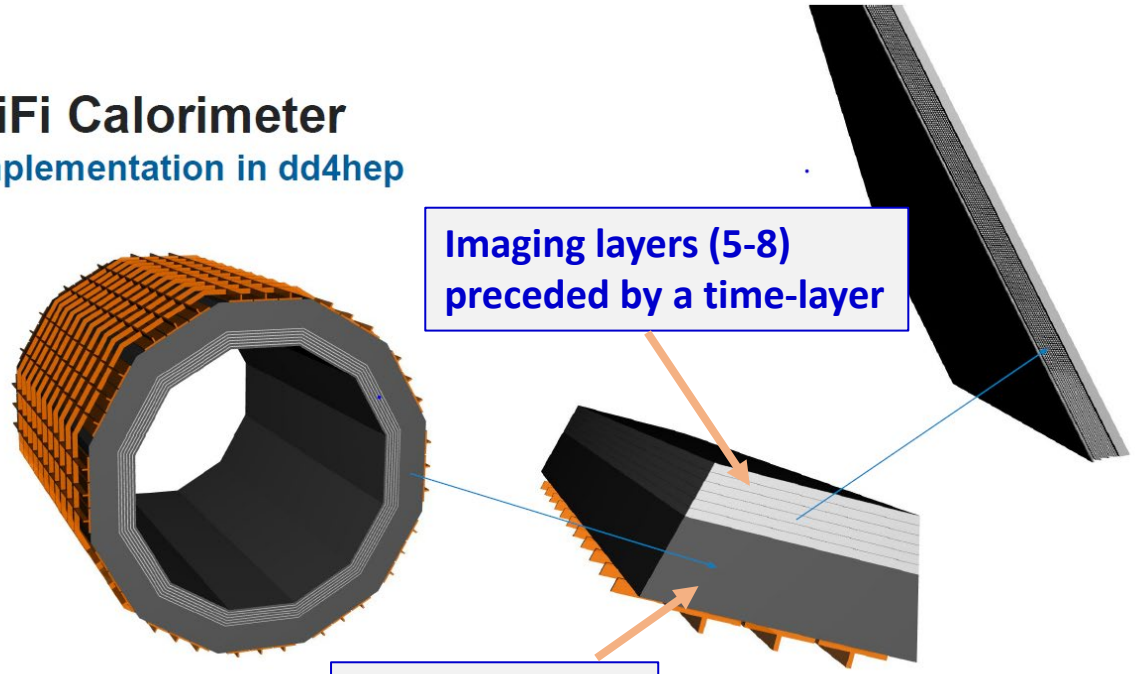
Hybrid imaging calorimeter

Imaging calorimeter based on monolithic silicon sensors

AstroPix (developed for NASA, off-the-shelf)

SiFi Calorimeter

Implementation in dd4hep

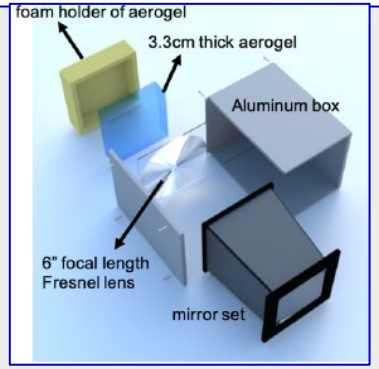


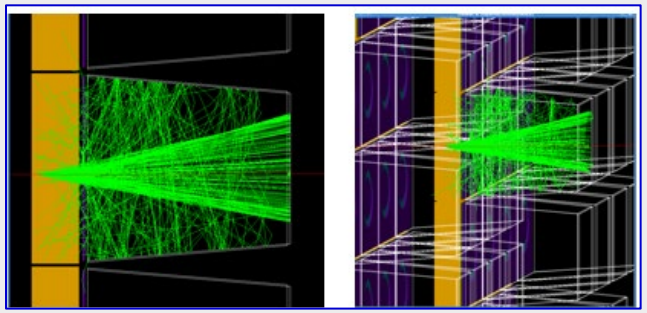
Layout optimization in progress

ATHENA PID

The YR PID baseline is still the ATHENA baseline

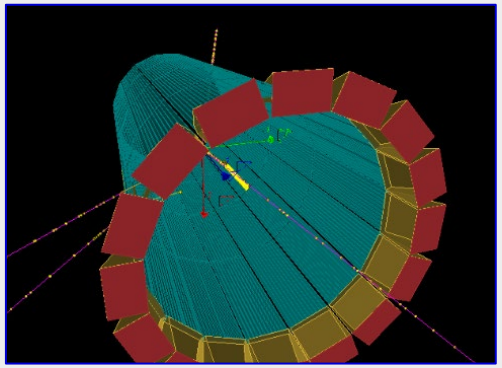
- **Backward: mRICH**





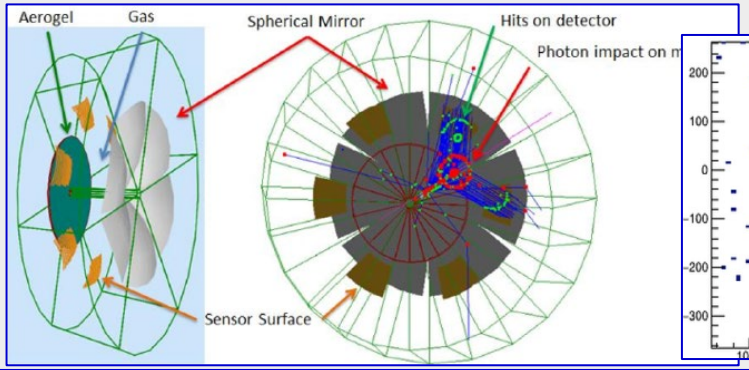
Electron Arm Technology	Range (GeV/c) e - π	π - K
dRICH (aerogel)	0.0025 - 5	2.46 - 16
dRICH (gas)	0.0127 - 18	12.34 - 60
dRICH (overall)	0.0025 - 18	2.46 - 60
HBD	0.0150 - 4.17	-
mRICH	0.0025 - 2	2.00 - 6
TOF (LAPPD 4m, 5ps)	0 - 3	0.00 - 16
TOF (LAPPD 3m, 10ps)	0 - 1.8	0.00 - 10
TRD	1.0 – 270.0	–

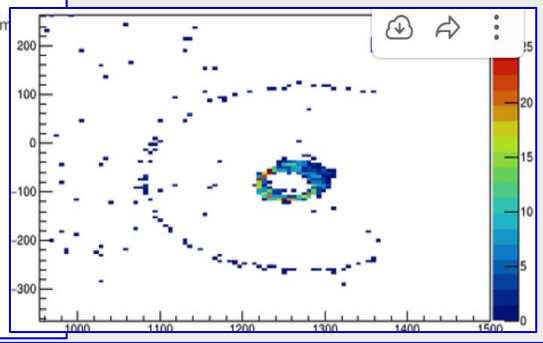
- **Barrel: DIRC**
  - **Important to underline: no longer support from a TPC**



Central Arm Technology	Range (GeV/c) e - π	π - K
$\frac{dE}{dx}$	0 - 2	0 - 3
$\frac{dE}{dx}$ (Cluster Count)	0 - 10	0 - 15
DIRC	0.00048 - 1	0.47 - 6
TOF (LGAD)	0 - 1	0.00 - 5
HBD	0.0150 - 4.17	N/A

- **dRICH**



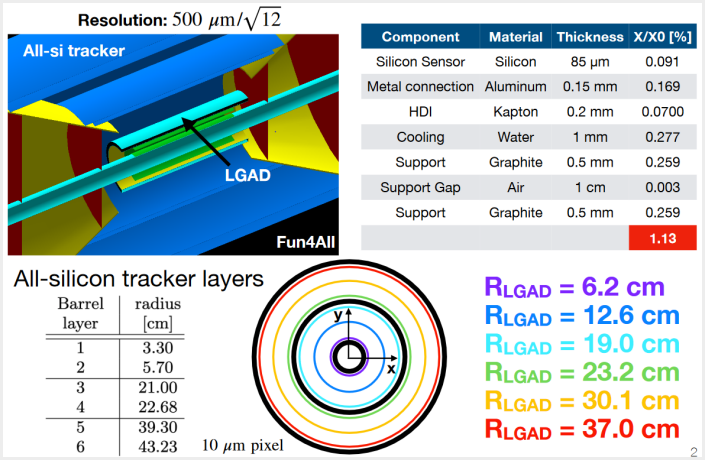


Hadron Arm Technology	Range (GeV/c) e - π	π - K
CsI RICH	0.0150 - 20	14.75 - 50
dRICH (aerogel)	0.0025 - 5	2.46 - 16
dRICH (gas)	0.0127 - 18	12.34 - 60
dRICH (overall)	0.0025 - 18	2.46 - 60
TOF (LGAD)	0 - 1	0.00 - 5
TOF (LAPPD 4m 5ps)	0 - 2.5	0.00 - 16
TRD	1.0 – 270.0	–

ATHENA PID

What else is presently considered within the ATHENA effort

- **TOF with LGAD sensors**

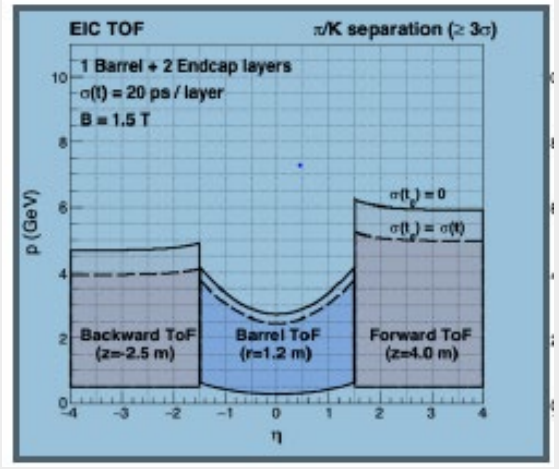


Component	Material	Thickness	X/X0 [%]
Silicon Sensor	Silicon	85 μm	0.091
Metal connection	Aluminum	0.15 mm	0.169
HDI	Kapton	0.2 mm	0.0700
Cooling	Water	1 mm	0.277
Support	Graphite	0.5 mm	0.259
Support Gap	Air	1 cm	0.003
Support	Graphite	0.5 mm	0.259
			1.13

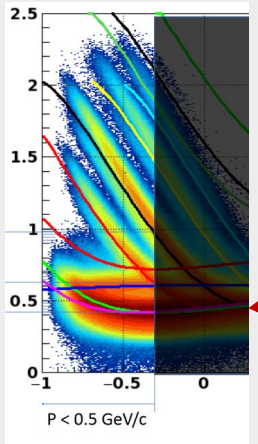
All-silicon tracker layers

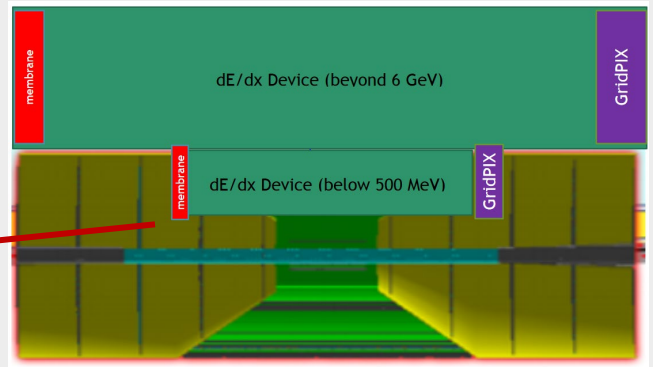
Barrel layer	radius [cm]
1	3.30
2	5.70
3	21.00
4	22.68
5	39.30
6	43.23

R_{LGAD} = 6.2 cm
R_{LGAD} = 12.6 cm
R_{LGAD} = 19.0 cm
R_{LGAD} = 23.2 cm
R_{LGAD} = 30.1 cm
R_{LGAD} = 37.0 cm

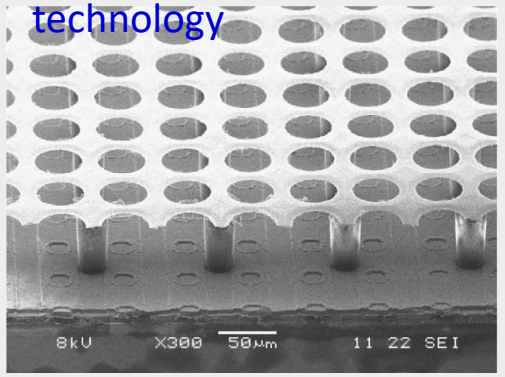


- **An option to make barrel PID more robust, in particular at low momenta: the gridpix miniTPC**





GRIDPIX,
a well-established
technology



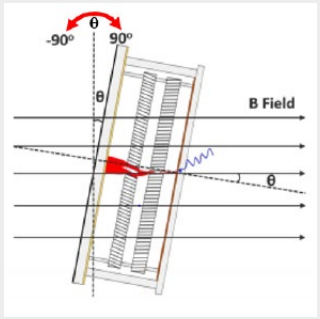
- Project in initial stage
- Issues related to best possible use of the space available in the barrel
- Tracking contributions of the miniTPC to be quantified

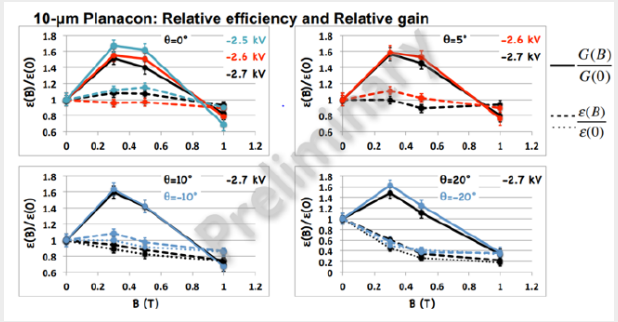
S. Park,
Athena PID meeting,
14 June 2021

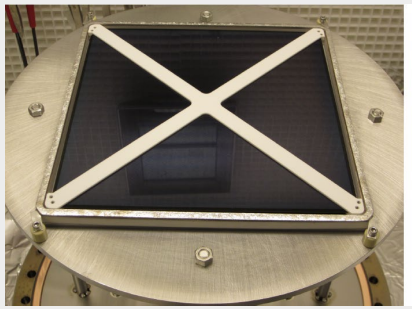
ATHENA PID

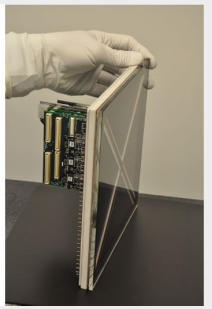
The photon sensors

- **From YR**
  - **MCP-MPTs, commercially available**
    - **B-field issues, costs**
  - **LAPPDs**
    - **Still requiring full validation/characterization for Single photon detection**
    - **B-field issues**
    - **Also TOF information provided**
  - **Si PMs**



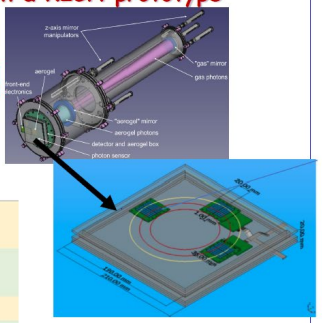






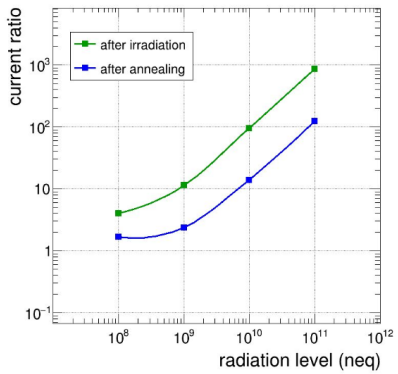
A dedicated effort for application at EIC by a cluster of INFN groups

- SiPMs from different producers mounted on a RICH prototype
  - Part as received
  - Part irradiated
  - Part irradiated and thermal annealing cycle
- → Performance in a test beam
- Coupled to specific FE r-o:
  - ALCOR, developed for DarkSide



MULTIUPLE MANIFACTURES	
SENSEL (OnSemiconductors)	microFJ-30020-TSV
	microFJ-30035-TSV
Broadcom	AFBR-SAN33C013
Hamamatsu Photonics	S13360-3050VS
	S13360-3025VS
	S14160-3015HS
	S14160-3050HS
FBK, Fondazione Bruno Kessler	custom SiPM

[NUV-HD-RH] 1 week of annealing at T = 125 C



T = 20 C
V_{bias} = 33 V

annealing reduced dark current by a factor of ~5-10, in line with expectations

SiPM irradiated up to 10^{11} now behave like if they were irradiated by 10^{10}

for the time being we stop here with FBK sensors, or perhaps we extend annealing at T = 125 C for another 2 weeks (expecting no improvements)

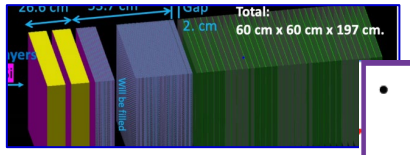
issue with FBK carriers related to the solder paste used during assembly, unfortunately we have used low-T (138 C) solder paste which does not allow to reach the ultimate annealing temperature of T = 175 → needs reworking of the carriers → will be done after test beam

Preliminary !

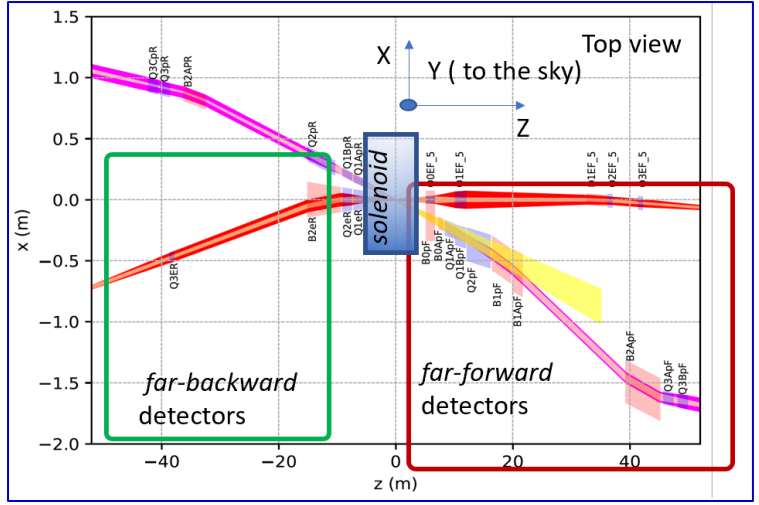
Much more coming from data analysis and test beam in Fall

R. Preghenella
Athena PID meeting,
5 July 2021

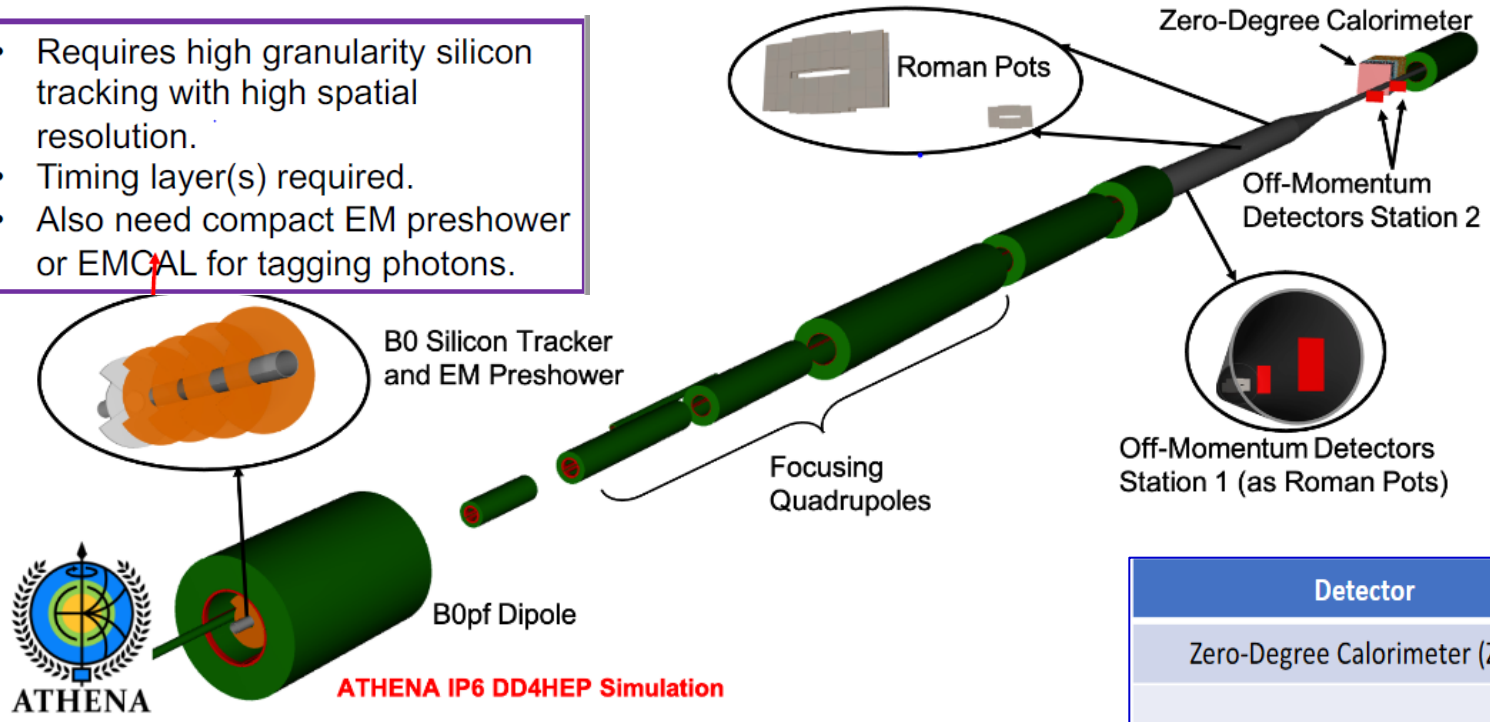
ATHENA far forward detectors



- Combination EMCAL and HCAL with high granularity and resolution.
- Design starting point is ALICE FoCal.



- Requires high granularity silicon tracking with high spatial resolution.
- Timing layer(s) required.
- Also need compact EM preshower or EMCAL for tagging photons.

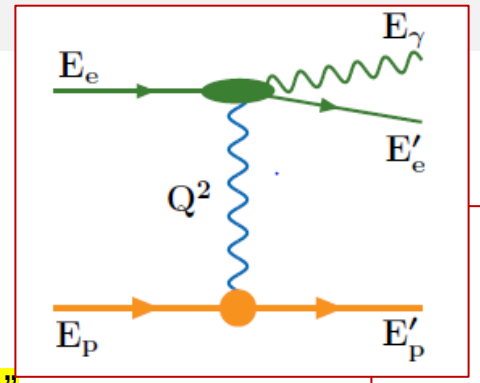


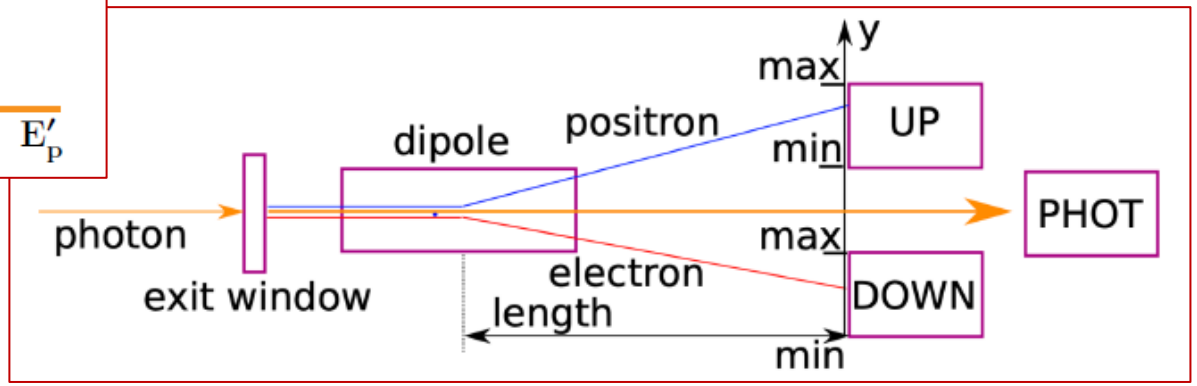
- Both can rely on use of AC-LGAD technology for fast (~20-30ps) timing and good spatial resolution.
- Roman Pots require special care since we plan to go with “potless” design to maximize acceptance.

Detector	Acceptance	Notes
Zero-Degree Calorimeter (ZDC)	$\theta < 5.5$ mrad ($\eta > 6$)	About 4.0 mrad at $\varphi \sim \pi$
Roman Pots (2 stations)	0.0* $< \theta <$ 5.0 mrad ($\eta > 6$)	$0.65 < \frac{p_{z,nucleon}}{p_{z,beam}} < 1.0$ *10σ cut
Off-Momentum Detectors (OMD)	$0.0 < \theta < 5.0$ mrad ($\eta > 6$)	Roughly $0.3 < \frac{p_{z,nucleon}}{p_{z,beam}} < 0.6$
B0 Sensors (4 layers, evenly spaced)	$5.5 < \theta < 20.0$ mrad ($4.6 < \eta < 5.9$)	Also looking at photon tagging via EMCAL/preshower.

ATHENA far backward detectors

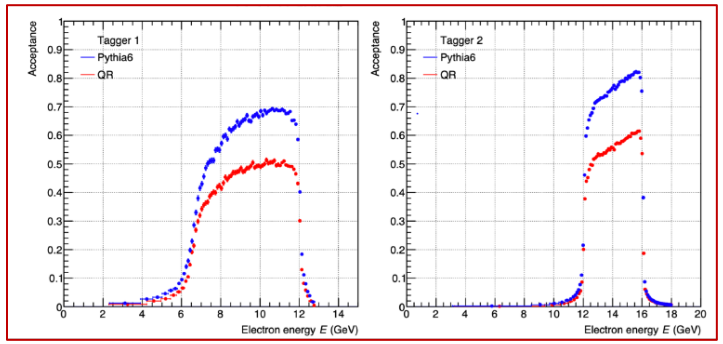
- We aim to measure the EIC luminosity with a precision better than 1% using the electron-ion bremsstrahlung

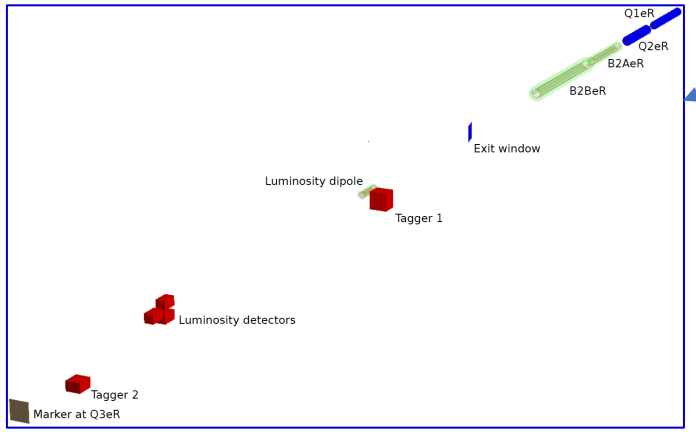


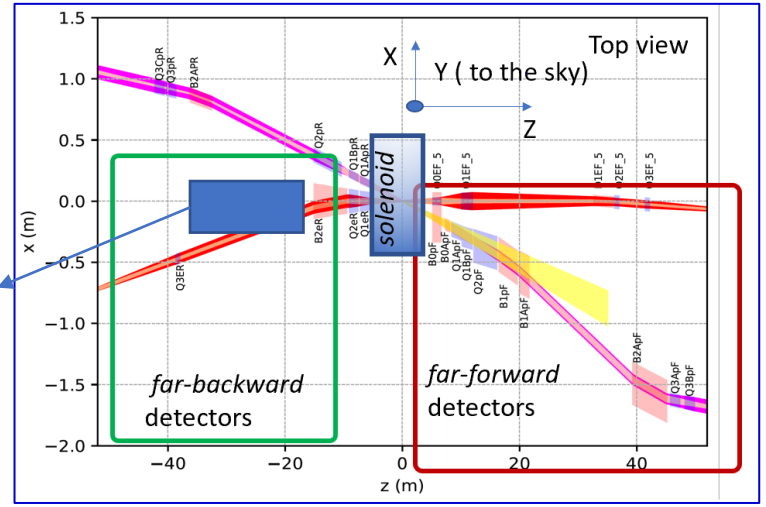


- Dedicated detectors will measure "zerodegree" photons, and the design effort started from the challenging design of the photon exit window; need to minimize the direct SR flux

- A fraction of the scattered electrons in bremsstrahlung will be measured too, and the electron detectors will also be used to tag low-Q^2 Events (photoproduction) in ATHENA







Polarimetry (joint with EICUG WG)

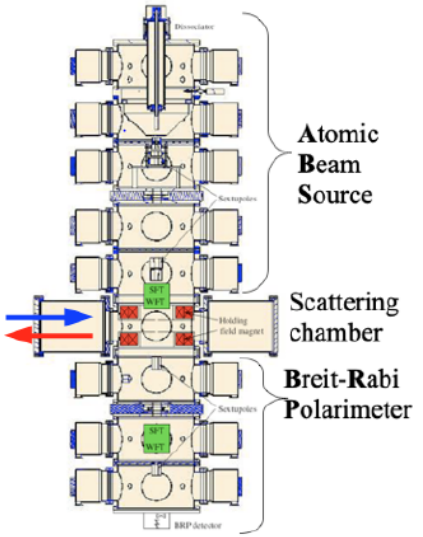
- **Hadron Polarimeter at IP6 (elastic recoil)**
- pC for relative polarimetry
- Inside of spin rotators / crab cavities
- Confirmation of polarization vector (start of fill)
- Polarization bunch profile (after crab rotation)
- Ultra-thin Carbon fiber targets may not be suitable for high bunch repetition rate at EIC

- **Electron Polarimeter at IP6 (Compton scattering)**
- Backscattered photon needs feedthrough for some magnets
- Available acceptance, effect of beam pipe/exit window
- Cross talk between longitudinal/transverse asymmetries

EIC UG working group on polarimetry/luminosity

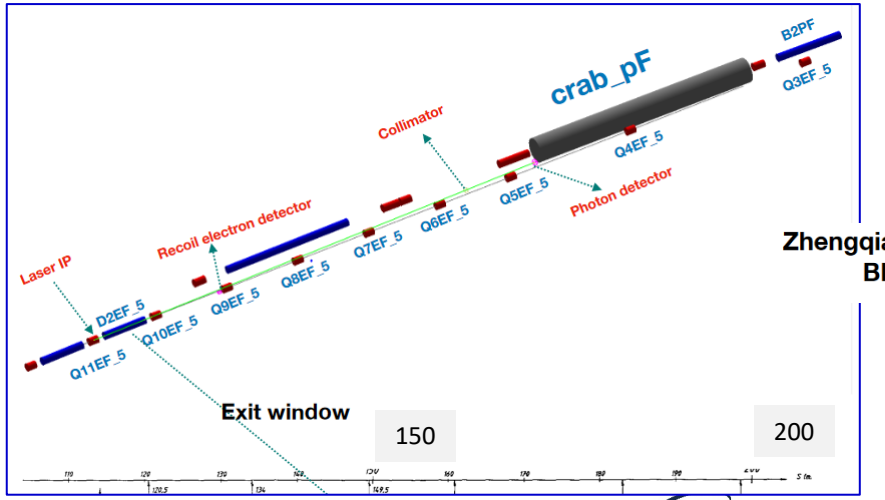
https://indico.bnl.gov/category/280/

Monthly meetings → higher frequency for proposal specific topics



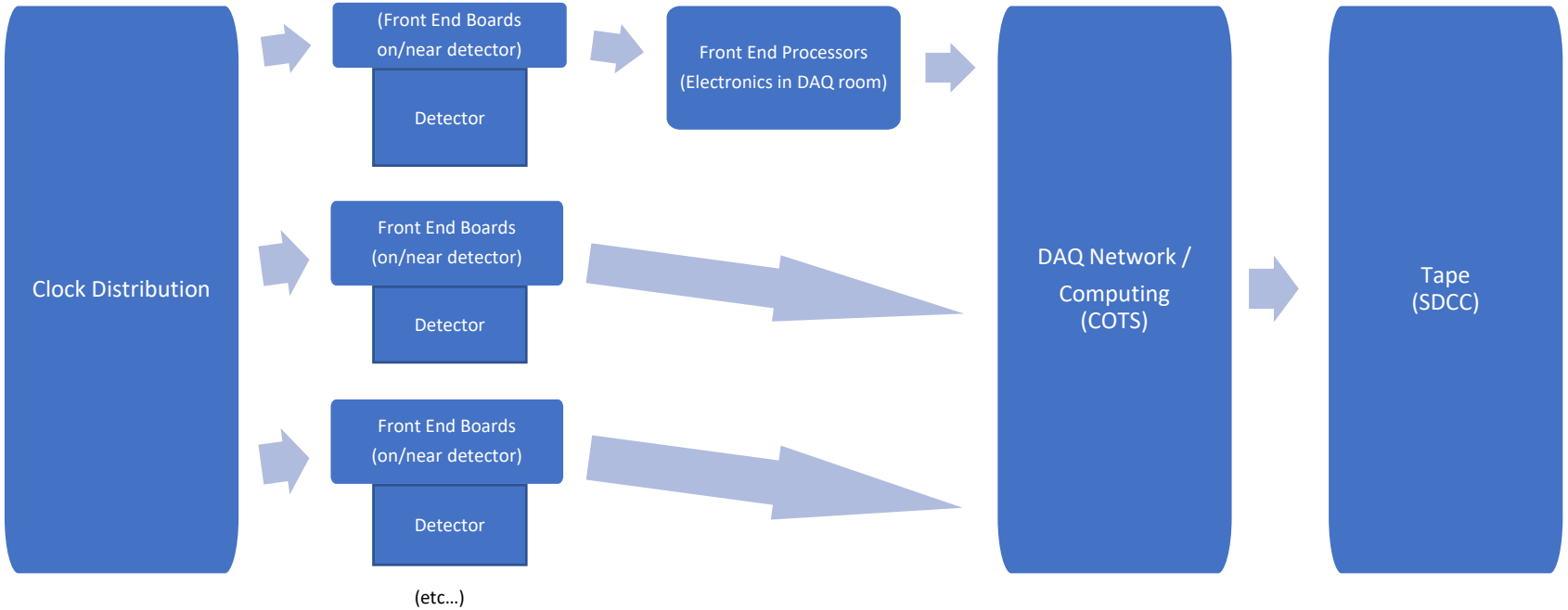
The RHIC polarized hydrogen jet polarimeter.

The Compton polarimeter in IR6



Zhengqiao Zhang
BNL

DAQ for ATHENA



The DAQ system is a triggerless streaming system following the outline described in the Yellow Report

We are currently evaluating the specific needs of the proposed Athena Detectors to determine what the specific readouts imply for streaming mode, data volume, interface specifications, and processing requirements in order to determine the scale, cost, and optimal design of the system.

SUMMARY

ATHENA is international collaboration, currently including 95 institutions

- The guide-line: the best possible to perform the whole EIC physics program
  - A new 3 T magnet with large bore diameter
  - State of the art detectors
  - Modern software
- The community
  - making it coherent (frequent meetings, web-documentation)
  - structuring it for a fully transparent management
  - preserving the collaborative and synergistic attitude within the global EIC community
- The detector
  - Important progress towards the new magnet
  - Software packages supported by large international collaborative efforts across experiment and lab boundaries
  - *Starting from the YR with optimizations and novel elements*
    - Full Si or hybrid tracking
    - A novel approach considered for Calorimetry in the barrel
    - Grid-pix miniTPC proposed for PID & tracking
    - Important steps forward to establish SiPMs as sensors for Cherenkov imaging techniques
  - *Large integration of activities within the whole EIC community*
    - Si consortium
    - Calorimeters (**EEEMCAL effort)**
    - Far-fwd/far-bwd detectors
    - Polarimetry

Thank you !

SPARE SLIDES

ATHENA reconstruction, status backup slide

Reconstruction Status

✅ **Calorimetry**
- ✅ Algorithms
  - ✅ Simple Clustering
  - ✅ Island Clustering (2D)
  - ✅ 2+1D Clustering
  - ✅ Topological Clustering (3D)
- ✅ Clustering benchmarks

🚧 **PID**
- 🚧 Algorithms
  - ✅ Fuzzy-K ring clustering
  - 🚧 MRICH clustering (Murad)
  - 🚧 DIRC clustering
- ❌ PID benchmarks

🚧 **Far Forward & Far Backward**
- ❌ Integrate B0 with tracker
- 🚧 Matrix transform for Roman Pot & OMD reconstruction
- ❌ low Q2 tagger

🚧 **Tracking**
- 🚧 Algorithms
  - ✅ Proof-of-concept working again!
  - 🚧 Finalize tracking for baseline
  - 🚧 Tracking benchmarks
  - ❌ Incorporate B0
  - ❌ Setup realistic vertex reconstruction
- 🚧 Tracking Benchmarks
  - ✅ Basic benchmarks working
  - ❌ Tracking with realistic background

🚧 **Global**
- Event builder (produces ReconstructedParticle)
  - ✅ Dummy event builder to test reco chain
  - 🚧 Implementation of full realistic event builder
- 🚧 Finalize data model
- 🚧 Tutorial on full reconstruction

ATHENA
Collaboration Meeting
SWG Update
Friday 2021-07-22

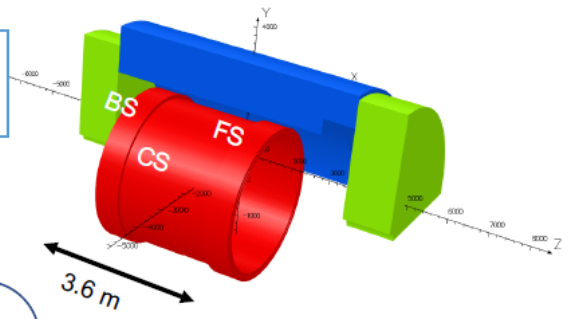
The ATHENA solenoid

New Solenoid (up to 3T)

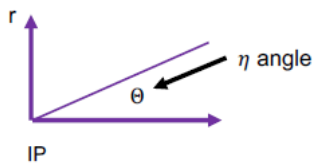
By: V. Calvelli (CEA), R. Rajput-Ghoshal (JLAB)

Solenoidal Configuration

Magnetic field map released 07/05/2021



On the Interaction Point rz plane



$$Proj = \frac{B_z \tan\Theta - B_r}{J_E}$$

If $Proj = 0$ everywhere, particles are not deflected from the original trajectory (same as $\frac{dP}{dt} = 0$)

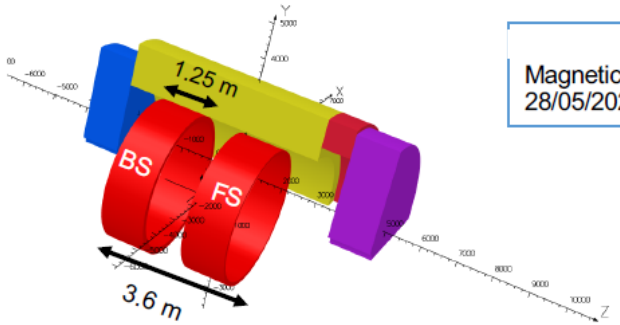
Parameter	Values
B_{IP} (T)	3.15
B_{peak} (T)	4.35
Coil thickness (mm)	200
Energy (MJ)	183.9
H TPC 2 (%)	6.61
H FLAT 1 (%)	25.12
Projectivity (T/Amm²)	14.82

Parameter	Goal
B_{IP} (T)	3.00
Bore diameter (mm)	1600
Coil length (mm)	3600
H TCP 2 (%)	5.0
H FLAT 1 (%)	10.0
Projectivity (T/Amm²)	min

$$H^2_{TPC} = \left|\frac{B_r}{B_z}\right| < 5\%$$

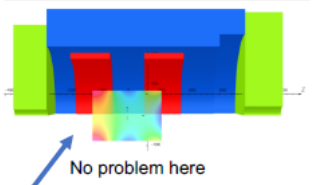
$$H^1_{FLAT} = \frac{B_{max} - B_{min}}{B_{IP}} < 10\%$$

Helmholtz Configuration

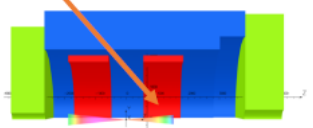


Magnetic field map released 28/05/2021

Parameter	Values
B_{IP} (T)	2.97
B_{peak} (T)	4.84
Coil thickness (mm)	210
Energy (MJ)	235.7
H TPC 2 (%)	4.83
H FLAT 1 (%)	16.37
Projectivity (T/Amm²)	17.51



No problem here

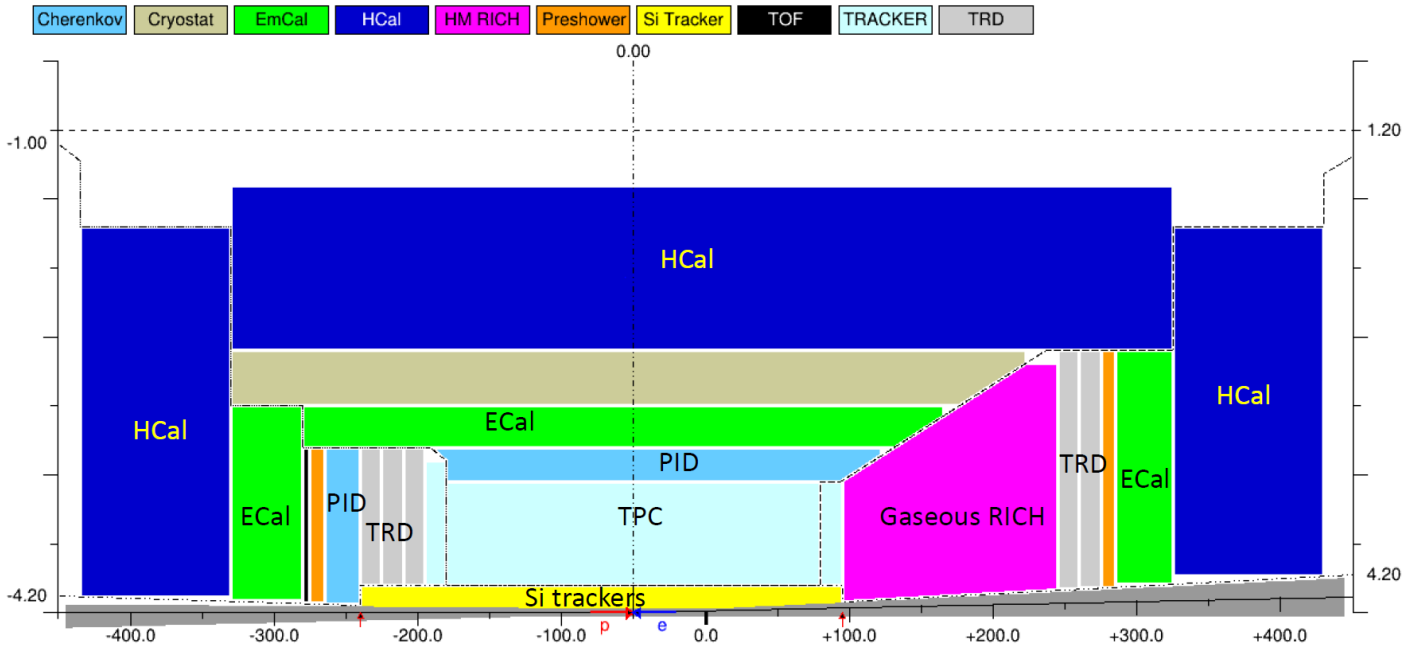


Mostly difficult to reach before the RICH
Due to the short length of the magnet

(Frd RICH)

16

calorimetry



eECAL Hybrid, PWO insert and Glass outer ring, EEEMCAL collaboration

bECAL ANL group interesting to design the concept of the hybrid calorimeter: few layers of imaging calorimeter combined followed by sampling calorimeter in barrel region. Possibility of having a timing for a first layer (LGAD) if technology ready for day 1, possible for upgrade

hECAL Wpowder/SciFi

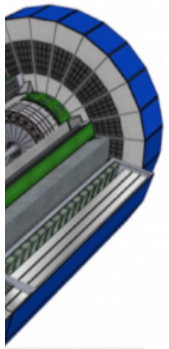
eHCAL Fe/Sc, ongoing detector optimization in barrel and endcap regions, to make a first detector

bHCAL model without extensive simulations will be impossible. Trade-offs need to be found

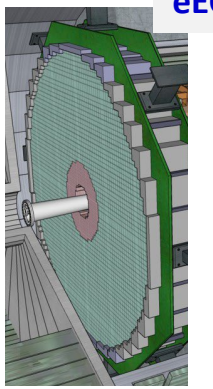
hHCAL between energy resolution, transverse and longitudinal segmentation, and the whole system will be better AI/ML oriented from the start or as possible upgrade.

Proposed 'over-designed' versions with 2 cm thick steel absorber, with 3 or 5mm scintillator plates between. The tile size 3x3 cm^2 with readout of each tile separately. Fine granularity may be re- grouped in all possible ways to come up with cost effective solution. Number of layers - determined by what is allocated in integration envelopes.

For up-to-date approach in the barrel: next slide



er meeting

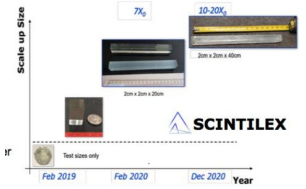


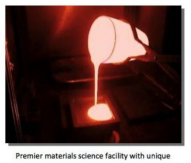
eECAL

Sensor: SiPMs (TBC)

Detection – $PbWO_4$ crystals

- Up to 2010 – PWO-II production at BTCP, Russia
  - Missing funding -> bankruptcy of BTCO
- Limited availability of reliable SICCAS (China) crystals that would be compatible with experiment requirements
  - ~900 produced for JLab projects since 2017 – Q&A concerns, 30-40% rejection
- 2014 – restart of high-quality PWO-II production at CRYTUR, Czech Republic
  - ~900 produced for JLab projects since 2018 at rate of ~20-30 crystals /month
- Cost of PWO crystals ($15-25/cm^3)

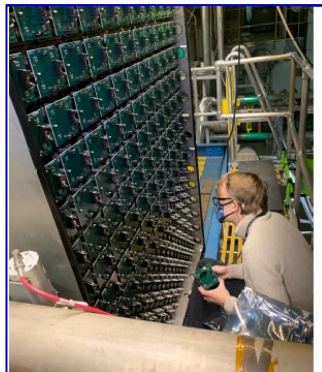




Production & cost issue

sPHENIX Wpowder/SciFi Cal
Sensor: Si PMs

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



STAR Forward Calorimeter System.

Constructed in 2020 with new, very efficient method.

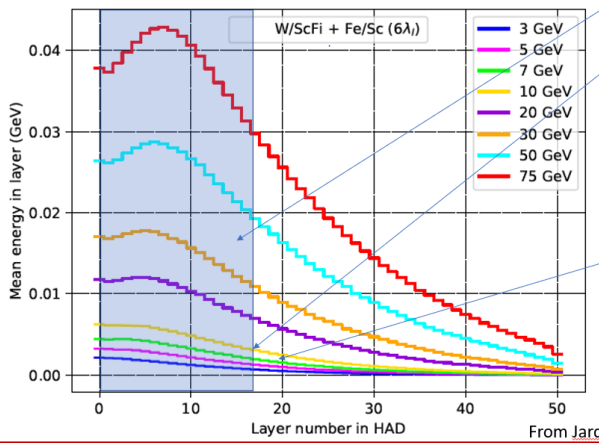
HCal Fe/Sc, similar technology for EIC reference detector.

ATHENA calorimetry

The puzzle of calorimetry in the barrel: a proposal within ATHENA

06/05/21 Coils and Bhcal, General Info for Discussion session O.Tsai

Sc Magnet is very thick ~ 2 interaction length!



SC Magnet ~ 2 int. length

N.B. Hadrons in barrel well below 10 GeV

Measuring tails with good precision makes no sense, once major port of shower is eaten by magnet.

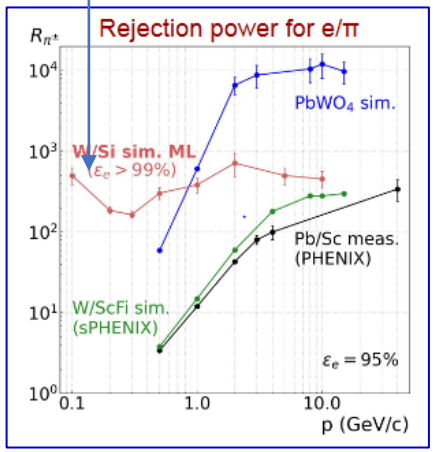
It does not matter what will be before coils and what will be after for energy measurements It is ruined by thick magnet.

'Patter' (showers separation) recognition ?

From Jarda's MC for hadron endcap

Barrel ECal approach:
Hybrid imaging calorimeter

This option is not in YR

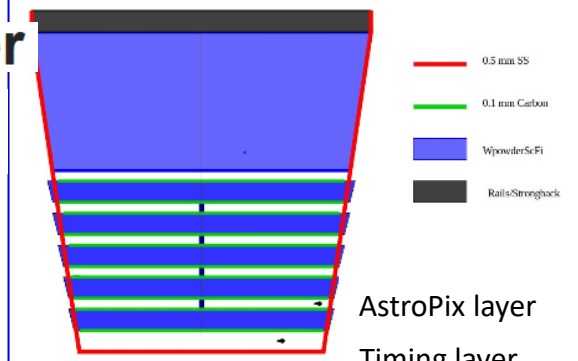


Imaging calorimeter based on monolithic silicon sensors

AstroPix (developed for NASA, off-the-shelf)

Hybrid Calorimeter

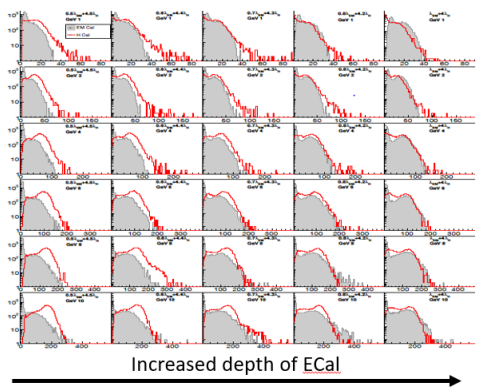
- 5 layers AstroPix + SiFi/W (~5 X_0)
- SiFi/W ~15 X_0



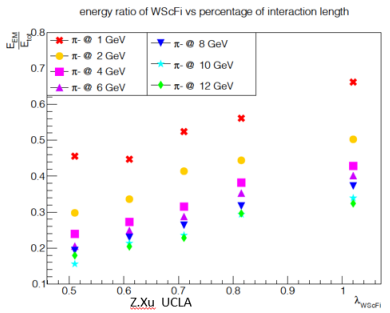
AstroPix layer

Timing layer

Does deeper Ecal helps to reconstruct low energy hadrons?



Increased depth of ECal



Can thick Ecal help?

Increased depth of Ecal does help a bit to improve energy resolution of the system for low energy hadrons. Assuming we have good PID, additional e/h (TRD etc.,) you can do that.

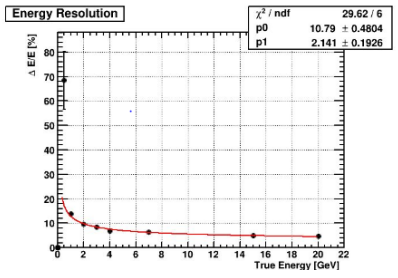
Not for energy measurement, but as a 'pattern' recognition device, i.e. ability to detect showering neutral hadrons, if they will interact before coils.

Detector R&D Advisory Committee Meeting. BNL, March 25, 2021
https://wiki.bnl.gov/conferences/index.php/March_2021#Report

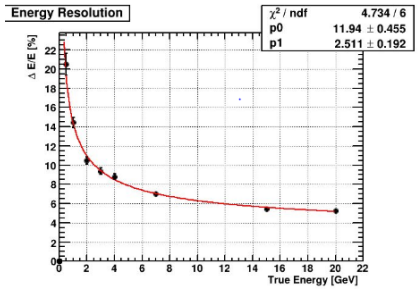
Heavier barrel Ecal
→ Engineering issue

First rough simulations

electrons

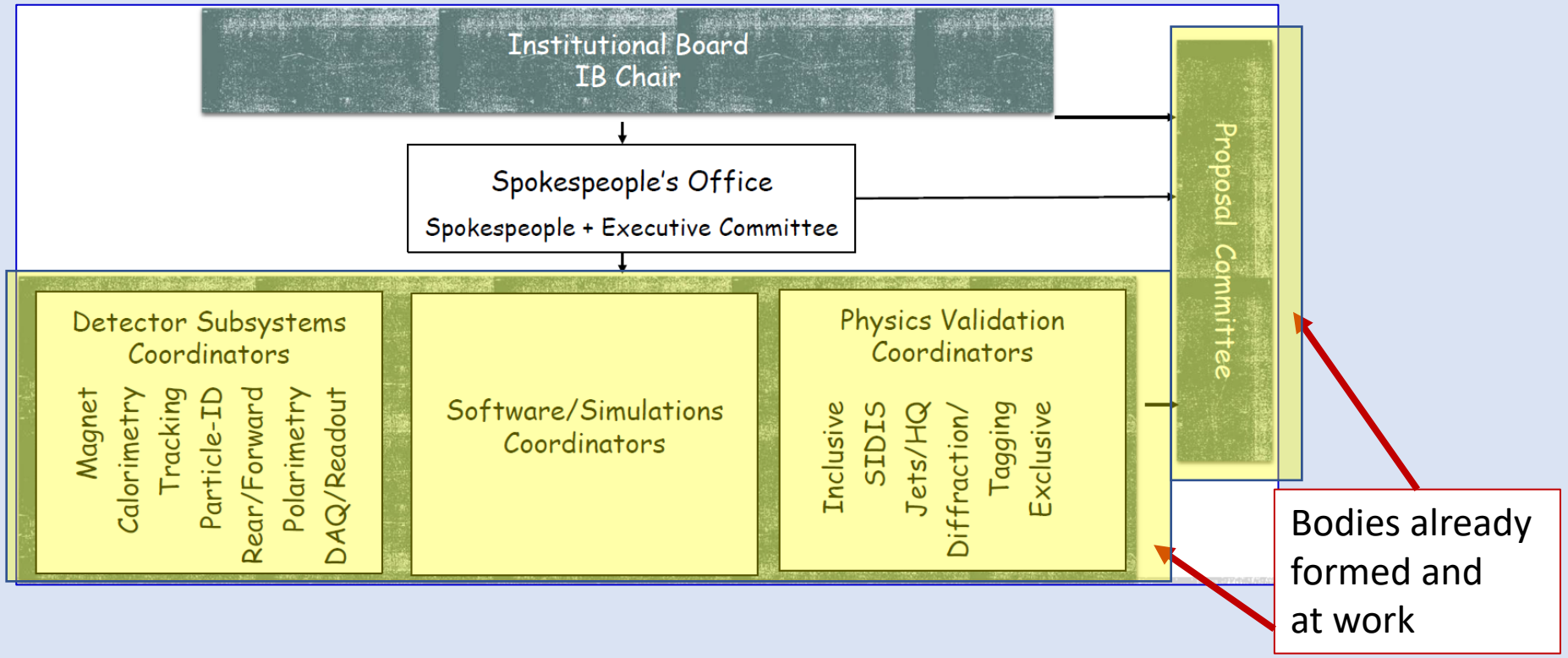


photons



ATHENA MOVING FORWARD

ATHENA structure



Next steps:

- Election procedure started (IB chair and deputy, SP and deputy);
- will be completed at the beginning of September

Election/Nominating Committee

- Pietro Antonioli (INFN-Bologna)
- John Arrington (LBL)
- Nicole d'Hose (CEA Saclay)
- Yulia Furletova (JLAB)
- Sylvester Joosten (ANL)
- Brian Page (BNL)