



Particle Identification with the ePIC detector at the EIC

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- On behalf of ePIC collaboration



Introduction: ePIC in EIC

Plenary talk by Silvia Dalla Torre on ePIC, tomorrow (@14:30)





2

⁷ γ*(Q²)

 $X (M_X)$

Largest rapidity

gap in event

P'.p'

Introduction: ePIC in EIC

Plenary talk by Silvia Dalla Torre on ePIC, tomorrow (@14:30)





- Magnet and Tracking
 - 1.7 T solenoid
 - Micro-Rwell and Micro-Megas
 - Si-MAPS
- Calorimetry
 - Barrel Imaging Calorimeter
 - e-Cap: PbWO4 EMCal
 - Forward: finely segmented EMCal and hCal

PID

Backward

Proximity focusing RICH (aerogel RICH + peripheral conical mirrors + HRPPD) Central

8.5 m

Time Of Flight (AC LGAD), DIRC (fused silica bar with novel lensing and MCP-PMT based readout)

Forward

Time Of Flight (AC LGAD) and Dual radiator RICH (aerogel + C2F6 gas + spherical mirrors + SiPM sensors)

Backward PID



Talk on pfRICH by A. Kiselev today at 18:10

Talk on pfRICH by A. Kiselev.



e-endcap RICH for ePIC detector

- A classical proximity focusing RICH
- Pseudorapidity coverage: -3.5 < η < -1.5
- Uniform performance in the whole $\{\eta, \phi\}$ range
- π/K separation above 3σ up to ~ 9.0 GeV/c and ~10-20ps t₀ reference with a ~100% geometric efficiency in one detector



Sophisticated chi-squared analysis capable of performing efficient pid with complicated event topologies.

Backward PID



Talk on pfRICH by A. Kiselev today at 18:10



Backward PID

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Beam tests at Fermilab, CERN







CERN

Test bench setup at BNL





Test setup at INFN Trieste

- Sophisticated PID algorithm for event level analysis: Software used by dual RICH.
- HRPPD as photo sensors: cost effective alternative solution for DIRC.
- ✓ <u>Potential application as a timing detector</u>.

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Central PID *hpDIRC*

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- Improved resolution.
- Key components:
 - Innovative focusing lens
 - Compact fused silica
 - Fast photon detection.

Frontend electronics (PADIWA) (air-cooled)

DAQ boards (TRB)

HADRON 2023, Genova

Central PID hpDIRC





 3D (X,Y,t) reconstruction thanks to fast photon detection sensor.
 Potential commonality with pfRICH for using HRPPD.

 Excellent agreement between simulation and beam test results.
 3 sigma pi/K separation up to 6 GeV/c (covering -1.73<eta<1.73).

Central and Forwrad PID TOF







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10

4.6

Central and Forwrad PID TOF

TOF PID Performance – Single Particle Gun



AC-coupled electrodes

DC contact

(dead area)

Forward particle identification



Requirements:

- Wide acceptance (<u>+- 300 mrad/ 1.5<η≤3.5</u>)
- High momentum coverage up to <u>50 GeV/c π-K</u>
 - ★ Dual radiator (aerogel (n ~1.02)+ C₂F₆ gas (n~1.0008))

Compact geometry: <u>short radiator space available</u>

• Smaller number of detected photons \rightarrow Critical optical tuning and control over background hits.

Large sensor surface to be covered in magnetic field.

Limited choice of photon-sensor (SiPM as a cheap solution)

Simulation contains: 6 identical sectors

- Spherical mirror with radius 220 cm
- SiPM sensors with realistic PDE and additional 70% safety factor.
- Realistic parameters for aerogel and C₂F₆

Forward particle identification Simulation Studies







W/ conservative 70% safety factor <u>18 photo electrons</u> are detected. Over a wide range of rapidity required resolution is achieved. Region affected w/ spherical aberration are limited in momentum (**6σ** sep. upto **20 GeV/c**).

Forward particle identification Simulation Studies



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Forward particle identification: *sensor*

• pros

- o cheap
- high photon efficiency
- excellent time resolution
- o insensitive to B field

cons

- \circ large DCR, ~ 50 kHz/mm² @ T = 24 °C
- not radiation tolerant
 - moderate fluence < 10¹¹ n_{eq}/cm²

R&D on mitigation strategies

- reduce DCR at low temperature
 - operation at T = -30 °C (or lower)
- recover radiation damage
 - in-situ high-temperature annealing
- exploit timing capabilities
 - with ALCOR (INFN) front-end chip



Different types of SiPMs are understudy.

Forward particle identification: Beam test @ CERN







Ring angle and single particle resolution is in good agreement with simulation studies.

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Forward particle identification: Beam test @ CERN





- Compatible results between simulation and beam test for very forward high momentum PID.
- First beam test with SiPM provided very promising results.
- Commonality of reconstruction algorithm with pfRICH

PID @ ePIC : Summary



a. Different PID technologies adopted by the ePIC collaboration to achieve desired physics goals:

- 1. AC-LGAD TOF
- 2. high performance DIRC
- 3. proximity focusing RICH
- 4. dual radiator RICH

b. Matured simulation and test beam results have validated the conceptual designs. Ongoing R&D exercises are focusing the risk minimization and optimization.

References:

- 1. TOF: EIC UG Meeting January 2023; https://indico.bnl.gov/event/17621/#b-7032-working-group-reports-v
- 2. TOF: Zhenyu Ye at POETIC 2023; https://www.ictp-saifr.org/wp-content/uploads/2023/05/yezhenyu_POETIC_20230505.pdf
- 3. DIRC: Nilanga Wickramaarachchi at DIS 2023; https://indico.cern.ch/event/1199314/contributions/5193192/attachments/2619099/4530710/DIS2023 hpDIRC_Nilanga.pdf
- 4. DIRC: EIC UG Meeting Januray 2023; https://indico.bnl.gov/event/17621/#sc-9-4-hpdirc
- 5. dRICH beam tests and photo-sensors: R.Preghenella at DIS 2023;

https://indico.cern.ch/event/1199314/contributions/5193188/attachments/2619053/4528569/%5B20230326%5D%5BDIS%5D%20PID%20with%20EPIC%20at%20EIC.pdf S. Vallarino; https://indico.bnl.gov/event/19345/#2-prototype-data

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Back up

dRICH : *Radiators*



wavelength [nm]





5 1

600

700

wavelength [nm]

dRICH : QE

duantum efficiency

0



200

400

600

800

1000

1200

HA

dRICH : events example







dRICH : optics tuning

- 5, wide collimated photon beams
 - · Emitted from IP
 - Within full dRICH η acceptance, evenly spaced



Parallel-to-point focal region to *approximate* the real Cherenkov focal region





dRICH : detector proposals



ePi

29

PID in detector proposals



- backward
 proximity-focus RICH
- central
 high-performance DIRC
 AC-LGAD TOF
- forward dual-radiator RICH



- backward AC-LGAD TOF
- central
 high-performance DIRC
- forward
 dual-radiator RICH



- backward
 modular RICH
 AC-LGAD TOF
- central high-performance DIRC AC-LGAD TOF
- forward dual-radiator RICH AC-LGAD TOF

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dRICH : *resolutions*





dRICH : *Nuetron Flux*





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