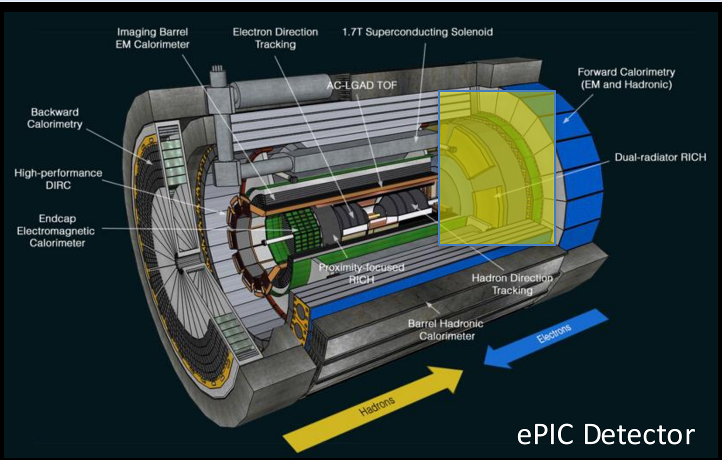
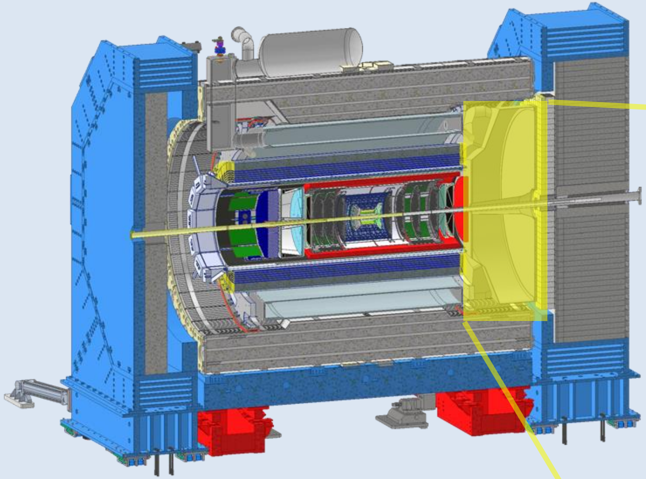
ePIC dRICH Status



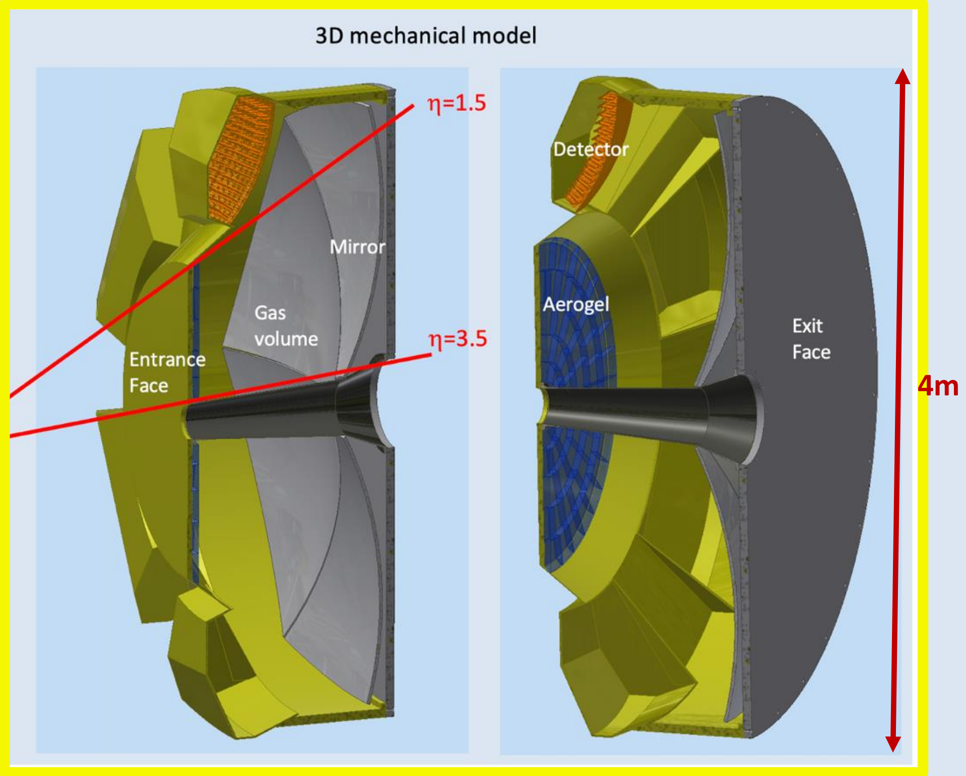
M. Contalbrigo – INFN Ferrara - DSCL

10th EIC DAC Meeting – June 11th - 13th, 2025



Dual-radiator Ring-imaging Cherenkov Detector (dRICH)

Essential to access flavor information



Goals:

- Hadron 3σ–separation between 3 - 50 GeV/c
- Complement electron ID below 15 GeV/c
- Cover forward pseudorapidity 1.5 (barrel) - 3.5 (b. pipe)

dRICH Features:

- Extended 3-50 GeV/c momentum range --> Dual radiator
- Single-photon detection in high Bfield --> SiPM
- Limited space --> Compact optics with curved detector

Review Charges

Charge 1: Is the design of the ePIC detector and its sub-systems appropriate and progressing well ?
Slides 4 - 5 - 6 - 7 - 9 - 10 - 11 - 15 - 18

Charge 2: Are the remaining work and technical, cost and schedule risks adequately understood ?
Are there opportunities?
Slides 5 - 8 - 13 - 14 - 16 - 17 - 20 and pre-TDR (pre-brief material)

Charge 3: Will the detector be technically ready for baselining by late 2025 ?
Slides 12 - 21 - 24

Charge 4: Are the detector integration and planning for installation and maintenance progressing well ?
Are there areas where further ideas should be pursued ?
Slides 19

Charge 5: Will the detector be ready for start of construction by late 2026 ?
Slides 12 - 21 - 24

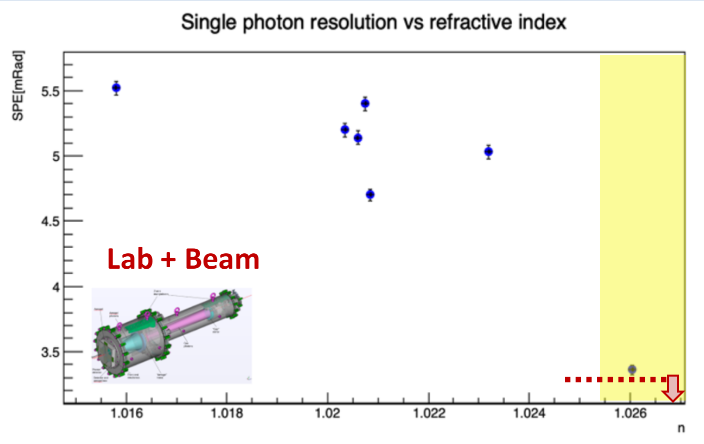
Past Review: Action taken following recommendations
Slide 14 - 19 - 22 - 23 - 24

Design Status

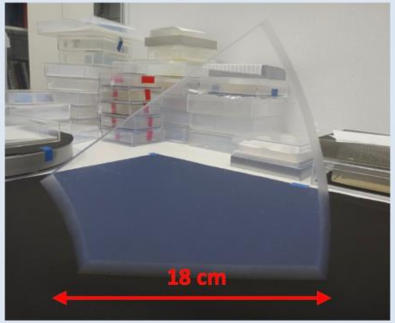
	Technical requirements			Validated technical solutions		Before CD-2
Aerogel:	Momentum reach above 15 GeV/c to overlap with gas More than 10 detected photons from 4 cm thickness Single photon resolution approaching 2 mrad	⇨		n = 1.026 $dn/d\lambda = 6\ 10^{-6}\ nm^{-1}$ scattering length > 50 mm	⇨	Dimensions
Gas:	Momentum reach above 50 GeV/c at pseudorapidity > 2.5 More than 20 detected photons from 1 m depth Single photon resolution approaching 1 mrad	⇨	C_2F_6	with n = 1.00086 $dn/d\lambda = 0.2\ 10^{-6}\ nm^{-1}$ absorption length > 100 m	⇨	Purging
Mirror:	Focalization of Cherenkov light onto the detector surface Preservation of the Cherenkov information Material budget limited to O(2 %) of radiation length	⇨		Carbon fiber material Roughness of few nm Angular precision < 0.3 mrad	⇨	Coating
Sensors:	Single photon detection capability in highly non-uniform magnetic field Excellent PDE in the visible range to cope with aerogel Marginal contribution to the angular resolution Preserve prompt Cherenkov information Tolerance to few 10^{10} 1-MeV neutron equivalent fluence	⇨	SiPM	Spatial resolution of 3 x 3 mm^2 Time resolution O(100 ps) Operation at < -30 degrees Annealing curing cycles	⇨	Layout Annealing
Readout:	Below 1 p.e. signal threshold capability Preserve sensor time resolution to cope with dark counts and accidentals More than 300 kHz/ch rate capability Streaming readout with suppression of no-interaction frames	⇨	ALCOR	ALCOR chip (ToT architecture) Time resolution < 200 ps Rate > 300 kHz/ch	⇨	ALCOR 64ch RDO
Mechanics:	Acceptance maximized in 1.5 – 3.5 pseudorapidity range Material budget minimized in acceptance Compatibility with barrel maintenance at IP6	⇨		Composite materials Single open volume Detector in the barrel shadow	⇨	Real-scale prototype Cooling

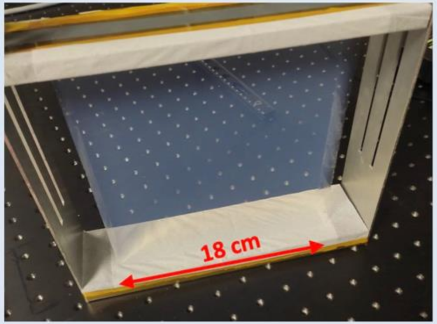
Aerogel Pre-Production

Aerogel with n=1.026 validated with lab and prototype tests

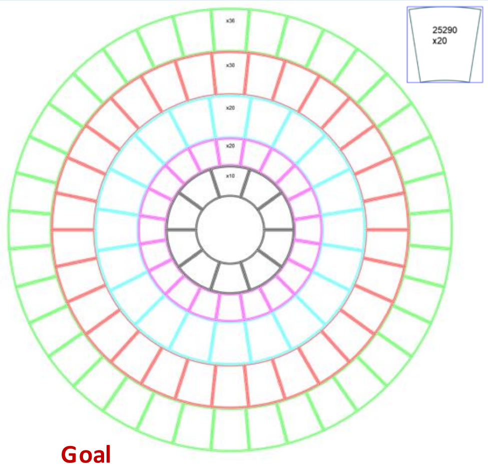


Details on Backup 26



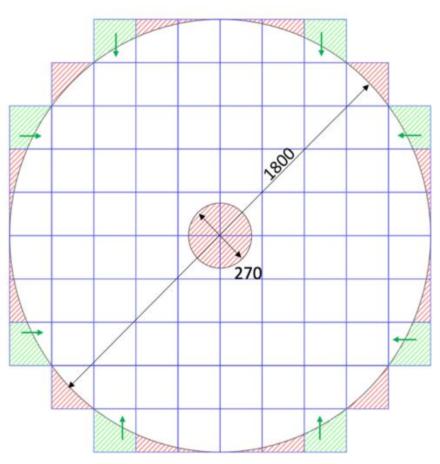


Engineering of the aerogel wall expected by 2026



Goal

Active Area = 21605 cm^2
Dead Area = 3269 cm^2 (13%)
Wasted Area = 9112 cm^2 (27 %)



Active Area = 21368 cm^2
Dead Area = 3506 cm^2 (14%)
Wasted Area = 1868 cm^2 (7 %)

First large aerogel tile demonstrators delivered

dRICH baseline specifications

An effort should be pursued by the vendor to keep the aerogel quality parameters as close as possible or better than the following reference values.

General specifications:

- No cracks or bubbles inside the block. Single spallings which decrease its area no more than 0.25 % are acceptable on the top surface;
- Lateral dimension tolerance within 0.25 mm;
- No evident disuniformity inside the tile volume.

Technical specifications:

- Refractive index, to be chosen by the customer, in the range from 1.025 to 1.030, with a maximum tile-to-tile variation of +/-0.002;
- Tolerance on thickness +/- 1 mm, being the error intended as the maximum tile-to-tile variation;
- Absorption coefficient, defined as the constant term of the Hunt parameterization of the aerogel transmission, bigger than 0.95;
- Scattering length wavelength bigger than 45 mm at 400 nm;
- Planarity of the transmission surface, defined as the maximum peak to valley variation, does not exceed 1.5 % of the lateral dimensions.

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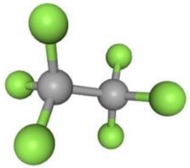
Baseline Hexsafluoroethane validated with lab and beam tests



1 covalent + 6 hydrogen bonds

C_2F_6 molecular weight: 138.01 g/mol

boiling point: -78.1 °C

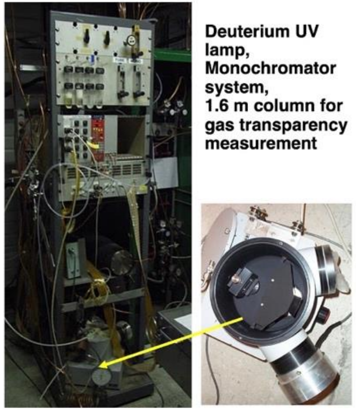
melting point: -100.6 °C

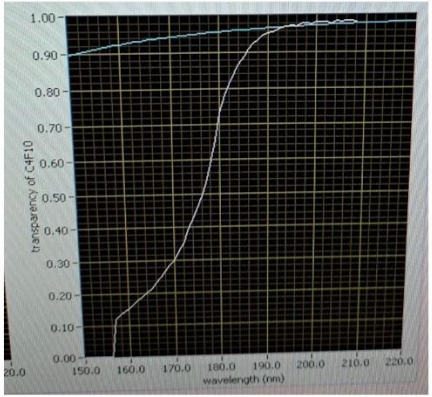
density: 5.734 kg/m³ at 24 °C

density: 16.08 kg/m³ at -78 °C

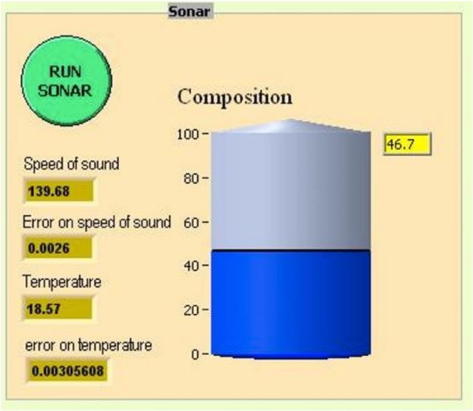
Gas	Npe(π/K)	θ_π	θ_K	σ_π	σ_K	N_σ	ρ = Δθ/θ (λ = 300 nm)
C_2F_6	16.0/14.9	36.8	35.7	0.32	0.33	3.5	1.8 %
C_4F_{10}	24.8/23.8	48.6	47.8	0.29	0.30	2.8	2.4 %

Transmission in UV range > 98 %

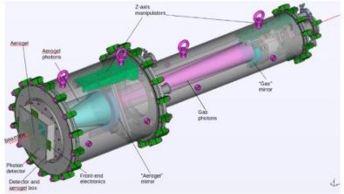


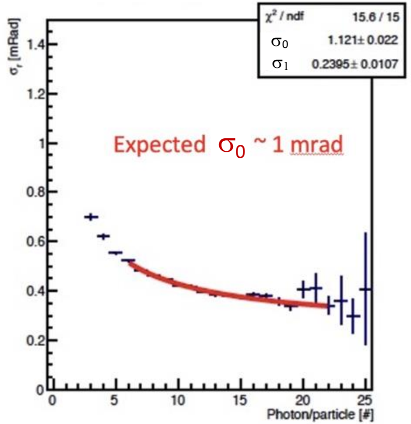


Measured 139.7 m/s speed of sound confirms negligible contaminants after few year in bottle



Expected performance obtained with dRICH prototype

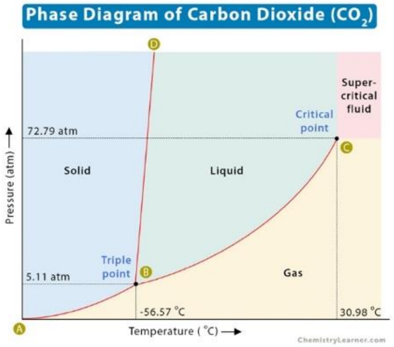


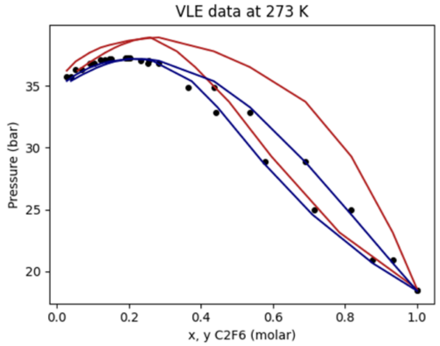


Development of gas separation protocols expected by 2026

Purging via liquefaction of stand-by gas

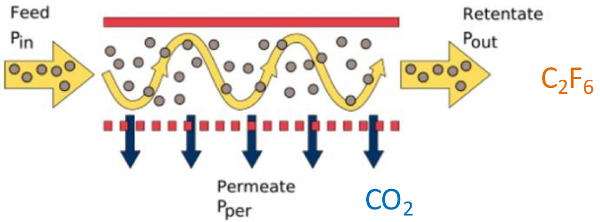
Updated vapor-liquid equilibrium C_2F_6-CO_2 model, test in preparation at CERN

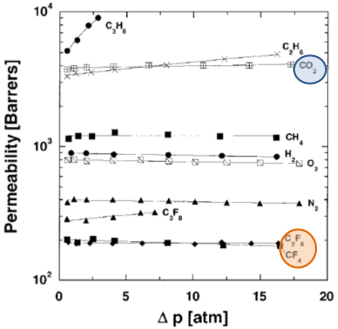




Purging via membranes

Effective separation of CF_4 and CO_2 demostrated in LHCb
hpps://edms.cern.ch/document/2816490/1

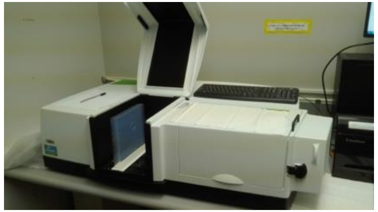


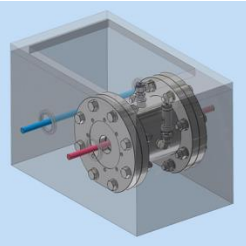


Design of online purity monitors expected by 2026

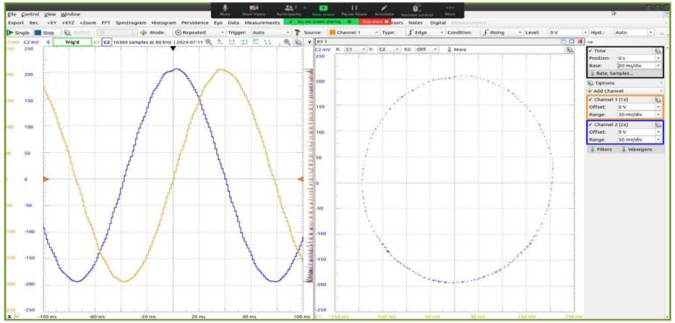
Sonar to measure speed of sound

10 bar chamber + specrophotometer to measure light transmission in the visible range





Jamin interferometer for precise n determination



Nominal sensitivity down to 10 ppm of refractive index

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Mirror Technical Performance

CFRP substrate mid-size (~50 cm side) demonstrator validated with lab tests before coating

Details on Backup 27

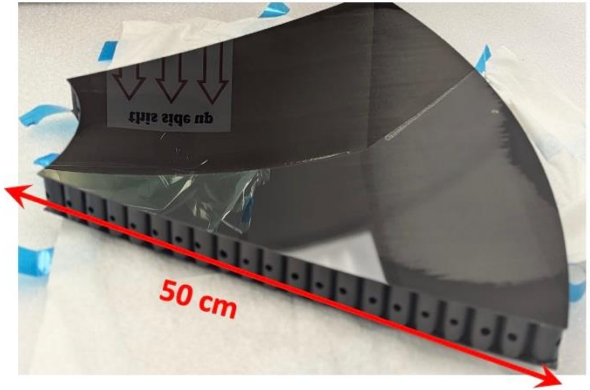
Annex C. Technical Requisite

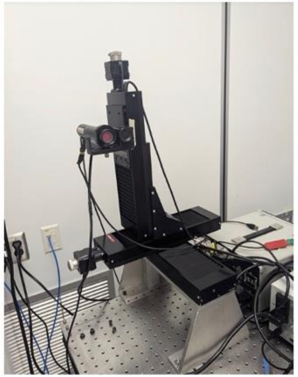
Each spherical mirror is supplied with

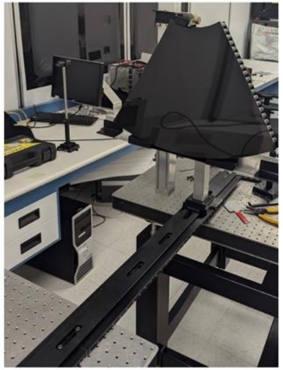
- a spot-size measurement,
- a report on dimensions,
- no reflective coating.

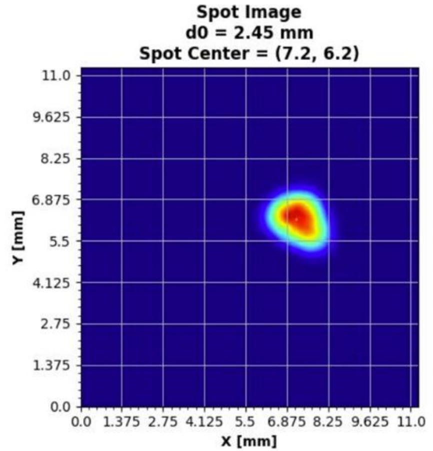
The spherical mirrors are replicated from the same mandrel. The latter is realized with the novel cost-effective technology that reduces the mandrel total mass and cost. Each mirror fulfills the following optical quality specification:

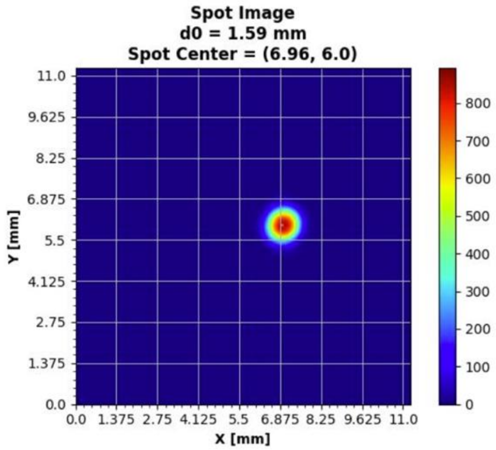
- Radius within 1% of nominal RoC value (the nominal RoC values is defined by the customer before production in the range 2000 mm +/- 10%),
- Roughness < 2 nm,
- Pointlike image spot size D0 < 2.5 mm,
- Compatibility with fluorocarbon gases (C_2F_6),
- Compatibility with SiO_2 reflecting coating.



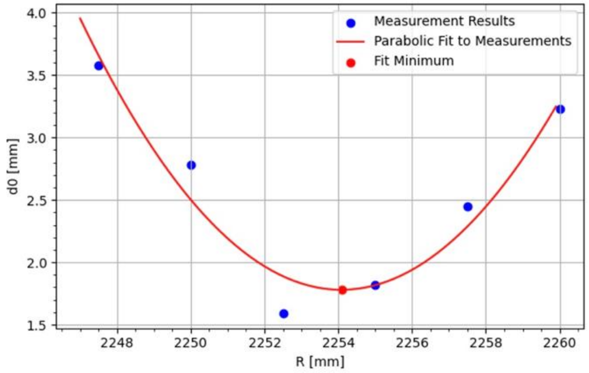








✓ D0 < 2.5 mm ✓ R = 2200 +/- 1%



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Mirror:	Focalization of Cherenkov light onto the detector surface Preservation of the Cherenkov information Material budget limited to O(2 %) of radiation length	⇨		Carbon fiber material Roughness of few nm Angular precision < 0.3 mrad	⇨	Coating
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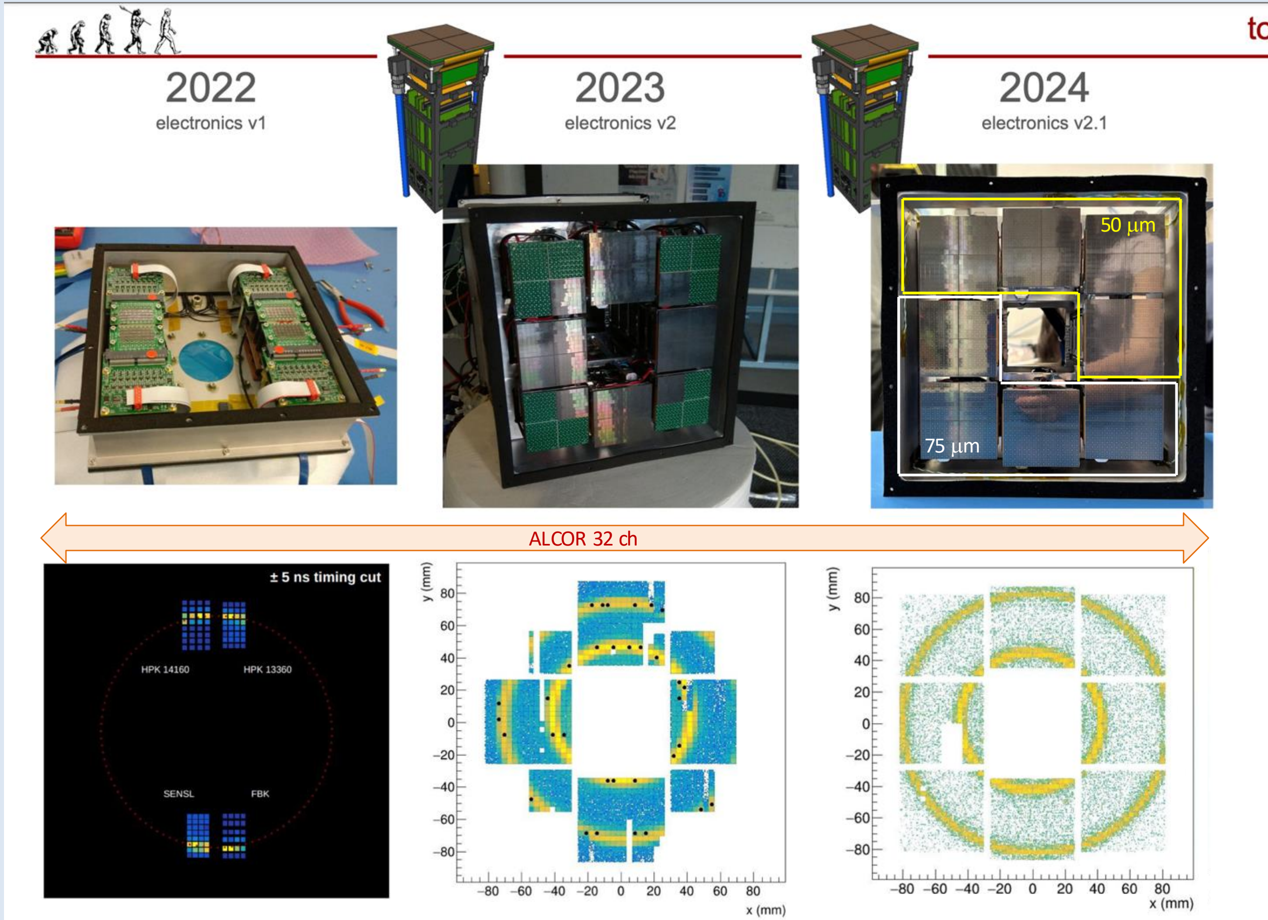
Photon Detector

Steadly progress of photodetector towards integrated design completion in 2026

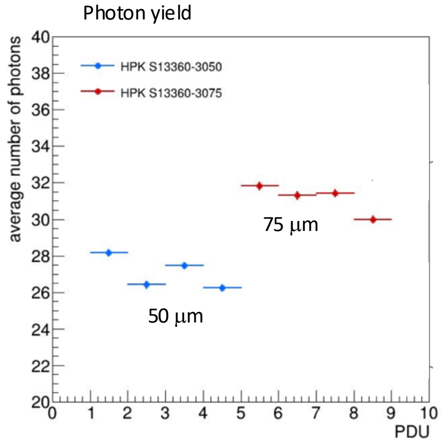


Full size engineering test article

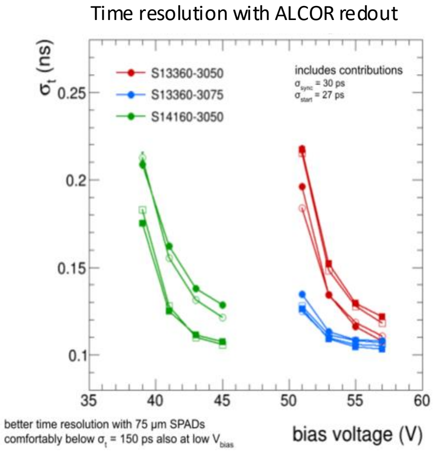
2025	+ SiPM carrierv3 + RDO
2026	+ ALCOR 64ch + FEB 64

Baseline specs defined at the SiPM LLP Rewiew in fall 2023 after several tests on a variety of sensors

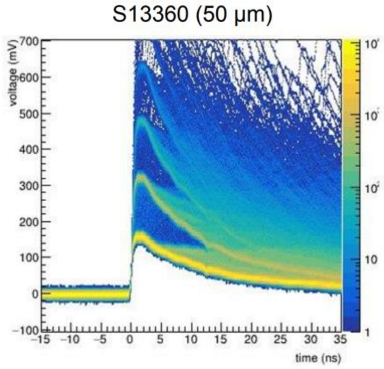
Details on Backup 28

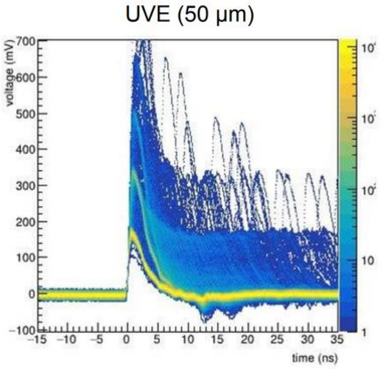


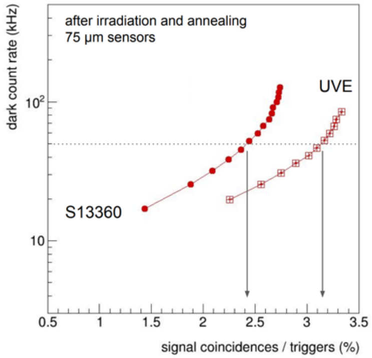
SPAD size



Novel HPK UVE fast SiPM

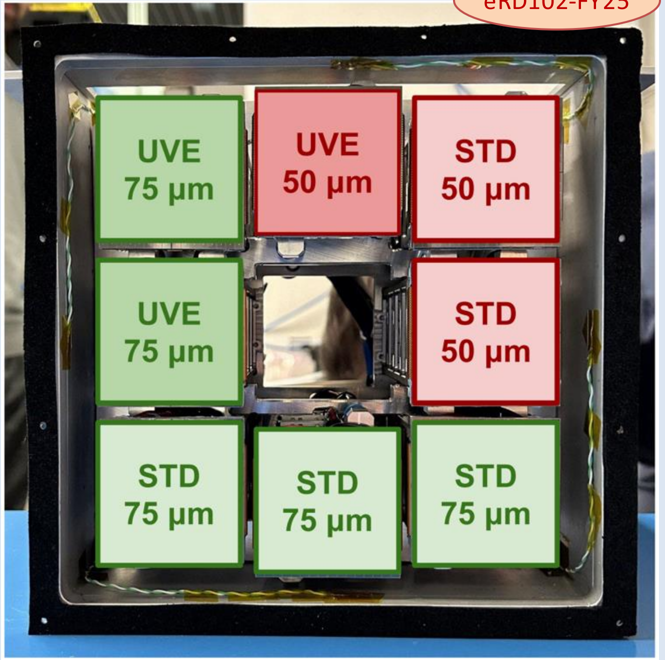






- **purchased and received**
  - 4x matrices with 50 μm SPADs
  - 12x matrices with 75 μm SPADs
  - several single-SiPM sensors
- **goal**
  - assemble few new PDUs
  - use them in the next beam test
  - evaluate expected PDE improvement

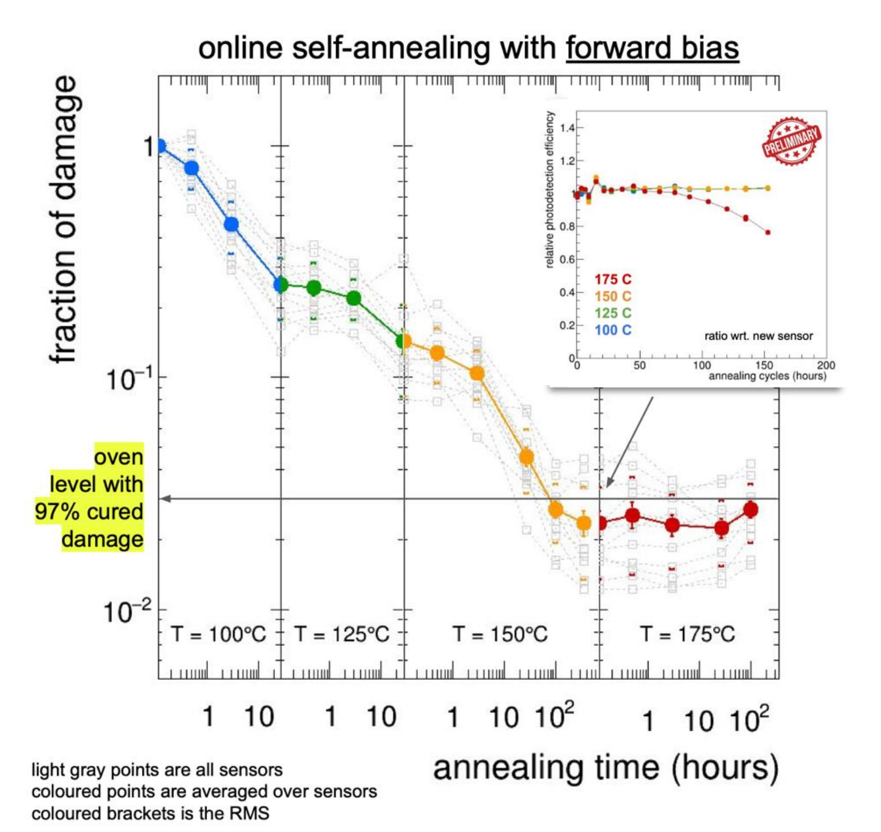
eRD102-FY25



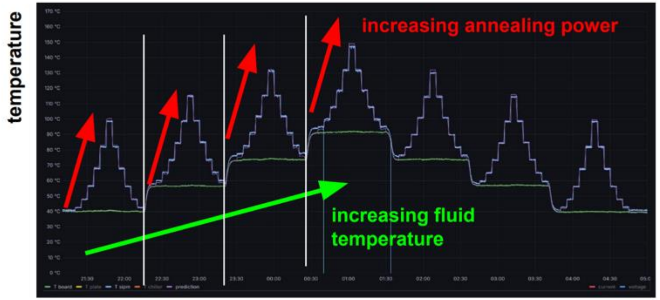
PED funds

Completion of engineering of the SiPM optimized layout and temperature treatments expected by 2026

Recomm. (DAC): Annealing procedures should be investigated, and defined; this will have implications for the design of the read-out board (heating).

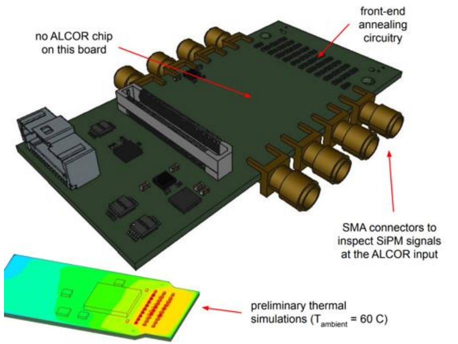


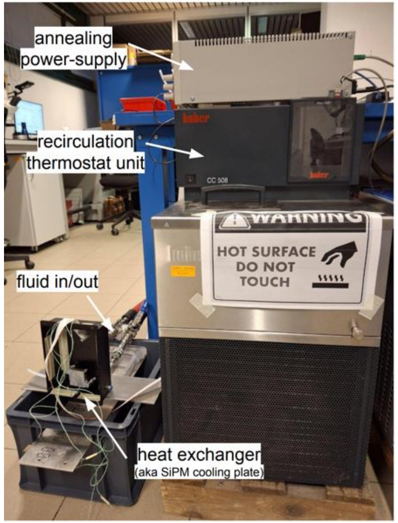
Details of in-situ annealing protocol based on Joule-effect



features
- like a final FEB with all annealing circuitry
- SMA connectors to inspect SiPM signals on scope

goals
- test realistic dRICH annealing electronics
- study/engineering of annealing process details





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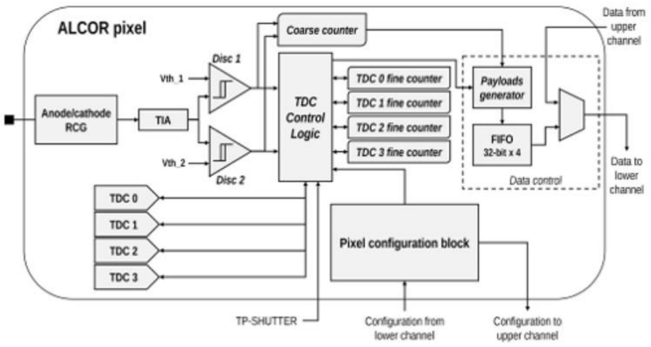
ALCOR spces defined with years of lab + beam tests with the 32 channel version - ALCORv64 ready for pilot production

MPW run in March ‘25

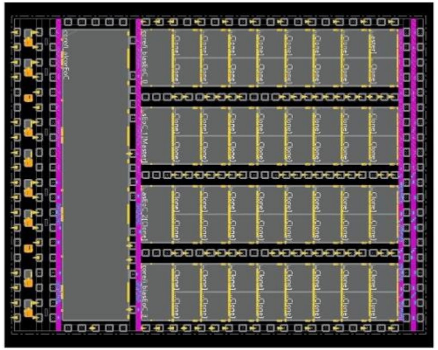
ALCOR block diagram



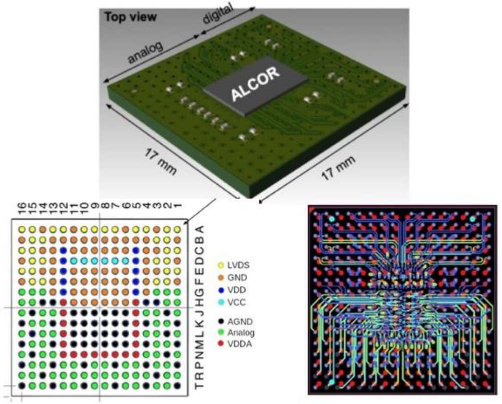
ALCOR key specifications

Function	Digitization from SiPMs with 1 p.e. sensitivity
Mode	Single-photon tagging or time and charge
Tech Node	110 nm CMOS
Channels	64 (8x8), dual polarity
Cdin	<1 nF
Digitization	20-40 ps TDCs, TOA + TOT; Timing <150 ps
Shutter	Width: 2–3 ns, programmable latency
Input Rate	<2.4 MHz (up to 5 MHz on single channel)
Clock	394.08 MHz operation from BX 98.5 MHz
Links	788 Mbps LVDS, SPI configuration
Power	12 mW/ch
Package	BGA
Rad Tolerance	Radiation hard

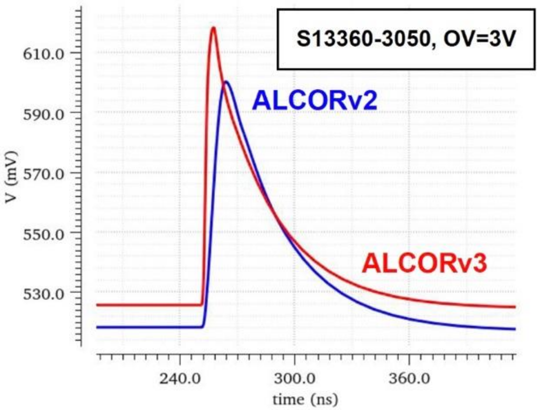
Silicon die layout

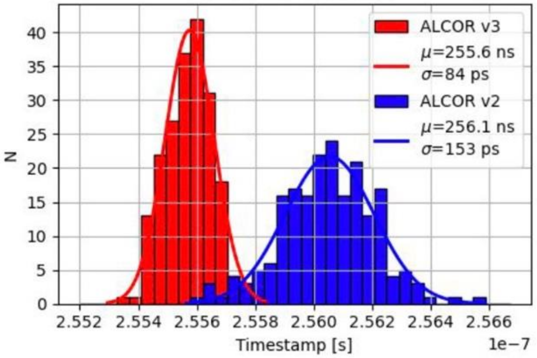


Compact ball-grid array (BGA) package with interposer



Improved timing and digital shutter





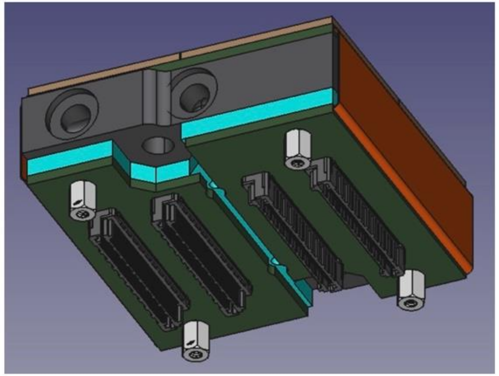
Design of the readout electronics in the "final" ePIC layout version is ready for test production.

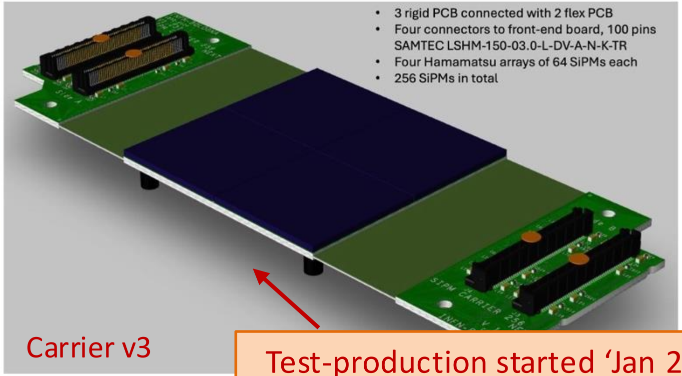
Proton irradiation campaigns for ALCOR-32 and key RDO components showed SEU rate is within the expected manageable levels

A working DAQ scheme has been identified to support ML online data filtering at sub-detector level against pure dark-count event

Details on Backup 29

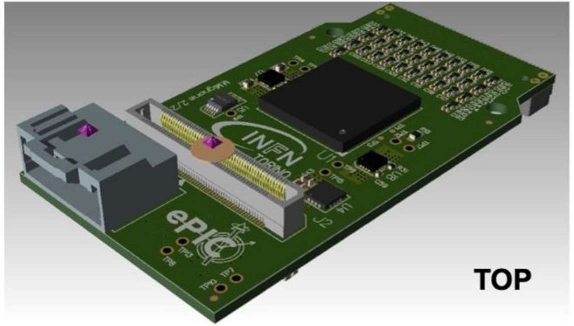
Backup 30





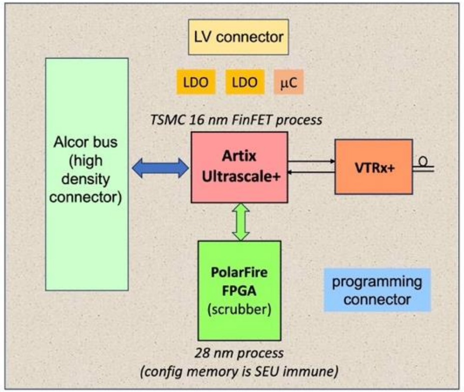
Carrier v3

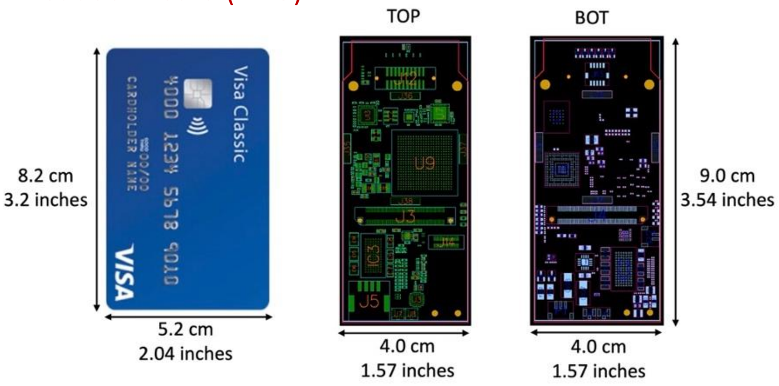
Test-production started 'Jan 25

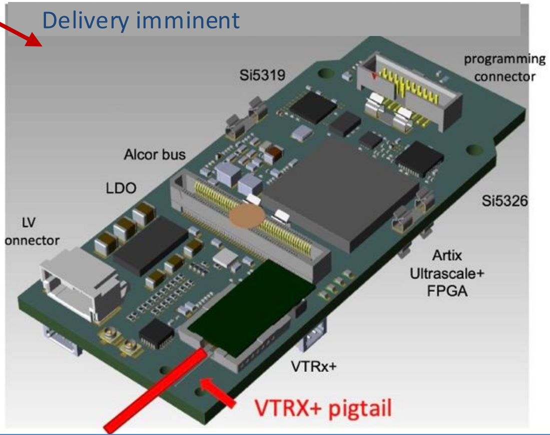


Front-End Board (FEB)

Readout Board (RDO)





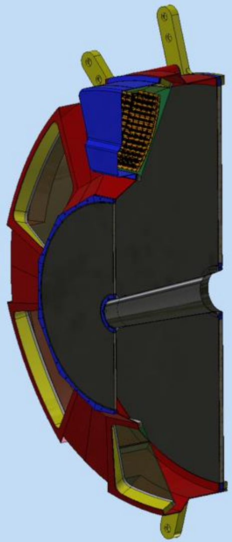


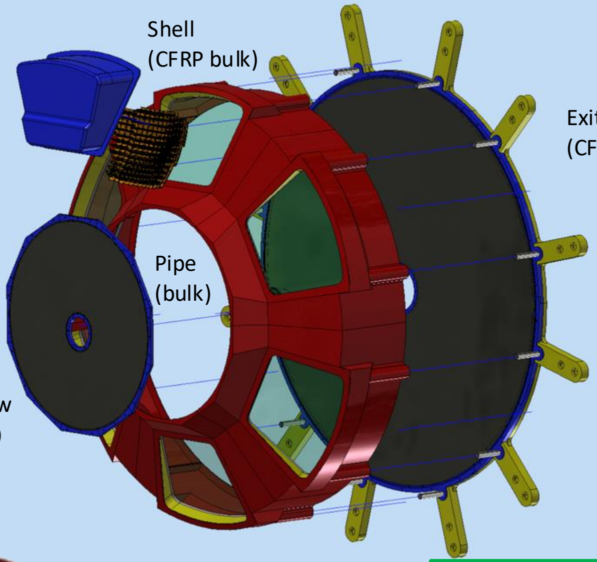
Design Status

	Technical requirements			Validated technical solutions		Before CD-2
Aerogel:	Momentum reach above 15 GeV/c to overlap with gas More than 10 detected photons from 4 cm thickness Single photon resolution approaching 2 mrad	⇨		n = 1.026 $dn/d\lambda = 6\ 10^{-6}\ nm^{-1}$ scattering length > 50 mm	⇨	Dimensions
Gas:	Momentum reach above 50 GeV/c at pseudorapidity > 2.5 More than 20 detected photons from 1 m depth Single photon resolution approaching 1 mrad	⇨	C_2F_6	with n = 1.00086 $dn/d\lambda = 0.2\ 10^{-6}\ nm^{-1}$ absorption length > 100 m	⇨	Purging
Mirror:	Focalization of Cherenkov light onto the detector surface Preservation of the Cherenkov information Material budget limited to O(2 %) of radiation length	⇨		Carbon fiber material Roughness of few nm Angular precision < 0.3 mrad	⇨	Coating
Sensors:	Single photon detection capability in highly non-uniform magnetic field Excellent PDE in the visible range to cope with aerogel Marginal contribution to the angular resolution Preserve prompt Cherenkov information Tolerance to few 10^{10} 1-MeV neutron equivalent fluence	⇨	SiPM	Spatial resolution of 3 x 3 mm^2 Time resolution O(100 ps) Operation at < -30 degrees Annealing curing cycles	⇨	Layout Annealing
Readout:	Below 1 p.e. signal threshold capability Preserve sensor time resolution to cope with dark counts and accidentals More than 300 kHz/ch rate capability Streaming readout with suppression of no-interaction frames	⇨	ALCOR	ALCOR chip (ToT architecture) Time resolution < 200 ps Rate > 300 kHz/ch	⇨	ALCOR 64ch RDO
Mechanics:	Acceptance maximized in 1.5 – 3.5 pseudorapidity range Material budget minimized in acceptance Compatibility with barrel maintenance at IP6	⇨		Composite materials Single open volume Detector in the barrel shadow	⇨	Real-scale prototype Cooling

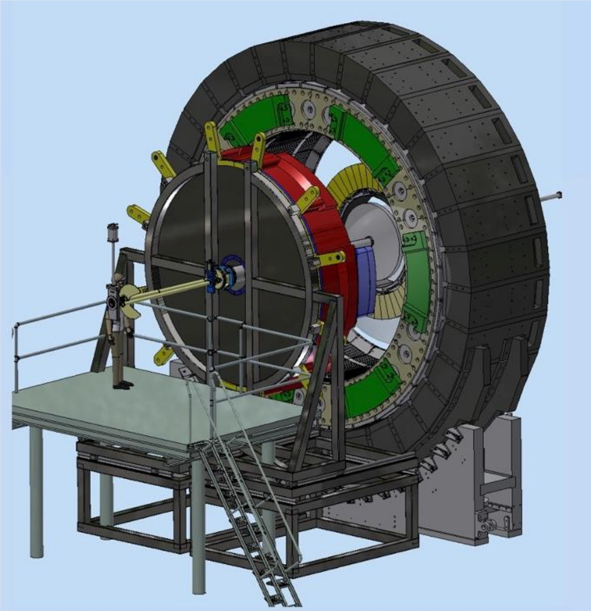
General Layout

A detailed mechanical model of the single-vessel detector is outlined with composite materials



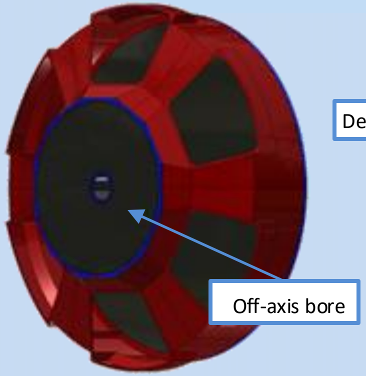


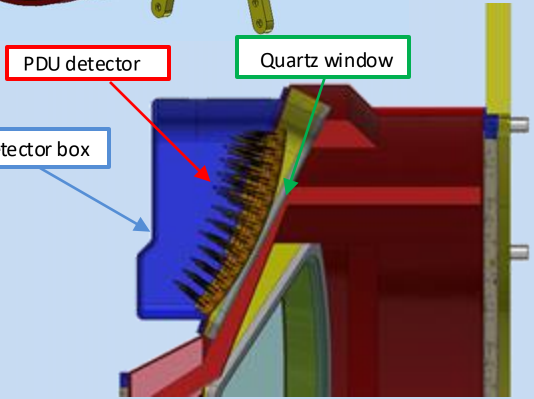
Recomm. (DAC): Provide material for the pending decision on the single vs two vessel version of the detector.

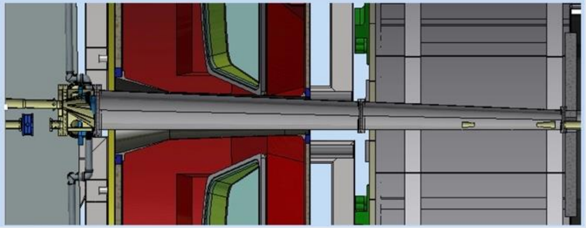


Composite materials

Total wieght: ~ 2 ton



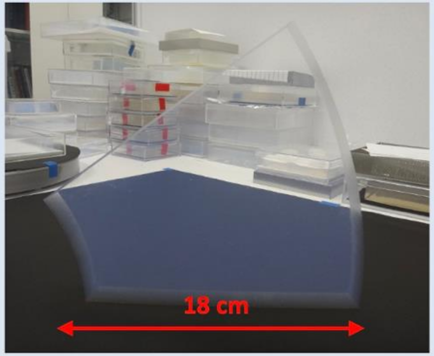


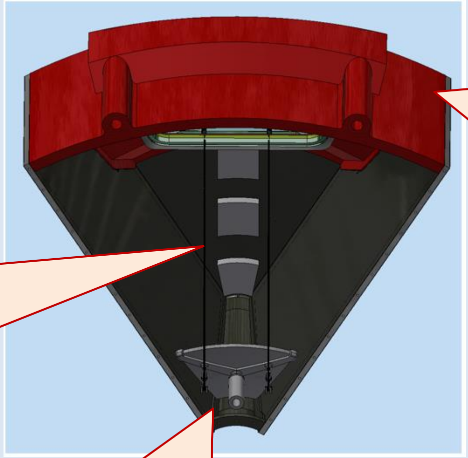


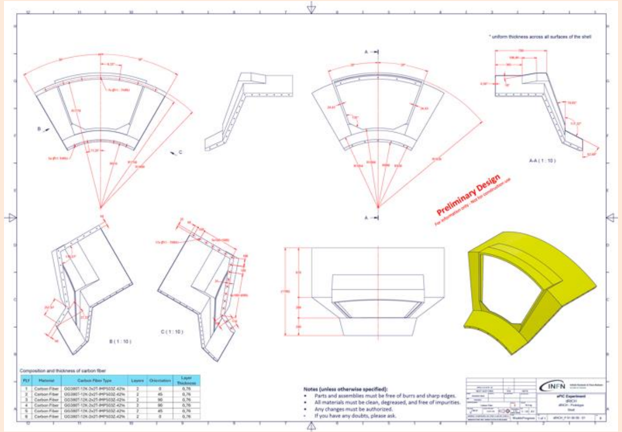
Realistic Components

Engineering of all the mechanical details pursued with the real-scale prototype being realized in 2025

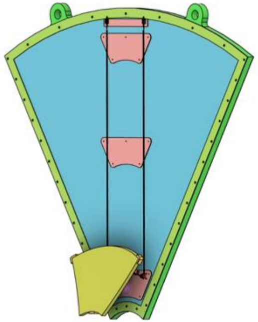
Aerogel support

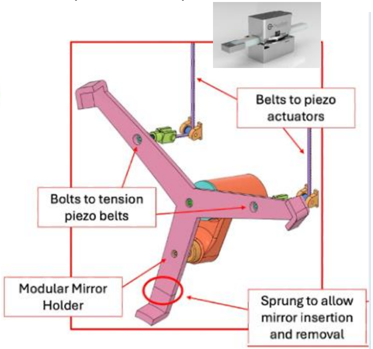


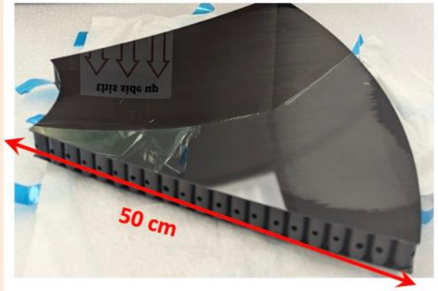




Mirror mounting and alignment (aka NA62)







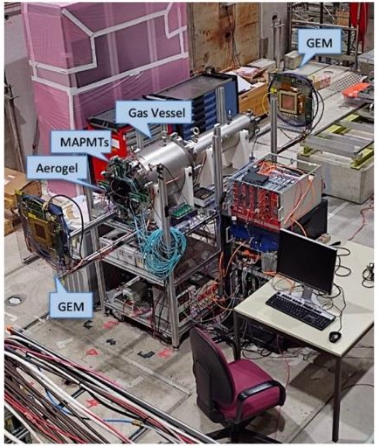
Vessel

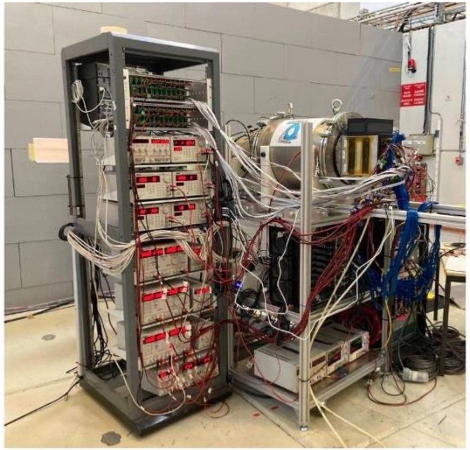
PO issued

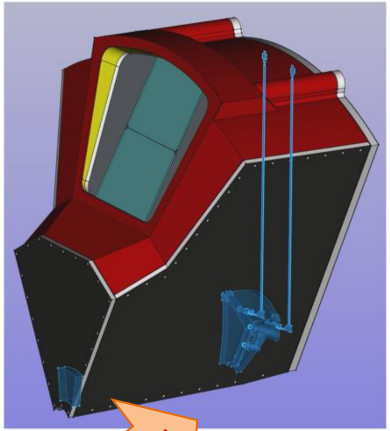
CFRP Layer composition

Previous validations:

- Dual-radiator concept
- C_2F_6 radiator gas performance
- Aerogel rafractive index
- SiPM-ALCOR readout chain
- EIC-drive readout plane
- Temperature gradients





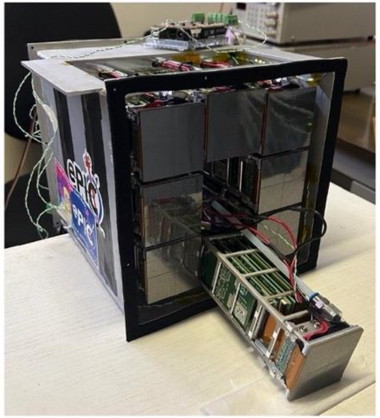


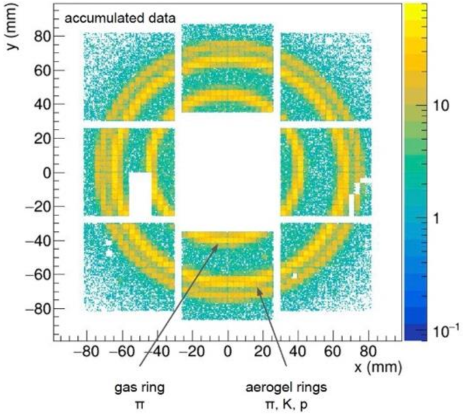
2025

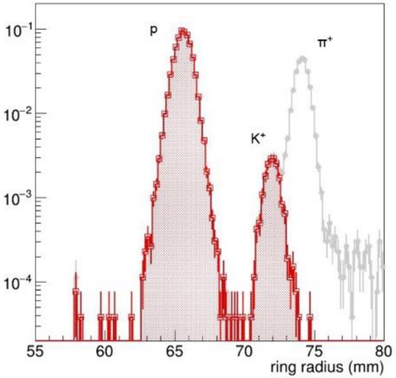
2025 main goals:

- Real scale 1-sector prototype with demo components
- ALCOR readout with RDO

Slot at SPS H8 in November







Ongoing comparative simulation vs prototype thermal study expected to be completed by mid 2026

Details on Backup 33

Recomm. (DAC): Investigate whether windows are necessary to separate regions at different temperatures (gas radiator and the photon detector), and if needed, whether they impact performance significantly.

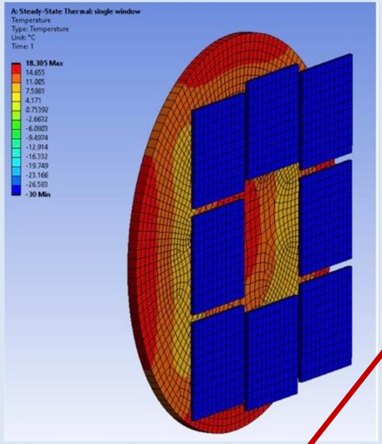
Ongoing study with ANSYS workbench simulations

Benchmarked by dRICH prototype

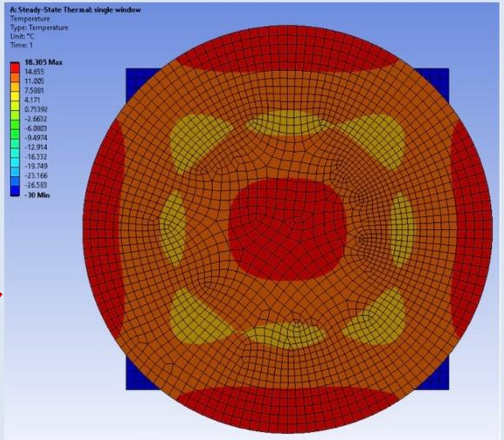
Gradients are largely mitigated by

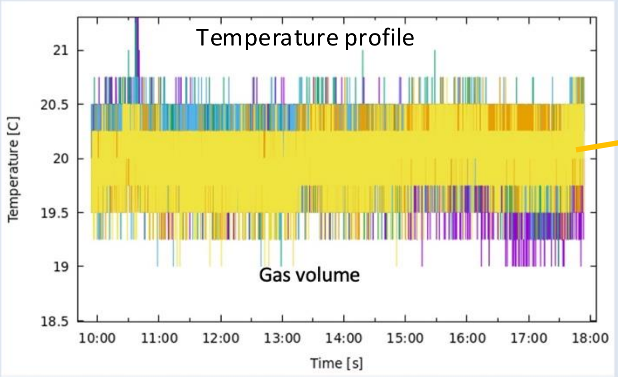
- double lucite window (with air gap) x 0.5
- 8 mm thick quartz window
- inner gas recirculation x 0.1

SiPM plane, cycled from 22º to -30º

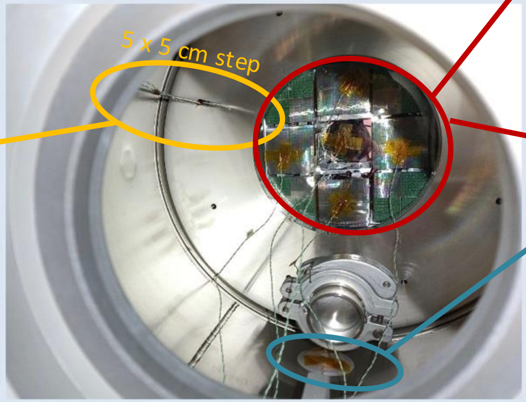


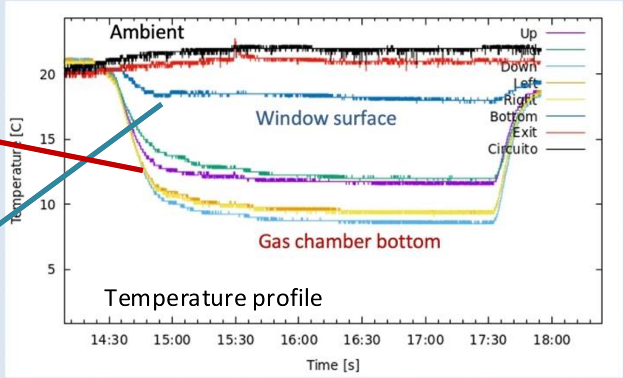
3 mm lucite window





Gas volume with thermocouples





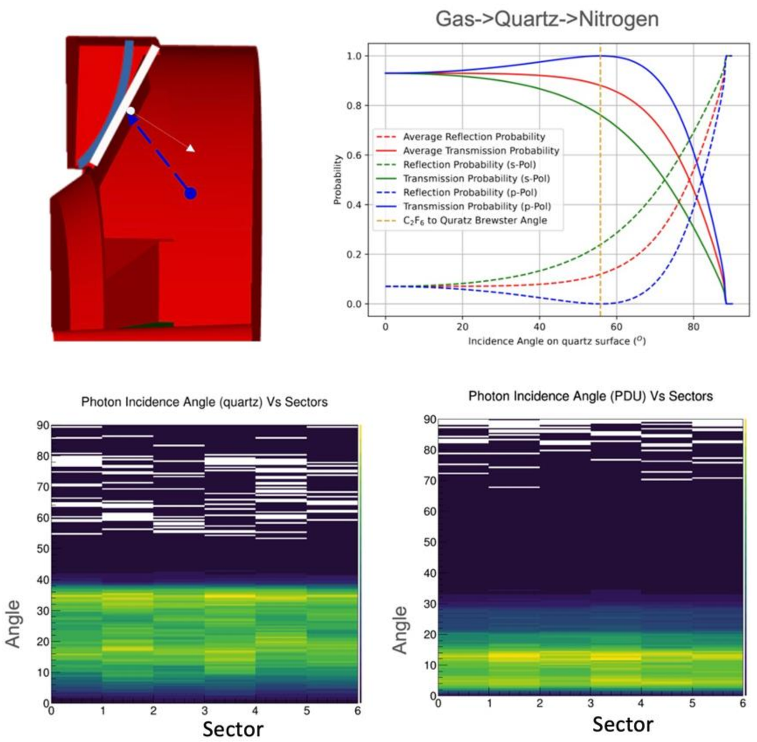
dRICH Performance Study

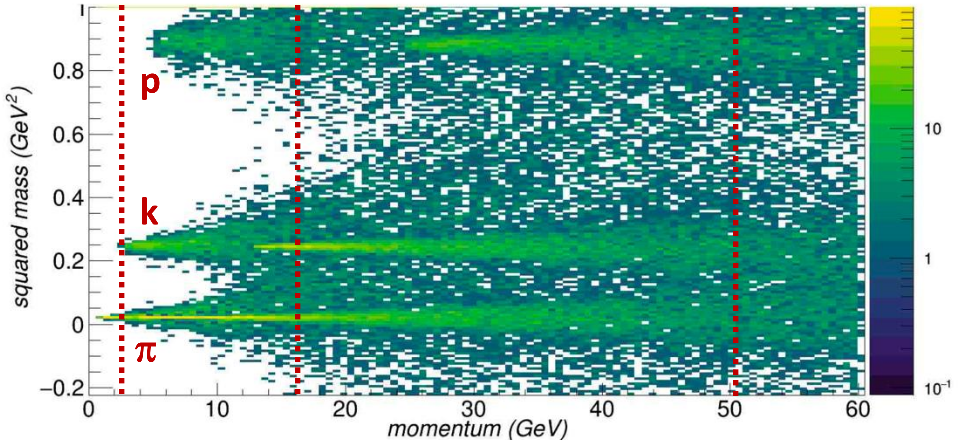
Simulation within ePIC dd4hep framework accounts for tracking, material budget and magnetic bending.

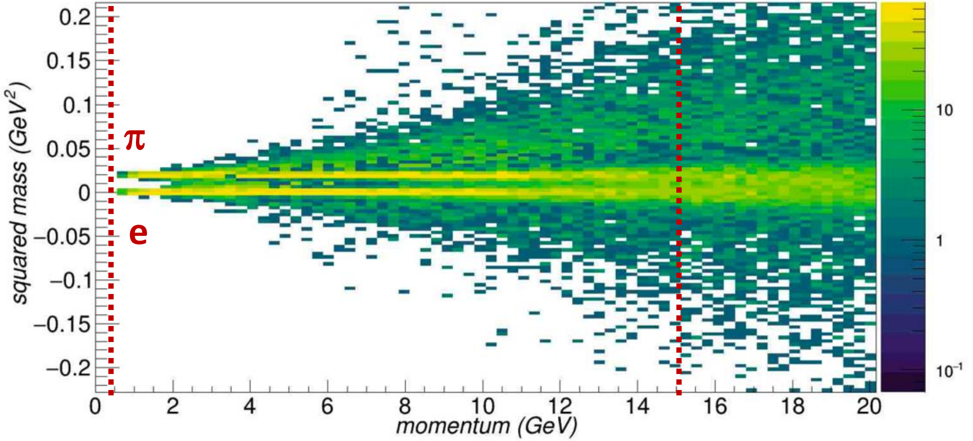
Details on Backup 34

Model bases on lab characterization and test-beam data of components

Photons impinging angles and transmission probability





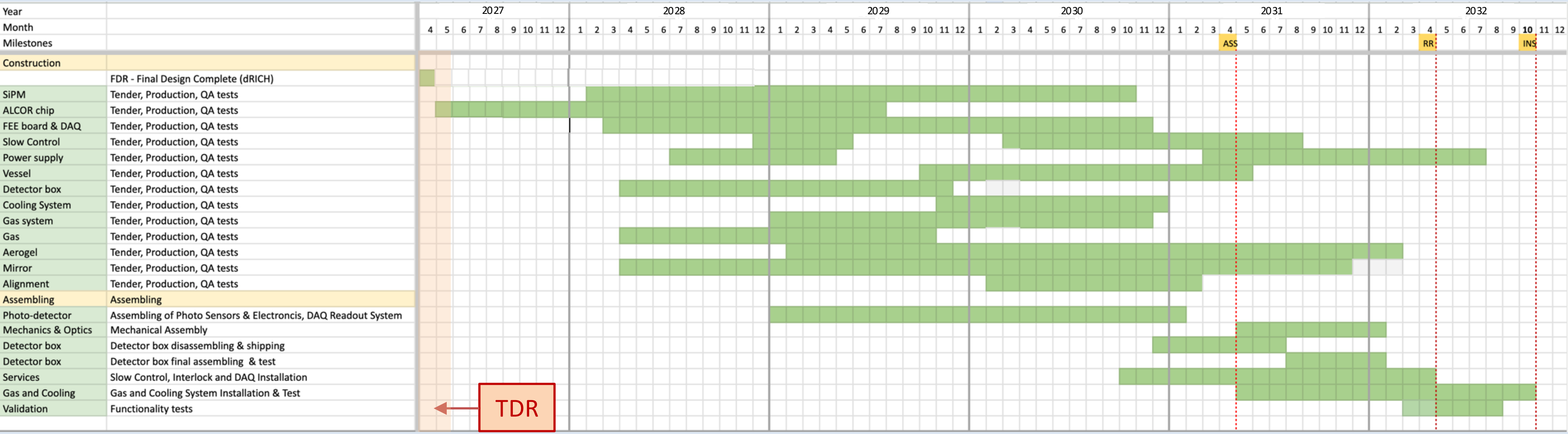


Construction Plan

60% Preliminary Design Review passed. A construction and QA plan is outlined accounting for lead, assembling and commissioning time

Recomm. (DAC): Present at least a vague timeline for the project at the next DAC review.

Details on Backup 31-32



CD-2: Validate ALCOR-64 & RDO design
Validate real-scale prototype mechanics
Study detector box engineering
Define baseline integration and maintenance plan
Work out a baseline cooling & gas sytem

CD-3: Optimize component performance
Complete component integration
Finalize cooling & gas system
Detail detector integration and maintenance

Stage 1: Procurement for the PDU components (asics, SiPM, carrier, FEB, RDO…)
Anticipate mirror and gas procurement to reduce risk

Stage 2 : Central 2-3 year for the detector box assembling before delivery to BNL
Aerogel production after engineering optimization
Gas system realization after BNL authority approval

Stage 3: Mechanical structures
Assembling and completion of services
6 months of contingency and functionality tests

Conclusions

dRICH Design Status is documented in the pre-TDR:

dRICH passed 60% Preliminary Design Review on April 1-2, 2025

Essential technical performance has been validated for each dRICH component

Engineering is ongoing with pre-productions for performance vs cost optimization

Workforce is increasing, with focus in simulations and engineering

Ultimate R&D achievements expected in 2025 (real-scale prototype, RDO, ALCOR64)

On track for CD-2 in 2026 and Final Design completion in January 2027 as for P6

Previous DAC Recommendations:

- ✓ Annealing procedures should be investigated and defined; this will have implications for the design of the read-out board (heating).
- ✓ Provide material for the pending decision on the single vs two vessel version of the detector.
- ✓ Present at least a vague timeline for the project at the next DAC review.
- ✓ Investigate whether windows are necessary to separate regions at different temperatures (gas radiator and the photon detector), and if needed, whether they impact performance significantly.

Aerogel with n=1.026 validated with lab and prototype tests

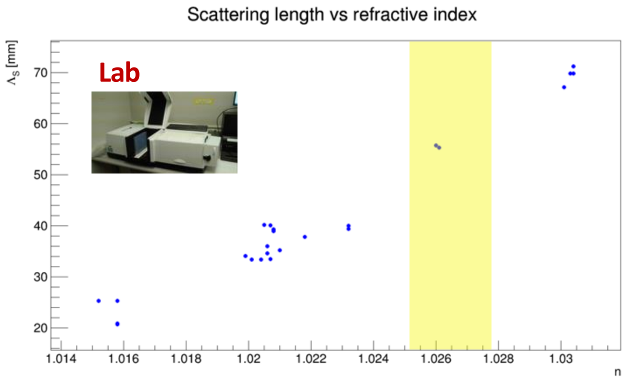
* meet SPE resolution expectations

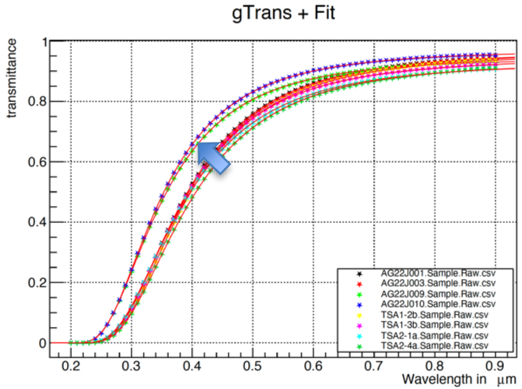
* scattering length > 50 mm

* match with TOF end point (2.5 GeV/c)

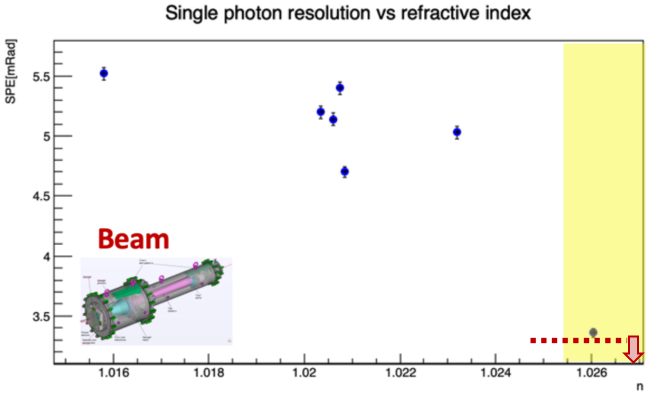
* overlap with gas (> 12 GeV/c)

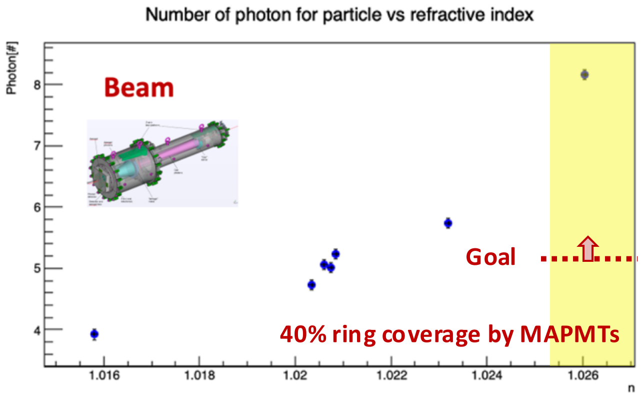
* photon yield > 10 per particle with MAPMTs





Various samples from Aerogel Factory

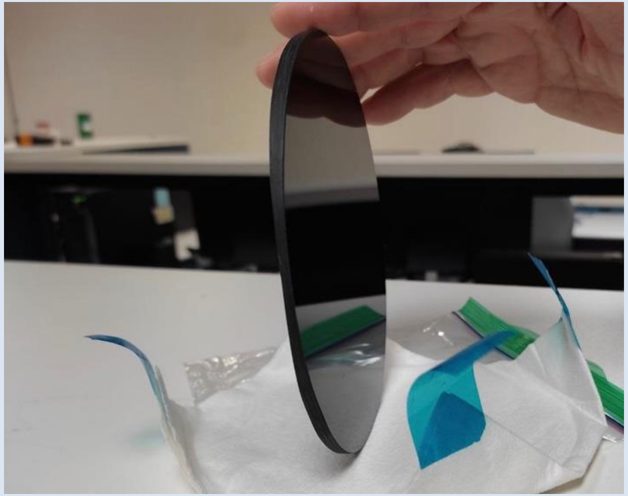




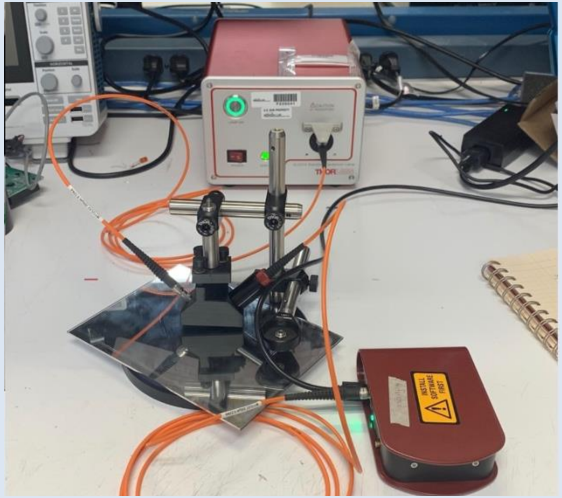
Mirror Substrate & Coating

Ongoing activities with possible synergies with pfRICH to be completed by 2026

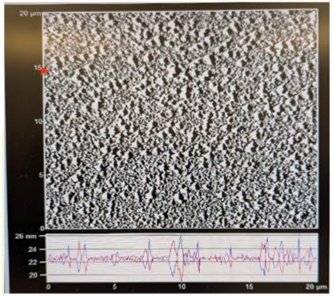
Studying special material (ultra-low degassing)



Developing portable reflectivity test bench



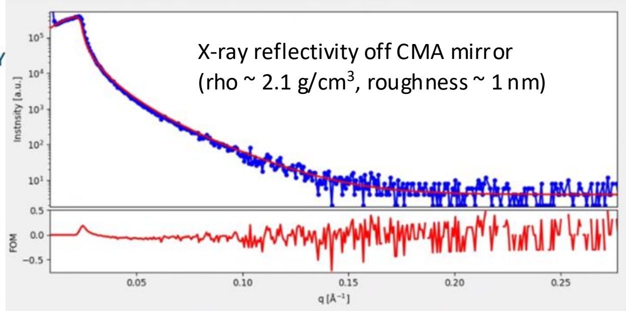
Testing coating (SBU) on dRICH samples



SMiF | SHARED MATERIALS INSTRUMENTATION FACILITY

Access to a variety of instruments for precision characterization of materials

AFM images of coated surface (SBU) showing roughness of $< 100\ nm$



Baseline specs defined at the SiPM LLP Rewiew in fall 2023 after several tests on a variety of sensors

SiPM technical specs

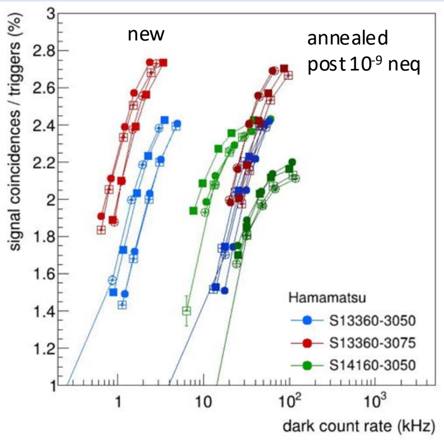
baseline sensor device
64 (8x8) channel SiPM array
3x3 mm^2 / channel

Parameters	Value	Notes (all parameters at the recommended operating voltage and T = 25 C, unless specified)
Device type	SiPM array	
Number of channels	64	8 x 8 matrix
Active Area	3 x 3 mm²	active area of one channel, total active area is 64 x 3 x 3 mm²
Device Area	< 28 x 28 mm²	device area should be small such as to have > 75% fraction of active area over device total area
Pixel Size	40 - 80 um	pitch of the microcell SPAD
Package Type	surface mount	
Operating voltage	< 64 V	
Peak Sensitivity	400 - 450 nm	
PDE	> 35%	at peak sensitivity wavelength
Gain	> 1.5 10⁶	
DCR	< 1.5 MHz	
Temperature coefficient of Vop	< 60 mV / C	
Direct crosstalk probability	< 10%	
Terminal capacity	< 600 pF	
Packing granularity		
Vop variation within a tray	< 300 mV	Vop variation between channels in one device
Recharge Time	< 100 ns	ctau recharge time constant
Fill Factor	> 70%	
Protective Layer	silicone resin (n = 1.5 - 1.6)	radiation resistant, heat resistant (up to T = 180 C)
DCR at low temperature	< 10 kHz	at T = -30 C
DCR increase with radiation damage	< 1 MHz / 10⁹ neq	at T = -30 C, after a radiation damage corresponding to 10⁹ 1-MeV neutron equivalent / cm² (neq)
Residual DCR after annealing	< 25 kHz / 10⁹ neq	at T = -30 C, after a radiation damage of 10⁹ neq and a 150 hours annealing cycle at T = 150 C
Single photon time resolution	< 200 ps FWHM	corresponding to < 85 ps RMS

we will evaluate as part of QA, testing sensor samples in received batches

8

Based on PDE vs DCR studies over a variety of SiPM



Readout Irradiation Tests

Singe-event upset (SEU) rate of dRICH electronics is manageable with standard firmware redundancy and resets features

Regular irradiation campaign ongoing:

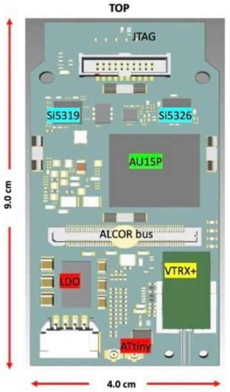
Neutron irradiation campaign at LNL-CN (9-11 October 24)

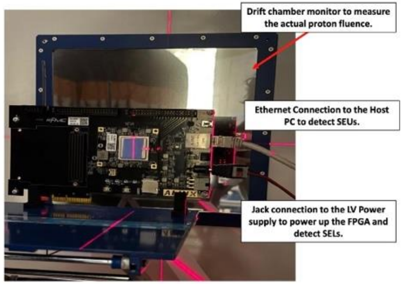
Gamma irradiation campaign at CERN-GIF (14-16 October 24)

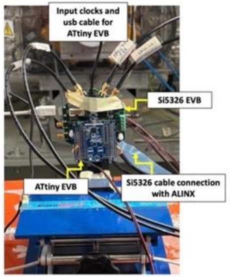
Proton irradiation campaign at TIFPA (12-14 December 24)

$TID_5 \cong 2.3$ krad (for 1000 fb^{-1})

RDO radiation tolerance



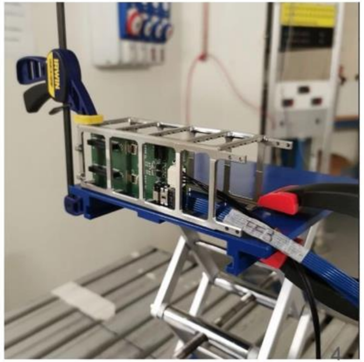




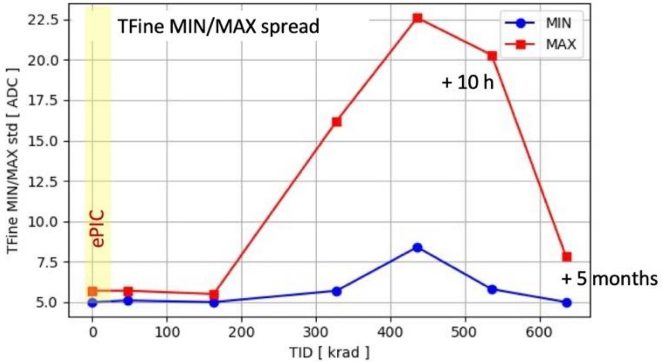
	Measured	Mean SEU time @ ePIC
Si5326 (clock)	$\sigma_{SEU} = (3.89 \pm 0.54) \cdot 10^{-14} \frac{cm^2}{bit}$	4 h
Attiny (power)	$\sigma_{SEU} = (2.11 \pm 0.50) \cdot 10^{-14} \frac{cm^2}{bit}$	3.8 h
AU15P (FPGA)		2 min

Our estimates	$\sigma_{SEU}\left(\frac{cm^2}{bit}\right)$
BRAM	$(1.78 \pm 0.23) \cdot 10^{-15}$
CRAM	$(2.30 \pm 0.28) \cdot 10^{-16}$

ALCOR radiation tolerance



- ECCR $\sigma = 9.8 \cdot 10^{-14}$ cm²/bit periphery register → no TMR in ALCOR v2.1
- BCR $\sigma = 6.1 \cdot 10^{-14}$ cm²/bit periphery register → no TMR in ALCOR v2.1
- PCR **no SEU detected** re-written every 10 seconds to mimick TMR

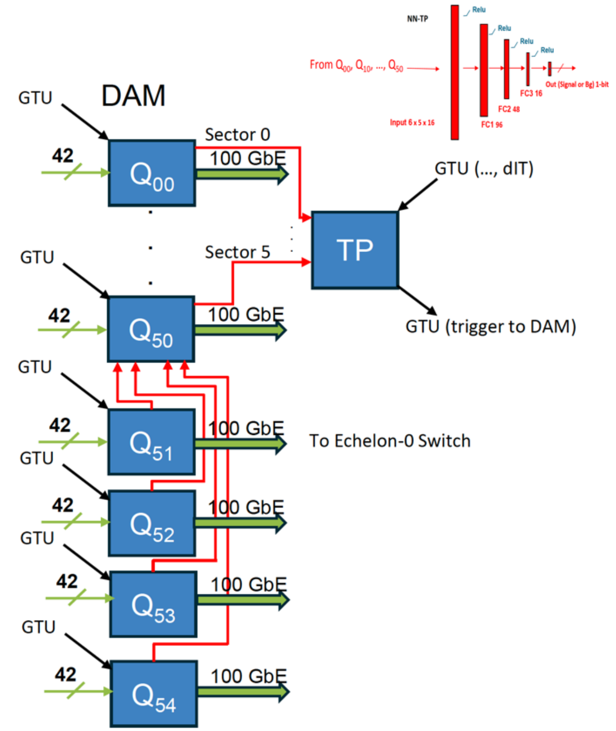


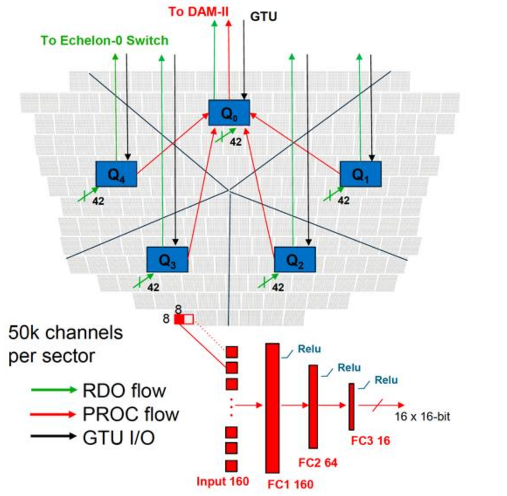
dRICH Online Filtering

A working DAQ scheme has been identified to support ML online data filtering at sub-detector level against pure dark-count event

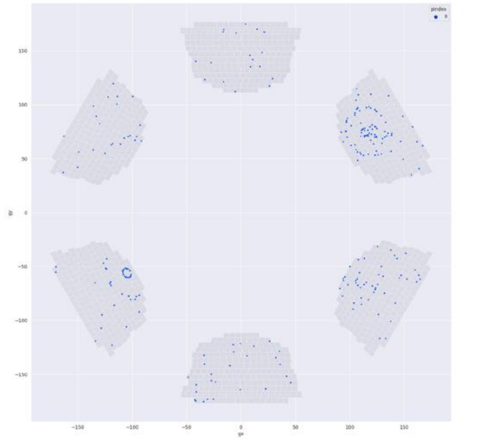
Scheme based on ePIC DAM (Felix) &
APEIRON communication network (INFN)

sub-sector integrated analysis   detector integrated analysis





Phys Signal+Phys Background+Noise

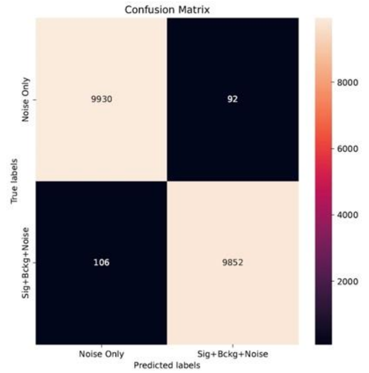


Preliminary tests

Classifier

- Accuracy = (TP+TN)/(TP+TN+FP+FN) = 0.990
- Precision = TP/(TP+FP) = 0.989
- Recall = TP/(TP+FN) = 0.991

➔Through **quantization**, we defined:
quantized fixed point<16,6> inputs
quantized fixed point<8,1> weights
quantized fixed point<8,1> biases



dRICH Overview

Preliminary commitments for the construction phase are defined

Institution	Nation	Activity	
INFN-FE	Italy	Mechanics, detecor box and control panels	24 staff 18 postdocs/ students 18 technicians/ engineers
INFN-BO	Italy	Photosensors, photodetection unit PDU and readout board RDO	
INFN-TO	Italy	ALCOR and front-end board FEB	
INFN-BA	Italy	Aerogel radiator	
INFN-CS-SA-CT	Italy	SiPM quality assurance	
INFN-GE	Italy	dRICH tagger	
INFN-LNS	Italy	Mechanical design	
INFN-RM1-RM-TV	Italy	Online data reduction	
INFN-TS	Italy	Radiator gas, gas system and software, SiPM quality assurance	
Duke-U.	USA	Mirror	8 staff 2 postdocs/ students 2 technicians/ engineers
JLab	USA	Mechanical design and mirror characterization	
BNL	USA	Mechanical design, integration, infrasctructure	
Temple U.	USA	Aeorgel quality assurance	
M.S. Ramaiah U.	India	Simualtions and performance study	8 staff 2 postdocs/ students
NISER	India	Performance study	
Central U. of Haryana	India	Performance study	
Central U. of Karnataka	India	Performance study	

Many groups have committed to the construction phase of the above items

QA stations are of common interest: best performance with co-funded equipment & shared workforce
open to collaborators: opportunity for secondments and students traning

Quality Assurance

QA is organized to allow essential acceptance tests on 100% of components plus in-depth sample characterization

QA stations organized in order to

- Be close to the assembling site
- Ensure adequate personnel training
- Provide redundancy & investment synergy
- Support specific in-deep characterization studies

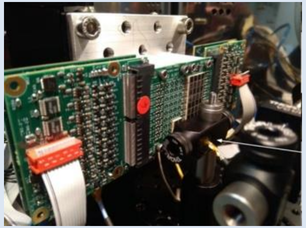
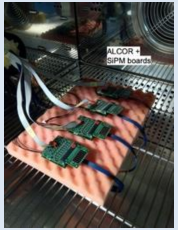
Aerogel: Integrity, defects, transmittance, refractive index, dimensions, planarity

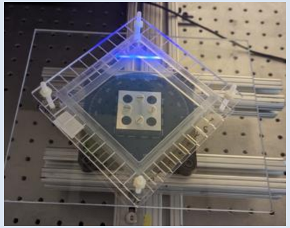
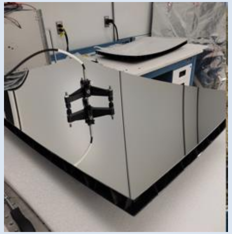
Mirror: Dimensions, shape accuracy, radius, reflectivity

Sensors: Electrical connections, quench resistor, I-V characteristics, DCR, relative PDE

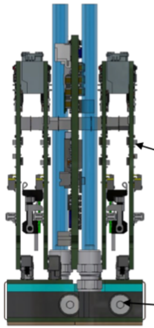
Readout: Electrical connections, bias levels, threshold and gain scans, time jitter, DAQ rate

Gas: Refractive index, transparency, sound speed, leakage rate

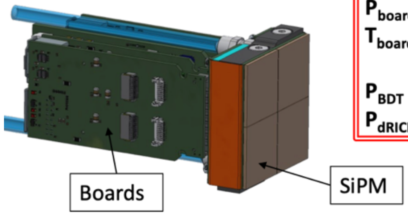




Component	QA station 1	QA station 2	QA detail and backup	QA Acceptance	In-depth
Aerogel	Temple U.	BNL	INFN-BA	100 %	5%
Gas	BNL		INFN-TS	2 %	2%
Mirror	JLab	Duke U.		100 %	10%
Sensor (SiPM)	INFN CS-SA-CT	INFN-TS	INFN-BO	100 %	1%
Readout	INFN-BO	INFN-FE	INFN-TO	100 %	1%



Designed and Engineered by Roberto Preghenella (INFN-BO)



dRICH PDU = 1200
Detector Box PDU = 242
dRICH Detector Boxes = 6

SiPM

P_{PDU} **= 5 W** (cooling power to be supplied to each PDU unit)
T_{SiPM} **= -40°C** (SiPM temperature)

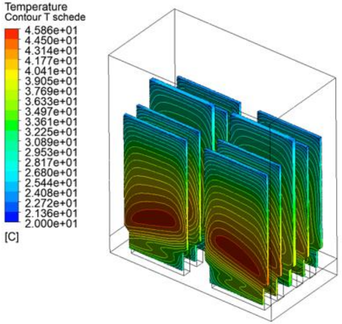
P_{DT} **= 242 × 5 W = 1210 W** (cooling power to be supplied to each detector box)
P_{dRICH} **= 6 x 1210 W = 7260 W** (cooling power to be supplied to dRICH)

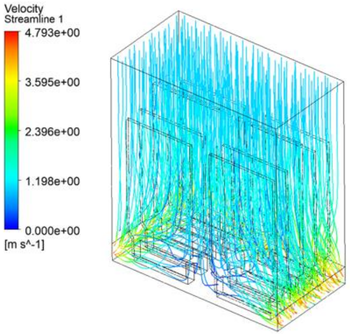
Electronic Boards

P_{boards} **= 11 W** (thermal power generated by each PDU unit)
T_{boards} = **30°C (maximum admissible boards temperature)**

P_{BDT} **= 242 × 11 W = 2662 W** (thermal power generated by each detector box)
P_{dRICH} **= 6 x 2662 W = 15972 W** (thermal power generated by dRICH)

Preliminary CFD (Computational Fluid Dynamics) Simulation

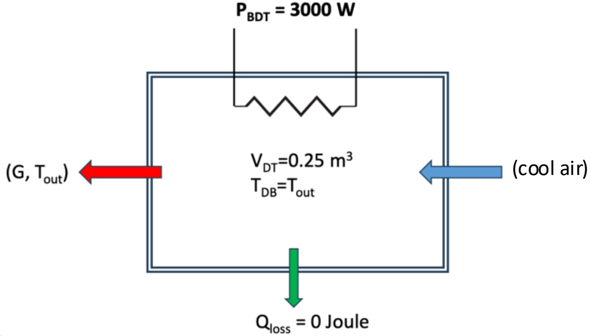




Disadvantages:

- Risk of condensation
- High noise
- High vibrations
- Big size of ducts

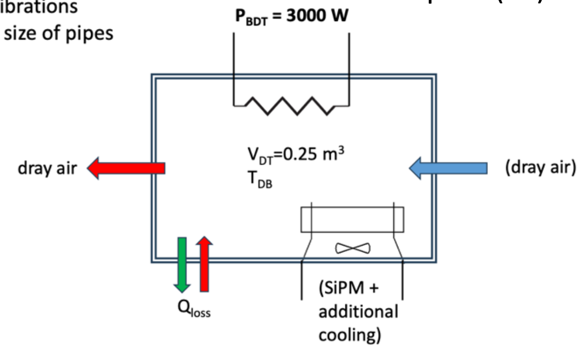
Duct O(10”)



Advantages:

- Low risk of condensation
- No noise
- low vibrations
- small size of pipes

Pipe O(1”)



dRICH technological choices are supported by a structured performance and simulations activity

Essential to guide technological choices

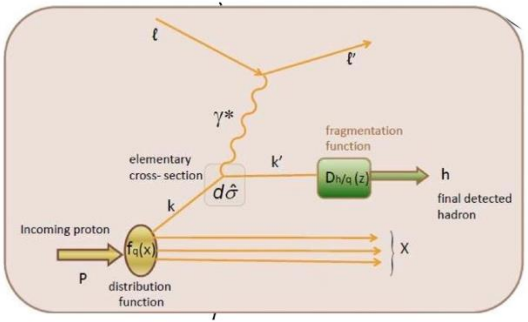
Effective entry-point for new collaborators

New performance study group being initiated

Focussed on SIDIS physics

Experience in Spin Physics and Nucelon Structure gained at HERMES (DESY), CLAS12 (JLab) and COMPASS (CERN)

INFN FE-BO-PV-TO-SA-LNS-TS (7 staff, 5 student/postdoc)

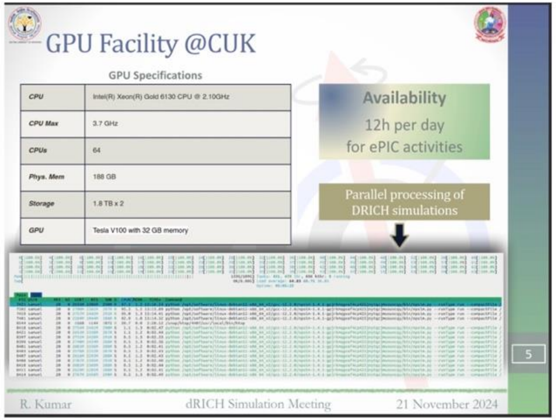


Close collaboration with Theory groups already active in inpact studies on (un-)polarized TMDs

INFN PV-TO (4 staff, 1 student/postdoc)

Significant reinforcement of the simulation group

- New group also provided resources to perform many new simulation - 12h/day allocation for ePIC
  - Substantial use of GPUs
- Simulations and Reconstruction in EICrecon



INFN TS-CS
U. of Salerno
Duke U.
Central U. of Karnataka
Central U. of Haryana
Ramaiah U. of Applied Science

(5 staff, 11 student/postdoc)