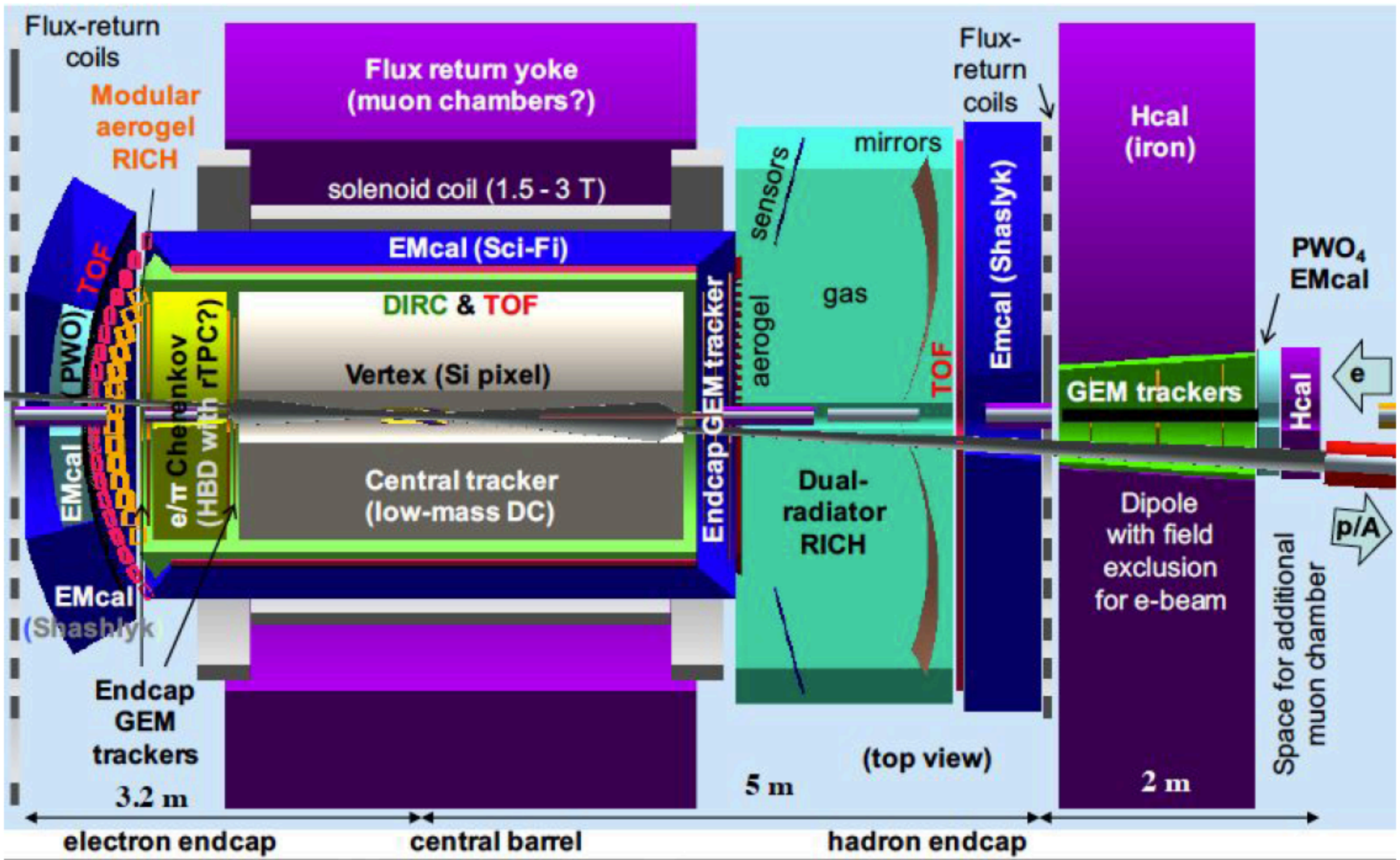
EIC CHERENKOV DETECTORs (FE, LNF, CT, RM1)

mRICH as compact solution for
Limited momentum range
(up to ~ 10 GeV/c)

dRICH as dual radiator for
Extended momentum range
(up to ~ 50 GeV/c)

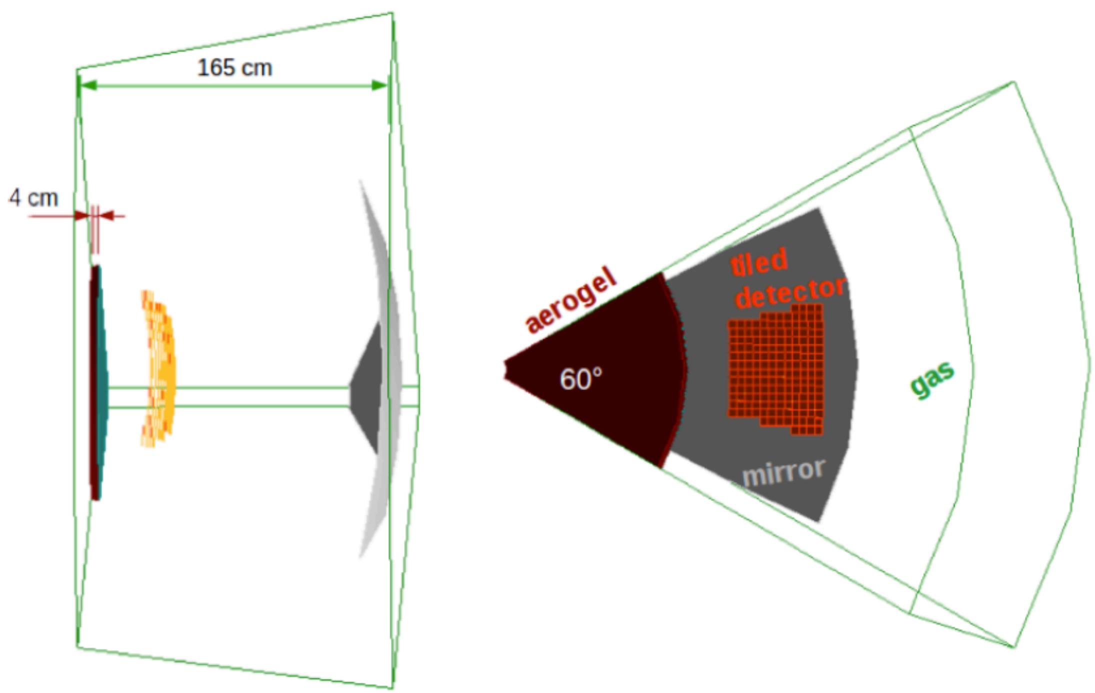


Collaboration with JLab, GSU, Hawaii U., DUKE

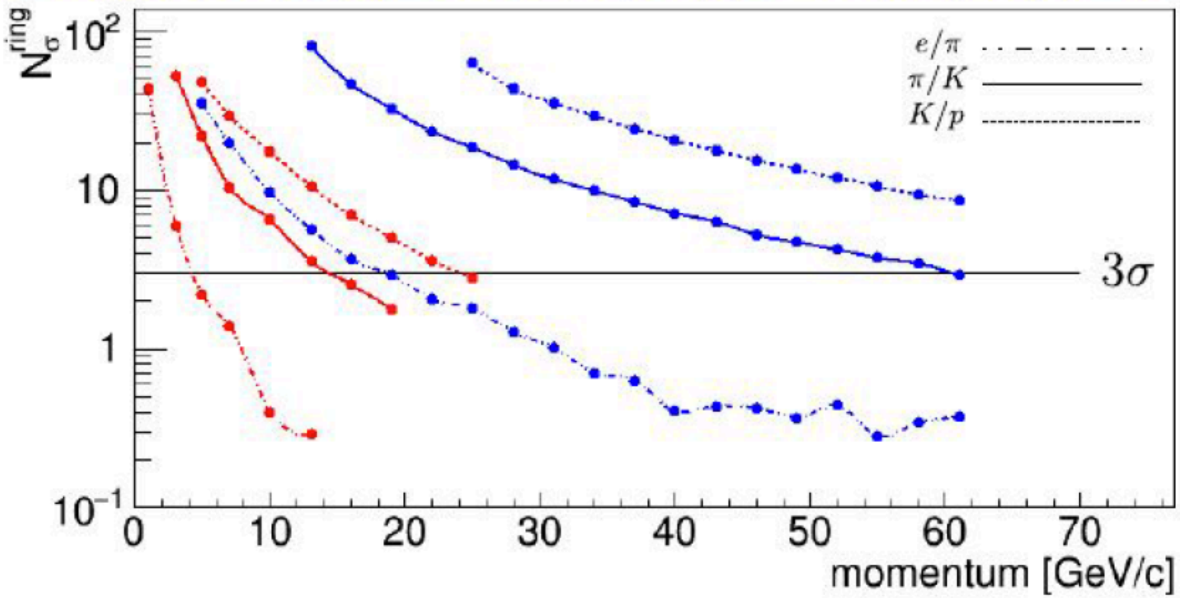
Dual RICH (dRICH)

Classic approach

- delicate interplay between the two radiators
- expensive MCP-PMT or new technology (cooled SiPM) for single-photon detection in magnetic field



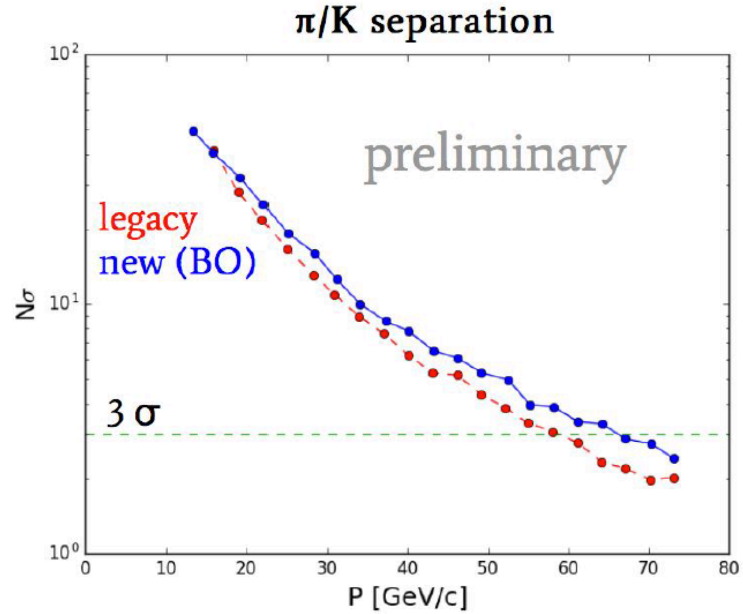
dRICH Expected Performance



	Nominal Momentum Threshold	
Particle	Aerogel (n=1.02)	Gas (C_2F_6, n=1.0008)
	(GeV/c)	(GeV/c)
e	0.003	0.013
π	0.694	3.49
K	2.46	12.3
p	4.67	23.5

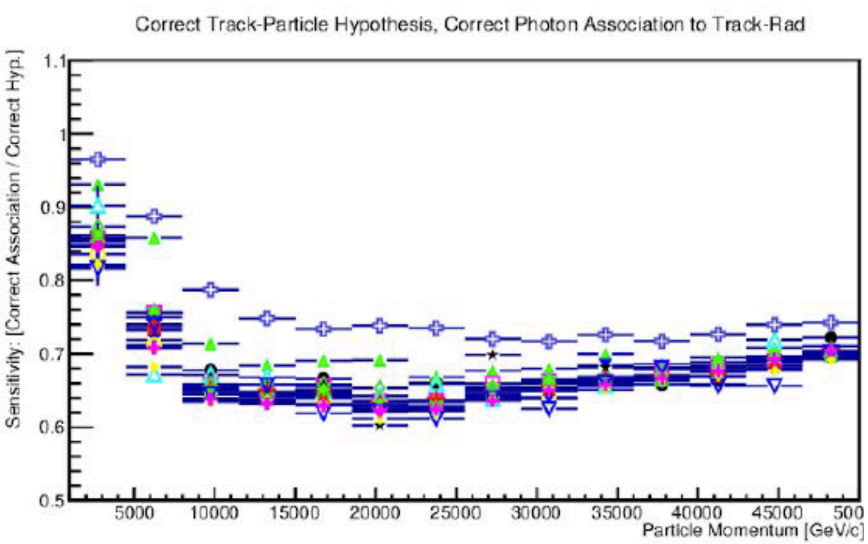
dRICH Optimization

dRICH design refinements based on Bayesian optimization

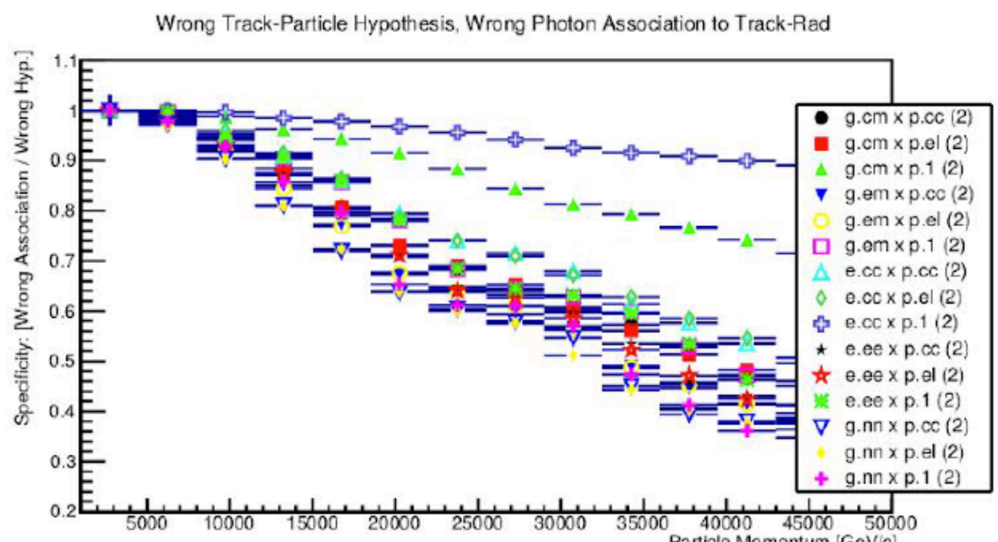


Likelihood for hit association in multi-track events

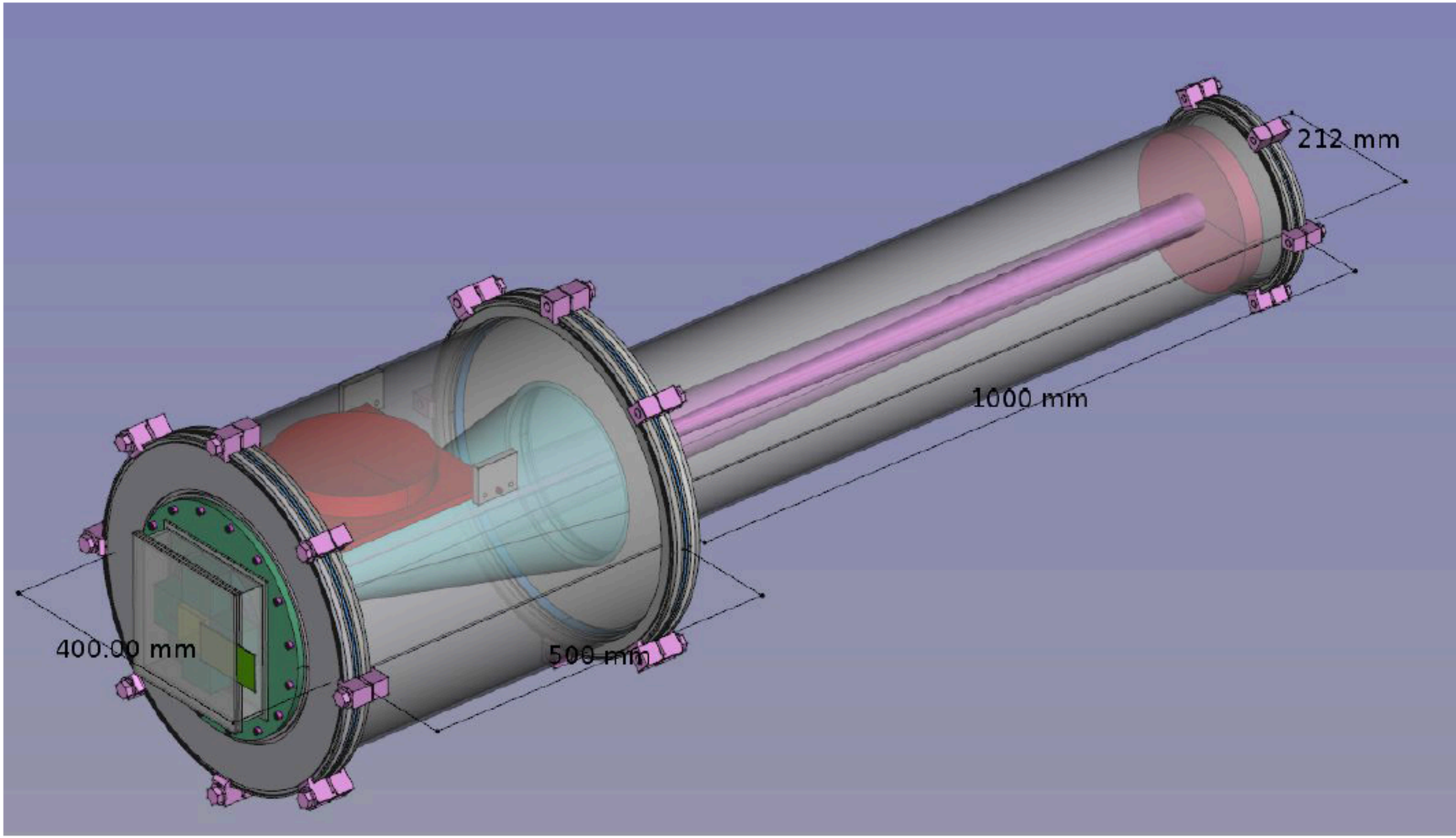
Success for good hypothesis



Failure for bad hypothesis

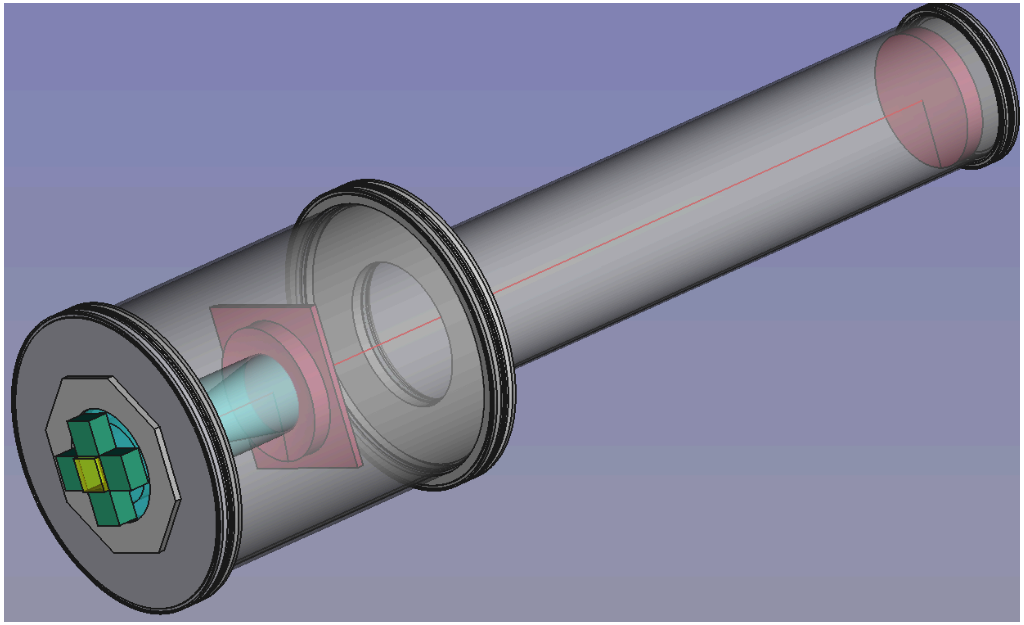


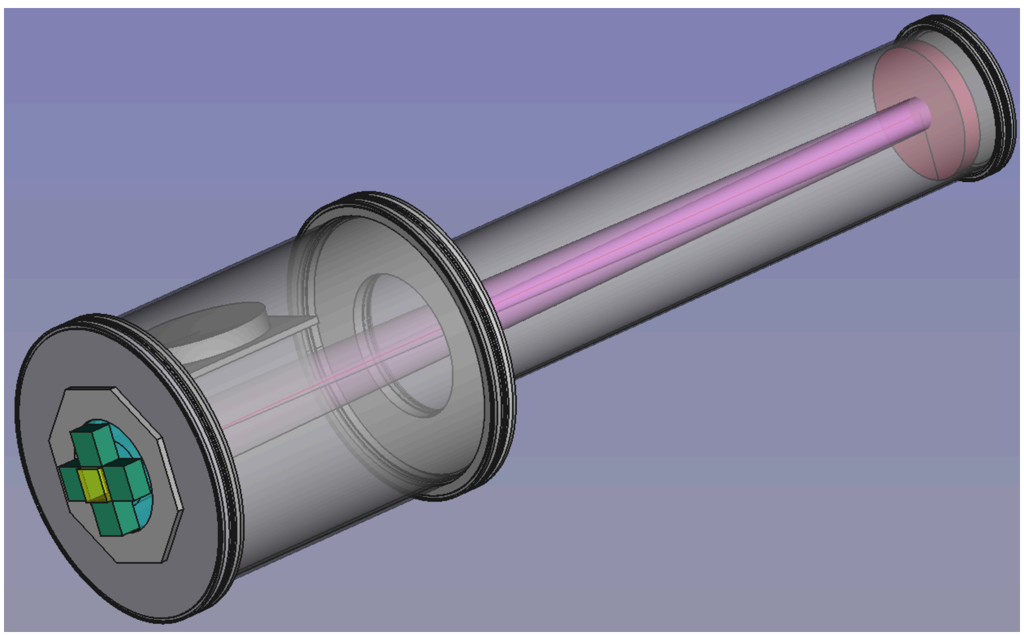
dRICH Prototype Design



Commercial vacuum technology for safety and cost effectiveness

dRICH PROTOTYPE Design

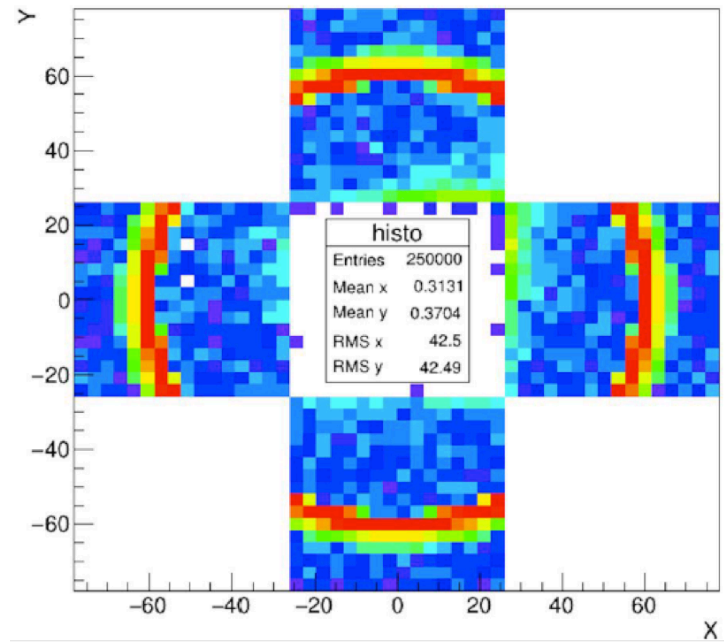




Two radiators with almost overlapping rings
(to optimize the active area)

Configuration 1:

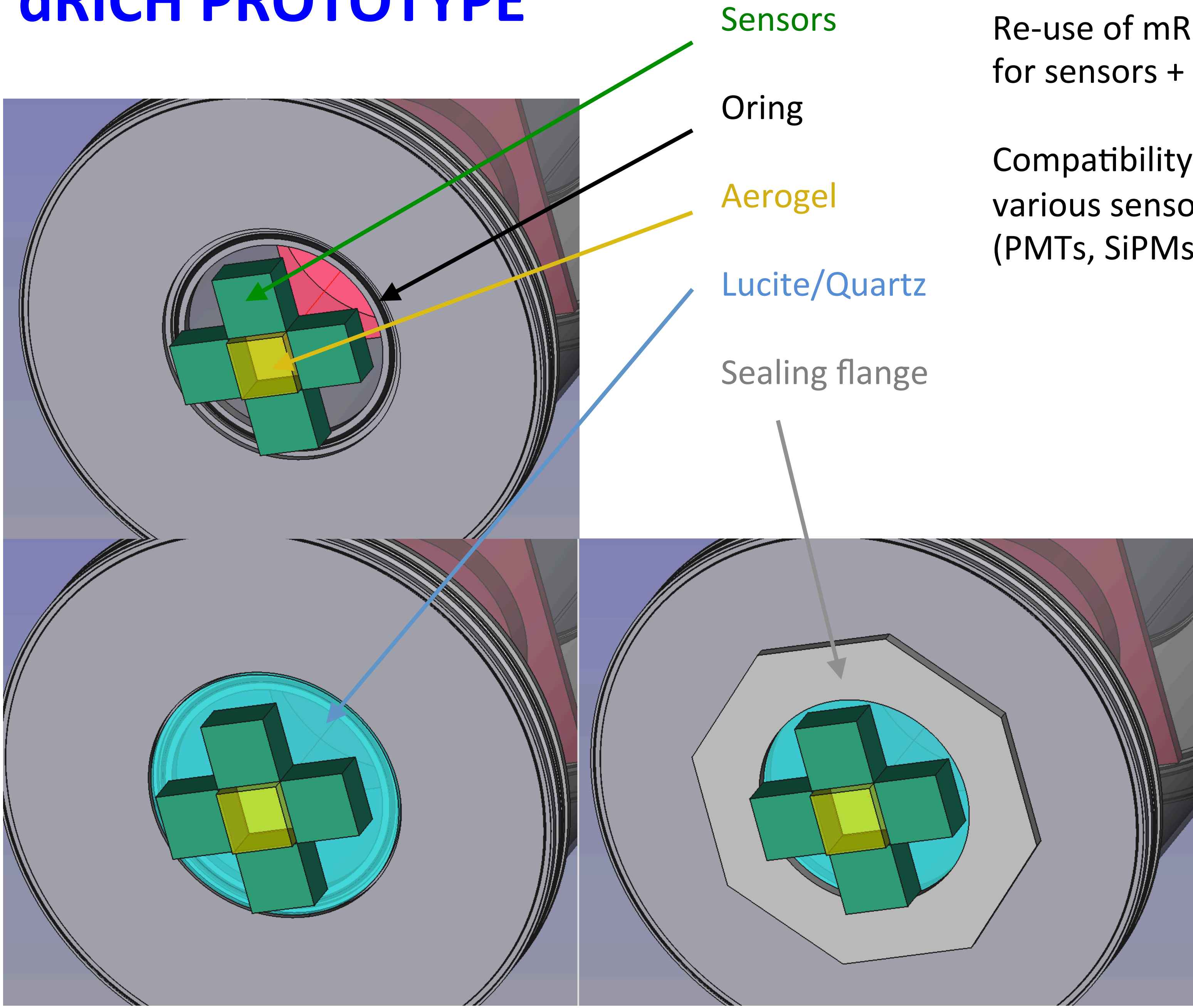
Aerogel ring



Configuration 2:

Gas (freon) ring

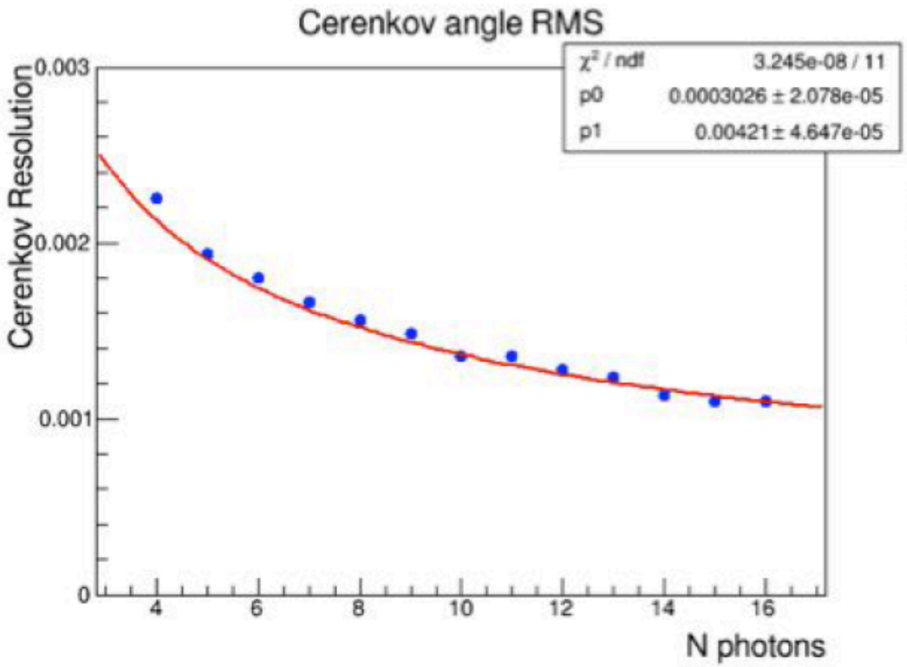
dRICH PROTOTYPE

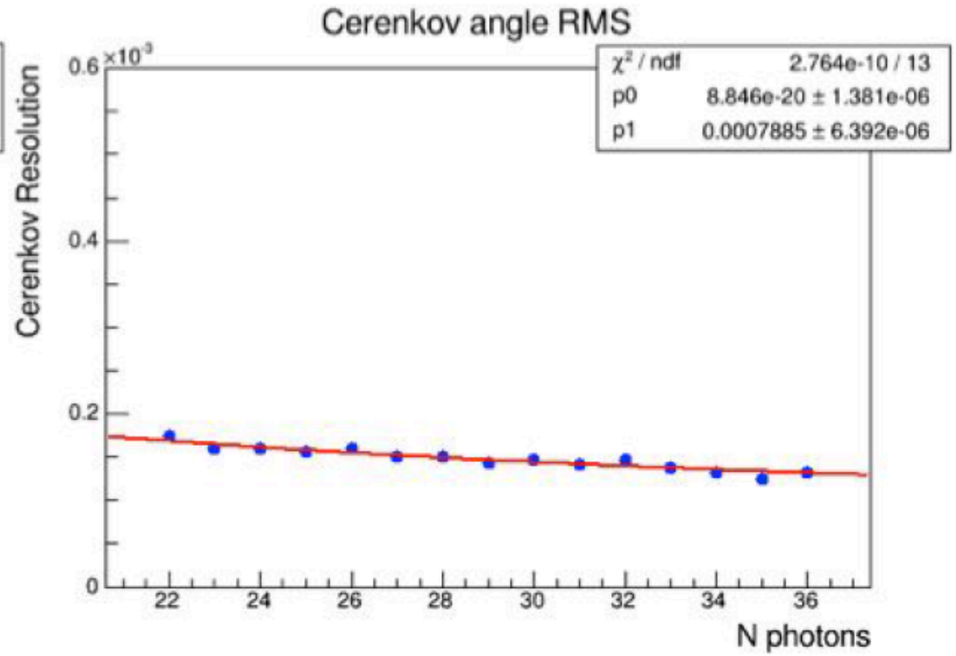


Re-use of mRICH concepts for sensors + electronics

Compatibility with various sensor types (PMTs, SiPMs, GEMs)

dRICH Prototype Performance

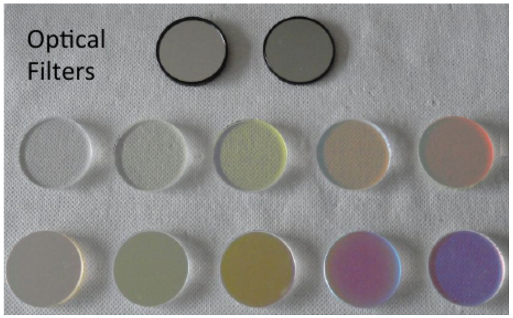


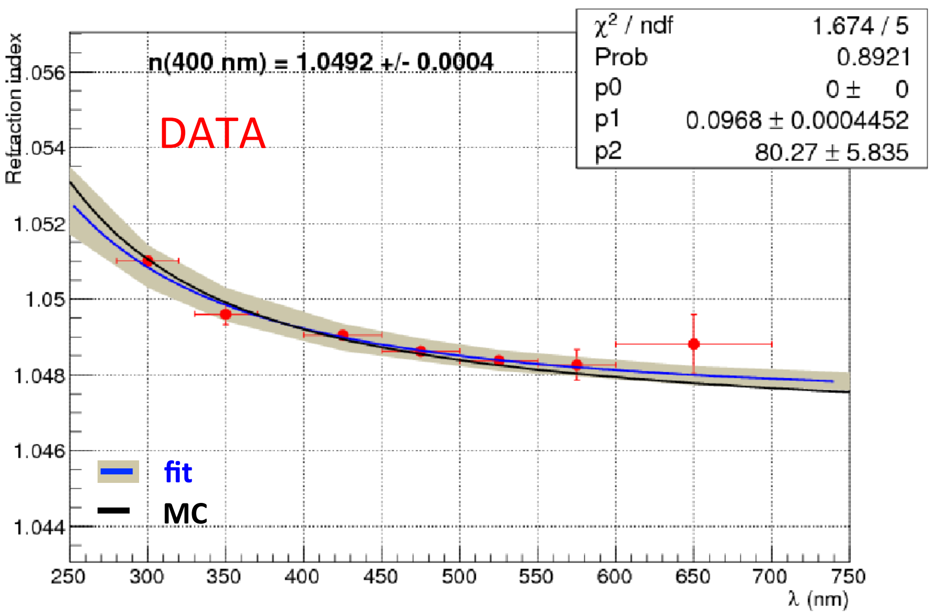


1 p.e. Error (mrad)	Aerogel	C_2F_6 Gas
Chromatic error	3.2	0.51
Emission	0.5	0.5
Pixel	2.5	0.42

Aerogel Chromatic Dispersion by Filters

CLAS12 prototype



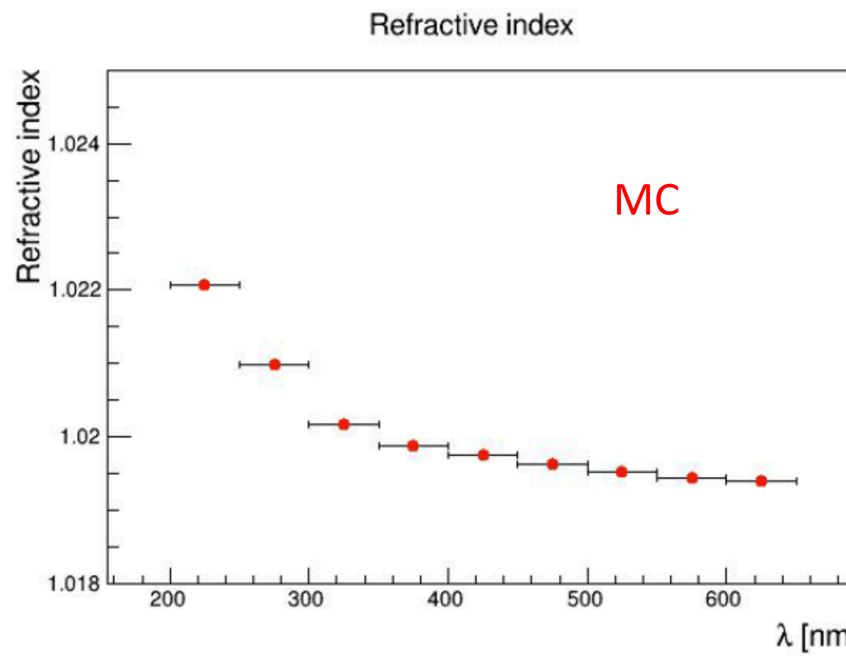


Expected value from density:

$n^2(400nm) = 1+0.438\rho$

$n(400nm) = 1.0492$

dRICH prototype

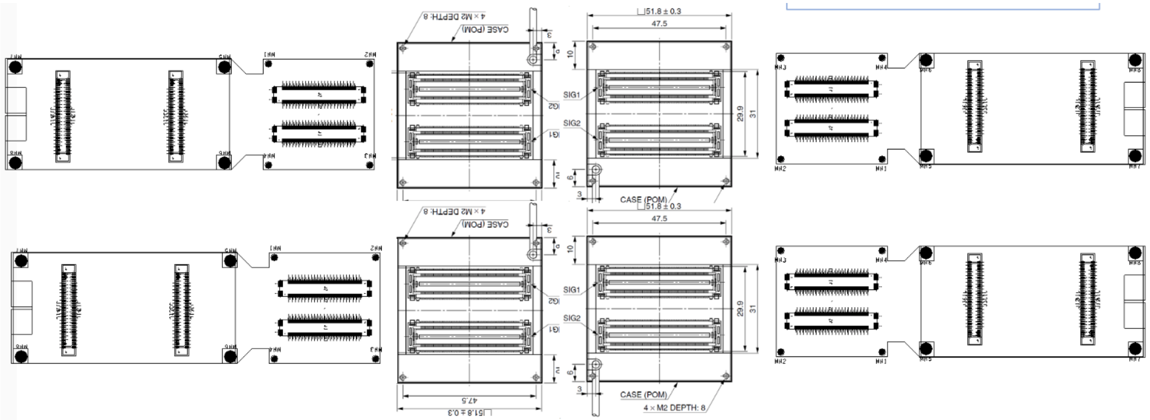


Direct measurement of the major expected contribution to the dRICH Cherenkov angle resolution.

H13700 READOUT BOX

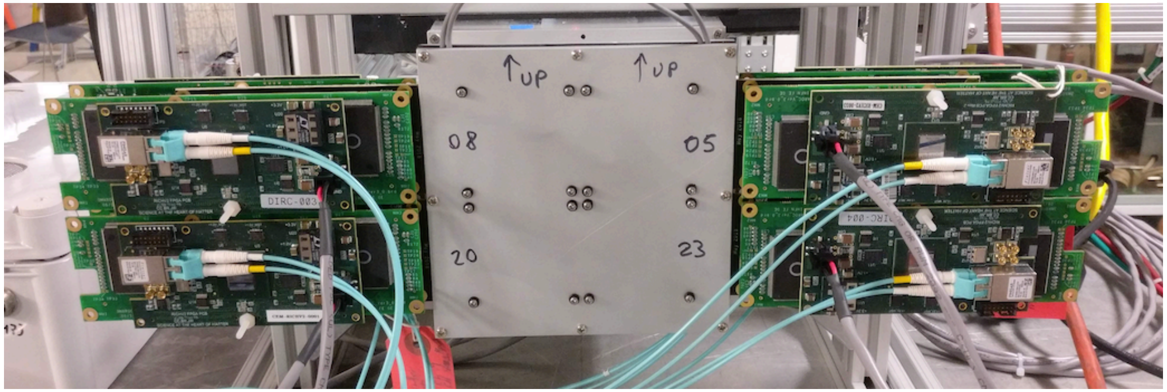
Derived from CLAS12 RICH readout:

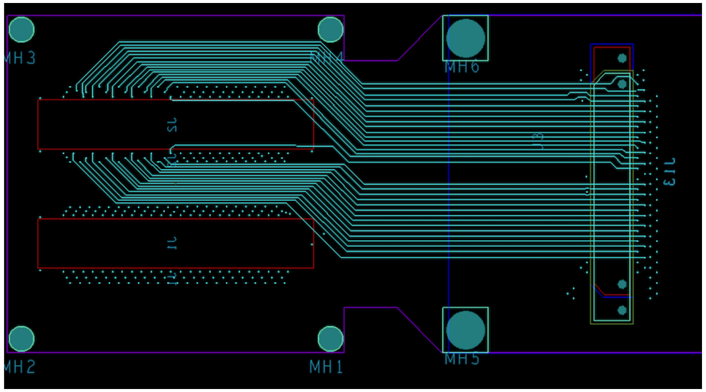
- 1024 channels
- MAROC 64 channel parallel digitalization
- FPGA generated 1 ns timestamp
- DAQ protocol based on VME/VSX SSP



Custom adapter boards

- Compact distribution
- Use of existing MAROC boards
- Light and gas tightness





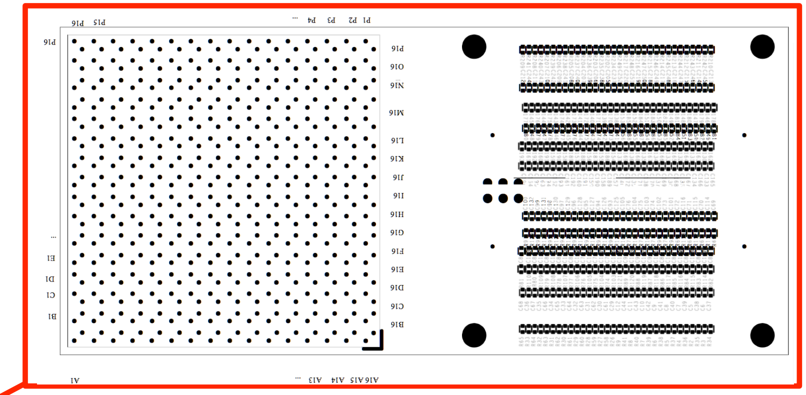
SIPM READOUT BOX

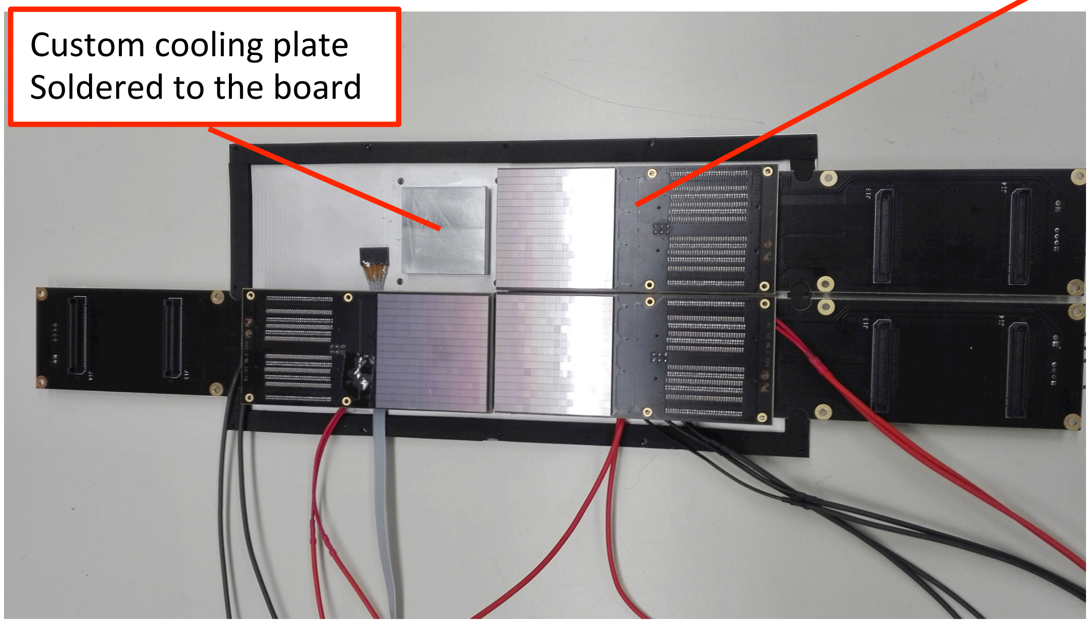
SiPM might offer a cheaper and more efficient solution, expecially in a longer time perspective for other sectors

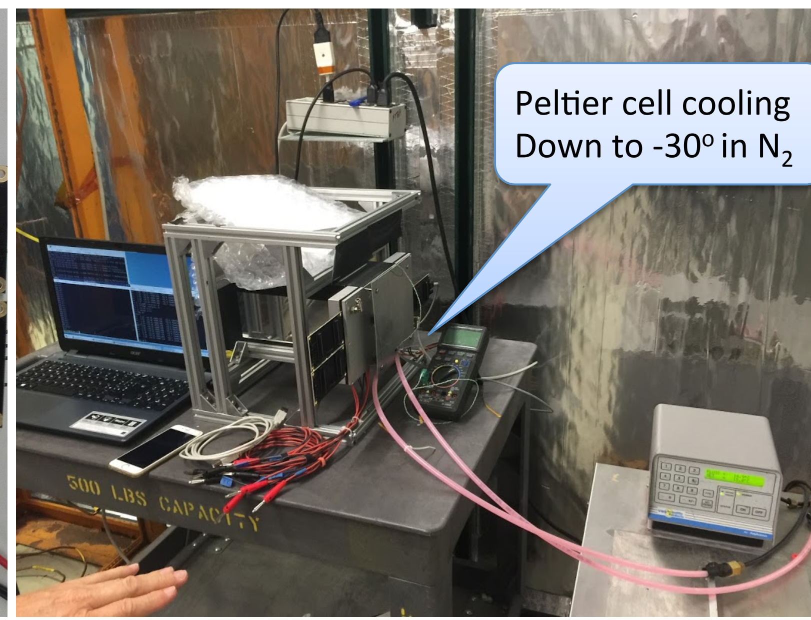
Robust device with low sensitivity to magnetic field
Fast improvement in dark rate and cost
but so far missing radiation hardness

Challenge: cooling integrated into the sensitive readout

Dedicated board for readout and cooling of a surface Mounting SiPM Matrix







Capitolo	Sezione	Anagrafica	Materiale	2019 (assegnato)	2020 (richiesto)
Consumo	CT	0.4 FTE (5)	Meccanica (flange / dark box)	3	4
	LNF	0.3 FTE (3)	Scheda lettura ottica	2	
			Mirrors and supports		4
	RM1	0.2 FTE (2)	Gas+aerogel	1.5	2
	FE	0.3 FTE (2)	SiPM + cooling	3	
			Adattamento elettronica		2

Goal: base prototype ready for a test-beam in 2020.

Notes:

- bare mechanics elements costs quoted around 4 keu
  (does not account for mechanical adaptation for feed-throughs and windows)

- Freon gas is expensive due to minimum delivery requirements

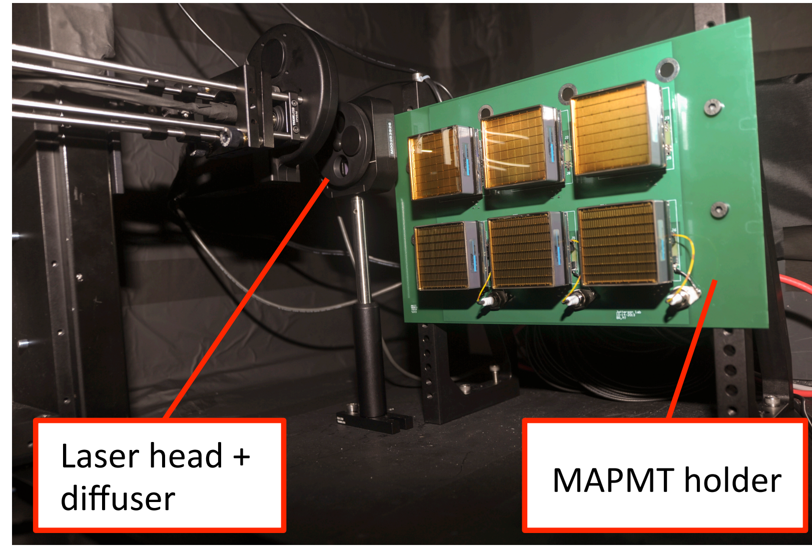
- Commercial mirrors are quoted around 1000 euro each
  The supports should allow alignment

PULSED LASER TEST BENCHES

Detailed characterization
Sensors: gain, efficiency, cross-talk, radiation tolerance
Electronics: gain, cross-talk, thresholds, time resolution

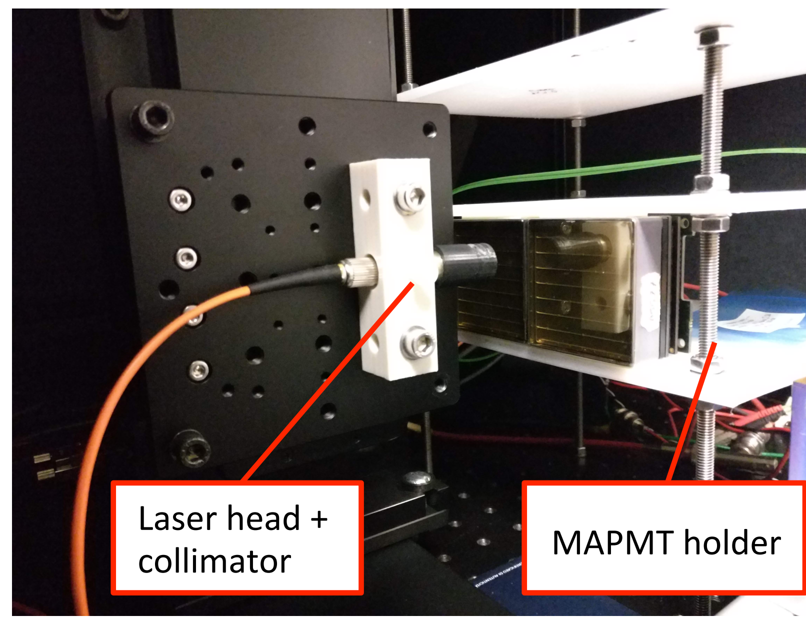
JLab

632 nm picosecond pulsed laser light
Light diffuser to illuminate the whole MAPMT surface
Standardized system with CLAS12 electronics
H8500 6x6 mm^2 pixel sensor so far



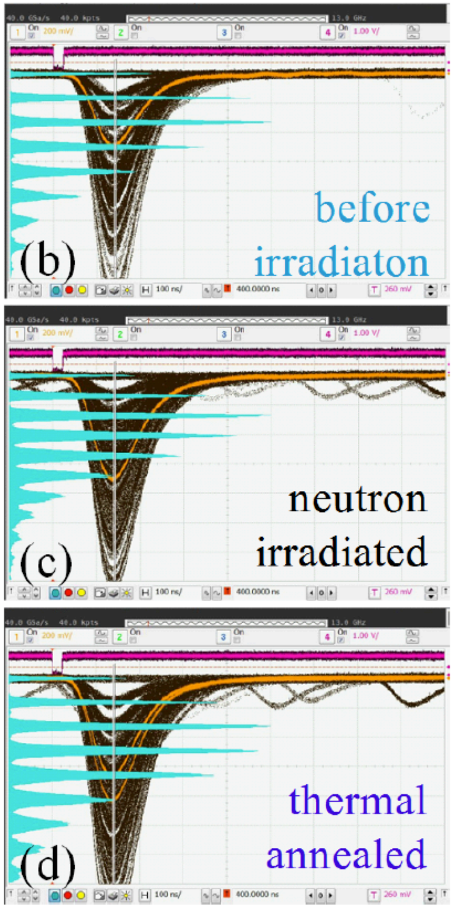
INFN

632 nm and 407 nm picosecond pulsed laser light
Light concentrator to scan the sensor surface
Flexible layout supporting various sensors and Front-End electronics



SIPM RADIATION TOLERANCE

T. Tsang et al.
JINST 11 (2016) P12002

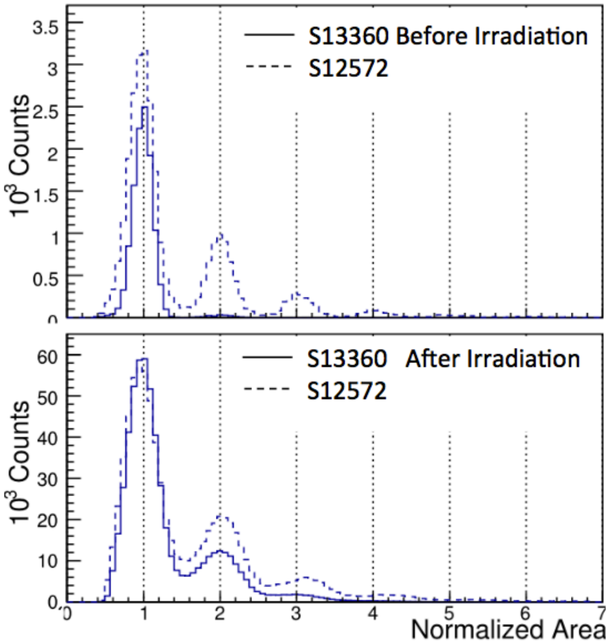


T= 84 K
10^9 n_{eq} cm^2
Annealing at 250 °C

I. Balossino et al.
NIMA 876 (2017) 89

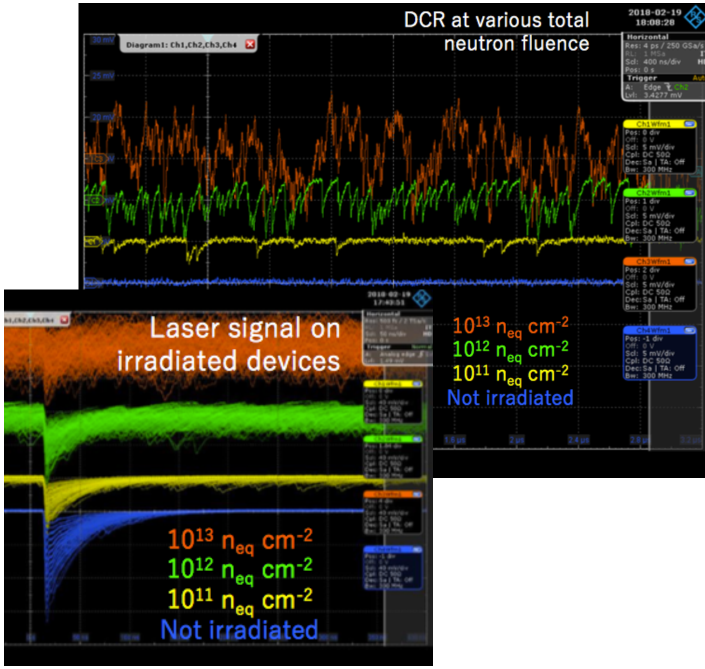
Single-photon capability after irradiation ?

S12572 standard technology
S13360 trench technology



T= 0 C
few 10^9 n_{eq} cm^2

Paolo Carniti
@ RICH 2018



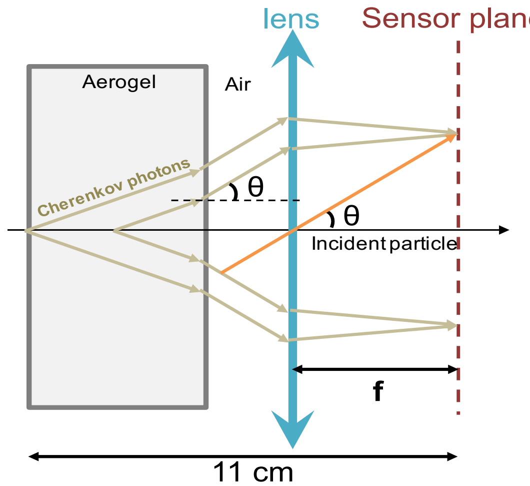
SiPM: Hamamatsu S13360-1350CS (50 μm cells)

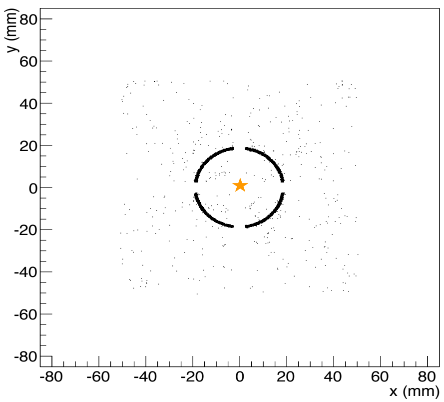
Temperature: –30 °C

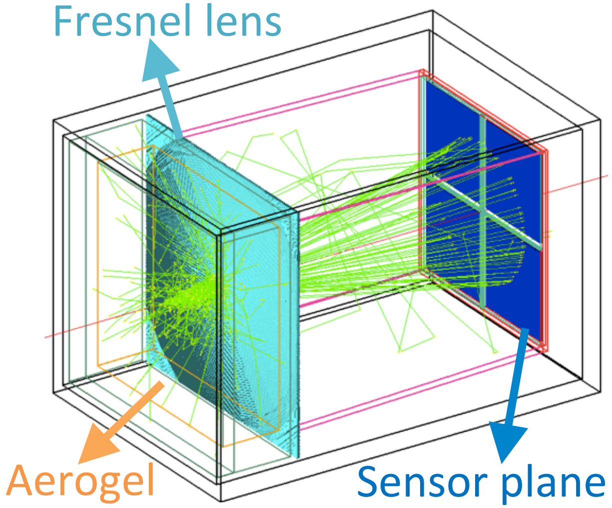
Bias: V_{BR} + 1.5 V

Application: Modular RICH @EIC

Compact and modular RICH indipendent elements



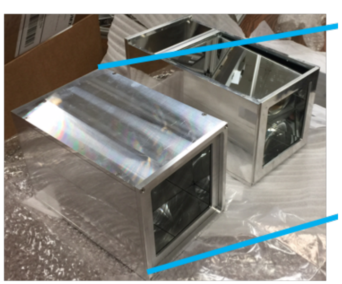


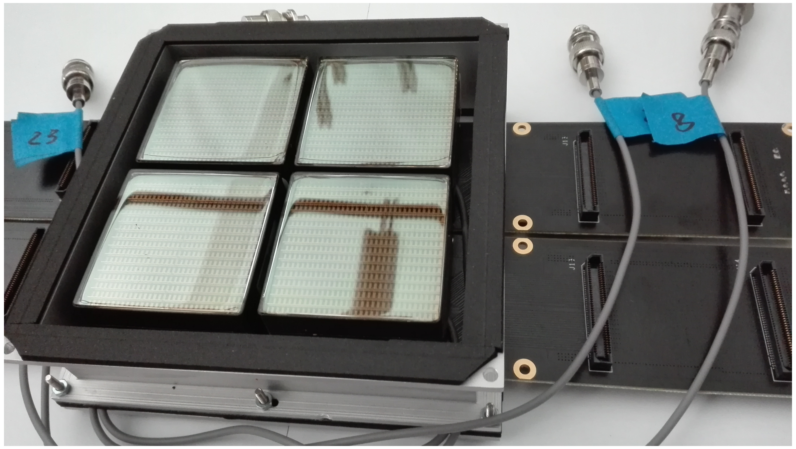


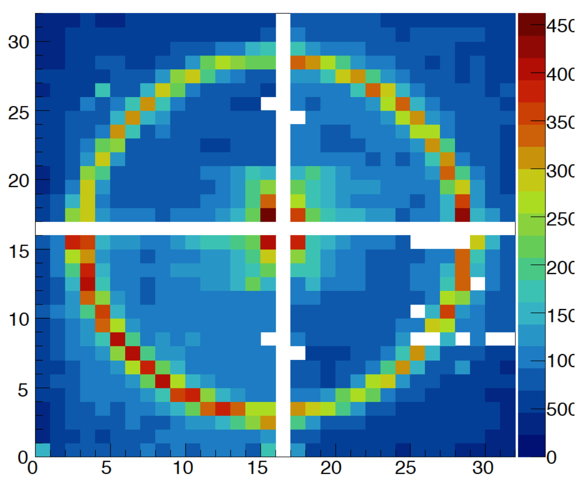
See Xiaochun He talk

H13700 to reach the 3 mm spatial resolution

Two completed mRICH prototypes

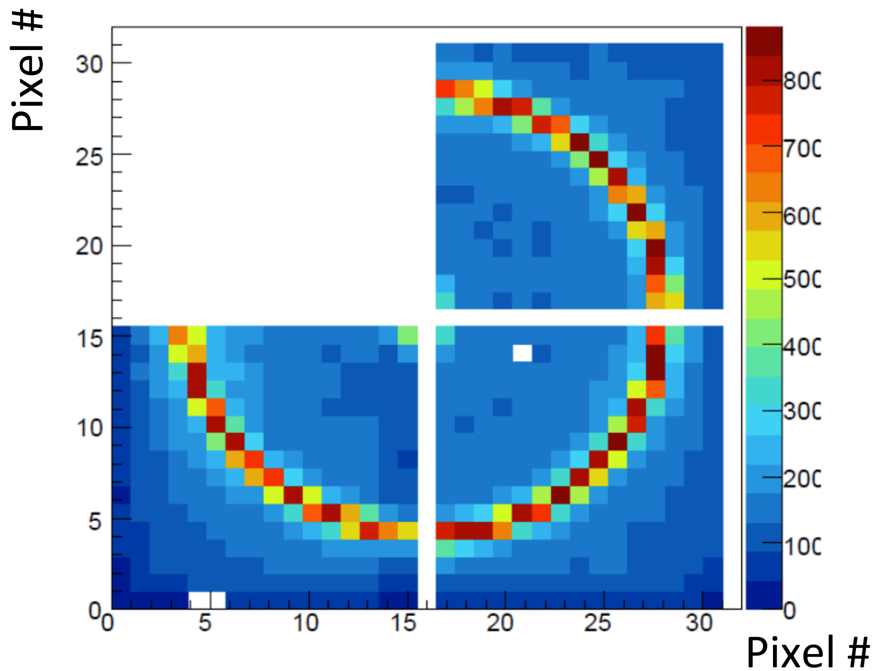


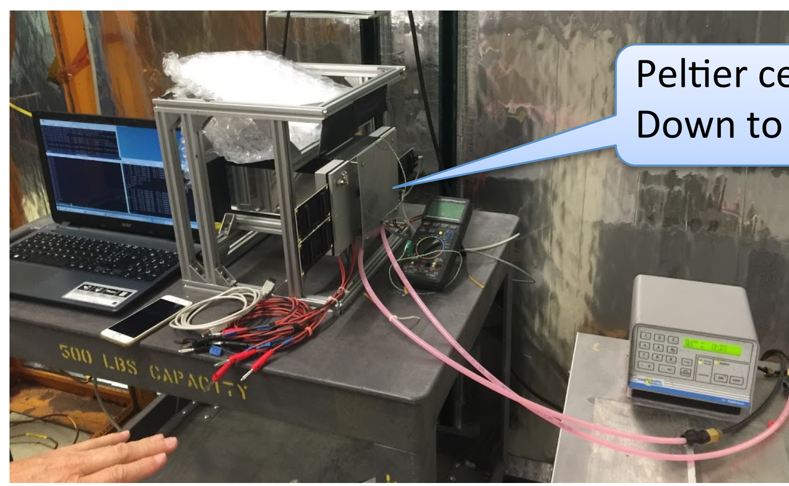




Application: SiPM Arrays

Test of SiPM with RICH electronics





Peltier cell cooling
Down to -30° in N_2