dRICH – TDR Plans

PID WG Meeting, 23rd February 2024

dRICH Sub-System Organization

6.10.04 Particle Identification Level-3 — CAM from Project

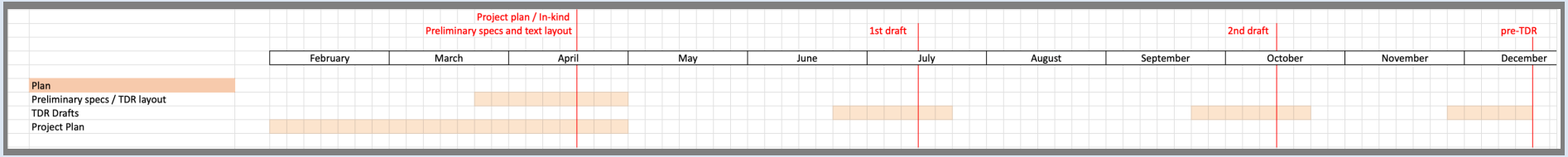
6.10.04.03 dRICH Level-4 — CAM from Project + DSTC from EPIC (**M. Contalbrigo**)

Work packages lead from EPIC	
Photo-Detector Level-5	**R. Preghenella**, INFN-BO, INFN-FE, INFN-CS, INFN-SA, INFN-LNF, INFN-CT, NISER
Front-end Asics Level-5	**F. Cossio**, INFN-TO, INFN-BO
Data-acquisition Level-5	**P. Antonioli**, INFN-BO, INFN-FE
Mechanics Level-5	**A. Saputi**, INFN-FE, INFN-CT, INFN-GE, JLAB, BNL
Gas radiator Level-5	**F. Tessarotto**, INFN-TS, BNL
Mirror Level-5	**A. Vossen**, DUKE, INFN-FE
Aerogel Radiator Level-5	**G. Volpe**, INFN-BA, INFN-FE, RICH Consortium
High-Pressure Level-5	**S. Dalla Torre**, INFN-TS, INFN-FE, INFN-LNS
Simulation	**C. Chatterjee**, INFN-TS, DUKE, INFN-FE, RICH Consort.

Work packages not yet active

- Interlock Level-5
- Slow Control Level-5
- Cooling Level-5
- Gas purging Level-5
- Detector box Level-5
- Alignment Level-5
- Power Supply Level-5
- …… Level-5

TDR Effort in 2024



April: Preliminary specs & text layout
Project plan / in-kind preview

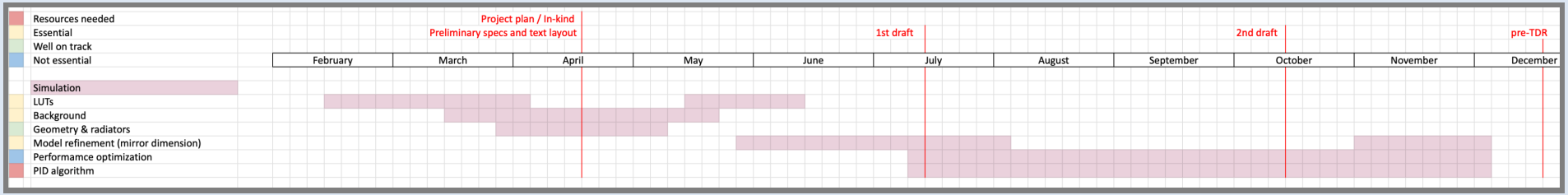
July: 1st draft

October: 2nd draft

December: Pre-TDR

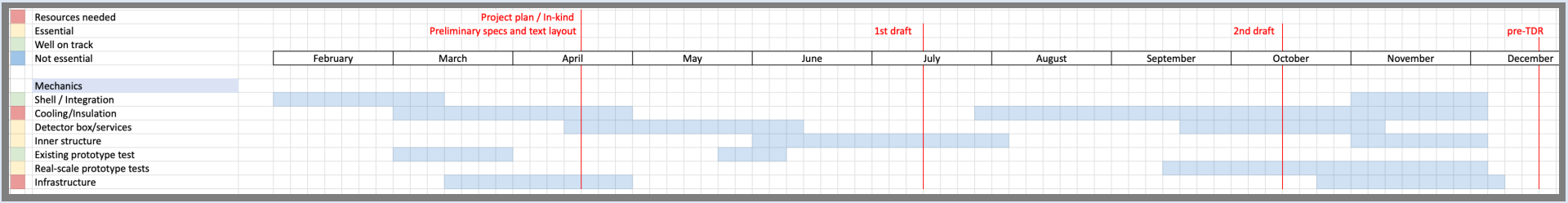
Assumptions: Pre-TDR (CD2) required at the end of the year
Scheme driven by manpower/lead time: remains the same for a TDR (CD3)
Extra-time needed fo real-scale mechanics & RDO demonstrators

dRICH simulation is already performed within ePIC framework



LUTs:	Tabulated PID performance	March - June
Reconstruction:	Backgroud (dark count)	April
	Refined IRT / Alternative pattern recognition	Along the year
Model:	Optical description (aerogel, gas, mirror)	By summer
	Photon detection unit	By summer
	Geometry refinements	Following mechanics
	Performance optimization	Along the year
PID algorithm:	dRICH & ePIC combined information	Beyond scope

Engineering Design (Mechanics)



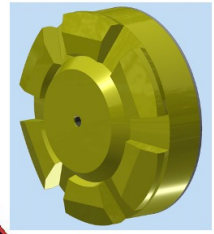
Structure:	Shell & Integration	March
	Inner Structure	July
Cooling:	Insulation / Services (preliminary)	April
	Insulation / Services (realistic)	November
Detector:	Detector box	June
	Services (power)	April
Infrastructure:	Installation tools / Services lines	After summer

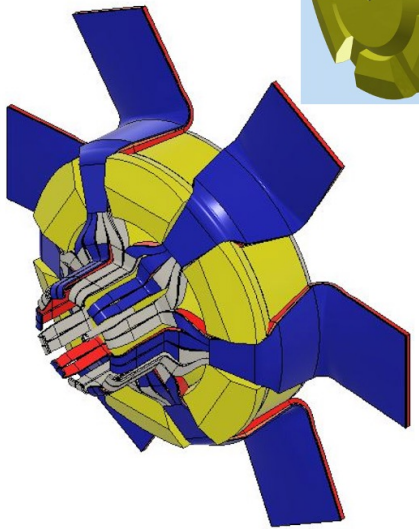
Assumption: preliminary design shall be refined with real-scale prototype

Mechanics

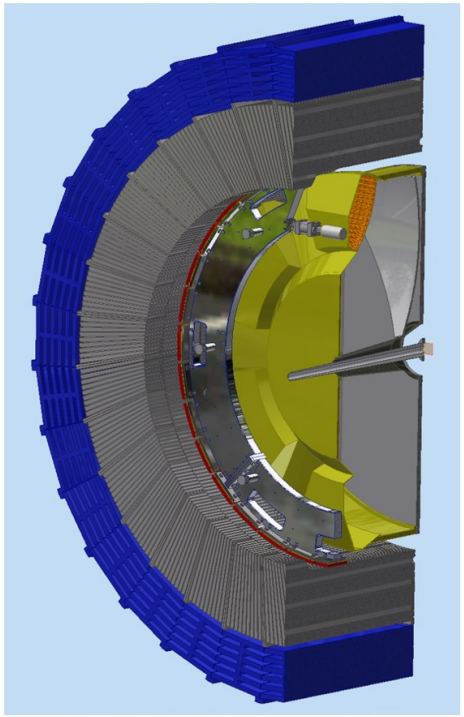
Services

- Φ3600 mm x L1200 mm
- Operating pressure up to 200 Pa
- Operating temperature of 22 °C

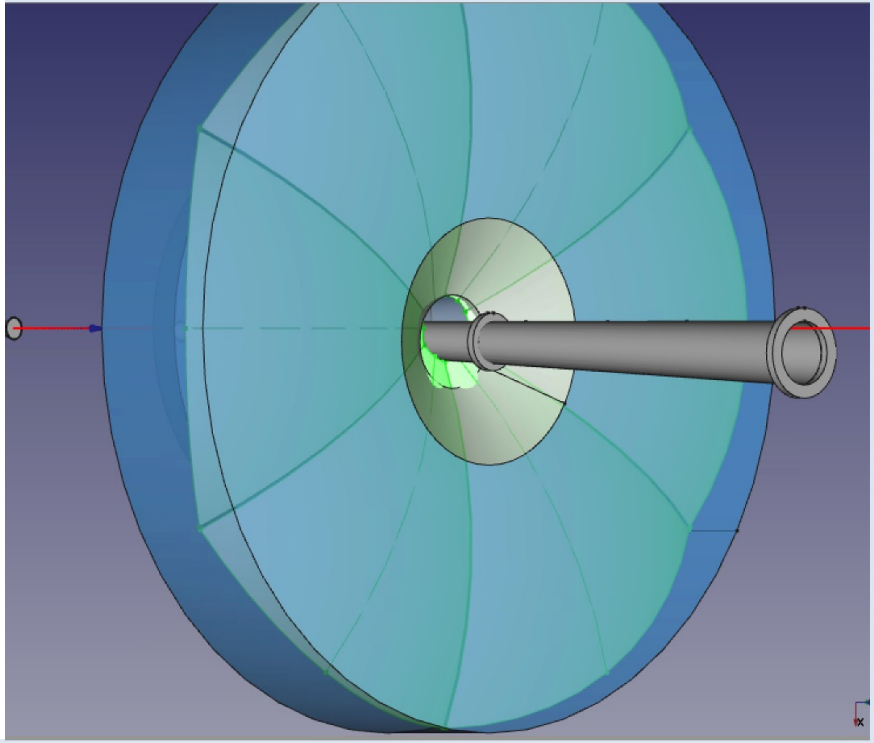




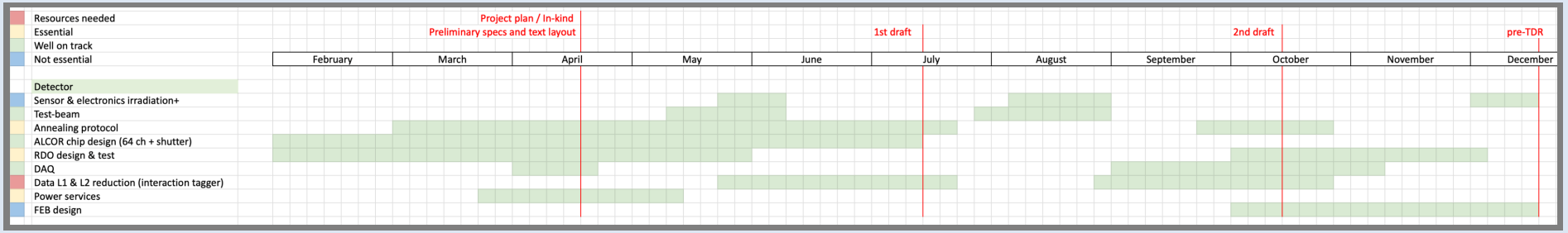
Integration



Maintenance



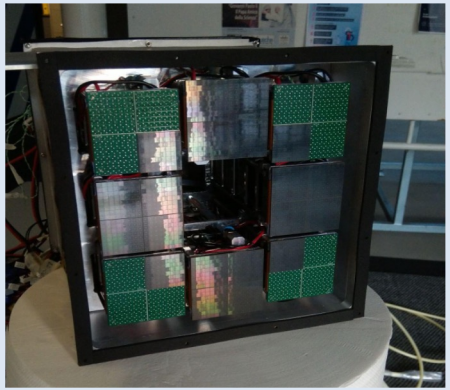
Engineering Design (Readout)

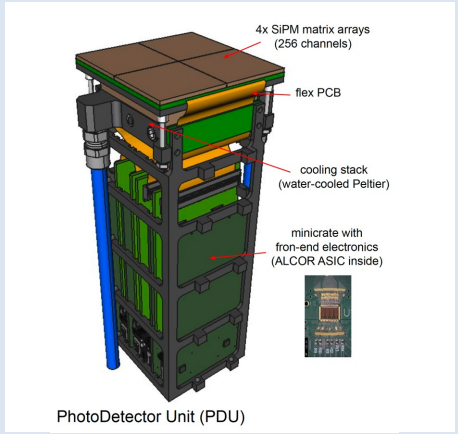


Fron-end:	RDO Design	May
	ALCORv64	July
	FEB Design	December
DAQ:	General scheme	April
	Data L1 & L2 Reduction (prelimary)	July
	Data L1 & L2 Reduction (refined)	October
Services:	Power distribution	April

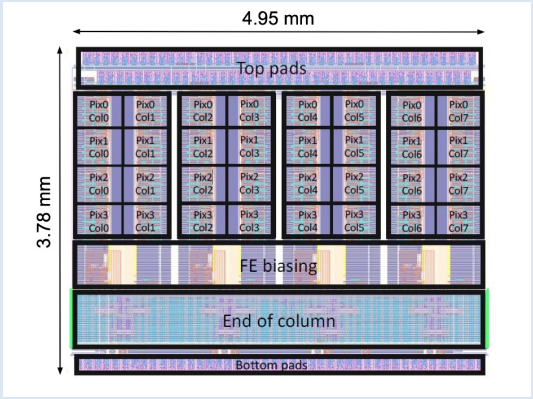
Assumption: readout design in 2024 but hardware realization in 2025

PDU

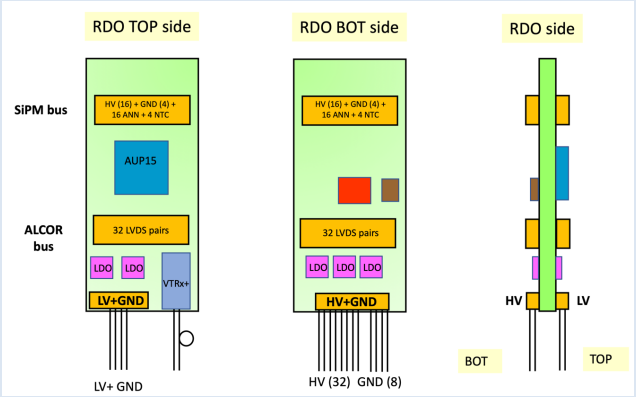


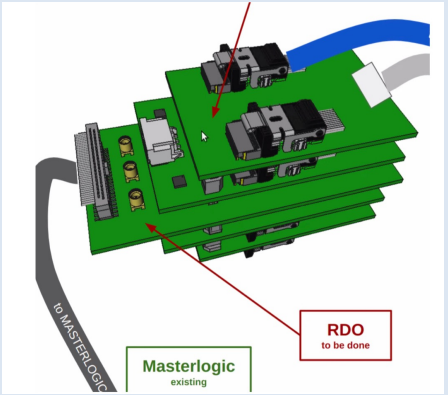


ALCORv64

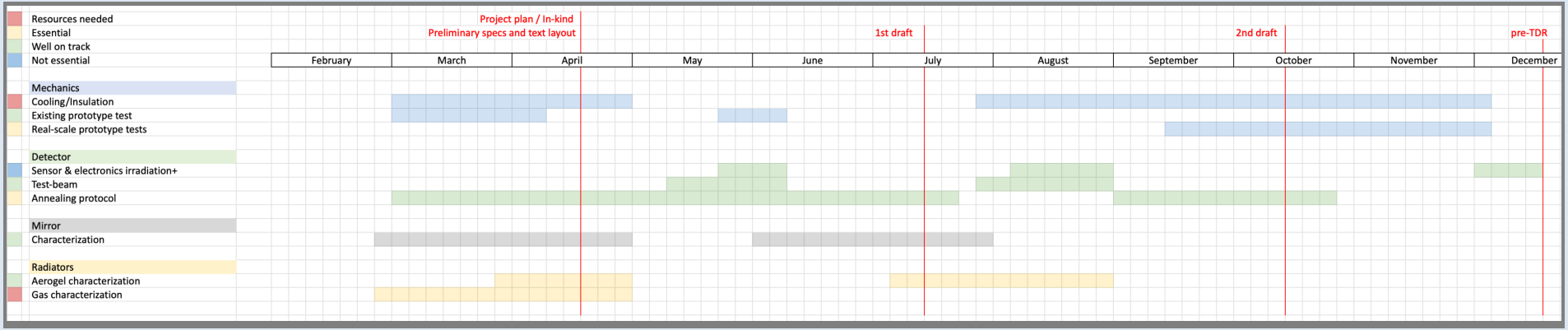


RDO



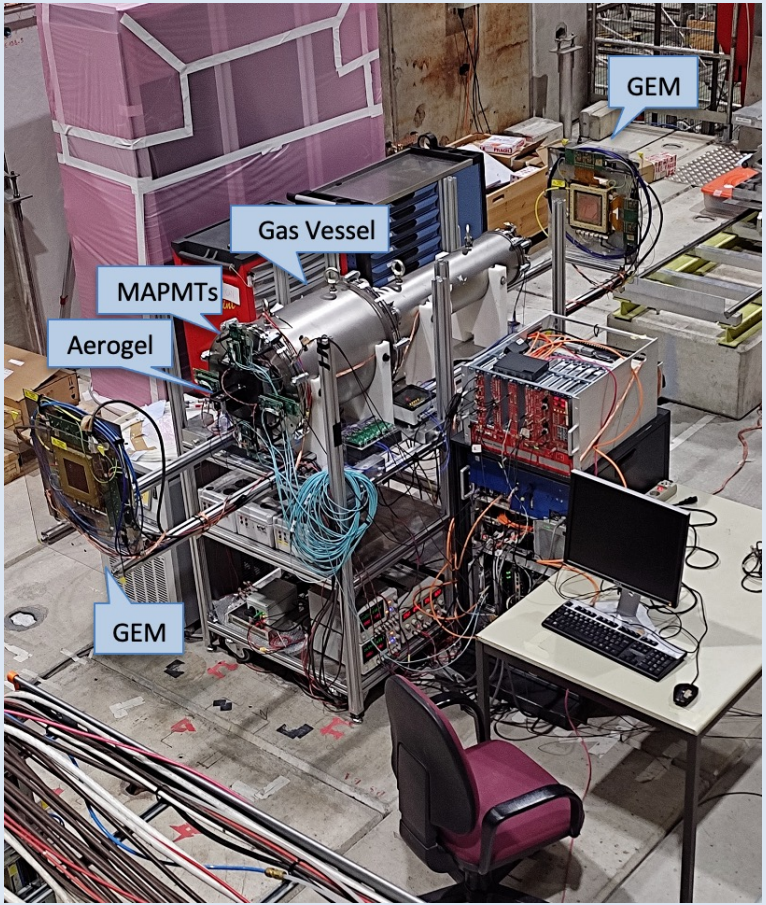


Prototypes

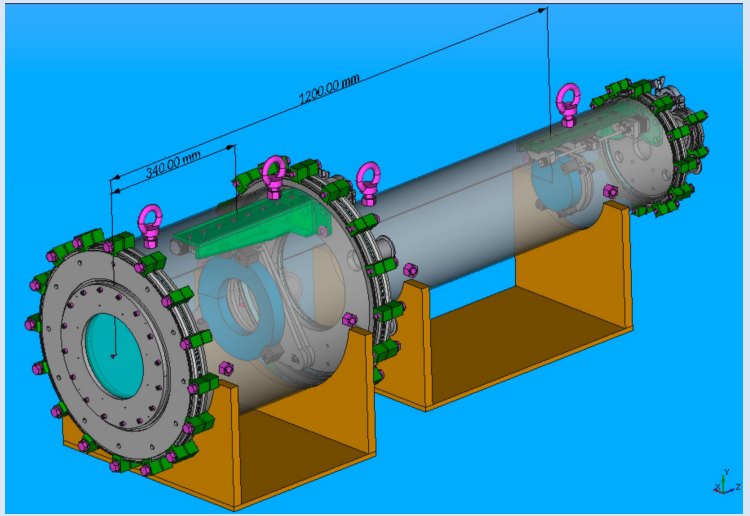


Existing prototype:	Temperature control & insulation (preliminary)	March
	Photon-detection unit (PDU) validation / gas alternatives	June
	RDO validation	After October
Real-scale prototype:	Mechanics (shell and inner structure)	After summer
	Temperature control & insulation	
	ePIC off-axis optics	
	Detector integration	
Realistic components:	CFRP mirror substrate	April
	Aerogel dimensions	After summer

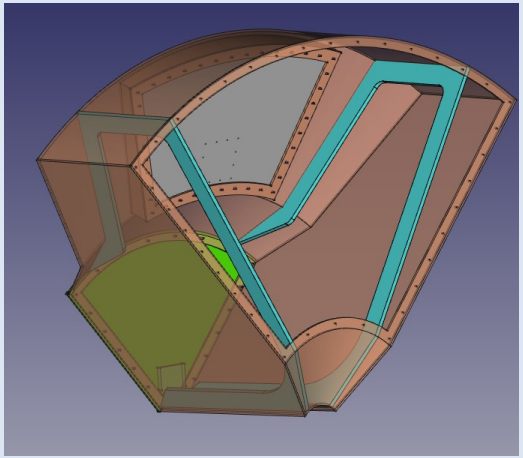
Prototypes



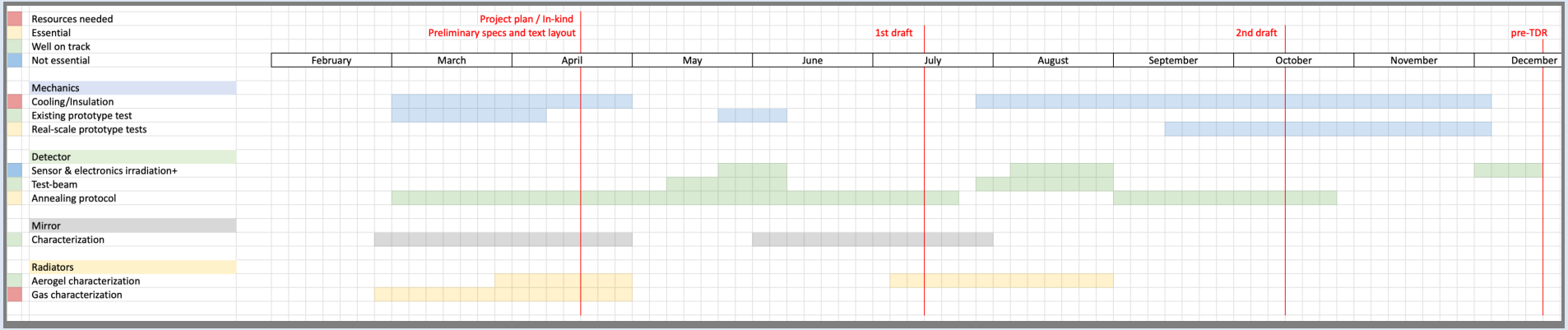
Existing prototype:



Real-scale prototype
(one ePIC sector):

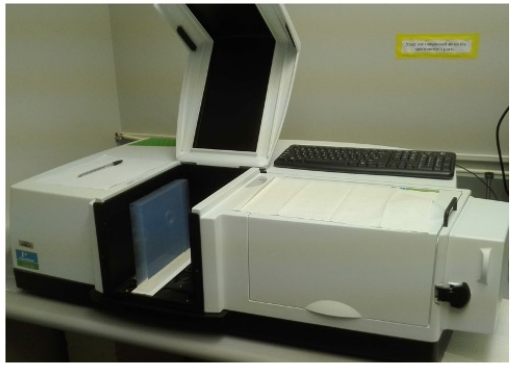


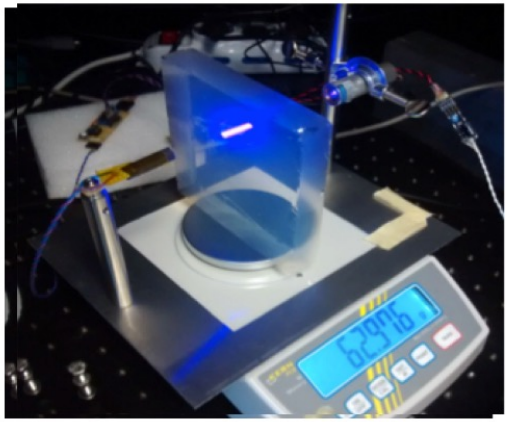
Lab Characterization & Beam Tests



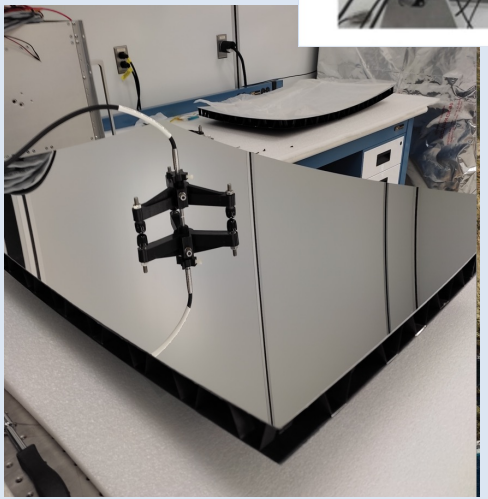
Radiators:	Quality assurance stations	March-April
	Continue aerogel validation (refractive index & dimensions)	Summer
	Gas characterization	April
Mirrors:	Quality assurance stations	March-April
	CFRP substrate validation	April
	Coating validation	June
Sensors:	Continue irradiation camapign	Along the year
	Annealing protocol	

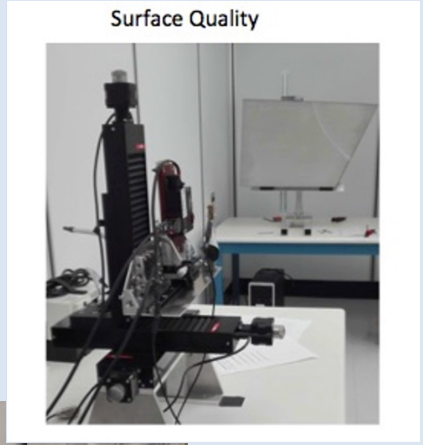
Aerogel: Temple - BNL - INFN



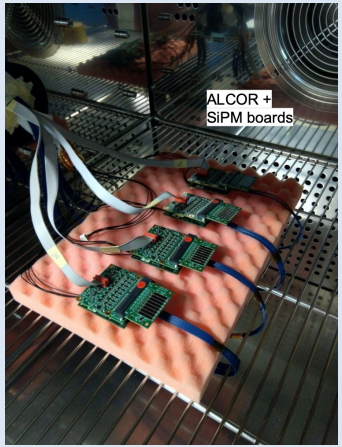


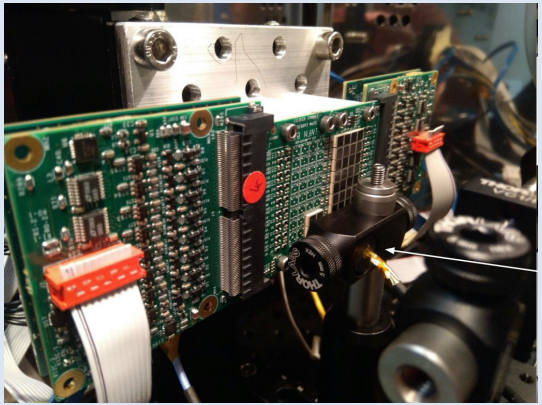
Mirror: JLab - Duke





Sensors: INFN





Timescale

The timescale is aggressive due to the limited manpower
A 60% readiness within 2024 is realistic, a 90% readiness appears challenging

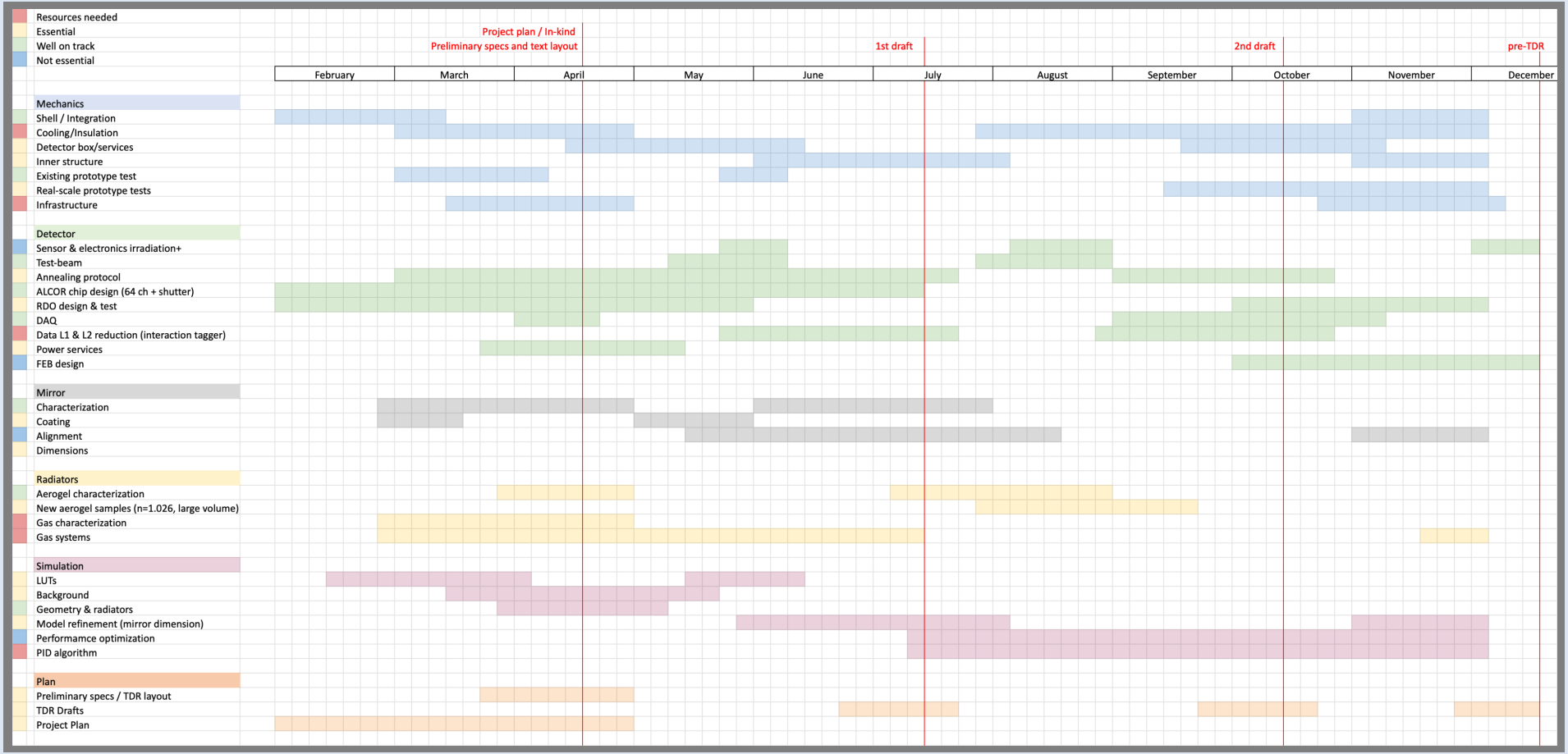
dRICH @ 60% :	Design of major components (mechanics, readout) No hardware real-scale demonstrators Realistically achievable in 2024
dRICH @ 90% :	Hardware real-scale demonstrators (mechanics, readout) Design refinement based on hardware tests Realistically achievable during 2025 (1st half)
Left over:	Aerogel (mass production) and SiPM (temperature treatments) may require longer engineering to reach best performance Detail of ancillary systems

Needed Resources

The timescale is aggressive due to the limited manpower
A 60% readiness within 2024 is realistic, a 90% readiness appears challenging

Mechanics:	Limited manpower Searching new personnel at INFN Help needed from the EIC Project
Gas:	Safety & infrastructure Help needed from EIC Project & CERN experts
DAQ:	Data reduction & interaction tagger Help needed from EIC Project
Quality Assurance:	Manpower & test stations in US Help needed from EIC Project & within RICH Consortium
Simulation:	Pattern recognition and global PID Help needed within RICH Consortium

TDR Effort Overview



Backup Slides

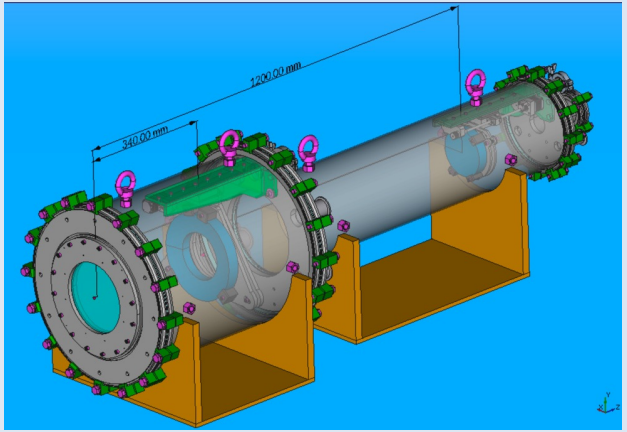
Test: 1 week at SPS in May (open from mid-April to mid-July)
Simple case: pencil & parallel beam of high energy
saturated rings, no tracking

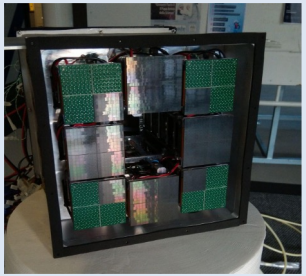
Goals:

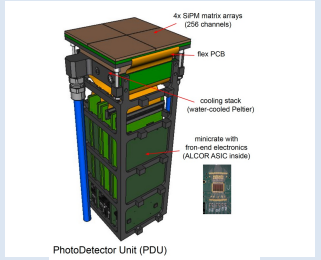
Performance with extended EIC-driven plane
Note: complementary test of radiators due to sensor QE/PDE at variance with so far used reference H13700 MA-PMT
New sensors and readout boards ordered

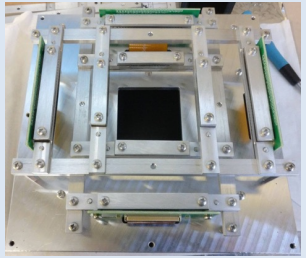
Alternate gas with over-pressure capability
Note: subject to the prototype upgrade, the only relevant change being a thicker entrance window
Quartz windows, dedicated o-rings/clamps, gas lines ordered

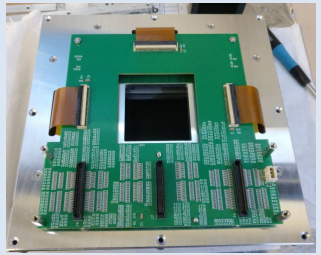
Test fast sci-fi tracking
Note: designed for MAROC3 readout, can be an independent system
Mechanics & electronics ready, sci-fi procured



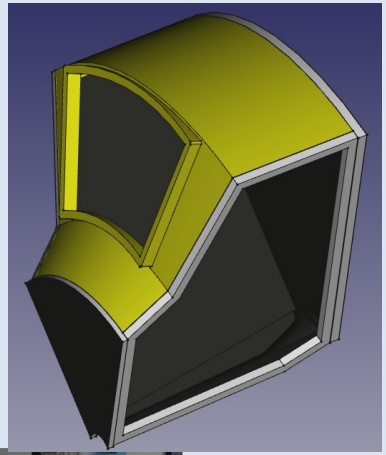








Test: 2 week at PS in September/October (open from mid-July)
Real case: intermediate energy, extended and focussed beam
interplay of radiators, tracking



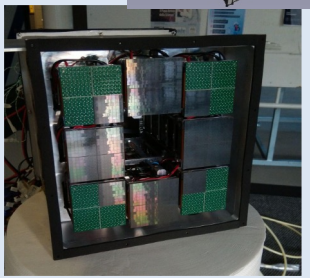
Goals:

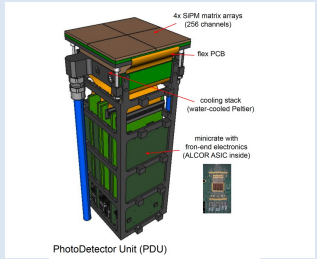
Backup/extension of Test-beam 1

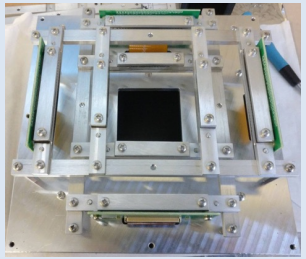
Performance with real-scale prototype & realistic ePIC configuration

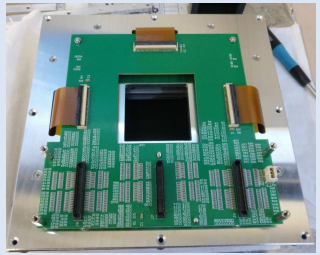
Note: off-axis optics, real imaging for earogel, ePIC-driven assembly

Real-scale prototype design being finalized (matching with ePIC integration)
Medium-size mirror & piezo-motor demo ordered
Large scale aerogel tile under negotiation
Detector box/support to be decided

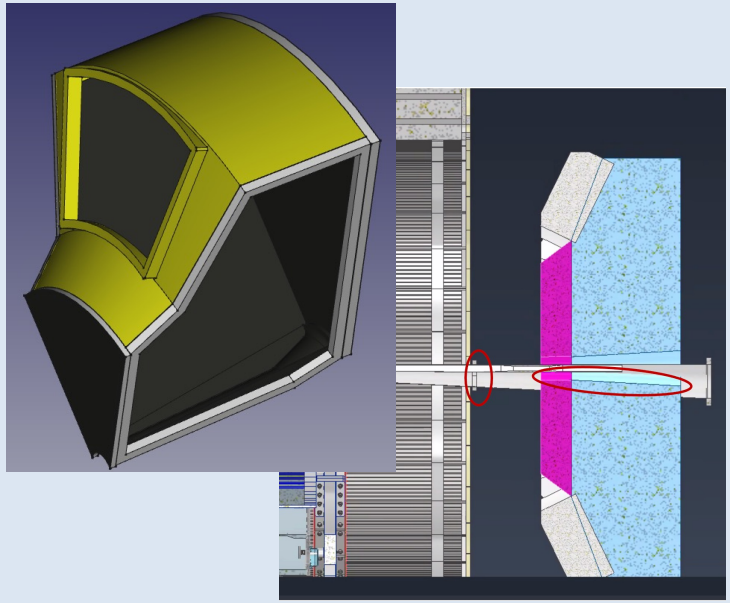








- **General layout**
- **dRICH Shell**: *integration &maintenance under discussion*
- **Real-scale prototype**: *under negotiation with ACS*
- ***Thermal tests**: being prepared with existing prototype/detector box*
- ***Services**: gas and cooling lines*
- ***Detector box prototype:** may be needed for a good modeling*
- ***Production/Assembling/Installation plan***
- ***Thermal model**: on queue, man-power needed*



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4) We recommend that a detailed design of the gas box and circulation system be given high priority.
5) To address concerns with multiple track PID, we recommend the implementation in the simulation of the expected backgrounds from the accelerator and study performance in the presence of overlapping tracks.
6) We recommend the development of a detailed design of the mechanical support of the photon detectors, as the arrangement seems complex.
7) We support the development and testing of the full-scale prototype.
8) The parameters of the annealing of the SiPMs should be studied to ensure they don't affect neighbouring systems.

- ***PDU**: baseline basically validated*
  Alternate/additional PDUs: *timeline, Peltier, basket ?*
- **Irradiation**: *just intrumental to annealing study ?*
- ***Carrier board**: baseline is fine*
- **Specs**: *largely defined with LLP review*
- **Online annealing protocol and materials**: *ongoing*
- **Cooling without Peltier**: *new chiller being prepared*
- **Insulation**: *test with dRICH prototype in March*
- ***Production & Quality assurance plan***

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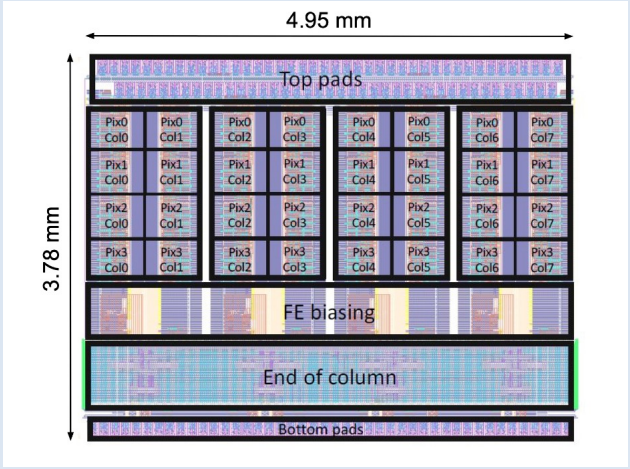
- To reduce dark current, heavy annealing is planned. It is required to check that the charge collection efficiency is not reduced due to over-annealing. The reviewers understand that this is part of the ongoing R&D campaign and that encouraging first results have been obtained.
- We advise exploring the operation of SiPMs at a lower temperature (for example -40C) to guarantee a low level of DCR.
- The online annealing procedure requires forward biasing of the sensors creating local heat generation and large current flows close to the front-end electronics. Precautions will have to be taken to avoid damage to the ASIC. It was understood that this is a part of the R&D effort, for example, through the use of MOSFETs to protect the readout.
- For online self-annealing, all materials, including glue, PCB, etc., have to be checked to see if these are tolerant to the high temperature and if the thermal cycling does not affect the components due to CTE mismatch.

- The quartz window to separate the photodetector box from the gas radiator was identified as a point of attention. A thermal simulation is required with the SiPM array at the foreseen operating temperature of -30 C and the approach to avoid condensation or convection of the C2F6 gas radiator should be described. The reviewers fully recognize the importance of the foreseen small-scale system tests in the SPS test-beam facility later this year.

- **ALCOR v2.0 – v2.1**: *chip available or produced*
- ***Irradation***: *no evident issue*
- **ALCORv3 64**: *being designed (AC vs DC)*
- ***BGA Packaging***: *being negotiated*
- ***ALCOR Board***: *being outlined*
- ***Specs***: *to be formalized (ToT?)*
- ***Production & Quality assurance plan***



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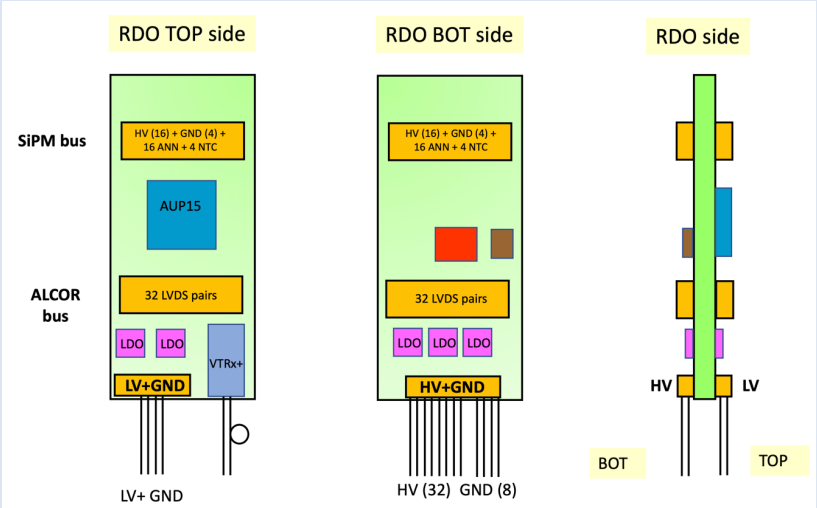
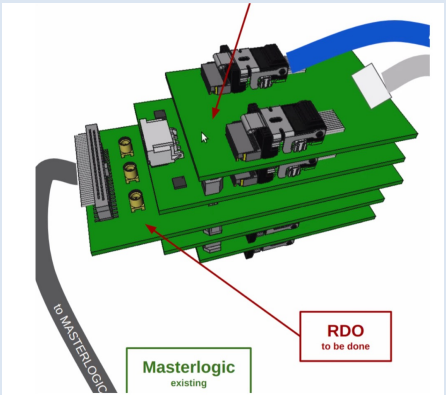
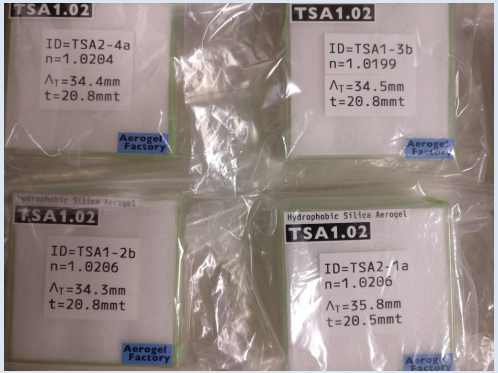
5) We recommend continuing to move forward as quickly as possible to integrate readout solutions, developed as part of the eRD109 efforts, to the various relevant subdetector integration tests.
6) Proposals related to ASIC development activities are encouraged to make sure to consider potential additional cost of chip packaging in future years budget requests

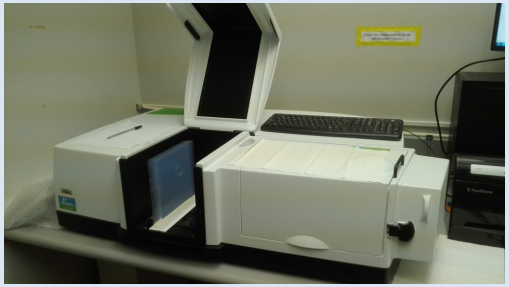
- ***General layout***
- ***RDO Board**: being designed*
- ***RDO FPGA**: ARTIX Ultrascale+ & Polarscale scrubber*
- **RDO Transceiver**: *VTRX+ (secured)*
- ***Fake-FEB**: being designed*
- ***L1-filter:** interaction tagger or dRICH tagger*
- ***L2-filter**: ML patter recognition study (test-beam data)*
- ***Production & Quality assurance plan***
- ***Felix DAM**: to be implemented (can be post-TDR)*





- **Test-beam data analysis:** *preliminary result available*
- **Characterization:** *preliminary study done*
  transmittance, forward scattering, planarity, chromaticity
- **Reproducibility**: *under negotiation with Aerogel Factory*
- ***Real-scale sample**: being prepared with Aerogel Factory*
- ***Specs**: refractive index & thickness optimization*
- ***Production & Quality Assurance plan (Temple U., Chiba ?)***
- *Long-term tests with C_2F_6 or pressurized N2*





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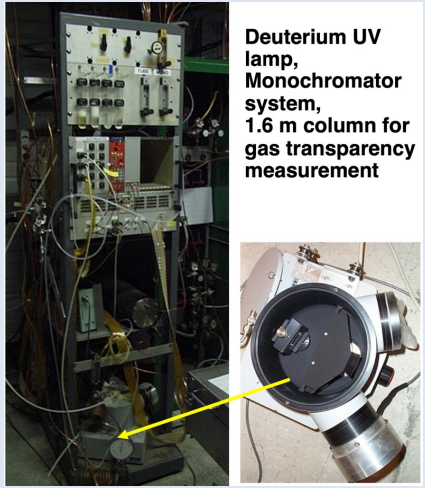
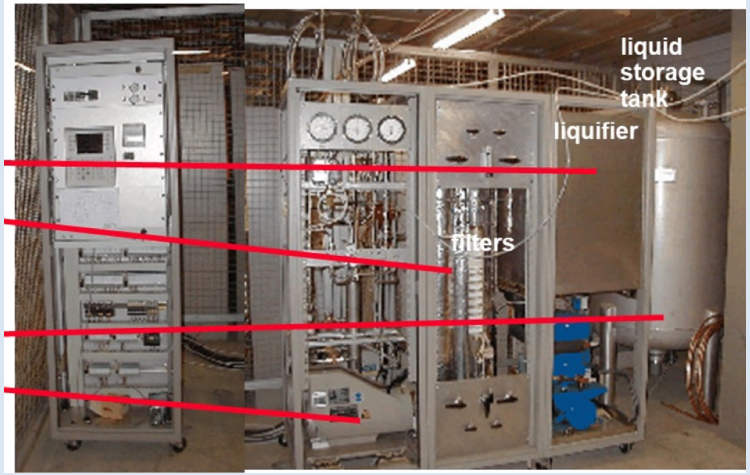
3) It is important to understand the aerogel quality issues and give feedback to this manufacturer in order to allow time for the production of aerogel which meets the requirements of the detector.

- **Test-beam data analysis:** *preliminary result available*
- ***Long-term tests with composite materials****: in preparation*
- **Characterization:** *basic information*
  transmittance, purity
- ***Specs****: need formalization*
- **Purging system**: *basic scheme to define services*
- ***Fast-recirculation system****: basic scheme to define services*
- ***Mitigation***





- **Specs:** *derived from CLAS12 / LHCB*
- ***Samples**: ordered*
- **Small demo:** *compatible with present prototype*
  suitable for long-term test with gas
- **Medium-size proto**: *ePIC structure, material under discussion*
- ***Characterization (JLab, DUKE)***
- ***Alignment/Support**: aka NA62, piezo-motor acquired*
- ***Production & Quality Assurance plan***