dRICH beam test CERN-PS May 2024

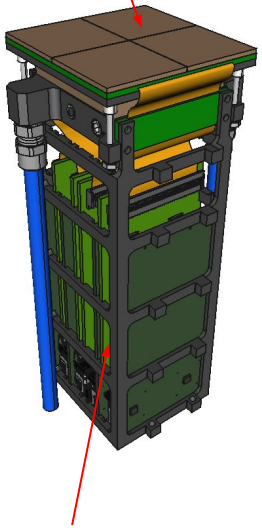
Roberto Preghenella

2023 test beam at CERN-PS

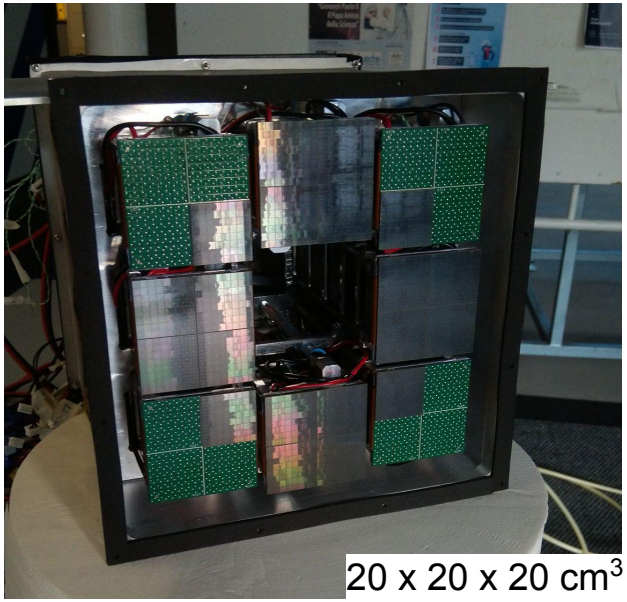
successful beam test with prototype SiPM photodetector units (CERN-PS, ended on 18th October)

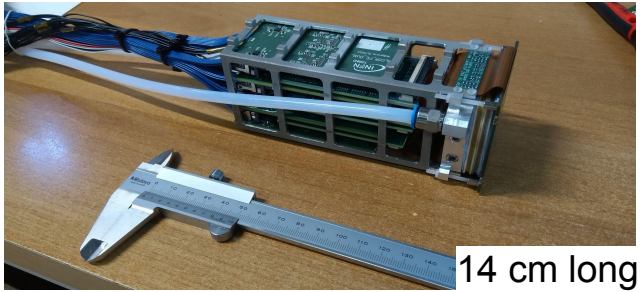
PDU

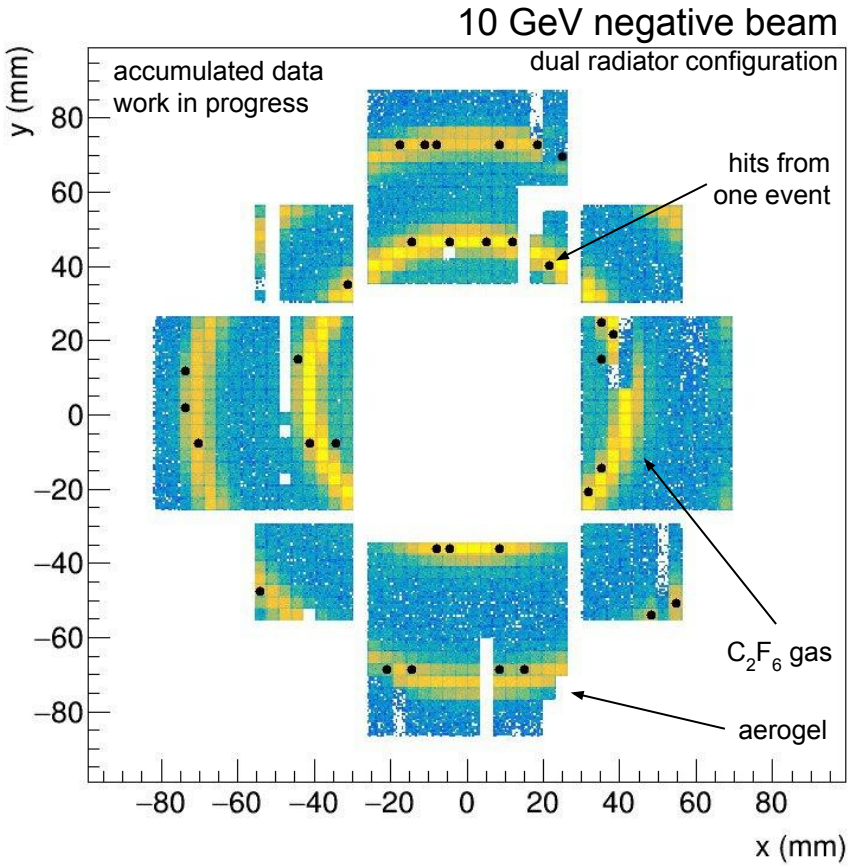
4x SiPM matrix arrays
(256 channels)



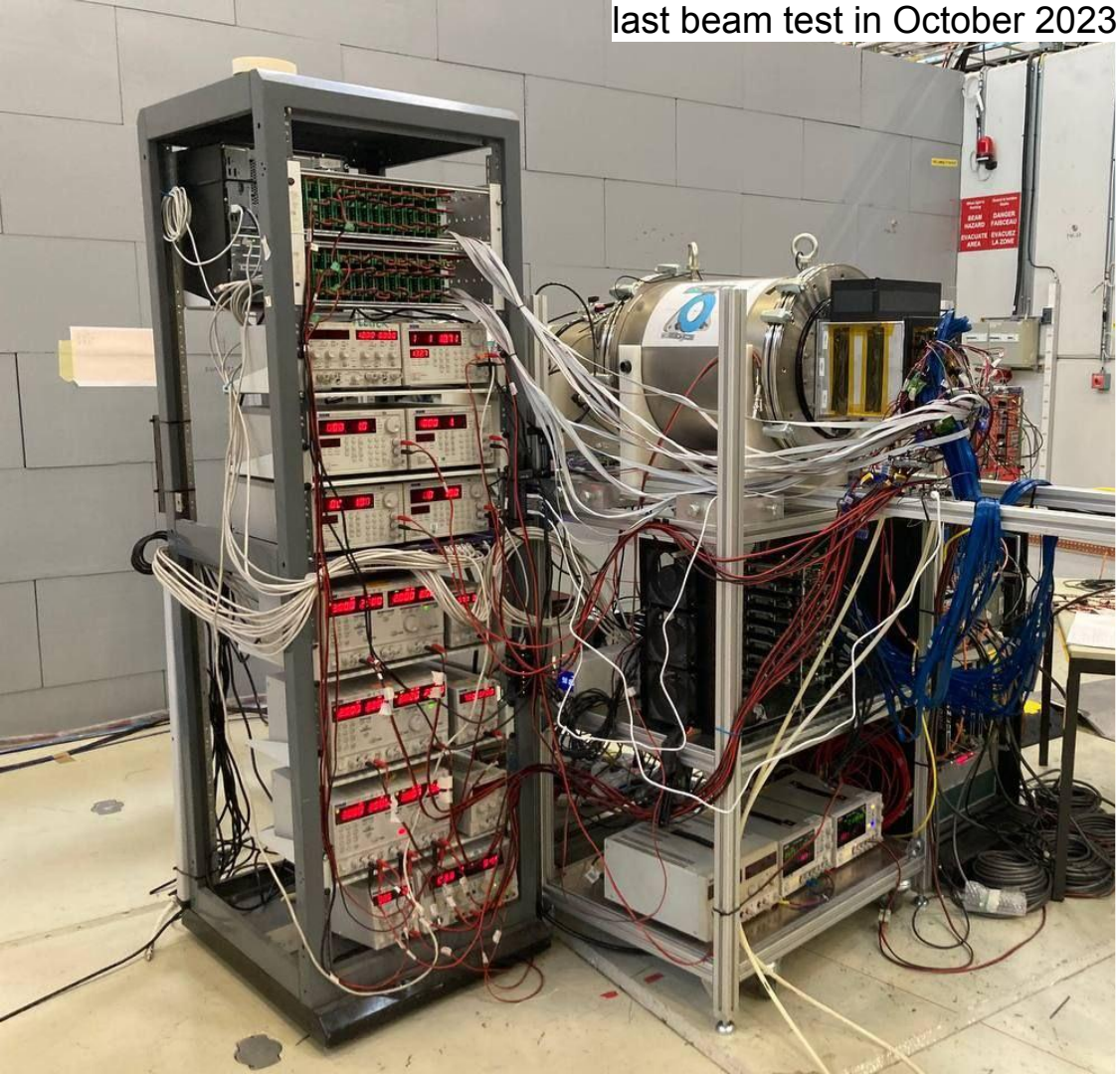
front-end electronics
(ALCOR ASIC inside)

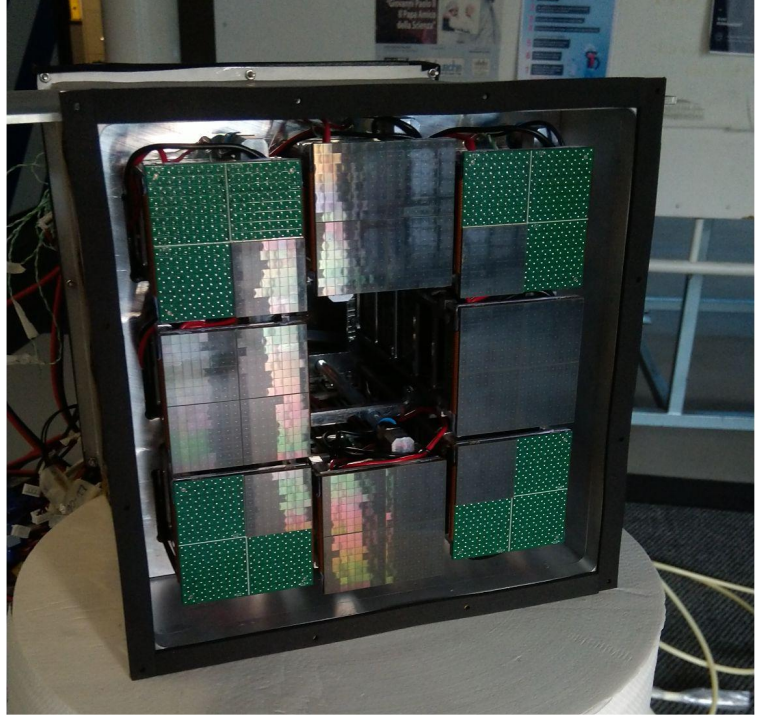


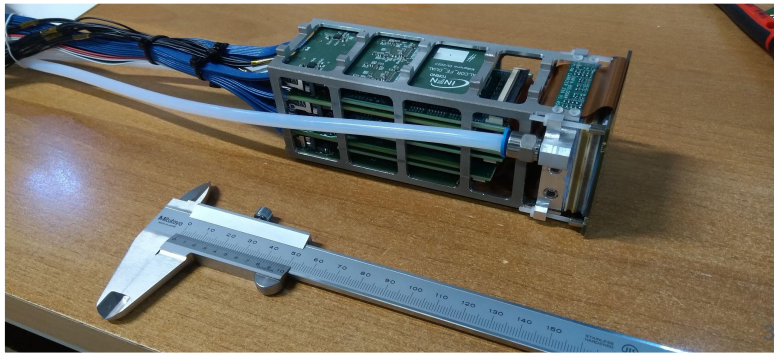




last beam test in October 2023



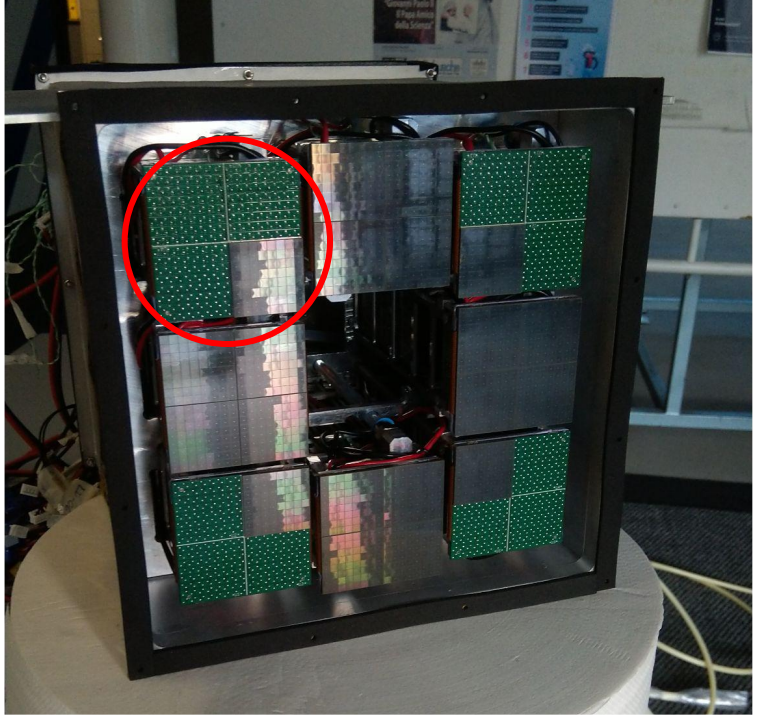


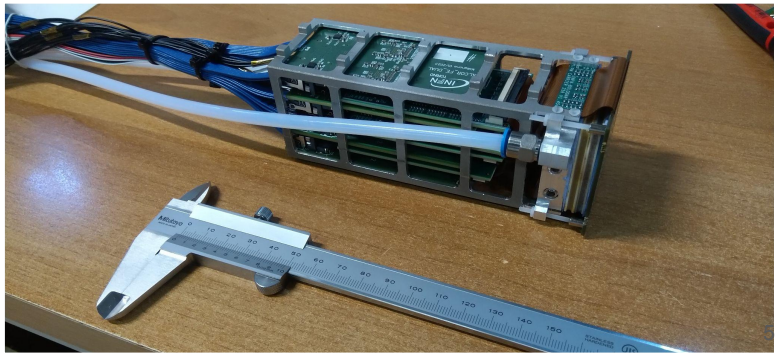


hardware

Hardware goals (important)

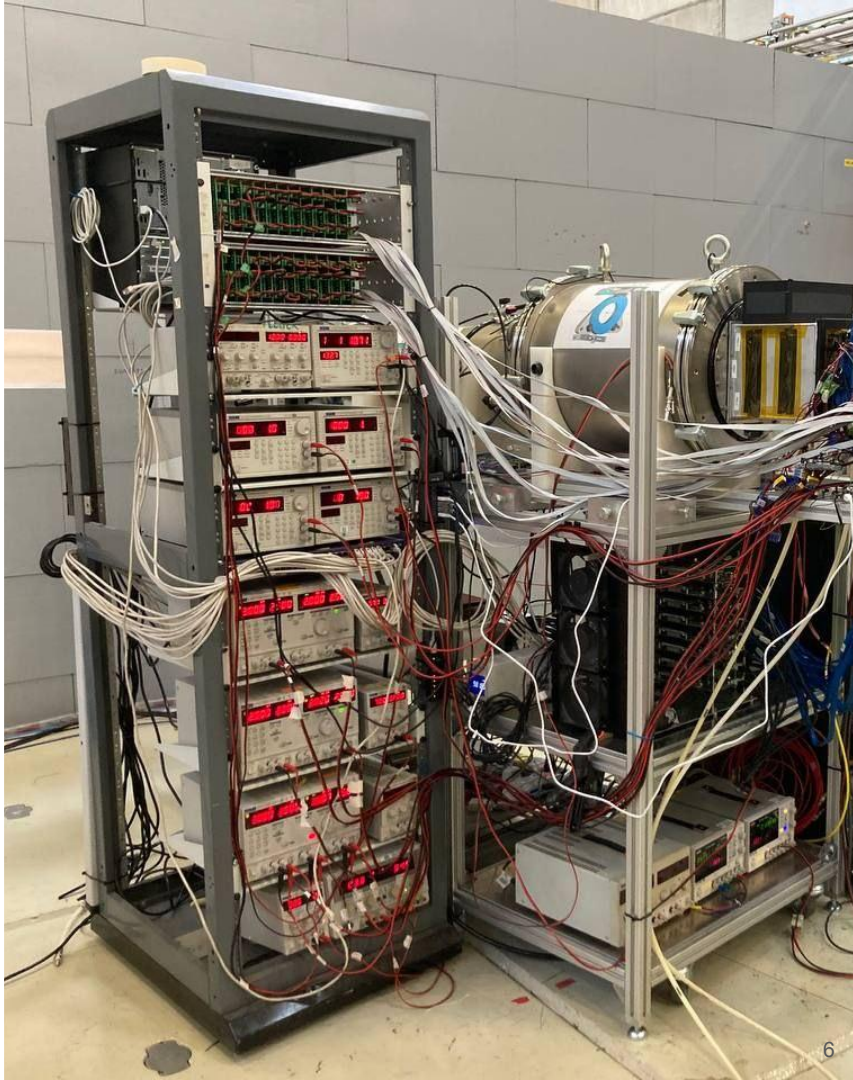
- **replace the partial PDUs at the corners**
  - 8x full 256-channels PDUs
  - 2048 readout channels
  - full ring imaging
- **test different Hamamatsu sensors**
  - we have matrices to build
    - 4x S13360-3050 PDU heads
    - 4x S13360-3075 PDU heads
    - 4x S14160-3050 PDU heads
  - although not obviously simple to change configuration during beam test
  - we might decide to equip the readout with
    - 4x S13360-3075 PDUs
    - 2x S13360-3050 PDUs
    - 2x S14160-3050 PDUs
- **replace faulty electronics**
  - install as many ALCOR v2.1 chips as possible
- **include a tracker**
  - GEMs or another tracking system
  - add information on track direction



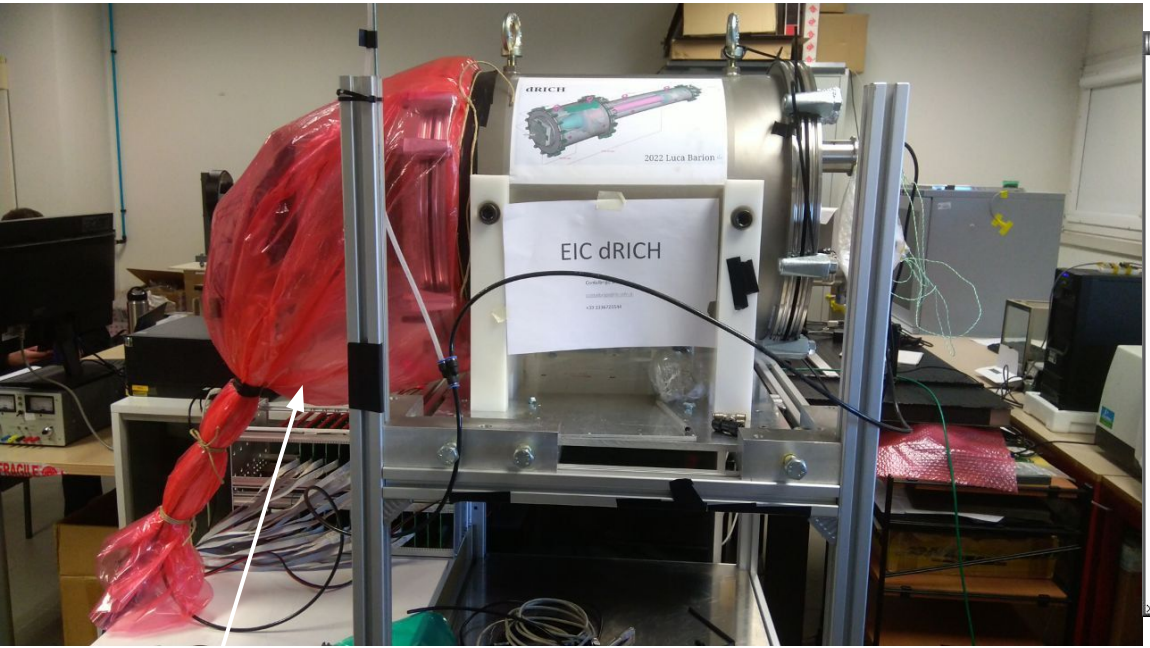


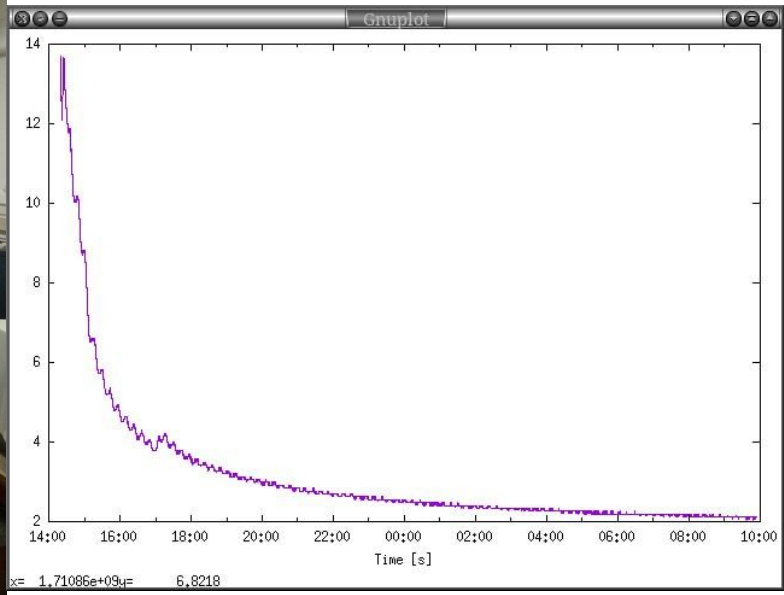
Hardware goals (less important)

- **sub-zero cooling with liquid fluid**
  - this will be very unlikely
  - presently still issues with tiny fluid leaks
    - even if we understand how to deal with soon, we will likely need a long rework of the PDU cooling system
    - unlikely to fit in the preparation schedule
  - baseline is to keep Peltier cooling
    - need to improve humidity, on the right track
- **use compact power-supply system**
  - LV distribution based on CEAN SY mainframe
    - might help reduce rack allocated space
    - will look closer to a real experiment detector
- **improve timing system**
  - currently based on two scintillators
    - time resolution is not fantastic: 150-200 ps
  - would be nice to go below 50 ps
    - system must be in sync with ALCOR readout
    - not impossible, but need extra work and thinking



Thermal and humidity tests

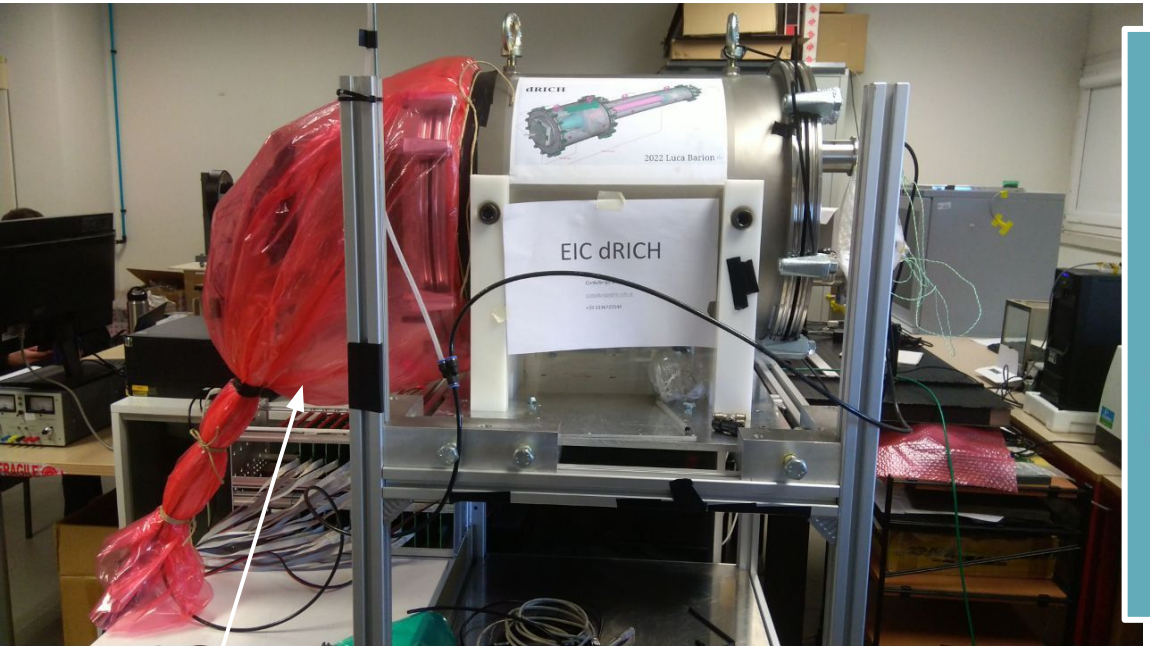


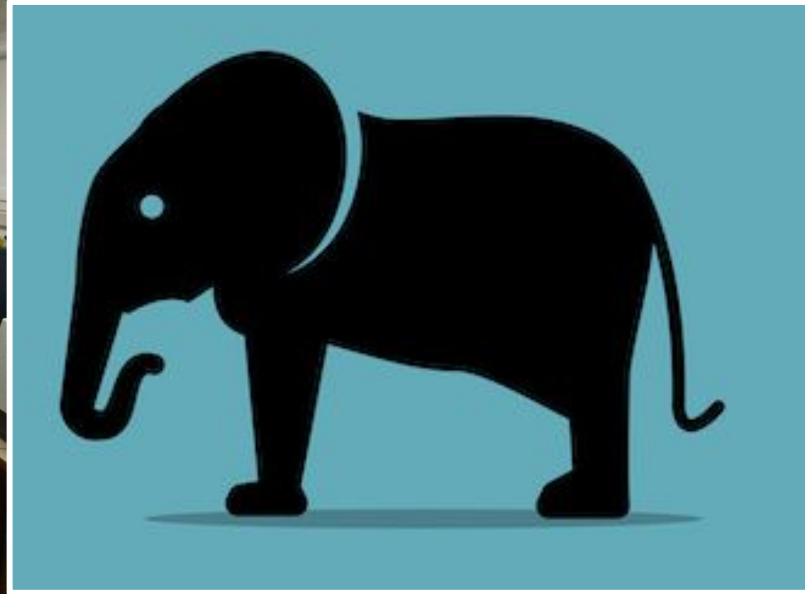


seems to be promising

new "technology" being tested in Ferrara to keep the SiPM volume better sealed for dry operations

Thermal and humidity tests





it looks like an elephant to me

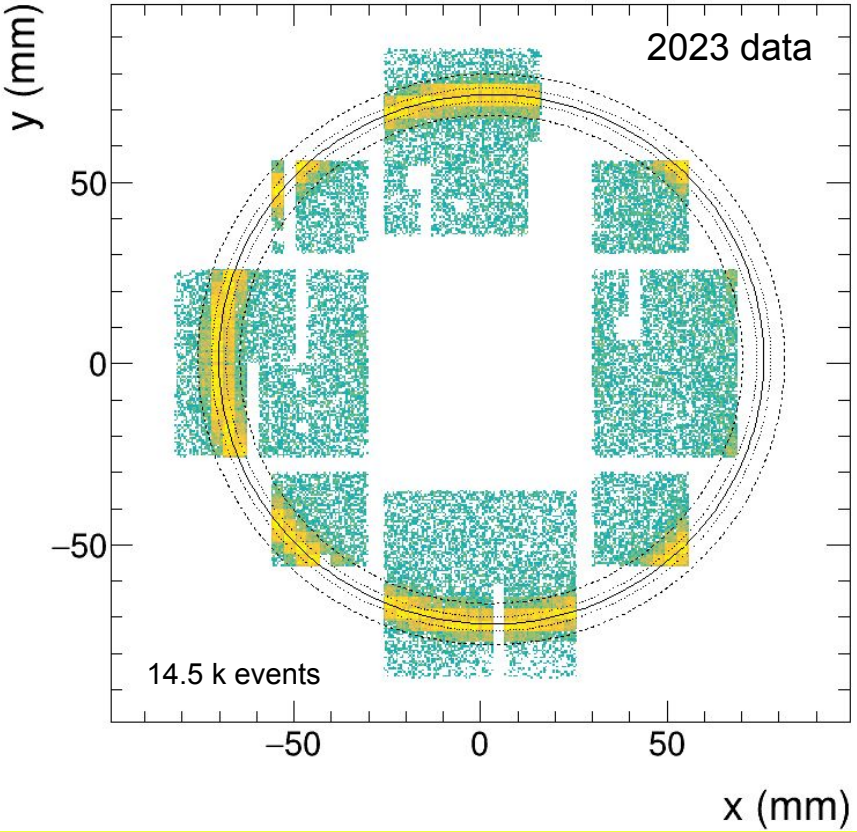
new "technology" being tested in Ferrara to keep the SiPM volume better sealed for dry operations

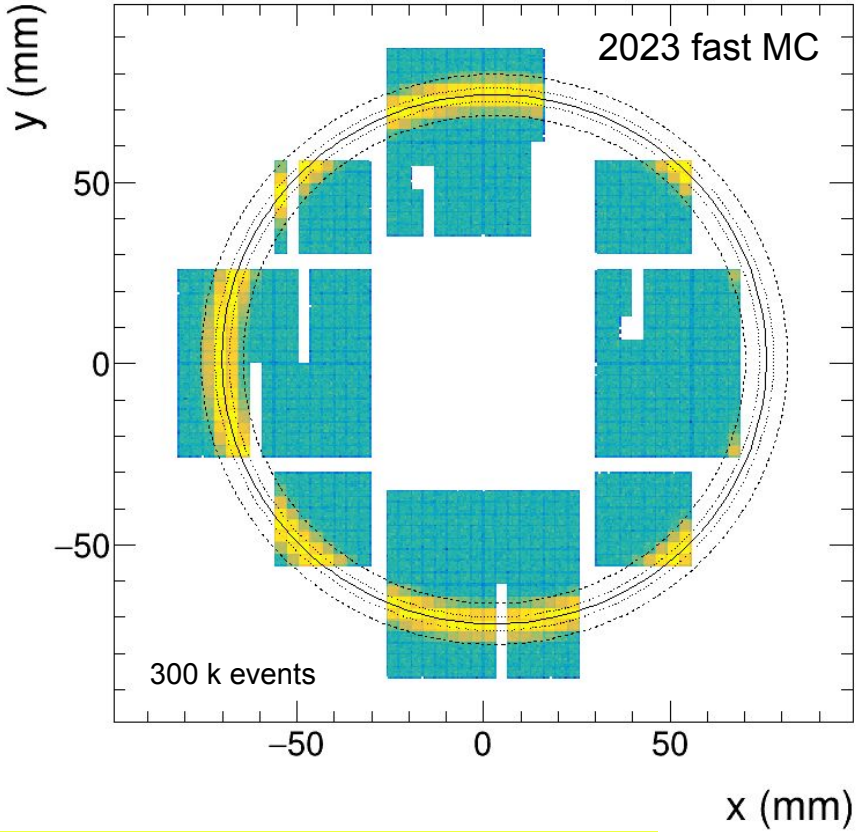
physics

Number of photoelectrons

2D fit parameters match accurately fast MC input
notice redefinition of Nsig and Nbkg

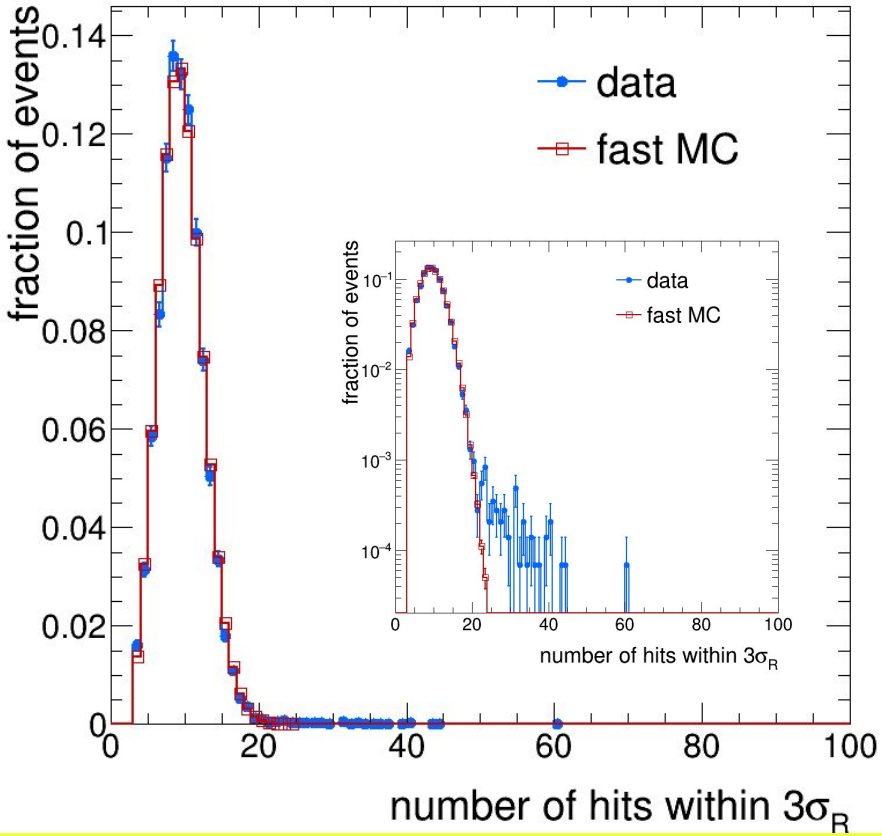
Nsig	=	23.6048	+/-	0.0154101
X0	=	2.87125	+/-	0.00255149
Y0	=	1.18834	+/-	0.00193679
R	=	73.0013	+/-	0.00166626
sigmaR	=	1.88591	+/-	0.00123206
Nbkg	=	10.3538	+/-	0.0133316





large number of detected aerogel photons in 2023, on average **more than 9 photoelectrons over the active area**

Number of photoelectrons



event-by-event distribution of the number of detected hits within 3σ of the globally-fitted ring radius

excellent agreement between data and fast simulation

⟨N⟩ = 9.056 ± 0.025

don't know why last time I got a different value ⟨N⟩ = 11.31 see (slide 11), maybe I did something wrong

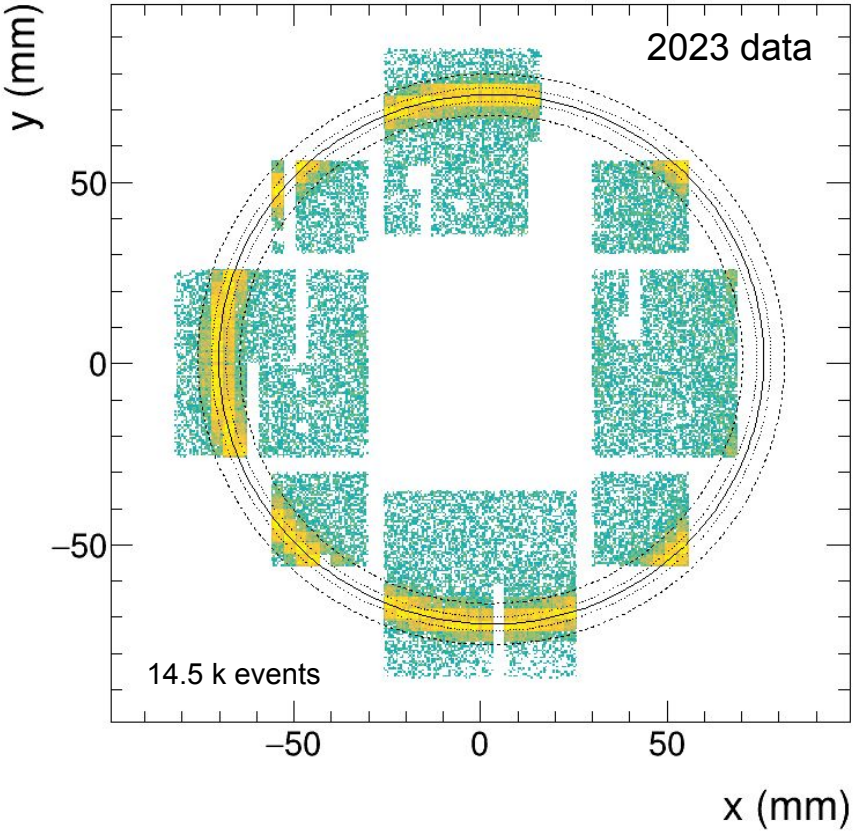
tail of events with an excess of hits can be nicely appreciated comparing data and fast MC

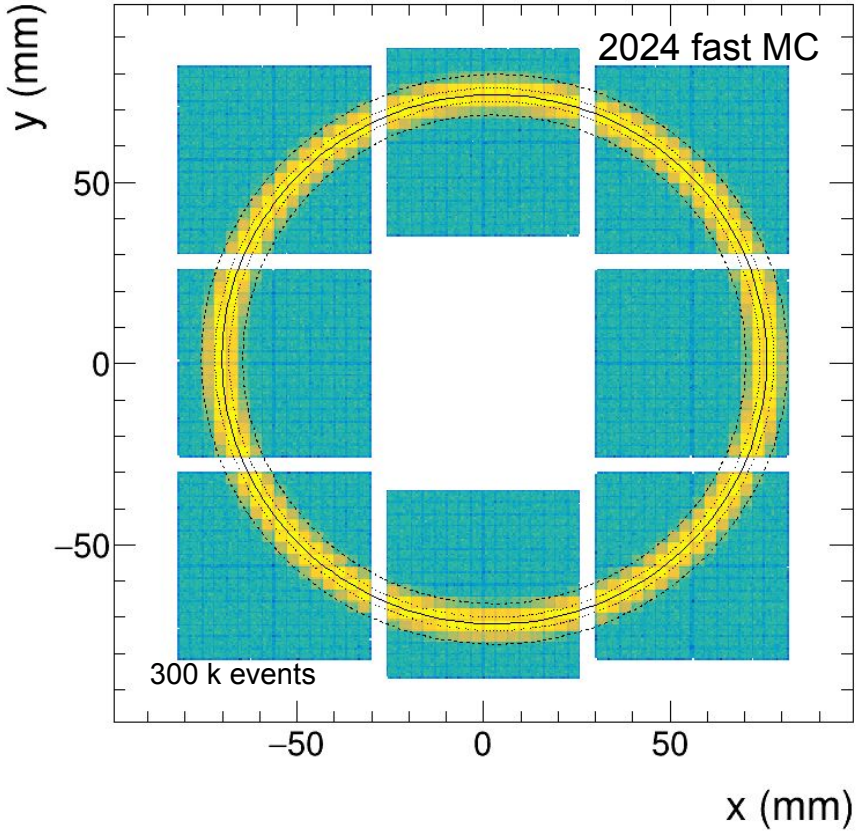
nice agreement with fast MC simulations, would be **nice to have detailed GEANT4 simulations** with the ePIC SiPM parameters

Number of photoelectrons

2D fit parameters match accurately fast MC input
notice redefinition of Nsig and Nbkg

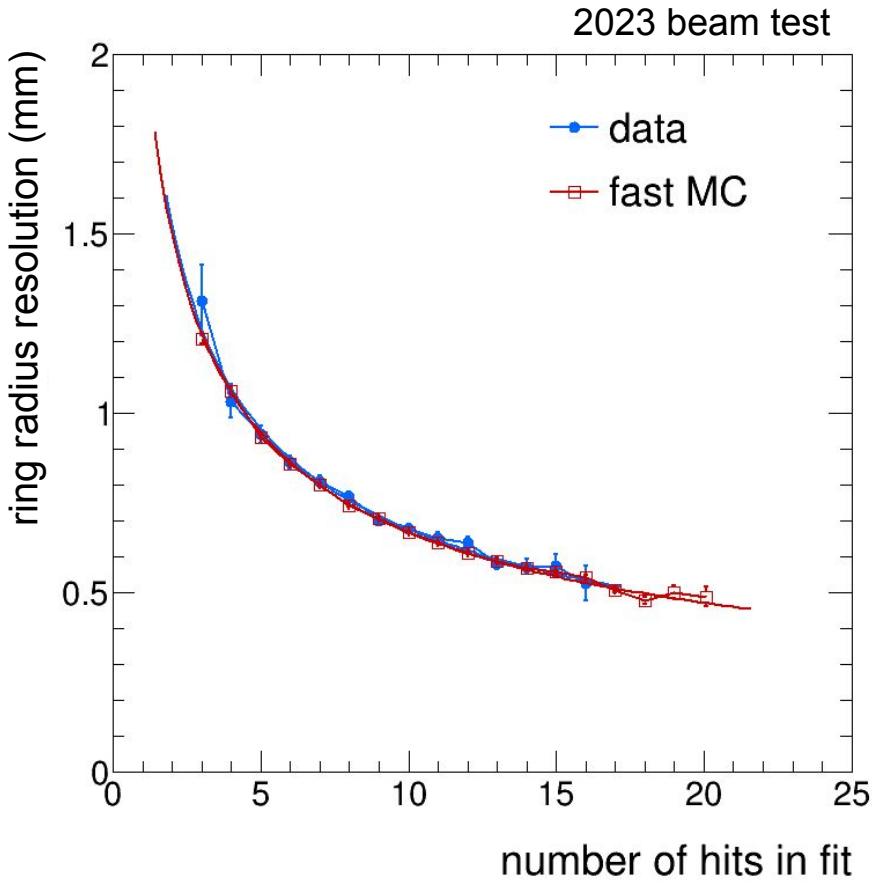
Nsig	=	23.6048	+/-	0.0154101
X0	=	2.87125	+/-	0.00255149
Y0	=	1.18834	+/-	0.00193679
R	=	73.0013	+/-	0.00166626
sigmaR	=	1.88591	+/-	0.00123206
Nbkg	=	10.3538	+/-	0.0133316





fast MC expectation for a 2024 beam test with 8x full PDUs is a **very large average number of photoelectrons for aerogel > 18**

Ring radius resolution



fitting with a circle the hits that fall within 3σ of the globally-fitted ring radius

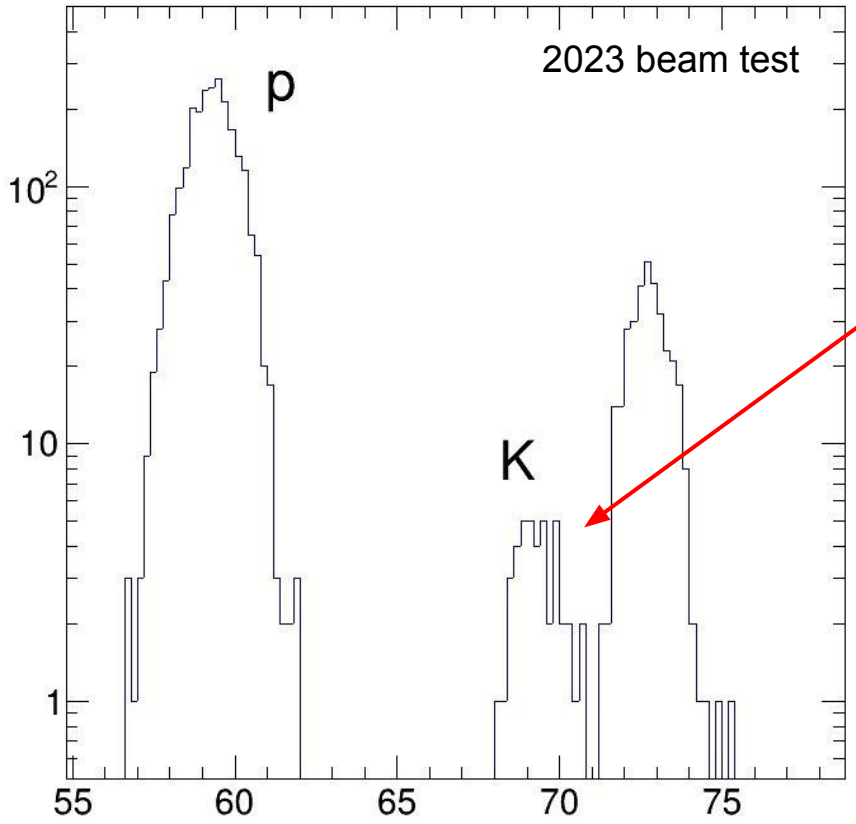
X_0 and Y_0 parameters fixed, R free
this gives the best radius resolution, try if you do not believe it

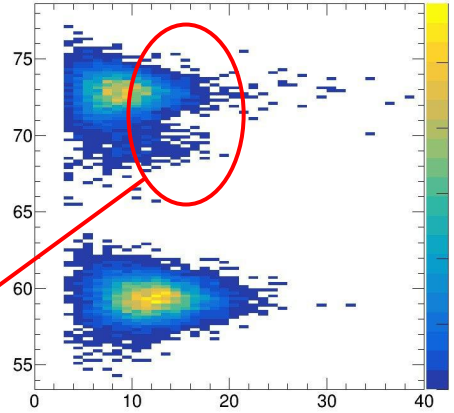
excellent agreement between data and fast simulation

A / √N fit to data and fast MC yield consistent single photon resolution

$\sigma_{R,1pe}$ = 2.141 ± 0.014 mm

Particle identification





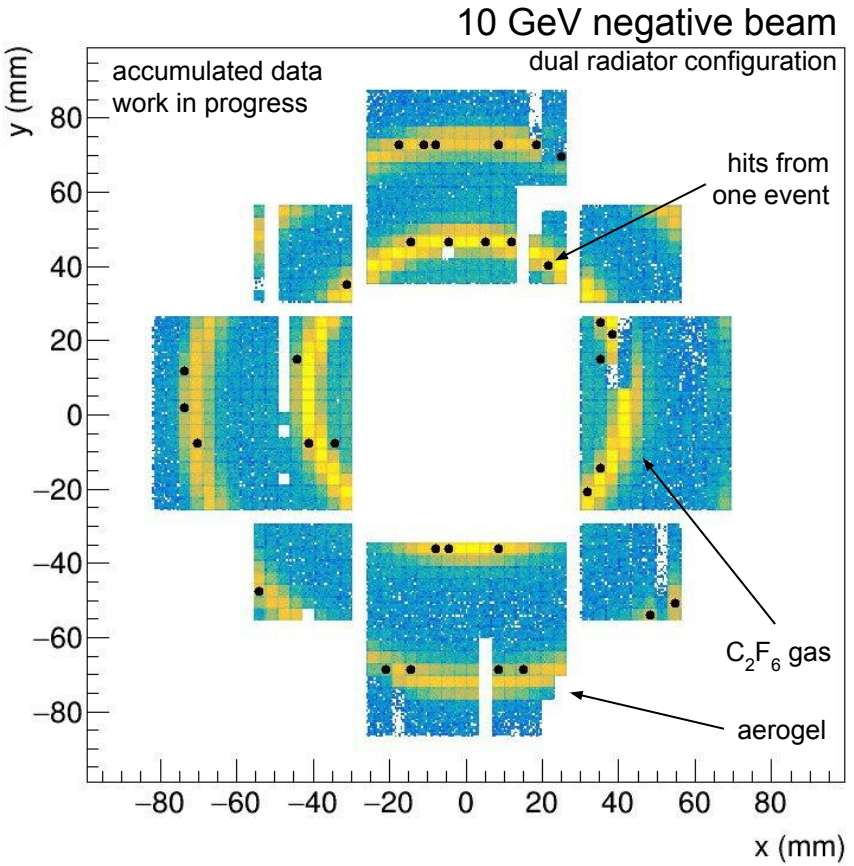
with an 8 GeV/c positive beam we could have nice separation of kaons from pions

trick: select events with a large number of photons
but in 2024 we expect to have many photons

momentum beam scans will provide beautiful propaganda plots of the PID performance of the dRICH prototype

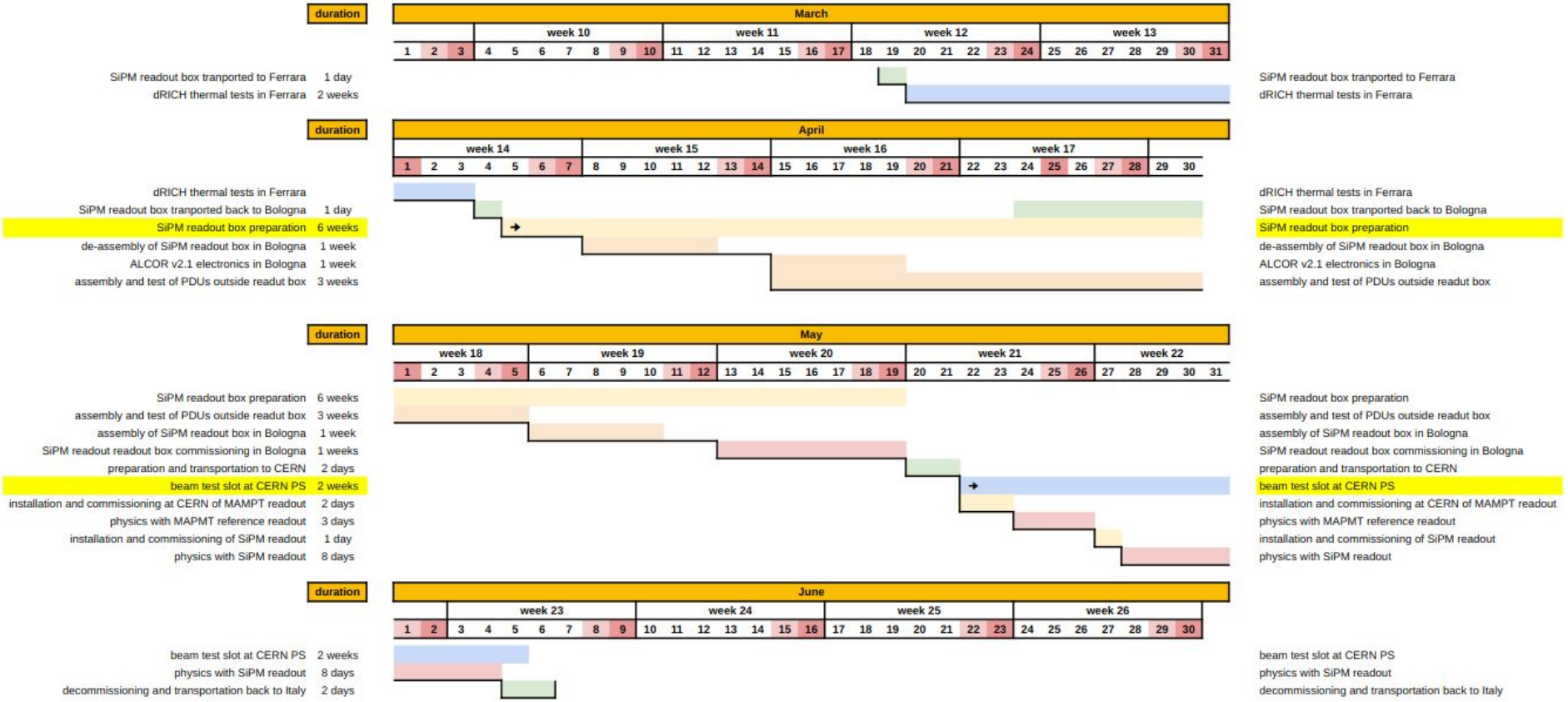
Physics goals (from the top of my head, my personal opinion)

- **number of photoelectrons**
  - aerogel and gas
    - in 2023 we did not collect much gas data
  - compared to reference MAMPT readout
  - with different Hamamatsu SiPM sensors
  - with different aerogel
    - refractive index
    - thickness
  - with wavelength filters
    - number of SiPM detected photons vs. λ
    - effective SiPM chromaticity
- **single-photon angular resolution**
  - tune the position of mirrors for optimal focus
    - in 2023 we did it almost "by eye"
    - we need to have online performance analysis
  - make use of tracking system
- **particle identification**
  - as a function of beam momentum
  - with tracking and more photons might yield something unexpectedly nice 😉



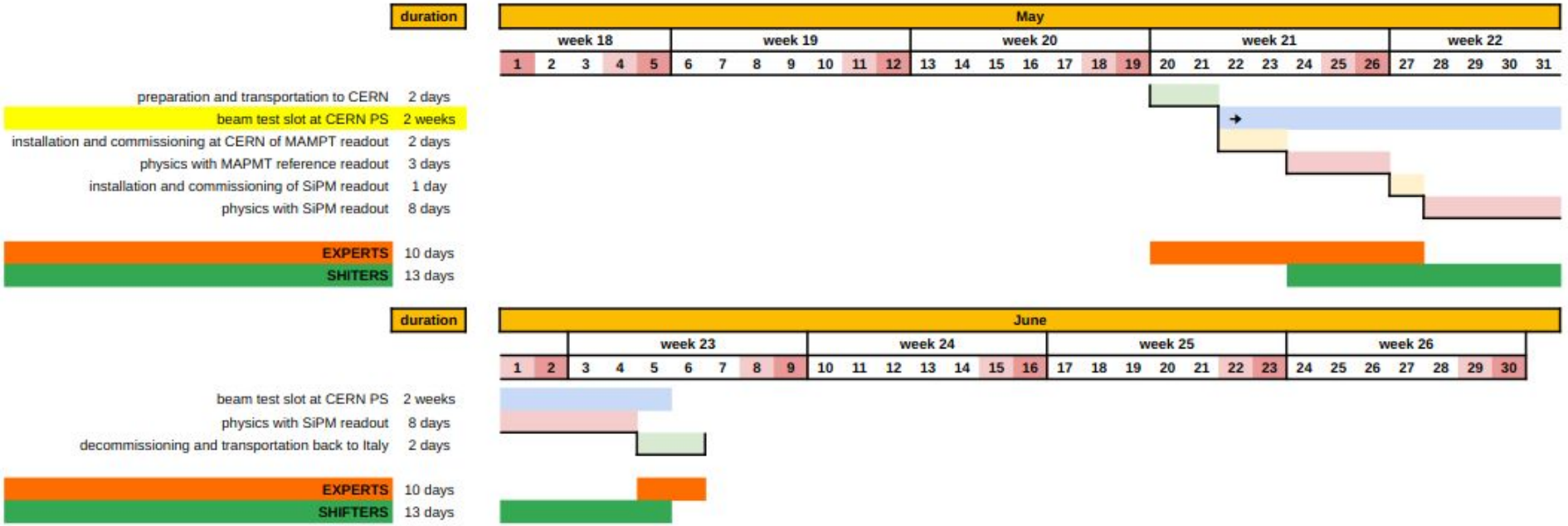
planning

Planning at a glance



https://docs.google.com/spreadsheets/d/1Y-hVsSOhIhytjAh1xGwsOto5v1LAQ2kSNmqUo_u5ixY/edit?usp=sharing

Focus on test beam required people



presence of experts actually depends on what measurements we really want to do and when, and how simple certain operations are

for instance: change aerogel, change wavelength filters, put/remove gas and so on are likely all operations to be done by experts around

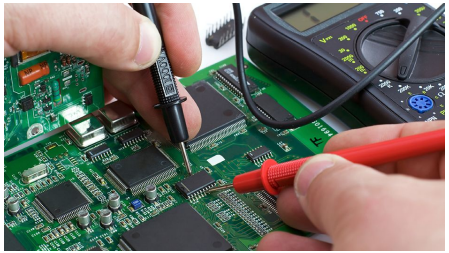
experts: 3-4 people / day

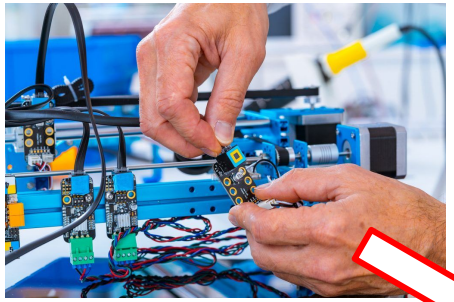
shifters: 6 people / day (2 people / shift, 3 shifts / day)

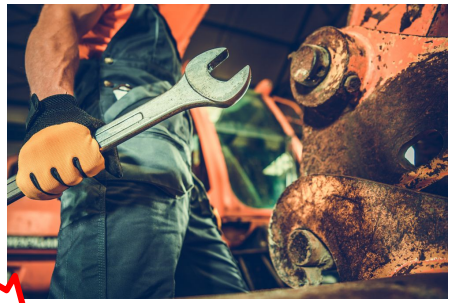
Fun ahead and help needed towards success

- **analysis software and Monte Carlo**
  - can be done anywhere
  - this is crucial
  - realistic simulation very important
- **test of ALCOR electronics**
  - in Torino
- **assembly and test of PDUs**
  - in Bologna
- **assembly of SiPM readout box**
  - likely in Bologna
  - also full system commissioning
- **dRICH prototype installation**
  - at CERN
  - also tracking system
- **dRICH operation and data taking**
  - at CERN
  - online performance monitor

very diverse set of activities







everybody can have fun and can help in making this beam test a success of the dRICH Collaboration