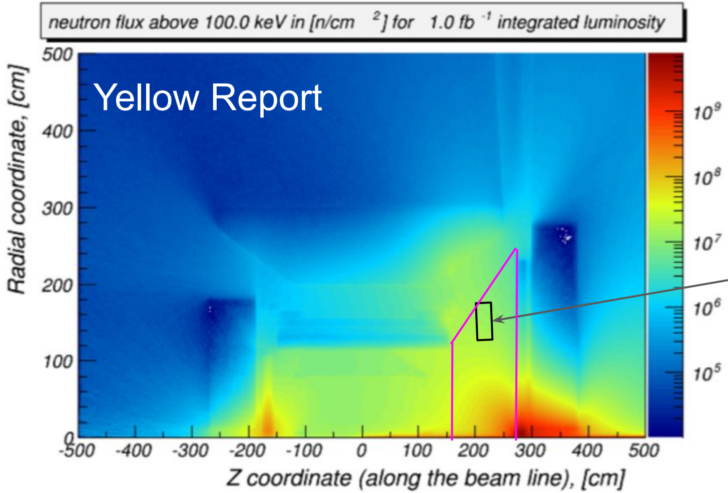
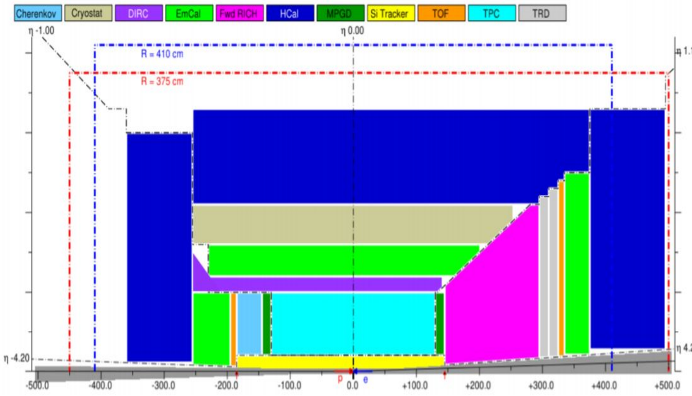
SiPM option for RICH optical readout

- **pros**
  - cheap
  - high photon efficiency
  - excellent time resolution
  - insensitive to magnetic field
- **cons**
  - large dark count rates
  - not radiation tolerant

a quick report on SiPM R&D activity within INFN groups

Neutron fluxes and SiPM radiation damage





Most of the key physics topics discussed in the EIC White Paper [2] are achievable with an integrated luminosity of 10 fb^{-1} corresponding to 30 weeks of operations. One notable exception is studying the spatial distributions of quarks and gluons in the proton with polarized beams. These measurements require an integrated luminosity of up to 100 fb^{-1} and would therefore benefit from an increased luminosity of $10^{34}\text{cm}^{-2}\ \text{sec}^{-1}$.

possible location of dRICH photosensors
neutron fluence for 1 fb^{-1} → 1-5 10^7 n/cm^2 (> 100 keV ~ 1 MeV n_{eq})

- radiation level is moderate
- magnetic field is high(ish)

R&D on SiPM as potential photodetector for dRICH, main goal
study SiPM usability for Cherenkov up to 10^{11} 1-MeV n_{eq}/cm^2

notice that 10^{11} n_{eq}/cm^2 would correspond to 2000-10000 fb^{-1} integrated $\mathcal{L}$
quite a long time of EIC running before we reach there, if ever
it would be between 6-30 years of continuous running at $\mathcal{L} = 10^{34}\ \text{s}^{-1}\ \text{cm}^{-2}$

→ better do study in smaller steps of radiation load

10^9 1-MeV n_{eq}/cm^2	*most of the key physics topics*
10^{10} 1-MeV n_{eq}/cm^2	*should cover most demanding measurements*
10^{11} 1-MeV n_{eq}/cm^2	*possibly never reached*

1st irradiation round done in mid-may 2021

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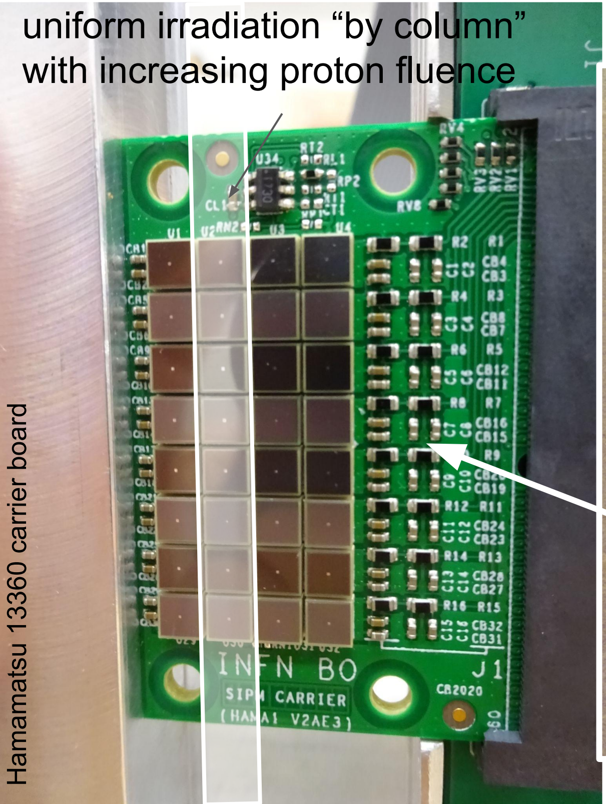
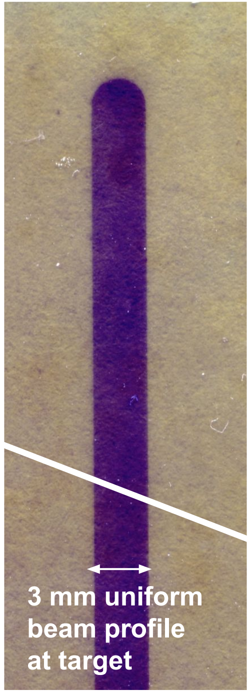
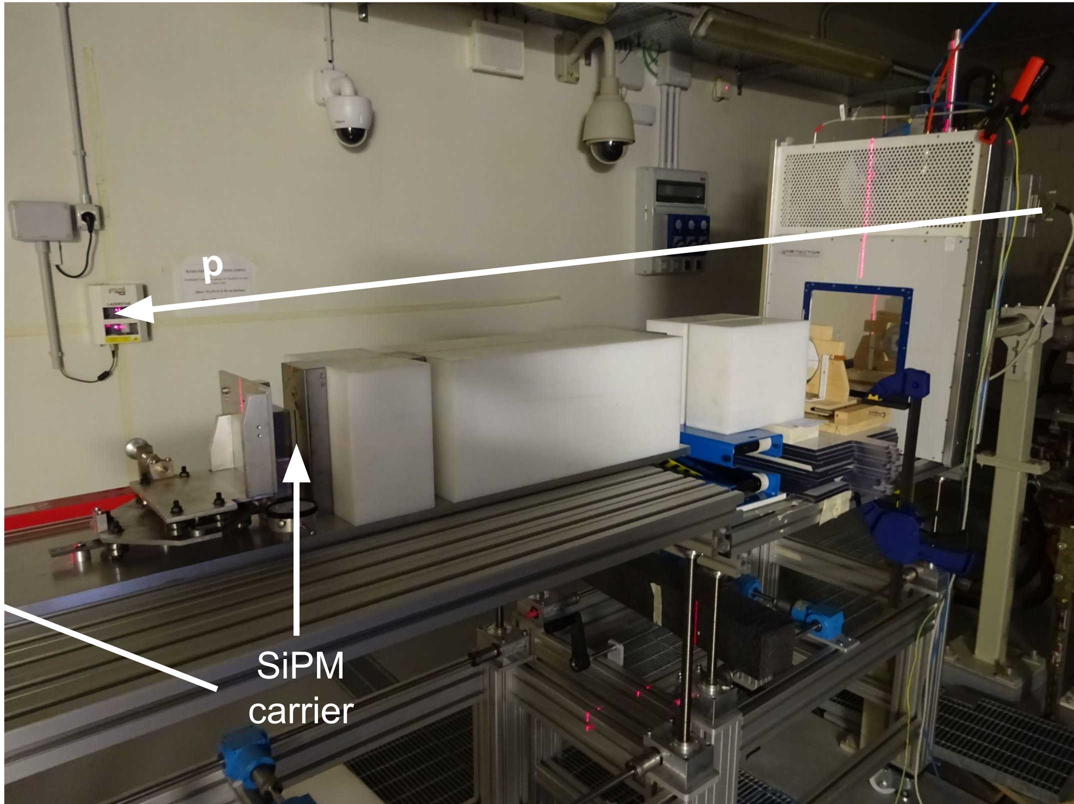
3x3 mm^2 SiPM sensors
4x8 “matrix” (carrier board)

multiple types of SiPM: **Hamamatsu** commercial (13360 and 14160)
FBK prototypes (rad.hard and timing optimised)

148 MeV protons → scattering system → collimation system → carrier board







SiPM radiation damage and mitigation strategies

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Radiation damages increase currents, affects V_{bd} and increase DCR
With very high radiation loads can bring to baseline loss, but…
does not seem to be a problem up to 10^{11} n_{eq}/cm^2 (if cooled, T = -30 C)

If the baseline is healthy, single-photon signals can be be detected one can work on reducing the DCR with following mitigation strategies:

- Reduce operating temperatures (cooling)
- Use **timing**
- High-temperature annealing cycles

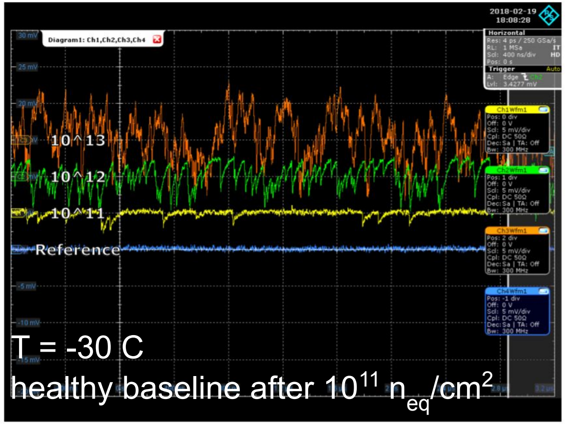
Key point for R&D on RICH optical readout with SiPM:

- demonstrate capacity to measure Single Photon
- keep DCR under control (ring imaging background)

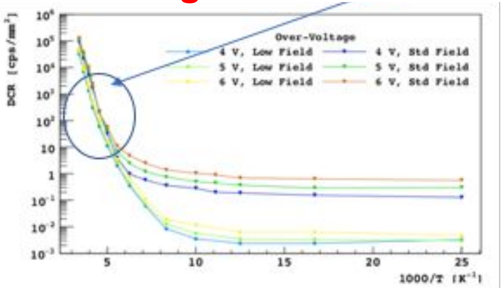
despite radiation damages

Calvi, NIM A 922 (2019) 243

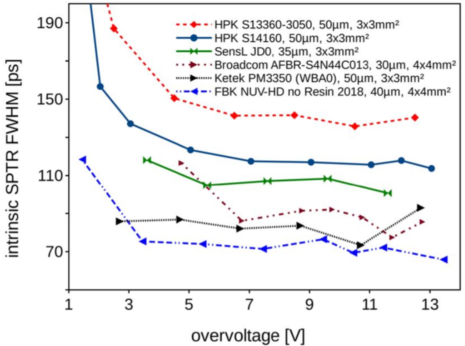
10^{11}

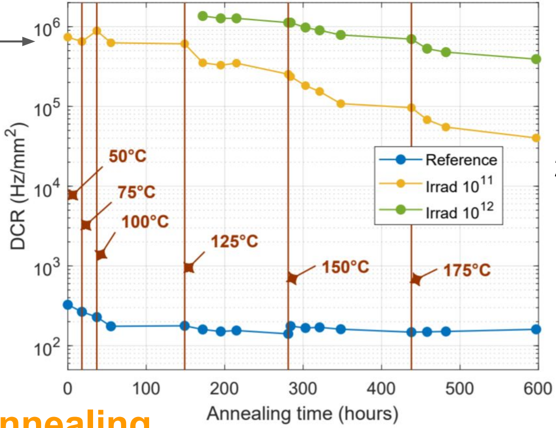


cooling



timing





200x less DCR

annealing