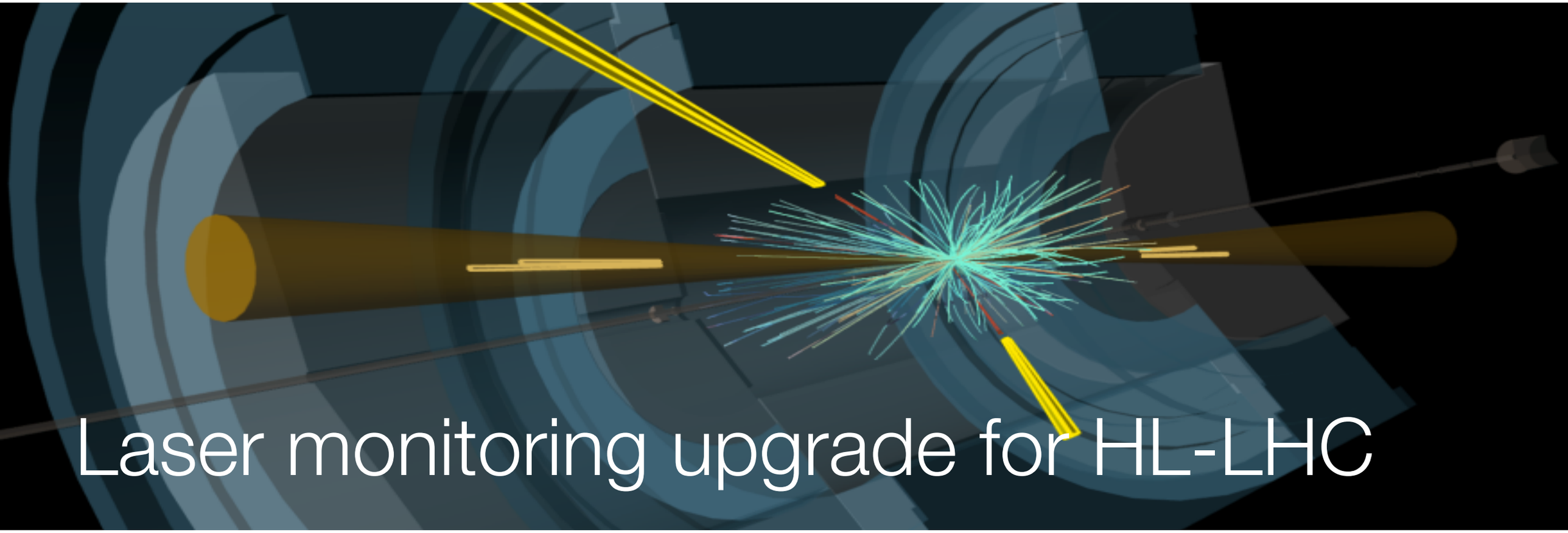


# Laser monitoring upgrade for HL-LHC

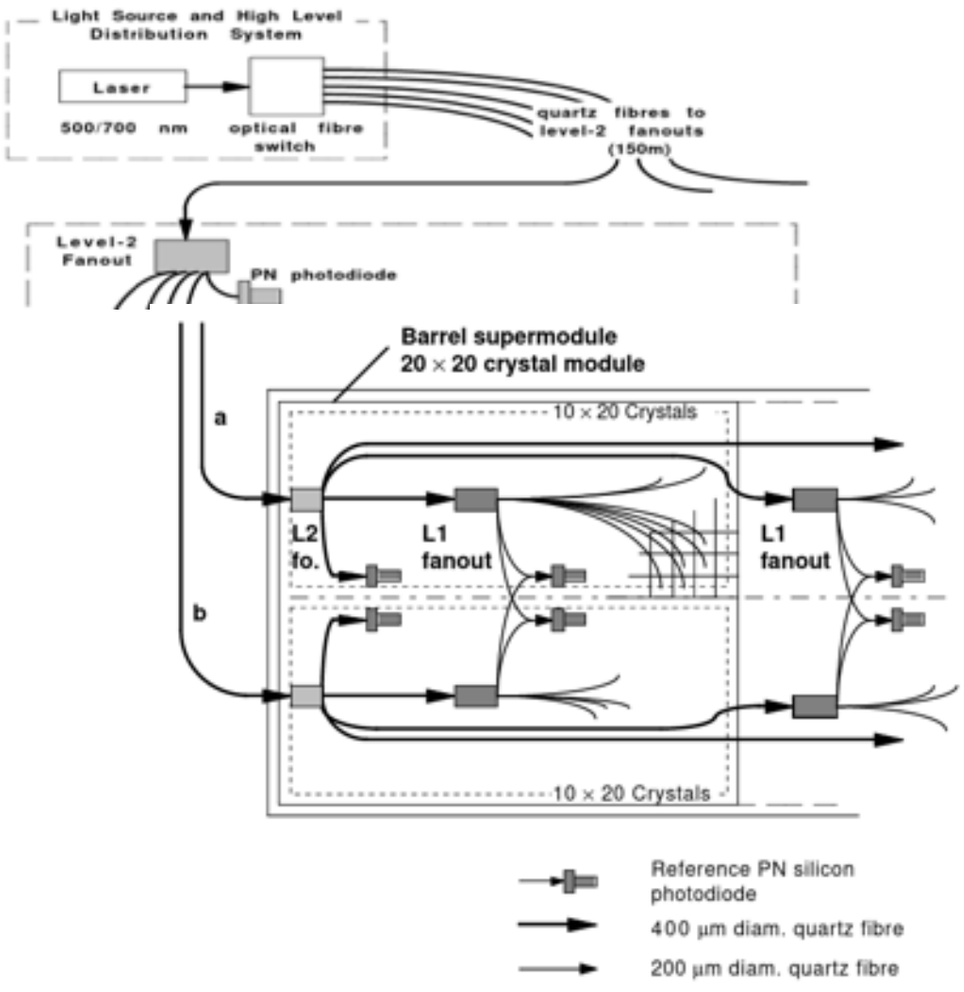
Bruno Lenzi on behalf of the ECAL laser team

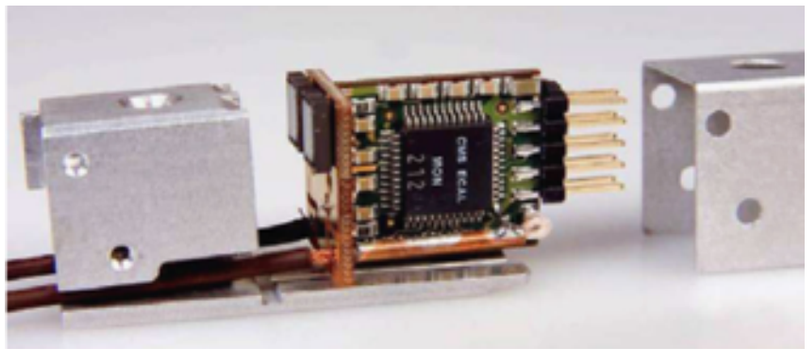
ECAL days @ ETH Zurich

22/05/2019

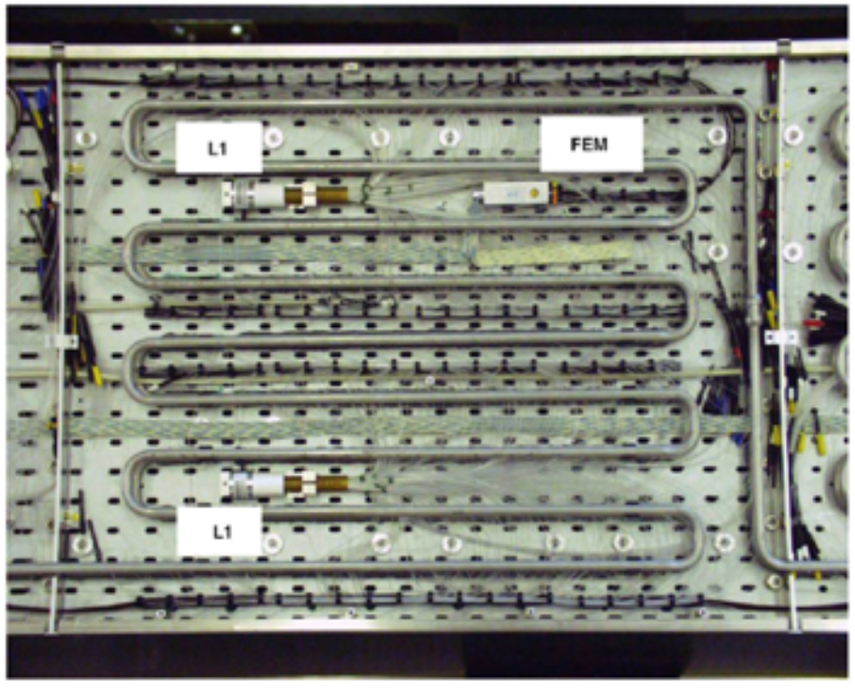
# Present system

- Laser injected in each crystal, grouped into Light Monitoring (LM) regions
  - Each ECAL module (100-200 crystals) includes 2 reference PN diodes
  - Each PN diode monitors 2 LM regions



FEM

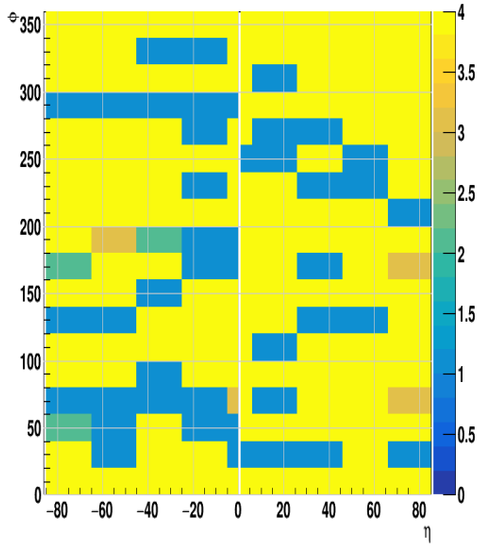


# Known and possible issues (i.e. why changing ?)

- Laser barrack to be moved to surface to free space for tracker cooling
  - Tests with long fibers (100-200m) in March
- Fibers darkening with radiation
  - L2 fibers with different lengths/locations inside detector → differential ageing
    - Major work required to change them, not planned!

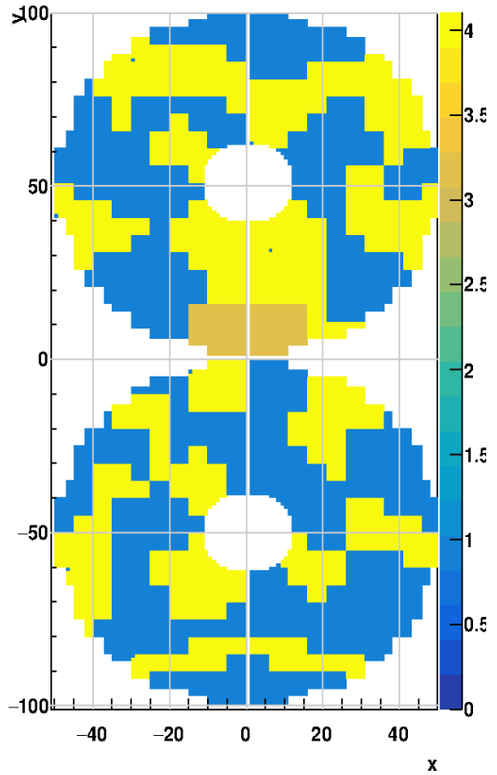
Data at end october 2018

EB




1 – know region with one PN
2 – pnA/pnB drifts (>1%) for both sides – PN problem
3 – pnA/pnB drifts (>1%) only on one side – fiber problem
4 – no drift (<1%)

EE



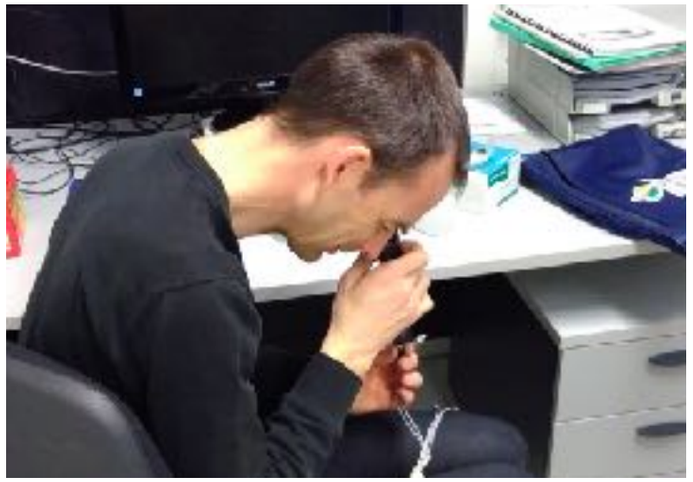

- PN diodes expected to stand HL-LHC conditions but some already show strange behaviour
- Electronics (MEM) not compatible with HL-LHC readout system

**See talk by M. Dejardin on upgrade meeting**

# Tests with long fibers

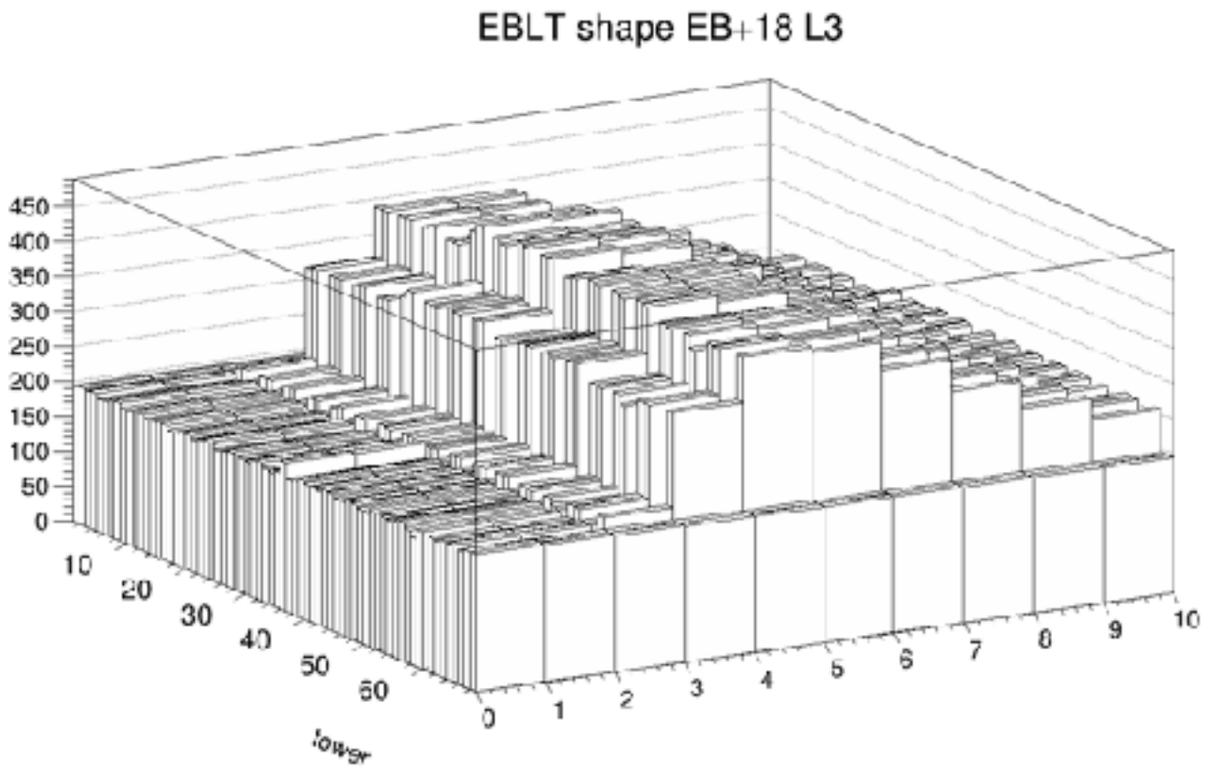
- 6 spare bundles of ~100m fibers
- First tests in March 2018 during data-taking not fully conclusive. Could not recover all inputs and data
- Initial plan for 2019: read simultaneously regions with and without long fibers adjusting delays of LM regions individually
  - Not possible (see elog) with current software
  - Dedicated runs / delay settings for each fiber length (no fiber, 100m fibers, 200m fibers)

- Configurations / runs:
  - No fiber: run 328437 (reference) or 328483 (with delays)
  - 100m: LMs 45-50 / EB+5-7, runs 328485 and 328486
  - 200m: LMs 45-47 / EM+5-6, runs 328492 and 328493
  - 200m before monitoring box/Matacq, runs 328562 (EB+5-6), 328593 (full barrel)



# Tests with long fibers

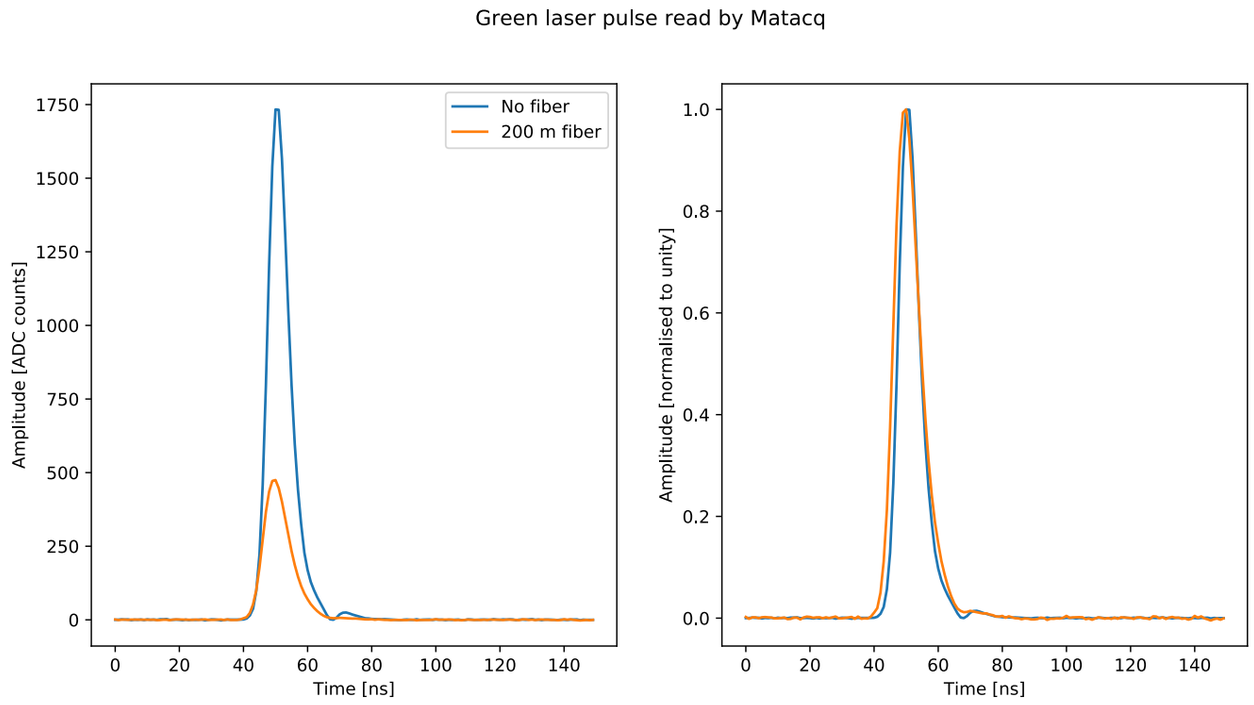
- Delays / DAQ configurations worked as expected
  - Signals seen on Matacq and APDs (DQM - thanks to G. Cucciati)




- Tuning of laser processing software needed in order to derive precise corrections
  - Manual analysis of Matacq data in the following

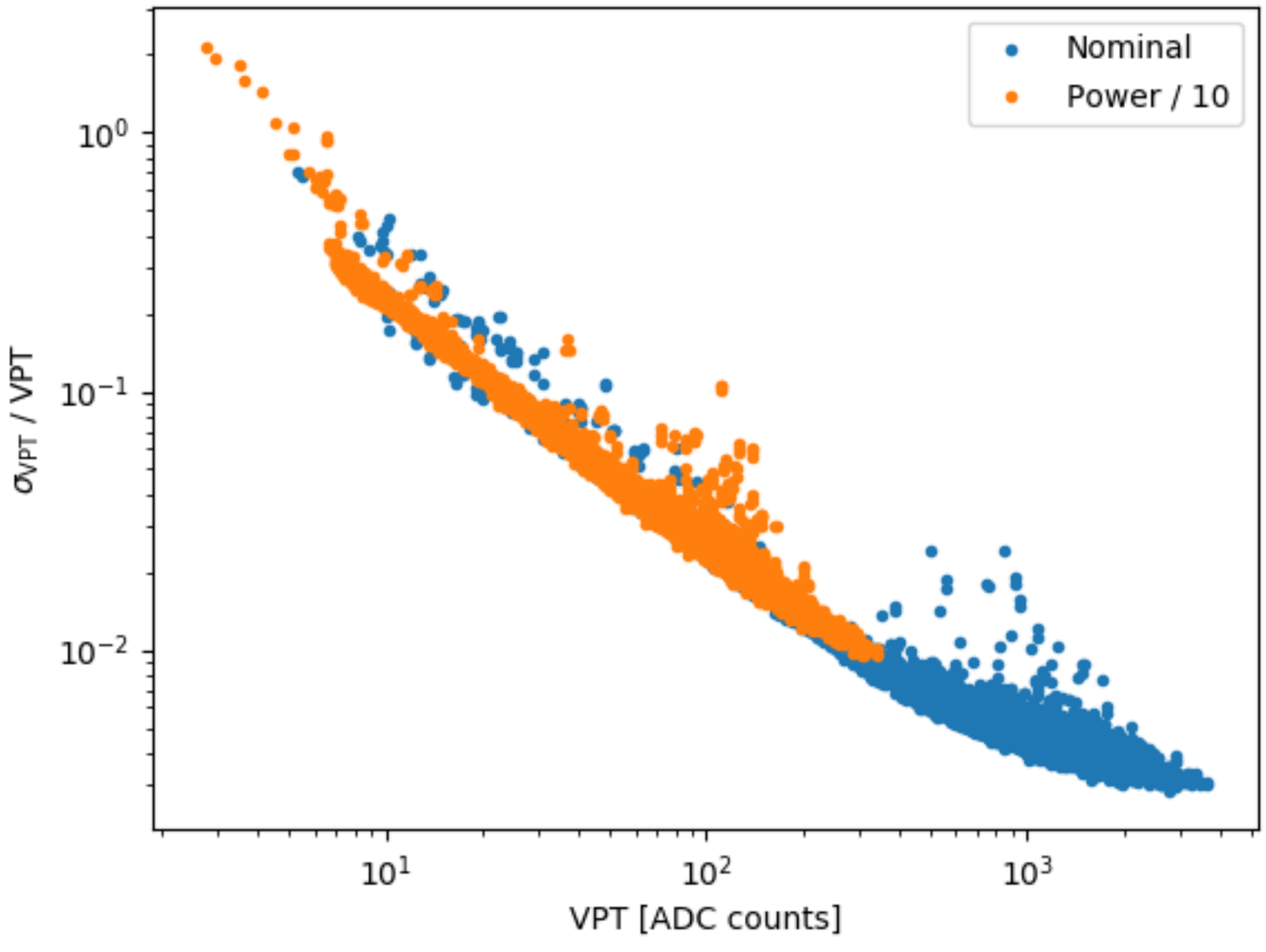
# Tests with long fibers

- Amplitude decreased by factor ~2 (~4) with 100m (200m) fibers
  - Expected (1 dB for connector + ≤ 1 dB for fiber)/100m, observe 3 dB
- Small impact on laser pulse shape (~invisible on APDs)
- In contact with DAQ experts to investigate constraints in receiving trigger signals and sending Matacq data (links, latency)
  - 150m probably still just about ok, to be confirmed



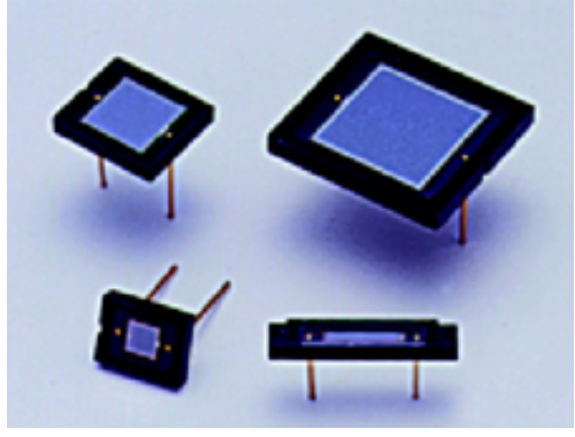
# Bonus: laser power scan

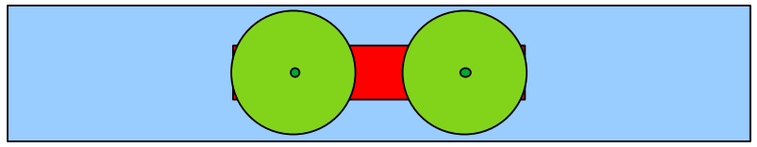
- From laser power scan performed in March
  - Relative error of measured amplitude (N.B. divide by √600 ~25 to get error on the mean) ~ok even with lower power



# Upgrade of laser monitoring system

- Current plan: upgrade MEM + FEM + PN diodes with enhanced redundancy
  - Should help distinguishing between drifting fibers, PNs ,…
  - New PN diodes (rectangular instead of square)
    - Same ferrule as for crystals (new porte-ferrule)
    - Double the number of PNs (24 / SM), read out by FEM (1 FEM every 2 PNs)
  - 1 MEM / SM digitises data @ 80 MHz (LiTE-DTU) from FEMs in gains 1 and 10. Includes 1 ECAL FE card per gain
    - BCP will read 2 MEM FEs + 68 crystal FEs
- New interface between CMS and laser monitoring box
  - Integrate laser data (Matacq) in ECAL DAQ

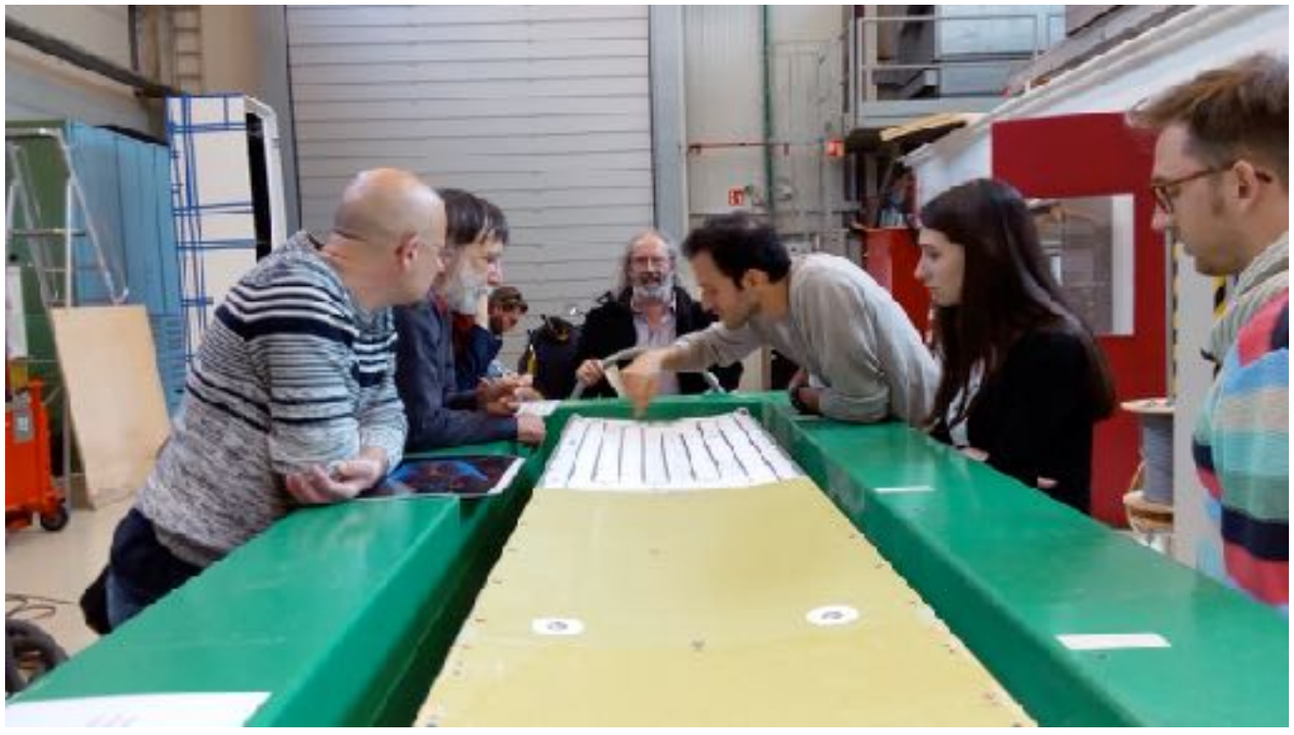


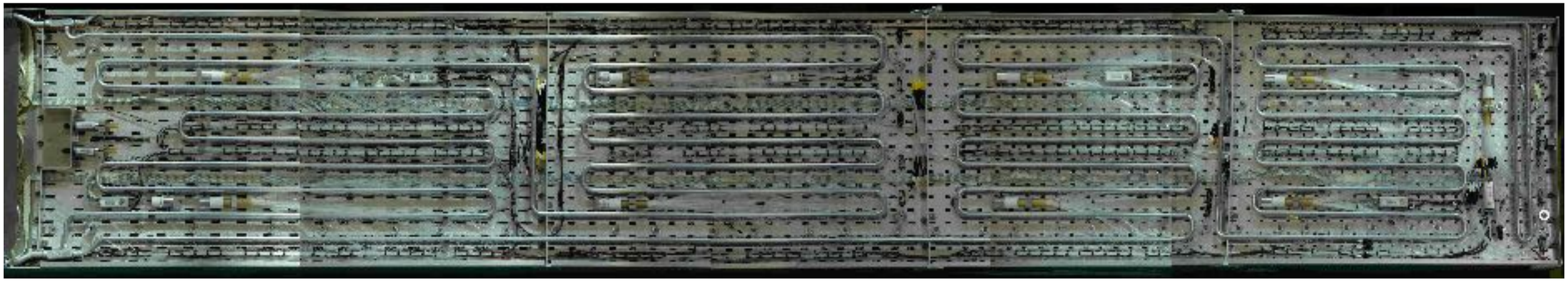


S1227-16BQ

# Opening of SM36

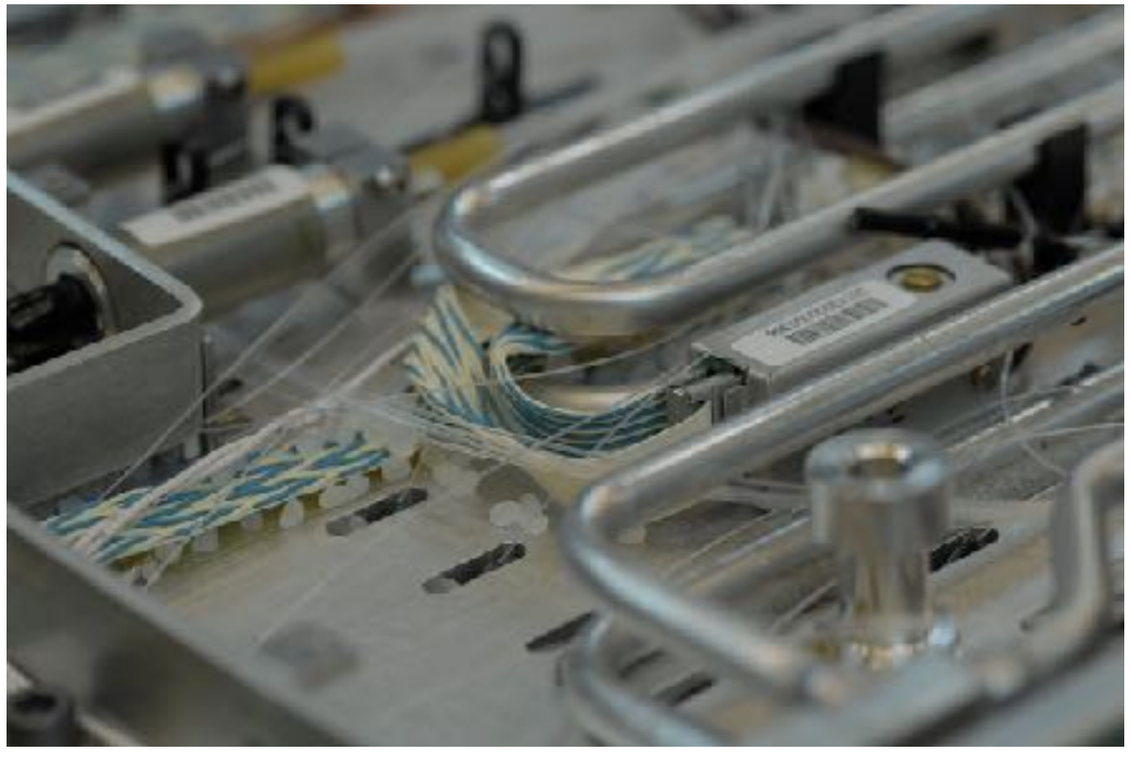
- SM36 opened in April to investigate constraints and possibilities
  - Thanks to ECAL technical coordination, CERN ( Dominique, Igor) and ETH staff (Michael Dröge, …) and everyone involved

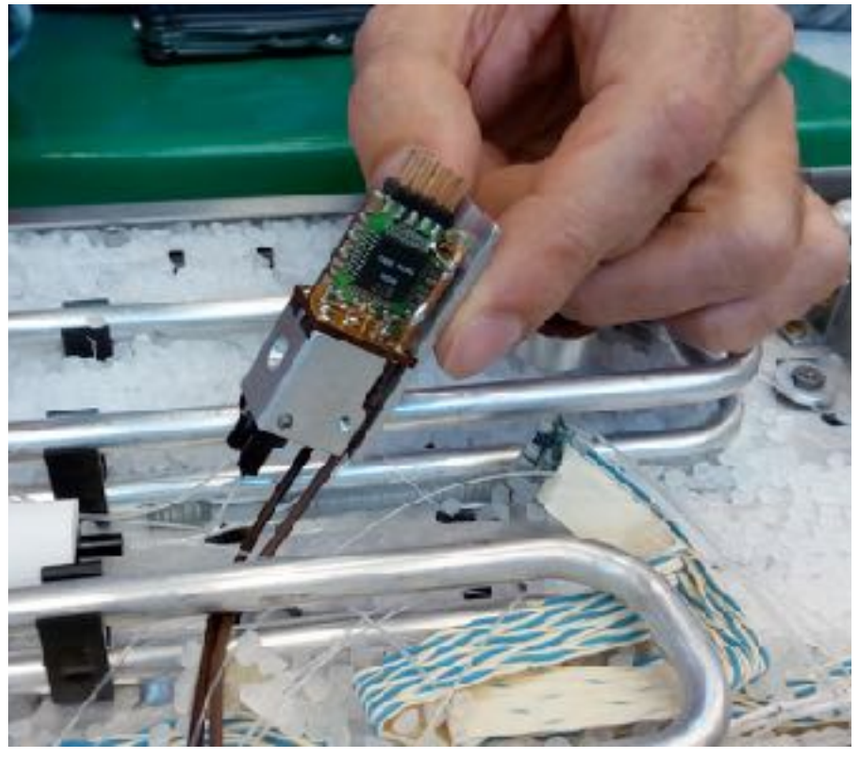




# Opening of SM36

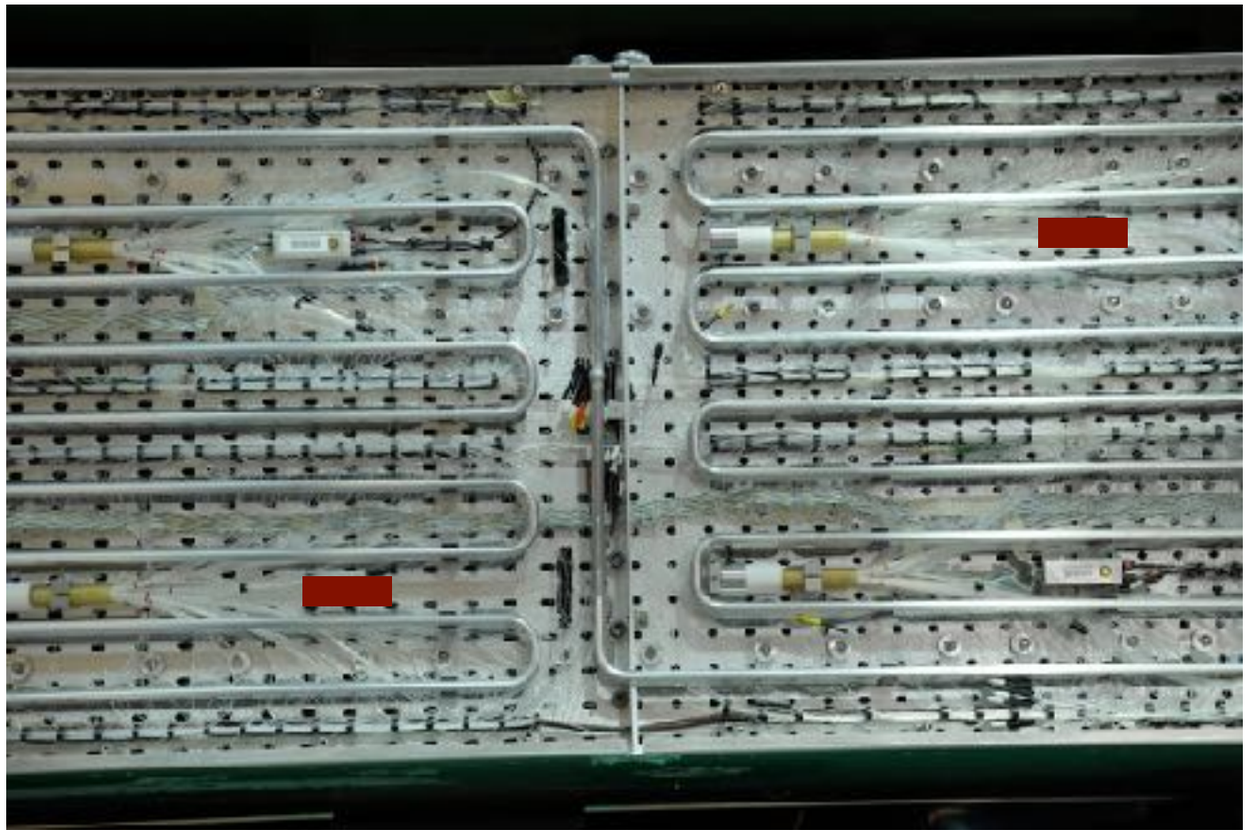
- Removal of polyethylene grains took ~4h with vacuum cleaner. Can be optimised
- Difficult to find exact path of L2 fibers to understand their transparency loss
- Cooling pipes not glued to metal plate anymore
- FEMs are screwed to metal plate. Can be easily be dismounted and inspected. No obvious reason for ageing effect





# Opening of SM36

- Enough space to add extra FEMs with similar geometry (▬ in right fig.)
- Enough spare fibers in each module for new FEMs
- New cables would be needed to power and read out FEMs
  - Propose to place new cables above fibers. Need to foresee additional holes in inter-module plates to pass cables across modules

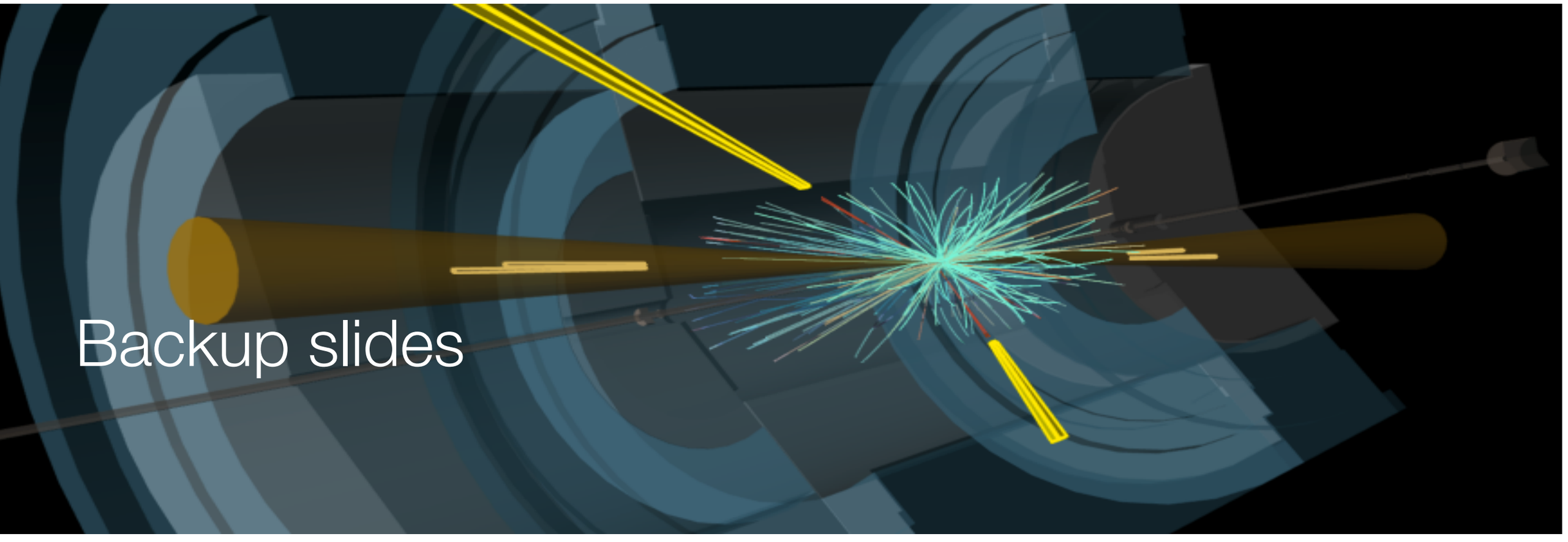


# Other ongoing activities

- Design of ASIC for new FEM has started. In constraint/requirement definition phase
- PNs ordered few weeks ago
  - Need to design a system to measure quantum efficiency dependency on radiation. Challenging to achieve 1% accuracy
- Possibility of irradiation tests at Novosibirk
  - $10^{13}$ neutrons / s with E ~ 13-14 MeV (50%) on a target (10 cm disk). Full irradiation ($10^{14}$ 1MeV neq)  in few hours (see ref. for details)
- Frascati ?

# Summary

- Tests with long fibers to investigate effect of moving of laser barrack: no showstopper as of now
  - Light attenuated by factor 2-4
  - Investigating requirements and limitations with DAQ experts
- Good progress in the design of laser monitoring system upgrade
  - Inspection of SM36 allowed to define PN readout architecture (12 FEMs / SM) and define constraints (geometry, cable path, ferrules / spare fibers)



# Backup slides

# Test with long fibers: blue laser pulse