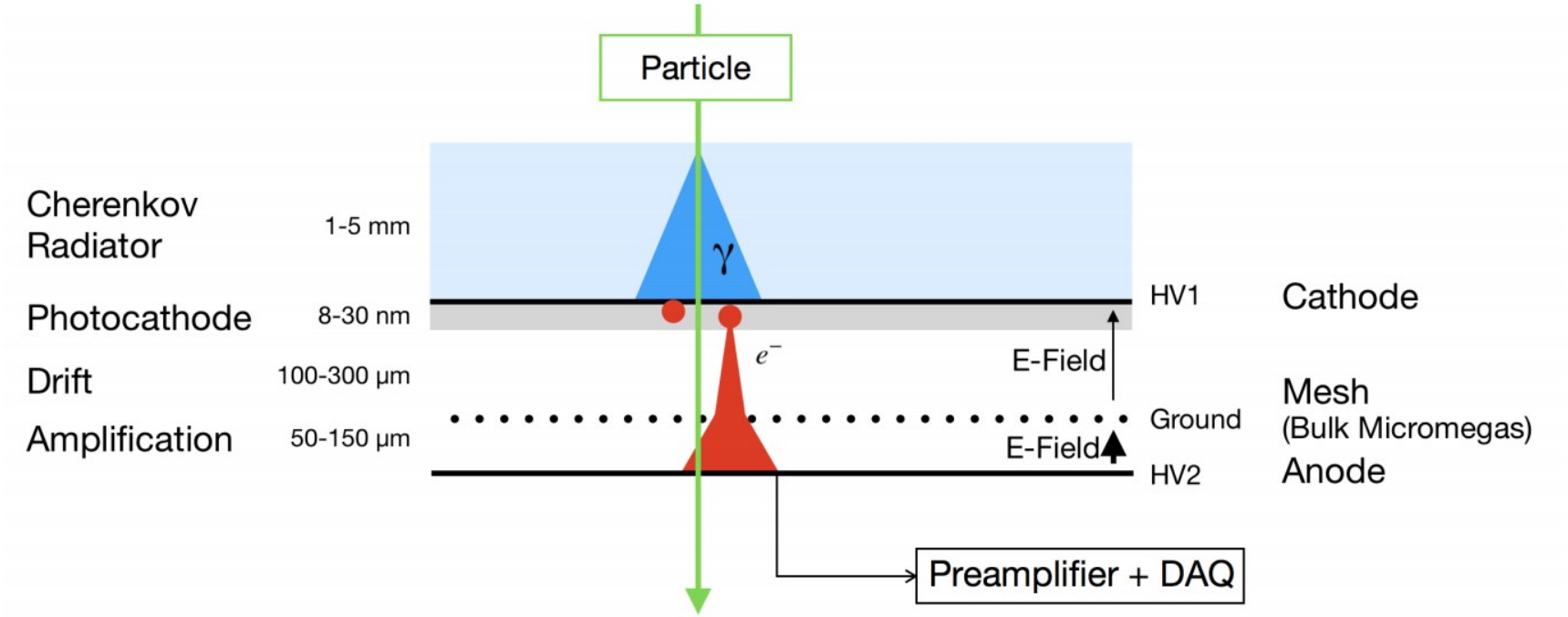
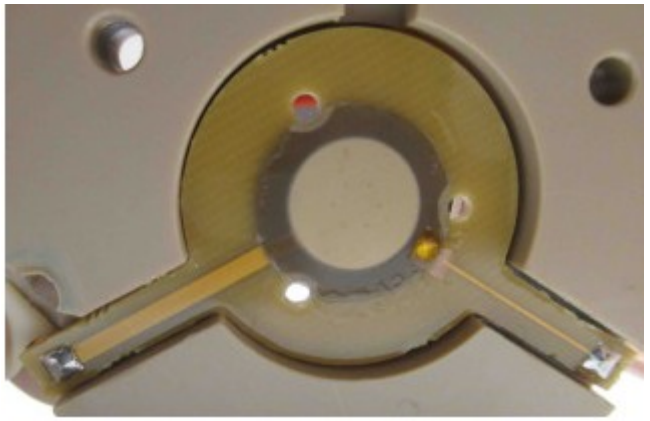
PICOSEC
2021 RD51 beam test

Antonija Utrobičić
on behalf of the CERN EP-DT-DD GDD group and of the PICOSEC collaboration
RD51 Collaboration Meeting, February 19, 2021

PICOSEC detector concept





- Purpose: give **precise timing** information in the passage of the particle. Timing resolution of order of tens ps.
- **Cherenkov radiator:** passage of relativistic charged particle creates UV photons.
- **Photocathode:** conversion of UV photons into electrons.
- **Drift /preamplification region:** Preamplification of electrons in high drift field region (~20 kV/cm)
- **Anode/amplification region:** final electron amplification in high electric field (~40 kV/cm)
- Arrival of the amplified electrons to the anode creates a signal.
- First single pad detector prototype->time resolution below 25~ps.

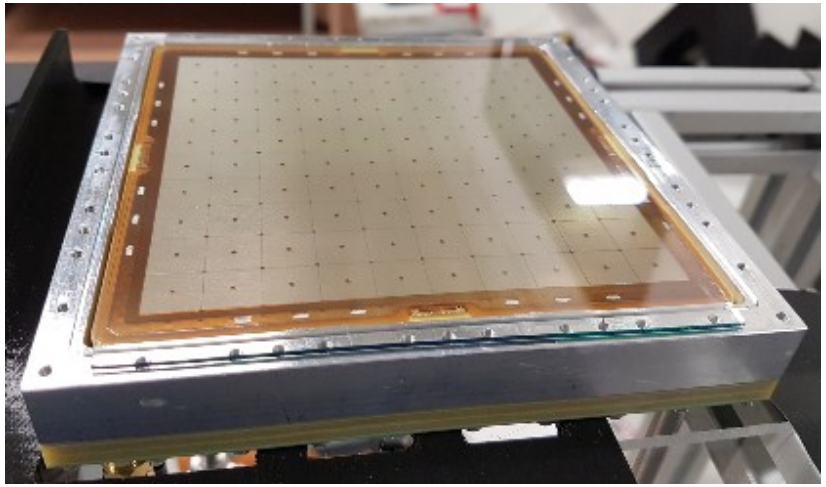
Bortfeldt, J., et al. "PICOSEC: Charged particle timing at sub-25 picosecond precision with a Micromegas based detector." *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment* 903 (2018): 317-325.

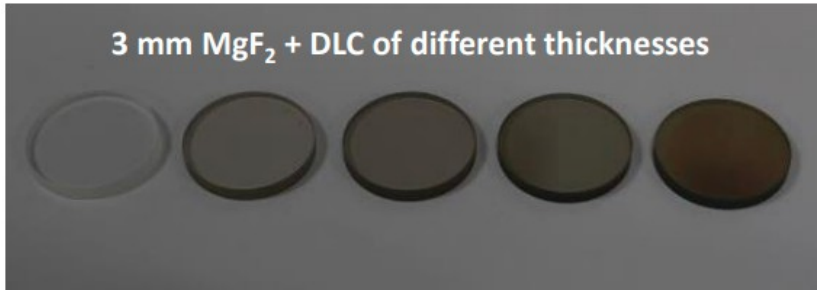
General info

- **Main purposes:**
  - Multipad micromegas/detector prototypes.
  - Photocathodes.
  - Timing for EM calorimeter.
  - FE electronics.
- **Beam type:** high rate muons (e^- for short period)
- **Infrastructures:** tracking and timing telescope, flammable gas
- **Periods:** summer & fall
- 2021 vs 2022: **important to validate** asap the **new large area prototype** - mandatory in view of possible application of the proposed concept/ technology in the context of timing (O tens of psec) systems.

Detectors, components and electronics planned to test

- **Large area PICOSEC detectors:**
  - 100 channel multipad (GDD) with CsI photocathode as baseline
  - Other large area from Saclay and USTC.
- **PHOTOCATHODES:**
  - large area photocathodes with CsI
  - Alternatives for CsI tested in the lab: DLC/B4C photocathodes
  - Futher research in the lab to evaluate the use of polycrystalline diamond and GaN.
- **ELECTRONICS:**
  - New FE developments (P. Legou/Saclay).
  - SAMPIC digitizer.

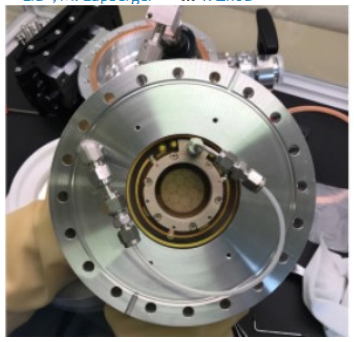




Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment
Volume 993, 21 March 2021, 165076

Timing performance of a multi-pad PICOSEC-Micromegas detector prototype

S. Aune [a], J. Bortfeldt [b], F. Brunbauer [b], C. David [b], D. Desforge [a], G. Fanourakis [f], M. Gallinaro [h], F. García [i], I. Giomataris [a], T. Gustavsson [j], F.J. Iguaz [a], M. Kebbiri [a], K. Kordas [d, e], C. Lampoudis [d, e], P. Legou [a], M. Lisowska [b], J. Liu [c], M. Lupberger [b, 1] ... Y. Zhou [c]



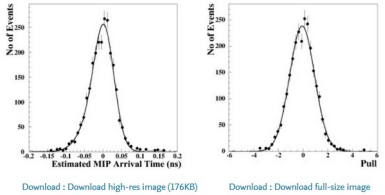


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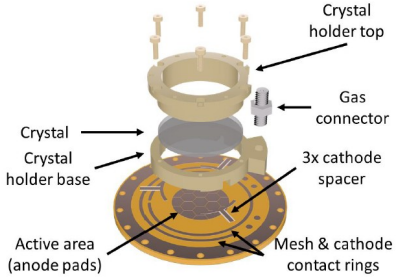
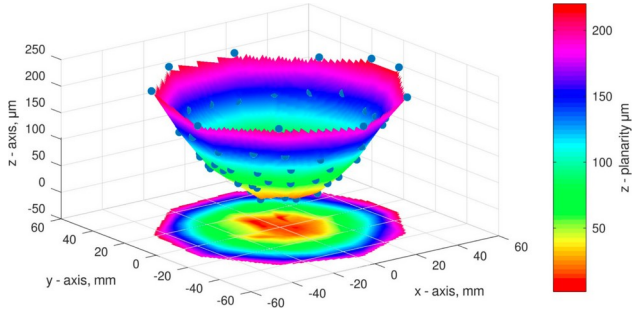
Fig. 19. (left) Distribution of the arrival time of MIPs, passing within 2 mm of a common pad corner (pads No. 4, 7 and 8), estimated by Eq. (9) combining the individual single-pad measurements and their expected errors. The solid line represents a fit to the data points by a sum of two Gaussian functions corresponding to an RMS of 32.2 ± 0.5 ps. (right) Pull distribution of estimated arrival times by Eq. (9). The solid line represents a Gaussian fit to the data points, consistent with mean and σ values equal to 0 and 1 respectively.

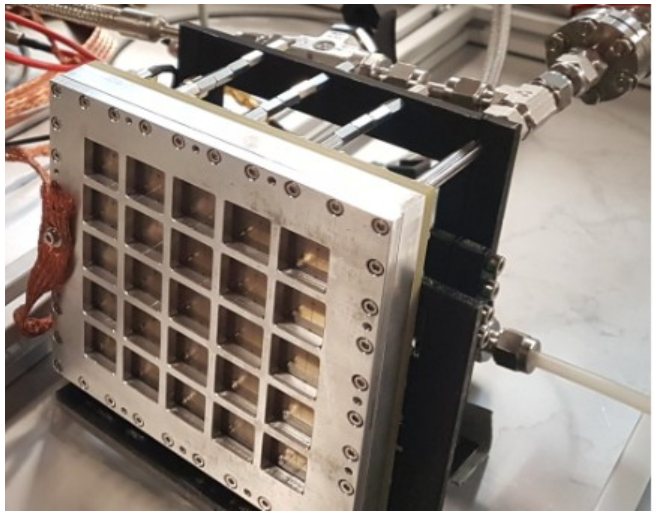
Very good results (25 / 30 ps at the pad center / edges) but only after correction using impact position from tracker to account for PCB bending

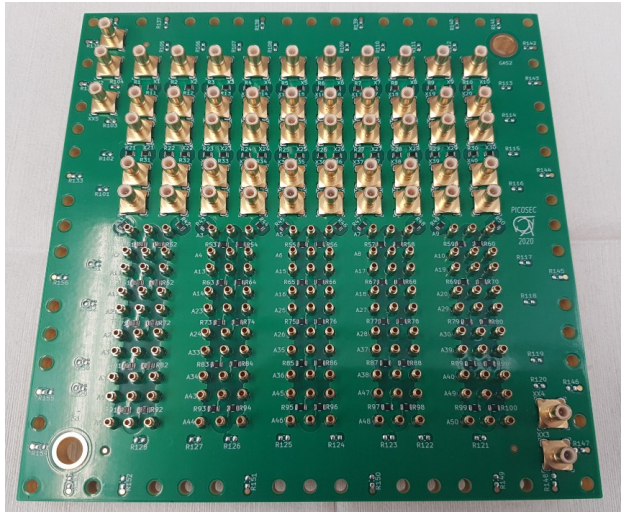


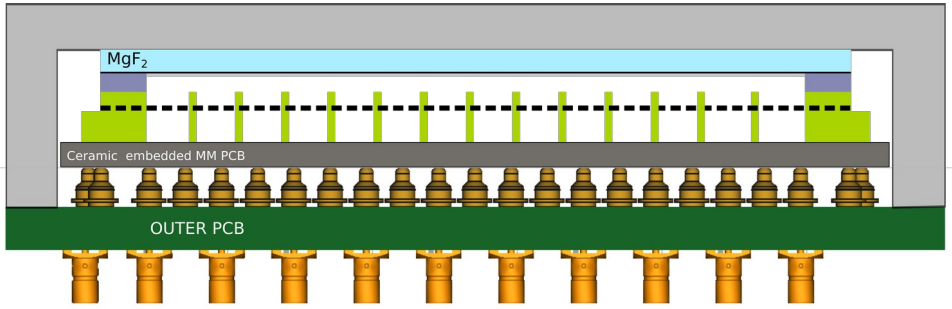


https://doi.org/10.1016/j.nima.2021.165076

New multipad PICOSEC detector



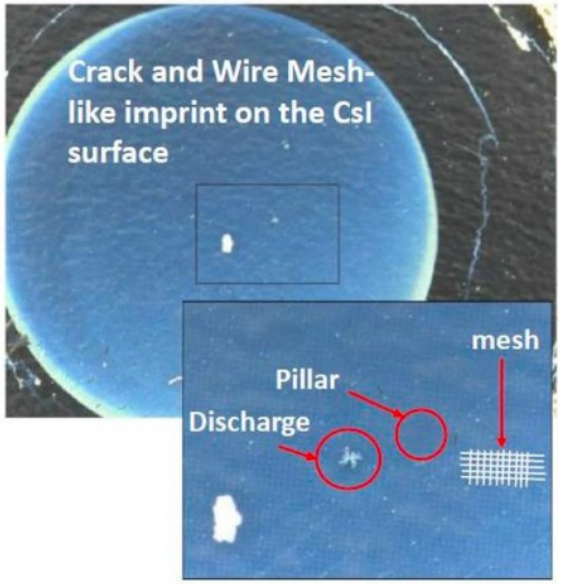


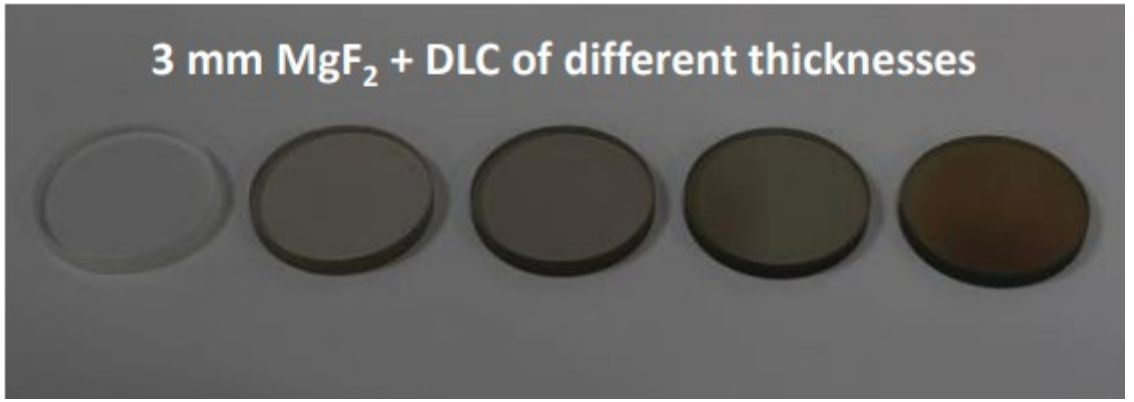


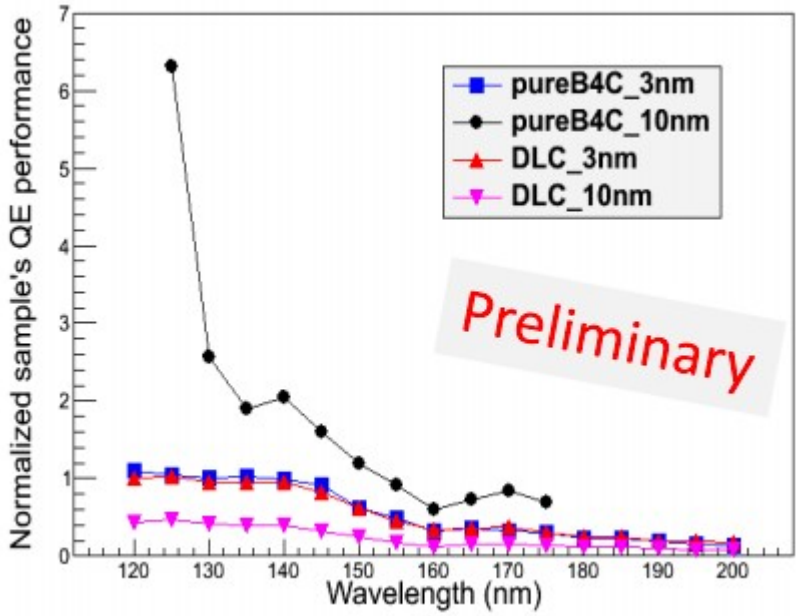
- Test of the detector prototype with a larger number of channels (19->100) and increased active area (≈10 times).
- Micormegas on ceramic embedded PCB (with planarity below 10 µm over the active area) and detached from the housing.

https://indico.cern.ch/event/989298/contributions/4225012/attachments/2190525/3702164/PICOSEC-RD51-16022021-v3.pdf

Photocathodes







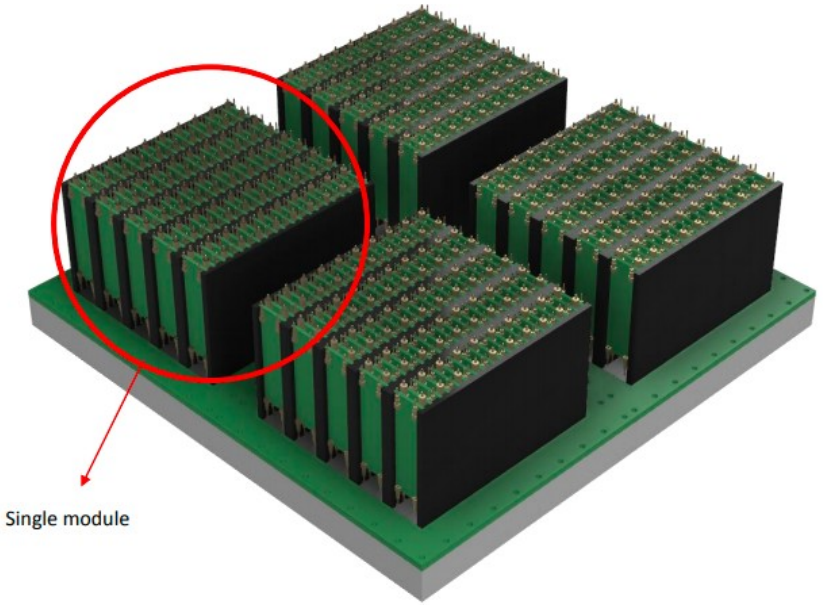
- CsI- difficult to handle and store due to the sensitivity to humidity.
- Can be damaged by sparks and ion bombardment.
- Research for alternative photocathodes: DLC, B4C.

https://indico.fnal.gov/event/45109/contributions/194818/attachments/133408/164540/SNOMASS_IF5_PICOSEC_talk_21082020.pdf

https://indico.cern.ch/event/757322/contributions/3387110/attachments/1839691/3015624/MPGD2019_WangXu_f.pdf

Electronics

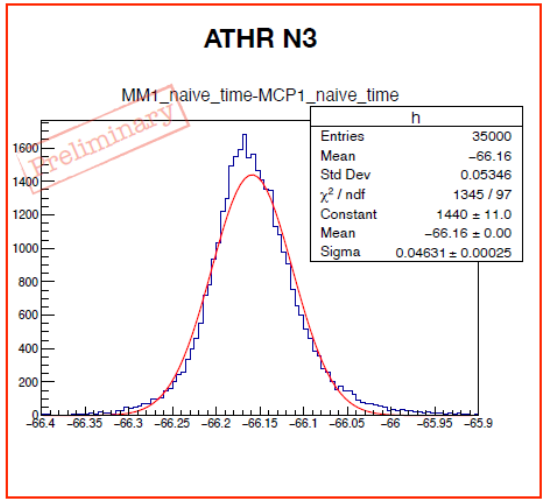
- New preamplifier: P. Legou/Saclay
- Custom design.
- Performance is comparable to the CIVIDEC.

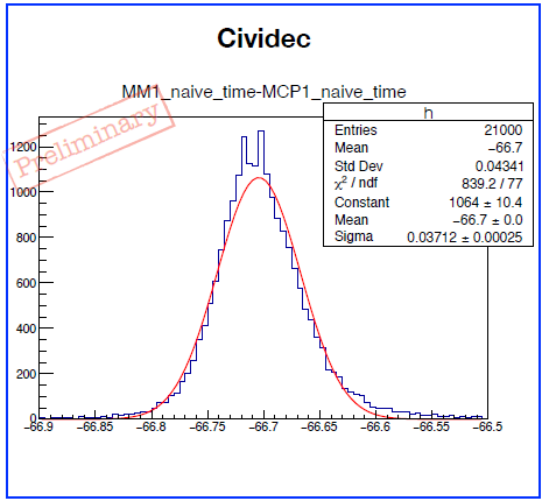


Marta Lisowska-RD51 CB
https://indico.cern.ch/event/889369/contributions/4042727/attachments/2119909/3567610/Marta_Lisowska_-_RD51_CB_-_New_PicoSec_Module.pdf

PICOSEC Amplifier „ATHR N3“

Anode: 275 V
Drift: 600 V
Drift gap: 194 μm
4 photoelectrons

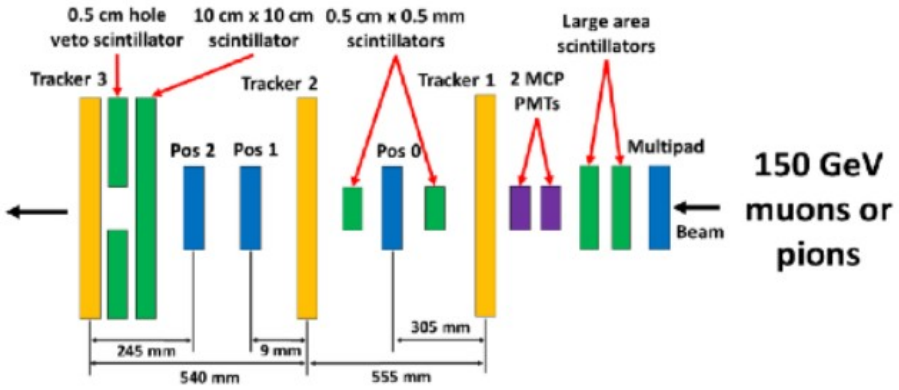


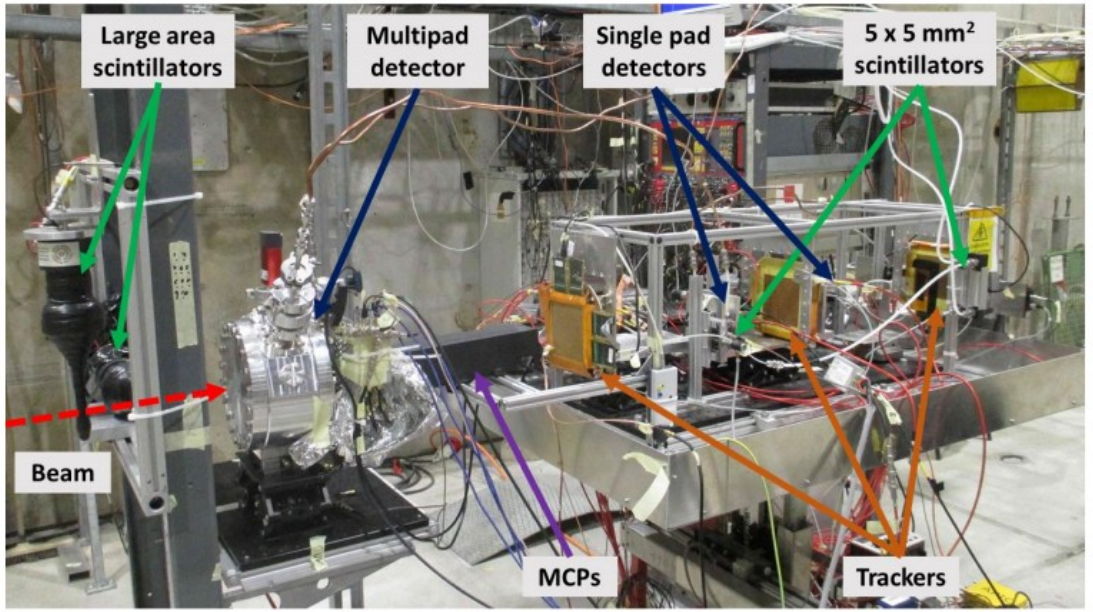


Lukas SOHL, RD51 Mini-Week February 2020:
https://indico.cern.ch/event/872501/contributions/3726013/attachments/1984848/3306891/PicosecRD51.pdf

Test bench setup

- **Triggering/tracking/timing telescope**
  - **Timing**
    - MCP-PMT (available 11 mm diameter)
    - Large area
  - **Triggering**
    - Scintillators (small area single MIP selection and large area)
  - **Tracking**
    - Triple GEM detectors, XY readout
- Rack for HV, LV, NIM logic integration in RD51 slow control.





Florian M. Brunbauer (INSTR-20), February 26, 2020
https://indico.inp.nsk.su/event/20/contributions/925/attachments/541/626/PicoSecINSTR20.pdf

Test bench setup

- **FE and Data Acquisition:**
  - CIVIDEC C2, Ortec 142 IH
  - Oscilloscopes:
    - CERN (LeCroy WaveRunner 625Zi, R&S RTO 1044)
    - CERN-pool (LeCroy LECROY WR8104 oscilloscopes [8] operated at 1.0 GHz analogue bandwidth and at a sampling rate of 10 GSamples/s.)
- UV led for single p.e spectrum (model: UVTOP240TO18BL)
- Gas: Compass Mixture (Ne:Ethane: CF4- 80:10:10)
- Remotely controllable support/table.
- Geometry Survey for the alignment with the beam.

https://cividec.at/index.php?module=public.product&idProduct=33&scr=0

https://indico.cern.ch/event/532518/contributions/2195706/attachments/1287366/1915899/PicosecondeTestBeam.pdf

https://www.yumpu.com/en/document/read/46184952/uvtop-catalogue-pdf-sensor-electronic-technology-inc

For the end

- Beam period and support/needs for NA services
    - Summer (2 weeks) and fall (2 weeks).
    - Remotely controllable table (DESY).
    - Geometry Survey for the alignment with the beam.
    - Authorization for flammable gases.
    - It is uncertain if the presence of external research groups will be possible due to the COVID-19.

Thank you for your attention ☺