AMBER Hardware:
Proton Radius Measurement

Technical Board Meeting 20.9.2022

Report by Physics Coordinator

Proton Radius Measurement – Plans and Developments (status April 2022)

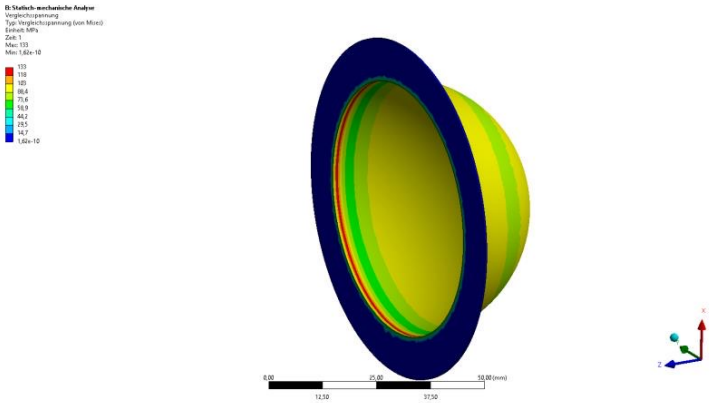
- Active-target TPC
  - Main structure ready to be ordered (GSI/German groups), depends on funding grants (pending)
  - Work on the gas system further pursued at PNPI
  - Subject to further development concerning Russian group
  - Due to delays with production of main TPC: possible fallback for a physics running in 2023 is to reuse existing IKAR TPC (limited Q^2 range, ¼ of statistics)
- Muon tracking
  - Unified Tracking Station (UTS) design being finalized
  - Precise timing: Scintillating Fiber Hodoscope (SFH)
  - Precise space resolution: ALPIDE silicon pixel detectors
  - New FriDAQ free-running data acquisition system
  - Plan: full proof-of-principle until this autumn

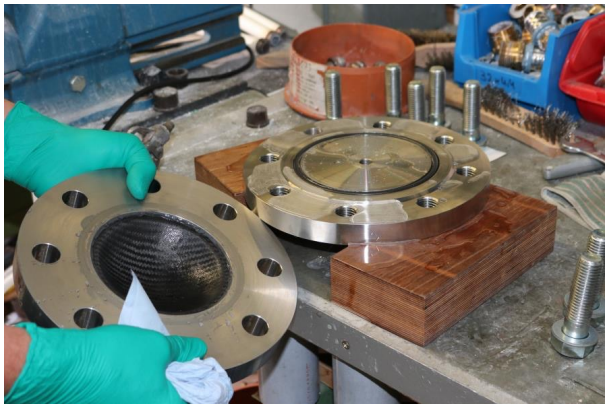
Proton Radius Measurement – Tests in 2022

- We foresee several parasitic tests of the tracking detectors during the 2022 beam time, in the downstream test area
- Install and operate the new FriDAQ for the available detector components
- We plan **dedicated tests in beam**, at the end of the beam time, for testing the tracking detectors in realistic conditions and with new FriDAQ compatible electronics
  - 100 GeV beam
  - nominal PRM intensity $2 \cdot 10^6$ muons per second
  - Focused beam
- Goal: get one station characterized (space & time resolution, efficiencies, noise level etc), in combination with spectrometer scintillating fibers
- Two possible places: Upstream the polarized target (between FI01 and FI15/FI02) or downstream SM2 (between FI07 and FI08)

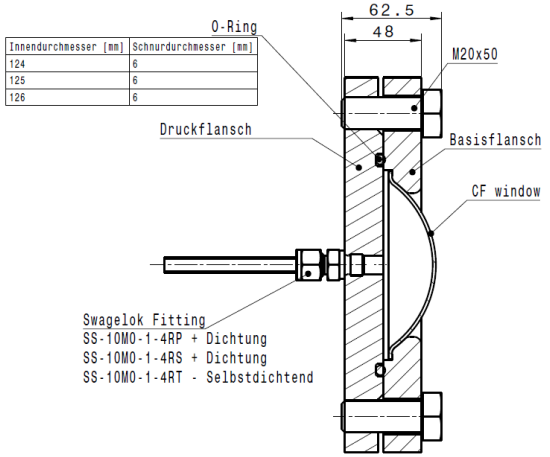
News from TPC: Carbon fiber window

(slides Oleg Kiselev, Joachim Weinert, Sandra Schwab, Kalliopi Dermati, Rainer Heseitl, GSI Darmstadt)



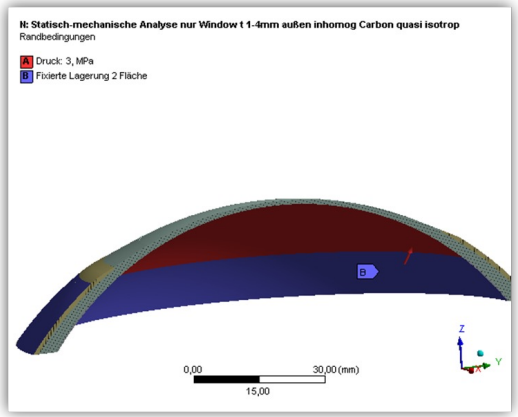


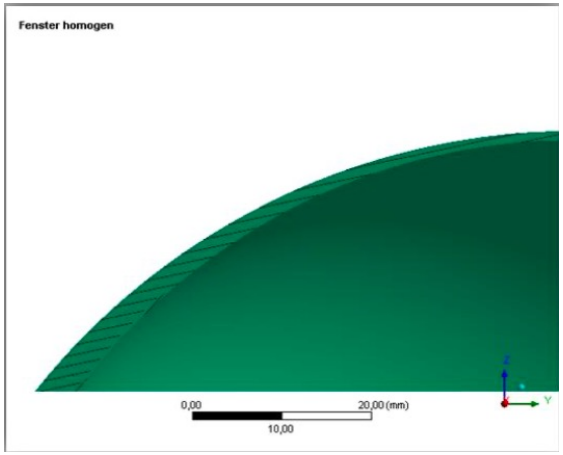
- Window simulated with ANSYS
- Flanges for testing produced
- Two windows made, 1.0 and 1.6 mm
- Carbon fabric 200 g/m2 (style 452-5 Aero, twill weave), for the supporting parts in aircraft construction, motorsports, marine construction

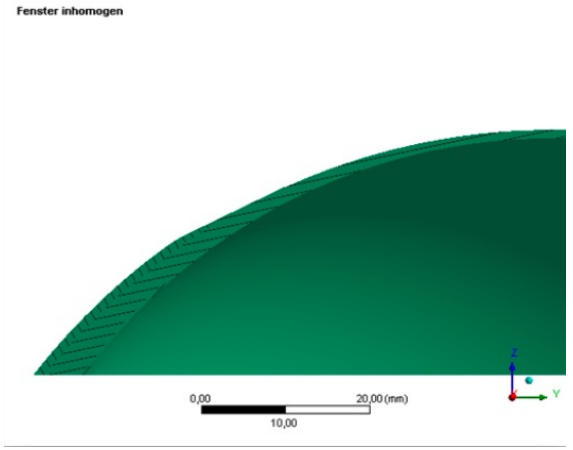


Innendurchmesser [mm]	Schnurdurchmesser [mm]
124	6
125	6
126	6

ANSYS simulations for variable-thickness windows





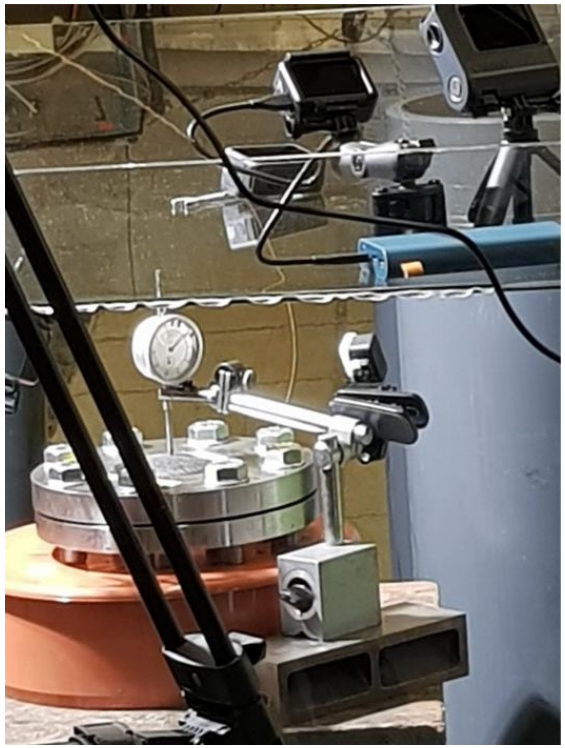


- Weak area: fixation to the flange
- Thicker window (4 mm) at the fixation area and thinner (1 mm) in the middle should be more stable
- Difficult to make

Pressure test at MPA Darmstadt

- The Center for Construction Materials - Staatliche Materialprüfungsanstalt Darmstadt (MPA) and the Department and Institute of Materials Science (IfW) at the Technical University of Darmstadt
- Short pressure tests
- Long-term pressure tests
- Proved and certified laboratory
- Up to 30 samples can be tested in parallel
- Pressure up to 100 bar (distilled water)

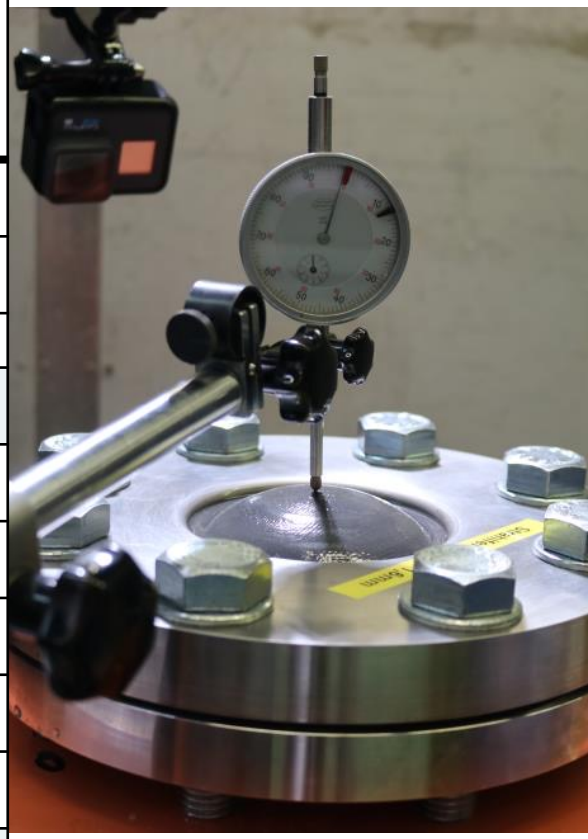
Pressure test at MPA Darmstadt



- Setup with 8 cameras
- One professional high-speed camera (up to 5000 fps)
- Z deformation measured in the middle, precision 0.01 mm

Pressure test at MPA Darmstadt

Pressure, bar	Deformation in the middle Z, mm (Fully uniform thickness, 1 mm)	Deformation in the middle Z, mm (homogeneous, 1-4 mm)	Deformation in the middle Z, mm (inhomo-geneous, 1-4 mm)	Measured deformation in the middle Z, mm (Fully uniform thickness, 1 mm)
10		0.04	0.04	0.02 / 0.04
20		0.08	0.08	0.06 / 0.08
30	0.09	0.12	0.11	0.10 / 0.12
40		0.16	0.15	0.14 / 0.19
50		0.20	0.19	0.19 / 0.25
60		0.24	0.23	0.24 / 0.32
70		0.28	0.27	0.31 / 0.39
80		0.32	0.31	0.37 / 0.45
90				0.42 / 0.49
100				0.49 / 0.495



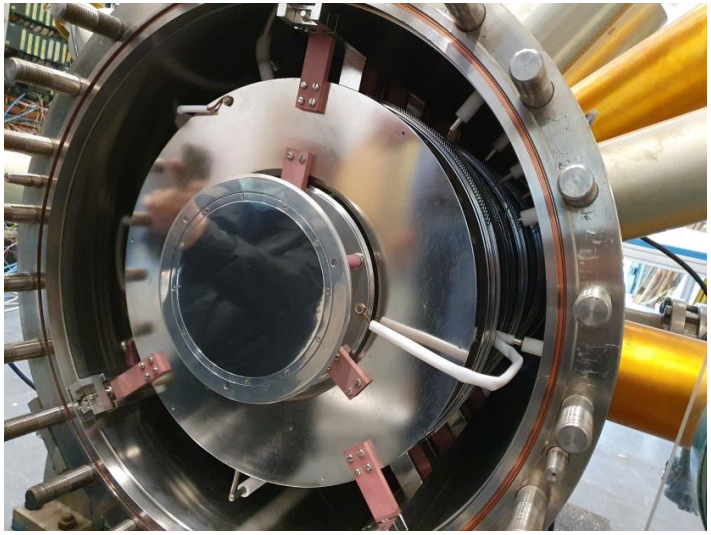
Measured deformation while increasing pressure and then while decreasing

Both windows, 1.6 mm (7 layers) and 1.0 mm (4 layers) did not break up to 100 bars!

Carbon fiber window: further plans

- Vacuum test of both windows
- New windows with a gas-stop foils
- Pressure test in November 2022
- Long-term pressure test in December 2022

IKAR refurbishment and operation in 2021



→ main parameters and details presented by Evgeny

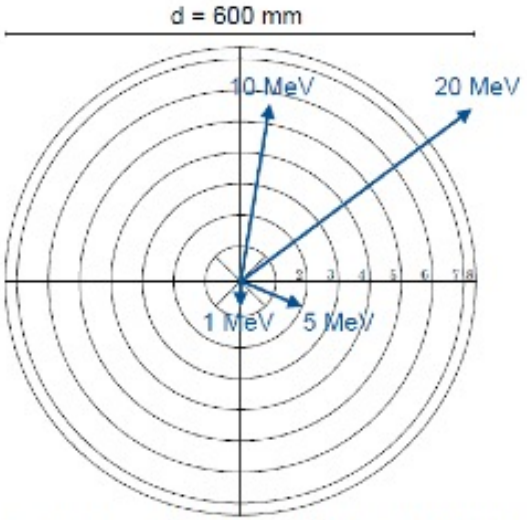
Plans for the new TPC as of March 2021

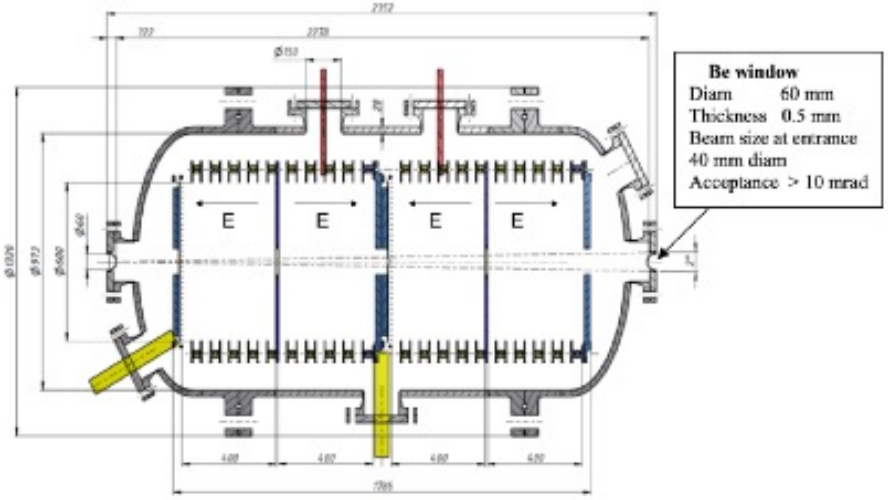
Time Projection Chamber

Construction of a new TPC

New TPC vessel and readout parts required.

- New TPC construction:
  - → 4x drift cells with 400 mm length
  - → Maximal operation pressure: 20 bar
  - → Segmented anode plane: 600 mm diameter
- Construction of TPC about 1.5 years in total
  - → Split work and construction to be on time





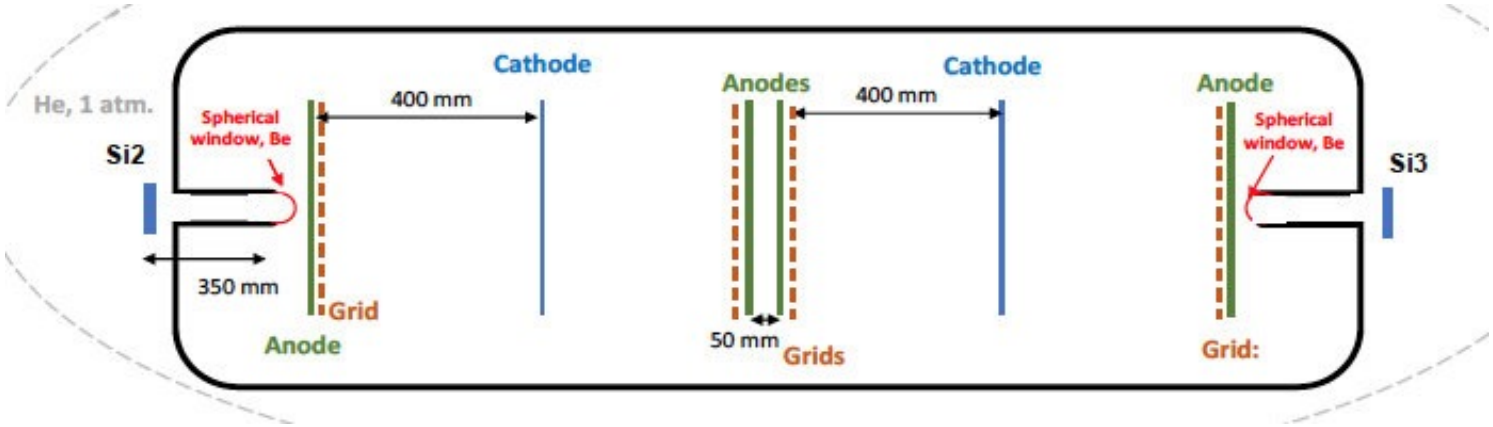
Optimisation of geometry ongoing:

- Material budget, beam noise and proton ranges
  - → optimal pressure settings for Q^2-range
  - → optimal internal geometry
  - → optimal read-out plane segmentation
  - → optimal beam-window size

Test run: IKAR TPC (2-cell version with smaller radius)

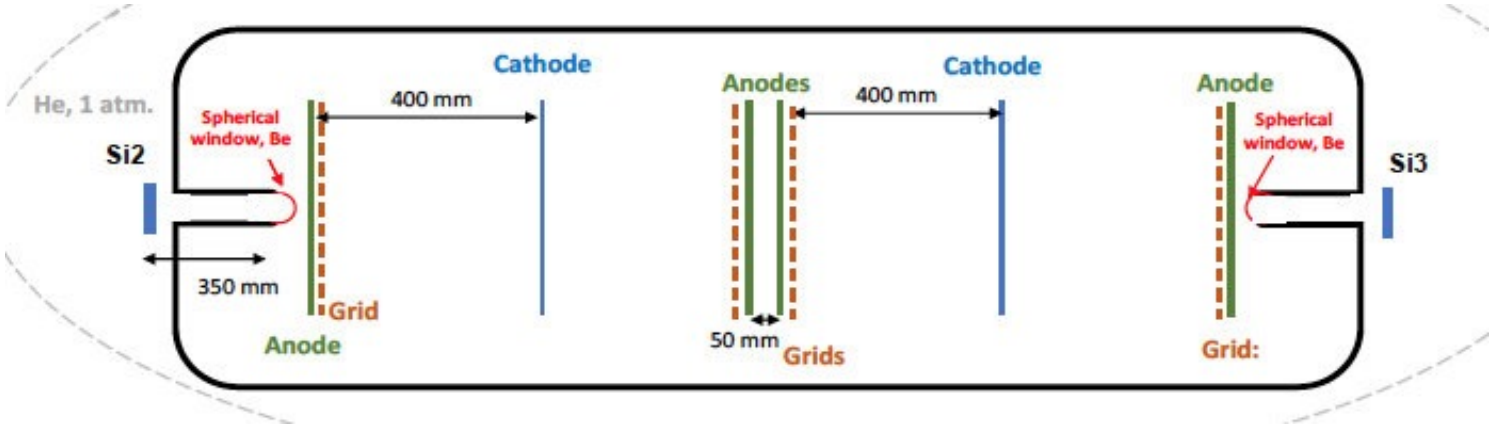
Christian Dreisbach | 10th March 2021 | EHN2 Working Group - AMBER: PRM 4

Plans for the new TPC in 4-cell geometry



Drift cells: four, 400 mm long
Pressure: 20 bar operational, 31 bar test
Anode plane: 600 mm diameter
Signal outputs: 8 x 16-channels SubD vacuum feedthroughs
HV inputs: 1 pair of 10 kV and 50 kV vacuum feedthroughs (might be 2 pairs)
20 field shaping rings: special profile stainless steel rings on the MACOR or PEEK
Anode structure: 32 ring/sector structure similar to the modified IKAR TPC

Plans for the new TPC in 4-cell geometry



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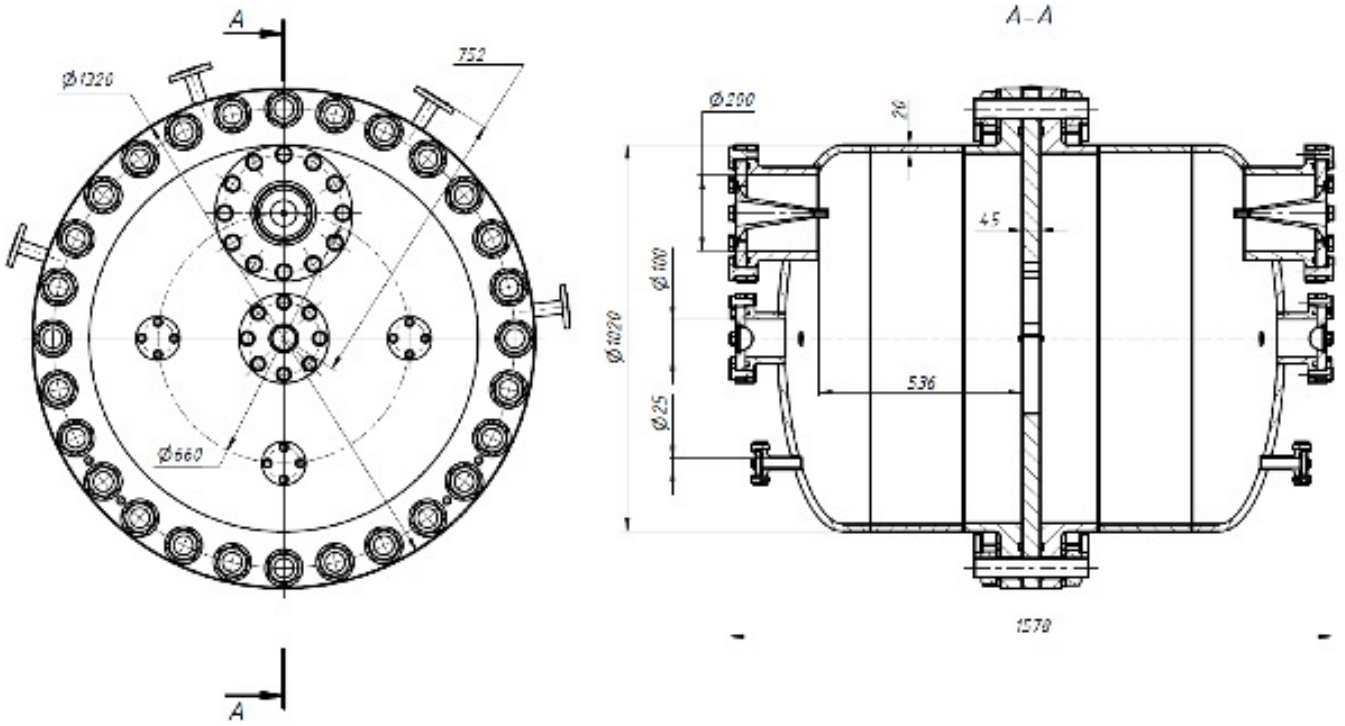
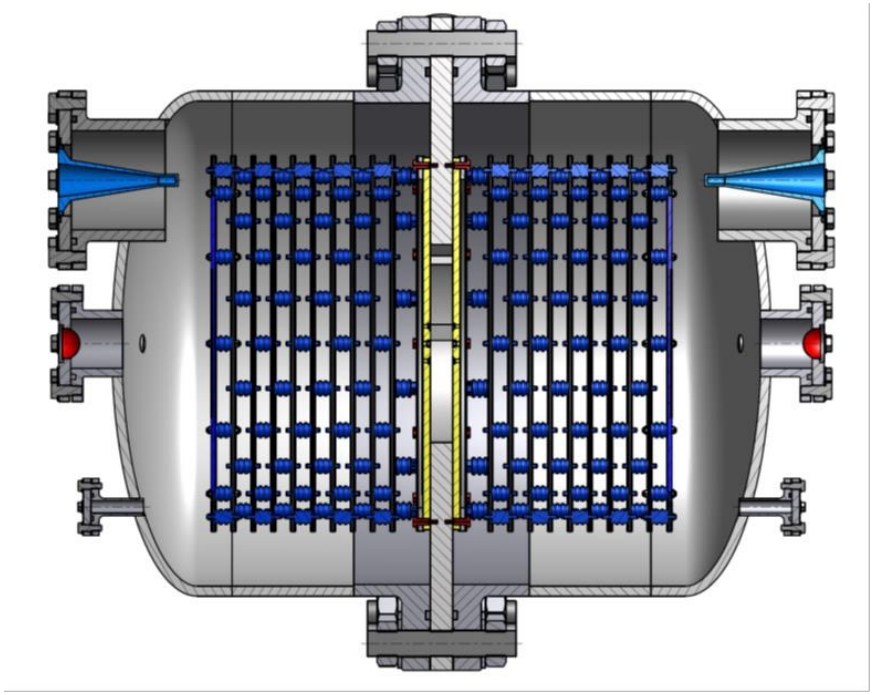
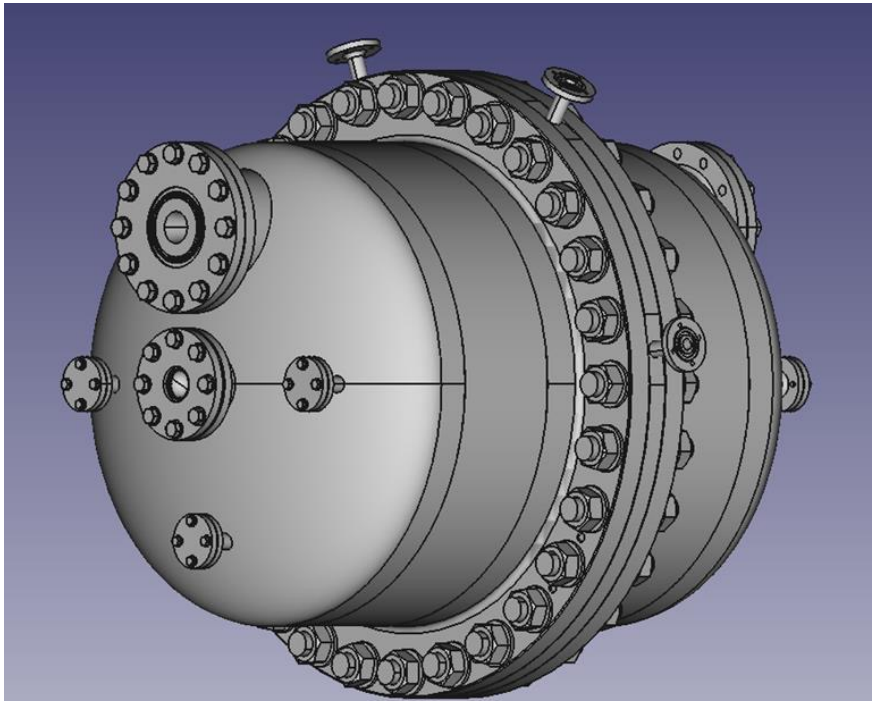
Plans for the new TPC: 2 cells



- Two sections instead of four
- Same construction, diameter, gas pressure
- Endcaps are the same
- Smaller and lighter – less expensive
- To be investigated: impact on physics (less hydrogen, shorter track extrapolation)

2-cell Time Projection Chamber

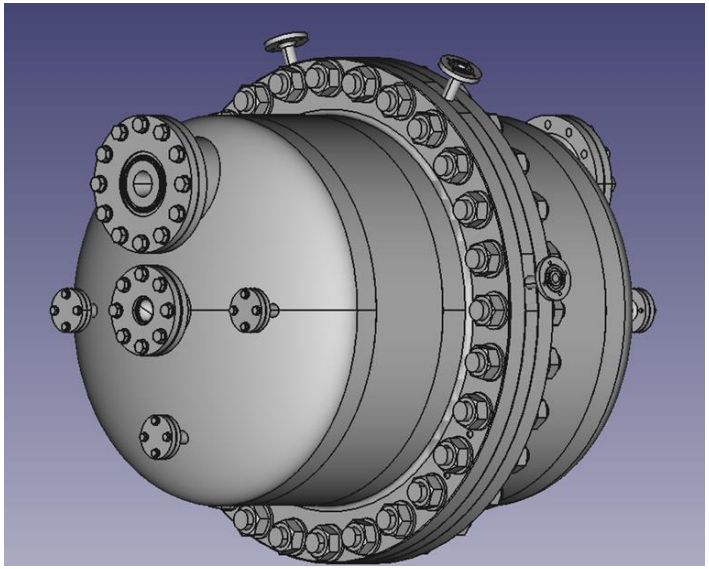




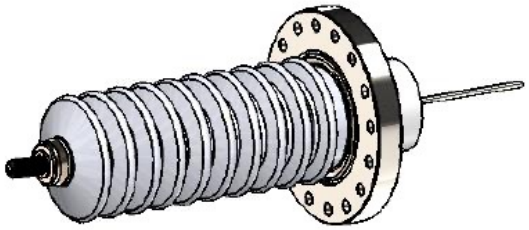
- Same deformation-free mounting of the electrodes
- Two pairs of HV feedthroughs instead of four
- Beam windows, gas connectors are the same

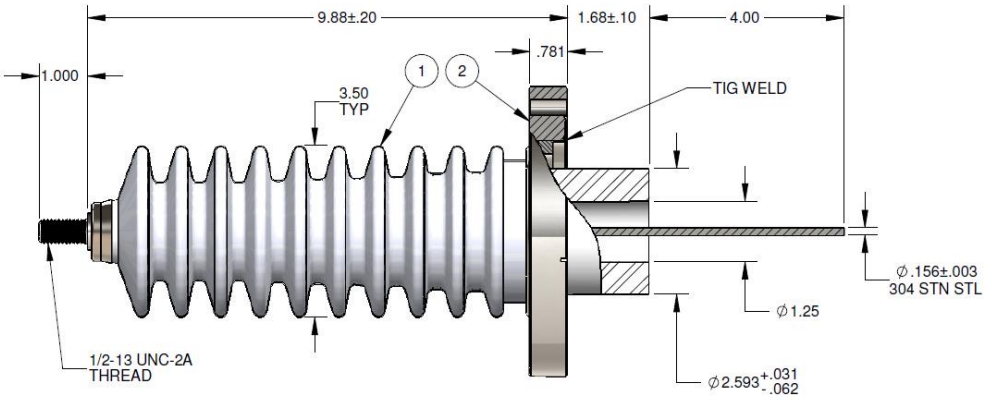
Production of the pressure vessel

- Preliminary drawings and description of the 2-cell TPC is a basis of the tendering documents
- Funds from GSI, TUM, Bonn and Mainz are collected and will be used for the order
- EU-wide tender is opened, will go up to November
- 6 companies are contacted up to now
- Engineering phase – up to the end of 2022
- Production phase – up to the middle of 2023



TPC: 100 kV feedthroughs



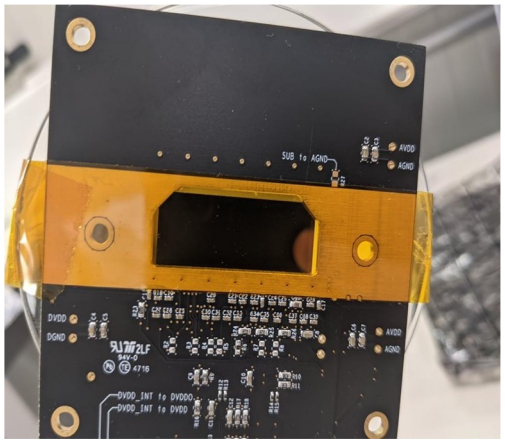


- No feedthroughs certified up to 30 bar are available on the market
- The idea is to test those are potentially robust and should stand high pressure
- One sample (from CeramTech) is obtained
- Flange will be constructed, feedthrough welded and tested

ALPIDE tests in 2022

Slides/Team: Martin Bajzek, Oleg Kiselev, Bastian Löher, Valerii Panin, Luke Rose, Jose Luis Rodriuez Sanchez

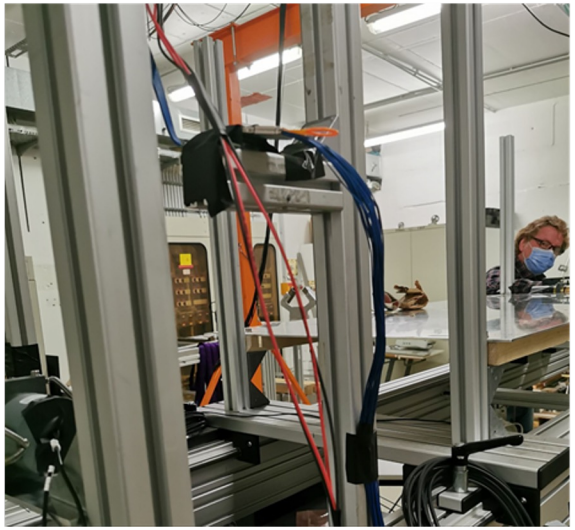
- Designed by ALICE for ITS2
- 512 x 1024 pixels-> 1 pixel: 29x27μm²
  → Active area of 1.5x3cm²
- 50 μm thick
- Radiation hard
- ALICE quote >99% detection efficiency
  → To be measured/confirmed for AMBER/R3B purposes



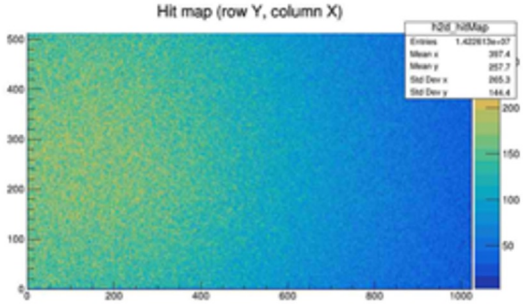
ALPIDE tests Jülich/COSY 03/2022

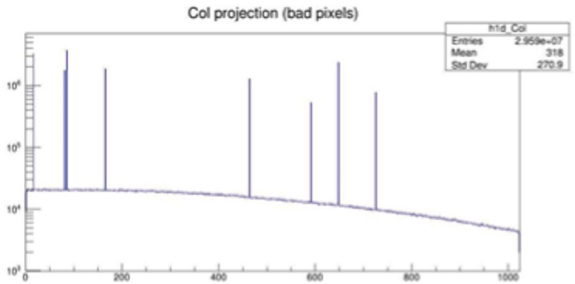
- One ALPIDE detector
- Readout: 1x MOSAIC board
- Continuous readout
- Parasitic mode
  - Minimal beam discrepancy?

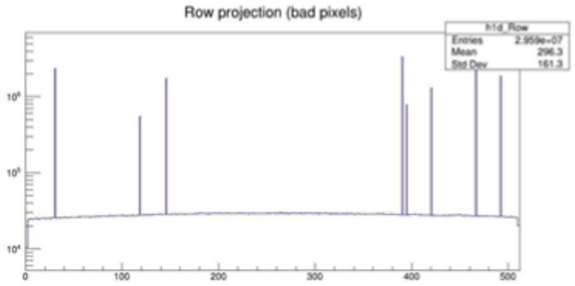
- Deuteron at 1 GeV/u, 800 MeV/u, 200 MeV/u

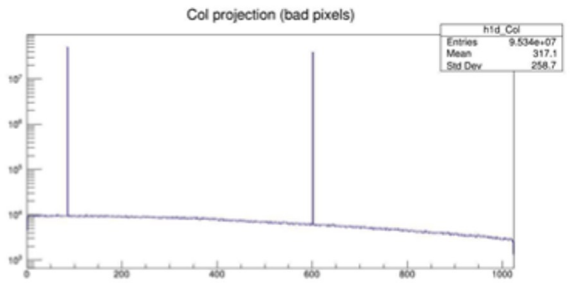


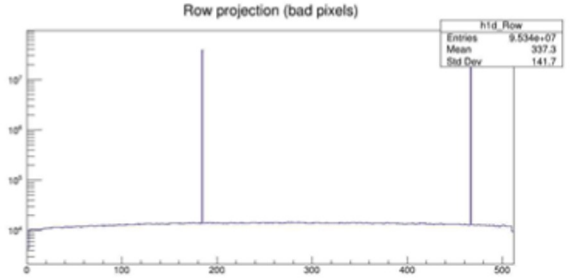
ALPIDE tests Jülich/COSY: Results







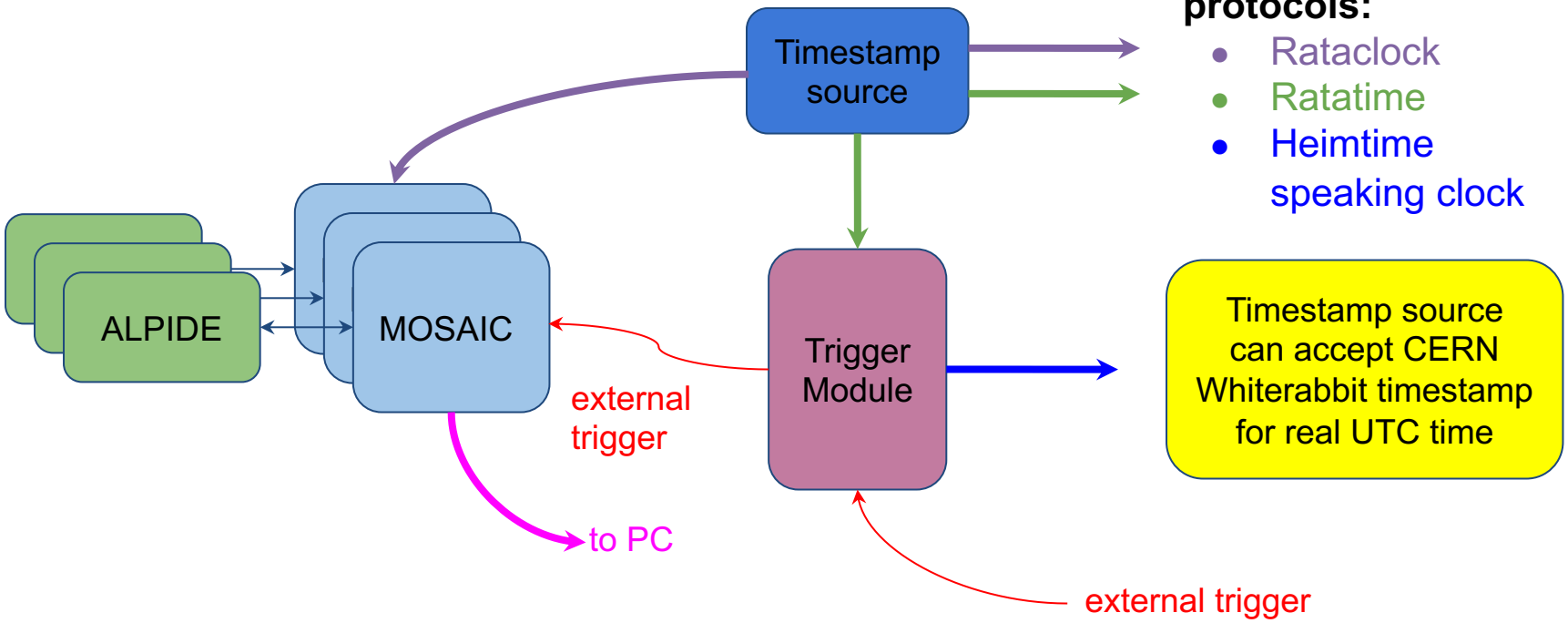




- **Read out with the MOSAIC board works.**
- **Noisy pixels if not removed before readout can dominate.**
- **ALICE/ITS2 DAQ is obsolete and needs to be modified.**
- **Further analysis macros must be prepared.**

DAQ is fully redesigned and meanwhile changed

ALPIDE DAQ overview



Triggering:

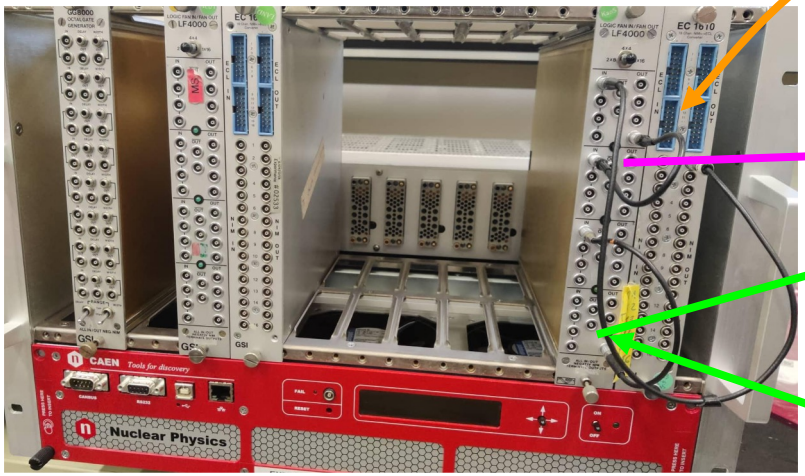
- internal trigger / continuous readout
- external trigger from Compass (latency ~2 µs)
- external trigger from trigger module (pulser) for quasi-continuous readout
- MOSAIC trigger to ALPIDE with variable delay

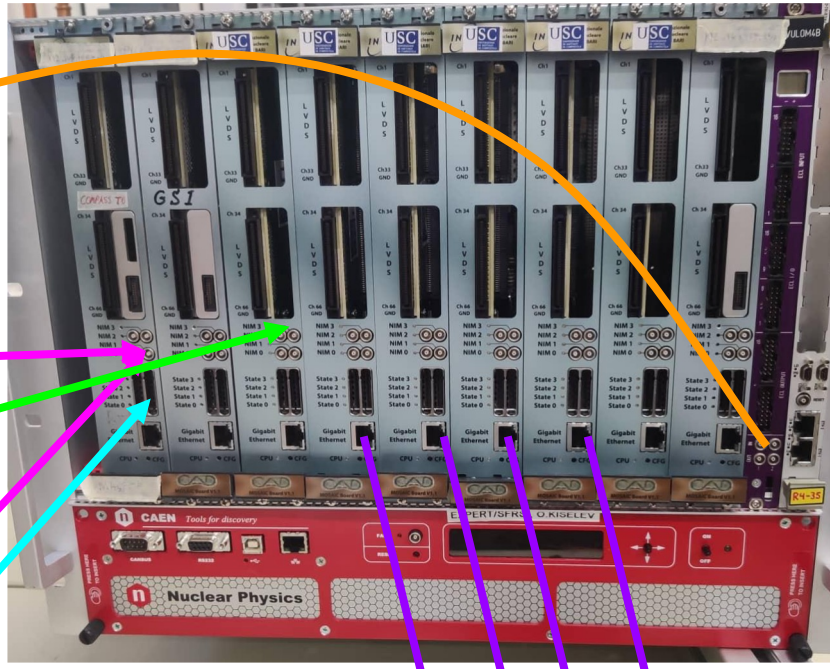
ALPIDE PC

- Start/stop synchronisation
  - DIM messages sent from COMPASS DAQ to TPC computer
  - Not yet implemented

- Readout
  - R3B DAQ (drasi)
  - Data format: GSI LMD with timestamps
  - Data rate: 1 GBit/s per MOSAIC, >100 kHz trigger rate with low hit occupancy

ALPIDE tests 10/2022





Pulser

Trg

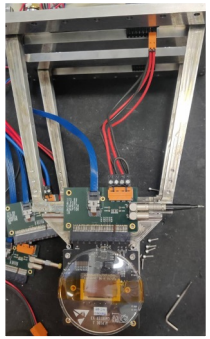
Trg

Clock

Data

Data

Data



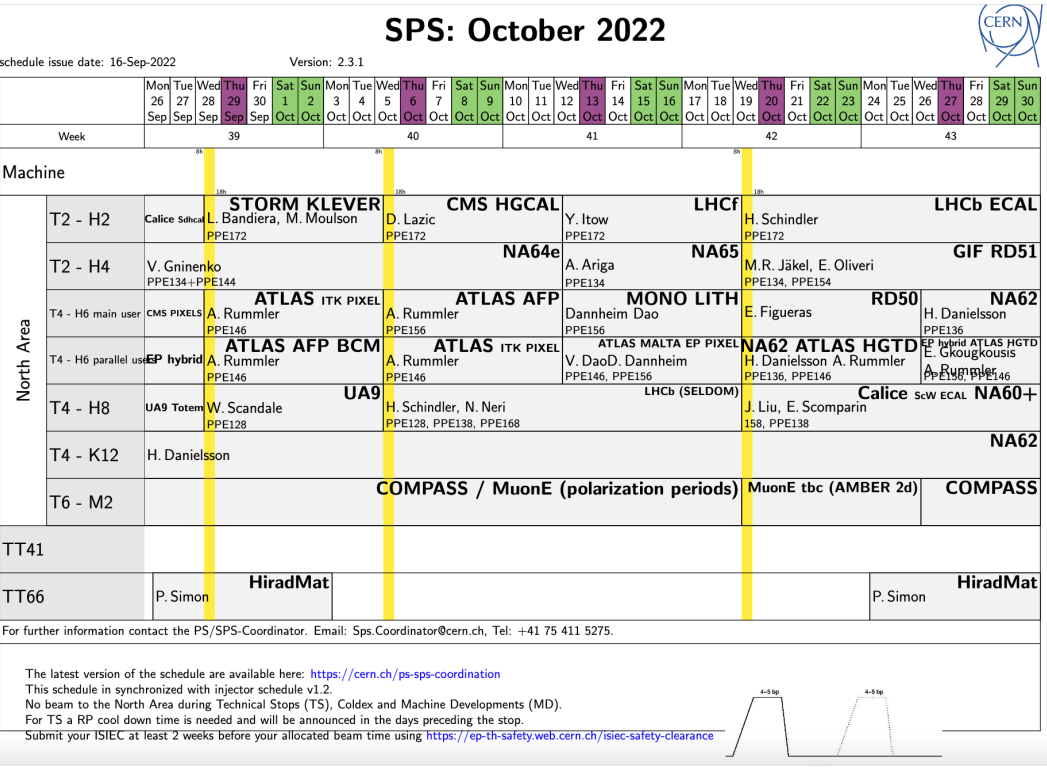
- Rio4 VME controller configers pulser.
- VULOMB 4B (reprogammable FPGA board) generates pulse trigger signal.
- EXPLODER (desktop FPGA module) ->Timestamping, WhiteRabbit.
- ECL to NIM convertor
- FiFo->distributes trigger and trigger signals to MOSAICs.

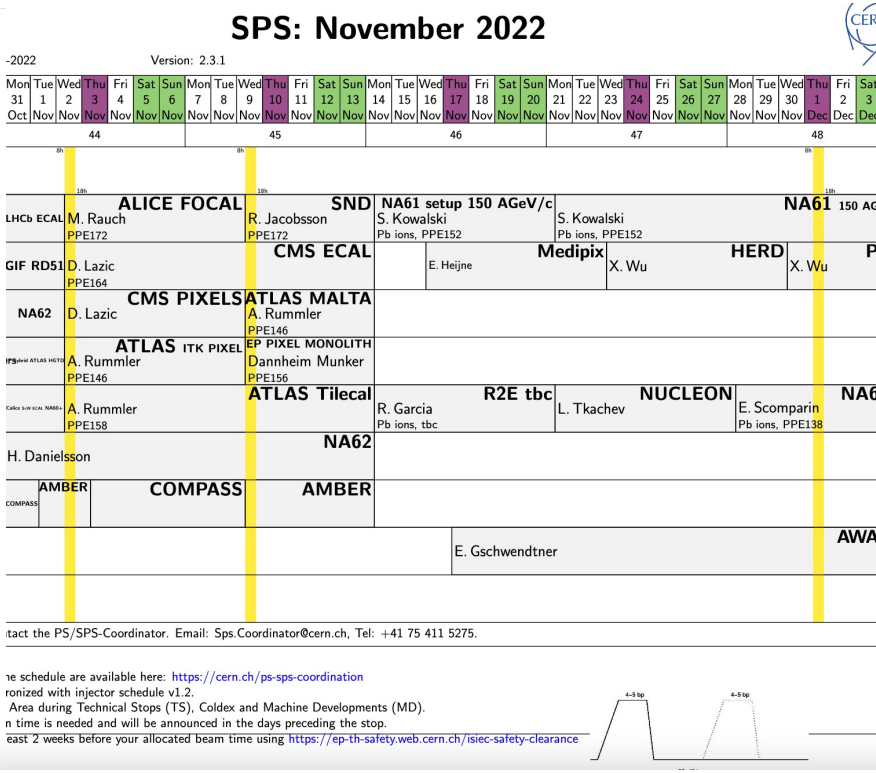
Goals for test beam November 1-3

- **Verify new DAQ works and pixel masking improves efficiency under beam conditions.**
- **Sync DAQ with SciFi Detectors and COMPASS/AMBER DAQ.**
- **Measure position resolution of APIDE telescope setup + SciFi.**

11 ALPIDEs and 9 MOSAIC boards are available and working

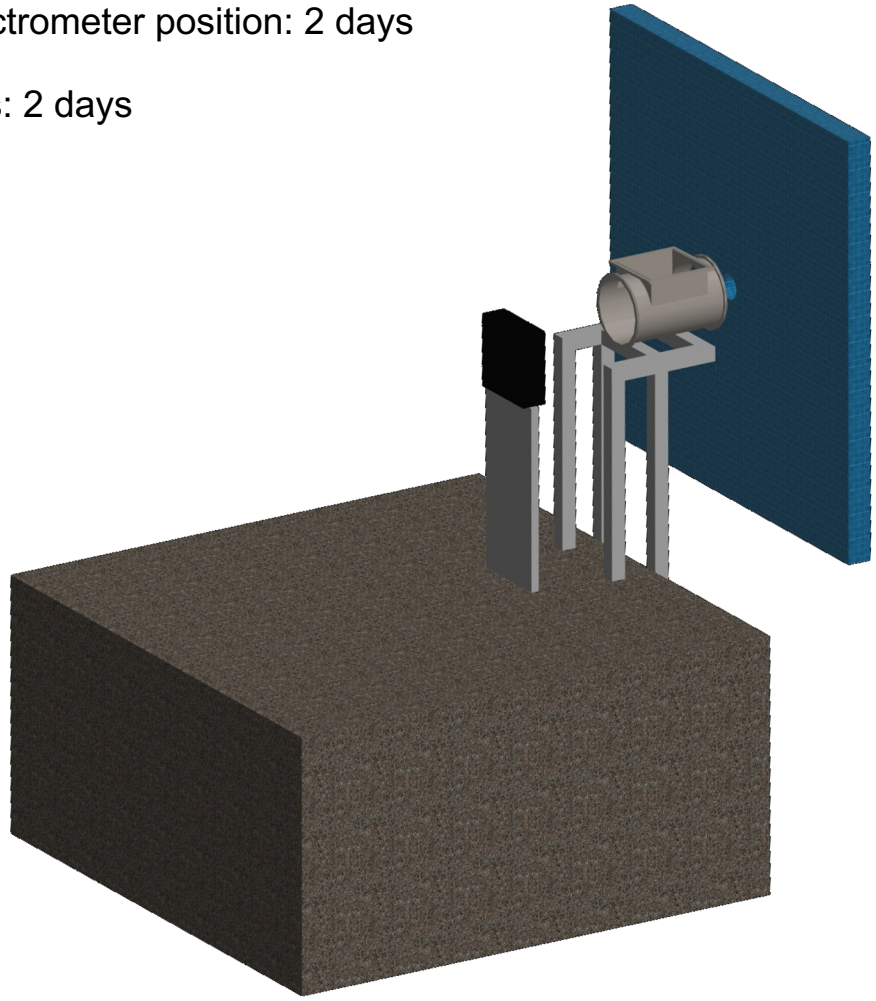
SPS planning





Unified Tracking Station: Installation planning (from April)

- Setup and cabling of UTS in the spectrometer position: 2 days
- Readout tests with the new detectors: 2 days



Ongoing work on the UTS

- The UTS has arrived at CERN on Sunday 18.9.
- Installation of the ALPIDEs is ongoing
- SFH detector status and plans: Karl's talk

Proposed 2023(+) setup

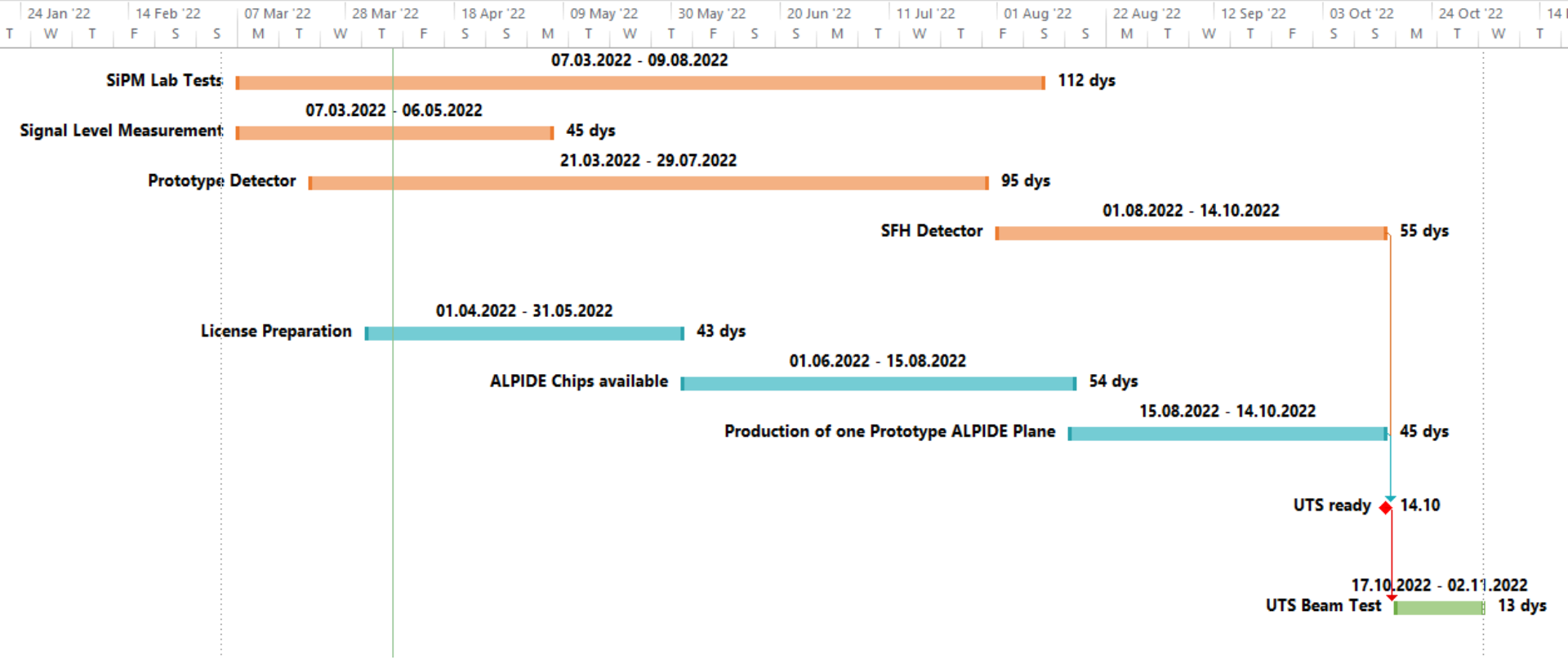
- The actual simulation of the 2023 setup (M. Hoffmann) includes as active detector components:

Component	**Purpose**
BMS	Beam momentum
IKAR TPC (8 bar)	Recoil proton
4 Pixel Silicons (SP, 3 planes)	Vertexing
4 SciFi Tracker (FT, 2 XY planes)	Timing
8 Compass SciFis (FI)	Timing (vertexing, momentum)
3 GF	Momentum
MWPCs (PB, PA06, PA11)	Momentum and muon Id.
HI05, HL, HM04/5Y	Muon Identification
ECAL2	Radiative corrections

- Magnet setting: SM1 off, SM2 on
- GF: Same as GM, active dead zone
- Material, not used in reconstruction: ST, DC, W45, RICH, ECAL1, HCAL1, HCAL2, MWPCs (PA01-05, PS), MW1, MW2, HI04, HO, HM04/5X, HG, 3 GF

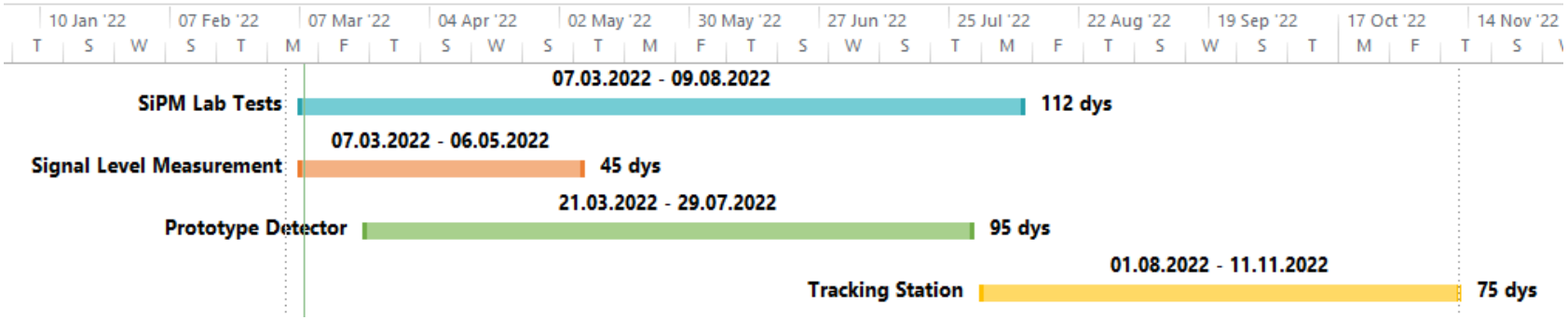
Backup

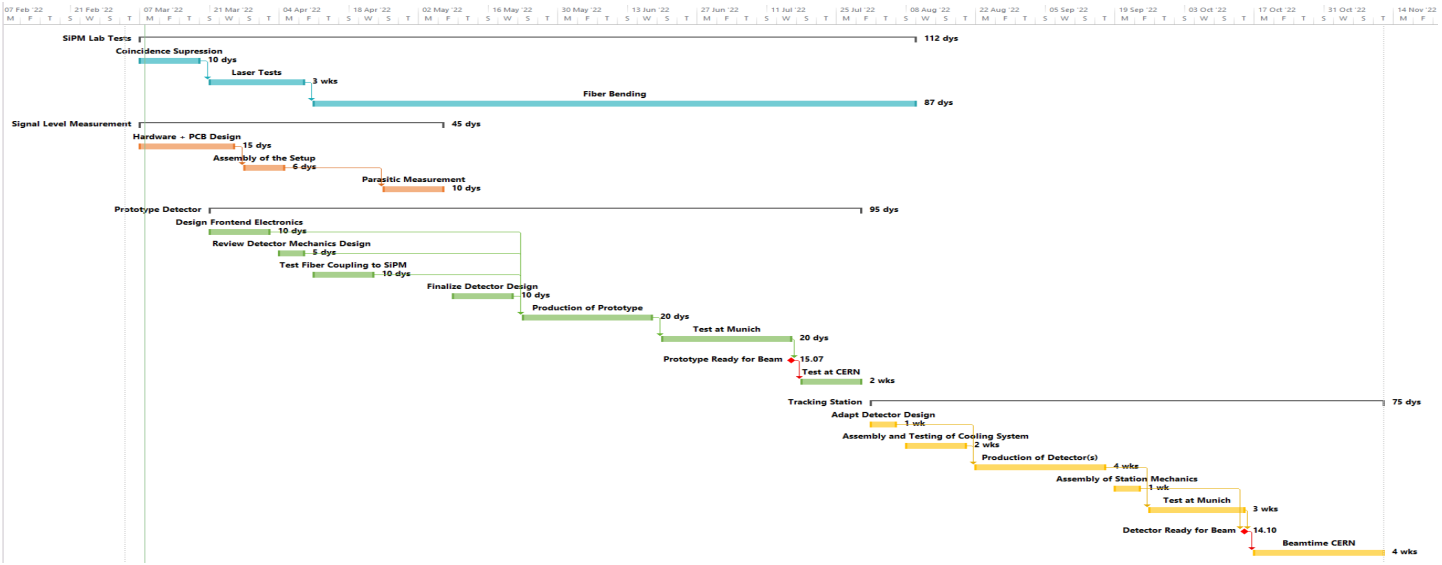
Timelines for the Detector Developments in 2022



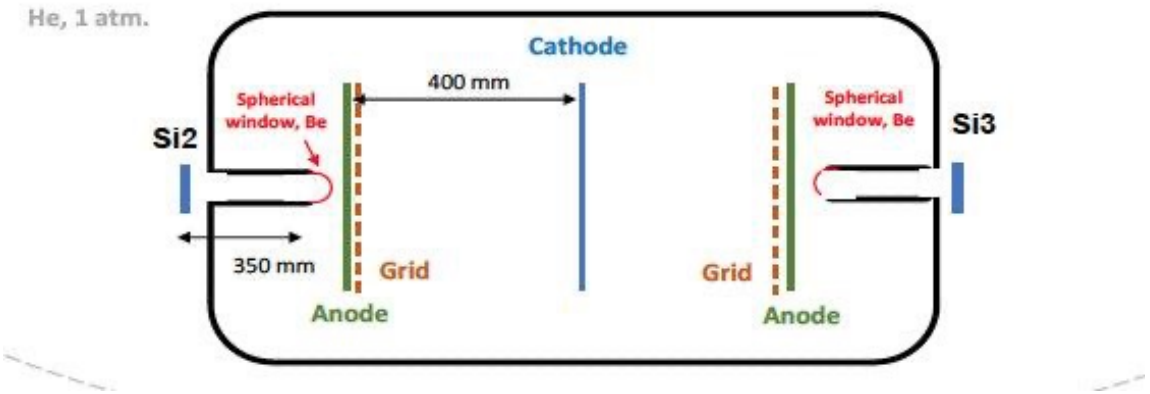
Fiber Hodoscopes – Tests in 2022

Detailed timelines have been worked out, input for TB





TPC: IKAR as in the 2021 test



- Pressure vessel inner diameter: 740 mm
- Pressure vessel length: 1600 mm
- Total volume 0.55 m^3
- Maximal operating pressure: 10 bar
- Spherical Be windows: 70 mm diameter, 0.5 mm thickness
- Total weight with the support : ~1500 kg
- Drift cells: two 400 mm drift cells
- Anode plane consists of a 10 mm diameter central pad surrounded with six rings
- The outer diameter of the largest ring is 480 mm