Status of
Fast Forward Detector
(FFD)

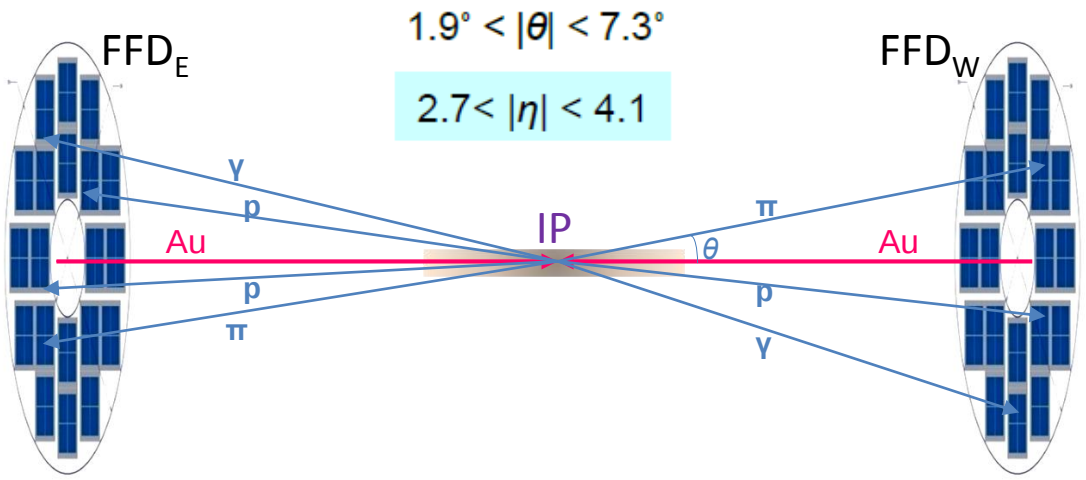
Vladimir Yurevich

LHEP / JINR

Aim and Concept of the Detector

Requirements to FFD

- Fast triggering nucleus – nucleus collisions (ε ~ 100 % for central and semi-central collisions)
- Fast determination of IP position with two subdetectors FFD_E and FFD_W ($\sigma_Z \approx 1 – 3$ cm)
- T0- pulse for TOF detector ($\sigma_t \leq 50$ ps)



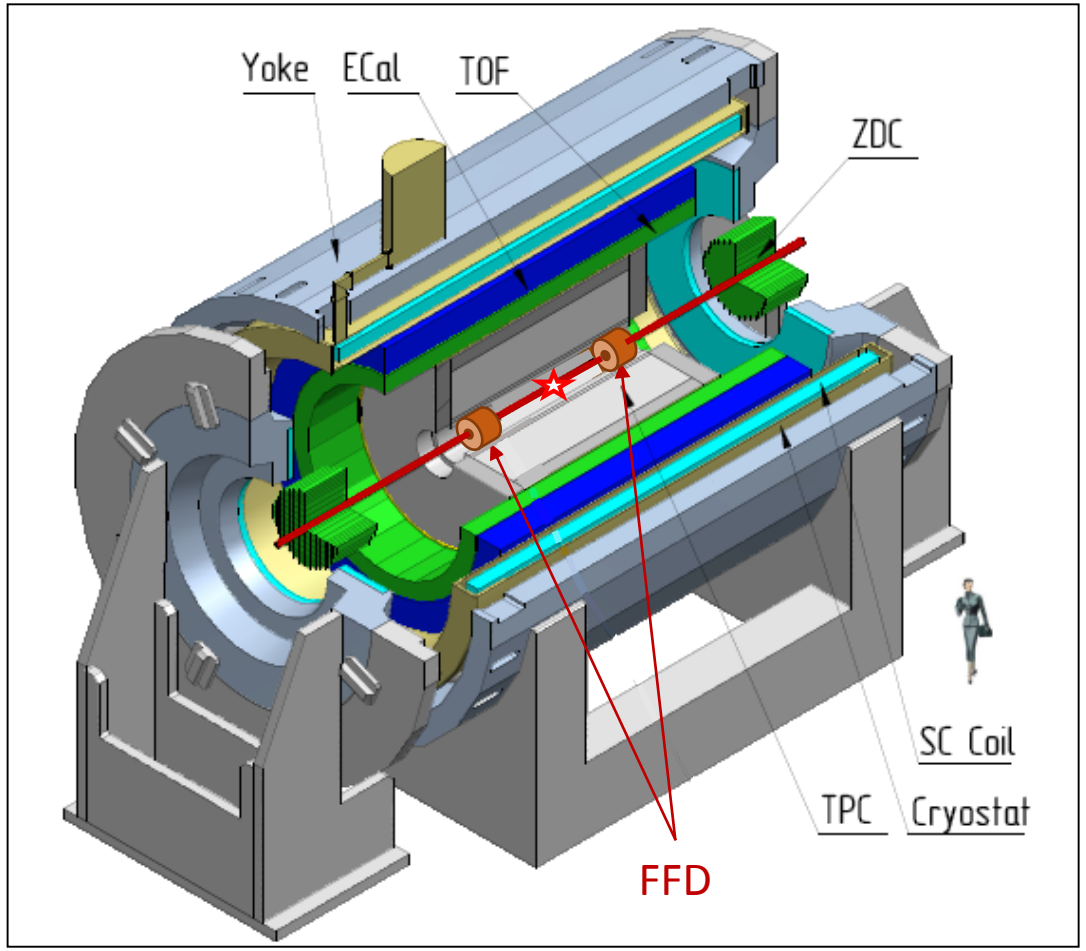
Troubles in the NICA energy range

- ✓ Low multiplicity of charged particles produced in *AA*- collisions
- ✓ Not all particles have velocity close to the velocity of light

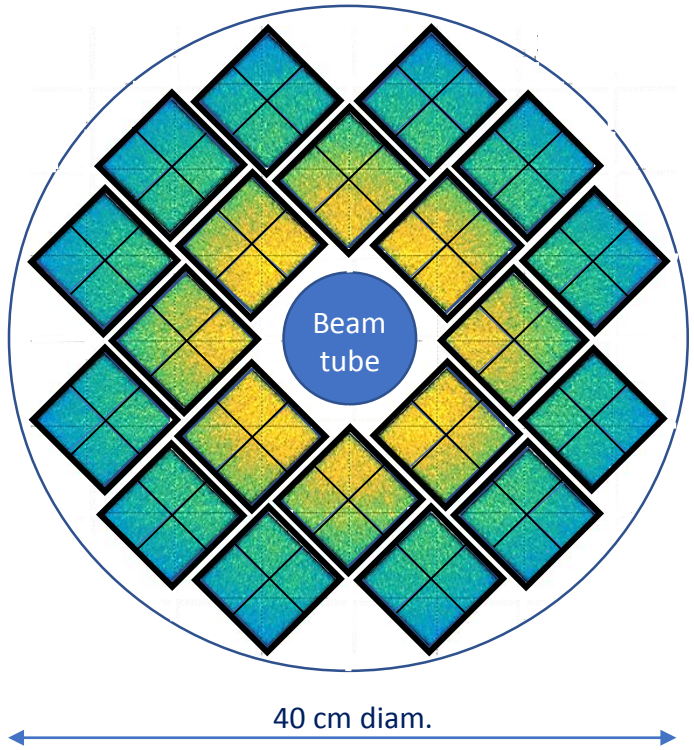
Detector features

- ✓ Large active area
- ✓ Small distance from IP (140 cm from MPD center)
- ✓ Pb convertor for detection of high-energy photons

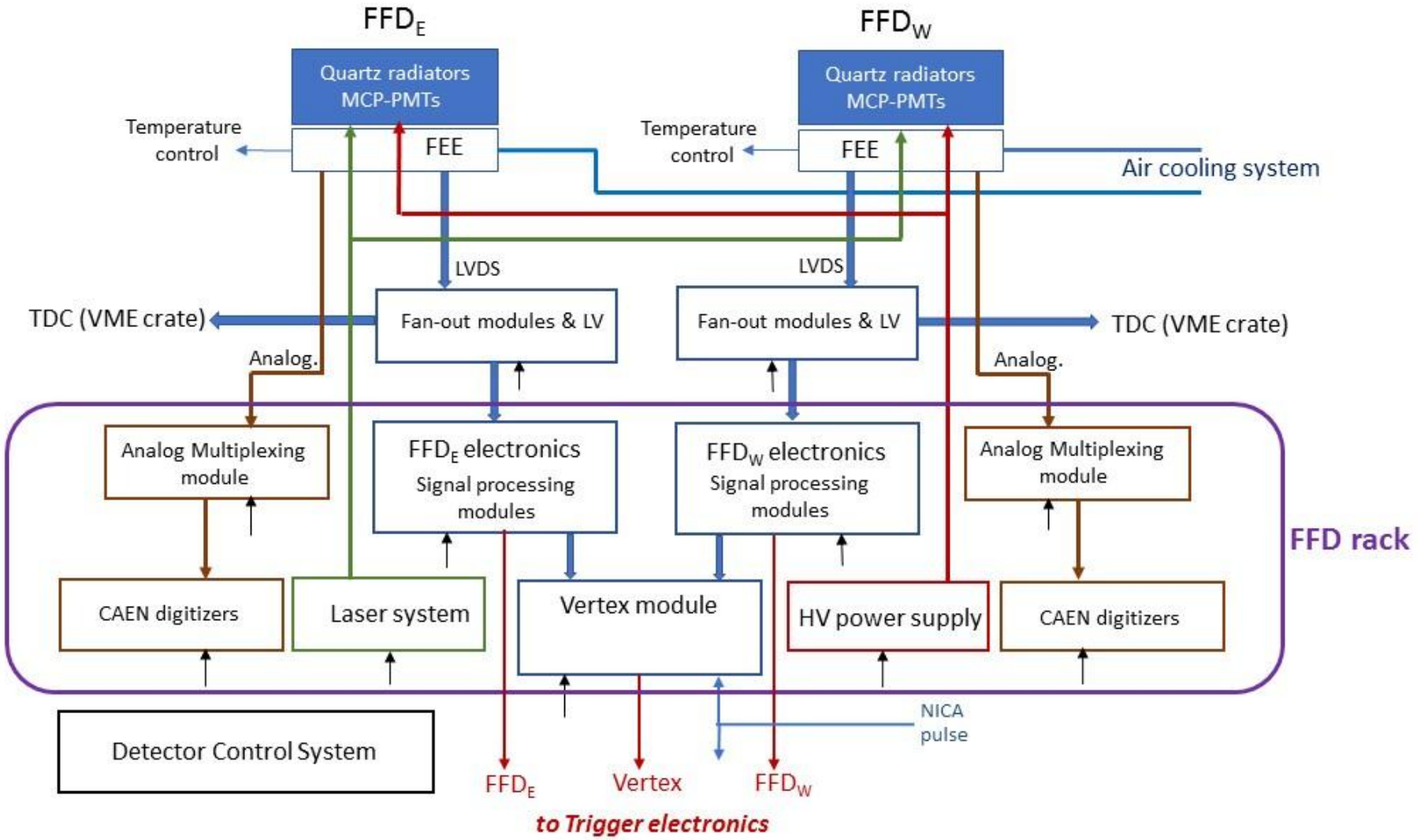
FFD Design and Composition



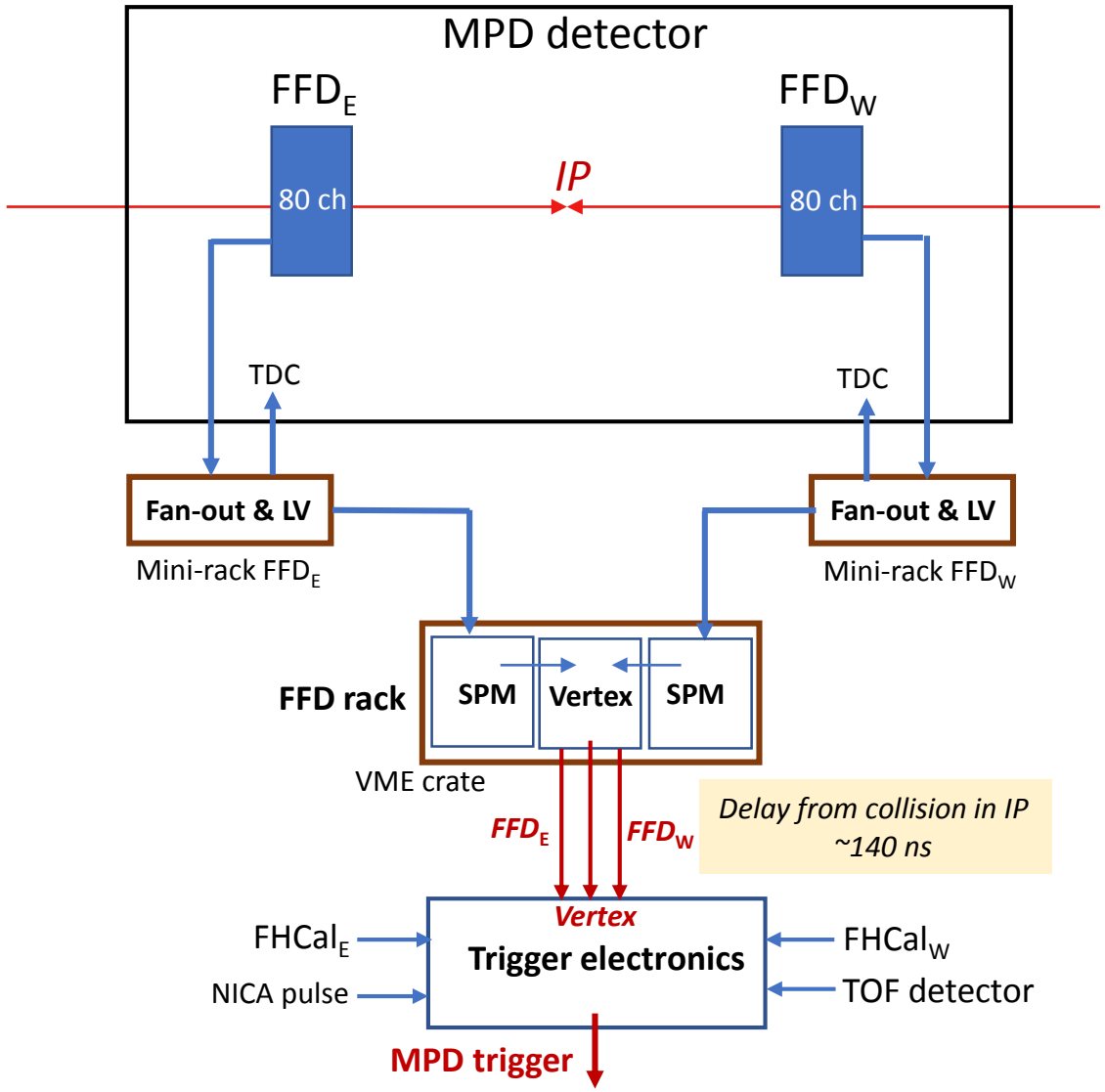
Two Cherenkov subdetectors FFD_E and FFD_W
has 20 modules & 80 cells each
with position at 140 cm from MPD center



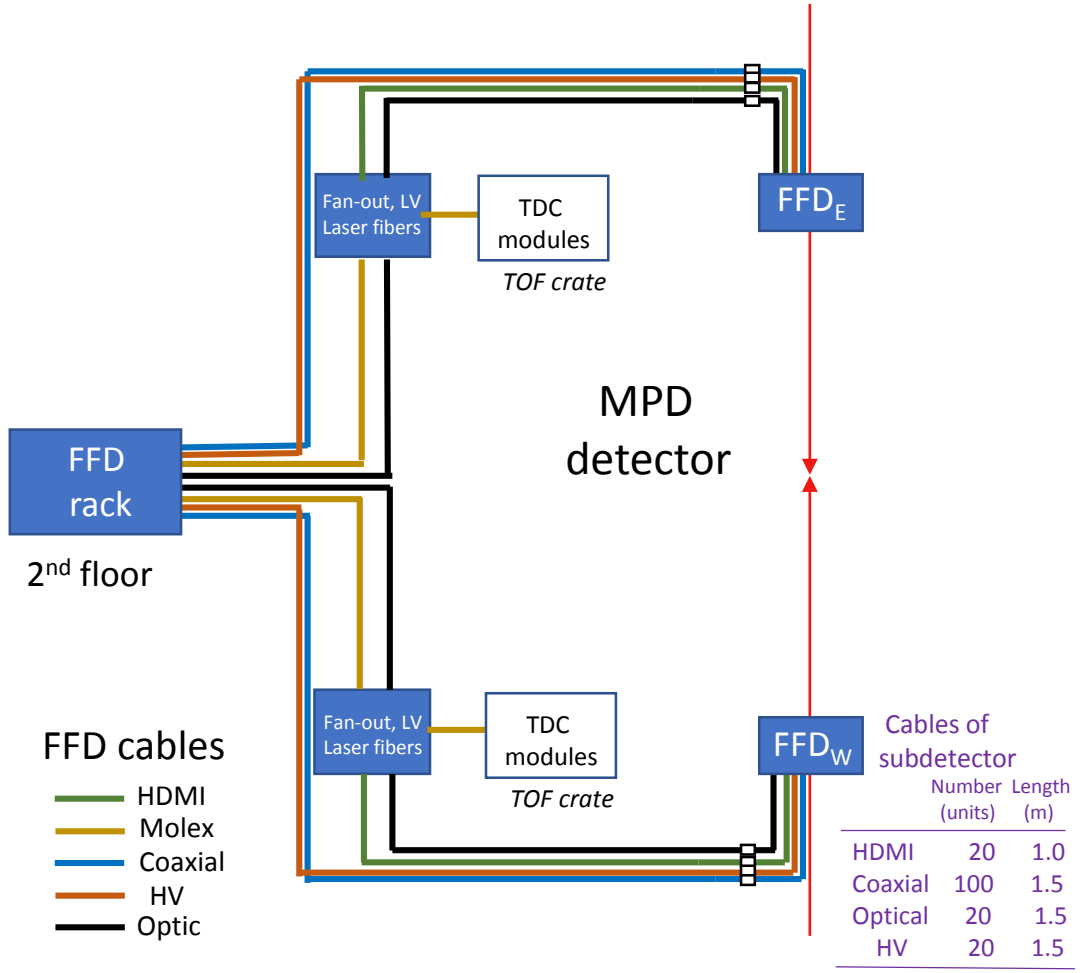
FFD Electronics and Sub-systems



FFD in MPD Trigger



FFD cable lines



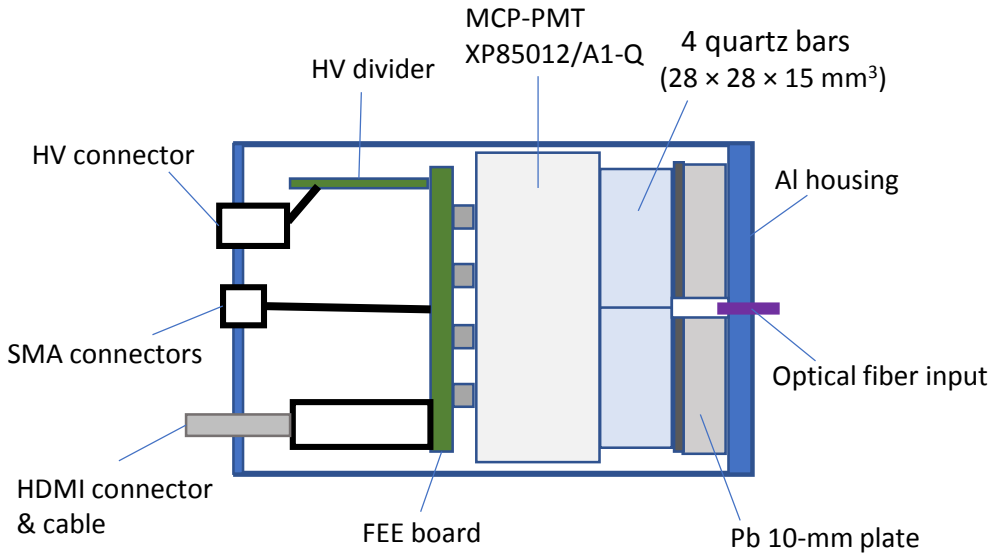
Cables of subdetector

	Number (units)	Length (m)
HDMI	20	1.0
Coaxial	100	1.5
Optical	20	1.5
HV	20	1.5

Currently the design of FFD cable connections and cable lines is under development

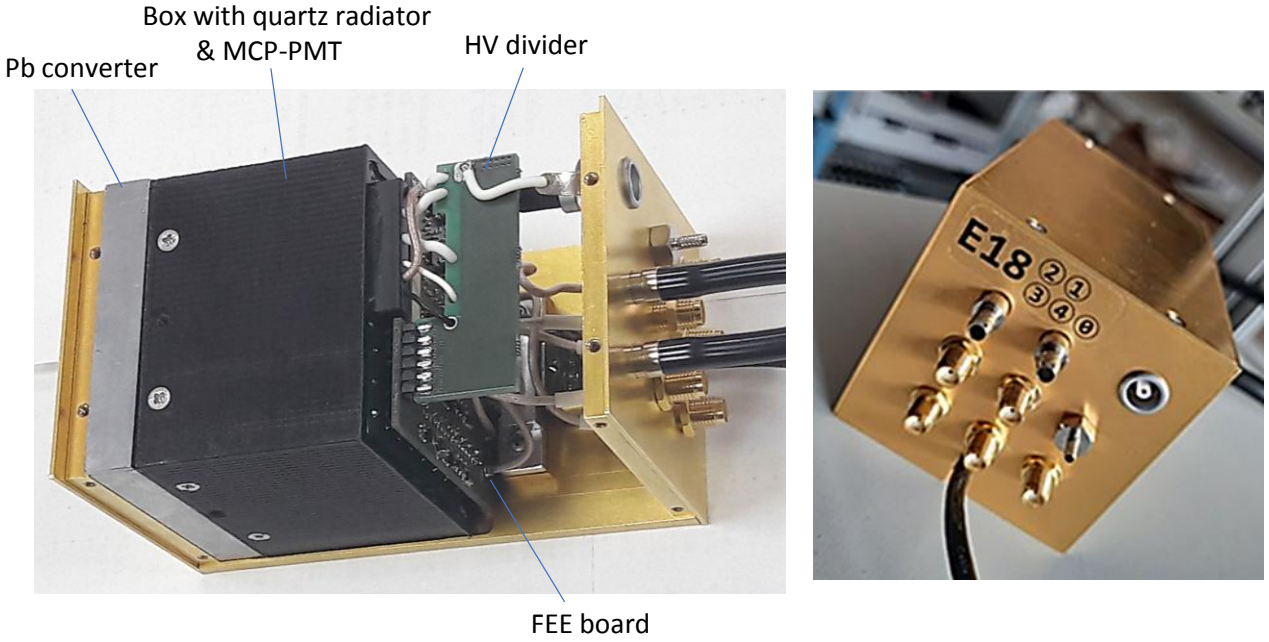
FFD Cherenkov modules

Concept



FFD module size: 64 × 64 mm²
Quartz radiator size: 56 × 56 mm²
Occupancy: 76.6%

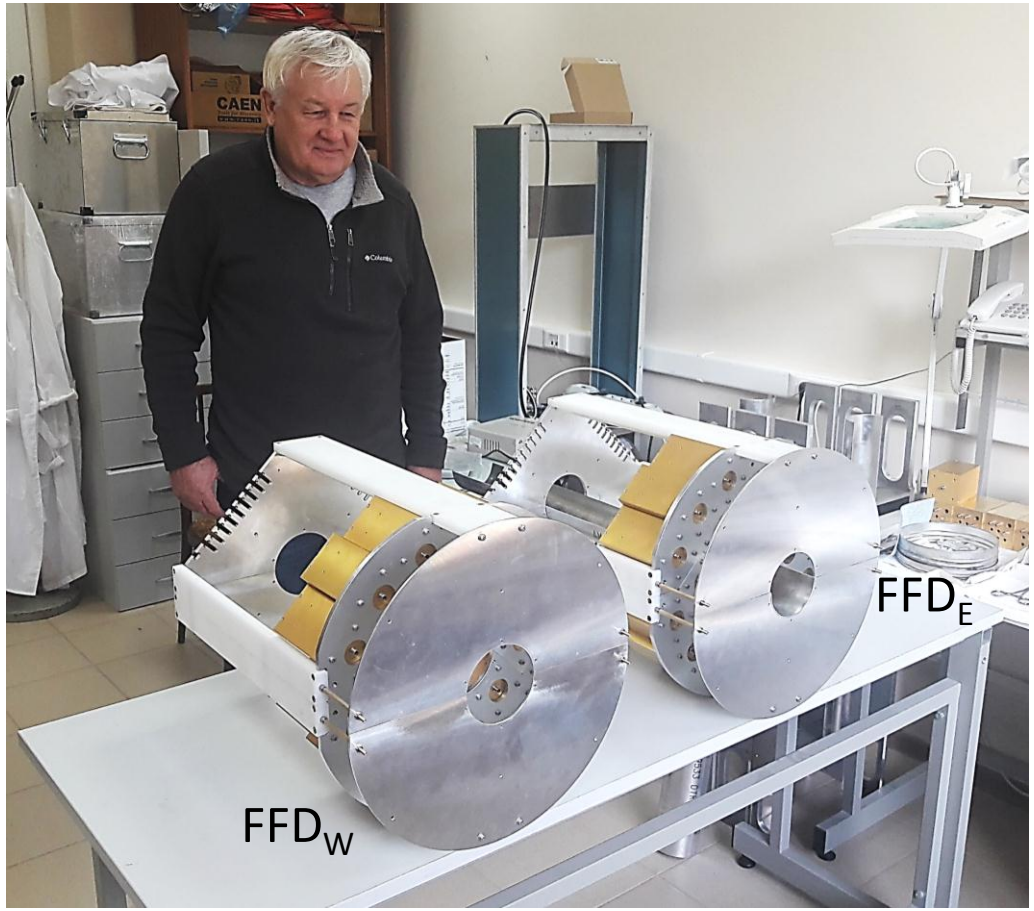
Real modules



All 40 detector modules are ready for final tests and installation

The time resolution of 40 ps was obtained in test measurements with proton beam and cosmic muons with full chain of cables and electronics

FFD Mechanics



FFD subdetector mechanics

Tools for FFD installation

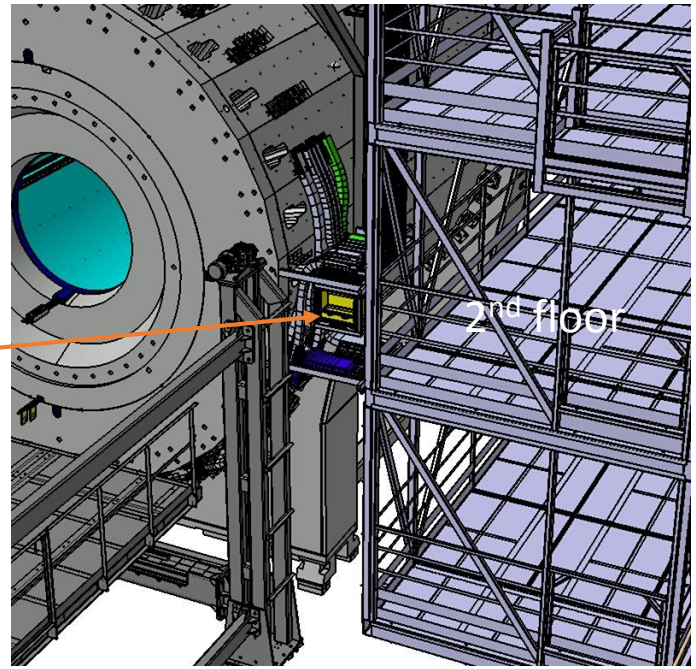
Current status: All mechanics is ready for installation of the subdetectors into the MPD

Intermediate FFD crates

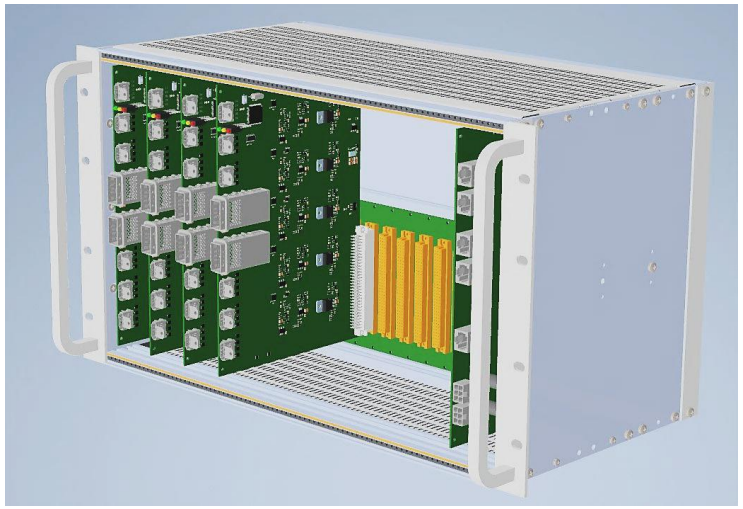
The intermediate crates of the FFD subdetectors together with patch panels for laser optical fibers are located in two mini-racks close to cable outlets of the magnet yoke at the 2nd floor of the MPD frame.

Each crate includes four modules with LV power supplies and fanout of LVDS pulses (LVM) and power distribution module (PDM).

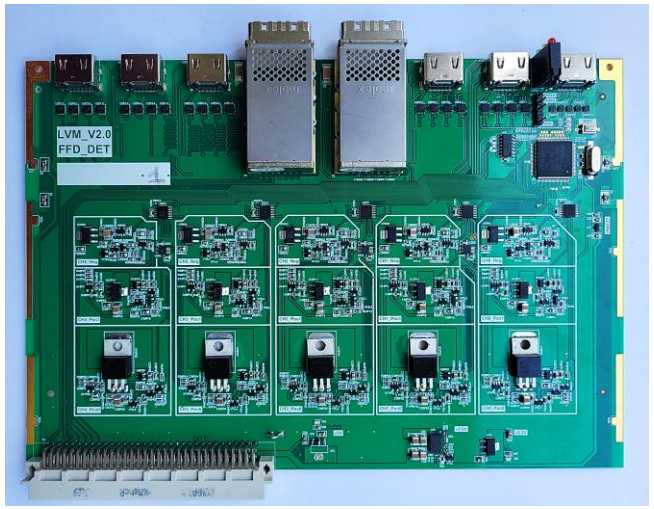
The electronics modules and crates will be produced till the end of 2023



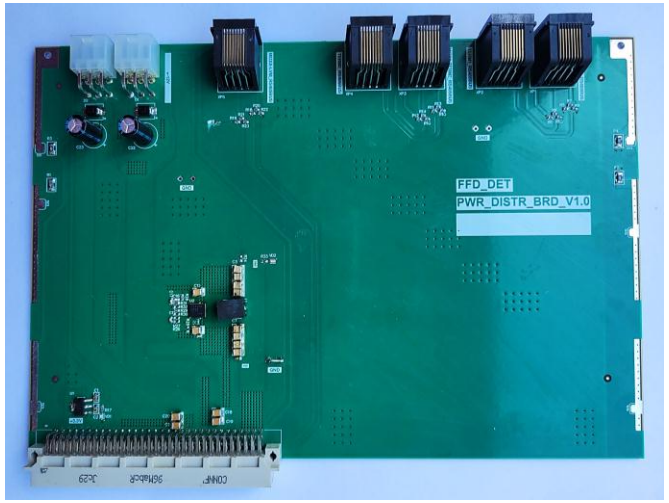
3d model of intermediate crate with modules



LVM module

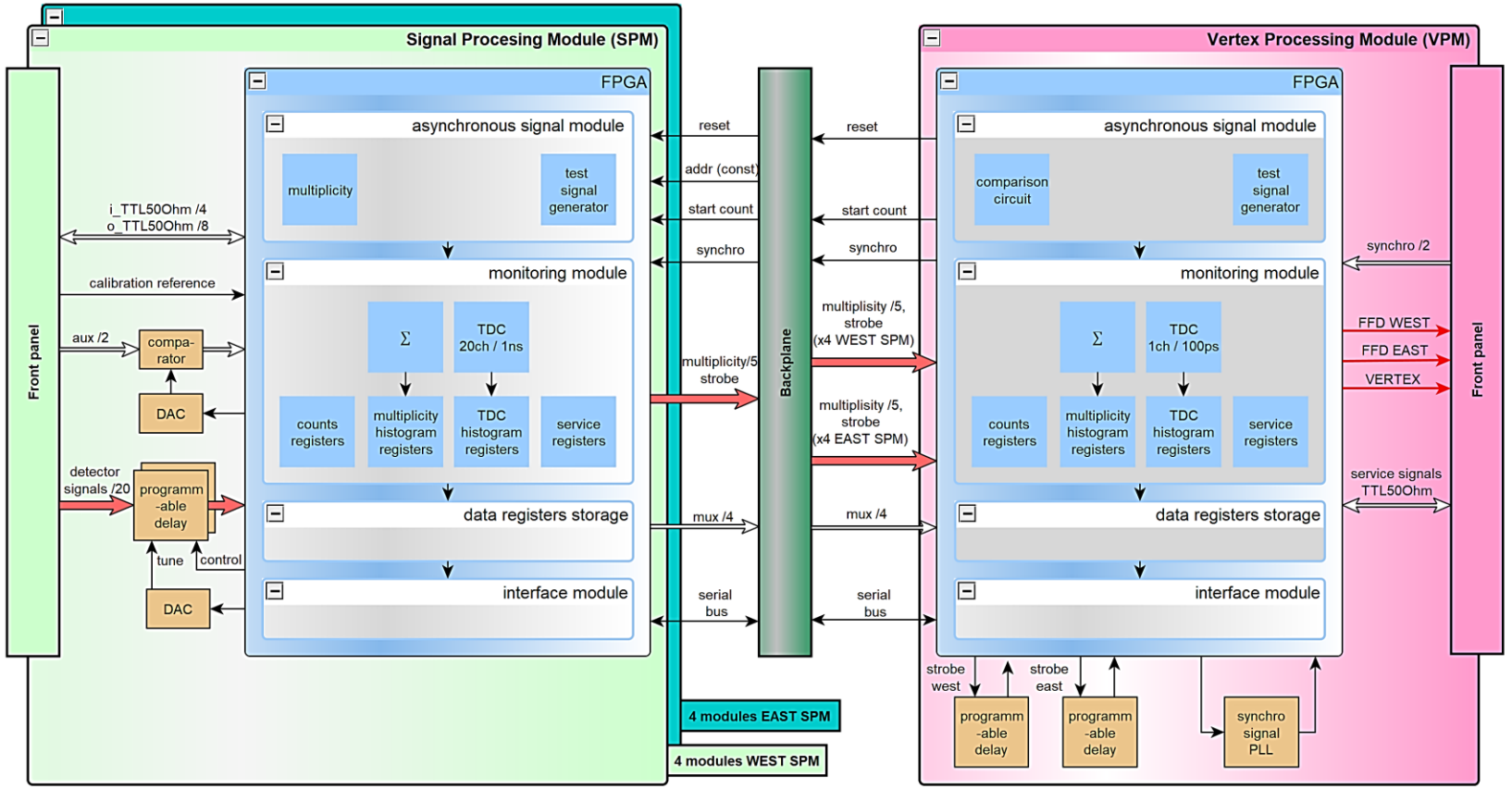


PDM module



FFD Electronics (final design)

Functional scheme of SPM and Vertex modules based on FPGA with backplane communication

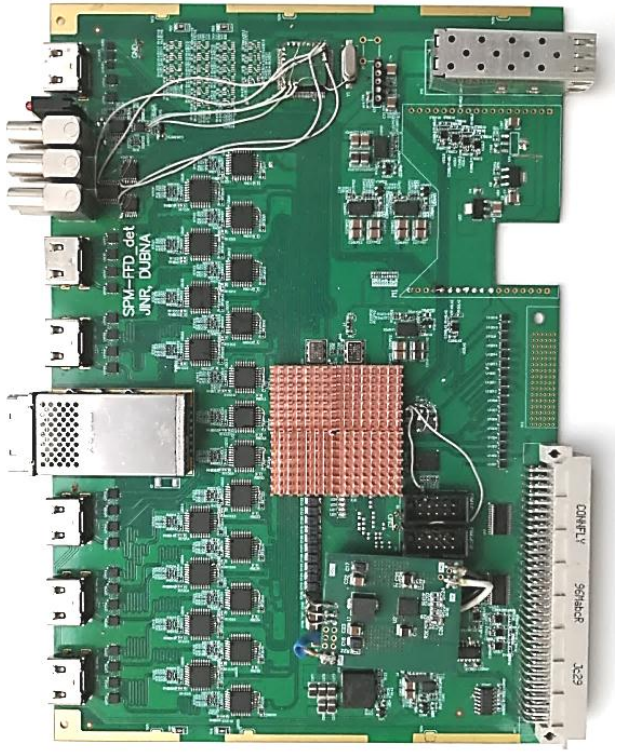


All modules are placed in a single VME crate with custom backplane

At the moment we have passed the studies with SPM prototypes and the modules are under production.
The tests with VPM prototype continue and the production is planned in the beginning of next year.

Status of Electronics

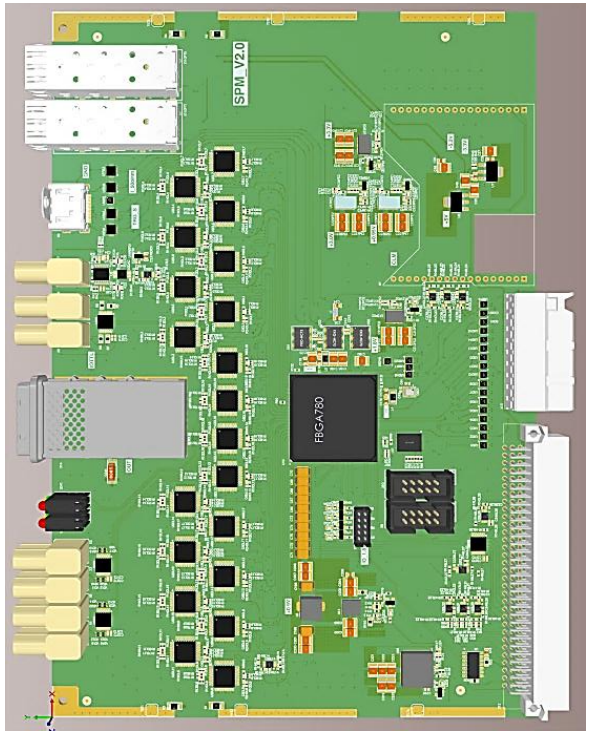
Prototype



PCB SPM_V1.0

It has been tested together with high-level software in 2023

Final version



3d model of SPM_V2.0

New SPM modules are in production and will be tested in September - October

Plan 2023:

- Production of all SPM modules (8 units)
- Production of crate backplane
- Production of VPM prototype

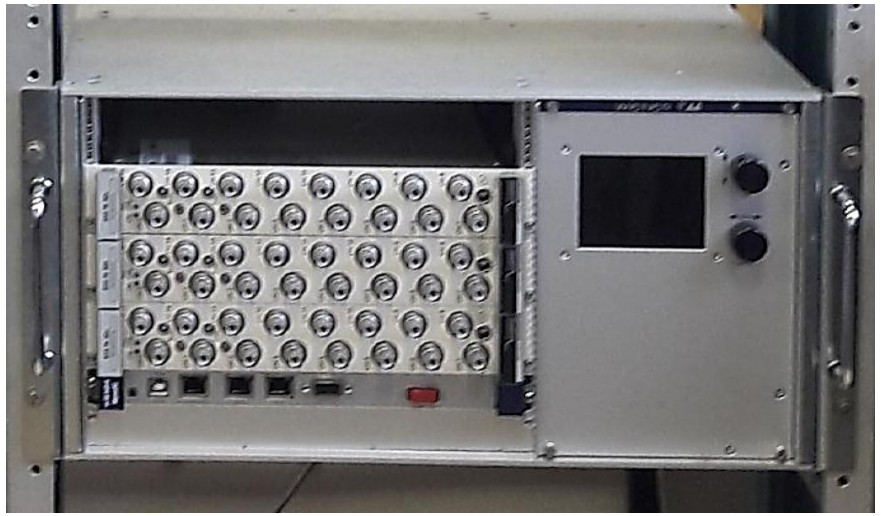
Plan 2024

- Production and testing of VPM module
- Study of operation of FFD electronics together with FFD subdetectors in measurements with cosmic muons at laboratory

High Voltage power supply

High voltage system has 48 channels (for FFD modules we need 40 ch. + 1 ch. for the reference detector of the laser system).

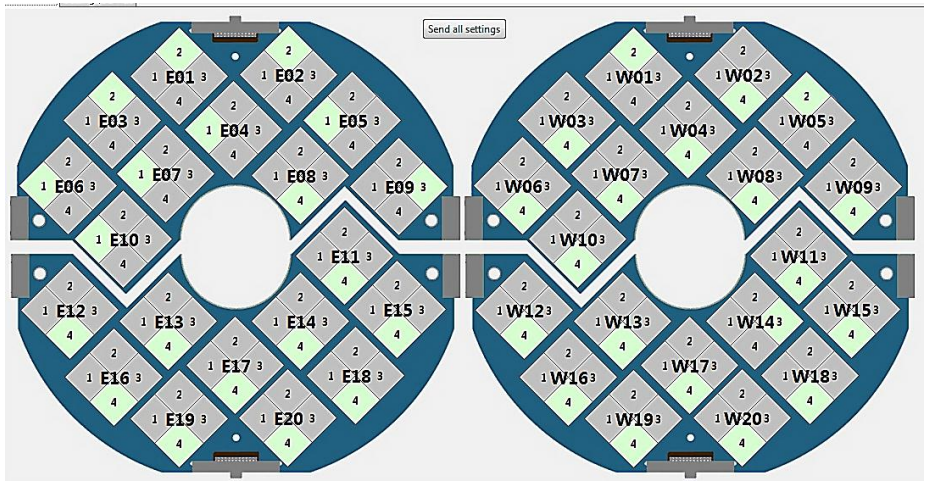
It consists of three 16- channel modules and controller module from ISEG placed in Mpod crate from WIENER.

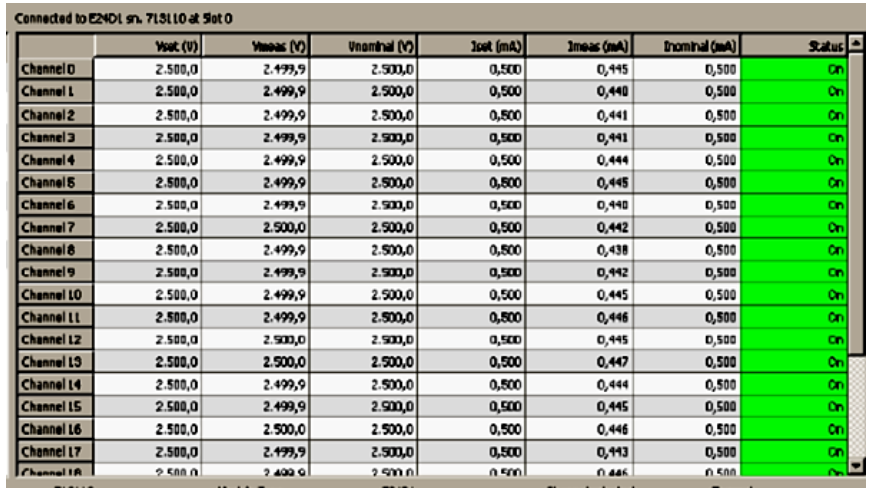


The HV system has passed tests and it is ready for use.

HV system is 100% ready

Interface





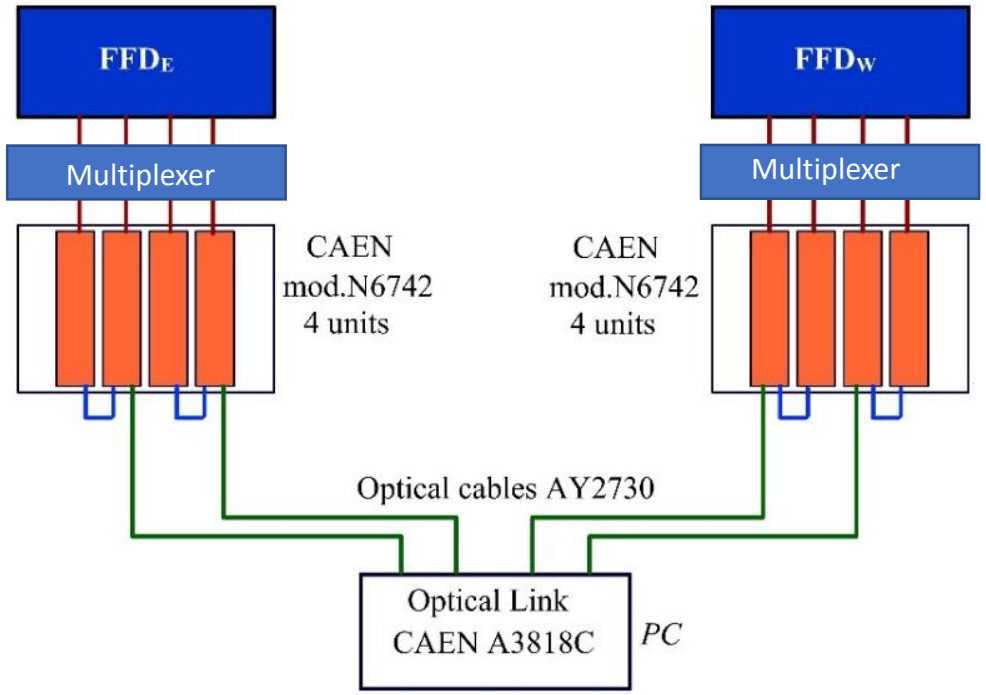
Connected to E24D1 sn. 7131L10 at Slot 0

	Vset (V)	Vmeas (V)	Vnominal (V)	Iset (mA)	Imeas (mA)	Inominal (mA)	Status
Channel 0	2.500,0	2.499,9	2.500,0	0,500	0,445	0,500	On
Channel 1	2.500,0	2.499,9	2.500,0	0,500	0,440	0,500	On
Channel 2	2.500,0	2.499,9	2.500,0	0,500	0,441	0,500	On
Channel 3	2.500,0	2.499,9	2.500,0	0,500	0,441	0,500	On
Channel 4	2.500,0	2.499,9	2.500,0	0,500	0,444	0,500	On
Channel 5	2.500,0	2.499,9	2.500,0	0,500	0,445	0,500	On
Channel 6	2.500,0	2.499,9	2.500,0	0,500	0,440	0,500	On
Channel 7	2.500,0	2.500,0	2.500,0	0,500	0,442	0,500	On
Channel 8	2.500,0	2.499,9	2.500,0	0,500	0,438	0,500	On
Channel 9	2.500,0	2.499,9	2.500,0	0,500	0,442	0,500	On
Channel 10	2.500,0	2.499,9	2.500,0	0,500	0,445	0,500	On
Channel 11	2.500,0	2.499,9	2.500,0	0,500	0,446	0,500	On
Channel 12	2.500,0	2.500,0	2.500,0	0,500	0,445	0,500	On
Channel 13	2.500,0	2.500,0	2.500,0	0,500	0,447	0,500	On
Channel 14	2.500,0	2.499,9	2.500,0	0,500	0,444	0,500	On
Channel 15	2.500,0	2.499,9	2.500,0	0,500	0,445	0,500	On
Channel 16	2.500,0	2.500,0	2.500,0	0,500	0,446	0,500	On
Channel 17	2.500,0	2.499,9	2.500,0	0,500	0,443	0,500	On

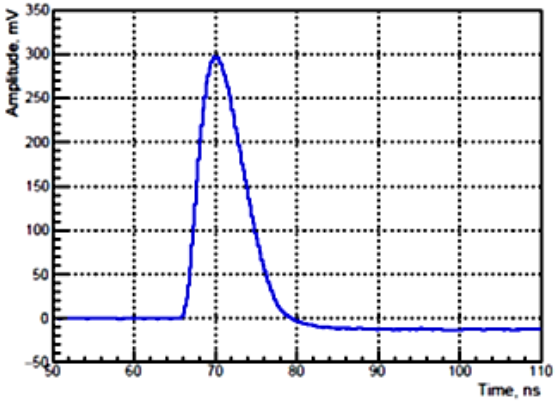
FFD module Monitoring system

A special branch of equipment is applied to control of the detector modules operation by study of analog pulses of each detector cell.

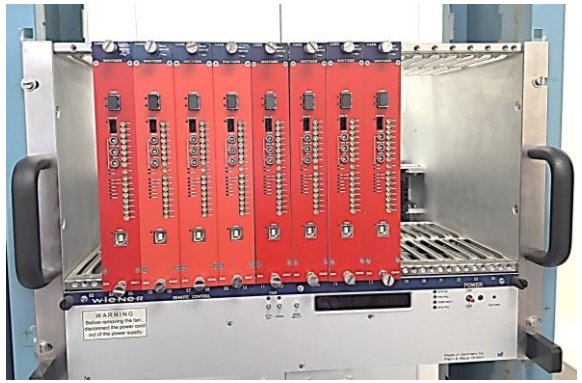
For this purpose a set CAEN digitizer modules with 200- ps binning is used.



Analog Multiplexing Module



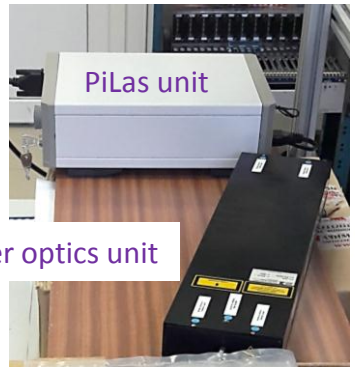
FFD pulse



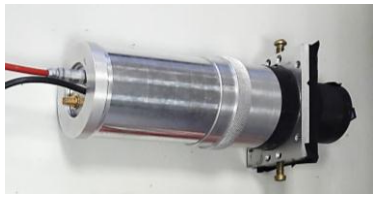
NIM crate with CAEN digitizers

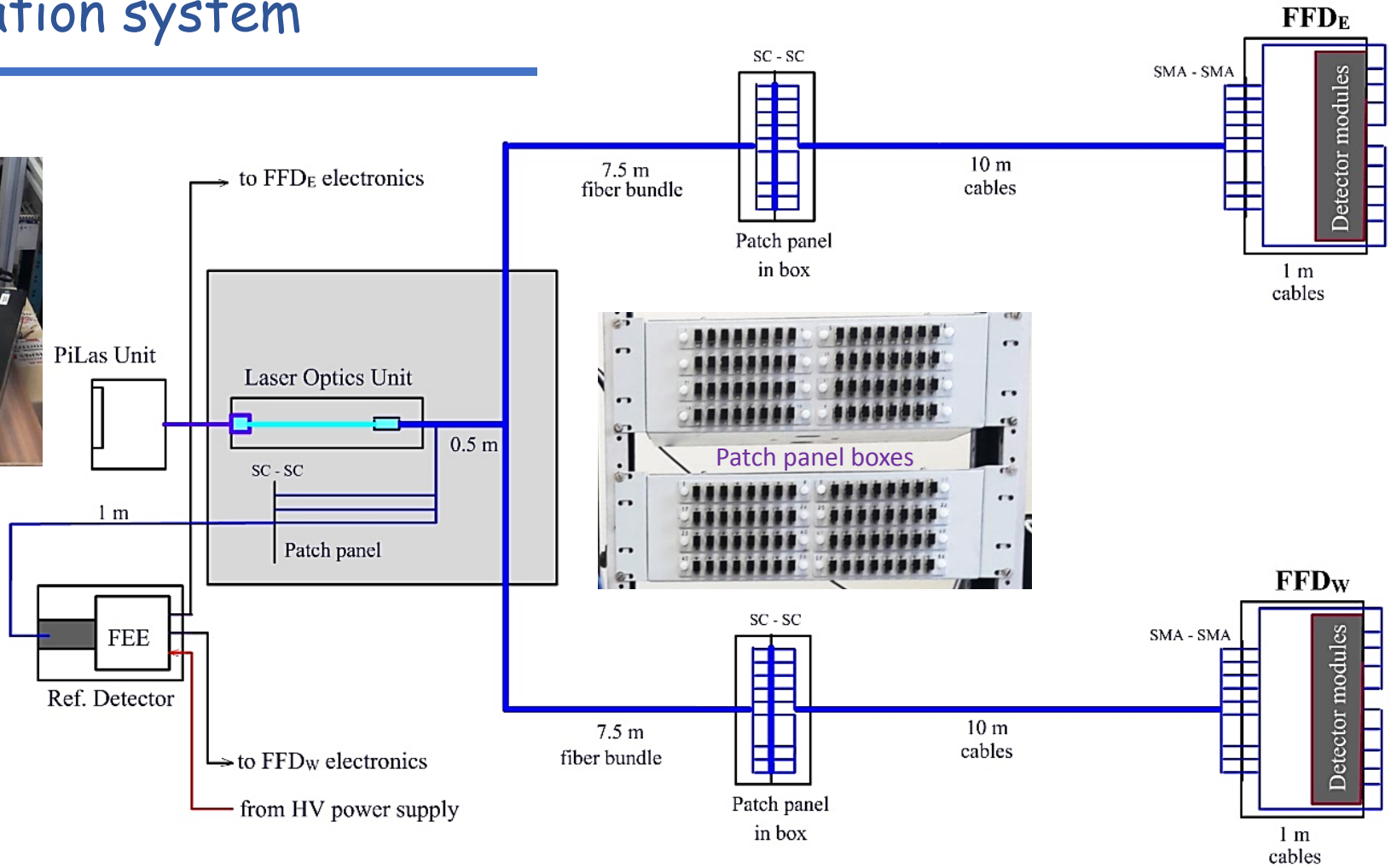
All this equipment is available and now it is used in our studies at laboratory.

Laser calibration system



Reference detector with MCP-PMT



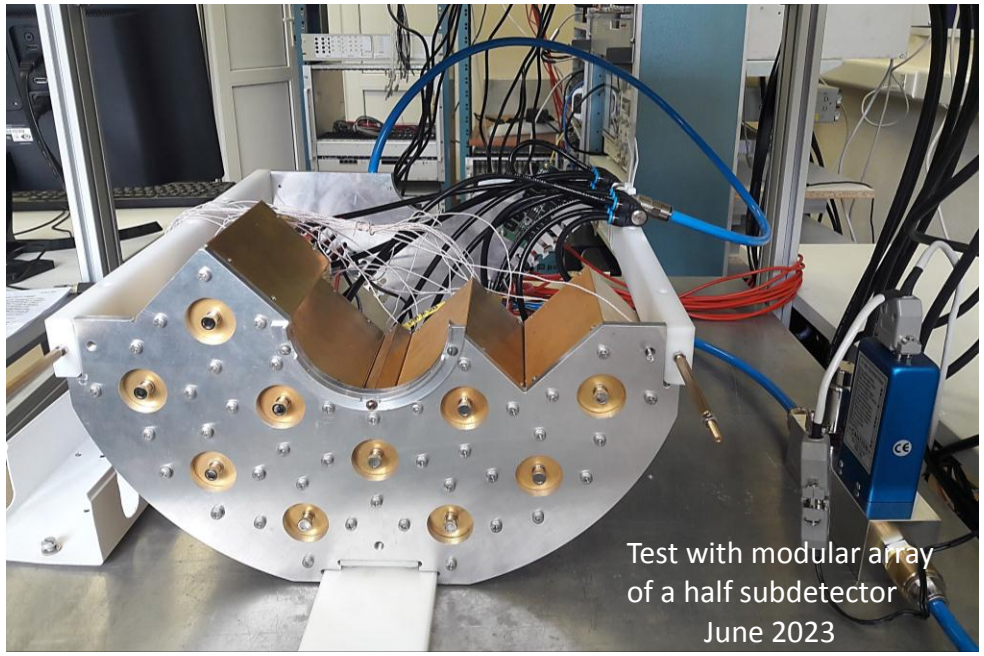


Existing parts:

- PiLas laser
- Reference detector
- Optical fibers
- Patch panels

- All these elements are available and the laser system is successfully used in our tests in laboratory
- High level software needs to be developed in 2023

Test of Temperature Conditions and Cooling



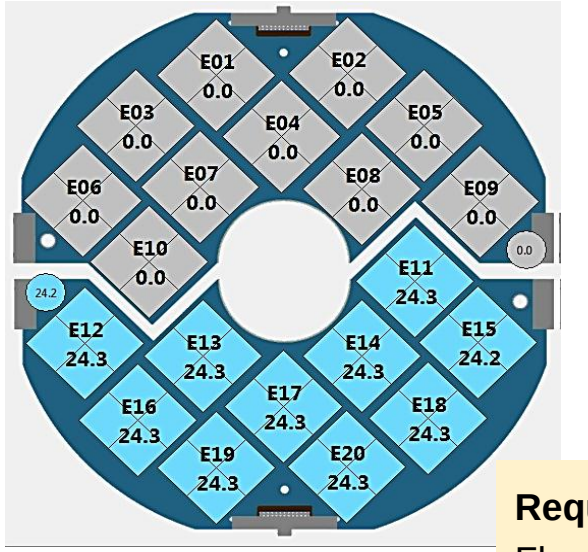
Temperature inside modules

No air flow	Air flow 40 l/min
+8° C	+4° C

Air of room temperature was used in the tests

We expect that during MPD operation a flow of cool and dry air (nitrogen) will be used.

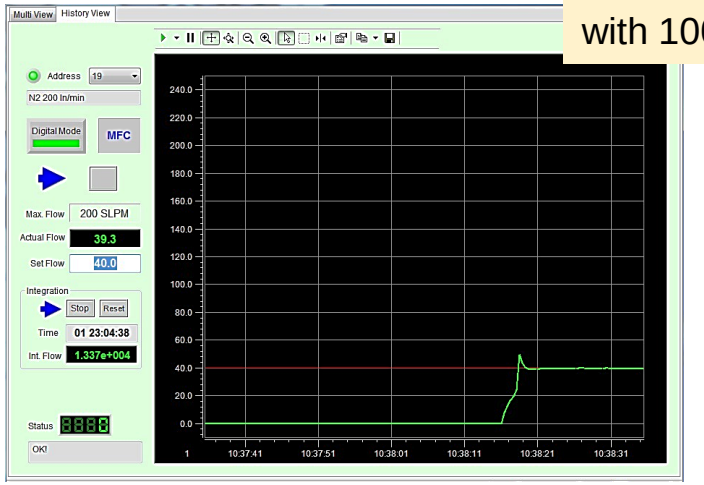
Interface of temperature monitoring



The FFD cooling system is a part of the MPD cooling system which is currently under development

Requirement for FFD cooling:

Flow of cool and dry air or nitrogen with 100 L/min per subdetector



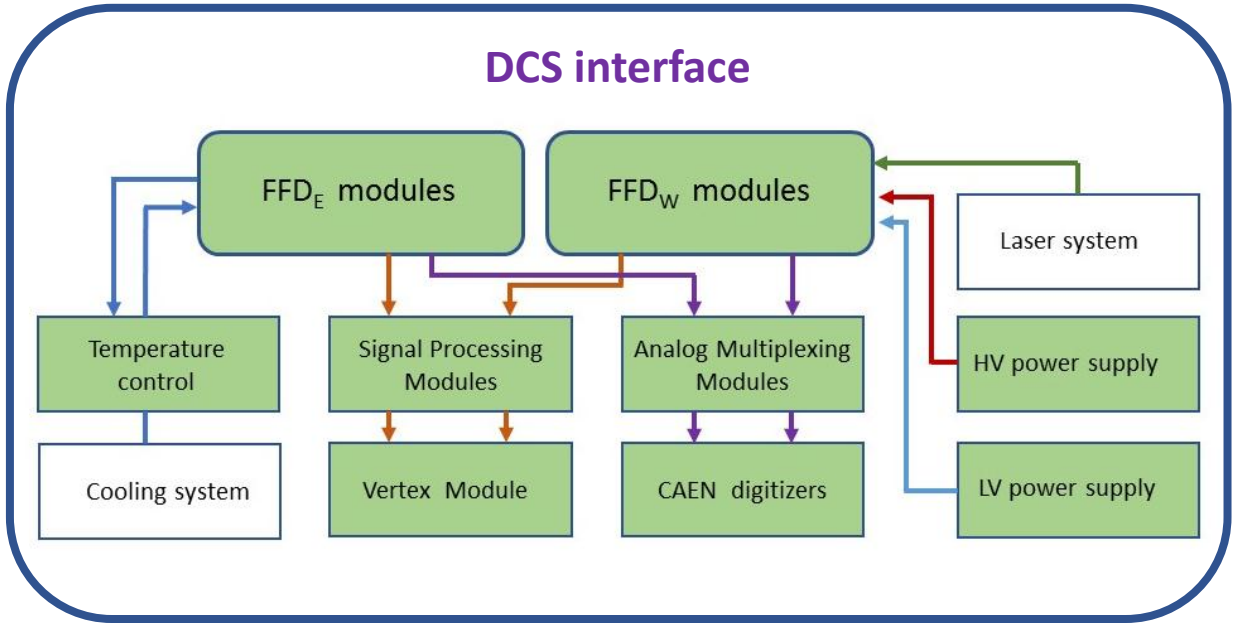
Detector Control System

The system is built using client-server architecture

It includes control and monitoring of operation of all FFD subsystems

Plan 2023 - 2024

- HV system (ready)
- LV system (2023)
- Laser calibration system (2023 - 2024)
- Thermo-monitoring and cooling system (2023)
- Trigger hardware control system (2023-2024)
- Multiplexer control system (ready)
- Partitioning and FSM manager (2023-2024)
- Configuration manager (2024)



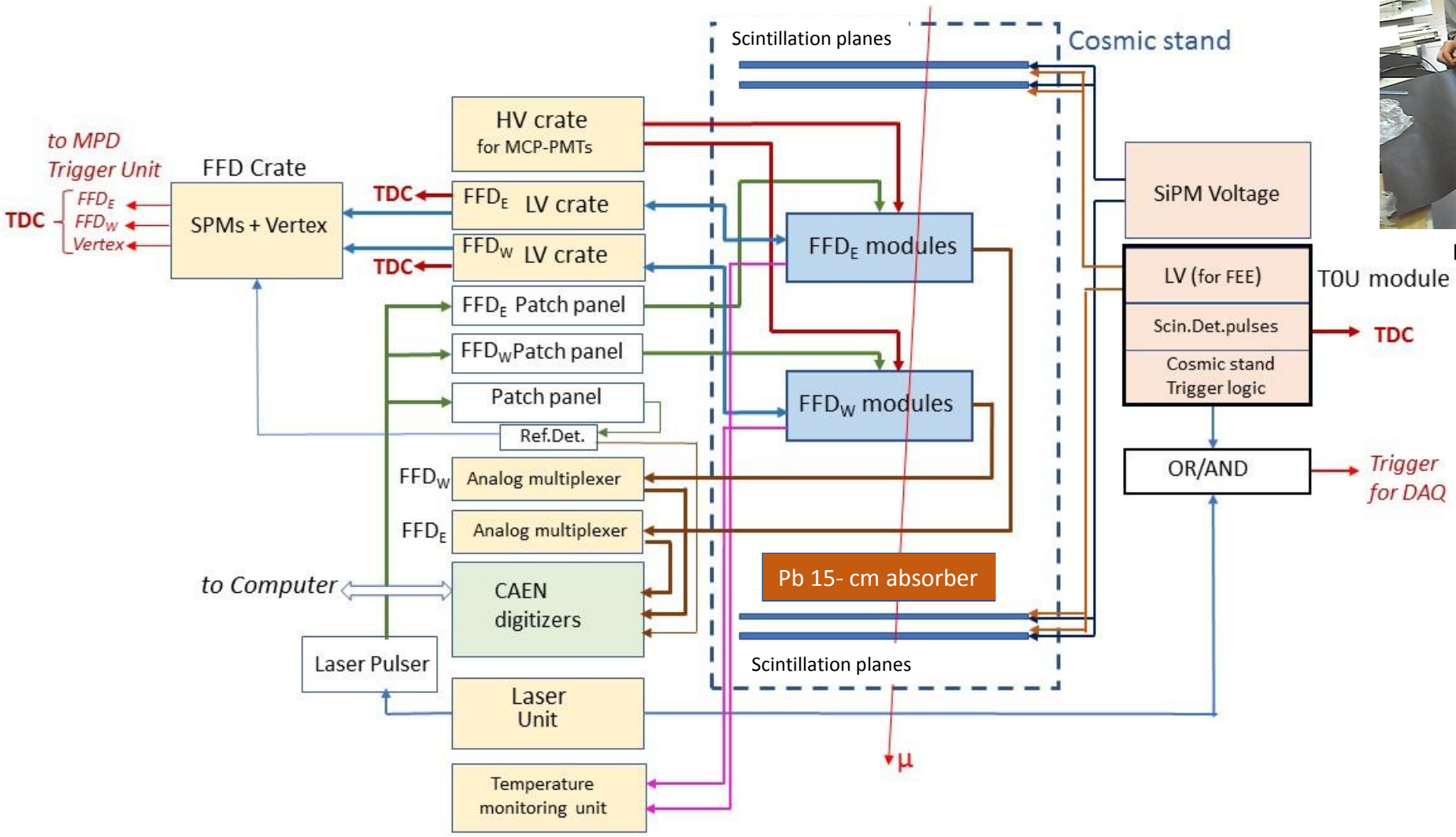
States of equipment:

- "OFF" – not in operation (switched off)
- "StdBy" – in Stand-by mode
- "Ready" – in operation (on)
- "Wrng" – warning - something is out of operation range
- "ALRM" – alarm - dangerous regime (must be switched off and repaired)

Tests of the full-scale DCS with FFD equipment will be finished and the DCS will be ready for running in the middle of 2024

Test Measurements with Cosmic Muons

Production of scintillation planes



Summary

In the beginning 2024 we will be ready for combining all FFD parts together into a single installation for global tests with cosmic muons and laser using our stand in the laboratory.

Aim of these tests is study of the detector and its subsystems characteristics during long term operation.

After this stage the Fast Forward Detector will be ready for installation into the MPD setup.

FFD team:

Vladimir Yurevich – leader of FFD project
Sergey Sedykh – tests and study of FFD performance
Sergey Sergeev – electronics and Detector Control System
Viktor Rogov – electronics and cables
Vladimir Tikhomirov – mechanics and cooling
Pavel Grigoriev – electronics and software
Nikita Lashmanov – tests and study of FFD performance
Vitaliy Azorskiy – mechanics
Alexander Timoshenko – mechanics

Thank You for Your Attention!