Status of
Fast Forward Detector

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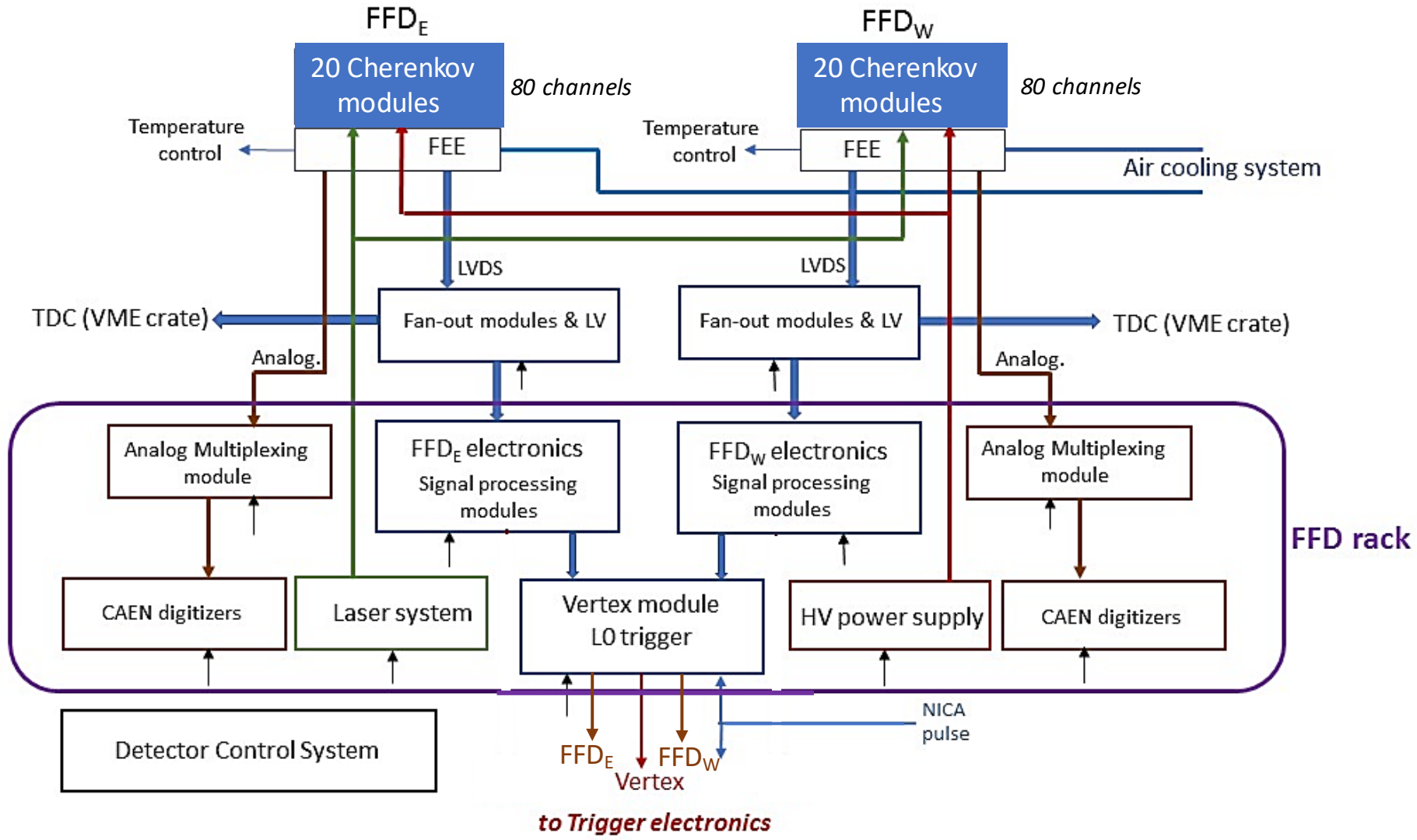
LHEP / JINR

Fast Forward Detector sub-systems

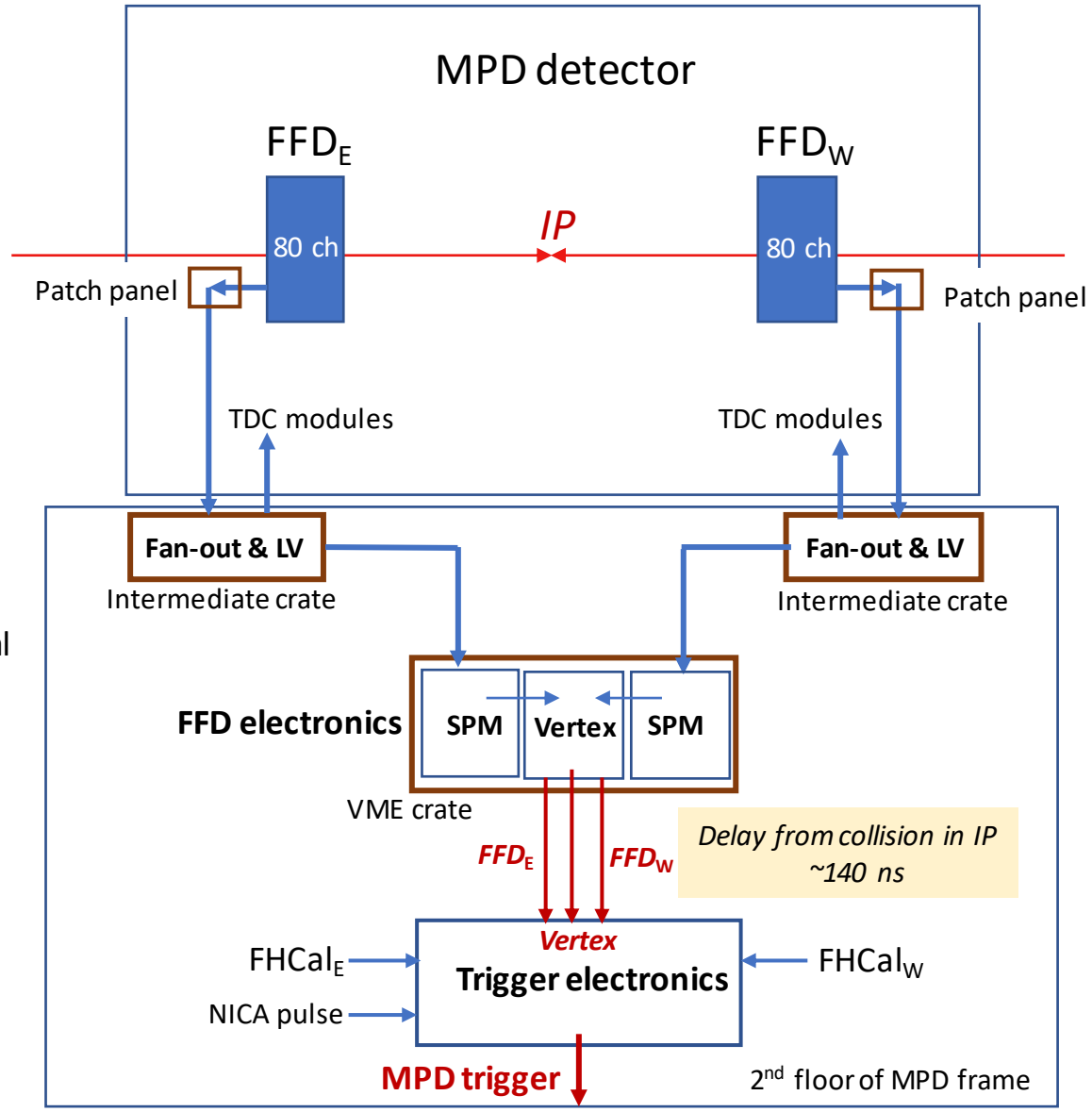


FFD in MPD Trigger

The LVDS pulses, coming from detector modules of each sub-detector, are split into 2 branches, one goes to TDC modules and the second – to main FFD electronics for pulse processing and generation of special signals for trigger electronics

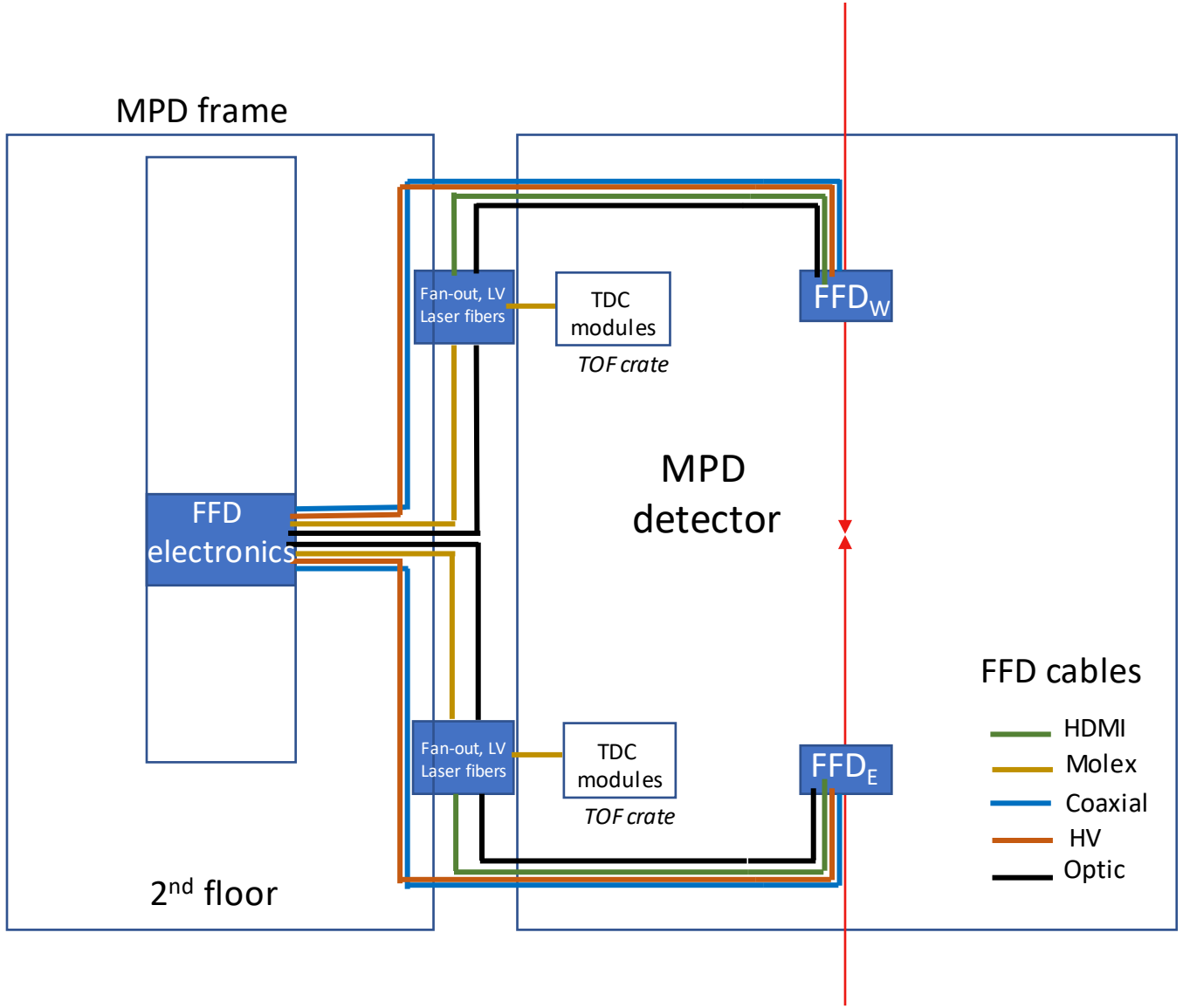
The aim of main FFD electronics is processing of pulses from 80 + 80 channels of FFD sub-detectors for generation of special signals for trigger electronics: FFD_E , FFD_W and Vertex

The pulse Vertex means that the measured time gap between FFD_E and FFD_W pulses corresponds to selected interval along beam axis around center of the MPD setup



FFD cable lines

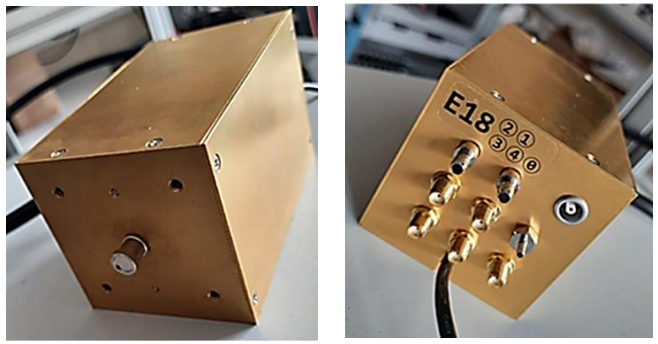
- All cables are available except some Molex cables (have to be purchased).
- The length of optical bundles is ~ 7m.
  This is the limitation for length of cable line between FFD rack and patch panel in FFD intermediate crate.
- Up to now, the cable lines are under design by cable group and the FFD requirements have to be taken into account.
- The output of cables from the detector modules through the container and ITS cables is under discussion and development.
  Here there is some contradiction between cable lines of FFD and ITS and it has to be solved working together with ITS group.



FFD Cherenkov modules

- All 40 Cherenkov modules of FFD_E and FFD_W are available for test measurements.
- Study of temperature conditions inside modules with/without air flow is carrying out this April in our laboratory.
- We are in preparation for measurements with laser system and long-term tests with cosmic muons using our special stand with 4 scintillation planes:
  - April – June 2023 – the first stage
  - October – December 2023 – the second stage with all FFD sub-systems

FFD Cherenkov modules



FFD mechanics

- Mechanics of FFD sub-detectors is available for test installation in container with vacuum beam tube.
- Special mechanical tools for the sub-detector installation are ready for use.
- Now we do the common work with designers responsible for the container and ITS detector for preparation of the first test with FFD detector prototype (size and weight). We expect it will be done in the second half of this year.

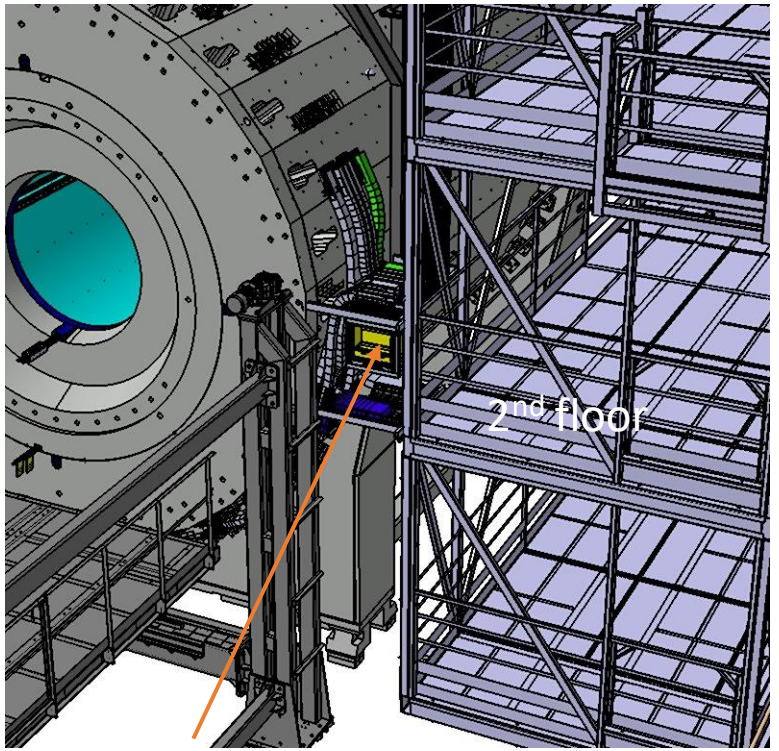
Sub-detector mechanics

Installation tools

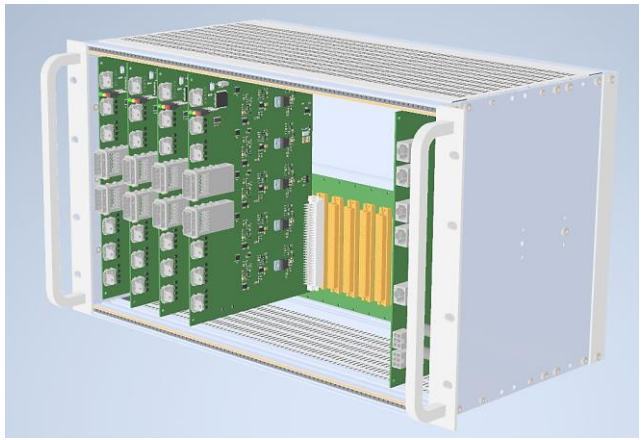
Intermediate FFD crates

- The intermediate FFD crates with fanout modules and LV power supplies of FEE, together with patch panels for laser fibers and some space for cables are located in 9U mini-racks of FFD_E and FFD_W sub-detectors placed close to cable outlets of the MPD magnet yoke at the 2nd floor of MPD frame.

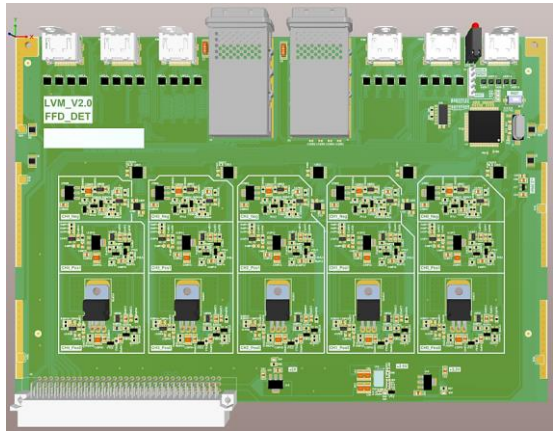
- LVM module provides low voltages for 5 FFD modules and splits LVDS pulses in two branches. LVM module and Power distribution module (PDM) prototypes have been tested and the production of LVM and PDM modules begins in April 2023.



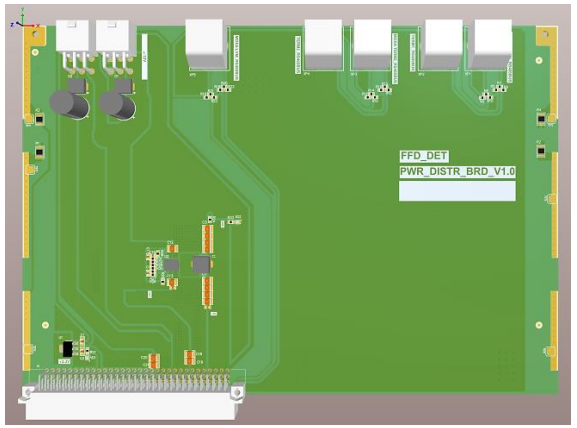
3d model of 6U crate with Fanout & LV modules



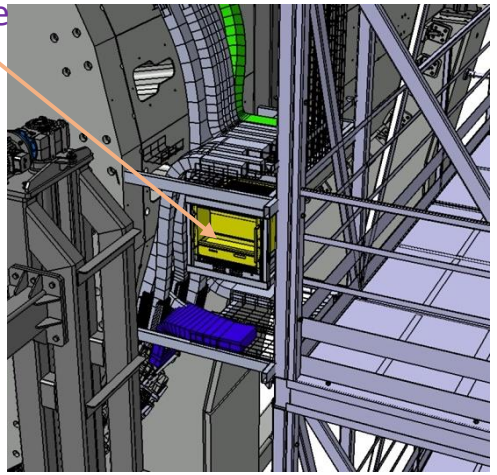
3d model of LVM



3d model of PDM

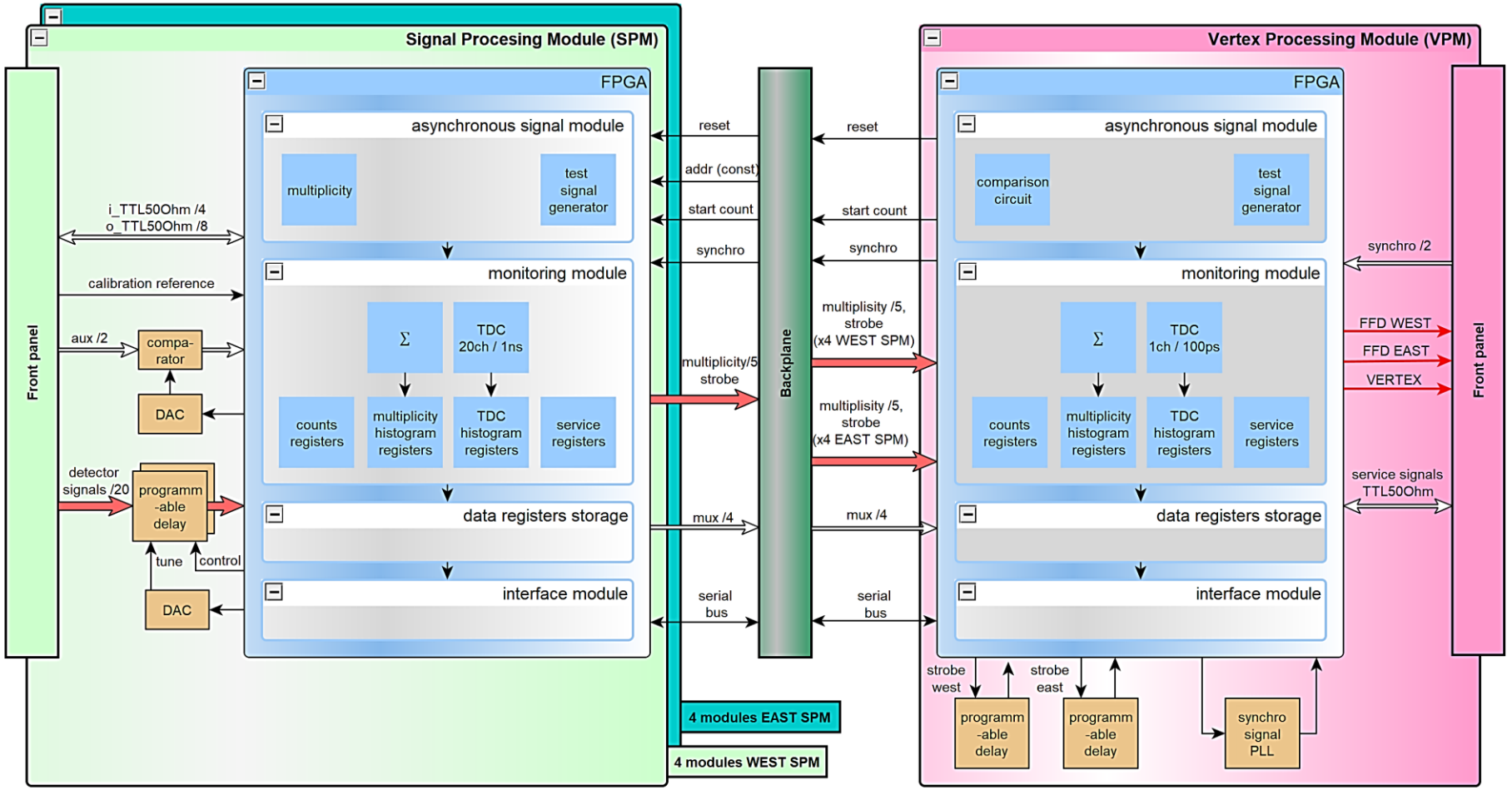


FFD int. crate



FFD Electronics (final design)

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



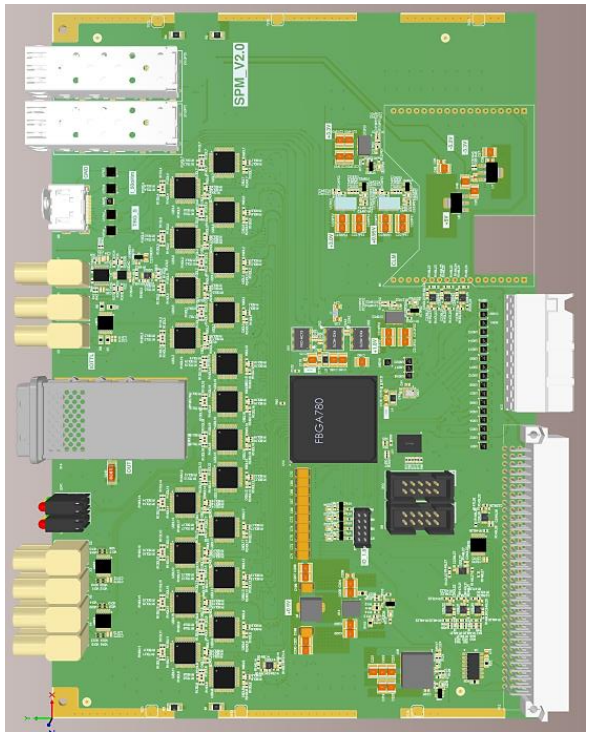
All modules are placed in a single VME crate with custom backplane

Signal Processing Modules (SPM)

- In the central FFD crate the FFD pulses are processed in 8 signal processing modules (SPMs), 4 modules per sub-detector
- The SPM provides following monitoring information:
  - counts in FFD channels
  - signal multiplicity histogram
  - channel signal width distribution histogram

  (20 histograms per SPM)
- SPM prototype has been developed and tested. The production is beginning in April 2023.
- High level software is under development. The prototype with an event display will be tested with the modules of electronics in the second half of 2023.
- Vertex Processor Module (VPM) is under development with high level software. The tests are planned in the end of 2023.

PCB SPM_V1.0



3d model of SPM_V2.0

Status of Electronics

To date:

- FPGA project for SPM prototype board is ready; operation verified on the board using internal test signals and signals from the generator on the console debugging software.
- Partially developed Vertex functional blocks including TDC with σ_t < 100ps (requires verification).

In plan for 2023:

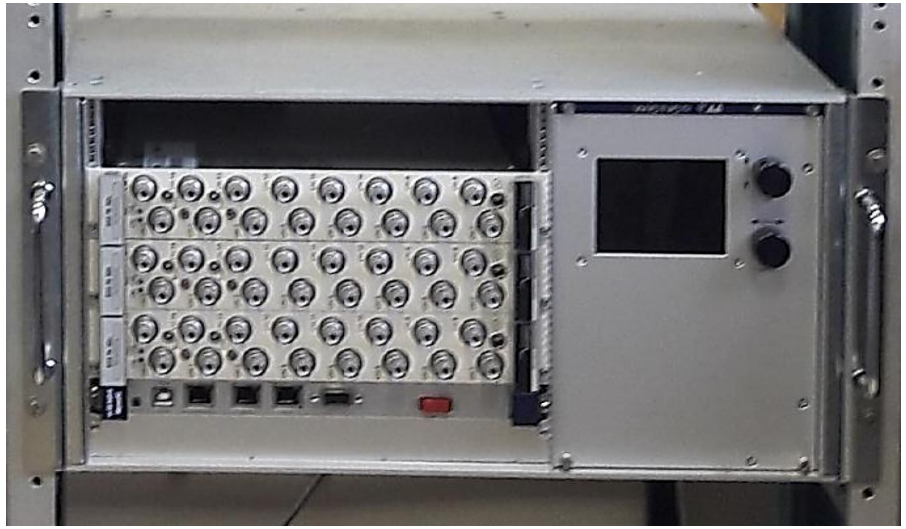
- Finalization of the FPGA project for the final version of SPM;
  adding a delay line control function; checking the work on the board.
- Work on the FPGA project for the Vertex module.
- Debugging work for the system of boards in the crate and work with top-level software.

High Voltage power supply

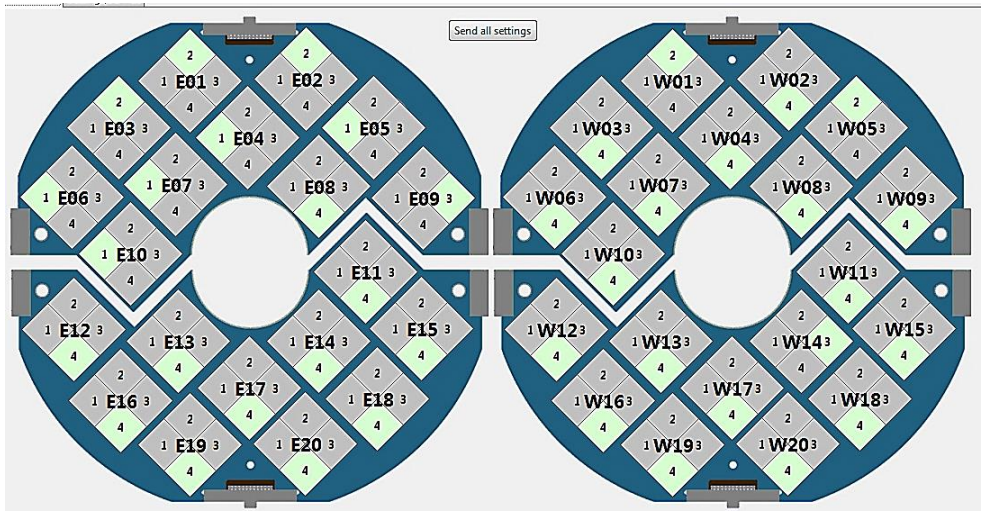
- HV modules + mainframes are available
- HV Server and HV client are ready for use and passed the tests

HV system is 100% ready

Wiener crate with 48 HV channels



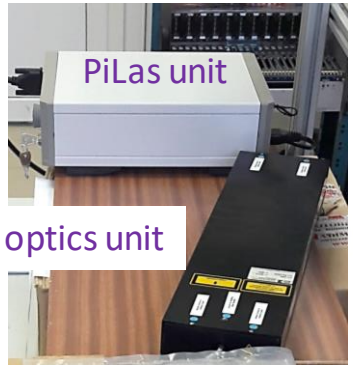
Interface



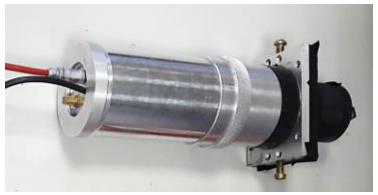
Connected to E24DL sn. 7L3L10 at Slot 0

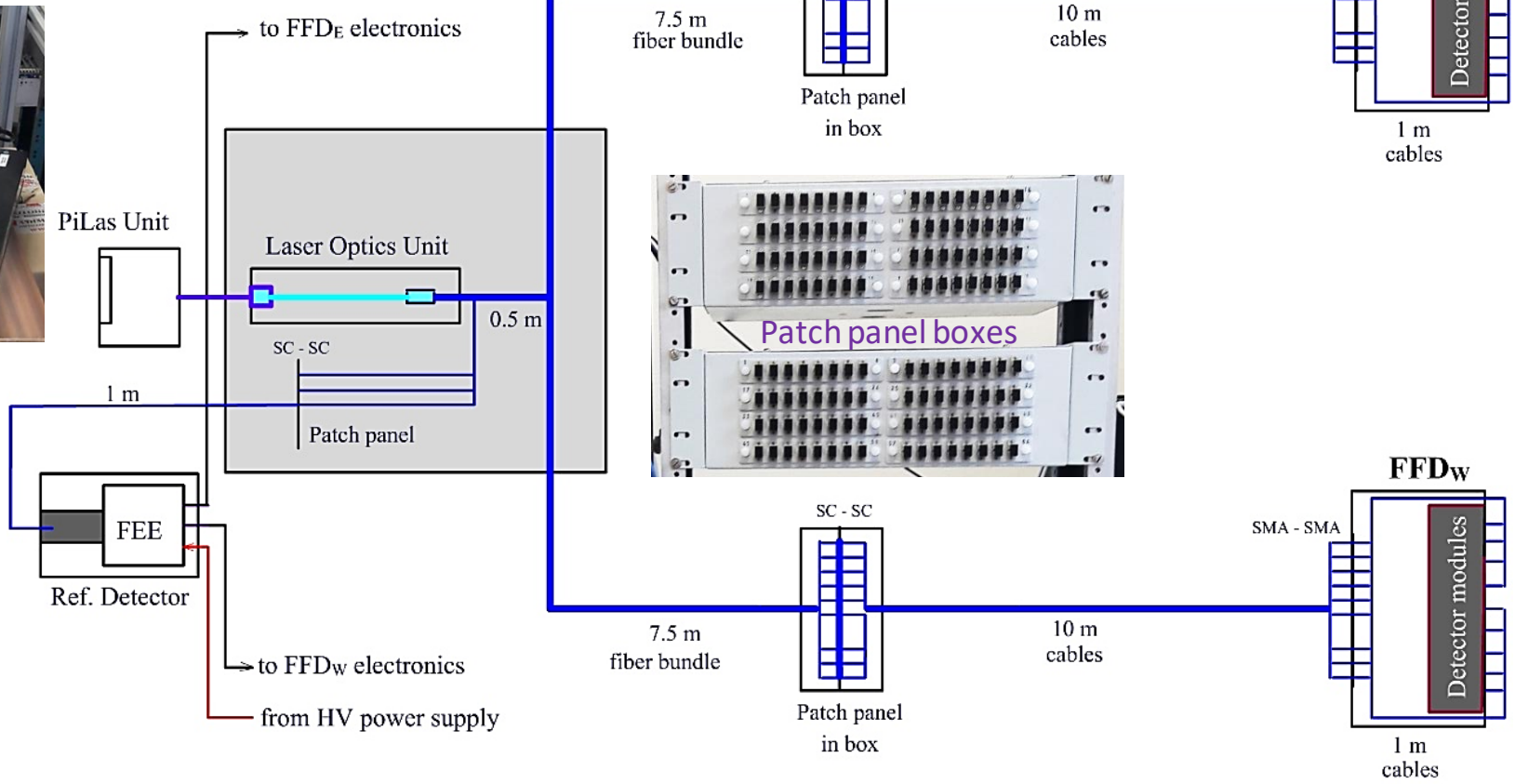
	Vset (V)	Vmeas (V)	Vnominal (V)	Iset (mA)	Imeas (mA)	Inominal (mA)	Status
Channel 0	2.500,0	2.499,9	2.500,0	0,500	0,445	0,500	On
Channel 1	2.500,0	2.499,9	2.500,0	0,500	0,440	0,500	On
Channel 2	2.500,0	2.499,9	2.500,0	0,500	0,441	0,500	On
Channel 3	2.500,0	2.499,9	2.500,0	0,500	0,441	0,500	On
Channel 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

Laser calibration system



Reference detector with MCP-PMT





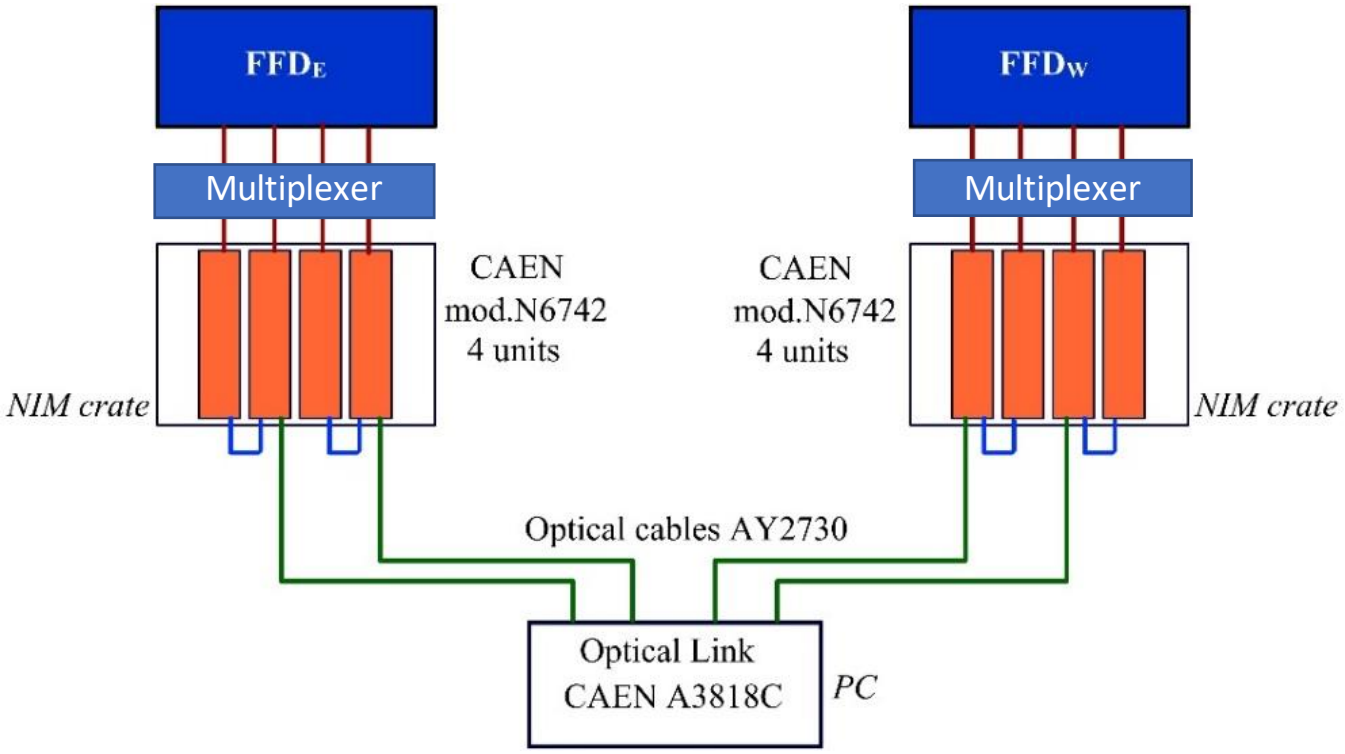
Existing parts

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

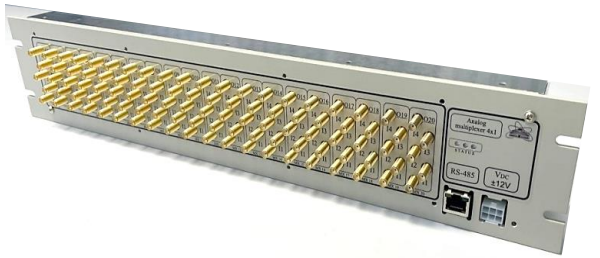
High level software needs to be developed in 2023

FFD module Monitoring system

- All electronics modules and readout with optical cables are available.
- The test measurements with FFD modules, laser and cosmic muons will be perform in 2023.



Analog Multiplexing Module



NIM crate with CAEN digitizers

Detector Control System I

DCS concept

- The system is built using client-server architecture
- Servers have GUI-interfaces oriented to present controlled hardware
- Clients have GUI-interfaces showing FFD geometry
- Communication protocol is DIM
- One server could have many clients connected

DCS sub-systems

- HV system (ready)
- LV system (minor modification are needed)
- Laser calibration system (software to be developed in 2024)
- Thermo-monitoring (almost ready) and cooling control system (to be developed in 2023)
- Trigger hardware control system managing 8 SPMs and a VPM (to be developed in 2023-2024)
- Multiplexer control system (ready)
- Partitioning and FSM manager (to be developed in 2023-2024)
- Configuration manager (to be developed after the Central DCS architecture is fixed)

Detector Control System II

DCS interface

- FFD DCS interface provides status information and it is able to set a required trigger hardware configuration
- States of FFD:
  - “OFF” – at least one of modules is not powered (not responding)
  - “StdBy” – at least one of modules is in Stand-by mode
  - “NotRdy” – at least one of modules is in transition between Stand-by mode and “Ready” mode
  - “Ready” – all modules are ready for operation
  - “Wrng” – one of modules is close to leave the safe operation range
  - “ALRM” – one of modules left the safe operation range and is switched off (HV trip, overheating etc).
- This information is generated by a Partitioning and FSM manager

DCS interaction with MPD control system

- FFD DCS reports to the Central DCS its state (see above) and possibly a problem specification (if any)
- FFD DCS receives commands from the Central DCS as follows
  - “Go_To_Stand_By” and
  - “Load_configuration <Filename/Run type>”

Temperature monitoring system

- Since the MCP-PMTs are sensitive to overheating we have to use the Temperature monitoring system
- Sensors (1-wire bus)
  - tested (100% + 10% spares)
  - installed to FFD modules
- Readout boards are ready and tested
- Minor problems related to the LV system modification
- Temperature server and client are ready, few minor modifications required
- Cooling gas flow control system needs to be developed.

Gas cooling of detector modules

- Cooling by pressed dry air (nitrogen)
- Flow controllers in hands
- High level software to be developed
- Study of temperature condition inside detector modules in April 2023

Requirement for cooling:
Flow of cool and dry air or nitrogen of
100 L/min/sub-detector
i.e. 200 L/min/FFD

Summary

In 2023 main activity on realization of the FFD project includes:

- ✓ Study of operation of FFD sub-detectors and sub-systems with laser and cosmic muons
- ✓ Production and tests of FFD electronics
- ✓ Development of the Detector Control System and Interfaces
- ✓ Preparation for test installation of FFD sub-detectors into container with ITS group
- ✓ Participation in final design of FFD equipment location in MPD frame with cable lines

Plan for next year

- ✓ The FFD sub-detectors with cables will be ready for installation but it depends on readiness of the container and vacuum pipe.
- ✓ To finish production and testing the FFD electronics and the Detector Control System.