

Version 4

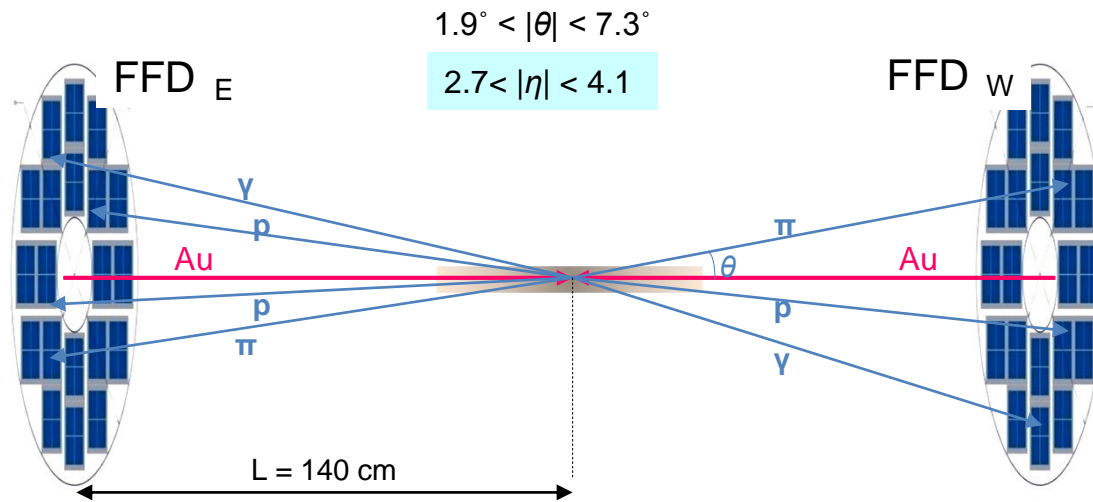
MPD

Fast Forward Detector
Technical Design Report

15 Chapters
78 pages
28 references

LHEP / JINR
May 2017

Concept & Performance



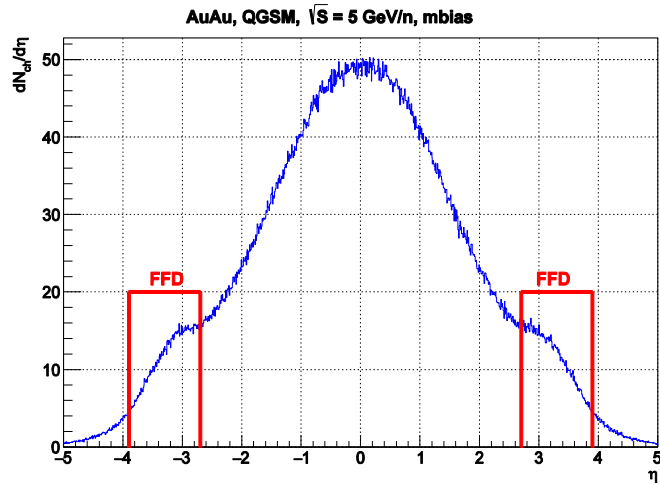
Fast interaction trigger by Vertex FFD_E - FFD_W (on-line processing of FFD pulses)

Requirement: good timing signals from modules of both sub-detectors

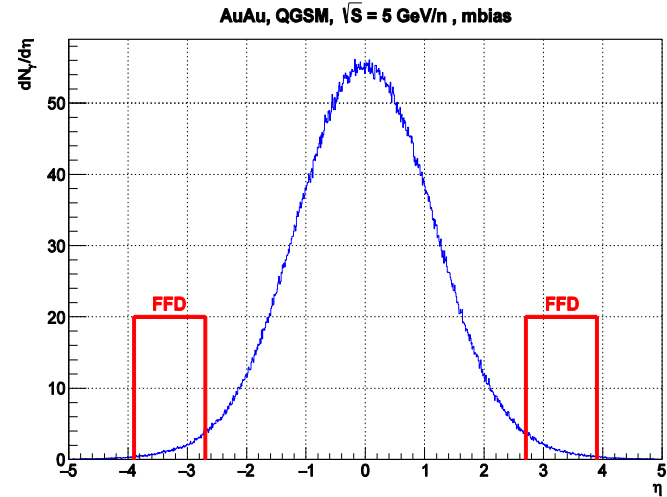
Start signal production for TOF (off-line analysis of FFD pulses in TDC72VHL)

Requirement: a single pulse with good timing from all FFD channels

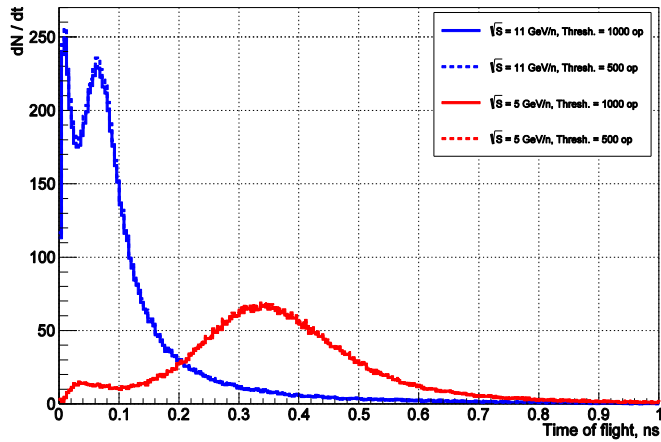
Au + Au collisions



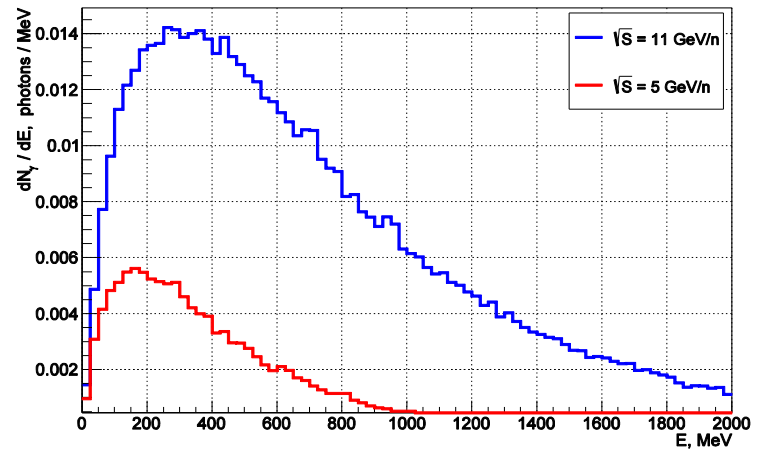
The charged particle distribution



The high-energy photon distribution



The delay of charged particle arrival in FFD

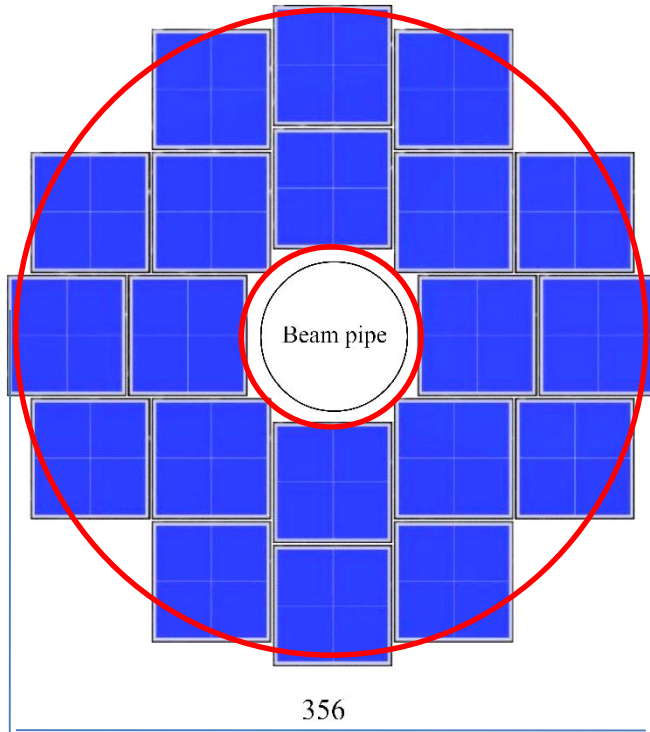


Energy spectra of the photons emitted into the FFD

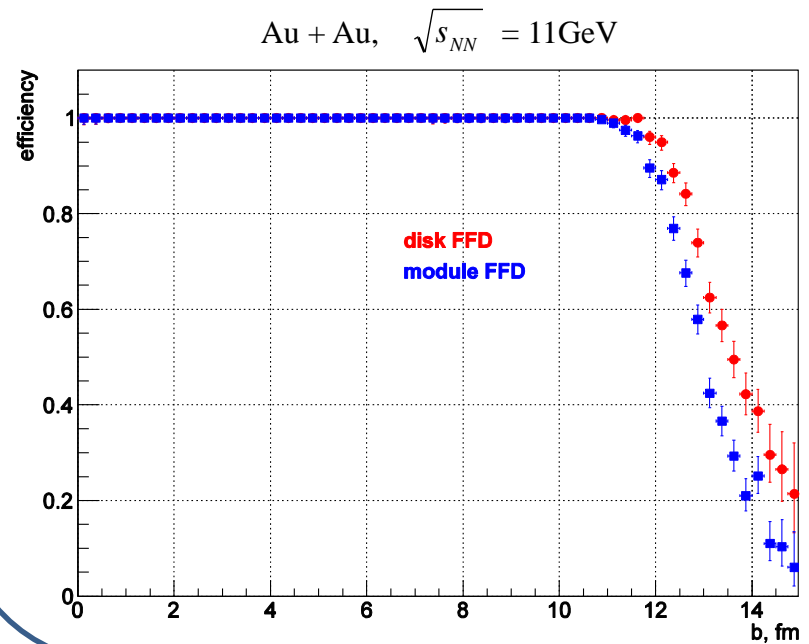
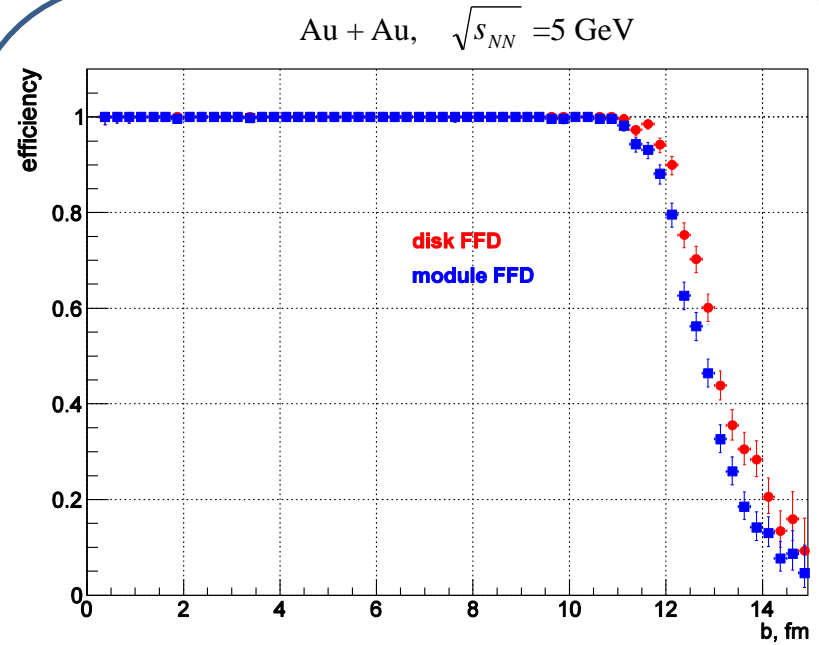
FFD modular array

20 modules

80 + 20 channels

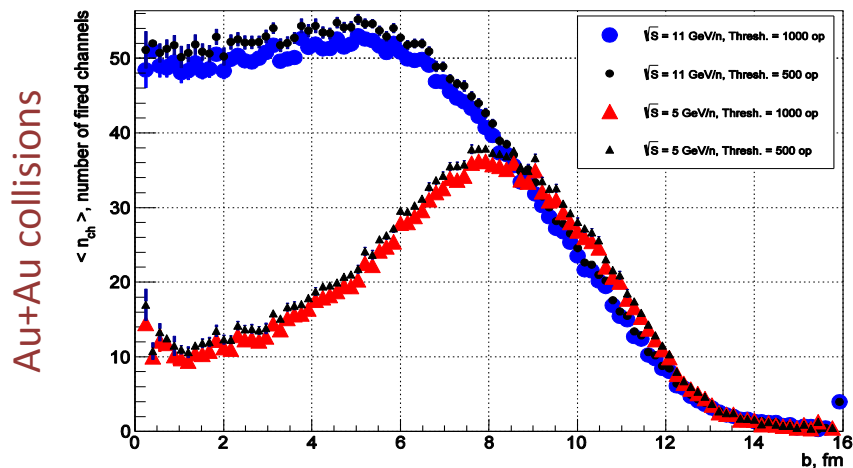


Vertex – Trigger efficiency
for Au + Au collisions

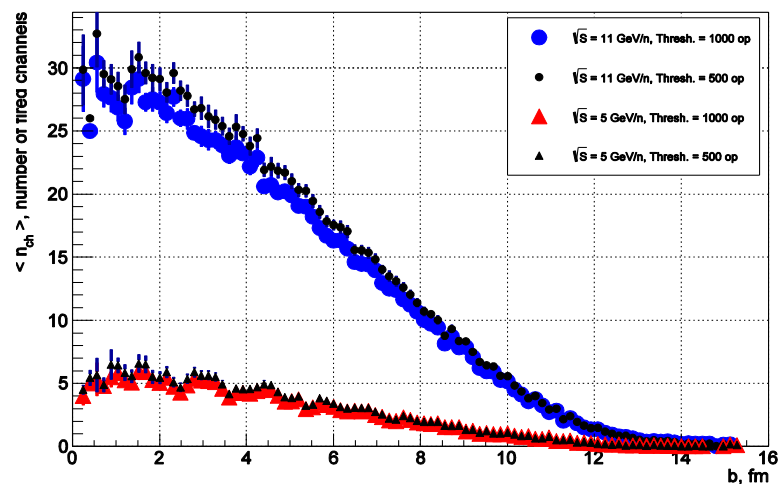


The mean number of fired channels

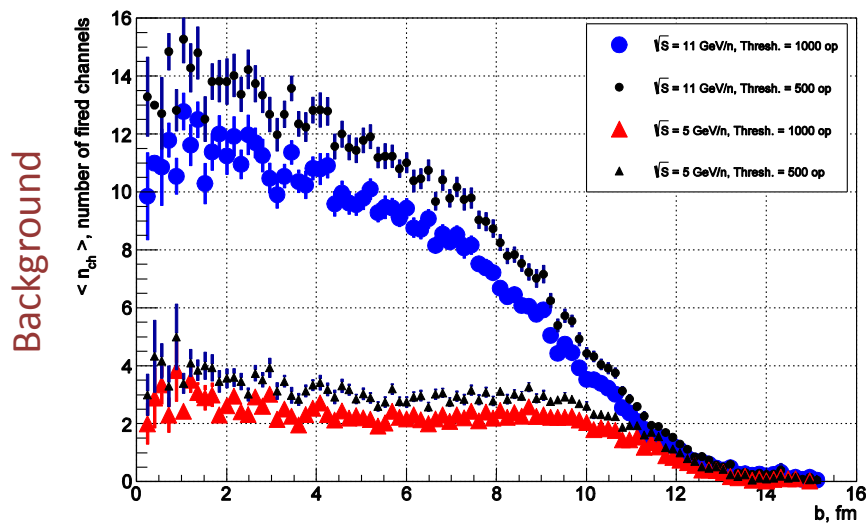
Charged particles from IP in single sub-detector



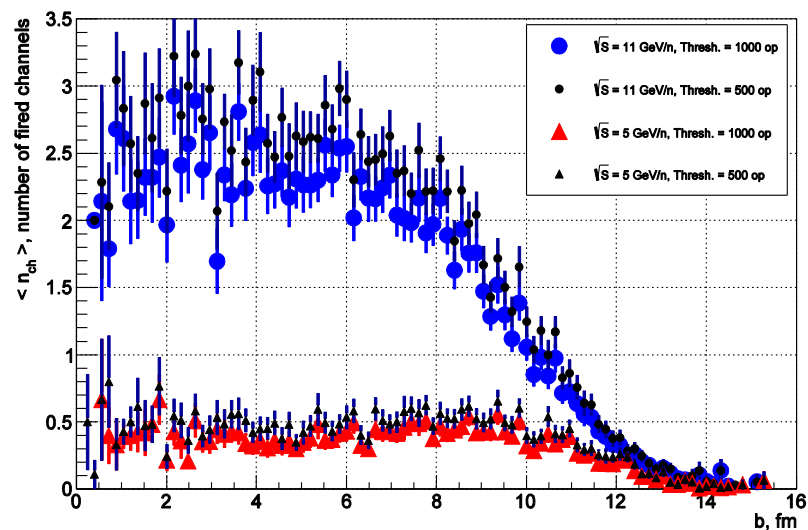
Photons from IP in whole FFD



Background charged particles in whole FFD



Background photons in whole FFD



Vertex – Trigger detectors

- For all energy range of NICA, the FFD provides the efficiency of vertex – trigger of $\sim 100\%$ for **Au + Au collisions** in an interval of the impact parameter of $0 \leq b < 11$ fm.
- For **collisions of light-mass nuclei, $p + Au$, and $p + p$** , two large area scintillation detectors BBC (Beam-Beam Counters) will be used for effective triggering the collisions.

Vertex-trigger detectors for different type of collisions.

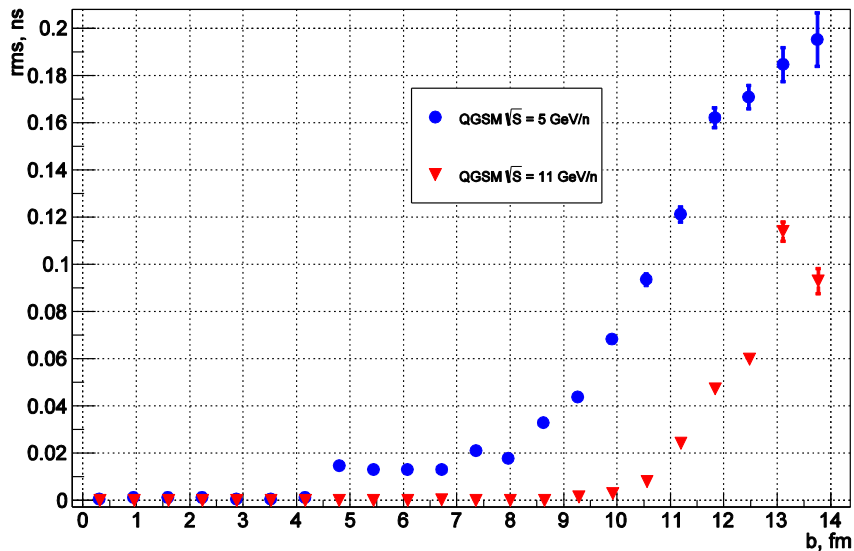
Collisions	Vertex-trigger detectors	Efficiency
Au + Au	FFD _E , FFD _W	good
$p + Au$	FFD & BBC	Simulation in progress
$p + p$	BBC	Simulation in progress

We expect that BBC will be the contribution to MPD experiment from Mexican group. Preparation of the agreement in progress.

Time resolution of start signal

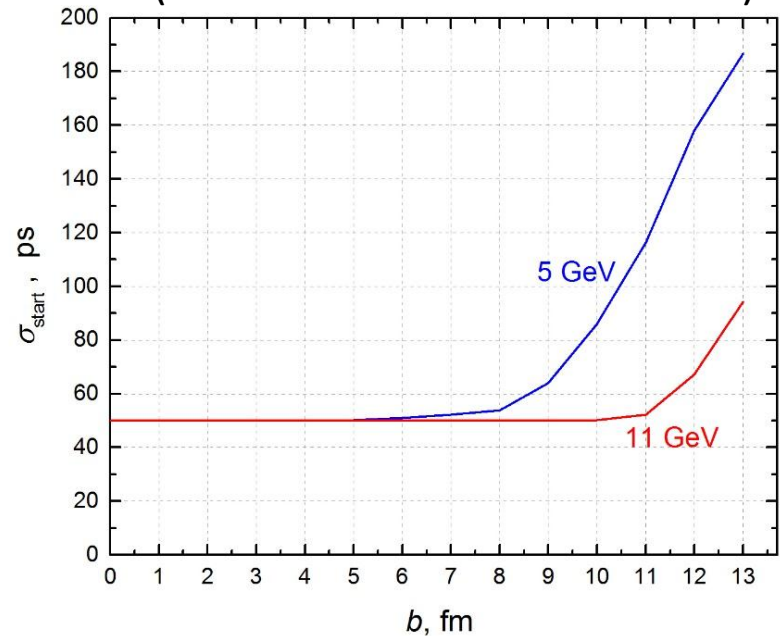
Due to a time spread of particle arriving

AuAu, L = 140 cm, -50 cm < Z < 50 cm



The time uncertainty of the first hit in FFD

Estimation for real FFD chain
(module + cables + electronics)

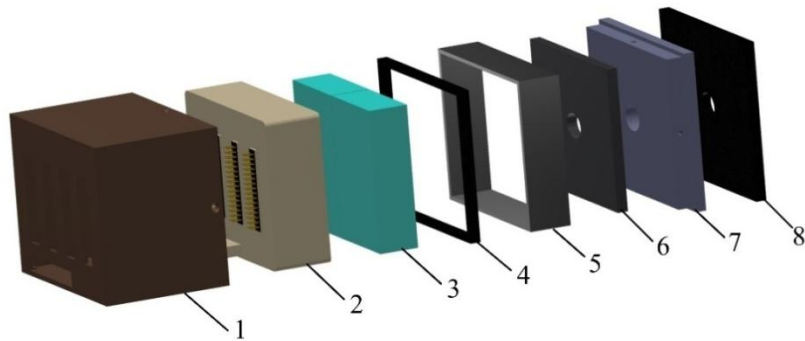
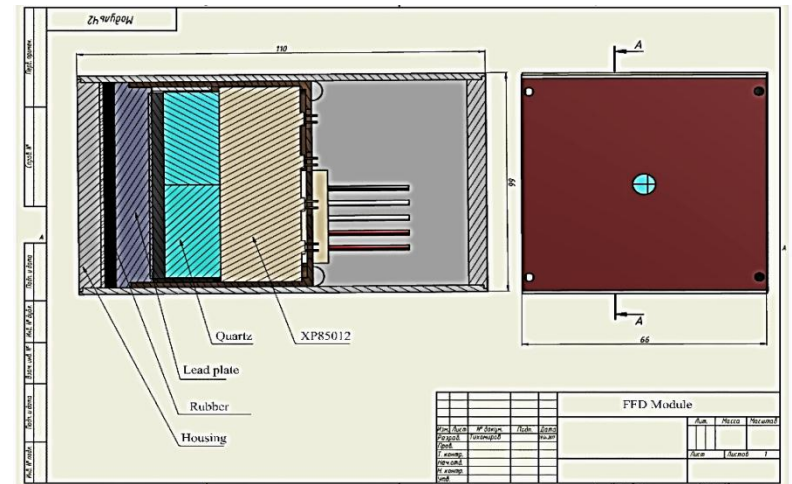
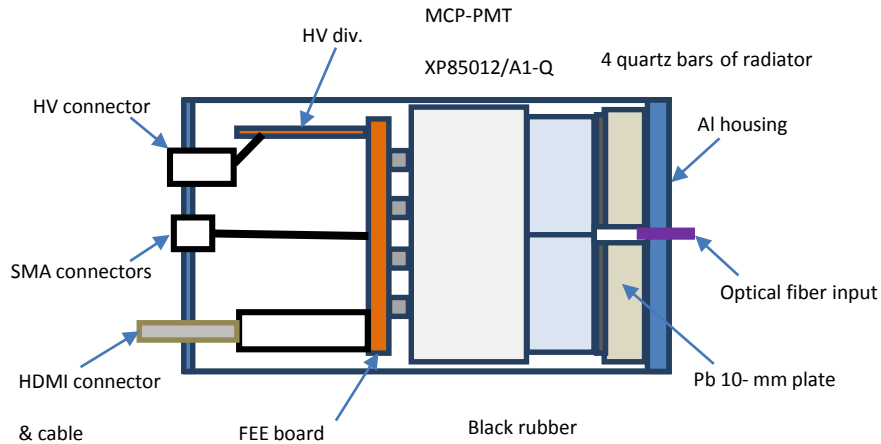


The start signal resolution

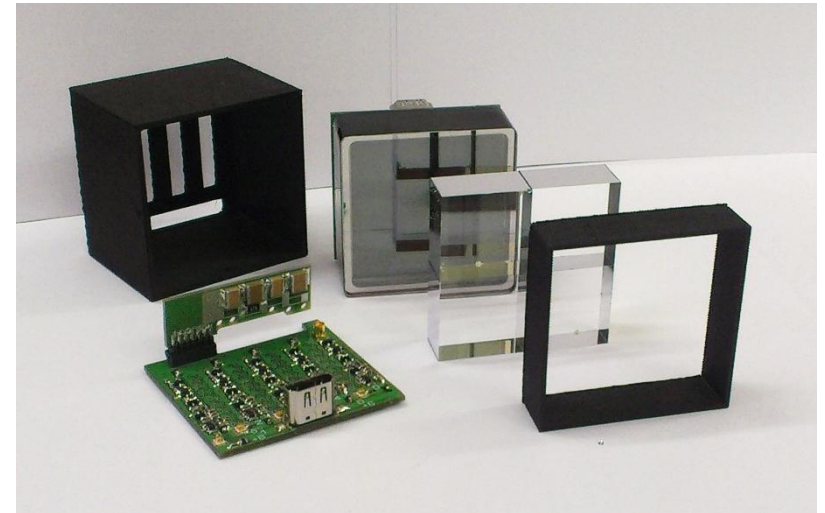
FFD channel $\sigma_{\text{FFD}} \approx 50$ ps

FFD modules

Module design



Module elements (FFE plate with HV divider are not shown):
 1 – the plastic box, 2 – the MCP-PMT, 3 – the quartz radiator,
 4 – the rubber 1, 5 – the plastic frame of the radiator,
 6 – the rubber 2, 7 – the lead converter, 8 – the rubber 3.



A photo of plastic box, FFE plate with HV divider, XP85012/A1, quartz radiator, plastic frame of the radiator

FFD modules

	units	Status	Plan
Photodetectors XP85012/A1	40	40 +7 (reserve) units	
Quartz radiators	160	160 units	
Lead converters	160	10- mm plate	Production in 2018
FEE	40	Final design	Production in 2017-2018
Housings and mechanical elements	40	Final design	Production in 2017-2018
Connectors	SMA , HV, HDMI 200+40+40		Purchase in 2017

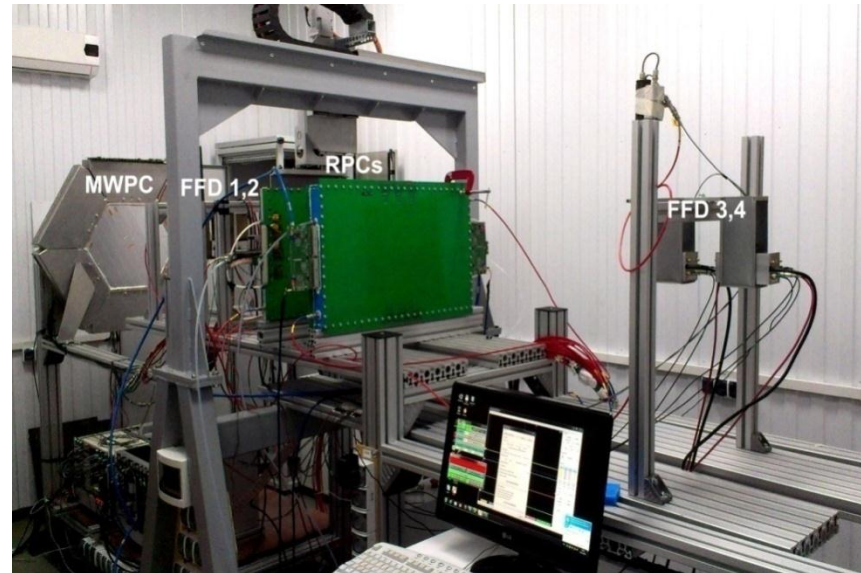
2018 – 2019 Module production and tests

Test measurements with prototypes

- tests in laboratory with LED and cosmic rays
- tests with deuteron beam of Nuclotron
- tests in magnetic field of BM@N magnet up to $B = 0.9$ T.



Module prototype

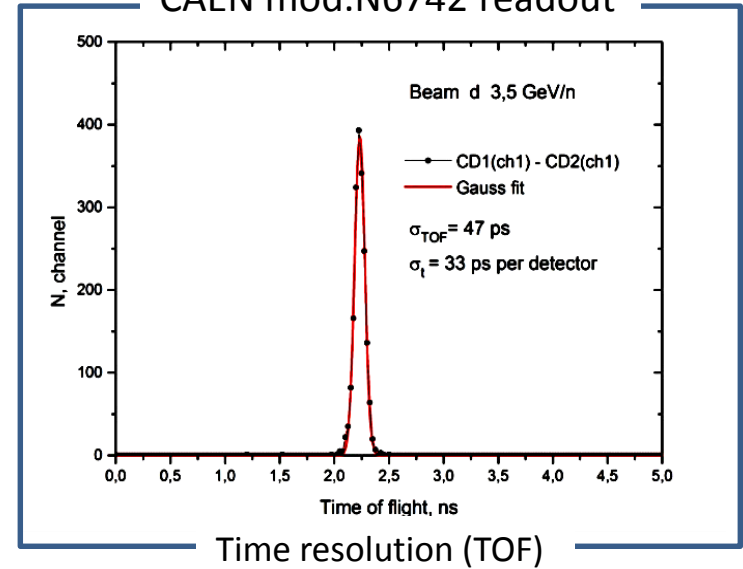
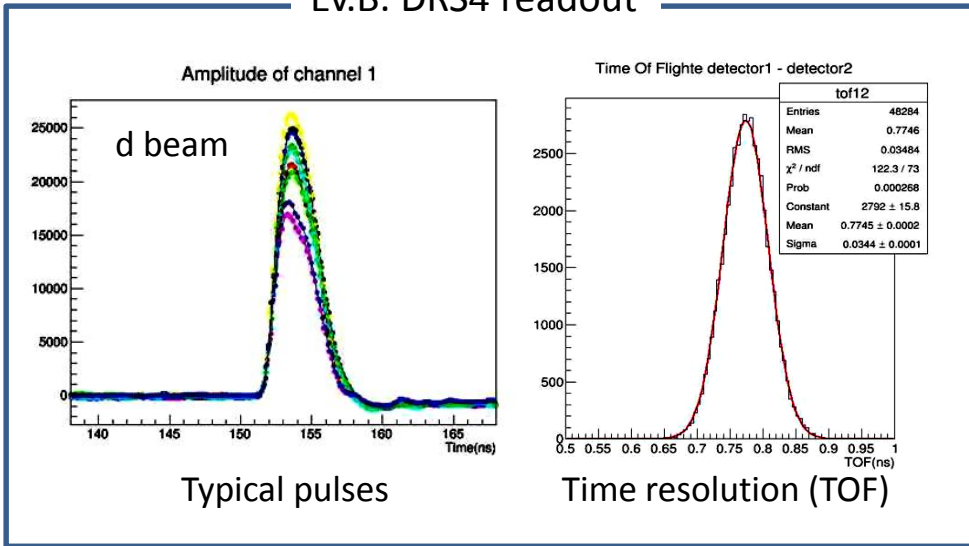


FFD modules on the beam line of MPD-test area.

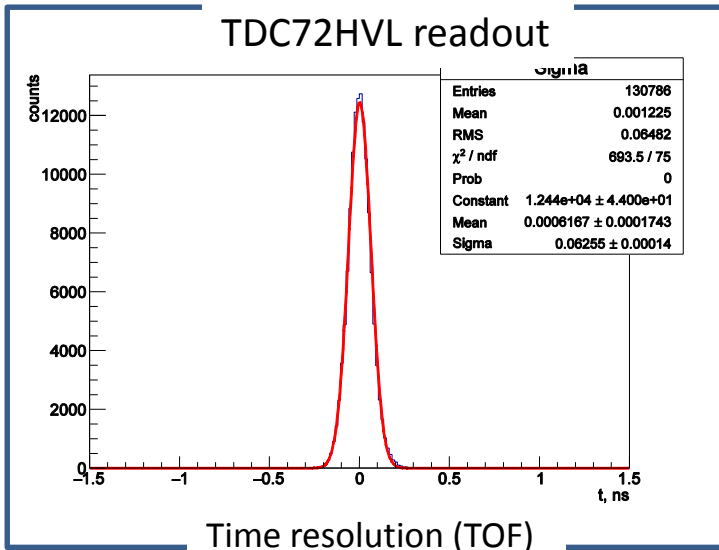
Results of the test measurements

Ev.B. DRS4 readout

CAEN mod.N6742 readout



TDC72HVL readout



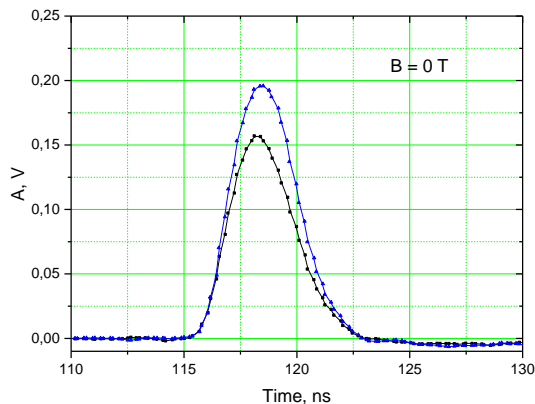
Conclusions

- The time resolution of FFD module - 21.5 ps
- with readout by E.B. DRS4 digitizer - 24 ps
- with readout by digitizer CAEN mod.N6742 - 34 ps
- real chain with readout by TDC72VHL - 44 ps

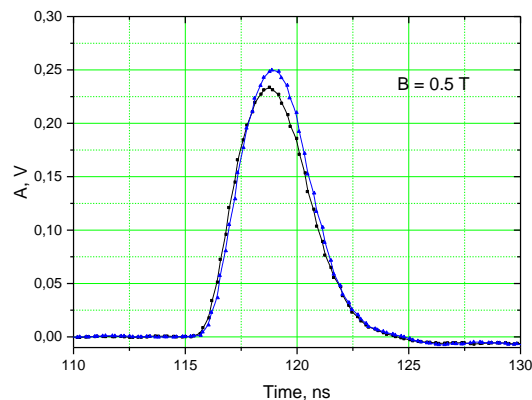
Realistic chain of cables and electronics.

Tests in magnetic field of BM@N magnet

Light pulses of laser LED
Readout by digitizer E.B. DRS4 V5



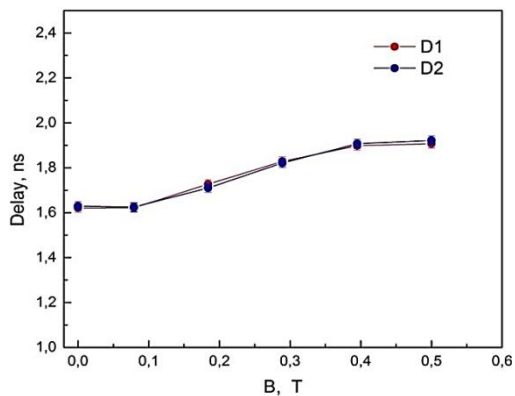
Typical pulses with and without magnetic field



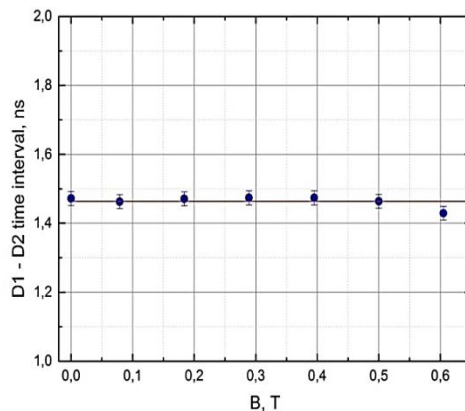
Estimated time resolution

Individual channel of module
(used for start signal production)

$$\sigma = 40 - 50 \text{ ps}$$



Time delay as a function of B



Time interval between pulses of modules at angles of 0 and 180 deg. as a function of B

Common channel of module
(used for vertex - trigger)

$$\sigma = 48 - 54 \text{ ps}$$

The FFD electronics

	Units Channels	Status 2017	Prototypes & Tests	Production
Sub-detector units	2 80 +20 /unit	prototyping	2018 - 2019	2019 - 2020
LV power supplies for FEE	2 60 /unit	prototyping	2018 - 2019	2019 - 2020
HV power supplies for XP85012	2 24 /unit	Study for purchase		Purchase in 2018
Readout TDC72VHL	4			2019 - 2020
Local readout CAEN N6742	6			Purchase in 2018-2019
Vertex-trigger unit	1	prototyping	2018 - 2019	2019 - 2020

FFD sub-systems

Sub-system	Status 2017	2018	2019	2020
Detector control system	Prototyping	Prototypes	Prototypes Production	Production &Tests
Laser calibration system	PiLas laser unit Laser head with optics Quartz fiber bundles Reference photodetector	Design, purchase of optical cables & components	Production	Tests
FFD sub-detector mechanical construction	Design	Design	Production	Production
Cable system	Types of cables, preparation for purchase	Purchase	Purchase	

FFD will be ready for installation in the beginning of 2021

