Cosmic Ray Detector for MPD (MCORD)

Dr. Marcin Bielewicz
for Polish consortium NICA-PL

NARODOWE CENTRUM BADAŃ JĄDROWYCH ŚWIERK

JINR

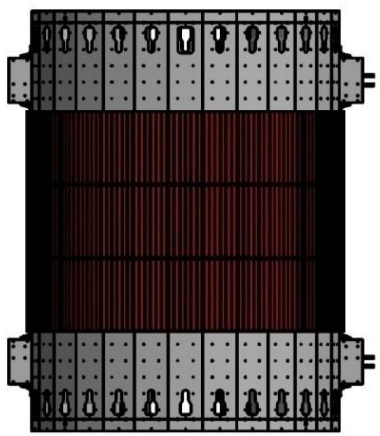
POLITECHNIKA WARSZAWSKA
WARSAW UNIVERSITY OF TECHNOLOGY

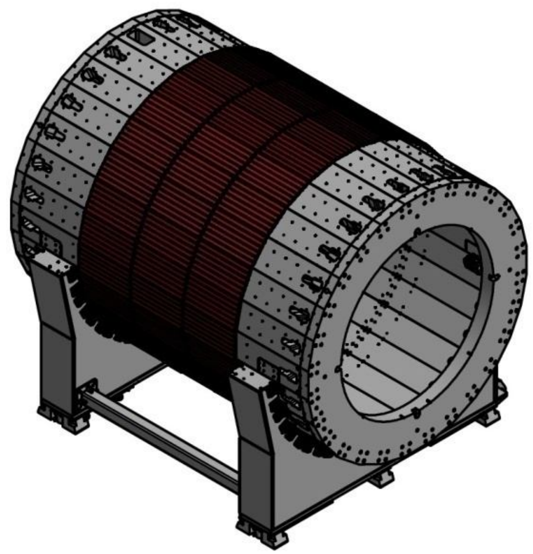
Uniwersytet Jana Kochanowskiego w Kielcach

ifj

Outline

- **Motivation**
- **Reply to DAC comments**
- **Present status of Demonstrator**
- **Numbering, Construction on MPD surface**
- **Conclusions**



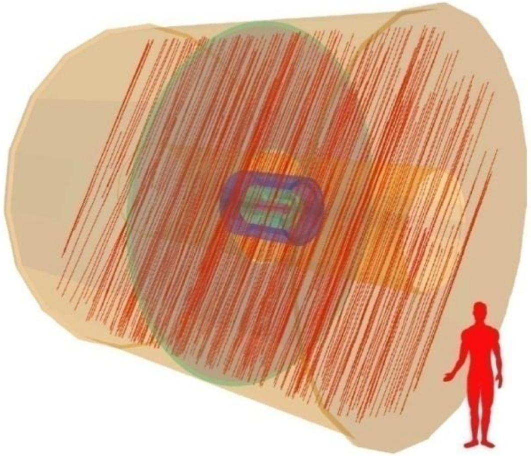


MCORD – motivation

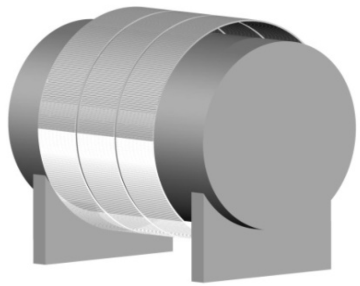
a) Trigger (for testing or/and calibration)
- testing before completion of MPD
(e.g. **two separate MCORD sections or modules**)
(testing of TOF, ECAL modules and TPC)
- calibration before experimental session
(e.g. **minimum 2-4 MCORD modules**)

b) Muon identifier (created inside the MPD)
(minimum muon energy: 600 MeV)
- Pions and Kaons decays
- rare mesons decays (etha, rho)
- possible decays of new „dark" particles

c) Astrophysics (muon showers and bundles)
- **the position identification of extremely high energy particle source**
- unique for horizontal events
- working in cooperation with TPC and TOF



Additionally
Veto and Calibration
(normal mode - track and time window recognition)
Mainly for TPC and eCAL



Comments from the DAC

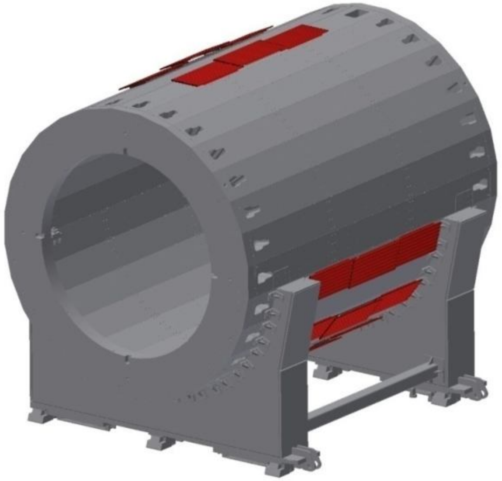
The DAC notes with satisfaction the achieved progress.

The DAC asks the team to re-evaluate the MCORD task and design options such that following requirements are fulfilled:

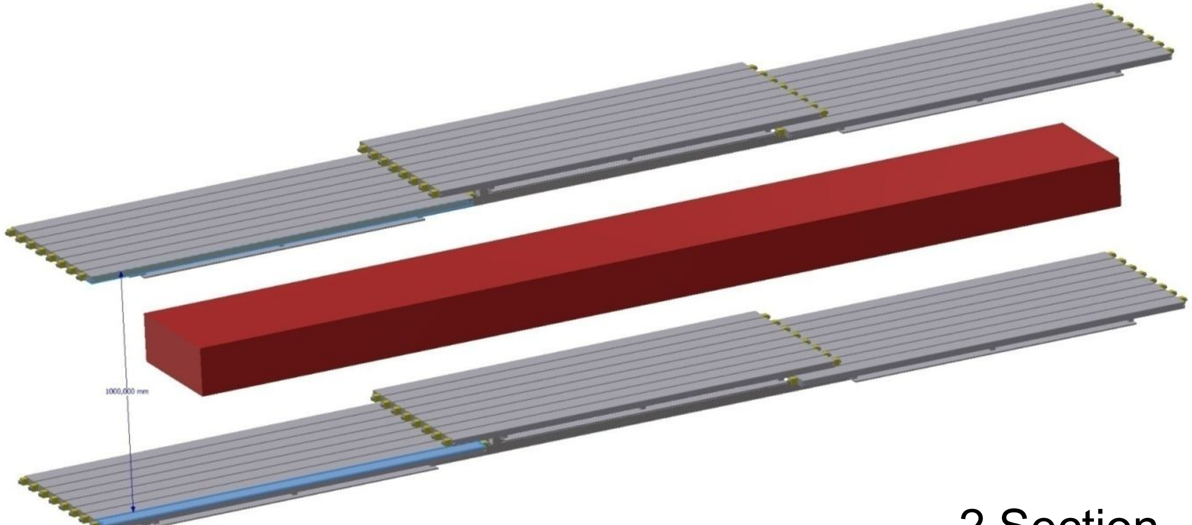
1. MPD needs an effective trigger during commissioning. Thus it should offer maxiumum coverage of MPD and it should enable work with other subsystems (e.g. TOF) prior to installation.
2. The DAC encourages the MCORD team to look into the possibility for MCORD serving as muon identifier within the MPD system.
3. MCORD physics case for cosmic ray studies needs to be strongly improved.
4. The DAC asks the team to improve motivation for MCORD physics cases and perform detailed MC simulation of MCORD performance in (di)muon reconstruction.

Ad. 1 – Trigger during commissioning

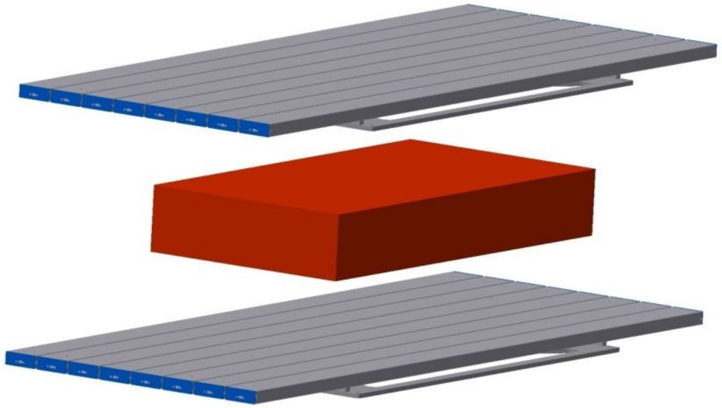
Examples:



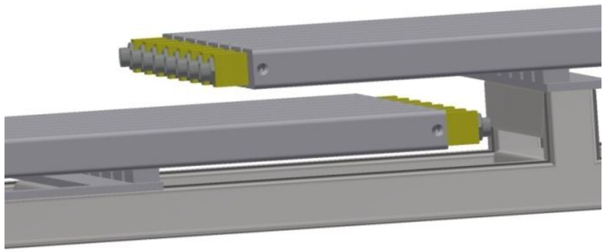
4-6 Modules



2 Modules

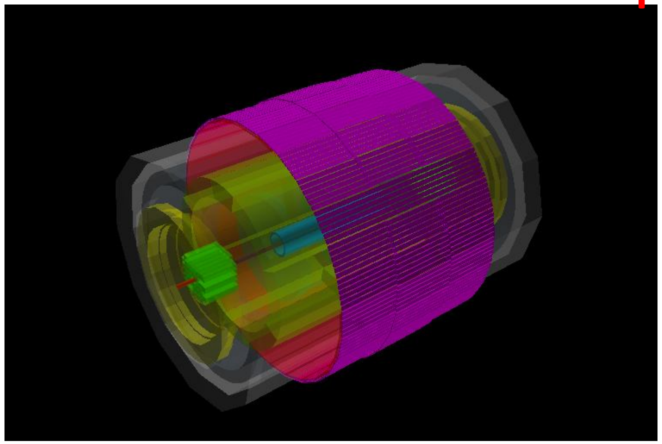


2 Section

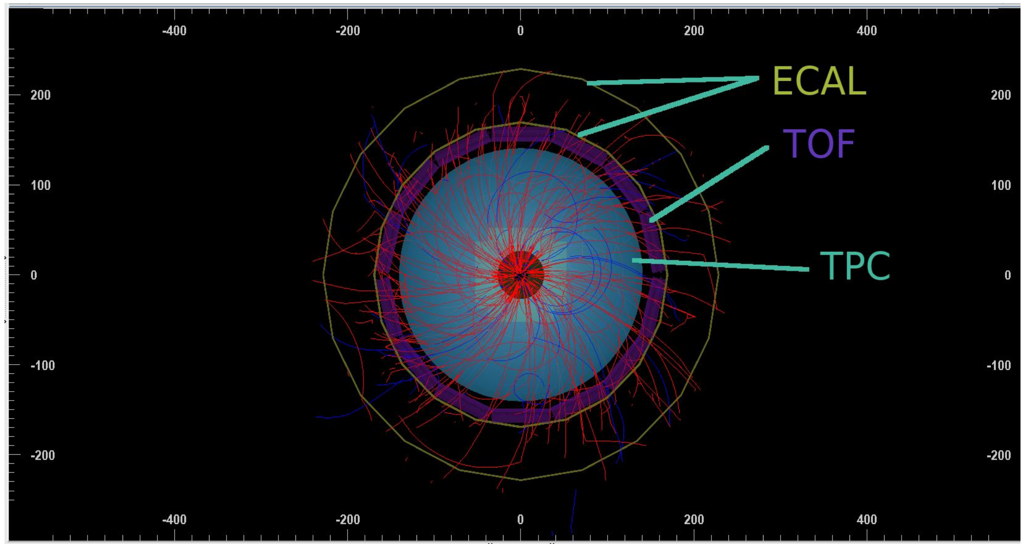


No Null Zone at MCORD

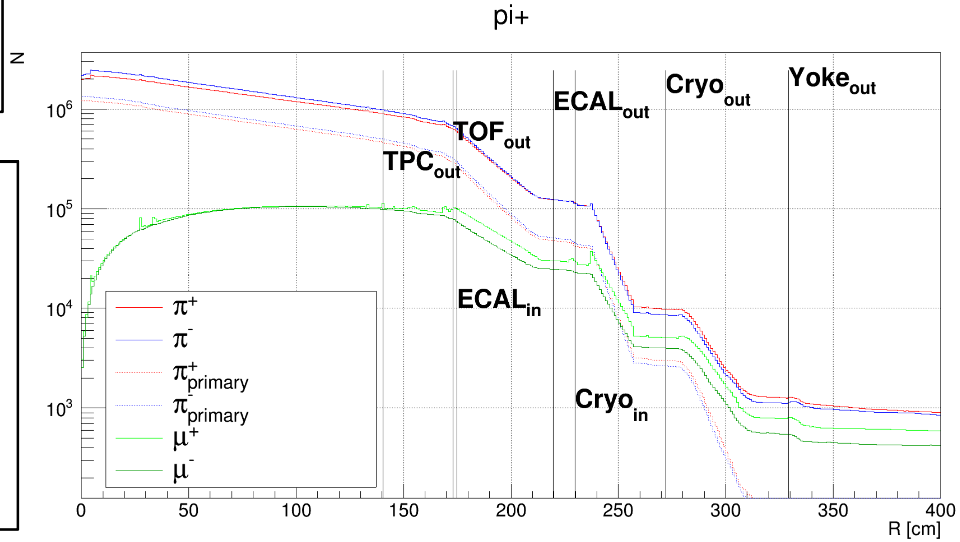
Ad. 2 – Muon identification



Positive pions and **positive muons** from central Au-Au collision.
Almost all pions vanish is ECAL without production of muon.



Current MCORD geometry available on **branch MCORD2 repository.** Adding MCORD geometry to official MPD geometry version, should be discuse –> O.Rogachevskiy



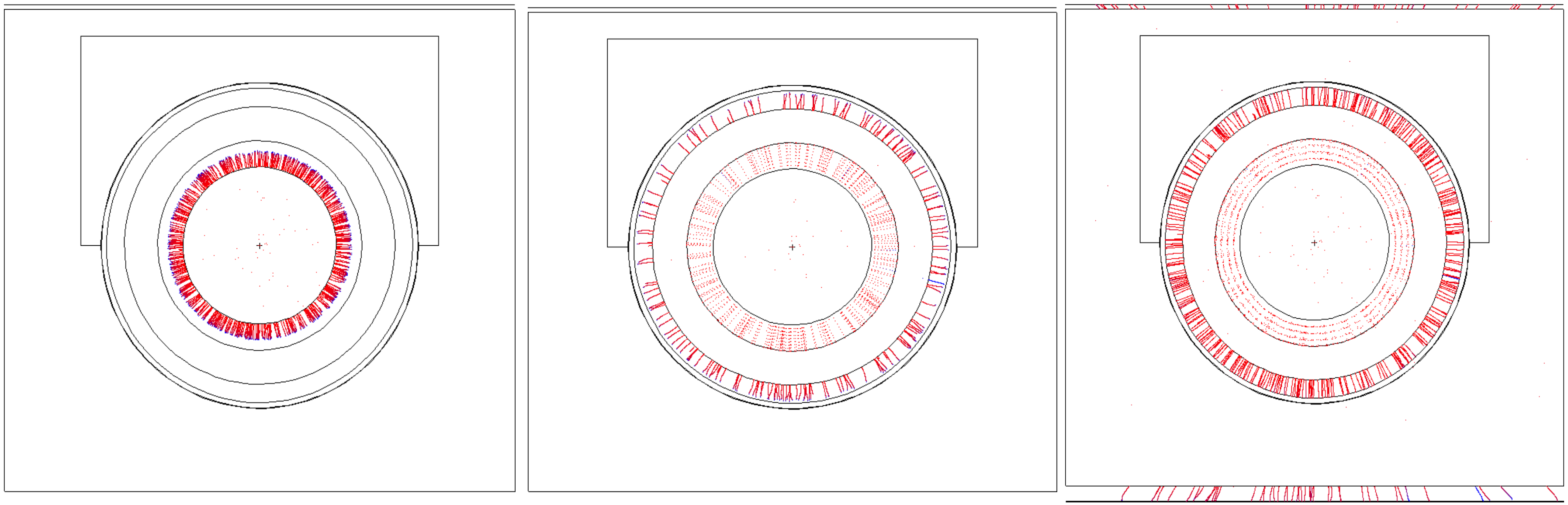
- UrQMD 3.4
- 19k Au+Au central collisions at 11 GeV
- impact parameter < 3.5 fm
- $|Z|$< 190 cm and p > 1MeV/c
- primary particles do not include the particles from strong decays

The Flux of pions/muons vs. distance from the beam axis (not normalized)

Ad. 2 – Muon identification

MCNP calculations for MCORD muon detector

(MCNP 6.11, MCNPX 2.7.0. number of iteration 1E9)



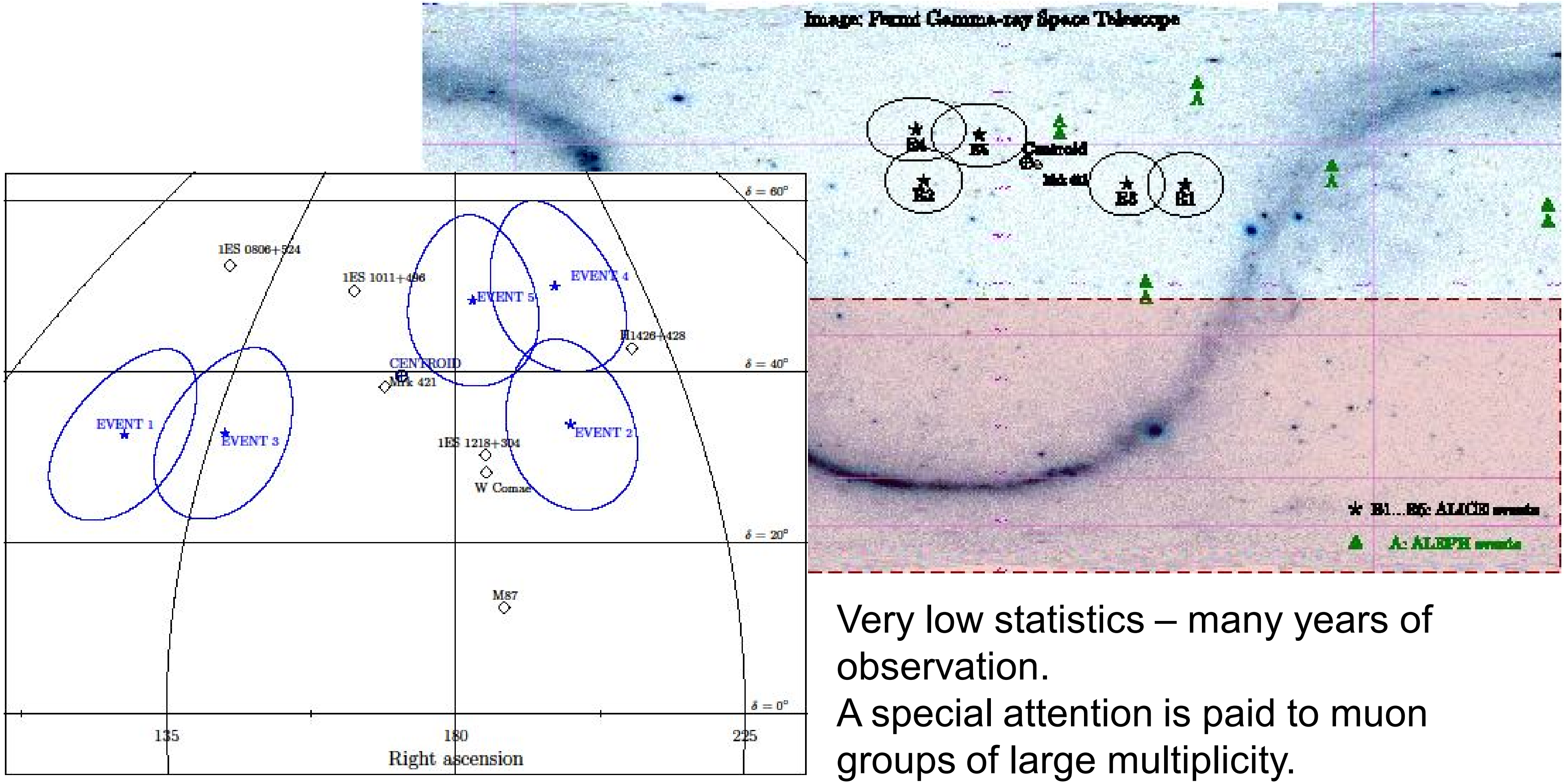
100MeV 500 MeV 1000MeV

Energy of Muons emited from the central point

MCNPX calculated central muon transmission through the MPD, MCORD and concrete walls.

Ad. 3 – Astrophysics

The position identification of Extremely high energy particle source



ALICE (multi events data) sphere position recognition

Very low statistics – many years of observation.
A special attention is paid to muon groups of large multiplicity.
Horizontal Events Experiments needs more data.

Ad. 3 – Astrophysics

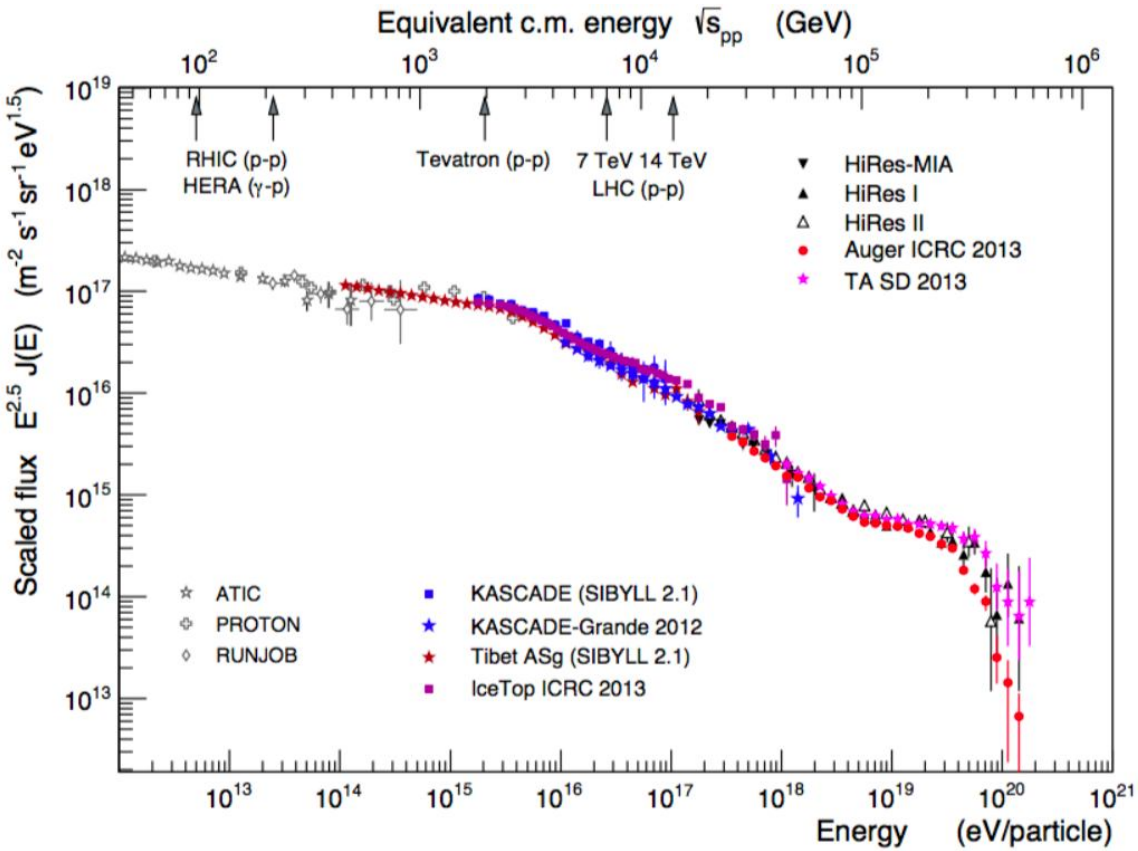
GZK-cutoff problem

- 4x10E19 eV
- 50 Mega Parsec
- Cosmic Microwave Background

Example: DECOR exp. 2002-2003y (near horizontal observation (60-90 deg. angular range)
1-10 PeV primary particle) (see ref. 2)

Bibliography:

1. Pavluchenko, V. P.; Beisembaev, R. U., Muons of Extra High Energy Horizontal EAS in Geomagnetic Field and Nucleonic Astronomy, 1995 ICRC....1..646P
2. Yashin I. et al., Investigation of Muon Bundles in Horizontal Cosmic, 2005 (28) ICRC p.1147-1150
3. Neronov A. et al., Cosmic ray composition measurements, 2017, arXiv:1610.01794v2 [astro-ph.IM]
4. Shih-Hao Wang, 2017_Cosmic ray Detection ARIANNA Station, PoS ICRC2017_358



All-particle cosmic-ray energy spectrum derived from direct and indirect (air shower experiments) measurements, as well as results from different hadronic models

Ad. 4 – Physics

Motivation for the study of muon production in nucleus-nucleus interactions with MCORD at NICA.

In the existing NICA program the study of e^+e^- dileptons is mentioned as one of important goals. When the available energy in the process is larger than the two muon mass ($2 \cdot 105 = 210$ MeV/c^2), the lepton universality lead to the production of muonic dileptons.

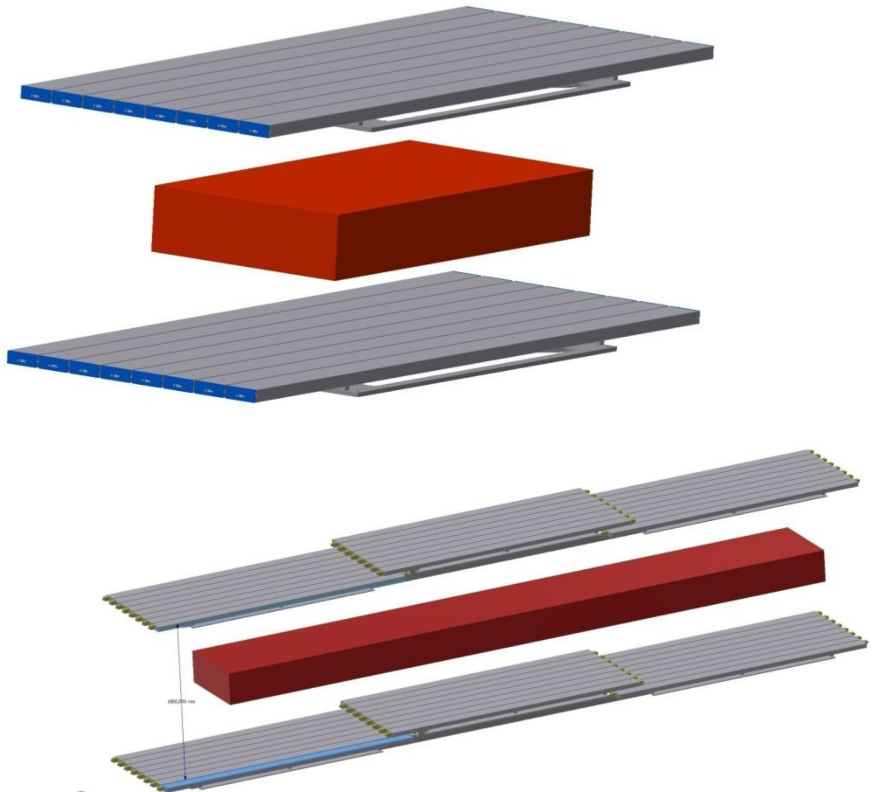
The major sources of dileptons are:

1. The decays of light scalar (η, η' …) and vector (ρ, ω , ϕ ..) mesons.
2. Open charm meson decays.
3. Drell-Yan processes.
4. Thermal muon pairs from dense, hot matter.
5. Possible decays of new, beyond SM, “dark” particles (dark photon and Higgs-like particles).

These are very rare processes !

Demonstrator

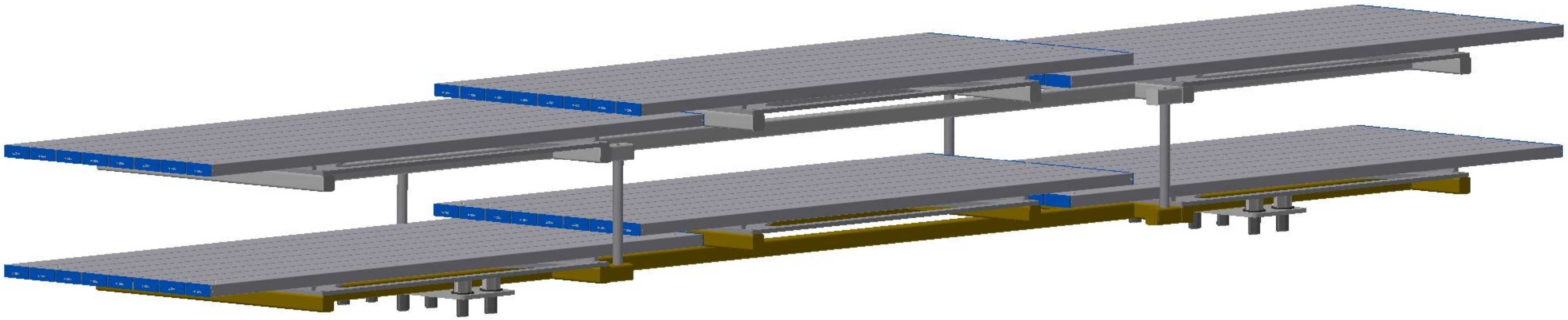
- Modular construction of MCORD allows to work with different subsystems during laboratory tests.
- 2 sections (2x8 scintillators) or 6 sections (6x8 scintillators) could be used for comissioning of TOF detectors.
- First 2 sections with dedicated electronics and full signal analysis should be delivered in 2020.



Example: testing facility for the TOF module

Demonstrator

- Full modules that comprise 3x8 scintillators are foreseen to allow installation on MPD yoke surface, but ...
- It can also be used separately, e.g. in Phase-0 experiment on the beam provided by NICA.
- 2 MCORD modules should be ready by the beginning of 2021 year.



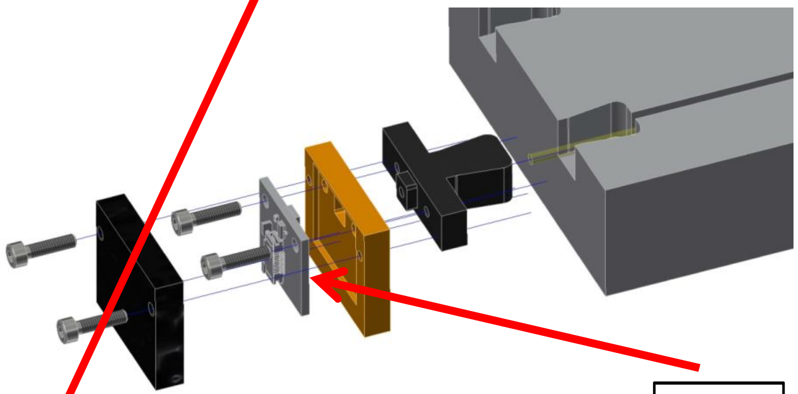
Demonstrator – present status

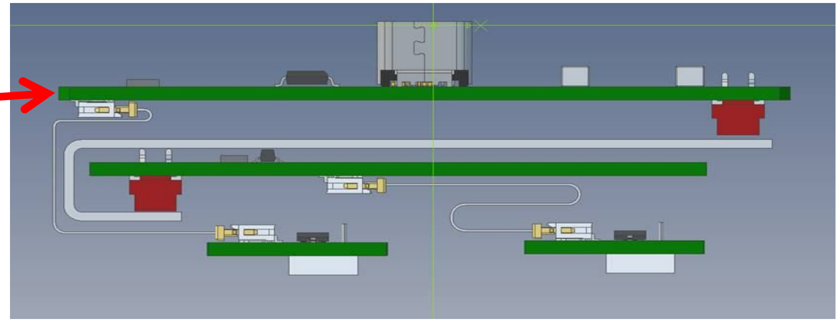
1. SiPMs (Hamamatsu) – received 70 pcs.
2. Scintillators (NUVIA) for demonstrator – received 16 pcs.
3. Aluminum profiles for scintillators – received
4. Components integration in progress (mechanical and electronic connections, scintillator-SiPM-fiber-AFE integration)
5. Electronic (CreoTech) – AFE, Hub modules and adapters, converter modules , FMC-TDC boards – tests and programing – we order - waiting for received 20 complets

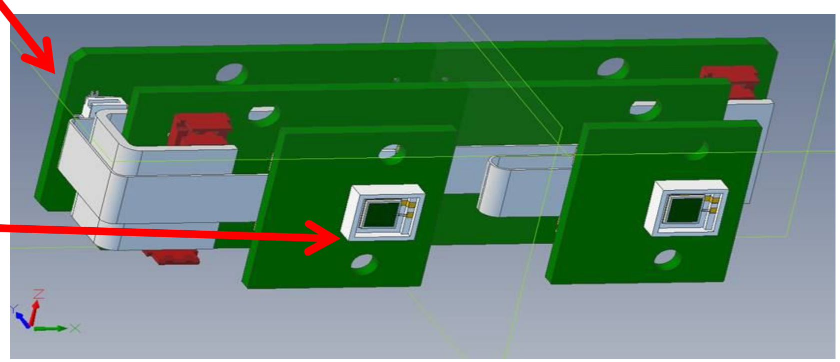
Demonstrator – present status

Project of the mechanical connection scintillator-SiPM-fiber-AFE board

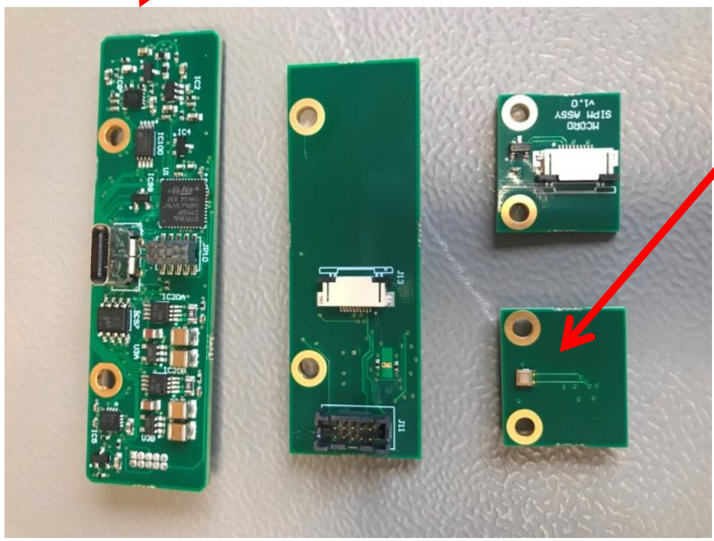
Amplifier & Power supply





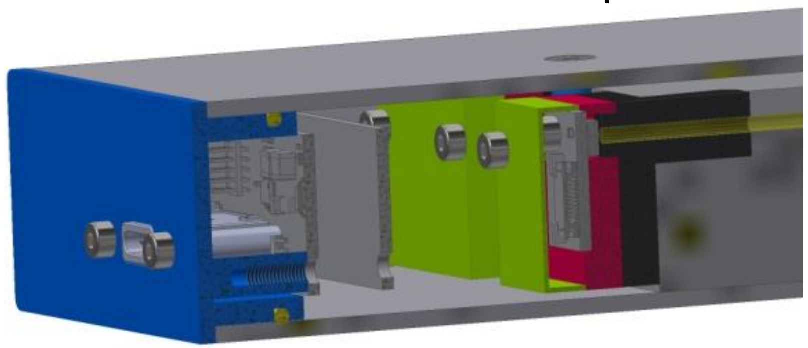


SiPM



MCORD AFD boards

View of the area between the end of scintillator and End-Cap



Demonstrator – present status

HUB - back

HUB - front

HUB - board

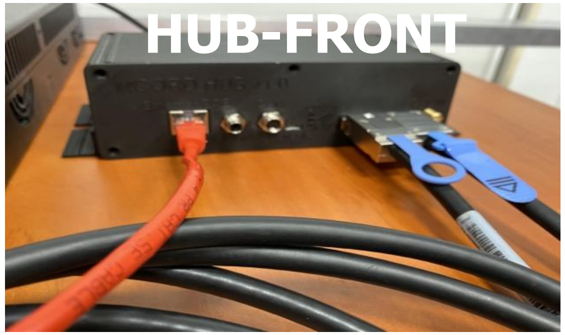
FPGA mezzanine card (FMC)

AMC FMC carrier board

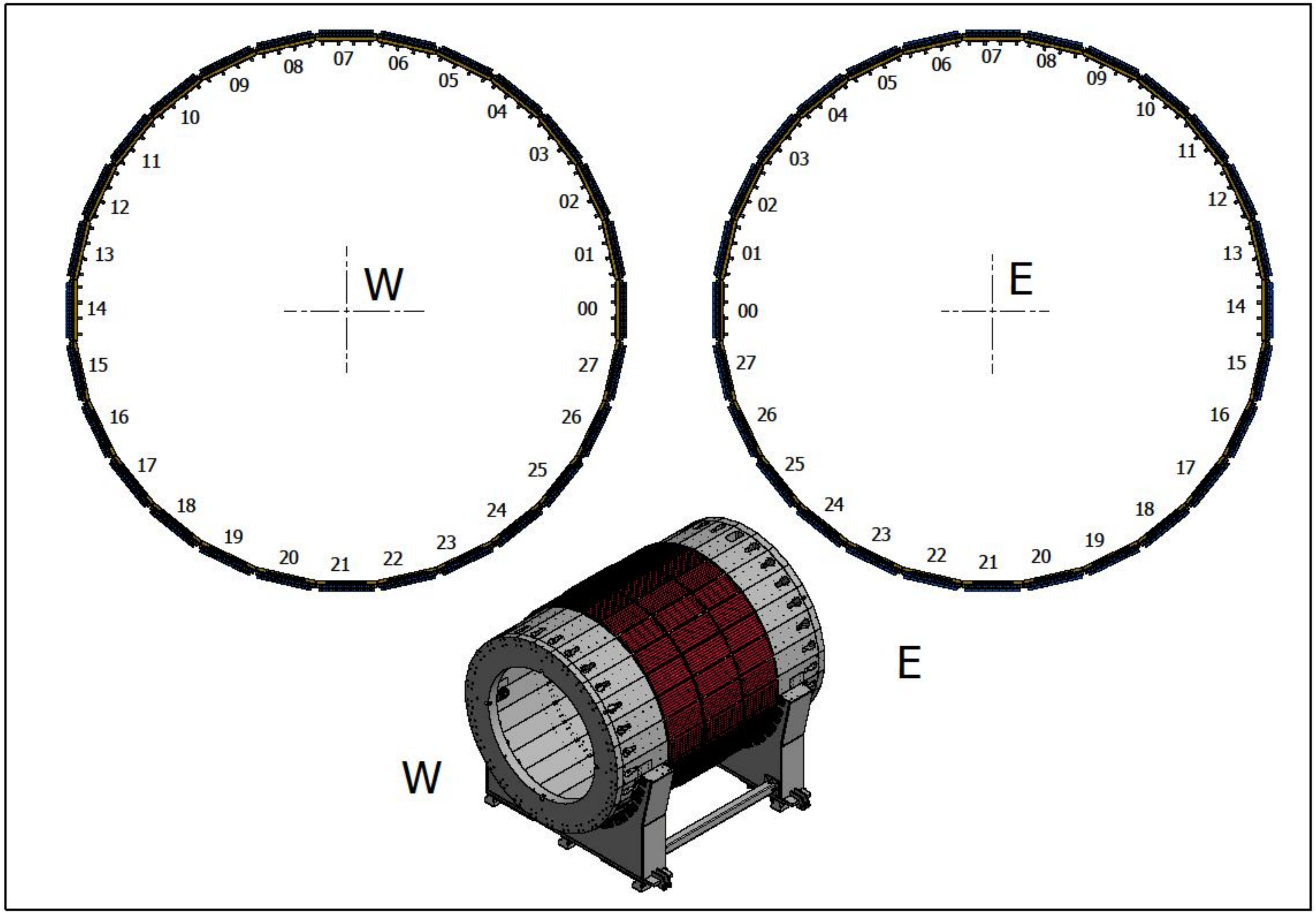
Standard MTCA crate (8U)

PoE Switch

Demonstrator – present status

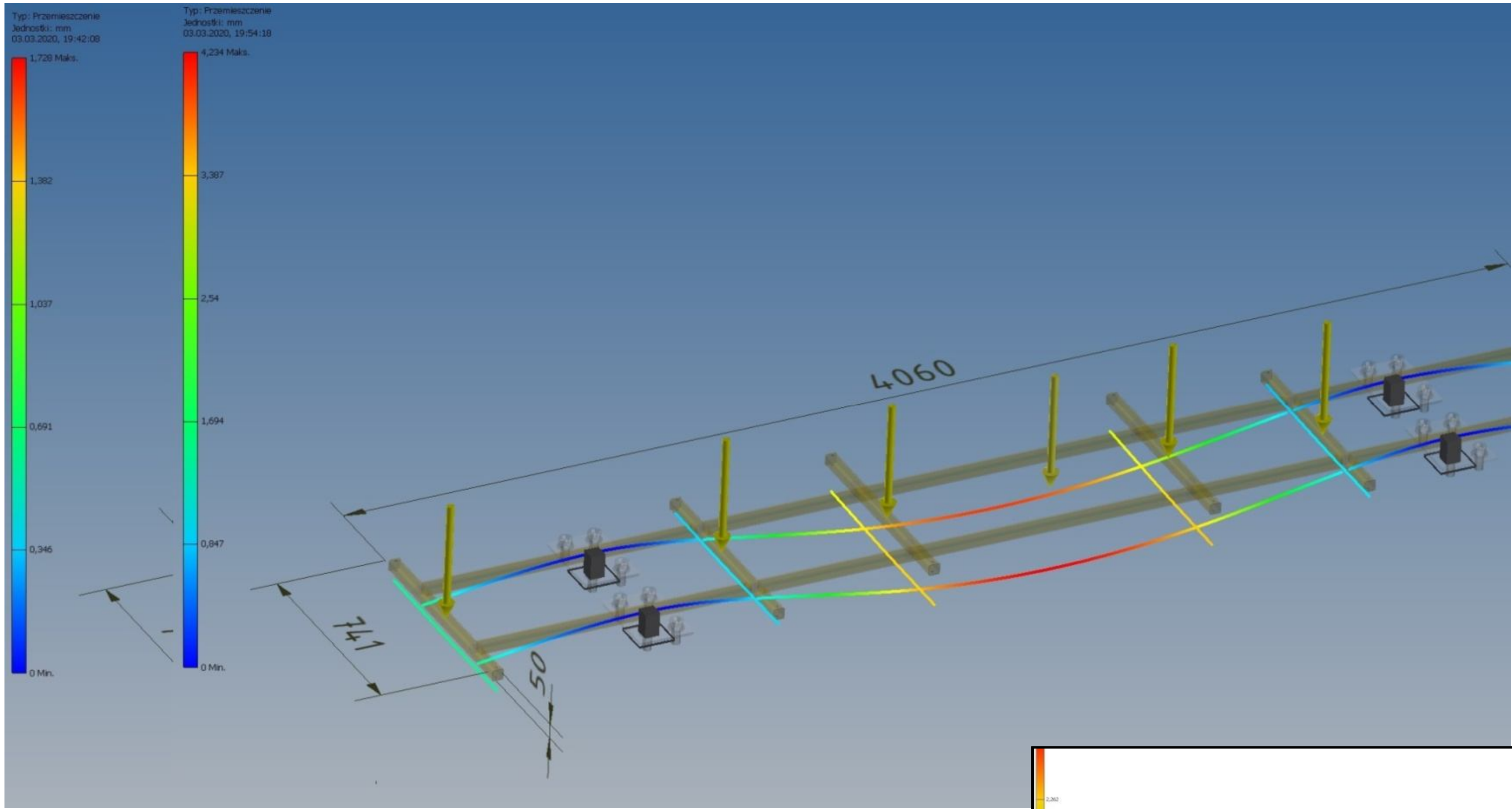


MCORD section numbering



NARODOWE CENTRUM BADAŃ JĄDROWYCH ŚWIERK

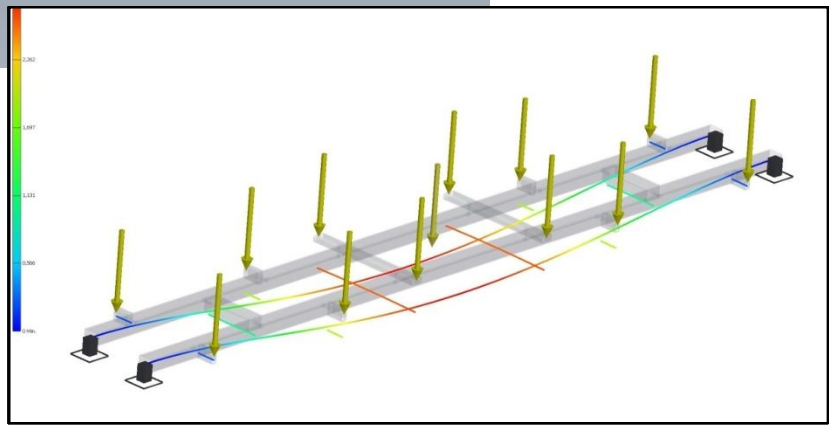
MCORD construction



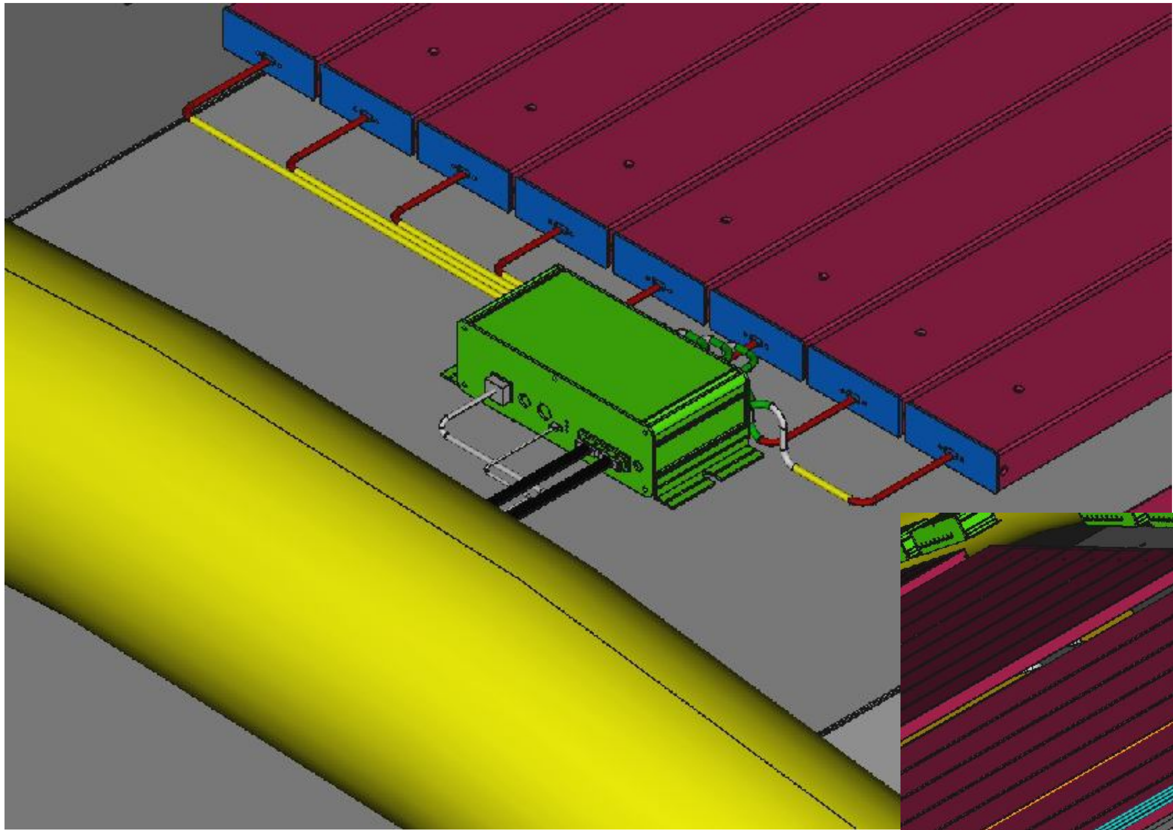
Upper:
Frame mass:
23 kg
Bottom:
Frame mass:
51 kg

Aluminum:
6060
Crosssection:
40x40x3

Upper Part:
Bend the Aluminum structure 4.2 mm
Bottom Part
Bend the Aluminum structure <3 mm

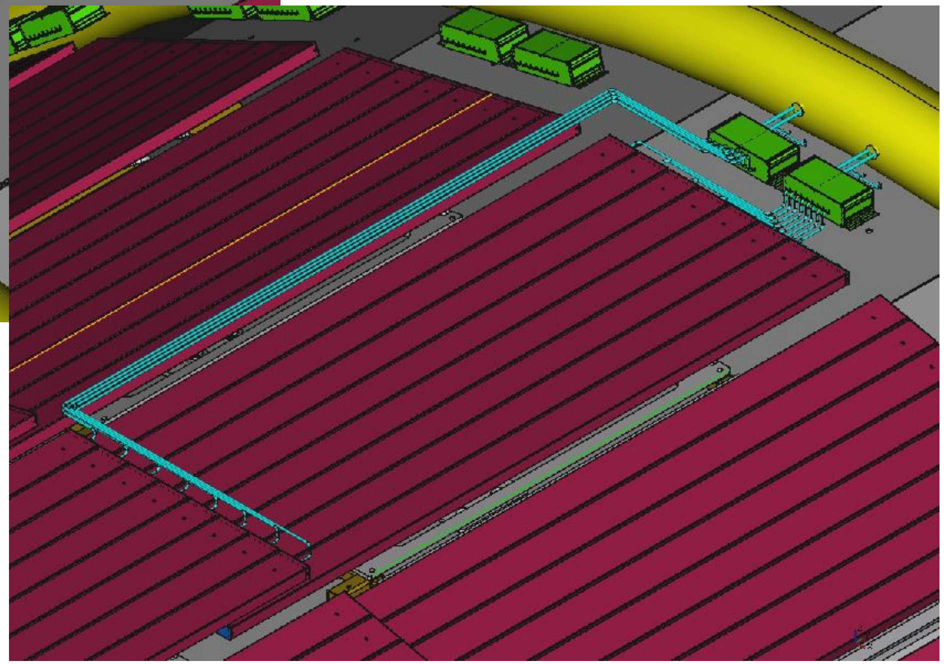


MCORD construction



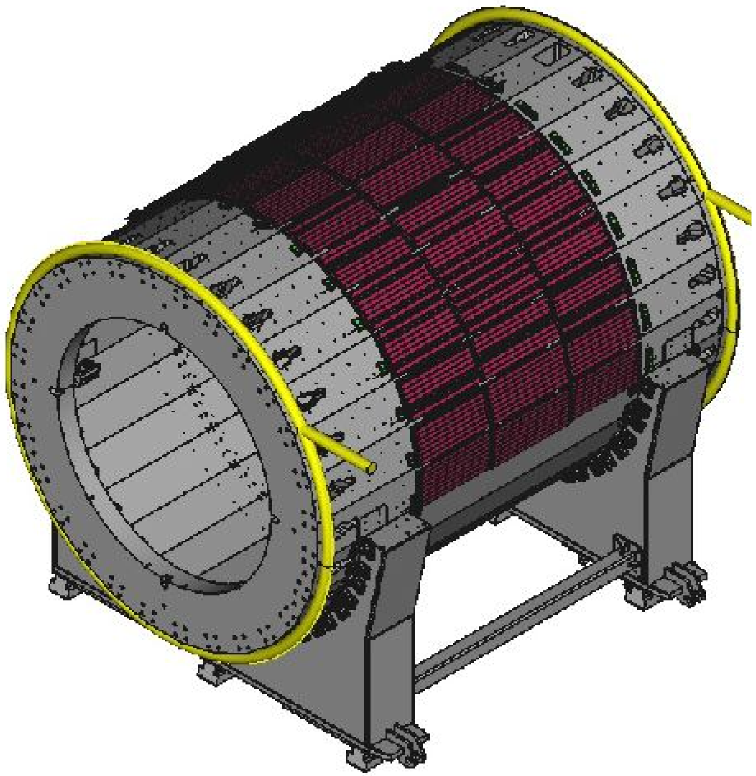
From each MCORD modul go 6xSAS, 3xLAN and 3xSMA cables

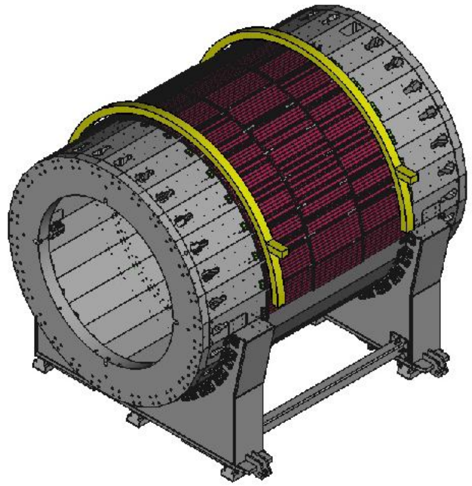
We have 28 modules!

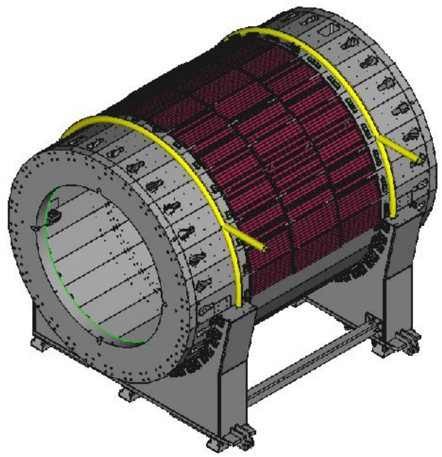


How we can take those cables to Platform ?

MCORD construction







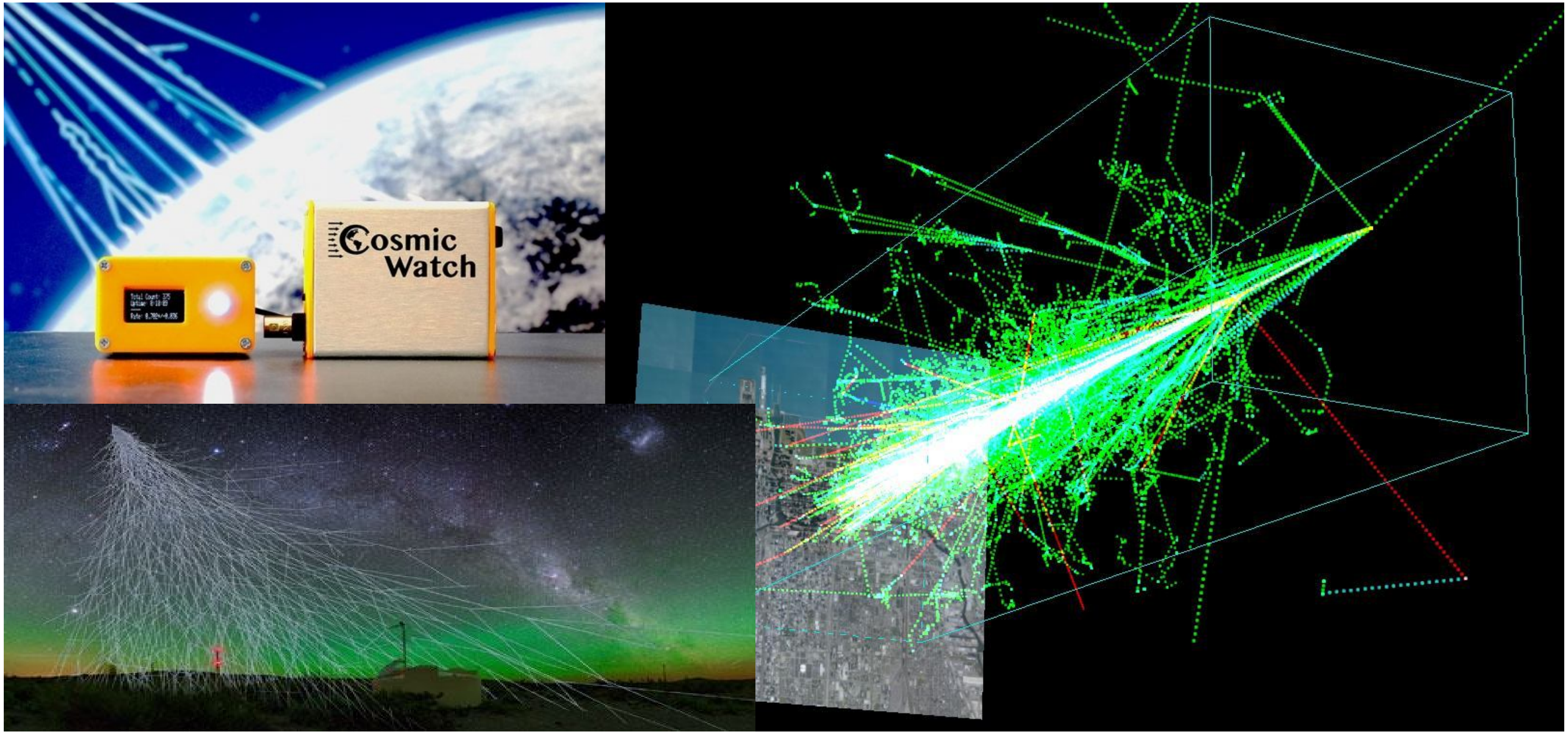
NARODOWE CENTRUM BADAŃ JĄDROWYCH ŚWIERK

Conclusions

1. MCORD offers opportunity for good calibration of TPC, TOF and ECAL detectors before completion of the MPD.
2. MCORD can be useful for detection of rare processes of muonic dilepton production.
3. Additionally MCORD can be used for unique astrophysics observations similar to past collider experiments.
4. **The first demonstrator (two MCORD sections) were foreseen to be ready by the half of 2020 – rescheduling...**
5. The first two MCORD modules should be ready in the beginning of 2021, ready for installation on the MPD surface.
6. Mechanical support and cabling issues needs further discussions.

Polish consortium NICA-PL

Thank You for Attention!



Ad. 1 – Trigger during commissioning

Data processing and resolution

Latency estimation for L1 trigger (event without parameters)

- ✓ AFE cabling 8ns/m, with 10m cabling latency is 80ns
- ✓ ADC + SERDES latency: 400ns

Latency estimation for L2 trigger (event with parameters)

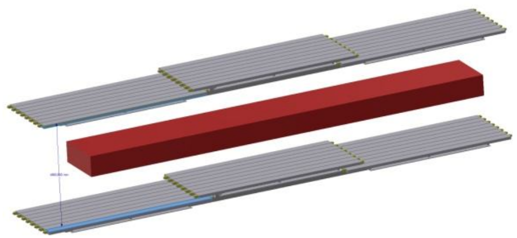
- ✓ MGT latency: 500ns
- ✓ Algorithm latency : 2-5μs
- ✓ Formatter and transmitter latency: 1μs

Estimated total latency: 3.5 – 7.5μs

Latency estimation for L3 trigger (between MTCA systems)

- ✓ MGT latency: 500ns
- ✓ Fiber latency: 500ns + 8ns/m
- ✓ Algorithm latency : 2-5us
- ✓ Formatter and transmitter latency: 1us

Estimated total latency: 10 – 15us



RESOLUTION

Position resolution: In X axis – up to 5 cm, In Y axis – 5-10 cm
Time Resolution – about 300-500 ps
Number of events (particles): about 100-150 per sec per m2
Calculated Coincidence factor: about 98%