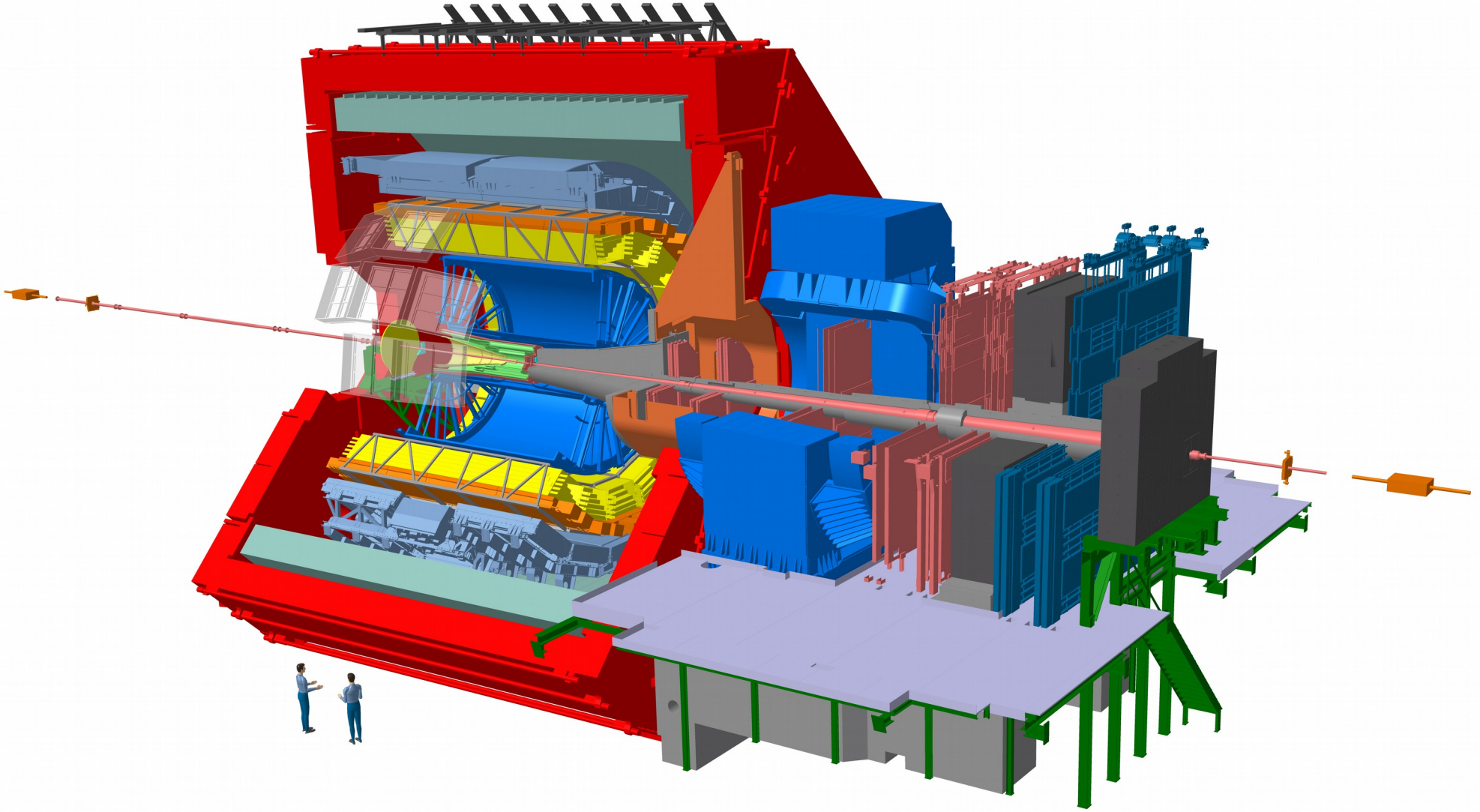
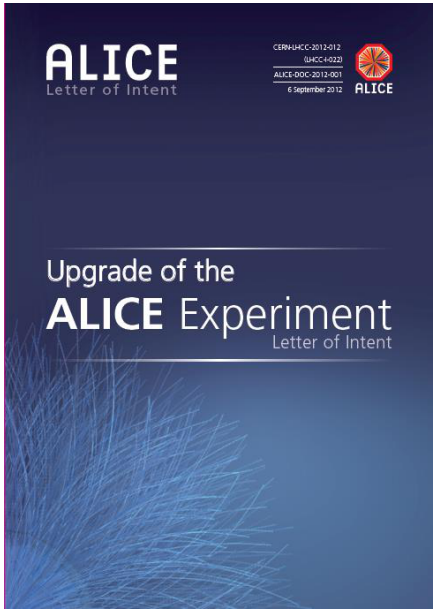
ALICE Upgrades



Filip Křížek, ÚJF AV ČR

Motivation



ALICE LoI,
J.Phys. G41 (2014) 087001

- ALICE physics goals for Run 3
  - open HF hadrons, quarkonia down to zero p_T

    thermalization, hadronization, recombination, temperature evolution of the QGP
  - vector mesons and low-mass di-leptons

    chiral symmetry restoration, virtual thermal photons from the QGP
  - high-precision measurement of light (anti-)nuclei and hyper-nuclei

    nucleosynthesis, exotics
- Increase of delivered luminosity of Pb+Pb after LS2

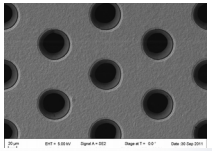
$L = 6 \times 10^{27}$ cm^{-2} s^{-1} ≈ collision rate 50 kHz (increase by factor 100)

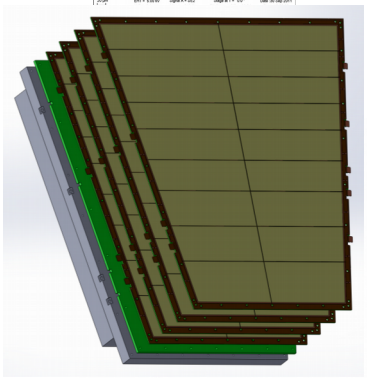
Observables do not have suitable signatures for triggering →
Readout untriggered PbPb interactions at > 100 kHz

ALICE Upgrades in LS2

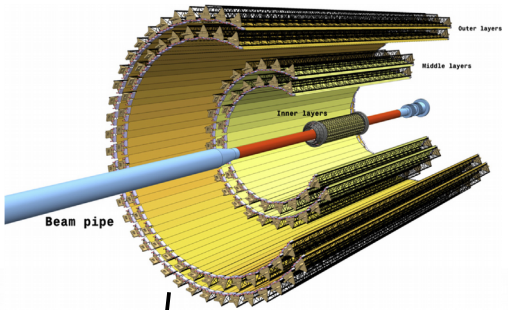
Time Projection Chamber
new readout chambers
new front-end and read-out

GEM

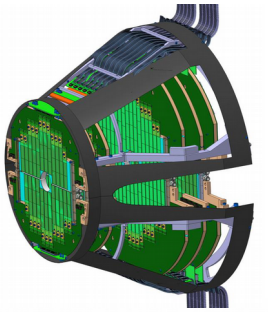




Inner Tracking System
completely new detector



Muon Forward Tracker
completely new detector



Fast Interaction Trigger
completely new detector

FDD
upgraded AD

ZDC & CPV
change of read-out

FDD
upgraded AD

Time Of Flight
new read-out

Muon Identifier
new front-end
new read-out

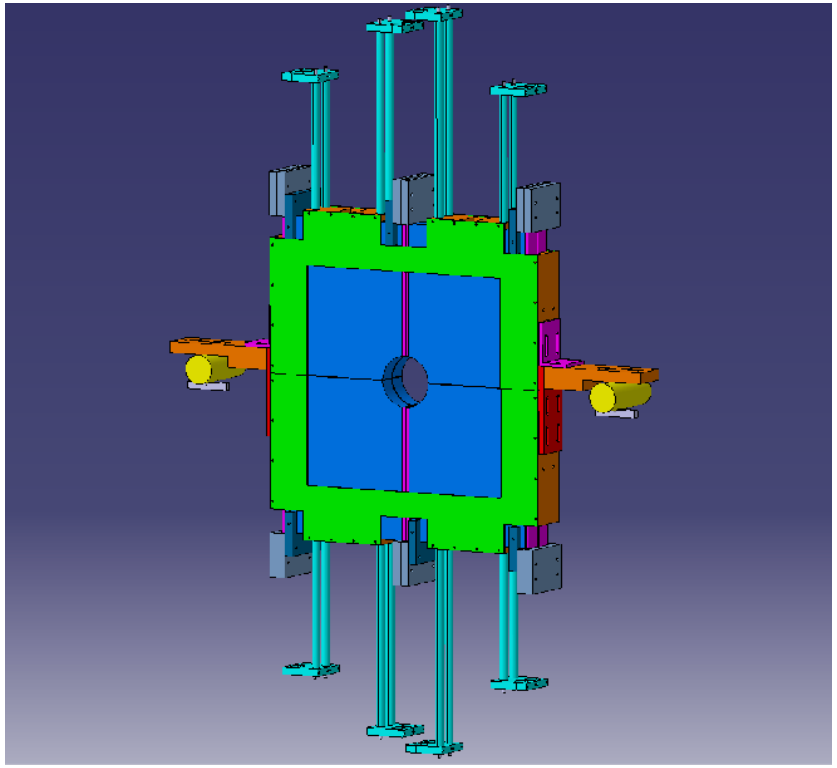
Muon Chabers
new front end and readout

News from 2018

- FNSPE CTU will join Muon Forward Tracker (MFT) and plans to work also on Forward Diffractive Detector (FDD)
- Czech investment to MFT and FDD will be about 500 kCHF. Share between projects is a matter of negotiations.
- To be funded from the 2020-2022 budget (Run3 starts 2021)

- NPI CAS continued in radation hardnes tests of silicon sensors for the upgraded Inner Tracking System
- Readout unit for the upgraded ITS passed sucessfully Production Readines Review in April

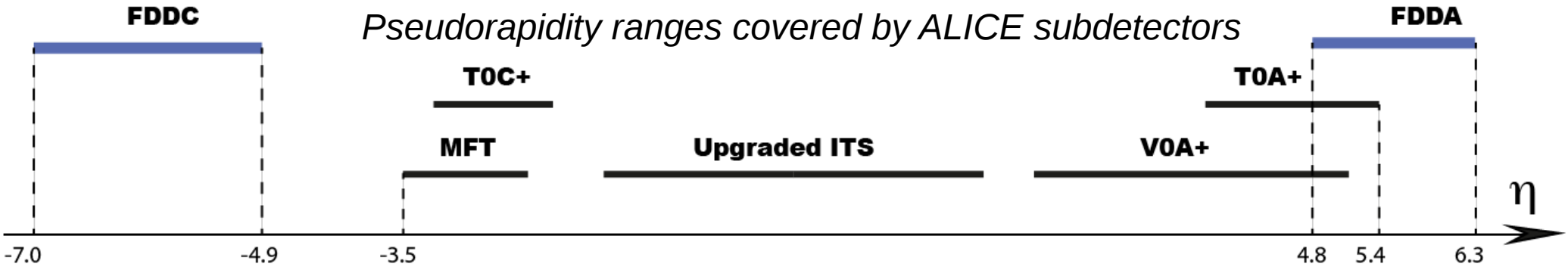
Forward Diffractive Detector



Total cost 250 kCHF

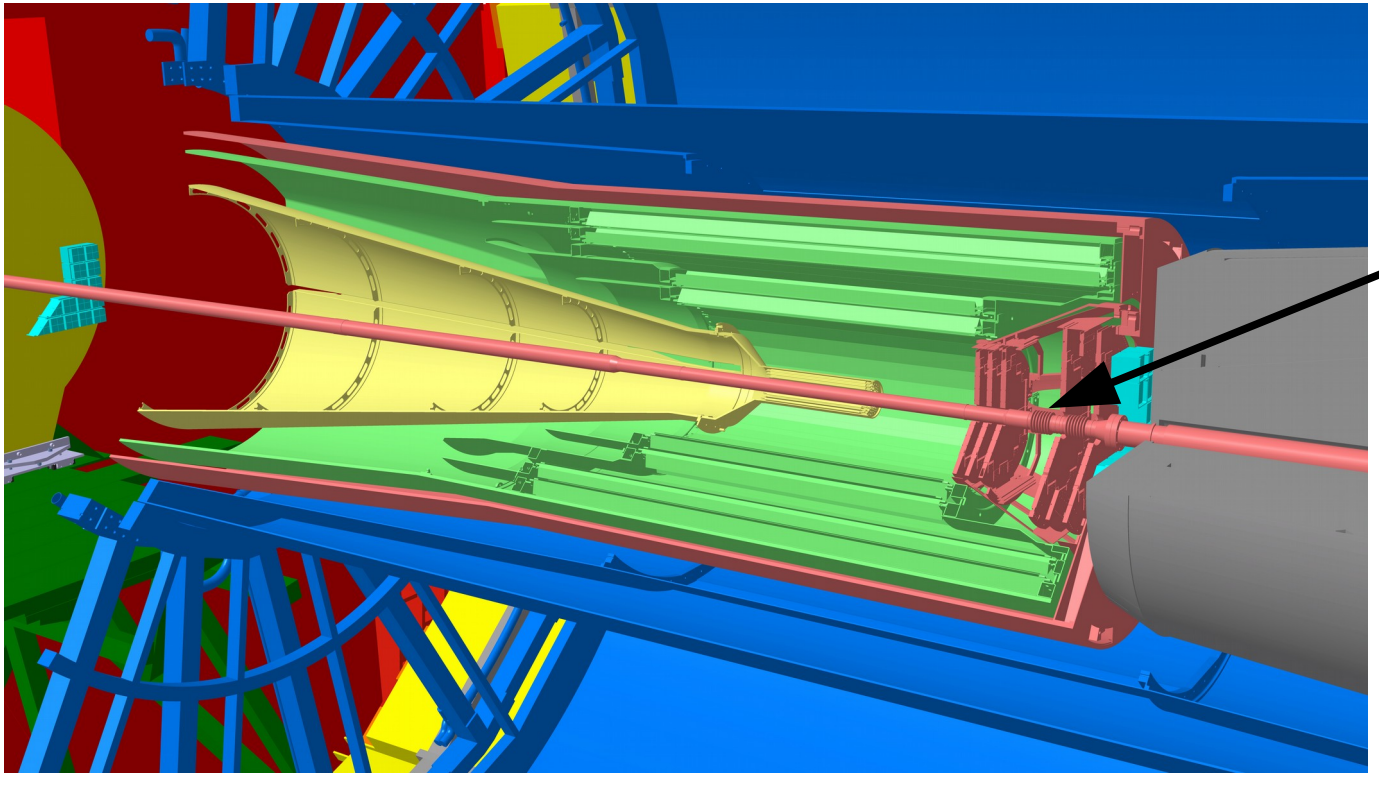
- Beam monitoring, luminometer, centrality, identification of diffractive processes
- Four modules of two plastic scintillators, read by wave-length shifters coupled to PMTs.
- Charge and time measurements.
- Expected time resolution below 0.5 ns
- Large dynamic range.
- Timeline: 2019-2020 construction, 2020 installation and testing, 2021 physics
- FNSPE joins prototyping, testing, construction

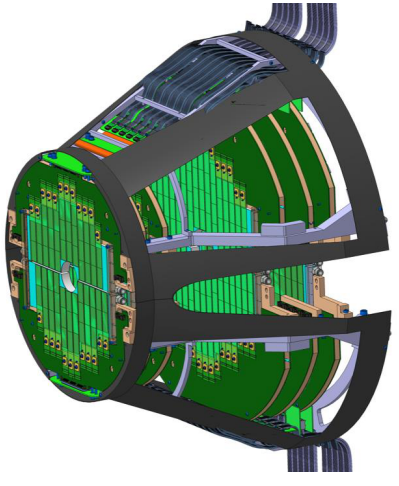
Pseudorapidity ranges covered by ALICE subdetectors



Muon Forward Tracker

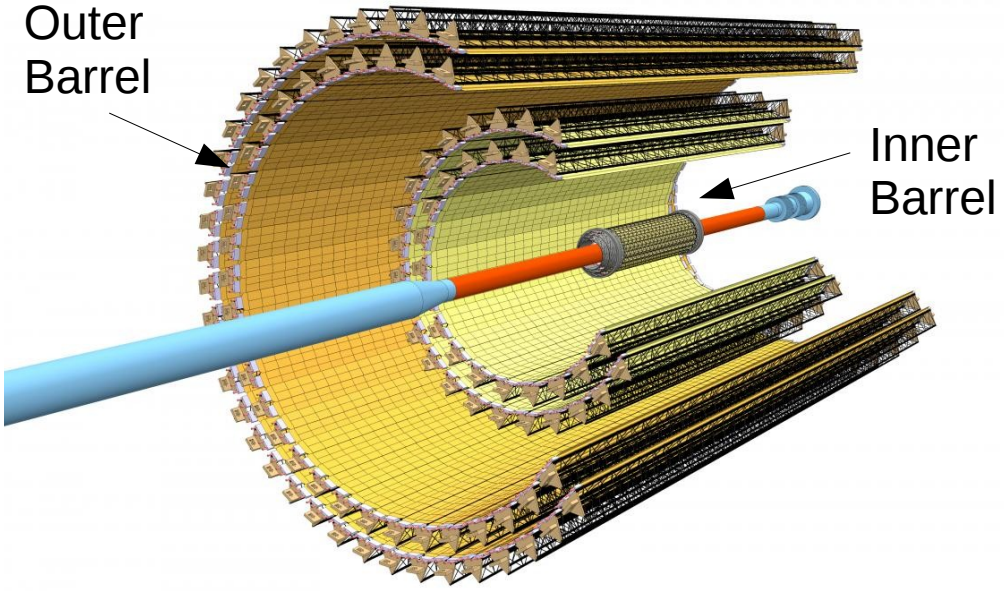
- Improves tracking resolution in front of the ALICE muon arm
- Open heavy flavor in single muon chanel, B from non prompt J/ψ, UPC
- FNSPE will participate in
  - testing and characterization of the readout
  - physics and development of the software in O_2



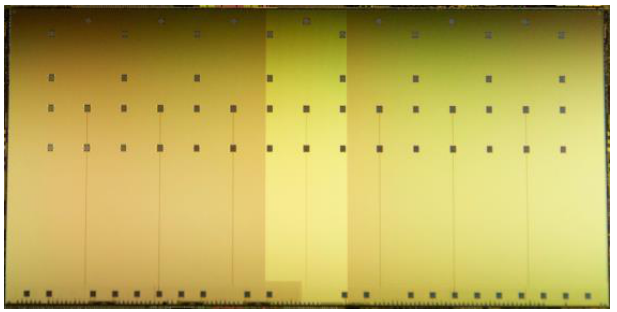


Total cost 3.3 MCHF
Czech contribution will go to readout costs

Layout of the New ITS



1024 pixels / 30 mm



512 pixels / 15 mm

ALPIDE sensor

Number of layers 7
Range of radii 23 - 400 mm
Pseudorapidity $|\eta| < 1.22$
Number of chips 24000
Number of pixels 12.5 G
Area 10 m^2

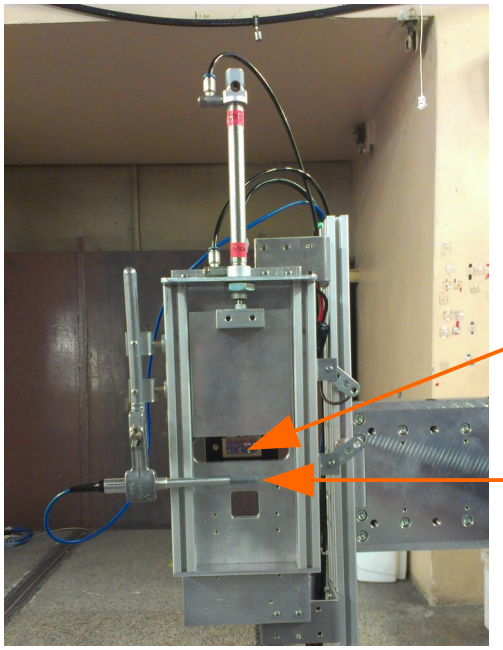
Monolitic Active Pixel Sensors
ALPIDE = ALICE PIxel DEtector
180 nm CMOS imaging process by TowerJazz
3 cm x 1.5 cm x 50_{IB} / 100_{OB} µm
Power consuption < 40 mW cm^{-2}

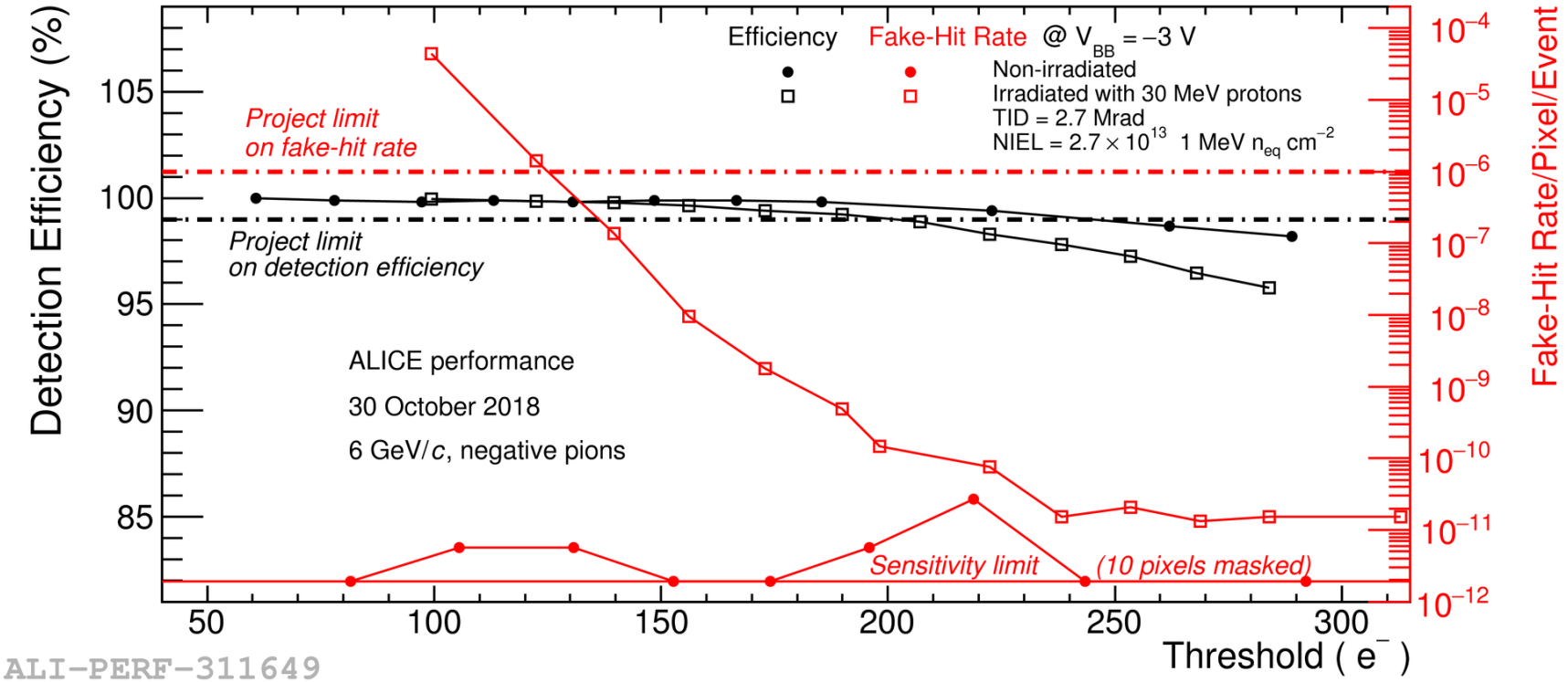
Radiation load for the Inner Barrel
TID 270 krad
NIEL 10^{12} $1MeVn_{eq}$ cm^{-2}
proposal requires an additional safety factor of 10

Total cost 13.6 MCHF
Czech contribution 257 kCHF (1.9%) payed in 2016
Faster ITS readout 230 kCHF payed in 2018 (addendum to the MoU)

Tests of radiation hardness for ITS at NPI

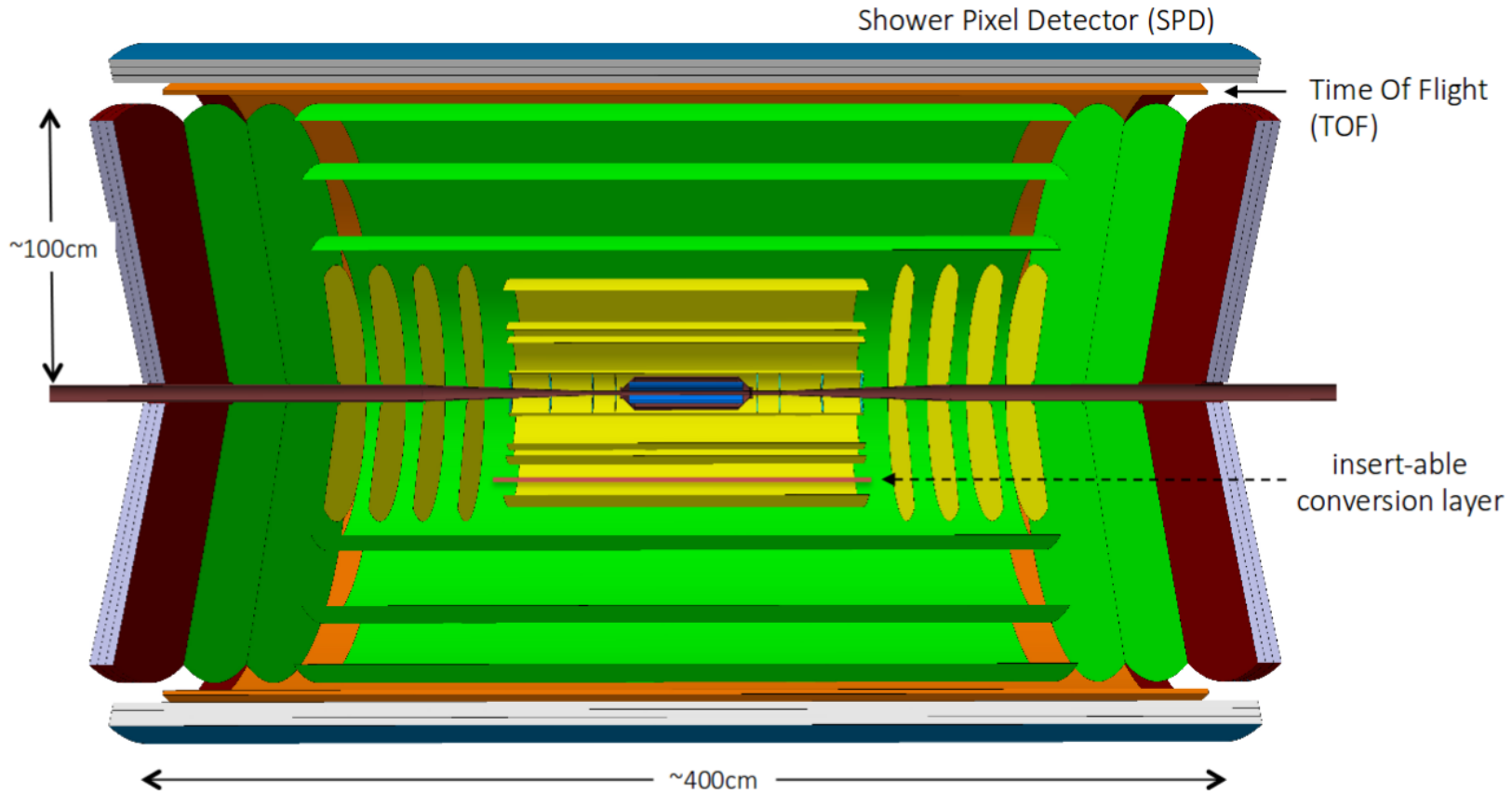
- 30 MeV protons from the NPI cyclotron
- Long term irradiation of ALPIDE sensor is finished (in 3 years the sensor obtained 2.7 Mrad TID and 2.7×10^{13} 1 MeV n_{eq} cm^{-2} NIEL exceeding more than 10× the expected radiation load for the inner barrel)
- ALPIDE fulfils radiation hardness requirements defined by the project technical design report!





ALI-PERF-311649

A next-generation LHC heavy-ion experiment

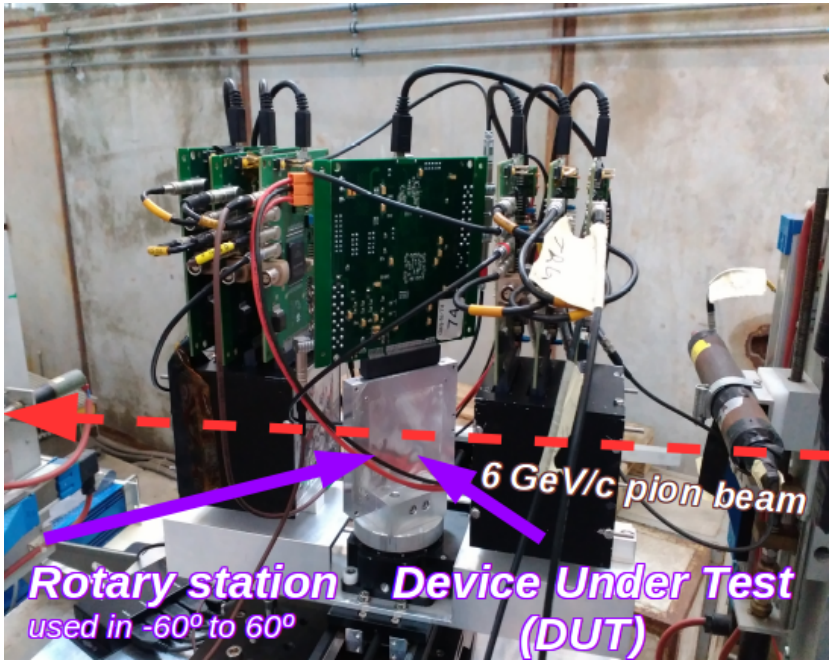


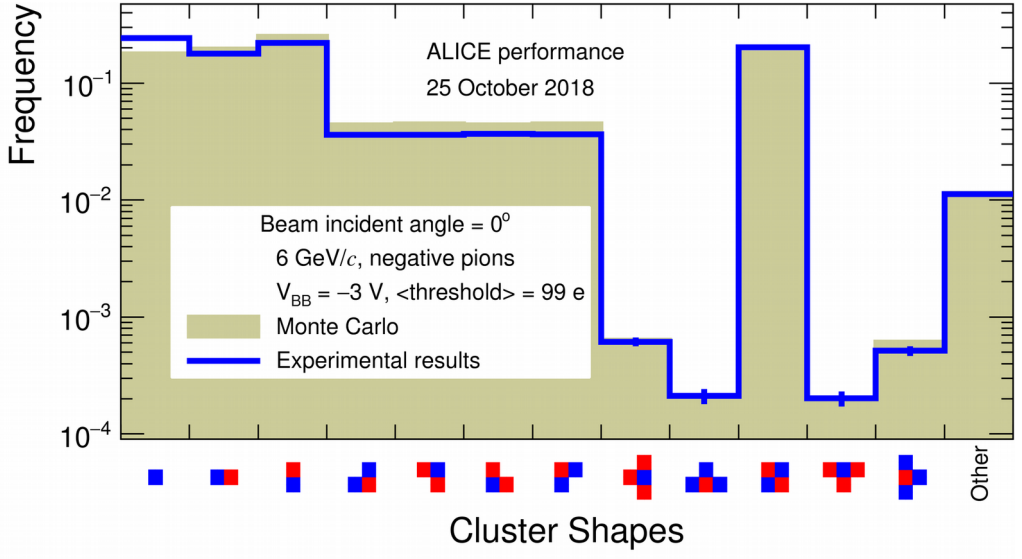
Proposed to replace ALICE in 2030 during LS4 (proposal for Open Symposium in Granada)
Heavy flavor measurements down to p_T 10 MeV/c, low mass dileptons, thermal QGP radiation
Silicon tracker based on MAPS (IB placed in beam pipe 0.05% X_0/layer, OB 0.5% X_0/layer)
Time of flight (CMOS Single Photon Avalanche Diodes, ~20 ps resolution)
Shower Pixel Detector to identify electrons and gammas

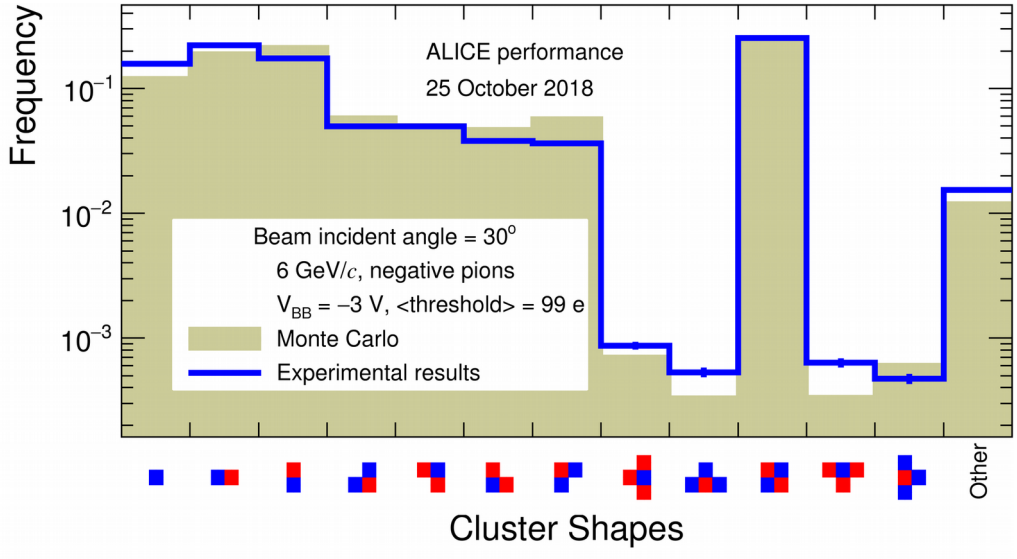
Backups

Characterization of ALPIDE response with inclined tracks and comparison to MC

- CERN PS 6 GeV/c pion beam
- Telescope of 7 ALPIDE planes, the ALPIDE in the middle is Device Under Test
- Simulation calculates drift and diffusion of charge in epitaxial layer and substrate volume and accounts for carrier lifetime
  [M.Suljic, CERN-THESIS-2017-304]



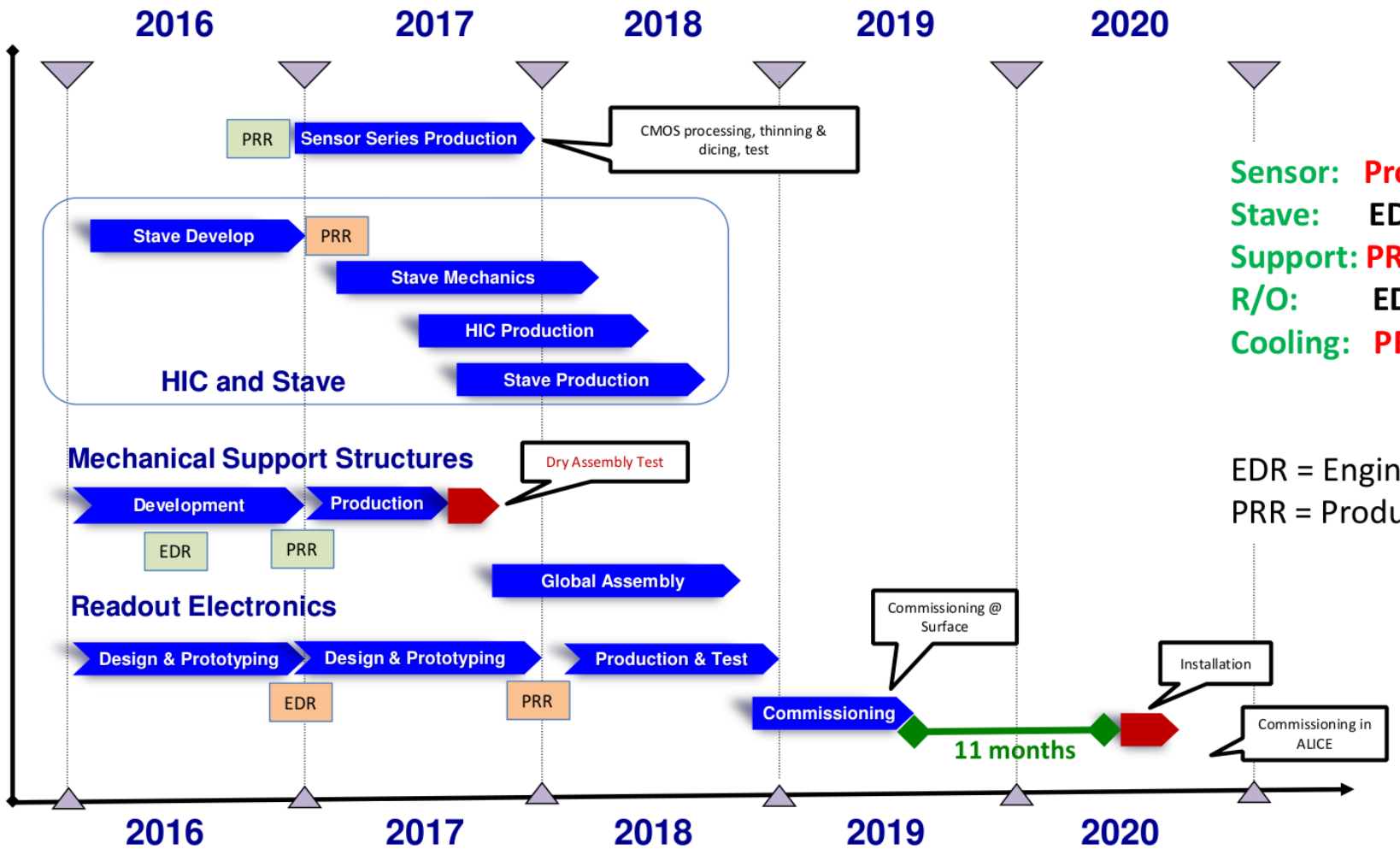




ALI-PERF-311628

ALI-PERF-311632

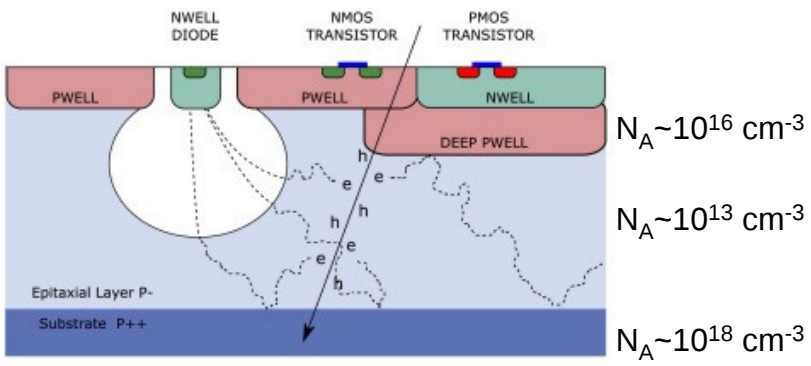
Time plan



Sensor: Production started
Stave: EDR ok, PRR in March
Support: PRR passed
R/O: EDR ok, PRR end '17
Cooling: PRR passed

EDR = Engineering Design Review
PRR = Production Readiness Review

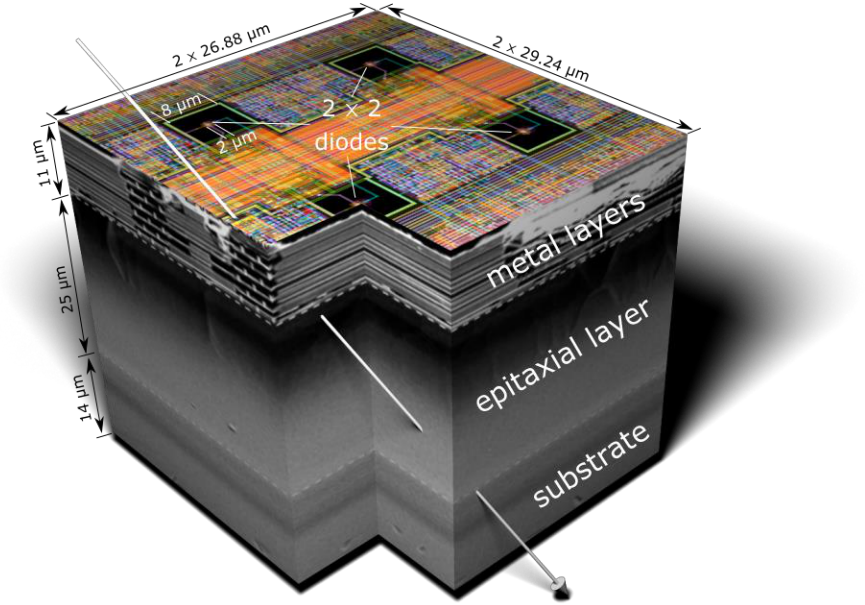
ALPIDE Technology and Pixel Layout



N_A~10^{16} cm^{-3}

N_A~10^{13} cm^{-3}

N_A~10^{18} cm^{-3}



- CMOS Pixel sensor using 180 nm CMOS Imaging Process by TowerJazz
- High-resistivity (> 1kΩ cm) p-type epitaxial layer (25 µm) on p-type substrate
- Small n-well diode (2 µm diameter), ~100 times smaller than pixel → low capacitance (~fF)
- Deep PWELL shields NWELL of PMOS transistor
- Reverse bias to -6 V < V_{BB} < 0 V substrate
- Full CMOS circuitry within active area (amplification, discrimination, 3-hit register)