

# Experiment ALICE

Filip Křížek

on behalf of the CTU, IoP and NPI ALICE teams



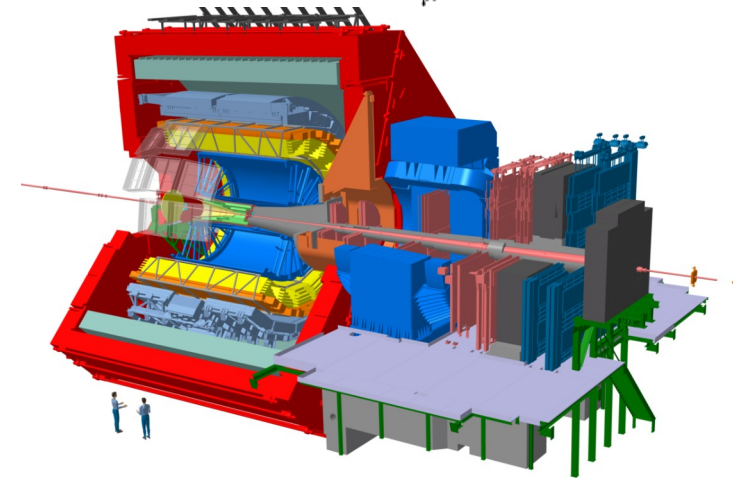
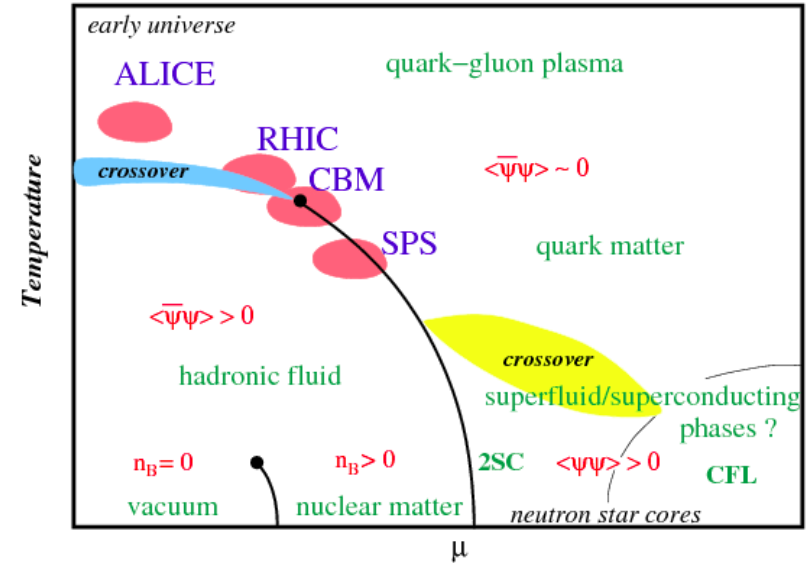
**ALICE**

# ALICE at the LHC

- Investigates properties of Quark-Gluon Plasma created in collisions of heavy-ions
- Rich pp program
- ~ 1000 signing authors from ~150 institutions
- **20 authors affiliated with 3 Czech institutions**

Czech Technical University (CTU)  
Nuclear Physics Institute (NPI)  
Institute of Physics (IoP)

- **Czech authors are among the leading contributors to:**
  - flow and correlations
  - jets
  - heavy flavor
  - photon-induced interactions
  - luminosity

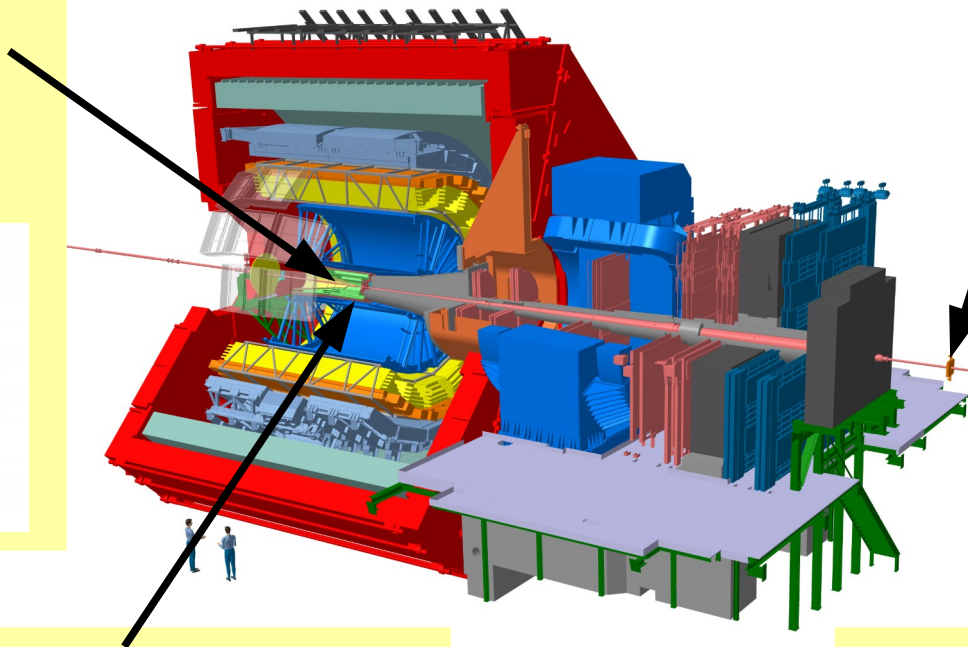
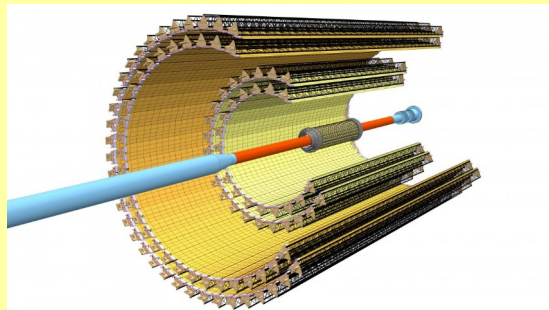


# Czech involvement in ALICE

## Inner Tracking System

### NPI

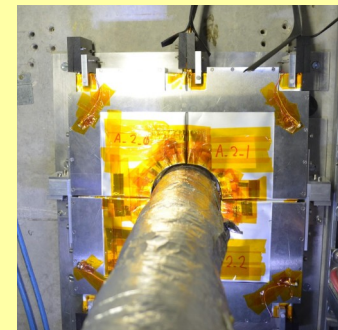
- jets
- heavy-flavor
- flow and correlations
- photon-induced reactions



## Forward Diffractive Detector

### CTU

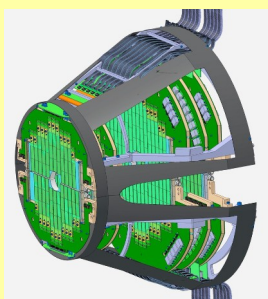
- photon-induced reactions
- luminosity



## Muon Forward Tracker

### CTU

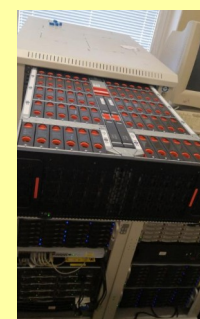
- heavy-flavor
- flow and correlations
- photon-induced reactions



## Computing

### NPI + IoP

- Tier 2 center at IoP
- data storage server at NPI



# Inner Tracking System (ITS)

## Physics goals:

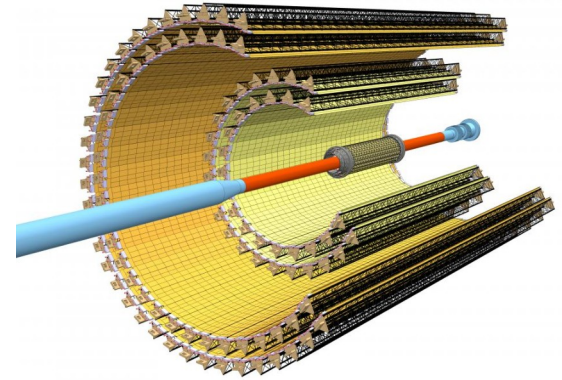
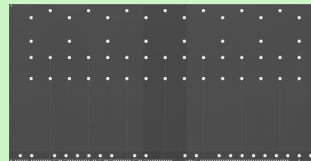
Heavy flavor quark/jet physics through large improvements on:

- primary and secondary vertex reconstruction
- tracking

- 7 layers of Monolithic Active Pixel Sensors
- 10 m<sup>2</sup> with 12·10<sup>12</sup> pixels
- Low material budget
  - inner barrel 0.35% X<sub>0</sub>/layer
  - outer barrel 1% X<sub>0</sub>/layer

## ALPIDE sensor

- 180 nm CMOS imaging process by TowerJazz
- 3 cm × 1.5 cm × 50/100 μm (1024 × 512 pixels)
- 29 μm × 27 μm pixel pitch
- average power density < 40 mW·cm<sup>-2</sup>
- efficiency > 99 % , fake-hit-rate < 10<sup>-6</sup> events / pixel / event
- radiation tolerance TID 2.7 Mrad, NIEL 2.7×10<sup>13</sup> 1 MeV n<sub>eq</sub> cm<sup>-2</sup>



## NPI contributions to ITS:

- radiation hardness tests sensors & readout unit
- sensor characterization
- development of quality control software
- detector commissioning
- in Run 2 one Ph.D. student was Silicon Strip Detector system run coordinator

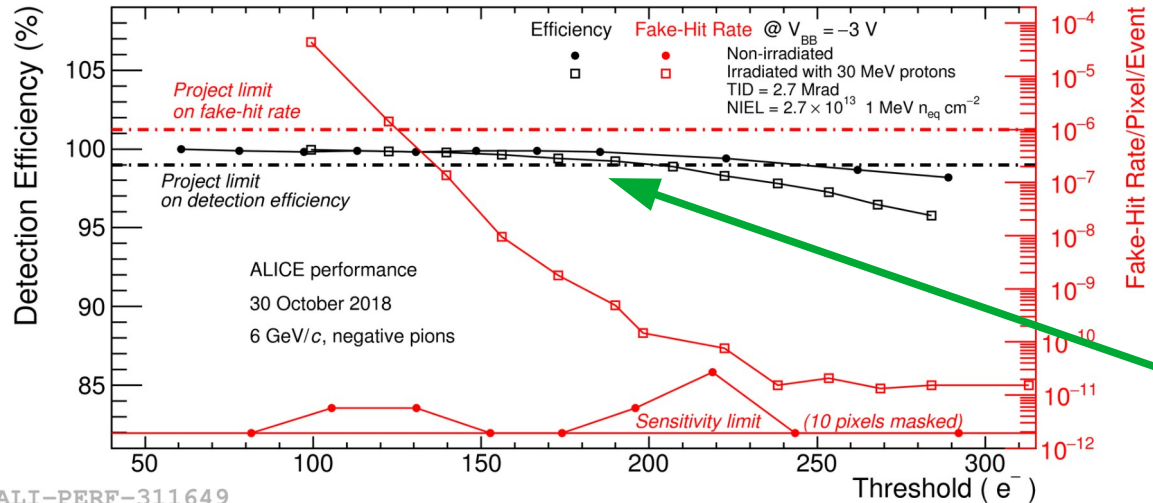
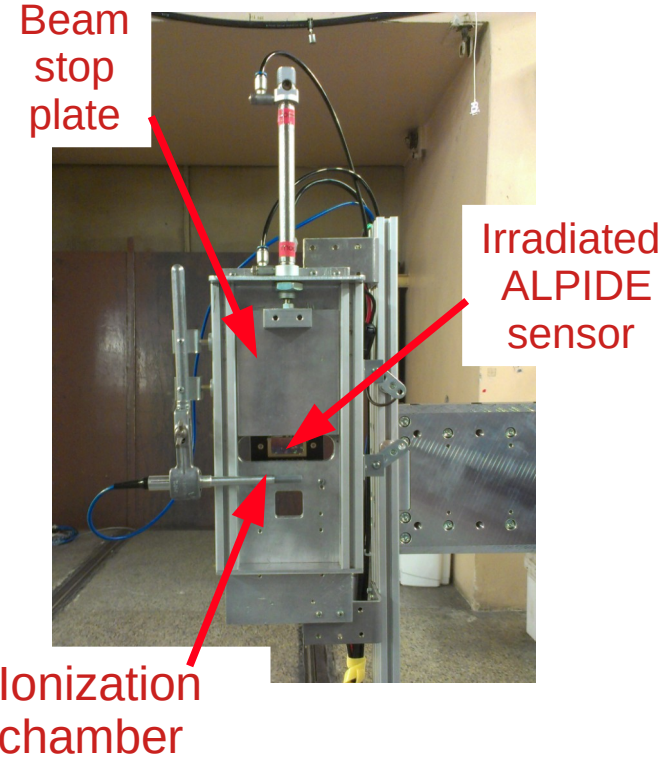
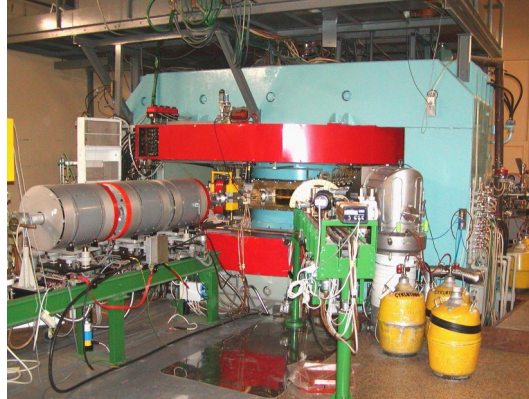
# Tests of radiation hardness at the NPI cyclotron <sup>5</sup>

## NPI cyclotron U-120 M

Protons ~ 30 MeV

Intensity ~1000 cm<sup>-2</sup> s<sup>-1</sup> to μA

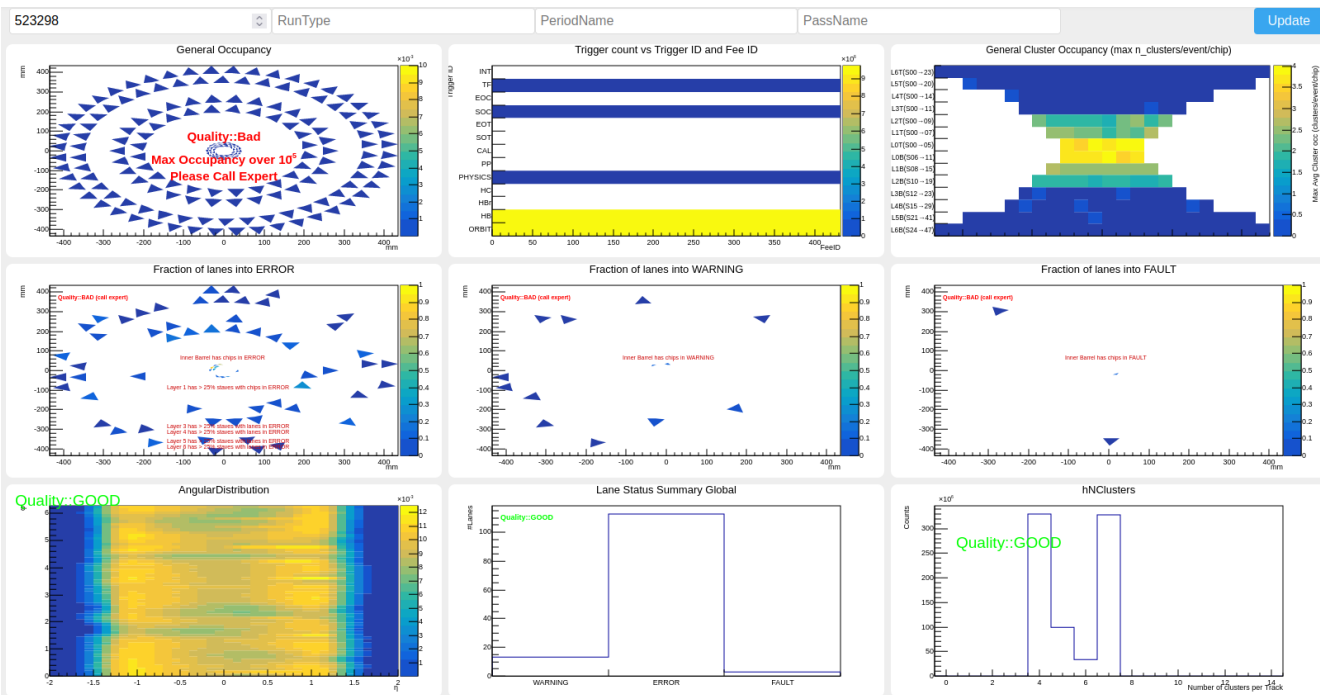
Krizek et al., NIM A 894 (2018) 87



Characterization of irradiated ALPIDE with 6 GeV/c  $\pi^-$  at CERN PS  $\Rightarrow$  sensor fulfills TDR requirements

# Quality Control (QC) for ITS

QC provides quality assessment of data recording and handling during data-taking

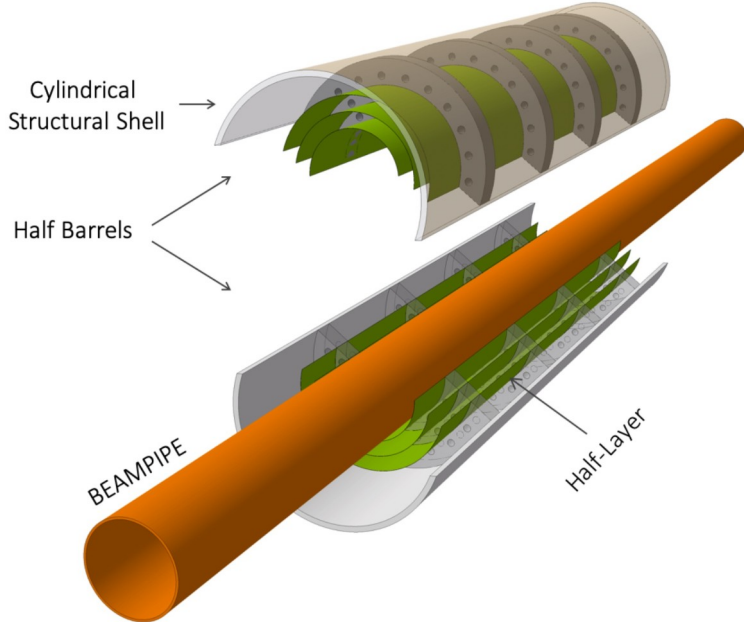


Layout of ITS quality plots for a QC shifter

## NPI contributions:

- Modules for online data monitoring of Fake-Hit rate, clusters and tracking
- Offline trending tasks to control time evolution of ITS performance
- QC modules for MC
- Offline QA of ITS data
- **Coordination of ITS QC** by one Ph.D. student in second half of 2022

# ITS3 - Inner Barrel of ITS for Run 4



**Physics goals:** further improve pointing resolution and tracking efficiency of ITS at low  $p_T$   
 ⇒ **enhance HF reconstruction capabilities**

LoI ALICE-PUBLIC-2018-013

MAPS produced by **65 nm CMOS** process

**2D stitching on 300 mm wafers**

**Sensor length 280 mm**

Sensor width 56.5 / 75.5 / 94 mm

**Thickness 20–40  $\mu\text{m}$**

Pixel pitch  $O(10 \times 10 \mu\text{m}^2)$

Time resolution  $< 100 \text{ ns}$

Radial position **18 / 24 / 30 mm**

## NPI contributions to ITS3:

- measurement of SEU cross section in shift registers of sensor prototype
- software development for DAQ board

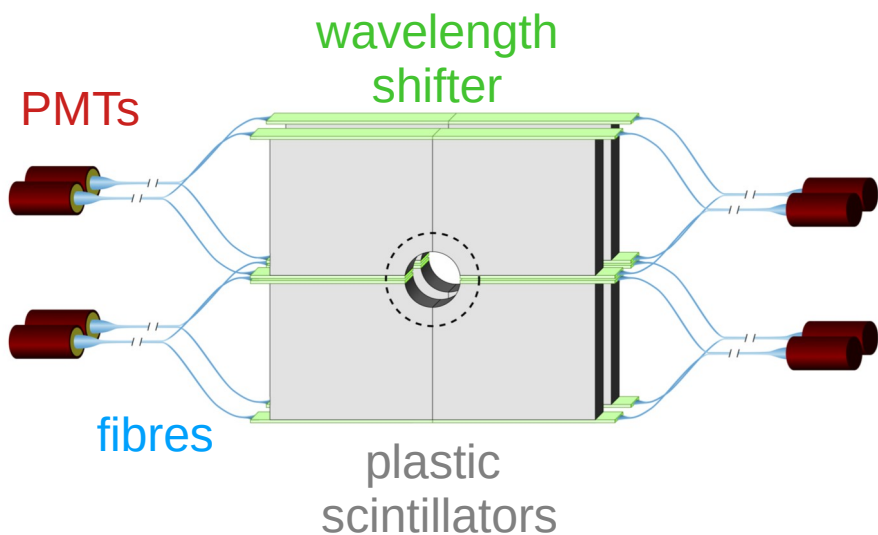
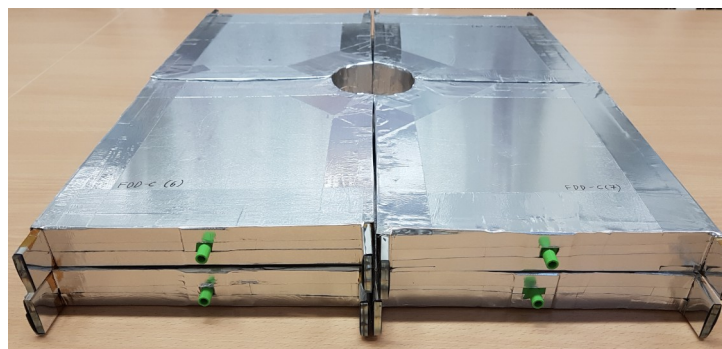
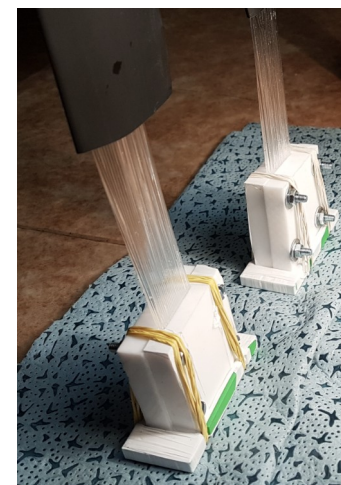
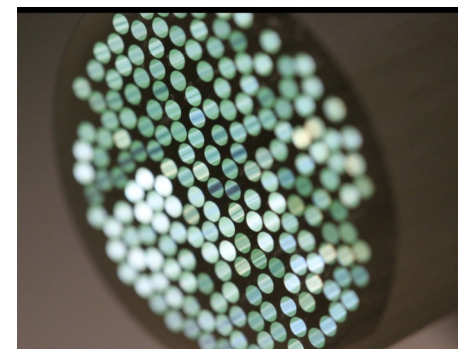


# Forward diffractive detector (FDD)

## Physics goals:

- tags diffractive events by vetoing activity in forward direction
- provides triggers
- acts as a luminometer and
- monitors beam conditions.

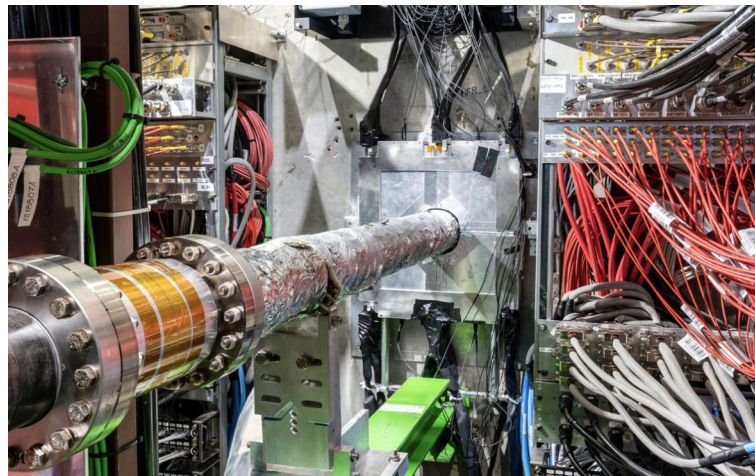
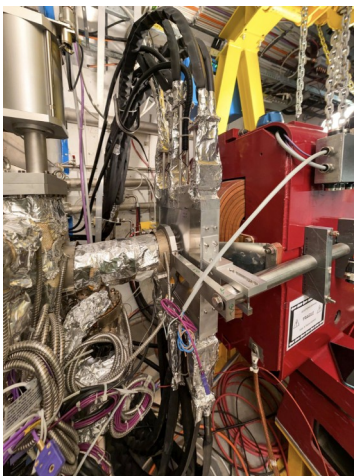
Completely built at CTU in Prague



Two detectors one at each side of the interaction point



# FDD

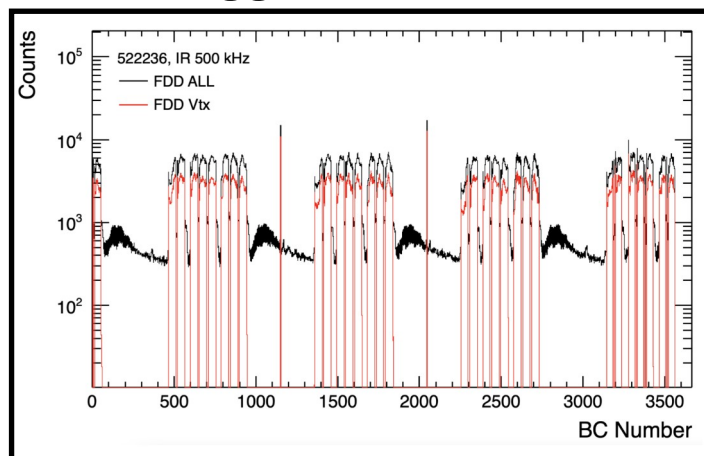


**CTU is in charge of the FDD project in ALICE**

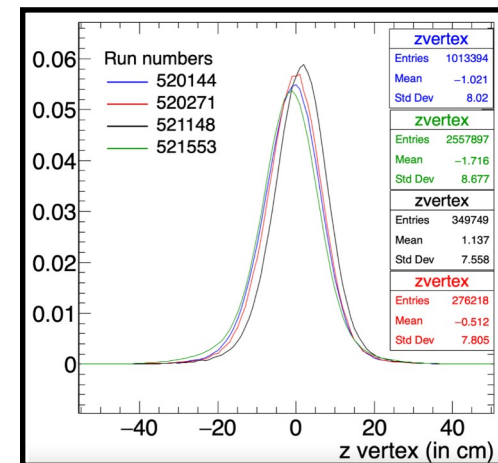
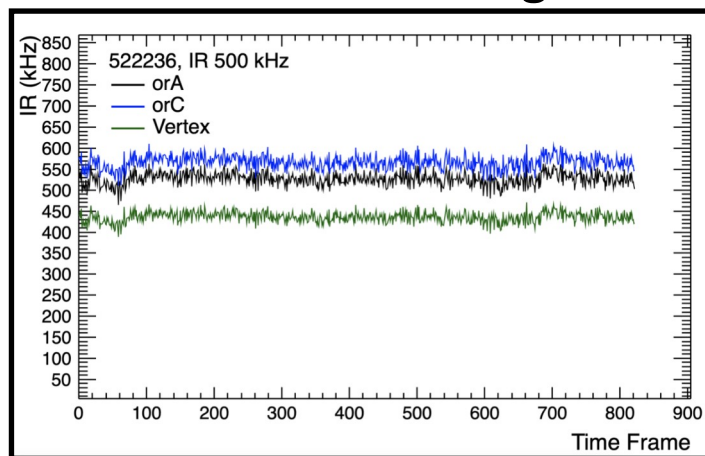
FDD installed at CERN in 2021  
C-side in Feb. A-side in July

Nice vertex reconstruction  
with FDD timing

Clean trigger even at 500 kHz



Stable detector signal

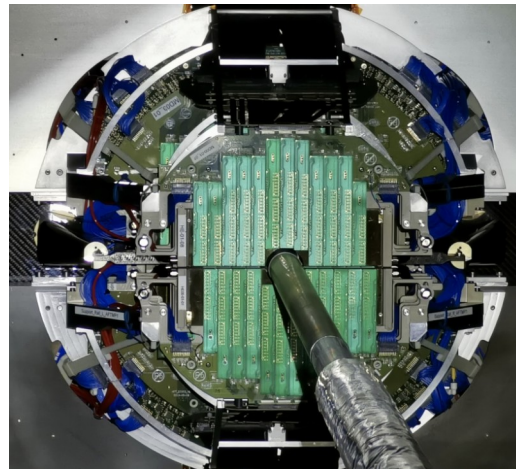
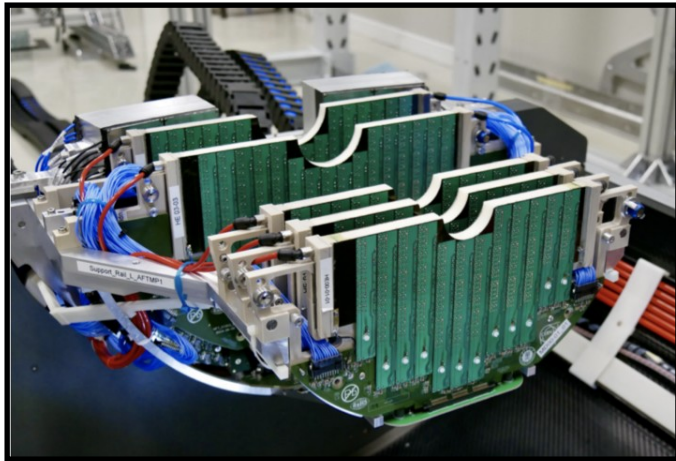
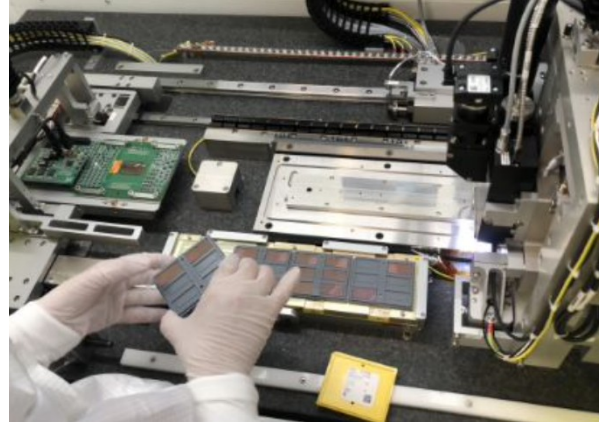


# Muon Forward Tracker (MFT)

## Physics goals:

precise measurements of open HF quarks and quarkonia in the forward direction

- 500 M pixels in 5 discs the same chips as ITS
- installed in Dec. 2020

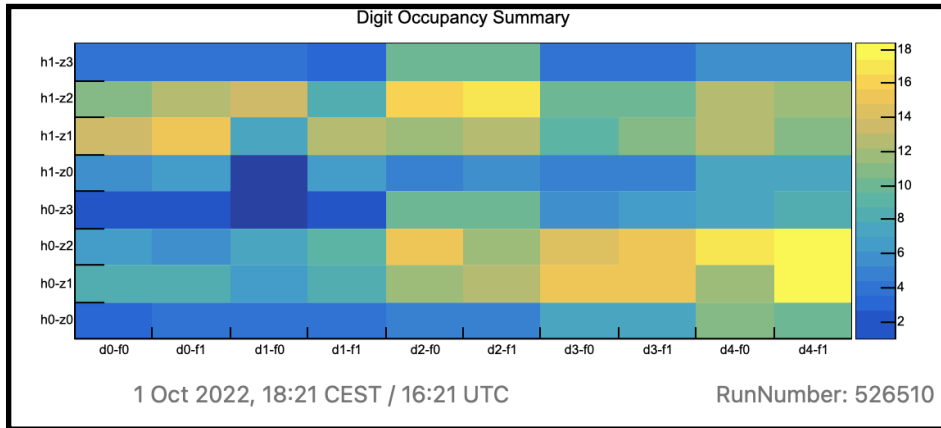


## CTU contributions to MFT

- CTU group took part in the construction & commissioning
- One CTU student served as **MFT system run coordinator** in the first half of 2022

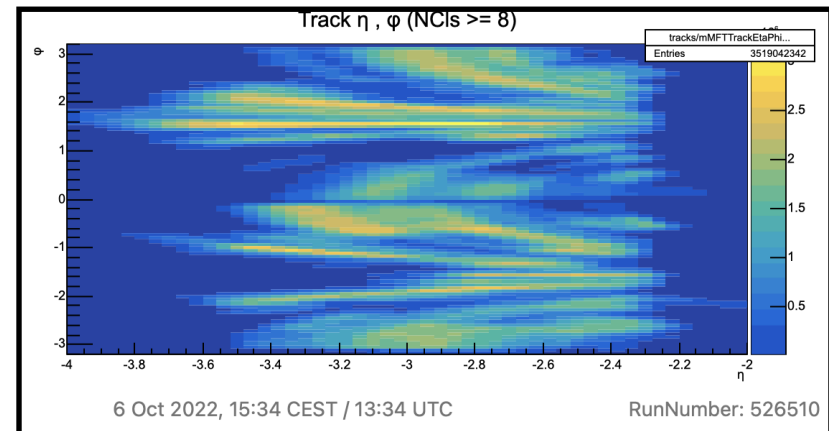
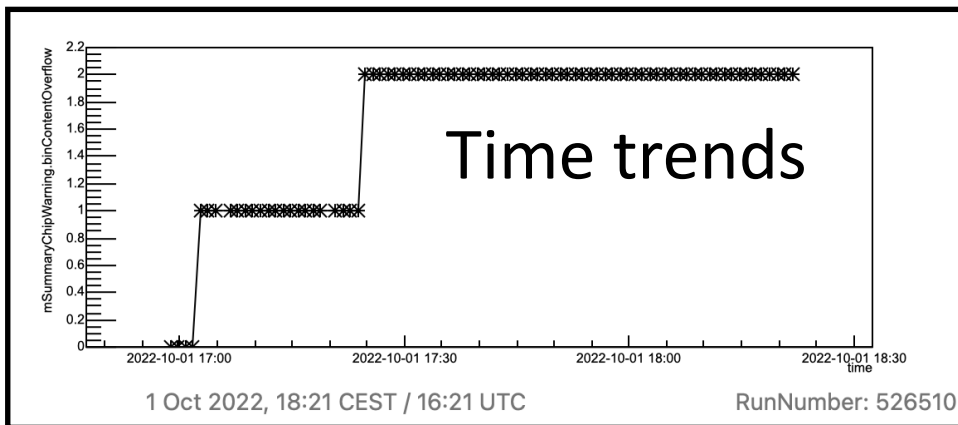
# Quality Control software for MFT

## Online checks



QC for MFT was developed, implemented and now is operated by the CTU group

## Offline assessment



# Benefits for society

- **Student theses fully or partially related to subsystems**  
(defended or in progress)

FDD: 1 MSc. + 3 BSc.

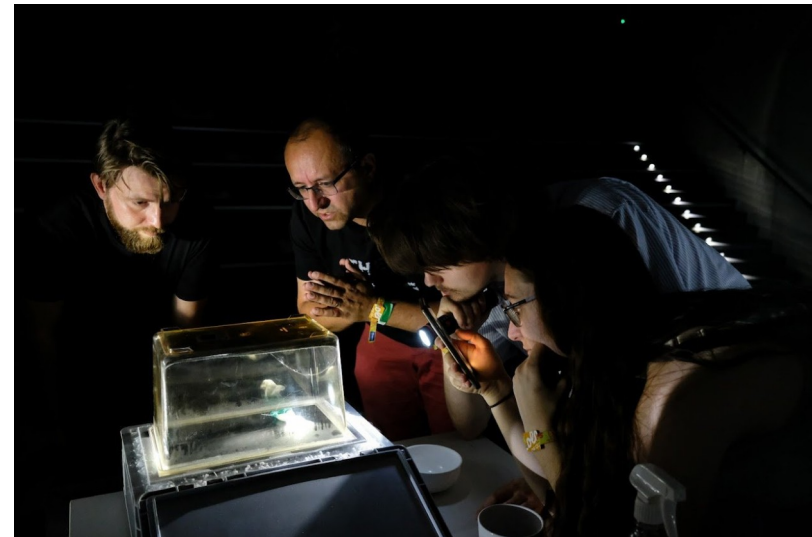
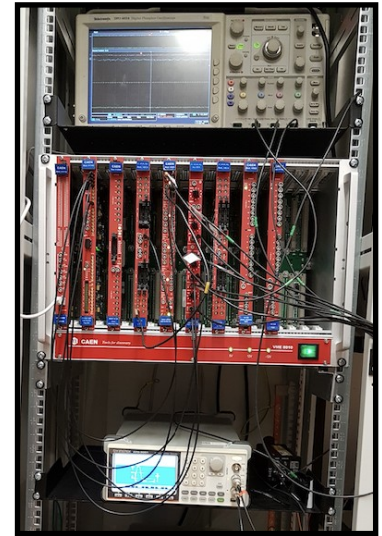
MFT: 2 Ph.D. + 1 MSc.

ITS: 5 Ph.D. + 4 MSc. + 2 BSc.

Computing: 2 MSc.

*CERN fellows 3 physics + 4 technical*

- **Improvement of local infrastructure**
  - new lab for development and characterization of plastic scintillators and photosensors at CTU
  - setup for radiation hardness tests at NPI
- **Outreach**
  - CERN master classes, Colors of Ostrava, International day of women in science, ALICE exhibition guide, ...



# Outlook: ALICE 3

## Physics motivation:

- high rate, high resolution, large coverage heavy-ion experiment for Run 5 (2030)
- new kinematic regime for soft QCD physics at LHC

Czech teams interested to participate in

- Tracker
- Muon chambers

Fair share contribution 2.8 M CHF

ALICE  
Upgrade  
Week

19–23 September 2022  
House of CASTS  
Novotného lávka 5, Prague, Czech Republic

