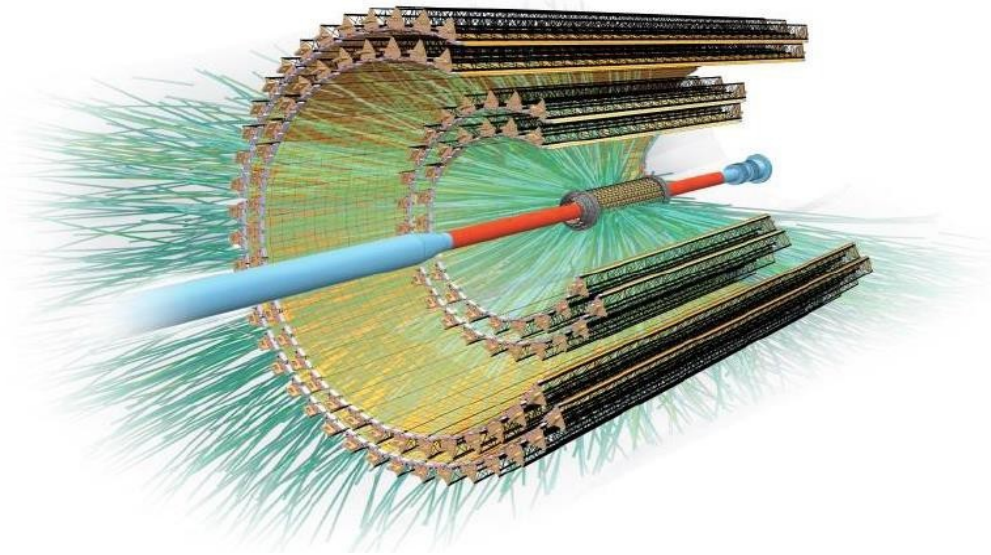


Svetlana Kushpil on behalf of the ALICE Collaboration
Nuclear Physics Institute of the CAS Řež, Czech Republic

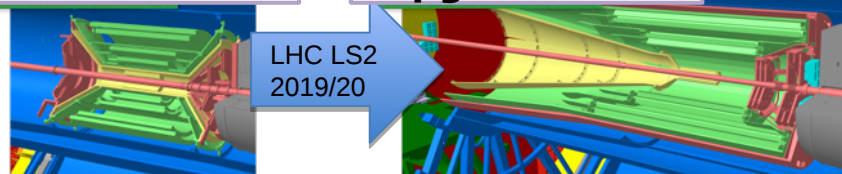


Monolithic Active Pixel Sensor (ALPIDE) for ITS upgrade

“Old” ITS-1

Upgraded ITS

LHC LS2
2019/20

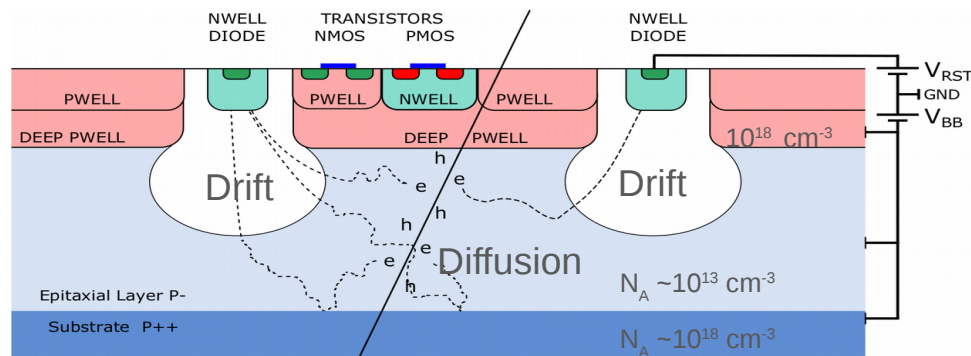


Motivations and Goals: Improved vertex & tracking precision
(closer to IP, smaller pixels, less material)
Faster readout

7 layers of pixel sensors ($r = 23 - 400$ mm) 10 m² of silicon

$|\eta| < 1.22$ for tracks from 90% of the most luminous region

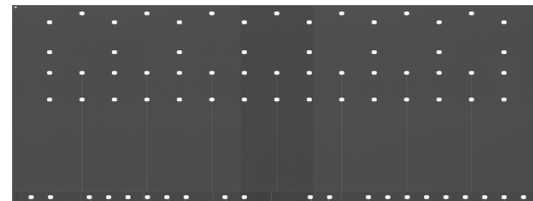
ALPIDE produced using TowerJazz 180 nm CMOS Imaging Process



- Deep P-well allows in-pixel full CMOS (complex in-pixel circuitry without charge loss)
- Enables low-power read-out
- High granularity, low material budget
- Resistivity (> 1 k Ω ·cm) p-type epitaxial layer (25 μ m)
- Possibility of reverse biasing (up to -6 V)

1024 pixel columns

512 rows



Chip size: 30 mm x 15 mm

Pixel pitch: 29 μ m x 27 μ m

Chip thickness:

50 μ m (Inner Barrel)

100 μ m (Outer Barrel)

Required radiation hardness* :

2700 krad Total Ionising Dose (TID)

1.7×10^{13} 1MeV n_{eq} cm⁻² Non-Ionising Energy Loss (NIEL)

Technical Design Report for the Upgrade of the ALICE Inner Tracking System
J.Phys. G41 (2014) 087002, CERN-LHCC-2013-024 ALICE-TDR-017

BENEFIT: ALPIDE uses a higher resistivity epitaxial layer & reverse bias

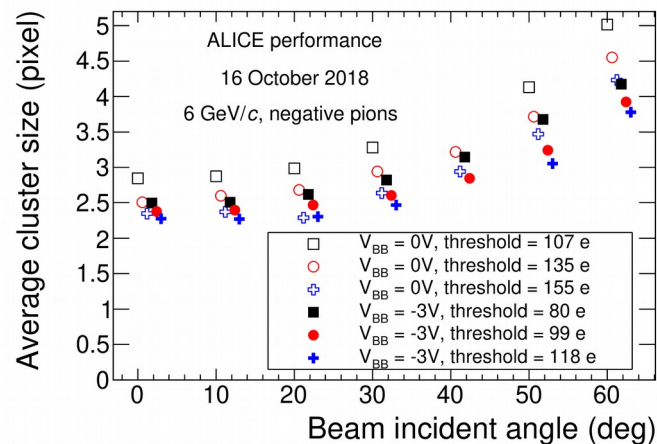
(* with safety factor)

Svetlana Kushpil

ICHEP 2020

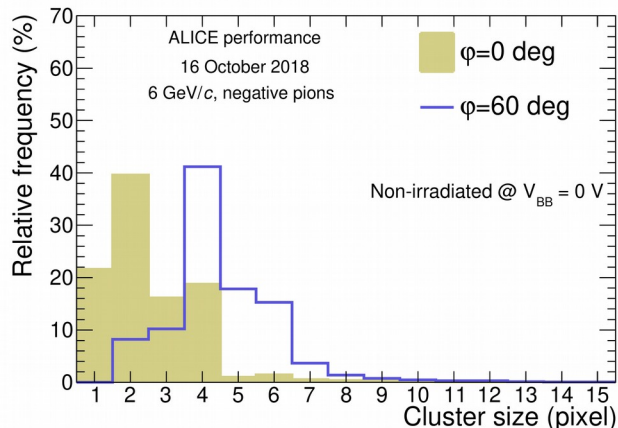
Selected results vs DUT inclination

Cluster size



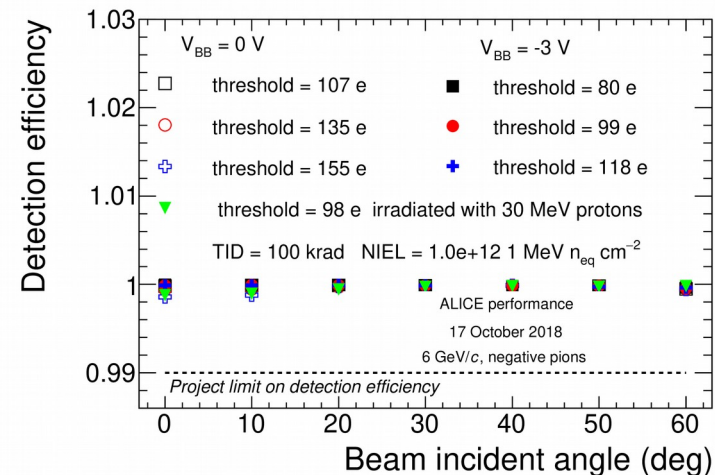
- Average cluster size increases with incident angle

- Trend is the same for different thresholds and back-bias settings



- The number of clusters with more pixels increases with inclination
- At inclination of 60 deg
 - One-pixel cluster disappears
 - 5 and 6 pixel clusters form about 20% of the total number of clusters

Efficiency



- Detector efficiency stays close to 100% - over a wide range of thresholds for all inclination angles
- Also in the case of the irradiated sensor
 - 100 krad (TID)
 - 1.0×10^{12} 1 MeV n_{eq} cm^{-2} (NIEL)

- **ALPIDE** shows **good performance** and large operational margin for inclined tracks. We also tested an irradiated sensor following the test with beam. After radiation ALPIDE is fully operational and fulfills TDR requirements.