Silicon@GSI: Kick-Off Meeting

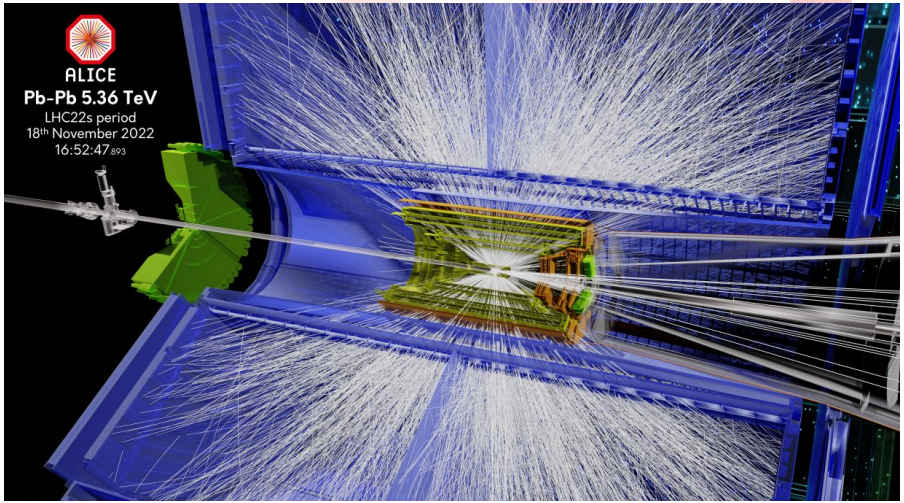
PIXELS: ALICE ITS & ALICE 3

Silvia Masciocchi, Bogdan Blidaru, Pascal Becht, Simon Groß-Bölting, Marius Wilm Menzel, Bent Buttwill, Maurice Donner, Johannes Hensler, Anouk Kaiser, Fabian Königstein, Sarah Michel

https://www.physi.uni-heidelberg.de/~sma/research/detectors.php

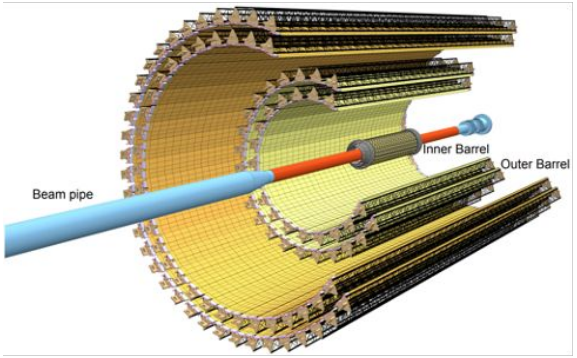
January 31, 2025

ALICE at the LHC

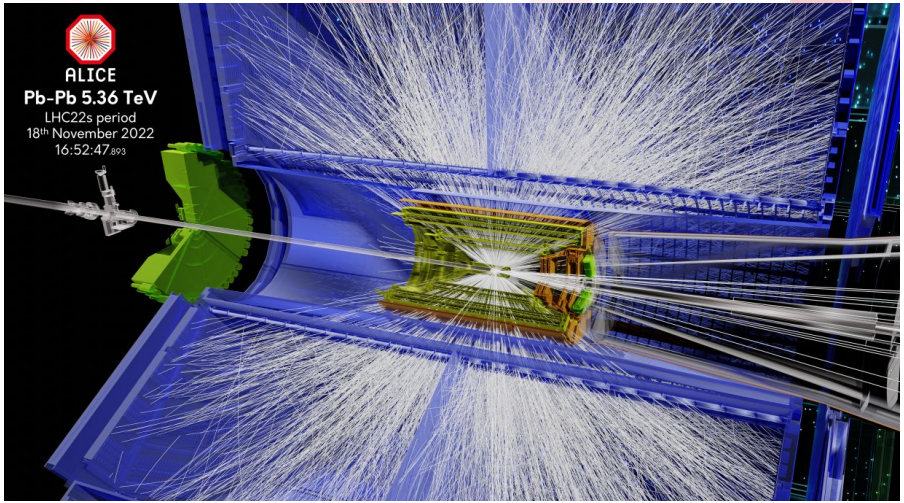


Inner
Tracking
System
ITS2

CERN-LHCC-2013-024

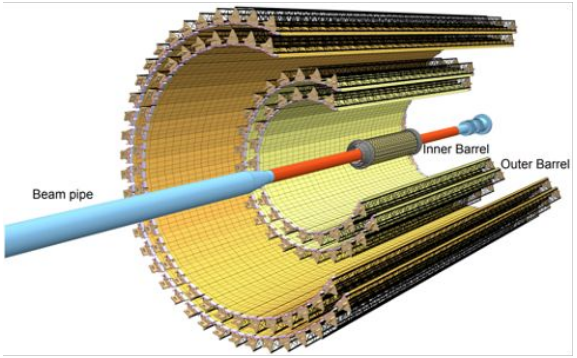


ALICE at the LHC



Inner
Tracking
System
ITS2

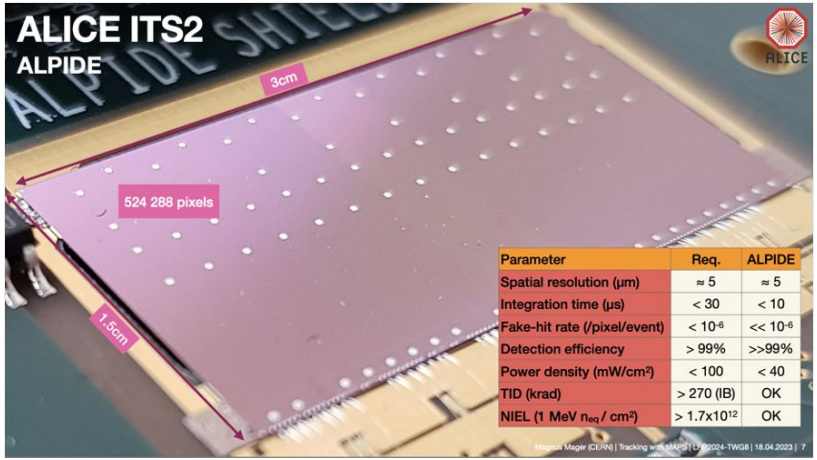
CERN-LHCC-2013-024



CMOS Monolithic Active Pixel Sensor

ALPIDE

180 nm TowerJazz Semiconductor

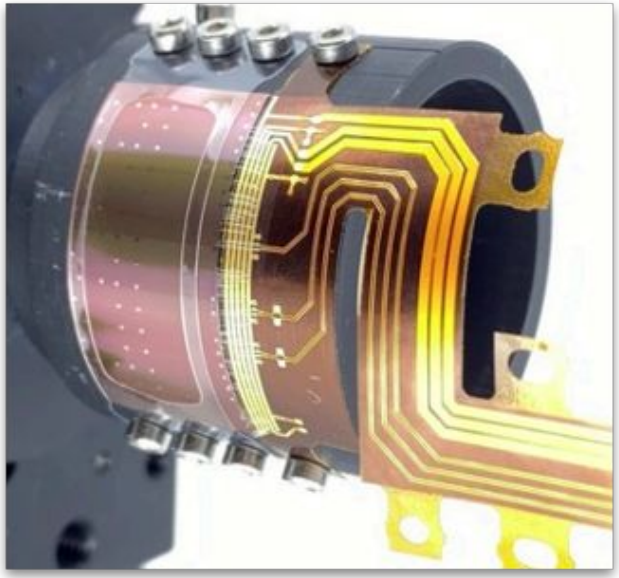


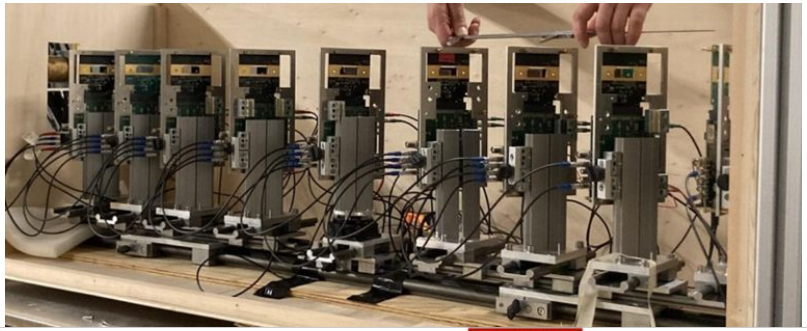
Parameter	Req.	ALPIDE
Spatial resolution (μm)	≈ 5	≈ 5
Integration time (μs)	< 30	< 10
Fake-hit rate (/pixel/event)	$< 10^{-6}$	$<< 10^{-6}$
Detection efficiency	> 99%	>>99%
Power density (mW/cm²)	< 100	< 40
TID (krad)	> 270 (IB)	OK
NIEL (1 MeV n_{eq} / cm²)	$> 1.7 \times 10^{12}$	OK

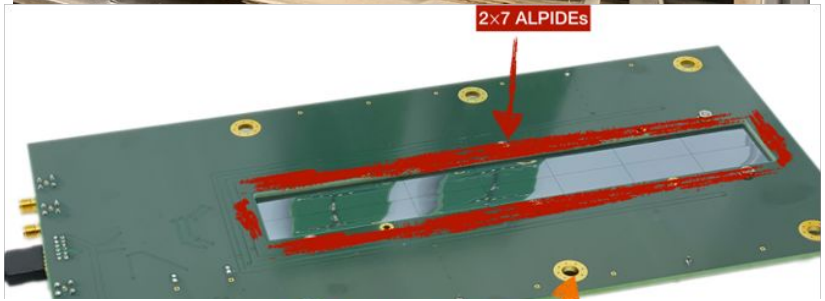
10 m^2
successful operation since 2021

ALPIDE and lead people

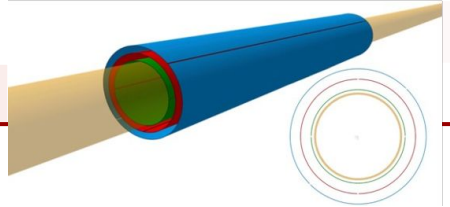
Our team: since 2019 → Bogdan Blidaru
→ Pascal Becht

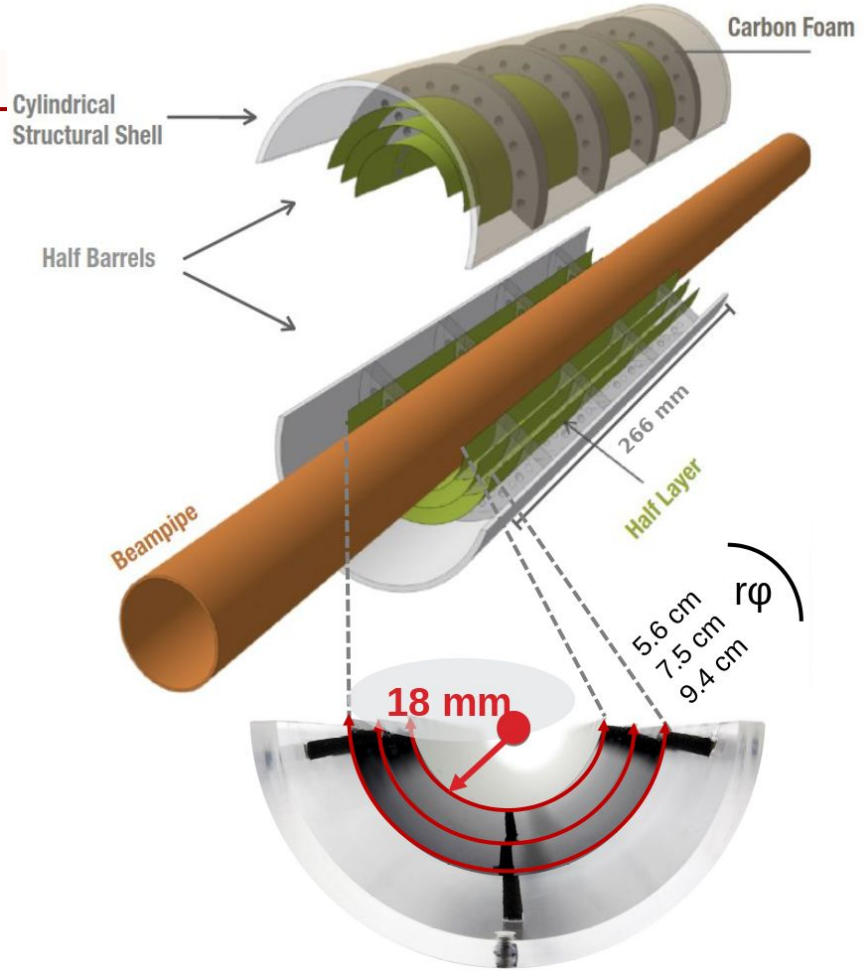






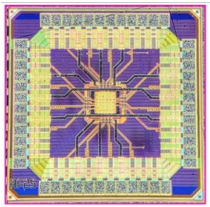
ALICE ITS3

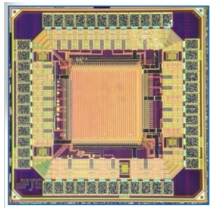




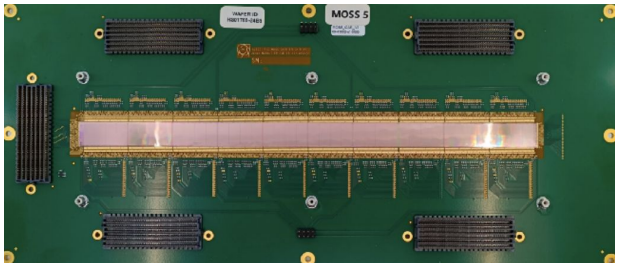
CMOS TPSCo 65 nm technology

Validation: MLR1

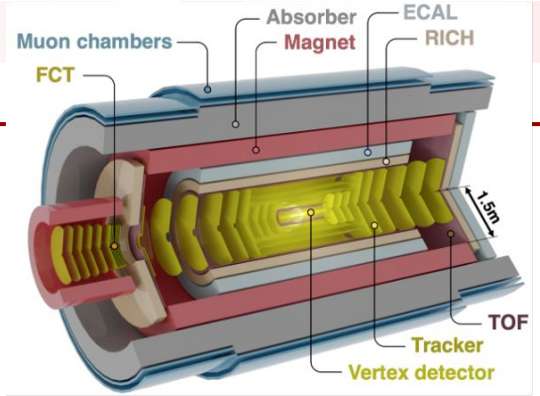




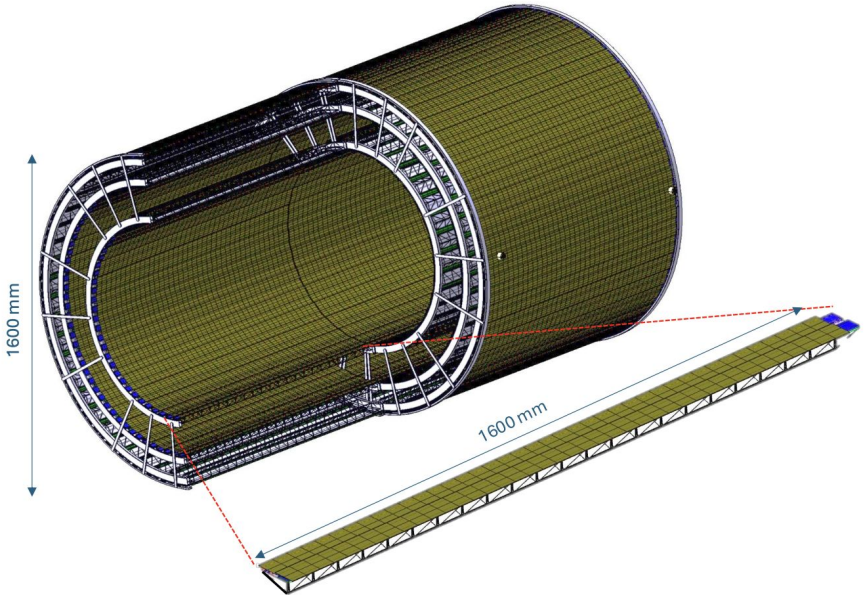
Stitching: Engineering Run 1



ALICE 3: LHC 2035 - 2043



Outer Tracker:
up to 60 m^2 of MAPS



- larger pixel pitch (50 µm)
- low power consumption
- 1.6 m long modules

LOTS OF FUN !!!

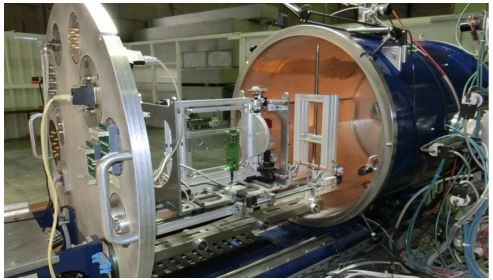
TDR in 2027

65 nm Technology: Results from ER1

Maurice Donner
Master Student

65 nm Technology: Results from ER1 - Maurice

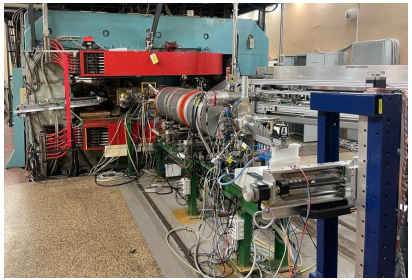
Single event latchup

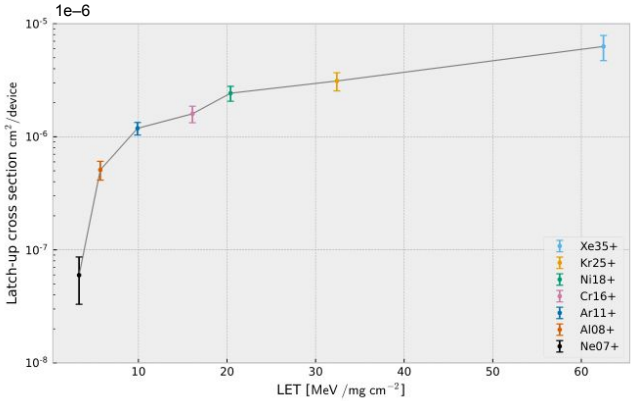


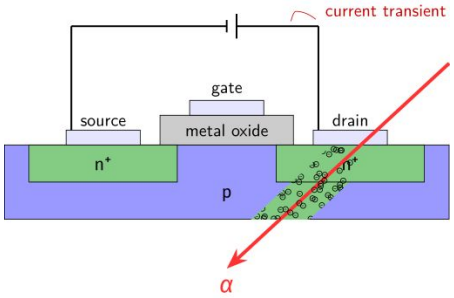
Goal

Characterisation of 65nm technology for usage within ALICE detector environment

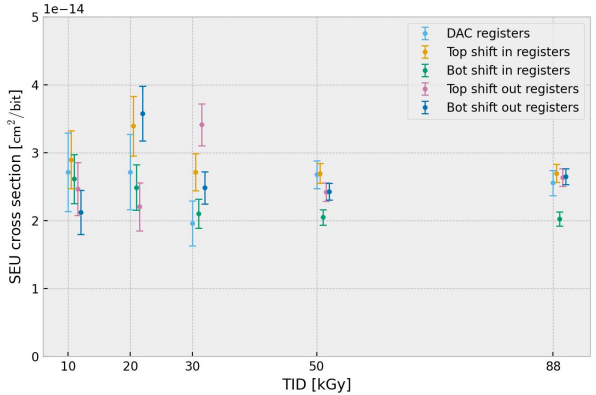
Single event upset







Concept of ion-induced bit flip



Readout for ITS2 Outer Barrel Modules

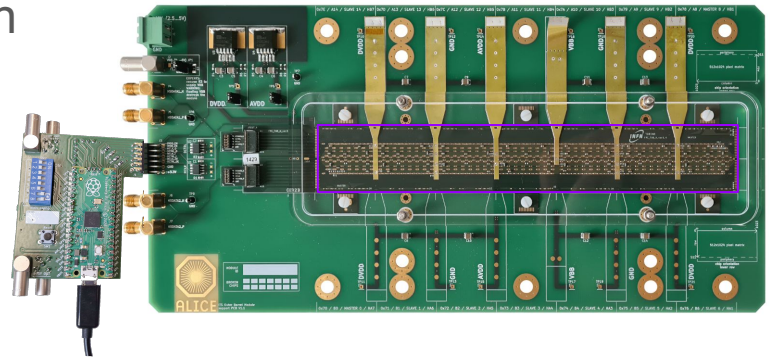
Bent Buttwill
Master Student

Readout for ITS2 Outer Barrel Modules - Bent

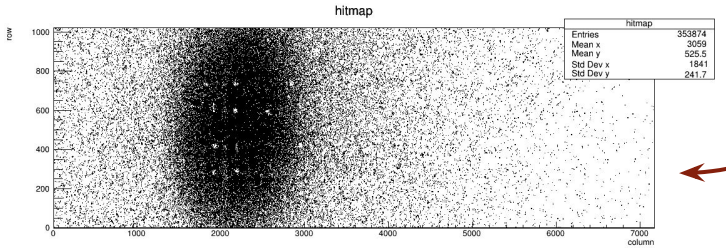
RP2040 µC
Communication via slow control

- ALPIDE initialization
- data readout

Outer Barrel Module (OBM)
14 ALPIDEs in 2 rows of 7



^{90}Sr measurement



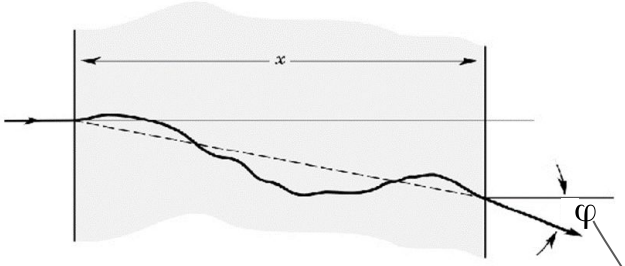
Enables the use of OBM in **tabletop experiments** and **beam tests**

Material Budget Imaging

Simon Groß-Bölting
PhD Student

Material Budget Imaging - Simon

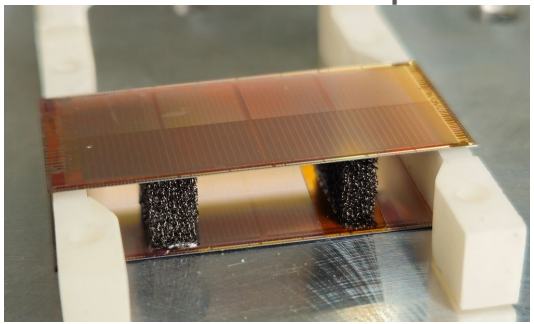
Multiple Coulomb scattering

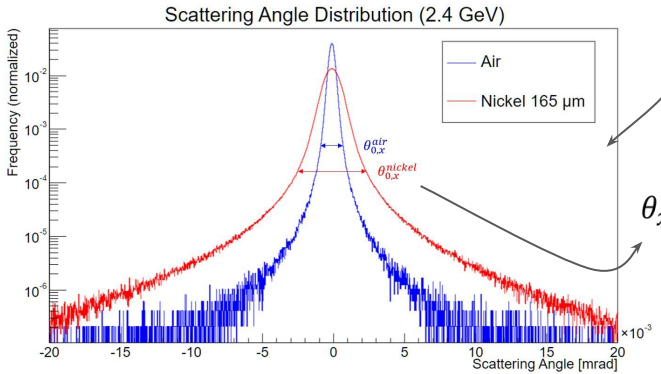


Calibration targets used to account for:

- Non-linearity scaling
- Momentum gradient (DESY testbeam)

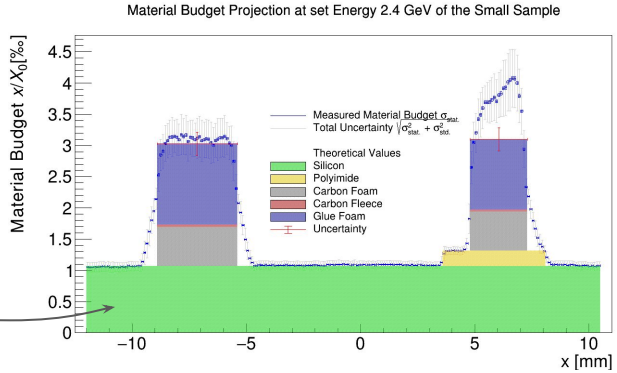
ITS3 mockup



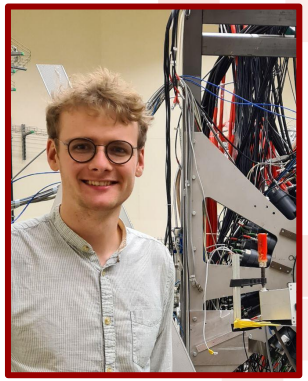


Highland formula:

$$\theta_{x,y} = \frac{13.6\ \text{MeV}}{\beta cp} z \sqrt{\frac{x}{X_0}} \left[1 + 0.038 \ln\left(\frac{x}{X_0} \cdot \frac{z^2}{\beta^2}\right)\right]$$



Front-end pixel grouping for the ALICE 3 Outer Tracker



Johannes Hensler
Master Student

Front-end pixel grouping for the ALICE 3 OT - Johannes

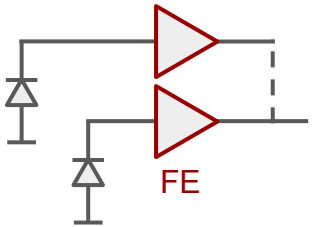
Goal:

- **Large active area** ~60m²
- **Position resolution 10 µm**
- → **Large pixel pitch** O(50 µm)

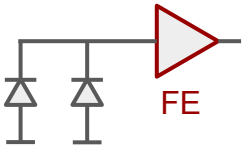
But: Moving to larger pitch not trivial!

- Efficiency loss in pixel corners (limited by lateral field)

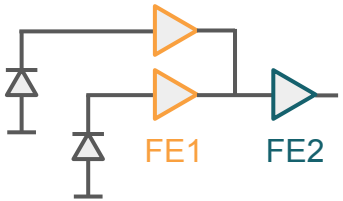
Possible Solution: Front-end grouping of small “pixels”



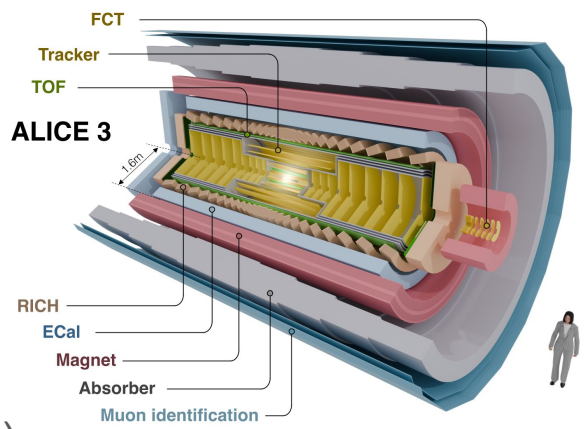
Digital Grouping
FE Power!



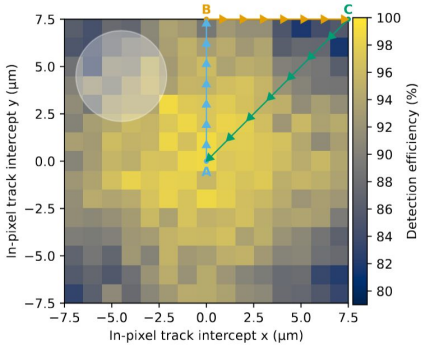
Diode Connection
S/N Degradation!



Two-Stage Front-End
R&D required!



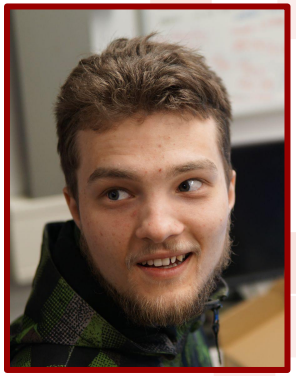
Dobrigkeit Chinellato, D. (2024). ALICE 3 experiment. Zenodo. https://doi.org/10.5281/zenodo.13894032



In-pixel detection efficiency at high threshold (160 e⁻)

Aglieri Rinella, G., et al. (2023). *Digital pixel test structures implemented in a 65 nm CMOS process.* Elsevier BV. arXiv:2212.08621

Calibrating a cold atom CCD camera



Fabian Königstein
Master Student

Calibrating a cold atom CCD camera - Fabian

highly sensitive, low-noise EMCCD camera

Goal: Increase single atom recognition efficiency

+ position resolution

→ Aid research into collectivity in few-body systems