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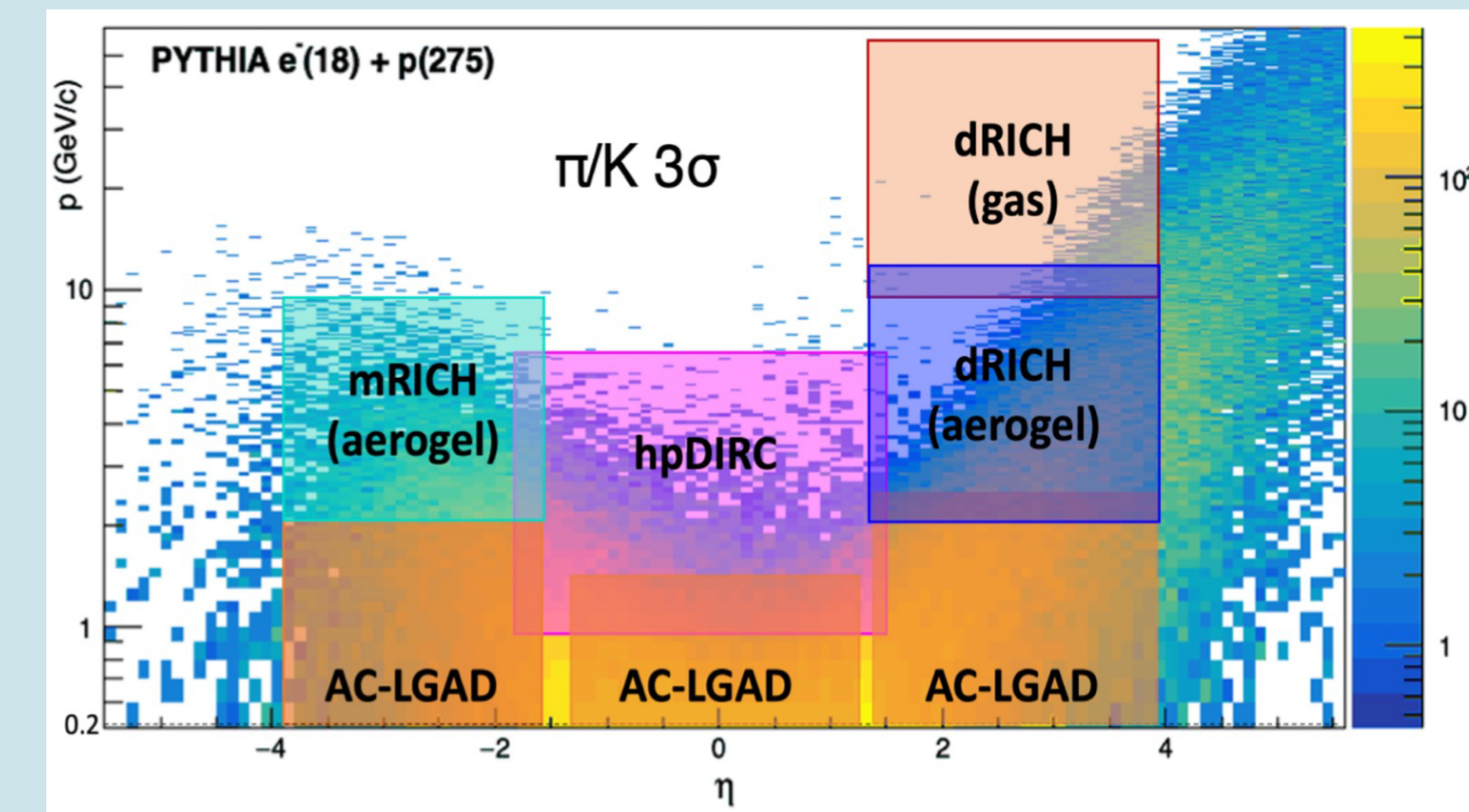
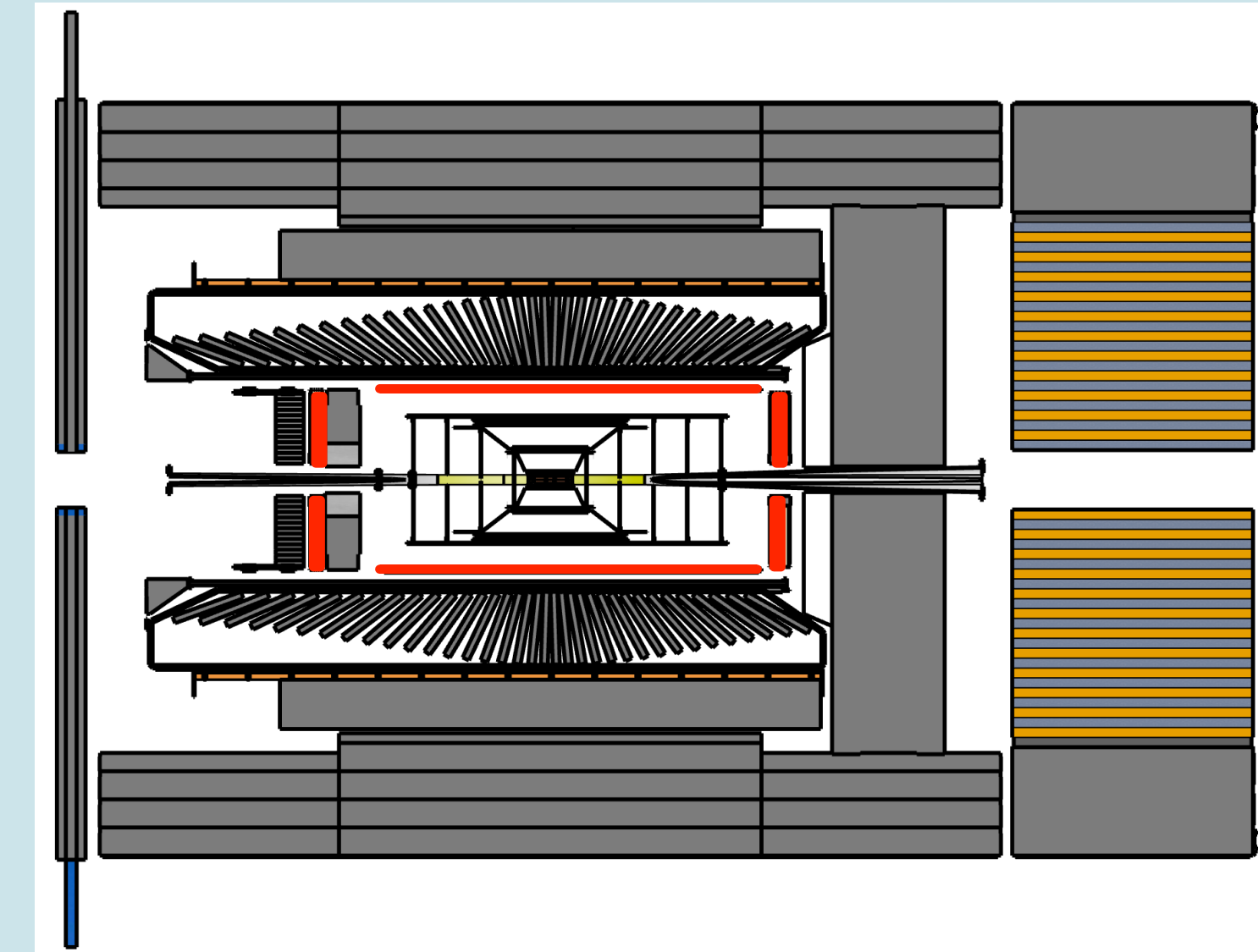
EIC-Asia meeting

05/25/2023

Time of Flight (TOF) in ePIC detector

Default (v0) design

- Time of flight (TOF) covers $|\eta| < 1.4$ (barrel-TOF) and $1.7 < |\eta| < 4$ (endcap-TOF)
- Timing resolution of ~ 30 ps is required for low to middle p_T PID
 - $R_{\text{barrel}} = \sim 63\text{cm}$ (1 layer), $z_{\text{endcap}} = 156$ cm and 171 cm (2 disks)
- Spatial resolution of ~ 30 μm is required for the tracking performance
- $X/X_0 \sim 1\%$ material budget is required for hpDIRC and dRICH performance
- AC-LGAD technology is the best choice for the detector
 - Barrel: 0.5×10 mm^2 strip
 - Endcap: 0.5×0.5 mm^2 pixel



Working group structure in ePIC

- TOF PID WG
 - Detector performance and simulation study
- eRD112/LGAD
 - Sensor R&D, Sensor/ASIC integration, Module structure
- eRD109
 - Frontend ASICs, Frontend electronics
- PED (Project Engineering Design)
 - Mechanical engineering, Electronic engineering



TOF

News from TOF PID WG

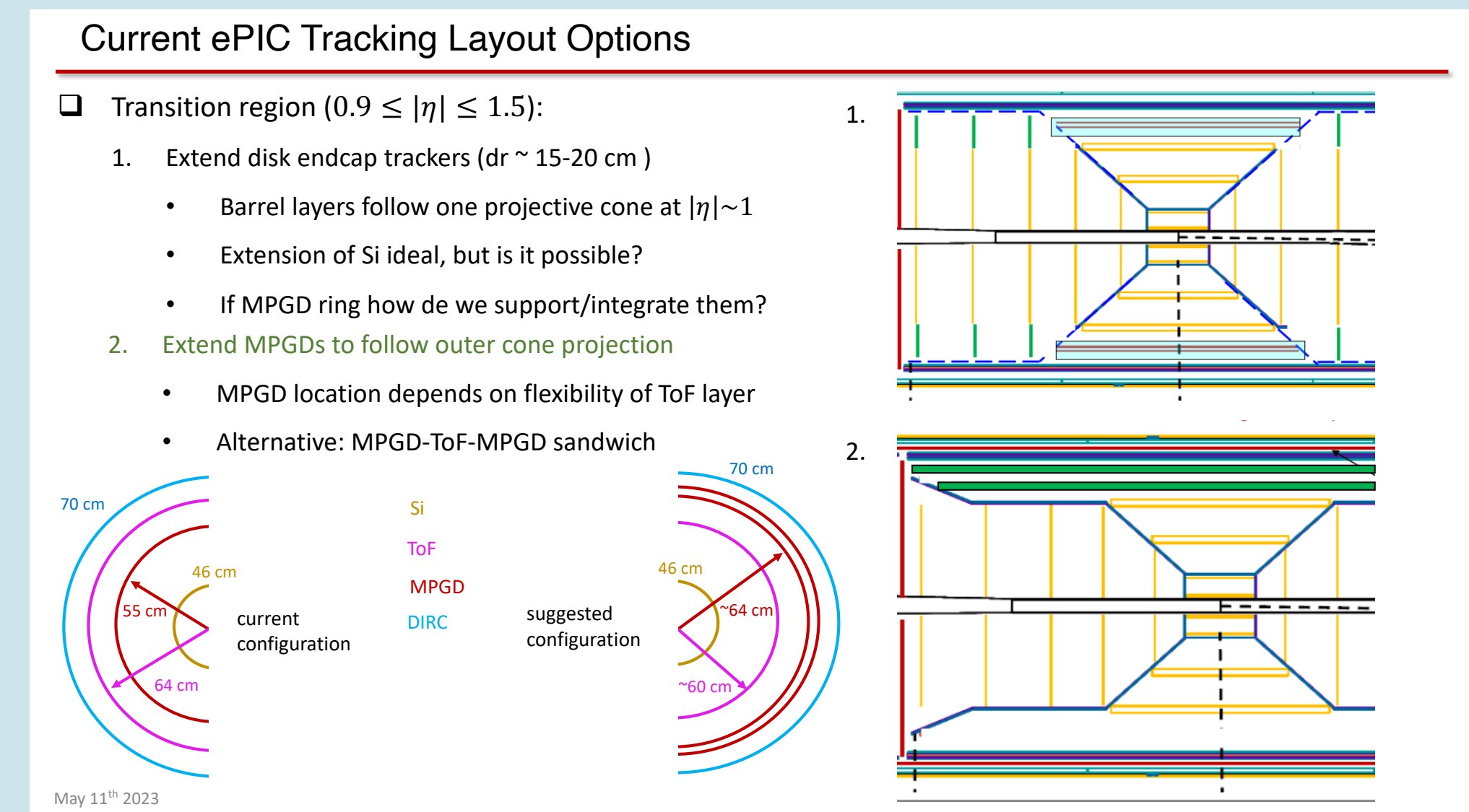
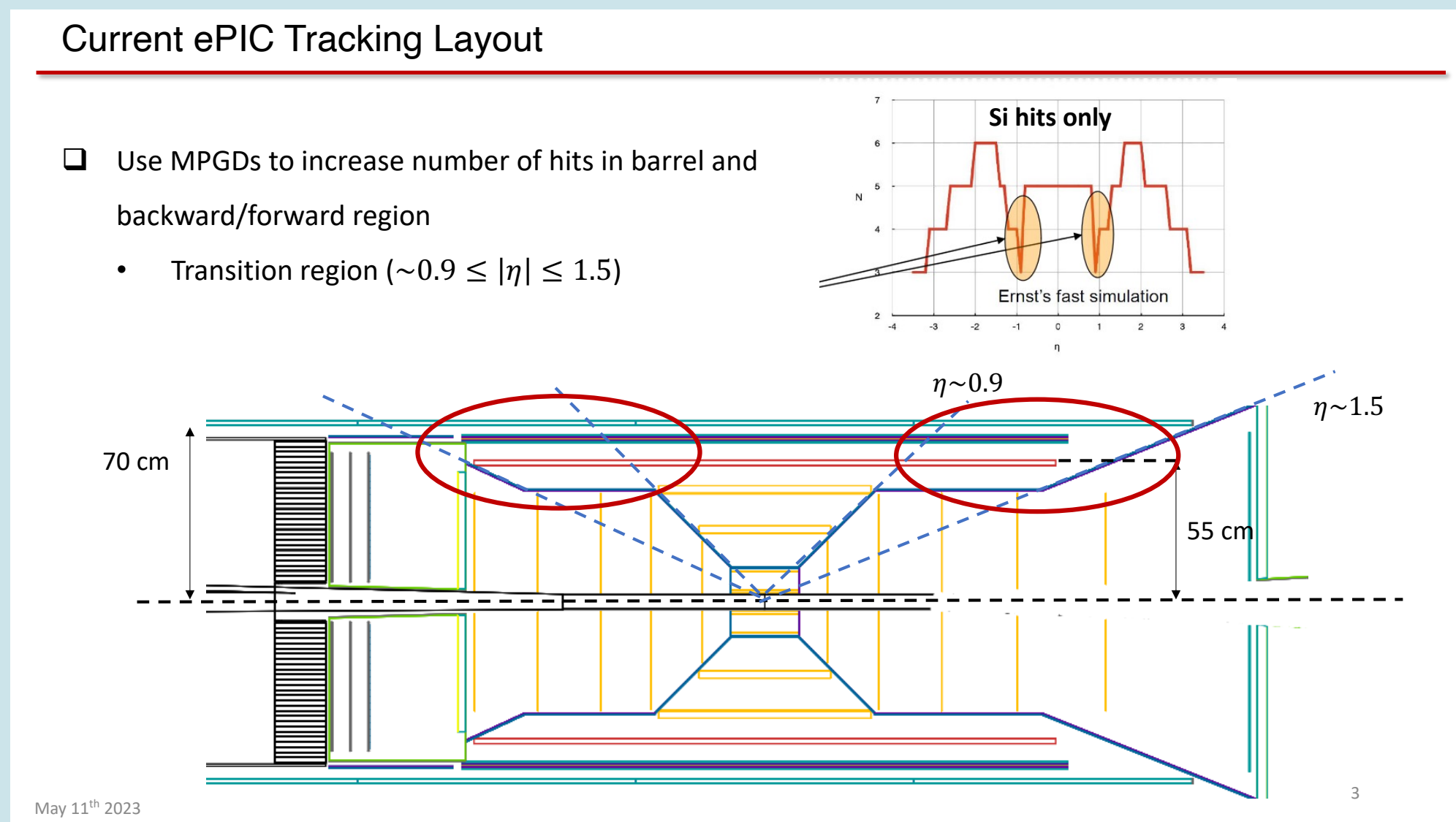
News

From Zhenyu's presentation ([link](#))

- **TOF DSC organization**
 - Collect interests in R&D and construction [query](#)
 - Connect institutions with working groups [list](#)
- **ePIC Simulation (next campaign starts on June 1, next next one on July 1)**
 - TOF in tracking – Nicolas: fix the issue with full forward TOF geometry in tracking
 - TOF PID in reconstruction – Oskar/Zhenyu: reconstruction, validation plots
 - TOF digitization – Adam/Souvik: charge sharing and detector noise
 - TOF service in simulation – TBD: implement the missing material for mechanical support structure, cooling and cabling
- **EIC Project Detector R&D (eRD112/109)**
 - Latest updates: Indico pages [May 16](#) and [June 6](#)
 - FY23 report and FY24 proposal due on **July 7 (internal deadline June 20)**: Overleaf view [link](#) (for editing, please contact Zhenyu)
- **EIC Project Engineering Design (TOF PED)**
 - Presentation on updated mechanical engineering proposal by Andy et al. next week (**May 30**)
 - Meeting on integration with project engineer team **tentatively in the week of June 5**
- **EIC Project Review on ePIC PID detectors on July 5-6 or 6-7**
 - To assess the current state of all PID detectors, serve as a status report for Project Management and DOE
 - EIC Project Technical Review of the calorimeters in 12/2022: <https://indico.bnl.gov/event/17721/> (PC: TR2022ECalHCal)
- **EIC User Group Meeting @ Warsaw on July 23-31** <https://indico.cern.ch/event/1238718/>

News from TOF PID WG

- There is a proposal to place TOF $\sim 4\text{cm}$ ($\sim 6\%$) inside and a new gas detector is installed just behind TOF
 - With the current tracking configuration, the tracking performance within $0.9 < \eta < 1.5$ is not sufficient
 - Some options have been proposed (we must keep a close eye on their study)



From Ernst's presentation (link)

News from eRD112/LGAD

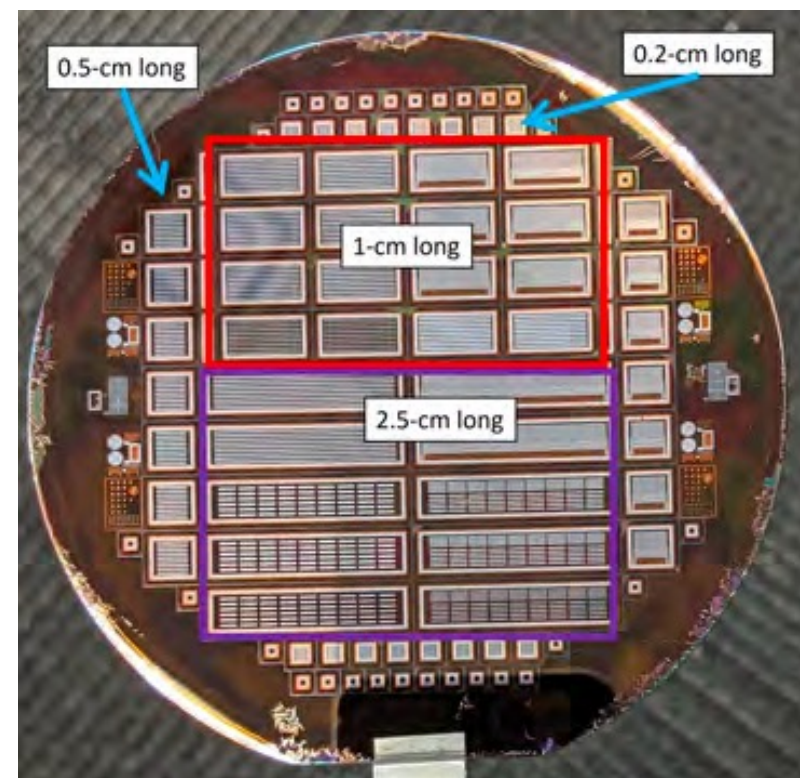
- The most recent meeting took place last week Tuesday (16 May 2023)
 - <https://indico.bnl.gov/event/19471/>

From Zhenyu's presentation (link)

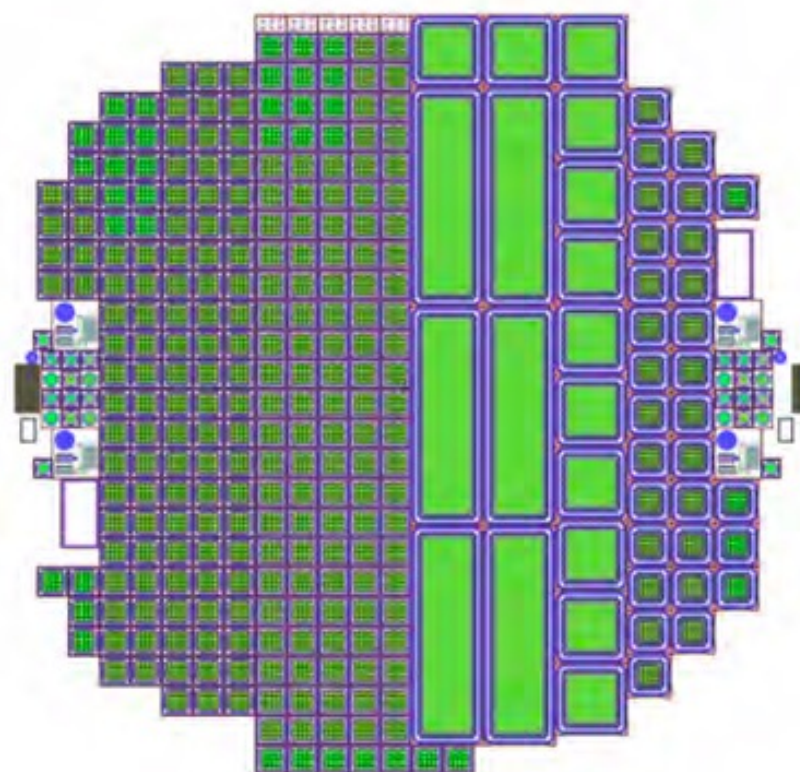
AC-LGAD Sensor R&D

- Production of medium/large area sensors with different doping concentration, pitch and gap sizes between electrodes and Si thickness to optimize performance by BNL IO and HPK.
 - 1st BNL (06/2021-11/2021): 5-25 mm strips with 500 μm pitch, 100-300 μm electrode width, 50 μm active Si
 - 2nd BNL (06/2022-11/2022): 5-25 mm strips with 500-700 μm pitch, 50-100 μm electrode width, 20-50 μm Si
 - 3rd BNL (08/2022-12/2022): pixels with 500-700 μm pitch, various electrode shapes, 20-50 μm Si
 - 1st HPK (06/2022-04/2023): strip+pixel sensors with different electrode width, active thickness and n^+ doping
 - 4th BNL (02/2023-06/2023): deep gain layer to increase signal amplitudes

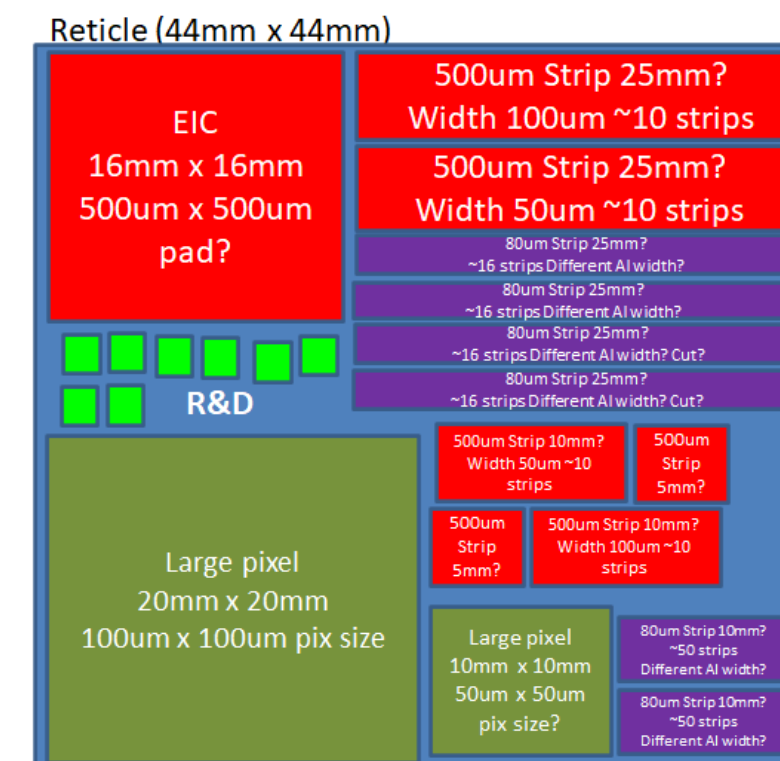
1st/2nd BNL Production



3rd BNL Production



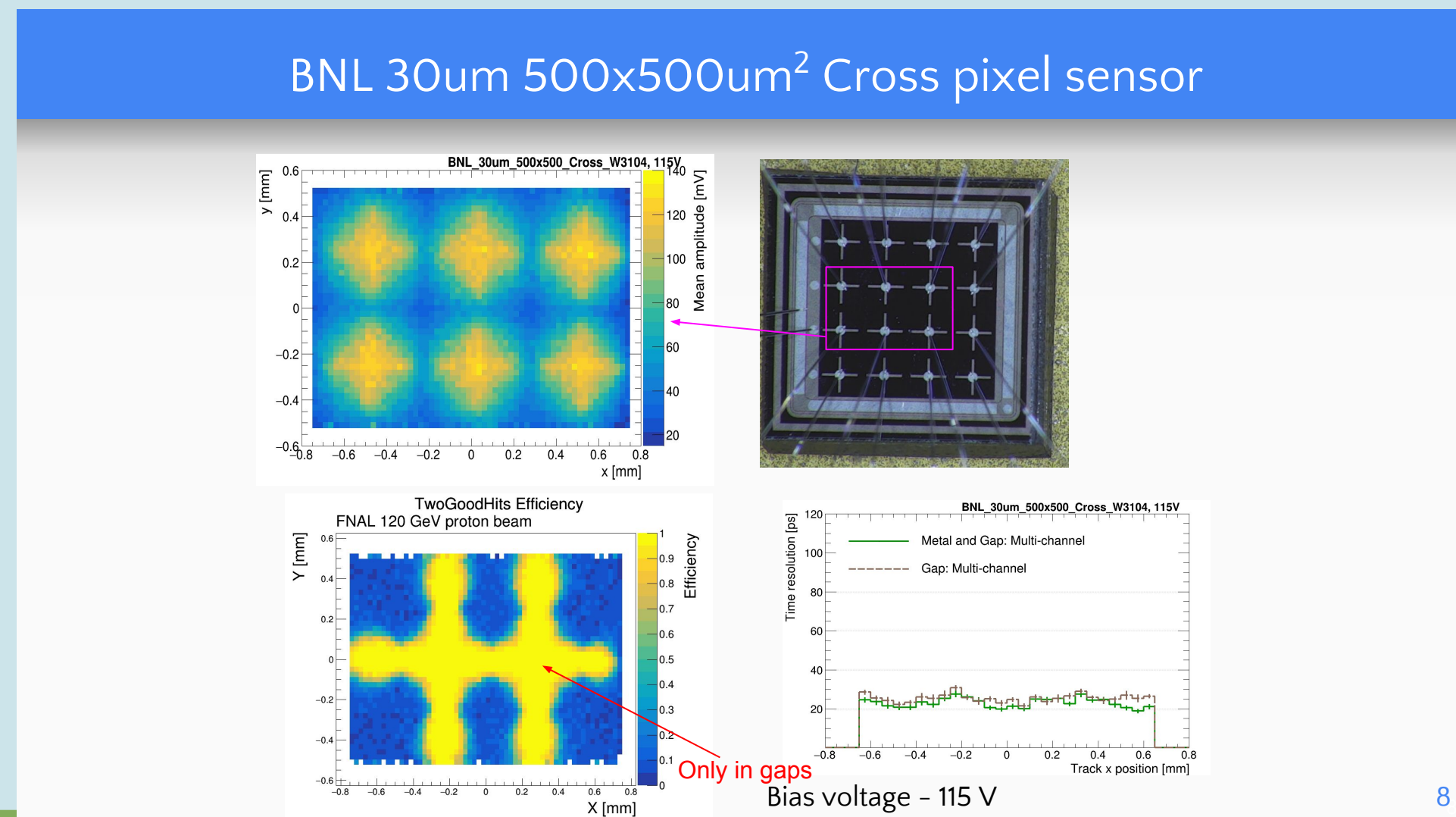
Joint HPK Production



News from eRD112/LGAD

- The latest BNL sensor test has been proceeded by several institutes
 - FNAL: 120 GeV proton beam
 - Signal strength with varying active volume thickness and electrode geometry
 - UCSC: IR laser tuned for MIP signal
 - Signal strength and charge sharing with varying strip electrode width, length, and pitch

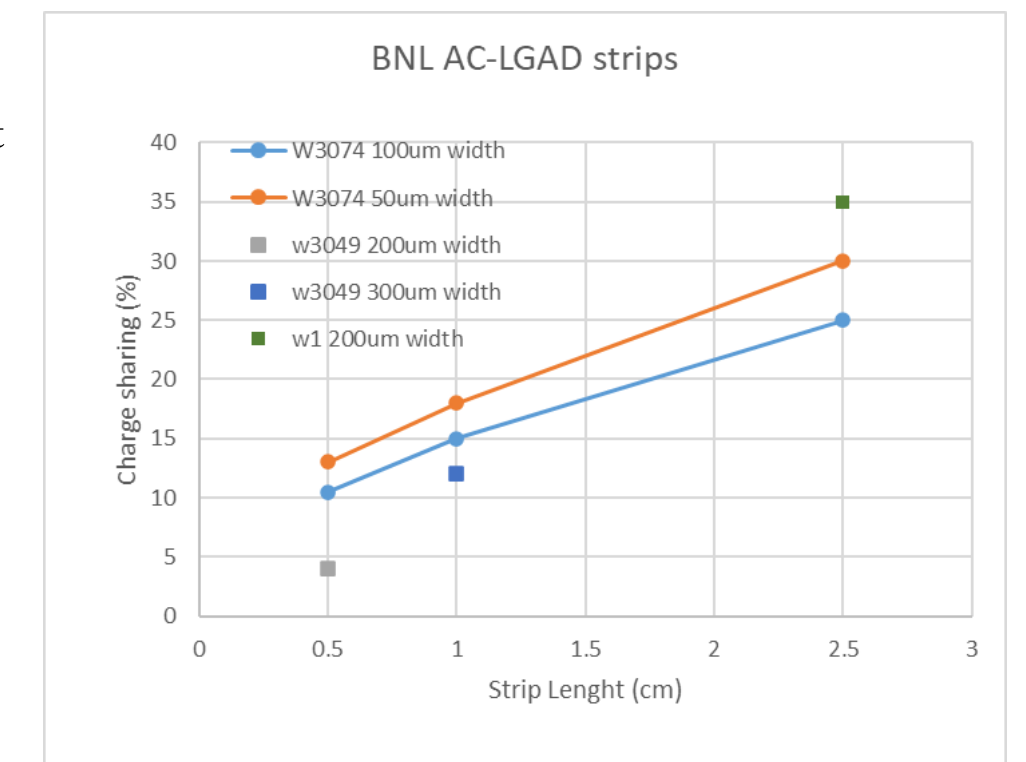
From Irene's presentation (link)



From Simone's presentation (link)

Charge sharing comparison

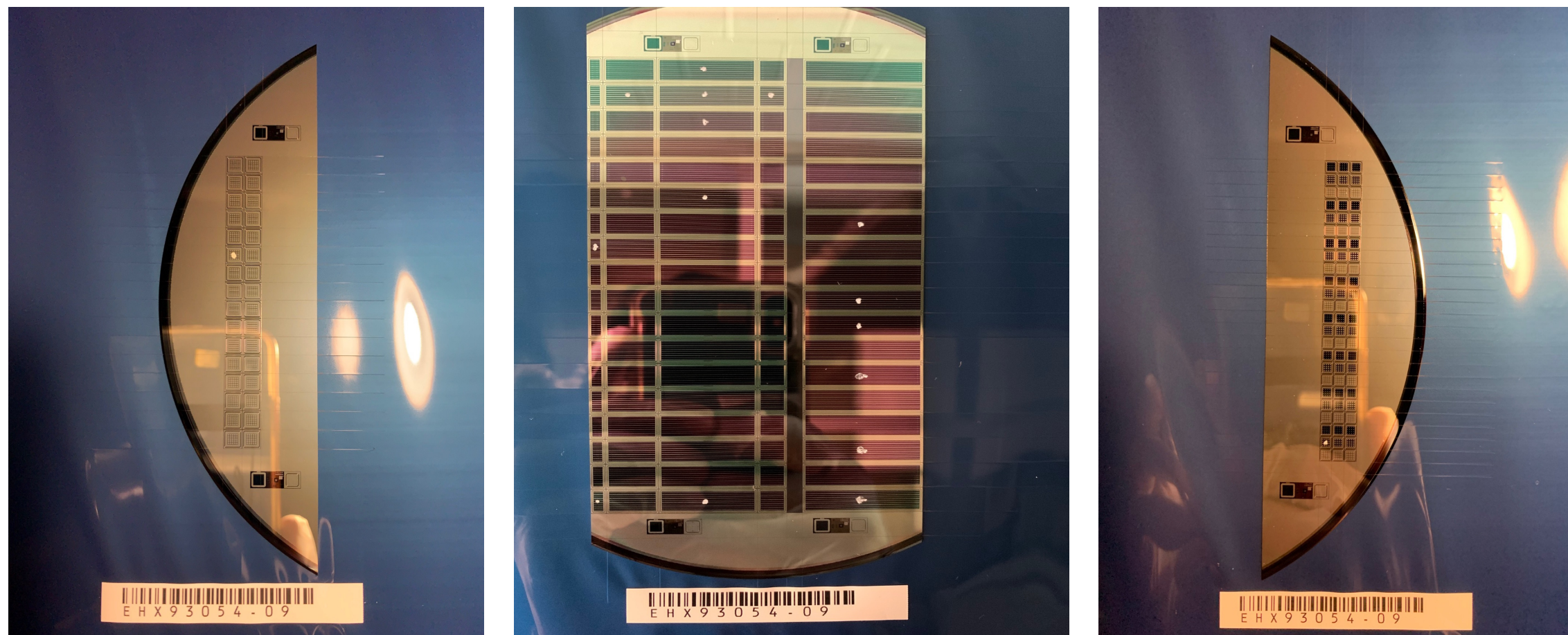
- Charge sharing % after second neighbor for different sensors width and width but same pitch (500um)
- Some preliminary conclusions
 - With larger strips the charge sharing is less
 - Charge sharing increases with strip length
 - Thicker sensors (W3049) increase charge sharing
- **Plots to be refined and completed!**
 - Work on the same plot for time/position resolution and rise/fall time



News from eRD112/LGAD

- New HPK sensors have arrived at UIC!
 - Several type sensors with varying parameters

HPK Sensors



- Total of 90 strip sensors
 - 5 different lengths (18 sensors for each kind)
- Total of 72 pixel sensors
 - 3 different sizes of metal pads (24 sensors for each kind)
- Total of 32 pad sensors
 - Same pad size

5/17/23

Zhenyu Ye @ UIC

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From Zhenyu's presentation (link)

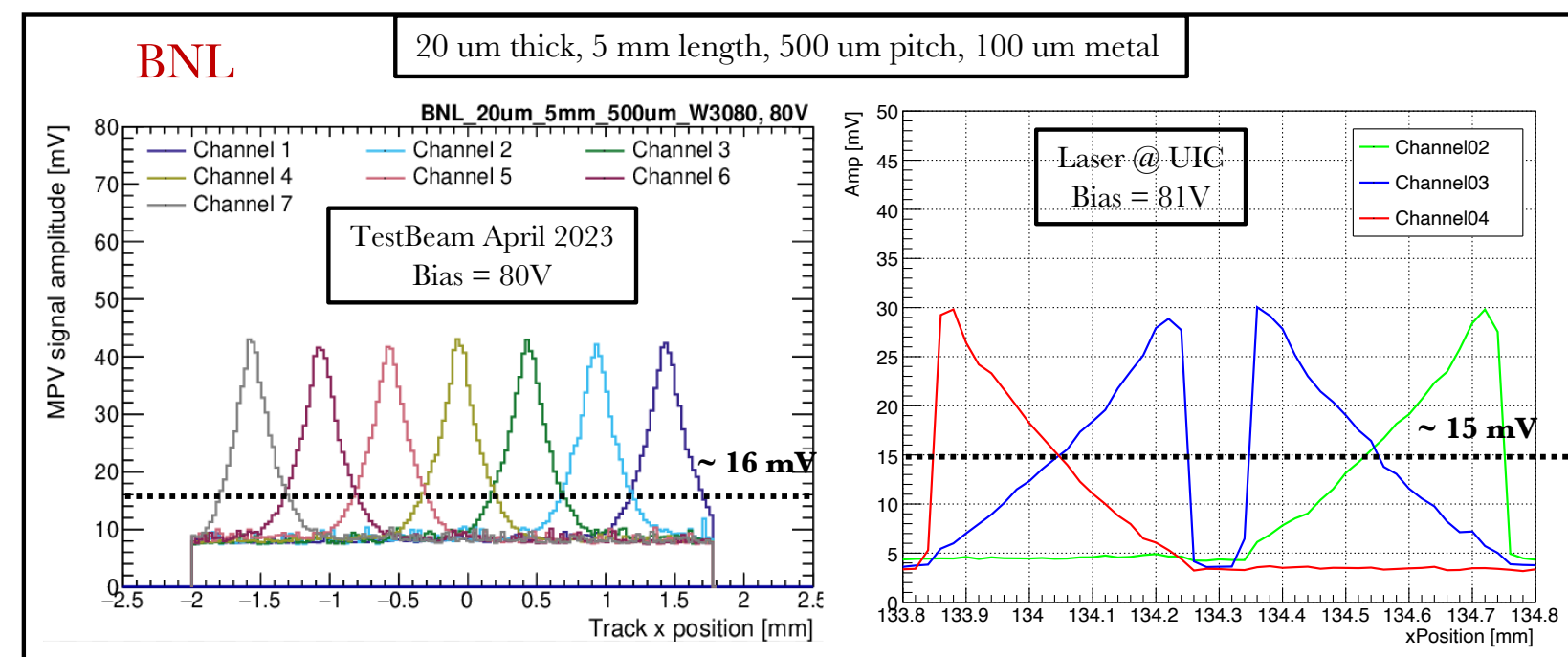
If you are interested in AC-LGAD sensor R&D, please contact Zhenyu!

News from eRD112/LGAD

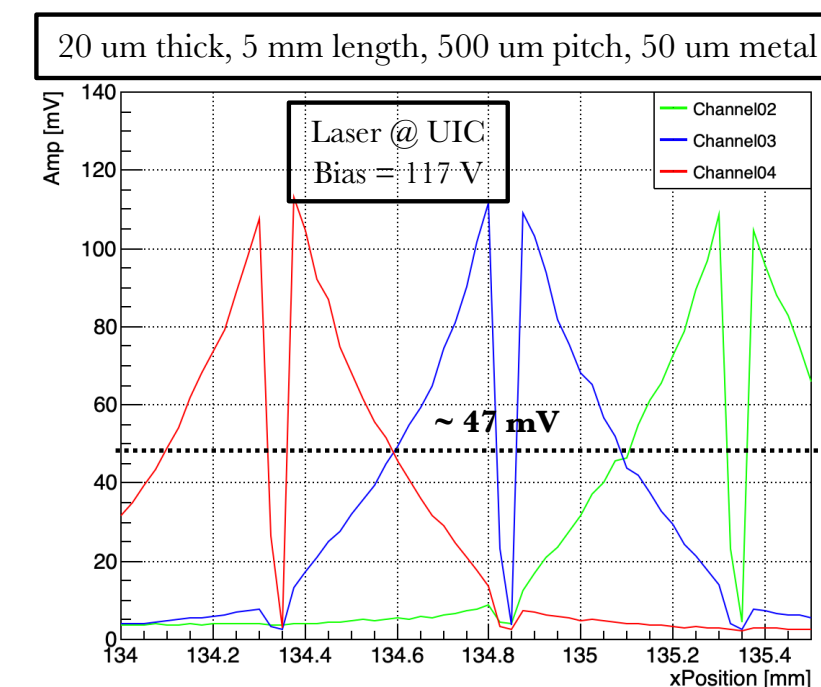
- Breaking news about HPK sensors from UIC
 - Quick test with IR laser

From Shirsendu's presentation (link)

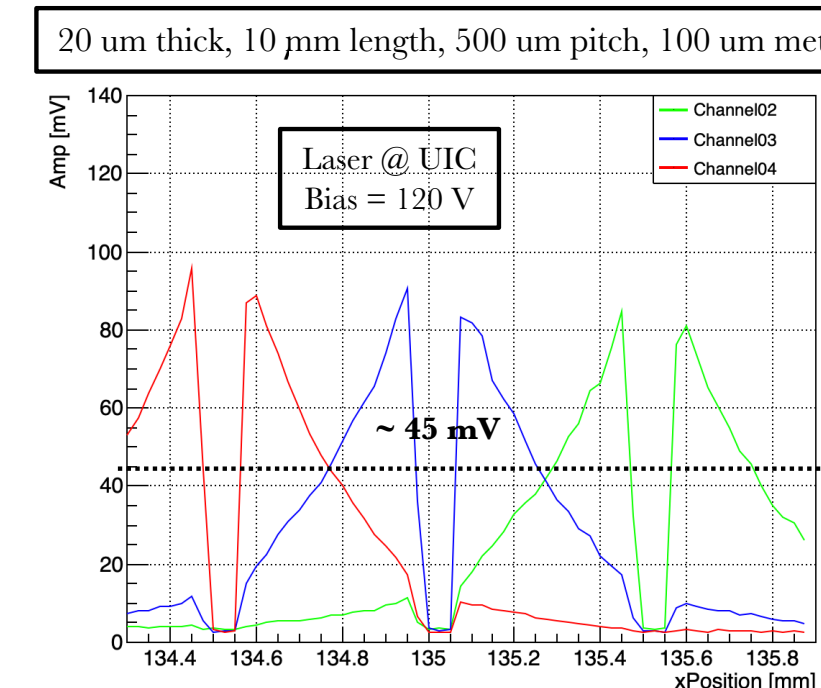
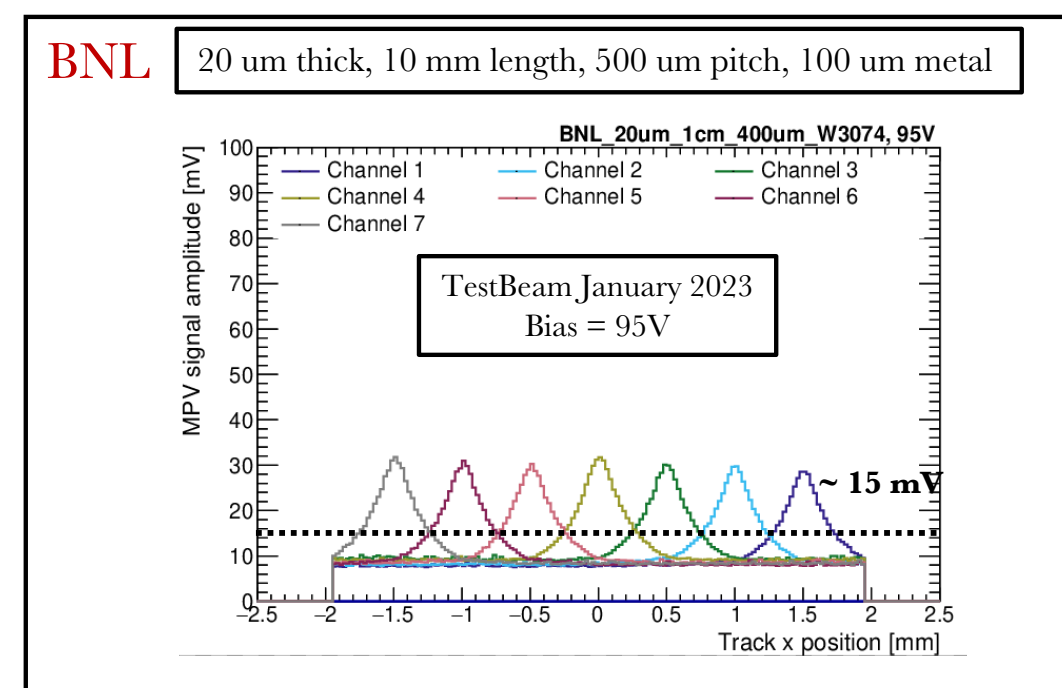
Comparing signal size for different BNL and HPK sensors:



HPK



Signal size in HPK:
3X compared to BNL



HPK has 3 x larger signal compared to BNL sensors with RI laser

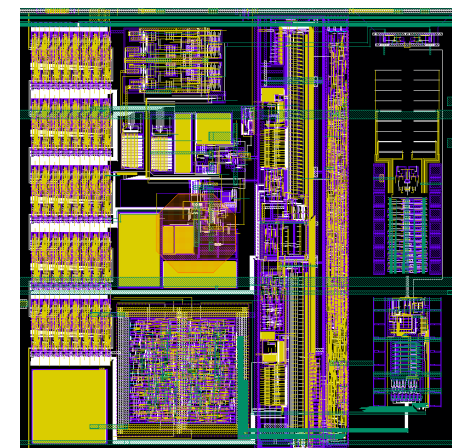
News from eRD109

- The next meeting will take place on 6 June 2023
 - <https://indico.bnl.gov/event/19471/>

From Zhenyu's presentation (link)

Frontend ASIC R&D

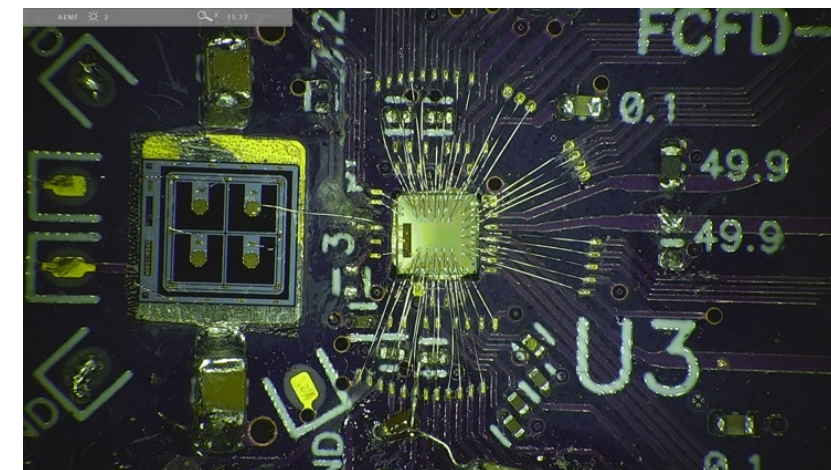
- **R&D Goals**
 - 15-20 ps jitter with minimal (1 mW/ch) power consumption, match AC LGAD sensors for EIC
- **Plan**
 - Continue the ASIC prototyping efforts and utilize the design and experience in ASICs for fast-timing detectors from ATLAS and CMS, and investigate common ASIC design and development for RP/B0 and ToF



EICROC by IJCLab/Omega/Irfu/AGH

- Preamp, discri. taken from ATLAS ALTIROC
- I2C slow control taken from CMS HGCROC
- TOA TDC adapted by IRFU Saclay
- ADC adapted to 8bits by AGH Krakow
- Digital readout: FIFO depth8 (200 ns)

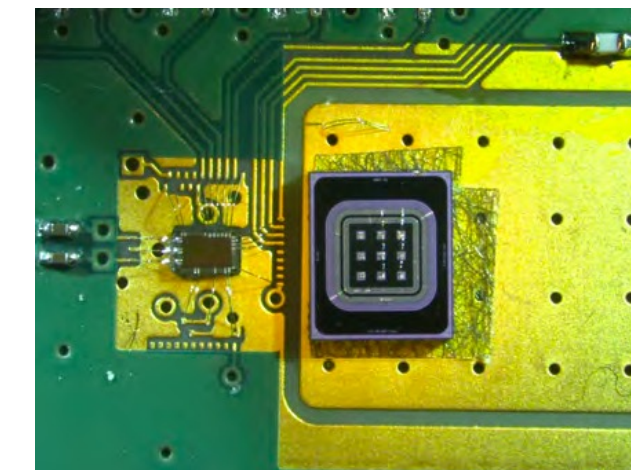
5/5/2023



FCFD by Fermilab

- Adapt the Constant Fraction Discriminator (CFD) principle in a pixel paired with a TDC, one time measurement gives the final answer.
- Charge injection consistent with simulations: ~30 ps at 5 fC, and <10 ps at 30 fC
- Tested with laser, beta source and beam

Zhenyu Ye @ UIC



ASICs by SCIPP

Developer	ASIC	Technology
INFN Torino	FAST	110 nm CMOS
NALU Scientific	HPSoC	65 nm CMOS
Anadyne Inc	ASROC	Si-Ge BiCMOS

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EICROC's follow-up report is awaited!

Summary

- TOF is the most important PID detector from the low to middle p_T range
 - There is a proposal to place TOF ~4cm inside and a new gas detector is installed just behind TOF
- AC-LGAD technology is being planned to use
- BNL product sensors have been tested
 - Beam and IR laser have been used
 - Timing resolution ~ 30 ps has been achieved
- HPK sensors have arrived at UIC
 - 3 x larger signal length compared to the BNL sensor has been observed by the IR laser test
 - Next week beam test will proceed at FNAL
 - If you are interested in AC-LAGD sensors R&D, please contact Zhenyu