

# Taiwan's contribution and plans for the ZDC

**Chia-Ming Kuo (NCU, Taiwan)**  
**on behalf of the EIC-Taiwan team**

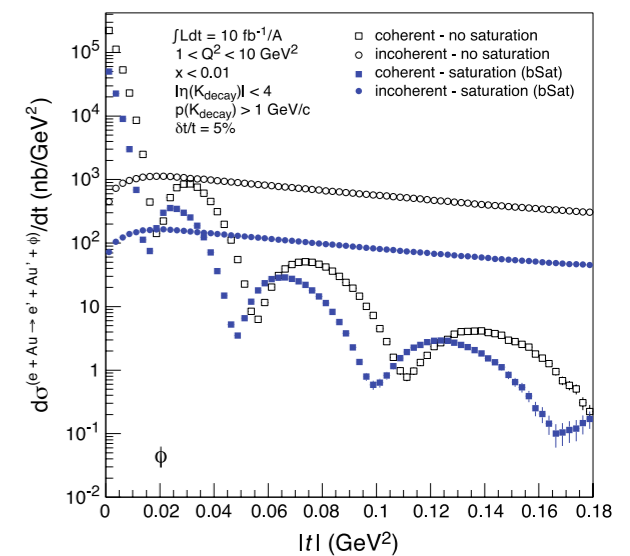
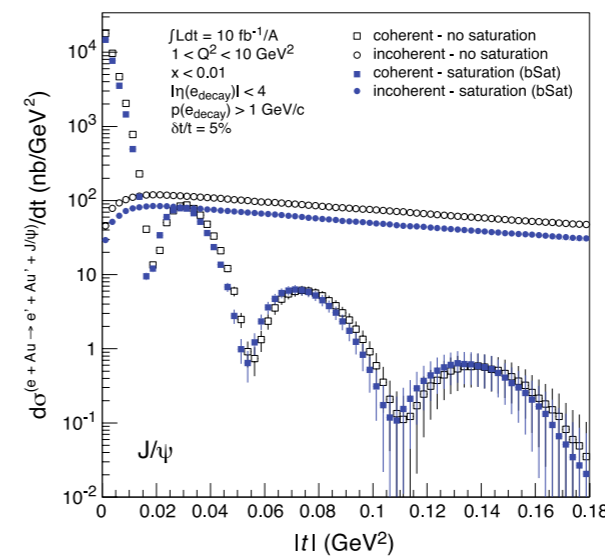
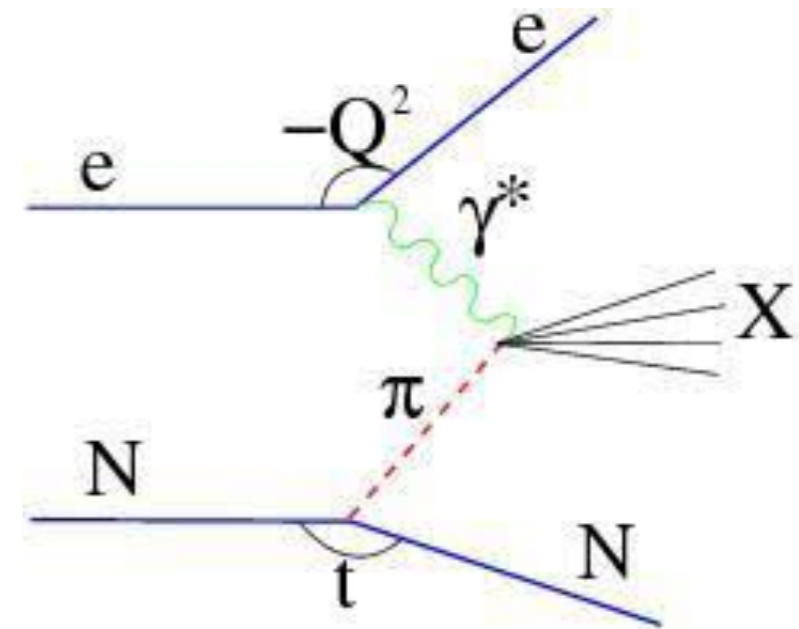
# Physics motivation

- **meson structure**

- meson's PDFs, GPDs
- gluon energy in the meson
- meson form factors
- valence-quark distributions in the meson at large momentum fraction
- quark fragmentation into mesons

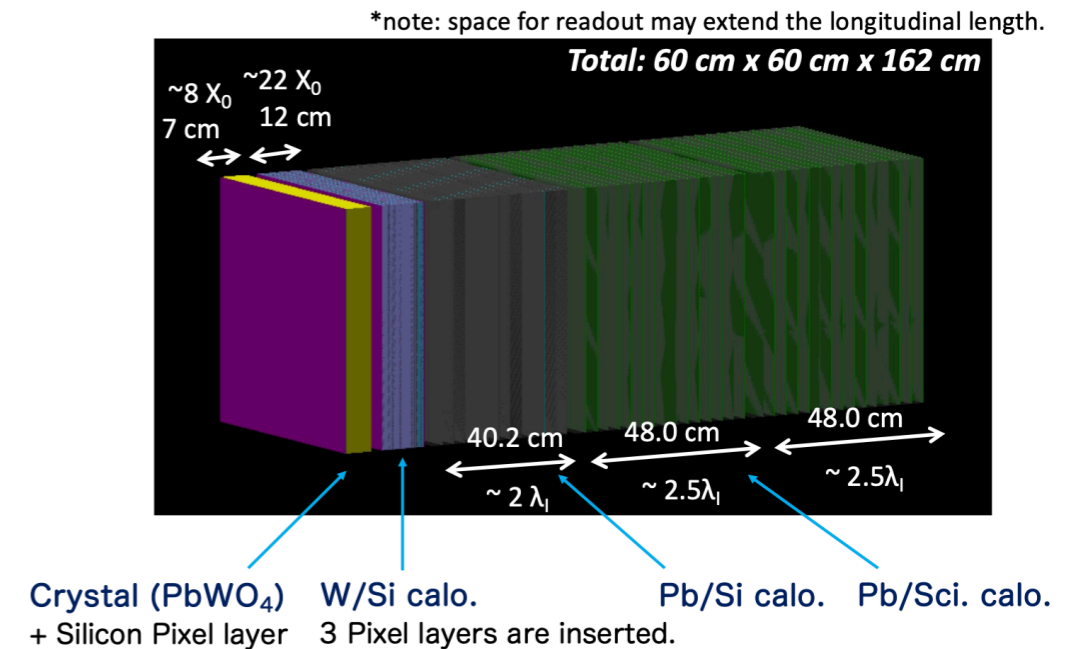
- **CGC**

- exclusive vector meson production in e+A



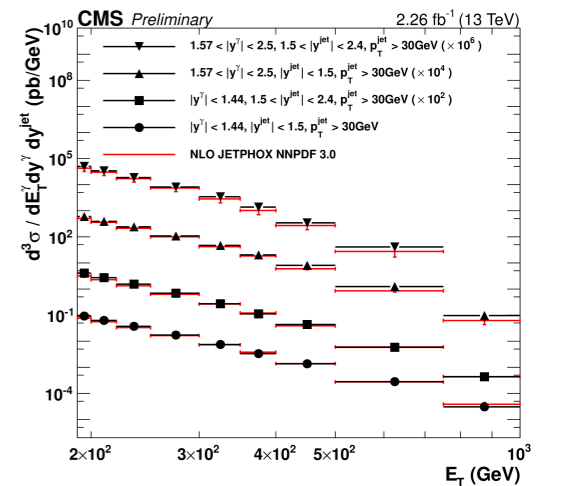
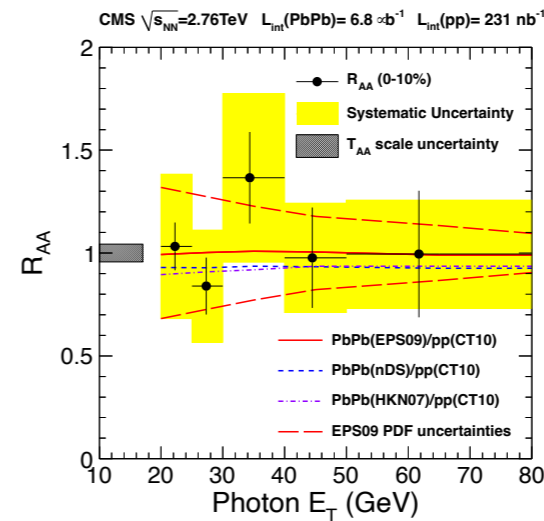
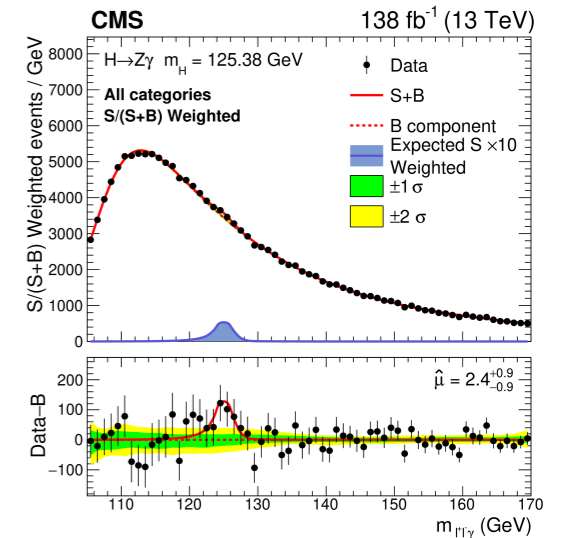
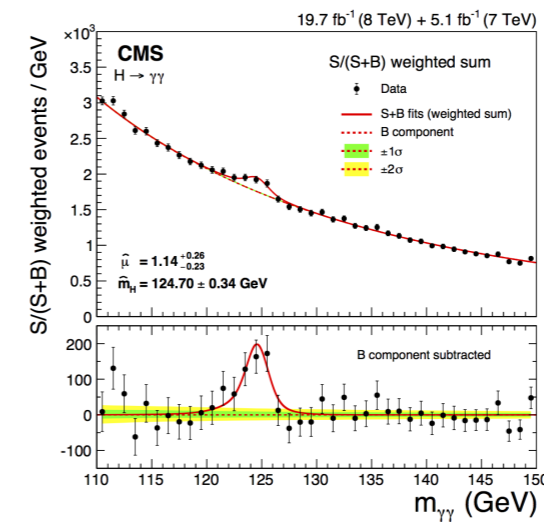
# Physics requirements for ZDC

	Energy range	Energy resolution	Position resolution	Others
Neutron	up to the beam energy	$\frac{50\%}{\sqrt{E}} + 5\%$ , ideally $\frac{35\%}{\sqrt{E}} + 2\%$	$\frac{3\text{mrad}}{\sqrt{E}}$	Acceptance: 60 cm × 60 cm
		Note: The acceptance is required from meson structure measurement. Pion structure measurement may require a position resolution of 1 mm.		
Photon	0.1 – 1 GeV	20 – 30%		Efficiency: 90 – 99%
	20 – 40 GeV	$\frac{35\%}{\sqrt{E}}$	0.5–1 mm	Note: Used as a veto in e+Pb exclusive J/ψ production u-channel exclusive electromagnetic π <sup>0</sup> production has a milder requirement of $\frac{45\%}{\sqrt{E}} + 7\%$ and 2 cm, respectively. Events will have two photons, but a single-photon tagging is also useful. Kaon structure measurement requires to tag a neutron and 2 or 3 photons, as decay products of Λ or Σ.



# Our detector motivation

- Taiwan-CMS has been working on the CMS ECAL ( $\text{PbWO}_4$ ), electromagnetic objects and photon related physics
- Taiwan Applied Crystal
  - one of qualified LYSO producers for CMS MTD
  - can deliver LYSO crystals with CMS standard wrap

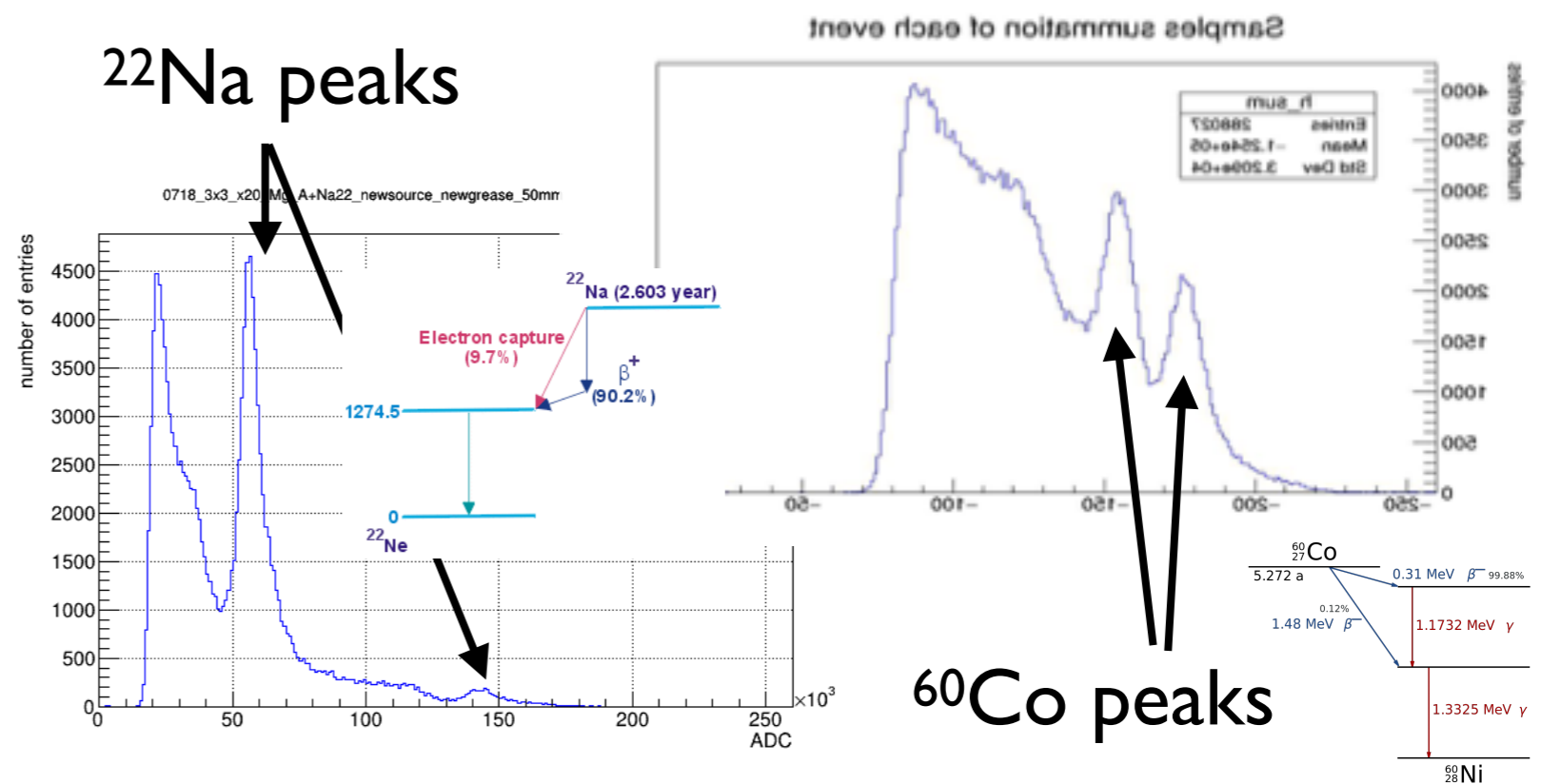
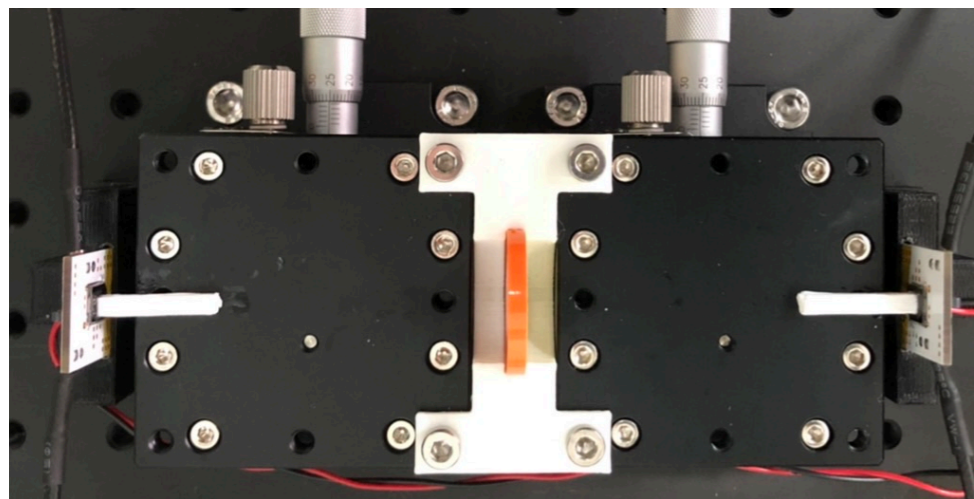
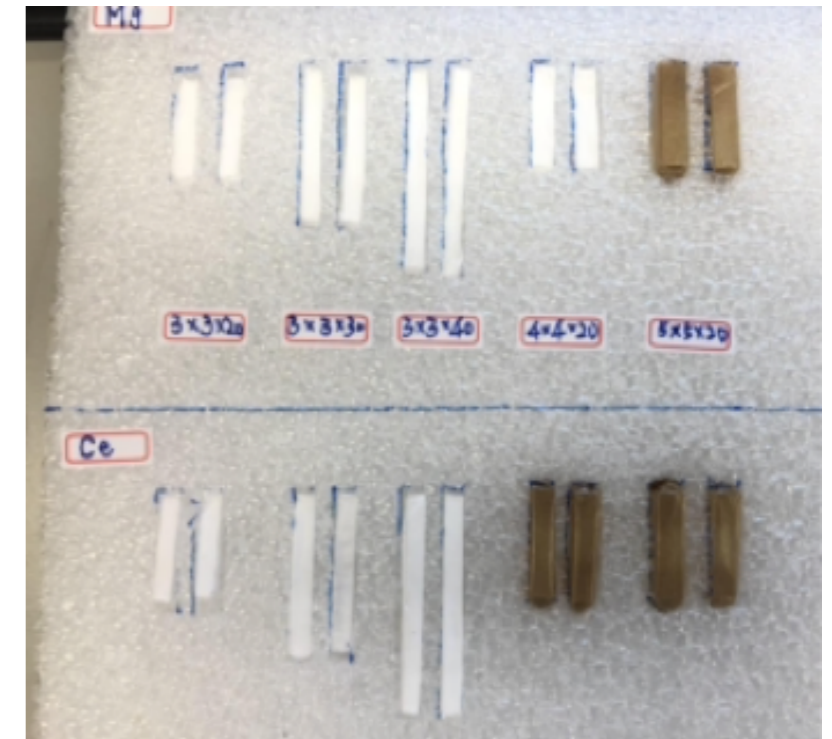


# PbWO<sub>4</sub> vs LYSO vs SciGlass

	$X_0$	LY (ph/MeV)	T dep. of LY (%/K)	Decay time (ns)	$\lambda_{em}$ nm
<b>PbWO<sub>4</sub> (CMS)</b>	0.89 cm	200	-1.98	5 (73%) 14 (23%) 110 (4%)	420
<b>LYSO</b>	1.14 cm	30,000 (market standard)	-0.28	36	420
<b>SciGlass</b>	2.4-2.8 cm	>100		22-400	440-460

# LYSO crystal characterization

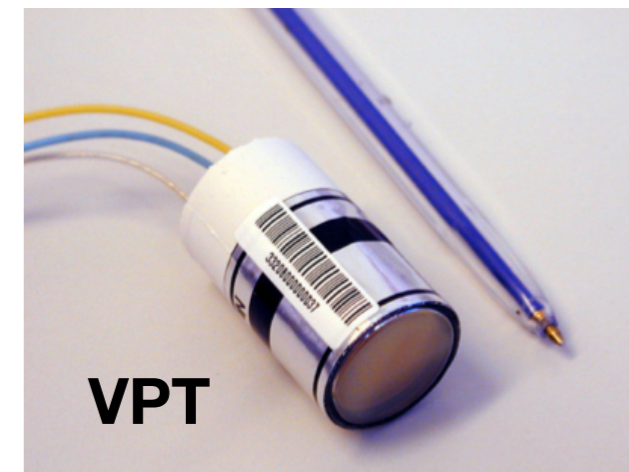
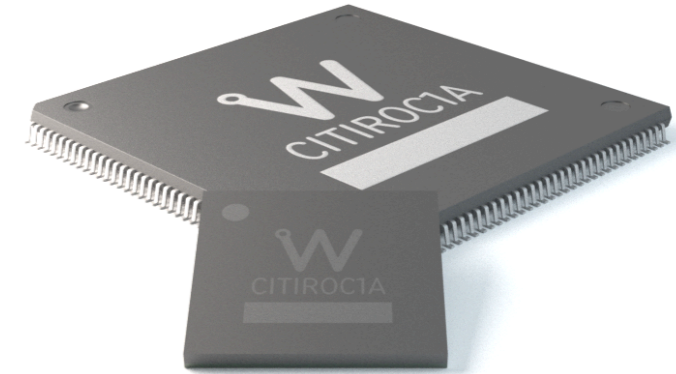
- NTU is setting up measurements for
  - absolute light yield of LYSO crystal using PMTs
  - time resolution of LYSO using SiPM
  - reach coincident time resolution of  $\sim 130\text{ps}$





# Readout (1/2)

- available readout board with Citiroc1A from wee roc for multichannel SiPM (Chih-Hsun Li, Academia Sinica) → can be used for first prototype study
- need a suitable readout for critical fluence value ( $10^{14}/cm^2$ )
  - CMS ECAL
    - barrel: APD, up to  $4 \times 10^{13}/cm^2$
    - endcap: VPT (vacuum phototriodes), up to  $7 \times 10^{15}/cm^2$
  - CMS MTD BTL (LYSO tiles with SiPM readout)
    - radiation (4/ab):  $2 \times 10^{14}/cm^2$



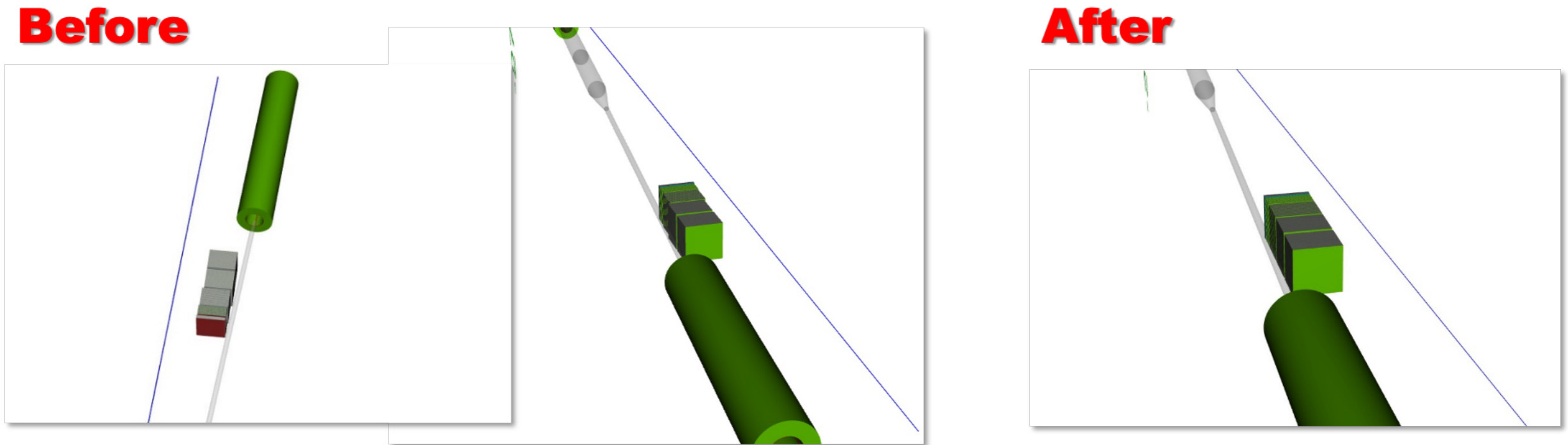
# Readout (2/2)

- extensive studies of radiation damage, including temperature effects and annealing on SiPM were performed by CMS MTD
- HPK MPPC-HDR2-3015 used by CMS in R&D in 2019
- However, there are challenges
  - need to operate at  $-45^{\circ}\text{C}$  to suppress the noise from increased dark count rate and avoid SiPM SPAD saturation
  - still high power consumption → specific packaging and mechanical support for heat extraction for stable operation



# ZDC Monte Carlo implementation (1/2)

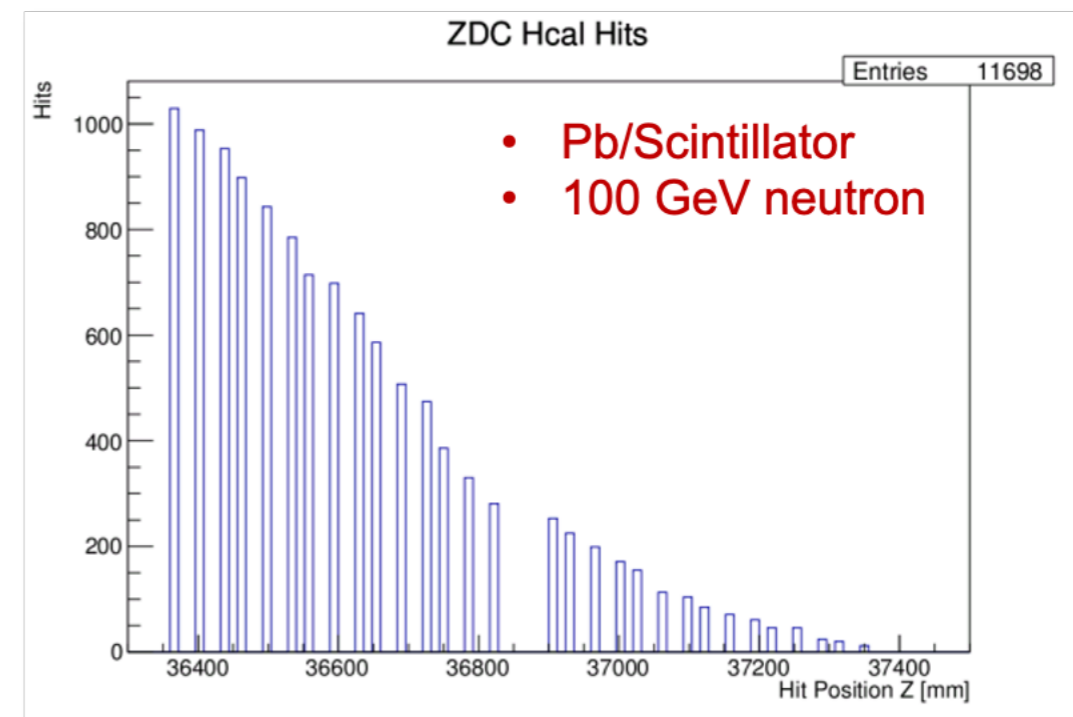
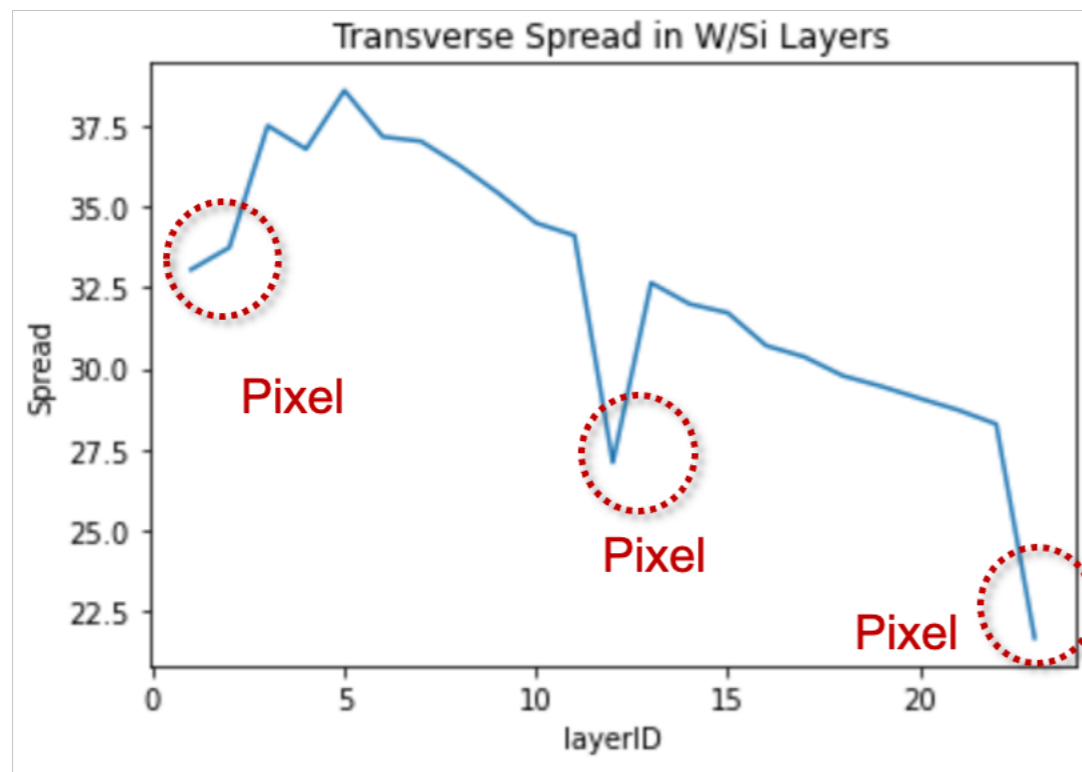
Po-Ju Lin



- Po-Ju Lin of Academia Sinica started to pick up simulation work from Shimizu-san
- A bug of alignment issued reported by other collaborators (issue #309) was fixed
- The ZDC complex rotation has been modified to have a consistency in codes between Athena and ECCE version. Merged to the EPIC GitHub already.

# ZDC Monte Carlo implementation (2/2)

Po-Ju Lin



- discrepancy in energy deposit/spread between silicon pad and pixel layers was understood (issue #1020)
- further debugging on-going

# Funding situation

- Prototype
  - funding situation will be clear in April
  - preliminary quote: 65 USD/cm<sup>3</sup> for 10 crystals
- Final one assuming if LYSO meets our needs and is selected
  - a very good chance to be funded by the Taiwanese funding agencies if the overall cost is reasonable
  - a joint project between Taiwan Instrumentation and Detector Consortium (TIDC) and Taiwan Consortium of Emergent Crystalline Materials (TCECM)

# Summary

- EIC-Taiwan proposes building a LYSO-based calorimeter prototype for ZDC
- Po-Ju Lin started to pick up the ZDC simulation work from Shimizu-san
- We will collaborate with colleagues from EIC-Japan and EIC-Korea at ZDC