CEPC Ref-TDR ECAL updates

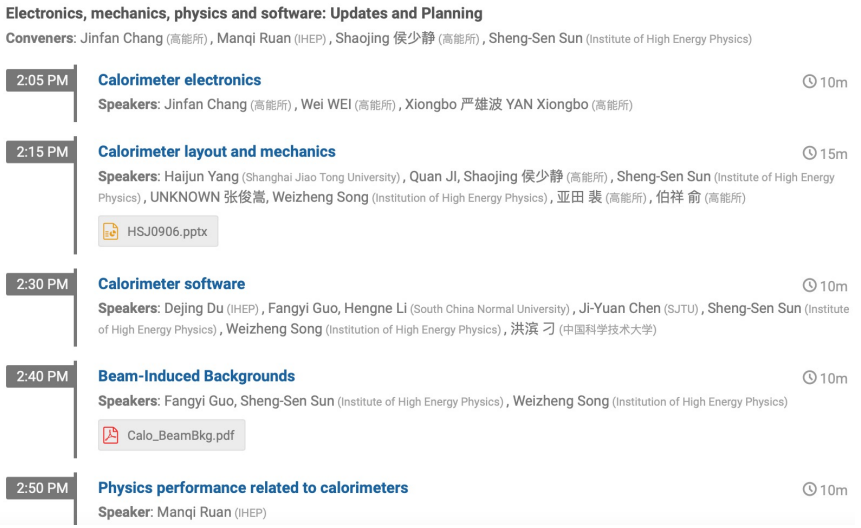
Yong Liu (IHEP) for the CEPC Ref-TDR ECAL team

CEPC Reference Detector TDR Weekly Meeting

September 10, 2024

Latest updates

- CEPC ECAL Weekly Meeting on TDR
  - Indico on Sep. 6, 2024: https://indico.ihep.ac.cn/event/23509/
    - Meeting Minutes
  - Online note: https://note.ihep.ac.cn/cTyoJQbeT3WDTfY6mm2LZw
- New agenda
  - *Part 1* on updates/status: electronics, mechanics, software, backgrounds, etc.
  - *Part 2* on Ref-TDR documenting: contributions and updates



Electronics, mechanics, physics and software: Updates and Planning

Conveners: Jinfan Chang (高能所) , Manqi Ruan (IHEP) , Shaojing 侯少静 (高能所) , Sheng-Sen Sun (Institute of High Energy Physics)

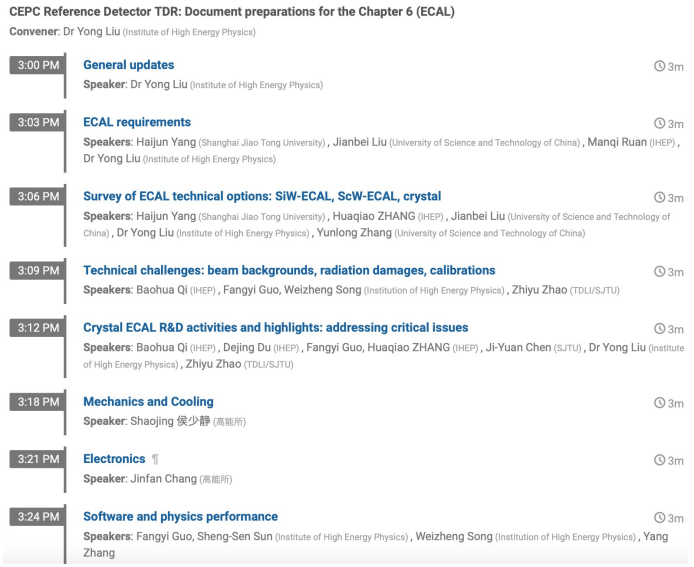
2:05 PM **Calorimeter electronics** 10m
Speakers: Jinfan Chang (高能所) , Wei WEI (高能所) , Xiongbo 严雄波 YAN Xiongbo (高能所)

2:15 PM **Calorimeter layout and mechanics** 15m
Speakers: Haijun Yang (Shanghai Jiao Tong University) , Quan JI, Shaojing 侯少静 (高能所) , Sheng-Sen Sun (Institute of High Energy Physics) , UNKNOWN 张俊嵩, Weizheng Song (Institution of High Energy Physics) , 亚田 裴 (高能所) , 伯祥 俞 (高能所)
HSJ0906.pptx

2:30 PM **Calorimeter software** 10m
Speakers: Dejing Du (IHEP) , Fangyi Guo, Hengne Li (South China Normal University) , Ji-Yuan Chen (SJTU) , Sheng-Sen Sun (Institute of High Energy Physics) , Weizheng Song (Institution of High Energy Physics) , 洪滨 刁 (中国科学技术大学)

2:40 PM **Beam-Induced Backgrounds** 10m
Speakers: Fangyi Guo, Sheng-Sen Sun (Institute of High Energy Physics) , Weizheng Song (Institution of High Energy Physics)
Calo_BeamBkg.pdf

2:50 PM **Physics performance related to calorimeters** 10m
Speaker: Manqi Ruan (IHEP)



CEPC Reference Detector TDR: Document preparations for the Chapter 6 (ECAL)

Convener: Dr Yong Liu (Institute of High Energy Physics)

3:00 PM **General updates** 3m
Speaker: Dr Yong Liu (Institute of High Energy Physics)

3:03 PM **ECAL requirements** 3m
Speakers: Haijun Yang (Shanghai Jiao Tong University) , Jianbei Liu (University of Science and Technology of China) , Manqi Ruan (IHEP) , Dr Yong Liu (Institute of High Energy Physics)

3:06 PM **Survey of ECAL technical options: SiW-ECAL, ScW-ECAL, crystal** 3m
Speakers: Haijun Yang (Shanghai Jiao Tong University) , Huaqiao ZHANG (IHEP) , Jianbei Liu (University of Science and Technology of China) , Dr Yong Liu (Institute of High Energy Physics) , Yunlong Zhang (University of Science and Technology of China)

3:09 PM **Technical challenges: beam backgrounds, radiation damages, calibrations** 3m
Speakers: Baohua Qi (IHEP) , Fangyi Guo, Weizheng Song (Institution of High Energy Physics) , Zhiyu Zhao (TDLI/SJTU)

3:12 PM **Crystal ECAL R&D activities and highlights: addressing critical issues** 3m
Speakers: Baohua Qi (IHEP) , Dejing Du (IHEP) , Fangyi Guo, Huaqiao ZHANG (IHEP) , Ji-Yuan Chen (SJTU) , Dr Yong Liu (Institute of High Energy Physics) , Zhiyu Zhao (TDLI/SJTU)

3:18 PM **Mechanics and Cooling** 3m
Speaker: Shaojing 侯少静 (高能所)

3:21 PM **Electronics** ¶ 3m
Speaker: Jinfan Chang (高能所)

3:24 PM **Software and physics performance** 3m
Speakers: Fangyi Guo, Sheng-Sen Sun (Institute of High Energy Physics) , Weizheng Song (Institution of High Energy Physics) , Yang Zhang

Latest Status

- ECAL electronics (Jinfan Chang)
  - Finished a first estimate of the **number of cables (power, optical fibres)**
  - Will be released as soon as the *internal review* is completed (in electronics group)
- ECAL mechanics (Shaojing Hou)
  - Proposed a first design of **assembly procedures** for barrel crystal modules
  - A separate progress report to be presented by Shaojing, as an action item of last week
- Beam-induced backgrounds (Weizheng Song)
  - Simulation results with 2 running modes: **50MW Z-pole (23ns), 50MW Higgs (355ns)**
- Software (Shengsen Sun)
  - Ongoing work with longer crystal bars of 60cmx1.5x1.5cm
- Crystal calorimeter prototype: performance studies with beamtest data
  - Updates on digitistation, data analysis; further meeting with CERN beamline physicists

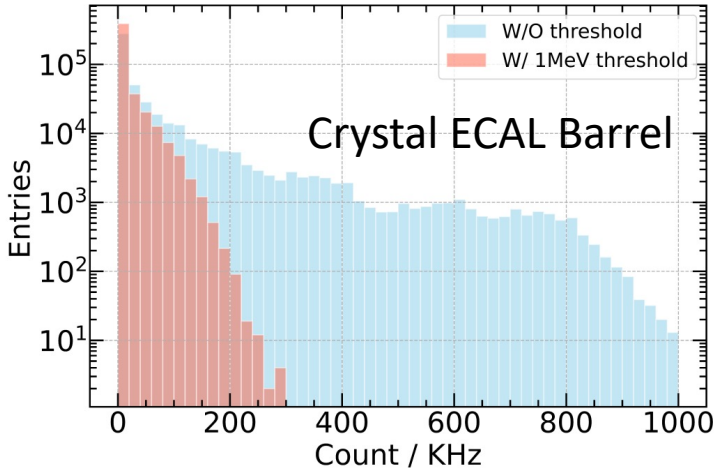
Beam-induced backgrounds: Higgs

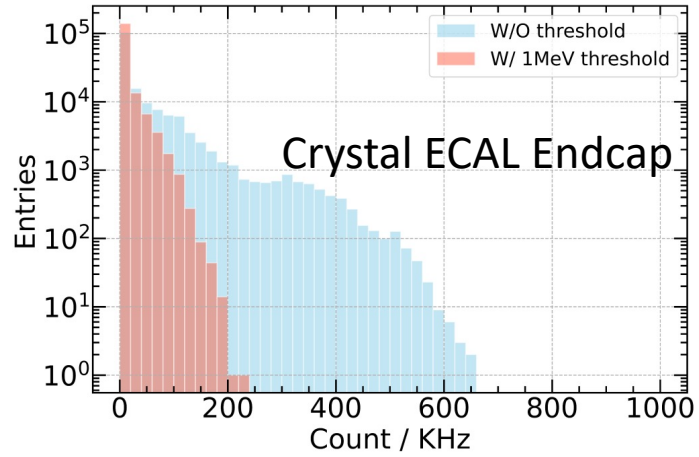
Weizheng Song (IHEP)

- **50MW** Higgs runs (355ns bunch spacing): updates from 30MW
  - Count rate: 650kHz – 1MHz in all energy hits
  - Rate reduced to 200-300 kHz with 0.1 MIP threshold

Beam Backgrounds		50MW Higgs (355 ns)	50MW Z-pole (23 ns)
Luminosity dependent	Pair Production	1300/BX	TBD
Single Beam	Beam-Thermal Photon	359kHz *2	265MHz *2
	Beam-Gas Bremsstrahlung	41kHz *2	19MHz *2
	Beam-Gas Coulomb	238kHz *2	2.4GHz *2
	Touschek Scattering	/	6.2GHz *2

Table remade from the talk of Weizheng



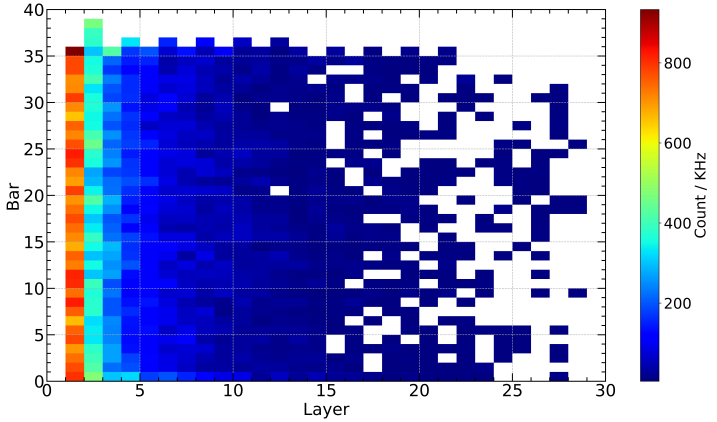


Beam-induced backgrounds: Higgs

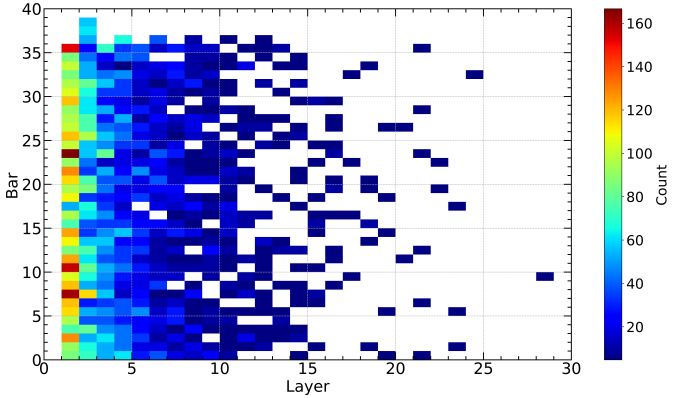
Weizheng Song (IHEP)

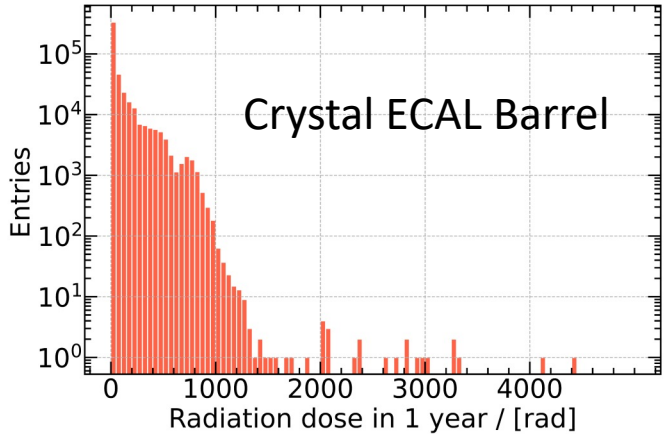
- **50MW** Higgs runs (355ns bunch spacing): updates from 30MW
  - TID per year: ~4k rad for barrel crystals; 50k rad for endcap crystals

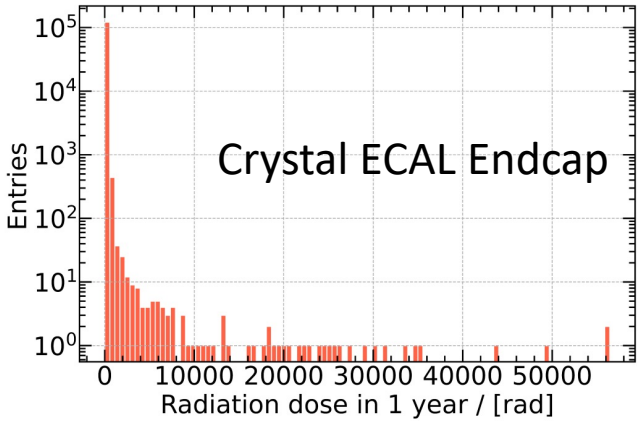
Barrel Module: BarID vs LayerID (raw hits)



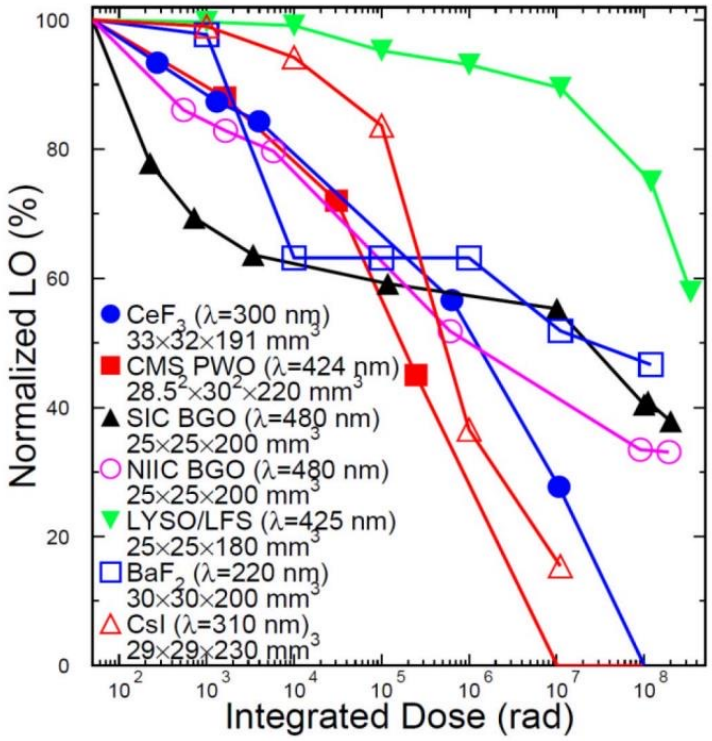
Barrel Module: BarID vs LayerID (hits>1MeV)







Radiation Damages to Crystals



Beam-induced backgrounds: Z-pole

Weizheng Song (IHEP)

- **50MW** Z-pole runs (23ns bunch spacing): new results
  - Single beam only, not including pair production yet
  - On average 115 GeV energy deposition in a single ECAL endcap within every 23ns

Beam Backgrounds		50MW Higgs (355 ns)	50MW Z-pole (23 ns)
Luminosity dependent	Pair Production	1300/BX	TBD
Single Beam	Beam-Thermal Photon	359kHz *2	265MHz *2
	Beam-Gas Bremsstrahlung	41kHz *2	19MHz *2
	Beam-Gas Coulomb	238kHz *2	2.4GHz *2
	Touschek Scattering	/	6.2GHz *2

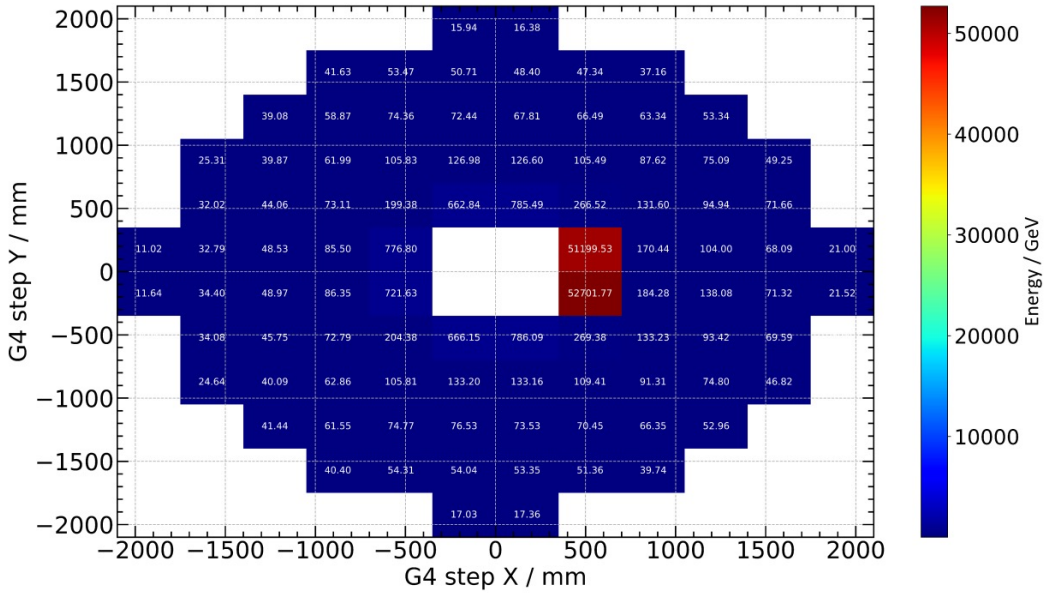


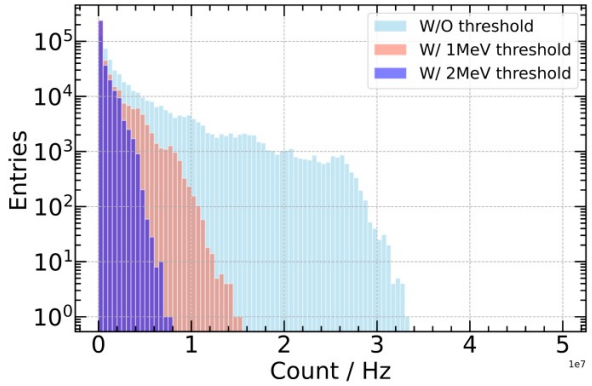
Table remade from the talk of Weizheng

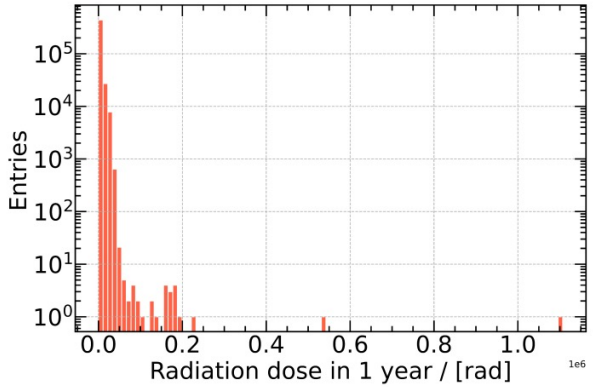
Beam-induced backgrounds: Z-pole

Weizheng Song (IHEP)

- **50MW** Z-pole runs (23ns bunch spacing): new results
  - Feedback from Haoyu: requires careful collimator design, to be discussed with accelerator colleagues

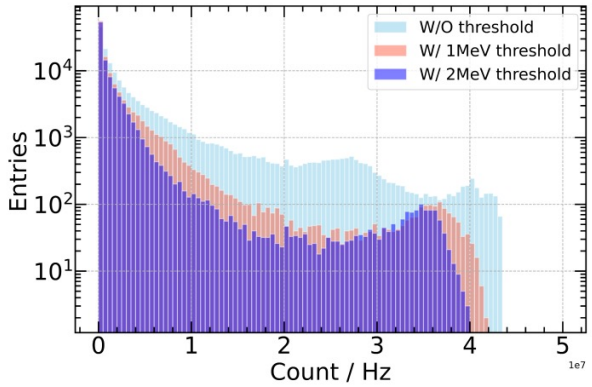
Crystal ECAL Barrel

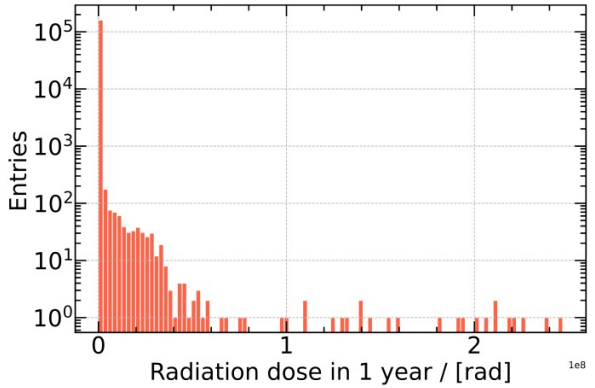




Count rate: 8-34 MHz
TID: 1M rad per year

Crystal ECAL Endcap





Count rate: ~40 MHz
TID: ~200M rad per year

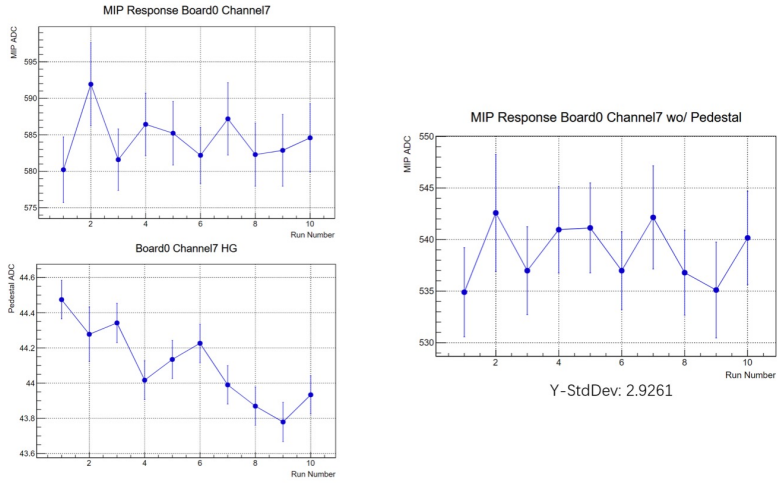
Crystal calorimeter prototype

Baohua Qi, Zhiyu Zhao, etc.

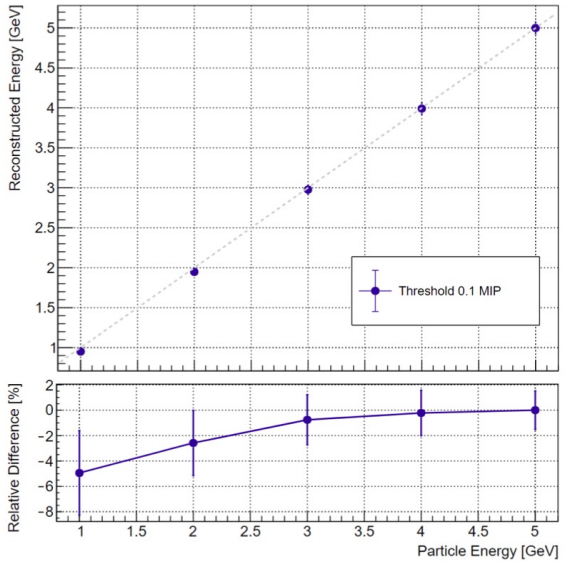
- Performance studies with beamtest data: updates in many aspects
  - Better understanding of calibration precision (~0.5%): MIP and pedestal stability
  - Observed and quantified crosstalk effects in ASIC neighbouring channels: significantly improved energy linearity after crosstalk corrections (now within $\pm 1\%$)
  - Updates in digitisation for crystal-SiPM and ASIC: ongoing crosschecks

MIP and pedestal: stability over runs

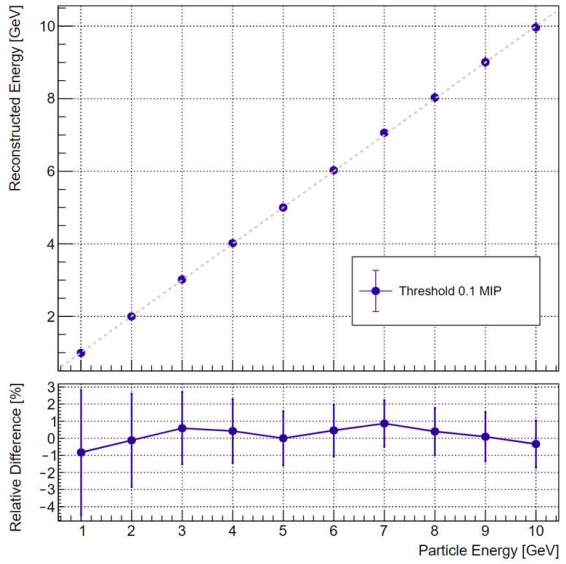
- MIP and pedestal changing with RunNum: calibration precision 0.54%



Energy Linearity before corrections



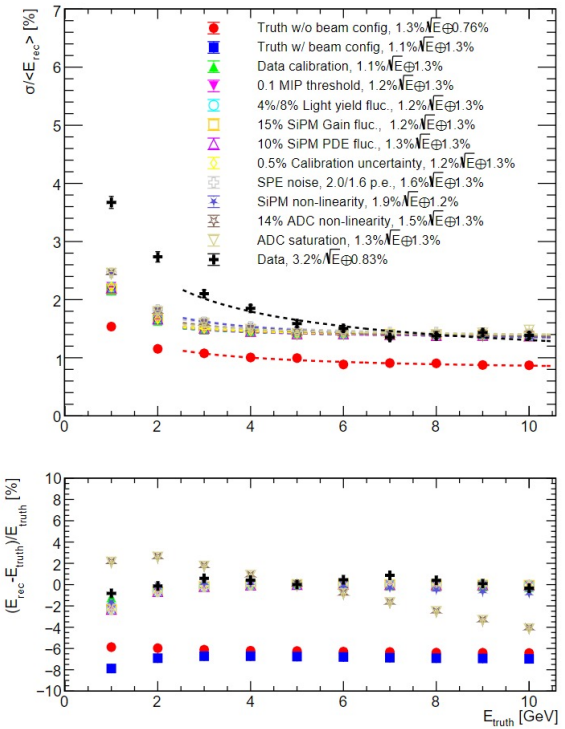
Energy Linearity after corrections



Crystal calorimeter prototype

Baohua Qi, Zhiyu Zhao, etc.

- Performance studies with beamtest data: **EM resolution**
  - Observed significant impacts from beam momentum spread
    - Much larger than 1% (an estimate for beamline lattice only)
    - Due to upstream materials from *beam instrumentation* (Cherenkov detectors, SciFi tracker for beam profiles)
  - Momentum spread tends to depend on the beam momentum
    - Observed larger momentum spread in lower energy beams
    - **Requires quantitative results for further possible corrections**



- Discussions with CERN beamline physicists
  - Will share with us the existing beamline simulation results
  - Scheduled a remote meeting this evening for further discussions

Ref-TDR documenting: Chapter 6 on ECAL

- Updates on major contact persons of ECAL sessions
  - Survey of ECAL technical options
    - SiW-ECAL: Haijun Yang, Huaqiao Zhang (synergies with CMS HGCAL)
    - ScW-ECAL: Yunlong Zhang (prototyping and beamtests)
    - Crystal: YL and Huaqiao Zhang
  - Electronics: Jinfan Chang
  - Mechanics + cooling: Shaojing Hou
  - Software: Shengsen Sun