

CALICE Collaboration Meeting at Shanghai



Status of CEPC ECAL R&D

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On behalf of the CEPC calorimeter working group

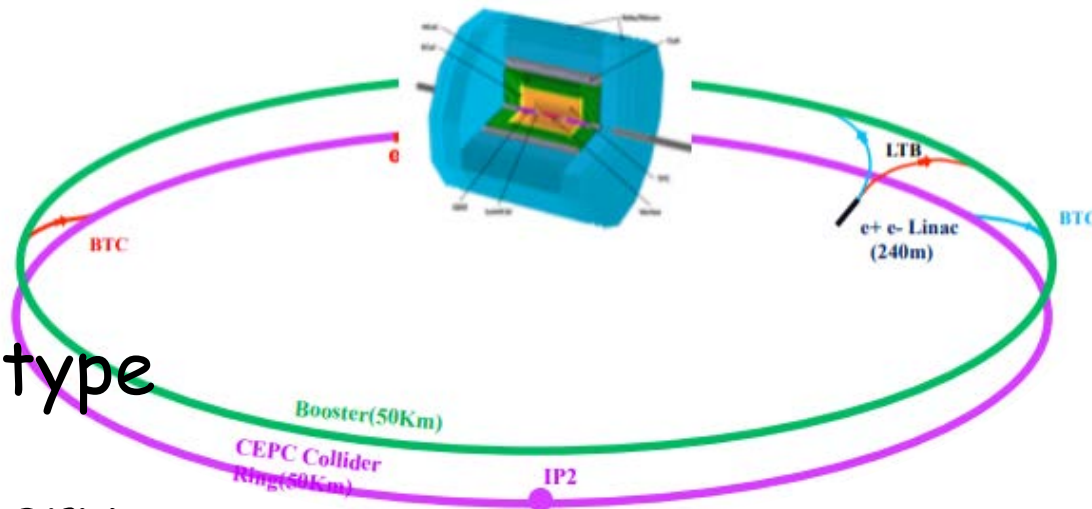


中国科学技术大学

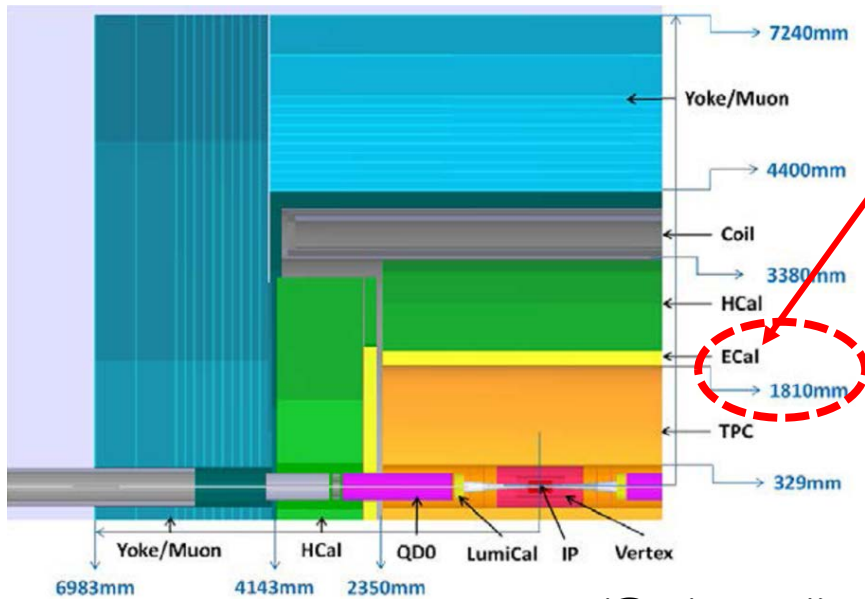
University of Science and Technology of China

紅專并進一甲子 科教報國六十年

- Motivation : PFA and Imaging Calorimetry
- ECAL Unit Study and Optimization
 - Simulation and Optimization
 - Photon sensor
 - Scintillator strip
 - Readout Electronics
- Single Layer Prototype
- Outlook and Summary

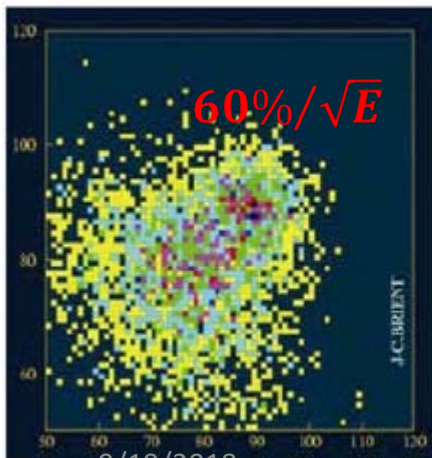


Motivation

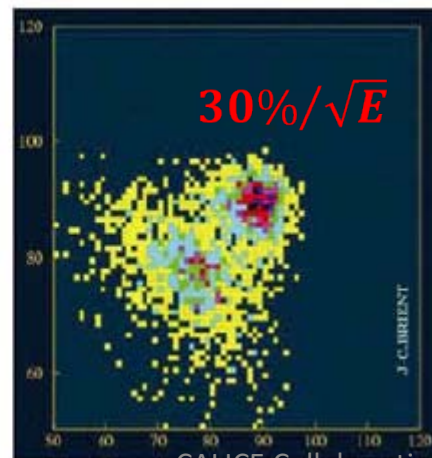


- Energy resolution of γ :
 - $\sigma_E/E \approx 16\%/\sqrt{E} \oplus 1\%$
- Jet energy resolution (combined tracker, ECAL and HCAL)
 - $\sigma_E/E \approx (3\% \sim 4\%)@100\text{GeV}$

CEPC preCDR: <http://cepc.ihep.ac.cn/preCDR/volume.html>



9/19/2018

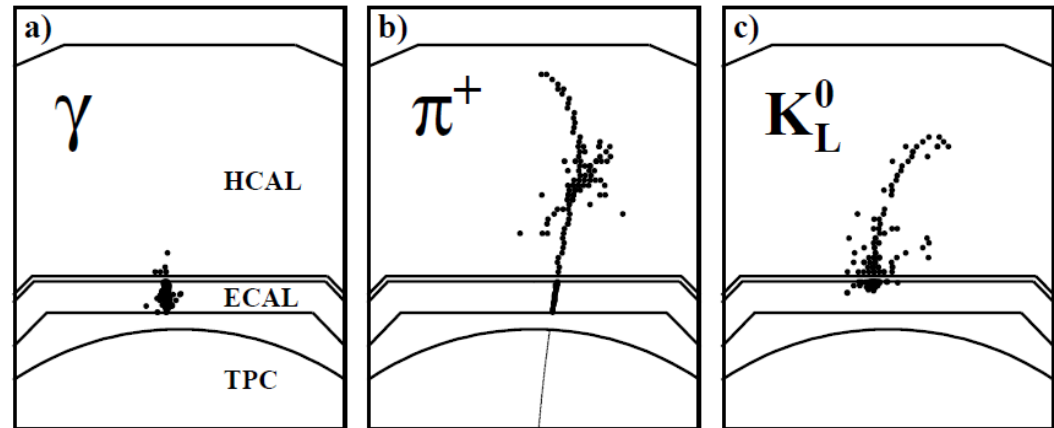


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- Simulation of WW and ZZ separation power for the events in 4 jets

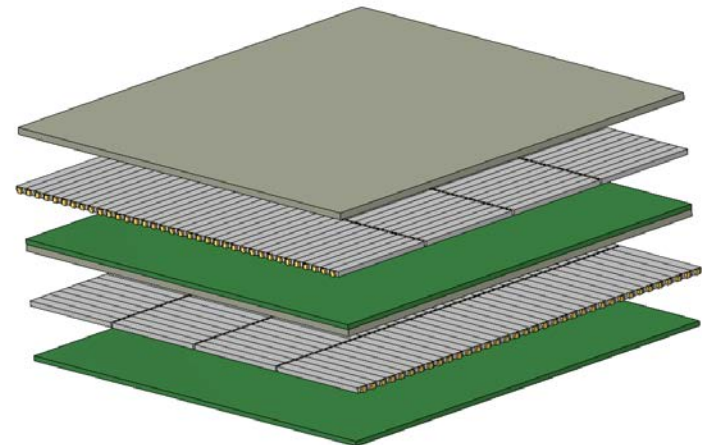
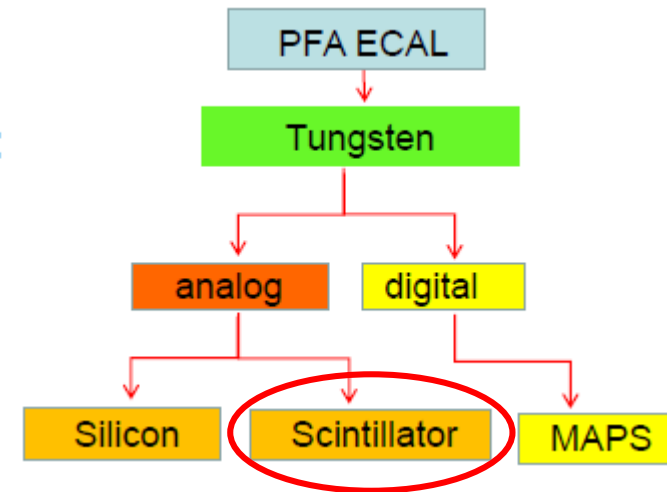
- Particle Flow Algorithm(PFA) calorimetry concept proposed : Reconstruct each individual final state particle in the most suitable sub-detector

- ✓ High granularity
- ✓ Good shower separation
- ✓ Good energy resolution



✓ Scintillator-tungsten ECAL

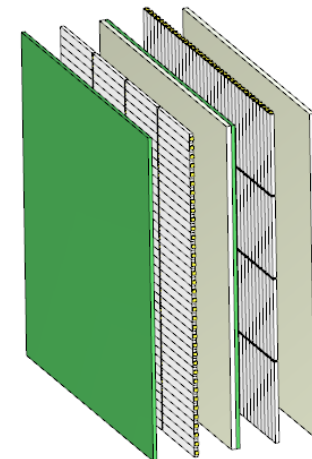
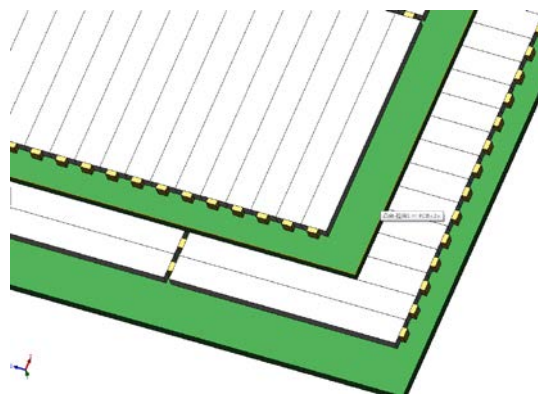
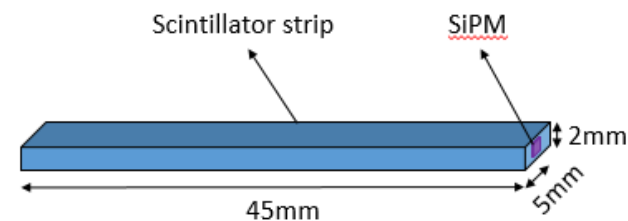
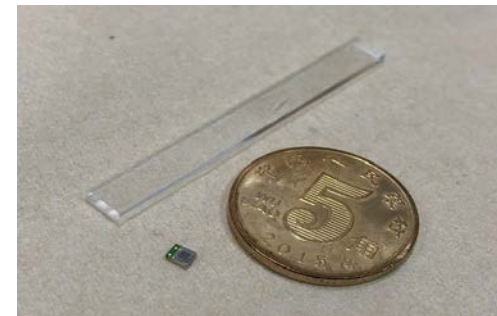
- Larger detector PFA
 - Sandwich structure
 - Absorber + SD + Electronics
- Smaller Moliere radius
 - Tungsten
- Larger dynamic ranger
 - Scintillator + SiPM
 - SPIROC Chip



Structure Overview



- Scintillator strip: $45\text{mm} \times 5\text{mm} \times 2\text{mm}$
- High pixel SiPM: 10K
- Front-end electronics chip: SPIROC
- Assemble scintillator module in the other side of EBU
- Orthogonal arrangement of adjacent layers: achieve effective $5\text{mm} \times 5\text{mm}$



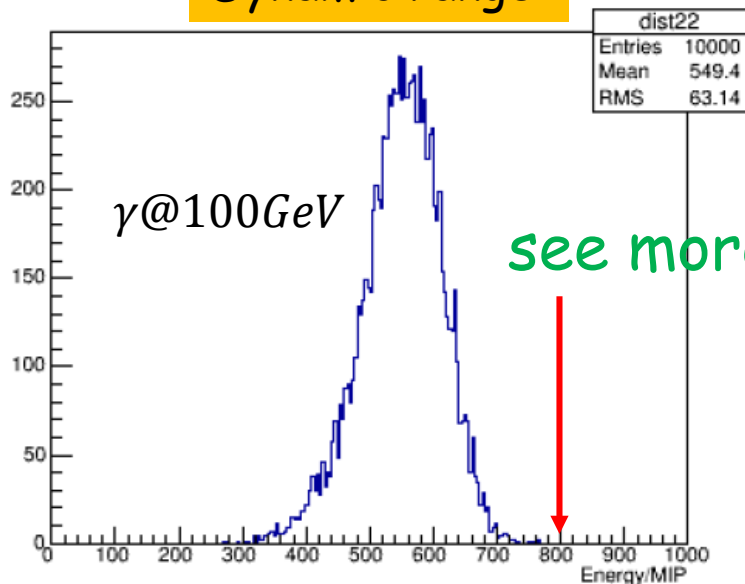
ECAL Optimization



ECAL crucial parameters:

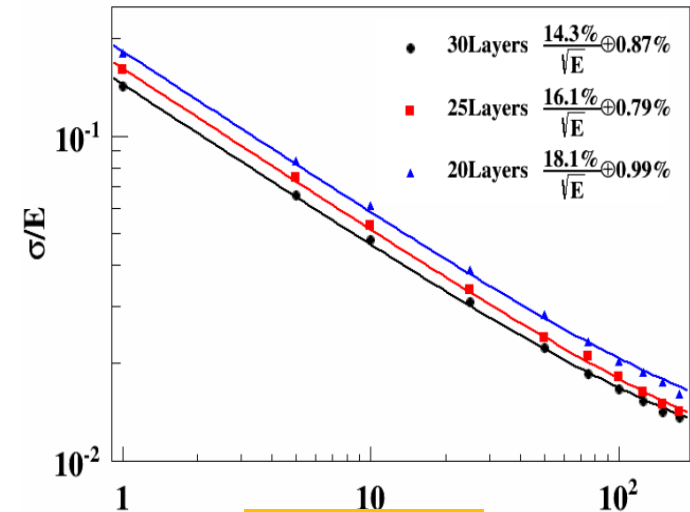
- Absorber thickness: $24X_0$
- Layer number: 30 layers
- Cell size: $< 10\text{mm} \times 10\text{mm}$
- Dynamic ranger: $1\text{MIP} \sim 800\text{MIPs}$

Dynamic range

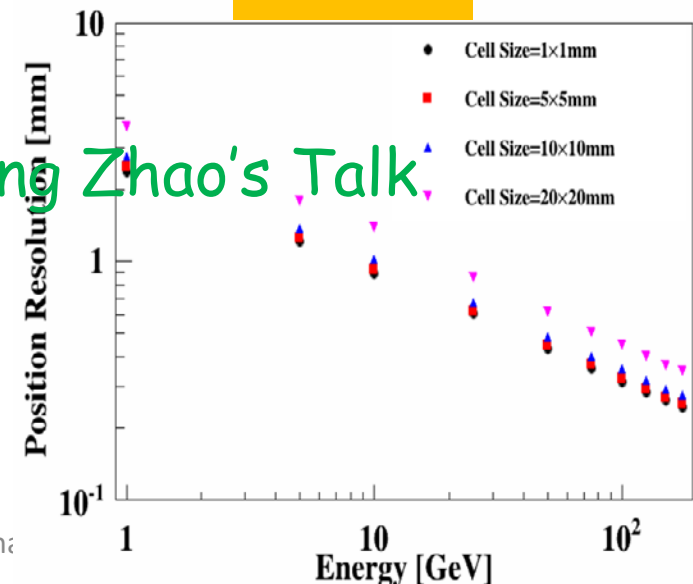


see more @ Hang Zhao's Talk

Layers number



Cell size

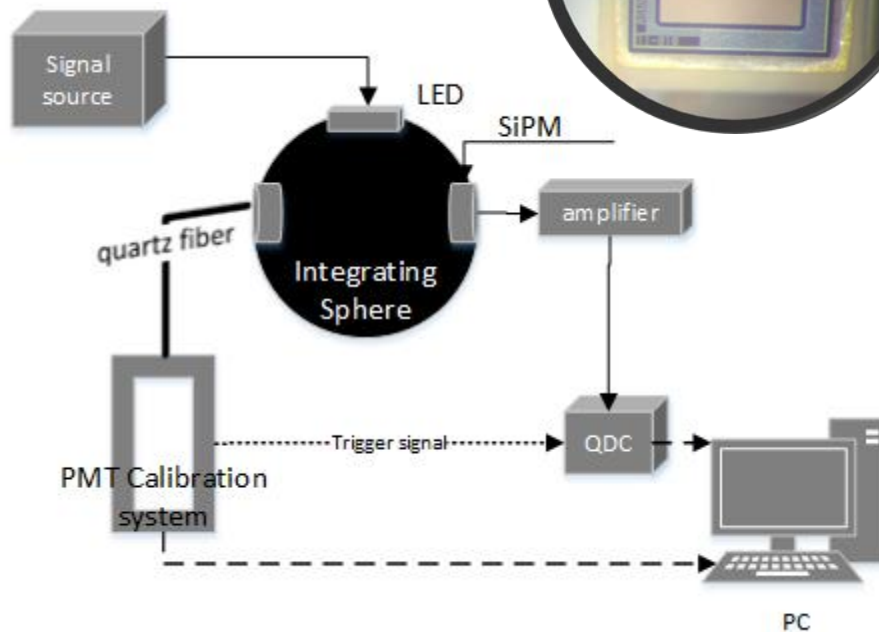
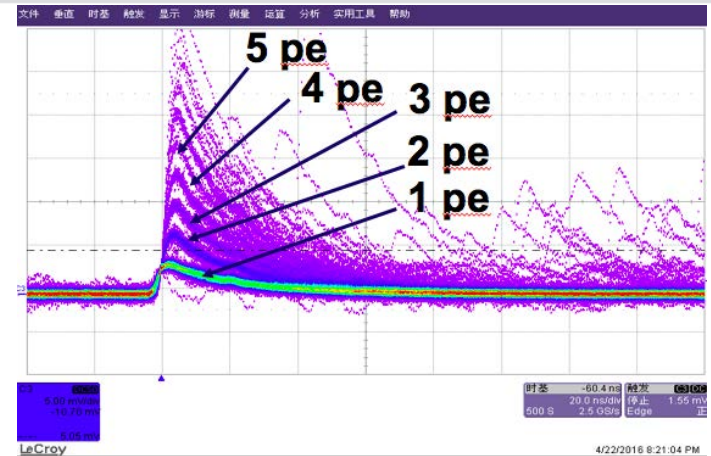
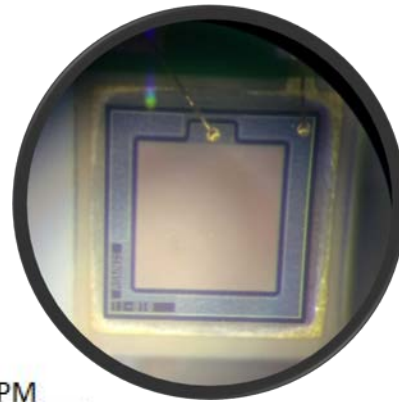


SiPM Study

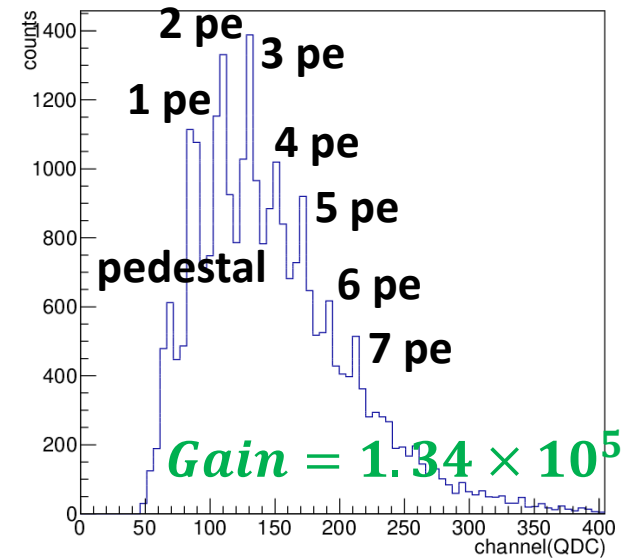


Hamamatsu S12571-010P

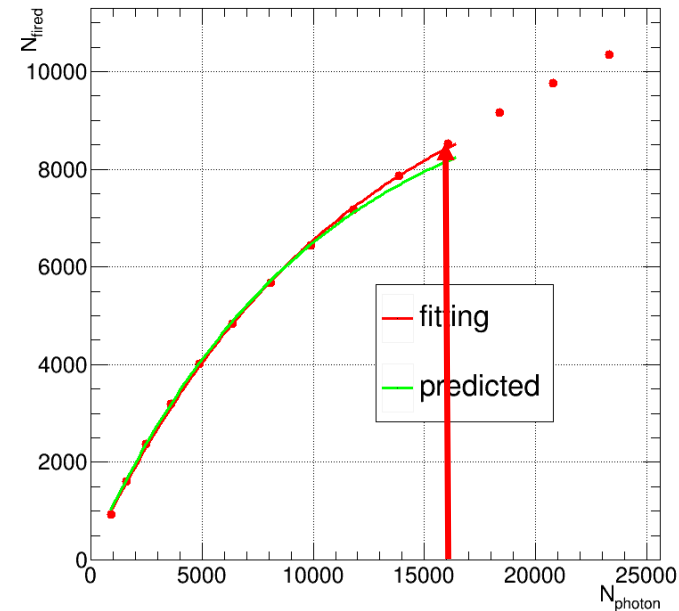
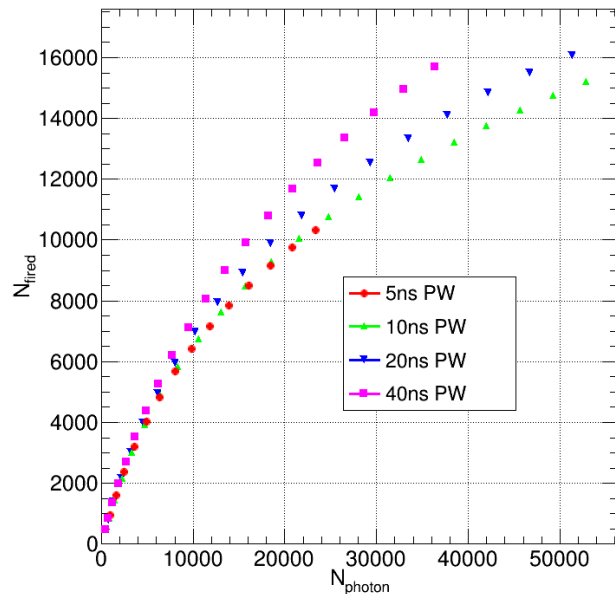
- Area: $1\text{mm} \times 1\text{mm}$
- Size: $10\mu\text{m}$
- Pixels: 10K



single photon distribution

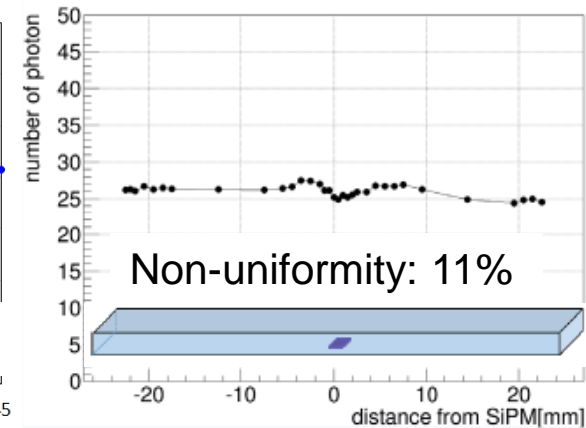
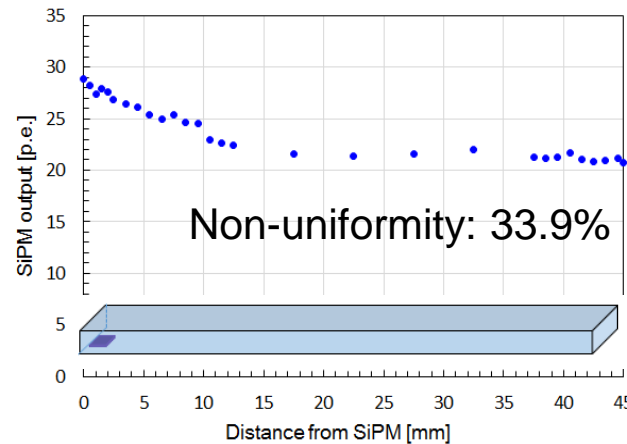
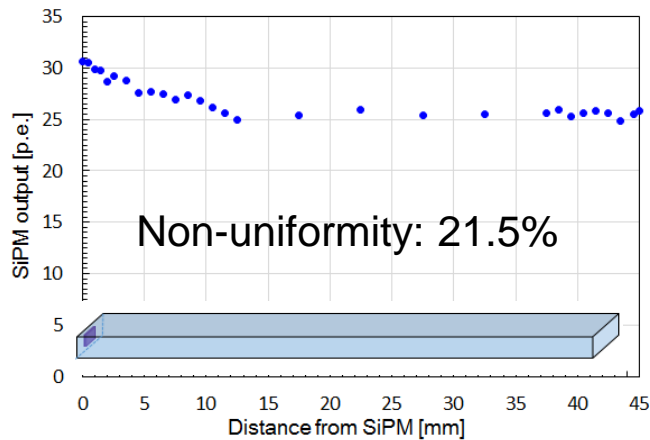


5ns PW

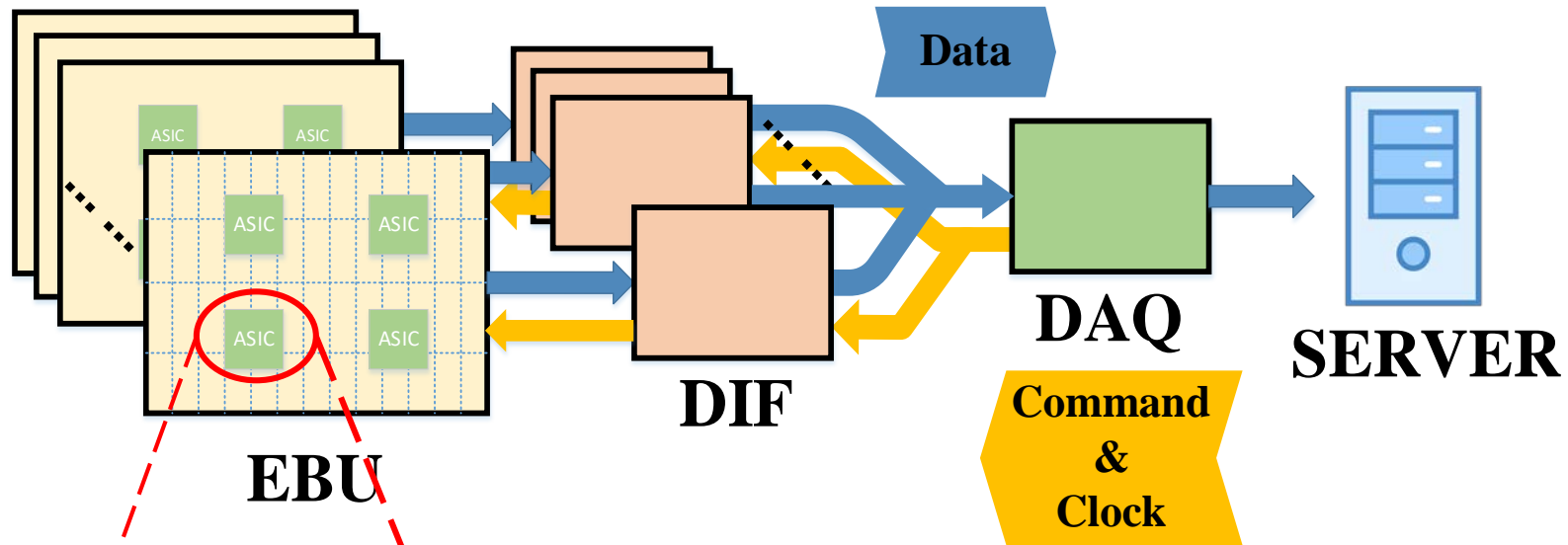


- As the photon width increases, SiPM effective pixels also increase
- SiPM response can be described well with the theoretic formula
- Through correction SiPM dynamic range can up to **16,000** photons with less than 1% error with 10k pixles

Scintillator Uniformity



- Three classes coupling mode i.e. side-end, bottom-end and bottom-center
- Light outputs along the length of the scintillator strip is non-uniformity, degrades the energy resolution
- Bottom-center coupling have the minimum non-uniformity
 - Avoiding the dead area between scintillators
 - Simplifying scintillators assembling process
 - Enabling to extend the SiPM area with more pixels



see more @ Shensen's Talk

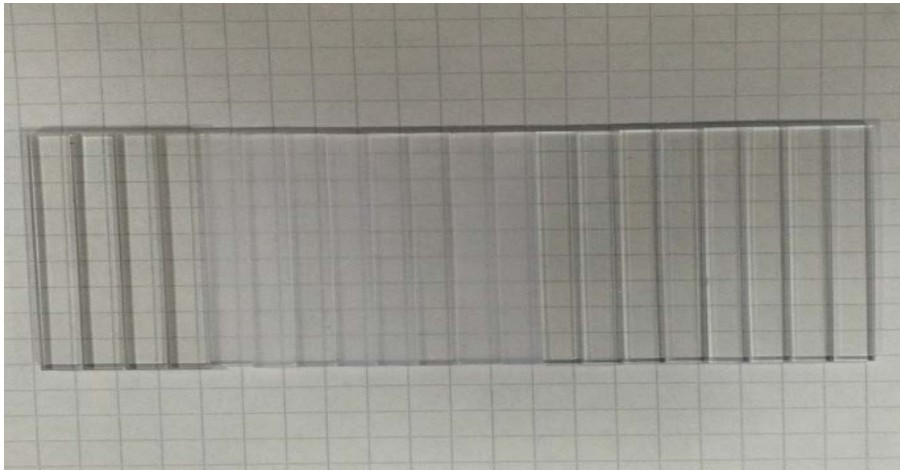


- 36 channels
- Charge measurements: ~2000 dynamic range
- Power Consumption: ~7mW/Ch (@no idle)
- Time measurements: ~100ps
- Bias voltage adjustment online

Single Layer Prototype



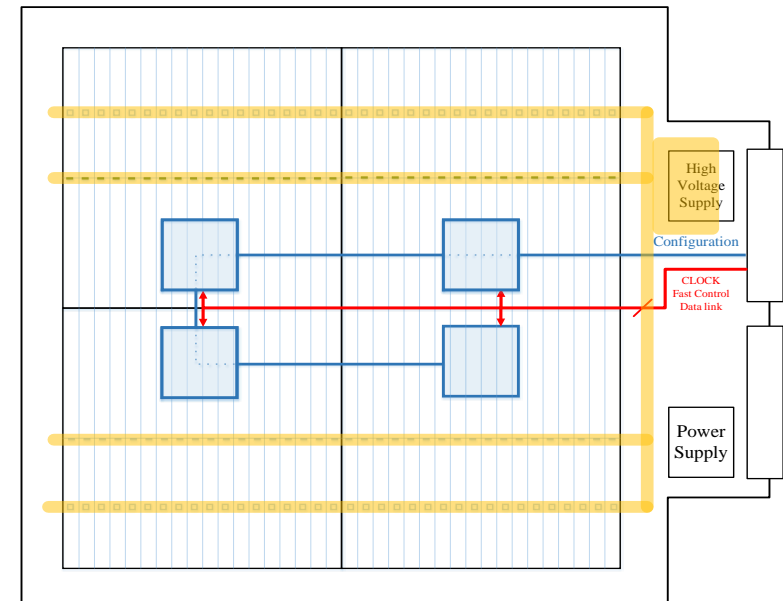
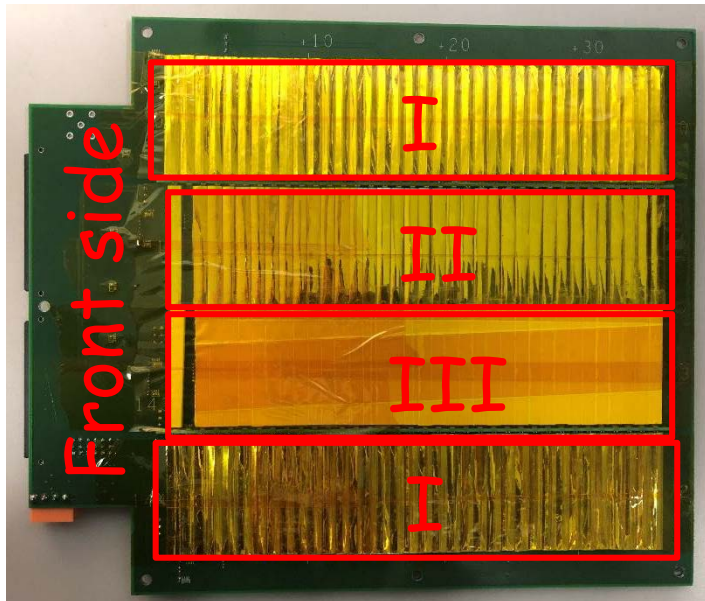
- 4 SPIROCs ASIC consist one EBU
- $18\text{cm} \times 18\text{cm}$ one EBU with 144 scintillator strips
- Scintillator strips are processed and wrapped in the Shanghai institute of Ceramics (SIC)



Single Layer Prototype



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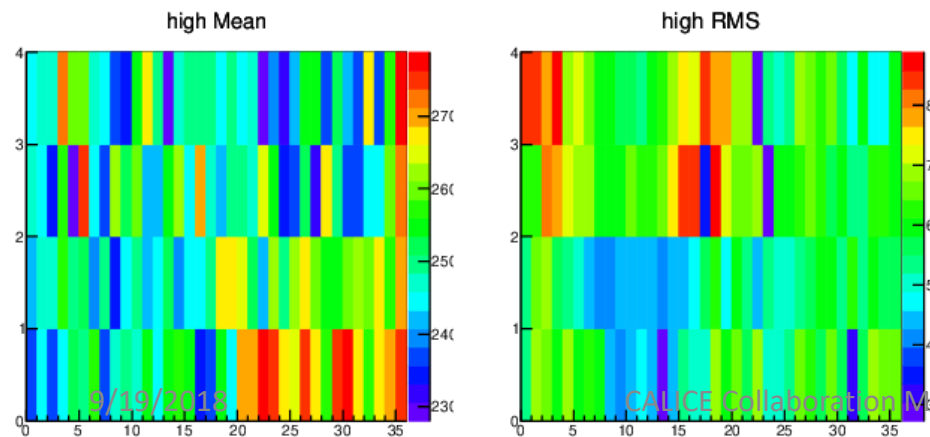
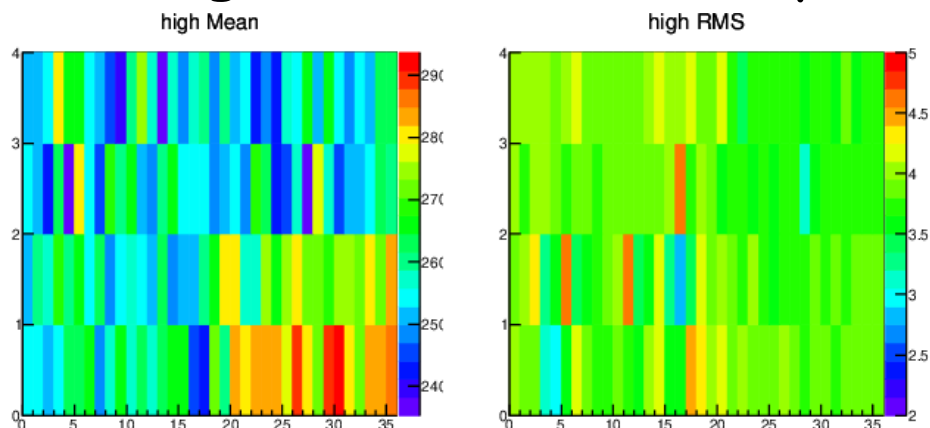


- Single layer prototype for the study of modules layout, integration, preliminary performance
- 144 modules of scintillator strip coupling with SiPM
- Half are bottom-center embedded coupling mode and wrapped with ESR (**I**)
- The other half are side-end coupling mode and scintillators wrapped with ESR(**II**) or Teflon(**III**)

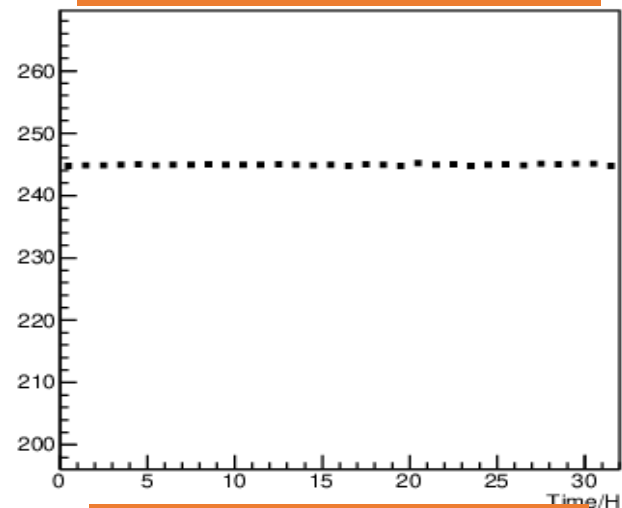
EBU Performance



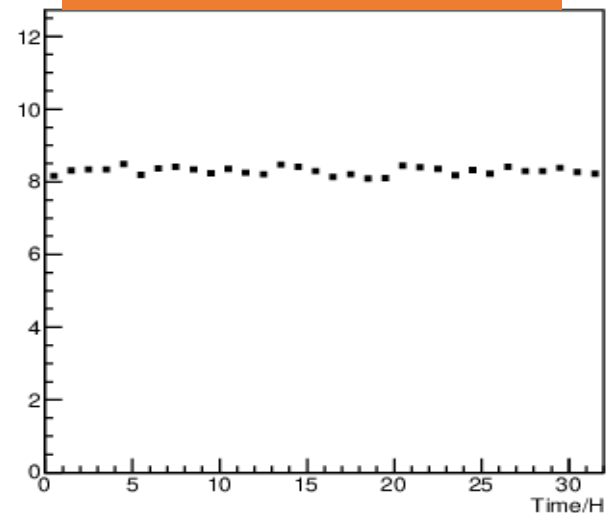
- Working in high gain mode
- SiPM without H.V.
- SiPM with H.V.
- Long time work stability



Mean value of High Gain



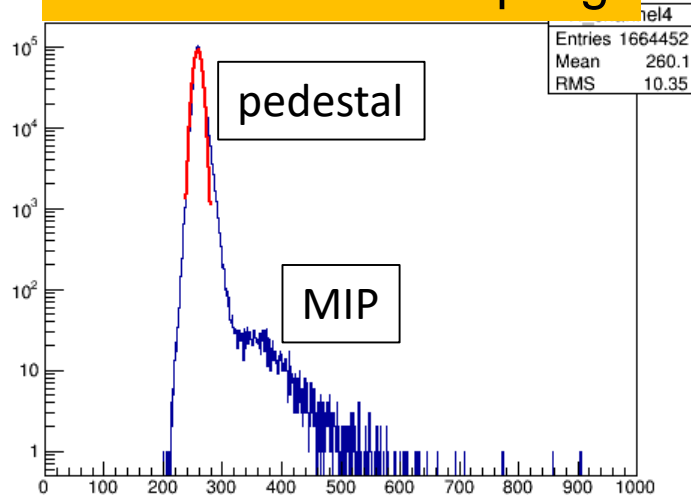
RMS value of High Gain



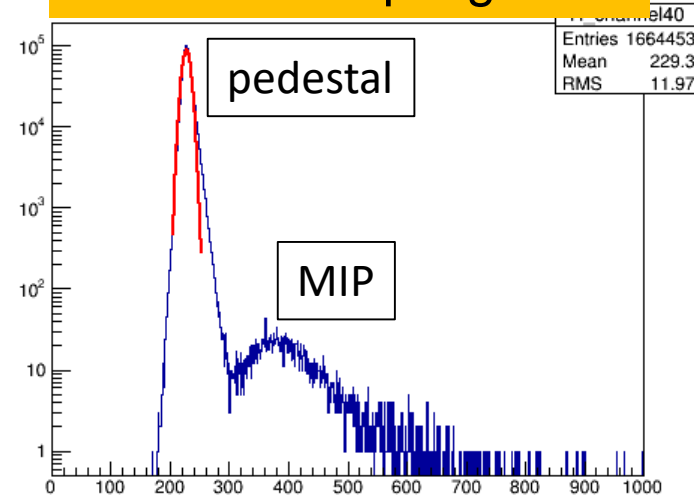
Cosmic Ray Test



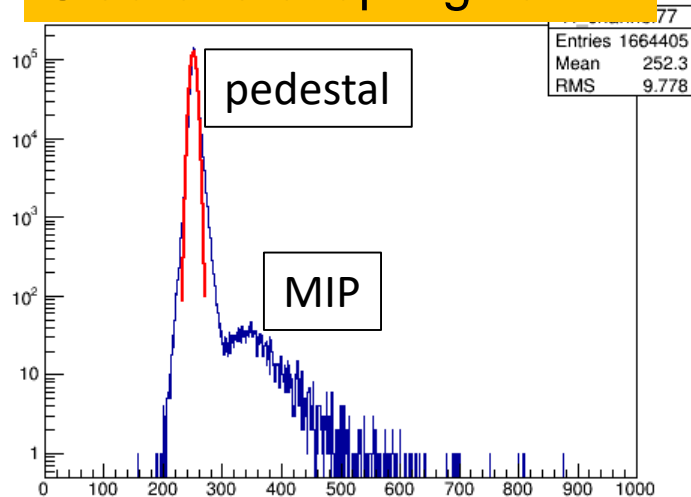
Bottom-center coupling



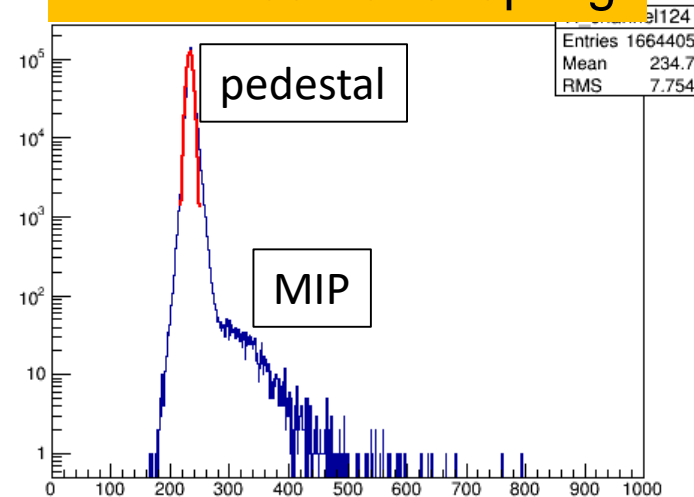
Side-end coupling ESR



Side-end coupling Teflon



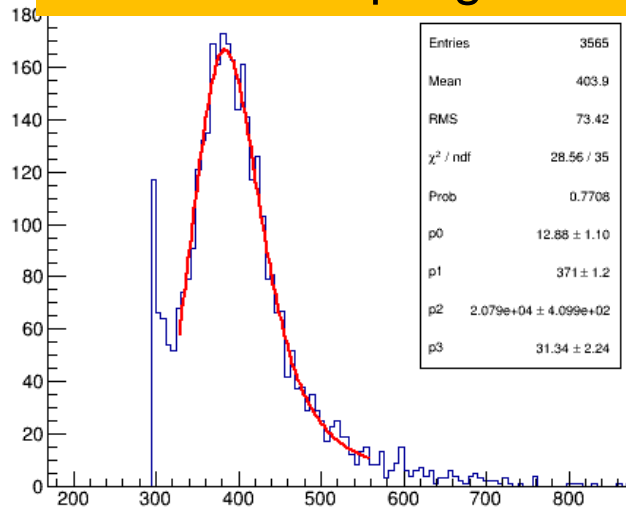
Bottom-center coupling



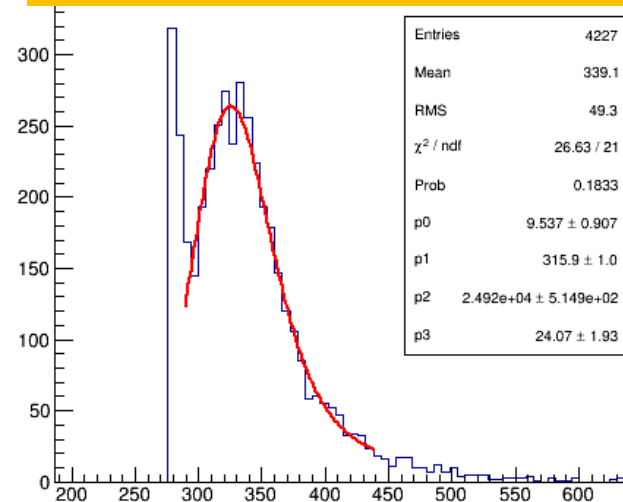
Cosmic Ray Test



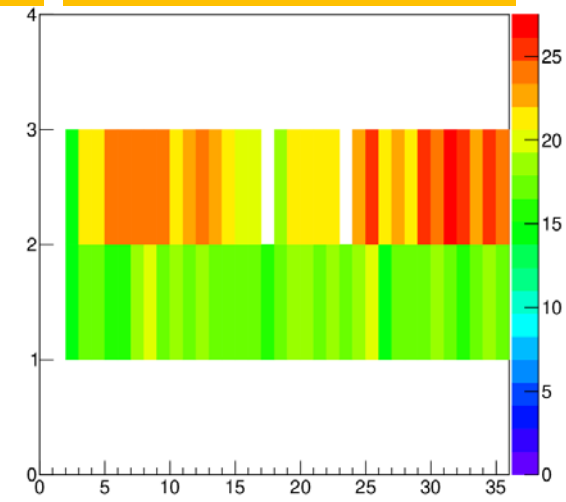
Side-end coupling ESR



Side-end coupling Teflon



Signal noise ratio



- Side-end coupling can separate pedestal and MIP well both wrapped with ESR and Teflon
- Signal noise ration is larger than 10 for all channels except two channels
- Wrapped with ESR's signal larger than wrapped with Teflon's



- Improving the LY of grooved scintillator strips
- Developing another EBU with SP2E ASIC and validating which coupling mode in 2018
- Completing 30 layers physical prototype assembly in 2019
- Developing software algorithm for strips to achieve effective $5\text{mm} \times 5\text{mm}$ position resolution
- Performing beam test about mid-2020???
- Analysis beam test data

- Achieved SiPM response function for nonlinearity correction
- Proposed bottom-center coupling mode to improve uniformity of scintillator strip light output
- Assembled single layer prototype and obtained preliminary cosmic ray test results
- Great progress has been made, but much more needs to be done

Thanks for your attention!

backup

