Study of SiPM dynamic range of ECAL

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Abstract:

CEPC-ECAL is designed based on the Particles Flow Algorithm (PFA) which requires the ECAL's position resolution better than 5mm. SiPM can be used as CEPC-ECAL photon sensor with small size and large dynamic range. A advanced study about SiPM saturation response in high photon range will be presented. Electronics based SP2E ASIC dynamic range can satisfy the ECAL required also be validated. A very preliminary digitization in simulation have been programmed base on the CEPC-software Simplify Geometry with $H \to \gamma\gamma$ process. SiPM saturation would have non-trivial influence on the invariant-mass reconstruction, especially for heavy mass particles.

SiPM or MPPC

Hamamatsu S12571-010P

- Area: $1mmm \times 1mm$
- Size: $10um$
- Pixels: $10K$

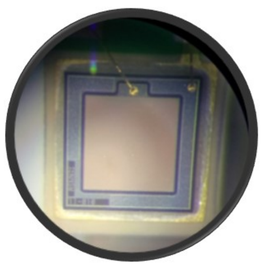
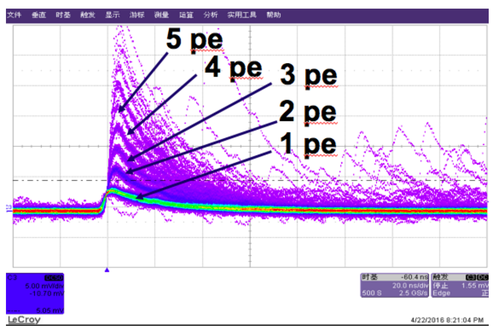


Fig 1. An actual matrix of MPPC microcells



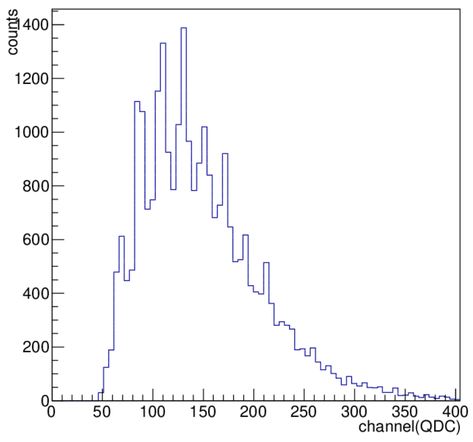


Fig 2. Single Photon-electron Spectrum (SPS)

Saturation Curve

- Study SiPM saturation curve with different photon width LED

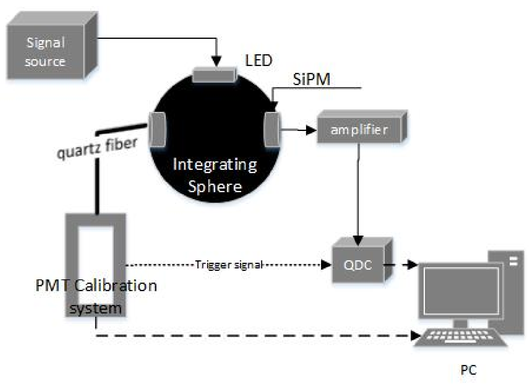


Fig 3. Scintillation emission spectrum

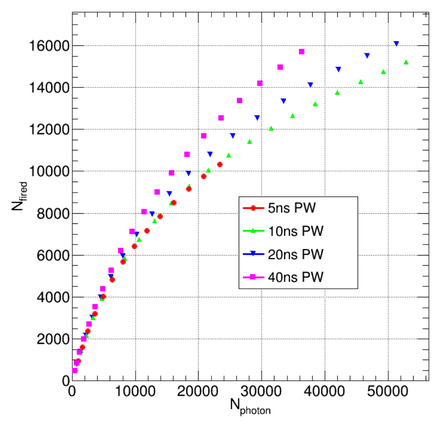
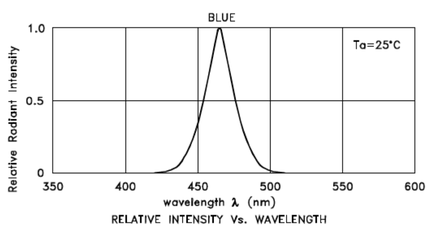
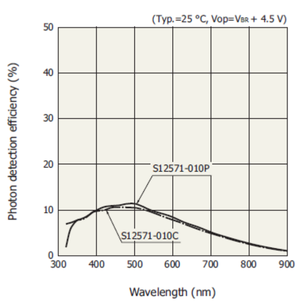


Fig 5. SiPM output with different PW





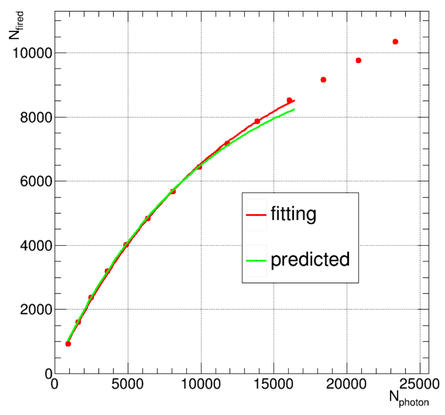


Fig 6. Fit saturation curve with theoretical function

Fig 4. SiPM PDE vs. wavelength and LED spectrum

Compares:

- ✓ SiPM output almost identical when PW is small than 10ns
- ✓ SiPM signal would increase with the PW increase when PW large than 10ns for same photons number
- ✓ SiPM saturation curve fit well with theoretical function

Readout with SP2E

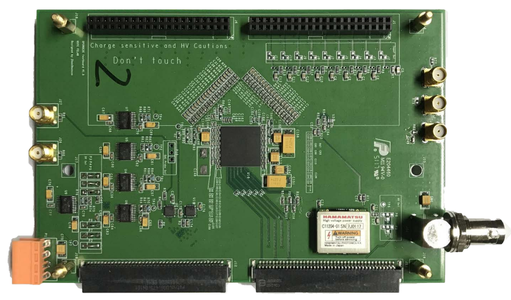


Fig 7. Single SP2E electronics

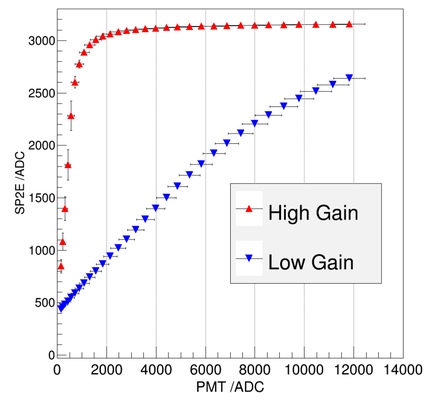


Fig 8. Readout SiPM with SP2E

- ✓ 5ns LED photon width pulse through Integrated Sphere
- ✓ SP2E dynamic range is about 2000 satisfied ECAL required
- ✓ Saturation curve of SiPM should be used to correct non-linearity

$$e^-e^+ \to ZH \to \nu\nu\gamma\gamma$$

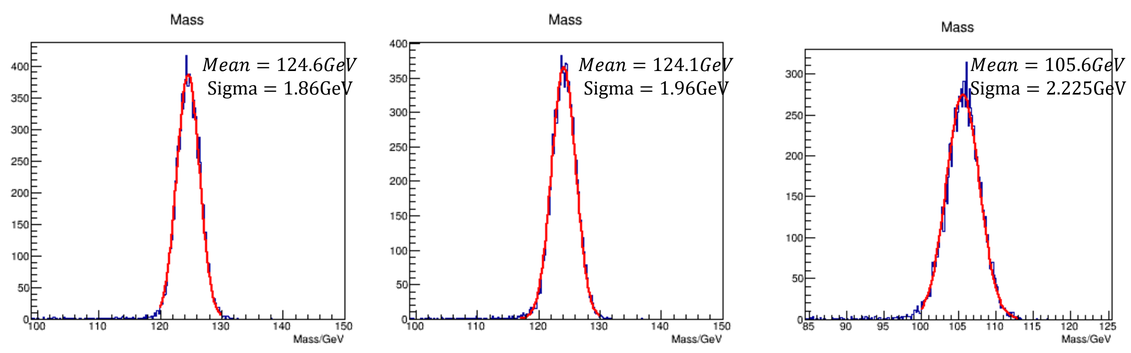


Fig 9. Reconstruction $H \to \gamma\gamma$ invariant mass in the simplify geometry based on the CEPC-software Left: reconstruction with Arbor Center: program digitization with linearity SiPM response Right: mix SiPM saturation curve from test result with LED without correction

Conclusion

- ➢ SiPM as one new photon-counter detector has been studied with LED
  - ➢ Measuring the single photon can estimate the gain
  - ➢ Studying the output linearity with different photon width
  - ➢ Fit SiPM saturation curve with theoretical function well
- ➢ Readout SiPM with SP2E ASIC electronics
  - ➢ Validated the dynamic range is satisfied
  - ➢ Non-linearity will present in high light range for low gain mode
  - ➢ SiPM saturation curve correction can expand the dynamic range
- ➢ Reconstruction Higgs invariant mass in simulation
  - ➢ Invariant-mass sigma will increase 5% with linearity SiPM response
  - ➢ SiPM saturation have non-trivial influence on the invariant-mass

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