# Studies of a Large Dynamic Range SiPM Readout ASIC MPT2321-B

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## Introduction

**Future Higgs Factory: Circular Electron Positron Collider (CEPC)**

- Boson Mass Resolution (BMR) 3%~4%: stringent requirements on calorimeters

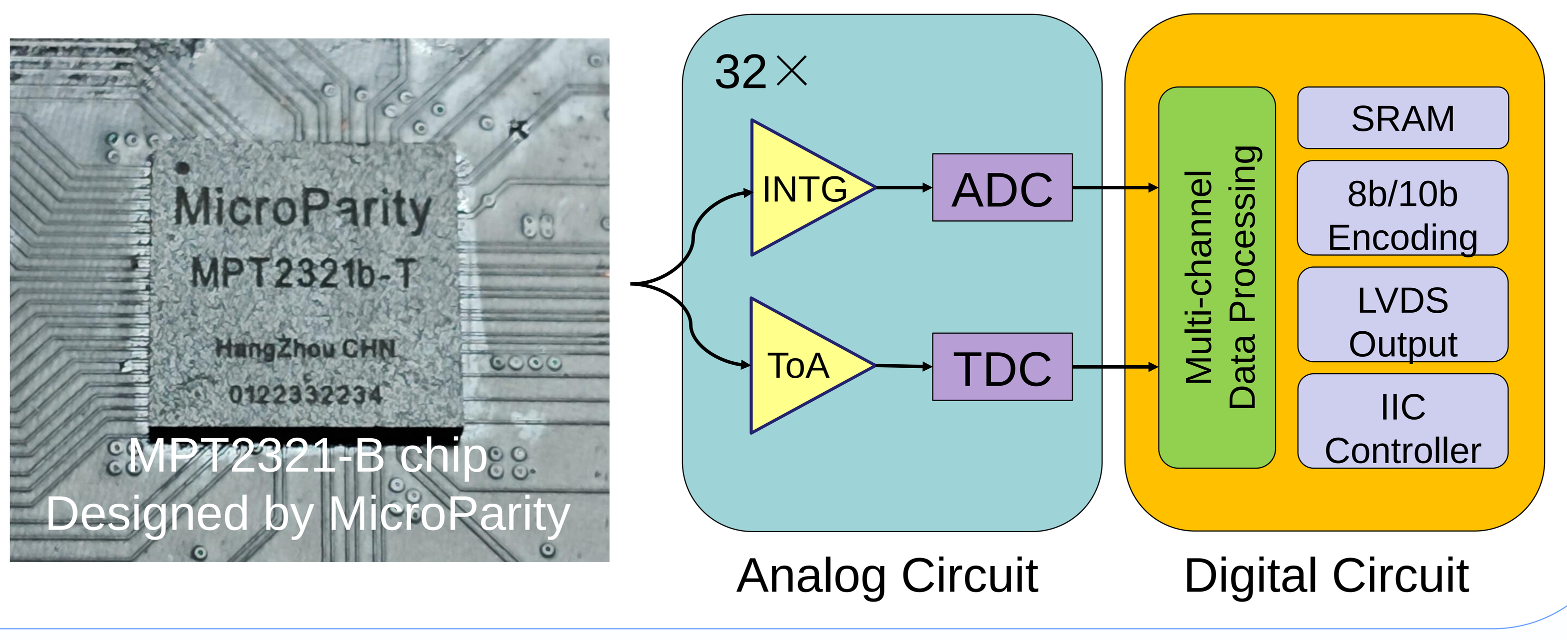
**Novel high-granularity crystal ECAL: orthogonally arranged crystal bars**

- 5D calorimetry, optimal EM energy resolution $\sim 3\%/\sqrt{E}$
- Critical requirements on dynamic range: detecting up to ~$10^5$ level photons

**Electronics candidate with large dynamic range: MPT2321-B**

- 32-channel readout, 12-bit ADC and 20-bit TDC per channel
- Large dynamic range: nominal design value 1.8 nC
- Lab/beam experiments to study functionality/performance

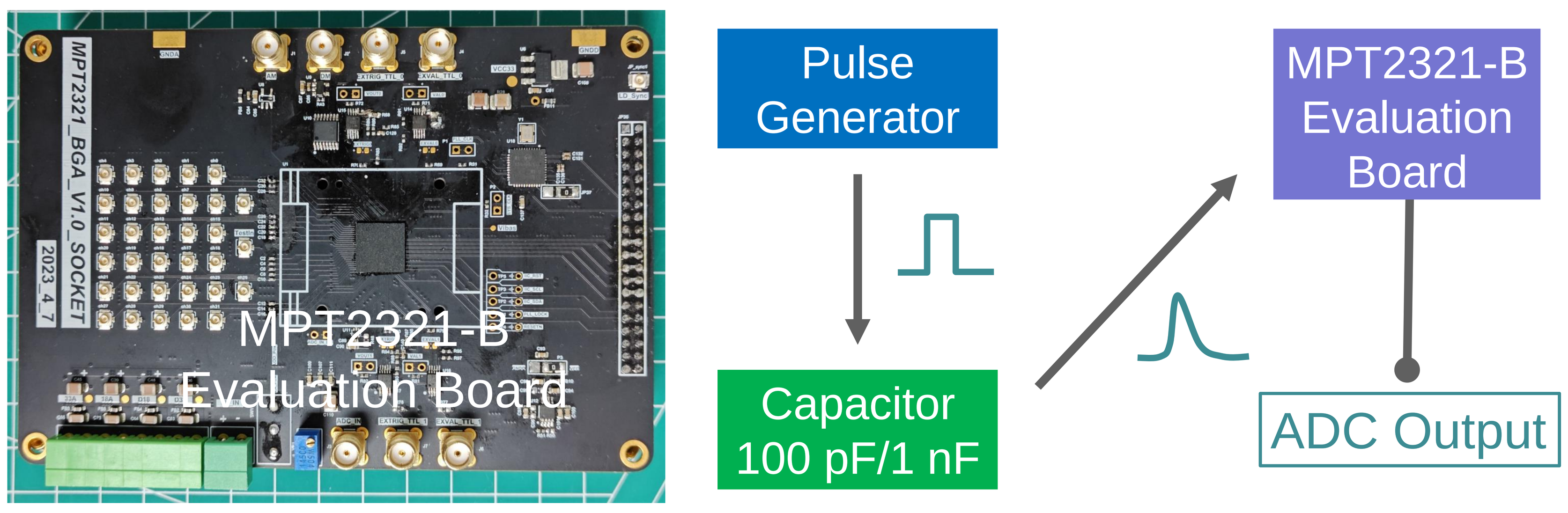
*Talk on high-granularity crystal ECAL: CALOR 2024 Session Future Colliders 2*



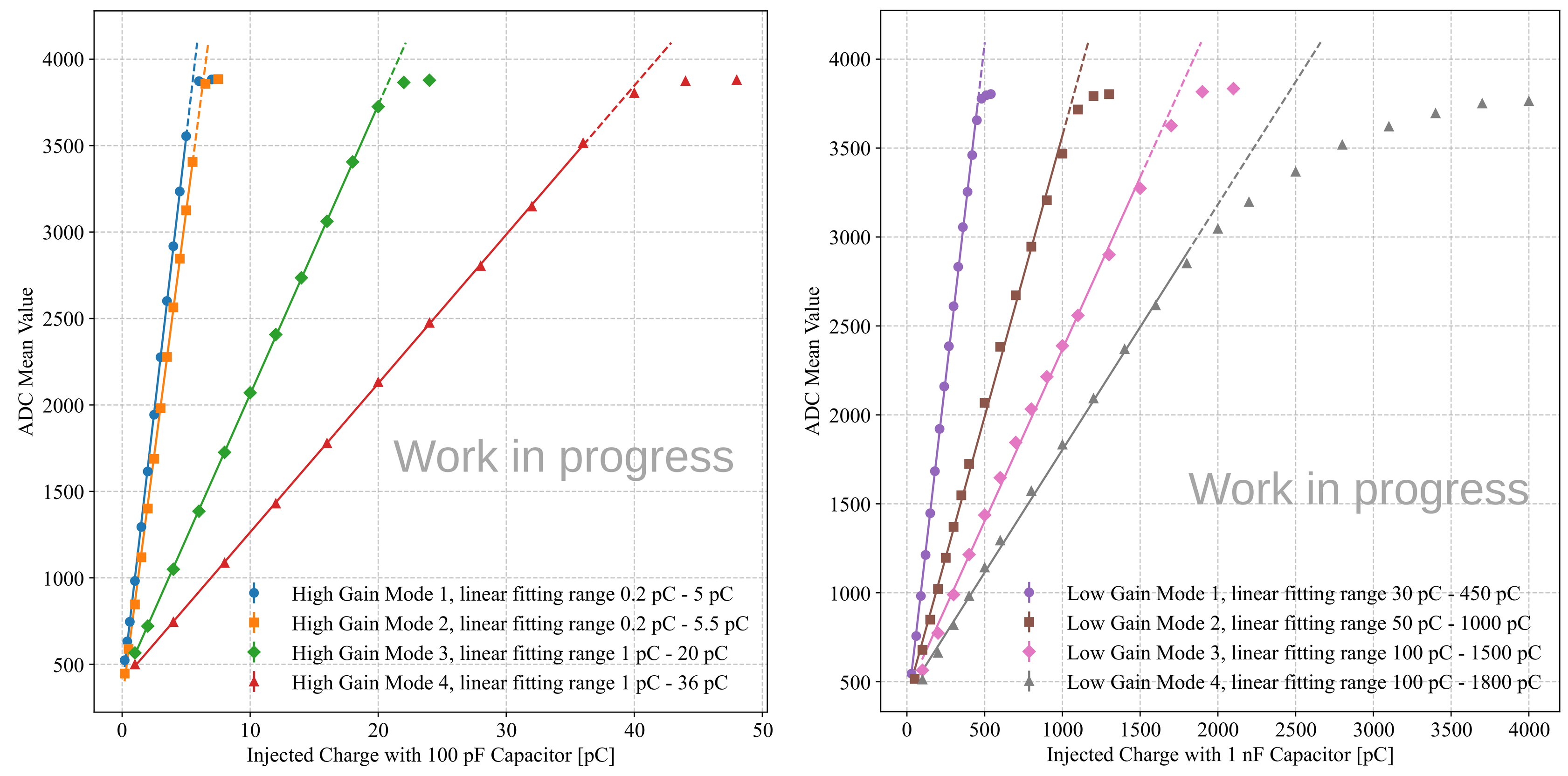

## Lab Characterization

**MPT-chip response linearity with charge injection**

- Determining the linear range of the chip with an evaluation board
- 4 high gain modes and 4 low gain modes were tested

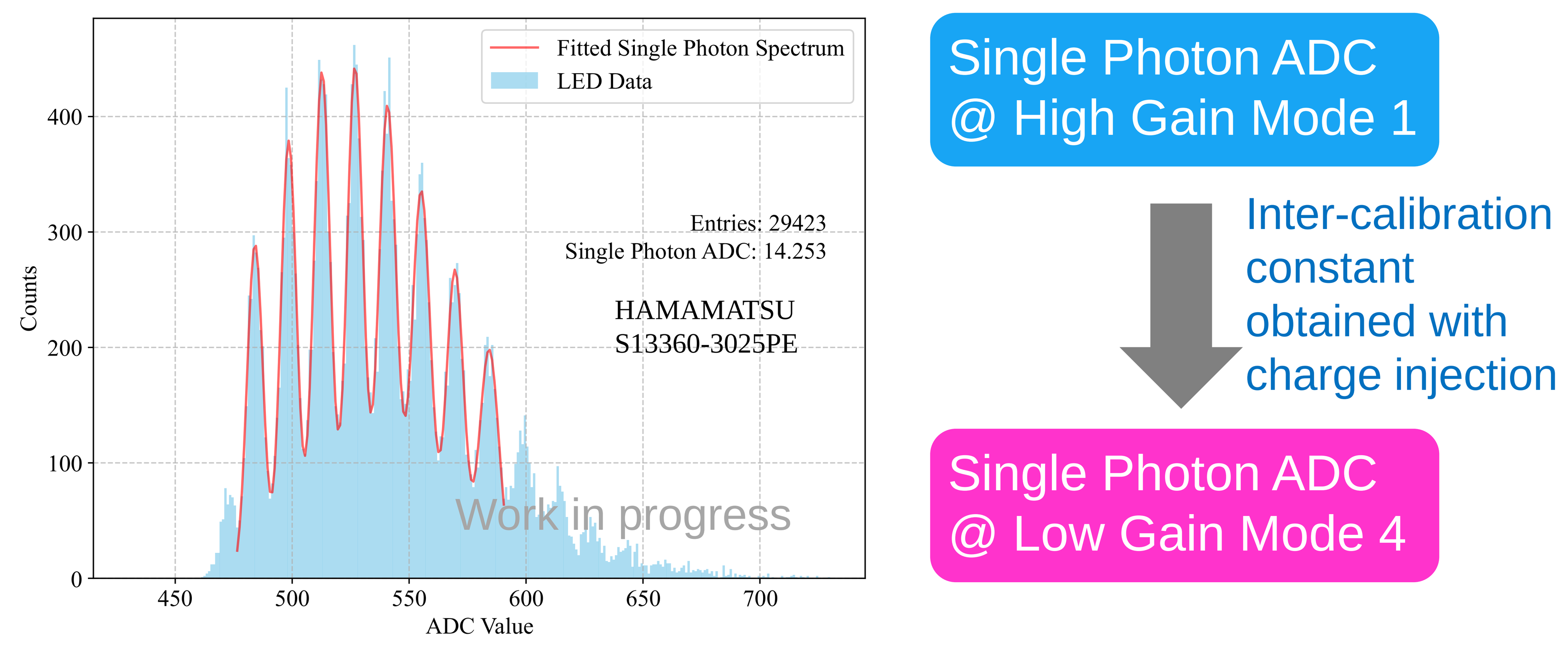



- Excellent linearity with high gain modes
- Low gain mode 4 has the largest dynamic range but also observed non-linearity effects
- With 1 nC capacitor, the maximum linear range reaches up to 1.8nC




**Single Photon Calibration**

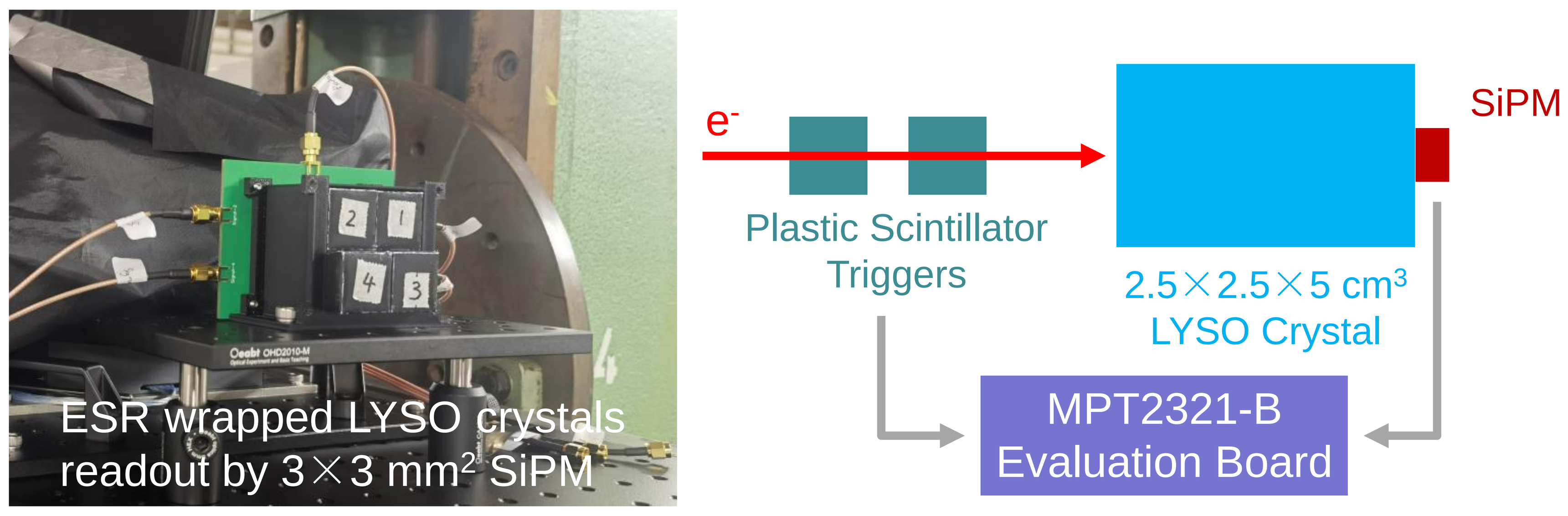
- LED tests with SiPMs: single-photon detection capability



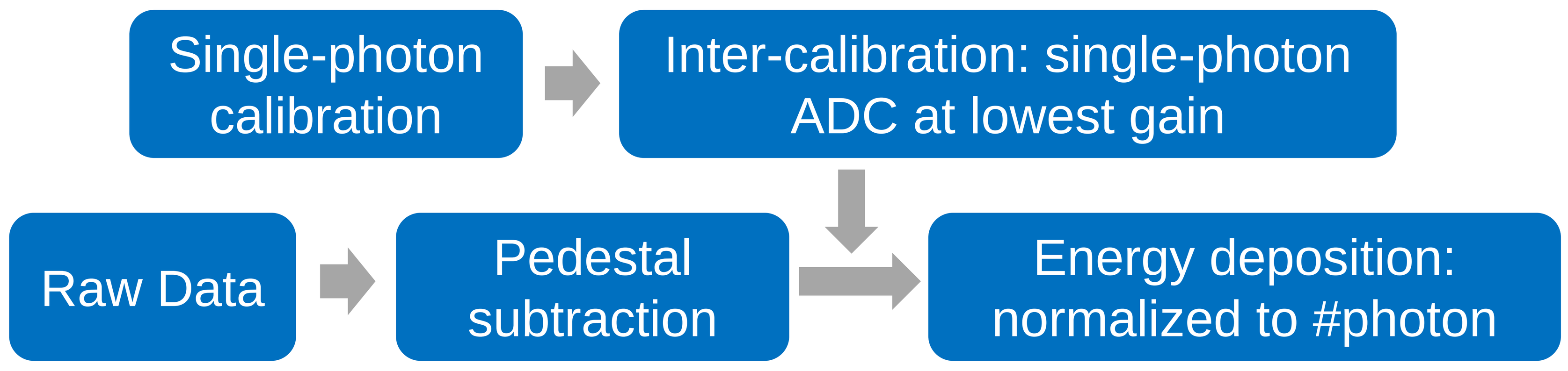

## Beam-test at DESY in 2023

**Beam-test: first test of MPT-chip with high energy particles**

- Dynamic range validation with crystal + SiPM units
- 5 GeV/c electrons hit on each one of a matrix of 4 LYSO crystals

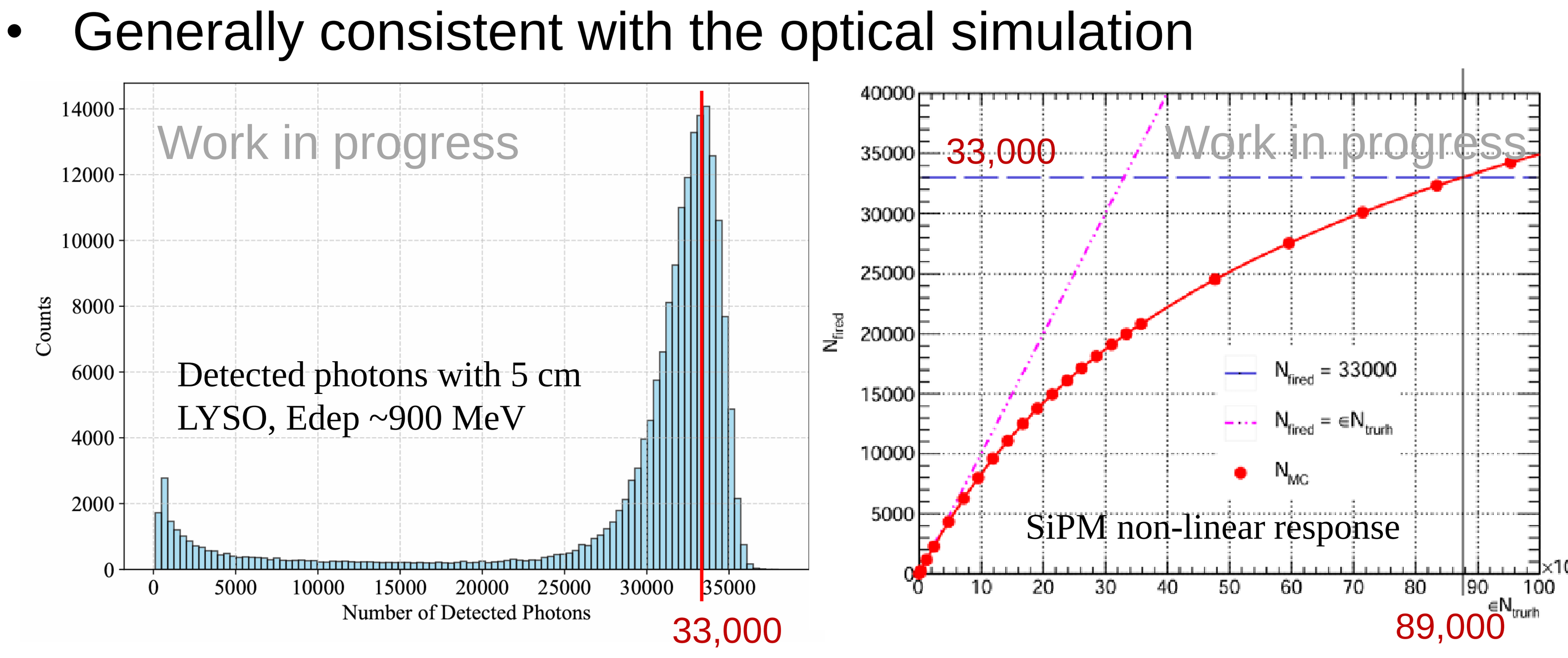



**Data analysis scheme**




**DESY beam-test results**

- Electron beam response: MPV ~33,000 detected photons
  - Not reaching the plateau of the ADC value
  - Very close to the non-linear region (over 3000 ADC channel)
- Geant4 optical simulation with a similar setup
  - Detected photons ~82,000 (w/o saturation effects)
- Toy Monte Carlo for SiPM saturation modelling
  - Around 89,000 input photons for 33,000 detected photons
  - Generally consistent with the optical simulation




**Further discussions**

- For SiPMs used with 7×$10^5$ gain: 33,000 photons → 3.7 nC charge
  - Note: The actual ADC is not simply equal to the input charge
  - Output depends on signal waveform, shaping time, hold-delay, etc.

## Conclusions

- Successfully conducted the laboratory and beam experiments of a new SiPM readout chip
  - Demonstrated good S/N for single photon calibration
  - Capability of detecting ~33,000 photons, shows a moderately large dynamic range for SiPM readout
    - Could be improved by utilizing SiPMs with lower gains, reducing shaping time, etc.
    - New features are expected in future chip iterations

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