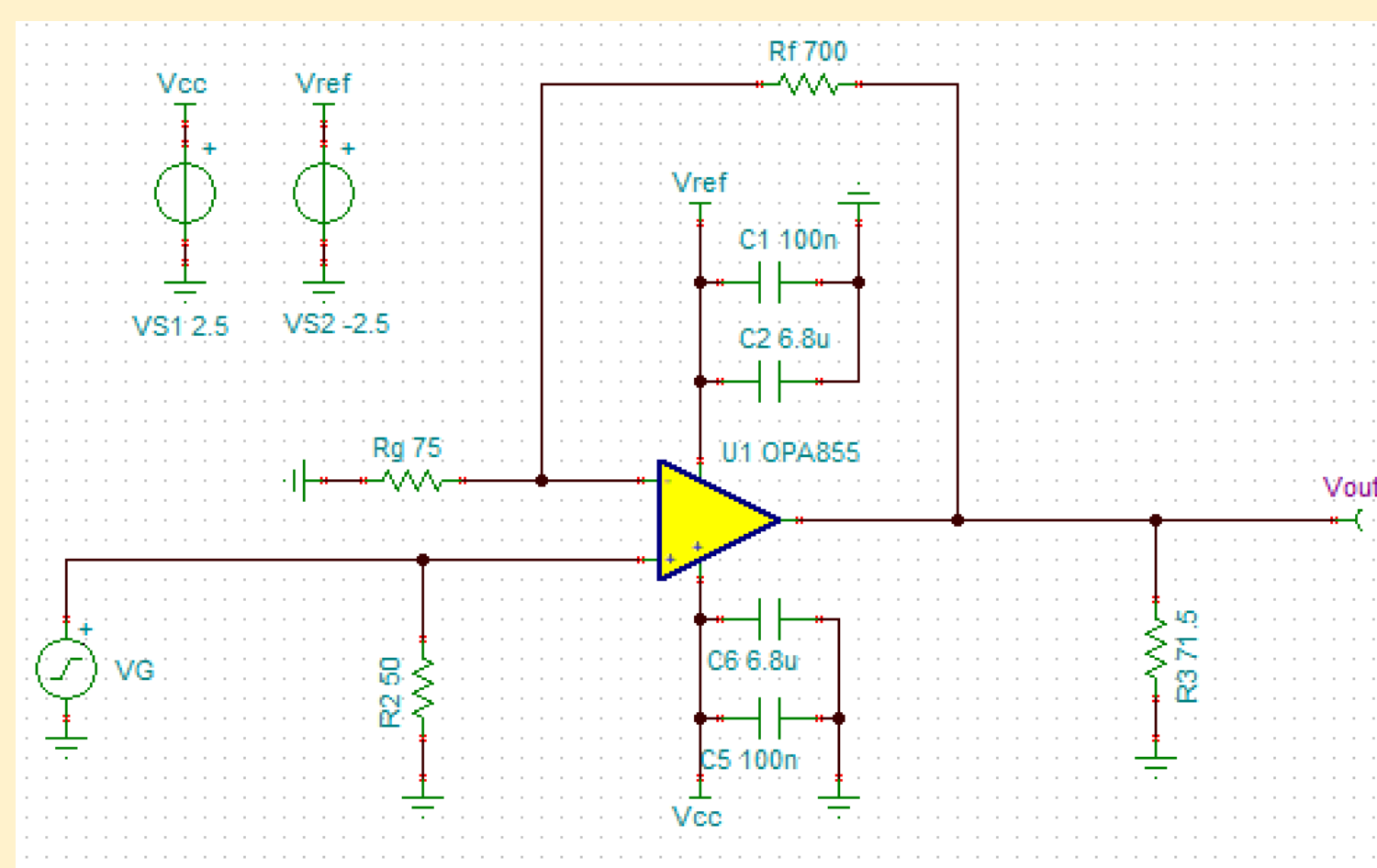


1. Introduction

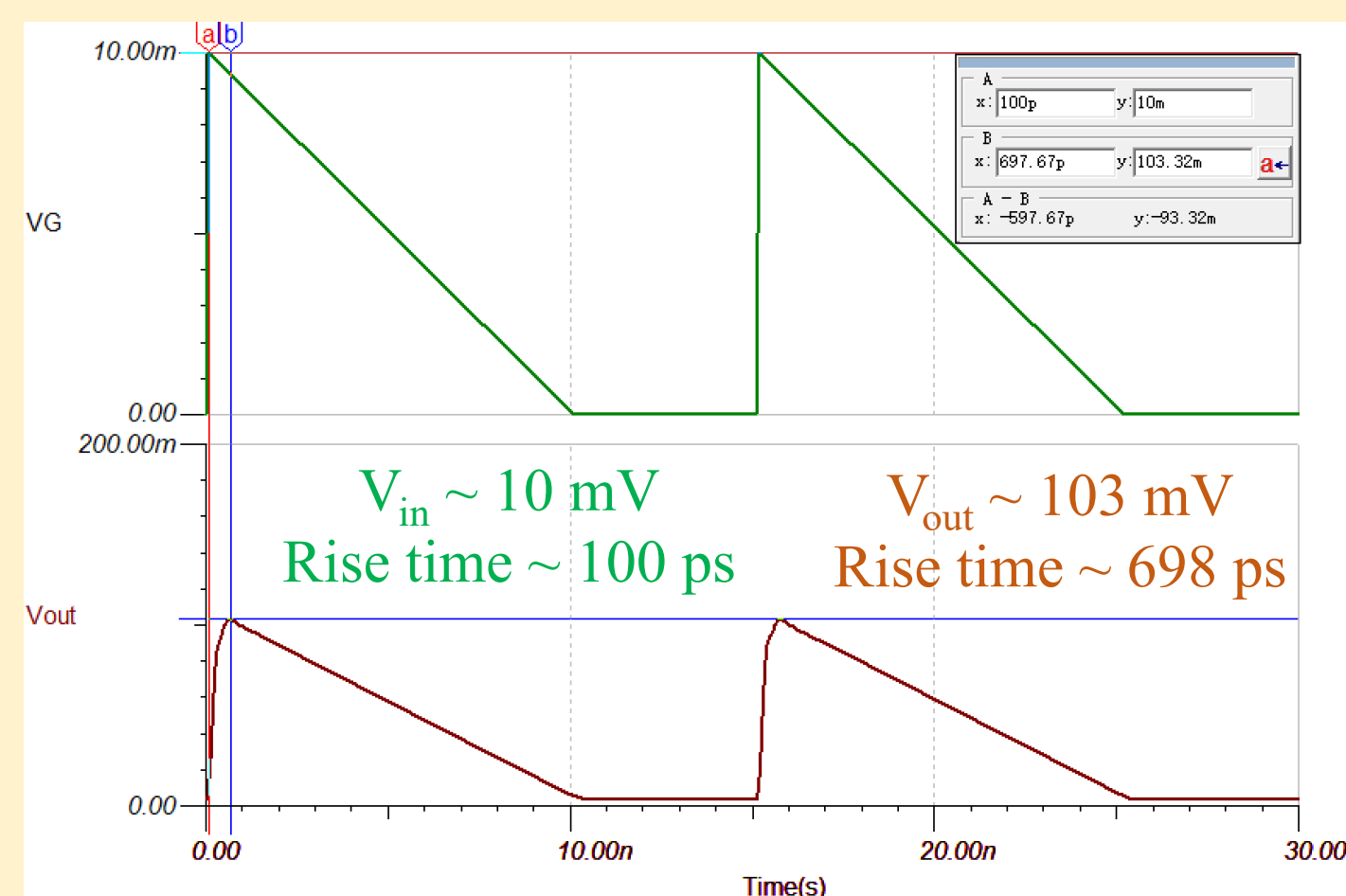
- Fast Silicon Photomultipliers (SiPMs) feature fast response and excellent time resolution (rise time $\sim 10^2$ ps, time resolution $\sim 10^1$ ps), showing great application potential in high energy physics, nuclear medicine instruments and space astronomical detection, etc.
- A fast-timing amplifier circuit board based on OPA855 has been designed, which was used to evaluate time performance of three types of SiPM (NDL, Hamamatsu and SensL)
- This preliminary study aims to promote the implementation of the Analog Hadronic Calorimeter (AHCAL) scheme based on SiPM readout in the Circular Electron Positron Collider (CEPC)

2. Design of fast-timing characteristics amplifier circuit boards

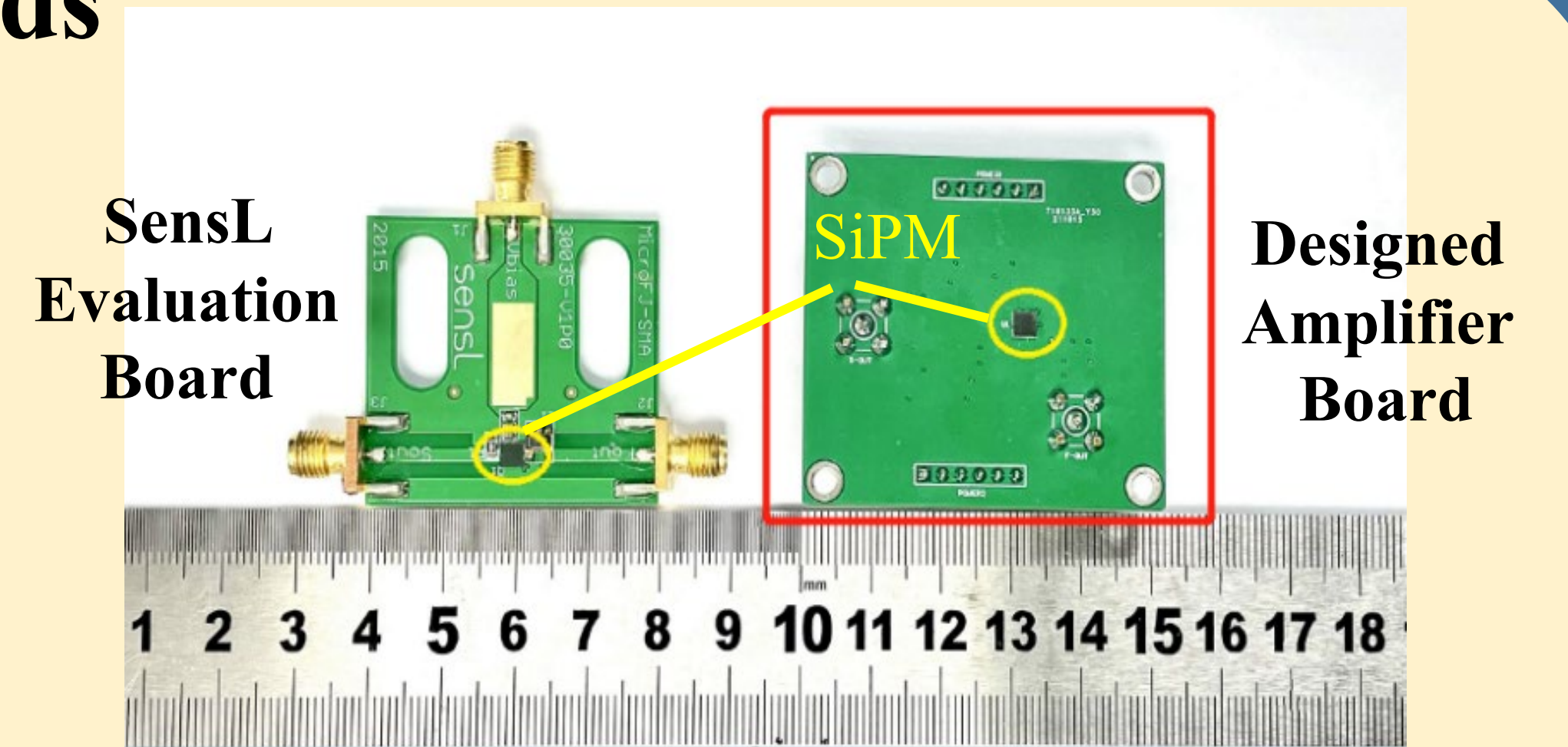
- OPA855 - broadband, low-noise operational amplifier with bipolar inputs for broadband transimpedance and voltage amplifier applications
- A TINA-TI simulation was used to design the amplifier circuit board



Schematic diagram of Simulation with OPA855 amplifier



Simulated input and output waveform

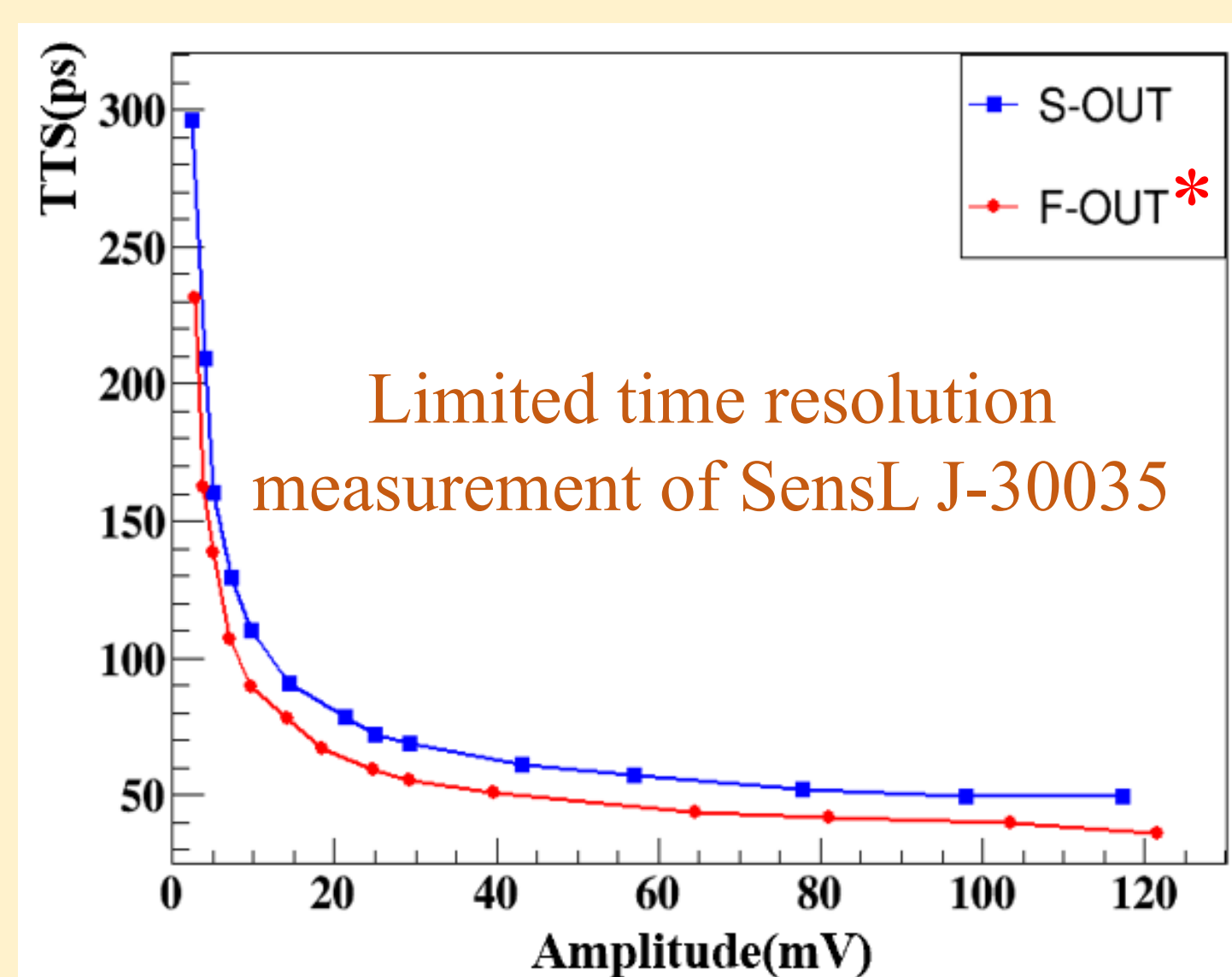
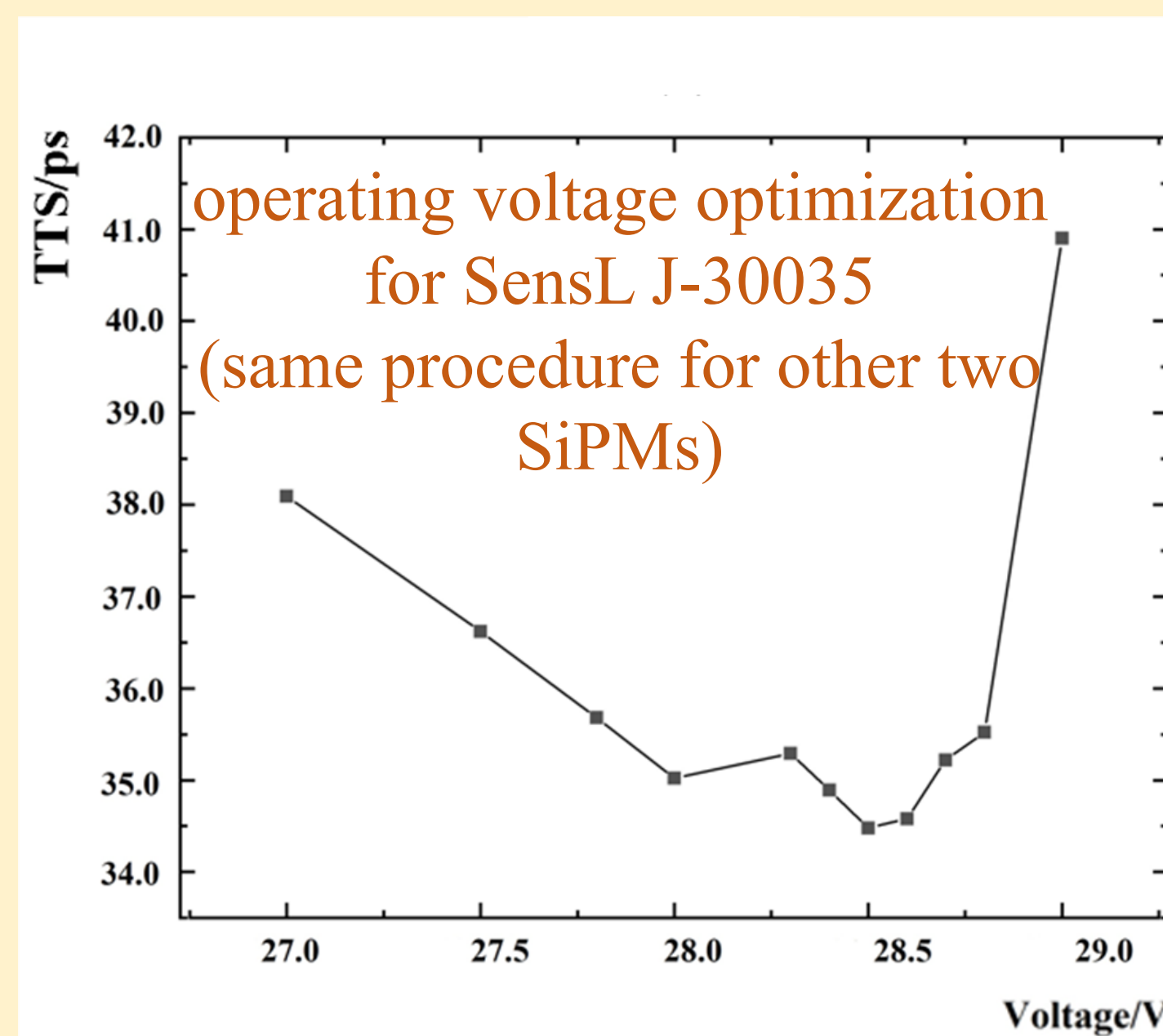


Simulated and measured parameter values for this designed amplifier board

Parameters	Gain	Noise [mV]	Bandwidth [MHz]	Power [mW]
Target Value	10	1	1000	50
Simulated Value	10.3	0.5	>1000	40
Measured Value	10.5	0.8	>1000	45

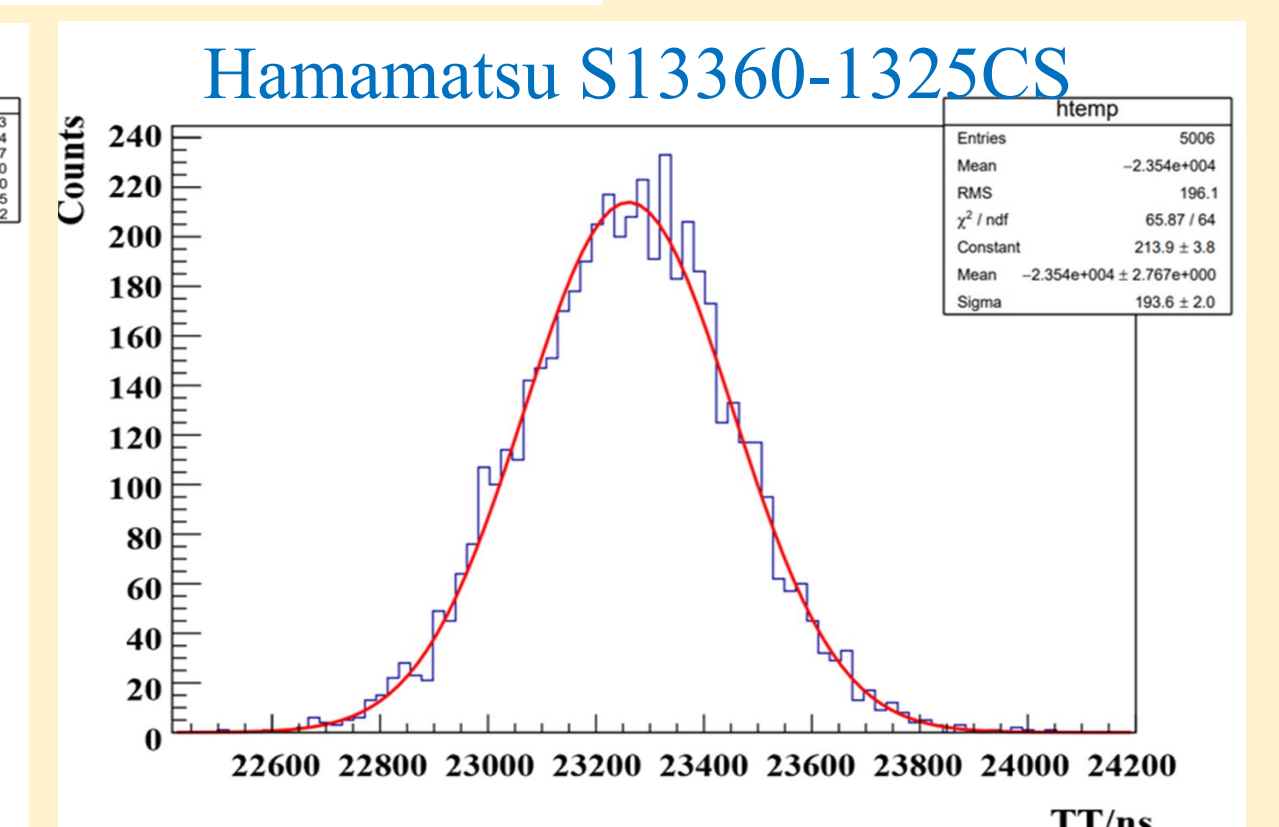
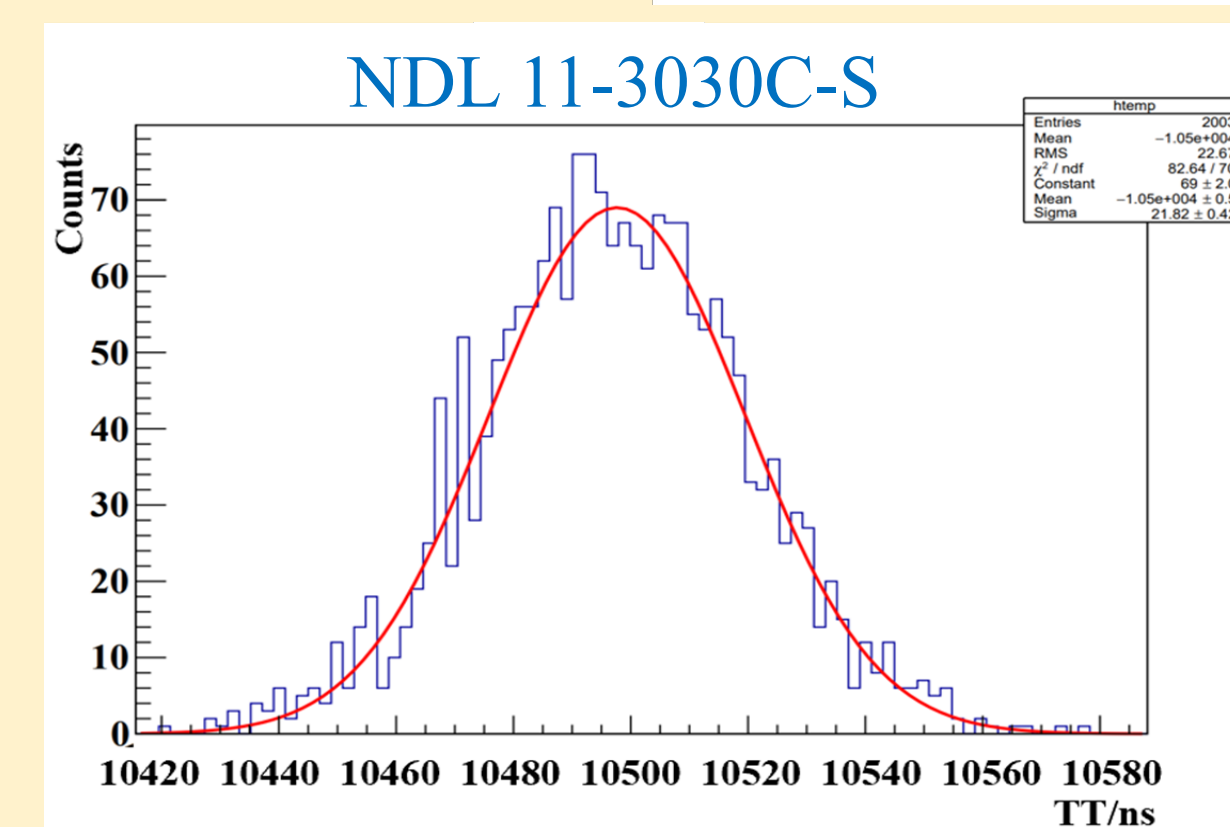
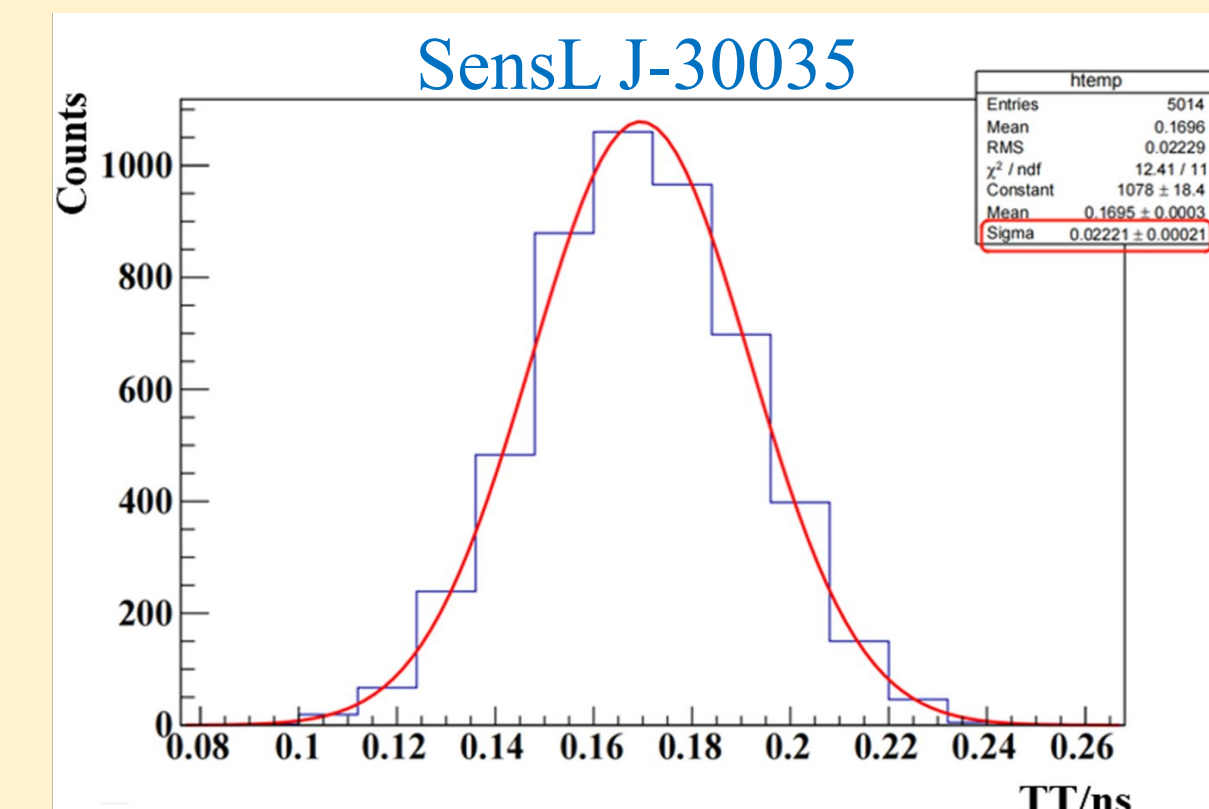
3. Timing characteristics test of fast SiPMs

- LD (400 nm) driven by a picosecond signal generator; sampling with HD oscilloscope (sampling rate 40 GS/s, bandwidth 4 GHz)
- Scanning the time resolution, here denoted as transition time spread (TTS), at different operating voltage to get optimized value
- The time resolution improves as output amplitude (i.e. light intensity) increases, and limited time resolution can be obtained



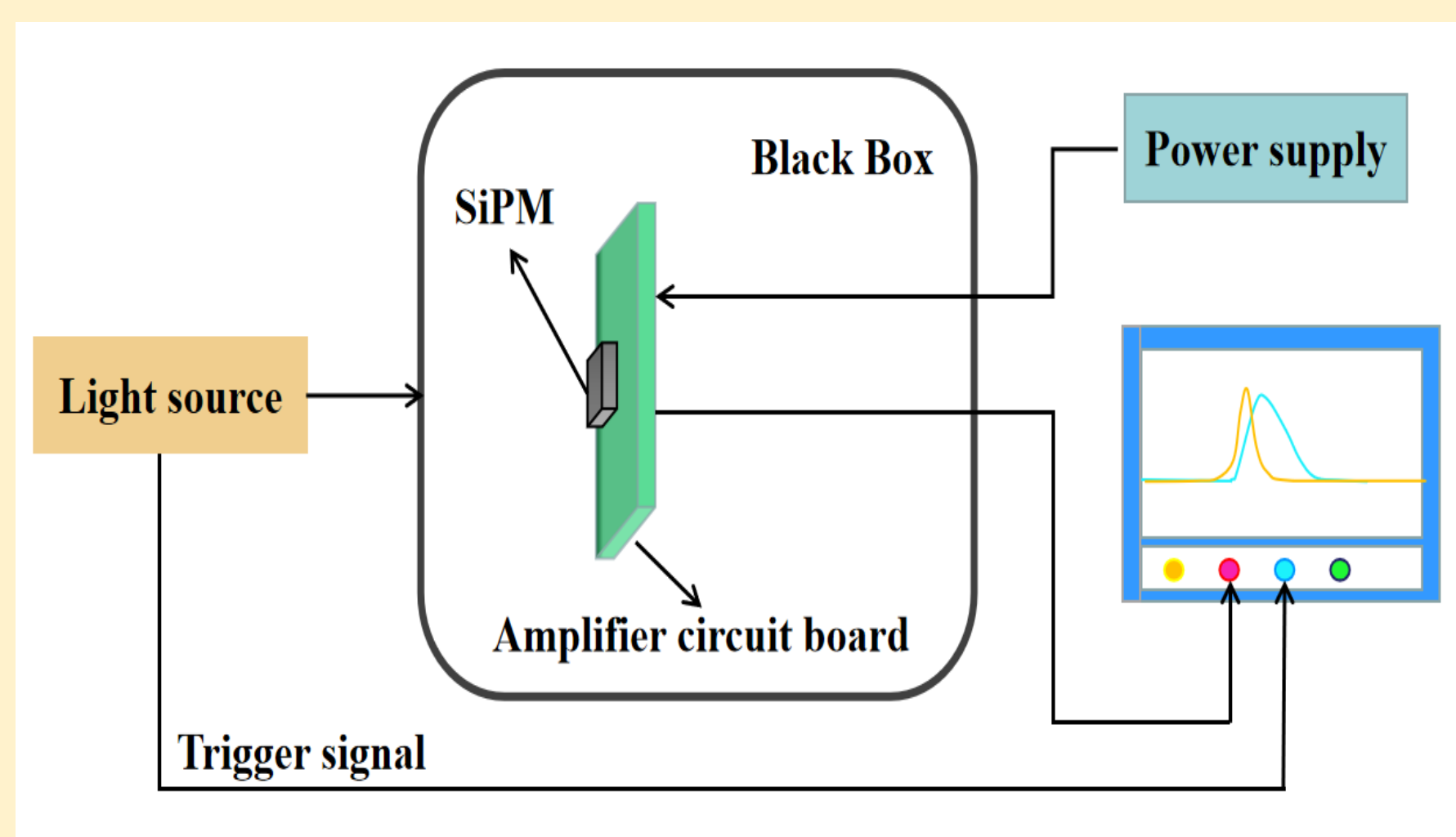
* The fast output port (F-OUT) of SensL J-30035 is designed for better time performance

- Limited time resolution of NDL 11-3030C-S, Hamamatsu S13360-1325CS and SensL J-30035 (fast output port) were measured



Measurement of limited time resolution and rise time at optimized voltage for the three type of SiPM

	SensL J-30035	NDL 11-3030C-S	Hamamatsu S13360-1325CS
Optimized Voltage [V]	28.5	41.0	58.0
Rise Time [ns]	~ 0.5	~ 1.5	~ 1.5
Limited Time Resolution [ps]	~ 22.2	~ 21.8	~ 193.6



Schematic diagram of the test system for time resolution

4. Conclusion

- A fast-timing amplifier circuit board based on OPA855 operational amplifier was designed, which is compatible with the SiPM from NDL, SensL and Hamamatsu and facilitate the time characteristic test
- Based on the designed amplifier, an excellent time resolution of ~ 20 ps can be obtained for NDL and SensL SiPMs, and the rise time can be as good as 0.5 ns for SensL SiPMs, having great potential in timing measurement.

Reference

- M. Yan et al., "Preliminary Study on the Timing Characteristics of a Fast SiPM for the TOF of the Beam Line in IHEP," in IEEE Transactions on Nuclear Science
- CEPC Study Group. (2018). CEPC Conceptual Design Report: Volume 2-Physics & Detector. arXiv preprint arXiv:1811.10545.