# A Detector Capacitance Compensation Technique for SiPMs

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## INTRODUCTION

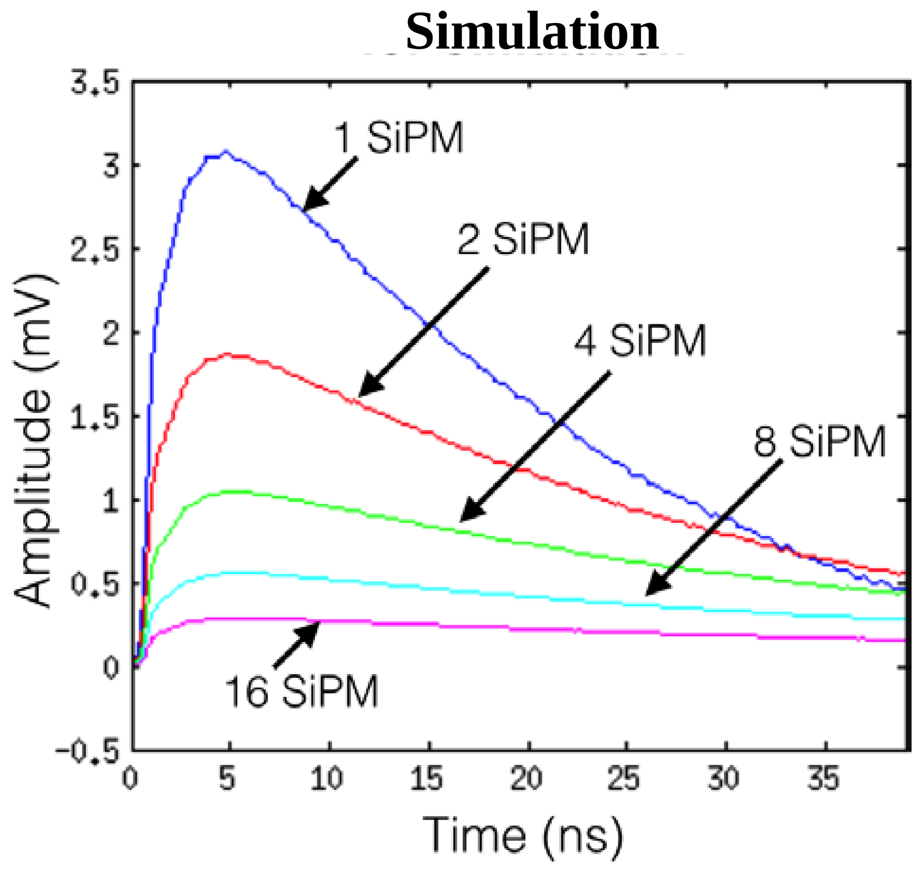
❑ **SiPM Applications : Need signal multiplexing for large detecting area**

- Radiation Monitoring system of Nuclear industry
- Medical instruments such as PET and SPECT
- High energy physics

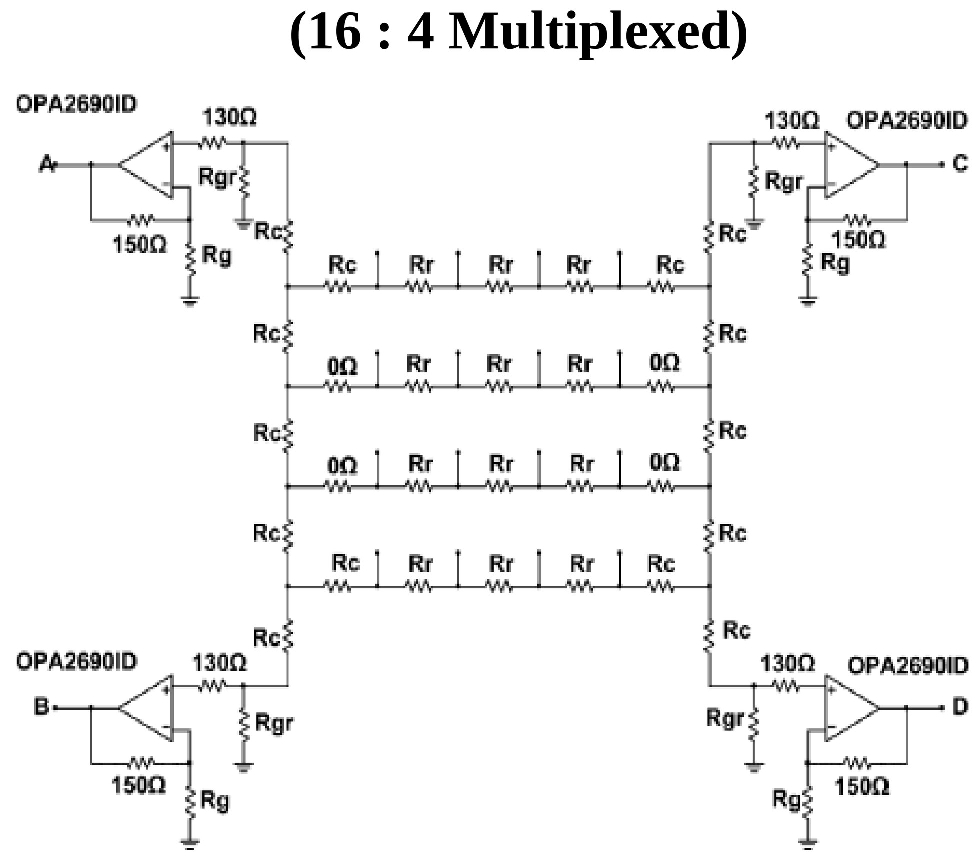
❑ **High capacitance of SiPMs: Amplitude degradation when many SiPMs are connected in parallel to a single channel of readout**

- Amplitude degradation [1-3]
- Traditionally, in order to mitigate the effect on high capacitance, signal distribution methods were proposed : A lot of CSA required [4]

**Single Micro-Pixel Pulses for Simulation**



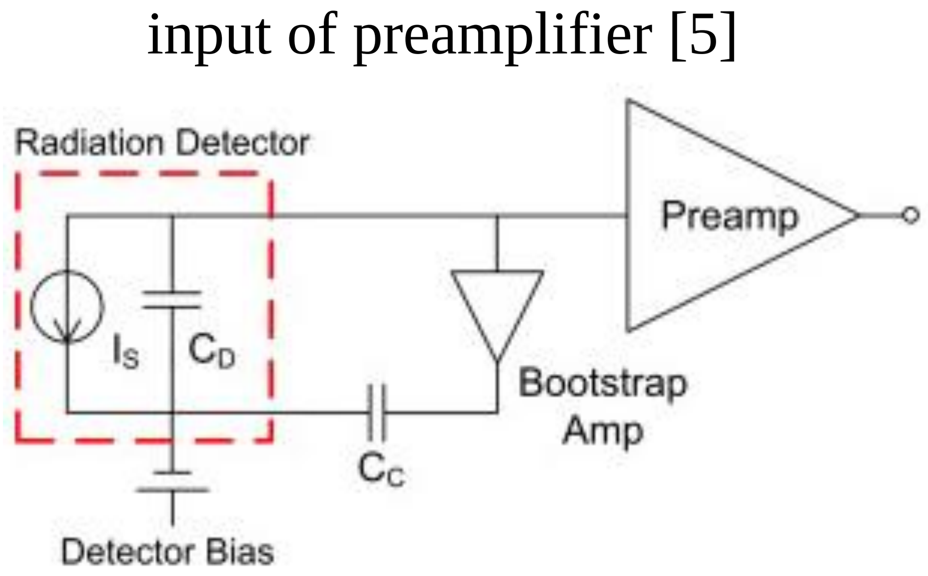

**Traditional Multiplexing Technique (16 : 4 Multiplexed)**




## Proposed Technique : Bootstrap Circuit

❑ **Bootstrap Circuit**

- This technique exploits the Miller effect to reduce capacitance at input of preamplifier [5]

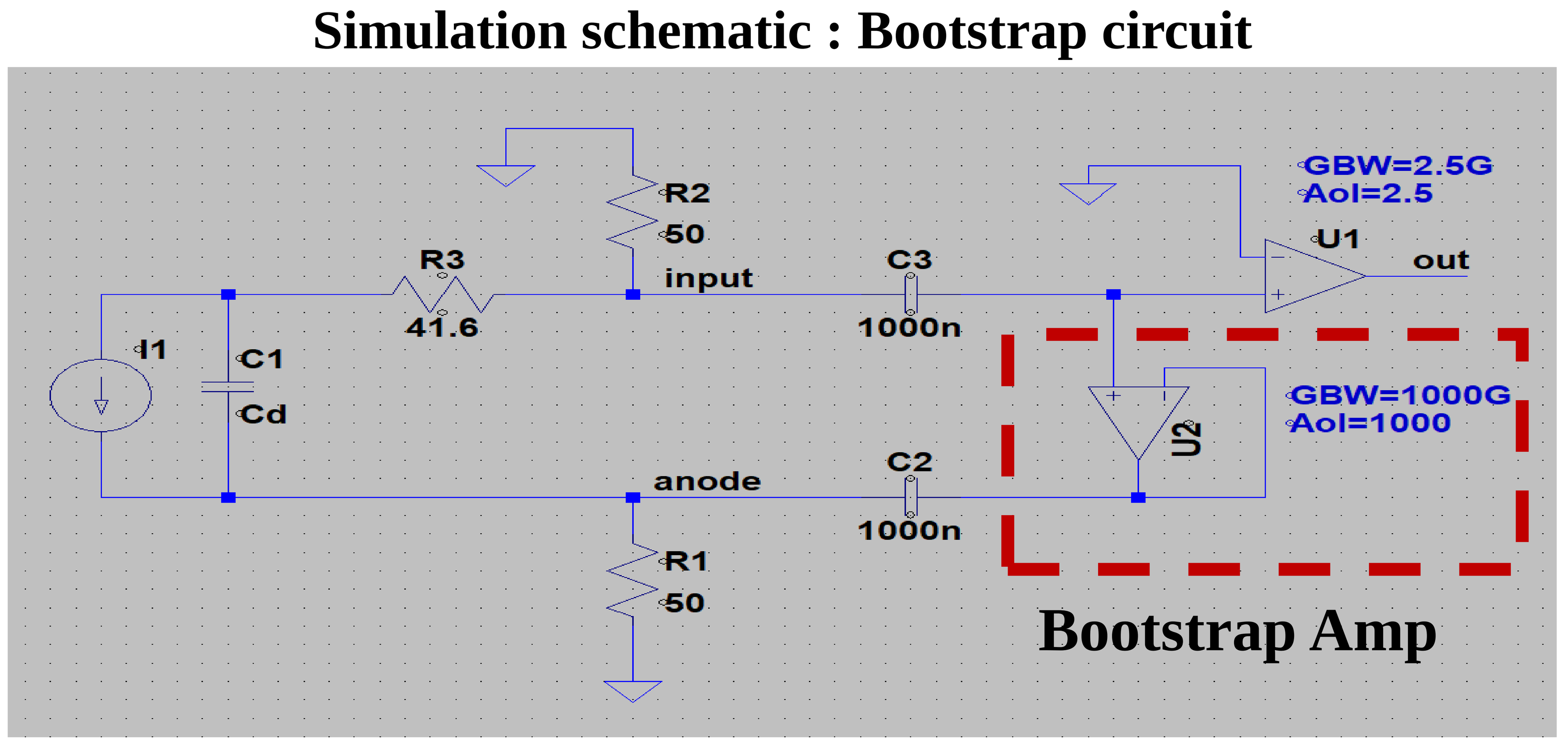



$$V_{out} = -A\frac{Q}{C_D + (A+1)C_F}$$

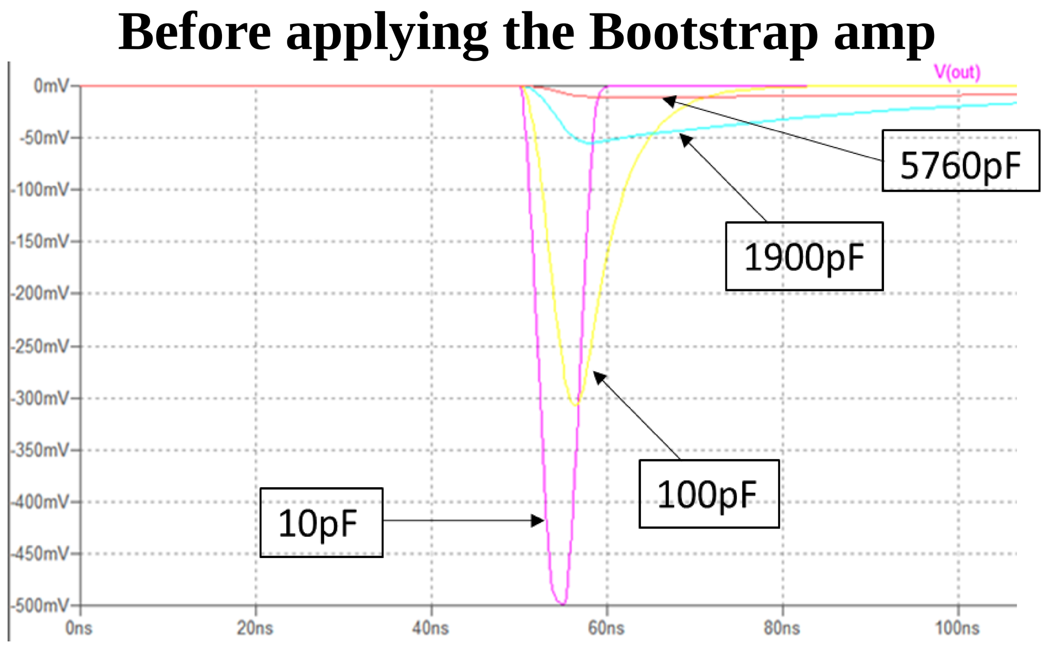
$$C_{in} = C(1-A)$$

❑ **Simulation : Multiplexed SiPMs with bootstrap technique**

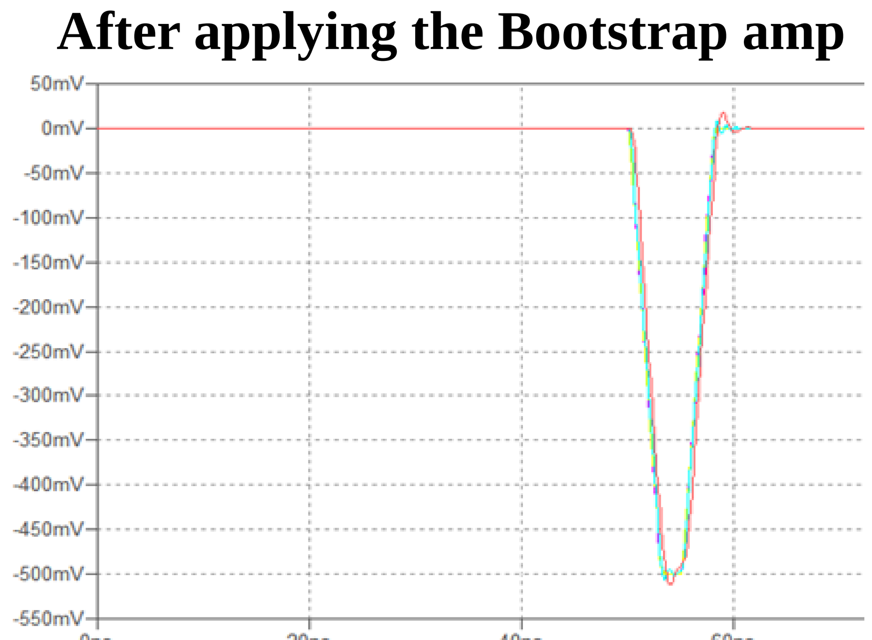
**Simulation schematic : Bootstrap circuit**




**Before applying the Bootstrap amp**




**After applying the Bootstrap amp**

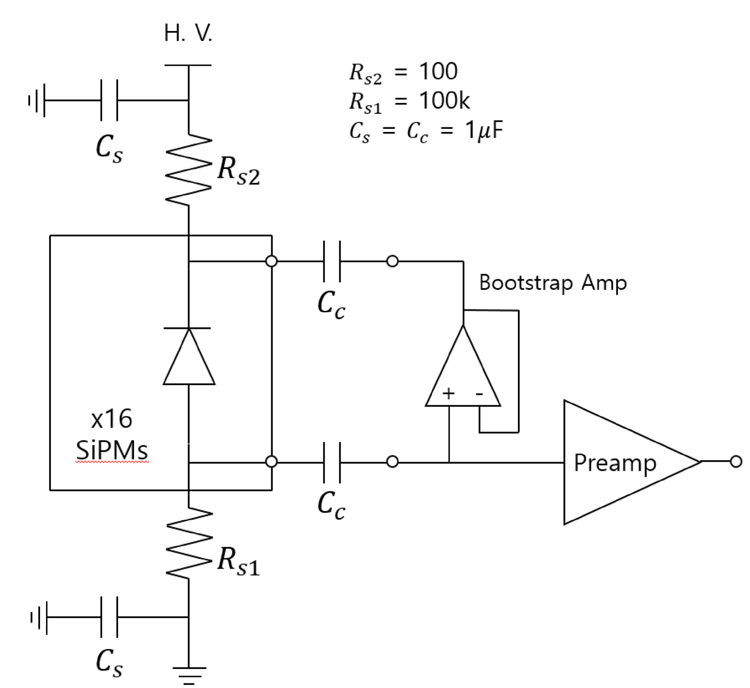


## Measurement Result

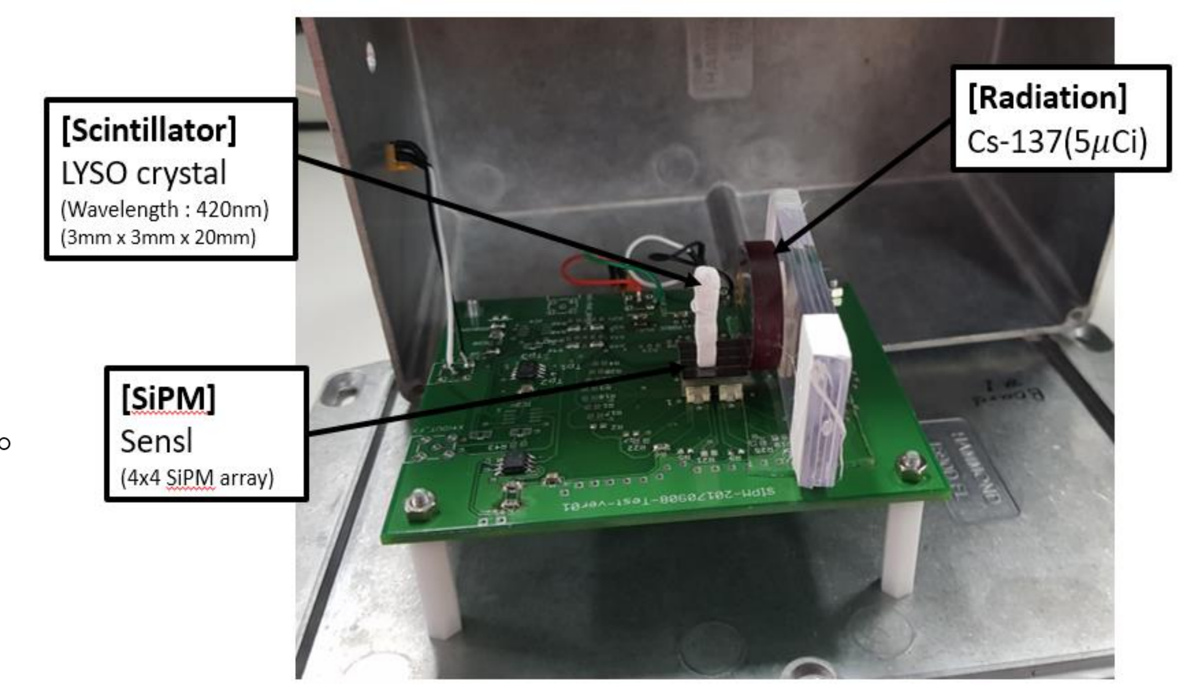
❑ **Experimental Setup**

- SiPM : Sensl MicroFJ-30035-TSV
- Scintillator : LYSO crystal 3mm x 3mm x 20mm
- Radiation source : Cs-137(5$\mu$Ci)

**Circuit Schematic**



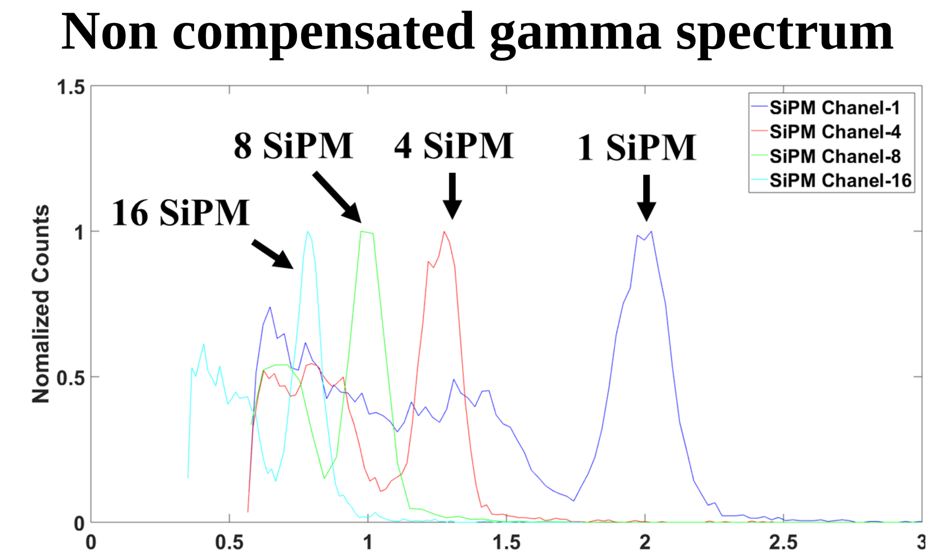

**Completed Sensor and Circuit in an aluminum box**



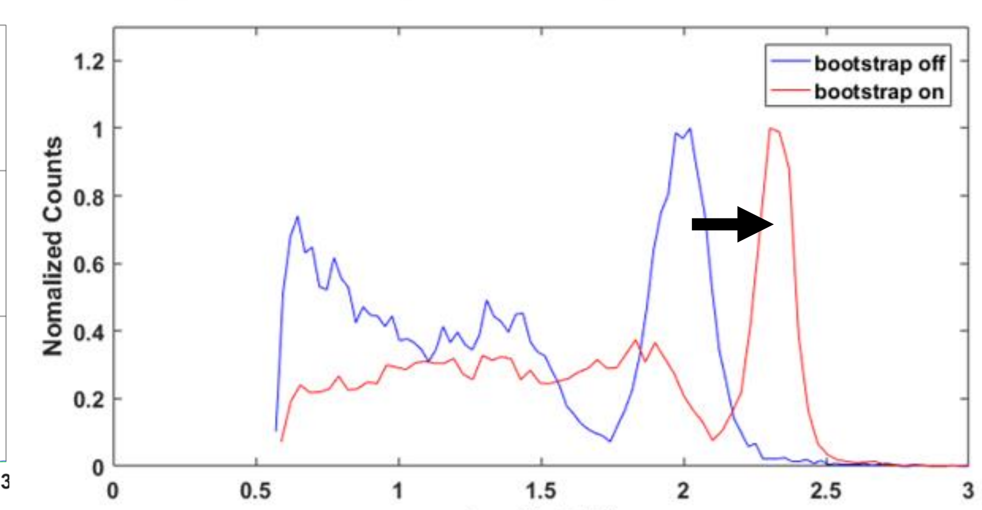

❑ **Result 16 : 1 Multiplexed SiPMs With and Without the Bootstrap**

- Different multiplexing ratio of 1, 4, 8, and 16 : Detector capacitance increase

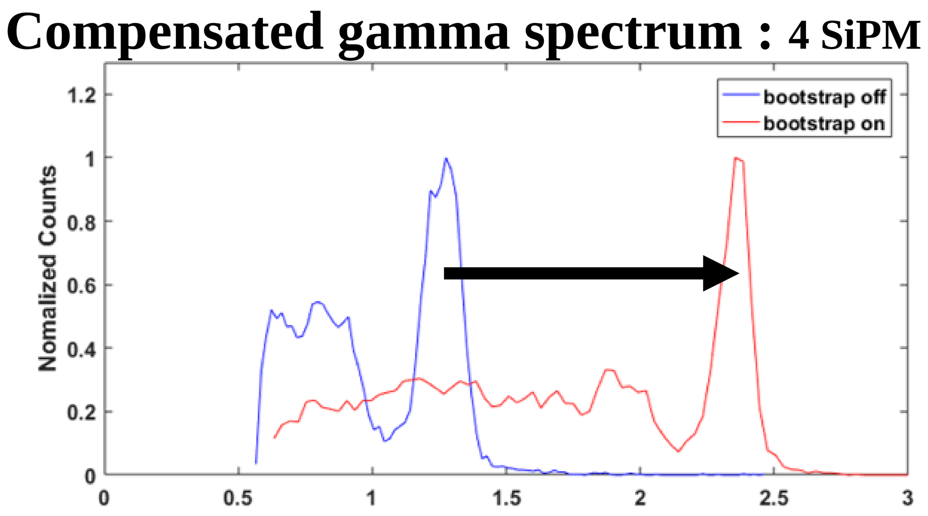
**Non compensated gamma spectrum**



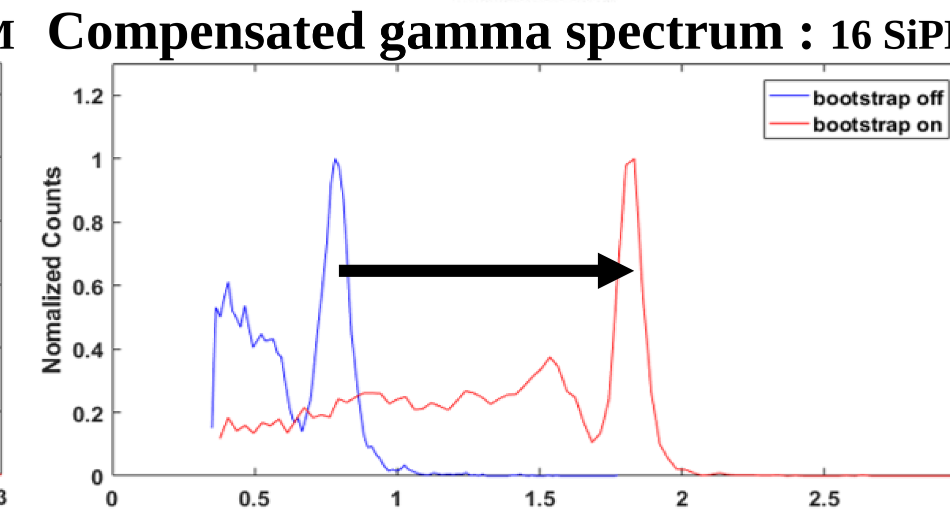

**Compensated gamma spectrum : 1 SiPM**




**Compensated gamma spectrum : 4 SiPM**




**Compensated gamma spectrum : 16 SiPM**




## Conclusion & Future Work

❑ **Conclusion**

- Successfully enhanced signal amplitudes even though SiPM channels increase
- The proposed configuration can greatly reduce the number of preamplifiers while maintaining the pulse shapes without losing information

❑ **Future work**

- Optimization for the circuit configuration
- Measurement timing resolution for time dominant applications
- Overall theoretical analysis

**Acknowledgement**

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**References**

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[5] I. Kwon, "Compensation of the detector capacitance presented to charge-sensitive preamplifiers using the Miller effect," *Nucl. Instrum. Meth. A*, vol. 784, no. 1, pp. 220-225, June 2015.