

Development of the muon entrance trigger system for the PSI muEDM experiment



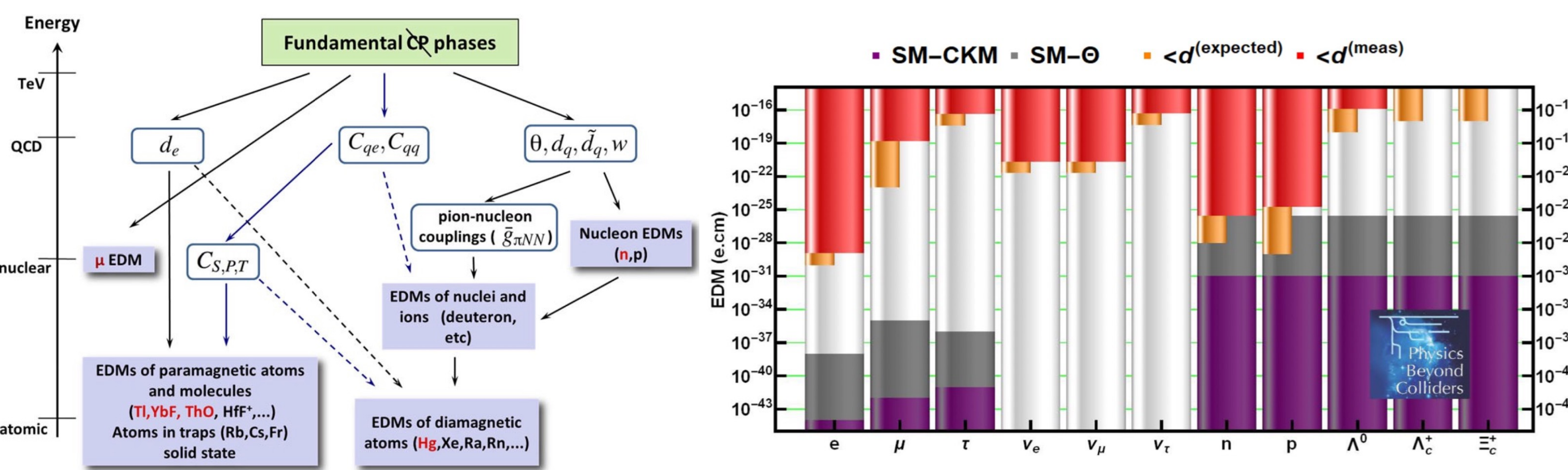
Tianqi Hu hutianqi@sjtu.edu.cn

Shanghai Jiao Tong University



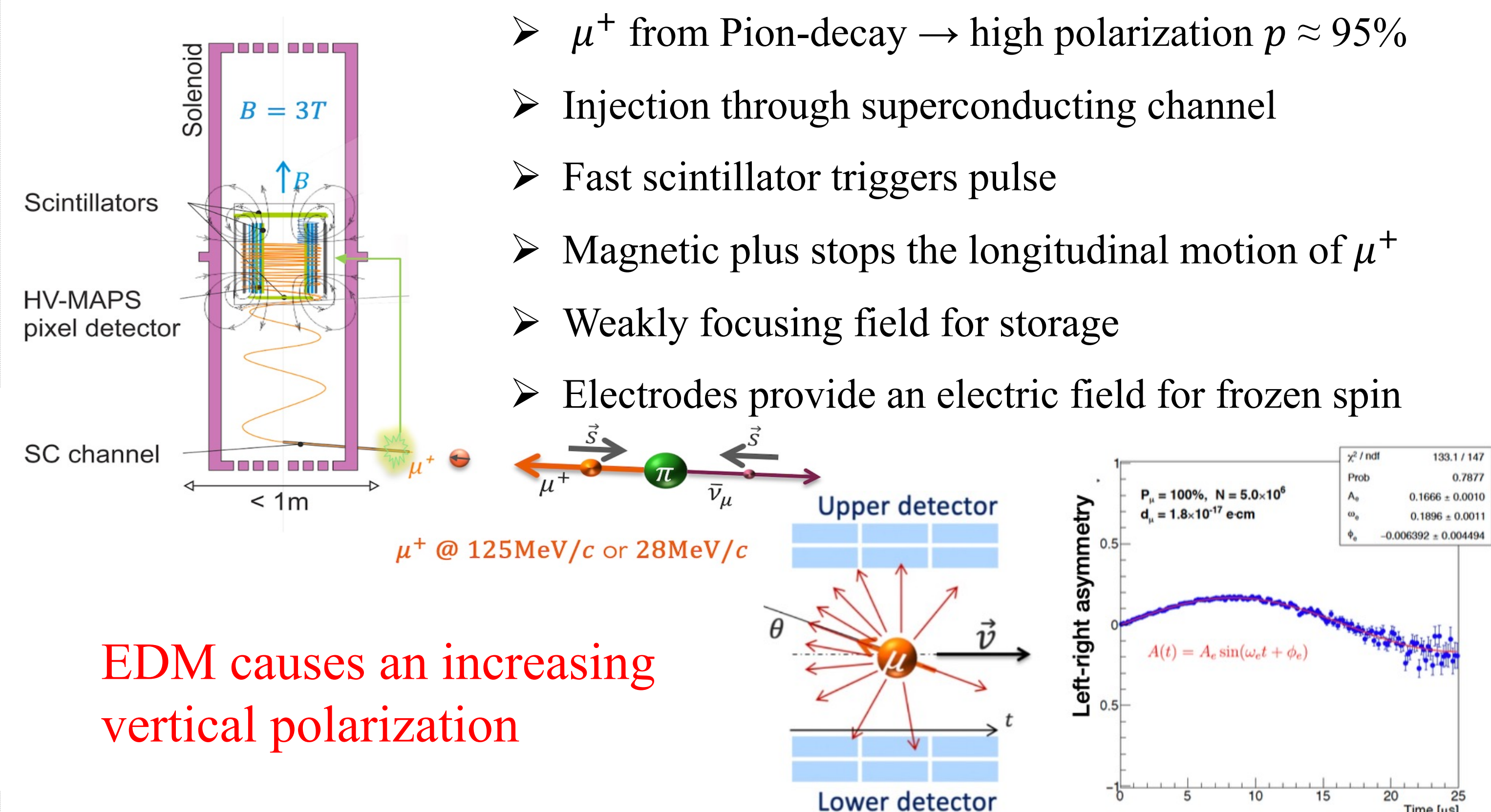
1. Muon Electric Dipole Moment

- The complementarity to the LHC search
- Many BSM models predict large EDMs [1]
- Matter-antimatter asymmetry requires more CP Violation source
 - CP violation exists in the phase in the CKM matrix ($\sim 10^{-38}$ e cm) [1, 2]
- G-2 and EDM are connected in some BSMs (effective field theory [3,4])



PSI muEDM Experiment: Frozen-spin approach, Freeze g-2

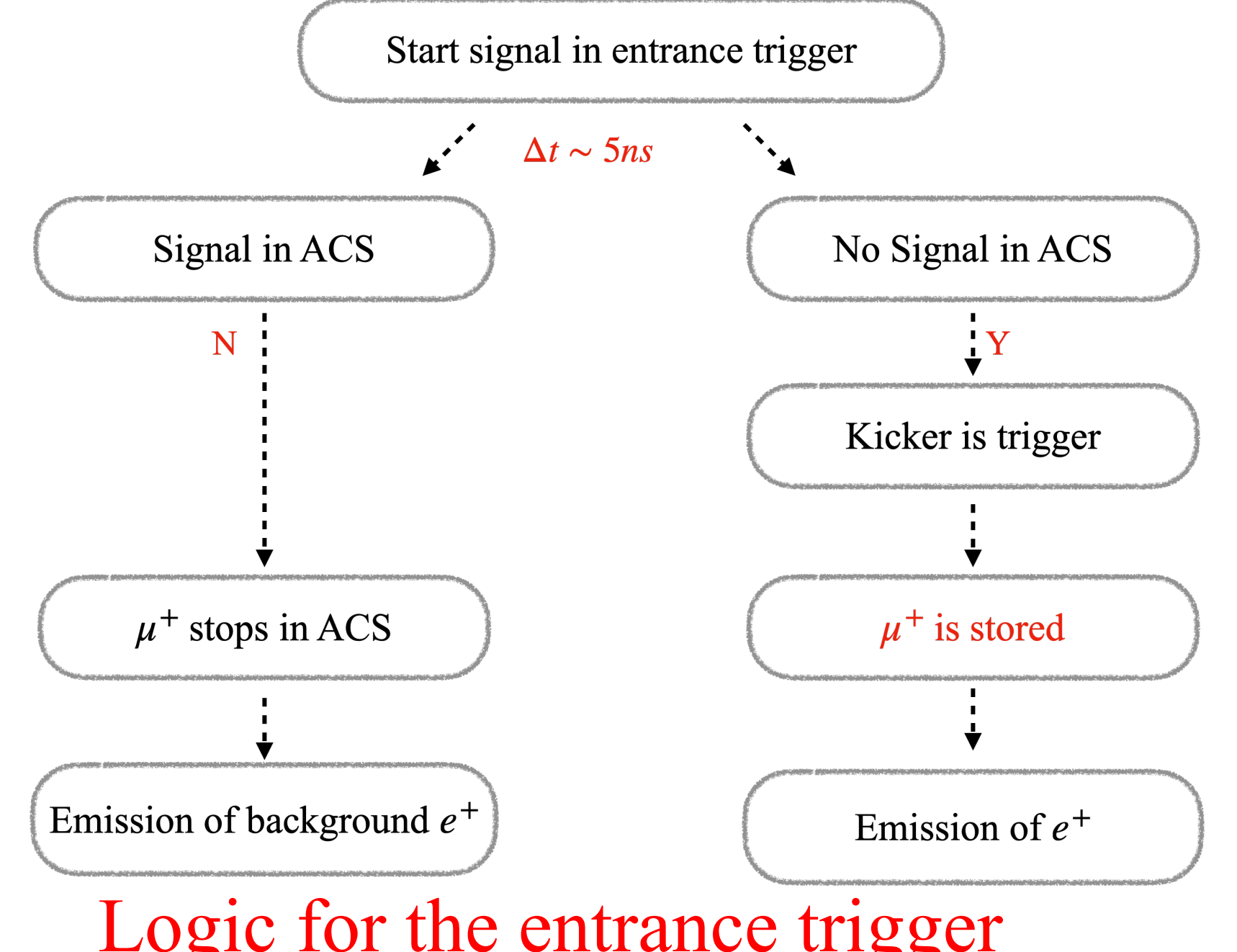
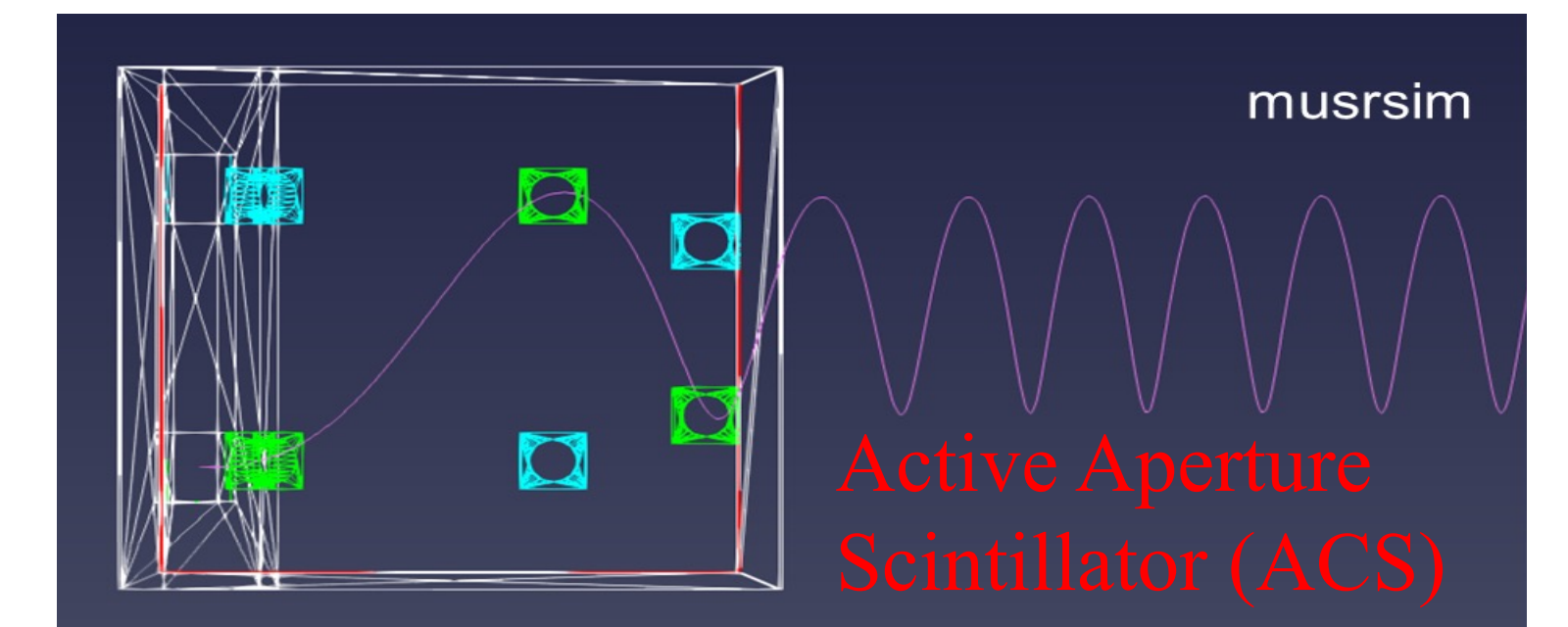
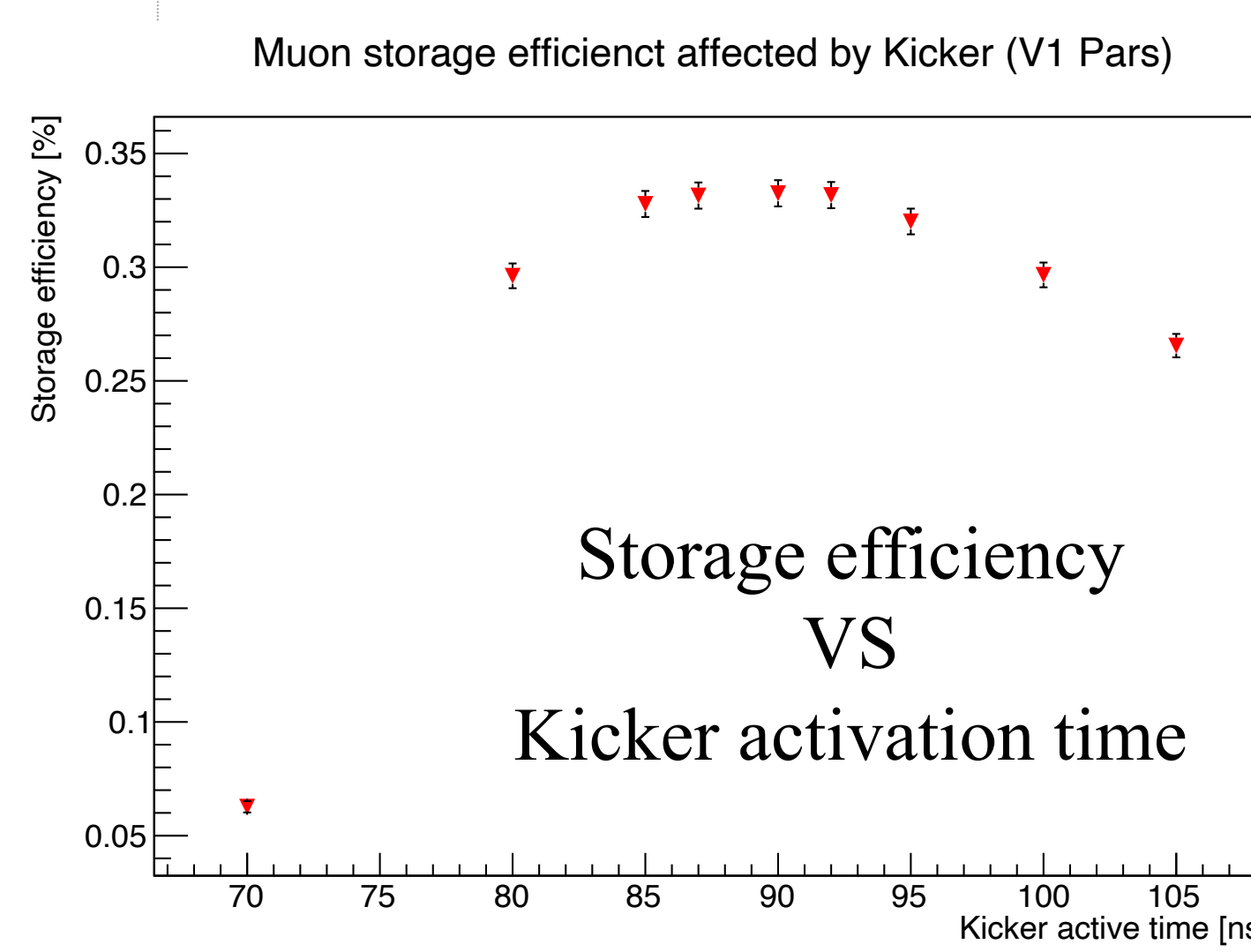
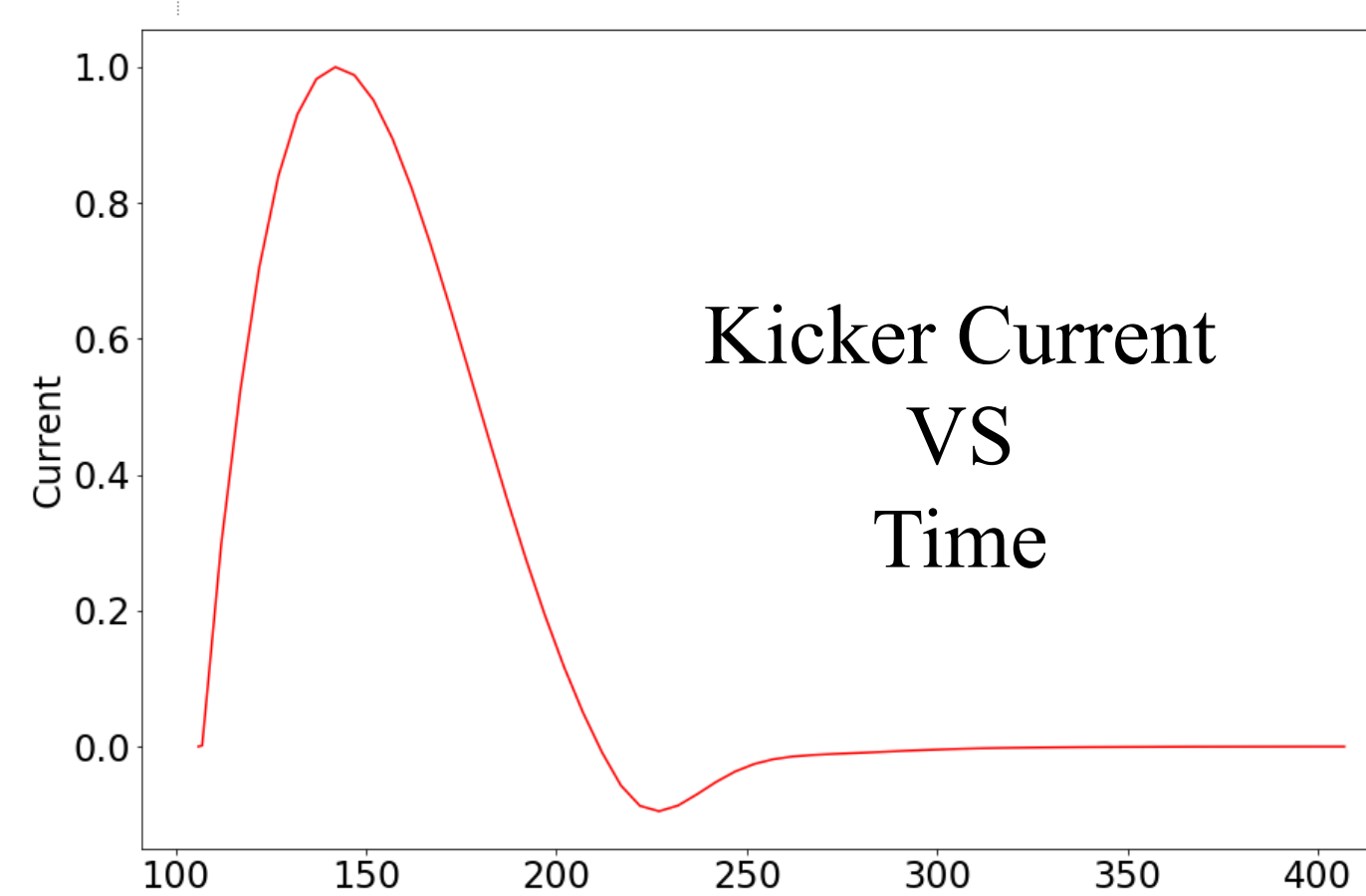
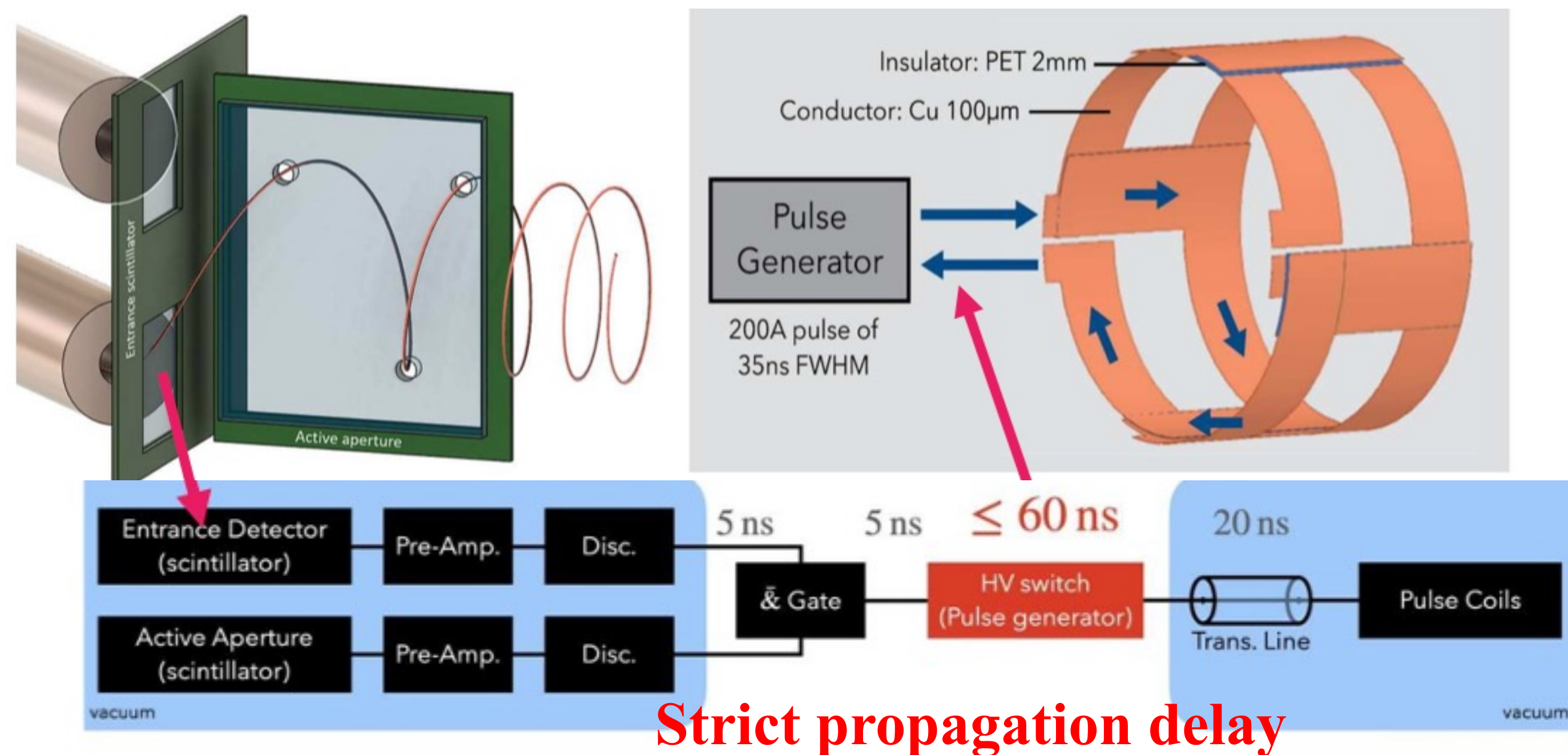
- μ^+ from Pion-decay \rightarrow high polarization $p \approx 95\%$
- Injection through superconducting channel
- Fast scintillator triggers pulse
- Magnetic plus stops the longitudinal motion of μ^+
- Weakly focusing field for storage
- Electrodes provide an electric field for frozen spin



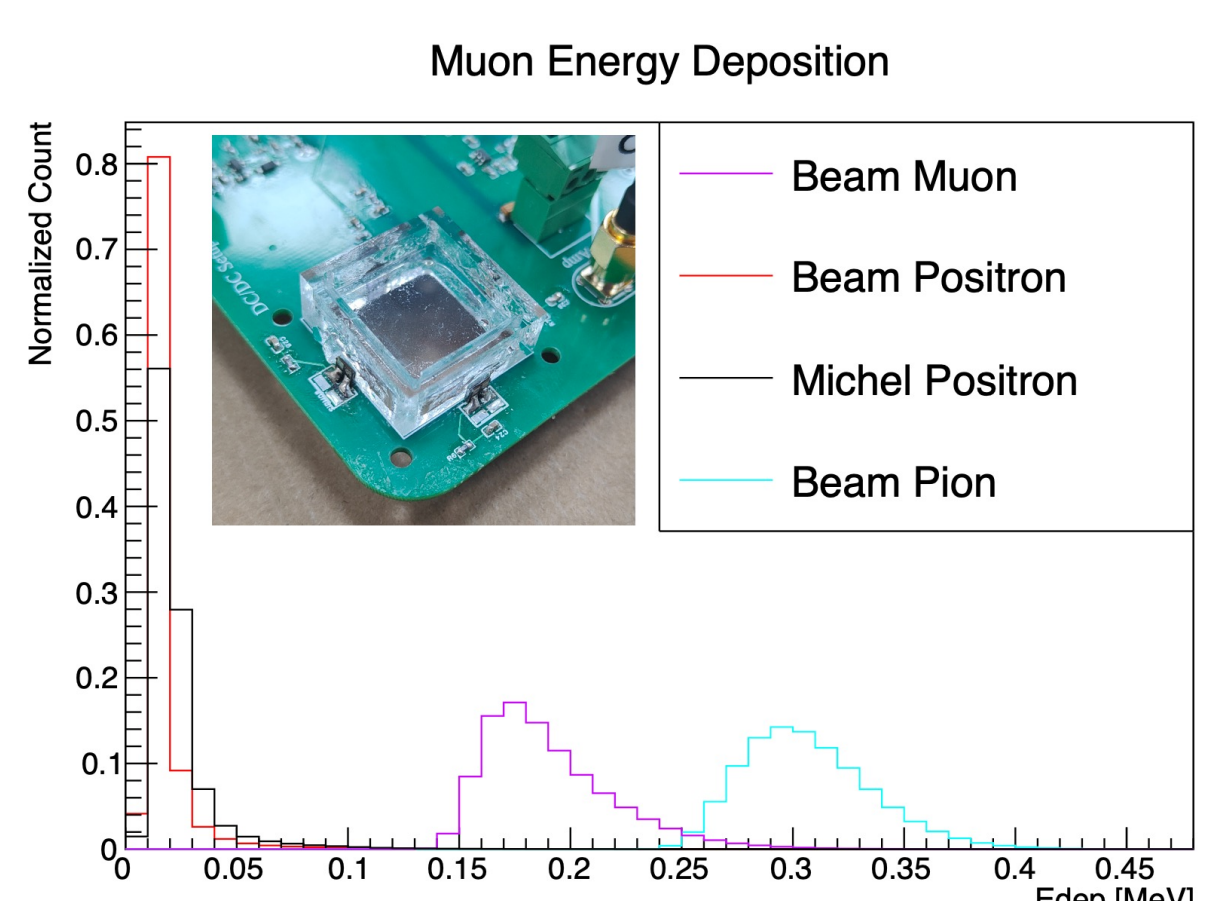
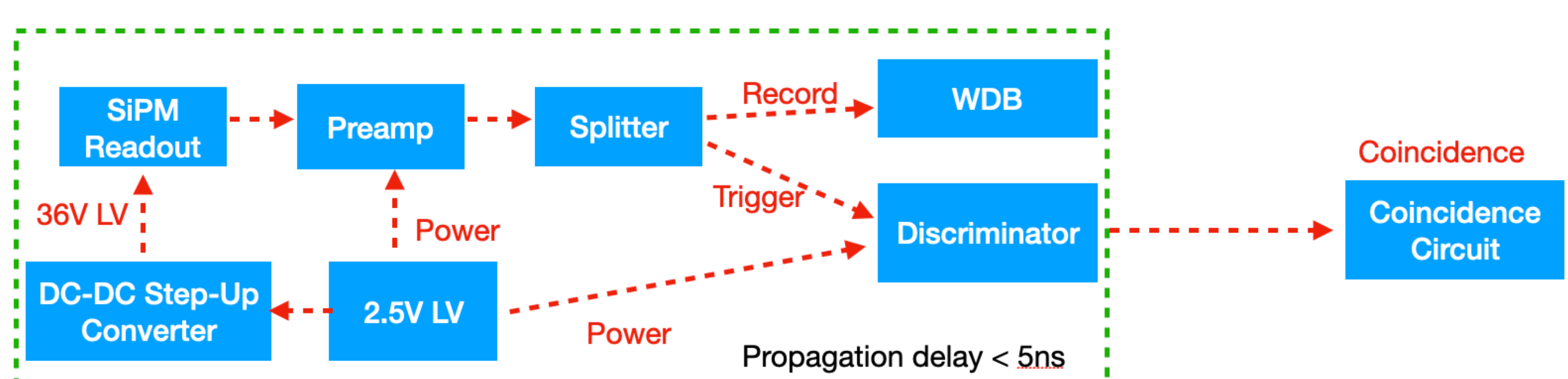
EDM causes an increasing vertical polarization

2. Entrance trigger detector: Fast scintillator triggers and Electronic logic

- Providing a trigger signal to the pulsed magnetic kicker
- Match the phase space between the beamline and solenoid
- **Strict Requirements:**
 - To be fully efficient while minimizing multiple scattering.
 - Short propagation delay (< 5 ns)

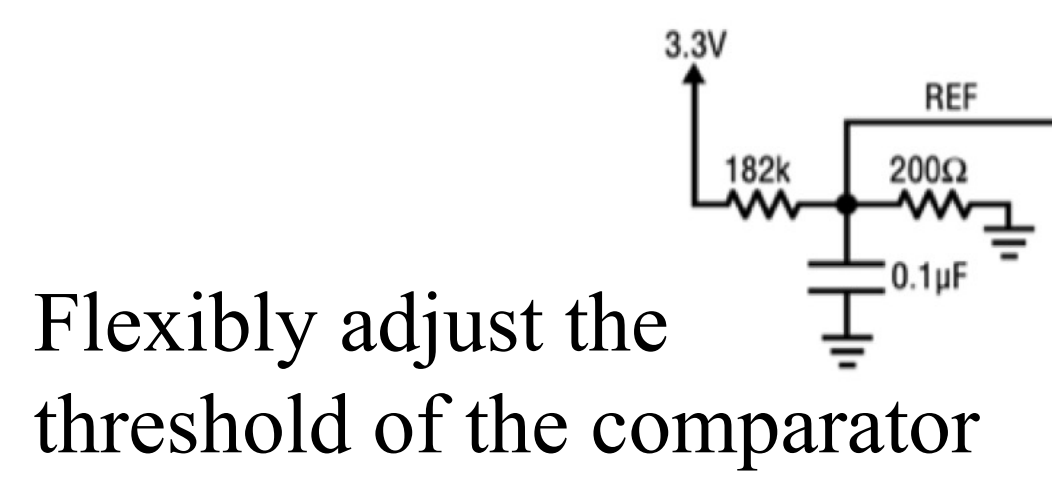


3. Dynamic range: Front-end electronics and SiPMs



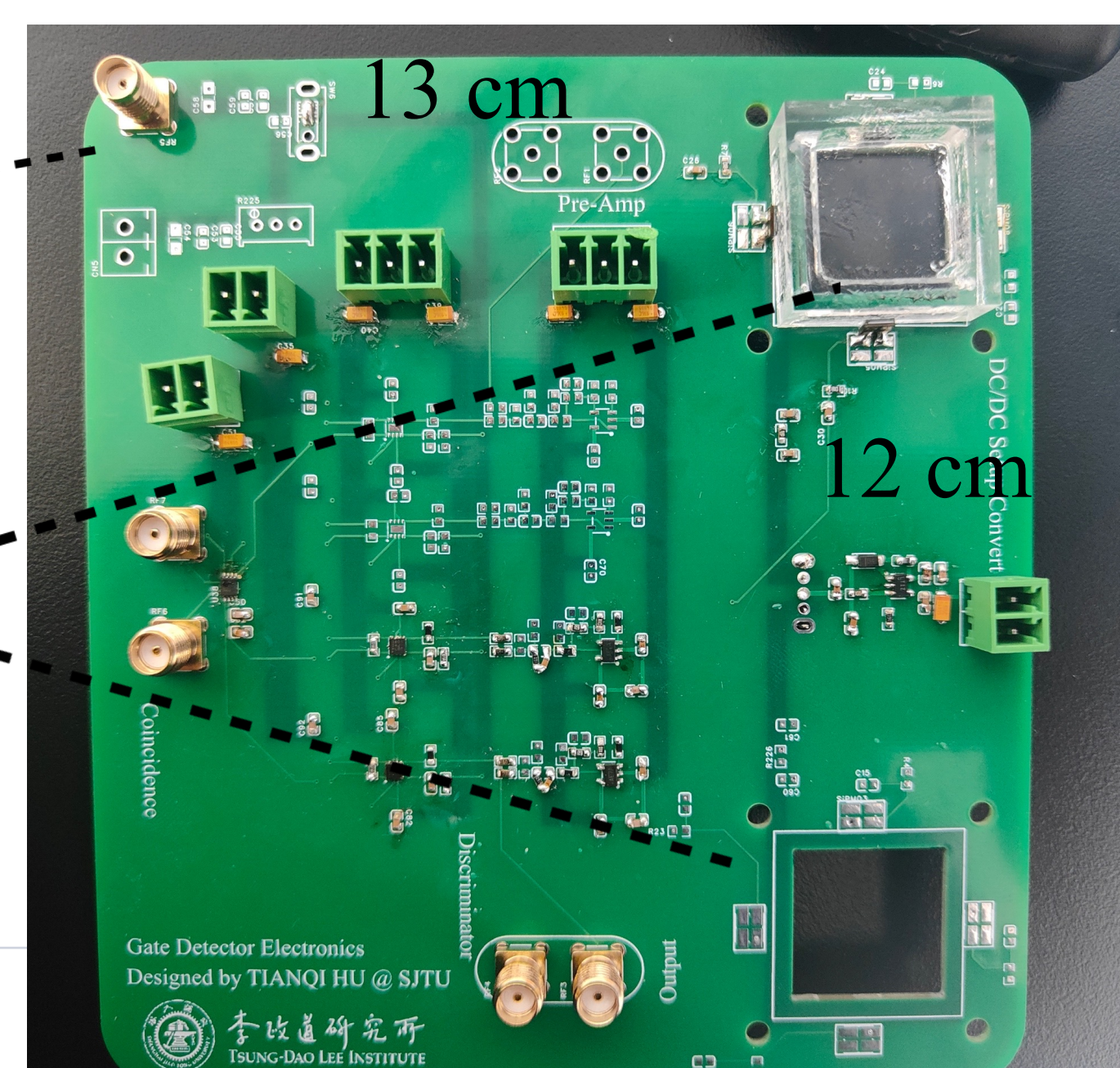
Particles	Average Energy deposition (MeV)	Photons per SiPM GNKD	Pre-amp (mV) (20dB)	Split Output (mV)
Positron	0.017	<3	<12	<4
Muon	0.190	5-9	20-36	7-12
Pion	0.307	8-12	32-48	11-16

Clear separation: the range of deposition energy for these particles

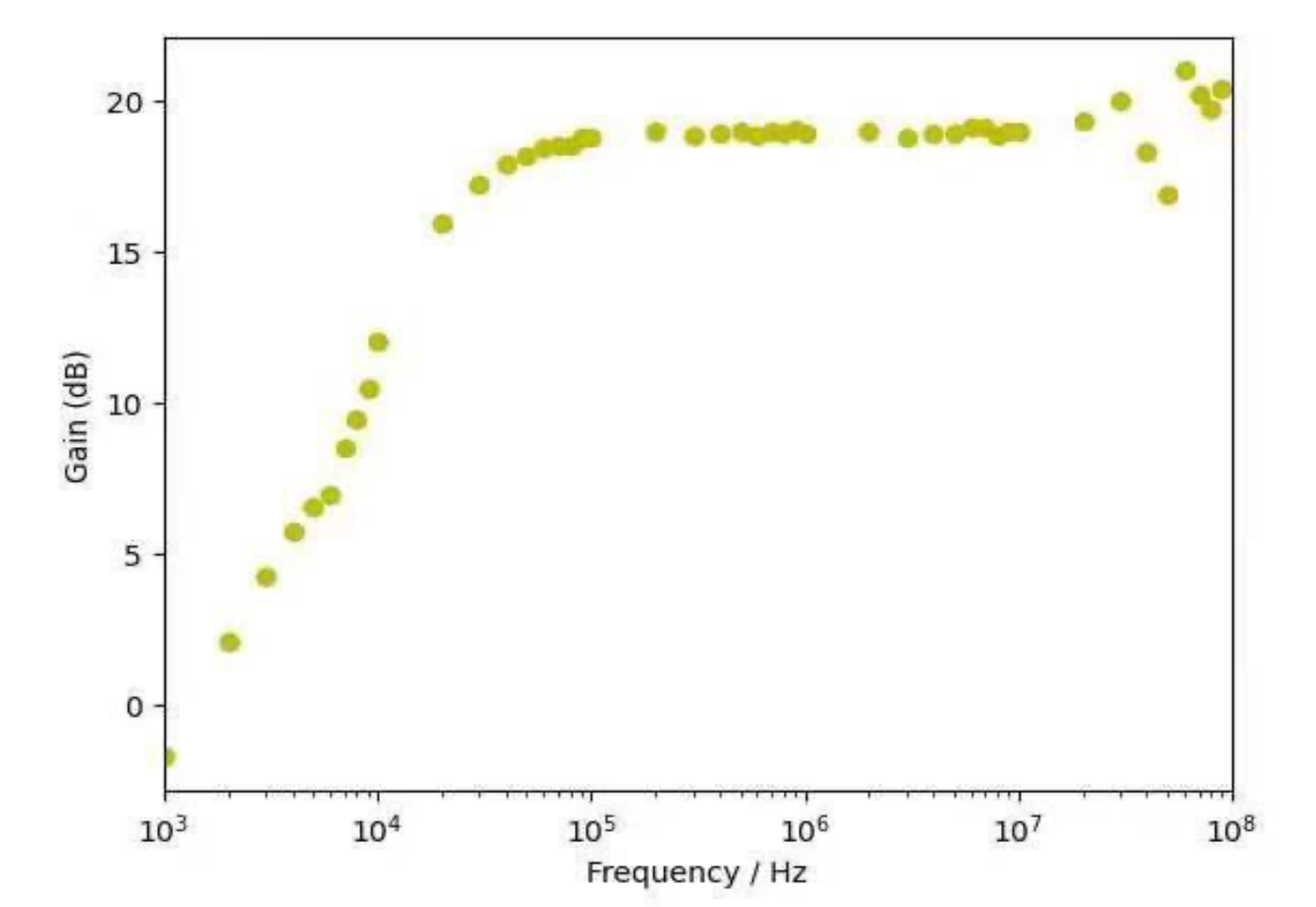
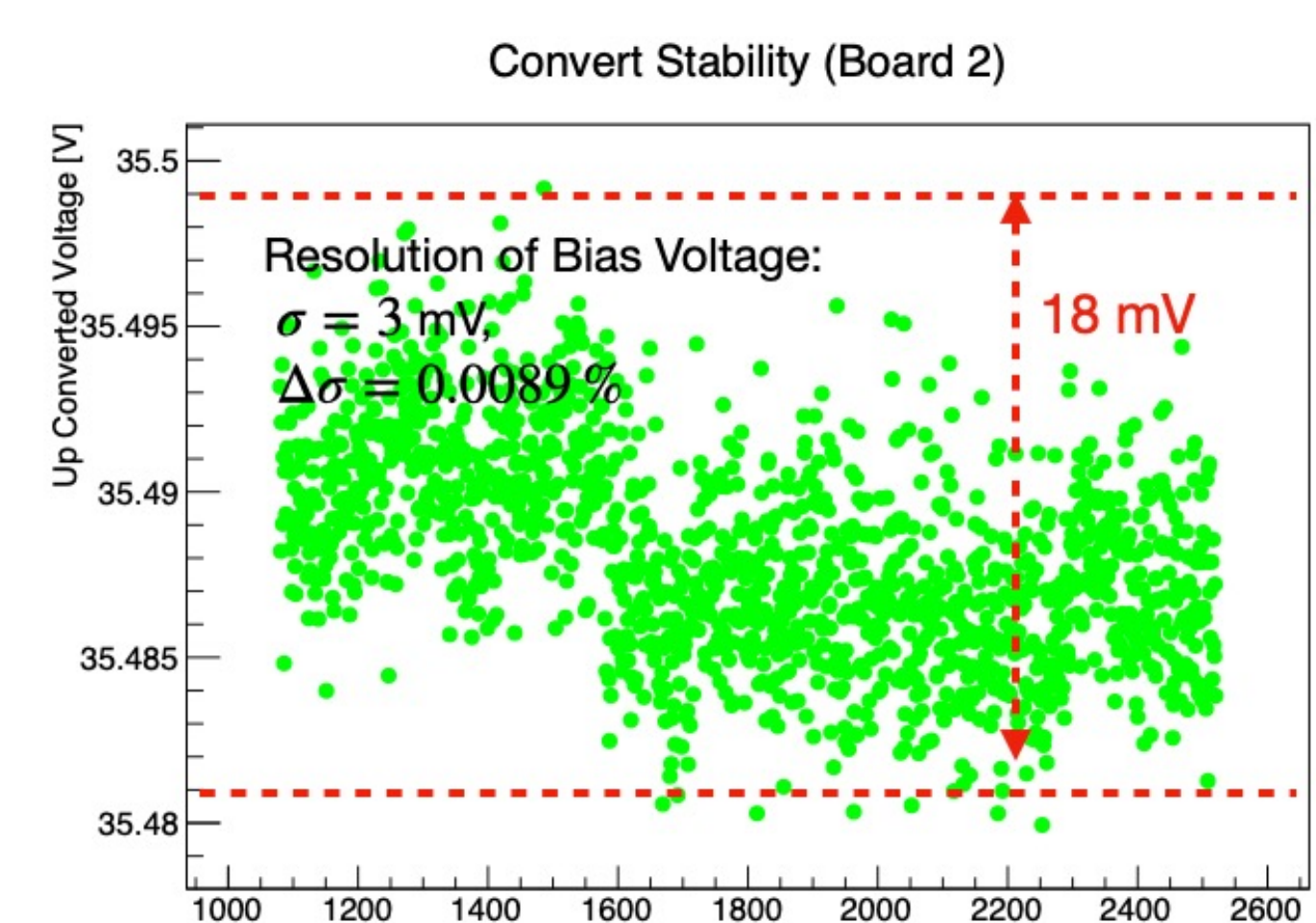


Two holes for the CW and CCW injection of muons, to cancel the systematic due to a longitudinal E-field component

Fast electronics prototype of the gate

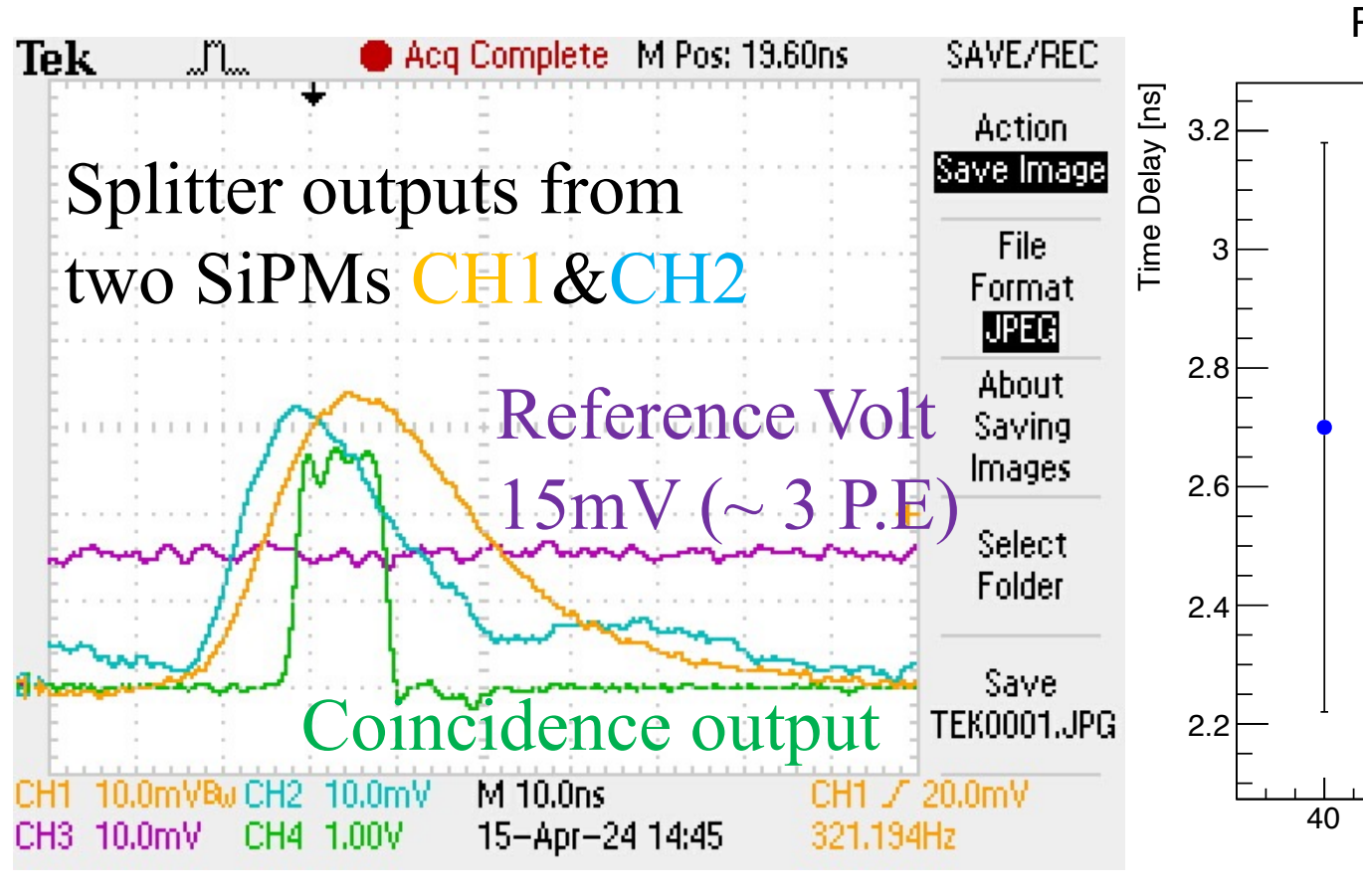


4. Performance for the fast electronics



- The peak-to-peak fluctuation of the DC-DC step-up converter is 18 mV.
- The fluctuation in the SiPM gain is approximately $\sim 0.26\%$

- The frequency response for the pre-amp has a bandwidth of less than 90 MHz.



Propagation delay (reference voltage 30 mV)

Components	Delay (ns)
Preamp	< 1
Split	~ 0
Discriminator	< 3

5. References and Acknowledgments

- 1.Rev.Mod.Phys. 91 (2019) 1, 015001
- 2.Phys. Rev. D 89, 056006 (2014)
- 3.Nucl. Phys. B613 (2001) 366
4. Phys. Rev. D 98 (2018) 113002

This work is supported by the China Scholarship Council No. 202206230093 and the National Natural Science Foundation of China under Grant No. 12050410233.