# Study of cosmic ray impacts on cryogenic high sensitivity detectors

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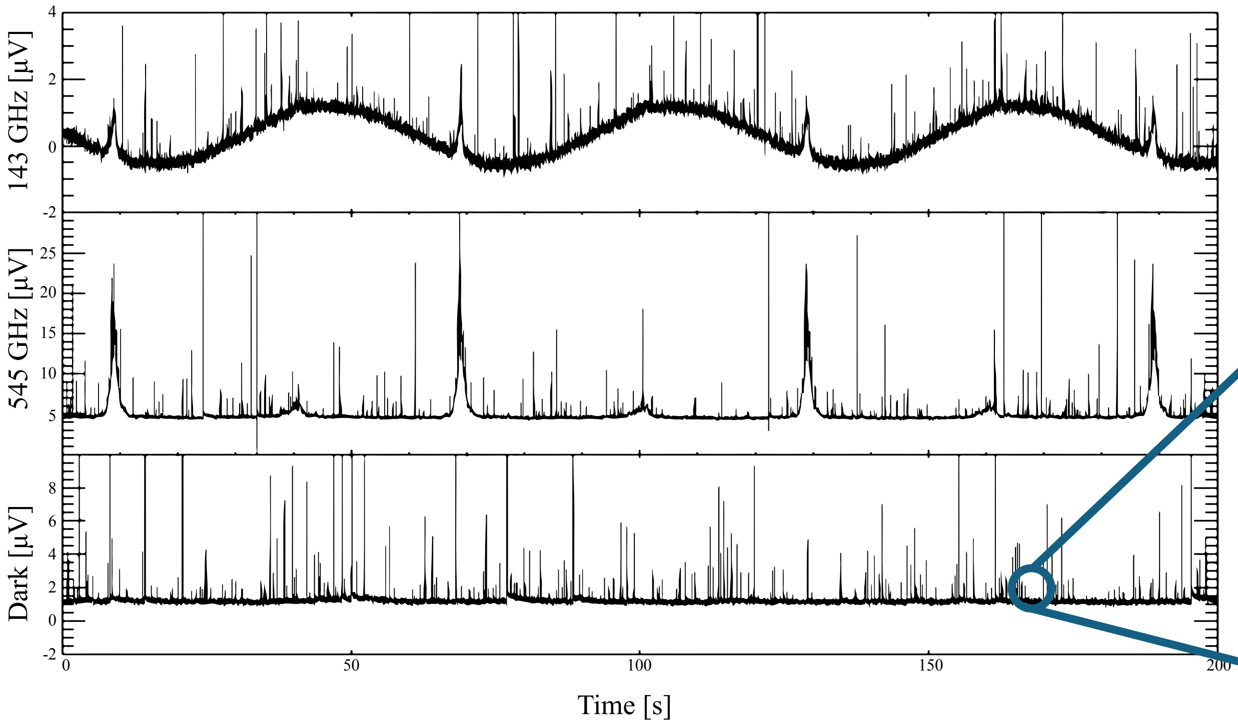
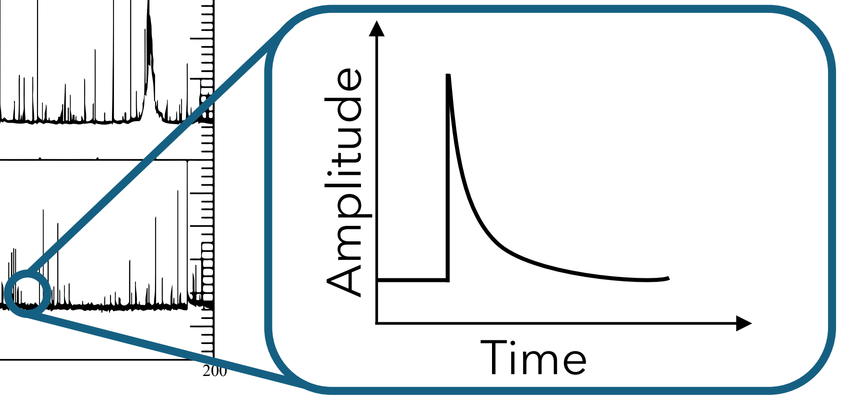
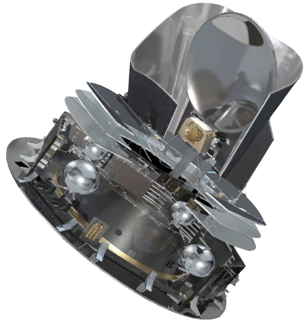
# Cosmic-rays problematic



Signals from Planck HFI's detectors (top : 143 GHz, middle : 545 GHz, bottom : dark)

- Impacts of cosmic-rays (CRs) on Planck bolometers (@ 100 mK)
  ⇢ several years of post-data treatment to clean data

Few % of the data unusable even after glitches cleaning **A.Catalano et al.** – 2013

# Cosmic-rays problematic



**Ground-based experiments**

- Altitude ~ 5000 m
- Duration = years

Some events captured on ACT **S.K.Nerval et al.** – 2025

Rare events, not much disturbing **Ferazzoli et al.** – 2026 QUBIC

**Balloon-borne experiments**

- Altitude ~ 40 km
- Duration = 1-60 days

Sensitive to cosmic-rays **S.Masi et al.** – 2010

Numerous events ⇢ have to take into account **Masi et al.** – 2019 OLIMPO

# Prepare the future

**After Planck ?**

⟹ IAS started to explore the impact of cosmic rays (SYMBOL) **S.L.Stever** – 2019

- <u>CRs at L2 :</u> mainly protons and $\alpha$-particles ~ GeV

⇢ Galactic origin
⇢ Solar origin

- <u>Future CMB missions :</u>

❑ Higher sensitivity
❑ Larger detection surface

**More info on BISOU and FOSSIL :**
**⇢ see talks from Bruno, Valentin and Morgane**

**⟹ There is a real need to characterize the impact of the CRs on detector prototypes**

# DRACuLA

**D**etector ir**RA**diation **C**ryogenic faci**L**ity for **A**strophysics : developed to study the impact of cosmic-rays on cryogenic detectors and part of focal planes

⇢ **Adaptable to particle accelerators w/ customize features**

⇢ **Excellent thermal stability :**

500 μW of cooling power at 100 mK

+ 100 mK ± 11 μK over 5 days **Besnard et al.** – 2024

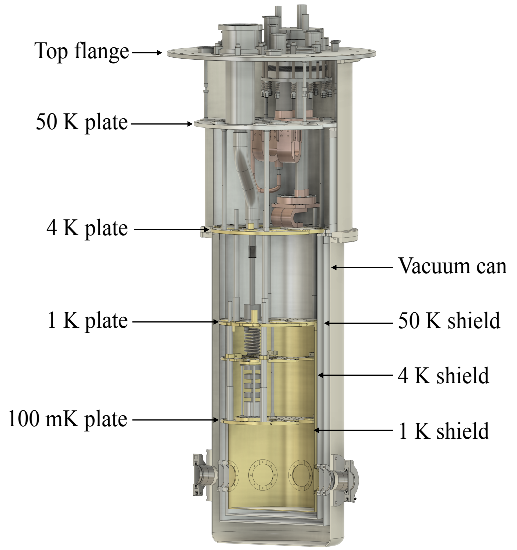
+ Handle exposure to energetic particles

⇢ **Various experiments possible :**

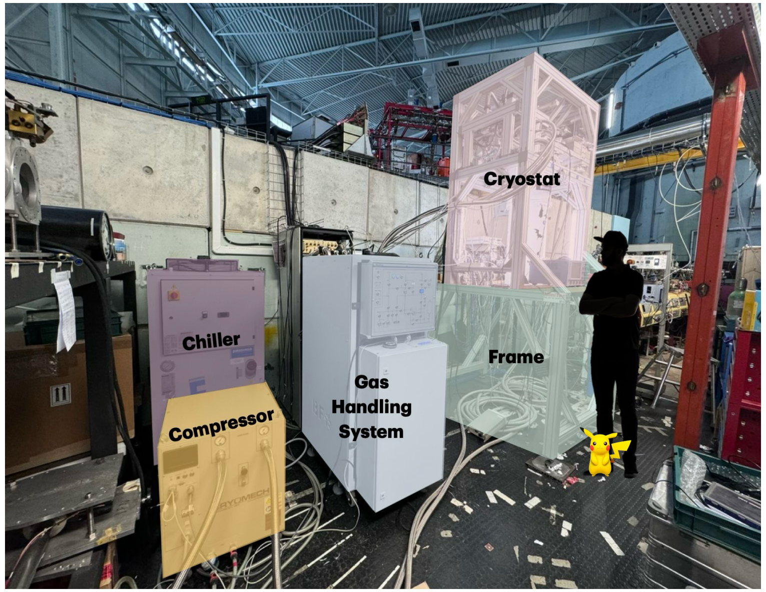
- Internal source irradiation
- Single event experiment
- Total dose irradiation

⇢ **3 irradiation campaigns :**

- 2022 : bolometers
- 2024 : TES
- 2025 : KIDs




Anatomy of DRACuLA

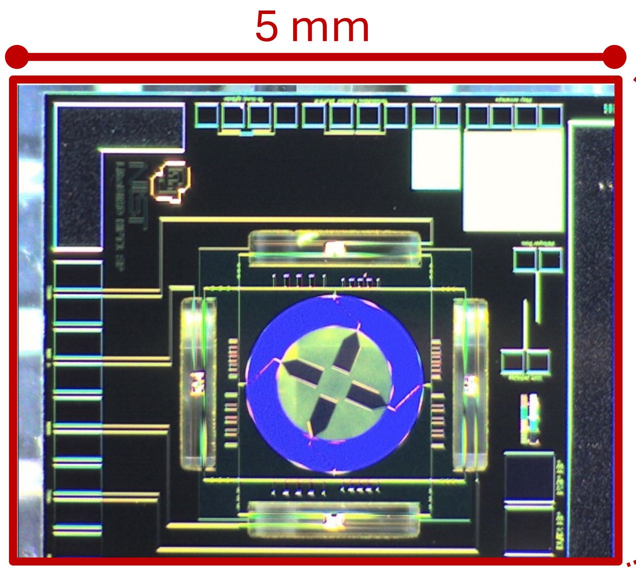


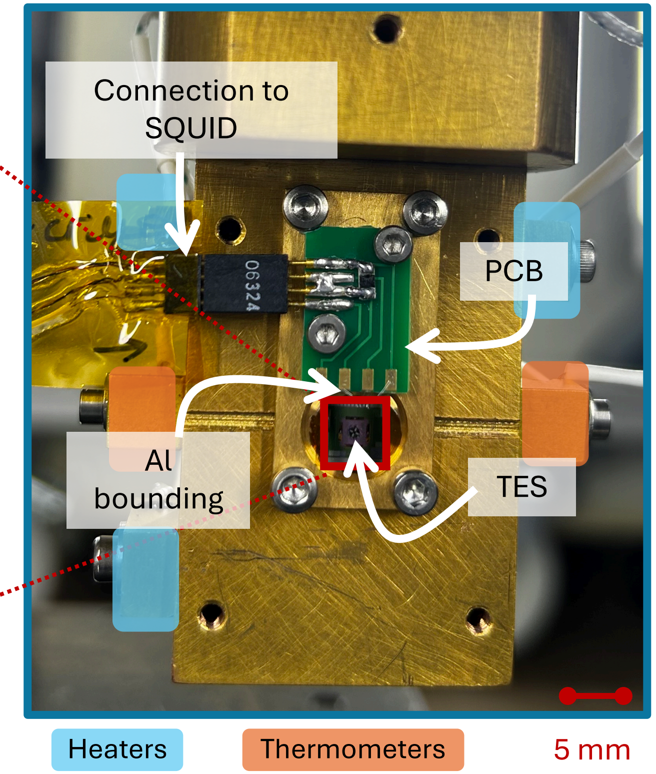

Components of DRACuLA installed in front of a beam line at TANDEM in ALTO – IJCLab, Orsay, France

# Single event

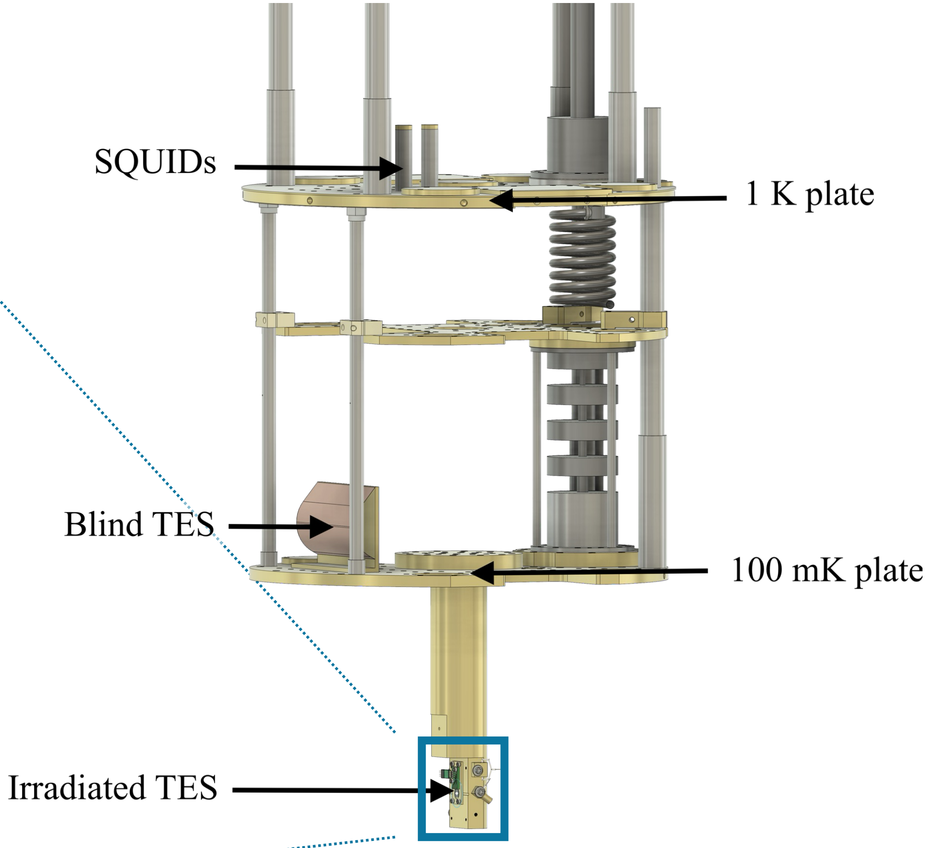
**Characterization of TES (LiteBIRD)**

- Prototype from NIST M.Lueker et al. – 2009
- Protons @ 18 – 22 MeV
- Blind detector



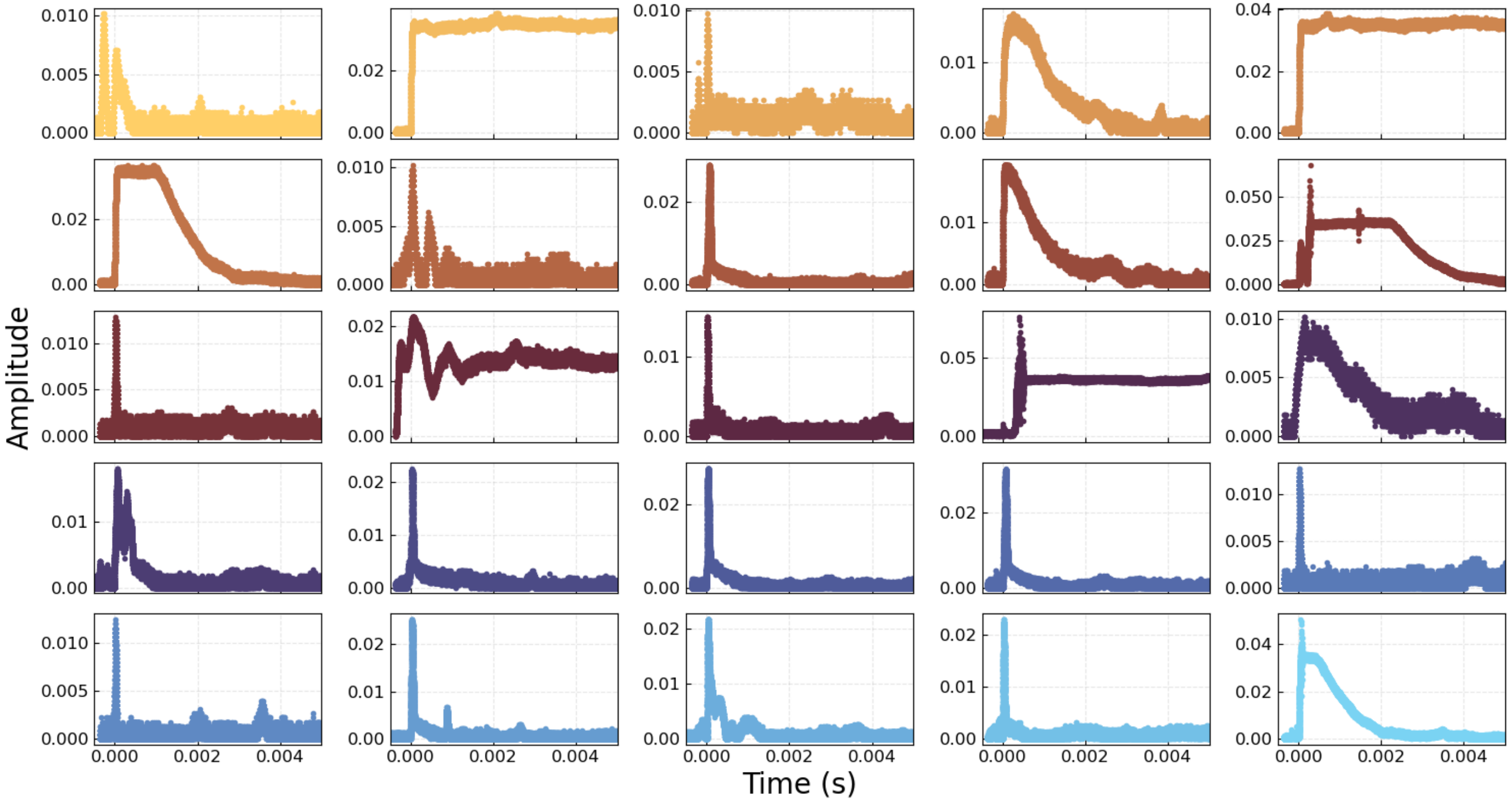

**Experimental set-up**



# Single event

**Alpha source ($^{241}$Am)**

- @ 5.4 MeV : 150 events
- First measurements in the lab to ensure TES sensitive to CRs

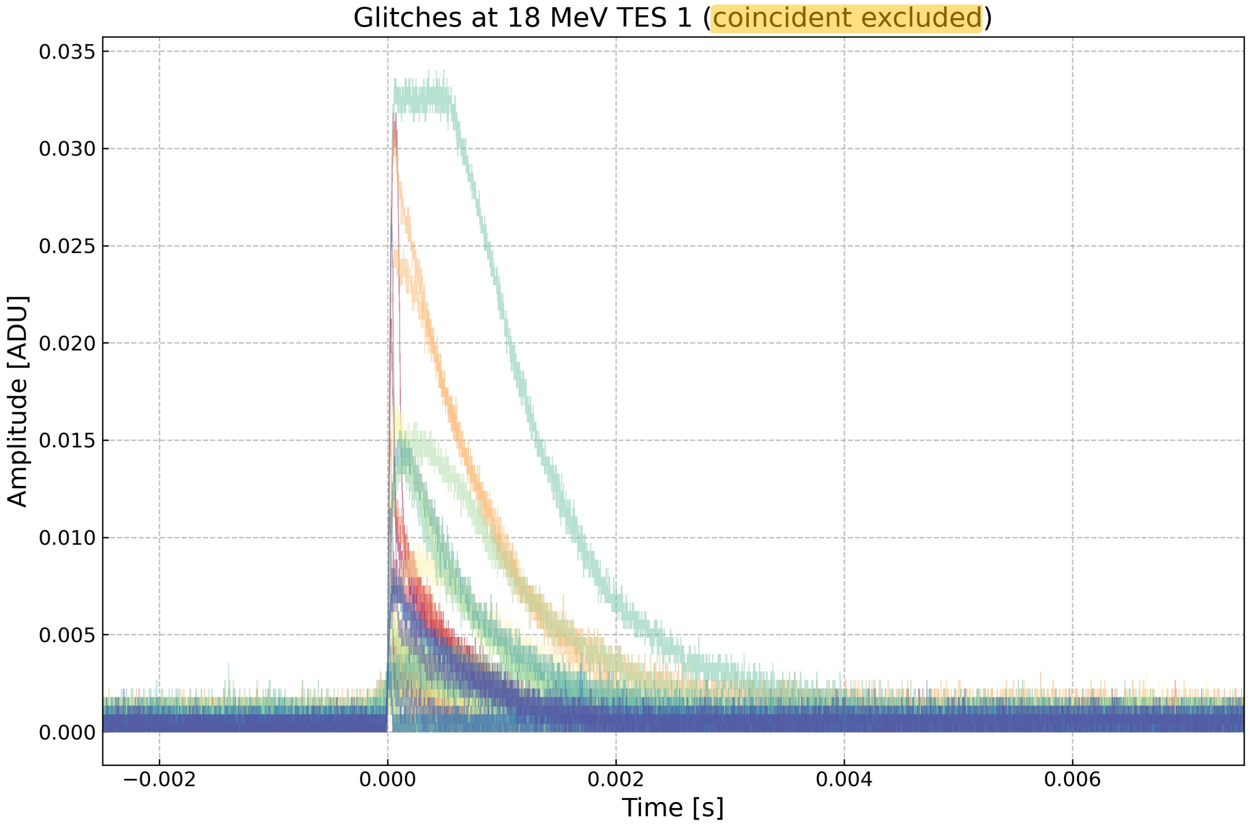


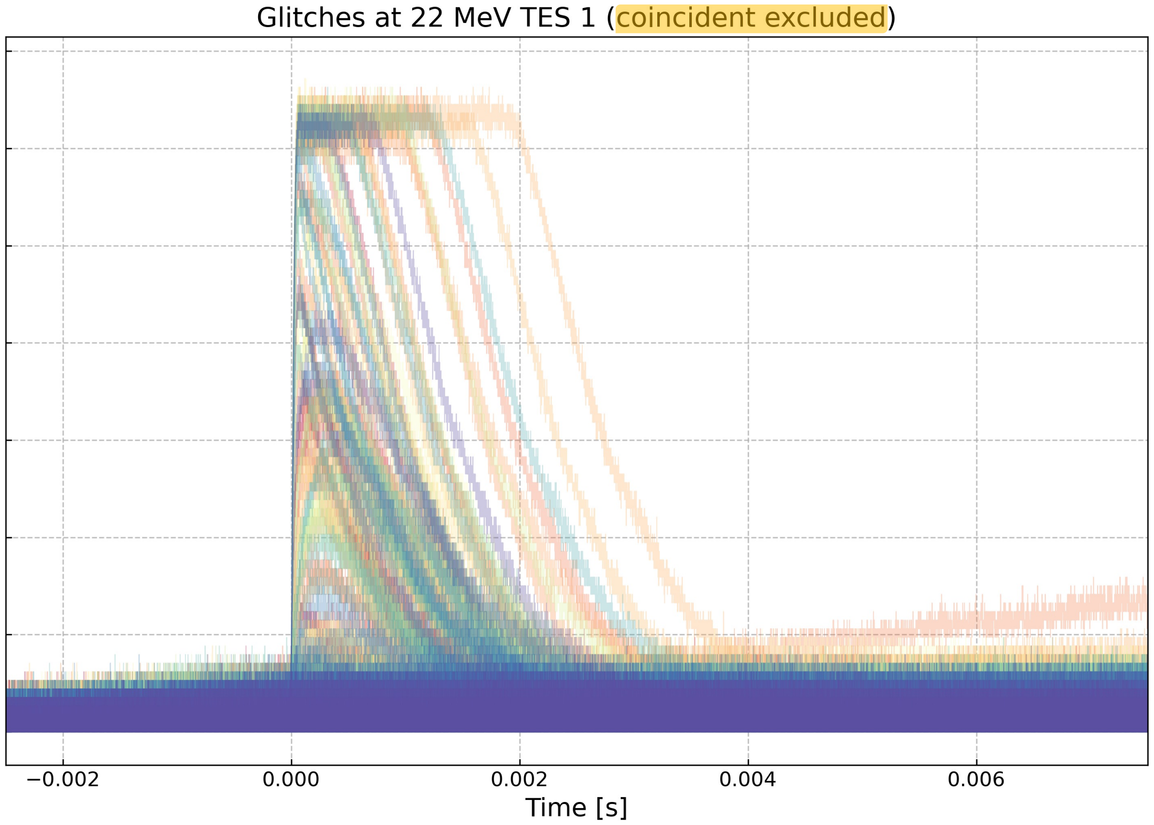
# Single event

**Irradiation with protons**

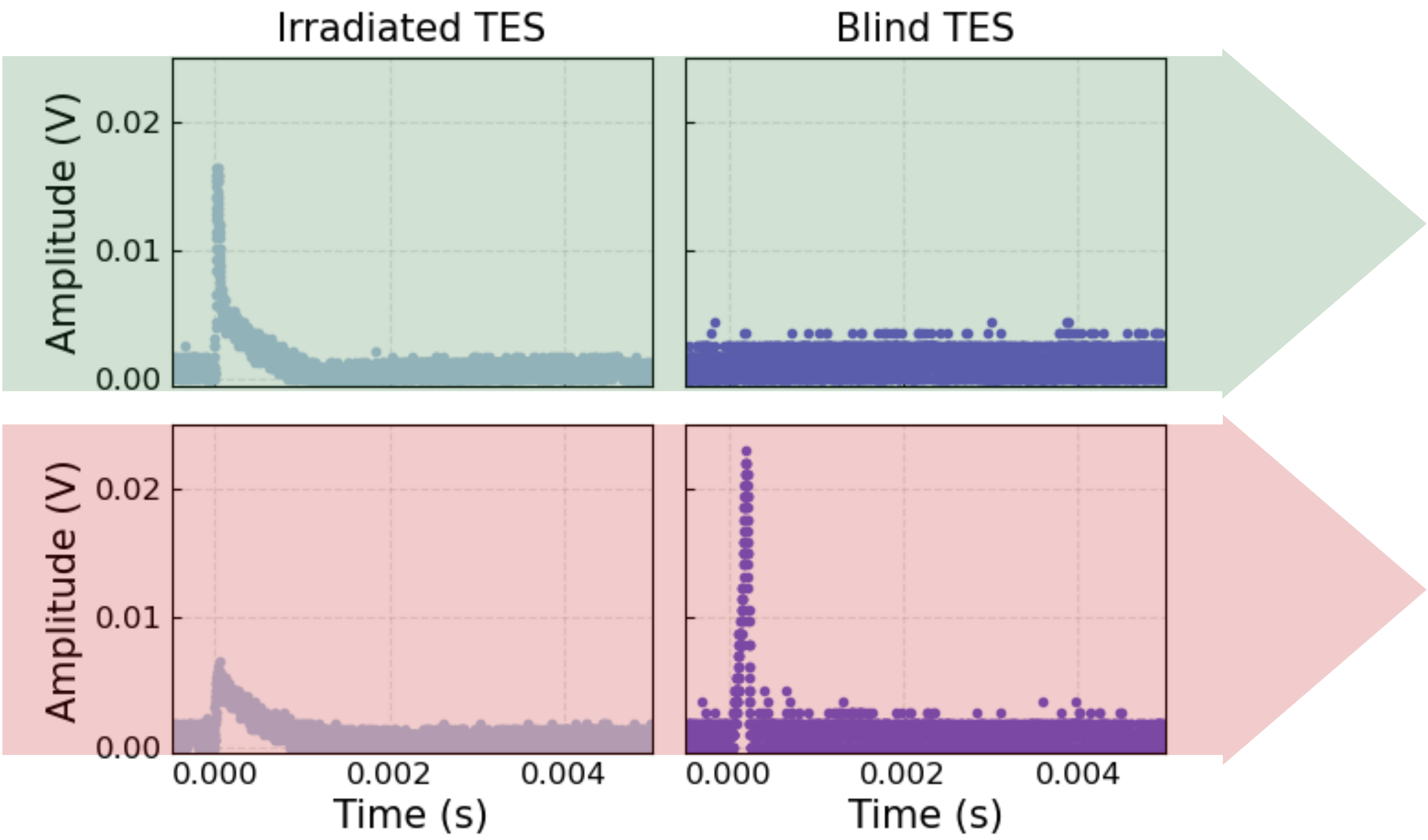
- 2x8 hours
- @ 18 MeV : 51 events
- @ 22 MeV : 2885 events

Coincident glitch = event detected by both TESs (blind and irradiated)



# Single event



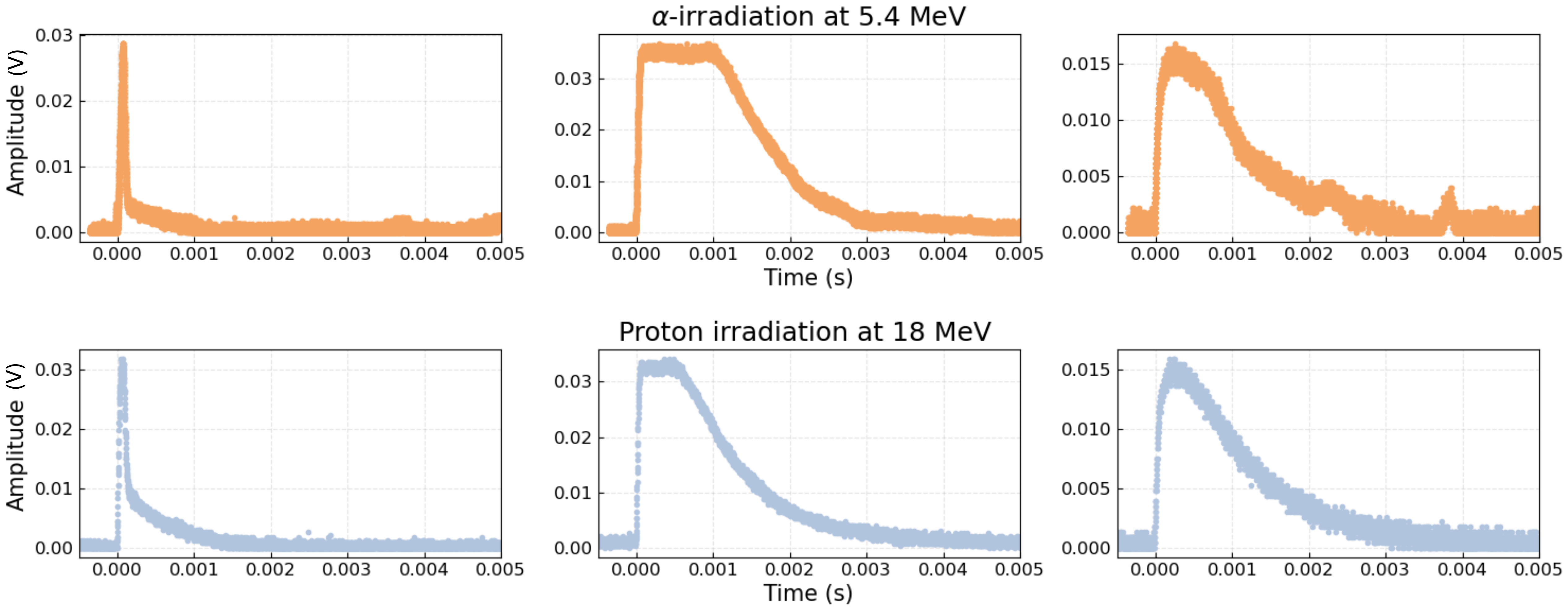

**No coincident glitches** resulting from direct particle hit on irradiated TES

⇒ **GOOD**

**Coincident glitches** resulting from secondary particles or electronics

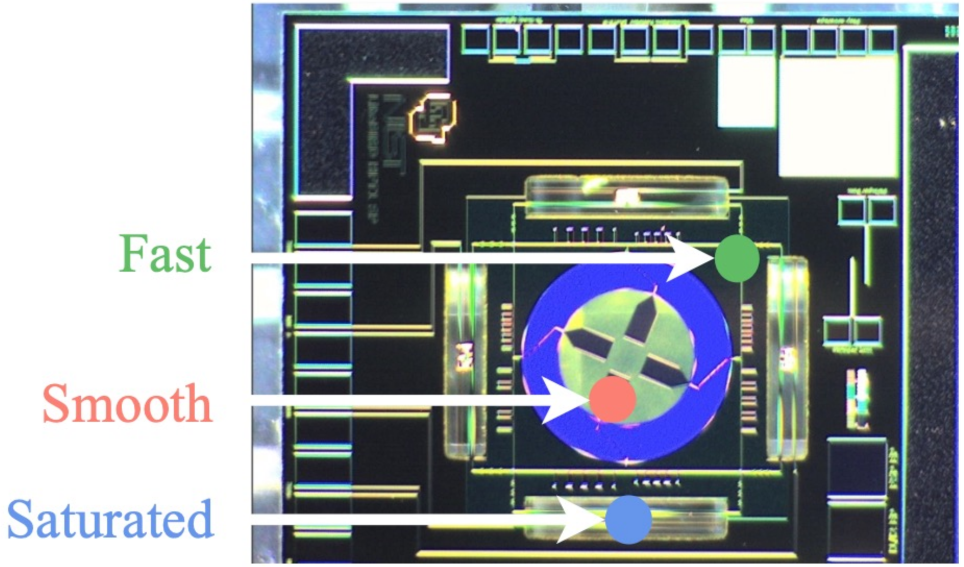
⇒ **DISCARDED**

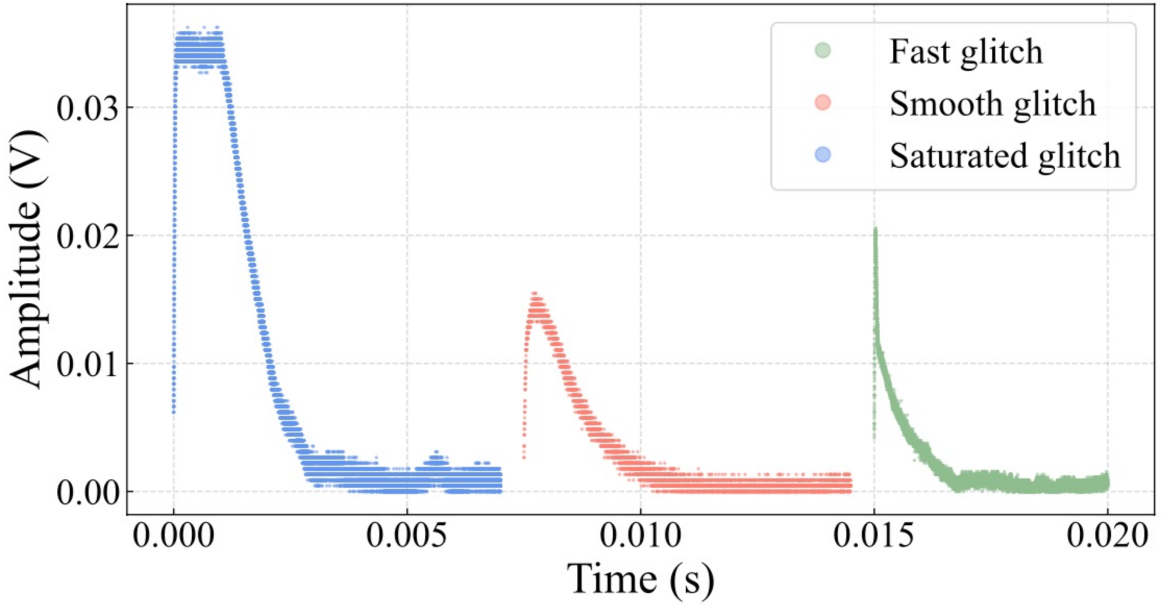
# Pulse shapes



# Pulse shapes

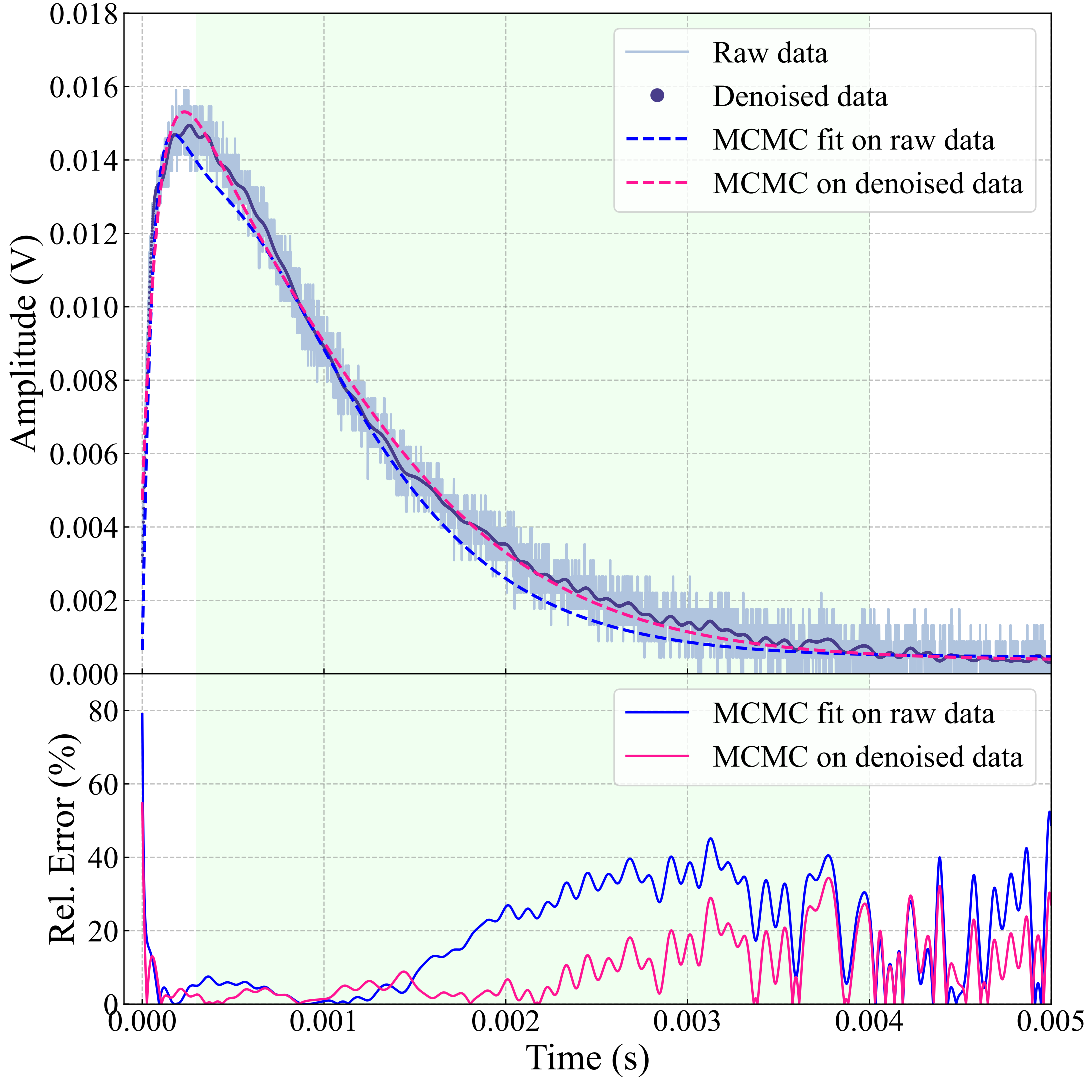
| Shape | Hypothesis | 5.4 MeV | 18 MeV |
|---|---|---|---|
| Saturated | Direct hit on TES ? | 500 µs | 480 µs |
| Smooth | Hit on antenna ? | 510 µs | 453 µs |
| Fast | Somewhere in between ? | 580 µs | 520 µs |




⟹ **To be confirmed with further analysis and simulations** ⇢ **see talk from Guillermo**

# Pulse shapes




⇢ **Goal :** extract $\tau_{th}$

| **MCMC fit on raw data** |
|---|
| $\tau_{th} = 485.76^{+0.3}_{-0.3}\ \mu s$ |

| **MCMC fit on denoised data** |
|---|
| $\tau_{th} = 584^{+0.35}_{-0.32}\ \mu s$ |