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INFN TORINO

Timing resolution in BGO of the FOOT calorimeter

determined with cosmic rays

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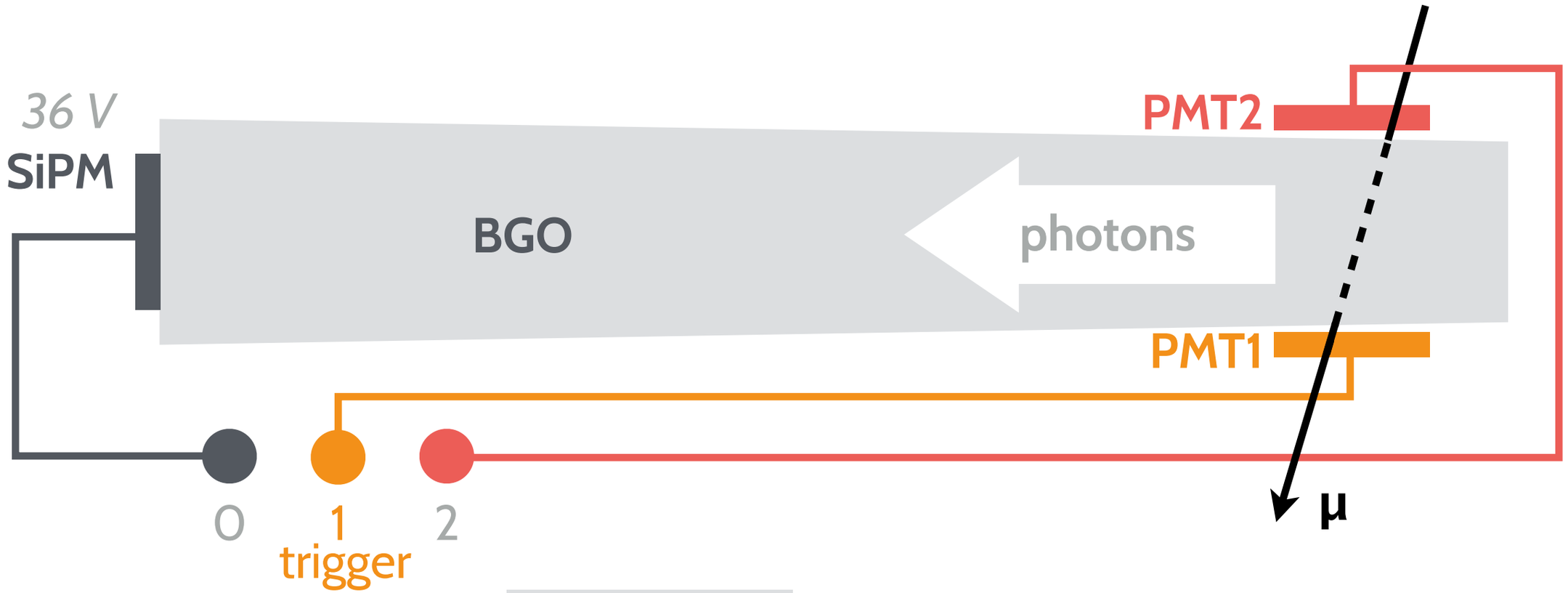
Introduction: objectives + setup

Evaluate the possibility of Time Of Flight (TOF) measurement using the BGO crystals of the FOOT calorimeter

↳ measure the time resolution achievable with the BGO crystal alone

Using cosmic tracks passing through the BGO crystal to measure the time of the pulse in the SiPM+BGO wrt the fast trigger pulse in the PMT+plastic scintillators

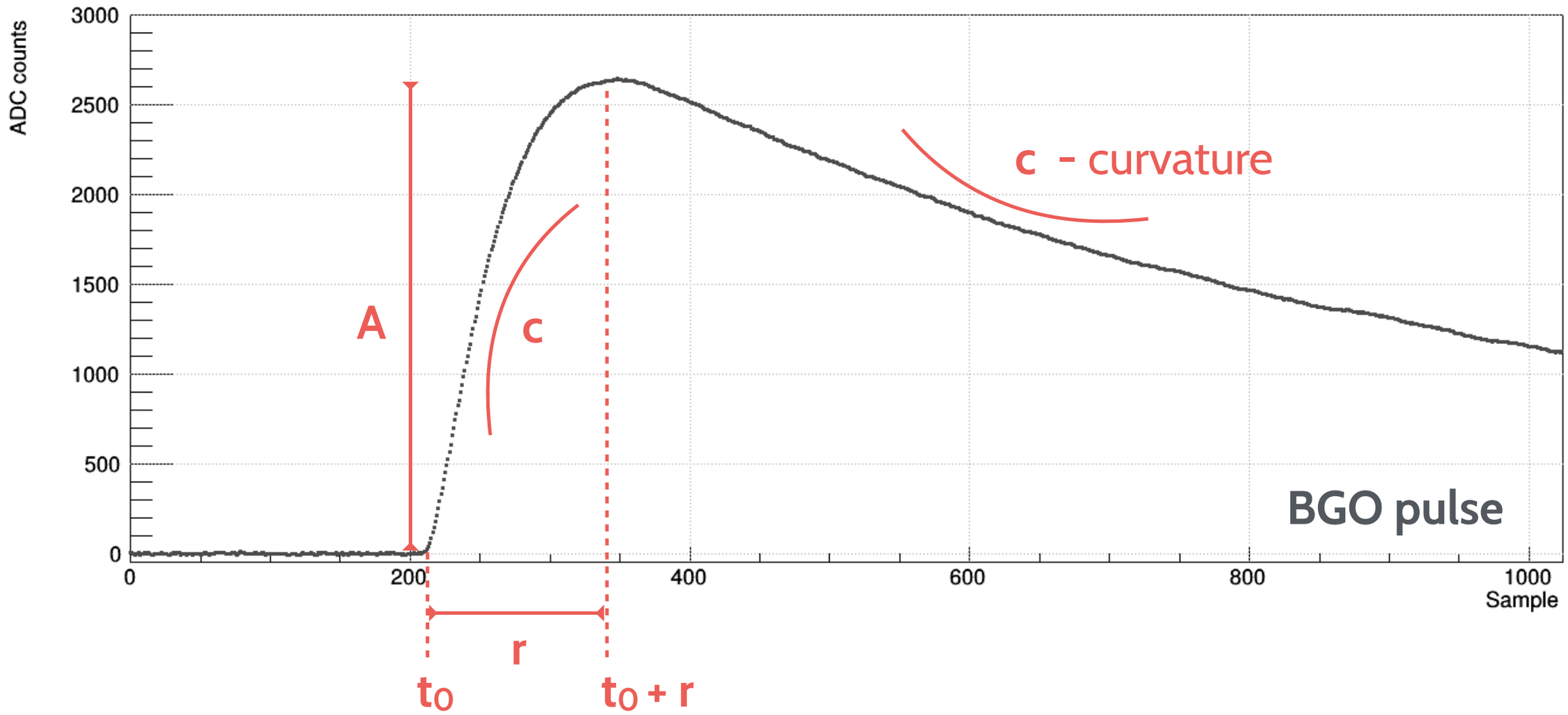


All three pulses digitised with CAEN V1742 at 2.5 GS/s → 1024 samples/event

- triggering on a single channel: **PMT1** → further event cleaning done offline

Pulse fit function

BGO and Plastic pulses fitted by the same function: $A \cdot \exp\left[c \cdot \log^2\left(\frac{x - t_0}{r}\right)\right]$

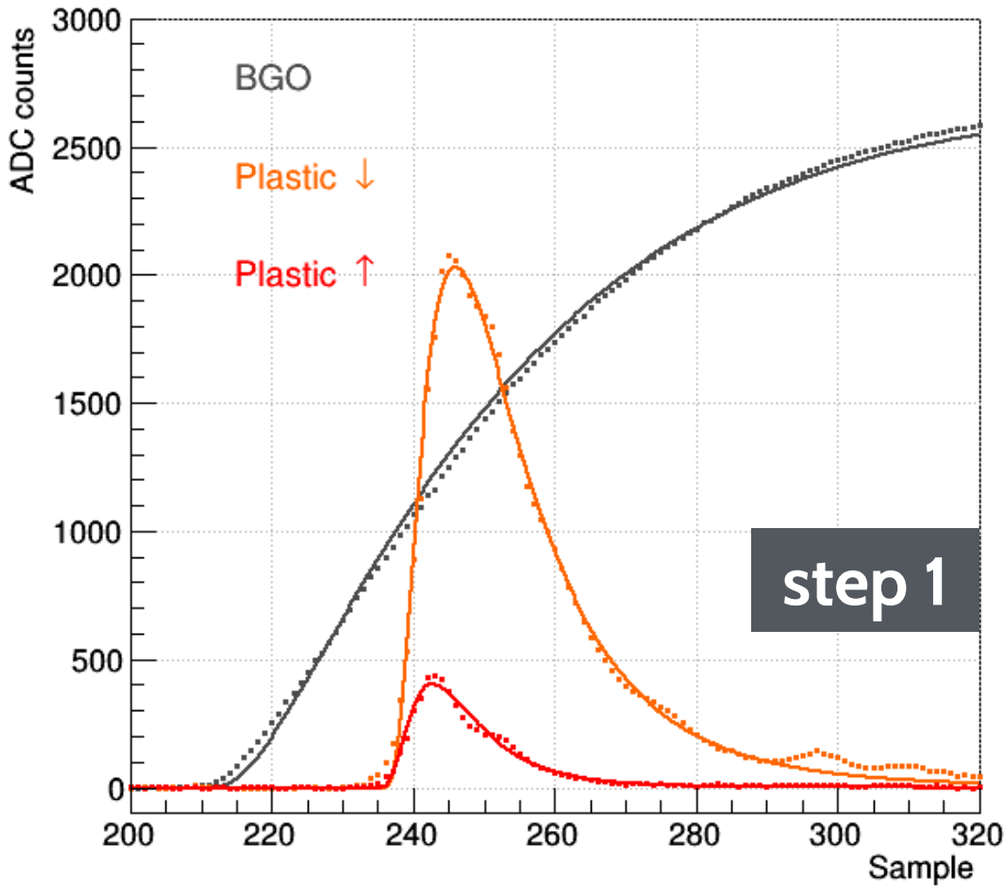


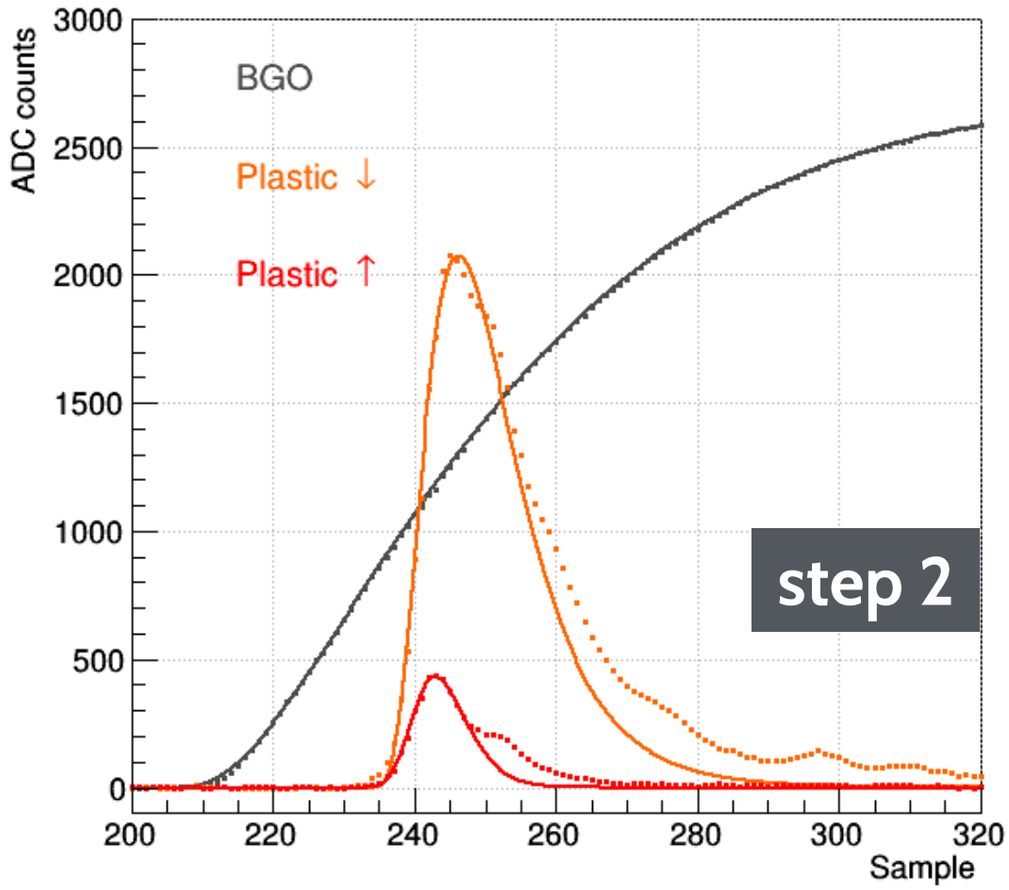
Only events with all three pulses having substantial maximum deviation from the baseline are selected to perform the fits: $ADC_{max} > 50$

Pulse fitting sequence: rising edge

Pulse fitting performed in two steps:

1. **fit of the complete pulse shape using the full range:** samples 0 → 1023
   ↳ to find the approximate values for t_0 and **r**
2. **precise fit of the rising edge**: samples 0 → $t_0 + 1.5r$



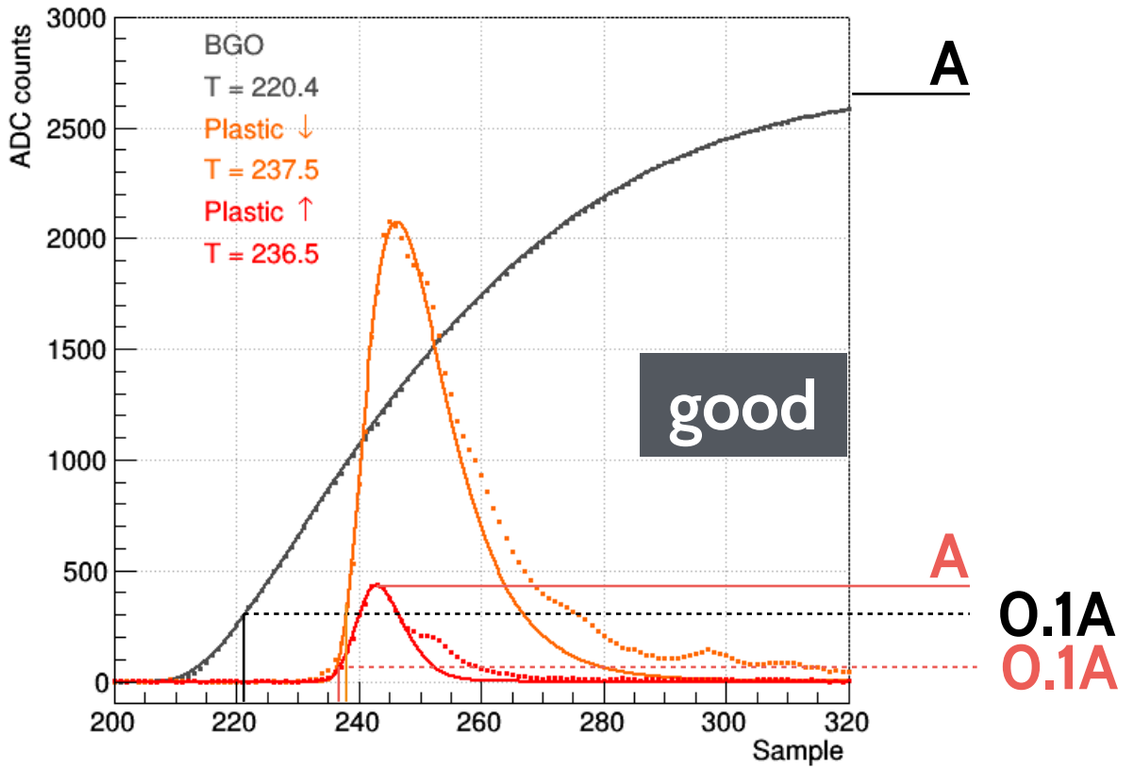


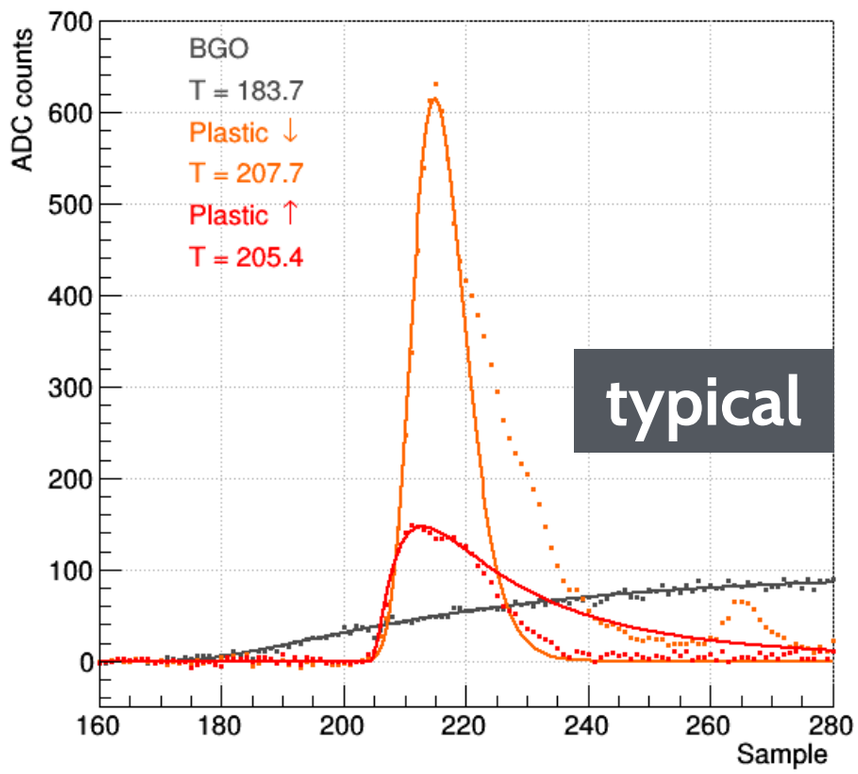
Rising edge is fitted perfectly → time extracted from the smooth function

Time extraction: functional form

t_0 parameter is not stable enough → use a constant fraction **f** of the amplitude

$$\mathbf{f} \cdot A = A \cdot \exp\left[c \cdot \log^2\left(\frac{x - t_0}{r}\right)\right] \rightarrow x = t_0 + r \cdot \exp\left[-\sqrt{-\frac{\log \mathbf{f}}{c}}\right] \rightarrow \mathbf{f = 0.1}$$





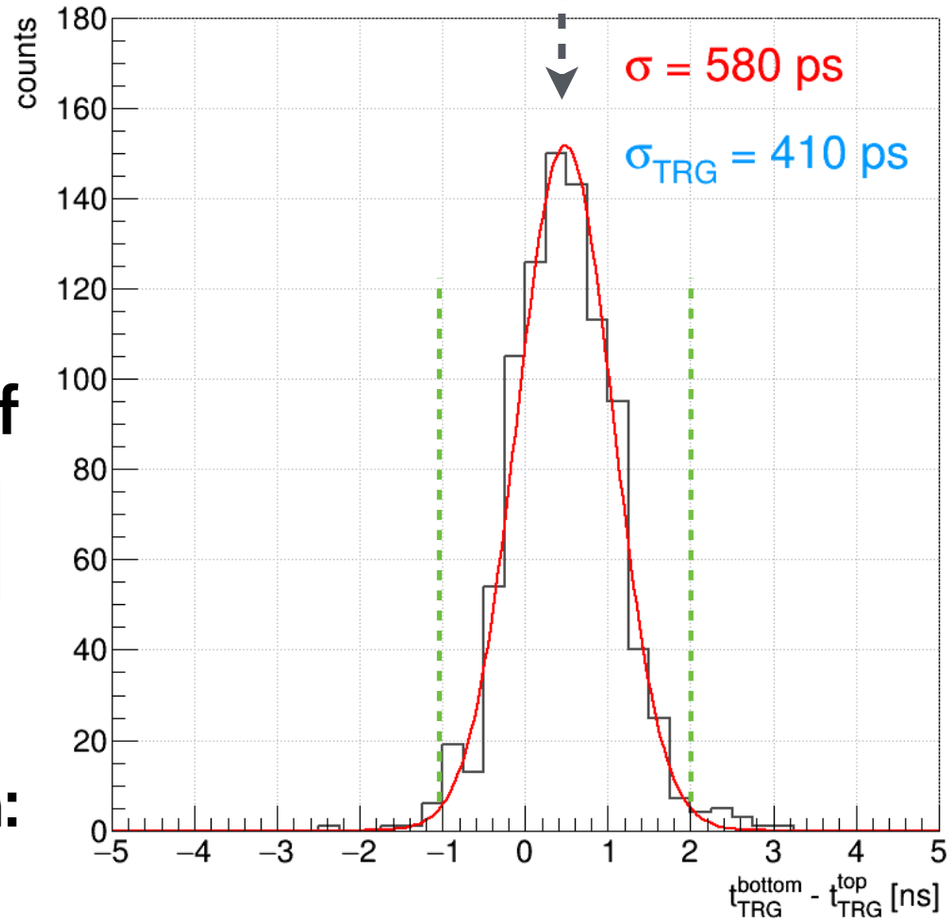
Low pulse amplitude in BGO from cosmics limits the rising edge shape precision

↳ time resolution might be better with a proper ion beam

Time resolution: event selection

Fast signals in plastic scintillators represent the best achievable time resolution with the given readout setup at 2.5 GS/s

- 2.5 GS/s → 400 ps/sample
- σ = 580 ps → σ_{TRG} = 410 ps
  2 uncorrelated measurements



Calculating time resolution in BGO from width of

$$\frac{t_{PMT1} + t_{PMT2}}{2} - t_{BGO} = \Delta t$$

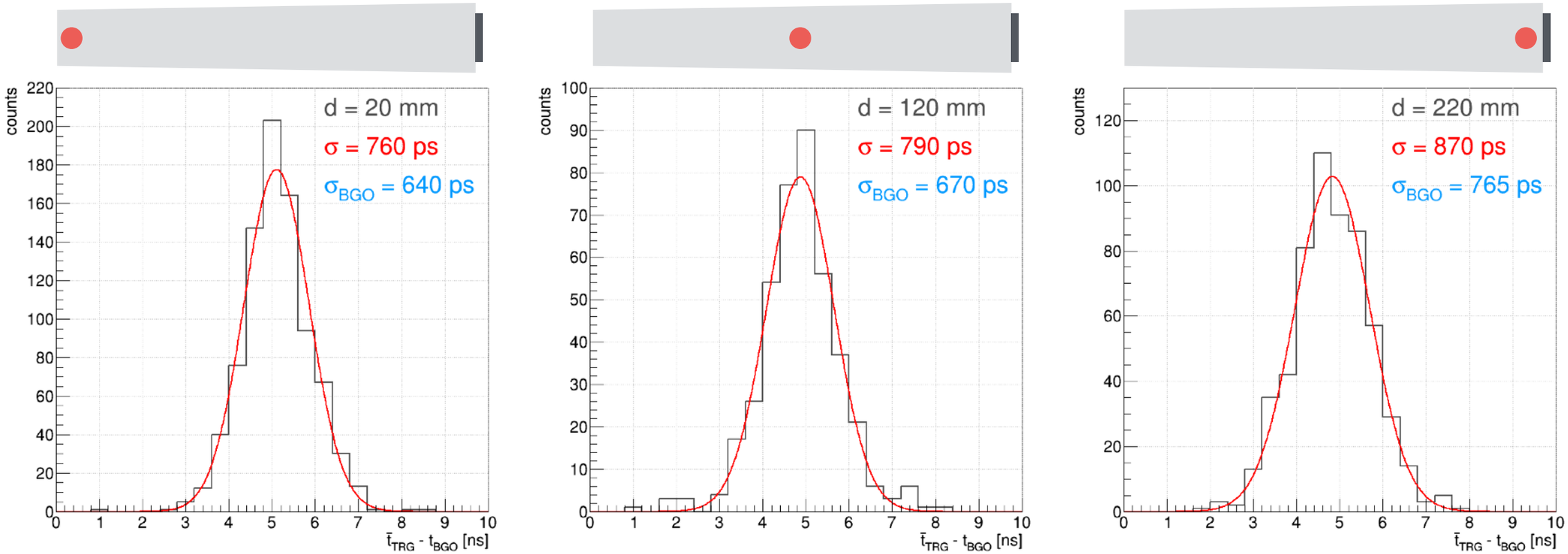
Only good events selected for the Δt calculation:

- all 3 pulses with high amplitude and good fit X^2
- $1 < |t_{PMT1} - t_{PMT2}| < 2$

Time resolution: $d_{trg\text{-}SiPM}$ = 22 cm

Obtained time resolutions in BGO at 2.5 GS/s

$$\sigma_{BGO} = \sqrt{\sigma^2 - \sigma_{TRG}^2}$$



Better time resolution might be achieved with more light from ion beams