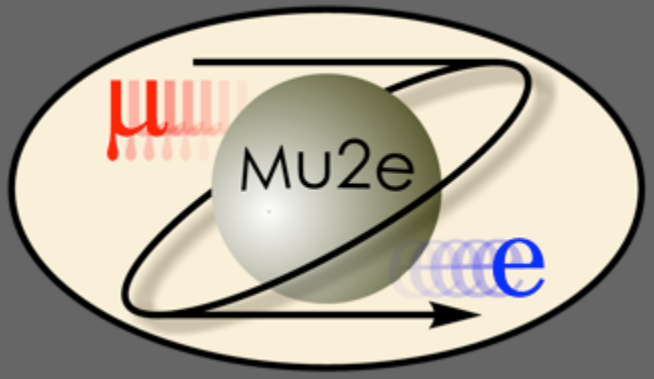
Mu2e Calorimeter Cosmic Ray Tagger Status



Daniele Paesani
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On behalf of the Mu2e calorimeter group

September 3, 2020

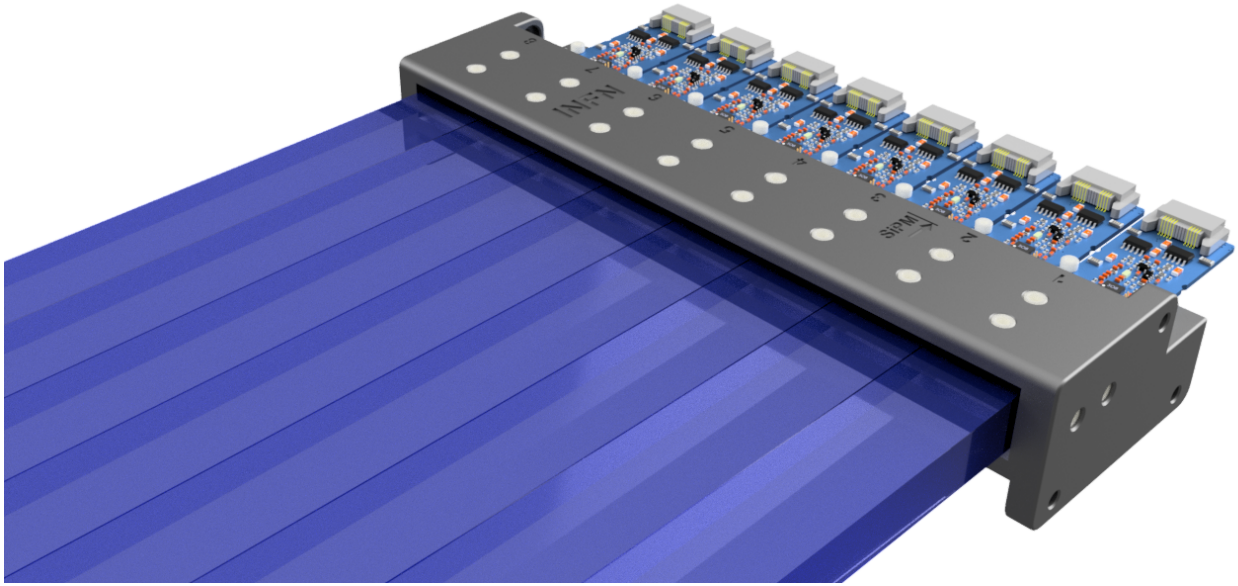
INFN
Istituto Nazionale di Fisica Nucleare

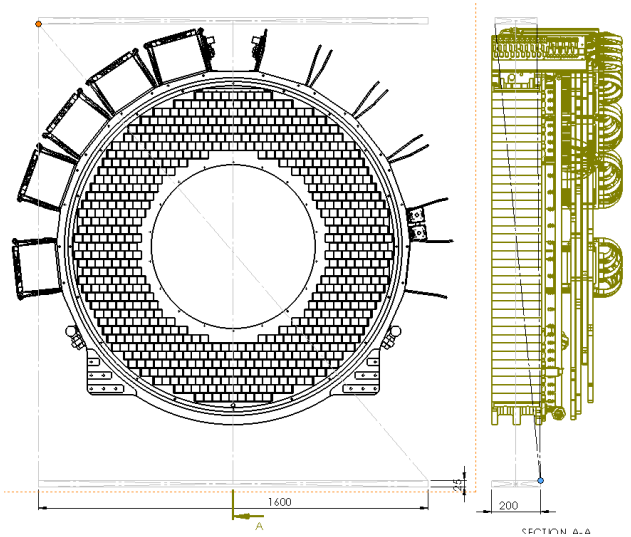
Fermilab

CRT – Physics reasons

Cosmic Ray tagger to test each calorimeter disk at SiDET prior to installation, in order to evaluate

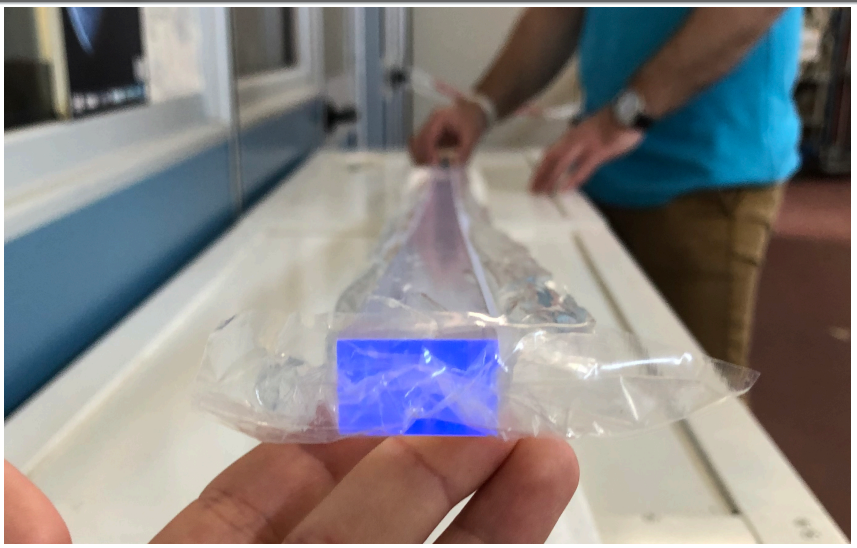
- Crystals LRU
- Channels equalization at 21 MeV
- Time offset alignment
- Timing resolution dependence on crystals z-axis

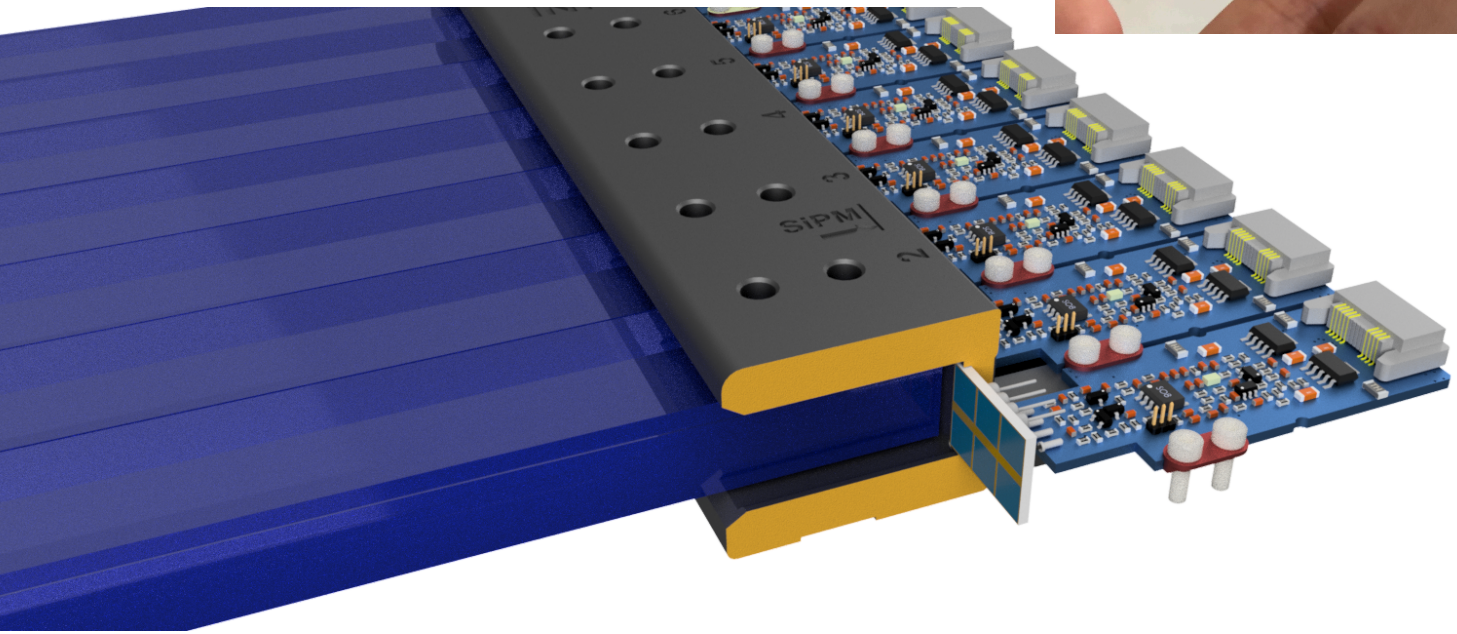




CRT – design

- 2 sub-modules
- 8x EJ-200 bars (15x25x1600 mm^3)
- Tyvek wrapping
- Tedlar darkening
- Direct coupling w/ optical grease
- Mu2e SiPM readout
- 3D MIP track reconstruction

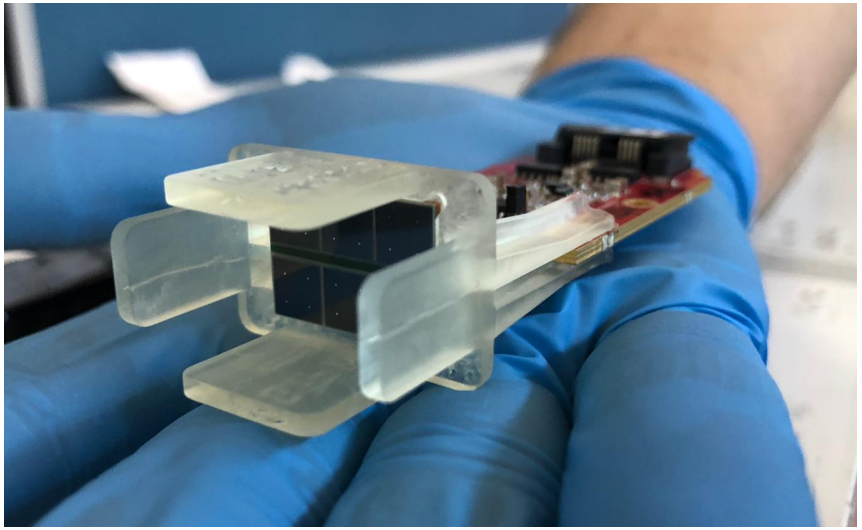


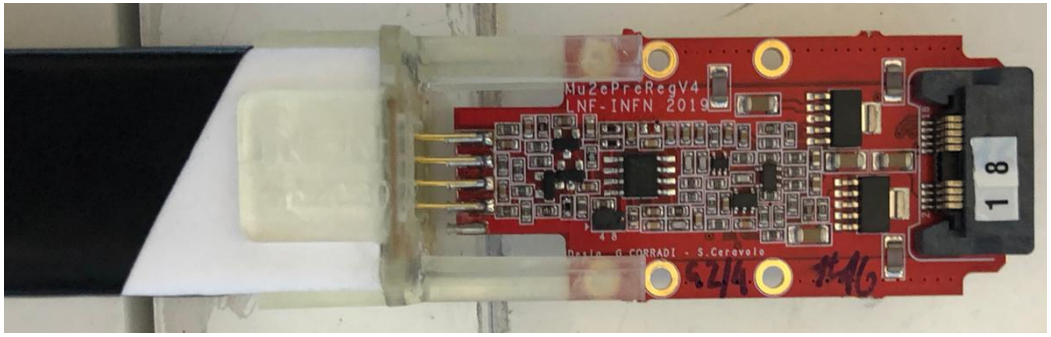


CRT – status

Status:

- Mechanical design concluded
- First optic block successfully 3D printed at LNF
- Single bar test w/ double readout concluded
- Longitudinal resolution of 7 mm
- Dedicated FEE PBCs calibration is ongoing





Next steps…

- Mechanical assembly due in October
- Scintillator pack assembly due next week
- Module M0 vertical slice test w/ CRT will follow

CRT – trigger scan test

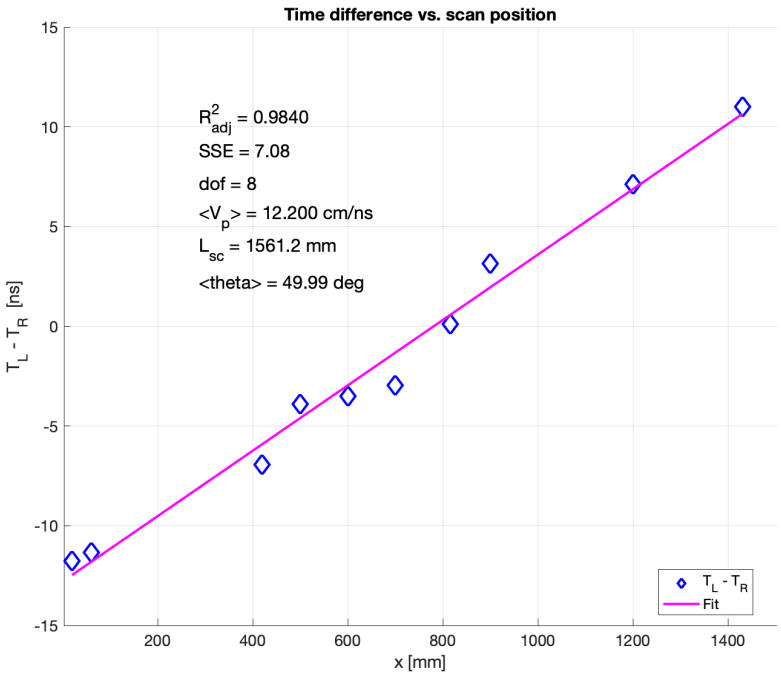
- Signal time has been obtained w a *Logn* fit on the WF leading edge and w a CF at 20%

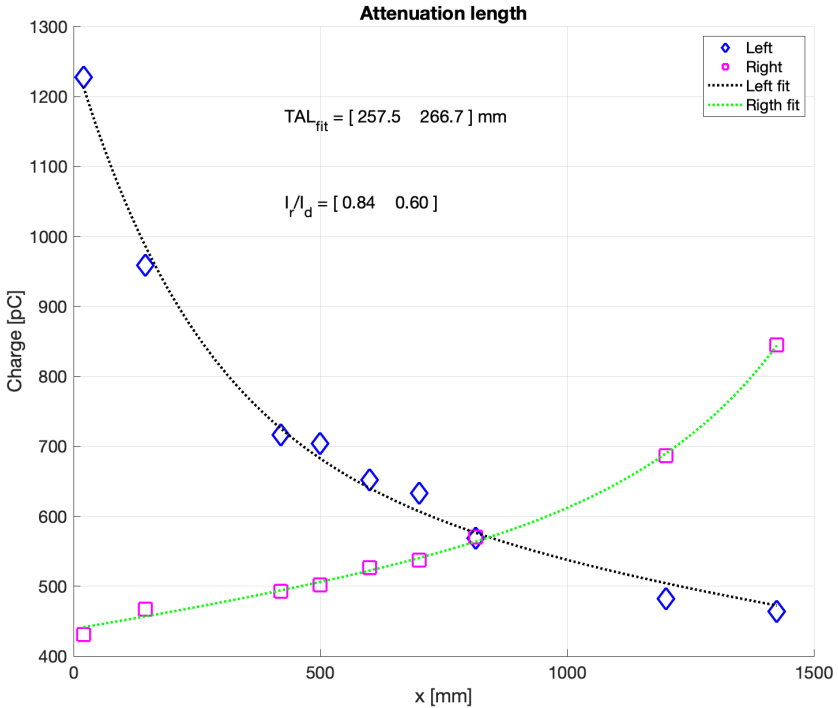
  TL – TR = 2*x/V - L/V

- Fitted light propagation speed → ***V = 12.2 cm/ns***
- Fitted scintillator length → ***L = 156.1 cm***

  (vs 160 cm actual)

- Avg. propagation angle **<θ> = acos (n*V/c) = 49.99 °**



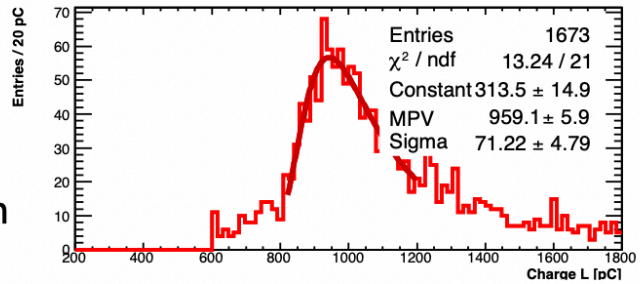


- Sigma (TL-TR) ~ 100 ps
- Time resolution ~ 100 ps / sqrt(2) ~ 70 ps
- **Longitudinal resolution = Vf*sigma/2 ~ 6 mm**

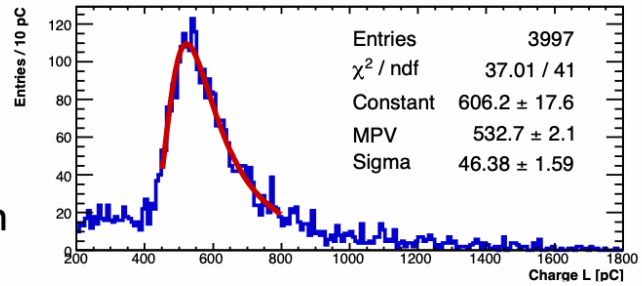
CRT – MIP peaks

Left SiPM

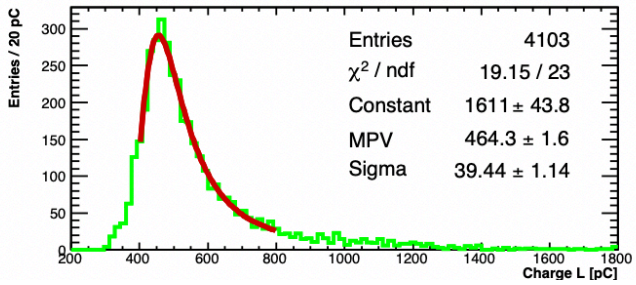
50 mm



815 mm

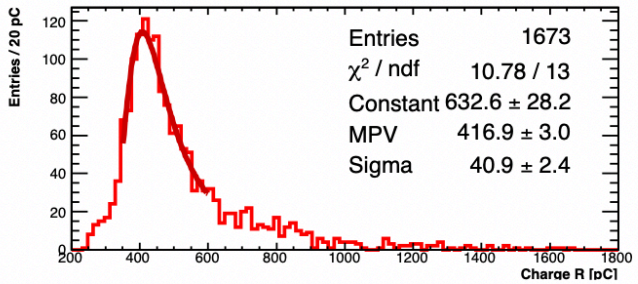


1430 mm

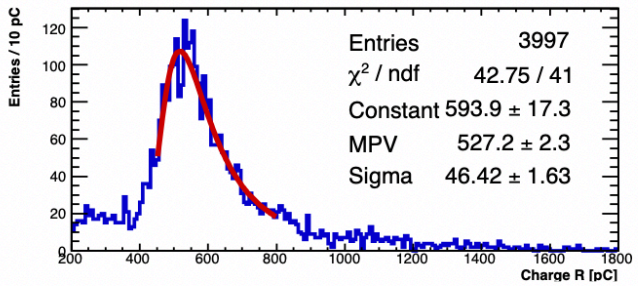


Right SiPM

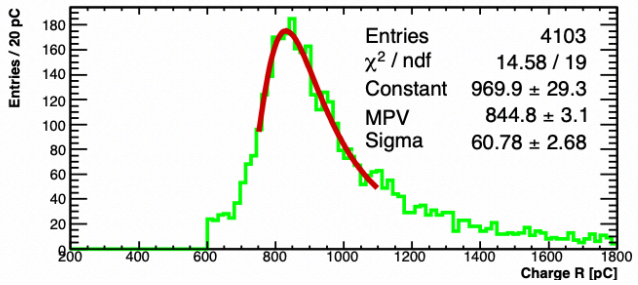
1550 mm



785 mm

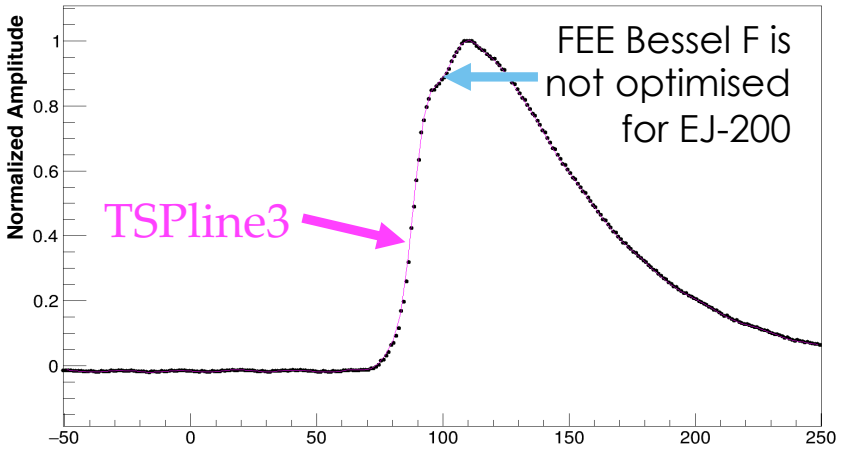


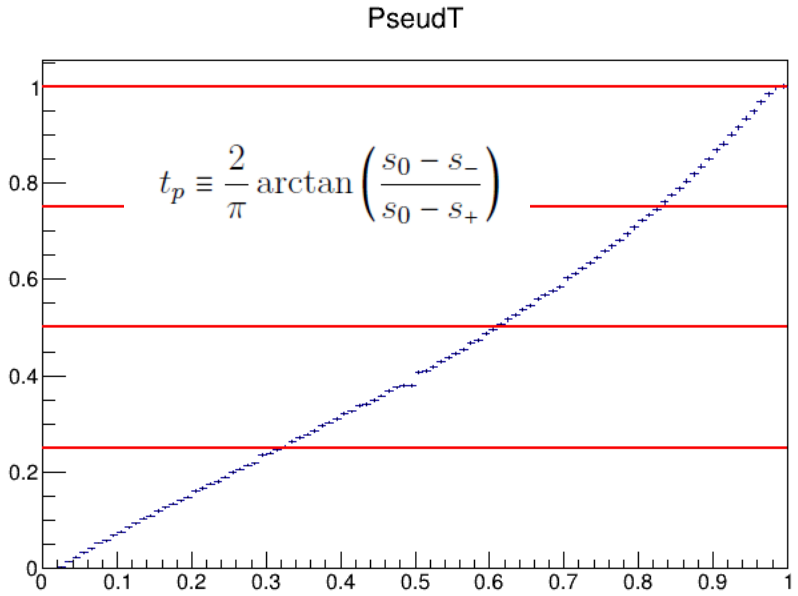
170 mm



CRT – template fit

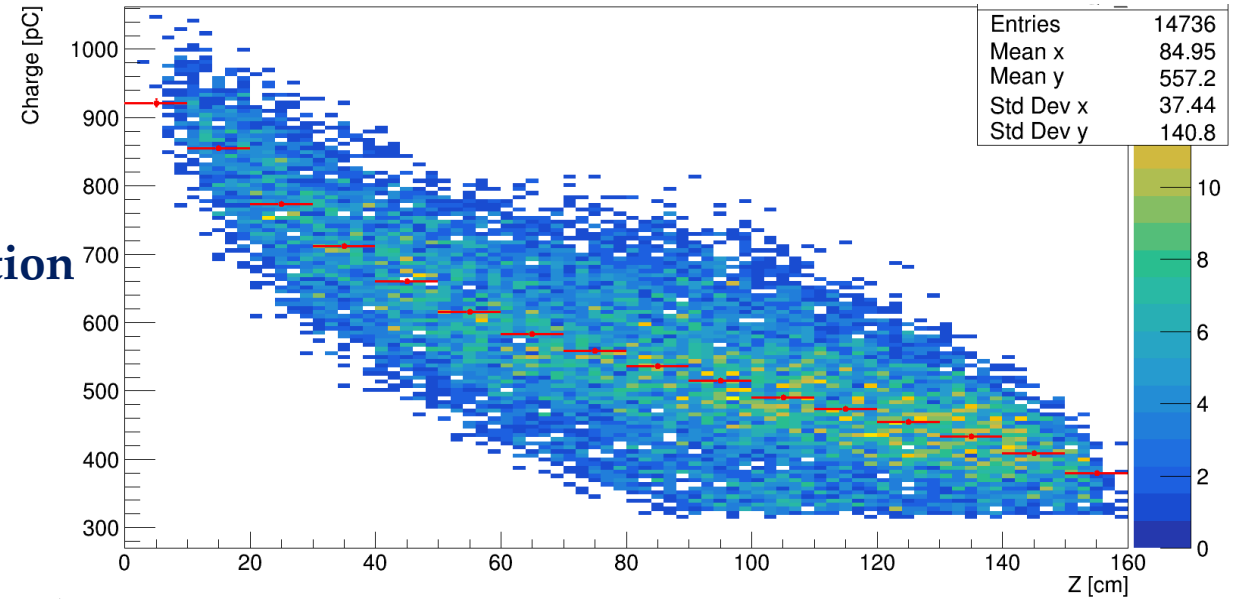
- Template fit constructed and applied to evaluate SiPMs time
- TRG on SiPMs coincidence -> interaction point reconstruction via TOF



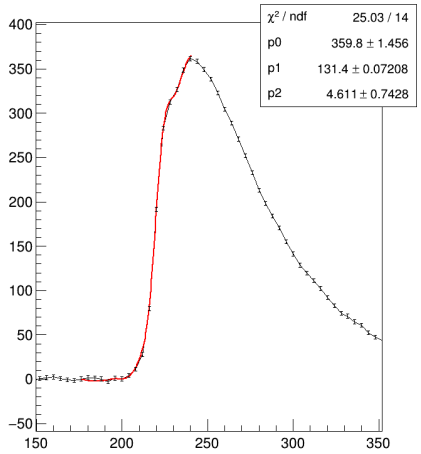


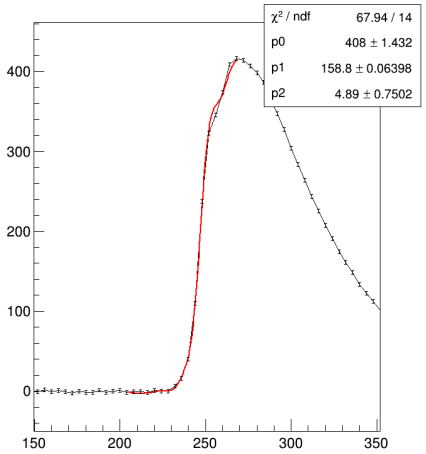
CRT – TOF resuslts (1)

Interaction point reconstruction



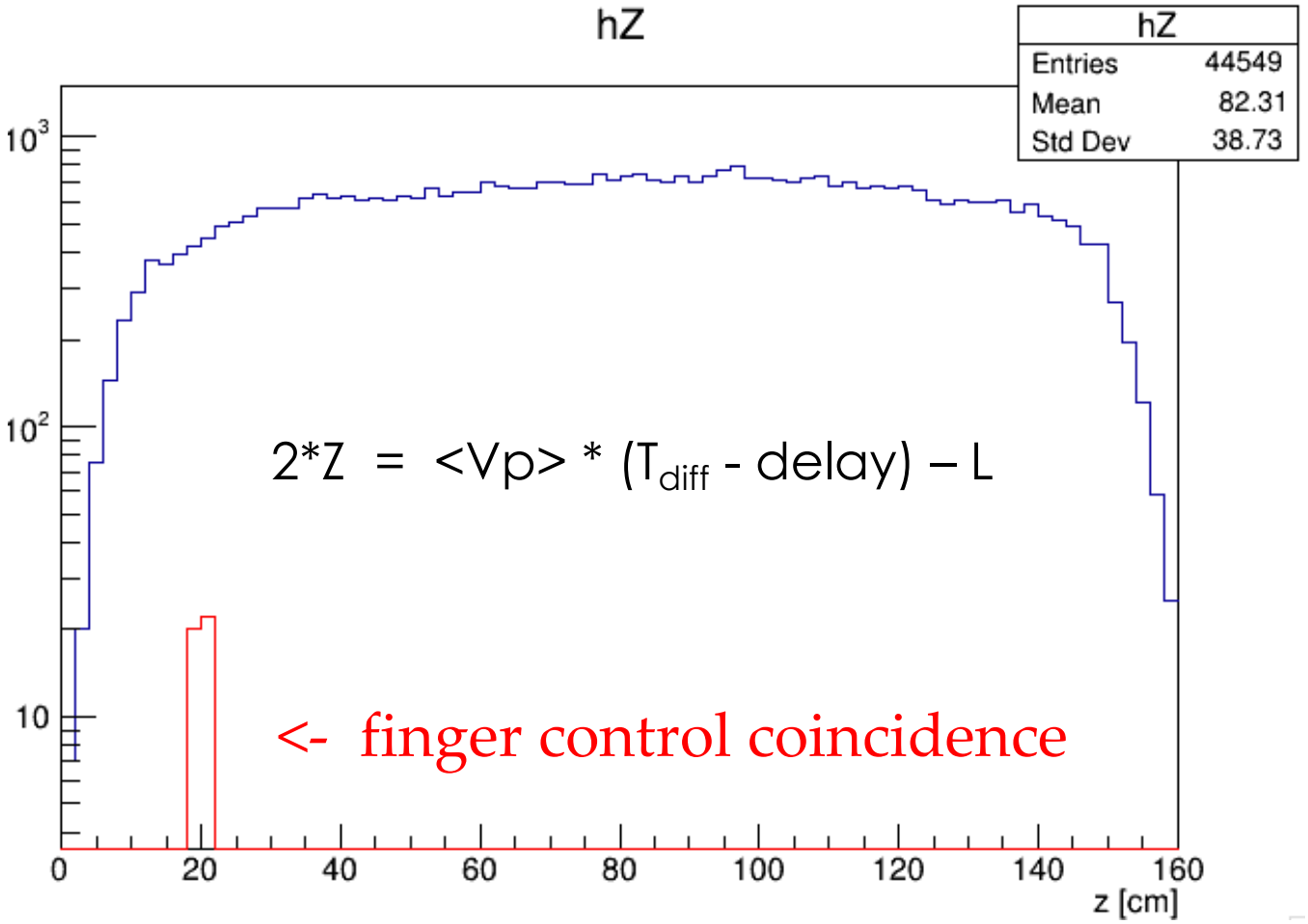
Fitted template example



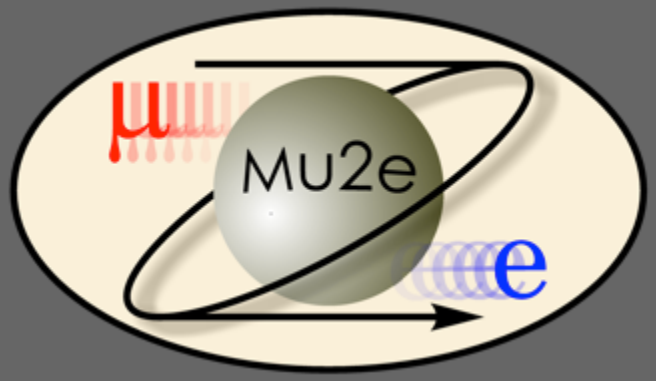


CRT – TOF resuslts (2)

Reconstructed scintillator profile



Grazie



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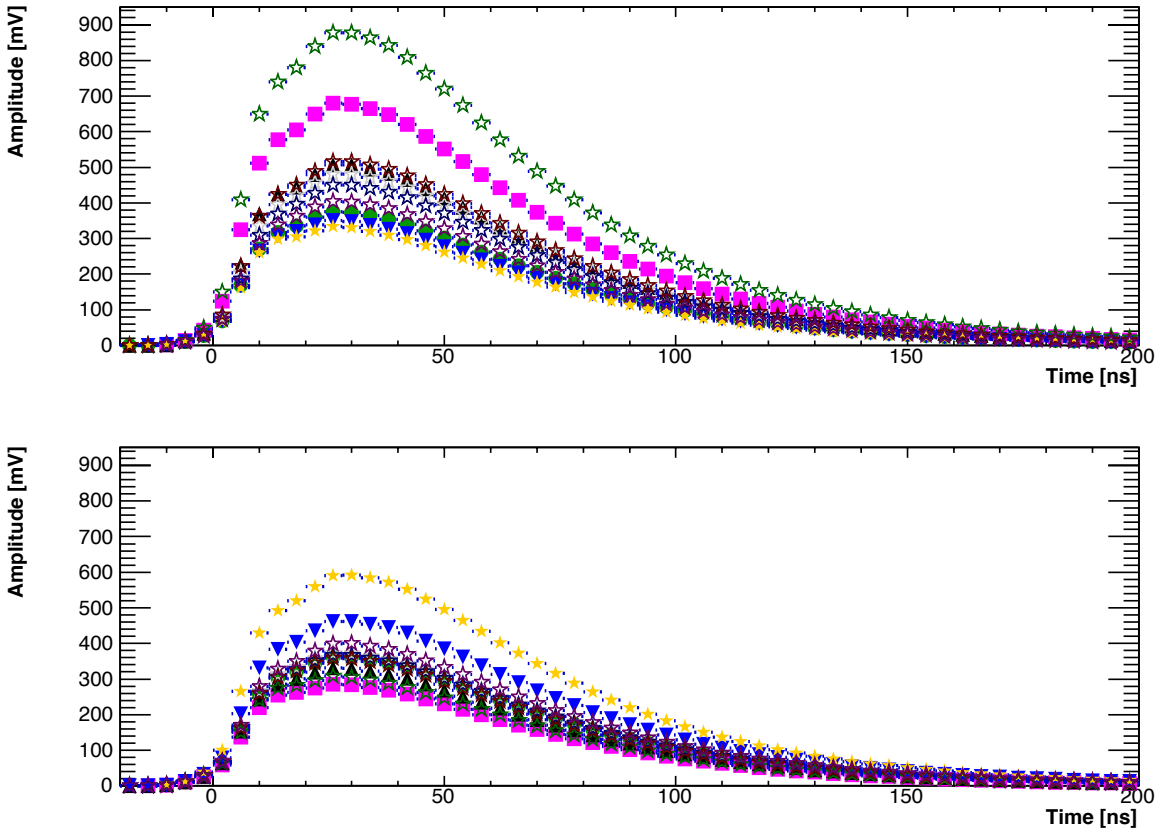
Waveform profiles
Scan over 10 positions

Trg – SiPM distance from side L

- 0 mm
- 400 mm
- 800 mm

Trg – SiPM distance from side R

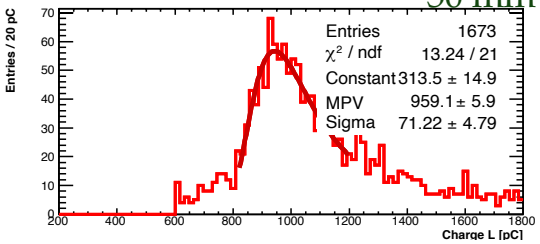
- 1600 mm
- 1200 mm
- 800 mm



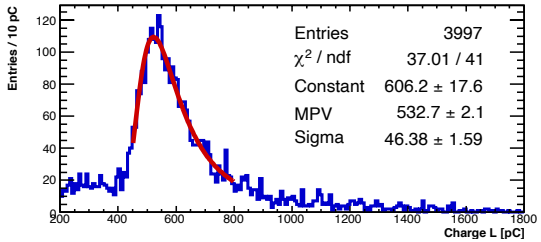
Charge spectra examples

Left SiPM

50 mm



815 mm



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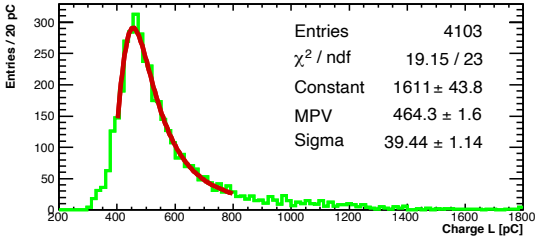

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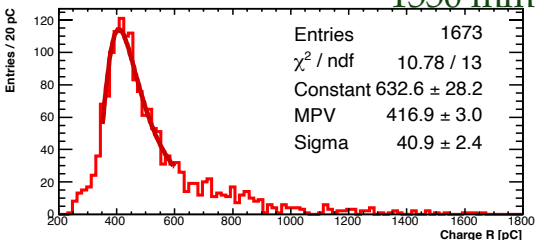
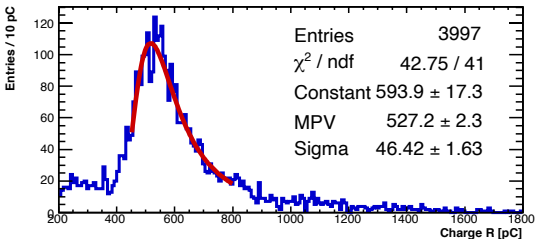


785 mm



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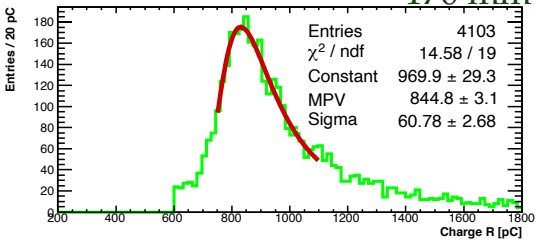

TOF, propagation spe

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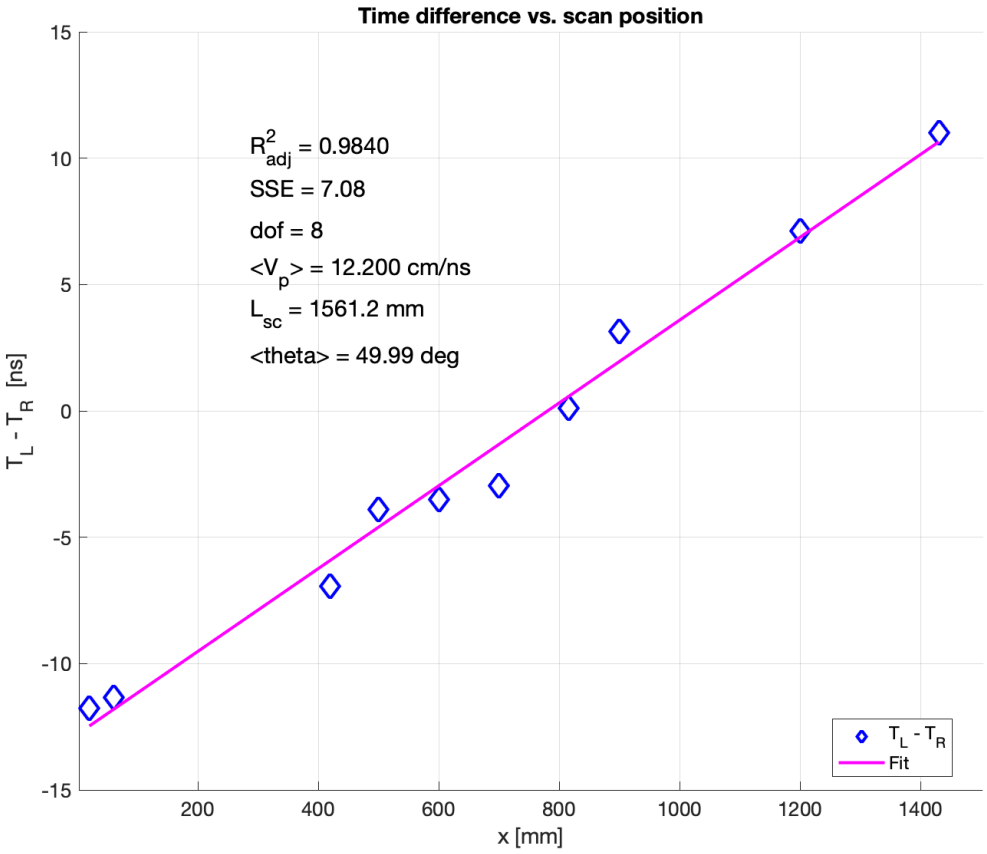
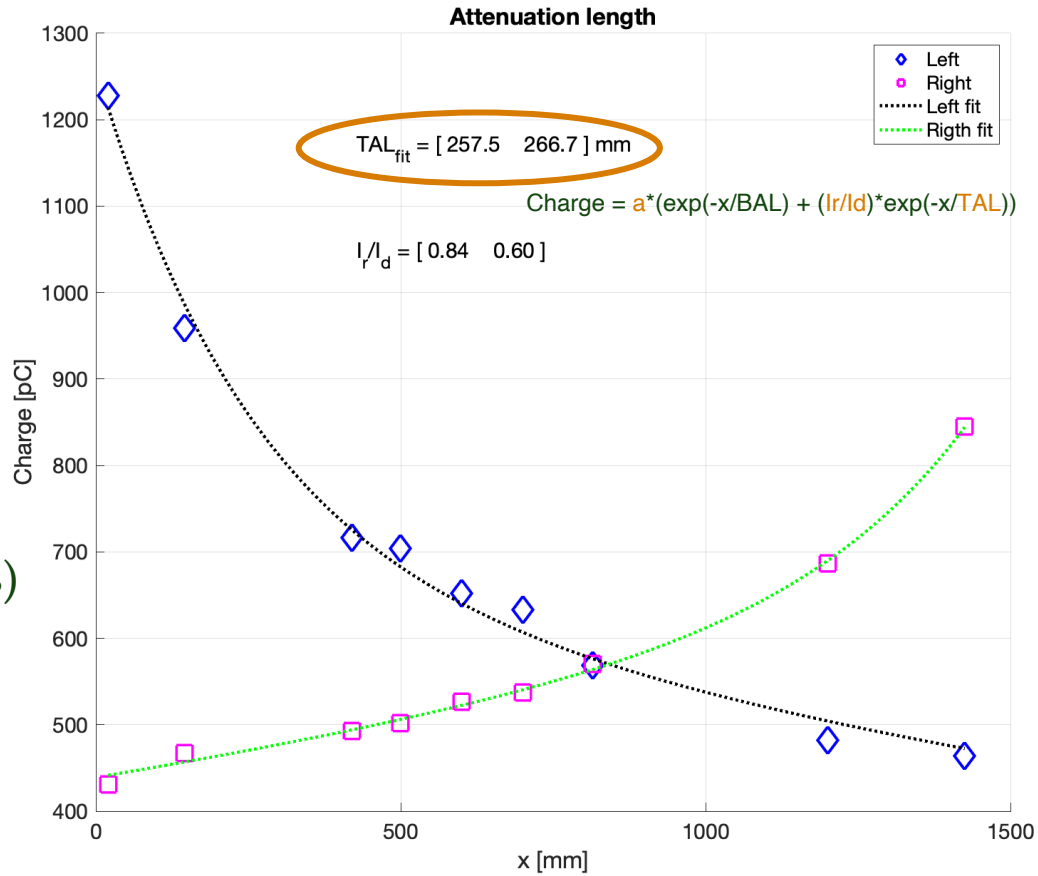


TAL (technical att. length) estimation

Considering

- Reflection efficiency = 0.95
- Vf = 12.2
- <θ> = 49.9 deg

- cross sectional dimension:
  h = 2*h1*h2/(h1+h2)
  (h1=25 mm , h2 = 15 mm)
- d*cosθ = x , d*sin θ = m*h ,
  (d = average light path, *m* reflections)
- BAL = 3800 mm (bulk attenuation length)
- h / BAL + log(1/R)*sinθ = h* cosθ / TAL



We expect a TAL ~ 273.5 mm