Study of a tracking system for neutron-induced reactions at the n_TOF facility

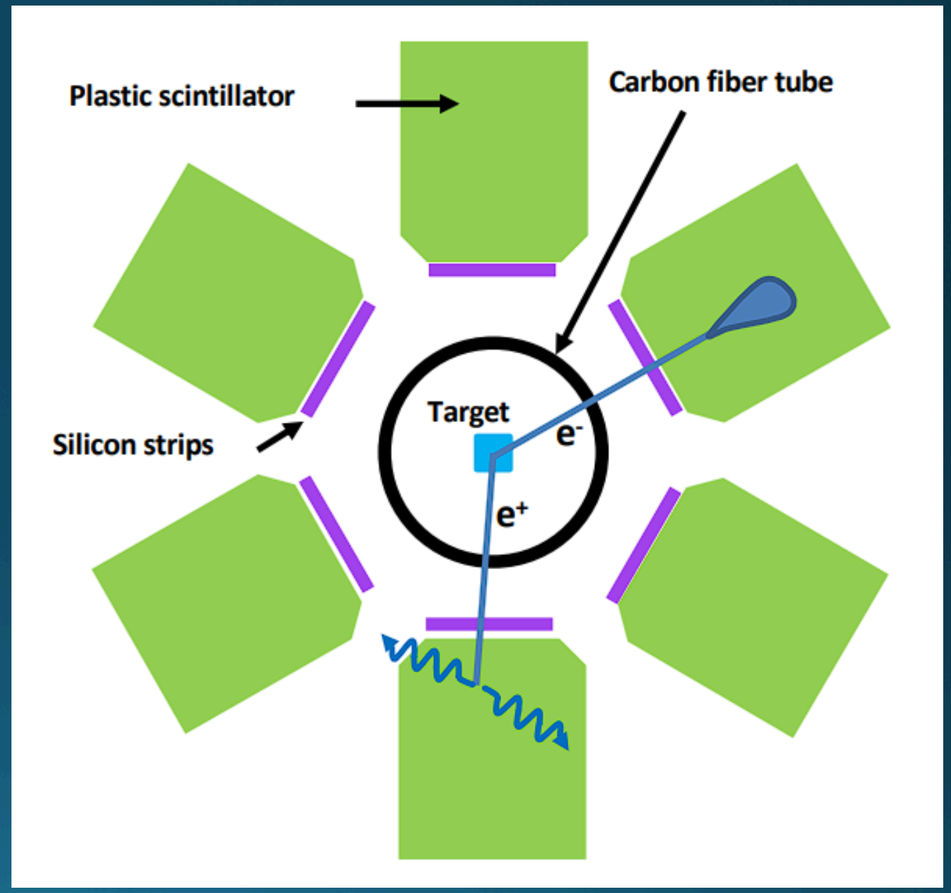
The X17 anomaly

- A significant anomaly has been observed in the emission of electron-positron pairs in the and reactions at ATOMKI, Hungary.
- While the origin of this anomaly remains unexplained, among other hypotheses it can be interpreted as the signature of the existence of a new particle beyond the standard model: a boson called X17.

Reaction	MX17 ± ΔMstat ± ΔMsyst (MeV)	Statistical Evidence
$^{7}\mathrm{Li}(\mathrm{p},\mathrm{e}^{+}\mathrm{e}^{-})^{8}\mathrm{Be}$	$16.70 \pm 0.35 \pm 0.50$	$> 5\sigma$
$^{3}\mathrm{H}(\mathrm{p},\mathrm{e}^{+}\mathrm{e}^{-})^{4}\mathrm{He}$	$16.94 \pm 0.12 \pm 0.21$	$> 9\sigma$

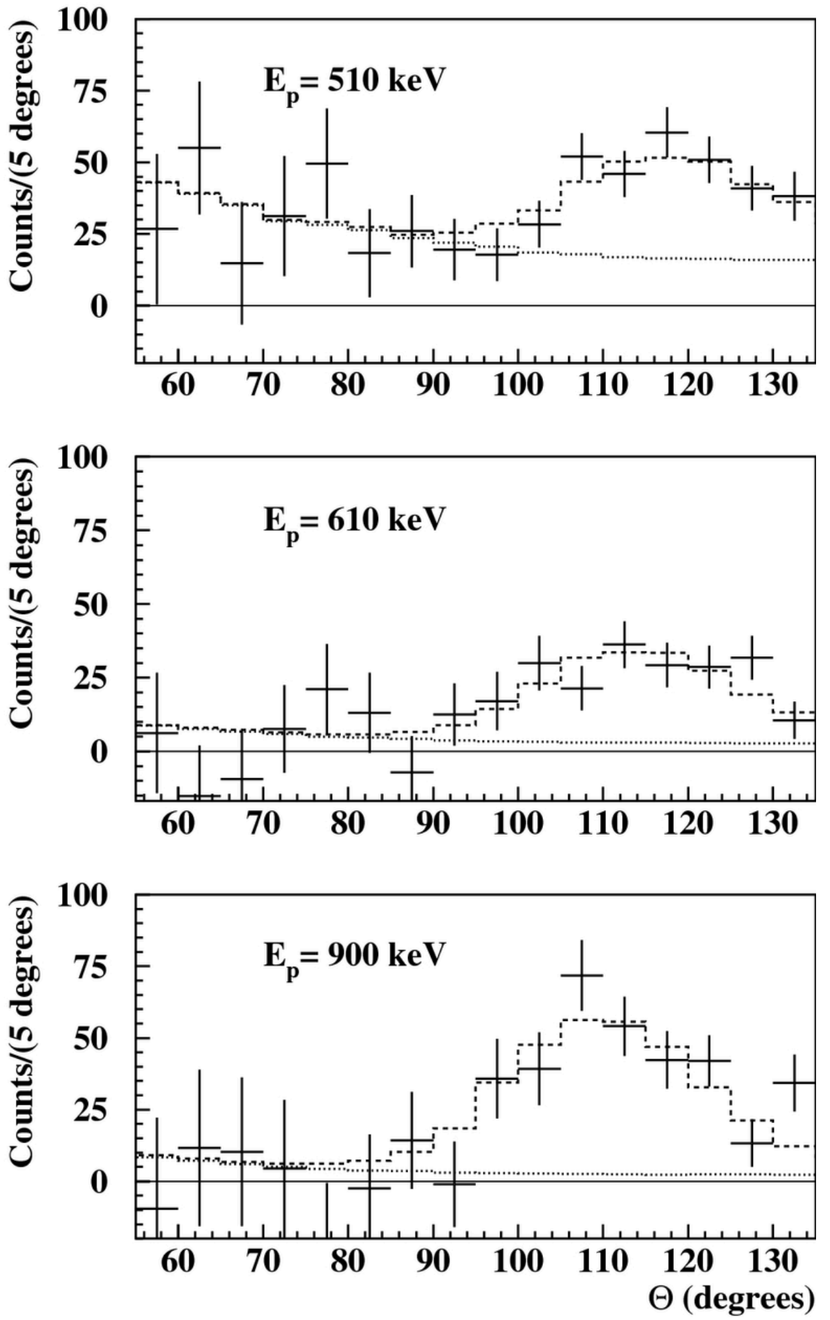
The ATOMKI experiment

- ^{3}H on Ti layer
- 6 plastic scintillators $82 \times 86 \times 80\ mm^{3}$
- 6 double-sided silicon strip detectors
- $1\ mm$ thick carbon fiber tube
- Detector acceptance only $\sim 90°$ with respect to the beam axis
- No tracking



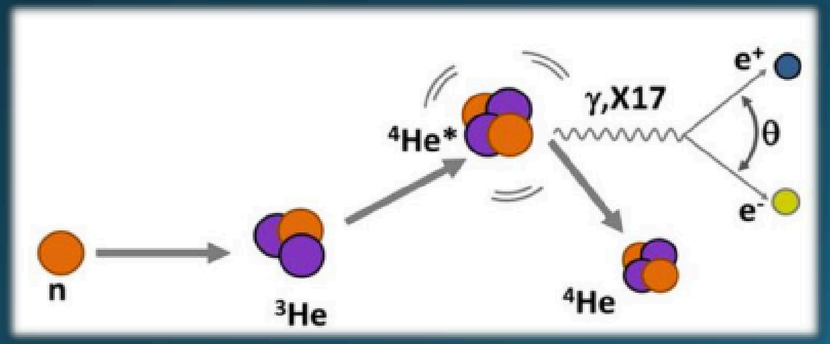
The X17 anomaly

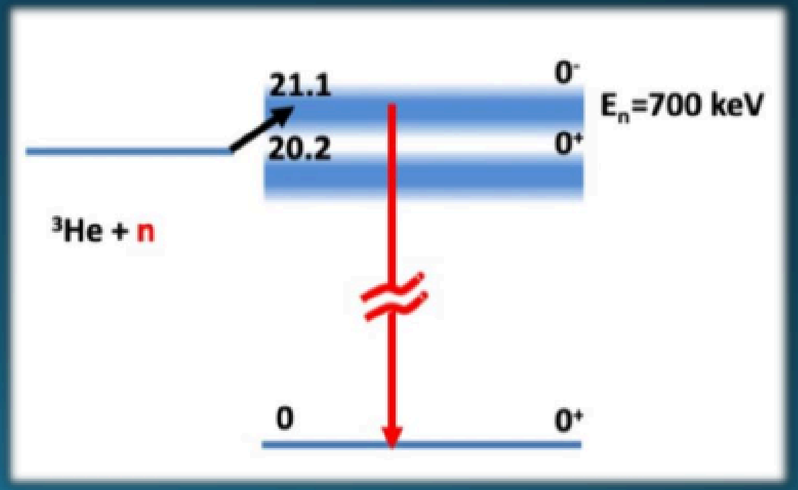
- This evidence/scenario is presently not confirmed or excluded by other experiments or groups.



X17 @ n_TOF

- The idea is to investigate the conjugate neutron-induced reaction $^{3}\mathrm{He}(\mathrm{n}, \mathrm{e}^{+}\mathrm{e}^{-})^{4}\mathrm{He}$
- Wide energy range needed (proton and neutron beams) to explore all resonances with different J^{π}
- Large detector acceptance needed (statistics and kinematics)





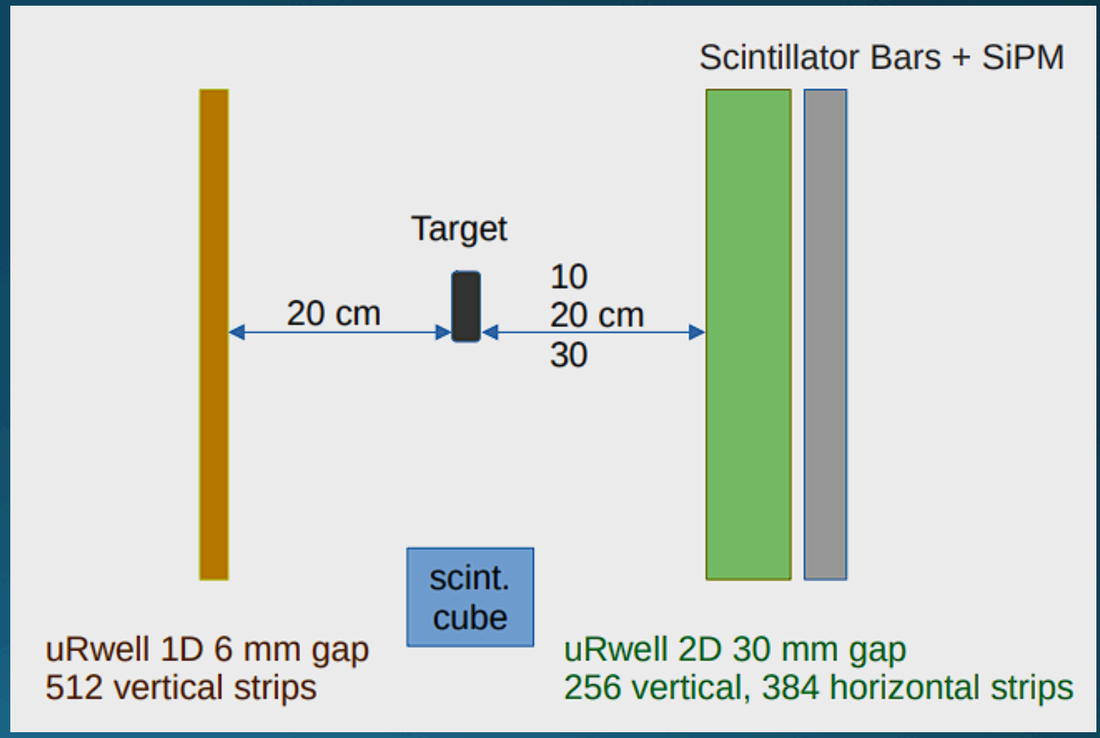
The n_TOF test

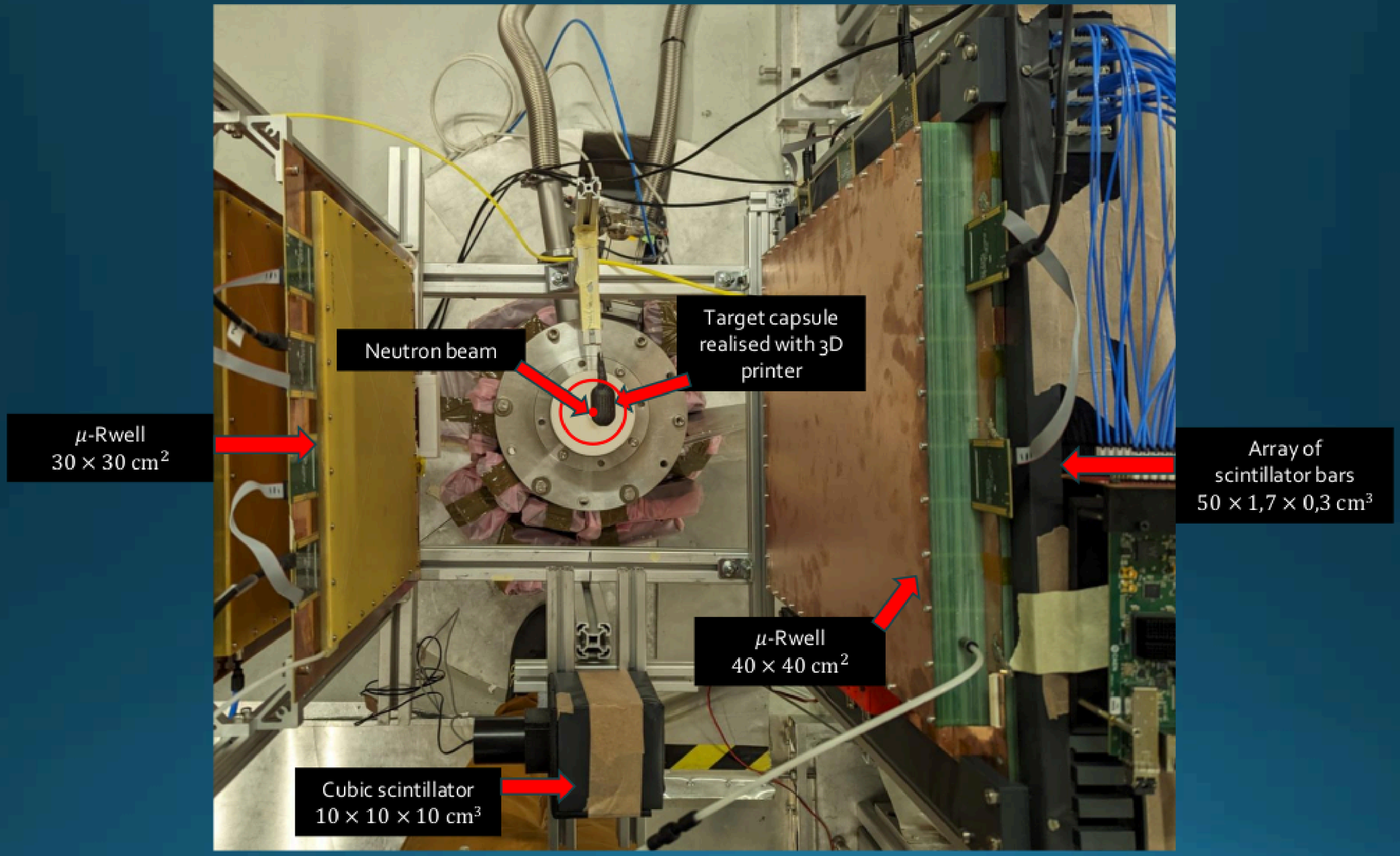
The studied setup is a demonstrator, composed by:

- A target of Al and Carbon_fibre capsule projected to contain ^{3}He at high pressure (~ 380 bar)
- A large μ-Rwell and an array of scintillator bars
- A small μ-Rwell
- A cubic scintillator

Each detector has a specific readout and DAQ chain.
The goal of the demonstrator is to assess noise and saturation effects as a function of:

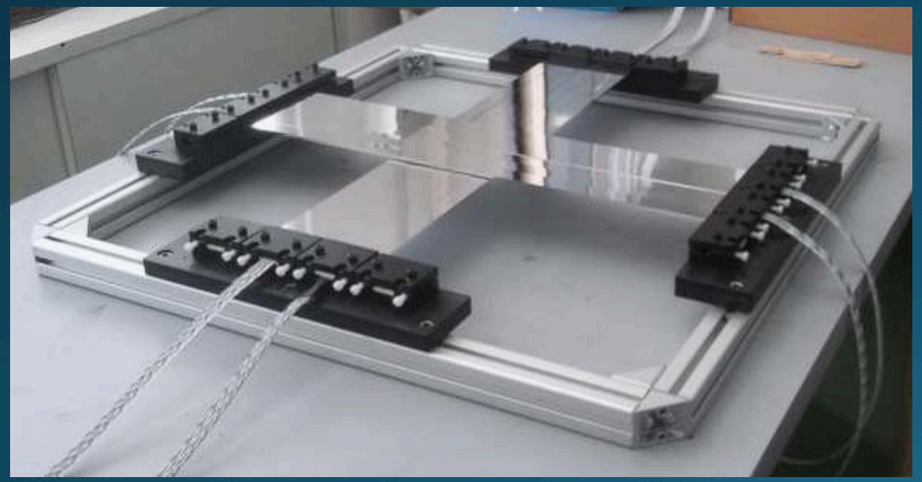
- Target type
- Demonstrator distance from the beam ($10, 20, 30$ cm):
- Time after γ-flash ($0, 500, \ldots \rightarrow$ 10000 ns)

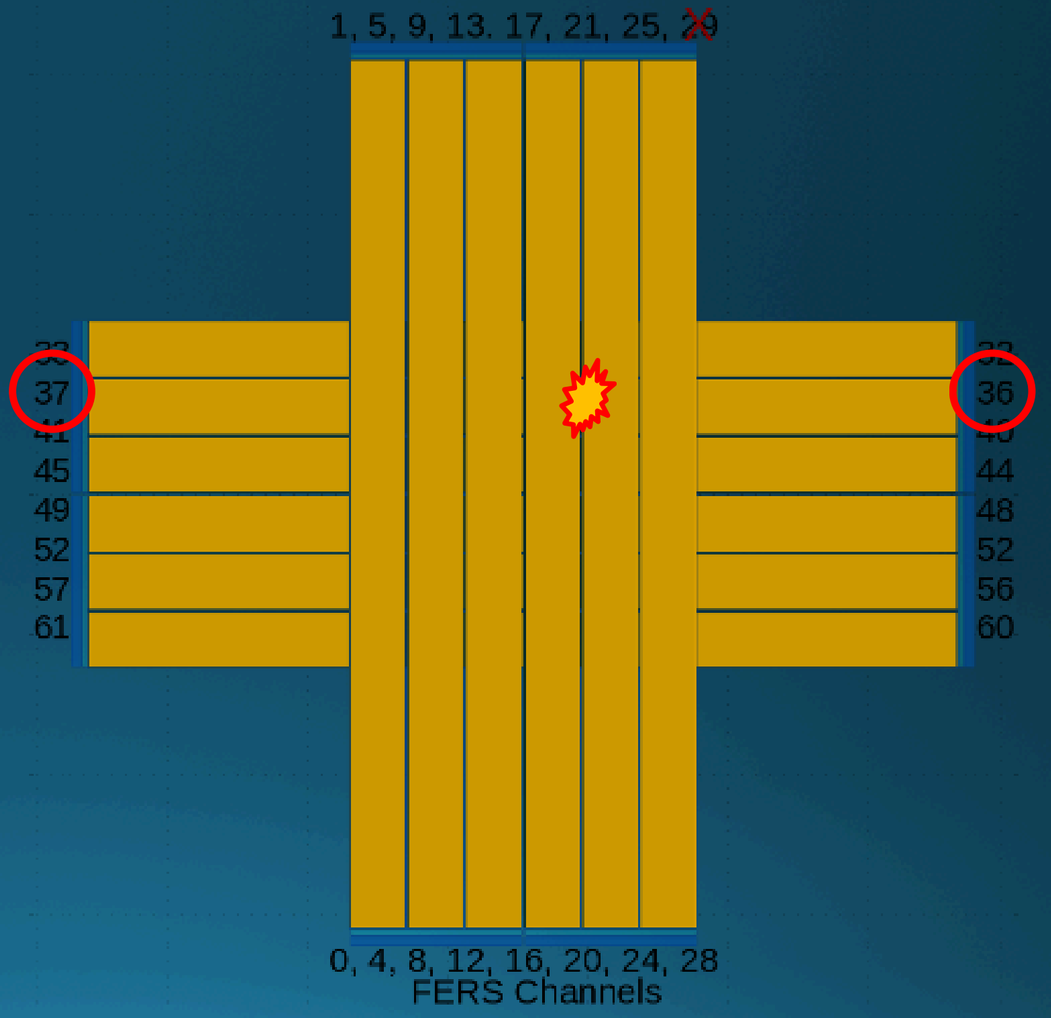



Neutron beam
Target capsule realised with 3D printer
μ-Rwell 30 × 30 cm²
Array of scintillator bars 50 × 1,7 × 0,3 cm³
μ-Rwell 40 × 40 cm²
Cubic scintillator 10 × 10 × 10 cm³

The scintillator array

- Coincidences:
  - H-Signal → Left & Right (e.g. 36&37)
  - V-Signal → Top & Bottom (e.g. 20&21)
- Timing and Spectroscopy acquisition modes
- Readout and DAQ with SiPM + FERS (CAEN)





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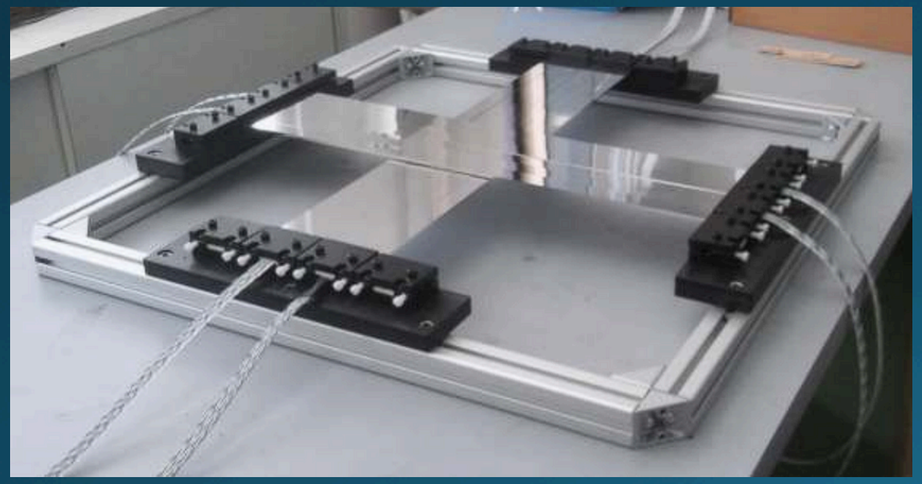
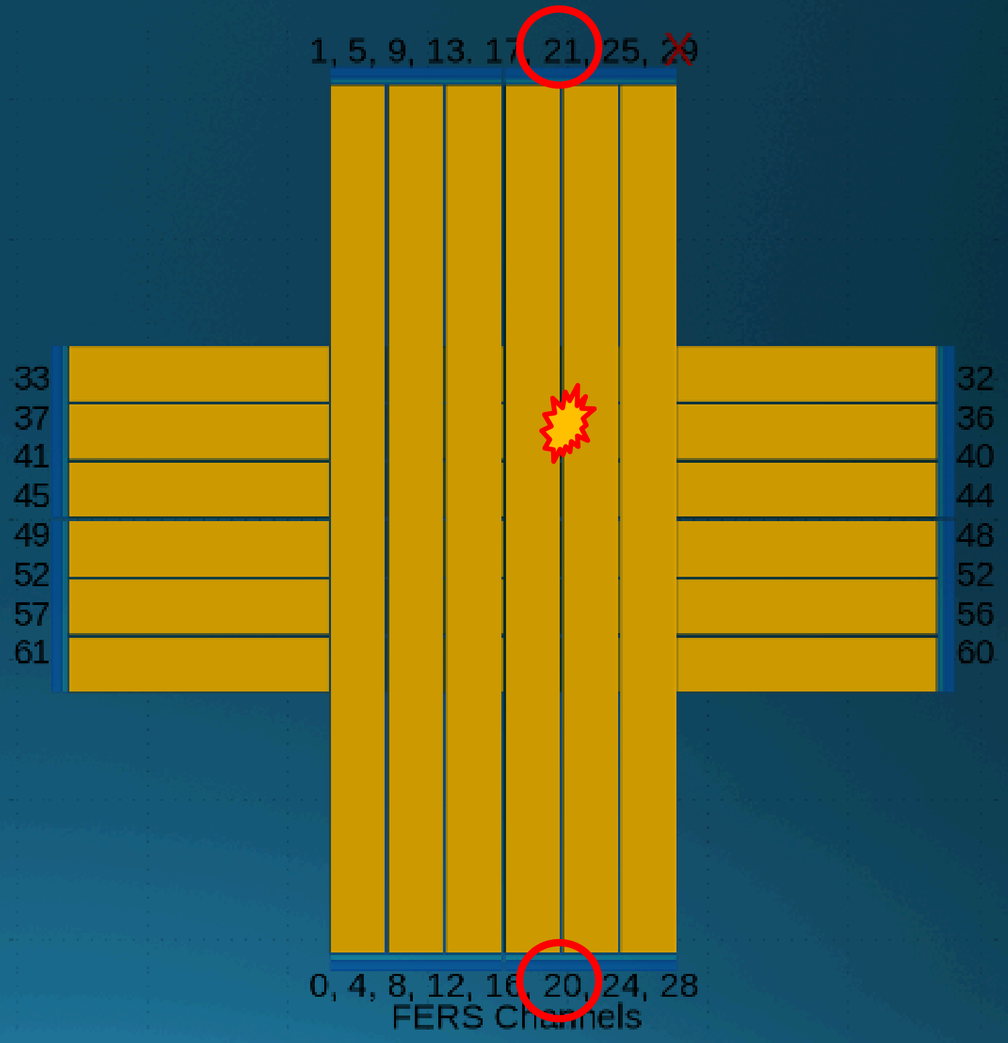
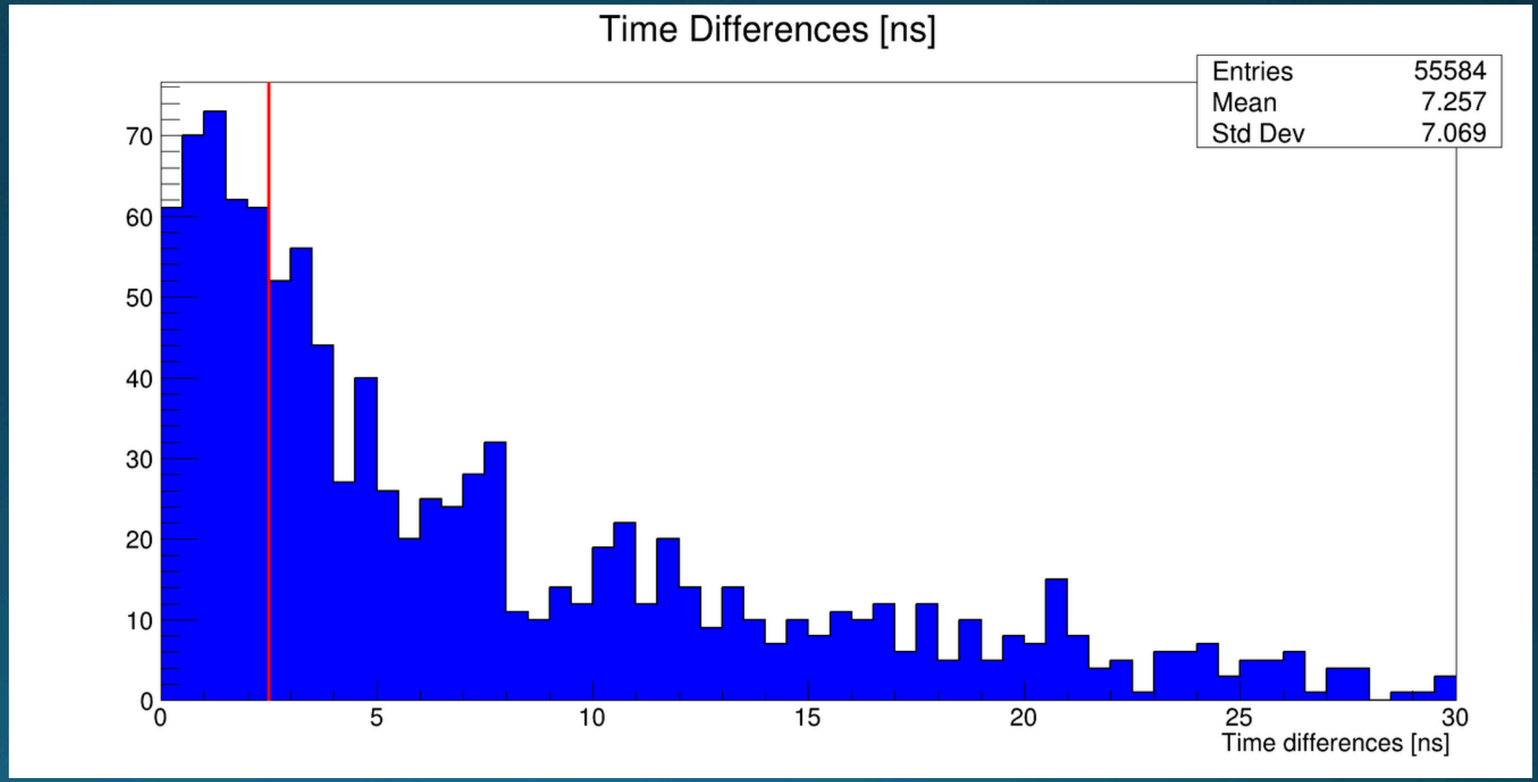




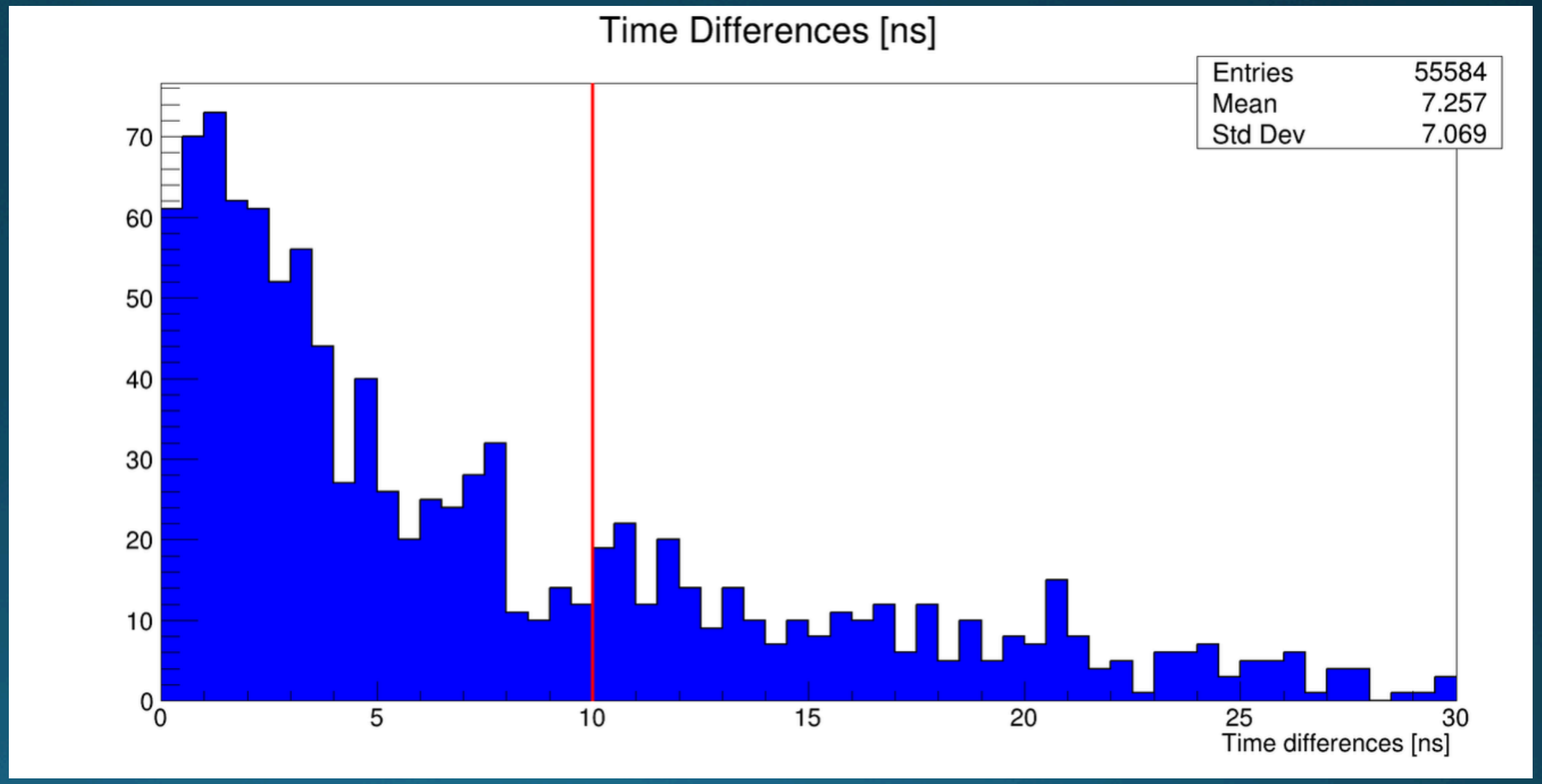
Looking for coincidences

- A coincidence takes place when two channels that see the same bar at opposite ends fire within a specific time window
- The time window should match the time traveled by light in the scintillator bar (refractive index $n \simeq 1.58$ $\rightarrow t \simeq 2.5\ \mathrm{ns}$)

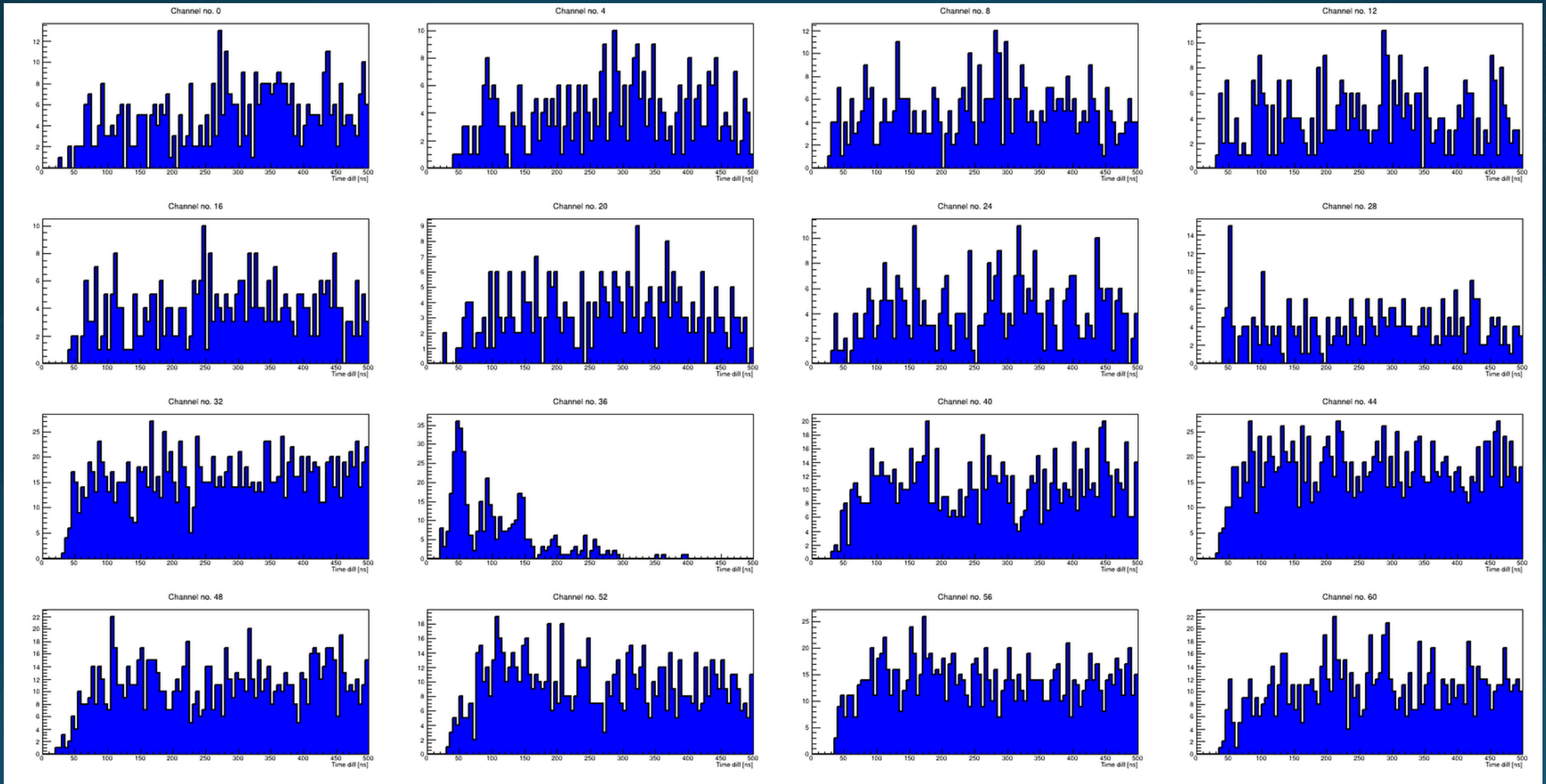


Looking for coincidences

...but actually it should account for delays and smearing

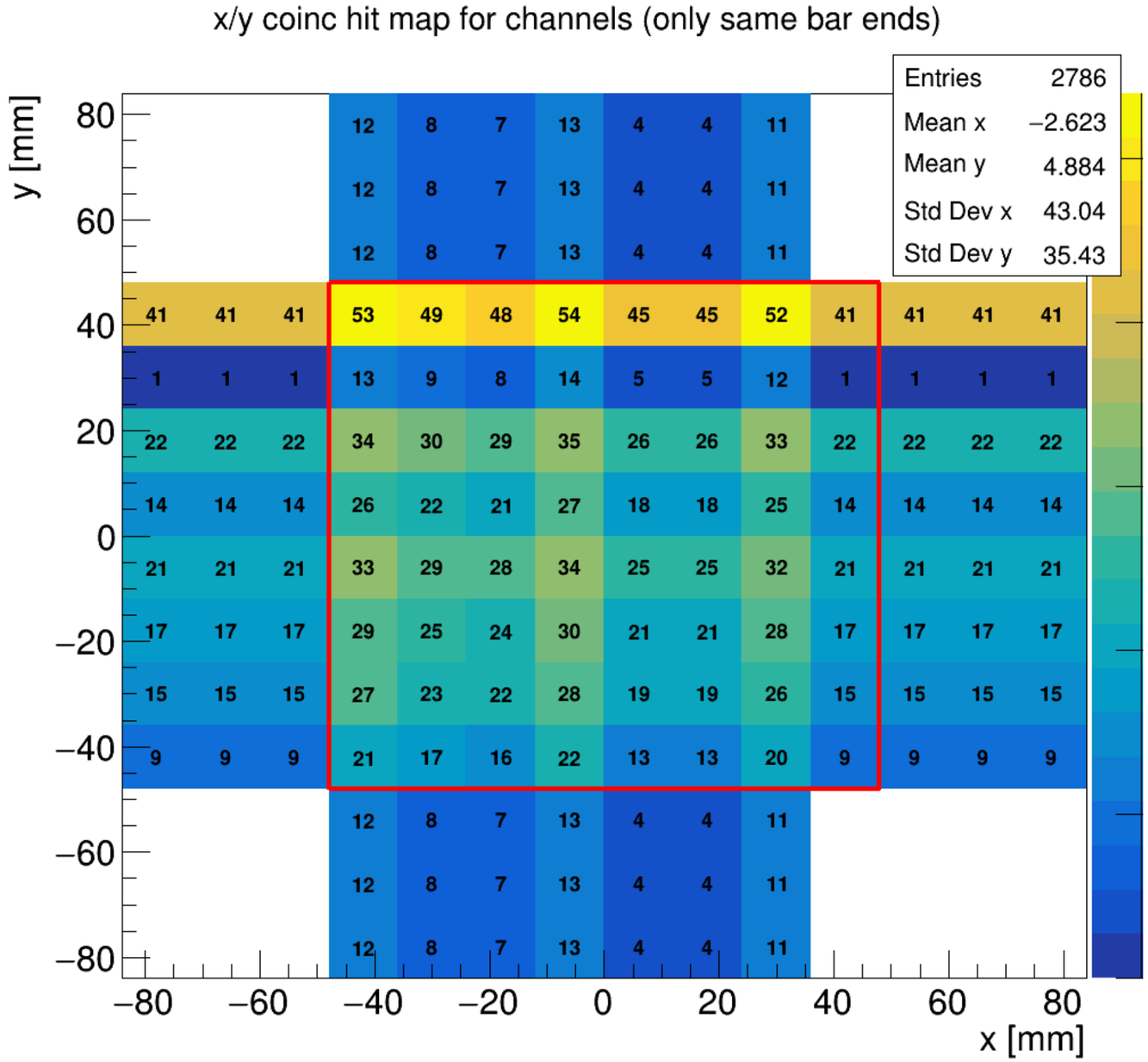


Dead time estimation



Mapping

xy mapping can be done either by considering fired channel couples or by reconstructing the fired scintillator bar



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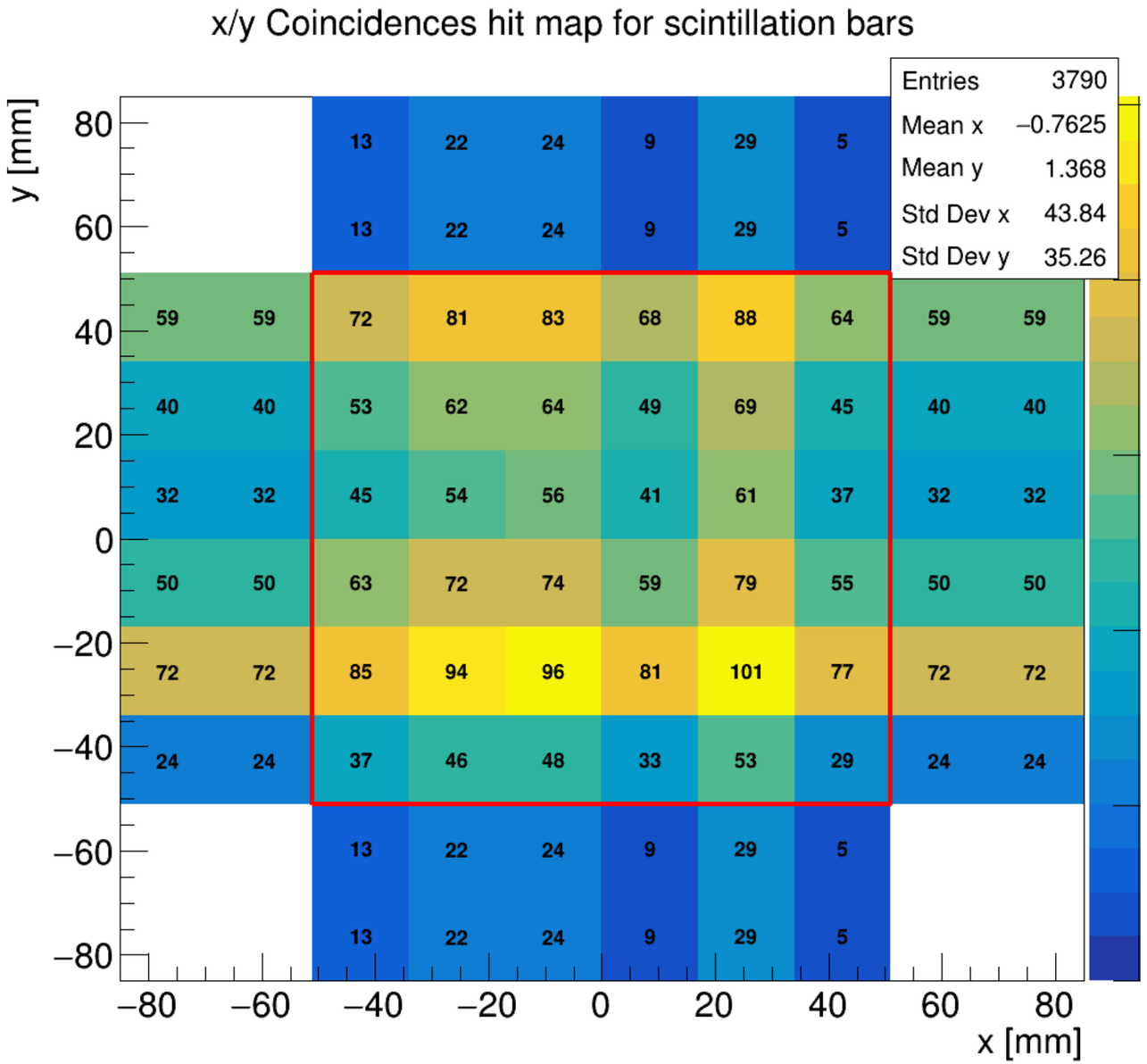
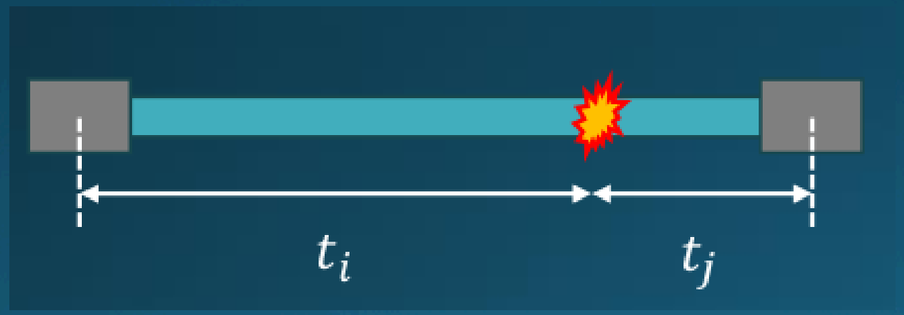
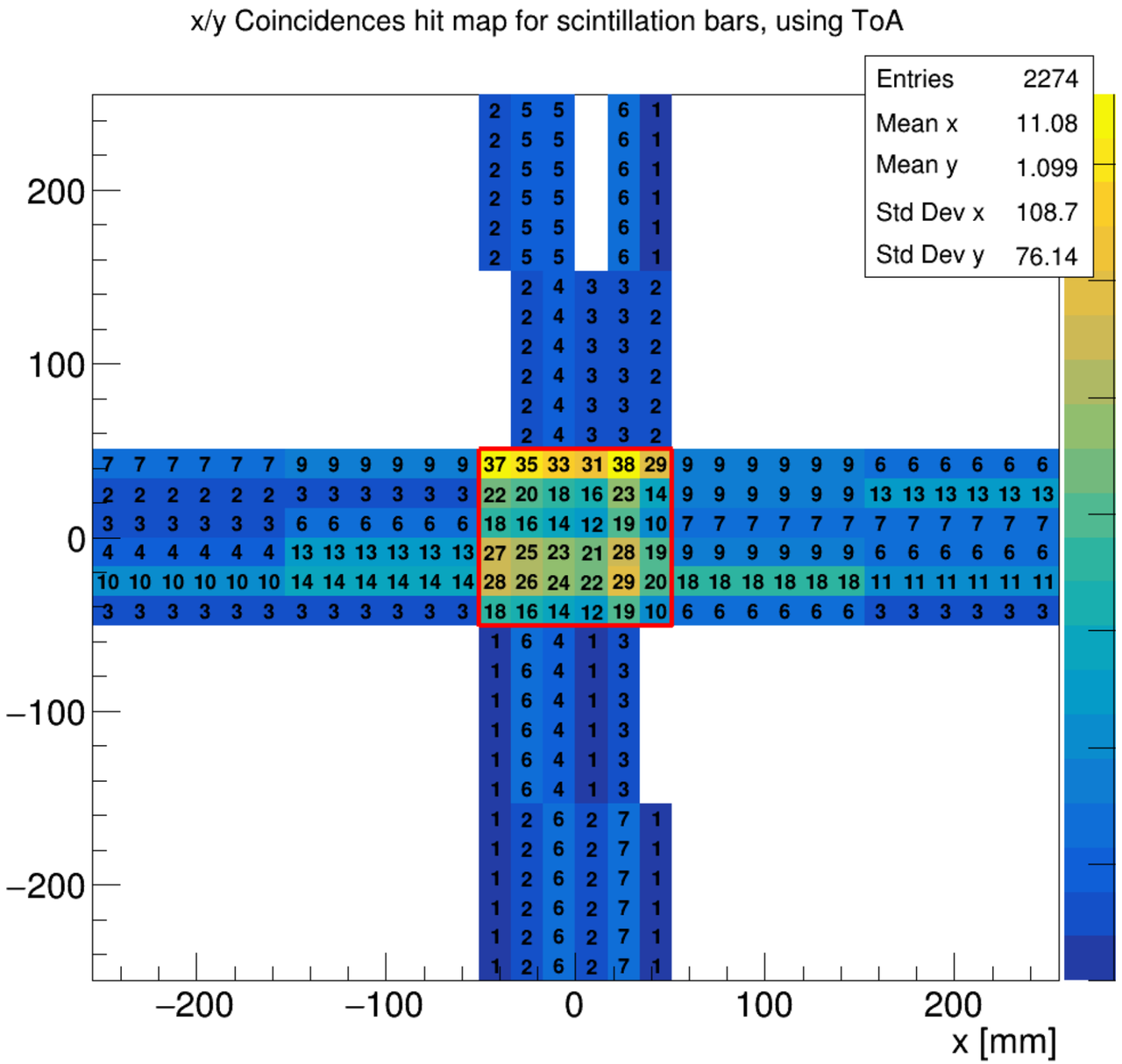


Mapping

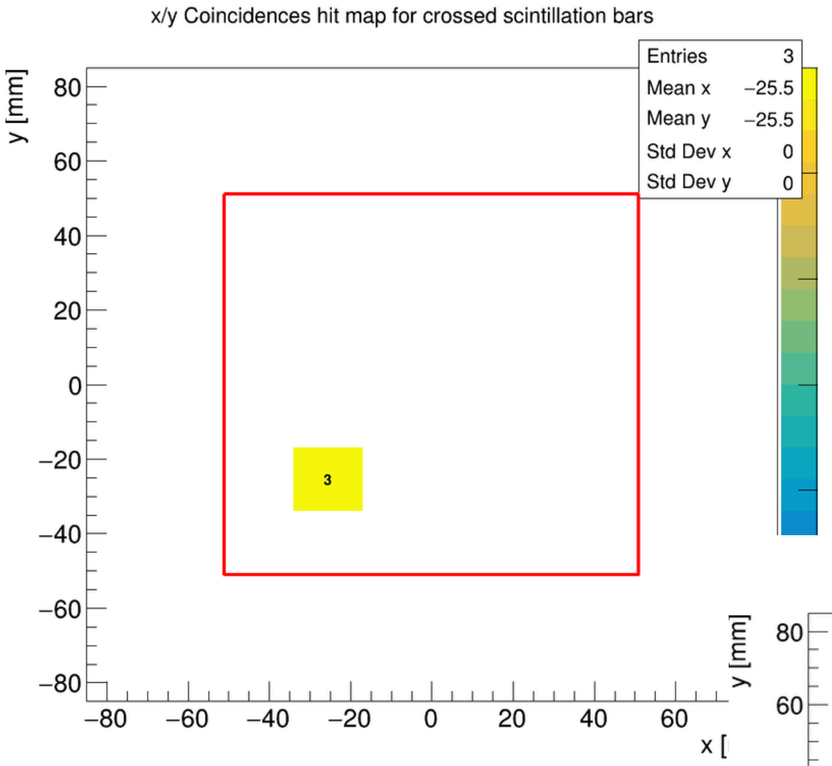
Time of Arrival (ToA) of signal on the channels can be used to map the hit position on the scintillator bars





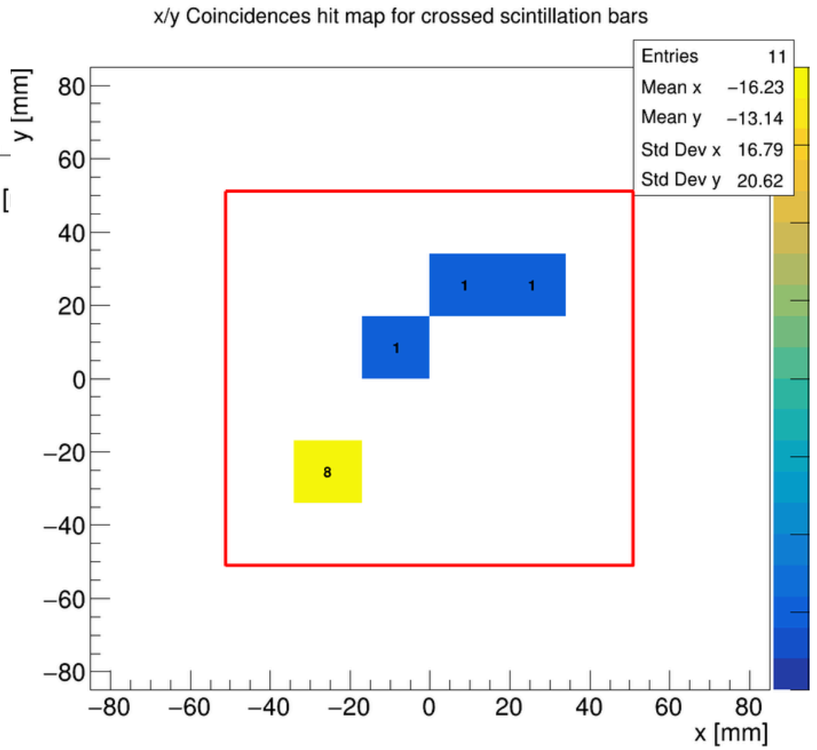
What about cross coincidences?

Cross coincidences (using the same time window as the single bar coincidence) appear to be much less



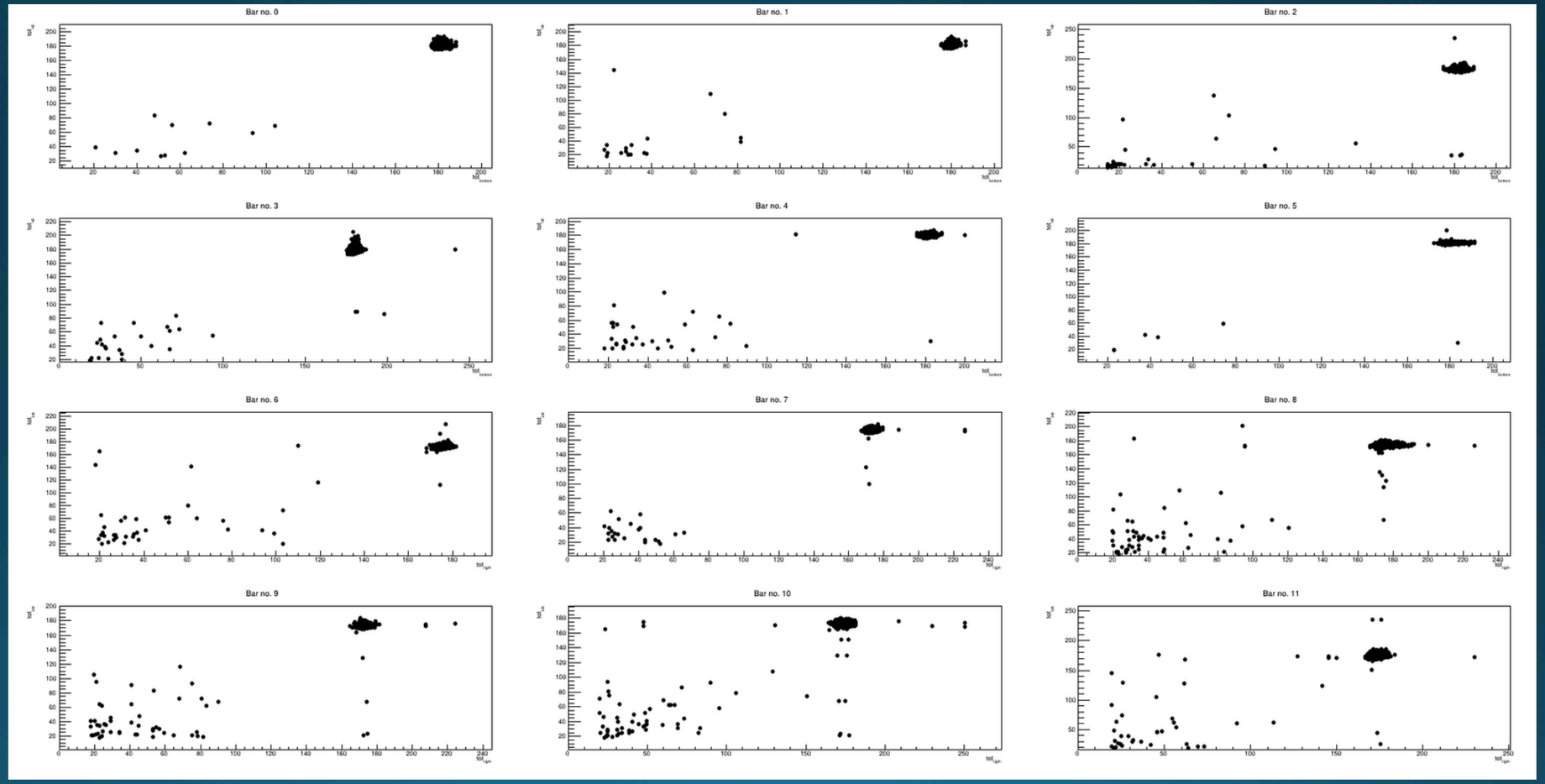
10 ns

2.5 ns



What about ToT?

Using Time over Threshold (ToT) information can improve mapping and extract useful information



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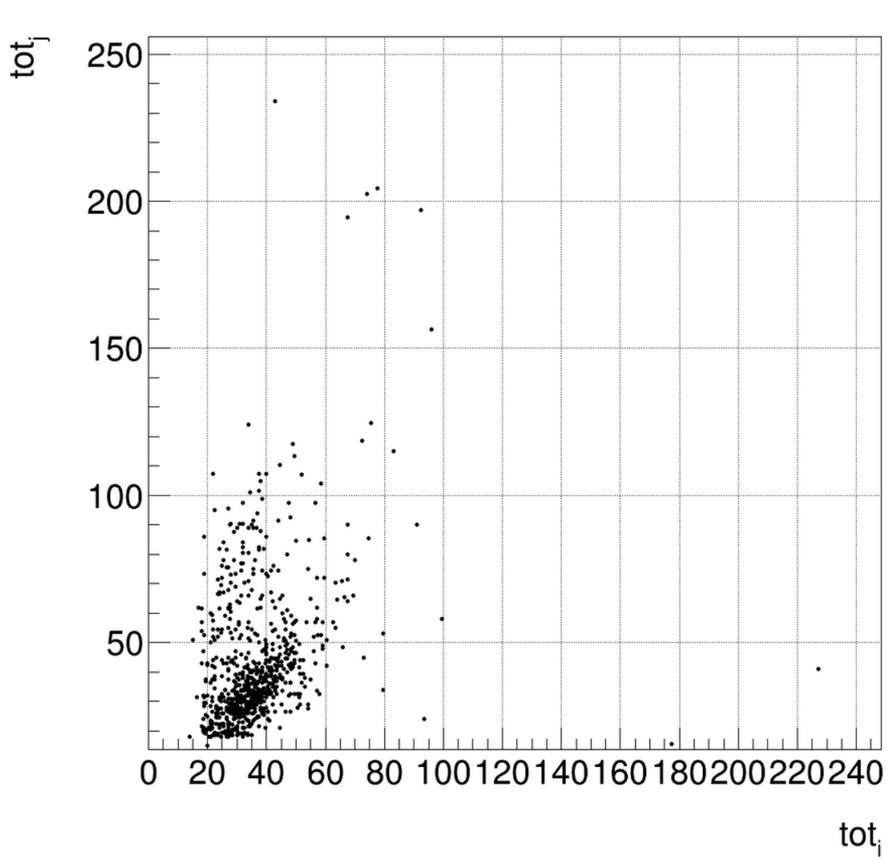
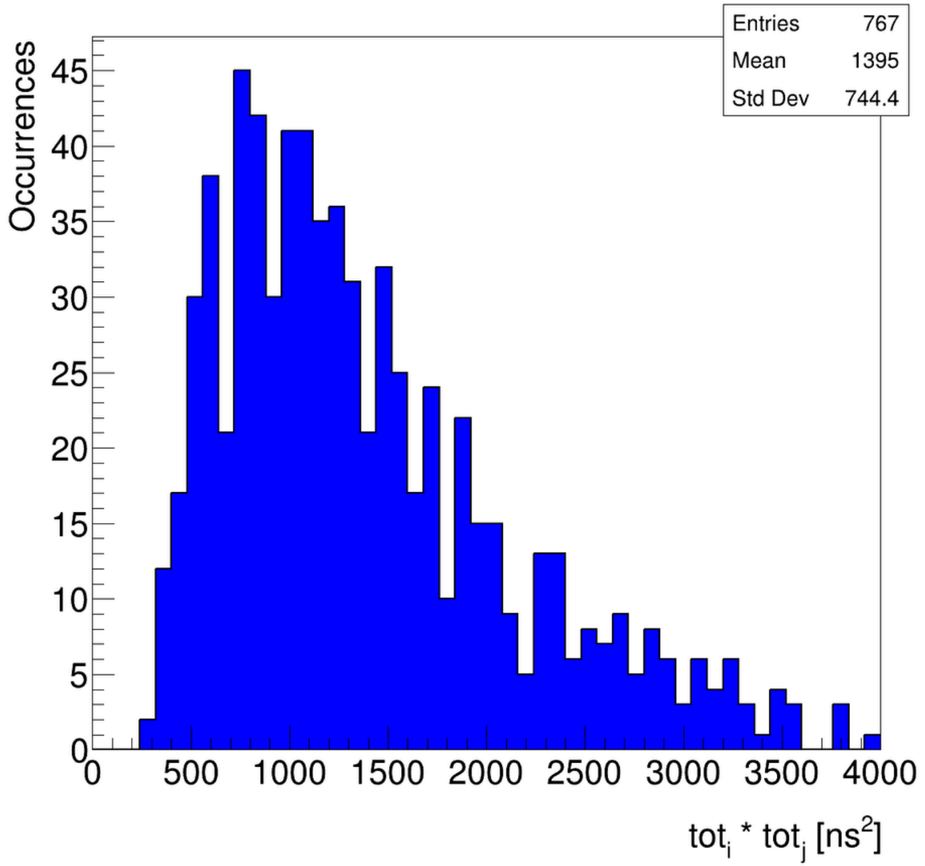
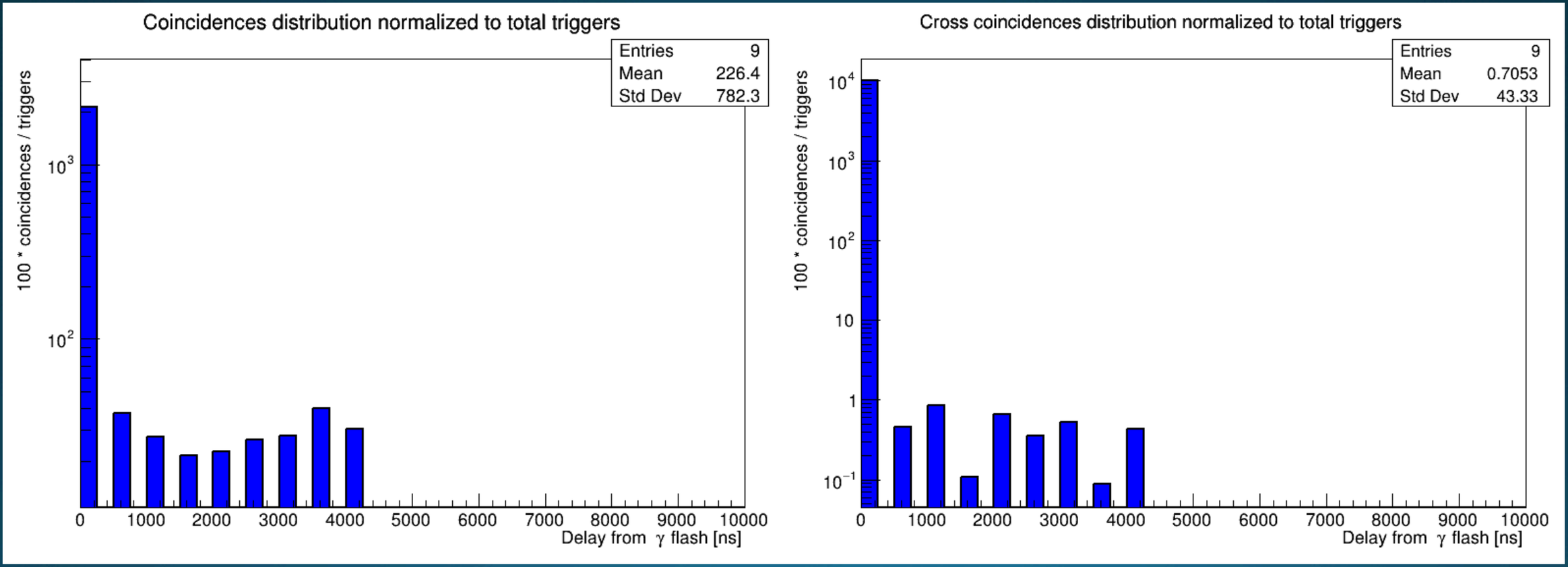




Coincidences global behaviour



To do next

- Try to implement reconstruction via ToT
- Combine SiPM and mu-Rwell data

Thank you for your attention!

Bibliography

- **Krasznahorkay, A.J.; et al.**: “ Observation of Anomalous Internal Pair Creation in : A Possible Indication of a Light, Neutral Boson“.
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