ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

The search of the X17 boson at the n_TOF facility: demonstrator data analysis

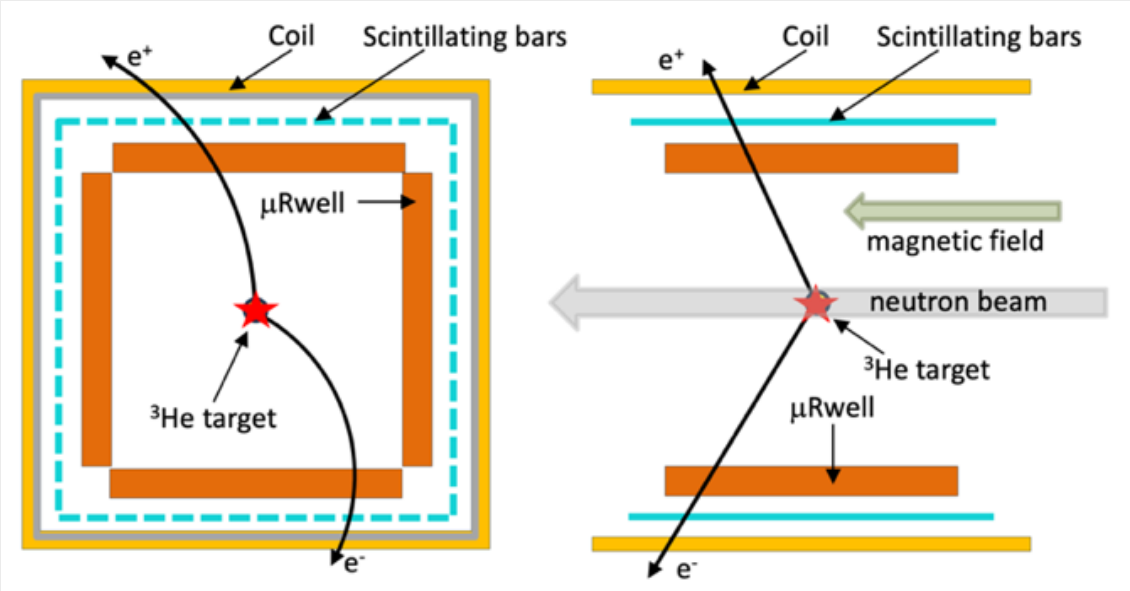
Nicholas Pieretti on behalf of the n_TOF collaboration

29 April 2025 – n_TOF collaboration national meeting

X17 at n_TOF: detector design

- **Large acceptance**
- **Tracking and PID**

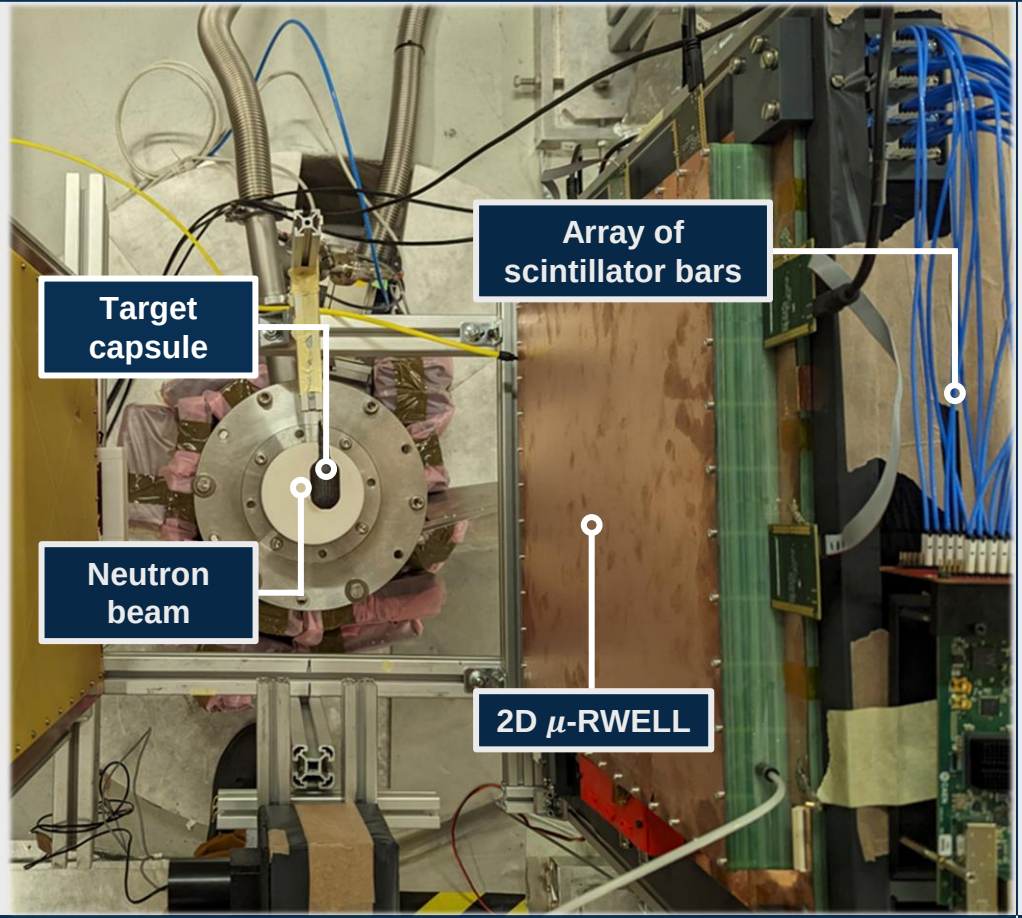
- 2D μ-RWELL
- Array of scintillator bars
- 500 Gauss magnetic field



First detector prototype test (2023)

- **Large acceptance**
- **Tracking and PID**

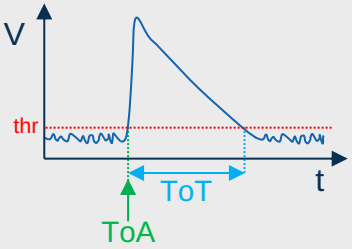
- Al and C fiber capsule
- 2D μ-RWELL
- Array of scintillator bars



The scintillator bar array

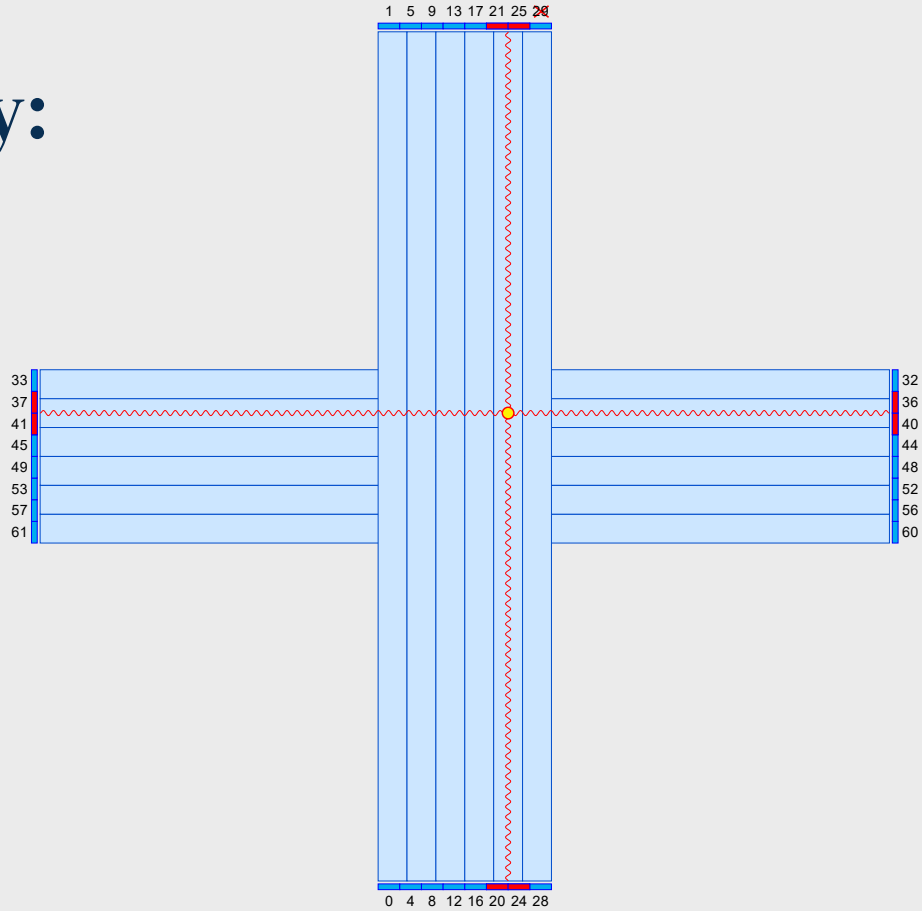
- Provide trigger and neutron TOF
- Improve spatial resolution

- Readout and DAQ with SiPM + FERS (CAEN)
- Only timing data available:
  - Time of Arrival (ToA)
  - Time over Threshold (ToT)



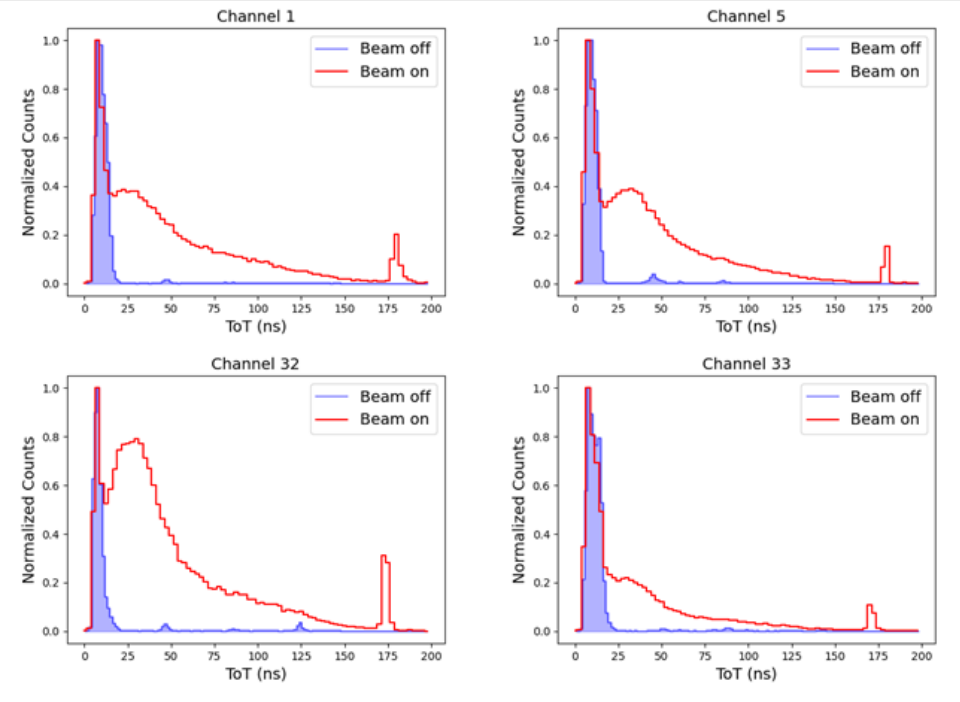
The scintillator bar array: analysis performed

- Background estimation
- Dead time estimation
- Hit map reconstruction
- Neutron energy dependence



Background estimation

- Pedestal data (beam off)
- Threshold on ToT as event selection cut ≈ 22 ns
- Mainly electronic noise
- Visible γ-flash peak at ≈ 175 ns



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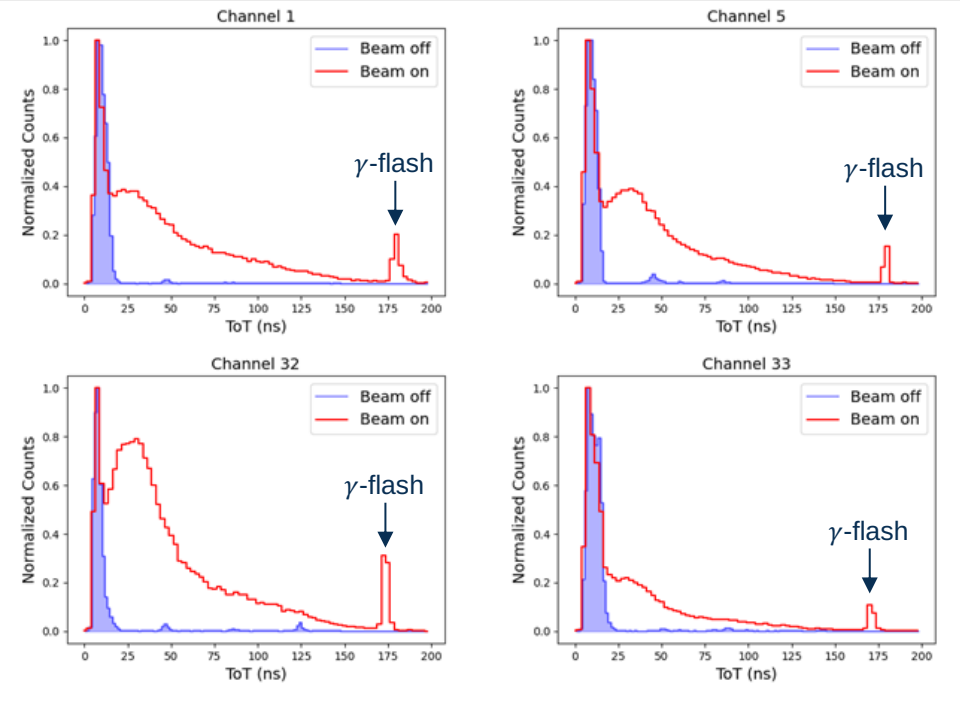
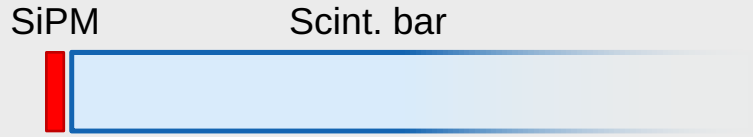
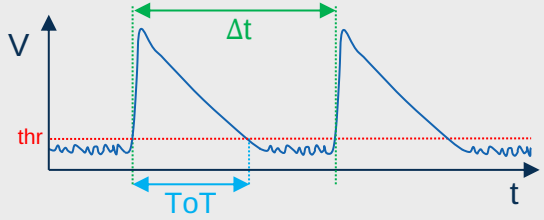
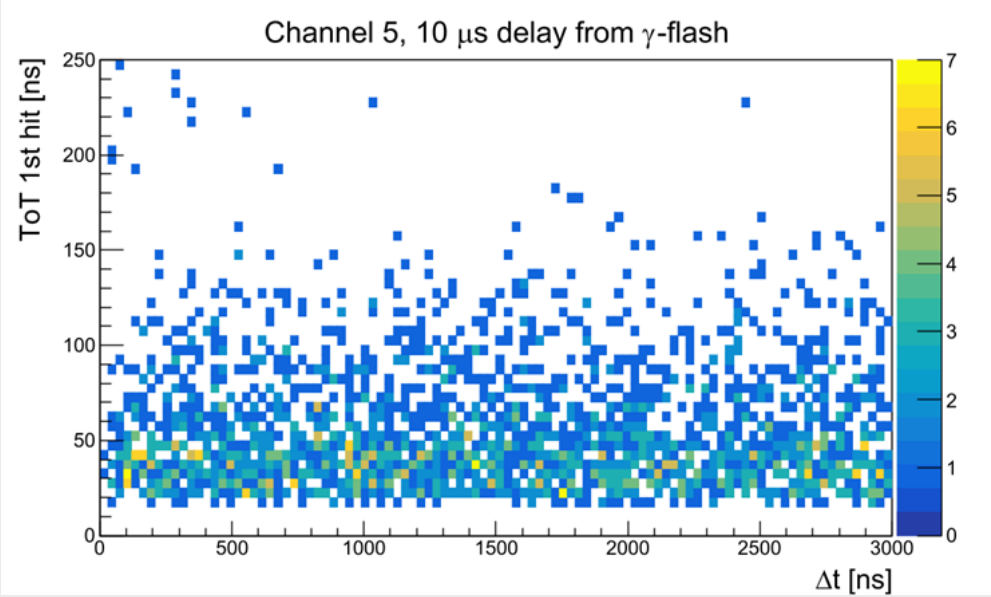


Dead time estimation



- ToT vs time difference between two consecutive events Δt





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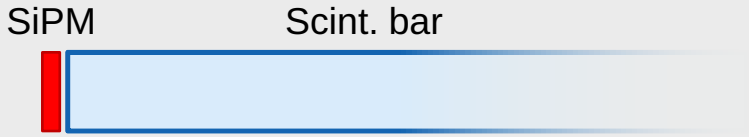

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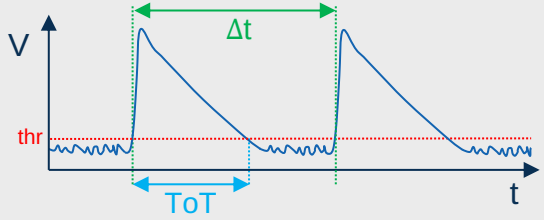
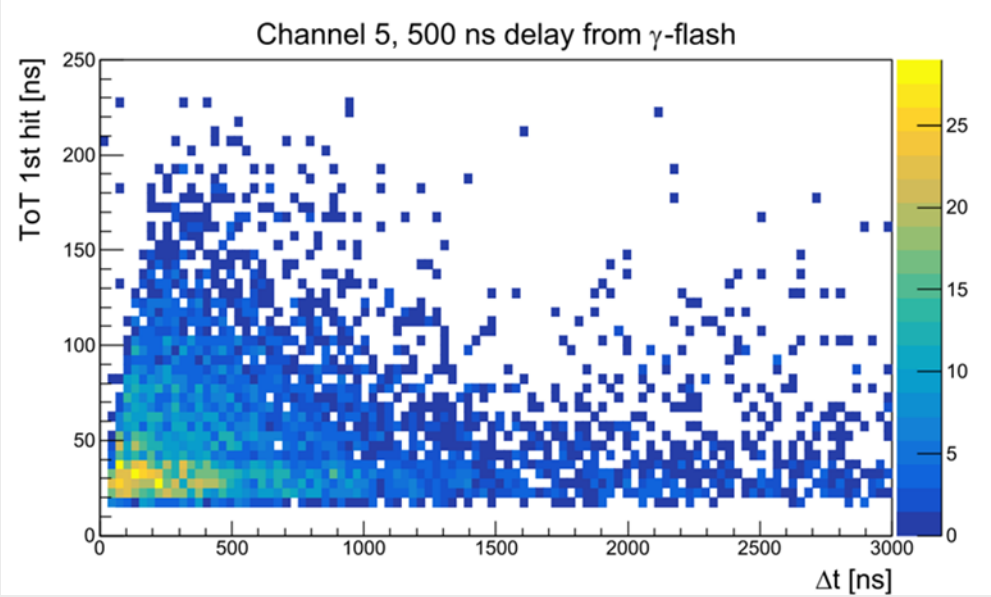


- Dead time ≈ 100 ns
- Possible pileup events



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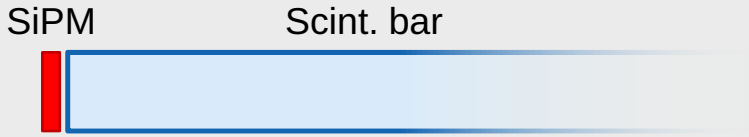

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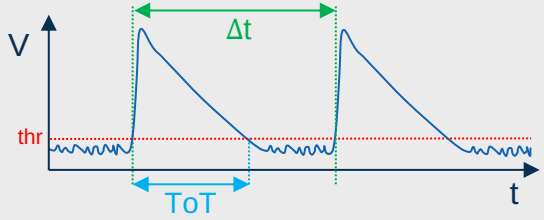
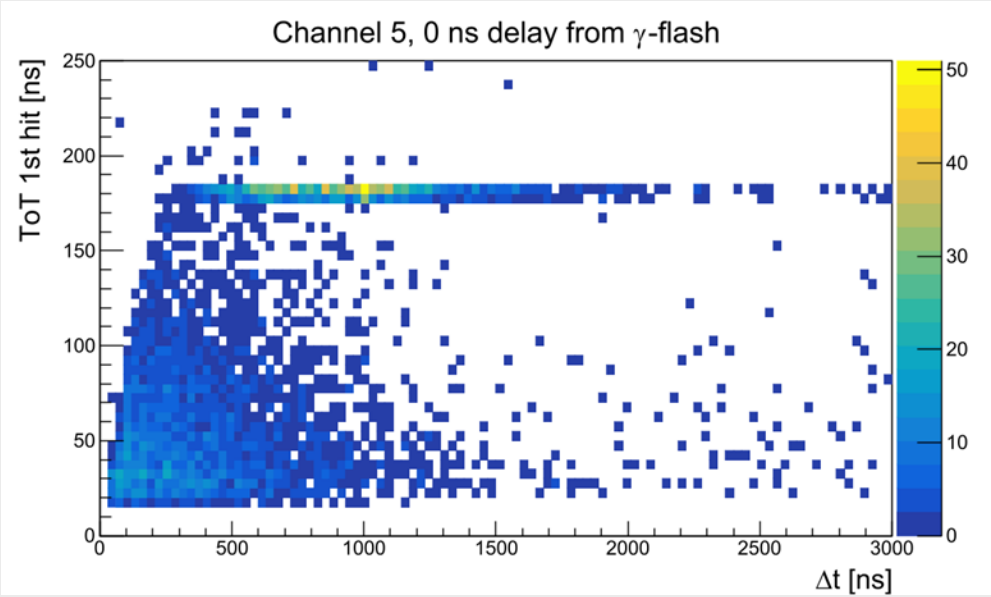
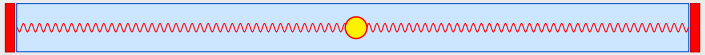


- Dead time ≈ 100 ns
- Possible pileup events
- γ-flash saturates the detector

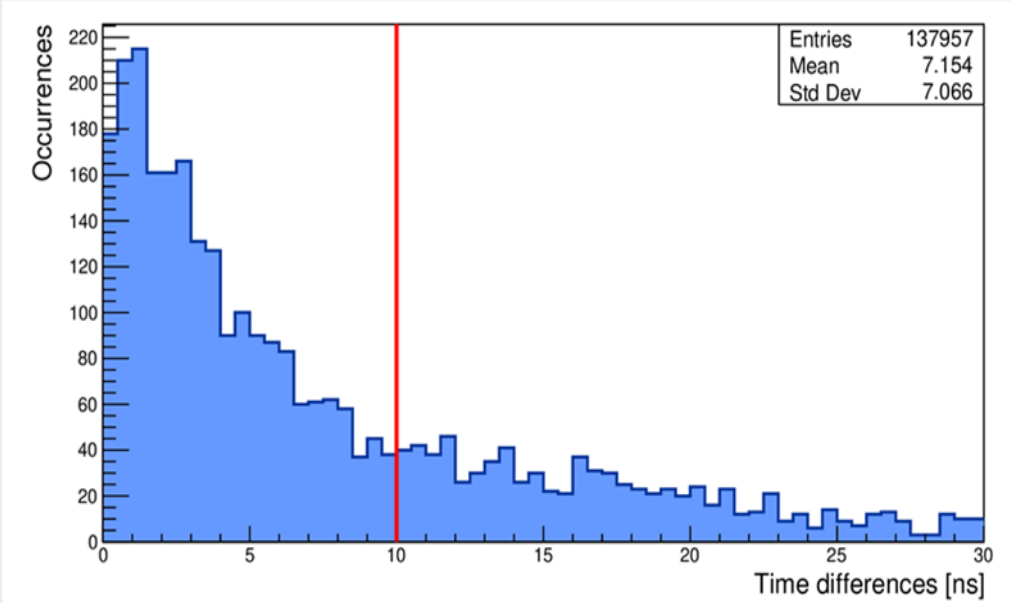


Hit map reconstruction

Time window estimation

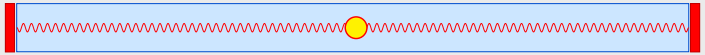


- Coincidences between signals at opposite ends of a bar
- First estimation $Ln/c \approx 2.5$ ns
- Account for several delays $\rightarrow \Delta t_c = 10$ ns

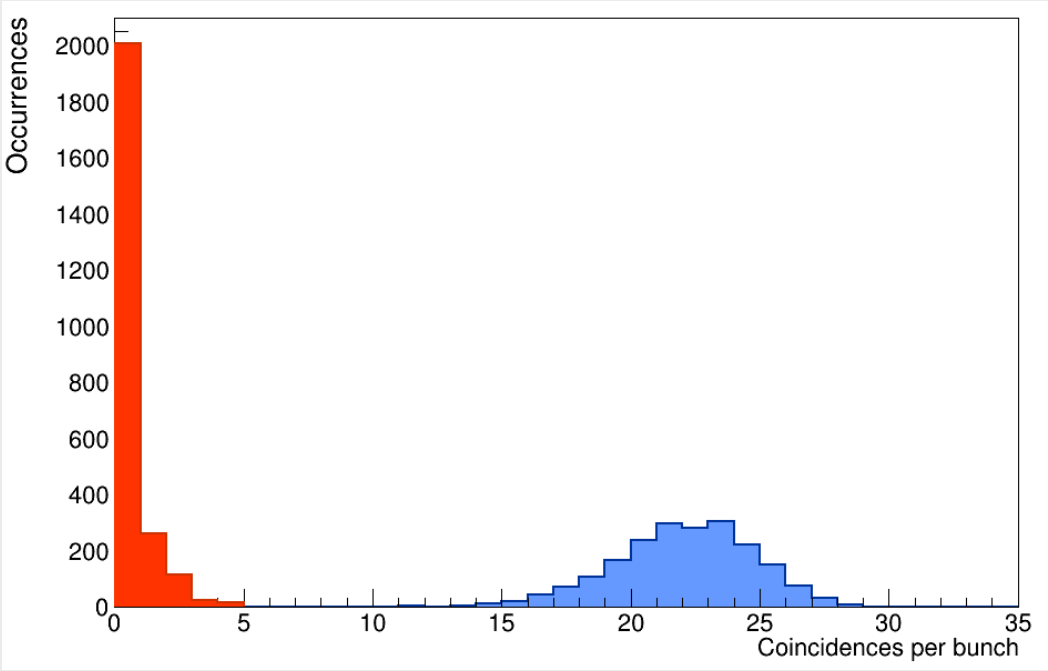


Hit map reconstruction

Coincidence rate



- Low coincidence rate, except for γ-flash
- Very low single bar coincidence rate
- Noisy bars flagged in the analysis



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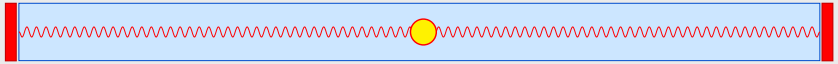
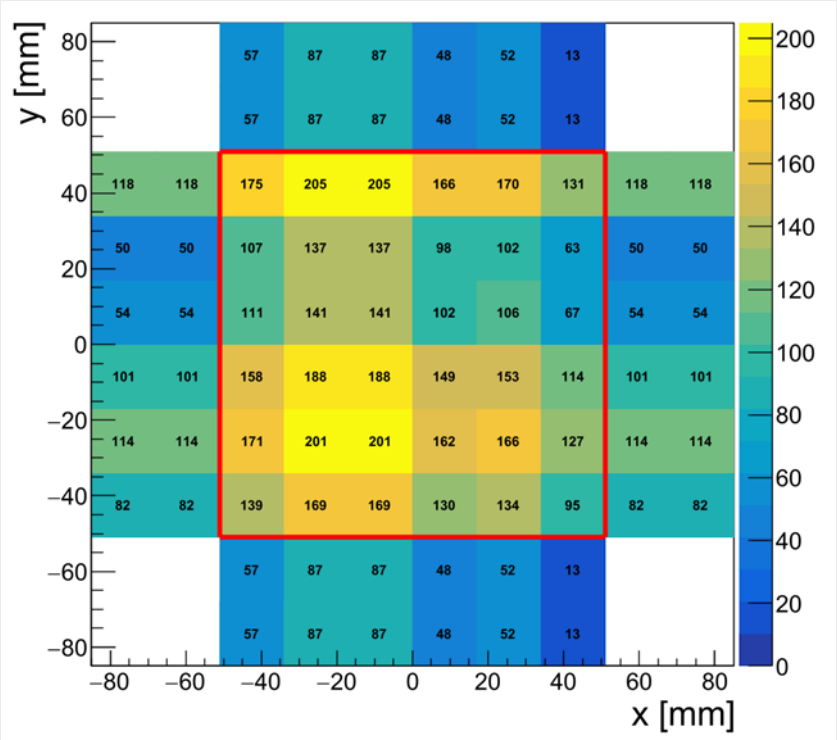


- Reconstruction on channels and bars
- Different response and non-uniform background



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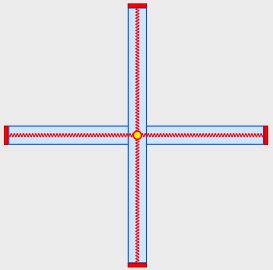
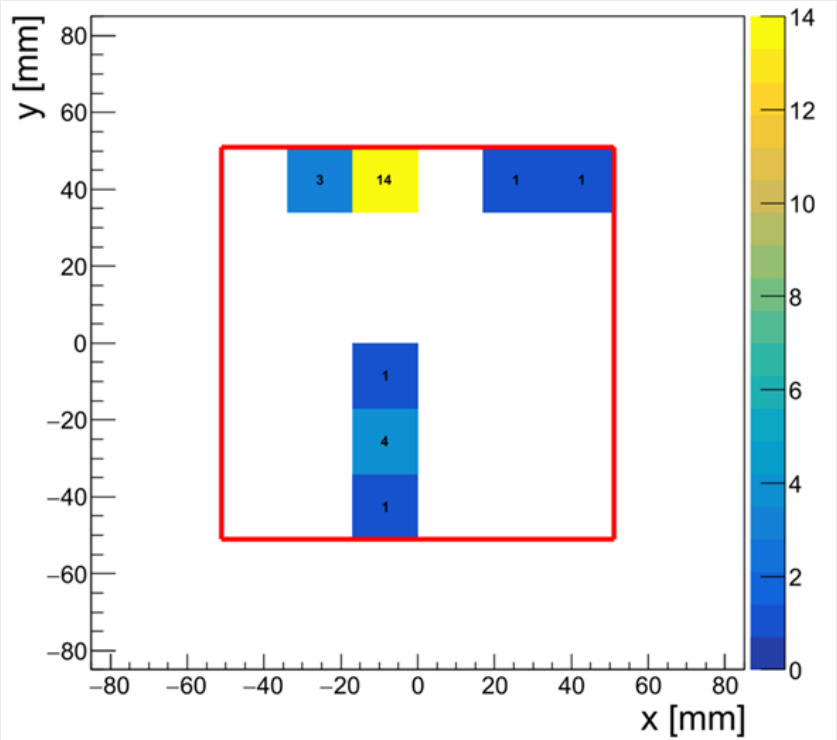


- Reconstruction on channels and bars
- Different response and non-uniform background
- Very few crossed coincidences



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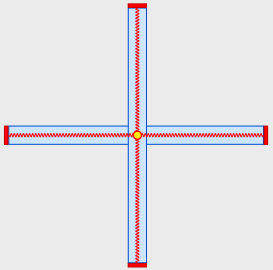
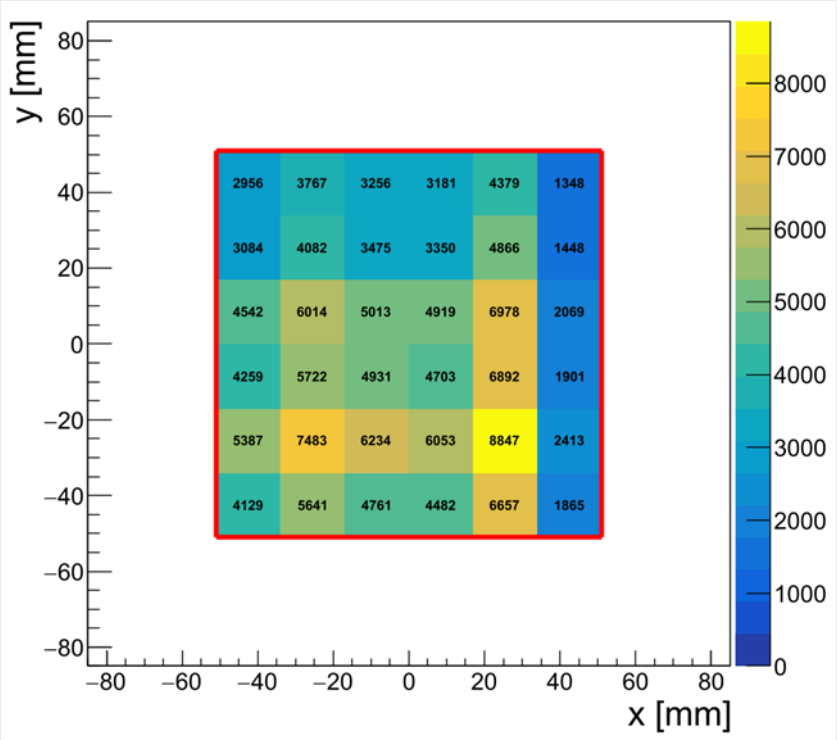
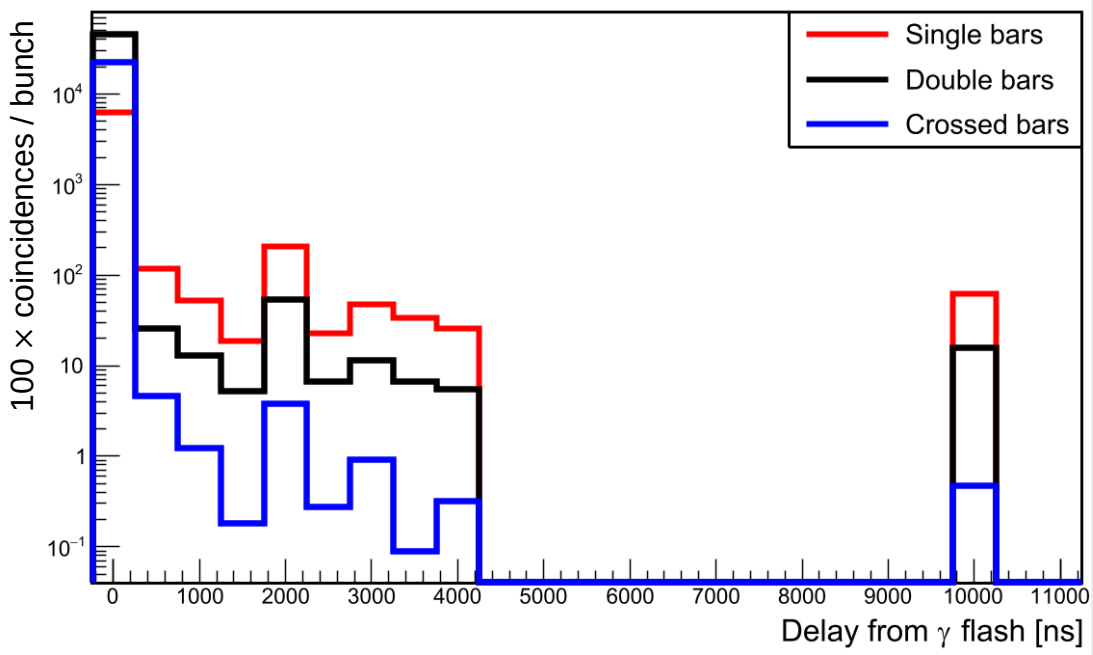


- Reconstruction on channels and bars
- Different response and non-uniform background
- Very few crossed coincidences (except for γ-flash)



Neutron energy dependence

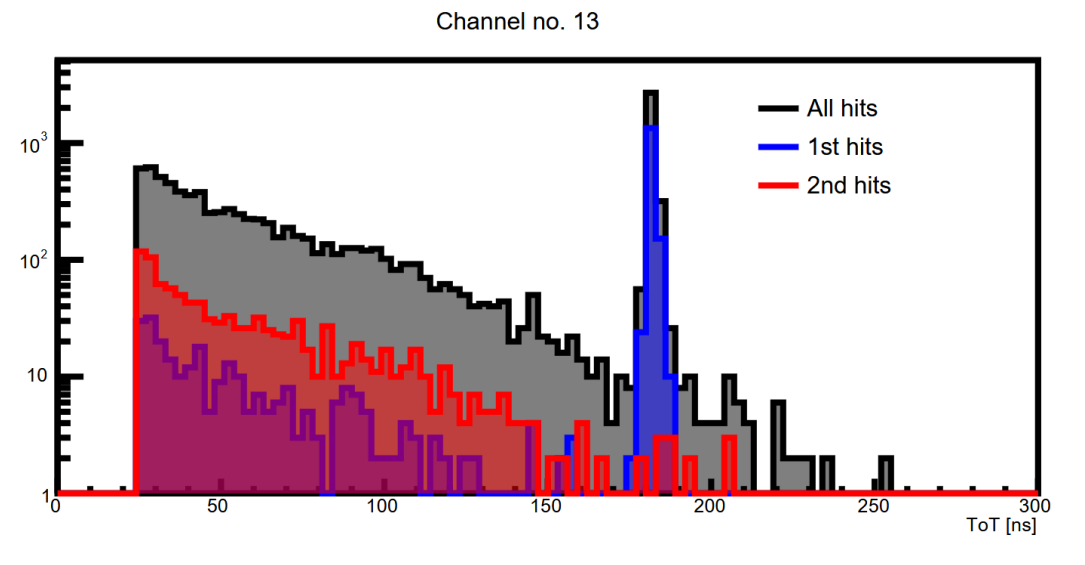
- Main background: elastically scattered neutrons
- Other channels open from 1500 ns (1 MeV)
- Relevant γ-flash tail



Neutron energy dependence: ToT

- Study of ToT signals after triggers
- Usual γ-flash population at 175 ns, only for 1st signals
- Same distributions from 500 ns

0 ns from γ-flash



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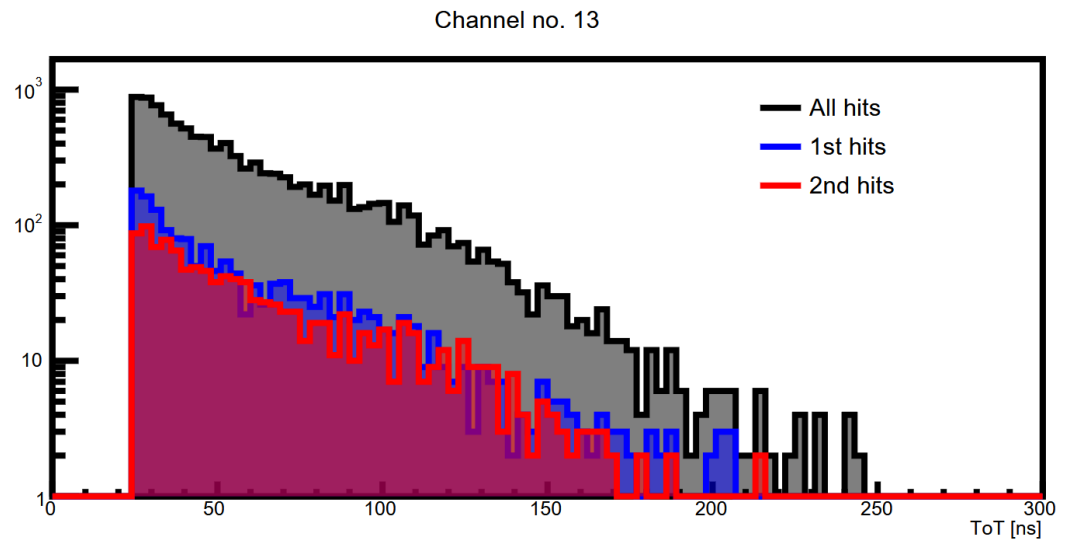

Neutron energy dependence: ToT

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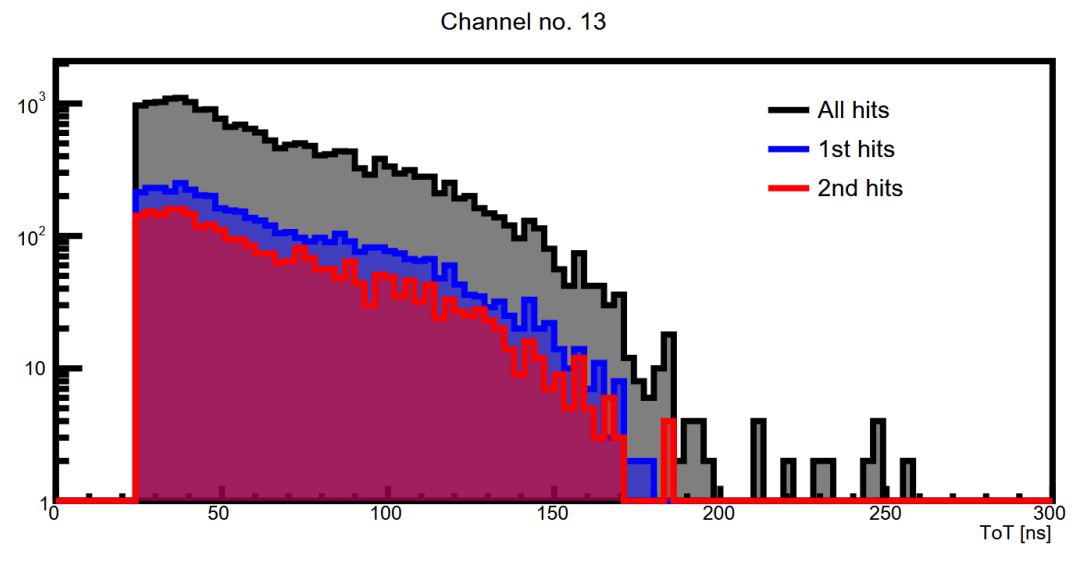
10000 ns from γ-flash



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- Greater Δt observed just after γ-flash
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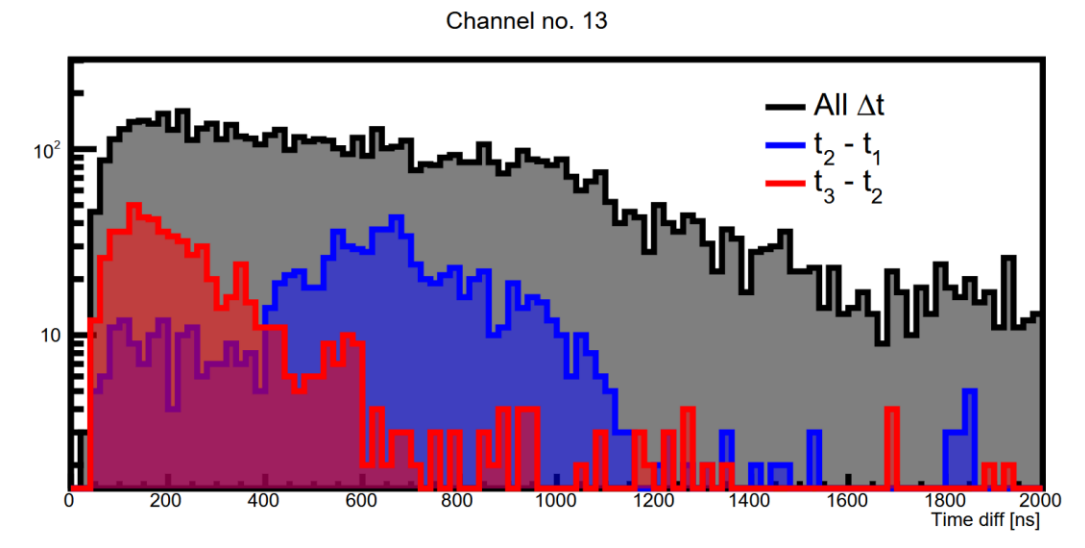

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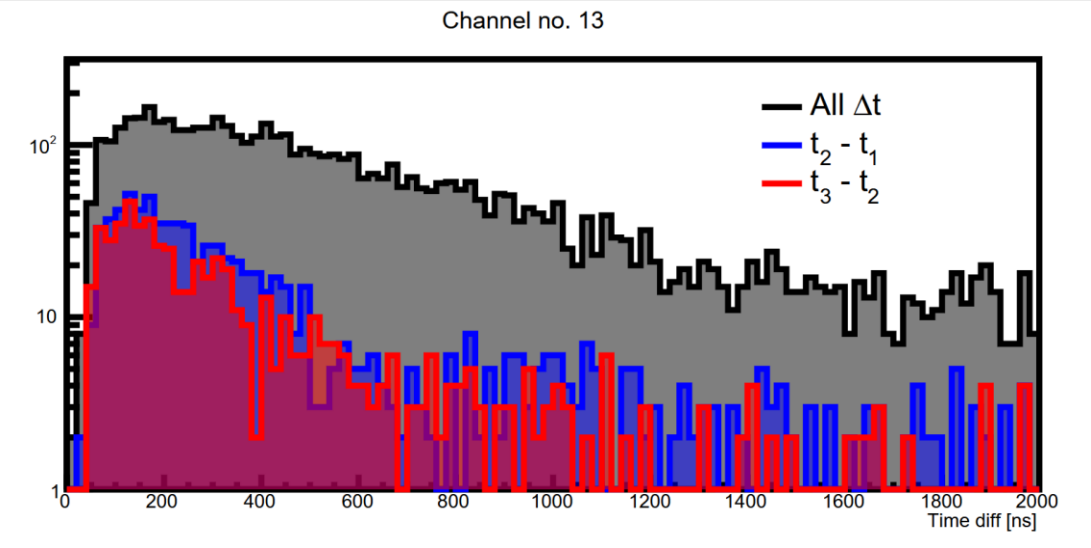

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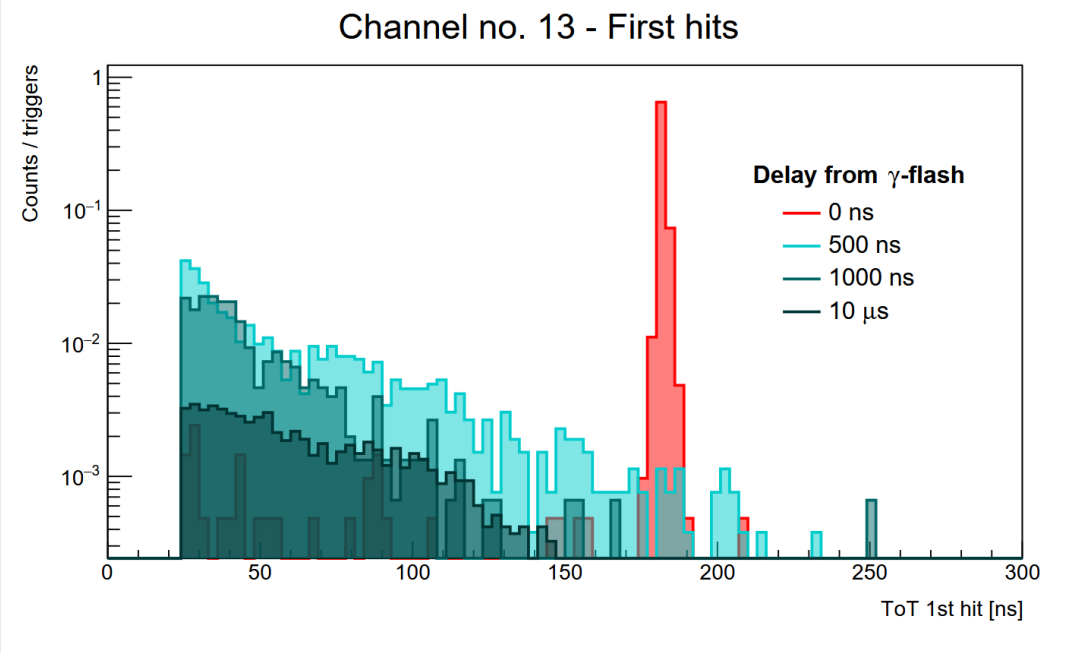

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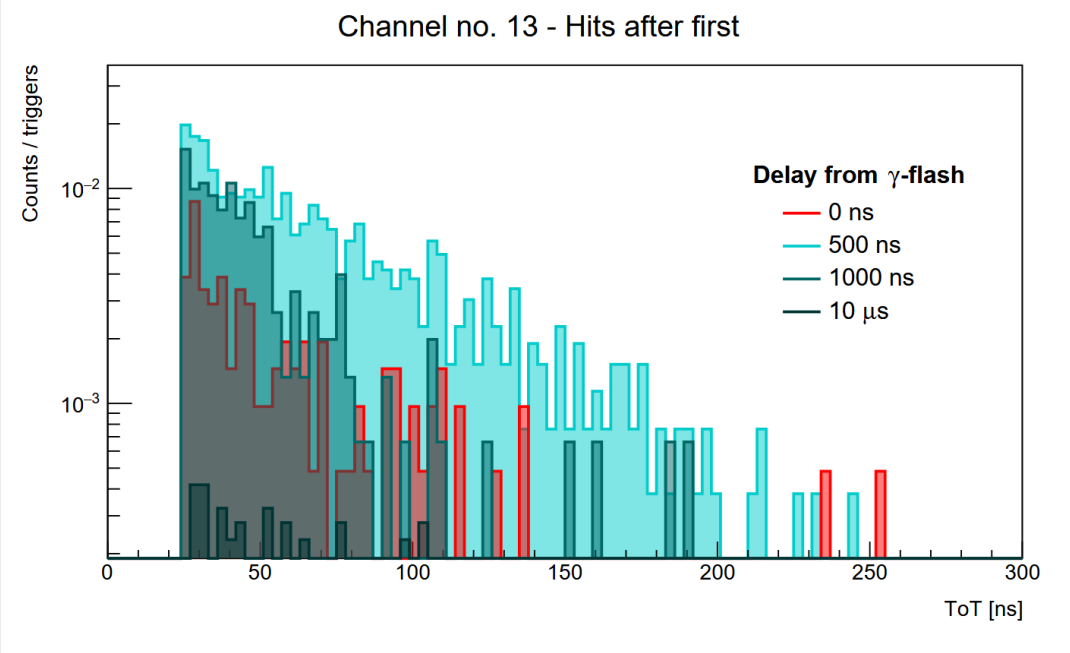
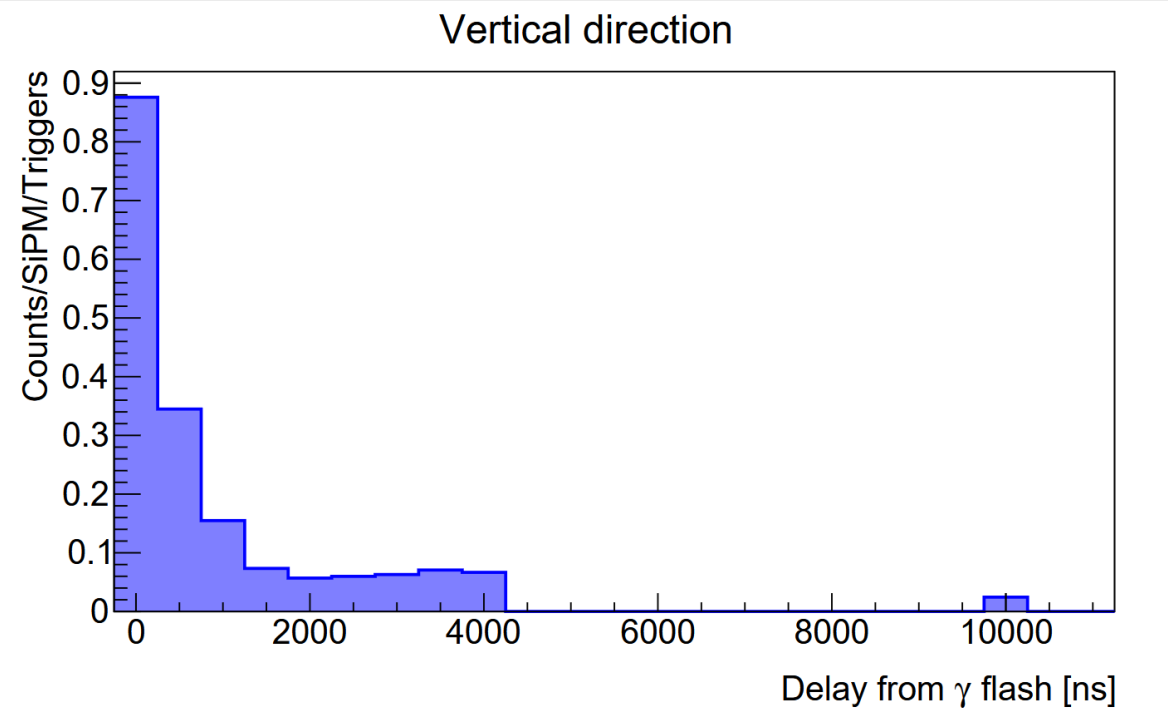


Conclusions

- Performance evaluation of scintillator bar array
- Detector suitable for neutron energies of interest
- γ-flash sensitivity, but short dead time
- Different DAQ system for extended acquisition time window and amplitude information

Neutron energy dependence: hits on channels



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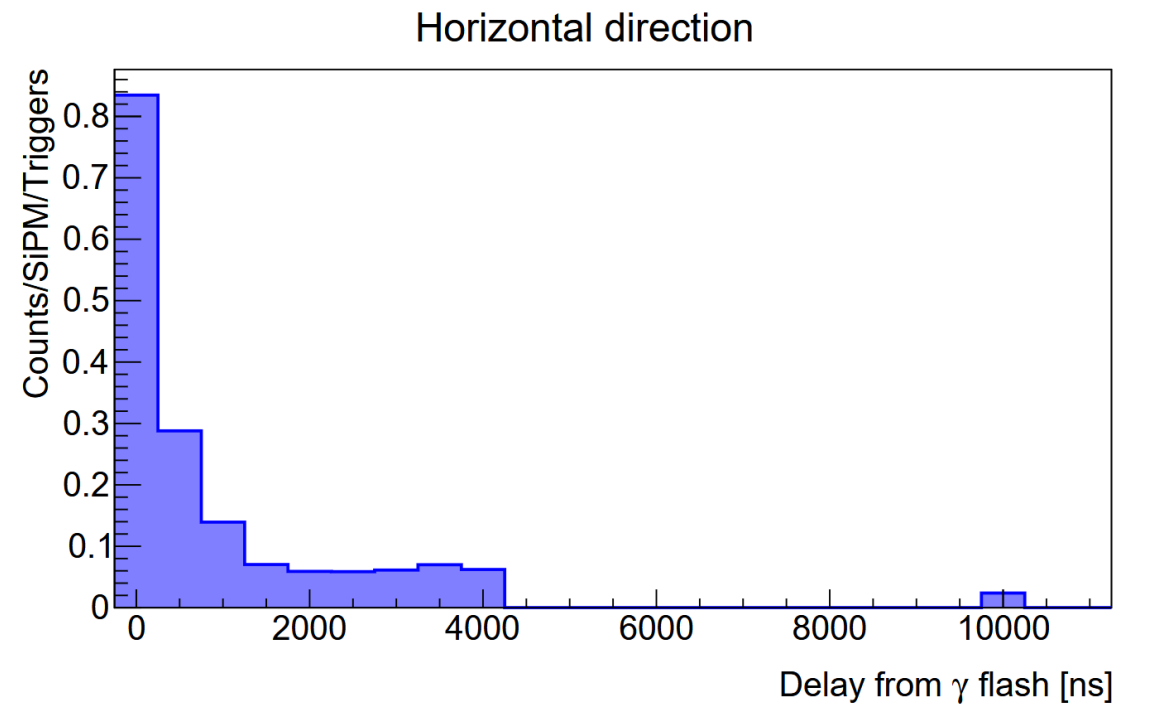

Thank you for your attention!

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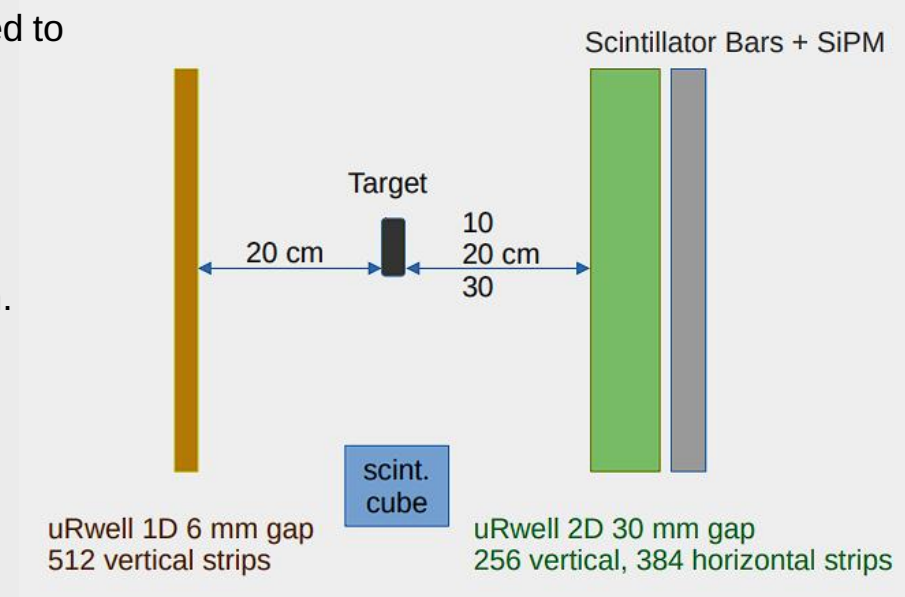
nTOF

First detector prototype test (2023)

- 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 $(10, 20, 30\ \mathrm{cm})$:
- Time after γ-flash $(0, 500, \ldots \rightarrow\ 10000\ \mathrm{ns})$



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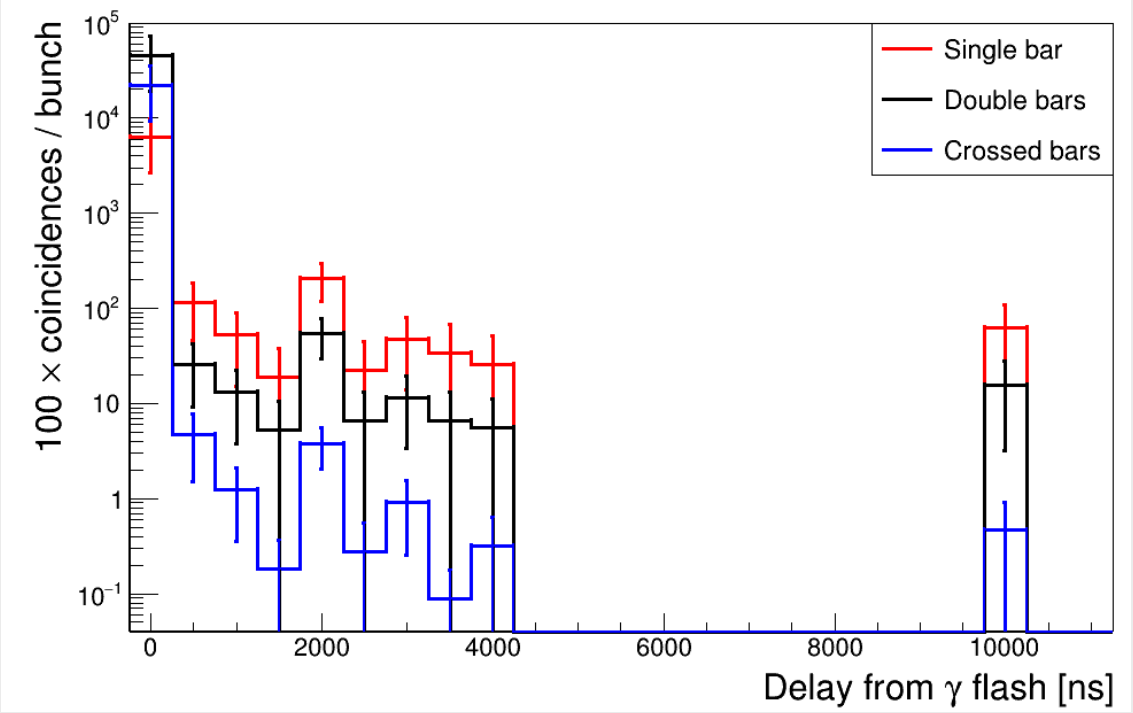

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10000 ns from γ-flash