Multiparameter study of ^{239}Pu fission with STEFF at n_TOF

Special thanks to Tobias Wright, Gavin Smith, Nikolay Sosnin, Adhitya Sekhar and all the n_TOF team

PhD student: Angelica D'Ottavi
Supervisor: Tobias Wright
University of Manchester

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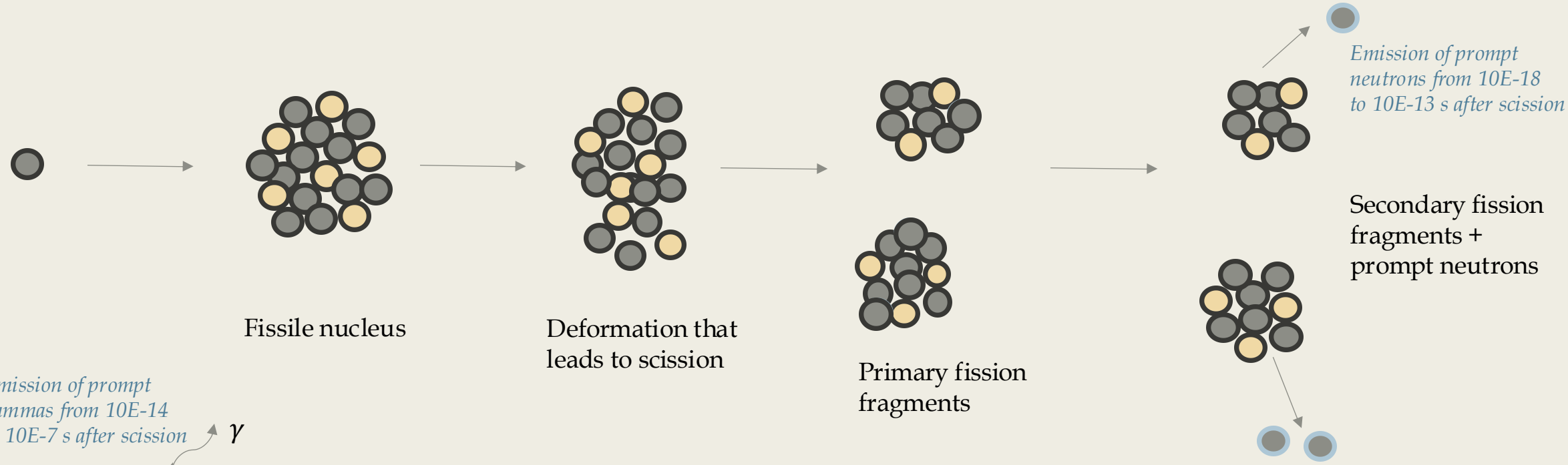
Fission observables: names and time scales



Time scales from the document available here

The nomenclature, from the document available here, may differ from other documents (often there's no distinction in names between pre and post gamma emission).

Reason for the ^{239}Pu(n,f) reaction study

		Incident neutrons energy range [a]		
Fission observable [b]	Tot. n. of studies	Thermal	Resonances	Fast
^{239}Pu(n,f) CS	143	47	86	39
Fission daughters	85	59	19	18
PFG	7	6	2	1
PFN	24	10	9	6

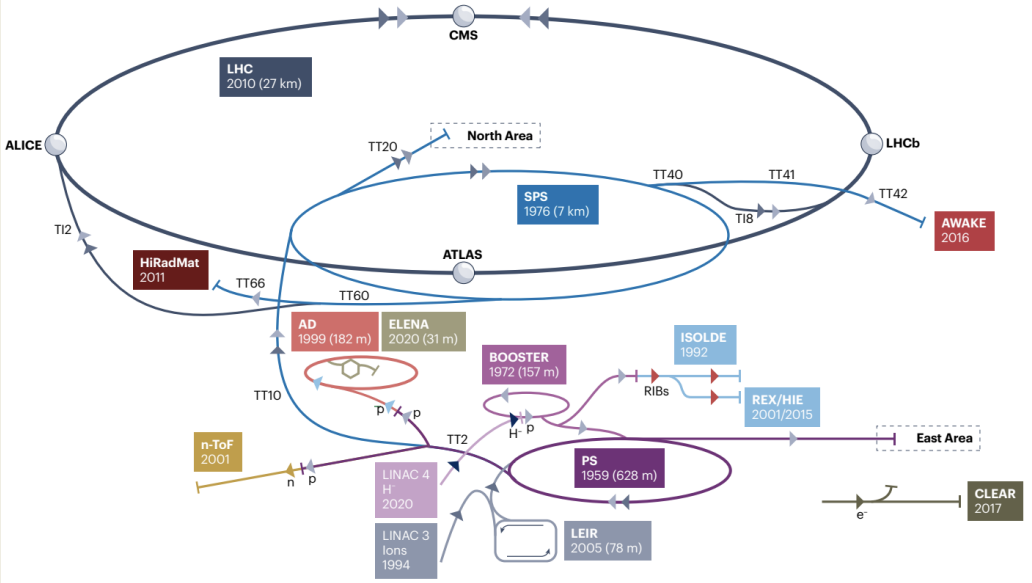
[a] Thermal: below 1 eV, Resonance: 1 eV < E < 1 MeV, Fast: above 1 MeV.
[b] CS stands for cross section, Fission daughters are both fragments and products, PFG is prompt fission gamma-rays, PFN is prompt fission neutrons.

Reason for ^{239}Pu(n,f) reaction study →

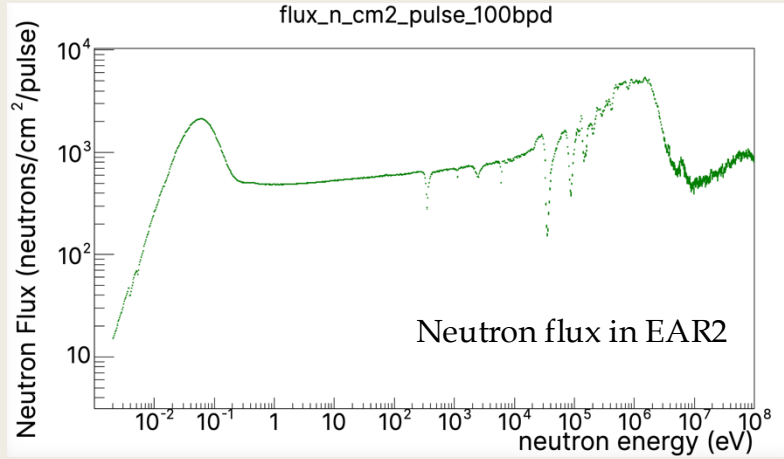
Review of existing studies shows lack of information on prompt fission gammas energy and multiplicity. STEFF will, hopefully, provide data on them, as well as on FF observables (mass and energy yield curves).

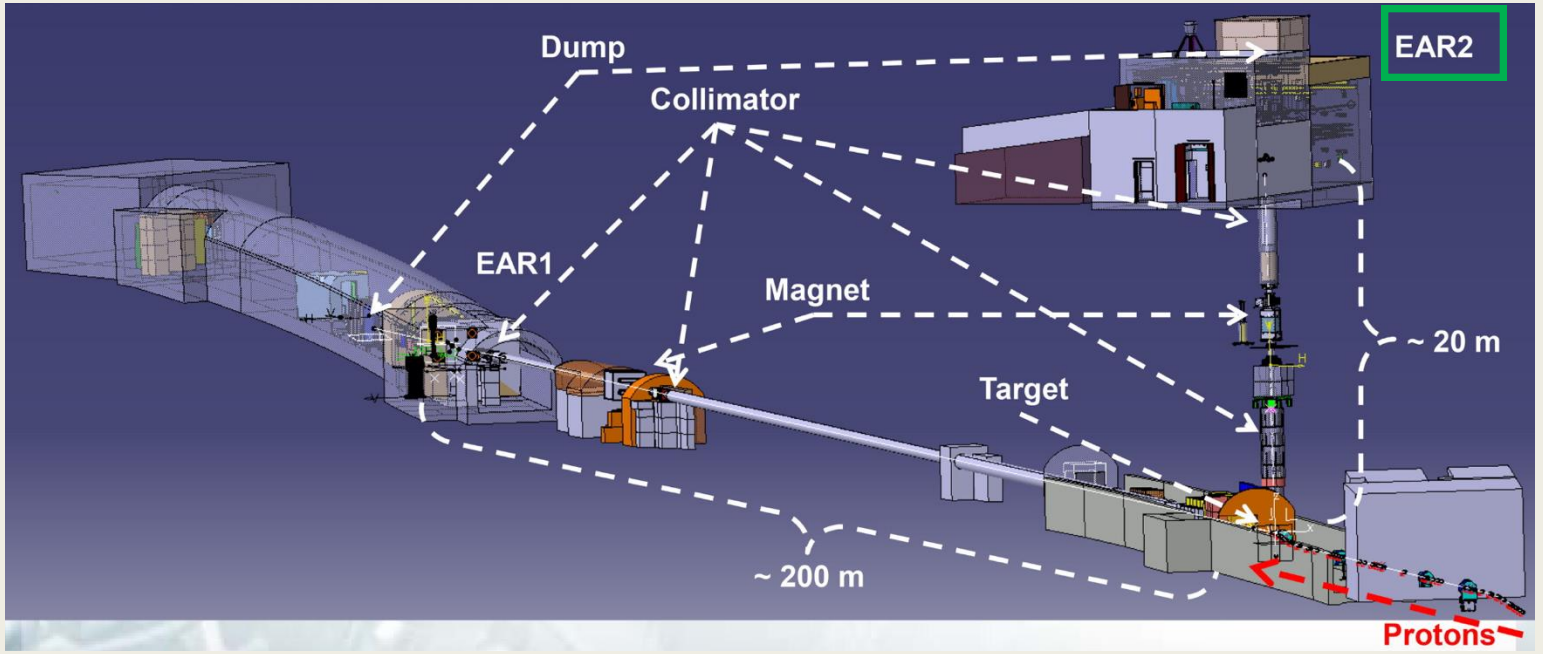
Multi-parameter study with a wide neutron energy range supplied by the n_TOF facility.

n_TOF facility, CERN



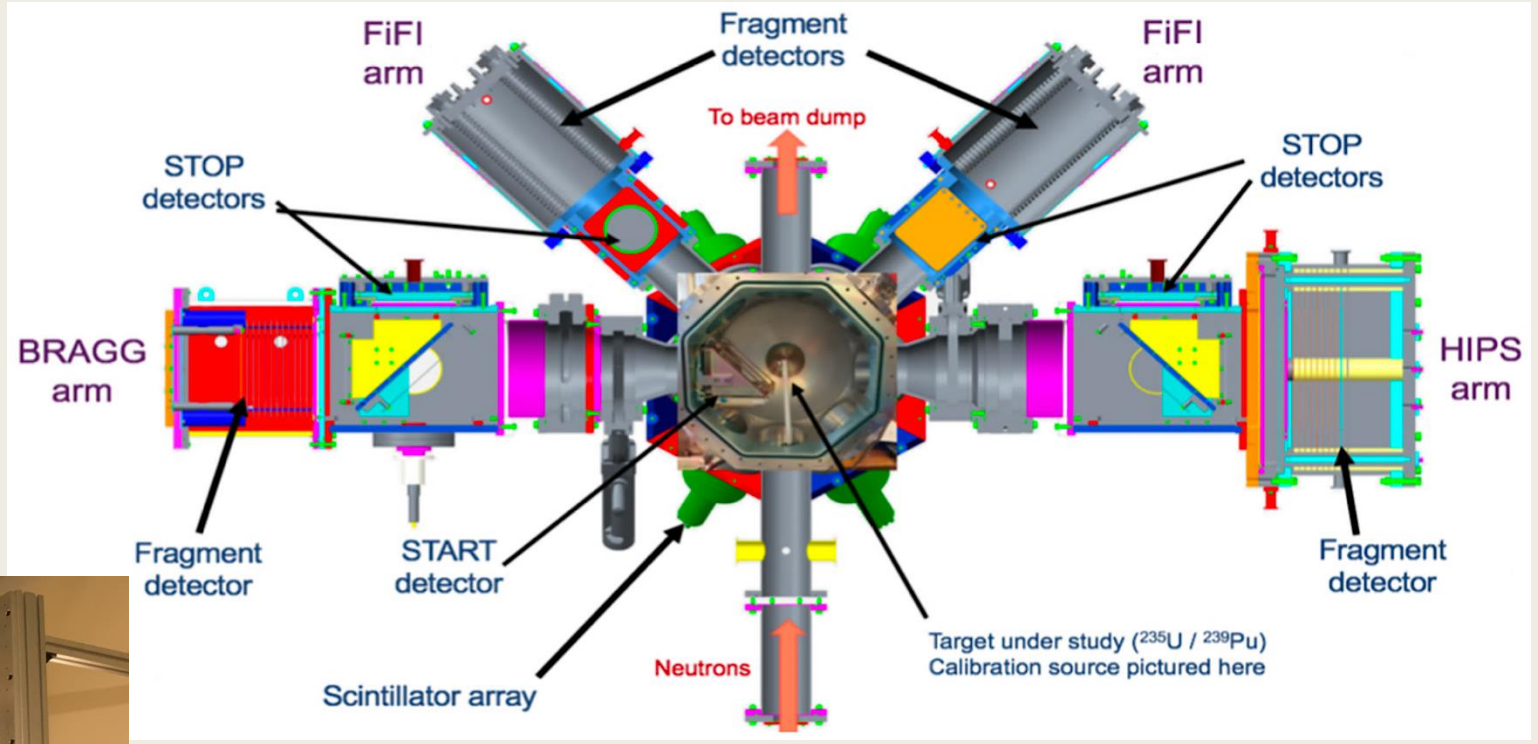
CERN chain of accelerators, reference available here.

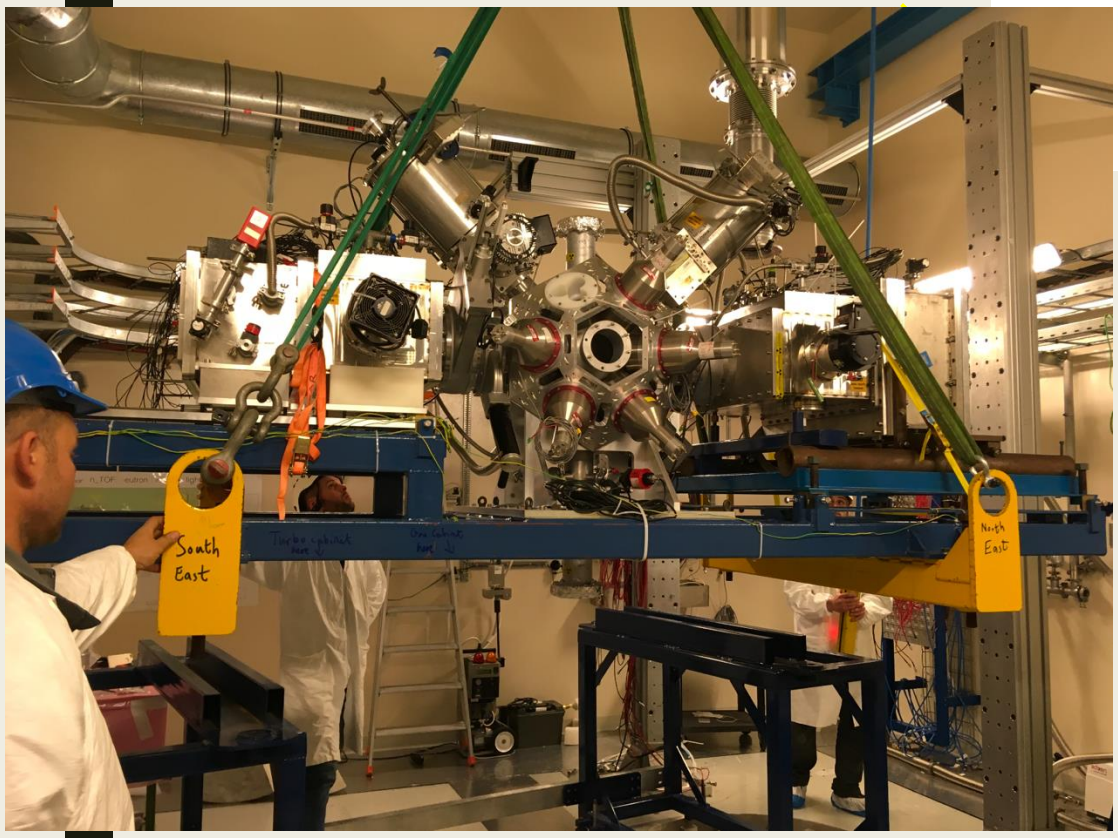




n_TOF uses PS protons to produce neutrons by spallation from a lead target. Their energy spans 12 orders of magnitude, from meV up to the GeV range.
Ref. available here

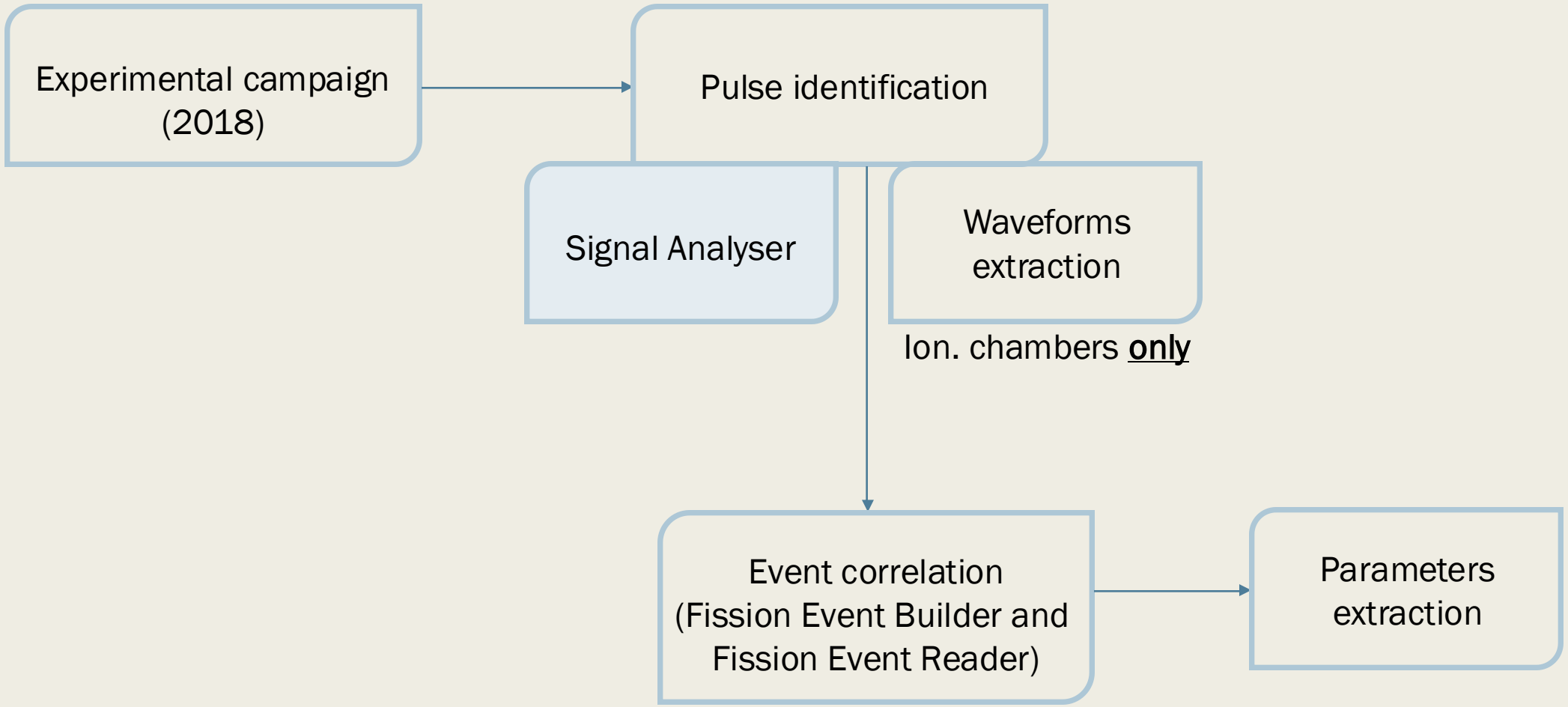
STEFF 2E2v spectrometer



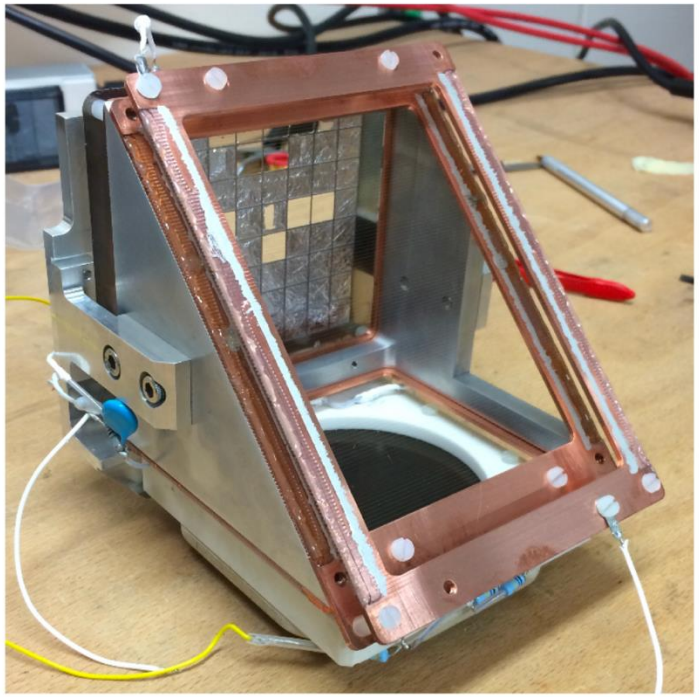


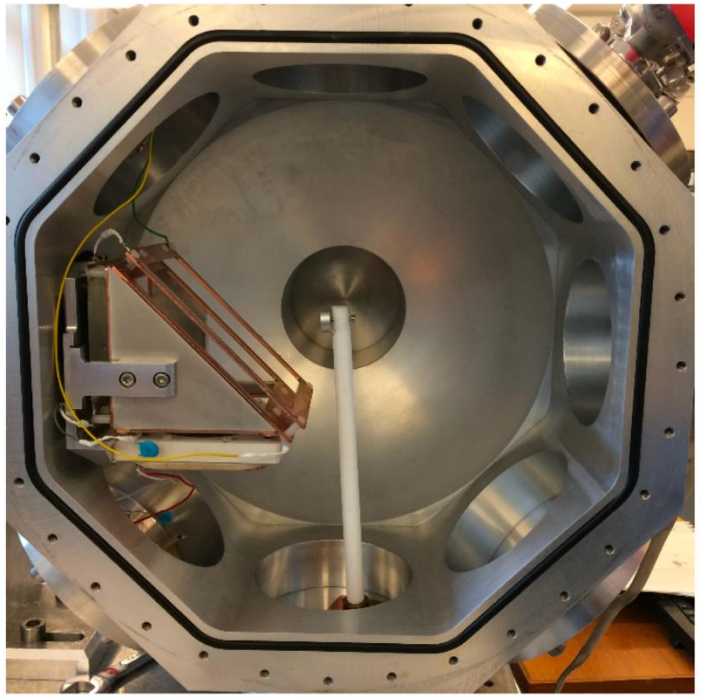
- Experimental campaign in 2018 at EAR2
- 5 timing detectors: to get the FF velocity
- 16 scintillators: to get energy and multiplicity of the γ-rays
- 4 ionisation chambers: to get the energy of the FF
- About 5 fission events per bunch expected

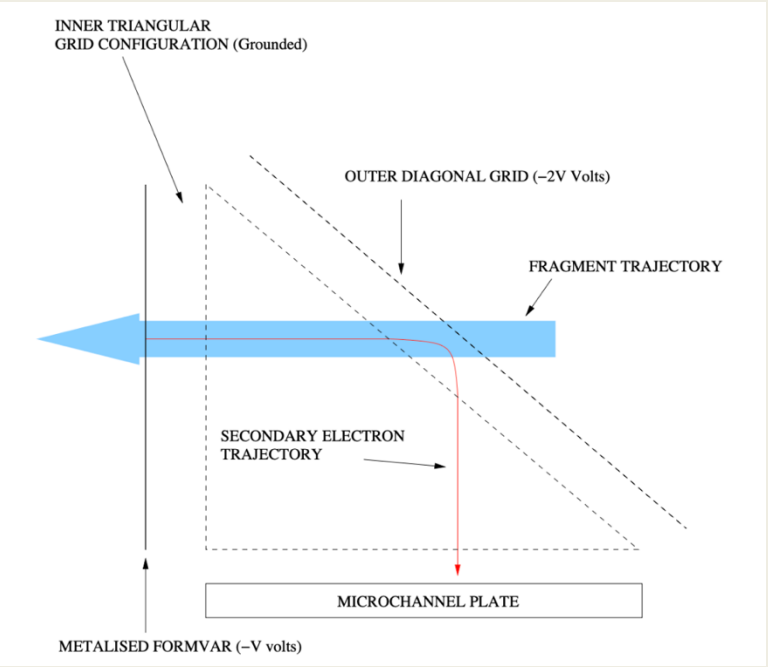
Flowchart of the data analysis



Timing detectors: Micro-Channel Plate

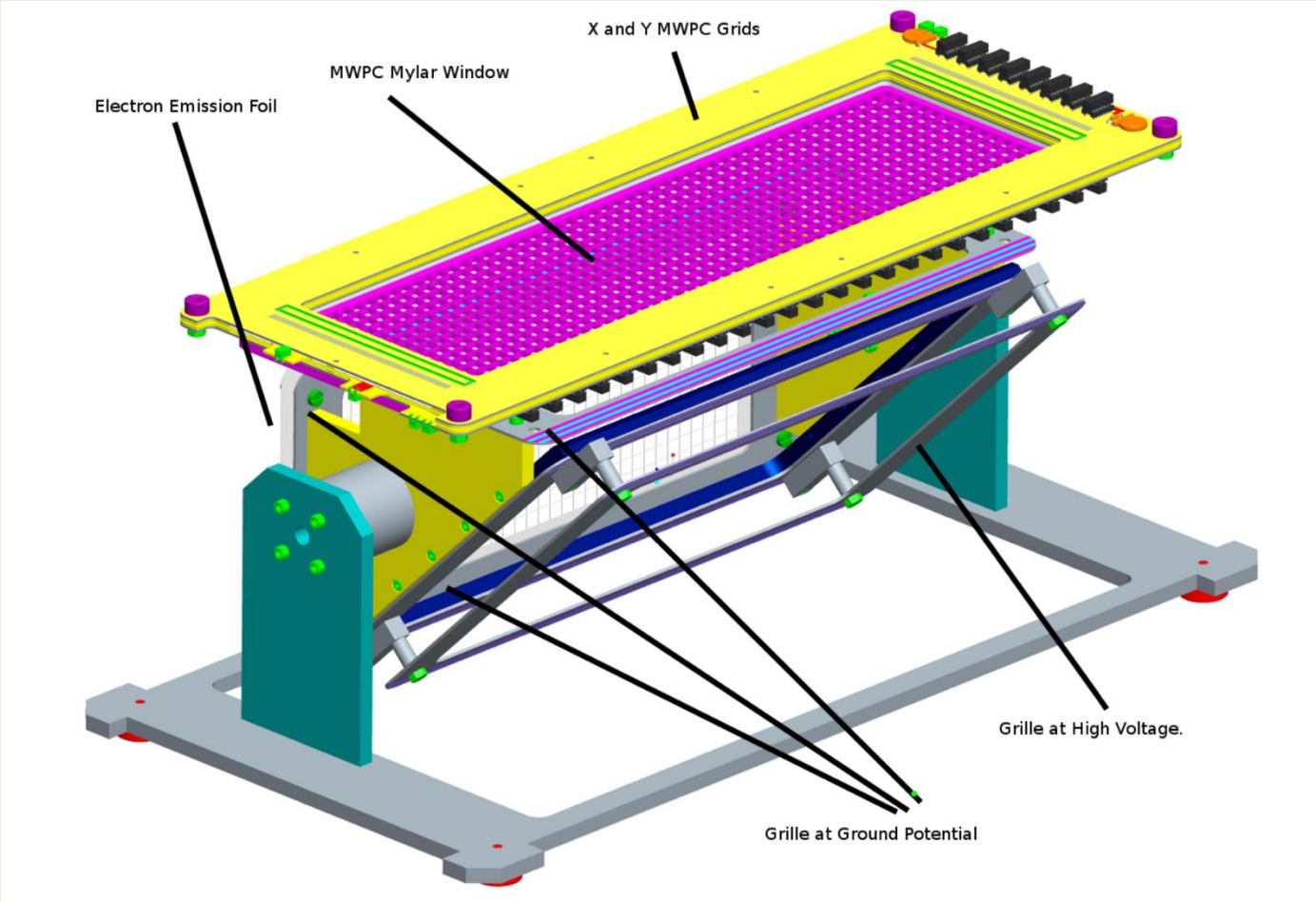






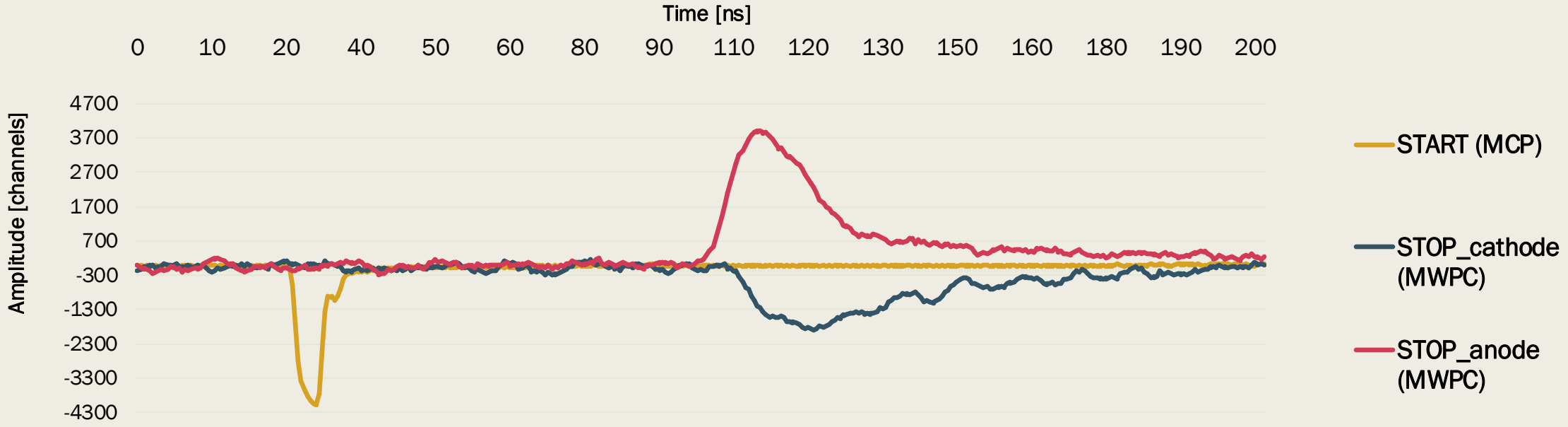
- Secondary electron emissive foil
- Electrostatic mirror
- Multi channel plate

Timing detectors: Multi-Wire Proportional Counter



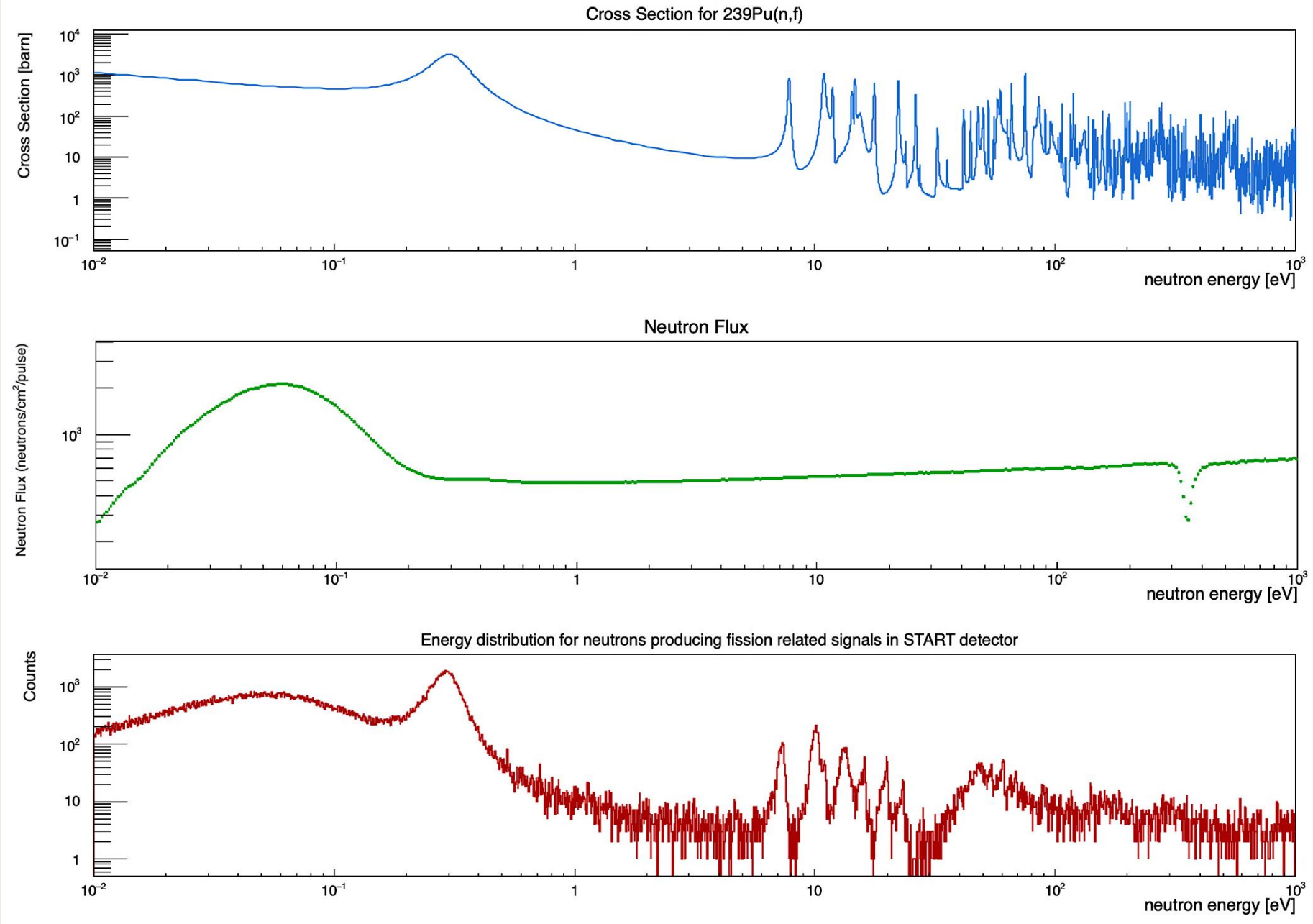
- Secondary electron emissive foil
- Electrostatic mirror
- Multi wire proportional counter: isobutane filled chamber is isolated from the electrostatic mirror by a mylar window

Timing detectors: signal traces

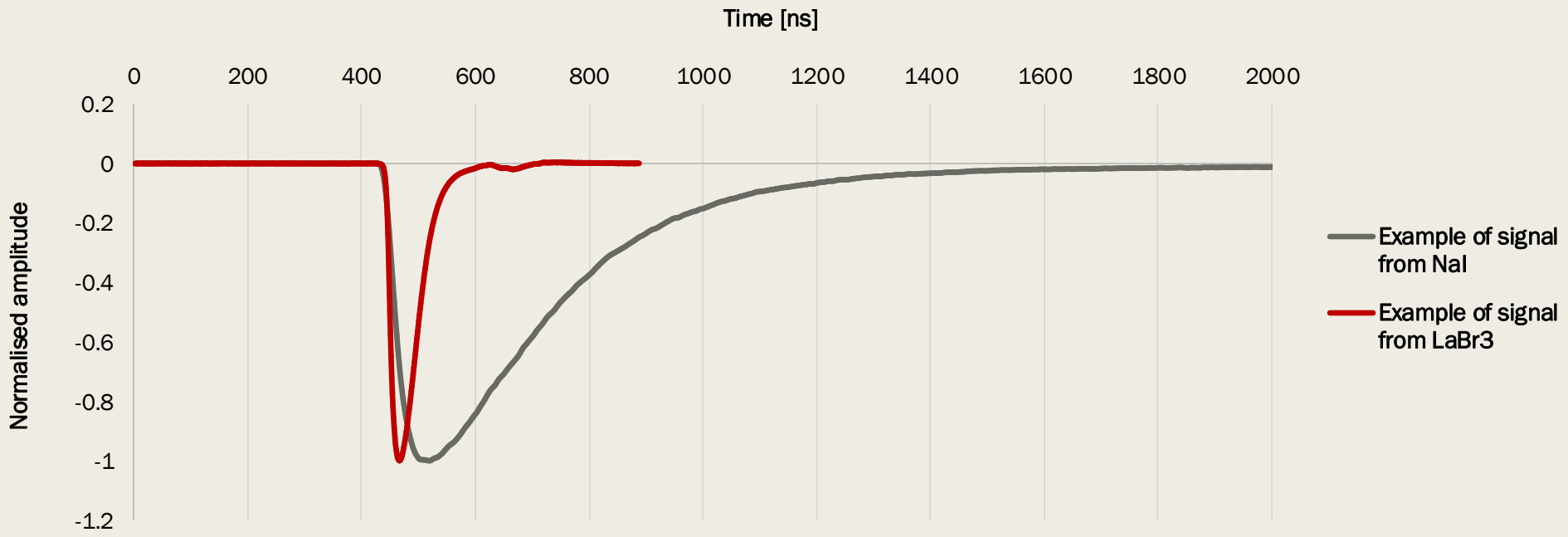


Detector	Rise Time [ns]	FWHM [ns]	Some signal characteristics
MCP	2.5	5	Saturation, deformation, ringing
MWPC cathode	10	34	noise
MWPC anode	8	19	Low amp., shared between pads, bipolarity, noise

Timing detectors: quality check on set of signals

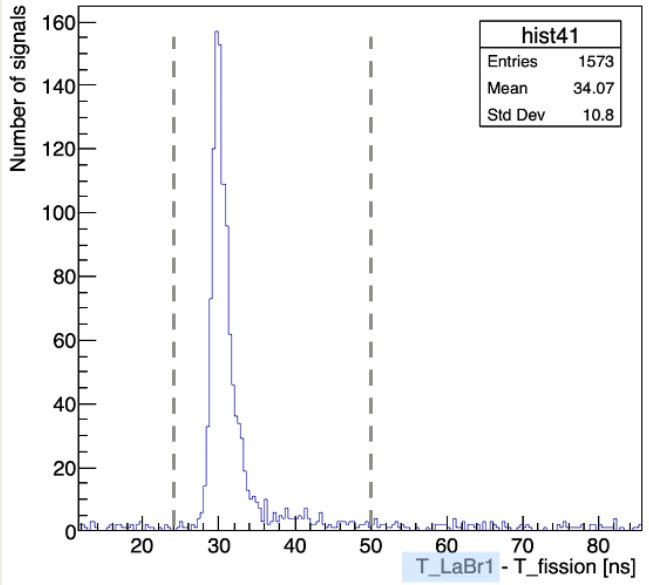


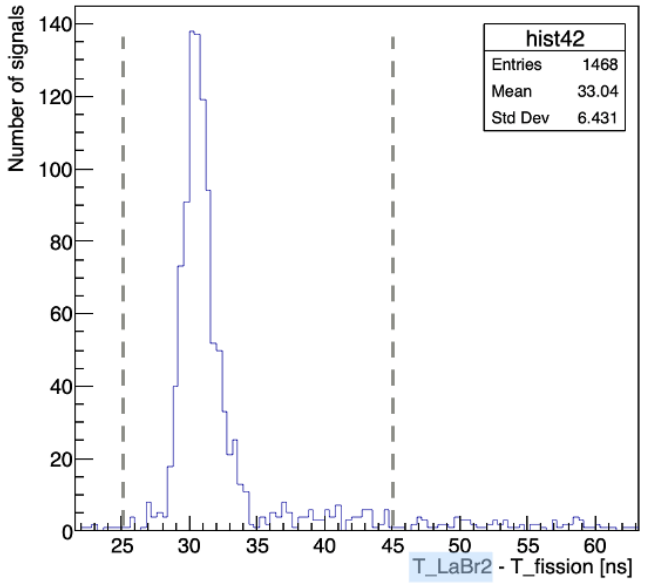
Scintillators: NaI and $LaBr_3$ example traces

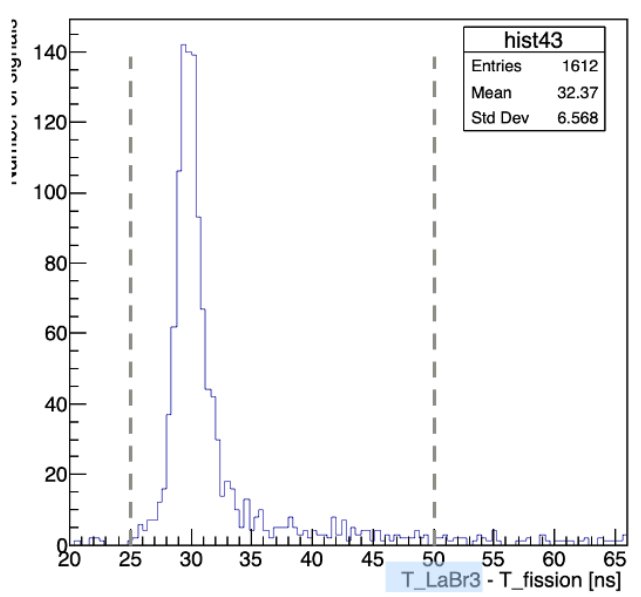


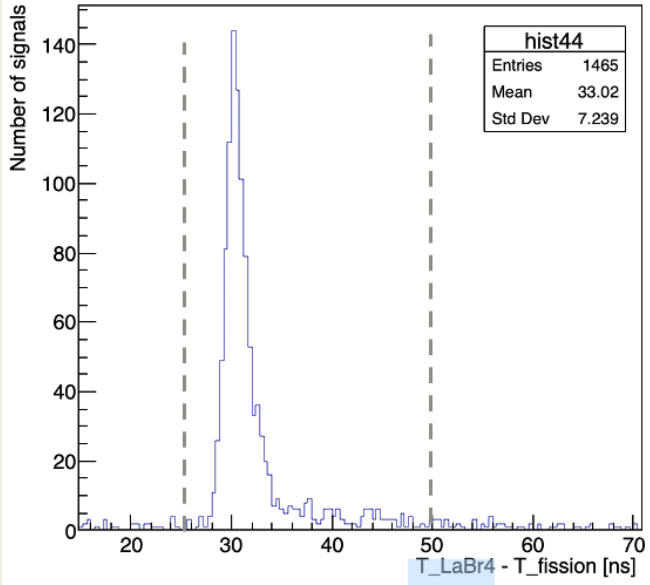
Detector	Rise Time [ns]	FWHM [ns]	Some signal characteristics
$LaBr_3$	14.57	41.6	[-]
NaI	75.26	252.78	Pile-up

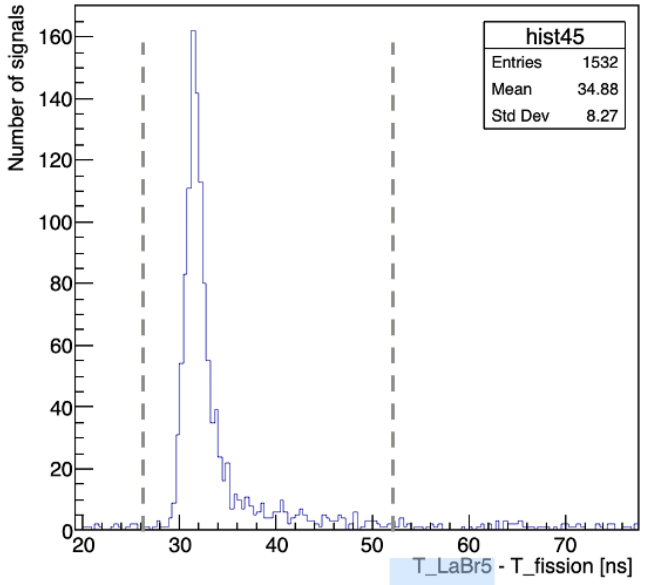
Scintillators: $LaBr_3$ detectors

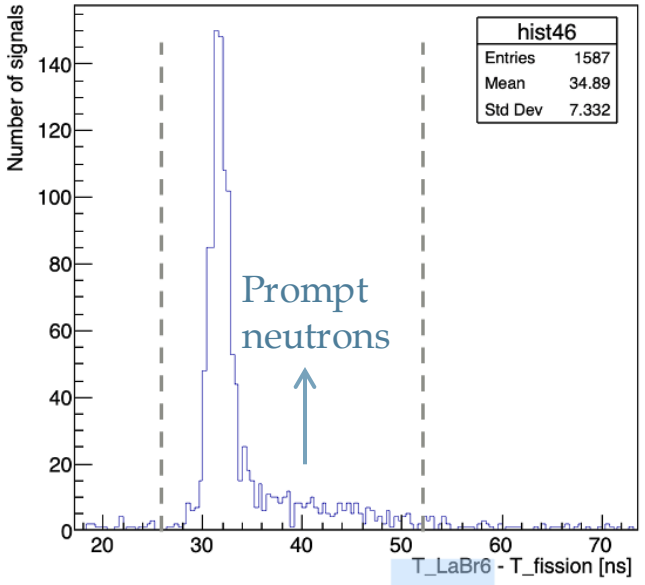












Preliminary prompt fission γ-ray spectra from $LaBr_3$ and NaI, compared to literature

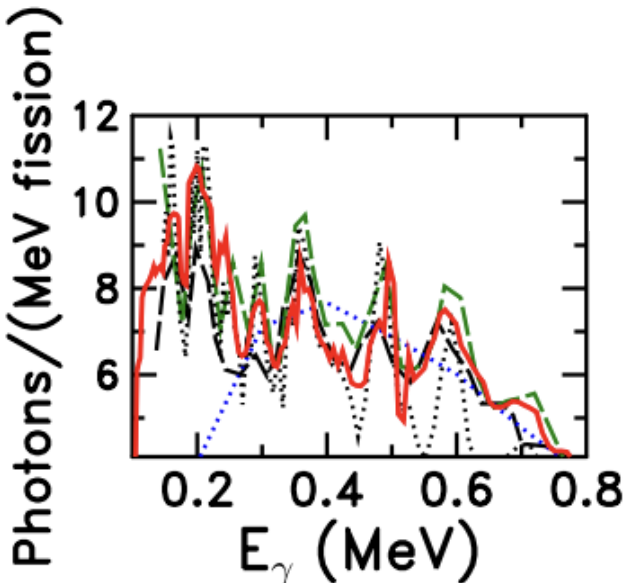


Figure 2. Prompt fission γ-ray spectra from thermal-neutron induced fission on ^{239}Pu (red line with error bars) compared with data from Verbinski et al. [23] and Chyzh et al. [24]. We also show recent calculations performed with the Monte-Carlo codes FIFRELIN [25] and CGMF [26]. The inset shows a zoom-in on the low-energy region in linear scale.

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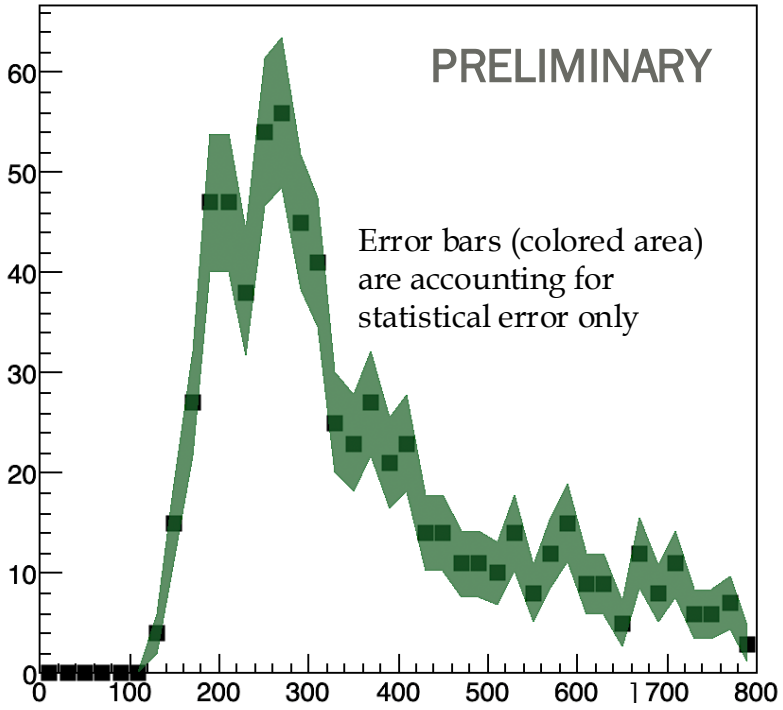
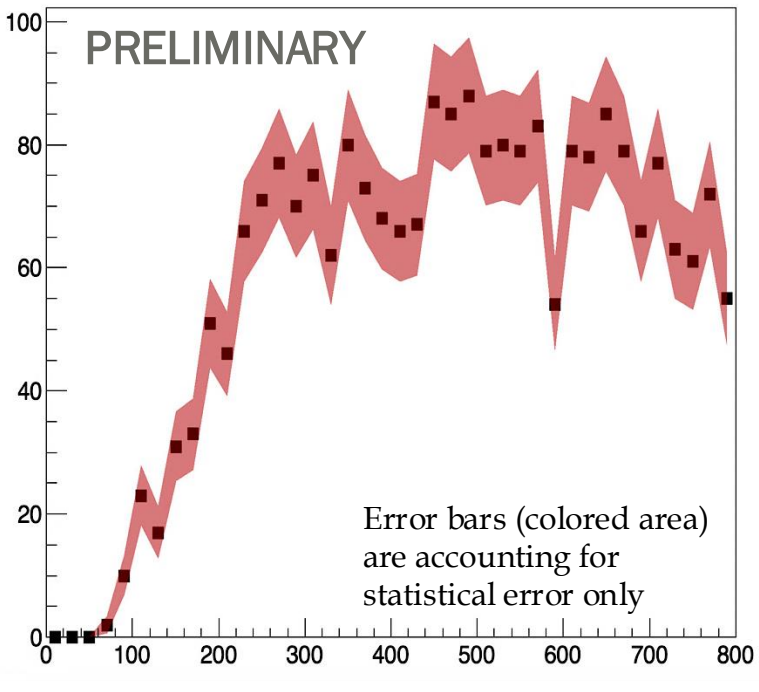
$LaBr_3$ spectrum of gamma rays form 23 runs



Spectrum of gamma rays form 3 runs, ALL NaI



Conclusions

- Signals traces observed for all the detectors; their reading has been optimized to build up a database of signals properties
- Quality check made using a single run as statistical sample (or a few runs, but still less then 10% of the campaign)
- Future steps: processing of the data for the entire campaign and event correlation to reconstruct fission events