Dead-time processing in the MTR2 module

BIPM Workshop on digital electronics for the RMO SIRTIs

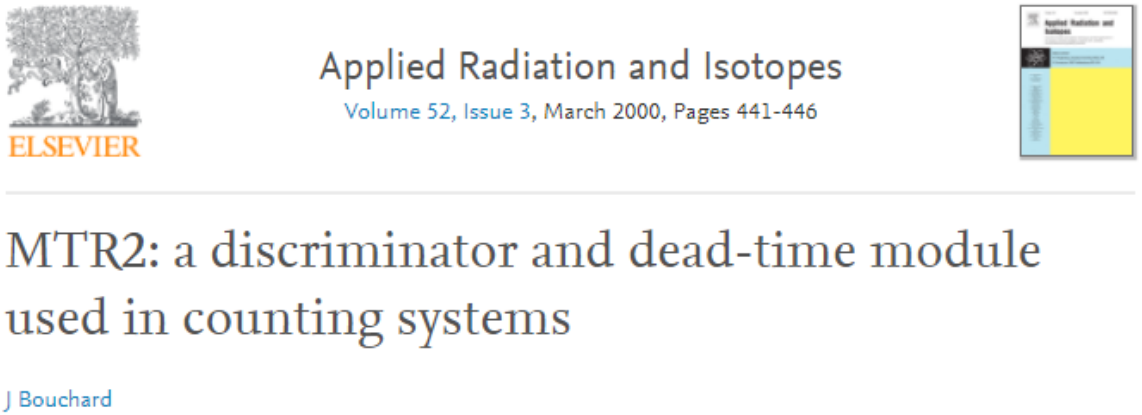
MTR2 module in short

- Multi-purpose dead-time module developed by J. Bouchard (LNHB)

- Main features
  - Extendable dead-time combined to live time measurements
  - Dead-time processing close to the real behavior of a nuclear instrumentation
    - Protection against saturated signals
    - Protection against dead-time in series (pile-ups, after-pulses)
  - Can be connected with an MCA for the acquisition of spectra

- LNHB: implemented in $4\pi\beta-\gamma$ anticoincidence and $4\pi-\gamma$ detection systems

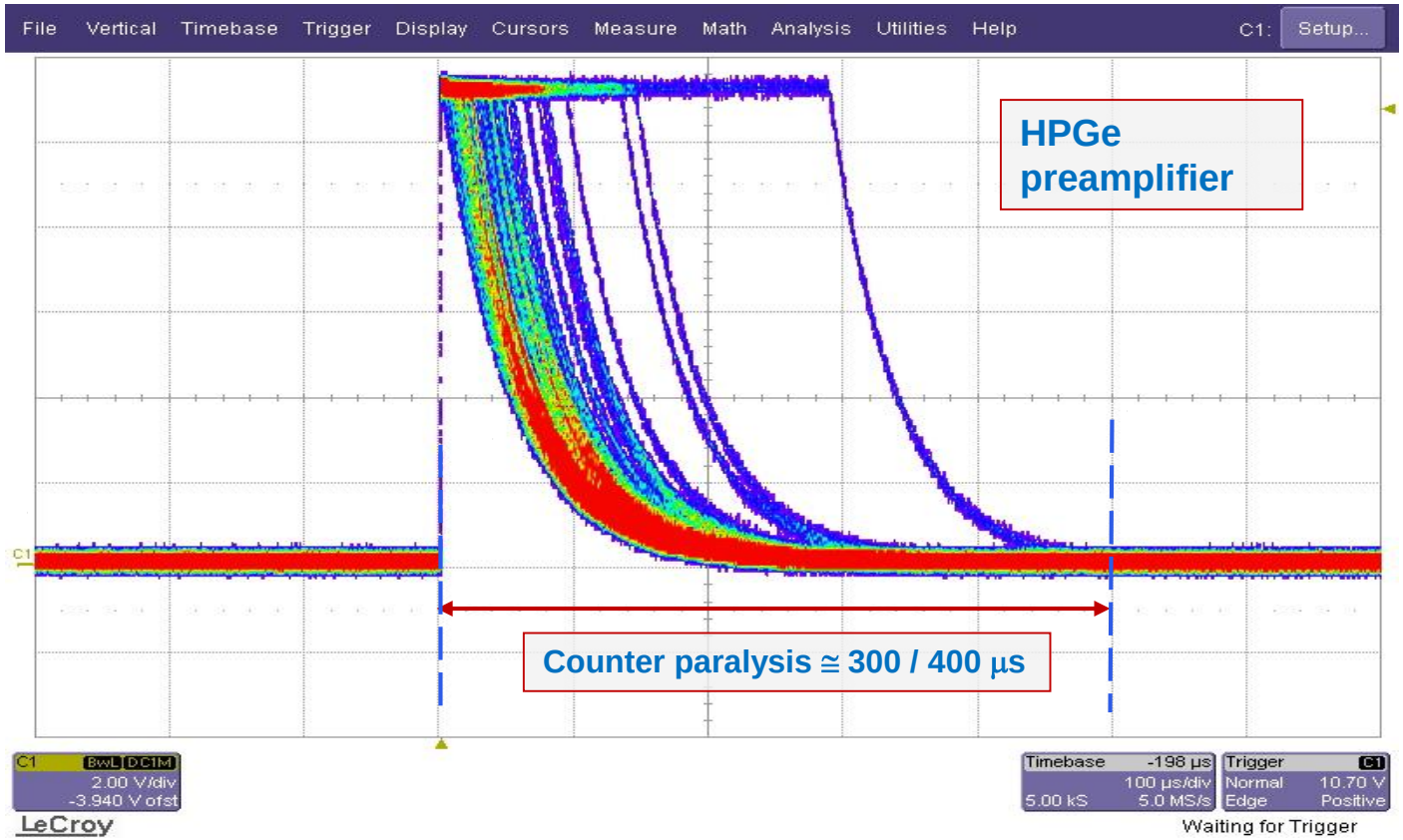
- Dead-time circuitry extended in the MAC 3 module (TDCR measurements)



Dead-time processing in the MTR2 module

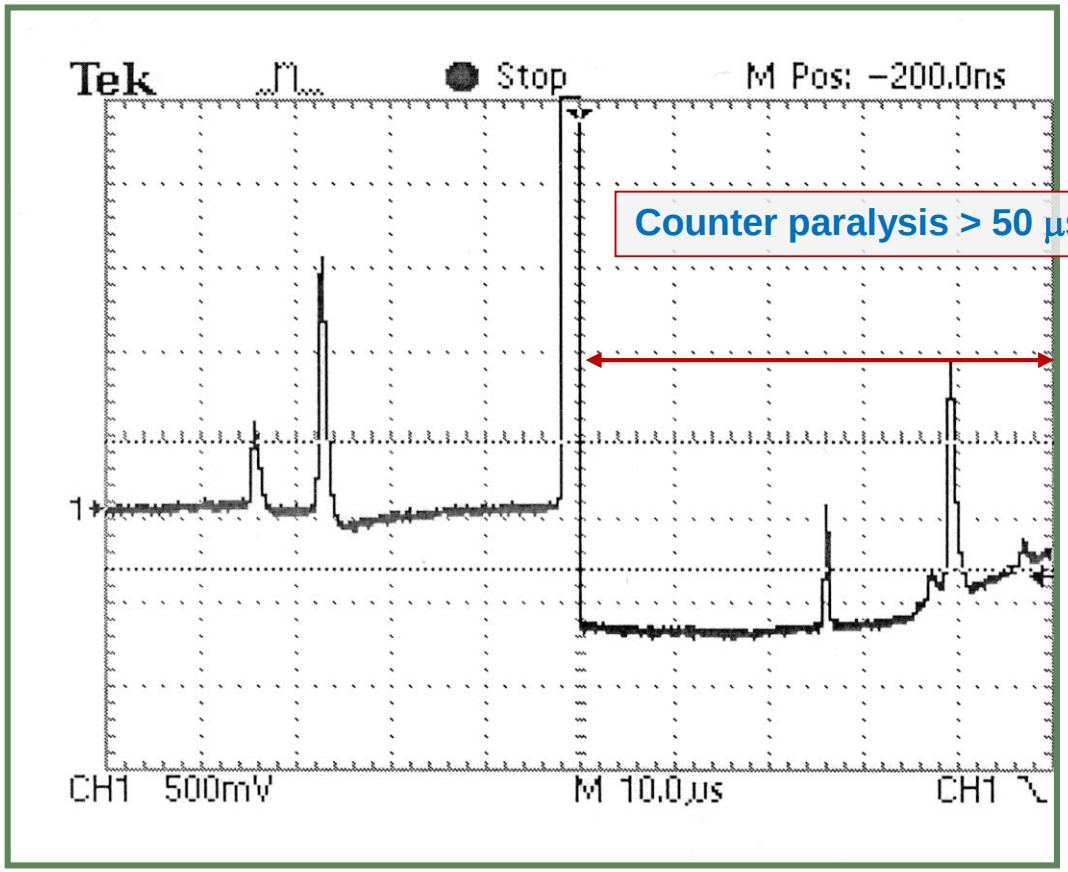
Basic idea for the design of the MTR2 module: fixed dead-time does not exist in a real nuclear instrumentation

- Variability of the duration of counter paralysis: saturated pulses, pile-ups, after-pulses



Dead-time processing in the MTR2 module

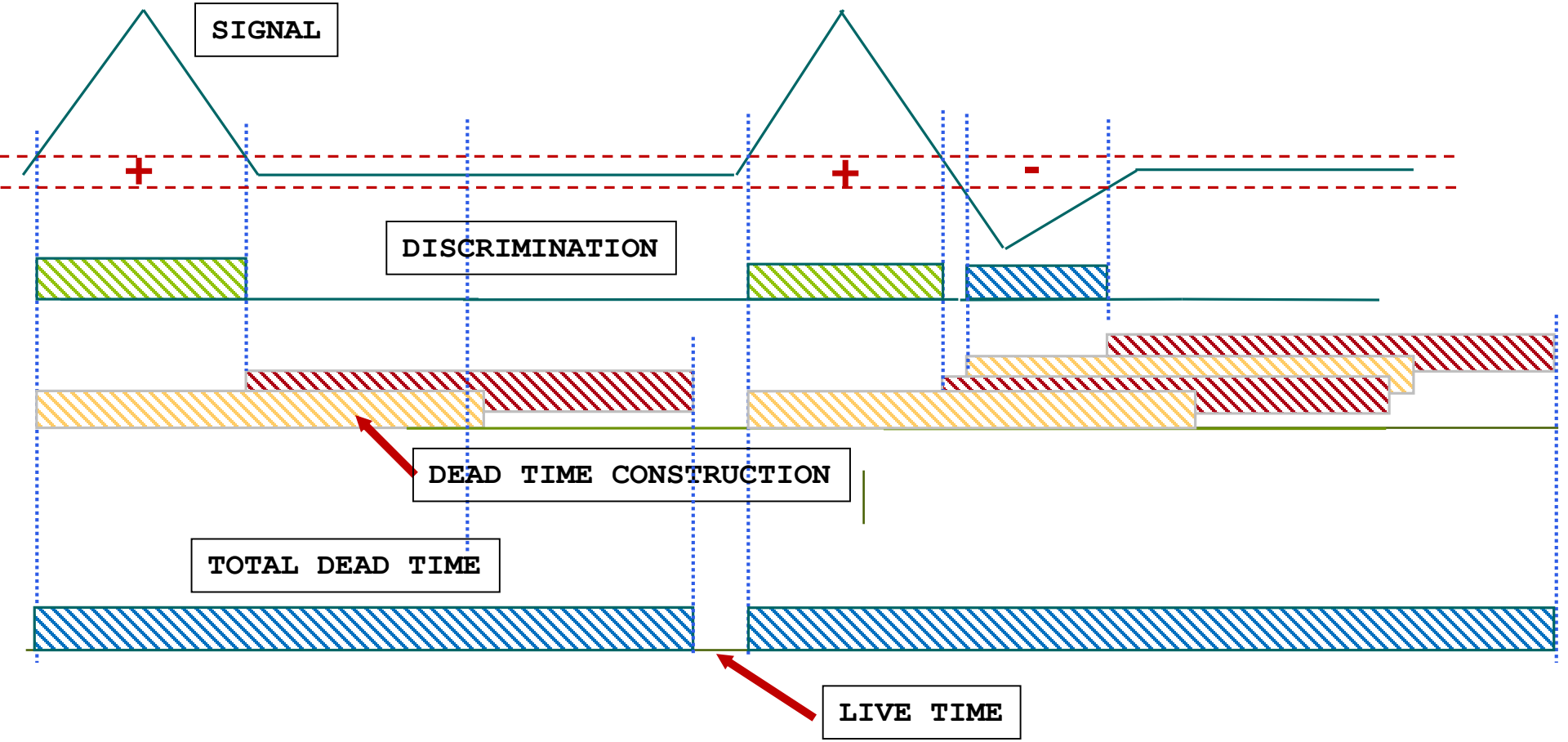
Large well-type NaI(Tl)
After the shaping amplifier



Dead-time processing in the MTR2 module

MRT2 module designed to include the discrimination duration in the dead-time processing

Dead-time processing in the MTR2 module



- **The prolongation of the dead time at the end of the discrimination signal implemented for protection against after-pulses**

Dead-time processing in the MTR2 module

Dead-time processing in the MTR2 module

To summarize, the extendable dead-time processing is implemented:

- ✓ By including the duration of the positive and negative discrimination signals for protection against saturated pulses, pile-ups and undershoots ;
- ✓ By extending the dead-time using the positive and negative edges of the discrimination signal for protection against after-pulses.

The dead-time electronics was tested in the case of coincidence counting (Co-60) using a proportional counter in the β-channel with a counting rate of ~ 10^6 s^{-1}
Total dead-time ~ 95 % - relative uncertainty on activity ~ 0,1 %

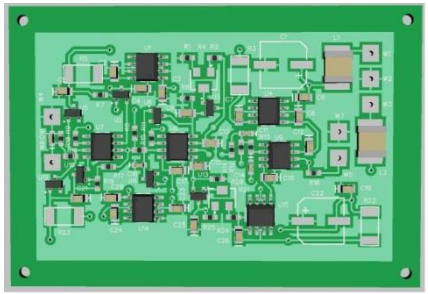
Two MTR2 modules in the case of anticoincidence counting

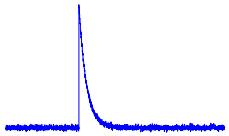
Digital transition of the MTR2 module

Home-made digital prototype at LNHB for complete on-line processing based on the same dead-time processing of the MTR2 module

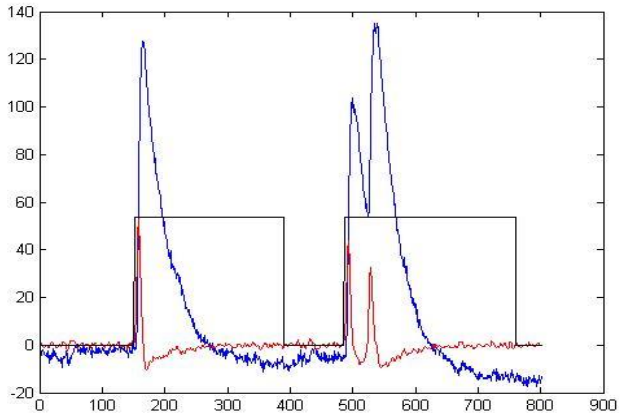
- All the the functionalities are implemented in the FPGA circuit
- Validated for different methods: TDCR, γ-spectrometry, anticoincidence counting, 4π–γ counting : difference with analog systems at LNHB lower than 0.05%

Front-end electronics

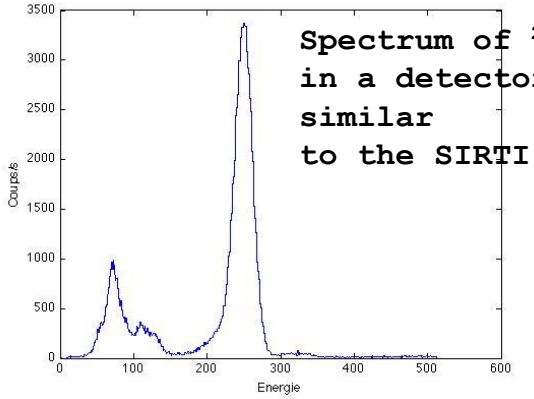




2 ADCs (14 bits – 125 MHz)
FPGA: Stratix III



Not compact enough for the SIRTI



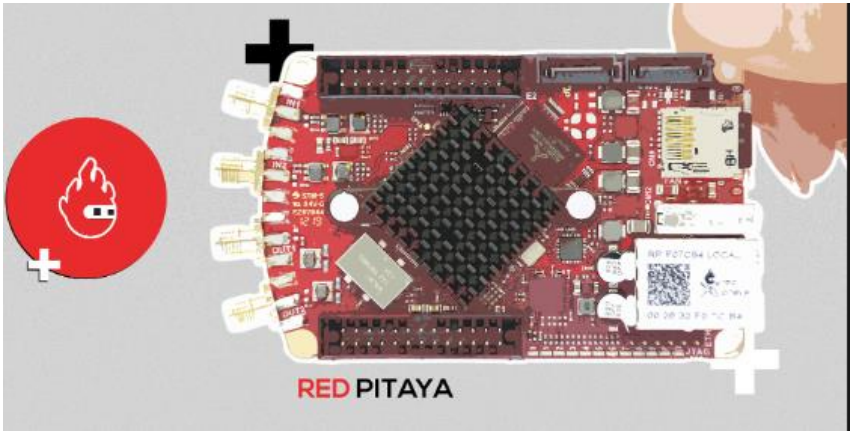
Spectrum of ^{241}Am in a detector similar to the SIRTI

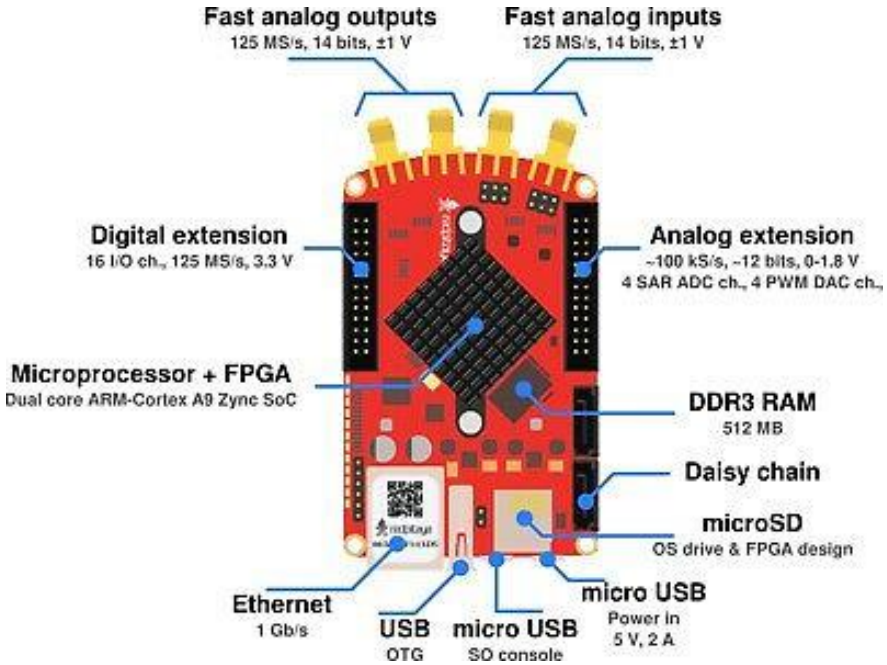
Dead-time triggering based on a fast channel

Digital transition of the MTR2 module

FPGA dead-time processing can be adapted in a more compact device

- Redpitaya StemLab 125-14 (~ 400 €)
- First development showed that γ-spectrometry is possible but not available yet (need more testing)





The nanoMCAII could be tested with the SIRTI

- Commercial MCA module
- Compact
- On-line processing
- 16-bit ADC 125 MHz
- Dead time processing: not based on extendable dead time
  - Possible contact with the designer to implement extendable dead-time as in the nanoTDCR module

THANK YOU FOR YOUR ATTENTION