Digital electronics for the RMO SIRTIs, 8 June, 2022

The existing developments and application experience of digital electronics at NIM

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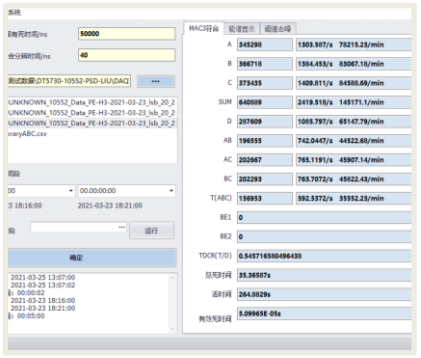
1. The existing developments at NIM

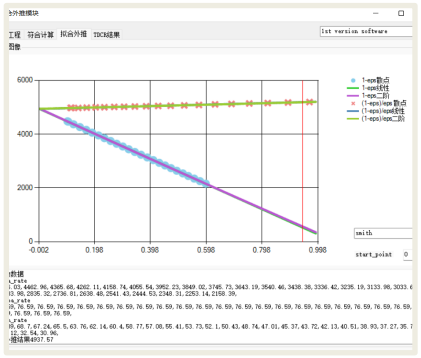
- **Digitizer used for radionuclide metrology**
  - **Data acquisition(DAQ)- CAEN digitizer**

730S Digitizer Family
14-bit @ 500 MS/s
8 / 16 Channels

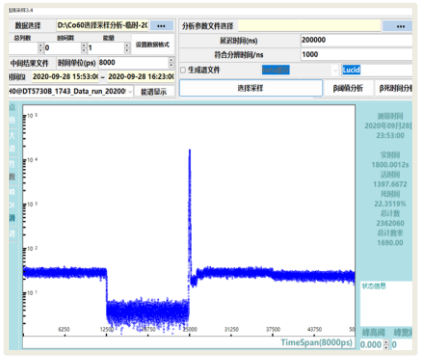
  - **Associated software-Software based circuits & Analysis software**



TDCR



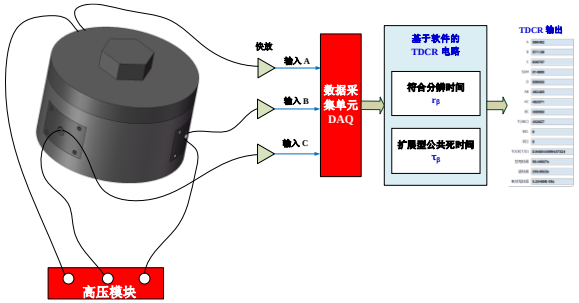
4πβ-γ DCC

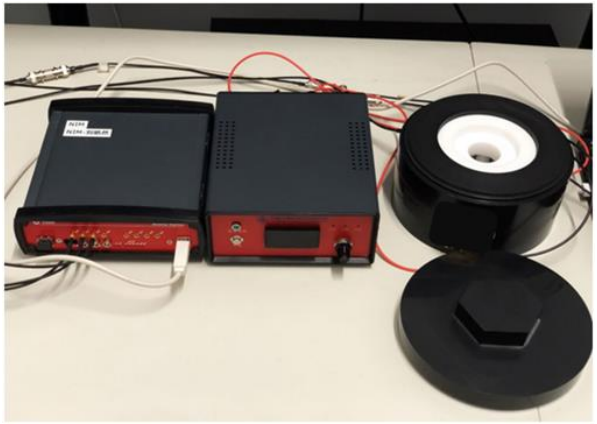


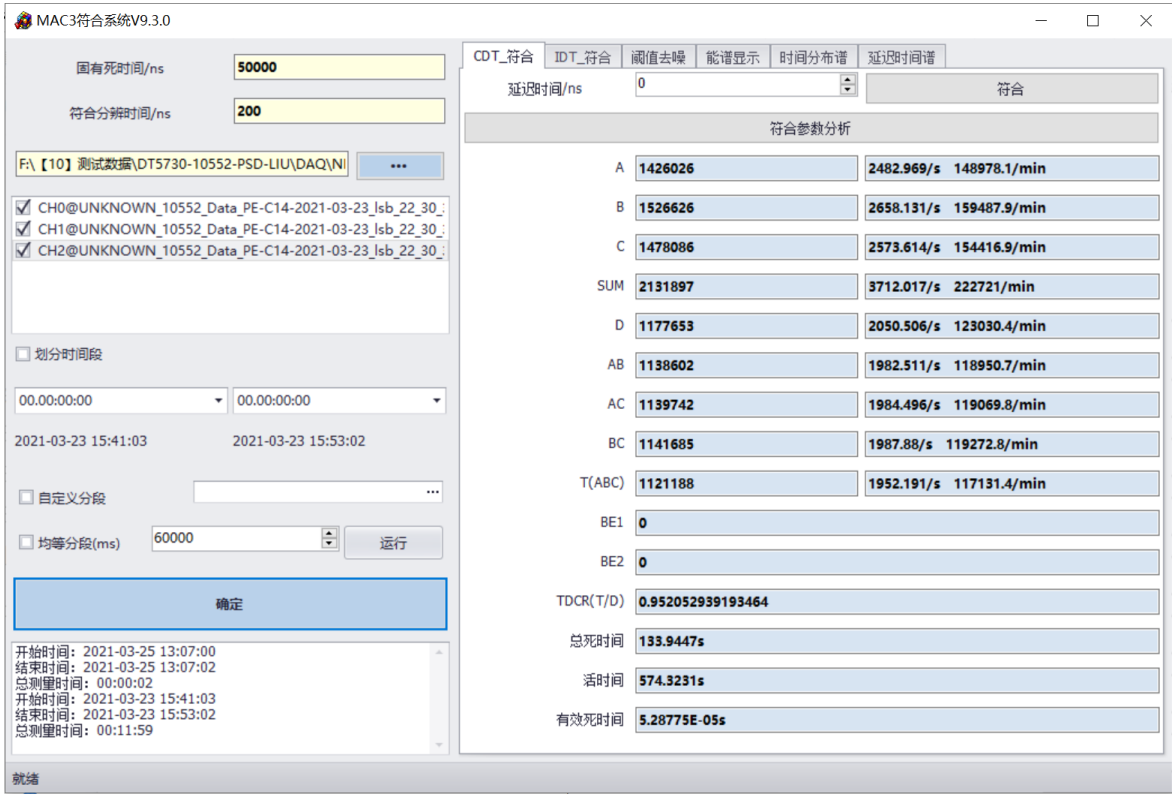
Selective sampling method

1. The existing developments at NIM

- **Digitizer used for radionuclide metrology**
  - **TDCR application**



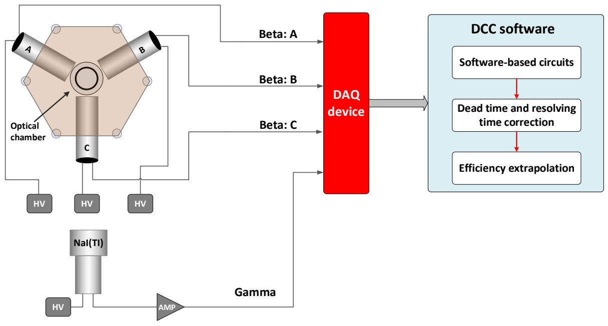


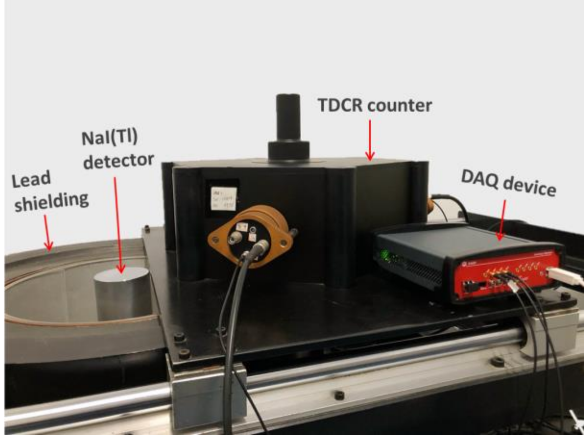


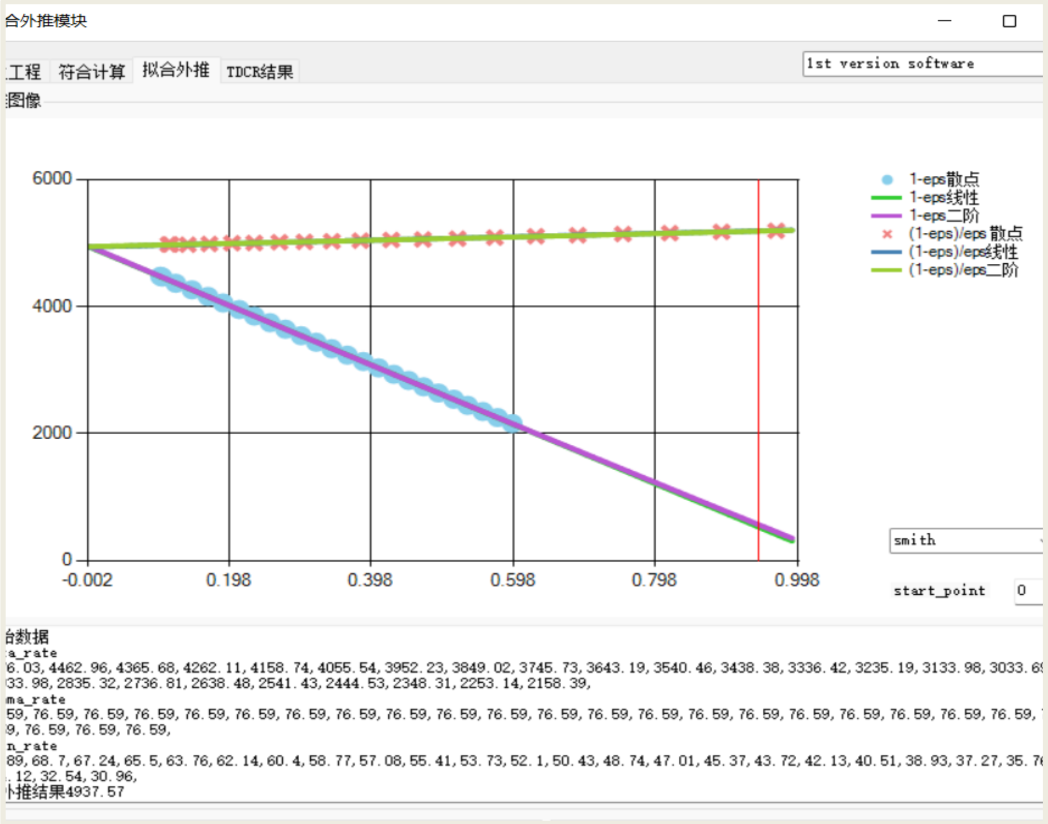
1. The existing developments at NIM

- **Digitizer used for radionuclide metrology**

  - **4πβ(LS)-γ DCC application**

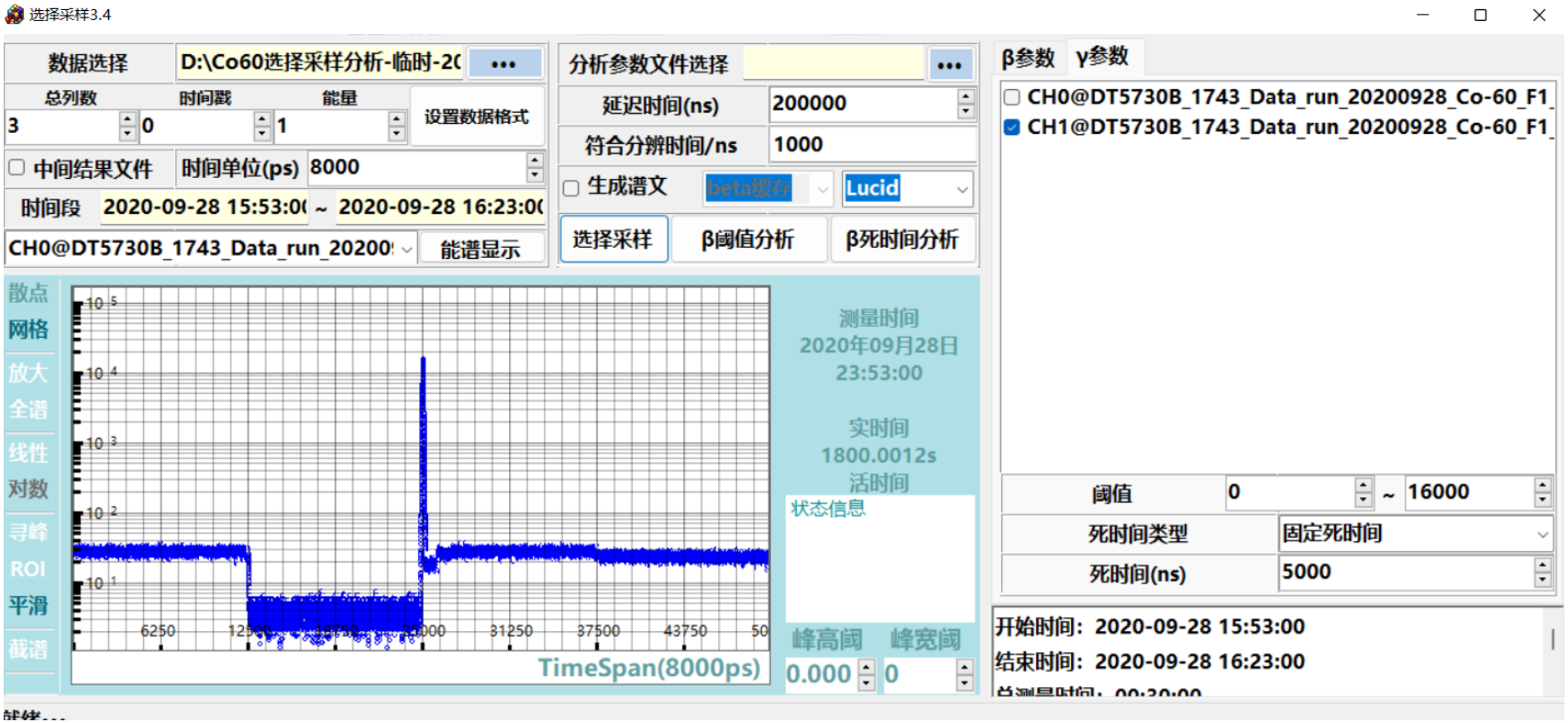






1. The existing developments at NIM

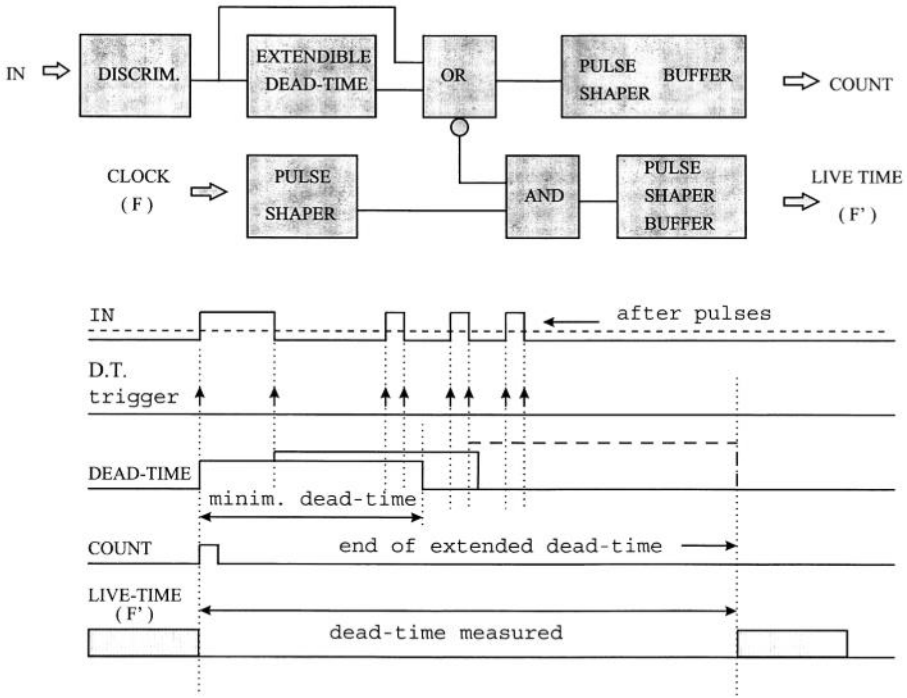
- **Digitizer used for radionuclide metrology**
  - **Selective sampling method application**



2. Some considerations about digital electronics for SIRTI

2.1 Dead-time processing

- **MTR2: Extendible dead-time & live-time method**



Extendible dead-time

An external clock-pulse generator is only required

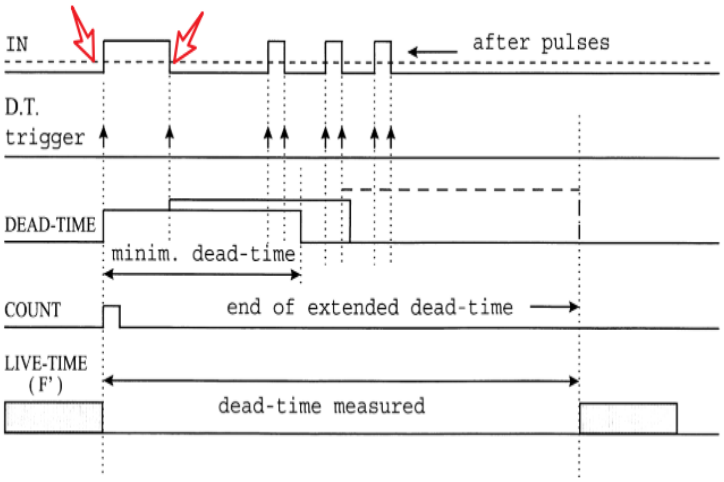
$$\rho = R \Big/ \left(\frac{C/T}{f} - R\mathrm{d}t \right)$$

Live-time method

2. Some considerations about digital electronics for SIRTI

2.1 Dead-time processing

- **MTR2: Special features**



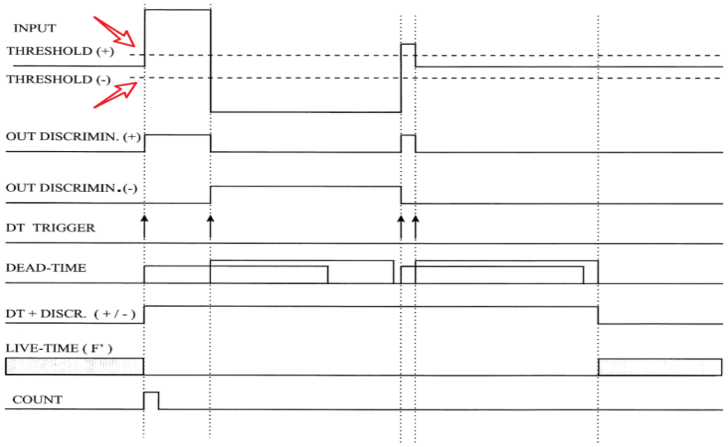


Fig. 5. Double threshold system to process the positive and negative parts of the input signal.

- dead-time is not only triggered by the leading edge but also by the trailing edge of the incoming pulse

- A double threshold system has been implemented

2. Some considerations about digital electronics for SIRTI

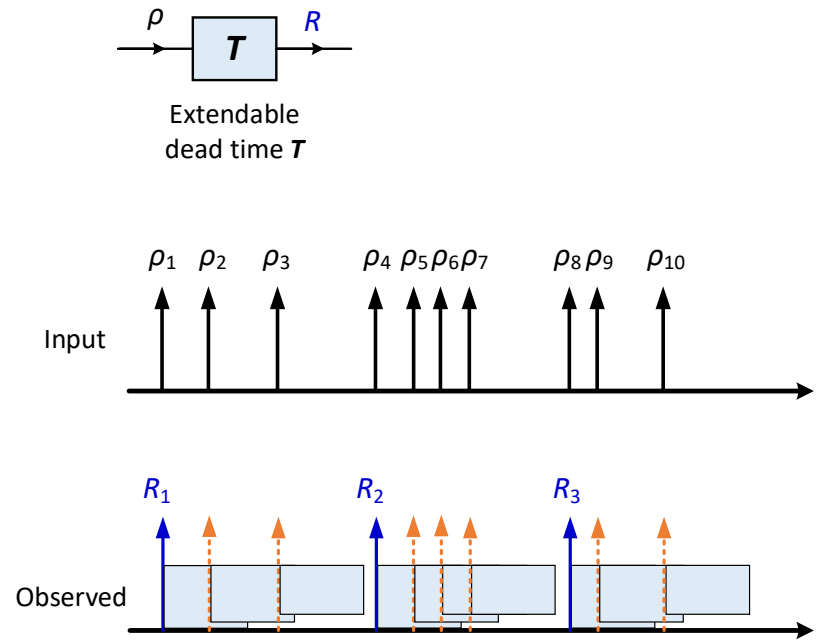
2.1 Dead-time processing

- **CAEN digitizer**: list mode data & software processing

```
BOARD;CHANNEL;TIMETAG;ENERGY;ENERGYSHORT;FLAGS
0;0;2406303749;4095;0;0x4080
0;0;43922782374;1;0;0x4000
0;0;166038797312;0;0;0x4000
0;0;596359591374;4;4;0x4000
0;0;607616806067;41;37;0x4000
0;0;651180316577;0;0;0x4000
0;0;883314405663;16;15;0x4000
0;0;1040260911678;24;23;0x4000
0;0;1096681713029;4095;2047;0x4080
0;0;1159758417662;4095;2047;0x4080
0;0;1166575378370;0;0;0x4000
0;0;1178534583515;4095;2047;0x4080
0;0;1482371707523;0;0;0x4000
0;0;1714611480273;4095;2047;0x4080
0;0;1747076108155;38;37;0x4000
0;0;1794617725576;0;0;0x4000
0;0;2034473937529;4095;2047;0x4080
```

timestamps

list mode data file



Extendible dead-time processing logic

2. Some considerations about digital electronics for SIRTI

2.2 Pile-up management

- **SIRTI:** No pile-up rejector in amplifier (ORTEC 590A)

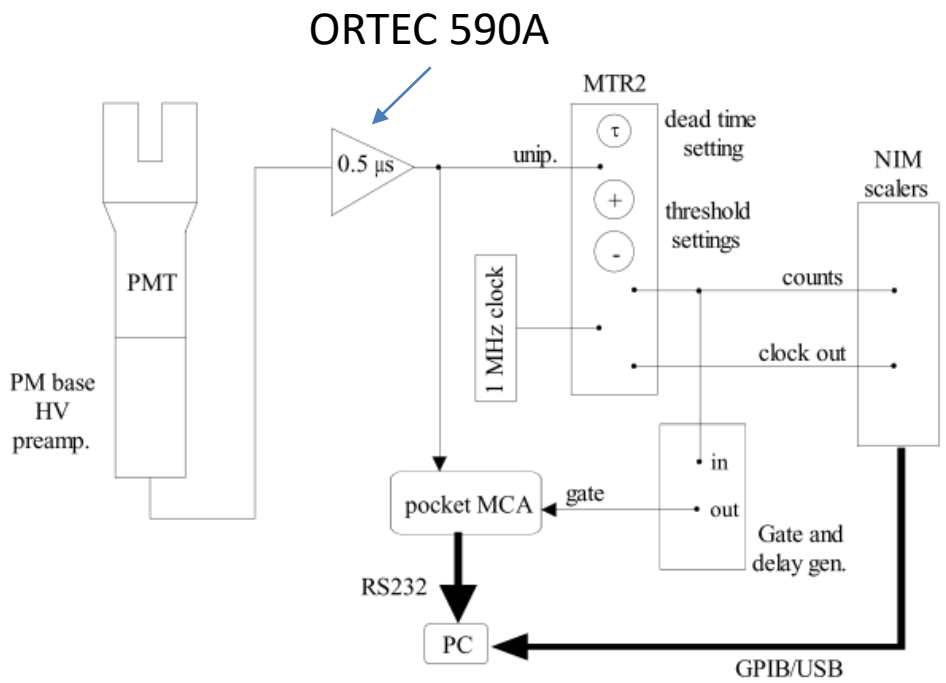


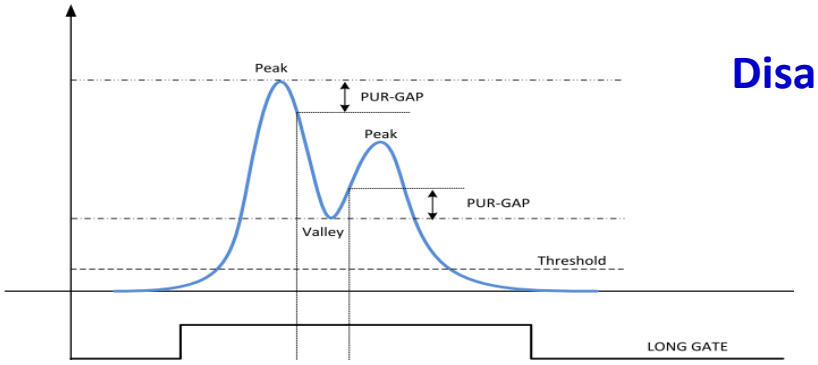
Figure 4: Block diagram of the SIRTI.

Pile-up rejector is incorporated in the amplifier to suppress the spectral distortion, which is caused by pulses piling up on each other at high counting rates

2. Some considerations about digital electronics for SIRTI

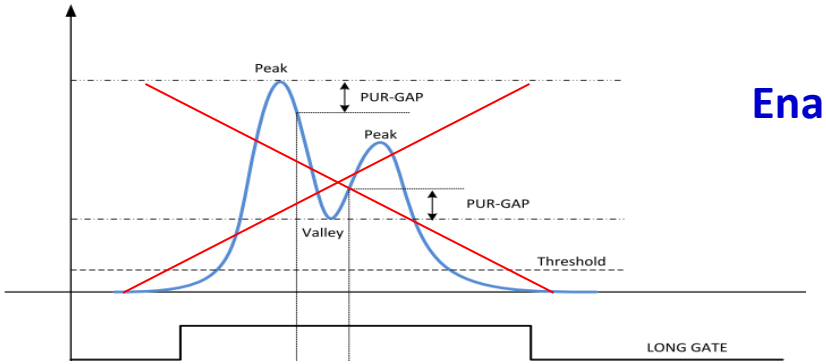
2.2 Pile-up management

- **CAEN digitizer: optional**



Disable ⇨ **Good for counting**

- Considered as a single “event”, and flags that event as “pile-up”
- The plie-up events can be rejected at software level



Enable ⇨ **Good for energy spectrum**

- The plie-up events are rejected at board level

720, 725, and 730 series with DPP-PSD firmware

2. Some considerations about digital electronics for SIRTI

2.2 Pile-up management

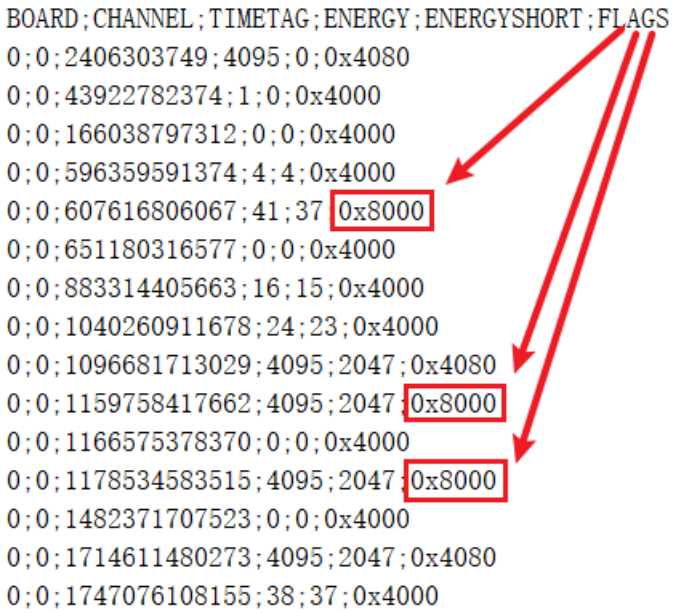
- **CAEN digitizer: optional**

➢ Possible solutions for both counting and energy spectrum

① Disable the pile-up rejection

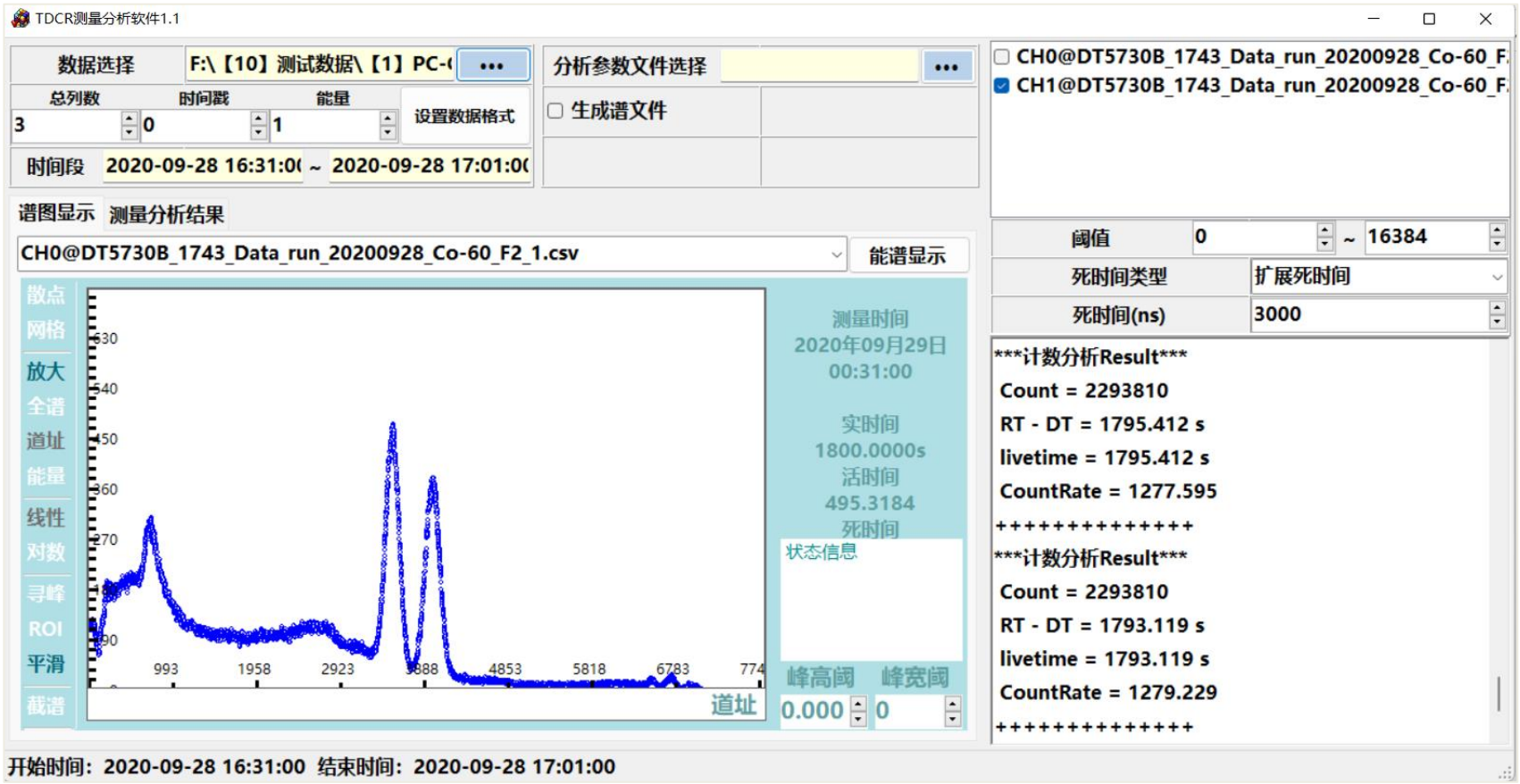
② Filter events at the software level for subsequent applications

- For counting: all events in the list-mode data file
- For energy spectrum: filter events without pile-up flags



2.3 Examples-count rate correction

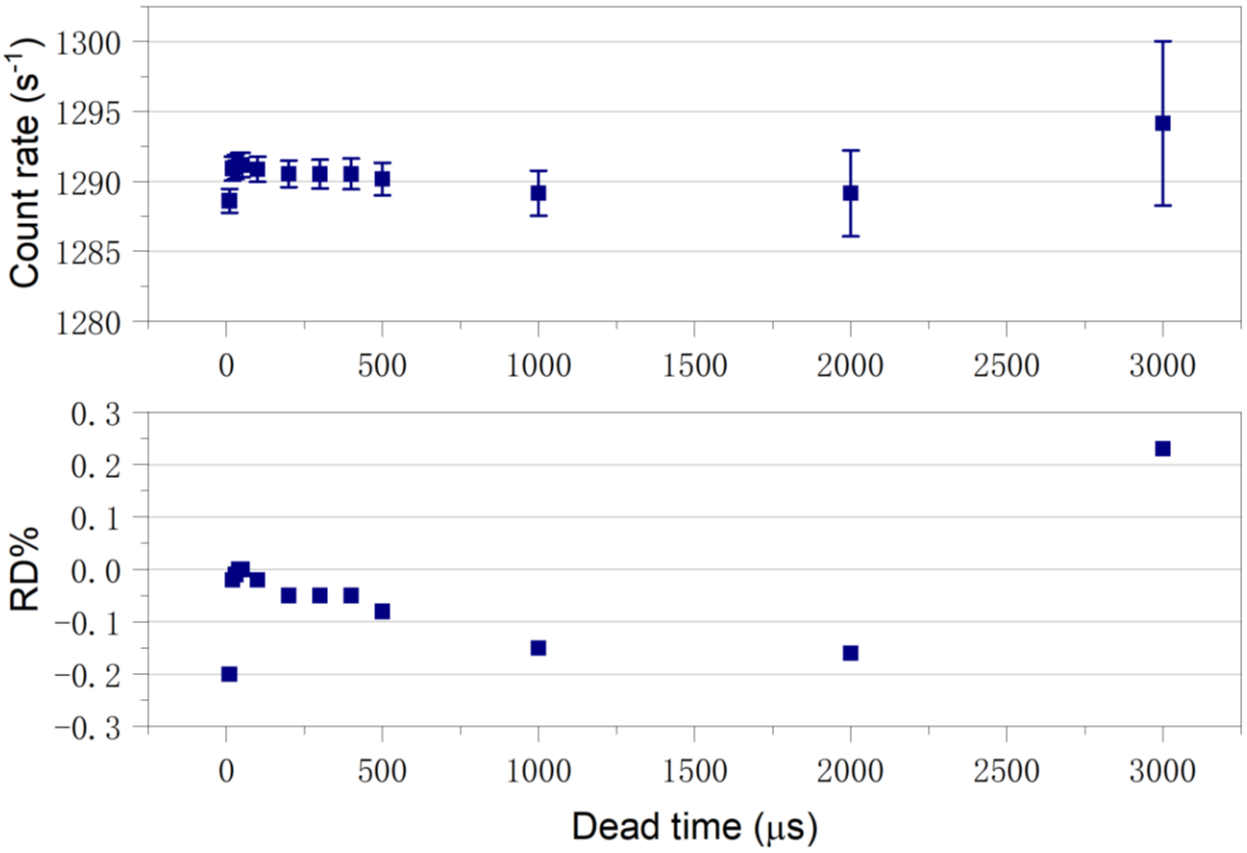
- **Co-60 measured by NaI(Tl)** **Digitizer + Dedicated software**



2.3 Examples-count rate correction

- **Co-60 measured by NaI(Tl)**

Digitizer + Dedicated software



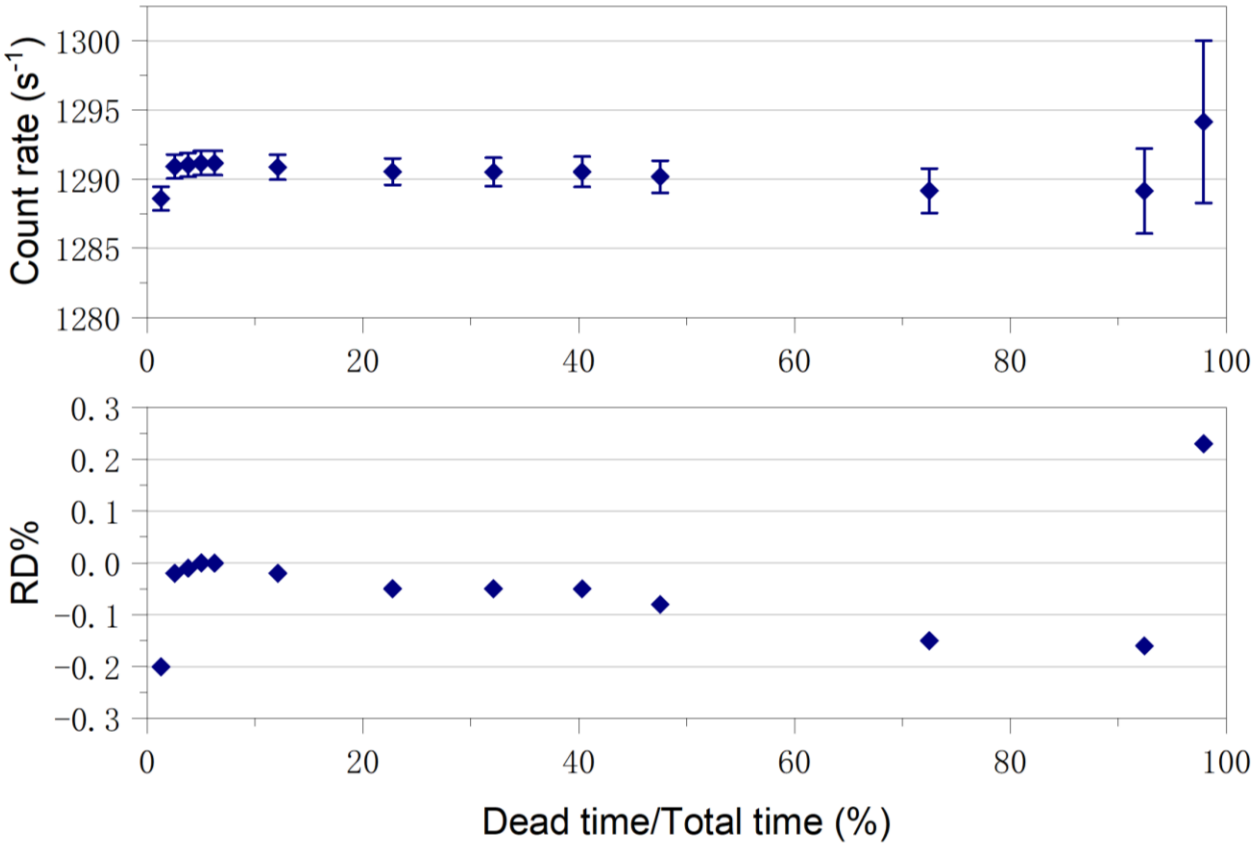
Extendable dead-time imposed by software

Dead time changed from 10 μs to 3000 μs

For the calculation of the relative deviation, the reference point is 50 μ s

2.3 Examples-count rate correction

- **Co-60 measured by NaI(Tl)** **Digitizer + Dedicated software**



Extendable dead-time imposed by software

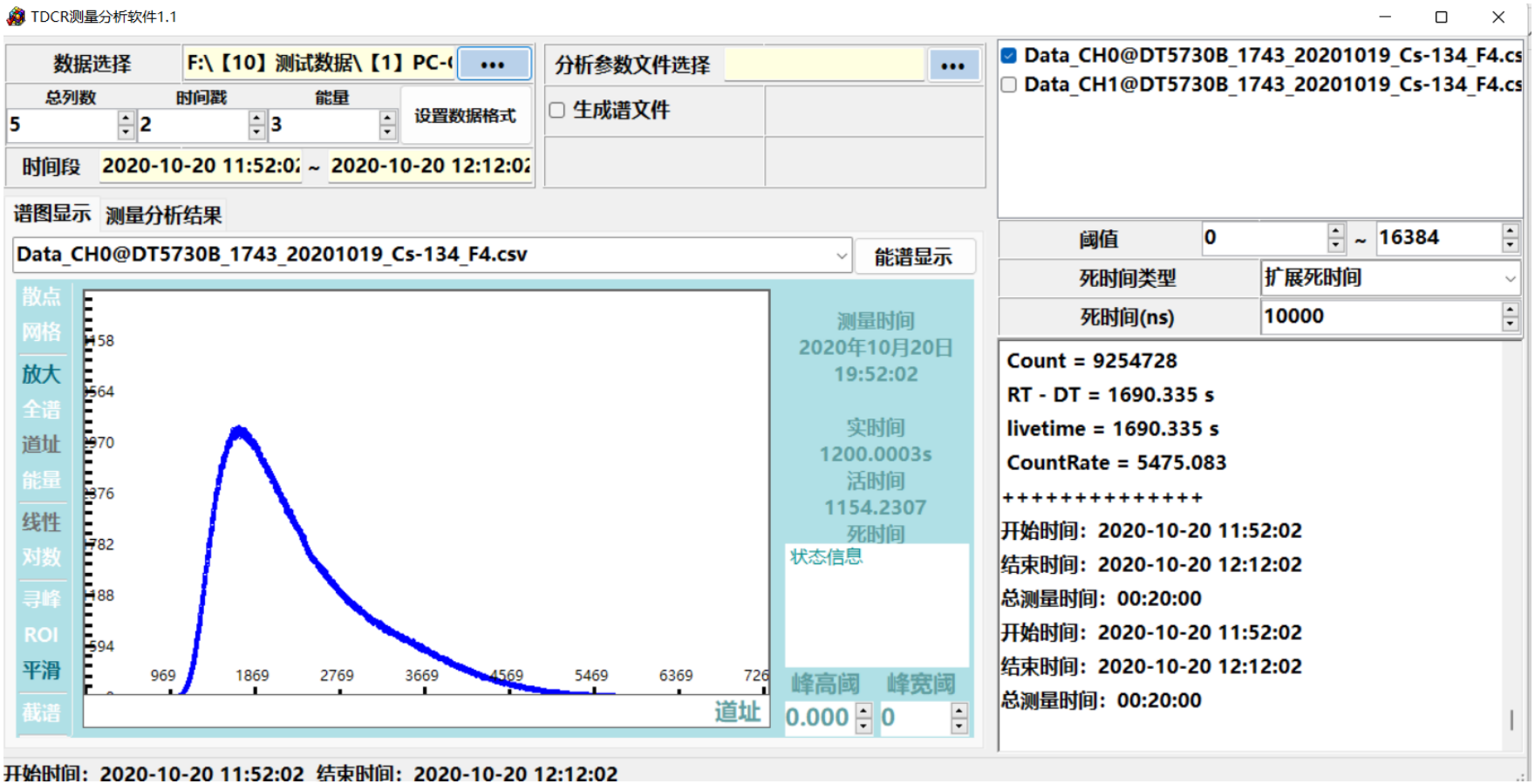
Dead time ratio changed from 0.6% to 98%

For the calculation of the relative deviation, the reference point is 50 μ s

2.3 Examples-count rate correction

- Cs-134 measured by Proportional counter

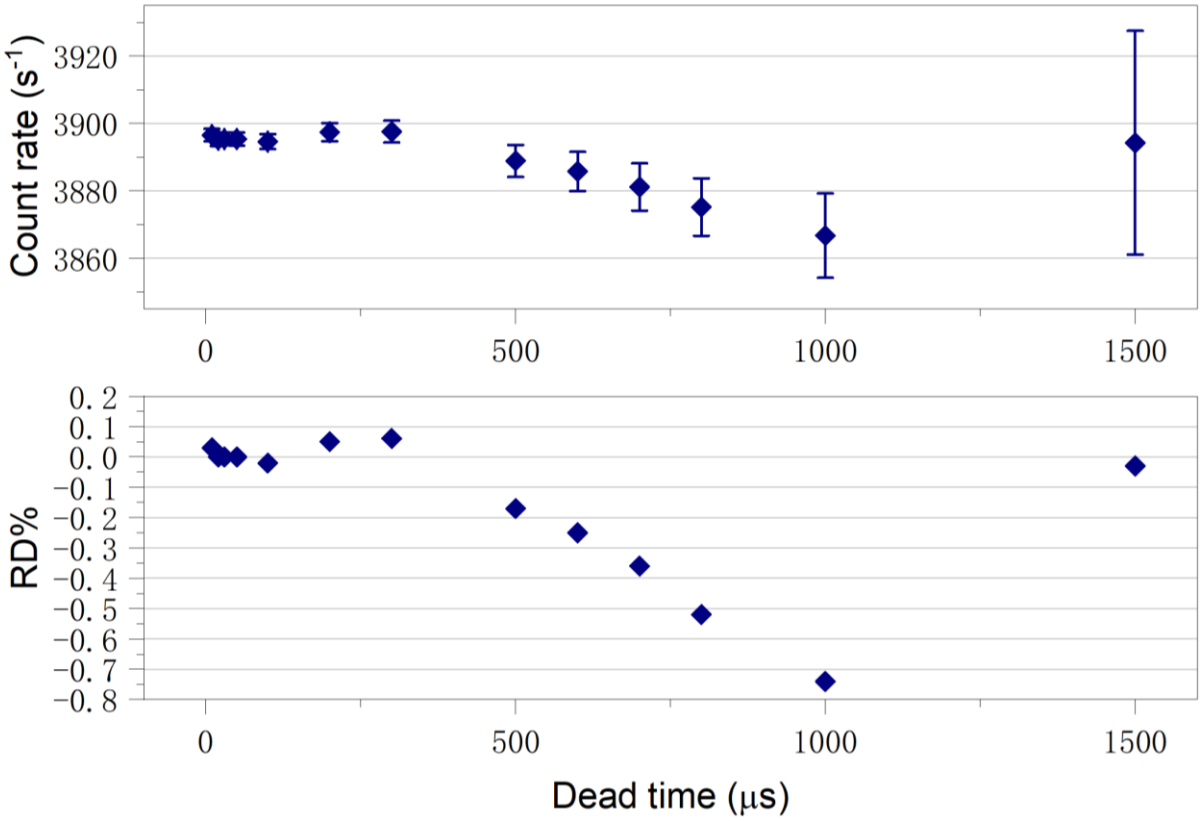
Digitizer + Dedicated software



2.3 Examples-count rate correction

- **Cs-134 measured by Proportional counter**

Digitizer + Dedicated software



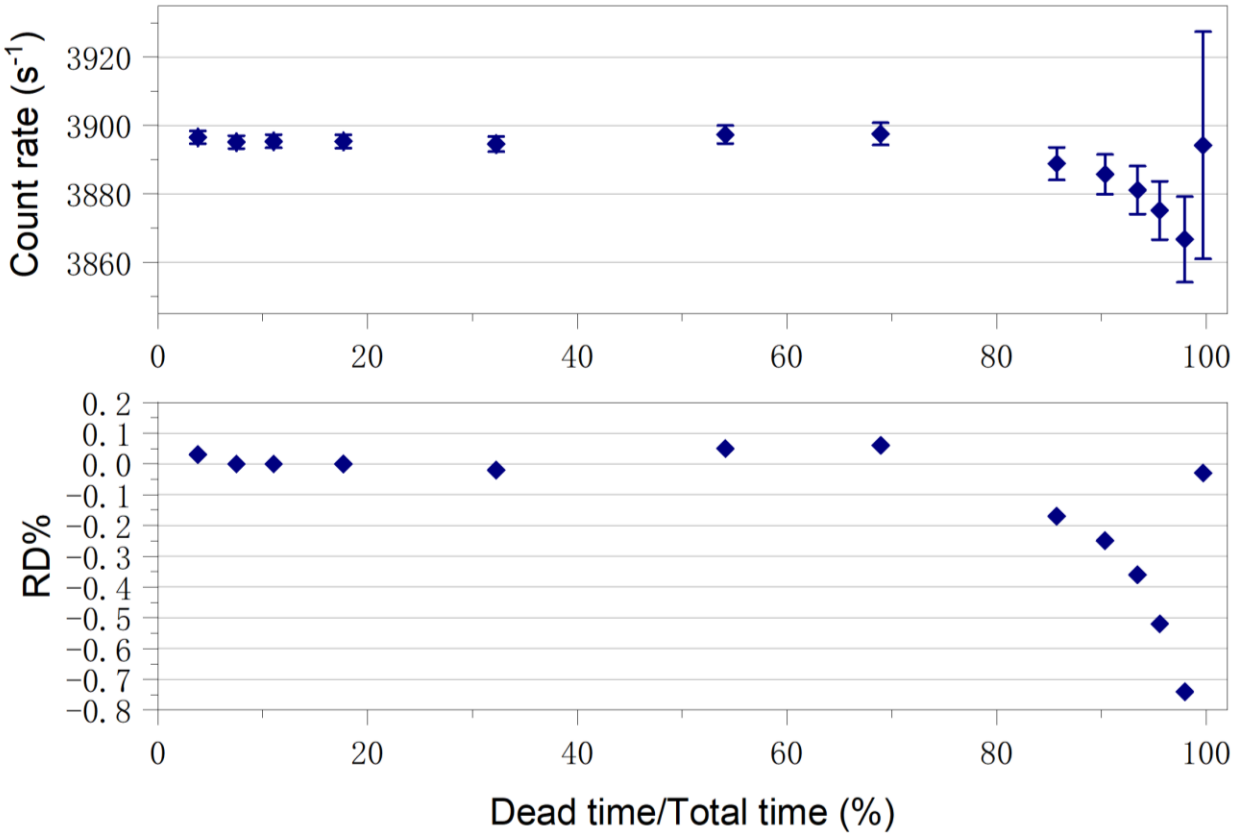
Extendable dead-time imposed by software

Dead time changed from 10 μs to 1500 μs

For the calculation of the relative deviation, the reference point is 50 μ s

2.3 Examples-count rate correction

- **Cs-134 measured by Proportional counter** **Digitizer + Dedicated software**



Extendable dead-time imposed by software

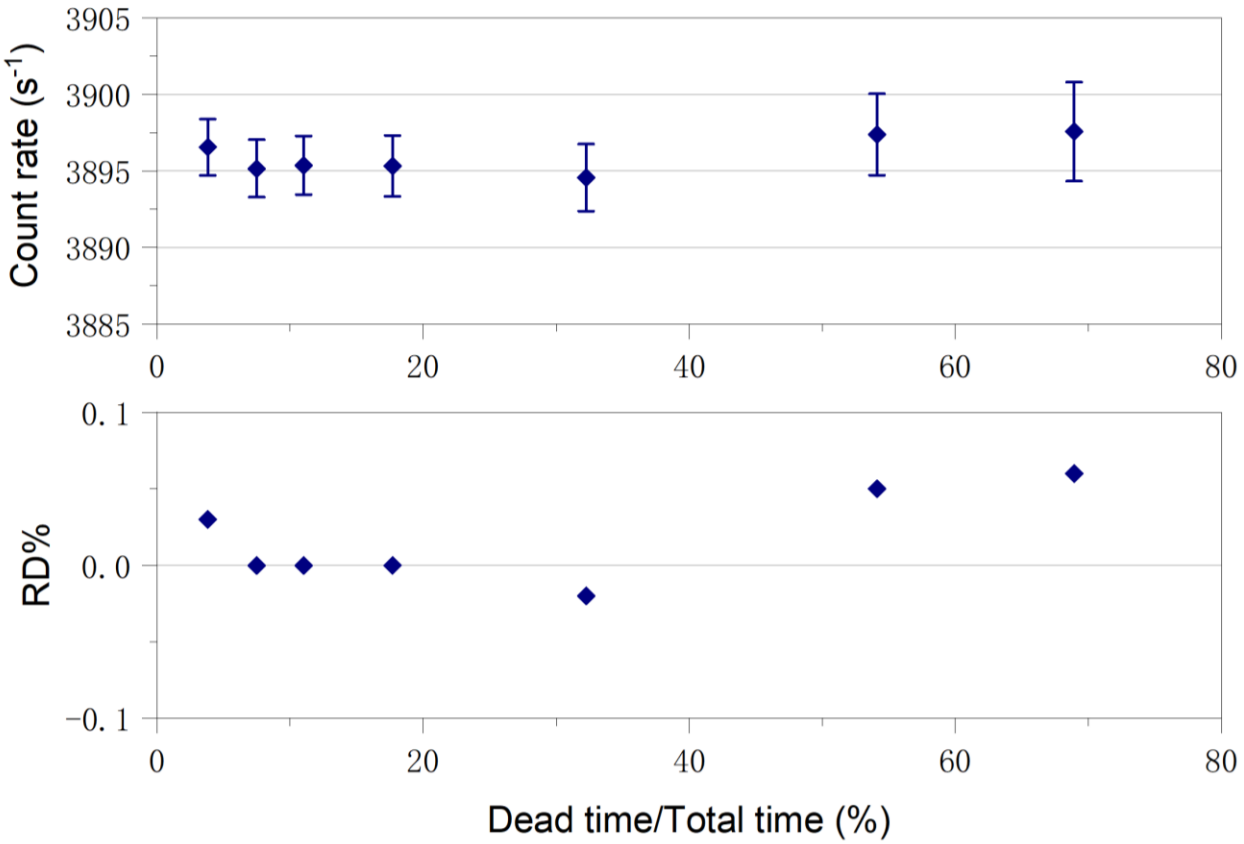
Dead time ratio changed from 3.8% to 99.7%

For the calculation of the relative deviation, the reference point is 50 μ s

2.3 Examples-count rate correction

- **Digitizer + Dedicated software**

Proportional counter for Cs-134



Extendable dead-time imposed by software

Dead time ratio changed from 3.8% to 80%

For the calculation of the relative deviation, the reference point is 50 μ s

2.3 Examples-count rate correction

- **Digitizer + Dedicated software**

  - The current tests are not sufficient, high count rate tests need to be carried out.

  - For example, measuring a strong ^{99m}Tc source and looking for deviations from the exponential decay law.

Thanks for your attention