Performance comparison of various electronics systems for fast-timing measurements using the KHALA LaBr3(Ce) detector array

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Motivation

- Fast-timing gamma-ray measurement
  - Measure time differences of gamma-rays
  - Aim to measure lifetimes of nuclear-excite states, down to few tens of picoseconds.
- LaBr3(Ce) scintillator
  - High light yield of 63 photons/keV, fast decay time of 16 ns
  - Best detector material for fast-timing measurement so far.
  - Arrays of LaBr3(Ce) are developed: KHALA, FATIMA, …

Motivation

KHALA
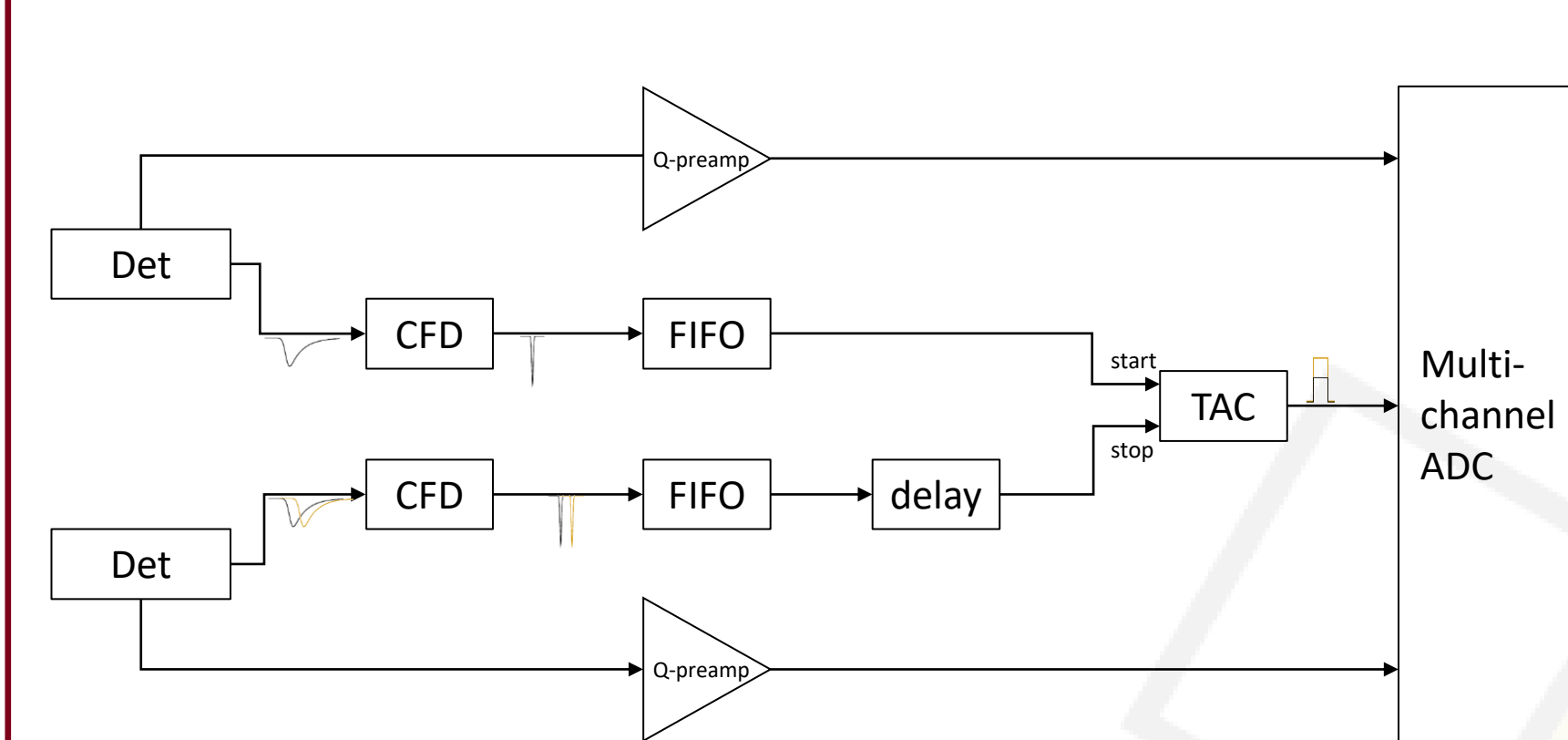36 ea. $\phi 1.5" \times 1.5"$ LaBr3(Ce)
developed by CENuM
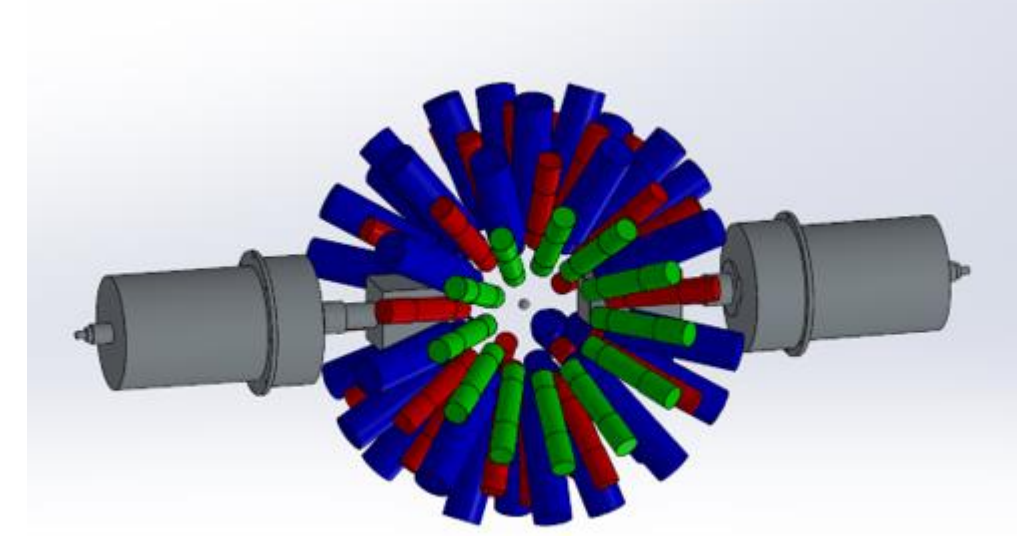
IDATEN
KHALA+FATIMA project
Total 84 ea. LaBr3(Ce) detectors
$26\% \times 4\pi$

- For detail, see presentation of B. Moon on Friday

What electronics system shall be suitable KHALA and IDATEN?

CFD+TAC

- Measure Signal amplitude.
- Charges are measured by charge-sensitive preamplifier.
- Times are discriminated by CFD
- Time differences of two hits are recorded.
- Gate window is decided by final MCA.
- FIFOs, delays are needed to make array.
- Tested with Ortec Quad CFD 935, Ortec TAC 566

FADC+dCFD
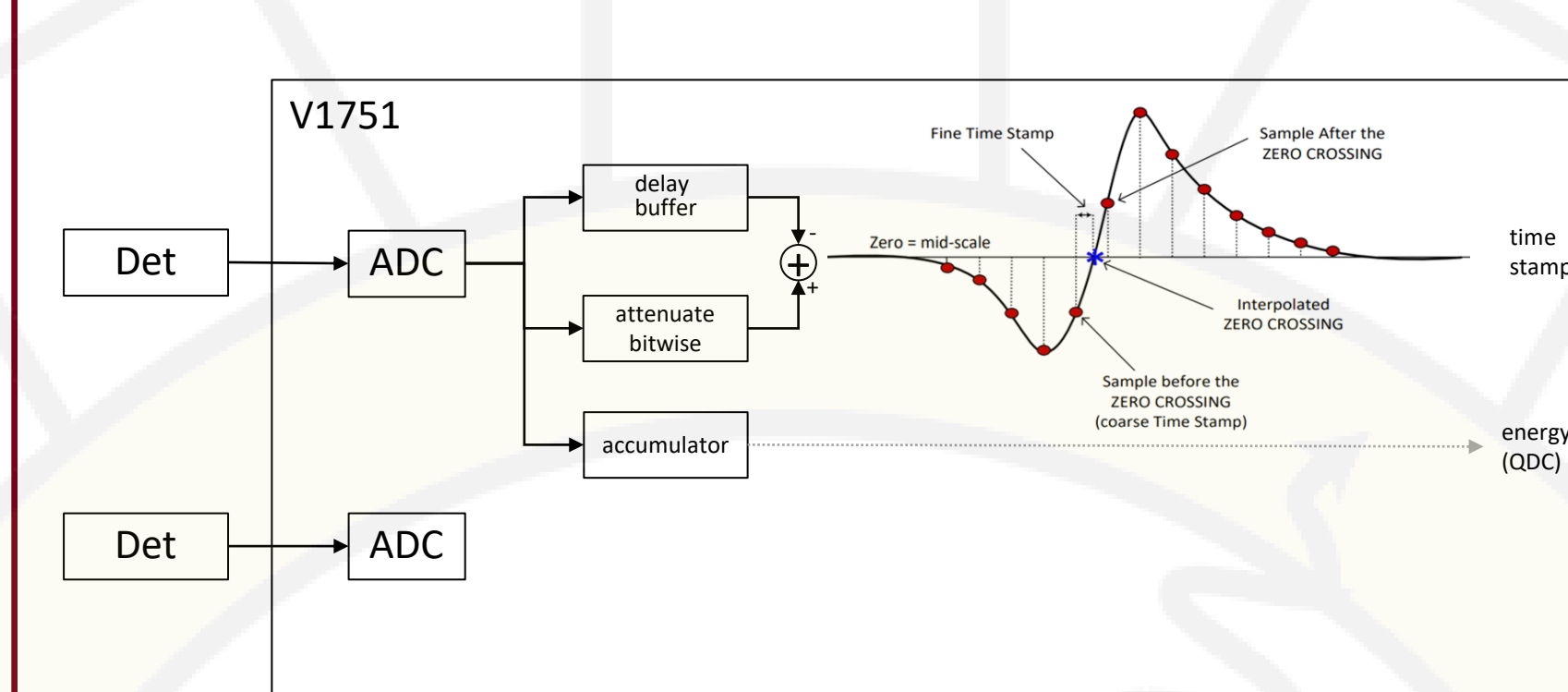
- sample waveform at high rate (1GSa/s)
- Charge measured by digital accumulator.
- Time discriminated by digital CFD.
- Coarse Timestamp (time of sample before zero-crossing) and fine timestamp (interpolation) are recorded.
- Gate window is decided by external veto/gate generator (typ ~10 µs)
- Easy to make array, but expensive
- Tested with CAEN V1751 (1GSa/s, 1Vpp 10bit)

TWINPEAKS+TAMEX
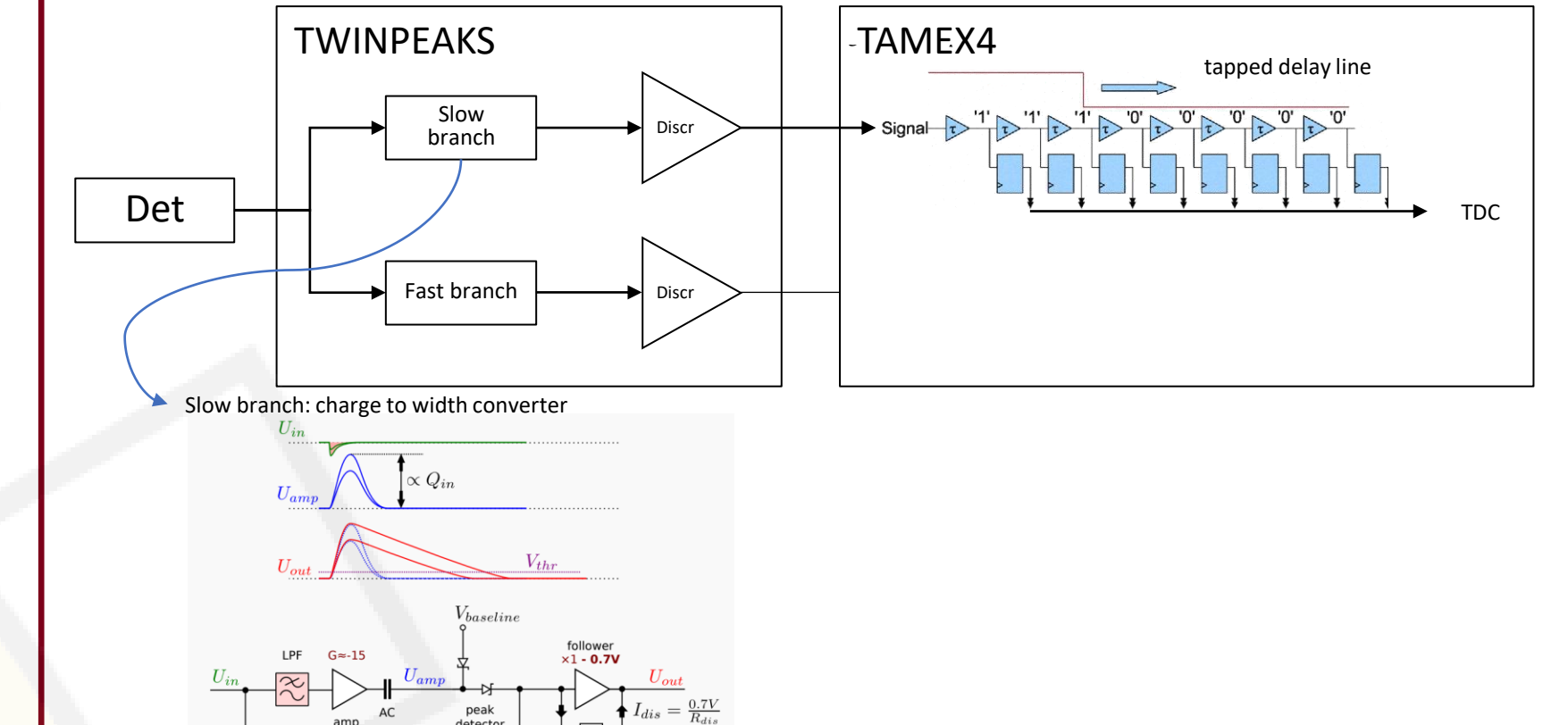
- Developed by GSI EEL.
- Measure TDC of threshold-crossing
- Charge measured by Time-over-threshold of linearly discharging capacitor
- Time discriminated by LED (Leading Edge Discriminator)
- Run-time counter (5 ns) and fine TDC(10 ps) by delay line recorded
- On-board gate configurable: ~100 µs
- Easy to make array.

Energy Resolutions
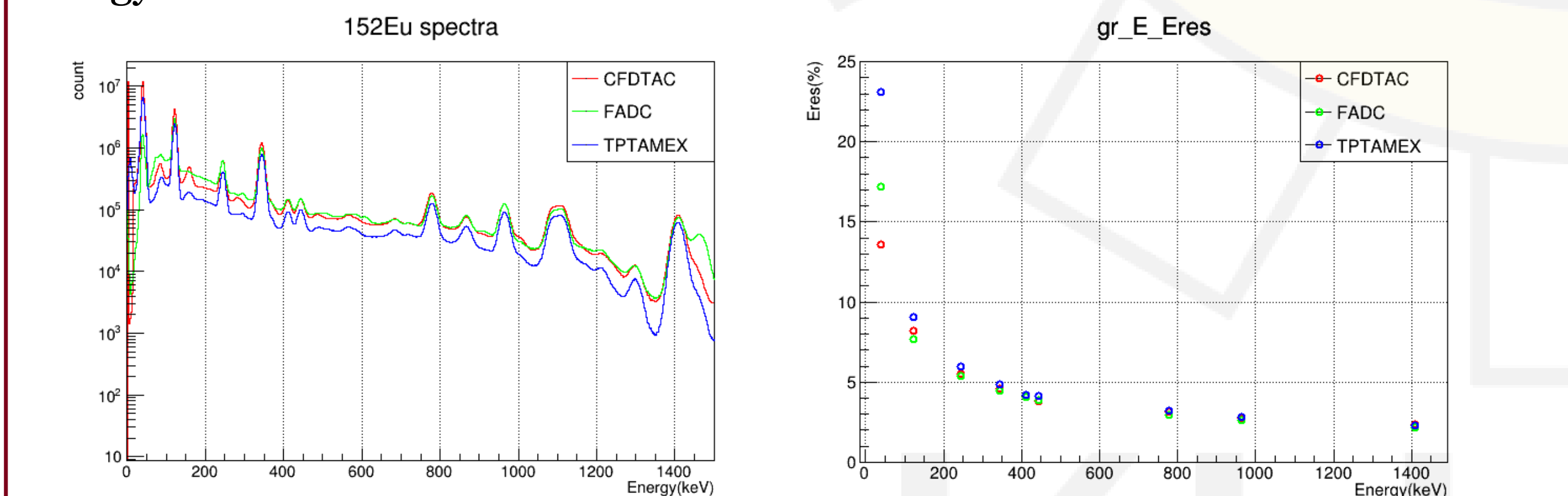
- Comparable energy resolution for all system at E > 200 keV
- CFDTAC presents best energy resolution at E < 200 keV

Time Resolutions
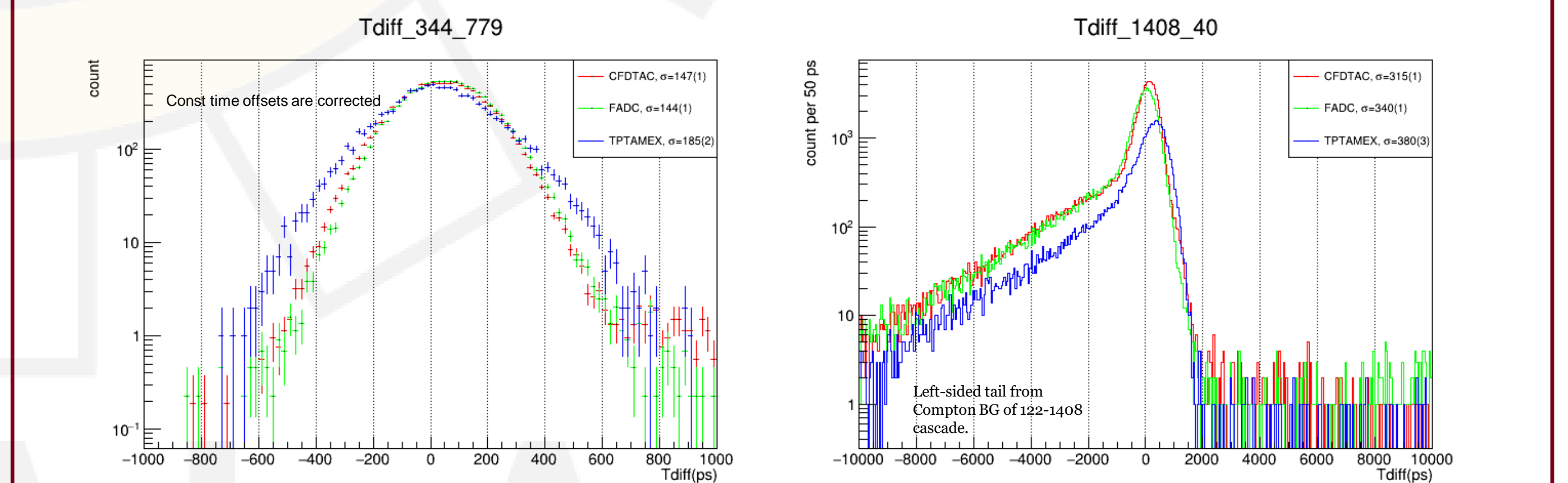
- Similar time resolution for CFDTAC and FADC.
- TPTAMEX system presented slightly worse but comparable time resolution

Time Correction: PRD (Prompt Response Difference)

J.-M. Régis et al. / Nuclear Instruments and Methods in Physics Research A 684 (2012) 36–45
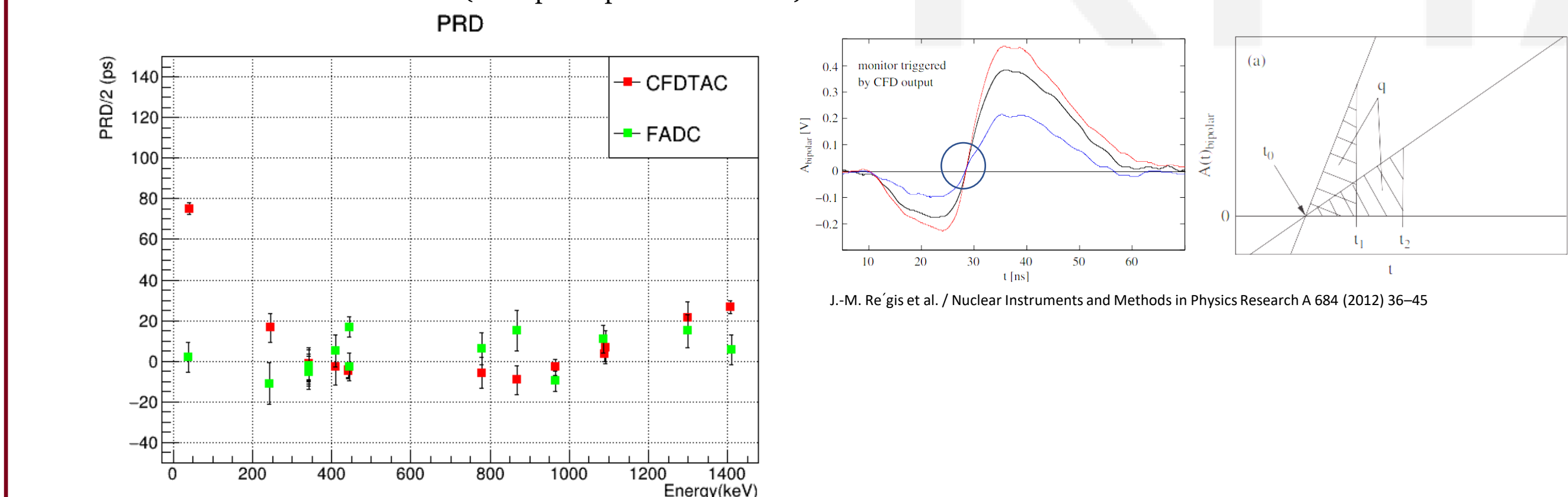
- Analogue CFD shows larger bias processing small signal.
- Digital CFD algorithm presents almost no bias.

Time Correction: Leading edge time-walk correction
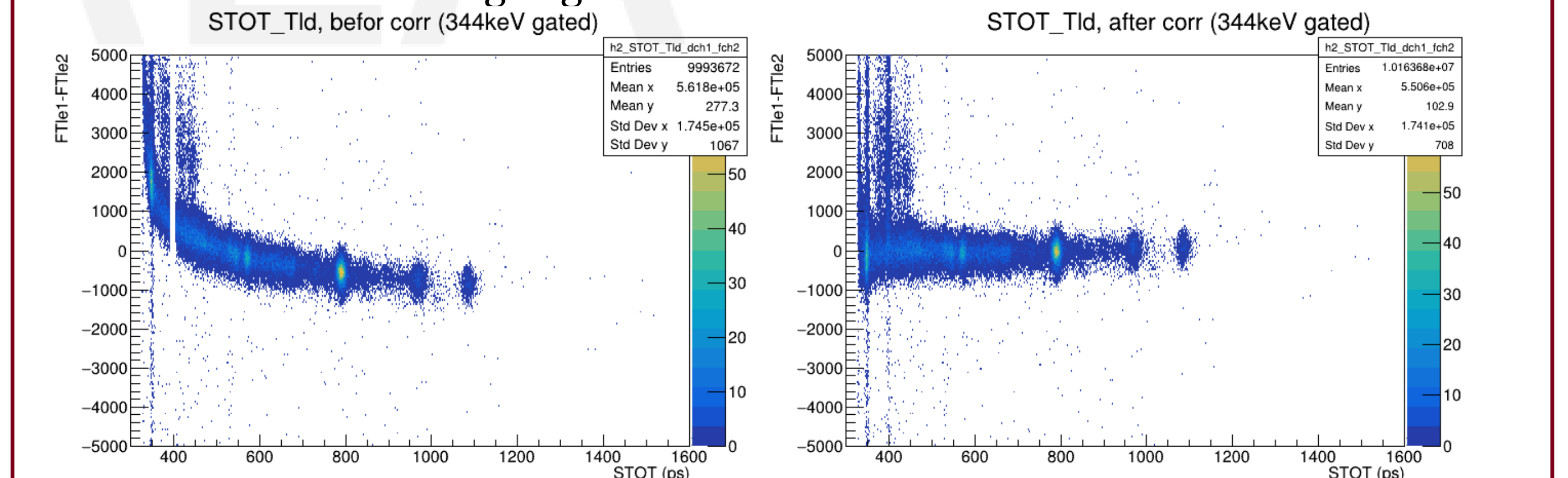
- Large time-walk effect due to adopting leading edge discrimination.
- Fine correction still needed after coarse LED time-walk correction.

Jittering among boards

- N/A for TAC
- Jittering of $\sigma \sim 10$ ps between two V1751 boards for a pulse source.
- No jittering ($\Delta t < 10$ ps, intrinsic time resolution of TAMEX4) reported with TP+TAMEX by GSI group

Summary

- Analog system performs best but is difficult to make large array.
- FADC provides similar performance as CFD-TAC but currently too expensive to make large array.
- TP+TAMEX system presents comparable performance with reasonable prices.
- Further study for optimization will be made after delivery of TP+TAMEX for KHALA.

Acknowledgement