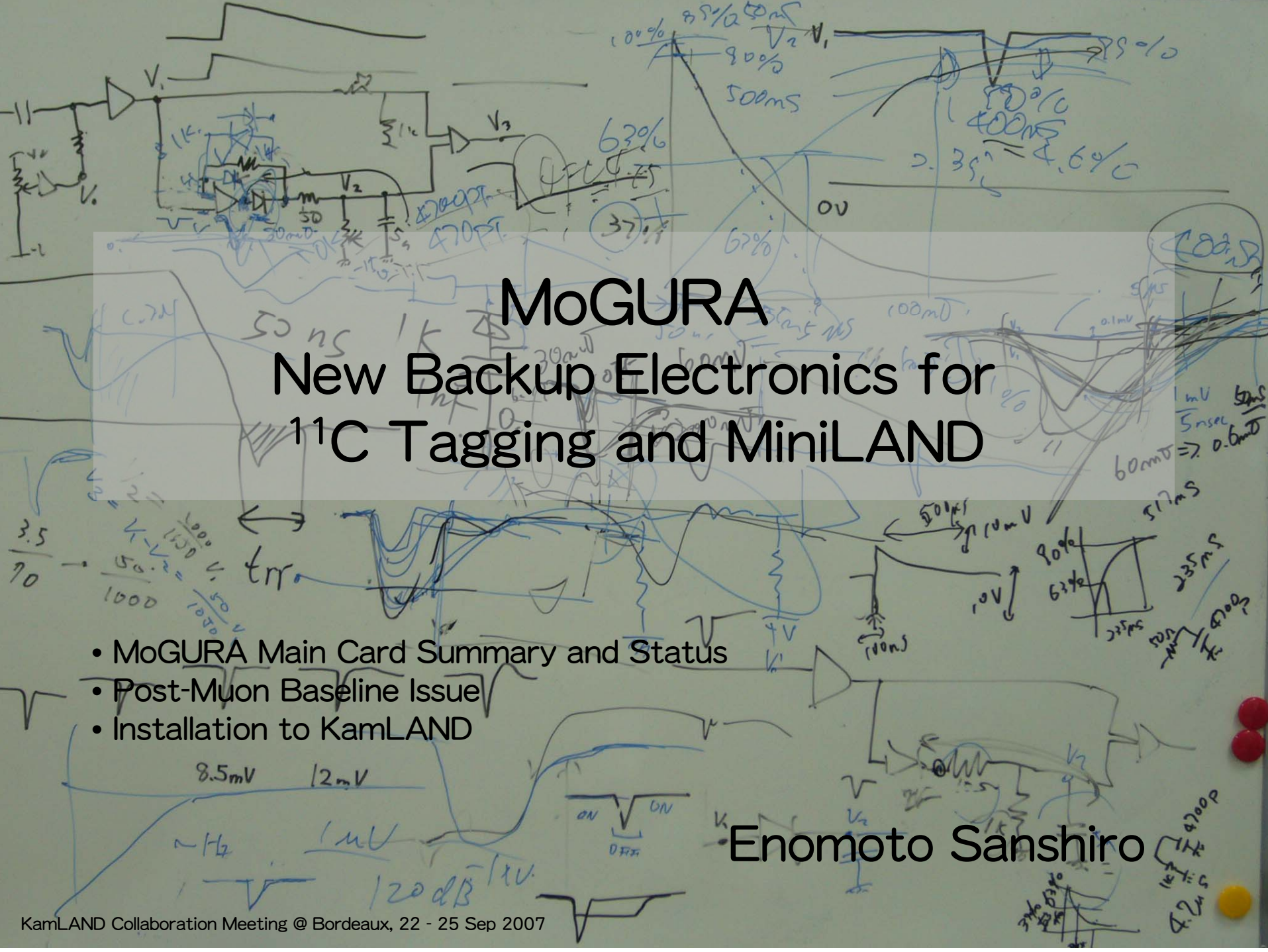


MoGURA
New Backup Electronics for ^{11}C Tagging and MiniLAND

- MoGURA Main Card Summary and Status
- Post-Muon Baseline Issue
- Installation to KamLAND

Enomoto Sanshiro

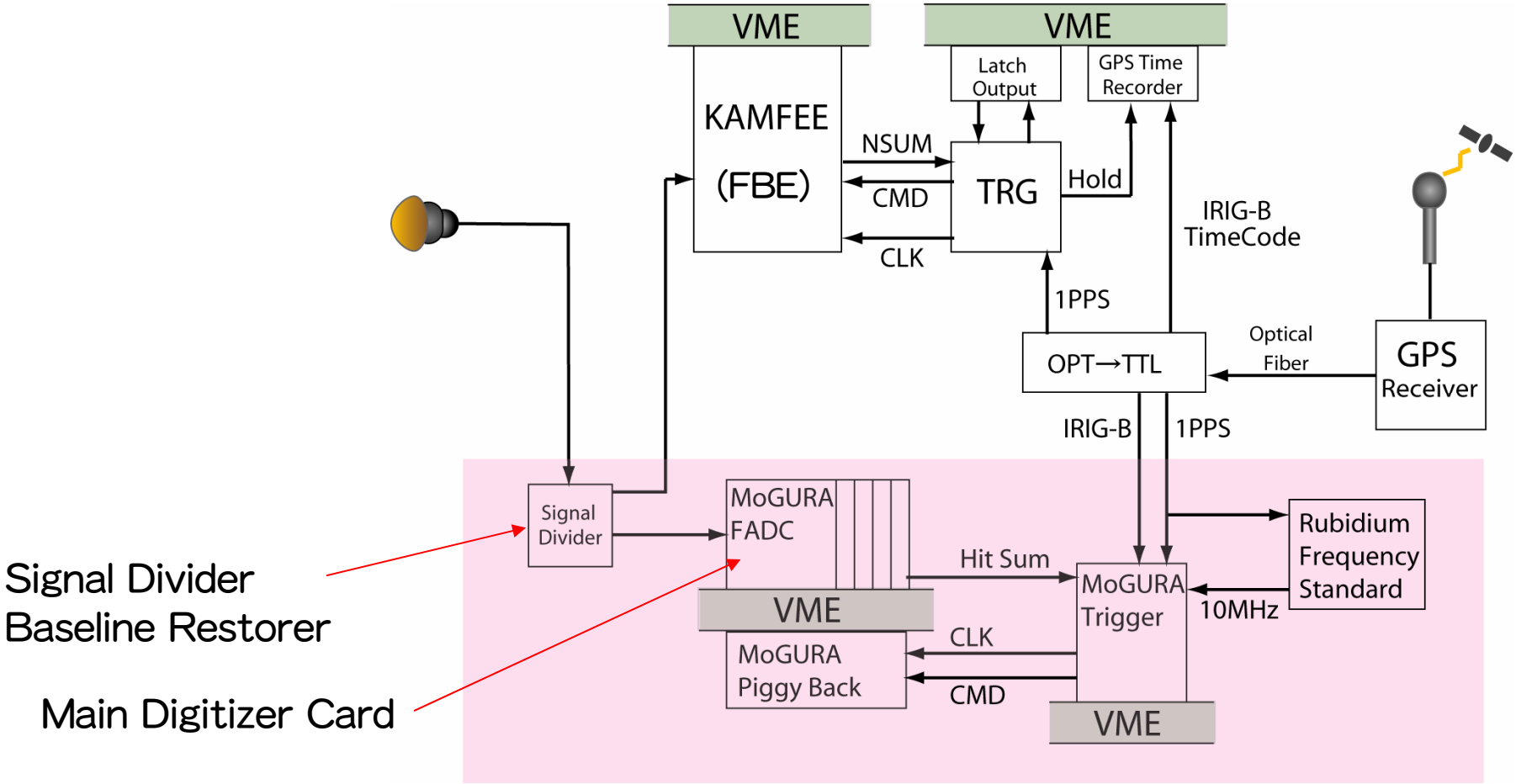
Requirements Summary

- KamLAND Application (^{11}C tagging)
  - ~60 neutrons within 1 msec following muon
  - Baseline Stabilization after muons
  - Decay electron recording (wide dynamic range)

- MiniLAND Application
  - No deadtime for Bi-Po cascade
  - ~300 psec timing resolution (for vertex reconstruction)
  - PSD capability

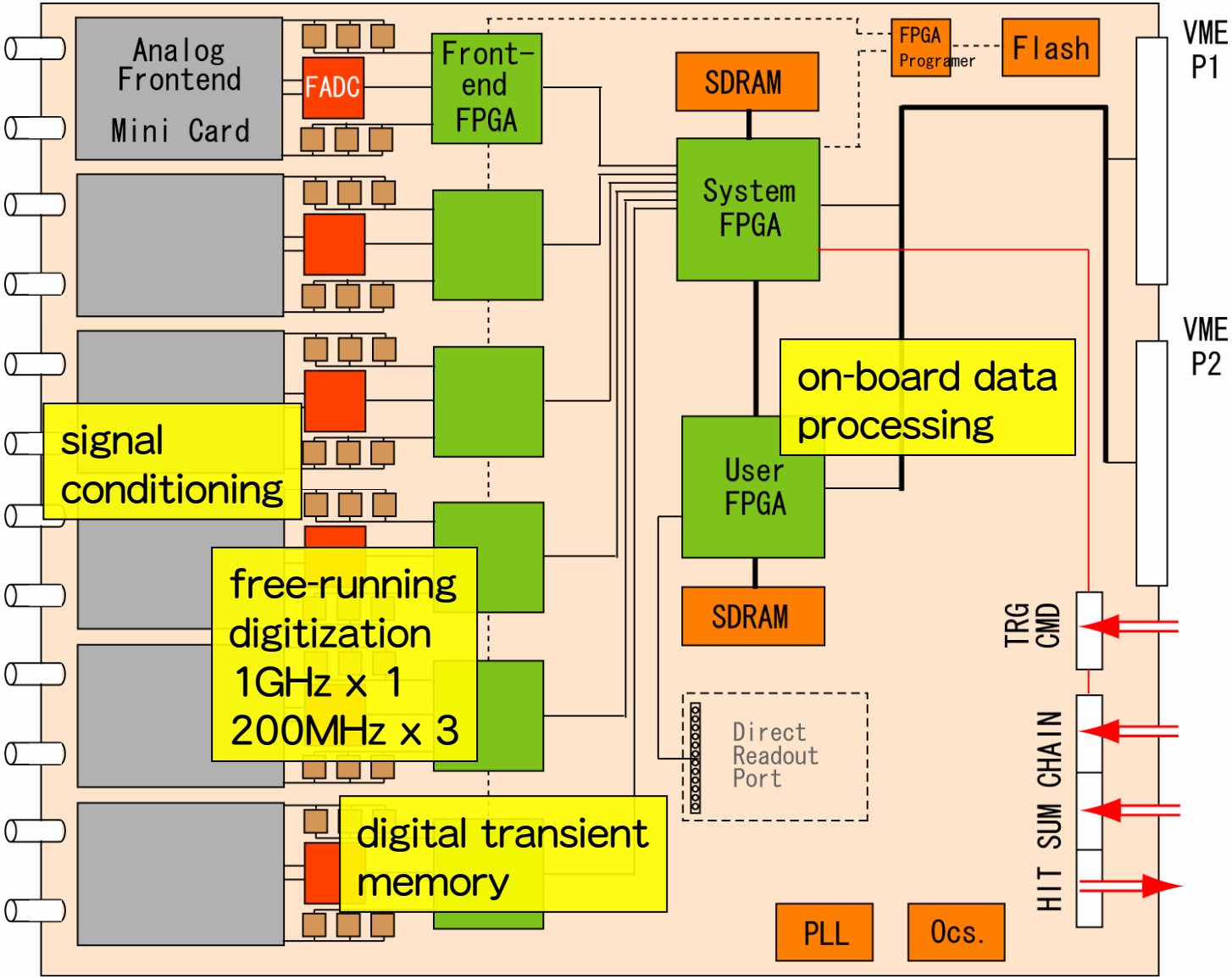
Absolutely Zero-Deadtime Electronics
w/ precise time resolution
w/ wide dynamic range

MoGURA for KamLAND

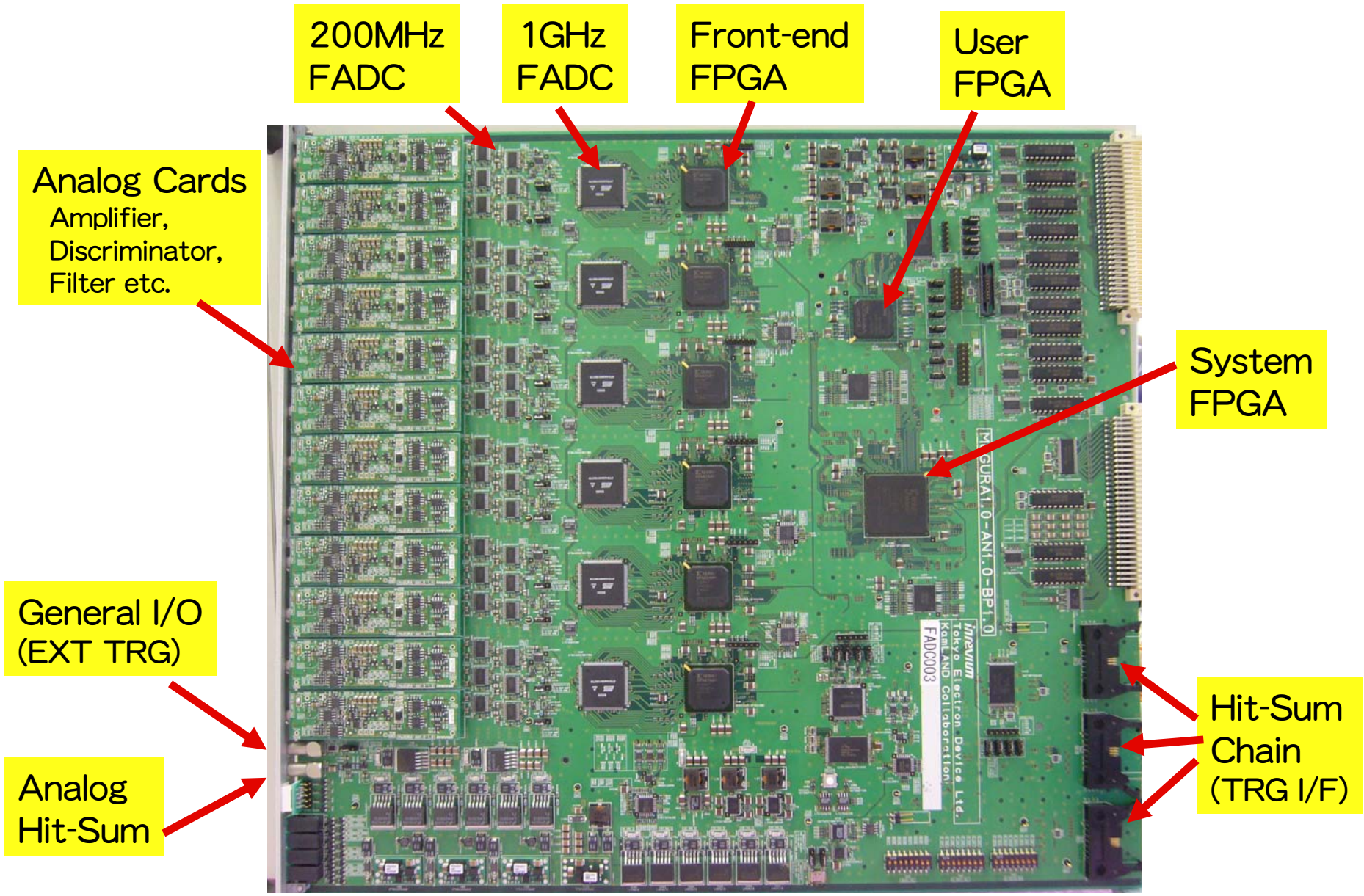


- PMT signals are “sneaked” from the main signal line (high-Z probing)
- Copied PMT signals are preprocessed with “baseline restorer”
- System clock is synchronized with the GPS time

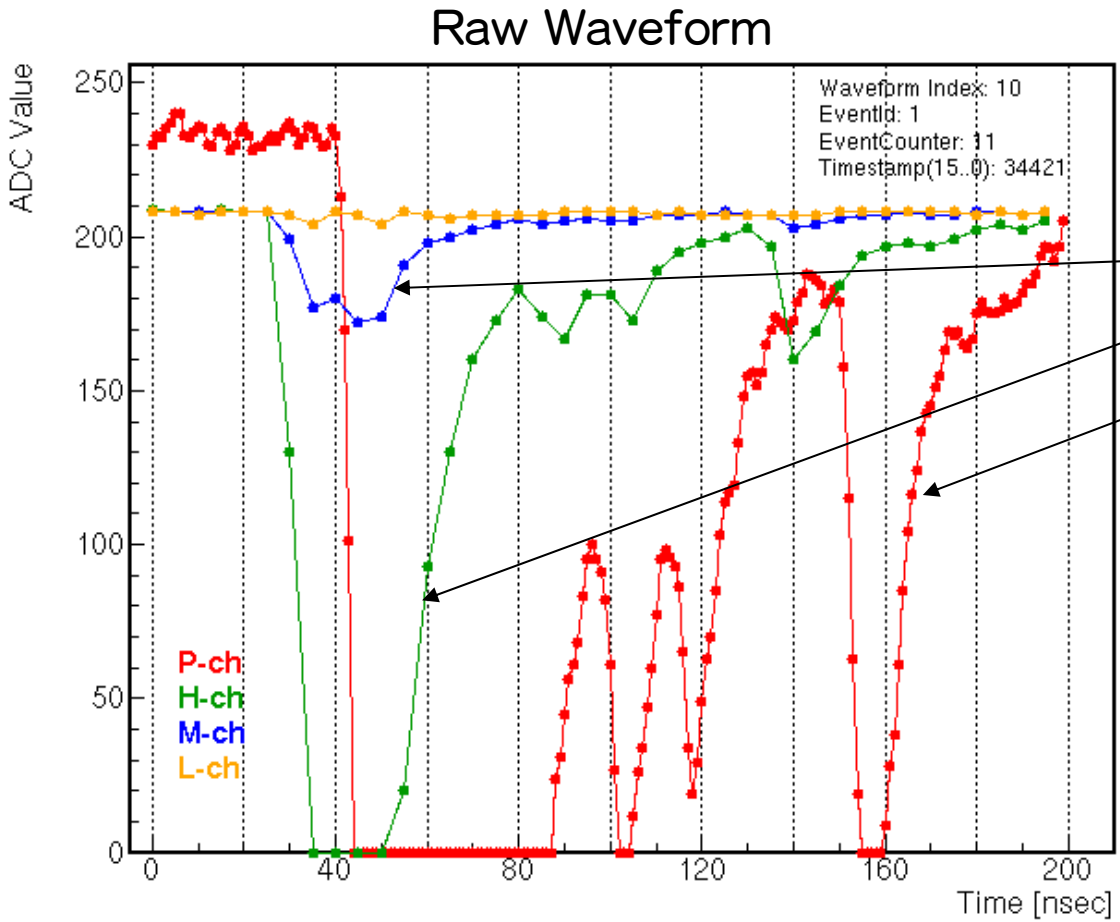
Main Digitizer Card (MoGURA FADC)



Prototype Card (Mini-MoGURA)



Mini-MoGURA Signal (MiniLAND with ^{60}Co)



L-Gain Channel (50mV/step)

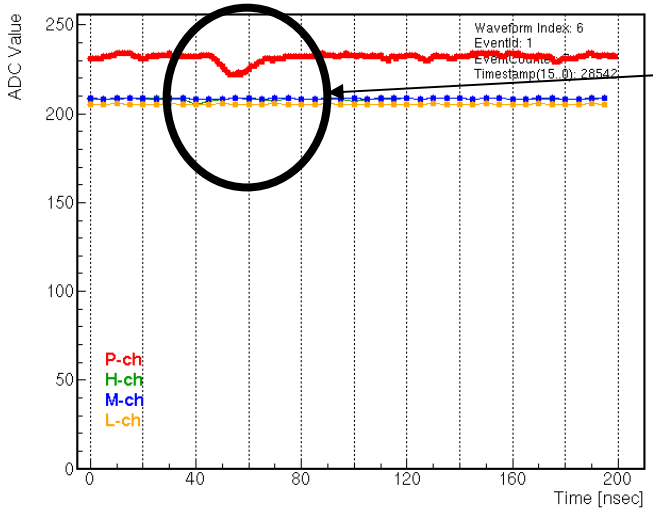
M-Gain Channel (5mV/step)

H-Gain Channel (0.5mV/step)

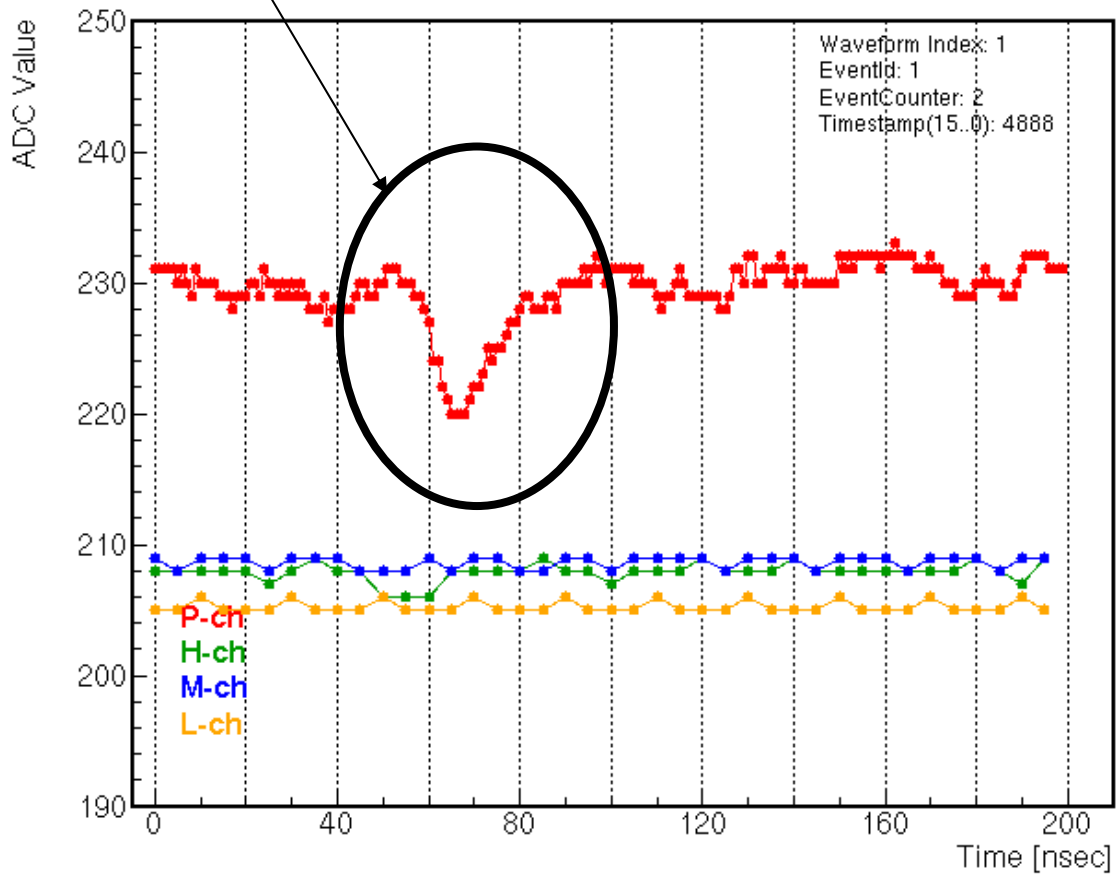
1GHz Channel (0.1mV/step)

Calculated Charge
(MiniLAND 1 cell)

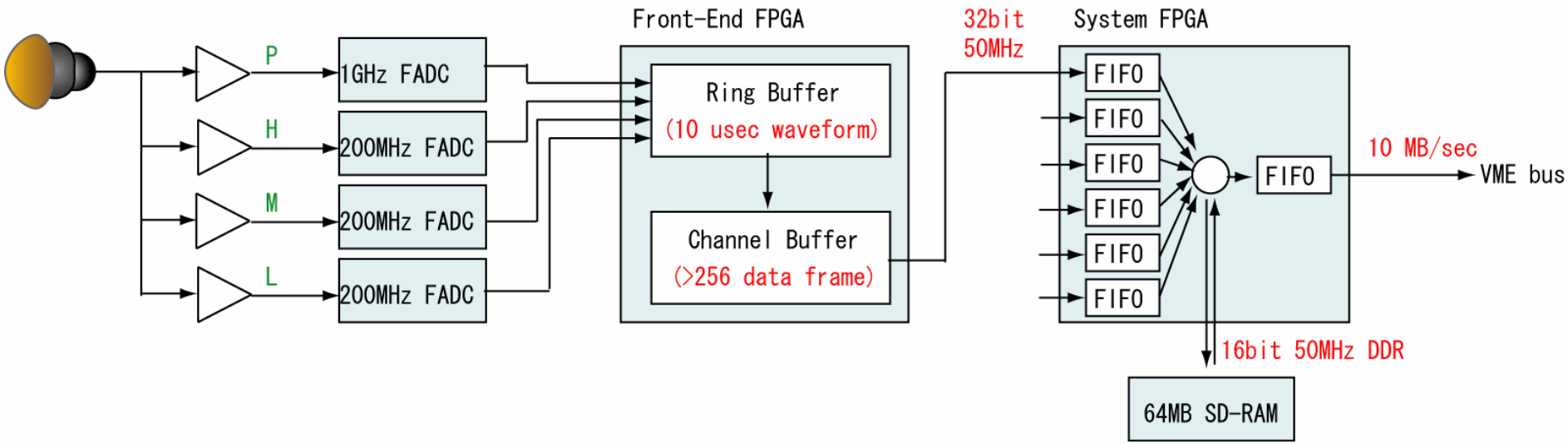
Sensitivity to 1 p.e. Signals



Dummy 1 p.e. Signal (~2mV)



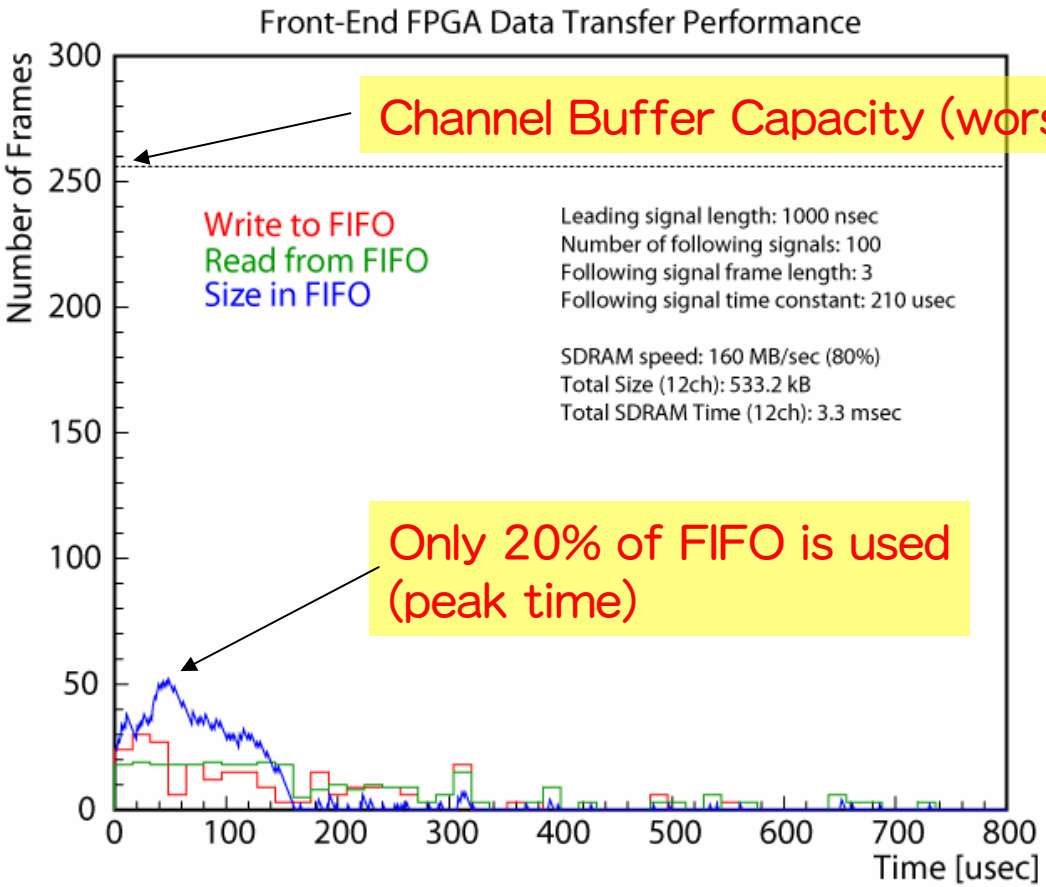
Capability for Intensive Signals



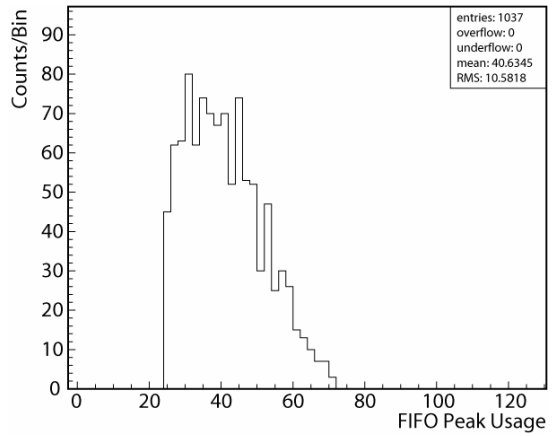
- Ring Buffer holds all waveform digitized by FADC for up to 10 μsec
- Triggered data is transferred to Channel Buffer (after zero-suppression)
- Channel Buffer can hold more than 256 data frames (40nsec/frame)
- Data in channel buffer is transferred to SDRAM via exclusive 32bit data line
- Channel Buffer to SDRAM is the bottleneck
- Roll-back up to ~10 μsec is acceptable (useful for ^{85}Kr β-γ coincidence?)

Capability for Intensive Signals

MC analysis for intensive signals (muon + turmoil + neutrons)
→ records all waveform for first 1000 nsec (muon and following turmoil)
→ records 100 successive small signals (neutrons)



Channel Buffer Peak Usage for 1000 MC events



P(overflow) << 0.001%

Main Card Development Status

- Analog mini-card has been re-designed
  - Lower noise level, better frequency characteristics
  - No overshoot etc. after huge signal inputs
  - Temporal stability improved

  ⇒ see Yonezawa's talk

- Main cards works well as designed
  - FPGA functions implemented and tested
    - Zero suppression, baseline scanning, etc.
  - Performance is good enough for intensive signals

  ⇒ see Takemoto's talk

Baseline Fluctuation

17-inch PMT Base Circuit

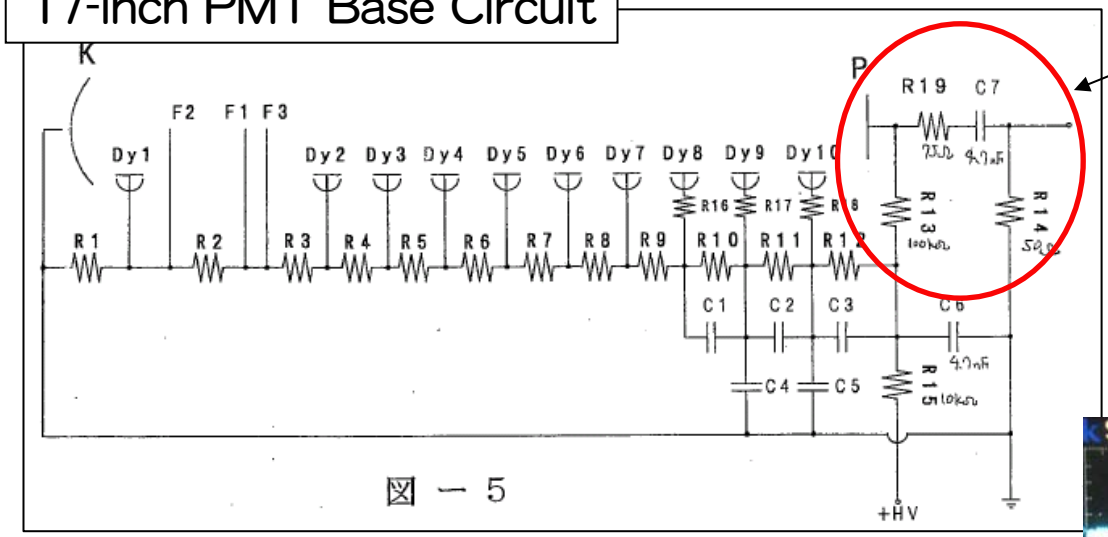
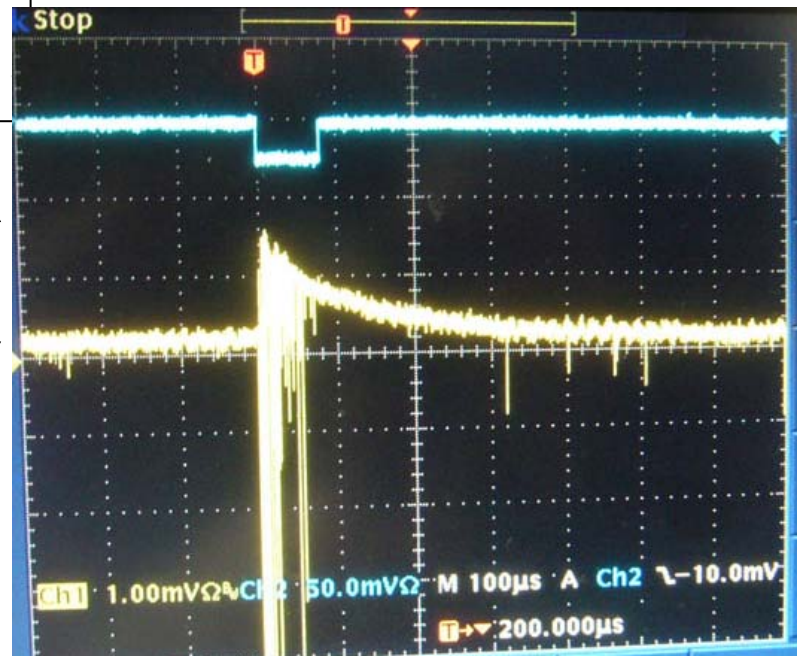


図 — 5

AC Coupling with τ ~0.5 ms

PMT Output after Muon
(-12 dB attenuated)



8 mV

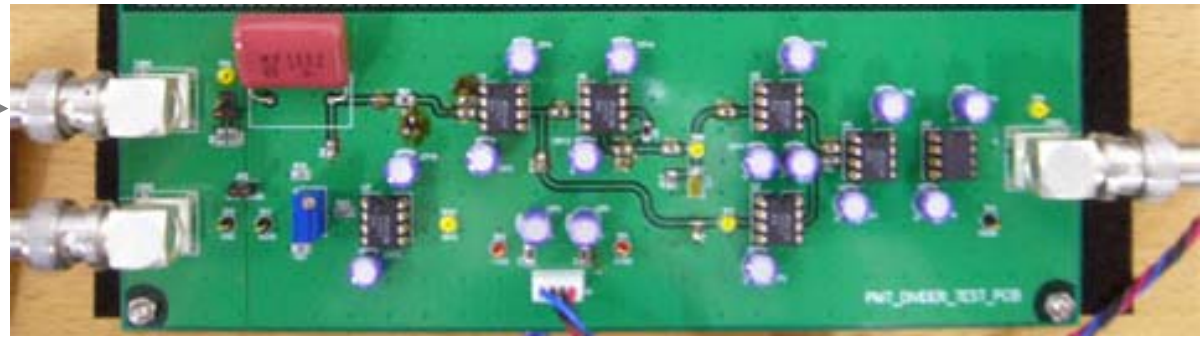
500 μsec

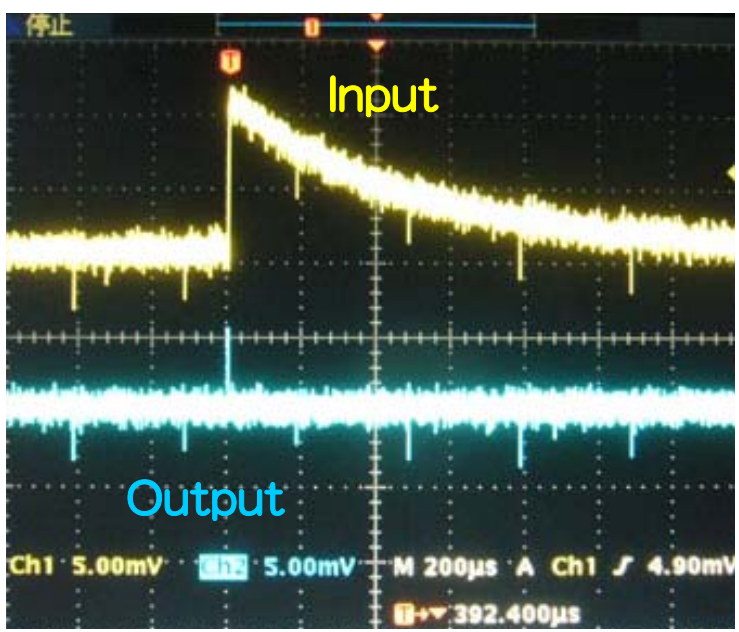
- AC coupling inside PMT makes ~10 mV overshoot after muons for ~ 500 μsec
- Neutron events are ~1mV within 200 μsec
- FADC range is -5mV to 20mV

Overshoot needs to be removed without affecting tiny signal shape

MoGURA Baseline Restorer

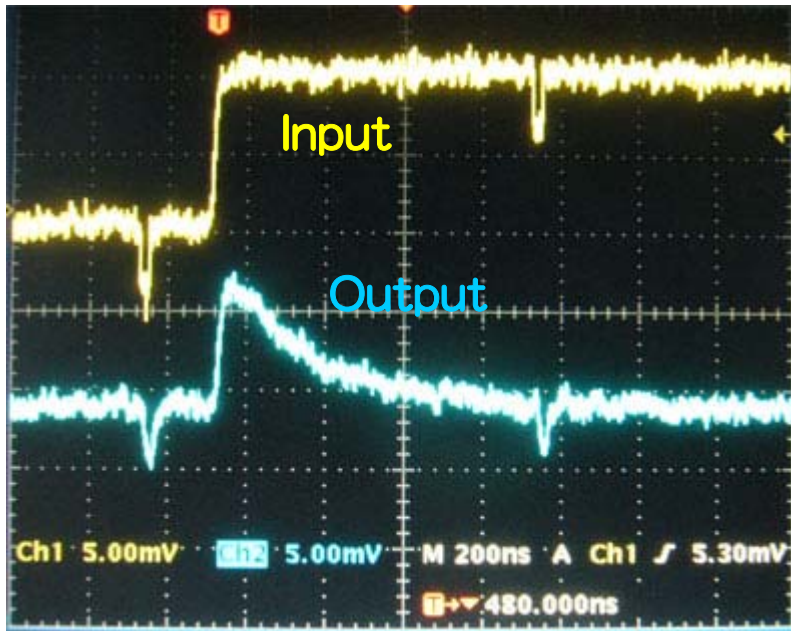
Prototype Card tested on 20th Sep 2007 (with dummy signals)





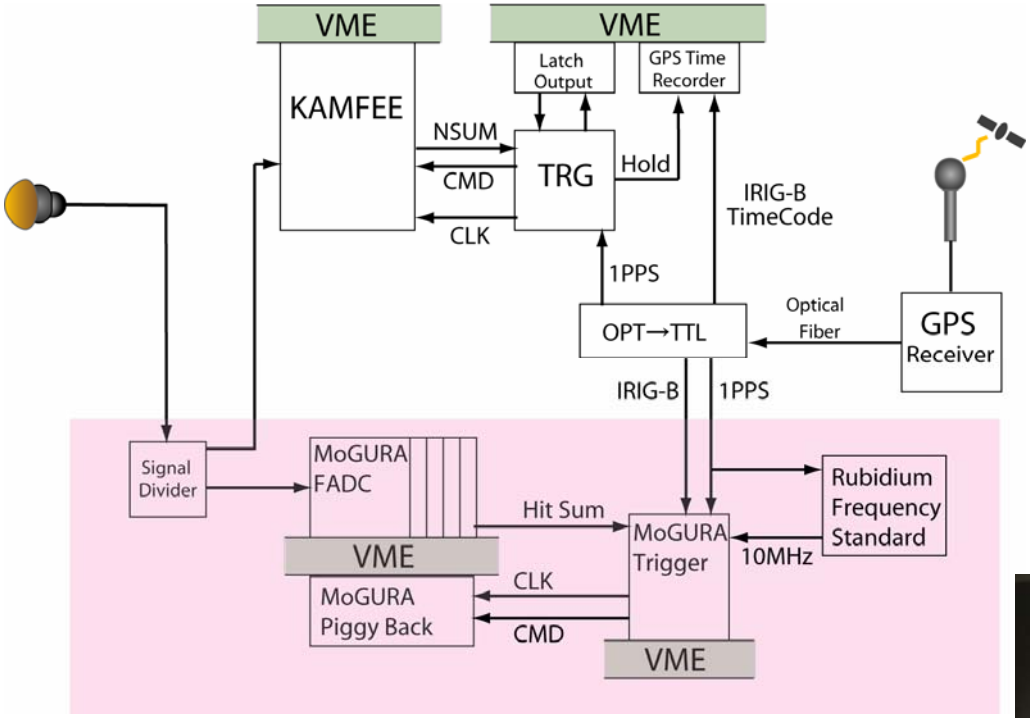
10 mV

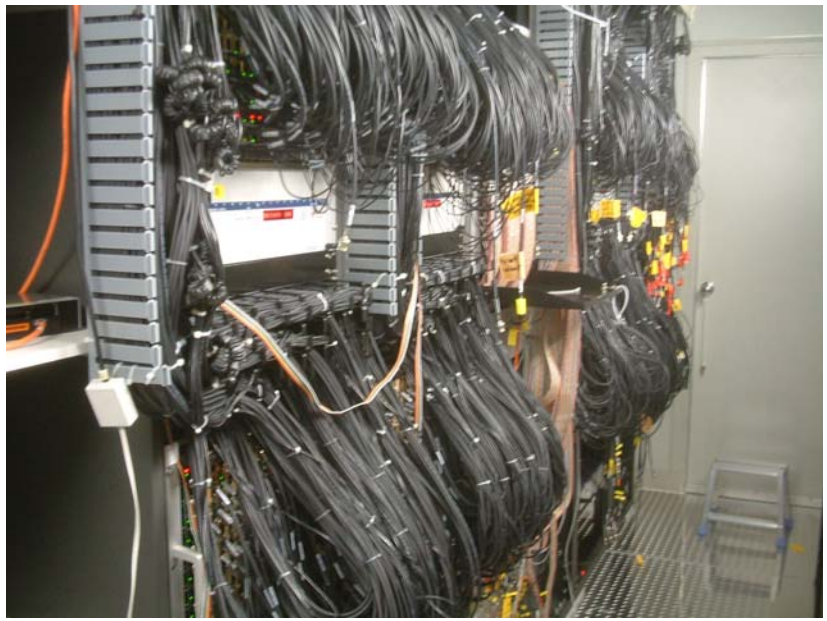
1 msec



1 μsec

Installation to KamLAND



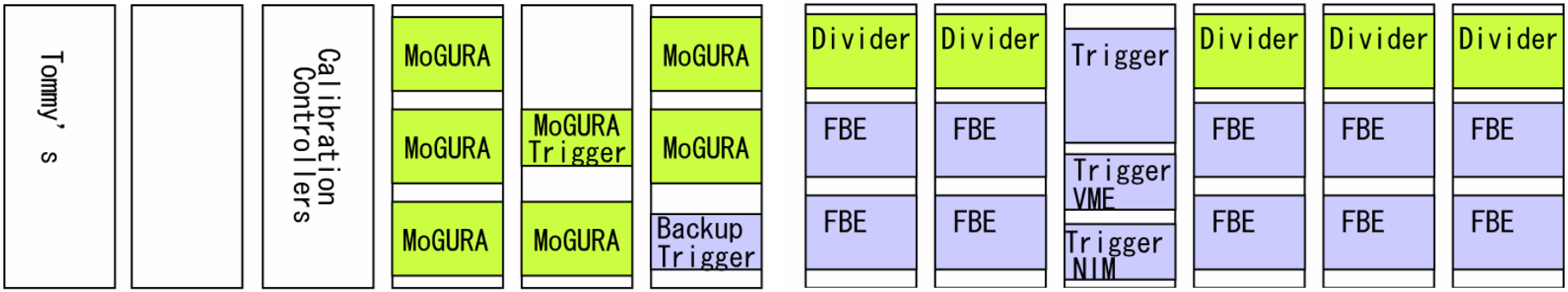


- Cables are tidily connected with length adjustment
- Changing layout easily causes a mess

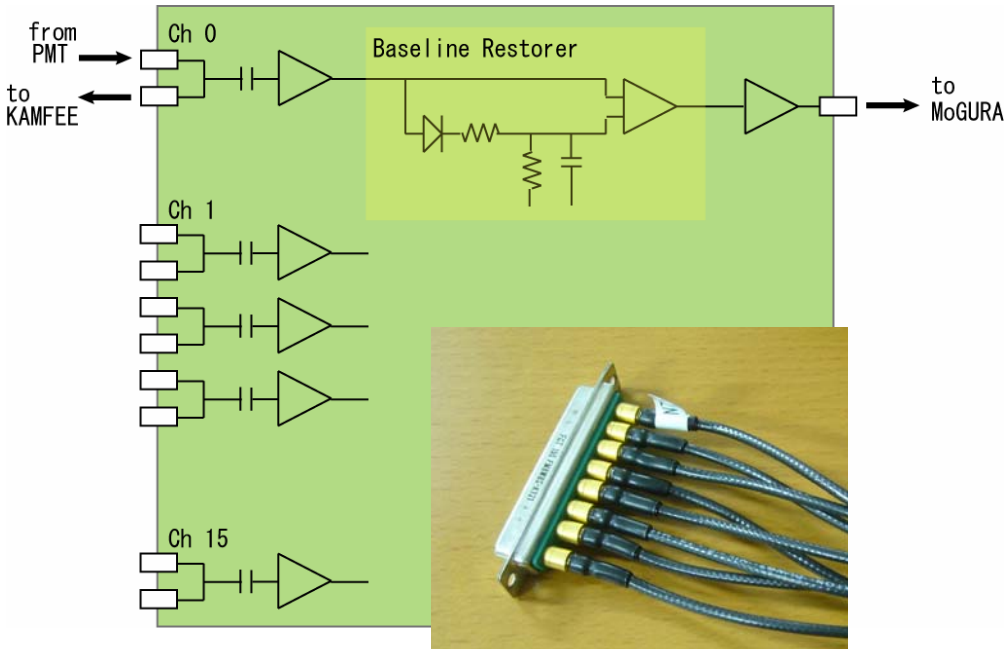
⇩

Try to minimize PMT cable relocation

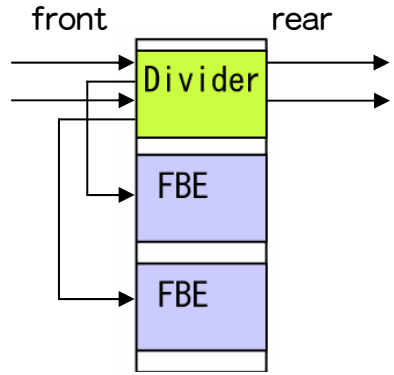
Cabling and Rack Layout Plan



Signal Divider Card



High-density coaxial connector
(Chuck's suggestion)



- Divider implements 16 ch/card
- FBE has 12 inputs/card
- MoGURA is only for 17-inch PMT

- Power: ~20 kW total

Summary & Schedule

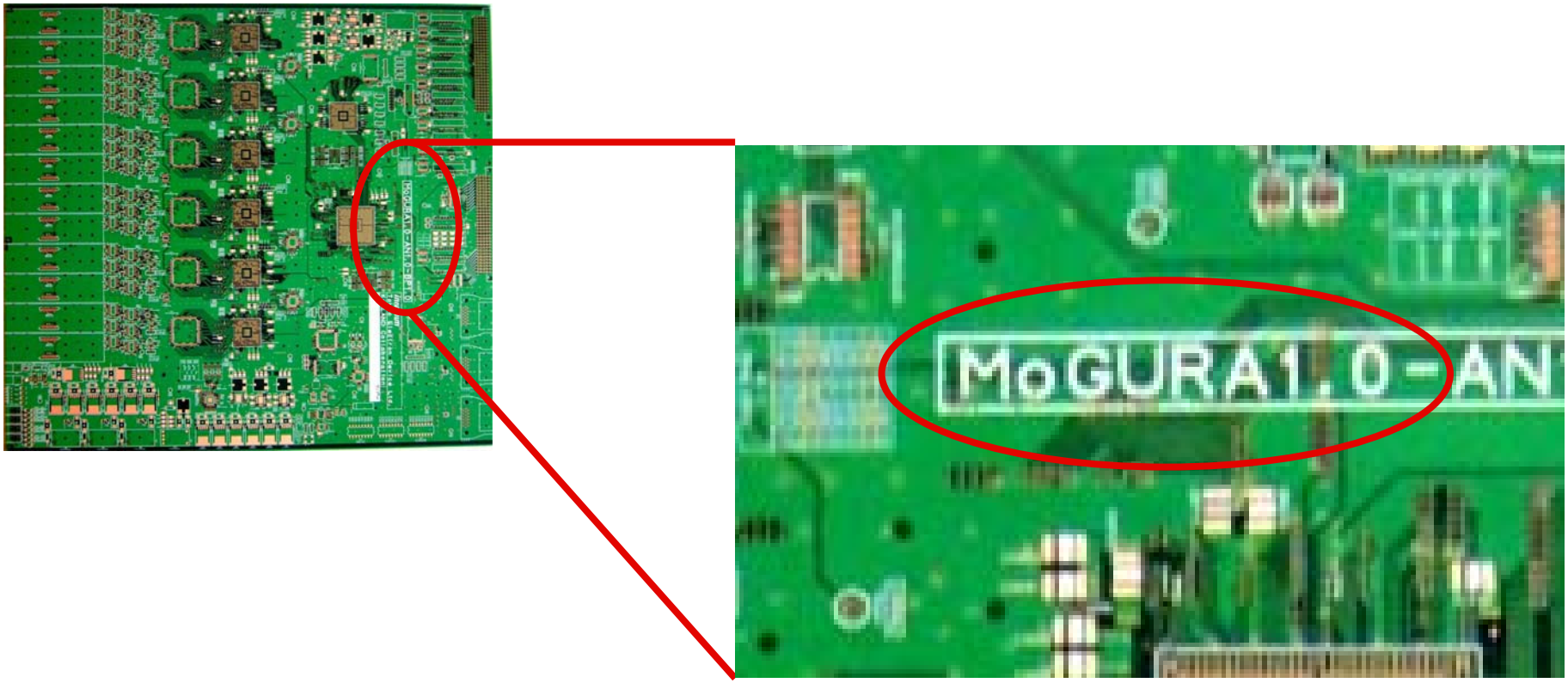
- Prototype (Mini-MoGURA) is fully implemented and tested
  - Sensitive enough for tiny 1 p.e. signals
  - Performance is good enough for muon + turmoil + 100*neutrons
  - Baseline restorer is working (final adjustments remain though)

- Draft E-hut layout is proposed
  - No major change for PMT signal cabling
  - FBE crates need to be shifted downward
  - 20 kW power consumption may require major utility upgrade
  - Ideas and suggestions would be appreciated

- Mass-production will start on Nov~Dec 2007

- Comments, Objections, ???

Don't call it "FTE"



"MoGURA" stands for
Module for General-Use Rapid-Application

参考資料

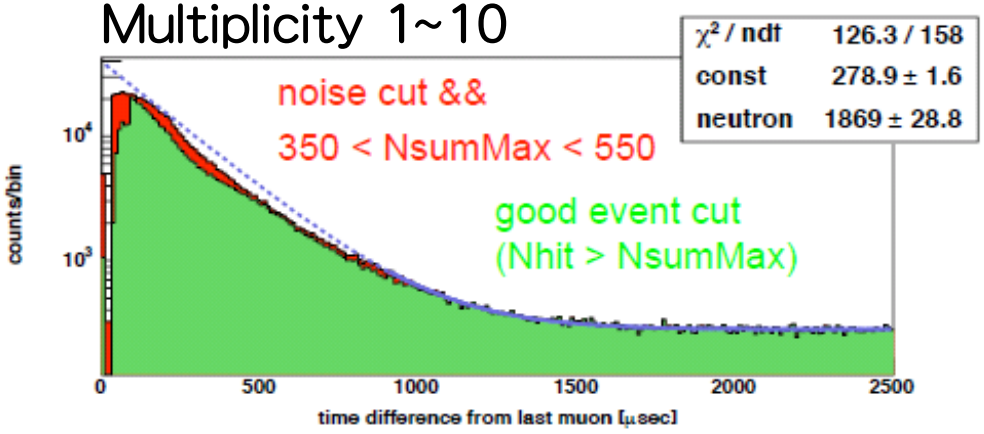
Quick Review of ^{11}C Tagging

(courtesy of I.Shimizu)

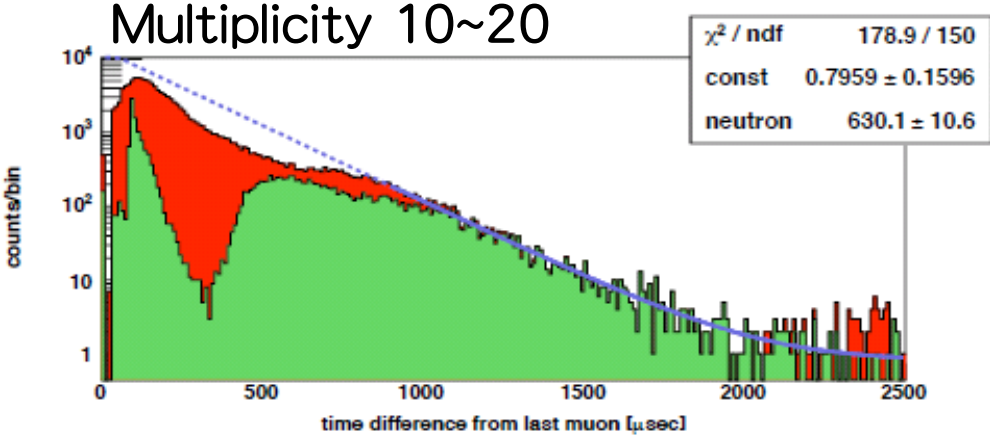
^{11}C Tagging with Neutrons

multiplicity (#$n_{detected}$)	^{11}C (events/day/kton)	fraction (%)
> 0	592.3 ± 13.9	88.4
= 1	323.6 ± 11.0	48.3
> 10	75.3 ± 3.7	11.2
> 20	34.0 ± 2.4	5.0
> 30	3.0 ± 0.9 < 1%	0.4
> 40	0.4 ± 1.9	0.1

Multiplicity 1~10



Multiplicity 10~20

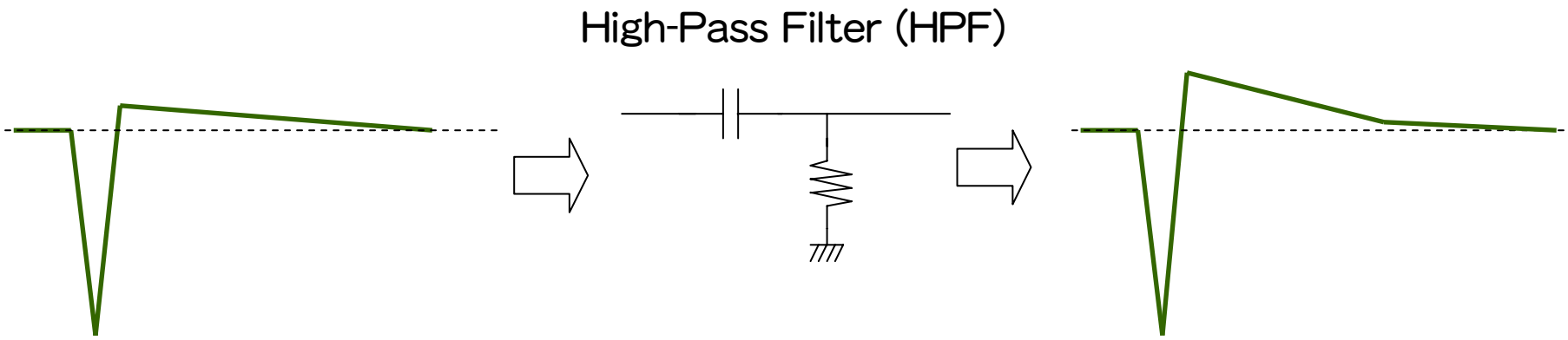


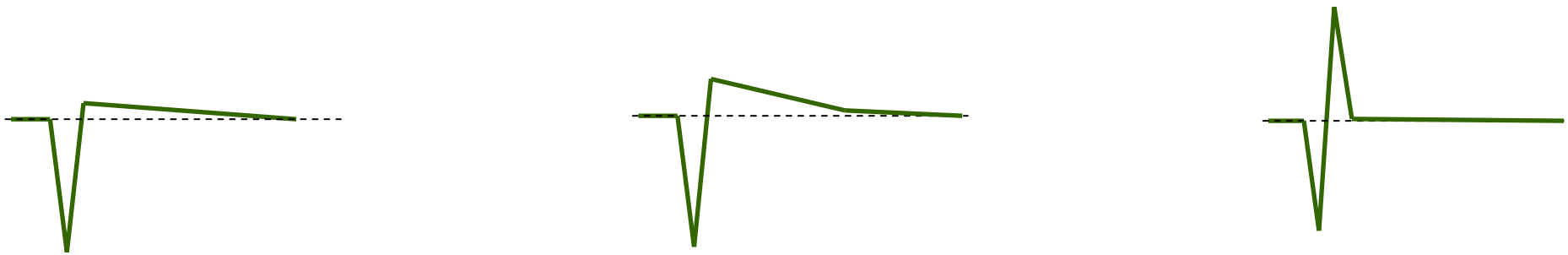
Summary

- Electronics requirement for pep/CNO solar neutrino detection is studied.

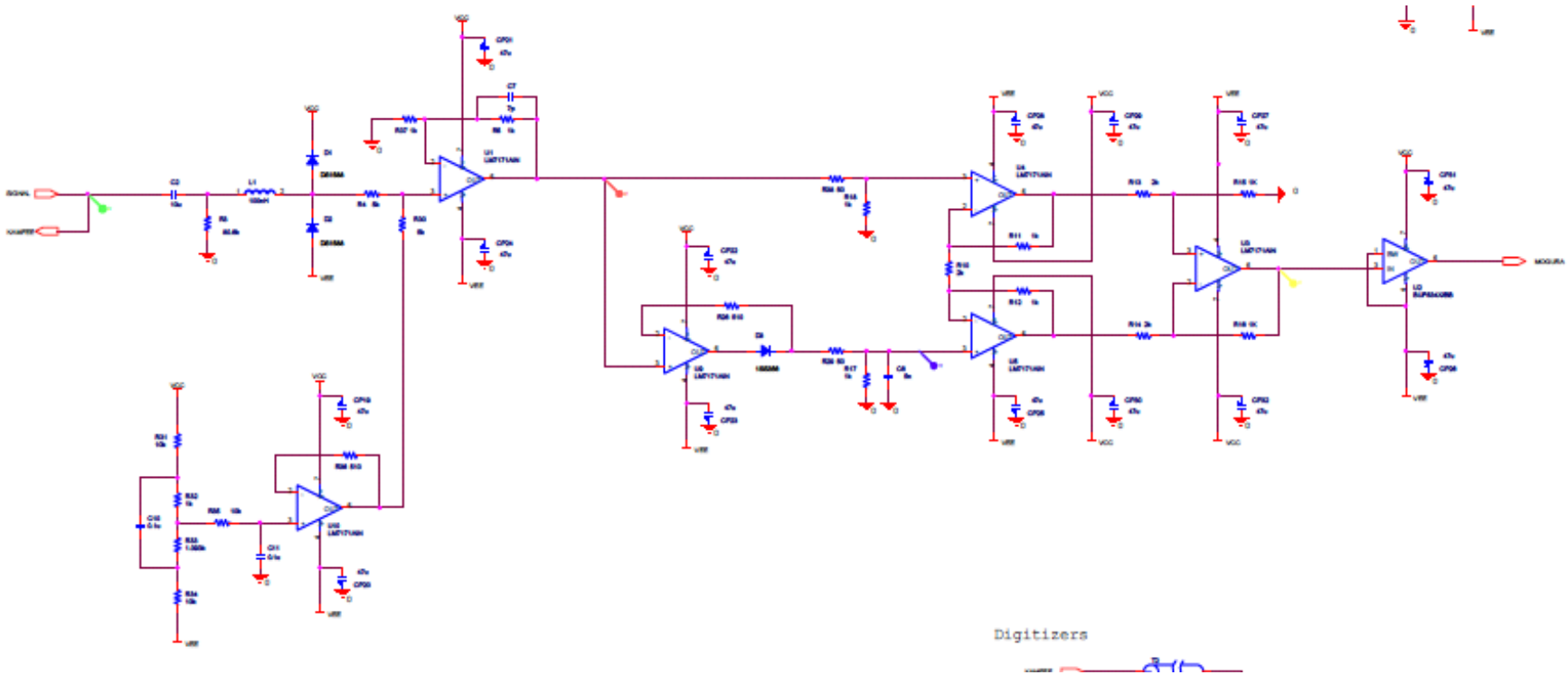
detectable n multiplicity	> 60
double hit resolution	< 100 nsec
resolution	< 30[cm] / sqrt(E[MeV])

Baseline Stabilization: The Problem

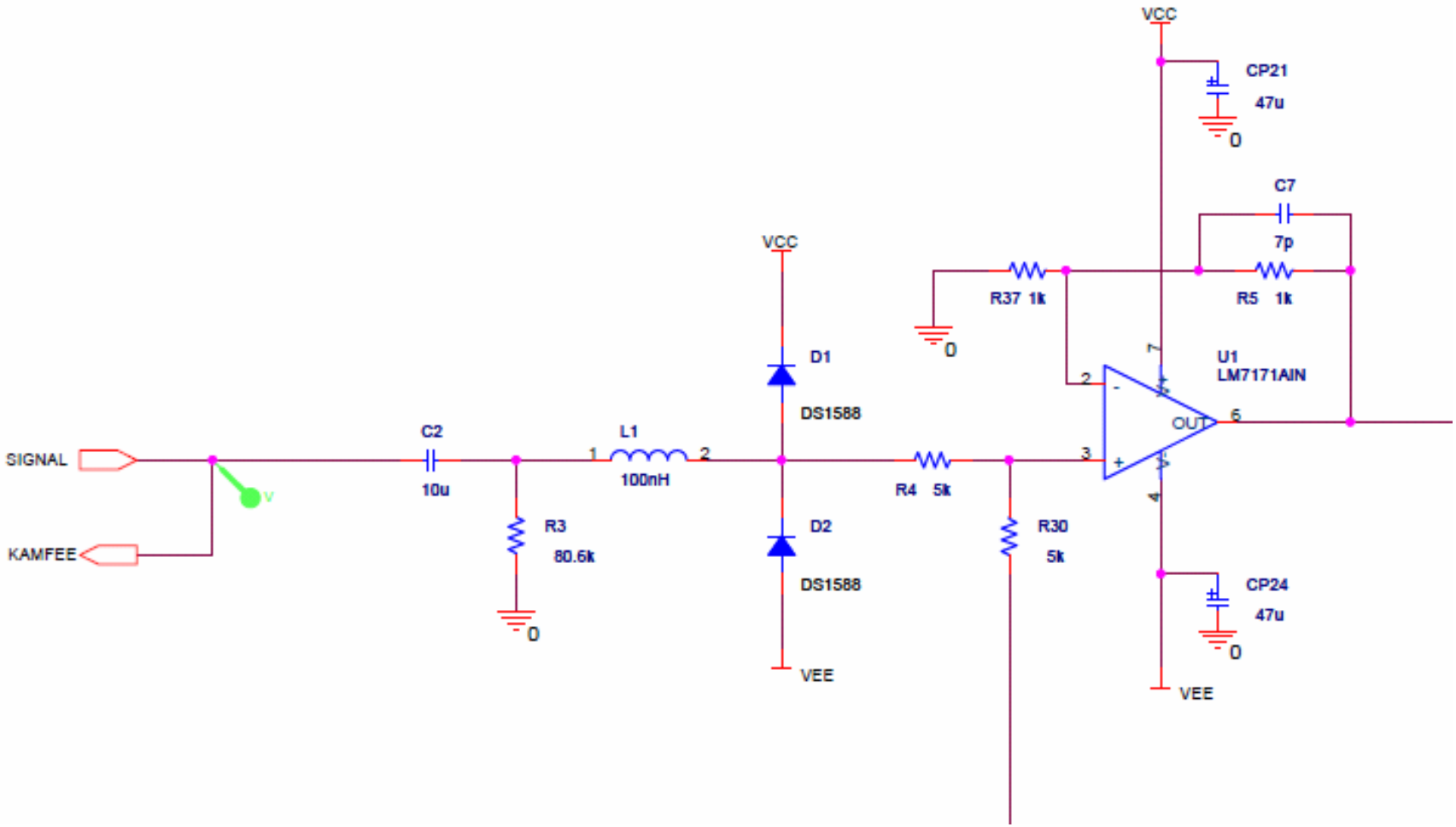




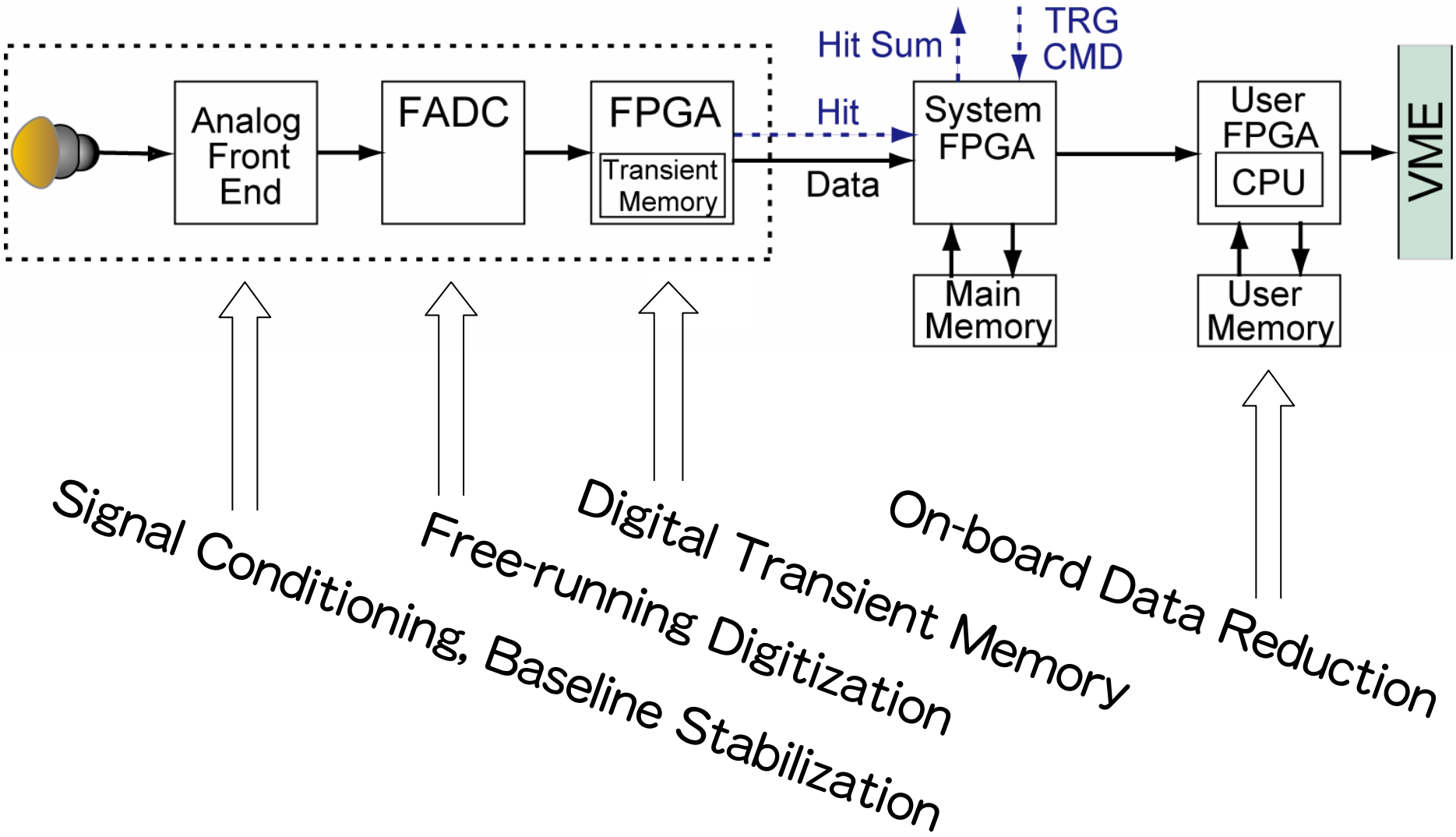
Baseline Restorer Schematics

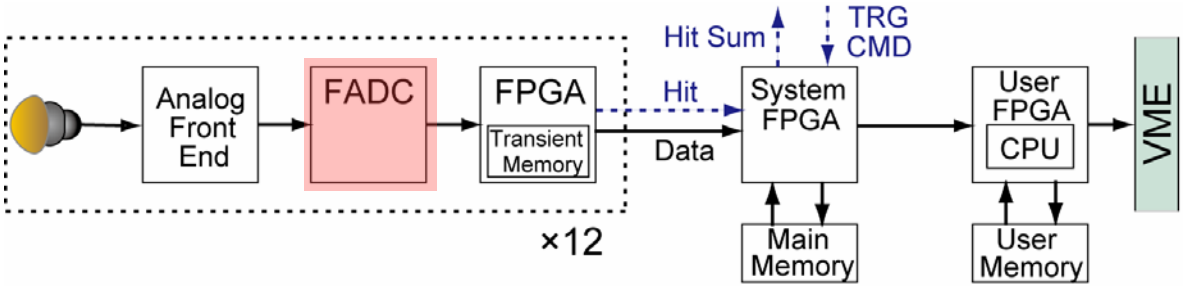


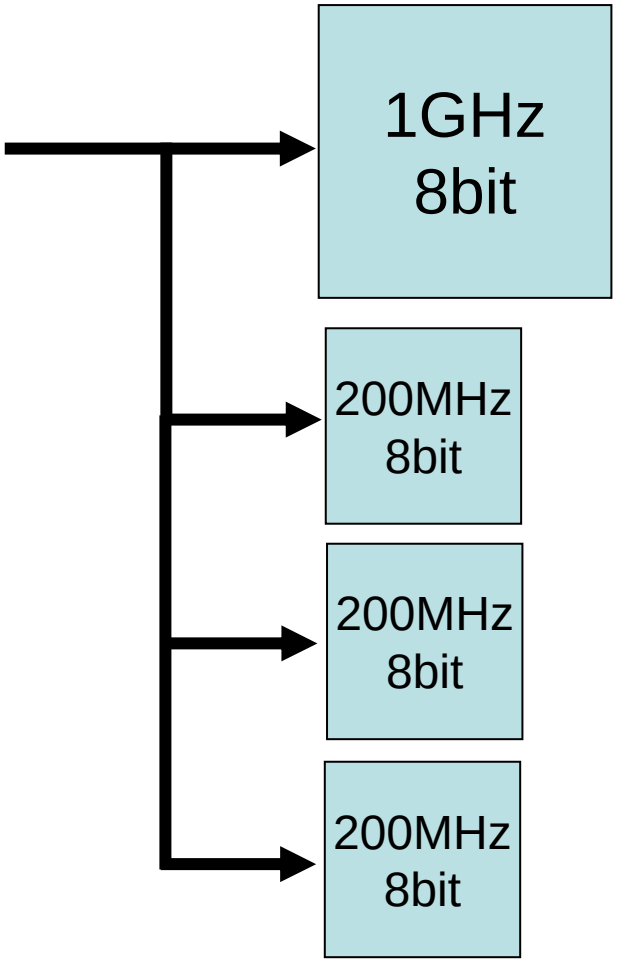
Signal Divider Inputs



Data Path


Hit Sum
TRG
CMD
Analog
Front
End
FADC
FPGA
Transient
Memory
Hit
Data
System
FPGA
User
FPGA
CPU
VME
Main
Memory
User
Memory
Signal Conditioning, Baseline Stabilization
Free-running Digitization
Digital Transient Memory
On-board Data Reduction





−0.5mV～＋20mV，0.1mV step

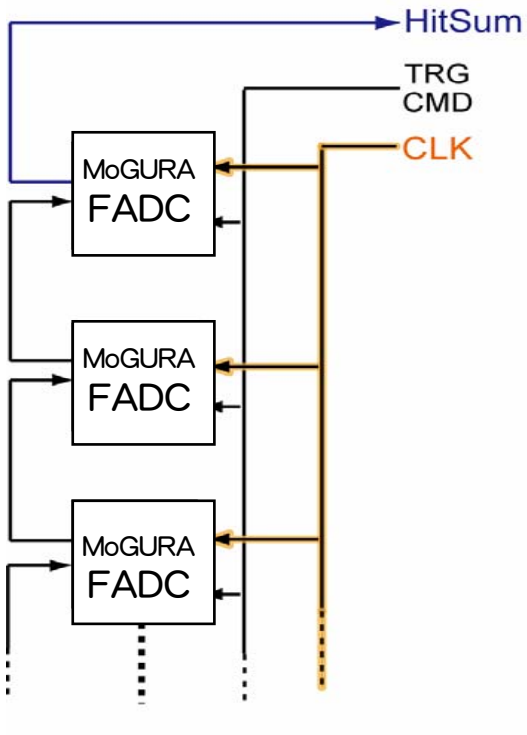
−25mV～＋100mV，0.5mV step

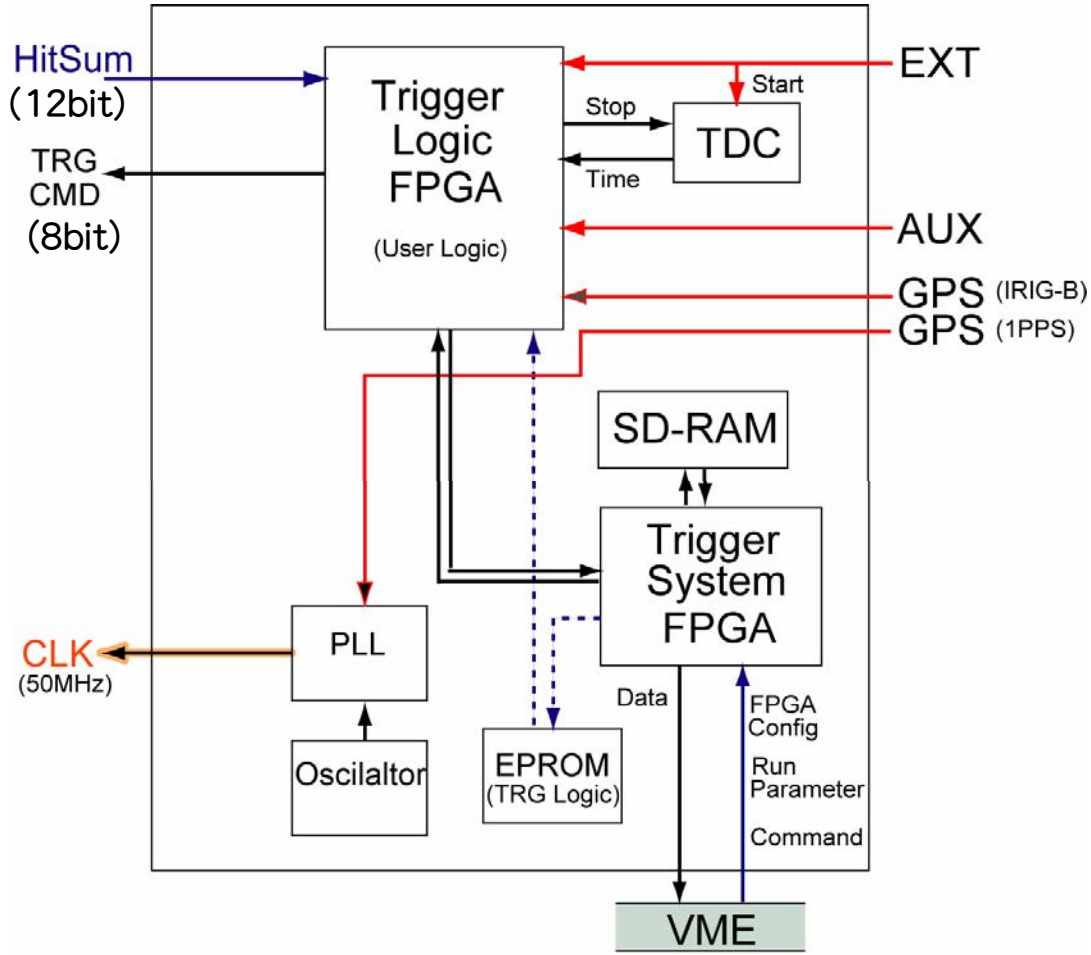
−250mV～＋1V，5mV step

−2.5V～＋10V，50mV step

MoGURA Trigger Card

- 12-bit Input, 8-bit Output, General Logic
- VME interface
- MoGURA FADC Card could be used (if we run out of budget)





MoGURA VME Piggy-Back Card

- Distributes trigger clock and commands
- FPGA is used instead of drivers
  ⇒ 1-crate system (such as MiniLAND) does not require external trigger card