Looking forward on Electronics (detectors, …)

Some topical issues

1. **When Digital ?**
2. **When Discrete (analog) ?**
3. **When CMOS ?**
4. **Special electronics for TPC's**
5. **Beam tracking (diamond detectors, …)**

L. G. Sobotka and A. Stolz

“To digital or not to digital…”

DIGITAL IF:

Multi-D CONTINUOUS information in analog pulse ➔ Go digital

Allows you do what you cannot otherwise do

Examples: Implant + Decay spectroscopy (a la ORNL, …)

Gamma tracking (a la GRETA)

IF analog, when discrete and when ASIC?

A. Discrete if channel count < 100 and E-resolution and/or time resolution a premium.

B. Go CMOS if channel count >> 100 and moderate requirements

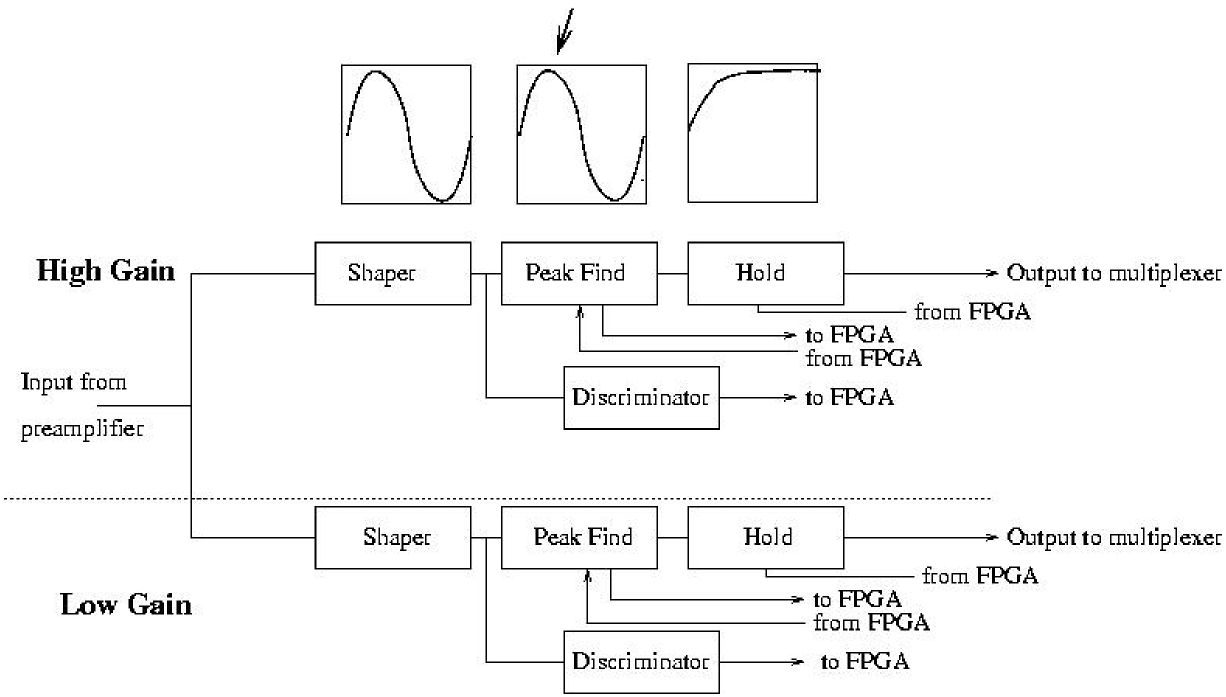
C. Not so clear what to do for a few hundred.

Example of present *discrete electronic* readout of a highly segmented Si detector

MASE

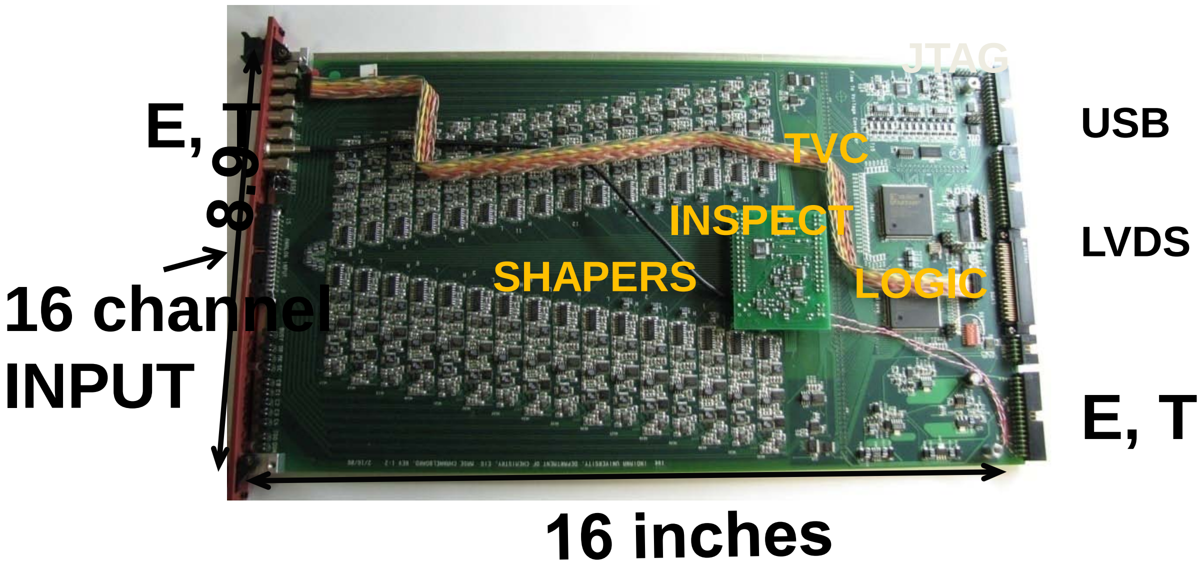
Goal: Design and build a high resolution, "low-cost", scalable system for processing the energy signals of an array that is < 1024 channels. (bridge between conventional electronics and ASIC)

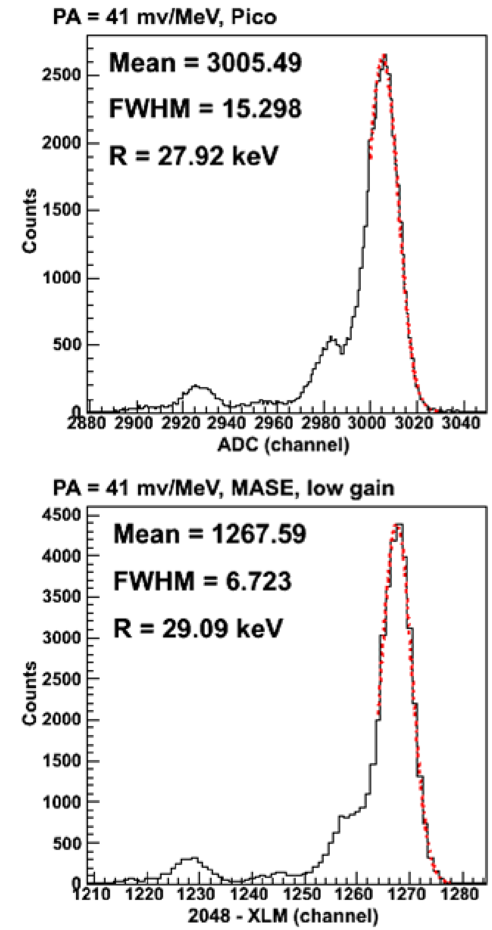
The basic MASE concept



C.J. Metelko et al., NIM A569, 801-815 (2006).

MASE channelboard





- 16 channels/module with dual H/L gain on each channel
- 32 independent discriminators

This system has been designed and built within a University electronics shop.

- test setup : LASSA 500 µm detector; ^{241}Am source

- MASE exhibits resolution of 30 keV for a 5.4 MeV α.

- Channelboard designed to work in standalone mode or crate mode.
- Inspect of the analog signal

CMOS implementations from …

SOUTHERN ILLINOIS UNIVERSITY EDWARDSVILLE

Tool bag now has two major implements

Washington University in St. Louis

1. **HINP-16C** made for Si strip detectors

   Makes getting E and T from Solid-state strip arrays easy.

   Only made sense to develop for arrays > 1000, but now makes sense to use for arrays > few hundred.

2. **PSD-8C** for processing signals from large arrays of scintillators. **Generates E and T (with external CFD) and useful for arrays of 100-1000 elements**

- The same infrastructure is used for both. EASY to switch from one to another.
- SIUE-IU-WU Could morph to a center of FRIB advanced Electronics design.
- Center would use both staff and STUDENT engineers.

Washington University in St.Louis

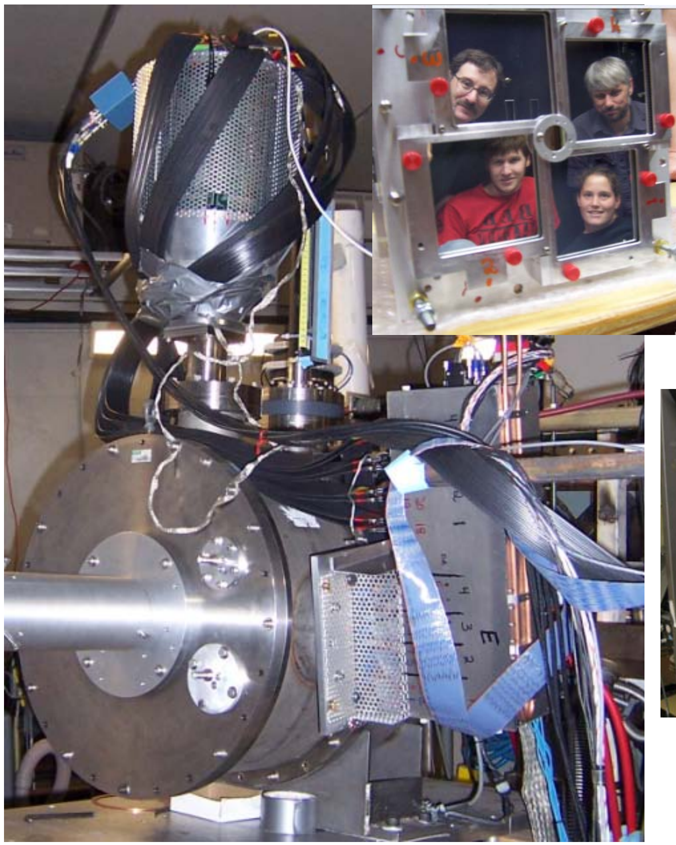
HINP-16C (For Si strip)

9 science papers in print

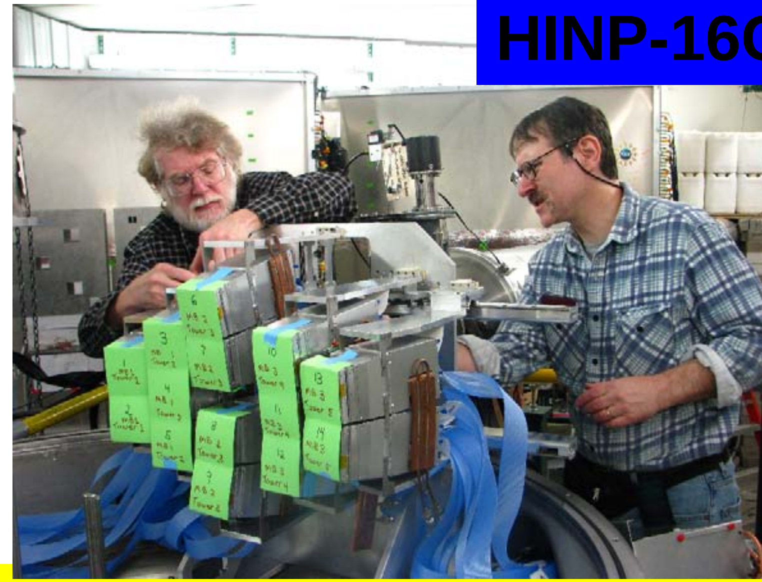
presently used by: WU, MSU, IU

to be used by ORNL, LSU, TAMU, RIKEN

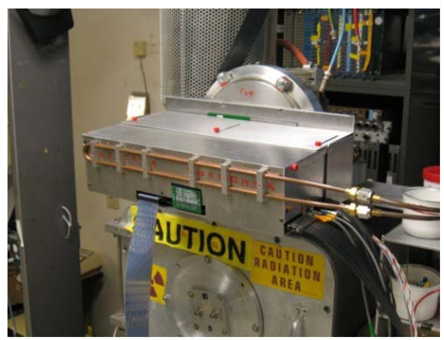
HINP-16C



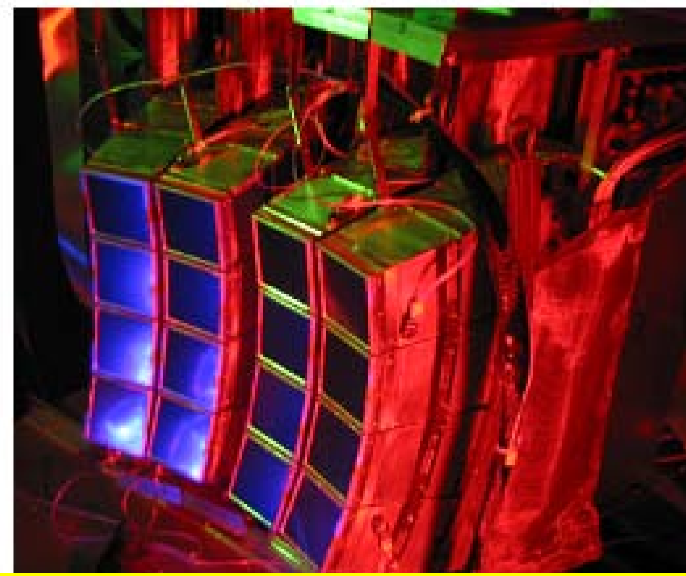
1. Decay spectroscopy
2. Transfer (p,d), (d.p), (α,t)
3. Proton knockout
4. Multifragmentation
5. Elastic and inelastic



Medium sized experiment ~ 1000 ch



Test rig at WU



Small experiment at TAMU ~ 400 ch
Used both internal and external CSA's

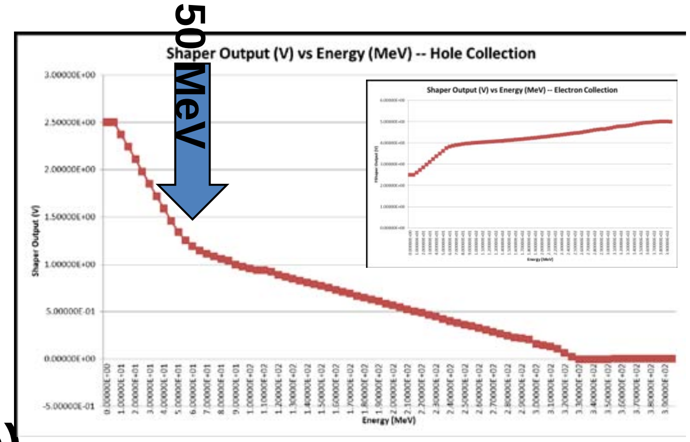
LARGE experiments (> 2000 ch)
Often used with S-800

Washington University in St.Louis

HINP-16C

Present Features

1. Two gain ranges 75 MeV (50 kev res), 350 MeV (80 keV res)
2. Ability to use external CSAs (e.g. 30 MeV range, 40 keV res, can handle large cap)
3. Two time ranges 500, 2000 ns, time res. 1-2 ns.

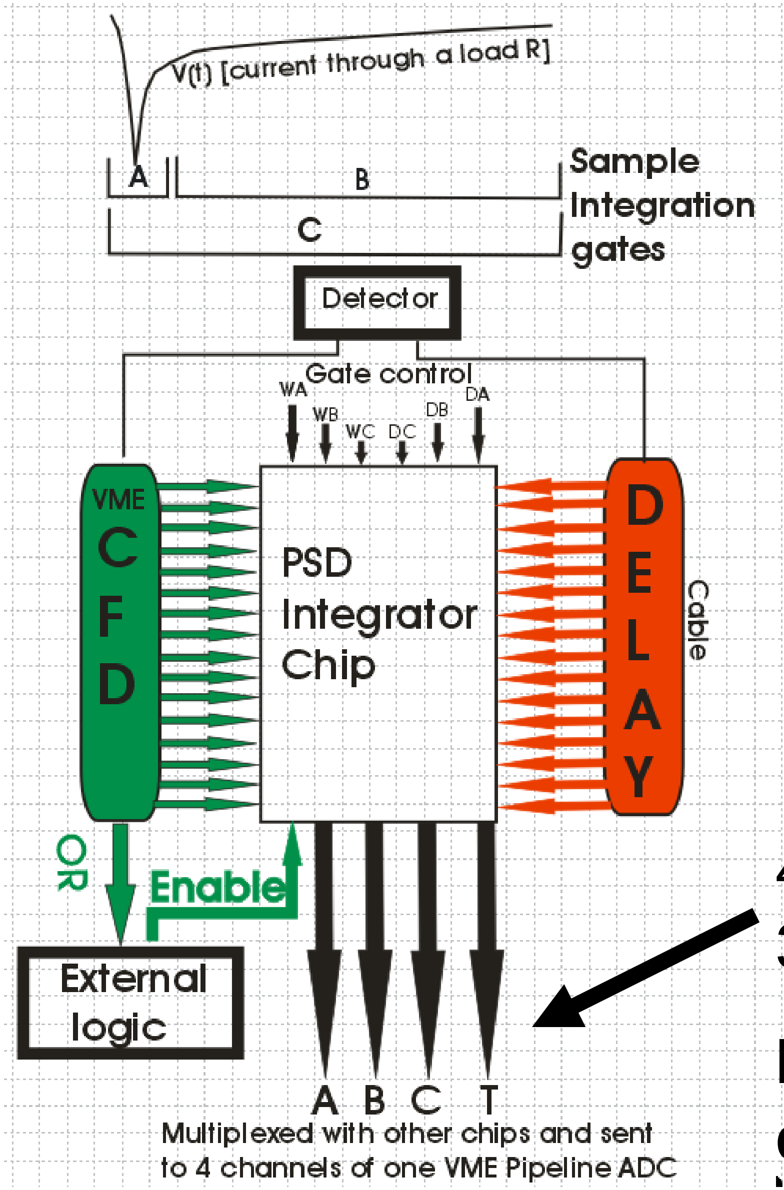


Planned upgrades

1. **Extended range**
   a) to 350 MeV
   b) 40-50 keV res. (~7000/1 Range/noise)
   c) Triggering threshold 150 keV
   (> 2000/1 range/thres - if in clean environment)
2. **On CB ADC’s (distributed ADC’s ➔**
   moving toward no VME ADC’s and then no VME.)
3. **Time stamp CB**

PSD-8C

Needs external timing unit

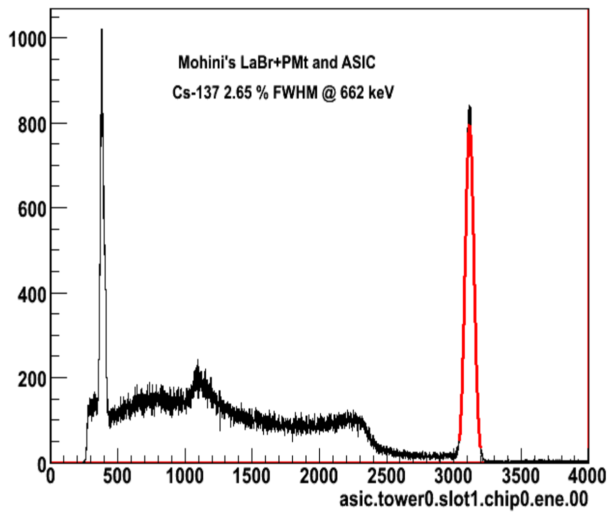


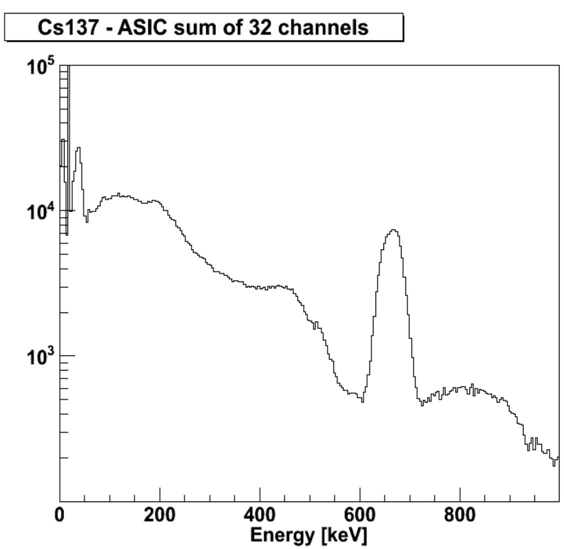
4 "outputs" =
3 integrals + 1 time

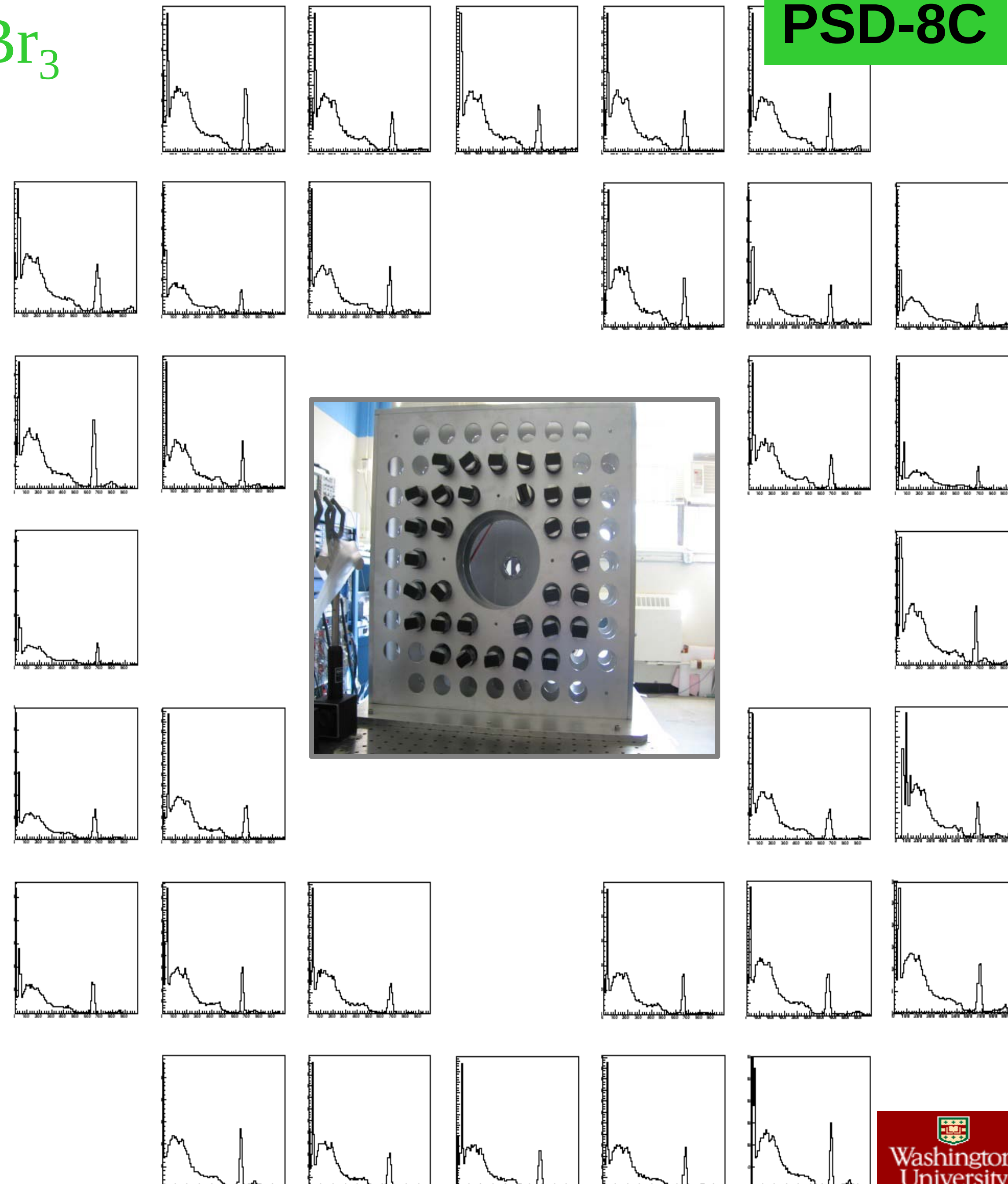
Presently needs external ADC

LANL –tests with $LaBr_3$ 2.7% @662 keV

PSD-8C







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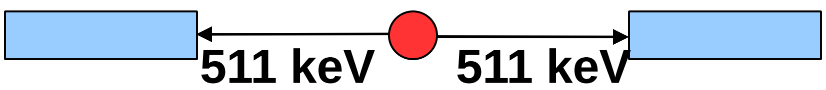
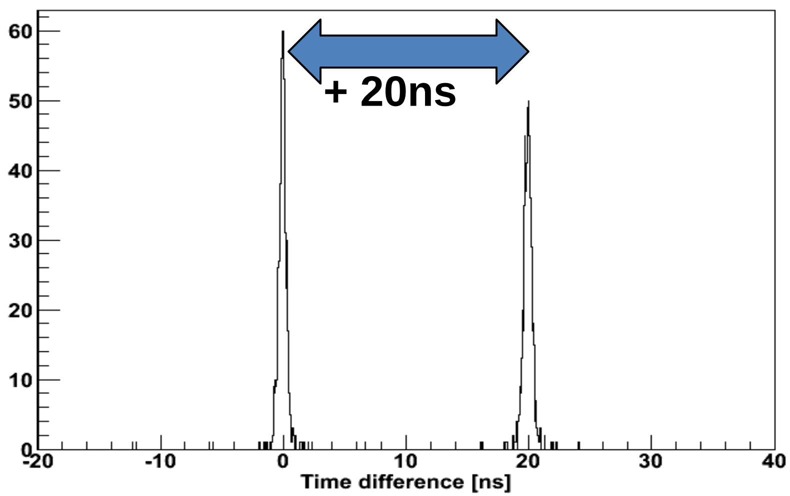
LANL timing tests

Two back-to-back gammas

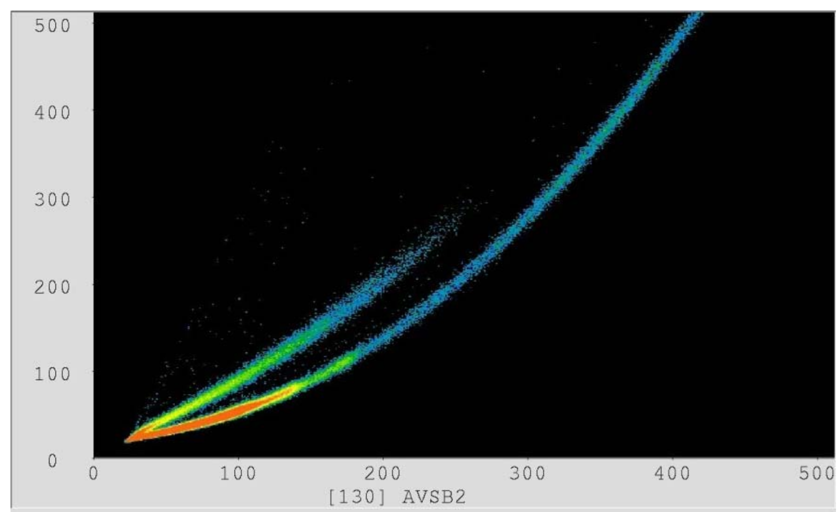
Time difference resolution~ 750 ps

Detector 1 **Ge-68 source** **Detector 2**





Finally a "PSD" check using 2 integrators



Standard n-γ PSD from a liquid scintillator.
The abscissa is a total integral and the ordinate is the integral from a gate delayed 100 ns after prompt. The physical detector is one from the set used from the neutron Shell of GammaSphere.

General Electronics for TPCs: GET

IRFU, GANIL, CENBG
MSU, RIKEN

For different detectors

AT-TPC: ~10000 channels

AGET Main features

64 Analog Channels: Analog part + Sampling Capacitor Array.

Channel

CSA + PZC + Filter (semi-Gaussian order 2).

SCA:512 analog memory cells.

Auto Triggering: discriminator + threshold (DAC) + inhibition.

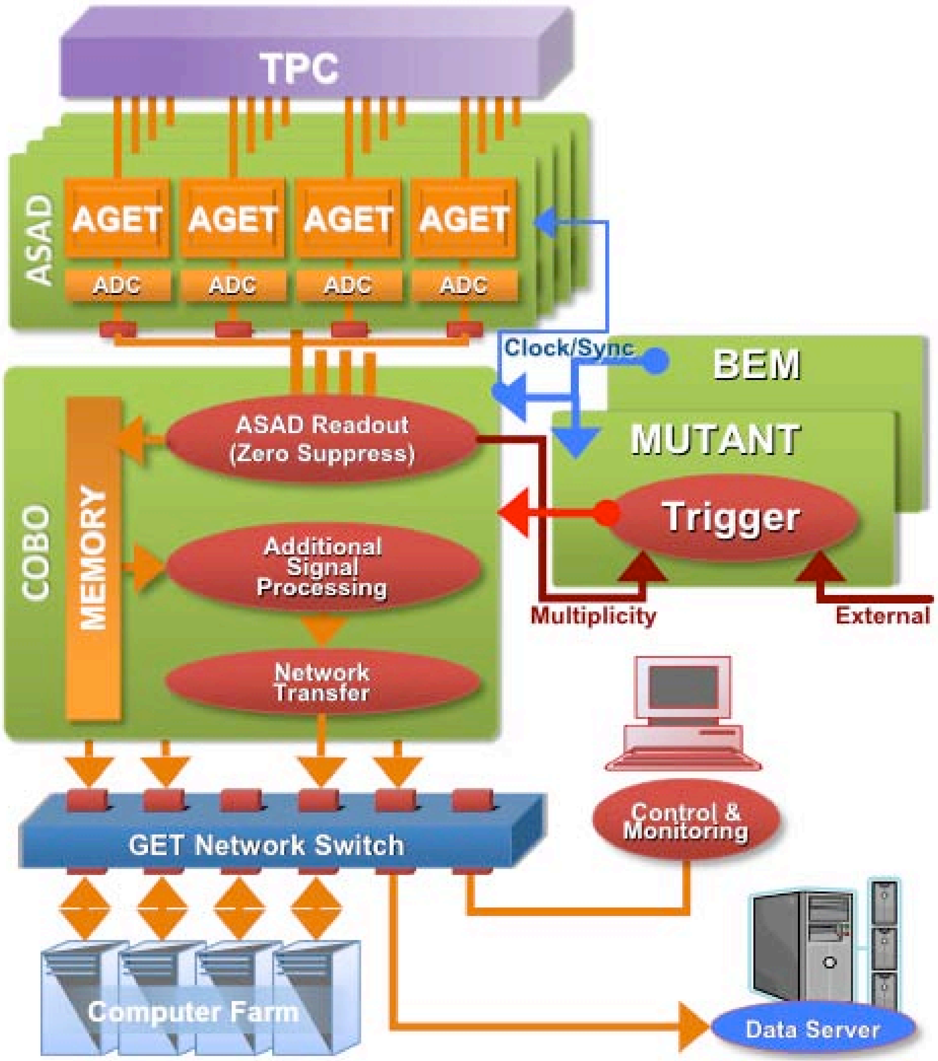
Trigger & Readout

Trigger [Analog sum of the 64 discri.].

Several SCA readout modes.

Address of the hit channel(s) [read & write].

2p acquisition mode



Tracking detectors requirements for fast beams

- transmission detector (thickness < 35 mg/cm^2)
- active area:
  - 300 mm x 20 mm (FRIB separator)
  - 100 mm x 100 mm (S800, HRS, …)
- position resolution:
  - 5 – 15 mm (FRIB separator)
  - 1 mm (S800, HRS,…)
- total count rate: >10^7 pps
- thickness homogeneity (if used in dispersive plane):
  - 0.5 (0.1) mg/cm^2 for low (high) Z beams
- radiation hardness: >20 MGy (10^7 pps for a week on 1x1 cm^2 detector)
- timing resolution: 50 ps, if used as simultaneous timing detector

Tracking detectors – possible alternatives

- tracking PPACs: rate capability ~400 kHz
- position-sensitive MCPs: detector rate capability ~1 MHz
- **segmented diamond detectors**

  seems to be most promising option for high intensity FRIB beams, but significant development effort will be still needed

Segmented diamond detectors

Very fast detectors: signal width ~1 ns, rate capability ~10^8 pps

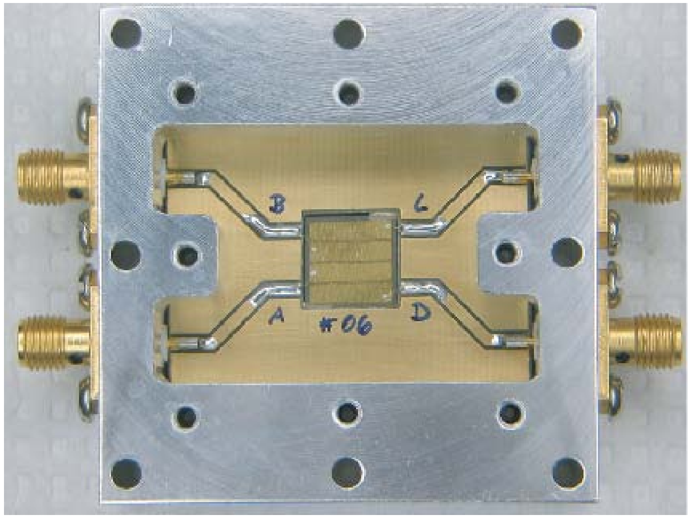
Excellent timing properties: sigma ~20 ps

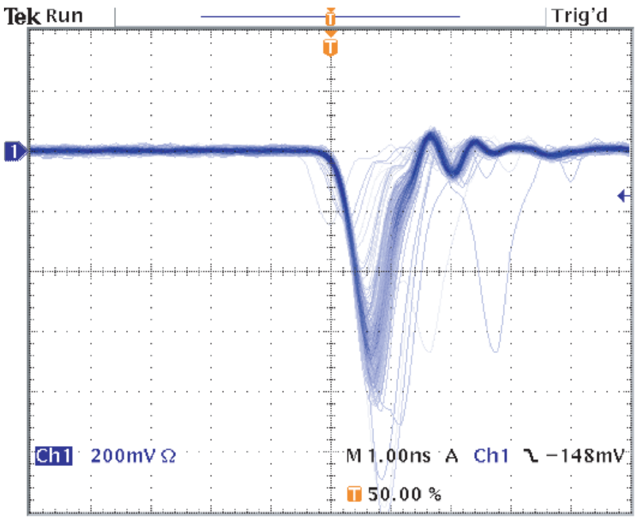
High radiation hardness: >10 MGy

Polycrystalline or single-crystal material (simult. E-loss measurement)

Electrode segmentation with mask or photolithography

10x10mm^2 detectors in use at NSCL, 20x20mm^2 in preparation





Segmented diamond detectors – Challenges

Detector with large sensitive areas
tiling might be required

Availability of single-crystal material
no large-area material, expensive

Homogeneous detector material
for detector use at dispersive focus point

Tracking readout electronics
local memory needed due to time delay between event and trigger
time stamps…

...

Summary

No universal solution – EACH of the following has its place

Digital - Discrete analog - CMOS analog

Full TPC (with ASIC CMOS chip sets)

Tracking detectors – Some clear and promising options.

Much work needs to be done

1. **University groups can contribute**

   Some interest in a WU-SIUE-IU "adv. Electronics FRIB-ELE" group.
   No need for this effort to be sited at FRIB!

2. **All should appreciate that**

   for a given problem, one should use what works.
   No single approach should take all the resources.