Activities in Electronics Lab. 2006

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Nuclear Electronics (INGA, NAND)

Pulse Shape Discriminator Electronics for NAND

National Array of Neutron Detectors (NAND)

* A large array of Neutron detectors at IUAC in BH-II

* The array consists ~ 30 Organic liquid scintillators (5"x5”) NE213 and BC501

* Detectors sourced from different institutions in the country

* PMT: XP-4512M (Philips)


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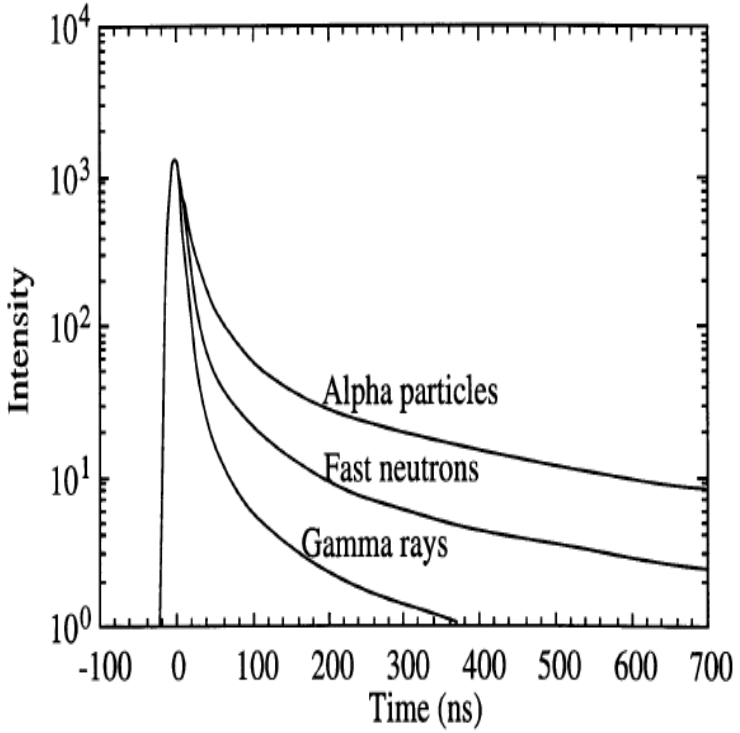
Electronics Requirement for NAND

- Front end Signal Processing Circuits required are
- From Dynode Signal
  - Pulse height or Energy of neutron, gamma radiations : Calibration purposes
- From Anode Signal
  - Timing *for* Time of Flight
  - Pulse Shape Information *for* Pulse Shape Analysis (PSA) or PSD
    - To segregate neutron and gamma events
      - based on the Anode Pulse Shape

Pulse Shape Analysis or PSD.



* To identify the type of radiation (gamma & neutron)

- *Scintillation (liquids) detector response
- differ for gamma & neutron by t rise, t fall, width (ie. Shape)
- * Arrangement of these pulses in same group – PSA or PSD
  - Pulse Shape Discrimination Types
- Zero-Crossover method : Implemented
- Charge comparison methods - Poor dynamic range, less complex electronics.
- Pattern recognition method: To be developed for real time applications

Zero Cross Method*

* Large Dynamic range & Requires conventional Timing electronics

* Incorporates TOF measurements simultaneously

Differentiation- Bipolar & Zero cross over Pulses

Different t fall pulses cross ZERO LINE @ different times

Optimum Pulse shape ~300nS τs Generate STOP for TAC

TIME Reference: CF Discriminator for START/GATE generation

TAC: Linear Spectrum corresponding to gamma & neutron

Evaluation of Performances of PSD

Figure of merit (M): Peak Separation & Sum of FWHM of peaks separated

FWHM for Time of Flight

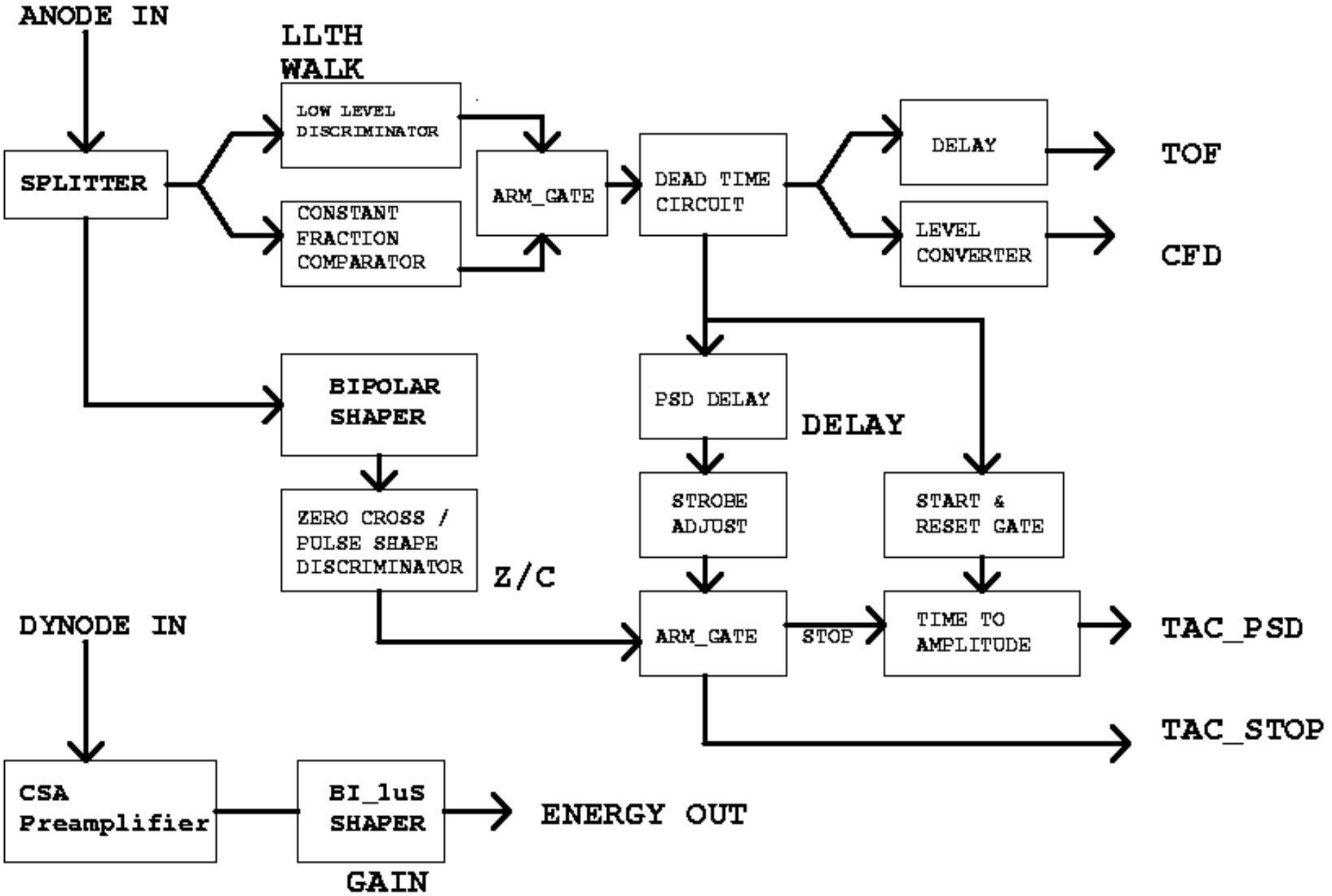
*** Alexander & Goulding et al:NIM (13)**

PSD Electronics Module for NAND

- Single Width NIM Module contains 2 Independent Channels of Electronics. Includes....
  - Dynode - CS PreAmplifier, Shaping Amplifier (Daughter card)
    - Anode - Signal Splitter, Signal Attenuator
      - Constant Fraction Discriminator (x0.2, 5nS Delay)
        - GATE & Delay Generators for
          - BLOCKING CFD, TOF, TAC- START, STOP
            - PSD Amplifier, PSD Zero Cross Amplifier
              - TAC Range: 100nS (Cardioid)
  - Reference & Control voltages for LLTH, PSD, Amplifier GAIN controls.

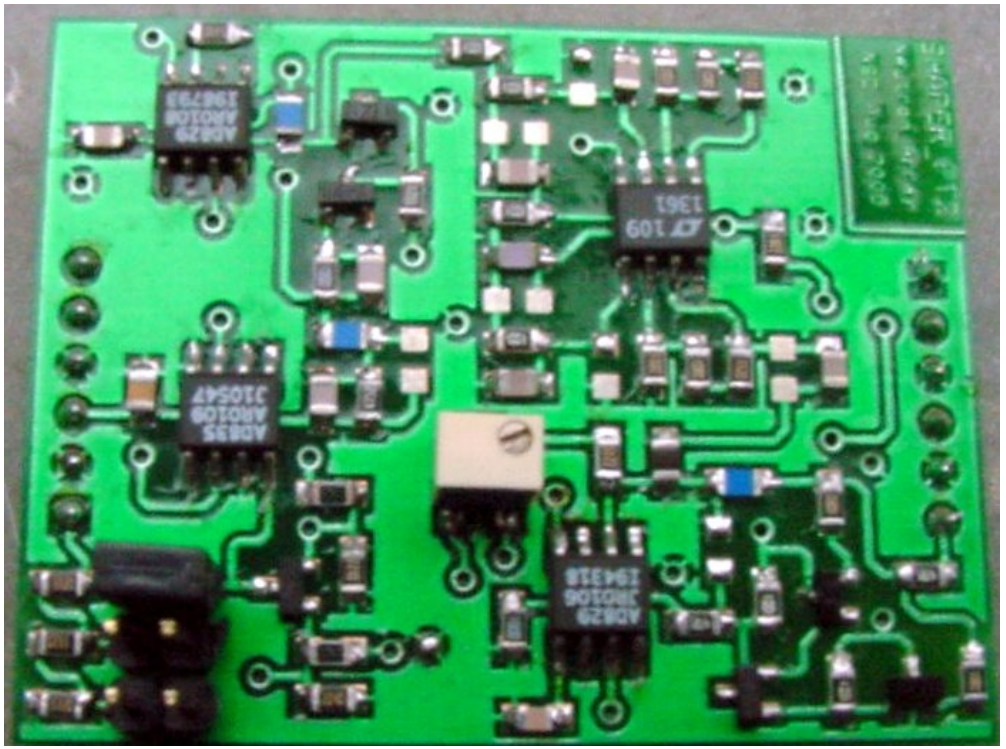
Circuit blocks inside the Module for 1 Channel

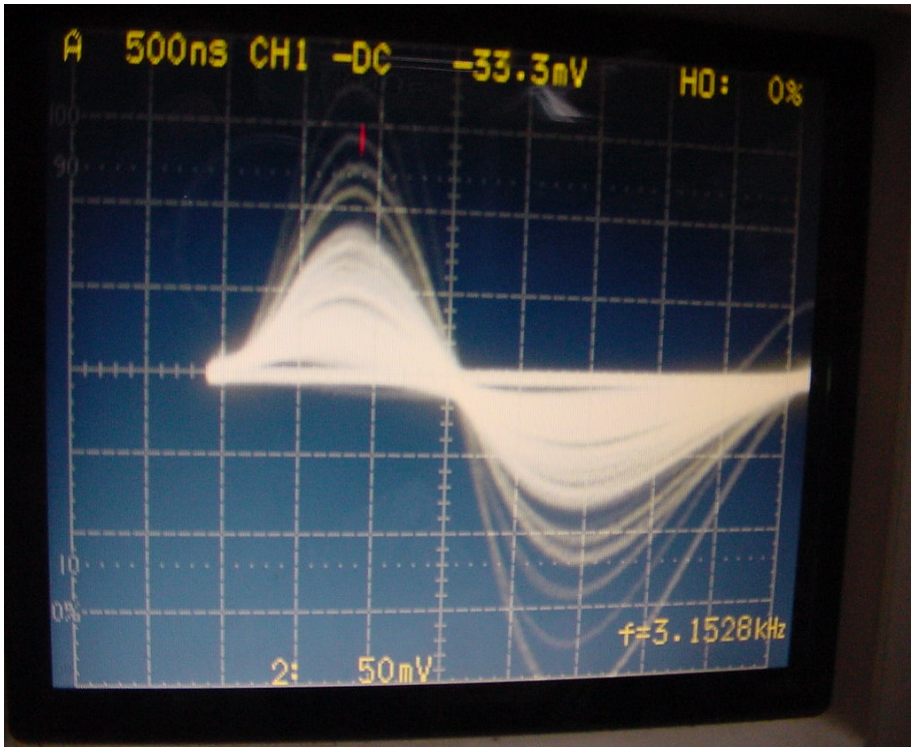
Fig: Block Diagram of PSD Electronics_IUAC



Shaping Amplifier for Dynode

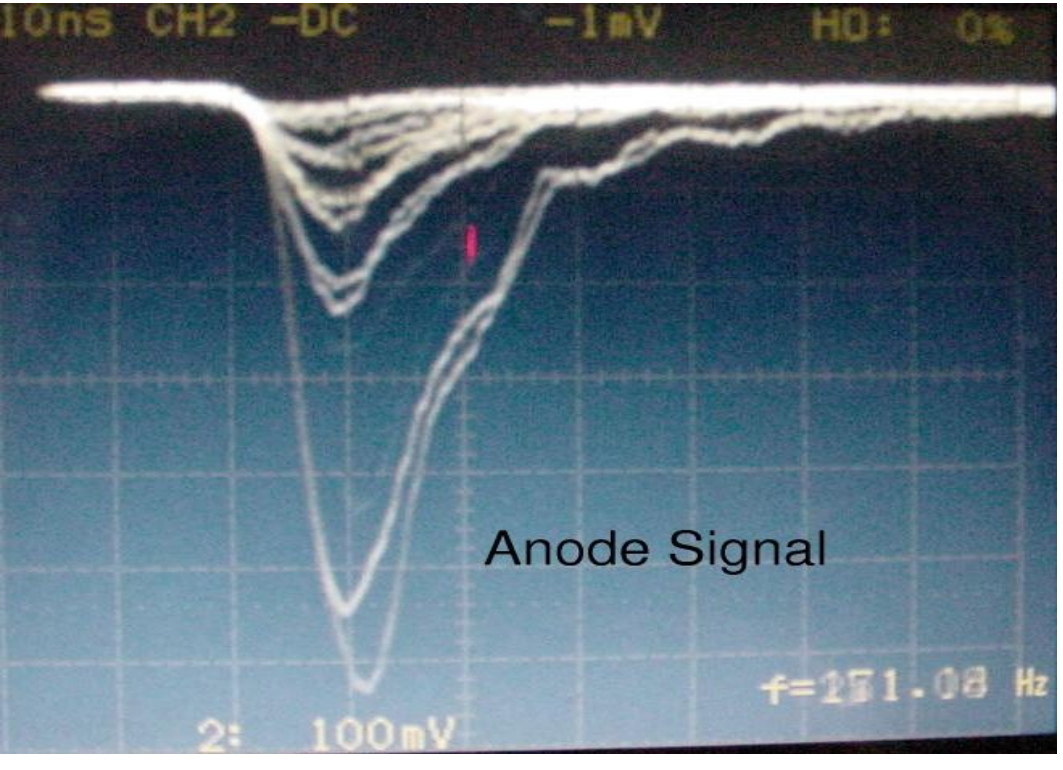
* Low noise Shaping amplifier_ <5 KeV_{Ge} (FWHM)
* 2nd Order Active Filter used
*Gain: Coarse:3 Settings, Fine:Remotely adjustable
* Bipolar Shape obtained to avoid BLR , 1uS
* Required for generating 2D Spectrum * Calibration

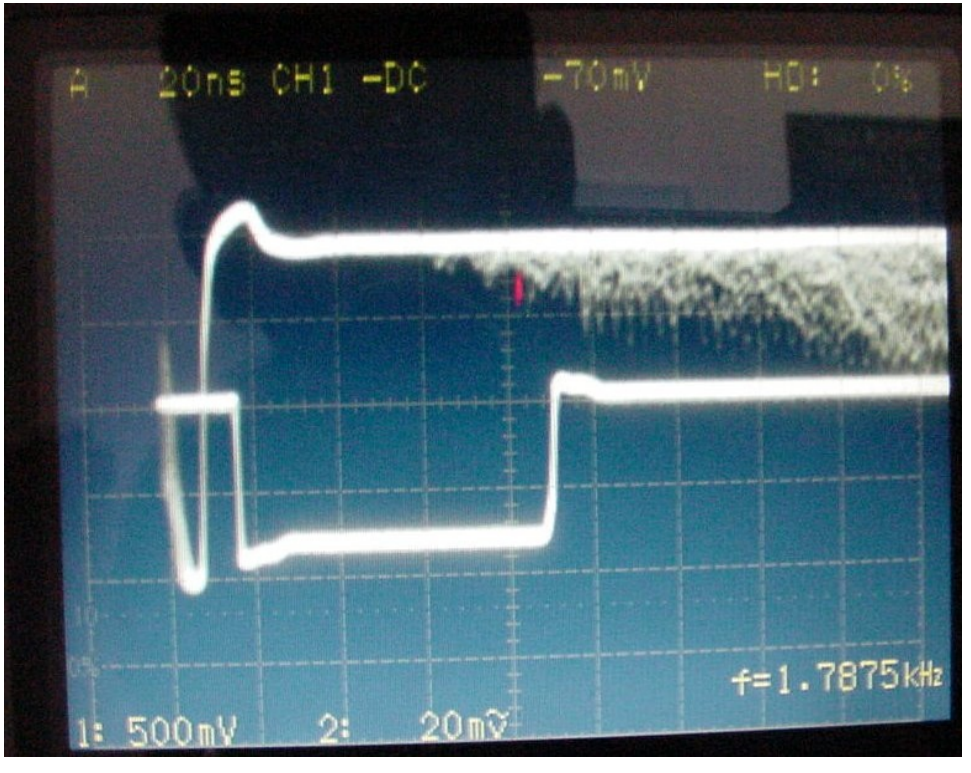




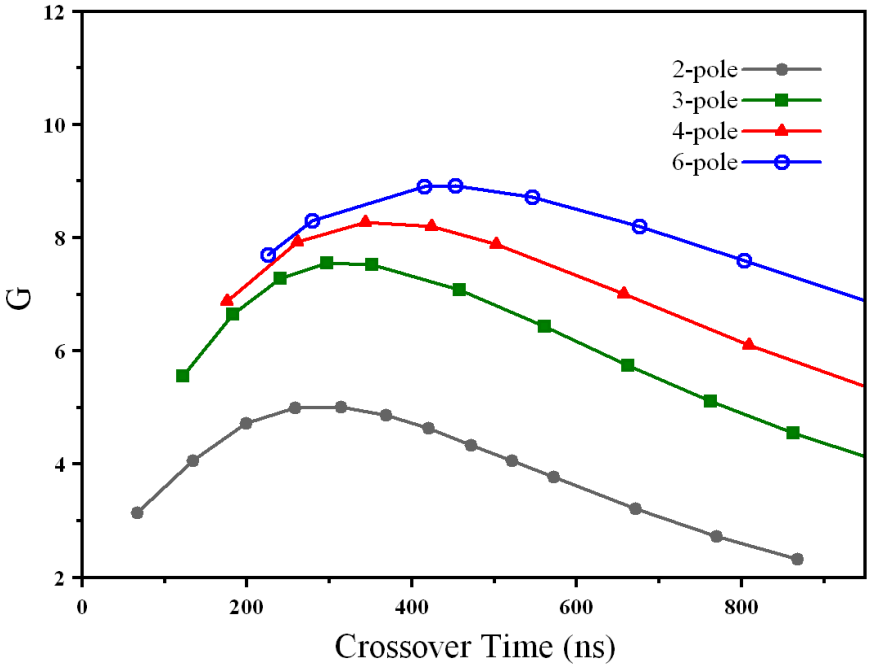
Constant Fraction Timing

* STROBE Generation for PSD
* High performance CFD with F: x0.2, Delay: 5nS
* Blocking 1.5uS to reduce multiple Trigger
* Generates TAC_START/RST of width 2uS
* Ultra Stable LLTH with ~25 ppm reference supply
* LLTH: 10KeVee to 250KeVee (-12mV to -250mV)





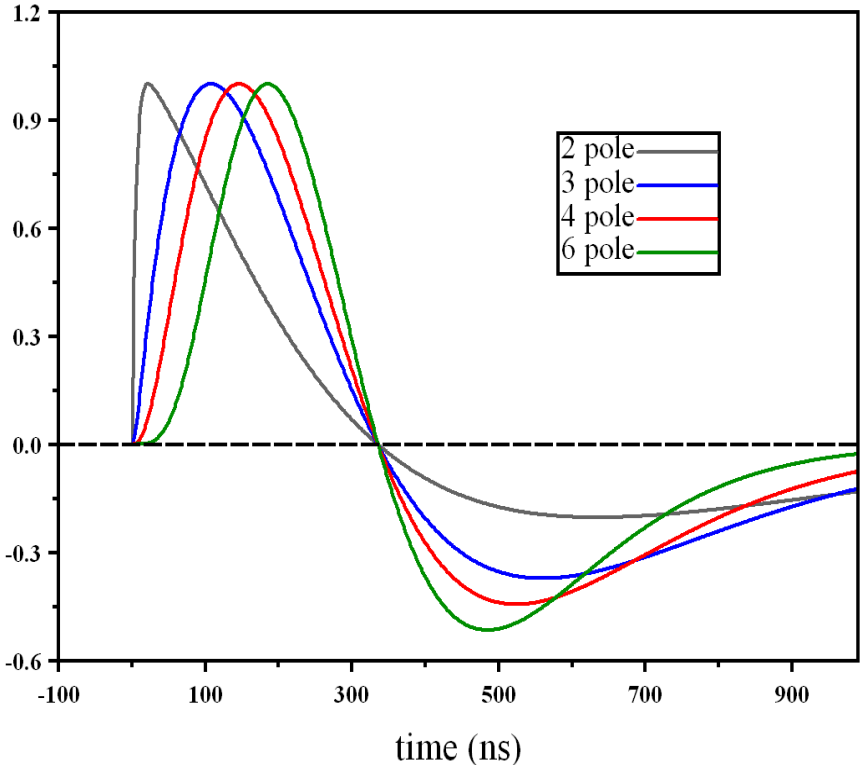
Optimisation of PSAmplifier design

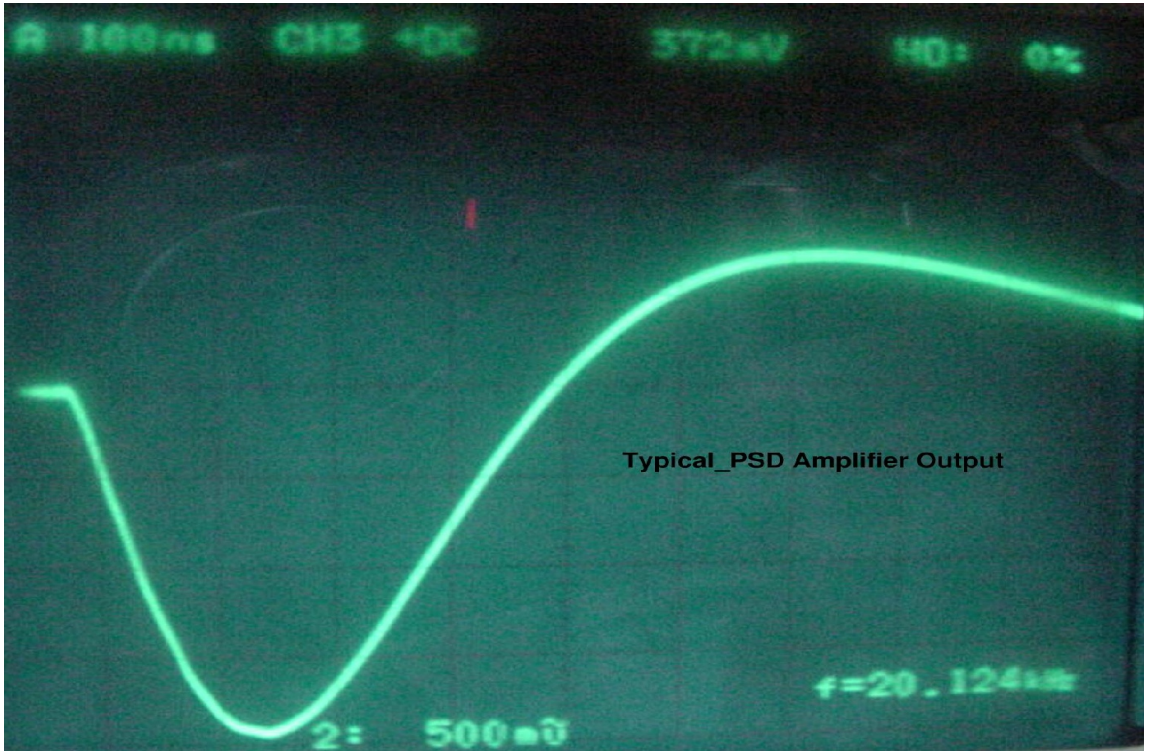


* 4 Pole filter network for Optimum Slope during Zero cross

FOM = (Tγ – T η) * Slope

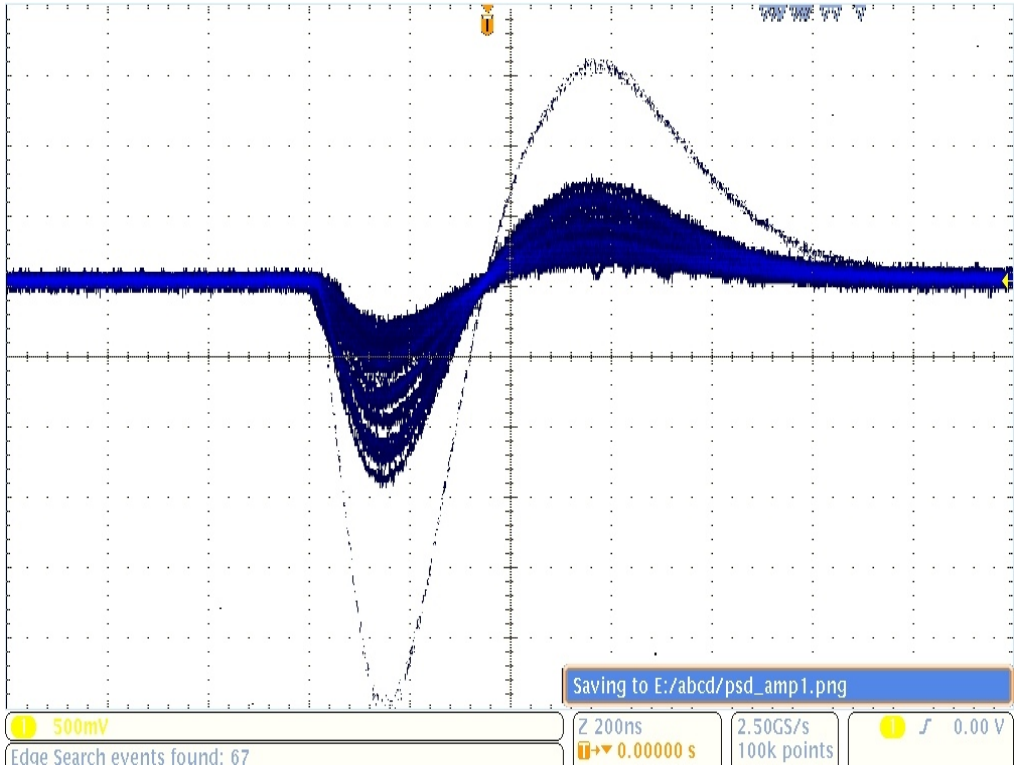
* (Tγ – T η) is less than 100nS

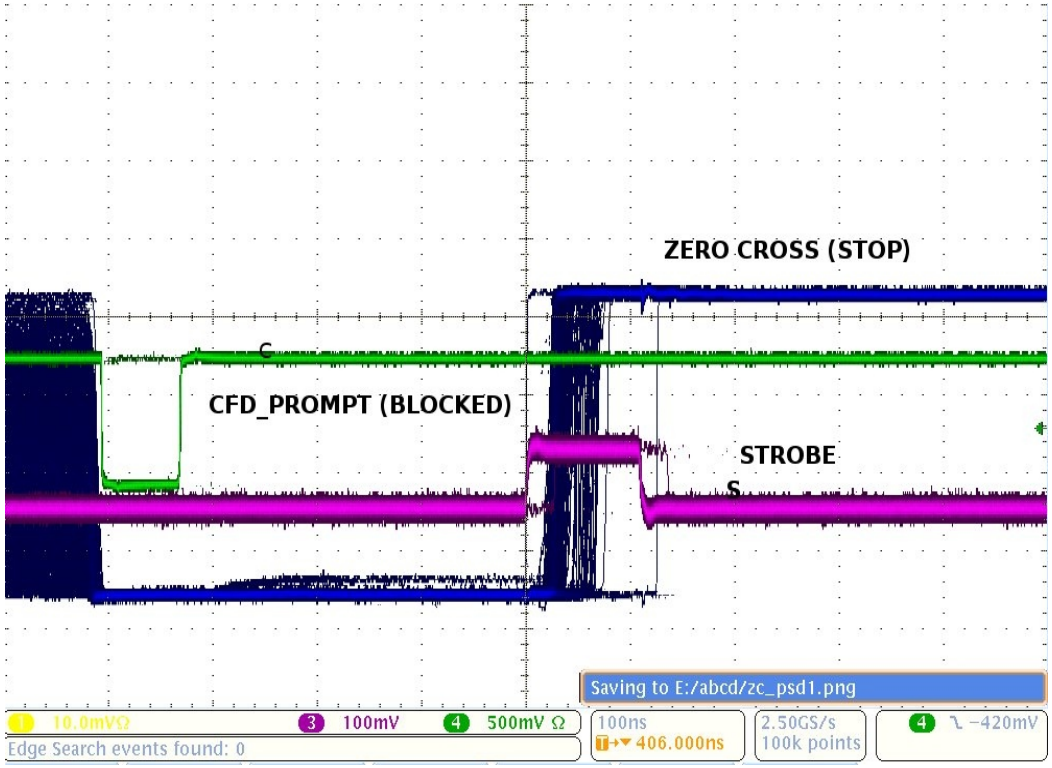




Pulse Shape Discriminator

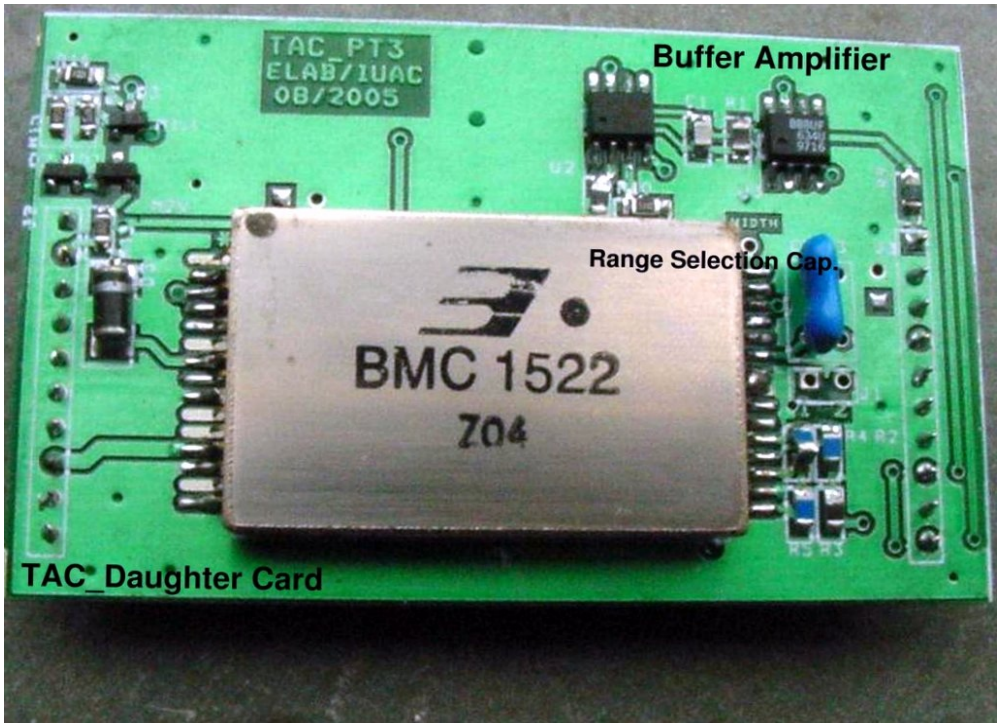
* High Dynamic range Amplifier upto10V.
* Low Noise, High Slew rate Device Used.
* Bipolar Shaping of ~ 300nS Selected.
* Protected against NOISE pick-up
* Ultra fast Comparator for (STOP) Logic generation.

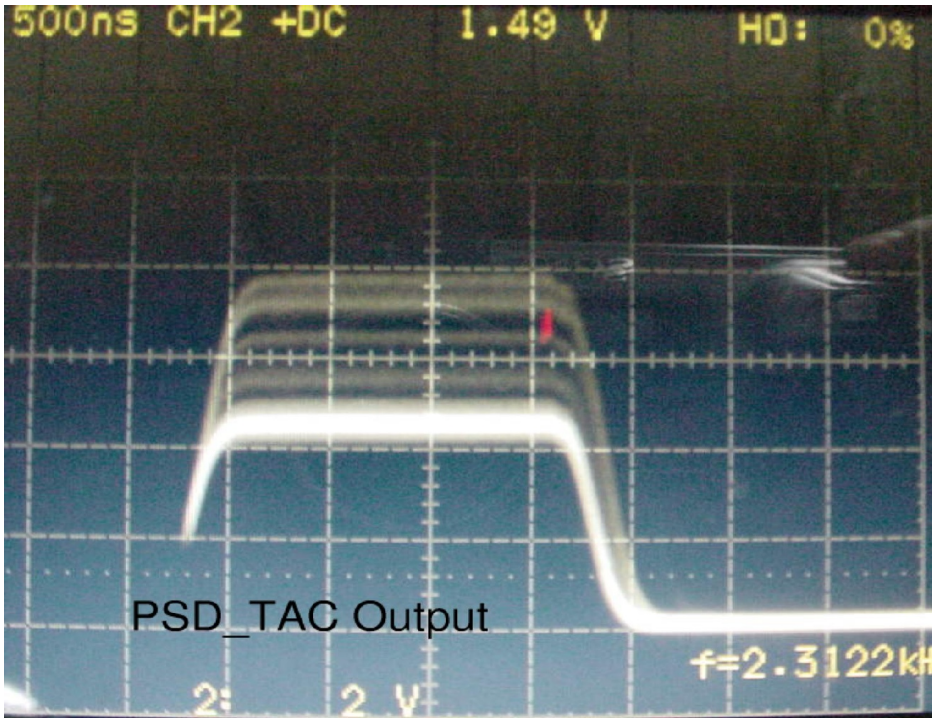




TIME TO ANALOG CONVERTER

* A BEL HMChip used
* Ranges: 100nS/ __ in 0-5V>>> 0-10V with Buffer
* Stand alone TAC module with F/NIM Inputs
* Resolution : 50pS
* Stability : 120 pS to 30pS (3 to 24 Hrs.)
* Best low cost solution.
*Thanks to BARC, BEL





Gate & Delay Generation

* Involves ECL Fast Monostable Multi vibrators
* Presently utilises ONSEMI MC10198P
* Operated at optimum charging current
* Equivalent circuit under development to replace Obsolete part.

Test Set-up for Performances

The Set-up prepared to evaluate following performances of both Commercial, IUAC made modules.

* Neutron Detectors, Cf-252 Strong source used

* Plastic Detector, Cs-137 used for TOF test results

*4K Philips ADC, Freedom as DAS

* FOM @ Various Energy gates

* Timing Performances

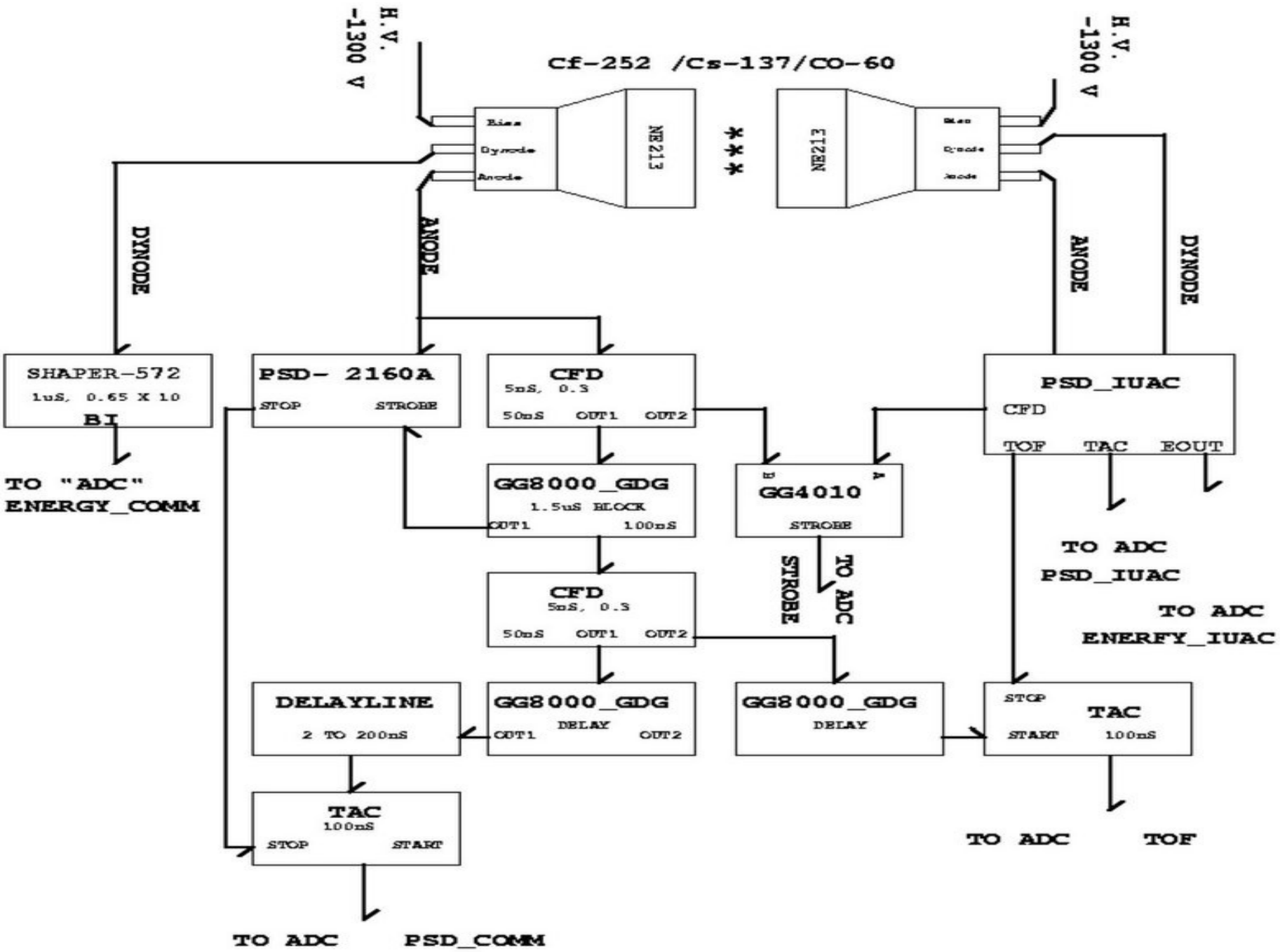
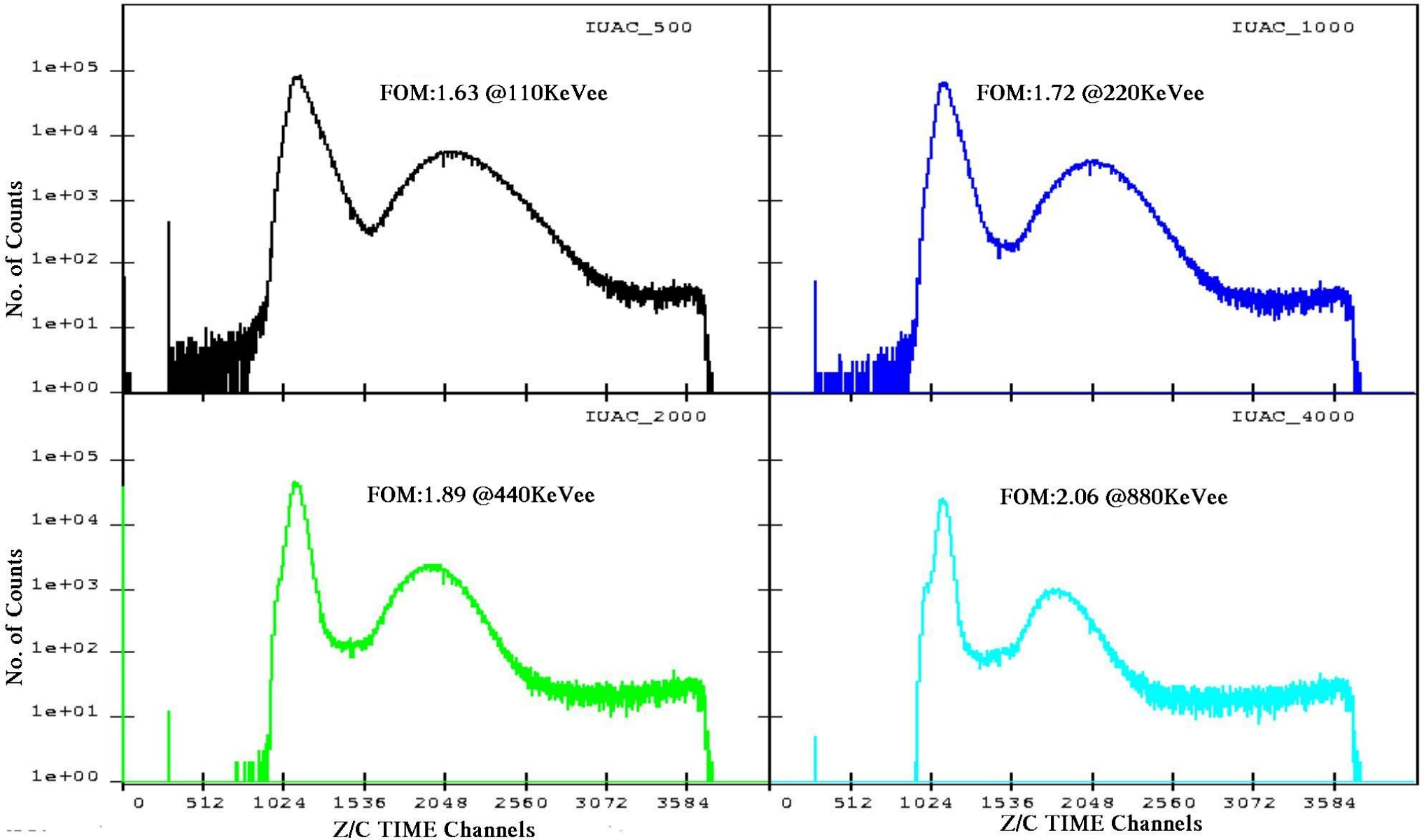


FIG: TEST SETUP FOR PSD ELECTRONICS

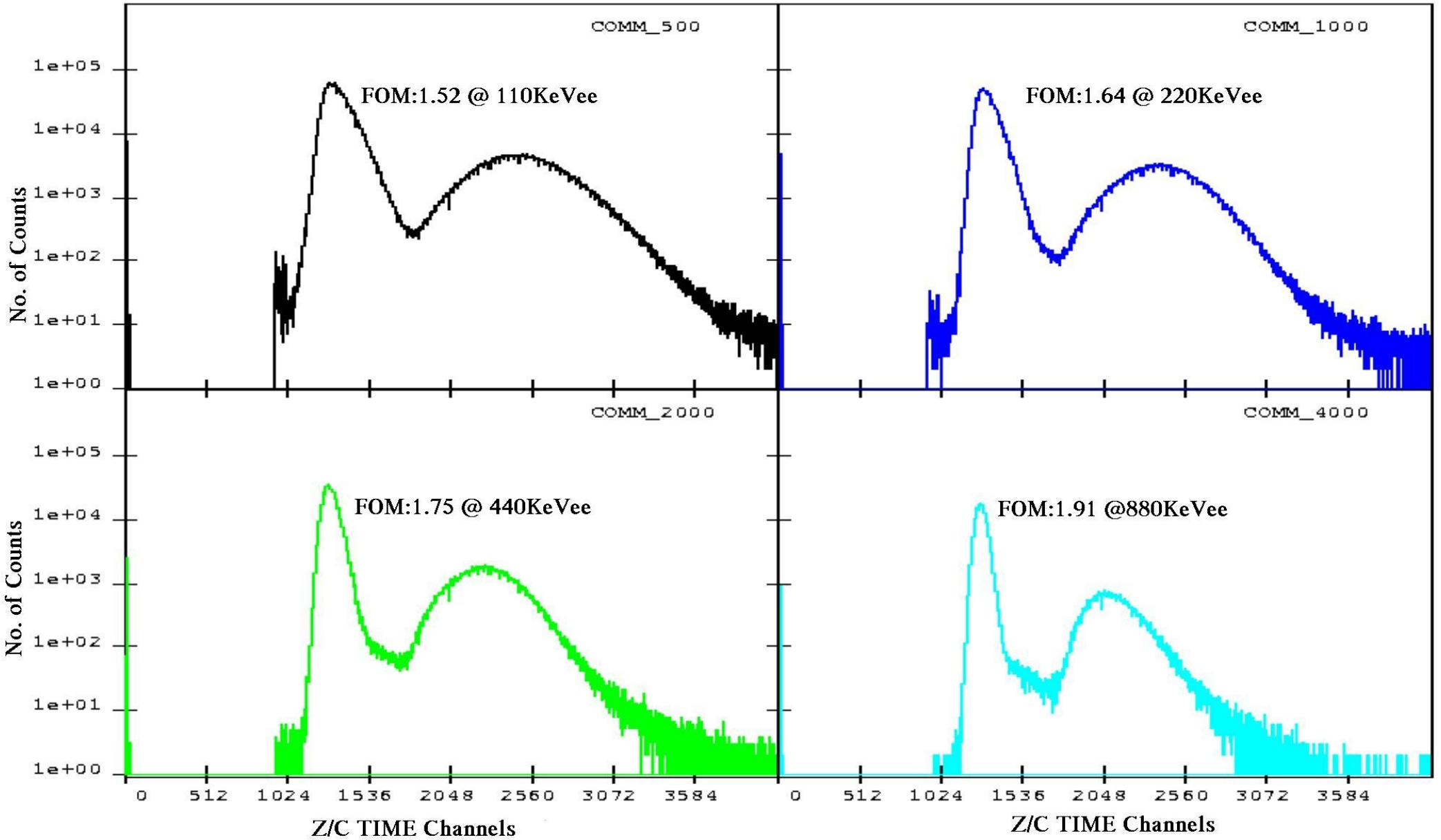
Performance Results: FOM (IUAC)

The n-γ Discrimination spectra for various Energy gates set.



Performance Results: FOM (COMM)

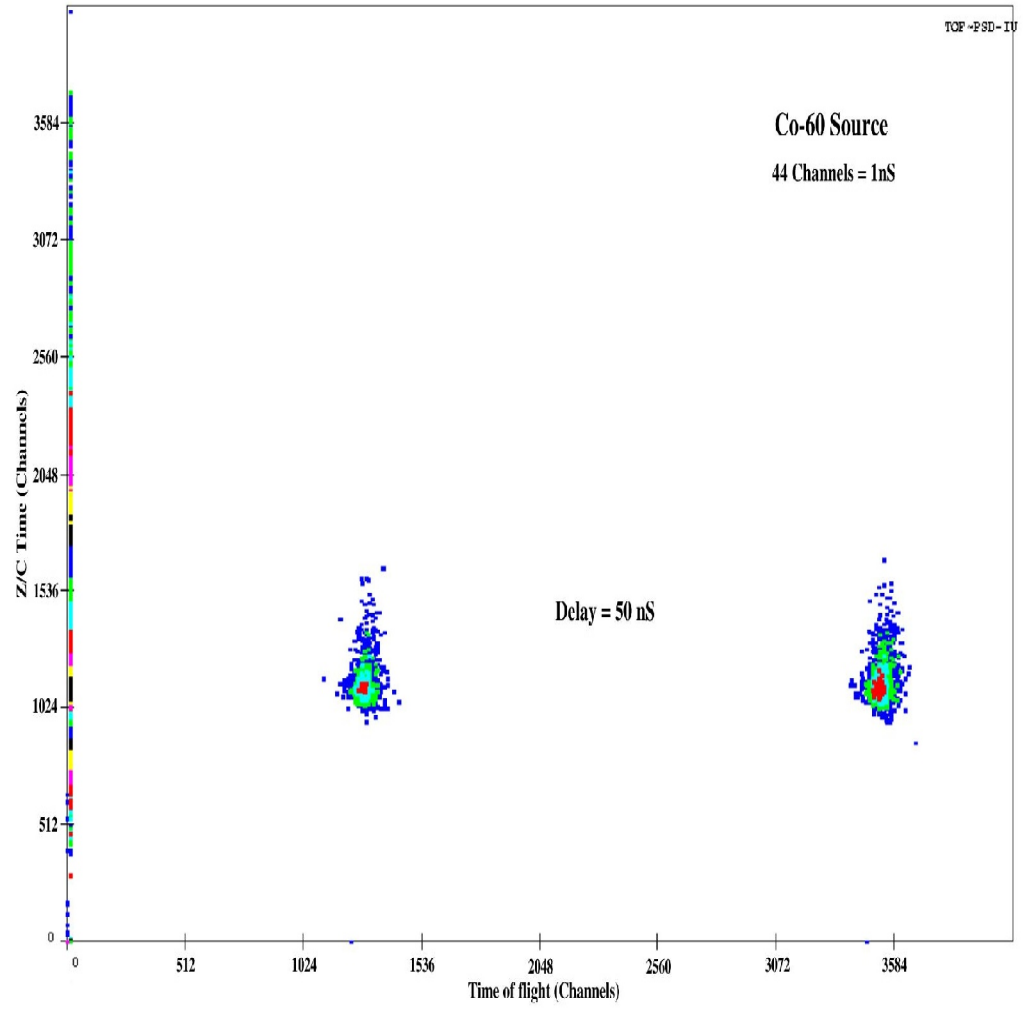
The n-γ Discrimination spectra for various Energy gates set.

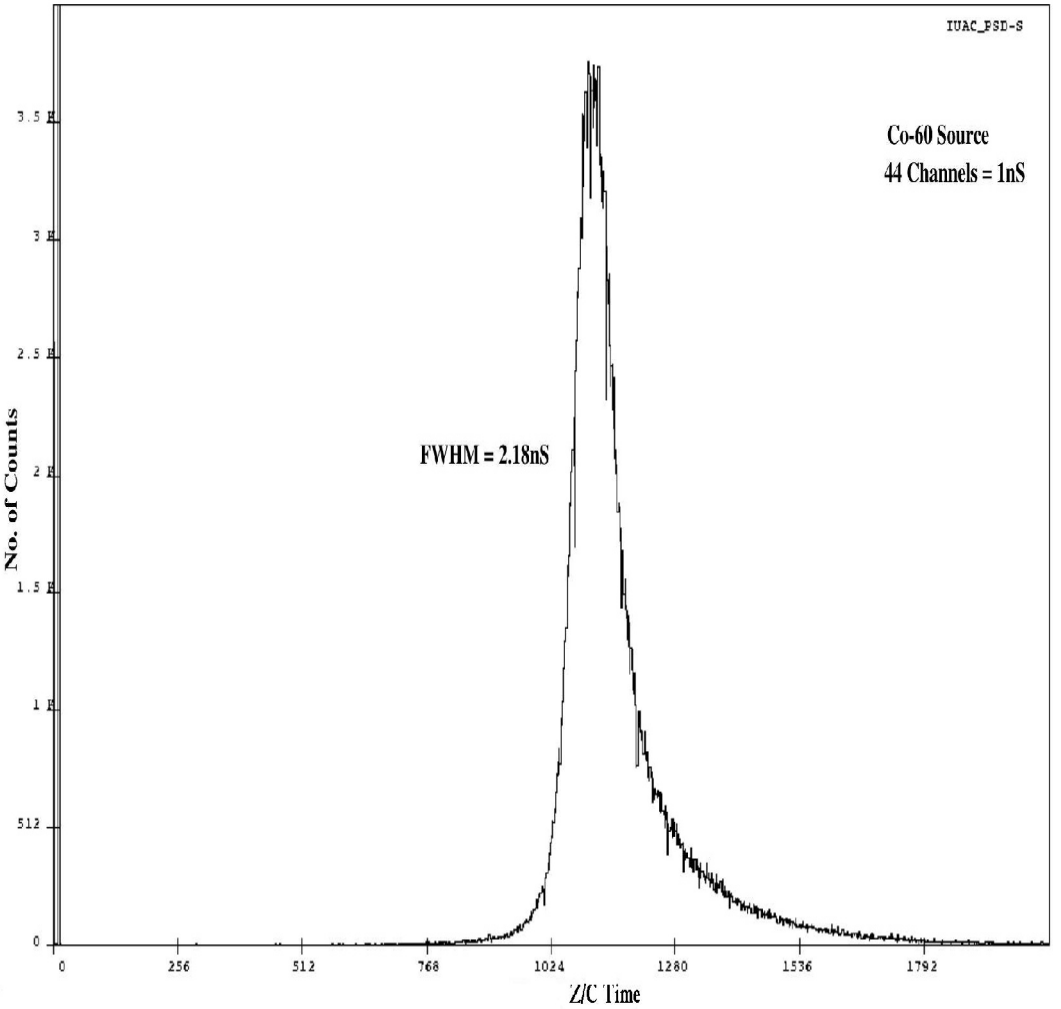


Time of Flight – TOF (IUAC-COMM)

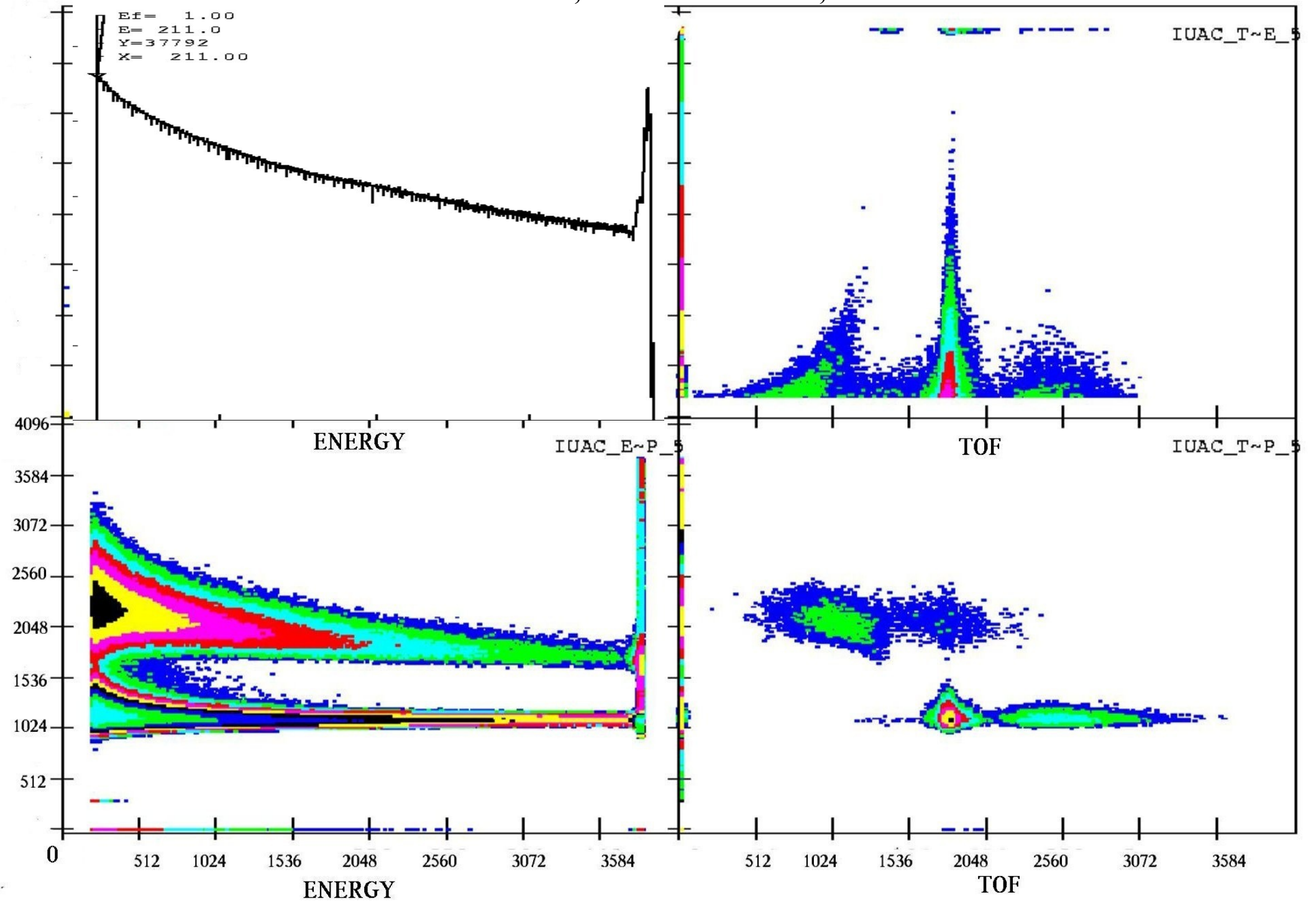
The performance for timing tested with γ radiation source Co-60.

* FWHM : 1.2 nS PSD: FWHM : 2.18nS

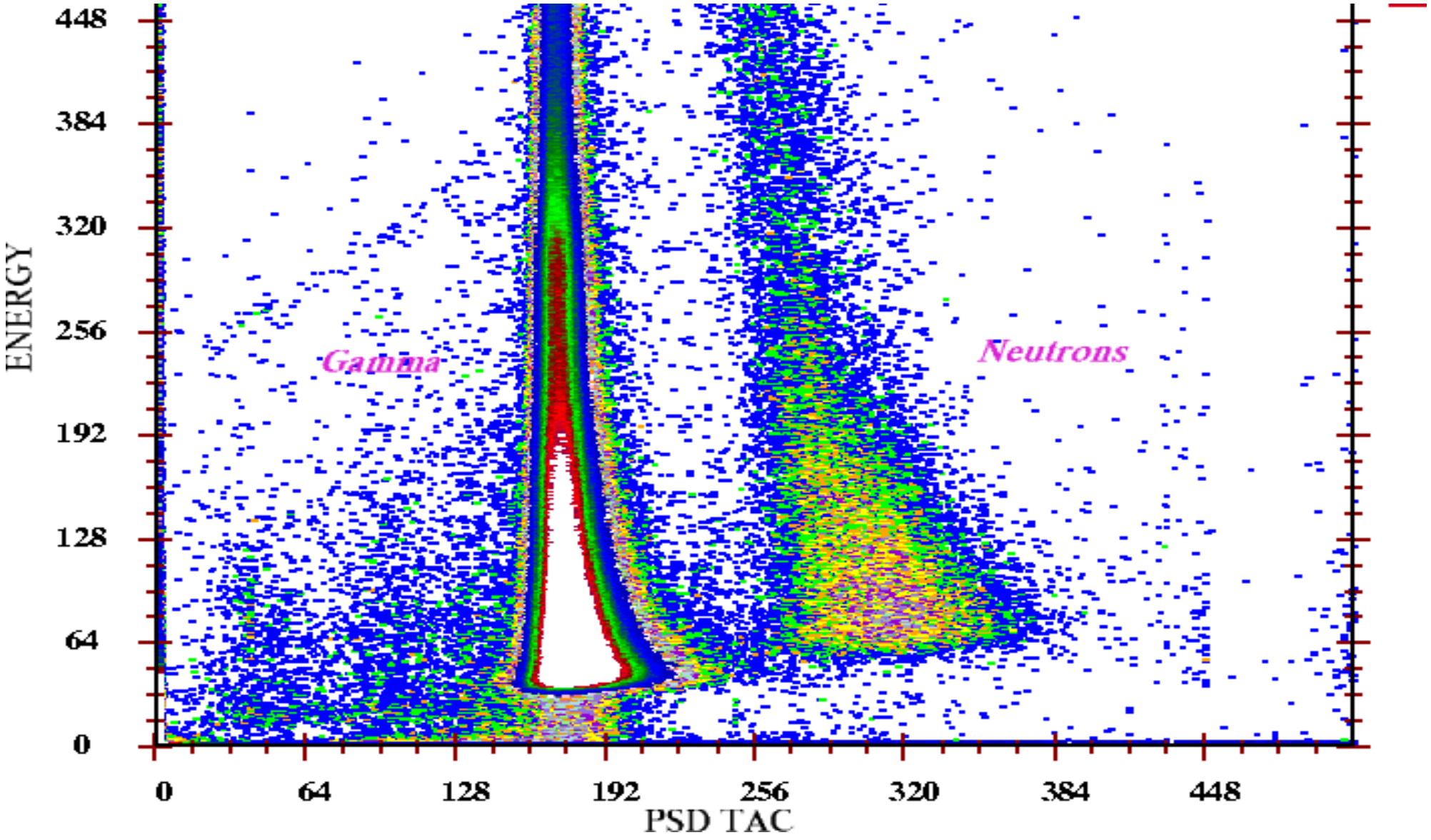




LLTH: 110KeVee, Neutron detectors, Cf-252



Result from NAND with Beam (Si +Ta)
FOM:1.5 @Eee=500KeV



Comparison of Results

The Performances of PSD electronics compared with
- Other PSD Electronics used

FOM

Eee	**Neutron Wall**	**IUAC**	**DEMON***	**Comm**
50KeV	**	1.19	**	1.23
110KeV	1.15	1.3	1.09	1.24
240KeV	1.54	1.4	**	1.27
300 KeV	**	1.6	1.65	1.36
500 KeV	1.84	1.63	**	1.48
1MeV	2.1	1.72	2.05	1.64

*** Demon: Charge Coparison method used**

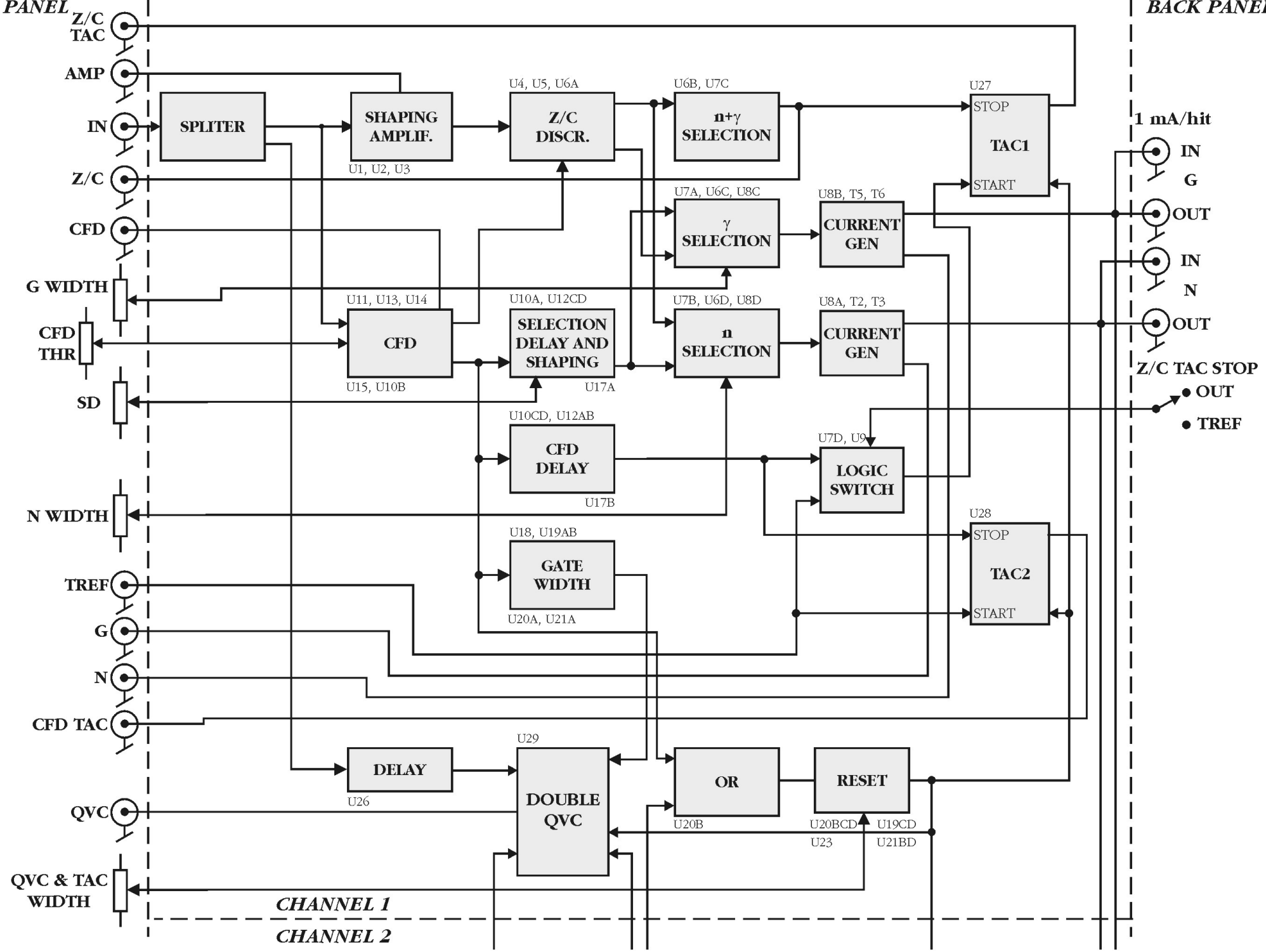
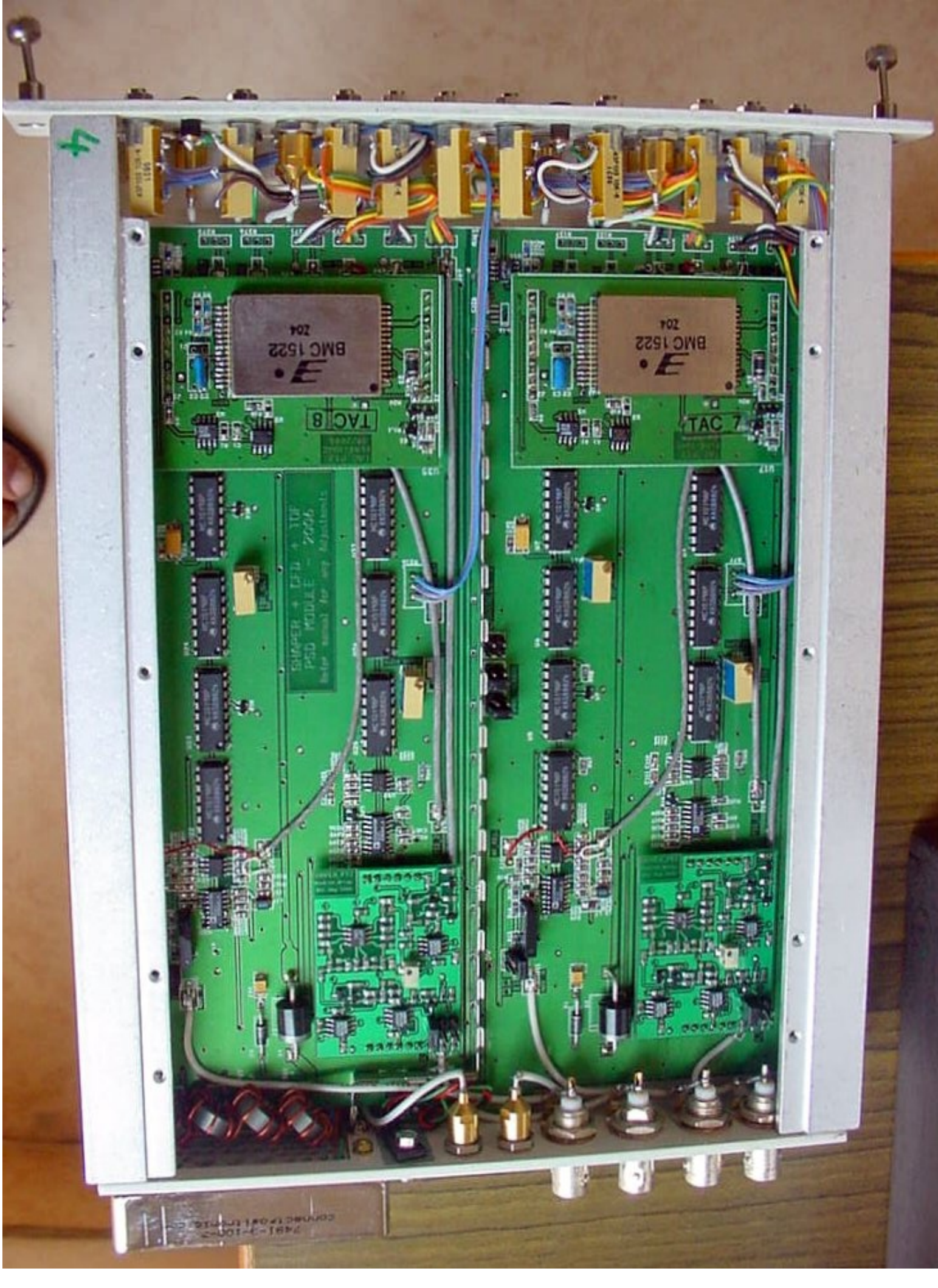


Fig. 1 Block scheme of one channel


BMC 1522
Z04
TAC 8
BMC 1522
Z04
TAC 7


IUAC
EOUT
GAIN
1
LLTH
WALK
CFD
TOF
PSD
Z/C
STB
DLY
TAC
EOUT
GAIN
2
LLTH
WALK
CFD
TOF
PSD
Z/C
STB
DLY
TAC
NEUTRON ARRAY ELECTRONICS


ANODE DYNODE 1
ANODE DYNODE 2
STOP:1
STOP:2
IUAC/

Development & Production Plans.

* So far 3 Prototypes have been developed and Problems are being rectified.

* Plan to make additional 20 Channels Yr- 2007

* Oral Presentation in DAE-2006

Future Nuclear Electronics
CsI + Photodiode- Electronics Development
General Purpose Modules....

Acknowledgement

Sincere Thanks to all those individuals and firms participated in the successful implementation of these projects

Thanks to the Organisers of this symposium for giving this opportunity