INGA & NAND Instrumentation at IUAC

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Design, Development & Implementation of

* Compact & High density Electronics
* Front end Analog & Logic circuits
* Pre-amplifiers, Shapers, TFA, CFD, TAC...
* Replacement for Commercial units
* Implementation for Large scale for Arrays
* Knowledge share & transfer
Why Develop Electronics here?

- Conventional NIM & CAMAC DAS set-up
- General purpose modules (commercial) are complex, under utilised
- Power, real estate, unreliable operation...
- Cost for large array
- Expertise.. in order to repair / maintain
- Develop Electronics as per user specifications with Performance at par commercial units
- >200 Signals (INGA), >140 signals (NAND)
INGA_ Indian National Gamma Array

- 24 Nos. Array of HPGe Clovers
- Compton Suppressed (ACS)
- National Collaborative Project
- IUAC, UGC-DAE, TIFR, BARC, SINP, VECC
- High quality signal Processing required
- Optimum utilisation of infrastructure
INGA-Clover Electronics Module

Double width NIM Cabinet

FIG: BLOCK DIAGRAM OF CLOVER ELECTRONICS
Features
- Double width NIM module
- 4 Modules in a NIM (200W) crate
- 4 Nos. Shaper cards
- 5 Nos. Timing Filter Amplifiers + CFD cards
- 1 Anti coincidence logic card
- Motherboard..Interconnections high stability Control voltage generation, DC distribution
- Time equaliser- Propagation delay equalisation
- 2 Layer PCB for easy duplication
Spectroscopy Amplifier

- 3μS, semi-Gaussian shaper (uniPolar)
- 3 gain ranges (2/4/6MeV) ~10V
- OL recovery
- Gated BLR (manual setting)
- Voltage controlled parameters are BLR LLTH, P/Z Adjustment
- PUR built-in Indication Logic
- Size: 4” x 1.5” x 1/2”
Tested with HPGe Clover- $^{60}$Co,$^{152}$Eu

~9Kcps

**Resolution:** 1.3KeV @122KeV, 2.0KeV@1408KeV

**Linearity:** +/-100eV ie. ~0.01%

**Peak Shift:** Better than 0.025% shift in 24 Hrs for 1408keV peak
TFA + CFD Card

- Optimised for HPGe Clover
- Fixed $\zeta_i, \zeta_d$ constants
- Fixed gain 1V/MeV (-2.5V)
- BLR_ Robinson diode type
- $T_d$: 25 nS, $F=0.3$
- LLTH : 1:100
- $T_{block} = 1.5 \mu S$
- 2 Nos CFD (F_NIM)
- ACS type : Prompt only (500nS)
Anti-Coincidence Logic

- Raw Timing HPGe & ACS are processed for PTR
- Anti-coincidence between HPGe - AC Shield is indicated
- MASTER GATE Accepted
- OR_ Prompt, TOF logic generated
- Individual ADC GATE, PUR logic
- LED indication
ACLogic card, ADC Gate, Unipolar output
Status

- Successfully used with INGA campaign at VECC
- Part of Super clover detector at GSI, Germany
- Modified version have added features
- Mass produced with better exterior finishing for INGA at IUAC
- Know-how shared with collaborators
- Superior quality Shaper for LEPS being developed
NAND-National Array of Neutron Detectors

- ~30nos. Neutron detectors with LINAC
- 5”x5” NE213 Scintillation detector, PMT: XP-4512B (Philips)
- High quality gamma, neutron separation
- Zero-cross technique PSD
- Compact (1W-NIM), cost effective electronics
NAND Electronics Module

- 1 width NIM Module, 2 Channels
- Energy & Timing signals processed
- Shaper for Dynode signal- 'E'-Calibration
- C F Discriminator
- Pulse Shape Discrimination (Z/C method)
- GDG, Built-in TAC$, TOF Logic

$ BARC developed BMC 1522 (BEL) ASIC
Fig: Block Diagram of PSD Electronics

- **F** = 0.2, **T_d** = 5nS
- **T_s** = 300nS (Z/C)
- **T_{AC}** = 100nS

- **ANODE IN**
  - **SPLITTER**
    - **LOW LEVEL DISCRIMINATOR**
    - **CONSTANT FRACTION COMPARATOR**
    - **LLTH WALK**
      - **LOW LEVEL DISCRIMINATOR**
      - **ARM_GATE**
        - **DEAD TIME CIRCUIT**
          - **DELAY**
            - **LEVEL CONVERTER**
        - **PSD DELAY**
          - **STROBE ADJUST**
            - **START & RESET GATE**
              - **TIME TO AMPLITUDE**
                - **TAC_PSD**
                - **TAC_STOP**

- **DYNOODE IN**
  - **CSA Preamplifier**
    - **BIlus SHAPER**
      - **ENERGY OUT**
      - **GAIN**
Zero Cross Method

* Large Dynamic range
* Requires Timing electronics
* Incorporates TOF measurements

Differentiation- Bipolar & Zero cross over Pulses

Different $\xi$ decay pulses cross ZERO LINE @ different times
Optimum Pulse shape $\sim$300nS ($\xi$s-Z/C) generate STOP for TAC

TIME Reference: CF Discriminator for START/GATE generation

TAC: Linear Spectrum corresponding to gamma & neutron
PSD Test Setup

* Pulse shape discrimination studied with $^{252}\text{Cf}$ spontaneous fission source

* Light output calibration done with standard $\gamma$ sources ($^{137}\text{Cs}$, $^{60}\text{Co}$, $^{22}\text{Na}$)

* Timing performance tested in TOF set up with fast plastic scintillator

* Compared performance with commercial modules

Figure of Merit (FOM) is

$$\text{Peak separation} / \text{Fwhm } \gamma + \text{Fwhm } \eta$$
PSD for Gamma and Neutron with different threshold

**IUAC_500**
- FOM: 1.63 @110KeVee

**IUAC_1000**
- FOM: 1.72 @220KeVee

**IUAC_2000**
- FOM: 1.89 @440KeVee

**IUAC_4000**
- FOM: 2.06 @880KeVee
<table>
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<th>IUAC$</th>
<th>DEMON*</th>
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* Demon: Charge Comparison method used

$ Calibration : 120 keVee ~ 500 keV η neutron energy

Reference: O.Skeppstedt et al NIM (A) 421 (1999) 531-541
Fig: ENERGY Vs PSD with two Neutron detectors
Source: Cf-252, Two Neutron detectors used
LLTH: 110keVee

Fig: 2D Plot of Energy Vs PSD
LLTH: 120keVee $^{252}$Cf
Time of Flight with Plastic Detector (START)

TOF: Fwhm: 1.2nS
2D Spectrum TOF vs PSD_Z/C
Added delay 50nS

Co-60 Source
44 Channels = 1nS

Delay = 50 nS
Status

- Adopted for existing NAND array of ~30 Detectors
- Successfully implemented and used with Linac beam
- Modified module to be adopted for BARC - Si PAD detector
Acknowledgement

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