Imaging X-Ray Detector Front-end with High Dynamic Range: IDeF-X HD

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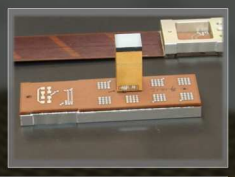
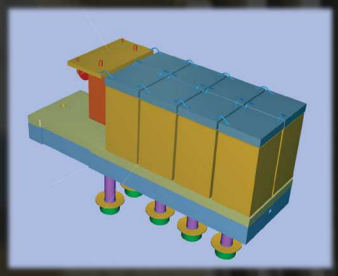


OBJECTIVES

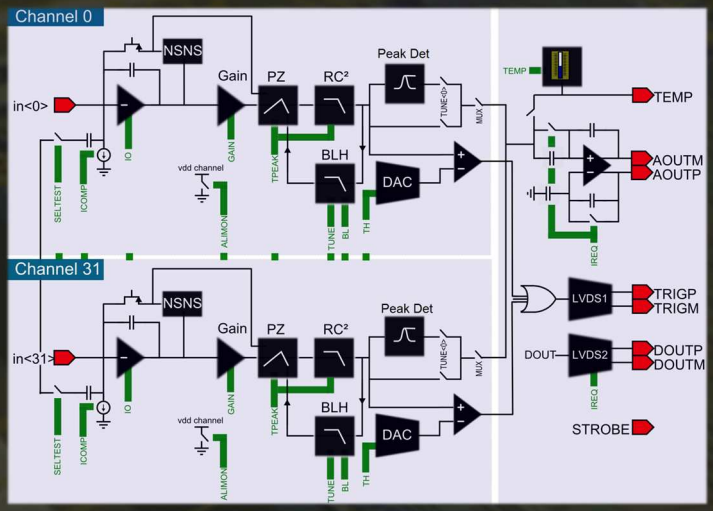


MACSI (Modular Assembly of Caliste Spectro-Imager) gamma ray camera module with large focal plane array

2048 pixels, 8 Caliste 256 modules

IDeF-X HD is designed for MACSI mini gamma-ray camera for spectroscopy in space applications with high spectral resolution (FWHM<1keV @ 60keV).
Presented ASIC is a new CMOS readout circuit realized in AMS 0.35µm. It is a low noise, low power, 32-channel front-end with self-triggering capability.
The circuit is aimed for readout of pixelated Cd(Zn)Te with 625µm pitch. It is optimized for input capacitance of 2pF and 20pA dark current.

ASIC DESIGN



Scheme of the chip : *each channel includes: continuous reset CSA with variable current, Non stationary noise suppressor (NSNS), pole-zero cancellation stage (PZ), gain stage, shaper (RC²), baseline holder (BLH), peak detector, discriminator with individual 6 bits threshold. Many parameters are tunable via serial link : gain (dynamic range), peak time, dark input current (I_{LEAK}), discrimination threshold, test mask …*

Three readout modes are achievable : hit channel only, "on demand", all channels.

Main characteristics of the chip:

Technology	**CMOS AMS 0.35µm**
Channel	**32**
Power supply	**3.3V**
Typical power consumption	**26mW (800µW/channel)**
Polarity	**Anode**
Conversion factor	**50-200 mV/fC (programmable)**
Dynamic range (charge)	**225 ke⁻ (1 MeV)**
Discrimination threshold	**90 e⁻ → 2.3k e⁻**
Peak time	**0.7µs → 10.7µs**
Temperature sensor	**1.5°C at -45..20 °C**

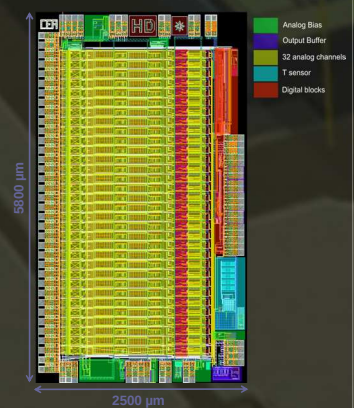


Image of IDeF-X HD *SEL hardened design in the standard CMOS AMS 0.35µm technology*

RESULTS

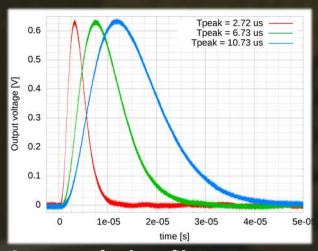
Functionality

Power consumption:

- ASIC total: 26mW
- Per channel: 0.8mW

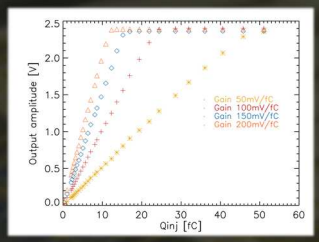
Peak time:

- The pole zero cancellation stage operates at all peak times
- Gain constant with peak time
- No variation of the baseline with I_{LEAK} 0.1pA .. 4nA



Output of the filter stage at different peak times, (gain=200mV/fC, I_{LEAK}=20pA, Qin=3.2fC)

Transfer function

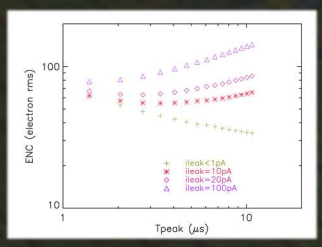


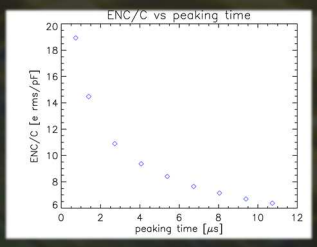
Gain MEASURED [mV/fC]	Dynamic range [fC]	Dynamic range CdTe [eV]	INL [%]
51.8	36	993 k	1.19
102.2	22	607 k	1.39
152.5	13.5	372 k	1.04
203.8	11	303k	1.16

Transfer function (I_{LEAK}=20pA, t_{PEAK}=10.7µA, at filter output)

❖ Dynamic range up to 1MeV with CdTe

Equivalent Noise Charge





Dark current

ENC measurement results at 4 different input currents levels (ileak).

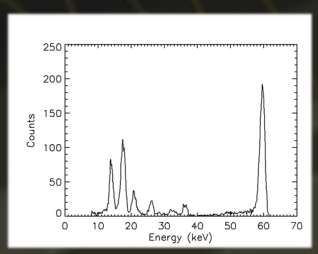
❖ ENC min = 33 e⁻ rms *(750 eV FWHM for CdTe) obtained at the leakage current below 1pA and peak time 10.7µs.*

Input Capacitance

The curves ENC=f(Cin) are fitted to extract the slopes ENC/Cin at different peak times (I_{LEAK}=20pA). The slope is plotted against the peak time.

❖ Minimal slope=6e⁻/pF

Spectroscopy measurements

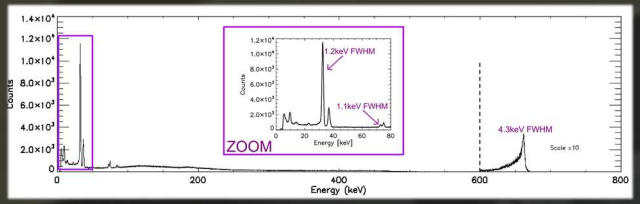


^{241}Am

❖1.01 keV FWHM at 14 keV
❖1.11 keV FWHM at 60 keV

^{137}Cs

❖4.3 keV FWHM at 662 keV



CdTe schottky 2x2x2mm³ with Guard Ring, vbias = -1020V, T=-10°C