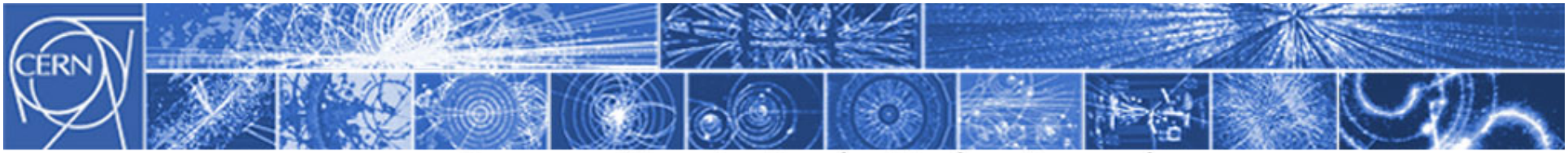


CERN
European Organization for Nuclear Research
Organisation Européenne pour la Recherche Nucléaire

Fast Counting mode front-end electronics

Danielle Moraes, Jan Kaplon
CERN, CH-1211 Geneva, Switzerland.

E. Nygard
Interon AS, N-1386 Asker, Norway.

Index

Motivation

Fast and low noise front-end electronics for the readout of compound semiconductors

- Cadmium-Telluride (CdTe)
- Cadmium-Zinc-Telluride (CdZnTe)

High flux x-ray applications, such as Computed Tomography machines

Background

- Amplifiers developed for the readout of silicon strip detectors for the ATLAS SCT detector.

Counting Mode Family

3 Application Specific Integrated Circuits

Technology: CMOS 0.25µm

128 channels per ASIC

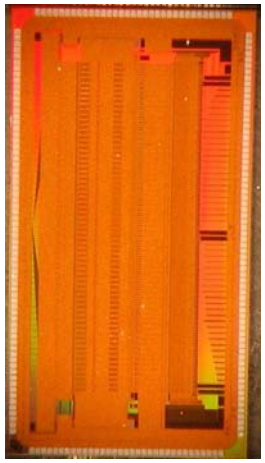
Each front-end channel comprises four basic blocks:

- Amplifier
- gain-shaper stage
- Discriminator
- Counter

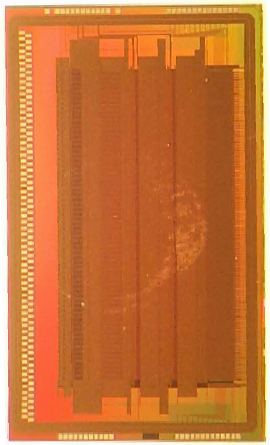
Different chip layout

Similar channel architecture

CERN_CZTGE_128AC



CERN_DxCTA

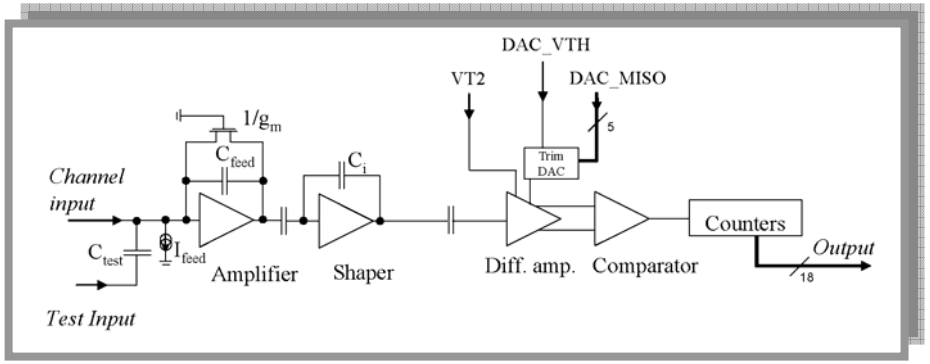


CERN_DxRuCT_128AC

Counting Mode ASIC Circuits

1) *CERN_CZTGE_128AC*

- Peaking time = 50ns
- Single Discriminator and 18-bit counter
- ASIC size = 7.5mm x 4.0mm

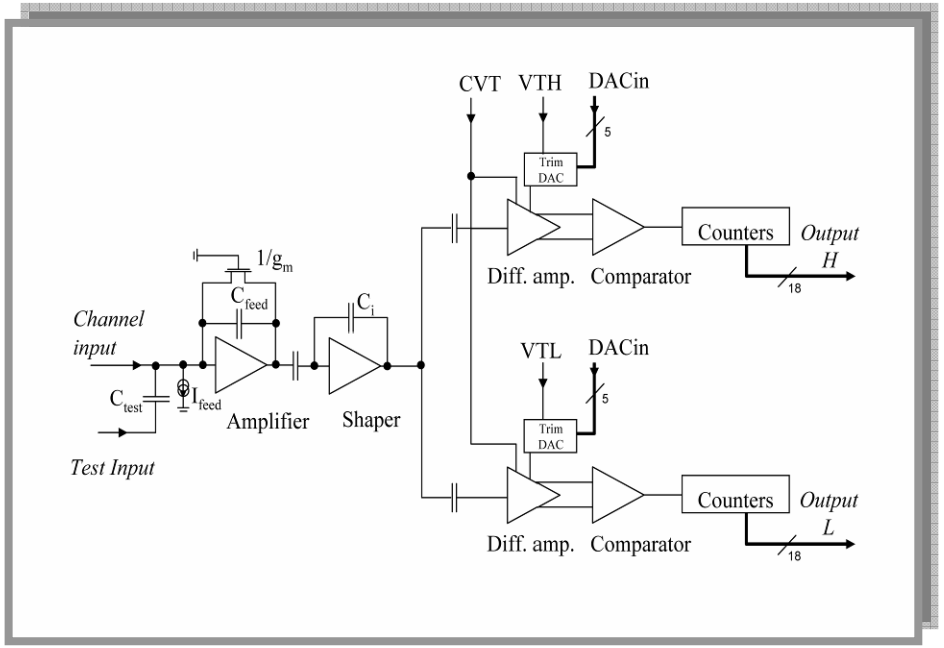


2) *CERN_DxRuCT_128AC*

- Peaking time = 50ns
- Double Discriminator and counter structure
- ASIC size = 7.5mm x 5.2mm

3) *CERN_DxCTA*

- Peaking time = 25ns
- Double Discriminator and counter structure
- ASIC size = 8.5mm x 5.0 mm
- One analog test channel

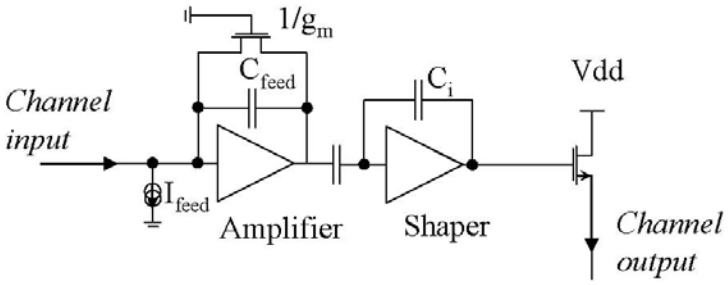


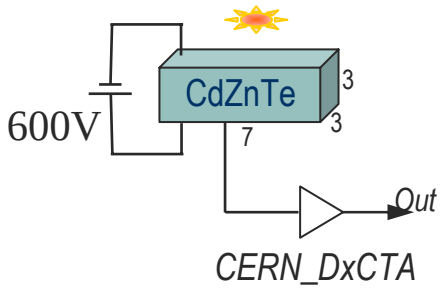
Main Characteristics

Power consumption = 2.1mW/ch

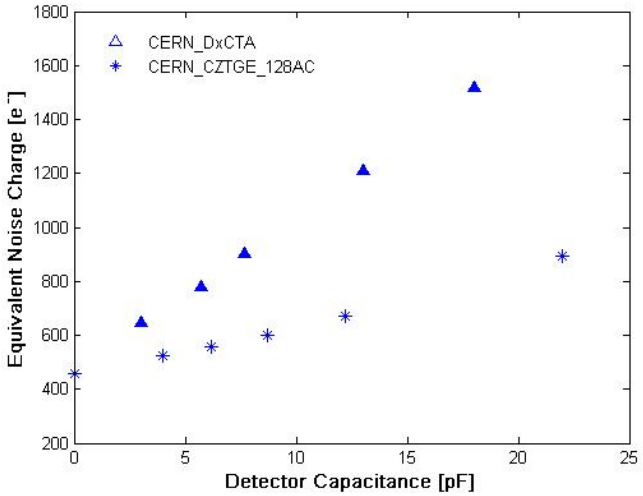
	CERN_CZTGE_128AC	*CERN_DxRuCT_128AC*	*CERN_DxCTA*
$C_{Detector}$	10 pF	10 pF	5 pF
Peaking Time	50 ns	50 ns	25 ns
Gain	264 mV/fC	155 mV/fC	144 mV/fC
ENC	650 e^-	790 e^-	750 e^-
	analog channel	–	analog channel
	–	allow for an energy window	allow for an energy window
	pads on 4 sides	pads on 2 sides	pads on 3 sides

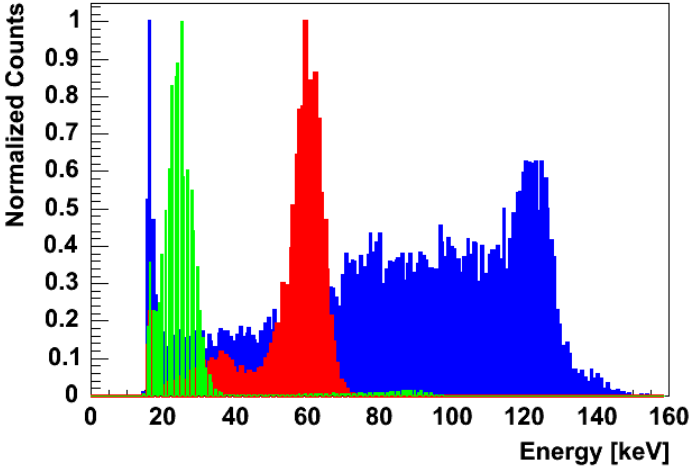
Analog Measurements





^{109}Cd – 22keV and 88keV
^{241}Am – 26.3keV and 59.6keV
^{57}Co – 122keV



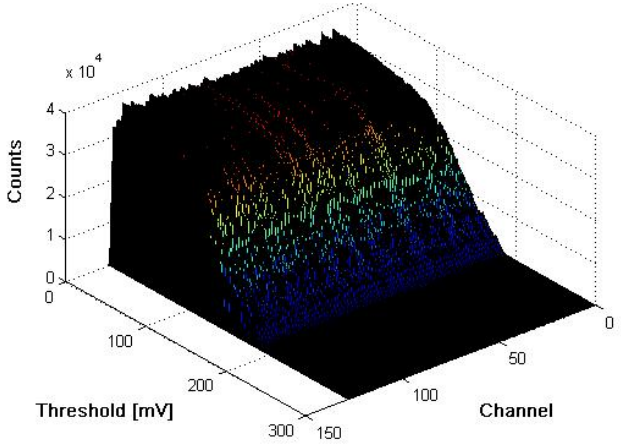


t_{Peak} = 25ns – ENC = 750 e⁻ @ 5pF
t_{Peak} = 50ns – ENC = 650 e⁻ @10pF

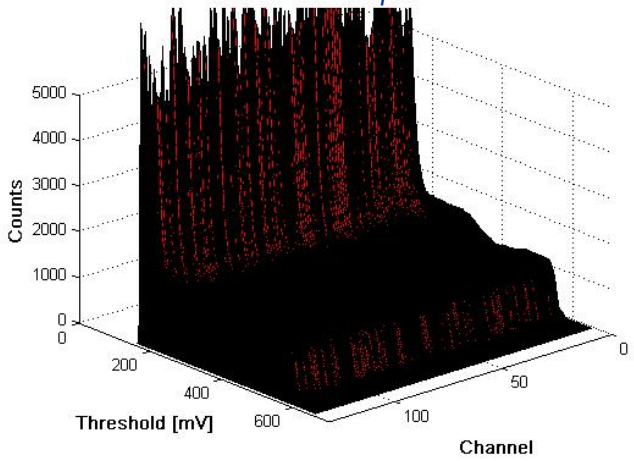
14 keV threshold

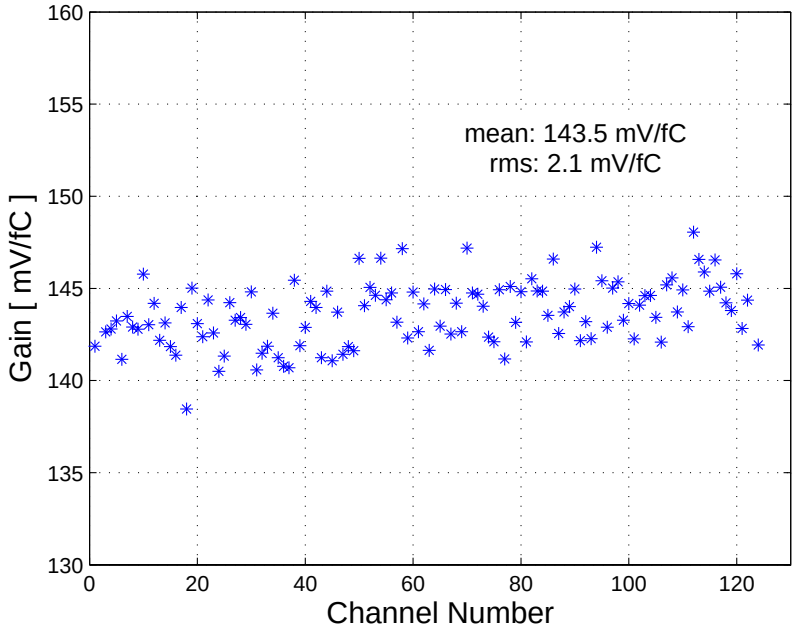
Full Channel Performance

Threshold scan of the noise



Threshold scan with Q_{input} ~19000 e^-





Distribution of gain across the 128 channels

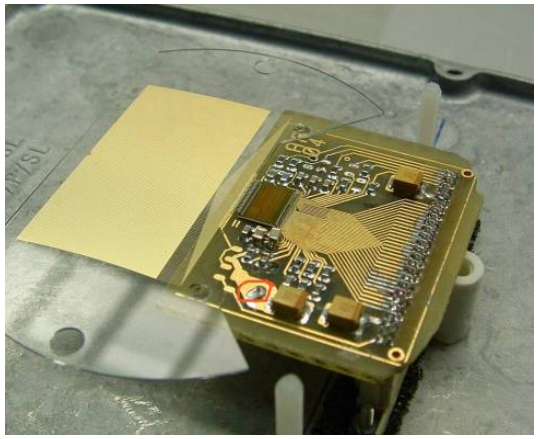
ch. – to – ch. variation = 1.5 % rms

Applications

The ASICS are currently being used on the readout of various detectors

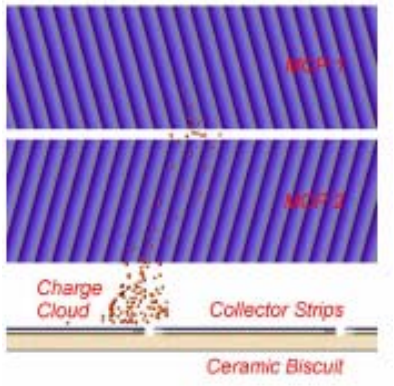
Readout of Micro Channel Plates

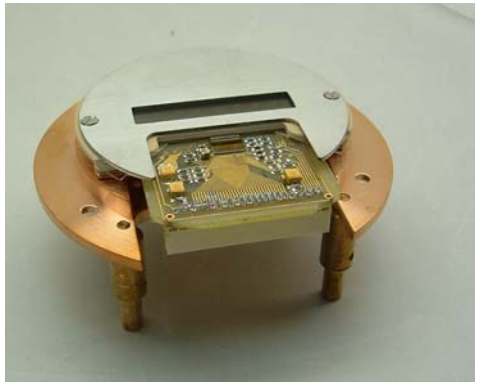
- Electron Spectrometer
- Three sub-assemblies:
  - electron transfer lens
  - energy prism
  - electron detector



1st prototype

- 128 collector strips
  - 20mm length
  - 300μm thick
- Chevron-pair of MCP
- Gap between 300 μm and 1mm





Measurements on going…

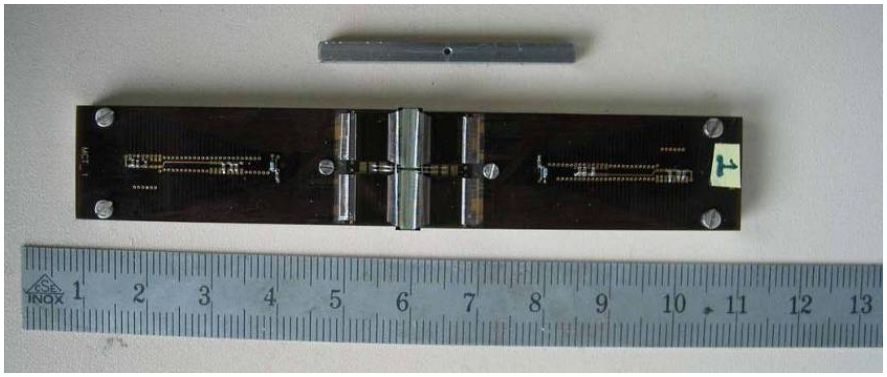
Applications

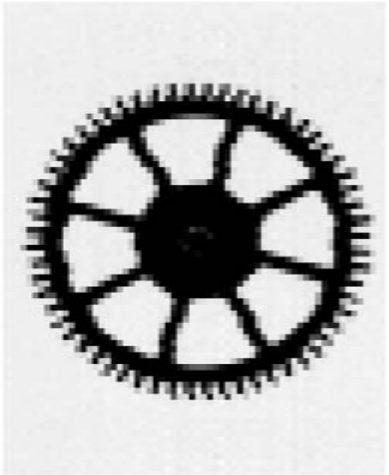
The ASICS are currently being used on the readout of various detectors

X-ray measurements with Silicon detectors

- 1mm thick
- 130μm x 130μm pixel
- 4 x 64 pixels

Module with 4 ASICs and 2 detectors

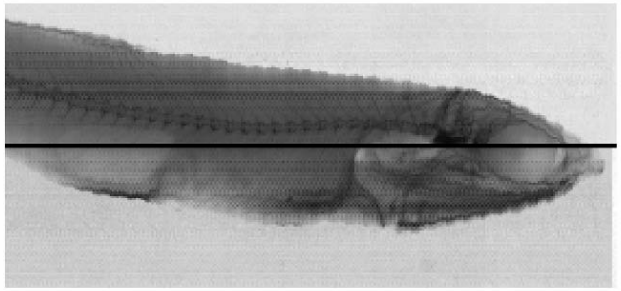




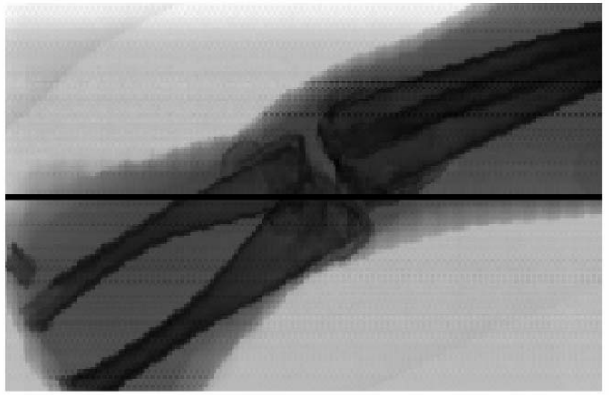
Present Applications

The ASICS are currently being used on the readout of various detectors

Small fish



Frog's leg



Applications

The ASICS are currently being used on the readout of various detectors

Readout of CdZnTe and CdTe crystals

- Good energy resolution and stopping power in room temperature
- Promising material for x-ray and gamma-ray imaging detectors

High flux of x-ray applications

New generation of Computed Tomography ?

- Direct conversion
- Counting mode
- Energy spectrum

Applications

The ASICS are currently being used on the readout of various detectors

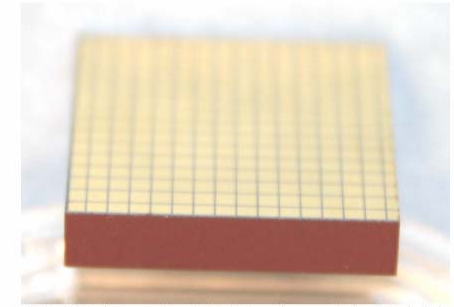
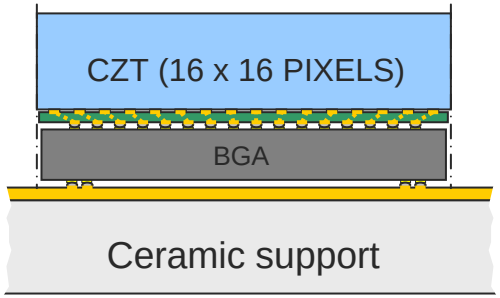
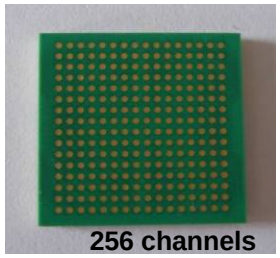
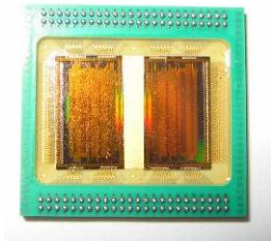


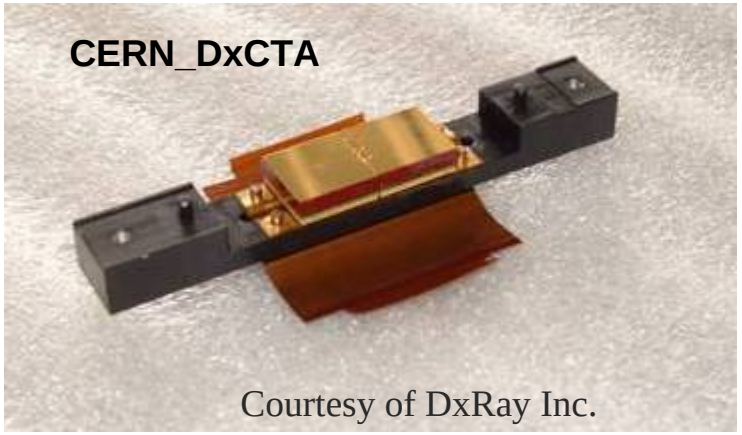
Fig.1: CdTe detector with a 256 pixels and no guard ring (pixel pitch = 1 mm).

- 16 x 16 pixels
- Centre pixels
  - 0.9mm x 0.9 mm
  - 0.1mm septa
- No guard rings
- Passivated lateral surfaces









- W.C. Barber et al., “Guard ring elimination in CdTe and CdZnTe detectors”, 2006 IEEE NSS/MIC Conference Record, Vol.4, p. 2414.
- A. Arodzero et al., “A System for the Characterization and Testing of CdZnTe/CdTe Pixel Detectors for X-ray and Gamma-ray Imaging” , 2006 IEEE NSS/MIC Conference Record, Vol.6, p. 3638.

Applications

Readout of CdZnTe crystals

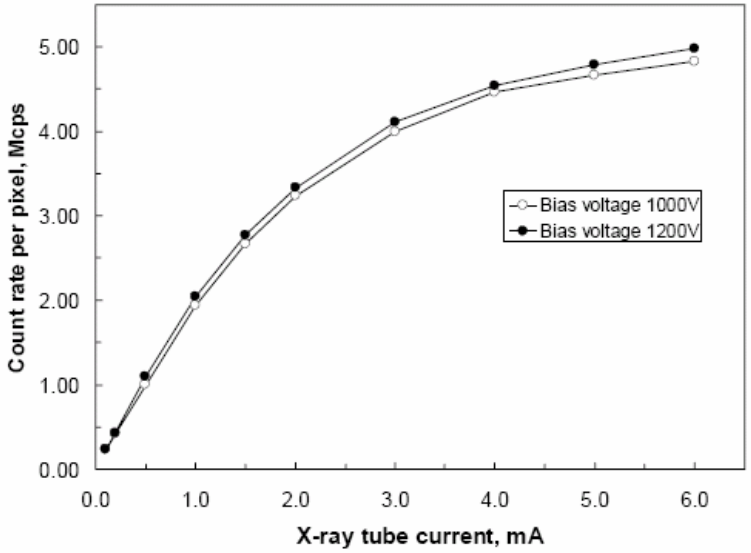


Fig. 5. Pixel count rate as a function of x-ray tube current for a CdZnTe detector read-out by the ASIC. The maximum energy of x-ray is 140 keV filtered by 1 mm Cu.

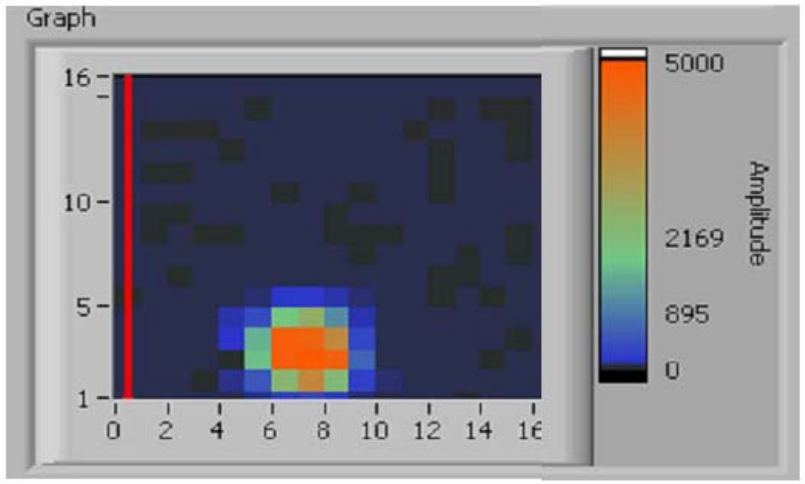


Fig. 6. Image of a collimated ^{57}Co source through 3 mm diameter hole in W collimator taken with a 256 pixel detector.

Courtesy of DxRay Inc.

Summary

3 Counting Mode ASICs have being developed

- Single and Double discriminator and counter structure
- Possible offline energy window
- Peaking time between 25ns and 50ns
- Detector capacitance up to 20pF
- ENC in the range of 650e^- to 800e^-

Readout of compound semiconductors (CdTe, CdZnTe), Silicon and any other detector suitable for the specifications.