Low Cost Alternative For High Resolution Imaging

Using modern gas detector technologies

Imaging

The visual representation of an object, such as a body part or celestial body, for the purpose of medical diagnosis or data collection, using any of a variety of techniques.

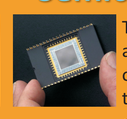
Today

Modern Imaging detectors are mostly based on Scintillators and/or Semiconductor devices.

Scintillators

Special materials which emit light when a charged particle pass through.
They have a low cost per surface unit but also a poor resolution, usually a cm or more.

Semiconductors



These devices can achieve resolution of a few µm, but they are also very expensive thus they're usually used only to cover small surfaces.

The Micro Pattern Gas Detectors are micrometric structures that multiply electrons produced in a gas by ionizing radiation. These devices can be used as imaging sensors.

MPGD

An Example: GEM

The Gas Electron Multiplier is one of many types of MPGD. They are thin plastic foil coated with copper electrodes and punctured by tiny holes. When the electrodes are charged the electrons entering the holes get multiplied in an avalanche process.

High Resolution

Better than 50 µm.

A resolution of 40 µm has been achieved using a GEM with a silicon pixel readout.
The detector resolution mostly depends on the read out system chosen and can be varied over several orders of magnitude.

Large Sensitive Area

MPGD can be produced with sensitive areas of several m^2.

The techniques used in the production of this detectors (i.e. photo lithography for GEM) can scale from few mm^2 to several m^2.

High Rate

The huge number of independent amplifying elements (i.e. the holes of the GEM) reduce the actual occupancy of the detector.
The gas amplification in MPGDs is a very fast process too which reduces to negligible value the dead times of the amplifying element.
The strength of the signals allows the use of very fast electronics.

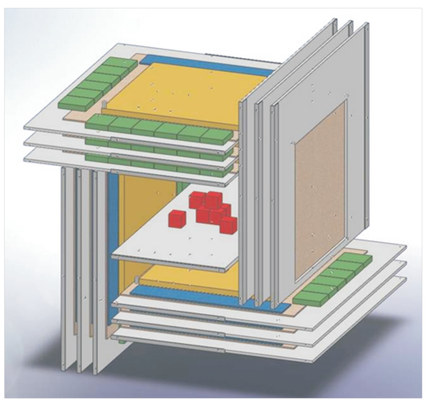
Can cope with extremely high radiation flux.

High Sensitivity

An MPGD detector can achieve an electron amplification (gain) of more than 10000 times with negligible noise.
The noise is mostly due to the read out electronics and is constant thus allowing for high S/N ratios. In comparison, in a silicon detector the noise usually increases with the gain.
The strong signal from the gas amplification stage allows for the use of simpler and cheaper electronics.

Allows for the use of faint sources and simple electronics.

Imaging Applications of MPGD

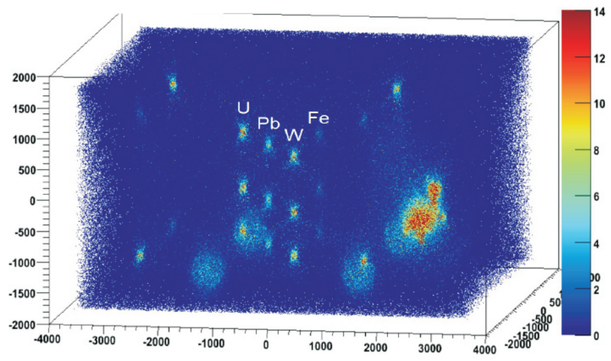


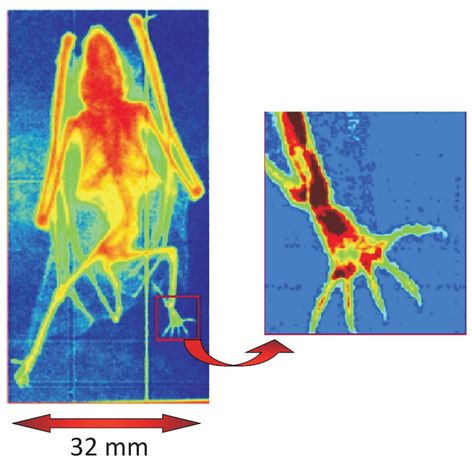
Real Time Portal Imaging

Using an external radiation source and a set of these detectors it's possible to perform a real time 3D scan on samples passing through the detection portal.

Muon Tomography

Using the cosmic ray muons as external source it's possible to identify heavy, shielded materials with a non-invasive scan.
On the right side you can see the scan of a truck hiding some samples.





Hi-res X-Ray Imaging

A GEM detector is also able to detect X-rays.
Because of the high efficiency of these detectors it's possible to lower the radiation dose needed to obtain a good image.
Because of the high rate capabilities it's possible to lower the exposure time of the sample.

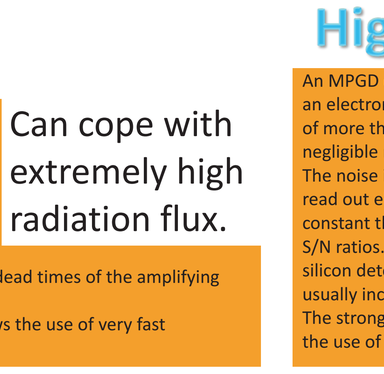
**We want to build a low cost GEM based detector that can be used as an imaging sensor for multiple application.
The detector will be engineered for large scale production.
This detector can be made portable to be deployed where necessary with little efforts.**

A low cost, Hi-res detector

Amplification

Self supporting GEM foils.

A stack of three 10x10 cm GEM foils will be used for the prototype of the detector.
This foils will be glued in a ceramic structure to support them inside the detector and keep them flat

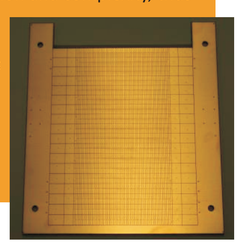


Read Out

Multiple read out for different resolutions.

For the readout of the detector a customer could choose between different option with increasing resolution and complexity, thus different costs.
The different possible solutions are:

- Strips
- Hexaboard
- Pads
- Silicon Pixels



Electronics

Integrated on the read out board.

On the backside of the readout board the signals coming from the sensitive elements (i.e. pads as in the board on the right) are digitized with a Flash ADC processor.
In the case of the silicon pixel readout, the sensitive pixel and the read out electronics could be integrated on the same chip.
The data will be then sent to an external elaboration unit or stored internally in an integrated memory unit in the case of a portable unit

Costs

A low cost alternative for high resolution detectors.

A high resolution alternative for large area detectors.

Compared to high resolution detectors this instrument can be extremely cheap.
The cost/cm^2 of a prototype detector could be of several euro.
This cost is of the same order of magnitude of mass produced semiconductor based detector.
Scale economies can reduce this price of an order of magnitude
Compared to large area detectors this technology can achieve resolution several order of magnitude better than scintillating detectors.

Portability

Your detector anywhere.

A GEM detector could be made portable and self contained.
The drift chamber can be sealed to preserve the gas purity for long periods and avoid the use of gas bottles (to be demonstrated).
To power both the electronics and the GEMs it's possible to use low voltage power supplies. The high voltages can be produced by an internal circuitry.
The acquired data can be stored in an internal storage unit. The raw data could then be downloaded in an external computer to perform the final elaboration.
Finally the system can be self triggered using the signals produced on the GEM themselves when the electron avalanche occurs.

Mass Production

Can be done.

The GEMs are produced using photo-litographic techniques and cheap materials (i.e. copper coated kapton)
The electronic read out is based on integrated systems on printed circuit boards. These technology are available on industrial scales.

**The technology is available to develop and produce such detectors.
We need some support and funding for the R&D to make it real**

Author: Sabato Stefano Caiazza

stefano.caiazza@desy.de