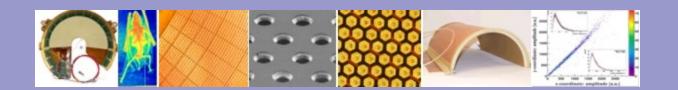


European Organization for Nuclear Research

CERN

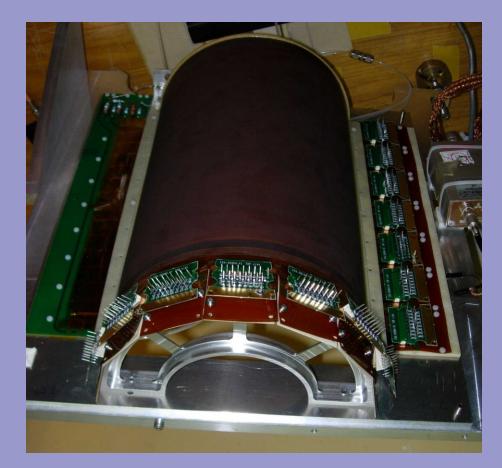
Gas Electron Multiplier Radiation Detector for the Future Invented and Produced at CERN

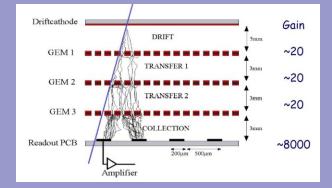


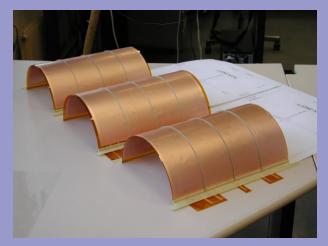


GEM Detector

Gas Electron Multiplier Detector consists of drift electrode, 3 GEM foils and readout electrode.







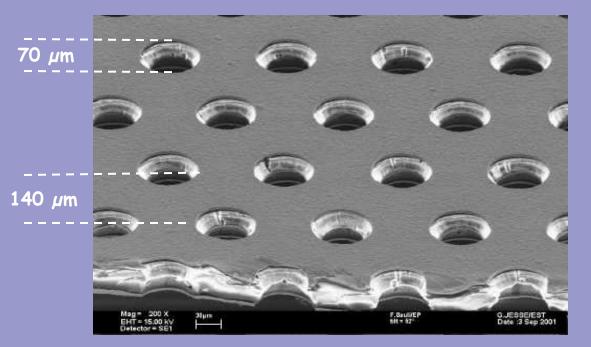
3 GEM foils before being mounted into detector

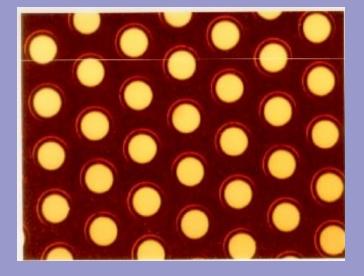
Semi-cylindrical GEM detector



GEM Foil

GEM foil – copper clad polyimide film, 50 mm thick, pierced with millions of tiny holes. Each hole diameter corresponds to the width of the human hair.

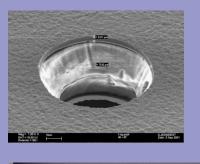


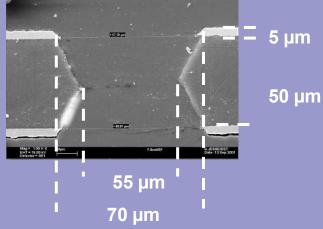


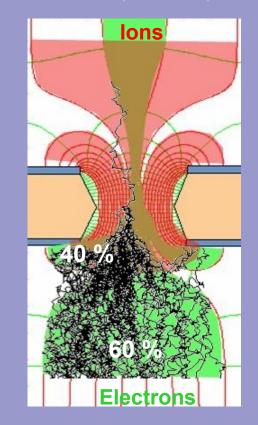


GEM Principle

Difference of potentials of ~ 500V is applied to each GEM foil. Primary electrons released by radiation, drift towards holes where high electric field triggers electron multiplication process.



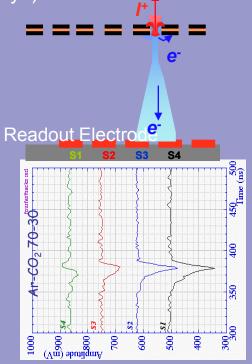




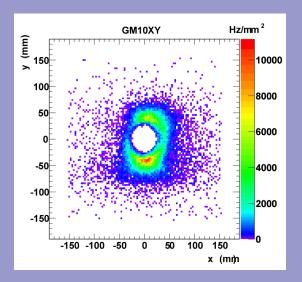


GEM Principle

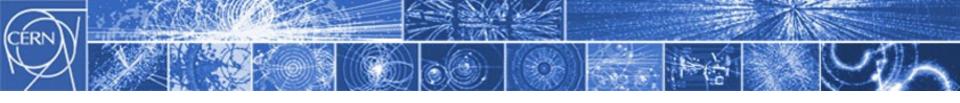
Electrons created in the multiplication (avalanche) process in GEM holes are collected on segmented readout electrode. Signal induced on the readout segments allows precise reconstruction of the time and position of the passage of original radiation (charged particles, X-rays).



Signals induced on the readout electrode by the electrons created in the avalanche process



Map of the reconstructed positions of the passage point of charged particles measured at very high intensity beam at CERN in COMPASS experiment.

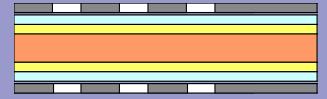


GEM Manufacturing

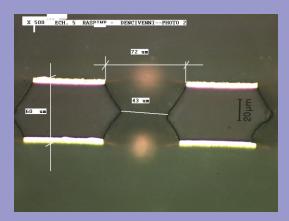
50 mm Kapton 5 mm Cu both sides



Photoresist coating, masking and exposure to UV light



GEM foils are produced at CERN using proprietary process.

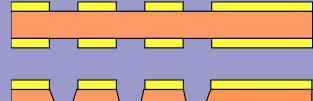


Metal chemical etching

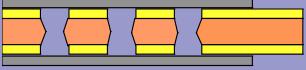
Kapton chemical etching

Second mas

Metal etching and cleaning



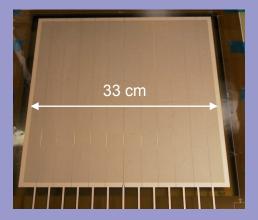


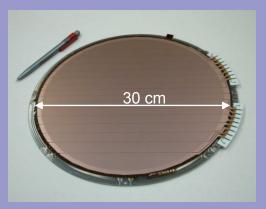




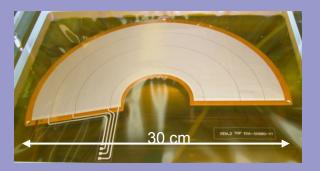


GEM Manufacturing









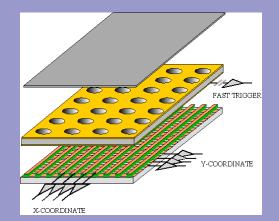


Wide range of shapes and sizes

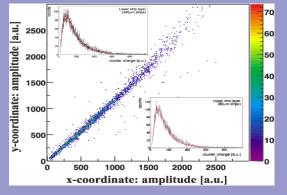
1500 \div 2000 foils manufactured at CERN 1 cm² to 1000 cm² 30-200 µm holes, 50-300 µm pitch



GEM – Gas Electron Multiplier



Full decoupling of the charge amplification structure from the charge collection and readout structure allows both structures to be optimized independently !



Charge correlation (Cartesian readout)

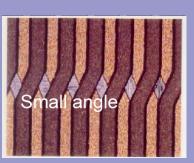


GEM detectors developed for different CERN experiments.



GEM – Gas Electron Multiplier



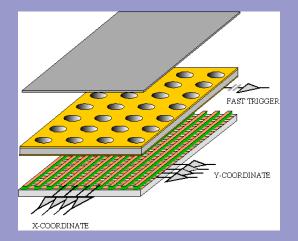


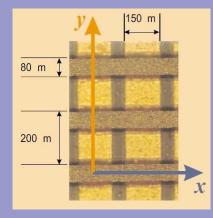


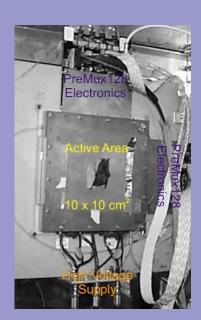


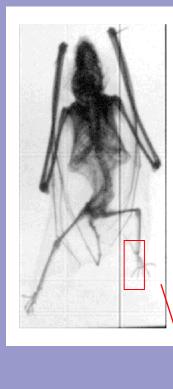


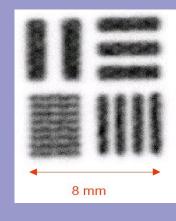
Absorption radiography with GEM

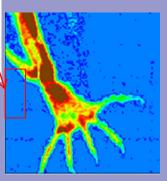








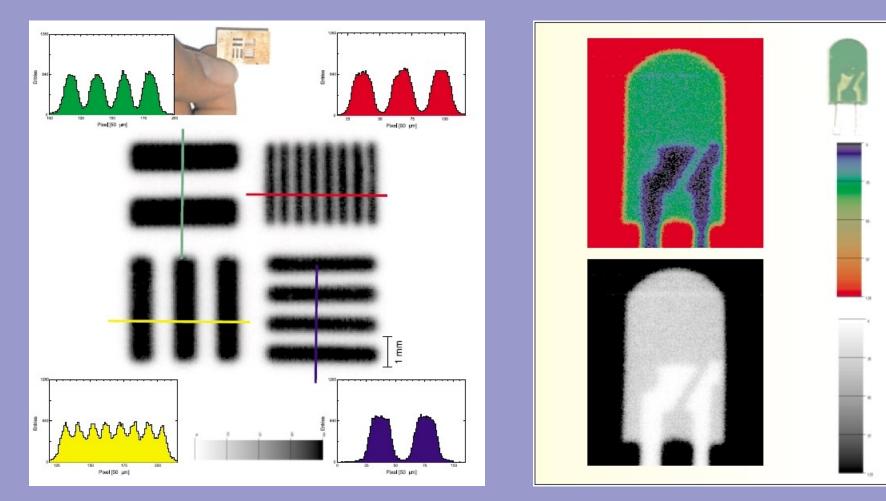




GEM detectors can be used to detect X-Rays !



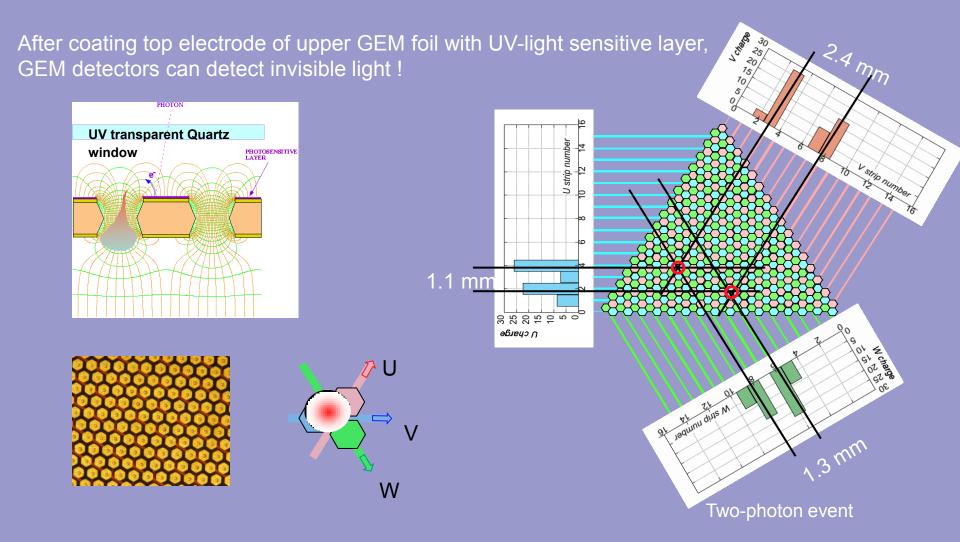
Absorption radiography with GEM



GEM detectors can be used to detect X-Rays !

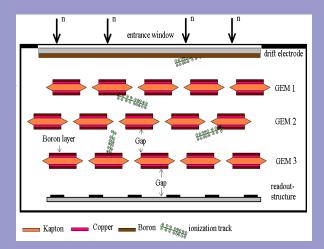


UV Light Detection



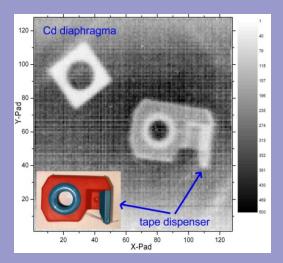


Detector for Neutron Detection



Coating GEM foils with appropriate converter makes GEM detectors sensitive to neutrons.

CASCADE Heidelberg





GEM Detectors at CERN

CERN is involved in all aspects of GEM detectors design, production and applications.

Detector Design

Component Production

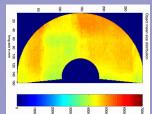
Component Quality Control

Detector Assembly

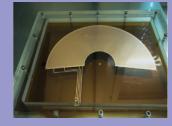
















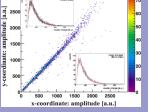


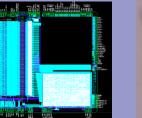


Detector Test

Readout Electronics







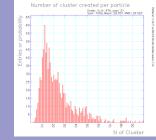




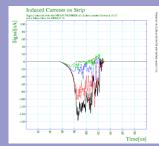
Detector Simulations

Technology Dissemination









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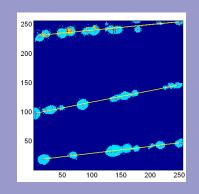


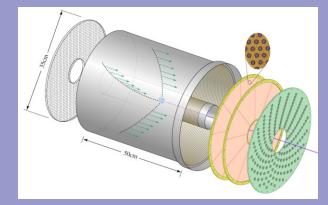
Perspectives

Tracking and triggering (LHCb & TOTEM)

- TPC end cap readout X-ray radiography UV light detection
- Parallax error free detector
- Hadron blind detector
- Neutron detection
- Optical GEM
- Cryogenic detectors
- Two-phase detectors
- High resolution detectors integrated with pixel CMOS chips Non planar large acceptance detectors Light detectors – mass reduction New readout structures adopted to experimental needs Large size detectors Radiation hardness of assembly materials Industrialization of the mass production Medical applications

http://cern.ch/GDD/

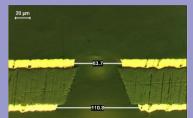








Double mask process



Single mask process