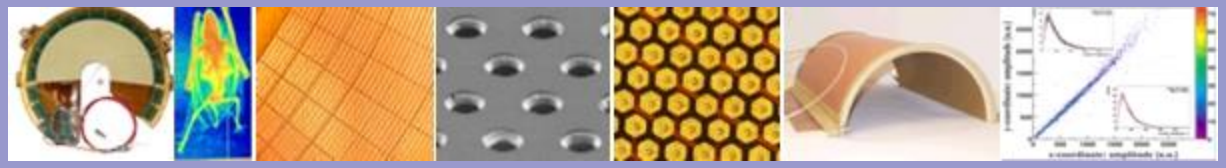
CERN

European Organization for Nuclear Research
Organisation Européenne pour la Recherche Nucléaire

Gas Electron Multiplier

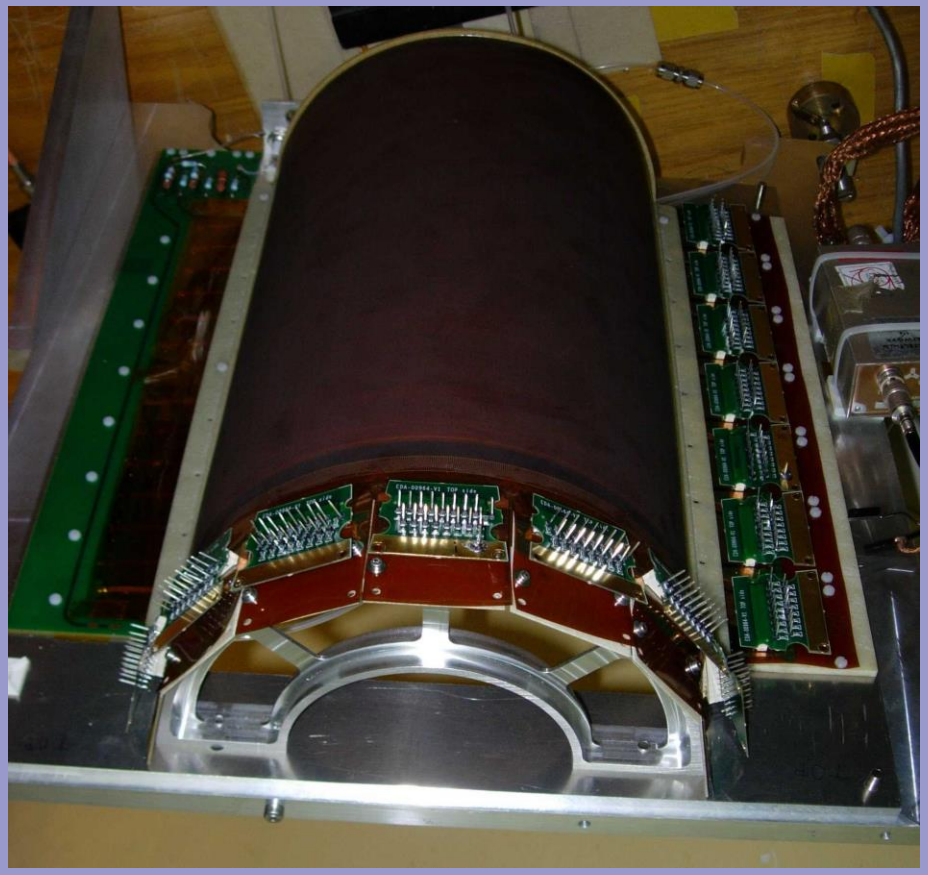
Radiation Detector for the Future

Invented and Produced at CERN

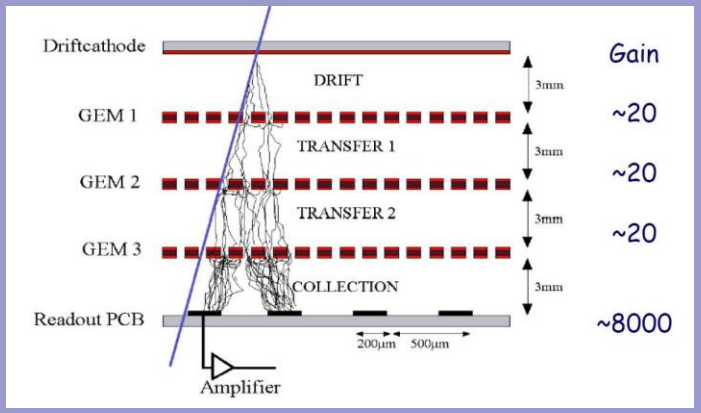


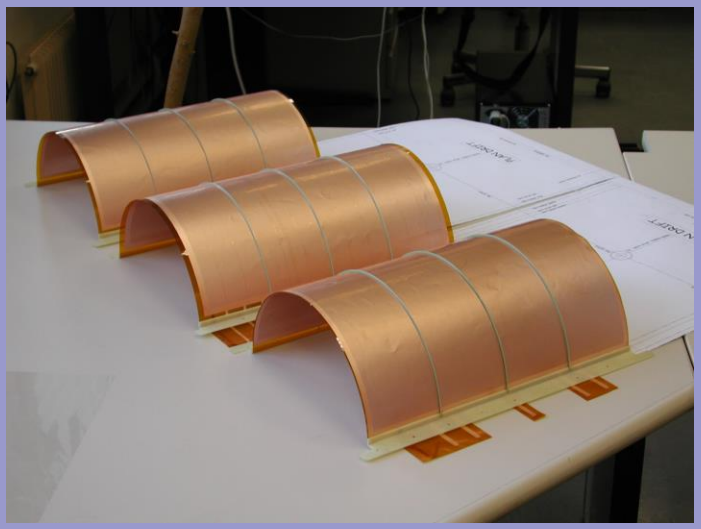
GEM Detector

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



Semi-cylindrical GEM detector

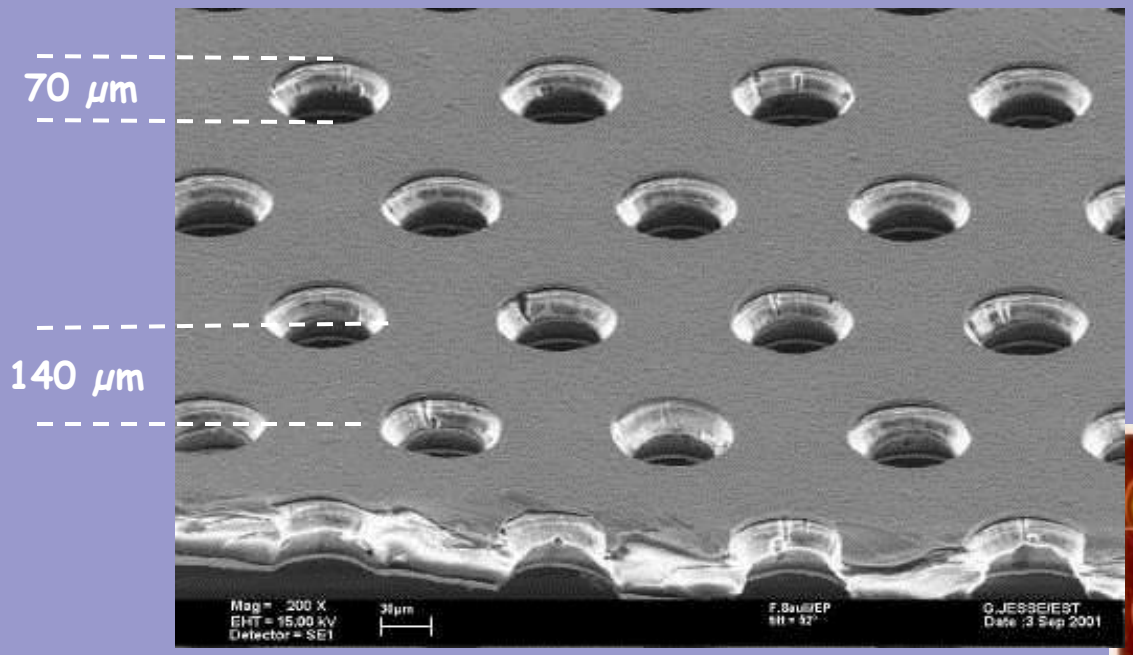


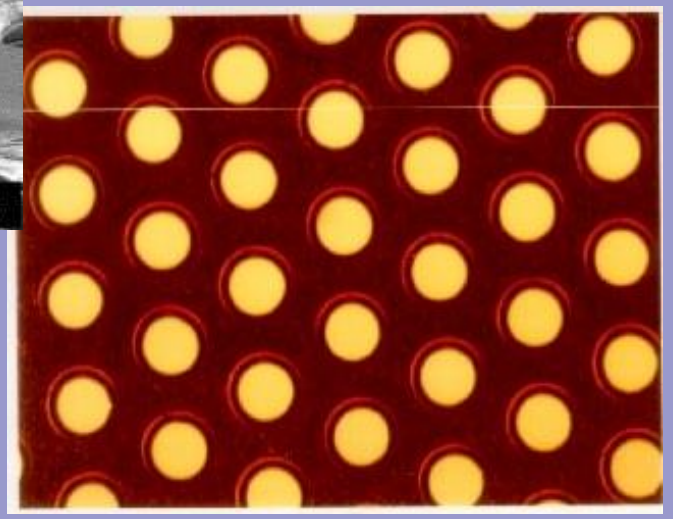


3 GEM foils before being mounted into detector

GEM Foil

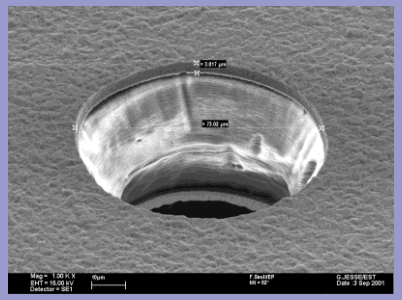
GEM foil – copper clad polyimide film, 50 μm thick, pierced with millions of tiny holes. Each hole diameter corresponds to the width of the human hair.

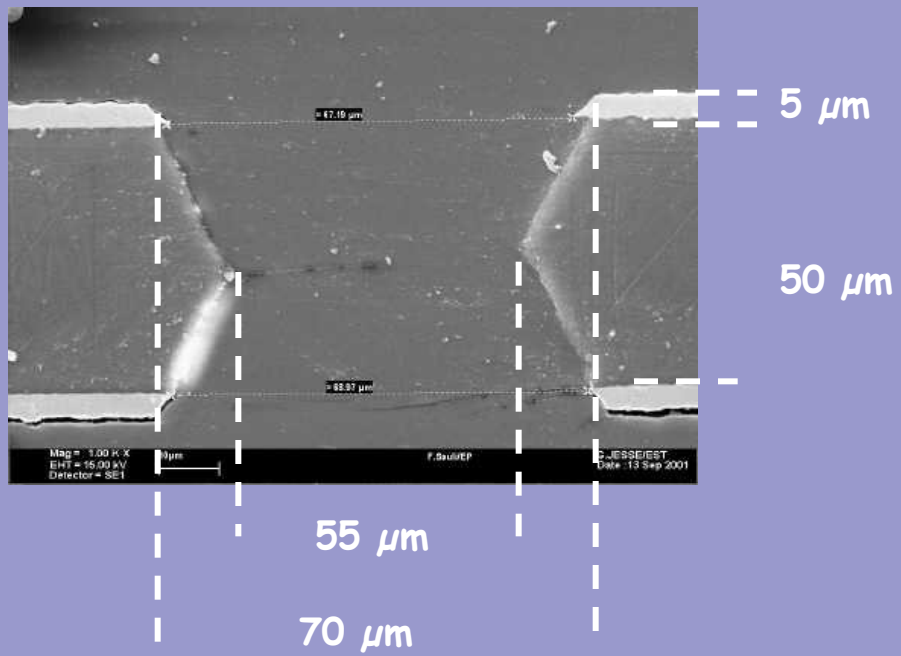


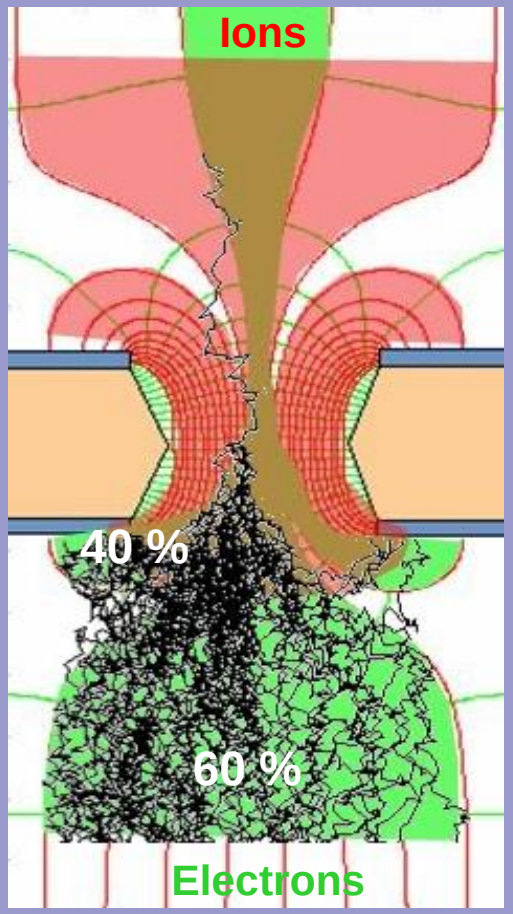


GEM Principle

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.

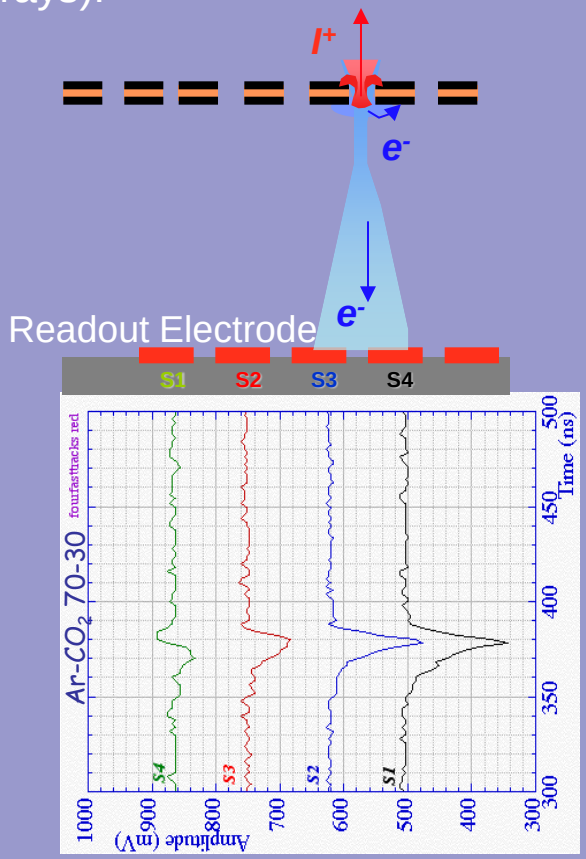




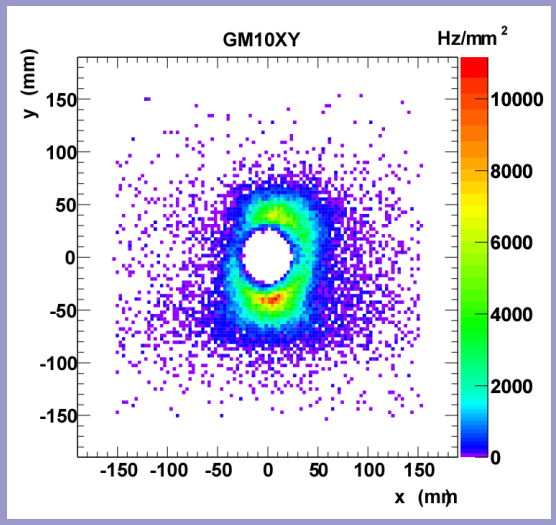


GEM Principle

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).



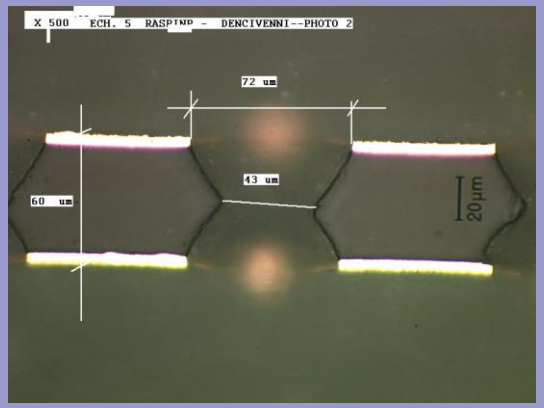
Signals induced on the readout electrode by the electrons created in the avalanche process



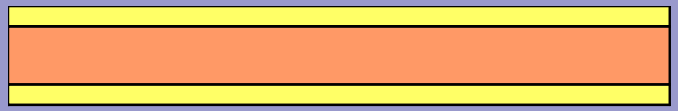
Map of the reconstructed positions of the passage point of charged particles measured at very high intensity beam at CERN in COMPASS experiment.

GEM Manufacturing

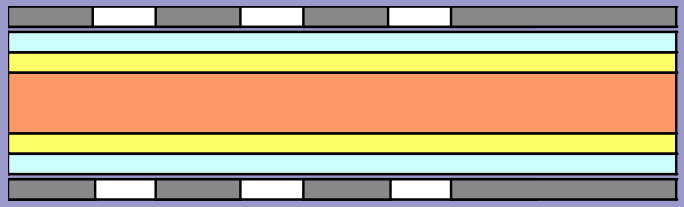
GEM foils are produced at CERN using proprietary process.



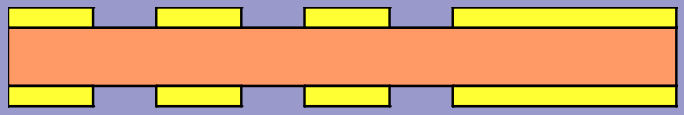
50 μm Kapton
5 μm Cu both sides



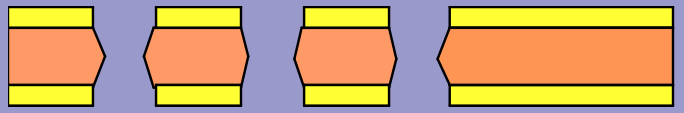
Photoresist coating, masking and exposure to UV light



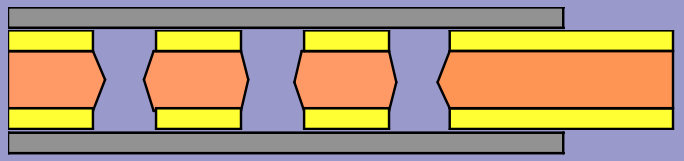
Metal chemical etching



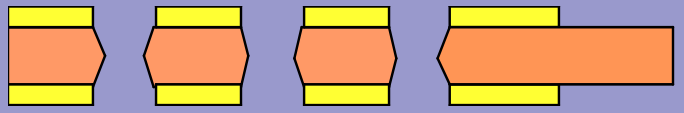
Kapton chemical etching



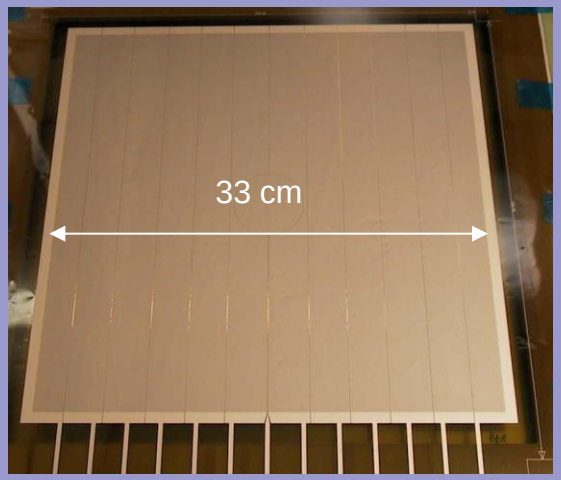
Second masking

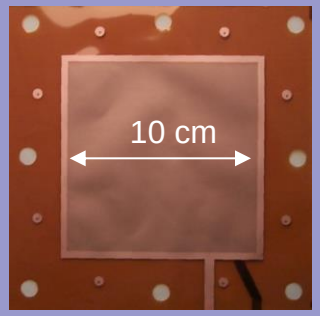


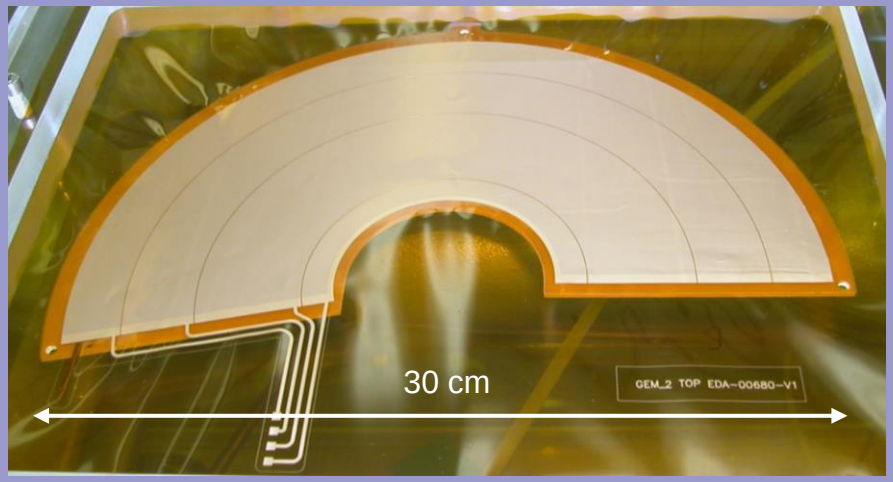
Metal etching and cleaning

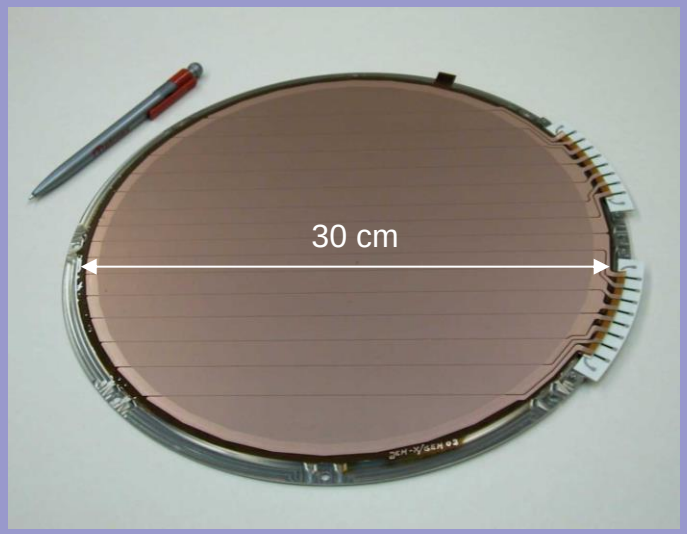


GEM Manufacturing







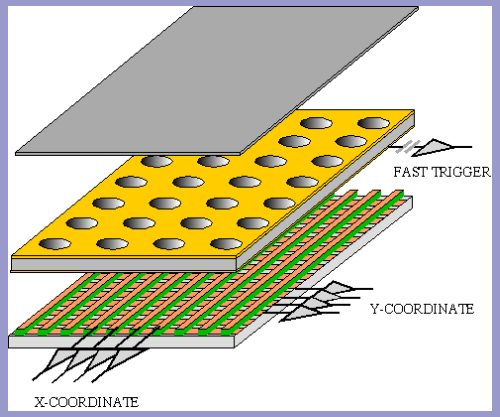


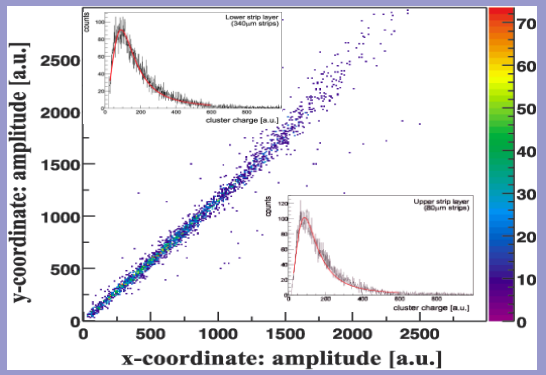
Wide range of shapes and sizes

1500÷2000 foils manufactured at CERN
1 cm^2 to 1000 cm^2
30-200 µm holes, 50-300 µm pitch

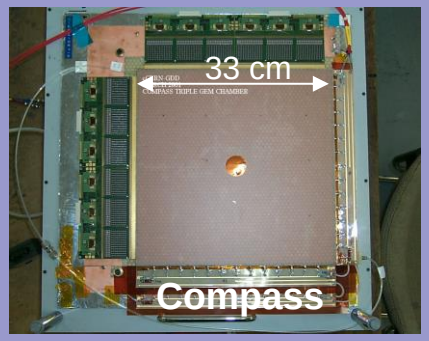
GEM – Gas Electron Multiplier

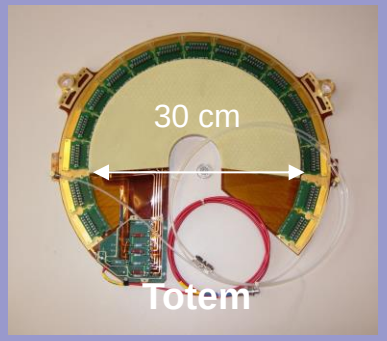
Full decoupling of the charge amplification structure from the charge collection and readout structure allows both structures to be optimized independently !

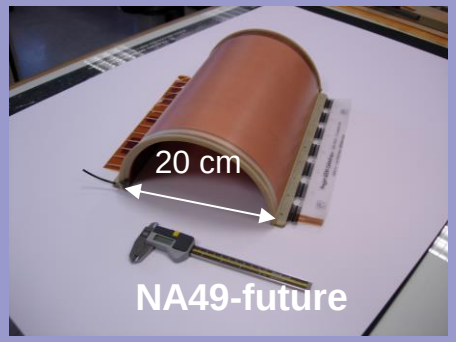




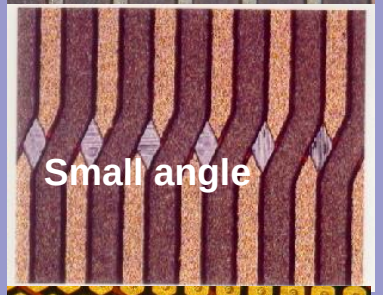
Charge correlation (Cartesian readout)

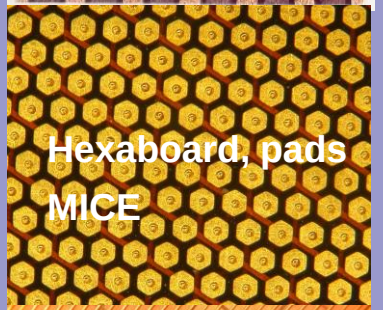






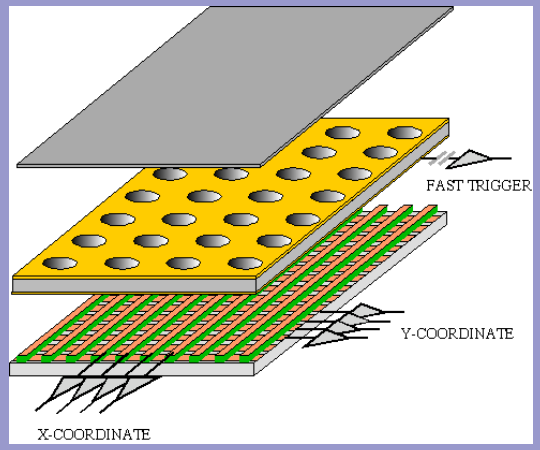
GEM detectors developed for different CERN experiments.

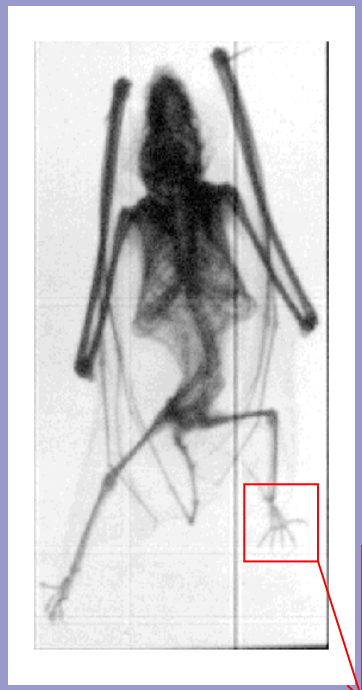


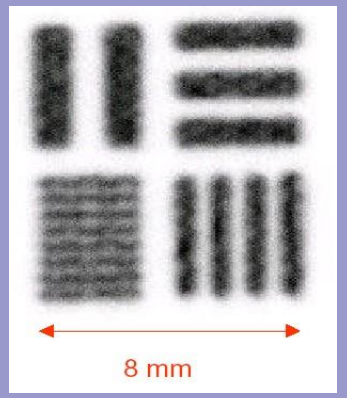


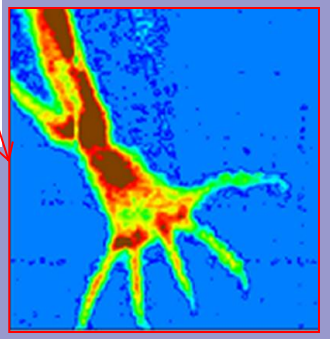
Absorption radiography with GEM

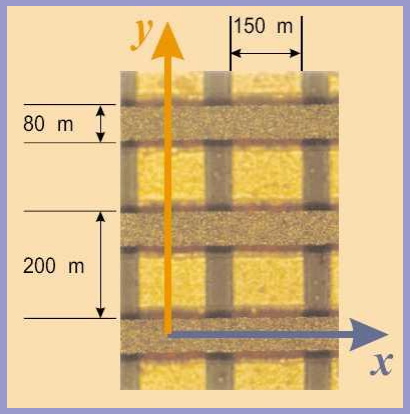
GEM detectors can be used to detect X-Rays !





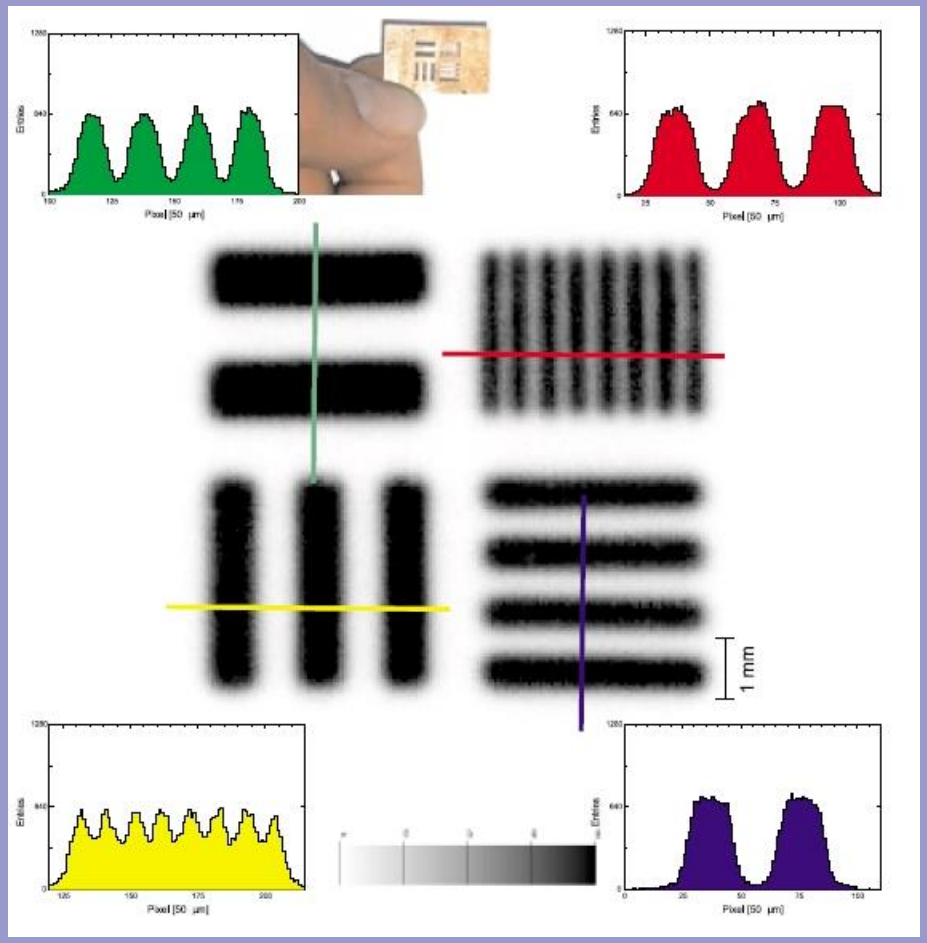


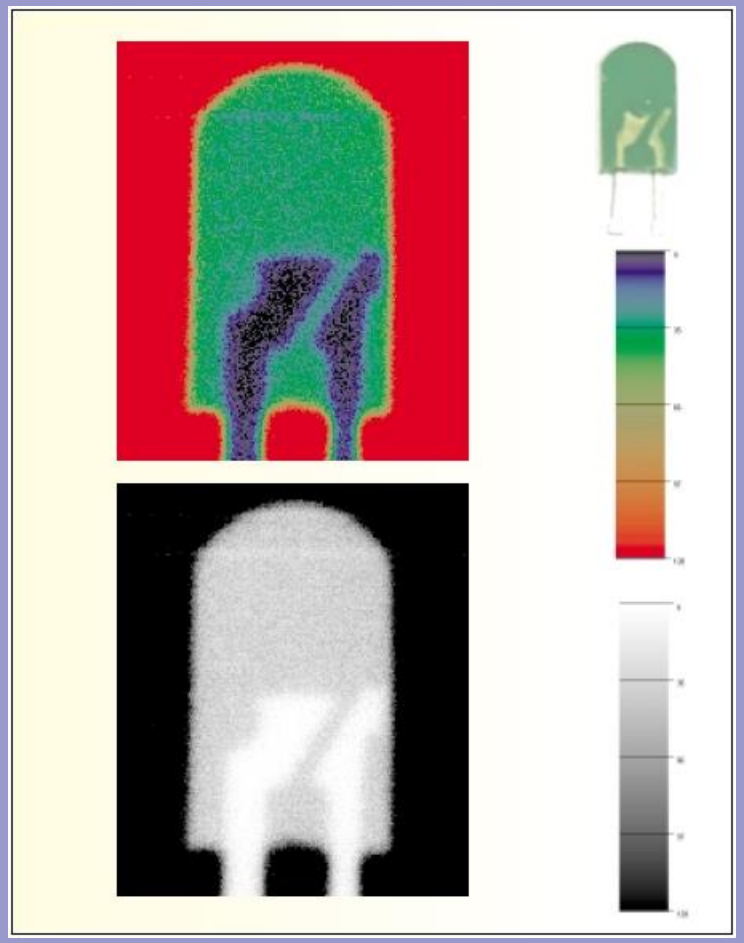




Absorption radiography with GEM

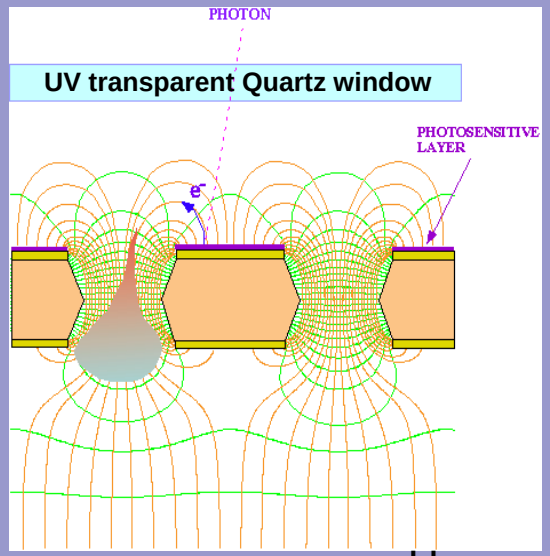
GEM detectors can be used to detect X-Rays !

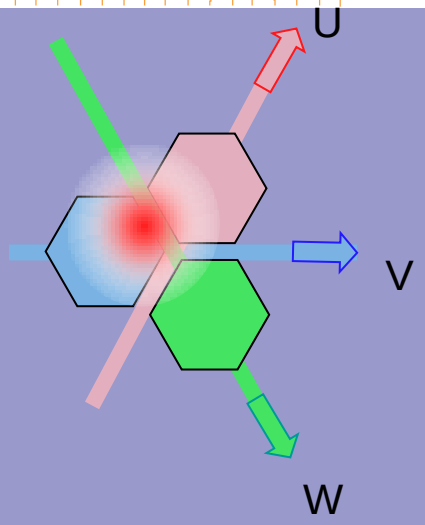


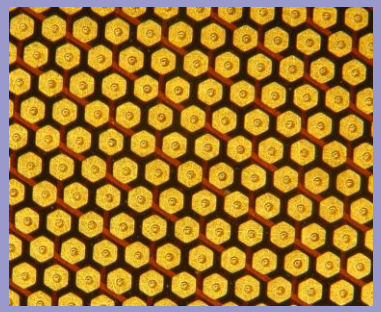


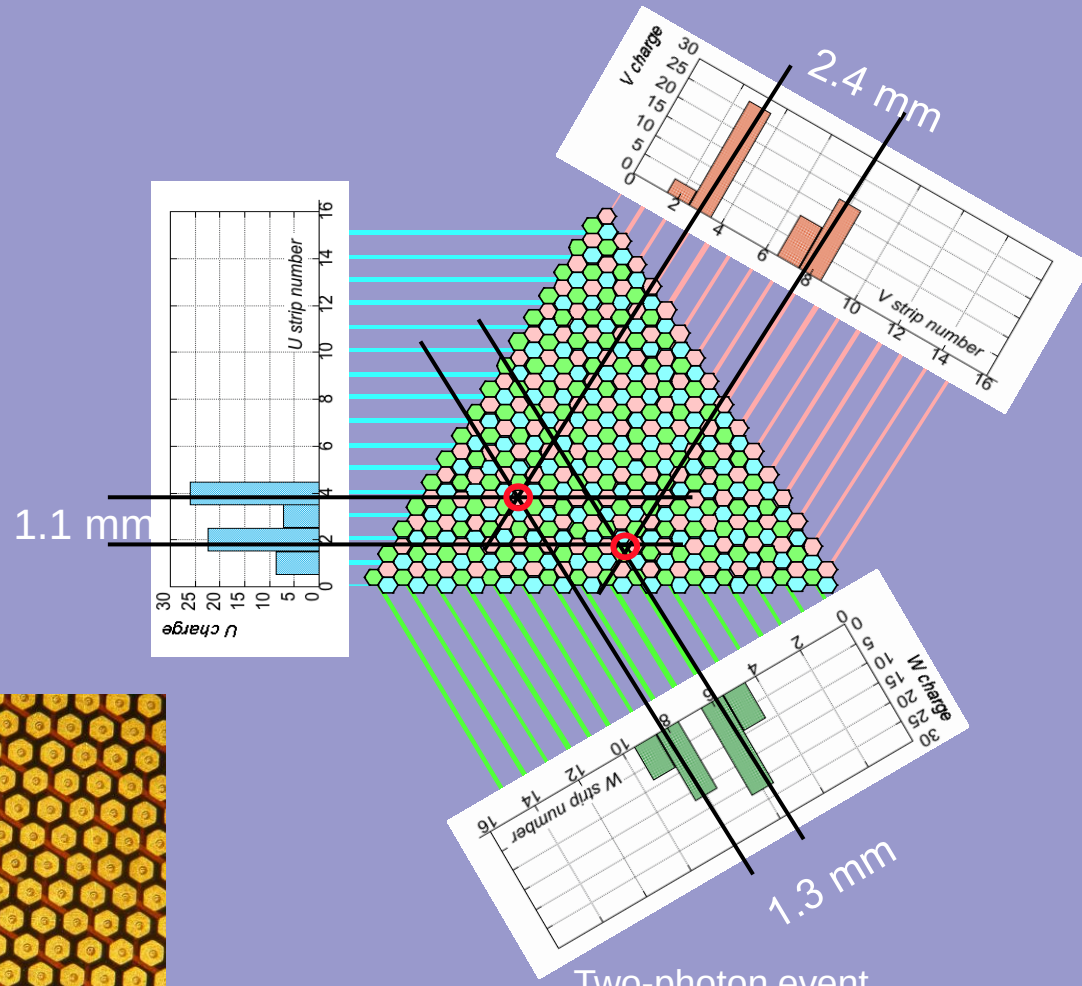
UV Light Detection

After coating top electrode of upper GEM foil with UV-light sensitive layer, GEM detectors can detect invisible light !



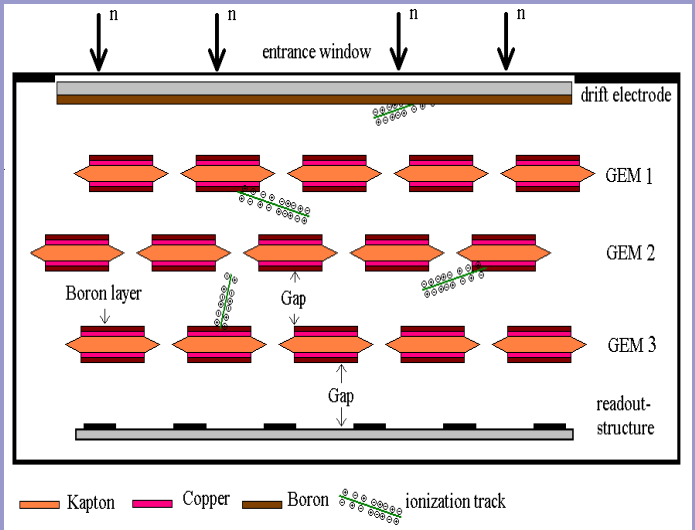






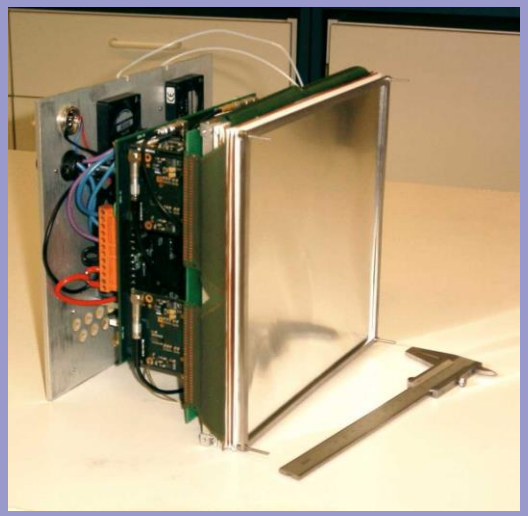
Two-photon event

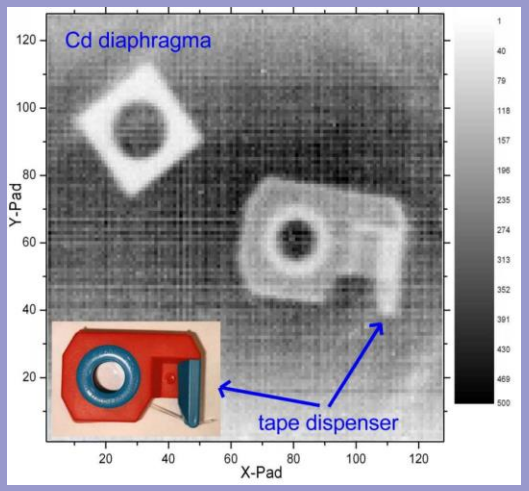
Detector for Neutron Detection



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

CASCADE Heidelberg





GEM Detectors at CERN

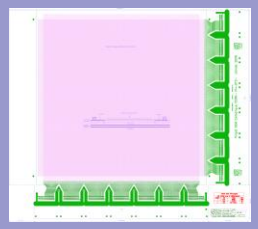
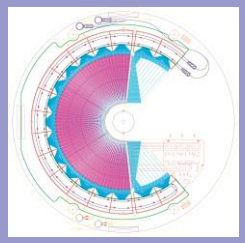
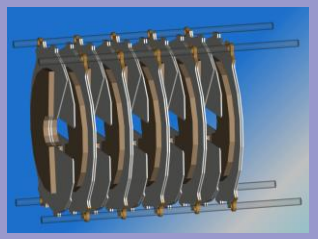
CERN is involved in all aspects of GEM detectors design, production and applications.

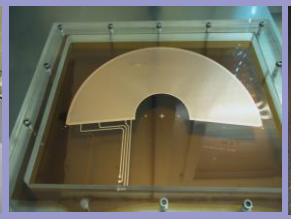
Detector Design

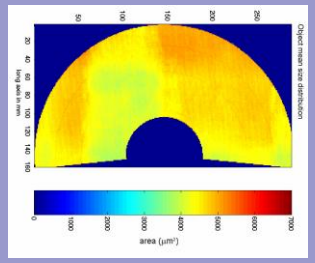
Component Production

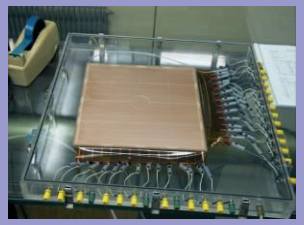
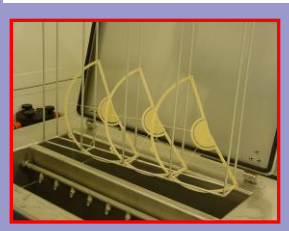
Component Quality Control

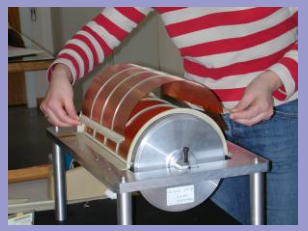
Detector Assembly







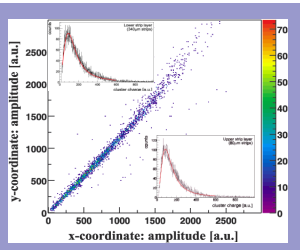
GEM Detectors at CERN

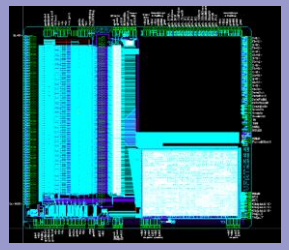
Detector Test

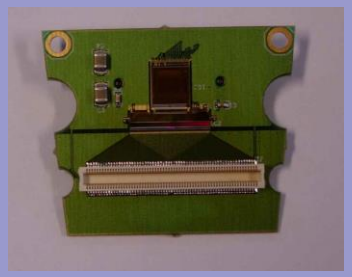
Readout Electronics

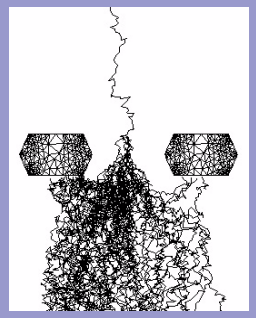
Detector Simulations

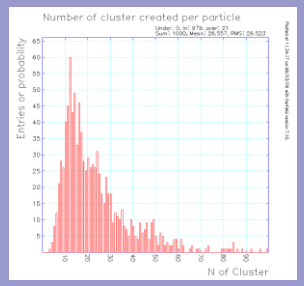
Technology Dissemination

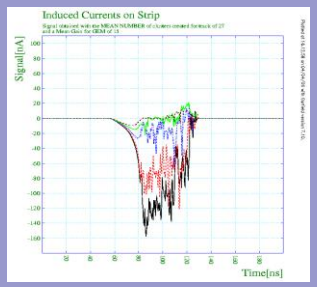


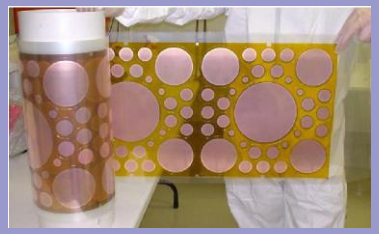


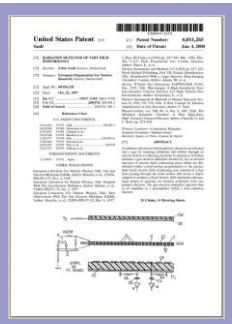






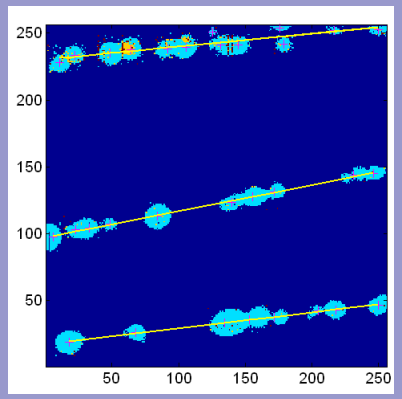


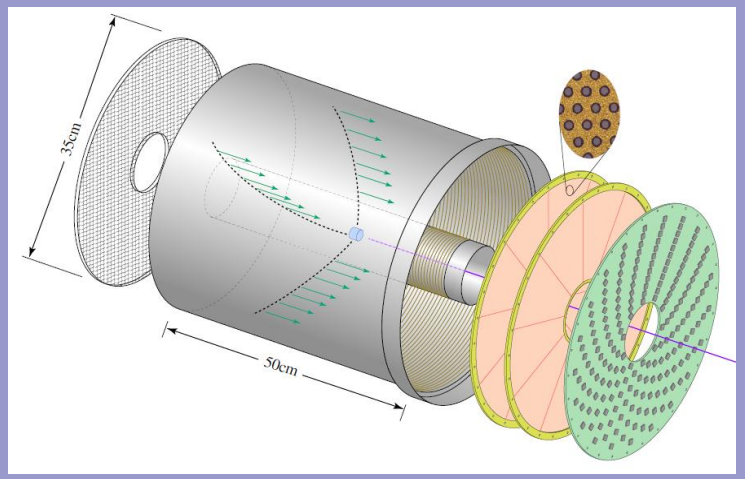


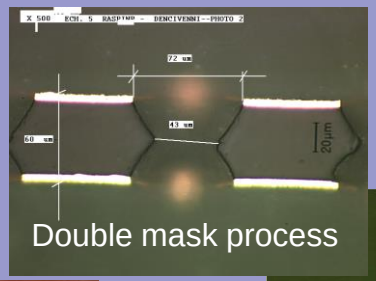


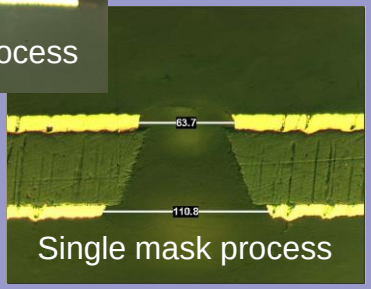
Perspectives

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






Double mask process



Single mask process

http://cern.ch/GDD/