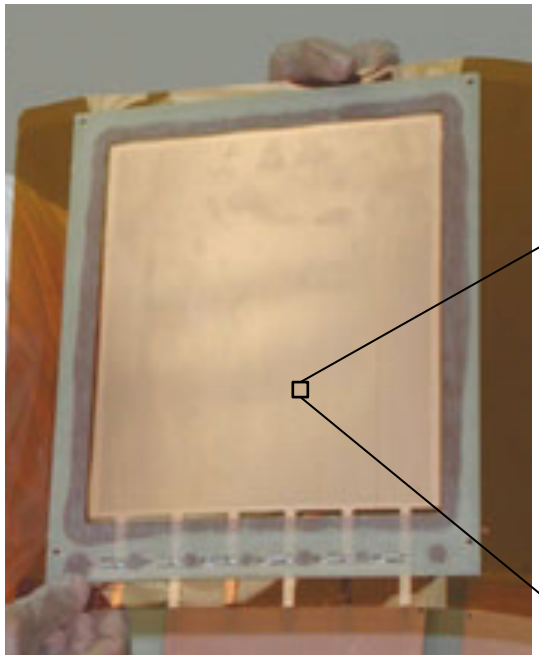
BAND-GEM detectors

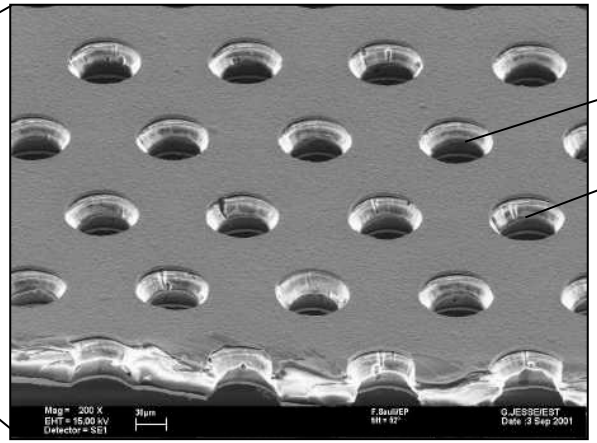
OUTLINE

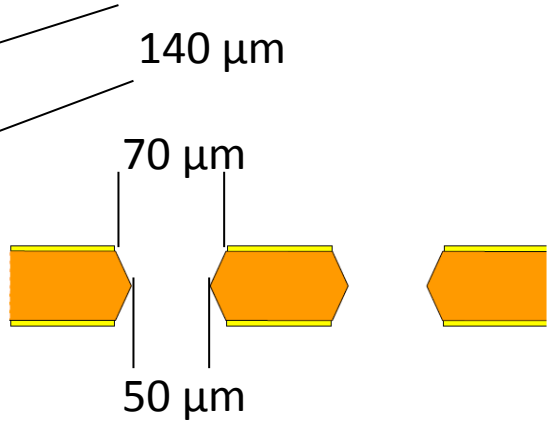
- GEM detectors
- The Boron array Neutron Detector BANDGEM Concept
  - First results
- Towards the BANDGEM Demonstrator for SANS @ ESS

WHAT IS A GEM?



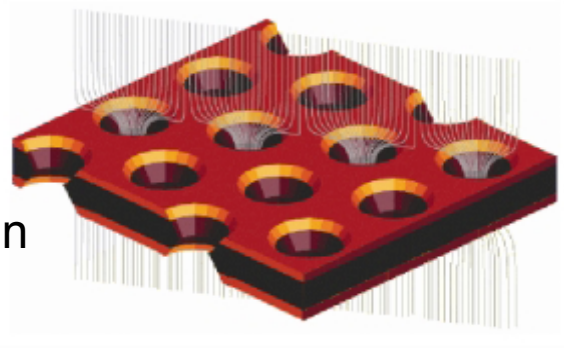
A Gas Electron Multiplier (F.Sauli, NIM A386 531) is made by 50 μm thick kapton foil, copper clad (5 μm thick) on each side and perforated by an high surface-density of bi-conical channels;

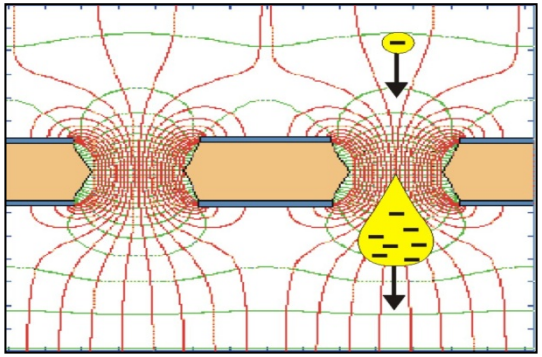




Applying a potential difference (tipycally between 300 and 500 volts) between the two copper cladding, an high intesity electric field is produced inside the holes (80-100 kV/cm).

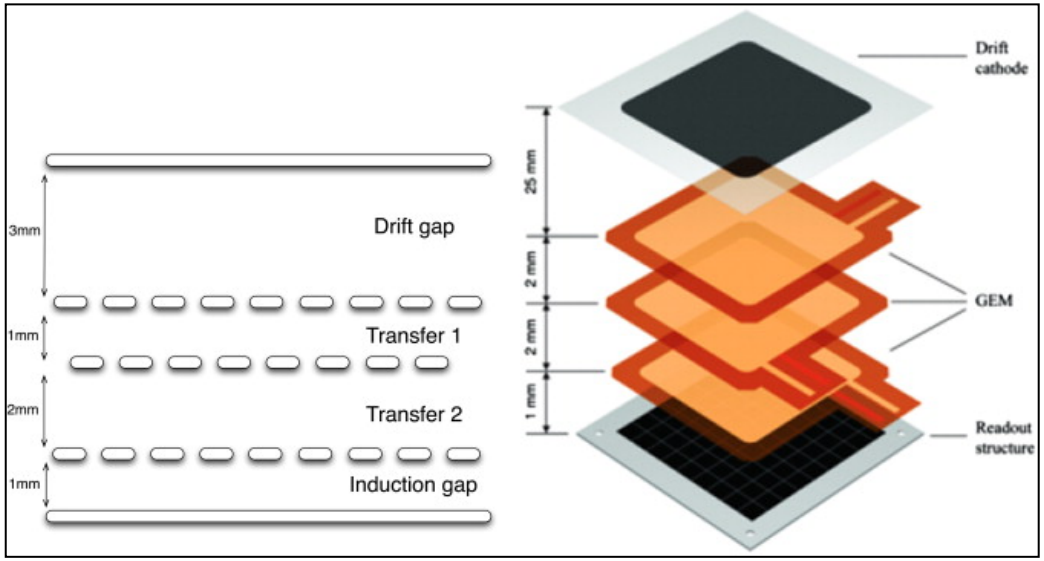
GEM is used as a proportional amplifier of the ionization charge released in a gas detector.



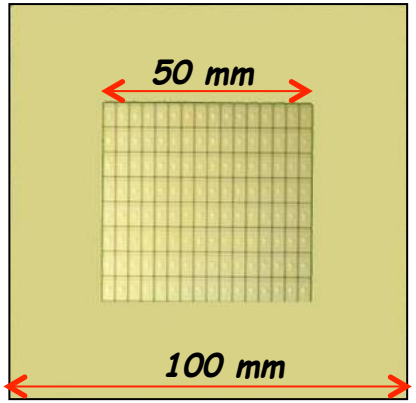


Triple-GEM detectors

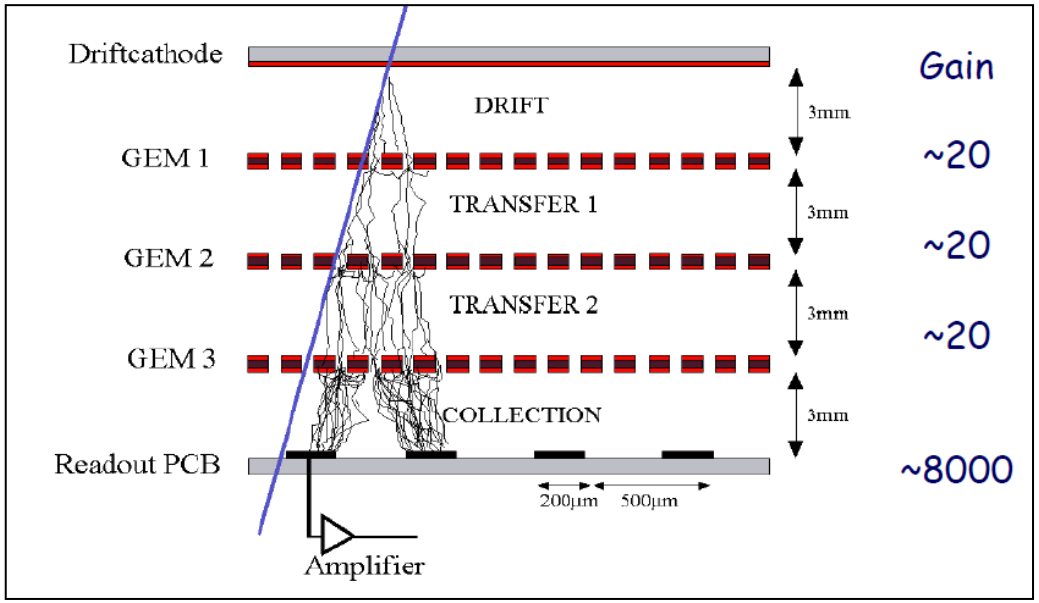
Layout of a typical Triple GEM detector constructed with standard 10 x 10 cm².



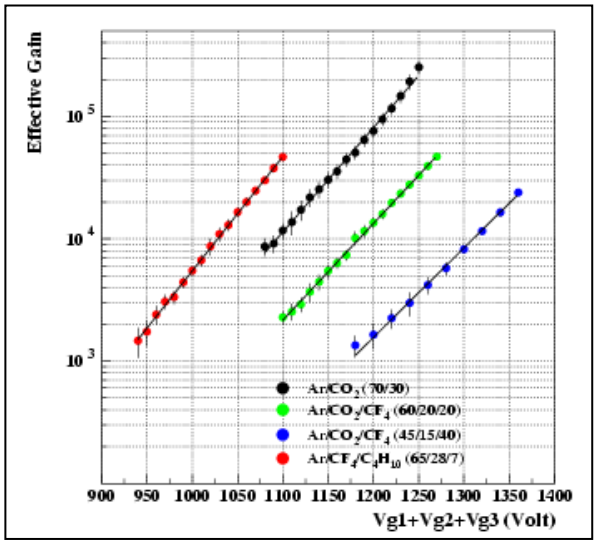
The anode has 128 pads. Each PAD can have a different geometry depending on detector applications.



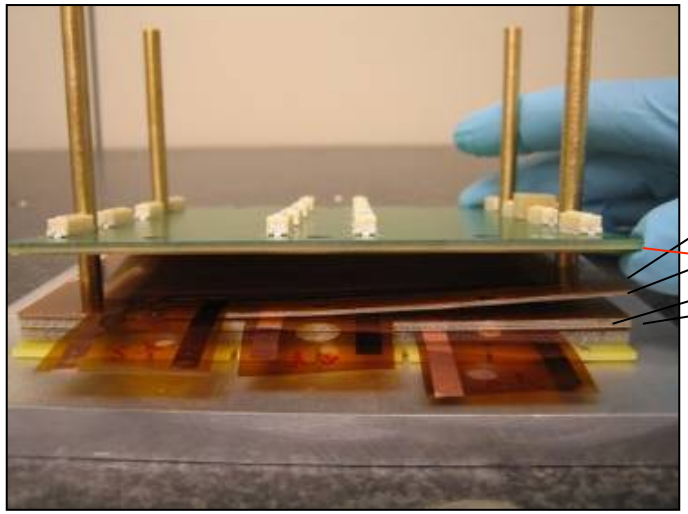
3x6 mm² PADs

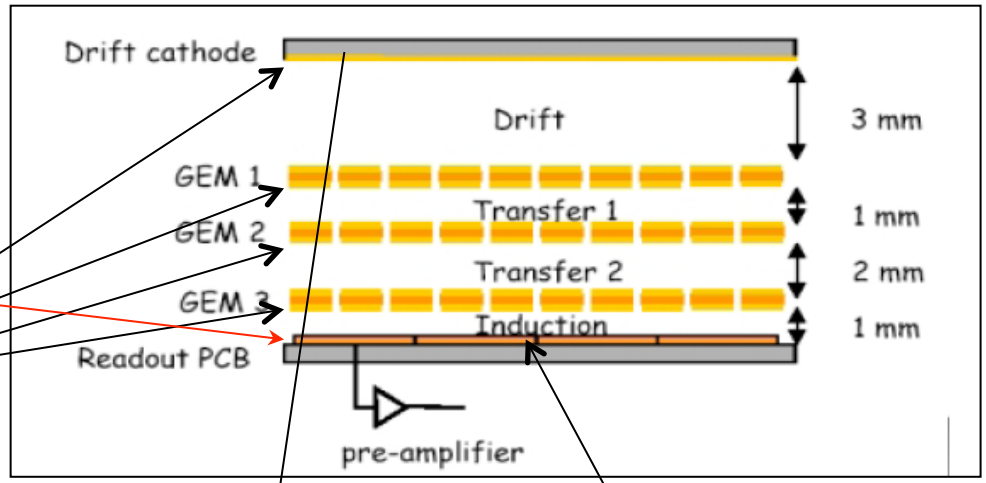


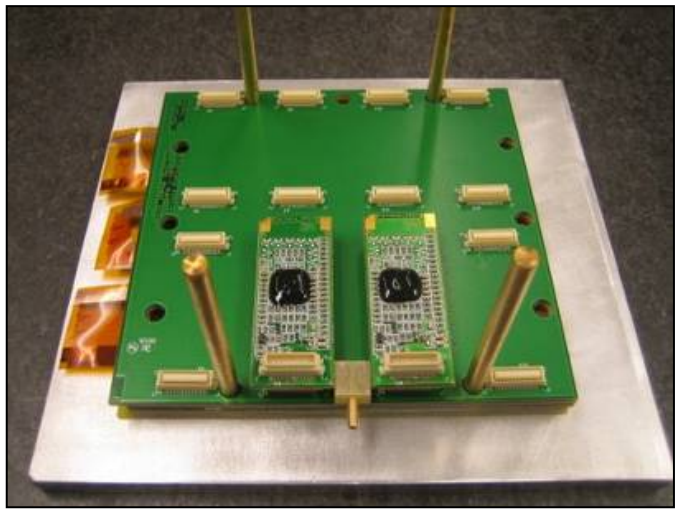
Gas Gain Curves



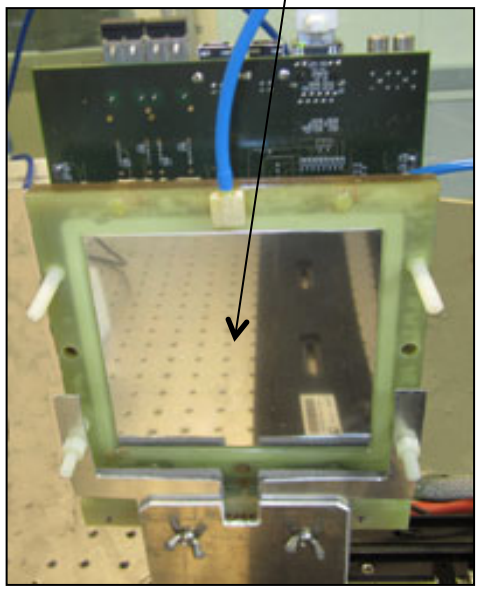
A STANDARD Triple-GEM detector



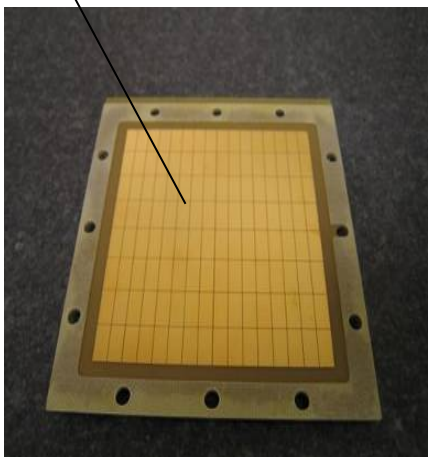




All the anode PCB have been designed with the same connector layout for a total of 128 channels.



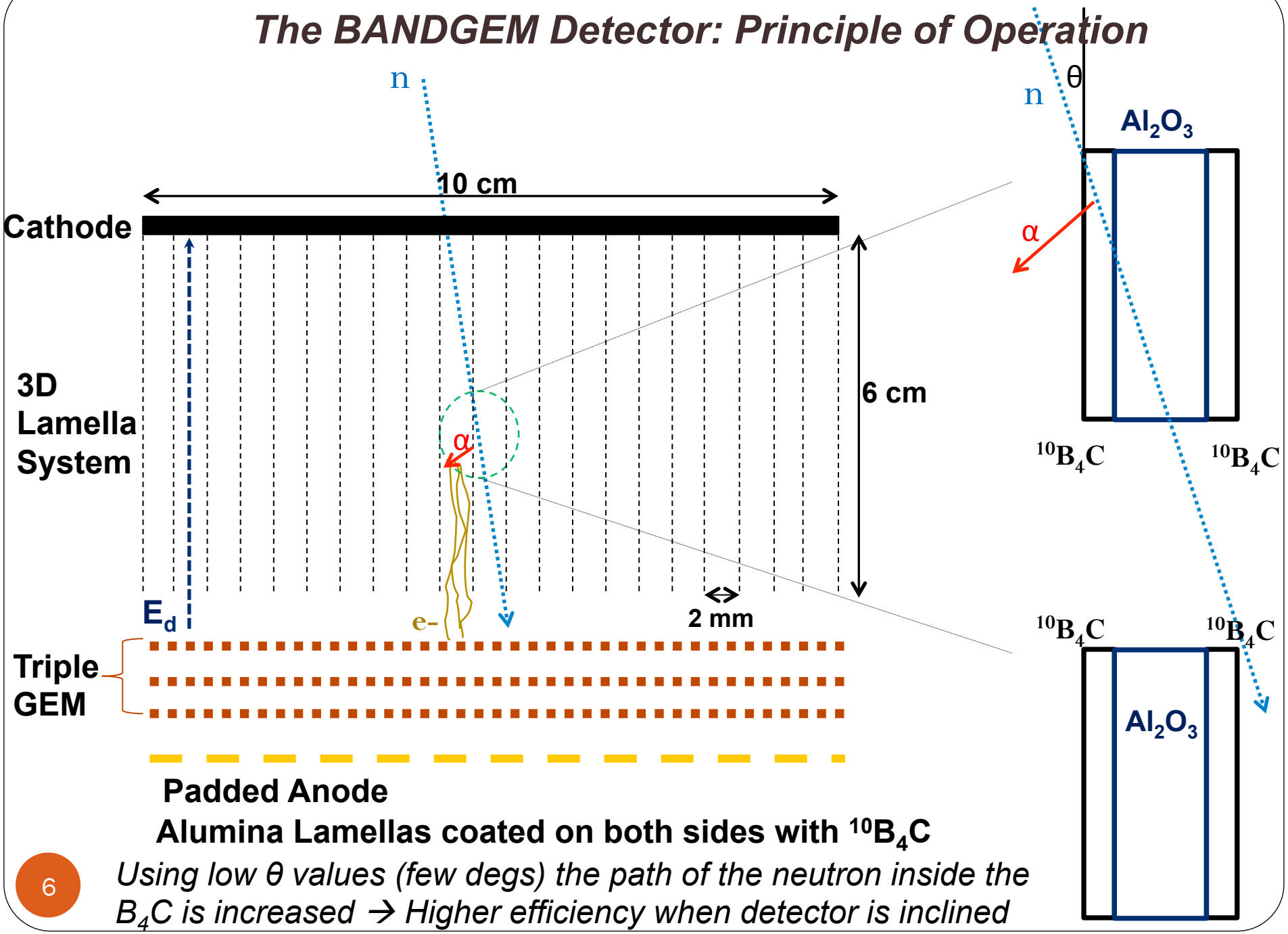
Detector window: typically made of Aluminate Mylar or Fiberglass



PCB anode divided in 128 PADs

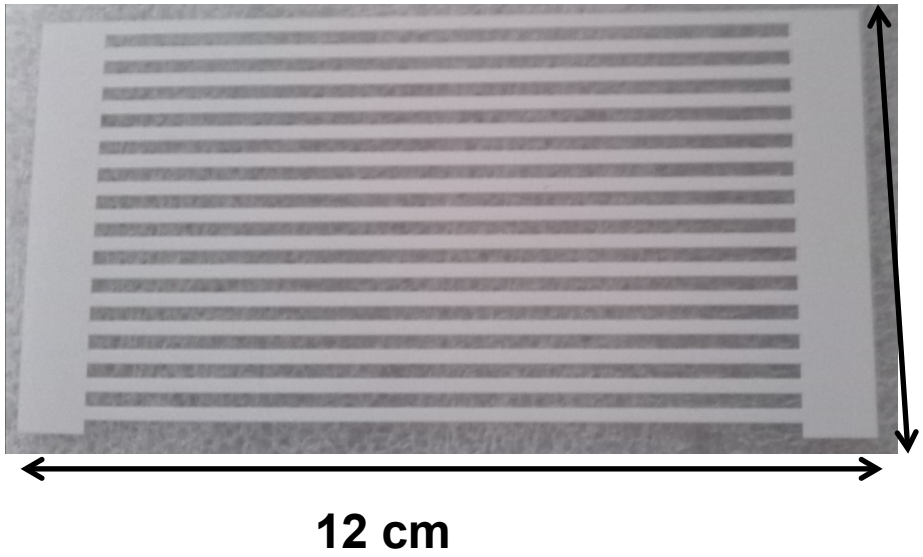
PADs dimension and geometrical configuration can be chosen according to the application of the detector.

The BANDGEM Detector: Principle of Operation



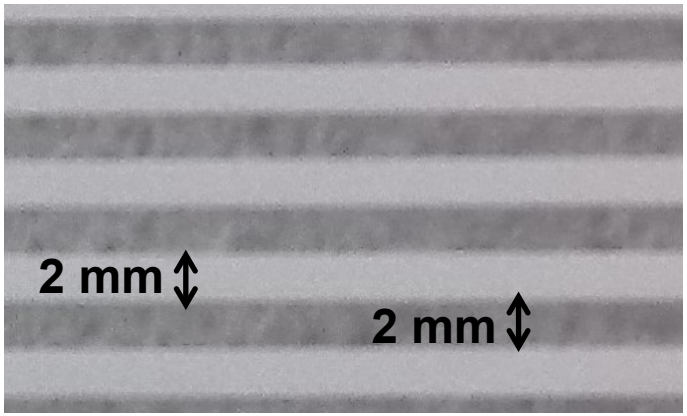
Using low θ values (few degs) the path of the neutron inside the B_4C is increased → Higher efficiency when detector is inclined

THE LAMELLAS



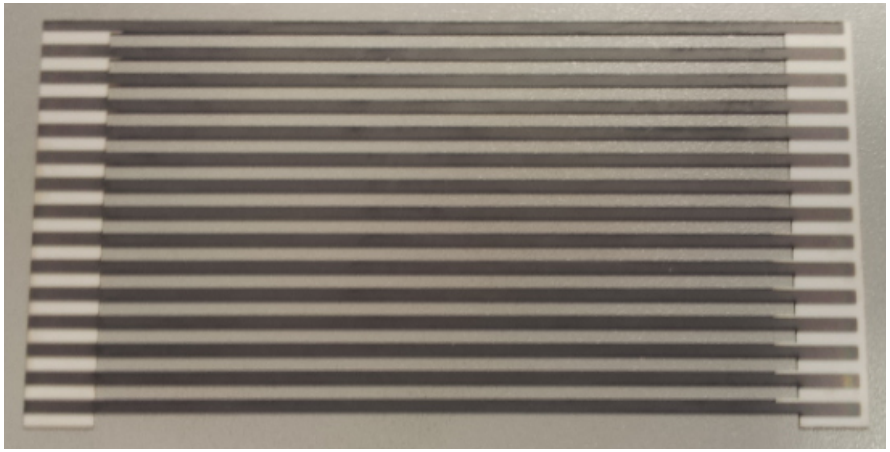
Material = Allumina (Al_2O_3)

A lamella is composed by 15 strips



$^{10}B_4C$ COATING ON THE LAMELLAS

Deposition: C Hoglund, Linköping



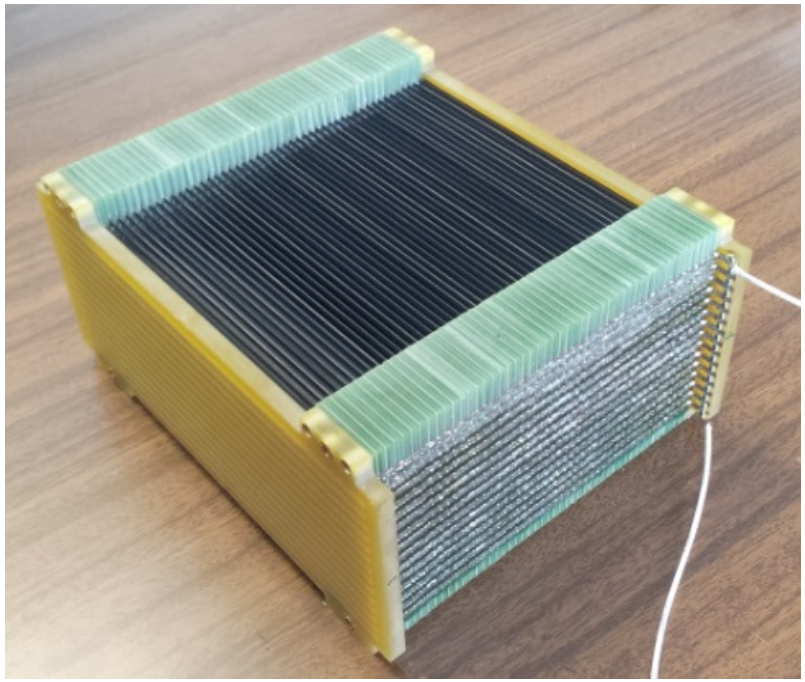
The resulting coated lamellas

A 1 µm $^{10}B_4C$ coating has been deposited on both sides of the lamella and on all the 15 strips

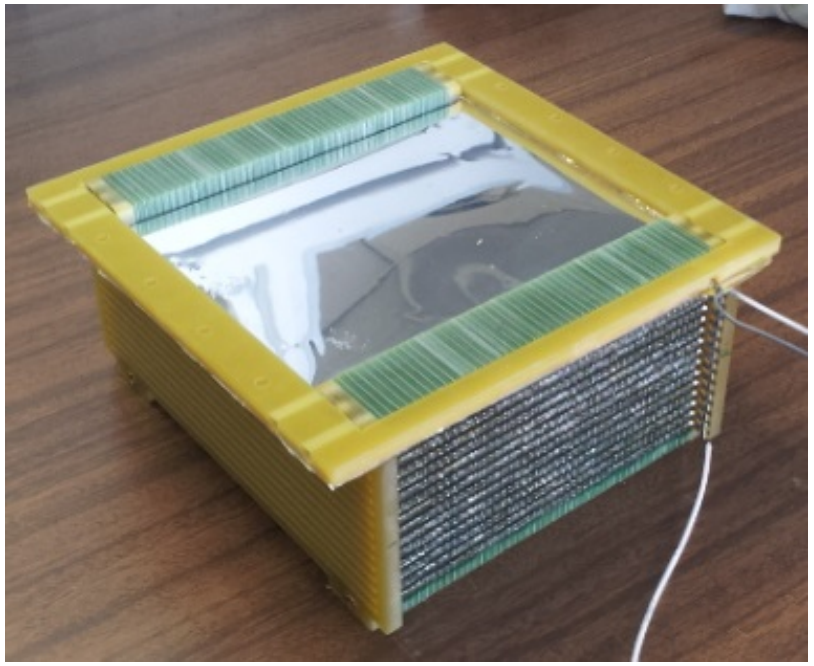
In total more than 50 lamellas have been coated
50 Lamellas are necessary to assembly the first detector prototype

Boron quantity has been determined through neutron absorption measurements (performed at ISIS-ROTAX beamline)

DETECTOR ASSEMBLY (1)

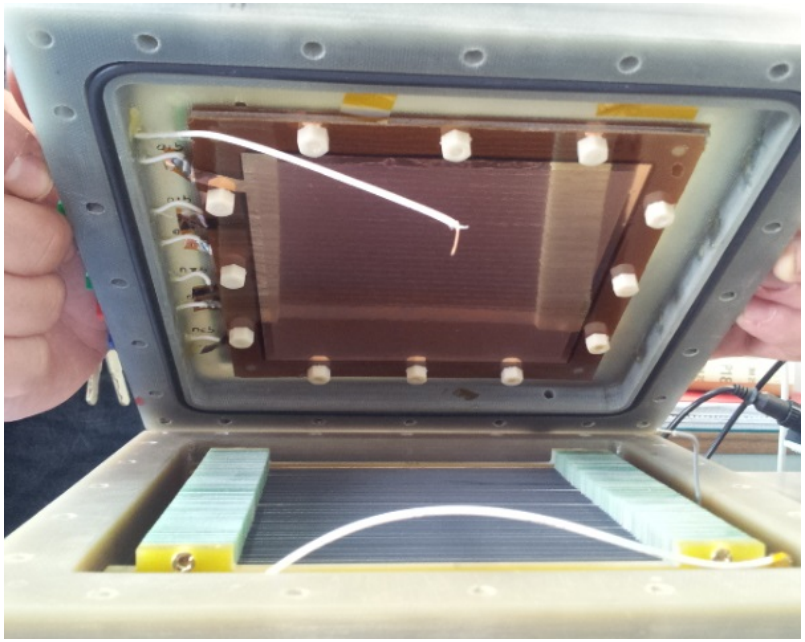


The full Lamella System. A total of 48 lamellas have been mounted mounted. Their distance is 2 mm

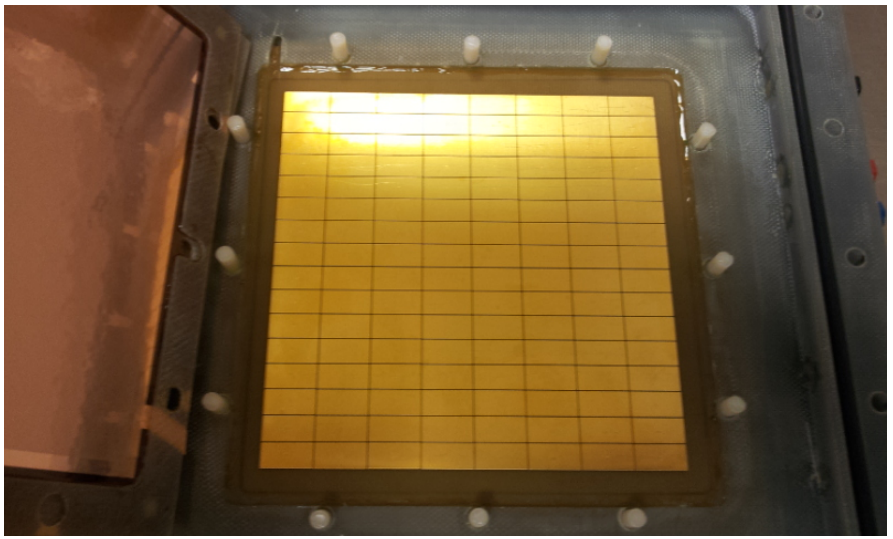


An aluminium cathode (few microns thick) has been mounted on top

DETECTOR ASSEMBLY (2)

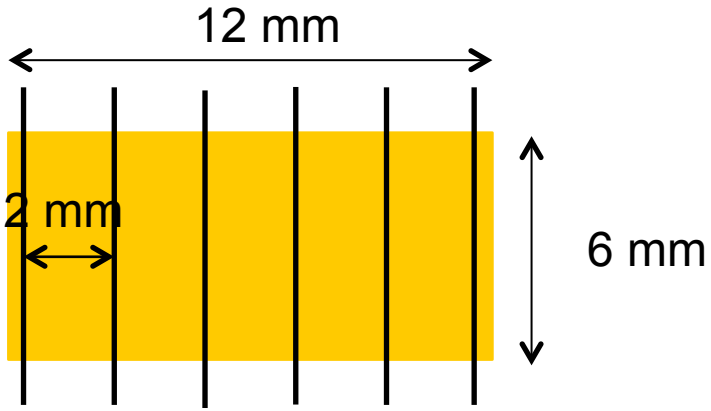


Assembly with Triple GEM detector



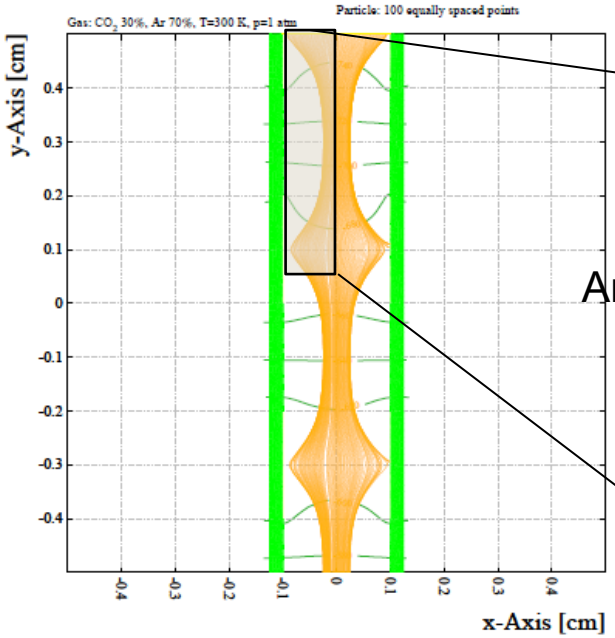
128 Pads of area 6x12 mm^2 have been used as anode

Lamella disposition on the pads



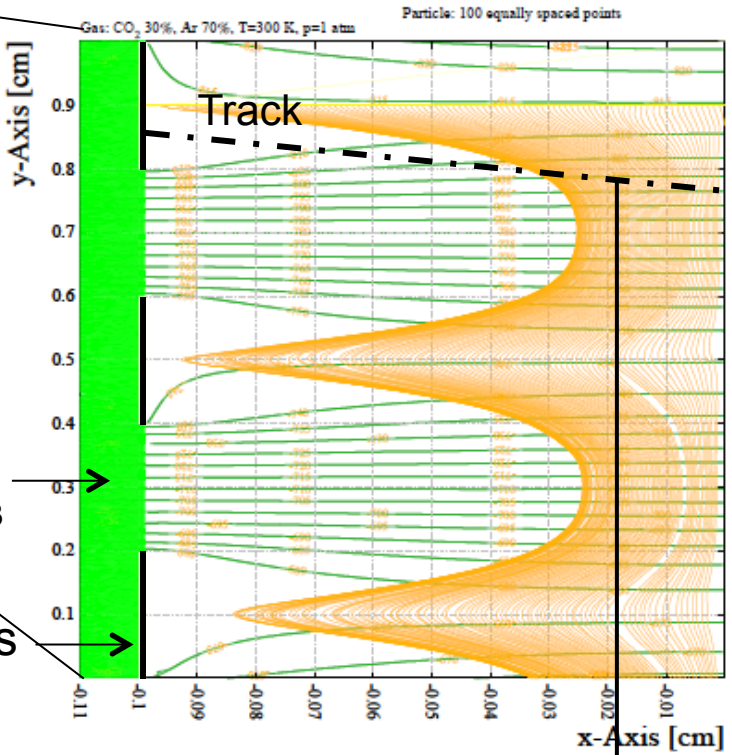
Electric field calculation and charge extraction simulations from the lamellas system (1)

Garfield+Ansys Drift Lines + Equipotential Lines calculation:



Gas: Ar/CO2 70%/ 30%

Zoom: 0 cm < y < 1 cm and -0.11 cm < x < 0 cm



Al_2O_3

B_4C Strips 1 µm

The elementary cell of the detector composed by two sides of two lamellas plus the gas in between. This view is -0.5 cm < y < 0.5 cm.

Calculation performed using the measured boron resistivity.

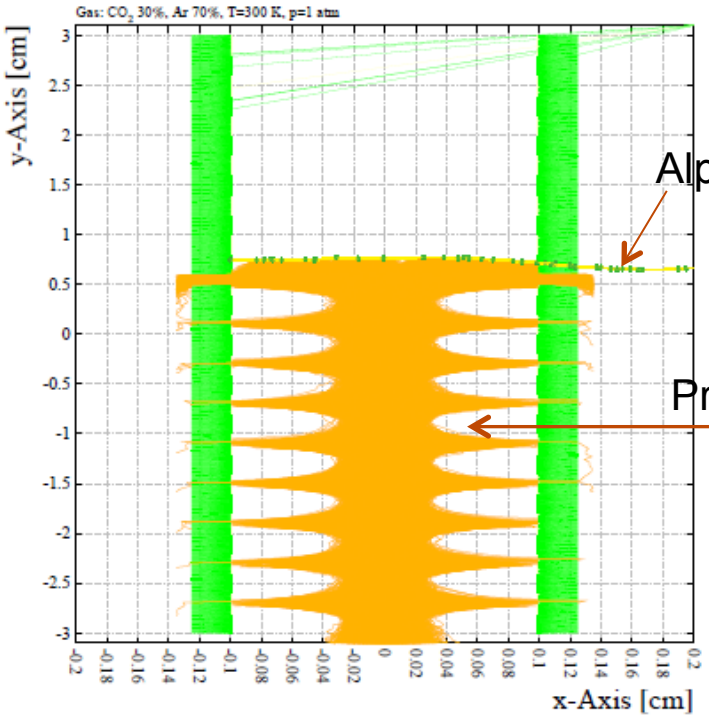
Boron strips on top of alumina

The drift electric field allows to extract primary charge from the lamella system

Collected charge fraction in the one intercepted by the drift lines

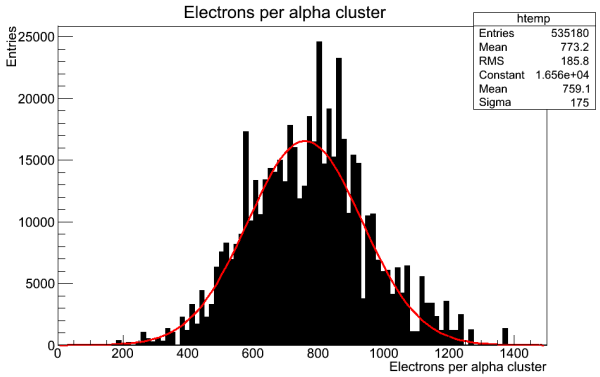
Electric field calculation and charge extraction simulations from the lamellas system (2)

Garfield simulation of 1000 alpha particles randomly generated inside the elementary cell.
The aim is to understand the quantty of the primary charge that reaches the GEM foils

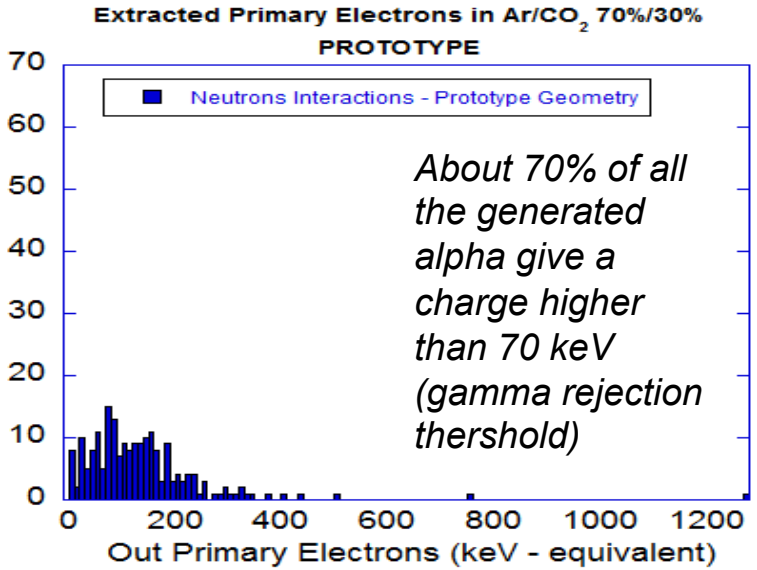


MC Simulation of primary charge generation/extraction for 1 alpha

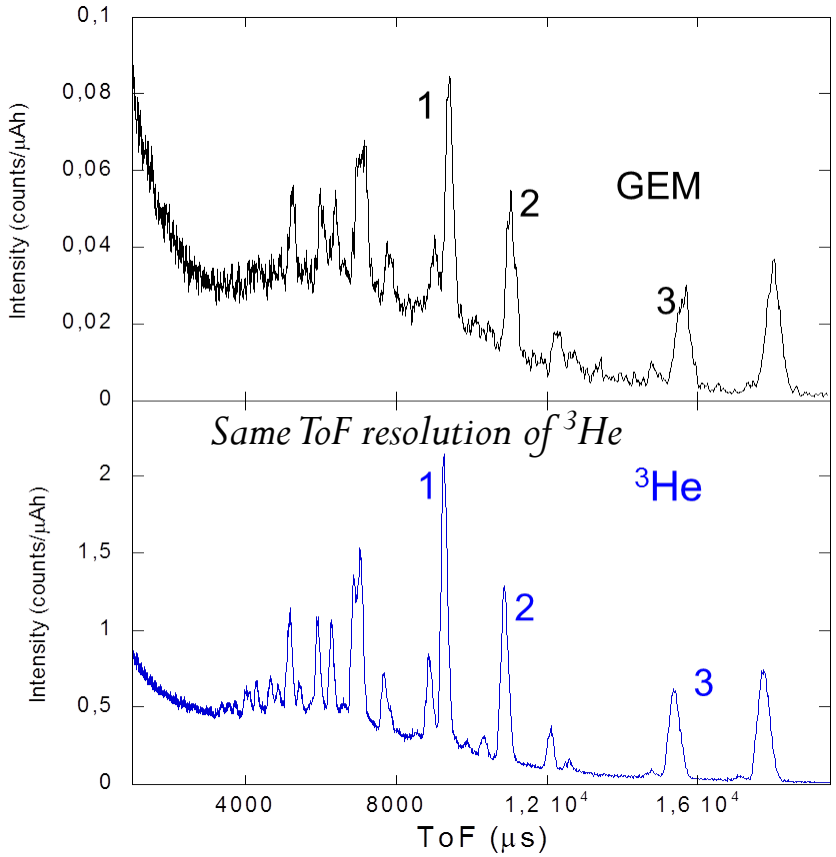
There are some losses on the walls

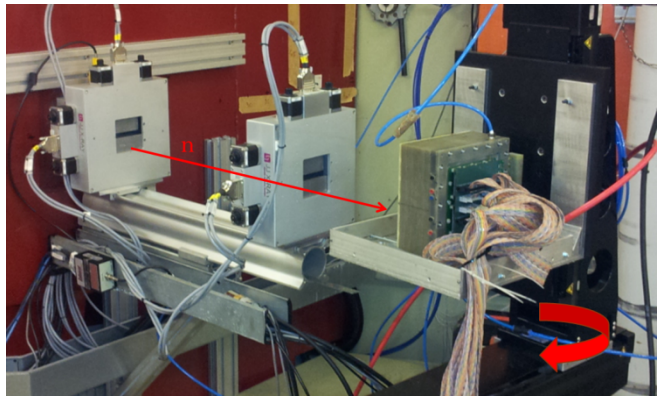


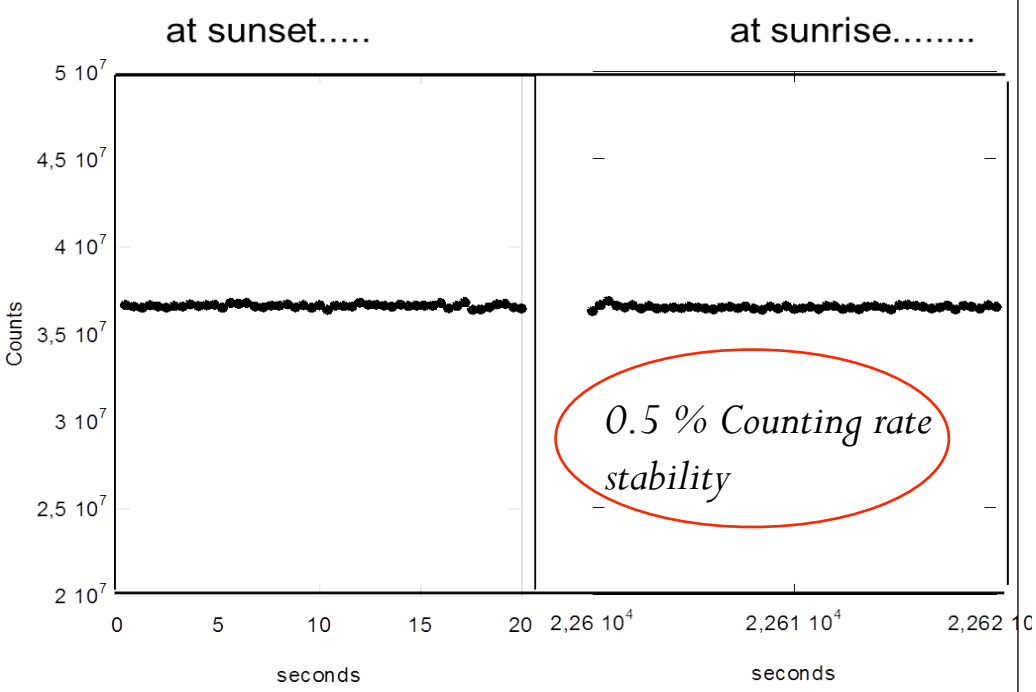
An average of 770 electrons are generated per alpha cluster in the gas. An alpha generates an average of few tenths of clusters

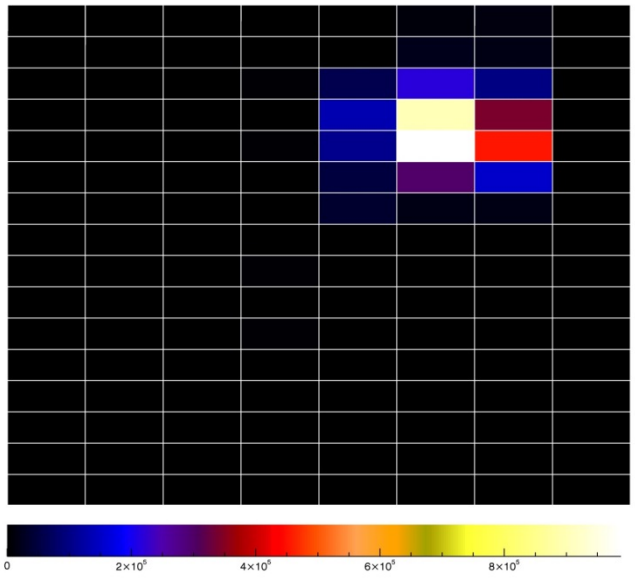


PERFORMANCE (1)









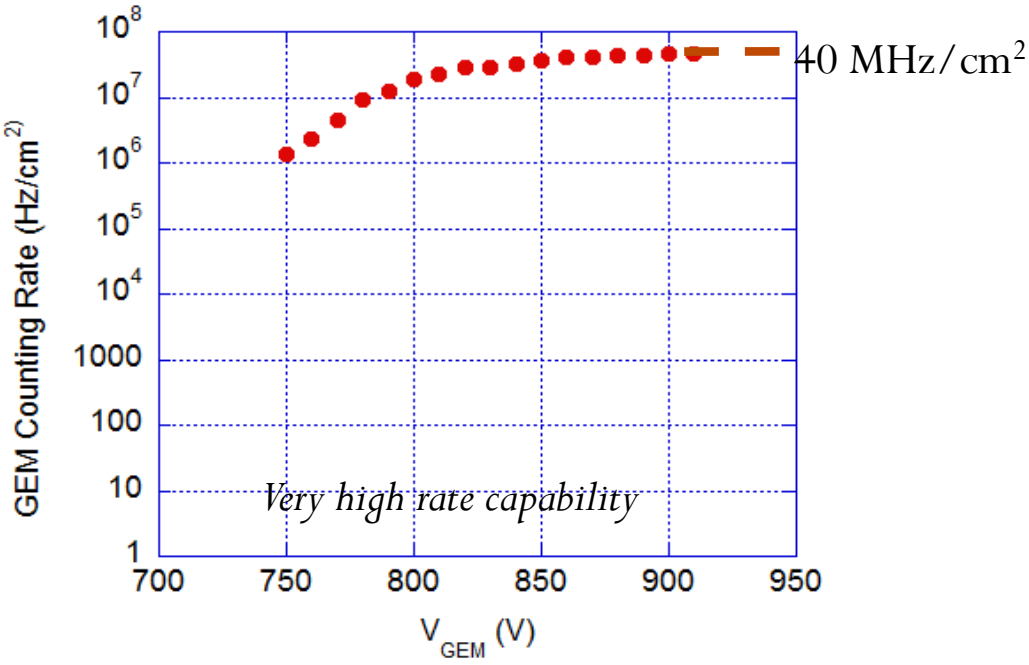
Beam Profile Reconstruction

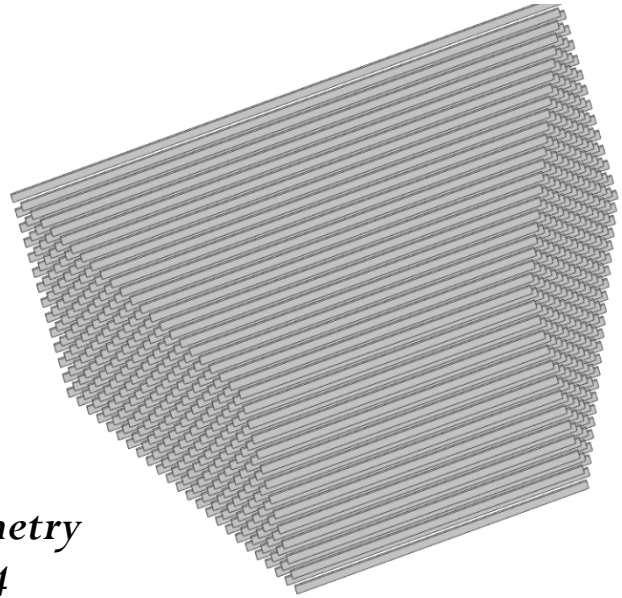
E_d = 230 V/cm
E_{t1}=E_{t2}= 3 kV/cm;
E_i = 5 kV/cm

Mixture Ar/CO2 70%/30%
Angle = 10 degrees

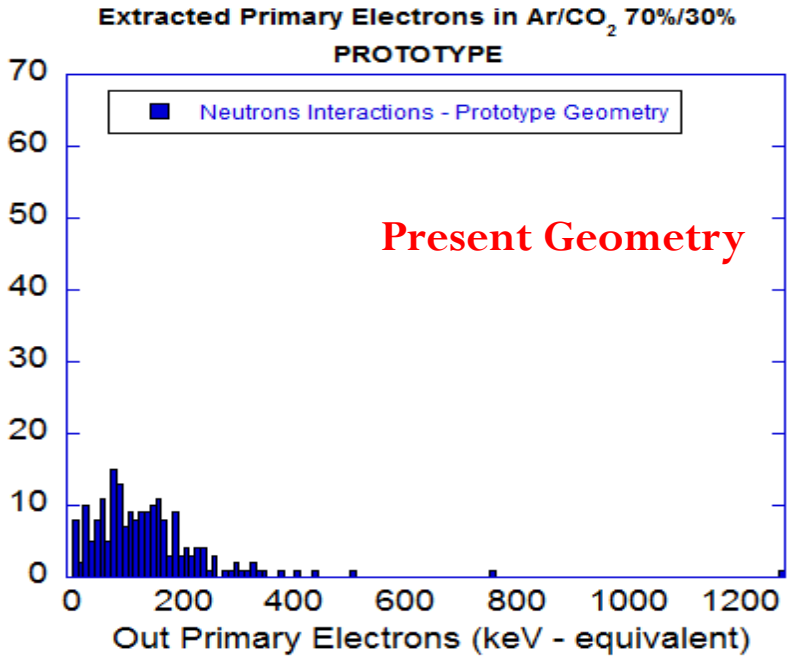
~~VGEM = 980 V~~

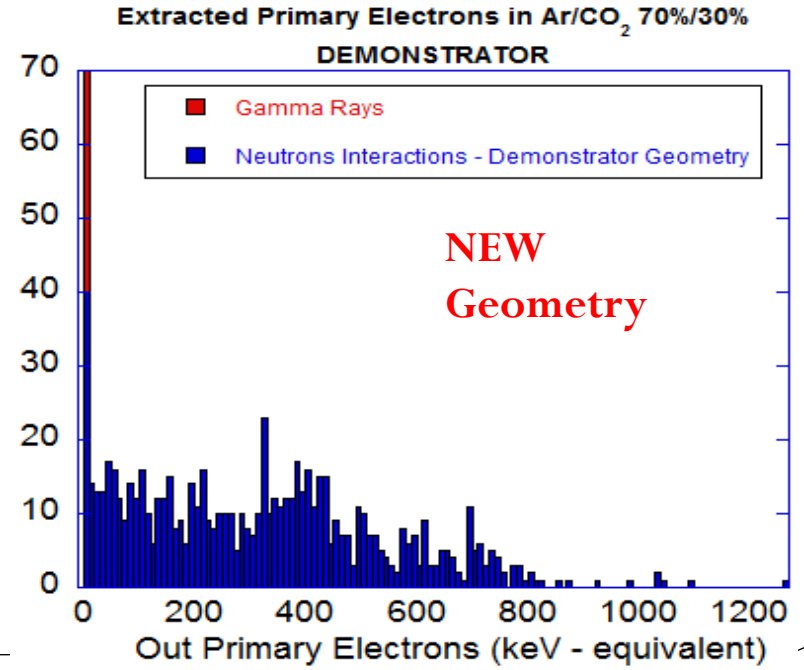
PERFORMANCE (2)



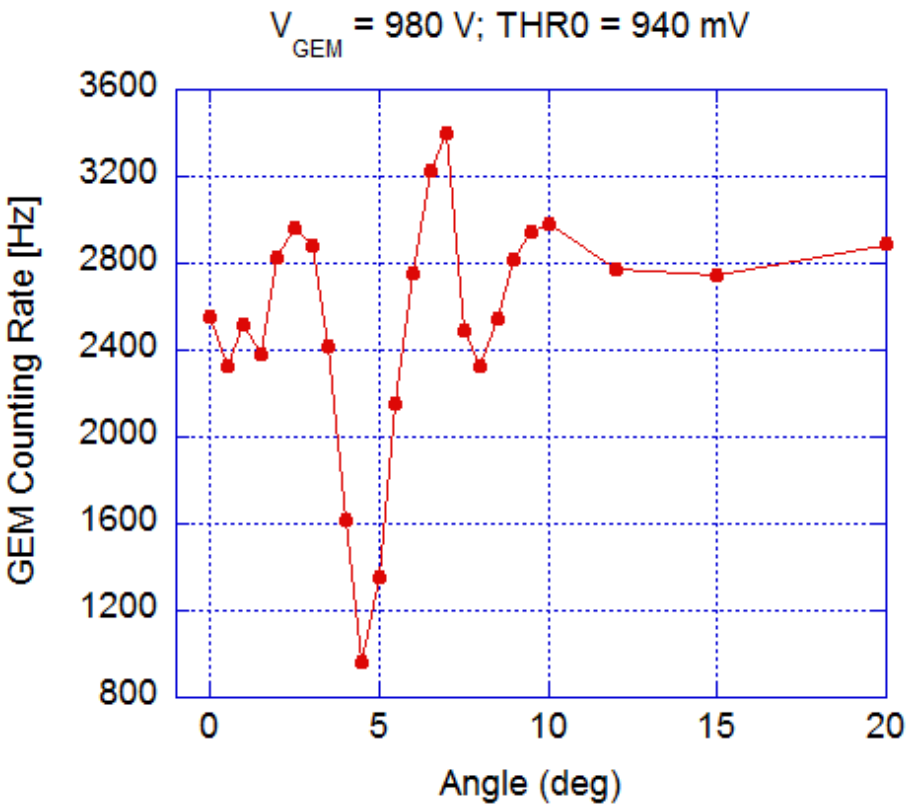


New geometry
In Geant4





PERFOMANCE: ANGULAR SCAN

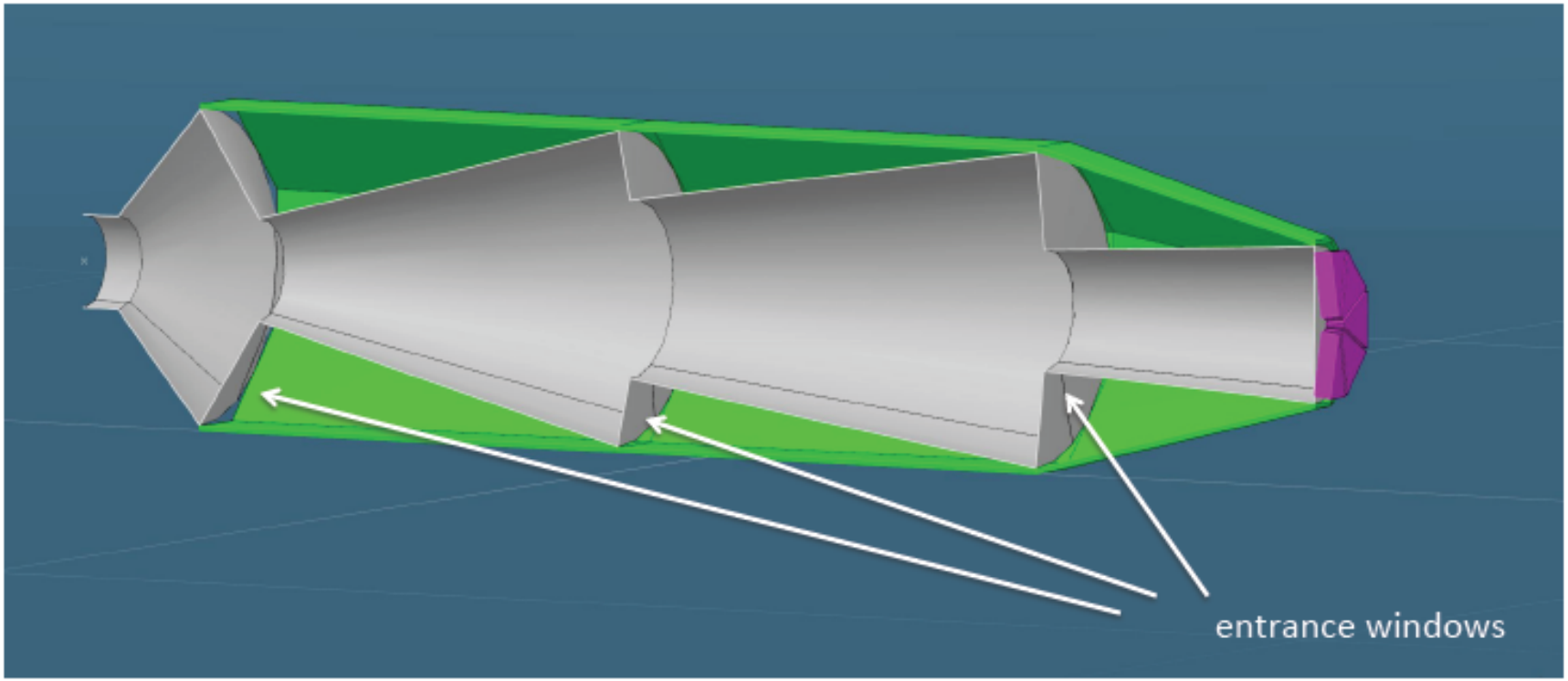


Neutron energy E_n = 34.5 meV
Beam size = 9 mm x 9 mm

The counting rate depends on the angle between the beam and the lamellas.

There is about 0.5° of systematic error settings due to the mechanics

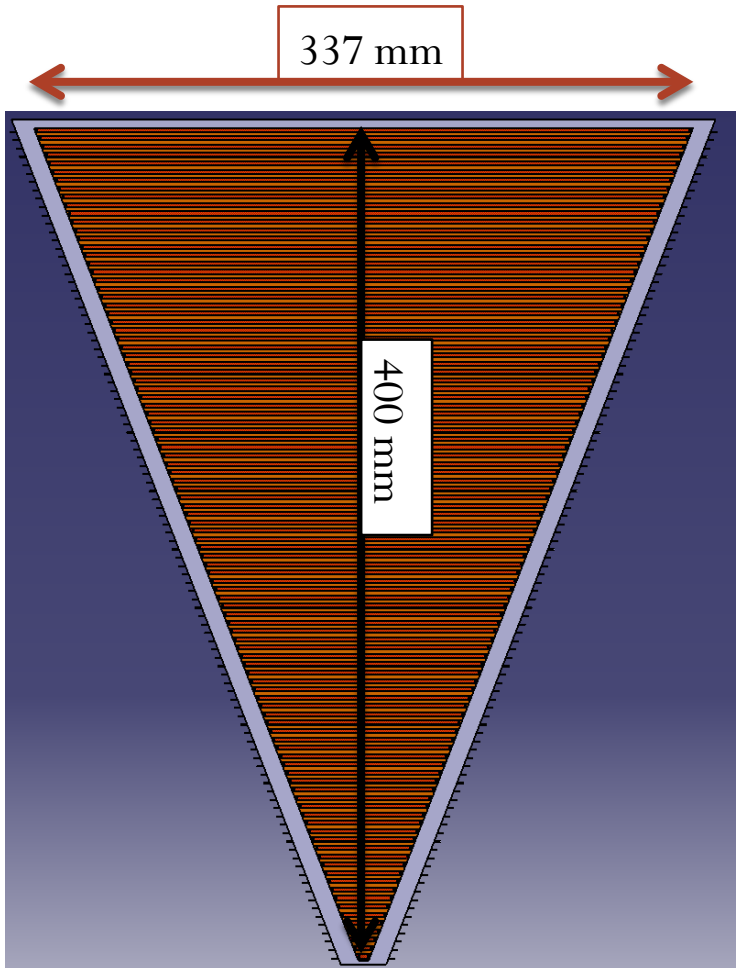
LOKI Instrument @ ESS



Small Angle Neutron Scattering Instrument
Q range form 0.001 to 1 $Å^{-1}$

BANDGEM will be used as rear panel (purple panel in the picture)
They may be used also for front and middle panel (under discussion)

The BANDGEM system for LOKI



Total active area: 647 cm^2