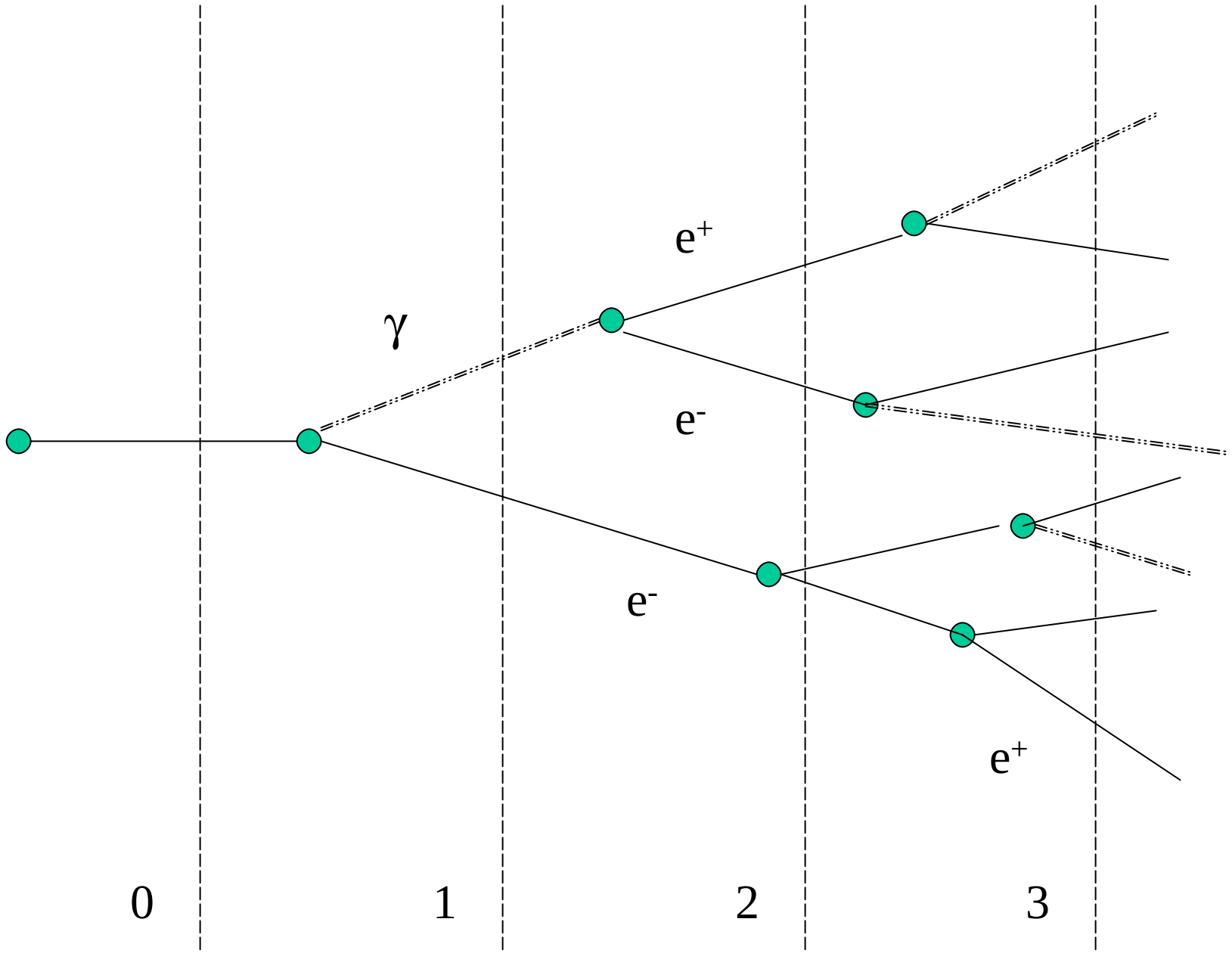
Outline

- Electromagnetic showers
- Shower Development
- Characteristics of showers
- Shower Detectors
- DHCal
- Design Concept
- Conclusion

Electromagnetic Showers

- Electrons with energies > 100MeV lose energy almost entirely through bremsstrahlung
- $\gamma \longrightarrow e^+ + e^-$

  (Pair Production)


γ
e+
e-
e-
e+
0
1
2
3

Characteristics

- $N(t) = e^{t\ln 2}$
- $t_{max} = \ln(E_o/E)/\ln 2$
- $L \approx E_0/E$
- Showers are statistical in nature

Shower detectors

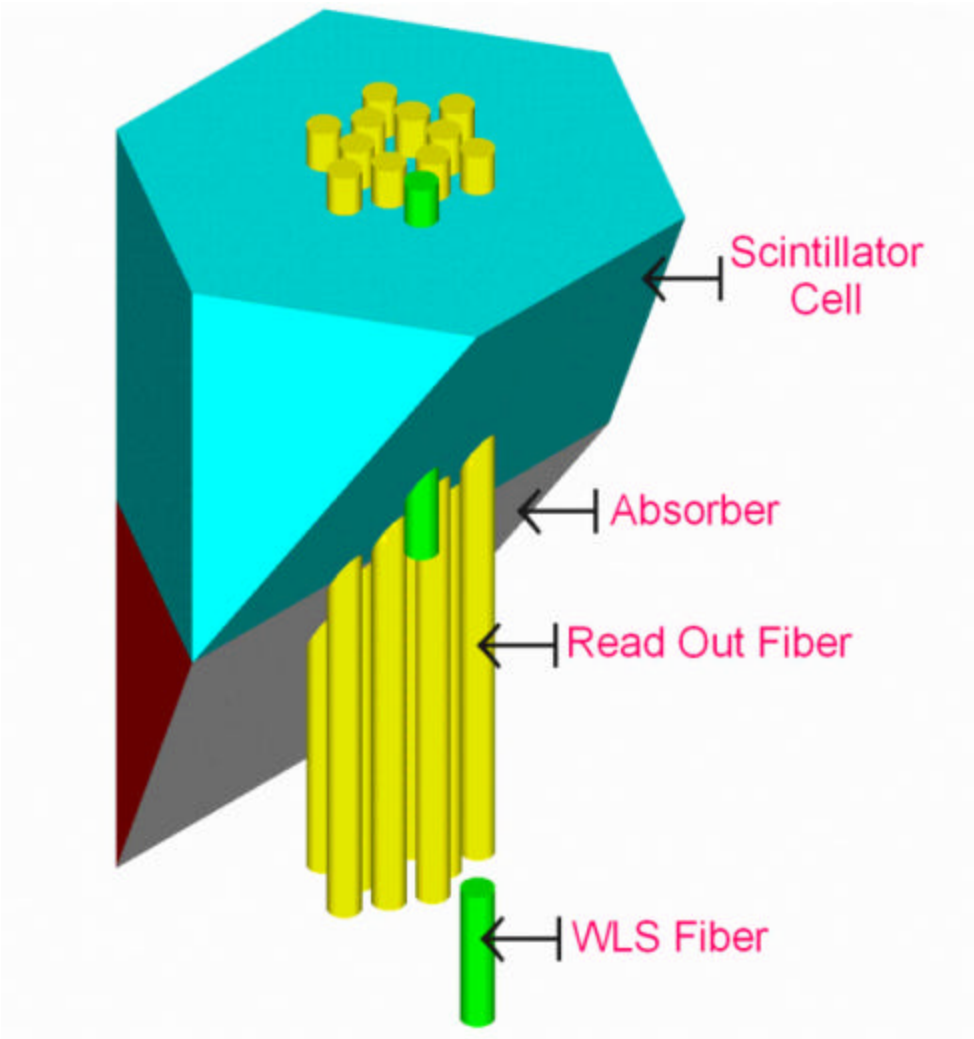
- Calorimeters measure the total energy deposited
- Two types – Electromagnetic and Hadronic
- $t_{max} = 3.9 + \ln E_o$

  The total energy is measured by counting the number of particles in the shower whose energy exceeds certain value

Hadronic Showers

- Transverse momentum = 350MeV/c Hence hadronic showers are more spread out.
- Most of the energy dissipated is by ionization losses and secondary protons
- $\pi^o \rightarrow 2\,\gamma$ (leading to showers)

DHCal


Scintillator Cell
Absorber
Read Out Fiber
WLS Fiber

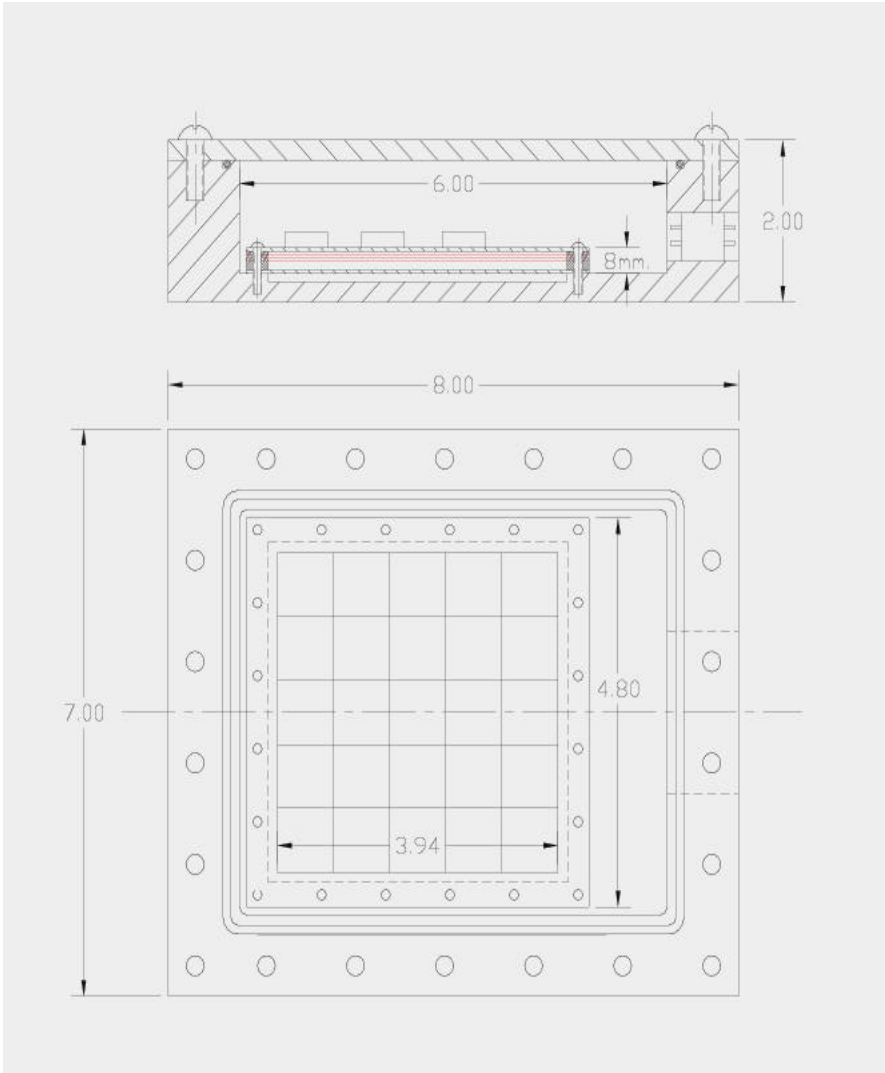

6.00
8mm
2.00
8.00
7.00
4.80
3.94

Fig. 14 (a) Chemical etching Process of a GEM (b) A GEM foil

A new concept of gas amplification was introduced in 1996 by Sauli: the Gas Electron multiplier (GEM) [27] manufactured by using standard printed circuit wet etching techniques' schematically shown in Fig. 14(a). Comprising a thin (~50 μm) Kapton foil, double sided clad with Copper, holes are perforated through (fig. 15b). The two surfaces are maintained at a potential gradient, thus providing the necessary field for electron amplification, as shown in Fig. 15(a), and an avalanche of electrons as in Fig. 15(b).

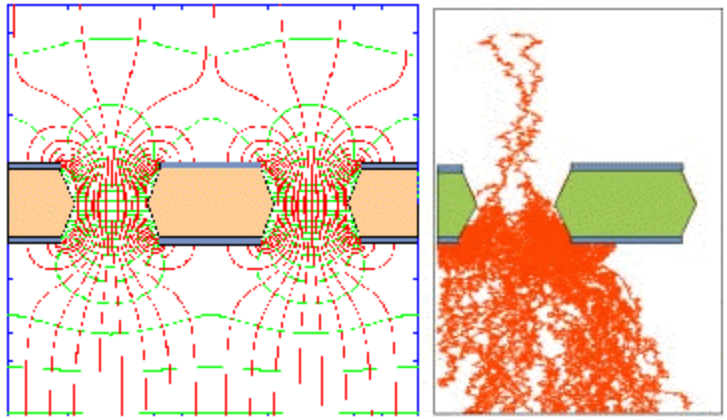
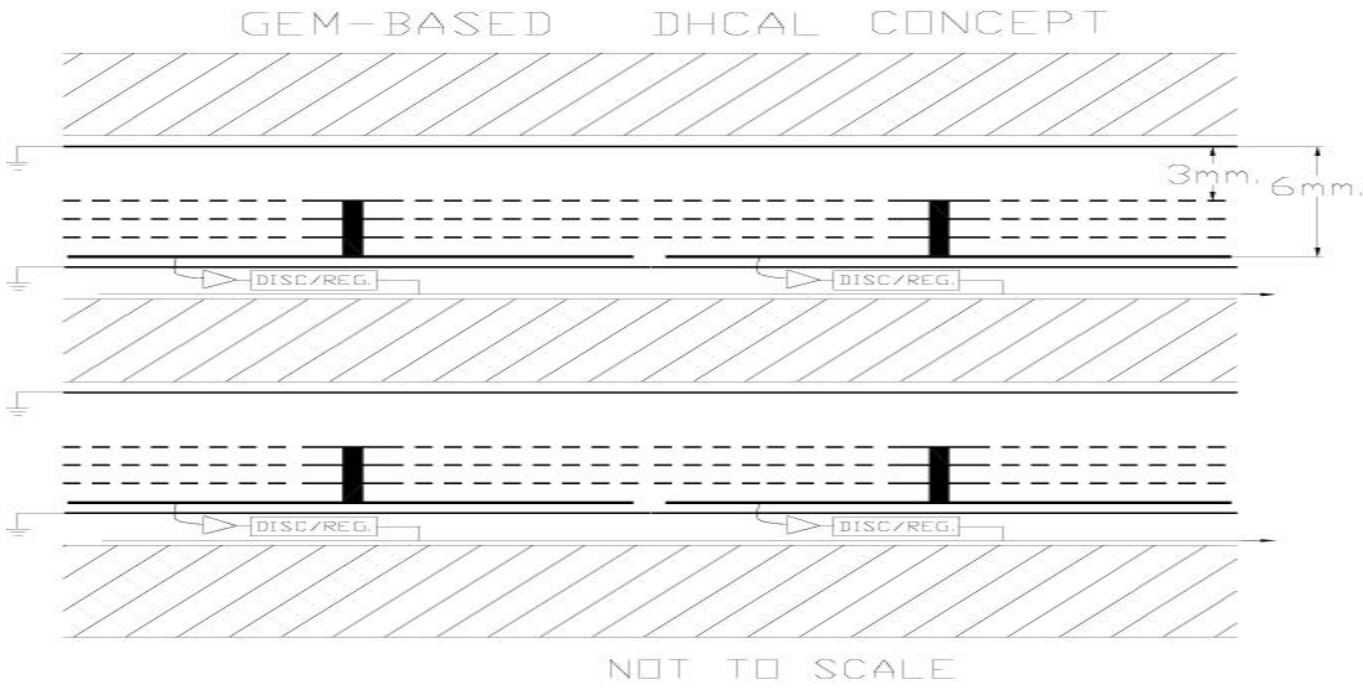


Fig. 15(a) Electric Field and (b) an avalanche across a GEM channel

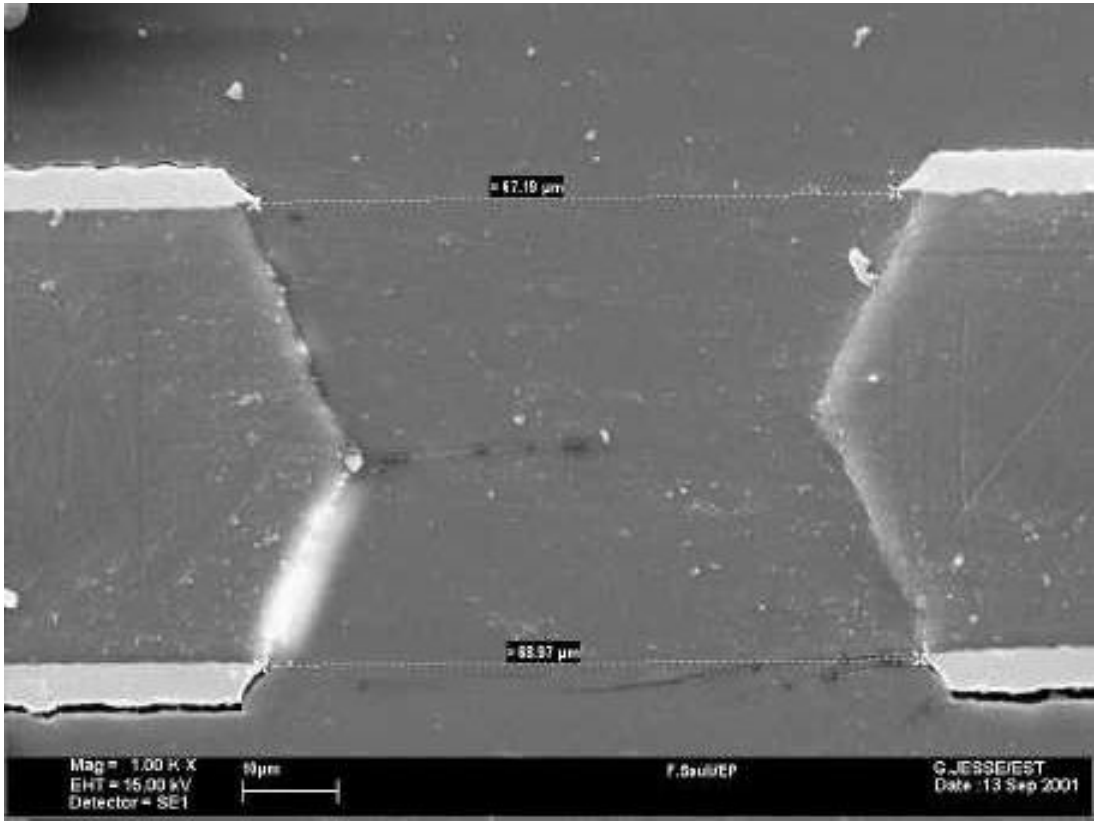
Coupled with a drift electrode above and a readout electrode below, it acts as a highly performing microparticle detector. The essential and advantageous feature of this detector is that amplification and detection are decoupled, and the readout is at zero potential. Permitting charge transfer to a second amplification device, this opens up the possibility of using a GEM in tandem with an MSGC or a second GEM.

From CERN-open-2000-344, A. Sharma

Initial design concept for gas amplification DHCAL



CERN GDD Group – electron-micrograph of GEM foil hole



Conclusion

- Study of various technologies
- Construction of mechanical prototypes
- Construction of multi layer prototype