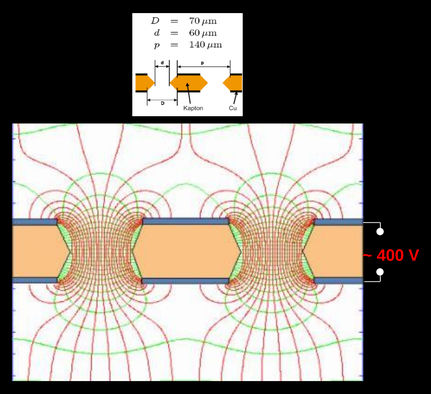
Gas Electron Multiplier (GEM) Detectors

Kondo GNANVO

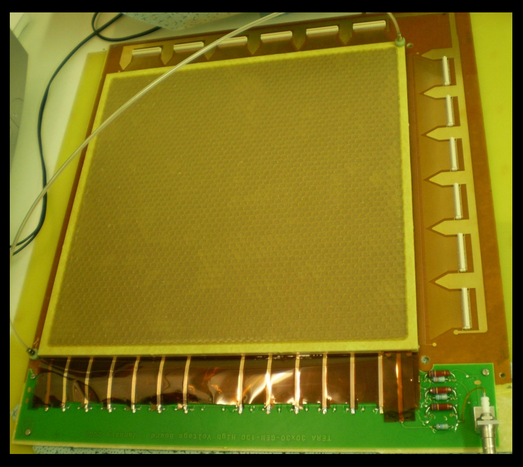
University of Virginia, Department of Physics, Charlottesville, VA 22901, USA

GEM Detectors: Basic Principle

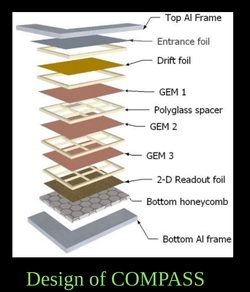
The Gas Electron Multiplier (GEM) is a Micro Pattern Gaseous Detector (MPGD) technology invented by at CERN (F. Sauli 1997). Its main feature is the GEM foil which consists of a thin, metal-clad polymer foil, chemically pierced by a high density of holes (typically 50 to 100 per mm^2). On application of a difference of potential between the two electrodes, electrons released by radiation in the gas on one side of the structure drift into the holes, multiply and transfer to a collection region. Each hole acts as an individual proportional amplifier. The multiplier can be used as detector on its own, or as a preamplifier in a multiple structure detector.



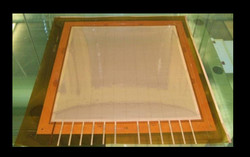
Strong E field ➔ Avalanche multiplication of electrons



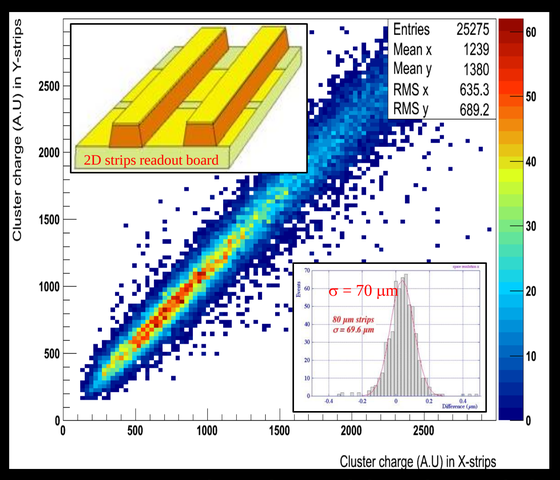
Florida Tech Triple GEM for Muon Tomography
(Based on COMPASS and TERA Design)



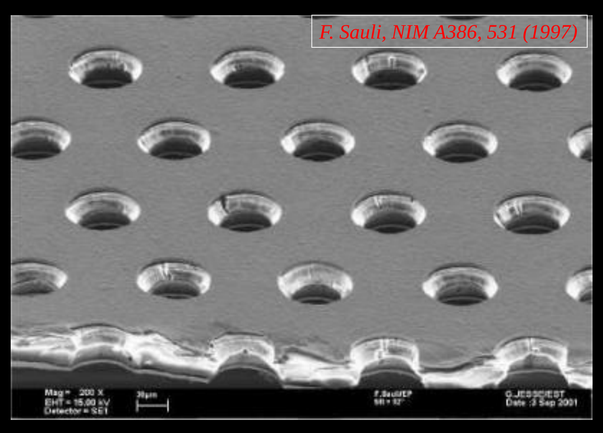
Design of COMPASS Triple GEM Chambers



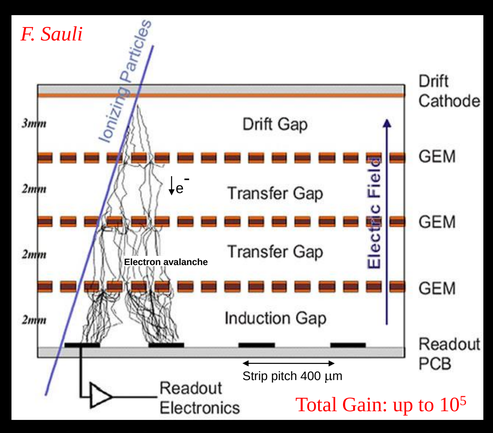
30 × 30 cm^2 GEM Foil
(Florida Tech)



2D Cartesian strips readout with an equal charge sharing in both X and Y ➔ Excellent position spatial resolution in X and Y



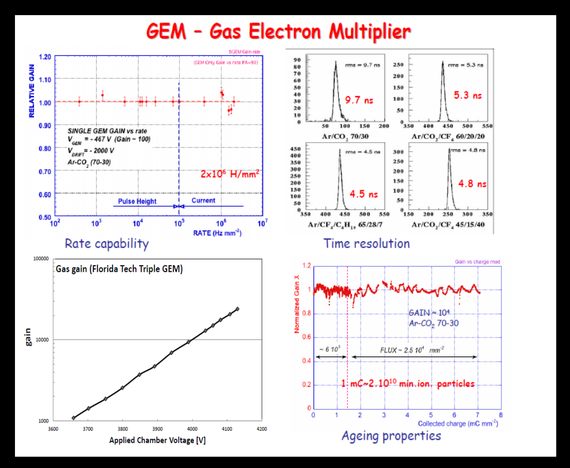
GEM foil under electron microscope



A triple-GEM detector: gain sharing between the foils improves the reliability of operation at high gain

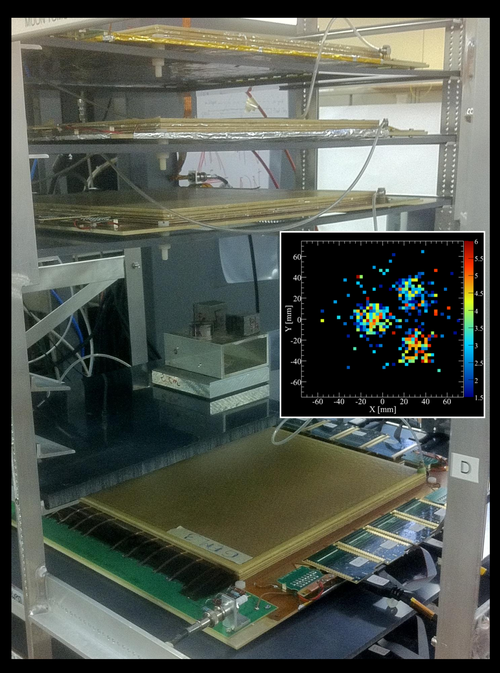
The main characteristics and performances of GEM detectors are:

- Operation in most gas fillings, including pure noble gases
- Proportional gains above 10^5
- Energy resolution 18% FWHM at 5.9 keV
- Space localization accuracy 60μm rms or better
- Rate capability above 10^5 counts/mm^{2}sec
- Flexible detector shape and readout patterns
- Robust, low cost

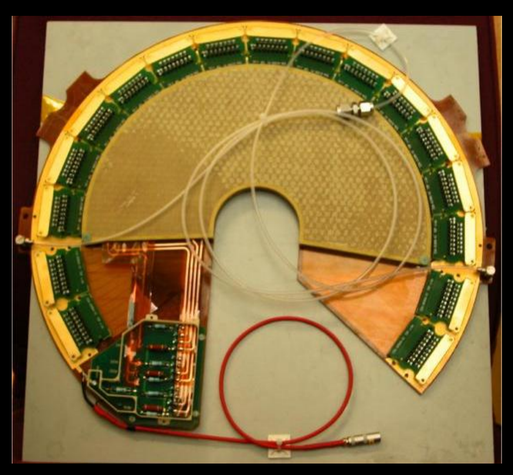


Characterization and performances of GEM detectors

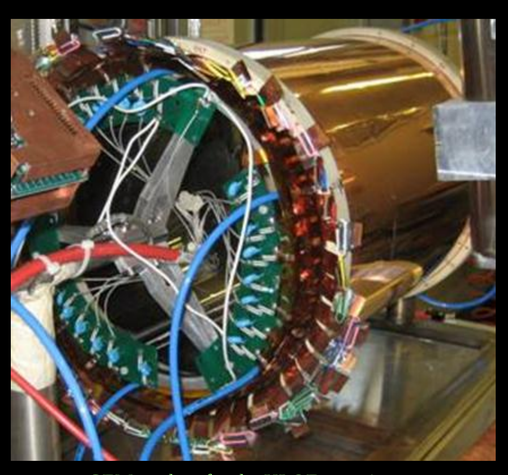
GEM in High Energy and Nuclear Physics / Industrial Applications



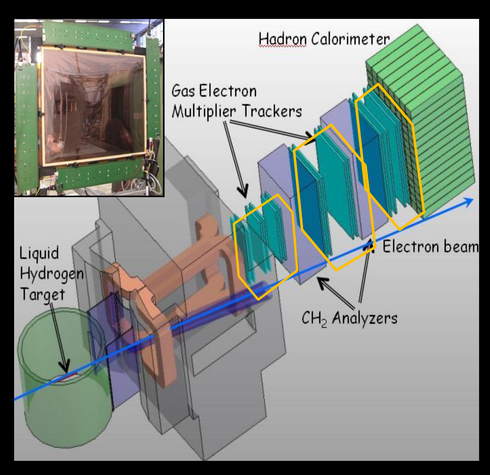
Muon Tomography GEM Tracker Prototype for Homeland Security application (*Florida Tech*)



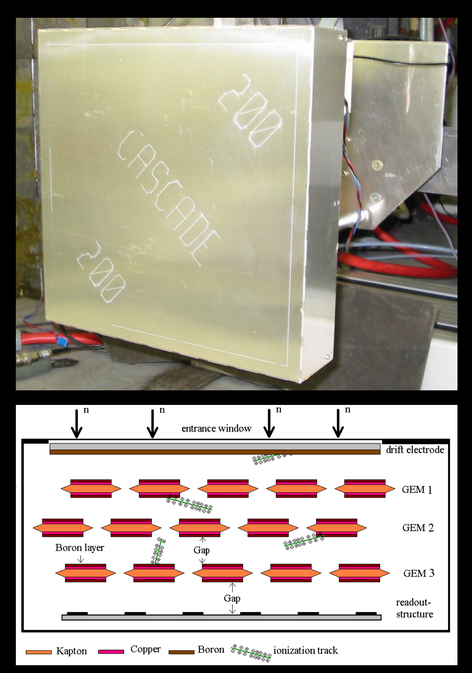
GEM tracker for the LHC TOTEM experiment @ CERN (Switzerland)



GEM tracker for the KLOE experiment @ DAFNE *(Frascati, Italy)*



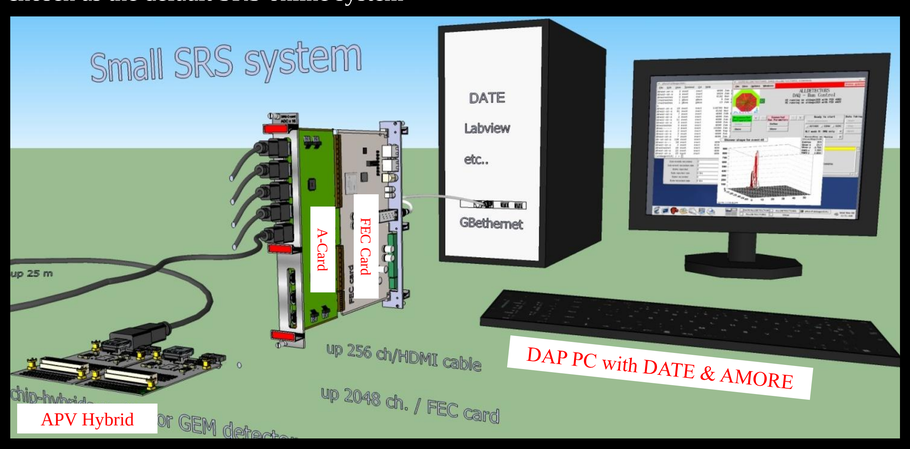
GEM for the Super BigBite Spectrometer for 12 GeV Experiment @ JLab

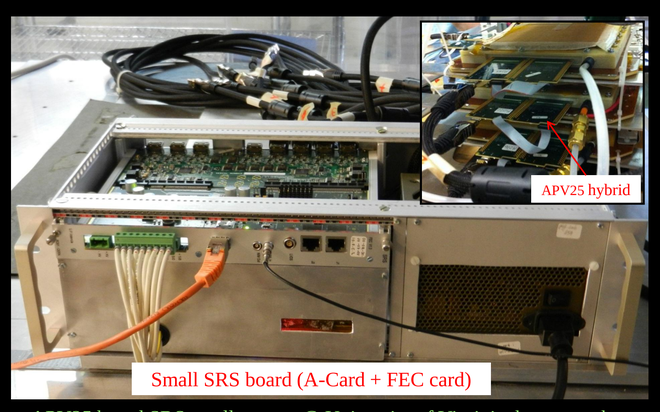


CASCADE GEM as Neutron Detector
(Heidelberg, GERMANY)

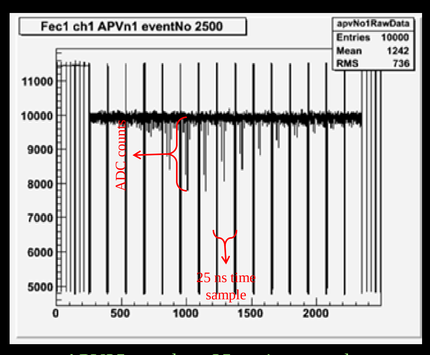
SRS: Multi Channel Scalable Readout Electronics for MPGDs

The Scalable Readout System (SRS) was developed within the RD51 collaboration as a complete readout system for MPGDs like GEMs or MicroMegas. SRS is a flexible approach that provides a choice of ASICs, hybrids or discrete frontends, with either analog, binary or digital readout, connected over a customizable interface to a DAQ system. This interface is implemented via application-specific adapter cards (A-cards) to a common module for all applications, the Front-End Concentrator (FEC). The FEC architecture is built around a configurable FPGA with event buffer, Gigabit Ethernet, I/O for Trigger, clocks and for the A-cards. The A-card must include all the necessary resources (like signal connectors, amplifiers, ADCs, buffers, logic, etc.) to readout and control the custom front-end. For small systems, the FECs are directly connected via gigabit Ethernet to the online system. Large systems require the Scalable Readout Unit (SRU) for aggregating up to 40 FEC cards to 10-Gbit Ethernet network ports of an online PC or PC farm. ALICE DAQ system DATE has been chosen as the default SRS online system

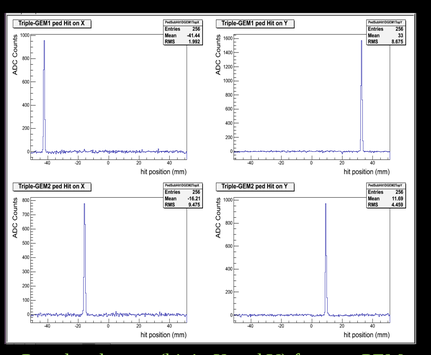




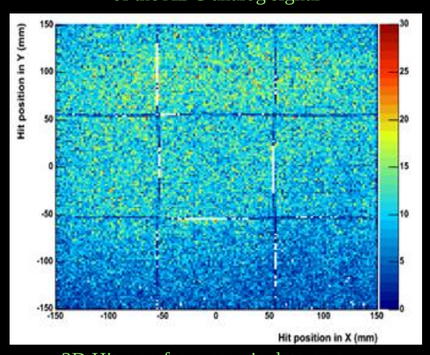
APV25 based SRS small system @ University of Virginia the system has up to 2048 channels to read out 4 tripleGEM detectors (10 × 10 cm^2)



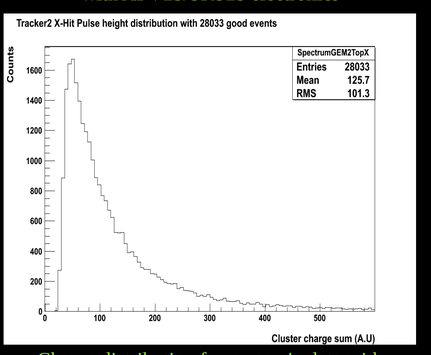
APV25 raw data: 25 ns time samples of the ADC analog signal



Correlated event (hit in X and Y) for two GEM with APV25/SRS25 electronics



2D Hit map from cosmic data on a large Florida Tech triple GEM



Charge distribution from cosmic data with landau distribution of the mip particle