GEM Studies for LCTPC

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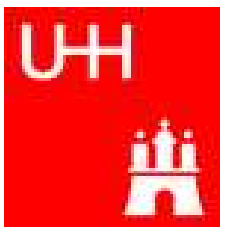


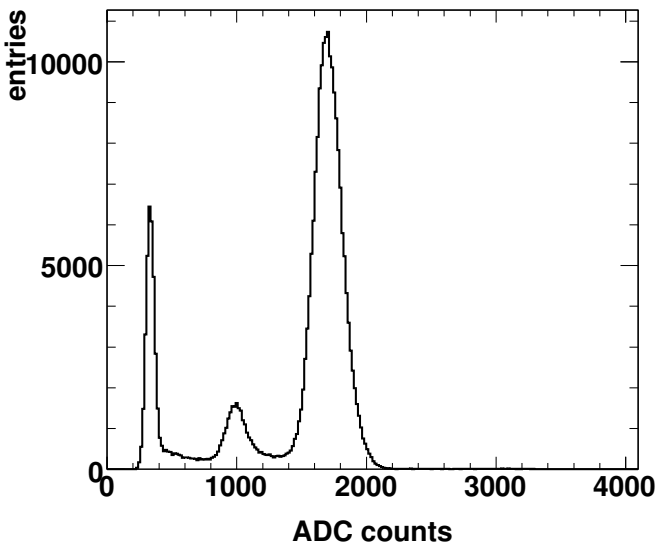
content

test chamber

diameter: 21 cm
height: 19 cm
drift distance: 2 cm
source on top of cathode

Iron 55 source
pedestal, escape and photo peak (5.9 keV)

corrected photo peak position and preamp calibration
$\Rightarrow$ gain determination

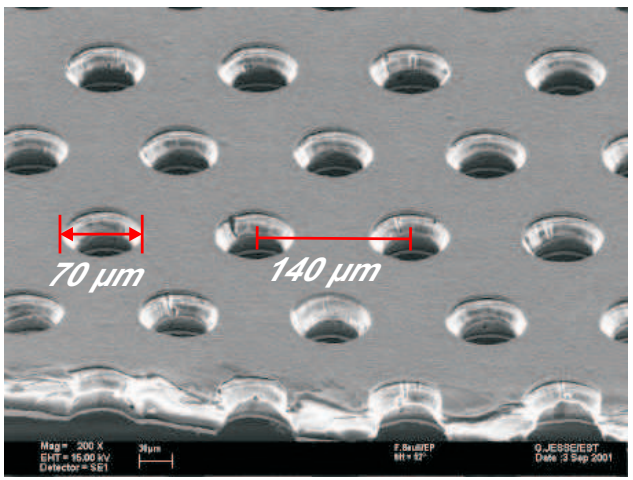


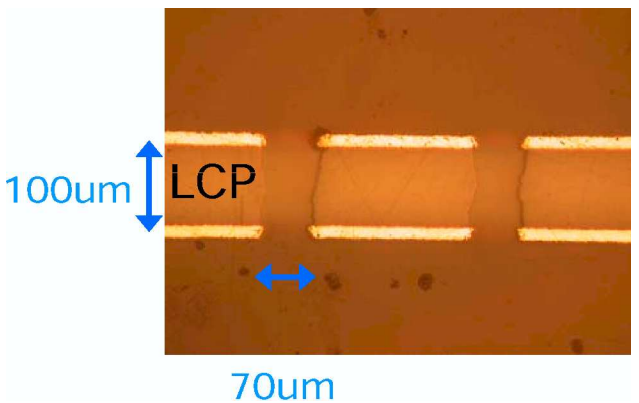
measurement conditions

- double GEM setup
- voltage divider
- drift distance 2 cm
- drift field 250 V/cm
- transfer field 1000 V/cm
- induction field 1000 V/cm
- TDR gas (93 % Argon, 5 % CH_4, 2 % CO_2)
- unsegmented anode
- transimpedance preamplifier
- no magnetic field

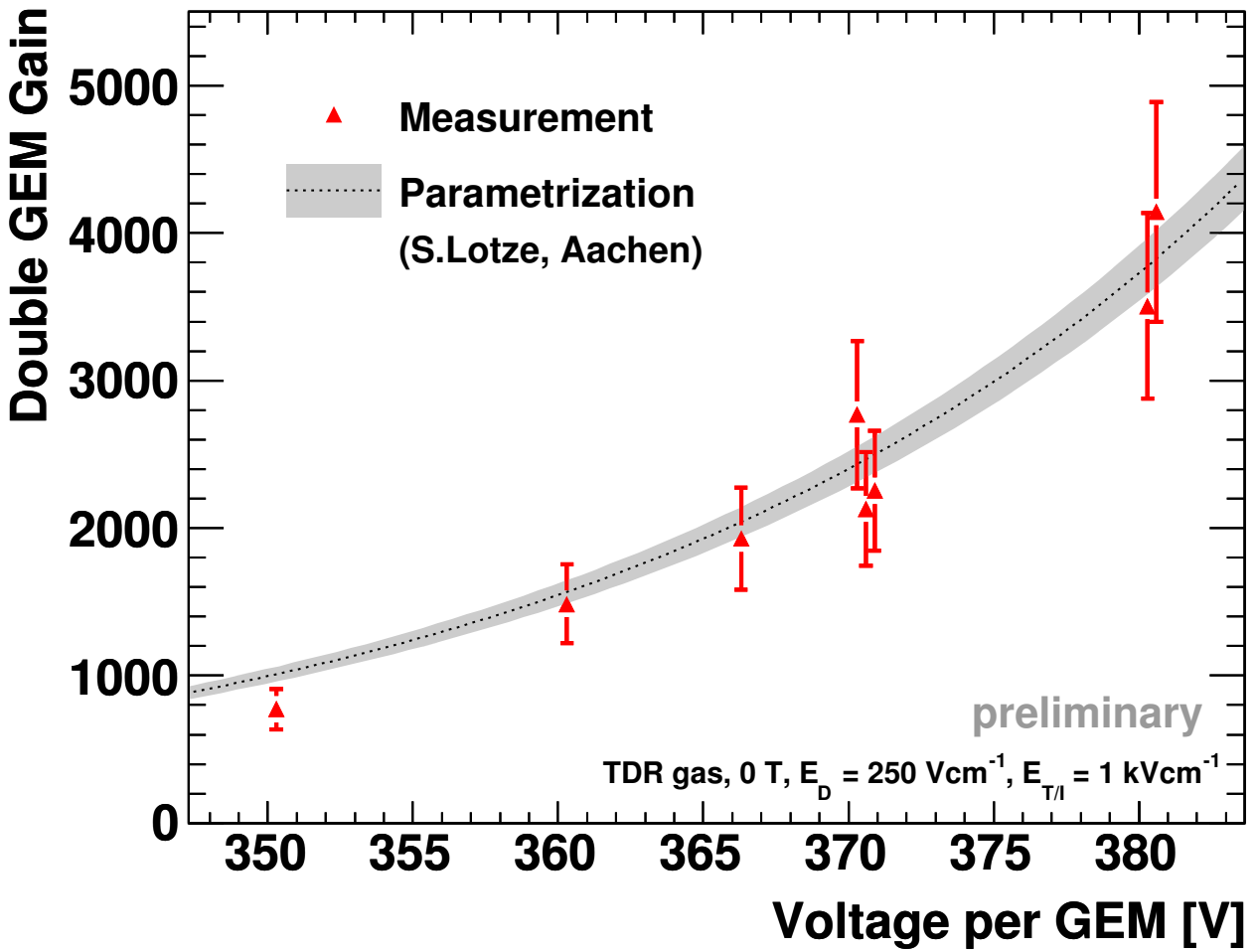
tested GEM types

manufacturer	substrate	thickness	pitch	etching	hole shape
CERN GDD group	Polyimid	50 µm	140 µm	chemical	double conical
CERN GDD group	Polyimid	50 µm	225 µm	chemical	double conical
TechEtch, USA	Kapton®	50 µm	140 µm	chemical	double conical
SciEnergy, Japan	LCP	50 µm	140 µm	Laser/plasma	cylindrical
SciEnergy, Japan	LCP	100 µm	140 µm	Laser/plasma	cylindrical

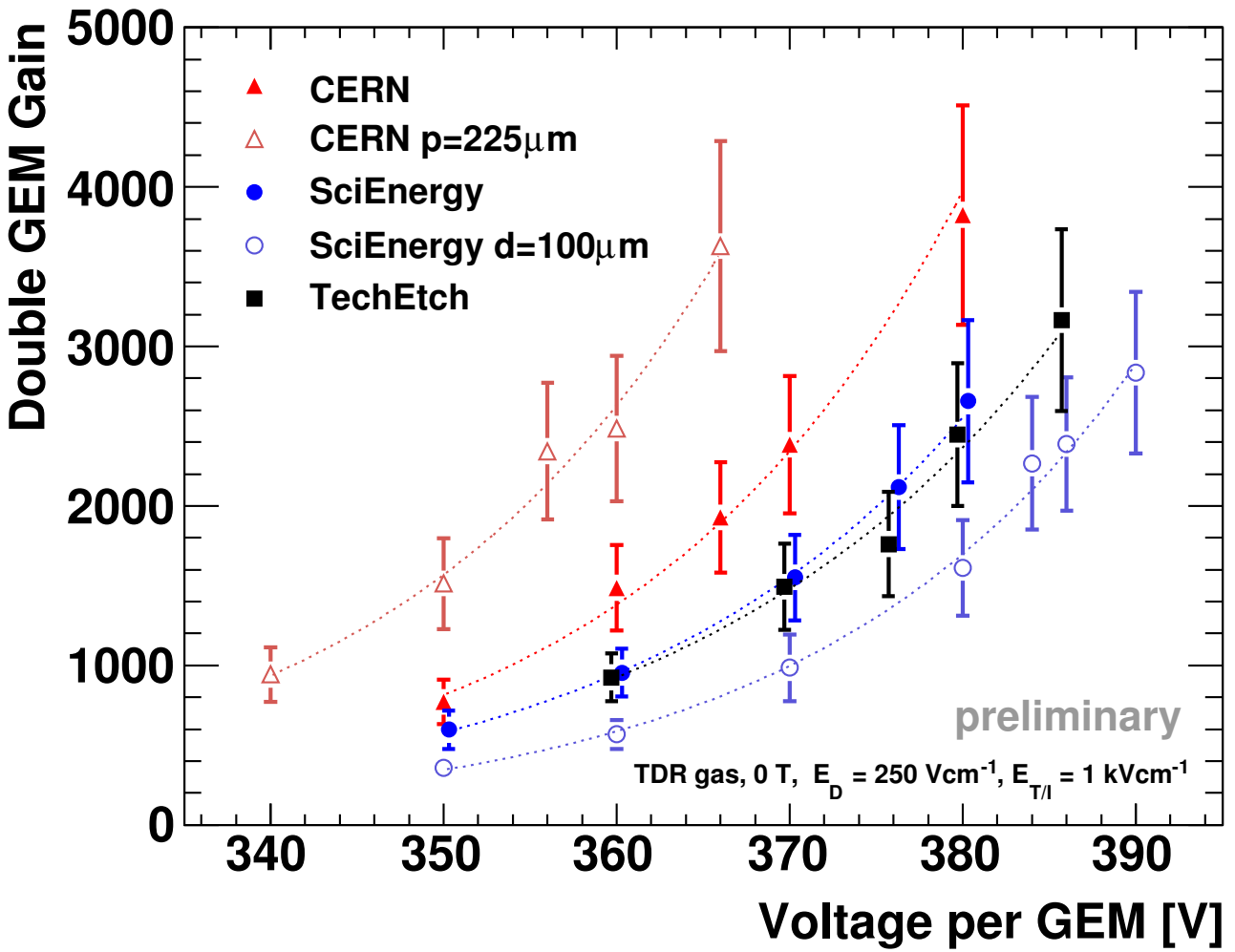




gain parametrization describes data

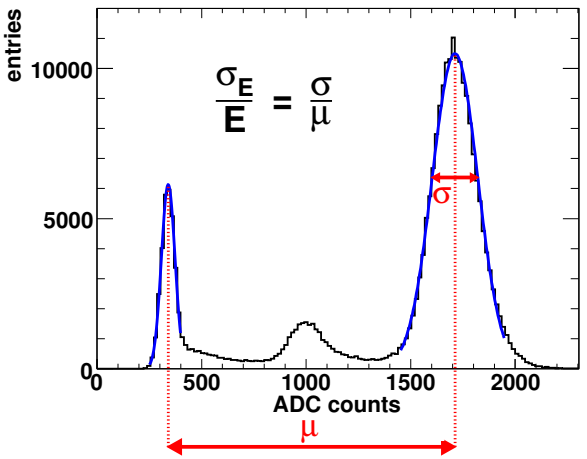


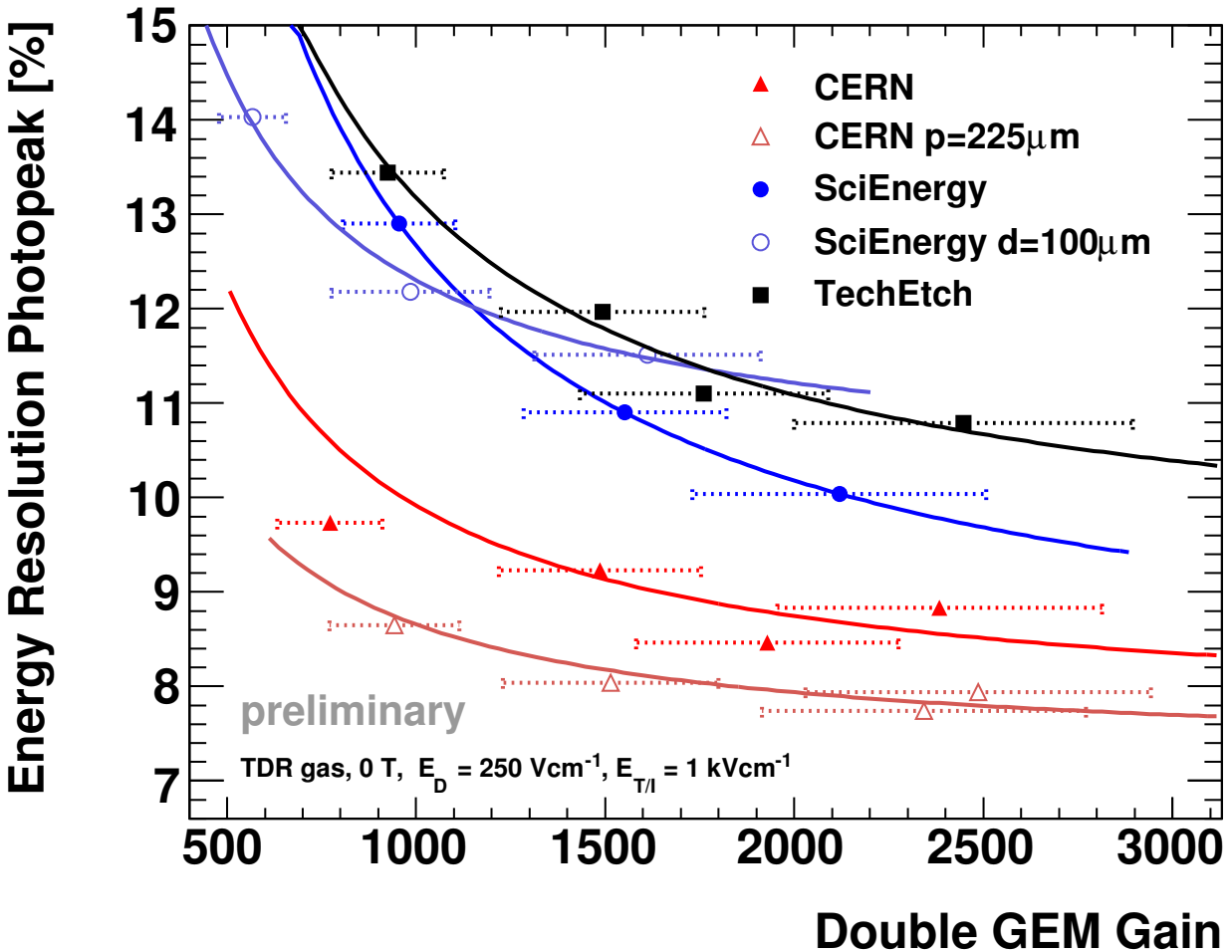
gain comparison for different GEM types



- hole shape matters
  $\text{gain}_{d.con} > \text{gain}_{cyl.}$
- material seems to matter
  $\text{gain}_{polyimid} > \text{gain}_{LCP}$

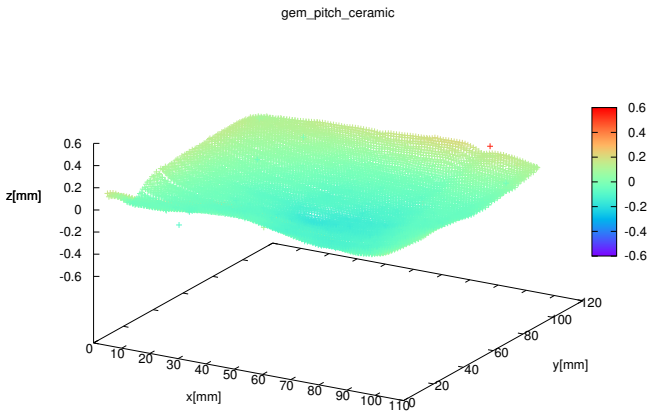
energy resolution



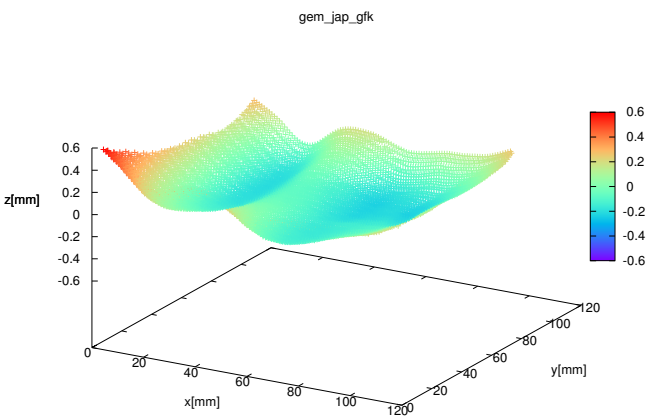


reason for differences under study with simulation

profile measurement of framed GEMs



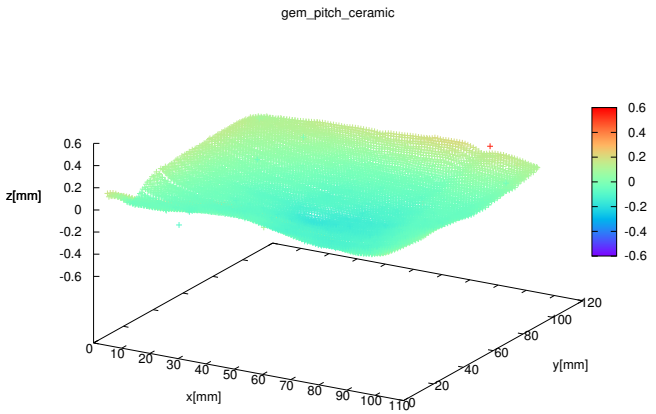
CERN GEM with GRP frame



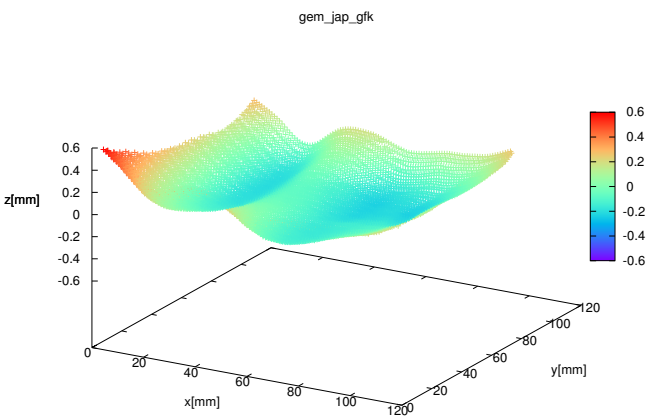
SciEnergy GEM with GRP frame

- measured with laser device
- deviations less than 1 mm
- impact on gain:
  380 µm cause variations
  up to ±6 %

profile measurement of framed GEMs



CERN GEM with GRP frame



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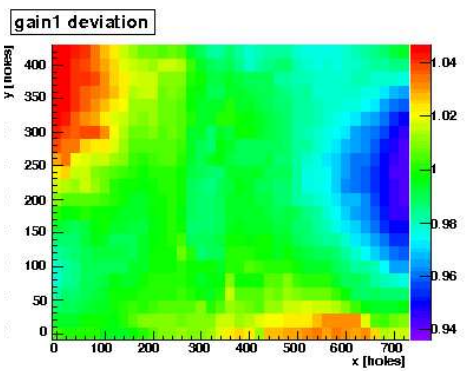
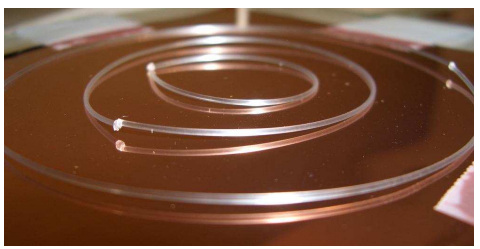
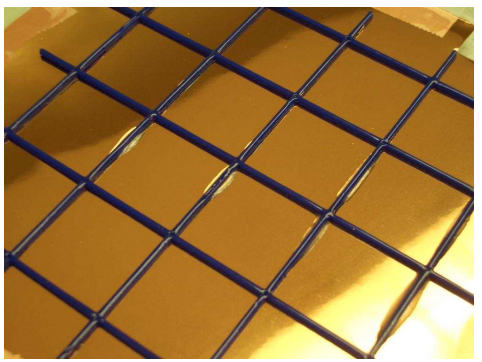


support structure development

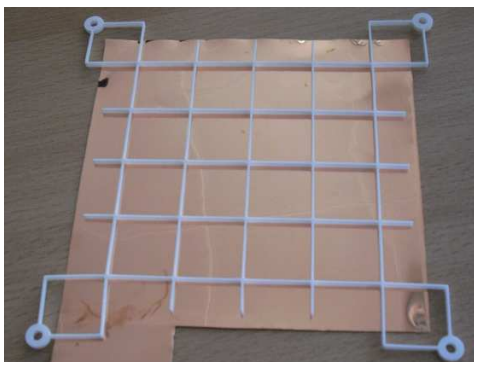
- TPC prototypes use mainly framed $10 \times 10\,\mathrm{cm}^2$ GEMs
- towards ILD larger coverage is needed
- new support structure requires
  - small dead regions
  - mechanical stability and flatness
  - least possible radiation length
- first tests with nylon thread and rapid prototyping grids



nylon thread



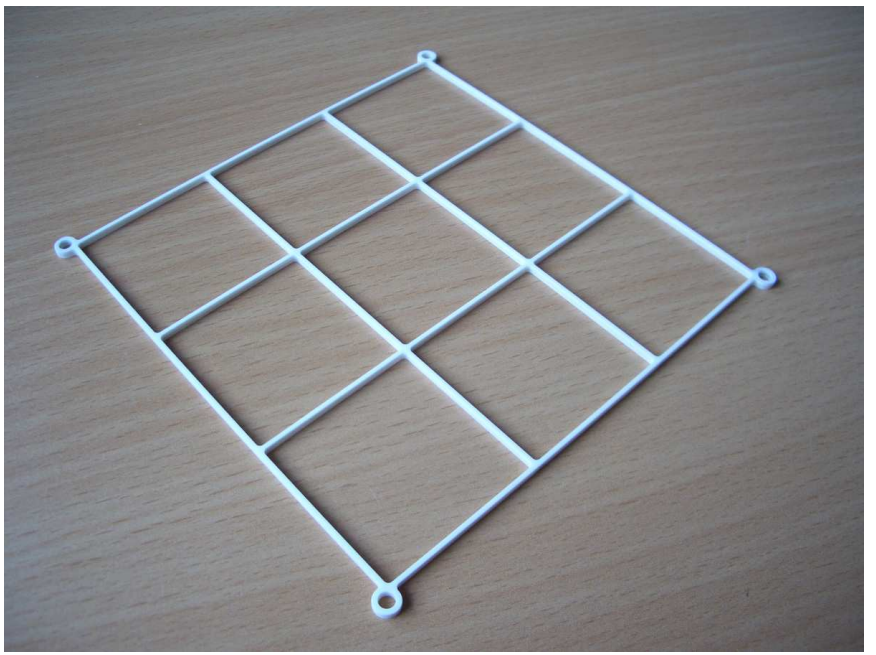
ABS polymers



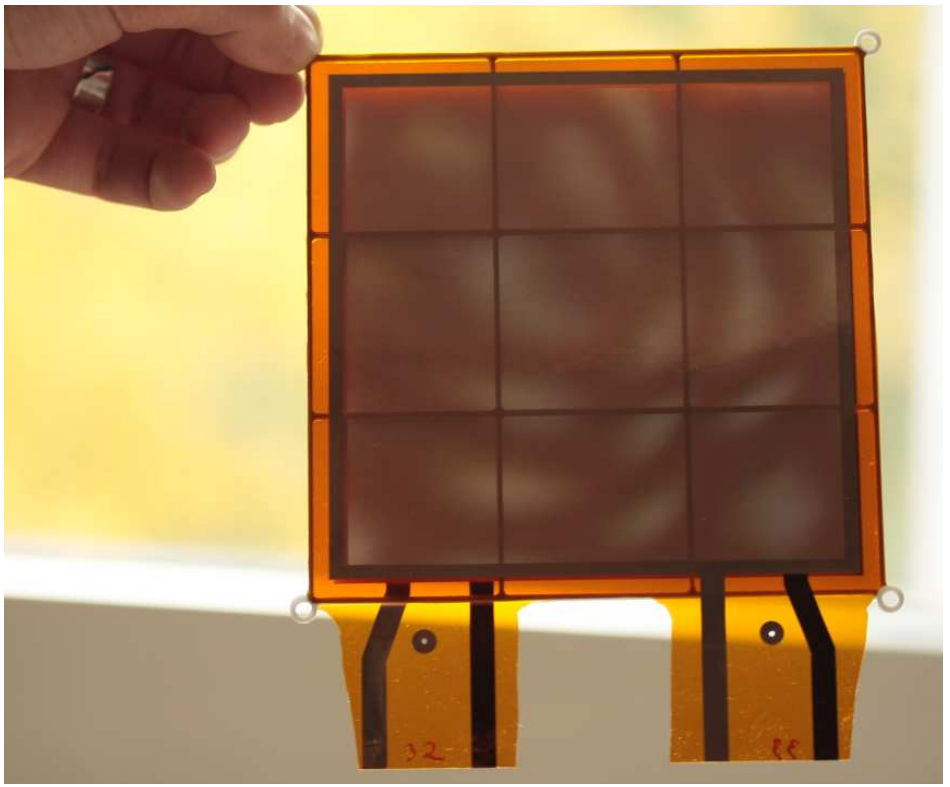
polyamid (PA 12)

ceramics seem to work best

- Aluminum Oxide Al_2O_3
- radiation length $X_0 = 7.1\,\text{cm}$ ($\text{GRP } X_0 = 13.3\,\text{cm}$)
- harder
- higher contour accuracy
- minimum width: 1 mm
- thickness: 1 mm, height: 2 mm



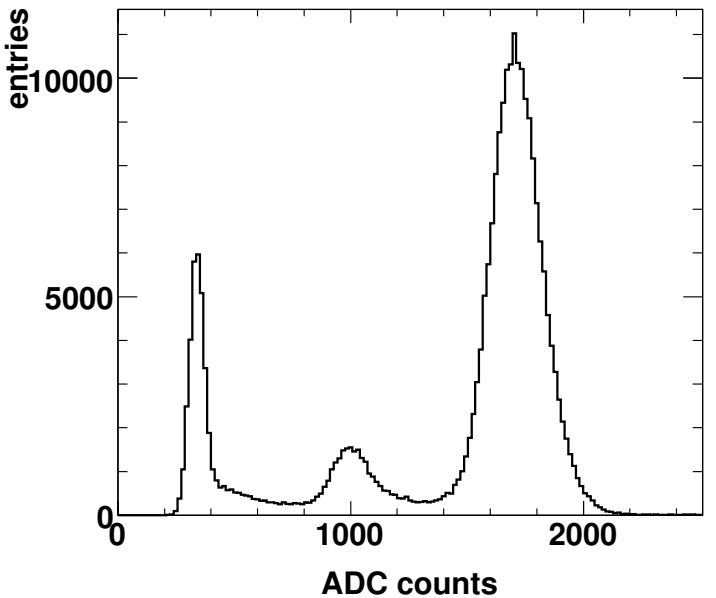
grid GEM



- standard CERN GEMs glued to both sides of grid
- glue only on outer bars
- dispensing robot used
- procedure worked well

proof of principle

- voltage test for electrical stability in air
  - GEMs withstand $> 600\,\mathrm{V}$
  - same values as before gluing
- grid used in test TPC
  - first iron spectra measured
  - detailed studies will follow



370 V over both GEMs

summary and outlook

summary

- CERN GEMs show best performance
  - gain
  - energy resolution
  - flatness and handling
- ceramic grid very promising

outlook

- Polish GEM ordered for testing
- repeat comparative measurements with P5 gas
- study of profile impact in simulation and experiment
- spatial resolved measurement of grid GEM in Medi TPC
- development of Large Prototype module with grid GEM