Single Point Resolution Studies and Development and Analysis of Grid GEMs

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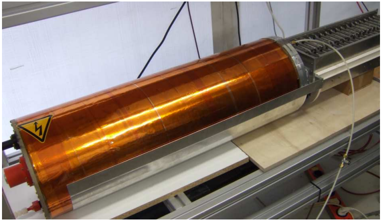
content

cosmics in a TPC prototype

MediTPC



goal of data taking:

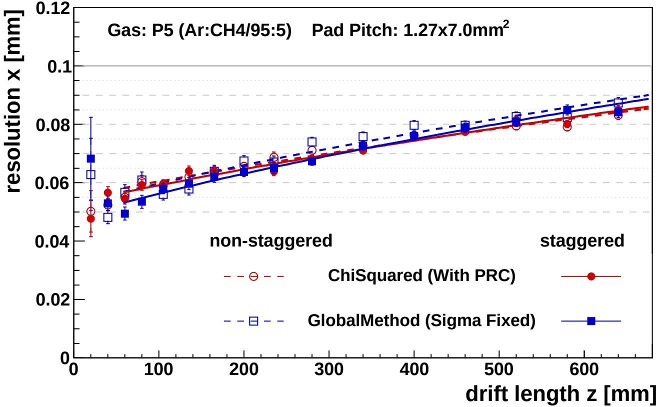
→ single point resolution studies with conventional GEM mounting

→ check single point resolution with grid GEM

→ quantify impact of grid GEM

- prototype with triple (grid) GEM
- sensitive volume: $6 \times 8 \times 67\,\mathrm{cm}^3$
- cosmic muons, 4 T magnetic field
- P5 gas: 95 % Ar, 5 % $\mathrm{CH_4}$
- pad size $1.27 \times 7\,\mathrm{mm}^2$
- 10 pad rows, 480 channels
- pad plane staggered for grid GEM studies

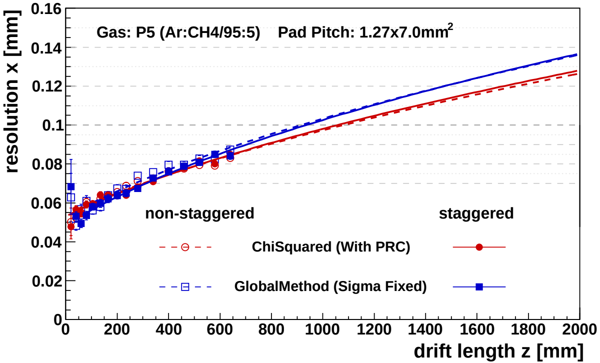
resolution studies



inclination angle $\mid \phi \mid < 1^{\circ}$

single point resolution well below envisaged value of 100 μm over the whole drift length

resolution studies - extrapolation



$\sigma_x^2 = \mathrm{D}_\mathrm{T}^2/\mathrm{N}_\mathrm{eff} + \sigma_0^2$

input: D_T from Magboltz

effective number of e^-: $\mathrm{N}_{\mathrm{eff},\chi^2} \approx 29$, $\mathrm{N}_{\mathrm{eff,global}} \approx 24$

intrinsic resolution: $\sigma_{0,\chi^2} \approx 53\,\mu\mathrm{m}$, $\sigma_{0,\mathrm{global}} \approx 53\,\mu\mathrm{m}$

slope: matter of diffusion $\Rightarrow$ gas choice

requirements on a new GEM support structure

future application in large scale TPCs like the ILD TPC need scalable mounting scheme for GEMs

- large area coverage with GEMs
- small amount of insensitive material
- single point resolution
  of 100 µm achievable
- dE/dx resolution of 5 % feasible
  $\Rightarrow$ flat installation of GEMs
  framed GEMs:
  $\Delta z \sim 400 - 900\,\mu\mathrm{m}$
- structure cell size:
  order of GEM surface profile structure

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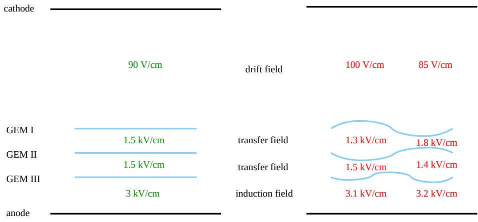

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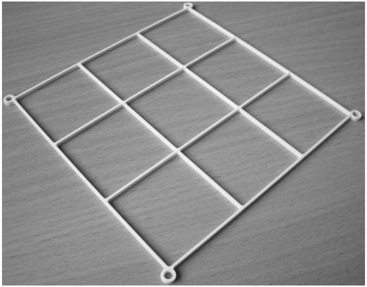
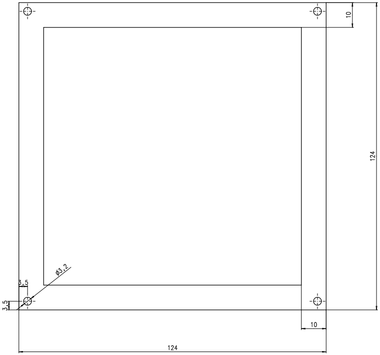
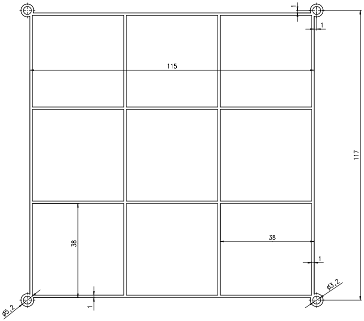


material usage for grid

- ceramic (Al_2O_3) structures of 1 mm width
- almost edgeless for large area coverage
- no stretching of foils needed $\Rightarrow$ smaller forces
- $X_{0,GRP} = 19.4\,cm$, $X_{0,ceramic} = 7.0\,cm$
- only one fifth of material in the detector





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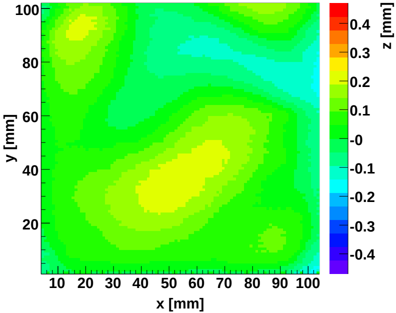
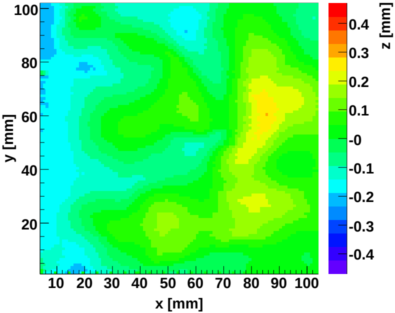
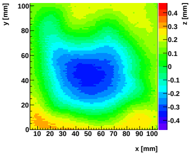
flatness of grid GEMs

surface profiles of both sides of triple GEM structures measured





framed GEM



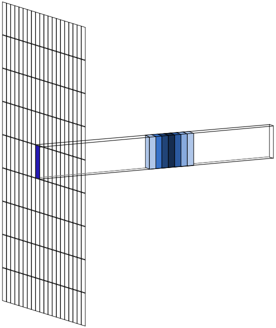
- flatter than conventionally framed GEMs
- without stretching

$\Rightarrow$ less material, no sagging as observed for framed GEMs

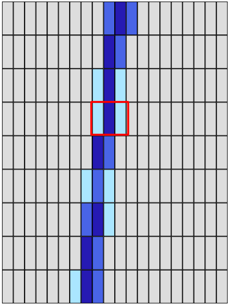
data reconstruction

- charge in time bins on pads $\longrightarrow$ pulse
- pulses in one row $\longrightarrow$ hit
- hits on pad plane $\longrightarrow$ track
- track fitting

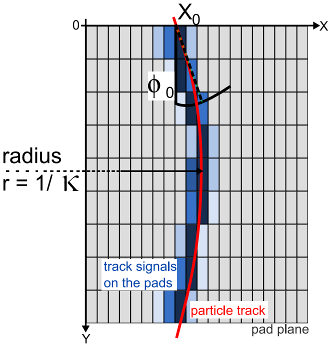
pulse



hit

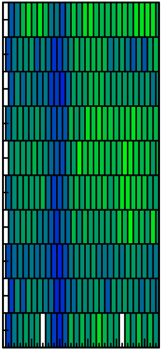


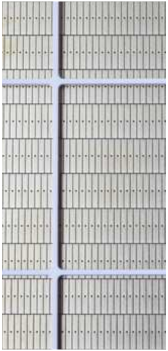
track



pulses and charge per pad

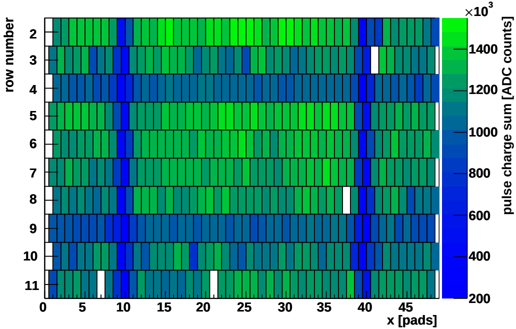
number of pulses per pad





less pulses in grid region

charge per pad



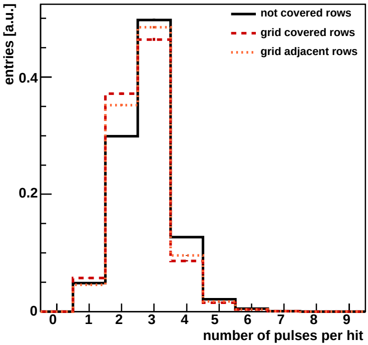
less charge on these pads

⇒ threshold effect: pulses with less charge below or in direct vicinity of grid are cut away

number of pulses per hit

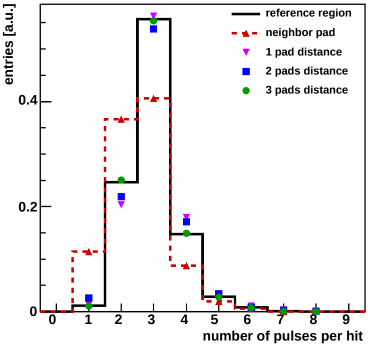
number of pulses per hit important for single point resolution

horizontal structure



hits below horizontal structure:
less pulses per hit

vertical structure



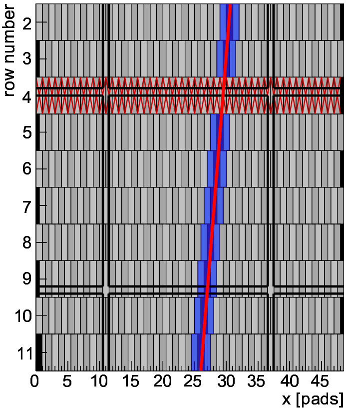
hits in direct vicinity (± 1 pad width):
less pulses per hit

$\Rightarrow$ charge loss under and near to grid: more narrow hits

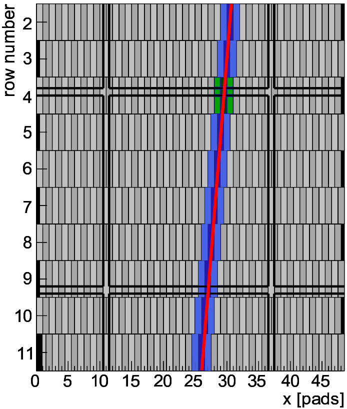
single hit efficiency determination

two reconstructions of same data sample

monitor sample



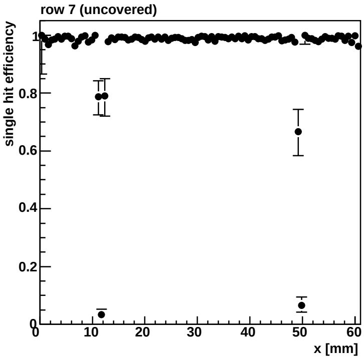
analysis sample



⇒ single hit efficiency

single hit efficiency

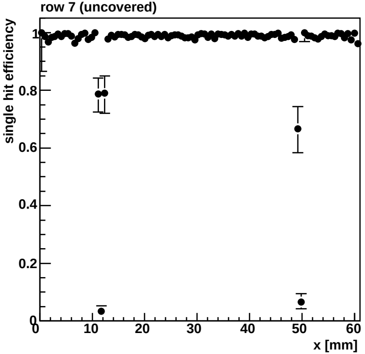
single hit efficiency over x



dip around vertical structures:
twice the grid width

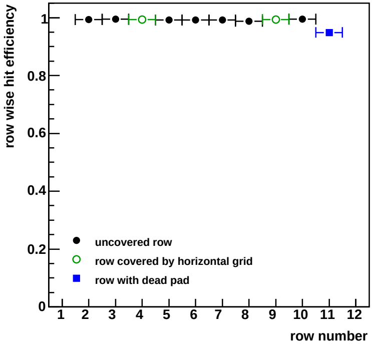
single hit efficiency

single hit efficiency over x



dip around vertical structures:
twice the grid width

single hit efficiency over y

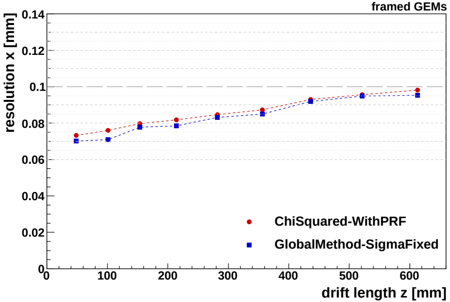


no influence of horizontal structures

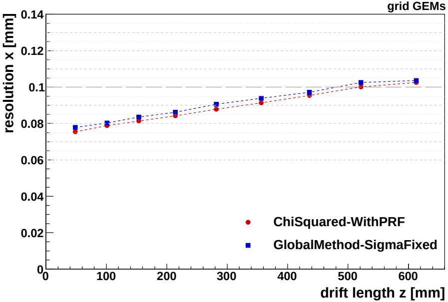
⇒ only vertical structures reduce hit reconstruction efficiency

single point resolution - comparison frame/grid GEMs

reference run



grid GEM run

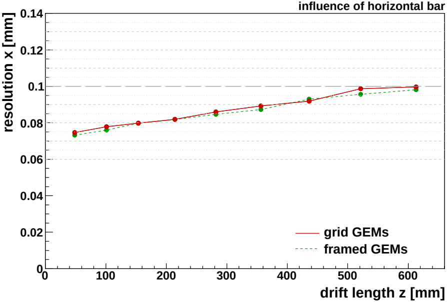


deviation of the order of normal run to run fluctuations

$\Rightarrow$ grid influence on single point resolution is small

single point resolution - horizontal/vertical structures

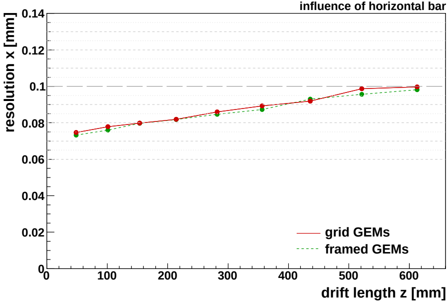
horizontal structure



averaged over all rows:
negligible impact of horizontal structures

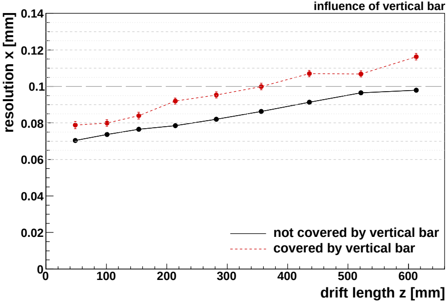
single point resolution - horizontal/vertical structures

horizontal structure



averaged over all rows: negligible impact of horizontal structures

vertical structure



strong influence of vertical structures: deterioration of resolution about 10-20 μm

⇒ only vertical structures influence single point resolution

influence of grid structures

- threshold effect of charge yields less pulses below grid
- additional quality cuts for dE/dx determination needed

horizontal structures

- no impact on single hit efficiency
- single point resolution comparable to reference run without grid

vertical structures

- hits in ± 1 pad width vicinity significantly changed
- single hit efficiency shows dips of twice the grid width
- single point resolution degrades up to 20 %

$\Rightarrow$ horizontal structures unproblematic
$\Rightarrow$ vertical structures should be used as seldom as possible

application of grid GEMs in a large TPC

- advantages: almost edgeless, large area coverage, minimizes dead material, flat GEM mounting
- grid GEM mounting: negligible impact on single point resolution
- grid cell size: optimization problem of material usage and achievable flatness of GEM foils
- horizontal preferred to vertical structures

$\Rightarrow$ development of grid GEM allows for step from prototype application to large scale TPC with GEM amplification structure

summary and outlook

resolution studies

- over 67 cm drift length: envisaged goal achieved
- extrapolation to 2 m of drift: resolution of about 130 µm
- with different gas: diffusion reducible → 100 µm goal will be in reach
- data with T2K gas taken, systematics have to be understood

grid GEM studies

- new mounting scheme developed
- flat installation without stretching possible
- no impact on resolution
- large prototype module will prove utility of grid GEMs for large detectors