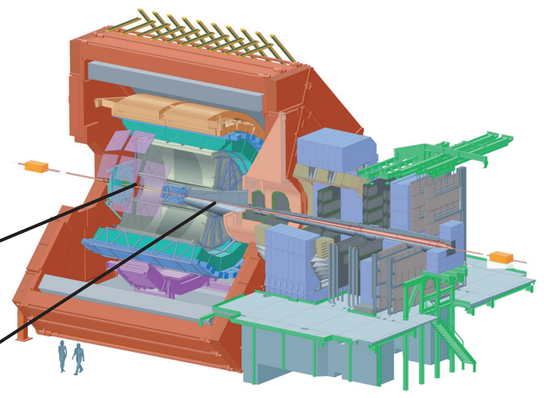
Ion backflow and energy resolution in stacks of four GEM detectors for the upgrade of the ALICE TPC

Esther Bartsch for the ALICE Collaboration

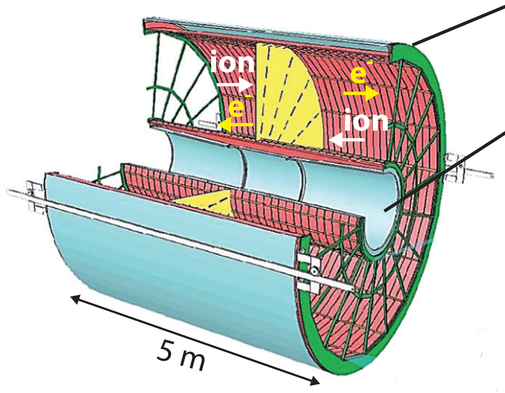
Motivation for the TPC upgrade

During the LHC Run 3 and 4 period, 2020 and beyond, the interaction rate will be increased to **50 kHz** in Pb-Pb collisions.

ALICE detector setup



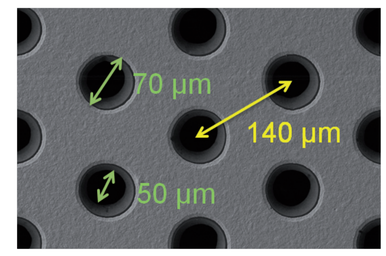
Time Projection Chamber (TPC)



Currently a gating grid in the ALICE TPC introduces a dead time of about **300 µs** which leads to a rate limitation of 3.3 kHz. Therefore the multi-wire proportional readout chambers shall be exchanged for a GEM-based readout which allows a **continuous readout** without gating grid.

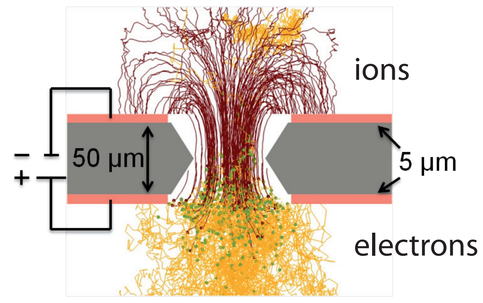
Gas Electron Multiplier (GEM)

A GEM consists of a 50 µm thick Kapton foil with a 5 µm thick copper electrode on each side. Inside there are conical holes with a diameter of 50 µm in the Kapton and 70 µm in the copper.



GEM voltage between electrodes
→ high field in holes
→ gas amplification

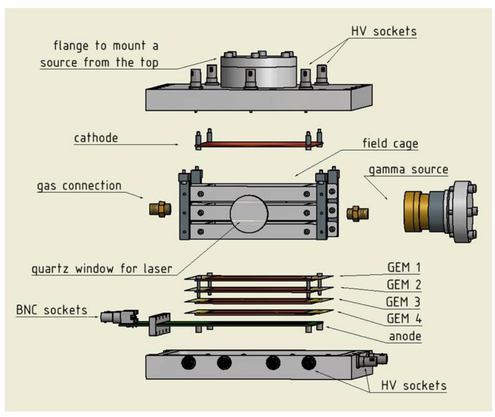
A stack of several GEM foils reduces the number of back-drifting ions.



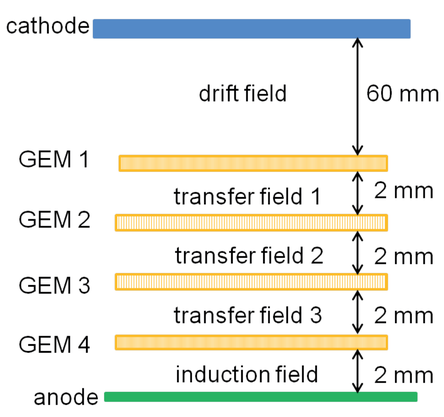
Several pitch sizes exist:
- 90 µm in **Small-Pitch** (SP) GEMs
- 140 µm in **Standard** (S) GEMs
- 280 µm in **Large-Pitch** (LP) GEMs

GEM test setup

Exploded view of the test chamber



Schematic diagram



Goal of this investigation

Minimize ion backflow (IBF < 1 %)	Maintain present energy resolution (σ (^{55}Fe) ≤ 12 %)
to reduce space charge, that leads to track distortions, and keep drift field homogeneous	to preserve excellent particle identification via dE/dx

→ Competing requirements

$$IBF = \frac{I_{cathode}}{I_{anode}}$$

σ (^{55}Fe): resolution of ^{55}Fe peak

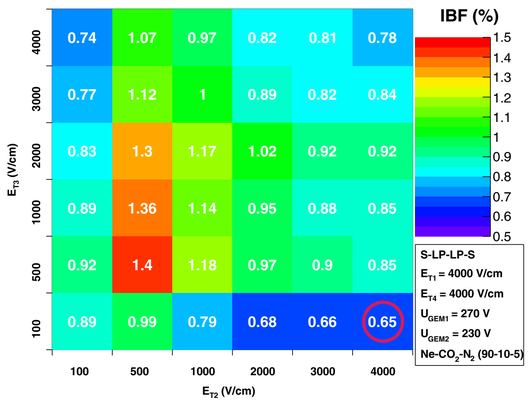
Tunable parameters:
- GEM foil types (SP, S, LP) and order
- Transfer fields
- GEM voltages

Optimize transfer field settings

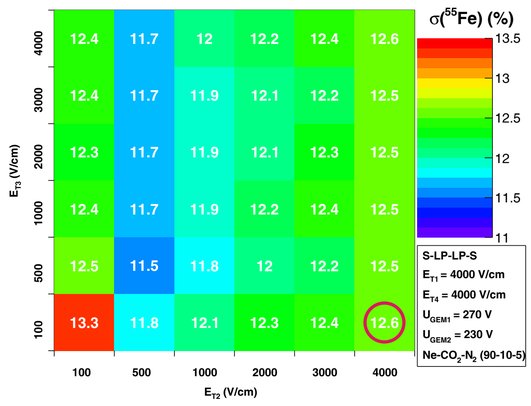
→ all configurations showed best performance for $E_{T1} = E_{T4} = 4000$ V/cm

S-LP-LP-S GEM configuration

Ion backflow

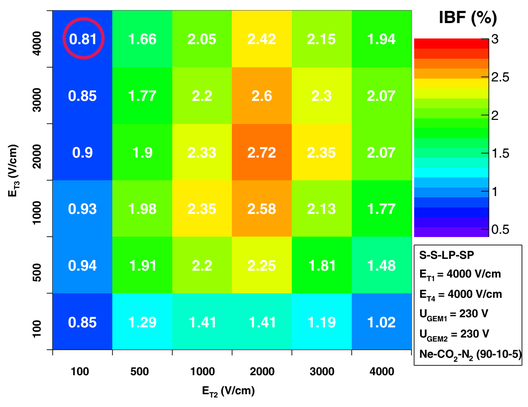


Energy resolution

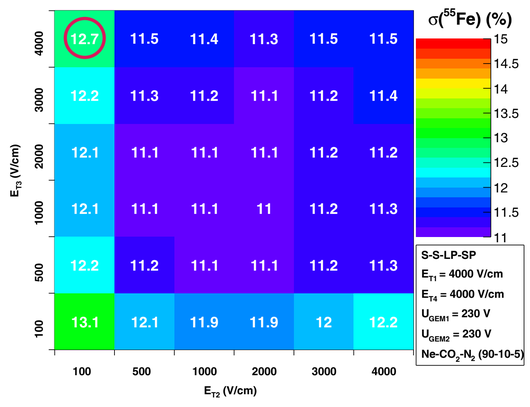


S-S-LP-SP GEM configuration

Ion backflow



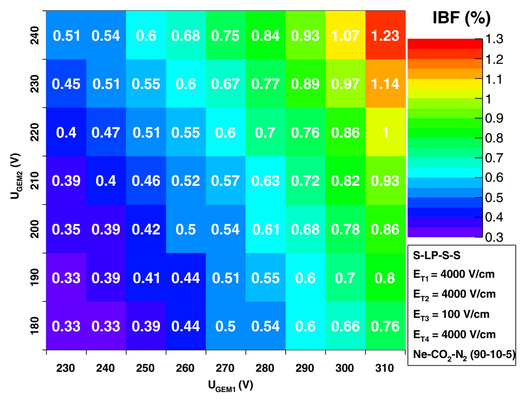
Energy resolution



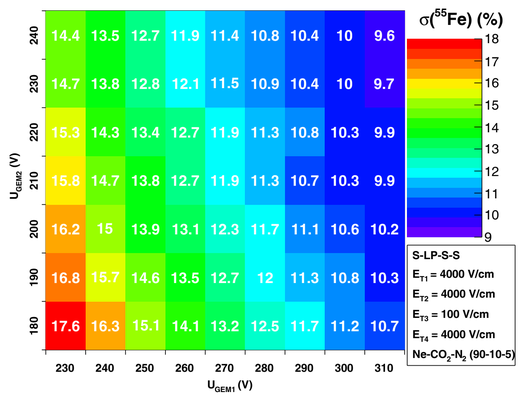
Scan of GEM 1 vs GEM 2 voltage

S-LP-S-S GEM configuration

Ion backflow



Energy resolution



Comparison of different GEM configurations

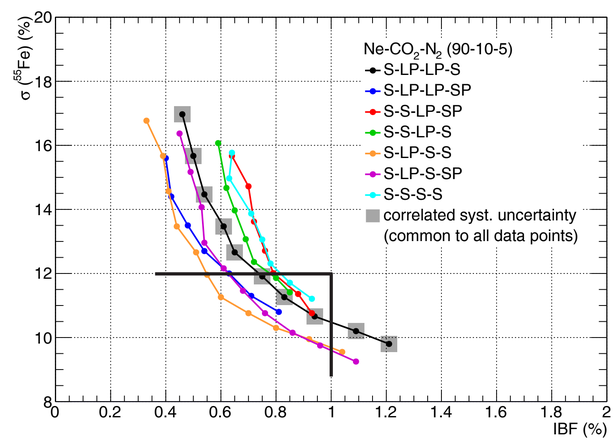
Voltage scans of GEM 1 and GEM 2

Gain 2000 by adjusting GEM 3 and GEM 4 voltage (keeping ratio at 0.8)

Gas: Ne-CO_2-N_2 (90-10-5)

Operational point with IBF 0.5-1 % at energy resolution ~12 % was found with various 4-GEM configurations

S-LP-S-S configuration shows the best results



ebartsch@ikf.uni-frankfurt.de, IKF, Goethe-Universität Frankfurt

22.02.2017

ALICE
BMBF Forschungsschwerpunkt ALICE Experiment 202
GOETHE UNIVERSITÄT FRANKFURT AM MAIN
IKF Institut für Kernphysik Frankfurt
HGS-HIRe for FAIR Helmholtz Graduate School for Hadron and Ion Research