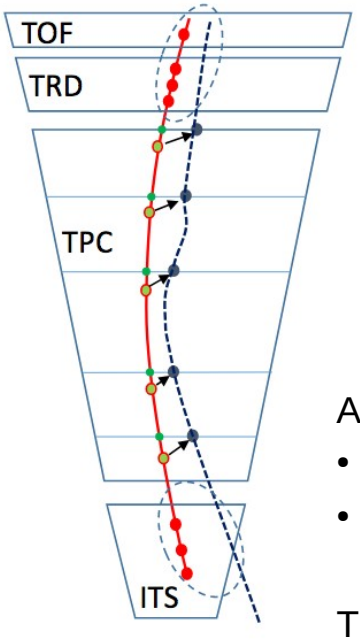
Update on Outer Tracker detector studies

Hugo Pereira Da Costa, for the task force *
Université Paris-Saclay/LANL
sPHENIX General Meeting, August 7, 2020

* The task force: Maxence Vandenbroucke, Maxence Revolle, Stephan Aune, Irakli Mandjavidze, Ed O'Brien,Tom Hemmick, Klaus Dehmelt,Tony Frawley, Joe Osborn, Hugo Pereira Da Costa, Christof Rolland, Takao Sakaguchi, Aiwu Zhang

Reminder: monitoring space charge distortions using tracks



From ALICE

Use detectors outside of the TPC to define trajectories

Compared interpolated positions in the TPC to that provided by the TPC to derive space charge distortions

For ALICE: rely on ITS (inside) and TRD+TOF (outside)

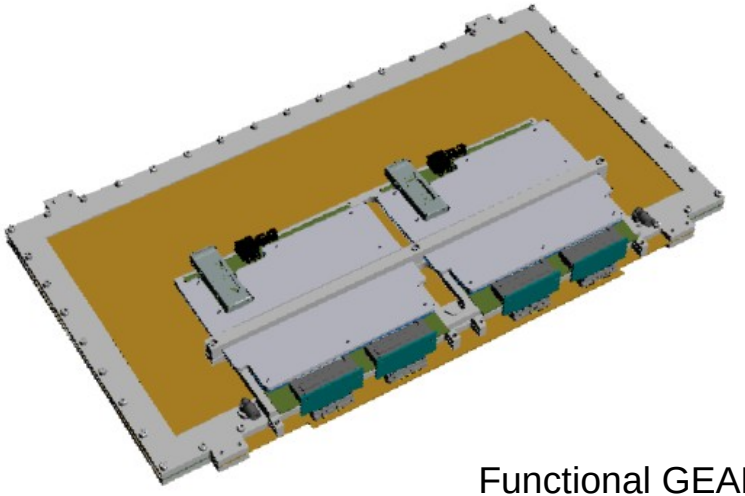
For SPHENIX: rely on MAPS and INTT (inside) + Outer Tracker (?)

Accuracy of the correction in a given volume element depends on

- accuracy of the extrapolation (available detectors)
- (square root of) number of available tracks per unit of time and volume element

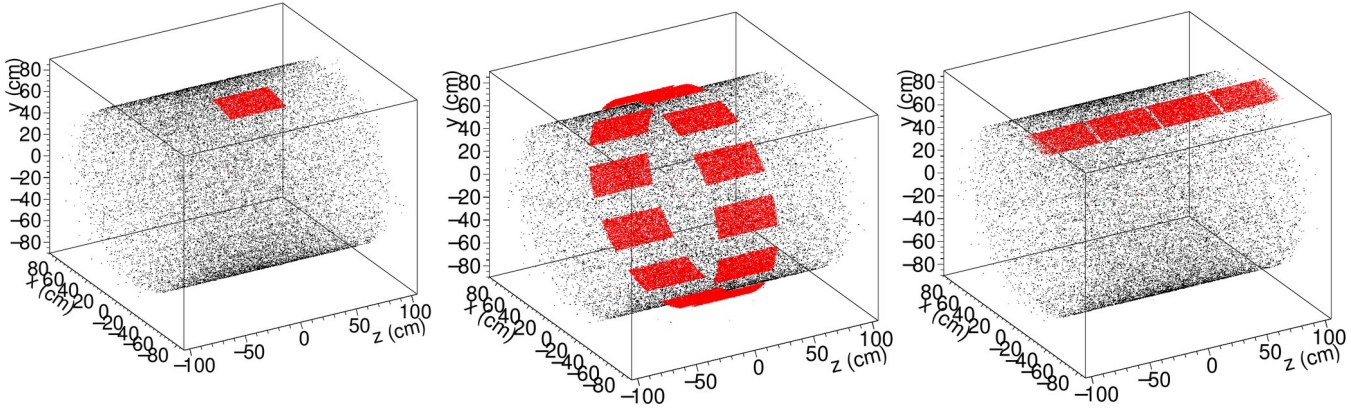
The more precise the extrapolation, the less tracks (and time) you need to reach the desired accuracy

Micromegas proposal



Flexible tile design proposed by Saclay

Functional GEANT4 + Fun4All implementation



https://indico.bnl.gov/event/8548/contributions/37753/attachments/28212/43343/2020_05_Proposal_sPhenixMonitoring_update_19052020.pptx

Tasks, milestones, deadline

Task	Output	Manpower	Deadline
Hijing production	G4Hits	Chris	Week 28 (early Jul.)
Realistic reconstruction chain	Realistic detector resolution, occupancy, noise, ...	Maxence R., Hugo	Week 28 (early Jul.)
Occupancy studies	Constraints on detector segmentation	Maxence R., Hugo	Week 30 (end Jul.)
Study tracking with MVTX+INTT+ MICROMEGAS	Get expected interpolation accuracy in the TPC, optimal eta coverage, etc.	Maxence R., Hugo, Tony, Joe	Week 34 (mid Aug.)
Apply realistic SC distortions	How precise can the setup measure them, with which granularity, and over which timescale	Need coordination with Ross and SC TF.	Week 34 (mid Aug.)
Combine with other SC monitoring methods (laser, currents)	Complete strategy for SC calibration	Need coordination with Ross and SC TF.	Week 36 and beyond (end Aug.)
Coordinate detector design and integration in sPHENIX	Ensure integration is possible, no conflict with other detectors (ECAL, TPC)	Klaus, Stephan, Maxence V., R. Takao, Irakli (for DAQ part)	Week 36 (end Aug.)
Make recommendations for optimal design (number of tiles, position, segmentation) and cost and HR estimate	Technical note on recommended detector design	Everybody from the TF	Week 36 (end Aug.)

Today: week 32

Current status - HIJING production

Chris has produced 10k MB HIJING collisions

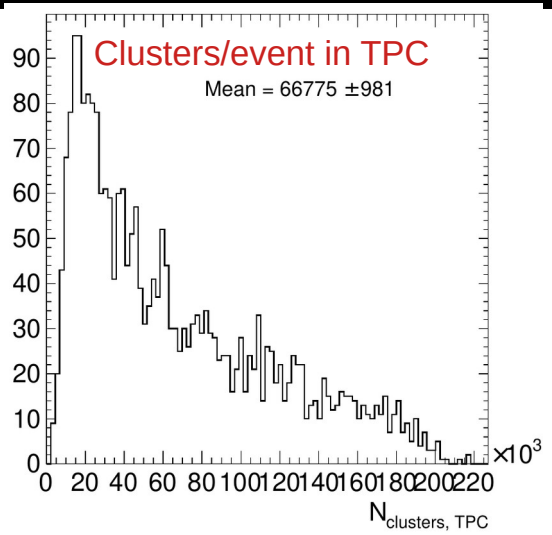
Vertex distribution is Gaussian with width 30cm in z (= full vertex range), and 0.1mm in x,y

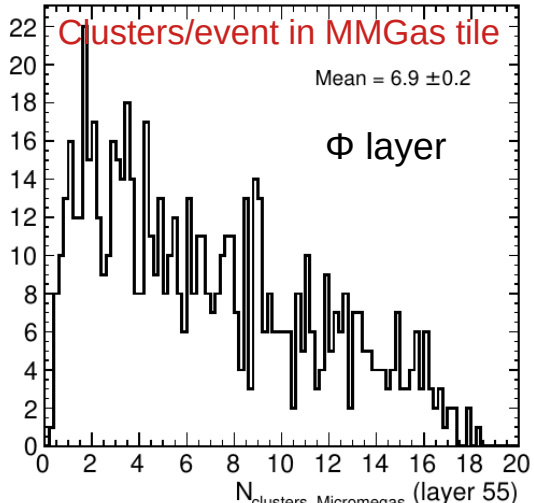
Files contain

- the G4Hits in all tracking detectors detectors, including Micromegas layers
- some extra material to mimic the backsplash from calorimeters in the Micromegas and outer TPC layers

They are suitable for both reconstruction and space-charge distortions

Right now this corresponds to 0.1s of data. Will probably need > 10 times more





Current status - HIJING production (cont.)

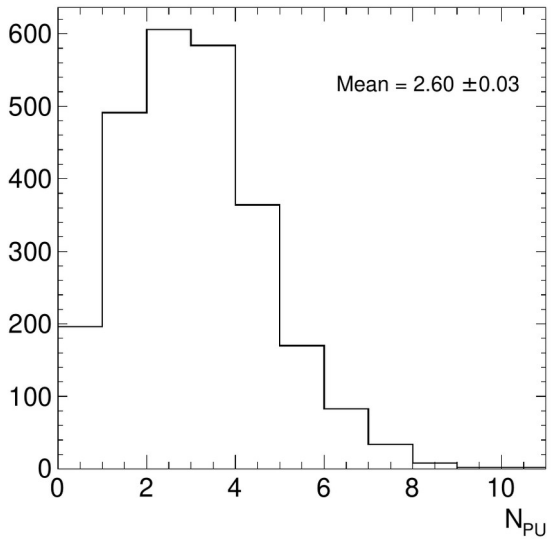
Full HIJING events consist of:

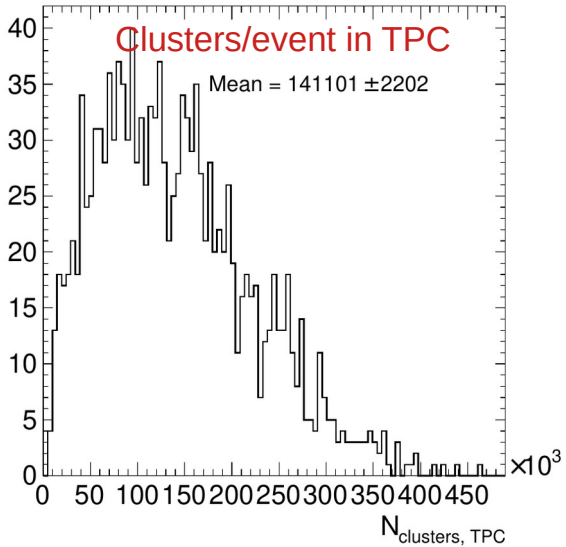
- a trigger event with |z_vtx| < 10cm
- a number of pile-up events corresponding to collisions occurring during +/- TPC max drift time = +/- 13.2us

To generate such events we :

- estimate the mean number of events per bunch crossing corresponding to 100kHz collisions (0.0106 collision / BC)
- associate a time stamp (= BC id) to each single HIJING event from Chris using Poissonian distribution
  same time stamp can be used by Ross and co. to generate the corresponding distortion map
- select “trigger events”, and merge background events that fall in the time window above using the assigned time stamps

On average 2.6 background collisions per trigger event





Note: number of clusters in TPC does not scale with number of pileup events, because a significant fraction of time shifted BG hits are outside the TPC time window

(still double checking the fraction of rejected hits)

Current status - Occupancy studies

Using 800ns time window to collect hits (needs double-check)

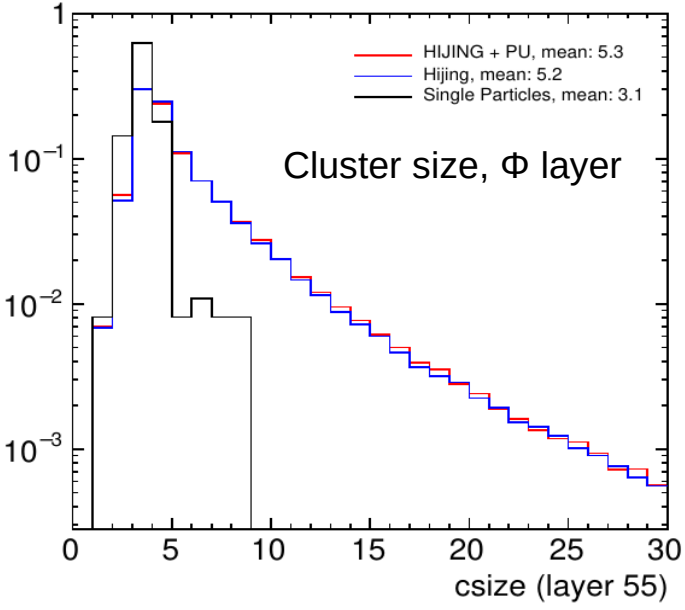
Increase of about 6% (expect 8% for 10kHz collisions) due to pile-up

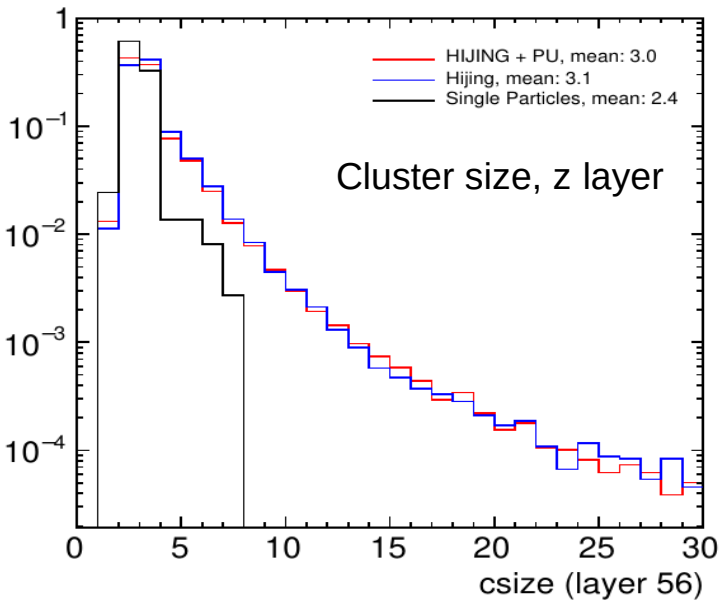
Difference between Φ and z layer is dues to strip length

Mean occupancy is about 16% in Φ layer and 10% in z layer

Current status - Occupancy studies

Using 800ns time window to collect hits (needs double-check)





Little difference between HIJING + PU and HIJING

Difference between Φ and z layer is due to strip width

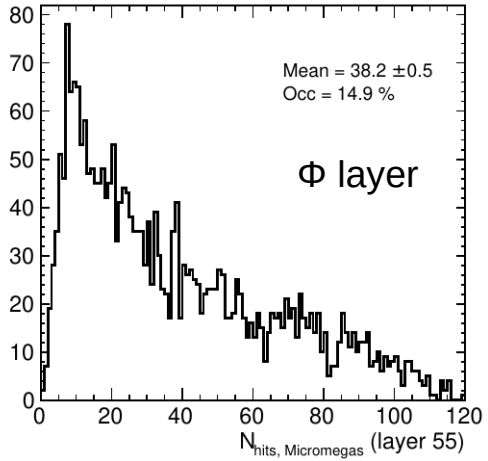
Large difference in mean cluster size between HIJING and single particle simulations

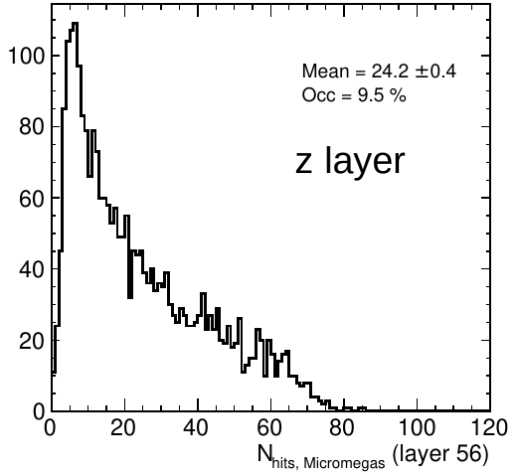
Due to a combination of

- overlapping clusters in high multiplicity
- larger track angle (smaller momentum) on average

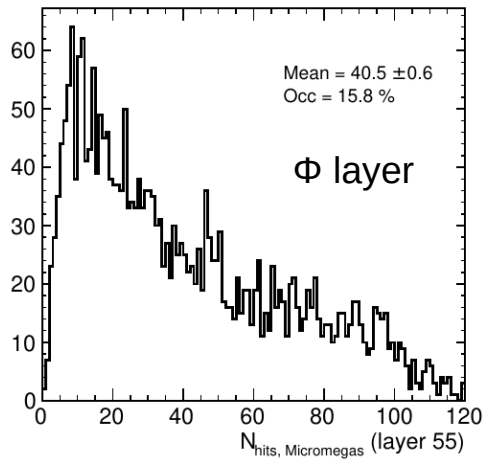
Current status - Occupancy studies

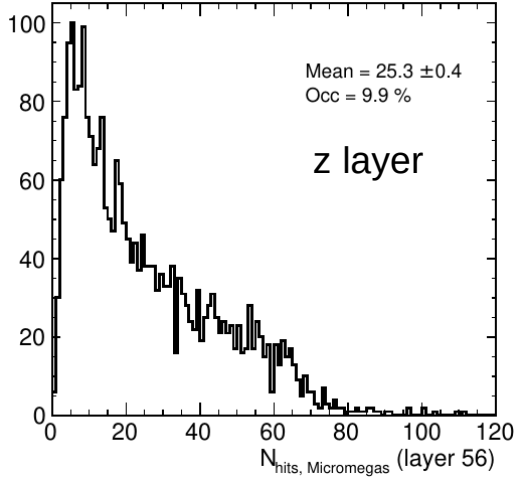
Single HIJING events





Full HIJING (signal + PU)





Using 800ns time window to collect hits (needs double-check)

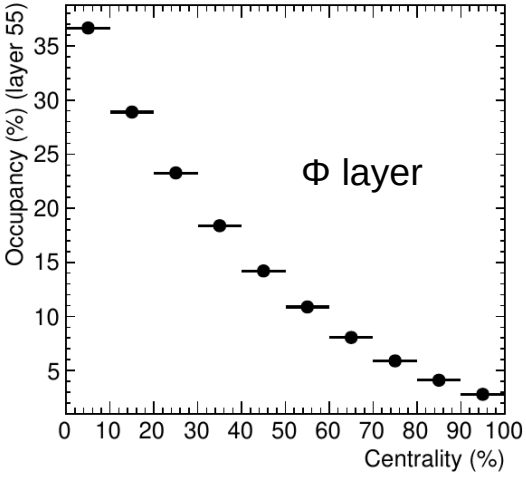
Increase of about 6% (expect 8% for 10kHz collisions) due to pile-up

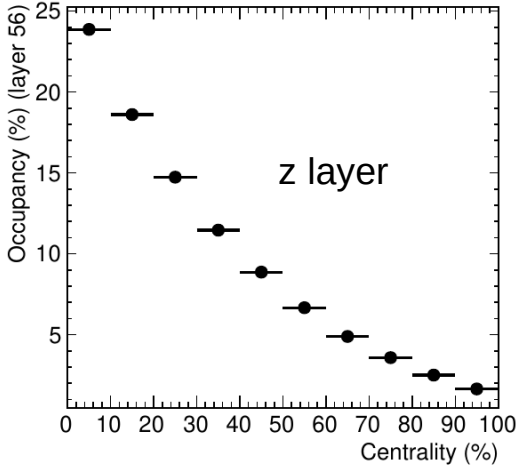
Difference between Φ and z layer is dues to strip length

Mean occupancy is about 16% in Φ layer and 10% in z layer

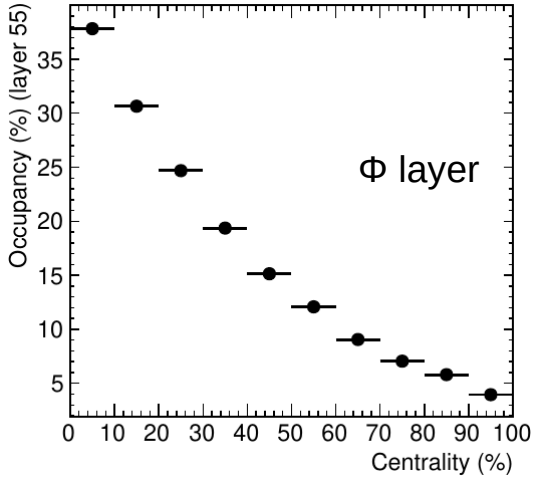
Current status - Occupancy studies (cont.)

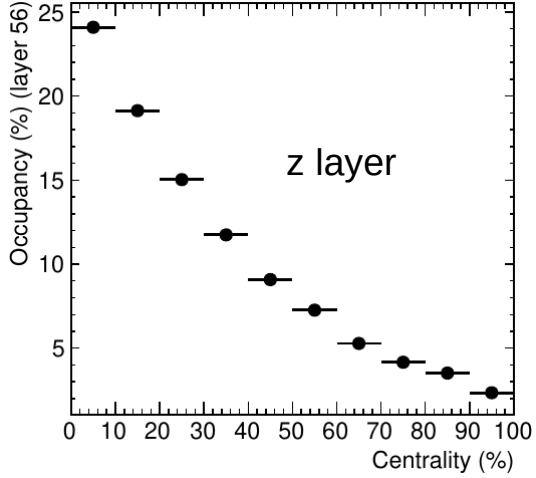
Single HIJING events





Full HIJING (signal + PU)





- Occupancy increases quadratically for decreasing centrality
- Reaches 38% for most central collisions in Φ layer
- Such collisions might not be usable for space charge monitoring

Same order of magnitude as for the TPC inner layers

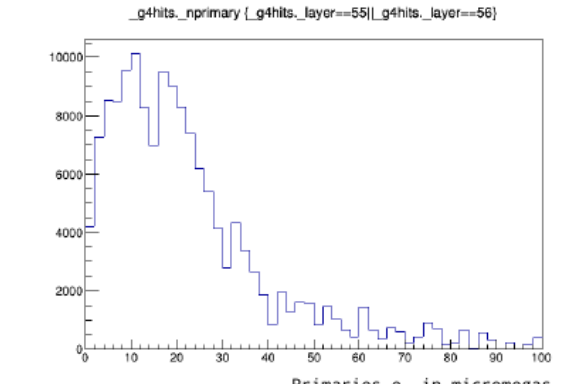
Other ongoing activities

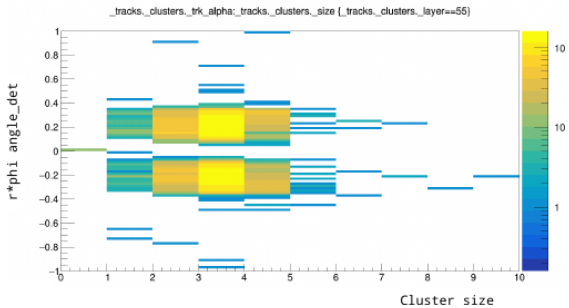
Maxence Revole is working on validating the Micromegas simulation chain

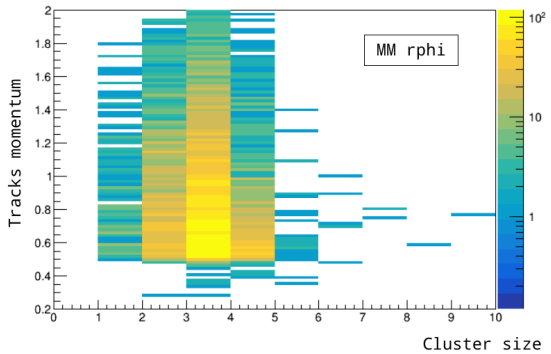
- fundamental quantities such as number of primary electrons, cluster size, peak/sum charge distributions, etc.
- comparison to test-beam data

Takao and Aiwu working with Saclay to setup test bench
Micromegas + SAMPA + sPHENIX DAQ at BNL

Klaus in contact with Saclay to study mechanical integration with the TPC in more details







Outlook and next steps

Coming three weeks will be busy because we will

- run full reconstruction on merged Hijing events with Micromegas
- integrate realistic (and ideally synchronized) SC distortions in the reconstruction
- study the ability of the setup to measure the SC distortions

Stay tuned !