Update on Drift Chamber ~~simulation and~~ digitization

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Full simulation meeting

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DCH digitizer

- New Drift chamber digitizer available from k4Rectracker, which handles:

  - Hit position projection and smearing.

    - Each simulated hit is transformed into a digitized hit. The digitized hit position is the projection of the simulated hit position onto the sense wire (at the center of the cell)

    - Smearing of the digitized hit position along the wire and radially is done according to the input parameter values

    - Debug histograms are created if `create_debug_histograms` option is enabled

    - It requires that the cellID contain the layer and number of cell within the layer (nphi). It does not matter if the segmentation comes from geometrical segmentation by using twisted tubes and hyperboloids (and the cellID is created out of volume IDs), or the segmentation is virtual DD4hep segmentation

    - Data extension has now the functionalities to calculate the required quantities

  - Adds dN/dx information: number of clusters and their size, which are derived from precalculated distributions contained in an input file specified by the parameter `fileDataAlg`. The method and distributions corresponds to the option 3 described in F. Cuna et al, arXiv:2105.07064

- New digitized hit class is used as an EDM4hep data extension, to be integrated into EDM4hep

- Random number generator uses the seeds calculated on an event basis by the UID service, from the podio header information (run/event number)

DCH digitizer. Data extension

```
extension::DriftChamberDigiV2:
  Description: "Digitized hit (before tracking) for Drift Chamber v2 (requires data exter
  Author: "A. Tolosa-Delgado, B. Francois, CERN"
  Members:
    - uint64_t cellID            // ID of the sensor that created this hit
    - int32_t type               // type of the raw data hit
    - int32_t quality            // quality bit flag of the hit
    - float time                 // time of the hit [ns]
    - float eDep                 // energy deposited on the hit [GeV]
    - float eDepError            // error measured on eDep [GeV]
    - edm4hep::Vector3d position    // point on the sensitive wire (SW) which is closest
    - edm4hep::Vector3d directionSW // direction of SW
    - float distanceToWire       // distance hit-wire [mm]
    - uint32_t nCluster          // number of clusters associated to this hit
  VectorMembers:
    - uint16_t nElectrons        // number of electrons for each cluster
```

DCH digitizer. Data extension

- Drift chamber digitized hit is not yet an official class of EDM4hep (open PR 385), at the moment we are working with a data extension
- Which requires redefinition of TrackerHitPlane and TrackerHit3D as data extensions as well, in order to create an EDM4hep interface for all of them

```
interfaces:
  extension::TrackerHit:
    Description: "Tracker hit interface class"
    Author: "Thomas Madlener, DESY"
    Members:
      - uint64_t cellID // ID of the sensor that created this hit
      - int32_t type // type of the raw data hit
      - int32_t quality // quality bit flag of the hit
      - float time [ns] // time of the hit
      - float eDep [GeV] // energy deposited on the hit
      - float eDepError [GeV] // error measured on eDep
      - edm4hep::Vector3d position [mm] // hit position
    Types:
      - extension::TrackerHitPlane
      - extension::TrackerHit3D
      - extension::DriftChamberDigiV2
```

DCH digitizer. Position projection and smearing

- Example of proton at 10 GeV, direction (3,2,1), 10 events, secondary production range cut 0mm, maxstep 1cm. Each sim hit is translated into a digi-hit
- Black dots correspond to Geant4 energy deposit positions, red dots to the same positions projected onto the closest wire and smeared along and perpendicularly to it

DCH digitizer. Cluster counting information
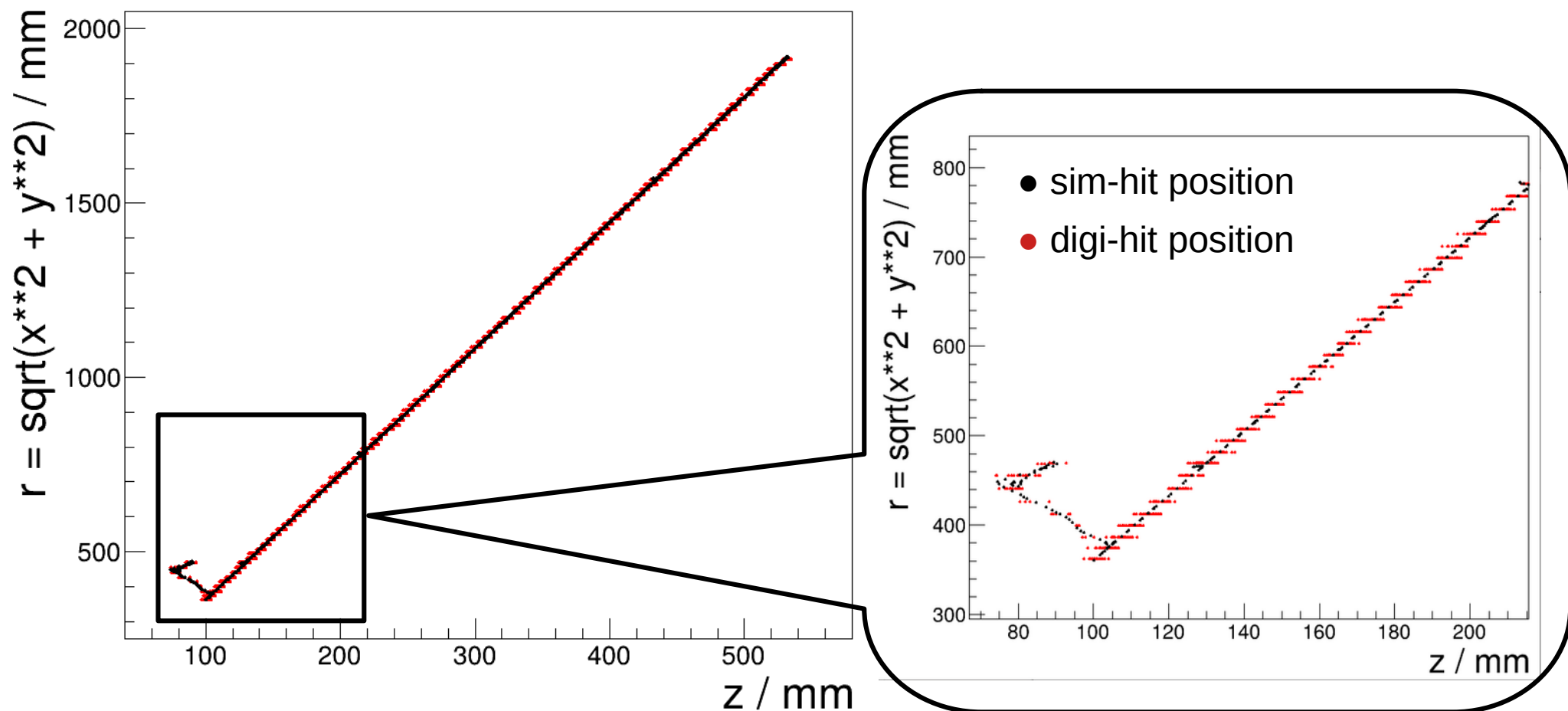
- Example of particles at 10 GeV, direction (3,2,1), 10 events, seconday production range cut 0mm, maxstep 1cm, default physics EM0

- **Very preliminary results, tuning of physics to experimental data is still to be done**
  - ➢ **Revision of the code by a drift chamber expert would be desirable**

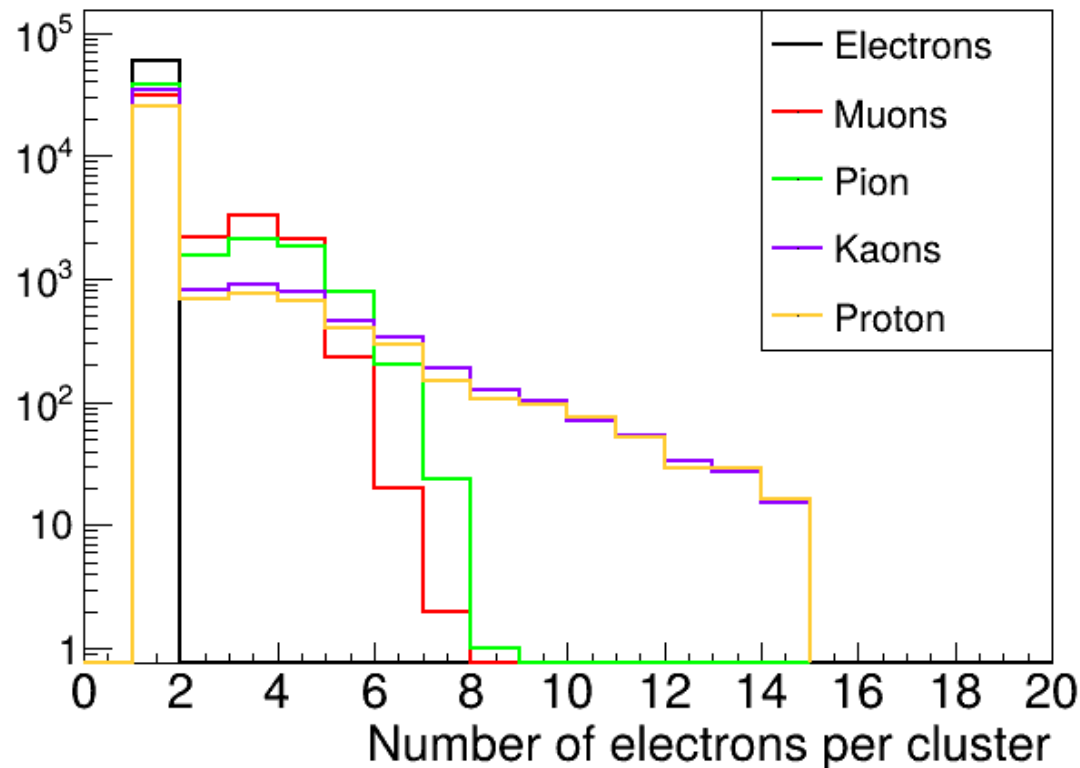- Cluster size (number of electrons per cluster) seems very different for muon/pio from kaon/proton. Electron cluster size seems to be 1, to be checked if it is expected
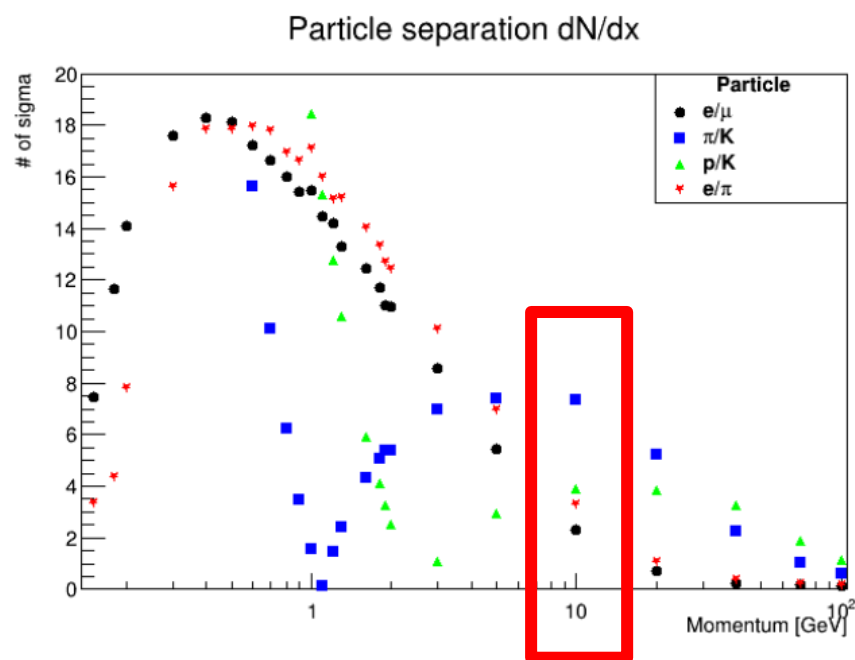

Fig. 7 in arXiv:2105.07064 [link]

DCH digitizer. Cluster counting information

- The number of clusters per cm (**for each step in Geant4**) are shown different distributions for different particles
  - ➢ **Again, this is very preliminary result from first code implementation**
- Electrons have very broad distribution
- Proton's distribution is centered at 11.2, kaon's 11.8, muon's at 12.7, pion's at 13.7
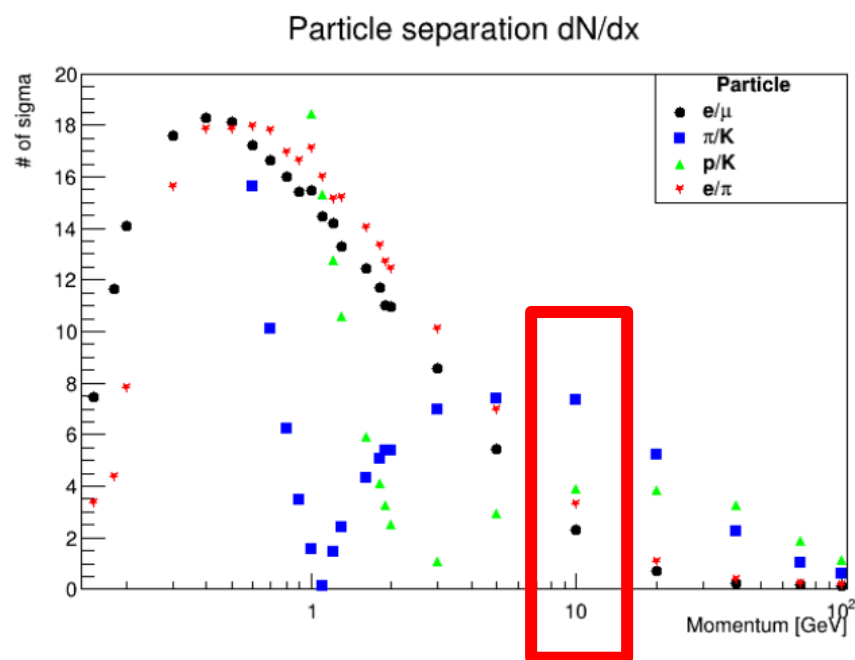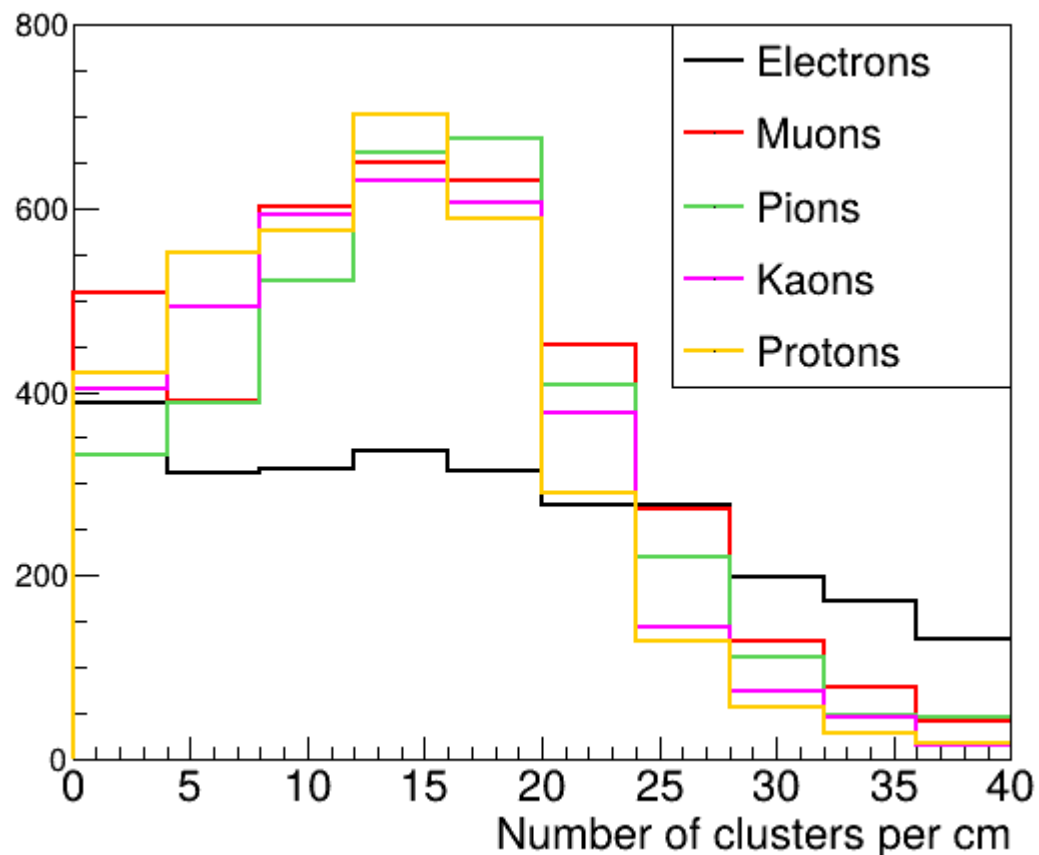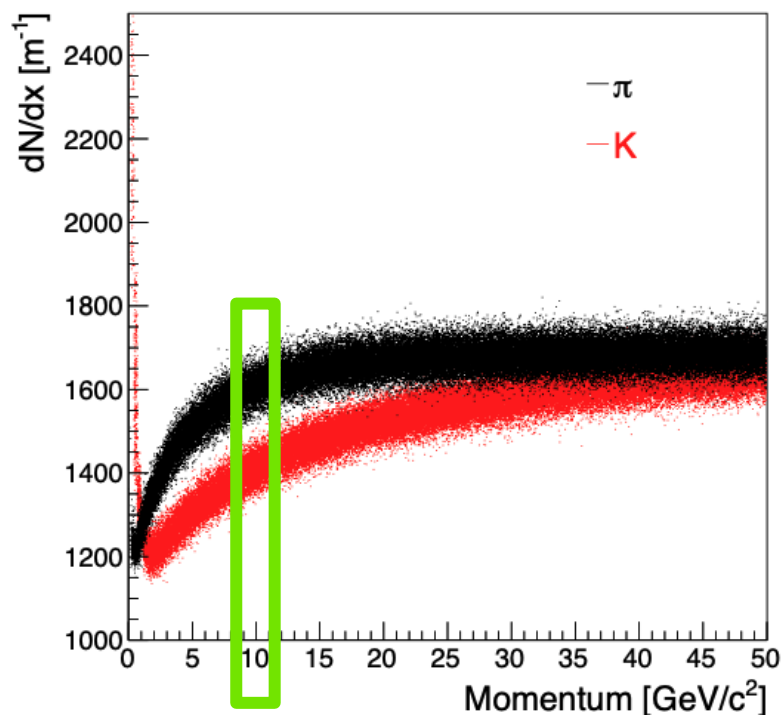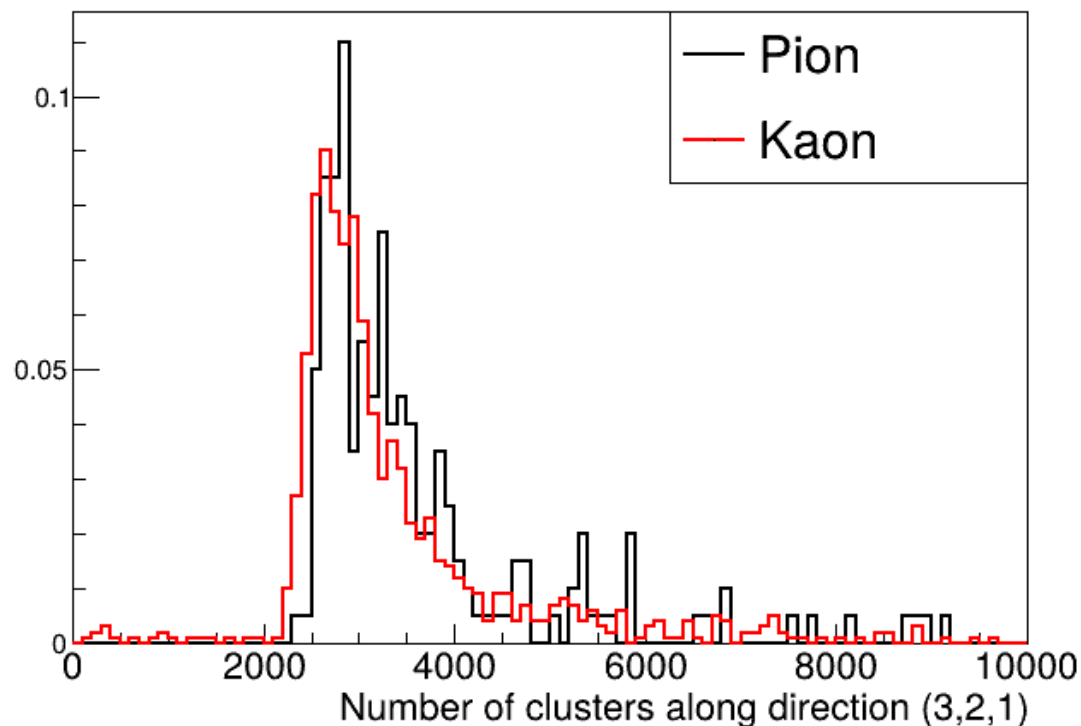

Fig. 7 in arXiv:2105.07064 [link]

DCH digitizer. Cluster counting information

- If the number of clusters is summed up along the full track, the distributions should be well separated, as it is shown below for Delphes parametrization

- **Negligible separation is observed in the current implementation**

dN/dx parametrization implemented for Delphes

Distribution of number of cluster per track, normalized by the number of events run (1k events)

Conclusions

- New digitizer for the drift chamber is available

- Projection and smearing of the hit position are done by means of the machinery provided in the data extension of the drift chamber

    - For this algorithm, the data extension must be provided by the detector itself

    - In general, a data extension object can be instantiated at any time, providing the global geometry parameters

- EDM4hep data extension is proposed for the drift chamber

    - To be centralized within EDM4hep repository (open PR 385)

- Cluster counting algorithm is implemented

    - Preliminary results do not show expected behavior

    - Help from experts is welcome

    - Alternatively, we can try with Delphes parametrization of dN/dx