CEPC Silicon Drift Chamber Tracker

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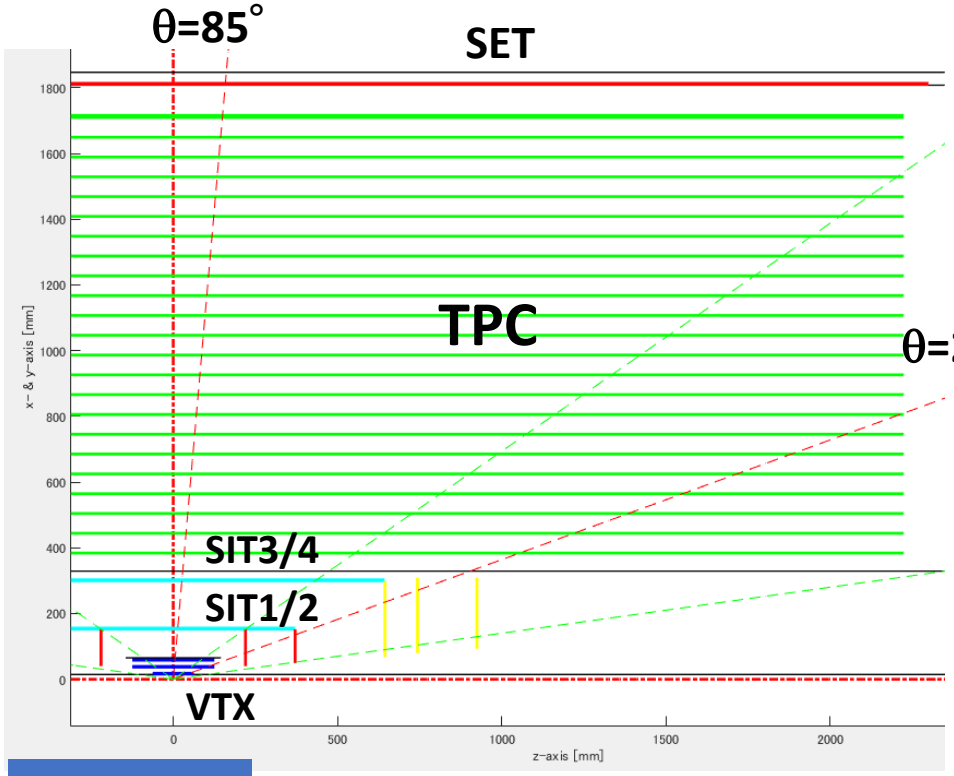
Motivation for Silicon Drift chamber Tracker (SDT)

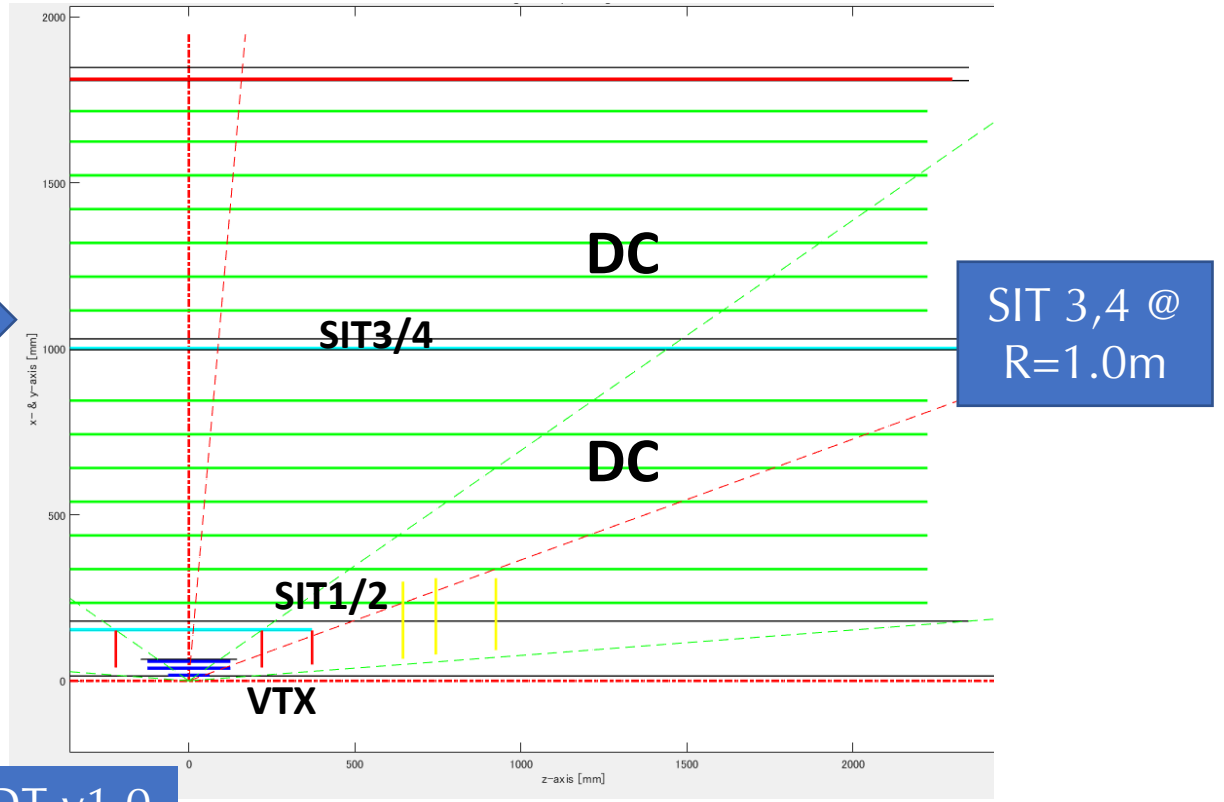
- Explore a different tracker option for CEPC
- Capable for both tracking and particle ID (flavor, JES, jet flavor,...)
- Combine the Silicon technology (strip, CMOS) and Drift chamber technology (dE/dx, cluster counting, ...)
- Provide concrete platform to integrate smaller crystal ECAL
- Open path for better particle ID with faster timing layer (LGAD) between SDT and crystal ECAL

CEPC SDT v1.0 recap

- Based on the baseline Silicon + TPC
- Replace TPC layers with two drift chamber layers
  - SIT 3&4 set at R=1.0m / larger cell size of DC than TPC



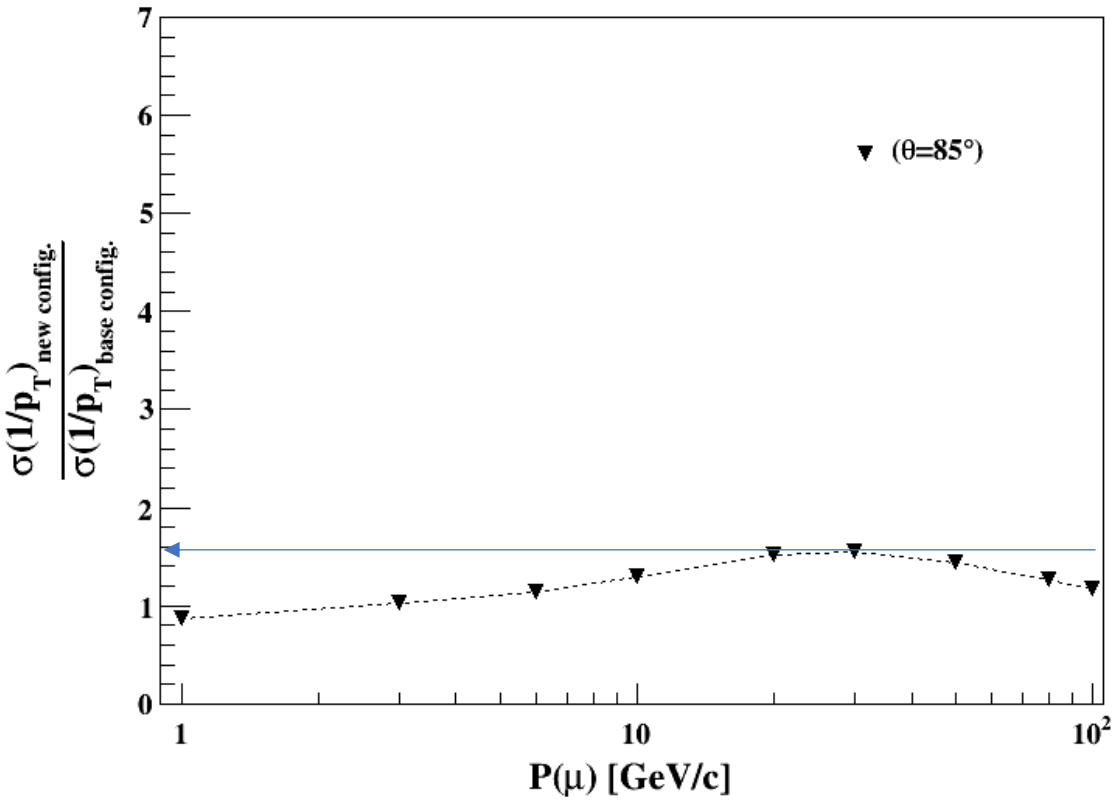
baseline



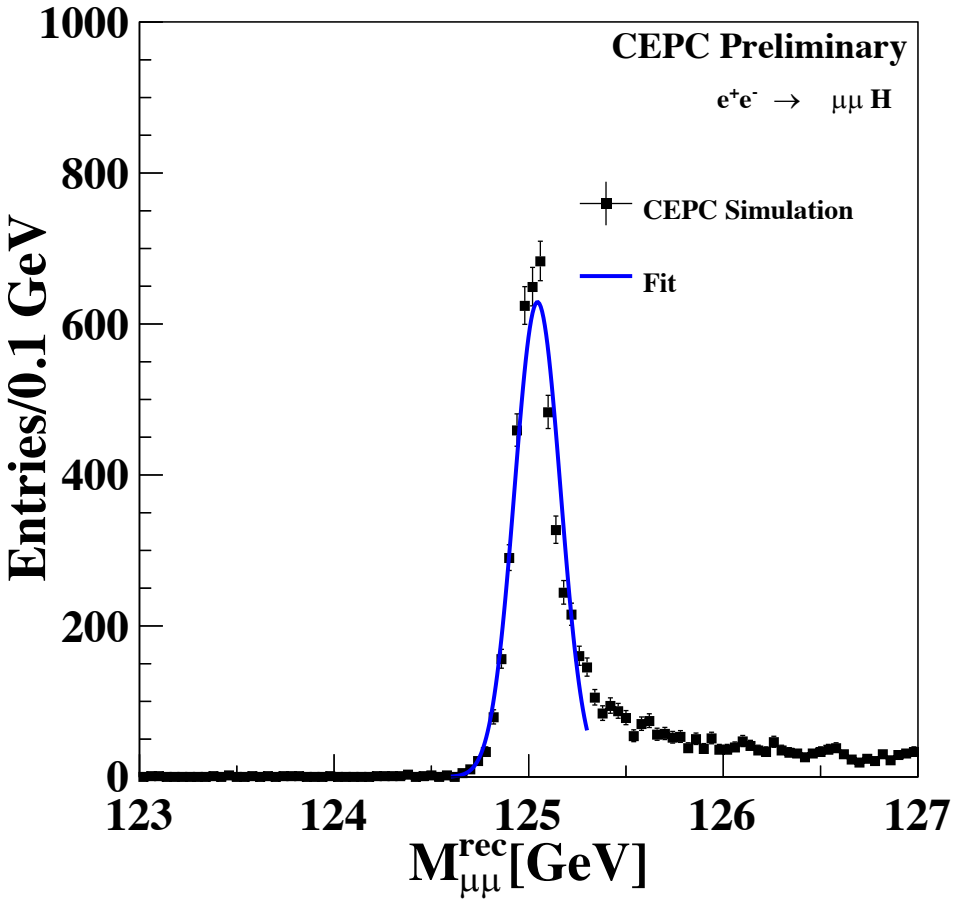
SIT 3,4 @ R=1.0m

SDT v1.0

SDTv1.0: Momentum and recoil mass resolution



- < 1.6 degradation for momentum resolution
  - Can be improved with more silicon layers



- ~12% increase for recoil mass resolution

SDT v2.0

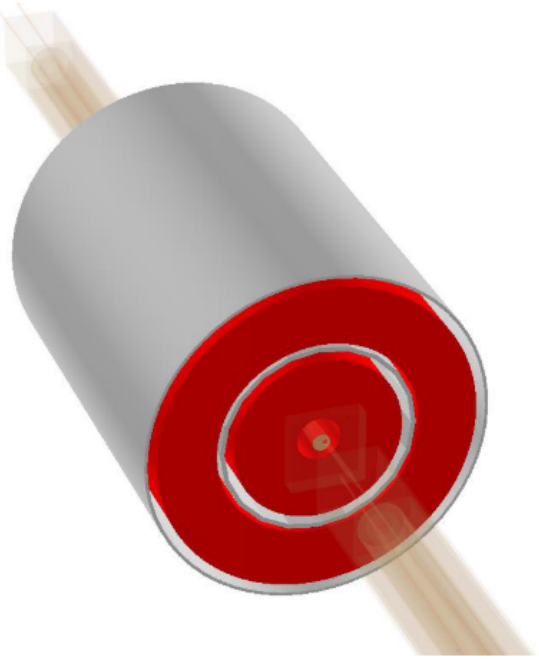
- Switch to CEPCSW: https://github.com/cepc/CEPCSW
  - Implement SDT basic configuation
  - Straight cell structure along beam axis
  - Extract dE/dx & PID sepration

cpp file

```
#include "DD4hep/DetFactoryHelper.h"
#include "DD4hep/DD4hepUnits.h"
#include "DD4hep/DetType.h"

#include "XML/Utilities.h"
#include "XML/XMLElements.h"
#include "XMLHandlerDB.h"

static dd4hep::Ref_t create_element(dd4hep::Detector& theDetector,
                                    dd4hep::xml::Handle_t e, dd4hep::SensitiveDetector sens)
{
   // typedef dd4hep::xml::DetElement     xml_det_t;
   xml_det_t x_det( e );

   std::string det_name = x_det.nameStr();

   dd4hep::DetElement sdet( det_name, x_det.id() );

   // since createPlacedEnvelope function calls following, it is turned off.
   //dd4hep::Volume mother_vol = theDetector.pickMotherVolume( sdet );


   // --- create an envelope volume and position it into the world :
   // --- this function call "addPhysVolID("system", sdet.id()) inside of it.
   dd4hep::Volume envelope_vol = dd4hep::xml::createPlacedEnvelope( theDetector, e, sdet );

   // --- Set detector type flag
   dd4hep::xml::setDetectorTypeFlag( e, sdet );

   // if only the envelope part is necessary,,,
   if( theDetector.buildType() == dd4hep::BUILD_ENVELOPE ){ return sdet; }


   // Set Sensitive-Detector (SD) type.
   // Following is just a type name, but it is used later ( i.e. geosvc in Gaidi framework )
   // to match its SD
   sens.setType("tracker");    // default type !

   // Read parameter values from the xml file
   xml_comp_t layer_params( x_det.child(_U(layer)) );

   int n_layer = layer_params.attr<int>( _Unicode(nLayer) );
   int n_cell = layer_params.attr<int>( _Unicode(nCell) );
   double cell_size = layer_params.attr<double>(  _Unicode(CellSize) );
```

```
<lccdd>

 <detectors>
  <!-- id=7, should be registered in basic_defs.xml-->
  <detector  id="7" name="aDCH" type="DCH" readout="DCHCollection" insideTrackingVolume="true" >

    <!-- Borrow an envelope of TPC,  to hold MDC inside -->
    <envelope vis="ILD_TPCVis">
      <shape type="Tube" rmin="329*mm" rmax="1808*mm" dz="2350*mm"  material = "Air" />
    </envelope>

    <!-- set the detector type flag which is defined in "detector_types.xml" -->
    <type_flags type="DetType_TRACKER +  DetType_GASEOUS + DetType_WIRE" />

    <!-- set a temporal parameters referred from  the LDT configurations -->
    <layer nLayer="133"  nCell="200"  CellSize="10*mm"  HalfLength="2350*mm"  r0="384*mm"  />

  </detector>

 </detectors>

 <readouts>
  <readout name="DCHCollection">
    <id>system:5,layer:11,module:16</id>
  </readout>
 </readouts>

</lccdd>
```

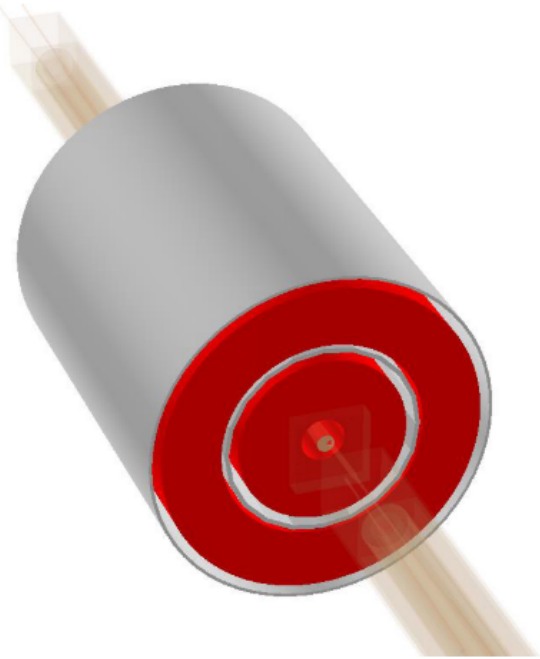
xml file



Simulation Settings

- Tracker: VXD – SIT1/2 – MDC1 – SIT3/4 – MDC2 – SET

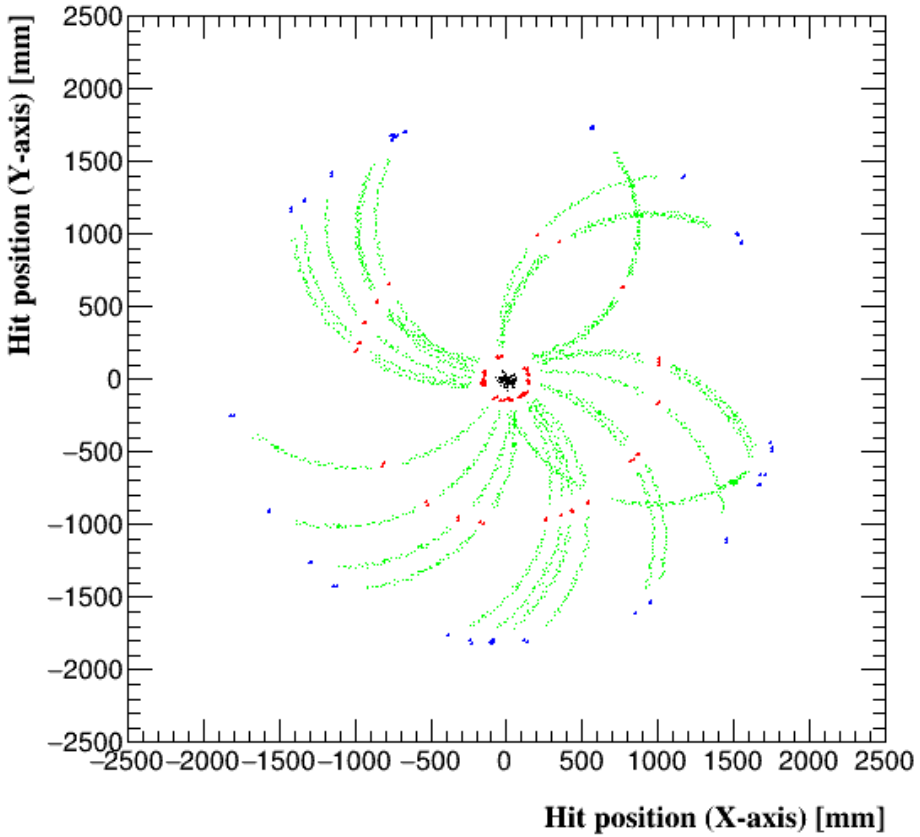
- Two Drift chambers:
  - cell size: 10mm
  - number of layers: 133
  - R: 0.3m to 1.8m
  - gas mixture: Ar:CH_4:CO_2 = 93%:5%:2%
    argon, methane and carbon dioxide
    taken from CDR TPC



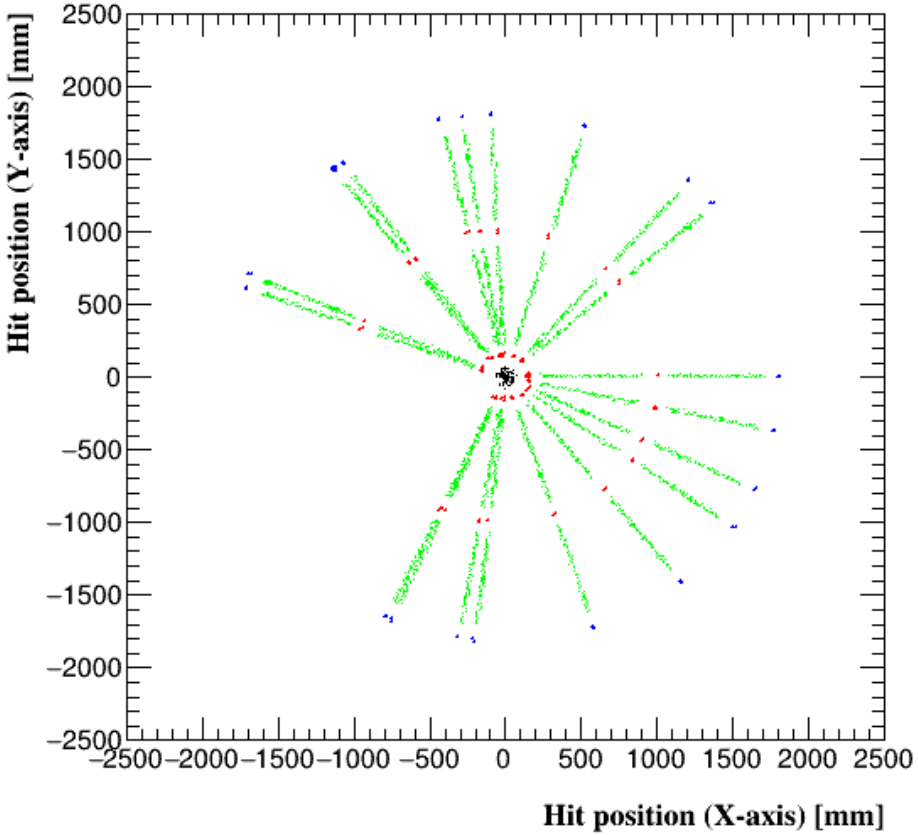
- Particle injection:
  - polar angle=85° for pion and kaon
  - particle gun momentum: 0.5, 0.75, 1, 3, 5, 10, 50, 100 GeV
  - 2000 events for each setting

Hit map for pion with θ =85° and B=3T

P=1 GeV/c



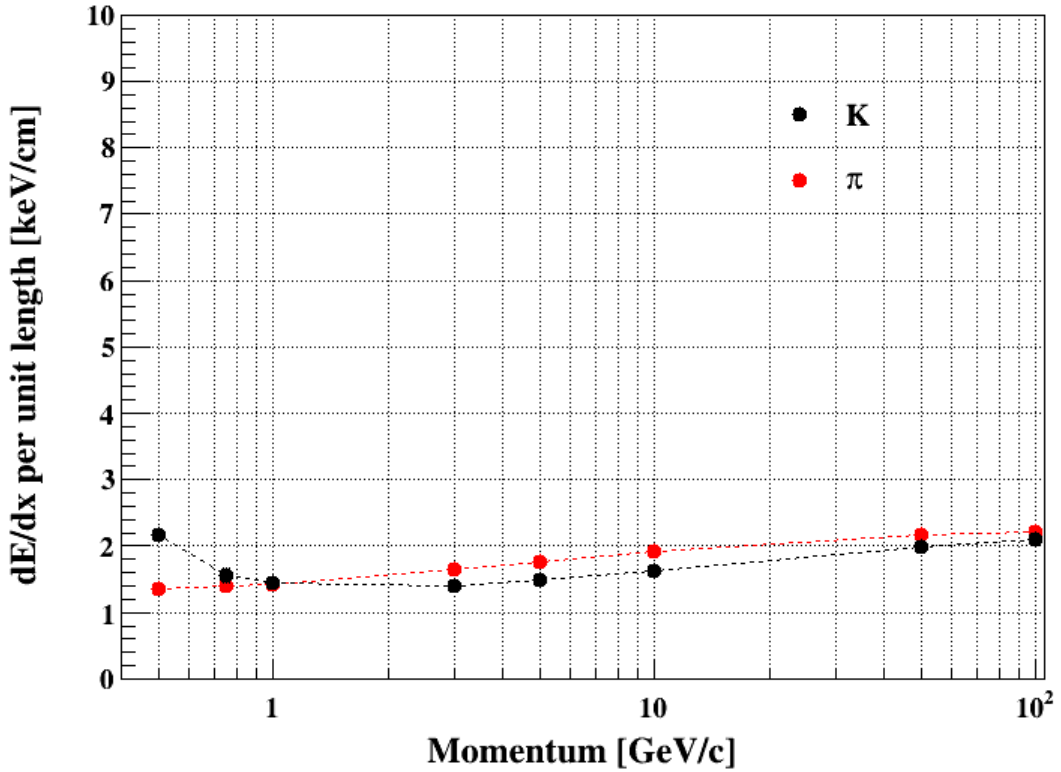
P=100 GeV/c



Dots represent hits for VXD (Black), SIT (Red), MDC1/2 (Green), SET (Blue)

dE/dx distribution

- Energy deposit per unit length (=10mm)



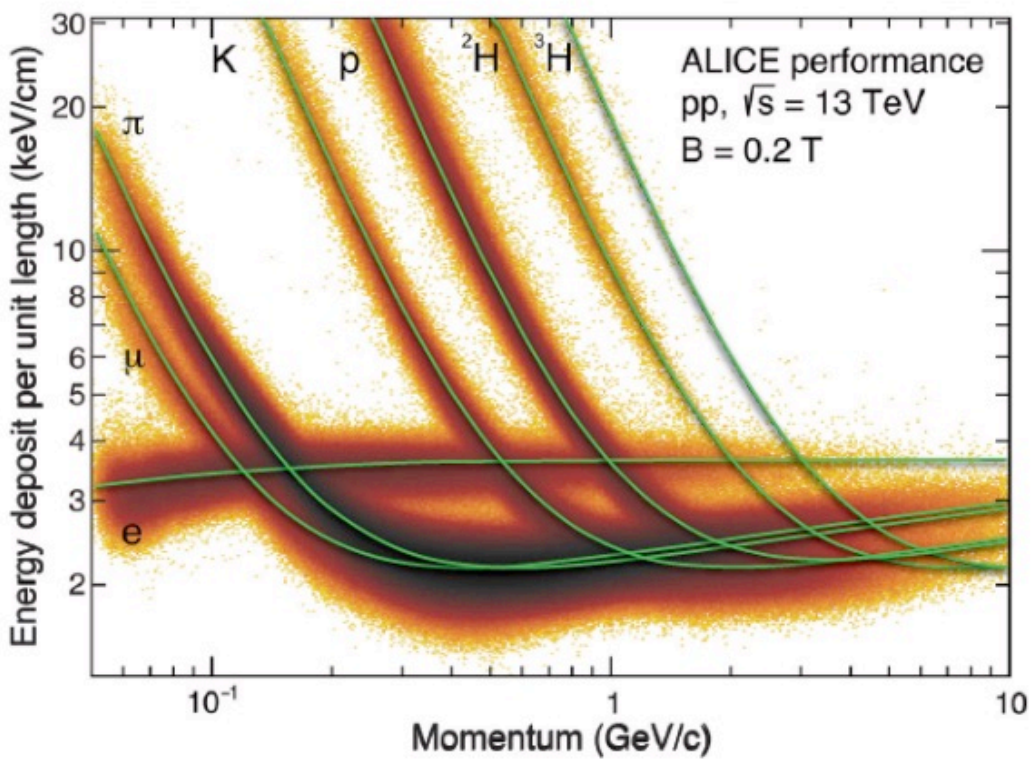
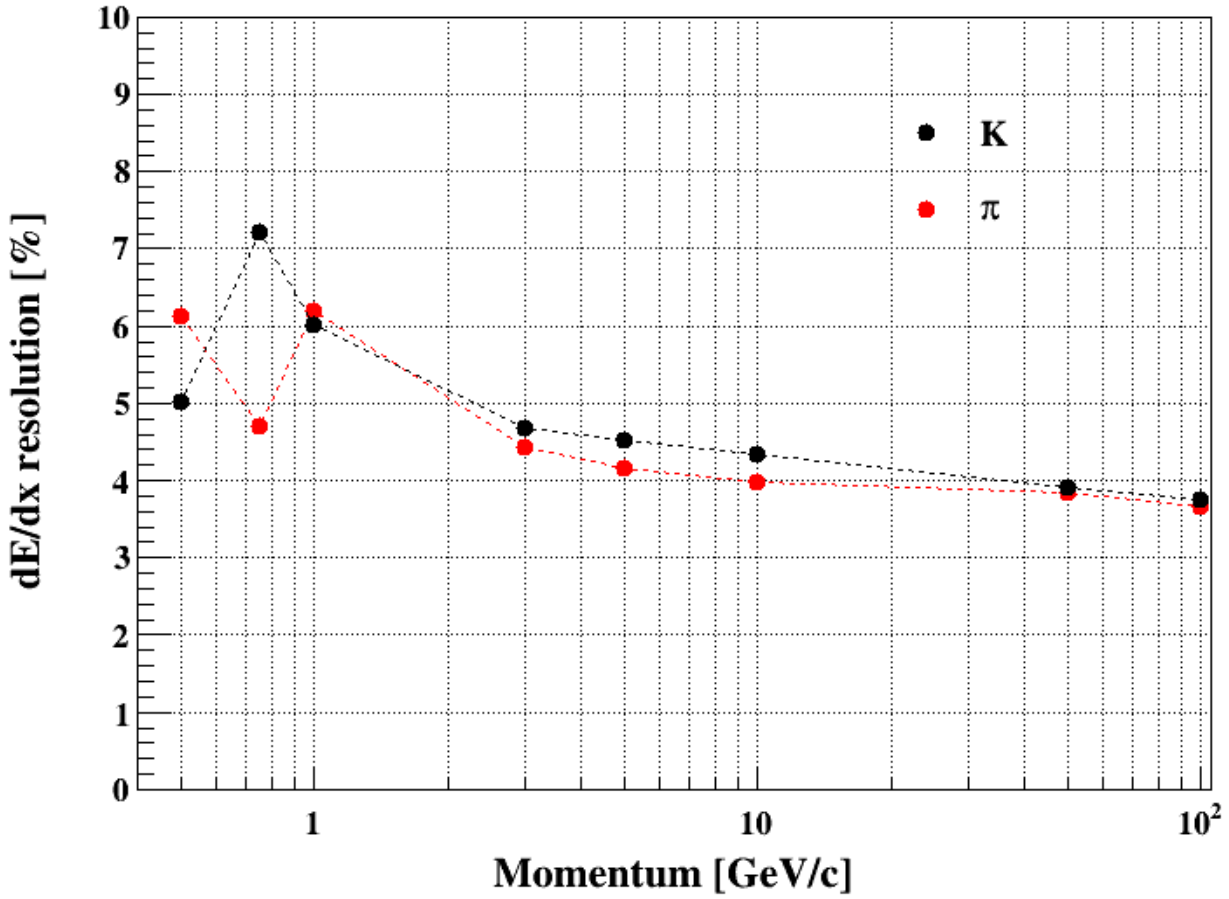


Figure 35.15: Energy deposit versus momentum measured in the ALICE TPC.

Energy deposition from GEANT4 with 90% truncation ratio

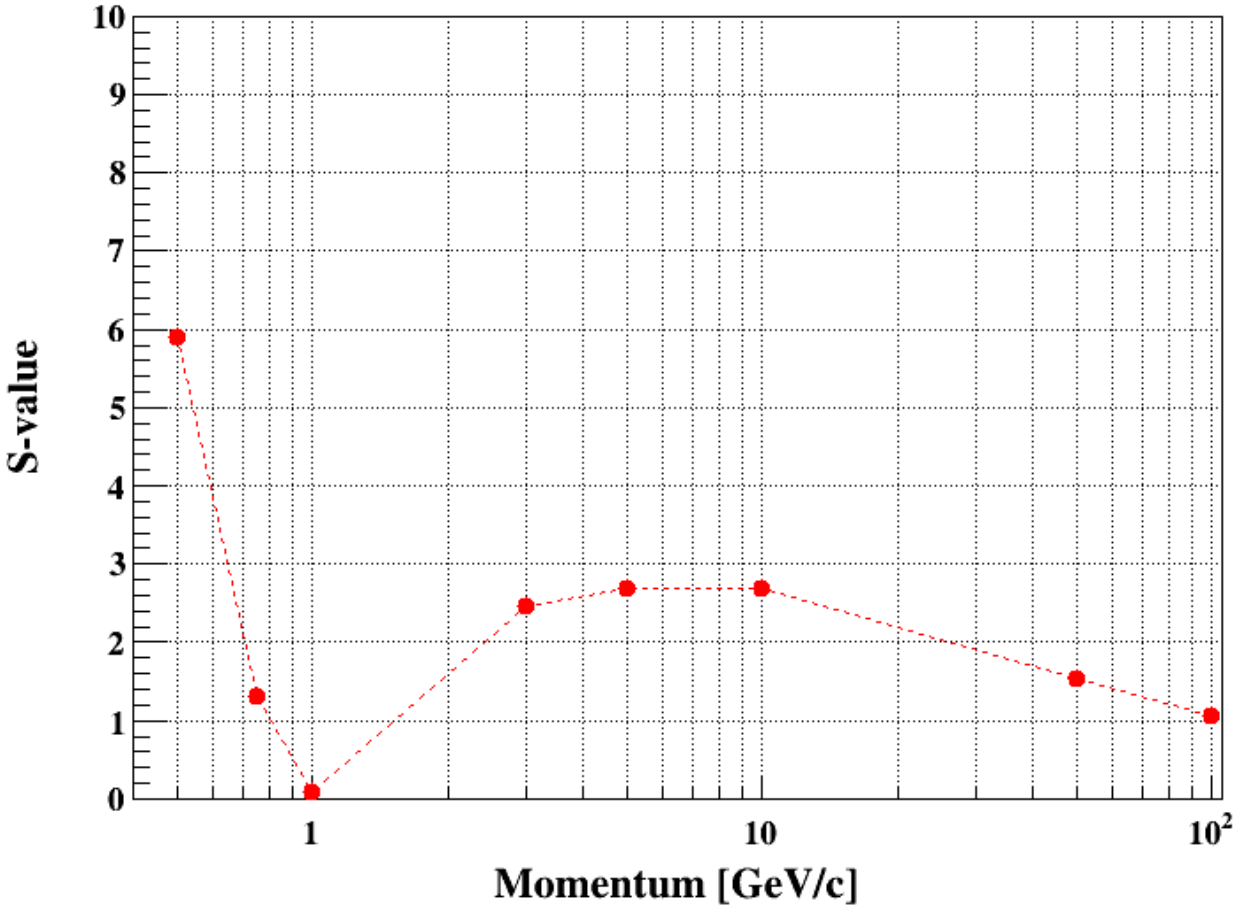
Resolution of dE/dx

- Resolution defined by (Gaussian) sigma/Mean



S-value (PID performance)

- S-value distribution for K/π case



Summary and Plan

- First look of dE/dx of SDT using the new softwre framework CEPCSW
  - Thanks for the strong support from the software team!
- Obtained distributions silmilar with references

- Next:
  - Investigate cluster counting to better dE/dx 2%
  - He based gas mixture (He: i-C4H10 = 90%:10%)
    - Lower material budget
    - Number of ionization cluster ~12/cm, allow for cluster counting
    - Suggested for IDEA and MEGII drift chamber
  - Smaller tracker volume (R=1.5) for crystal ECal
  - More layers of silicon for better momentum resolution
  - Signal digitization effect, GarField, ...