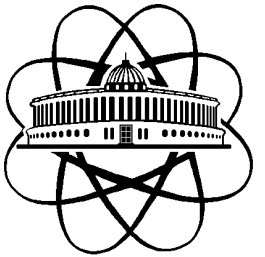
The XXVIth International Baldin Seminar
on High Energy Physics Problems
"Relativistic Nuclear Physics and Quantum Chromodynamics"



TPC geometries for NICA MPD simulations

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JINR
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Dubna, Russia

Geometric modelling (3D)

- Studies methods and algorithms for the mathematical description of shapes

- Used in

computer-aided design and manufacturing (CAD/CAM)

civil engineering

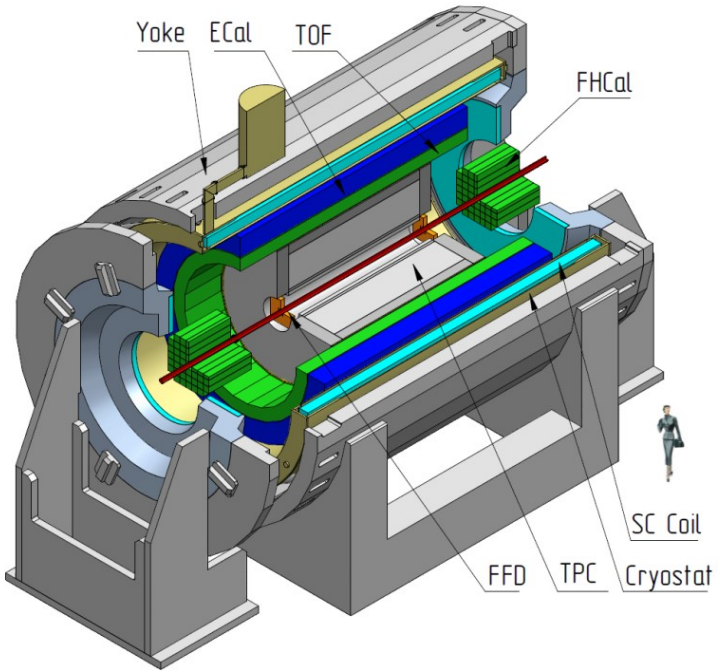
mechanical engineering

architecture

geology

medical image processing

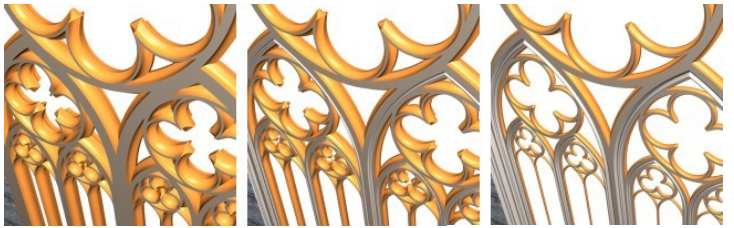
etc



Types of geometries

- **Procedural (define by an algorithm)**

  fractals, L-systems, generative modeling

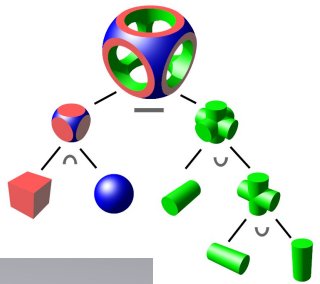


- **Solid geometry**

  3D space bounded by a two-dimensional closed surface

  Constructive solid geometry (CSG)

  complex surface by using boolean operators to combine simpler objects



  Boundary representation (B-rep or BREP)

  in addition to CSG has extrusions, surfaces (NURBS, B-splines, Bezier, etc.), parametric description and other features

- **Special geometries**

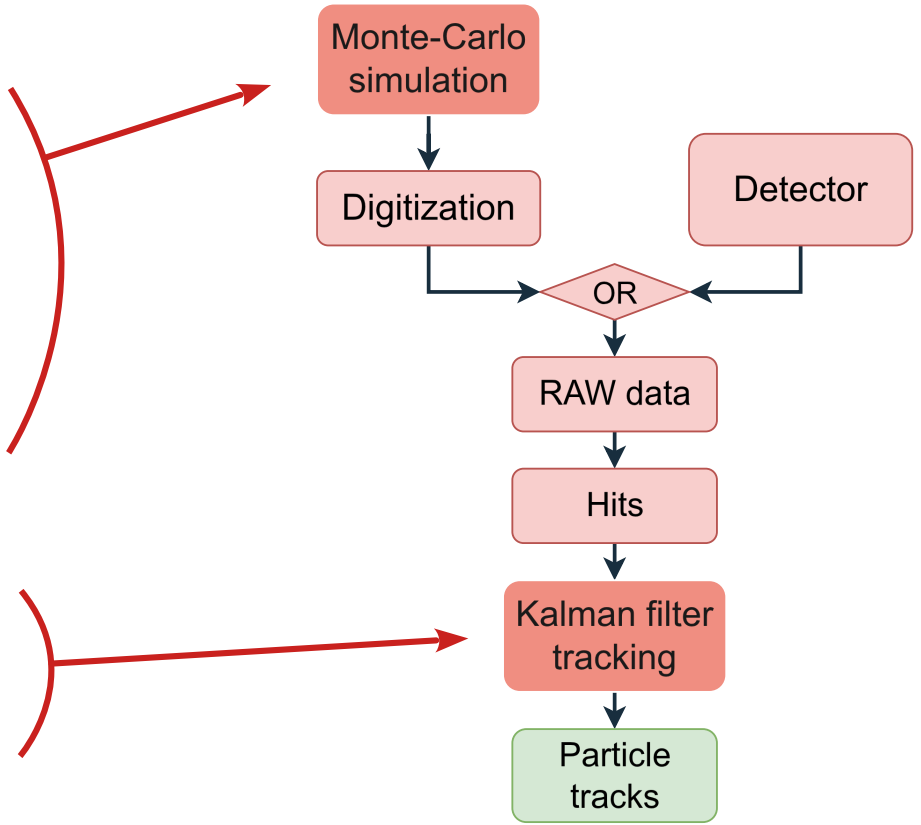
MPD TPC geometries

Simulation ROOT/GEANT geometry

- Many iterations of implementation during years of MpdRoot development
- Level of detail as high as possible
- Includes most of service constructions
  - thermoscreen, ROC-electronics, fieldcage, etc

Tracking ACTS geometry

- Representation of sensitive capabilities of detector
- New in-development addition to MpdRoot code



ROOT/GEANT geometry

Very similar to CSG

Hierarchy of

Shapes

simple – boxes, tubes, cones, torus, polygons, ets…

composite – unions or boolean intersection of simple shapes

positioned by 3D Transformations

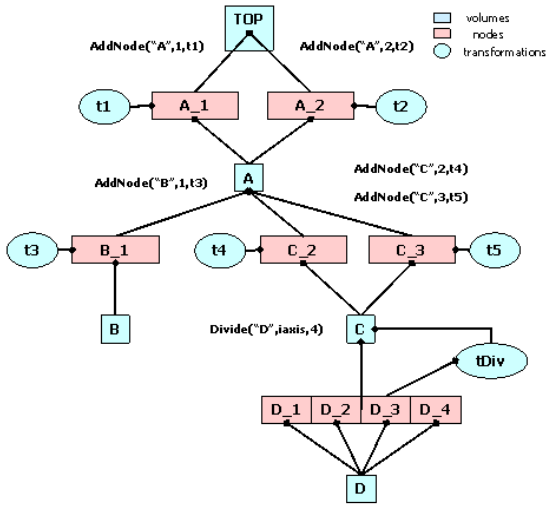
translations, rotations and scale

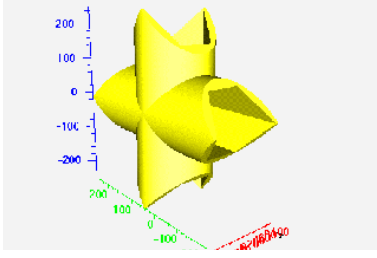
with shape Material description

described and constructed by code

(some elements of procedural generation)

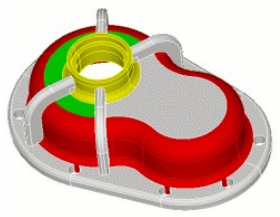
There is plugin for FreeCAD to build new ones ROOT/GEANT compatible geometries but it's a relatively new and not common way.



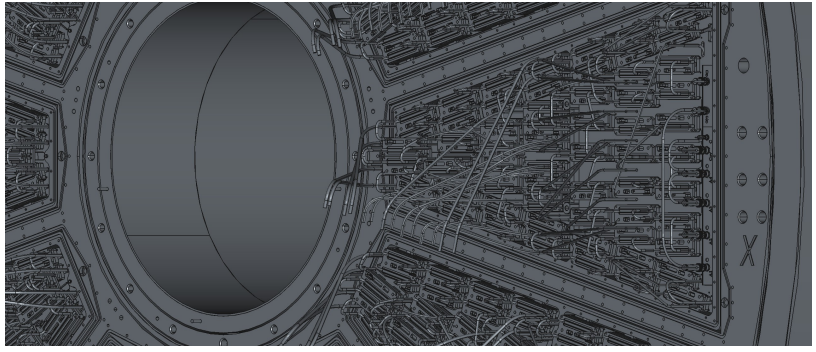


Problems

CAD production geometries → ROOT/GEANT geometries



No common and universal way



→ ? level of detail

precision

MPD TPC GEANT geometry evolution (1)

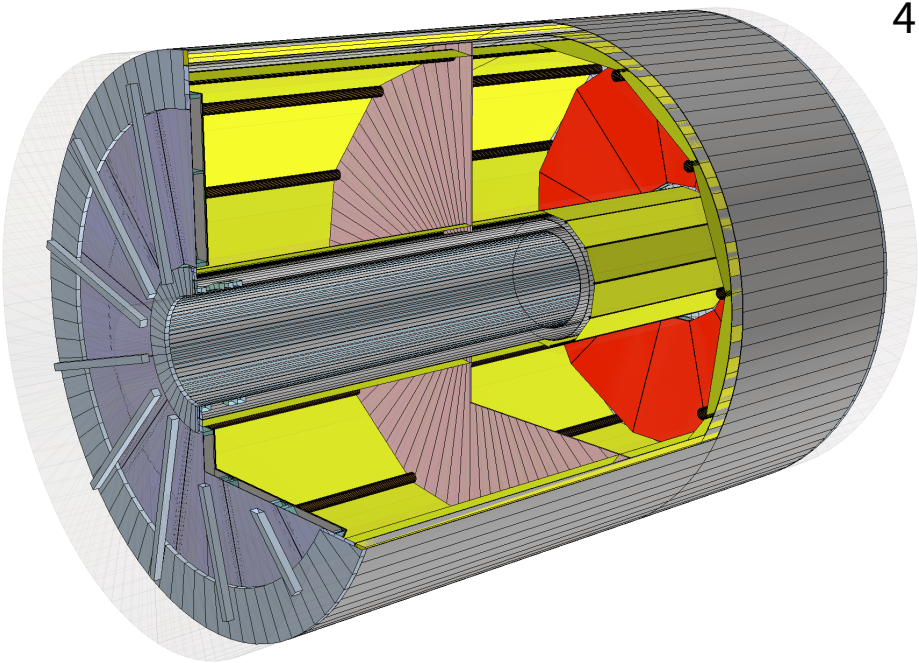
1st implementation

Until 2013

No correspondence to any production drawings

Physics rough expectation about detector

412 volumes



MPD TPC GEANT geometry evolution (2)

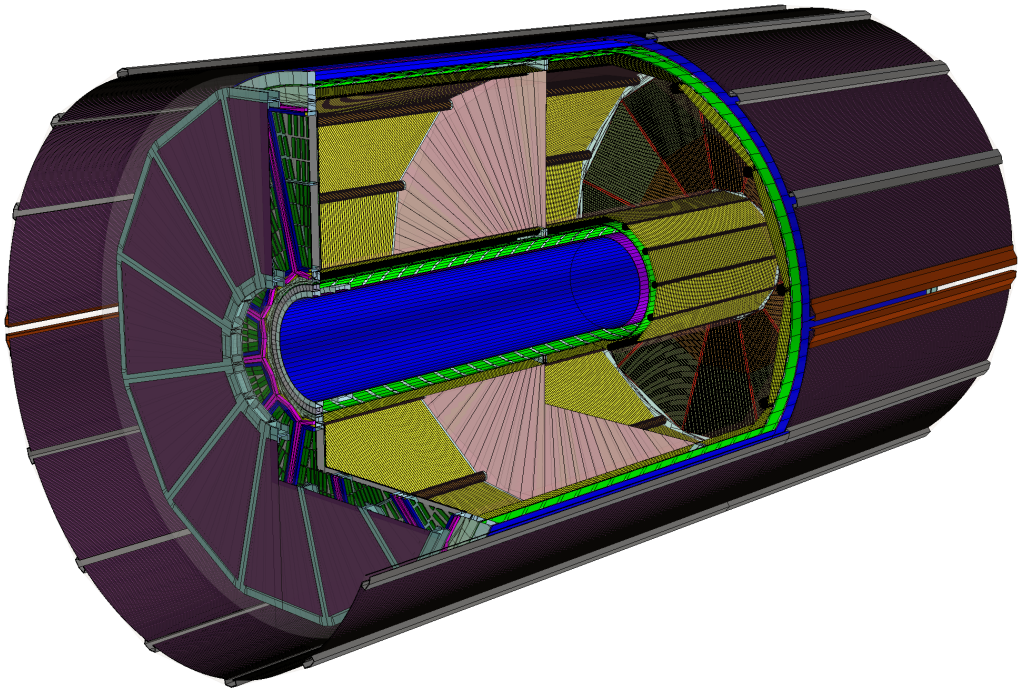
2nd generation

General correspondence to production drawings

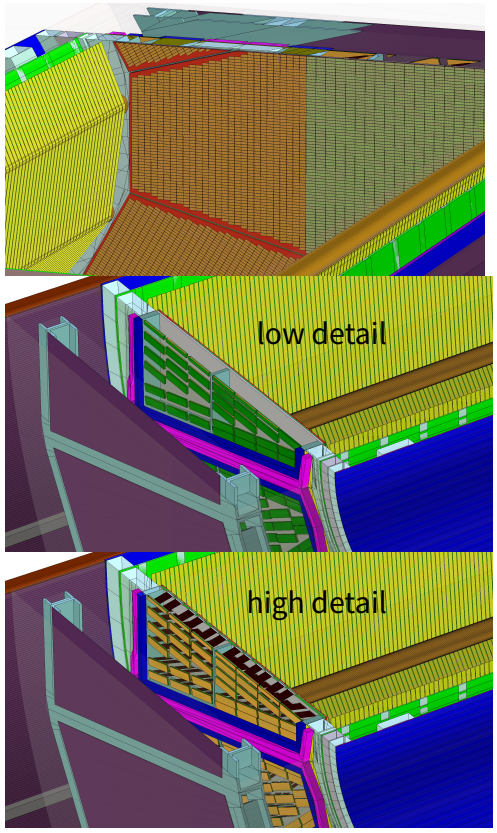
1st version of thermoscreen

3 level of ROC electronics detail

~2500 lines of code



103288 - 130936 volumes



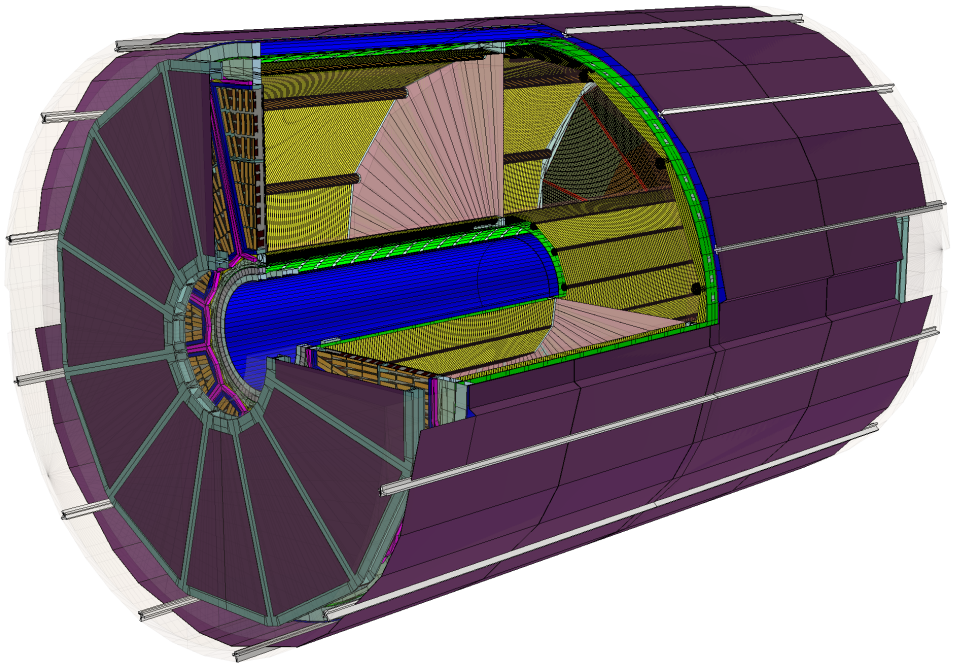
MPD TPC GEANT geometry evolution (3)

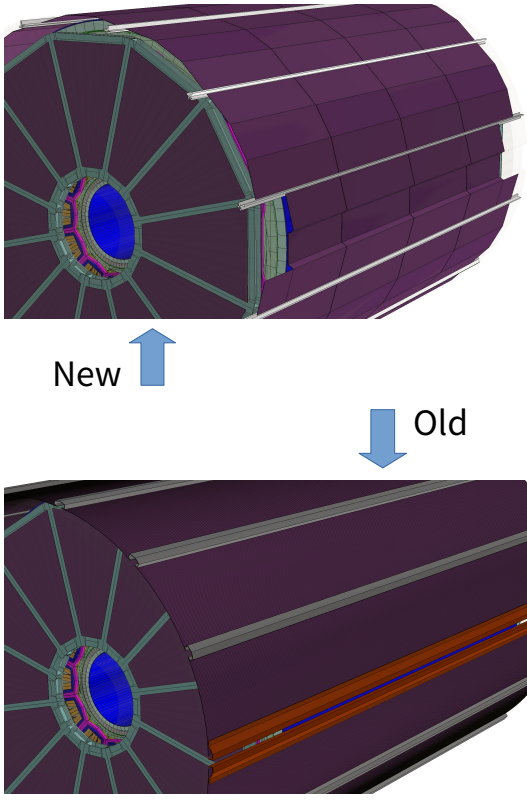
3rd generation

New thermoscreen because of production reasons

(curved → edged)

Anything else the same as 2nd generation



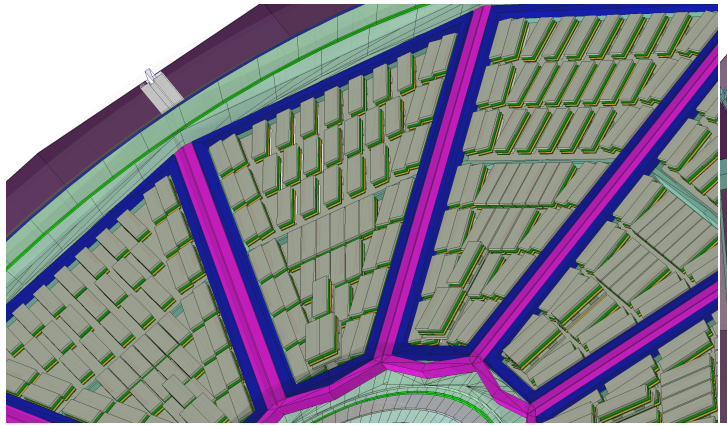


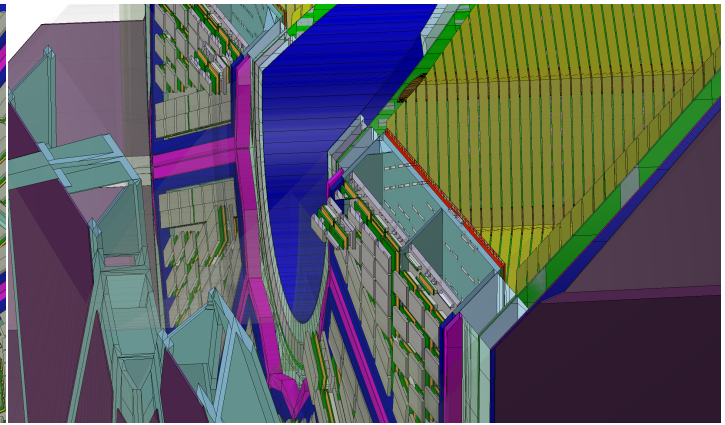
103326 - 130974 volumes

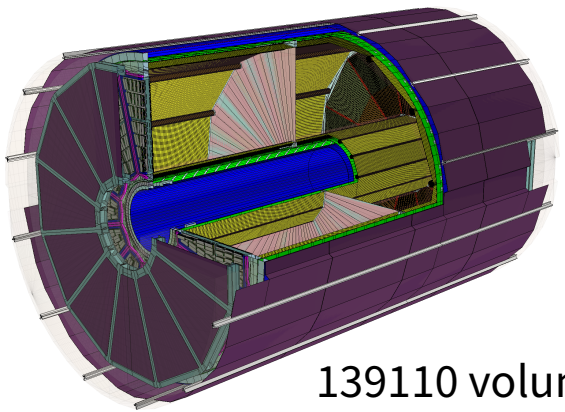
MPD TPC GEANT geometry evolution (4)

4th generation

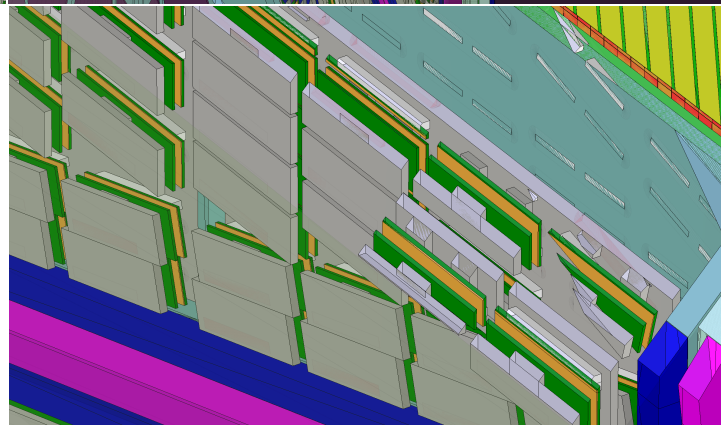
- Rebuild of Read-Out Cameras
  - New IO card modules
  - New IO cars layout
- Single level of detail
- Anything else the same as 3rd generation







139110 volumes



Why so detailed? (example)

TPC end-caps particle parameter changing

No magnetic field

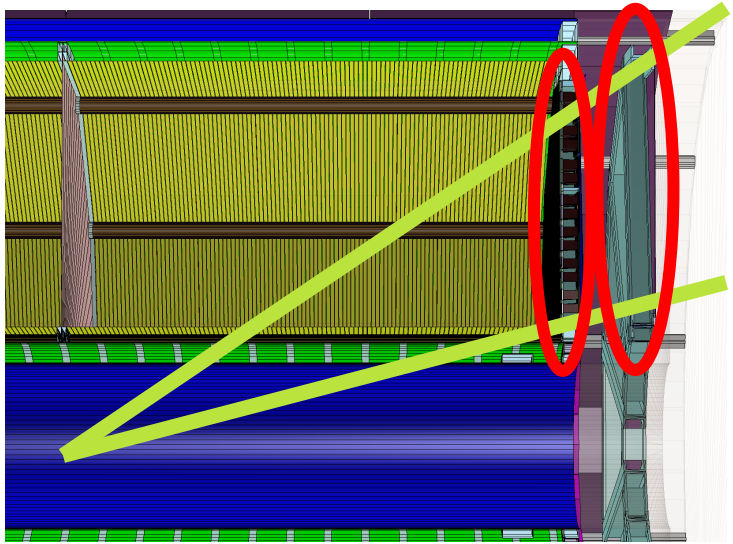
All tracks starts from (0, 0, 0)

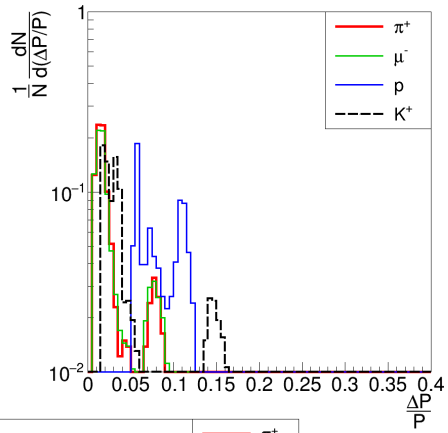
Tracks: p, π+, μ-, K+

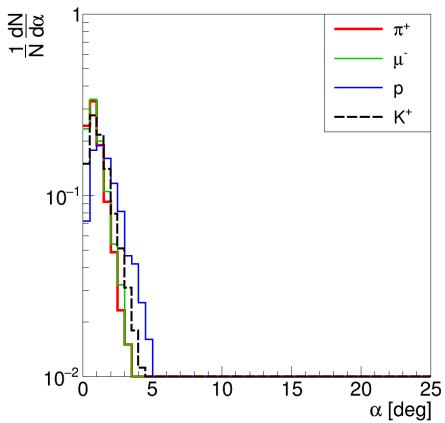
$\Delta P = P_{in}^{end\text{-}caps} - P_{out}^{end\text{-}caps}$

$P_{in}^{end\text{-}caps}, P_{out}^{end\text{-}caps}$ – momentum in/out TPC end-caps

$\alpha = \widehat{\vec{P}_{in}^{end\text{-}caps}, \vec{P}_{out}^{end\text{-}caps}}$





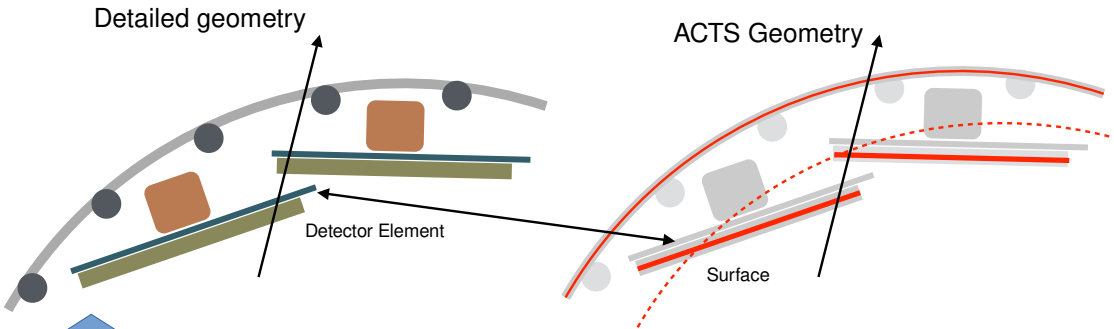


$P_0 = 600$ MeV

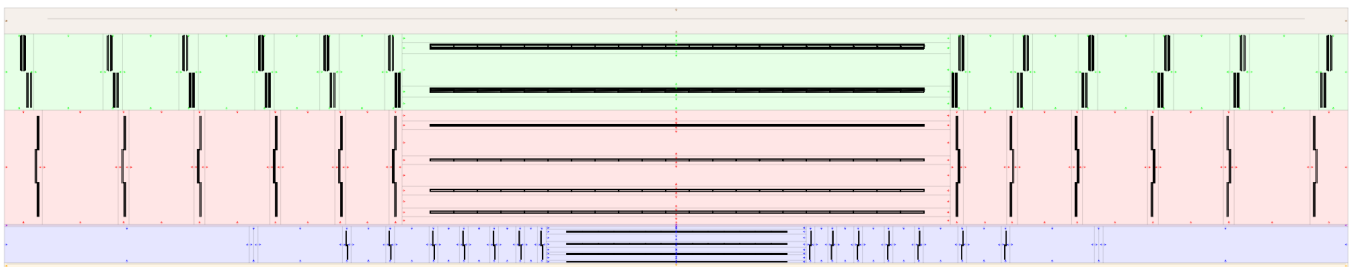
ACTS geometry

Special geometry for track propagation by Kalman filter

- All and any detectors as sensitive surfaces
  - No volume detectors
- Each reconstructed hit must belong to one and only one surface
- Volumes of material contain sensitive surfaces



ATLAS example: link of a complex geometry model to the surface representation



OpenDataDetector with its sub volumes

MPD TPC ACTS geometry evolution

Cylindrical geometry

Converted from ROOT/GEANT geometry

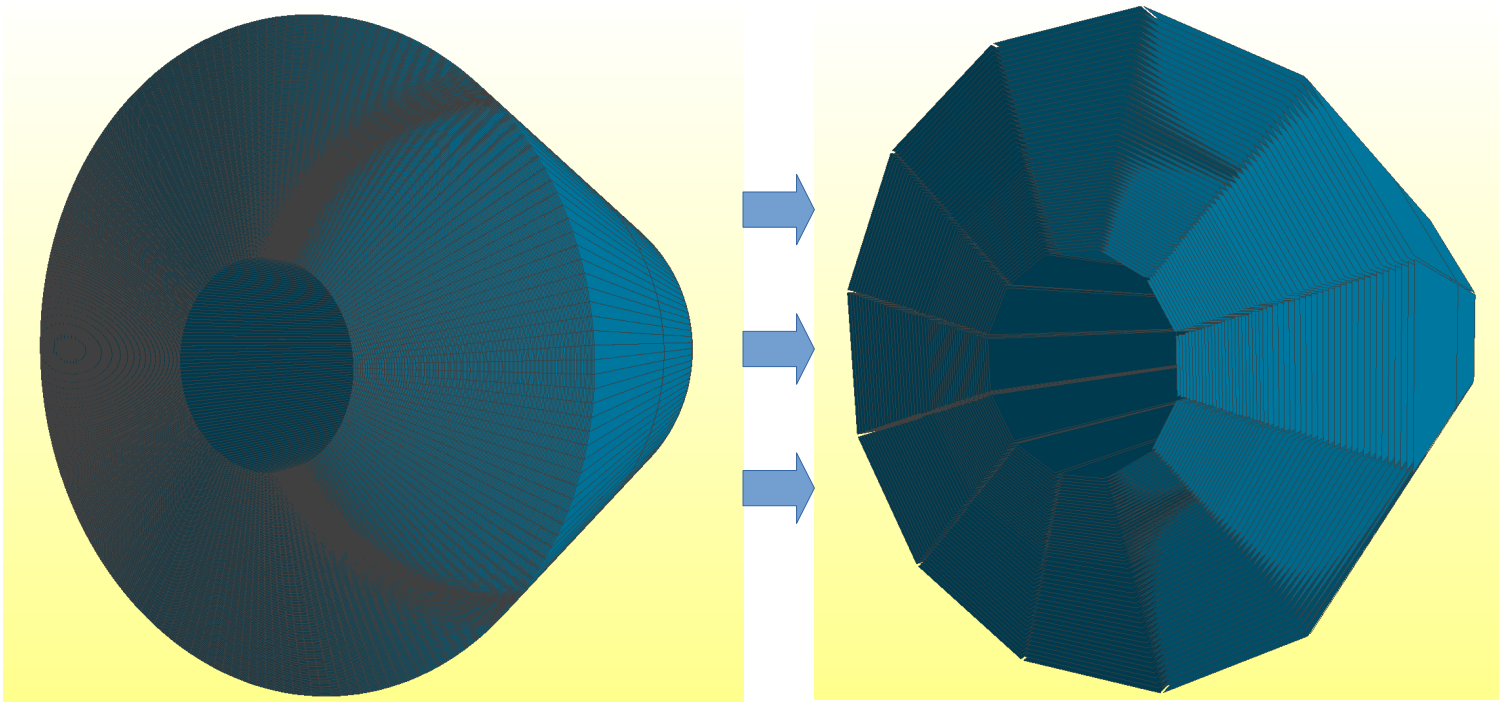
180 layers-cylinders

Sectoral geometry

Native (build w/o converter)

TPC exact representation

53 layers | 12 sectors



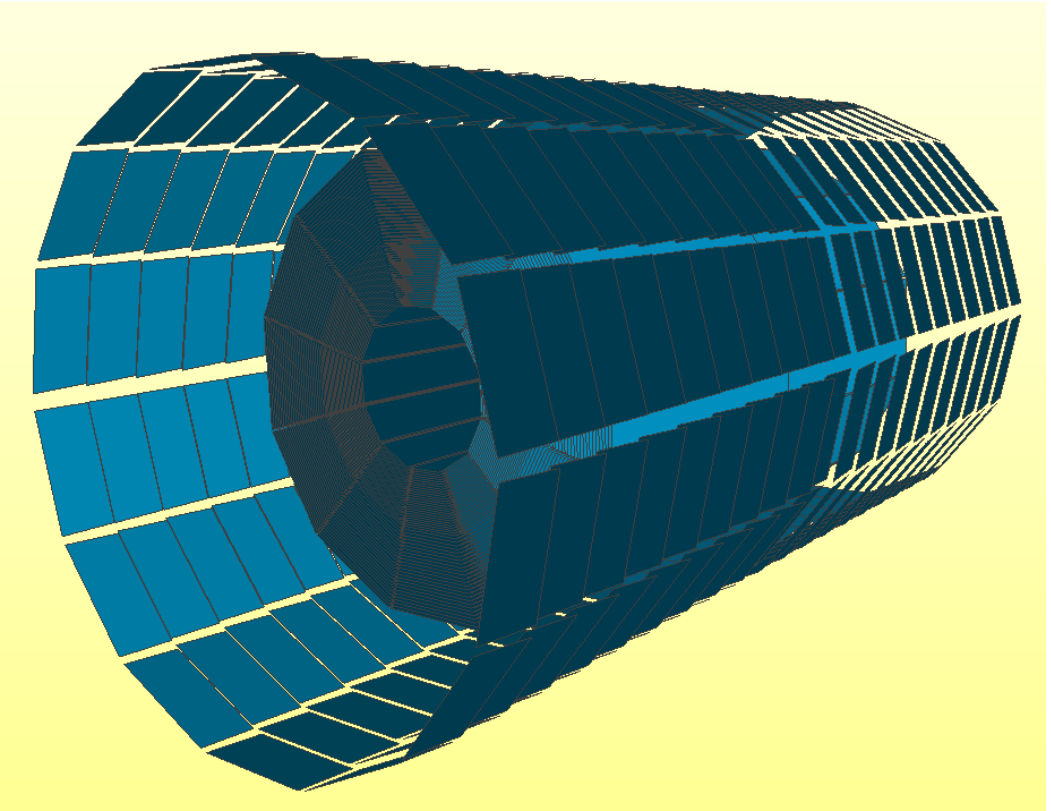
MPD TPC ACTS geometry evolution

TPC + TOF as single detector

ACTS Kalman filter works with single space for both detectors

Tracks propagates from TPC to TOF automatically

additional hits per track



Thats it

Thank you!

for your attention

Q & A ?