Update of the MCT detector model in SpdRoot source code (End-caps)

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Introduction

- On 1st stage Micromegas-based Central tracker will be installed;
- The idea of MCT is to improve the momentum resolution and tracking efficiency of the main tracking system during the first period of data taking;
- MCT parameters:
  - 1 super layer (~1.25% X_0);
  - Barrel layer length: 80 cm;
- It was proposal to simulate end-caps for MCT to improve momentum resolution for tracks without hits in ST barrel;

Previous reports:

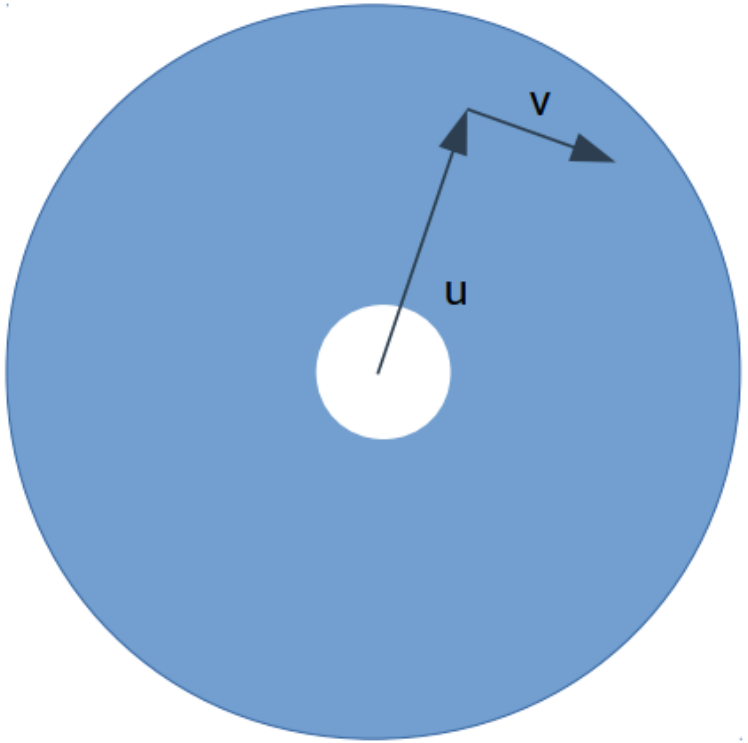
Latest presentation from MCT developers team im SPD CM
https://indico.jinr.ru/event/5000/contributions/30838/attachments/22218/39230/MCT_Status_20250513.pdf

Detailed performance tests for barrel-only MCT
https://indico.jinr.ru/event/5000/contributions/30991/attachments/22283/39350/SPD_Physics_CM_15_05_2025_Vasyukov.pdf

MCT End-caps

- 1 ec layer (~0.83% X_0 per layer) in each side of detector;
- EC position: ±80 cm;
- Rmin = 5 cm;
- Rmax = 18.5 cm;
- Resolution is modeled with gaussian smearing in simplified way;
- List of sublayers is same as for barrel part:

1) FR4: width = 0.0175 cm;
2) copper: width = 0.0019 cm;
3) kapton2: width = 0.0135 cm;
4) argon: width = 0.4000 cm;
5) copper: width = 0.00055 cm;
6) kapton2: width = 0.02400 cm;



U-resolution: 150. mcm
V-resolution: 150. mcm

MCT End-caps | script for simulation

```
void CustomMvdEC()
{
        SpdMvdGeoMapper* mapper = SpdMvdGeoMapper::Instance();

        Int_t ecl0, ecl1;

        mapper->EnableEndCaps();

        ecl0 = mapper->DefineECLayer(-80., 5.0, 18.5);
        mapper->SetECLayerActivity(ecl0,true);

        mapper->AddECSublayer(ecl0,0.01750,"FR4");
        mapper->AddECSublayer(ecl0,0.00190,"copper");
        mapper->AddECSublayer(ecl0,0.01350,"kapton2");
        mapper->AddECSublayer(ecl0,0.40000,"argon");
        mapper->AddECSublayer(ecl0,0.00055,"copper");
        mapper->AddECSublayer(ecl0,0.02400,"kapton2");

        ecl1 = mapper->DefineECLayerCopy(ecl0, 80.);
        mapper->SetECLayerActivity(ecl1,true);

        ecl1 = mapper->DefineECLayerCopy(ecl0, 80.5);
        ecl1 = mapper->DefineECLayerCopy(ecl0, -80.5);
}
```

z-position of EC layer [cm]

R_{min} of EC layer [cm]

R_{max} of EC layer [cm]

z-position of copy of ecl0 EC layer [cm]

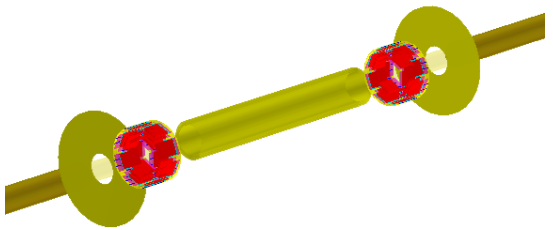
Overview of MCT options

- MCT (barrel only) without electronic modules;
- MCT (barrel only) with electronic modules of type #1;
- MCT (barrel only) with electronic modules of type #2;
- MCT (barrel + end-caps) without electronic modules;
- MCT (barrel only) with electronic modules of type #1;
- MCT (barrel only) with electronic modules of type #2;

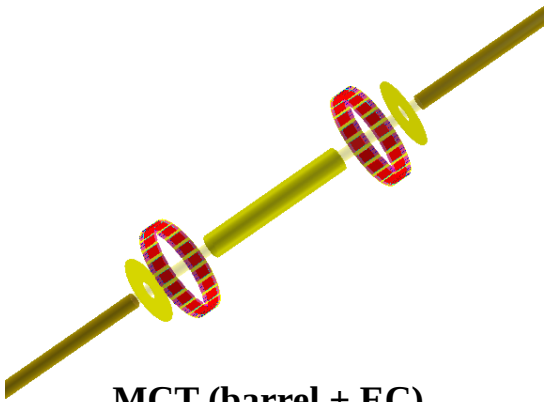
FEE location: 15 cm from MCT active area;

MCT (barrel only)

MCT (barrel + EC)



MCT (barrel + EC)
With FEE type#1



MCT (barrel + EC)
With FEE type#2

Performance test description | momentum resolution

Muon momentum resolution

- Isotopic production of 1.5 GeV muons at (0, 0, 0) point (no PV smearing);
- SpdIsotropicGenerator was used;
- For some performance tests the phase space is limited by the range of angles at which the tracks not enter Straw tracker barrel part: θ in range (0,)
- SpdMCTrackFinder settings:
  - Minimum number of ITS hits = 0;
  - Other settings has default values;

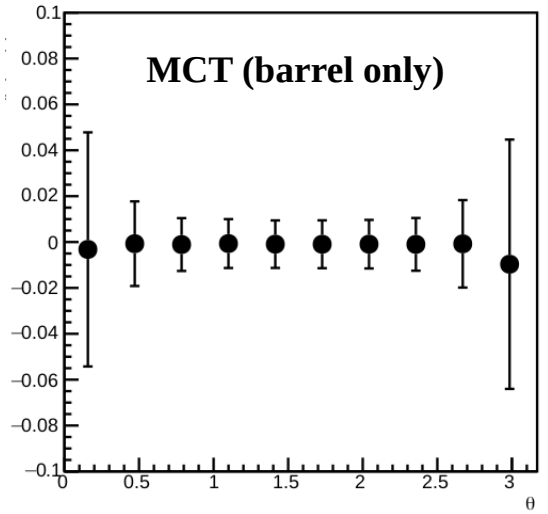
- Each $\Delta(p_{reco} - p_{gen})/p_{gen}$ distribution is fitted with two gaussians;
- σ is weighted average of two gaussians;

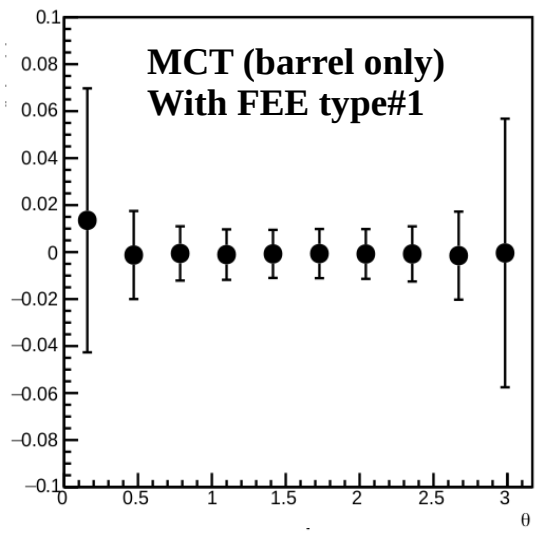
Detector setup:

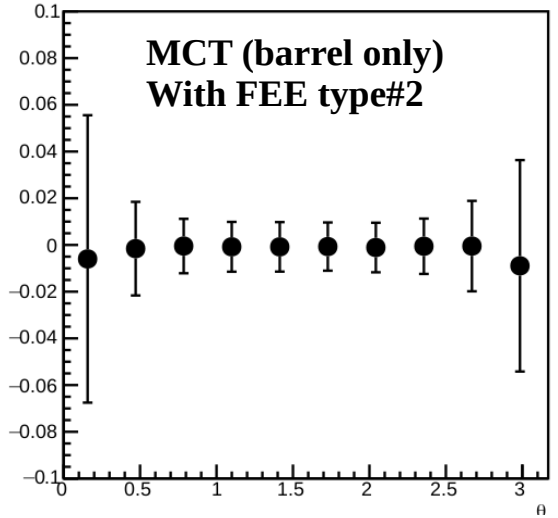
- Aluminium pipe;
- Magnetic field;
- MCT + Straw tracker (barrel + end-caps);

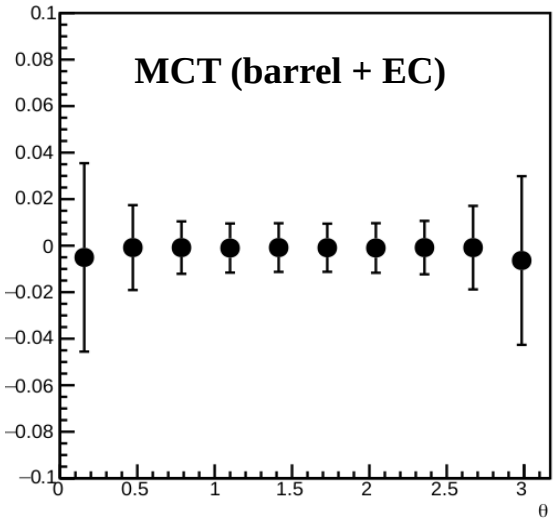
Performance test description | momentum resolution

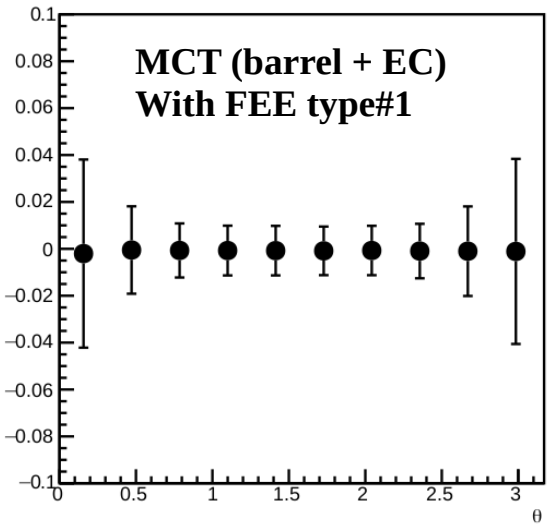
- Error bars represent momentum resolution in each theta bin;
- Events those don`t have hits in ST barrel are located in firts and last bins;

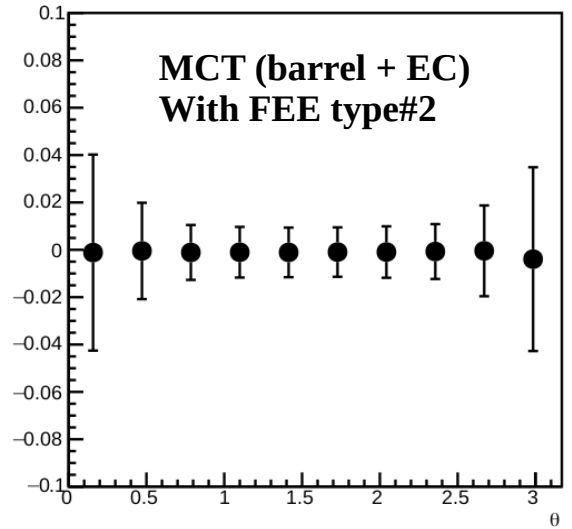




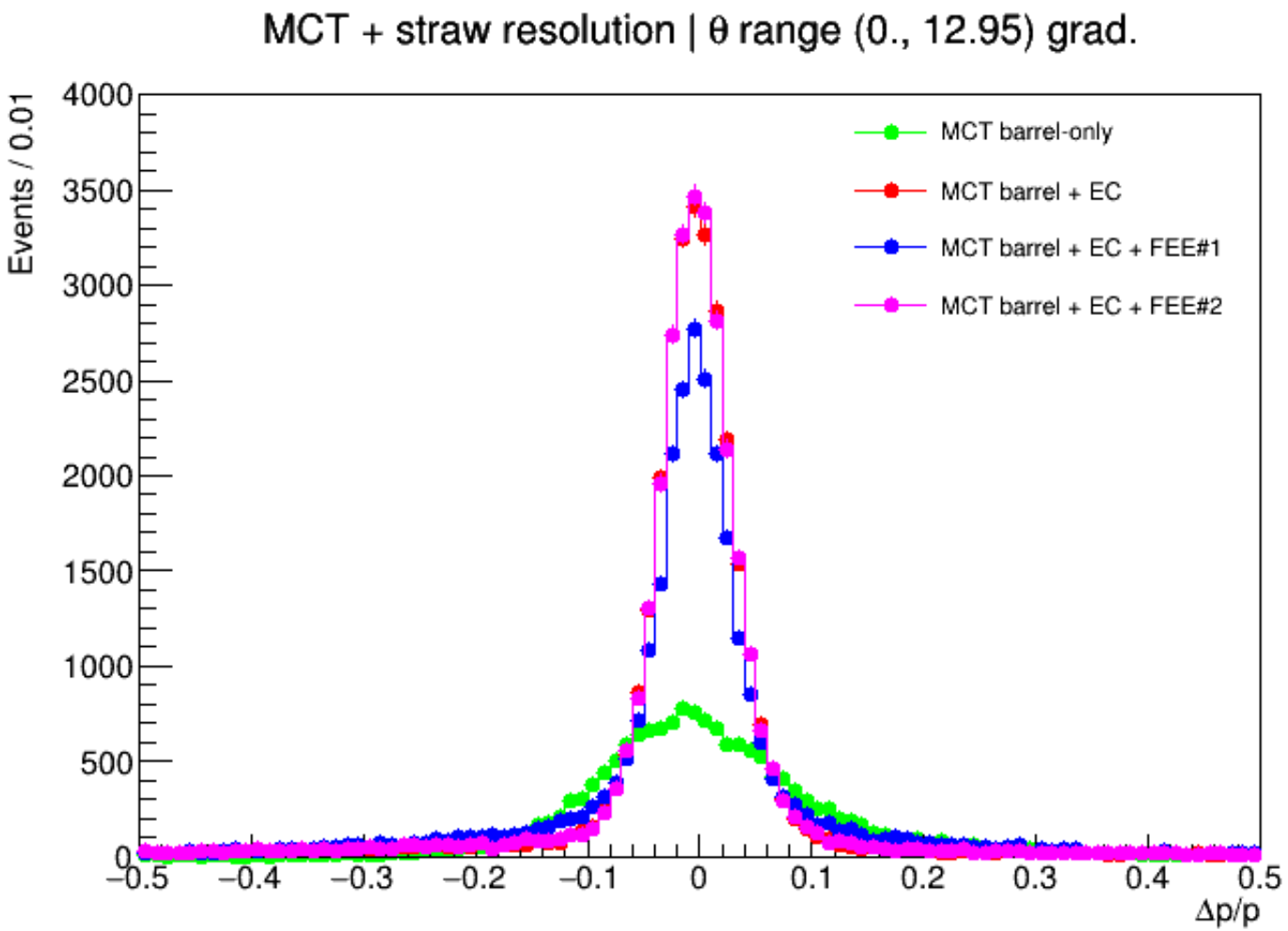








Performance test results | theta range: (0, 12.95) grad.



Conclusion

- Simplified version of MCT end-cap detectors were successfully simulated;
- MCT end-cap (EC) significantly improves momentum resolution for tracks without hits in the ST barrel;
- Technical feasibility of MCT EC development is currently under discussion;
- MCT front-end electronics (FEE) and EC are implemented in SpdRoot (branch: **mvd_update_endcap**);

ToDo

- Perform further tests to validate the necessity of MCT end-caps;
- Discuss technical feasibility of construction and integration MCT EC into the SPD Stage 1 setup;