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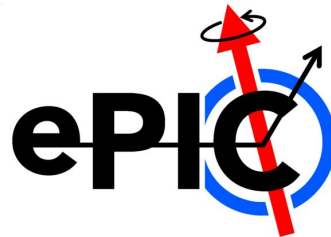
Office of Science

Auto Script for ACTS Material Map

Shujie Li

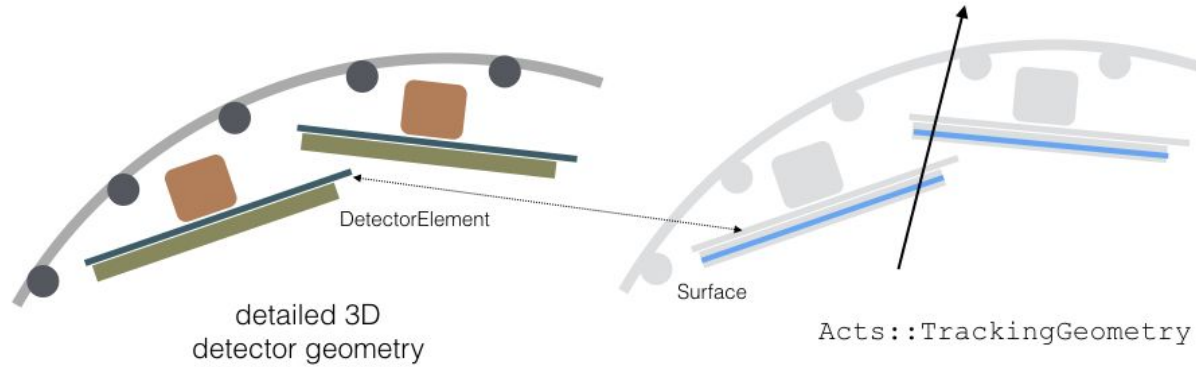
EIC-ePIC track recon meeting

Oct 12, 2023

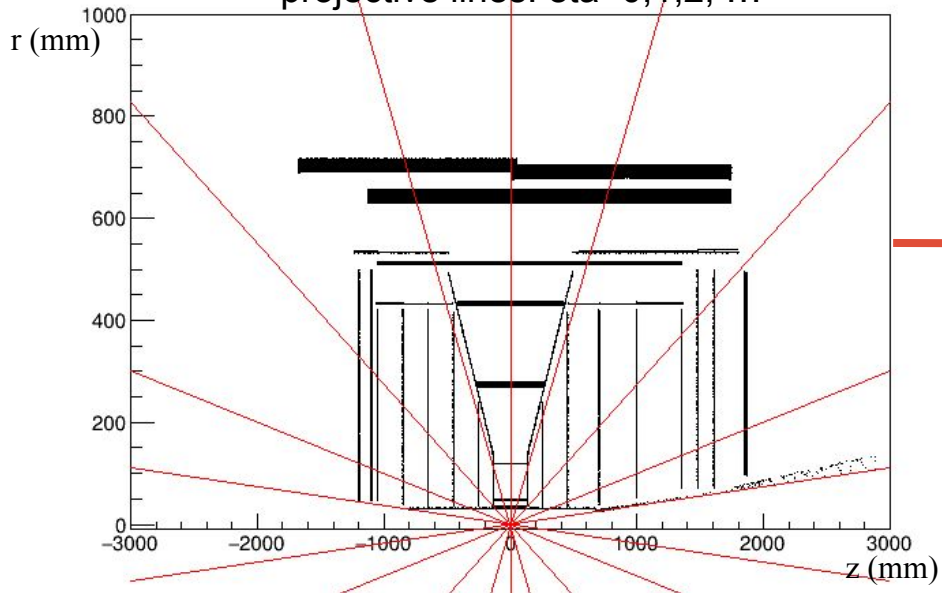




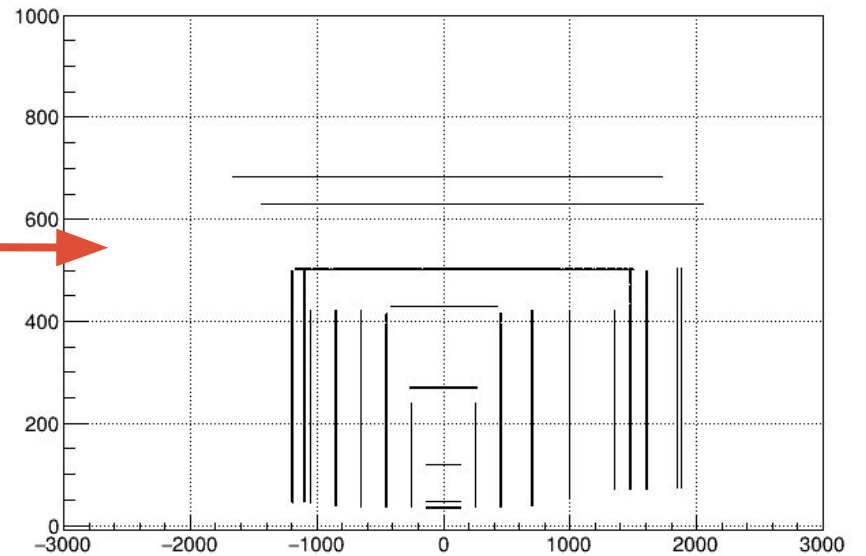
Simplified geometry in ACTS



Central tracker side view
projective lines: $\eta=0, 1, 2, \dots$



Project materials to surfaces



Script: run_materialmap.sh

works for ACTS v21. For later version, check the [tutorial](#)

Prerequisite:

`${ACTS_BUILD_DIR}` → `/usr/local/` in container

`${ACTS_PATH}/Examples/Scripts/MaterialMapping/` → need to download from github

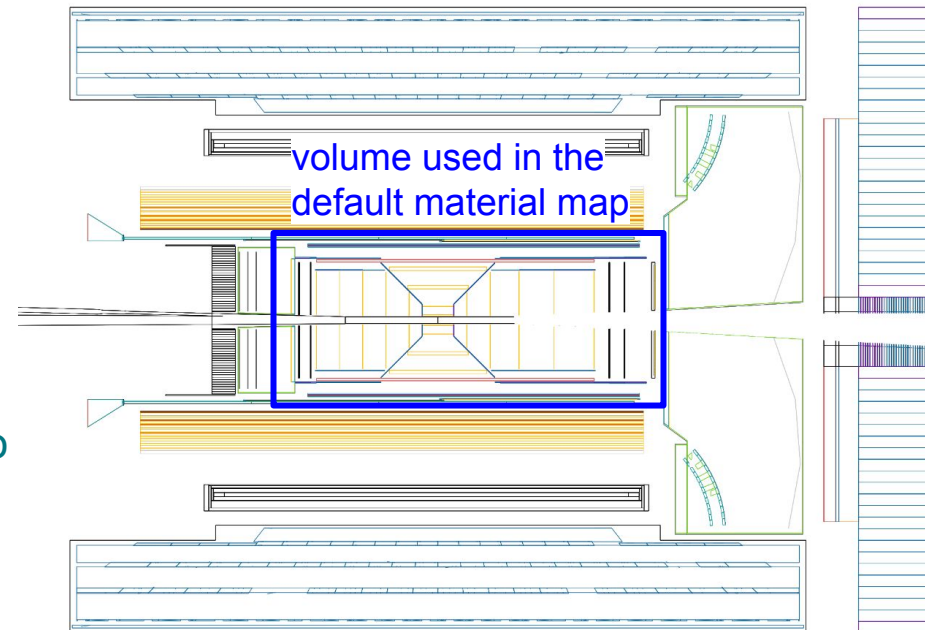
`epic_craterlake_modified.xml`:

- must include all geometry and materials **within the cylindrical volume** (r, Z) of interest, e.g.:
 - for track reconstruction, need to include everything up to the outer MPGD barrel and the TOF endcap. (default for the official craterlake materialmap)
 - to study **track projection** to HCal, need to also include RICH ... HCal and create pseudo ACTS surfaces for mapping

See instructions at

<https://github.com/acts-project/acts/issues/2403>

- can remove detectors/materials out of the volume (e.g. the solenoid) for efficiency.



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`epic_craterlake_modified.xml`

`$DETECTOR_PATH/compact/tracking/definitions`
`_craterlake.xml:`

```
120     <detectors>
121       <detector id="VertexSubAssembly_0_ID"
122         name="VertexBarrelSubAssembly"
123         type="DD4hep_SubdetectorAssembly"
124         vis="TrackerSubAssemblyVis">
125         <composite name="VertexBarrel" />
126       </detector>
127       <detector id="TrackerSubAssembly_0_ID"
128         name="InnerSiTrackerSubAssembly"
129         type="DD4hep_SubdetectorAssembly"
130         vis="TrackerSubAssemblyVis">
131         <composite name="InnerTrackerEndcapN"/>
132         <composite name="InnerTrackerEndcapP"/>
133       </detector>
134       <detector id="TrackerSubAssembly_1_ID"
135         name="MiddleSiTrackerSubAssembly"
136         type="DD4hep_SubdetectorAssembly"
137         vis="TrackerSubAssemblyVis">
138         <composite name="MiddleTrackerEndcapN"/>
139         <composite name="SagittaSiBarrel"/>
```

onion-like
envelopes



```
{ acts_beampipe_central::Barrel | { { {
  OuterBarrelMPGDSubAssembly::fGap | { {
  BarrelTOFSubAssembly::fGap | { { {
  EndcapMPGDSubAssembly::NegativeEndcap | { {
  OuterSiTrackerSubAssembly::NegativeEndcap | { {
  OuterSiTrackerSubAssembly::fGap | {
  MiddleSiTrackerSubAssembly::NegativeEndcap | { {
  MiddleSiTrackerSubAssembly::fGap | {
  InnerSiTrackerSubAssembly::NegativeEndcap | {
  VertexBarrelSubAssembly::Barrel |
  InnerSiTrackerSubAssembly::sGap } |
  InnerSiTrackerSubAssembly::PositiveEndcap } |
  MiddleSiTrackerSubAssembly::sGap } |
  MiddleSiTrackerSubAssembly::Barrel } |
  MiddleSiTrackerSubAssembly::PositiveEndcap } |
  OuterSiTrackerSubAssembly::sGap } |
  OuterSiTrackerSubAssembly::Barrel } |
  OuterSiTrackerSubAssembly::PositiveEndcap } |
  EndcapMPGDSubAssembly::sGap } |
  EndcapMPGDSubAssembly::PositiveEndcap } |
  InnerMPGDBarrelSubAssembly::Barrel } |
  EndcapTOFSubAssembly::PositiveEndcap } |
  BarrelTOFSubAssembly::sGap } | BarrelTOFSubAssembly::Barre
} } | OuterBarrelMPGDSubAssembly::Barrel } |
B0TrackerSubAssembly::PositiveEndcap } }
```

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For ACTS v21. Check the [tutorial](#) to get python scripts for later version

Steps (kopt = ...):

1. **Geantino scan**: use massless chargeless particle to map out materials along projective tracks.
2. **Set up mapping surfaces (no volume mapping by default) in json file:**

volume: e.g. `vertexbarrelsubassembly::Barrel`. Scroll down to the bottom of `geometry-map.json` (detailed description) or `config-map.json` (extracted from `geometry-map` to allow easy modification) to see name and volume id.

Surface (Radial: ϕ , R. Cylinder: ϕ , Z)

- **Boundary**: volume border. beampipe boundary is used as a mapping surface
- **Layer**: ACTS surfaces.
- **Approach 1,2**: inner(1) or outer(2) surface of the layer.

Modify config-map.json

```
"volume": 13,  
"approach": 1,  
"value": {  
  "material": {  
    "binUtility": {  
      "binningdata": [  
        {  
          "bins": 48, # of bins in phi  
          "max": 3.1415927410125732,  
          "min": -3.1415927410125732,  
          "option": "closed",  
          "type": "equidistant",  
          "value": "binPhi"  
        },  
        {  
          "bins": 50,  
          "max": 0.0,  
          "min": 0.0,  
          "option": "open",  
          "type": "equidistant",  
          "value": "binR"  
        }  
      ]  
    },  
    "mapMaterial": false, set to "true" to use  
    "mappingType": "Default" this surface for  
  },  
  "bounds": {  
    "type": "RadialBounds"  
  }  
}
```

dummy values. check geometry-map for actual range

Pre-define binning in xml files:

```
epic  
/compact  
/tracking
```

/silicon_disks.xml

```
<layer id="1">  
  <envelope vis="TrackerLayerVis"  
    rmin="InnerTrackerEndcapNLayer1_rmin"  
    rmax="InnerTrackerEndcapNLayer1_rmax"  
    length="SiTrackerEndcapLayer_thickness"  
    zstart="InnerTrackerEndcapNLayer1_zmin" />  
  <layer_material surface="inner" binning="binPhi,binR"  
    bins0="5*SiTrackerEndcapMod_count" bins1="100"/>  
  <layer_material surface="outer" binning="binPhi,binR"  
    bins0="5*SiTrackerEndcapMod_count" bins1="100"/>  
  <ring  
    r="InnerTrackerEndcapNMod1_rmin +  
    InnerTrackerEndcapNMod1_y/2"  
    zstart="0"  
    nmodules="SiTrackerEndcapMod_count"  
    dz="SiTrackerEndcapMod_dz"  
    module="Module1" />  
</layer>
```

Auto script materialmap_config.py:

- turn on all approach 1. Also turn on approach 2 for disk surfaces.
- still need to turn on the cylinder surface of beampipe manually

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Steps (kopt = ...):

3. Generate material map

- default: materials projected to the nearest surface.
- output: .cbor (smallest in size), .json, .root
- official material map provided in compact/tracking/definitions_craterlake.xml, and will be downloaded to calibration folder
- Flag to use a local version in EICrecon: `acts:MaterialMap=/path/to/file/`

```
191     <documentation>
192         ### Material map for ACTS
193         https://eicweb.phy.anl.gov/EIC/detectors/athena/-/issues/127
194     </documentation>
195     <plugins>
196         <plugin name="epic_FileLoader">
197             <arg value="cache:$DETECTOR_PATH:/opt/detector"/>
198             <arg value="file:calibrations/materials-map.cbor"/>
199             <arg value="url:https://eicweb.phy.anl.gov/EIC/detectors/athena,
200         </plugin>
201     </plugins>
202
203 </lccdd>
```

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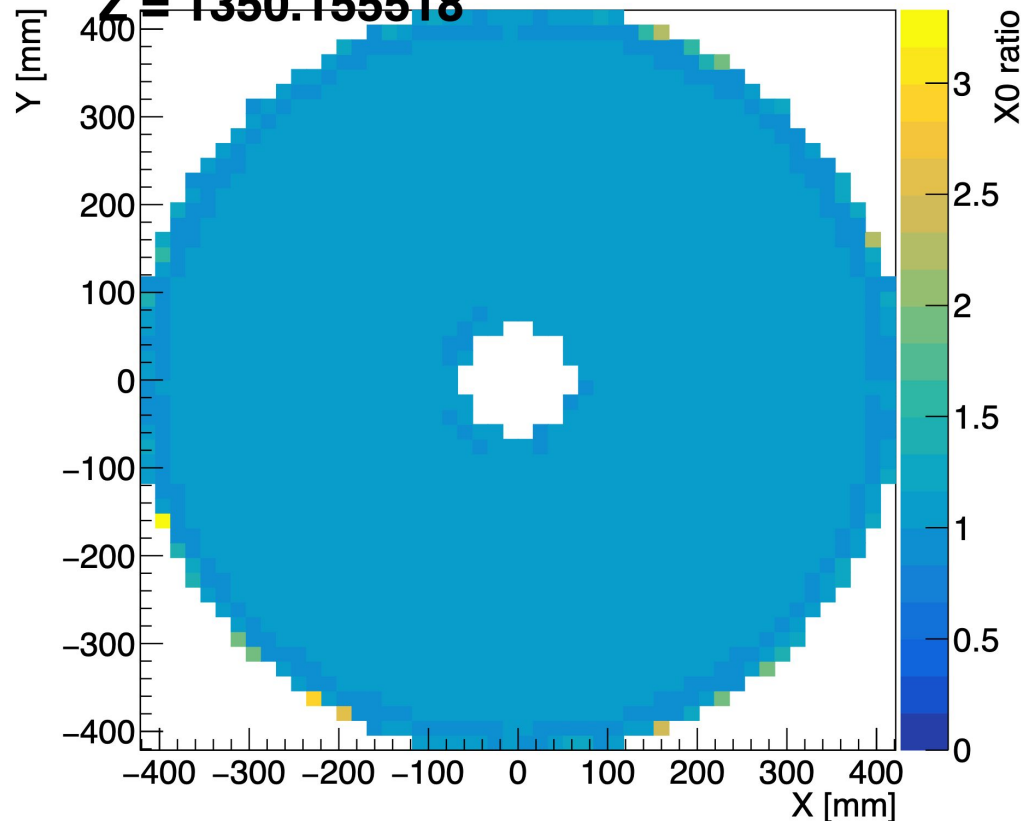
Steps (kopt = ...):

4: validation plots (e.g. Surfaces/ratio_plot)

volume | boundary | layer | approach | sensitive |

[36 | 0 | 6 | 2 | 0]

Z = 1350.155518



Summary

Available scripts (to be):

https://eicweb.phy.anl.gov/EIC/benchmarks/detector_benchmarks/-/tree/master/benchmarks/material_maps?ref_type=heads

- `run_materialmap.sh`
- `mat_map_local.C`
- `materialmap_config.py`

Need major revision once ACTS v24 is deployed in container.