ePIC far forward electron beam gas simulation

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Overview

- More detectors read out from the simulation output
  - Thresholds based on athena, not all used - will be updated
- Vertex position readout now working correctly
  - Different format of the `hepmc` file required
    - `/star/u/ceskajak/pwg/eic/simulation/beam_gas_ep_10GeV_foam_emin10keV_10Mevt_vtx.hepmc`
- Hit rate calculations for trackers performed - no readout issues expected
- Issues with calorimeter readout
  - eg. trying to access certain elements in the `EcalEndcapNHits` results in a segfault, same for others
  - python's `EventStore` ROOT wrapper used to read hits produced by the simulation

General overview

- Simulation performed using **epic-23.01.0** (latest stable) with included far forward electron beamline
- `/star/u/ceskajak/pwg/eic/simulation/23.01.0_vtx.edm4hep.root`
- Far forward electron beamline still being incorporated into epic source
  - Based on athena_particle_counter
  - Close to being done
  - `xml` files - created manually or is there an automated process?
- Unexpected issue with python-based readout
  - on SDCC cluster, when loading TFile module from ROOT library in python, module *libcppyy3_11* not found

Implemented detectors

Detector	Threshold
VertexBarrelHits	0.4 keV
SiBarrelHits	0.4 keV
MPGDBarrelHits	0.2 keV
MPGDDIRCHits	0.4 keV
TOFBarrelHits	0.4 keV
TrackerEndcapHits	0.4 keV
TOFEndcapHits	0.4 keV
DIRCBarHits	0.4 keV
MRICHHits	0.4 keV
DRICHHits	0.4 keV

Table 1: Detectors and their threshold currently used in readout. Threshold based on athena, will be revisited.

Hit energy distributions

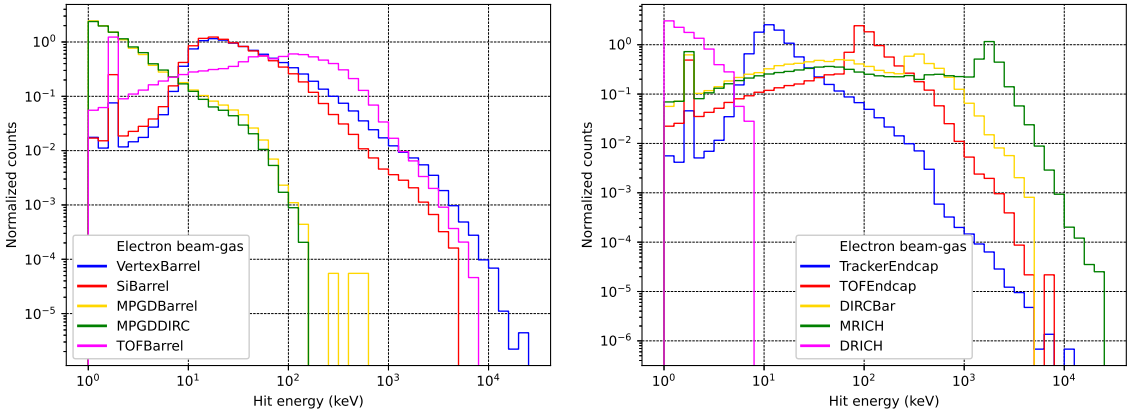

Figure 1: Hit energy distributions for individual detectors. There appears to be a 1 keV threshold applied somewhere, not sure about the location.

Hit *xy* position

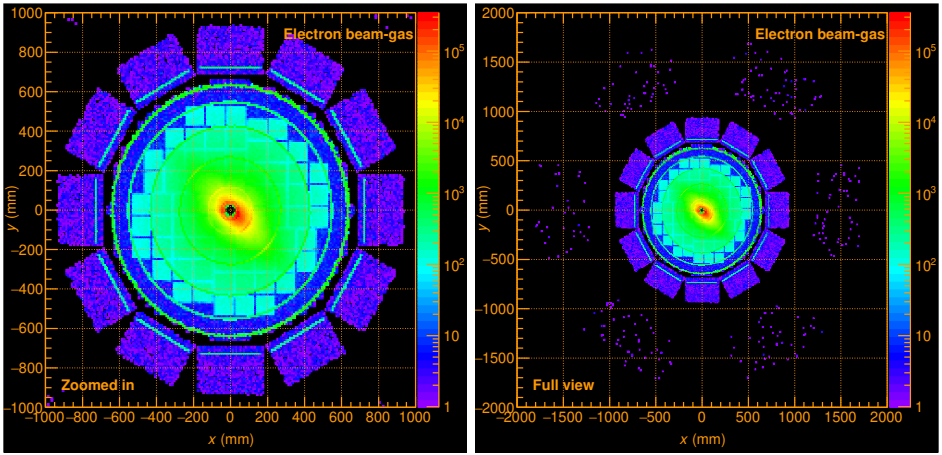

Figure 2: Hit x and y position from this simulation for aforementioned detector setup.

Hit *rz* position

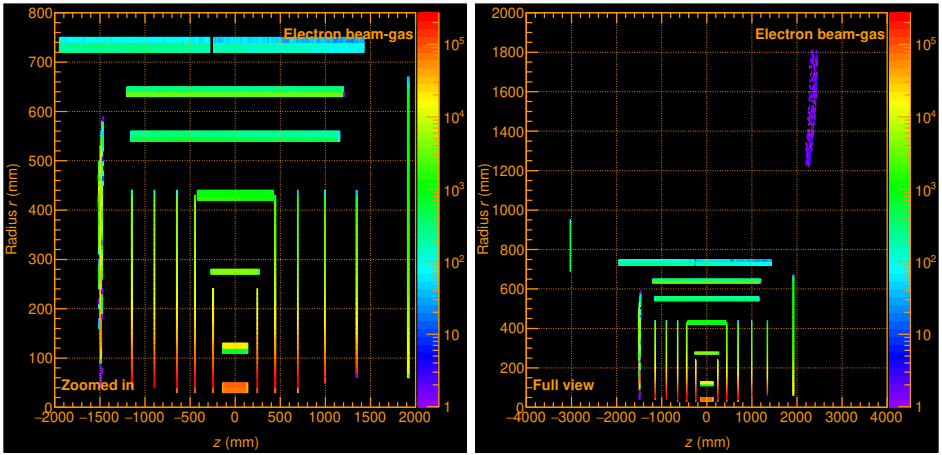

Figure 3: Hit r and z position from this simulation for aforementioned detector setup.

Hit $v_z t$

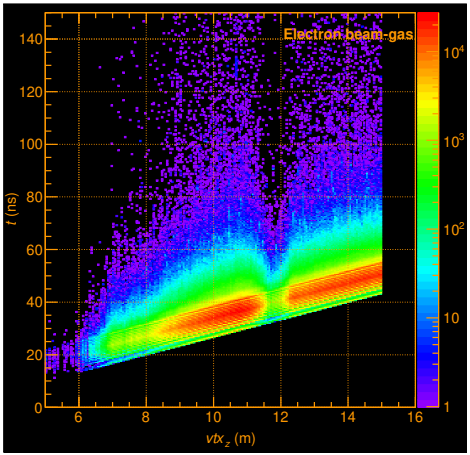

Figure 4: Hit vertex z position and time from this simulation for aforementioned detector setup.

Hit rate

Detector and besm parameters

- Total production rate for electron-beam gas due to bremsstrahlung for $E_\gamma > 10$ keV calculated as 3.177 MHz
- Integration time for detector readout (information from Elke) - 2 μs
  - 3.177 Mhz * 2 μs $\doteq$ 6.35 bremsstrahlung interactions per integration time

Simulation paramteres

- $\sim$2M events (bremsstrahlung interactions) simulated
- number of hits in the most populated detector (*Tracker Endcap*) $\sim$15M
  - 15 M hits / 2M events $\doteq$ 7.5 hits per simulated event/interaction

Conclusion

- 7.5 (hits/interaction) * 6.35 (interactions/integration time) $\doteq$ 47 hits in the entire detector per readout time

Hit rates

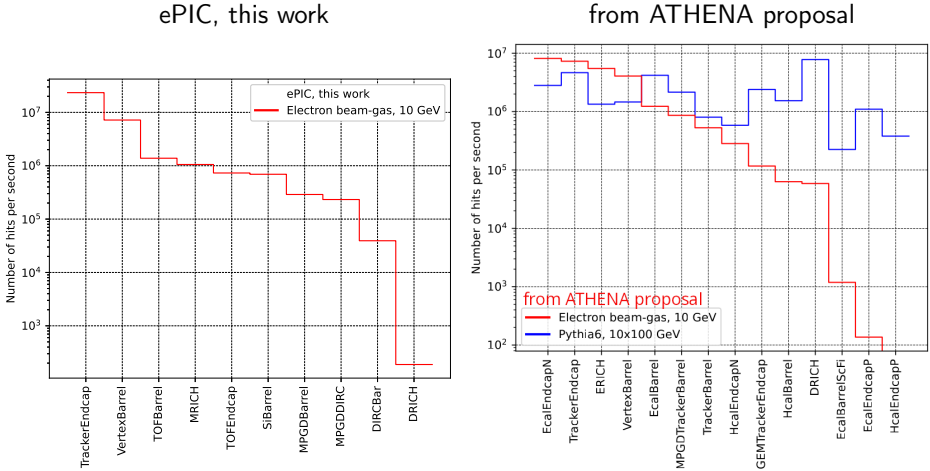

Figure 5: Detector hit rate for this simulation (left) and previous athena simulation (right).

Outlook

- Resolve outstanding issues with calorimeters and include them to the detector setup
- Revisit threshold for detectors (all as athena?)
- Work on completing the full simulation
- Incorporate forward electron beampipe to epic as a standalone git branch independent on previous athena software

Issue with pyROOT on SDCC

```
[rcas6009] ~/pwg/eic/> ./eic-shell
jug_xl> ceskajak@rcas6009:/gpfs01/star/pwg/ceskajak/eic$ source epic-23.01.0/install/setup.sh
jug_xl> ceskajak@rcas6009:/gpfs01/star/pwg/ceskajak/eic$ cd athena_particle_counter/macro/ddhits/
jug_xl> ceskajak@rcas6009:/gpfs01/star/pwg/ceskajak/eic/athena_particle_counter/macro/ddhits$ ./run_ddhits.py
Traceback (most recent call last):
  File "/usr/local/lib/root/cppyy/__init__.py", line 60, in <module>
    importlib.import_module(libcppyy_mod_name)
  File "/usr/lib/python3.11/importlib/__init__.py", line 126, in import_module
    return _bootstrap._gcd_import(name[level:], package, level)
           ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^
  File "<frozen importlib._bootstrap>", line 1206, in _gcd_import
  File "<frozen importlib._bootstrap>", line 1178, in _find_and_load
  File "<frozen importlib._bootstrap>", line 1142, in _find_and_load_unlocked
ModuleNotFoundError: No module named 'libcppyy3_11'

During handling of the above exception, another exception occurred:

Traceback (most recent call last):
  File "/gpfs01/star/pwg/ceskajak/eic/athena_particle_counter/macro/ddhits/./run_ddhits.py", line 8, in <module>
    from analysis import analysis
  File "/gpfs01/star/pwg/ceskajak/eic/athena_particle_counter/macro/ddhits/analysis.py", line 3, in <module>
    import ROOT
  File "/usr/local/lib/root/ROOT/__init__.py", line 22, in <module>
    import cppyy
  File "/usr/local/lib/root/cppyy/__init__.py", line 62, in <module>
    raise ImportError(
ImportError: Failed to import libcppyy3_11. Please check that ROOT has been built for Python 3.11
jug_xl> ceskajak@rcas6009:/gpfs01/star/pwg/ceskajak/eic/athena_particle_counter/macro/ddhits$
```

Issue present on CVMFS release of eic-shell on SDCC. Not present on same eic-shell version run localy.