

Seeding Efficiency

Jeetendra Gupta & Barak Schmookler

Simulation configuration

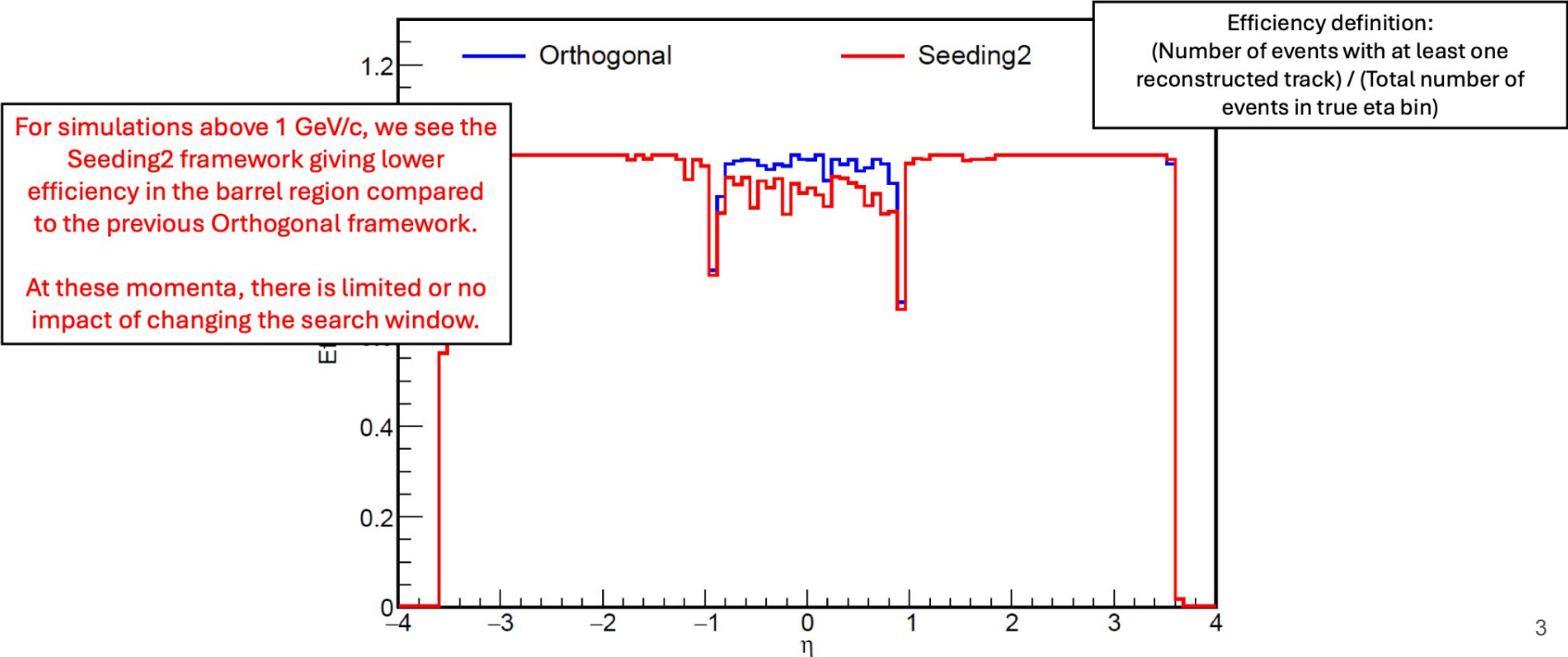
```
if [ "$run_npsim" -eq 1 ]; then
    npsim --compactFile "$DETECTOR_PATH/epic_craterlake.xml" --enableGun --gun.distribution 'eta' \
        --gun.thetaMax 3.106 --gun.thetaMin 0.036 \
        --gun.momentumMin "${p}*GeV" --gun.momentumMax "${p}*GeV" \
        --numberOfEvents "${nevents}" --outputFile "$simfile"
fi

# tag:seedingMethod pairs -- add more here if another method is needed
local seed_configs=("orth:orthogonal" "seed2:seeding2")
local cfg tag seedmethod dpm
for dpm in "${delta_phi_values[@]}; do
    for cfg in "${seed_configs[@]}; do
        tag=${cfg%%:*}
        seedmethod=${cfg##*:}

        eicrecon -Ppodio:output_file="output/eicrecon_${tag}_delPhiMax_${dpm}_${label}.root" \
            -Pjana:nevents="${nevents}" \
            -Pctrk:siendcaptrackernoiserawhits:addnoise=0 \
            -Pbvtx:sibarrelvertexnoiserawhits:addnoise=0 \
            -Pbtrk:sibarrelnoiserawhits:addnoise=0 \
            -Ptracking:CentralTrackSeeds:deltaPhiMax="${dpm}" \
            -Ptracking:CentralTrackSeeds:seedingMethod="${seedmethod}" \
            -Pdd4hep:xml_files=epic_craterlake.xml "$simfile" \
            | tee "output/log/out_${tag}_delPhiMax_${dpm}_${label}.txt"
    done
done
```

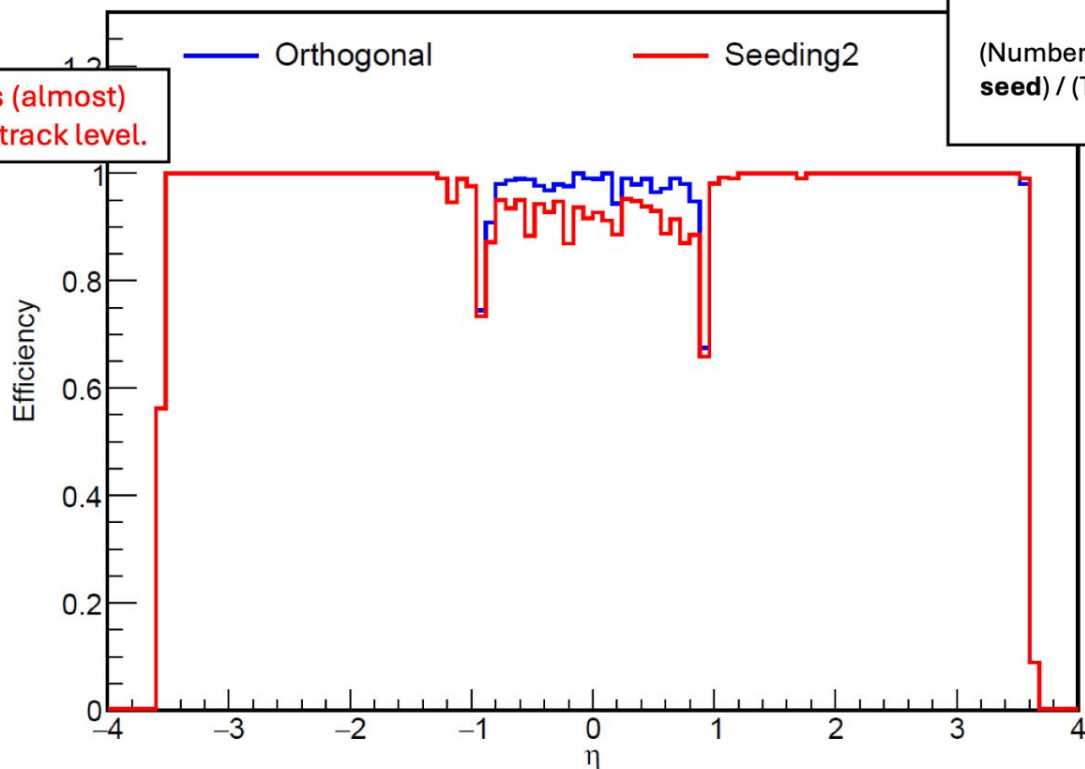
Results at higher momentum: $p = 20 \text{ GeV}/c$

Tracker efficiency vs generated particle η : $p = 20.00 \text{ GeV}/c$, real seeding ($\Delta\phi_{\text{max}} = 0.085$)



Results at higher momentum: $p = 20 \text{ GeV}/c$; seed level

Seed finding efficiency vs generated particle η : $p = 20.00 \text{ GeV}/c$ ($\Delta\phi_{\text{max}} = 0.085$)



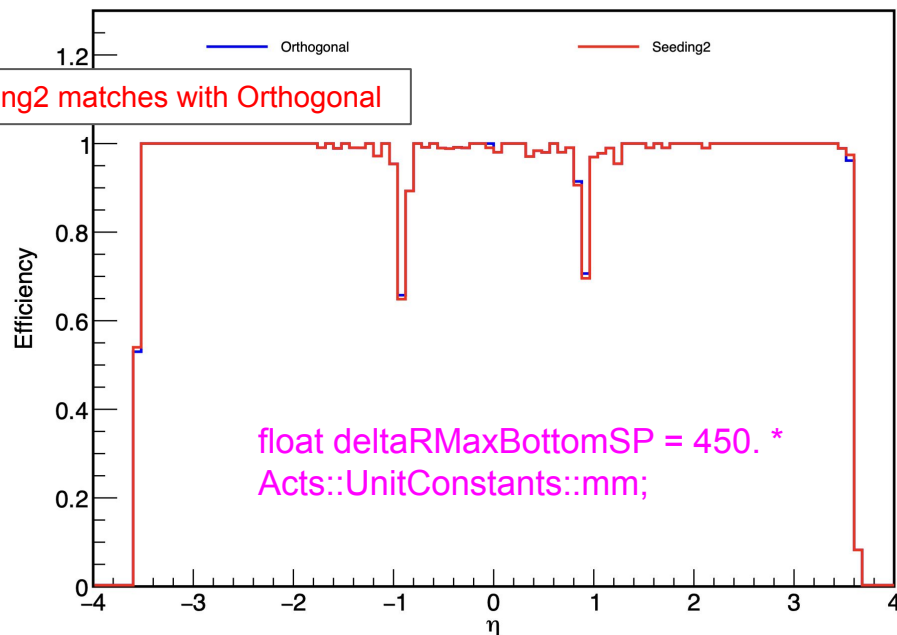
Efficiency at seed level is (almost) equivalent to efficiency at track level.

Efficiency definition:
(Number of events with at least one found **seed**) / (Total number of events in true eta bin)

Lets' Change Some Parameters!

Changing deltaRMaxBottomSP to 450 mm

Tracker efficiency vs η : $p = 20000.00$ MeV/c, real seeding, $\Delta\phi_{\max} = 0.085$, (existence only (raw))



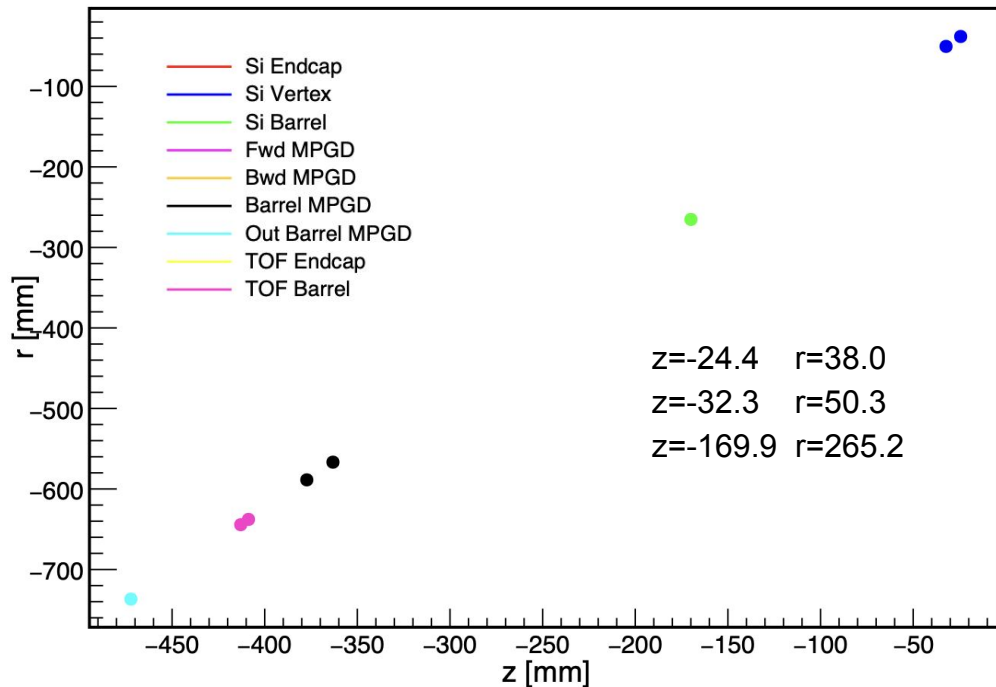
```
/// Generic minimum radial distance between doublet space points.  
/// Used by Seeding2 and Orthogonal seed-filters and as initial construction-time  
/// value for specialized top/bottom doublet windows.  
float deltaRMin = 10. * Acts::UnitConstants::mm;  
  
/// Minimum radial distance for top (outer) space point doublets.  
/// Allows independent tuning of top doublet constraints.  
/// Initialized from deltaRMin at construction time.  
/// If deltaRMin is overridden via parameters, set this explicitly as needed.  
float deltaRMinTopSP = deltaRMin;  
  
/// Maximum radial distance for top (outer) space point doublets.  
/// Allows independent tuning of top doublet constraints.  
float deltaRMaxTopSP = 450. * Acts::UnitConstants::mm;  
  
/// Minimum radial distance for bottom (inner) space point doublets.  
/// Allows independent tuning of bottom doublet constraints.  
/// Initialized from deltaRMin at construction time.  
/// If deltaRMin is overridden via parameters, set this explicitly as needed.  
float deltaRMinBottomSP = deltaRMin;  
  
/// Maximum radial distance for bottom (inner) space point doublets.  
/// Allows independent tuning of bottom doublet constraints.  
float deltaRMaxBottomSP = 200. * Acts::UnitConstants::mm;
```

Is deltaRMaxBottomSP = 200. * Acts::UnitConstants::mm; really the culprit?

Lets dig deeper!

An example of seed not formed with 200 mm but formed with 450 mm

Tracker hits from primary particle for event 8



```
/// Generic minimum radial distance between doublet space points.  
/// Used by Seeding2 and Orthogonal seed-filters and as initial construction-time  
/// value for specialized top/bottom doublet constraints.  
float deltaRMin = 10. * Acts::UnitConstants::mm;  
  
/// Minimum radial distance for top (outer) space point doublets.  
/// Allows independent tuning of top doublet constraints.  
/// Initialized from deltaRMin at construction time.  
/// If deltaRMin is overridden via parameters, set this explicitly as needed.  
float deltaRMinTopSP = deltaRMin;  
  
/// Maximum radial distance for top (outer) space point doublets.  
/// Allows independent tuning of top doublet constraints.  
float deltaRMaxTopSP = 450. * Acts::UnitConstants::mm;  
  
/// Minimum radial distance for bottom (inner) space point doublets.  
/// Allows independent tuning of bottom doublet constraints.  
/// Initialized from deltaRMin at construction time.  
/// If deltaRMin is overridden via parameters, set this explicitly as needed.  
float deltaRMinBottomSP = deltaRMin;  
  
/// Maximum radial distance for bottom (inner) space point doublets.  
/// Allows independent tuning of bottom doublet constraints.  
float deltaRMaxBottomSP = 200. * Acts::UnitConstants::mm;
```

Technically, seed should form with
 $\text{deltaRMaxBottomSP} = 200$

The Problem!

<https://github.com/eic/ElCrecon/blob/main/src/algorithms/tracking/TrackSeeding.cc>

```
// Find valid tuples of (bottom, middle, top) candidates
candidates.clear();
kdTree.validTuples(bottomOptions, topOptions, spM, nTopSeedConf, candidates);
```



acts/Core/src/Seeding/CylindricalSpacePointKdTree.cpp

<https://github.com/acts-project/acts/blob/2790f1b05c0c94cb3b569cbb18262b24867c7855/Core/src/Seeding/CylindricalSpacePointKdTree.cpp>

```
void CylindricalSpacePointKdTree::validTuples(const Options &lhOptions,
                                              const Options &hlOptions,
                                              const ConstSpacePointProxy &spM,
                                              std::size_t nTopSeedConf,
                                              Candidates &candidates) const {
    using range_t = Tree::range_t;

    /*
     * Calculate the search ranges for bottom and top candidates for this middle
     * space point.
     */
    range_t bottom_r = validTupleOrthoRangeHL(hlOptions, spM);
    range_t top_r = validTupleOrthoRangeLH(lhOptions, spM);
```



```
Bottom_r = validTupleOrthoRangeHL(topOptions, spM)
Top_r = validTupleOrthoRangeLH(bottomOptions, spM)
```

The Problem and the Solution!

<https://github.com/eic/ElCRecon/blob/main/src/algorithms/tracking/TrackSeeding.cc>

```
// Find valid tuples of (bottom, middle, top) candidates
candidates.clear();
kdTree.validTuples(bottomOptions, topOptions, spM, nTopSeedConf, candidates);
```



acts/Core/src/Seeding/CylindricalSpacePointKdTree.cpp

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```
void CylindricalSpacePointKdTree::validTuples(const Options &lhOptions,
                                              const Options &hlOptions,
                                              const ConstSpacePointProxy &spM,
                                              std::size_t nTopSeedConf,
                                              Candidates &candidates) const {

    using range_t = Tree::range_t;

    /*
     * Calculate the search ranges for bottom and top candidates for this middle
     * space point.
     */
    range_t bottom_r = validTupleOrthoRangeHL(hlOptions, spM);
    range_t top_r = validTupleOrthoRangeLH(lhOptions, spM);
```



Change to :

```
kdTree.validTuples(topOptions, bottomOptions,
                  spM, nTopSeedConf, candidates)
```

Track seeding doublet options #2992

Open



bschmookler opened 1d ago

Contributor ...

As can be seen on slides 11-14 in [this presentation](#), single-particle simulations show lower seed-finding efficiency in the barrel region with the new (Seeding2) algorithm compared to the previous (Orthogonal) seeding algorithm.

@Jeet-bhai and I found that the older efficiency level can be recovered by adjusting this parameter from 200 mm to 450 mm:

```
float deltaRMaxBottomSP = 200. * Acts::UnitConstants::mm;
```

In one single-particle event, no seeds were formed when using the default `deltaRMaxBottomSP` parameter value but the following triplet of spacepoints appeared when the parameter was set to 450 mm:

```
x=-30.9 y=22.2 z=-24.4 r=38.0  
x=-40.9 y=29.3 z=-32.3 r=50.3  
x=-215.1 y=155.1 z=-169.9 r=265.2
```



The strange thing is that the radial distance between the middle and lower spacepoint is much smaller than 200 mm.

In [TrackSeeding.cc](#), we have this call:

```
kdTree.validTuples(bottomOptions, topOptions, spM, nTopSeedConf, candidates);
```

The function it is calling is in [CylindricalSpacePointKdTree.cpp](#):

```
void CylindricalSpacePointKdTree::validTuples(const Options &lhOptions,  
                                              const Options &hlOptions, ...)
```



So, we have `lhOptions = bottomOptions` and `hlOptions = topOptions`.

This is what the function does with these options:

```
range_t bottom_r = validTupleOrthoRangeHL(hlOptions, spM);  
range_t top_r = validTupleOrthoRangeLH(lhOptions, spM);
```



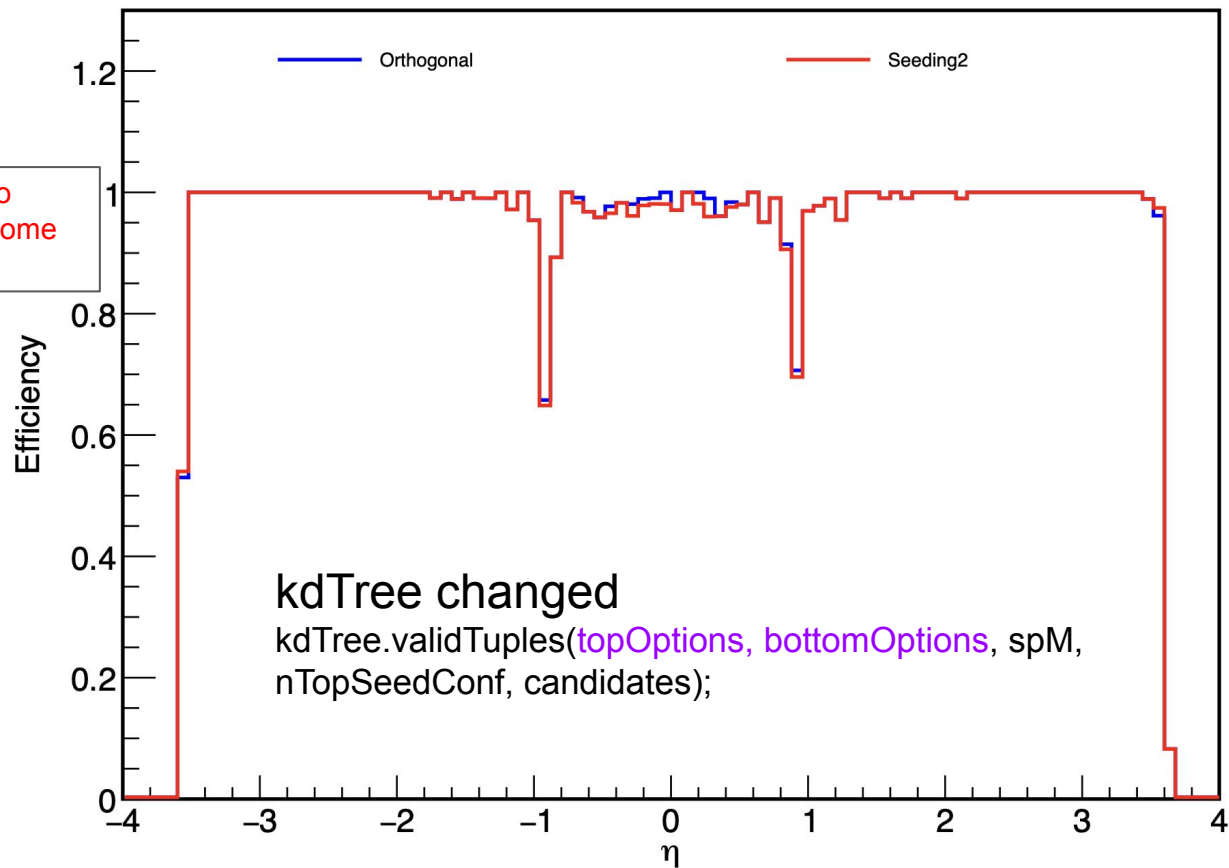
`bottom_r` (the search window for candidates below `spM` — the physically-bottom side) is built from `hlOptions`, which is `topOptions`.

To resolve the inefficiency and for clarity, I think we want to swap the options in the call:

```
kdTree.validTuples(topOptions, bottomOptions, spM, nTopSeedConf, candidates)
```

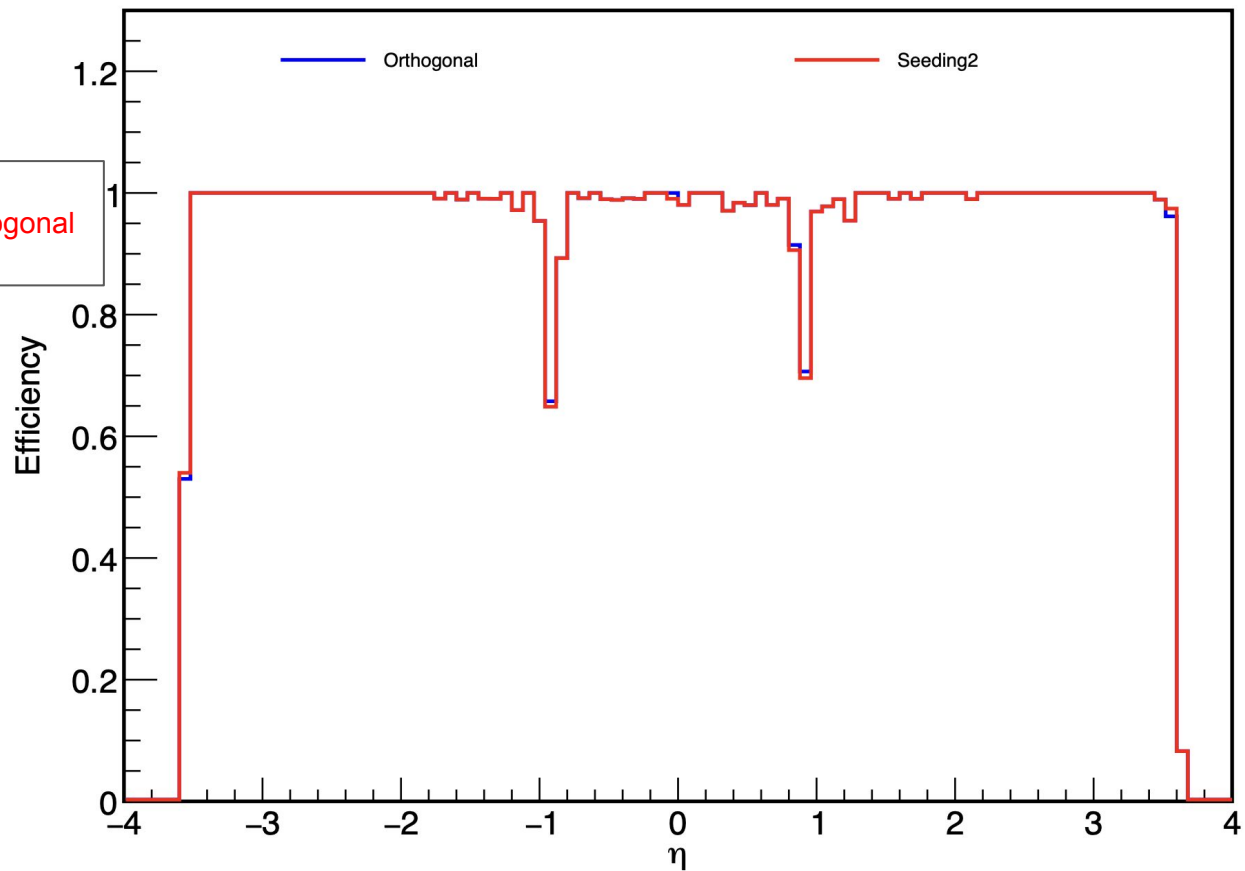
kdTree.validTuples Changed!

Tracker efficiency vs η : $p = 20000.00$ MeV/c, real seeding, $\Delta\phi_{\max} = 0.085$, (existence only (raw))



kdTree.validTuples Changed + deltaRMaxBottomSP = 450!

Tracker efficiency vs η : $p = 20000.00$ MeV/c, real seeding, $\Delta\phi_{\max} = 0.085$, (existence only (raw))



Seeding2 matches with Orthogonal

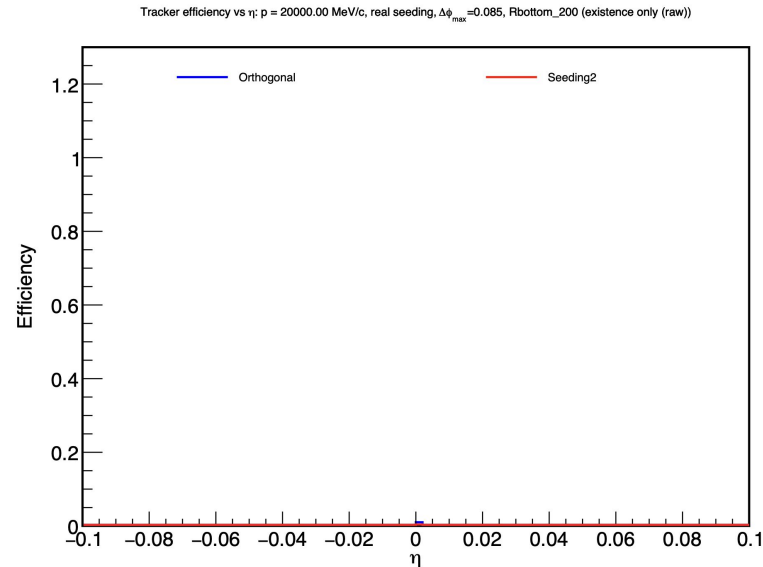
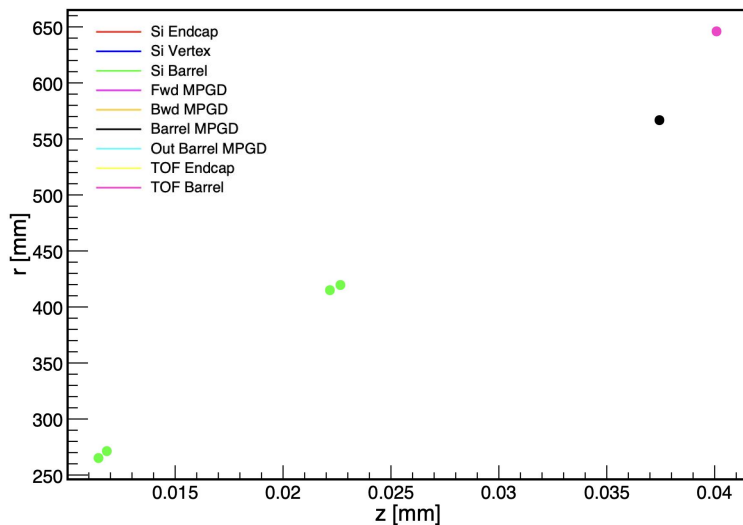
Summary:

- `kdTree.validTuples(bottomOptions, topOptions, spM, nTopSeedConf, candidates)` needs to be swapped with `kdTree.validTuples(topOptions, bottomOptions, spM, nTopSeedConf, candidates)`
<https://github.com/eic/EICrecon/pull/2996>
- `float deltaRMaxBottomSP = 200. * Acts::UnitConstants::mm` needs higher value (not necessarily 450 → tuning needed)
- Next step: at $\eta = \pm 1$, understand the efficiency drop due to service cone
- Next step: in barrel region, understand the source of remaining small inefficiency
- Next step: Look at DIS events

backup

Next: muon generated at eta = 0

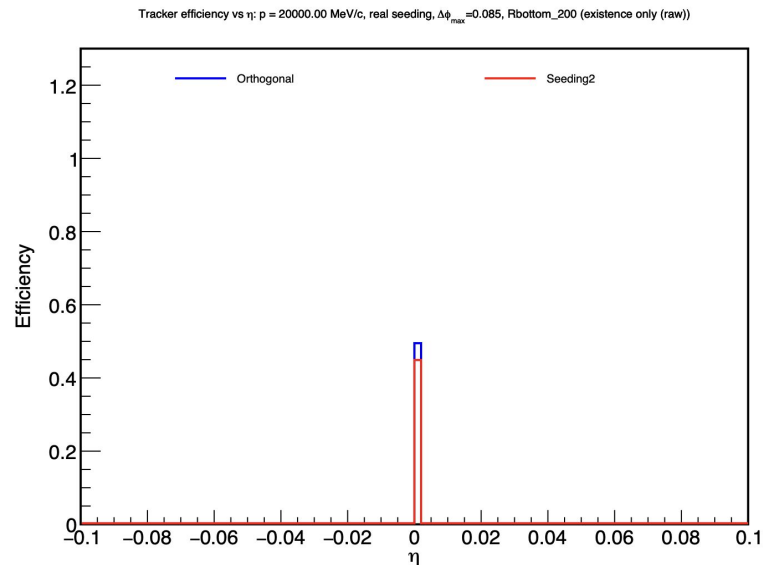
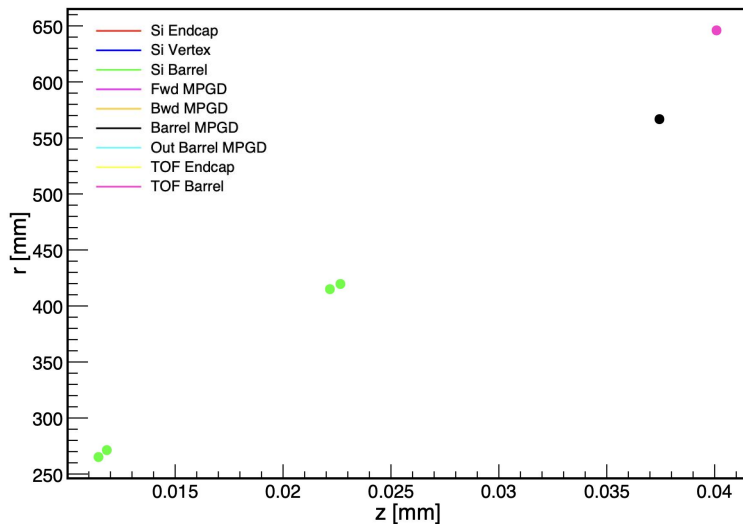
Tracker hits from primary particle for event 4



float deltaRMin = 10. * Acts::UnitConstants::mm;
(default)

Next: muon generated at eta = 0

Tracker hits from primary particle for event 4



float deltaRMin = 5. * Acts::UnitConstants::mm;

The Problem!

<https://github.com/eic/ElCrecon/blob/main/src/algorithms/tracking/TrackSeeding.cc>

```
// Find valid tuples of (bottom, middle, top) candidates
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```
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     */
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    range_t top_r = validTupleOrthoRangeLH(lhOptions, spM);
```



Change to :

kdTree.validTuples(topOptions, bottomOptions,
spM, nTopSeedConf, candidates)

Track seeding doublet options #2992

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bschmookler opened 1d ago

Contributor

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The function it is calling is in [CylindricalSpacePointKdTree.cpp](#):

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So, we have `lhOptions = bottomOptions` and `hlOptions = topOptions`.

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`bottom_r` (the search window for candidates below `spM` — the physically-bottom side) is built from `hlOptions`, which is `topOptions`.

To resolve the inefficiency and for clarity, I think we want to swap the options in the call:

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kdTree.validTuples(topOptions, bottomOptions, spM, nTopSeedConf, candidates)
```

<https://github.com/eic/ElCrecon/issues/2992>