STAR Forward Upgrade

Software Update

Daniel Brandenburg

July 20, 2020

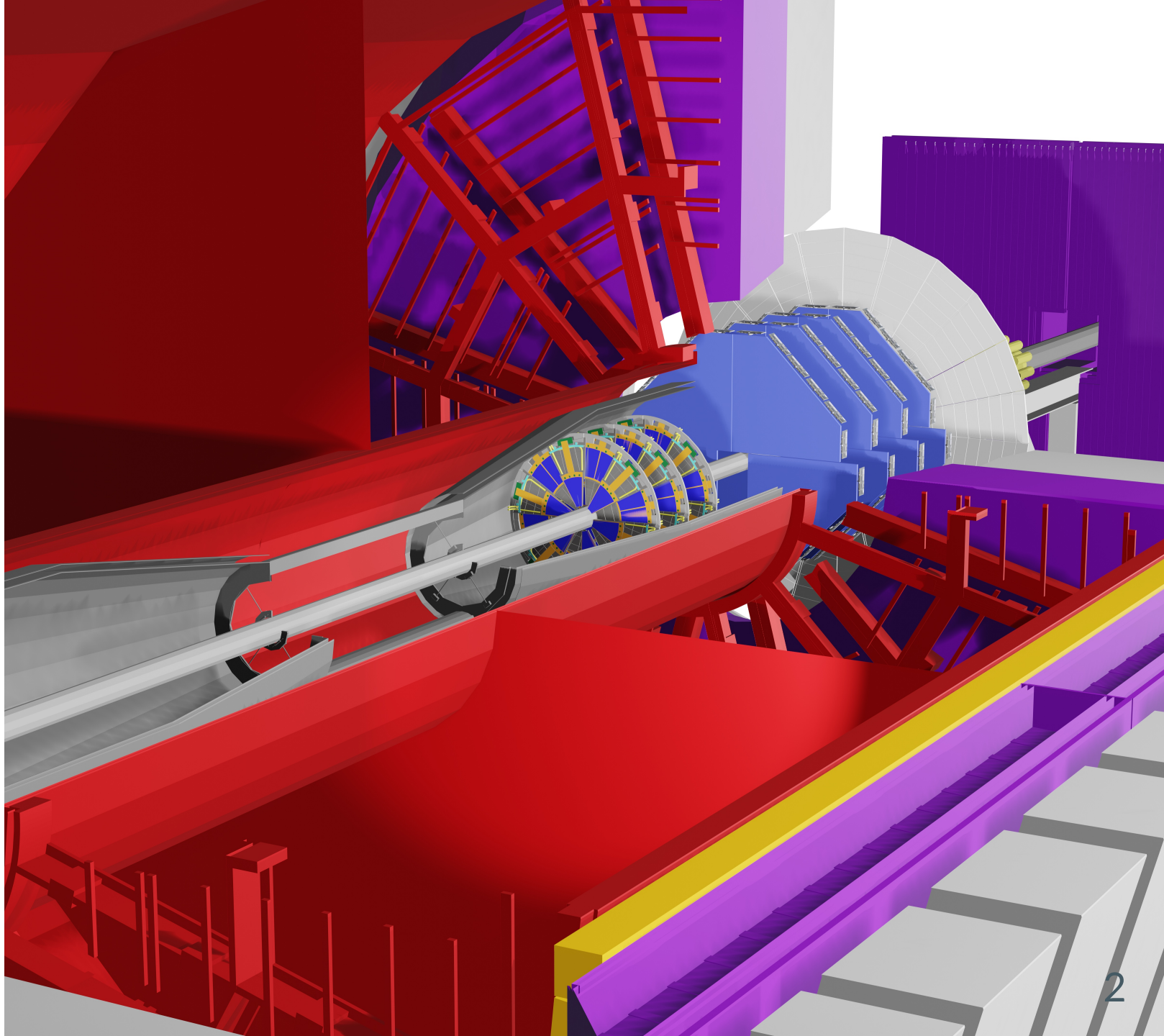
Forward Upgrade Face-2-Face Meeting

Outline

- ➜ Forward Tracking
  - ➜ Refitting with Si hits
  - ➜ Geometry
- ➜ sTGC simulations
- ➜ Tracking Studies
- ➜ Roadmap

backup slides contain renders of STAR forward upgrade for talks, etc.

[STAR Fwd renders on my dropbox]



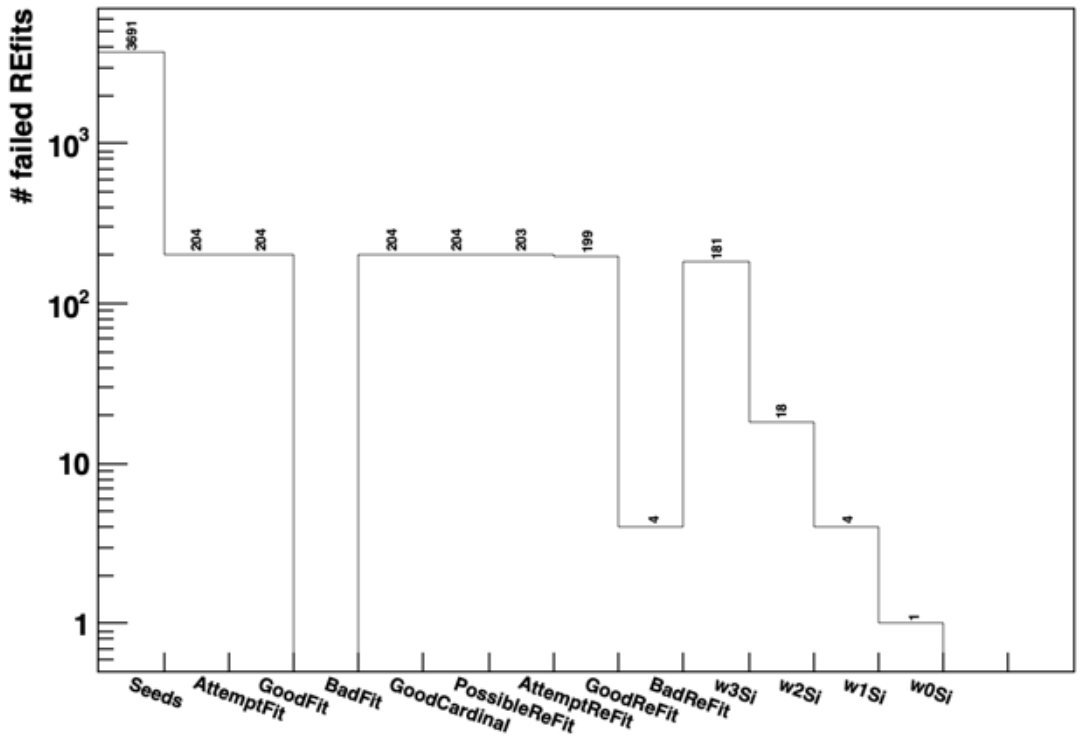
STAR Forward Software packages

- ➜ STAR Forward tracking : https://github.com/jdbrice/star-fwd-dev
- ➜ StRoot maker (StgMaker) for forward tracking (currently includes fast simulators) : https://github.com/jdbrice/star-sw
- ➜ standalone sTGC cluster simulator : https://github.com/jdbrice/stgc-cluster-sim
- ➜ Tracking software on RCF (32-bit): https://github.com/jdbrice/star-fwd-tracking-rcf-32
- ➜ FWD Simulation tools : https://github.com/jdbrice/star-fwd-sim
- ➜ CA Optimization : https://github.com/jdbrice/FwdCAOptimization
- ➜ Analysis of simulated HIJING / Pythia events : https://github.com/jdbrice/StHijingAna

All code lives on github. StRoot packages are being gradually integrated into STAR CVS as part of StRoot

Forward Tracking Updates : Si Refitting

- Last f2f meeting: Presented track refitting with Si hits
  - At that time I required simplest case $\rightarrow$ 3 Si hits found on track projection
  - Suggestion to look for 1 at a time & re-project track to improve finding others.



Simulation Details:

- $1\ \pi$ track / event
- $p_T > 0.2$ GeV/c
- $2.5 < \eta < 4.0$
- Refit $\approx$ 90% tracks found with all 3 Si
  - Search in $\pm 3\sigma$ window
  - Large search window works well in very low multiplicity

NOTE: hits are rejected if multiple are found

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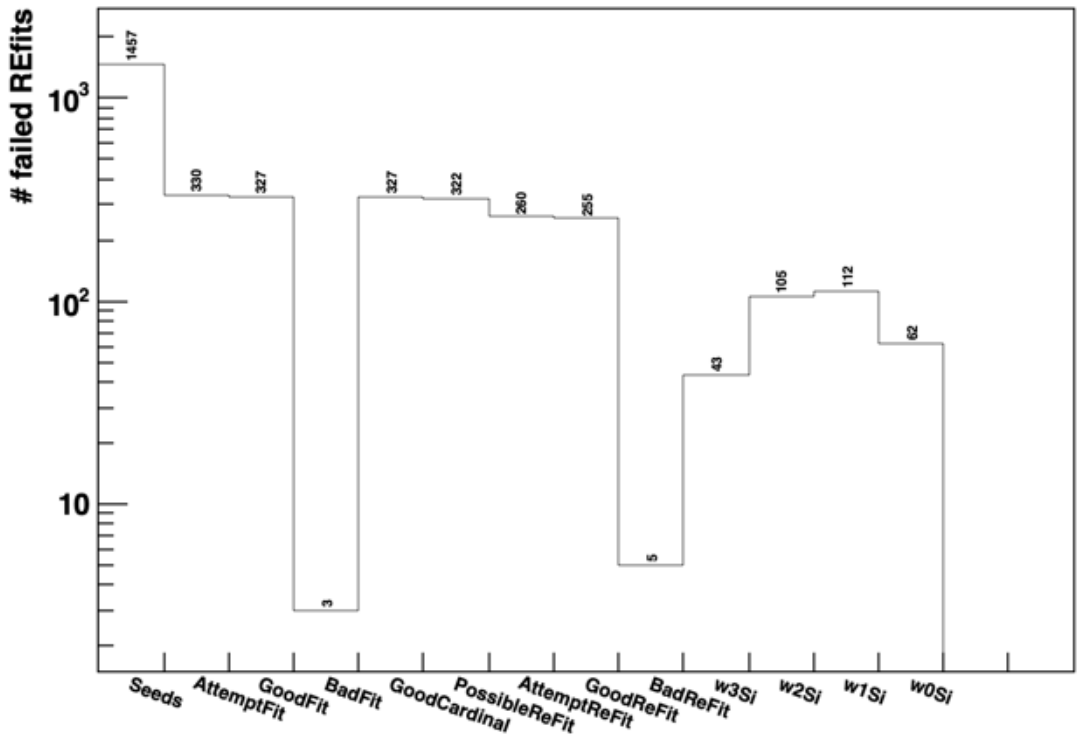

Simulation Details:

- Pythia8 p+p events @ 200 GeV
- $p_T > 0.2$ GeV/c
- $2.5 < \eta < 4.0$
- Refit 80% more tracks than requiring all 3 Si hits
  - Search in $\pm 3\sigma$ window
  - Not as many tracks find all 3 Si hits
  - Still working on improving this

NOTE: hits are rejected if multiple are found

Forward Tracking Updates : Si Refitting

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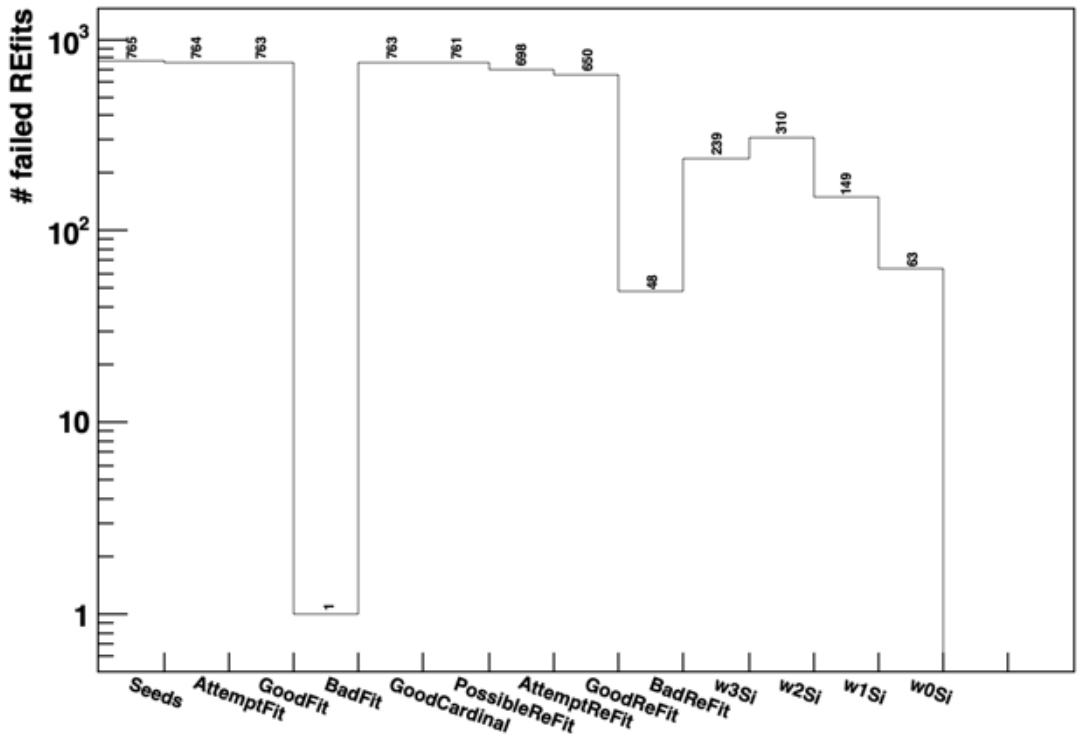
  - At that time I required simplest case $\rightarrow$ 3 Si hits found on track projection
  - Suggestion to look for 1 at a time & re-project track to improve finding others.



Simulation Details:

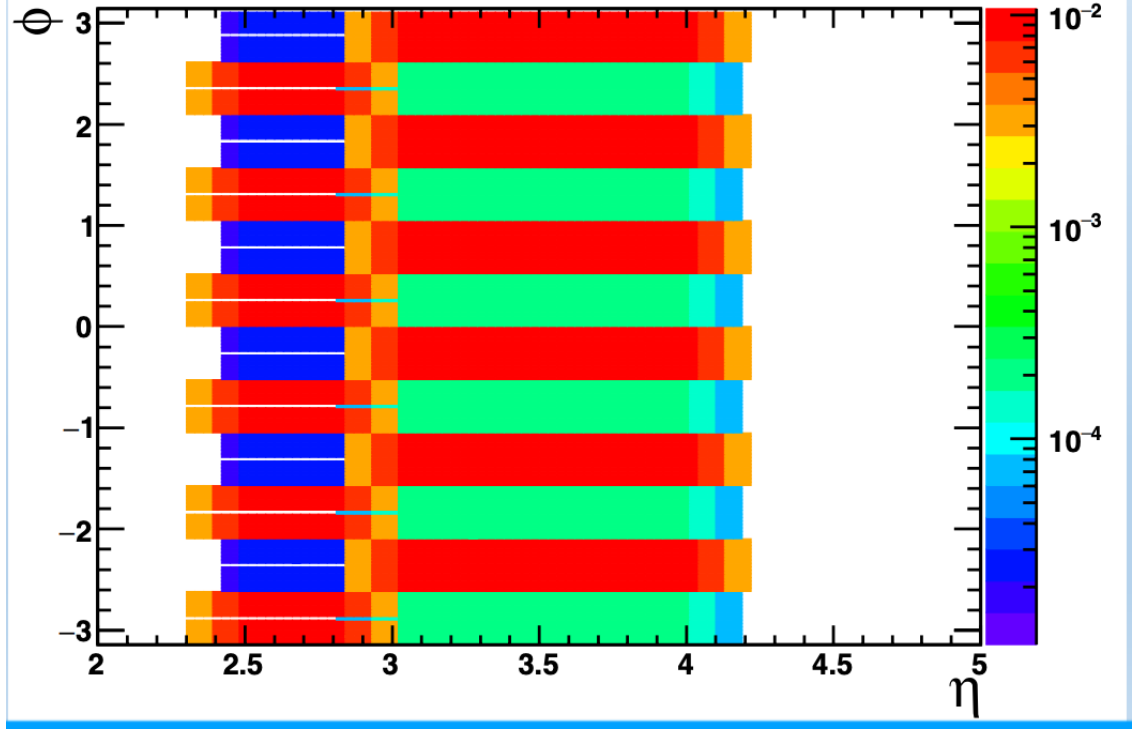
- 4 μ tracks / event
- $p_T > 0.2$ GeV/c
- $2.5 < \eta < 4.0$
- Refit 60% more tracks than requiring all 3 Si hits
  - Search in $\pm 1\sigma$ window
  - Working to understand why so many find only 1 Si hit.

NOTE: hits are rejected if multiple are found

Forward Tracking Updates : Geometry

- ➜ We discovered (~March) that the high-detail FST geometry causes GenFit to run **extremely slow** - note: GenFit only uses geometry for computing Kalman transfer function .
- ➜ May (or may not) be related to the strange behavior found recently in the FST material plot.
- ➜ Both use the ROOT TGeo interface for interacting/stepping through geometry

```
$ cvs co StarVMC/Geometry/macros
$ cvs co StarVMC/StarAgmlChecker/
$ ln -s StarVMC/StarAgmlChecker/macros/makeMaterialPlot.C
$ root makeMaterialPlot.C
root [0] materialPlot("FTUS")->Draw("colz")
```



Forward Tracking Updates : Geometry

Two "solutions" are being pursued:

1. **Immediate:** Use low-resolution FST geometry in GENFIT
   - ➜ Identical to `dev2021` except for the FST Geometry - use 'old' low res model.
   - ➜ A separate geometry `dev2021x` is used to keep it organized.
   - ➜ For now seems to work OK (see next slides)
     - ➜ A better solution may improve tails of momentum distribution slightly
2. **Long-term:** Fix underlying root issue
   - ➜ Understand problem and patch in place existing GENFIT (ROOT5)
   - ➜ STAR-wide upgrade to ROOT6 imminent(?)
     - ➜ ROOT6 support would allow upgrade to newest GENFIT
     - ➜ New version of GENFIT may solve problem directly (need to investigate).

Integration of sTGC simulator

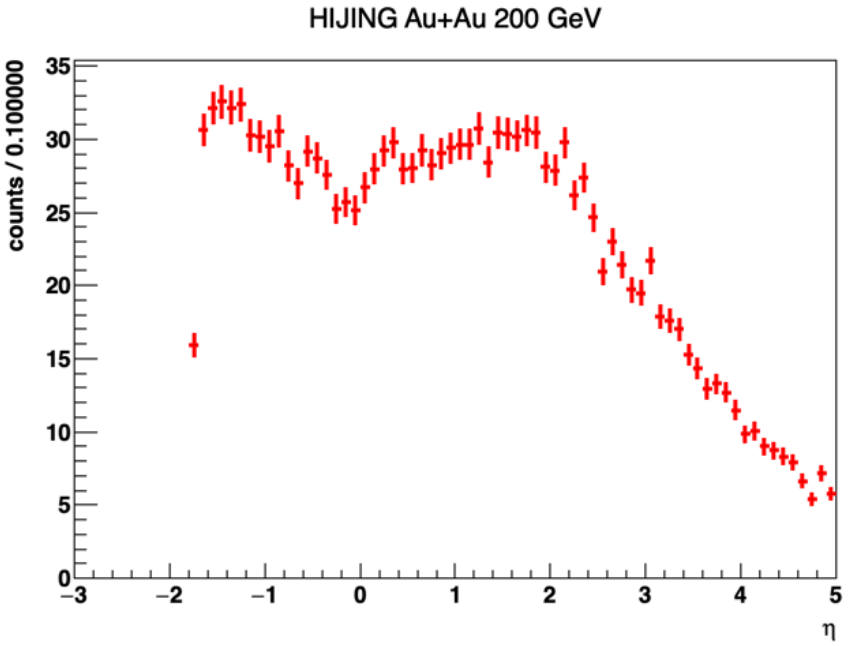
➜ Zhen Wang has a detailed presentation about the sTGC simulator progress - see next

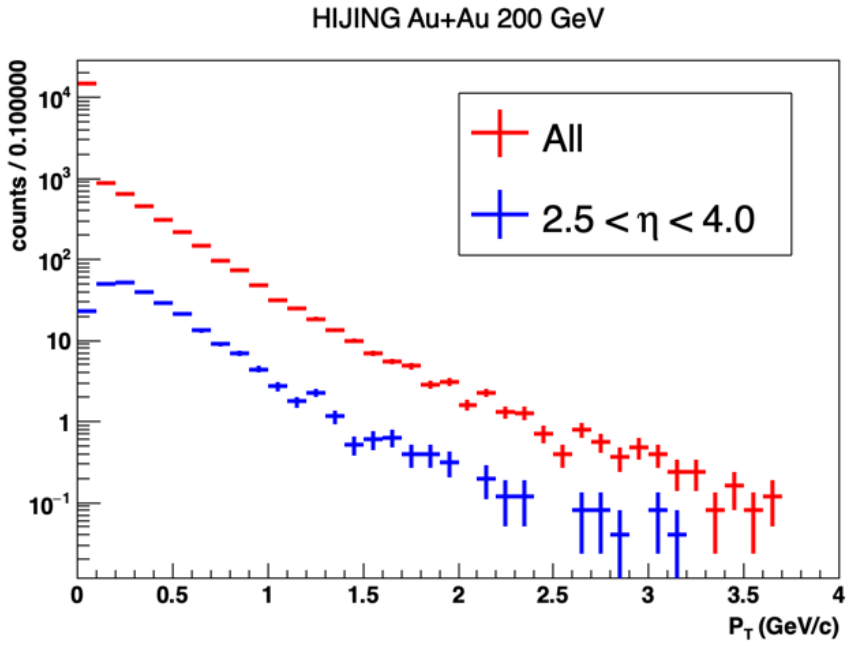
Plan for sTGC slow simulator

1. `StgcSlowSimulator` : Convert existing standalone cluster simulator into sTGC slow simulator
   ➜ Slow sim output into StEvent (goal: use the same data structure as for data)
2. `StgcClusterFinder` : Integrate standalone cluster finder (what Zhen is working on) into StRoot chain
3. Integrate with tracking framework

Tracking in HIJING Events

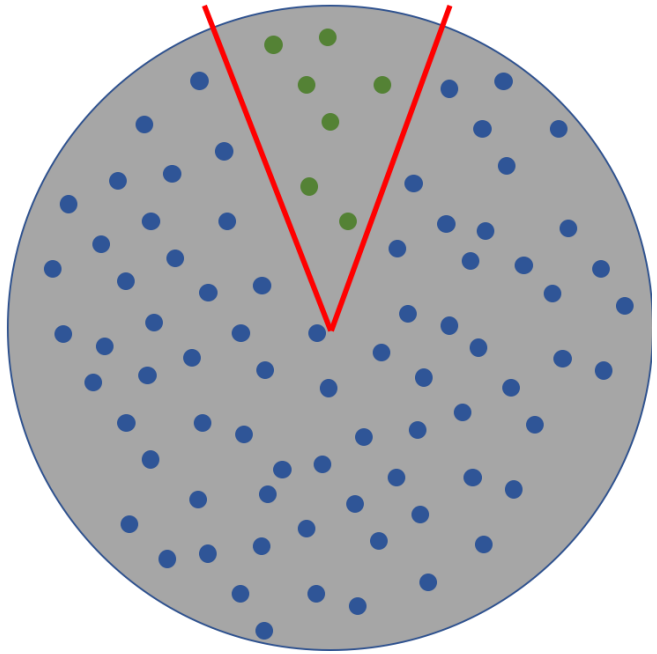
- ➜ For HIJING Au+Au events @ 200 GeV:
- ➜ Mean multiplicity in Forward region $\approx$ 255 (with maximum up to ~1000)
- ➜ Shown below, average η and p_T spectra for 25 events.





Tracking in HIJING Events

- ➜ Naïve CA implementation is very slow for high-multiplicity events.
  - ➜ Scales with combinatorial pairs
- ➜ Split high multiplicity events into $\phi-$slices
  - ➜ I showed a proof of concept few months ago



Tested on p+p (pythia8) events

- ➜ No visible loss in efficiency
- ➜ I expect some efficiency loss though (tracks that cross boundary), need to study more.
- ➜ Speedup already noticeable on Pythia8 p+p events

Tracking in HIJING Events

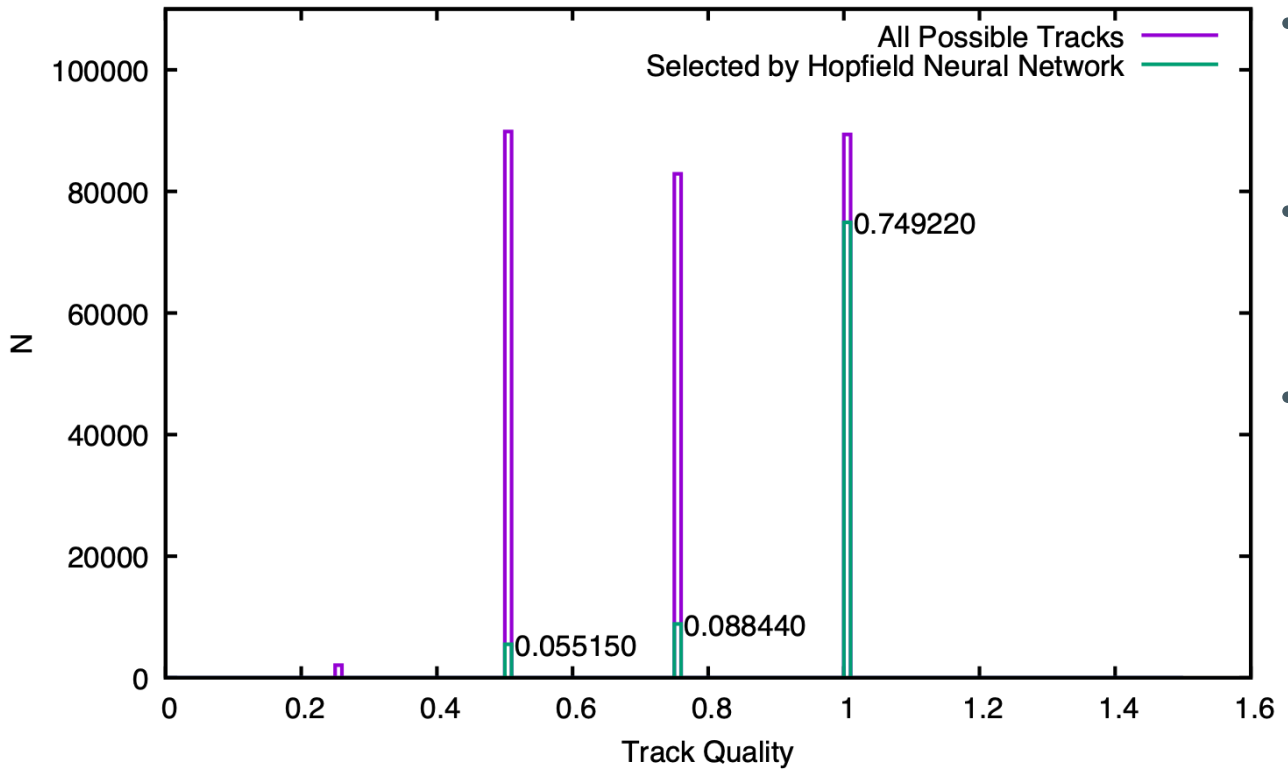
➜ Number of ϕ—slices can be set for each tracking iteration via config:

```
<?xml version="1.0" encoding="UTF-8"?>
<config>
    <TrackFinder nIterations="1">
        <!-- Options for first iteration -->
        <Iteration nPhiSlices="12" >
            <SegmentBuilder>
                ...
            </SegmentBuilder>
            <ThreeHitSegments>
                ...
            </ThreeHitSegments>
        </Iteration>
    </TrackFinder>
</config>
```

Tracking in HIJING Events

➜ For HIJING Au+Au events @ 200 GeV:

➜ About 75% correct hits on tracks (3/4)



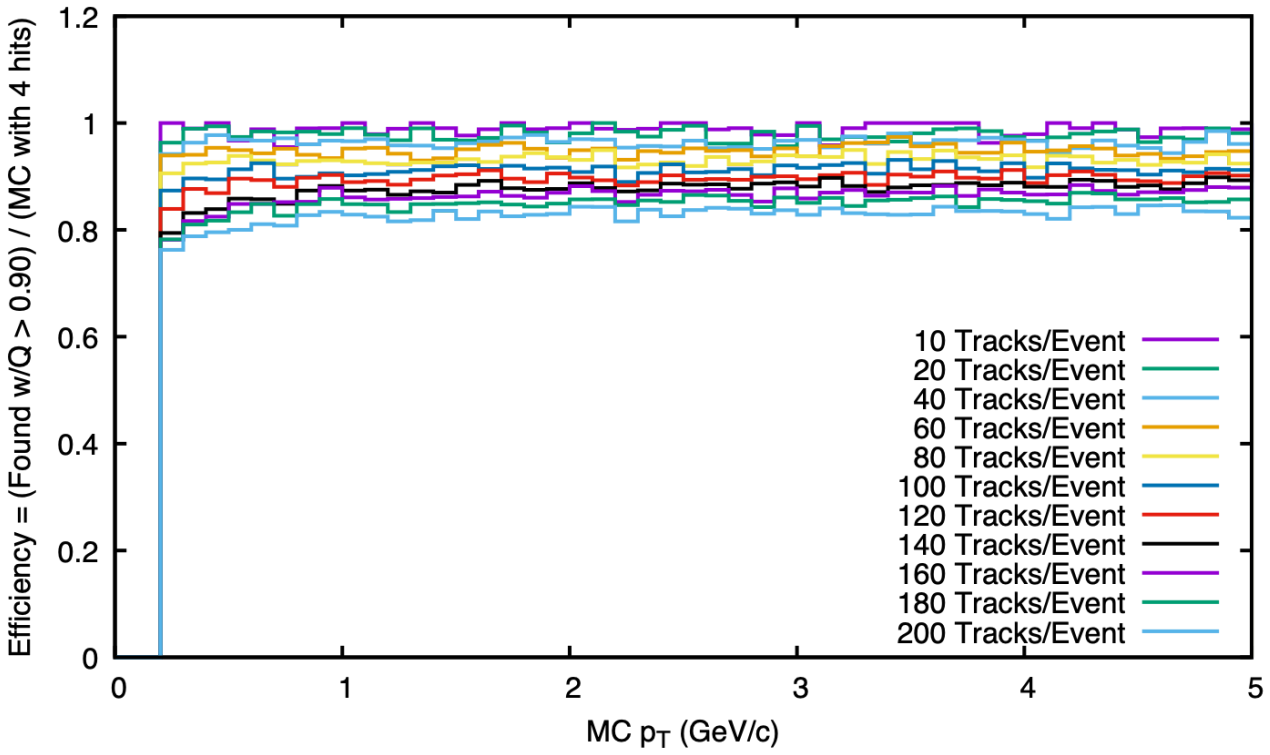
➜ Tracking code is highly configurable, good but

➜ Still need dedicated studies to understand optimal settings

➜ Initial optimization studies performed using pythia8 p+p events (see https://github.com/jdbrice/FwdCAOptimization)

Tracking in HIJING Events

➜ For HIJING Au+Au events @ 200 GeV:



very similar to previous result

Good behavior with increased multiplicity

Caveats:

➜ No ghost hits in sTGC yet.

➜ No merged clusters

Notes:

➜ Tracks = $p_T > 0.2$ GeV/c and $2.5 < \eta < 4.0$

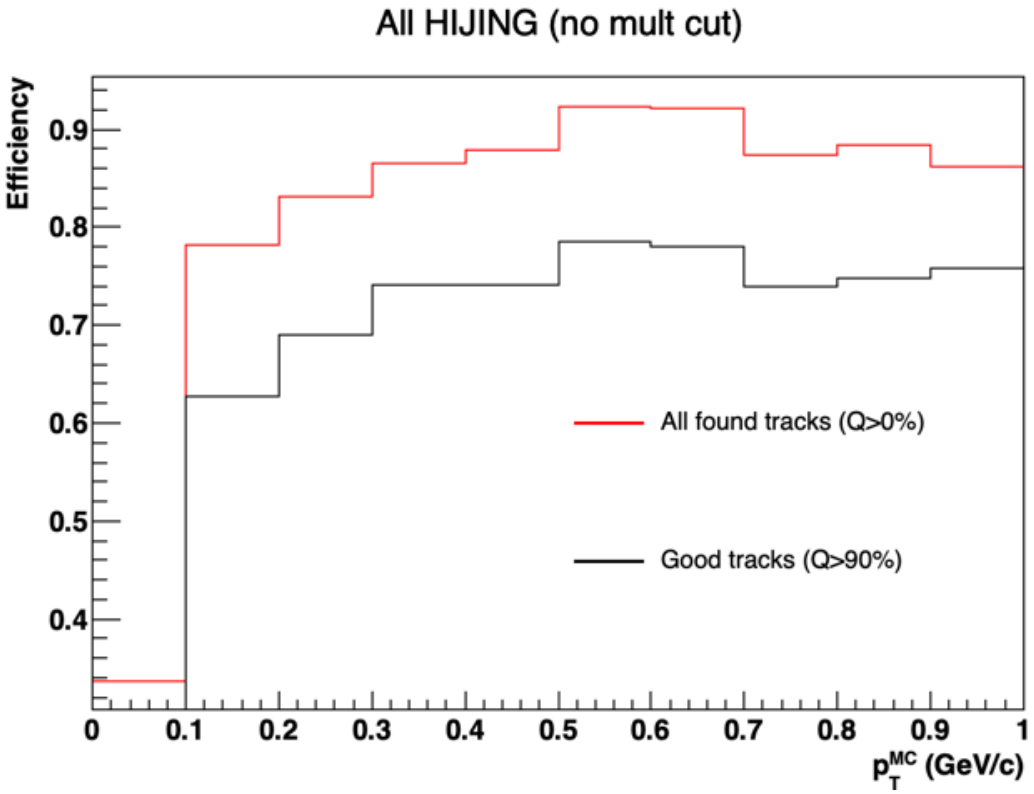
➜ Events have:

➜ 60k+ MC Tracks (including secondaries)

➜ $\approx$ 5k sTGC hits

Tracking in HIJING Events

➜ For HIJING Au+Au events @ 200 GeV:



Notes:

➜ All HIJING Events $\langle \text{mult} \rangle \approx 255$

➜ $\approx$ 10 % of tracks reconstructed with 4 sTGC hits are very low quality.

➜ Maybe we can clean up by requiring matching Si hits

➜ Need to study HIJING cases more

TODO List

Immediate

- ➜ Integrate FST Slow simulator
- ➜ Implement diagonal strips in sTGC cluster simulator
  - ➜ +Incorporate into cluster finder
- ➜ **sTGC slow simulator chain** : Integrate sTGC cluster sim/cluster finder into simulation / reconstruction chain
- ➜ With sTGC slow sim
  - ➜ realistic studies of tracking Au+Au (high multiplicities)

On the horizon

- ➜ Vertex finding with forward tracks
  - ➜ Last f2f meeting: demonstrate viability
  - ➜ Implement RAVE vertex finder (part of GENFIT package)
- ➜ Match tracks to ECAL/HCAL
- ➜ Allow track refit using CAL energy measurement?
- ➜ StEvent formats