Progress update on tracking efficiencies

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Organisation of these meetings

Current meeting time: Tuesdays 10:30

- Is this slot suitable for everyone? Or should we move it?
  - As RD RTA liason, I have biweekly RTA WP3 at 10:00 meetings
- Note: As I'm not working full time on tracking efficiencies, it's likely I'll only organise these meetings biweekly instead of weekly
- I'll provide minor updates on MatterMost

TrackCalib2 update: Environment

- Issue: The TrackCalib2 environment setup has caused headache
  - Conda environment takes several hours to set up and occupies significant disk space
  - Personally, the `mamba` instructions never worked for me on lxplus
  - Different machines seem to throw different warnings/errors
- Solution: Set up an `lb-conda` environment
  - MR has been approved and merged: !247
  - I tested on lxplus and it worked out-of-the-box
  - Anyone can clone TrackCalib2 and have it running in a few seconds

TrackCalib2 update: Environment

Clone TrackCalib2 repository:

```
git clone ssh://git@gitlab.cern.ch:7999/lhcb-rta/trackcalib2.git
git submodule init && git submodule update
```

Load environment: ← now takes seconds instead of hours

```
lb-conda trackcalib2
```

Run TrackCalib2:

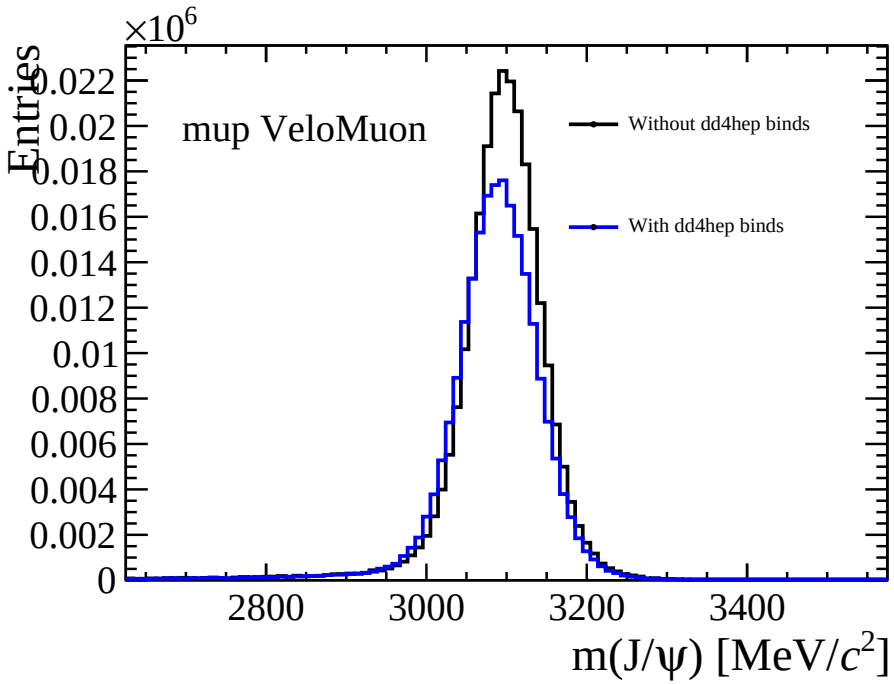
```
python trackcalib.py prepare -year 2024_Block1
python trackcalib.py fit -year 2024_Block1
```

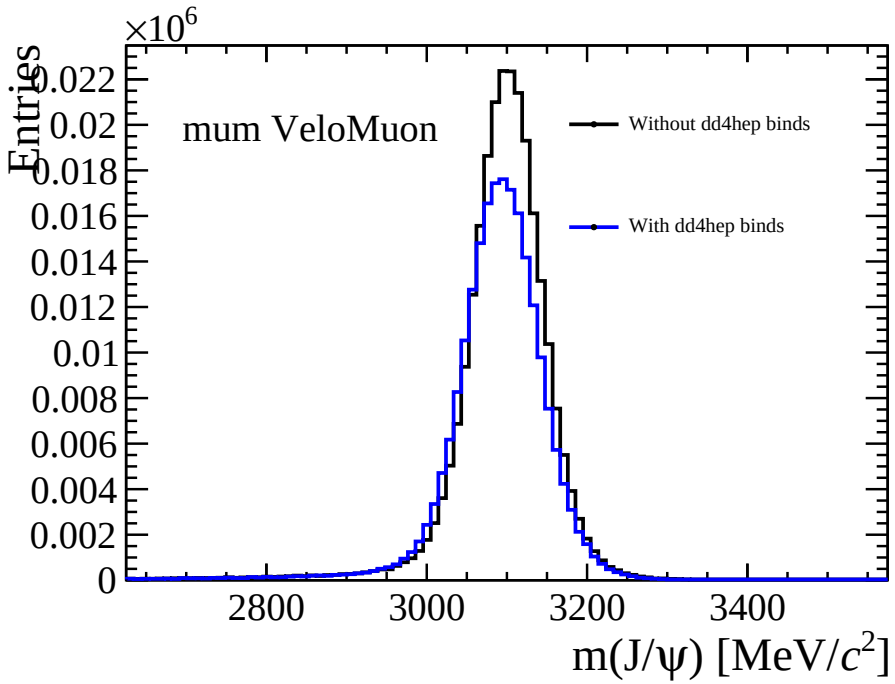
Missing DD4HEP binds

```
if UseDD4Hep:
    # This needs to happen before the public tools are instantiated,
    # which means we cannot put it inside make_streams().
    from PyConf.Tools import TrackMasterExtrapolator, TrackMasterFitter
    TrackMasterExtrapolator.global_bind(
        ApplyMultScattCorr=False,
        ApplyEnergyLossCorr=False,
        ApplyElectronEnergyLossCorr=False)
    TrackMasterFitter.global_bind(ApplyMaterialCorrections=False)
```

- Do I understand correctly that multiple scattering and energy loss corrections are disabled for data, but not MC? Why...?
- I ran a quick comparison between MC with and without these corrections, and differences are huge for VeloMuon and MuonUT

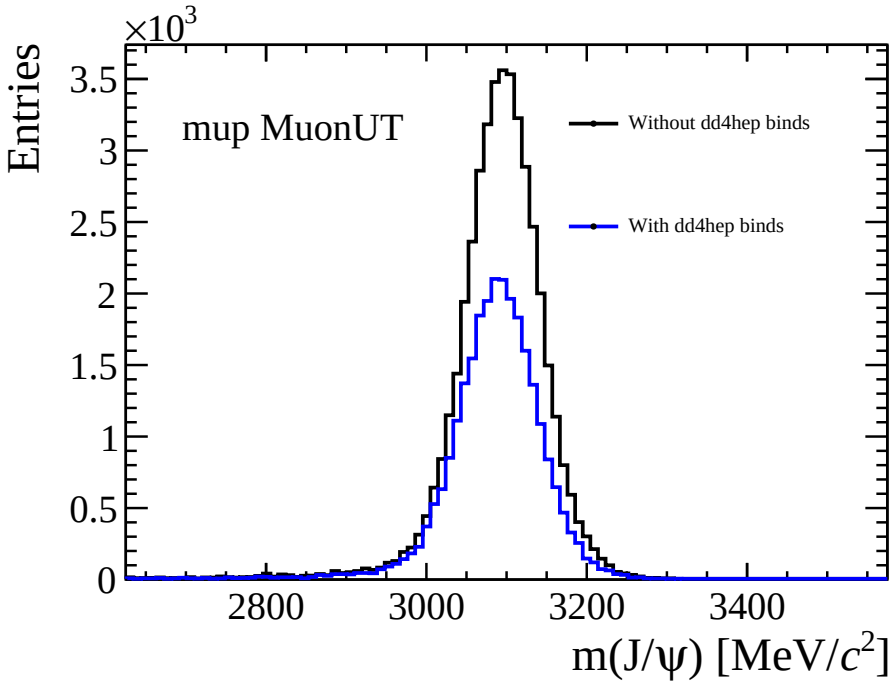
Missing DD4HEP binds

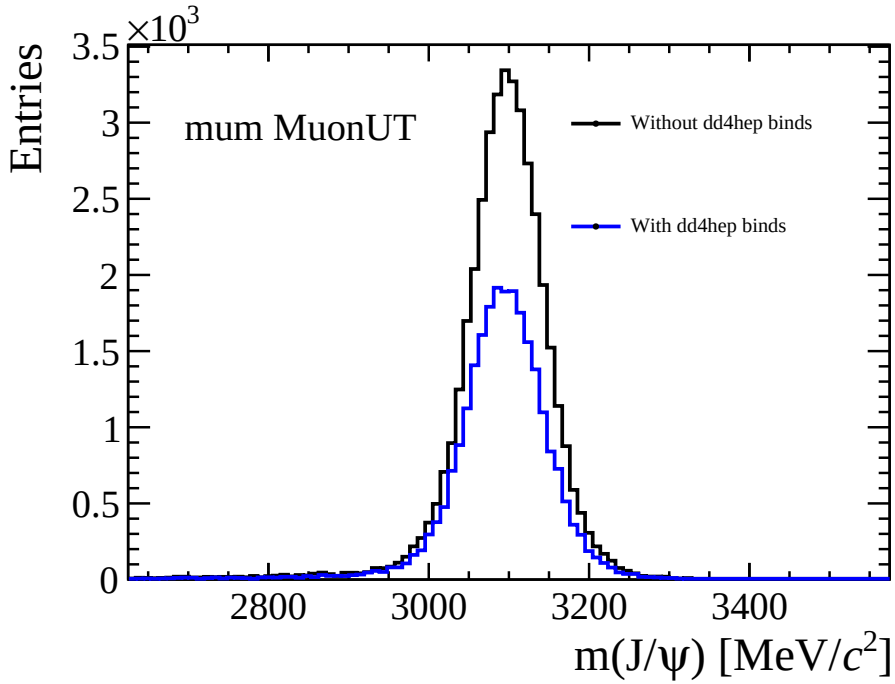




- Fewer candidates with DD4HEP binds for VeloMuon

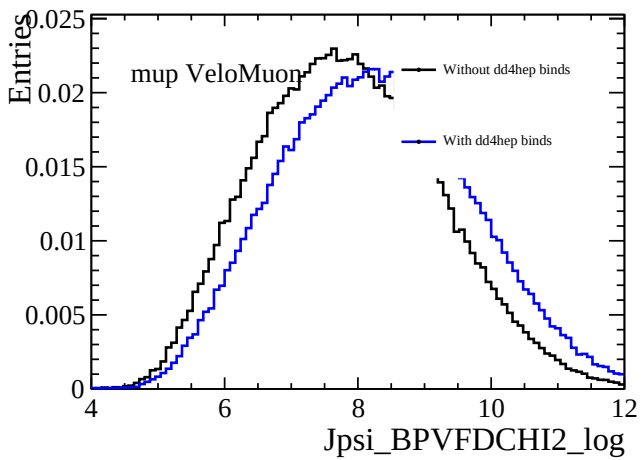
Missing DD4HEP binds

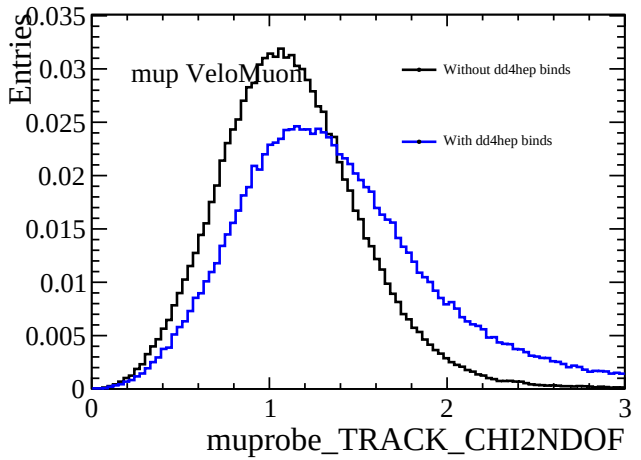


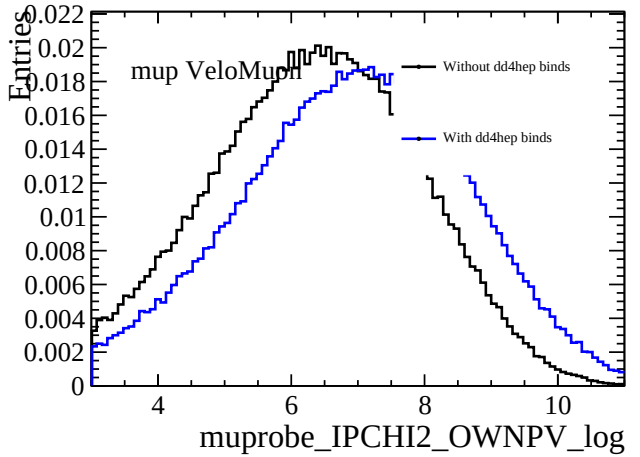


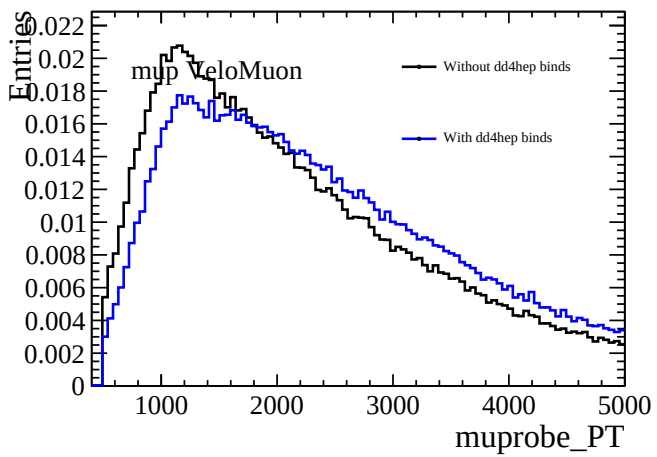
- Difference is much larger for MuonUT!

Missing DD4HEP binds









- It's mostly VeloMuon probe muon distributions that are different...
- ... but I don't see much difference in MuonUT distributions

Sprucing decision filter

- Reminder: Michel discovered a prescale in blocks 7/8
- Events failing the prescale but triggered by other lines are kept when rerunning reconstruction
- Solution: Apply sprucing decision filter directly in Moore
- Rowina discovered that applying the filter in blocks 5/6 also changed the tracking efficiencies, and I confirmed this in TrackCalib2 as well...
- ... and for the number of J/ψ candidates, I see a 10% discrepancy (!!!) in block 5/6

Sprucing decision filter

- Check impact of DD4HEP binds using block 6 data
- The numbers are surprisingly consistent with Moore v55r12p3:

Spruce decision	DD4HEP binds	VeloMuon	Downstream	MuonUT
No	No	197/183	719/706	121/45
Yes	No	180/169	719/706	115/39
No	Yes	195/178	719/706	131/46
Yes	Yes	195/178	719/706	131/46

Sprucing decision filter

- We need to run Moore v55r12p8 due to bug fixes
- Here there are differences, but they are very small:

Spruce decision	DD4HEP binds	VeloMuon	Downstream	MuonUT
No	No	193/182	665/665	114/43
Yes	No	176/168	661/660	108/37
No	Yes	195/172	665/665	123/44
Yes	Yes	193/172	661/660	123/44

Missing DD4HEP binds and sprucing decision filter

- Sprucing decision filter definitely needed to get correct efficiencies in blocks 7/8
- But clearly we don't get consistent numbers in blocks 5/6 unless DD4HEP binds are included
- Don't quite understand the DD4HEP binds yet...
- ... but I will rerun all data APs with them

TrackCalib2 development 1

TrackCalib development 1: Remove Run 1/2 code

- Run 1/2 used different methods/variables/cuts/matching... huge amount of code unecessary for Run 3
- I suggest separate releases for Run 1/2 and Run 3
  - Less code $\Longrightarrow$ Easier to maintain

TrackCalib2 development 2

TrackCalib development 2: Change to RDataFrame

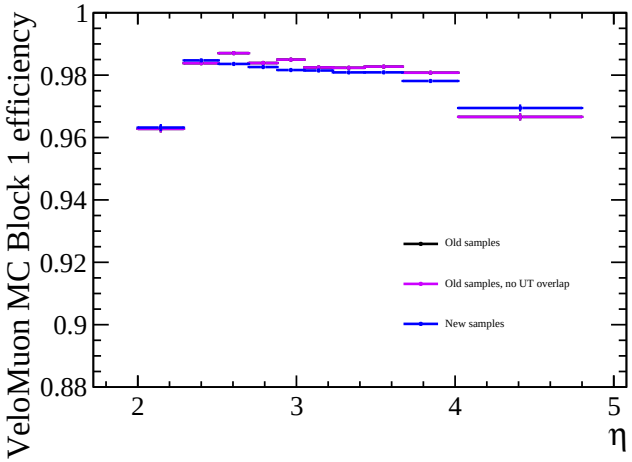
- Uproot processes hundreds of files one by one
- Preparing samples can take hours
  - Very difficult to perform studies that require reprocessing the samples
- I know ROOT dependency was removed in the past, but for sample preparation RDataFrame is much more suitable in my opinion
  - Multi-thread support
  - Lazy evaluation $\Longrightarrow$ Only need to loop once to apply all cuts and matching criteria
- After this change, sample preparation only takes a few minutes!
  - Allows me to prepare new samples and produce tracking efficiencies almost instantly once AP is ready

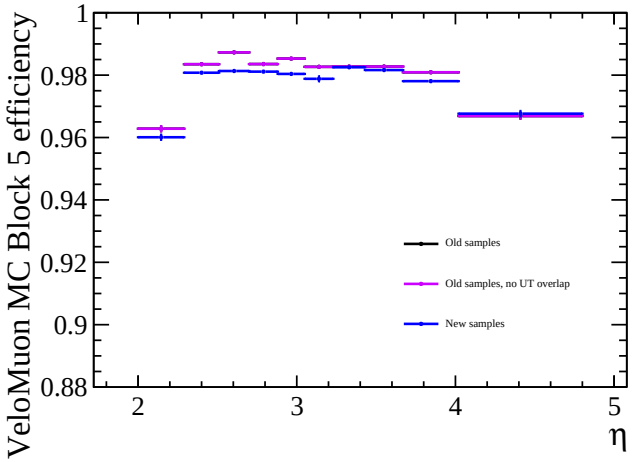
TrackCalib2 development 3

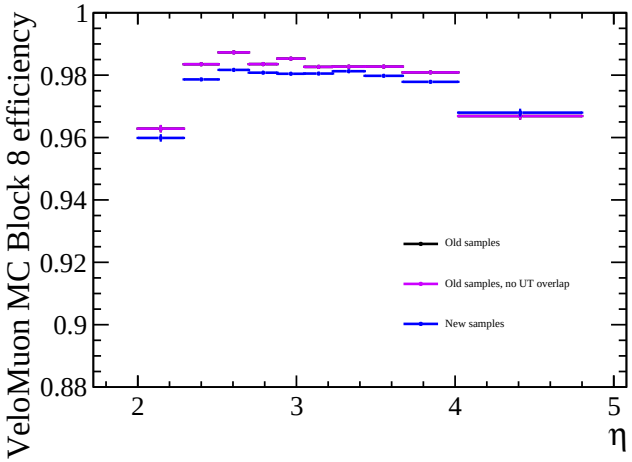
TrackCalib development 3: New data/MC samples

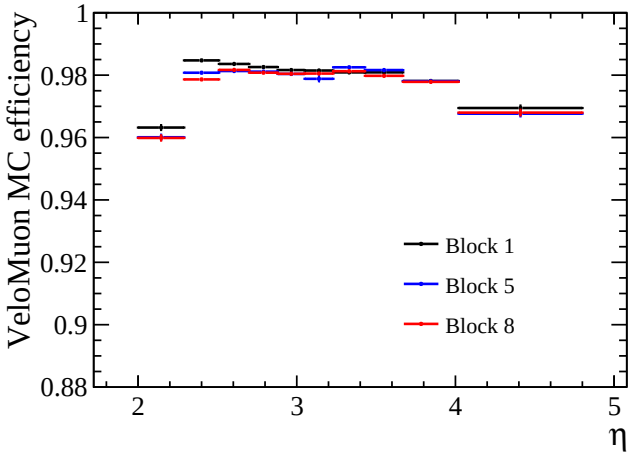
- Use overlap functors for matching
- All cuts and matching criteria updated (after discussion with Maurice and Rowina)
- Tracking efficiencies were compared before and after to understand differences
  - Small differences understood to be sprucing decision filter and wrong/outdated matching criteria in TrackCalib2
- Note: Plots I'm going to show don't have DD4HEP binds, which is expected to have a large impact

TrackCalib development 3: New data/MC samples



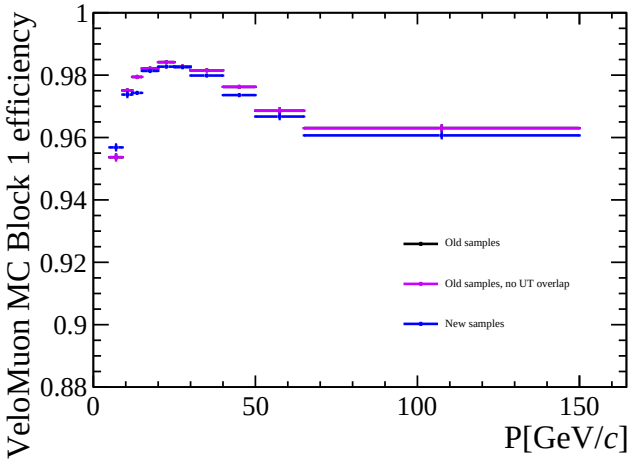


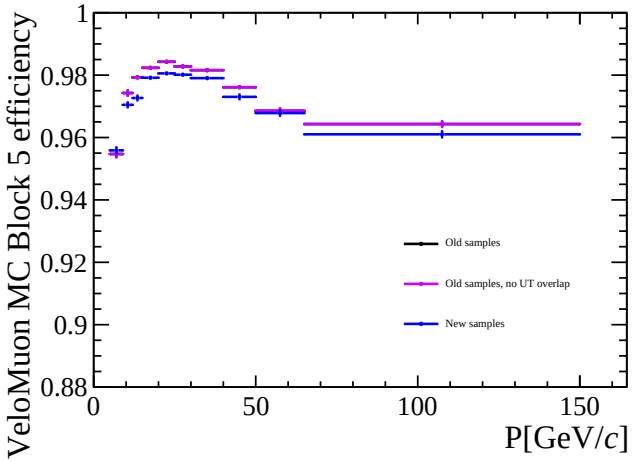


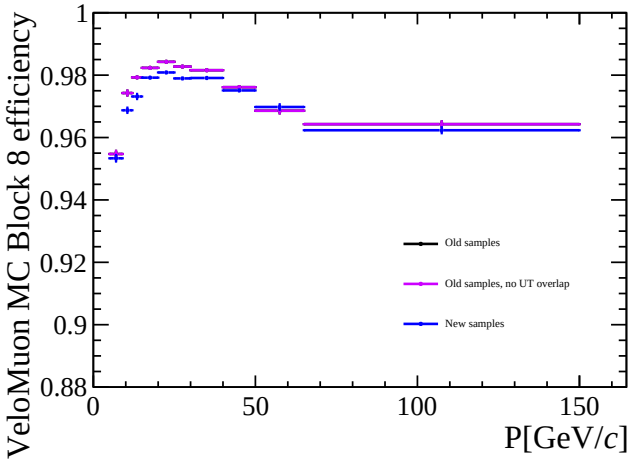


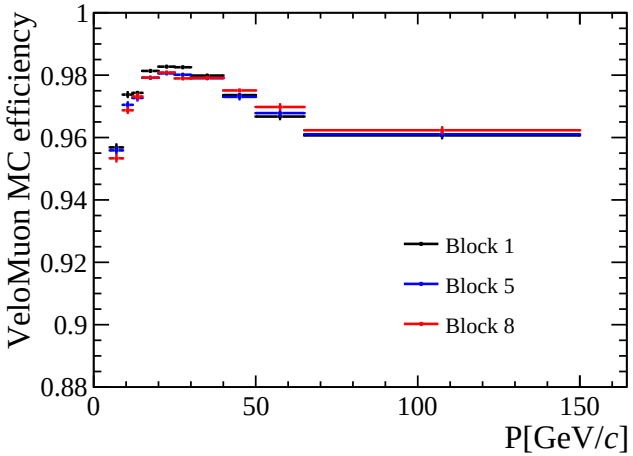
MC VeloMuon track efficiencies in η

TrackCalib development 3: New data/MC samples









MC VeloMuon track efficiencies in p

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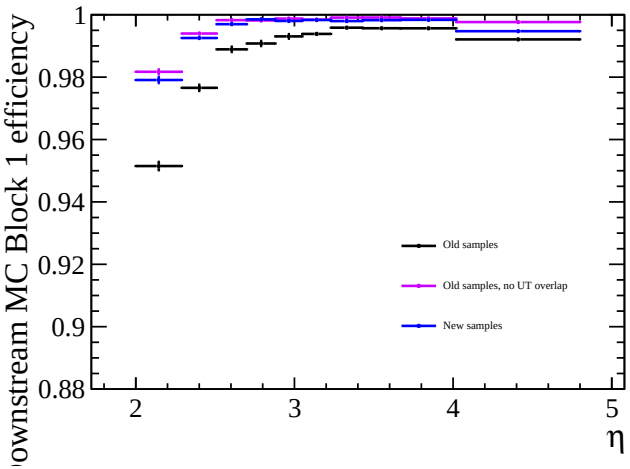

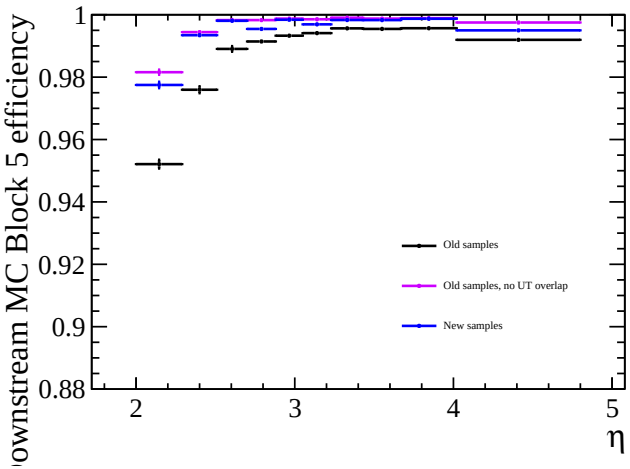

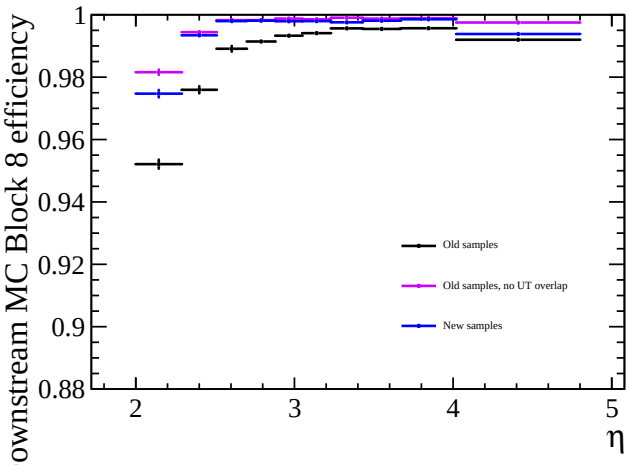

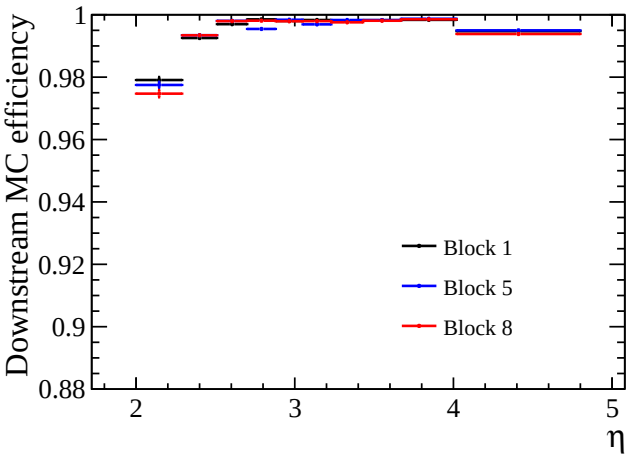

Downstream VeloMuon track efficiencies in η

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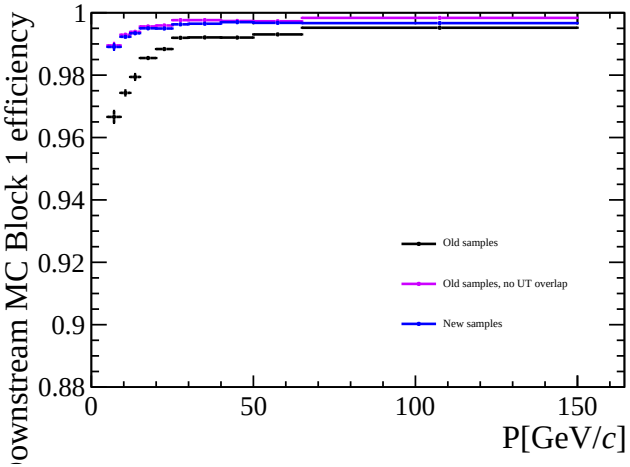

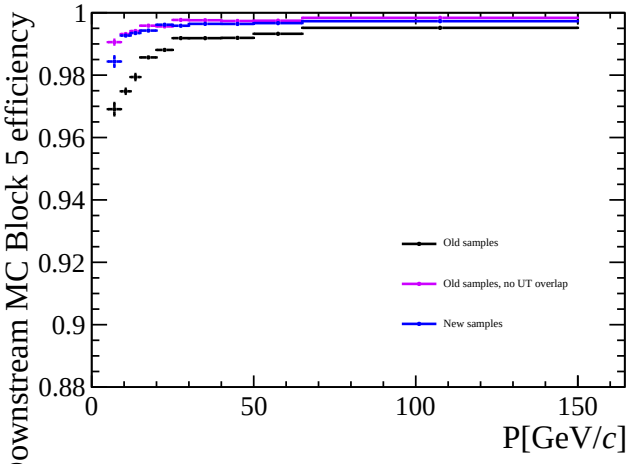

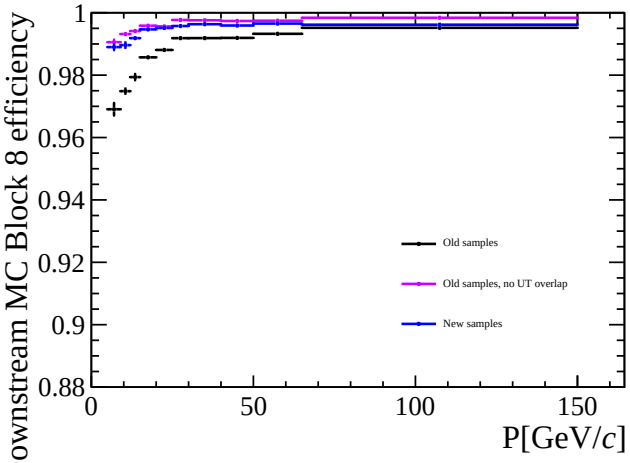

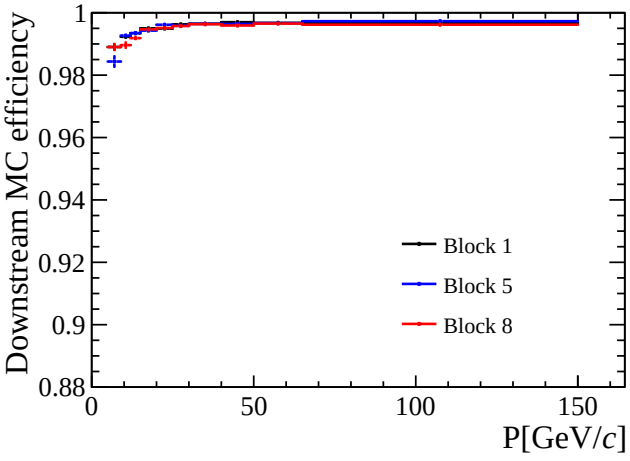

MC Downstream track efficiencies in p

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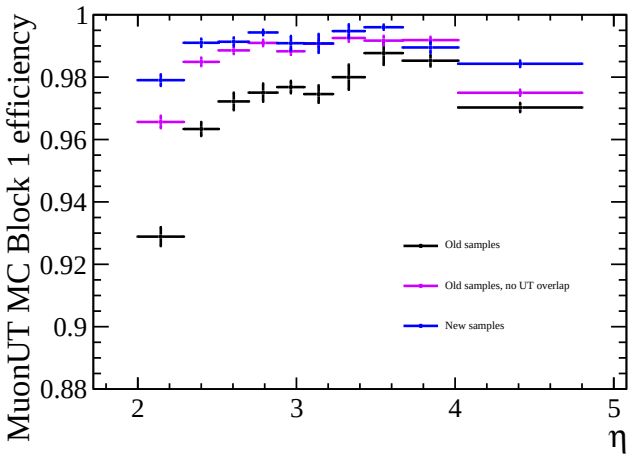
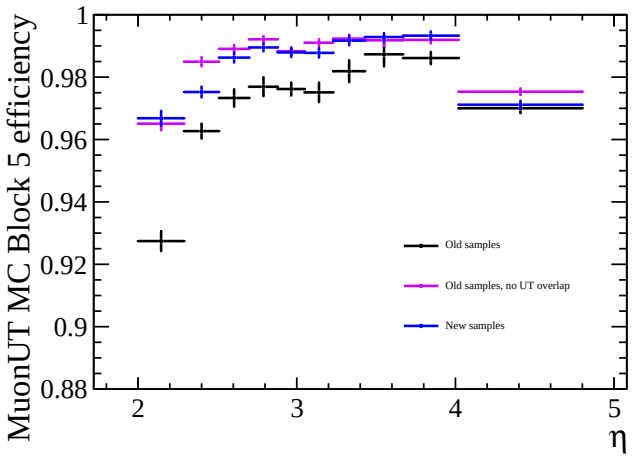
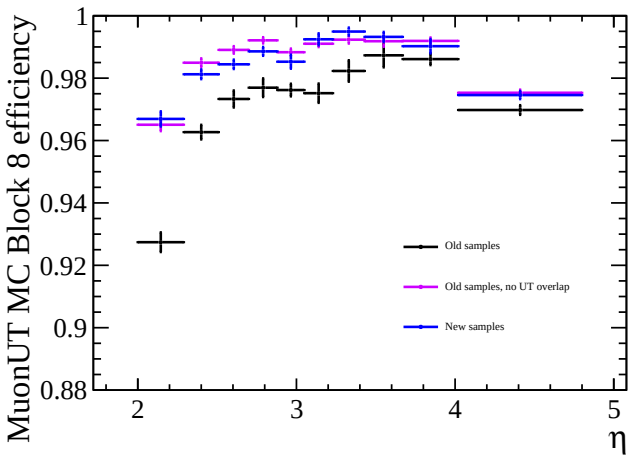
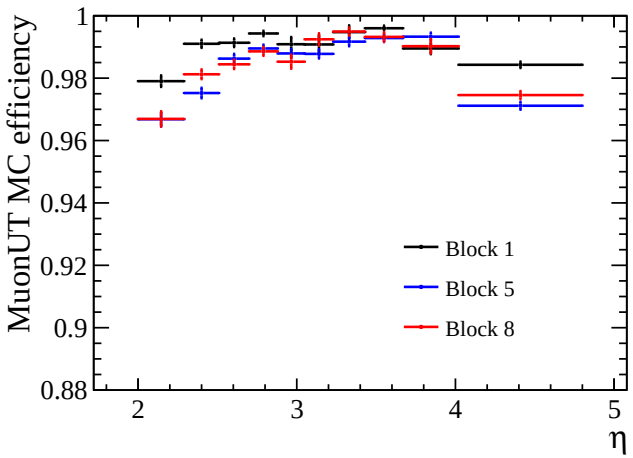


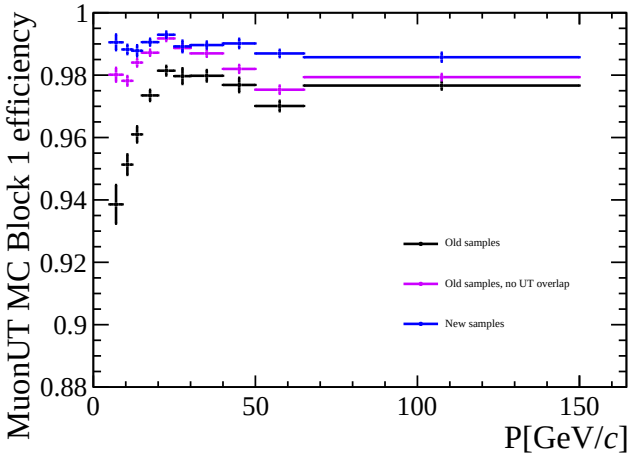


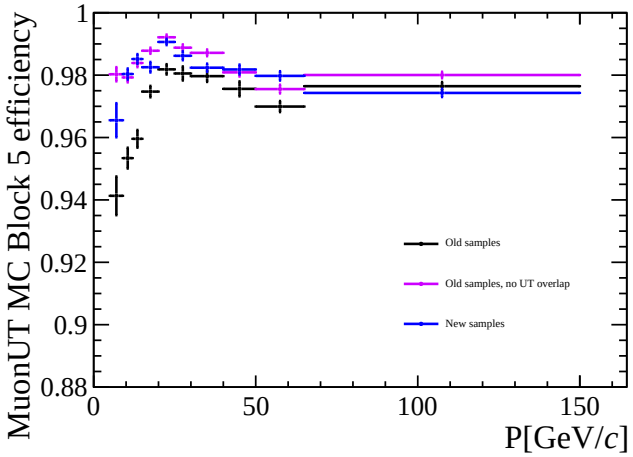


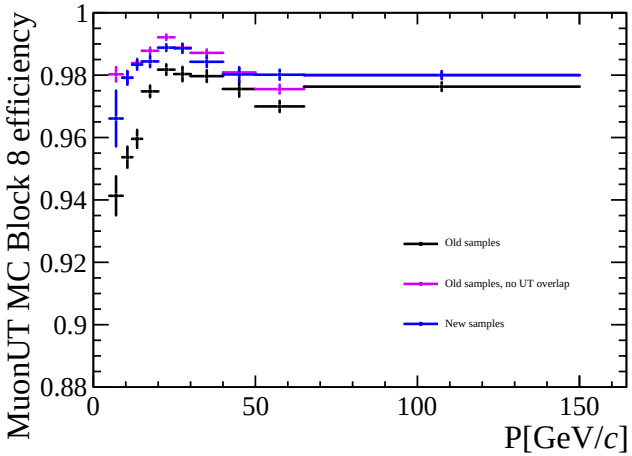


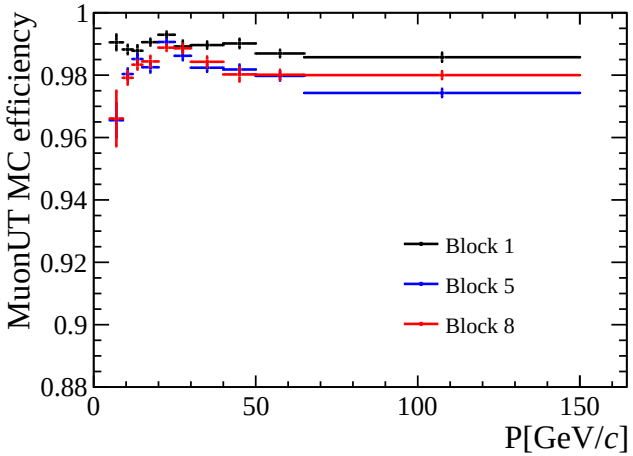
MC MuonUT track efficiencies in η

TrackCalib development 3: New data/MC samples









MC MuonUT track efficiencies in p

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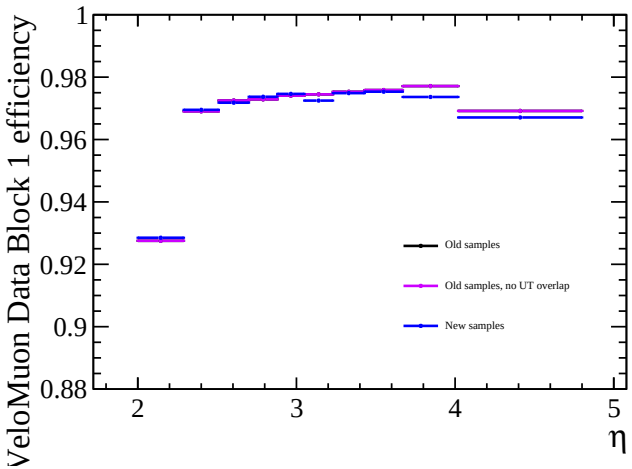
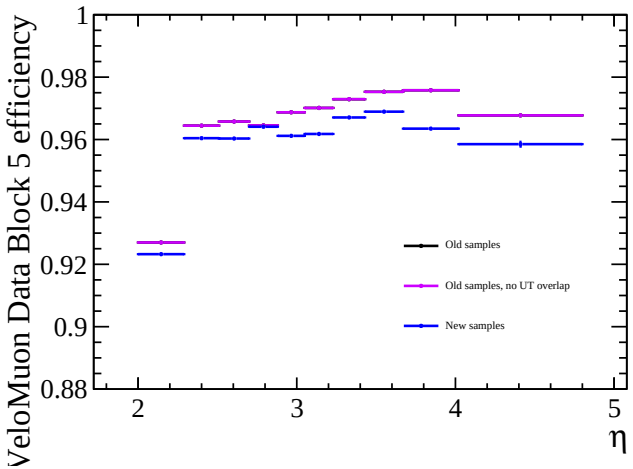
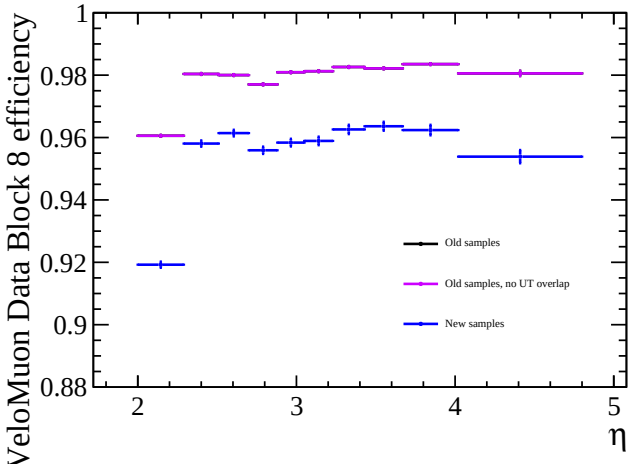
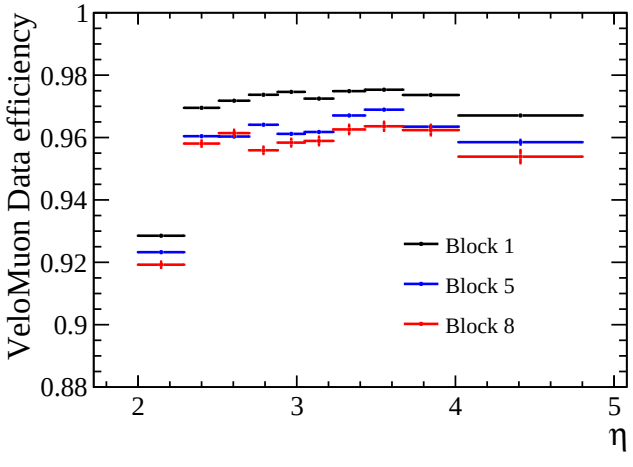


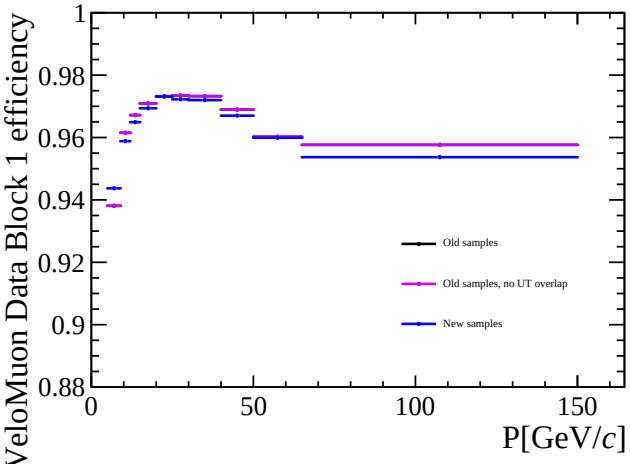


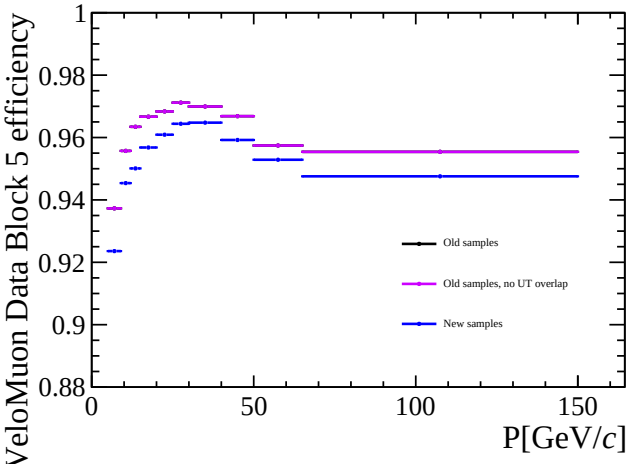


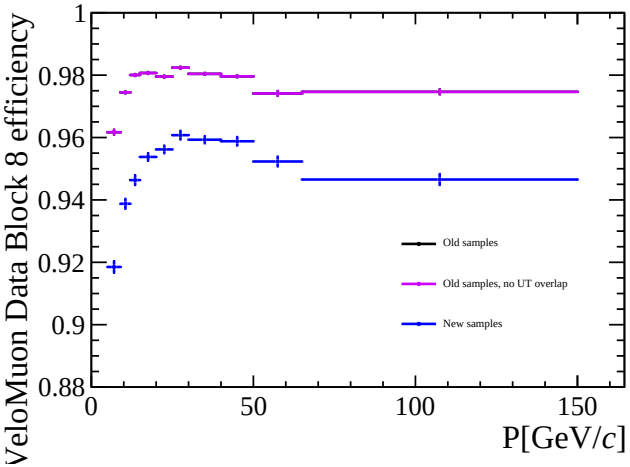


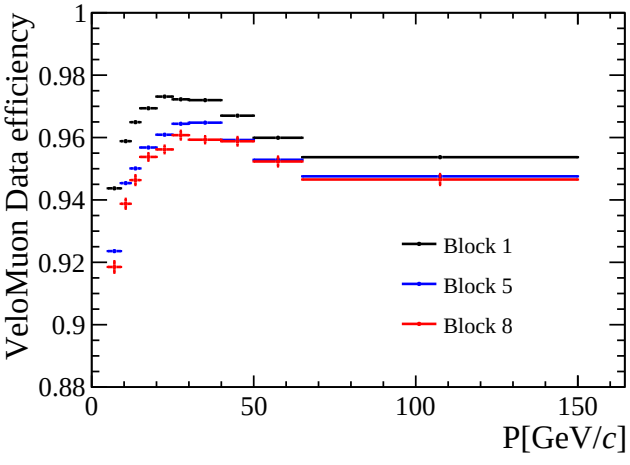
Data VeloMuon track efficiencies in η

TrackCalib development 3: New data/MC samples



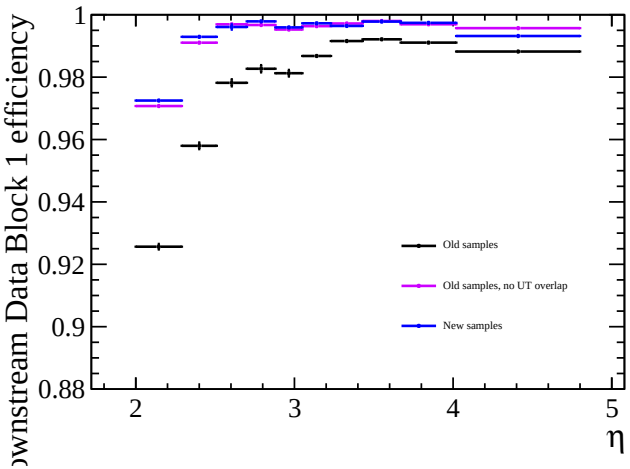


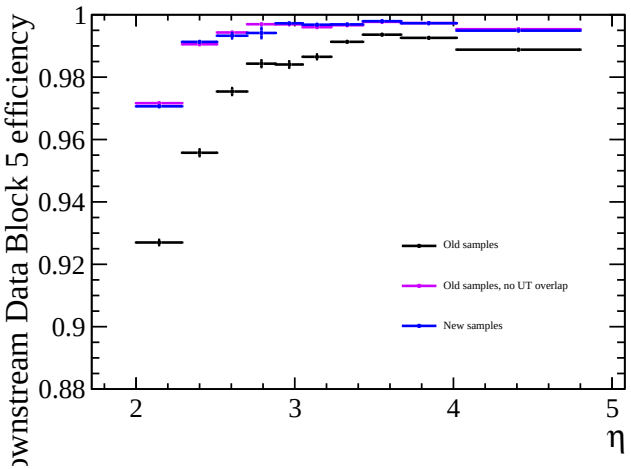


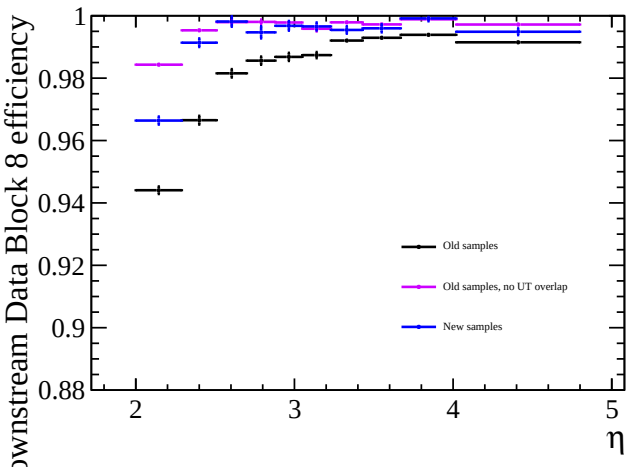


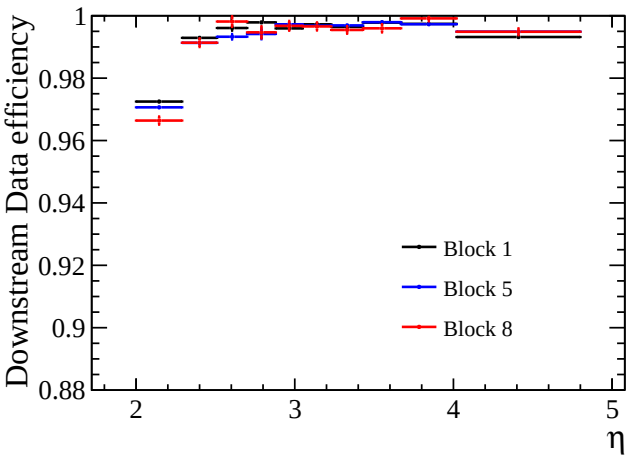
Data VeloMuon track efficiencies in p

TrackCalib development 3: New data/MC samples



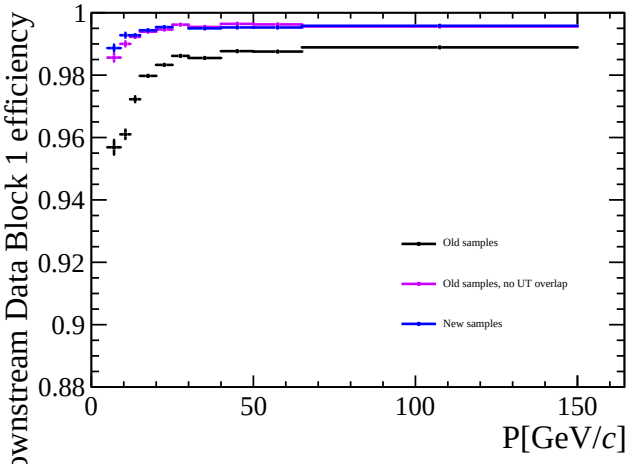


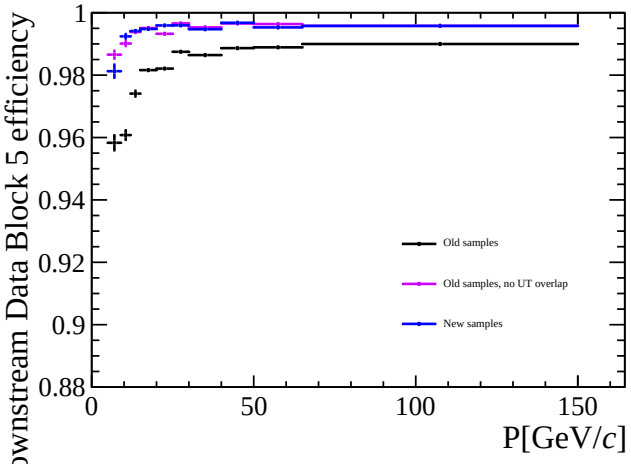


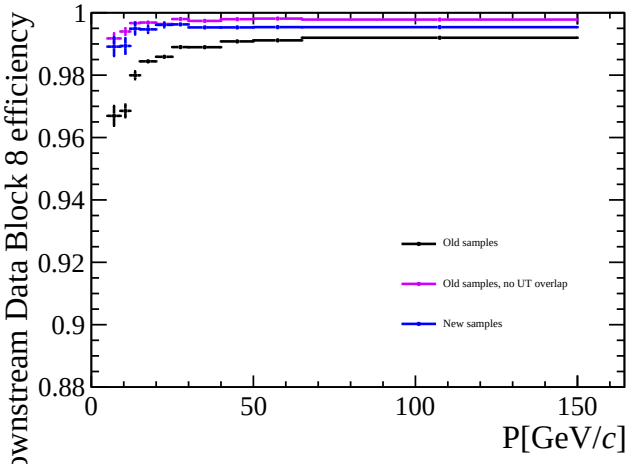


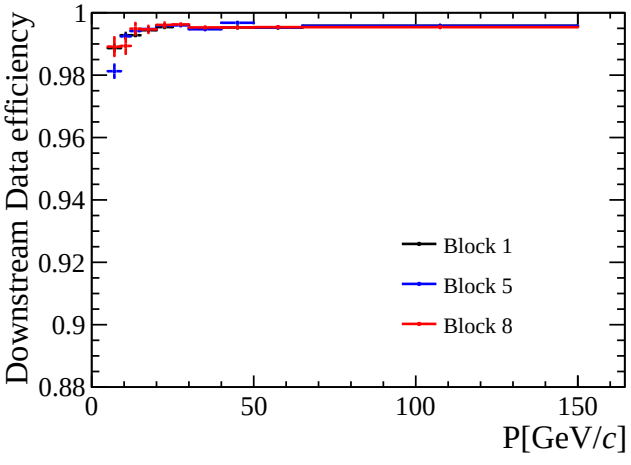
Data Downstream track efficiencies in η

TrackCalib development 3: New data/MC samples



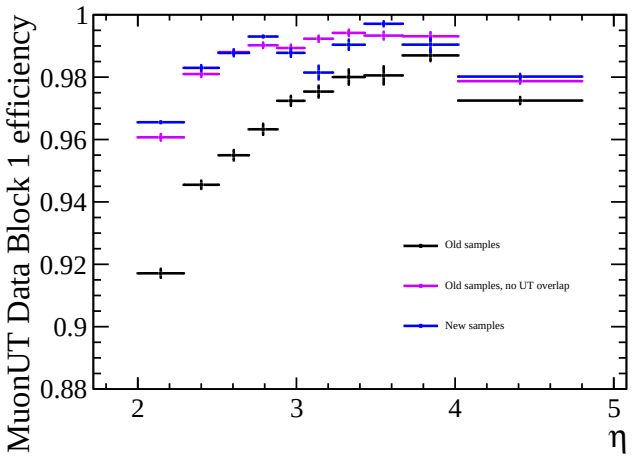


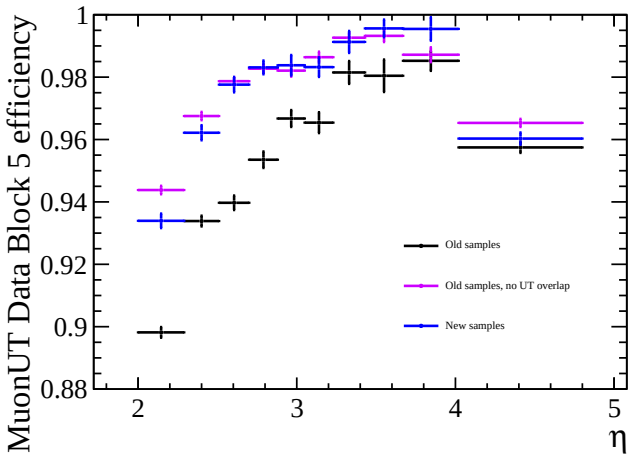


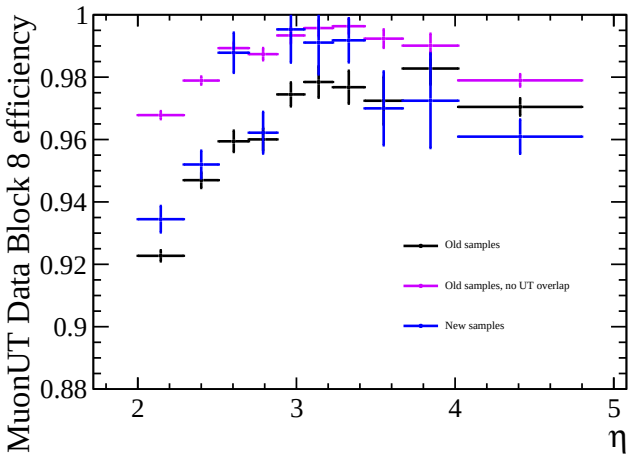


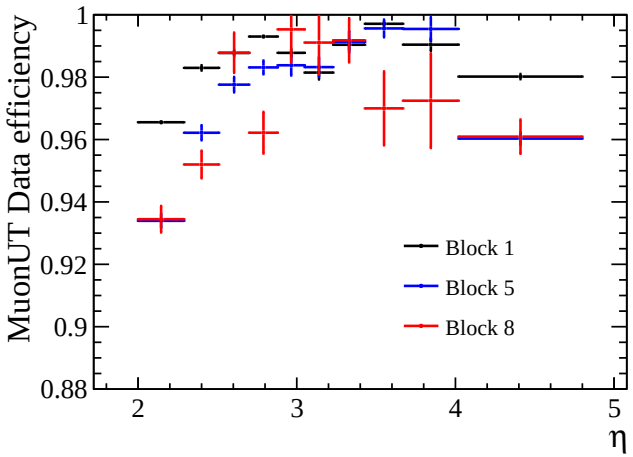
Data Downstream track efficiencies in p

TrackCalib development 3: New data/MC samples



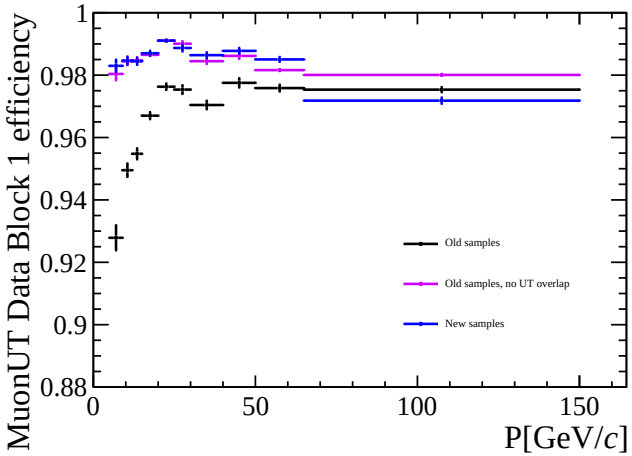


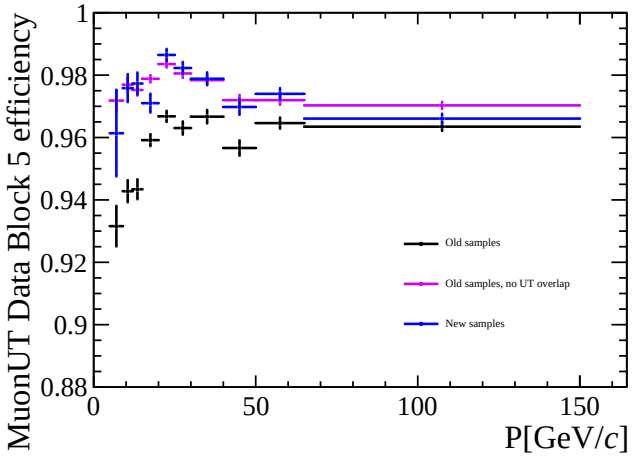


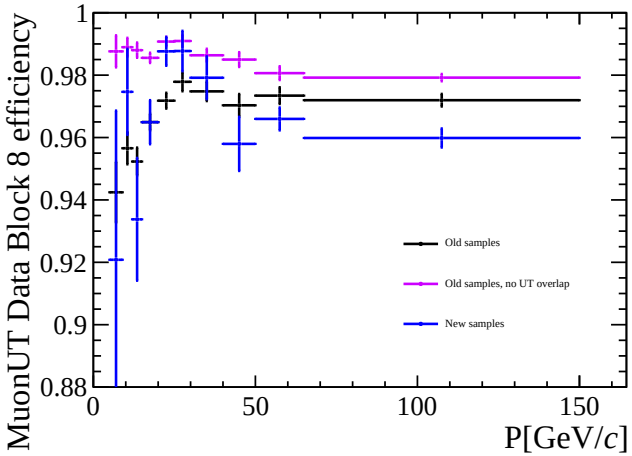


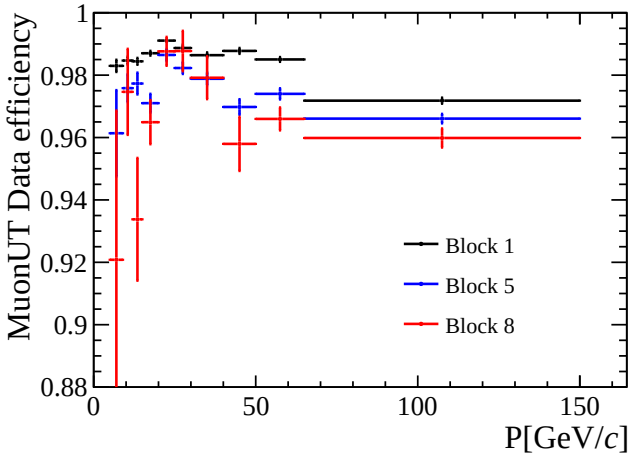
Data MuonUT track efficiencies in η

TrackCalib development 3: New data/MC samples



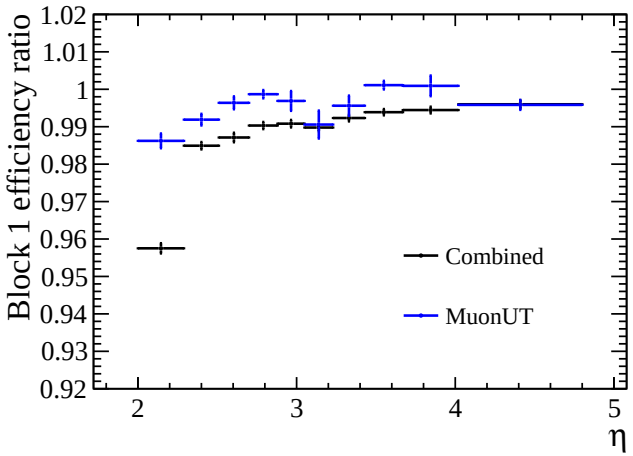


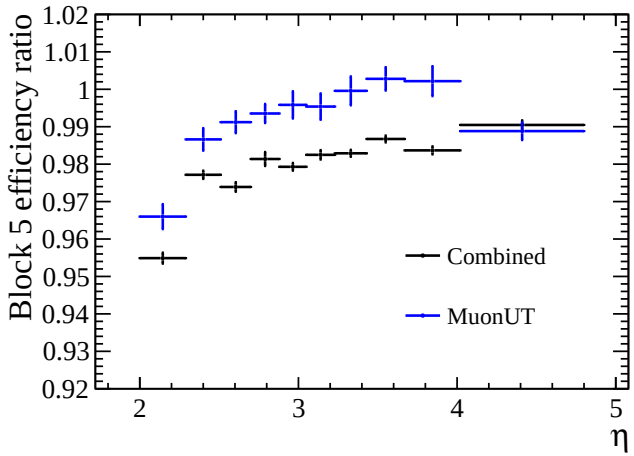


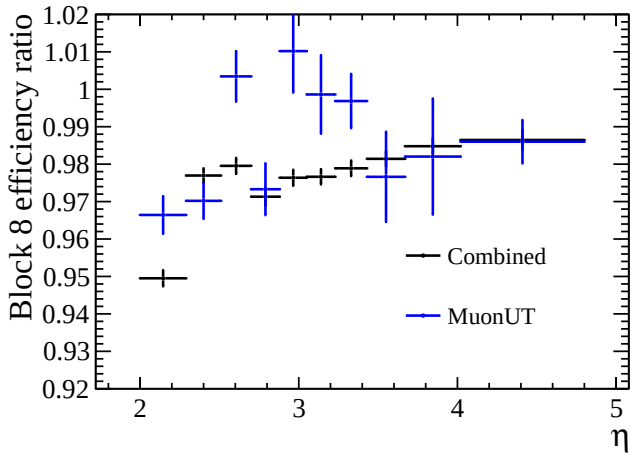


Data MuonUT track efficiencies in p

TrackCalib development 3: New data/MC samples

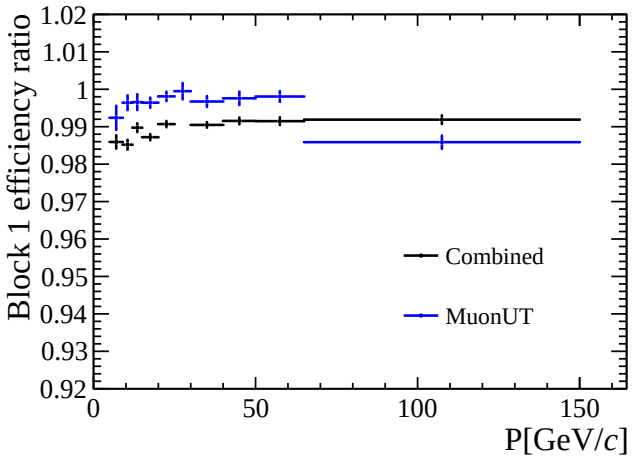


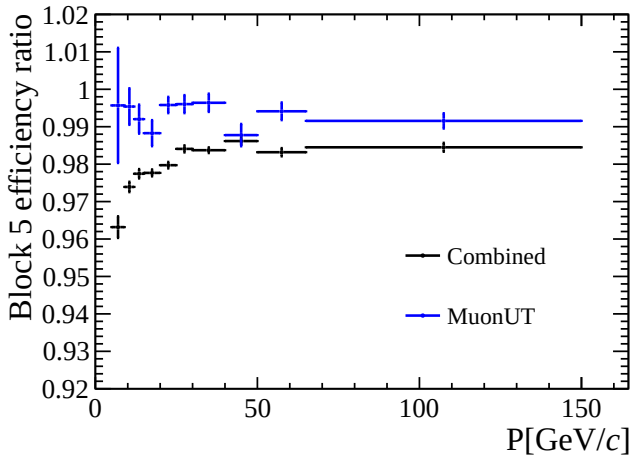


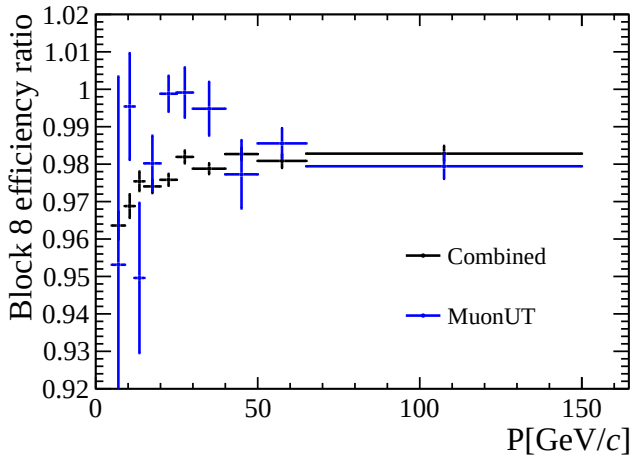


Data/MC ratio for Combined/MuonUT track efficiencies in η

TrackCalib development 3: New data/MC samples







Data/MC ratio for Combined/MuonUT track efficiencies in η

New AP

Need to submit new APs:

1. Blocks 1, 5, 6, 7, 8 of 2024 data
   - AP ready: !xxx
   - Include sprucing decision
   - Include DD4HEP binds
   - Apply tag muon TOS filter (removes around 75% of candidates)
   - Remove unecessary tag muon overlap variables (removes around 20% of branches)
2. Submit MC over block 1b MC
   - AP ready: !xxx
3. Should we consider running block 2 as well?
   - Need to check if we have MC
4. *pp* reference run?
5. Might remove some older samples as well
   - Track efficiency AP currently takes up 13 TB(!)

Summary

1. Standard environment for TrackCalib2 works
2. Briefly looked at impact of missing DD4HEP binds, impact seems to be significant but not understood yet
3. Sprucing decision inconsistency in block 5/6 has been resolved, understood to be inconsistent DD4HEP binds when rerunning reconstruction
4. Several updates to TrackCalib2:
   - Run 1/2 stuff removed, we should create a separate release for Run 3
   - RDataFrame for sample preparation is much faster
   - New data/MC samples
     - Overlap functors for matching
     - Sprucing decision filter included
   - New tracking efficiencies are consistent with previous samples once accounting for new matching criteria and sprucing decision

Next steps

1. Submit AP over 2024 data and block 1b MC
2. Optimise 2D binning scheme and produce 2D data/MC ratio tables for all 2024 blocks and $\mu^{\pm}$, μ^{+}, μ^{-}
3. Unfortunately I've had limited time to look into Combined/MuonUT discrepancies, but I'll try to do this in parallel