2019 MC update

HPS Collaboration Meeting
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October 20, 2026

Stanford University

Contents

- Recap of 2019 preselection
  - Data/MC Samples
  - Step-by-step comparison with 2021
  - Full Preselection
  - MC / Data Comparison after full preselection
- Data/MC agreement with newest alignment, reconstruction including L5.
  - Attempts at understanding data/MC rate differences.

Data Samples

Path: `/sdf/data/hps/physics2019/data/recon/pass2/1pc-merged`

Run	Luminosity	Detector	trigger config
10051	0.007943	HPS_Physics2019_survey_v4p8_L1L2L3_10064_yaw_0p00317	HPS/Run2019/hps_v8.cnf
10074	0.008064	HPS_Physics2019_survey_v4p8_L1L2L3_10064_yaw_0p00317	HPS/Run2019/hps_v8.cnf
10105	0.005434	HPS_Physics2019_survey_v4p8_L1L2L3_10064_v2a_10105_yaw_0p00317	HPS/Run2019/hps_v9.cnf
10111	0.005419	HPS_Physics2019_survey_v4p8_L1L2L3_10064_v2a_10111_yaw_0p00317	HPS/Run2019/hps_v9.cnf
10112	0.005394	HPS_Physics2019_survey_v4p8_L1L2L3_10064_v2a_10112_yaw_0p00317	HPS/Run2019/hps_v9.cnf
10113	0.005428	HPS_Physics2019_survey_v4p8_L1L2L3_10064_v2a_10113_yaw_0p00317	HPS/Run2019/hps_v9.cnf
10114	0.00536	HPS_Physics2019_survey_v4p8_L1L2L3_10064_v2a_10114_yaw_0p00317	HPS/Run2019/hps_v9.cnf
10115	0.005386	HPS_Physics2019_survey_v4p8_L1L2L3_10064_v2a_10115_yaw_0p00317	HPS/Run2019/hps_v9.cnf
10118	0.005343	HPS_Physics2019_survey_v4p8_L1L2L3_10064_v2a_10118_yaw_0p00317	HPS/Run2019/hps_v9_1.cnf
10119	0.005353	HPS_Physics2019_survey_v4p8_L1L2L3_10064_v2a_10119_yaw_0p00317	HPS/Run2019/hps_v9_1.cnf
10125	0.005346	HPS_Physics2019_survey_v4p9_L5_10235_yaw_0p00317	HPS/Run2019/hps_v9_2.cnf
10138	0.005492	HPS_Physics2019_survey_v4p9_L5_10235_yaw_0p00317	HPS/Run2019/hps_v9_2.cnf
10186	0.008704	HPS_Physics2019_survey_v4p9_L5_10235_yaw_0p00317	hps_v10.trg
10235	0.00864	HPS_Physics2019_survey_v4p9_L5_10235_yaw_0p00317	hps_v10.trg
10263	0.007228	HPS_Physics2019_survey_v4p9_L5_10235_yaw_0p00317	hps_v10.trg
10286	0.007371	HPS_Physics2019_survey_v4p9_L5_10235_yaw_0p00317	hps_v10.trg
10323	0.00719	HPS_Physics2019_survey_v4p9_L5_10235_yaw_0p00317	hps_v10.trg
10377	0.00701	HPS_Physics2019_survey_v4p9_L5_10235_yaw_0p00317	hps_v10.trg
10389	0.007884	HPS_Physics2019_survey_v4p9_L5_10235_yaw_0p00317	hps_v10.trg
10431	0.009182	HPS_Physics2019_survey_v4p9_L5_10235_yaw_0p00317	hps_v11_5.trg

Skimming Criteria

Desc.	2019	2021
trackChi2Cut	30	30
nHitsMin	9	8
v0Chi2Cut	30	30
trackDtCut	20	20
trackPMax	5.5	4.5
v0PMax	5.5	4.5
reqClusterMatch	FALSE	FALSE
posClusterEnergy	0.2	0.2

MC Samples

Readout steering file: `PhysicsRun2019TrigSinglesWithPulserDataMerging.lcsim`

Recon steering file: `PhysicsRun2019MCRecon_KF_WithSpacing_pass2.lcsim`

Detector: `HPS_Physics2019_survey_v4p9_L5_10235_yaw_0p00317pass2`

Hps-mc parameters:

```
  "target thickness": [0.0008],
    "beam_energy": [4550.00],
    "target_x": [0.0],
    "target_y": [0.0],
    "target_z": [-7.54],
    "beam_sigma_x": [0.055],
    "beam_sigma_y": [0.045],
    "beam_rot_x": [0.0],
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```

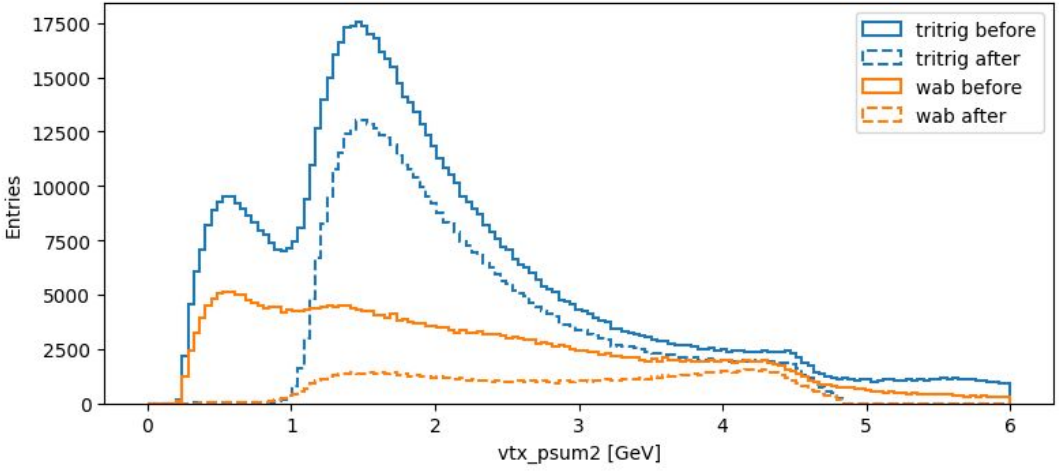
Sample	MG5 Cross Section [pb]
2019 WAB	6.381E10
2019 Tritrig	4.556E9
2021 WAB	8.079E10
2021 Tritrig	4.026E9

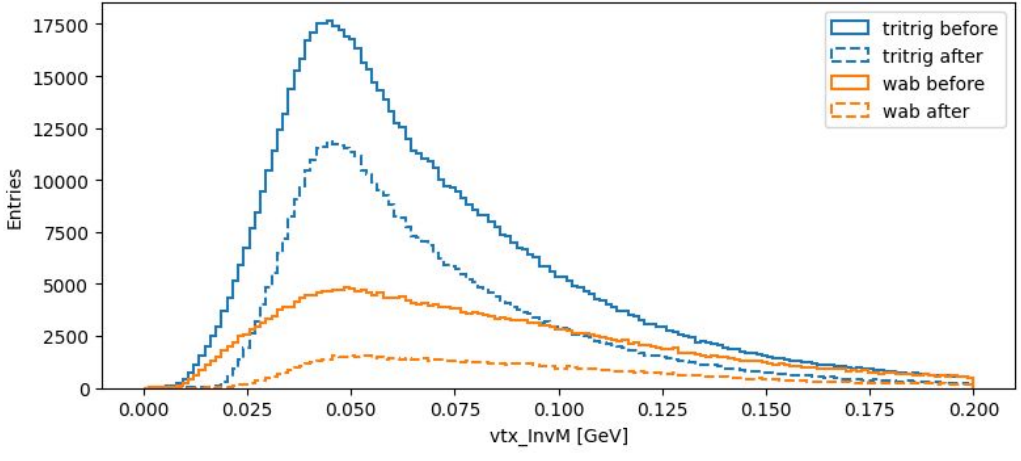
Sanity Selections

First set of cuts designed to remove FEEs and obviously misconstructed events

Description	**2019 Selection**	**2021 Selection**
Trigger Requirement	Single2 || Single3	Single2 || Single3
FEE cut	$P_{e-} < 3.64$ GeV	$P_{e-} < 2.9$ GeV
Vertex Momentum cut	$P_{vertex} < 4.81$ GeV	$P_{vertex} < 4.0$ GeV
Positron Energy Cut	$E_{e+} > 0.2$ GeV	$E_{e+} > 0.2$ GeV

Sanity Selections MC

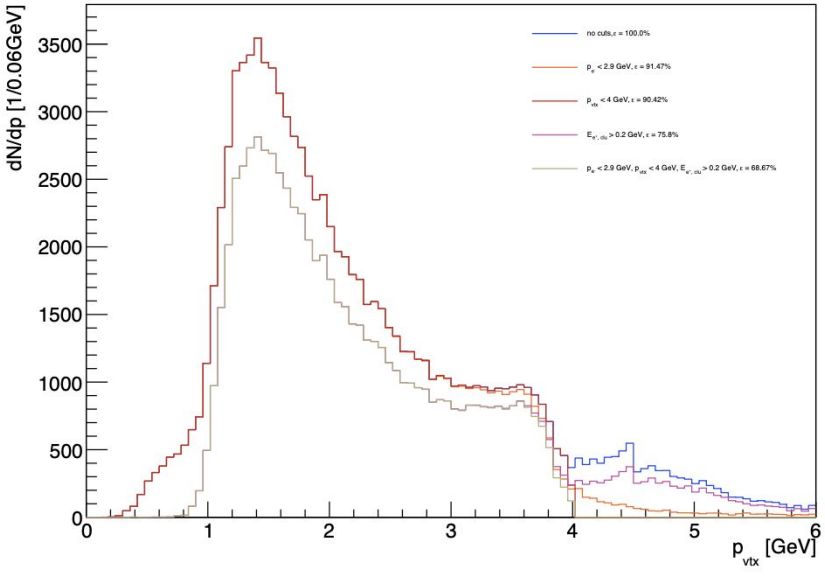




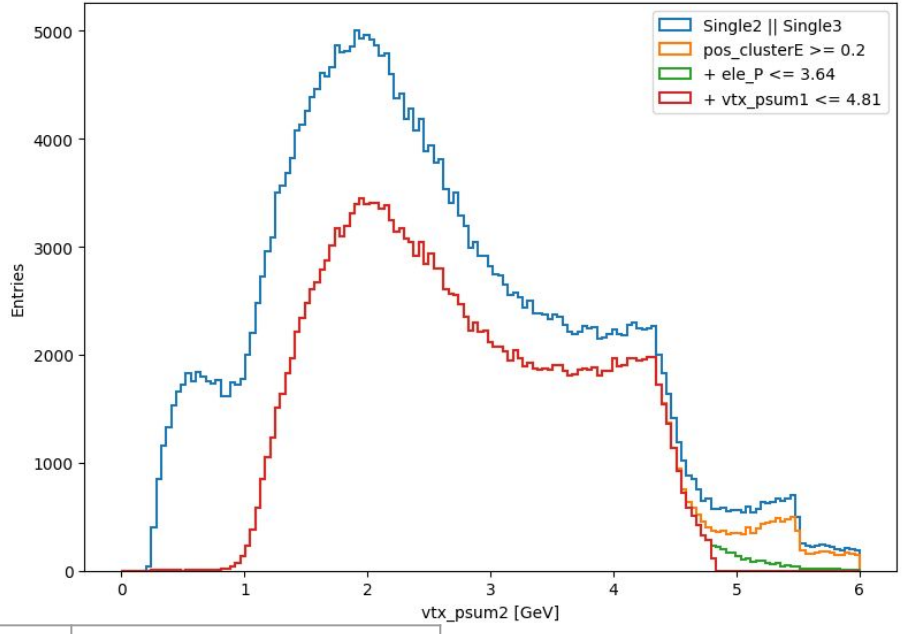
Sample	Efficiency
2019 Tritrig	56.10 %
2019 WAB	29.83 %
2021 Tritrig	66.47 %
2021 WAB	48.34 %

Sanity Selections MC

2021 run 14567



2019 run 010051

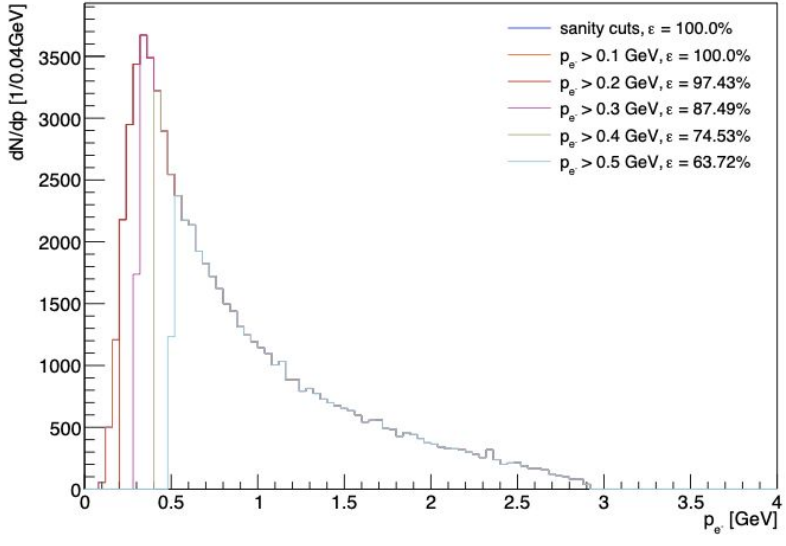


Sample	Efficiency
2019 run 010051	59.67 %
2021 run 14567	68.67 %

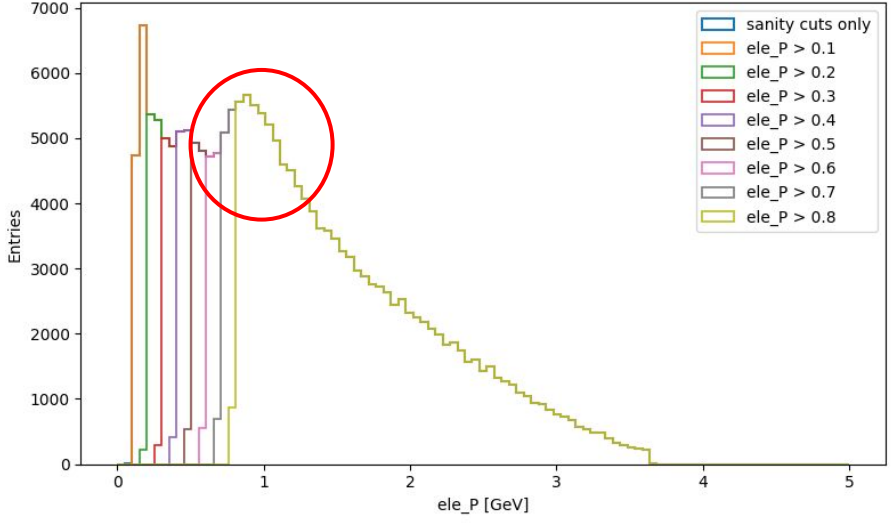
Electron Track Momentum

- Sarah Derives an estimate of the lower limit on momentum based on number of hits (2021 Analysis note Eq.14)
- The lower limit is linearly proportional to B, extending this to 2019 we multiply by a factor of 1T/0.8T to get a lower limit of **0.5 GeV/c**

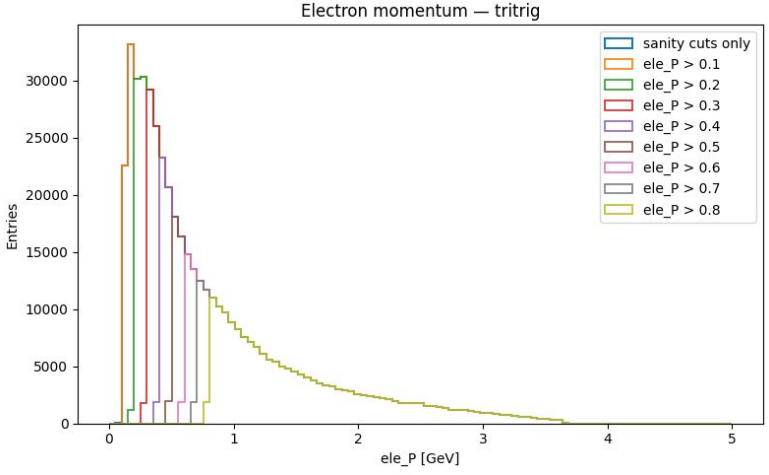
2021 run 14567

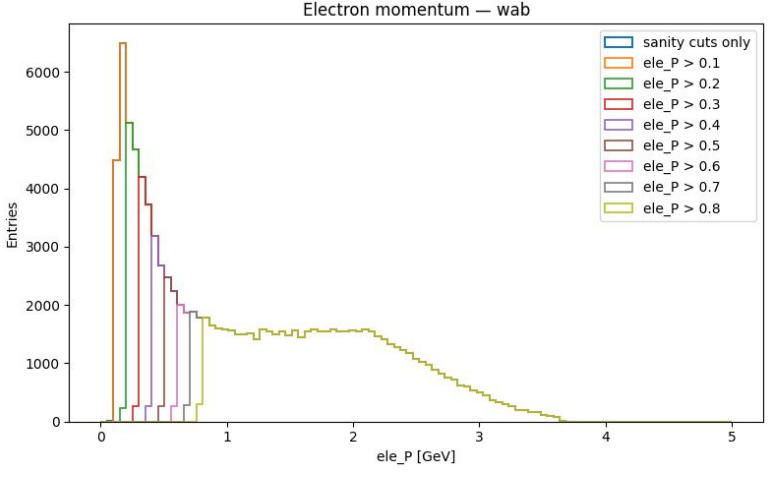


2019 run 010051



Electron Track Momentum

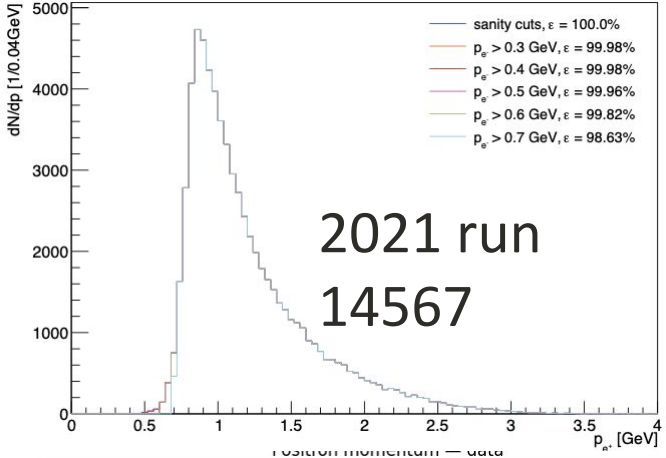


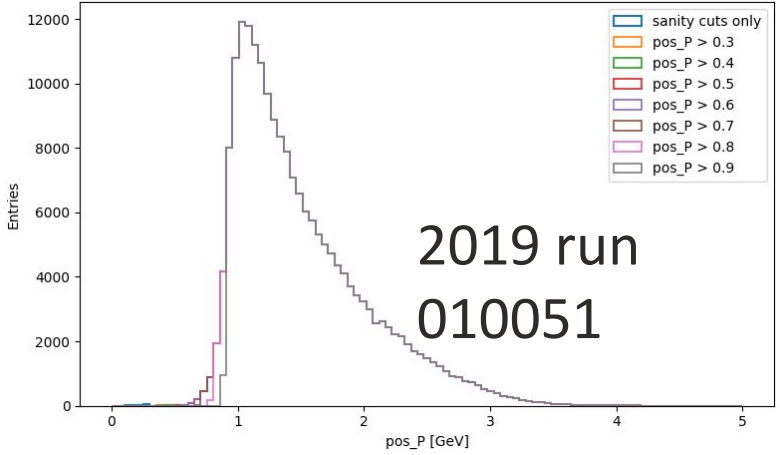


Sample	ele_P >	Efficiency
2021 run 14567	0.4 GeV	74.53 %
2021 WAB	0.4 GeV	81.76 %
2021 Tritrig	0.4 GeV	71.65 %
2019 run 010051	0.5 GeV	79.01 %
2019 WAB	0.5 GeV	55.21 %
2019 Tritrig	0.5 GeV	68.19 %

Positron Track Momentum

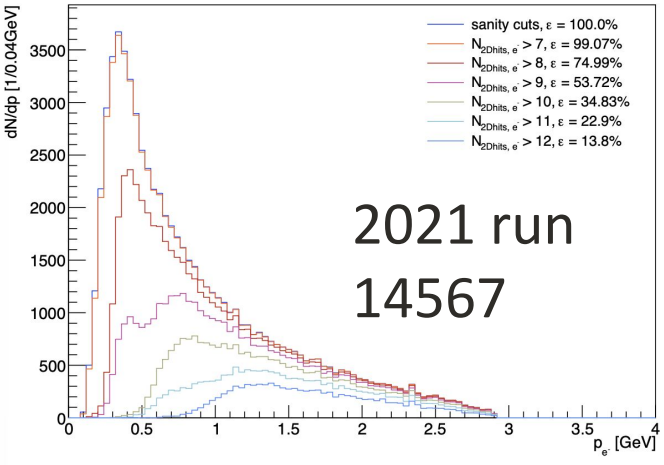
A minimum of **0.5 GeV/c** is applied to the positron

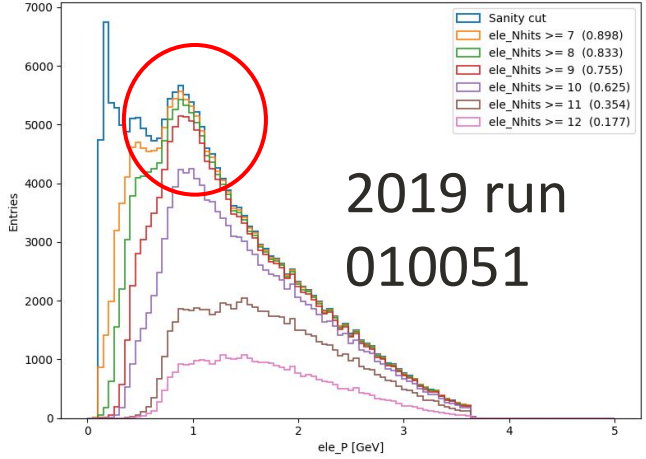




Sample	pos_P >	Efficiency
2021 run 14567	0.4 GeV	99.98 %
2021 WAB	0.4 GeV	99.81 %
2021 Tritrig	0.4 GeV	99.97 %
2019 run 010051	0.5 GeV	99.95 %
2019 WAB	0.5 GeV	99.79 %
2019 Tritrig	0.5 GeV	99.95 %

Electron Track Nhits

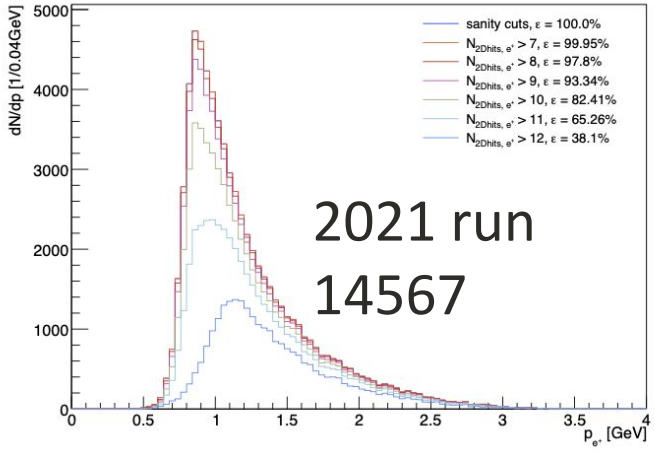


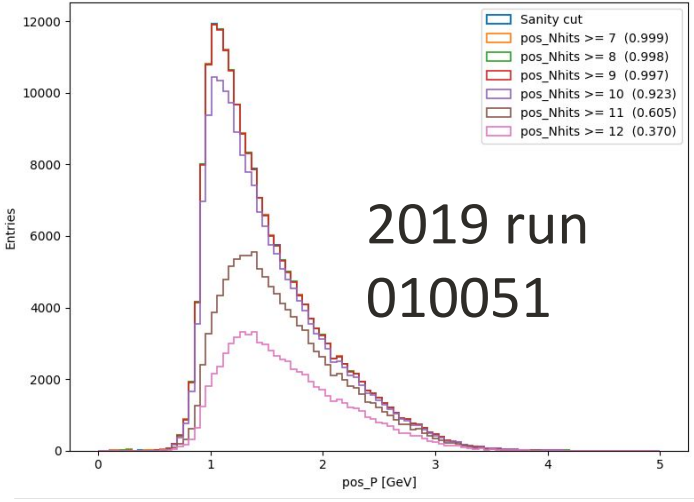


2021 uses ele_Nhits >= 10, for 2019 we relax this to ele_Nhits >= 9

Sample	ele_Nhits >=	Efficiency
2021 run 14567	10	53.72 %
2021 WAB	10	62.28 %
2021 Tritrig	10	49.44 %
2019 run 010051	9	75.53 %
2019 WAB	9	50.77 %
2019 Tritrig	9	34.34 %

Positron Track Nhits





2021 uses pos_Nhits >= 10, for 2019 we relax this to pos_Nhits >= 9

Sample	pos_Nhits >=	Efficiency
2021 run 14567	10	93.34
2021 WAB	10	77.57 %
2021 Tritrig	10	96.54 %
2019 run 010051	9	99.68 %
2019 WAB	9	72.10 %
2019 Tritrig	9	97.14 %

Fit Quality

2021 uses Track chi2/ndf < 20, and vertex chi2 < 20. We keep the same selections for 2019

Electron track

Sample	Efficiency
2021 run 14567	98.70 %
2021 WAB	97.82 %
2021 Tritrig	97.25 %
2019 run 010051	98.34 %
2019 WAB	97.08 %
2019 Tritrig	96.32 %

Positron track

Sample	Efficiency
2021 run 14567	99.62 %
2021 WAB	97.30 %
2021 Tritrig	99.78 %
2019 run 010051	99.91 %
2019 WAB	97.45 %
2019 Tritrig	99.87 %

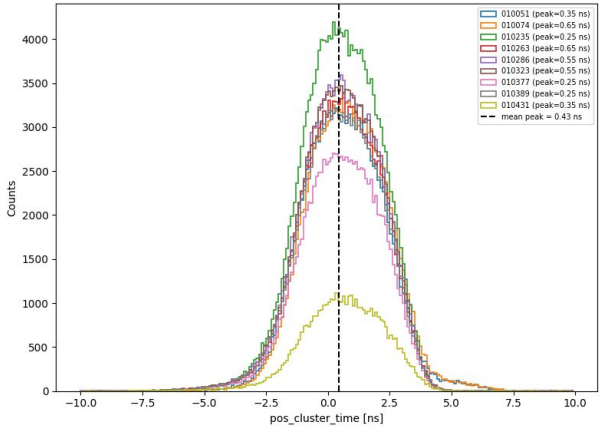
Vertex

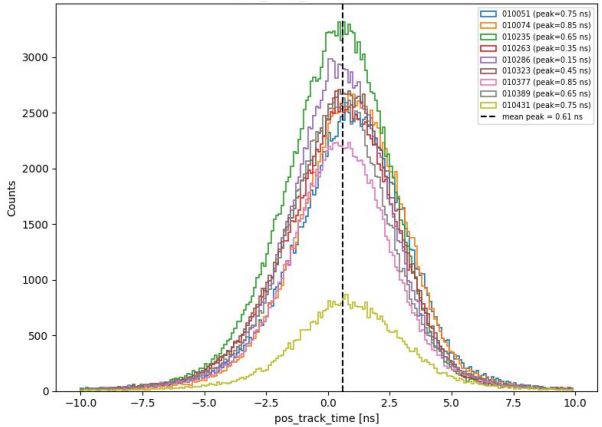
Sample	Efficiency
2021 run 14567	90.43 %
2021 WAB	56.56 %
2021 Tritrig	83.15 %
2019 run 010051	90.21 %
2019 WAB	66.08 %
2019 Tritrig	83.93 %

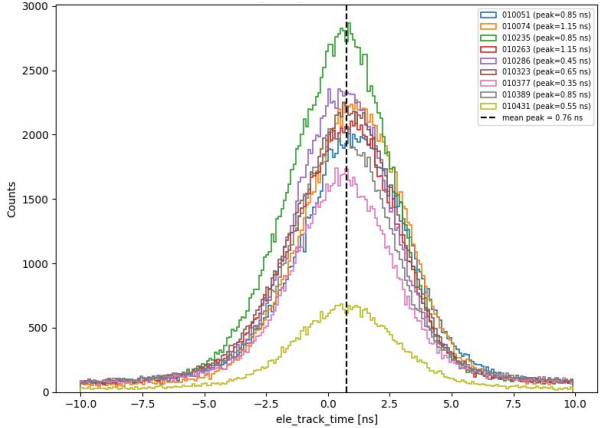
Timing Selections

- Other preselection are evaluated after the sanity cuts but timing preselection are evaluated after all previously mentioned selections
- First we need to shift cluster and track time distribution to be centered at 0, 2021 time shifts are used with the exception of MC cluster time, which is shifted by an additional 0.2 ns
- The timing distribution for certain runs (highlighted in slide 3) exhibit a strange behaviour

runs with regular time distributions

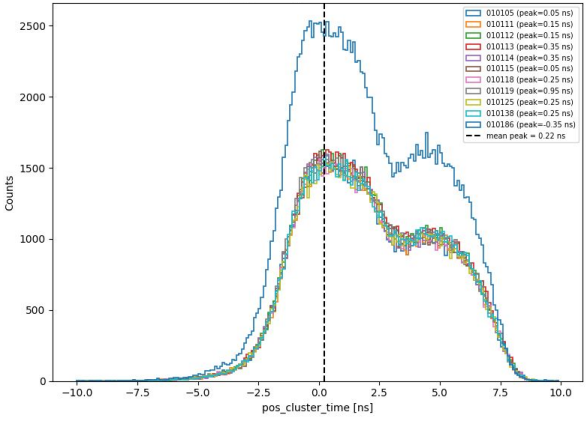


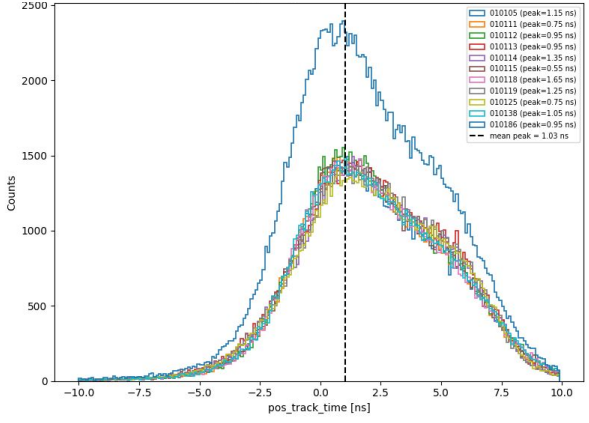


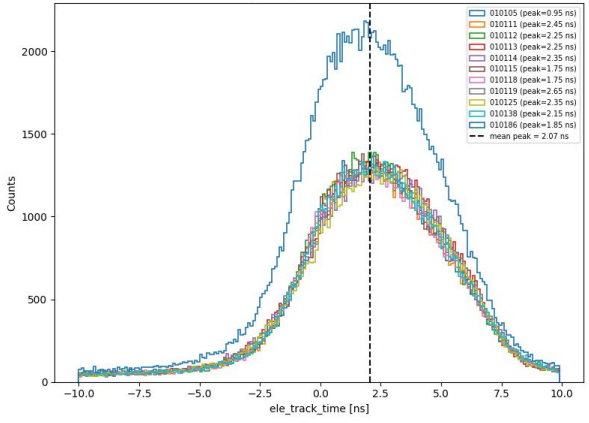


Timing Selections

runs with irregular time distributions



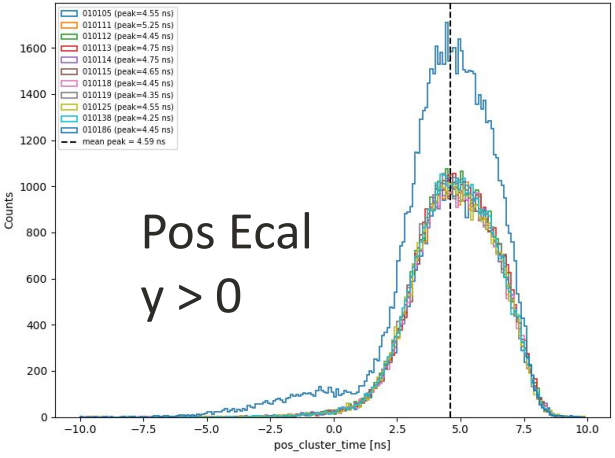


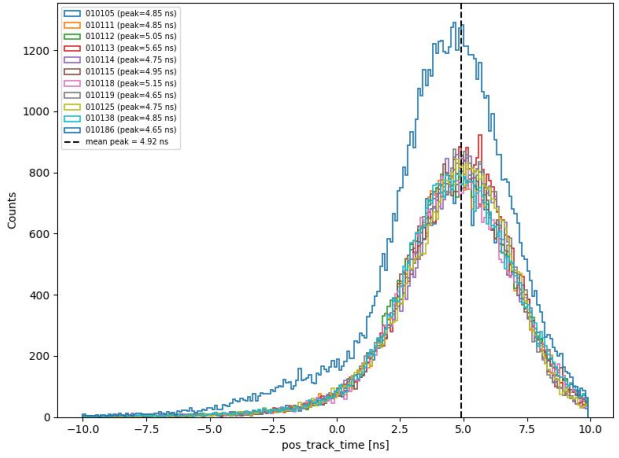


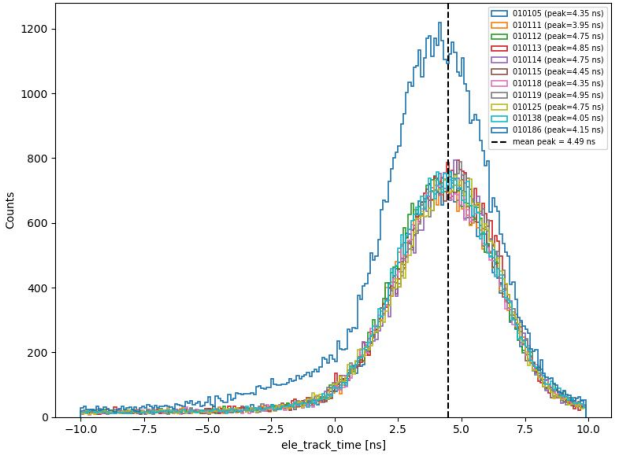
- Cluster time distribution is bimodal
- There's a clear effect on the track time distributions

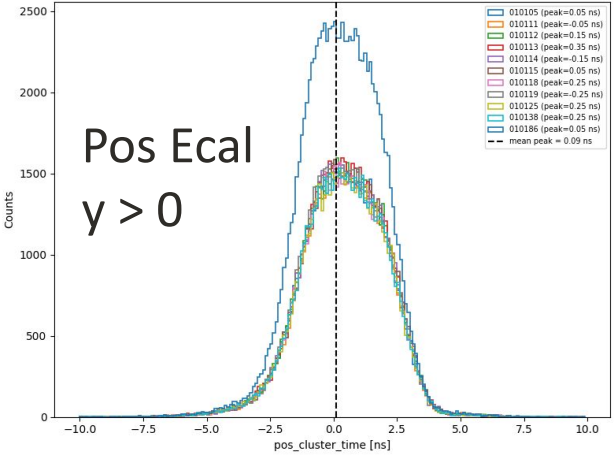
Timing Selections

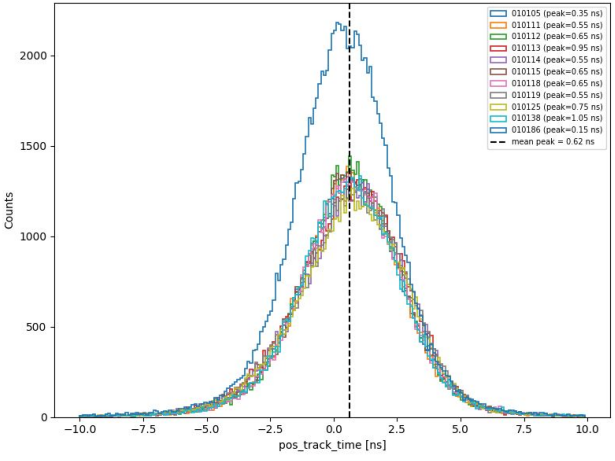
runs with irregular time distributions

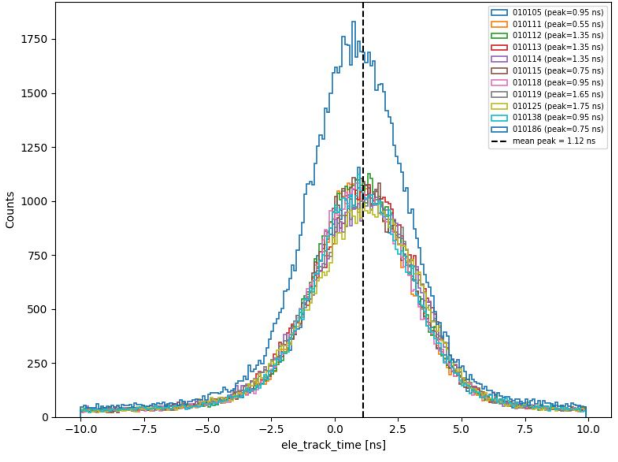






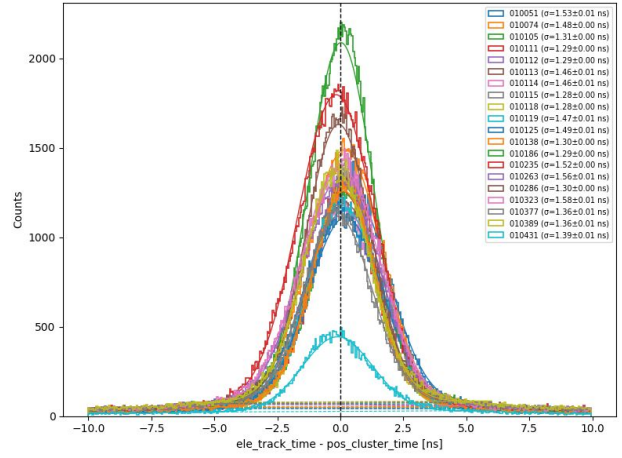


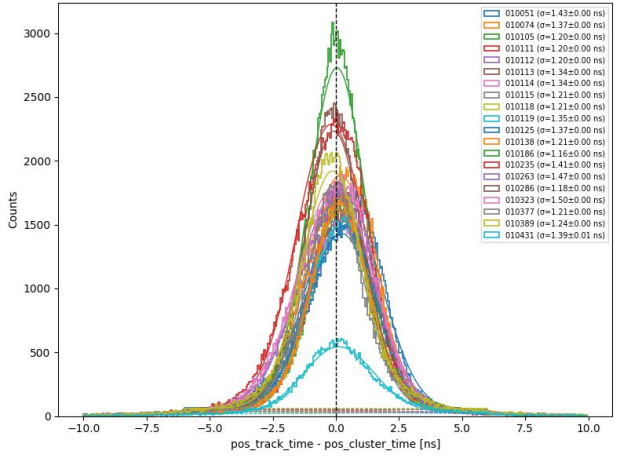


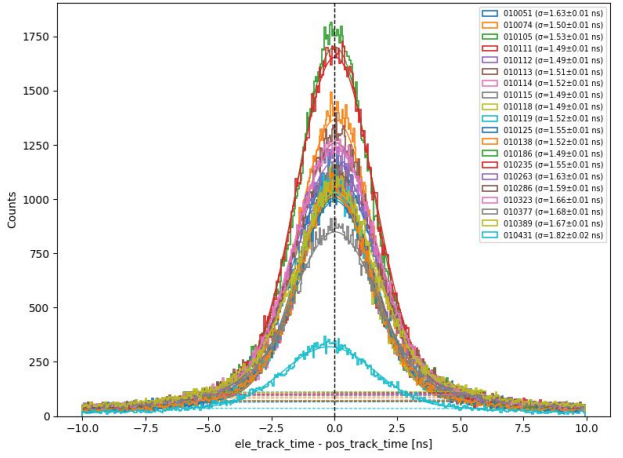


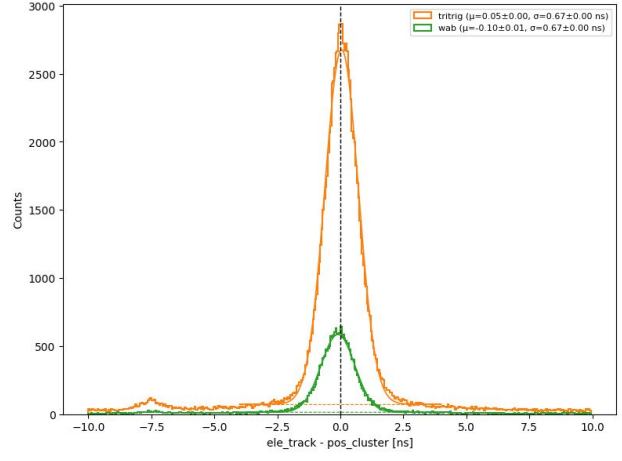
Timing Selections

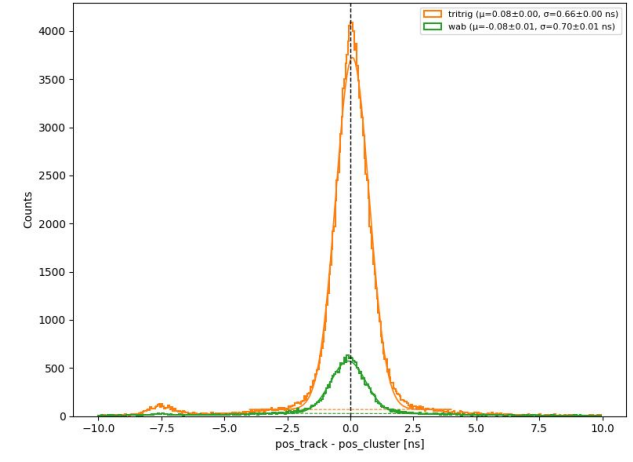
Fit time difference distributions to Gaussians

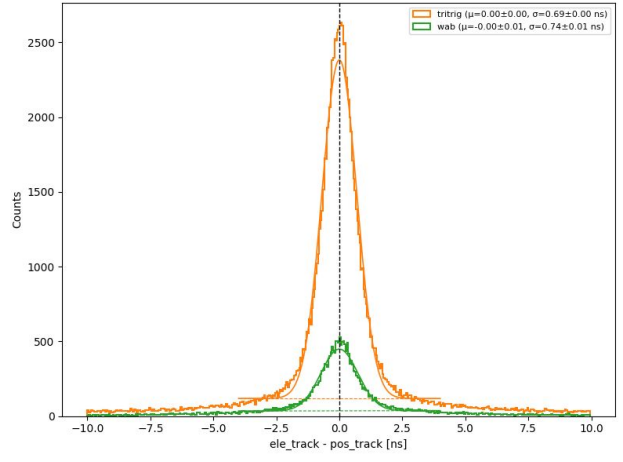












Timing Selections

$\Delta(t_{e^-,\mathrm{trk}}, t_{e^+,\mathrm{clu}})$

Sample	Sigma [ns]
2021 mean	2
2021 WAB	2
2021 Tritrig	2
2019 mean	1.400
2019 WAB	0.667
2019 Tritrig	0.669
MC mean	0.668

$\Delta(t_{e^+,\mathrm{trk}}, t_{e^+,\mathrm{clu}})$

Sample	Sigma [ns]
2021 mean	1.7
2021 WAB	1.9
2021 Tritrig	1.9
2019 mean	1.299
2019 WAB	0.702
2019 Tritrig	0.665
MC mean	0.683

$\Delta(t_{e^-,\mathrm{trk}}, t_{e^+,\mathrm{trk}})$

Sample	Sigma [ns]
2021 mean	2.6
2021 WAB	3.1
2021 Tritrig	3.1
2019 mean	1.566
2019 WAB	0.738
2019 Tritrig	0.693
MC mean	0.716

following 2021, a selection is made keep to ΔT values within 3σ

Timing Selections

$\Delta(t_{e^-,\mathrm{trk}}, t_{e^+,\mathrm{clu}})$

Sample	Efficiency
2021 run 14567	0.7086
2021 WAB	0.6951
2021 Tritrig	0.6743
2019 run 010051	0.7760
2019 WAB	0.6871
2019 Tritrig	0.6559

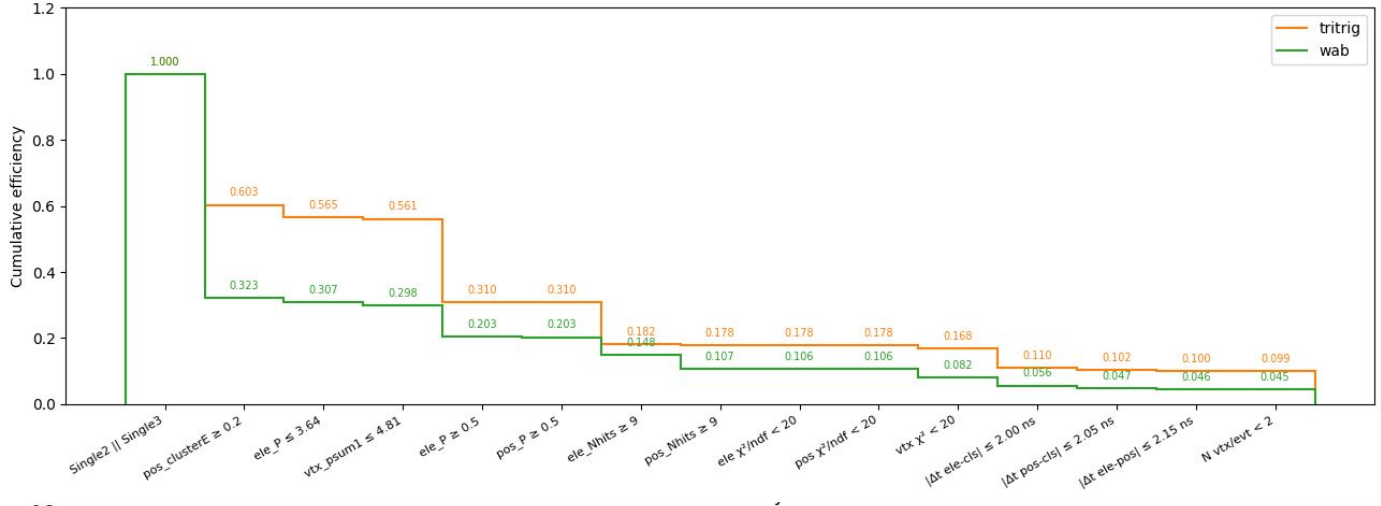
$\Delta(t_{e^+,\mathrm{trk}}, t_{e^+,\mathrm{clu}})$

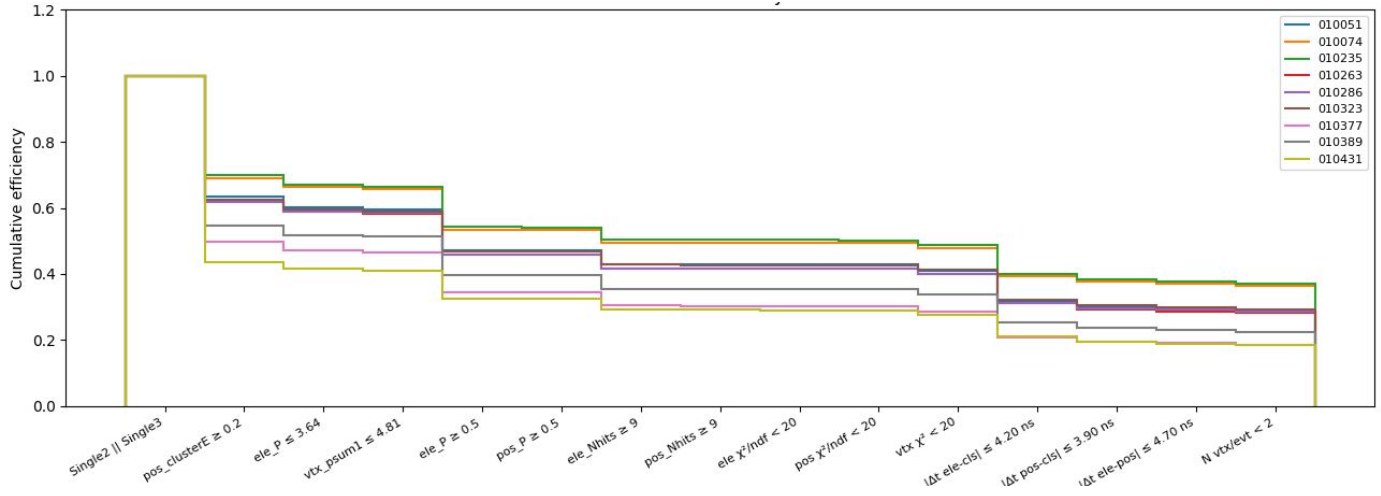
Sample	Efficiency
2021 run 14567	0.9239
2021 WAB	0.8201
2021 Tritrig	0.9334
2019 run 010051	0.9353
2019 WAB	0.7266
2019 Tritrig	0.8992

$\Delta(t_{e^-,\mathrm{trk}}, t_{e^+,\mathrm{trk}})$

Sample	Efficiency
2021 run 14567	0.7288
2021 WAB	0.7697
2021 Tritrig	0.7257
2019 run 010051	0.7554
2019 WAB	0.6292
2019 Tritrig	0.6330

Full Preselections

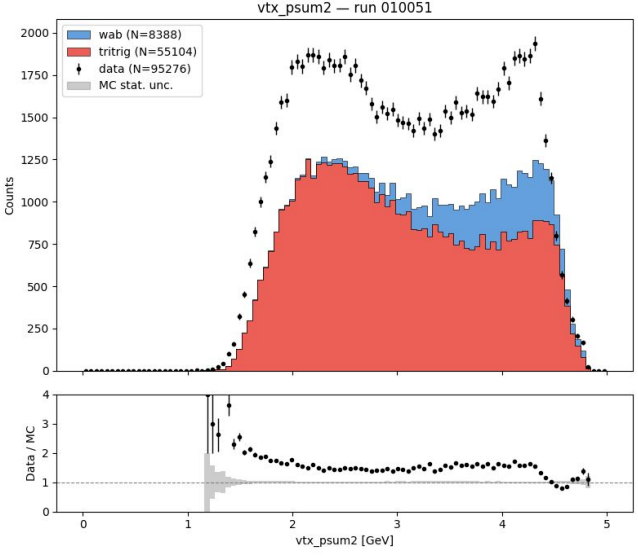




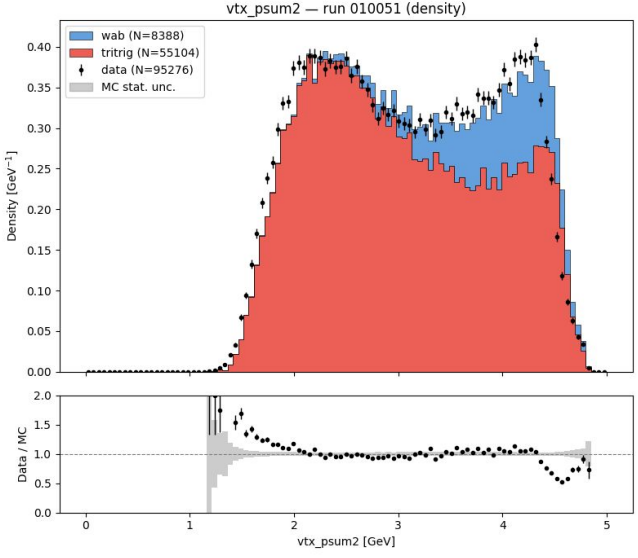
Sample	Efficiency
2021 run 14567	0.1511
2021 WAB	0.0707
2021 Tritrig	0.1432
2019 run 010051	0.2862
2019 WAB	0.045
2019 Tritrig	0.099

MC / Data Comparison: Psum

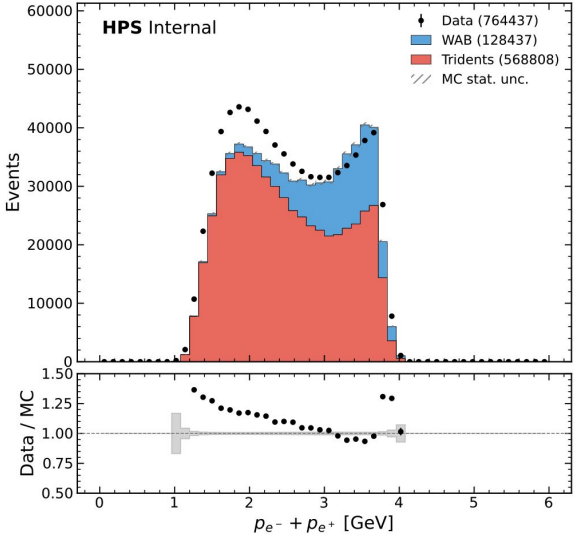
2019 run 010051



2019 run 010051 Density

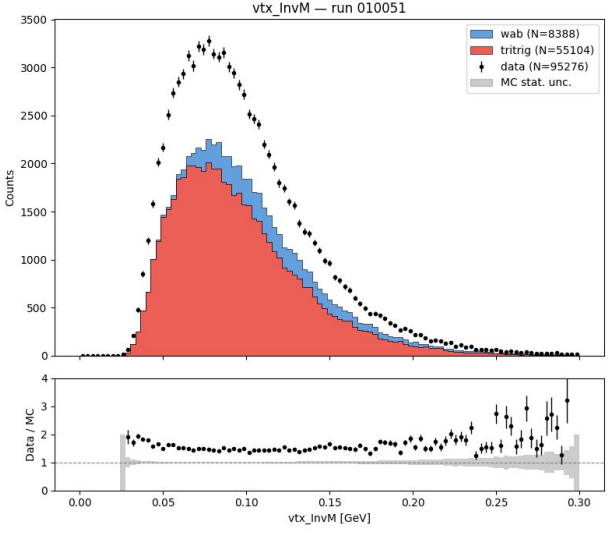


2021 run 14272

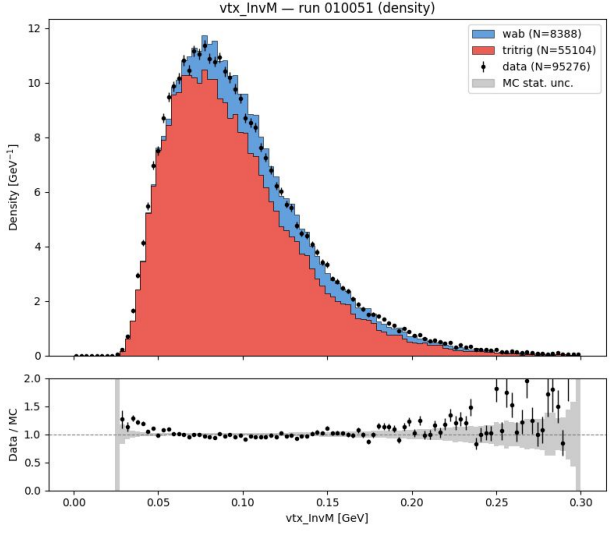


MC / Data Comparison: Inv M

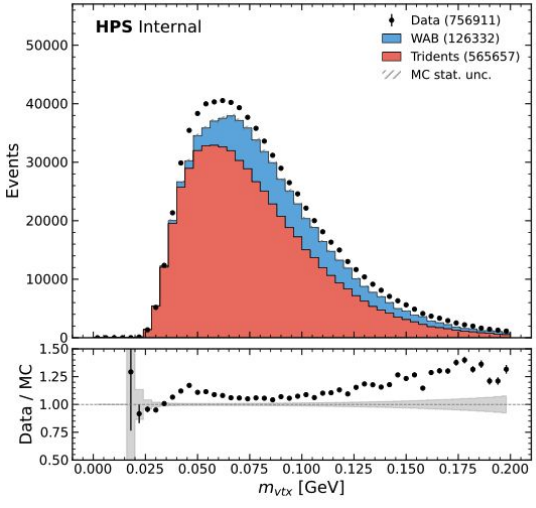
2019 run 010051



2019 run 010051 Density

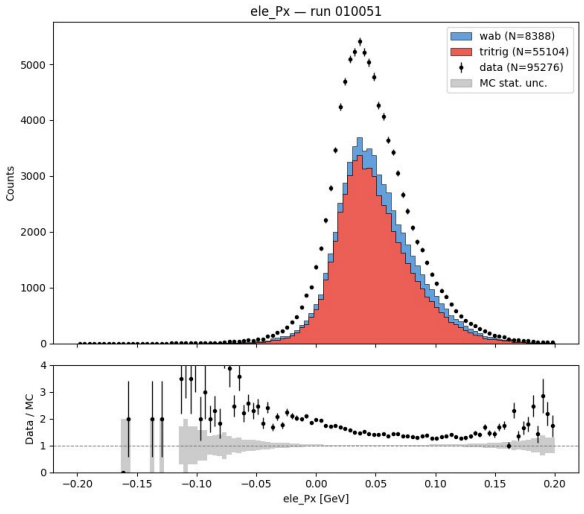


2021 run 14272

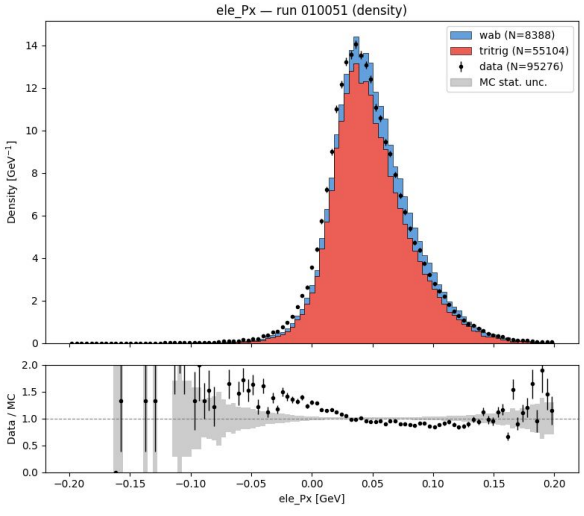


MC / Data Comparison: Electron Px

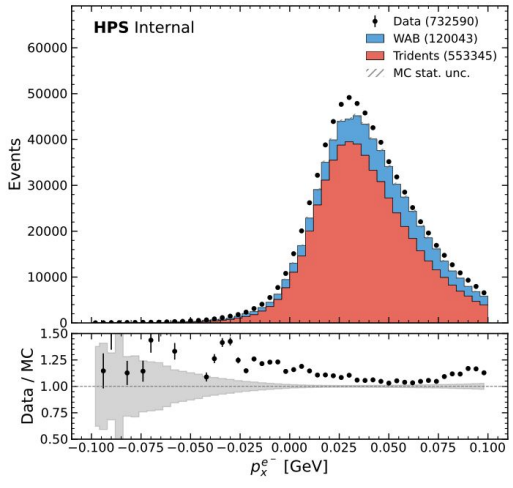
2019 run 010051



2019 run 010051 Density

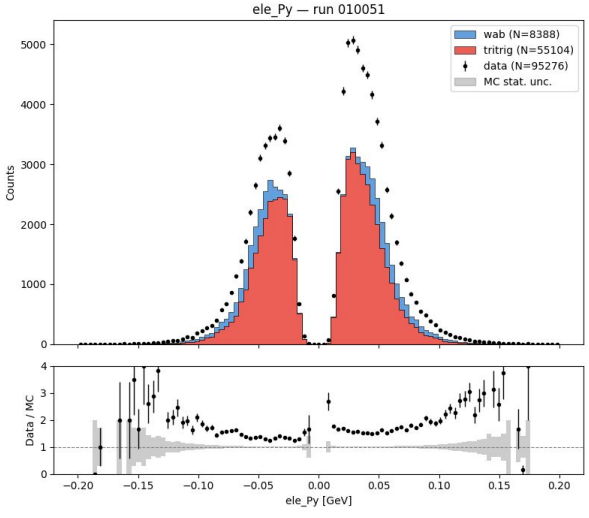


2021 run 14272

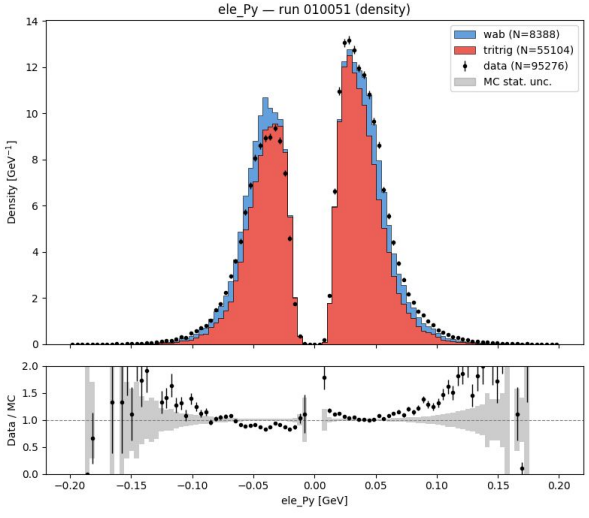


MC / Data Comparison: Electron Py

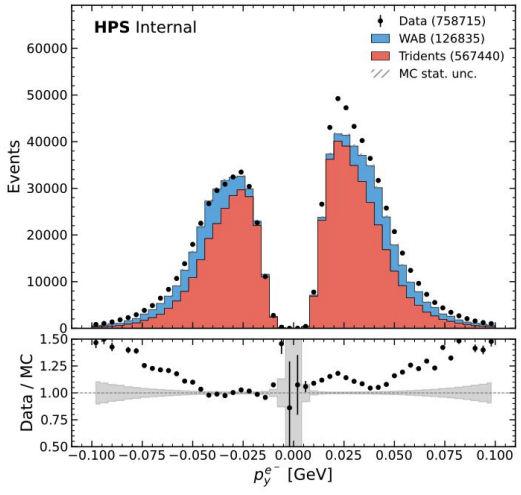
2019 run 010051



2019 run 010051 Density

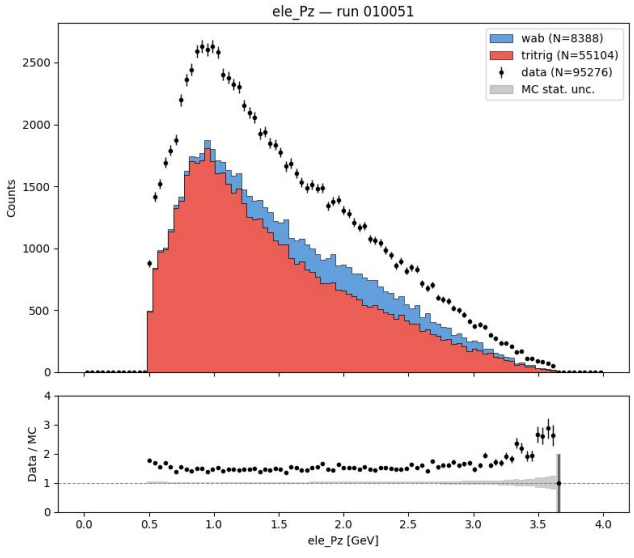


2021 run 14272

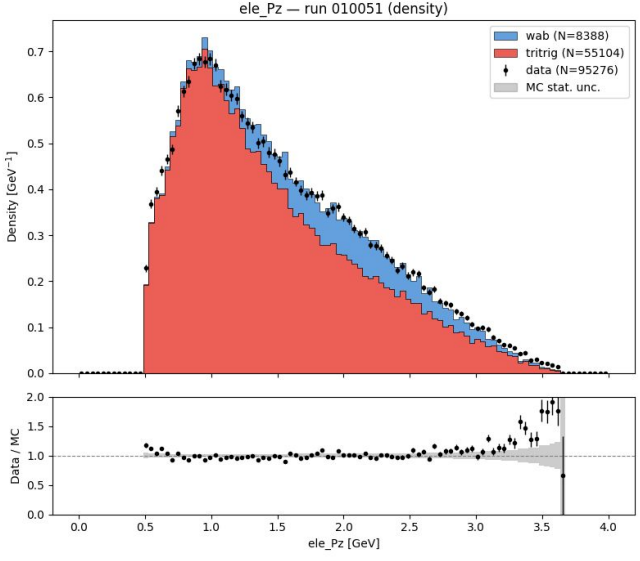


MC / Data Comparison: Electron Pz

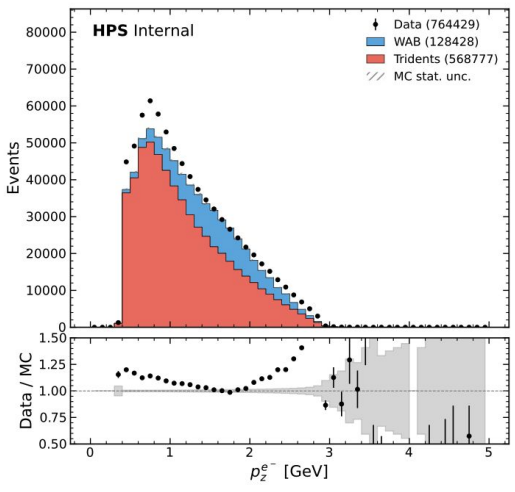
2019 run 010051



2019 run 010051 Density

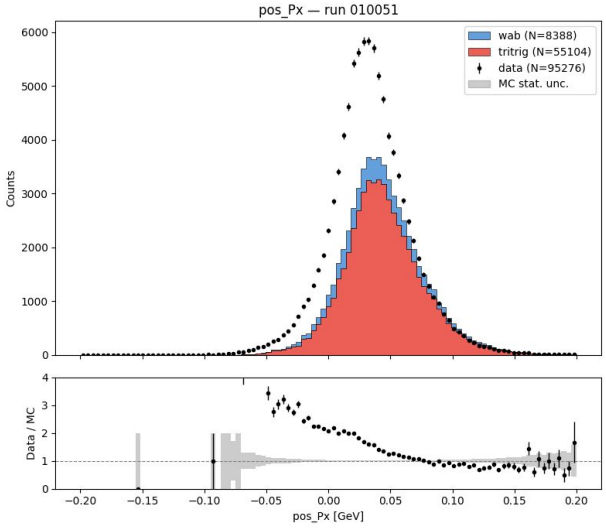


2021 run 14272

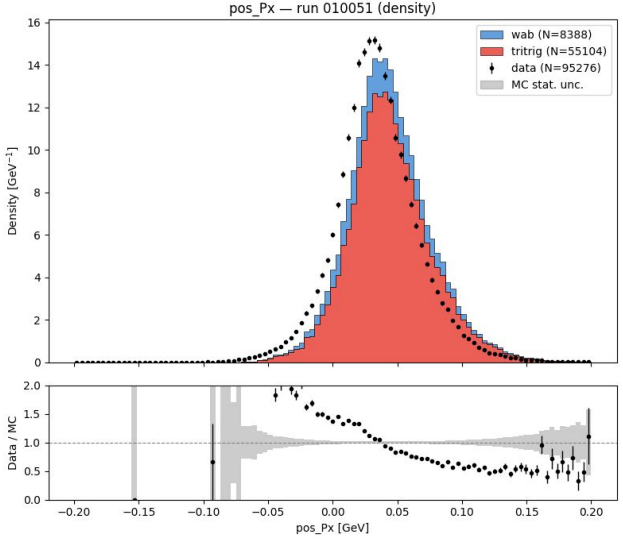


MC / Data Comparison: Positron Px

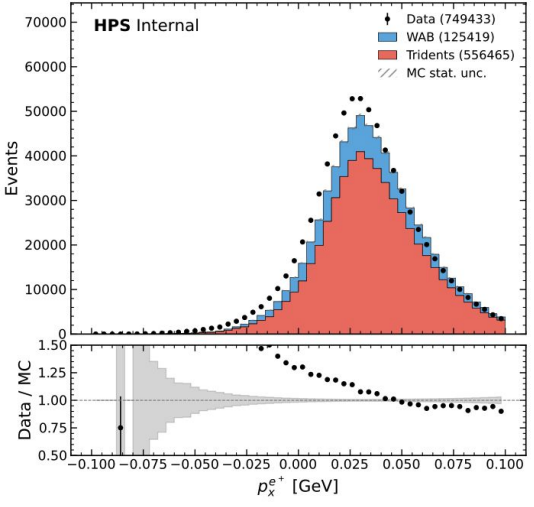
2019 run 010051



2019 run 010051 Density

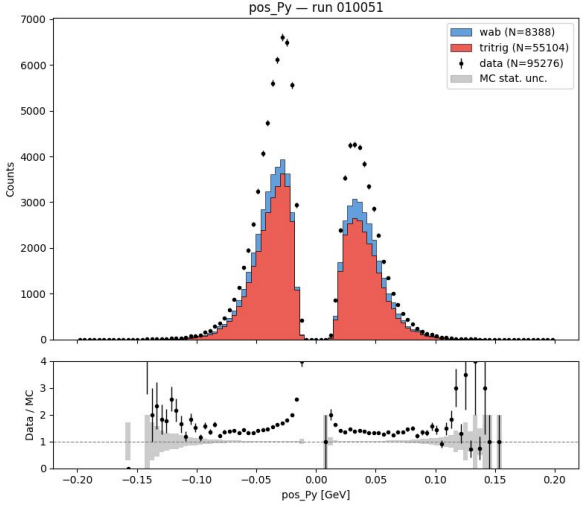


2021 run 14272

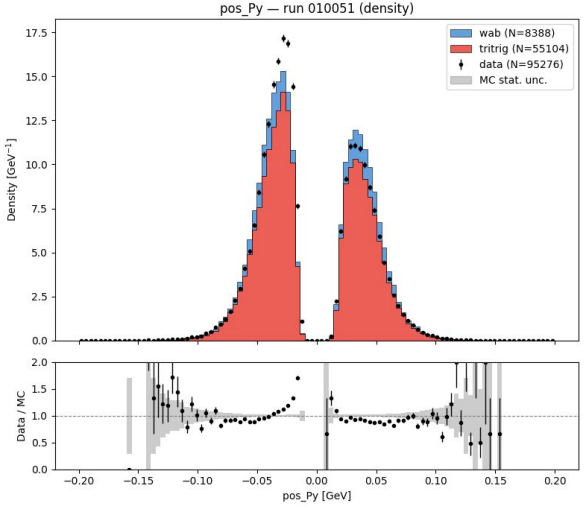


MC / Data Comparison: Positron Py

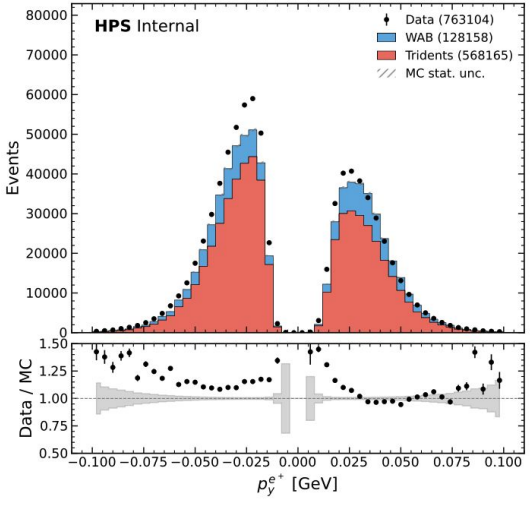
2019 run 010051



2019 run 010051 Density

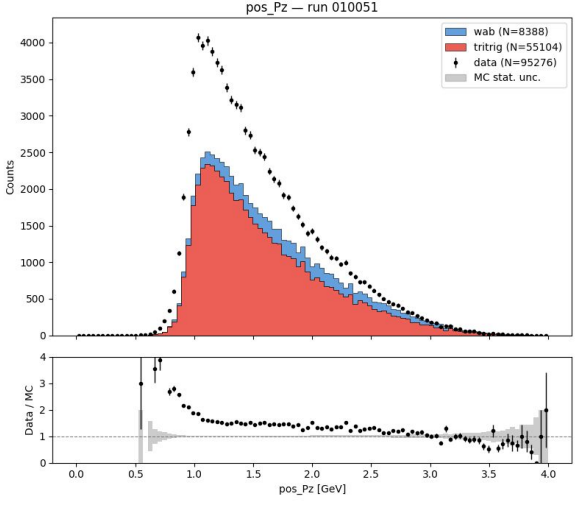


2021 run 14272

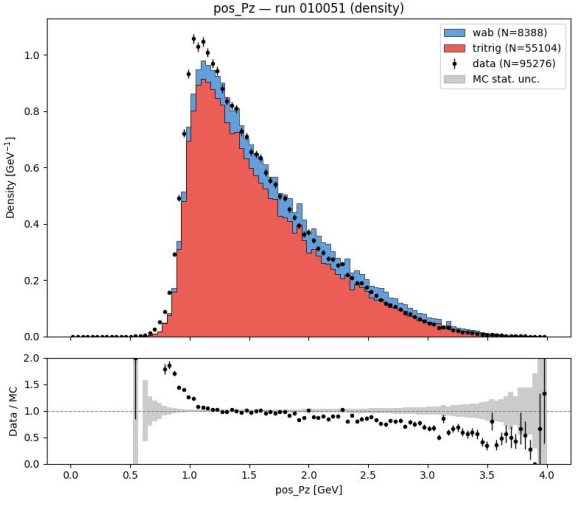


MC / Data Comparison: Positron Pz

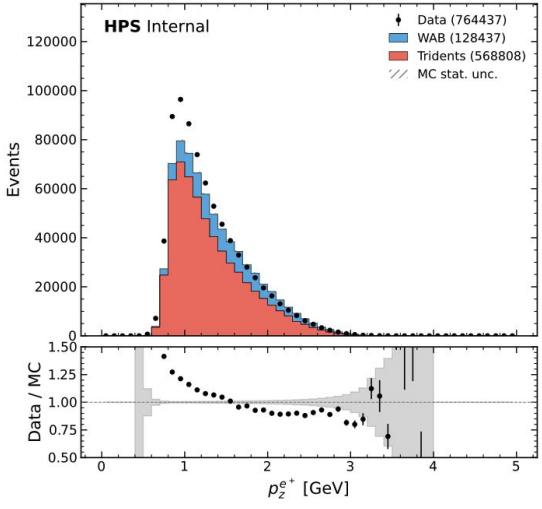
2019 run 010051



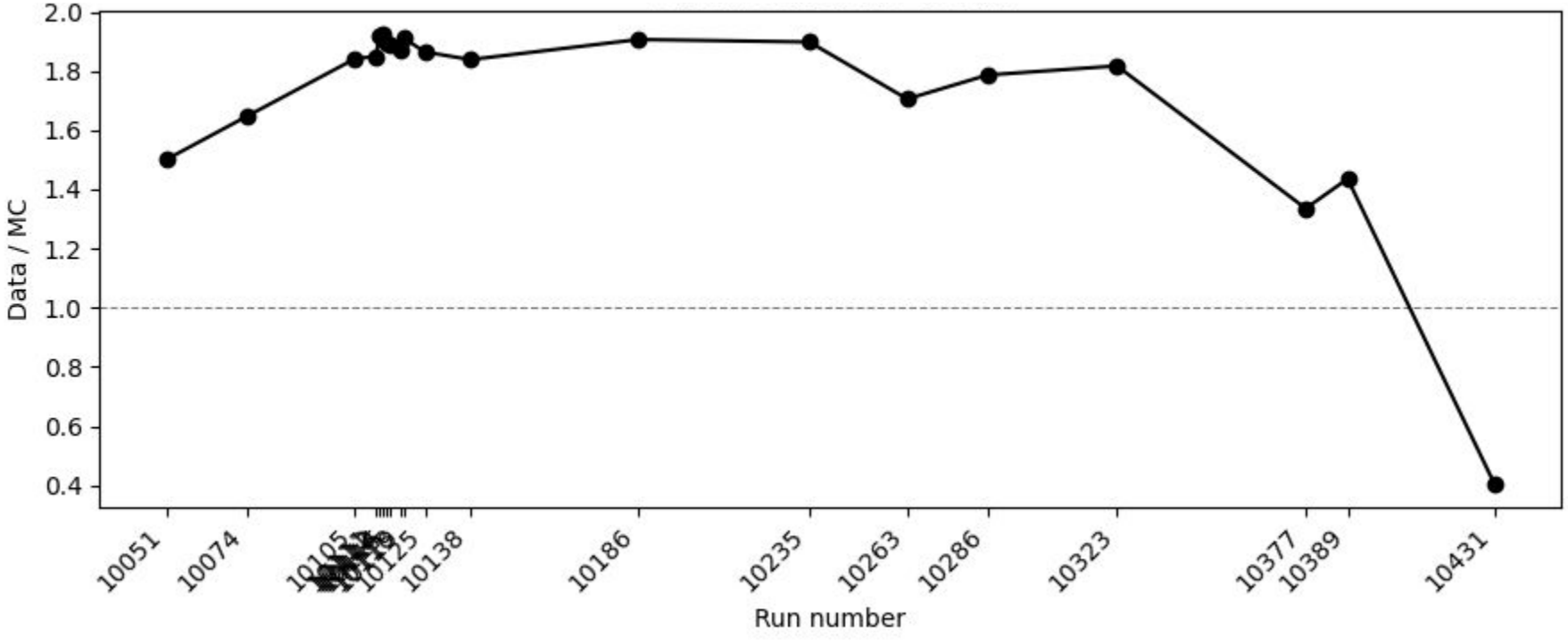
2019 run 010051 Density



2021 run 14272



Data / luminosity scaled MC event rates

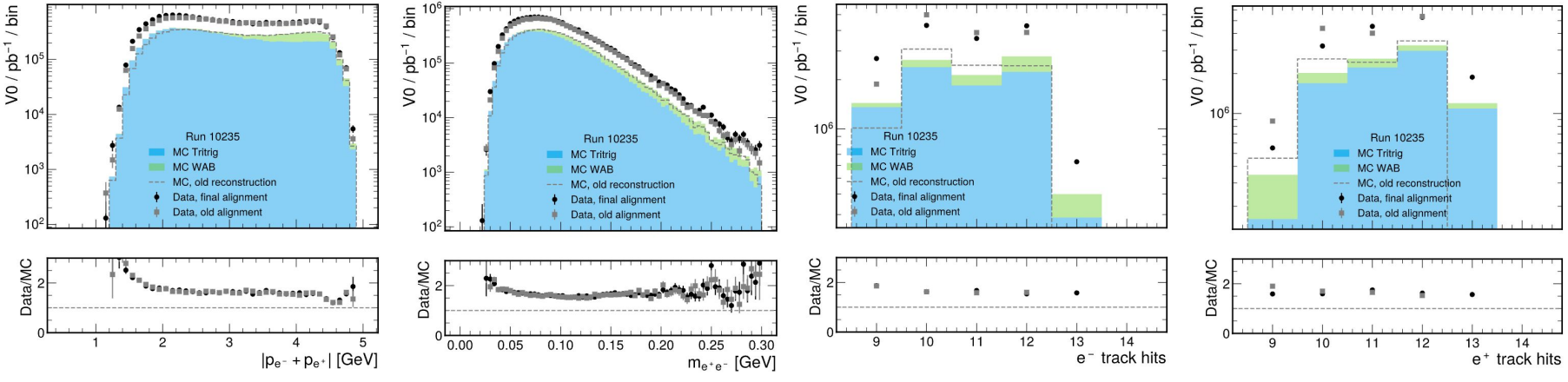


Recap Conclusion

- First round of 2019 preselections has been completed
- While most of our finding seem reasonable / consistent with 2021 there are two main problems to address:
  - Runs with irregular time distributions
  - Data > Luminosity scaled MC event rates

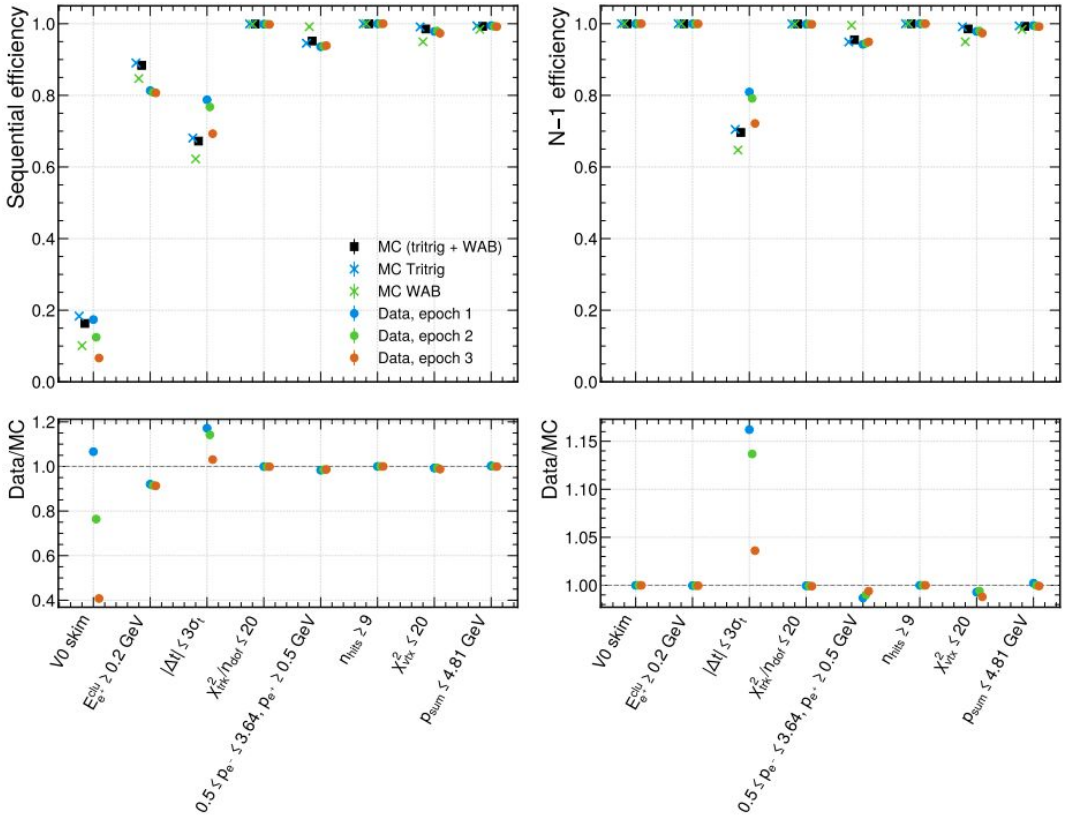
Data/MC with Newest Alignment

- New alignment does not change data/MC comparison conclusions.
- Fraction of 13/14 hit tracks is consistent with ratio in other layers, indicating reasonable alignment of L5/L7.



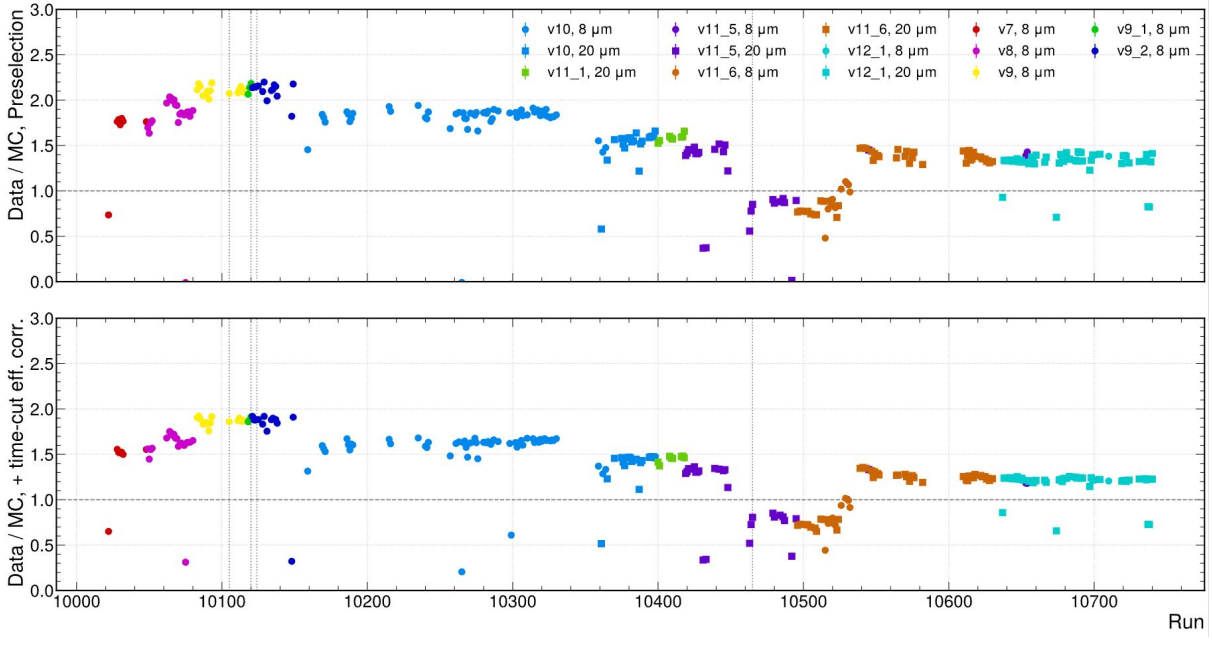
Data/MC Rates

- Data rates are higher than luminosity-scaled MC.
- Data/MC efficiencies are consistent across most preselection cuts, with the biggest differences in timing distributions.



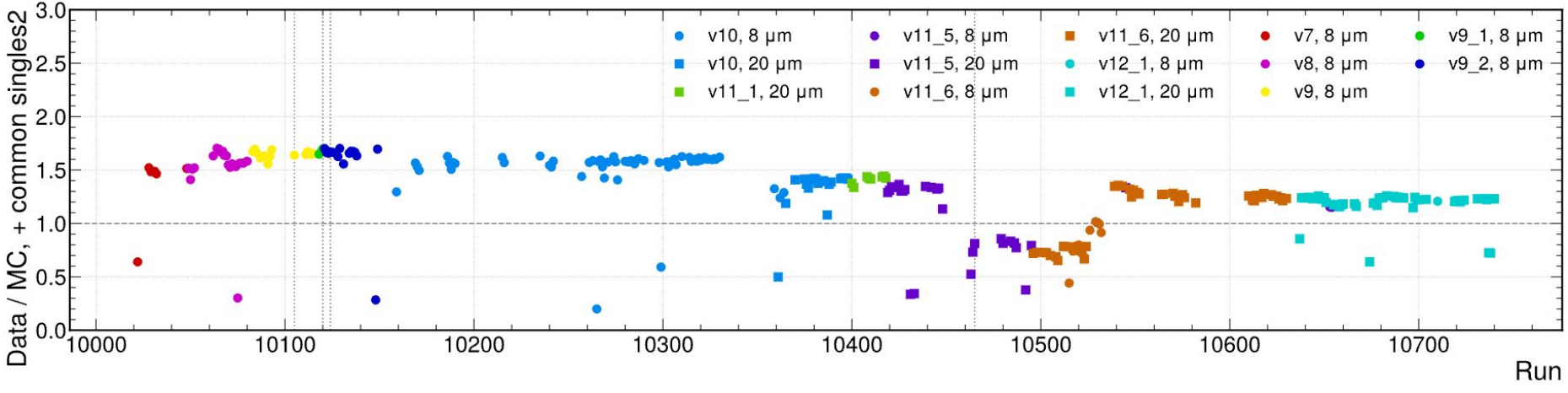
Data/MC Rates

- Correcting for differences in time-cut efficiencies does not explain data/MC rate differences.



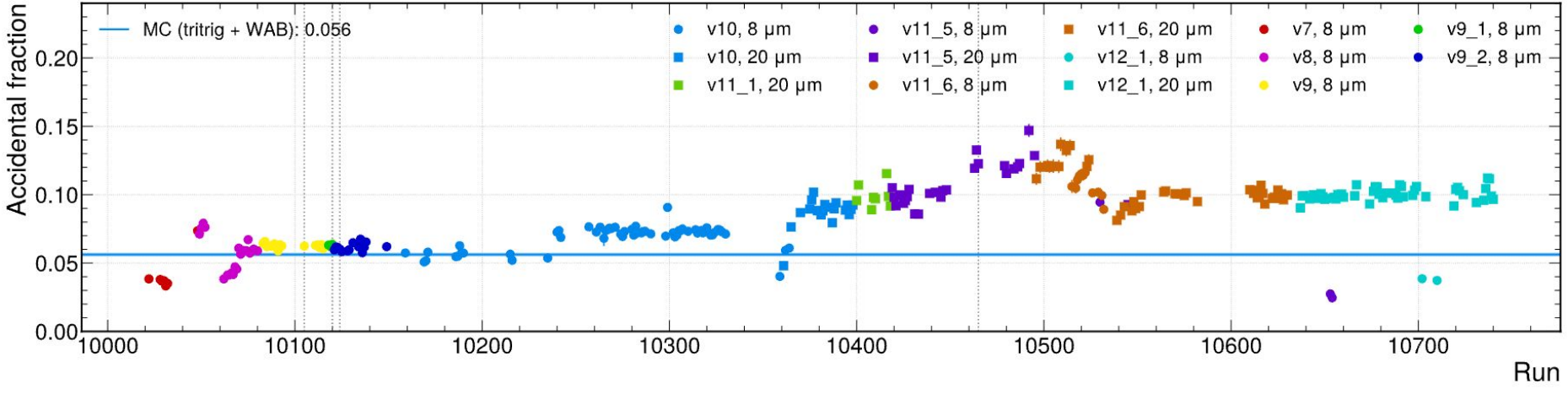
Data/MC Rates

- MC is read out using a single trigger configuration, while trigger configuration changed several times over the run period.
- “Common singles2”: Applying an additional cut on positron’s ECal cluster in all V0s, requiring it to pass the tightest singles2 conditions across all trigger configurations.
- Cleans up variations in early runs, primarily in ‘v9’ triggers.



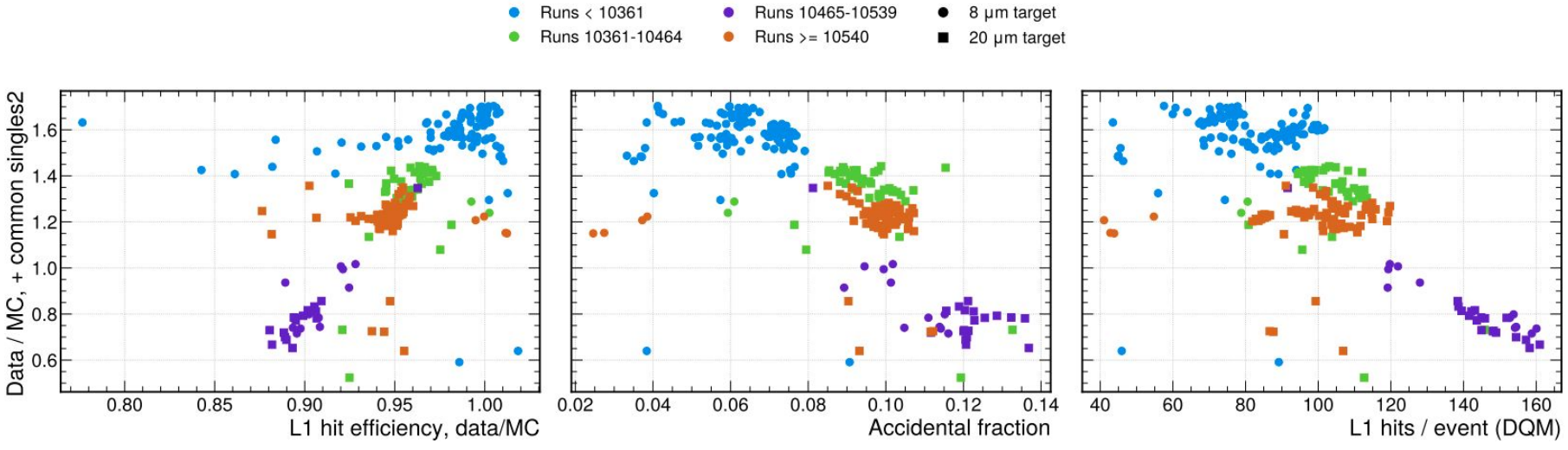
Data/MC Rates

- Variations in data/MC ratios over the run period are strongly correlated with L1 hit efficiency, accidental fraction, L1 occupancy.
- MC is generated with Run 10291 pulser, which falls into the lower-occupancy region, where data/MC ~1.5.



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- MC is generated with Run 10291 pulser, which falls into the lower-occupancy region, where data/MC ~1.5.



MC Plans

- New Tritrig and WAB production with latest detector(s)
- Signal MC, useful for tuning tracking parameters, as in 2021.
- Current MC is generated with 8um target. 20um target MC?
- …