Where are my electrons!?

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DESY SM roundtable

21st October 2024

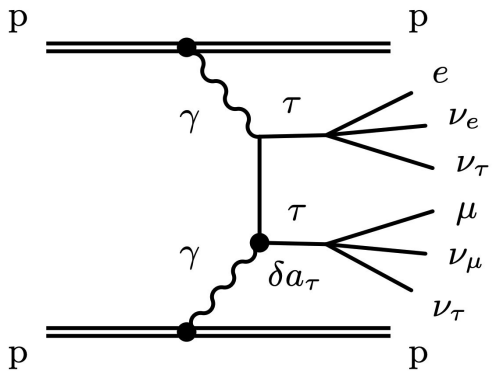
HELMHOLTZ

DESY.

ATLAS EXPERIMENT

First noticed in $\gamma\gamma \to \tau\tau$

- **New analysis**: STDM-2024-05 kicked off 12 Apr 2024.
- **Goal**: observe & measure $\gamma\gamma \to \tau\tau$ in pp, SMEFT dipole interpretation.
- **Timeline**: **Full Run 2+3 analysis** after end of Run 3 data (2027+).



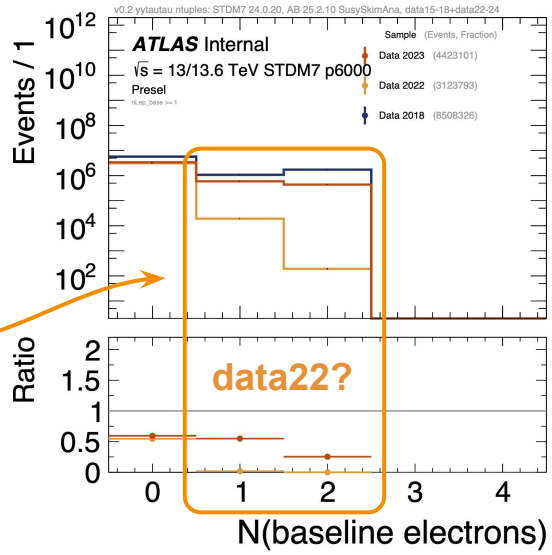
Derivations:

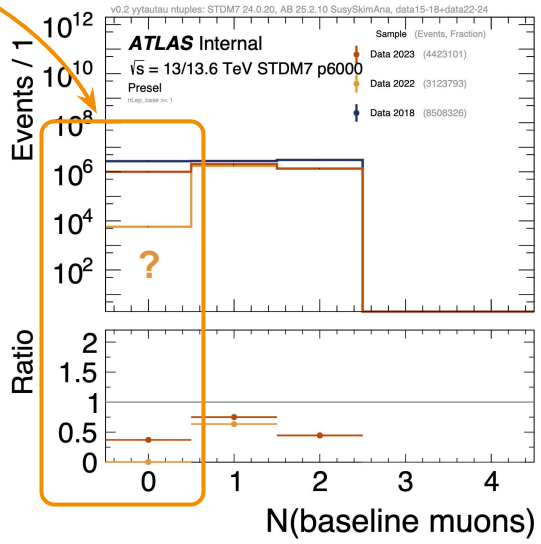
- **PHYS/LITE unsuitable**: skims p_T(trk) > 10 GeV ⇒ S/B ≪ 1.
  But can be used for setup and testing
- **Current custom STDM7 derivation**: N(e/μ) ≥ 2 + p_T(trk) > 0.5 GeV
  Can only study CR-ee+μμ & SR-eμ until we add taus to N(e/μ/τ) ≥ 2 skim
- **STDM7 has been migrated to R22+ but not yet fully validated**
  Philip Sommer migrated STDM7 to R22
  Lydia requested data 15-23 in 24.0.20

Derivations: STDM7 electron deficit puzzle

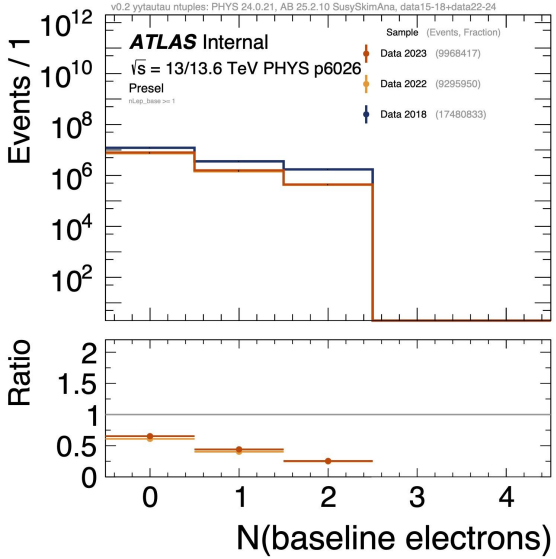
- **Electron deficit in 2022 STDM7 data** but not in PHYS data →
- Fewer events with > zero electrons in 2022
- Fewer events with exactly zero muons in 2022
- All points towards a **trigger issue** as STDM7 only keeps events triggered by electron and muon triggers

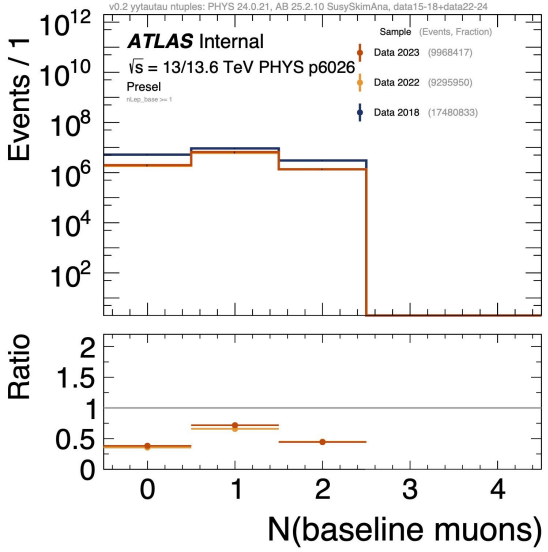
STDM7 24.0.20 (p6000)





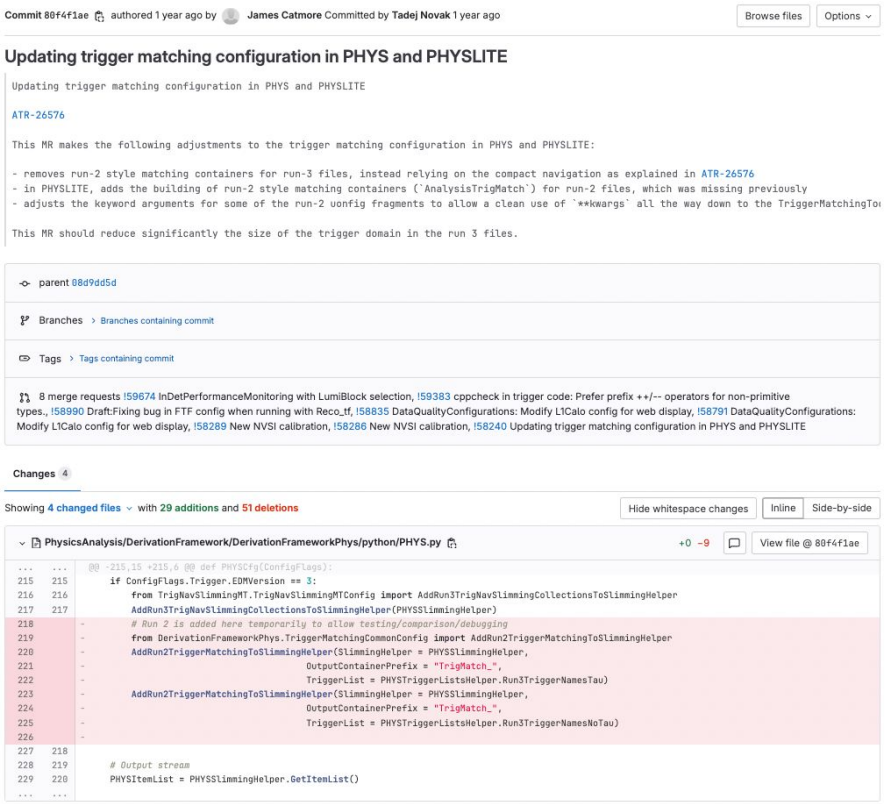
PHYS 24.0.21 (p6026)





Trigger matching problem?

- Noticed by Egamma group when using EGAM2 derivations [ATLEGAMDPD-249]
- Trigger matching was updated for PHYS and PHYSLITE [ATR-26576] in 23.0.10, changing the way trigger matching is done between mc20 and data samples
- Problem impacted Run 2 derivations being reprocessed in new releases



Commit 80f4f1ae authored 1 year ago by James Catmore Committed by Tadej Novak 1 year ago

Browse files | Options

Updating trigger matching configuration in PHYS and PHYSLITE

```
Updating trigger matching configuration in PHYS and PHYSLITE

ATR-26576

This MR makes the following adjustments to the trigger matching configuration in PHYS and PHYSLITE:

- removes run-2 style matching containers for run-3 files, instead relying on the compact navigation as explained in ATR-26576
- in PHYSLITE, adds the building of run-2 style matching containers (`AnalysisTrigMatch`) for run-2 files, which was missing previously
- adjusts the keyword arguments for some of the run-2 uonfig fragments to allow a clean use of `**kwargs` all the way down to the TriggerMatchingTo

This MR should reduce significantly the size of the trigger domain in the run 3 files.
```

parent 08d9dd5d

Branches > Branches containing commit

Tags > Tags containing commit

8 merge requests !59674 InDetPerformanceMonitoring with LumiBlock selection, !59383 cppcheck in trigger code: Prefer prefix ++/-- operators for non-primitive types., !58990 Draft:Fixing bug in FTF config when running with Reco_tf, !58835 DataQualityConfigurations: Modify L1Calo config for web display, !58791 DataQualityConfigurations: Modify L1Calo config for web display, !58289 New NVSI calibration, !58286 New NVSI calibration, !58240 Updating trigger matching configuration in PHYS and PHYSLITE

Changes 4

Showing 4 changed files with 29 additions and 51 deletions | Hide whitespace changes | Inline | Side-by-side

PhysicsAnalysis/DerivationFramework/DerivationFrameworkPhys/python/PHYS.py +0 -9 | View file @ 80f4f1ae

```
@@ -215,15 +215,6 @@ def PHYSCfg(ConfigFlags):
    if ConfigFlags.Trigger.EDMVersion == 3:
        from TrigNavSlimmingMT.TrigNavSlimmingMTConfig import AddRun3TrigNavSlimmingCollectionsToSlimmingHelper
        AddRun3TrigNavSlimmingCollectionsToSlimmingHelper(PHYSSlimmingHelper)
-       # Run 2 is added here temporarily to allow testing/comparison/debugging
-       from DerivationFrameworkPhys.TriggerMatchingCommonConfig import AddRun2TriggerMatchingToSlimmingHelper
-       AddRun2TriggerMatchingToSlimmingHelper(SlimmingHelper = PHYSSlimmingHelper,
-                                              OutputContainerPrefix = "TrigMatch_",
-                                              TriggerList = PHYSTriggerListsHelper.Run3TriggerNamesTau)
-       AddRun2TriggerMatchingToSlimmingHelper(SlimmingHelper = PHYSSlimmingHelper,
-                                              OutputContainerPrefix = "TrigMatch_",
-                                              TriggerList = PHYSTriggerListsHelper.Run3TriggerNamesNoTau)
-

    # Output stream
    PHYSItemList = PHYSSlimmingHelper.GetItemList()
```

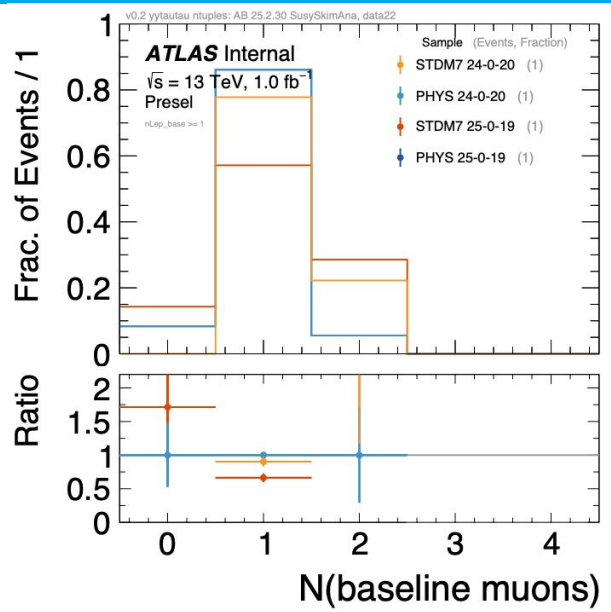
So is this the problem we see?

- Perhaps…
- Some **updates to trigger matching syntax for all derivations** recently

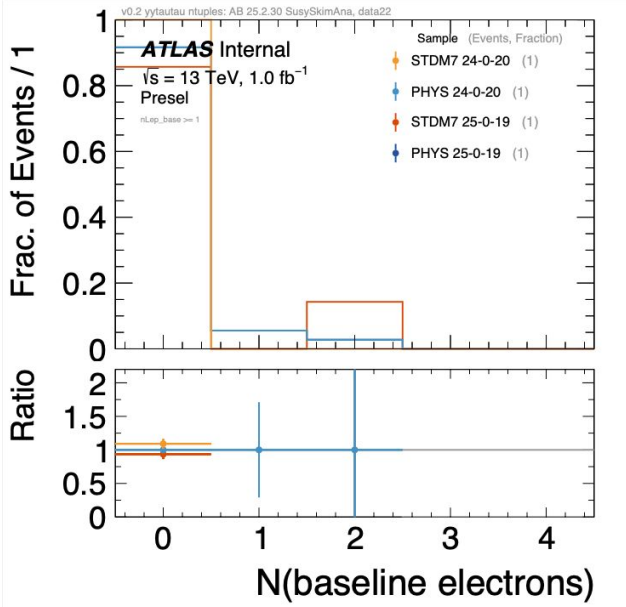
  → See changes made to STDM7.py
- Let's try a new release and see!

Testing a newer release

- I made local mini derivations, running over 2000 events of **data22_13p6TeV.00438481.physics_Main.merge.AOD.r15869_p6304** (random run that was in the AllGood GRL for 2022)
- Produced **STDM7 and PHYS** using Athena **25.0.19** (will be used for latest bulk PHYS production [ATLASDPD-2162]) and **24.0.20** (version used for original STDM7 derivations with missing electrons)
- Using SusySkimAna framework to compare
  - → Ratios are to PHYS 25.0.19
- Two PHYS versions agree perfectly = good!
- Clear differences in STDM7 versions
- Differences between PHYS and STDM7 not unexpected - different derivation skimming



Presel = >= 1 baseline lepton



Problem solved?

But, during my investigations

I noticed something else suspicious…

Missing extra trigger checks?

- STDM7 asks for all lowest unprescaled electron and muon triggers and combinations of the two
- It then also checks the list of “extra” triggers in the PHYS derivations
- BUT **this is only checked for Run 2 triggers**:

```
45      # require an OR of el and mu triggers, in the past we had a dedicated SM list but this should do just fine
46      from TriggerMenuMT.TriggerAPI.TriggerAPI import TriggerAPI
47      from TriggerMenuMT.TriggerAPI.TriggerEnums import TriggerPeriod, TriggerType
48      allperiods = TriggerPeriod.y2015 | TriggerPeriod.y2016 | TriggerPeriod.y2017 | TriggerPeriod.y2018 | TriggerPeriod.future2e34
49      TriggerAPI.setConfigFlags(flags)
50      trig_el    = TriggerAPI.getLowestUnprescaledAnyPeriod(allperiods, triggerType=TriggerType.el,  livefraction=0.8)
51      trig_mu    = TriggerAPI.getLowestUnprescaledAnyPeriod(allperiods, triggerType=TriggerType.mu,  livefraction=0.8)
52      trig_em    = TriggerAPI.getLowestUnprescaledAnyPeriod(allperiods, triggerType=TriggerType.el, additionalTriggerType=TriggerType.mu,  livefract
53
54      # Read list of triggers from PHYS
55      extra_notau = []
56      from PathResolver import PathResolver
57      with open(PathResolver.FindCalibFile("DerivationFrameworkPhys/run2ExtraMatchingTriggers.txt")) as fp:
58          for line in fp:
59              line = line.strip()
60              if line == "" or line.startswith("#"):
61                  continue
62              extra_notau.append(line)
63
64      ## Merge and remove duplicates
65      trigger_names_full_notau = list(set(trig_el+trig_mu+trig_em+extra_notau))
66      STDM7TriggerSkimmingTool = CompFactory.DerivationFramework.TriggerSkimmingTool(name = "STDM7TriggerSkimmingTool",
67                                                                                     OutputLevel   = 0,
68                                                                                     TriggerListOR = trigger_names_full_notau,
69                                                                                     TriggerListAND = [] )
```

- Compare this directly to PHYS, which also checks for extra Run 3 triggers:

```
170             ## Add extra chains from file
171             extra_file = read_trig_list_file("DerivationFrameworkPhys/run3ExtraMatchingTriggers.txt")
```

So what are these extra triggers?

- Included in [run3ExtraMatchingTriggers.txt]:

run3ExtraMatchingTriggers.txt 3.67 KiB | Blame | Edit | Lock | Replace | Delete

```
# A note on the format of this file
# Lines beginning with a '#' character are comments and will be ignored, as will empty lines
# Triggers are broken up into sections to make it easier to read, and when adding new triggers
# please try and keep them in alphabetical order

#####################
# Muon triggers     #
#####################

############################
# Electron triggers        #
# Legacy EM                #
# Used in 1st part of 2023 #
############################

HLT_2e17_lhvloose_L12EM15VHI
HLT_2e24_lhvloose_L12EM20VH
HLT_e24_lhvloose_2e12_lhvloose_L1EM20VH_3EM10VH
HLT_e26_lhtight_e14_etcut_probe_50invmAB130_L1EM22VHI
HLT_e26_lhtight_e14_idperf_tight_nogsf_probe_50invmAB130_L1EM22VHI
HLT_e26_lhtight_e14_idperf_tight_probe_50invmAB130_L1EM22VHI
HLT_e26_lhtight_ivarloose_e14_idperf_tight_probe_L1EM22VHI
HLT_e26_lhtight_ivarloose_e30_lhloose_nopix_lrtmedium_probe_L1EM22VHI
HLT_e26_lhtight_ivarloose_e30_lhloose_nopix_probe_L1EM22VHI
HLT_e26_lhtight_ivarloose_e4_etcut_probe_L1EM22VHI
HLT_e26_lhtight_ivarloose_e5_idperf_loose_lrtloose_probe_L1EM22VHI
HLT_e26_lhtight_ivarloose_e5_lhtight_probe_L1EM22VHI
HLT_e26_lhtight_ivarloose_e7_lhmedium_probe_L1EM22VHI
HLT_2e17_lhvloose_g20_tight_probe_L12EM15VHI
HLT_2e17_lhvloose_g25_medium_probe_L12EM15VHI
HLT_2e17_lhvloose_g50_loose_probe_L12EM15VHI
HLT_2e24_lhvloose_g20_tight_probe_L12EM20VH
HLT_2e24_lhvloose_g25_medium_probe_L12EM20VH
HLT_2e24_lhvloose_g50_loose_probe_L12EM20VH
HLT_2e12_lhloose_mu10_L12EM8VH_MU8F
HLT_e140_lhloose_L1EM22VHI
HLT_e140_lhloose_noringer_L1EM22VHI
HLT_e26_lhtight_ivarloose_L1EM22VHI
HLT_e30_lhloose_nopix_lrtmedium_L1EM22VHI
HLT_e300_etcut_L1EM22VHI
HLT_e60_lhmedium_L1EM22VHI
HLT_e24_lhmedium_g12_loose_g12_loose_02dRAB_02dRAC_02dRBC_L1EM20VH_3EM10VH
HLT_e24_lhmedium_g25_medium_02dRAB_L12EM20VH
HLT_e25_mergedtight_g35_medium_90invmAB_02dRAB_L12EM20VH
HLT_e26_lhtight_ivarloose_2j20_0eta290_020jvt_boffperf_pf_ftf_L1EM22VHI
HLT_e26_lhtight_ivarloose_j20_pf_ftf_L1EM22VHI
HLT_e12_lhloose_2mu10_L12MU8F
```

This is the lowest unprescaled single electron trigger for 2022 (and 2022 only!!)

Are we really missing this trigger?

- But surely the trigger tool is smart enough to know that this is the lowest unprescaled trigger for 2022..?
- You'd hope so, but there is no specific period defined for 2022

```
45      # require an OR of el and mu triggers, in the past we had a dedicated SM list but this should do just fine
46      from TriggerMenuMT.TriggerAPI.TriggerAPI import TriggerAPI
47      from TriggerMenuMT.TriggerAPI.TriggerEnums import TriggerPeriod, TriggerType
48      allperiods = TriggerPeriod.y2015 | TriggerPeriod.y2016 | TriggerPeriod.y2017 | TriggerPeriod.y2018 | TriggerPeriod.future2e34
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52      trig_em    = TriggerAPI.getLowestUnprescaledAnyPeriod(allperiods, triggerType=TriggerType.el, additionalTriggerType=TriggerType.mu,  livefract
```

- The period "future2e34" is used for all of Run 3

  → What does it mean? What triggers does this find? Even Tadej doesn't know…

- My **plan today** is to test adding this extra trigger check to STDM7.py to produce another set of mini derivations

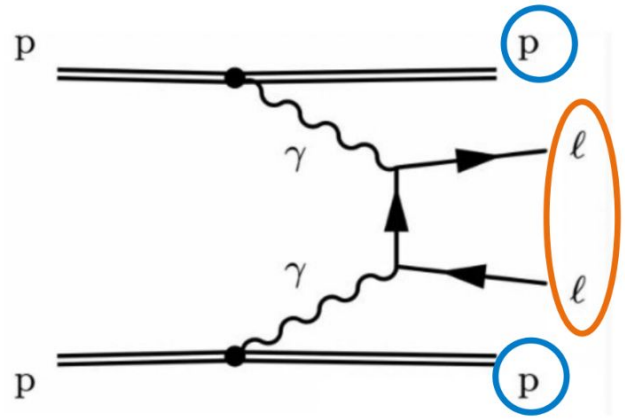
Aside: AFP global alignment

AFP global alignment

- Global alignment procedure compares dilepton kinematics in ATLAS to forward proton kinematics in AFP

See Weronika's ATLAS-D talk

Final in-situ global alignment correction:
use run 3 exclusive di-muon events



ATLAS central detector:
- calculate predicted position

$\xi_{\mu\mu} = (m_{\mu\mu}/\sqrt{s})\, e^{\pm y_{\mu\mu}}$ mapped to $x_{\mu\mu}$

AFP:
- measured proton position

x_{AFP}

- Alignment code is built to skim **STDM7 derivations**
- Tomasz Mróz (IFJ Kraków) is working on the same procedure using **dielectron events**
- Weronika sees no problem with muons but Tomasz sees something weird in 2022 data…

Electrons for AFP global alignment

Tomasz' talk in June ARP GM: https://indico.cern.ch/event/1418473/#208-global-alignment-with-excl

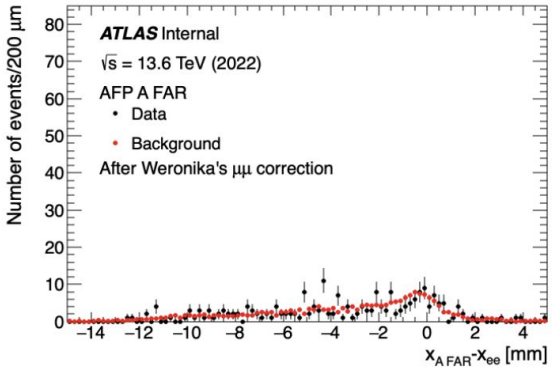
- **Applied Cuts**
  - Electron-positron events selected: leading and secondary
  - Confirming opposite charge signs
  - Individual pt >18 GeV
  - $\xi ll > 0.01$
  - pt(ll) < 5 GeV
  - |dz0| > 0.5 mm (the closest track must be at least that far from interaction center)
  - $|\eta| < 2.4$

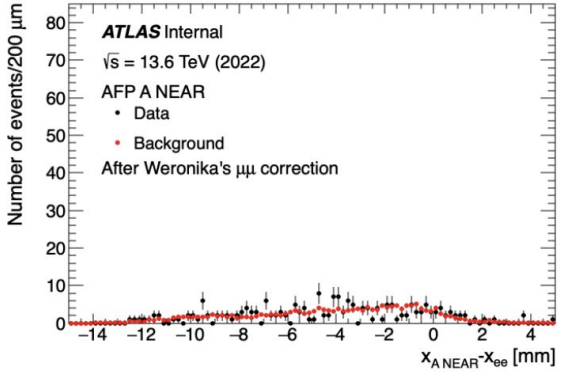
No explicit trigger requirement, other than those skimmed in STDM7

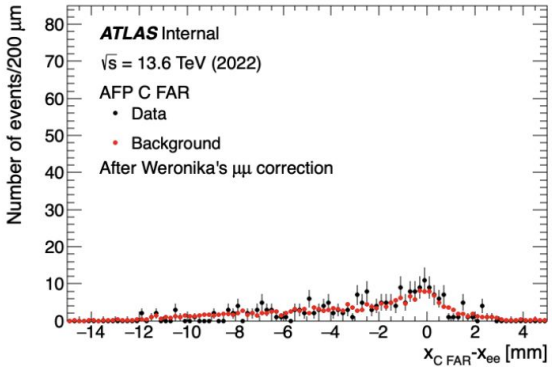
- **The three steps taken to process the data**
  - Skimming the STDM7 DAOD file,
  - Selecting the exclusive electron events for the calibration
  - Plots generation and calculation of corrective values

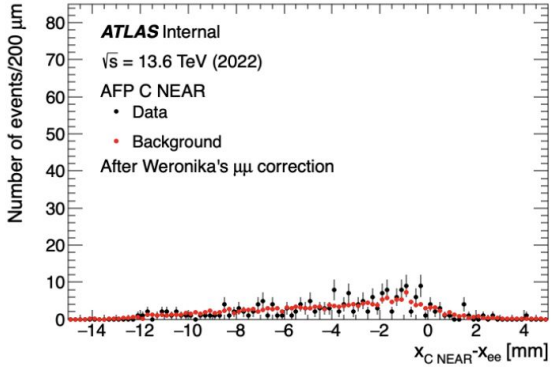
Electrons for AFP global alignment

Tomasz' talk in June ARP GM: https://indico.cern.ch/event/1418473/#208-global-alignment-with-excl

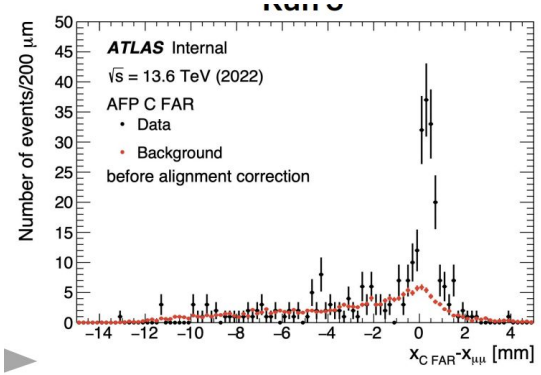








Compare to Weronika's plots for muons:



- Total data after exclusive di-electron cuts consistent with event-mixed background
- **Electrons exist - just no correlation with forward protons in AFP**
- But is it as many events as we would expect..?

Electrons for AFP global alignment

Tomasz' talk in June ARP GM: https://indico.cern.ch/event/1418473/#208-global-alignment-with-excl

What could be going wrong?

- **Central detector problem?** E.g. calorimeter synchronisation problem?
  - By this point, someone else would have noticed… surely..?
- **Problem in AFP?**
  - No problem seen for muons
- **GRL?**
  - Different GRLs in 2022 for different subsystems required
  - Tomasz is probably using muon GRL but electron all good is just a subset of this
- **Problem with STDM7 derivation?**
  - Could missing triggers/trigger matching bug cause the problems we see?
- **Problem with ntuple skimming?**
  - No selection on trigger here so only STDM7 skim applied in this sense
- **Problem in Tomasz' code?**
  - Same procedure applied between years and 2023 is okay

Getting closer to answering the question

Where are my electrons in 2022 data? :’(

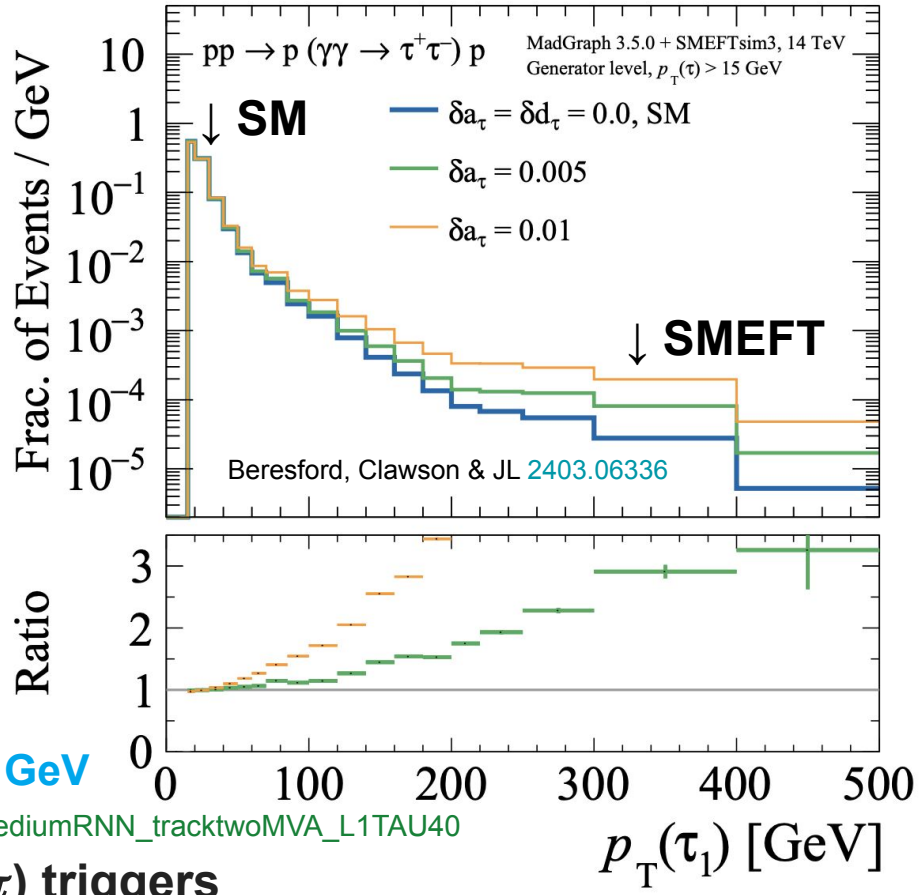
Probably just a trigger matching issue in custom derivations (now solved)
but I want to fully validate locally before requesting a new production

Backup

Trigger strategy

- **Single electron triggers**
  - 2015: **HLT_e24**_lhmedium_L1EM20VH
  - 2016–18: **HLT_e26**_lhtight_nod0_ivarloose
  - 2022: **HLT_e26**_lhtight_ivarloose_L1EM22VHI
  - 2023–: **HLT_e26**_lhtight_ivarloose_L1eEM26M
- **Single muon triggers**
  - 2015: **HLT_mu20**_iloose_L1MU15
  - 2016–18: **HLT_mu26**_ivarmedium
  - 2022–: **HLT_mu24**_ivarmedium_L1MU14FCH
- **Di-tau triggers**
  - CMS ditau no ISR jet $p_T(\tau) > 40$ GeV
  - ATLAS ditau no ISR jet $p_T(\tau) > 80/60$ GeV

  HLT_tau80_mediumRNN_tracktwoMVA_L1TAU60_**tau60**_mediumRNN_tracktwoMVA_L1TAU40



- **To study: dilepton (ee, μμ, eμ, eτ, μτ) triggers**
  - **HLT_2e17**_lhvloose, **HLT_2mu14, HLT_e17**_lhloose_**mu14**
  - **HLT_e24**_lhmedium_ivarloose_**tau20**_mediumRNN, **HLT_mu20**_ivarloose_**tau20**_mediumRNN
  - Trigger impact needs studies: SM dominates low p_T while BSM likely high p_T
- **Status: baseline triggers as any ττ analysis; yet to start dedicated studies.**