



# Phase2 Level-1 Trigger Software

Phase2 Upgrade Joint  
Muon DPG & Level1 Trigger Workshop

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Detector  
Geometry

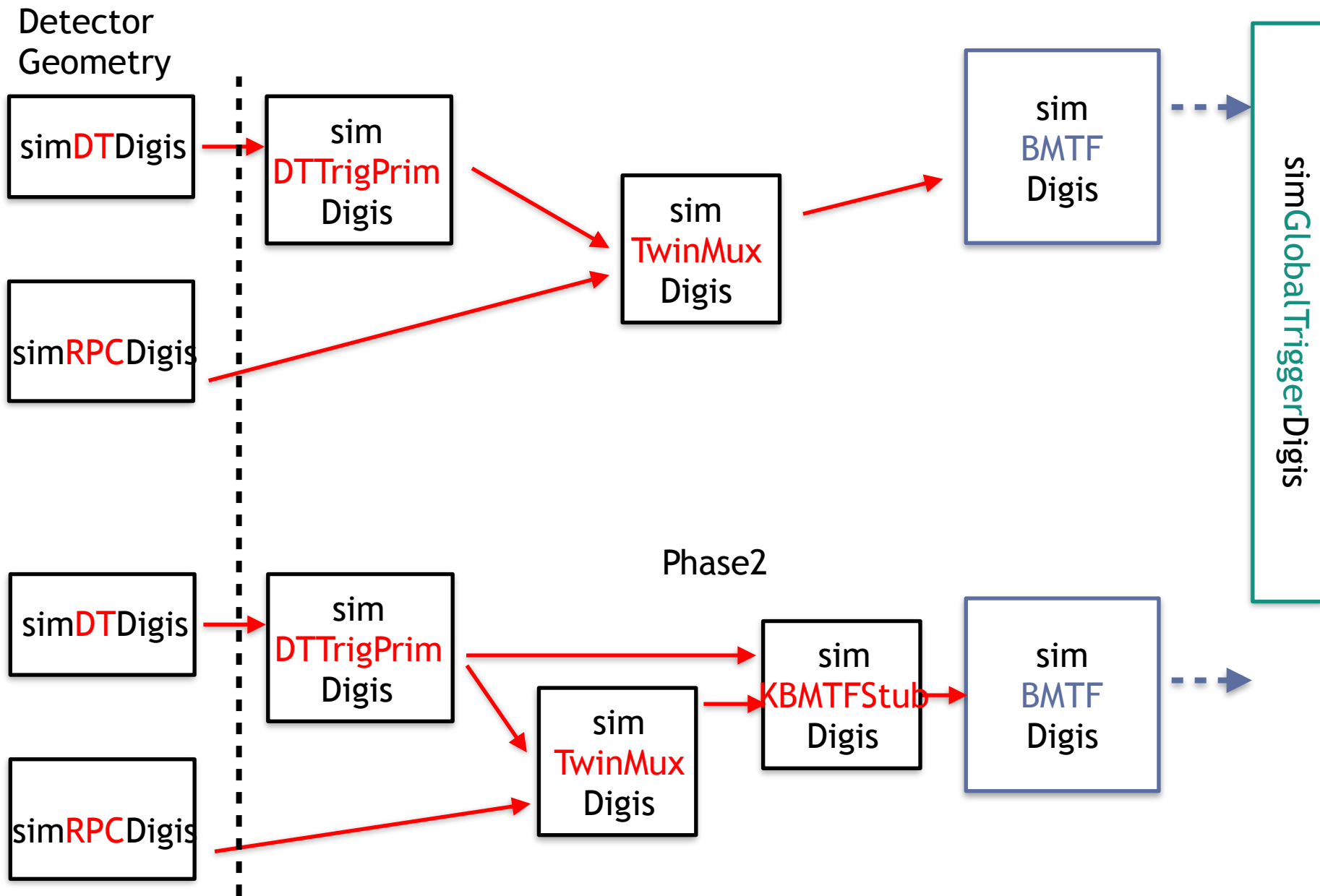
## Muon Track Finders



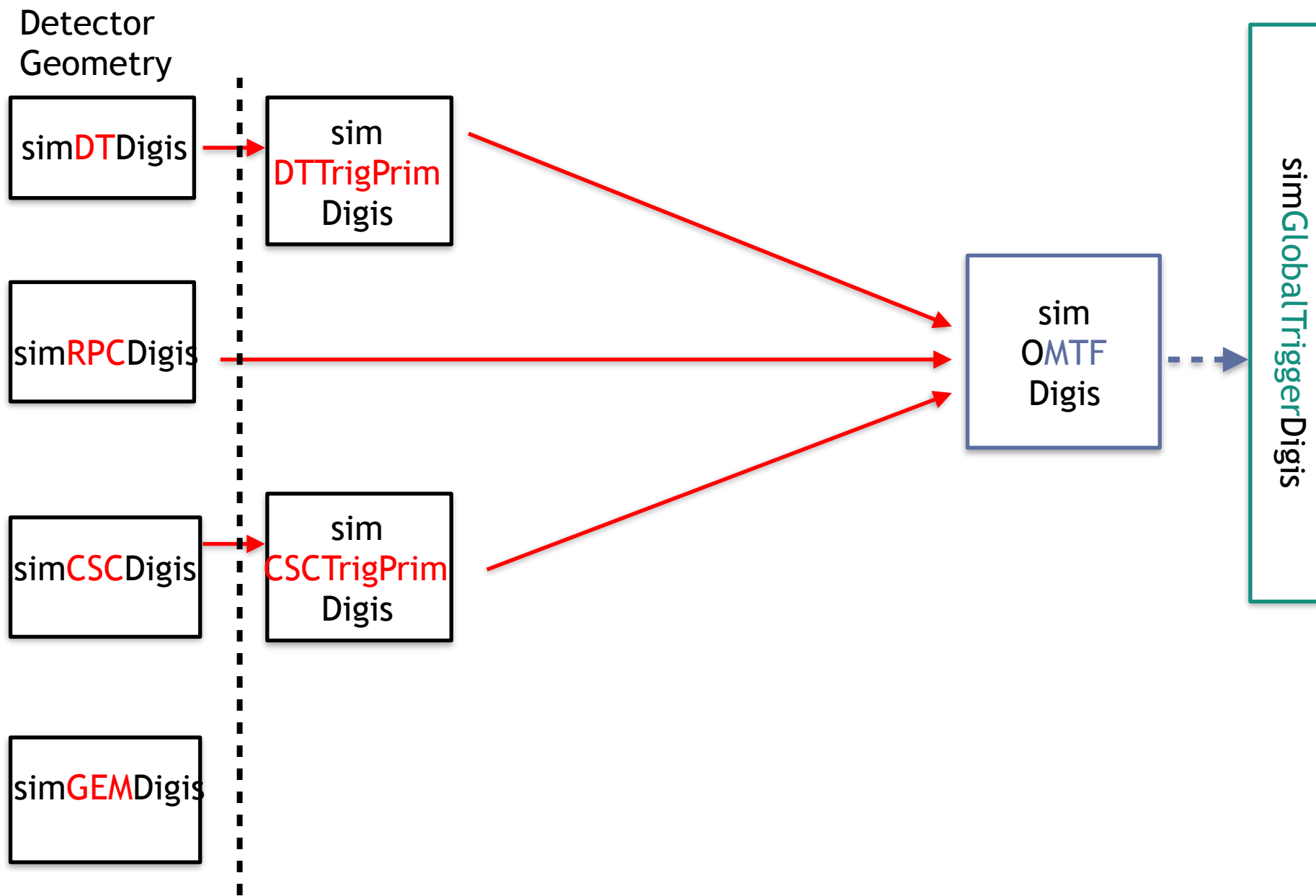
Muons

GlobalTrigger

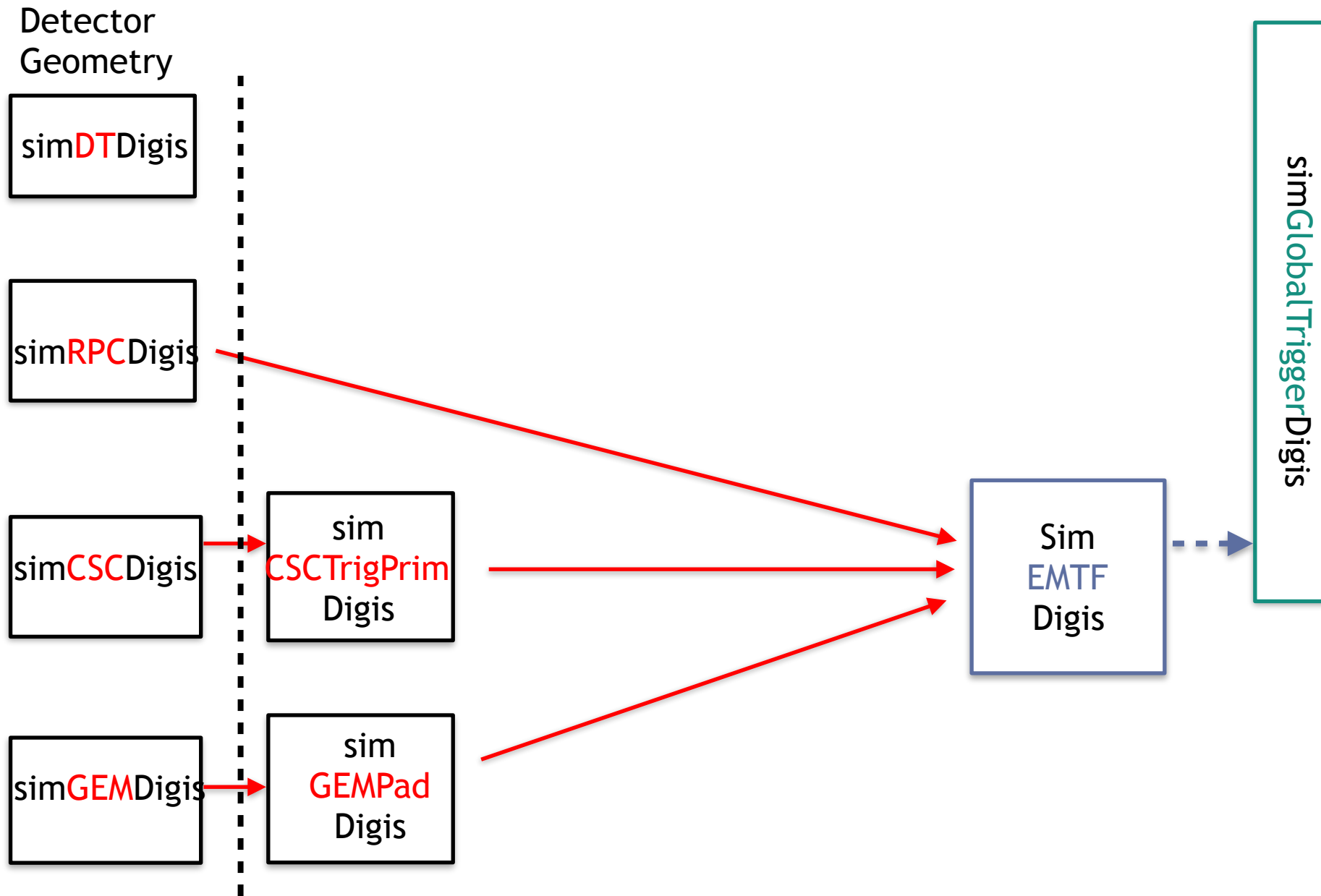
# Simulation Producers in Barrel



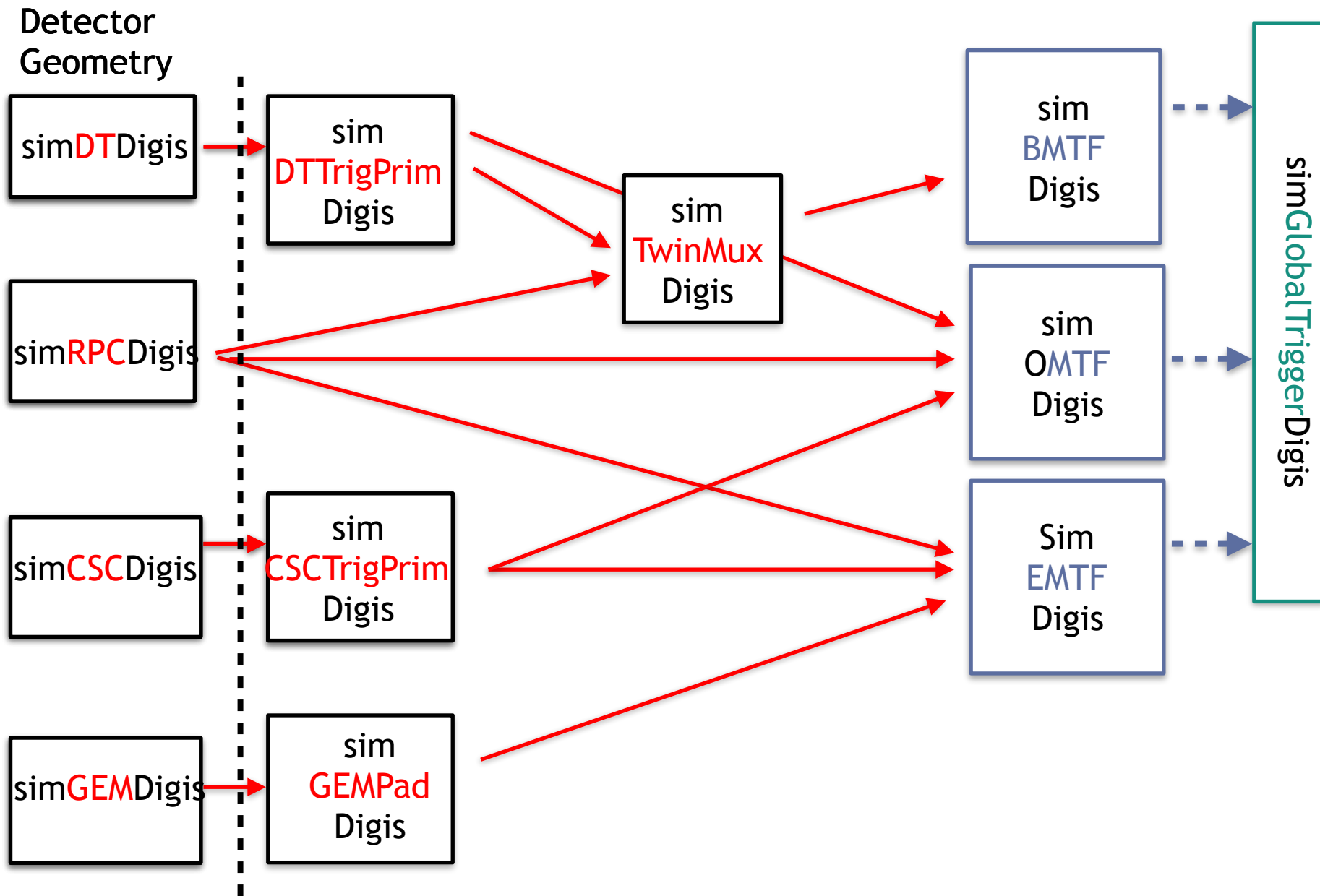
# Simulation Producers in Overlap



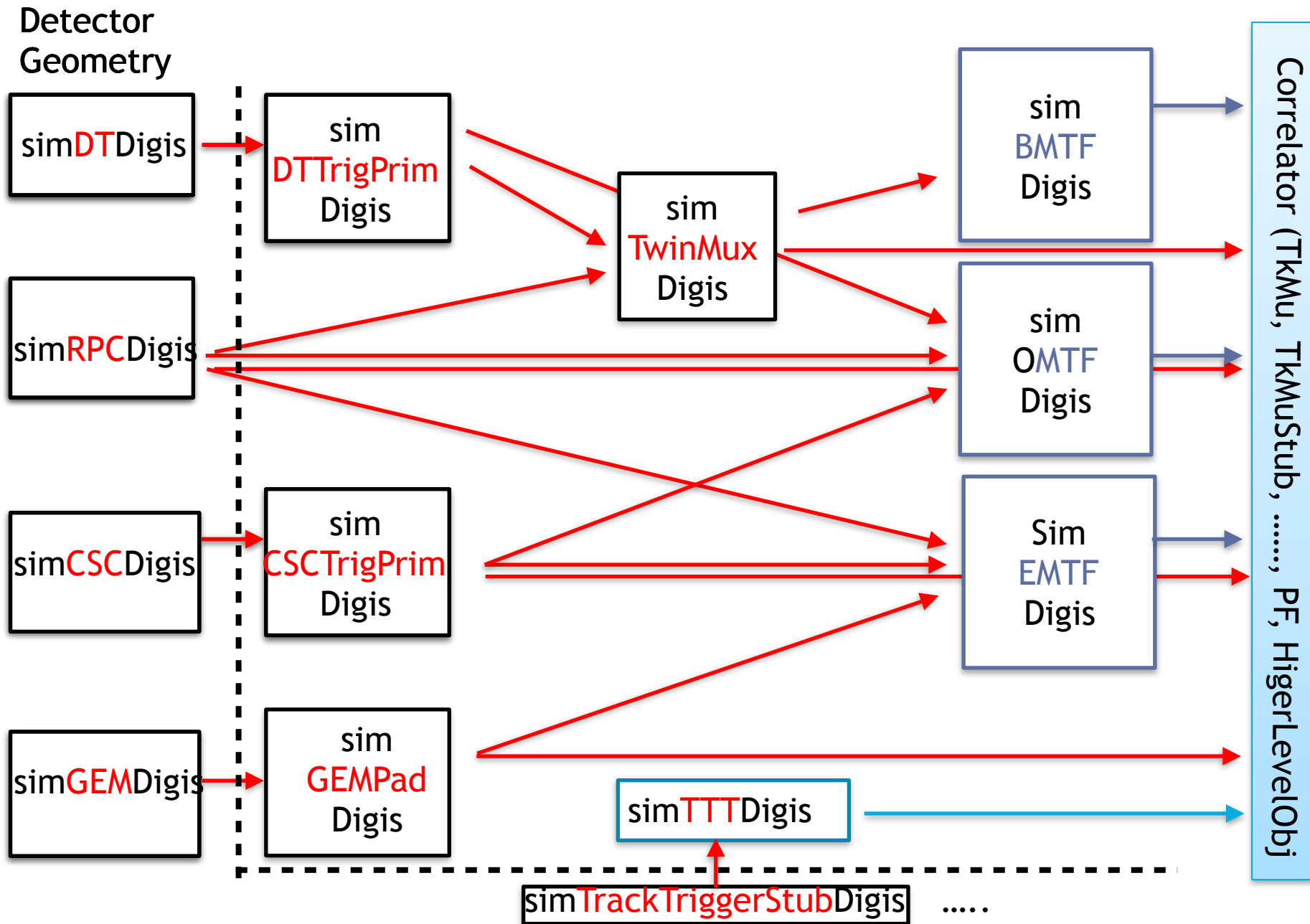
# Simulation Producers in EMTF



# Simulation Producers in Trigger System



# Add TrackTrigger



# Maximally useful MC samples

- MC Prod [PhaseII Fall17](#) (CMSSW\_9\_3\_7) included [all Muon PhaseII Detectors](#), Calorimetry (Barrel Ecal, Barrel HCAL, HGCal v8), Tilted Tracker
- If Detector geometry does not change, that is to say if the Detector digis are available, one has a complete freedom in designing all the steps in the Trigger chain down-stream.
  - Muon TriggerPrimitive design
  - Muon TrackFinder design
  - Correlator design
  - GlobalTrigger
  - Menu
- The model L1T has adopted for Phase-2 MC production to cope with still ongoing developments for Trigger Primitives
  - Step1 Run GEN-SIM → Write GEN-SIM
  - Step1 Run DIGI → Write out GEN-SIM-DIGI-RAW (full detector Digi), total size 1PB
- PU (both in-time and OOT) is done at DIGI step
  - Via MixingModule - overlay MinBias events
    - Poisson average nPU, with a bunch spacing of 25 ns, for a BX window [-12, 3]
    - Keep Truth TrackingParticles ( $p_T > 1$  GeV), increasing EvtSize (50 MB)
- Aging
  - Only applied in Barrel Calorimetry...(for muons can do a posteriori)



# PhaseII Fall17 MC Production

2	All samples need DIGI, but not RECO in first instance				
3	Keep RAW+calo digi+tracker stubs to re-run L1 (and optionally RECO in future)				
4					
5	<b>Sample</b>	<b>N event</b>	<b>PU</b>	<b>Notes</b>	<b>PhaseII Fall17 MC Prod Status</b>
6	<b>Rates</b>				<a href="#">Samples In DAS</a>
7	MinBias	100M	n/a	GEN-SIM only, for PU overlay (use existing if available)	
8	Neutrino gun	50k	0,140,200	Staged production (26% uncertainty at 10kHz)	
9		500k	140,200	Staged production (8% uncertainty at 10kHz)	DONE
10		250k	250,300		DONE, PRODUCTION
11	<b>L1 reco studies</b>				
12	Muon+- gun	250k	0,140,200	flat pT [2,100] GeV,  eta  < 2.6	DONE
13	Electron+- gun	250k	0,140,200	flat pT [2,100] GeV,  eta  < 3.1	DONE
14	Tau+- gun	250k	0,140,200	flat pT [2,150] GeV,  eta  < 3.1	DONE
15	Pt+- gun	500k	0,140,200	flat pT [2,100] GeV,  eta  < 5.2	DONE
16	PID gun	500k	0,140,200	flat pT [8,100] GeV,  eta  < 5.2	DONE
17	Photon gun	250k	0,140,200	flat pT [8,150] GeV,  eta  < 3.1	DONE
18	QCD	500k	0,140,200	flat pT-hat [0,1000] GeV,  eta  < 5.2	DONE
19	Quark-initiated jet gun	500k	0,140,200	flat pT [50,300] GeV,  eta  < 5.2	DONE
20	Gluon-initiated jet gun	500k	0,140,200	flat pT [50,300] GeV,  eta  < 5.2	DONE
21					
22	<b>Efficiency studies</b>				
23	tbar	100k	0,140,200		DONE
24	tbar	9k	250,300		<a href="#">tbar ReVal Samples In DAS</a>
25	Z(l)	100k	0,140,200		<a href="#">ZMM and ZTT ReVal Samples In DAS</a>
26	W(lv)	100k	0,140,200		DONE
27	H(4l)	100k	0,140,200		DONE
28	VBF H(4l)	100k	0,140,200		DONE

# PhaseII Fall17 MC Production (cont)

22	<b>Efficiency studies</b>				
23	ttbar	100k	0,140,200		DONE
24	ttbar	9k	250,300		ttbar ReVal
25	Z(II)	100k	0,140,200		ZMM and
26	W(lv)	100k	0,140,200		DONE
27	H(4l)	100k	0,140,200		DONE
28	VBF H(4l)	100k	0,140,200		DONE
29	HH(4b)	100k	0,140,200		DONE
30	HH(bb gammagamma)	100k	0,140,200		DONE
31	VBF H(bb)	100k	0,140,200		DONE
32	H(tau tau)	100k	0,140,200		DONE
33	H(mu mu)	100k	0,140,200		DONE
34	H(gamma gamma)	100k	0,140,200		DONE
35	VBF H(gamma gamma)	100k	0,140,200		DONE
36	VBF H(lrv)	100k	0,140,200		DONE
37	HH+	100k	0,140,200		DONE
38	Dark SUSY (displaced mu: smuon to mu+nu)	100k x4	0,140,200	LHE files available (sven.dickh@cern same as Mu req)	DONE
39	SUSY, stop ctau (100cm)	100k	0-140-200	LHE files available (Jan.Tomalin@stfc.ac.uk)	DONE
40	Hidden Higgs mH(125,250) ctau(0,1,5cm) Phi(15,30,60) (GF, VH)	20k x 24	0,140,200	LHE files available (Rishi.gautam.patel@cern.ch)	DONE
41	Simplified Model SUSY stop	10k	0-140-200	LHE files available (Rishi.gautam.patel@cern.ch)	DONE
42	JPsi eel/mumu (Menu group)	100k x 2	0-140-200		DONE
43	HSCP stau (mass 200 and 671)	100k x 2	0-140-200		DONE
44					

Need to re-produce displaced Mu samples, and other interesting Muon samples  
 This can be done faster via ReVal MC workflows (9k evt/sample should be enough)  
 Shorter turn-around time ~ 2 weeks)

# MC production 2019

- Samples:

- Same as for Fall17 MC production,

- all completed by now, except displaced Mu that will probably have to have config put in the CMSSW.
    - Any additional samples, please speak up.

- In immediate/not so far future there are two Phase-2 MC prod scheduled

- 1. MTD: Nov 2018 to Feb 2019 (immediate attention... we are coordinating w/ PPD, MTD)

- Release CMSSW\_10\_4\_0\_pre(2/3)

- FEATURING: full simulation of MTD, and final geometry v9 HGCal D35 = D33 +v9HGCA
      - STATUS: Built but currently crashing, needs patches. ETA, hopefully this week

- Timeline of MC production submission

- MinBias 20M, GEN-SIM start end of Nov '18 (as soon as rel is fixed)
      - Object samples, GEN-SIM → DIGI → RECO, saving only RECO-SIM, start 15.Dec
      - Physics samples, GEN-SIM →DIGI→ RECO, saving only RECO-SIM, start 15 Jan

- Recources: request is shown in back-up.....note MinBias 20 M

- L1T want to piggy-back on MTD MC production .

- Need to ensure large enough sample of MinBias used for PU, 100 M , 200 M ?
    - For evaluation of HGCal v9 geometry effect on L1T, save GEN-SIM-DIGI-RAW produced during step2 of MTD production for a subset of samples
      - NuGun, Ttbar, VBF/GGF (H->gg, H->tautau, H->ZZ4L, H->bb) , HH->bbgg, Wlnu,
      - 500k + 1M + 2\*(100k + 100k + 100k + 100k) + 100k = 2 Mevents = 100 TB

- In immediate/not so far future there are two Phase-2 MC prod scheduled

### 2. L1T & HLT: Q2 2019 (in coordination with HLT)

- Release CMSSW\_10\_4\_X, featuring (expecting)
  - L1TTT code (probably some synthesis of Tracklet/TMTT)
  - HGCal TPs for v9 geometry
  - Can we also get new Muon Phase-2 TPs?
    - » in my view, we will probably know during the joint MuonDPG-MuonL1T workshop Nov '18)

# CMSSW for Phase2 L1T

- Twiki: <https://twiki.cern.ch/twiki/bin/view/CMSPublic/SWGuideL1TPhase2Instructions>
- Code integration on <https://github.com/cms-l1t-offline/cmssw/> branch phase2-l1t-integration-CMSSW\_10\_1\_7
- Phase-2 L1T SW code: DataFormats, producers, workflows (i.e. sequences), era Modifiers, customizations)
- Recipe to use latest version of code -> Run steps TriggerPrimitives, TrackTrigger (Tracklet/TMTT), L1T, Ntuple with examples:

```
CMSSW_10_1_7

cmsrel CMSSW_10_1_7
cd CMSSW_10_1_7/src
cmsenv
git cms-init
git remote add cms-l1t-offline git@github.com:cms-l1t-offline/cmssw.git
git fetch cms-l1t-offline phase2-l1t-integration-CMSSW_10_1_7
git cms-merge-topic -u cms-l1t-offline:l1t-phase2-v2.16.42

# #####
# TMTT tracks - if you want to use them uncomment below
# This will merge the TMTT code in your local working branch
# N.B. These instructions should be updated. Latest TMTT tracks are in branch TMTT_1025, NOT TMTT_938
# #####
# git checkout -b mydevel
# git remote add -f TMTT_938 TMTT https://github.com/CMS-TMTT/cmssw.git
# git fetch TMTT TMTT_938
# git cms-merge-topic -u CMSSW_10_1_7 CMS TMTT.TMTT_938
# git merge --no-ff TMTT_938 mydevel
#
# ##### cmsRun L1Trigger/TrackFindingTMTT/py:boos/TMTTrackProducer_Ultimate_cfg.py
# #####
# #####
# EB TPs - if you want to use private development not yet in CMSSW uncomment below
# This will merge the EB TP code of N.M. rebased in 10_1_7 in your local working branch
# #####
# git checkout -b mydevel
# git cms-merge-topic -u rekovic:NM_TP_PhaseII_V1_10_1_7
# #####
```

# Aging of Muon Detectors

- Aging of Muon detectors in CMSSSW phase2-l1t-integration
  - Tag *phase2-v2.16.23*
- Apply masking of Muon detector digis (DT, CSC, RPC, GEM) with probability provided by Lumi scenario via GlobalTag
- Aging is invoked via customizations of “L1T” step
  - `-customise=L1Trigger/Configuration/customiseUtils.appendDTChamberAgingAtL1Trigger`
  - `-customise=L1Trigger/Configuration/customiseUtils.appendCSCChamberAgingAtL1Trigger`
  - `-customise=L1Trigger/Configuration/customiseUtils.appendRPCChamberAgingAtL1Trigger`
  - `-customise=L1Trigger/Configuration/customiseUtils.appendGEMChamberAgingAtL1Trigger`

Or all together in future tag (will announce)

  - `--customise=L1Trigger/Configuration/customiseUtils.appendMuonChamberAgingAtL1Trigger`
- and muon Phase2 L1T sequence is configured to run on aged digis
- Amount of aging is scenario provided in GT
  - Example *'100X\_upgrade2023\_realistic\_Candidate\_2018\_07\_26\_10\_13\_24'*



# Pure L1 algos: Muon, EG, Tau, Jet, MET, HT

	Rates (kHz)	Thresholds ('offline', GeV)	Additional requirements
L1_SingleTkMu (single muon)	18.7	22	$ \eta  < 2.4$
L1_DoubleTkMu (double muon)	1.5	15,7	$ \eta  < 2.4, dZ < 1\text{cm}$
L1_TripleTkMu (triple muon)	11.9	5,3,3	$ \eta  < 2.4, dZ < 1\text{cm}$
L1_SingleTkEle (single electron)	95.8	36	$ \eta  < 2.4$
L1_SingleTkEleIso (single electron iso)	90.5	28	$ \eta  < 2.4$
L1_SingleTkEMIso (single photon iso)	66.4	36 (NA Now)	$ \eta  < 2.4$
L1_TkEleIso_EG (single ele iso + EG)	59.8	22,12	$ \eta  < 2.4$
L1_DoubleTkEle (double ele)	67.0	25,12	$ \eta  < 2.4, dZ < 1\text{cm}$
L1_DoubleTkEMIso (double photon iso)	23.1	22, 12 (NA Now)	$ \eta  < 2.4$
L1_SinglePFTau (single tau)	7.9	120	$ \eta  < 2.1$
L1_PFTau_PFTau (double tau)	4.0	70,70	$ \eta  < 2.1$
L1_PFIsoTau_PFIsoTau (double tau iso)	11.8	44, 44 (33,33 Now)	$ \eta  < 2.1$
L1_SinglePfJet (single jet)	54.4	180 (200 Now)	$ \eta  < 2.4$
L1_DoublePFJet_dEtaMax (double jet dEta)	62.8	125,125 (112,112 Now)	$ \eta  < 2.4, d\eta < 1.6$
L1_PFHT (ht)	19.7	360	
L1_PFMet (met)	71.7	150	

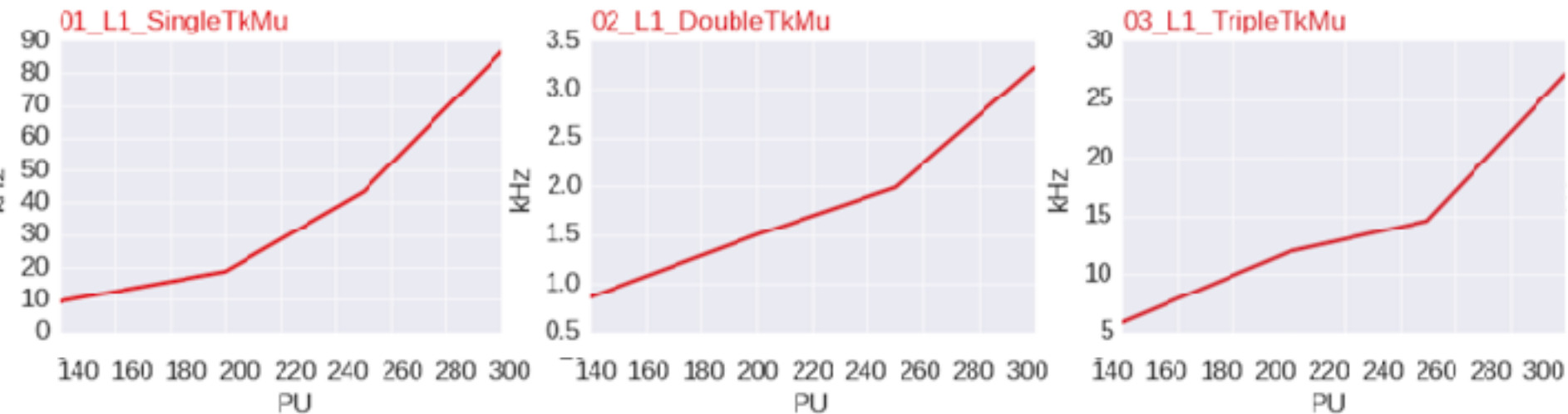
Now = 2018 data taking (2.0E34)





## PU dependence (preliminary)

- Latest results of PU dependence of TkMu (L1TTTk+MuTF) paths implemented in v6 Phase2 L1T Menu....
- this remains to be understood as Barrel, Overlap, and EndCap use different matching algos



- Advice, use stress test PU 250 and 300 to test your TriggerPrimitives and L1T rates.

# Steps Forward in Phase2 Muon -> Level1 Trigger

- Reprocessing MC Samples - New Trigger Primitives
  - Because of the MC Production model we adopted, and because the Phase2 Muon geometry included in the production has not changed we are in the position to
    - Run any newly developed algorithms for Muon TPs.
    - Running Muon TPs and L1T sequence is fast and can be done “on-fly” (when Ntuplizing) if it was not for re-running L1TTrackTrigger.
      - Solution: we saved Muon Digis in reprocessed samples (dropped Tracker Digis), so can run Muon TPs on re-processed samples.
  - At the moment, we are not exploiting nor running any Phase2 Muon TPs
    - Some available in CMSSW floating point (eg. DTTPs, see Camillo’s talk)
    - Some need developments (eg ME0, iRPCs, fitted CSCs)
  - As outcome of this workshop, I hope we can get a list of new Muon Phase2 TPs that we can already integrate and get an idea when the missing ones will be provided.
- New MC Samples
  - We can use the L1T Phase2 Fall17 MC campaign existing (
  - We do know that we need some new MC samples (RelVal size samples are OK)
  - If out of this Workshop we realize we need new interesting signal samples, please communicate via Muon L1T Group (Costas & Jaco). If sample non produced before in CMSSW need to provide configurations.