UPSG: PHYSICS AND PERFORMANCE STUDIES FOR HGCAL TDR

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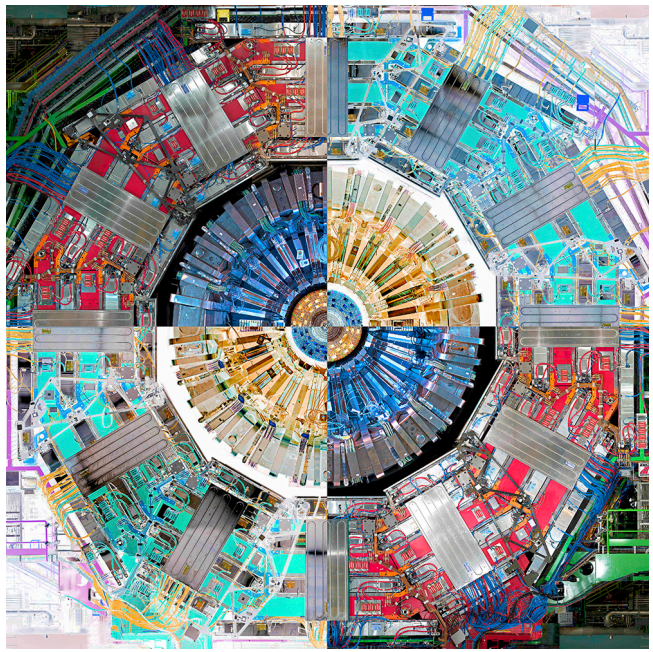
Patrizia Azzi, & Meenakshi Narain



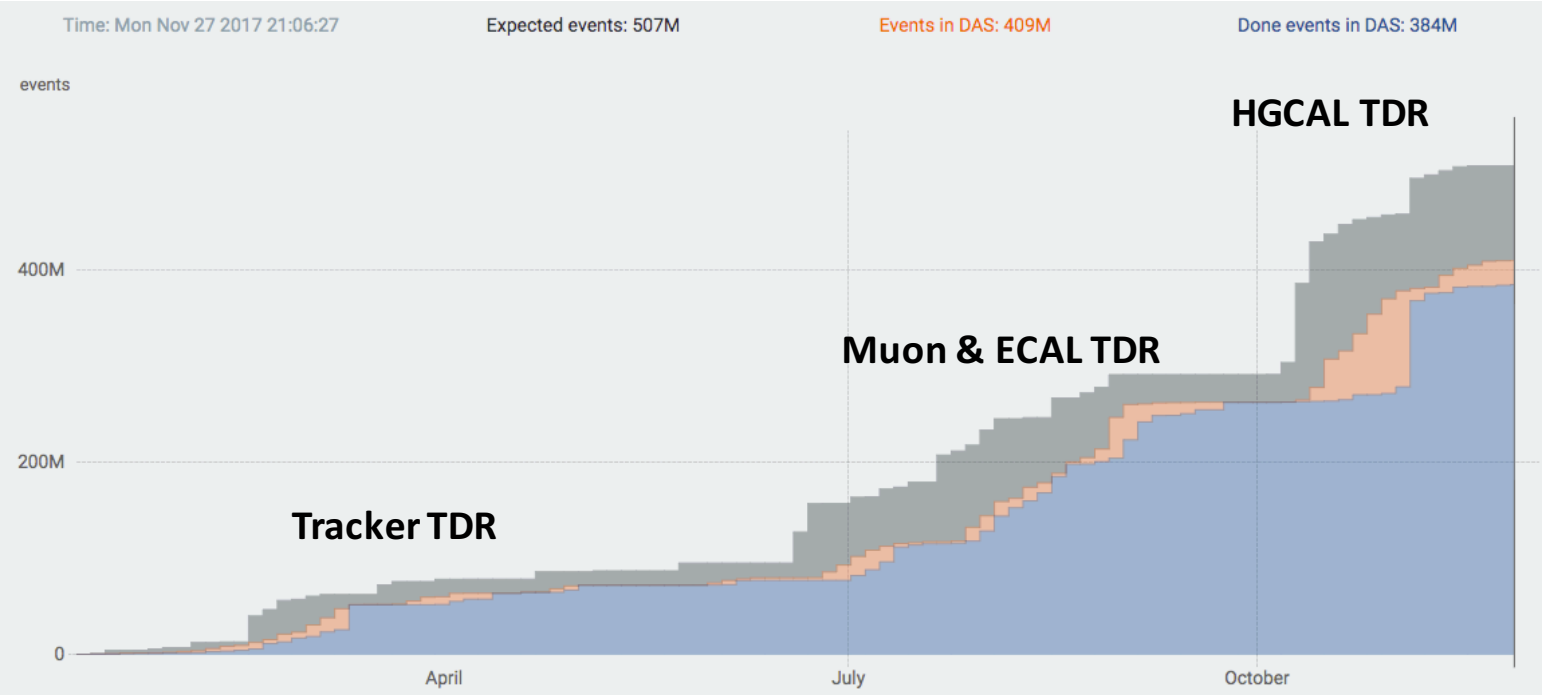
Upgrade Plenary meeting, CMS Week,
December 7, 2017

STATUS OF SAMPLES FOR ENDCAP CALORIMETER TDR:

- Production release :CMSSW 9_3_2
  - Sep24: Production for single object samples started with GenSim requests
    - Validation of e/gamma reco identified a few issues, a very fast debugging
  - Oct 3: Start of single object Digi Reco
    - Delays in the start of production of Digi-Reco (reco issues, memory leak etc).
    - 32.6M events @PU200 submitted with high priority (HGCal + QCD + ttbar + DY)
  - Oct 6: Start of physics samples
    - 60M events submitted (PU 200)
    - campaign stopped twice along the way
      - after 3 weeks due to underestimation of resources needed for large events (~2 weeks delay)
      - due to madgraph issues (~ 2 weeks — restarted this week)
    - This impacted our ability to carry out all planned analyses and had to reduce scope to 5 analyses (to be discussed later).
    - expect samples to be available prior to winter break.
  - (many thanks to PPD, computing and management team for their continued help)
- Samples proposed for the studies are listed on:
    - on https://docs.google.com/spreadsheets/d/1nQvqWGxm5OB216LWH1WKsp0qu4Fok843LsEA-RU26E4/edit#gid=1182854679

MC PRODUCTION

- Supported 2017 TDR pipeline
  - Two MC campaigns for Tracker and ECAL/Muon TDR
  - Finalizing for High-Granularity Endcap Calorimeter
  - Samples also used for interim reports for Timing Detector (MTD) and Trigger
- Production of Upgrade samples is most challenging.
  - Large pileup (<PU> = 200) results in large demands on CPU, memory, and storage.
  - Over 410M high pileup events produced
- reminder: MUON/ECAL TDR samples deletion request - please respond by tomorrow (see HN post)



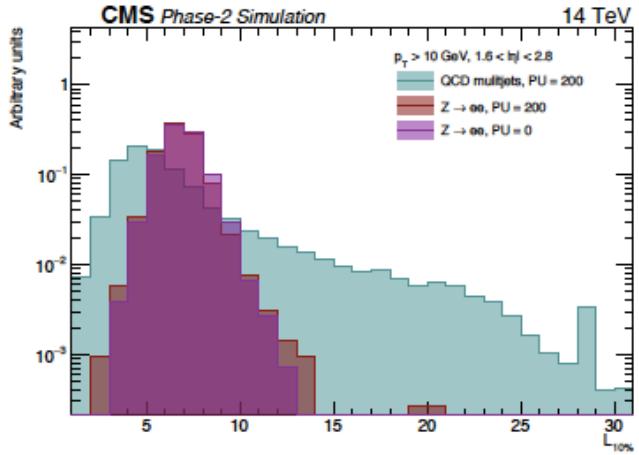
ENDCAP CALORIMETER TDR:

- Timeline for single object performance:
  - October 23: usable e/gamma ID in barrel and forward.
  - November 7: performance chapters with single object in CWR
- Timeline for physics studies:
  - October 23: validate and finalize analysis infrastructure with object ID
    - ~completed in mid November
    - PhaseTwoAnalysis package
      - incorporates all recommendations for object ID
      - allows to produce the same ntuple format from delphes input as from fullsim inputs. Advantage: delphes samples can be used transparently in subsequent analysis steps.
  - December 8: physics analysis chapter in CWR
    - Almost ready!
- [brand new object ID and use in analyses in a brand new detector in a record time. Many thanks to those who tirelessly to make this happen!]

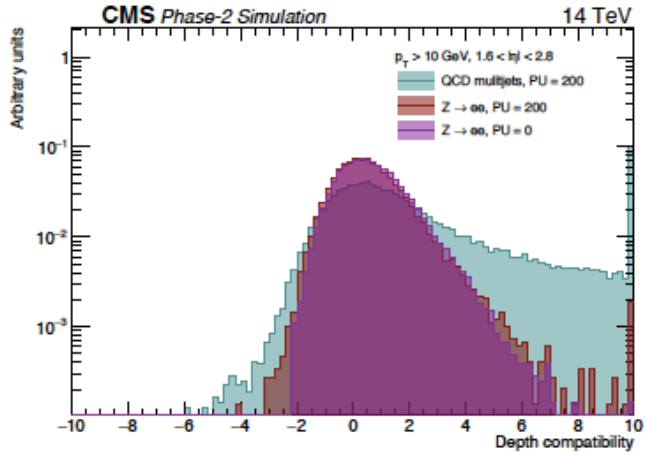
SINGLE OBJECT PERFORMANCE: ELECTRONS

➤Electrons: variables sensitive to the shower longitudinal development:

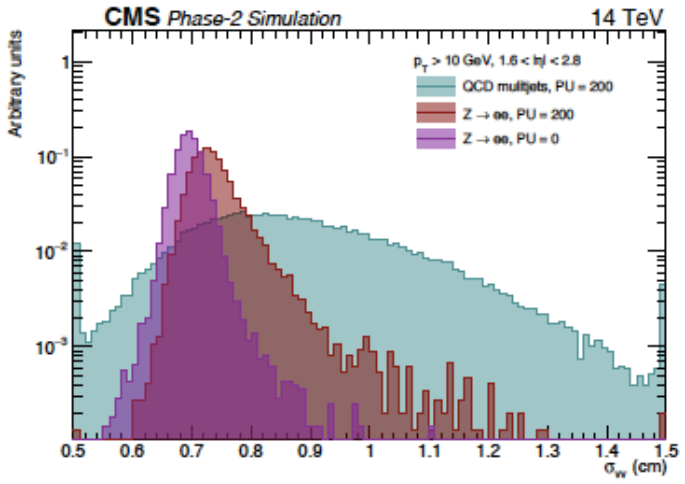
layer number for which the accumulated energy reaches 10% of the EE energy



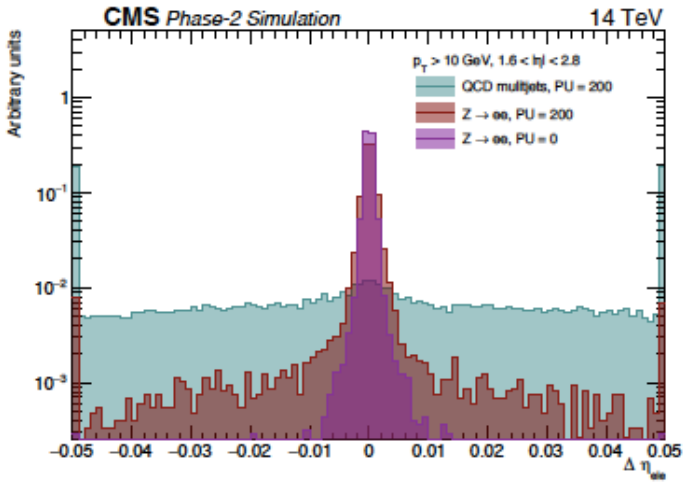
shower depth compatibility



shower spread along the radial direction



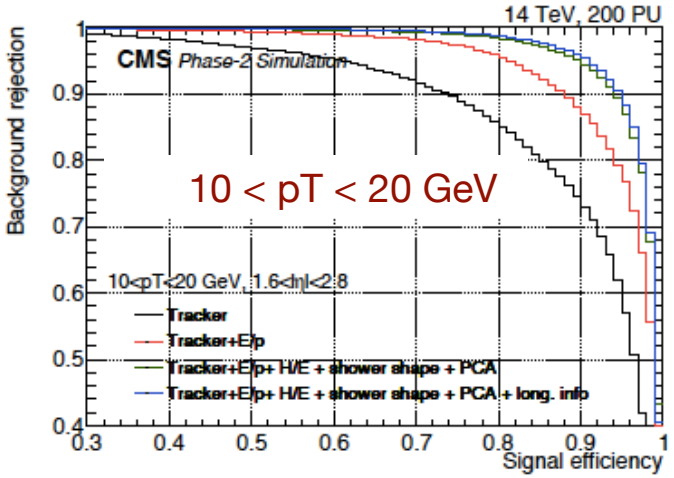
distance in η between electron cluster & track.

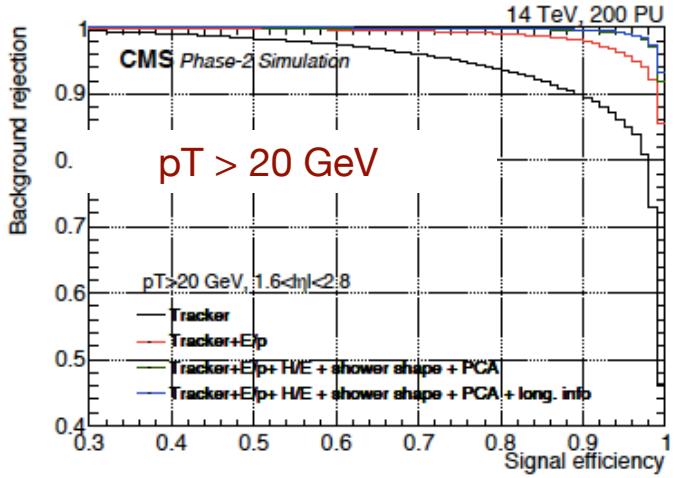


➤.

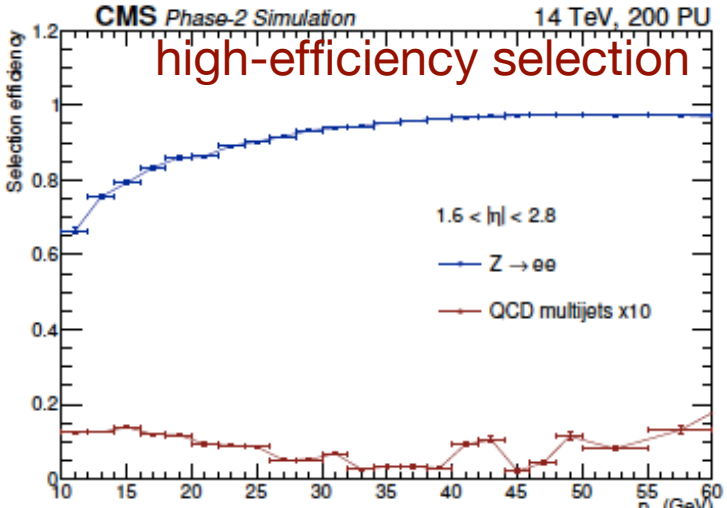
SINGLE OBJECT PERFORMANCE: ELECTRONS

- Electrons:
  - Purity as a function of the efficiency for different sets of MVA input variables

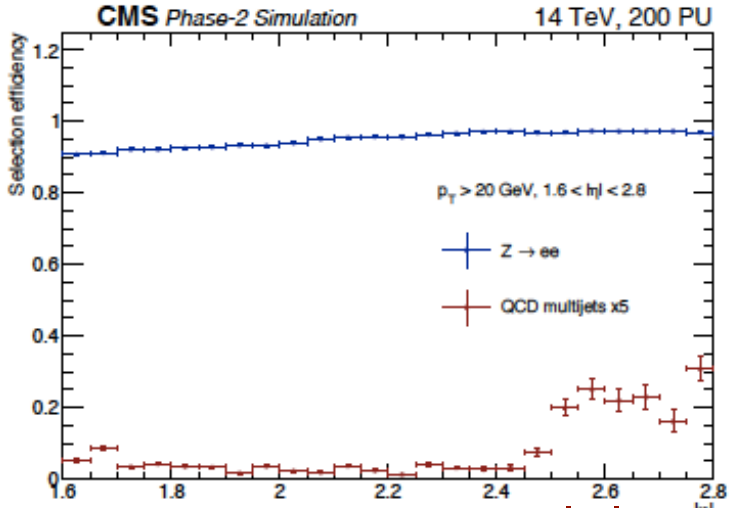




  - signal (blue) and background (red) efficiencies for electrons w/ pT > 20 GeV



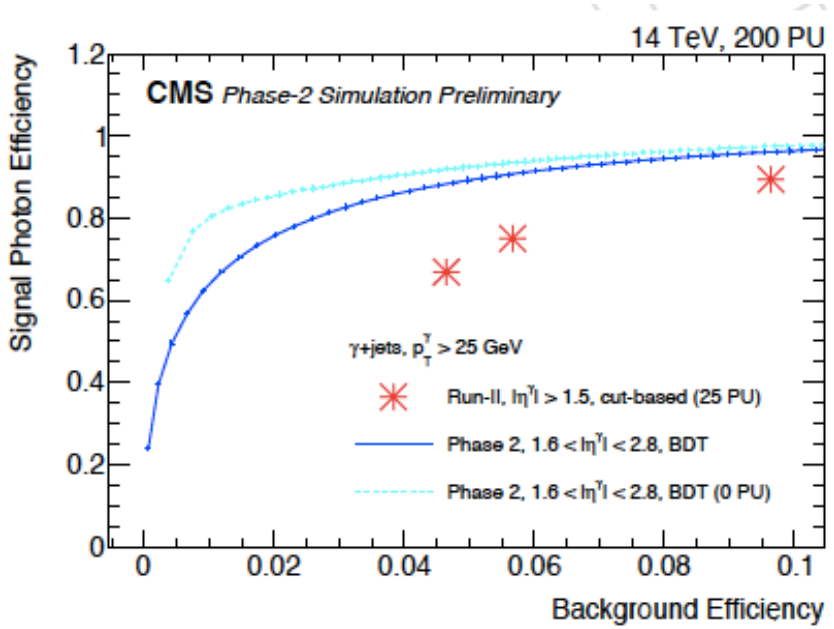
pT



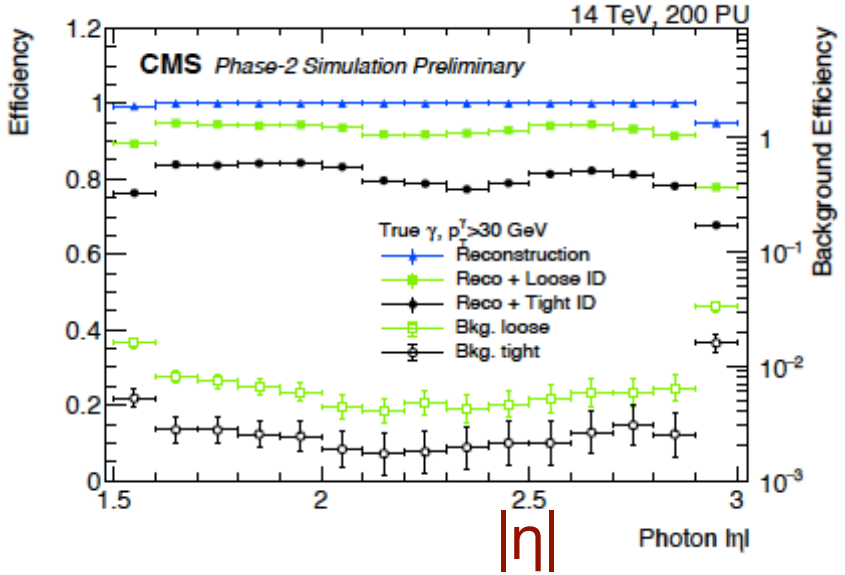
cluster |η|

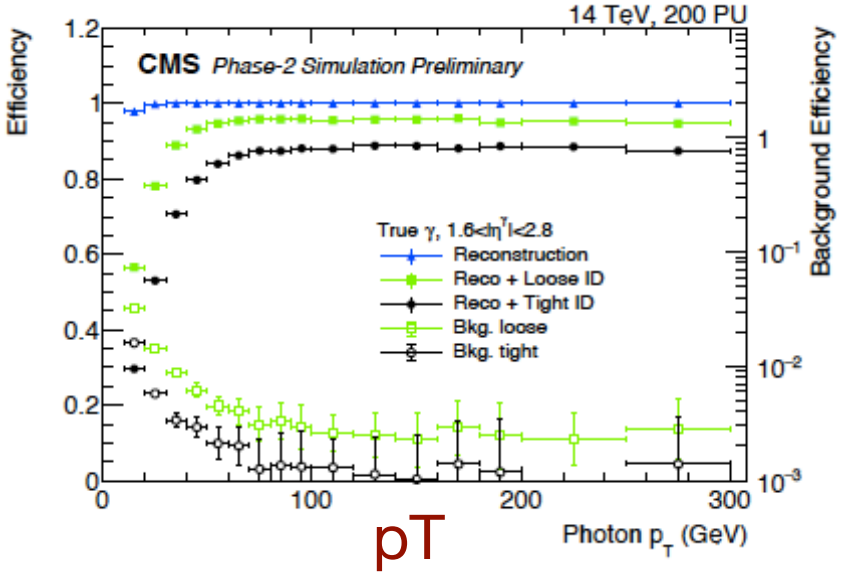
SINGLE OBJECT PERFORMANCE: PHOTONS

- Photon
  - Photon efficiency & background mis-identification probability



  - Reconstruction, identification efficiency, & background mis-id probability



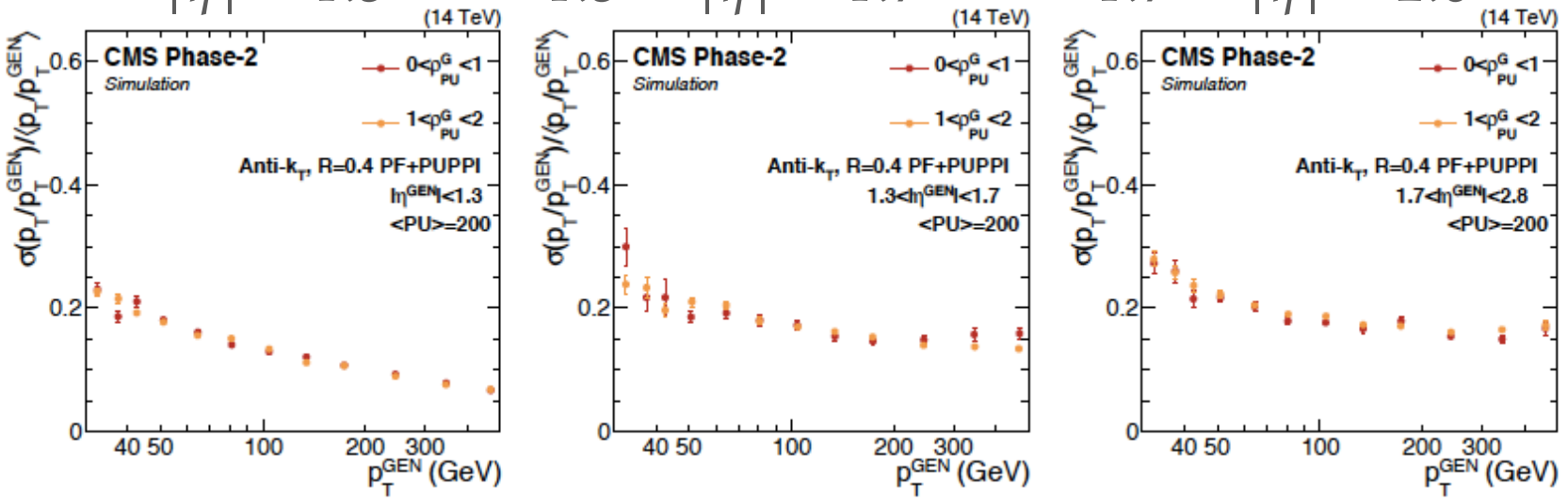


|η| pT

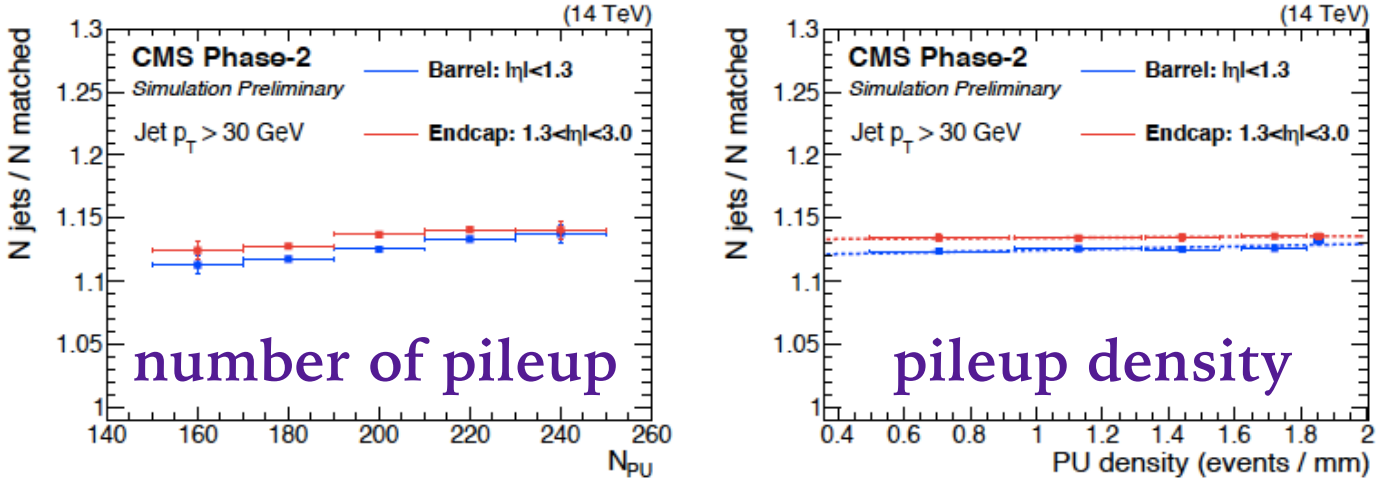
SINGLE OBJECT PERFORMANCE: JETS

- Corrected jet response resolution in a μ = 200 sample.

$|\eta| < 1.3$ $\quad 1.3 < |\eta| < 1.7$ $\quad 1.7 < |\eta| < 2.8$



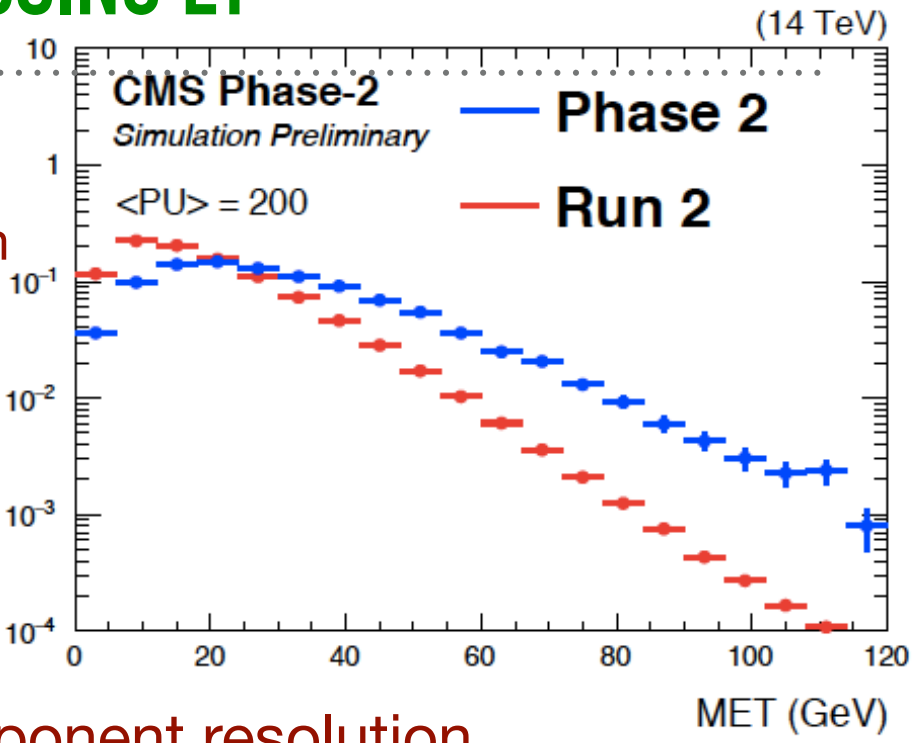
- Ratio of the number of PUPPI jets to the number of PUPPI jets matched to particle level jets from the hard scatter event



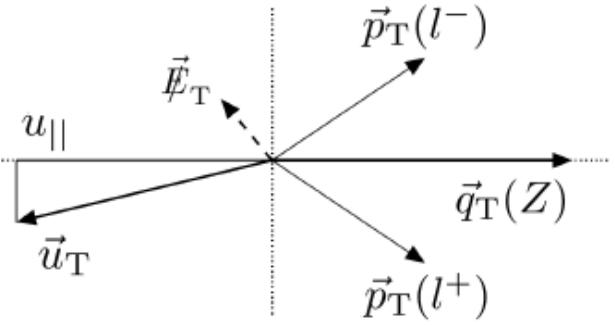
Andreas Delgado, Aram Apyan, Ricardo Eusebi, Alexx Perloff

SINGLE OBJECT PERFORMANCE: MISSING ET

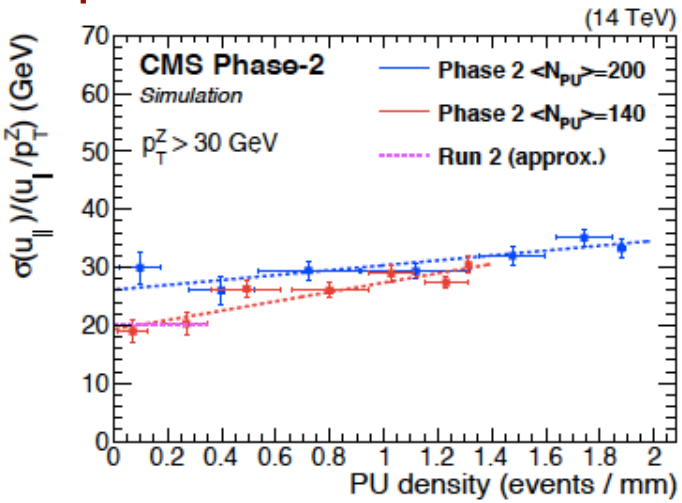
- Missing ET
  - The PUPPI ETmiss distribution PU 200 in Z → μμ events.
  - Etmiss distribution in Run 2 is red.



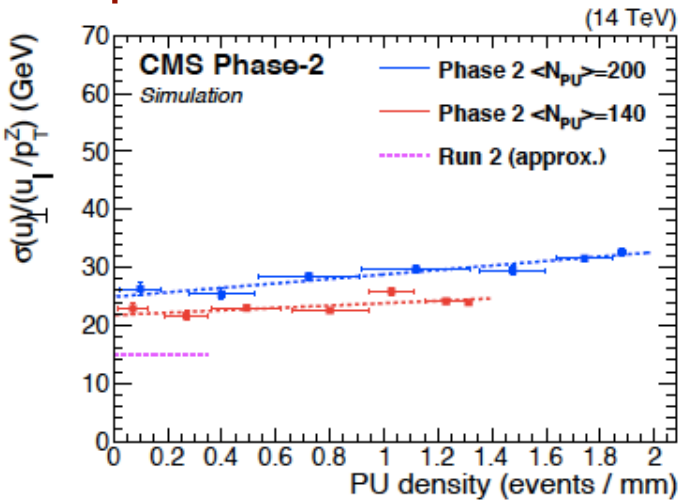
Response corrected PUPPI recoil component resolution



perpendicular



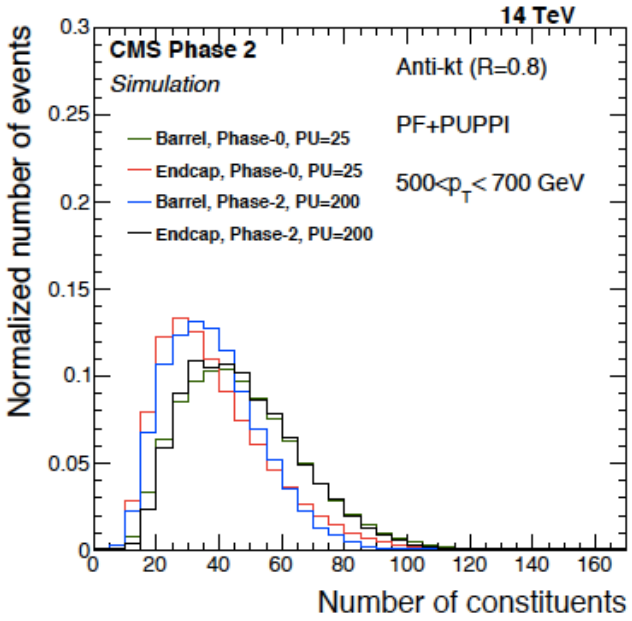
parallel

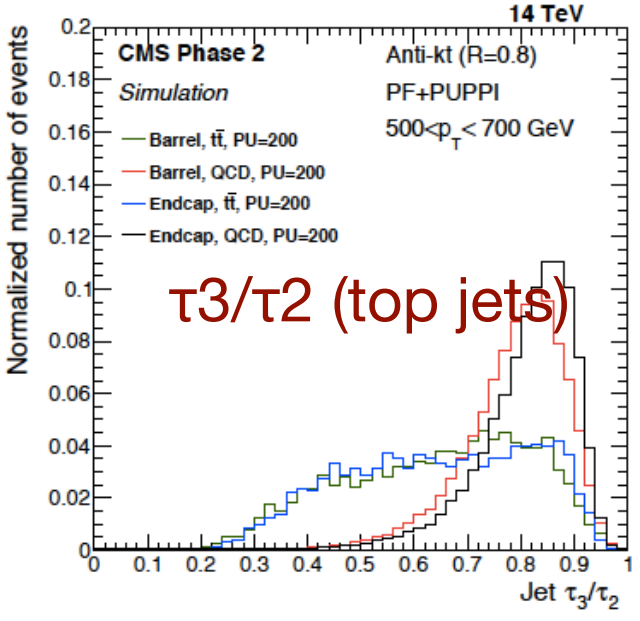


Bibhu Mahakud, Irene Zoi, Hinzman, Tran, Narain

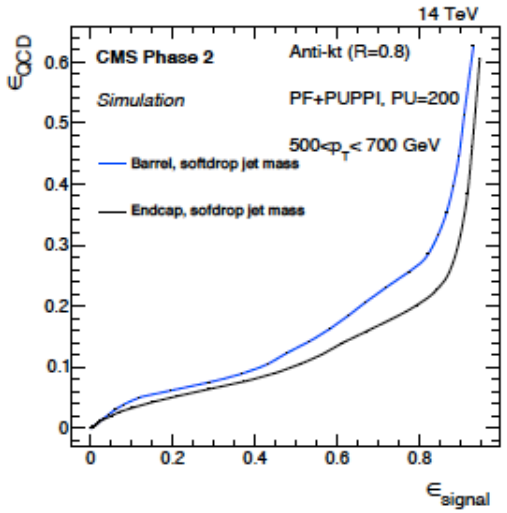
SINGLE OBJECT PERFORMANCE: JET SUBSTRUCTURE

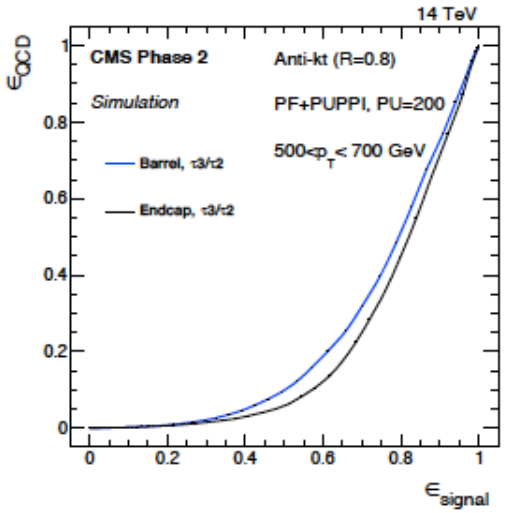
- Jet Substructure
  - Number of jet constituen
  - in QCD multijet simulatio

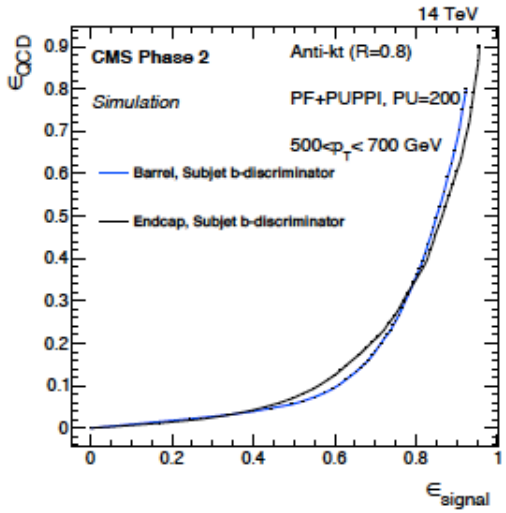




- Background rejection as a function of identification efficiency for
- (a) Softdrop jet mass, (b) τ3/τ2, (c) subjet-b-tagging.







PHYSICS PERFORMANCE

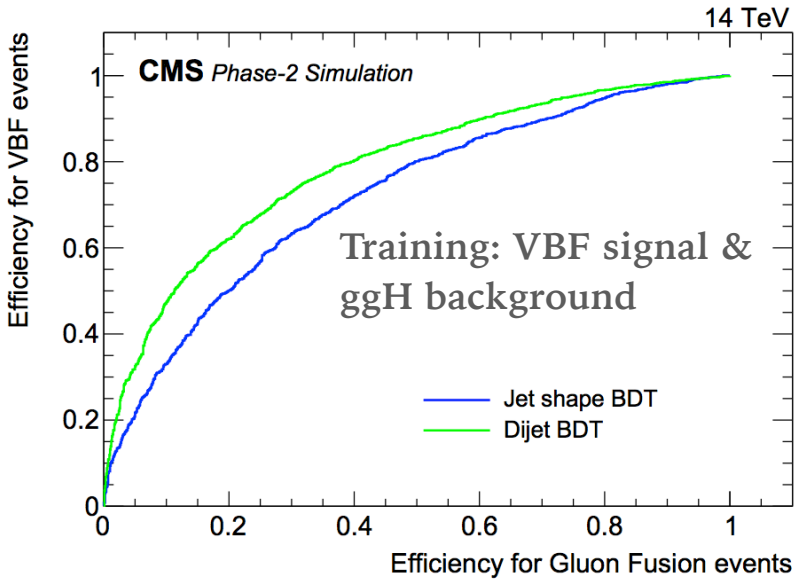
- Higgs
  - **VBF Higgs to Gamma Gamma**
  - **VBF Higgs to di tau**
  - **diHiggs - 2b2tau**
  - HZZ4e
  - Higgs invisible
- Top Physics and SM
  - **FCNC tgamma**
  - FCNC t->q+gluon
  - VBS WW
- Searches
  - RS graviton -> WW (bosted W); X—> HH 4b (boosted Higgs)
  - **SUSY - ISS searches for Higgsino and Winos**
  - SUSY- ISR searches for Higgsino and Winos, also stay search

H→$\gamma\gamma$ IN THE VBF CHANNEL

- Impact of HGCAL on VBF event selection
  - ability to identify jets from VBF production mode
  - distinguishing VBF from ggH, essentially q/g discrimination
  - attempting to showcase impact of better jet shape information
- Improved photon acceptance and performance vs η
  - Resolution of EE diphoton pairs is found to be similar to BB pairs
    - this represents a substantial improvement over the current detector.
- Result: simple analysis using signal and background samples
- In addition train background BDT
  - using VBF as signal and GJet and DiphoJetsBox as background
- Apply fixed cut on background BDT, then create working points by varying the dijet BDT cut
  - Relative composition of ggH, VBF, and background per GeV:

Event Categories	SM 125GeV Higgs boson expected signal			Bkg
	Total	ggH	VBF	per GeV
WP 0	750	25.4 %	74.6 %	678
WP 1	1275	35.9 %	64.1 %	876
WP 2	1926	45.8 %	53.2 %	1353
Run 2 WP	3878	42.0 %	58.0 %	1984

The Run 2 WP contains the sum of selected events in all three VBF categories,



Good Separation
'jet-shape': area 0.71
(ptD, Axis2, nCharged)
'dijet': area 0.79
includes kinematic variables

- comparison to Run 2 values shows performance is almost as good
- background numbers slightly higher, and would be improved with dedicated photon quality inputs, as in current analysis

$H \rightarrow \gamma\gamma$ IN THE VBF CHANNEL

- Apply fixed cut on background BDT, then create working points by varying the dijet BDT cut
  - Relative composition of ggH, VBF, and background per GeV:

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The Run 2 WP contains the sum of selected events in all three VBF categories,

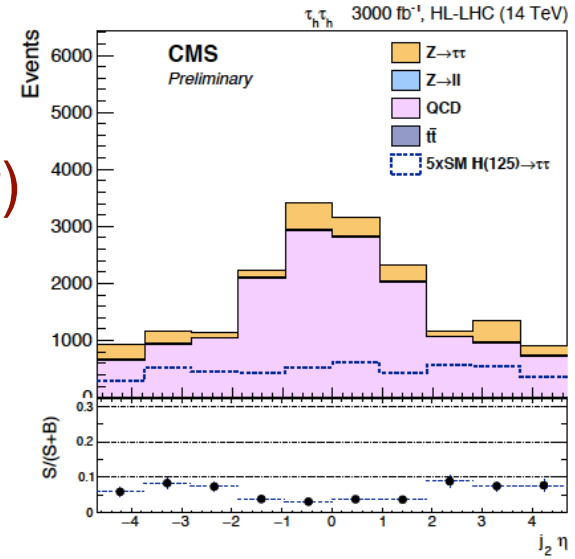
- **comparison to Run 2 values shows performance is almost as good**
- **background numbers slightly higher, and would be improved with dedicated photon quality inputs, as in current analysis**

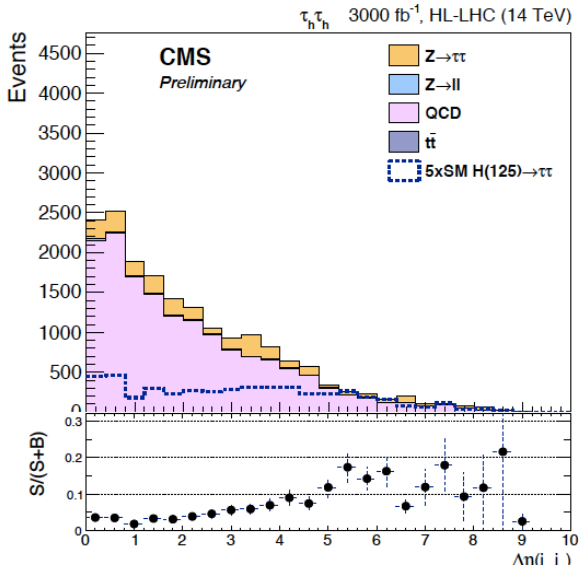
- **With the HGCal, the discriminating power between ggH and VBF is comparable to Run 2 despite the increase in amount of pileup.**
- In the near future quantify comparison with Run2 detector performance:
  - Rough parameterization of neutral particle spatial and energy resolution changes to ~restore current detectors in $1.5 < |\eta| < 3.0$. Then propagate to jet shape variables and compare BDT performance
  - Directly compare differences with Run 2-like detector resolutions (and possibly acceptances) with PU=200.

H→ττ IN THE VBF CHANNEL

Require event has two hadronic taus with pT > 40 GeV and at least two jets.

pT(J2)





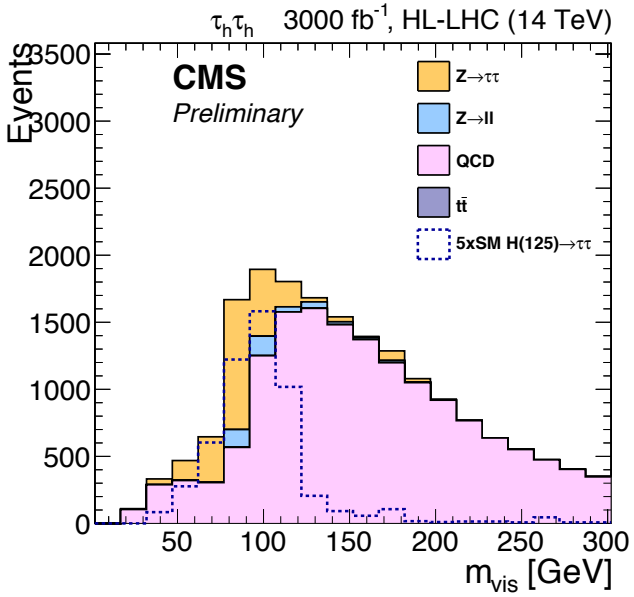
Δη(J1, J2)

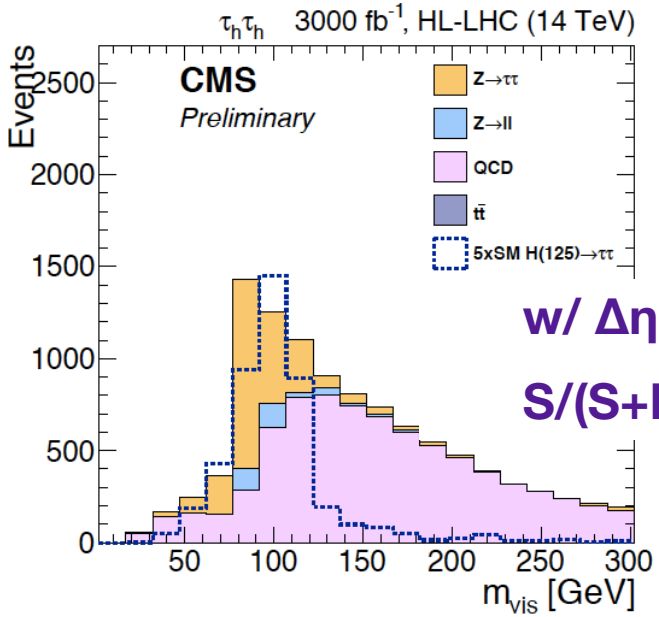
visible di-tau mass

w/ Δη(J1, J2) > 2.5

(a la Run 2)

S/(S+B)=0.068





w/ Δη(J1, J2) > 4.5

S/(S+B)=0.17

HH→2B2τ

➤With the increase in acceptance and performance obtained with HGCal, possibility to study anomalous VBF HH production.

➤Similar to Run2 analysis

➤ Use the most sensitive 2b-tagged category and the τHτH final state

➤ **Add a VBF category for Phase2 studies**

➤The 2 jets with the highest b-tag score are selected as H→bb

➤ mττ (SVFit) and mbb compatible w/ H125

➤**If the 2 remaining highest pt-jets have Δη>2.5 and mjj>250, the event is tagged as VBF-like (to be tuned)**

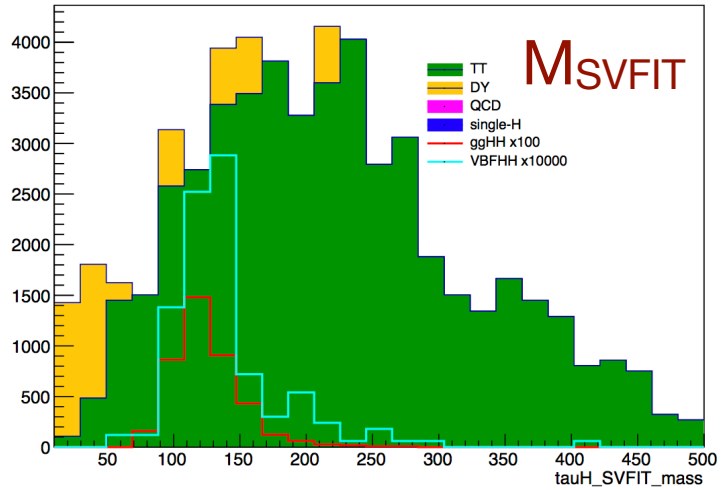
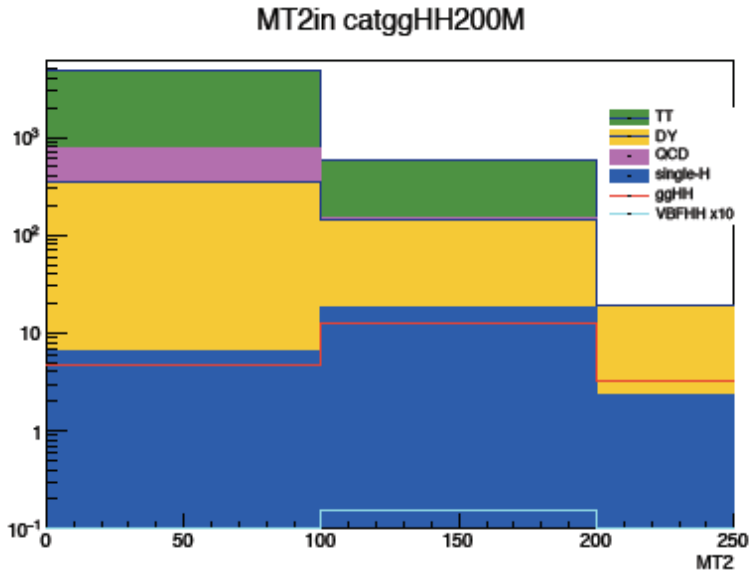


Table 3: Yields of different processes after the final selection.

Category	ggHH	VBFHH	TT	DY	QCD	single-H
2b-jets	21	0.3	4458	478	455	27
VBF	3.35	0.14	268	-	170	-

Final expected limit, presented as ratio over the SM double Higgs pr

Category	σ_{HH}/σ_{SM}	$\sigma_{ggHH}/\sigma_{SM}$	σ_{VBF}/σ_{SM}
2b0j	2.46	2.31	106
VBF	21.1	6.16	184
Combined	2.44	2.3	99



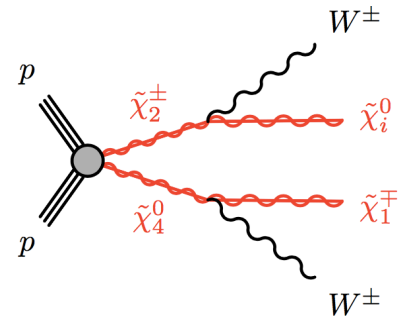
A. Canepa, V. Dutta, S. Kulkarni, I. Melzer-Pellmann,
B. Schneider, I. Suarez, G. Zevi della Porta

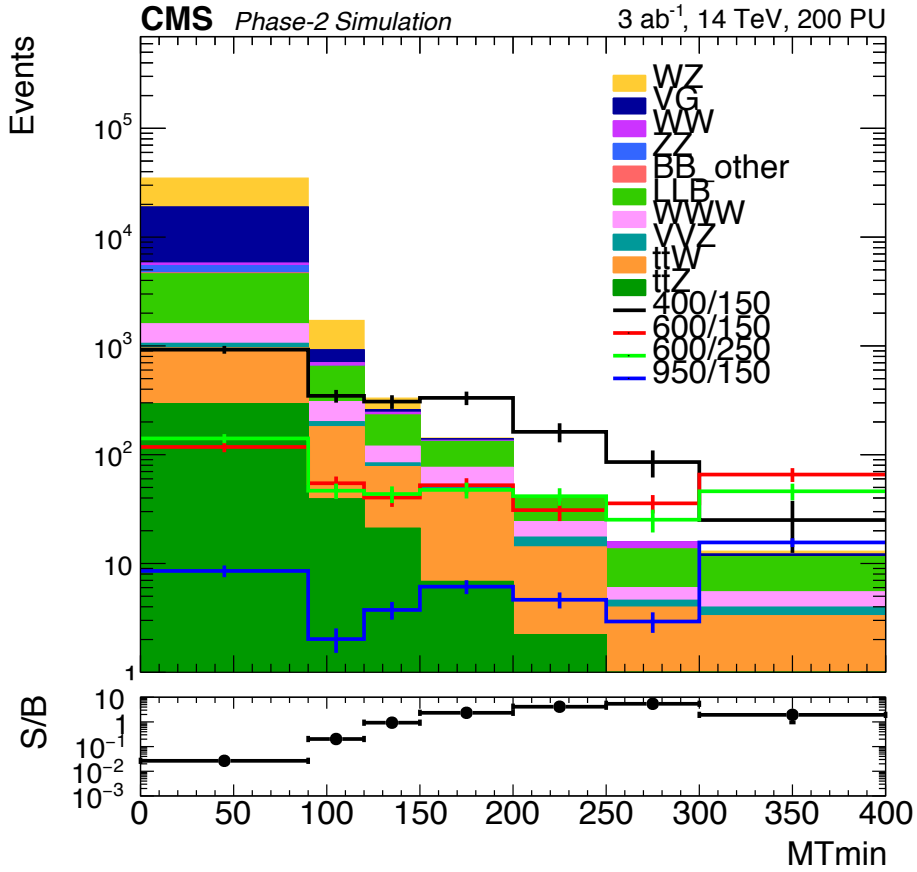
EWKINO SUSY SEARCH IN SAME-SIGN LEPTON CHANNEL

- Search for wino pair production in events with two soft same-sign leptons large MET and no jets. A challenging signature.
- Signal and background samples have been produced with Delphes tuned to the Phase-2 detector response.
- Selection:
  - 2 tight SS central isolated leptons with pT>20 GeV,
  - veto on additional lepton with pt>5GeV, |eta|<4 (suppressing multiboson bkg)
  - no b-jet, no extra jets
- Discriminating variable:

$$m_{T,min} = min\left[m_{T(lep_1,p_{\mathrm{T}}^{\mathrm{miss}})}, m_{T(lep_2,p_{\mathrm{T}}^{\mathrm{miss}})}\right].$$

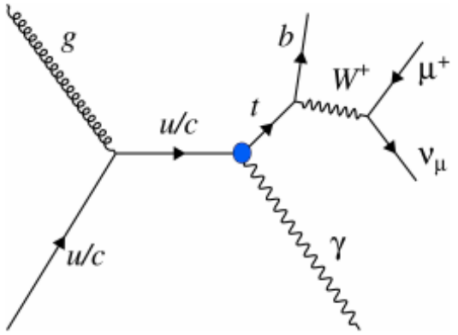
- Systematics on fakes are extrapolated from current Run2 analysis
- **Current limit estimate excludes up to 950GeV wino-like mass degenrates states, but work in progress to find the ultimate reach**
  - More samples being generated

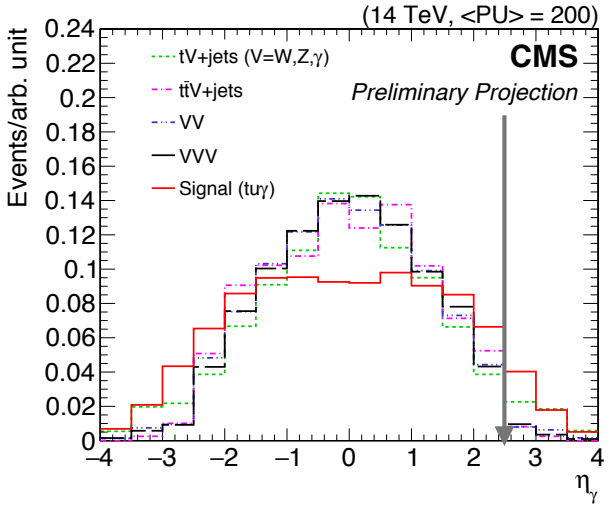




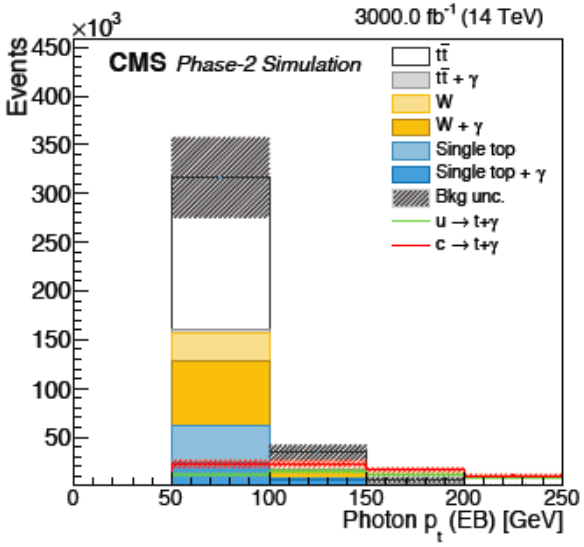
FCNC IN TOP->Qγ events

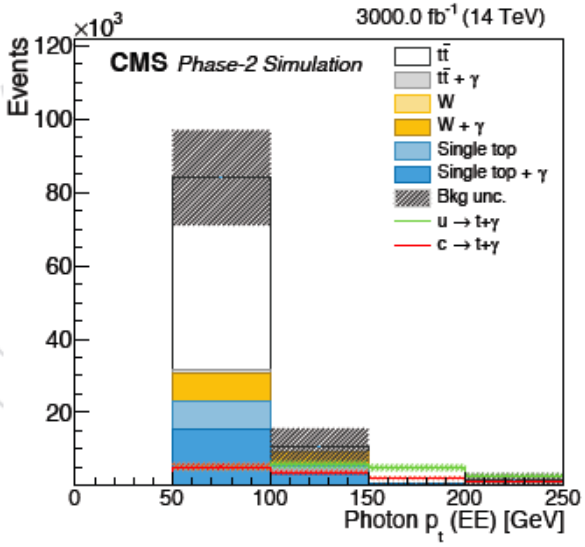
- FCNC are forbidden at tree level and heavily suppressed. Can be enhanced in several new physics models.
- Update analysis from FTR-16-006 to profit from extended Phase-2 acceptance and improved performance
- Focus on the FCNC single top production mode
  - Final state with a high-energetic photon and a leptonically decaying top.
- New analysis with full simulation, reoptimized for the HGCal acceptance.
- Preliminary new limits at 95% CL about one order of magnitude better than FTR-16-006 (systematics included)
  - $B(t \to u+\gamma) < 1.16 \times 10^{-5}$
  - $B(t \to c+\gamma) < 9.12 \times 10^{-5}$





|η(γ)|<2.4
FTR-16-006





SUMMARY

- TDR to LHCC on Dec 22nd

- Busy times still ahead:
  - Review period: Jan/Feb 2018
    - Anticipate questions ahead of time (based on our experiences with tracker/ muon/barrelTDRs) and plan for further investigations/additions to analyses.
  - Review of muon continues, barrel TDR - possibly done.
  - Work for the HL/HE-LHC Yellow Report will ramp up soon
    - (see A. Meyer's talk later).

- **Huge thanks to all the teams for their dedication and efforts through the demands of all the TDRs!**

- **Our special appreciation to Jan, Juliette, Kerstin, Miguel, Maria, Pedja, Sascha, Gurpreet, Sandhya for their tireless efforts!**