

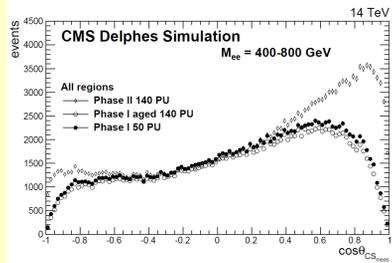
Enhanced Scope of a Phase-2 CMS Detector for Physics beyond the SM at the High-Luminosity LHC

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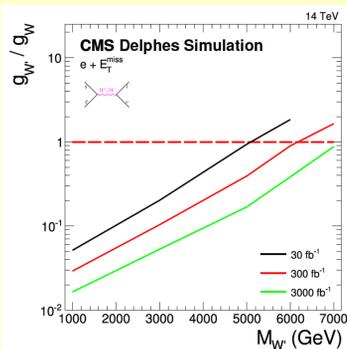
Physics Opportunities with HL-LHC

In phase-1 expect 300/fb, and 10x as much in phase-2. Great physics opportunities:

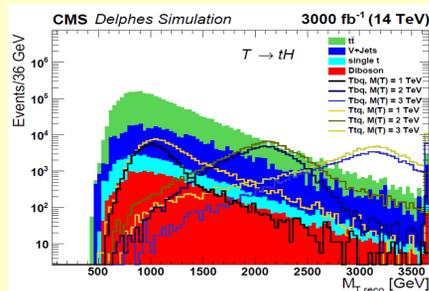
- Discover another **new particle** (e.g. dark matter, heavy resonances, the „unexpected“)
- If discovered something, study its **properties** (mass, couplings, spin, etc.)
- Access to **weak couplings** and **rare processes**



Observing a deviation in forward-backward asymmetry ($\cos\theta$) may reveal a new $e\bar{e}$ resonance. Phase-II with extended acceptance.



Study weak couplings in process $W' \rightarrow e\nu$ in sequential SM (SSM) model



Discover new vector-like quark (T) with charge +2/3 through decay $T \rightarrow tH \rightarrow l\nu_4 b$.

Upgrade of CMS for HL-LHC

High-luminosity (HL) means

Challenging detector conditions:

- Up to 200 overlaying (pileup) events
- 40 MHz operation (BX every 25 ns)
- $\sqrt{s} = 14$ TeV
- High rates and radiation levels, especially in the forward regions

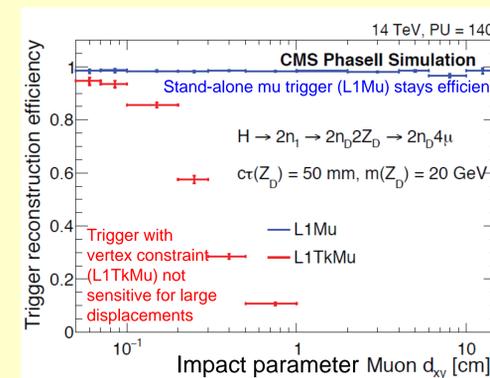
Great physics opportunities:

- Accumulate 3000/fb of data
- Discover, study or characterize processes

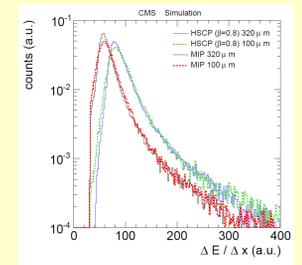
Ensure Detection of Unusual Signatures

Not known how new physics will look like. Could be a non-standard signature – need to be able to trigger on it and maintain sensitivity in upgraded detector.

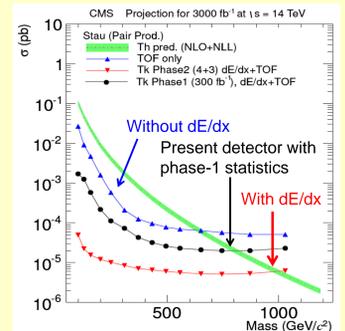
Example: displaced muons from decays of long-lived particles (e.g. with **large impact parameter** d_{xy}) need a stand-alone muon trigger without vertex constraint.



Slow moving particles (HSCP) will deposit **anomalous dE/dx** in silicon tracker. Feature to be kept for phase-2. Signature allows efficient separation from background (MIP).



If dE/dx not maintained, no sensitivity gain in phase-2 for this class of models.



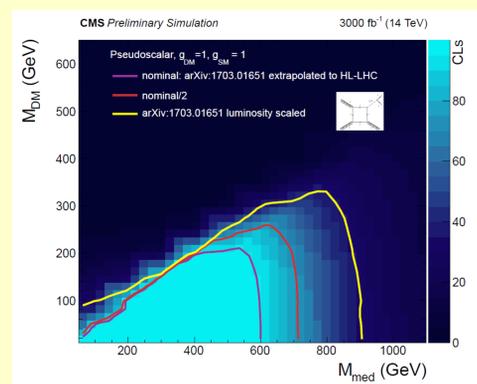
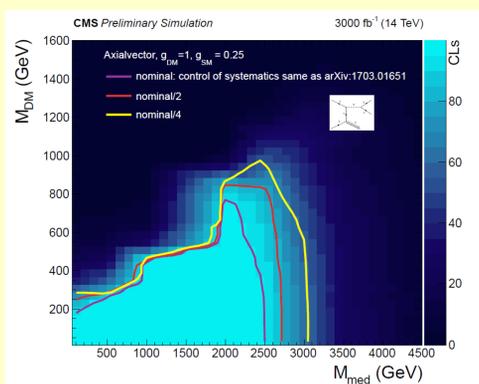
Search for Dark Matter (DM) in the jet+MET Final State

One of the top priorities of HL-LHC is the search and/or characterization of DM. Jet+Met channel is a **benchmark** among many DM collider searches. Interpretation in **simplified model** following recommendations of LHC DM forum (arXiv: 1507.00996):

4 parameters ($M_{med}, M_{DM}, g_{SM}, g_{DM}$)
2D exclusion limit

Axial vector mediator

Pseudoscalar mediator



Parametrized DELPHES simulation [4] with run-2 [arXiv:1703.01651] as baseline. Scenarios of systematic uncertainties: present knowledge and two reductions. Key = understanding MET: very high MET (AV) dominated by size of control sample and background extrapolation, low MET (PS) systematics dominated.

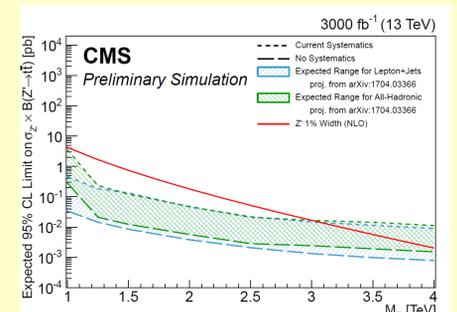
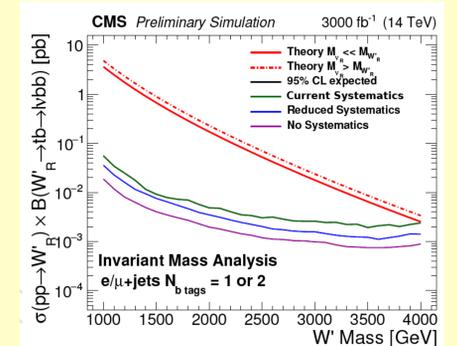
New **heavy bosons** (neutral as Z' , charged as W') are predicted in many SM extensions. Couplings to **third family** may be enhanced.

$W' \rightarrow tb \rightarrow e/\mu + b$ -jets
Model allows to probe scenarios such $M(v_R) > M(W'_R)$, which cannot be studied with leptonic W' searches.

Exclusion limit projected from run-2 [B2G-16-017] for three systematic scenarios (current, reduced and none).

$Z' \rightarrow tt \rightarrow e/\mu + jets$ (b- or t-tagged jet)
 $Z' \rightarrow tt \rightarrow all$ hadronic

Exclusion limit projected from run-2 [arXiv:1704.03366] with „current run-2“ and „no“ systematic uncertainties.



Visible impact of knowledge of systematic uncertainties on physics reach.

Expect improvements on theoretical knowledge of higher order corrections, detector understanding and data-driven methods will profit from larger statistics.

General references

- [1] CMS-PAS-EXO-14-007 [2] CMS-TDR-15-001, CDS1994307 (GE1/1 TDR)
[3] CMS-PAS-FTR-16-005 [4] DELPHES simulation, arXiv:1307.6346

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