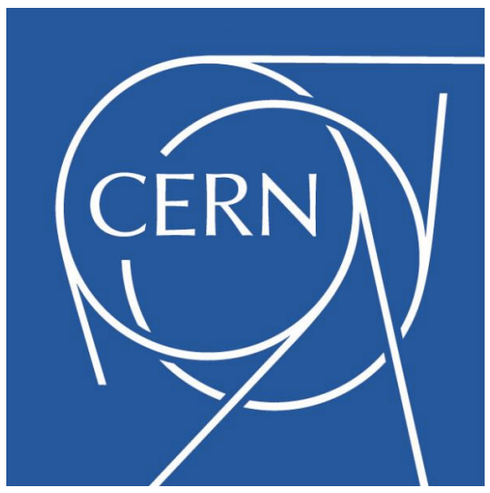
double parton scattering in same-sign WW at the HL LHC

HL/HE-LHC WG1 meeting

2nd march 2018, CERN

marc dünser (CERN)



introduction

double parton scattering usually 'low-profile' analyses

-> only very few studies related to the HL-LHC performed

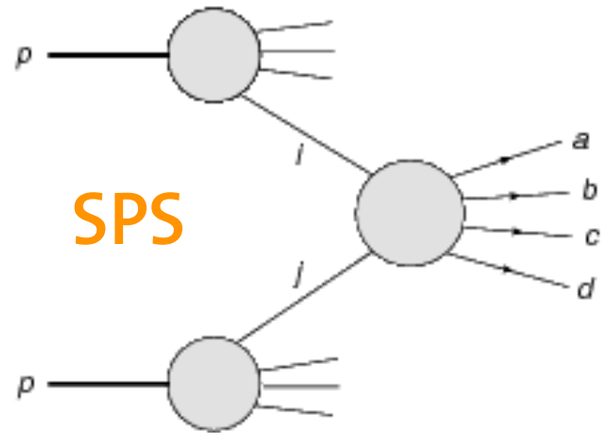
currently only one dedicated analysis for 3 ab^{-1} @ 14 TeV

-> studying the effects of the extended |eta| coverage in the CMS muon system on DPS WW

much more potential for the upgrade

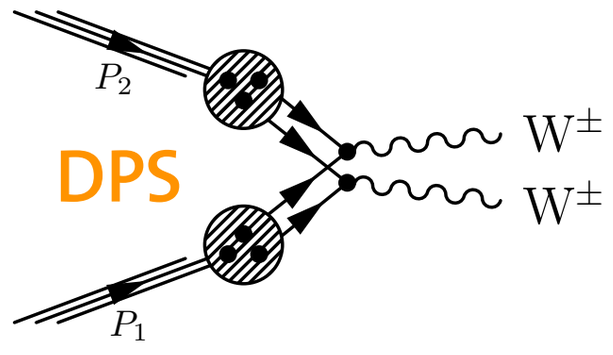
-> e.g. phase-2 trackers will go to much higher |eta|: perfect for electron channels in DPS (WW)

DPS WW in a nutshell



looking for two Ws from two *separate* parton-parton interactions within a collision

-> theoretical models exist to describe this



simplest model assumes complete factorization of both hard scatters

-> go from this:

$$\sigma^D_{(A,B)} = \frac{m}{2}\sum_{i,j,k,l}\int \Gamma_{ij}(x_1,x_2,b;t_1,t_2)\hat{\sigma}^A_{ik}(x_1,x_1')\hat{\sigma}^B_{jl}(x_2,x_2') \times\Gamma_{kl}(x_1',x_2',b;t_1,t_2)dx_1dx_2dx_1'dx_2'd^2b$$

partonic cross sections

pdf terms

transverse distance between partons

-> to something much simpler, this:

$$\sigma^D_{(A,B)} = \frac{m}{2}\frac{\sigma^S_{(A)}\sigma^S_{(B)}}{\sigma_{\text{eff}}}$$

must break down eventually! WW a good probe!

DPS WW - physics case @ HL LHC

so why is this process interesting to begin with?

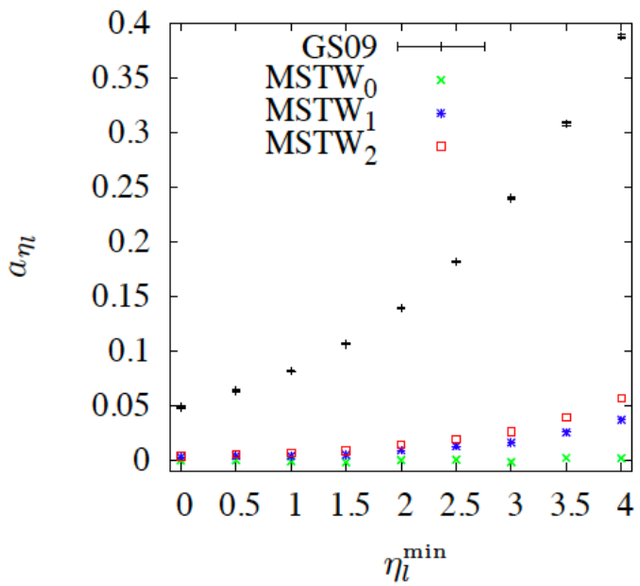
-> very sensitive to non-factorization models

-> we can learn something about the proton structure!
(and improve MC models)

non-factorization predicts observable differences w/r/t current MC models

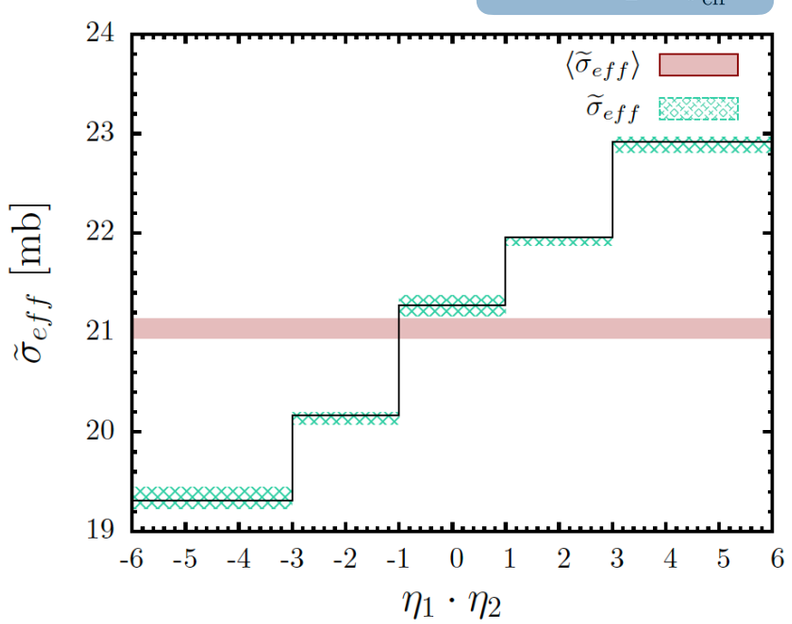
-> subtle overall change in cross section predicted

-> other observables related to the rapidities of the produced Ws



(b) Negatively charged leptons

$$\sigma^D_{(A,B)} = \frac{m}{2}\frac{\sigma^S_{(A)}\sigma^S_{(B)}}{\sigma_{\text{eff}}}$$



Gaunt, Stirling, arXiv:0910.4347v4, 2010
Double Parton Distributions Incorporating Perturbative QCD Evolution and Momentum and Quark Number Sum Rules

Ceccopieri, Rinaldi, Scopetta, arXiv:1702.05363v1, 2017
Parton correlations in same-sign W pair production via double parton scattering at the LHC

study on DPS WW at the HL-LHC

this study is part of the muon upgrade TDR in CMS

-> in the public document

took the 13 TeV result, and extrapolated to HL-LHC

-> performed full simulation of the signal and background process with PU = 200

-> scaling to higher acceptance of the muon system for signal and backgrounds

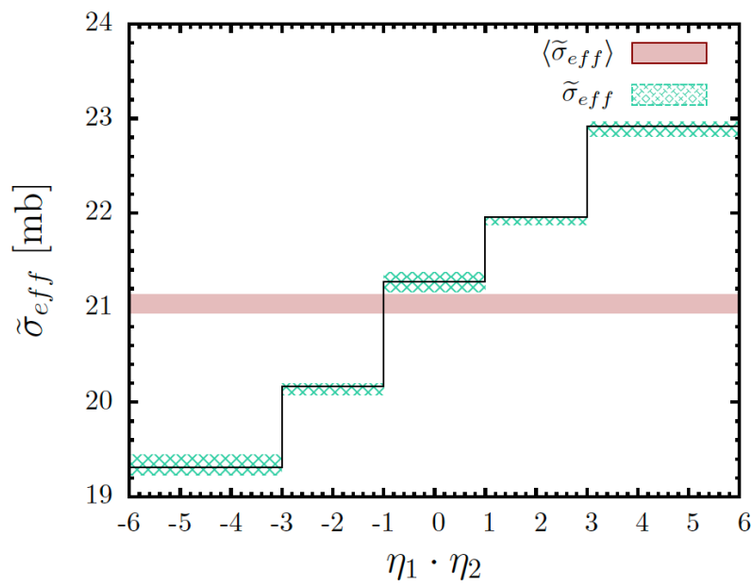
-> scaling to 3 ab^{-1} @ 14 TeV

question: are we sensitive to non-factorized calculations?

-> e.g. can we see this subtle slope?

CMS PAS FSQ-16-009

	expected	observed
$\sigma_{\mathrm{DPSWW}}^{\mathrm{pythia}}$	1.64 pb	$1.09^{+0.50}_{-0.49}$ pb
$\sigma_{\mathrm{DPSWW}}^{\mathrm{factorized}}$	0.87 pb	
significance for $\sigma_{\mathrm{DPSWW}}^{\mathrm{pythia}}$	3.27 σ	2.23 σ
significance for $\sigma_{\mathrm{DPSWW}}^{\mathrm{factorized}}$	1.81 σ	
UL in the absence of signal	< 0.97 pb	< 1.94 pb



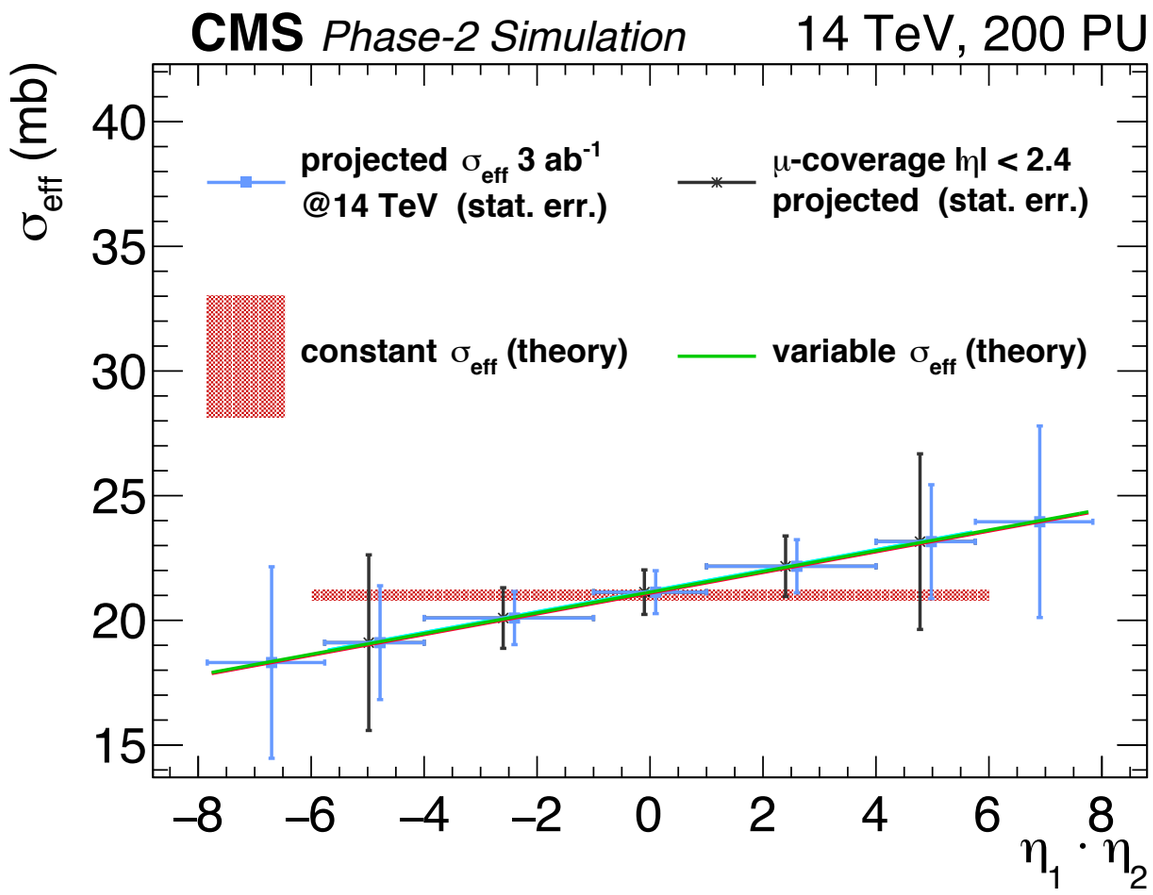
study on DPS WW at the HL-LHC

main result is this plot

-> sensitivity improved w/r/t 13 TeV result

-> extended coverage in |eta| really helps

-> uncertainty on a potential slope reduced by 30%



CMS muon TDR

summary

DPS an interesting topic for HL-LHC

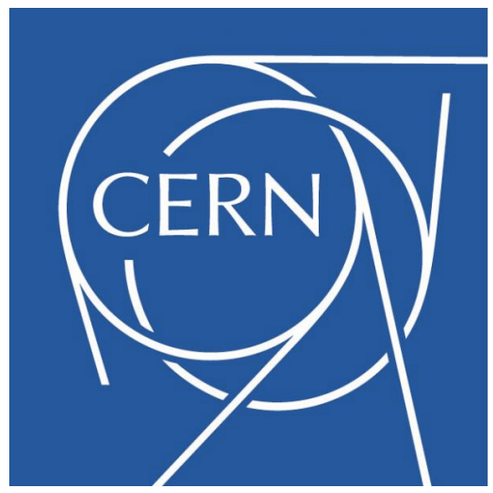
-> first studies for the physics reach coming in

will profit a lot from upgraded detectors

-> and forward detectors being built

the end

marc dünser



extras

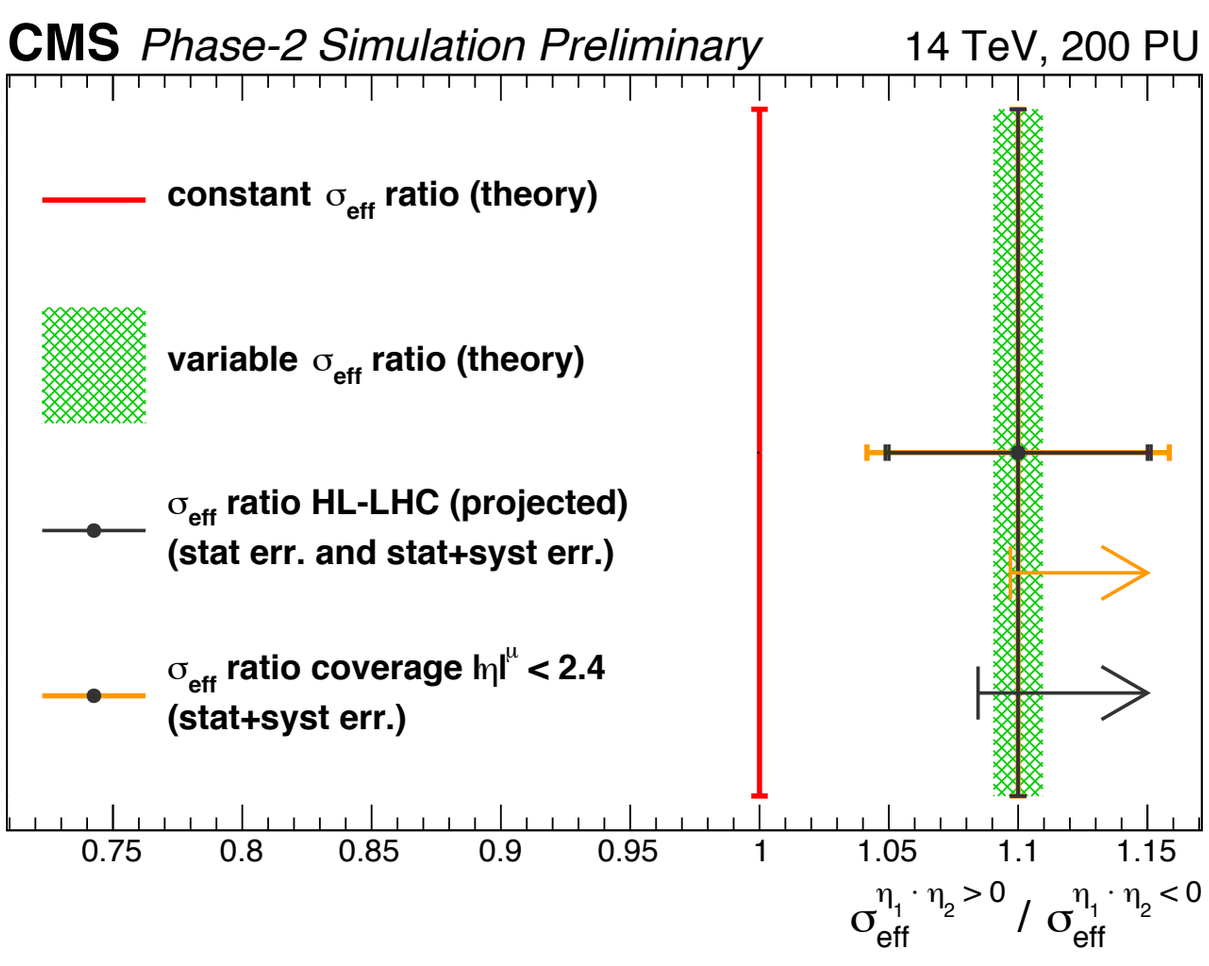
study on DPS WW at the HL-LHC

can also look at it in terms of a ratio (right over left)

-> sensitivity improved w/r/t 13 TeV result

-> extended coverage in |eta| really helps

-> combination of lumi + coverage will lead to sensitivity to these effects



CMS muon TDR