

Higgs Hunting 2015

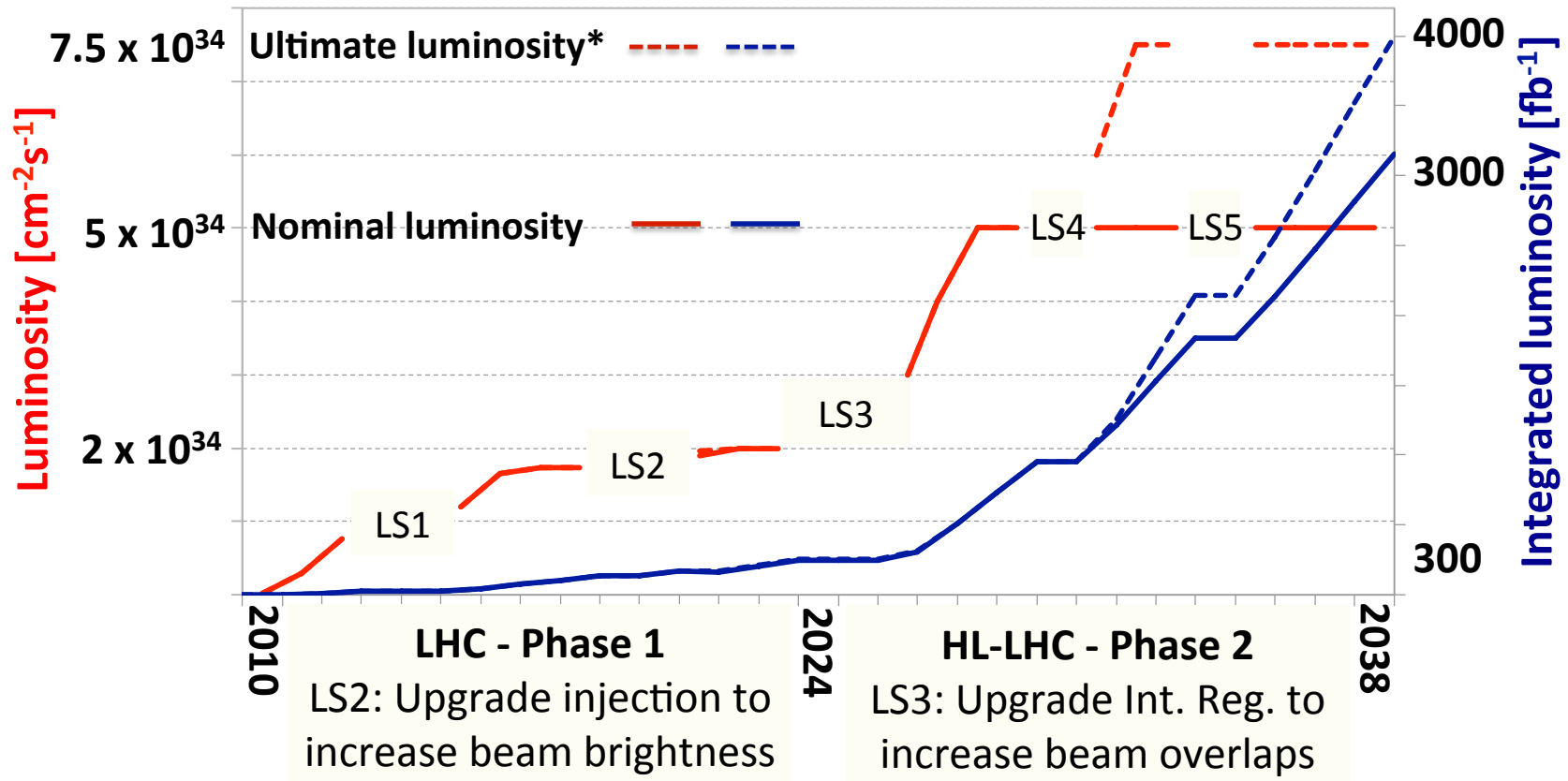
HL-LHC Session: Discussion



Joe Incandela
University of California Santa Barbara
1 August, 2015

$50 \text{ pb} * 3000 \text{ fb}^{-1} = 150 \text{ M Higgs produced per experiment}$

New schedule for Long Shutdowns and Accelerator perspective for luminosity

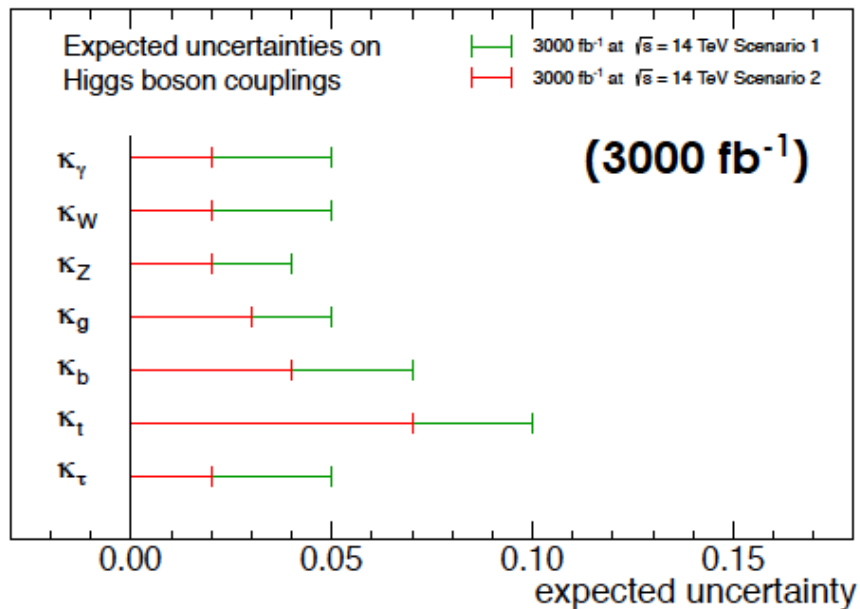


* "Ultimate luminosity" is a design specification - effective integrated luminosity is not limited by instantaneous luminosity - potentially 30% more $\text{fb}^{-1}/\text{year}$

* From talk by Didier Contardo (CMS) at EPS 2015

Precision on couplings

CMS Projection



Scenario 1:

All systematic uncertainties are left unchanged

Scenario 2:

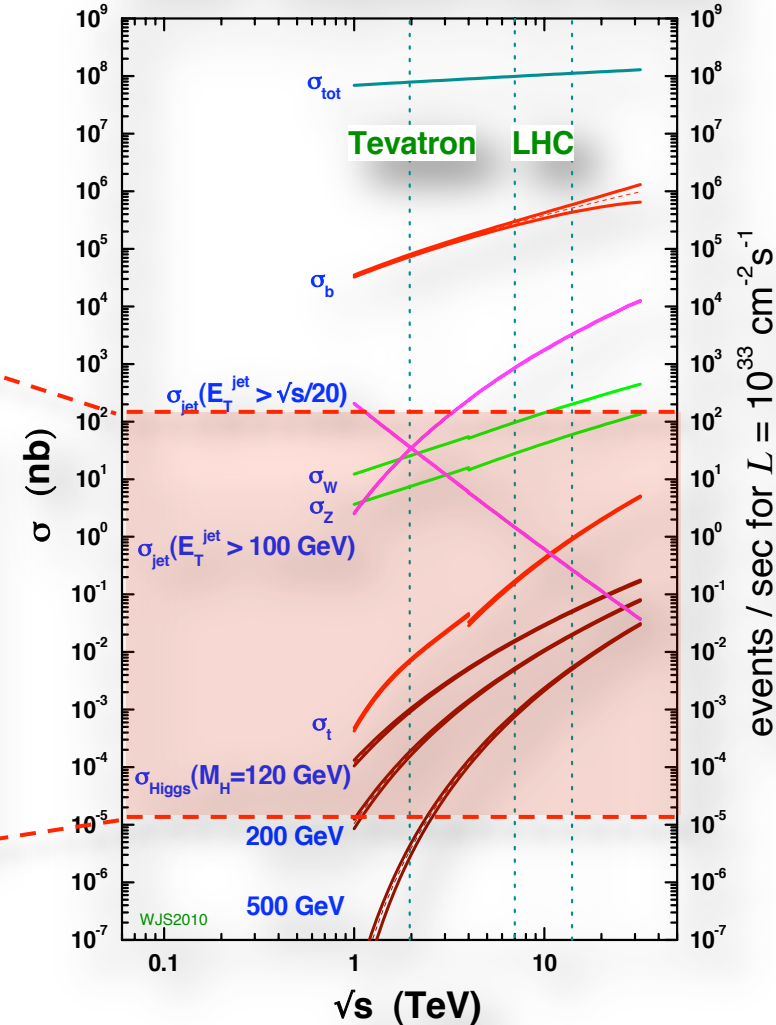
- Theoretical uncertainties scaled by 1/2
- Other systematic uncertainties scaled by $\sqrt{(\text{int. lumi.})}$

- Without changes from Run 1, theory uncertainties + PDFs dominate...
 - When CMS first proposed scenario 2, scaling theoretical errors by $\frac{1}{2}$ was not so well accepted

- Indeed, Run 1 was made possible by a huge improvement in theory uncertainties that had taken many years!

Higgs Hunting 2015 – Orsay – Preparing for the HL-LHC – Joe Incandela (UCSB)

- ## proton - (anti)proton cross sections

[illegible]

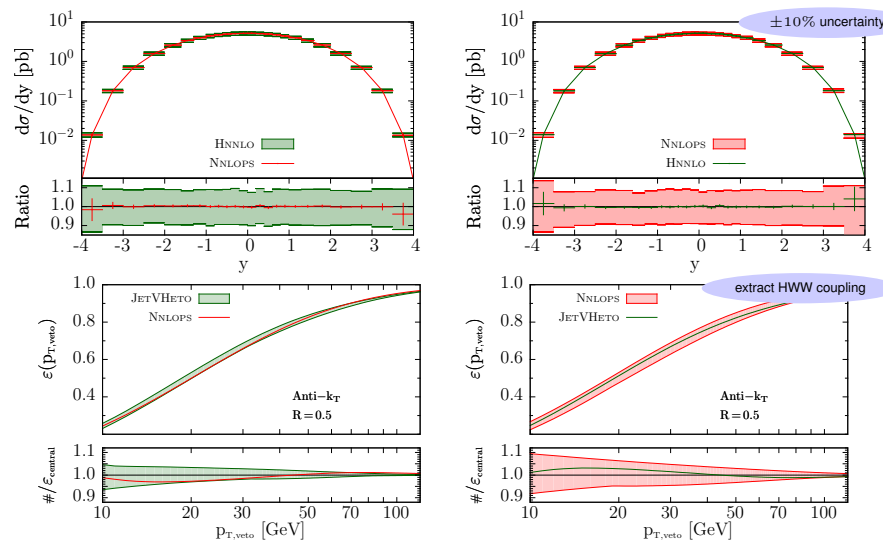
Adapted from a slide from Marumi Kado

Situation today

- This conference*
 - Inclusive ggH to N₃LO (+N₃LL soon)
 - MC NLO+PS, N₂LO+PS coming in time?
 - Much promise in off-shell physics:
 - Not clear if/how to get at it?

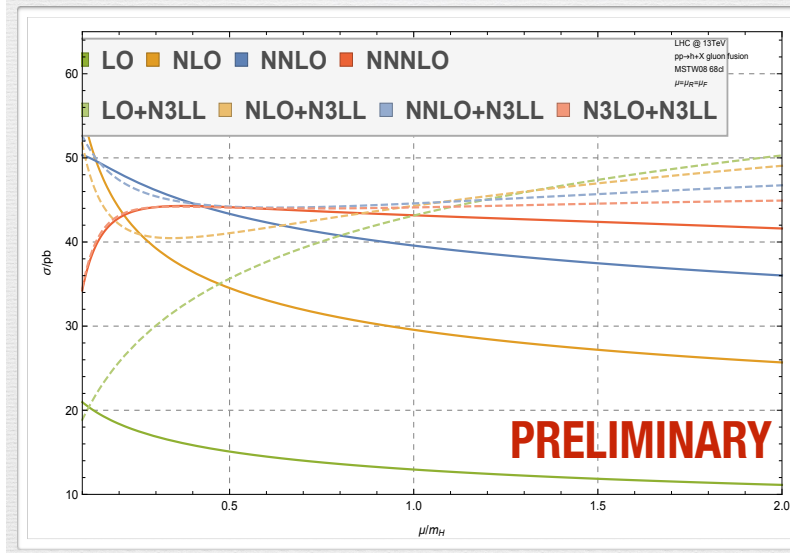
ggH at NNLO+PS (with MiNLO)

[Hamilton,Nason,ER,Zanderighi '13]



► approximate inclusion of t and b mass effects also studied
[Hamilton,Nason,Zanderighi '15]

N₃LL threshold resummation

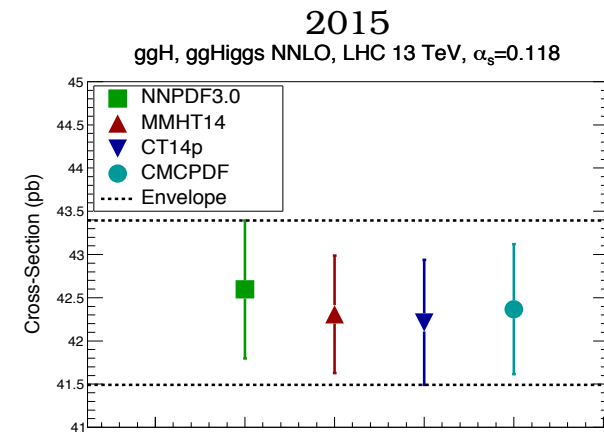
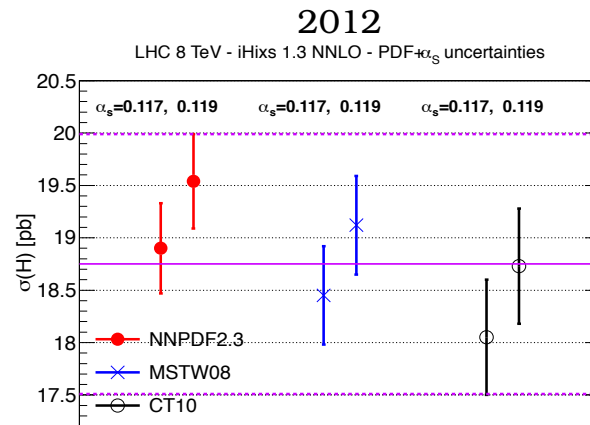


- Calculations appear to be progressing faster than expected!
- PDFs too
 - 1/2 scaling no longer looks impossible.
 - Can we have another factor of 2 please? 😊

But...

- α_s may be a limiting factor
 - More precision needed. How?

PDFs: RECENT PROGRESS HIGGS IN GLUON FUSION

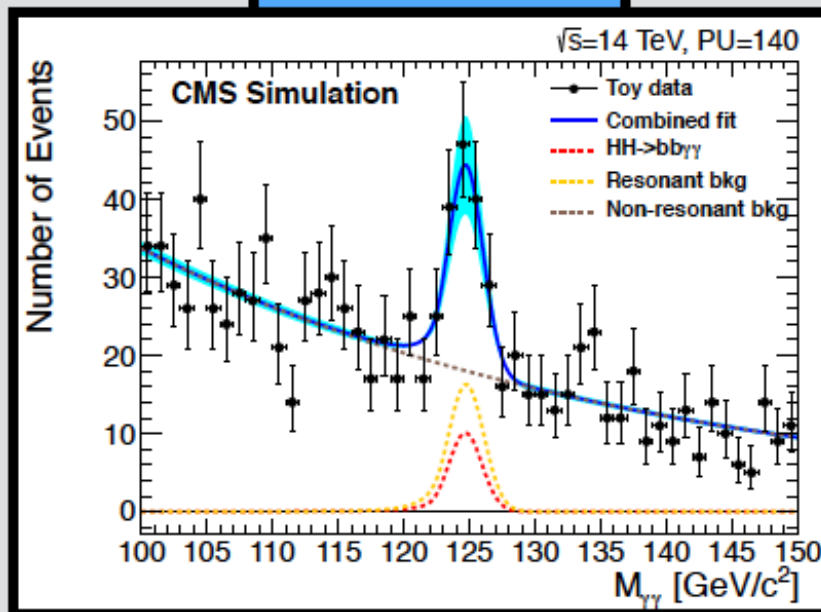


- MAJOR UPGRADES** FROM ALL GLOBAL FITTING GROUPS:
NNPDF2.3 → 3.0 (10/2015); MSTW08 → MMHT14 (12/2015); CT10 ⇒ CT14 (06/2015)
- METHODOLOGICAL IMPROVEMENTS:** CLOSURE TESTS (NNPDF); EXTENDED PARAMETRIZATIONS (CT, MMHT)
- LHC-I DATA INCLUDED
- PDF **UNCERTAINTY ON HIGGS PRODUCTION DOWN** TO ABOUT 2%
ENVELOPE NO LONGER NECESSARY

Is 5% the limit? Is it enough?

Key motivators & design drivers

HH \rightarrow bb $\gamma\gamma$



- Allows measurement of Higgs self-coupling λ_{HHH}
- **CMS Z_0 (3000 fb⁻¹): 1.9 σ for bb $\gamma\gamma$ + bb $\tau\tau$**
 - **54%** exp. uncertainty in signal yield
- **ATLAS Z_0 ($\lambda_{HHH} / \lambda_{SM} = 1$): 1.3 σ**

- DiHiggs crucial
 - Experiment studies so far fall slightly short
 - What are the limiting factors?
 - What more is needed?
 - Combining many/all channels alla Tevatron Higgs searches? Machine learning?
 - Better instrumentation?
 - E.g. timing for pileup? (i.e. neutral component)
- Design drivers
 - What other physics –BSM in particular – should be driving the designs?
 - Single Higgs already pushes the detectors, triggers hard....
 - NMSSM ?
 - See Tony Gherghetta's talk

*Need more sophisticated
detectors and techniques:
This is a new level of
challenge.*

Granularity is key

HL-LHC: PU~ O(140-200)

70MCHF descope of the detectors? Amortized over the period (2015,2038)~ 0.3% of CERN's budget