## Status of work on multiple fronts

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>8 TeV</td>
<td>Run 1 Physics:</td>
</tr>
<tr>
<td>2013</td>
<td>LS1</td>
<td>Run 2 Preparation:</td>
</tr>
<tr>
<td>2014</td>
<td></td>
<td>Main detector objectives</td>
</tr>
<tr>
<td>2015</td>
<td></td>
<td>Milestones for upgrade projects</td>
</tr>
<tr>
<td>2016</td>
<td></td>
<td>CMS strategy and preparations</td>
</tr>
<tr>
<td>2017</td>
<td>13-14 TeV</td>
<td>HL-LHC Physics Case:</td>
</tr>
<tr>
<td>2018</td>
<td>LS2</td>
<td>Physics program and potential</td>
</tr>
<tr>
<td>2019</td>
<td></td>
<td>Milestones for upgrade projects</td>
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<tr>
<td>2020</td>
<td></td>
<td>CMS strategy and preparations</td>
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<tr>
<td>2021</td>
<td></td>
<td>Physics program and potential</td>
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<tr>
<td>2022</td>
<td>LS3</td>
<td>Run 1 Physics:</td>
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<td>2023</td>
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<td>Run 2 Preparation:</td>
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<tr>
<td>2024</td>
<td></td>
<td>Main detector objectives</td>
</tr>
</tbody>
</table>

### Selected highlights

- **Run 1 Physics:**
- **Run 2 Preparation:**
- **Phase I Upgrades:**
- **Phase II Upgrades:**
- **HL-LHC Physics Case:**

### Milestones for upgrade projects

- **LS1:** 0.7x10^{34} cm^{-2}s^{-1}
- **LS2:** 1x10^{34} cm^{-2}s^{-1}
- **LS3:** 2x10^{34} cm^{-2}s^{-1}

### HL-LHC Physics Case

- 13-14 TeV
- 8 TeV

### CMS strategy and preparations

- LS1
- LS2
- LS3
New CMS Physics Results

Exploiting Run I data in pp, pPb, and PbPb

• numerous new public and published results this summer
• turning over more and more stones
• legacy publications, intensive program for 2013 & 2014
Status of Higgs Studies at CMS

Fantastic progress since discovery July 2012

- Observation in three bosonic channels
- Evidence for fermion couplings
- Precision mass measurement
- Spin determined
- **Looks more and more like the SM Higgs boson**
- No evidence for non-SM decays
- No evidence for additional Higgs boson
- Publication of Run I legacy paper in progress

Summary of the Higgs boson properties

- Mass
  - \( M = 125.7 \pm 0.3 \pm 0.3 \) GeV
  - 0.5% precision
- Signal strength
  - \( \mu = 0.80 \pm 0.14 \)
- Spin/CP
  - \( J^{CP} = 0^{++} \) (SM-like Higgs boson) preferred
  - \( 0^{-+} \) (2^{++}) disfavored at a 3.3 (2.8)\( \sigma \) level
Significant progress in ttH channel

- $H \rightarrow \gamma\gamma$ → HIG-13-015
- $H \rightarrow bb$ → HIG-13-019
- $H \rightarrow \tau\tau$ → HIG-13-020
- $H \rightarrow ZZ$ → HIG-13-020
- $H \rightarrow WW$

Sensitivity approaching SM Higgs, directly to top Yukawa coupling

$\mu = 2.5 \pm 1.1$
Invisible Higgs Decays

Studies in associated ZH and VBF production

- sensitivity to Higgs decays to DM candidates

- **ZH**
  - analyze shape of $m_T(Z,H)$
  - $\text{BR}(H\rightarrow\text{inv.}) < 75\%$ (91\% exp.) @ 95\% CL

- **VBF**
  - special VBF + MET trigger
  - $\text{BR}(H\rightarrow\text{inv.}) < 69\%$ (55\% exp.) @ 95\% CL

- gluon fusion
  - reinterpretation of monojet analysis

- **ZH and VBF combination**
  - $\text{BR}(H\rightarrow\text{inv.}) < 54\%$ (46\% exp.) @ 95\% CL

- studies underway to include coupling fits with $\text{BR}_{\text{BSM}}$ included in total widths
Dark Matter Searches

Search for DM in monojet, monophoton, and monolepton final states by triggering on ISR jets, photon, or W ( lv)

• limits are model-dependent (heavy mediator) yet competitive with (complementary to) direct searches
• unique sensitivity to DM-gluon couplings
• interpretation as Higgs to invisible search possible
Higgs in SUSY decays

GMSB-like search for stop pair production with Higgs production is cascade

- natural SUSY scenario
  \[ \tilde{t}_R \rightarrow b\tilde{\chi}_1^+ \text{ or } t\tilde{\chi}_i^0 \text{ or } \tilde{\chi}_1^0 \rightarrow H\tilde{G} \text{ or } Z\tilde{G} \]

- investigate diphoton Higgs decays in $\gamma\gamma bb + ME_T$ final states
- use $ME_T$ as discriminating variable
Higgs in SUSY decays

First search of this kind at the LHC
- like-sign dilepton, single-lepton, and multi-lepton final states
- exploring $H$ decays to $bb$, $WW$, $ZZ$, or $\tau\tau$

$\text{SUS-13-017}$

Also look for direct chargino and neutralino pair production

$\text{SUS-13-006}$
Natural SUSY: sbottom and stop

Direct sbottom and stop pair production in
- hadronic $\alpha_T + b$-jets
- razor + $b$-jets
- single-lepton + $b$-jets

SUS-12-028
arXiv: 1303.2985
The “we did not find SUSY” Plot

Summary of CMS SUSY Results* in SMS framework

- SUSY 2013
  - m(mother)-m(LSP)=200 GeV
  - SUSY 2013-012 SUS-12-028 L=19.5 11.7 fb
  - SUSY-12-006 SUS-12-024 L=4.7 fb
  - SUSY-13-004 SUS-12-024 SUS-12-028 L=19.3 19.4 fb
  - SUSY-14-011 L=4.98 fb
  - SUSY-12-004 L=4.98 fb
  - SUSY-12-010 L=4.98 fb
  - SUSY-13-008 SUS-13-013 L=19.5 fb
  - SUSY-11-010 L=4.98 fb
  - SUSY-12-021 SUS-12-002 L=4.98 4.73 fb
  - SUSY-13-013 L=19.5 fb
  - SUSY-13-011 SUS-13-004 L=19.5 19.3 fb
  - SUSY-12-004 SUS-12-005 L=4.7 fb
  - SUSY-13-014 L=19.5 fb
  - SUSY-13-028 L=11.7 fb
  - SUSY-13-008 SUS-13-013 L=19.5 fb
  - SUSY-13-008 L=19.5 fb
  - SUSY-13-008 SUS-13-013 L=19.5 fb
  - SUSY-13-006 L=19.5 fb

CMS Preliminary

For decays with intermediate mass,

\[ m_{\text{intermediate}} = x m_{\text{mother}} (1-x) m_{\text{LSP}} \]

*Observed limits, theory uncertainties not included

Only a selection of available mass limits

Probe "up to" the quoted mass limit

Markus Klute

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The “we did not find RPV SUSY” Plot
Top Physics Highlights

Most precise measurement of $R$

- $R = \frac{Br(t \rightarrow Wb)}{Br(t \rightarrow Wq)} = 1.023 + 0.036 - 0.034$

Search for FCNC top decay

- $Br(t \rightarrow Zq) < 0.05\%$ @ 95\% CL

Limit on FCNC top decay or Higgs coupling

- Using SUSY multilepton search
- $Br(t \rightarrow Hc) < 0.31\%$ @ 95\% CL

<table>
<thead>
<tr>
<th>Higgs Decay Mode</th>
<th>observed</th>
<th>expected</th>
<th>$1\sigma$ range</th>
</tr>
</thead>
<tbody>
<tr>
<td>$h \rightarrow WW$ (BR = 22.3%)</td>
<td>0.37%</td>
<td>0.38%</td>
<td>(0.26–0.52)%</td>
</tr>
<tr>
<td>$h \rightarrow \tau\tau$ (BR = 6.24%)</td>
<td>8.4%</td>
<td>7.6%</td>
<td>(5.8–11.2)%</td>
</tr>
<tr>
<td>$h \rightarrow ZZ$ (BR = 2.76%)</td>
<td>1.23%</td>
<td>0.97%</td>
<td>(0.74–1.42)%</td>
</tr>
</tbody>
</table>

| combined | 0.31\% | 0.31\% | (0.21–0.46)\% |
Top Quark Mass

Combination of all 7 and 8 TeV CMS analyses

- \( m_t = 173.49 \pm 0.36 \text{ (stat.)} \pm 0.91 \text{ (syst.) GeV} \)

Novel determination of \( m_t \) from cross section and \( \alpha_s \)

- required precise LHC beam energy of 0.65% (CERN-ATS-2013-040)
- \( m_t = 176.7 \pm 3.8 - 3.4 \text{ GeV (pole mass)} \)
Search for vector-like Top Partners

Predicted for example in Little Higgs models and can stabilize Higgs mass

Search in various possible decay modes in l+jets and dilepton channels

Limits between 687 and 782 GeV for all possible BR into three possible decays

B2G-12-015

<table>
<thead>
<tr>
<th>channel</th>
<th>OS1</th>
<th>OS2</th>
<th>SS</th>
<th>trileptons</th>
</tr>
</thead>
<tbody>
<tr>
<td>tt</td>
<td>5.2±1.9</td>
<td>80 ±12</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>single top</td>
<td>2.5±1.3</td>
<td>2.0±1.0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Z</td>
<td>9.7±2.9</td>
<td>2.5±1.9</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>ttW</td>
<td>-</td>
<td>-</td>
<td>5.8 ±1.9</td>
<td>0.25±0.11</td>
</tr>
<tr>
<td>ttZ</td>
<td>-</td>
<td>-</td>
<td>1.83±0.93</td>
<td>1.84±0.94</td>
</tr>
<tr>
<td>WW</td>
<td>-</td>
<td>-</td>
<td>0.53±0.29</td>
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<tr>
<td>WZ</td>
<td>-</td>
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<td>0.34±0.08</td>
<td>0.40±0.21</td>
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<tr>
<td>ZZ</td>
<td>-</td>
<td>-</td>
<td>0.03±0.00</td>
<td>0.07±0.01</td>
</tr>
<tr>
<td>WWW/WWZ/ZZZ/WZZ</td>
<td>-</td>
<td>-</td>
<td>0.13±0.07</td>
<td>0.08±0.04</td>
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<tr>
<td>ttWW</td>
<td>-</td>
<td>-</td>
<td>0.01±0.00</td>
<td>-</td>
</tr>
<tr>
<td>charge mis-ID</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>non-prompt</td>
<td>-</td>
<td>-</td>
<td>7.9 ±4.3</td>
<td>0.99±0.90</td>
</tr>
<tr>
<td>total background</td>
<td>17.4±3.7</td>
<td>84 ±12</td>
<td>16.5±4.8</td>
<td>3.7±1.3</td>
</tr>
<tr>
<td>data</td>
<td>20</td>
<td>86</td>
<td>18</td>
<td>2</td>
</tr>
</tbody>
</table>

CMS preliminary $\sqrt{s} = 8$ TeV 19.6 fb$^{-1}$

Observed T Quark Mass Limit [GeV]
New Physics Searches with Top Quarks

Combined search for tt-resonance in the l+jets and all-hadronic channels using full 8 TeV dataset

- optimized for low-mass (non-boosted) and high-mass (boosted) regimes
- sets most stringent limits today

B2G-13-001
arXiv:1309.2030
Lepton Resonance Searches

Searches for $W'$ and $Z'$ in leptonic decay channels
Set model dependent mass limits, e.g.

- $m(W'_{SSM}) > 3.2$ TeV
- $m(Z'_{SSM}) > 3.0$ TeV
Heavy Ion Highlights

- Long range correlations in pPb and PbPb collisions
  - studied 2 and 4-particle correlations and multiple harmonics ($v_2$, $v_3$)
  - striking similarities between pPb and PbPb for same multiplicity
  - hydrodynamic flow of strongly coupled medium presently the only theory capturing all observations
Heavy Ion Highlights

• New analysis on Ypsilon production in pPb collisions

• PbPb data shows strong suppression

• Suppression seen in pPb, but less strong

• More statistics are needed to answer whether suppression depends on event activity or on the type of colliding particles

HIN-13-003
Status of work on multiple fronts

Run 1 Physics

Selected Highlights

Run 2 Preparation:

Main detector objectives

Phase I Upgrades:

Milestones for upgrade projects

Phase II Upgrades:

CMS strategy and preparations

HL-LHC Physics Case:

Physics program and potential

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Markus Klute
Run 2 Preparation

LHC energy increase offers unique opportunity for discovery early on

Improvements on many CMS sub-systems

- new hardware: BRIL, DAQ, ECAL, HCAL, DT, RPC, CSC, L1, HLT
- new operating scheme: Pixel & Strip tracker at -20C, DAQ-HLT interface file-based, use of μTCA

Preparing for 25ns operation and for large pileup

Dealing with new collision conditions and detector improvements will require dedicated commissioning time.

Scheduled regular global CMS runs and extended run end of 2014.
Run 2 Preparation - Tracker

Operation at lower temperature to mitigate radiation damage

- -20 C instead of current +4 C
- new services outside vacuum tank finished
- first round of sealing and supporting work finished end of September
- all very encouraging; final test with complete system pending

Recover pixel modules with close to 100% efficiency
Run 2 Preparation - Calorimeter

HCAL mixture of recommissioning and upgrade preparation

- CCM refurbishments on HB, HE and HO. Completed ahead of time and tested OK
- HO HPD exchanged with SiPM. Good progress, ahead of schedule
- HF PMT replacements. First installation imminent
- HF μTCA BE installation. Installation in Jan’14
- Re-establish calibration system using radioactive sources. Planning to bring Co-60 source to HF next month

ECAL mixture of repair and operational procedures

- repairing non-working areas in EE+ES
- allow EB transparency correction at L1
- solid-state blue lasers for monitoring
- improve procedures in prompt-feedback tool and calibration procedures
Run 2 Preparation - Muons

Completions of stations
• 4th station with 67 ME4/2 and 144 RE4 chambers
• production on track
• ready for installation of positive endcap in October

ME1/1 refurbishment progressing well
• 22/72 ready to be refurbished

Maintenance and consolidation
• fixed 149/156 dead channels due to HV problems
• overpressure test successfully performed
• minicrate repair ongoing
Status of work on multiple fronts

Run 1 Physics
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8 TeV

LS1
LS2
LS3


0.7x10^{34}\text{cm}^{-2}\text{s}^{-1}
1x10^{34}\text{cm}^{-2}\text{s}^{-1}
2x10^{34}\text{cm}^{-2}\text{s}^{-1}
5x10^{34}\text{cm}^{-2}\text{s}^{-1}

13-14 \text{TeV} →
Phase I Upgrades (overview)

**Major milestone**
- System comes into operation

**Milestones in the TDRs**
- 2014: LS1
- 2015: YETS
- 2016: E-YETS
- 2017: LS2

**L1-Trigger**
- Installation of parallel paths Calo Trigger: May 2014
- Interim Calo Trigger operational
- Slice of TDR Trigger (Calo, Muon, Global) operating
- Full TDR Trigger commissioned

**PIXELS**
- Start sensor prod, submit final ROC: Oct 2013
- Install pilot blades
- Start module production: May 2014
- DAQ operational at P5
- Ready for Installation

**HCAL**
- HF BE upgraded to uTCA: Apr 2014
- HF FE upgraded (2-channels per PMT, TDC)
- HBHE BE upgraded to uTCA
- HBHE FE upgraded (SiPM and depth segmentation)
# Status of work on multiple fronts

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<thead>
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</tr>
</thead>
<tbody>
<tr>
<td>LS1</td>
<td>8 TeV</td>
<td>0.7x10^{34} cm(^{-2})s(^{-1})</td>
<td>13-14 TeV</td>
<td>1x10^{34} cm(^{-2})s(^{-1})</td>
<td>LS2</td>
<td>2x10^{34} cm(^{-2})s(^{-1})</td>
<td>LS3</td>
<td>5x10^{34} cm(^{-2})s(^{-1})</td>
<td></td>
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</tbody>
</table>

## Selected Highlights
- Run 1 Physics
- Run 2 Preparation:
- Phase I Upgrades:
- Phase II Upgrades:
- HL-LHC Physics Case:

Selected Highlights
- Main detector objectives
- Milestones for upgrade projects
- CMS strategy and preparations
- Physics program and potential
Phase II Upgrade Driving Considerations

Longevity of CMS sub-systems
- studies of radiation damage are well advanced

HL-LHC Physics Program
- continuation of ESG/Snowmass studies
- simulation studies of physics objects and benchmark signals
- assess performance of degraded detectors and high pileup
- demonstrate pileup mitigation of upgraded detectors
- improve detector capabilities

Constraints in experimental area
- Sequence of work during LS3 (installation of Phase II upgrades)
- Simulation of activation and possible mitigation
- Interface with HL-LHC new IP configuration
Longevity of Phase I detectors

Complete tracker needs replacement in LS3
- Strip tracker will survive 500 fb$^{-1}$ if operated at -20°C, but will start to lose significant amount of modules beyond
- Pixel Phase I detector built to sustain 500 fb$^{-1}$ with a replacement of the inner-most layer

Detailed studies of ECAL radiation damage effects of crystals and photo-detectors
- ECAL Barrel will sustain 3000 fb$^{-1}$
- Endcaps will collect less than 10% of light at 500 fb$^{-1}$ and needs replacement

HCAL radiation damage compatible with expectations in forward (HF) and larger than expected in endcaps (HE)
- HF will survive 3000 fb$^{-1}$ at least up to $= 4.5$
- HCAL barrel will sustain 3000 fb$^{-1}$
- Endcaps need replacement during LS3

Muon systems are expected to sustain 3000 fb$^{-1}$
Proposed Phase II Upgrade

Tracker
- replacement of tracker
- extended pixel coverage up to $|\eta|=4$
- L1 track trigger

Calorimeter
- extended calorimeter coverage up to $|\eta|=4$
- investigating precision timing measurements

Muon system
- extended coverage up to $|\eta|=4$

Trigger / DAQ system
- allow higher L1-trigger rates up to 1MHz
- allow 10μs latency
- upgrade HLT processing with 10kHz output rate
Develop the Scope of Phase II Upgrade

CMS Upgrade week at DESY
• Turning point

ECFA Workshop in Aix Les Bains
• HL-LHC experiments workshop

Document for CMS Phase II upgrade in preparation
• outlines current understanding for the scope for CMS Phase 2 upgrades with an initial cost estimate
• submission to LHCC after internal review

Technical Proposal in 2014
• conceptual designs for the detector upgrades
• supporting physics performance studies and benchmark signals
• scope of work, timeline and new cost estimate

Technical Design Reports in ~2016
• detailed design of major sub-detectors and systems
Status of work on multiple fronts

Selected Highlights

Run 1 Physics

Run 2 Preparation:

Phase I Upgrades:

Phase II Upgrades:

HL-LHC Physics Case:

Main detector objectives

Milestones for upgrade projects

CMS strategy and preparations

Physics program and potential
HL-LHC Physics Projections

Impressive Run 1 results with the discovery of a Higgs boson

Exciting opportunity to find new physics in Run 2 with 300 fb$^{-1}$ at 13-14 TeV

What is the Physics case for the HL-LHC (3000 fb$^{-1}$ at 14 TeV)?

- precision Higgs physics and the test of EWSB (vector boson scattering)
- direct searches for small cross section SUSY or other BSM scenarios
- investigate rare SM processes which might be enhanced in BSM
- potentially, precision measurements of BSM particles

CMS approach for ESG / Snowmass
- project measurements based on well tested analyses using Run I data

CMS approach for ECFA workshop and beyond (expect new results!)
- complement projections with full and parametrized simulation
- combine studies of the physics case with validation of upgrade concepts

Assumptions on systematic uncertainties
Scenario 1: no change w.r.t. Run I
Scenario 2: $\Delta$ theory / 2, rest $\propto 1/\sqrt{L}$
also studied: no theory uncertainties
Higgs Boson Coupling Modifier Fits

\[ \kappa_g, \kappa_Y, \kappa_{Z\gamma} : \text{loop diagrams} \rightarrow \text{allow potential new physics} \]

\[ \kappa_W, \kappa_Z : \text{vector bosons} \]

\[ \kappa_t, \kappa_b : \text{up- and down-type quarks} \]

\[ \kappa_\tau, \kappa_\mu : \text{charged leptons} \]

Total width from sum of partial widths

Alternatively:

\[ \Gamma_{\text{tot}} = \sum \Gamma_{ii} + \Gamma_{\text{BSM}} \]

\[ \text{BR}_{\text{BSM}} = \Gamma_{\text{BSM}} / \Gamma_{\text{tot}} \]

Assumption here \( \kappa_W, \kappa_Z < 1 \)

CMS Projection

<table>
<thead>
<tr>
<th>( L \ (\text{fb}^{-1}) )</th>
<th>( \kappa_\gamma )</th>
<th>( \kappa_W )</th>
<th>( \kappa_Z )</th>
<th>( \kappa_g )</th>
<th>( \kappa_b )</th>
<th>( \kappa_t )</th>
<th>( \kappa_\tau )</th>
<th>( \kappa_{Z\gamma} )</th>
<th>( \kappa_\mu )</th>
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<tbody>
<tr>
<td>300</td>
<td>[5,7]</td>
<td>[4,6]</td>
<td>[4,6]</td>
<td>[6,8]</td>
<td>[10,13]</td>
<td>[14,15]</td>
<td>[6,8]</td>
<td>[41,41]</td>
<td>[23,23]</td>
</tr>
<tr>
<td>3000</td>
<td>[2,5]</td>
<td>[2,5]</td>
<td>[2,4]</td>
<td>[3,5]</td>
<td>[4,7]</td>
<td>[7,10]</td>
<td>[2,5]</td>
<td>[10,12]</td>
<td>[8,8]</td>
</tr>
</tbody>
</table>

Coupling precision 2-10% factor of ~2 improvement from HL-LHC

* Additional channels under study, e.g. \( \text{ttH, H to VV} \)
Invisible Higgs Decays

Accessible via VBF and ZH production.

Assuming SM production cross section, observed (expected) 95% CL limits are

<table>
<thead>
<tr>
<th>Production</th>
<th>BR&lt;sub&gt;inv&lt;/sub&gt; Limit</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZH</td>
<td>&lt; 75% (91%)</td>
<td>HIG-13-018</td>
</tr>
<tr>
<td>VBF</td>
<td>&lt; 69% (55%)</td>
<td>HIG-13-013</td>
</tr>
</tbody>
</table>

Estimate from CMS for future performance based in ZH analysis only

<table>
<thead>
<tr>
<th>L (fb&lt;sup&gt;-1&lt;/sup&gt;)</th>
<th>H → inv.</th>
</tr>
</thead>
<tbody>
<tr>
<td>300</td>
<td>[17, 28]</td>
</tr>
<tr>
<td>3000</td>
<td>[6, 17]</td>
</tr>
</tbody>
</table>

Extended Higgs coupling fit has sensitivity to BR<sub>BSM</sub>

\[
\Gamma_{tot} = \sum \Gamma_{ii} + \Gamma_{BSM}
\]

\[
BR_{BSM} = \frac{\Gamma_{BSM}}{\Gamma_{tot}}
\]
**W' and Z' searches**

Discovery reach in di-electron and di-muon channel

<table>
<thead>
<tr>
<th>Luminosity (fb⁻¹)</th>
<th>Z'_{SSM} ee</th>
<th>Z'_{SSM} μμ</th>
</tr>
</thead>
<tbody>
<tr>
<td>300 fb⁻¹</td>
<td>5.1 TeV</td>
<td>5.2 TeV</td>
</tr>
<tr>
<td>3000 fb⁻¹</td>
<td>6.2 TeV</td>
<td>6.4 TeV</td>
</tr>
</tbody>
</table>
HL-LHC Physics Studies for ECFA

Carrying out large set of HL-LHC physics studies
• validated parameterized MC (Delphes) with full simulation
• produced signal and large background samples
• allows to optimize selection and
• performance tests of several proposed Phase 2 detectors

Established review process for upgrade simulation studies

Physics program includes
• Precision test of the SM
  • Higgs couplings, ratios, rare decays
  • Top mass
• Test of EWSB mechanism
  • di-H production (bbyγ)
  • Vector boson scattering
• Direct searches small cross-section “natural” BSM
  • EWKinos using VBF
• Rare SM processes
  • TOP FCNC
  • B→μμ
• Heavy Ion Physics
Conclusion

Big Program!

8 TeV


LS1

13-14 TeV


LS2

1x10^{34} cm^{-2} s^{-1}


LS3

5x10^{34} cm^{-2} s^{-1}


CMS advancing on all fronts

Run 1 Physics

Run 2 Preparation

Phase I Upgrades

Phase II Upgrades

HL-LHC Physics Case
Phase I Upgrades - Pixel

Upgrade

Current

4 layers / 3 disks
- 1 more space-point, 3cm inner radius
- improved track resolution and efficiency

New readout chip
- recovers inefficiency at high rate and pileup

Less material
- CO2 cooling, new cabling and powering scheme (DC-DC)

Longevity
- tolerate rates up to PU = 100
- survive integrated luminosity of 500 fb\(^{-1}\), layer 1 exchange after 250 fb\(^{-1}\)

Installation scheduled for year end technical stop 2016-2017
- production is on schedule
Phase I Upgrades - Trigger

Staged approach for L1 Trigger upgrade
- allows parallel operation of legacy and upgrade calo trigger
- full slice test scheduled for October’13
- integration test of calo trigger in July’14
- technical documentation for interim calo trigger under discussion

L1 muon and global trigger
- reviewed mezzanine card for parallel operation of CSC trigger
- prototype muon track-finder μTCA electronics has been tested
- document for global trigger upgrade is prepared
- reviewed specifications of trigger menu editor, key for menu development

L1 upgrade algorithm
- testing pileup mitigation using calorimeter timing information
- investigating muon isolation
- exploring the flexibility of the upgrade trigger system (workshop last week)
Phase I Upgrades - HCAL

Backend electronics
- HF upgrade to TCA already in LS1
- installation targeted for early 2014
- pre-production AMC13 delivered (10Gbps-capable)

Readout chip
- QIE10 delivered in March
- great performance for charged and time measurement
- proceeding with radiation tests

SiPM
- progress for HPK and KTEK devices
- factor of 2-3 in photon detection efficiency
- neutron sensitivity is (very) low