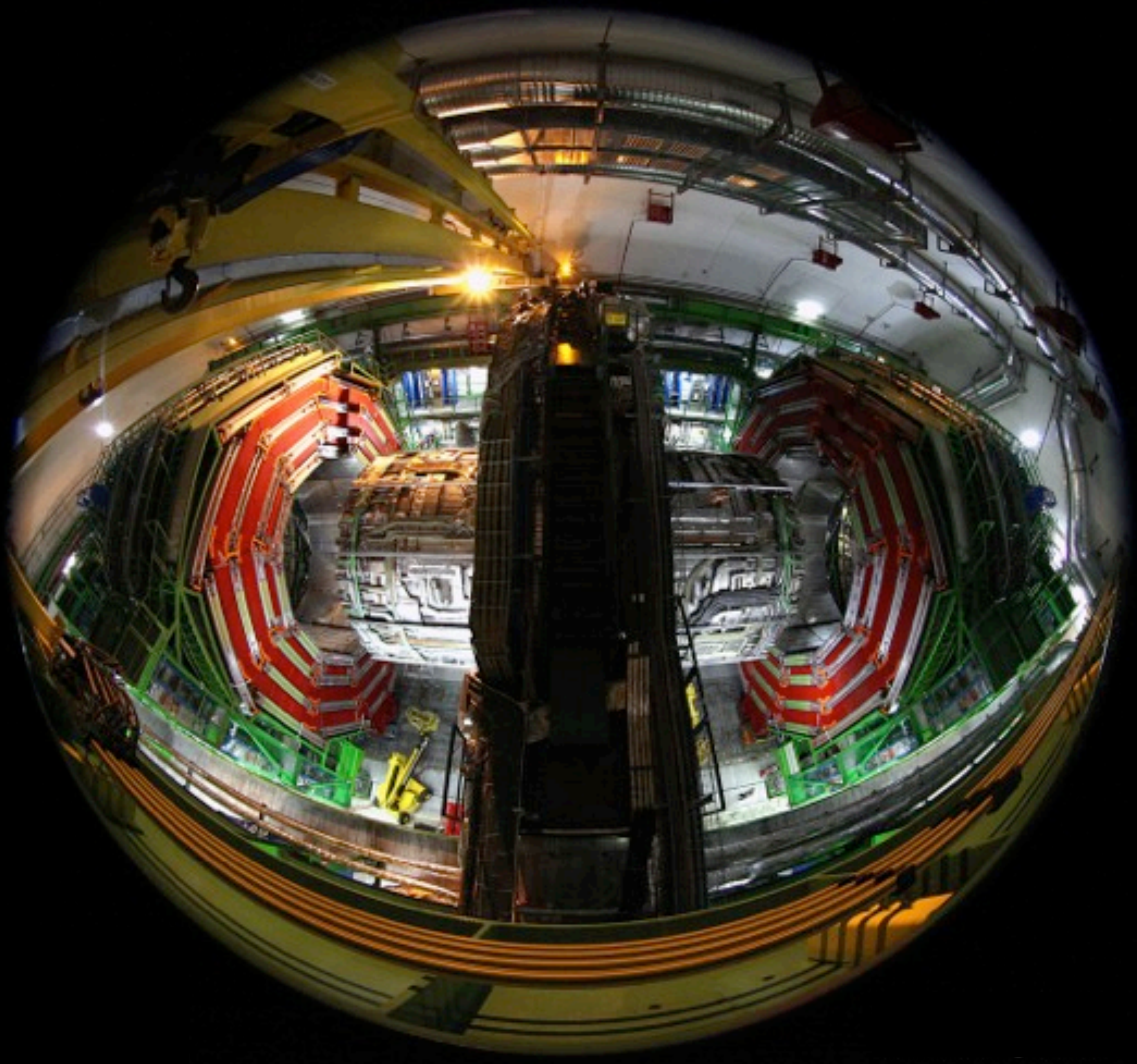
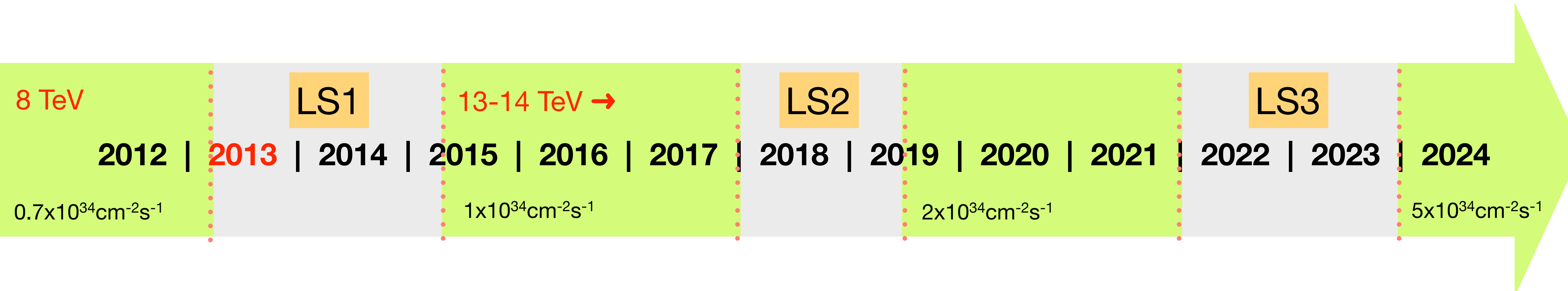
CMS Status Report

Markus Klute (MIT)
on behalf of the CMS Collaboration
115th LHCC - OPEN Session
September 25th, 2013



Status of work on multiple fronts

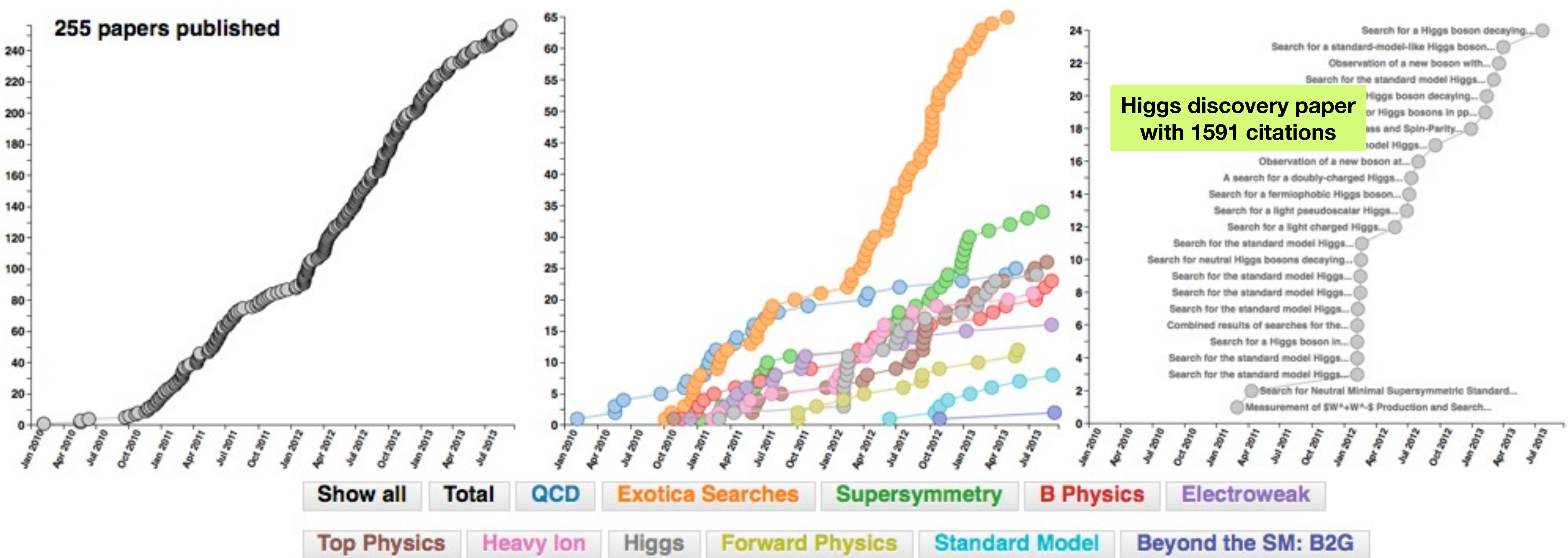


Run 1 Physics:	Selected highlights
Run 2 Preparation:	Main detector objectives
Phase I Upgrades:	Milestones for upgrade projects
Phase II Upgrades:	CMS strategy and preparations
HL-LHC Physics Case:	Physics program and potential

New CMS Physics Results

Exploiting Run I data in pp, pPb, and PbPb

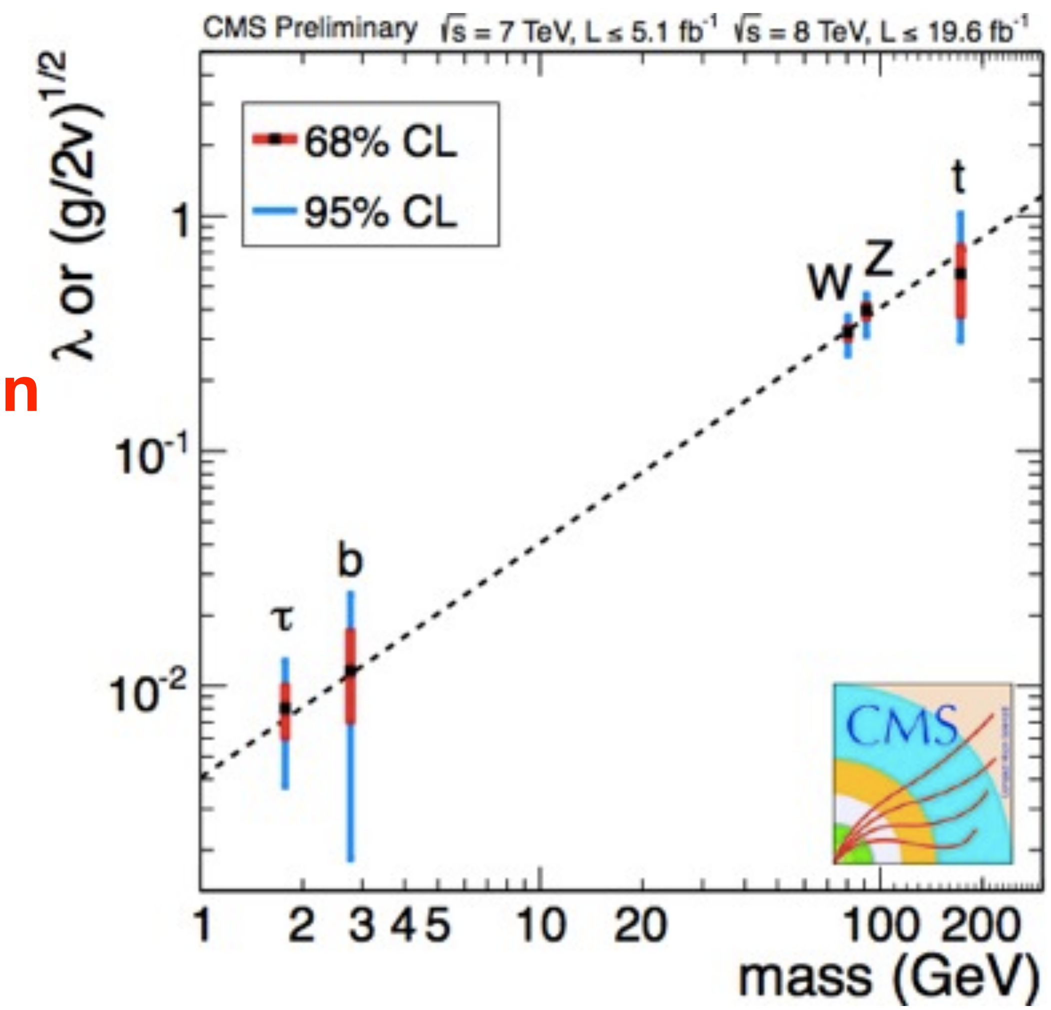
- numerous new public and published results this summer
- turning over more and more stones
- legacy publications, intensive program for 2013 & 2014



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



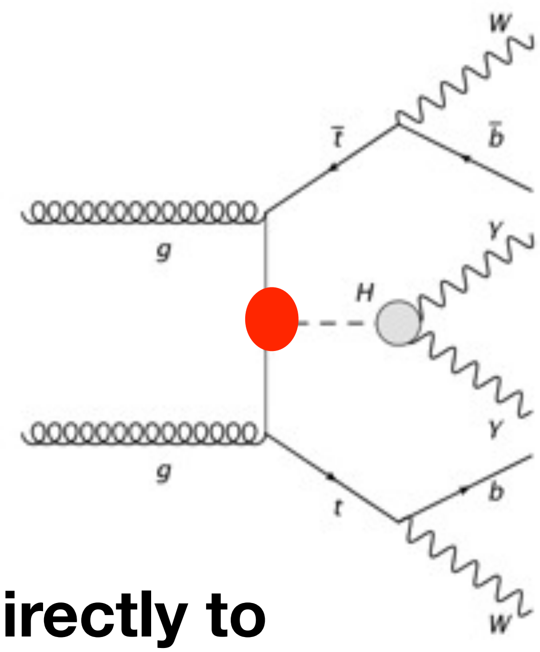
Summary of the Higgs boson properties

- Mass
  - M = 125.7 ± 0.3 ± 0.3 GeV
  - 0.5% precision
- Signal strength
  - μ = 0.80 ± 0.14
- Spin/CP
  - $J^{CP} = 0^{++}$ (SM-like Higgs boson) preferred
  - 0^{+-} (2^{++}) disfavored at a 3.3 (2.8)σ level

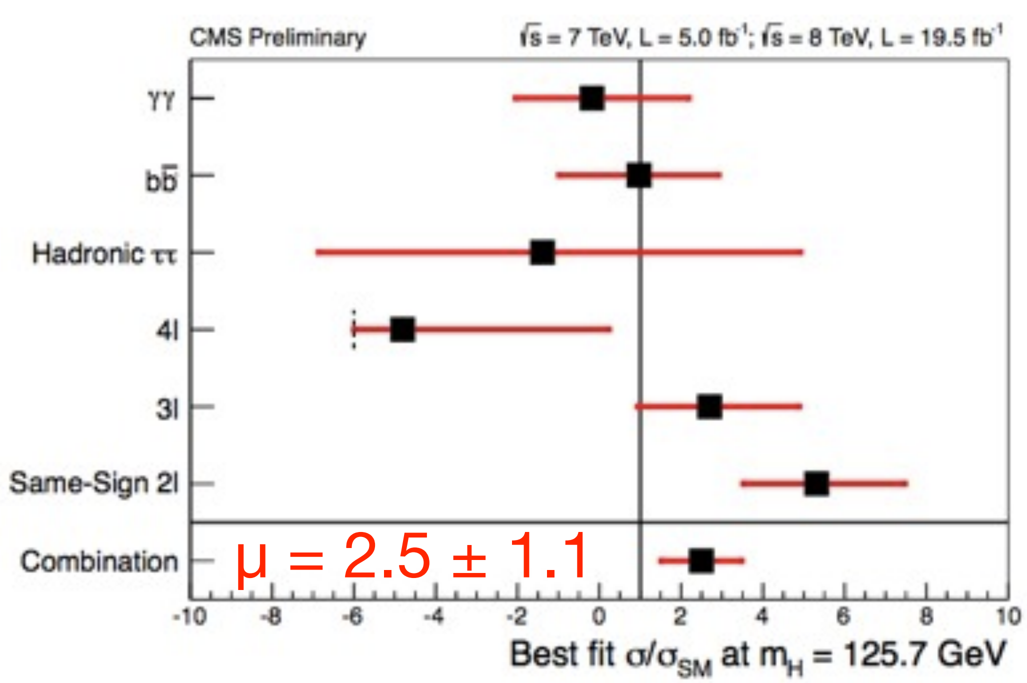
Discovery opened a new era of Higgs measurements

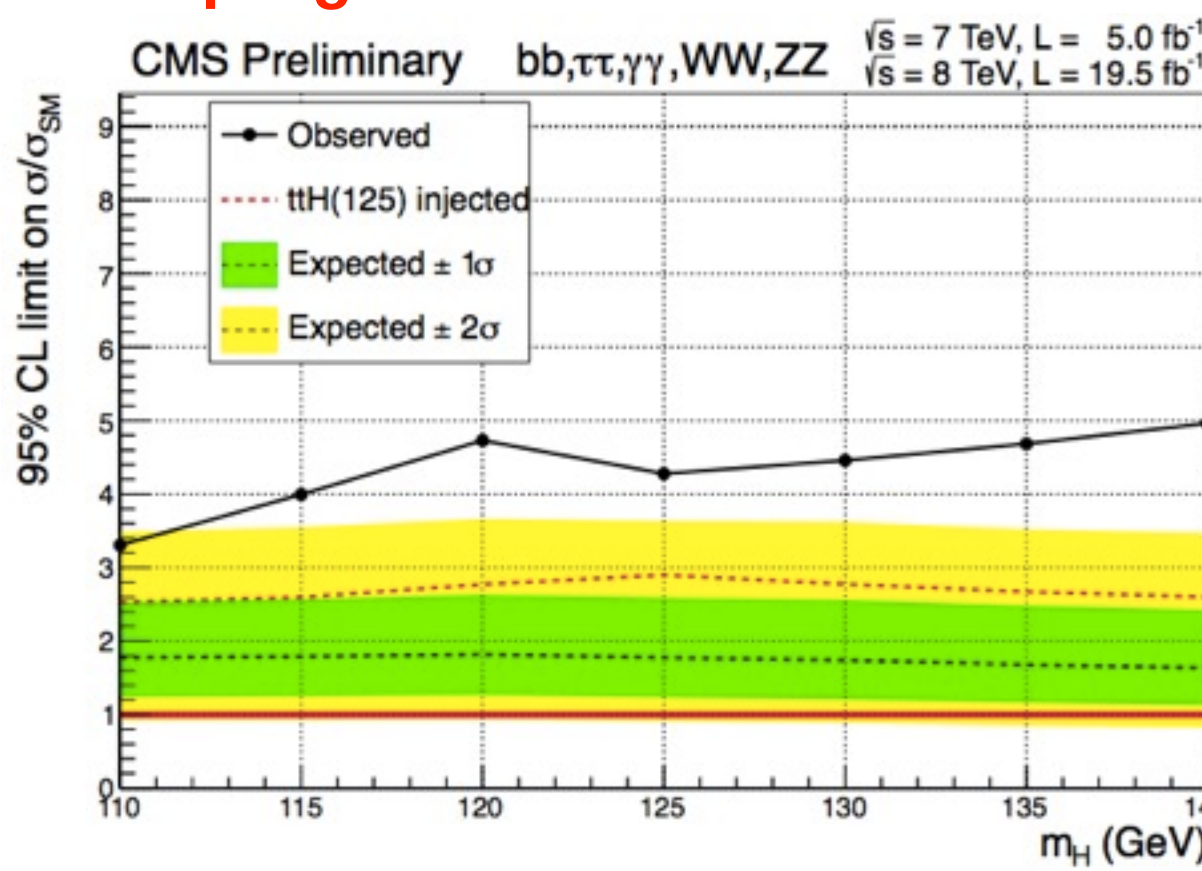
Significant progress in ttH channel

- H → γγ → HIG-13-015
- H → bb → HIG-13-019
- H → ττ → HIG-13-019, HIG-13-020
- H → ZZ → HIG-13-020
- H → WW → HIG-13-020



Sensitivity approaching SM Higgs, directly to top Yukawa coupling





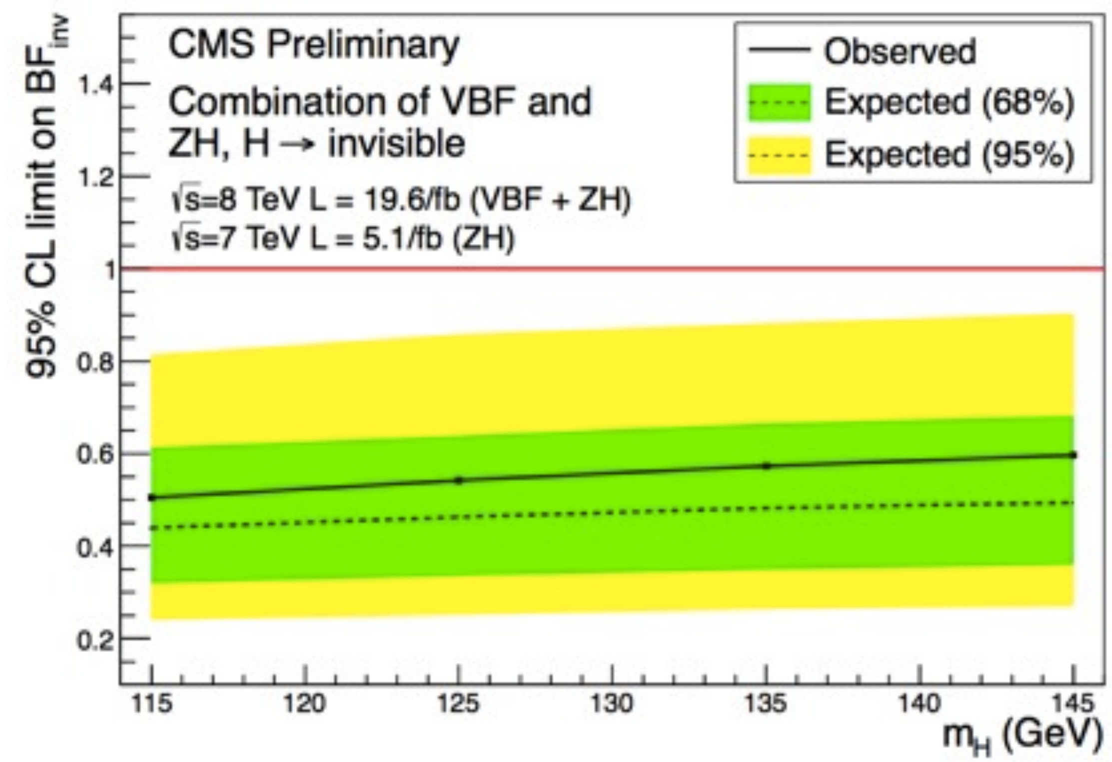
Invisible Higgs Decays

Studies in associated ZH and VBF production

- sensitivity to Higgs decays to DM candidates

- **ZH** HIG-13-018
  - analyze shape of $m_T(Z,H)$
  - **BR(H→inv.) < 75%** (91% exp.) @ 95% CL

- **VBF** HIG-13-013
  - special VBF + MET trigger
  - **BR(H→inv.) < 69%** (55% exp.) @ 95% CL



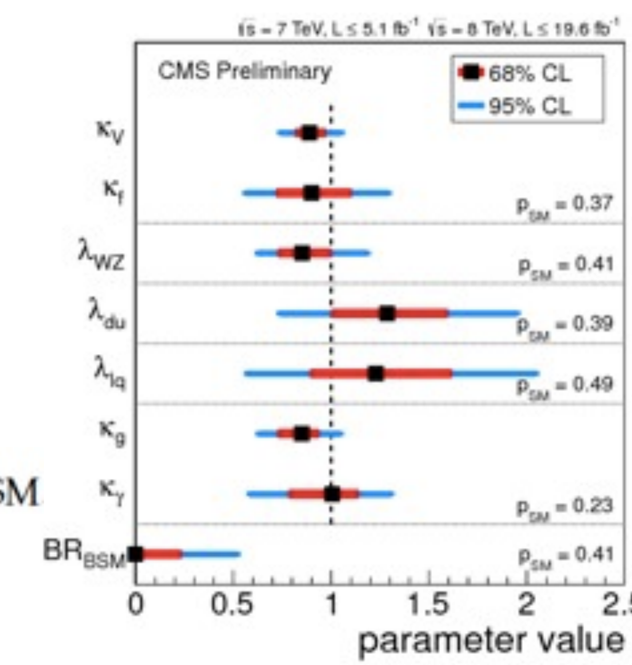
- gluon fusion
  - reinterpretation of monojet analysis

- **ZH and VBF combination**
  - **BR(H→inv.) < 54%** (46% exp.) @ 95% CL

- studies underway to include coupling fits with BR_{BSM} included in total widths

$$\Gamma_{tot} = \sum \Gamma_{ii} + \Gamma_{BSM}$$

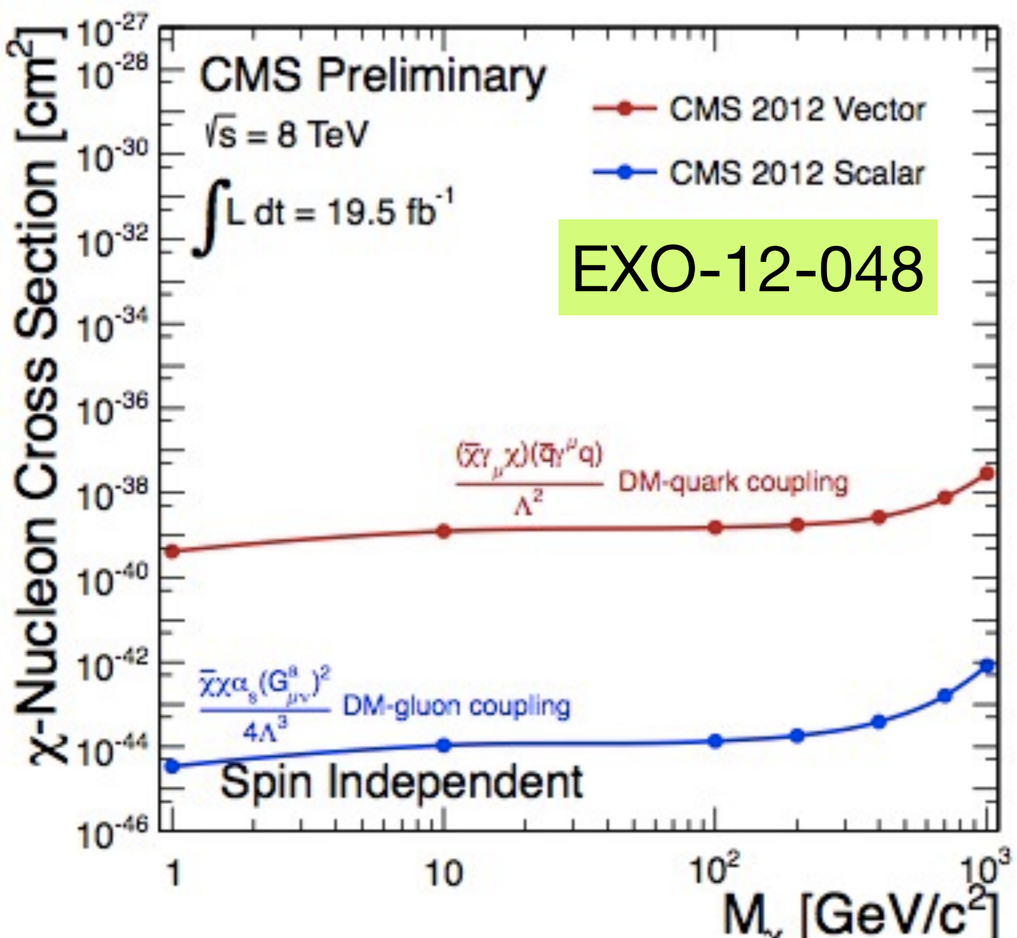
$$BR_{BSM} = \Gamma_{BSM} / \Gamma_{tot}$$

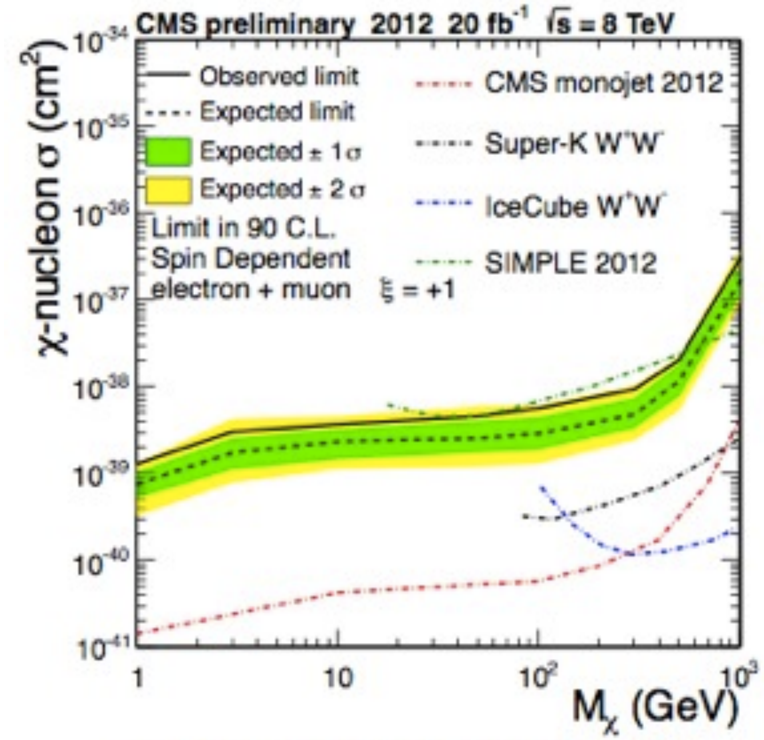


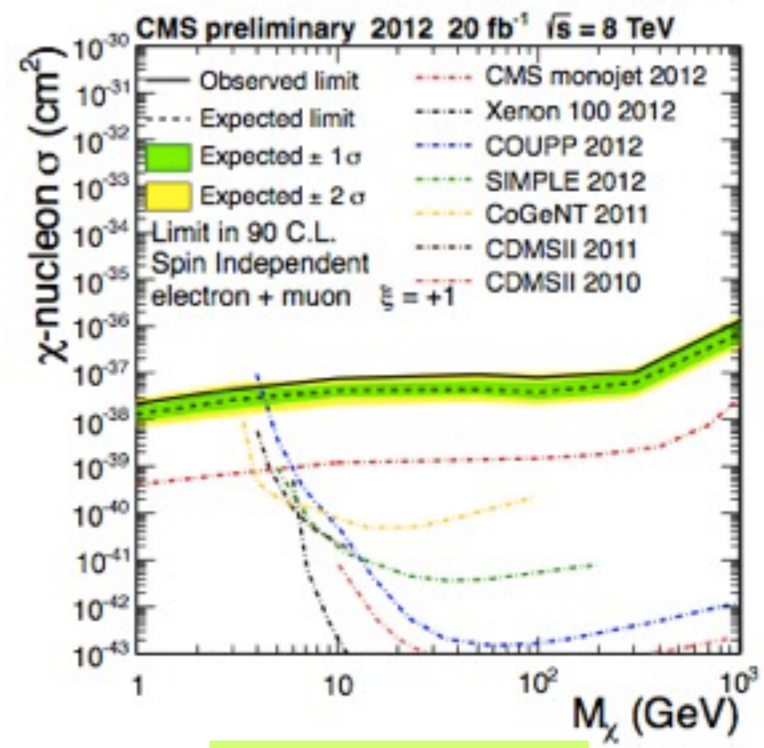
Dark Matter Searches

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

- 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





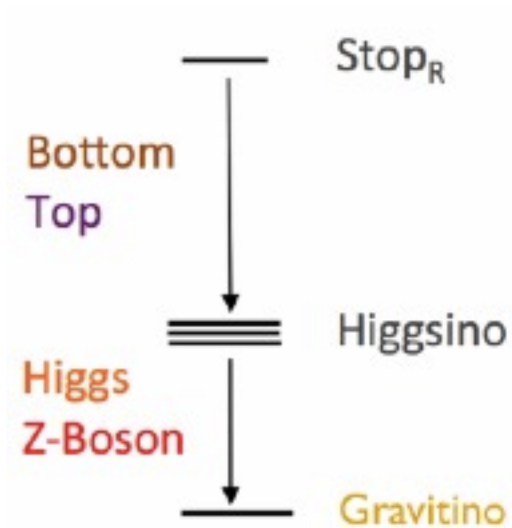


EXO-13-004

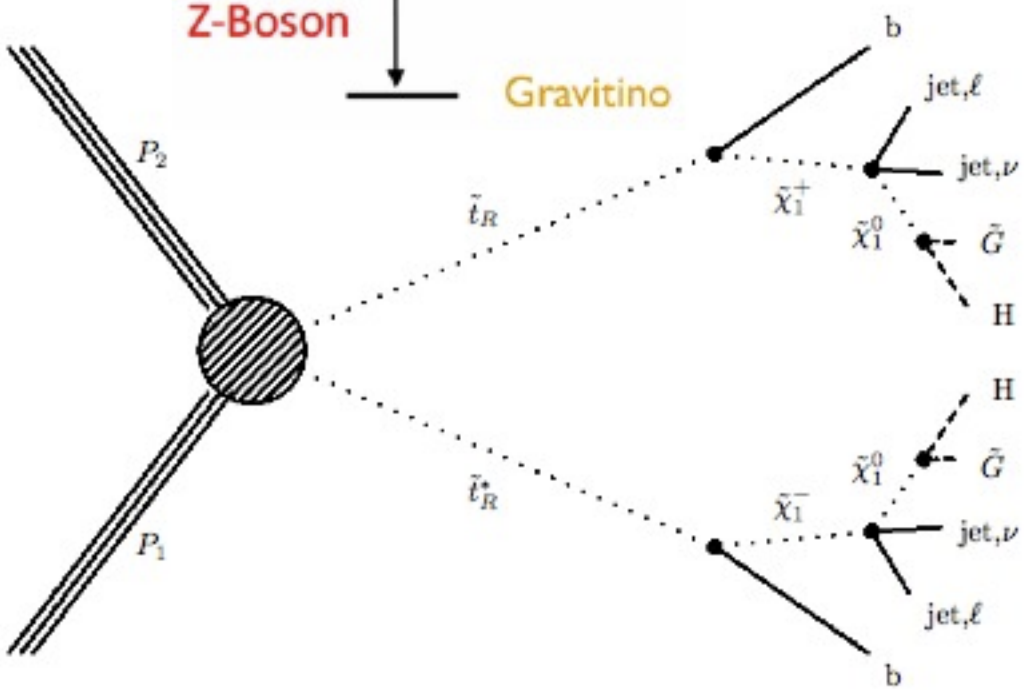
Higgs in SUSY decays

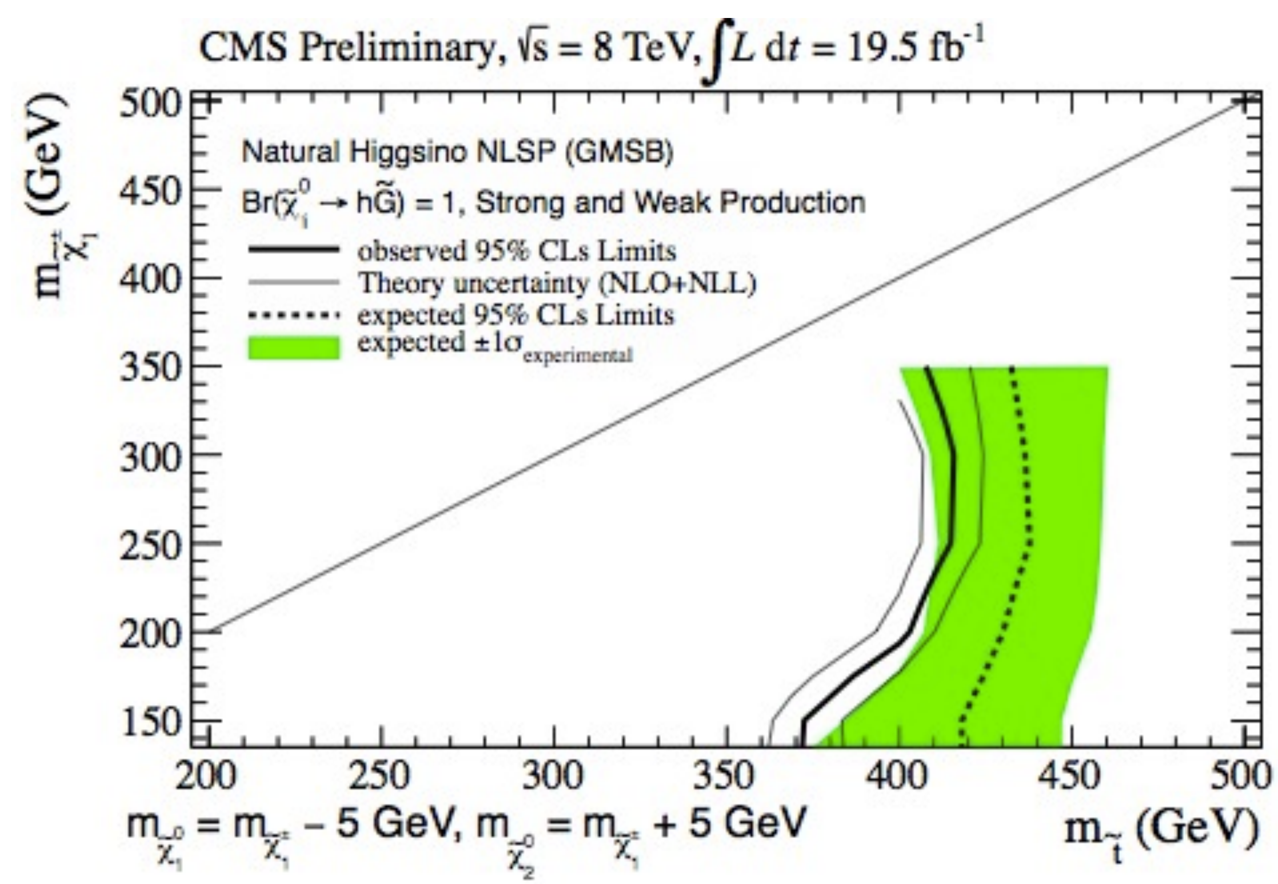
GMSB-like search for stop pair production with Higgs production is cascade

- natural SUSY scenario $\tilde{t}_R \to b\tilde{\chi}_1^+ \text{ or } t\tilde{\chi}_i^0 \qquad \tilde{\chi}_1^0 \to H\tilde{G} \text{ or } Z\tilde{G}$
- investigate diphoton Higgs decays in $\gamma\gamma bb+ME_T$ final states
- use ME_T as discriminating variable



SUS-13-014



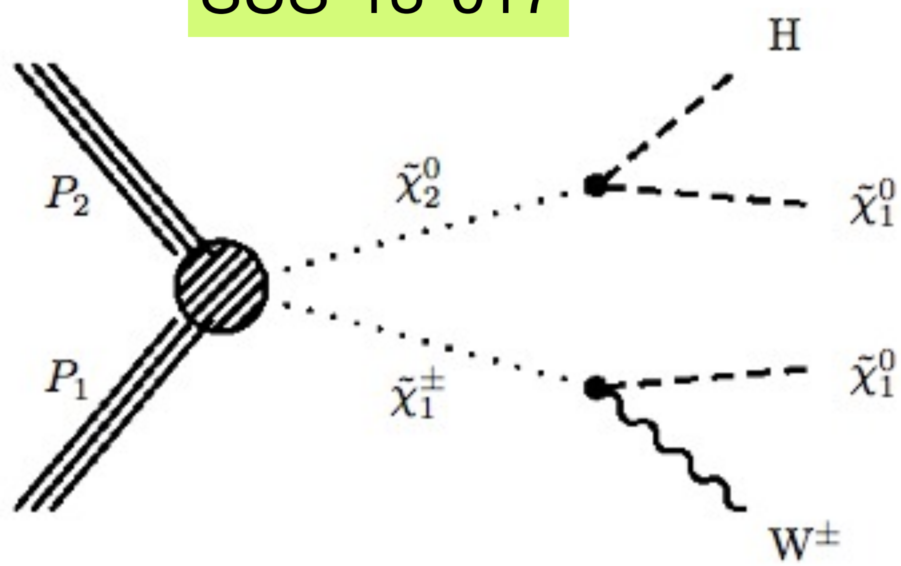


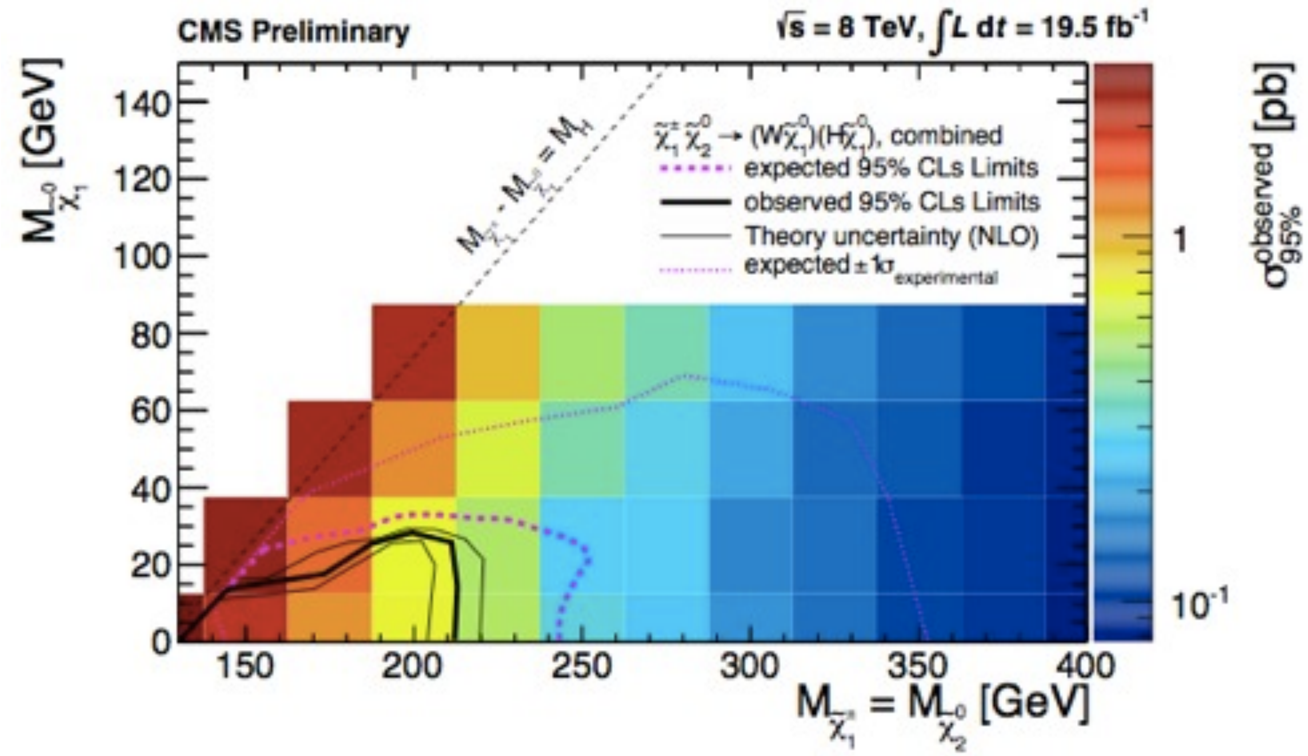
Higgs in SUSY decays

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 ττ

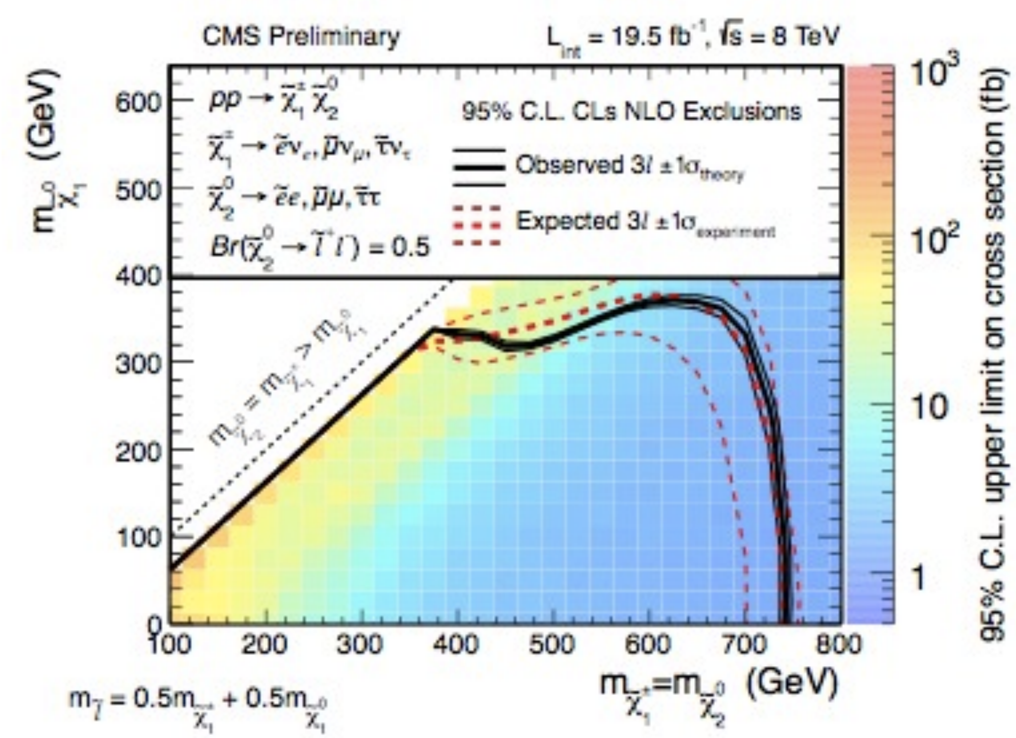
SUS-13-017





Also look for direct chargino and neutralino pair production

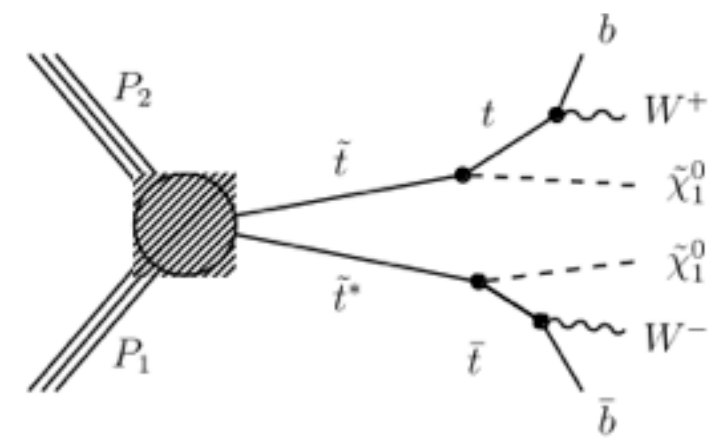
SUS-13-006



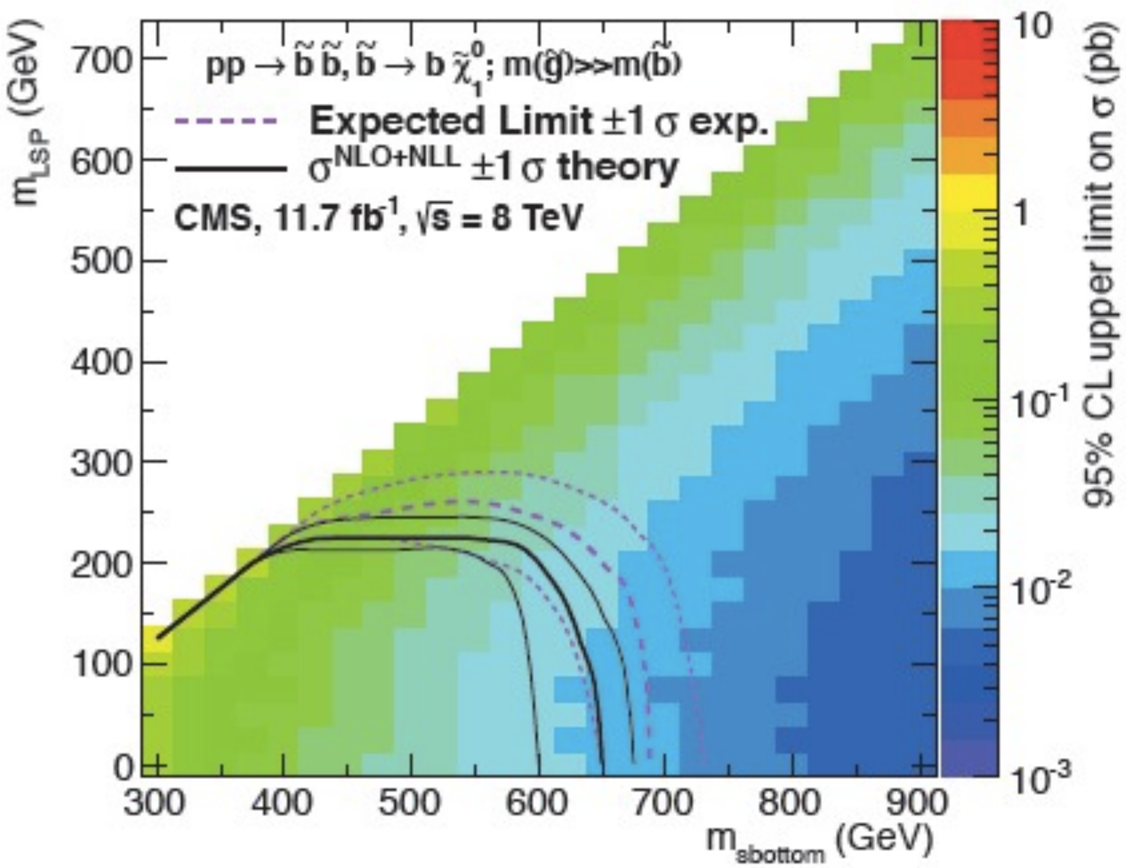
Natural SUSY: sbottom and stop

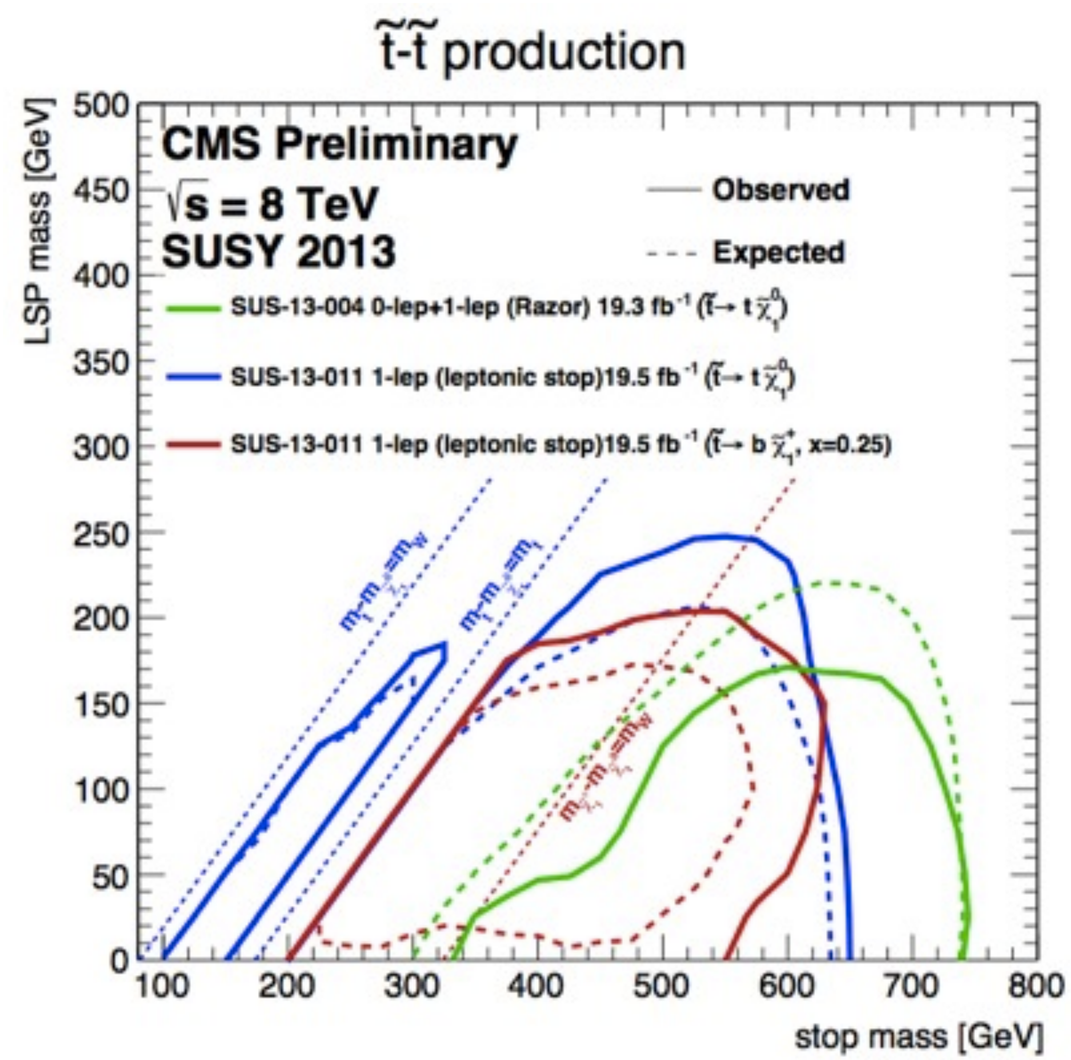
Direct sbottom and stop pair production in

- hadronic α_T + b-jets
- razor + b-jets
- single-lepton + b-jets

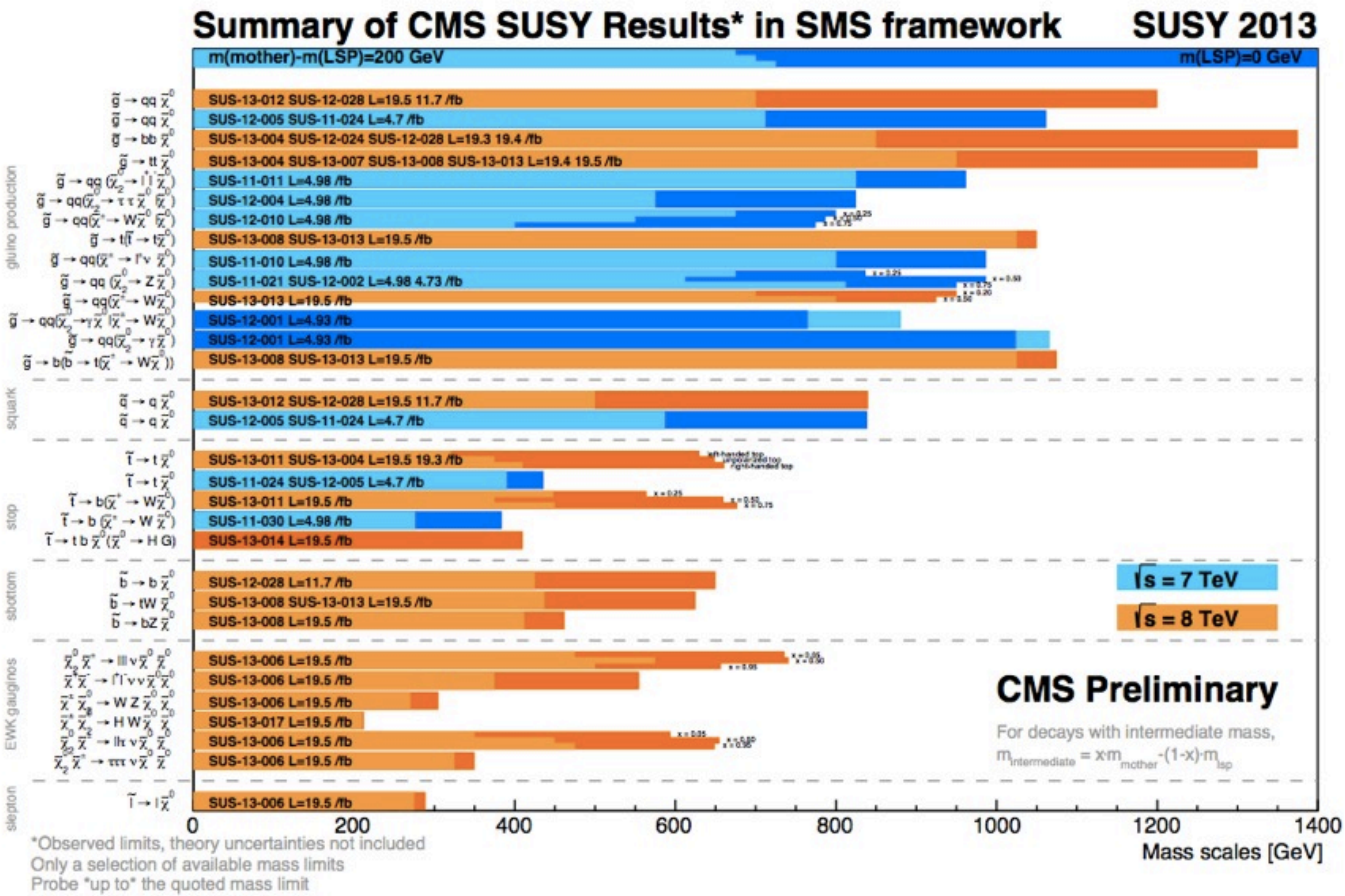


SUS-12-028
arXiv: 1303.2985

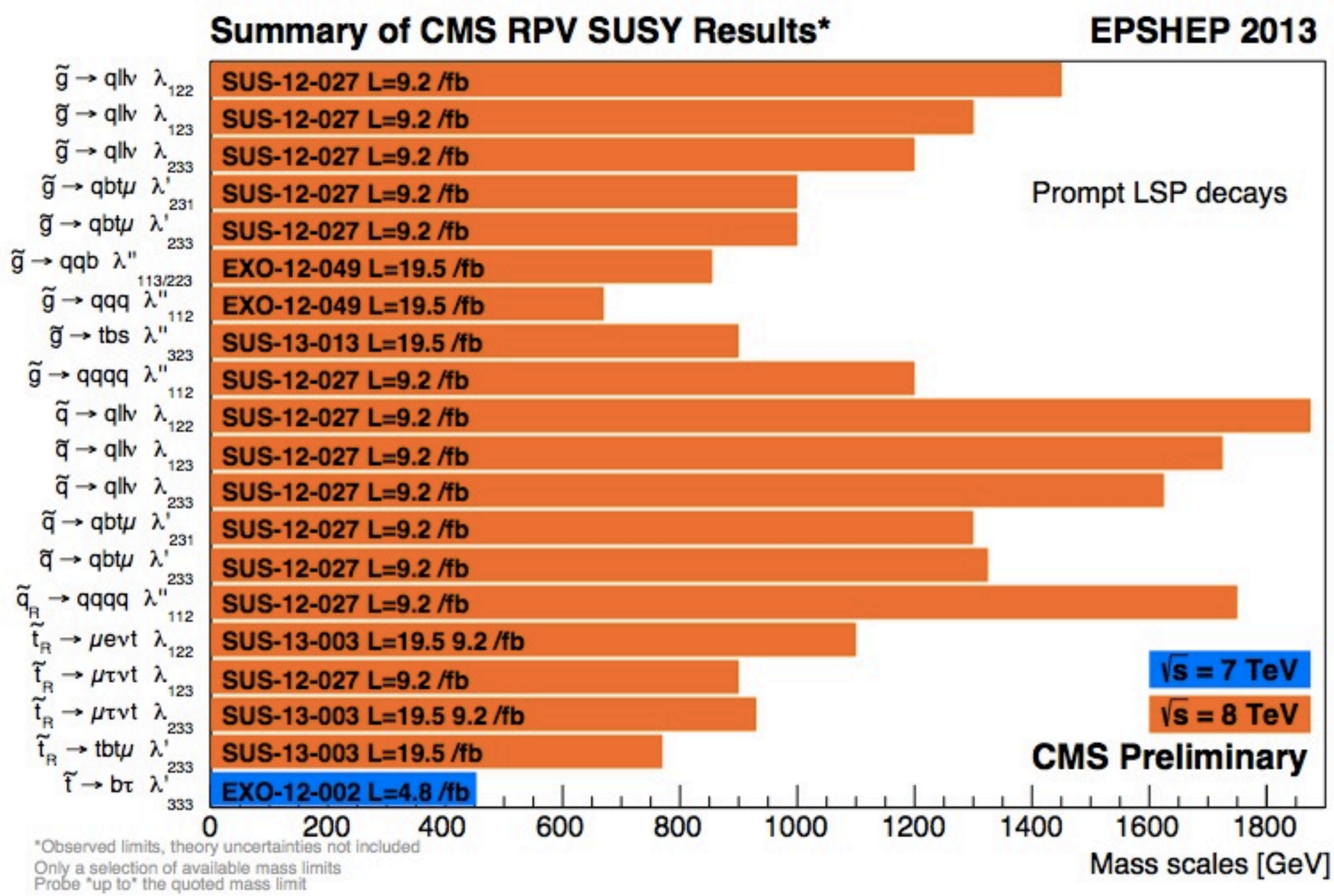




The “we did not find SUSY” Plot



The “we did not find RPV SUSY” Plot



Top Physics Highlights

Most precise measurement of R

TOP-12-035

- R = Br(t➔Wb) / Br(t➔Wq) = 1.023 + 0.036 - 0.034

Search for FCNC top decay

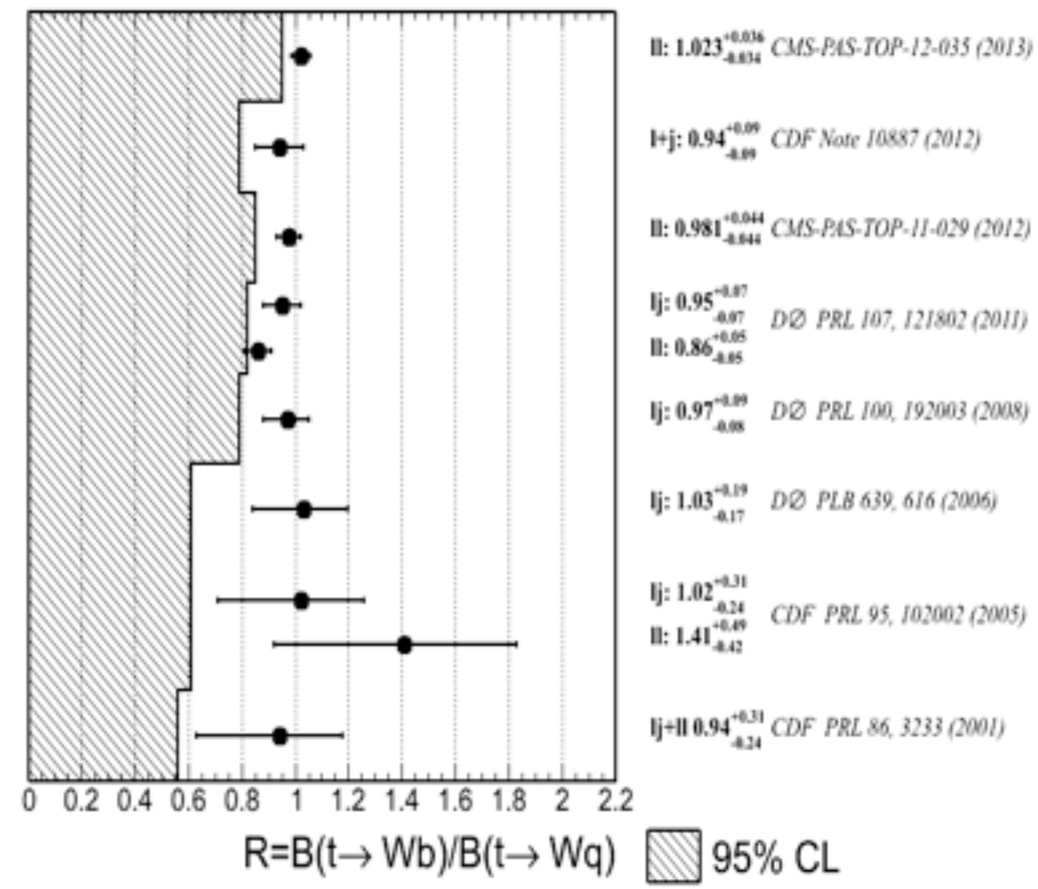
TOP-12-037

- Br(t➔Zq) < 0.05% @ 95% CL

Limit on FCNC top decay or Higgs coupling

SUS-13-002

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



Higgs Decay Mode	observed	expected	1σ range
$h \to WW$ (BR = 22.3 %)	0.37 %	0.38 %	(0.26–0.52) %
$h \to \tau\tau$ (BR = 6.24 %)	8.4 %	7.6 %	(5.8–11.2) %
$h \to ZZ$ (BR = 2.76 %)	1.23 %	0.97 %	(0.74–1.42) %
combined	0.31 %	0.31 %	(0.21–0.46) %

Top Quark Mass

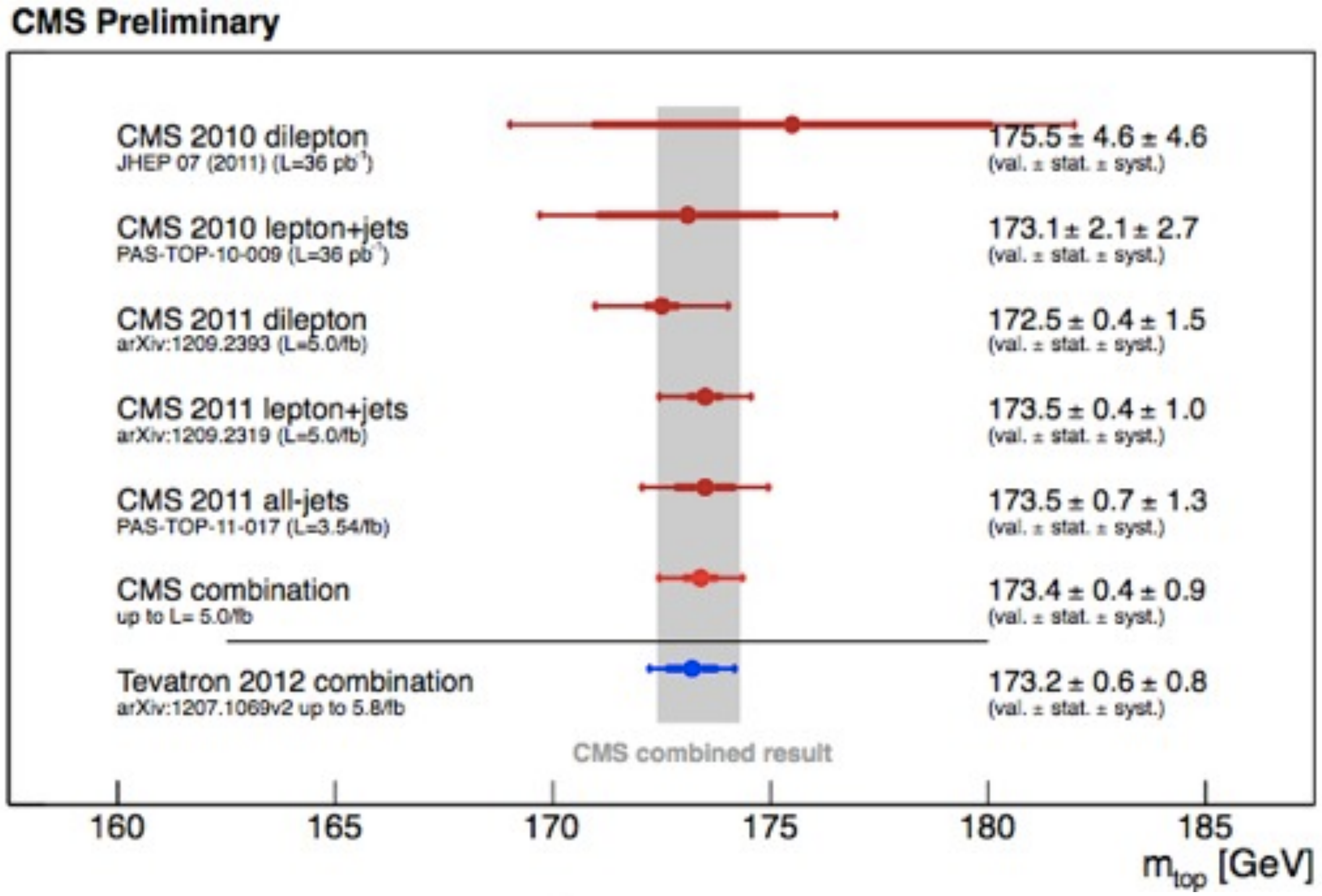
Combination of all 7 and 8 TeV CMS analyses

- m_t = 173.49 ± 0.36 (stat.) ± 0.91 (syst.) GeV

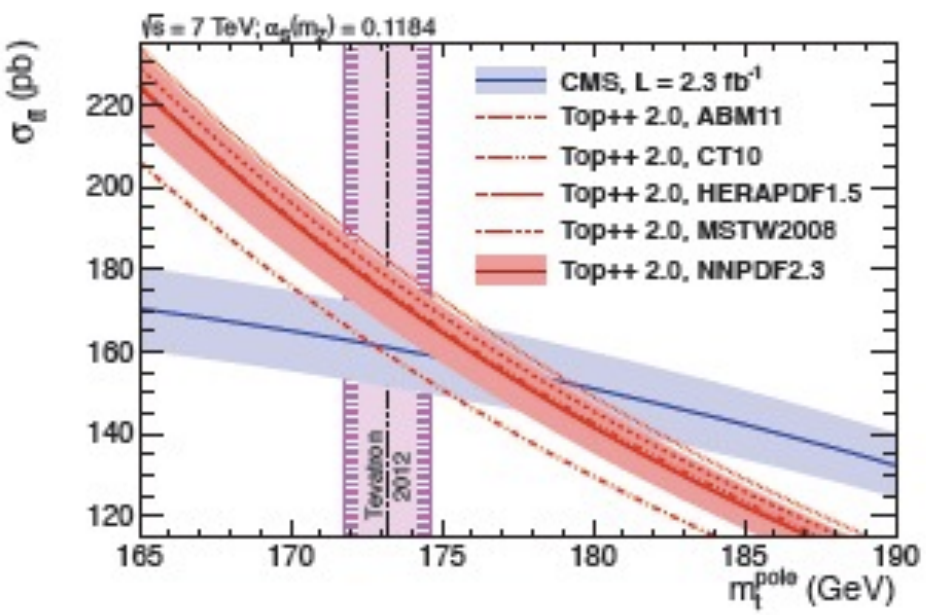
TOP-13-002

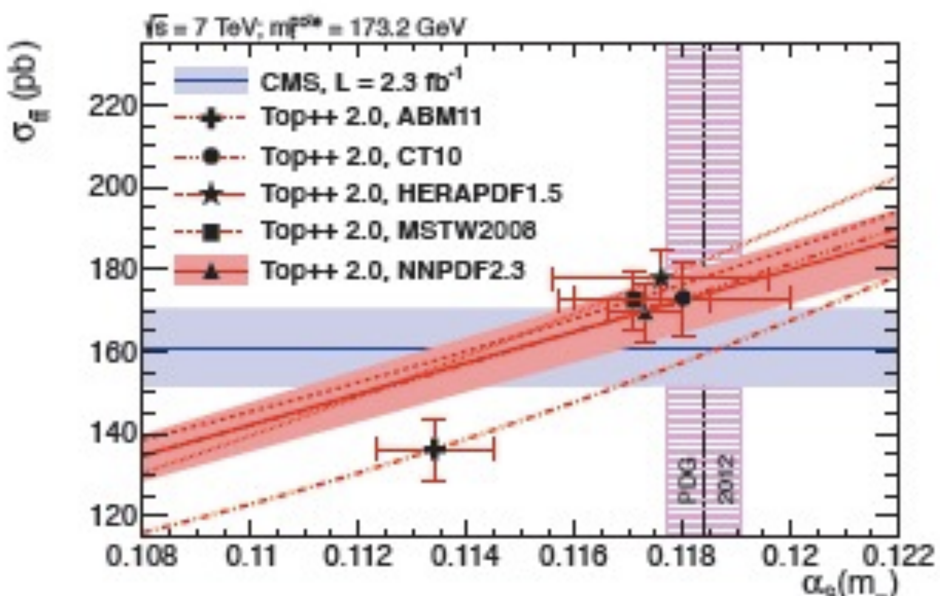
Novel determination of m_t from cross section and α_s

- required precise LHC beam energy of 0.65% (CERN-ATS-2013-040)
- m_t = 176.7 +3.8-3.4 GeV (pole mass)



TOP-12-022
arXiv:1307.1907





Search for vector-like Top Partners

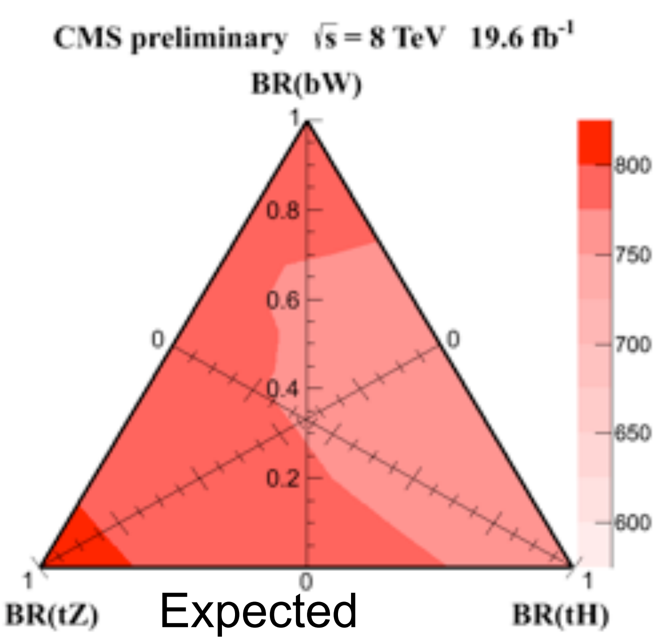
Predicted for example in Little Higgs models and can stabilize Higgs mass

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

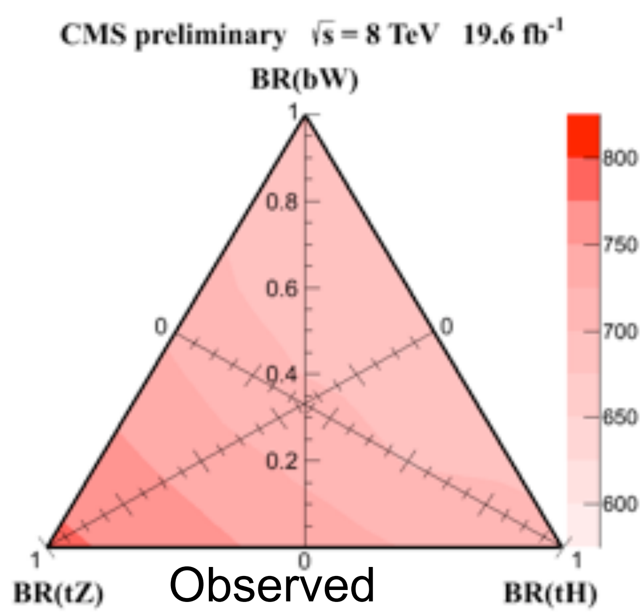
Limits between 687 and 782 GeV for all possible BR into three possible decays

channel	OS1	OS2	SS	trileptons
tt	5.2±1.9	80 ±12	-	-
single top	2.5±1.3	2.0±1.0	-	-
Z	9.7±2.9	2.5±1.9	-	-
$t\bar{t}W$	-	-	5.8 ±1.9	0.25±0.11
$t\bar{t}Z$	-	-	1.83±0.93	1.84±0.94
WW	-	-	0.53±0.29	-
WZ	-	-	0.34±0.08	0.40±0.21
ZZ	-	-	0.03±0.00	0.07±0.01
WWW/WWZ/ZZZ/WZZ	-	-	0.13±0.07	0.08±0.04
$t\bar{t}WW$	-	-	-	0.05±0.03
charge mis-ID	-	-	0.01±0.00	-
non-prompt	-	-	7.9 ±4.3	0.99±0.90
total background	17.4±3.7	84 ±12	16.5 ±4.8	3.7 ±1.3
data	20	86	18	2

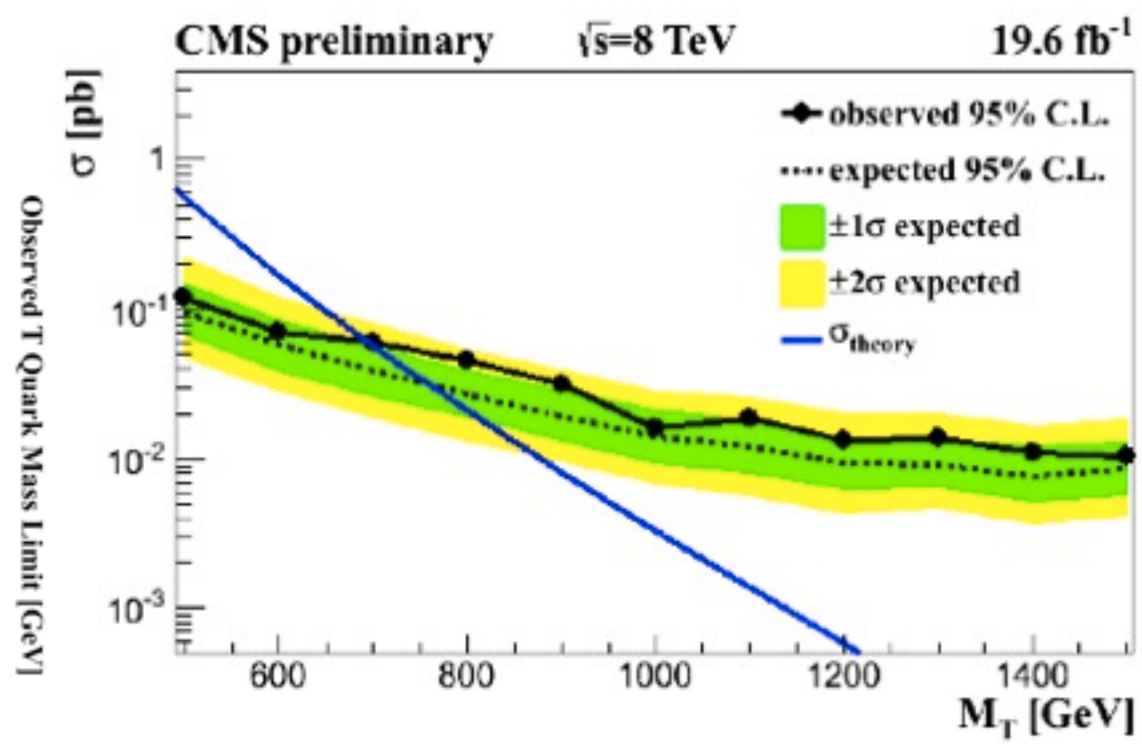
B2G-12-015



Expected



Observed



branching fractions into bW, tH, tZ of 50%, 25%, 25%.

New Physics Searches with Top Quarks

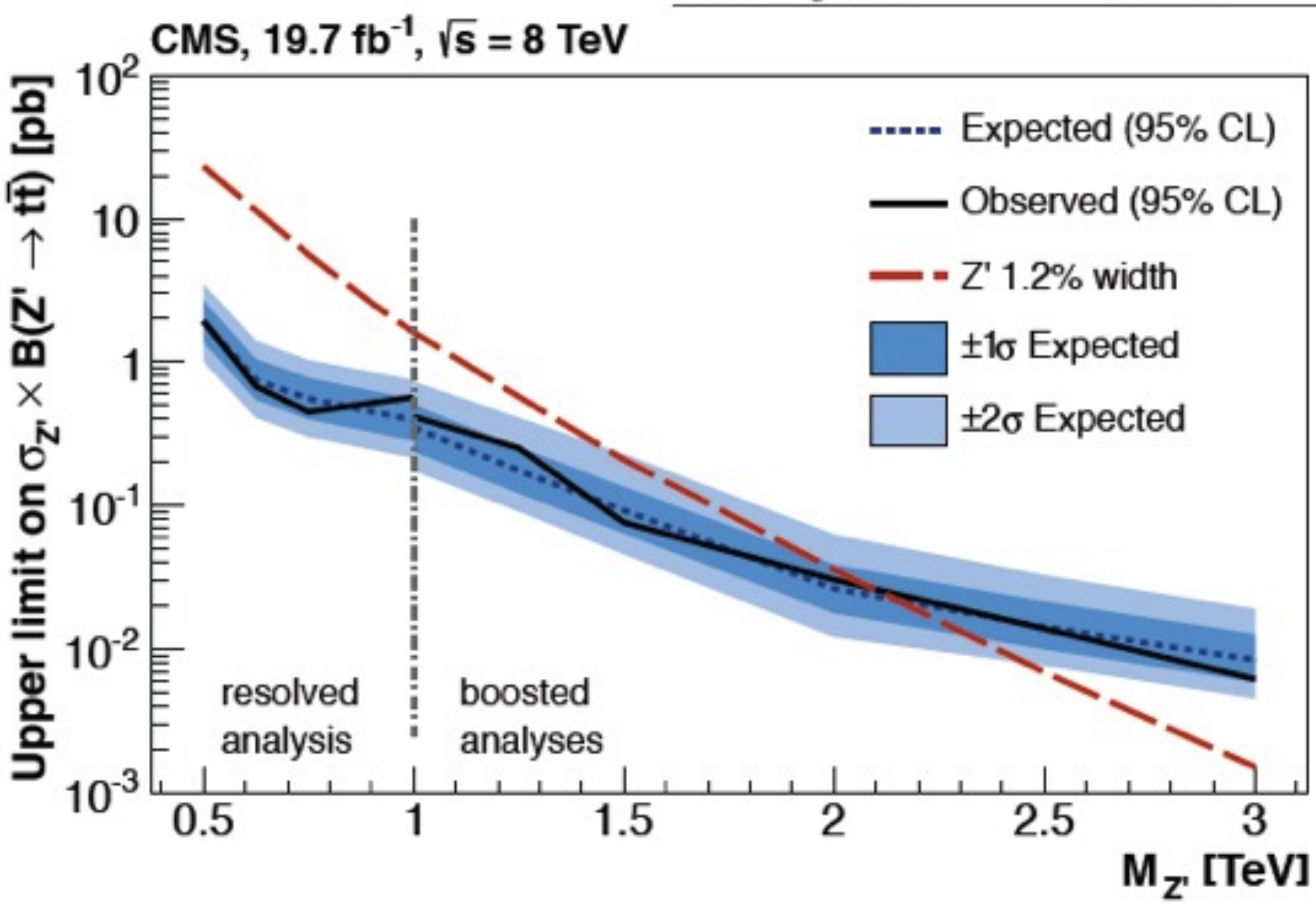
Combined search for tt-resonance in the l+jets and all-hadronic channels using full 8 TeV dataset

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

B2G-13-001
arXiv:1309.2030

95% CL lower limits on the masses of new particles in specific models.

Model	Observed Limit	Expected Limit
Z', $\Gamma_{Z'}/M_{Z'} = 1.2\%$	2.1 TeV	2.1 TeV
Z', $\Gamma_{Z'}/M_{Z'} = 10\%$	2.7 TeV	2.6 TeV
RS KK gluon	2.5 TeV	2.4 TeV



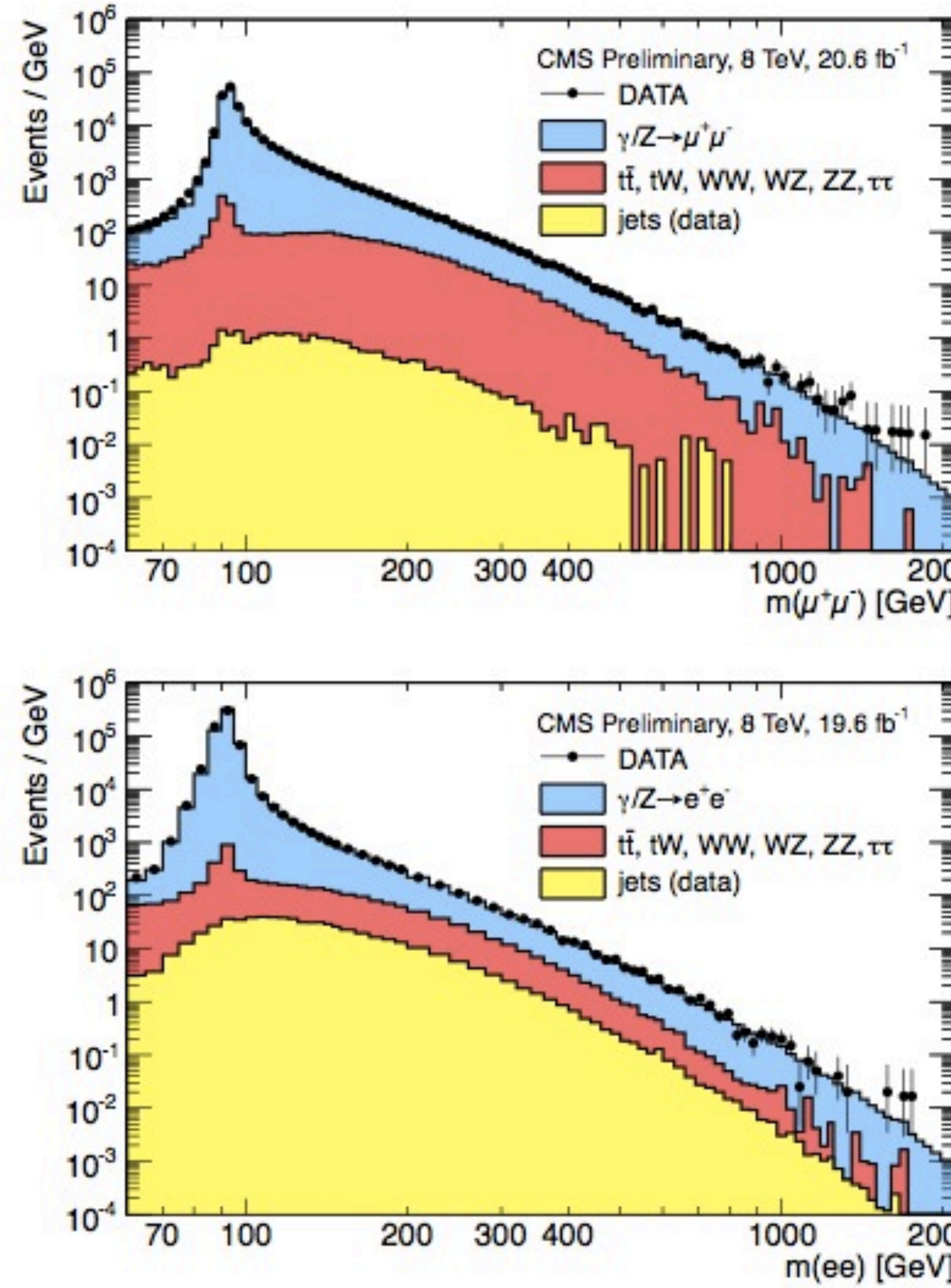
Lepton Resonance Searches

Searches for W' and Z' in leptonic decay channels

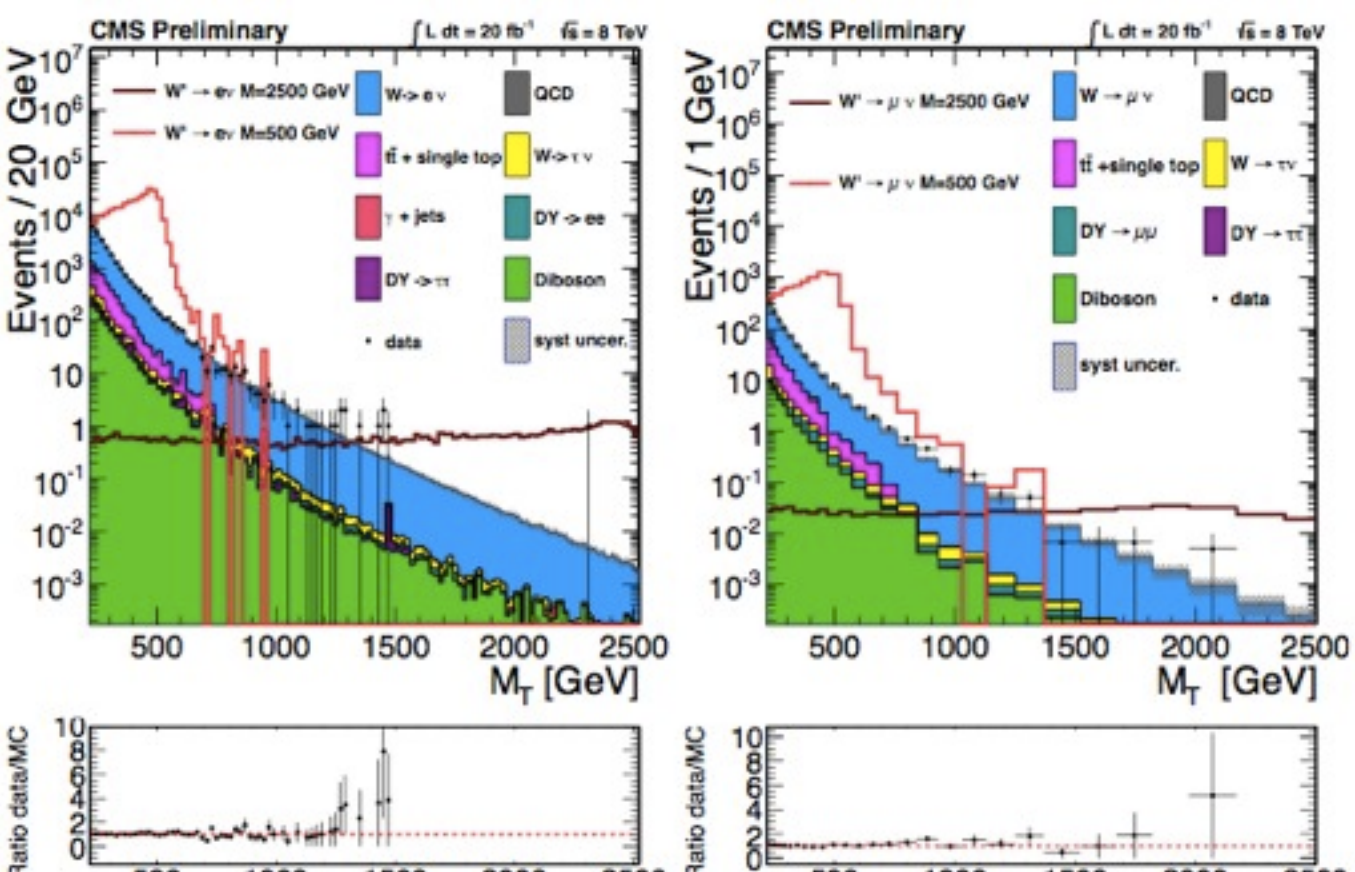
Set model dependent mass limits, e.g.

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

EXO-12-061



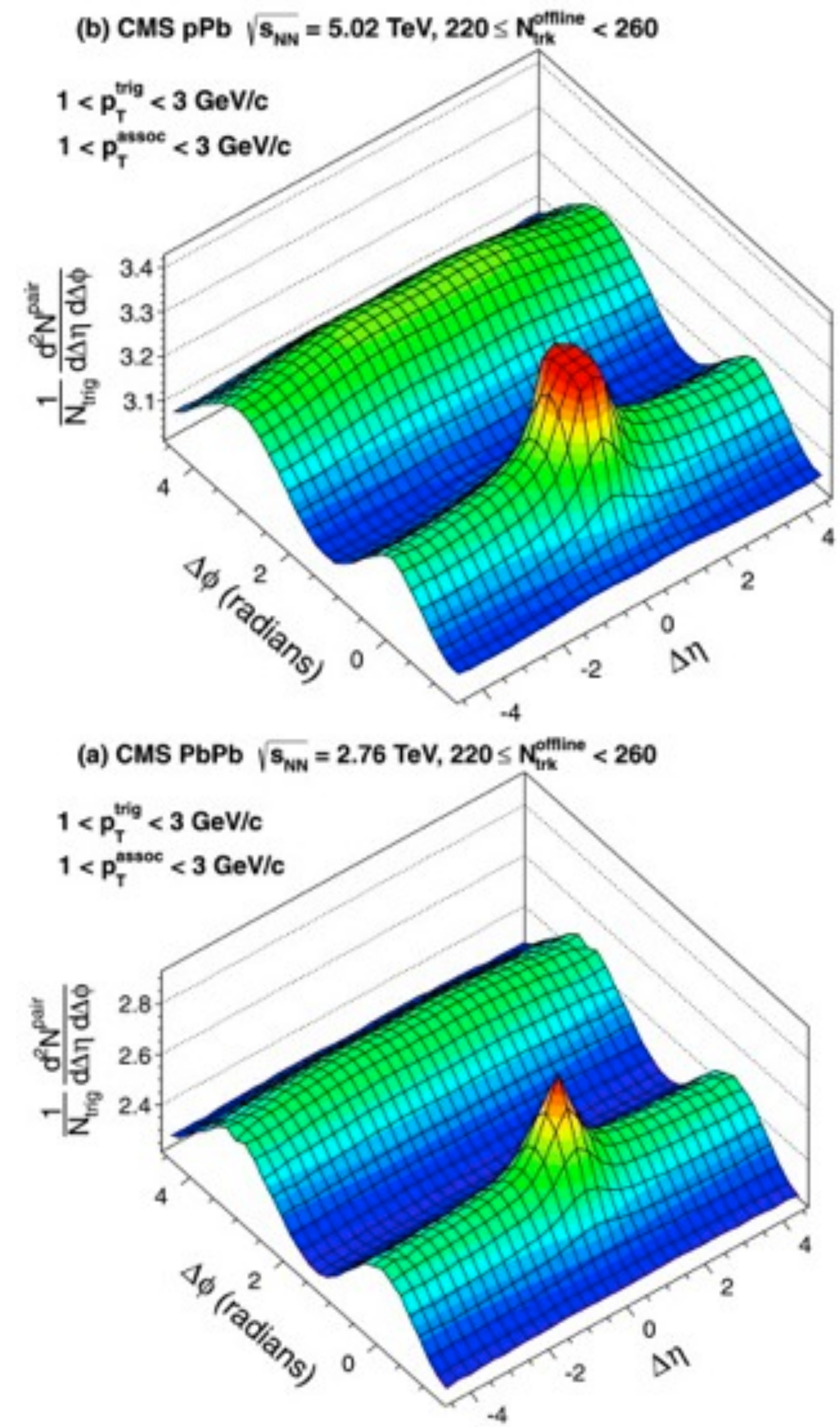
EXO-12-060



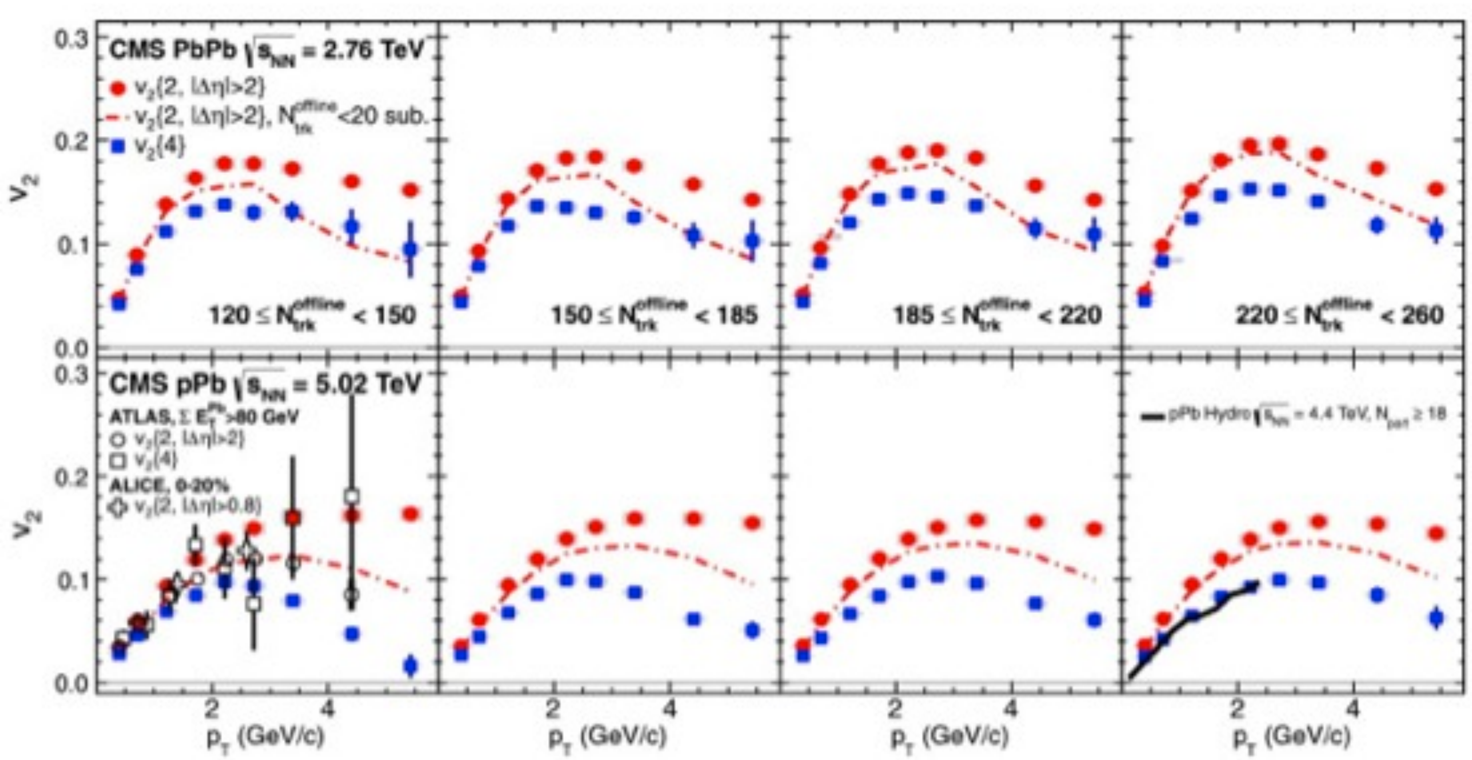
Heavy Ion Highlights

- Long range correlations in pPb and PbPb collisions

HIN-13-002, PLB 724 (2013) 213

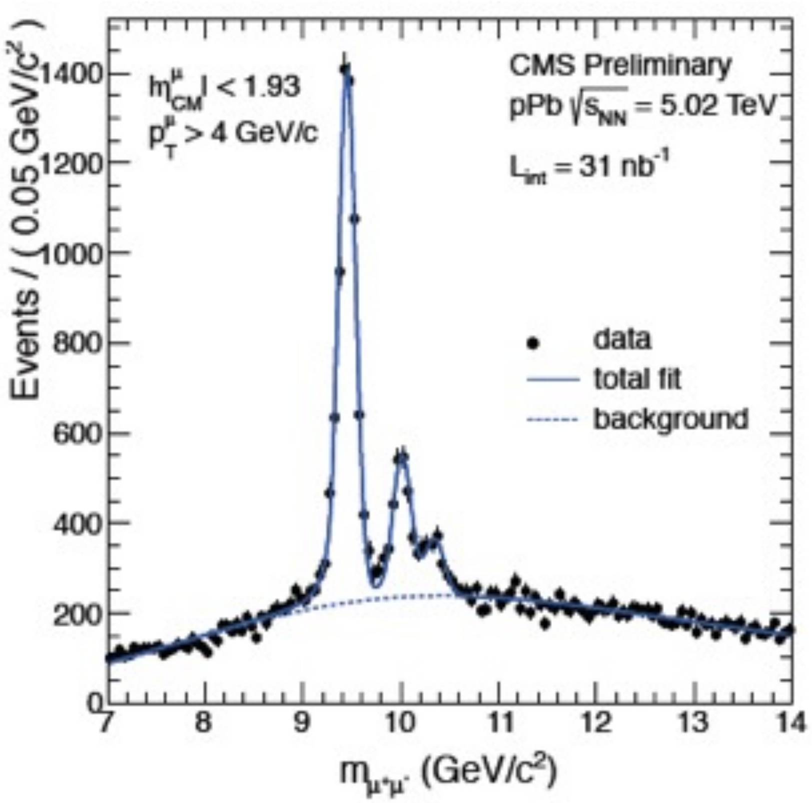


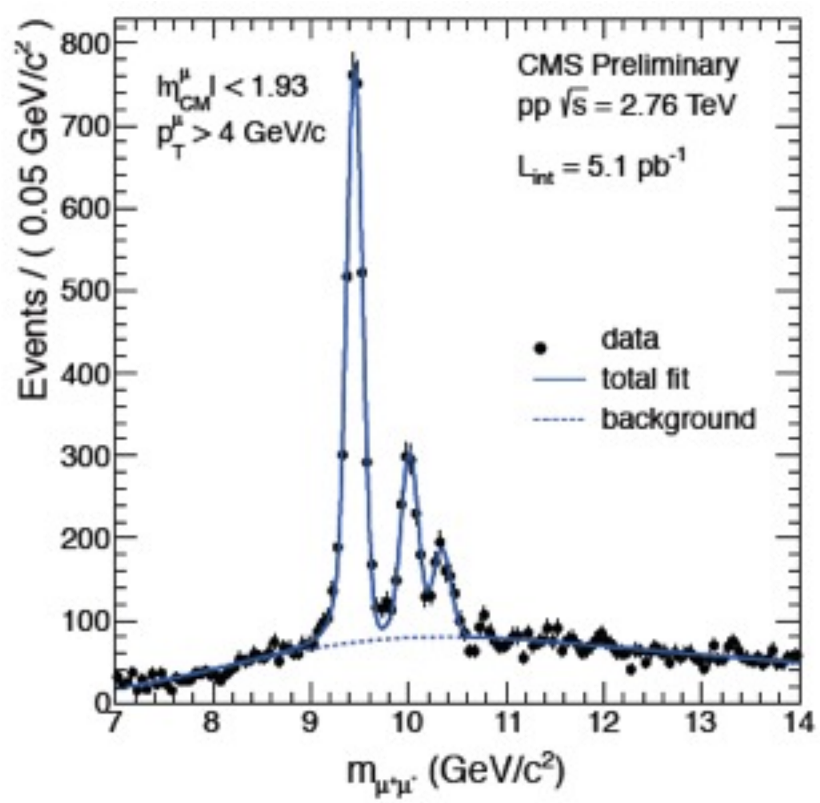
  - studied 2 and 4-particle correlations and multiple harmonics (v_2, v_3)
  - striking similarities between pPb and PbPb for same multiplicity
  - hydrodynamic flow of strongly coupled medium presently the only theory capturing all observations

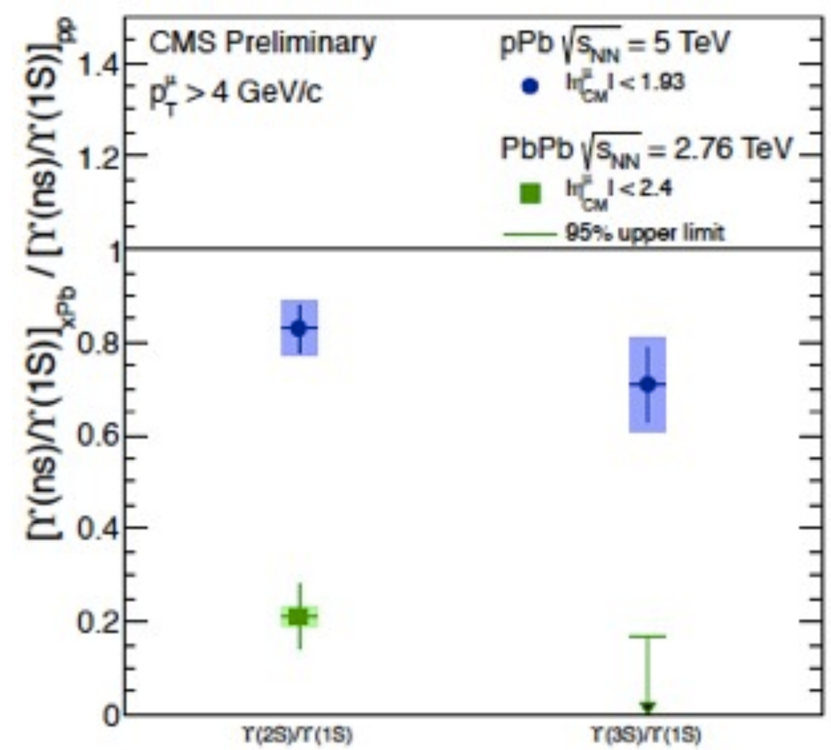


Heavy Ion Highlights

- New analysis on Ypsilon production in pPb collisions HIN-13-003
  - 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







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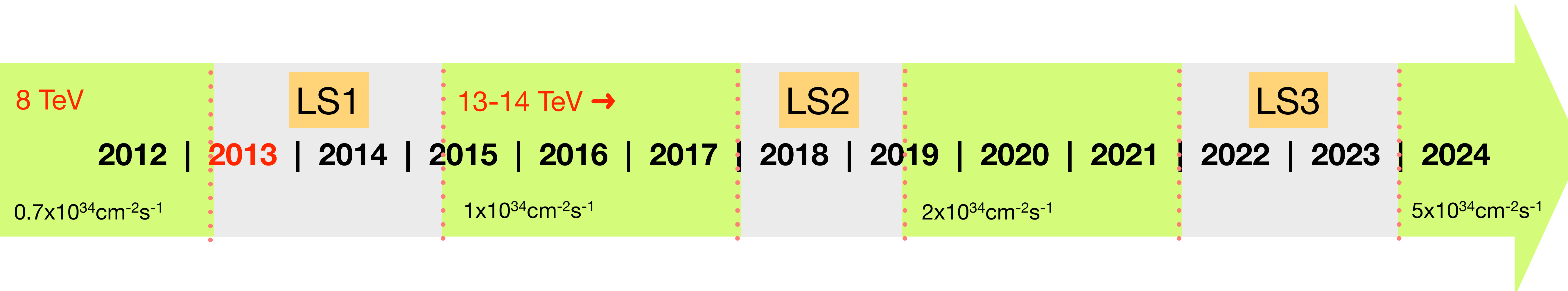

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Run 2 Preparation

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.

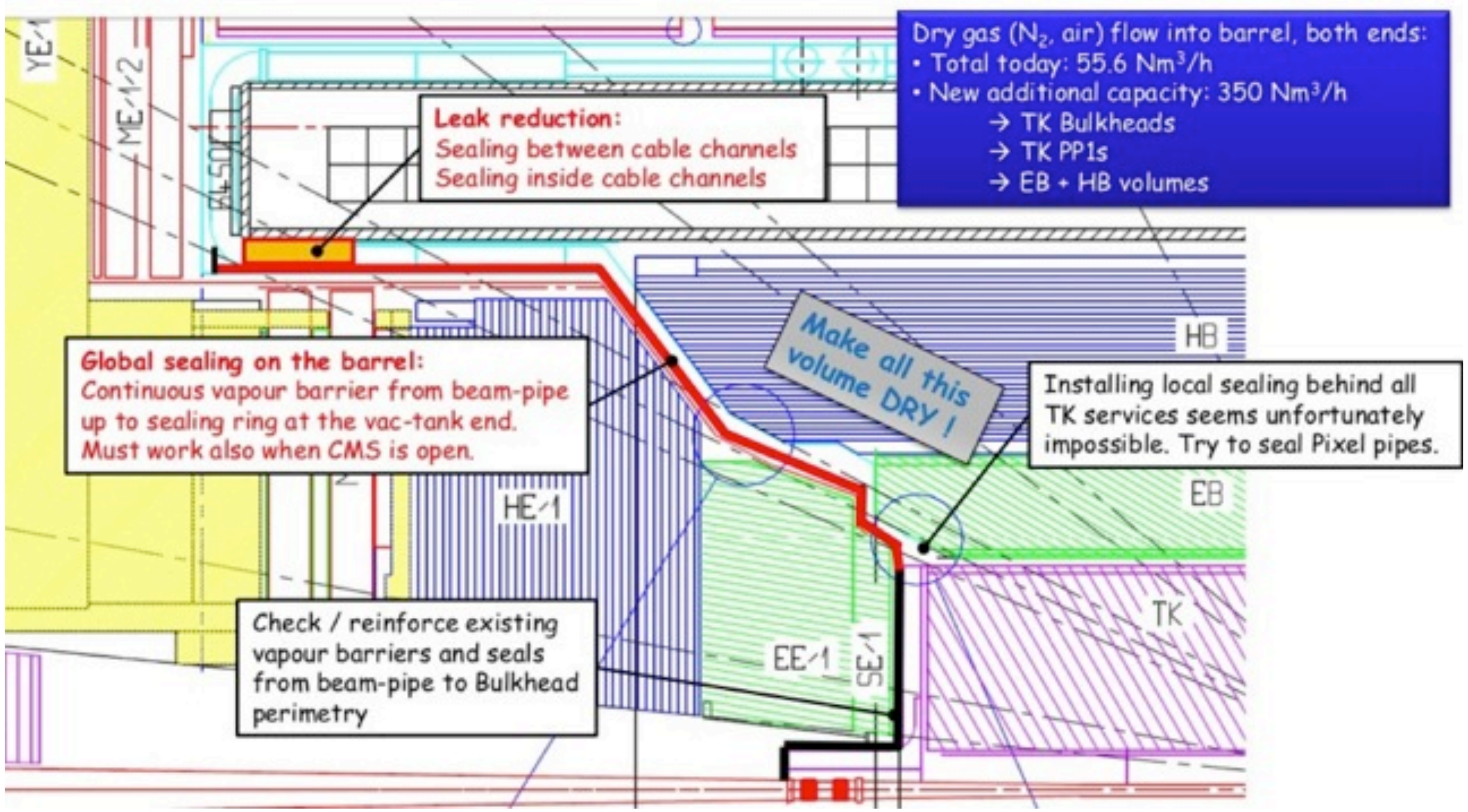
Scheduled regular global CMS runs and extended run end of 2014.

Run 2 Preparation - Tracker

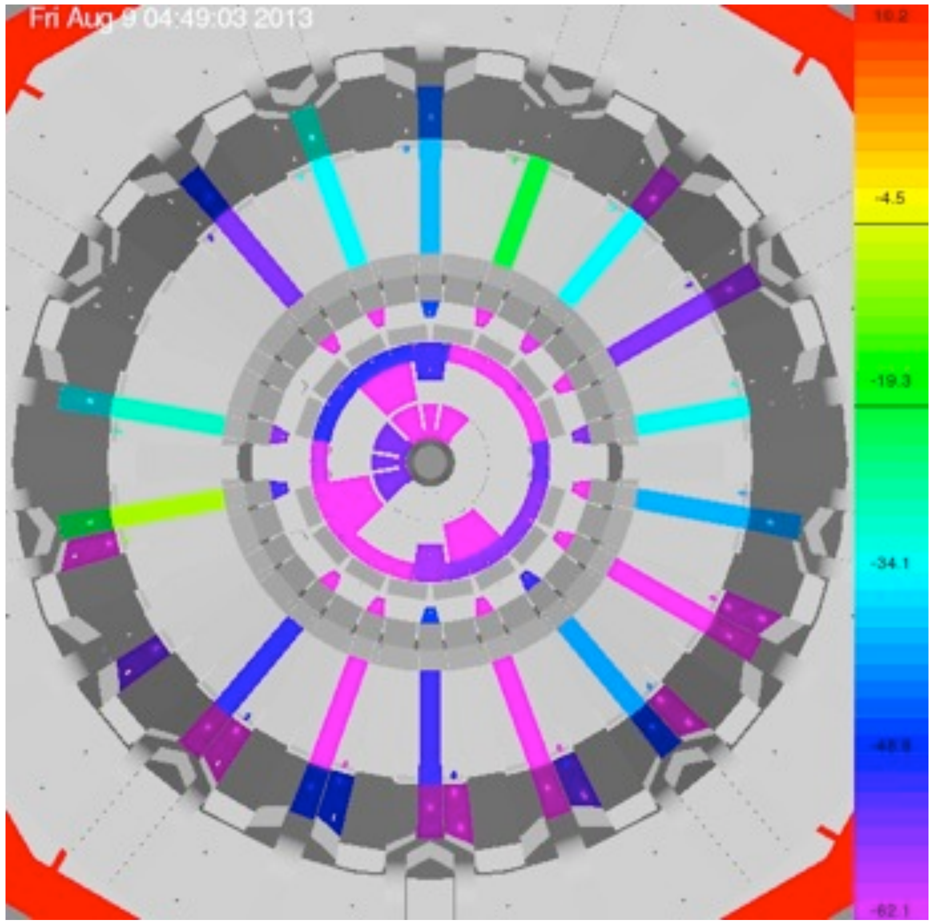
Operation at lower temperature to mitigate radiation damage

- -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



Dew point map

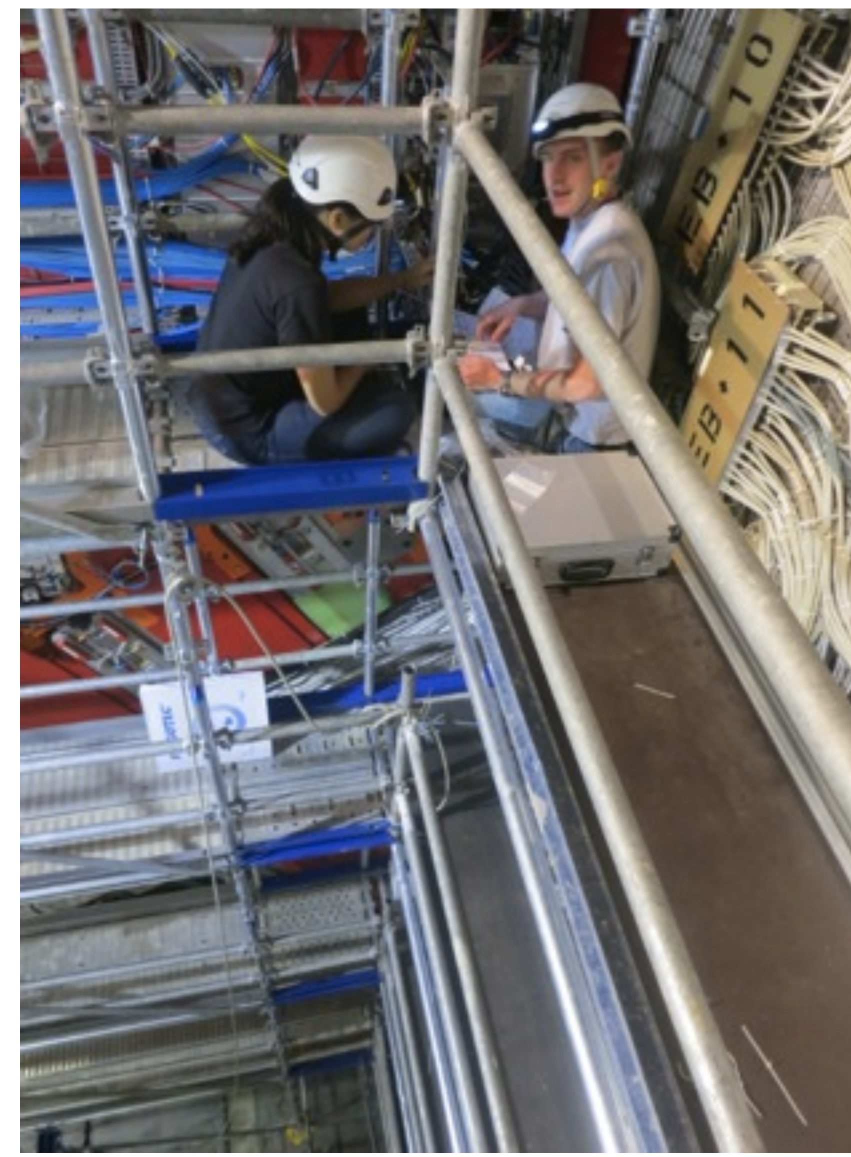


after sealing < -20C everywhere

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

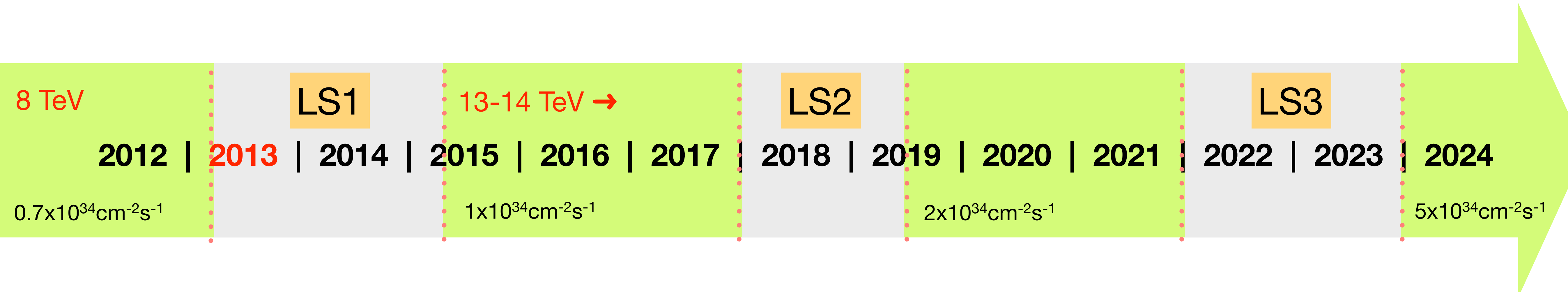
ME1/1 refurbishment progressing well

- 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



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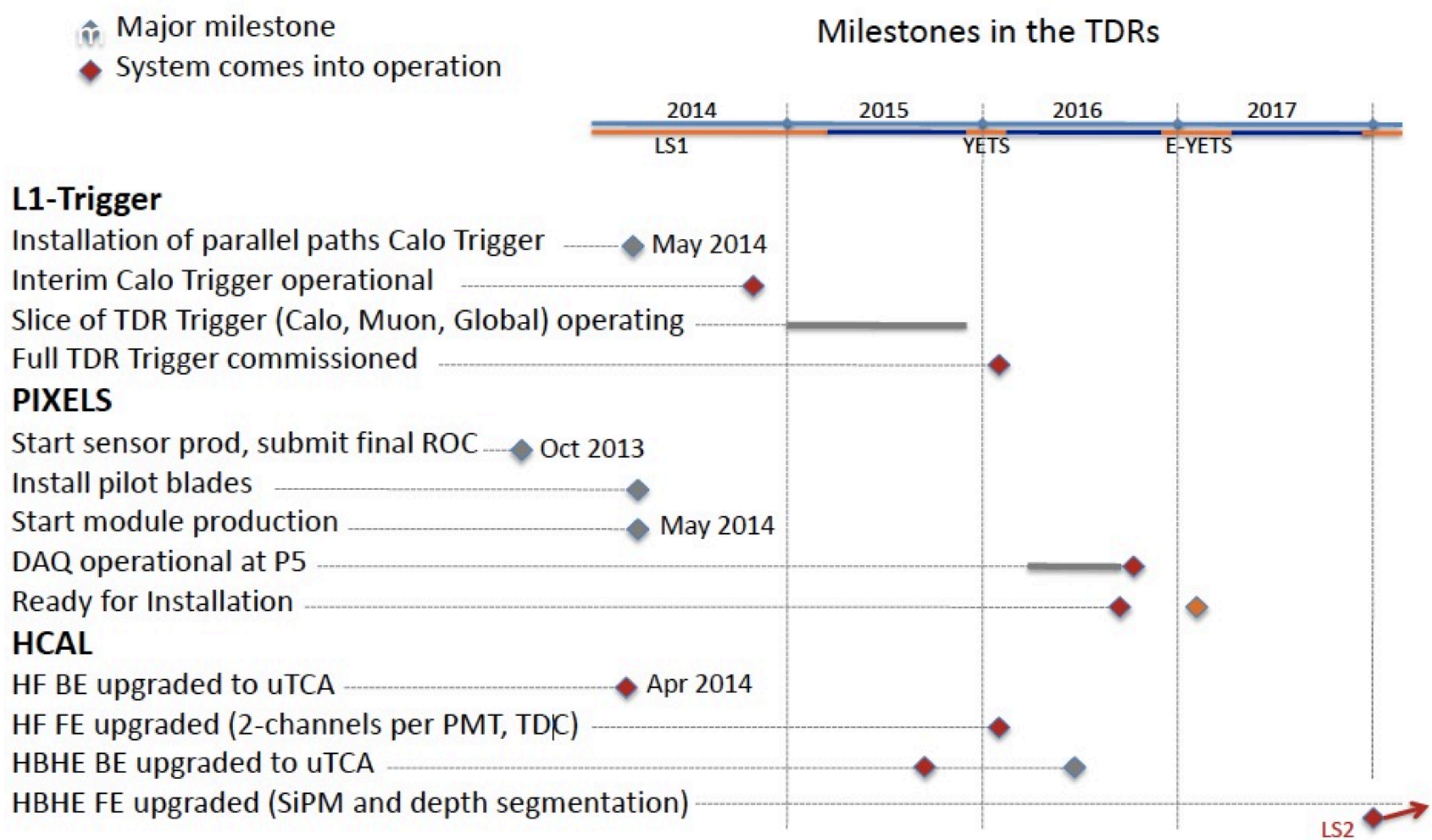
Phase I Upgrades (overview)



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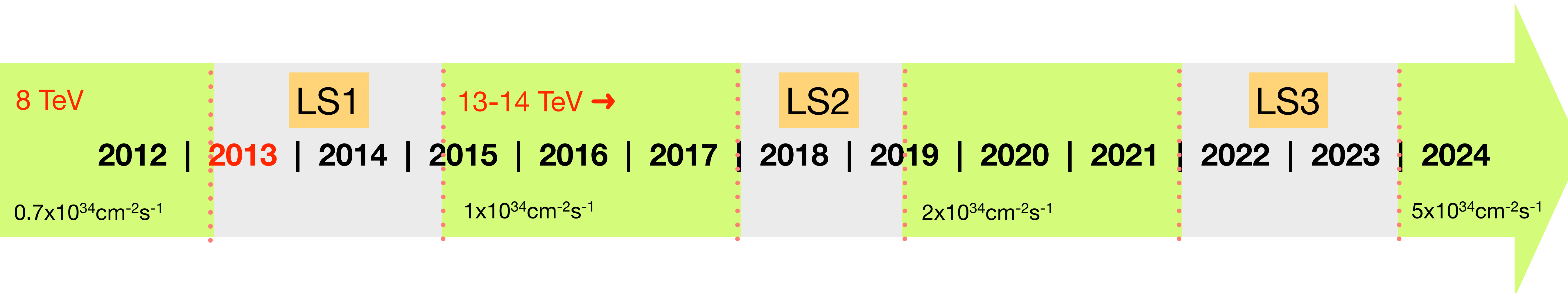

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detailed discussion yesterday by Didier Contardo

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

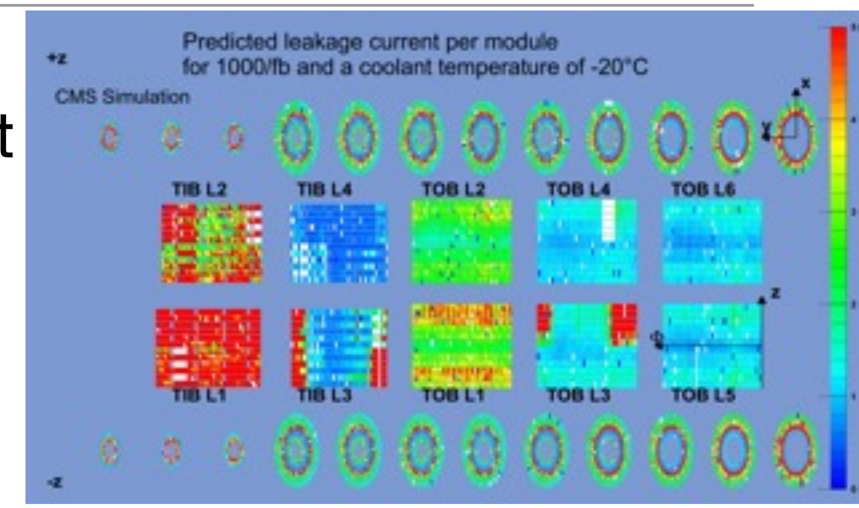
- Sequence of work during LS3 (installation of Phase II upgrades)
- Simulation of activation and possible mitigation
- Interface with HL-LHC new IP configuration

CMS was designed for 10 years operation and 500 fb^{-1}

Longevity of Phase I detectors

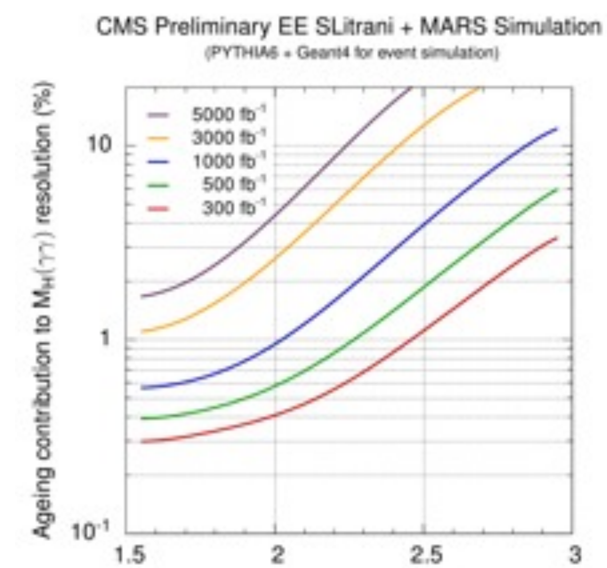
Complete tracker needs replacement in LS3

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



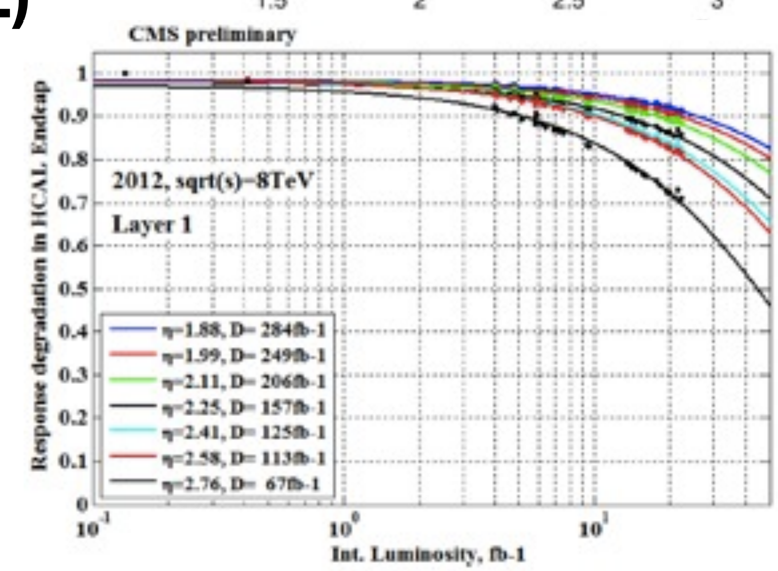
Detailed studies of ECAL radiation damage effects of crystals and photo-detectors

- 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 |η|=4
- L1 track trigger

Calorimeter

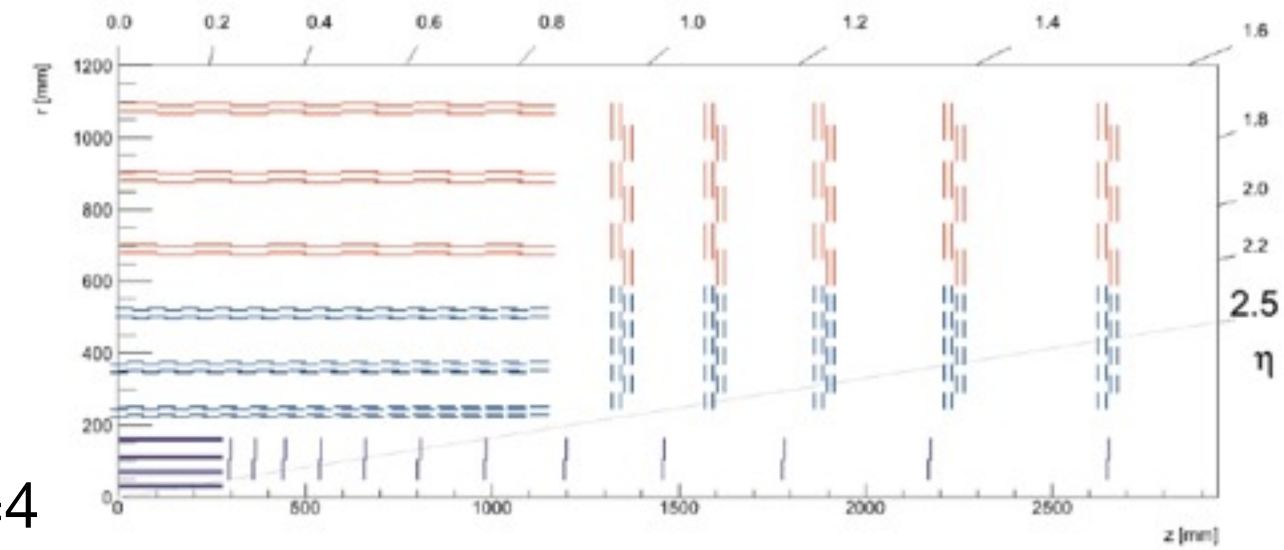
- extended calorimeter coverage up to |η|=4
- investigating precision timing measurements

Muon system

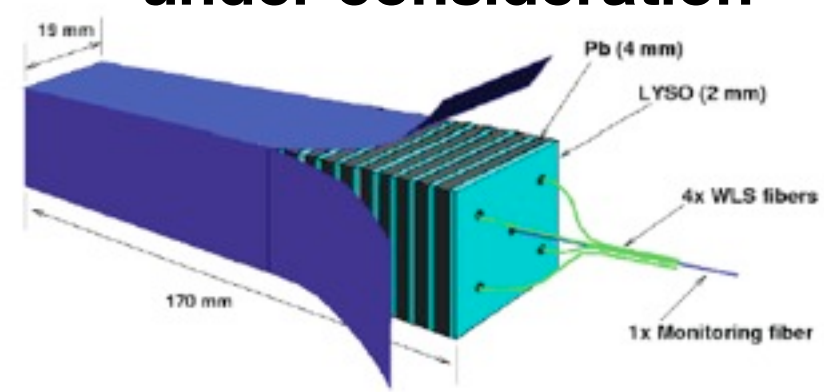
- extended coverage up to |η|=4

Trigger / DAQ system

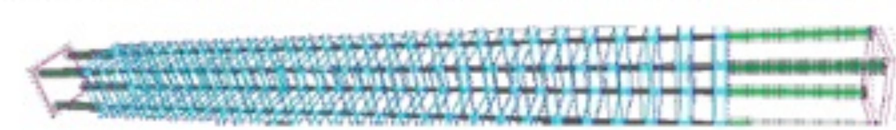
- allow higher L1-trigger rates up to 1MHz
- allow 10μs latency
- upgrade HLT processing with 10kHz output rate



Forward calorimeters under consideration



Prototype replacement for EE: Absorber plates could be W or Pb; Scintillation plates can be LYSO or other scintillator options. Fiber readout is likely Quartz Capillaries with WLS cores. Photosensors would be GaAs or GaInP Pixelated Geiger Mode APDs.



Simulation model of the Shashlik structure built using Litrani code

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

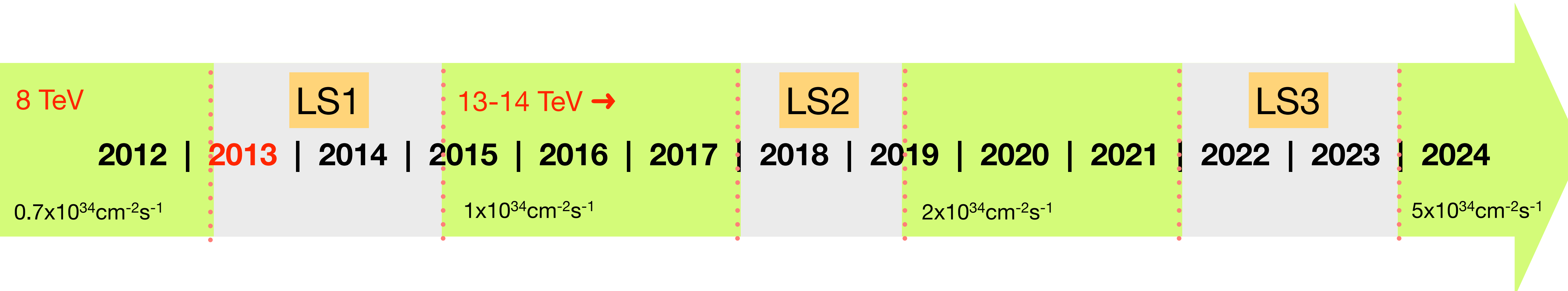
Technical Proposal in 2014

- 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



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

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: Δ theory / 2, rest $\propto 1/\sqrt{L}$
also studied: no theory uncertainties

Higgs Boson Coupling Modifier Fits

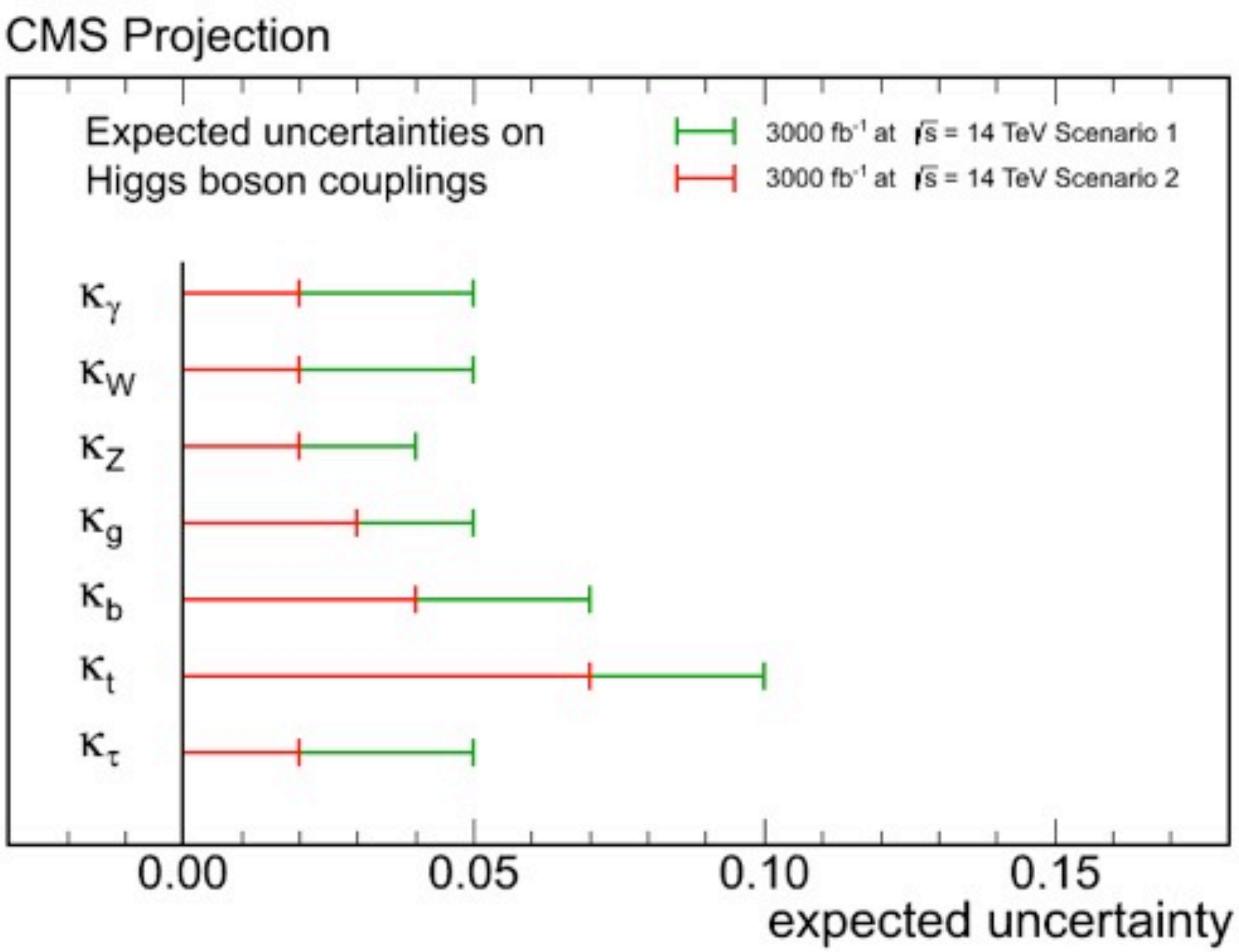
κ_g, κ_γ, $\kappa_{Z\gamma}$: loop diagrams ➜ allow potential new physics
κ_W, κ_Z: vector bosons
κ_t, κ_b: up- and down-type quarks
κ_τ, κ_μ: charged leptons
total width from sum of partial widths

alternatively:

$$\Gamma_{\text{tot}} = \sum \Gamma_{ii} + \Gamma_{\text{BSM}}$$

$$\text{BR}_{\text{BSM}} = \Gamma_{\text{BSM}} / \Gamma_{\text{tot}}$$

assumption here κ_W, $\kappa_Z < 1$



CMS Projection

L (fb^{-1})	κ_γ	κ_W	κ_Z	κ_g	κ_b	κ_t	κ_τ	$\kappa_{Z\gamma}$	κ_μ
300	[5,7]	[4,6]	[4,6]	[6,8]	[10,13]	[14,15]	[6,8]	[41,41]	[23,23]
3000	[2,5]	[2,5]	[2,4]	[3,5]	[4,7]	[7,10]	[2,5]	[10,12]	[8,8]

new

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

* additional channels under study, e.g. ttH, H to VV

Invisible Higgs Decays

Accessible via VBF and ZH production.

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

ZH: BR_{inv} < 75% (91%)
VBF: BR_{inv} < 69% (55%)

HIG-13-018
HIG-13-013

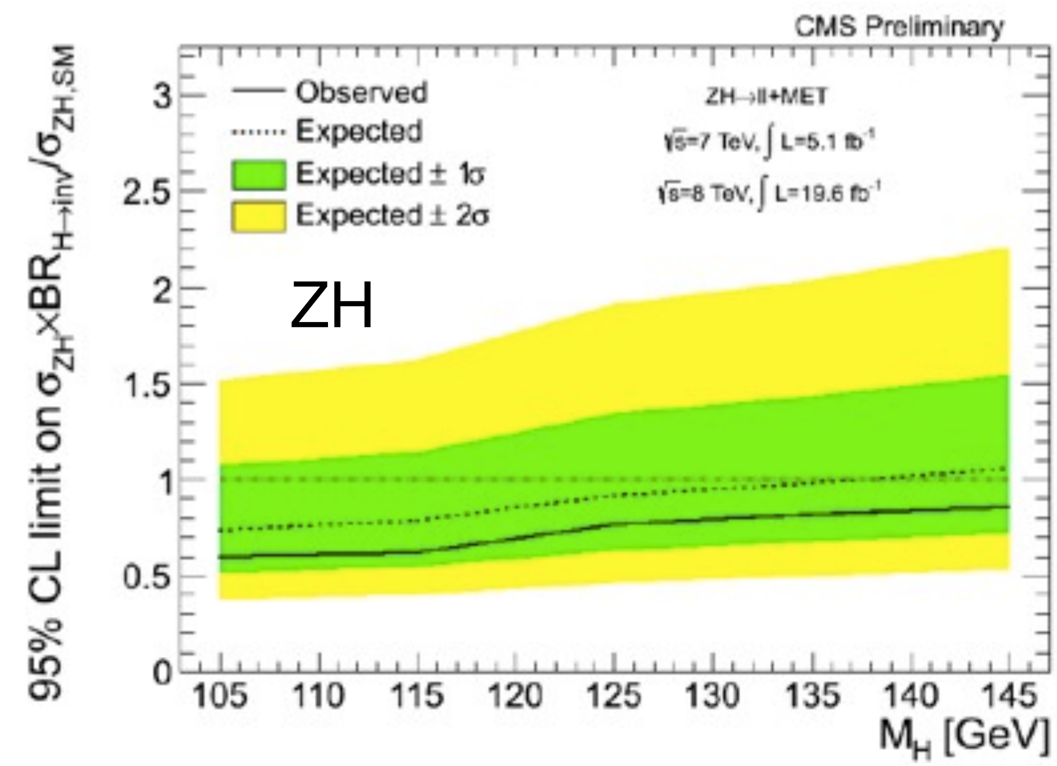
Estimate from CMS for future performance based in ZH analysis only

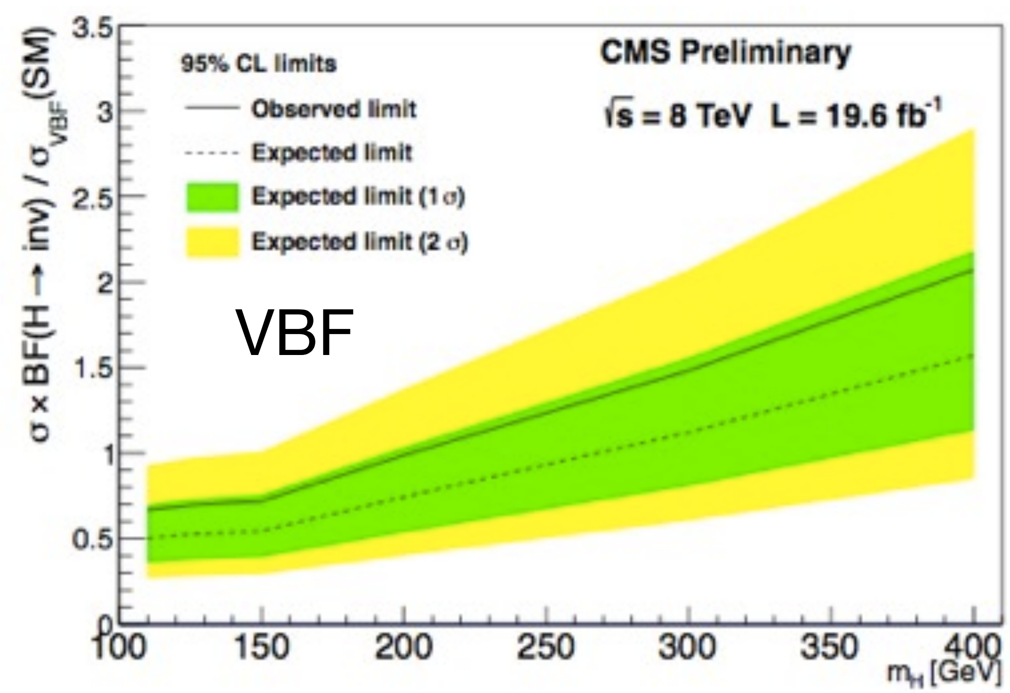
L (fb^{-1})	$H \to$ inv.
300	[17, 28]
3000	[6, 17]

Extended Higgs coupling fit has sensitivity to BR_{BSM}

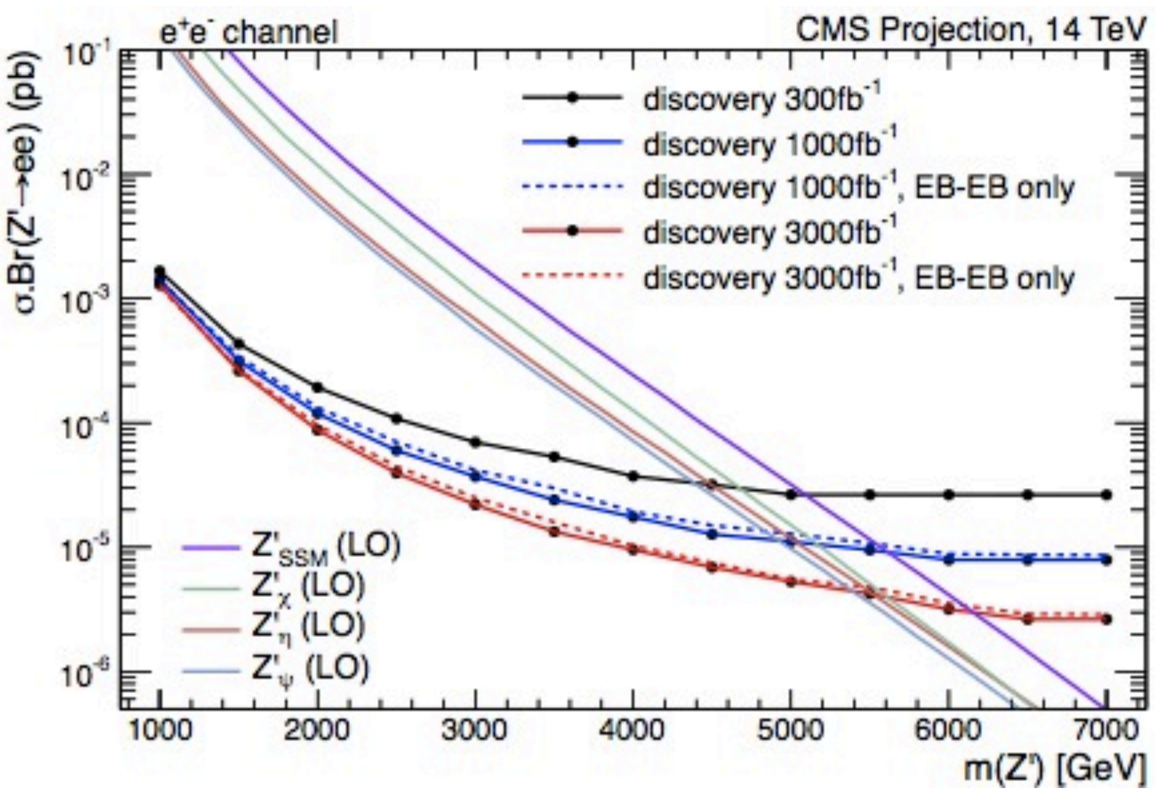
L (fb^{-1})	BR_{inv}
300	[14, 18]
3000	[7, 11]

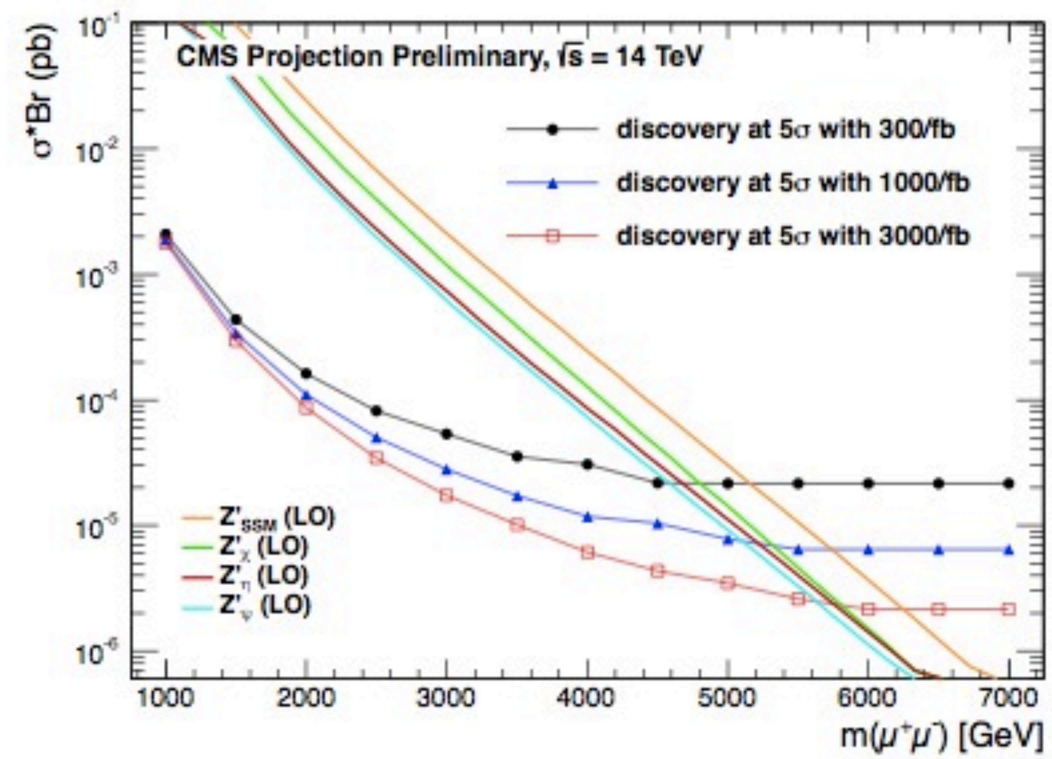
$$\Gamma_{tot} = \sum \Gamma_{ii} + \Gamma_{BSM}$$
$$BR_{BSM} = \Gamma_{BSM} / \Gamma_{tot}$$





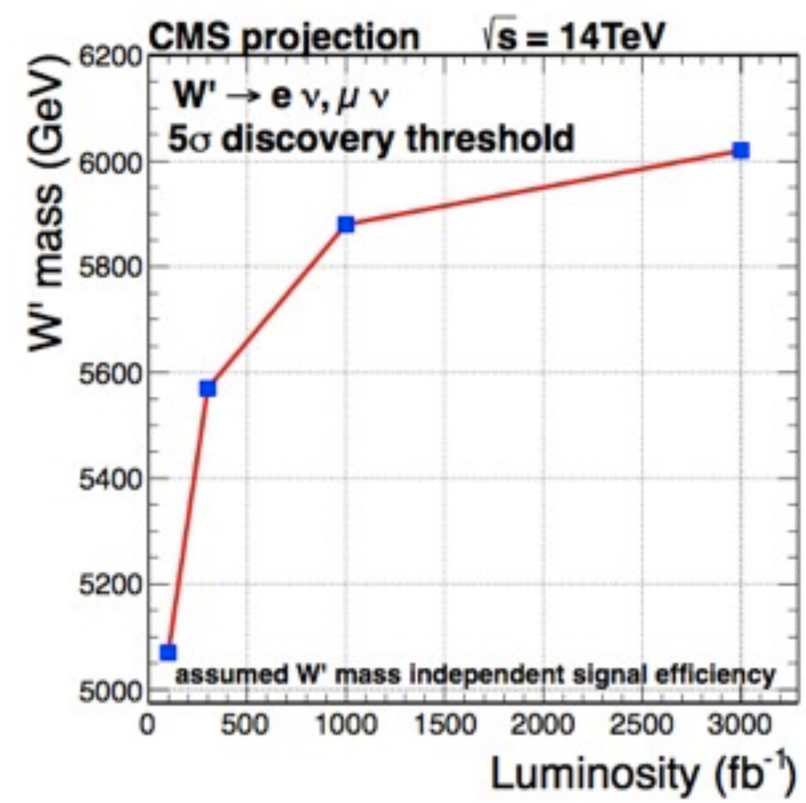
W’ and Z’ searches





Discovery reach in di-electron and di-muon channel

	Z'_{SSM} ee	Z'_{SSM} μμ
300 fb^{-1}	5.1 TeV	5.2 TeV
3000 fb^{-1}	6.2 TeV	6.4 TeV



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

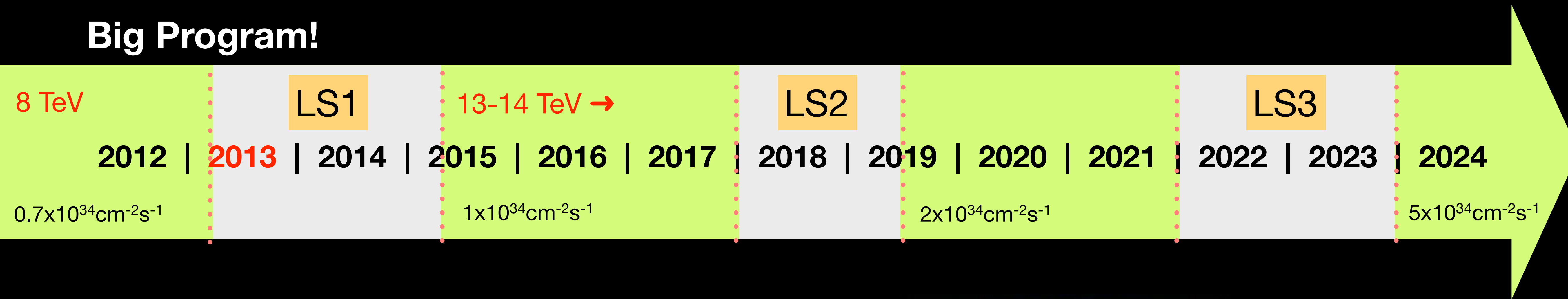
Physics program includes

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

Name	Code	Data	Conference
HH to bb gamma gamma	FTR-13-001	Upgrade	ECFA 2013
Projections for HH to bb+gamma gamma in 3000 fb-1 | Notes: AN-2013/050			
VBF H to tau tau	FTR-13-002	Upgrade	ECFA 2013
Projections for VBF H to tau tau in 3000 fb-1			
H to ZZ to 4l	FTR-13-003	Upgrade	ECFA 2013
Projections for H to ZZ to 4l in 3000 fb-1 | Notes: AN-2013/298			
H to gamma gamma	FTR-13-004	Upgrade	ECFA 2013
Projections for H to gamma gamma in 3000 fb-1 | Notes: AN-2013/295			
H to mu mu	FTR-13-005	Upgrade	ECFA 2013
Projections for H to mu mu in 3000 fb-1			
VV Scattering	FTR-13-006	Upgrade	ECFA 2013
Projections for VV scattering in 3000 fb-1 | Notes: AN-2013/297			
HH to bb tau tau	FTR-13-007	Upgrade	ECFA 2013
Projections for HH to bb+tau tau in 3000 fb-1			
1-lepton Stop Search	FTR-13-008	Upgrade	ECFA 2013
Projections for 1-lepton stop search in 3000 fb-1			
VBF EWKino Search	FTR-13-009	Upgrade	ECFA 2013
Projections for VBF EWKino search in 3000 fb-1 | Rel. to Analysis: FTR-13-014 | Note			
Dijet future	FTR-13-010	Upgrade	ECFA 2013
Projections of dijet resonances search in 3000 fb-1			
Monojets	FTR-13-011	Upgrade	ECFA 2013
Projections for monojets (DM) in 3000 fb-1 | Notes: AN-2013/294			
Monoleptons	FTR-13-012	Upgrade	ECFA 2013
Projections for monoleptons (W', DM, etc) in 3000 fb-1			
Snowmass Whitepaper	FTR-13-013	Upgrade	Snowmass
Projections of 8 TeV results to 3000 fb-1 | Notes: AN-2013/221, AN-2013/167			
ECFA SUSY Summary PAS	FTR-13-014	Upgrade	ECFA 2013
Summary PAS for SUSY sensitivity studies for 3000 fb-1 (including FTR-13-009, FTR-13-023 | Notes: AN-2013/293, AN-2013/289, AN-2013/290, AN-2013/291			
ttH	FTR-13-015	Upgrade	ECFA 2013
Projections for ttH in 3000 fb-1			
Top FCNC	FTR-13-016	Upgrade	ECFA 2013
Projections for top FCNC searches in 3000 fb-1 | Notes: AN-2013/299			
Top Mass	FTR-13-017	Upgrade	ECFA 2013
Projections for top quark mass measurements in 3000 fb-1 | Notes: AN-2013/301			
Anomalous Gauge Couplings	FTR-13-018	Upgrade	ECFA 2013
Projections for AGC searches in 3000 fb-1 | Rel. to Analysis: FTR-13-006			
EWKino Multilepton for ECFA	FTR-13-019	Upgrade	ECFA 2013
Chargino neutralino study for ECFA at 3000/fb | Rel. to Analysis: FTR-13-014 | Notes			
SUSY Jets+MHT for ECFA	FTR-13-020	Upgrade	ECFA 2013
SUSY Jets+MHT study for ECFA at 3000/fb | Rel. to Analysis: FTR-13-014 | Notes: A			
WH, H to bb	FTR-13-021	Upgrade	ECFA 2013
Projections for WH, H to bb in 3000 fb-1			
B to uu	FTR-13-022	Upgrade	ECFA 2013
Projections for B to uu in 3000 fb-1			
SUS - l+j+MET+b	FTR-13-023	Upgrade	ECFA 2013
Projections for SUS 1lepton+jets+MET+b in 3000 fb-1 | Rel. to Analysis: FTR-13-014			
2HDM Higgs studies (H->ZZ and A->Zh)	FTR-13-024	Upgrade	ECFA 2013
Projections for 2HDM Higgs studies (H->ZZ and A->Zh) in 3000 fb-1 | Notes: AN-2013			
Heavy Ions	FTR-13-025	Upgrade	ECFA 2013
Projections for Heavy Ions with HL-LHC | Notes: AN-2013/292			
Search for T'	FTR-13-026	Upgrade	ECFA 2013
Projections of T' search in 3000 fb-1 | Notes: AN-2013/300			
Higgs Couplings and Ratios	FTR-13-027	Upgrade	ECFA 2013
Projections of uncertainty on Higgs coupling and ratios with 3000 fb-1 | Notes: AN-201			

Conclusion

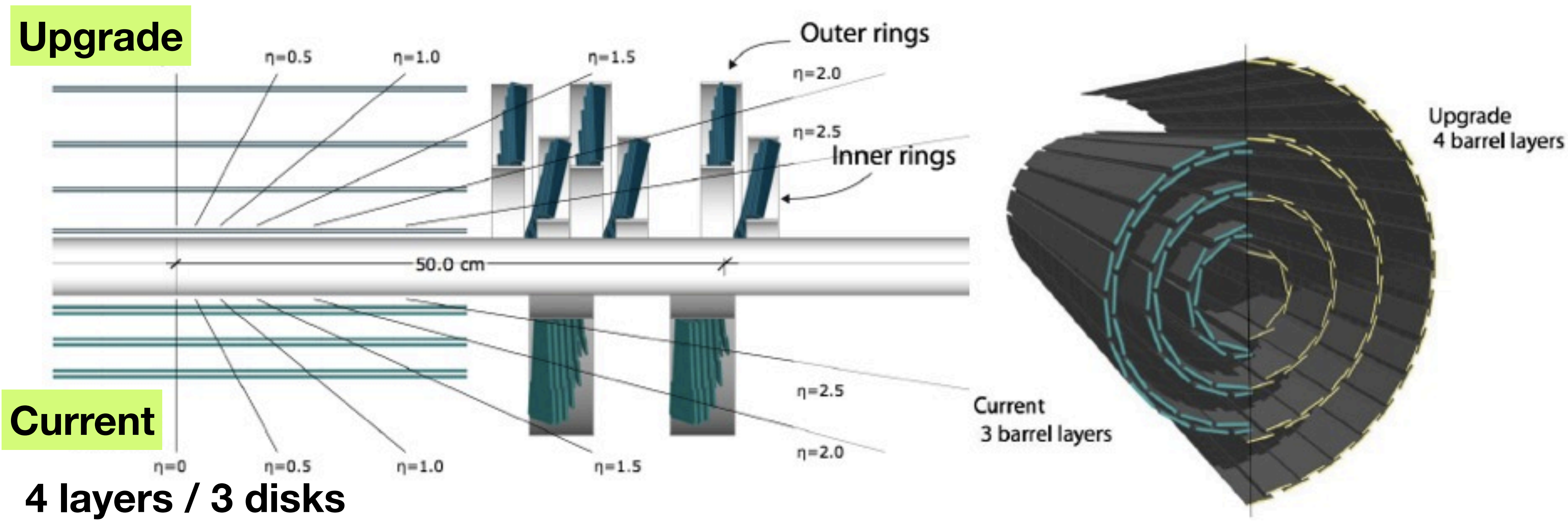
Big Program!



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



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

- CO_2 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

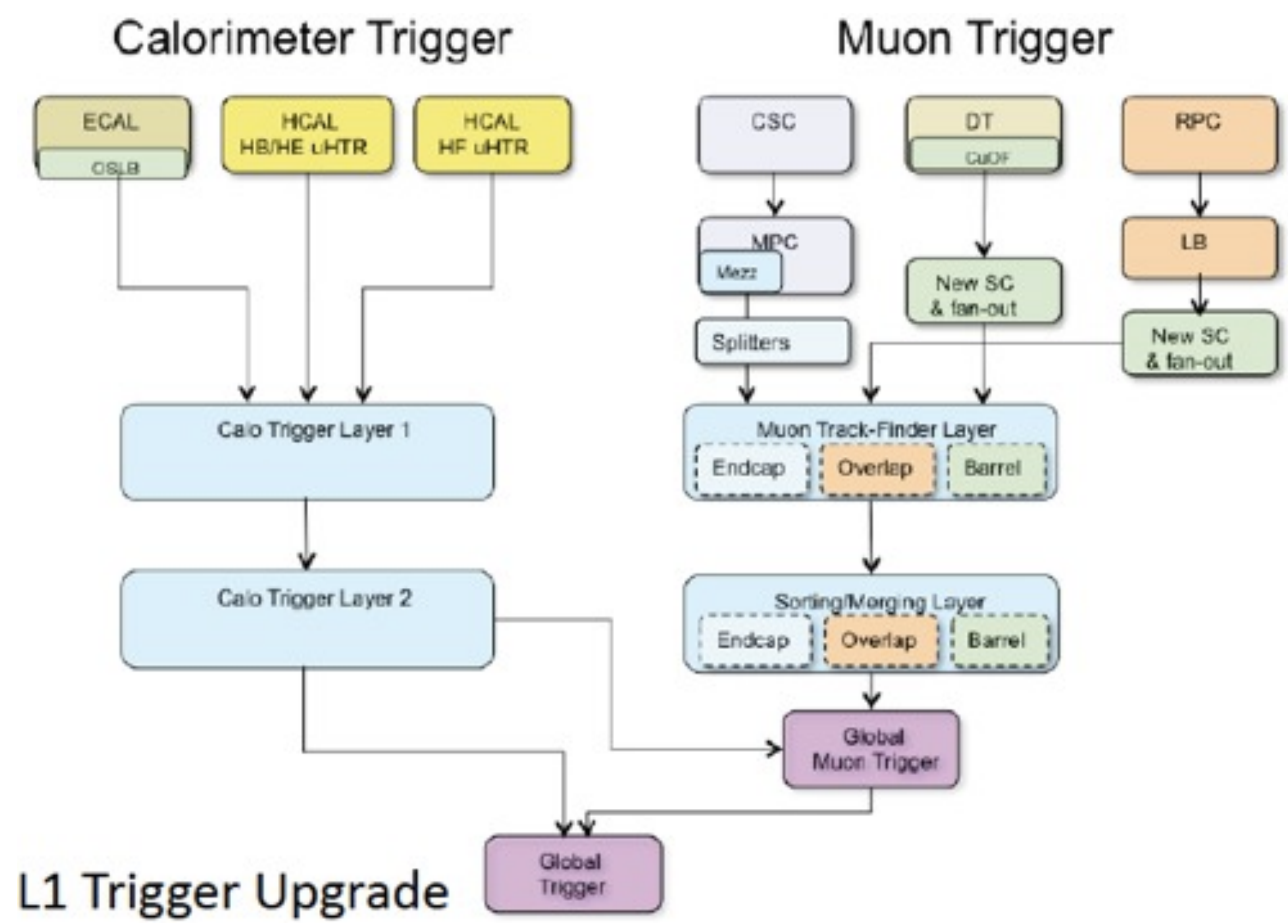
Phase I Upgrades - Trigger

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



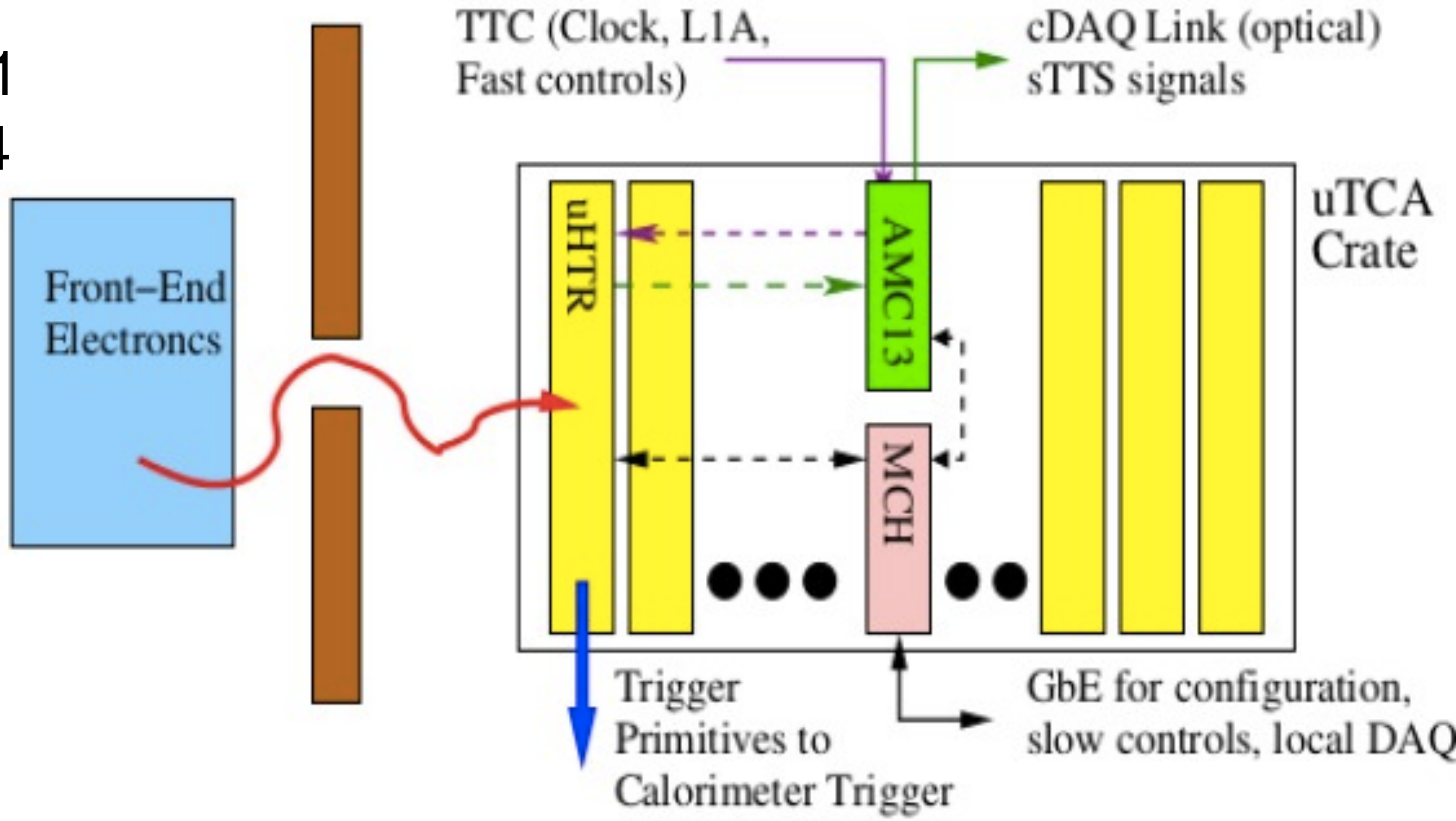
L1 upgrade algorithm

- 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

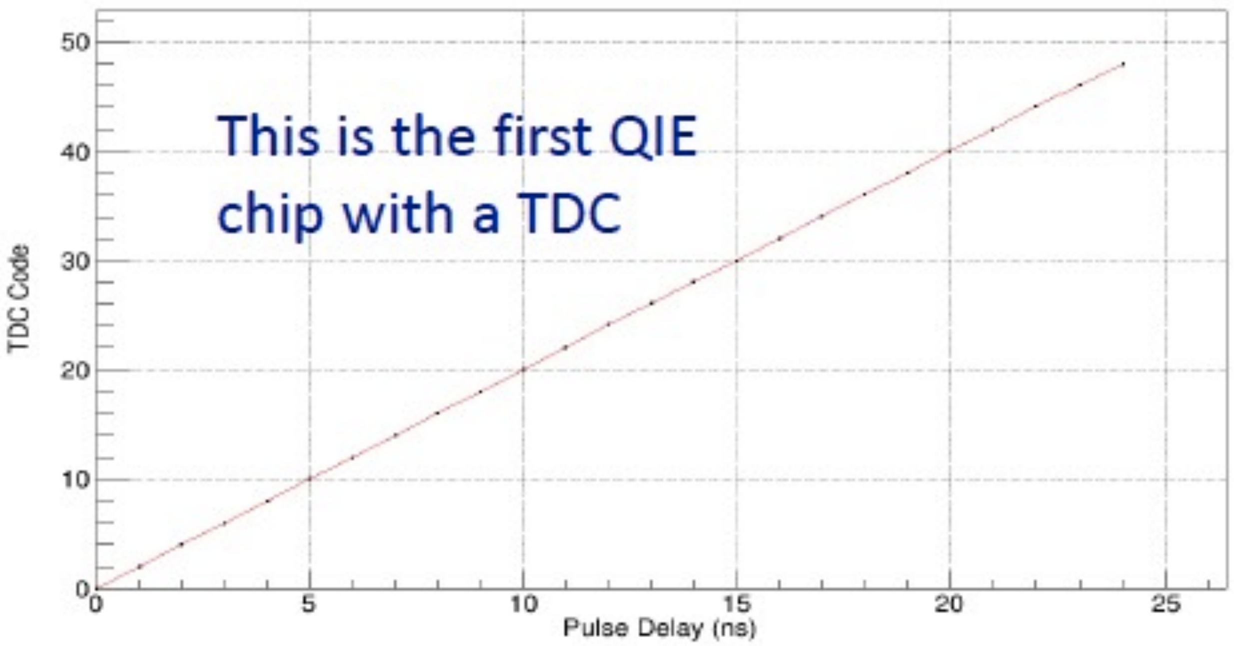
Backend electronics

- 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