Status of CMS

CERN KOREA (CKC) 10

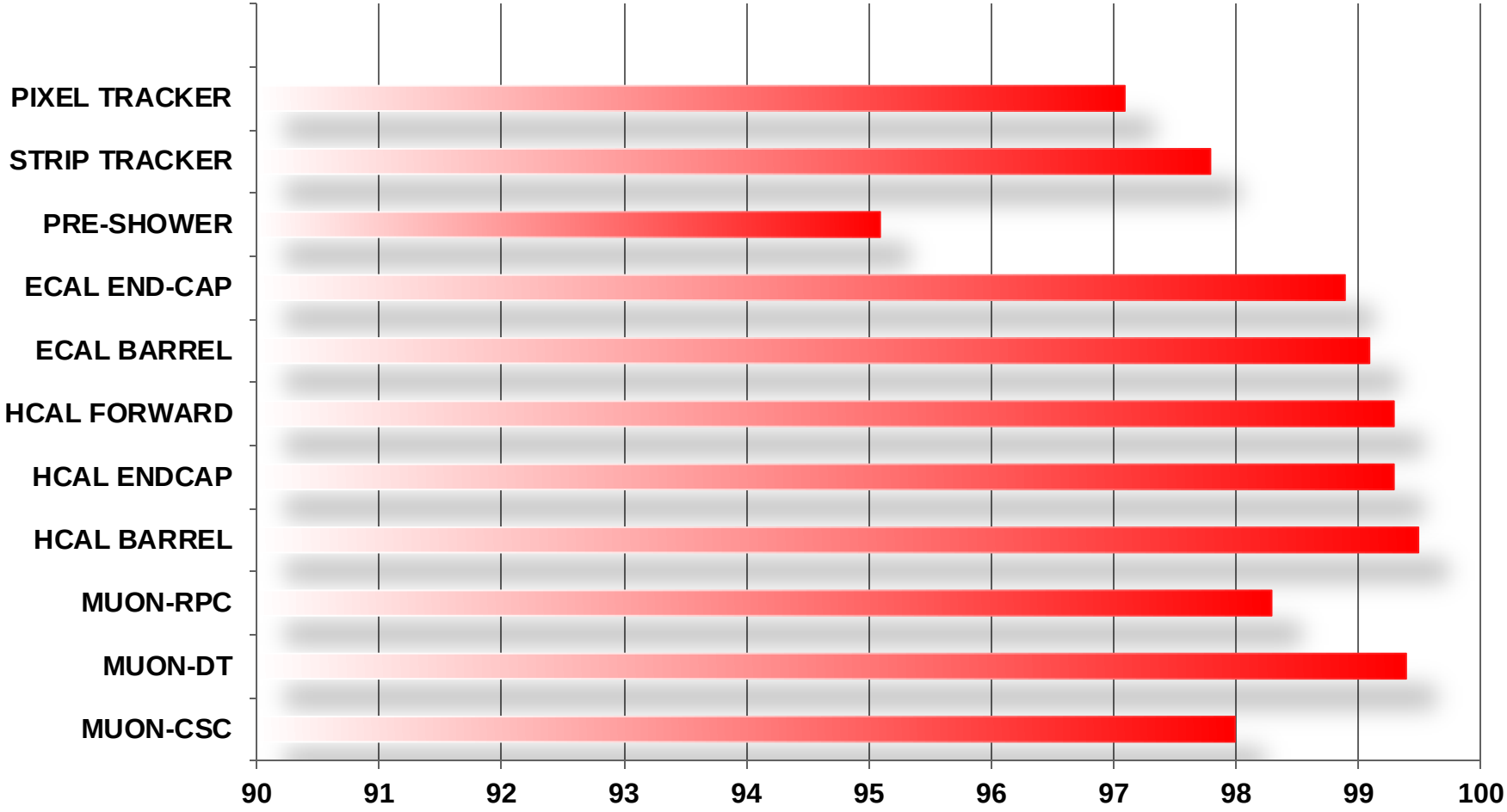
J. Incandela

University of California Santa Barbara

October 17, 20111

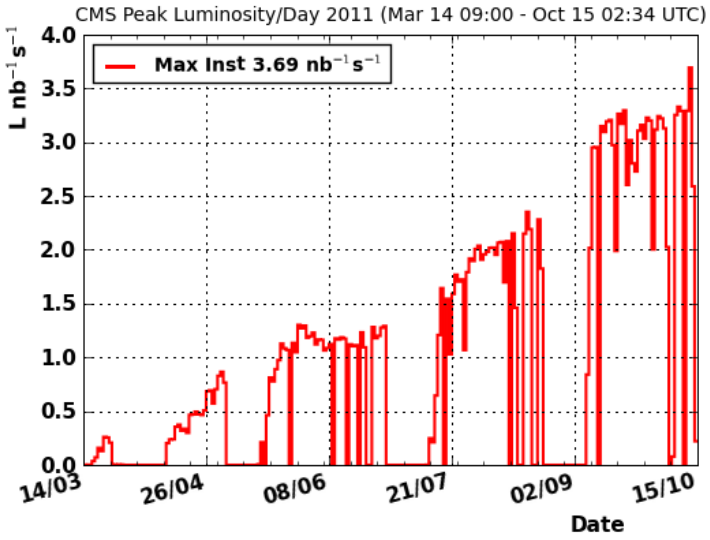
Korea CMS

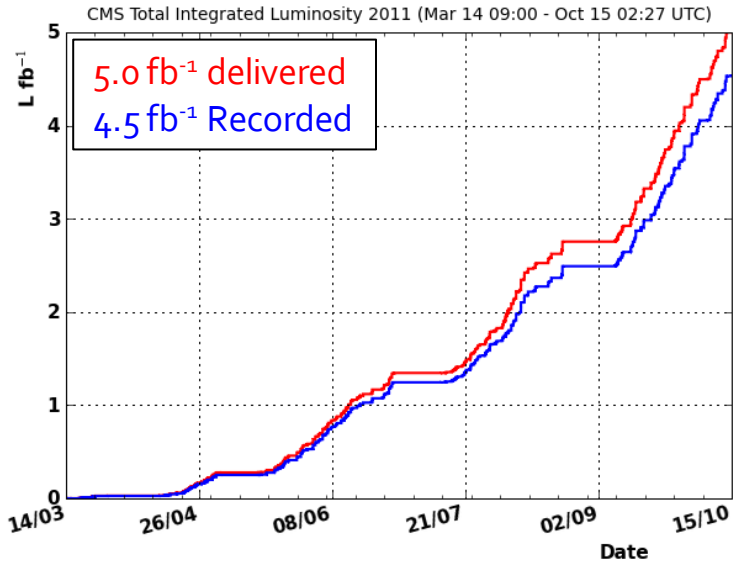
Sub-detectors operational status



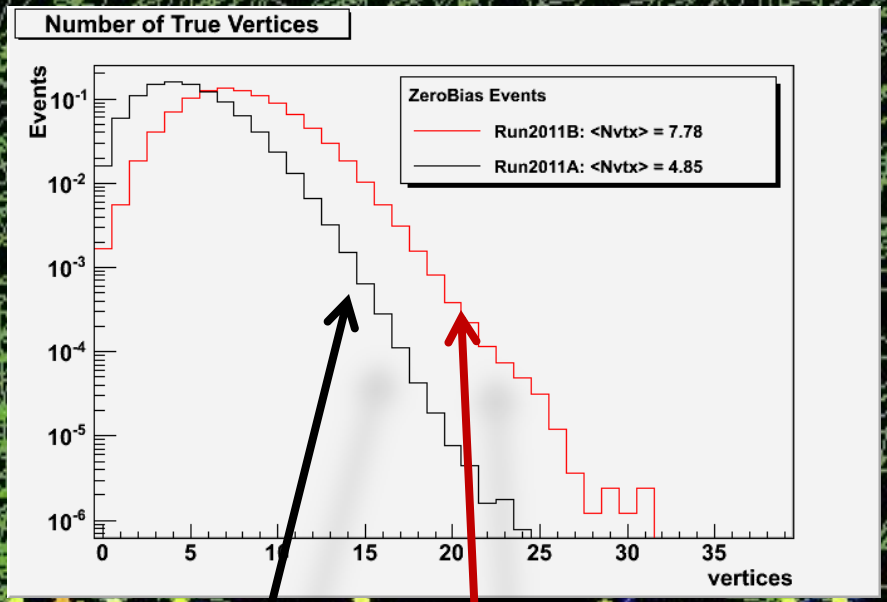
	MUON-CSC	MUON-DT	MUON-RPC	HCAL BARREL	HCAL ENDCAP	HCAL FORWARD	ECAL BARREL	ECAL END-CAP	PRE-SHOWER	STRIP TRACKER	PIXEL TRACKER	
Series1	98	99.4	98.3	99.5	99.3	99.3	99.1	98.9	95.1	97.8	97.1	

LHC/CMS p-p operations 2011





- >5fb^{-1} delivered by LHC
- >4.5fb^{-1} recorded by CMS.
  - Data taking efficiency ~91%.
    - > 100 pb^{-1} lost August 2-3 due to a single cooling incident.
  - 400 pb^{-1}/week steady delivery.
  - Max. L = 3.7x10^{33} cm^{-2}s^{-1}
- Certification for physics:
  - 85-90% if all systems perfect;
  - 90-95% for muon-based analyses.
- Analyses reported today:
  - Most at ~1.1 fb^{-1}
  - Luminosity uncertainty 4.5%.



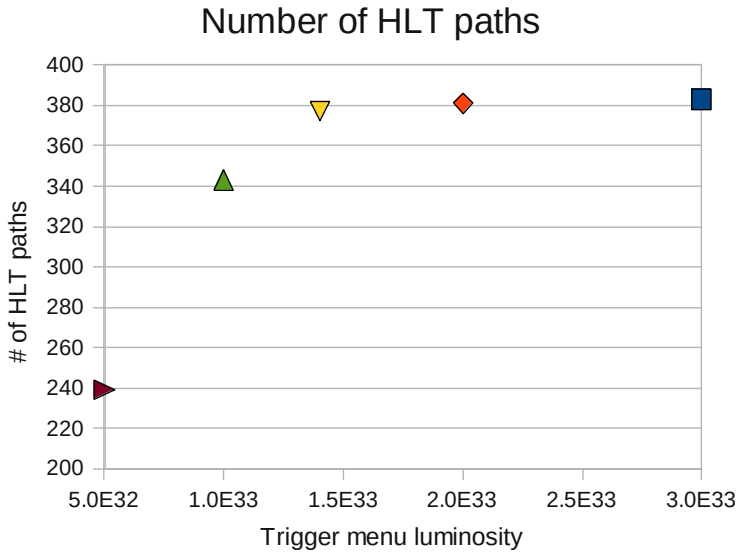
Before and after last Tech. Stop

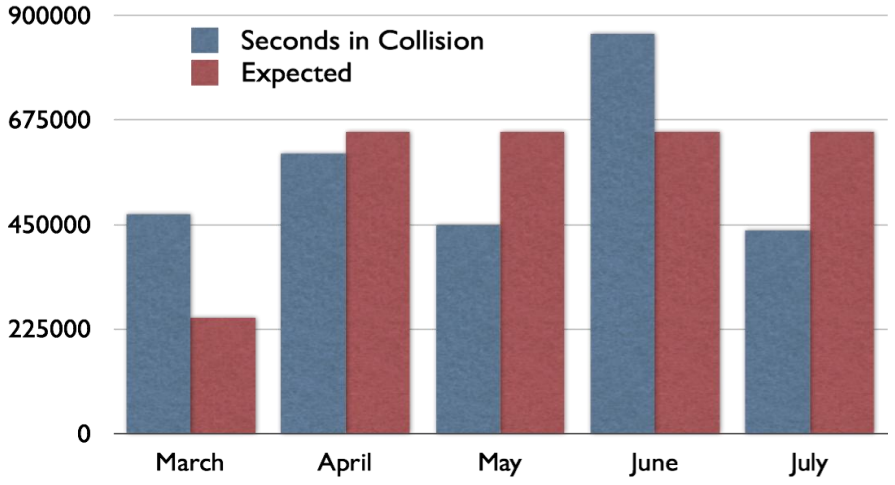
20 reconstructed vertices

Trigger & Computing

- DAQ & Trigger
  - Typical conditions (pp) :

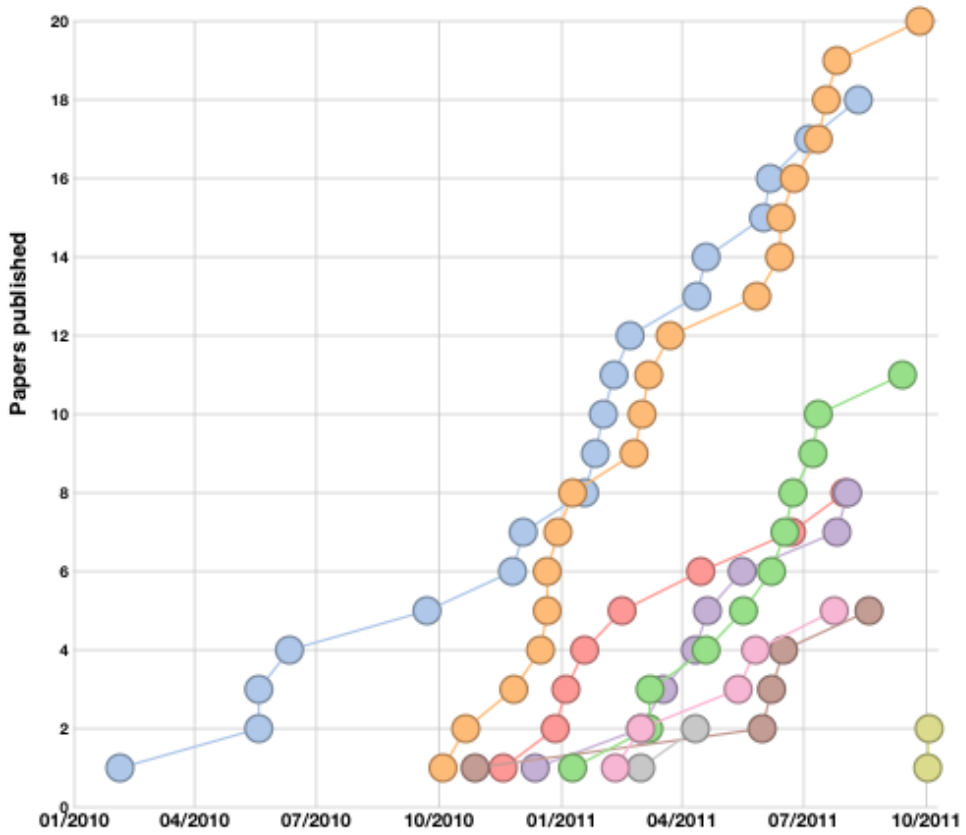
    ~500 kB event size, ~10k HLT CPU-cores, 3-4% Dead time
    - Start of fill: L ~3.3x10^{33}
      - 50% of FED limit on event size
      - Level-1 rate ~80 kHz
      - ~90% HLT CPU usage
      - 400 Hz recording
  - 240 HLT paths 2010, now ~400
    - Many improvements
      - Particle Flow, Faster tracking
      - Pileup/jet corrections at L1
      - Better spike/noise filters
- Computing
  - Keeping up on average





From Roberto Rossin & Ian Fisk

77 pp and HI papers*



QCD Physics

Exotica Searches

Supersymmetry

B Physics

Electroweak

Top Physics

Heavy Ion Physics

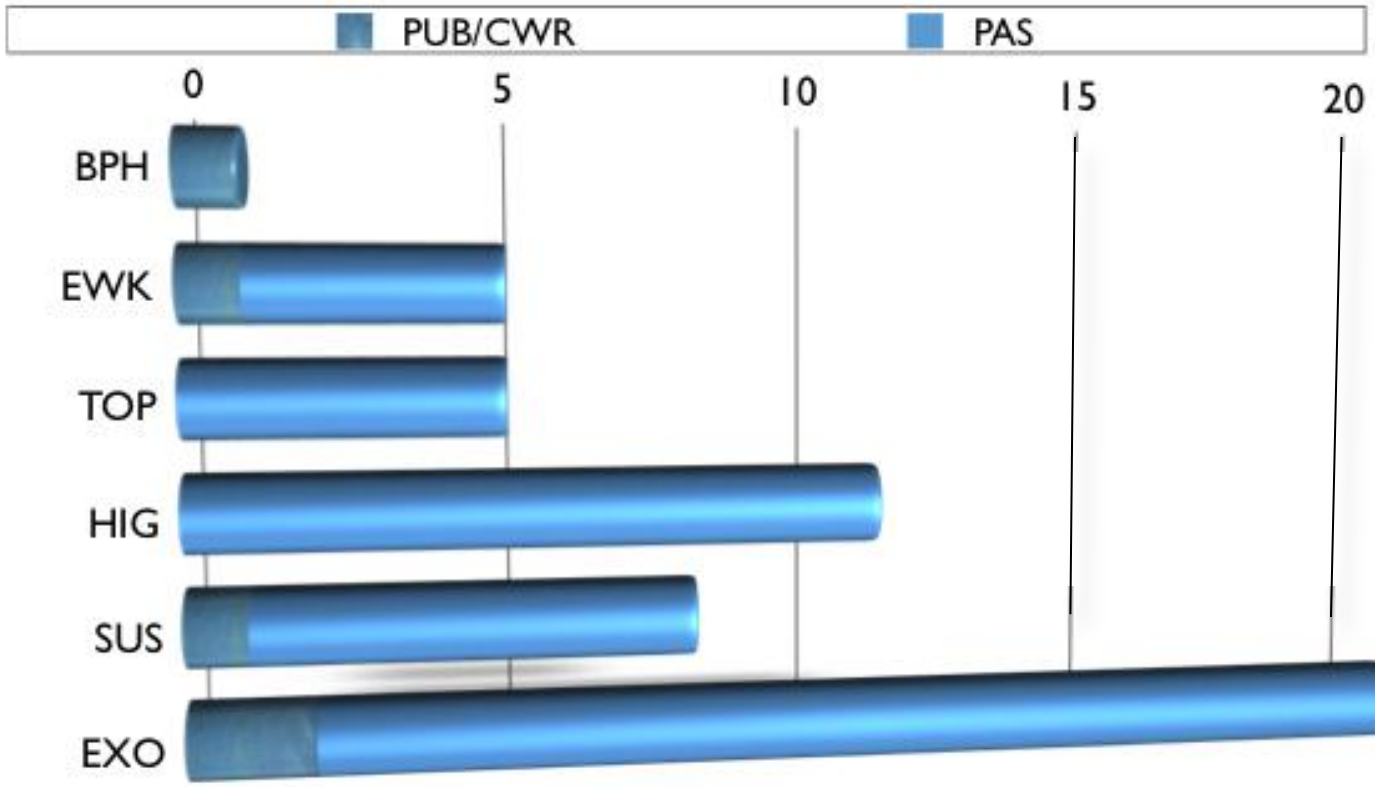
Higgs Physics

Forward Physics

See: http://cmsdoc.cern.ch/~mccauley/cmsphysics/

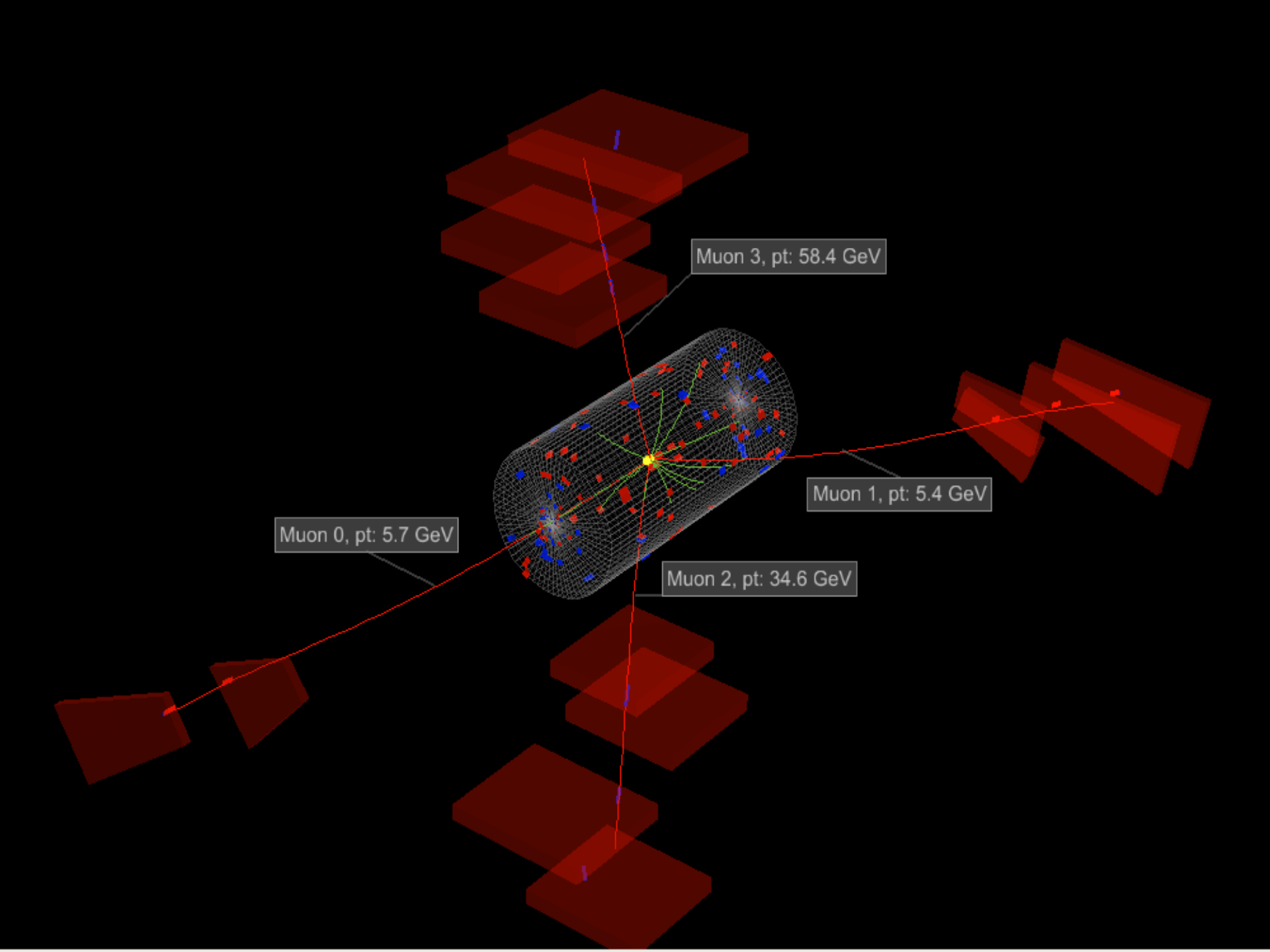
*mostly 2010 data

2011 Data Analyses



5 submitted, 45 PAS, 21 PRE-APP, +>41 more, TOT >112

https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResults
Papers, and Physics Analysis Summaries (PAS):
http://cdsweb.cern.ch/collection/CMS

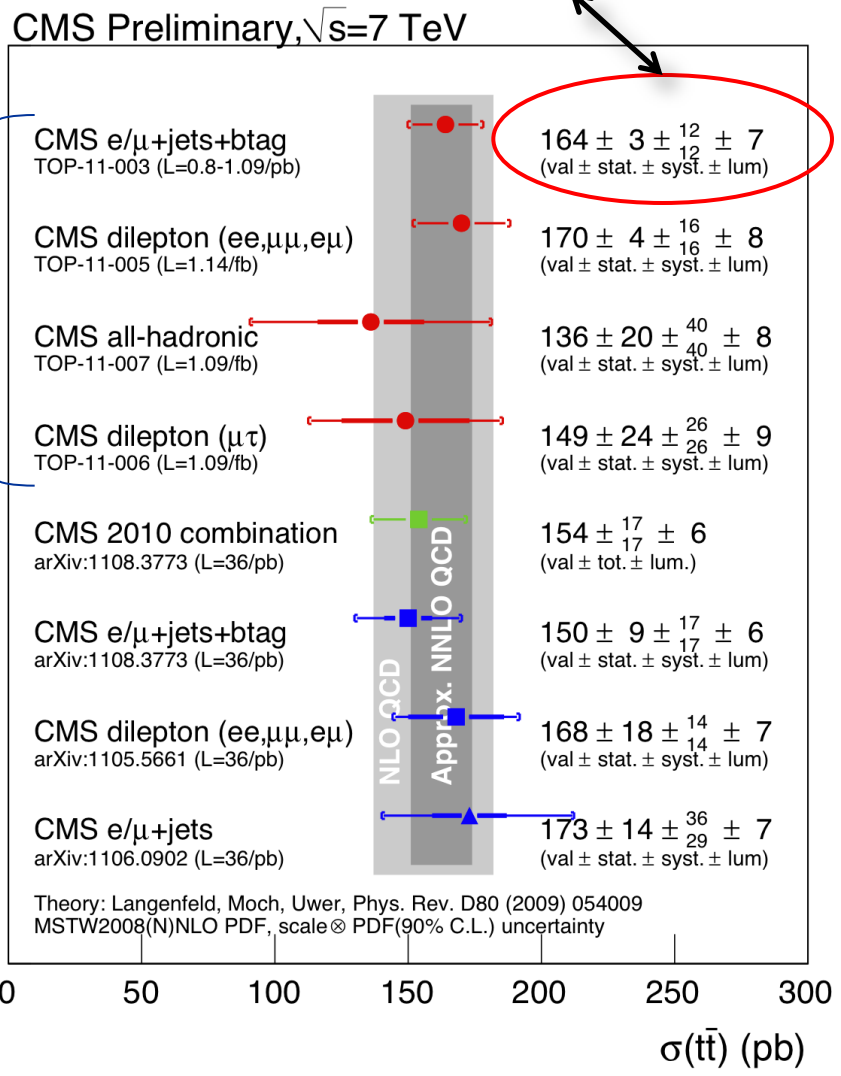

Muon 3, pt: 58.4 GeV
Muon 1, pt: 5.4 GeV
Muon 0, pt: 5.7 GeV
Muon 2, pt: 34.6 GeV

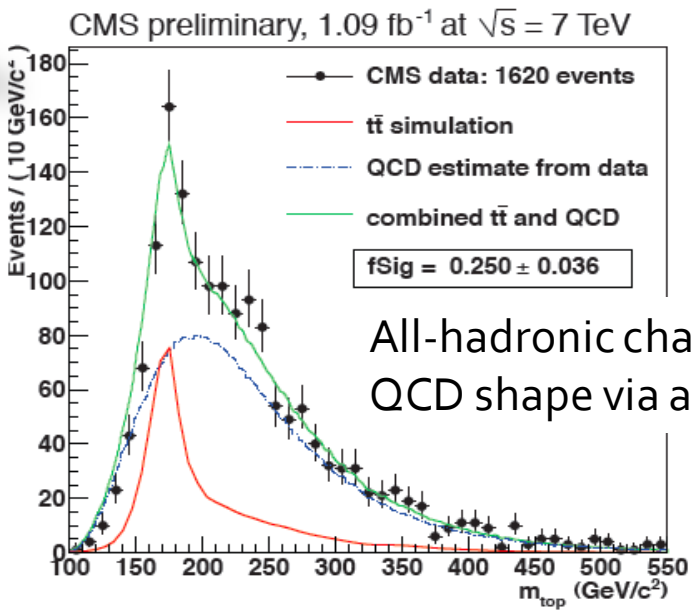
tt Cross Section, 1.1 fb^{-1}

σ(NLO)=158±24 pb

- Lepton+jets+b-tag
  - Most precise to-date
- Dileptons (ee,eμ,μμ) + b tag
- All-hadronic channel
  - kinematic fit for m_{top}
- Dilepton channel (μ-τ)
  - Reconstruct hadronic tau

2011

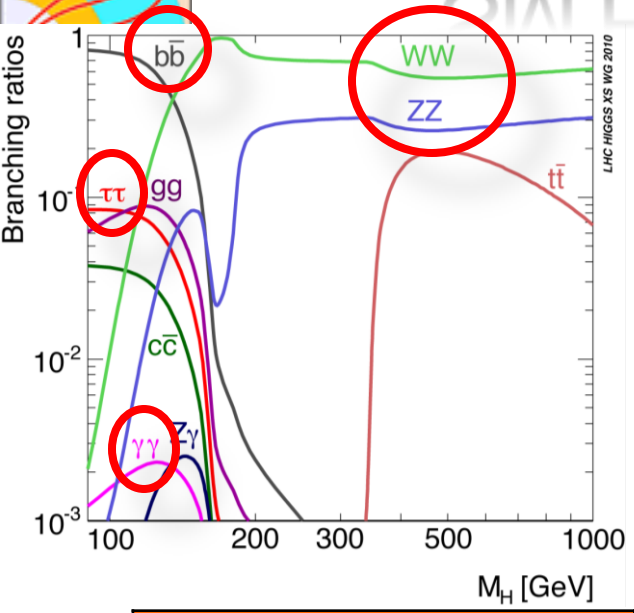


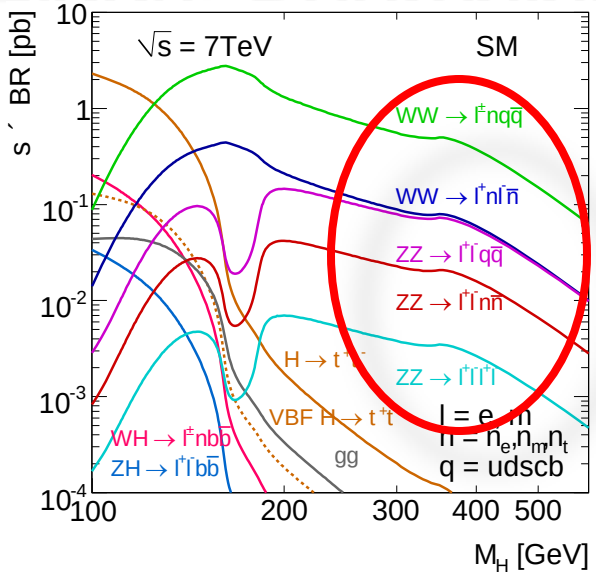


All-hadronic channel
QCD shape via anti b-tag

TOP-11-003, -005, -006, -007

SM Higgs: Searching Low and High



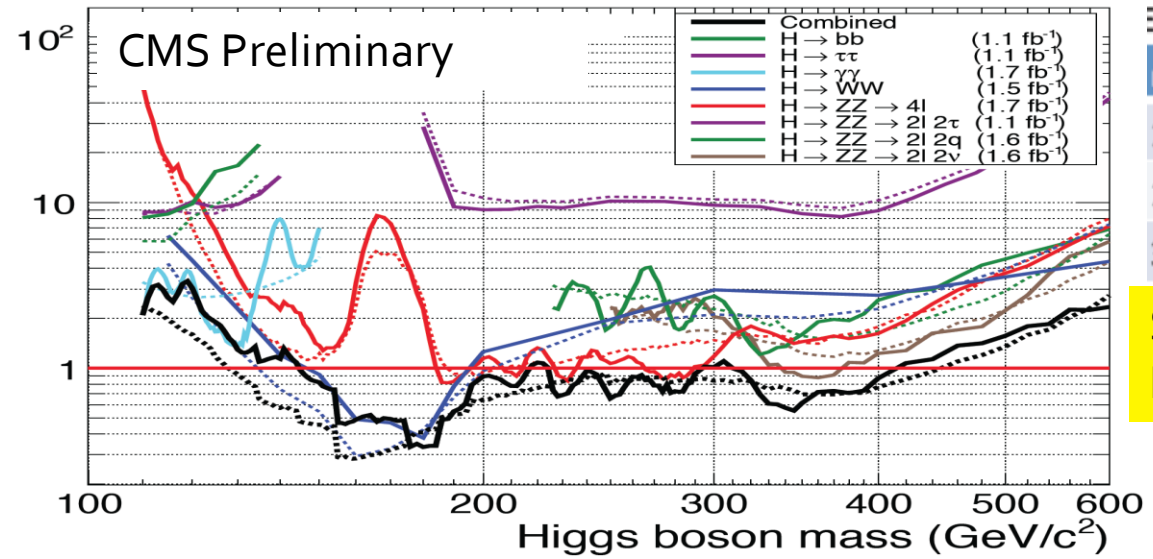


Events expected to be produced with L=1 fb^{-1}

m_H, GeV	WW→lvlv	ZZ→4l	γγ
120	127	1.5	43
150	390	4.6	16
300	89	3.8	0.04

Mode	Mass Range	Data Used (fb^{-1})	CMS Document
H → γγ	110-150	1.7	HIG-11-021
H → bb	110-135	1.1	HIG-11-012
H → ττ	110-140	1.1	HIG-11-009
H →WW →2l 2ν	110-600	1.5	HIG-11-014
H → ZZ →4l	110-600	1.7	HIG-11-015
H → ZZ →2l2τ	180-600	1.1	HIG-11-013
H → ZZ →2l2j	226-600	1.6	HIG-11-017
H → ZZ →2l2ν	250-600	1.5	HIG-11-016

SM Higgs Decay σ/σ_{SM} 95% CL Limits



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Solid = Observed limit
Dashed = Median Expected

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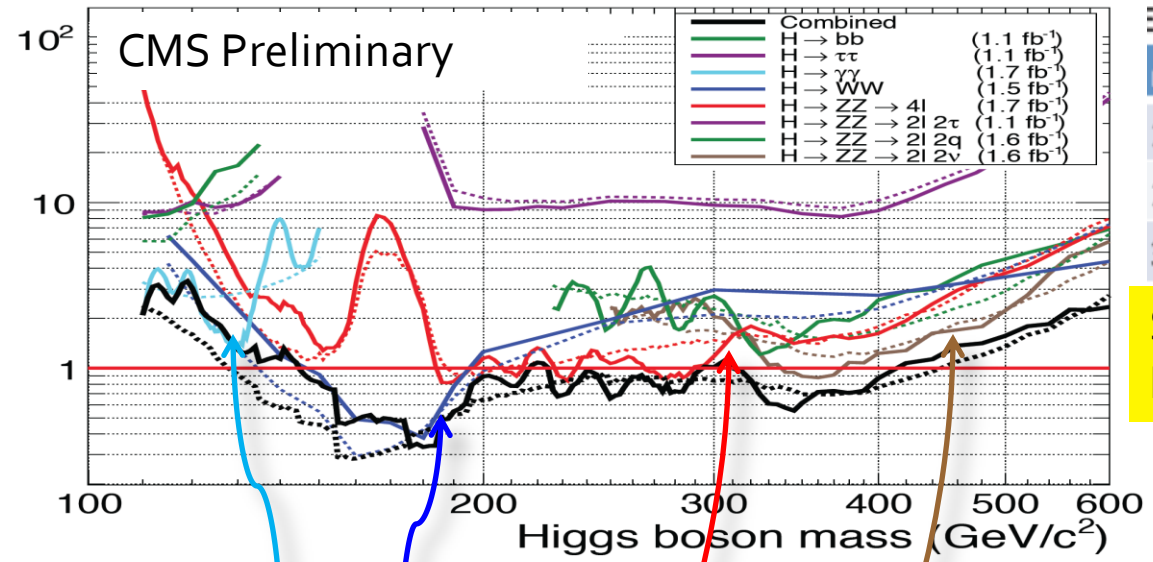

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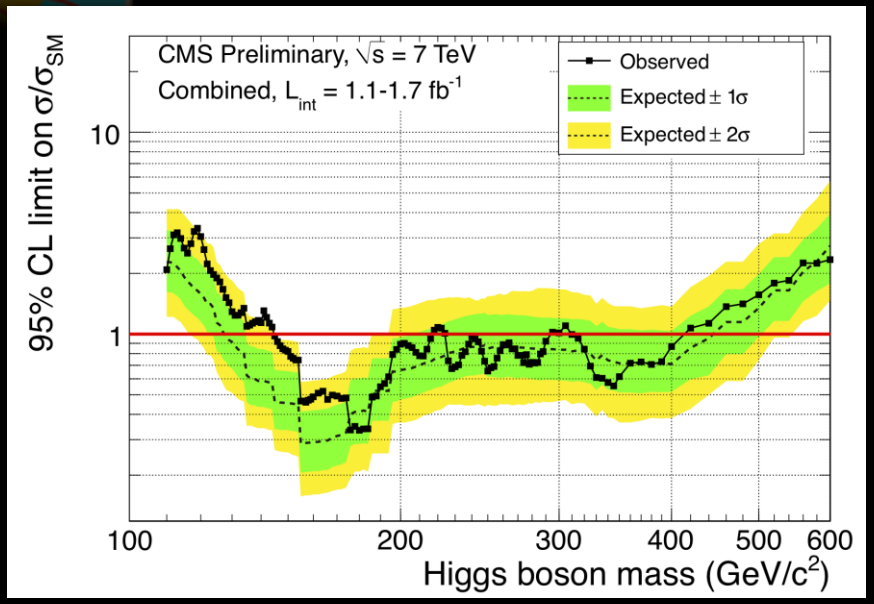
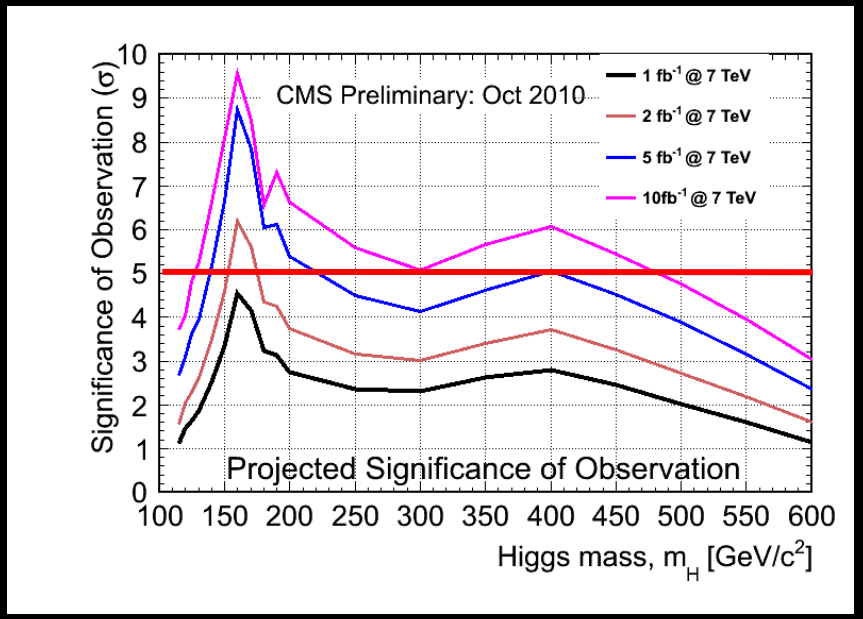
CMS SM Higgs Combination

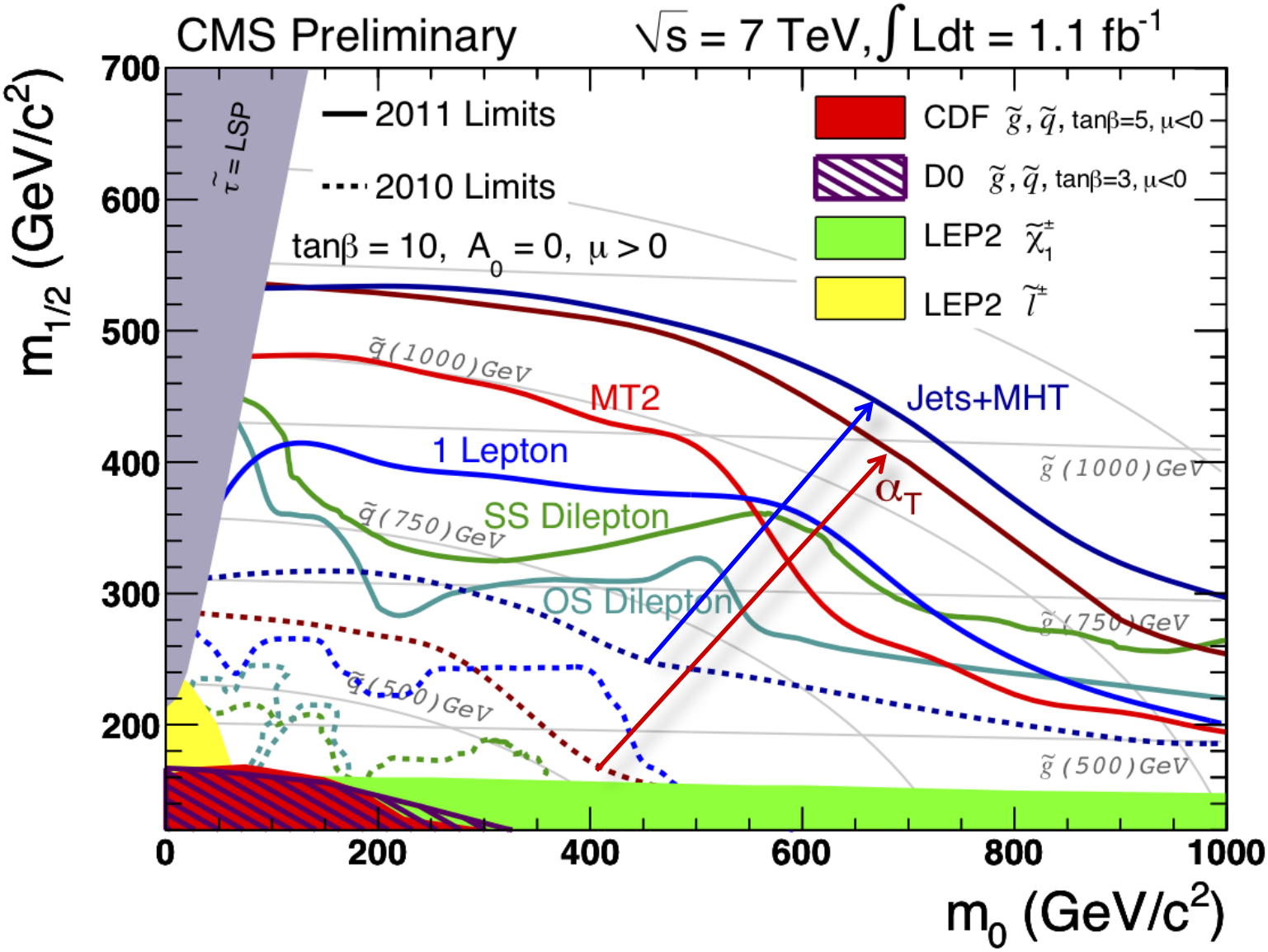




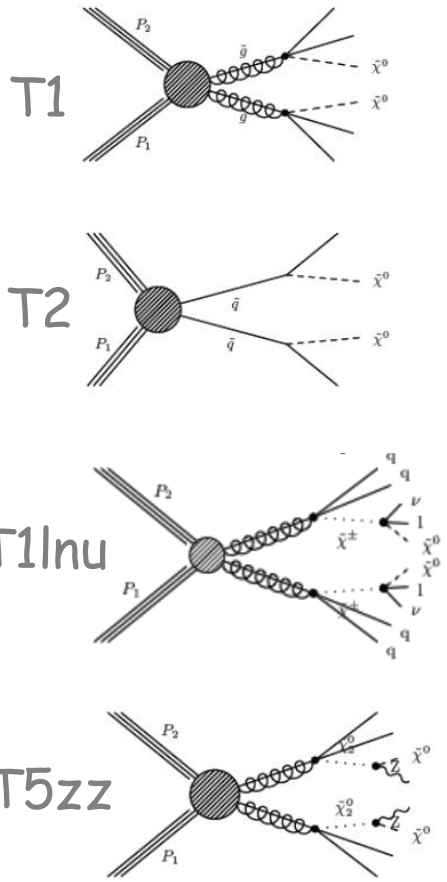
- Disfavored mass region:
  - Expected: 130 – 440 GeV
  - Observed: 145-216, 226-288, 310-400 GeV

- Definitive statement
  - With 10fb^{-1}
    - 3σ significance from LEP limit of 114 GeV up to 600 GeV
    - 5σ discovery potential from ~125 to ~475 GeV

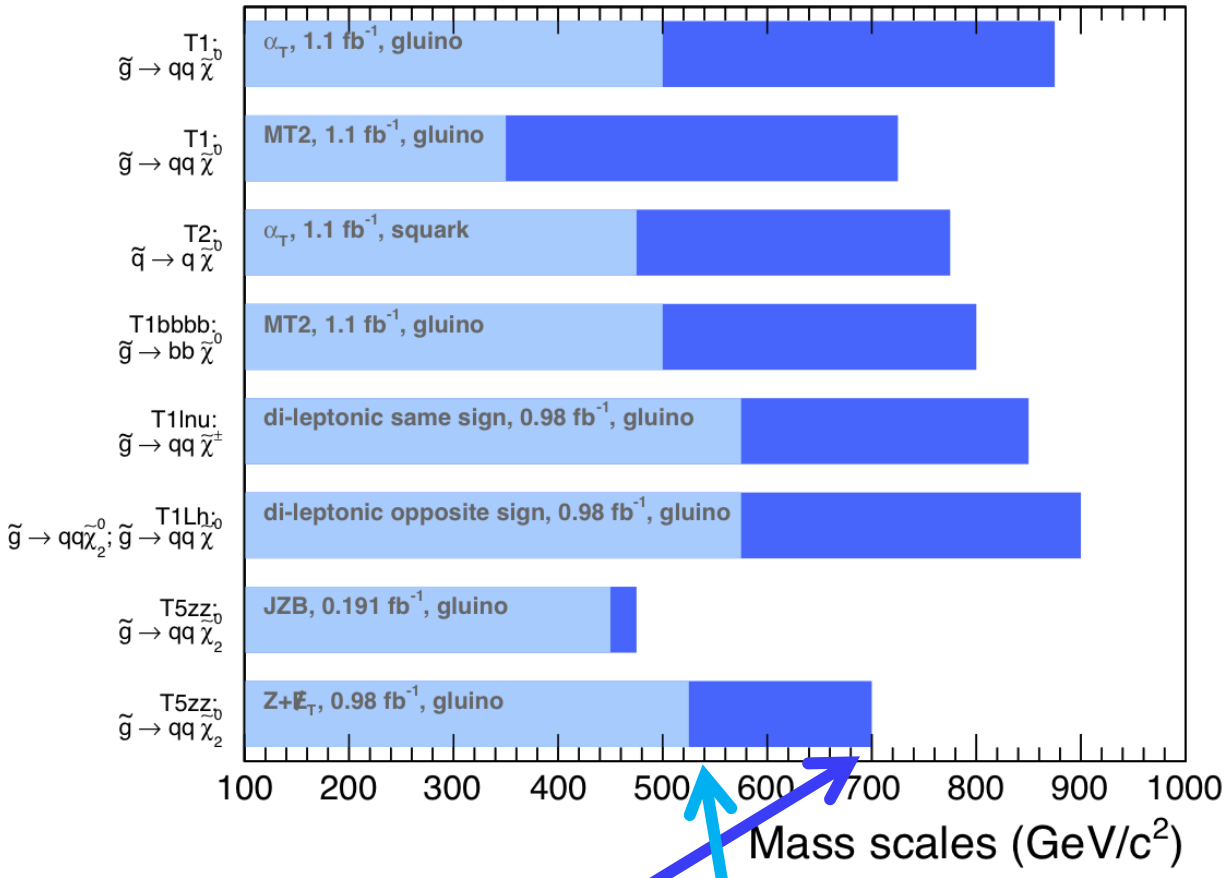
SUSY Combined Exclusions (cMSSM)



SUSY "Model-Independent"



Ranges of exclusion limits for gluinos and squarks, varying $m(\tilde{\chi}^0)$
CMS preliminary



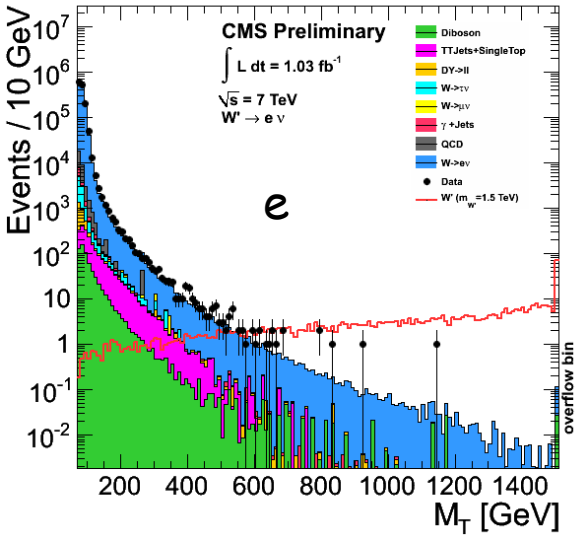
For limits on $m(\tilde{g})$, $m(\tilde{q}) >> m(\tilde{g})$ (and vice versa). $\sigma^{prod} = \sigma^{NLO\text{-}QCD}$.

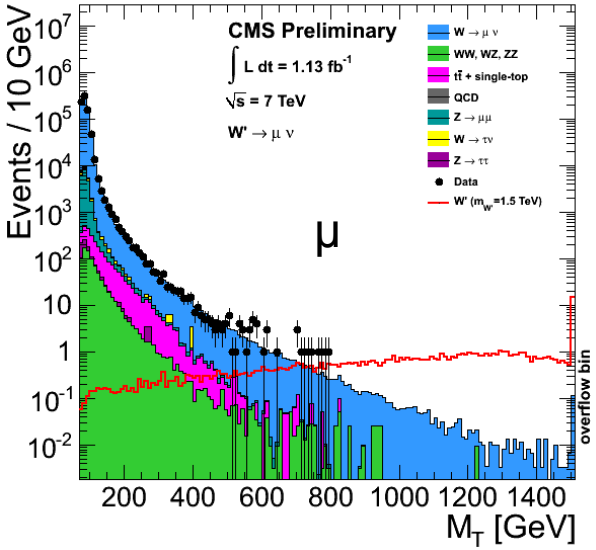
$m(\tilde{\chi}^\pm), m(\tilde{\chi}_2^0) \equiv \frac{m(\tilde{g}) + m(\tilde{\chi}^0)}{2}$.

$m(\tilde{\chi}^0)$ is varied from 0 GeV/c^2 (dark blue) to $m(\tilde{g})$-200 GeV/c^2 (light blue).

Heavy Gauge Bosons to leptons

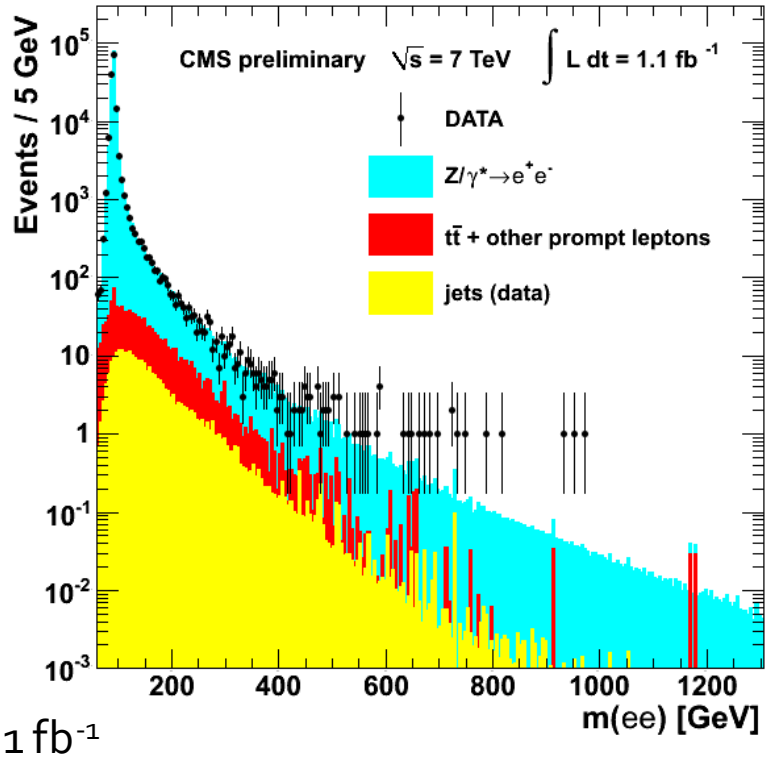
- Isolated single e or μ





1.1 fb^{-1}

W′ with SM couplings excluded @ 95% CL
M< 2.27 TeV



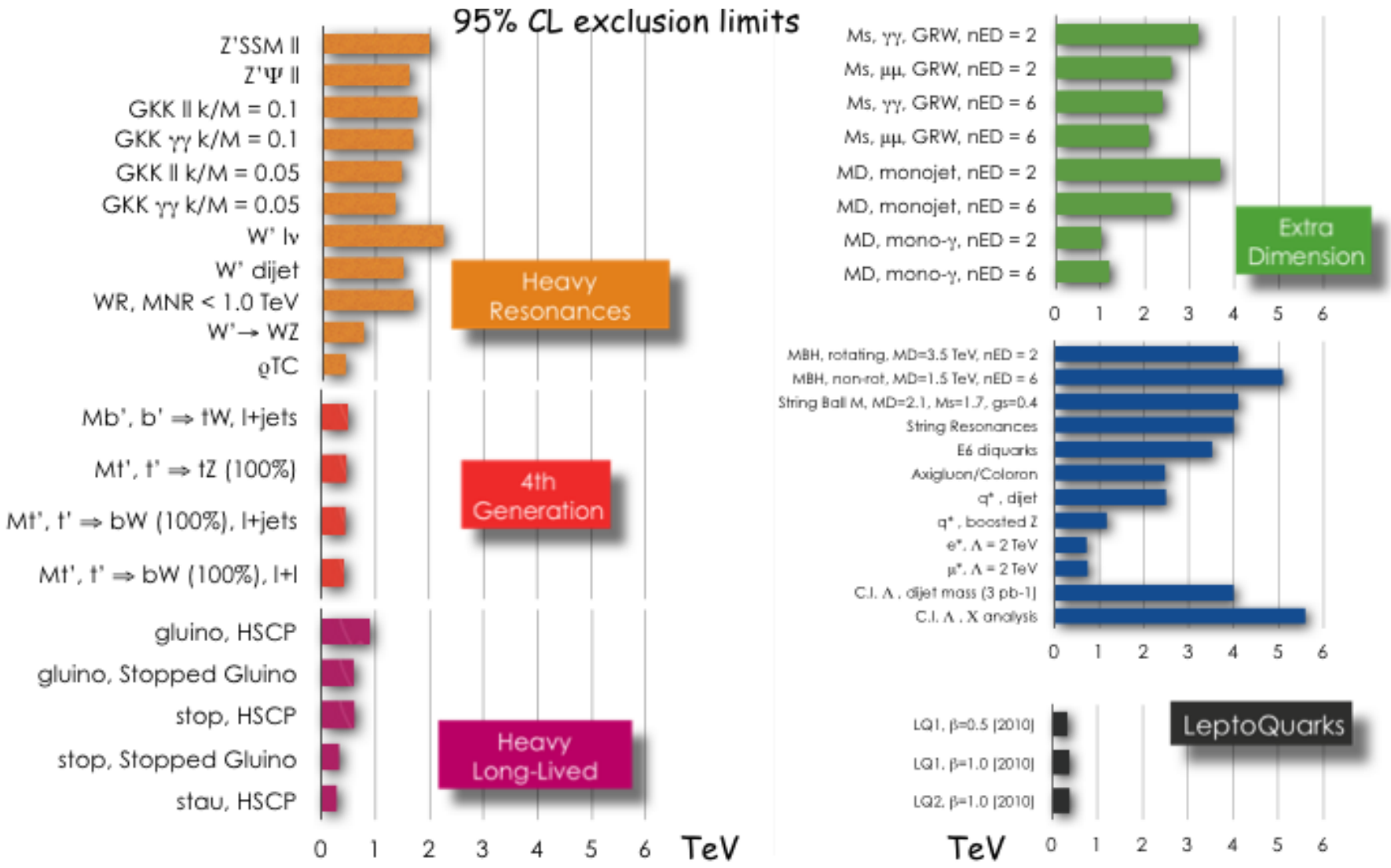
Z′ to leptons 1.1 fb^{-1}

Z' SSM	Z' Psi	RS G* k =0.05	RS G* k =0.1
1.94 TeV	1.62 TeV	1.45 TeV	1.78 TeV

Dijet resonances 1.0 fb^{-1}

String resonance	E6 Diquark	q*	Axigluon, coloron	W'
4.0 TeV	3.53 TeV	3.40 TeV	3.47 TeV	1.51 TeV

Exotica Summary



Running in 2012

- Very likely 50ns but issues for 25ns under study.
- Possible improvements relative to 2011
  - Reduce β^*
  - Increase the energy: Even 1 TeV increase to 8TeV has major benefits:
    - 20-30% for low mass Higgs
    - X2, x3, x5 high mass states
- Options to be discussed in Chamonix 2012.
  - Important to know the overhead
    - Additional tests needed for the machine
    - commissioning time needed to get back to production for physics.
- We are ready to face the additional challenges:
  - higher pile-up conditions and/or higher energy
    - new MC production needed
    - new measurements of major SM processes etc.
  - Computing resources requested for next year seem to be OK.
- Formal meeting of experiments with Directorate in November.

2012 M&O-A Budget Request

Preliminary Budget Request for 2012 at the April RRB: **16,733MCHF**

Revised Budget Request for 2012 October RRB: **15,035 MCHF**

Huge effort to reduce the requests and to smoothen the profile.

Re-profiling the DAQ investments; expenditures for the long shutdown incorporated in the estimates for 2013 and 2014.

	kCHF
Description	**2012 Budget**
A.1. Detector related costs	3,956
A.2. Secretariat	297
A.3. Communications	370
A.4. On-line computing	3,798
A.5. Test beams, calibration facilities	96
A.6. Laboratory operations	919
A.7. General services	1,835
A.9. Core Computing Infrastructure & Services	1,964
Maintenance & Operations Total	13,235
A.8. Electricity	1,800
Grand Total	15,035

Revised M&O-A Budget Profile

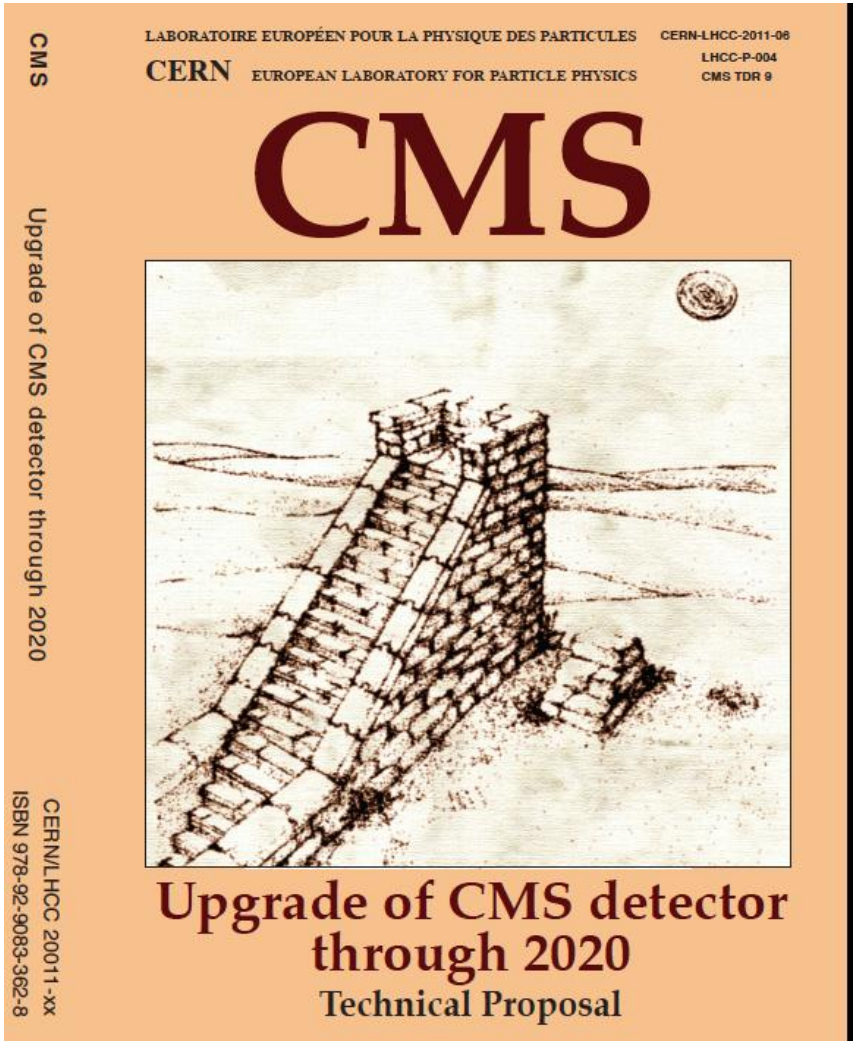
Description	Ref.	Details	Type	2011	2012	2013	2014	2015
General services	A.7.01	Cooling & ventilation	O	326	326	326	326	326
			C	269	269	269	269	269
	A.7.03	Power distribution system	C	60	60	60	60	60
	A.7.04	Heavy transport	O	296	237	332	296	237
			C	60	60	60	60	60
	A.7.05	Cranes	C	57	35	287	193	35
	A.7.06	Cars	C	41	30	49	42	30
	A.7.08	Survey	O	94	152	152	152	152
			C	5	5	5	5	5
	A.7.09	Storage space	C	50	50	50	50	50
	A.7.10	Common desktop infrastructure	C	40	40	40	40	40
	A.7.11	Reviewing & engineering	O	350	350	396	379	350
	A.7.12	Outreach	O	52	52	52	52	52
			C	170	170	170	170	170
General services Total				**1,870**	**1,835**	**2,247**	**2,093**	**1,835**
Core Computing Infrastructure & S	A.9.01	Central computing environment	O	562	562	562	562	562
	A.9.02	Software process service	O	317	317	317	317	317
	A.9.03	User support	O	208	208	208	208	208
	A.9.04	Central production operations	O	806	806	806	806	806
	A.9.05	Hardware	C	70	70	70	70	70
Core Computing Infrastructure & Services Total				**1,964**	**1,964**	**1,964**	**1,964**	**1,964**
Maintenance & Operations Total				**12,553**	**13,235**	**13,956**	**13,766**	**13,080**
Electricity				1,800	1,800	1,650	1,750	1,800
Power Total				1,800	1,800	1,650	1,750	1,800
Grand Total				**14,353**	**15,035**	**15,606**	**15,516**	**14,880**

O=Operation, manpower intensive
C=Consumables

Level profile

Upgrades summary

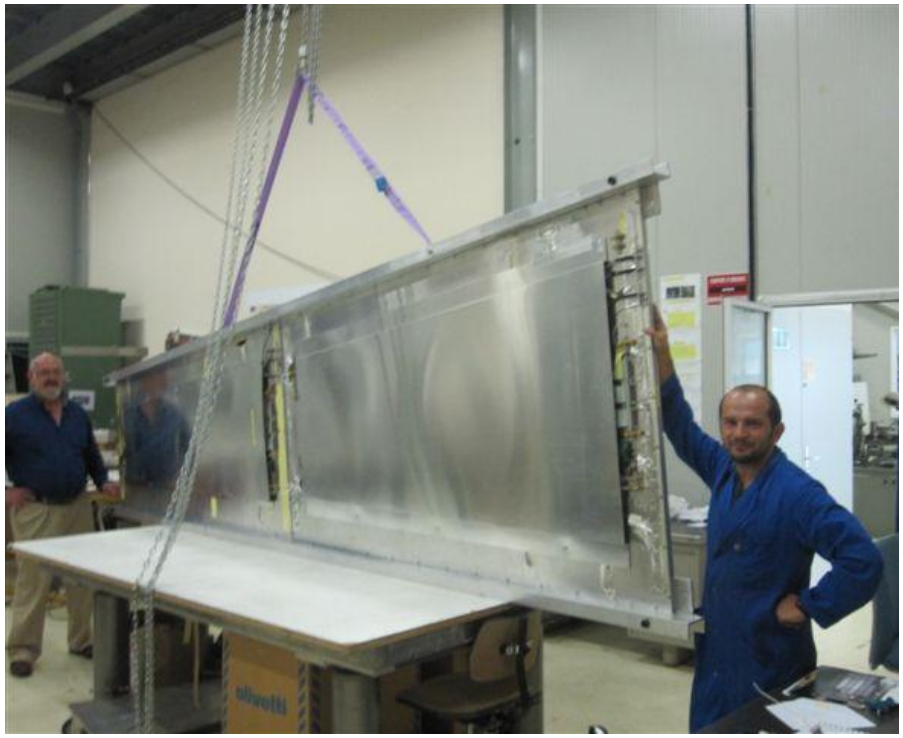
- Technical Proposal for Phase 1 Upgrade accepted by LHCC and document is now public.
- Technical Design Reports being prepared for Pixels, HCAL, Muon, Trigger.
- Detailed scheduling of installation and commissioning depends on the timing of the Long Shutdowns
  - Tasks for the first shutdown are clear
    - November workshop at Fermilab will focus on detailed schedule
  - Overall goals:
    - complete upgraded detector components relatively early (2016)
    - Maintain possible flexibility in installation



CMS Upgrade plan

Shutdown	System	Action	Result	
LS 1 2013-2014	Muon (ME4_2,ME1_1)	RPC and CSC (Complex YE4 installation) New electronics	Improved μ trigger and reconstruction (1.1<|η|<1.8, 2.1<|η|<2.4)	W acceptance WH, $H^{\pm} \rightarrow \tau\nu$
LS 1 2013-2014	Hadron Outer	Replace HPDs with SiPMs to reduce noise	Single μ trigger Tails of very high p_T jets	Muons from τ $Z/H \rightarrow \tau\tau \rightarrow \mu X$
LS 1 2013-2014	Hadron Forward	Install new PMT to reduce window hits	Forward jet tagging Improves MET	Vector-boson fusion H
LS 1 2013-2014	Beam Pipe	Install new beam pipe	Easier pixel installation	b-tagging
LS 2 2017 or 18	New Pixel system	Low mass 4 Layers, 3 Disks with new ROC	Reduces dead time Improves b-tag.	$H \rightarrow bb$, SUSY decay chains
LS 2 2017 or 18	HCAL Barrel and Endcap μTCA trigger	Replace HPDs with SiPMs for longitudinal segmentation New electronics	Reduces pileup effects Improves MET Improves τ, e, γ clustering and isolation	SUSY $H \rightarrow \tau\tau$ $H \rightarrow ZZ \rightarrow ll\tau\tau$
LS 3 >2020	TRACKER New Trigger Endcap Calo.	Replace tracker Replace trigger	Maintain performance at high SLHC Lumi	Guided by early discoveries

Muon System Factory at B904



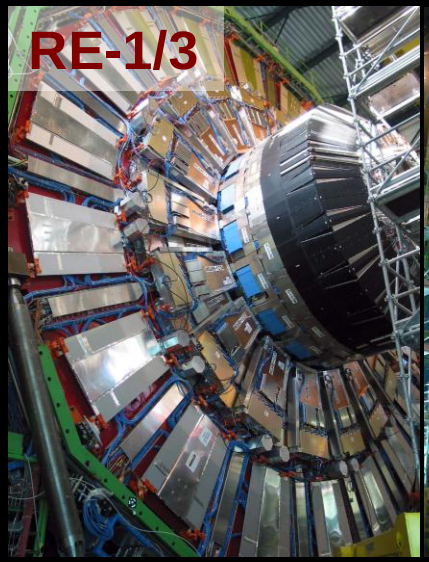
Factory for Muon CSC and RPCs in Building 904 at Prevessin

3 prototype chambers

- 1st finished, now HV training
- 2nd being assembled

Assembly and installation trial test of one 10 degree sector of the RPC Muon system

A tradition of strong contributions



- Korea made strong contribution to CMS Construction
  - Manufacture swiveling platform for the magnet
  - Forward Muon Detectors (Resistive Plate Chamber gaps)
  - Online Data Acquisition hardware
- We welcome important upgrade contributions
  - LS1: RE4/2-3 Gaps
  - LS2: 4/1 muon detectors - very challenging – or other areas

The Upgrade Money Matrix

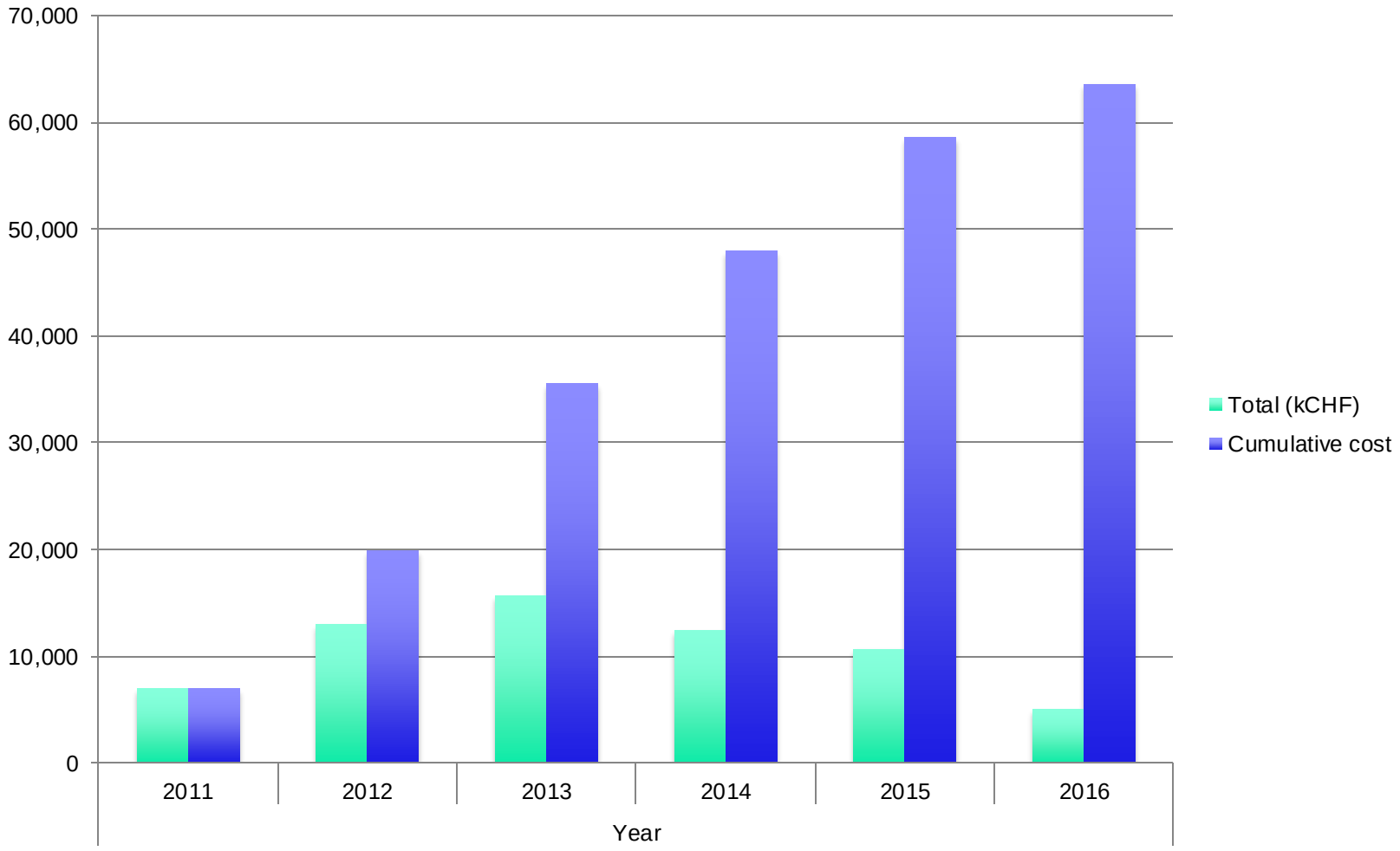
- Numbers are "targets" or "proposals" that are the starting point for discussions with the funding agencies.
  - The costs (in Swiss francs) are in a CERN metric that includes material costs and contracted labor without contingency
- The actual numbers vary by country:
  - firm commitments based on approved funding
  - proposals incorporated into national plans but not yet funded
  - hopes for funding that are still at an early stage of discussion
- Each Funding Agency has its own process and timetable for reaching a final decision on the upgrade
  - The entries reflect the stated national interests and approximate portions of financial commitments

Preliminary Money Matrix

14.10.2011

			Subdetector-specific Upgrades						Detector-wide items										
									Beam/DAQ/Trigger			Common Fund (CF) Items							
Institute FA	PhD #	PhD %	Pixel Tracker	HCAL	HF - Phototubes	Muon CSC	Muon DT	Muon RPC	Beam Instrumentation	DAQ	Trigger	Magnet power and cryo	Infrastructure	Test Beam Facilities Upgrade	Safety systems upgrade	Electronics Integration	Engineering Integration	Total expected (projects)	Common Fund (CF)	Total Upgrade Due (incl. CF)
			17,350,000	5,817,000	1,990,000	5,570,000	2,200,000	4,220,000	1,540,000	6,700,000	4,600,000	1,330,000	6,315,000	610,000	964,000	1,575,000	3,666,000			
Common Fund												592,797	2,814,673	271,885	429,667	701,997	1,633,981		6,445,000	
Austria	22	1.6%	68,846								1,200,000							1,268,846	102,154	1,021,494
Belgium-FNRS	16	1.2%						236,000										236,000	74,294	742,905
Belgium-FWO	16	1.2%						270,000										270,000	74,294	742,905
Brazil	17	1.2%																0	78,937	789,336
Bulgaria	8	0.6%																0	37,147	371,452
CERN	80	5.8%	3,000,000					500,000	500,000	3,500,000			1,500,000		500,000		1,000,000	10,500,000	371,470	3,714,524
China	10	0.7%				200,000		500,000										700,000	46,434	464,316
Colombia	3	0.2%						10,000										10,000	13,930	139,295
Croatia	7	0.5%								200,000								200,000	32,504	325,021
Cyprus	5	0.4%																0	23,217	232,158
Egypt	3	0.2%						150,000										150,000	13,930	139,295
Estonia	4	0.3%					167,153											167,153	18,573	185,726
Finland	14	1.0%	420,000					130,000						35,000				585,000	65,007	650,042
France-CEA	15	1.1%																0	69,651	696,473
France-IN2P3	53	3.8%	600,000							350,000	600,000			100,000		100,000		1,750,000	246,099	2,460,872
Germany-BMBF	62	4.5%	1,600,000				612,000											2,212,000	287,889	2,878,756
Germany-DESY	39	2.8%	1,200,000	XXXXXXX														1,200,000	181,091	1,810,831
Greece	15	1.1%								XXXXXX	XXXXXXX							0	69,651	696,473
Hungary	10	0.7%		XXXXXXX			XXXXXX											0	46,434	464,316
India	29	2.1%		495,000				720,000										1,215,000	134,658	1,346,515
Iran	6	0.4%																0	27,860	278,589
Ireland		0.0%									XXXXXXX							0	0	0
Italy	173	12.5%	1,400,000				1,000,000	350,000										2,750,000	803,303	8,032,659
Korea	21	1.5%						400,000										400,000	97,511	975,063
Mexico	11	0.8%																0	51,077	510,747
New Zealand	2	0.1%																0	9,287	92,863
Pakistan	2	0.1%						345,000					800,000					1,145,000	9,287	92,863
Poland	15	1.1%																0	69,651	696,473
Portugal	7	0.5%									500,000							500,000	32,504	325,021
RDMS - DMS	21	1.5%		400,000		500,000												900,000	97,511	975,063
RDMS - Russia	61	4.4%		1,400,000		1,300,000												2,700,000	283,246	2,832,325
Serbia	3	0.2%																0	13,930	139,295
Spain	49	3.5%					264,000											264,000	227,525	2,275,146
Switzerland (ETHZ,PSI,UNIV)*	38	2.7%	3,800,000															3,800,000	176,448	1,764,398
Taipei	15	1.1%	1,000,000															1,000,000	69,651	696,473
Turkey	18	1.3%		XXXXXXX	100,000													100,000	83,581	835,768
United Kingdom	56	4.0%	500,000							250,000	1,500,000		126,000			126,000		2,502,000	260,029	2,600,167
USA (DOE-HEP, NSF)	440	31.7%	4,500,000	5,817,000	2,000,000	5,570,000				700,000	3,000,000							21,587,000	2,046,032	20,459,365
USA (DOE-NP)	22	1.6%																0	102,302	1,022,968
Grand Total	1388	100.0%	18,088,846	8,112,000	2,100,000	7,570,000	2,043,153	3,611,000	500,000	5,000,000	6,800,000	592,797	5,240,673	406,885	929,667	927,997	2,633,981	58,111,999	6,445,000	64,447,000

Preliminary Spending Profile



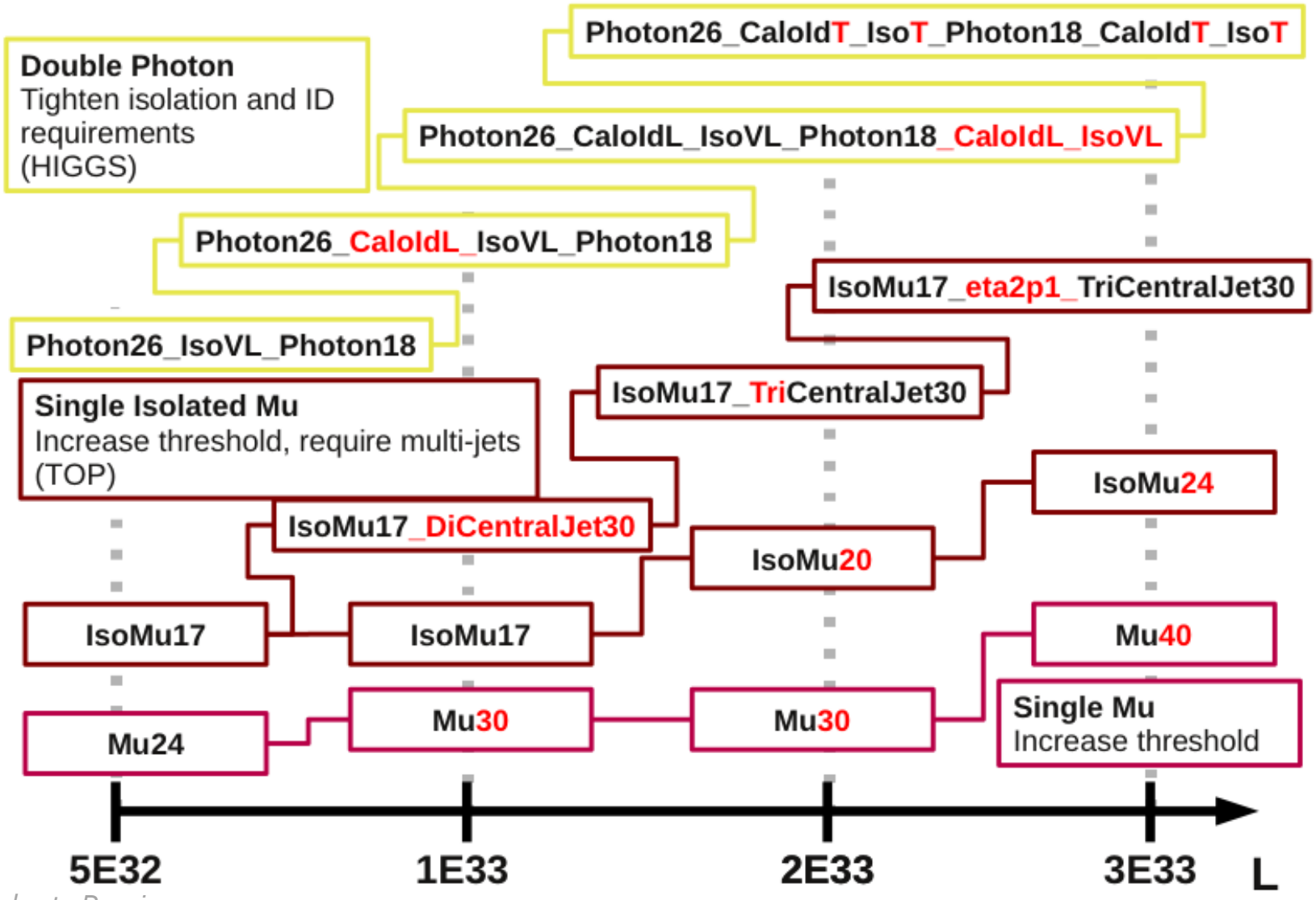
Conclusion

- CMS continues to live up to the challenges extremely well.
  - Instantaneous luminosities regularly higher than $3x10^{33}cm^{-2}s^{-1}$.
- Lots of new physics results
  - But no evidence for BSM physics so far.
  - SM Higgs exclusions are significant
- Detailed plans for 2012 running are in preparation:
  - Planned resources seem to be able to cope with the new challenges.
    - We have revised (reduced) the M&O-A request for 2012.
    - New long term planning incorporating LS1 and DAQ needs has been prepared and we expect to have a ~ flat profile.
- We are making progress on the Upgrades
  - Preliminary version of the Money Matrix sharing costs
  - Draft spending profile.
- KCMS is deeply involved: past, present, and future
  - These contributions are greatly appreciated by CMS

Additional Information

2011 evolution of some γ and μ triggers

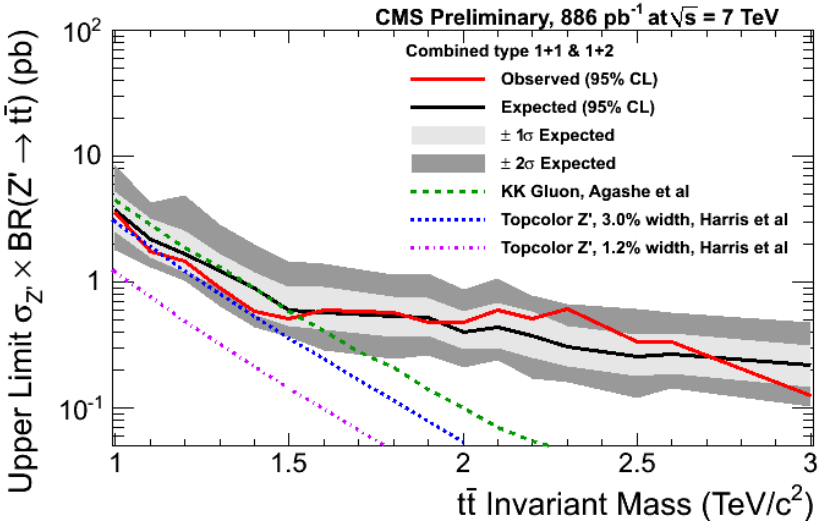
With rising L we fight to retain phase space with more triggers of greater complexity …



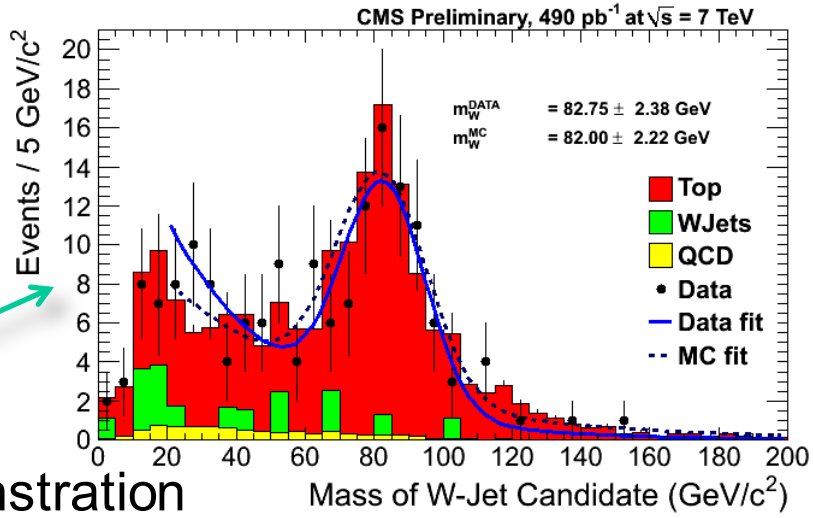
From Roberto Rossin

tt Resonance w/boosted tops

- Z' → boosted hadronic tops
  - 0.9 fb^{-1}
- Cambridge-Aachen algorithm to tag merged jets
  - R=0.8 using m_{jet}, number of subjets, etc.
  - Particle flow inputs used

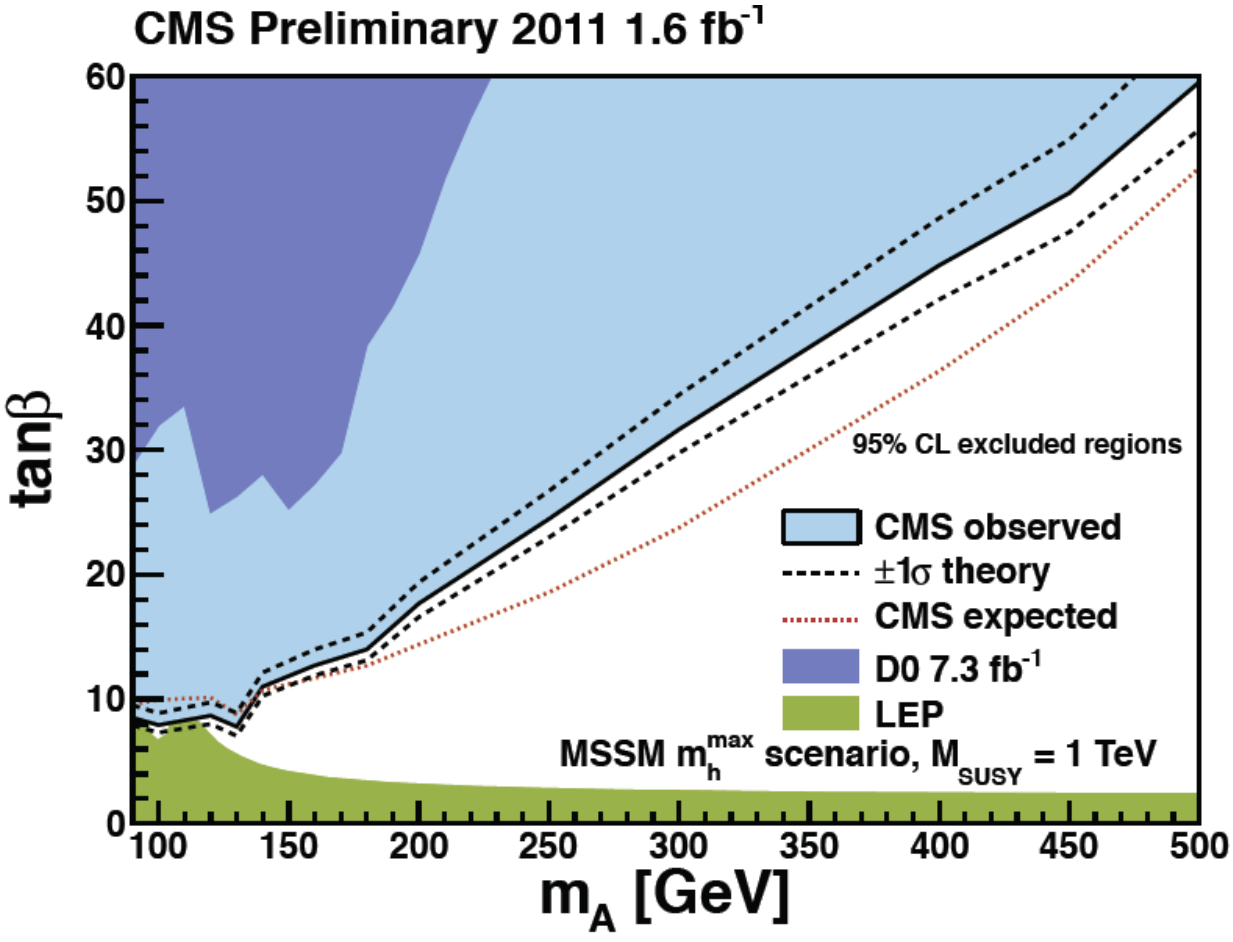


- Classify by jet merging:
  1. Fully merged into one jet
  2. 2 of 3 jets merged
     - Select 1+1 and 1+2

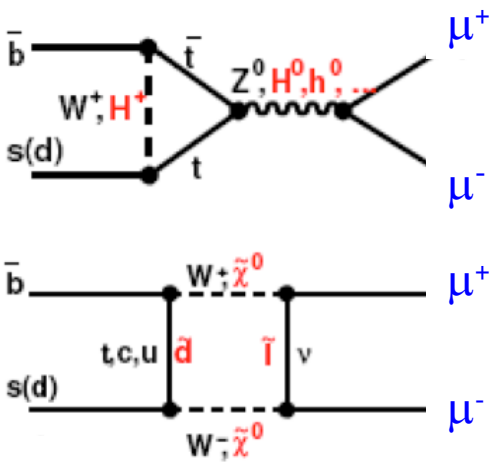


l+jets sample: Merged hadronic "W-jet" demonstration

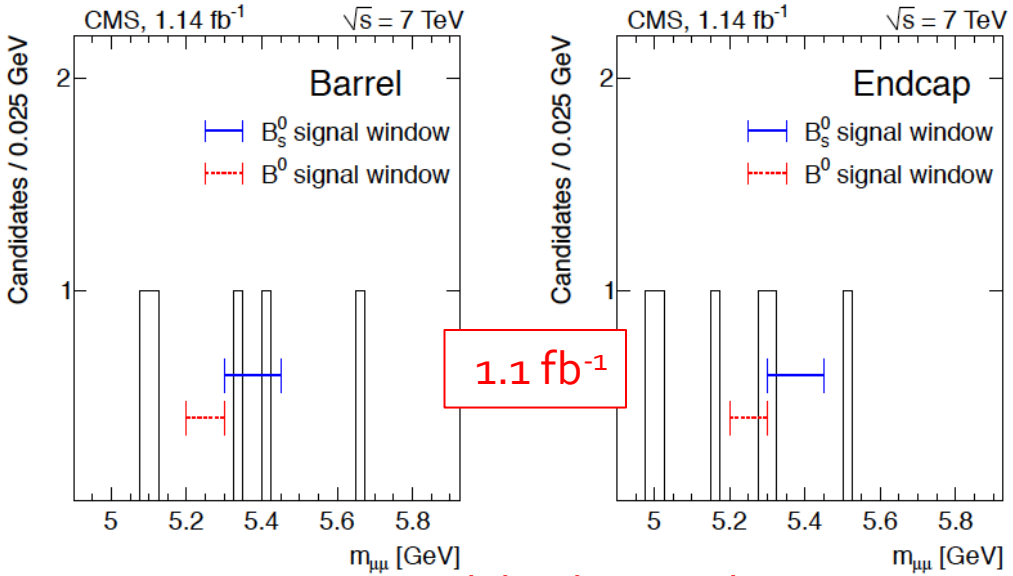
MSSM H→ττ


CMS Preliminary 2011 1.6 fb-1
tanβ
mA [GeV]
95% CL excluded regions
CMS observed
±1σ theory
CMS expected
D0 7.3 fb-1
LEP
MSSM mhmax scenario, MSUSY = 1 TeV
0
10
20
30
40
50
60
100
150
200
250
300
350
400
450
500

Search for $B_{s(d)} \rightarrow \mu\mu$



- Very suppressed in SM
  - Penguin & box only + helicity suppression
  - $BR(B_s \rightarrow \mu\mu) = (3.2 \pm 0.2) \times 10^{-9}$
  - $BR(B_d \rightarrow \mu\mu) = (1.0 \pm 0.1) \times 10^{-10}$
- MSSM: $BR \sim (\tan\beta)^6$
- Analysis (blind)
  - $B^+ \rightarrow J/\psi\, K^+$
    - for normalization
  - $B^0 \rightarrow J/\psi\, \phi$
    - validate MC, control diff's in fragmentation B, B_s



Consistent with backgrounds + SM

- CMS
  - $B_s \rightarrow \mu\mu$ BR< 1.9×10^{-8}
  - $B_d \rightarrow \mu\mu$ BR< 4.6×10^{-9}
- LHCb $B_s \rightarrow \mu\mu$ BR< 1.5×10^{-8}
- LHCb+CMS: $B_s \rightarrow \mu\mu$ BR< 1.08×10^{-8}
  - BPH-11-019

arXiv 1107.5834 accepted by PRL