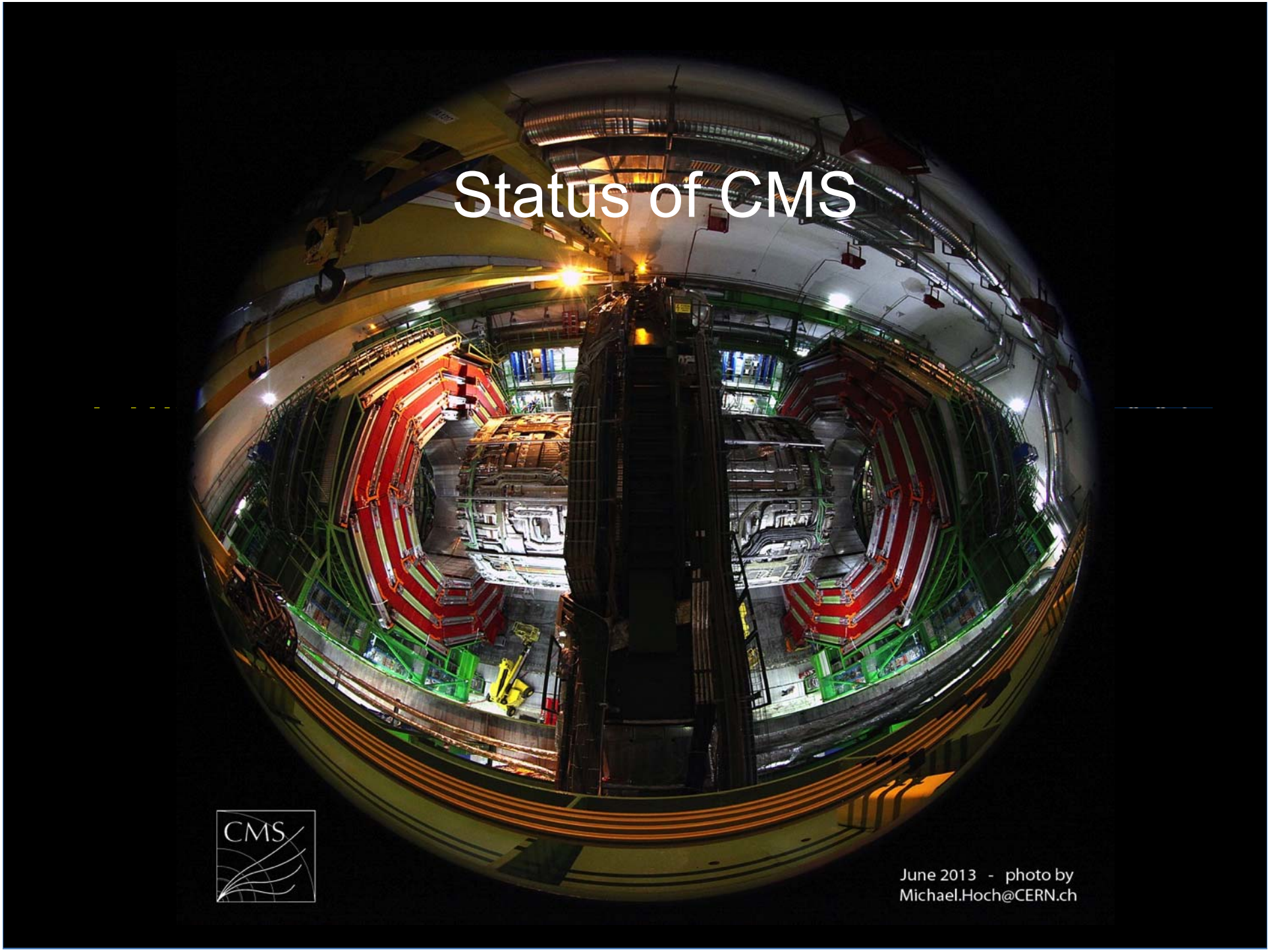
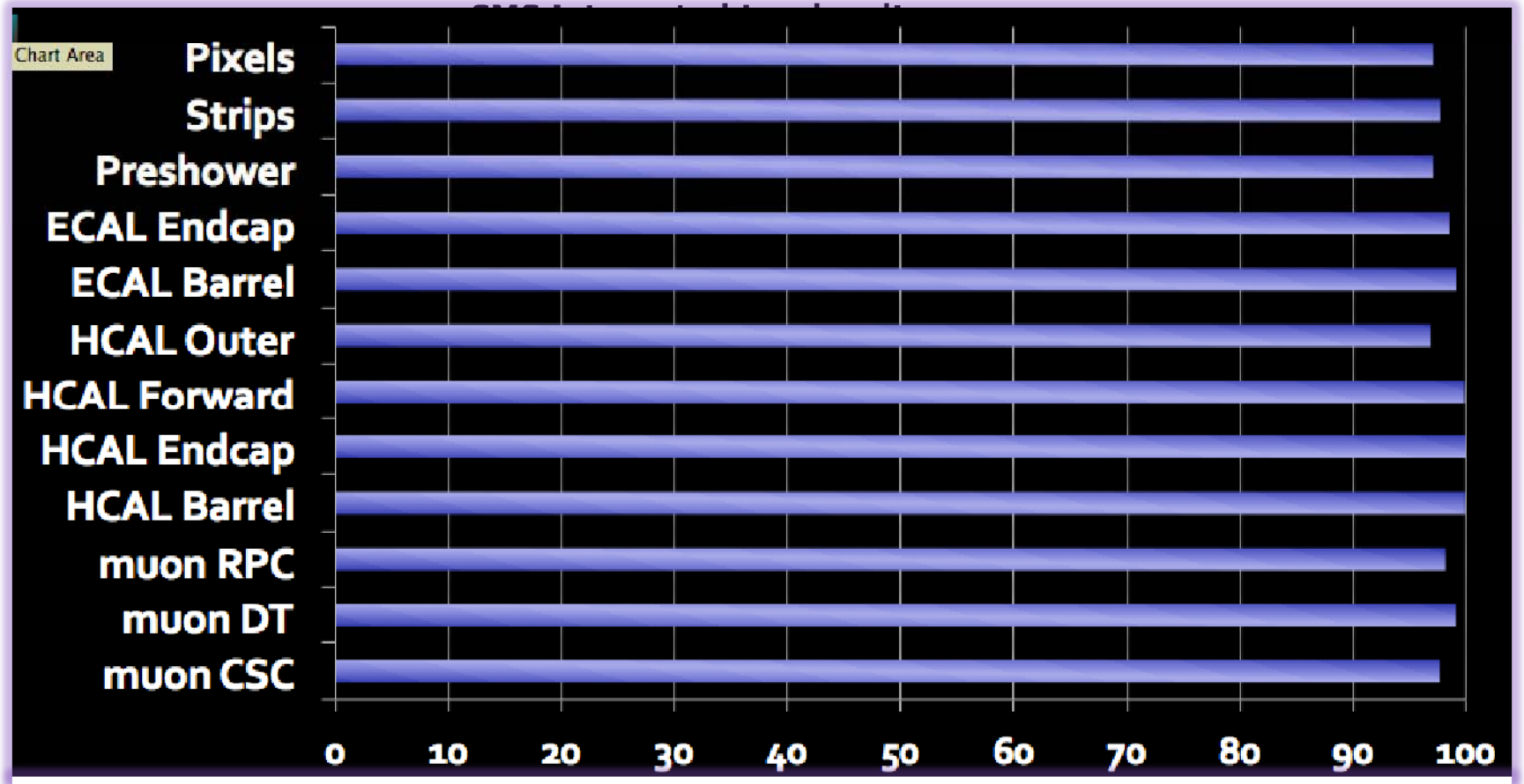
Status of CMS



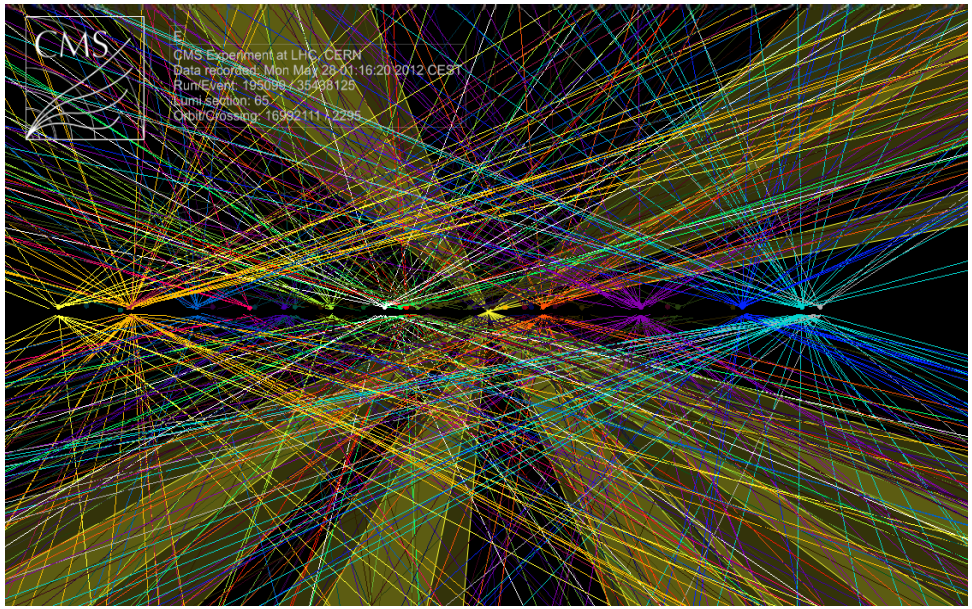
CMS and LHC in 2012

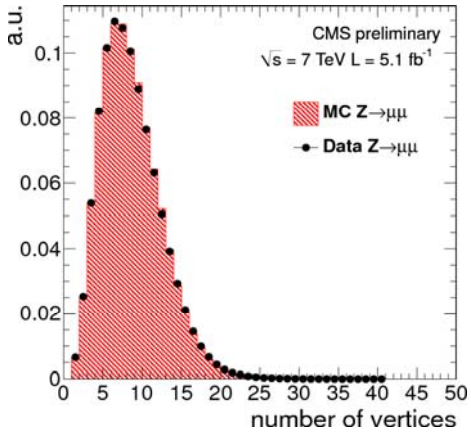
Fantastic performance

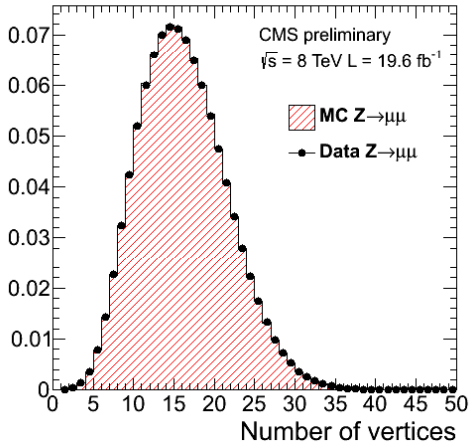


Fraction of working Channels > 98%

Despite pileup exceeding CMS design

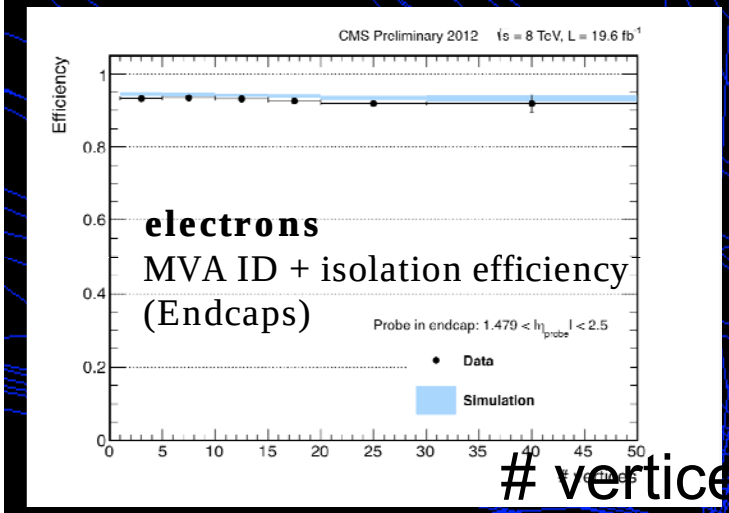


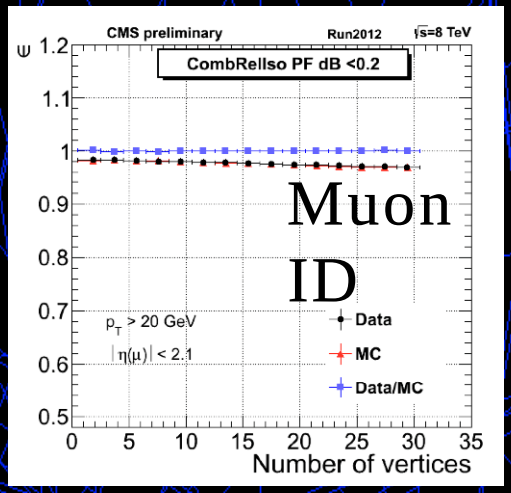




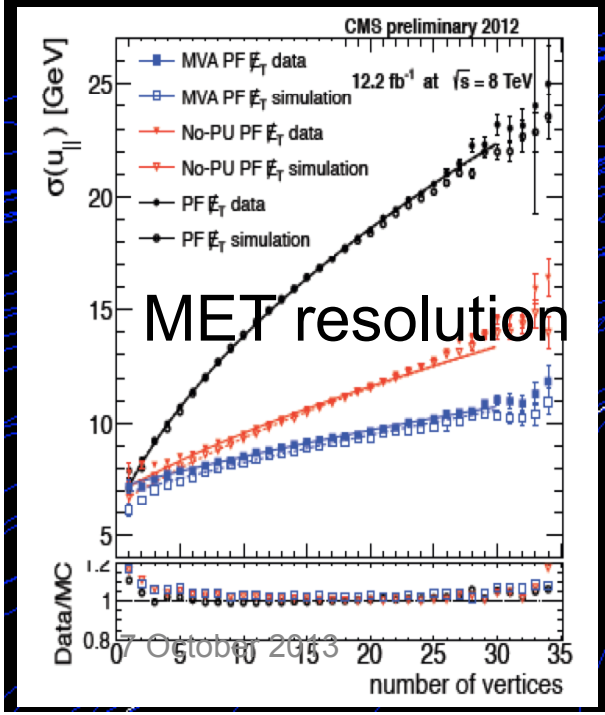
~ 25 events on average per BX

PU control



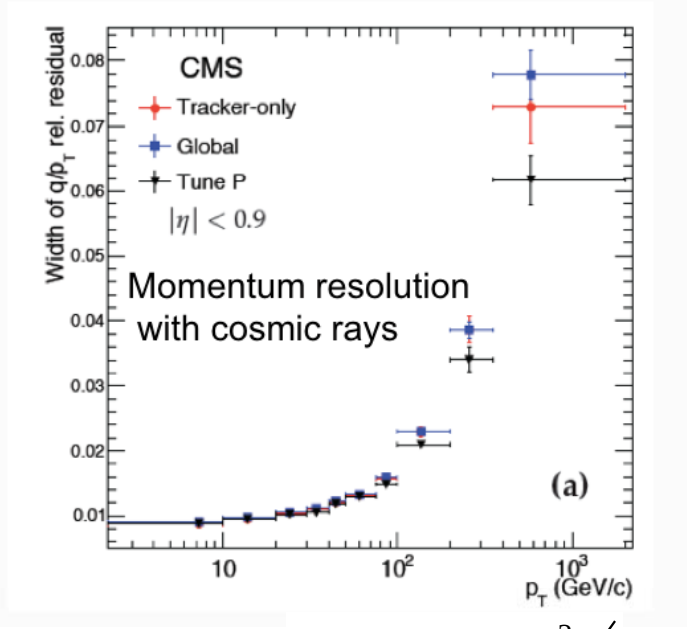


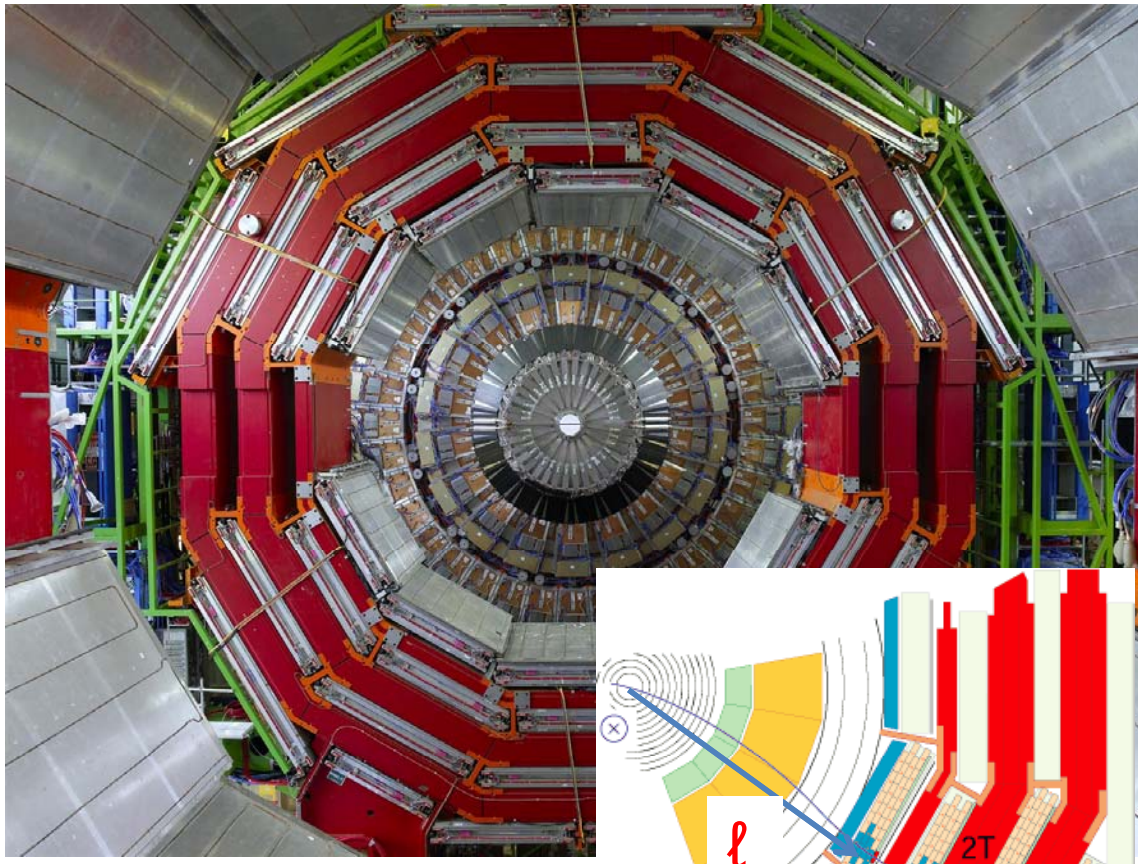
H→ ZZ →4l candidate
24 vertices

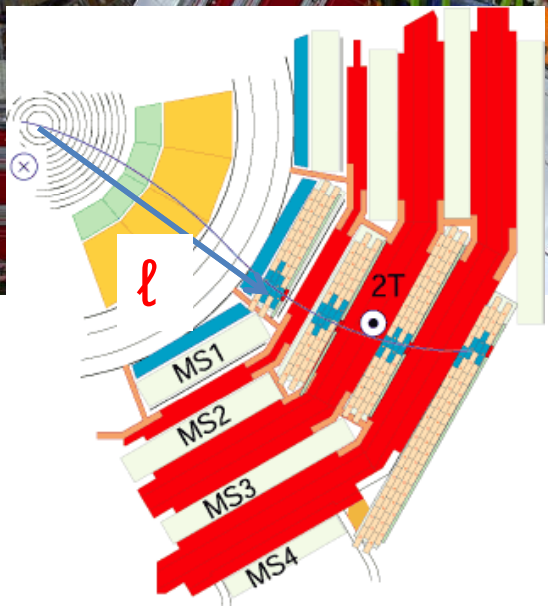


Leptons and MET
Almost insensitive
to pileup

Muon system





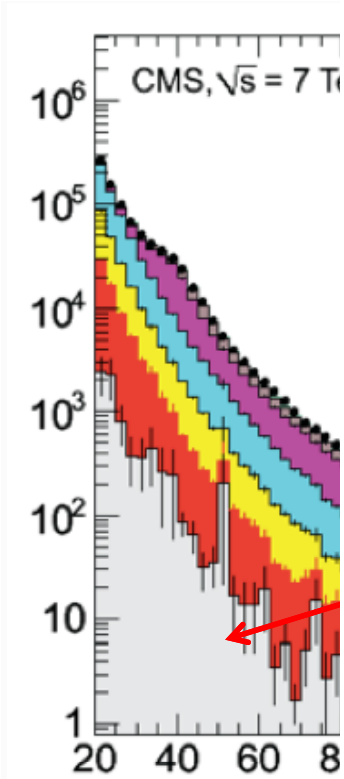


$$P_t \propto 0.3 \cdot B \cdot \ell^2 / s$$

$$\frac{\Delta P_t}{P_t} \propto \frac{\Delta s}{\ell^2} + \ldots.$$

Muon performance

Muons: achieved nominal (or better than) performance



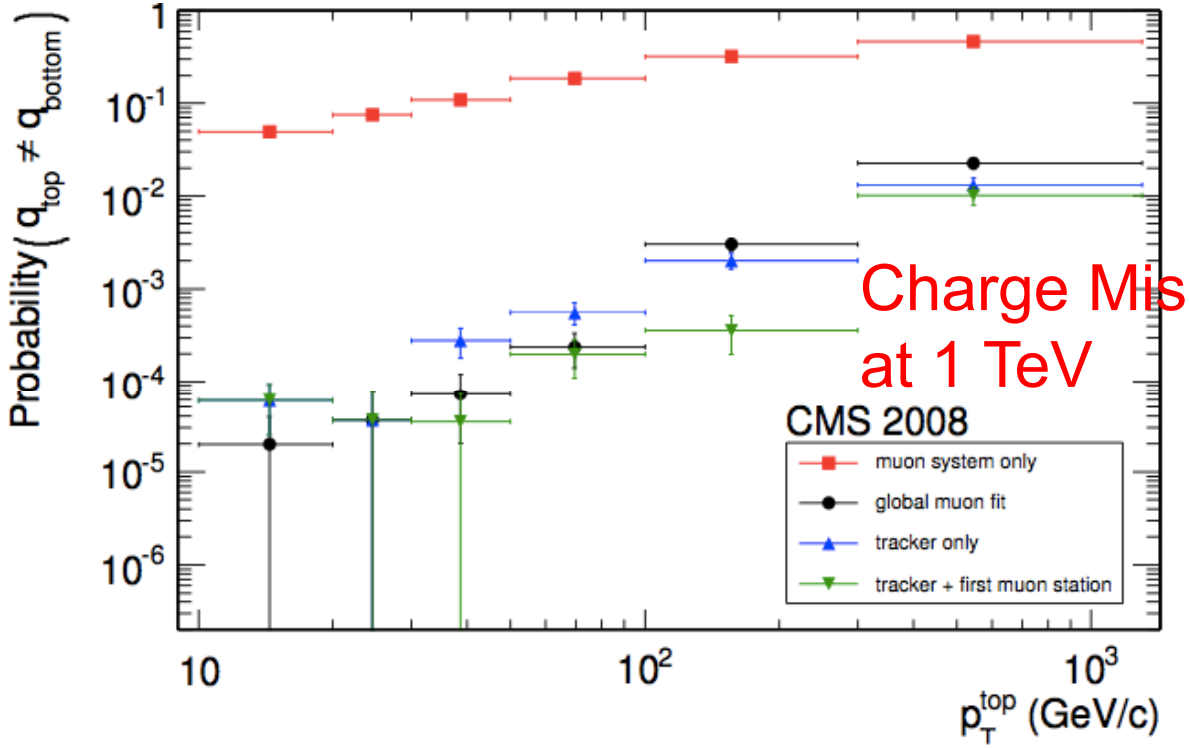
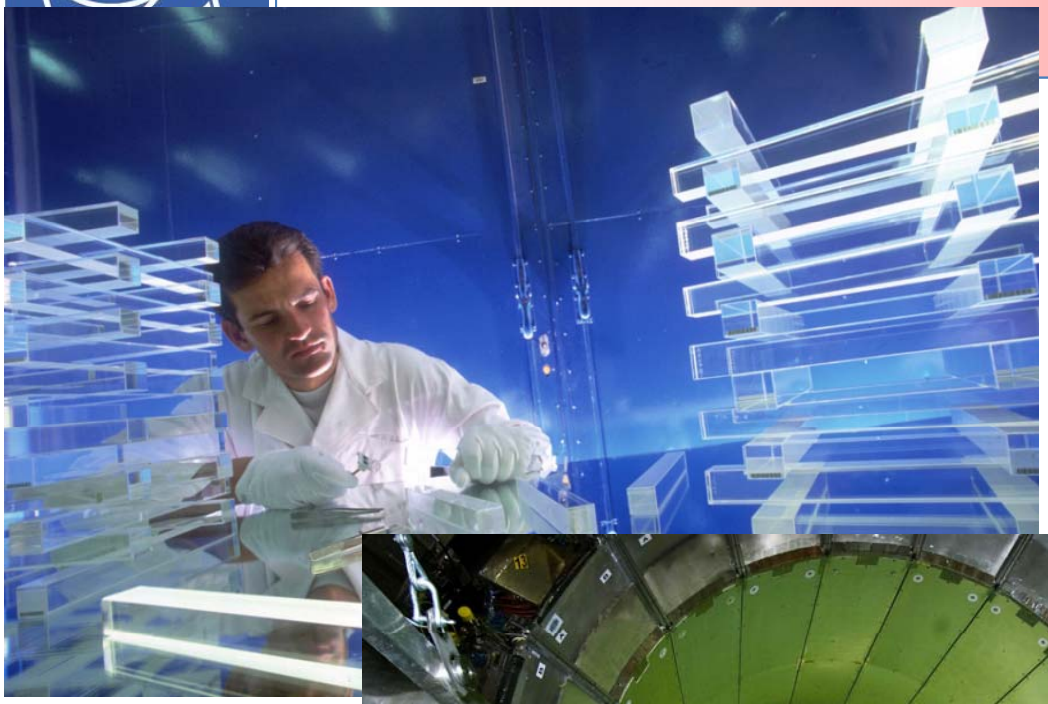
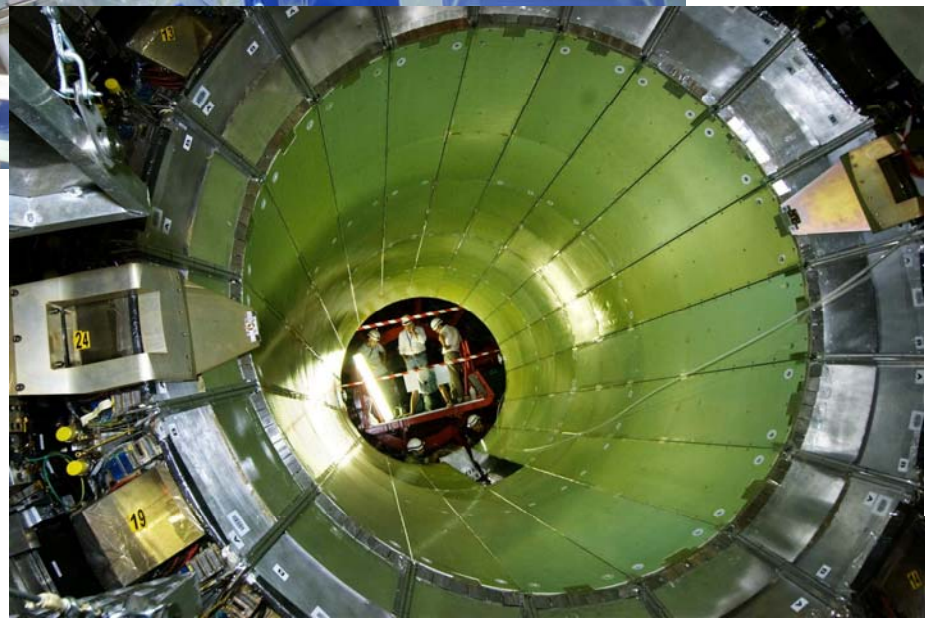
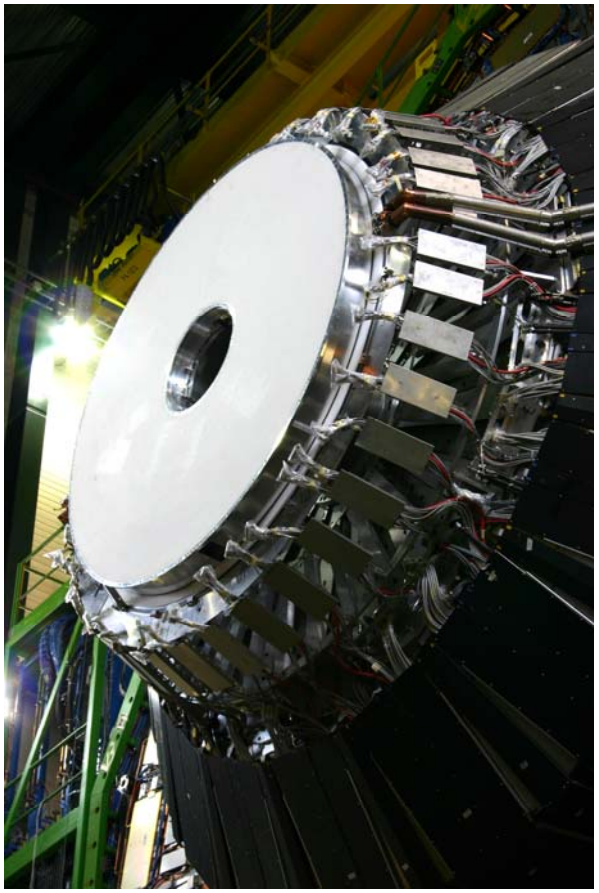


Figure 21. Rate of charge misassignment as a function of p_T of the tracker track reconstructed in the top hemisphere, for standalone muons (squares), tracker tracks (triangles), global muons (circles), and the TPFMS refit (upside-down triangles).

ECAL

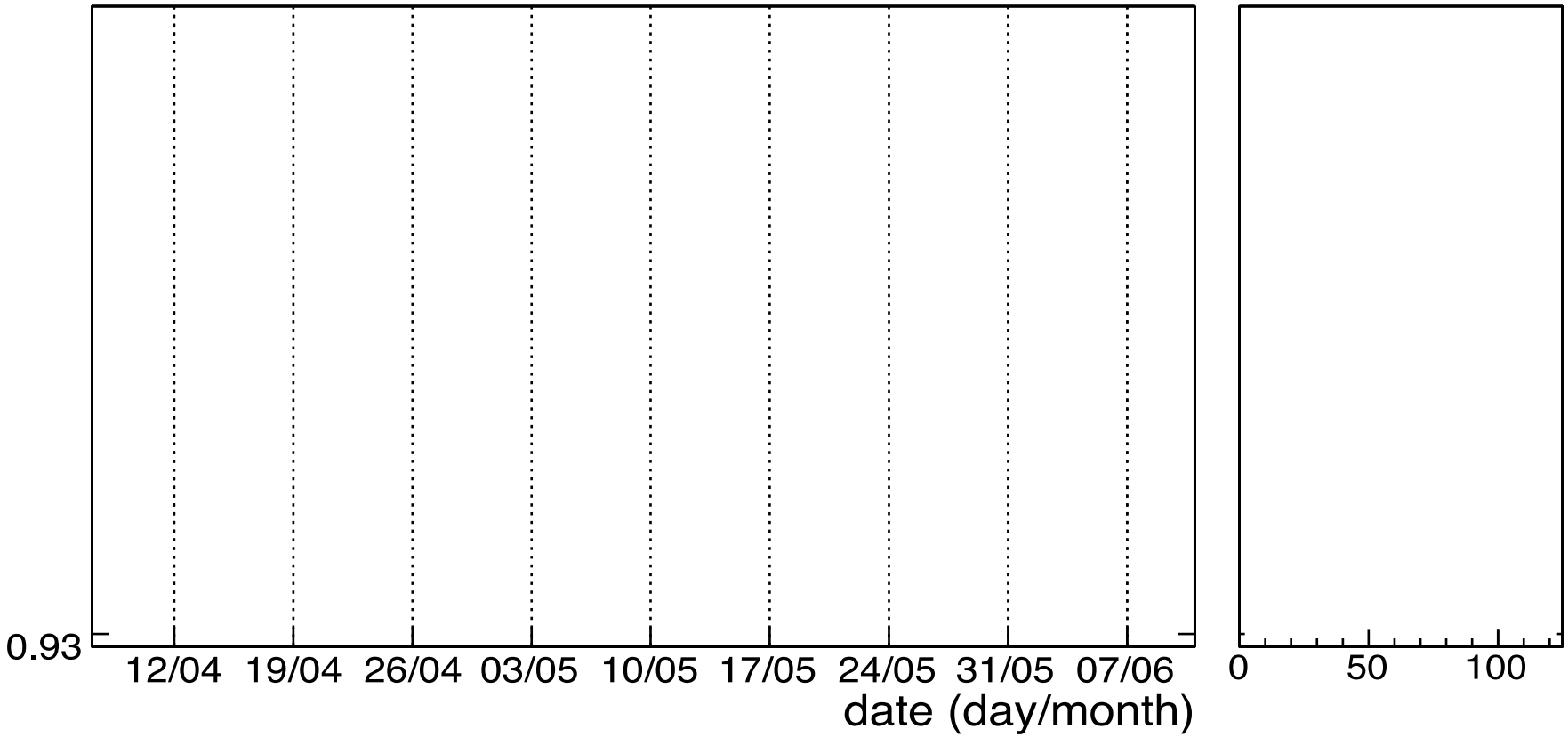






EM calorimeter

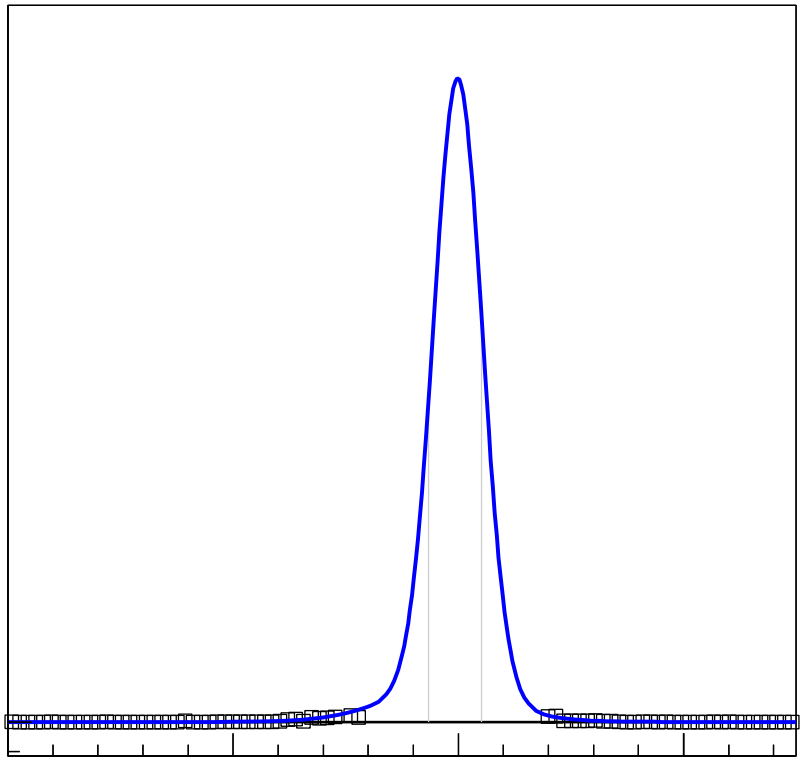
Energy scale stability ~ 0.1%



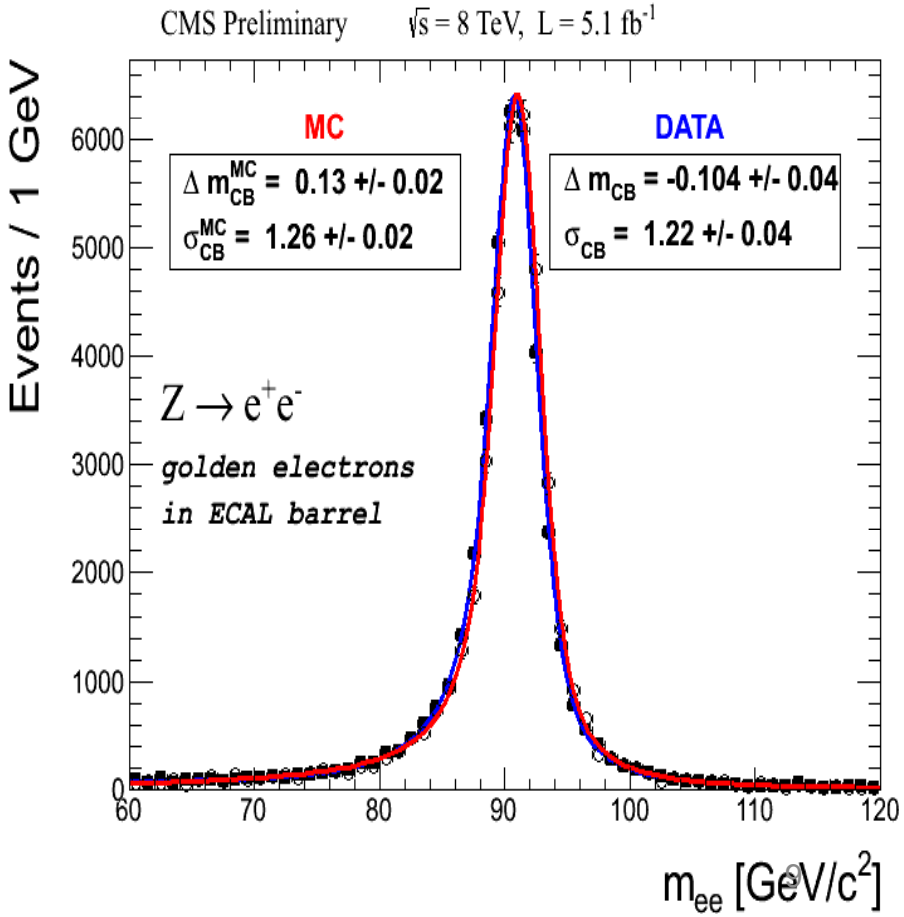
ECAL performance

Resolution on γγ resonance : for best category (H → γγ)

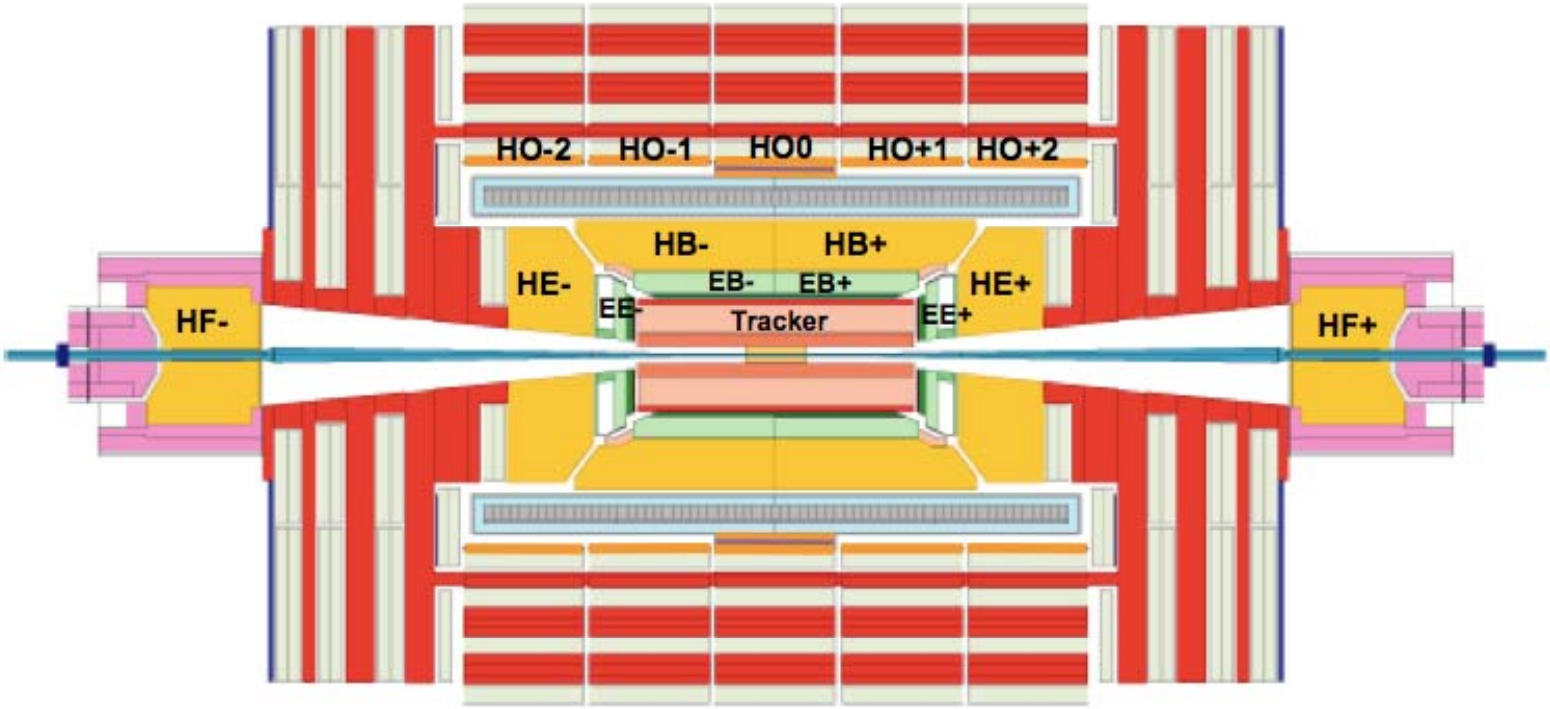
$Z^0 \rightarrow e^+e^-$



γγ

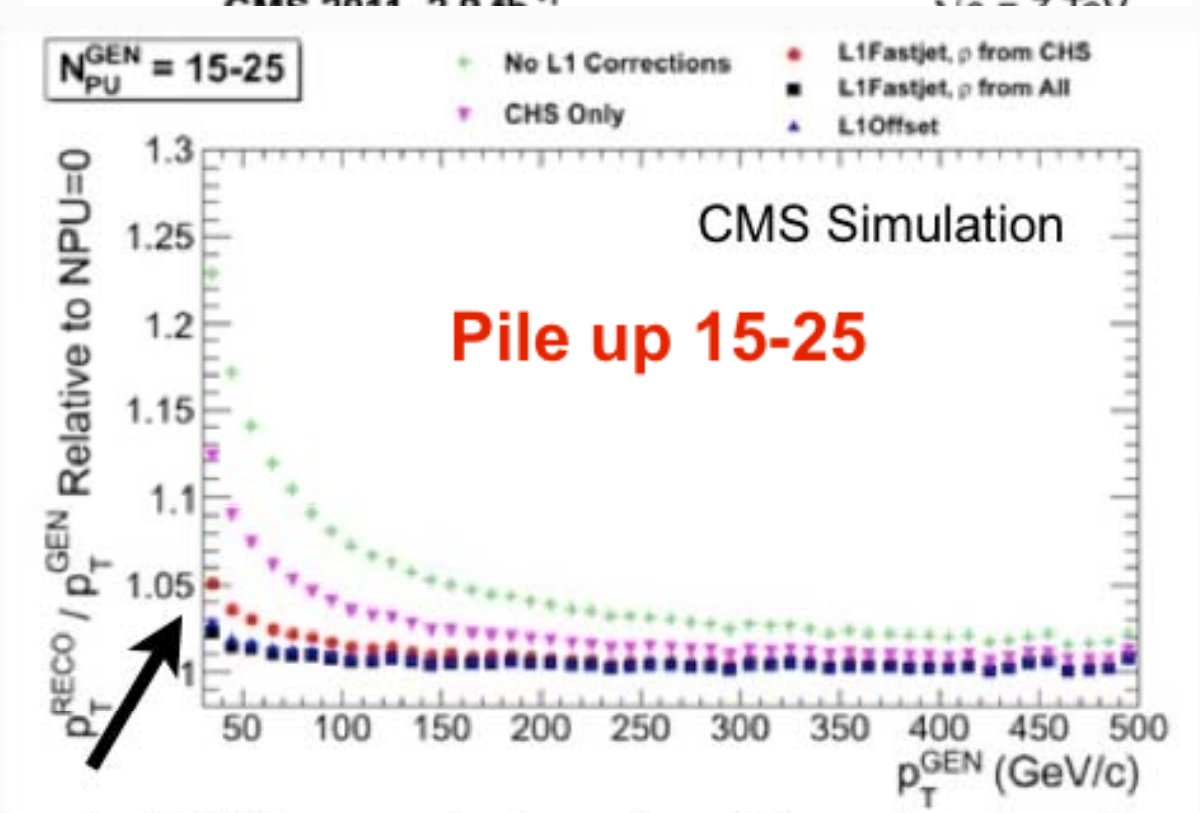


HCAL



HB	Brass Abosber (5cm) + Scintillator Tile (3.7mm)	Photo Detector (HPD)	$\|\eta\|$ 0.000 ~ 1.393
HE	Brass Absober (8cm) + Scintillator Tils (3.7mm)	Photo Detector (HPD)	$\|\eta\|$ 1.305 ~ 3.000
HO	Scitillator Tile (10mm) outside of solenoid	Photo Detector (HPD)	$\|\eta\|$ 0.000 ~ 1.305
HF	Iron Absober + Quaartz Fibers	Photo Detector (PMT)	$\|\eta\|$ 2.853 ~ 5.191

Jets



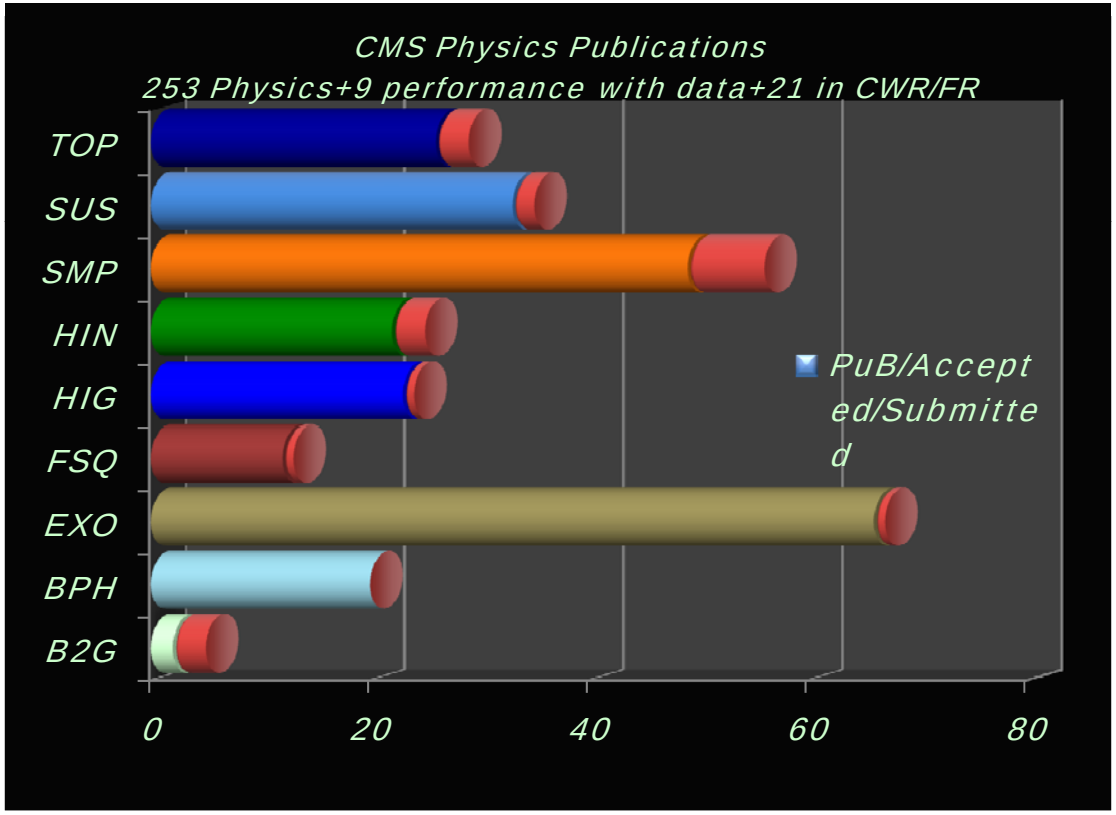
1-2% residual effects in the energy scale

Detector Level

$$\vec{p}_{T,\gamma} + R_{had}\vec{p}_{T,had} = -\vec{E}_T$$

Publication Stats

- The Higgs discovery paper: 1591 citations (steady flow of >100 citations a month!)



Here personal choice (limiting overlap with Albert, Joao, Roberto, Jorgen talks)

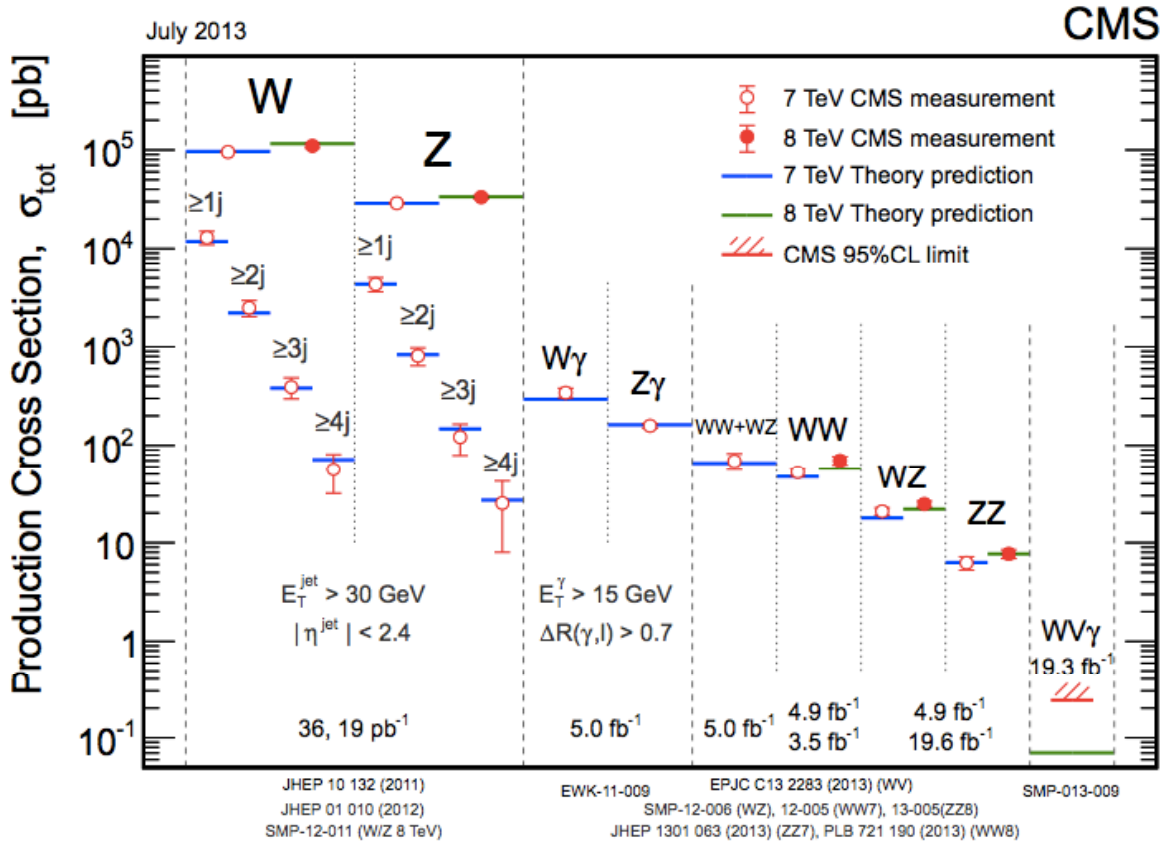
STANDARD MODEL RESULTS

Boson production

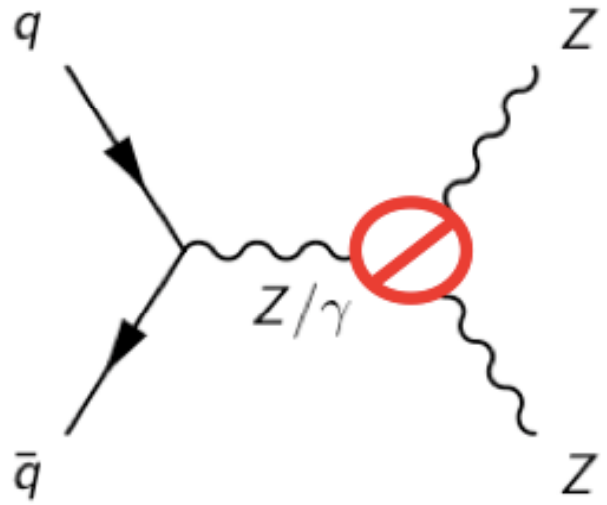
Fundamental questions:
Is the electroweak force a low energy manifestation of a more fundamental interaction at higher energy ?

Are there any surprises in the data ?

Boson productions address all of these issue!

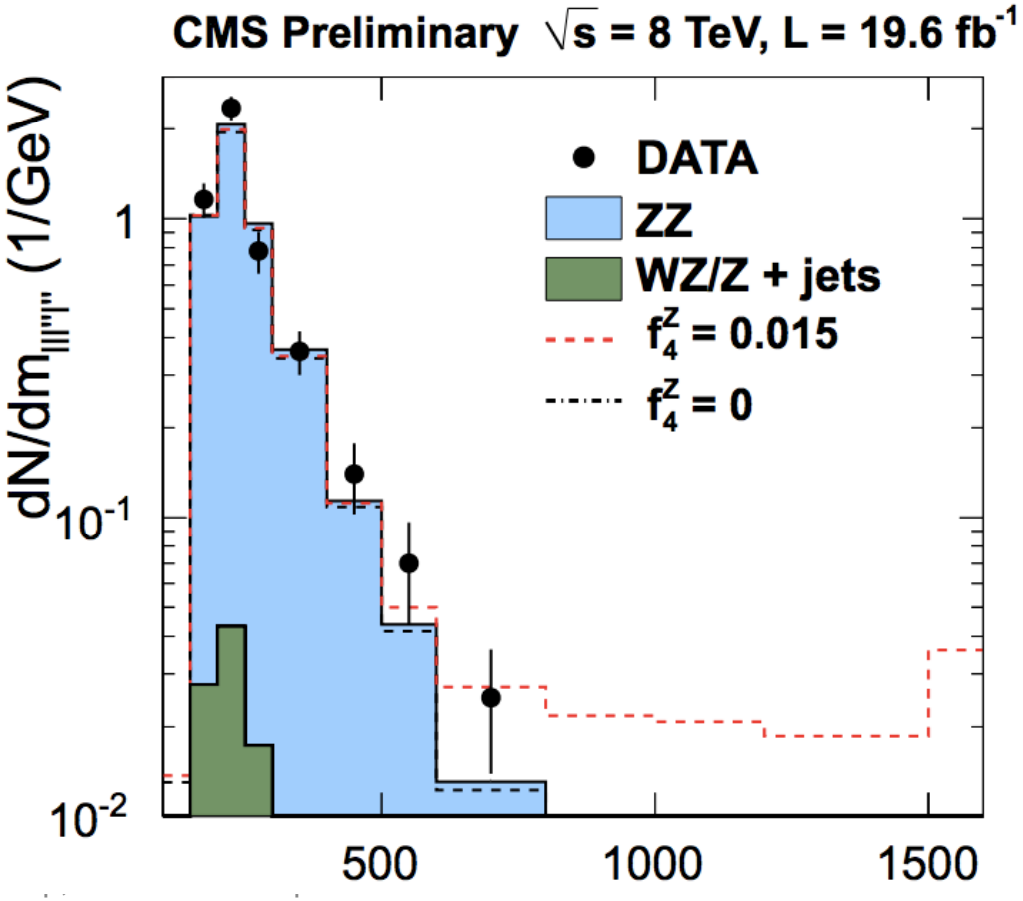


Neutral TGC



In the SM there is no all neutral TGC

CMS-SMP-13-005



LHC makes many more ZZ than LEP /Tevatron
Measure ZZ 4 leptons:
Sensitivity for deviations (dashed red) from SM (dashed black) at high masses is max… No significant excess observed

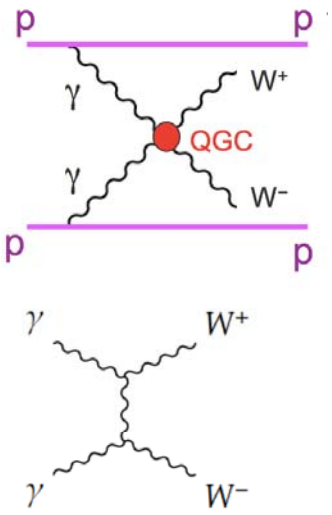
Quartic gauge coupling

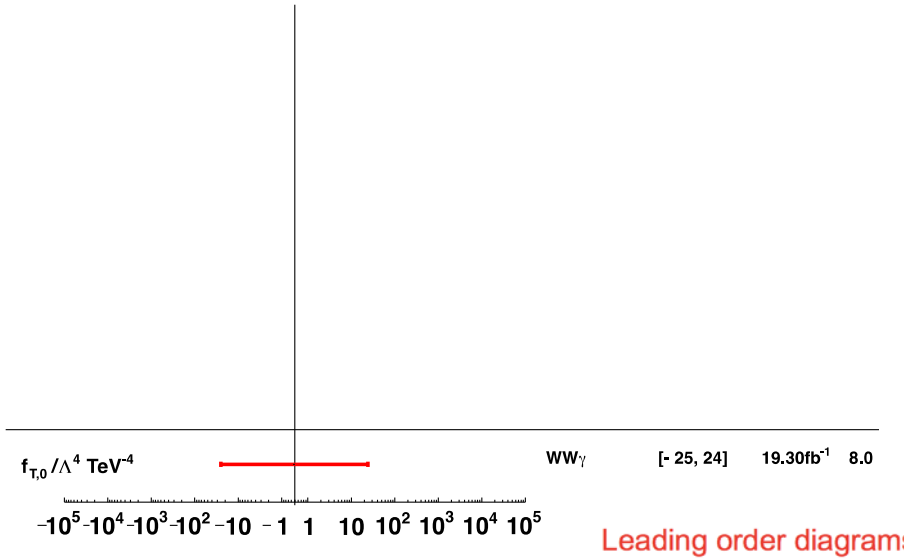
- CMS has the most stringent World limits on anomalous TGC… and now also on Quartic gauge couplings

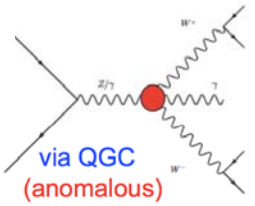
SMP-13-009

Red is CMS limits range

$\gamma\gamma \rightarrow WW$

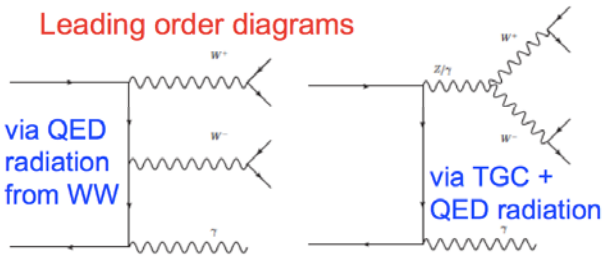






WWγ prod

Leading order diagrams

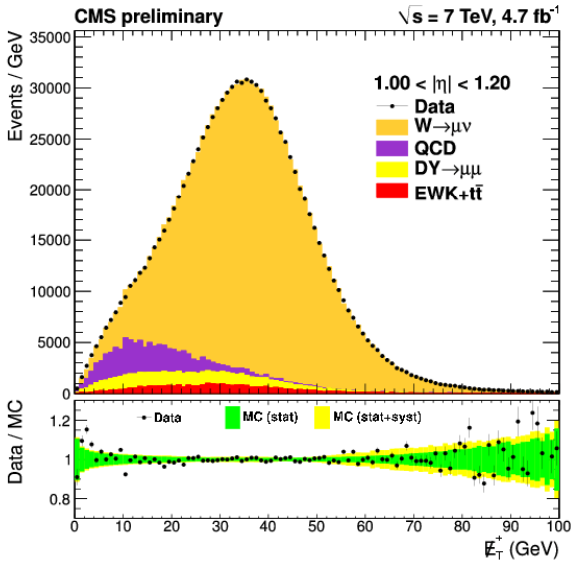


W charge asymmetry

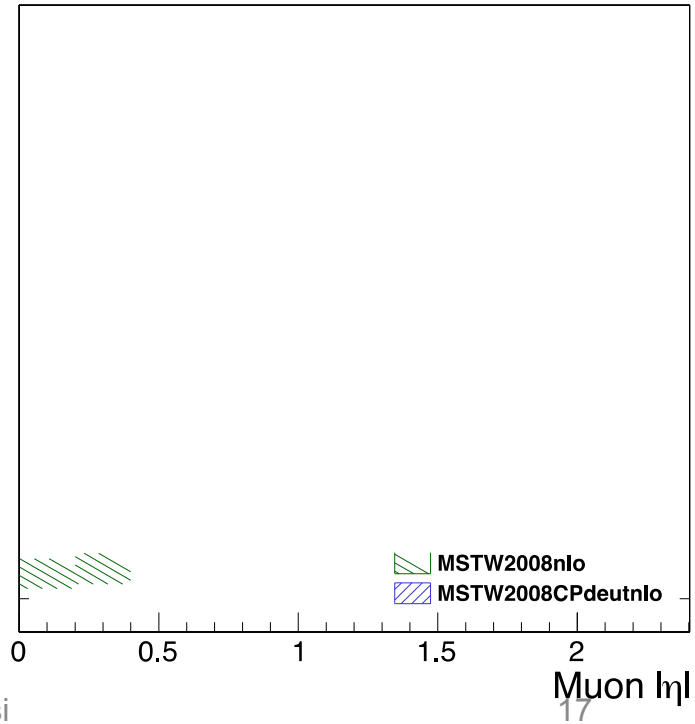
- New measurement of W charge asymmetry in the muon channel

SMP-12-021

Can constrain significantly PDF



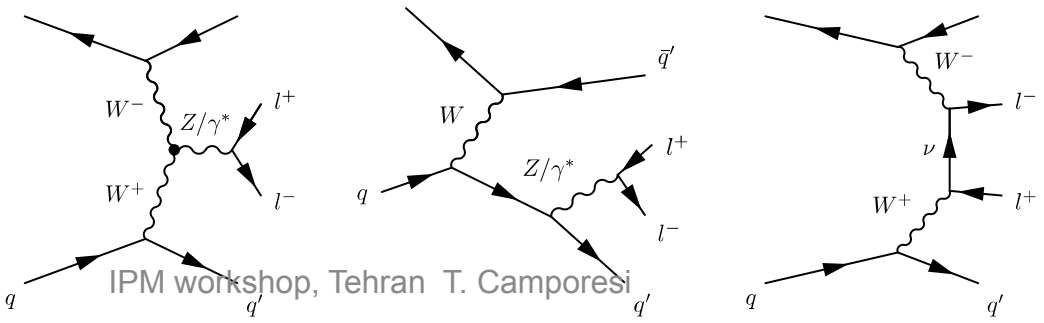
Extraction of W signal from Missing E_t: note that et starts at Zero !



Forward Physics Highlights

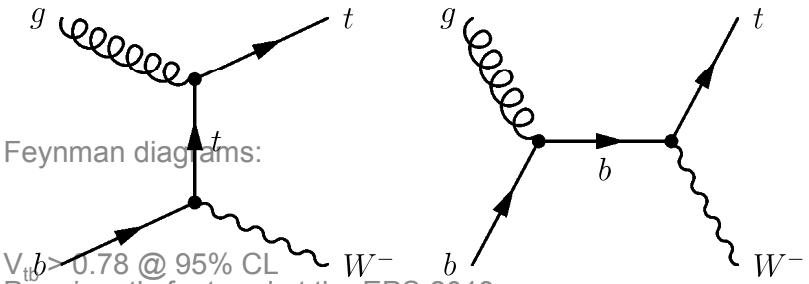
- A new, 8 TeV VBF Z production analysis FSQ-12-035
  - Improves and extends earlier analysis it to higher energy/statistics
  - Strong destructive interference between the VBF diagram (left) and bremsstrahlung (middle) & multiperipheral (right) production
  - Cross section is suppressed by x5 compared to the VBF contribution alone
- Important testing ground for understanding of the VBF Higgs production

$$\sigma(\text{EWK } \ell\ell jj) = 226 \pm 26_{\text{stat}} \pm 35_{\text{syst}} \text{ fb.}$$



Observation of tW Production

- Very nice measurement, previously reported only as an evidence by both ATLAS and CMS
- Use W(lν) decays for both W's; maximum sensitivity is in the eμ channel
- Selection based on BDT in jet and b-jet multiplicity categories
- Observed 6σ excess (5.4σ expected)
  - $\sigma = 23.4^{+5.5}_{-5.4}$ pb



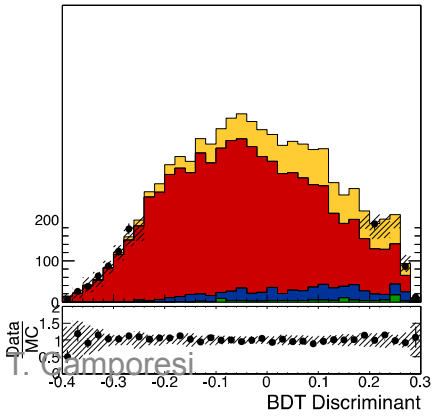
Feynman diagrams:

$V_{tb} > 0.78$ @ 95% CL

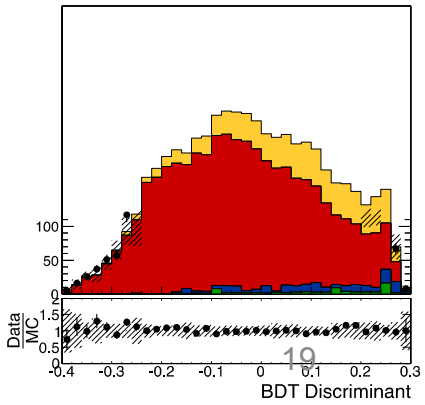
Prominently featured at the EPS 2013

TOP-12-040

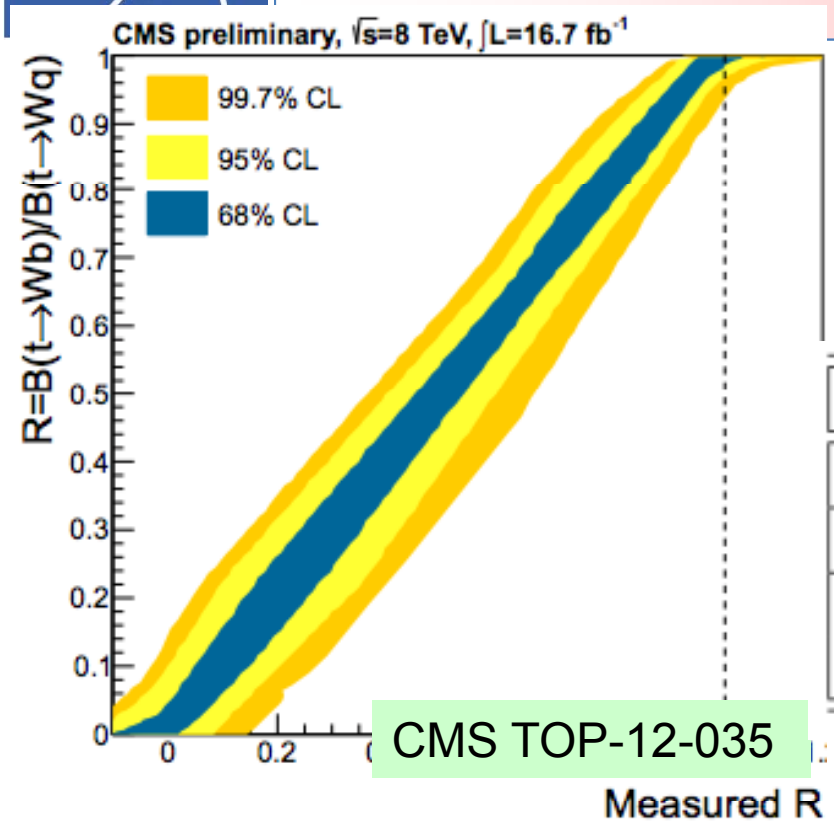
All channels



eμ alone



Top decays



CMS TOP-12-035

FCNC

CMS TOP-12-037

$\mathcal{B}(t \to Zq)$	8 TeV	7 TeV + 8 TeV
Expected limit	$< 0.10\%$	$< 0.09\%$
Observed limit	$< 0.06\%$	$< 0.05\%$
$1\,\sigma$ boundary	$0.06 - 0.13\%$	$0.06 - 0.13\%$
$2\,\sigma$ boundary	$0.05 - 0.20\%$	$0.05 - 0.18\%$

Br(t →Zq) < 0.07% @ 95% CL

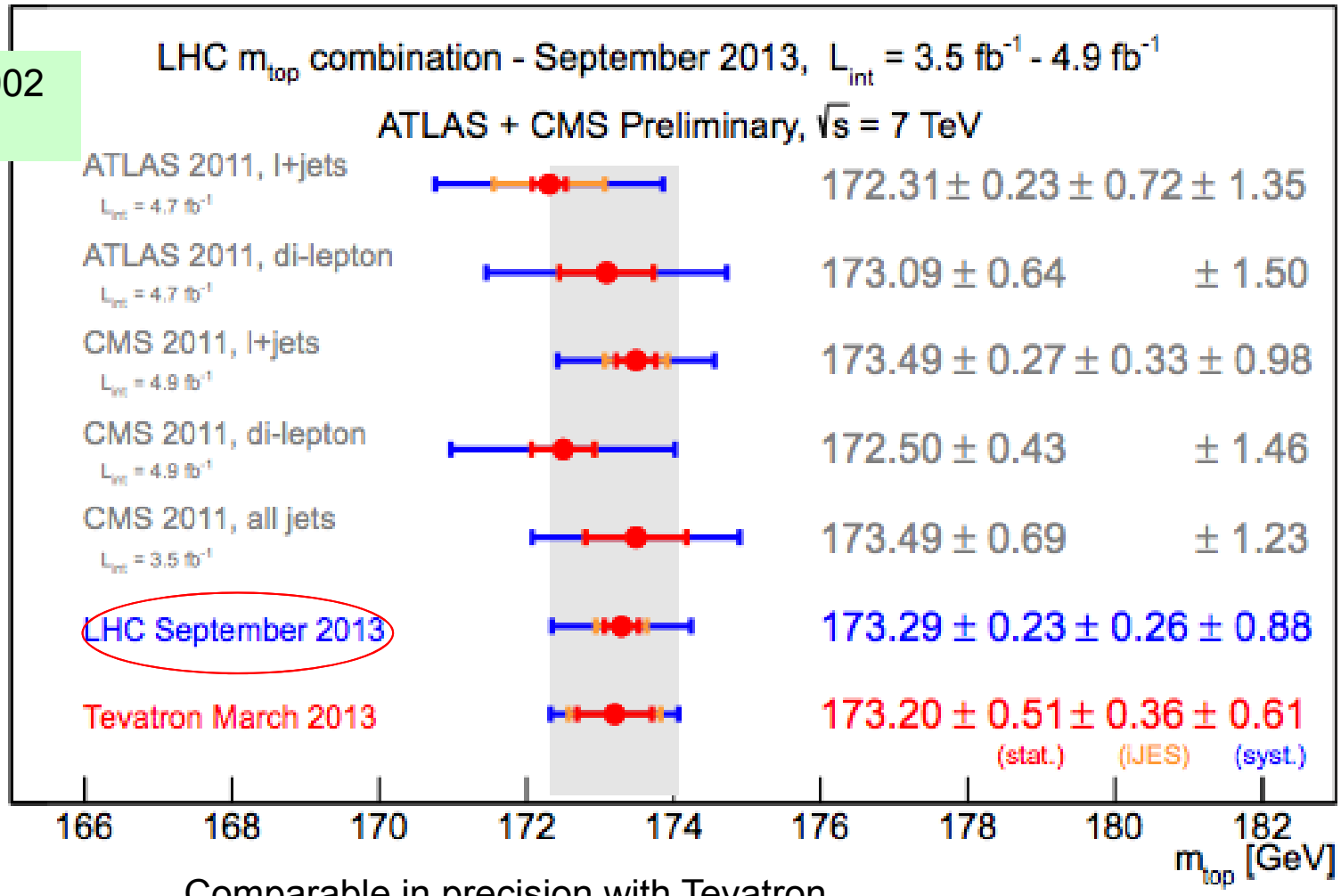
Most precise measurement of
R=Br(t→Wb)/Br(t→Wq)

R ∈[0.945–1.000] @95% CL

$|V_{tb}| \in [0.972–1.000]$ @95% CL

Top mass

CMS PAS Top-13-002 and TOP-13-005

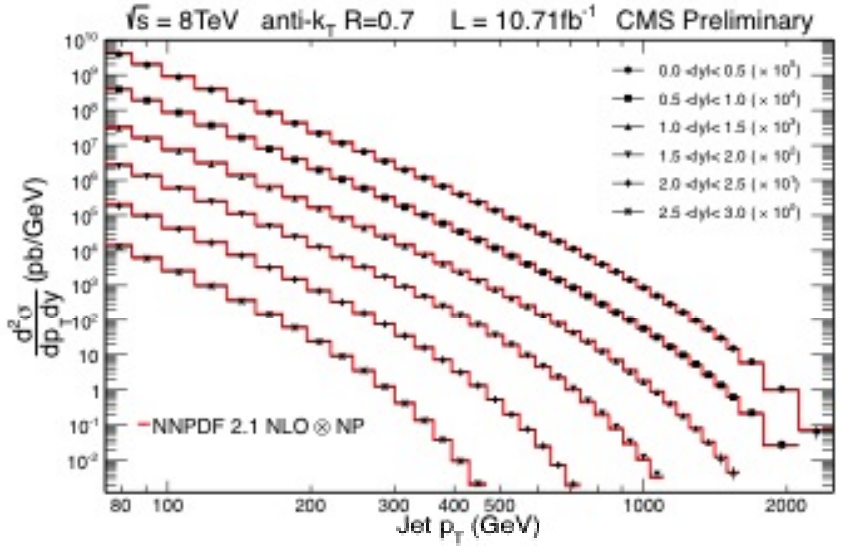


Comparable in precision with Tevatron

See Jorgen and Roberto's Talk for more on Top physics and details

Jet Physics Highlights

- New measurement of the α_S via the ratio of 3 to 2 jet events:
  - $\alpha_S(M_Z) = 0.1148 \pm 0.0014\ (\text{exp.}) \pm 0.0018\ (\text{PDF})\ ^{+0.0050}_{-0.0000}\ (\text{scale})$
- First differential inclusive jet cross section measurement at 8 TeV – important input to PDF fits

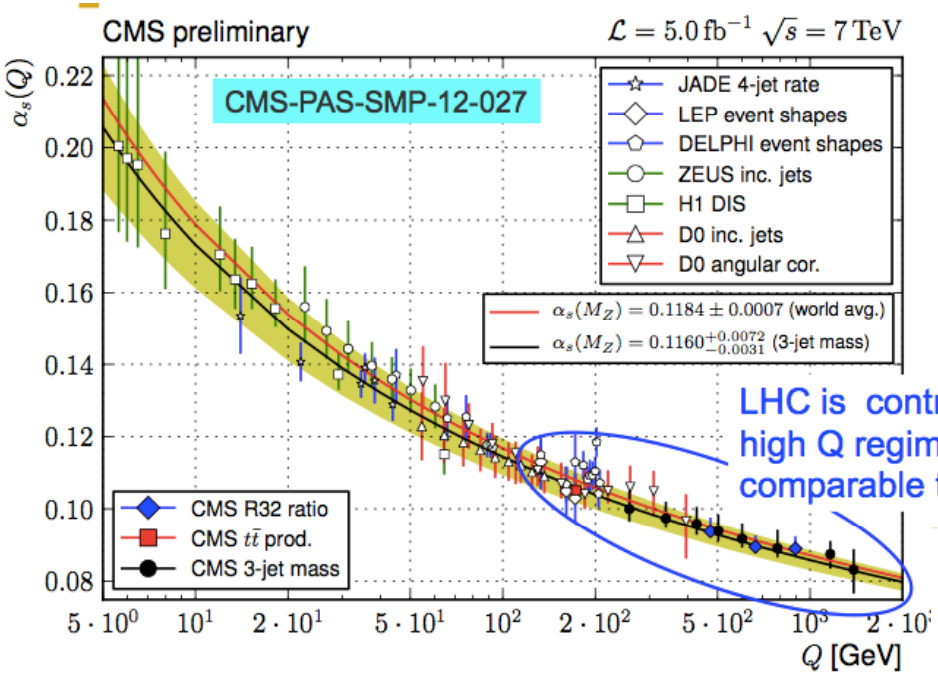


Q (GeV)

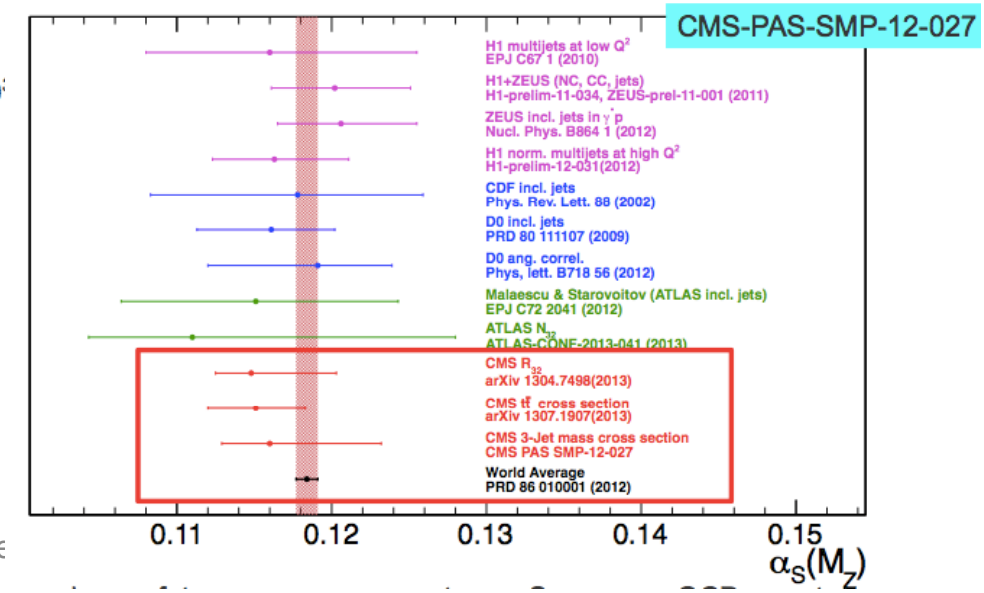
QCD-11-003
arXiv:1304.7498

SMP-12-012

α_s from 3 jets events

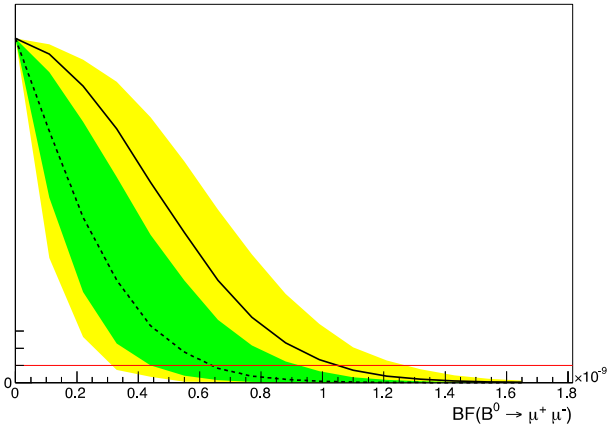


LHC is contributing in high Q regime. Precision comparable to HERA.



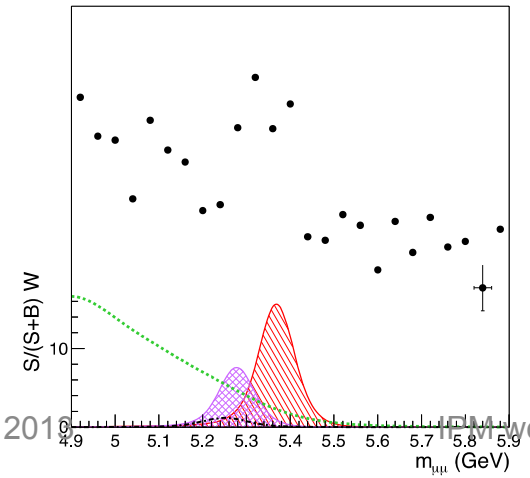
$B_s(\mu\mu)$ Results

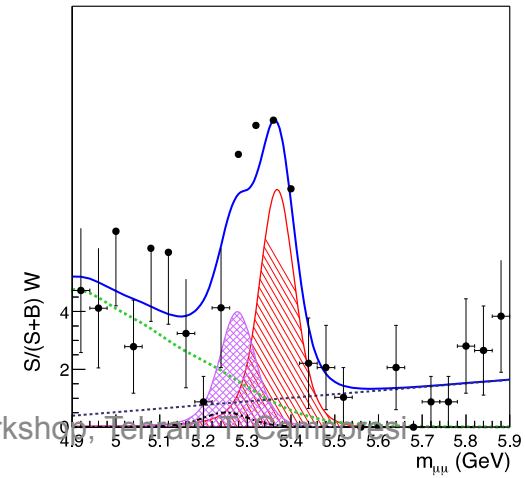
- The results:
  - $B(B_s \rightarrow \mu\mu) = (3.0^{+1.0}_{-0.9}) \times 10^{-9}$
  - $B(B_d \rightarrow \mu\mu) <$ 1.1×10^{-9} (9.2×10^{-10})
- Preliminary combination with LHCb:
  - $B(B_s \rightarrow \mu\mu) = (2.9 \pm 0.7) \times 10^{-9}$

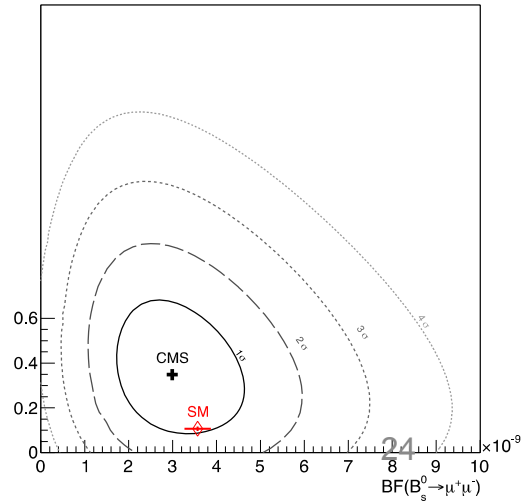


arXiv:1307.5025, PRL

1D+cat: 4.3σ (4.8σ exp.) 1D: 4.8σ (4.7σ exp.)







BPH-13-007/LHCb-CONF-2013-012

On to $B_d(\mu\mu)$

- We will not stop now
- Will reoptimize the analysis for B_d search

- Foreseen improvements:
  - Looser muon ID (in 2011 dataset)
  - 2D BDT fit
  - Better combinatorial background description

SEARCHES

Higgs hunting CMS

Processes/decays studied: Results release In progress

	untagged	VBF	VH	ttH
H-> gamgam				
H-> ZZ				
H->WW				
H-> bb				
H-> tau tau				
H-> Zgamma				
H-> mumu				
H-> invisible				

Main decay channel characteristics:

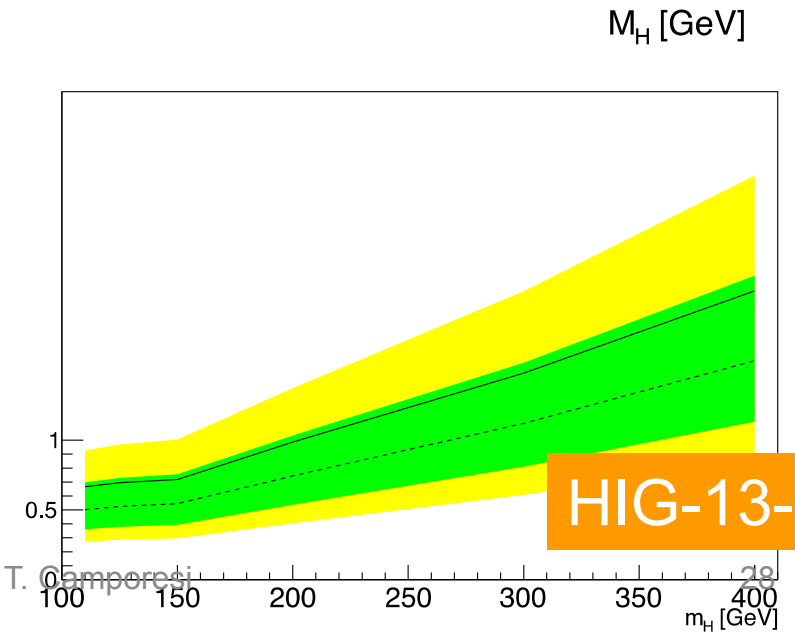
Channel	m_H range (GeV/c^2)	Data used 7+8 TeV (fb^{-1})	m_H resolution
H -> γγ	110-150	5.1+19.6	1-2%
H -> tautau	110-145	4.9+19.6	15%
H -> bb	110-135	5.0+19.0	10%
H -> WW -> lnulnu	110-600	4.9+19.5	20%
H -> ZZ -> 4l	110-1000	5.1+19.6	1-2%

See Albert de Roeck for details

Invisible Higgs

- New CMS analyses in associated Z(ll)H production in VBF production
- ZH:
  - **Br(H→inv.) < 75%** (91% exp.) @ 95% CL, m_H = 125 GeV
- VBF:
  - **Br(H→inv.) < 69%** (55% exp.) @ 95% CL, m_H = 125 GeV

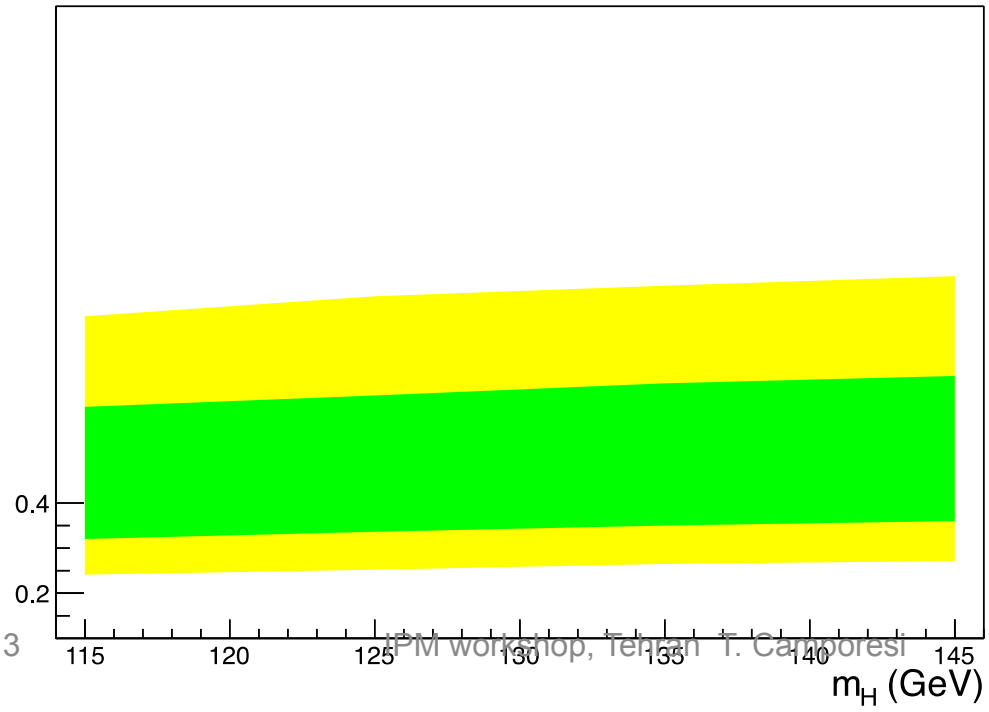
-018

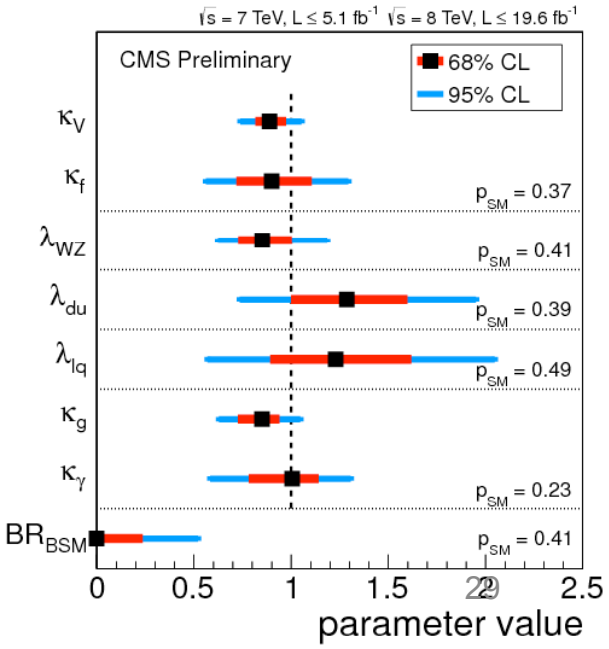


HIG-13-013

Invisible Higgs Combination

- Two direct searches have been combined
- Further improvement could come from combination with the indirect limit B < 0.52 @ 95% CL

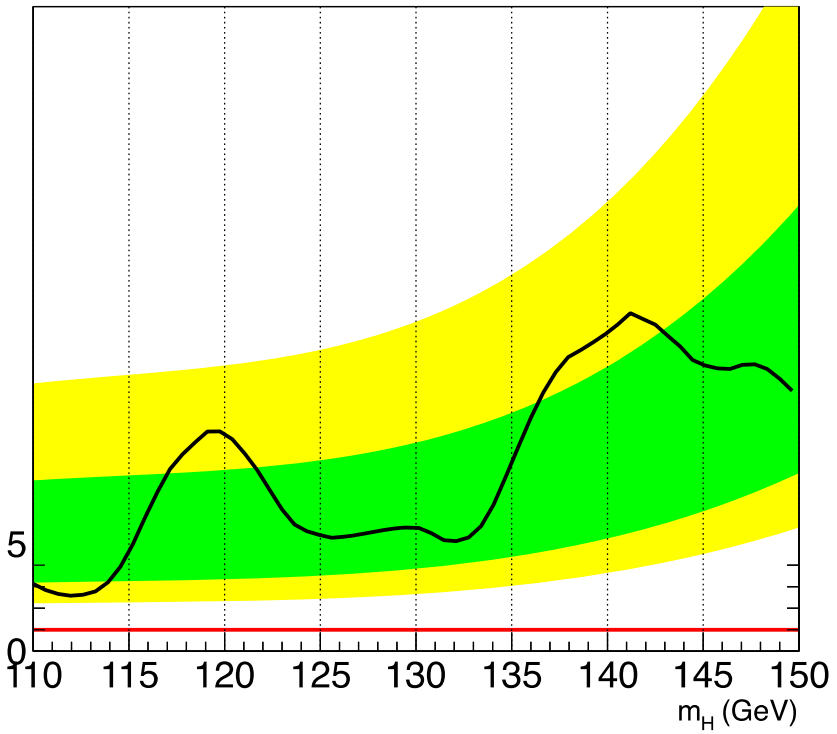




ttH – a New Kid on the Block

- Significant progress made in the ttH channel
- A recent result in ttH(©©) channel
  - **$\mu < 5.4$ (5.3 exp.)** @ 95% CL, $m_H = 125$ GeV
- New ttH(bb+ | |) results:
  - **$\mu < 5.2$ (4.1 exp.)** @ 95% CL, $m_H = 125$ GeV

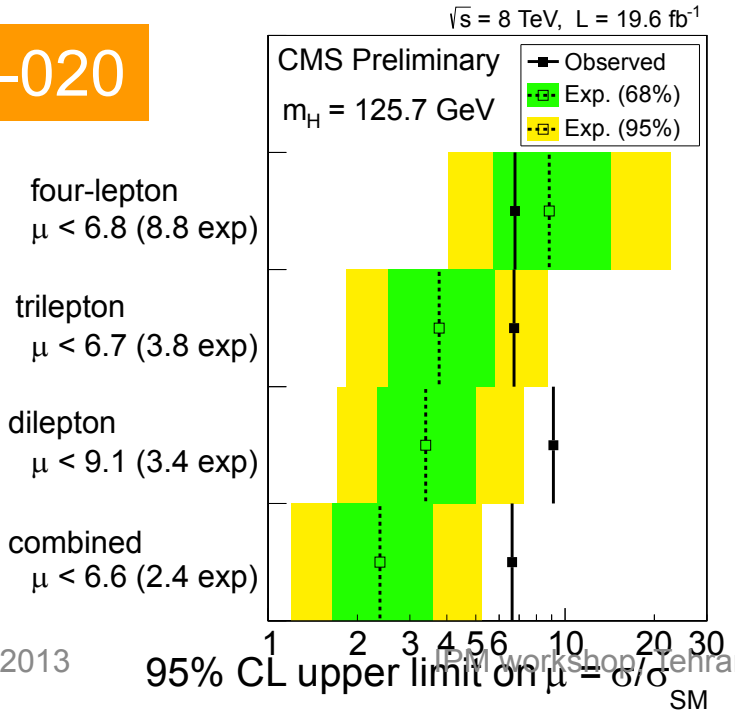
HIG-13-015

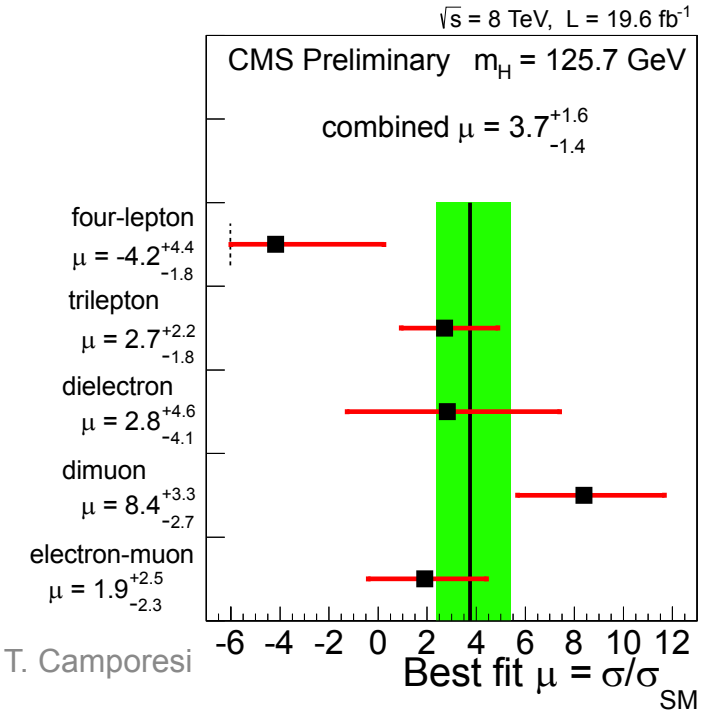


ttH in Multileptons

- New analysis exploring various top and Higgs decays resulting in like-sign dilepton, trilepton, and quadlepton final states
- An excess (~2.5σ) seen in like sign dimuons has been extensively scrutinized and demonstrated to have all the features of a statistical fluctuation
- Overall consistency with the SM: 3%

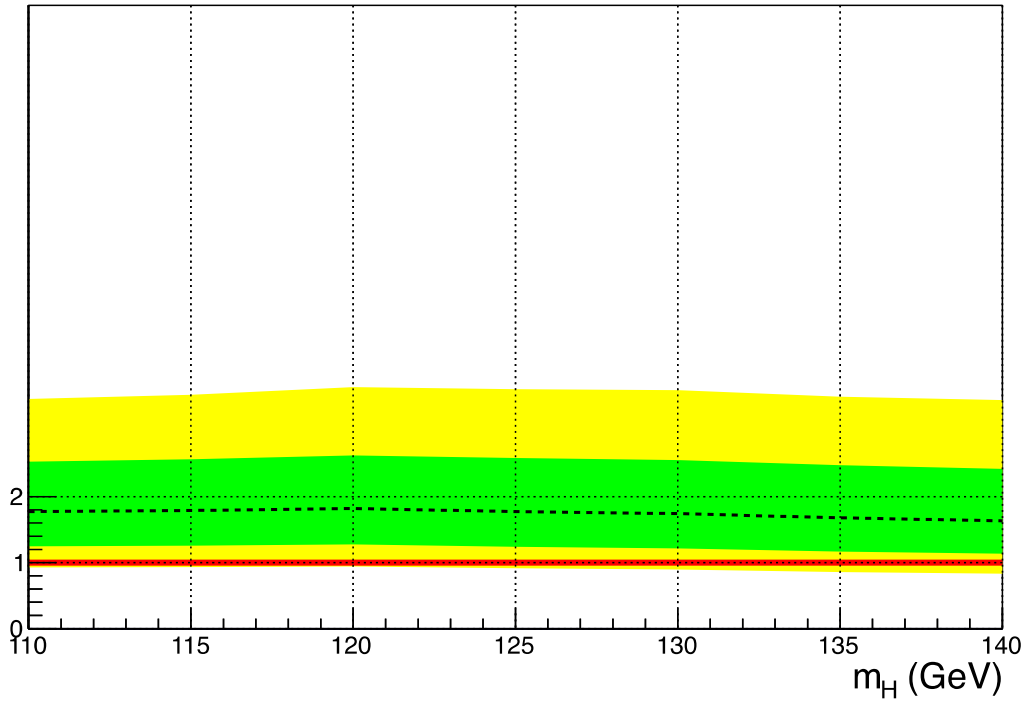
HIG-13-020





ttH Grand Combination

- All channels combined
- Impressive expected sensitivity $\mu < 2$!
  - Excess is driven by the dimuon excess in the multilepton analysis
  - Counting on a factor ~5 increase in production at 13 TeV this will join the 5 HPA in Run2



SUSY Multilepton Search

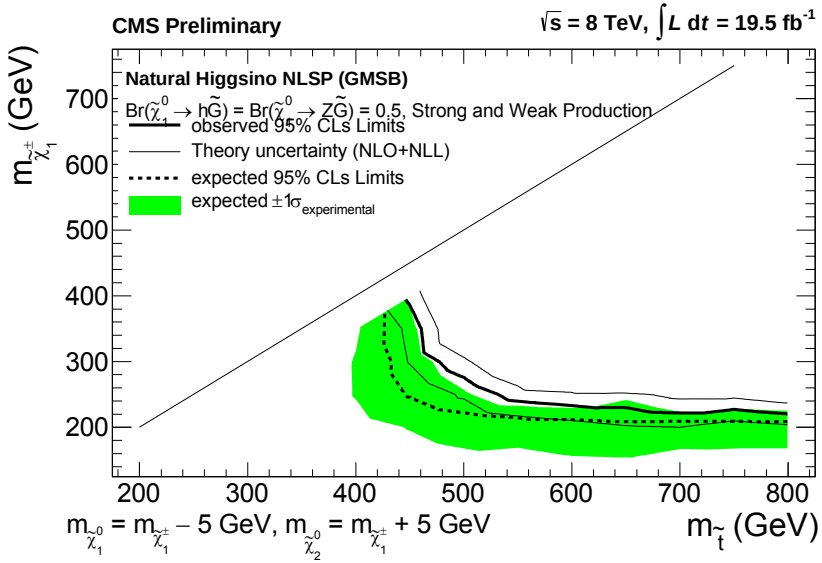
- Strict limit on B(t → cH) < 0.31%

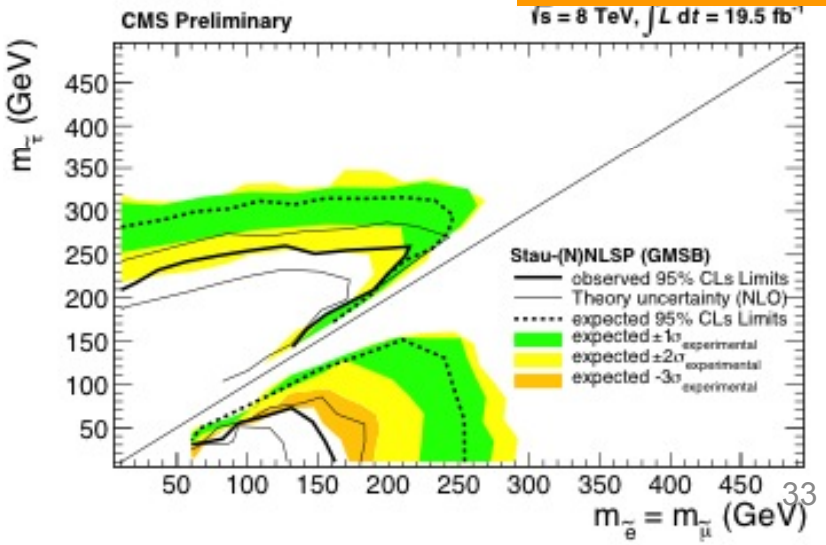
Higgs Decay Mode	observed	expected	1s range
h ! WW (BR = 22.3 %)	0.37 %	0.38 %	(0.26–0.52) %
h ! t t (BR = 6.24 %)	8.4 %	7.6 %	(5.8–11.2) %
h ! ZZ (BR = 2.76 %)	1.23 %	0.97 %	(0.74–1.42) %
combined	0.31 %	0.31 %	(0.21–0.46) %

Table 7: 95 % CL_s limits on BR(*t ! ch*) from individual Higgs decay modes.

- Number of stringent limits in various simplified models:

SUS-13-002



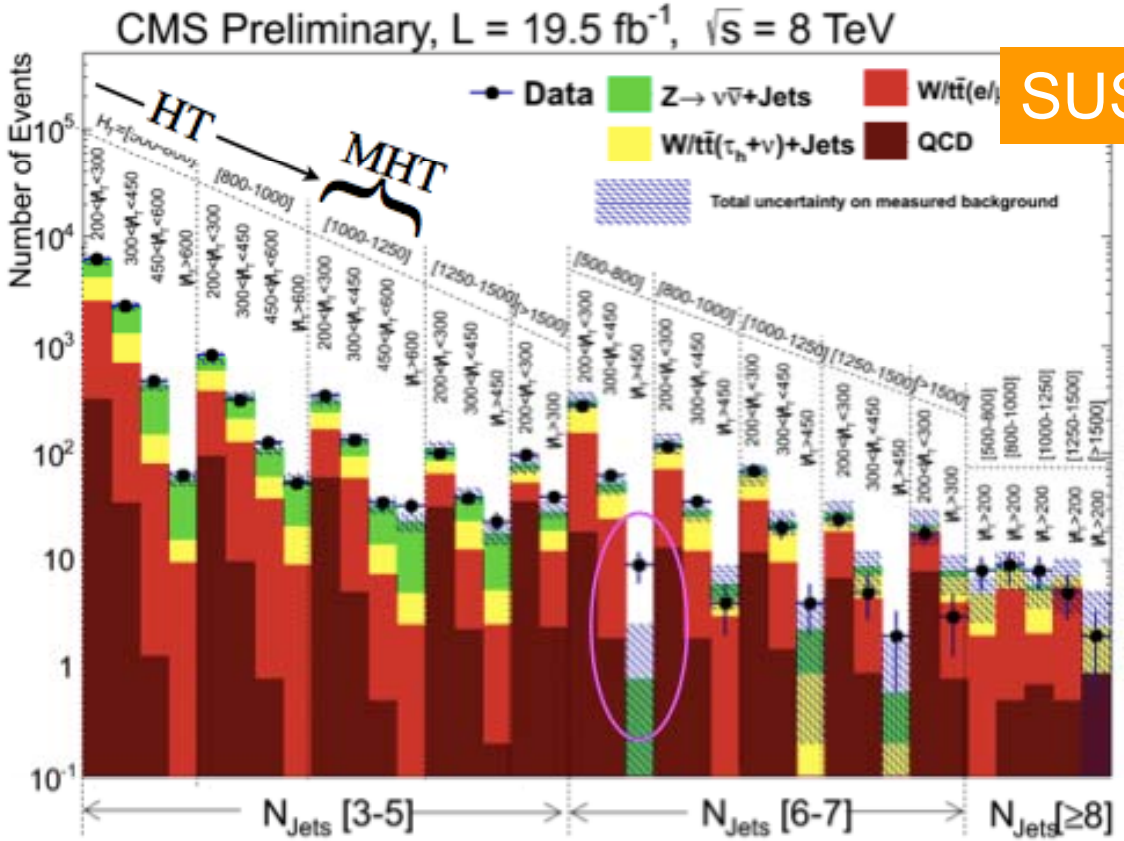


Susy: jets + MHT

$$H_T = \sum_{Jet} p_t$$

$$MH_T = -\sum_{jets} \vec{p}_t$$

SUS-13-002



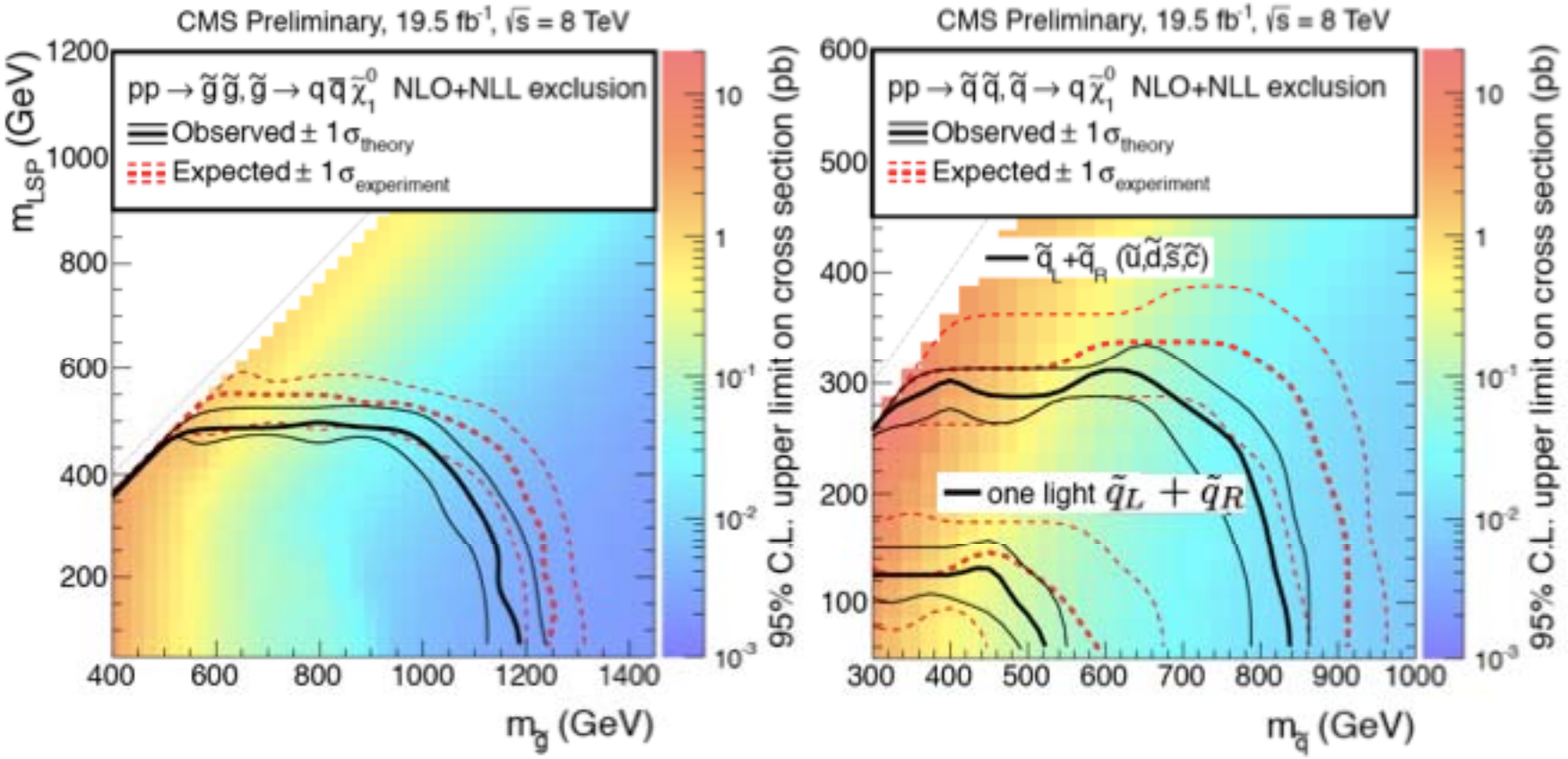
Observed events are consistent with expected standard model backgrounds in all 36 search regions in NJets, HT & MHT.

Excess in one bin : p(≥9| 0.7 ± 1.8) ~ 0.004 → ~2.7 σ

To observe such (or larger) fluctuation in any of 36 bins : p ~ 0.11 → ~1.2 σ

Jets+MH_T results

Define cross sections for simplified models defined by production model and decay channels



Probed Gluino masses up to 1.2 TeV and squark masses up to 0.85 TeV

SUSY Razor searches

In Di-jets topologies Define

$$M_R = \sqrt{(|\vec{p}_{q1}| + |\vec{p}_{q2}|)^2 - (p_{z,q1} + p_{z,q2})^2}$$

and

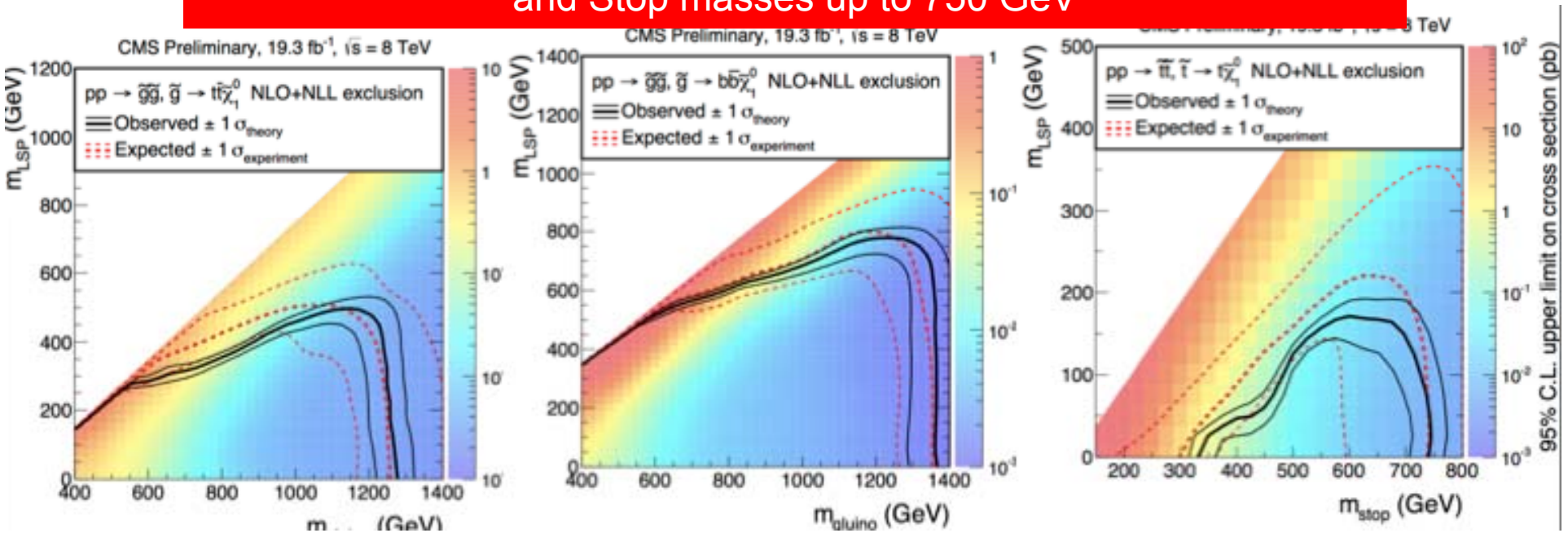
$$M_T^R = \sqrt{\frac{E_{\mathrm{T}}^{\mathrm{miss}}(p_{\mathrm{T}}^{q1} + p_{\mathrm{T}}^{q2}) - \vec{E}_{\mathrm{T}}^{\mathrm{miss}}(\vec{p}_{\mathrm{t}}^{\,q1} + \vec{p}_{T}^{\,q2})}{2}}$$

Define **the "Razor"**:

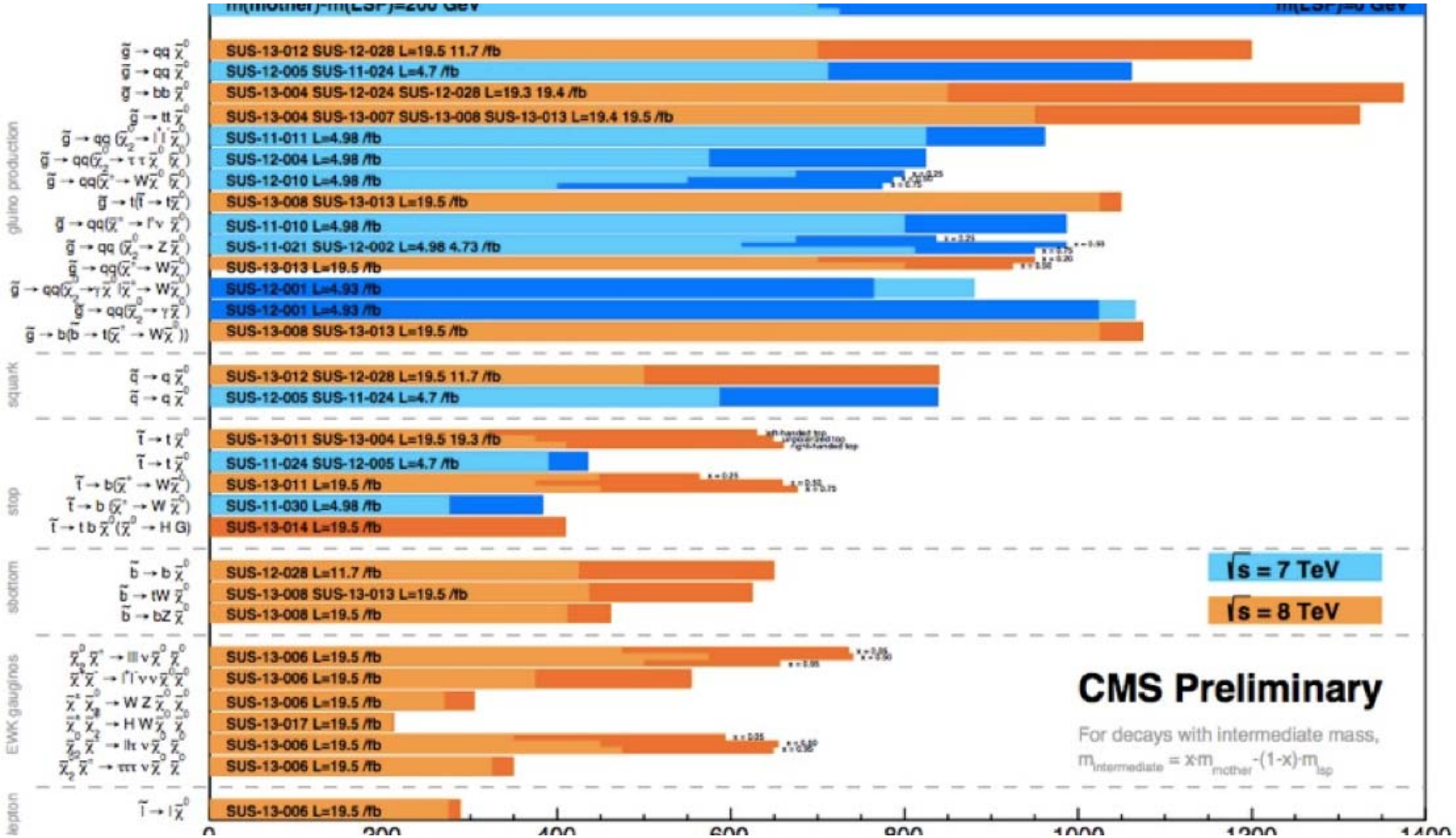
$$R = \frac{M_T^R}{M_R}$$

Then Search for a broadly peaking signal in $M_R R^2$ plane

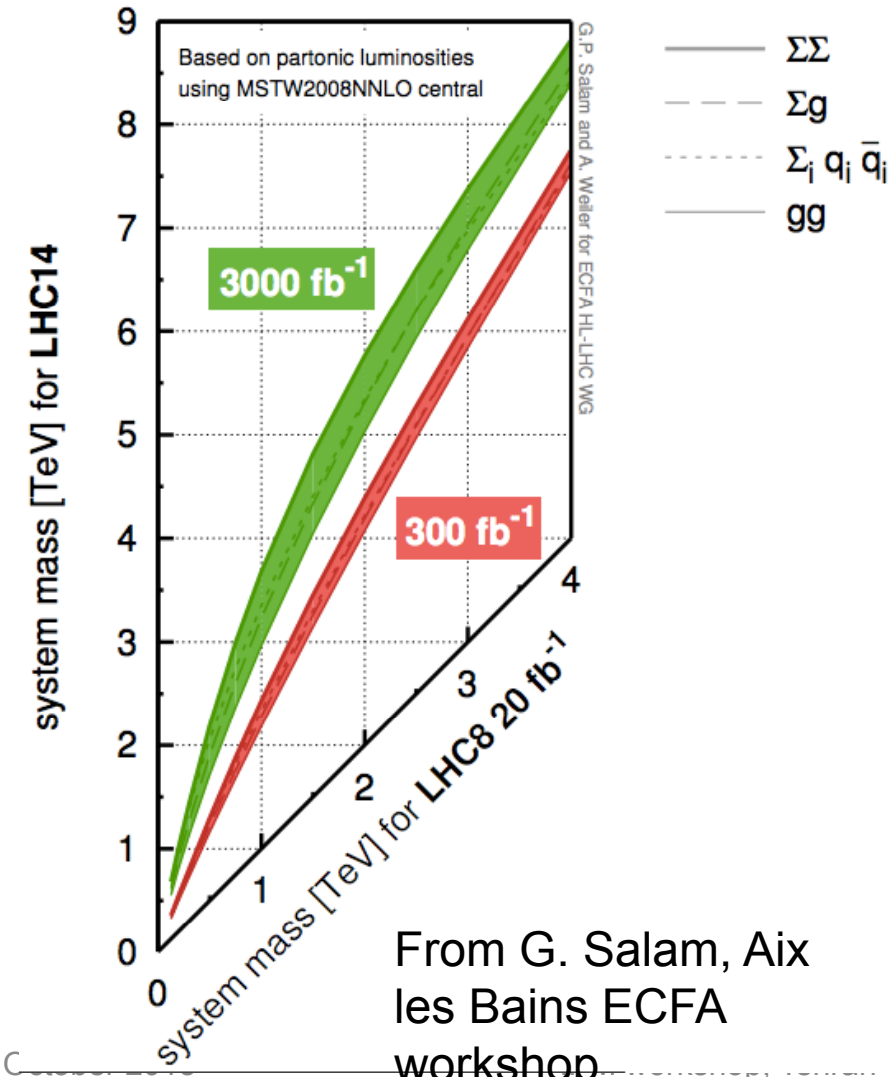
Interpretations: probed gluino masses up to 1.2-1.3 TeV and Stop masses up to 750 GeV



SUSY frustration…



It is not over ..yet



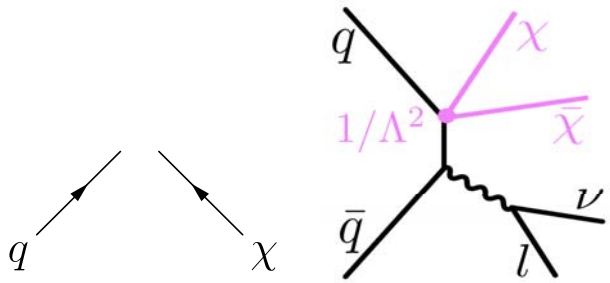
From G. Salam, Aix les Bains ECFA workshop

Reach of 14 TeV for new physics particle 'mass' (from parton luminosities ratios wrt to 8 TeV and for different integrated lumi)
Reality might be more difficult…but analysis will get smarter

The search is on!
e.g. Stop mass reach 1.4-18 TeV (now $\lesssim$700 GeV)

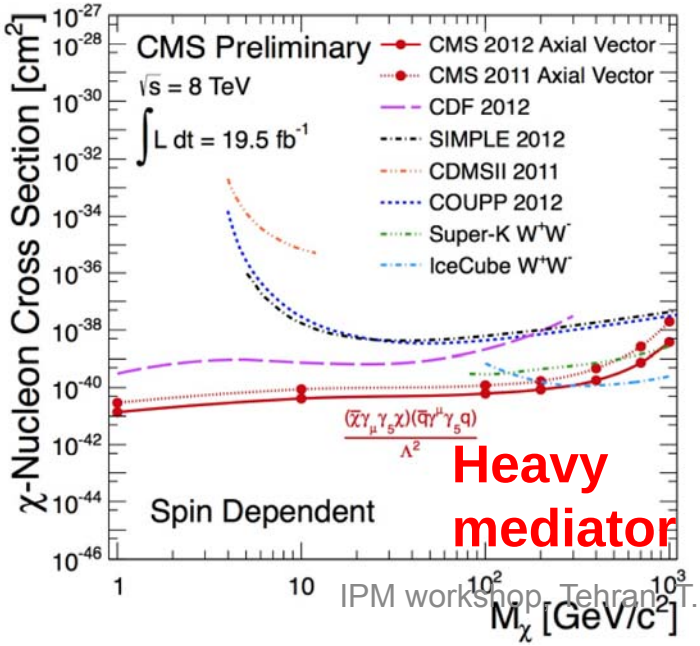
Dark Matter Searches

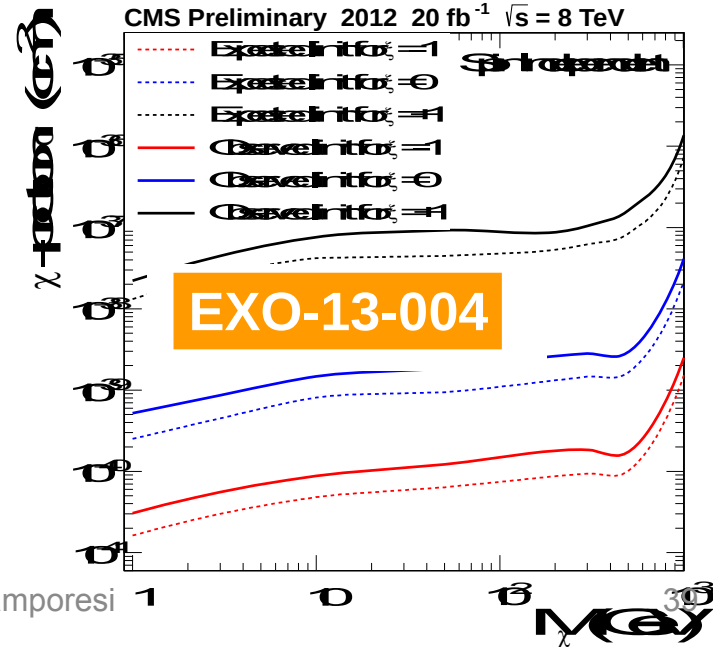
- Search for Dark Matter in monojet, monophoton, and monolepton final states a la the direct detection experiments by triggering on an ISR jet, photon, or W(lν):
  - Limits are somewhat model-dependent (sensitive to the mediator mass); yet competitive
  - Offer unique sensitivity to DM-gluon couplings
- Increased interest since the recent CDMS result (arXiv:1304.4279)!



Direct Detection (t-channel) *Collider Searches (s-channel)* *Monojet + MET*

EXO-12-048

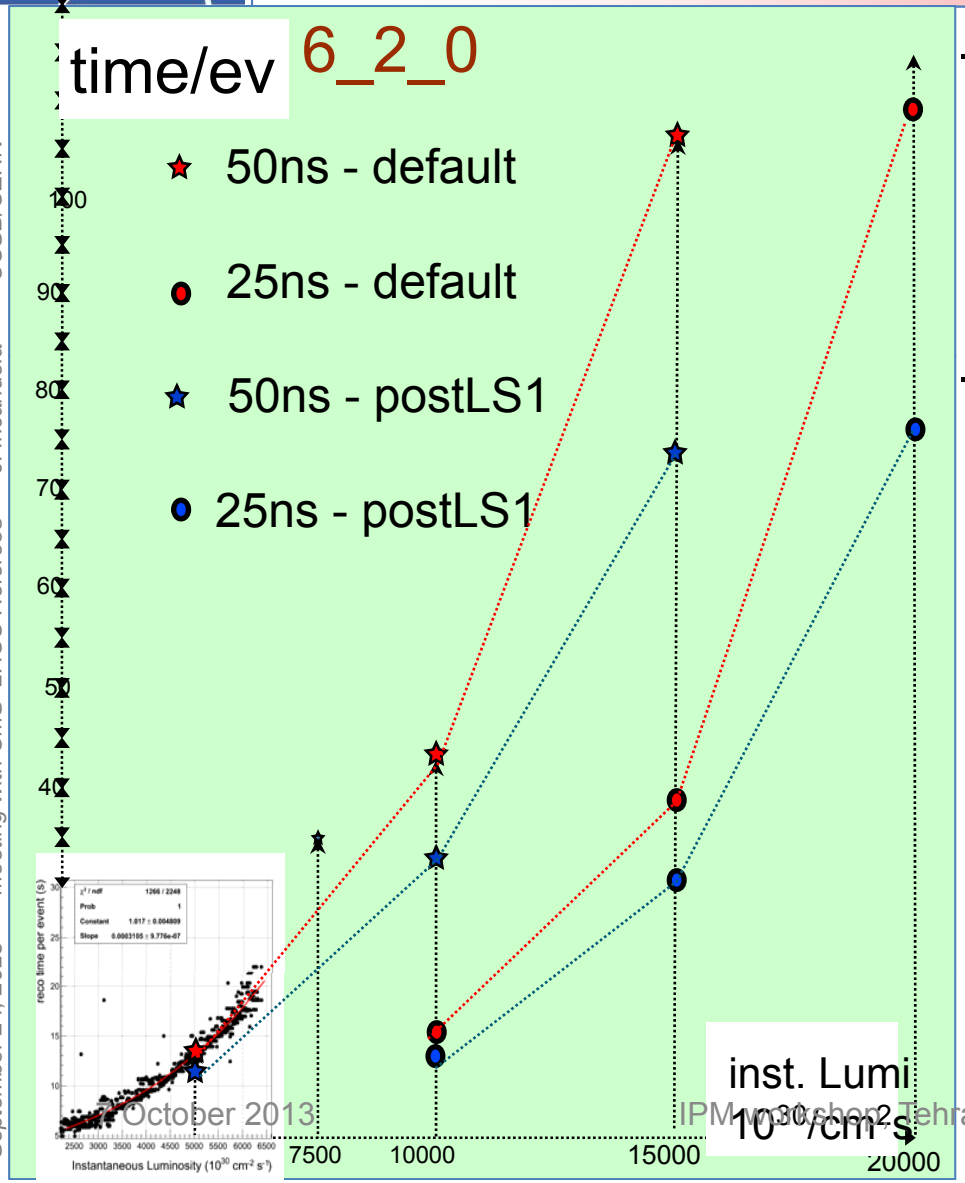




Plans

- Run 1 Physics
- LS1 consolidation
- Phase 1 upgrades
- Phase 2: scope and rough cost estimates document ready. Prepare a Technical proposal in 2014 (TDR for 2016) (see Joao's talk)
- Run 2 preparations

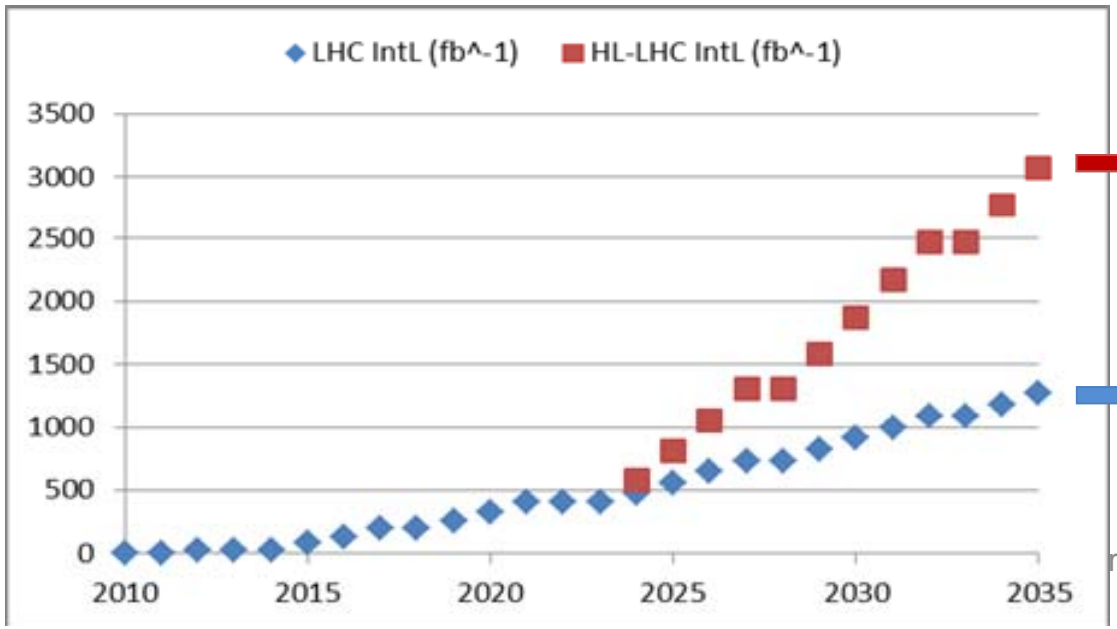
Offline: good news for run2



- Offline continues to make releases for 4 of the 5 fronts mentioned in the previsous slide.
- The first production release of 2013, CMSSW_6_2_X, was made in July.
  - Without any physics performance regression the technical performance at high pileup has improved (red points KD Tree approach to tracking)
  - With small compromises and more work from the tracker DPG (blue points, cut of cluster charge)
  - We are in the right ballpark for the most likely run2 scenarios.

The future

- High Luminosity LHC is now an approved project…. And we need to prepare for it (see Joao's presentation)
- **We count on all collaboration institutes to play a role for the CMS upgrade**
- IRAN has given valuable contributions to the construction of CMS and we count on having you onboard for the upgrades



HL-LHC

Almost a factor 3

By continuous performance


Thank’you !