Search for a Narrow Resonance Produced in 13 TeV pp Collisions Decaying to Electron Pair or Muon Pair Final States

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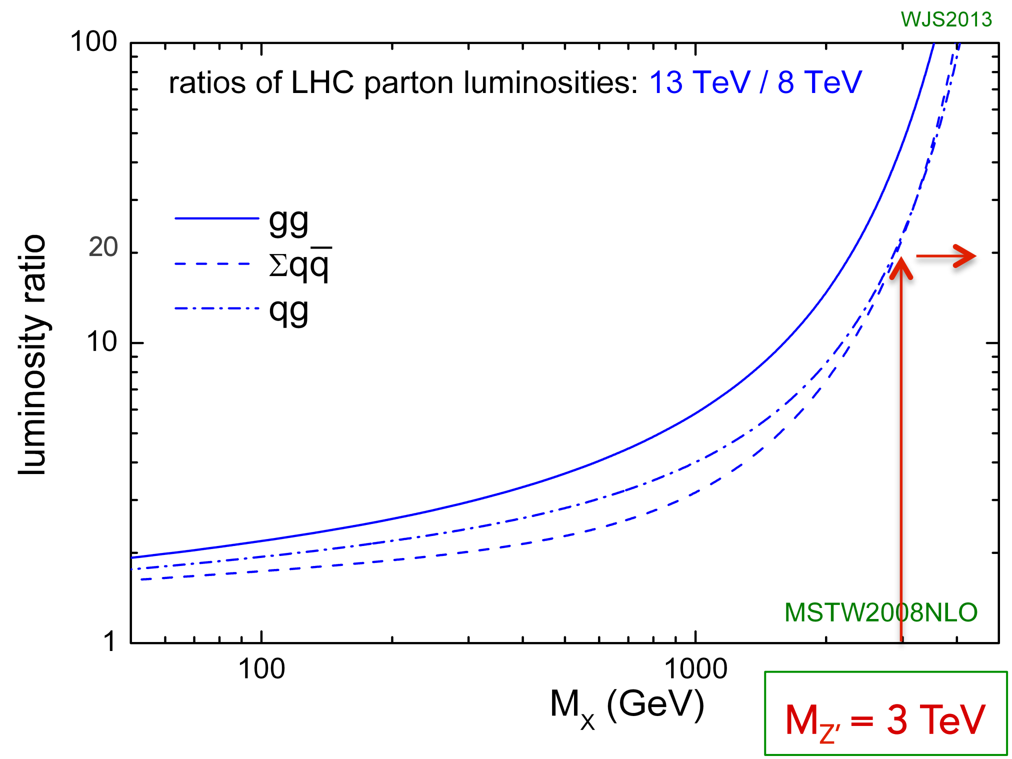
Outline

- Physics motivations
- The CMS detector
- Z′ search in a Nutshell
- Results: exclusion upper limits at 13 TeV
- Summary

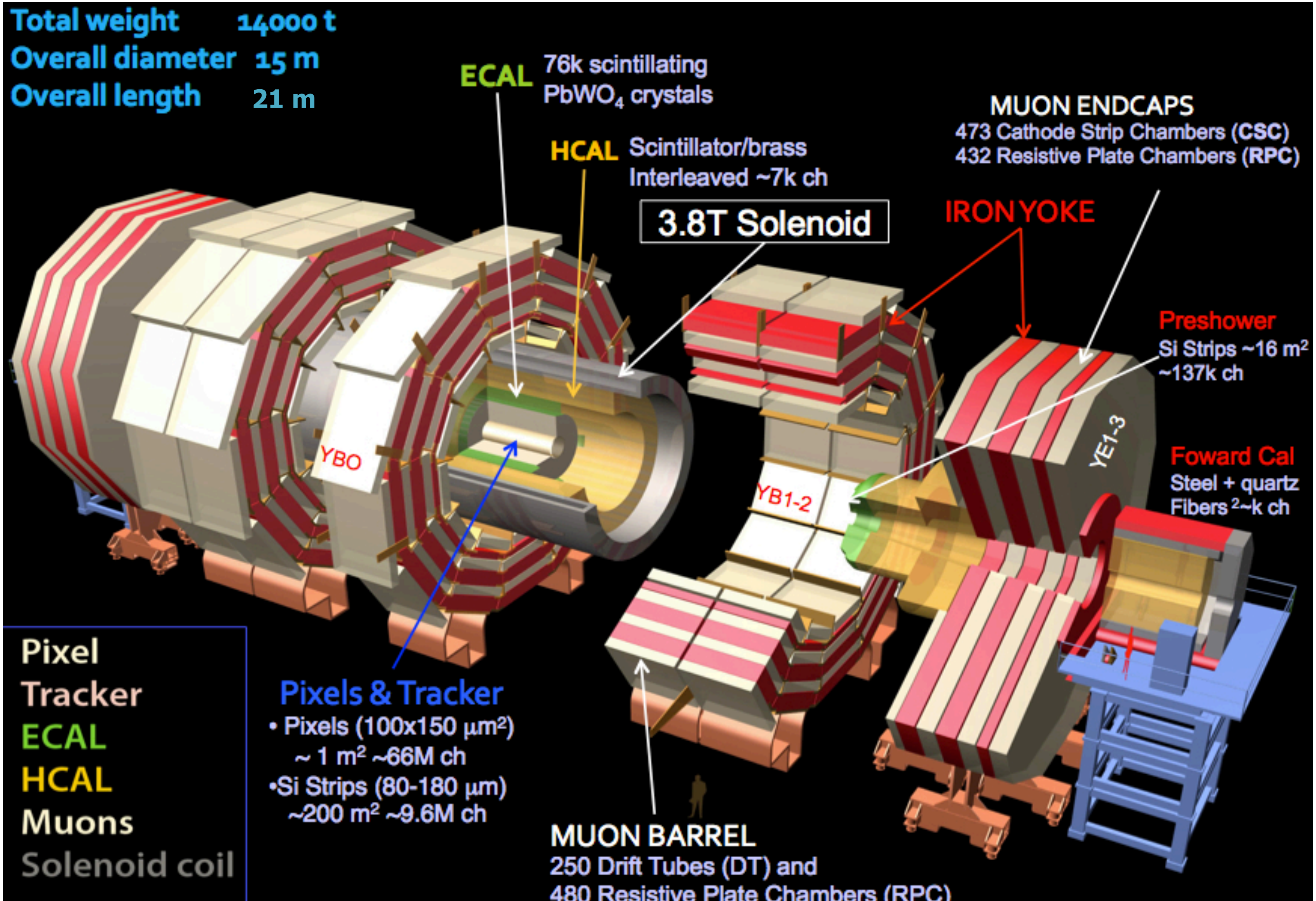
Physics Motivations

- The Standard Model (SM) is a successful theory supported by many experimental evidences, e.g. Higgs boson discovery, etc.
- SM has some omissions: hierarchy problem, absence of gravity, lack of dark matter . . .
- Many theories beyond the SM address these omissions
    - Predict new massive particles, heavy Z′ gauge bosons (motivation to search for dilepton resonances)

http://www.hep.ph.ic.ac.uk/~wstirlin/plots/plots.html



The CMS Detector



Z′ Search in a Nutshell

- Signal: clean signature of two same flavour high-p_T leptons
  - Triggers used: HLT_Mu50 and HLT_DoubleEle33
  - Well isolated leptons from same primary vertex making μμ or ee pair
  - Muons: $p_T > 53$ GeV, $|\eta| < 2.4$
  - Electrons: $E_T > 35$ GeV, $|\eta| < 1.4442$ or $1.566 < |\eta| < 2.5$
  - Backgrounds: irreducible Z/γ^*, reducible ttbar, tW and diboson, jet backgrounds, cosmic rays
- Strategy: search for a localised excess in m_{ll} spectrum, up to 5 TeV
- Three width scenarios: 0%, 0.6% (Z'_ψ) and 3% (Z'_{SSM})

Key Points

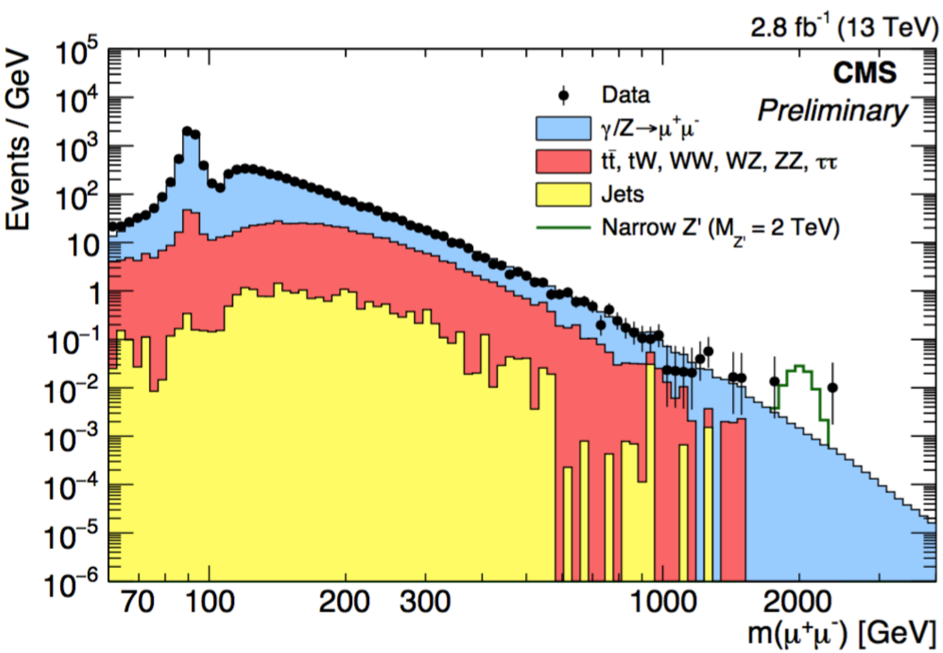
- Precise measurement of lepton energy, momentum scale and mass resolution
  - Huge dependence on detector alignment for high p_T leptons
- Good understanding of the acceptance x efficiency of high p_T leptons
- Rely on simulations for evaluating the background shape, the mass resolution at high masses, and selection efficiencies

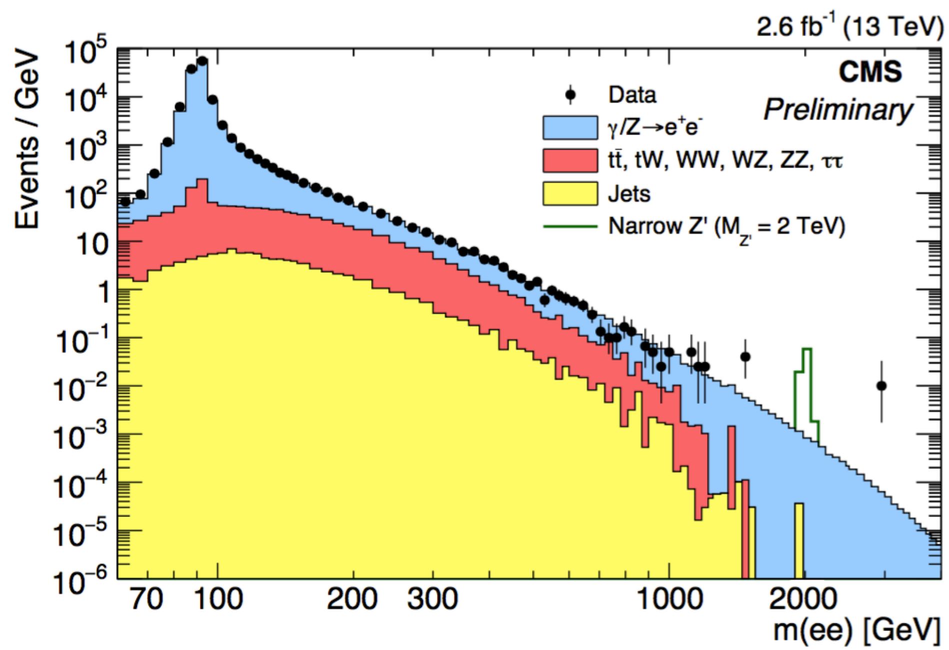
Dilepton Invariant Mass

Highest mass events observed in data

- Muon - 2.4 TeV
- Electron - 2.9 TeV

CMS PAS EXO-15-005

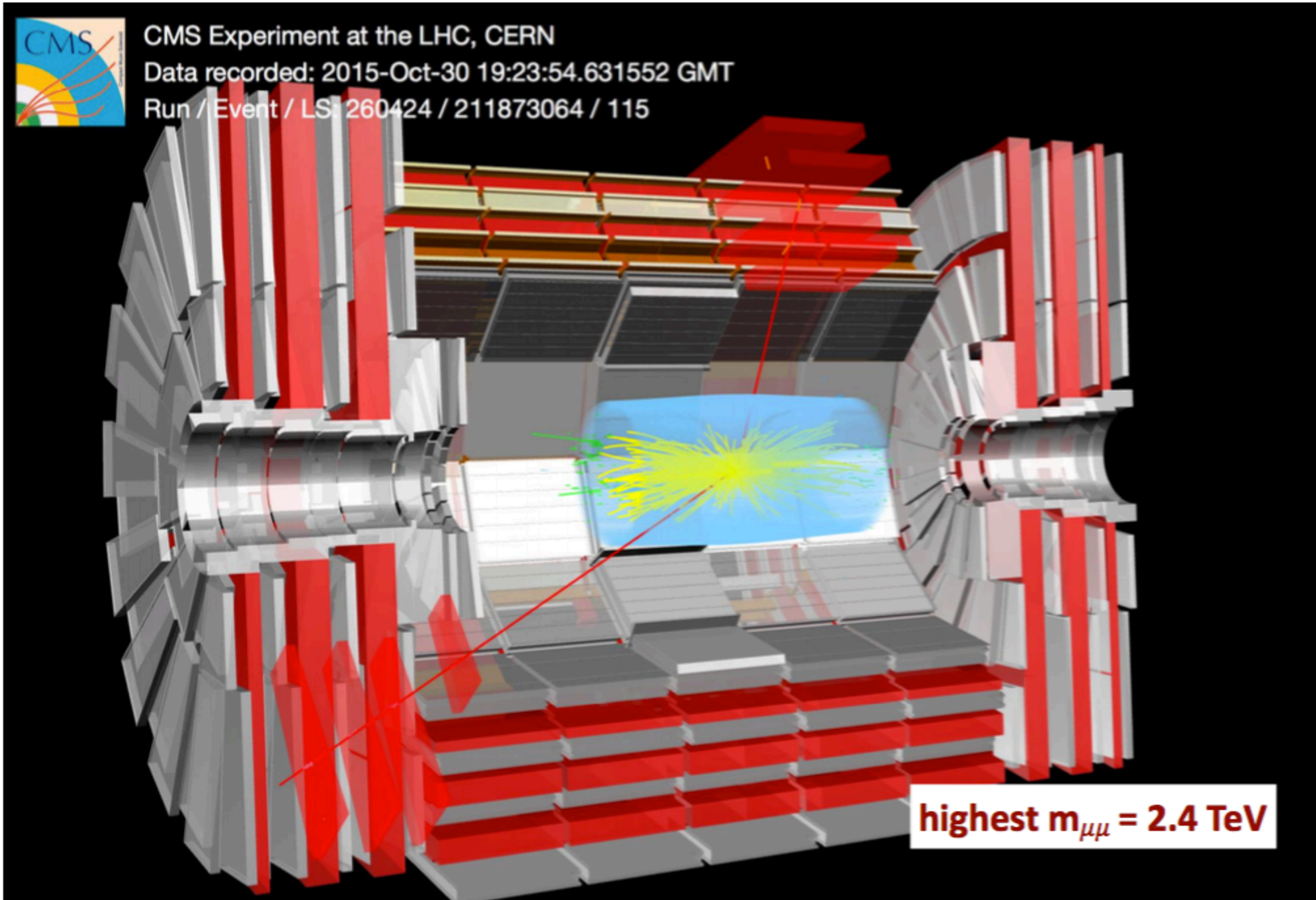




$Z' \rightarrow \mu\mu$

$Z' \rightarrow ee$

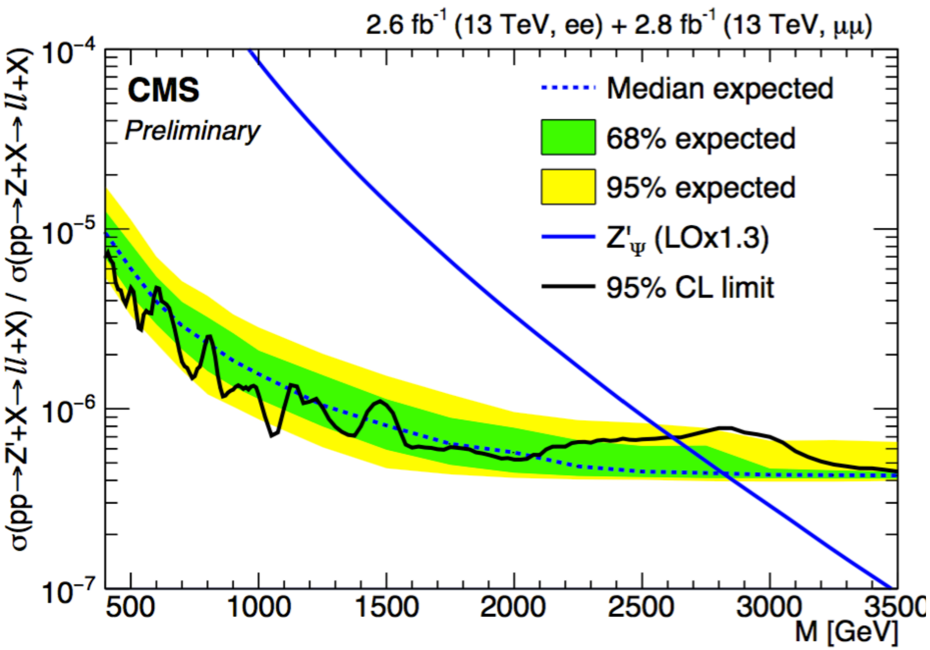
Dimuon Event @ 13 TeV

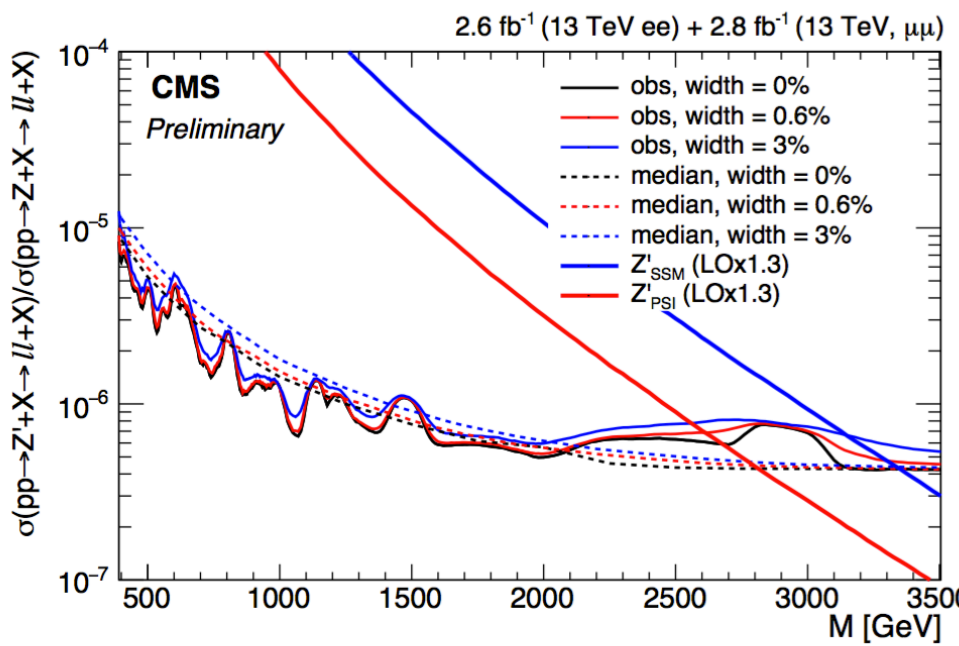


Exclusion Upper Limits @ 13 TeV

channel	Z'_ψ obs (TeV)	Z'_ψ expected (TeV)	Z'_{SSM} obs (TeV)	Z'_{SSM} expected (TeV)
ee	2.40	2.45	2.75	2.95
$\mu^+\mu^-$	2.40	2.55	3.00	3.05
$ee+\mu^+\mu^-$	2.60	2.80	3.15	3.35

CMS PAS EXO-15-005





Already surpassed the current best published limits at 8 TeV data (20.6 fb^{-1})

- Exclusion for Z'_{SMM} up to 2.9 TeV and Z'_ψ up to 2.57 TeV

Summary

- Search for a new massive gauge boson (Z′) decaying to ee or μμ final state has been performed, and results are presented
- Analysis performed using 2.6 fb^{-1} ($Z' \rightarrow ee$) and 2.8 fb^{-1} ($Z' \rightarrow \mu\mu$) @ 13 TeV
- No significant excess over the standard model backgrounds prediction has been observed
- Limits have been derived for Z'_{SSM} and Z'_{ψ} models
  - Mass range less than 3.15(2.60) TeV has been excluded for Z'_{SSM}(Z'_{ψ}) models

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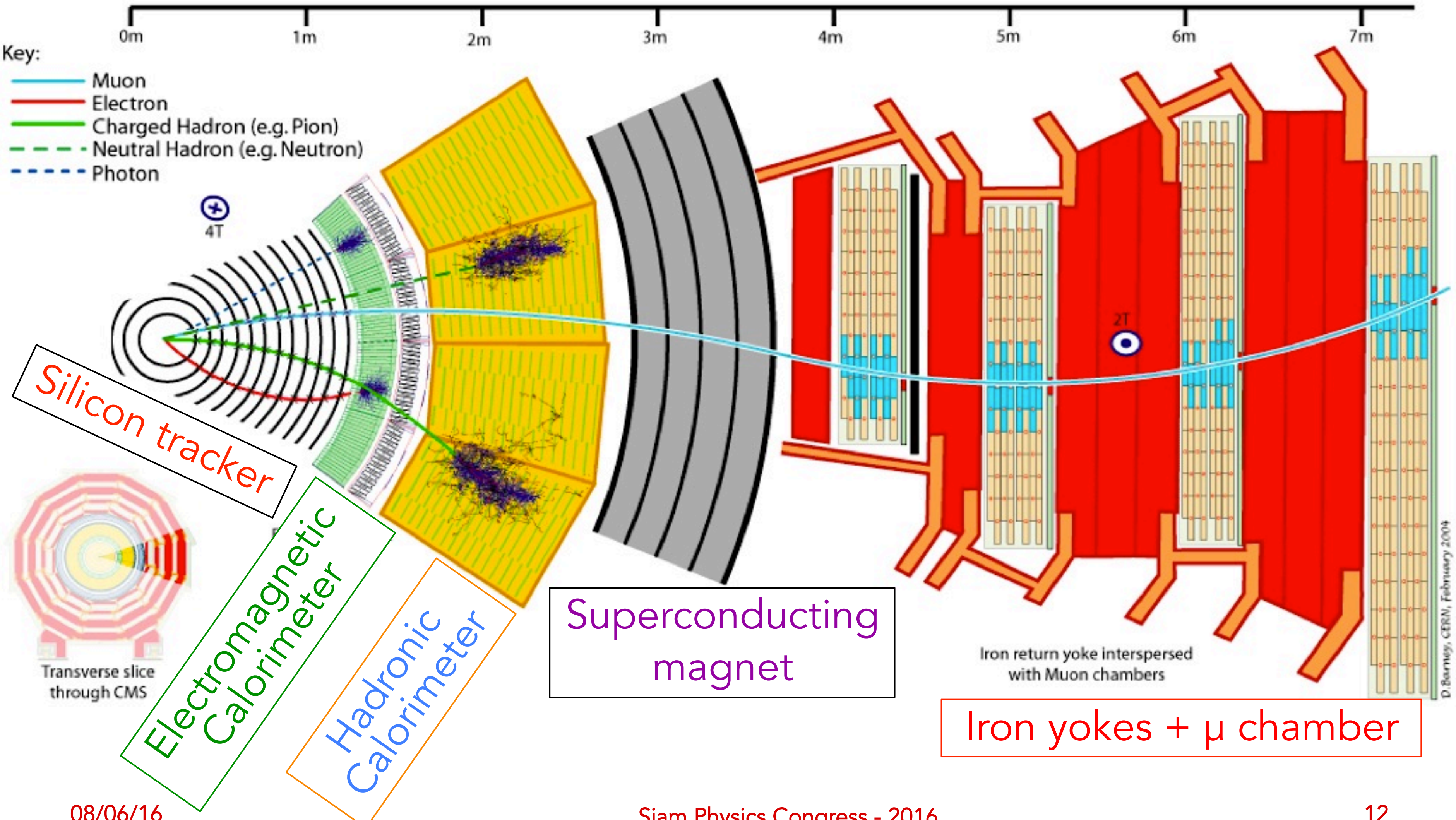
- All SPC 2016 staffs for organizing this event

Backup

Transverse Slice Through CMS

- 85 % - 90 % efficiency for collecting LHC delivered data
- High efficiency and resolution in object (e, μ, tau etc.) reconstruction
- The CMS detector provides good tracking and particle ID all around the interaction point ($0 < \phi < 2\pi$, $|\eta| < 3$)



$Z' \rightarrow ee$ Event Selection

- High energy electron pairs (HEEP) selection is used
- Cut-based selection designed to be highly efficient at high E_T
- Events categories: Barrel-Barrel (BB) or Barrel-Endcap (BE)
- The highest mass pair M_{ee} is selected

Variable	Barrel	Endcap
E_T	> 35 GeV	> 35 GeV
range	$\lvert\eta_{sc}\rvert < 1.4442$	$1.566 < \lvert\eta_{sc}\rvert < 2.5$
isEcalDriven	=1	=1
$\lvert\Delta\eta_{in}^{seed}\rvert$	< 0.004	< 0.006
$\lvert\Delta\phi_{in}\rvert$	< 0.06	< 0.06
H/E	<1/E + 0.05	< 5/E + 0.05
$\sigma_{i\,i}$	n/a	<0.03
E^{2x5}/E^{5x5}	>0.94 OR E^{1x5}/E^{5x5} > 0.83	n/a
EM + Had Depth 1 Isolation	<2+0.03*Et +0.28*rho	<2.5 +0.28*rho for Et<50 else
		<2.5+0.03*(Et-50) +0.28*rho
Track Isol: Trk Pt	<5	<5
Inner Layer Lost Hits	<=1	<=1
$\lvert dxy\rvert$	<0.02	<0.05

The total efficiency to trigger, reconstruct, and select a 1 TeV electron pair within the detector acceptance is predicted by the Monte Carlo simulation to be 75 ± 8% for barrel- barrel and 70 ± 10% for barrel-endcap electron pairs

$Z' \rightarrow \mu\mu$ Event Selection

Muon Selection

- Global muon and Tracker Muon
- $N_{(muon\ hits)} > 0$; and $N_{(muon\ stations)} > 1$
- d_{xy} wrt PV < 2 mm; and $N_{(pixel\ hits)} > 0$
- $N_{(tracker\ layers)} > 5$; and $\delta p_T/p_T < 0.3$
- Tracker Iso (ΔR=0.3) < 0.1; and $p_T > 53$ GeV

DiMuon and Event Selection

- good offline-reconstructed PV, opposite-sign muons
- χ^2/d.o.f. of a common vertex fit < 20
- 3D opening angle α between the two muons momenta < (π - 0.02) rad
- One of the muons matched within $\Delta R < 0.2$ to the HLT_Mu50 muon candidate

The total efficiency to trigger, reconstruct, and select a 1 TeV muon pair within the detector acceptance is predicted by the Monte Carlo simulation to be $89^{+11\%}_{-14\%}$