



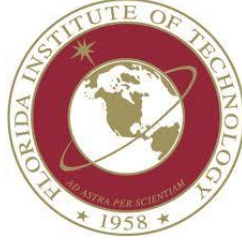
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Search for a Z' boson in the
dimuon channel in p-p collisions
at $\sqrt{s} = 7\text{TeV}$ with CMS
experiment at the Large Hadron
Collider

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Outline



- Standard Model
- Z' boson
- LHC and CMS Detector
- Physics analysis of 2011 data
- Summary



Standard Model and Elementary Particles



- Current knowledge of fundamental particles and their interaction.

Interactions:

- Strong
- Electromagnetic
- Weak

Elementary Particles:

Fermions: Leptons, quarks (Spin $\frac{1}{2}$)

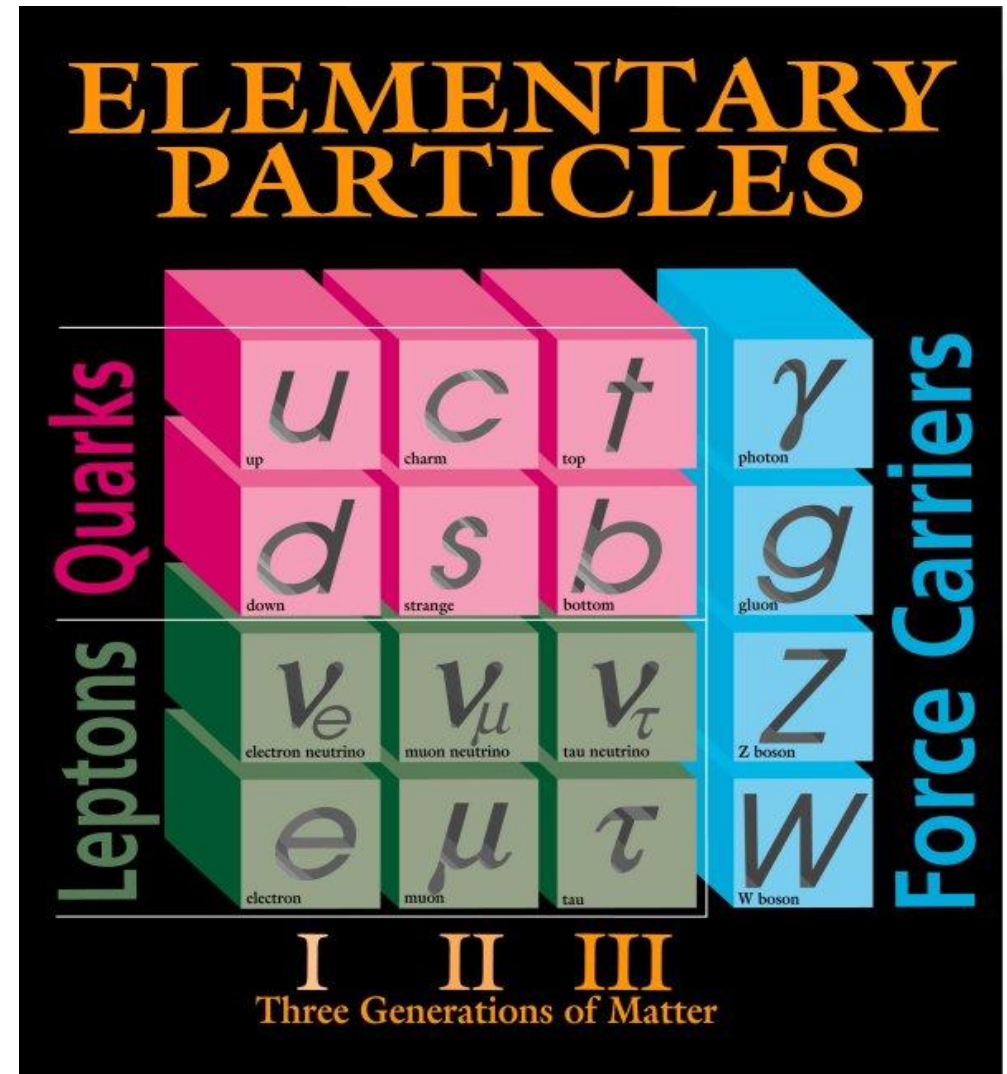
Bosons: Gauge Bosons (Spin 1)

Force Carriers:

photon, gluons : Mass less

W^+, W^-, Z^0, H : Heavy masses $> 80\text{GeV}$

H: Higgs boson(not discovered yet)



Fermilab 95-759



Proposed heavy boson(Z')



- Many proposed models(Beyond SM) of new physics includes particles that shows up as resonance in dimuon mass spectrum.
- An extended gauge model predicts a neutral and heavy gauge boson, Z' .

- **Sequential Standard Model(SSM)**

Z'_{SSM} : Same coupling with fermions as in SM Z .

- No theoretical prediction of Z' mass
- Current mass limit:
CMS: $\geq 2.135 \text{ TeV}/c^2$ (2011 Analysis)
ATLAS: $\geq 2.21 \text{ TeV}/c^2$ (2011 Analysis)

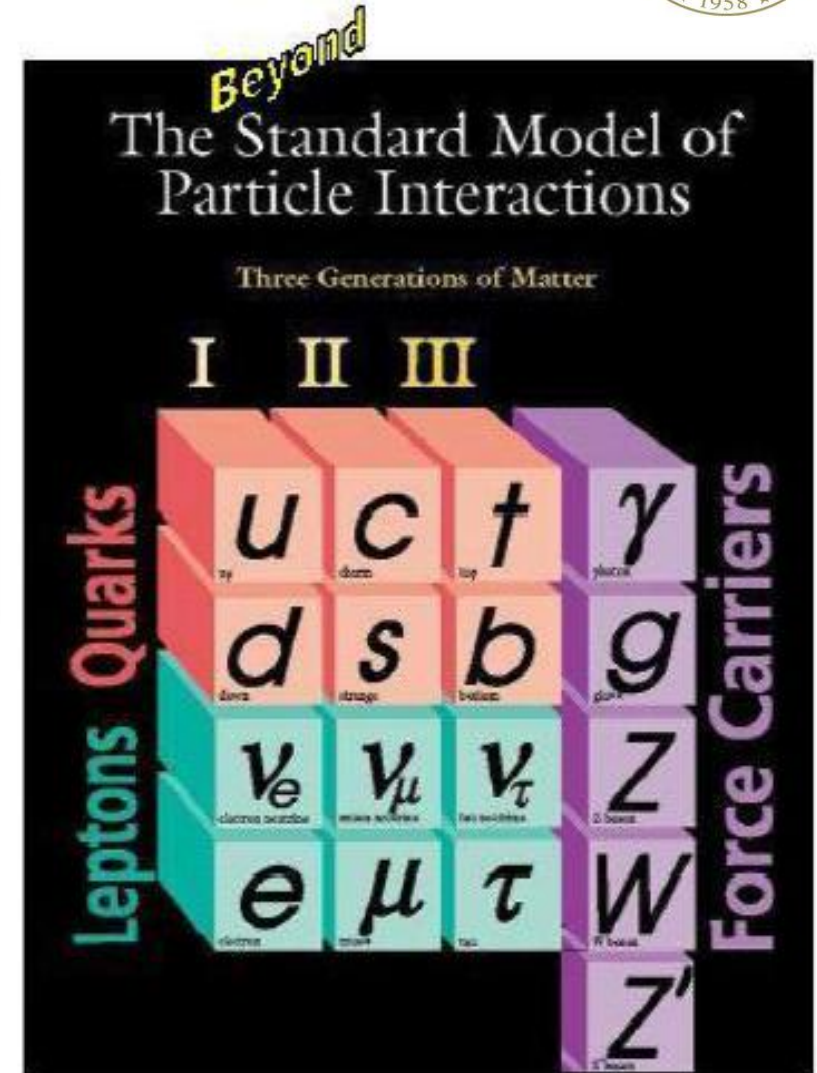


Table from H. Lee's talk



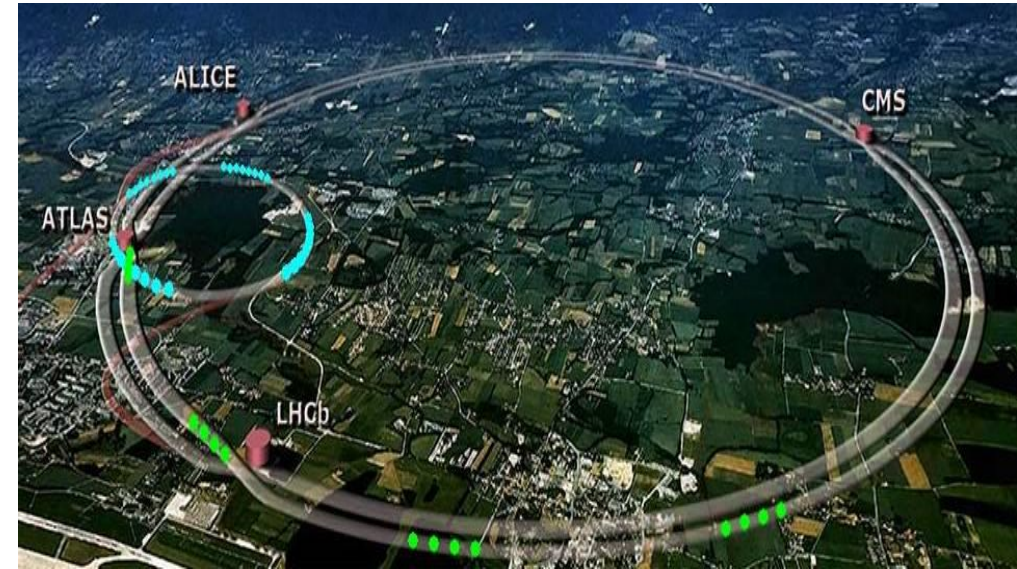
Large Hadron Collider(LHC)



- World's Largest and highest energy particle accelerator
- Built at CERN(European Center for Nuclear Physics), Geneva, Switzerland.
- 27 km long, 50-175 m underground.

Six Detectors:

- ATLAS: **A** Toroidal LHC Apparatu**S**
- ALICE: **A** Large Ion Collider **E**xperiment
- **CMS: Compact Muon Solenoid**
- LHCb: Large Hadron Collider **b**eauty
- LHCf: Large Hadron Collider **f**orward
- TOTEM: **T**otal **E**lastic and diffractive cross section **M**easurements



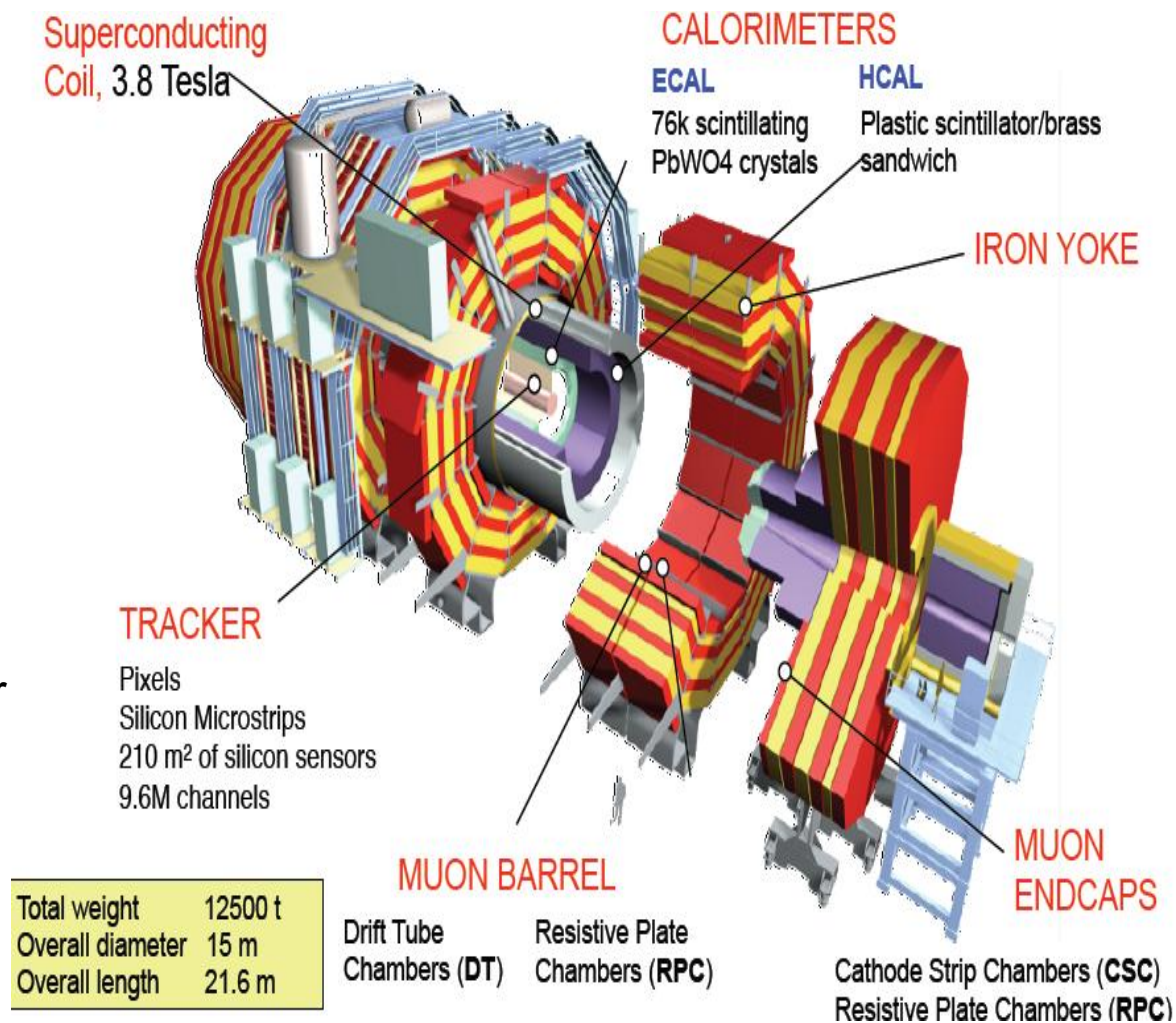
LHC tunnel ←



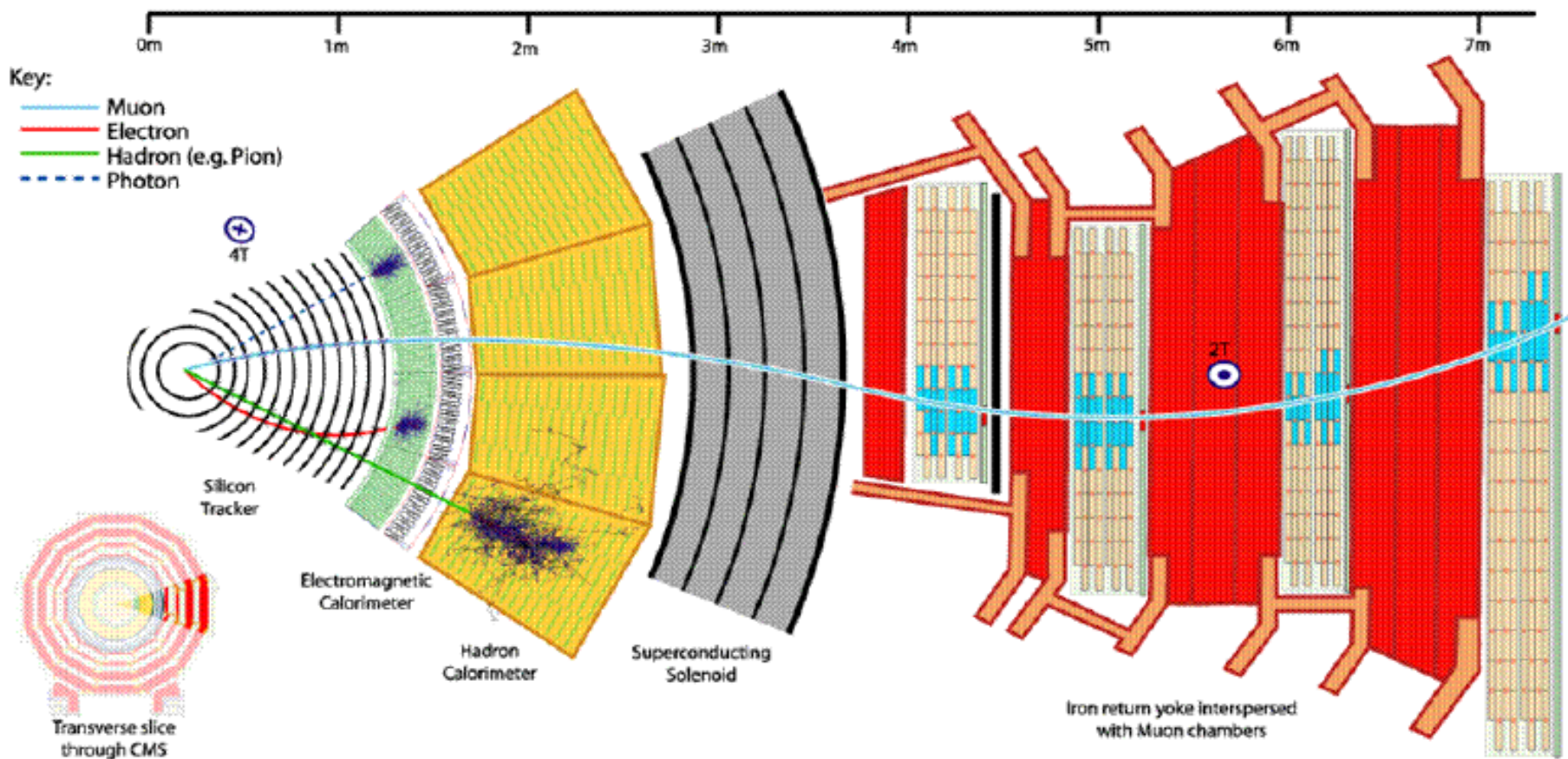
Compact Muon Solenoid(CMS)



- General purpose detector capable of studying many aspects of pp collision at 14 TeV CM energy.
- Contains subsystems to measure energy and momentum of photons, electrons, muons and other products of collisions.
- Explore physics at TeV scale, discover Higgs boson.
- Look for evidence of physics beyond standard model.
- Study aspects of heavy ion collisions.



Particle Detection in CMS



Particle detection strategy

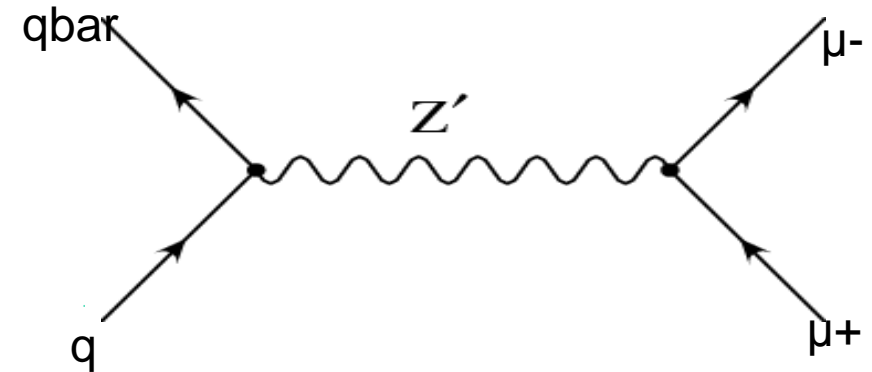


Z' search

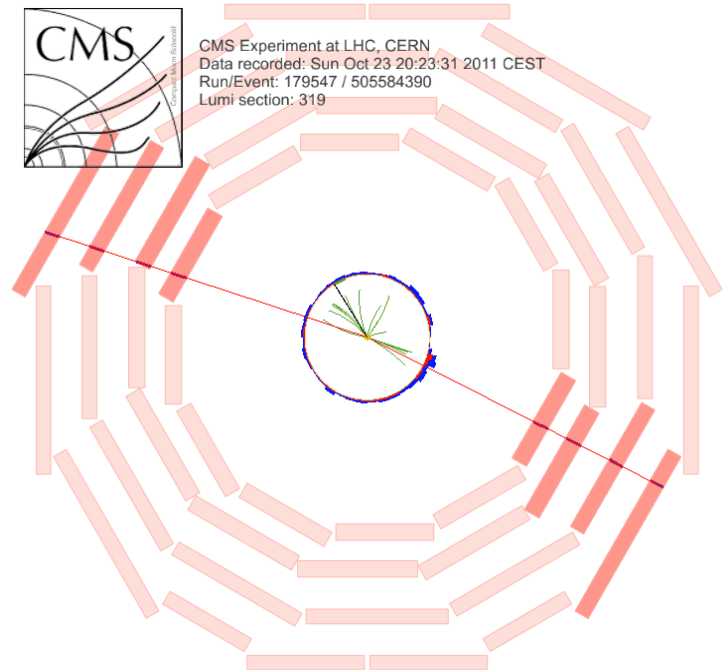


- Quark- antiquark annihilation and decay to opposite charge leptons.

$$pp \rightarrow Z' \rightarrow l^+ l^- + X, \text{ where } l = e, \mu, \tau$$



- LHC is the first opportunity to search for Z' in a high mass (TeV) range.
- $Z' \rightarrow \mu^+ \mu^-$ is one of the most promising channel for its discovery(Clean signature, low background.
- The search looks for high mass dilepton (dimuon) resonances.



Highest Mass(1379GeV/c²)
dimuon Event Display



Physics Analysis of 2011 Data



Run/event selection:

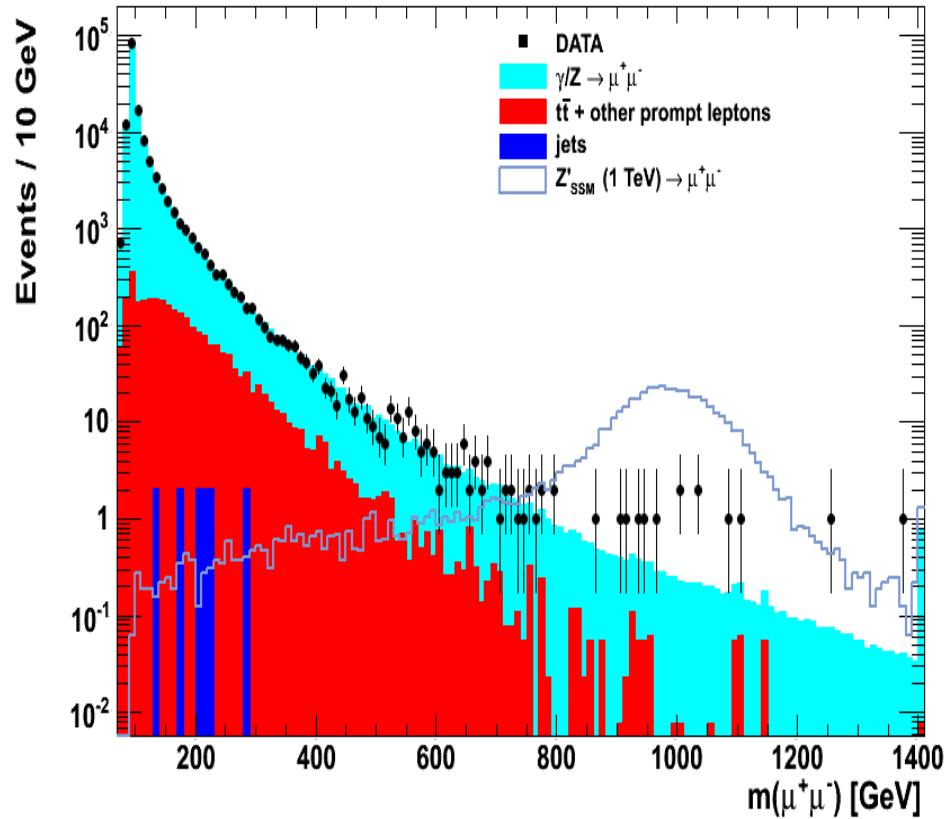
- Good runs of Muon Physics
- 2011 data (4.95 fb^{-1})
- **Luminosity(L):** The number of particles per unit area per unit time.
- **Integrated Luminosity ($\int L dt$):** Measure of total data collected in an accelerator
- **$N = \sigma \int L dt$** (No of events = Cross section x Integrated luminosity)
- Summer 11 **DY** ---> **Mu Mu** Sample:
 $N = 2148325$, $\sigma = 1631 \text{ pb}$
 $\Rightarrow \int L dt = N / \sigma = 2148325 / 1631 = 1317.18 \text{ pb}^{-1}$



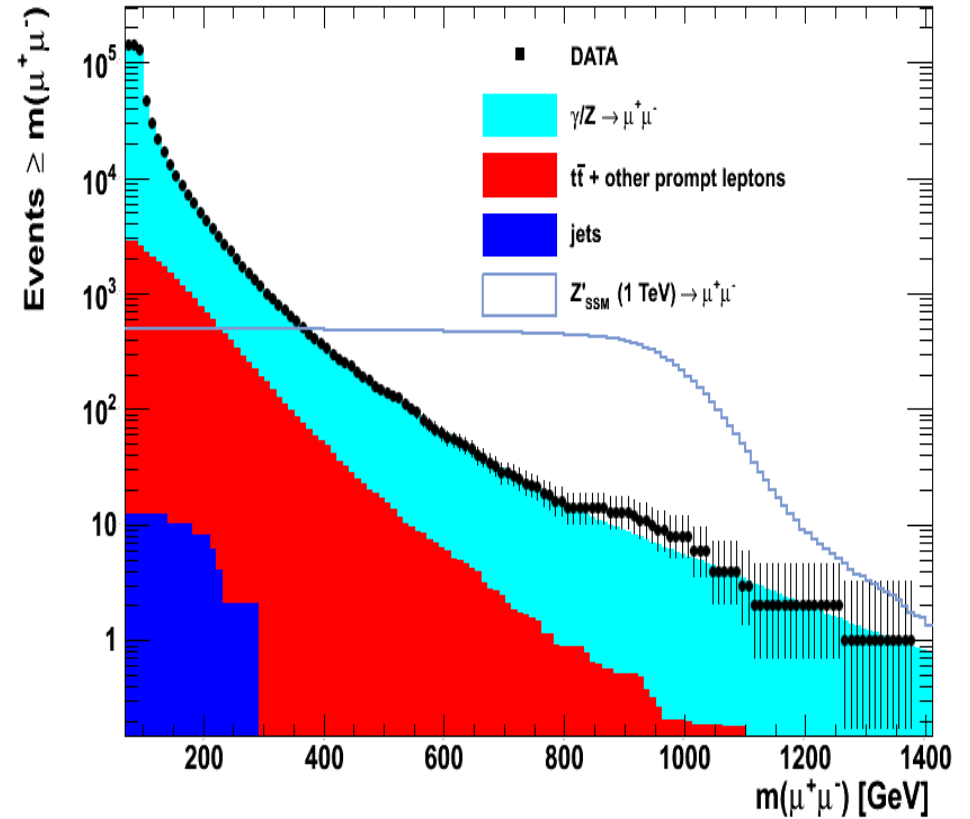
Dimuon Mass Spectrum



CMS 2011 preliminary $\sqrt{s} = 7 \text{ TeV}$ $\int L dt = 4.951 \text{ fb}^{-1}$



CMS 2011 preliminary $\sqrt{s} = 7 \text{ TeV}$ $\int L dt = 4.951 \text{ fb}^{-1}$





Z' mass limit (Dimuon channel)



$$R_\sigma = \frac{\sigma(pp \rightarrow Z' + X \rightarrow \ell\ell + X)}{\sigma(vv \rightarrow Z + X \rightarrow \ell\ell + X)}$$

- As there is no resonance in dimuon mass spectrum we set limit on Z' mass.
- The limit reported here for LHC result are using Bayesian method.

CDF(Collider Detector at Fermi lab) result:

$\sqrt{s} = 1.96 \text{ TeV}$, At 95% C.L:

$Z'_{\text{SSM}} = 1.071 \text{ TeV}/c^2 \text{ (4.6 fb}^{-1}\text{)}$

LHC 2010 result:

$\sqrt{s} = 7 \text{ TeV}$, At 95% C.L:

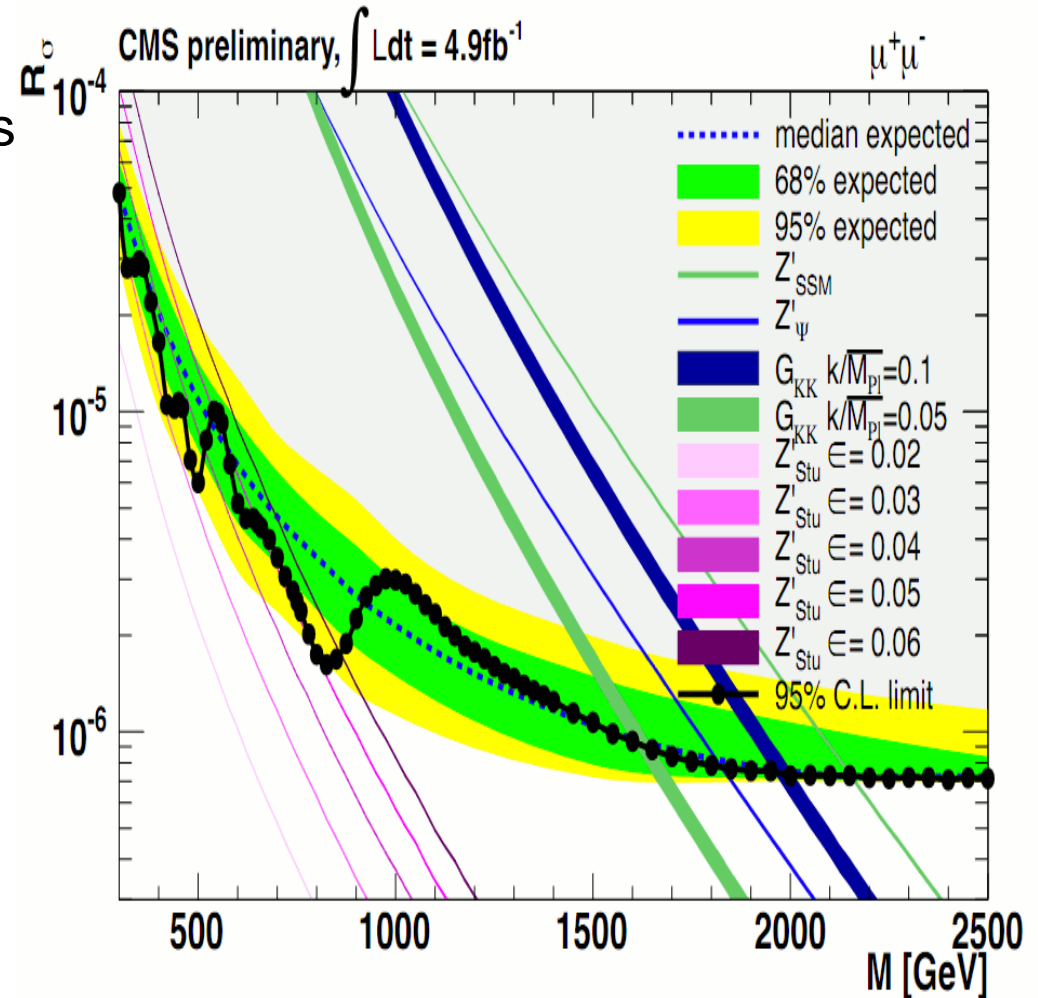
$Z'_{\text{SSM}} = 1.027 \text{ TeV}/c^2 \text{ (40 pb}^{-1}\text{)}$

LHC 2011 result:

$\sqrt{s} = 7 \text{ TeV}$, At 95% C.L:

$Z'_{\text{SSM}} \geq 1.78 \text{ TeV}/c^2 \text{ (1.1 fb}^{-1}\text{)}$

$Z'_{\text{SSM}} \geq 2.135 \text{ TeV}/c^2 \text{ (4.9 fb}^{-1}\text{)}$





Summary



- The Data / Simulation agreement looks good. Z' bump is not observed yet.
- The limit for lower Z' mass at 95% C.L, for dimuons is set at 2.135 TeV/c² (2011 analysis).
- We are working to see Z' bump in more data in 2012.