Searching for a Low-Mass Higgs Particle using Fermilab Collider Data

Jamie Ray (IMSA)

Craig Group (Fermilab)

created using
BCL easyPDF
Printer Driver
Click here to purchase a license to remove this image

Introduction

- Worked at Fermilab CDF Experiment
- Searching for Higgs particle
- Predicted by Standard Model of physics
- Accounts for particle mass
- Inquiry Question:
  - Does a Higgs particle exist?
  - If we can’t find it, what can we say about its existence?

created using
BCL easyPDF
Printer Driver
Click here to purchase a license to remove this image

Fermilab Background

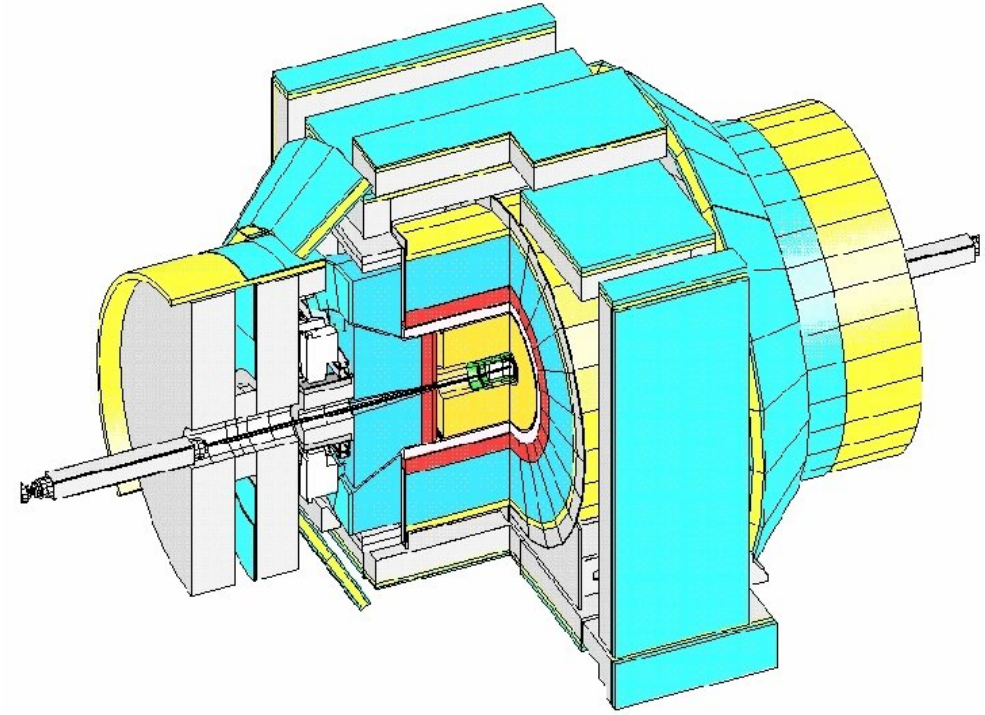
- Particle collider (Tevatron) and two detectors
- 4 mile ring
- Superconducting magnets
- Collides protons at 99.99…% speed of light
- Experimental physics from particles created by collision

Aerial view of the Tevatron [1]

created using
BCL easyPDF
Printer Driver
Click here to purchase a license to remove this image

Detector Apparatus

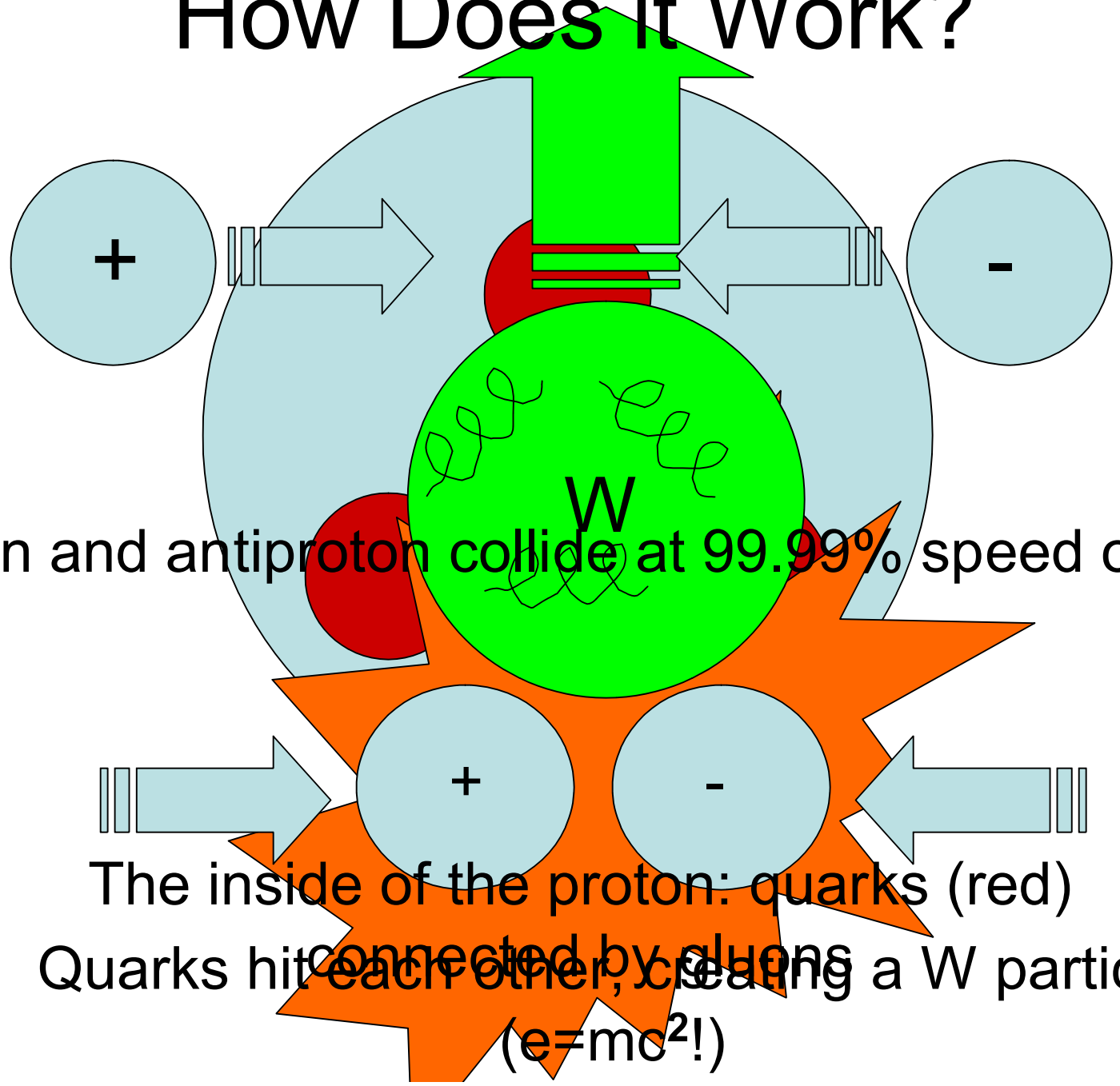
- 3 stories
- 5600 tons
- Two regions
- Records Tevatron collisions
- Measures data to help identify particles
- Probability that particles will be identified correctly (Efficiency)



Detector composition [1]

created using
BCL easyPDF
Printer Driver
Click here to purchase a license to remove this image

How Does it Work?

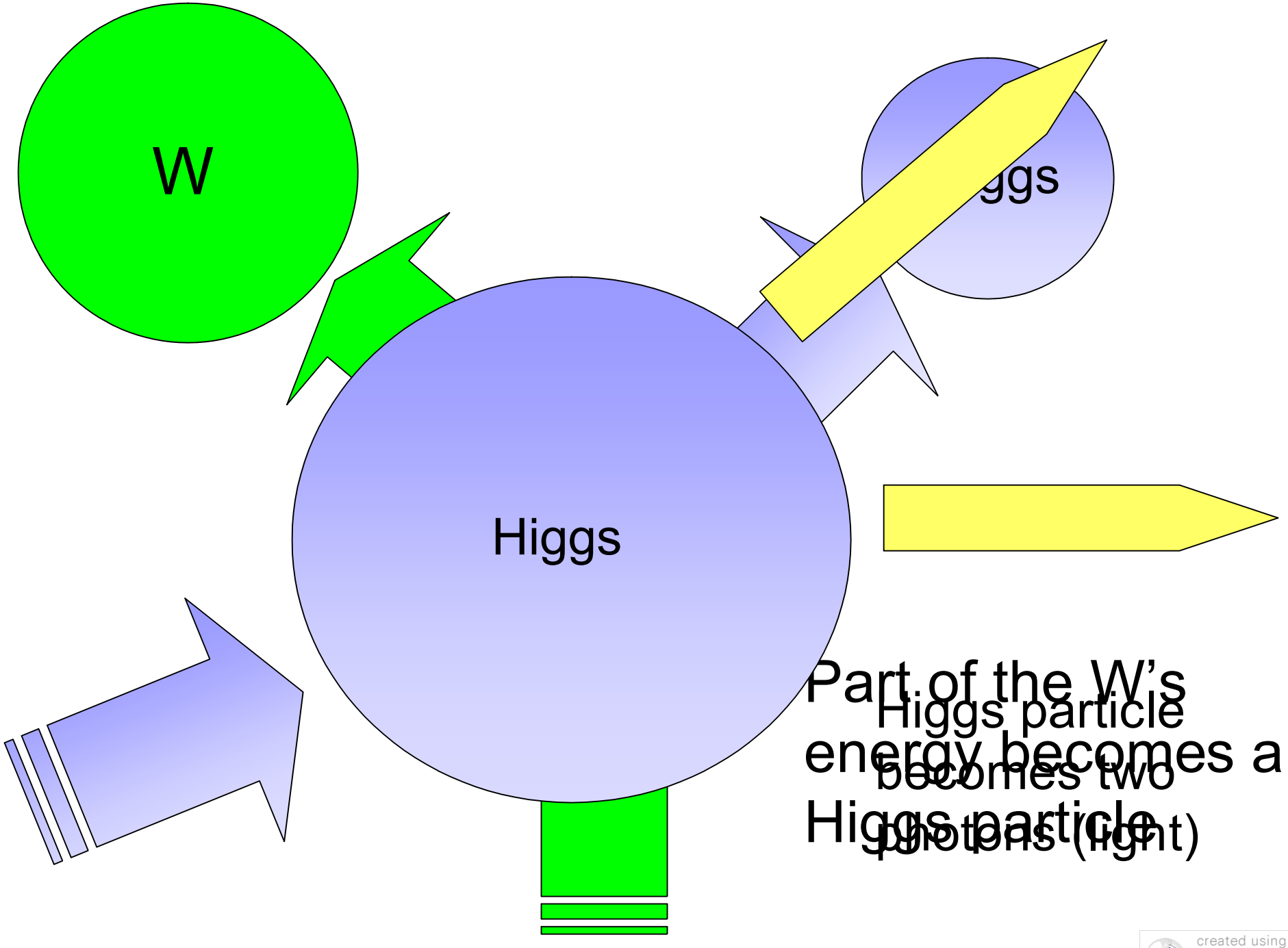


Proton and antiproton collide at 99.99% speed of light

The inside of the proton: quarks (red) connected by gluons

Quarks hit each other, creating a W particle ($e=mc^2$!)

created using
BCL easyPDF
Printer Driver
Click here to purchase a license to remove this image



Part of the W's energy becomes a Higgs particle

Higgs particle becomes two photons (light)

created using
BCL easyPDF
Printer Driver
Click here to purchase a license to remove this image

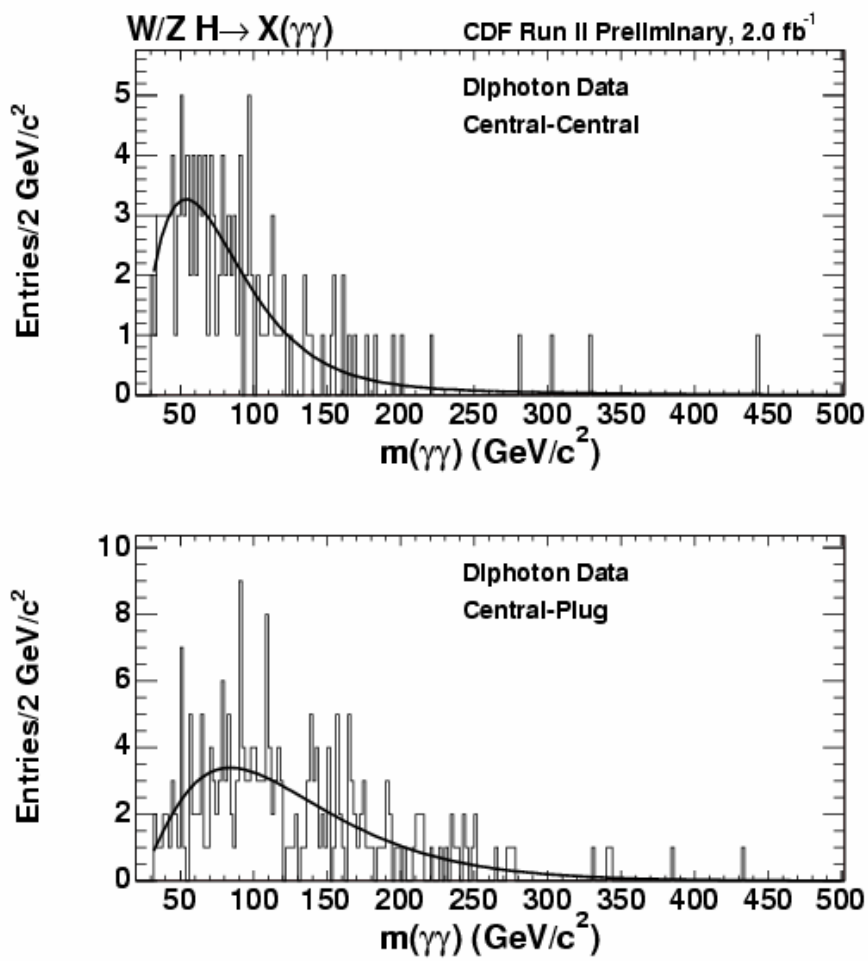
Importance

- Subatomic particles have different masses (or none at all)
- Higgs particle creates Higgs field
- Moving objects interact with field, giving them ‘mass’
- Proof of current particle physics model
- Searched for across the world (40 years)
- Conversion to photons is special case

created using
BCL easyPDF
Printer Driver
Click here to purchase a license to remove this image

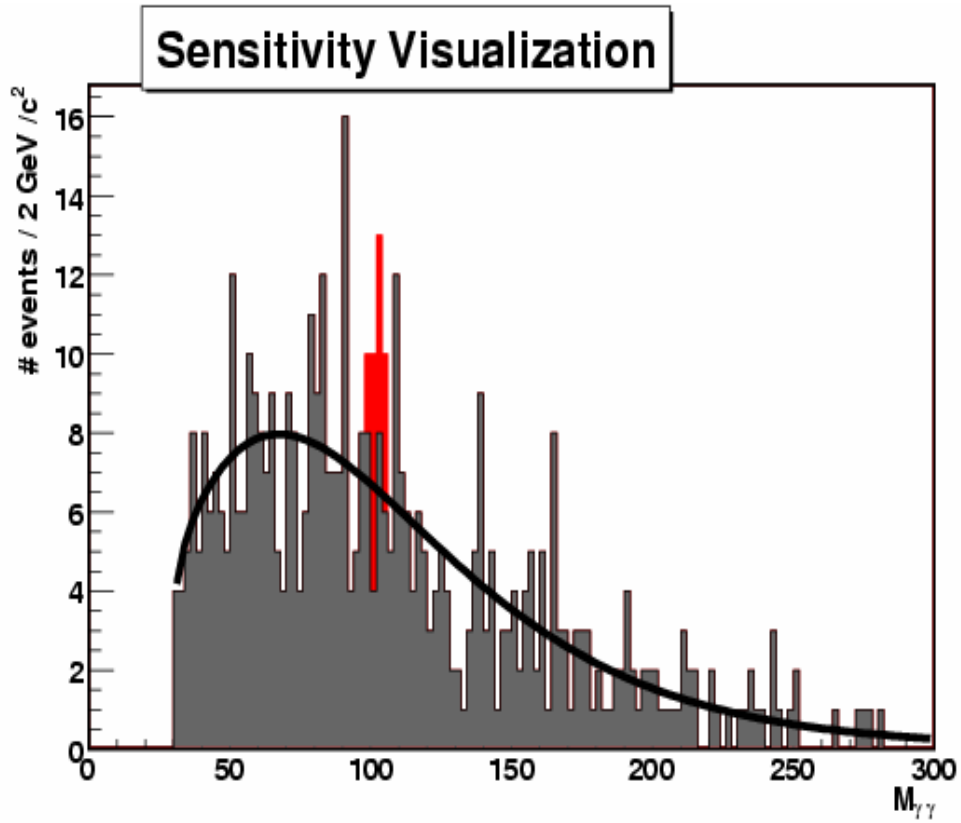
Photon Analysis

- Detector records photon events
- Analyze to find photon pairs
- Series of requirements imposed
- ‘Fakes’ reduced but not eliminated
- Examined for peaks



created using
BCL easyPDF
Printer Driver
Click here to purchase a license to remove this image

Sensitivity to Higgs Signal

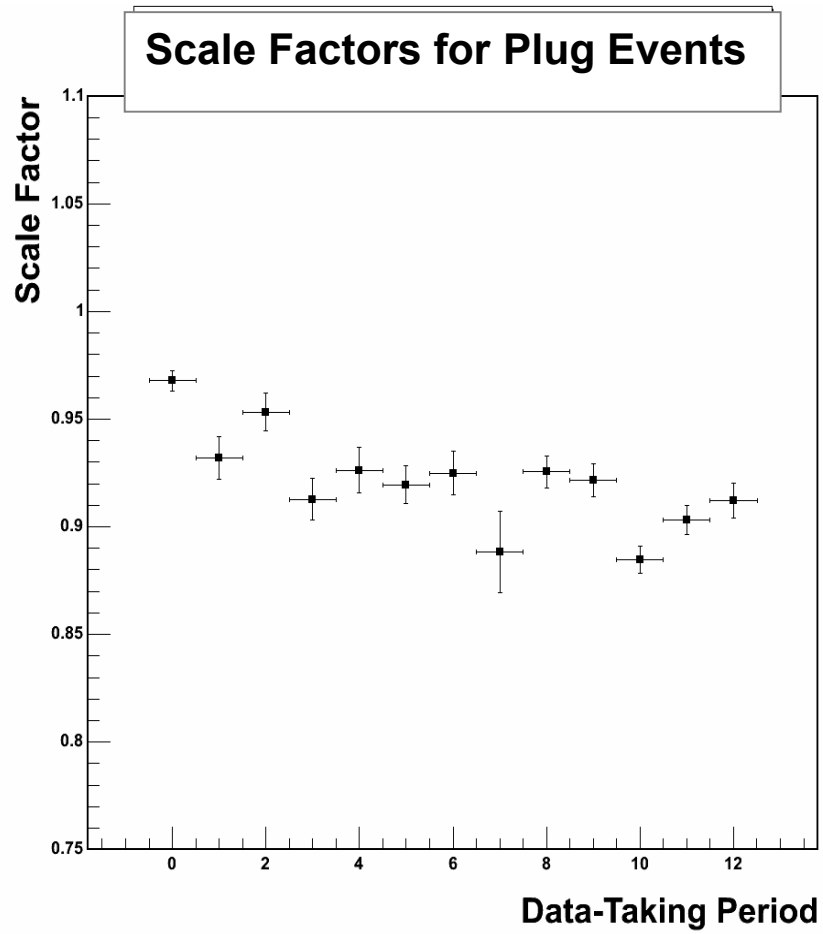


- No significant peaks
- N = LσEBr
- N is number of events detected (sensitivity)
- L is luminosity
- σ (production probability) and Br (decay probability) come from theory
- E is efficiency of identification (from simulation)

created using
BCL easyPDF
Printer Driver
Click here to purchase a license to remove this image

Scale Factor Study

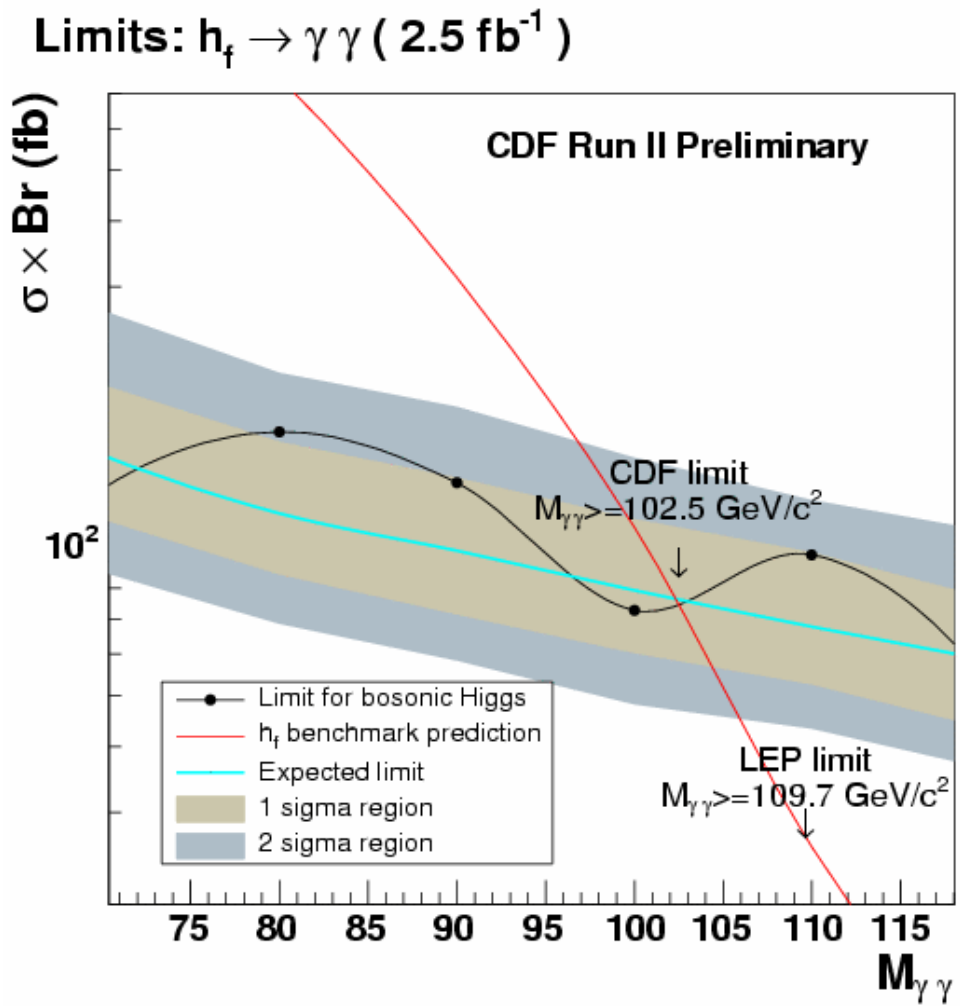
- Use simulation to find E
- Scale factor accounts for imperfection
- Compare ID efficiency from simulation and detector
- Scale factor = ratio of efficiencies
- 97.2 for central detector
- 94.3 for plug detector



created using
BCL easyPDF
Printer Driver
Click here to purchase a license to remove this image

Limit Results

- Data yields limit on N
- Equation yields upper limit on σ and Br
- σ and Br also predicted by theory
- Graph prediction against limit:
- Intersection at 102.5 GeV



created using
BCL easyPDF
Printer Driver
Click here to purchase a license to remove this image

Discussion

- Both incorporate all available data

- Scale Factor:
  - Useful to other CDF photon studies
  - Applicable to future work

- Higgs:
  - Highest for this type of collider
  - 100 GeV most recent published result [2]
  - Narrows the range of the Higgs

created using
BCL easyPDF
Printer Driver
Click here to purchase a license to remove this image

Future Work

- More data improves limit
- Higher energy improves limit (LHC)
- At higher energy: search conversion to W particle instead of photons
- Writing a note and working towards publication

created using
BCL easyPDF
Printer Driver
Click here to purchase a license to remove this image

Summary

- Great way to see physics research
- Many opportunities to participate
- Made progress on the limit
- Result may help future studies
- More fun than I expected!

- Acknowledgements:
  - Mike Lindgren, FNAL
  - Craig Group, FNAL
  - Ray Culbertson, FNAL

created using
BCL easyPDF
Printer Driver
Click here to purchase a license to remove this image

References

[1] CDF. (2005). “CDF Pictures.” Fermi National Accelerator Laboratory. Batavia, IL. [Online]. Available: http://www-cdf.fnal.gov/events/CDFPictures.html

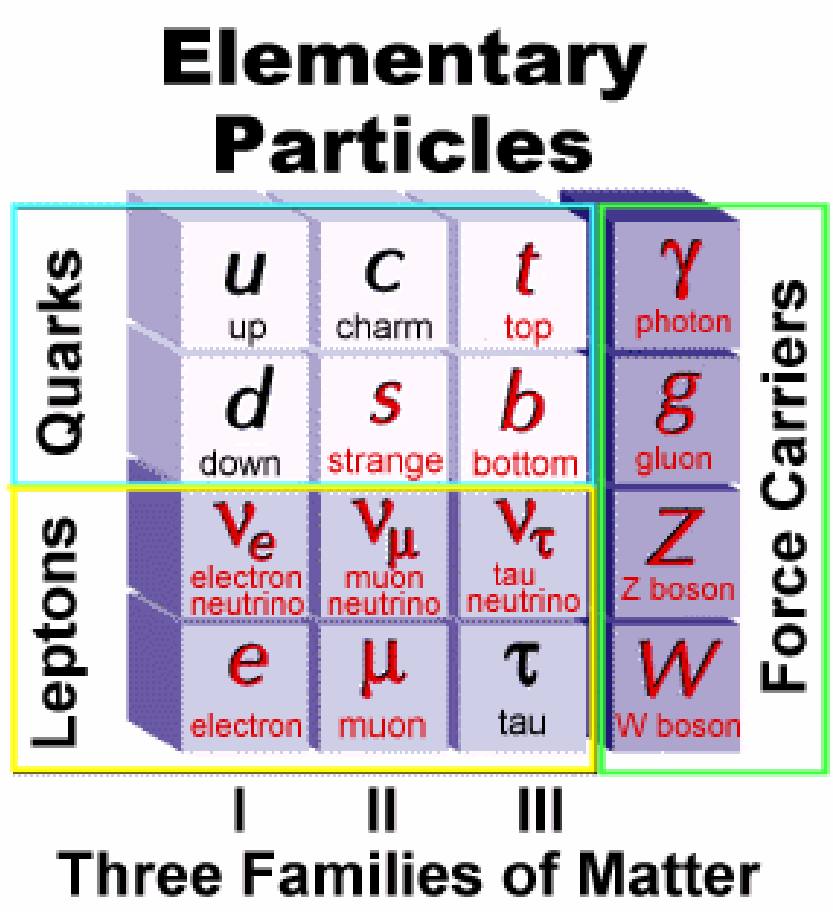
[2] The D0 Collaboration. (2008). “Search for the H -> γγ with the D0 detector.” Fermi National Accelerator Laboratory. Batavia, IL. [Online]. Available: http://arxiv.org/PS_cache/arxiv/pdf/0803/0803.1514v1.pdf

created using
BCL easyPDF
Printer Driver
Click here to purchase a license to remove this image

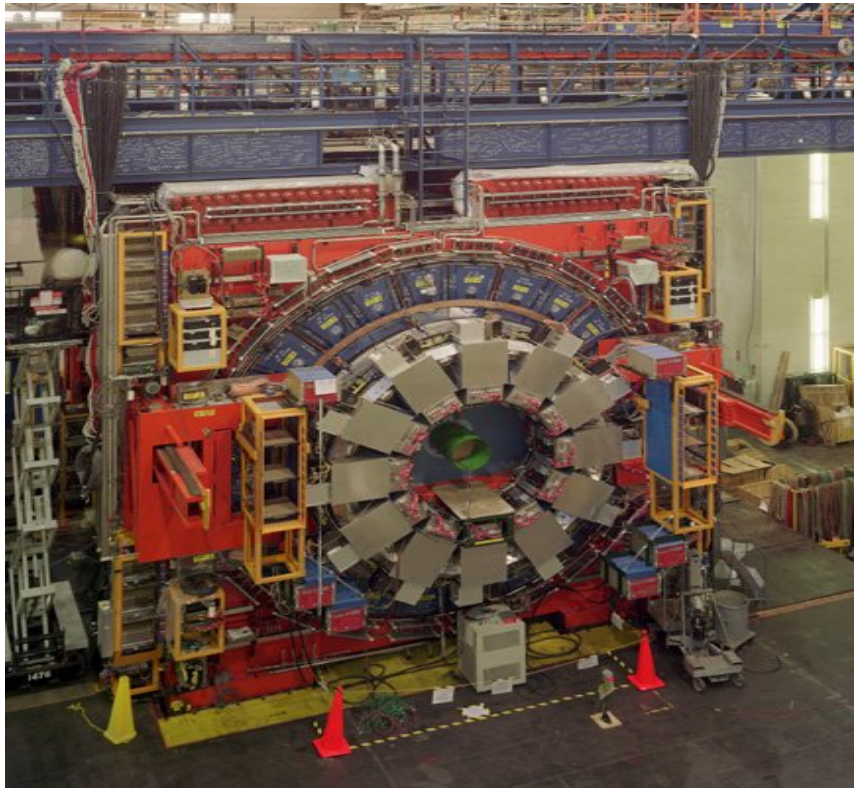
BACKUP

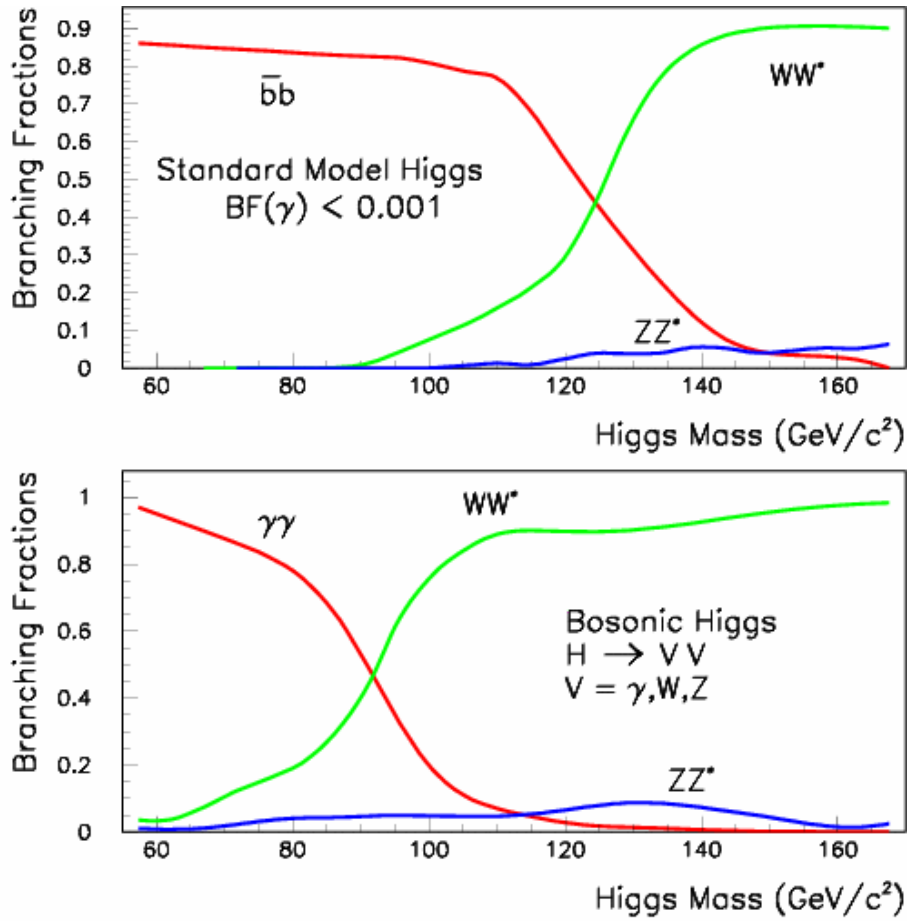
created using
BCL easyPDF
Printer Driver
Click here to purchase a license to remove this image

Figures

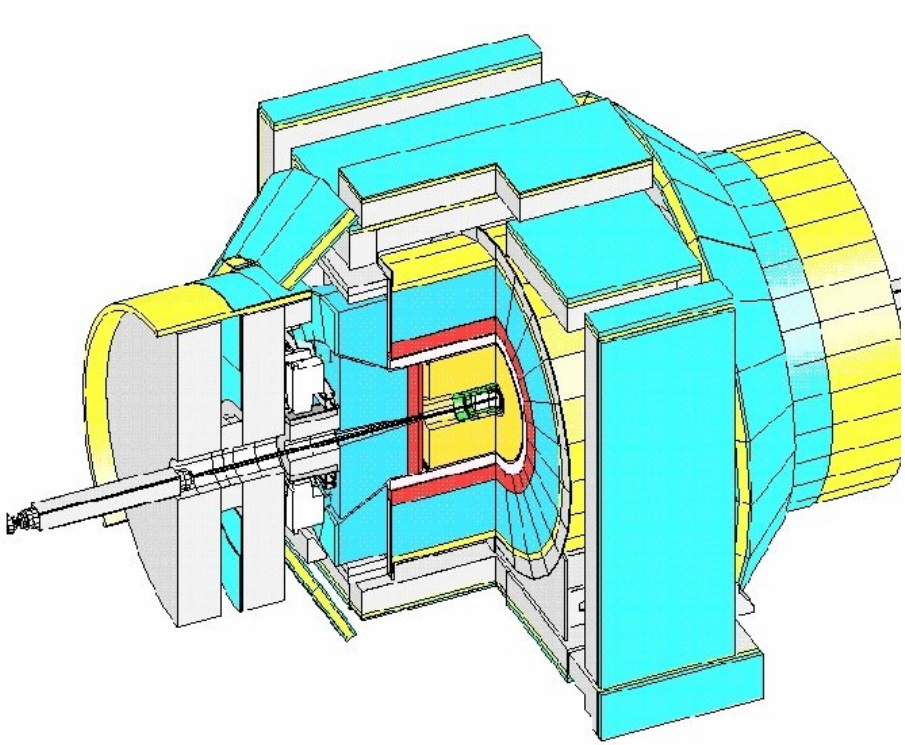


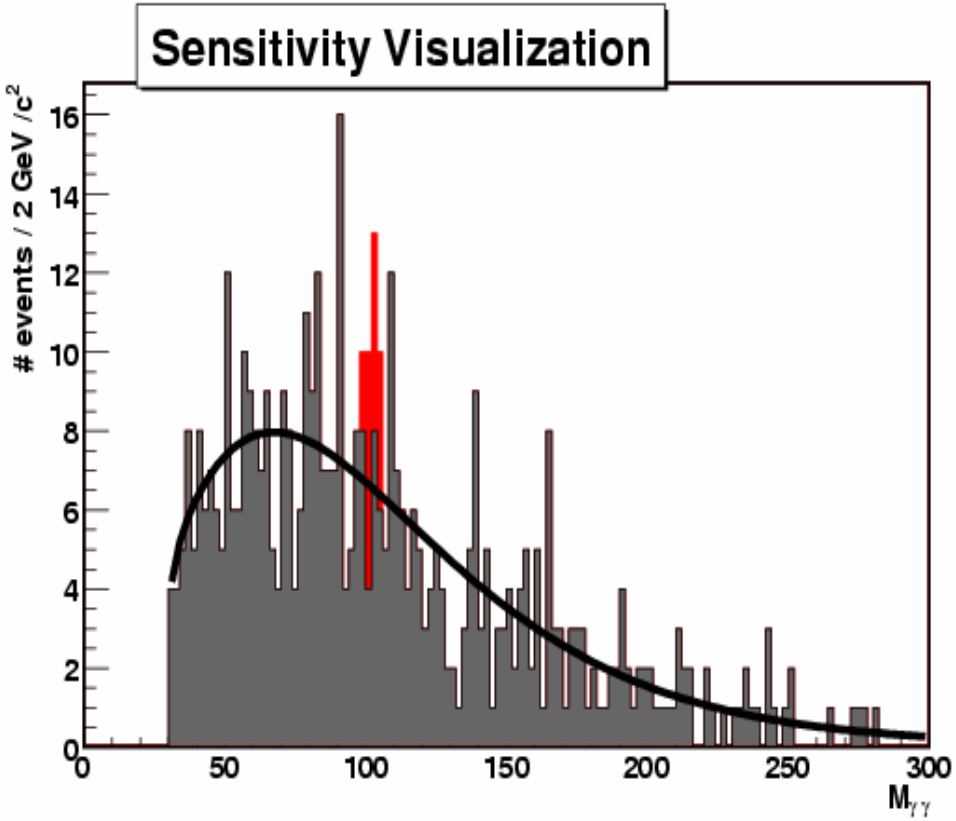
created using
BCL easyPDF
Printer Driver
Click here to purchase a license to remove this image



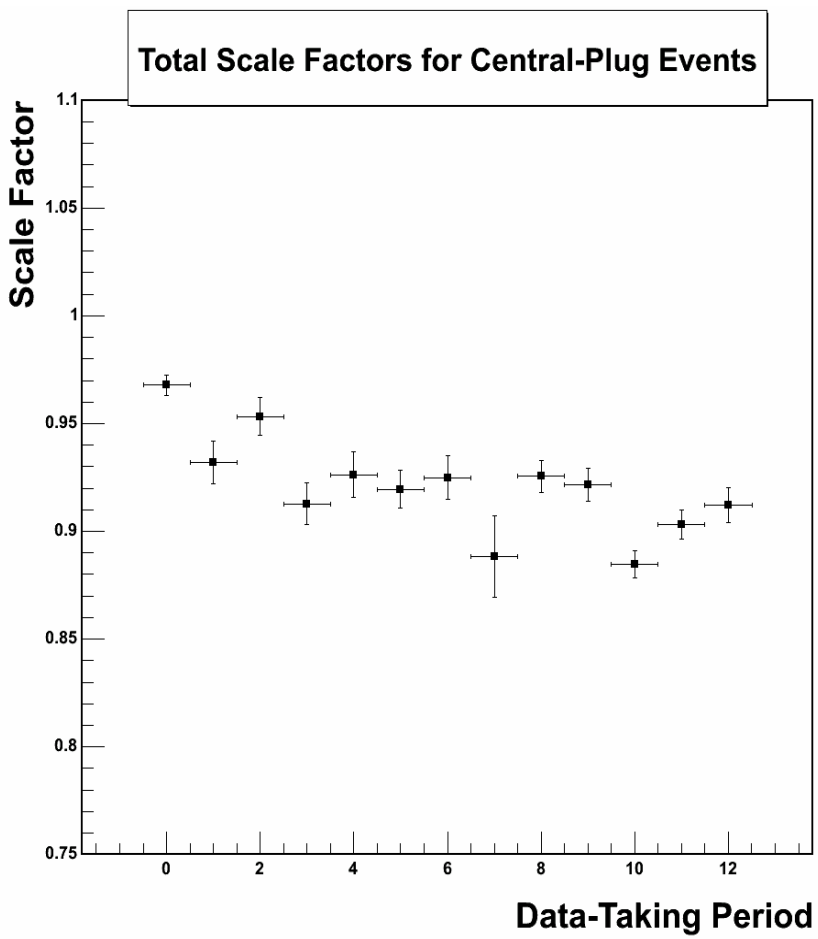


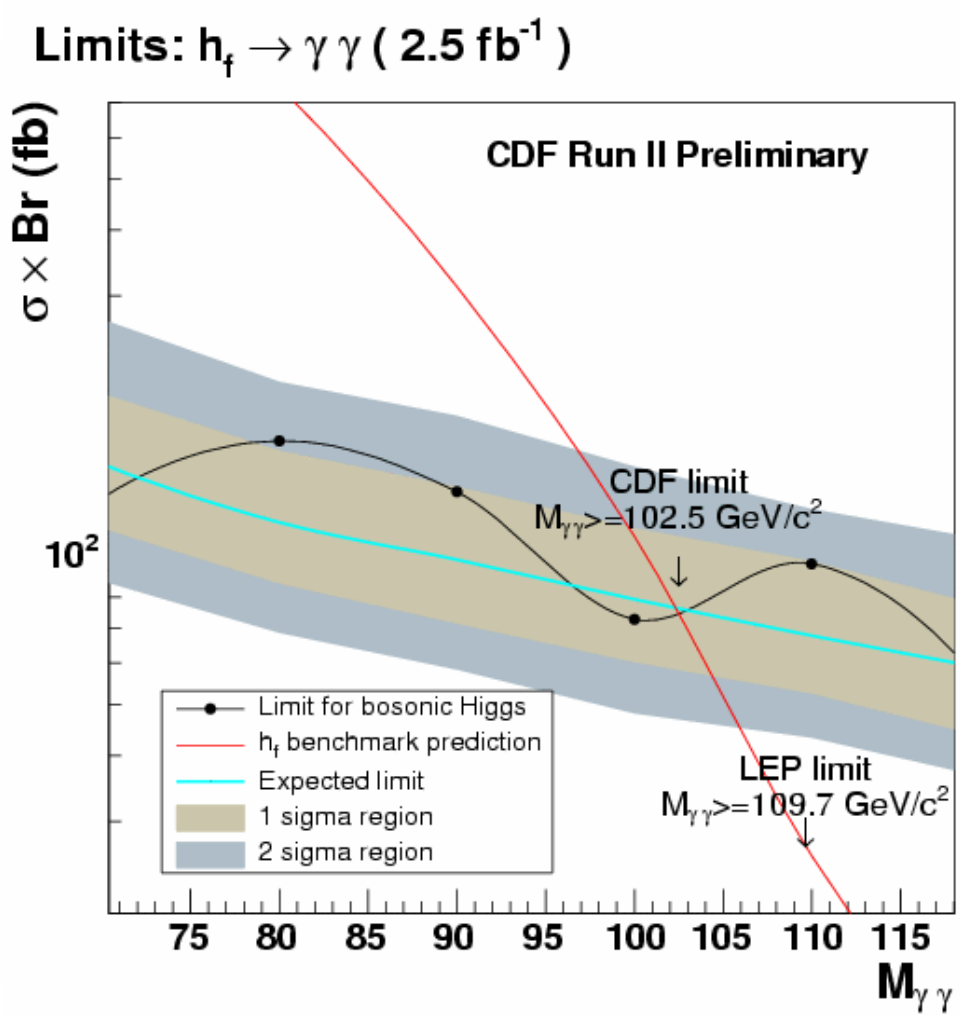
created using
BCL easyPDF
Printer Driver
Click here to purchase a license to remove this image





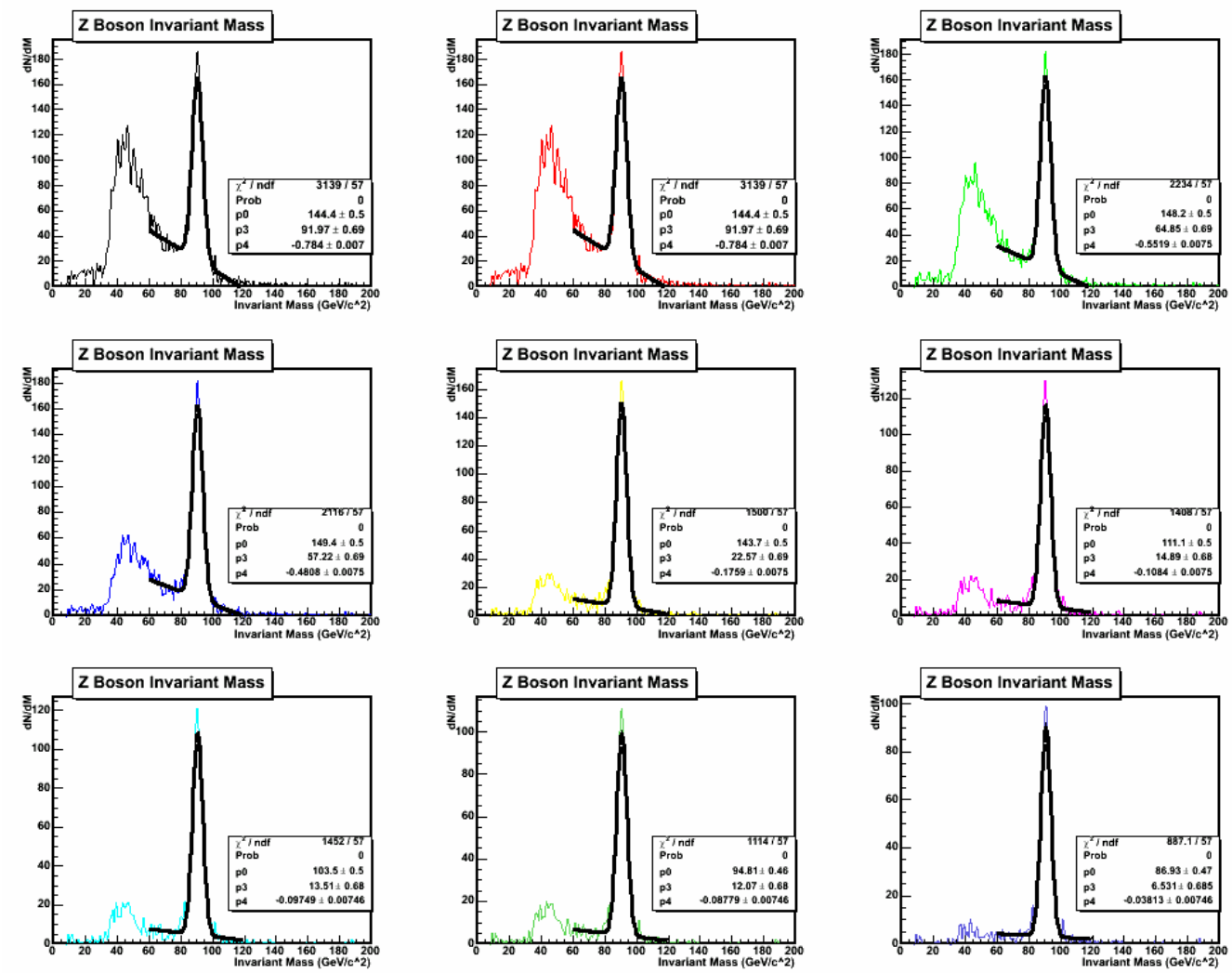
created using
BCL easyPDF
Printer Driver
Click here to purchase a license to remove this image





created using
BCL easyPDF
Printer Driver
Click here to purchase a license to remove this image

Scale Factor



created using
BCL easyPDF
Printer Driver
Click here to purchase a license to remove this image

Systematics

- PDF ~ 2
- IFSR ~ 4
- Energy scale ~ .1 central .8 plug
- Conversions ~ 2
- 8.7 central 9.4 plug
- Not completely understood

created using
BCL easyPDF
Printer Driver
Click here to purchase a license to remove this image