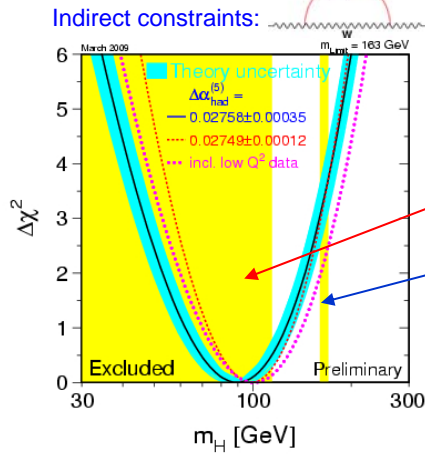


VI. Experimental Tests of the Standard Model

5. Higgs boson search

The only missing particle of the Standard Model



- Indirect constraints from precision electroweak measurements (not a proof that the Higgs really exists!)
- Direct searches at LEP: $m_H > 114.4 \text{ GeV}$ @ 95 % CL
- Direct searches at TEVATRON: excluded $160 \text{ GeV} < m_H < 170 \text{ GeV}$ @ 95% CL
- Direct searches at LHC

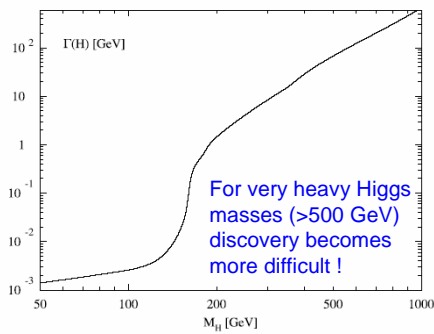
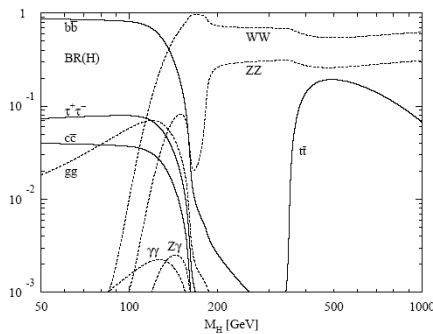
$M_H < 163 \text{ GeV}$ @ 95 % C.L.

Status March 2009

Higgs decay widths / branching ratios

$$\Gamma(H \rightarrow f\bar{f}) = N_c \frac{G_F m_f^2 M_H}{4\pi\sqrt{2}} \left(1 - \frac{4m_f^2}{M_H^2}\right)^{3/2}$$

$$\Gamma(H \rightarrow WW, ZZ) \sim \frac{G_F M_H^3}{8\pi\sqrt{2}} \times (\text{kinematical Factor})$$



VI. Experimental Tests of the Standard Model

5.1 Direct Higgs search at LEP

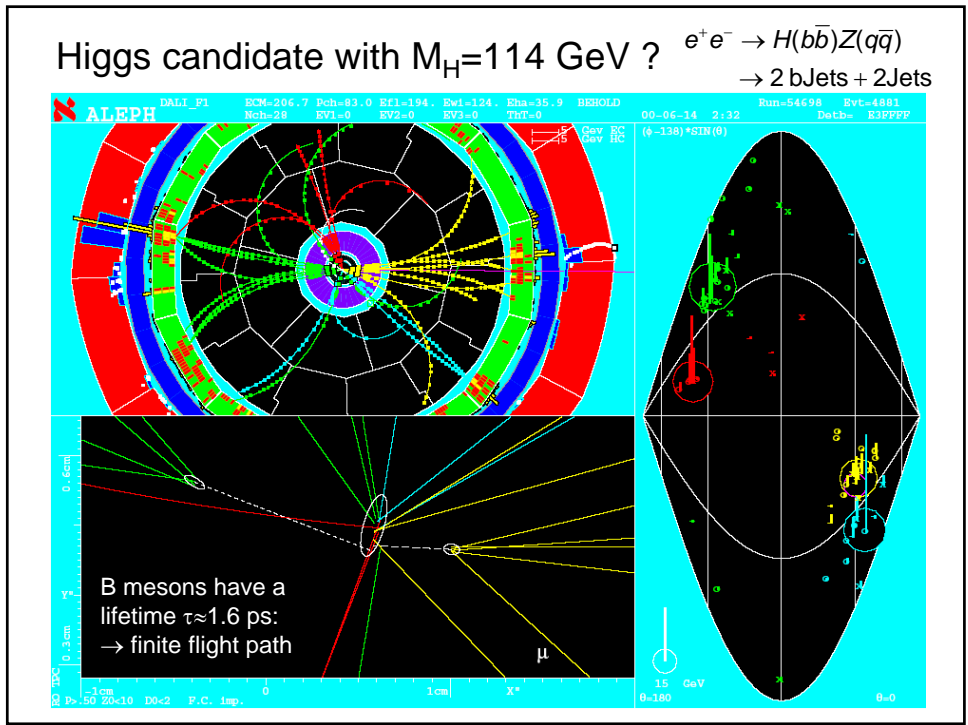
$$\Gamma(H \rightarrow f\bar{f}) \sim \frac{G_F m_f^2 M_H}{4\pi\sqrt{2}}$$

Production

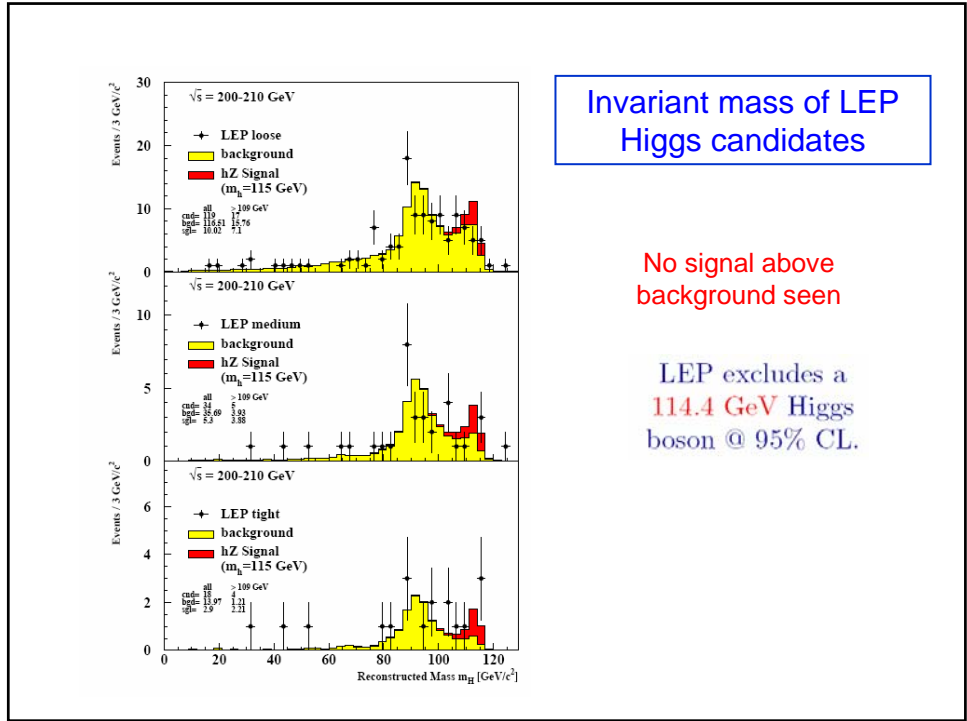
Decay

	4-Jet-Kanal 51%	Main background: WW → qq̄q̄q, ZZ → bbq̄q̄ QCD 4jets
	Neutrino-Kanal 15%	WW → qq̄lν, ZZ → qq̄ττ
	Tau-Kanal 2.4%	WW → qq̄τν, ZZ → qq̄ττ QCD (low-mult. jets)
	Lepton-Kanal 4.9%	ZZ → bbll

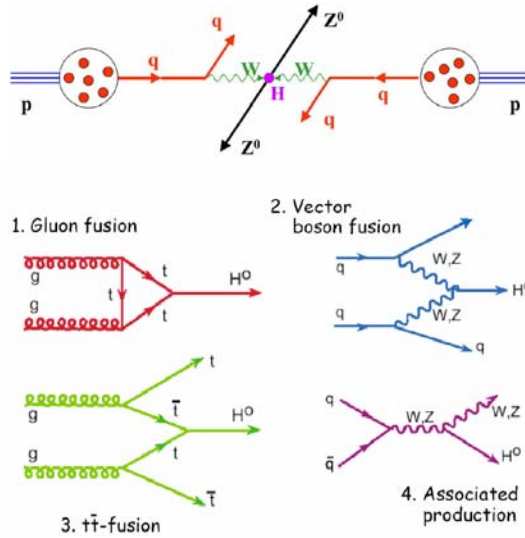
Higgs search at LEP includes 80% of the final states, selection efficiency ~40 - 50%



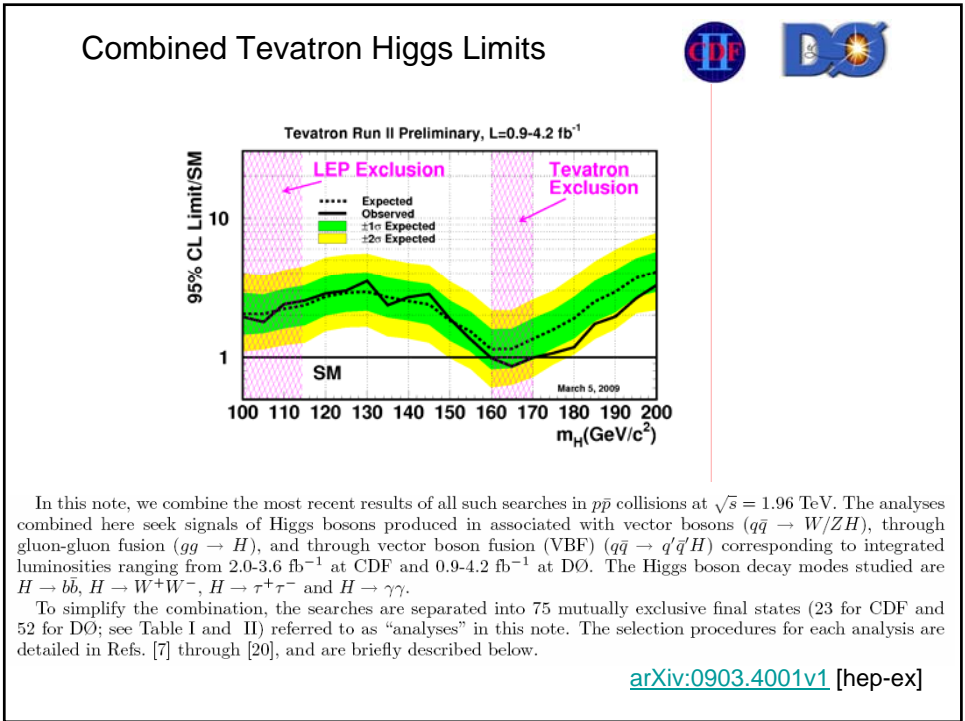
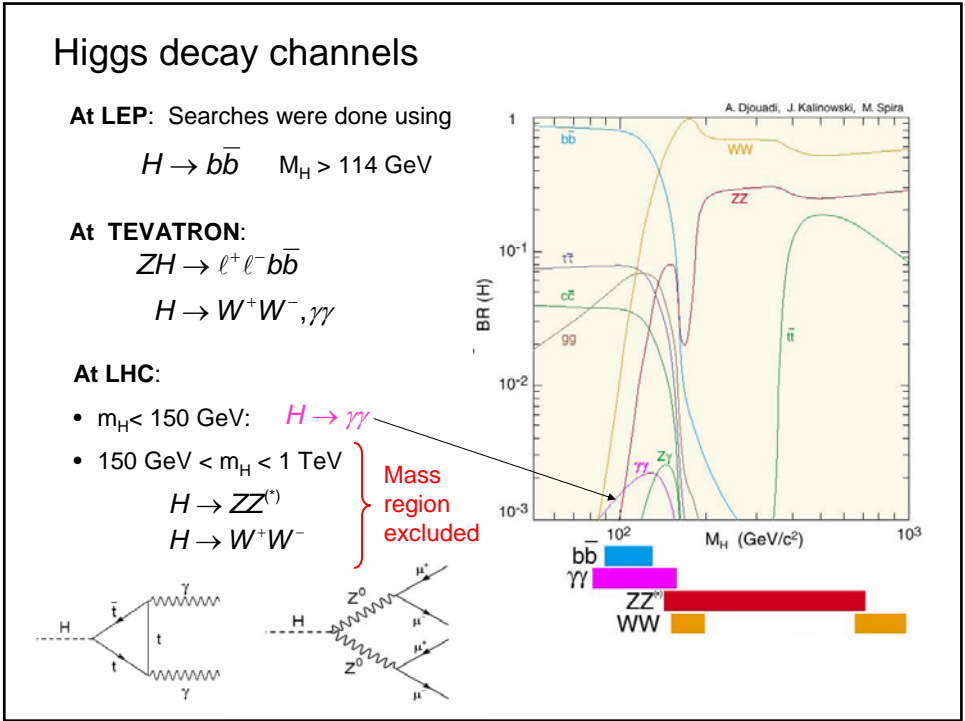
VI. Experimental Tests of the Standard Model



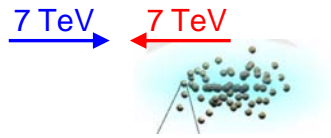
5.2 Higgs production at pp collider



VI. Experimental Tests of the Standard Model



Large Hadron Collider



Proton – Proton bunches:

2835 x 2835

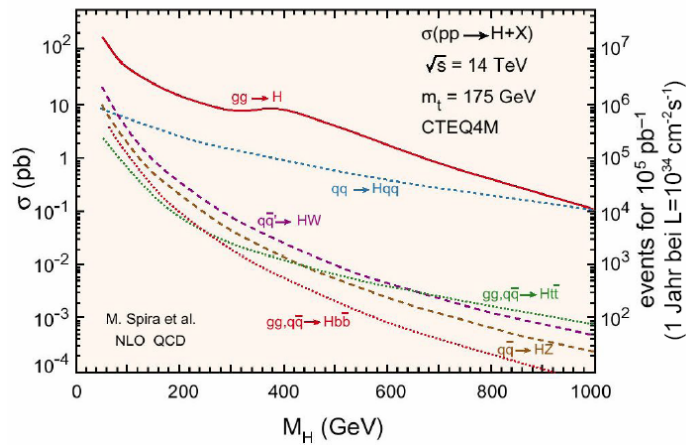
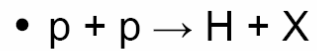
10^{11} protons / bunch

Crossing-Rate: 40 MHz

collisions: 10^8 bis 10^9 Hz

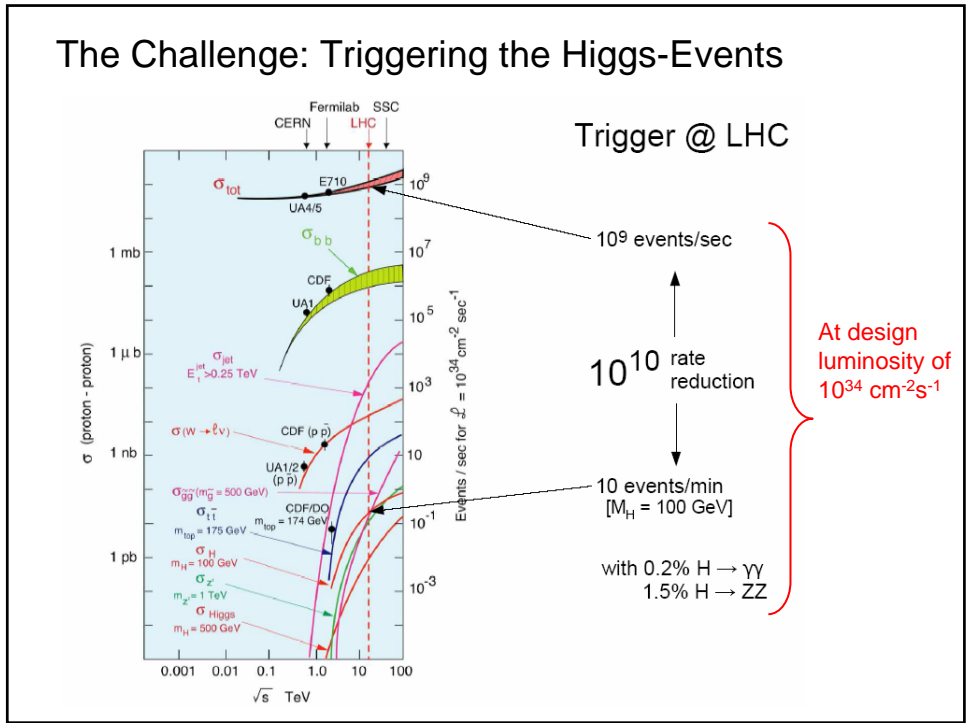
$E_{\text{CMS}} = 14 \text{ TeV}$

Higgs production at LHC (pp at 14 TeV)



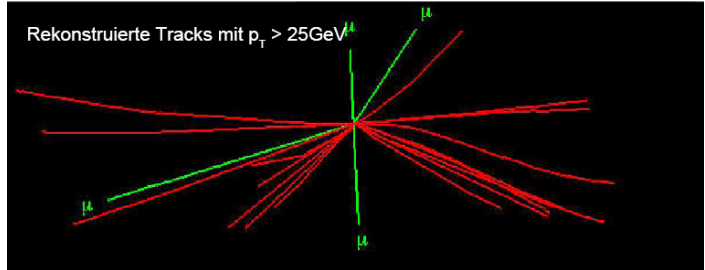
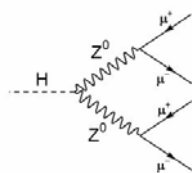
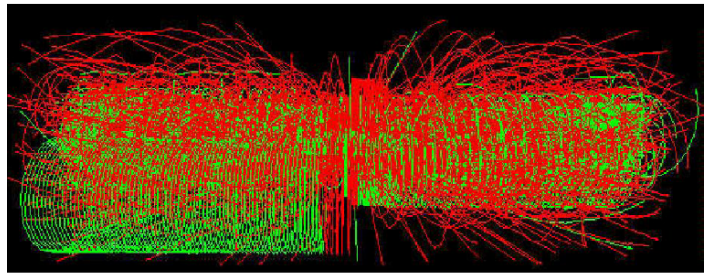
VI. Experimental Tests of the Standard Model

The Challenge: Triggering the Higgs-Events



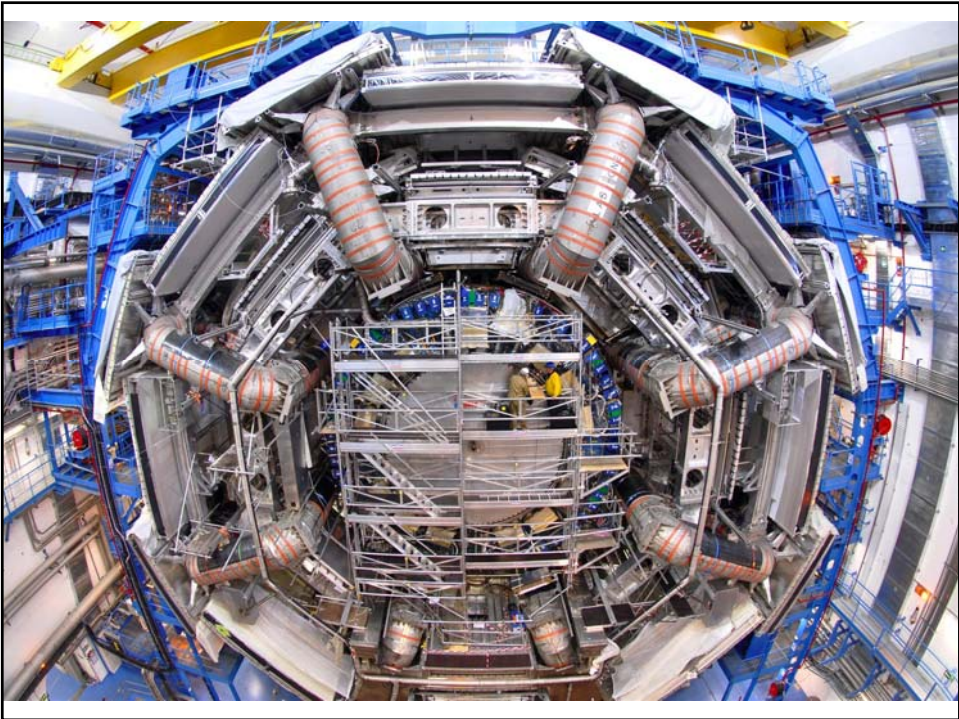
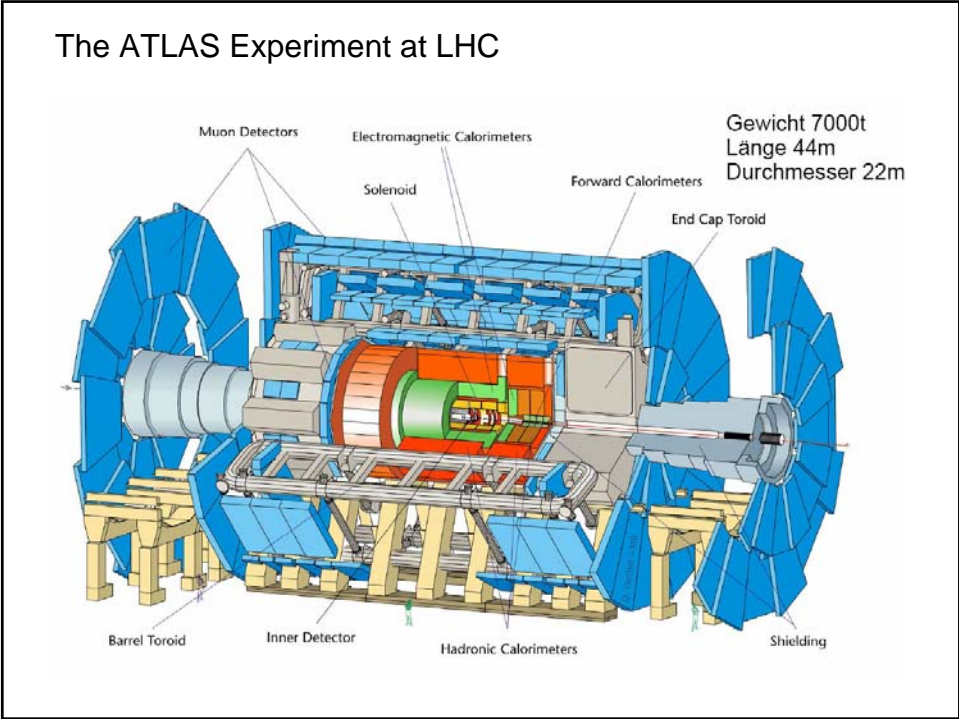
Simulated $H \rightarrow ZZ \rightarrow 4\mu$ event at LHC

- 20 pp interaction / event
- Large number of particles

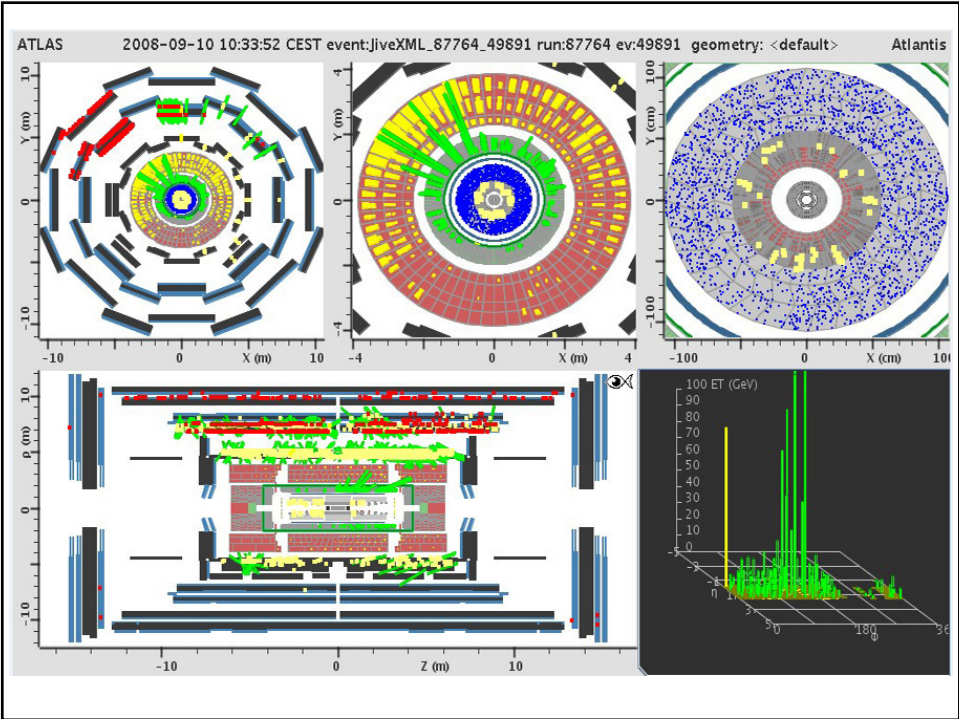
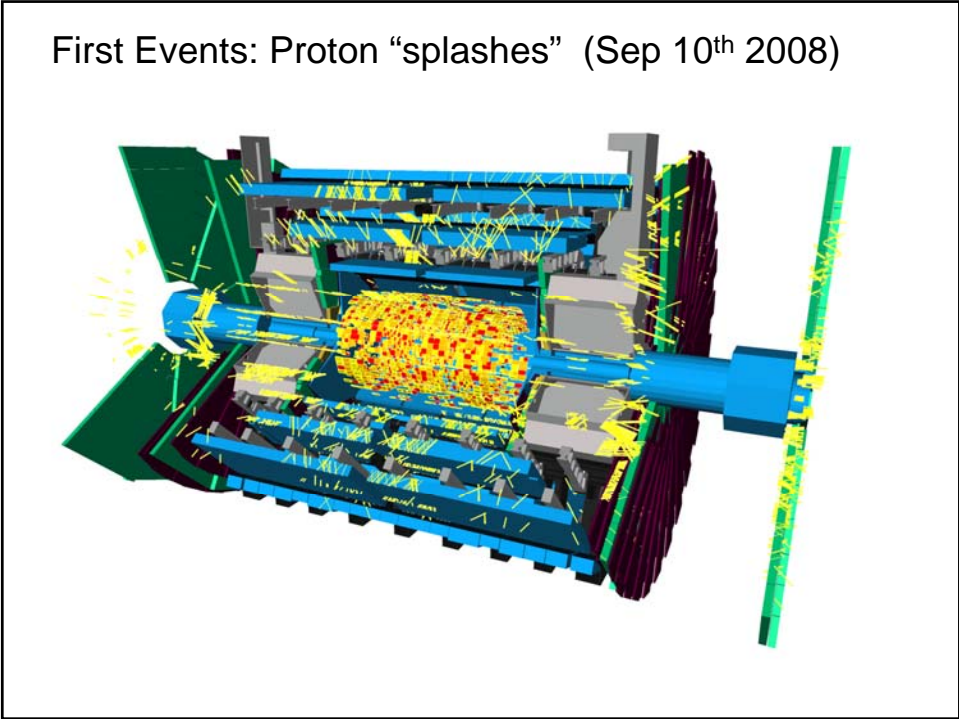


To trigger and to reconstruct these events is an exp. challenge.

VI. Experimental Tests of the Standard Model

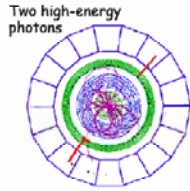


VI. Experimental Tests of the Standard Model



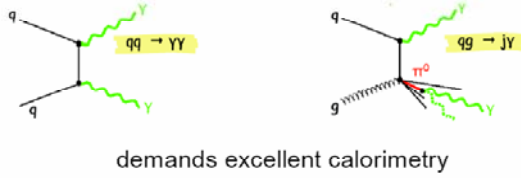
VI. Experimental Tests of the Standard Model

Higgs search: $H \rightarrow \gamma \gamma$ (simulation)

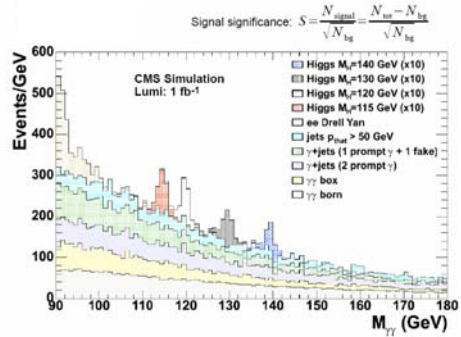


Main backgrounds:

- 2γ production: **irreducible** background
- γj and jj production: **reducible** background
jet rejection of $> 10^3$ is required



demands excellent calorimetry

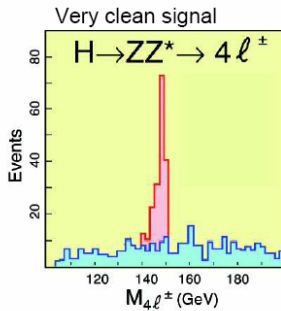
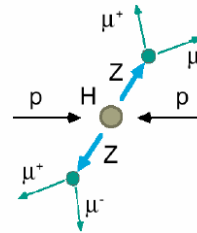


“Golden” Higgs decay channel: $H \rightarrow ZZ \rightarrow \mu\mu\mu\mu$

(Simulation)

Discovery potential:
130 – 600 GeV

4 leptons $p_T > 20$ GeV



Backgrounds:

- $tt \rightarrow Wb Wb \rightarrow l\nu cl\nu l\nu cl\nu$
- $Z bb \rightarrow ll cl\nu cl\nu$
- *continuum ZZ*

VI. Experimental Tests of the Standard Model

