Status of and Early Expectations from the LHC

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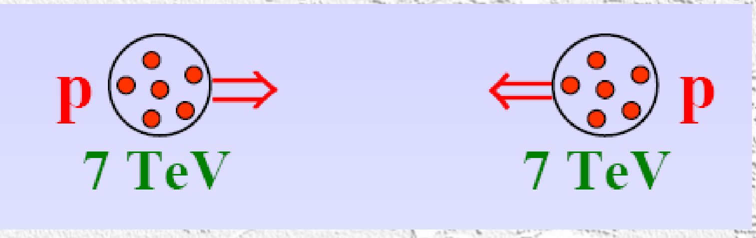
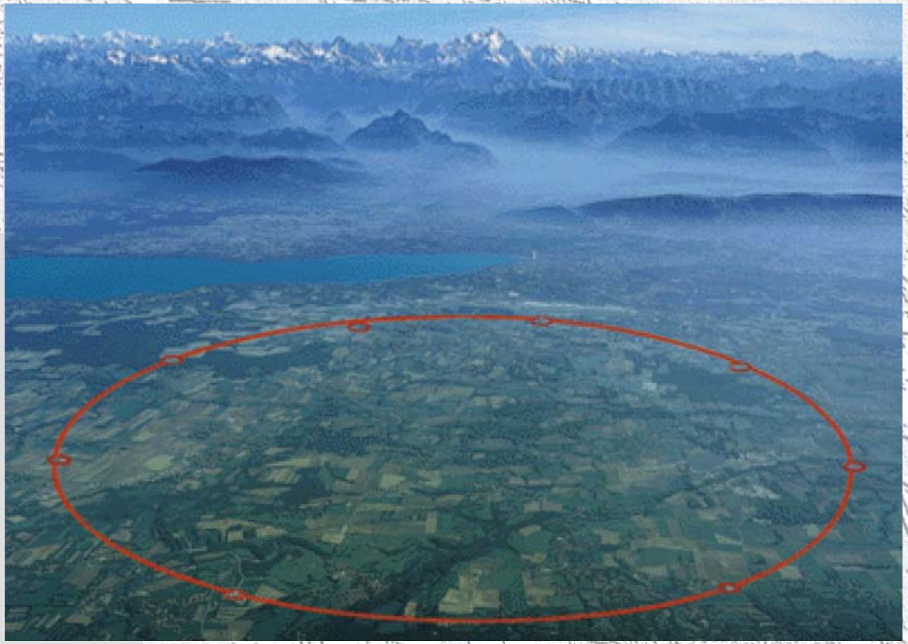
The Large Hadron Collider (LHC) at CERN

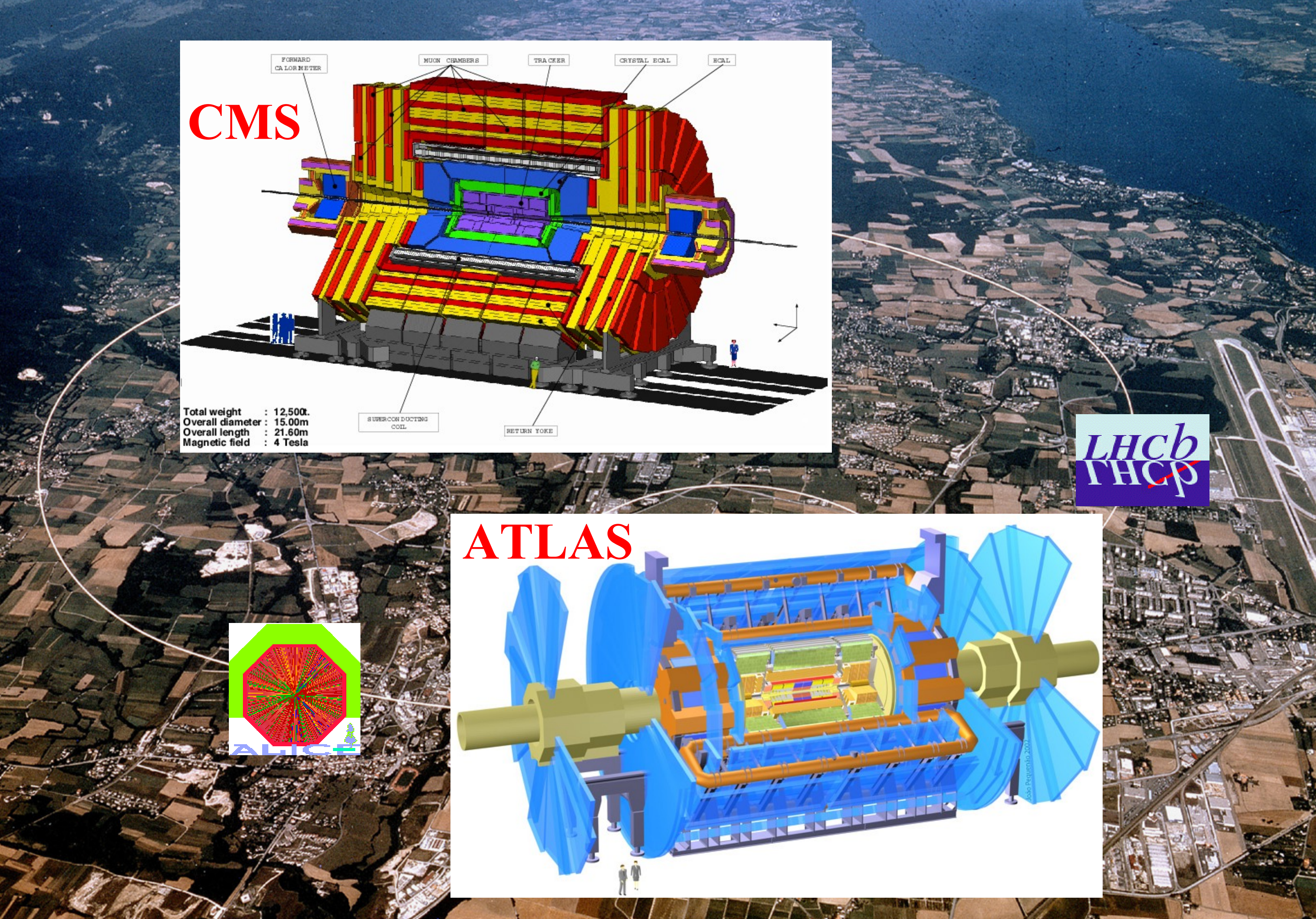
- Proton-proton collider in the former LEP tunnel at CERN (Geneva)





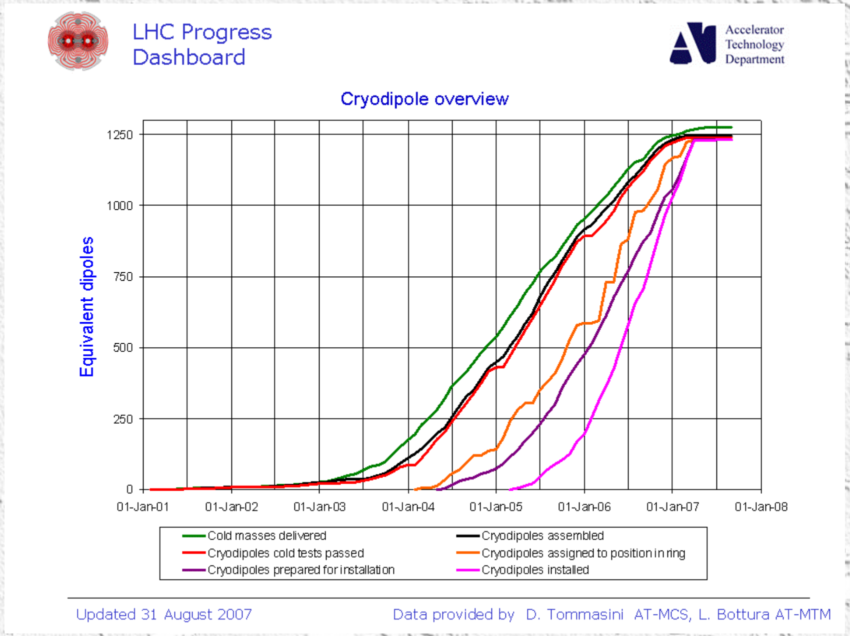
- Highest ever energy per collision
  14 TeV in the pp-system
- Conditions as 10^{-13} – 10^{-14} s after the Big Bang
- 4 experiments:
  ATLAS
  CMS
  LHC-B specialised on b-physics
  ALICE specialised for heavy ion collisons
- Constructed in worldwide collaborations
- Start planned for 2008

The Large Hadron Collider LHC



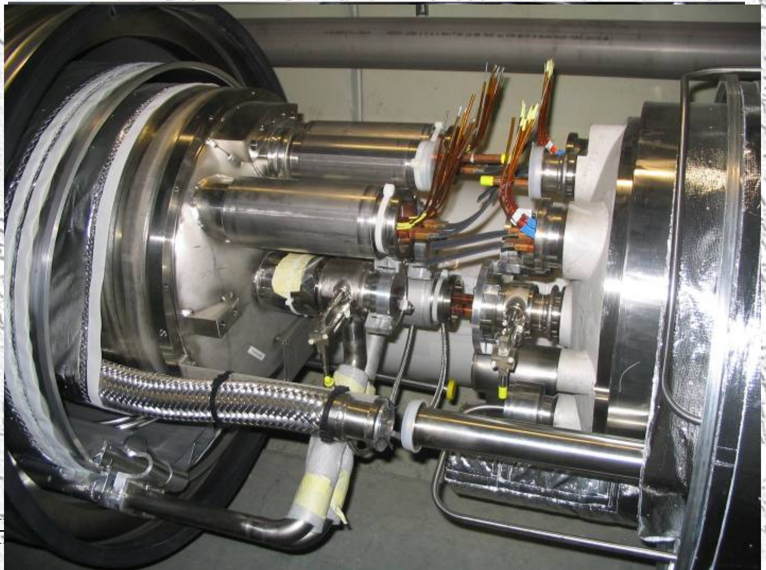
Status of the LHC

- **Example dipoles:**
  all 1232 dipoles built and installed



- **Last dipole lowered on April 26, 2007**

- **All magnets prepared on schedule**
- **Interconnections & closure of 6 sectors remaining 2 are about to be finished**



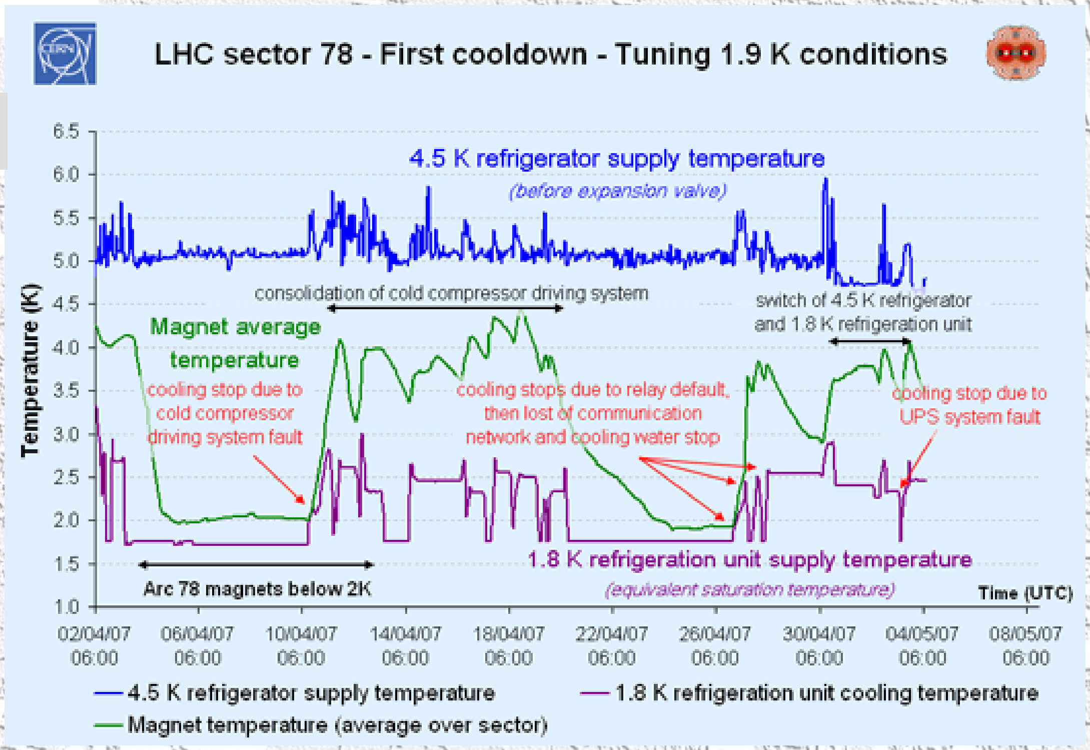
On track for first beam in 2008

Status of the LHC

- Cryogenics complete

sector 7-8

- First cooldown April 2007:



- **1.9 K: The coldest place in the universe!**

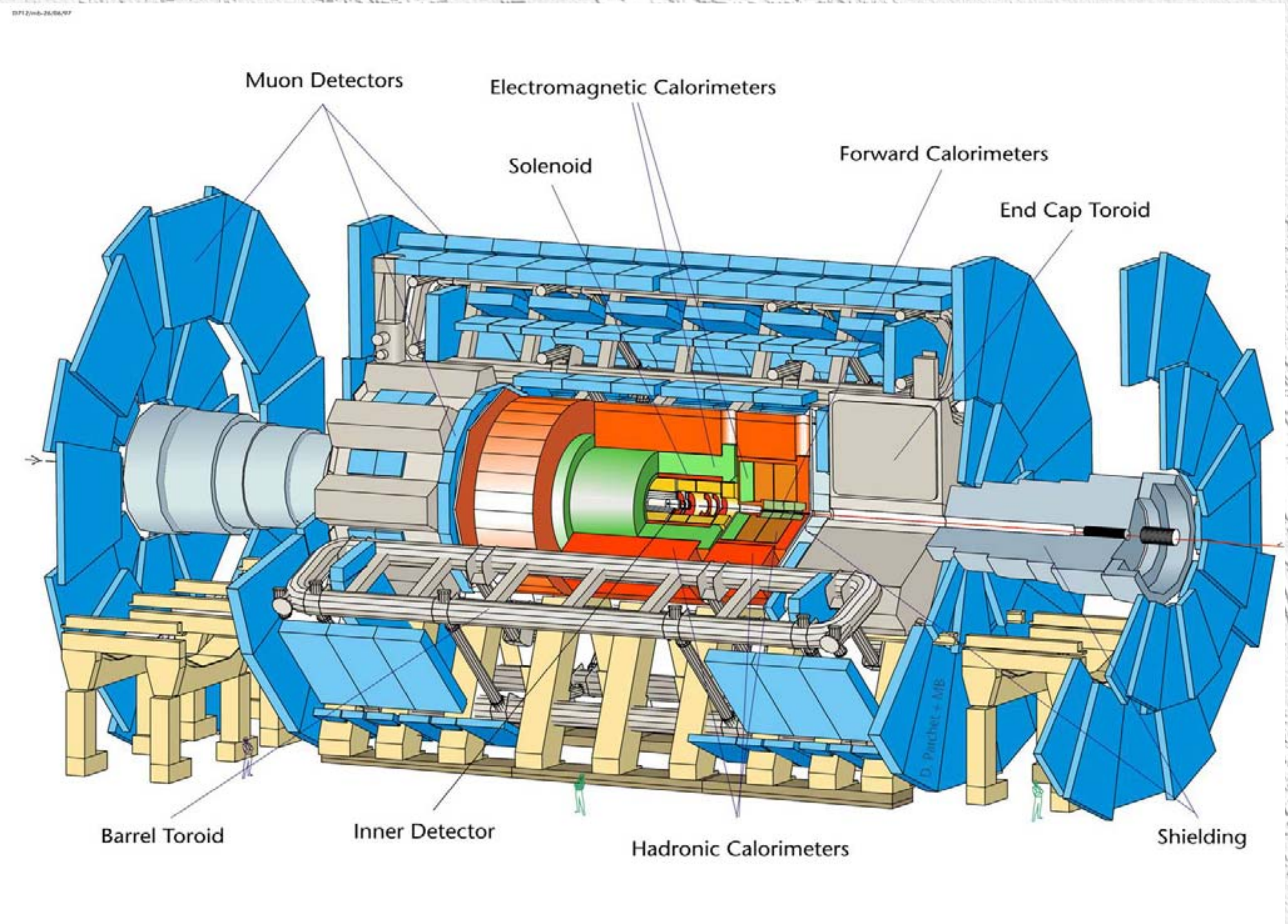
The ATLAS experiment

A Toroidal LHC ApparatuS

ATLAS in a nutshell:
- Large air toroid with μ chambers
- HCAL: steel & scintillator tiles
- ECAL: LAr
- Inner solenoid (2 T)
- Tracker: Si-strips & straw tubes (TRD)
- Si-pixel detector

10^8 channels

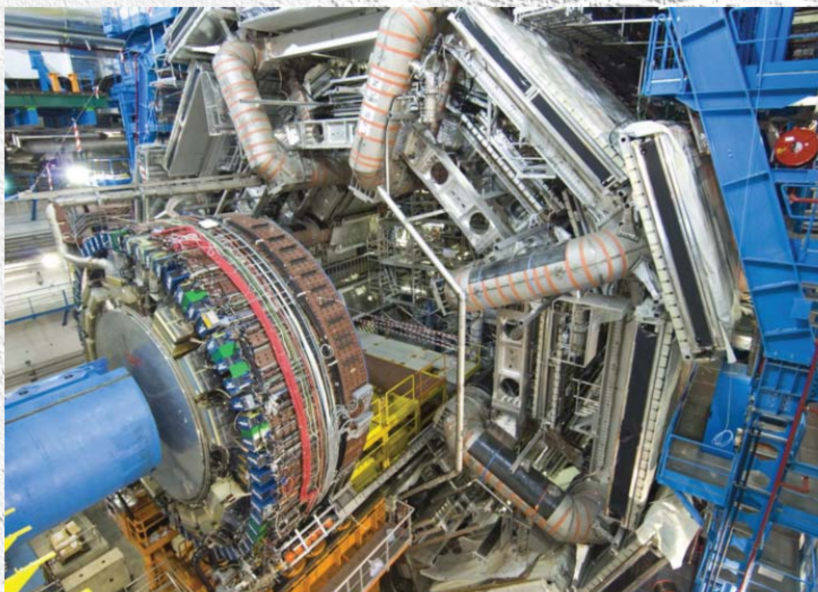
15 μm resolution



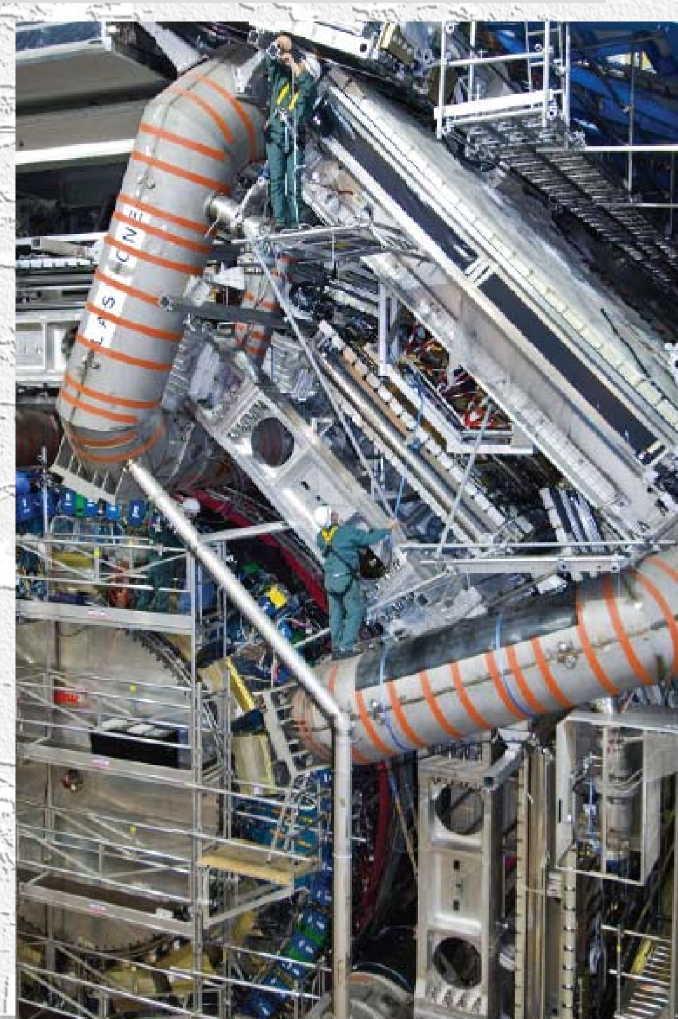
Status of ATLAS

Major structures assembled underground

- all calorimeters installed



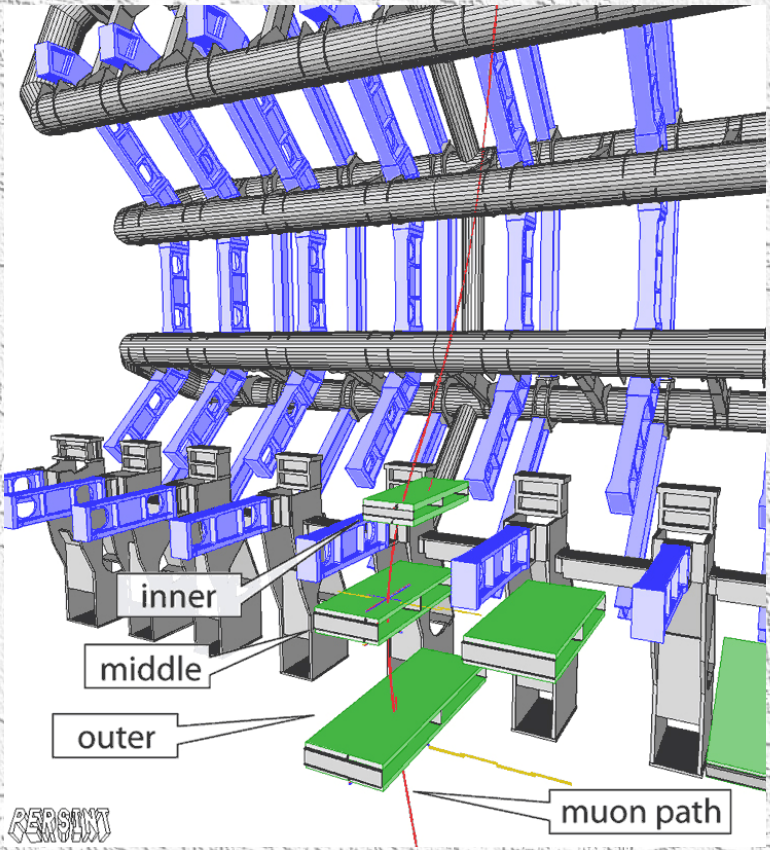
- barrel μ chambers installed



Status of ATLAS

- Completion of big endcap wheels September 2007

- Detector commissioning with cosmic muons

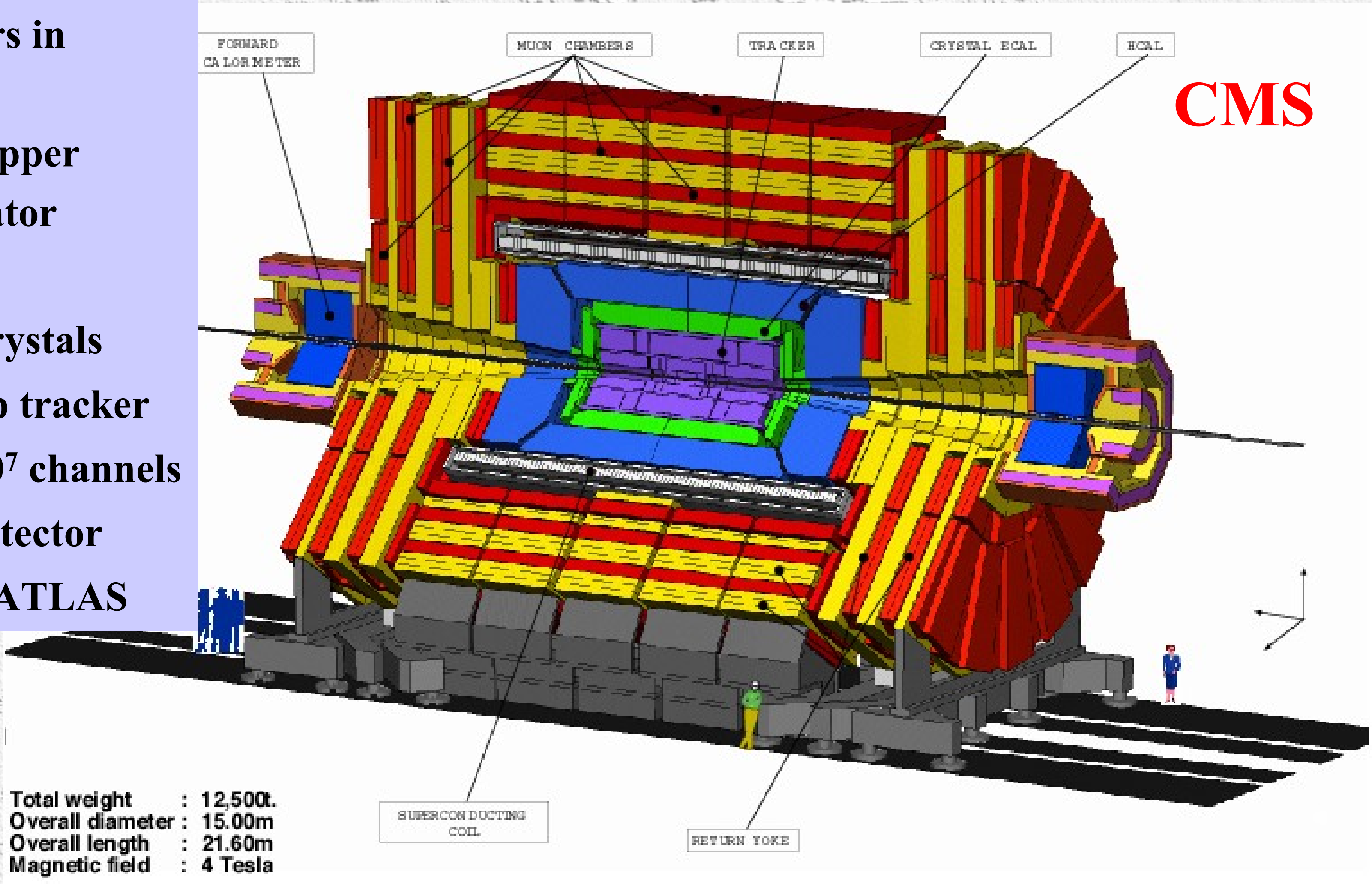


ATLAS: on track for LHC physics

The CMS experiment

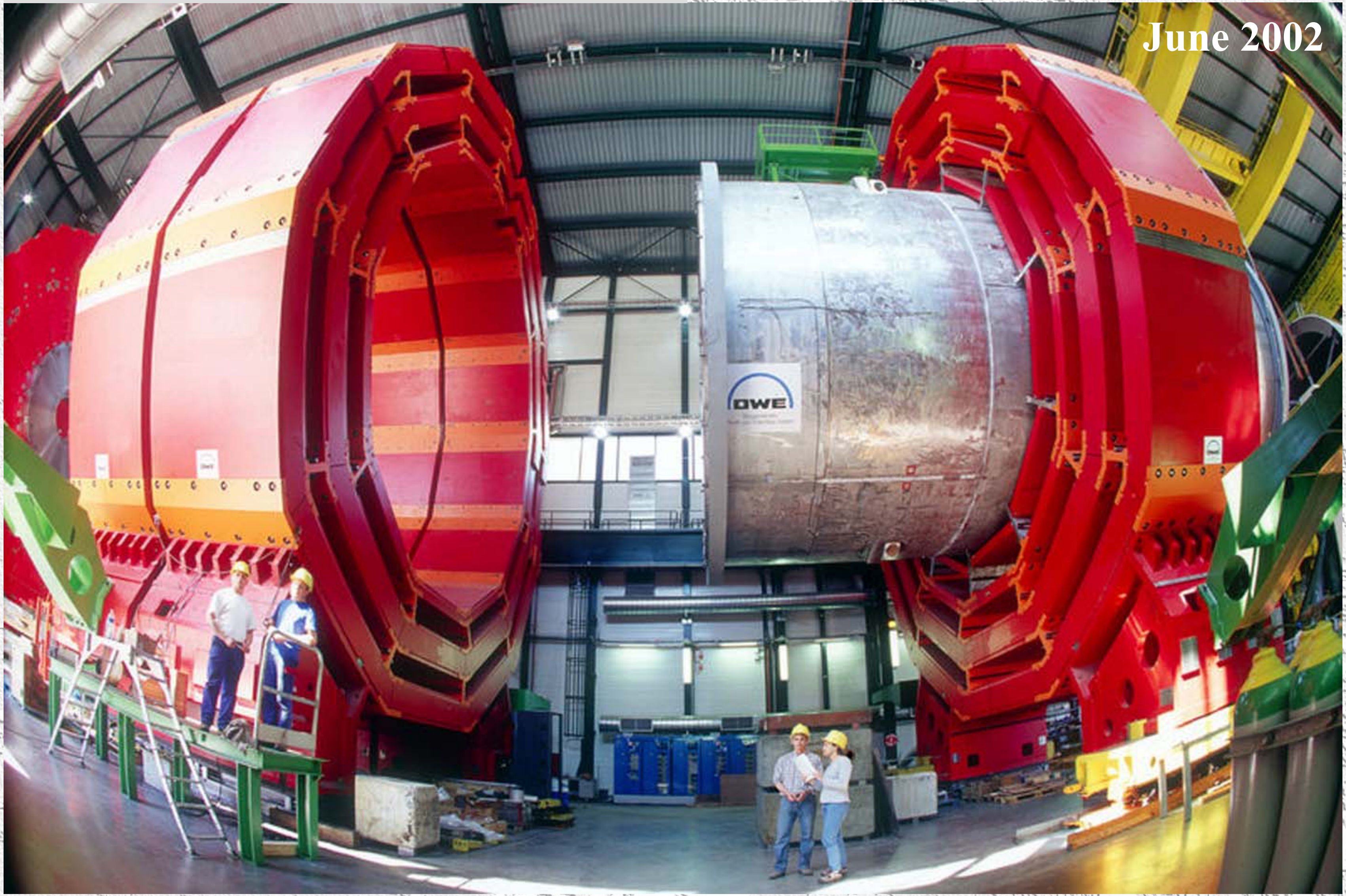
Compact Muon Solenoid

CMS in a nutshell:
- 4 T solenoid
- μ chambers in iron yoke
- HCAL: copper & scintillator
- ECAL: $PbWO_4$ crystals
- All Si-strip tracker $220\ m^2$, 10^7 channels
- Si-pixel detector similar to ATLAS



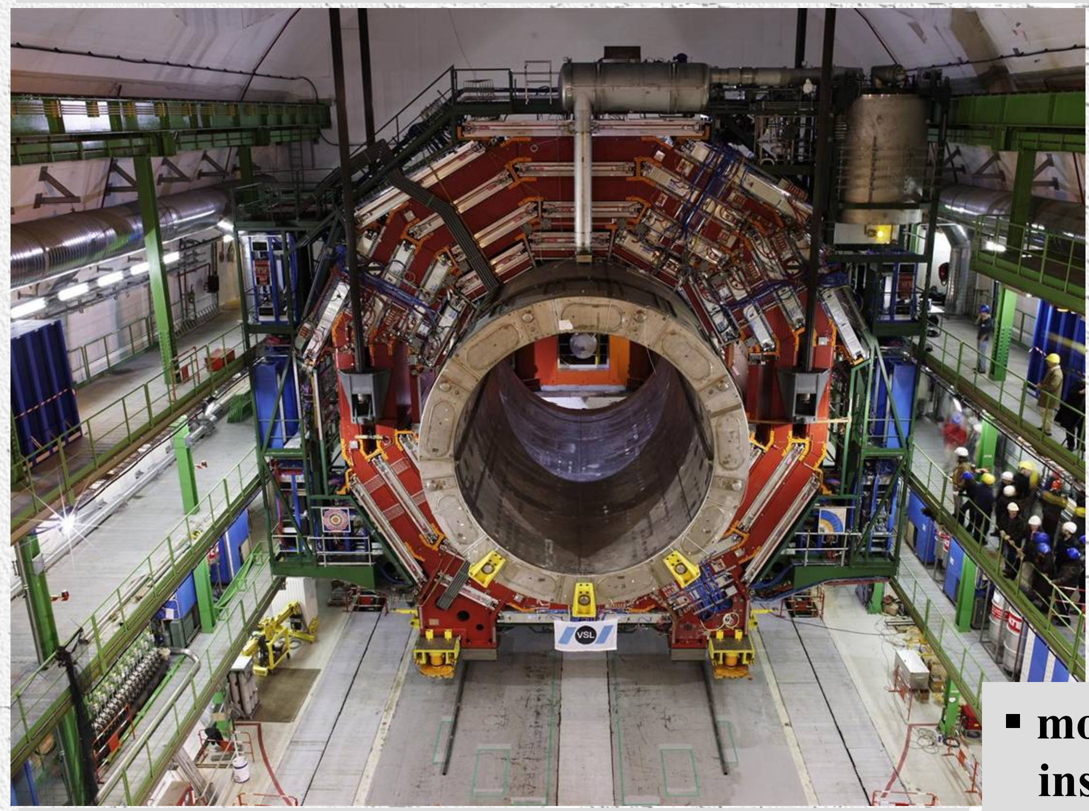
Layout of CMS

- 11 slices: 5 barrel and 2*3 endcaps

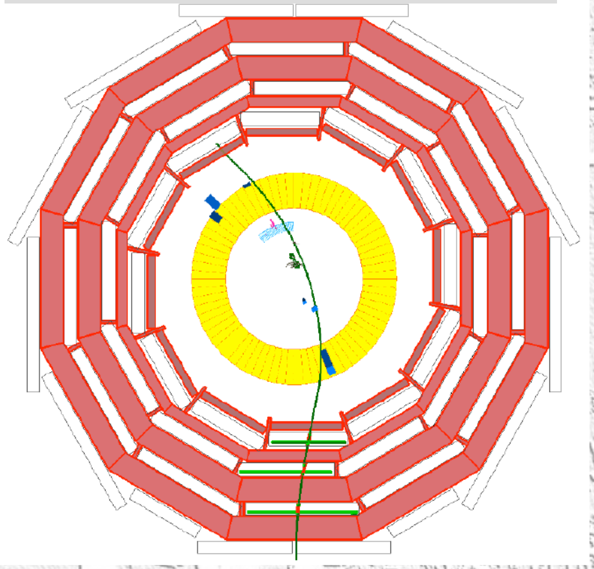


Status of CMS

CMS: major structures assembled on surface
- solenoid sucessfully operated at 4 Tesla (11/06), field map
- lowering of central magnet slice (YB0) on February 28th



Cosmic from magnet test



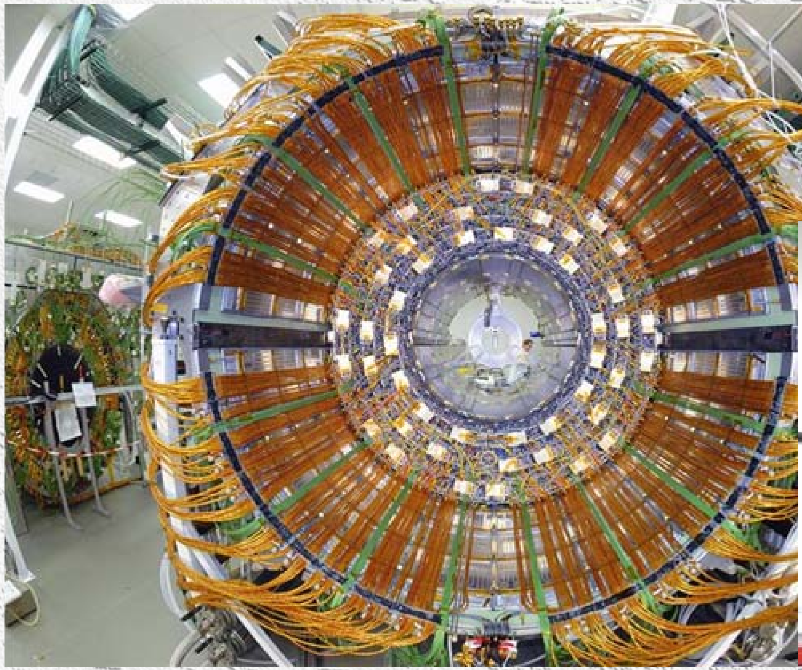
- most μ chambers installed

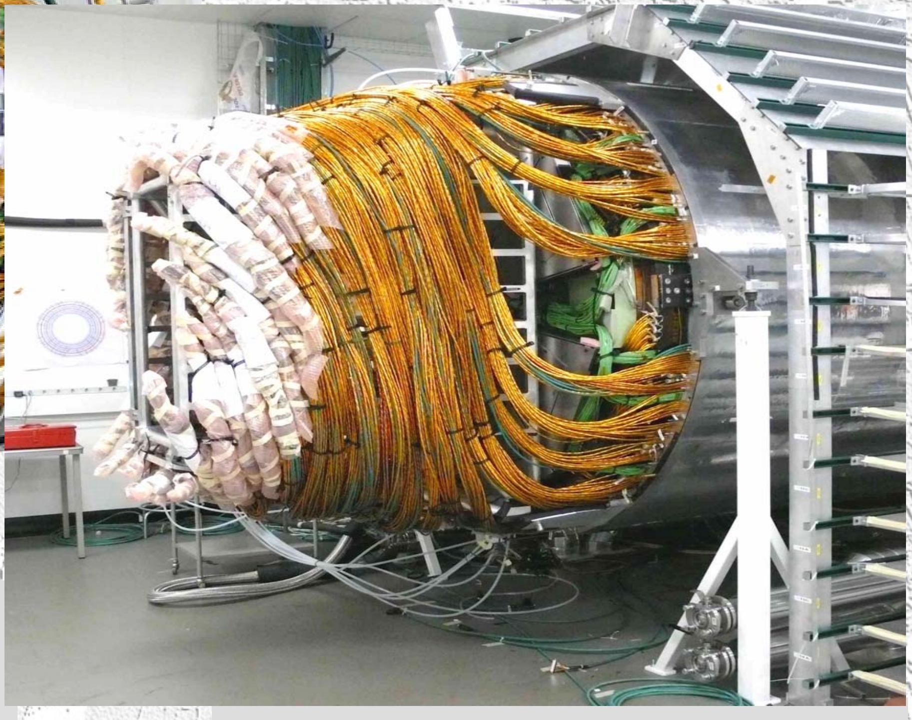
- 5/13 heavy pieces still to be lowered but all of known type
- 2nd endcap cabled, tested & commissioned on surface

Status of CMS

- Silicon tracker ready
  - under test at surface
  - to be installed in August 2007

CMS tracker:
- ≈ 220 m^2 of Si sensors
- 10.6 million Si strips
- 65.9 million Si pixel



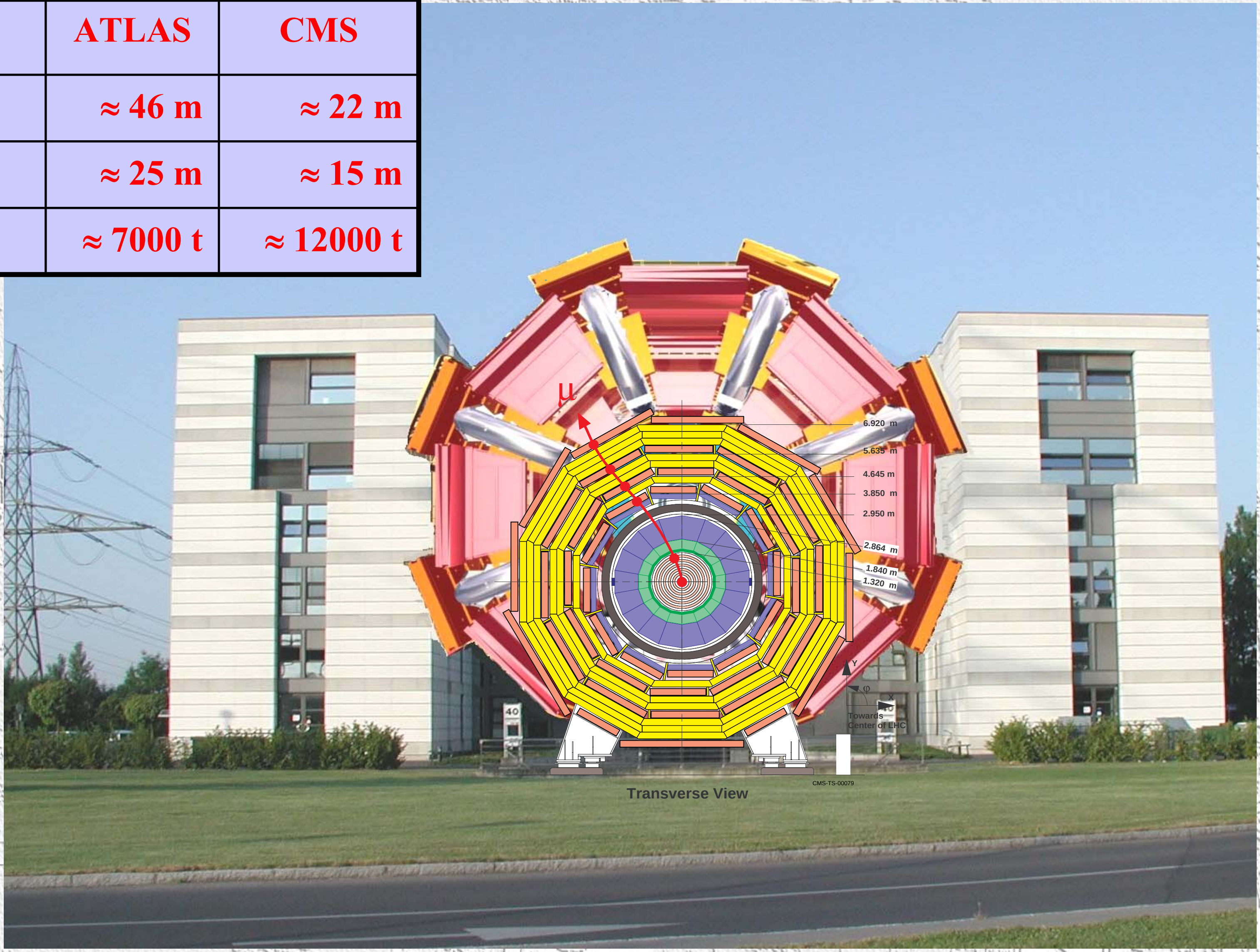


- Pixel detector:
  - modules produced
  - ready for installation end 2007

CMS: on track for LHC physics

Comparison of ATLAS and CMS

	ATLAS	CMS
length	≈ 46 m	≈ 22 m
diameter	≈ 25 m	≈ 15 m
weight	≈ 7000 t	≈ 12000 t



Cross Section of Various SM Processes

The LHC uniquely combines the two most important virtues of HEP experiments:

1. **High energy 14 TeV**
2. **and high luminosity $10^{33} - 10^{34}/cm^2/s$**

⇒ Low luminosity phase

$10^{33}/cm^2/s = 1/nb/s$

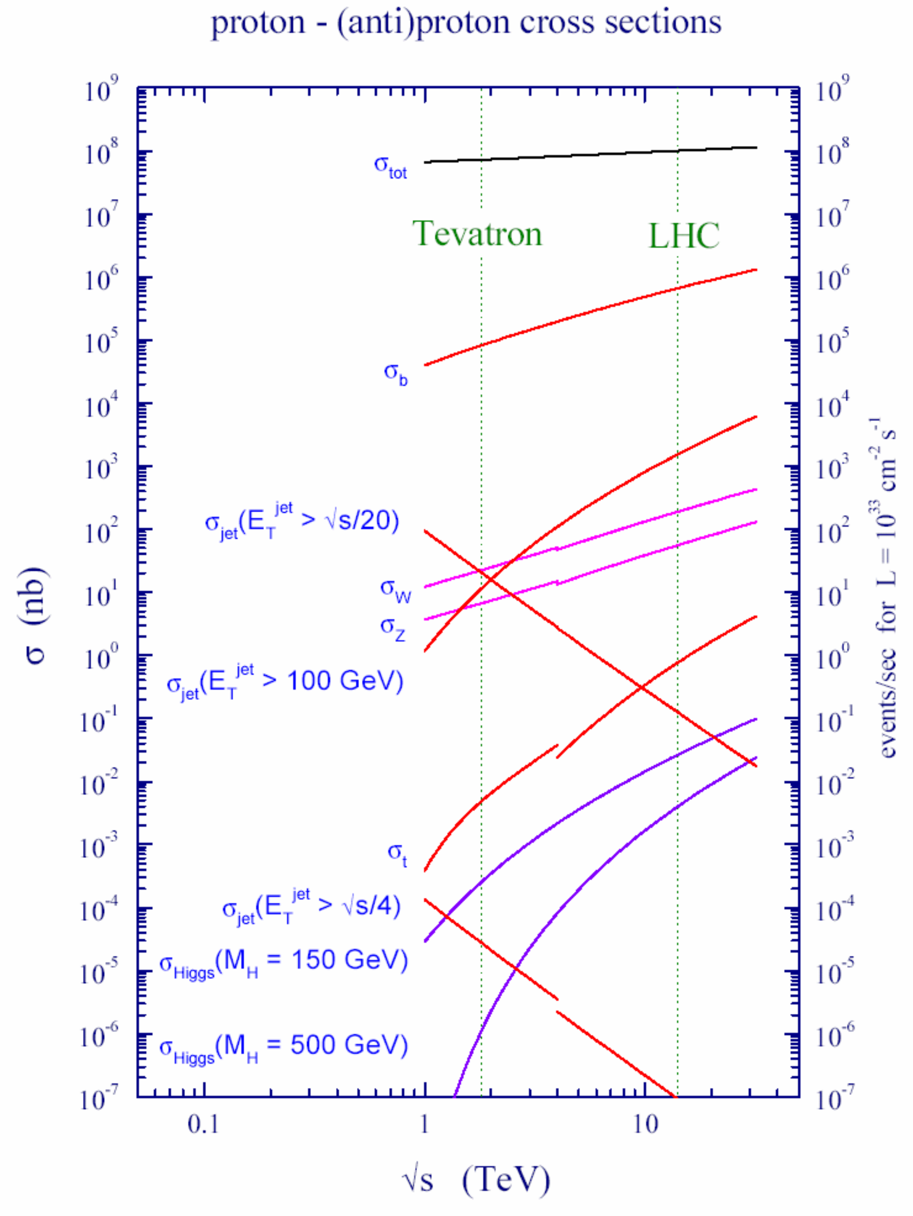
approximately

- **200 W-bosons**
- **50 Z-bosons**
- **1 $t\bar{t}$-pair**

will be produced per second and

- **1 light Higgs**

per minute!



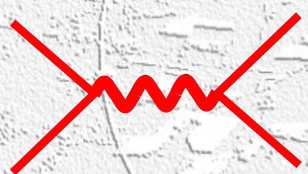
Parton Density Functions at the LHC

LHC is a proton-proton collider

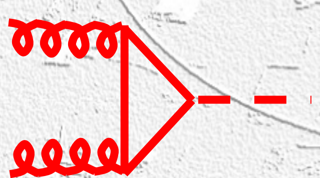
But fundamental processes are the scattering of

- **Quark – Antiquark**
- **Gluon – Quark**
- **Gluon – Gluon**

<u>**Examples:**</u>

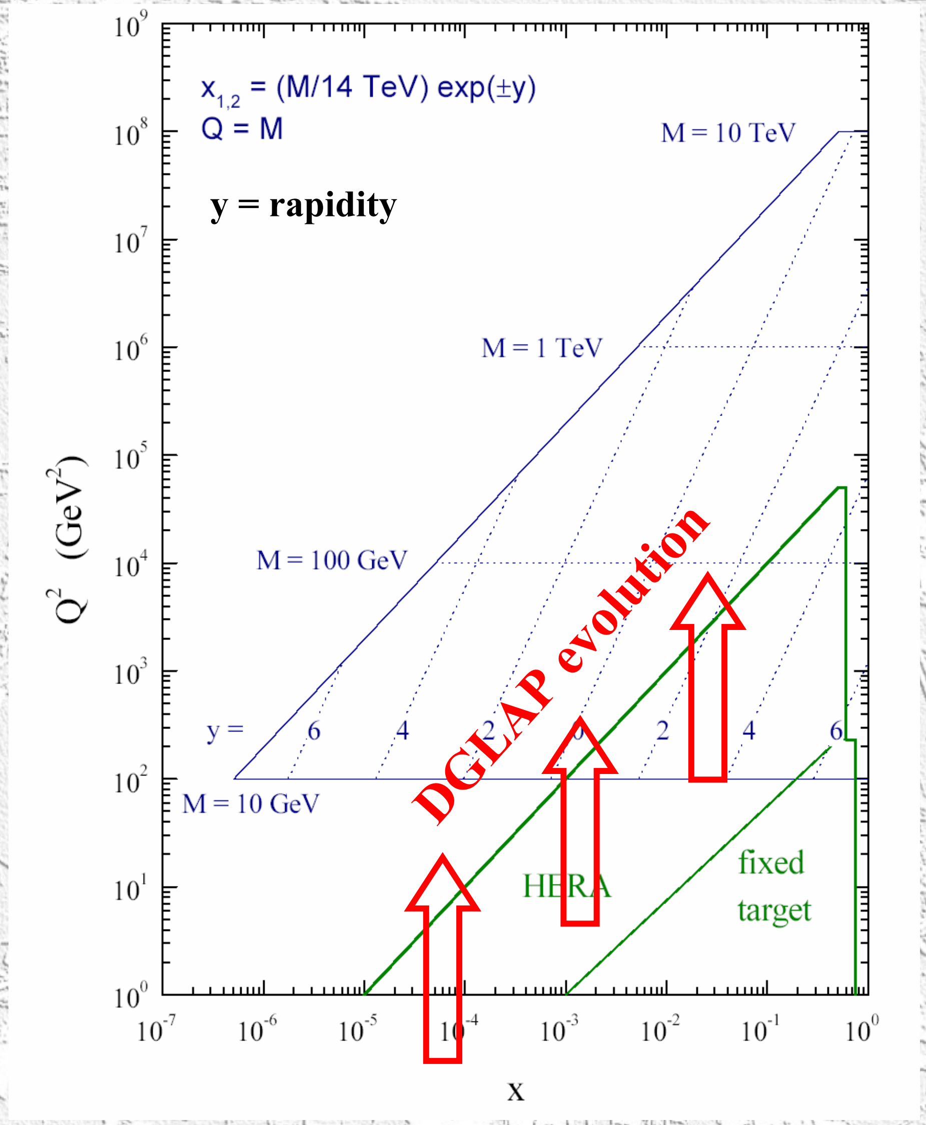


$q\bar{q} \rightarrow W \rightarrow l\nu$



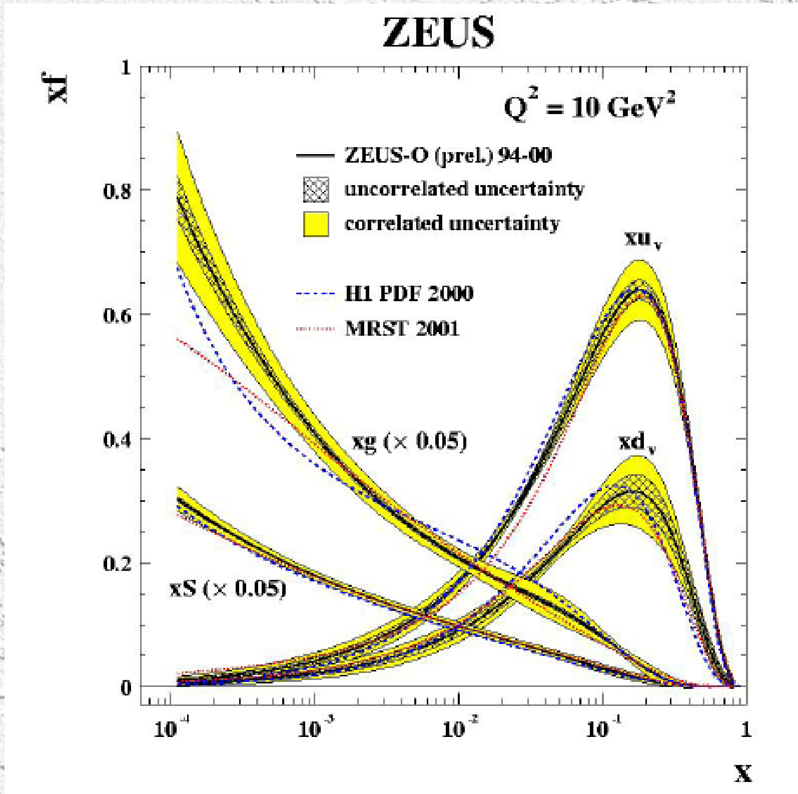
$gg \rightarrow H$

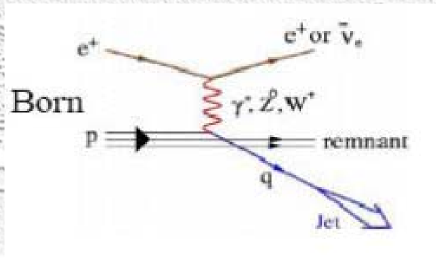
⇒ need precise PDF(x,Q²)
+ QCD corrections (scale)



Parton Density Functions

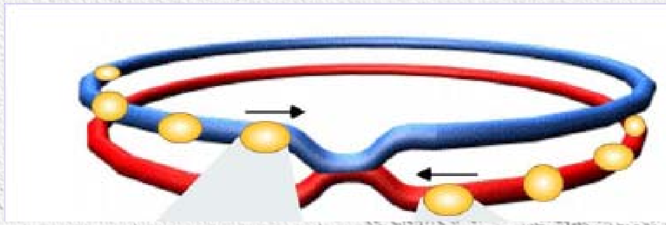
How do the distributions of the *x*-values look like?
Measured at HERA in ep-scattering, e.g.:

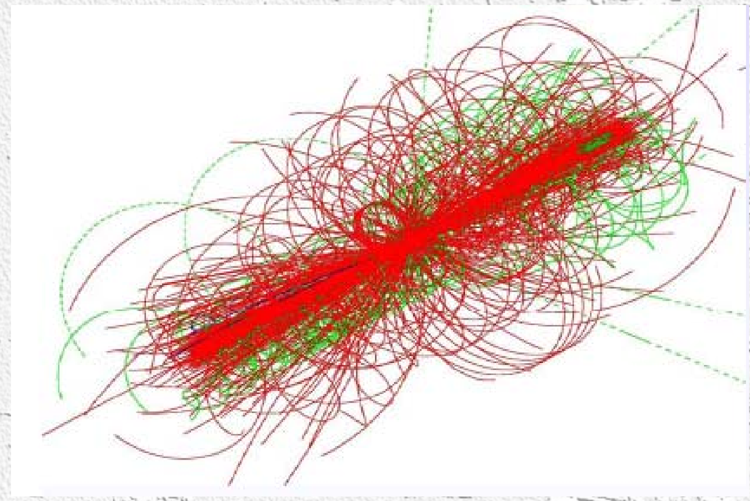




- u- and d-quarks at large x-values
- gluons dominate at small x
- large uncertainties for gluons

Proton-Proton Collisions at the LHC





- 2835 + 2835 proton bunches
  separated by 7.5 m

→ collisions every 25 ns
  = 40 MHz crossing rate

- 10^{11} protons per bunch

- at $10^{34}/cm^2/s$
  ≈ 35 pp interactions per crossing
  pile-up

→ ≈ 10^9 pp interactions per second !!!

- in each collision
  ≈ 1600 charged particles produced

enormous challenge for the detectors

Possible LHC Schedule

- **2008 first physics year**
  - **machine closure April**
  - **first collisions in summer at 7 TeV proton energy**
  - **try to reach $10^{32}/cm^2/s$**
    $\int L dt \leq 1\ fb^{-1}$

- **2009 – 2010/11 two or three years at 1 - $2 \cdot 10^{33}/cm^2/s$**
  - **$\geq 30\ fb^{-1}$ in total**
  - **important for precision physics and discoveries**

- **$\geq$ 2011 high luminosity running at $10^{34}/cm^2/s$**
  - **$100\ fb^{-1}$ per year**

- **2015 Upgrade to Super LHC $10^{35}/cm^2/s$**
  - **under discussion**
  - **requires major machine and detector upgrades**

LHC Startup Scenario

- Approx. 30 days of beam time to establish first collision
- Then push gradually:
  - bunches per beam: 1 to 43 to 156
  - squeeze
  - bunch intensity

Bunches	β*	I_b	Luminosity	Event rate
1 x 1	18	10^{10}	10^{27}	Low
43 x 43	18	3×10^{10}	3.8×10^{29}	0.05
43 x 43	4	3×10^{10}	1.7×10^{30}	0.21
43 x 43	2	4×10^{10}	6.1×10^{30}	0.76
156 x 156	4	4×10^{10}	1.1×10^{31}	0.38
156 x 156	4	9×10^{10}	5.6×10^{31}	1.9
156 x 156	2	9×10^{10}	1.1×10^{32}	3.9

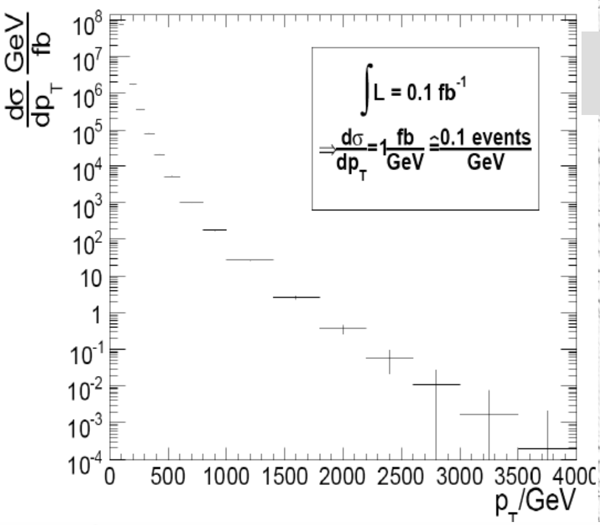
Expected LHC Luminosities

- **Disclaimer:**
  - my personal, very debatable and probably very wrong guess!
  - just for the sake of our discussion
  - to provide some orientation

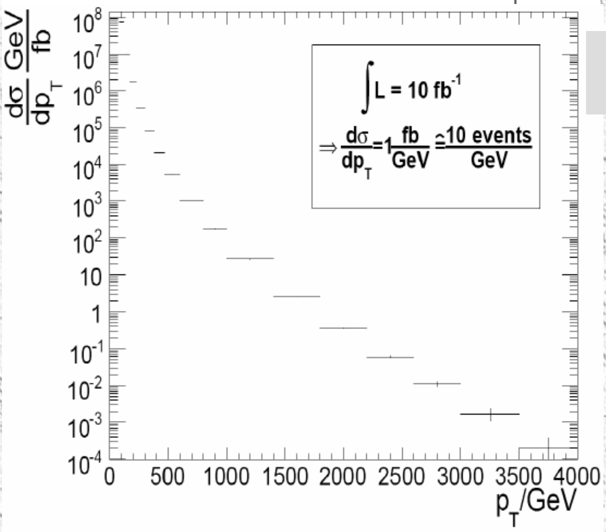
- **2008:**
  - 0.1 fb^{-1} i.e. ≈ 1 month at $10^{32}/cm^2/s$
- **2009:**
  - 1 fb^{-1} 1 year at $10^{32}/cm^2/s$
  - few fb^{-1} if $10^{33}/cm^2/s$ reached
- **2010:**
  - ≥ 10 fb^{-1} 1 year at up to $2 \cdot 10^{33}/cm^2/s$

LHC Jet Physics

- Jet rates will be one of the first LHC results
- Statistical precision:

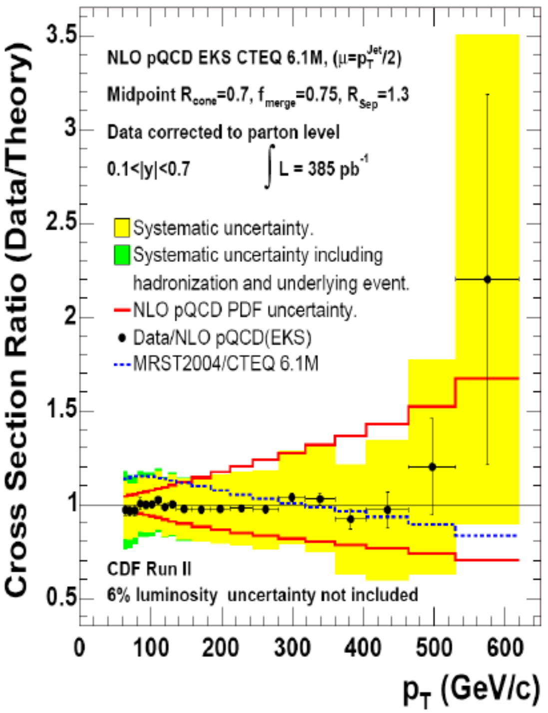


100 pb^{-1}



10 fb^{-1}

- compare to CDF result run II

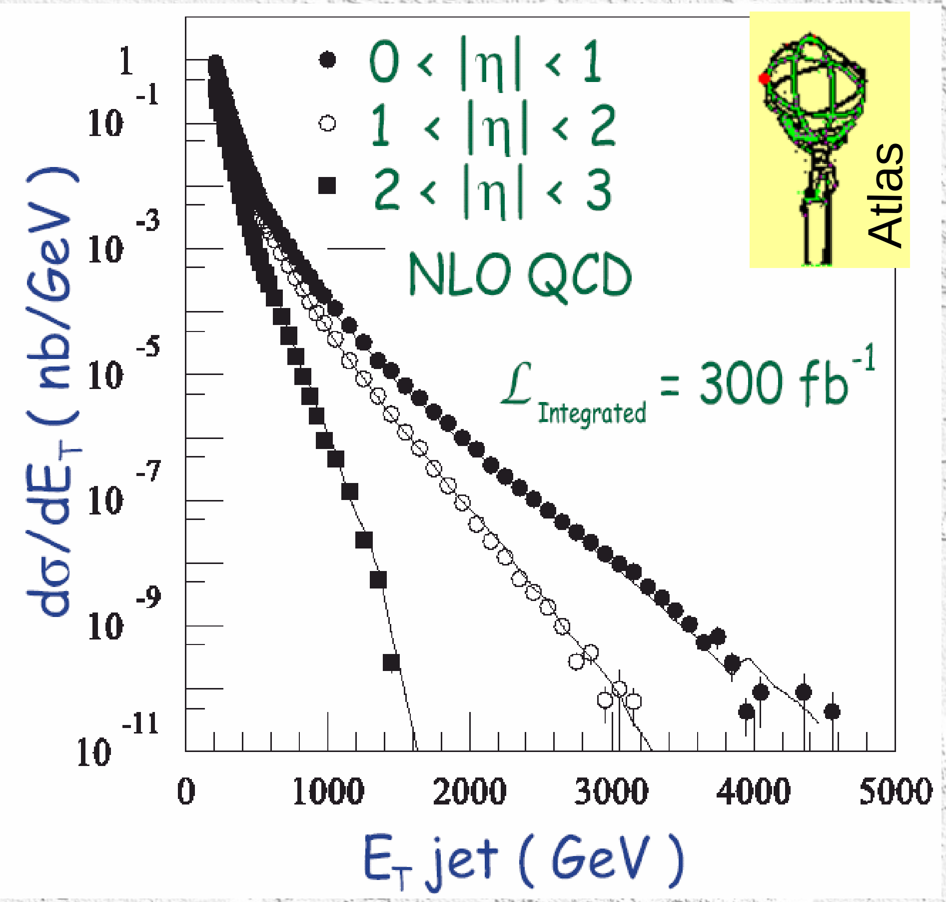


- detector systematic effects expected to be similar to Tevatron
- provides handle on PDF

Jet Physics

Jet physics at the LHC

- E_T spectrum, rate varies over 11 orders of magnitude
- Test QCD at the multi-TeV scale



Inclusive jet rates for 300 fb^{-1}:

E_T of jet	Events
> 1 TeV	$4 \cdot 10^6$
> 2 TeV	$3 \cdot 10^4$
> 3 TeV	400

QCD

Measurement of α_s at LHC limited by

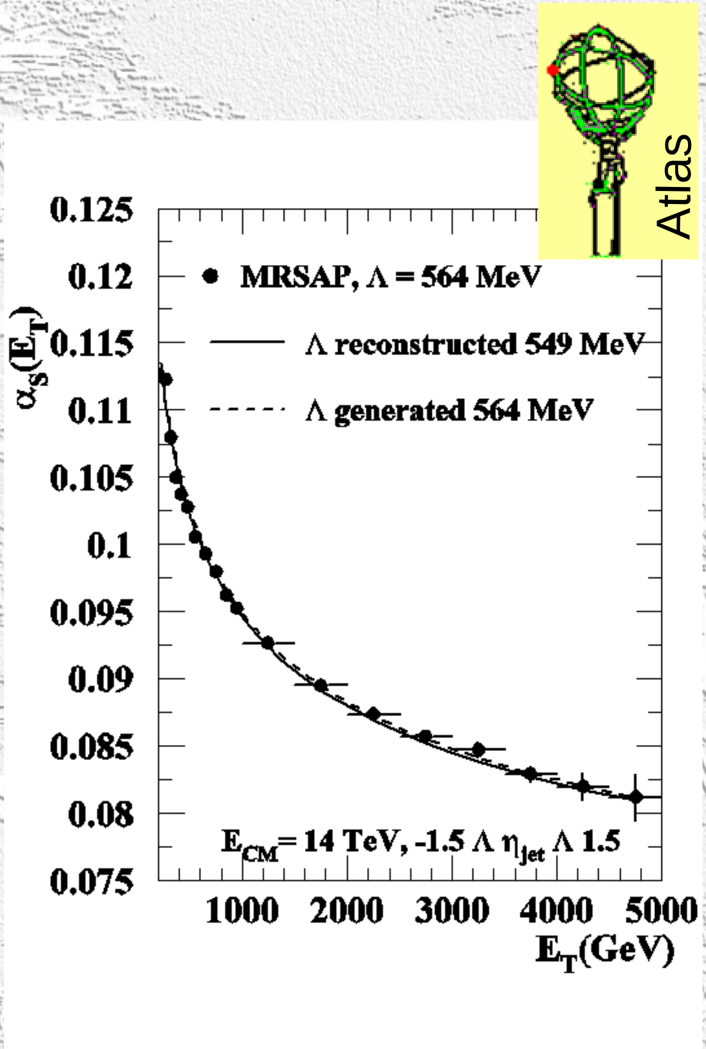
- **PDF (3%)**
- **Renormalisation & factorisation scale (7%)**
- **Parametrisaton (A,B)**

$$\frac{d\sigma}{dE_T} \sim \alpha_S^{2}(\mu_R)A(E_T) + \alpha_S^{3}(\mu_R)B(E_T)$$

- **10% accuracy $\alpha_s(m_Z)$ from incl. jets**
- **Improvement from 3-jet to 2-jet rate?**

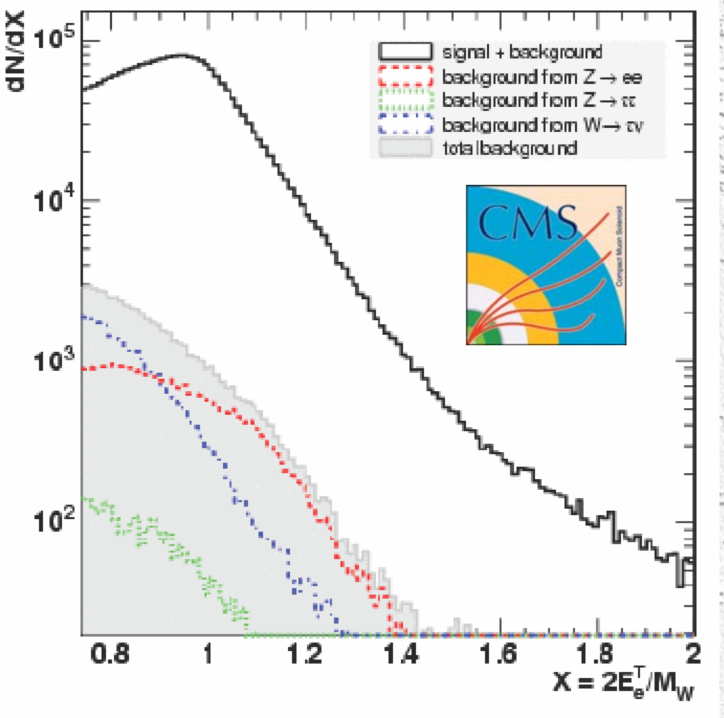
Verification of running of α_s and test of QCD at the smallest distance scale

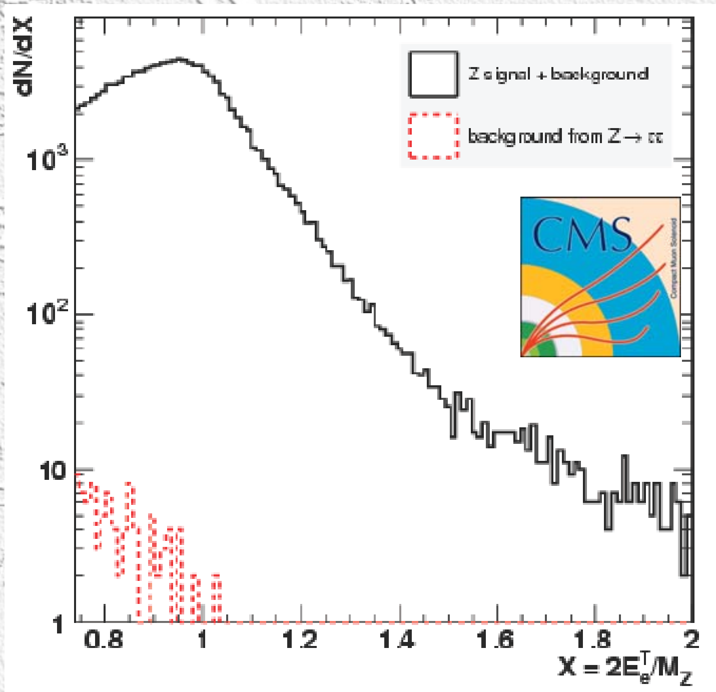
- **$\alpha_s = 0.118$ at m_Z**
- **$\alpha_s \approx 0.082$ at 4 TeV (QCD expectation)**



W/Z Physics at the LHC

- **Very clean selection of W and Z boson possible e.g. CMS study of W→ eν and Z → ee**





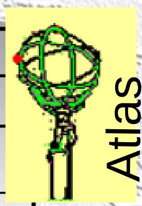
- **Recall rates (initial phase $10^{33}/cm^2/s$):**
  ≈ 200 W/s → ≈ 20 W→ eν /s
  ≈ 50 Z/s → ≈ 1.5 Z → ee /s
  plus the same rates for muon decays!

- **W and Z events will provide an excellent tool for detector calibration**

W Mass at the LHC

ATLAS study:

Source	CDF Run Ib	ATLAS or CMS	$W \to l\nu$, one lepton species
	30K evts, 84 pb^{-1}	60M evts, 10fb^{-1}	
Statistics	**65 MeV**	**< 2 MeV**	
Lepton scale	**75 MeV**	**15 MeV**	most serious challenge
Energy resolution	25 MeV	5 MeV	known to 1.5% from Z peak
Recoil model	33 MeV	5 MeV	scales with Z statistics
W width	10 MeV	7 MeV	$\Delta\Gamma_W \approx 30$ MeV (Run II)
PDF	**15 MeV**	**10 MeV**	
Radiative decays	**20 MeV**	**<10 MeV**	(improved Theory calc)
$P_T(W)$	45 MeV	5 MeV	$P_T(Z)$ from data, $P_T(W)/P_T(Z)$ from theory
Background	5 MeV	5 MeV	
TOTAL	**113 MeV**	**≤ 25MeV**	Per expt, per lepton species



- **Combine both channels & both experiments**

  $\Rightarrow \Delta m_W \leq$ 15 MeV (LHC)

Compare to

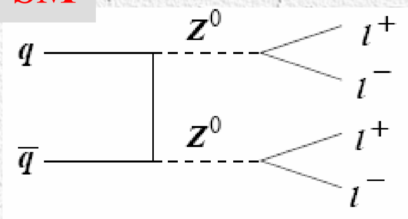
2007: $m_W = 80\,398 \pm 25$ MeV **LEP & Tevatron Run I/II**

2009: $m_W \approx 80$ ... ± 20 MeV (2.5 ·10^{-4}) **expected after Tevatron Run II**

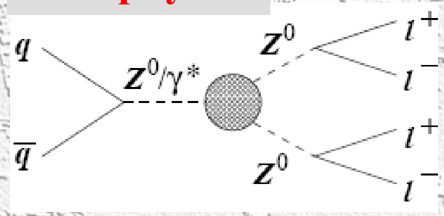
Di-Boson Production at the LHC

- Very interesting: WW,ZZ final states not yet observed at the Tevatron
  first WZ events observed early 2007
- Test triple gauge boson couplings (TGC)
  - γWW and ZWW precisely fixed in SM
  - γZZ and ZZZ do not exist in SM!

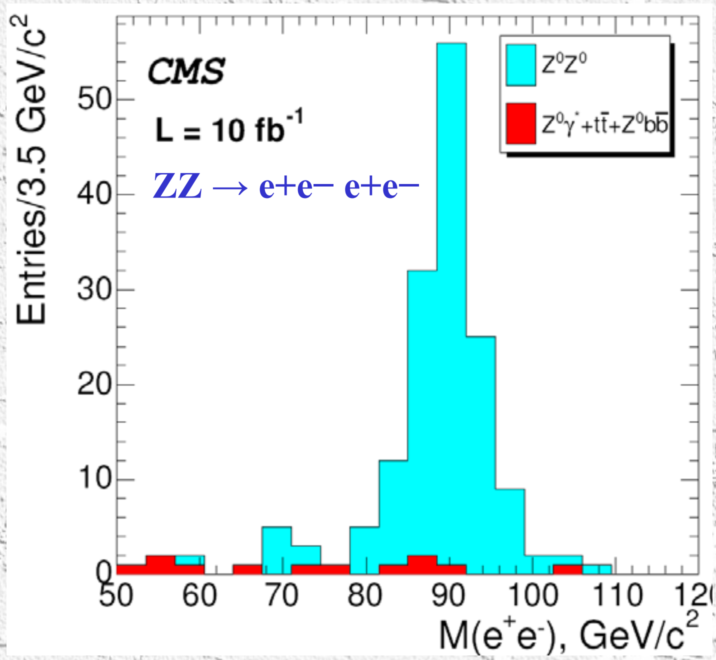
SM

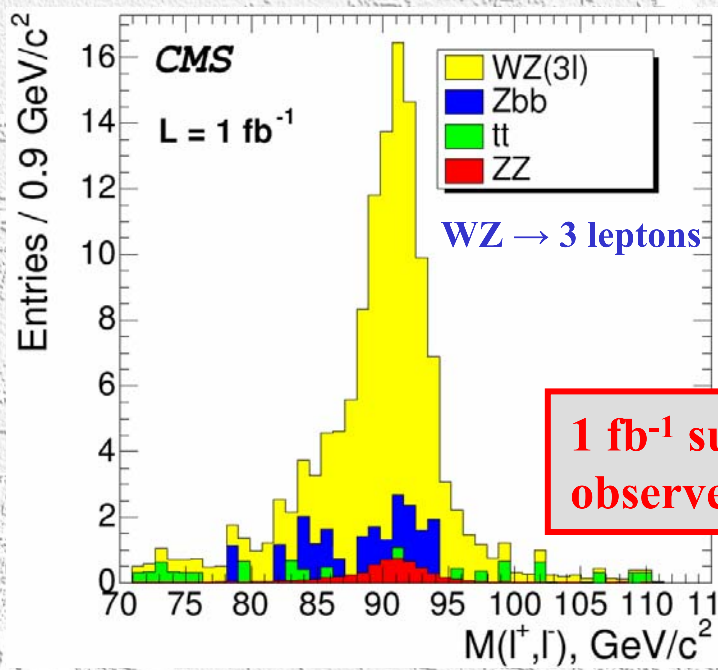


New physics



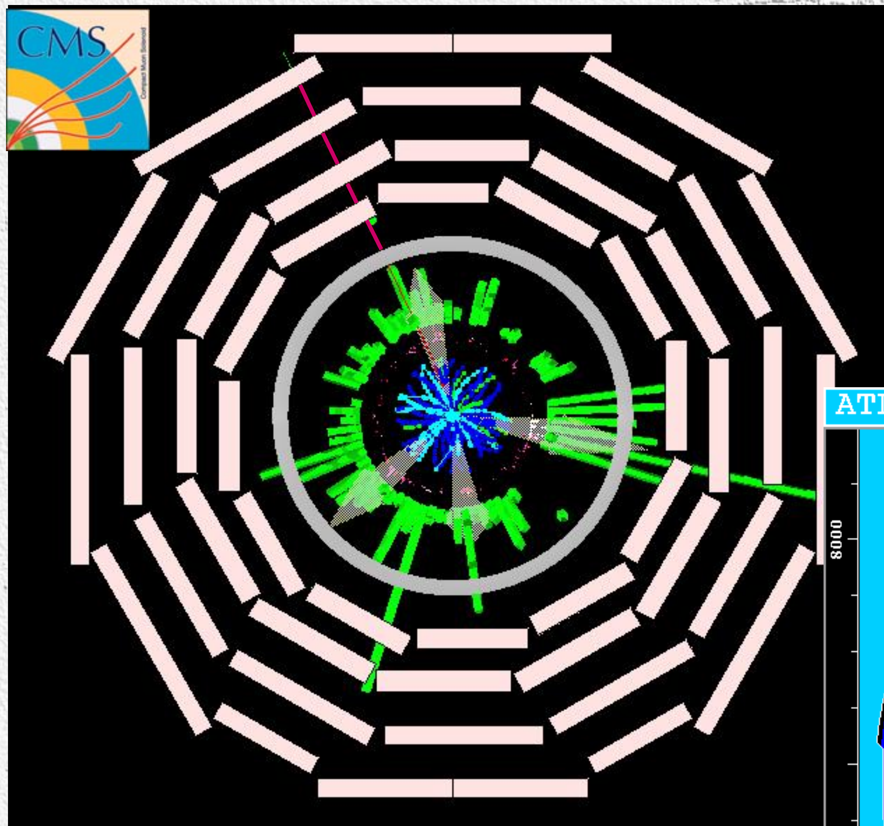
- deviations from SM are amplified with E
- also Wγ and Zγ final states can be used

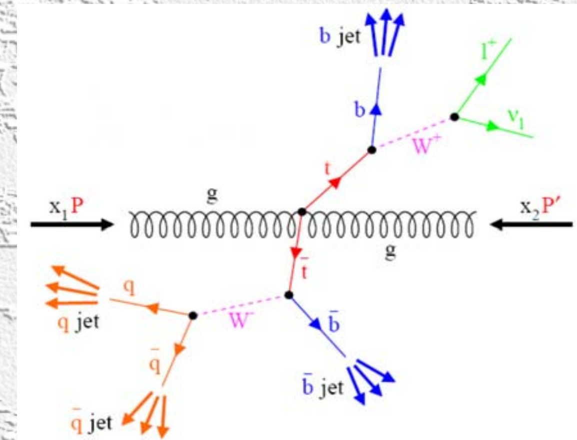


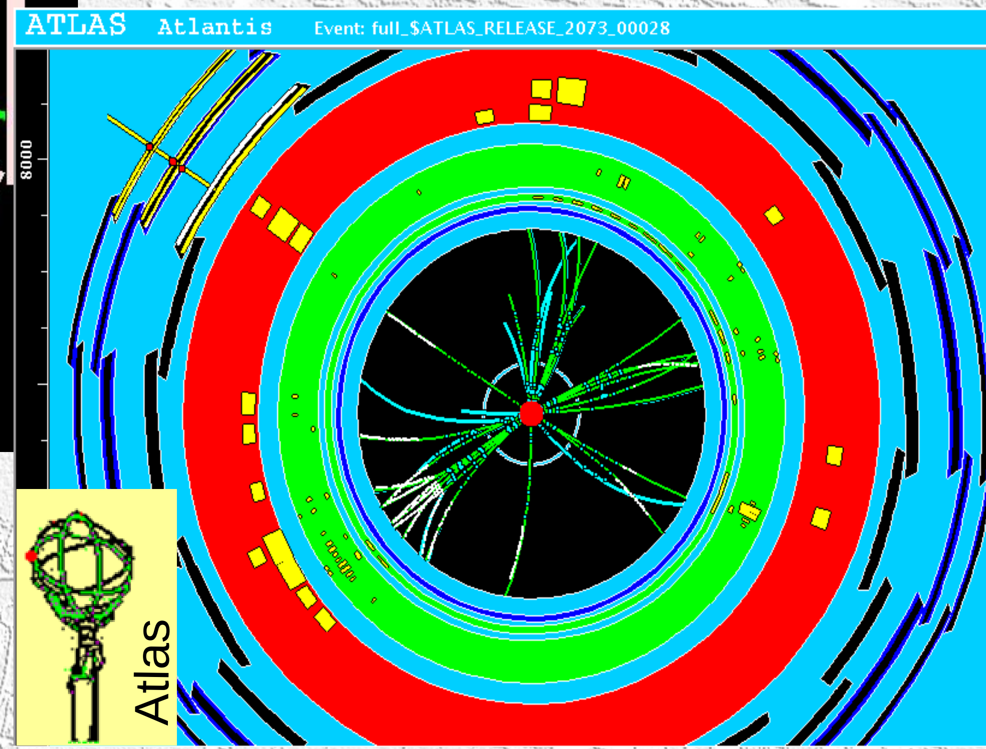


$1\ fb^{-1}$ sufficient to observe both processes

Top Quarks at the LHC



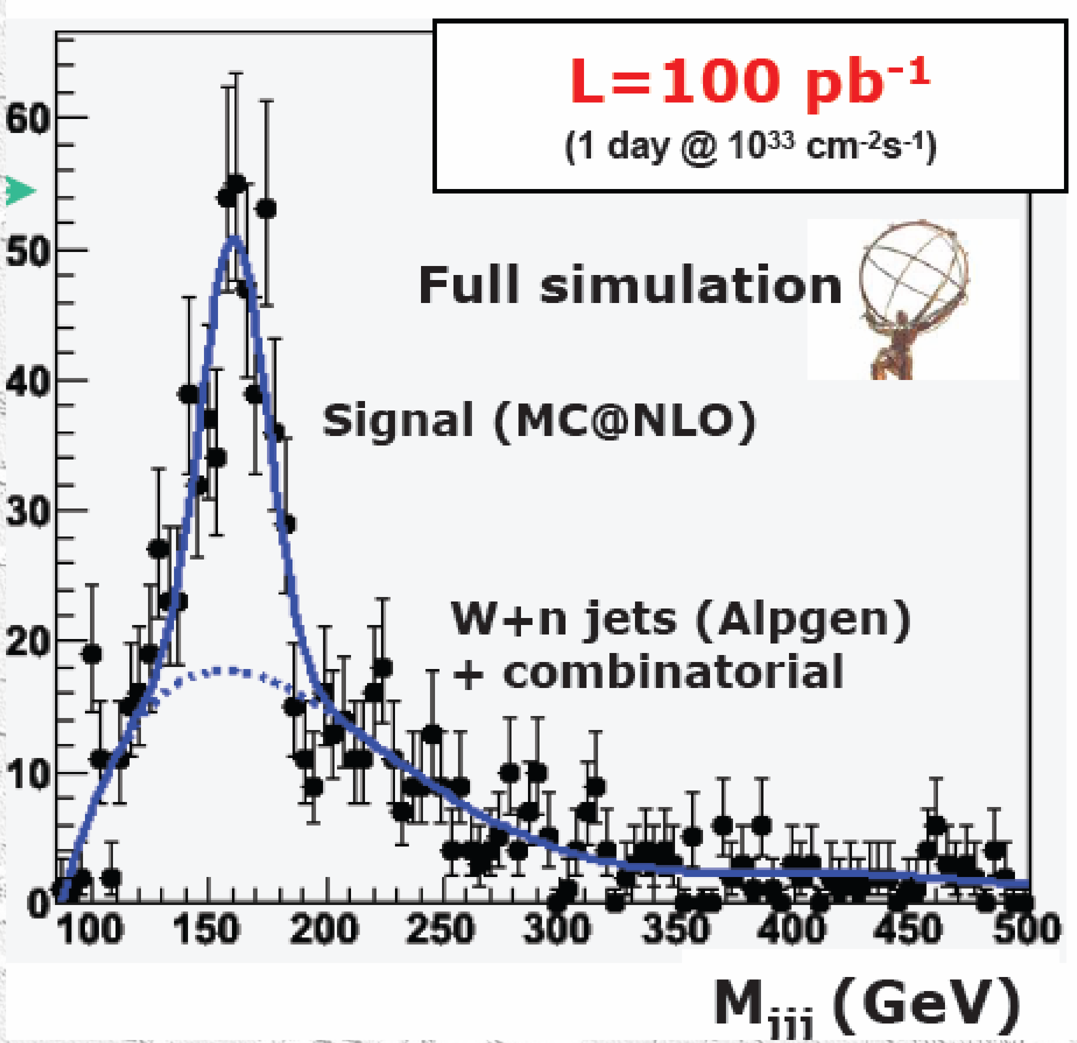




Examples of simulated tt → bb qq μν events from CMS & ATLAS

Top Pairs at the LHC

- Re-discovery of top possible with low luminosity (< 100 pb^{-1})
- Single-lepton channel:



Top Mass at the LHC

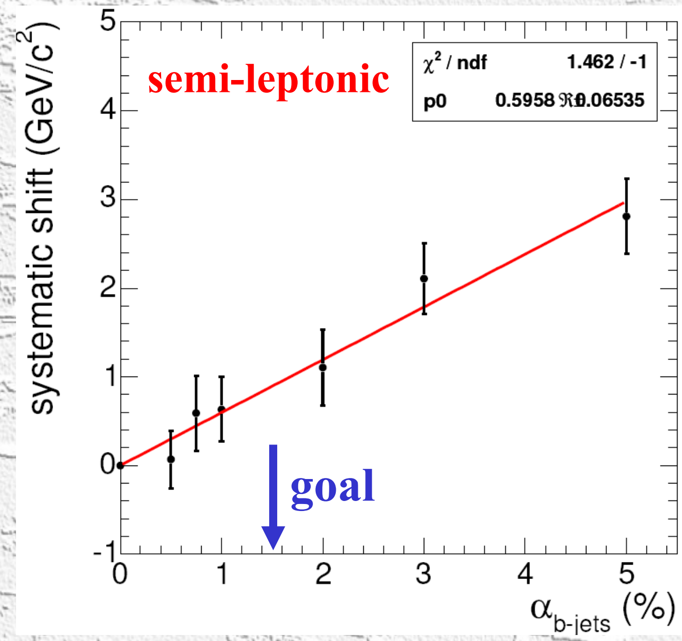
All decay topologies can be used:

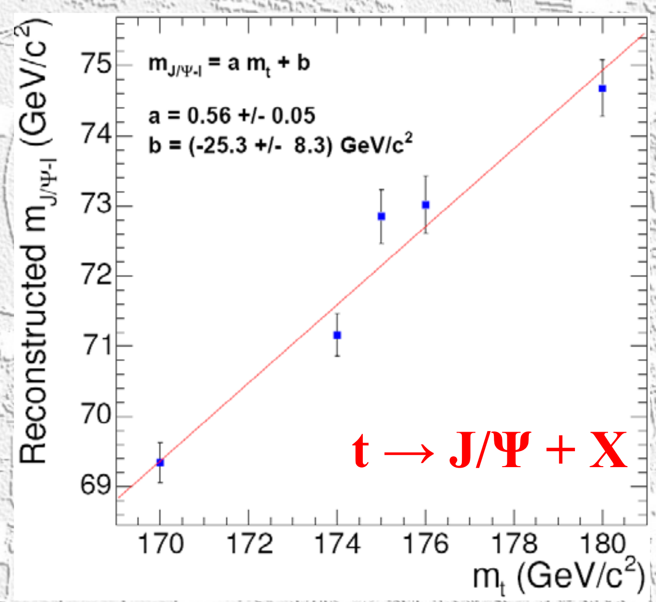
- **di-lepton events**
  kinematics underconstraint
  but sensitive to m_t

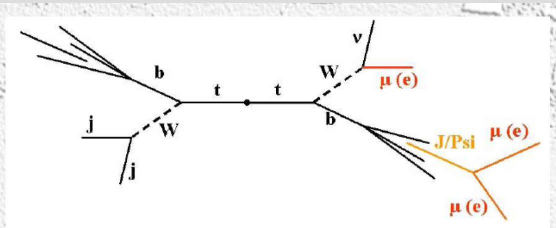
- **semi-leptonic events**
  golden channel, ideogramm method
  limited by b-jet E-scale

- **fully hadronic top pairs**
  suffers from QCD and combinatorial background

- **exclusive $t \rightarrow J/\Psi + X$ decays**
  low stat., but different systematic
  partial reconstruction J/Ψ + lepton from W



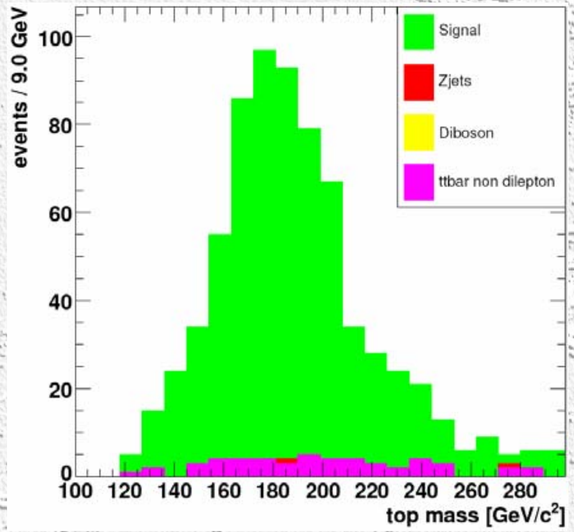


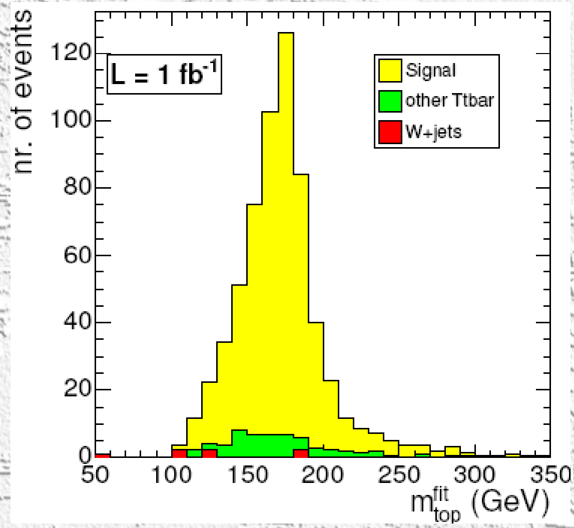


Top Mass at the LHC

Recent detailed studies by CMS:

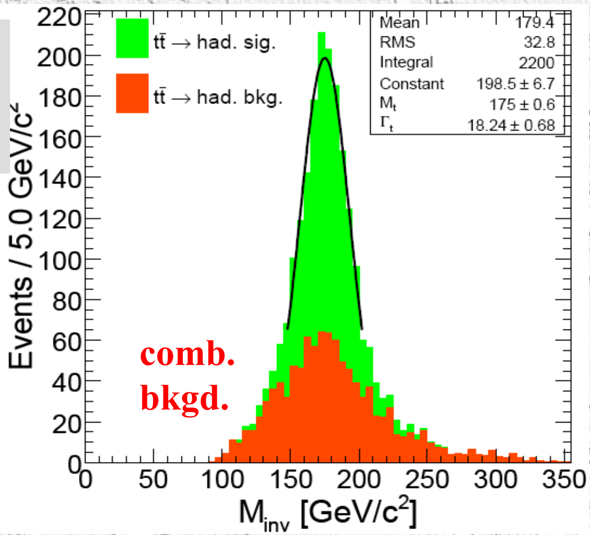
di-leptonic
± 1.2 GeV

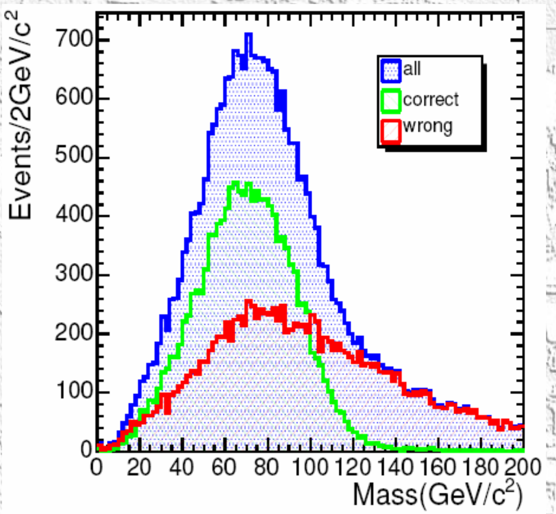




semi-leptonic
± 1.2 GeV

fully hadronic
± 2 GeV





$t \rightarrow J/\Psi + l + X$
± 1.5 GeV

→ total top mass error ≤ 1 GeV possible with O(10 fb^{-1}) of well understood data

Search for New Physics at the LHC

Some general considerations on LHC early phase

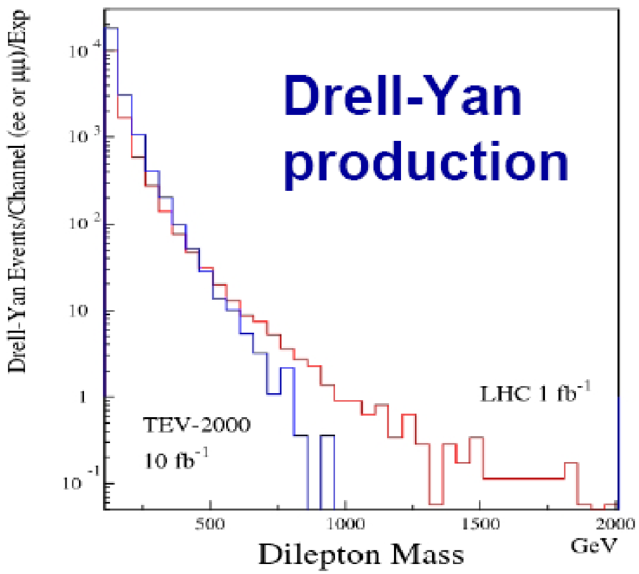
- time scale for discoveries not necessarily determined by ramp-up of integrated luminosity
- but progress and level of detector understanding
  - malfunctions, calibration, alignment

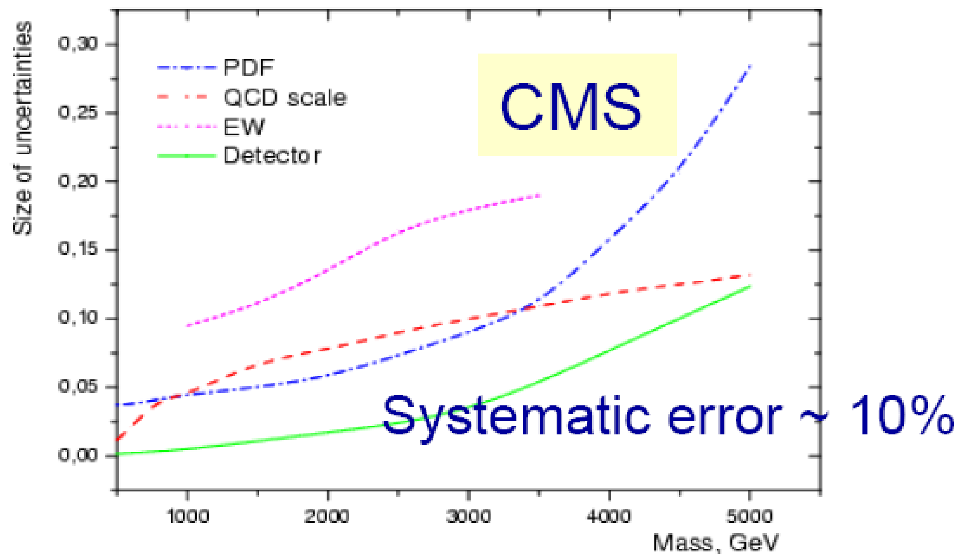
- difficult issues
  - jets
  - missing ET
  - forward detectors

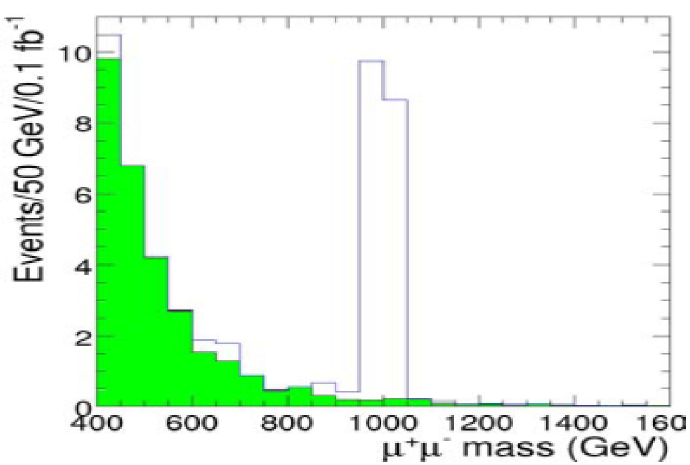
- less critical
  - lepton based measurements
    in particular muons

Understanding of the Detector

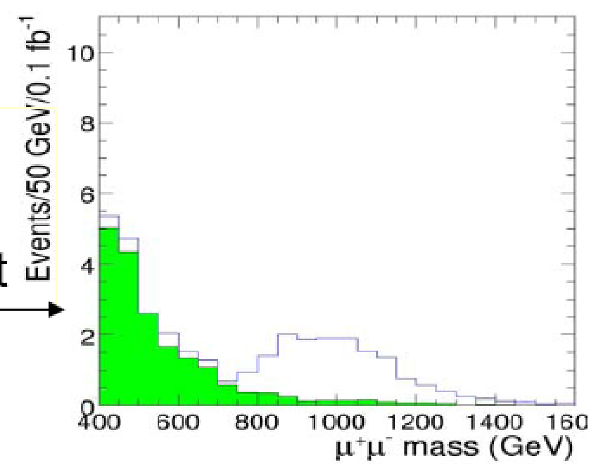
Easy example: muon pairs







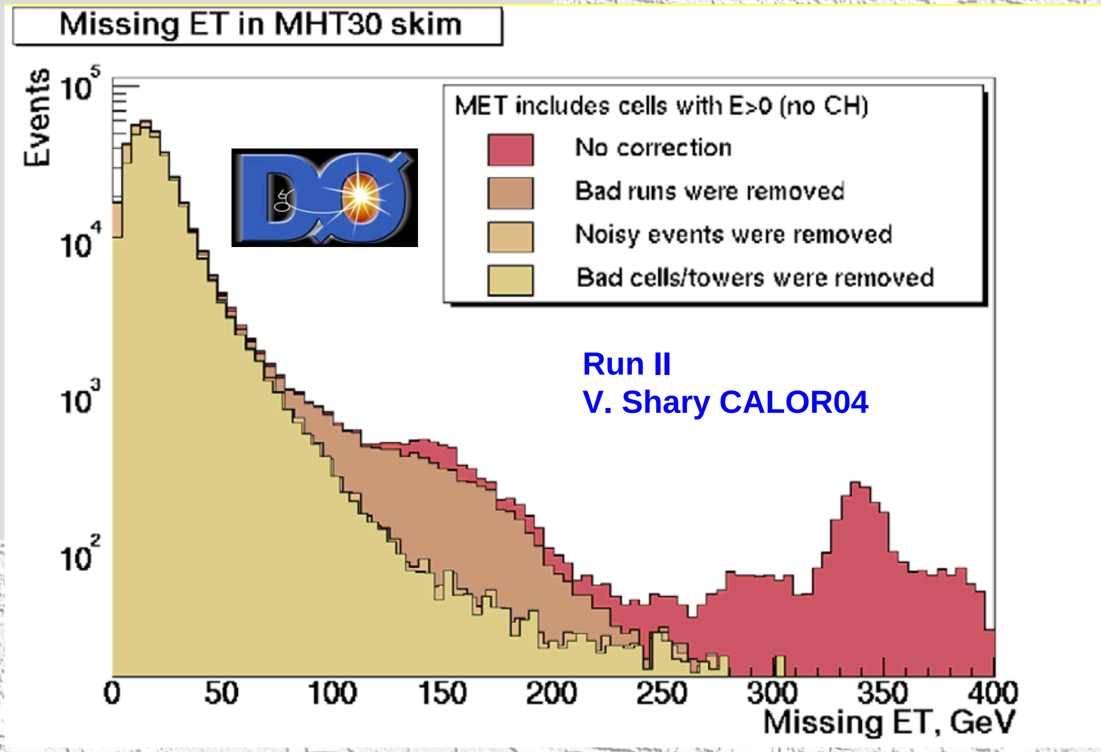
At **100 pb^{-1}**:
1 TeV Z' with
initial alignment



Understanding of the Detector

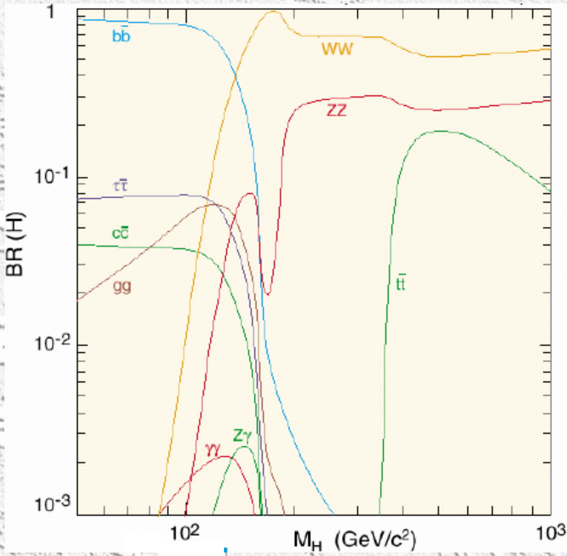
Difficult example: missing ET

- is a very powerful tool to look for new physics
- but very complicated variable and difficult to understand:
- collison effects
  - pile-up
  - underlying event
- beam related background
  - beam halo
  - cosmic muons
- detector effects
  - instrumental noise
  - dead/hot channels
  - inter-module calibration

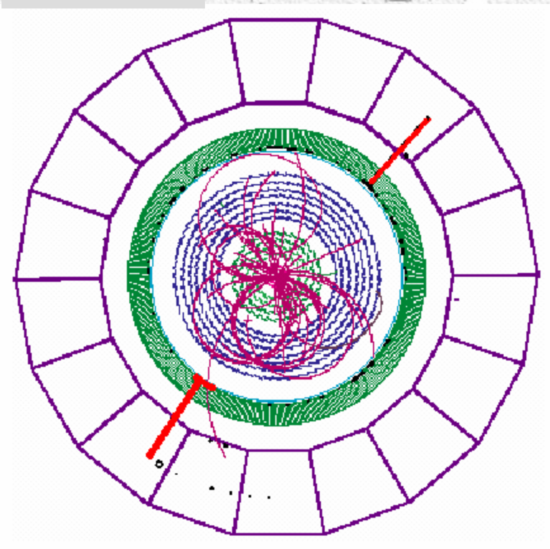


Search for the Higgs Boson

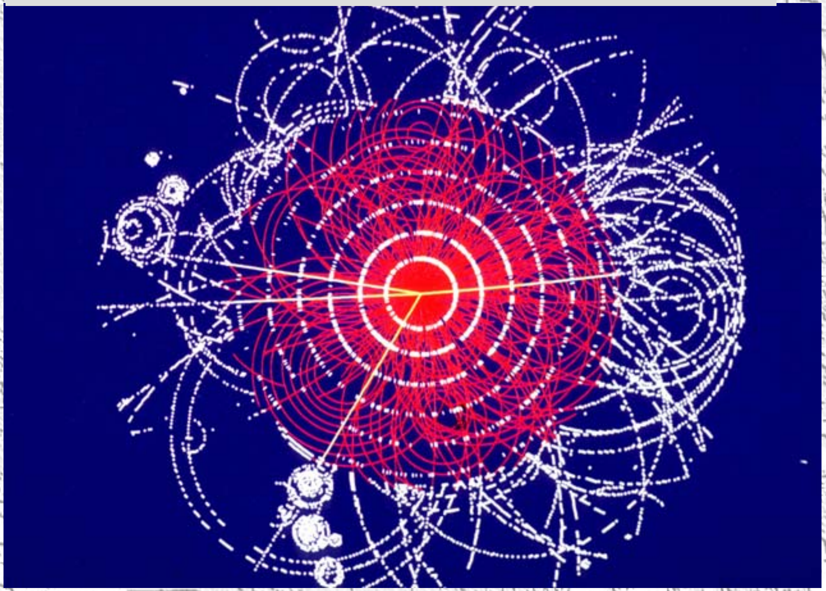
LEP:	LHC:	
$H \to bb$	$H \to bb$	enormous QCD bkgd
	$H \to \gamma\gamma$	low m_H (BR $\approx 10^{-3}$)
	$H \to W^+W^-$	medium m_H
	$H \to ZZ$	high m_H



$H \to \gamma\gamma$

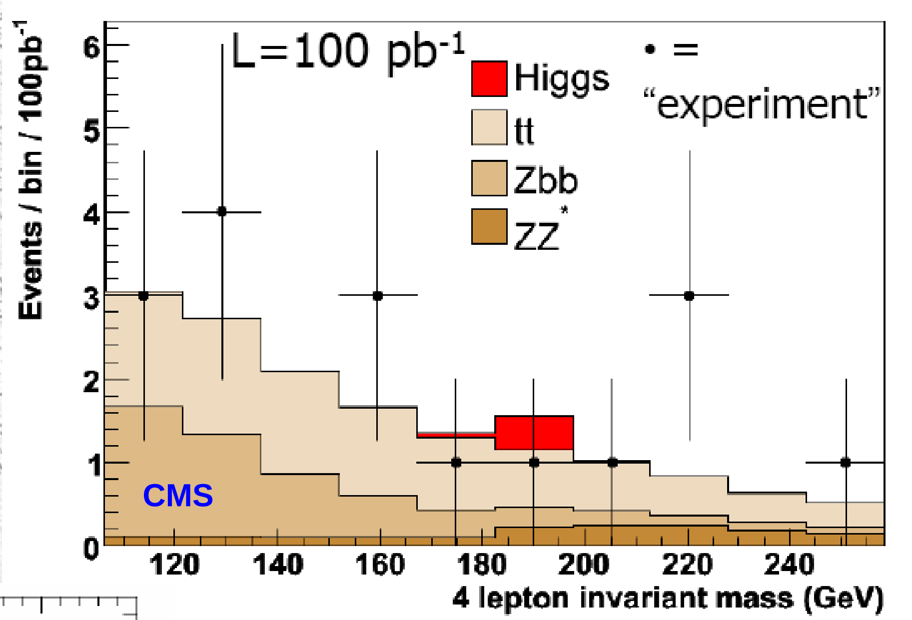


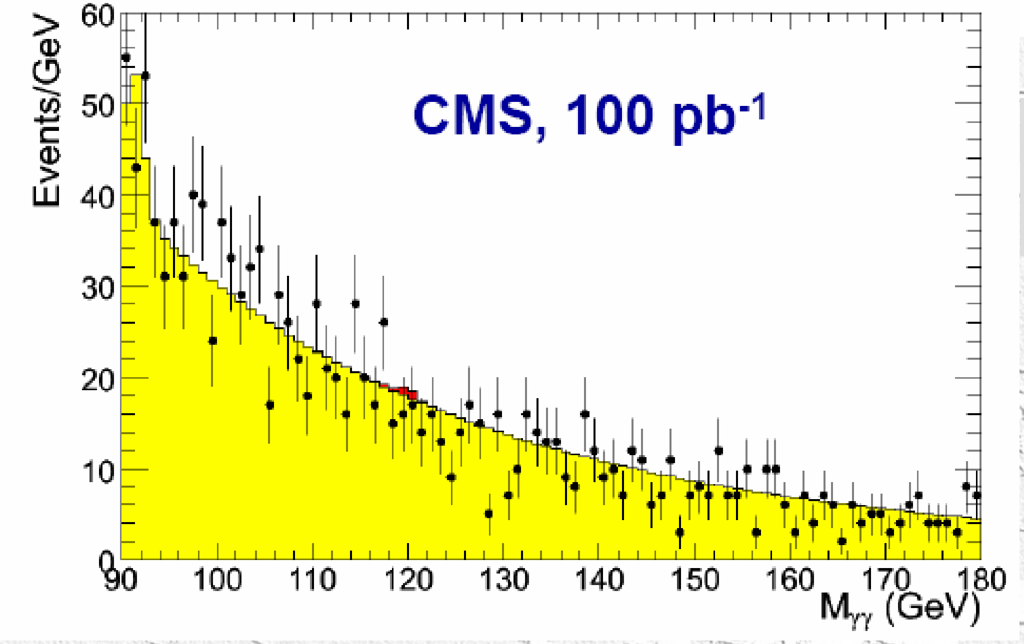
$H \to ZZ \to 4\mu$ (golden channel)



Early Higgs Searches

Early Higgs searches
- e.g. $H \to ZZ \to ee\mu\mu$ with 0.1 fb^{-1}

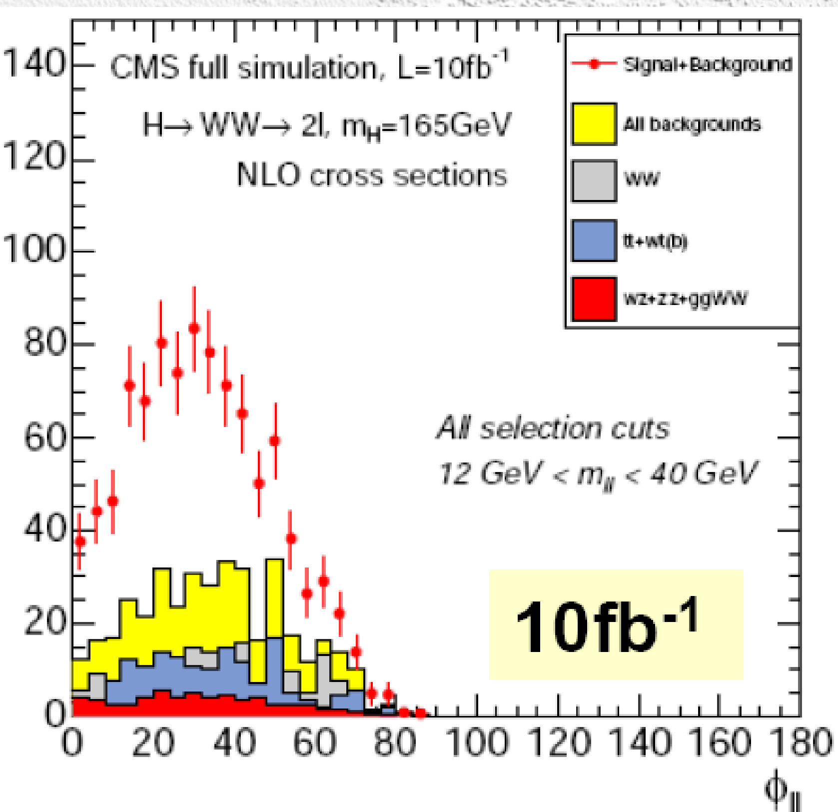


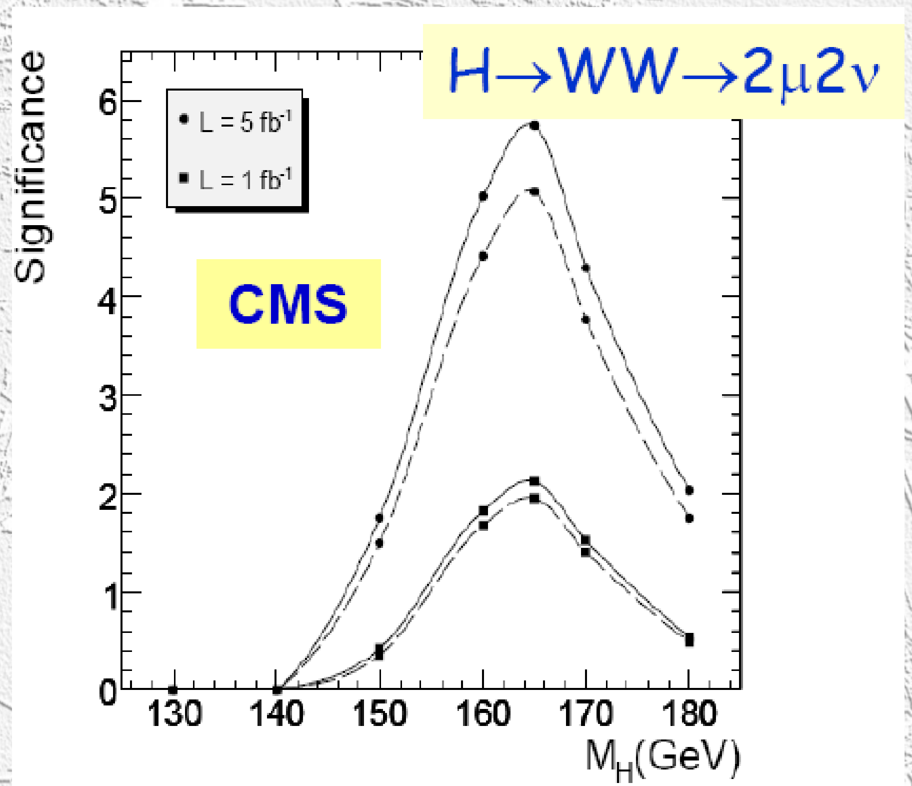


$H \to \gamma\gamma$
- **needs most integrated luminosity**

Early Higgs Searches

- Best chances around $m_H \approx 2\ m_W$ in $H \rightarrow WW \rightarrow 2l + 2\nu$ channel





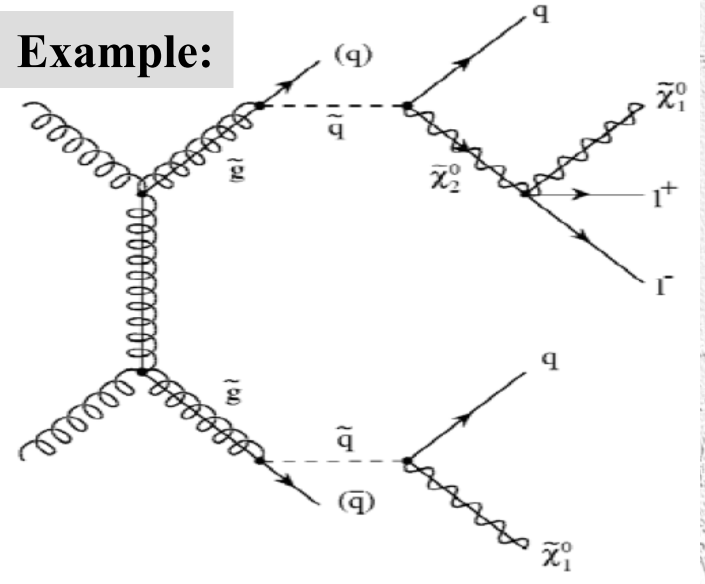
combining all channels $\approx 1\ fb^{-1}$ is needed to establish Higgs of ≈ 160 GeV

SUSY Search at LHC

Production of SUSY particles at the LHC

- squarks and gluinos are pair-produced through strong interaction, i.e. high cross sections
- but also sleptons and other SUSY particles can be pair-produced
- SUSY particles decay in a chain to SM particles plus the LSP

Example:



Signature:

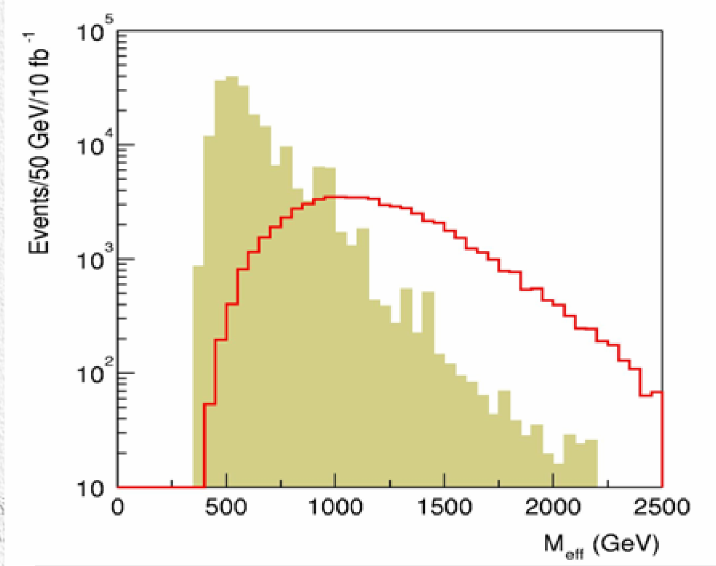
- leptons, jets and missing E_T
- depend of SUSY particles produced, on their branching ratios etc.

Strategy to discover SUSY at the LHC:

- look for deviation from SM in distributions e.g. multi-jet + E_T^{miss}, multilepton+ E_T^{miss}
- establish SUSY mass scale
- try to determine model parameters (difficult!)

Squarks and Gluinos

- Strongly produced, cross sections comparable to QCD cross sections at the same mass scale
- If R-parity conserved, cascade decays produce distinctive events: multiple jets, leptons, and E_T^{miss}
- Typical selection: $N_{jet} > 4$, $E_T > 100, 50, 50, 50$ GeV, $E_T^{miss} > 100$ GeV
- Define: $M_{eff} = E_T^{miss} + P_T^1 + P_T^2 + P_T^3 + P_T^4$ (effective mass)



example: mSUGRA
m_0 = 100 GeV, $m_{1/2}$ = 300 GeV
tan b = 10, A_0 = 0, m > 0

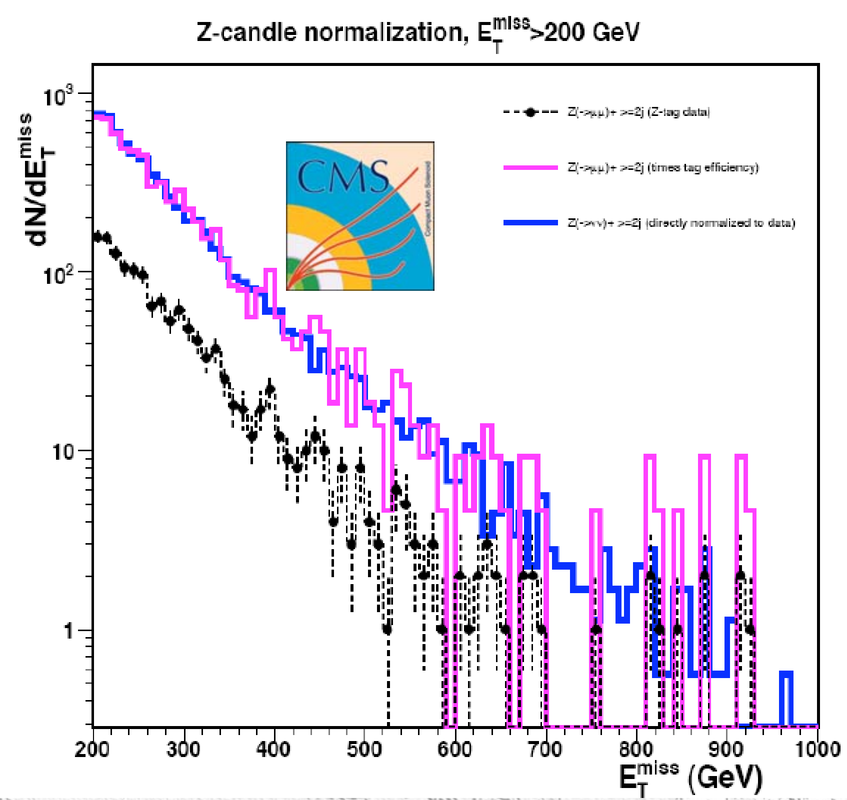
LHC reach for Squark- and Gluino masses:

1 fb^{-1}	⇒	M ~ 1500 GeV
10 fb^{-1}	⇒	M ~ 1900 GeV
100 fb^{-1}	⇒	M ~ 2500 GeV

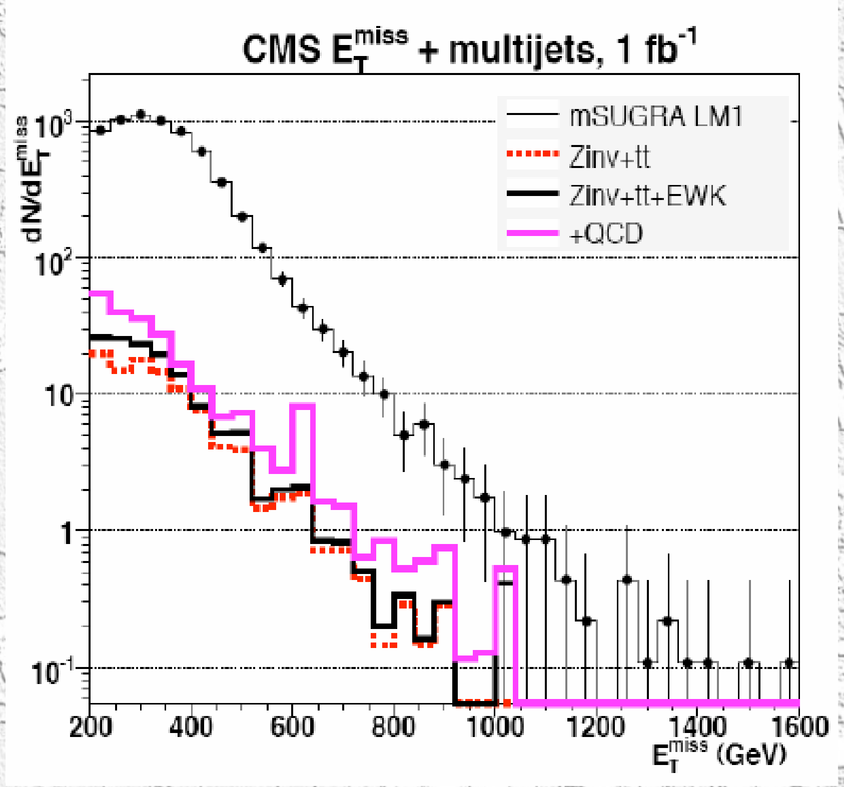
TeV-scale SUSY can be found quickly !

Early SUSY Searches

- Control over physics background
- Example E_T^{miss} + jets:
  - background from $Z \rightarrow \nu\nu$ (+jets)
  - normalise to $Z \rightarrow \mu\mu$ (+jets)



- Inclusive searches for 1 fb^{-1}



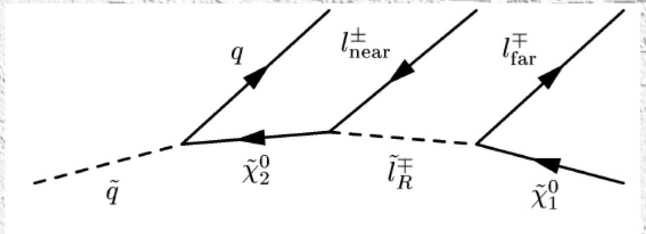
SUSY Searches

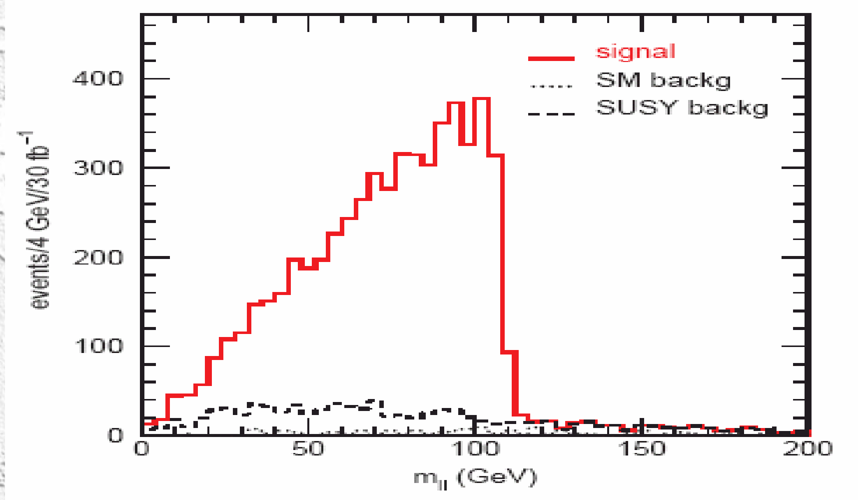
LHC Strategy: End point spectra of cascade decays

Example: $\tilde{q} \rightarrow q\tilde{\chi}_2^0 \rightarrow q\tilde{\ell}^{\pm}\ell^{\mp} \rightarrow q\ell^{\pm}\ell^{\mp}\tilde{\chi}_1^0$

$$M_{\ell^+\ell^-}^{max} = \frac{\sqrt{(m_{\chi_2^0}^2 - m_{\tilde{\ell}}^2)(m_{\tilde{\ell}}^2 - m_{\chi_1^0}^2)}}{m_{\tilde{\ell}}}$$

$$M_{\ell_1 q}^{max} = \frac{\sqrt{(m_{\chi_2^0}^2 - m_{\tilde{\ell}}^2)(m_{\tilde{q}}^2 - m_{\chi_2^0}^2)}}{m_{\chi_2^0}}$$

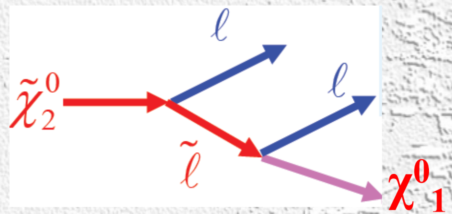


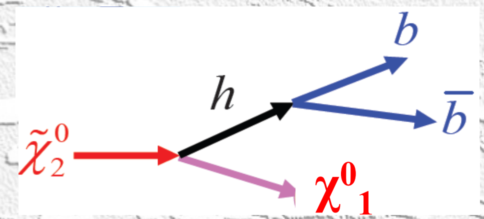


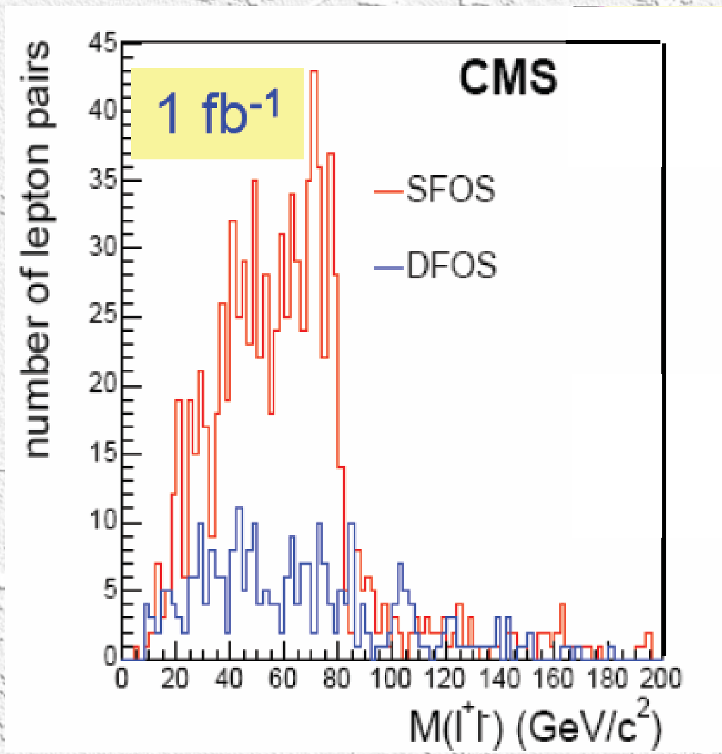
SUSY signals

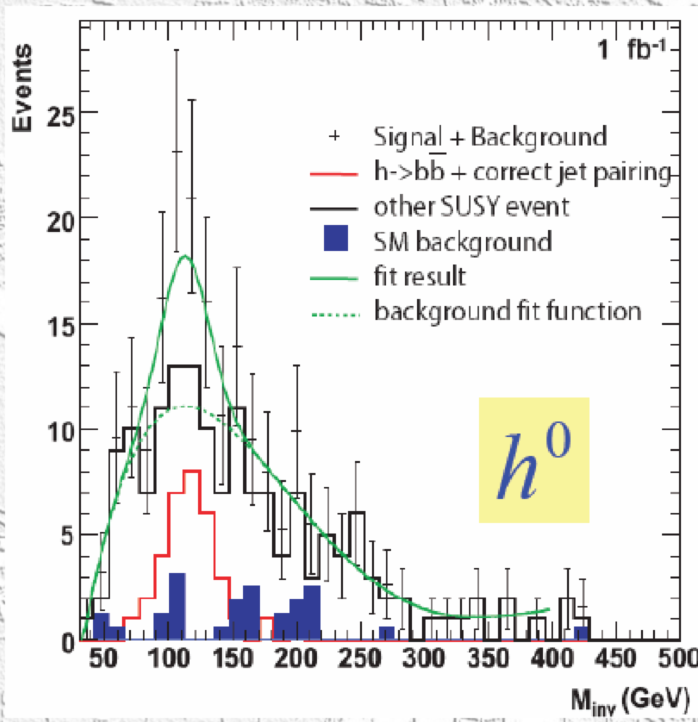
Second ligthest neutralino χ^0_2
- cascade decay
- leptons + E_T^{miss}

- cascade decay with h
- b-jets + E_T^{miss}



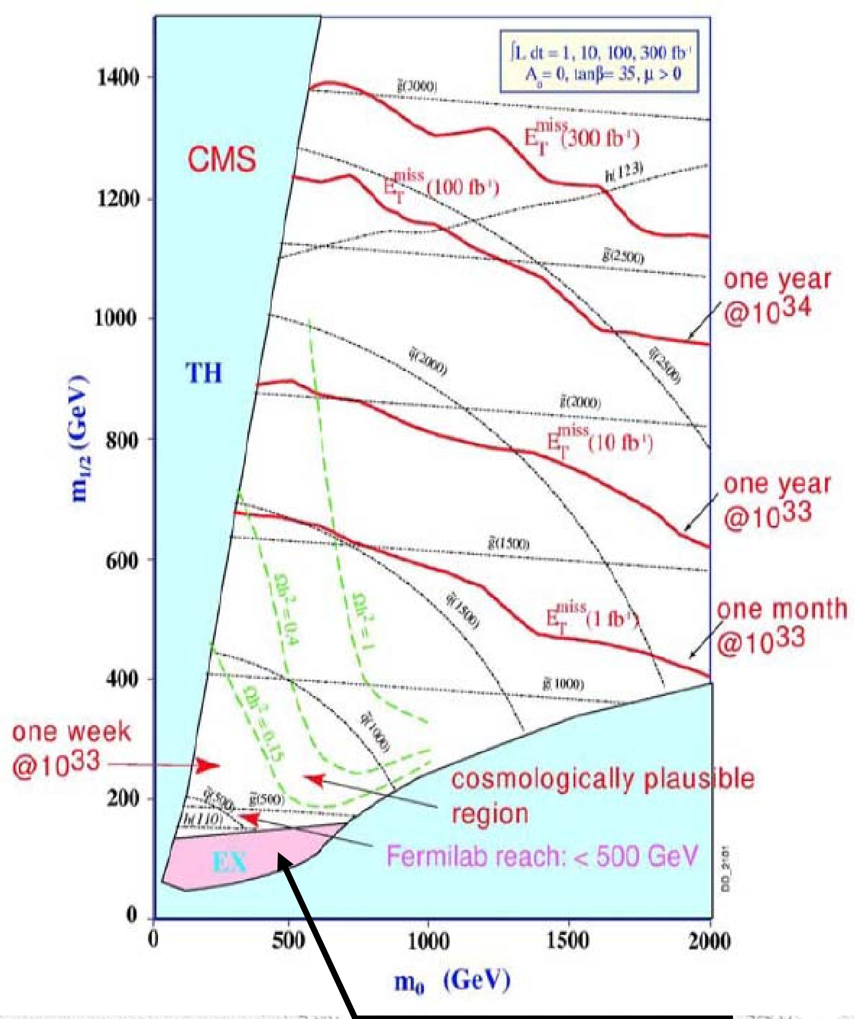






SUSY Search at LHC

Example: discovery reach as function of luminosity and model parameters which fix the mass scale of SUSY parameters



LEP exclusion

- **achievable limits exploiting E_T^{miss} signatures**
- **requires very good understanding of detectors**

Conclusion:

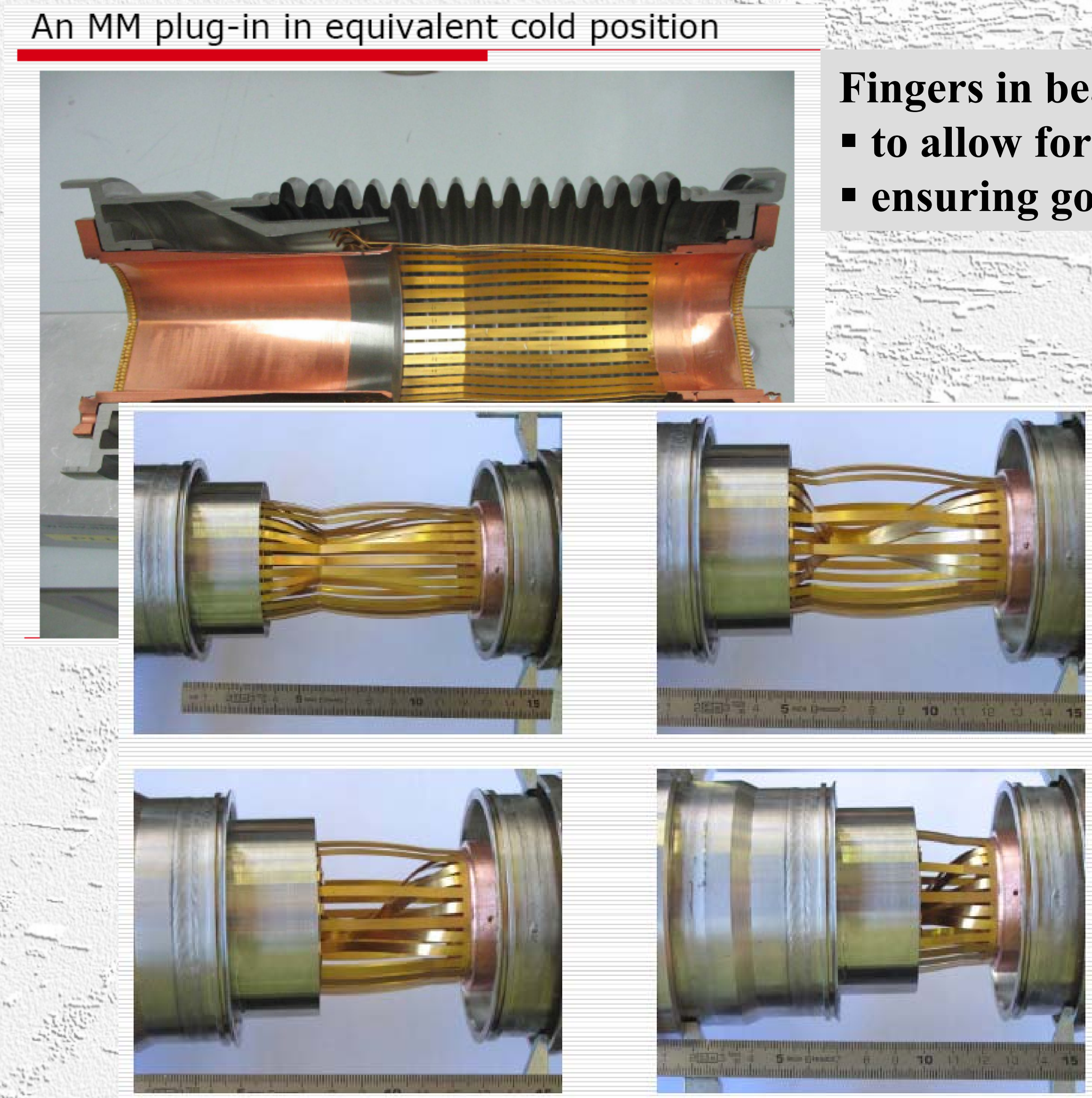
- **LHC will eclipse today's limits on SUSY particles and parameters**
- **or discover SUSY if it exists at the TeV scale**

Summary

- **LHC start expected 2nd half 2008**
  - collider & experiments on schedule
- **2008 luminosity O(100 pb^{-1})**
  - commissioning of detectors
  - calibrations, alignment
  - initial SM measurements: QCD, W/Z, top, …
  - light SUSY?
- **1 fb^{-1}, in range for 2009**
  - start SM precision measurements
  - enter Higgs discovery era
  - explore SUSY over large area
  - new resonances, e.g. Z′
- **10 - 30 fb^{-1}, until 2011/12**
  - most SM measurements, incl. precision m_t, m_W
  - cover entire Higgs mass range
  - start exploring multi-TeV region

Backup Slides

The RF Finger Problem



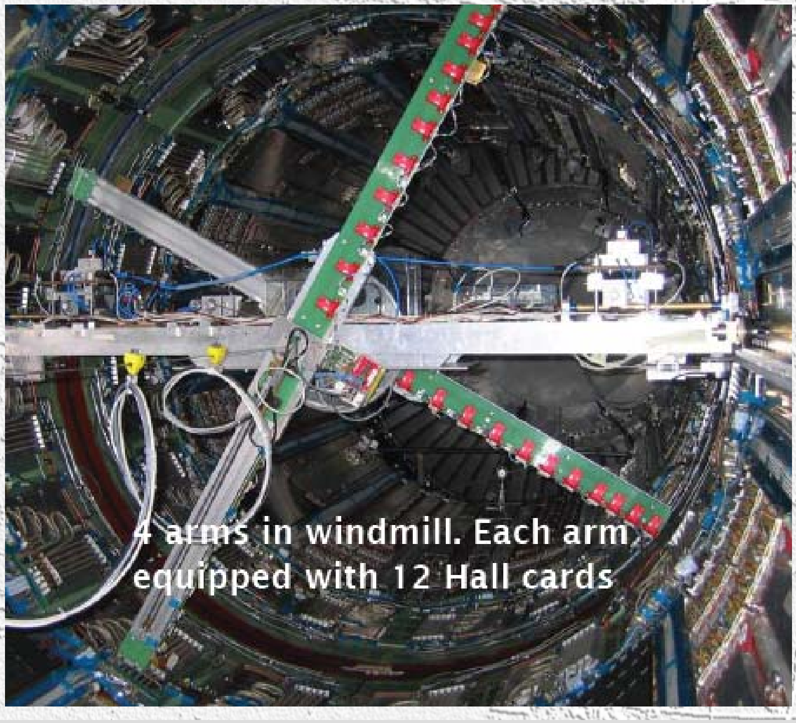
Fingers in beam pipe bellows:
- **to allow for thermal compression & expansion**
- **ensuring good electrical contactv**

- **problems found in 1 sector after warming up**
- **cause is still under study**

- **should not have big impact on schedule (as long as no more sectors have to warmed up again…)**

Status of ATLAS

- Magnets
  - barrel toroid tested sucesfully (11/06)
  - inner solenoid:
    tested & field map taken



- 1 endcap toroid sucessfully tested (03/07)
  moved to IP1
- 2nd followed in June

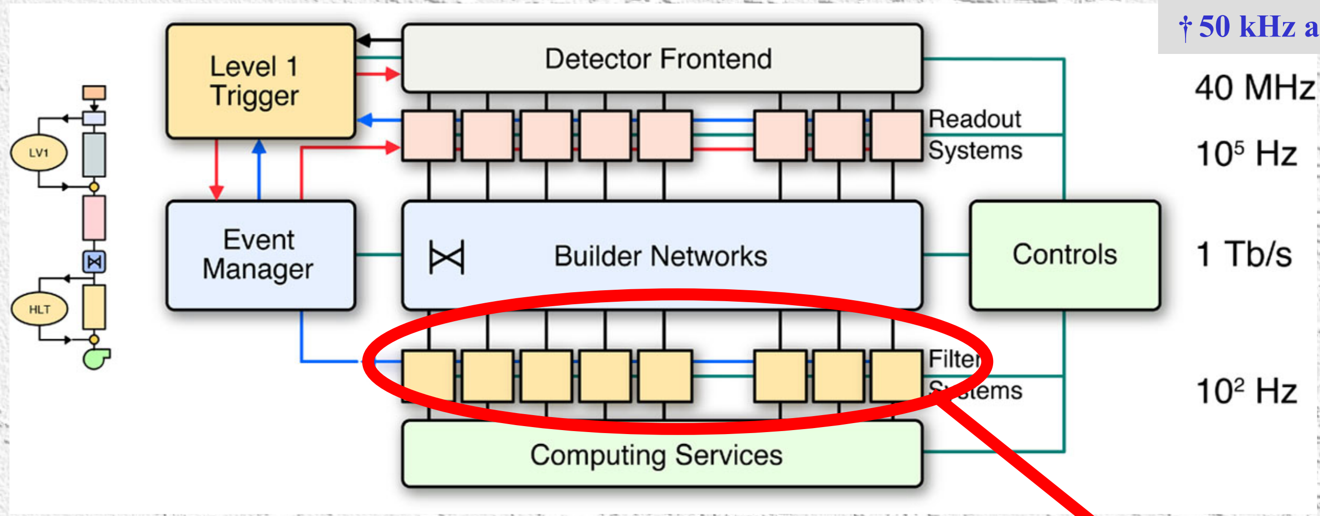
Trigger & DAQ system

Similar design for ATLAS & CMS

Example CMS:

Collision rate	40 MHz
Level-1 max. trigger rate	100 kHz†
Average event size	≈ 1 Mbyte

† 50 kHz at startup (DAQ staging)



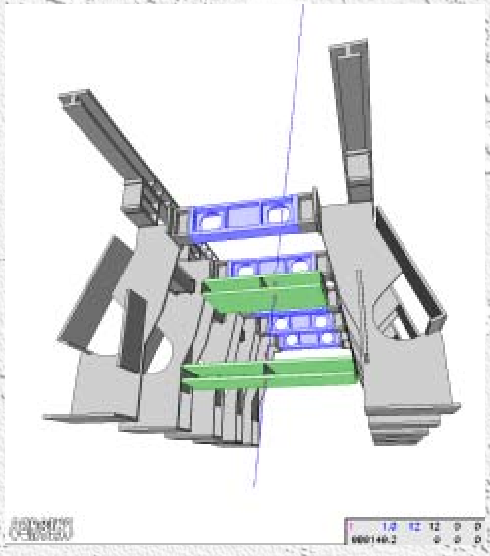
Filter farm:

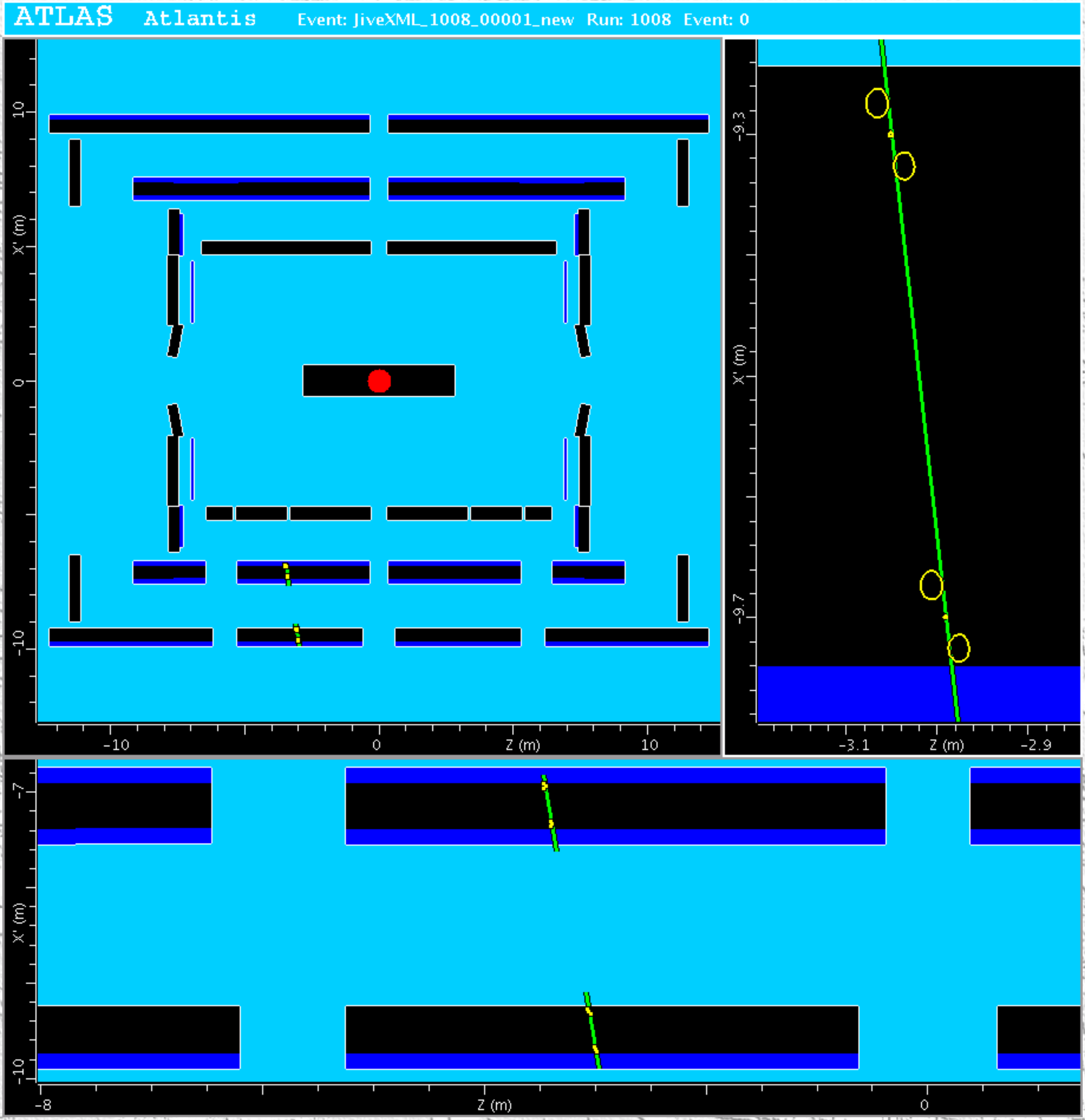
- approx. 2000 CPUs
- easily scaleable
- staged (lower lumi & saves money)
- uses offline software

The longest journey starts with the first step…

Just before Christmas:

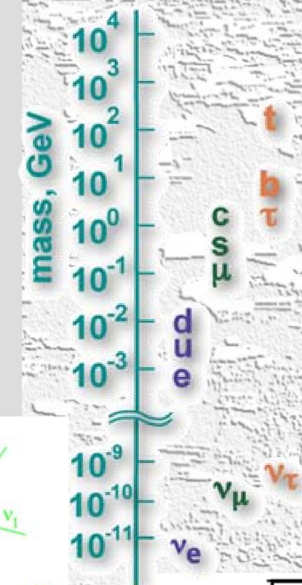
First cosmics muons registered in the stations installed in the bottom sector of the spectrometer

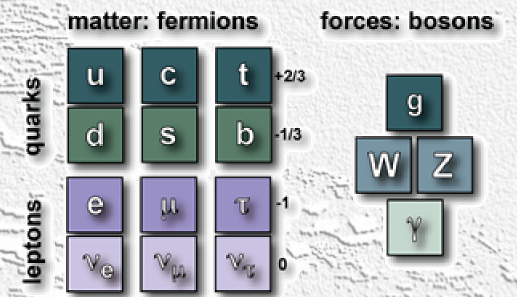




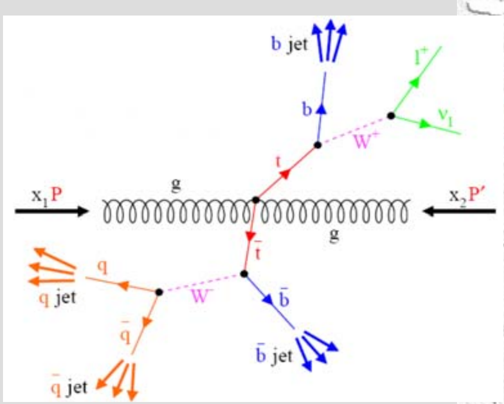
Motivation Top Physics

- **The top is by far the heaviest SM fermion**
  - could provide insight to mass generation
  - coupling to Higgs
    - neutral, e.g. loops
    - charged, e.g. $t \rightarrow H^+ b$
  - exotics $X \rightarrow$ ttbar

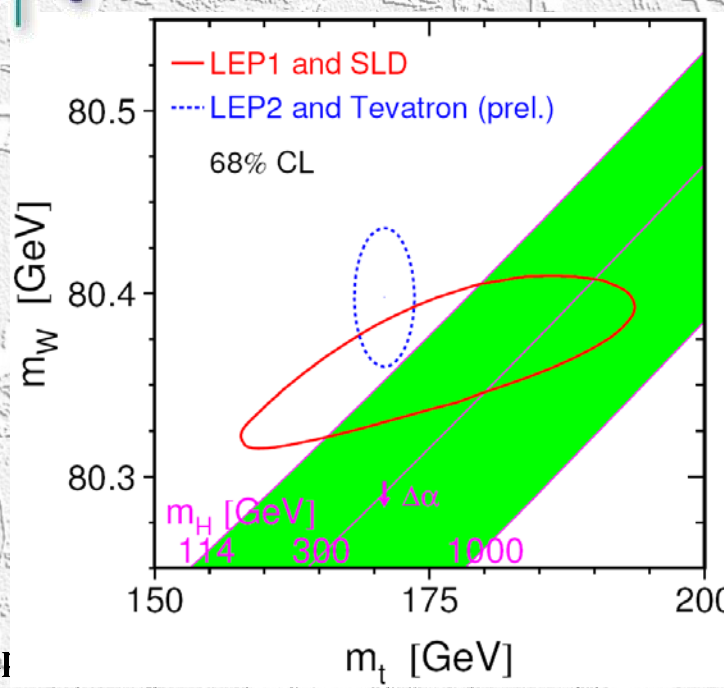




- **It has very short lifetime**
  - the only quark that does not hadronise!
  - allows spin analysis from decay products (à la tau)



- **Top mass**
  - important parameter in EW precision tests
  - m_t enters quadratically in rad. corrections
  - m_H only logarithmically!

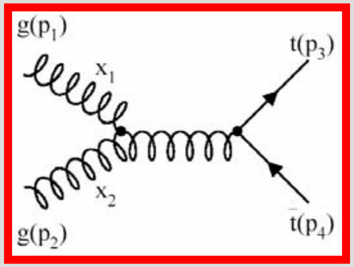


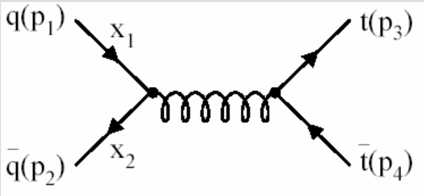
Why Top Physics at the LHC?

- **ttbar production is standard candle at high Q^2**
  - **relatively precisely measureable and calculable**
  - **cross checks impact of pdf, underlying event, pile-up, …**

- **ttbar production**

≈ 90% gluon fusion **≈ 10% quark annihilation**

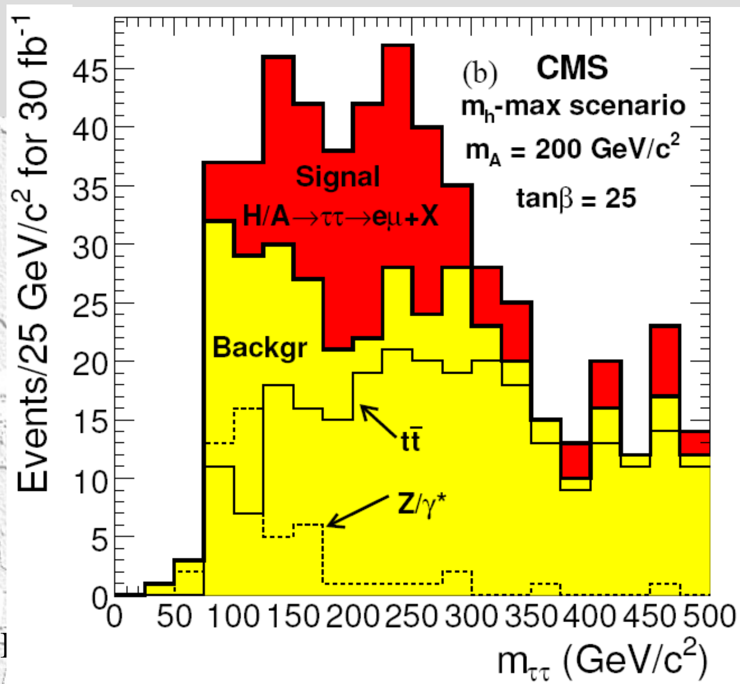




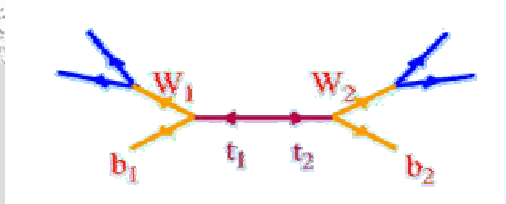
i.e. similar to e.g. Higgs production

- **Important background reaction for many New Physics channels**
  - **high cross section**
  - **presence of high p_T lepton(s)**
  - **multi-jet final states**

e.g. SUSY Higgs from CMS PTDR



Top Quark Decay

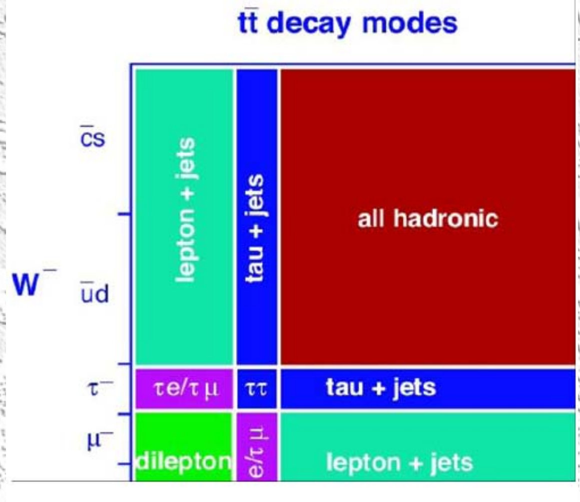


- Top decay: ≈ 100% t → bW
- Other rare SM decays:
  - CKM suppressed t → sW, dW: 10^{-3} – 10^{-4} level
- & non-SM decays, e.g. t → bH^+

In SM topologies and branching ratios are fixed:

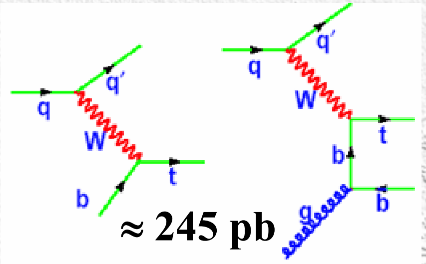
- expect two b-quark jets
- plus W^+W^- decay products:
  - 2 charged leptons + 2 neutrinos
  - 1 charged lepton + 1 neutrino + 2 jets
  - 4 jets (no b-quark!)

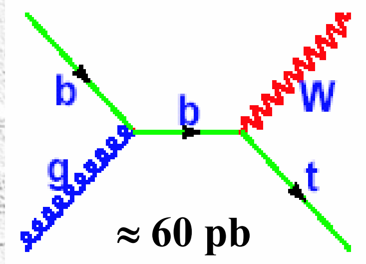
$t\bar{t} \to l\nu l\nu bb$	5%	$(e+\mu)$
$t\bar{t} \to l\nu qqbb$	30%	$(e+\mu)$
$t\bar{t} \to qqqqbb$	46%	

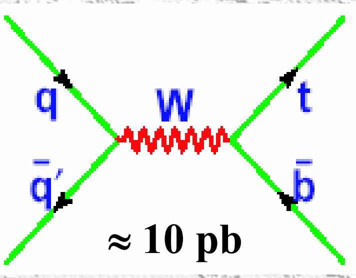


Single Top Production

Production mechanisms and cross sections:







- direct measurement of V_{tb}
- observable by Tevatron in Run II
- LHC $\sigma_t \approx 1.5\ \sigma_{\bar{t}}$

- Selection:

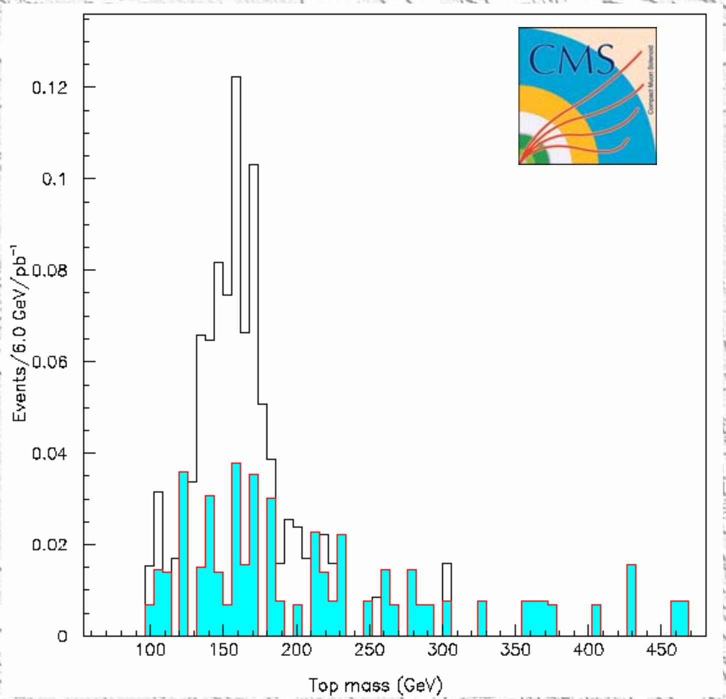
  $t \rightarrow bW \rightarrow b\ e\nu\ (\mu\nu)$

  b-jet + high p_T lepton

  reconstruction of top mass

- Background from $t\bar{t}$

  signal to bkgd. 3.5 : 1

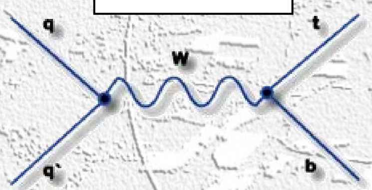


experimental determination of V_{tb} to percent level (with 30 fb^{-1})

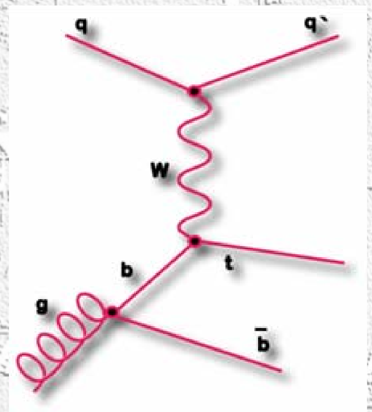
Search for Single Top

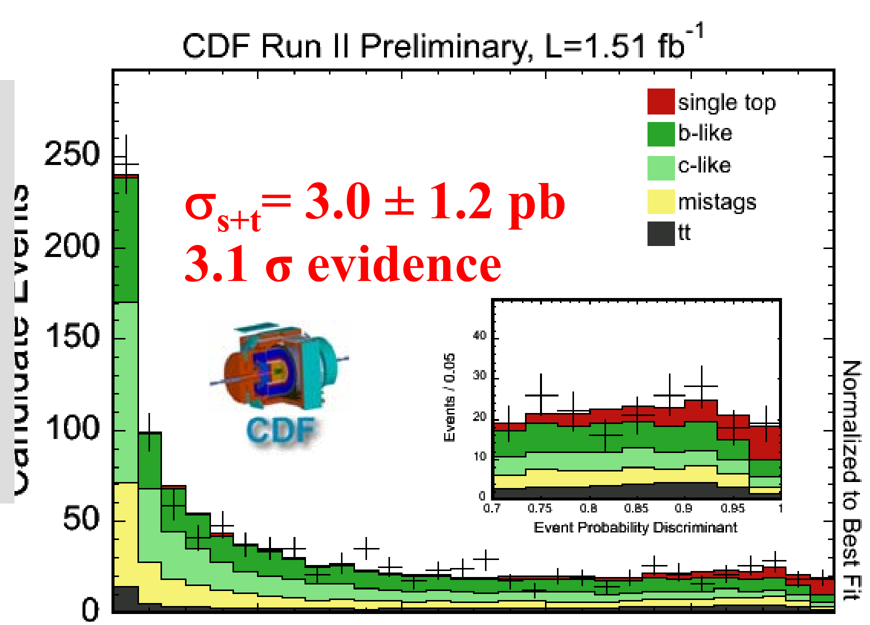
- **Electroweak production of single top quarks**
  - **measures V_{tb}**
  - **smaller x-section wrt to ttbar**
  - **more difficult signature**
- **First evidence established recently by CDF&D0**

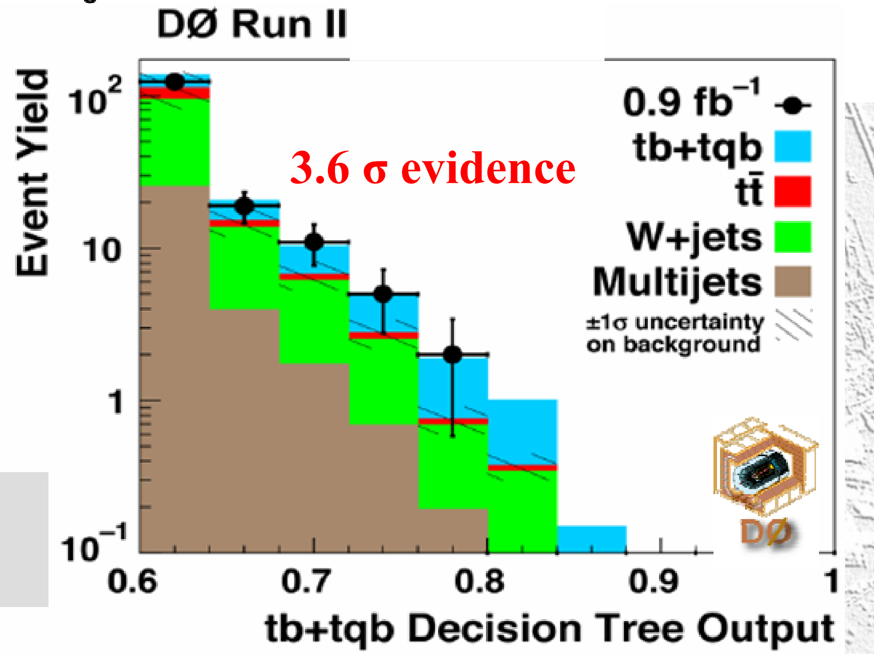
s-channel



t-channel



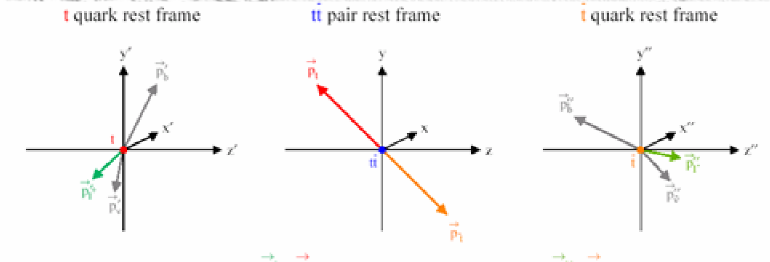




CDF: |Vtb| = 1.02 ± 0.18 (exp) ± 0.07 (th)
D0: |Vtb| = 1.3 ± 0.2

$t\bar{t}$ Spin Correlation

Very short lifetime,
no top bound states
⇒ Spin info not diluted by hadron formation



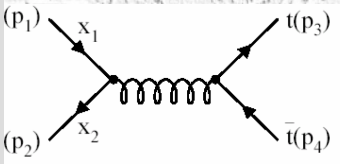
$$\cos\theta^*_{l^+} \equiv \frac{\vec{p}^{*}_{l^+}\cdot\vec{p}_t}{|\vec{p}^{*}_{l^+}||\vec{p}_t|} \qquad \cos\theta^*_{l^-} \equiv \frac{\vec{p}^{**}_{l^-}\cdot\vec{p}_{\bar{t}}}{|\vec{p}^{**}_{l^-}||\vec{p}_{\bar{t}}|}$$

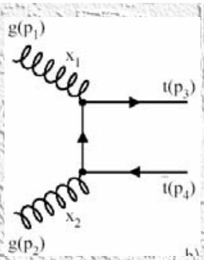
$$\mathcal{A} = \frac{N(t_L\bar{t}_L + t_R\bar{t}_R) - N(t_L\bar{t}_R + t_R\bar{t}_L)}{N(t_L\bar{t}_L + t_R\bar{t}_R) + N(t_L\bar{t}_R + t_R\bar{t}_L)}$$

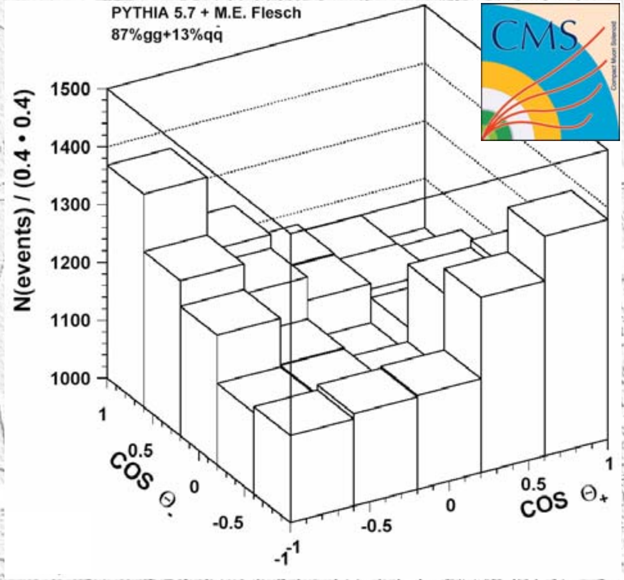
$$\frac{1}{N}\frac{d^2N}{d\cos\theta^*_{\ell+}\, d\cos\theta^*_{\ell-}} = \frac{1}{4}(1 - \mathcal{A}\cos\theta^*_{\ell+}\cos\theta^*_{\ell-})$$

Distinguishes between

- quark annihilation
  A = -0.469
- and gluon fusion
  A = +0.431





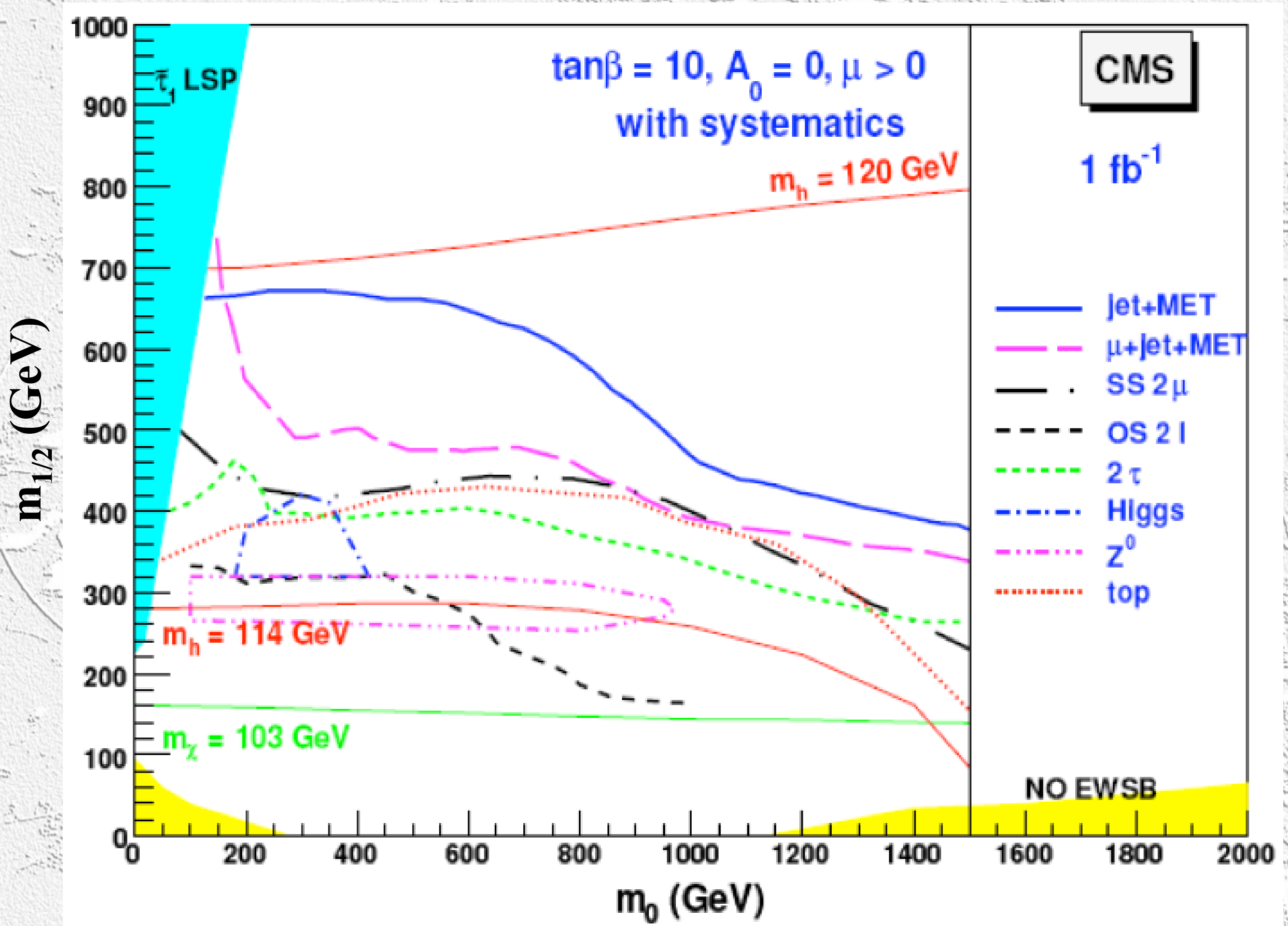


Use double leptonic decays
tt → bb lν lν

A= 0.311 ± 0.035 ± 0.028
(using 30 fb^{-1})

Early SUSY Searches

Inclusive searches for 1 fb^{-1}



Early SUSY Searches

- Low mass SUSY ($M_{sp} \approx 500$ GeV) accessible with O(100 pb^{-1})
- However time to discovery will be determined by
  - time to understand detector performance, e.g. E_T^{miss}
  - time to collect control samples e.g. W+jets, Z+jets, top,…