Some Highlights from Particle Physics Summer Conferences

Paul Newman, Birmingham Seminar
3 November 2010

- Highly personalised view *
- Strong emphasis on collider physics (HERA → TeVatron → LHC)
- Including a detour to Southern Italy (Diffraction 2010 conf)

* Caveat: I was not present for the plenary sessions ☹

Plenary Session Programme

ICHEP2010 Plenary Sessions

Monday 26 July 2010

Plenary Session 09:00-11:10 Grand Amphithéâtre

Chairperson: Etienne AUGÉ (CNRS IN2P3)

09:00	Official opening of the Conference	
09:20	Report on the LHC	Steve MYERS
09:50	The ATLAS experiment	Fabiola Gianotti
10:30	The CMS experiment	Guido TONELLI

Plenary Session 11:40-12:40

Chairperson: Felicitas PAUSS (ETH Zürich)

11:40	The ALICE experiment	Juergen Schukraft
12:10	The LHCb experiment	Andrey GOLUTVIN

Plenary Session 14:00-15:40

Chairperson: Umberto DOSSELLI (INFN)

14:00	IUPAP C11 Young Scientist Prize (experiment)	Florencia Canelli
14:20	IUPAP C11 Young Scientist Prize (theory)	Jose Santiago
14:40	Recent results on structure functions	Haiyan GAO
15:10	Exclusive hard Reactions and QCD	Dieter MÜLLER

Plenary Session 16:00-18:00

Chairperson: Persis DRELL (SLAC)

16:00	Higgs searches at the Tevatron	Ben KILMINSTER
16:30	The Physics of top, W and Z	Elizaveta Shabalina
17:00	A critical overview of electro-weak symmetry breaking	Csaba CSAKI
17:30	ICFA Report	Atsuto SUZUKI
17:45	C11 Report	Patricia MCBRIDE

Tuesday 27 July 2010

Plenary Session 09:00-11:00

Chairperson: Rohini GODBOLE (Indian Institute of Science Bangalore)

09:00	Experimental QCD results and impact on LHC physics	Emmanuel Sauvan
09:30	Perturbative QCD for the LHC	Gavin Salam
10:00	Progress in Lattice QCD	Yoshinobu Kuramashi
10:30	Review on low and high mass spectroscopy	Changzheng YUAN

Plenary Session 11:30-12:30

Chairperson: Joachim MNICH (DESY)

11:30	Ultrarelativistic heavy Ion Collisions	Brian COLE
12:00	What heavy Ion Collisions are teaching us	Raju VENUGOPALAN

Plenary Session 14:00-16:00

Chairperson: Young-Kee KIM (Fermilab)

14:00	The Challenges of Flavor Physics	Gino Isidori
14:30	Beyond the Standard Model searches through B physics at the Tevatron	Guennadi Borissov
15:00	Rare B decays	Karim TRABELSI
15:30	Rare lepton and K-meson decays	Alessandro Massimo Baldini

Plenary Session 16:30-18:00

Chairperson: Jean ZINN-JUSTIN (CEA Saclay)

16:30	CP Violation and the Determination of the CKM Matrix	Frank Porter
17:00	Progress in Beyond the Standard Model theories	James WELLS
17:30	Beyond the Standard Model searches	Pavel Murat

Wednesday 28 July 2010

Plenary Session 09:00-10:20

Chairperson: Hiroaki AIHARA (University of Tokyo)

09:00	Neutrinos: theory review	Eligio Lisi
09:20	New results on solar neutrinos	Alain BELLERIVE
09:40	Long-baseline neutrino experiments	Tsuyoshi NAKAYA
10:00	Reactor neutrinos, double beta and beta decays	Fabrice PIQUEMAL

Plenary Session 10:50-13:10

Chairperson: Hesheng CHEN (IHEP)

10:50	The challenge of Dark Matter	Joseph SILK
11:20	Dark Matter direct detection searches	Jules GASCON
11:50	Progress on cosmology	Sarah Bridle
12:20	Looking at the Universe with PLANCK	François BOUCHET
12:50	The violent Universe	Nicola Omodei

Plenary Session 14:30-15:40

Chairperson: Patricia MCBRIDE (Fermilab)

14:30	String theory	Ashoke SEN
15:00	Detector R&D	Junji HABA
15:20	Progress in computing	Ian Bird

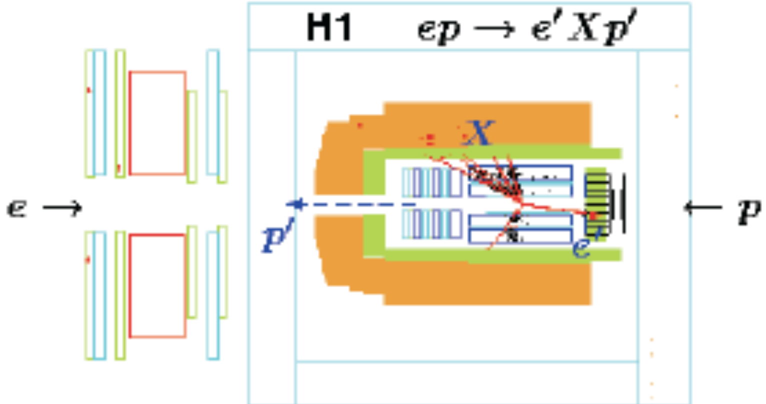
Plenary Session 16:10-18:00

Chairperson: Mikhail DANILOV (ITEP Moskow)

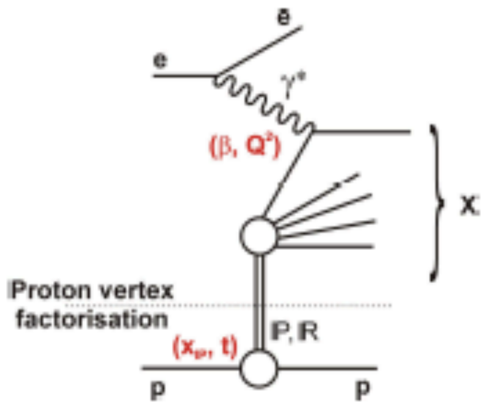
16:10	New accelerator techniques	Tor Raubenheimer
16:40	Linear colliders	Jean-Pierre DELAHAYE
17:10	Discussion on the future of High Energy Physics	
17:30	Summary Talk	Michel SPIRO

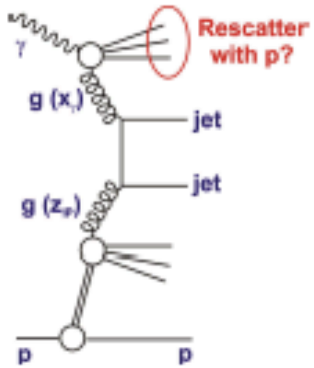
All slides (and even videos) available on the web

Inclusive Diffraction and Related Topics at HERA



Paul Newman
(University of Birmingham)
representing H1 & ZEUS





ICHEP 2010, Paris
23 July 2010

Supported in part by IPPP, Durham

ICHEP 2010 (Paris)

Opening of the conference
By Nicolas Sarkozy

45 minute lecture on importance of science funding and of fundamental research

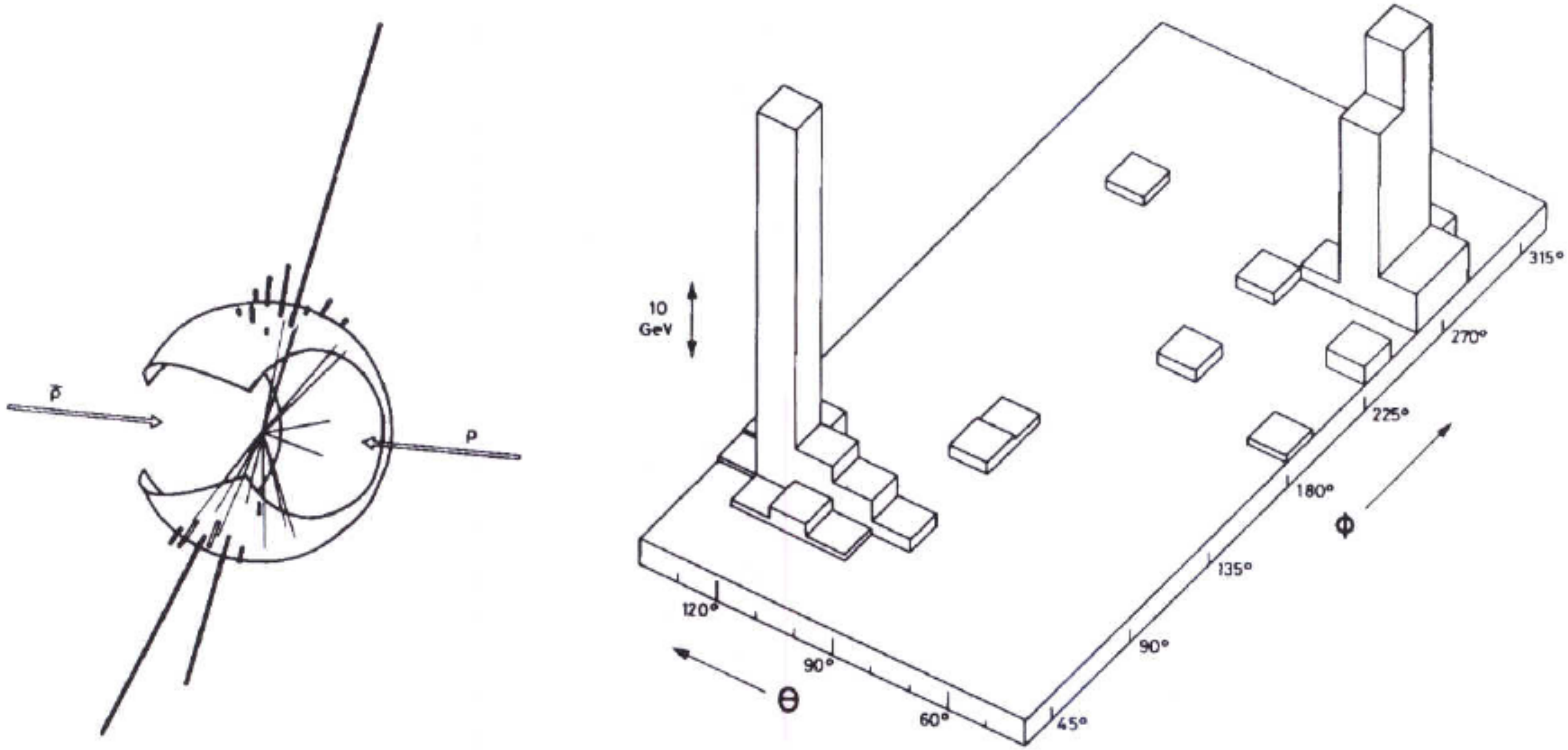
No doubt also an excellent photo-op …

ICHEP 1982 (Paris)

Jet discovery in p pbar collisions (UA2)

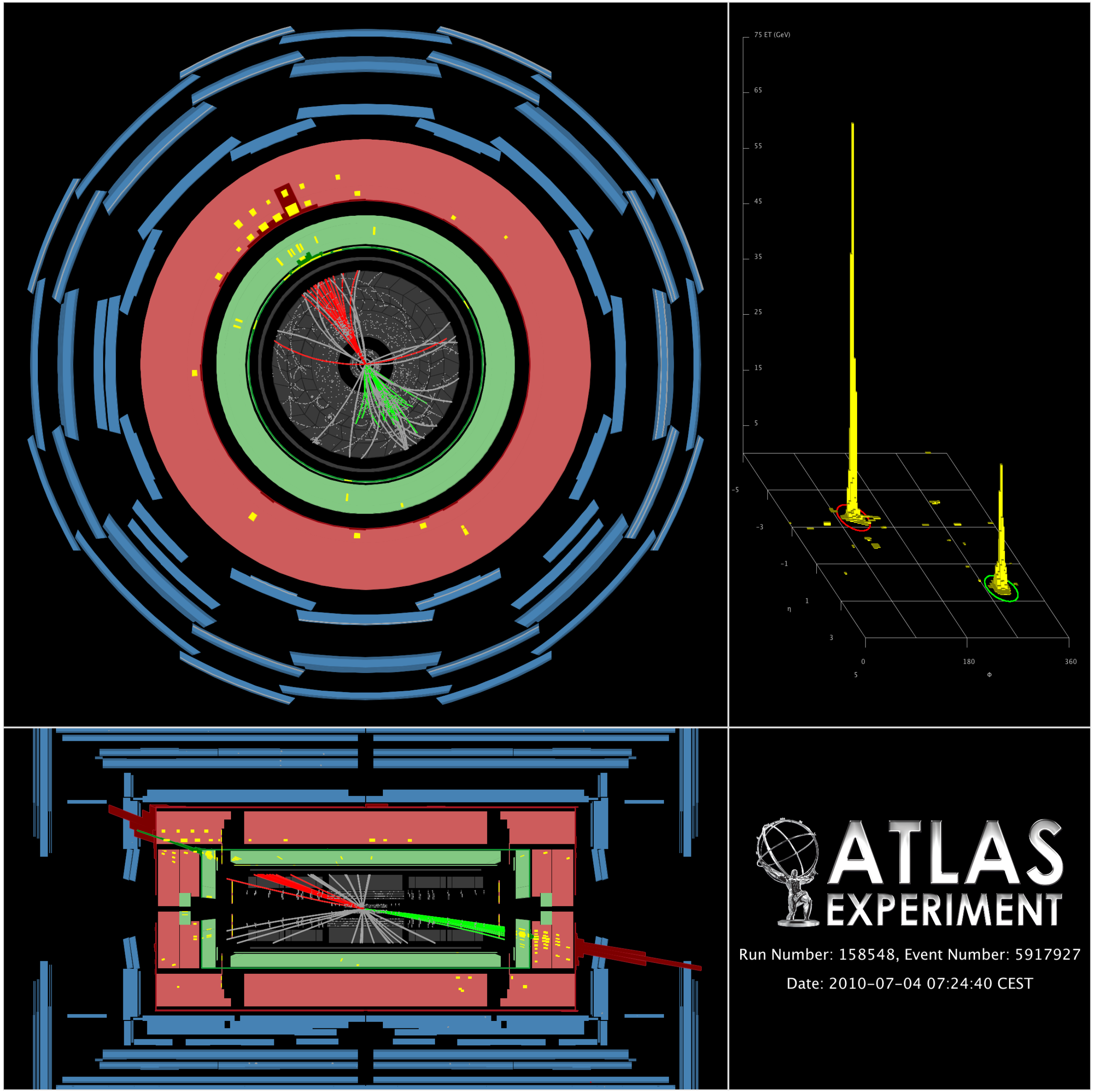
Note the hand-drawn event display ☺

Volume 118B, number 1, 2, 3 PHYSICS LETTERS 2 December 1982



(a) (b)

ICHEP 2010 (Paris)



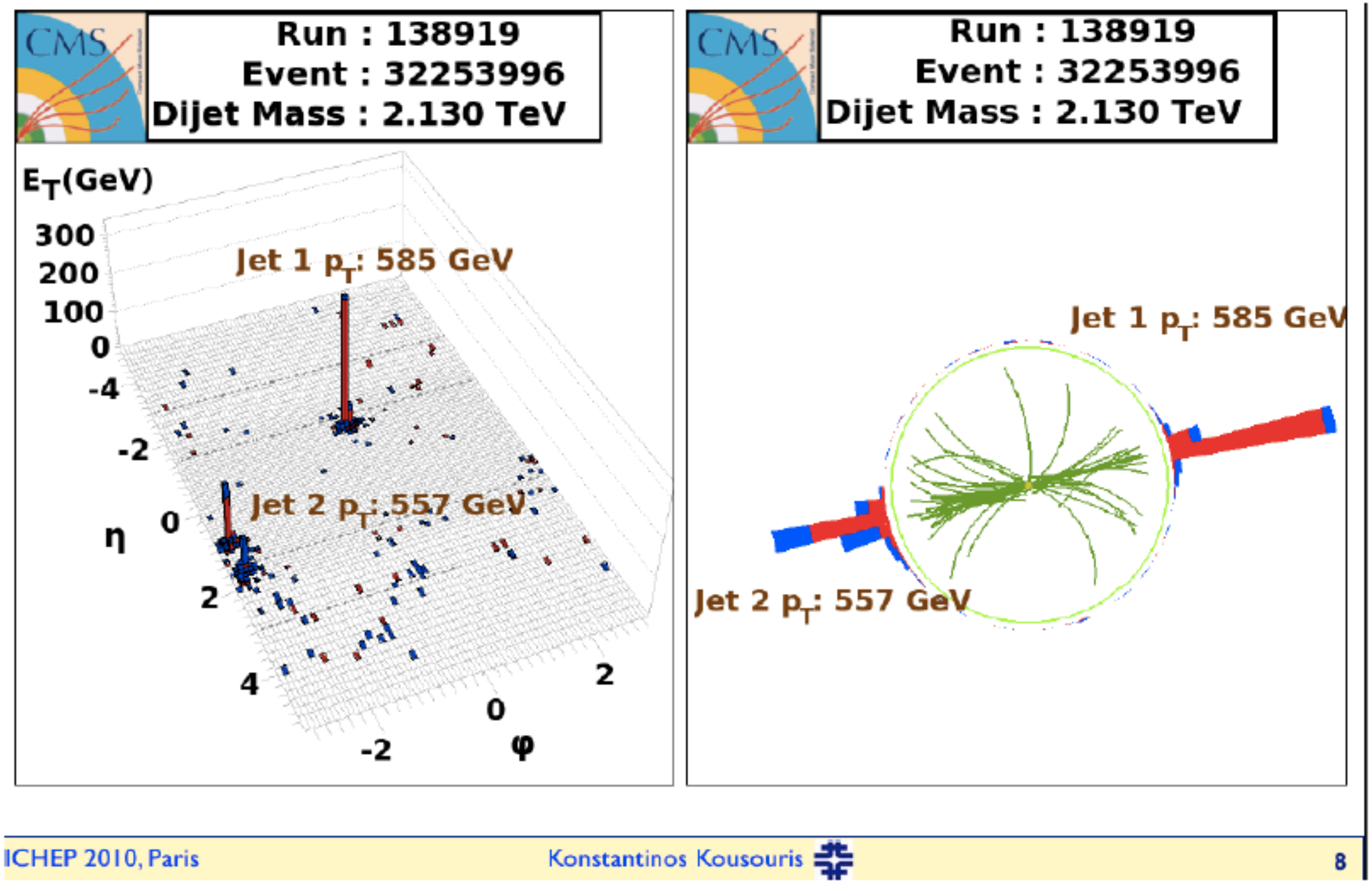
Jets at the LHC

Slightly more sophisticated event display ☺

$p_T\,(j_1)$=420 GeV
$p_T\,(j_2)$=320 GeV

Highest-mass di-jet event observed so far: M_{jj} = 2.55 TeV

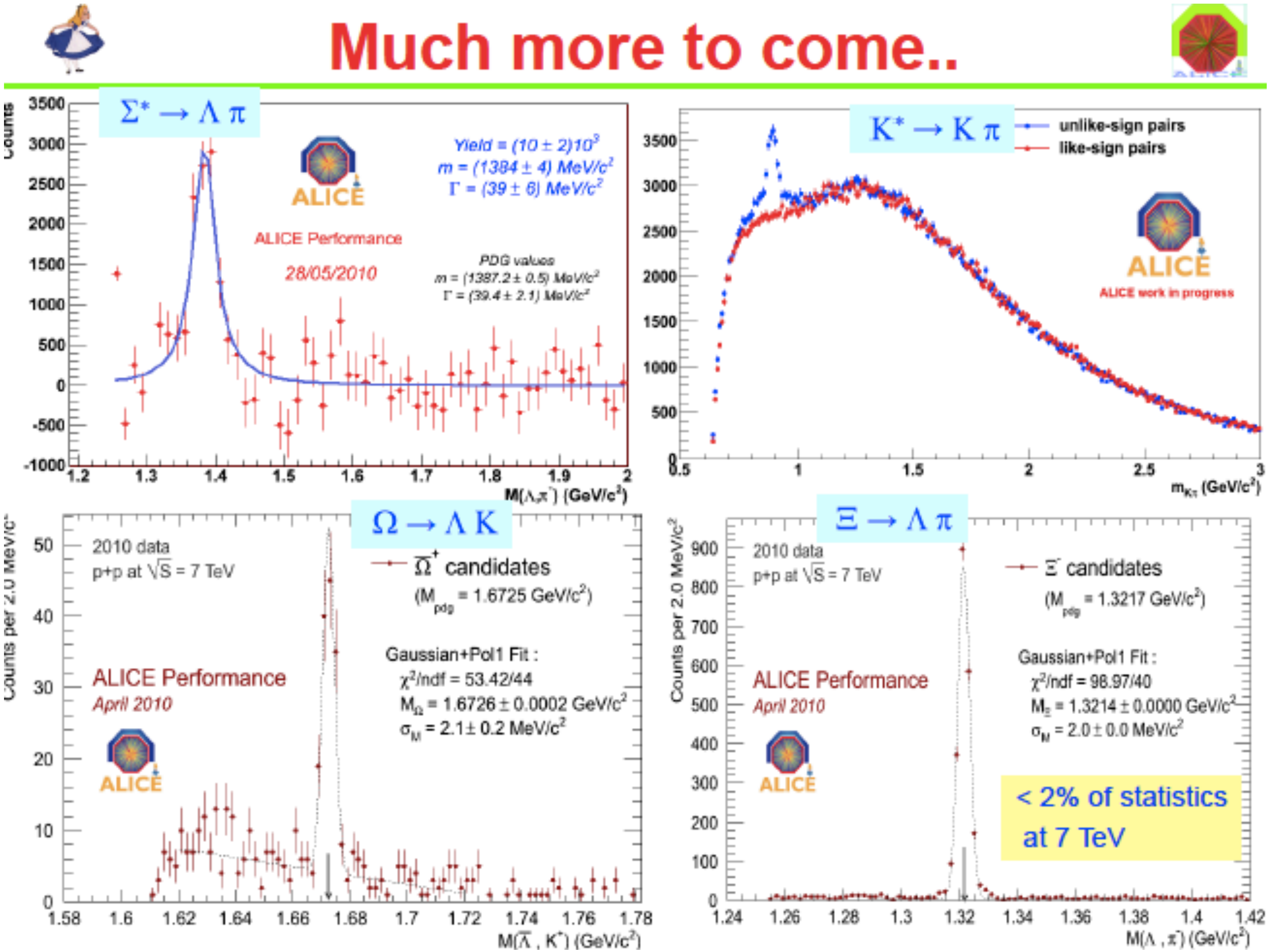
ICHEP 2010 (Paris)



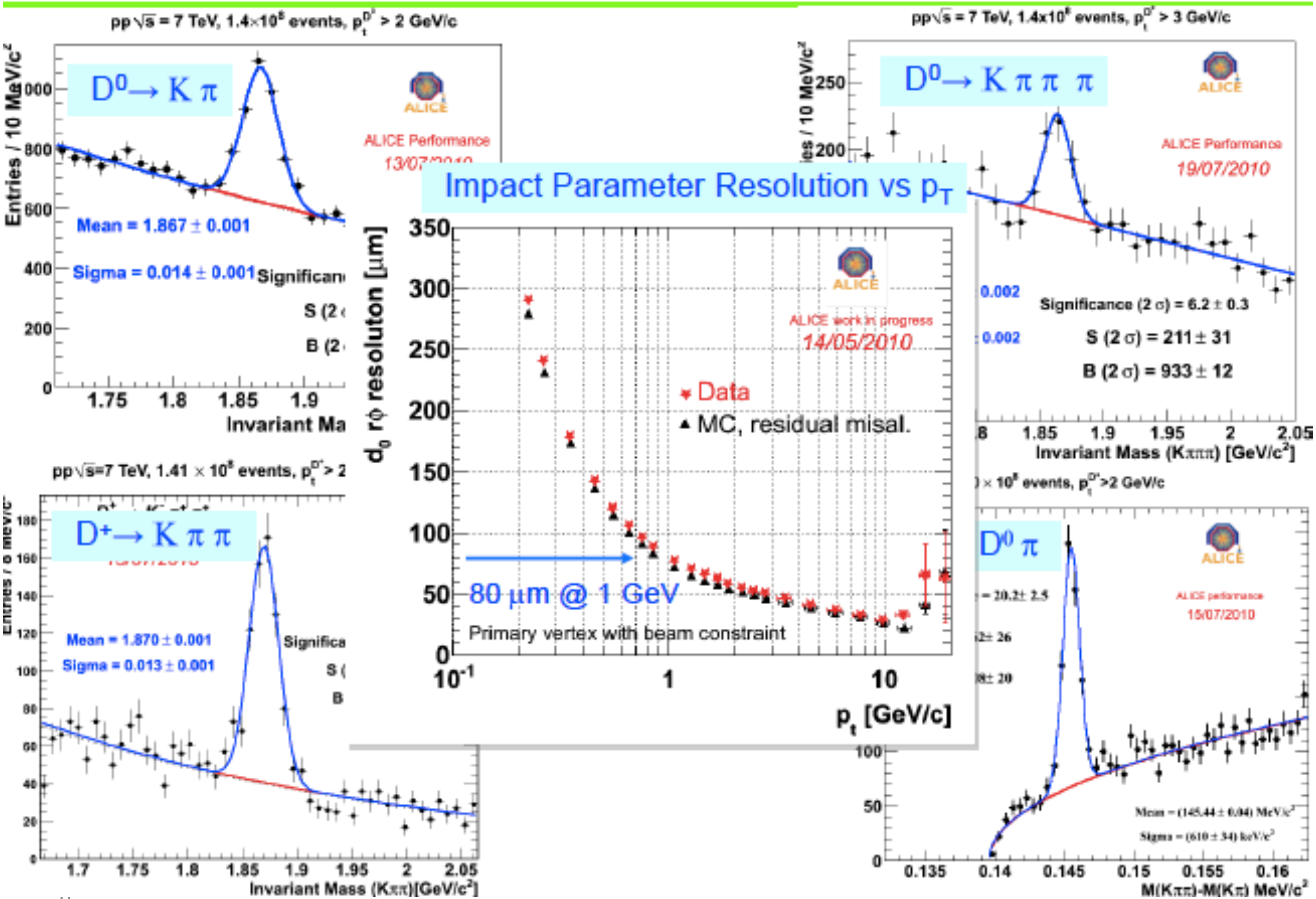
Similarly impressive Jets

Less impressive event display ☹

Along with charged track multiplicities and spectra, many identified particles appeared very early …

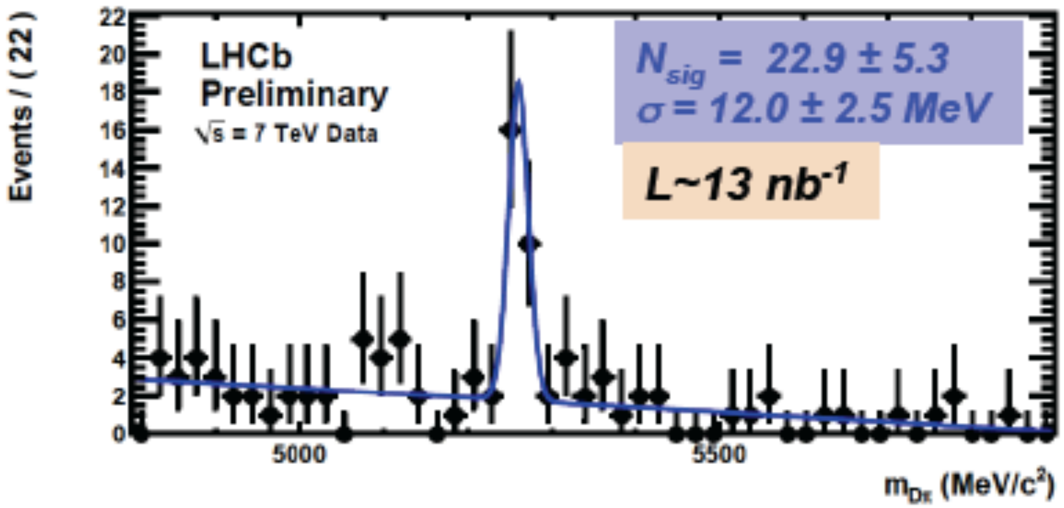


Charm at 7 TeV



First fully reconstructed B mesons

$B \rightarrow D\pi$



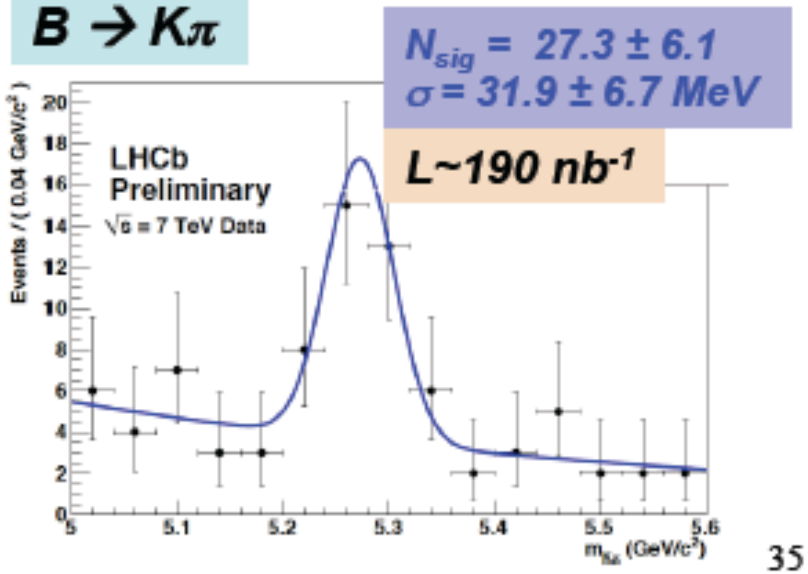
First signal in charmed B decays combining two channels:

- $B^0 \rightarrow D^+\pi^-$
- $B^+ \rightarrow D^0\pi^+$

Excellent mass resolution !

Expect soon $B_s \rightarrow D_s\pi$ and Cabibbo-suppressed $B \rightarrow DK$

$B \rightarrow K\pi$

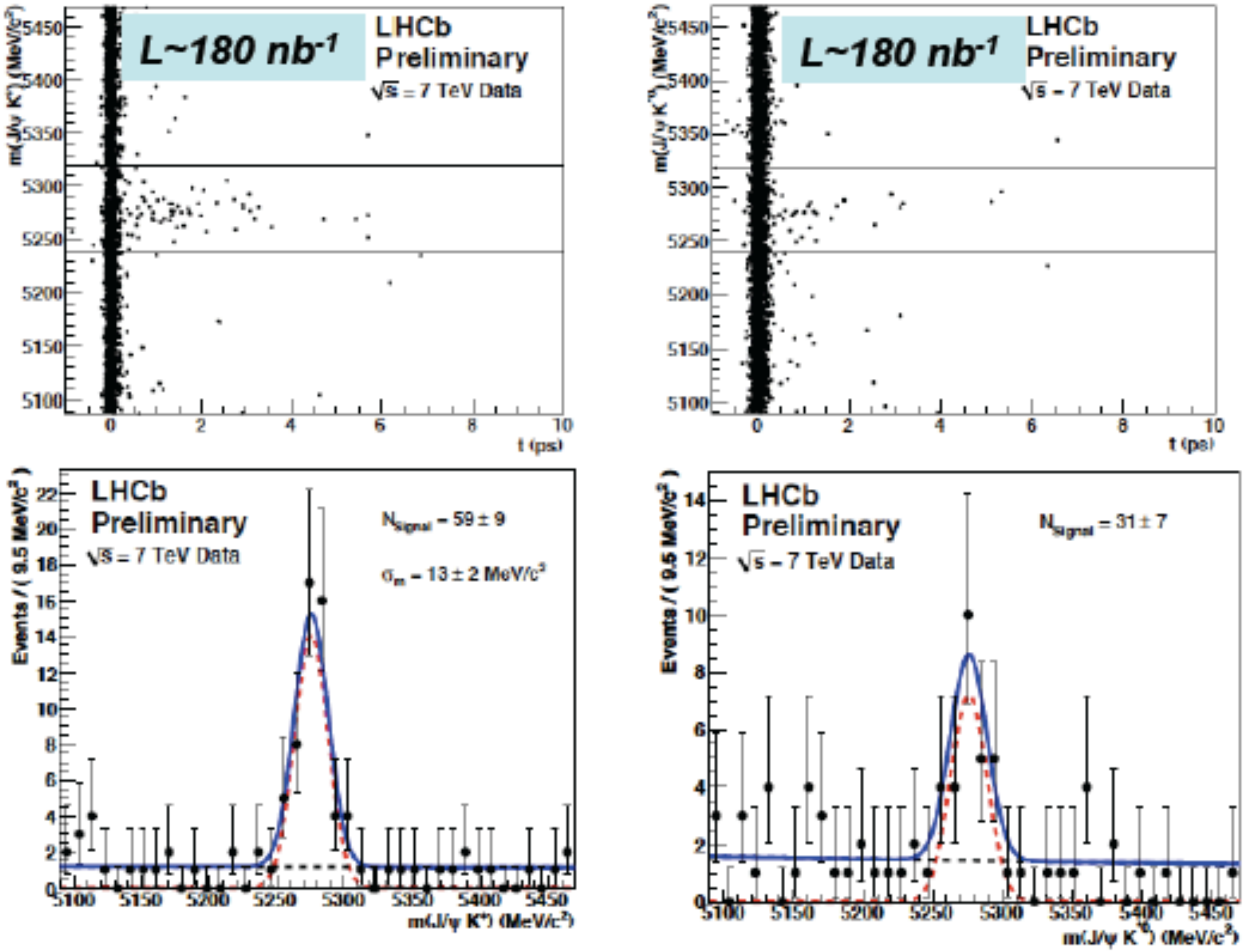


Observed number of signal events consistent with MC expectation

$B_s \rightarrow KK$ signal expected soon

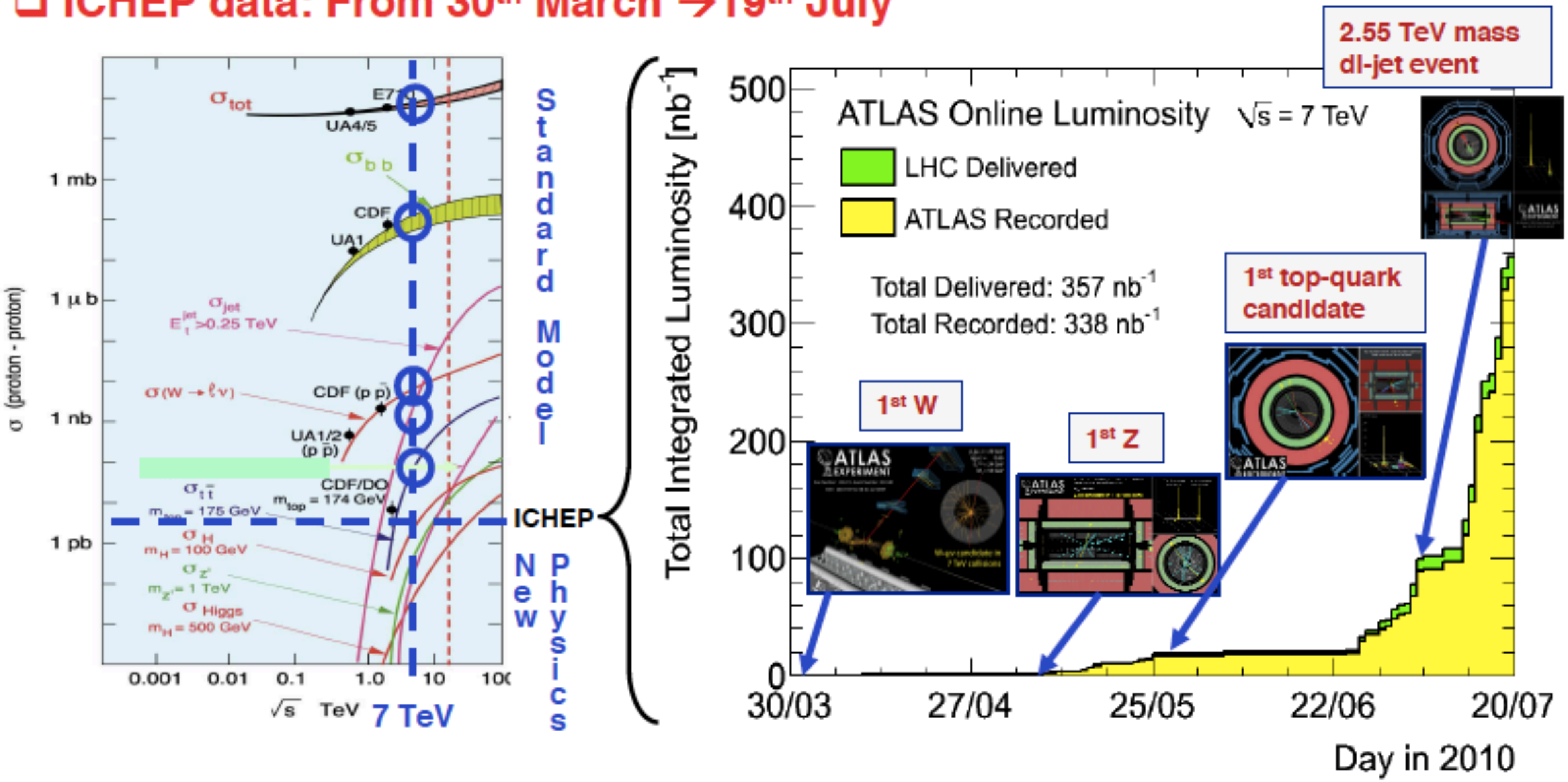
$B \rightarrow J/\psi K^+$ & $B \rightarrow J/\psi K^{*0}$

Unbinned likelihood fit of m, t distributions



Observed number of signal events consistent with MC expectations

❑ ICHEP data: From 30th March →19th July

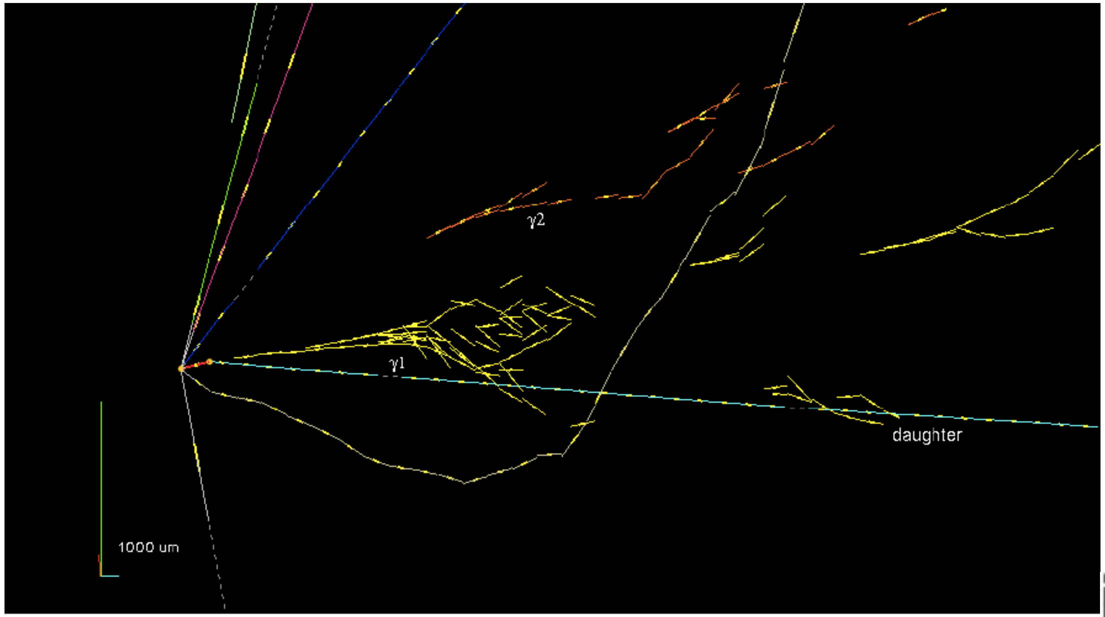


→ at the time of the conference, the LHC had produced ~350 nb-1 per experiment

→ we are now up to ~50 pb-1!

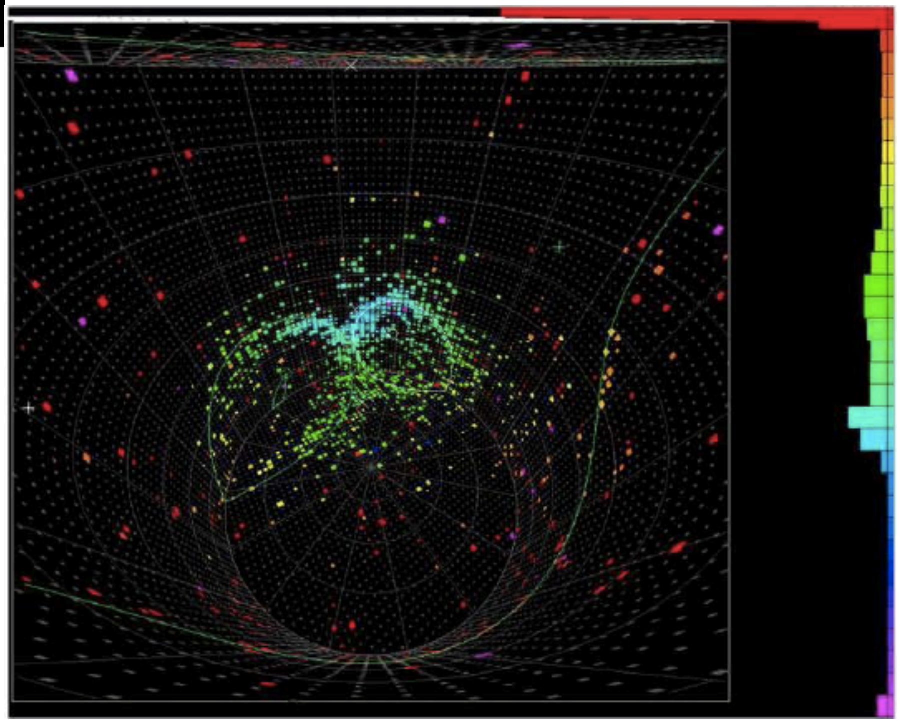
… more on first LHC data later …

Long Baseline Neutrino Experiments



First τ appearance events
In ν_μ beam at CNGS (OPERA)

First T2K event observed in JPARC → Super-Kamiokande ($\pi^0 \rightarrow \gamma\gamma$)



[Nakaya]

Rare K-meson and lepton decays

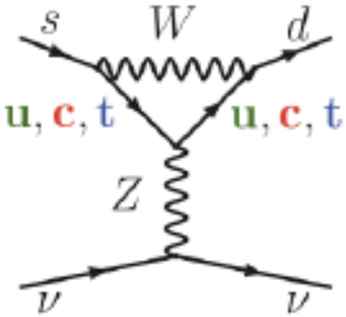
A.M. Baldini – INFN Pisa

2 OUTLINE

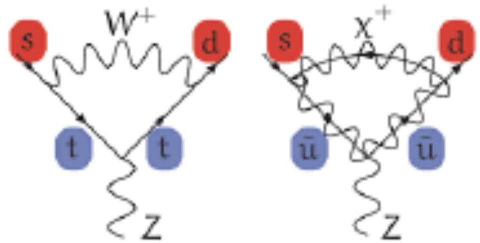
(Pardon!)

Ultra-rare K Decays

1) $K \to \pi\nu\bar{\nu}$



- The contribution to these processes due to the Standard Theory is strongly suppressed ($<10^{-10}$) and calculable with excellent precision (~%)
- They are very sensitive to possible contributions from New Physics



SGI March 24, 2010 Augusto Ceccucci 11

2) $$R_K = \frac{\Gamma(K^\pm \to e^\pm\nu)}{\Gamma(K^\pm \to \mu^\pm\nu)} = \frac{m_e^2}{m_\mu^2} \cdot \left(\frac{m_K^2 - m_e^2}{m_K^2 - m_\mu^2}\right)^2 \cdot (1 + \delta R_K^{rad.corr.})$$

$$= (2.477 \pm 0.001) \times 10^{-5}$$ (V. Cirigliano, I. Rosell, JHEP 0710:005 (2007))

New Physics could contribute to up 1% (Masiero, Paradisi, Petronzio, PRD 74, 2006)

3) In the lepton case SM prediction unobservable! $\tau \to lx$, $\mu \to e\gamma$

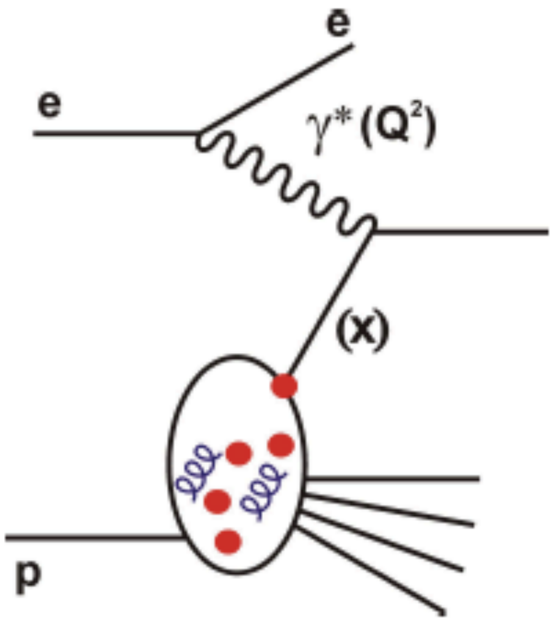
Observation = New Physics (Isidori's talk)

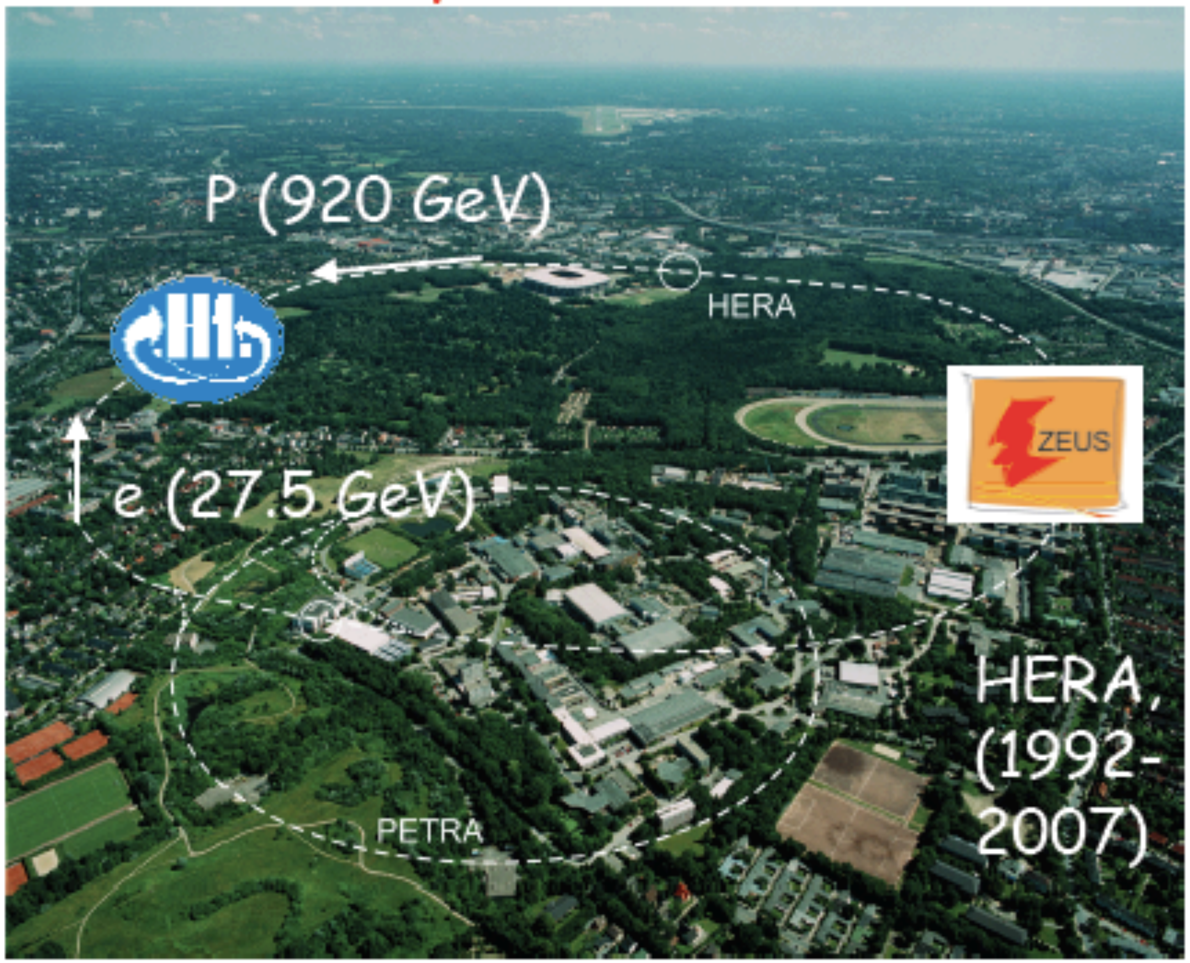
Inclusive Deep Inelastic Scattering at HERA

Paul Newman
(Birmingham)

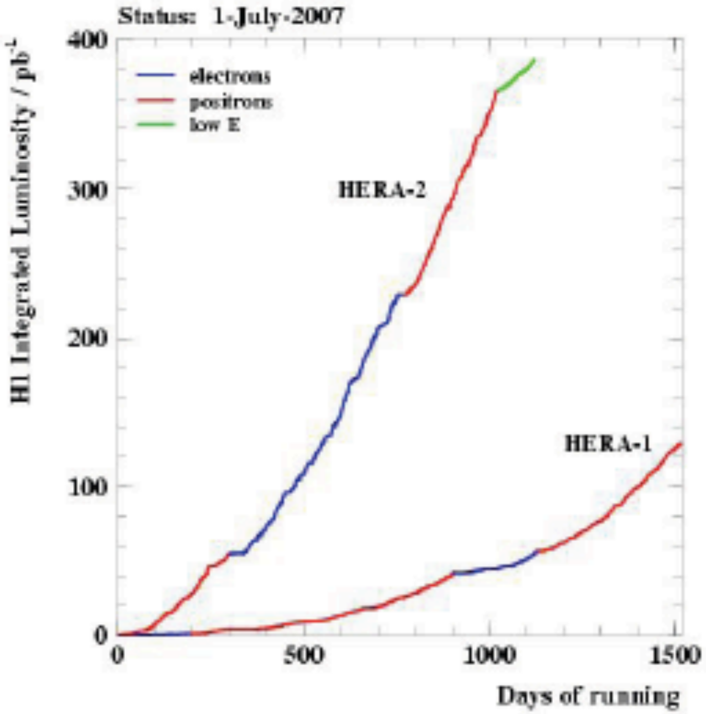
... for the H1 & ZEUS collaborations

Supported in part by
IPPP, Durham



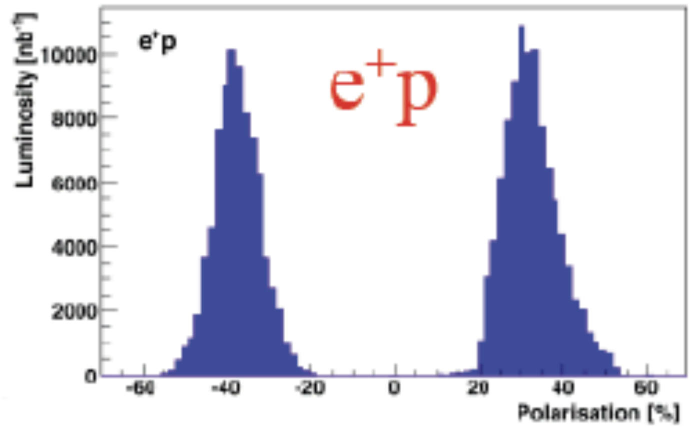


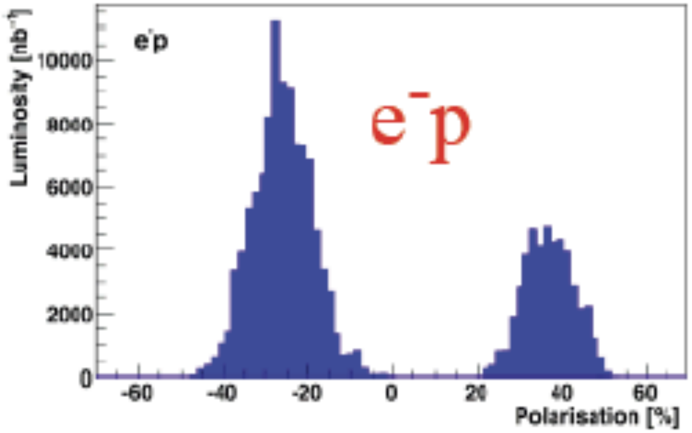
Diffraction'10
Otranto
11 September 2010



Final HERA Data Samples

- Total of ~200 pb^{-1} e$^-$p, 300 pb^{-1} e$^+$p per experiment.
- Both lepton polarisation states
- ~25 pb^{-1} @ lower E_p = 575, 460 GeV

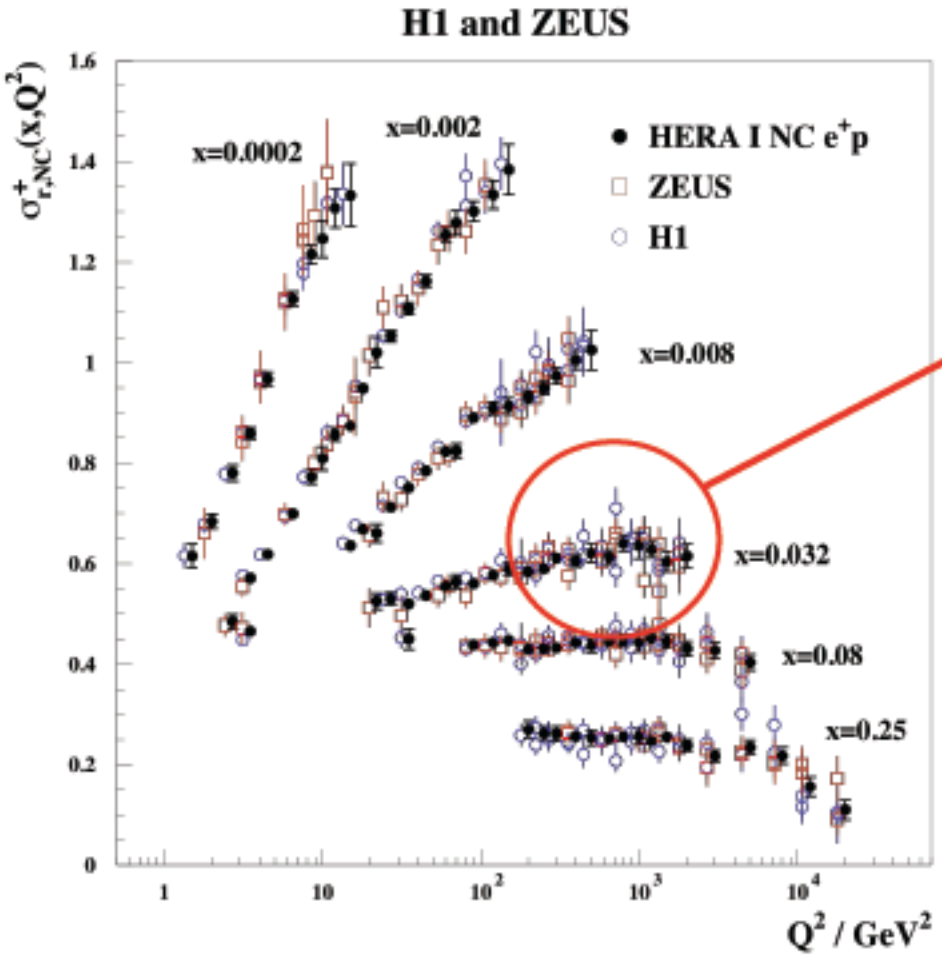


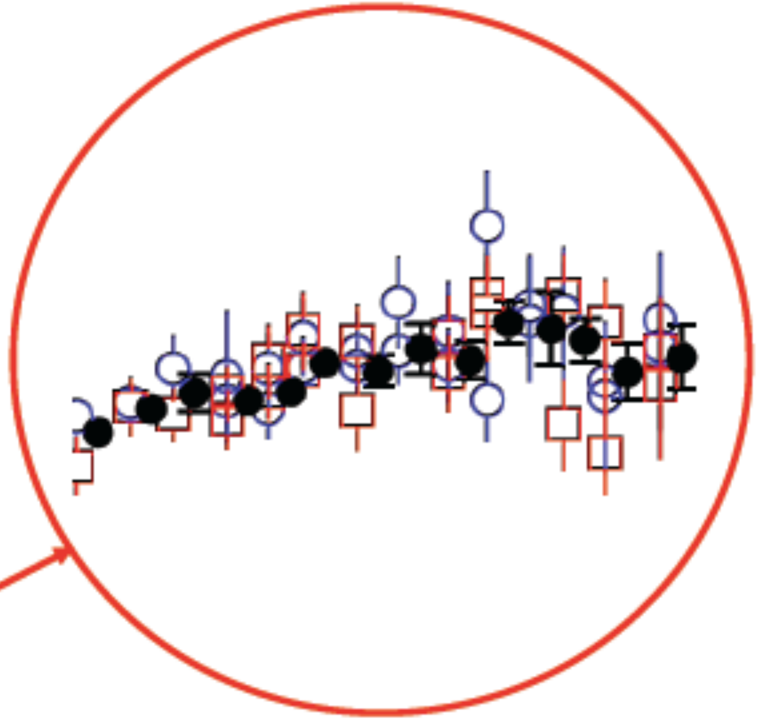


- HERA-I publications ~ complete
- Many HERA-II analyses still in progress (e.g. complicated final states such as diffraction)
- Work to combine H1, ZEUS results well underway

The Power of Combinations [JHEP 1001:109 (2010)]

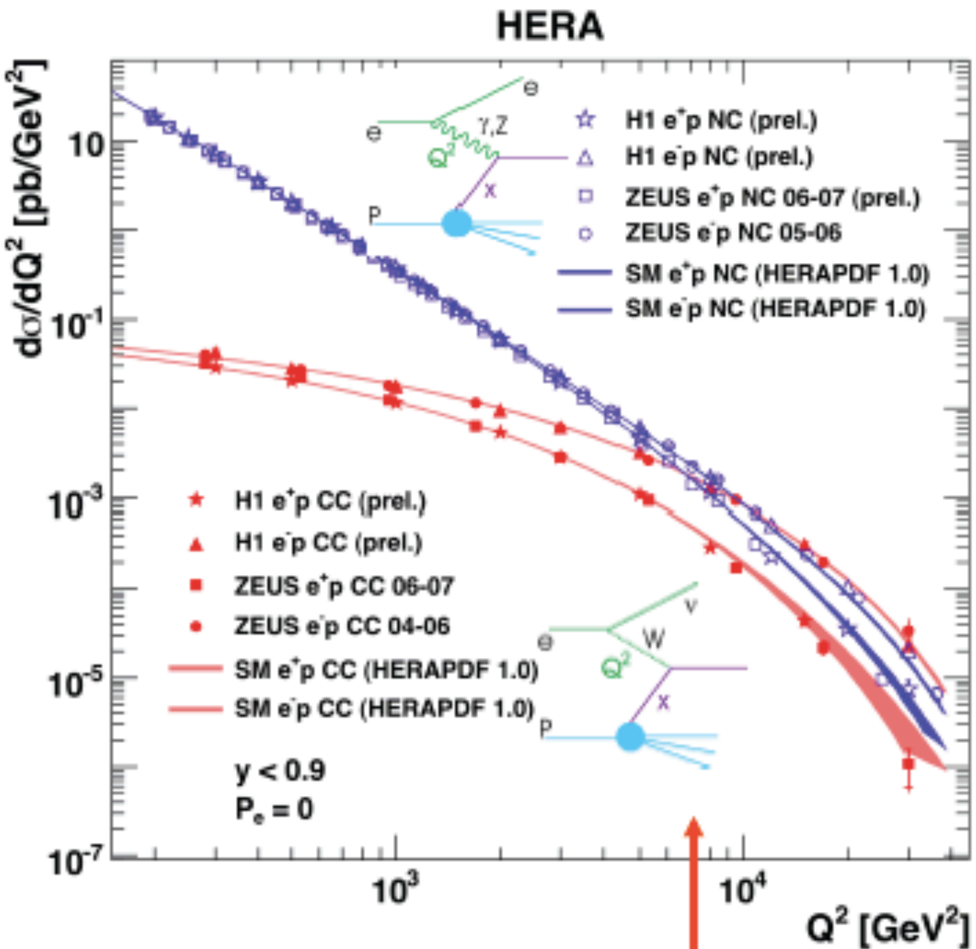
- Selected bins from the final combination of HERA-I NC data





Beyond the √2 statistical improvement, effectively cross-calibrate to tackle (different) dominating H1, ZEUS systematics.

Electroweak Unification for Space-like Bosons



$Q^2 \sim M_W^2, M_Z^2$

Neutral Current x-sec

$$\frac{d\sigma^{NC}}{dx\, dQ^2} \sim \alpha_{em}^2 \quad \bullet \quad \left(\frac{1}{Q^2}\right)^2 \quad \bullet \; \tilde{\sigma}_{NC}$$

Charged Current x-sec

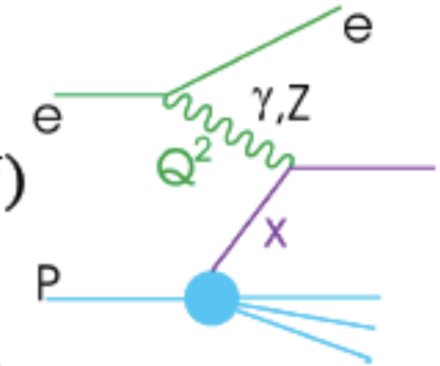
$$\frac{d\sigma^{CC}}{dx\, dQ^2} \sim G_F^2 M_W^2 \bullet \left(\frac{1}{Q^2 + M_W^2}\right)^2 \bullet \tilde{\sigma}_{CC}$$

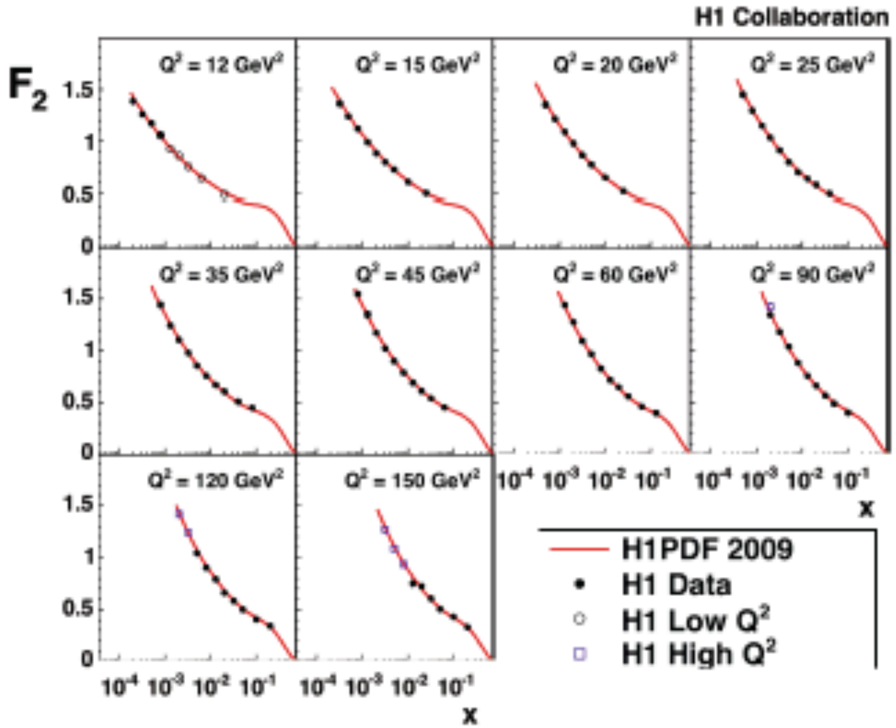
- NC and CC cross sections become comparable at EW unification scale (couplings unified)

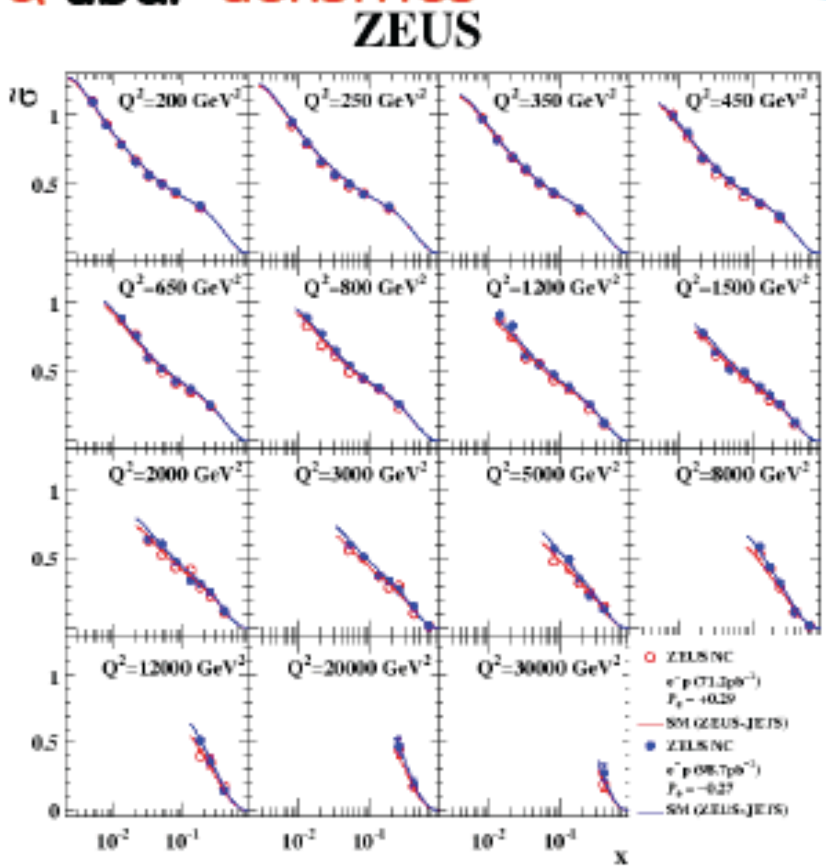
- Parton density info encoded in $\tilde{\sigma}_{NC}$ and $\tilde{\sigma}_{CC}$

Recent Neutral Current Data

- NC data primarily measure $F_2 = \sum_q e_q^2\, x\,(q + \bar{q})$
- Due to $e_q{}^2$ photon coupling, NC Provides best constraints on **u & ubar** densities



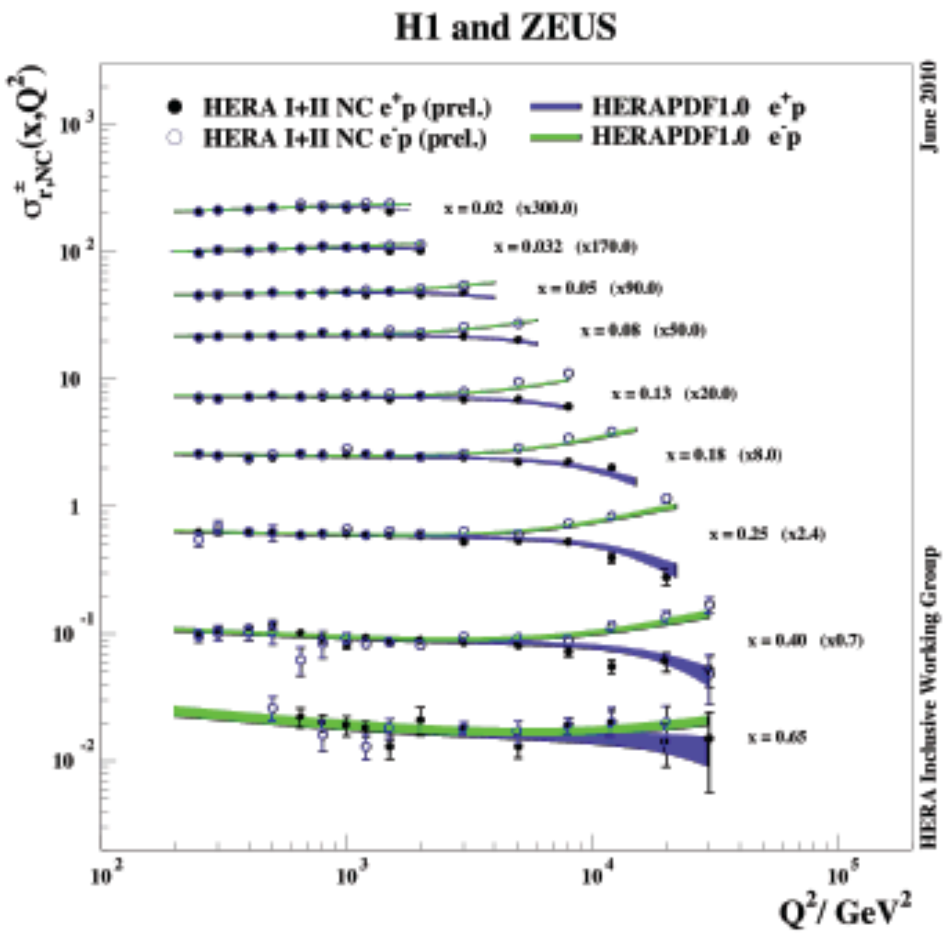




- 1.5-2% precision in final H1 intermediate Q^2 data

- 169pb^{-1} (final ZEUS high Q^2 e^-p data) … 2-3% syst precision

NC Lepton Charge Dependence & xF_3

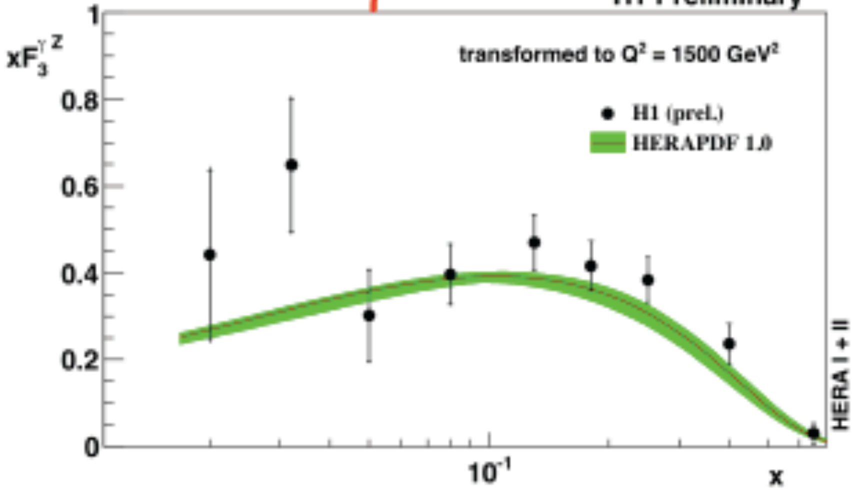


- Difference between e^-p and e^+p NC cross sections at large Q^2 measures **xF_3** structure fn…
- Dominated by interference Between γ and Z exchange

… unique sensitivity to **valence** quarks

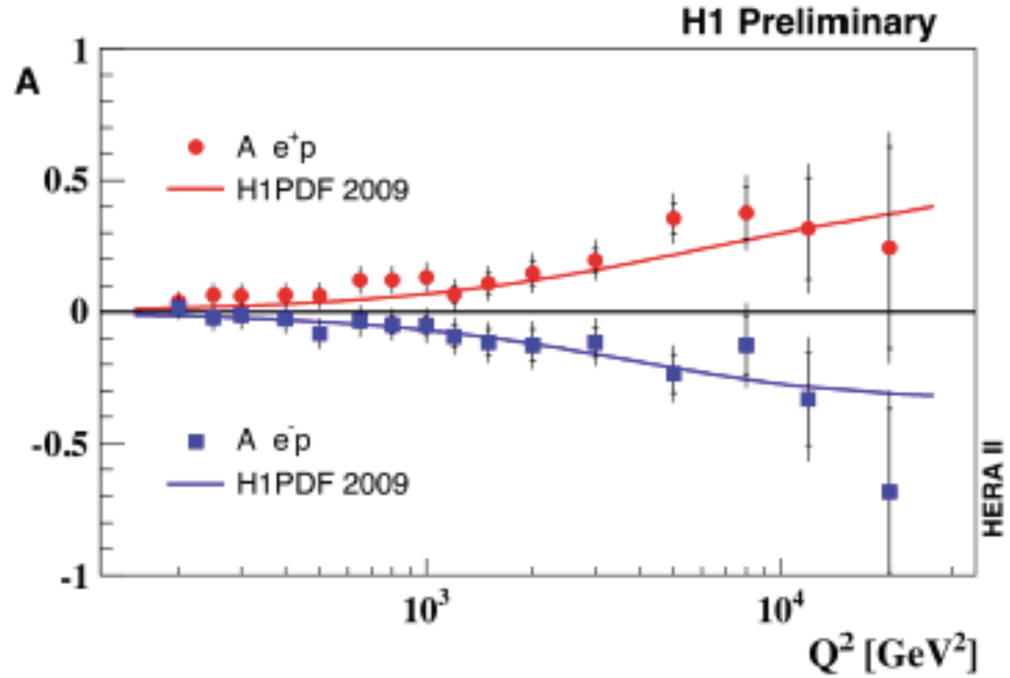
$$xF_3 = \frac{Y_+}{2Y_-}\left(\tilde{\sigma}_{NC}^{-} - \tilde{\sigma}_{NC}^{+}\right)$$

$$\approx \frac{x}{3}\left(2u_v + d_v\right)$$



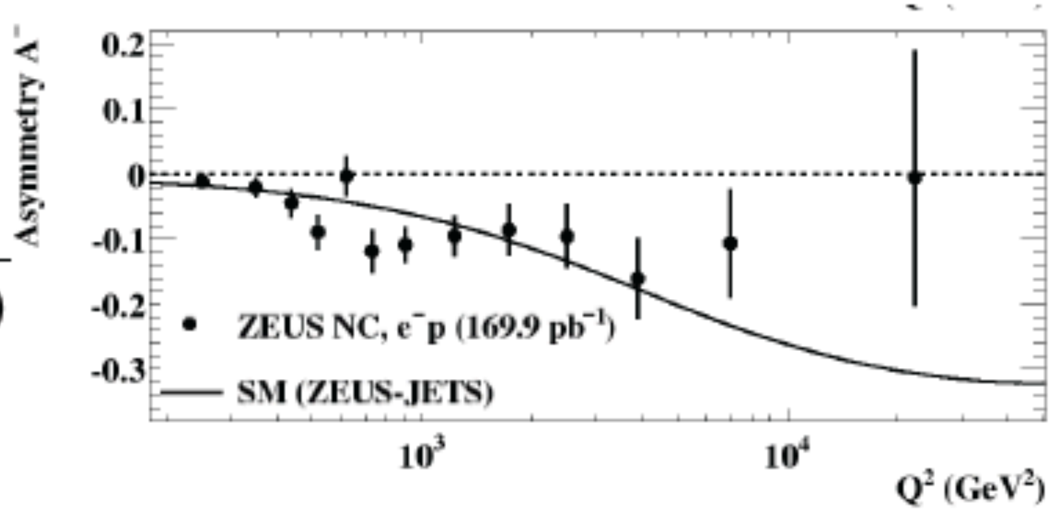
Left v Right Hand Polarised Leptons

Significant NC lepton polarisation asymmetry observed … tests vector and axial EW **lepton couplings** and **d/u** ratio as x→1

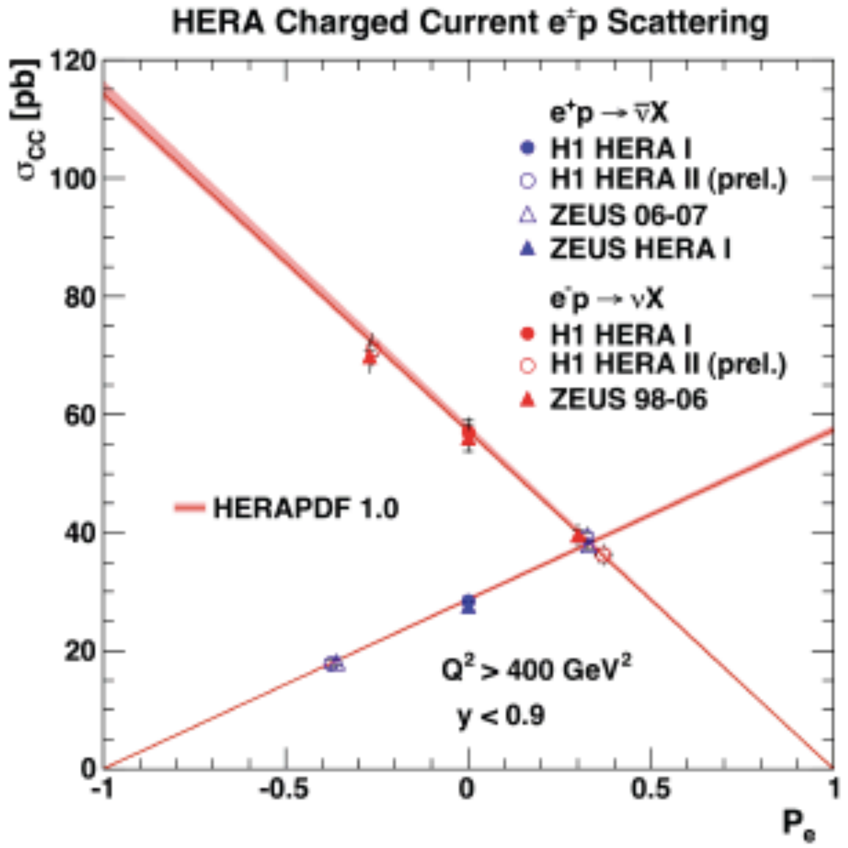


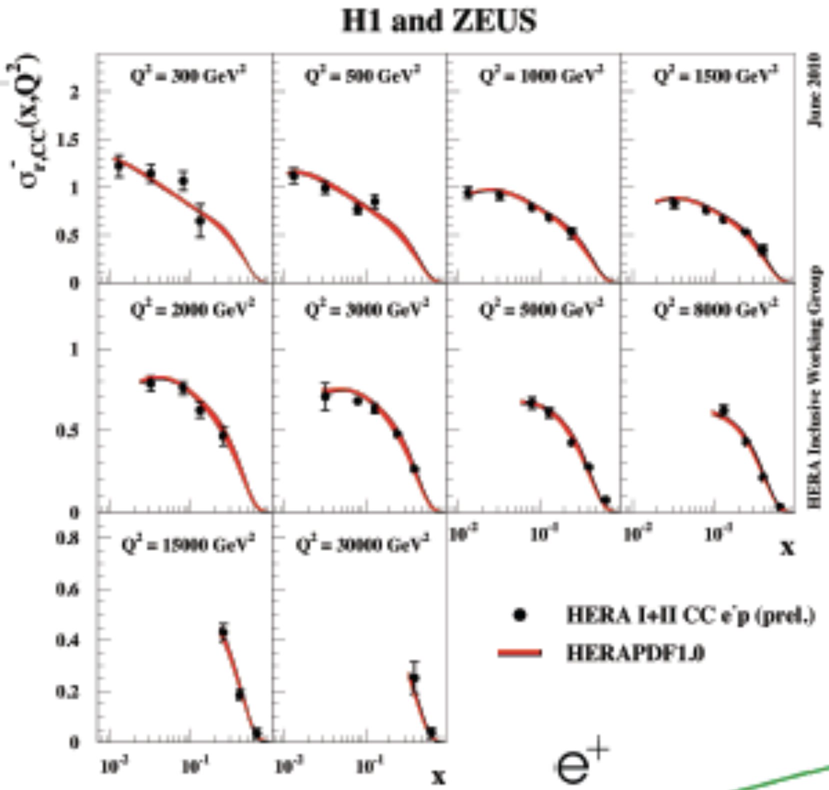
$$A = \frac{\tilde{\sigma}_{NC}(R) - \tilde{\sigma}_{NC}(L)}{\tilde{\sigma}_{NC}(R) + \tilde{\sigma}_{NC}(L)}$$

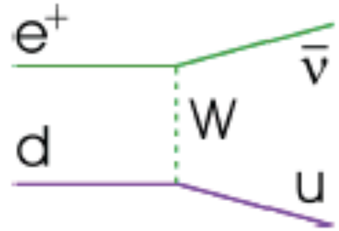
$$\approx \kappa\left(M_W, M_Z\right) \frac{(1 + d_v / u_v)}{(4 + d_v / u_v)}$$



Recent Charged Current Data



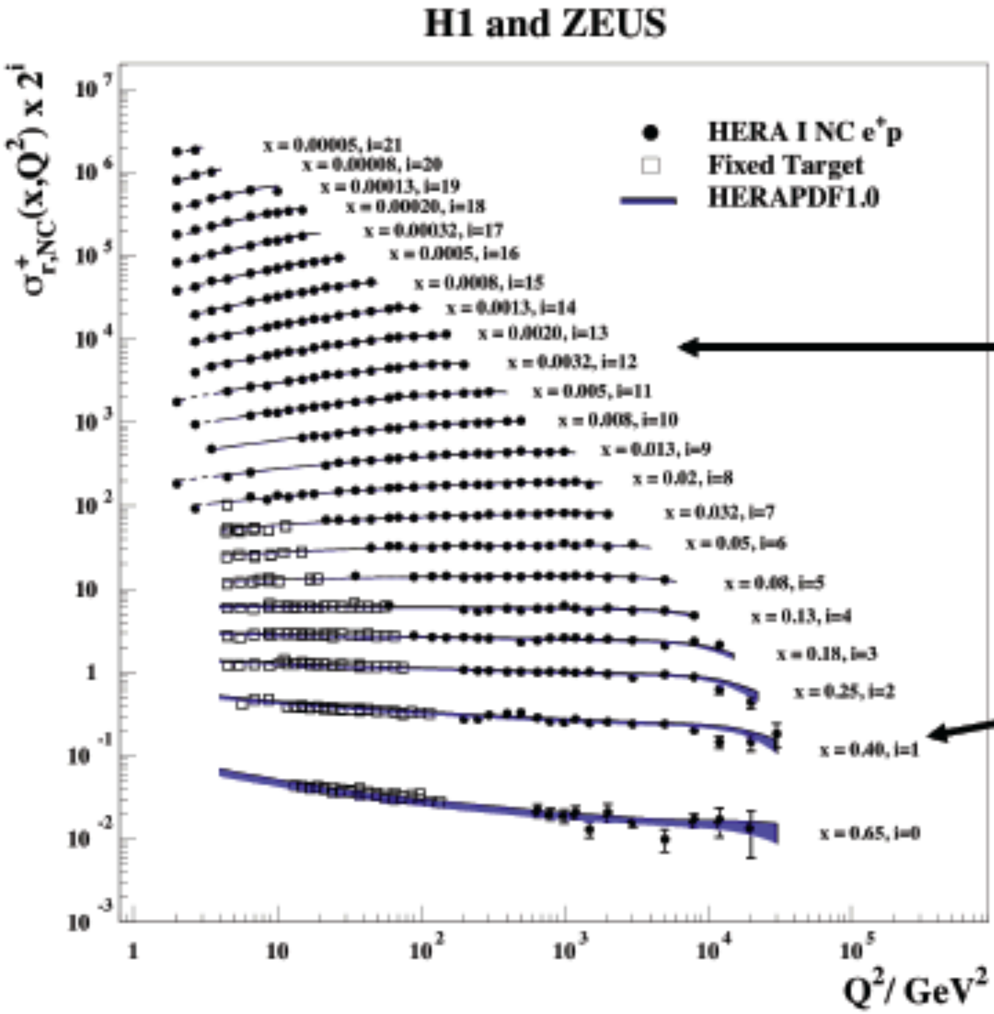




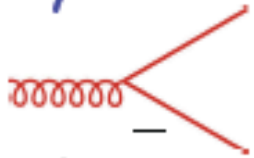
- Linear dependence on polarisation well tested … **chiral structure** of SM

- Charged current sensitive to flavour decomposition … e.g. e^+p constrains **d** density

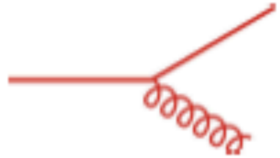
QCD Evolution and the Gluon Density



- NC Q^2 dependence driven by …



$g \rightarrow q\bar{q}$



$q \rightarrow qg$

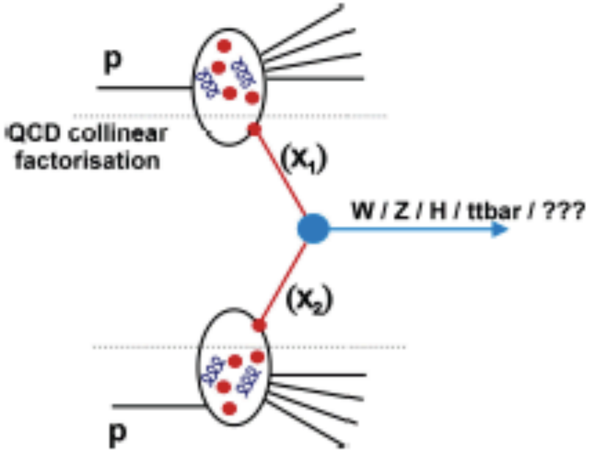
- Excellent QCD fit description over vast range.

- Q^2 evolution of F_2 yields **low x gluon**, assuming DGLAP
- Other observables needed @ high x, where g sensitivity lost

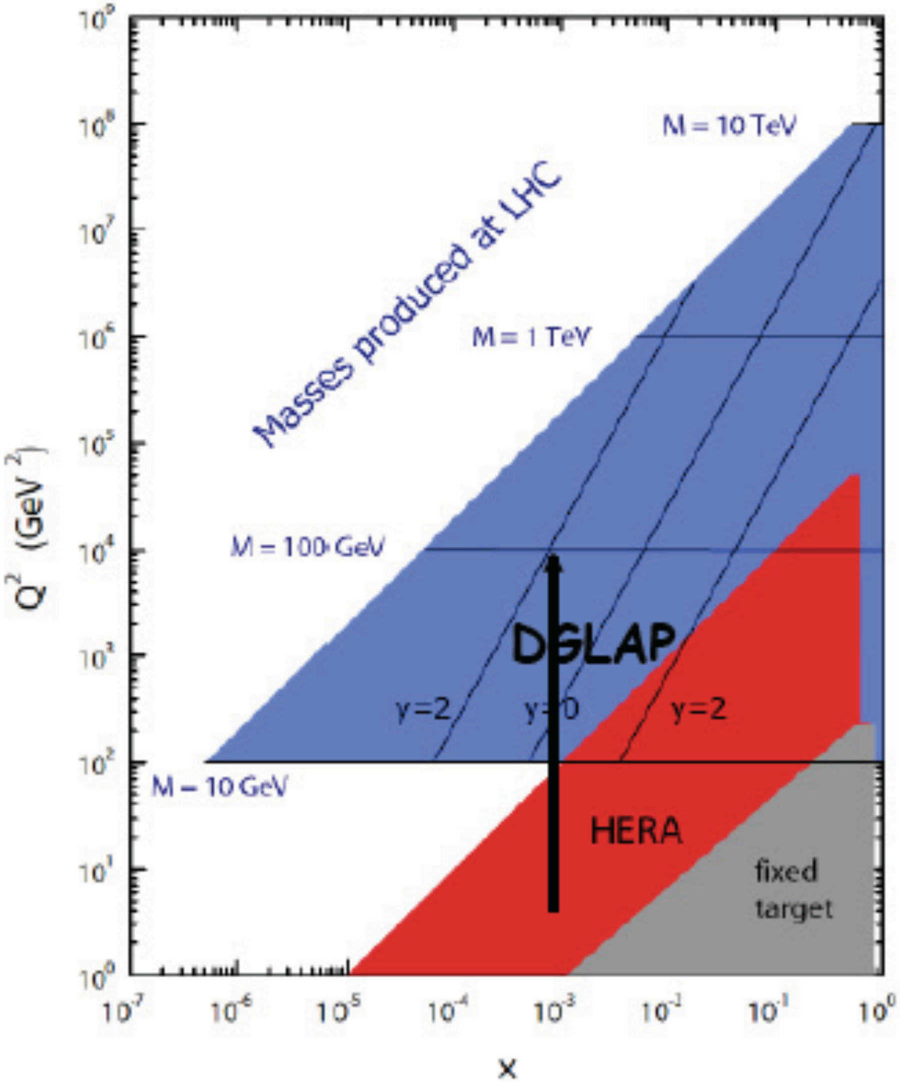
HERA kinematic range

- Unprecedented low x and high Q^2 coverage in DIS!

- HERA + **QCD factorisation** → parton densities in full x range of LHC rapidity plateau

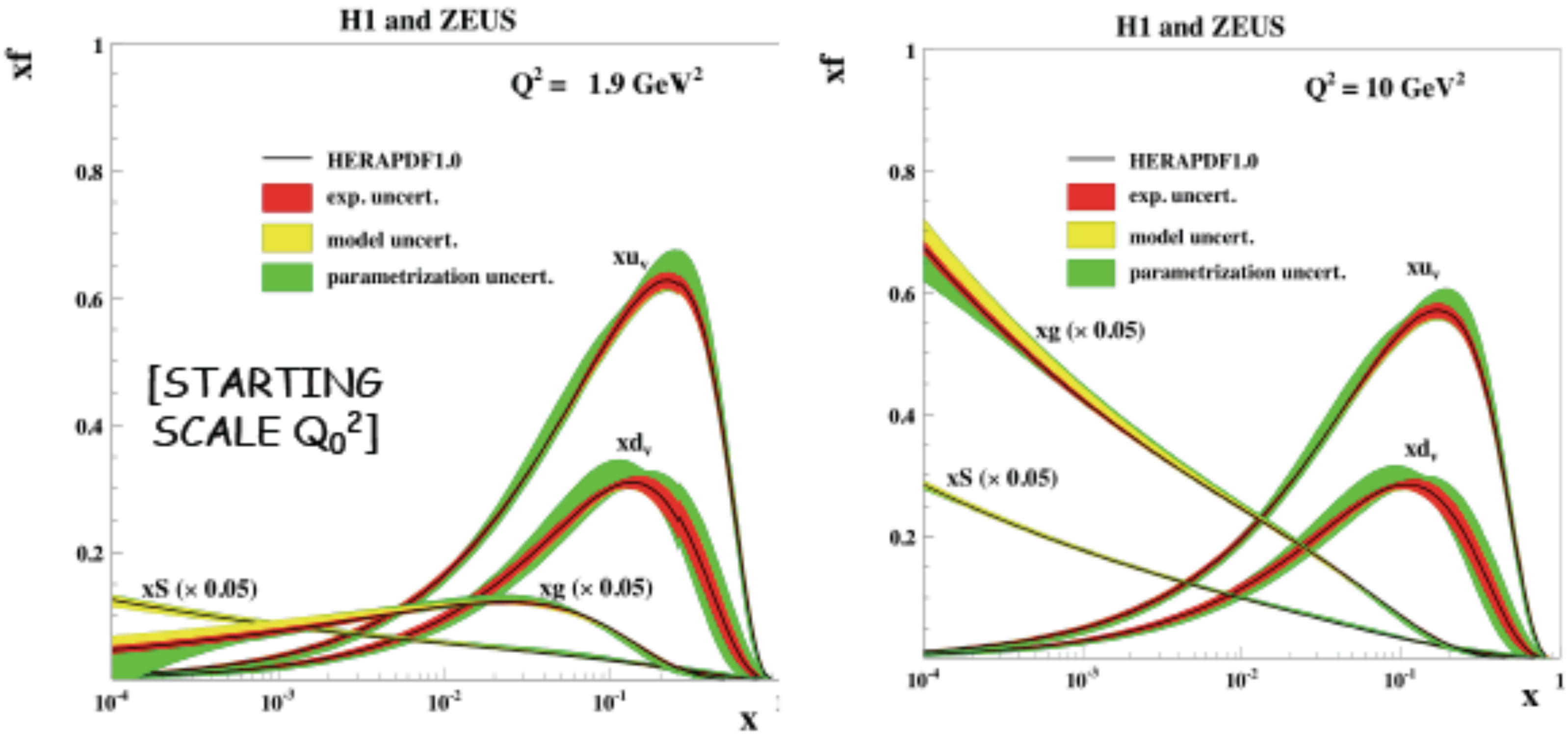


- Well established **`DGLAP' evolution** equations generalise to any scale (for not too small x)



e.g. pp dijets at central rapidity: $x_1=x_2=2p_t / \sqrt{s}$

So What *is* a Proton?

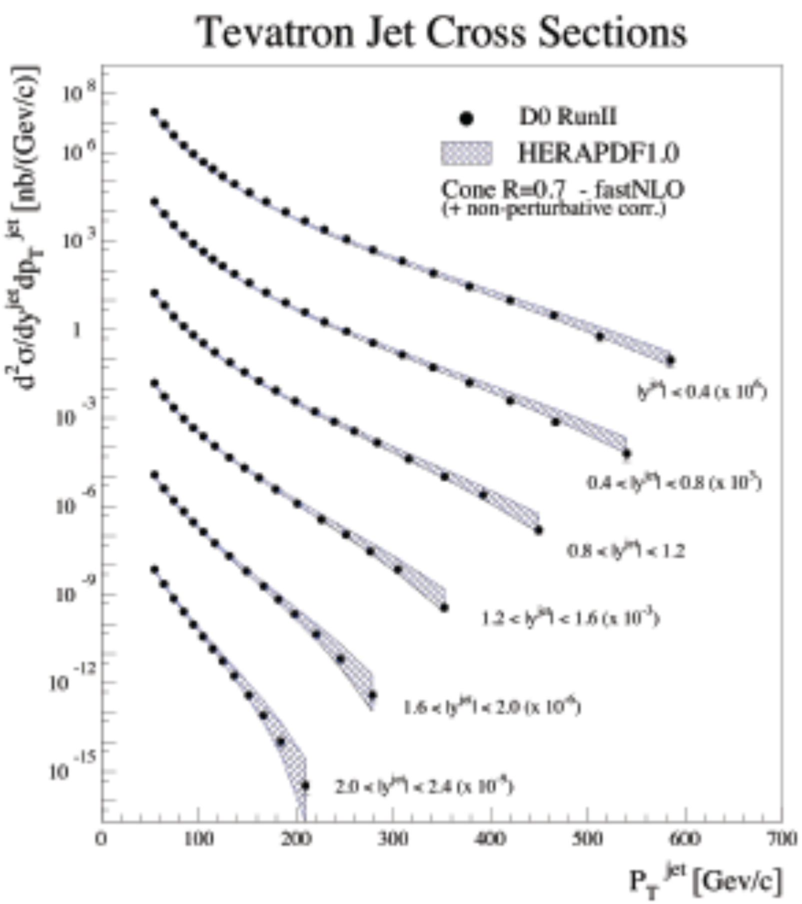


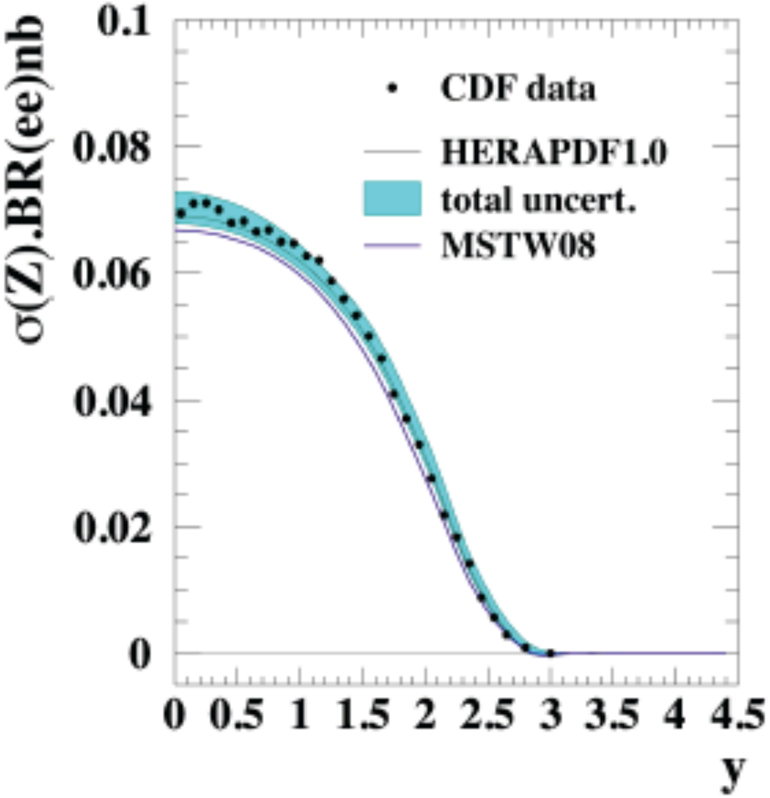
Parameterisation uncertainty dominates

Gluon 'valence-like' at starting scale, evolves to be very large at low x already by $Q^2 = 10\ GeV^2$

Broadly consistent with global fits (MSTW, CTeQ, NNPDF)

Comparisons with Tevatron Data





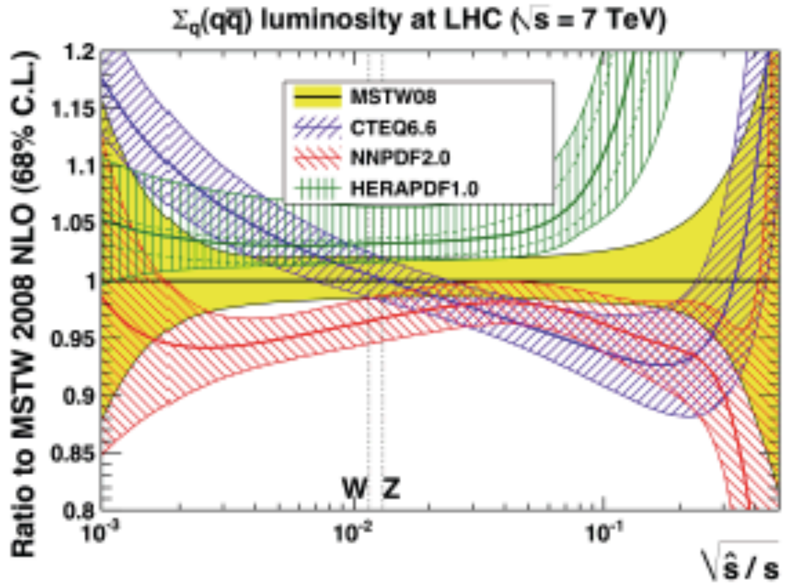
Tevatron observables well described by HERAPDF1.0

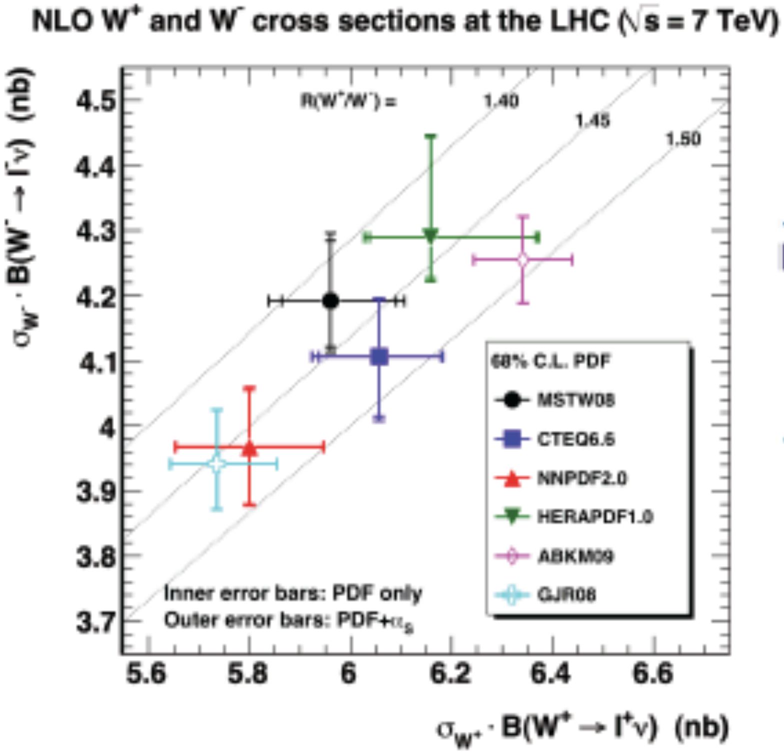
… universal parton densities describe ep and pp

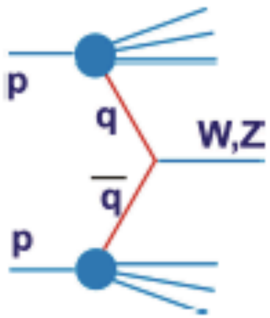
… the cleanest test of QCD collinear factorisation

Predictions for LHC: Quark Initiated Processes

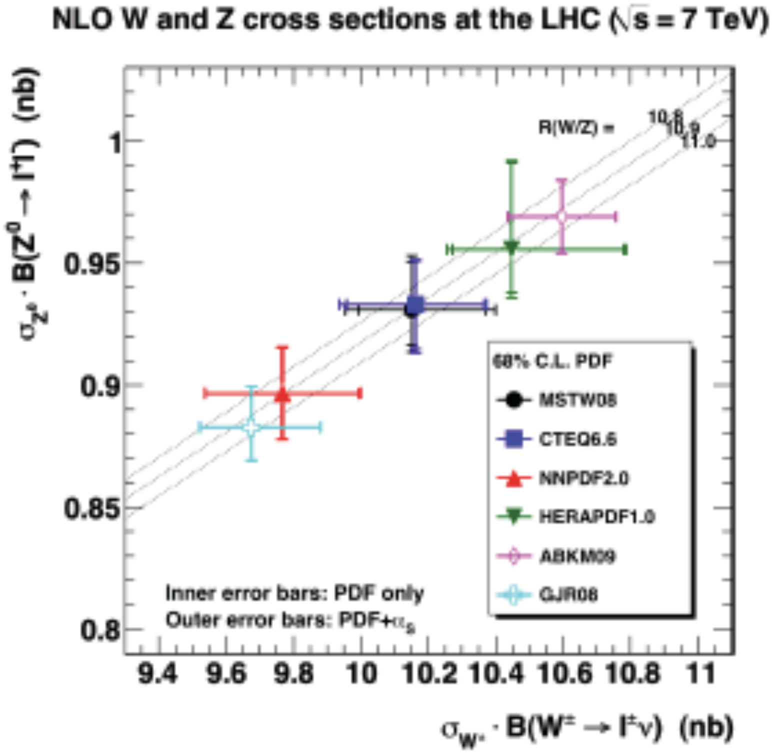
~5% uncertainty on σ(W), σ(Z)
… is MSTW/CTeQ/NNPDF sufficient to define uncertainty?





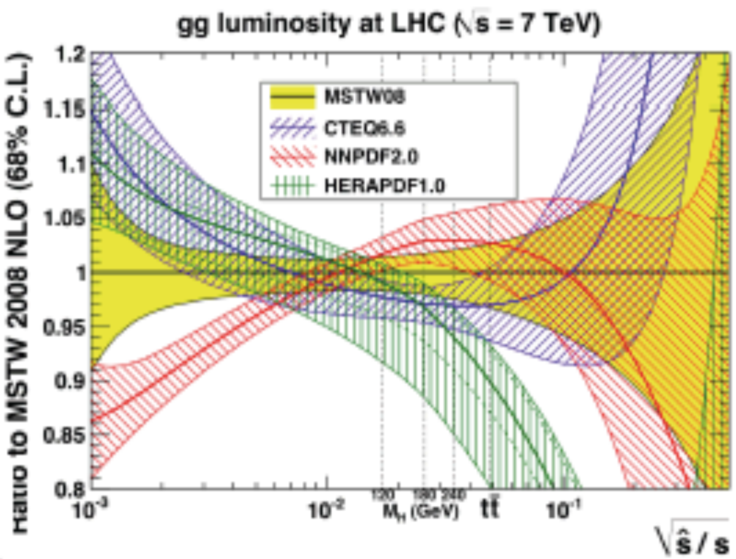


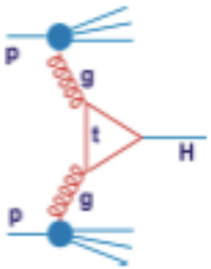
[Plots by G. Watt]

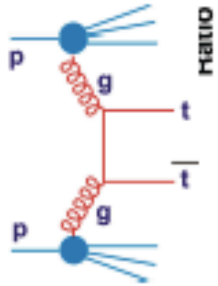


Predictions for LHC: Gluon Initiated Processes

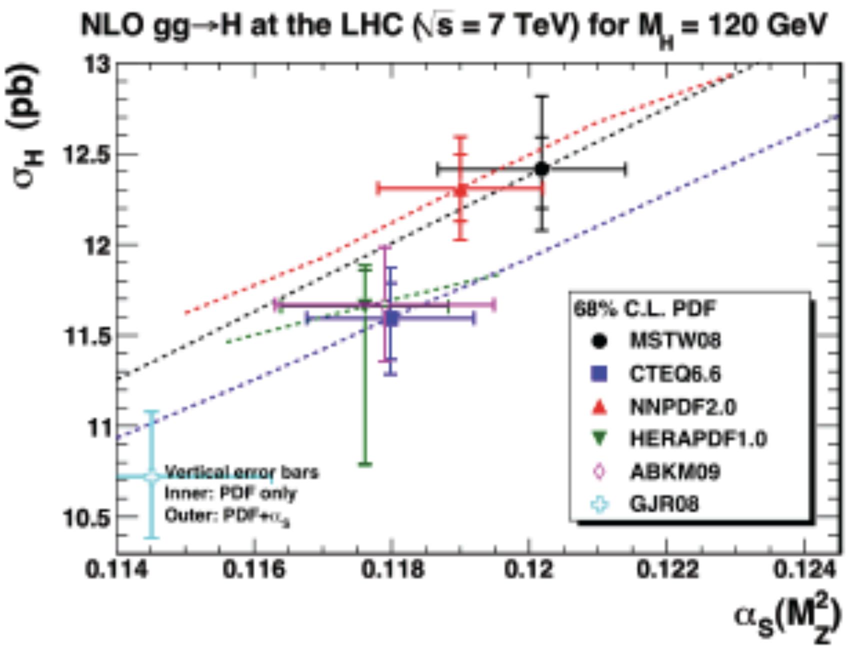
Top, Higgs cross section uncertainites up to 10-15%

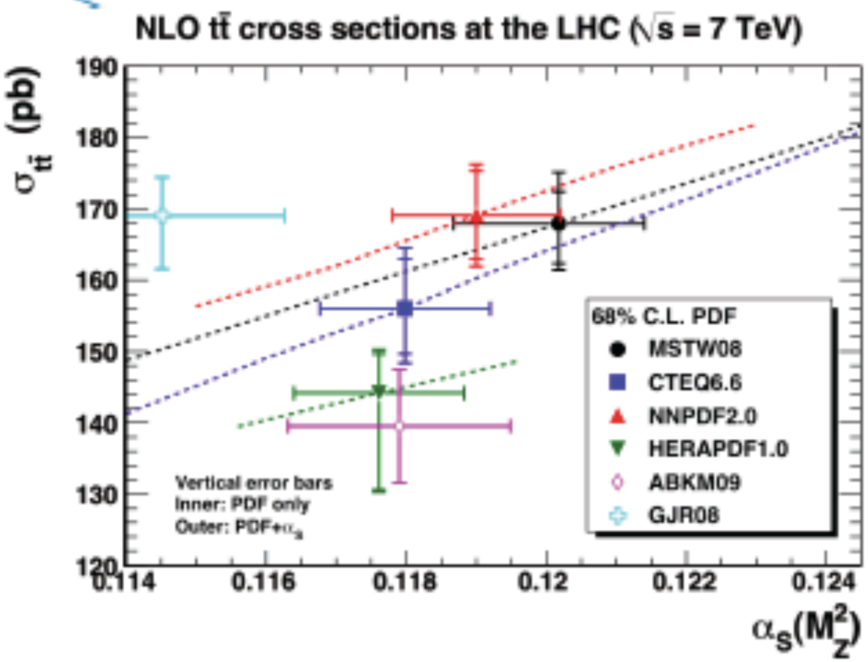




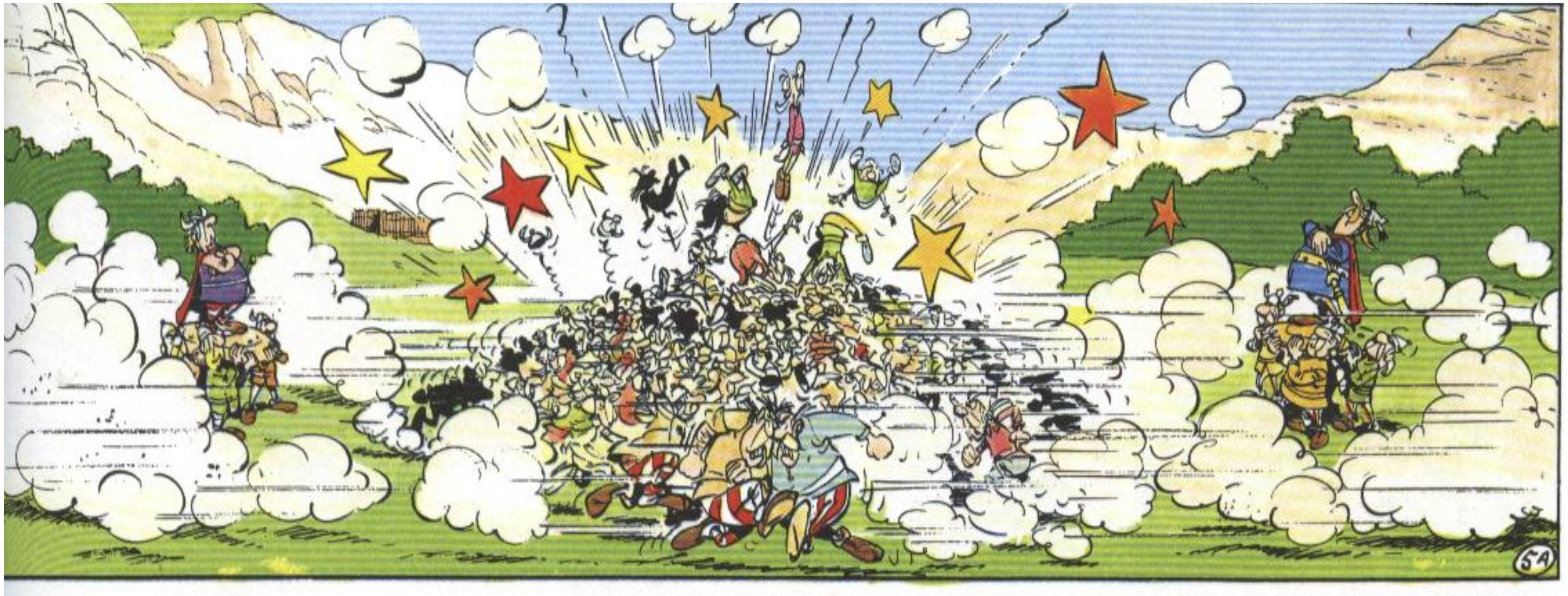


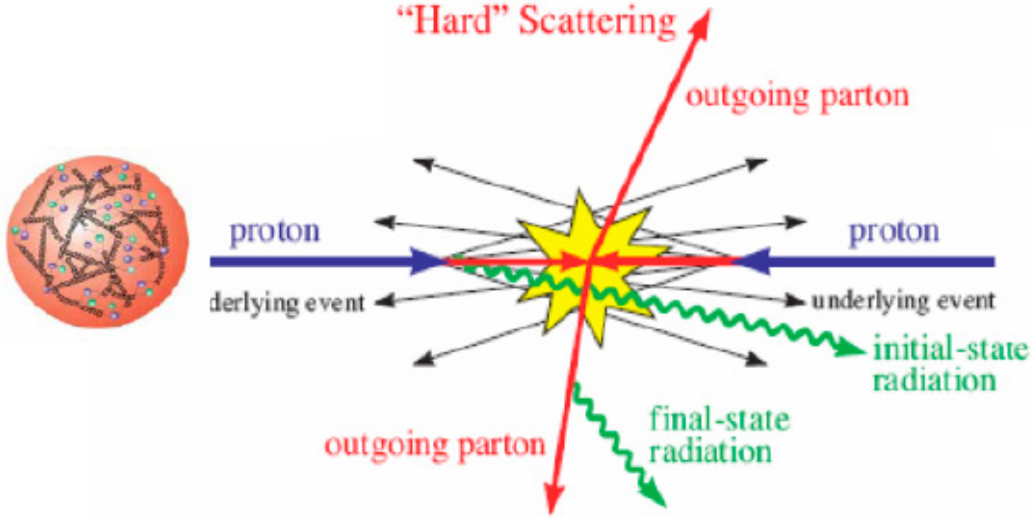
[Plots by G. Watt]





Proton-proton collisions are, err, complex



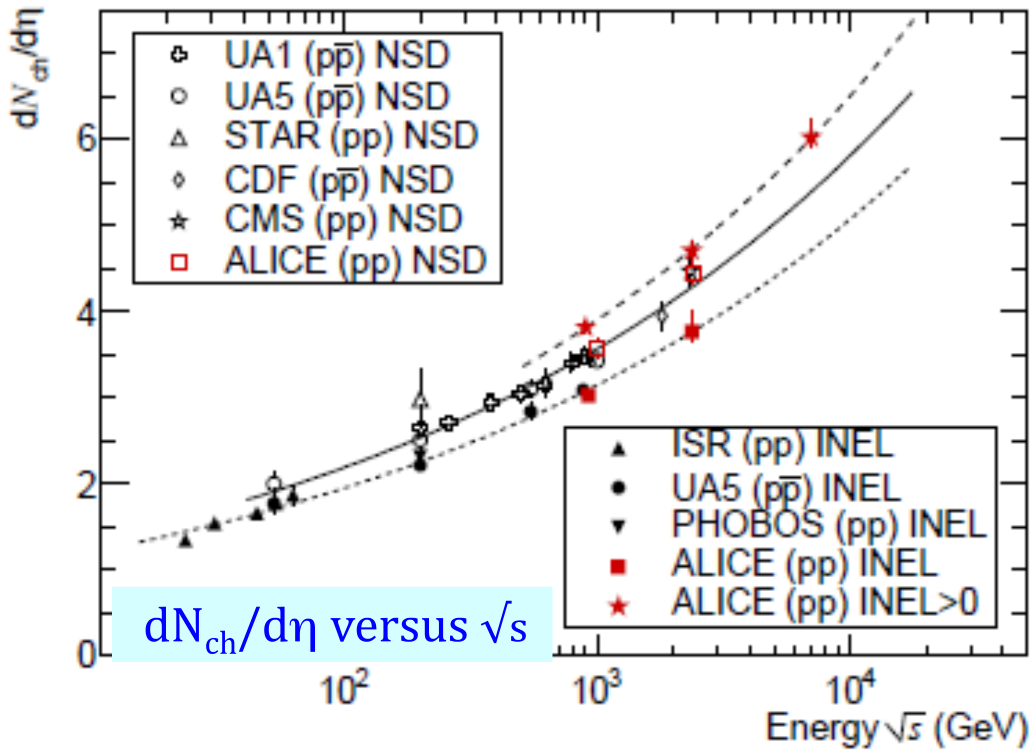


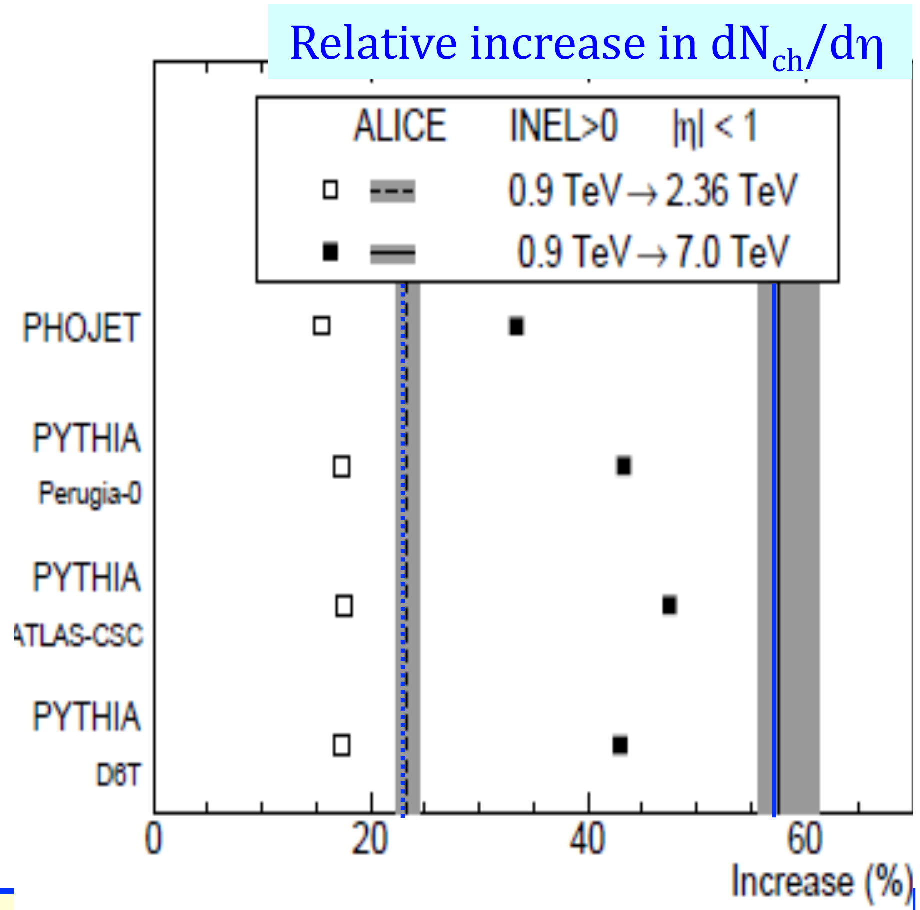
… and there's pile-up too!

… Searches / high pt studies first require an understanding of more mundane physics …

$dN_{ch}/d\eta$ versus $\sqrt{(s)}$

Earliest LHC data have been extensively exploited for charged particle spectra measurements
… good descriptions essential for underlying event, pile-up modelling …





Results:

- Measurements by different experiments in good agreement where comparisons possible
- increase with energy significantly stronger in data than MCs
- Monte Carlo tuning already well advanced as a result

A new general-purpose jet algorithm

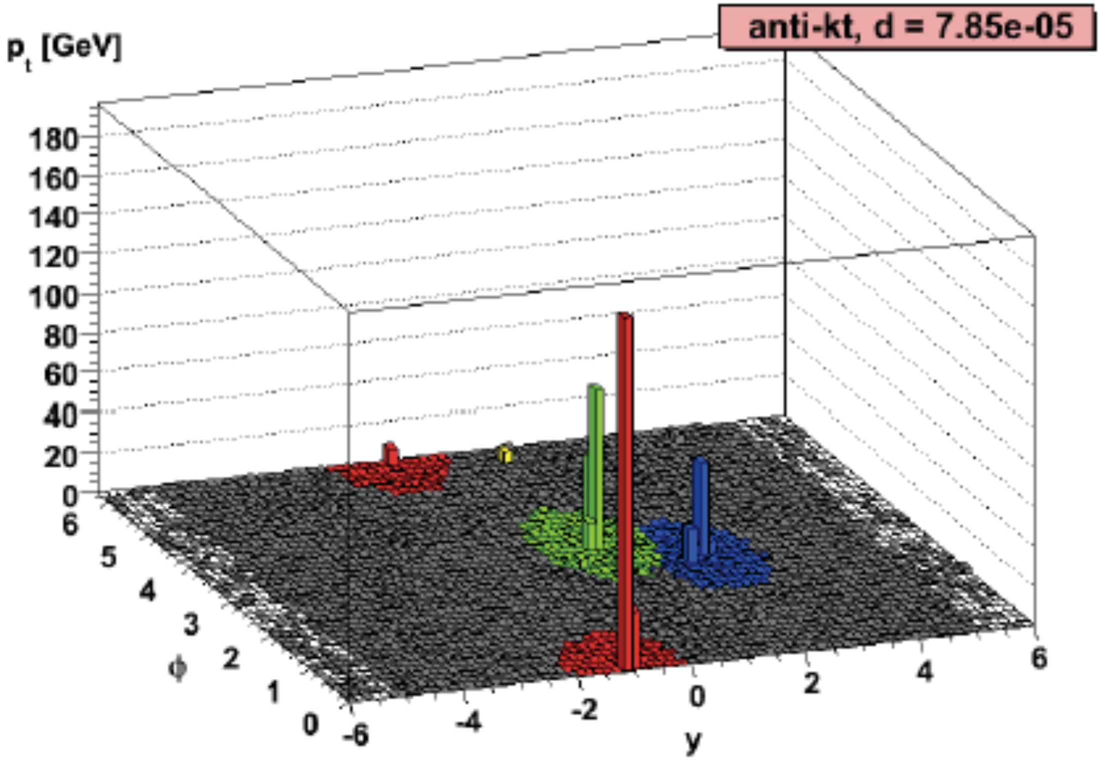
anti-k_t: repeatedly recombine pair of objects with smallest

$$d_{ij} = \frac{\Delta R_{ij}^2}{\max(k_{ti}^2, k_{tj}^2)}$$

Hard stuff clusters with nearest neighbour

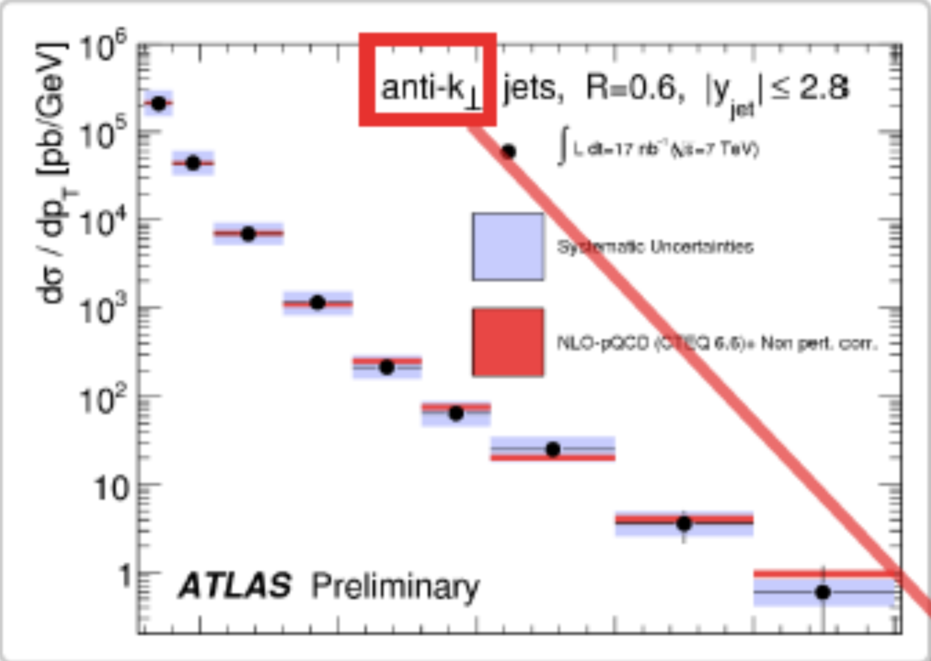
Cacciari, GPS & Soyez '08

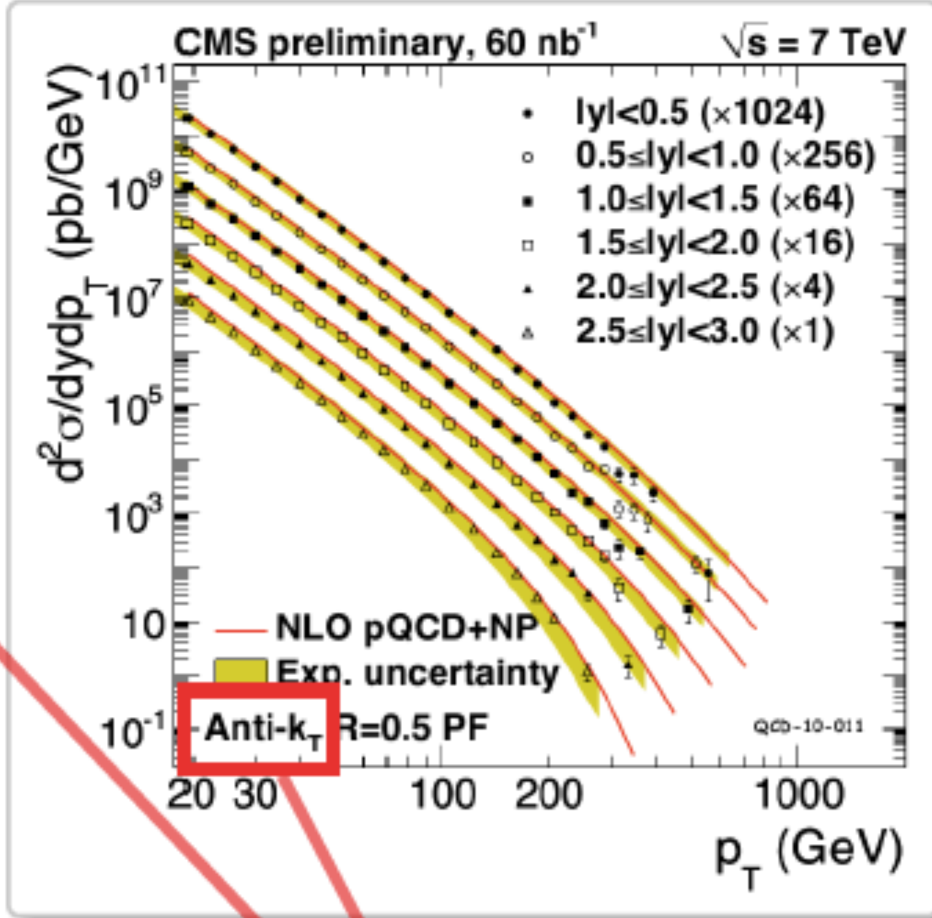
[included in FastJet]

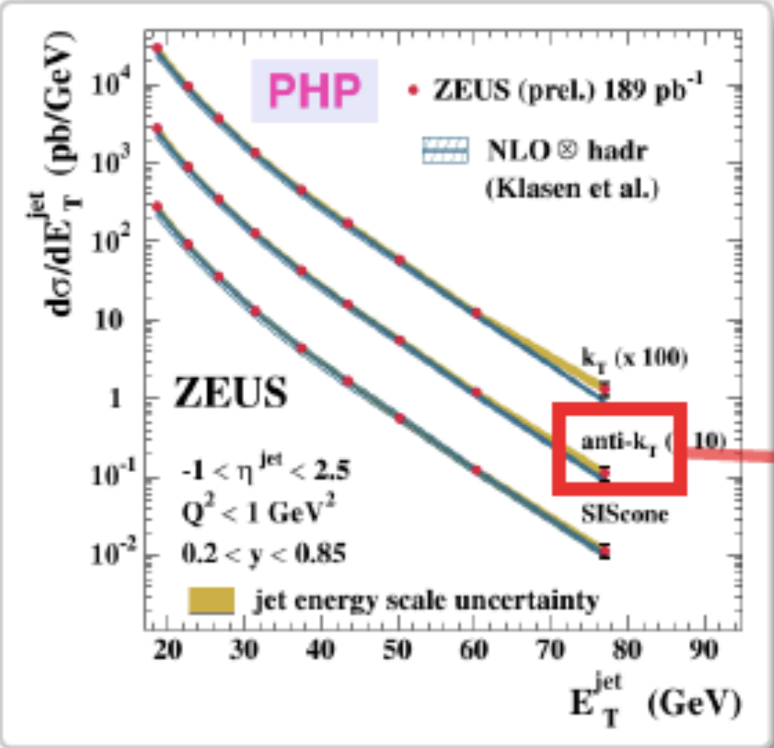


anti-k_t gives cone-like jets without using cones

And is infrared & collinear safe



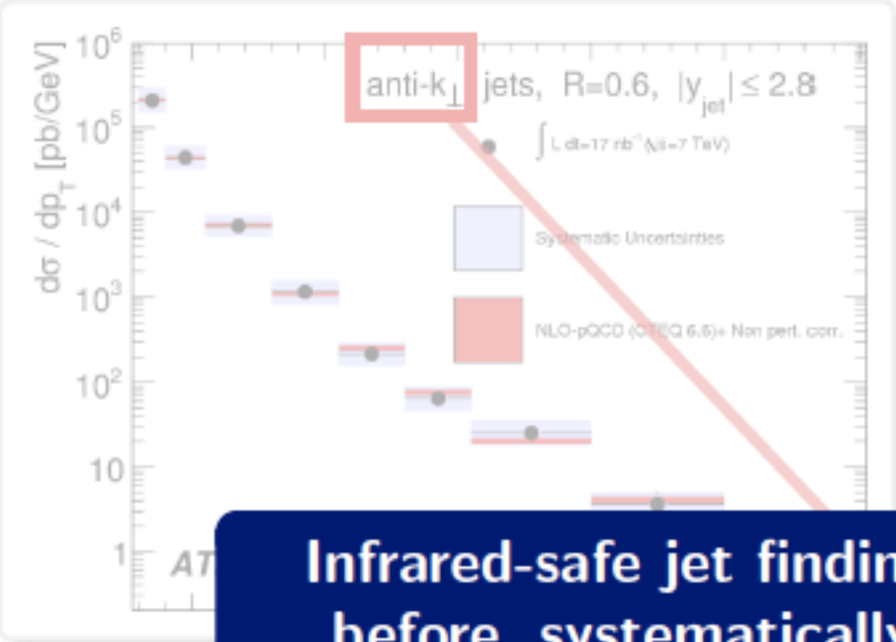


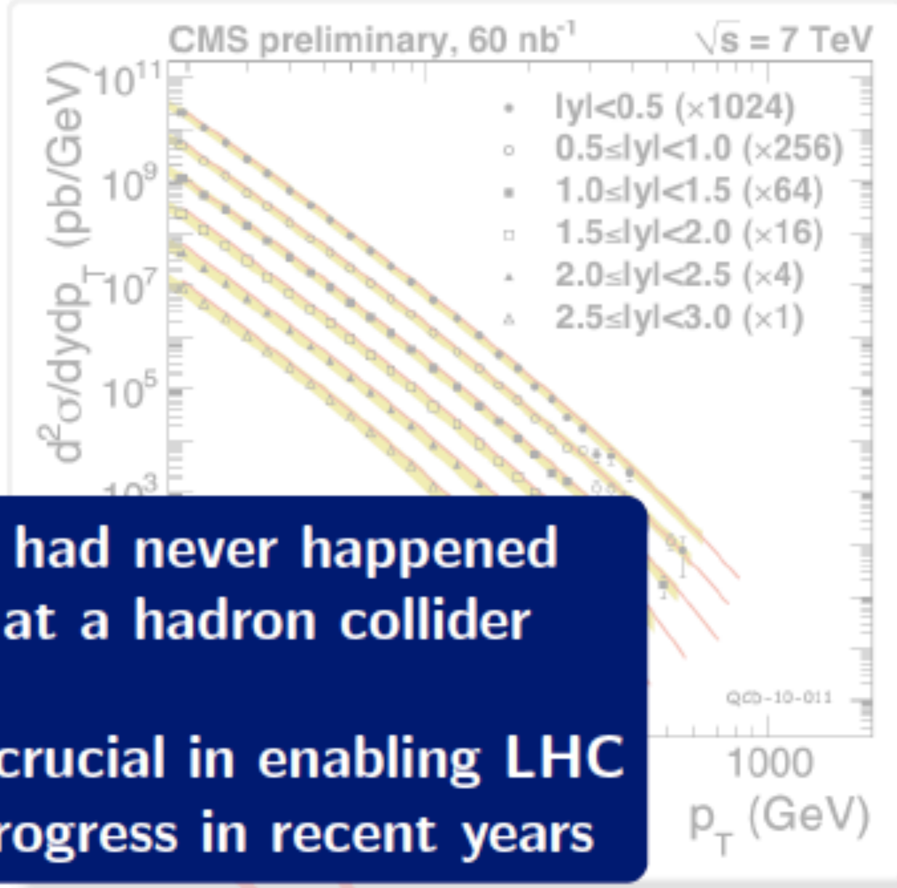


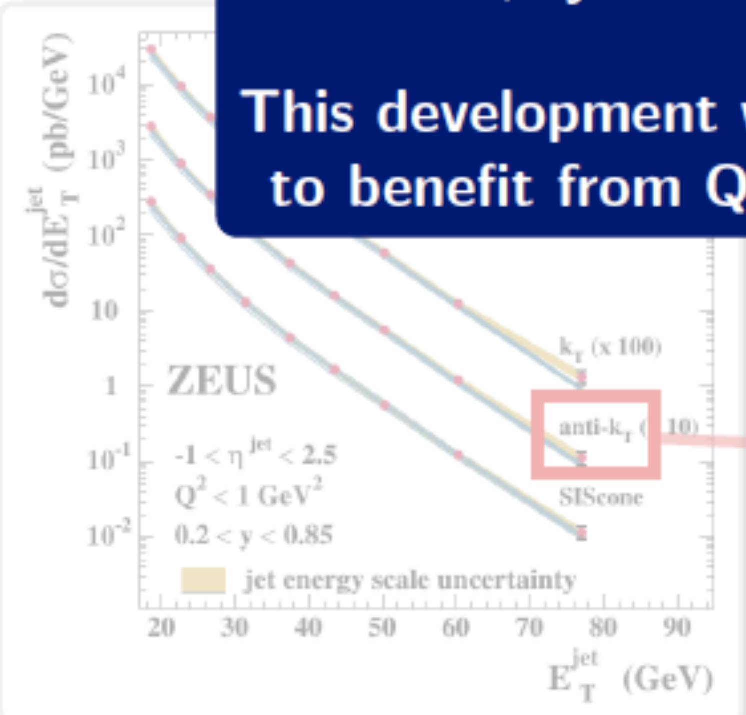
ATLAS and CMS have shown all jet results with an infrared and collinear safe jet finder, **anti-k_t**; also used at HERA!

soft junk doesn't change hard jets

NLO calculations are finite







Infrared-safe jet finding had never happened before, systematically, at a hadron collider

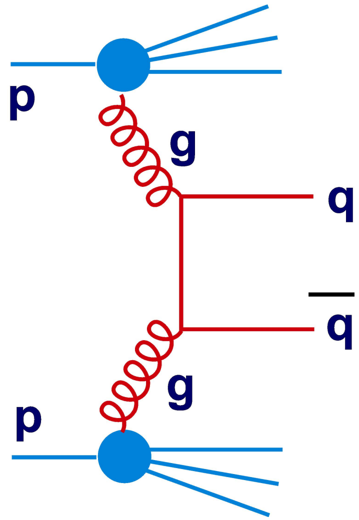
This development will be crucial in enabling LHC to benefit from QCD's progress in recent years

ATLAS and CMS have shown all jet results with an infrared and collinear safe jet finder, anti-k_t; also used at HERA!

soft junk doesn't change hard jets

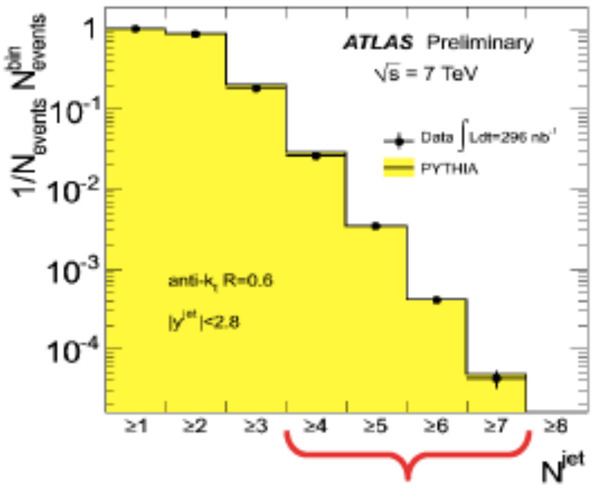
NLO calculations are finite

ATLAS Inclusive Jet data (now published,
Including single and double differential
Distributions for inclusive jets and dijets) …

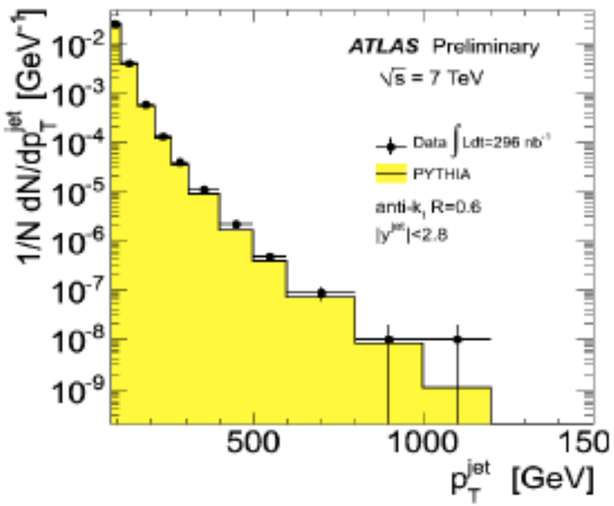


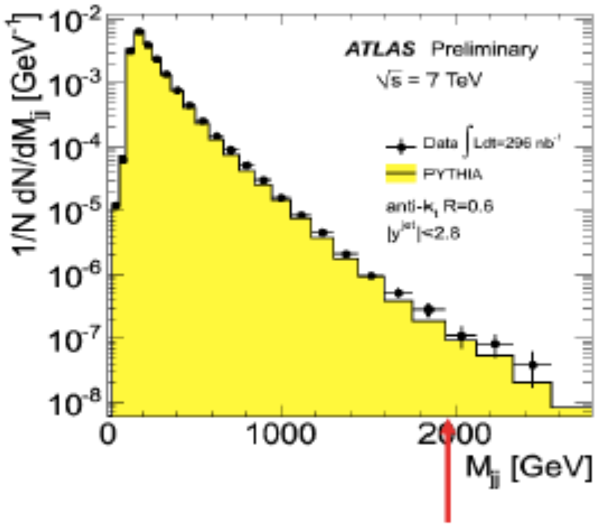
❑ Full ICHEP stat, MC normalised to data

- Main jet : p_T>80 GeV (and sub-leading jets: p_T>40 GeV) in $|y^{jet}|$<2.8
- Statistical error only



Few Top candidates in !





Tevatron $\sqrt{s}$=1.96 TeV !!

Already start to explore new phase space !

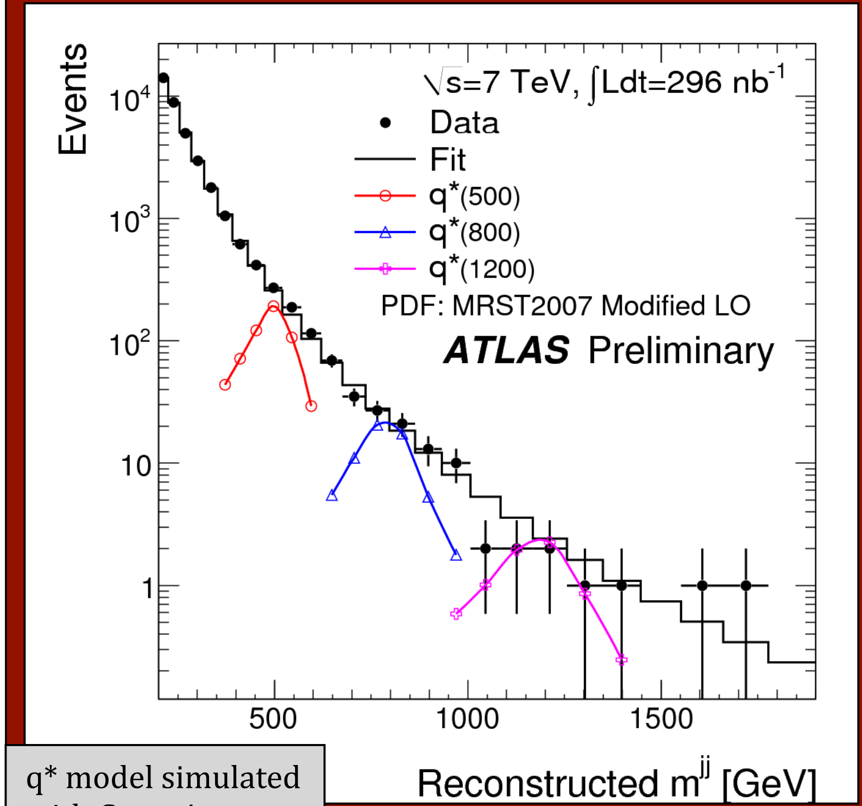
Searches for excited quarks: q*→ jj

Full data sample analysed

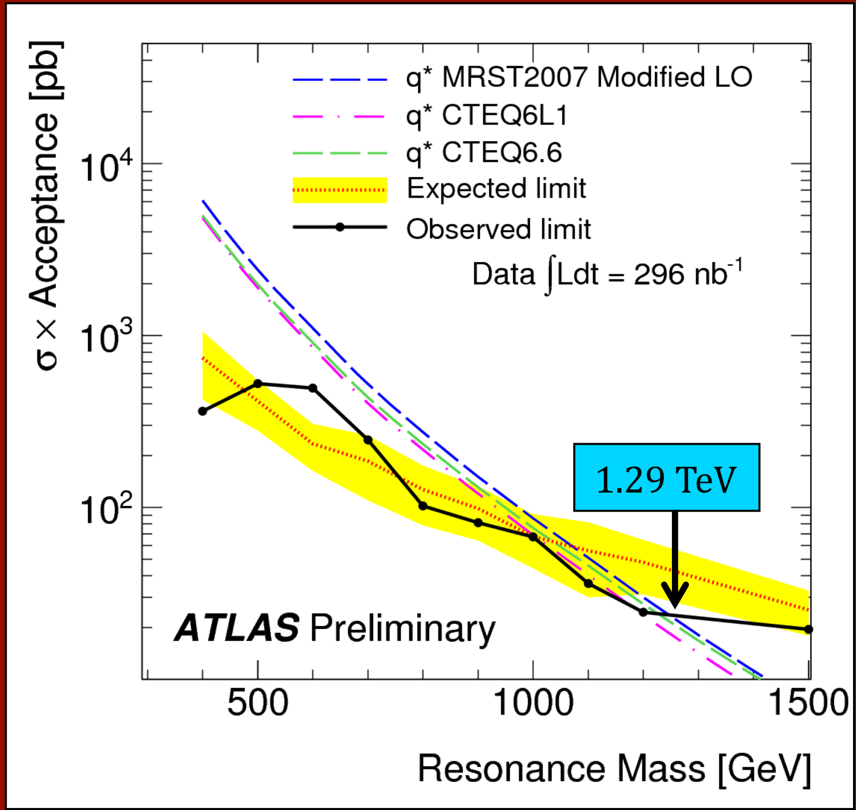
Looked for di-jet resonance in the measured M(jj) distribution
→ spectrum compatible with a smooth monotonic function → no bumps

→ 0.4 < M (q*) < 1.29 TeV excluded at 95% C.L.

Latest published limit:
CDF: 260 < M (q*) < 870 GeV



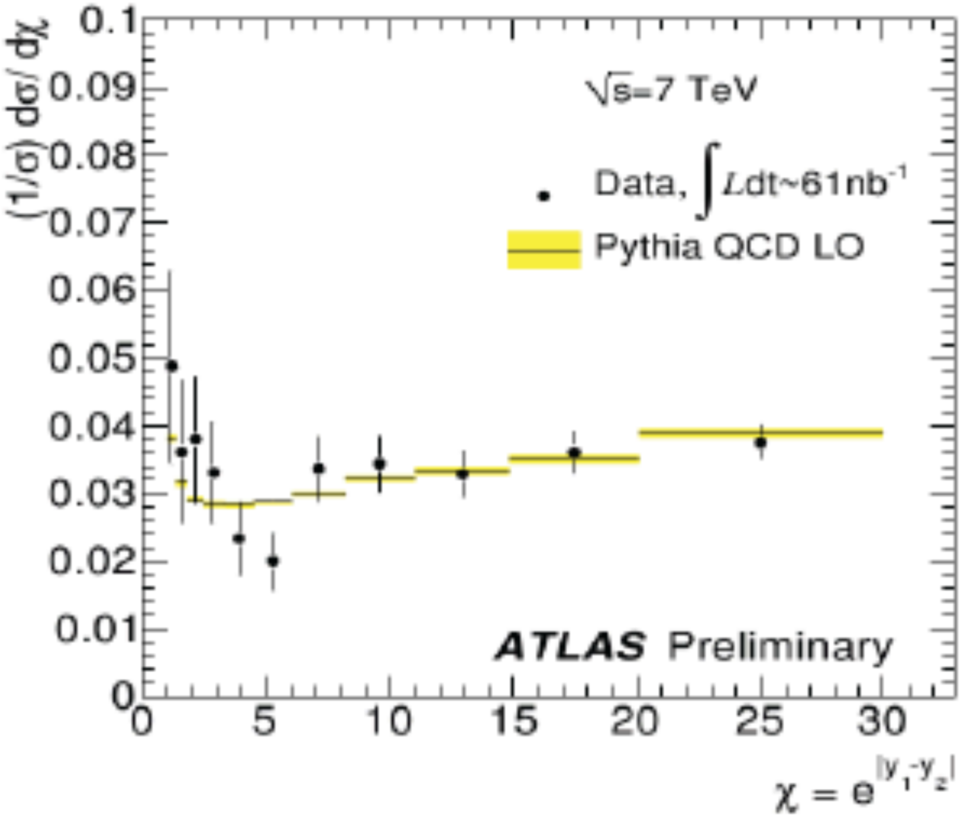
q* model simulated with Geant4

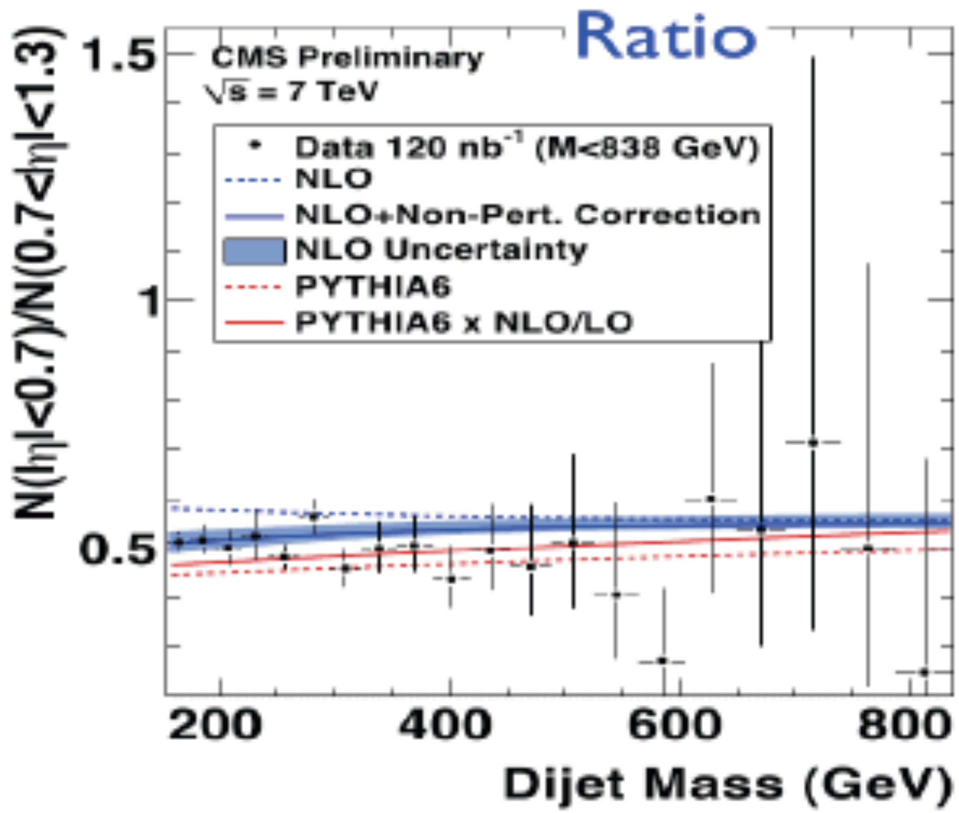


- ❑ Experimental systematic uncertainties included: luminosity, JES (dominant), background fit, ..
- ❑ Impact of different PDF sets studied → with CTEQ6L1: 0.4 < M (q*) < 1.18 TeV

Dijet angular distributions at LHC

Quark Compositeness?



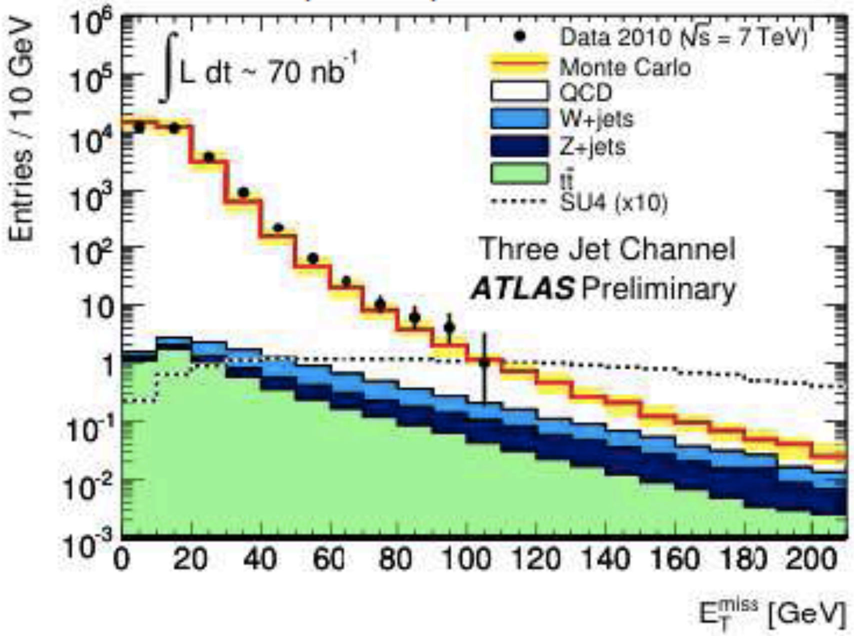


- first 95% CL results on compositness: ATLAS: $\Lambda > 875$ *GeV* , CMS: $\Lambda > 1900$ *GeV*
- Best published limit: $\Lambda > 2800$ *GeV* (D0, PRL 103,191803)
- all the tools needed to deal with higher luminosities are in place!

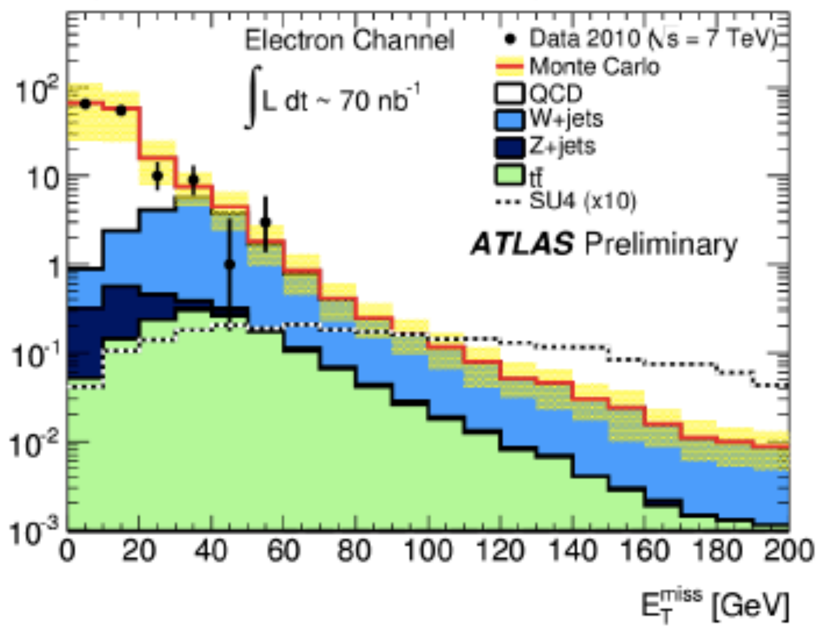
New Physics (1)

- **First task: Understand backgrounds !**
  - Some examples in SUSY-like searches

Jets + E_T^{miss} channel:
≥ 3 high-p_T jets, p_T (j1) > 70 GeV

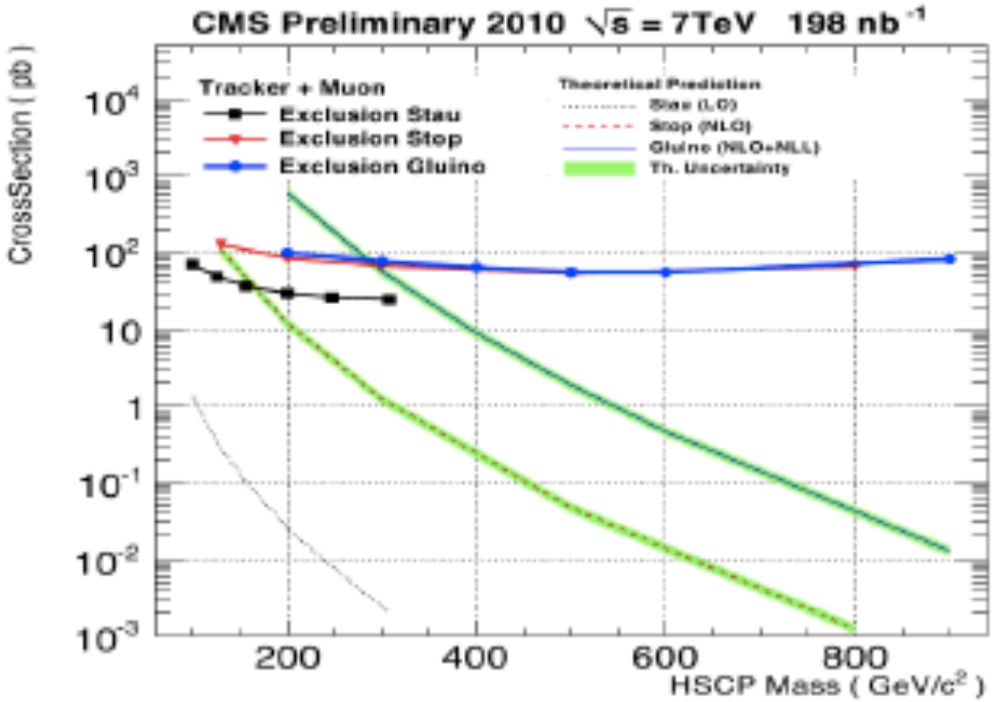


1 electron + Jets + ETmiss channel:
p_T (el) > 20 GeV, ≥ 2 high-p_T jets

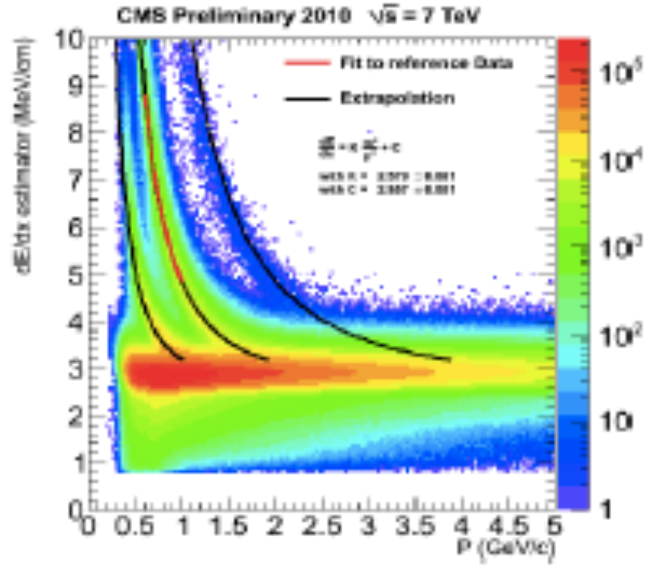


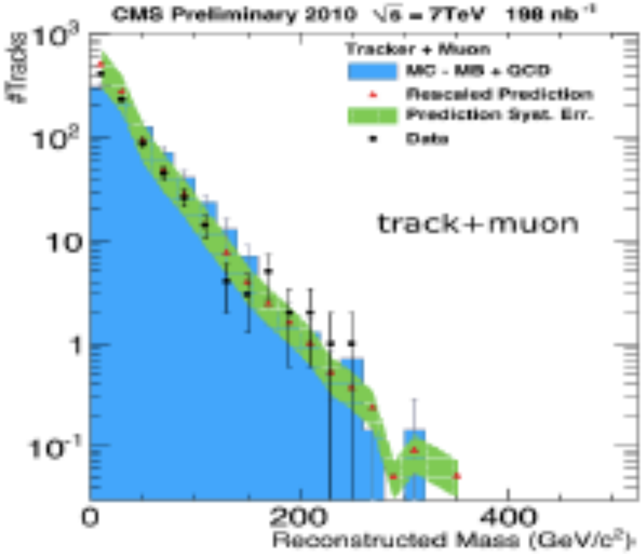
Meanwhile be prepared to set competitive limits with > 1pb^{-1} data

Search for Heavy Stable Charged Particles (HSCP) by CMS



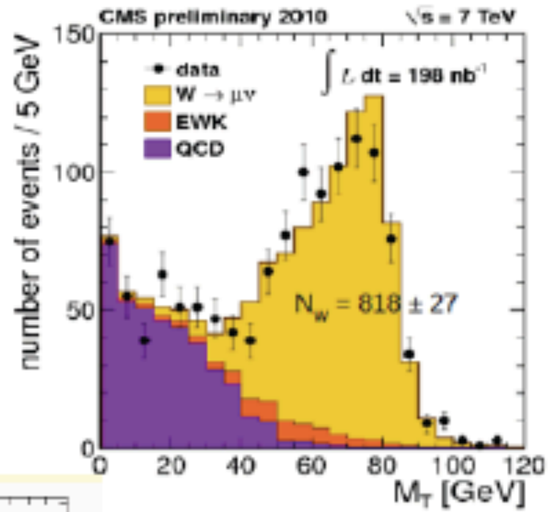
- seach for heavy gluino, hadronizing into a charged R-hadron
- reconstruct R-hadron mass based on measured dE/dX
- CMS'2010 95% CL exclusion:
  - $M_{\tilde{g}} < 271(284)\ GeV/c^2$ for track (muon)



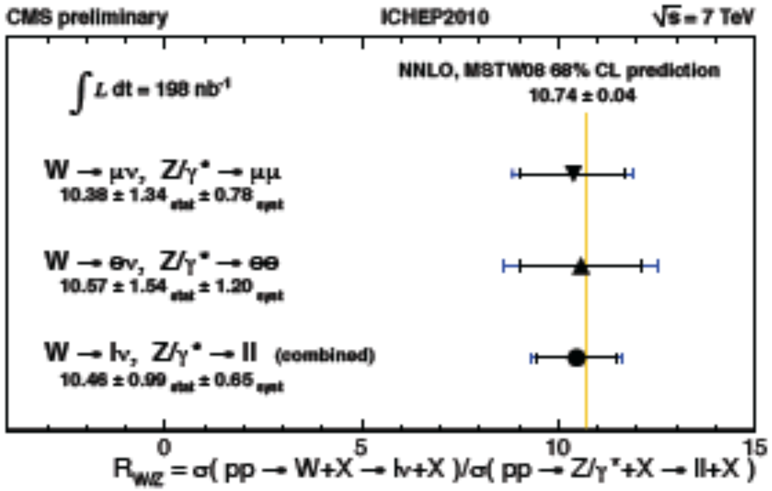


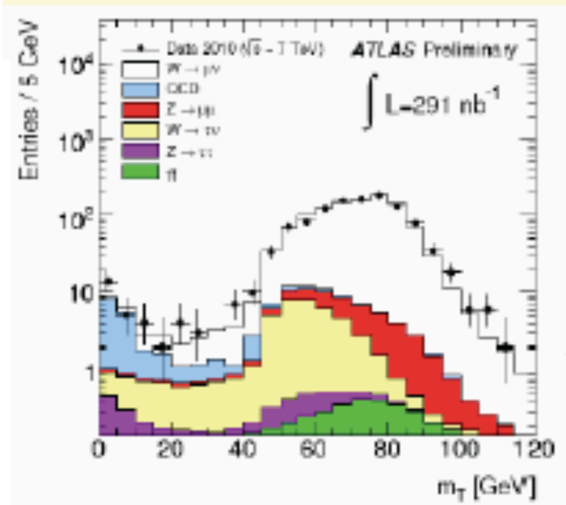
W and Z observation at LHC

- W inclusive cross section
  - CMS: L=196 nb^{-1}, Atlas: 17 nb^{-1}
- Z inclusive cross section
  - CMS: L=196 nb^{-1}, Atlas: ~225 nb^{-1}
- W/Z ratios (CMS)



W to Z ratios





Transverse W mass
$W \rightarrow \mu\nu$

← candidates in 291 nb^{-1} of data

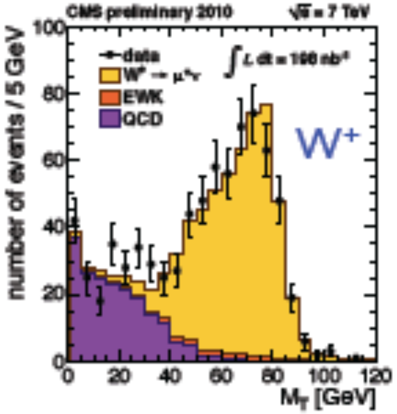
Measurements agree between electron and muon channels and with the NNLO calculation

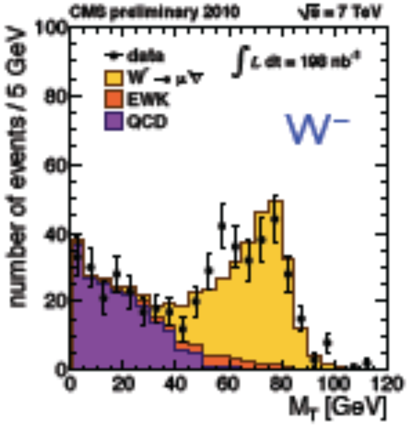
[... ATLAS also now published ...]

W distributions at LHC

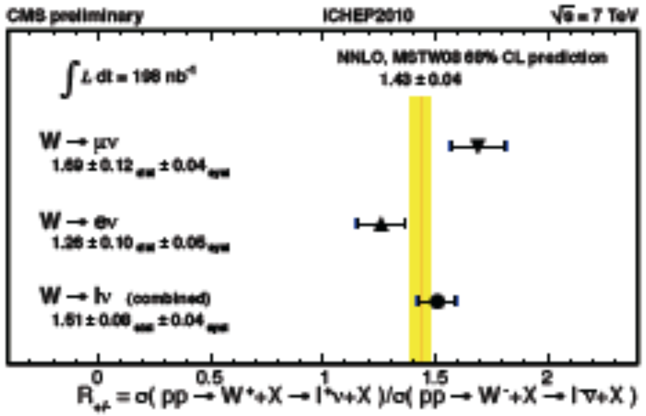
Splitting by charge

At LHC $\sigma(W^+)>\sigma(W^-)$

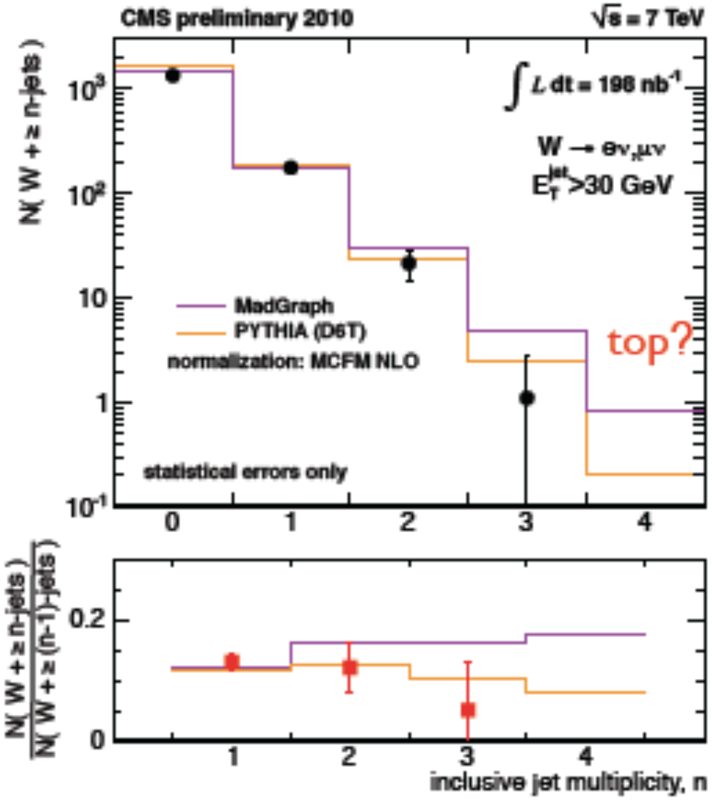




$\sigma(W^+)/\sigma(W^-)$



W+jets



- W+jets - main background for top pair production in l+jets channel
- Its understanding is a key to top physics analyses

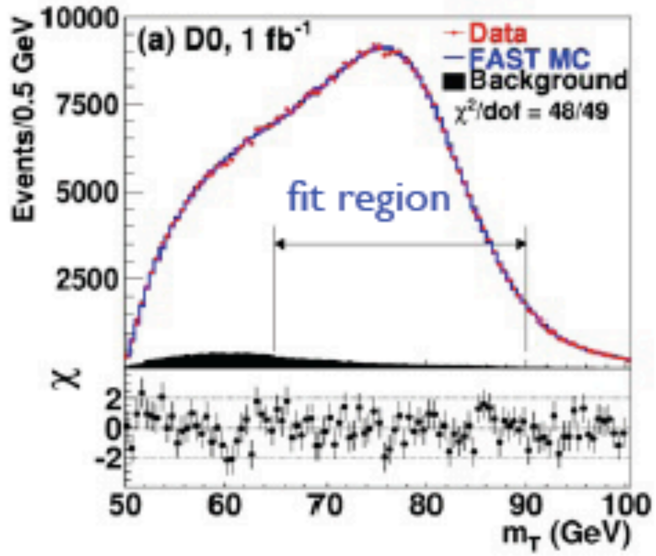
W mass and width

- ~499,830 W→eν candidates
- Many systematic uncertainties are due to limited statistics of calibration data samples

1 fb^{-1}

M_W=80.401±0.043 GeV

Single most precise measurement



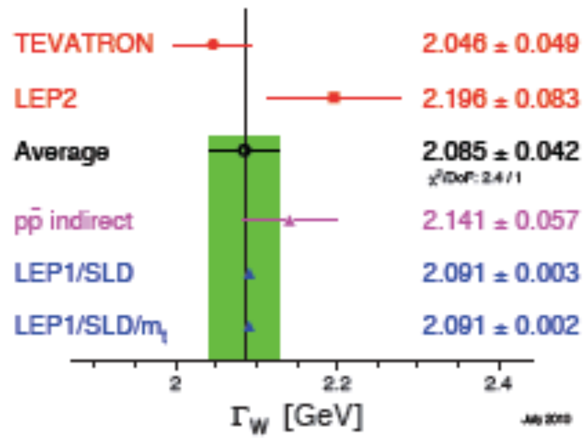
World average **M_W=80.399±0.023 GeV**

- Measure W width from the shape of transverse mass distribution

SM: Γ_W=2.093±0.002 GeV

Γ_W=2.028±0.072 GeV

World average **Γ_W=2.085±0.042 GeV**



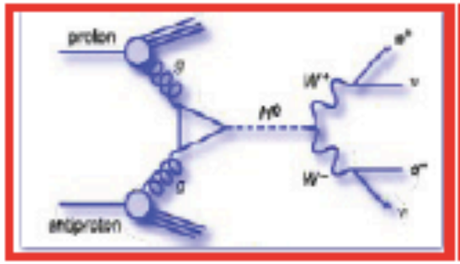
- study of W→πγ 4.3 fb^{-1}

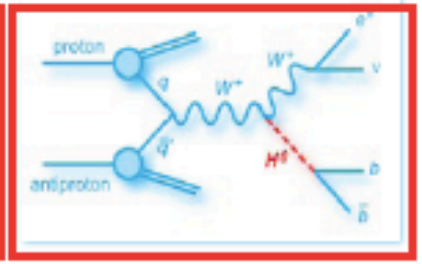
SM: BR(W→πγ)/BR(W→eν) =10^{-6}-10^{-8}

BR(W→πγ)/BR(W→eν) < 6.4 x 10^{-5} at 95% CL

Diboson physics

- Probe of electroweak sector of the standard model
  - cross sections
  - gauge boson couplings
- Background for Higgs searches
  - high mass Higgs (M_H>135 GeV) $H \rightarrow WW$
  - low mass Higgs (M_H<135 GeV) $WH \rightarrow l\nu bb$

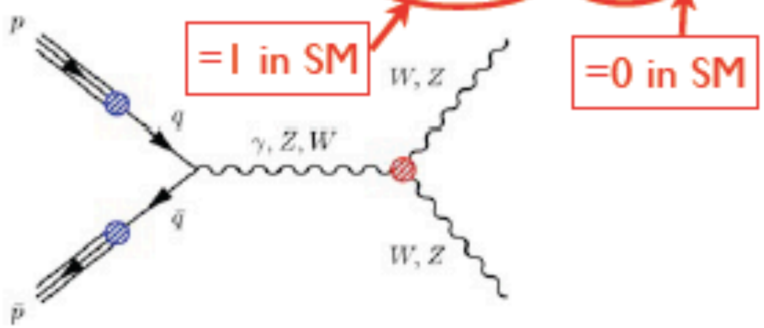




- Exercise multivariate analysis techniques used for Higgs searches

- Charged Triple Gauge Couplings
  - probed by WW, WZ, Wγ
  - general Lagrangian: 14 parameters
  - EM gauge invariance and CP conservation

5 TGC parameters: $g_1^Z, \kappa_\gamma, \kappa_Z, \lambda_\gamma, \lambda_Z$



$SU(2)_L \otimes U(1)_Y$, 3 parameters:

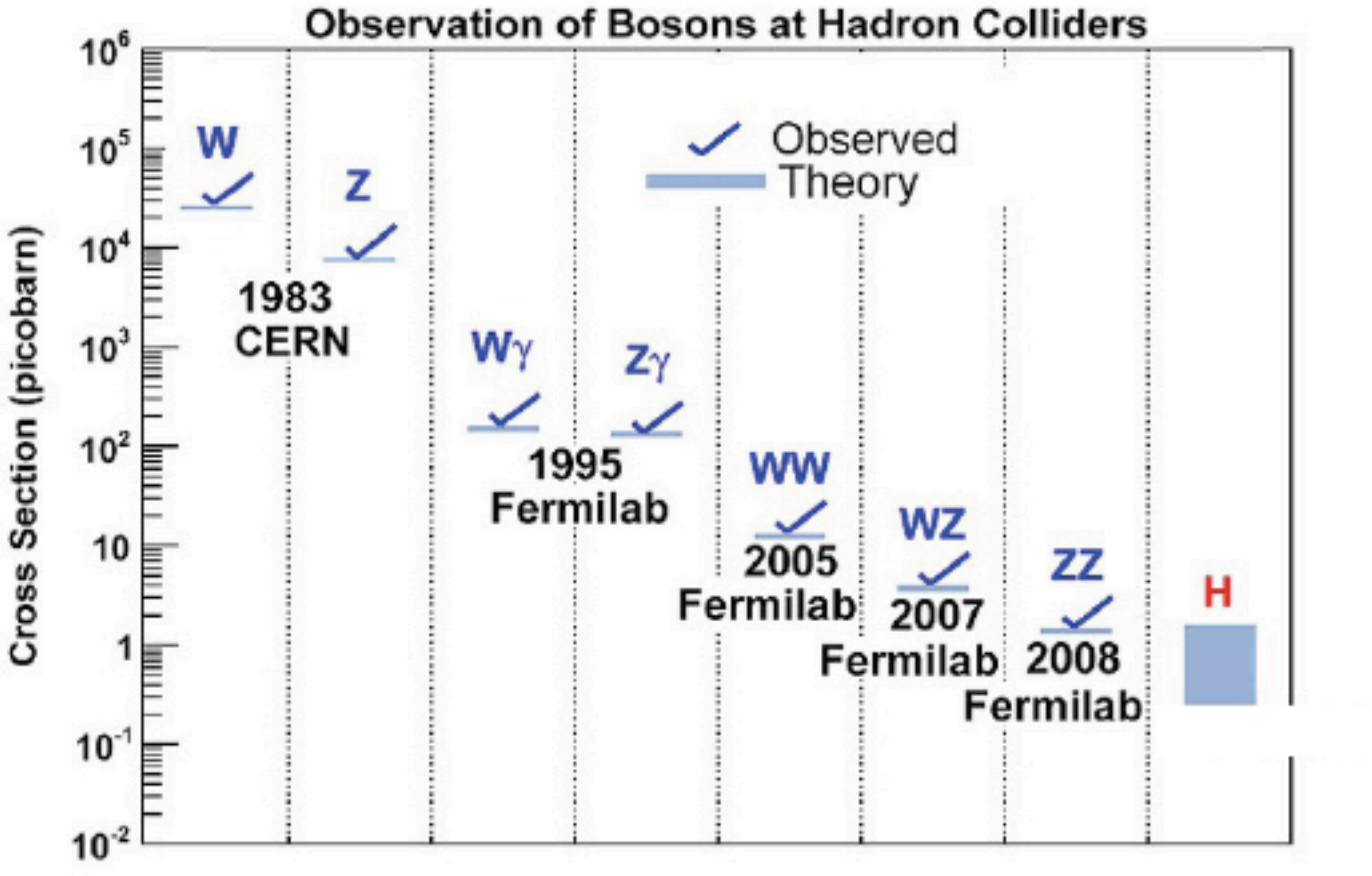
$\Delta\kappa_Z = \Delta g_1^Z - \Delta\kappa_\gamma \tan^2\theta_W,\ \lambda = \lambda_\gamma = \lambda_Z$

- Neutral Triple Gauge Couplings
  - probed by ZZ, Zγ
  - general Lagrangian: 8 parameters
  - CP conservation

4 TGC parameters: $h_3^\gamma, h_3^Z, h_4^\gamma, h_4^Z$

all zero in SM

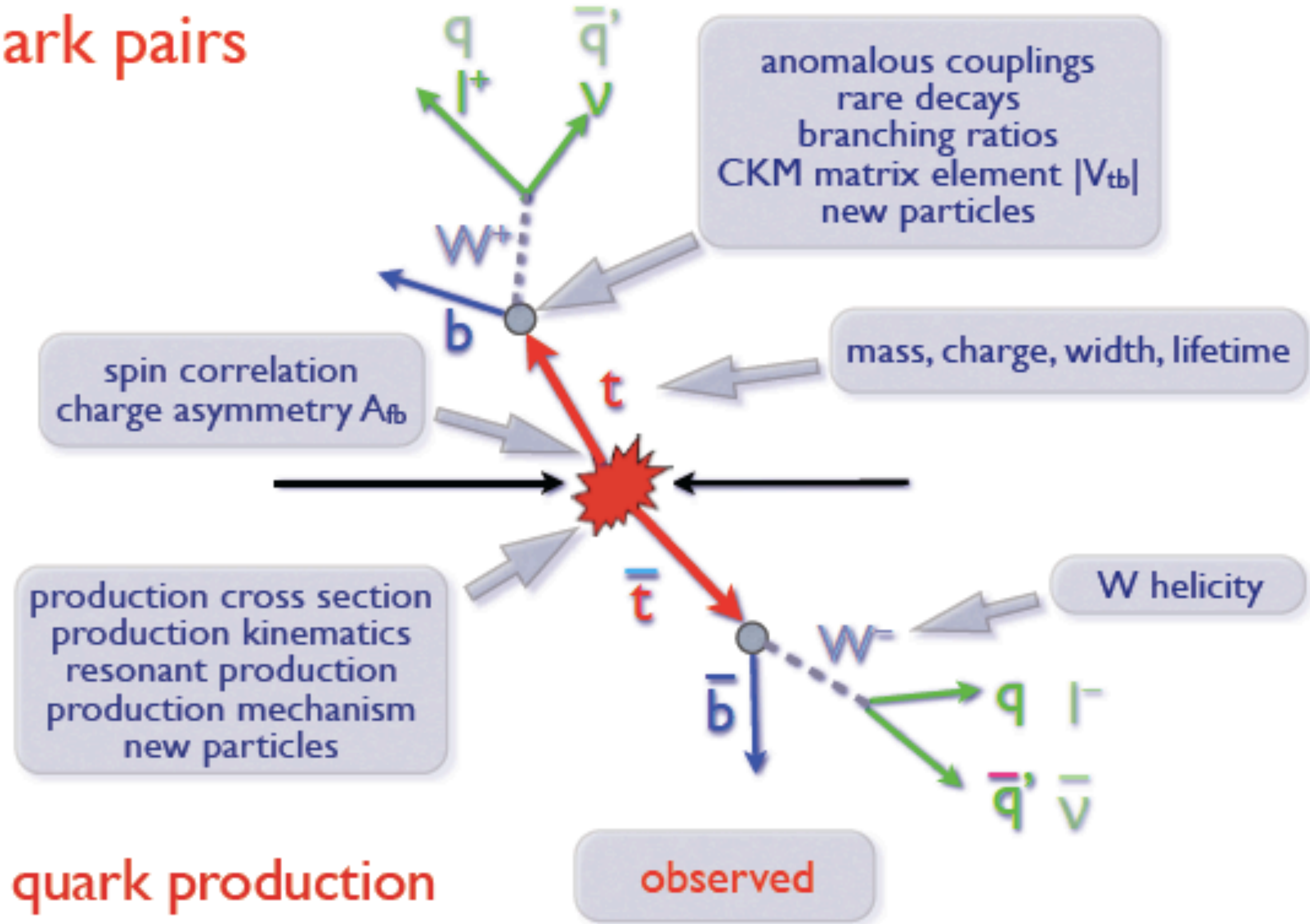
Observation of diboson signals



All diboson signals observed at Fermilab by both CDF and D0 in many different final states

What do we know about top?

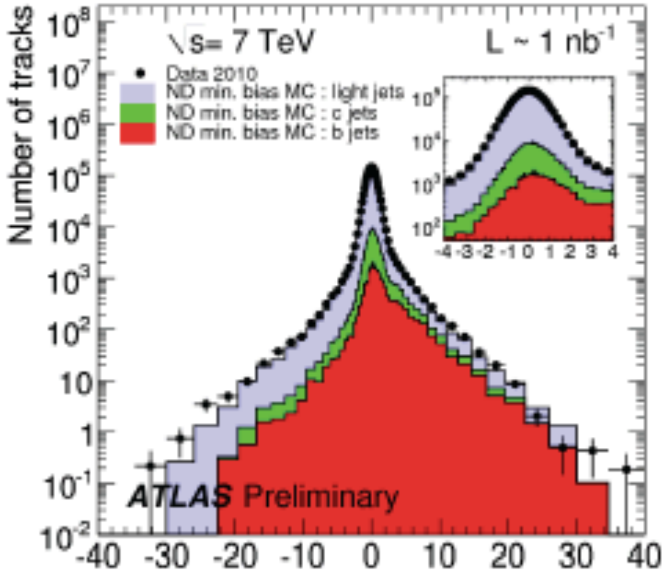
top quark pairs



EW top quark production

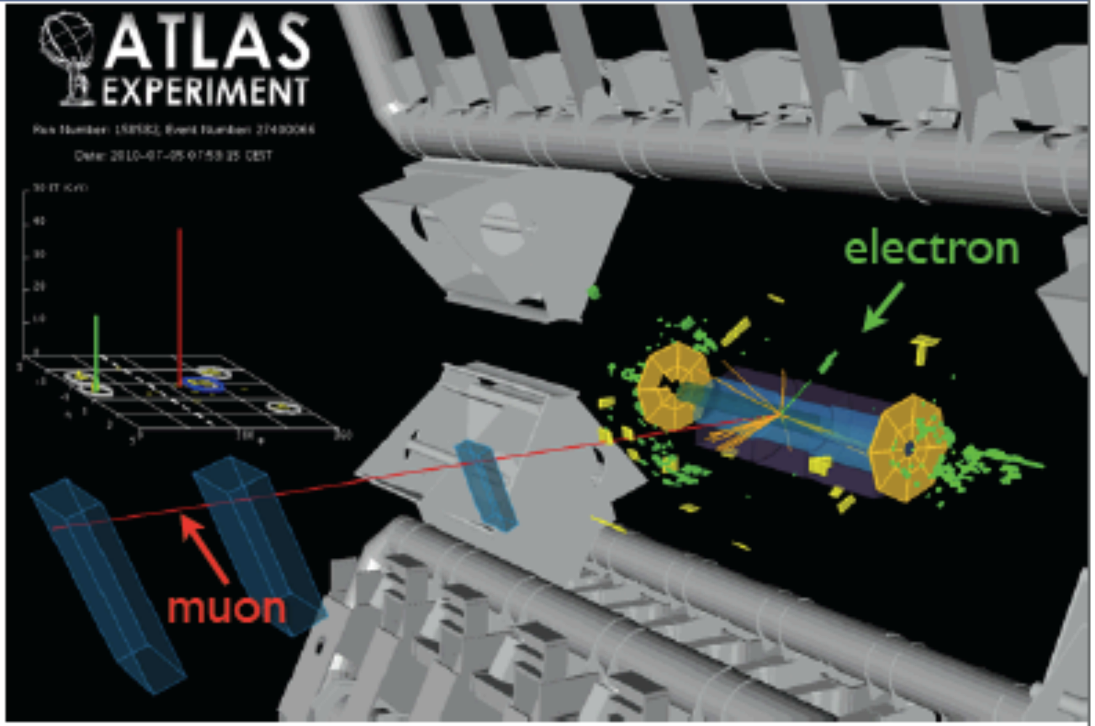
Top pair candidates at LHC

- Top physics requires excellent performance of all components
  - demonstrated by Atlas and CMS
- Impressive agreement between data and simulation



impact parameter significance S_{d_0}

critical for b-jet identification!



- Several top pair candidate events
- example: eμ event
  - 3 jets with p_T>20 GeV, H_T=196 GeV, E_T^{mis} = 77 GeV
  - one identified as b-jet

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH (CERN)

CMS-TOP-10-001

CERN-PH-EP/2010-039
2010/10/28

First LHC top publication now out (CMS – dilepton channel)

ATLAS soon to follow …

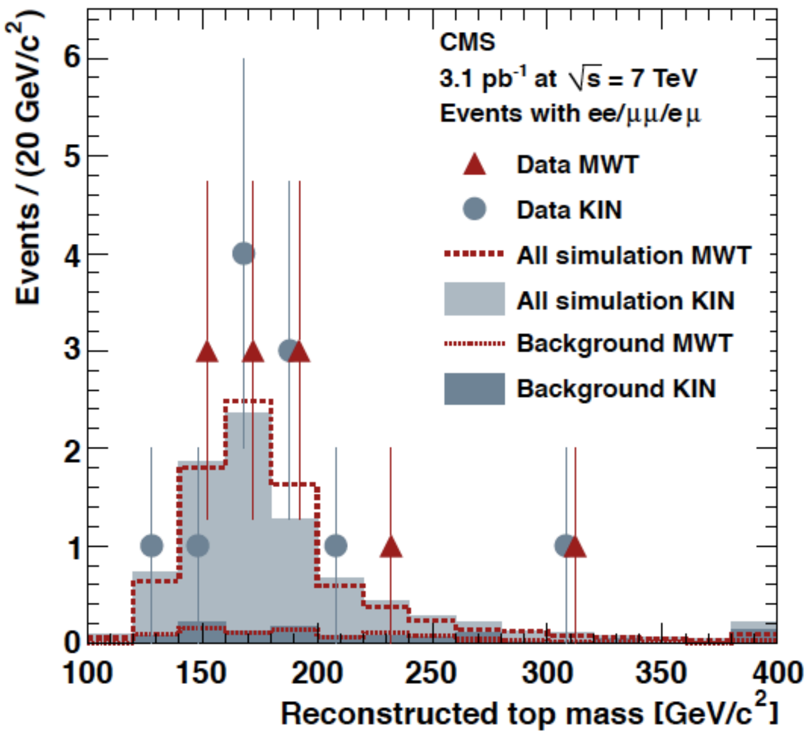
First Measurement of the Cross Section for Top-Quark Pair Production in Proton-Proton Collisions at $\sqrt{s} = 7$ TeV

The CMS Collaboration*

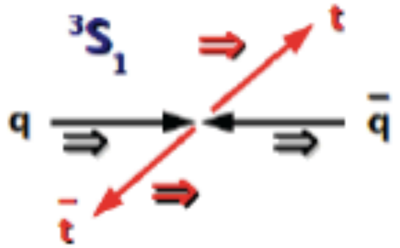
Abstract

The first measurement of the cross section for top-quark pair production in pp collisions at the LHC at center-of-mass energy $\sqrt{s} = 7$ TeV has been performed using 3.1 ± 0.3 pb^{-1} of data recorded by the CMS detector. This result utilizes the final state with two isolated, highly energetic charged leptons, large missing transverse energy, and two or more jets. Backgrounds from Drell-Yan and non-W/Z boson production are estimated from data. Eleven events are observed in the data with 2.1 ± 1.0 events expected from background. The measured cross section is $194 \pm 72(\text{stat.}) \pm 24(\text{syst.}) \pm 21(\text{lumi.})$ pb, consistent with next-to-leading order predictions.

Submitted to Physics Letters B



Spin correlations



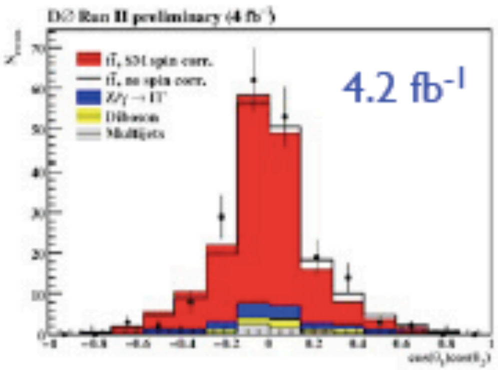
- Short lifetime
- Flight directions of top decay products carry information about top polarization at production

$$K = \frac{N_{\uparrow\uparrow} + N_{\downarrow\downarrow} - N_{\downarrow\uparrow} - N_{\uparrow\downarrow}}{N_{\uparrow\uparrow} + N_{\downarrow\downarrow} + N_{\downarrow\uparrow} + N_{\uparrow\downarrow}}$$

Strength depends on spin quantization axis:

beam line, off-diagonal

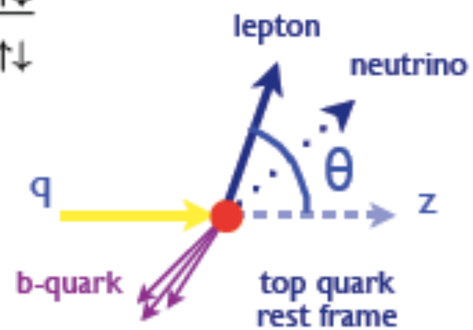
DØ Dilepton channel



4.2 fb^{-1}

$\kappa = -0.17\,^{+0.64}_{-0.53}$

beam basis, NLO: κ=0.777



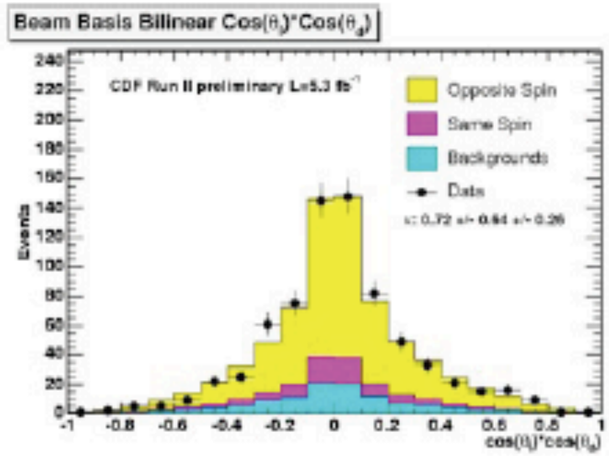
CDF 2.8 fb^{-1}

$\kappa = 0.32\,^{+0.55}_{-0.78}$

off-diagonal basis

NLO: κ=0.782

Lepton+jets channel CDF



5.3 fb^{-1}

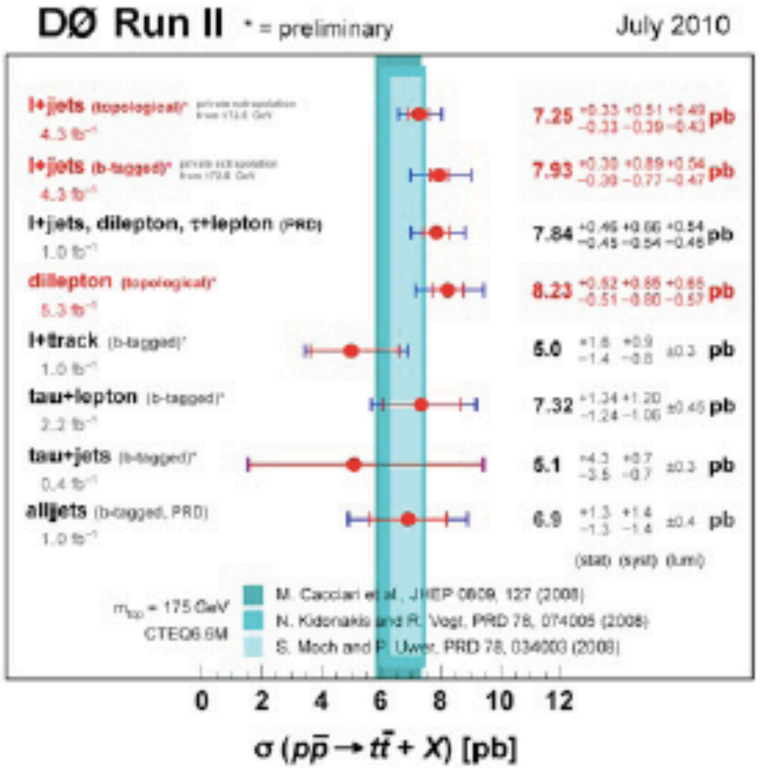
$\kappa = 0.72 \pm 0.64_{stat} \pm 0.26_{syst}$

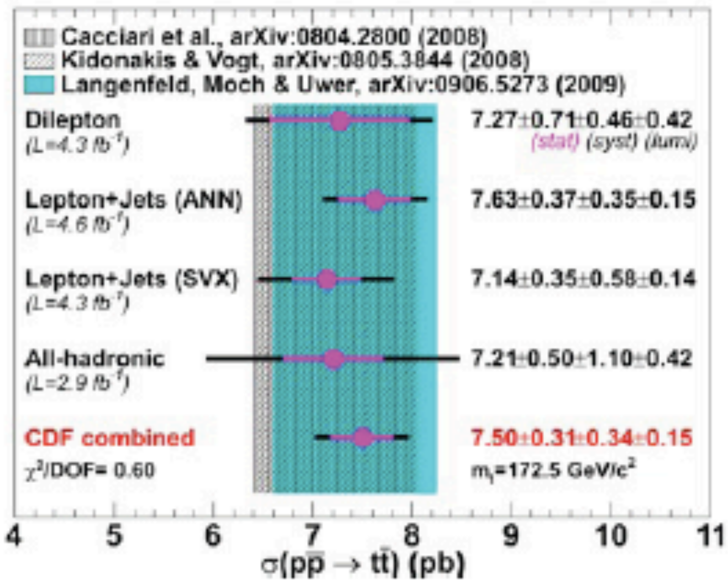
new

beam basis

Three measurements in last year!

Cross sections summary





CDF combination: 6% precision!

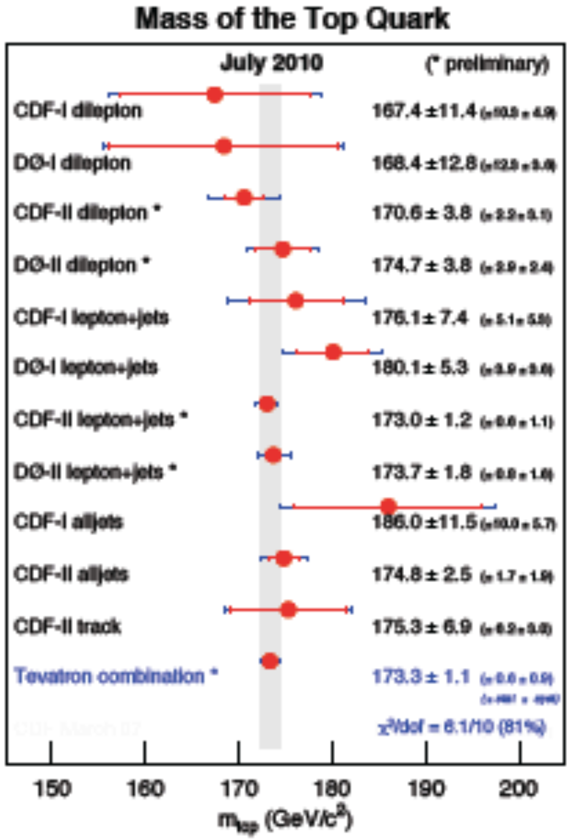
...exceeds Tevatron goal of 10%

- Measured in all channels but $\tau_{had}\tau_{had}$
- Agree between channels and methods

Consistent with theory prediction
Challenges its precision

Theoretical contributions:
P.Uwer, N.Kidonakis, M.Neubert, P.Ruiz-Femenia

Tevatron mass combination



new

0.6% relative uncertainty

m_{top}=173.3±1.1(total) GeV

- Measurement in different channels consistent with each other
- Different methods produce consistent results

Systematic source	δm_{top} (GeV)
iJES	0.46
aJES	0.21
bJES	0.20
cJES	0.13
dJES	0.19
rJES	0.15
Lepton pT	0.10
Signal model	0.19
Background	0.23
Fit	0.11
MC generator	0.40
Color reconnection	0.39
Multiple interactions	0.08
Total	**1.06**

statistical component of JES

b-jet response

b-jet energy scale

modeling uncertainties

residual JES

detector response

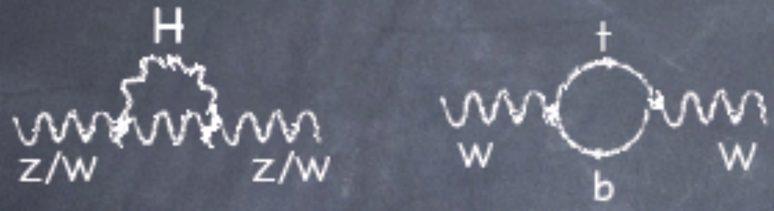
ISR/FSR, PDF, NLO

showering model

Constraints on Higgs mass

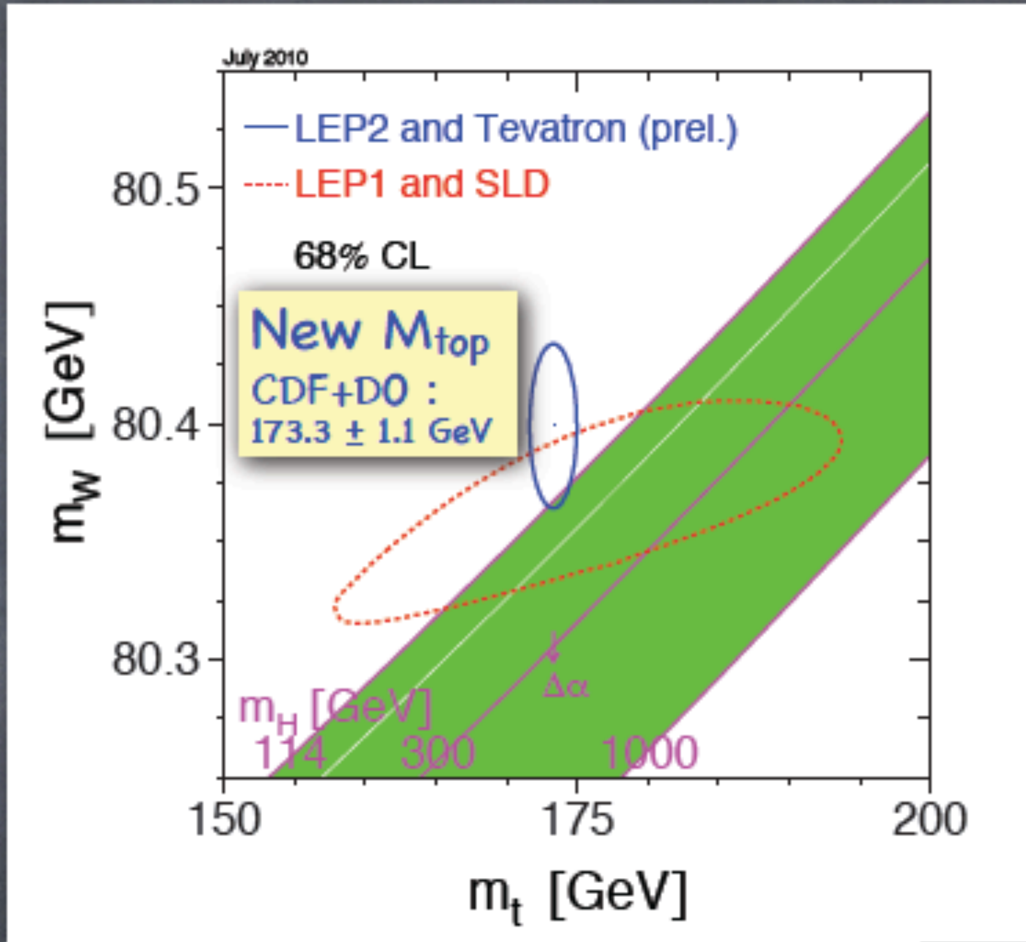
- Electroweak constraints

  $\ln M_H \propto \Delta M_W \propto M_t^2$



  - Other precision electroweak observables

- LEP direct searches
  - $m_H > 114.4$ GeV @ 95% CL
- Tevatron direct searches ...



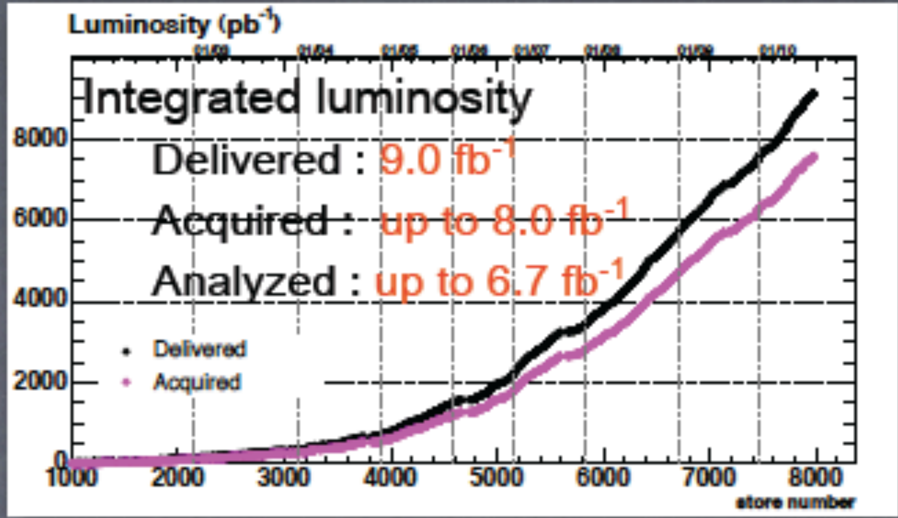
Precision Fit finds

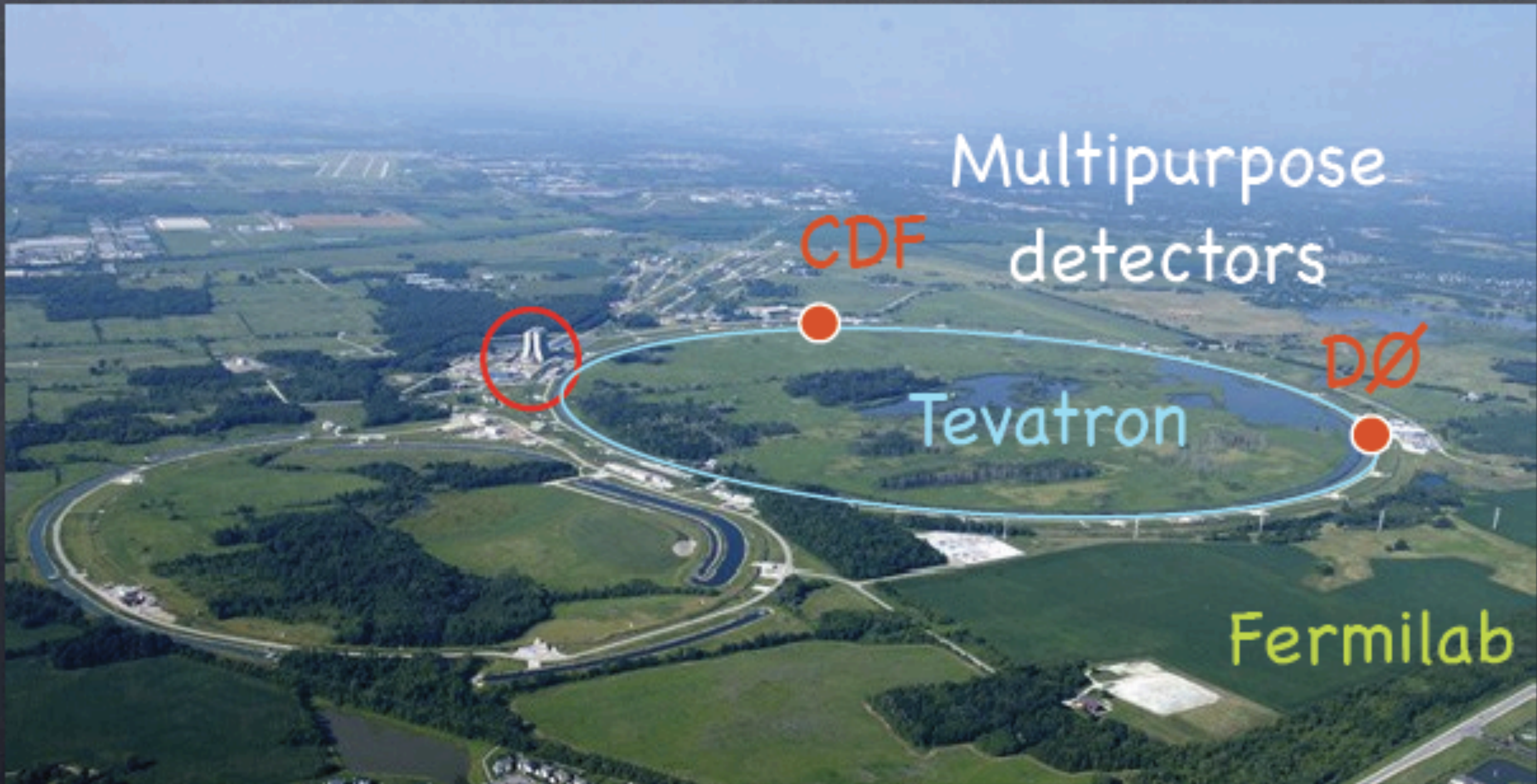
$m_H = 89.0^{+35}_{-26}$ GeV

$m_H < 158$ GeV @ 95% CL

Tevatron

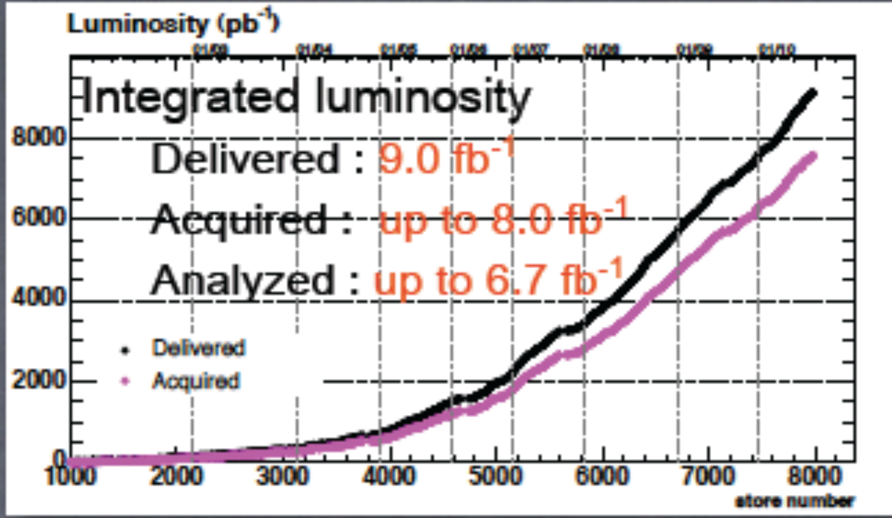
- $p\,\bar{p}$ collisions with $\sqrt{s}$ = 1.96 TeV
- Two collider experiments, CDF & DO

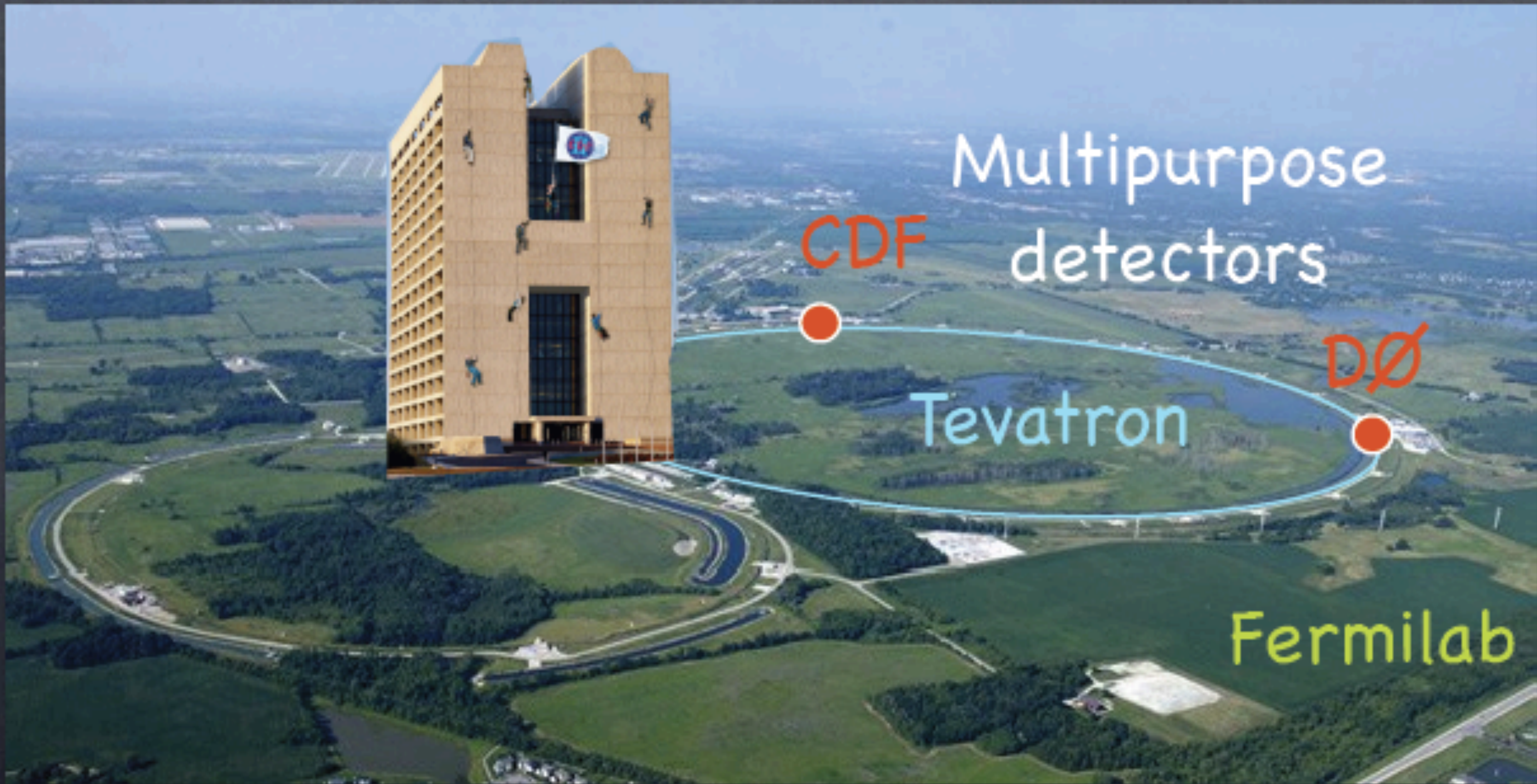




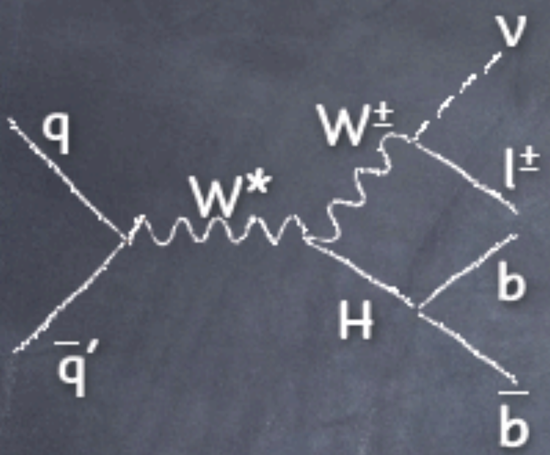
Tevatron

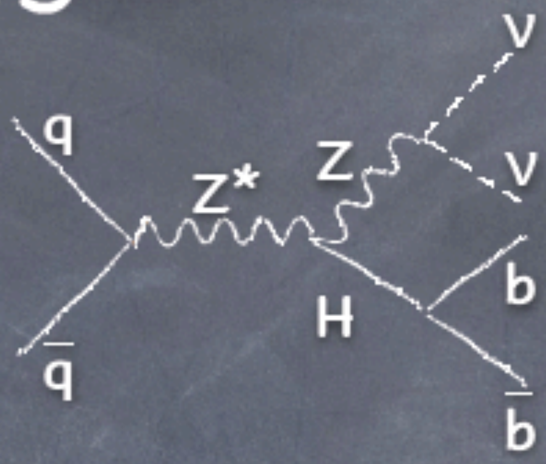
- p $\bar{p}$ collisions with $\sqrt{s}$ = 1.96 TeV
- Two collider experiments, CDF & D0

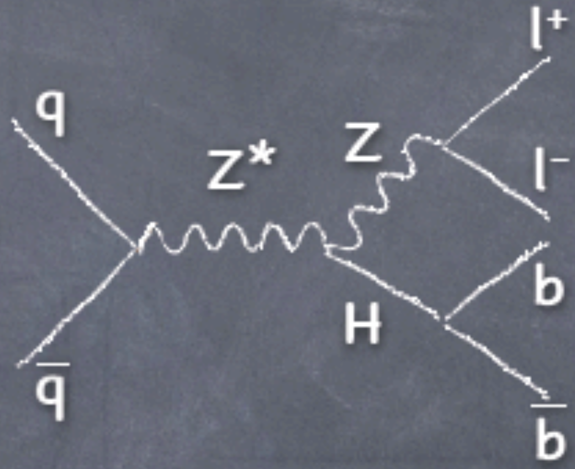




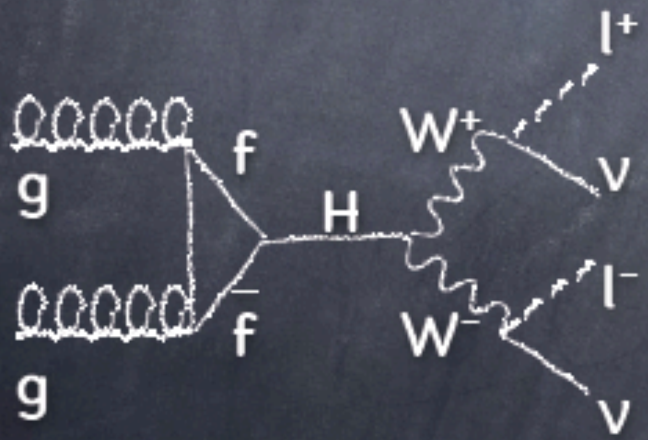
SM Higgs at the Tevatron

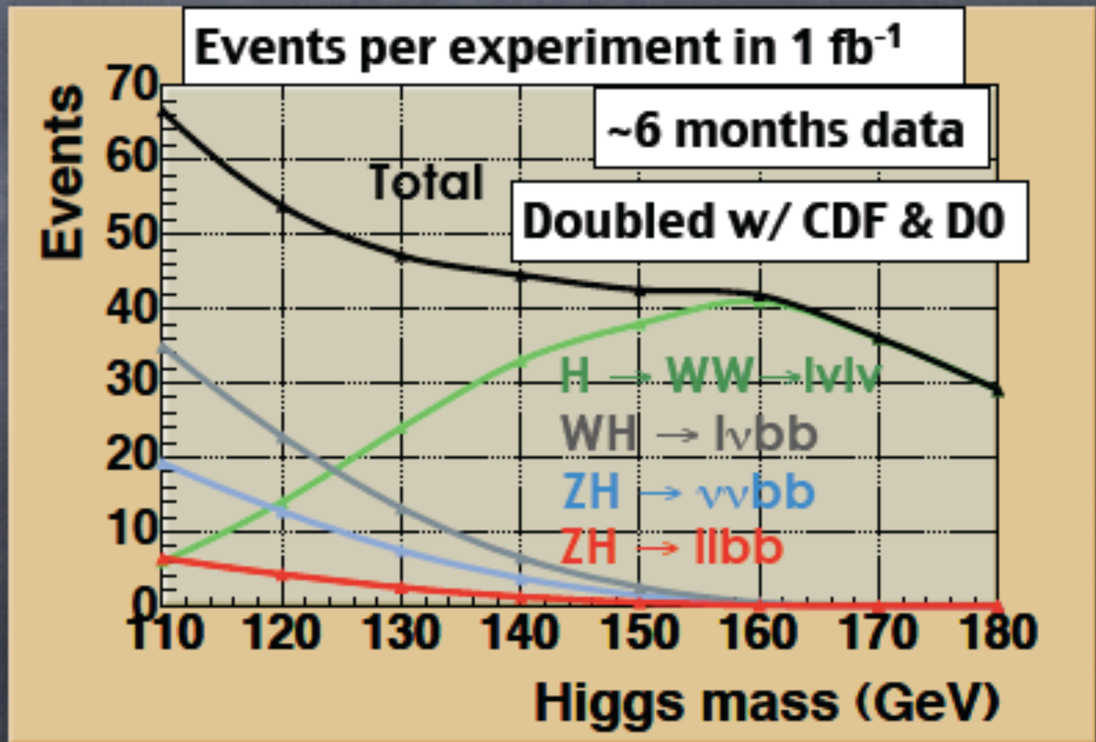






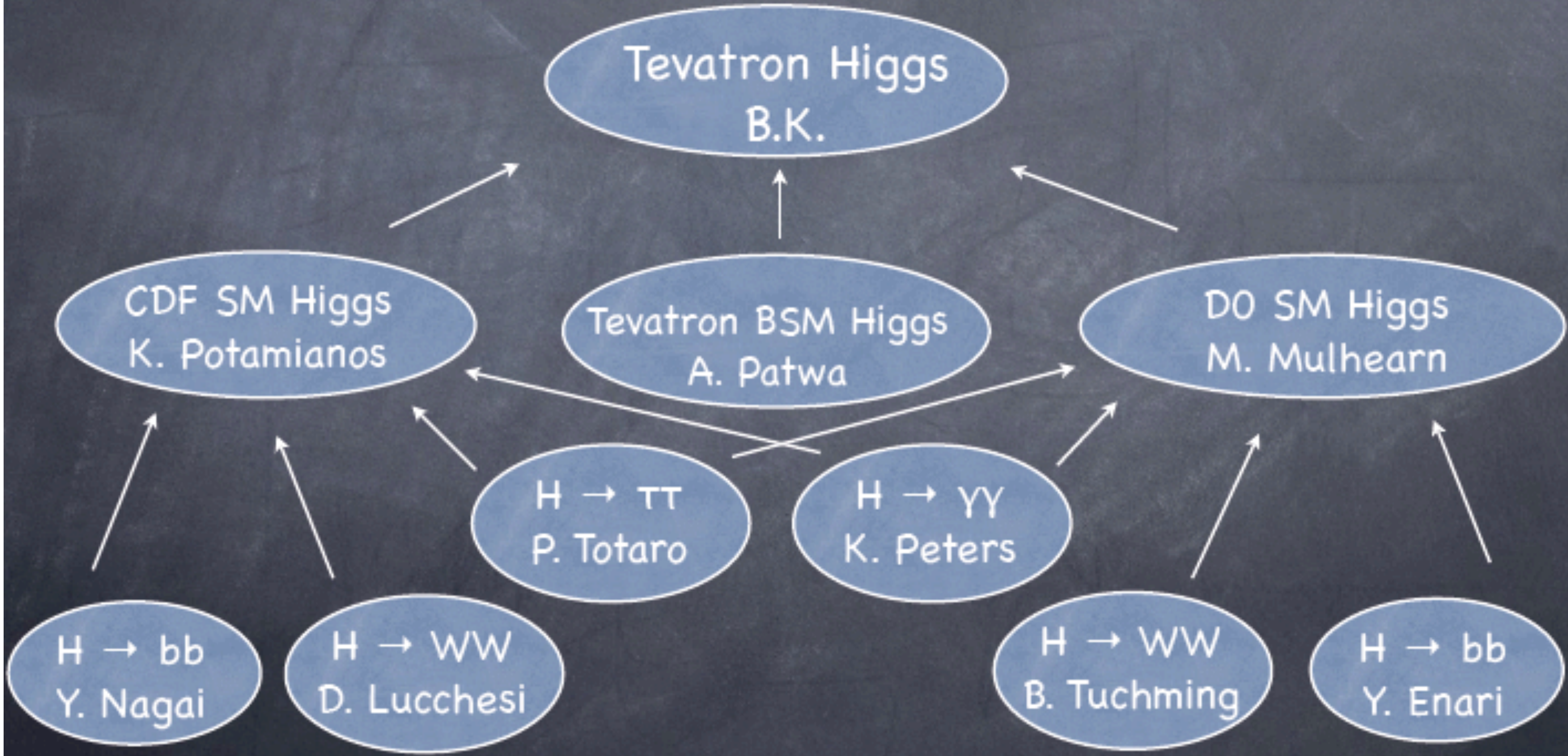
Main decay modes



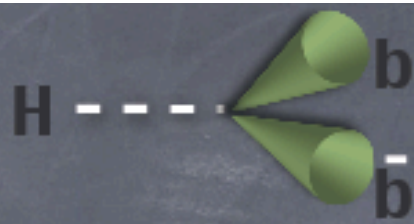


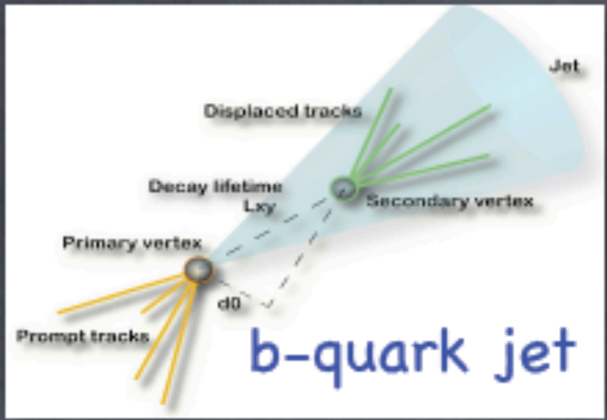
Foundation of presentations

- ICHEP Tevatron Higgs talks
  - Covered variety of Higgs searches and analysis techniques



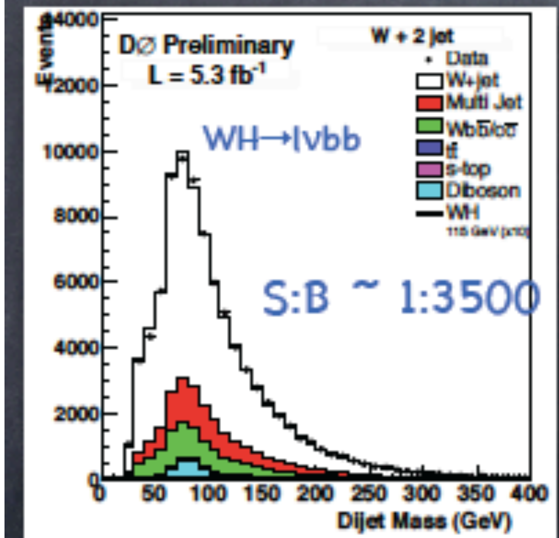
Identifying H → bb



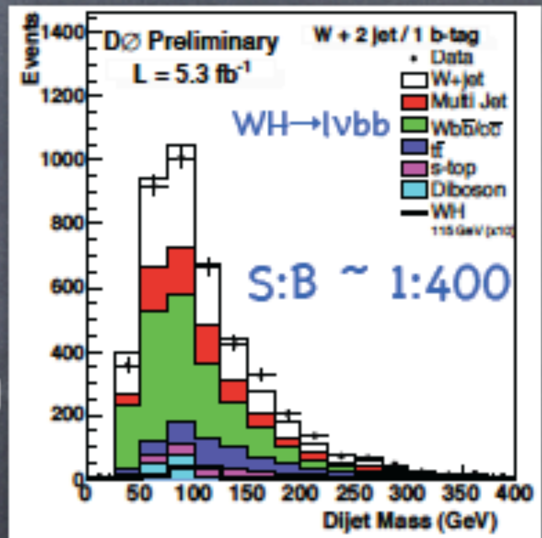


Low mass Higgs relies on various channels, mainly bbbar + two leptons (associated production + EW gauge boson)

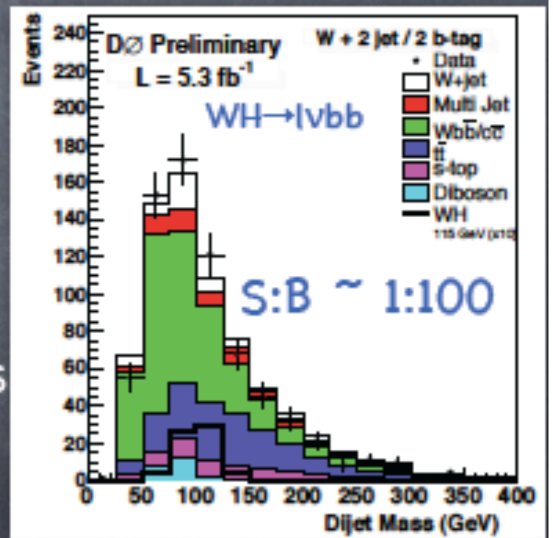
Relies on multivariate techniques ... hard!



1 b-tag



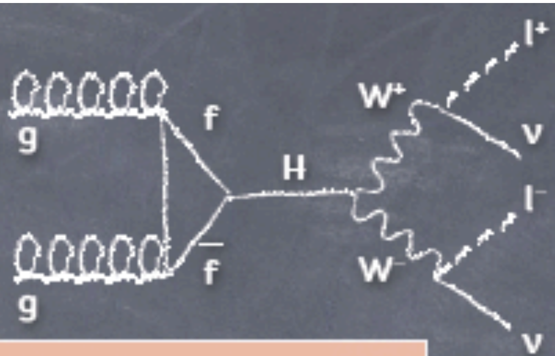
2 b-tags



2. After 1 or 2 b-tags

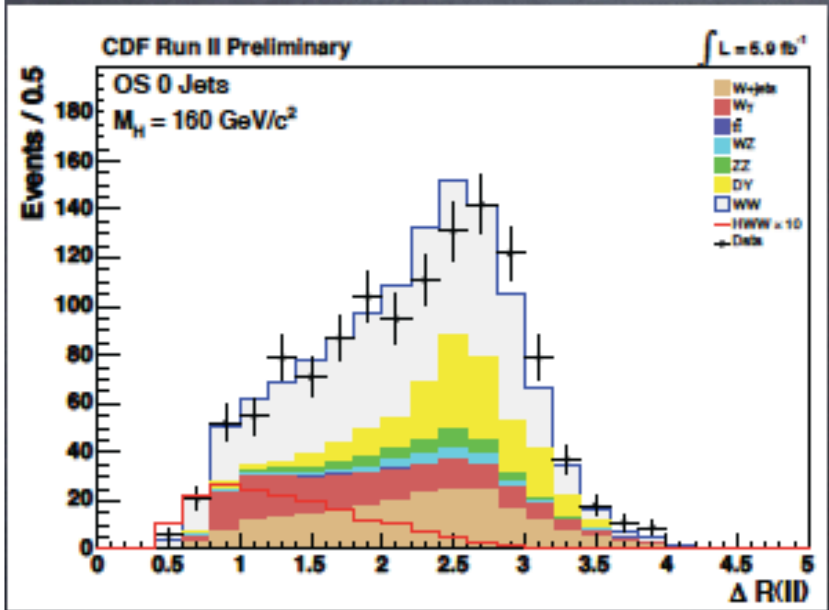
- Signal region with enhanced signal / background

Basic H → WW analysis



Signature: Opposite charge leptons, high MET, no jets

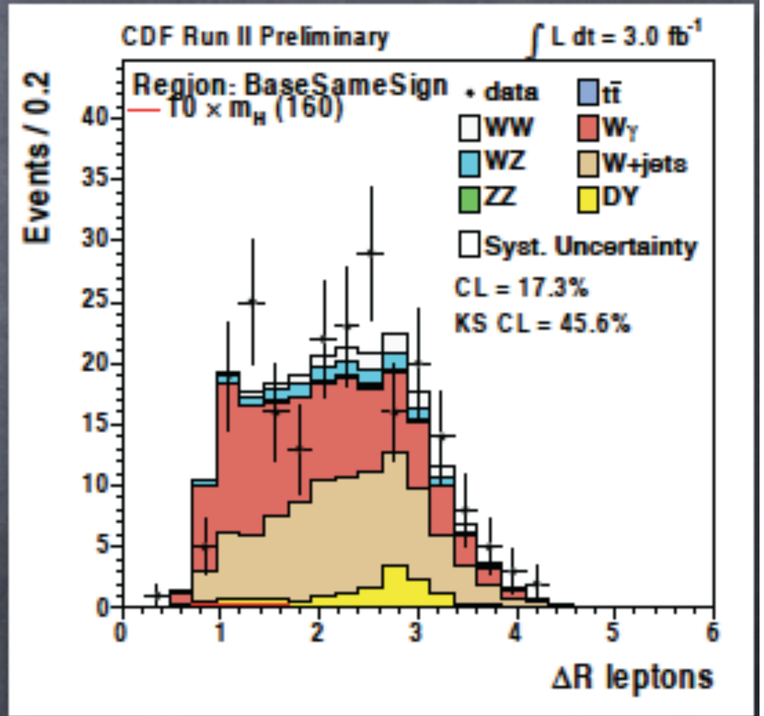
Main Signal	Main BKGs	Key discriminant
gg → H	WW, Wγ	ΔR leptons = "Angle" between leptons



Spin 0 H → WW

Spin 1 Z → WW

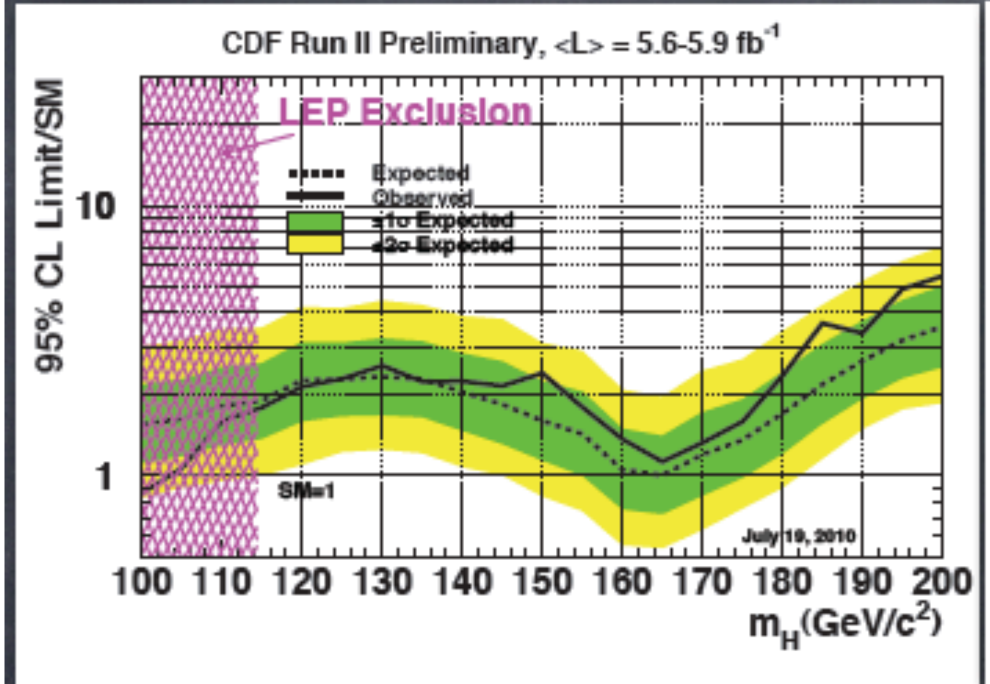
Fakes & conversions:
Can check Same
Sign modeling



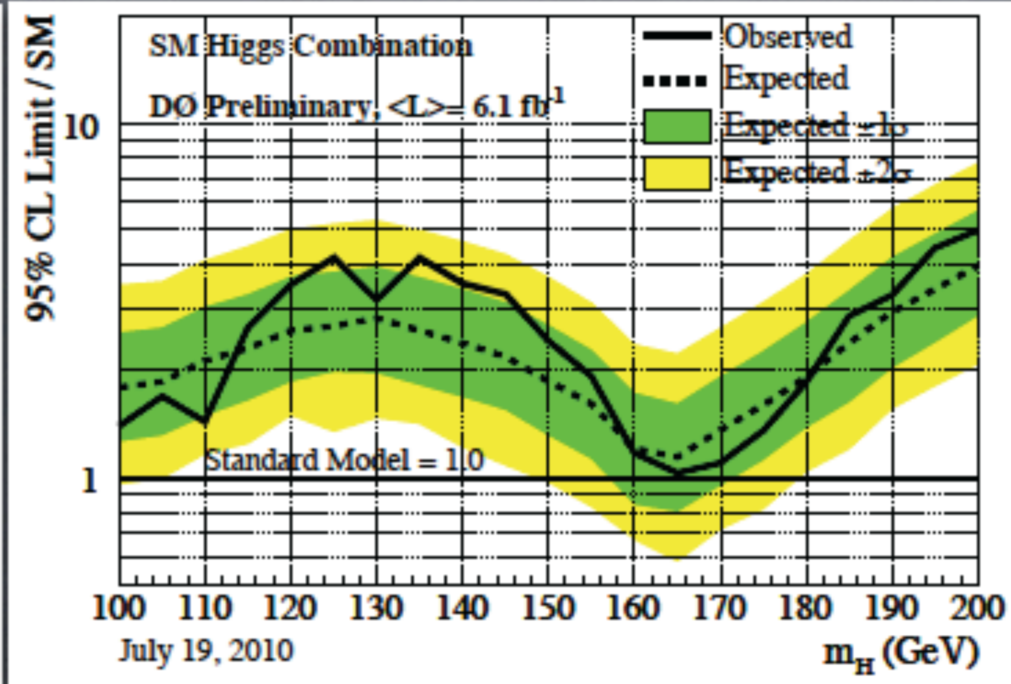
CDF & D0 combinations

Shown first on July 23, 2010

CDF's limits



D0's limits



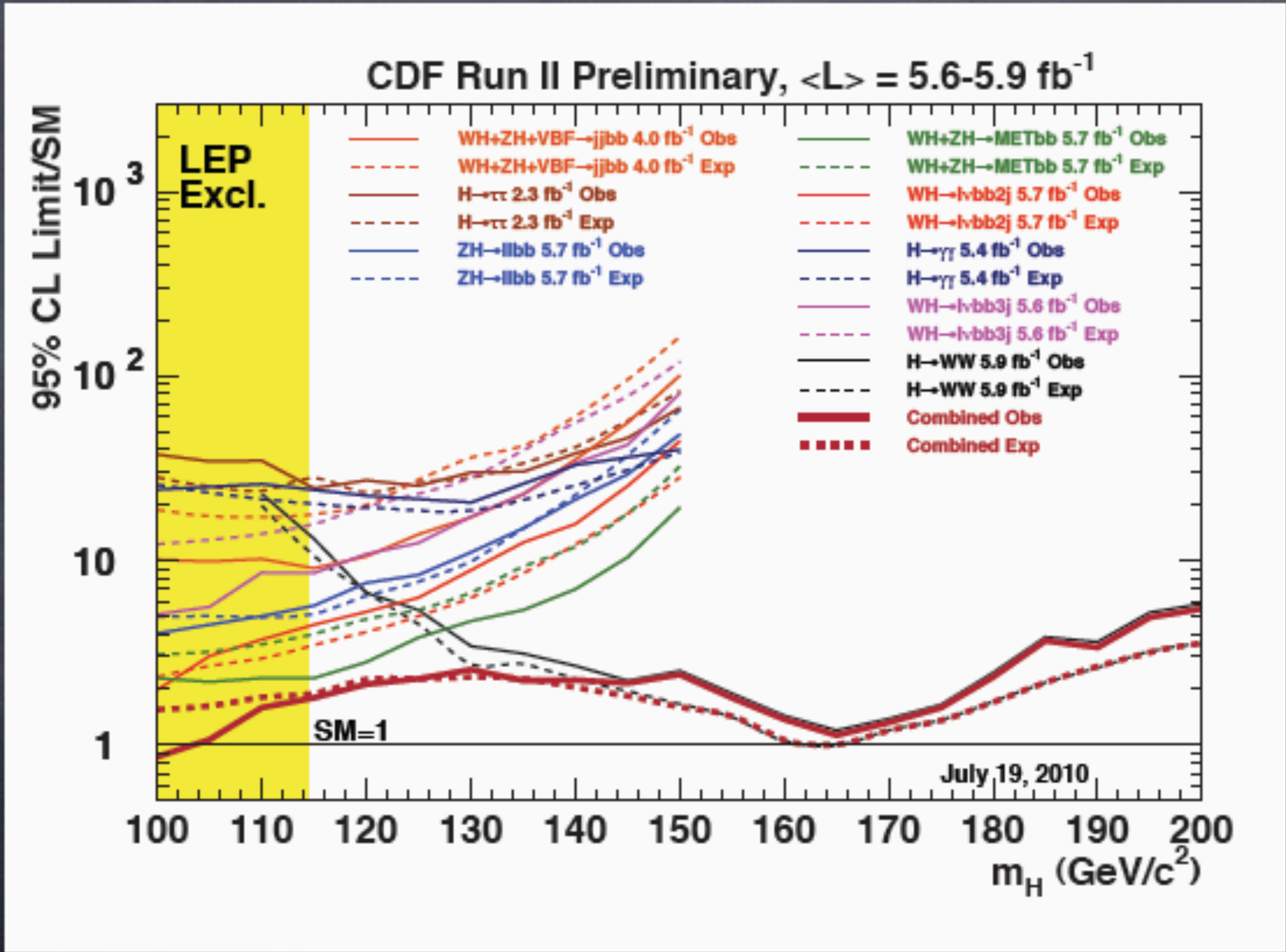
CDF achieves expected exclusion at 165 GeV

D0 almost achieves observed exclusion at 165 GeV

@ m_H = 100 GeV, both set observed limits below expected

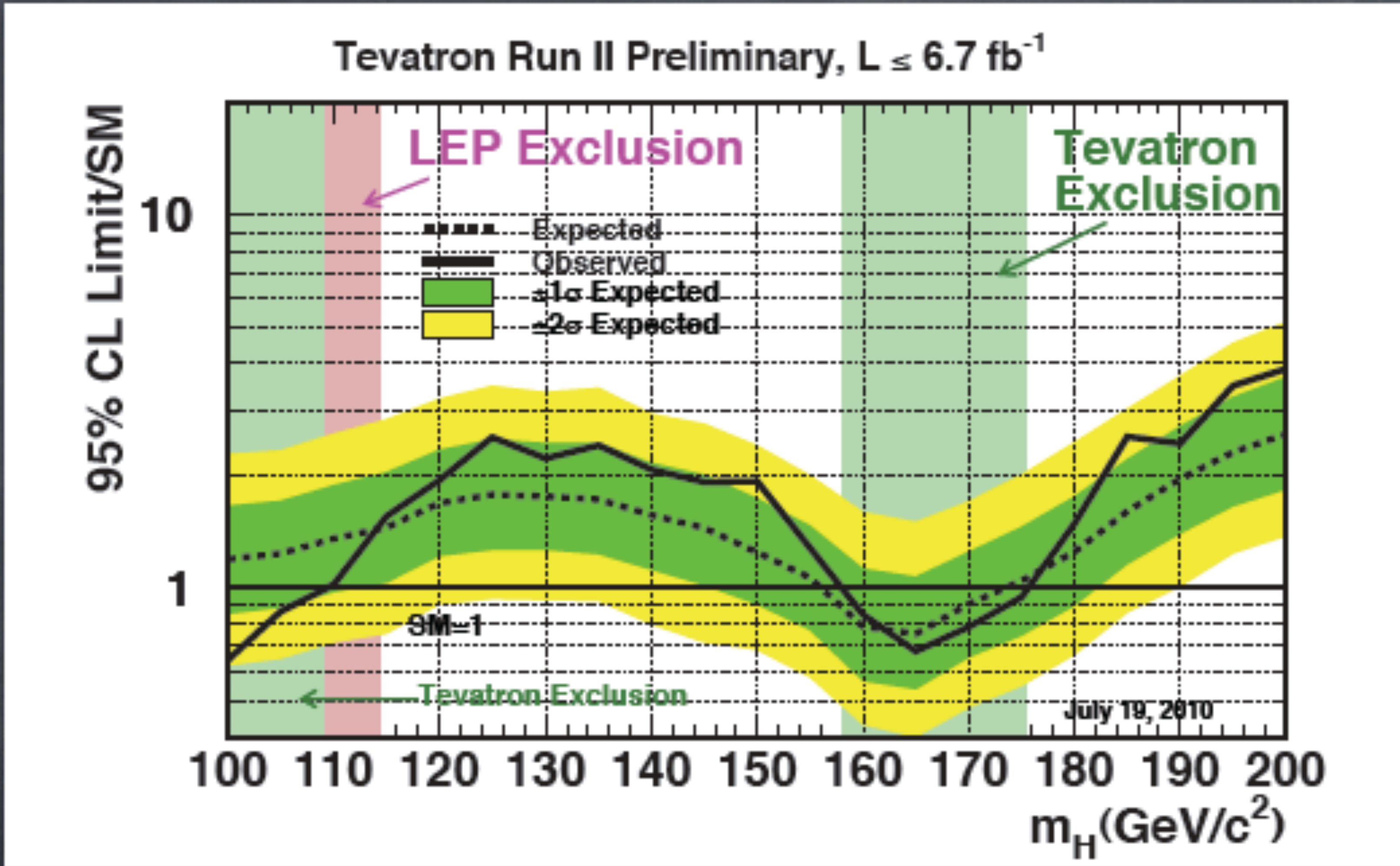
Closing in on low mass LEP exclusion

What goes into the combination?



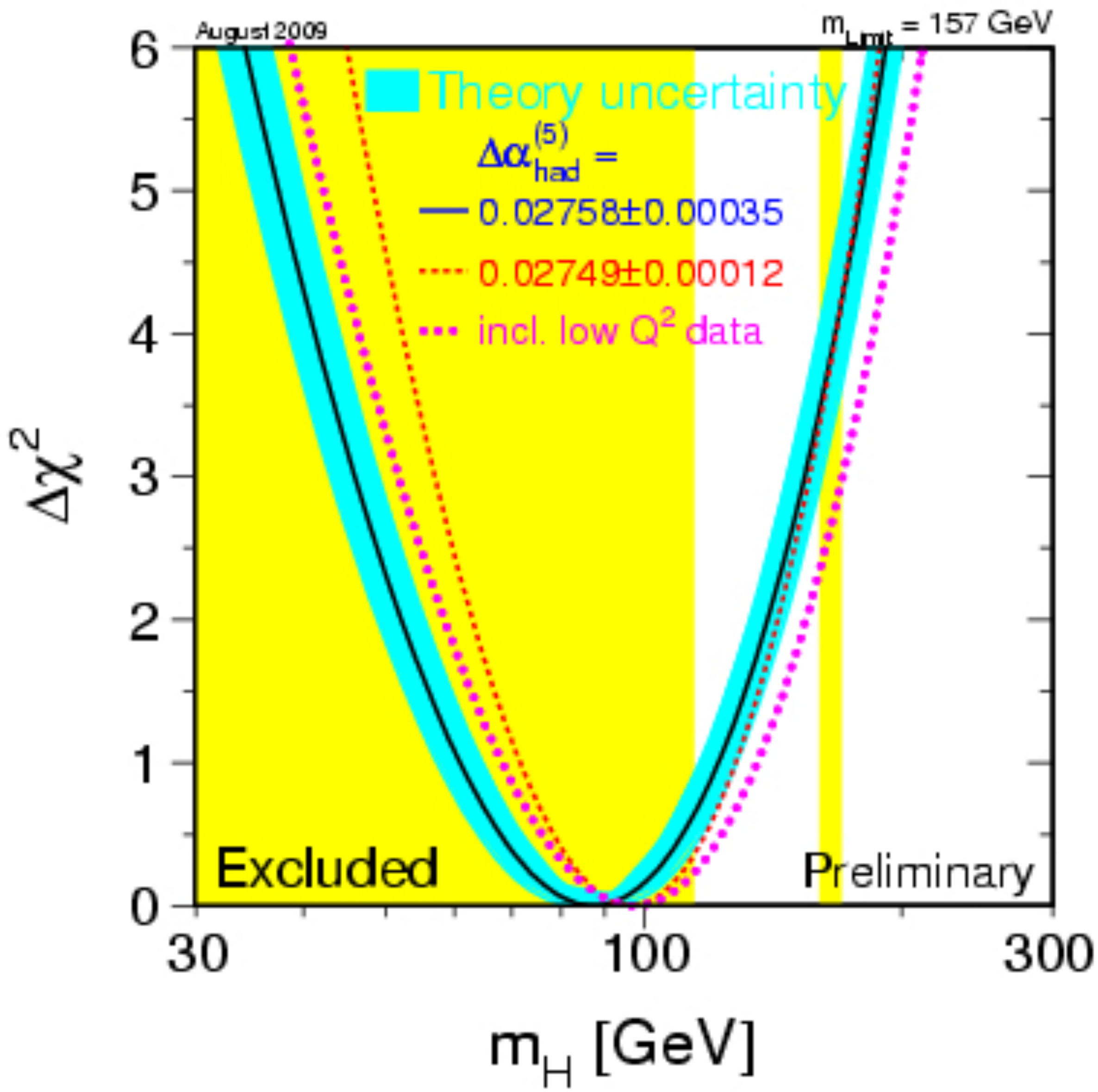
Tevatron combination

"Expected sensitivity"



- Low mass sensitivity approaching LEP exclusion :
  - Expected 1.45*SM @ 115 GeV
  - Expected 1.24*SM @ 105 GeV
- High mass 95% CL exclusion :
  - $158 < m_H < 175$ GeV
    - 4 times previous (162 - 166 GeV)
    - Expected ($156 < m_H < 175$ GeV)

What is the Mass of the Higgs?



2009 version!...

This plot needs updates for both diirect searches and new input to Electroweak fit from Tevatron Top and W Mass measurements.

Prospects for Higgs evidence

~16 fb^{-1} :*

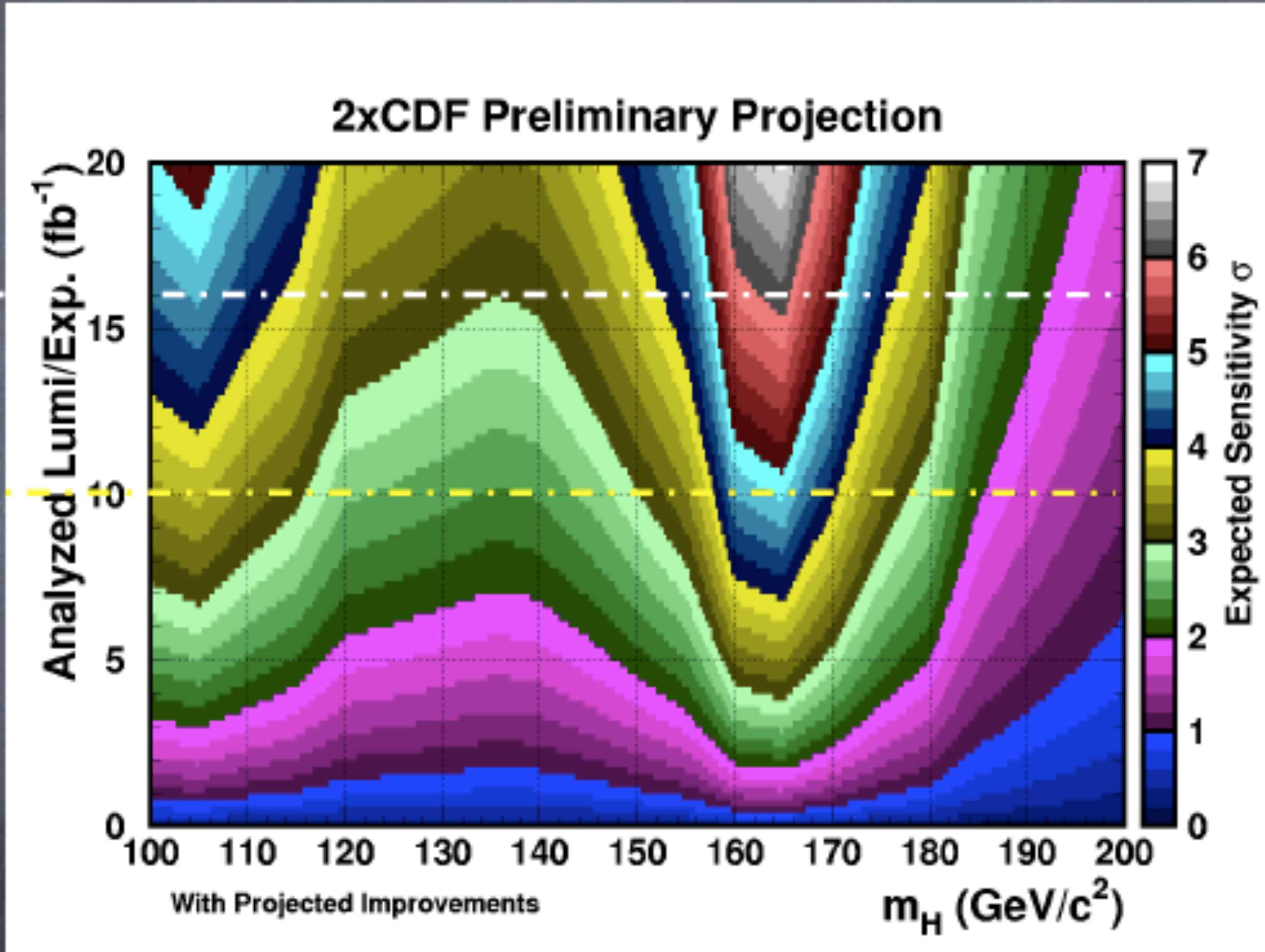
> 3 σ expected sensitivity from 100 - 185 GeV

4 σ @ 115 GeV

End of 2011:

> 2.4 σ expected sensitivity across mass range

3 σ at 115 GeV



* 16 fb^{-1} : based on "Run III" proposal to run 3 more years

Short term Objectives

LHC Plans

Integrated luminosity of ≥1 fb^{-1} by the end of 2011

- requires a peak luminosity of ≥ 1x10^{32} cm^{-2}s^{-1} during 2011
- → must reach ~1 x10^{32} cm^{-2}s^{-1} during 2010

Longer Term Objectives

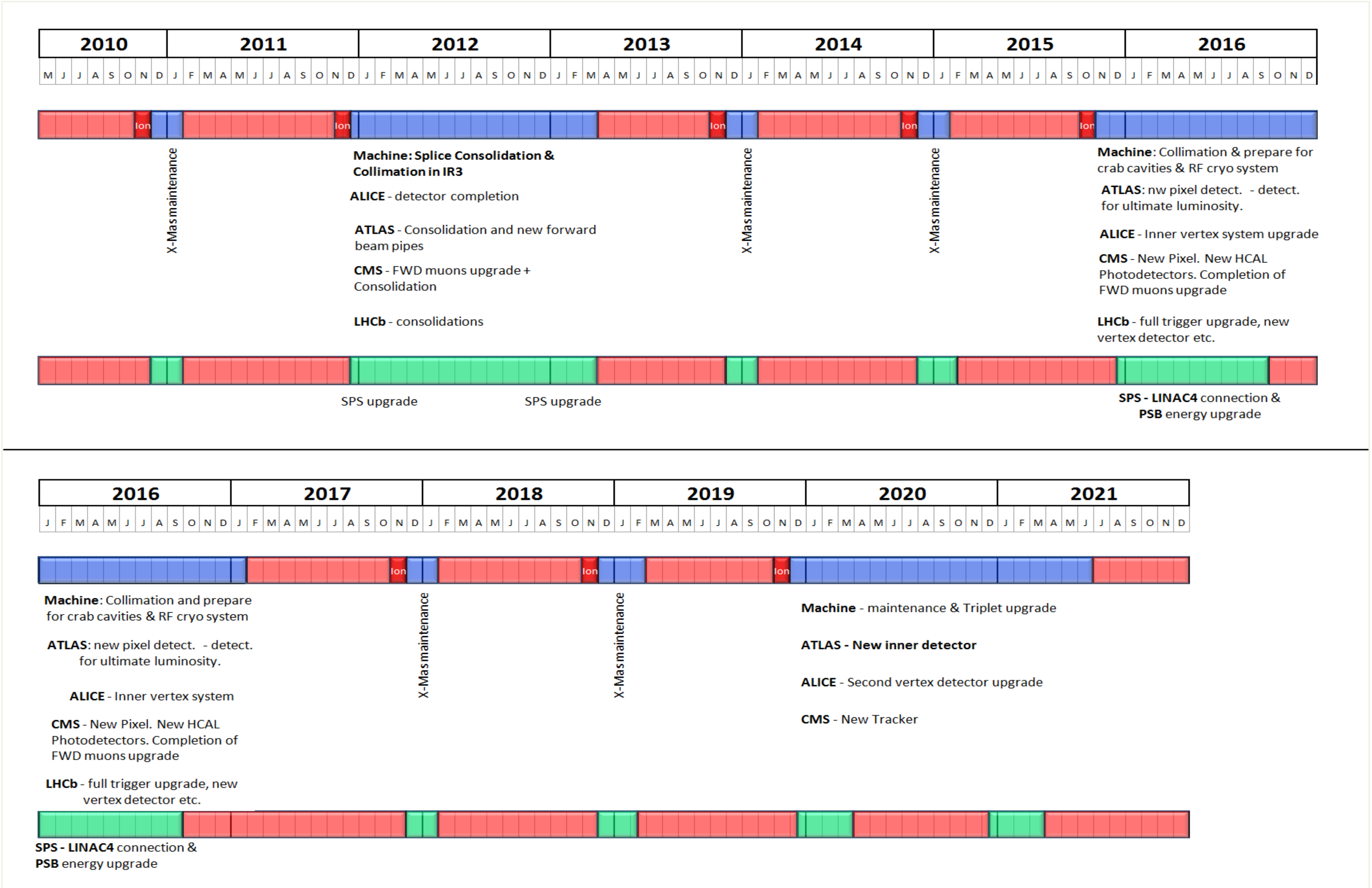
Integrated luminosity of ≥3000fb^{-1} by the end of the LHC life

- requires a peak luminosity of ≥ 5 x10^{34} cm^{-2}s^{-1} during 2021-2030
- → integrated yearly luminosity of around 250-300fb^{-1}

Discovery Potential at LHC 1 fb^{-1} 3.5 TeV (end 2011 or beginning 2012)

- HIGGS competitive with the Tevatron
- Z’: extend by a factor 2 the Tevatron potential
- SUSY from 400 GeV (Tevatron) to 800 GeV exclusions or discoveries
- Extra dimensions, mini black holes (extend by factor 2 the Tevatron limits (or discovery)

The 10 year technical Plan



Preliminary Luminosity Predictions

Year	TeV	OEF	β*	Nb	Ib	Itot	MJ	Peak luminosity	Pile up	pb-1/day	Physics Days	Integrated (fb-1/year)	Total Int (fb-1)
2010	3.50	0.20	2.00	796	8.0E+10	6.4E+13	36.0	1.886E+32	1.2643	3.3	20.0	0.1	0.07
2011	3.50	0.25	2.00	796	8.0E+10	6.4E+13	36.0	1.886E+32	1.2643	4.1	240.0	0.98	1.04
2012												0.0	1.0
2013	6.50	0.20	0.55	796	1.15E+11	9.2E+13	96.1	2.632E+33	17.6429	45.5	180.0	8.2	9.2
2014	7.00	0.20	0.55	1404	1.15E+11	1.6E+14	182.5	5.000E+33	19.0000	86.4	240.0	20.7	30.0
2015	7.00	0.20	0.55	2808	1.15E+11	3.2E+14	365.0	1.000E+34	19.0000	172.8	210.0	36.3	66.3
2016											0.0	0.0	66.3
2017	7.00	0.25	0.55	2808	1.15E+11	3.2E+14	365.0	1.000E+34	19.0000	216.0	240.0	51.8	118.1
2018	7.00	0.28	0.55	2808	1.50E+11	4.2E+14	476.1	1.701E+34	32.3251	411.6	240.0	98.8	216.9
2019	7.00	0.30	0.55	2808	1.70E+11	4.8E+14	539.6	2.185E+34	41.5198	566.4	210.0	118.9	335.8
2020											0.0	0.0	335.8
2021	7.00	0.20	0.30	2808	1.70E+11	4.8E+14	539.6	4.006E+34	76.1197	692.3	150.0	103.8	439.7
2022	7.00	0.27	0.25	2808	1.80E+11	5.1E+14	571.3	5.390E+34	102.4060	1257.3	220.0	276.6	716.3
2023	7.00	0.27	0.25	2808	1.80E+11	5.1E+14	571.3	5.390E+34	102.4060	1257.3	220.0	276.6	992.9
2024	7.00	0.29	0.25	2808	1.80E+11	5.1E+14	571.3	5.390E+34	102.4060	1350.5	220.0	297.1	1290.0
2025	7.00	0.29	0.25	2808	1.80E+11	5.1E+14	571.3	5.390E+34	102.4060	1350.5	220.0	297.1	1587.1
2026	7.00	0.29	0.25	2808	1.80E+11	5.1E+14	571.3	5.390E+34	102.4060	1350.5	220.0	297.1	1884.2
2027	7.00	0.29	0.25	2808	1.80E+11	5.1E+14	571.3	5.390E+34	102.4060	1350.5	220.0	297.1	2181.3
2028	7.00	0.29	0.25	2808	1.80E+11	5.1E+14	571.3	5.390E+34	102.4060	1350.5	220.0	297.1	2478.4
2029	7.00	0.29	0.25	2808	1.80E+11	5.1E+14	571.3	5.390E+34	102.4060	1350.5	220.0	297.1	2775.5
2030	7.00	0.29	0.25	2808	1.80E+11	5.1E+14	571.3	5.390E+34	102.4060	1350.5	220.0	297.1	3072.6

Summary

The 35th ICHEP Conference will be specially remembered as the first at which LHC data were available

→ start of a new era for HEP?
→ major buzz throughout …
→ even French government wanted to be part of it

No new fundamental discoveries to report

→ but with the 2010-11 LHC run going very well, would you bet against something really new at ICHEP'12?