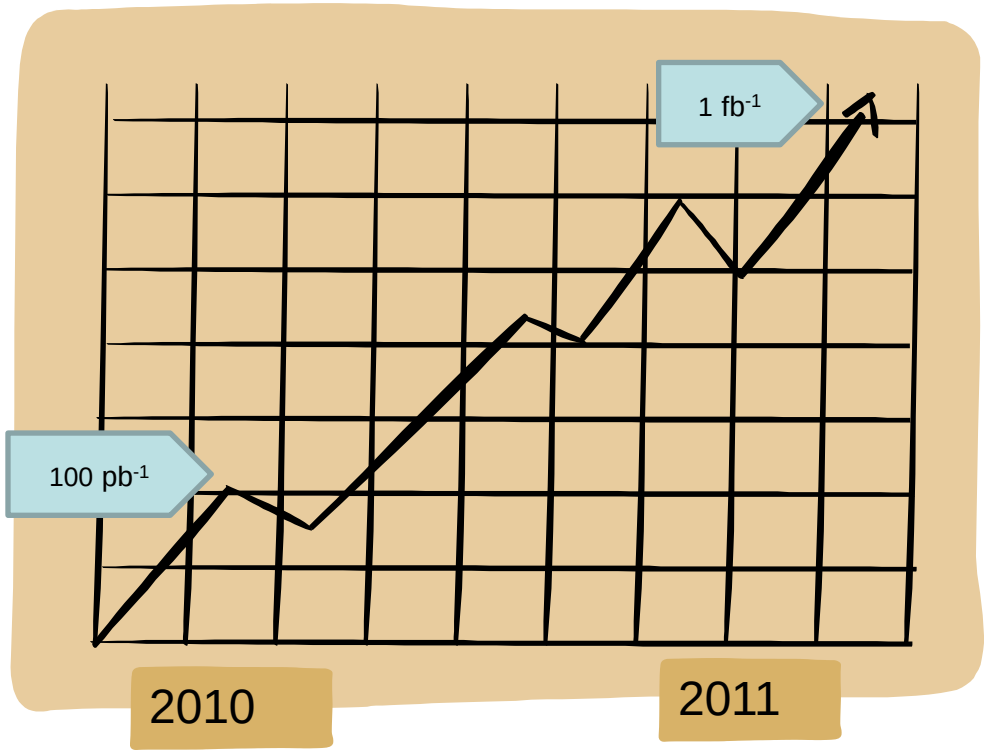
LHC prospects- first run

- The LHC schedule has been defined for the coming years
  - Run 2010/2011 with the aim of integrating 1 fb^{-1}
  - 2012 shutdown for consolidation of LHC (full energy) and detectors
  - ~ Design energy from 2013 on

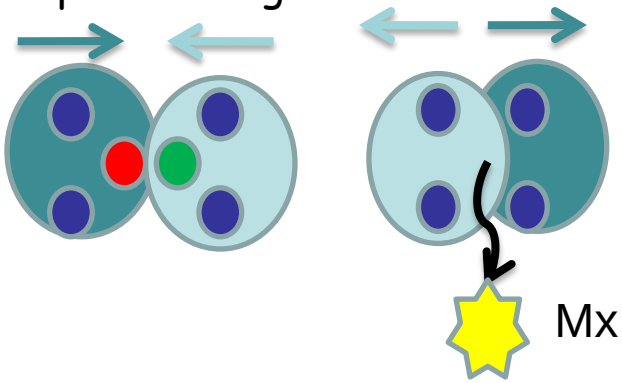
- In the following, I would like to show briefly what one could expect (or not expect) from this initial run.

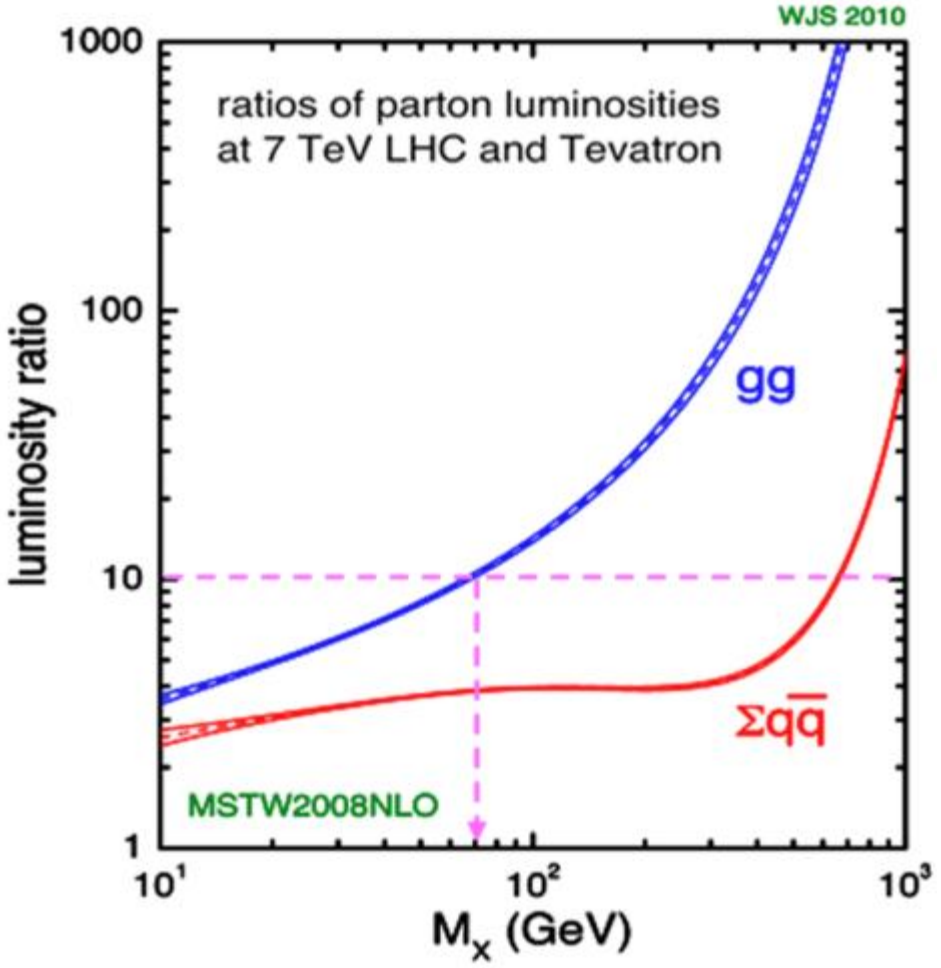
Why is the objective of 1 fb^{-1} so important for experiments ?



The gain from TeVatron to LHC

Can be inferred from parton luminosities to produce a given mass





Mass of produced object

Top: (85% qq, 15% gg at Tevatron)

- Factor: 0.85 x 5 + 0.15 x 100 ~ 20

Z': ~1 TeV (qq)

- Factor: ~ 50 to 100

Higgs: pp → H, H→WW and ZZ

- mainly gg ➔ Factor ~15

Squarks: 2x350 GeV :

- Factor: 0.85 x 10 + 0.15 x 1000 ➔ 150 to 200

1 fb^{-1} at 7 TeV > 10 fb^{-1} at 2 TeV

Courtesy O. Buchmuller

Expectations for top quark in 2010 (1)

The golden channel

- Signature is 2 leptons, 2 jets + missing E_T.

  $t \rightarrow b\ W^+ \rightarrow b\ l^+\ \nu$

  $\mathbf{t} \rightarrow \mathbf{b}\ W^- \rightarrow b\ l^-\ \nu$

- With ~10 pb^{-1}, we expect a convincing signal
  - Each experiment will have ~30 events with an expected background of 5 or 6.
- Even with 5 pb^{-1}, many will find the signal plausible:
  - Each experiment will have ~15 events over a background of around 3.

Expected 10 pb^{-1} sensitivity (per experiment)

Channel	N(Signal)	N(background)
e - μ	14	2.5
$e - e$	4.3	1.1
$\mu - \mu$	6.6	1.9
Total	**25**	**5.5**

This, however, is not the whole story: these aren't just jets – they are *b*-jets. The above table does not make use of this - additional confirmation can be obtained via flavour tagging.

Courtesy T.LeCompte

Expectations for top quark in 2010 (2)

Less golden channel: only 1 lepton

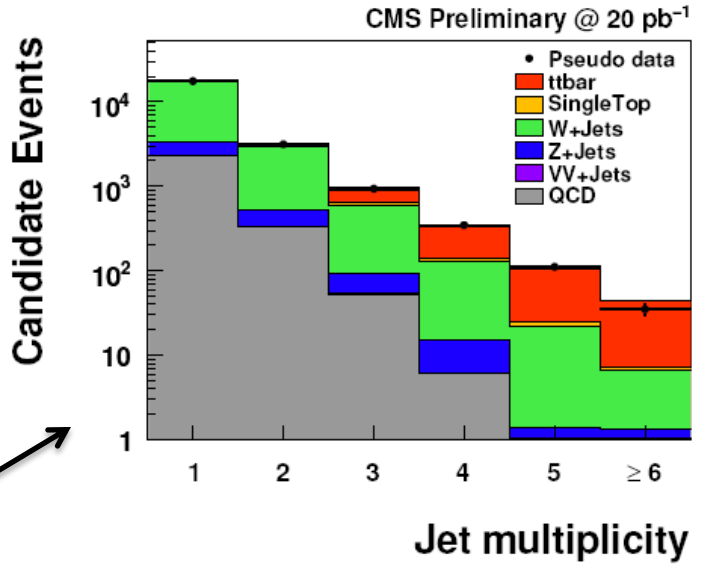
$t \rightarrow b\ W^+ \rightarrow b\ l^+\ \nu$

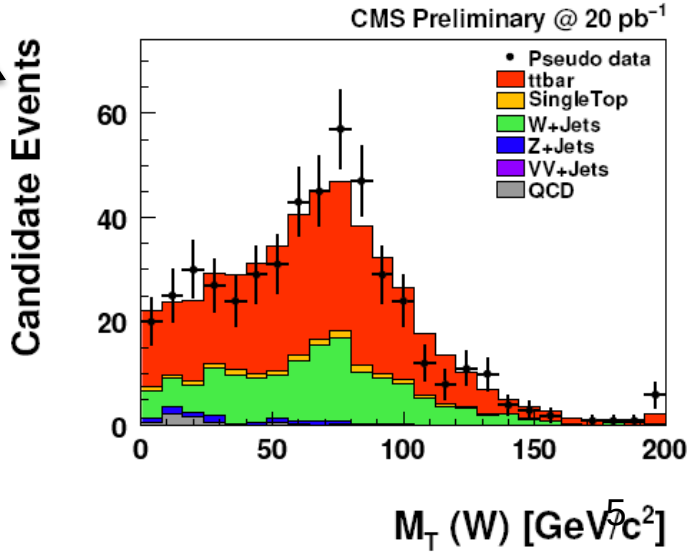
$\mathbf{t} \rightarrow \mathbf{b}\ W^- \rightarrow b\ j\ j$

Here too, a few pb^{-1} gets us to an interesting region

- This N_{jets} plot is for 20 pb^{-1} at 10 TeV; so it looks similar to what we would expect for ~50 pb^{-1} at 7 TeV.
- At 7 TeV and 10 pb^{-1}, we expect ~60 top events per lepton flavour per experiment over a background of ~40 in the 4 jet, 5 jet and 6+ jet bins.

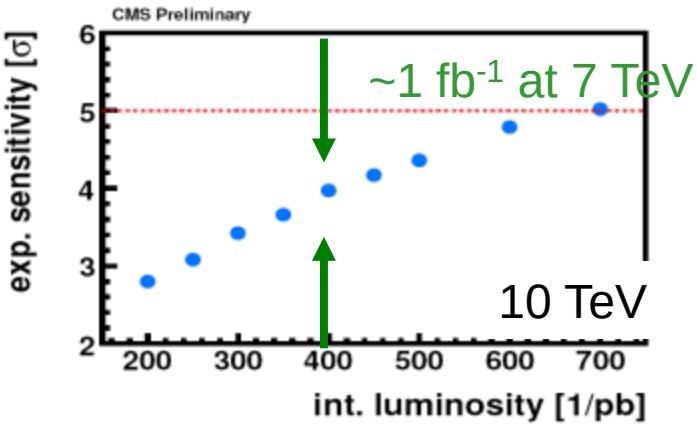
Again, this is done without flavour tagging, which can be used to confirm the top content of the W+multijet sample.



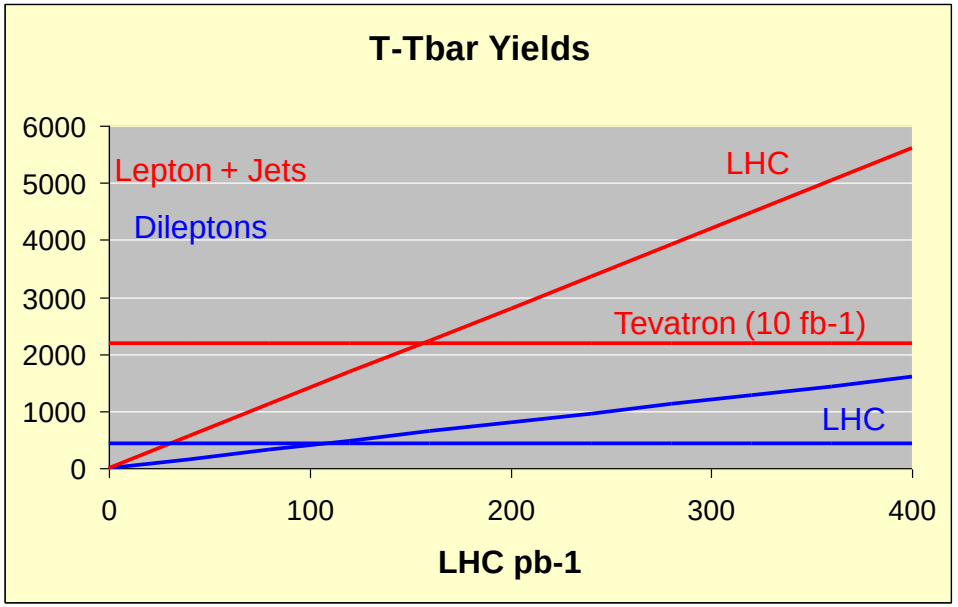


Expectations for top quark in 2011

- By the end of 2011, the top samples will be substantially larger than at TeVatron
- Open possibility to study
  - Top mass
  - Single Top
  - Rare decays



Single top

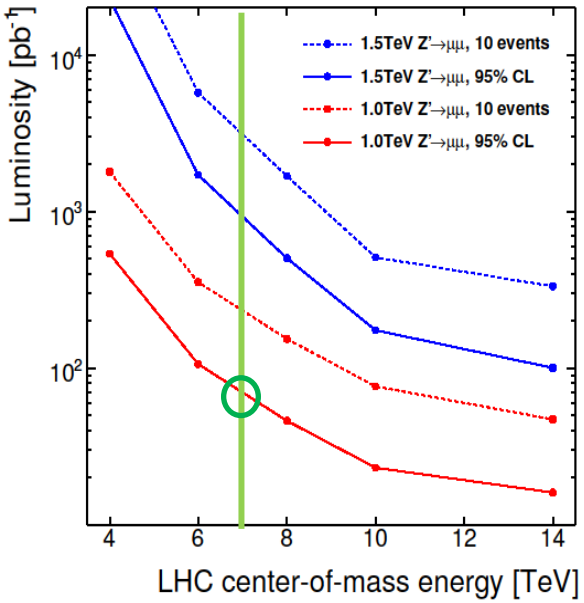


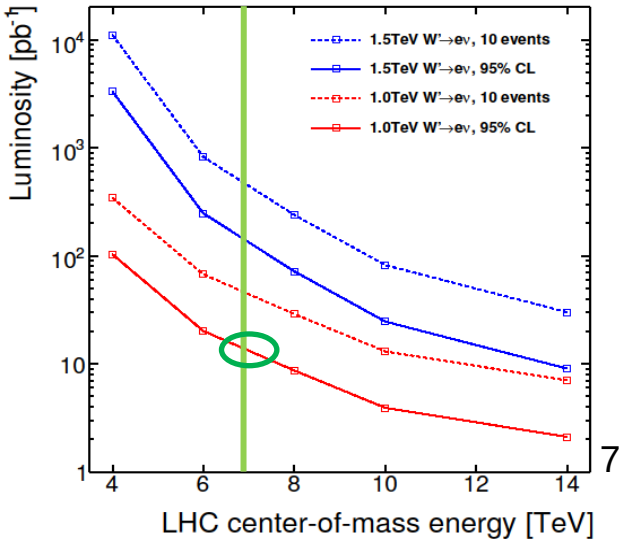
Heavy Z's or W's

•Predicted in many SM extensions
(Extra Dimensions, Technicolor, Little Higgs)
Low, well understood background

•**Z'**
- •Tevatron limit ~1 TeV
- •95% CL exclusion O(50pb^{-1}) at 1 TeV
- •Discovery up to 1.3 TeV at 100 pb^{-1}
- •Discovery up to 1.5 TeV at 1 fb^{-1}

•**W'**
- •Tevatron limit ~1 TeV
- •95% CL exclusion O(10pb^{-1}) at 1 TeV
- •Discovery up to 1.3 TeV at 100 pb^{-1}
- •Discovery up to 1.9 TeV at 1 fb^{-1}



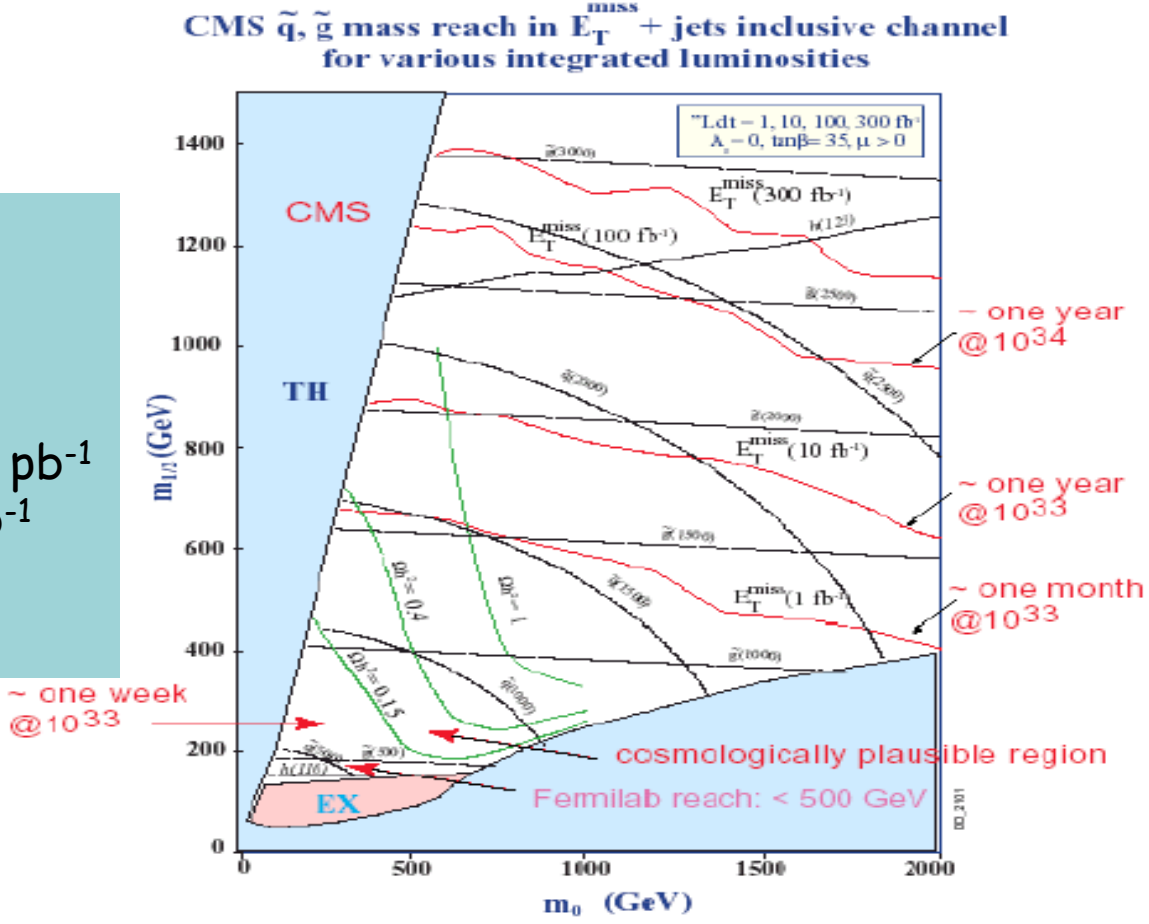


SUSY

Search for squarks and gluinos

Tevatron limit ~ 400 GeV

Discovery up to 400 GeV at 100 pb^{-1}
Discovery up to 800 GeV at 1 fb^{-1}



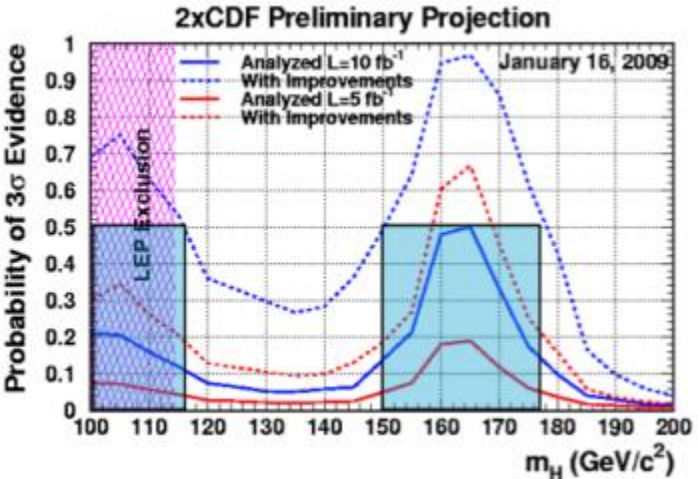
What about the SM Higgs ?

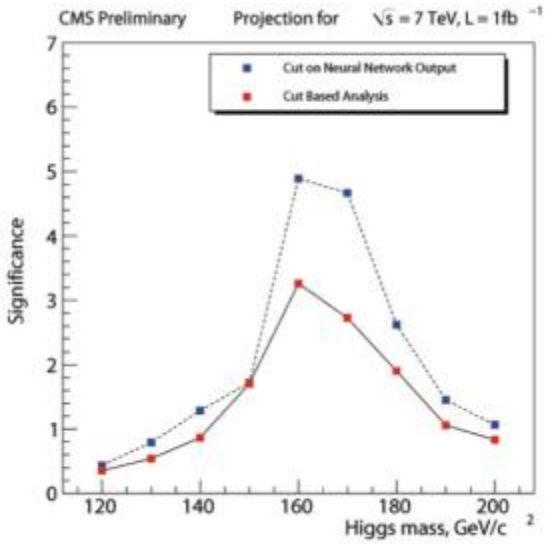
Tevatron today excludes 163-166 GeV/c^2

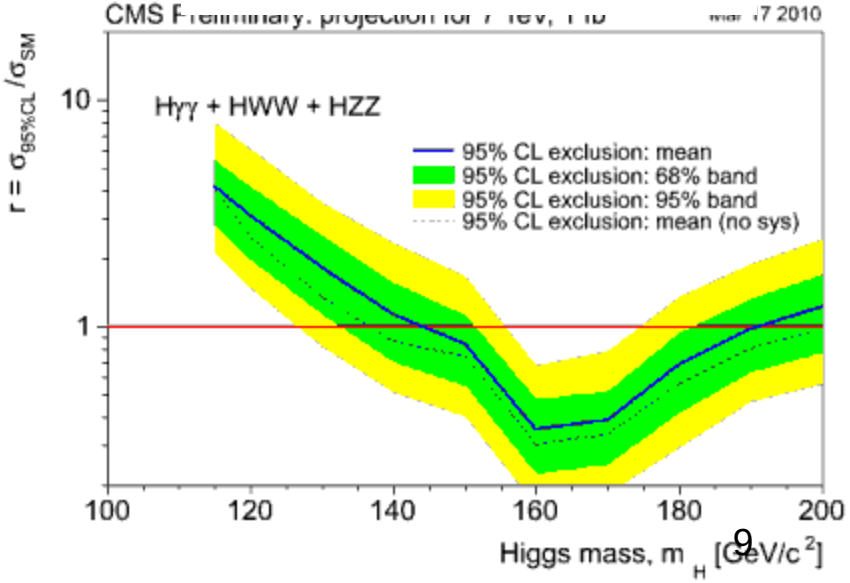
ATLAS + CMS can exclude 140-190 GeV/c^2 with 1 fb^{-1} , taking over from TeVatron above 140 GeV/c^2

Exclusion if the full mass range down to 115 GeV/c^2 requires 1.5 fb^{-1} at 14 TeV

Discovery at 115 GeV/c^2 requires 10 fb^{-1} at 14 TeV: a long way to go if the Higgs is just above LEP limit.

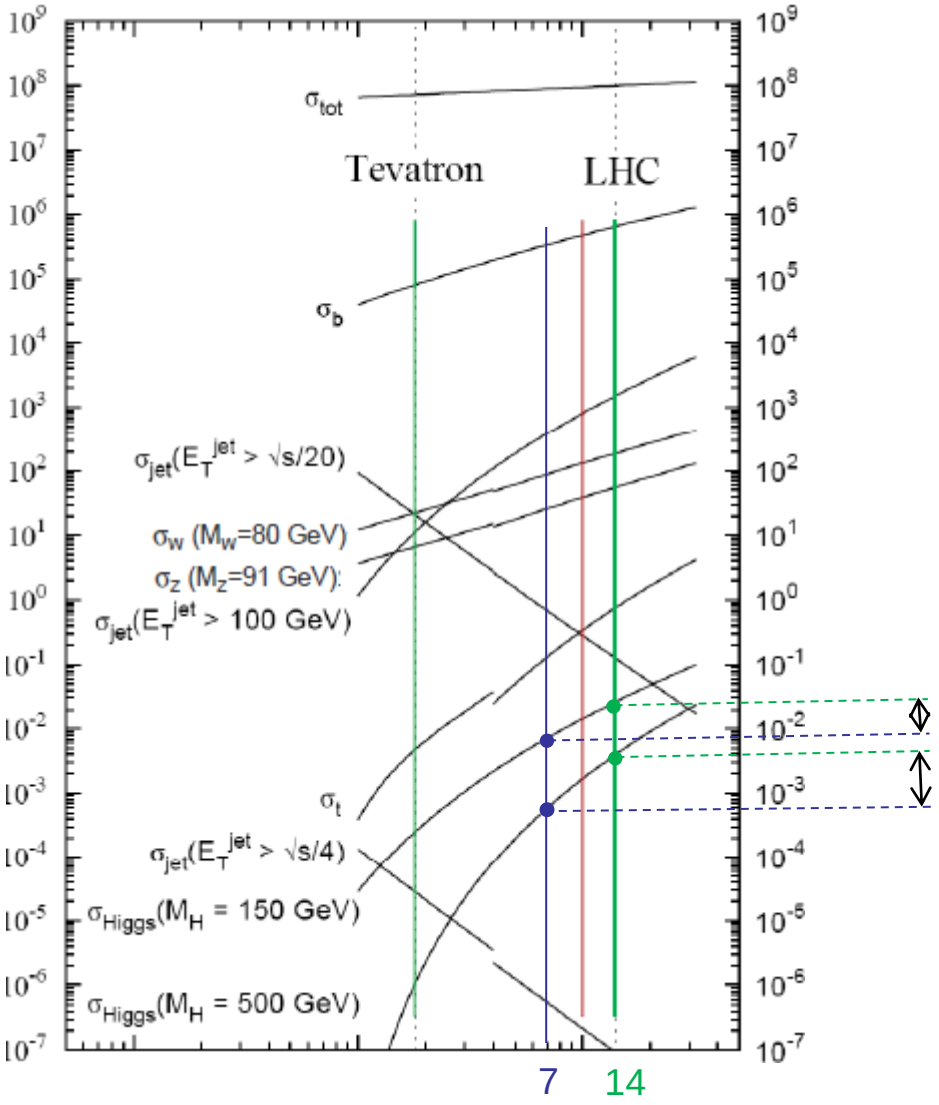






Exclusion: One experiment only

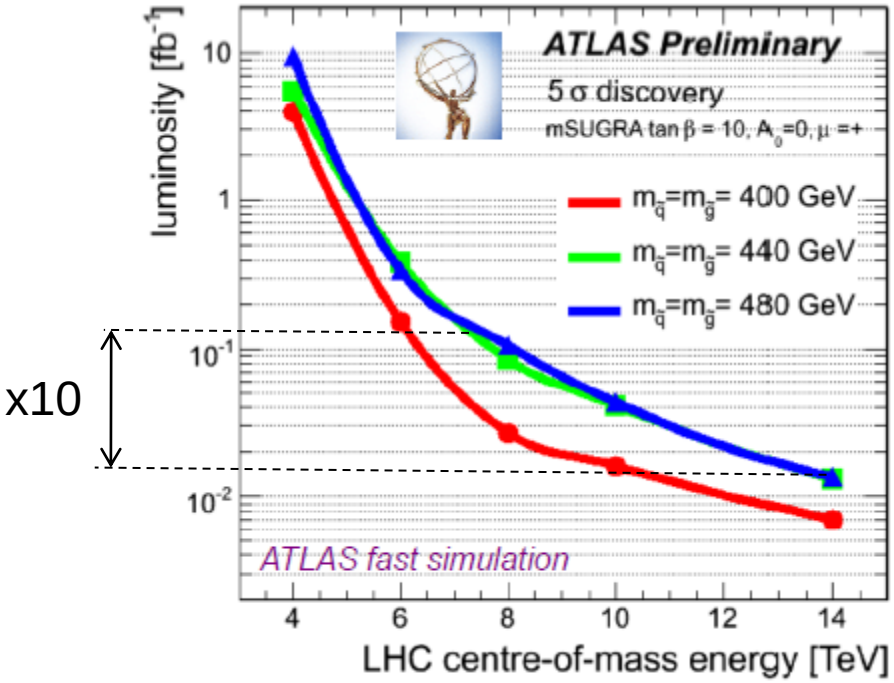
Importance of energy for Higgs search



Factor x4 at M_H=150 GeV

Factor x8 at M_H=500 GeV

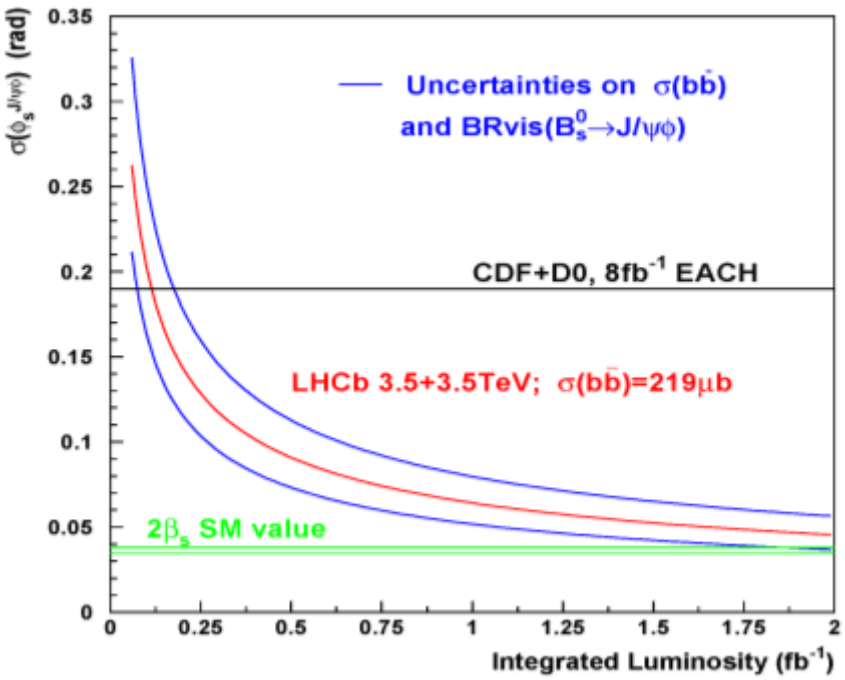
and for SUSY !



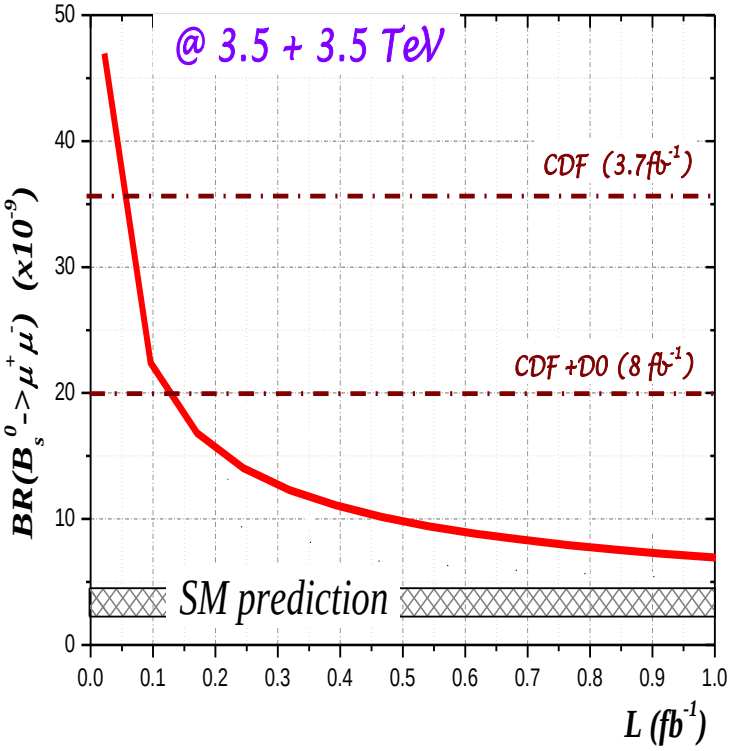
M.Ferro-Luzzi Chamonix 09

The physics potential of LHCb is not much affected by the reduced energy . Already much is possible with few 100 pb^{-1} !

$B_s \rightarrow J/\psi\Phi$



$B_s \rightarrow \mu\mu$



See talk of G. Wilkinson at LHCC May 2010

Heavy Ions

- Better conditions to study the QGP than at RHIC
  - 15 times higher $\sqrt{s}$
  - Higher energy density (x 3-10)
  - Initial temperature ~ 3 T_c
  - Larger QGP volume longer lifetime (x 3-5)
- Low luminosity Heavy Ion Runs will
  - Establish global event characteristics
  - Bulk properties (thermodynamics, hydrodynamics, …)
  - Start of hard probe measurements

See talk of A.Morsch at LHCC in May 2010

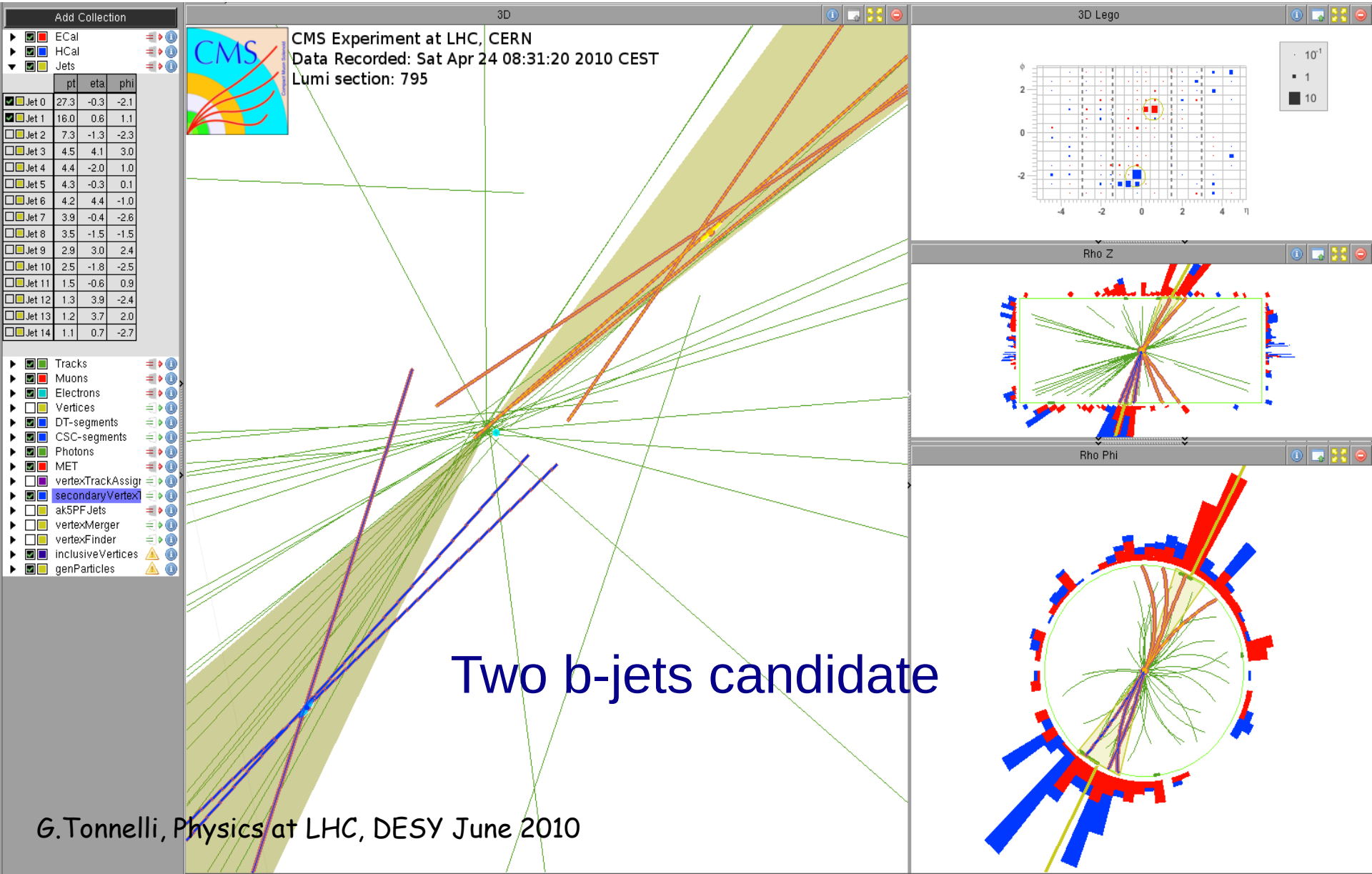
All these extrapolations assume good performance from the detectors

- B tagging
- Missing energy for ν detection
- Good lepton identification with muons spectrometer and electromagnetic calorimeter
- Jets reconstruction
- Calibrations

Are the experiments ready ??

Yes, they are !

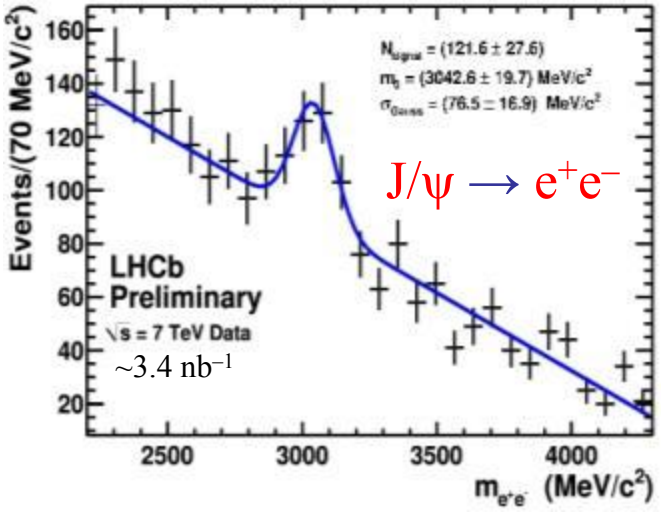
B tagging with secondary vertex

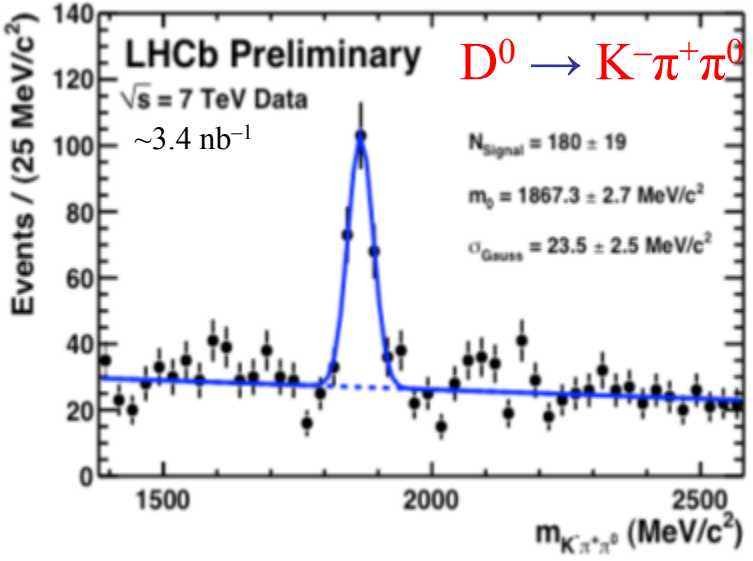


Two b-jets candidate

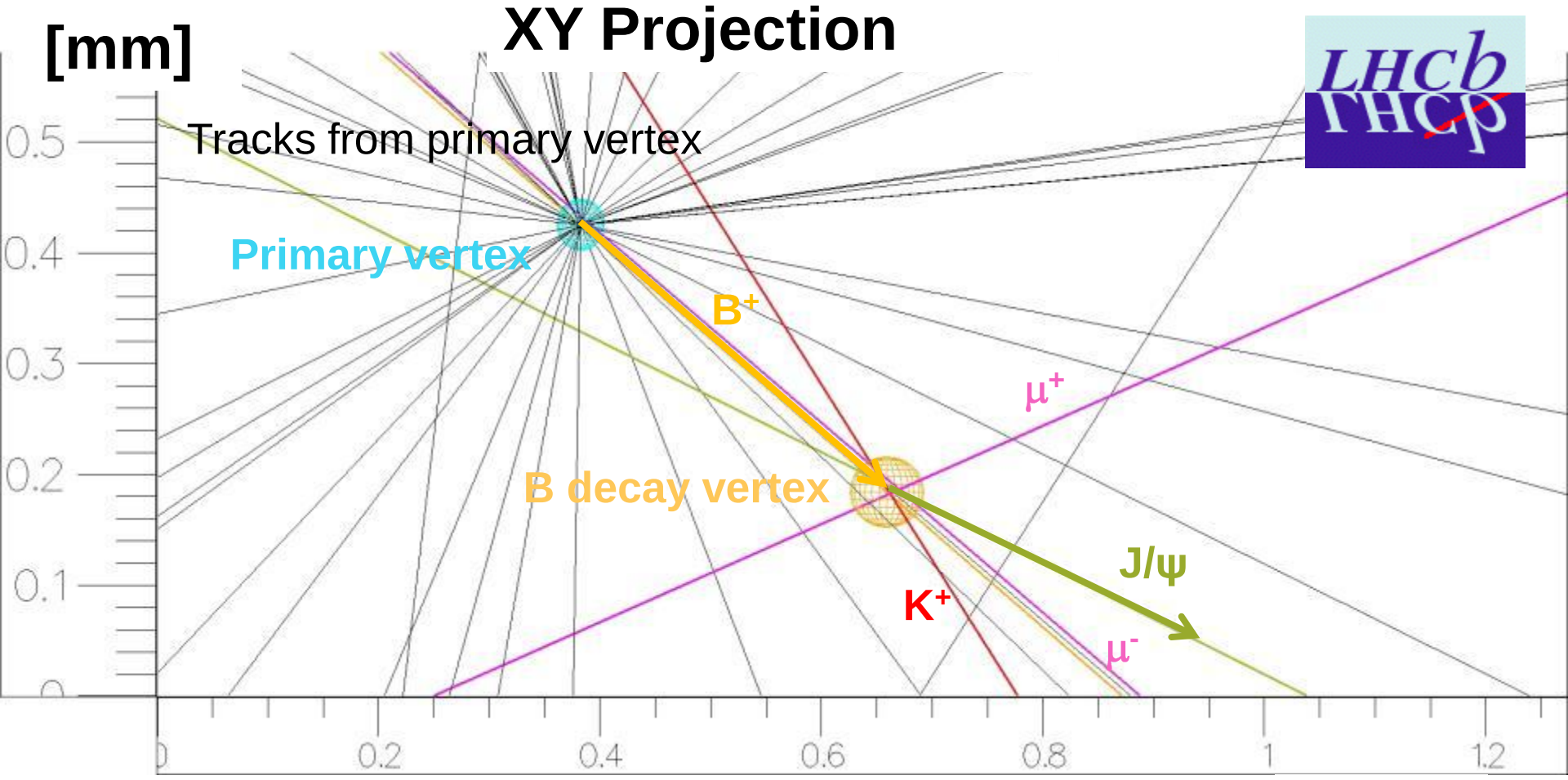
Charm decays in LHCb

$D^0 \to K^-\pi^+$, K^-K^+, $\pi^-\pi^+$
$D^0 \to K^-\pi^+\pi^0$, $K^-\rho^+$
$D^0 \to K^-\pi^+\pi^+\pi^-$
$D^+ \to K^-\pi^+\pi^+$, $K^-K^+\pi^+$, $K_S\pi^+$
$D^{*+} \to D^0\pi^+$
$D_s \to K^-K^+\pi^+$
$\Lambda_c \to p\, K^-\pi^+$
$J/\psi \to \mu^+\mu^-$, e^+e^-
$\psi(2S) \to \mu^+\mu^-$
$B^{0/+} \to D^{+/0}\pi^{-/+}$





and B decays



talk of G. Wilkinson at LHCC May 2010

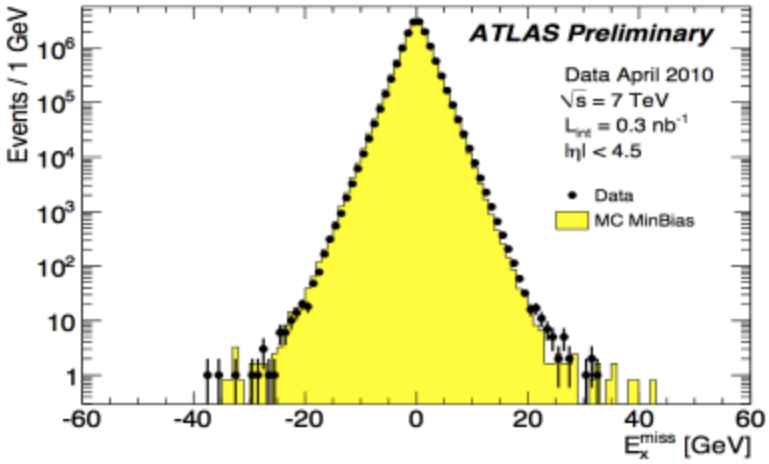
Performance of missing transverse energy

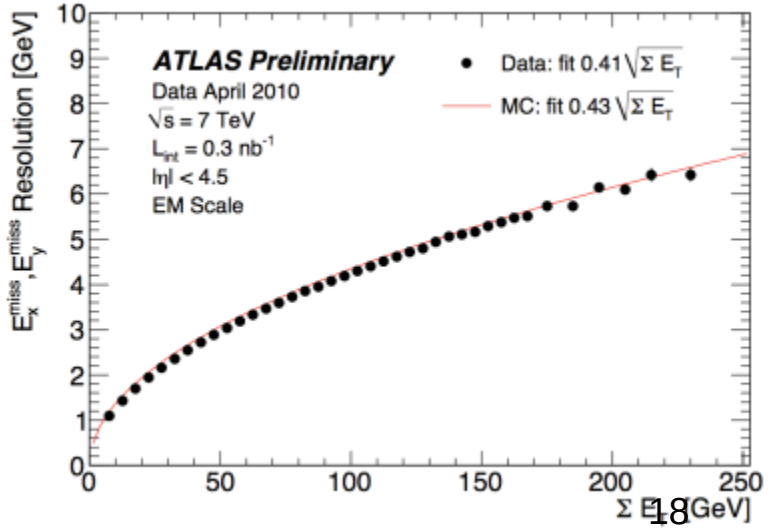
Understanding of high ETmiss tails is crucial for NP

Hopefully very low rate of new physics events sitting in these tails

Excellent agreement between data and MC at this early stage

More advanced computation of ETmiss including electrons, muons, taus, jets and their proper calibration under way



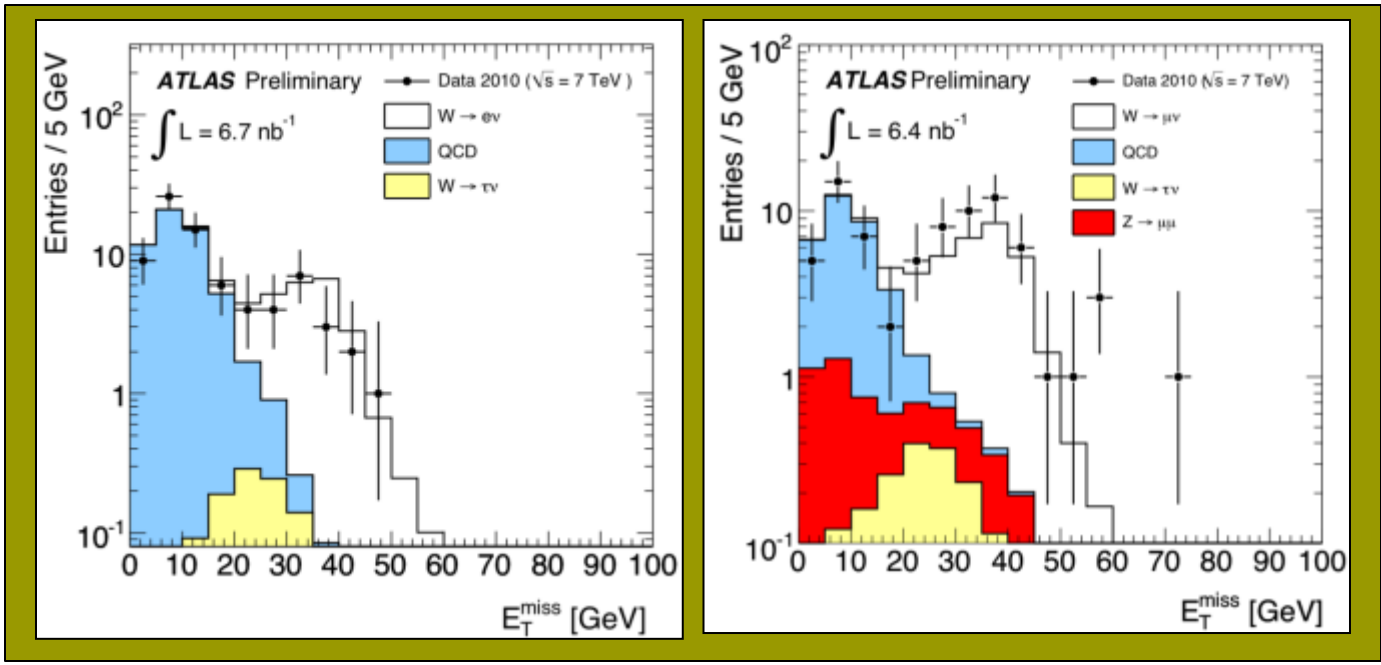


…which allows to find W's

After all cuts but E_T^{miss} and m_T

Observed events: 57

MC: normalised to data (total number of events)

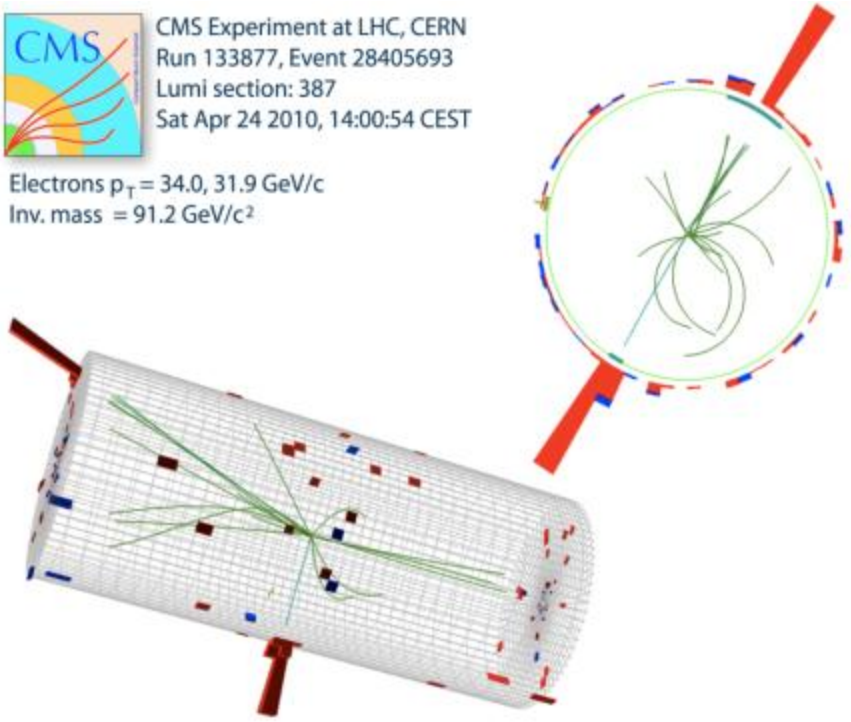


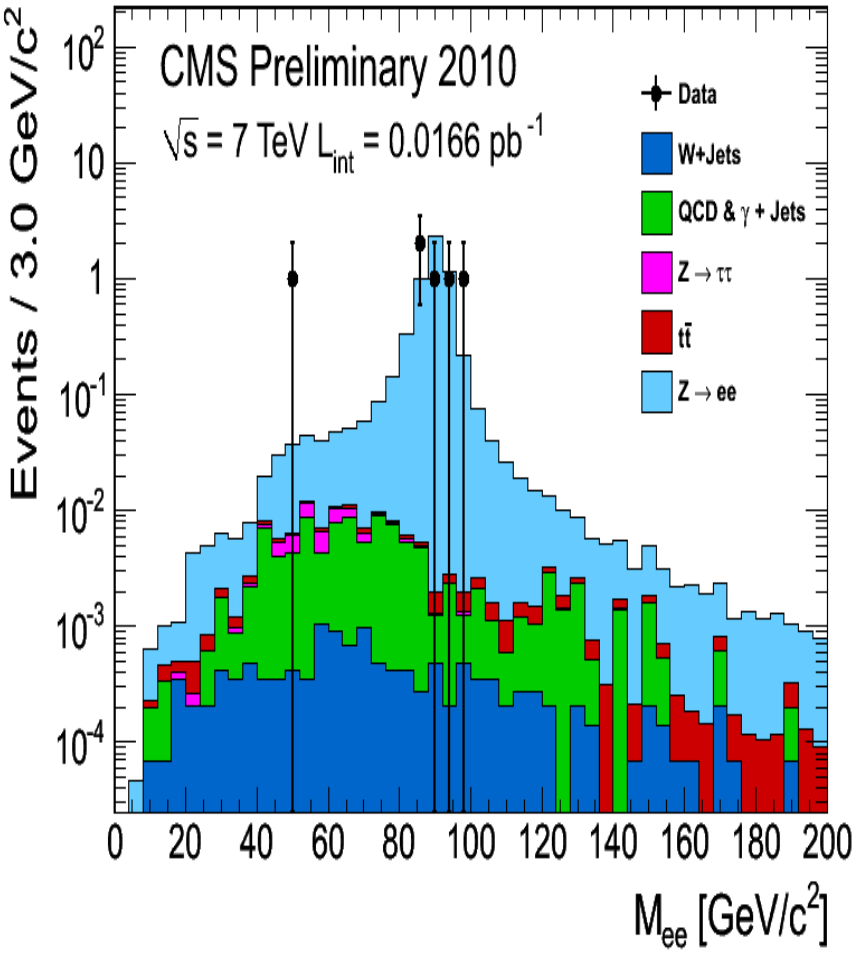
F.Gianotti, Physics at LHC, DESY June 2010

Z decays

Event selection: *both electrons with a SuperCluster with Et > 20 GeV*

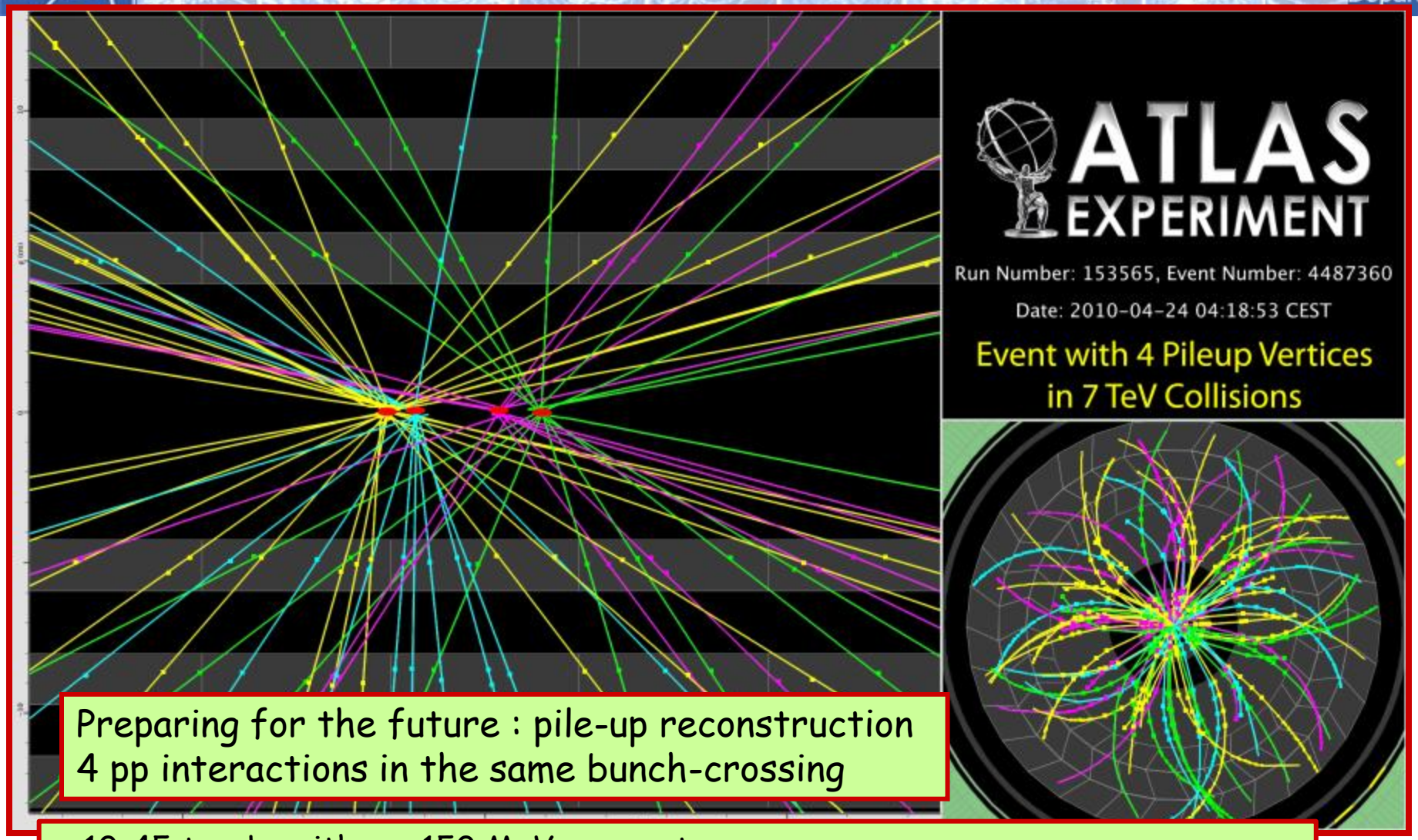
Monte Carlo : *cross section normalized to 17 nb^{-1} integrated luminosity*





5 $Z \rightarrow e^+e^-$ candidates

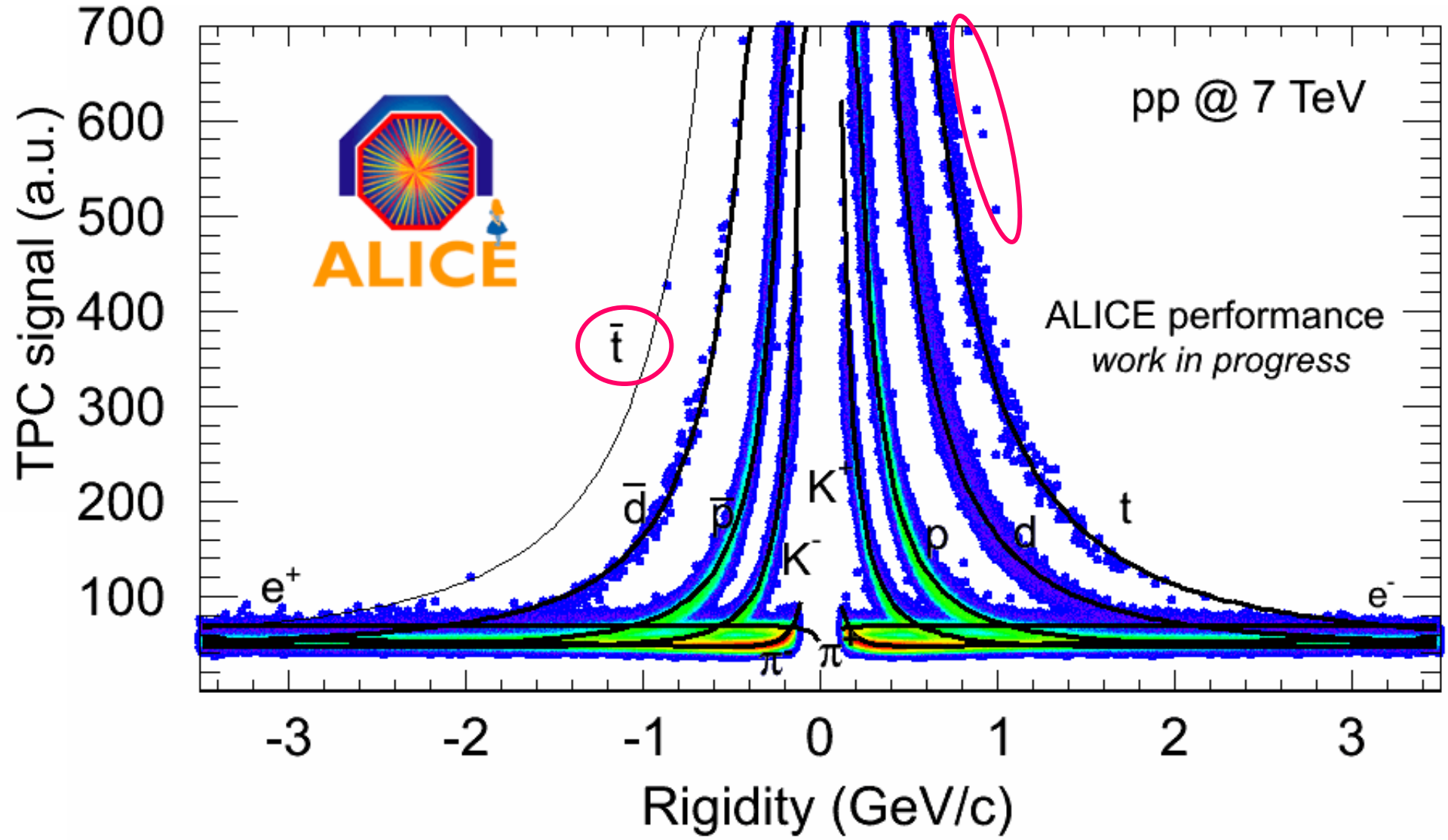
Multiple vertices reconstruction !



Preparing for the future : pile-up reconstruction
4 pp interactions in the same bunch-crossing

~ 10-45 tracks with p_T >150 MeV per vertex
Vertex z-positions : −3.2, −2.3, 0.5, 1.9 cm (vertex resolution better than ~200 μm)
Expect handful of 4-vertex events in this run

(Anti)Nuclei


TPC signal (a.u.)
700
600
500
400
300
200
100
-3
-2
-1
0
1
2
3
Rigidity (GeV/c)
ALICE
pp @ 7 TeV
ALICE performance
work in progress
$\bar{t}$
$\bar{d}$
$\bar{p}$
K^+
K^-
π^+
π^-
p
d
t
e^+
e^-

Upgrades

Nevertheless detectors

- require consolidation in 2011-2012, in particular in the area of cooling, ventilation, electrical engineering, UPS, control + maintenance area
- may proceed relatively soon (eg. ~2015+) to first upgrades to improve performance and make optimal use of the LHC
  - Pixel layers closer to beam pipe (ATLAS, CMS)
  - Full coverage of muon in the forward (ATLAS, CMS)
  - Faster readout/trigger to use increased Lumi (LHCb)
  - Better PID , faster TPC readout (ALICE)
  - More Roman pots stations (TOTEM)

Conclusions

- The near future is very promising and should allow CERN to take over the leadership on the energy frontier. We may even be lucky and find New Physics !

- The energy (and luminosity) increase beyond 2012 is mandatory for exploring rare sectors.

- We do not know what we will find but it is clear that on the long term we will need the highest possible LHC luminosity
  - To improve statistics and disentangle models by precision measurements
  - To extend our search limits

- Any improvement in the detectors performance is also useful and complements luminosity increase