Standard Model at LHC:
what we would like to learn form the first runs (2007-08)

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benefitted from talks on a similar subject by :

A. De Roeck,
G. Dissertori,
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P. Nason,
G. Rolandi

current LHC schedule

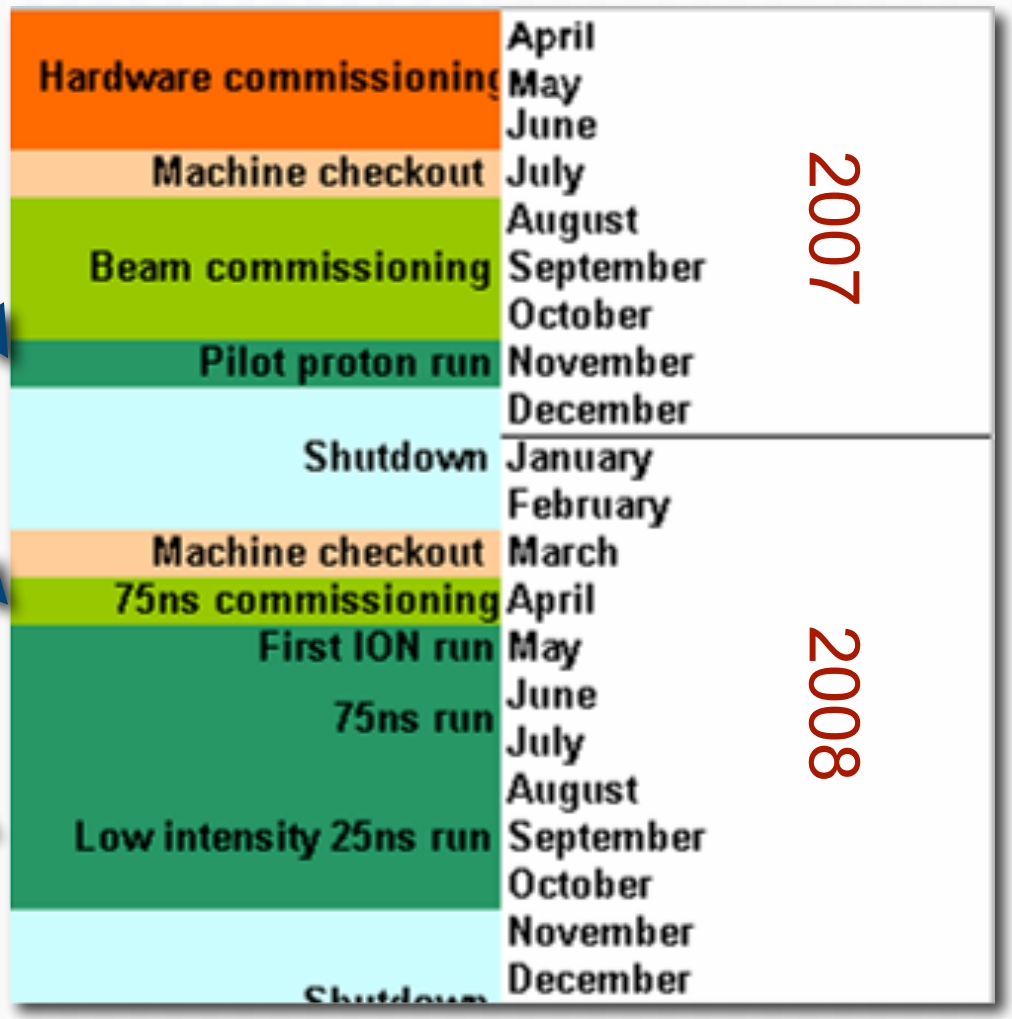
"*nominal luminosity*" :
2808 bunches (25 ns spacing), N=1.15 x 10^{11}/ bunch,
full *squeeze* at I.P. ($\Rightarrow L \sim 10^{34}\ cm^{-2}s^{-1}$)

Stage 1
Initial commissioning
43x43 to 156x156, N=3x10^{10}
Zero to partial squeeze
L=3x10^{28} - 2x10^{31}
(up to ~15 pb^{-1})

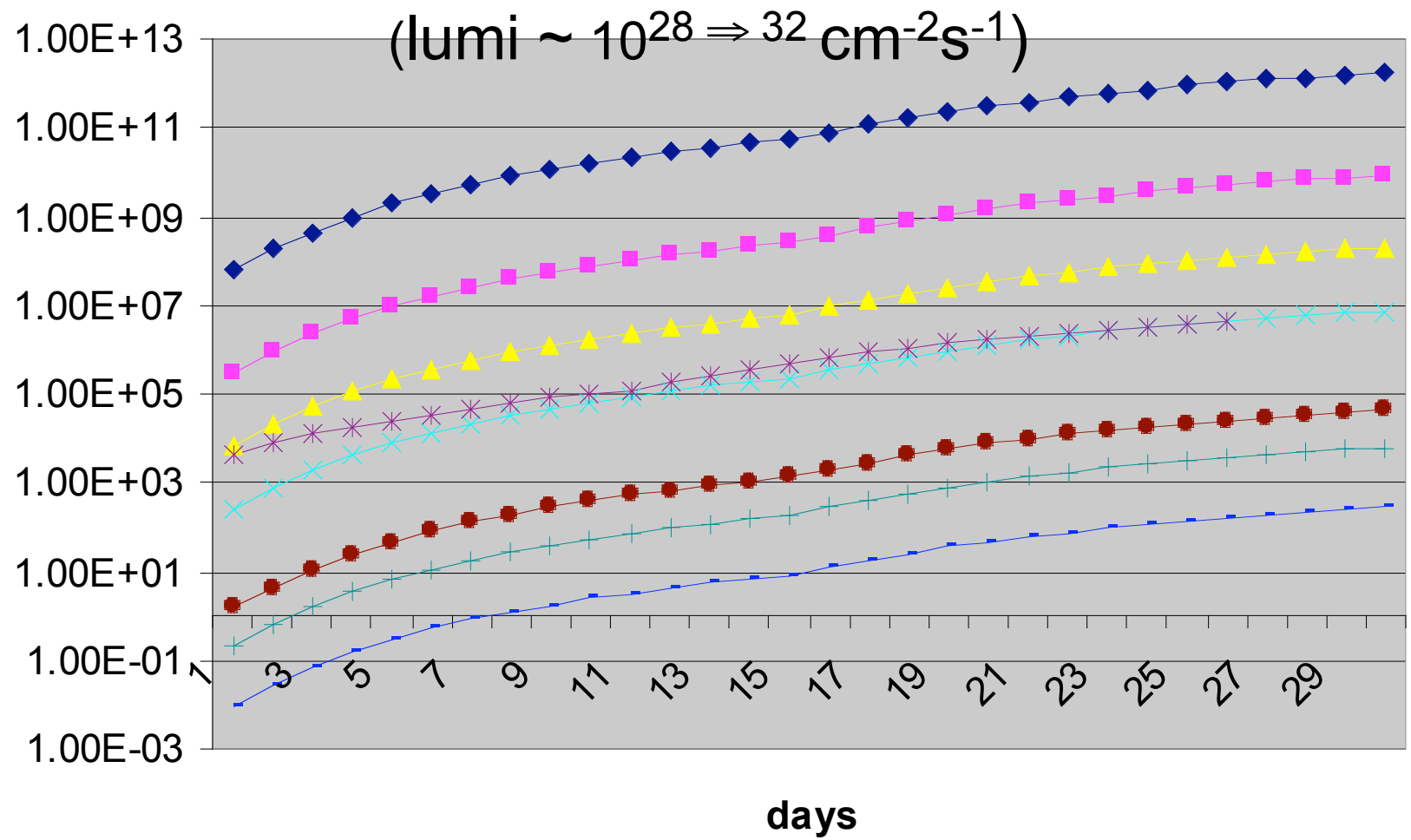
Stage 2
75 ns operation
936x936, N=3-4x10^{10}
partial squeeze
L=10^{32} - 4x10^{32}

Stage 3
25 ns operation
2808x2808, N=3-5x10^{10}
partial to near full squeeze
L=7x10^{32} - 2x10^{33}
(up to ~1 fb^{-1})

Stage 4
25 ns operation
Push to nominal per bunch
partial to full squeeze
L=10^{34}



Events produced Pilot Run



A few million di-jet events with E_T > 15 GeV within few hours !

Pilot run is max 30 days (up to~15 pb^{-1})

mainly for machine and detector commissioning !

ECAL&HCAL calibration
Tracker&Muon alignment
efficient trigger operation

data taking will be only for *a small fraction* of the time

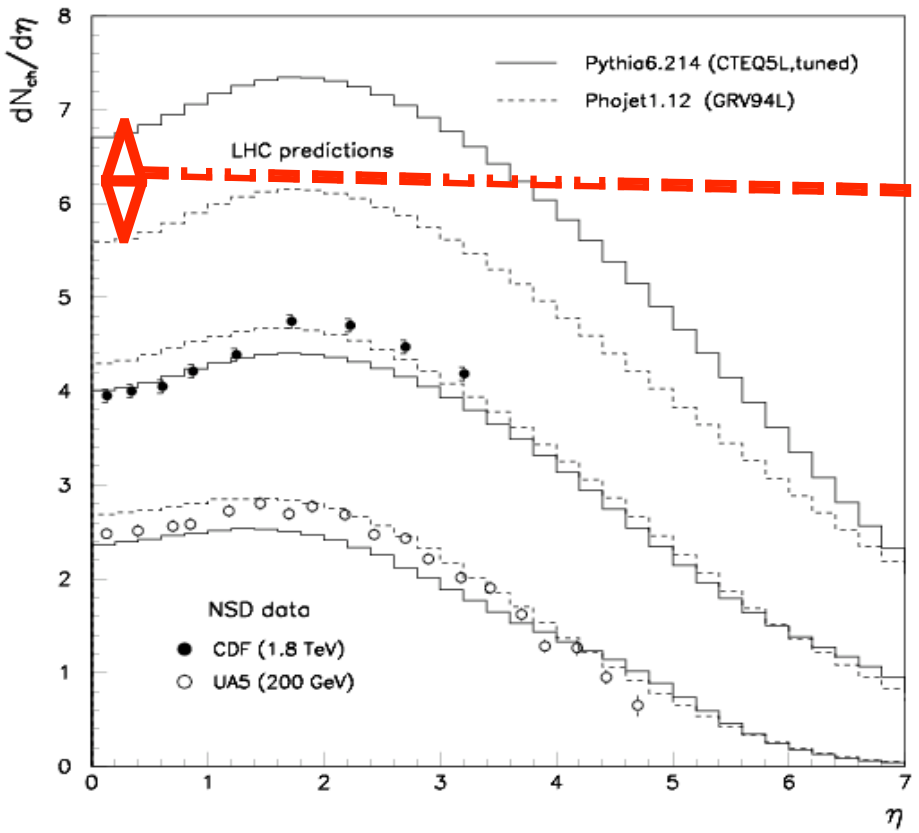
assumed efficiencies :

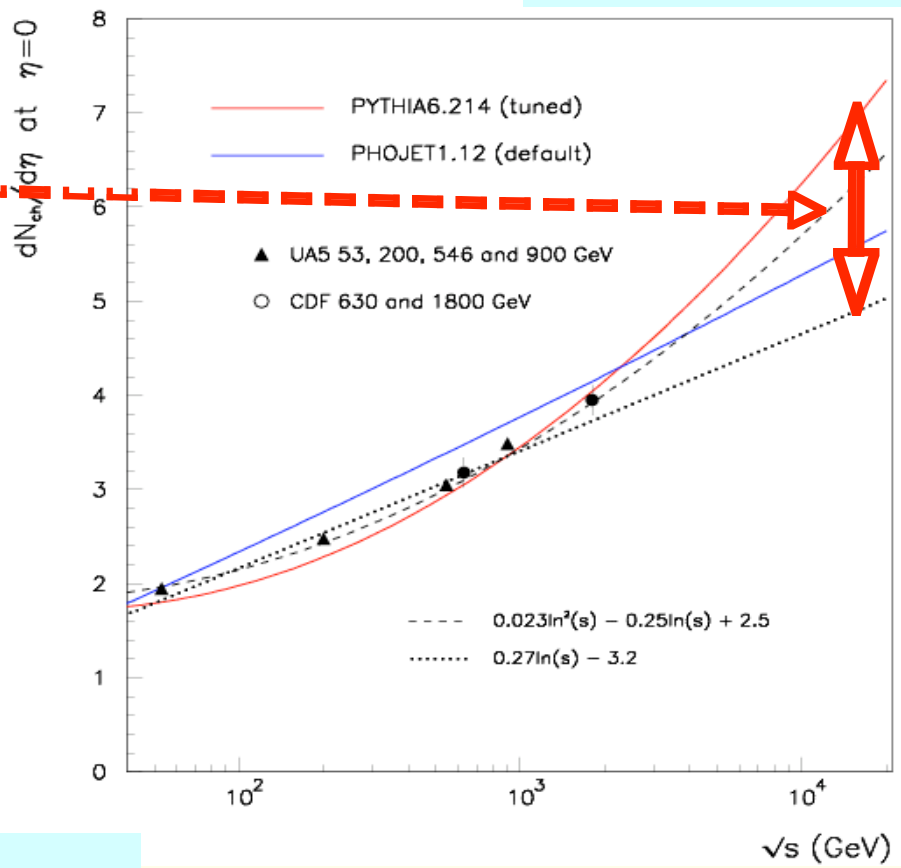
ε(jets)	= 100%
ε(W)	= 20%
ε(Z)	= 20%
ε(ttbar)	= 1.5%

Early Minimum-Bias Measurements

E.g. charged particle density

The pile-up for the future





LHC?

- Energy dependence of dN/dη ?
- Vital for tuning Underlying Event model
- Only requires a few thousand events.

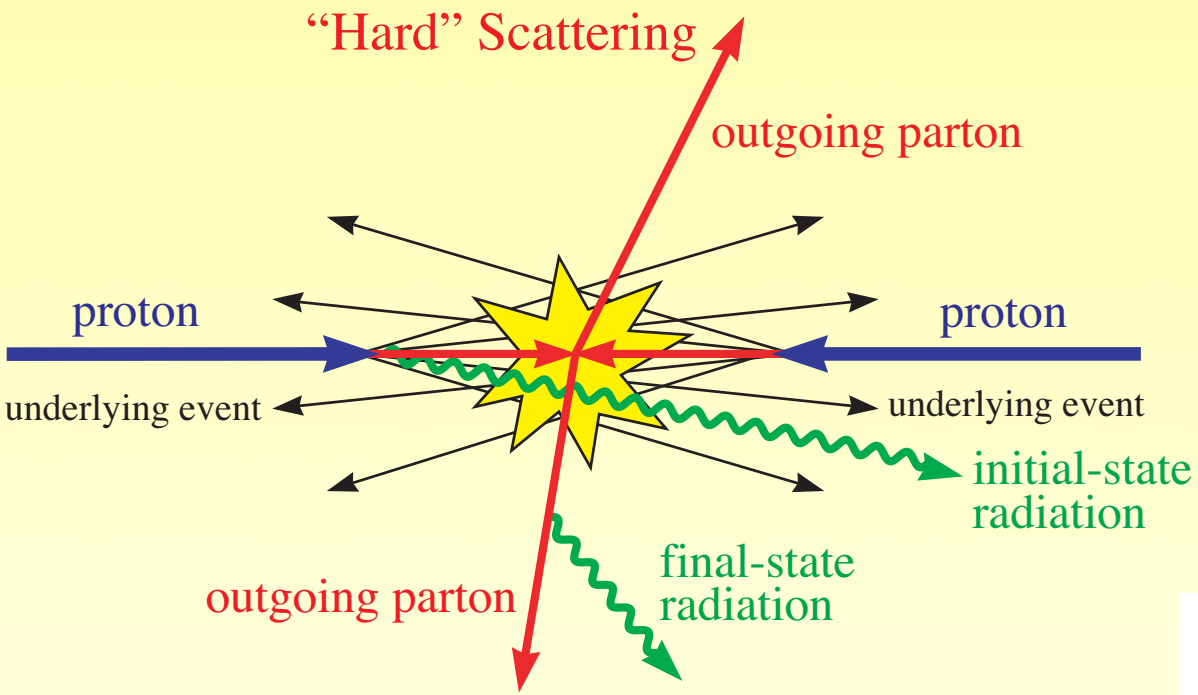
- **PYTHIA models favour $\ln^2(s)$;**
- **PHOJET suggests a $\ln(s)$ dependence.**

12% have pT(hard)>10 GeV (1% at Tevatron)

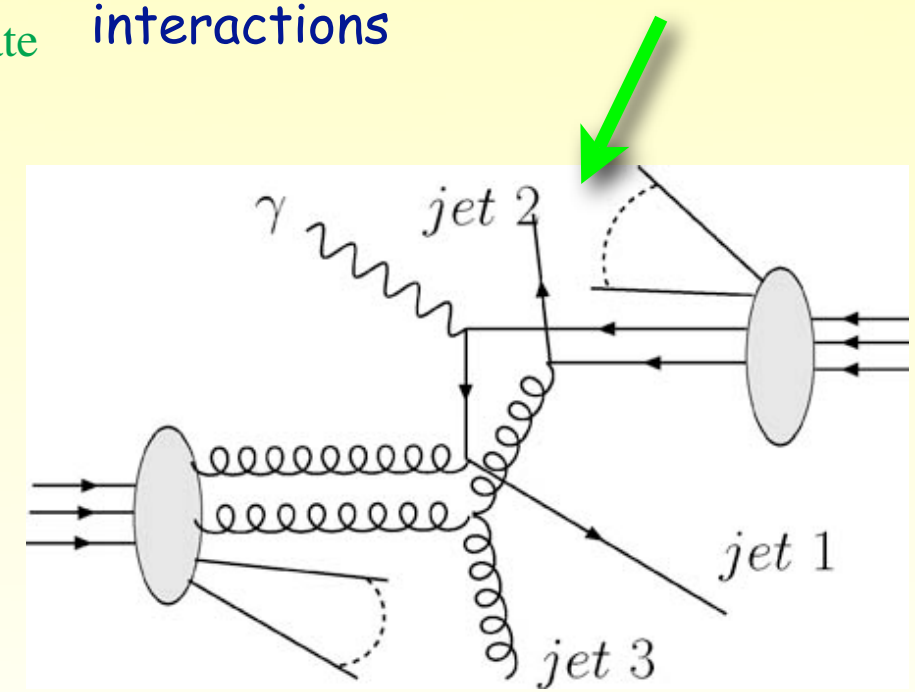
Expected average pT=0.7 GeV

The Underlying Event (UE)

No real theory : need exp input !



Being studied in great detail at the Tevatron !
Evidence that UE is the result of multiple semi-hard (mini-jet) interactions

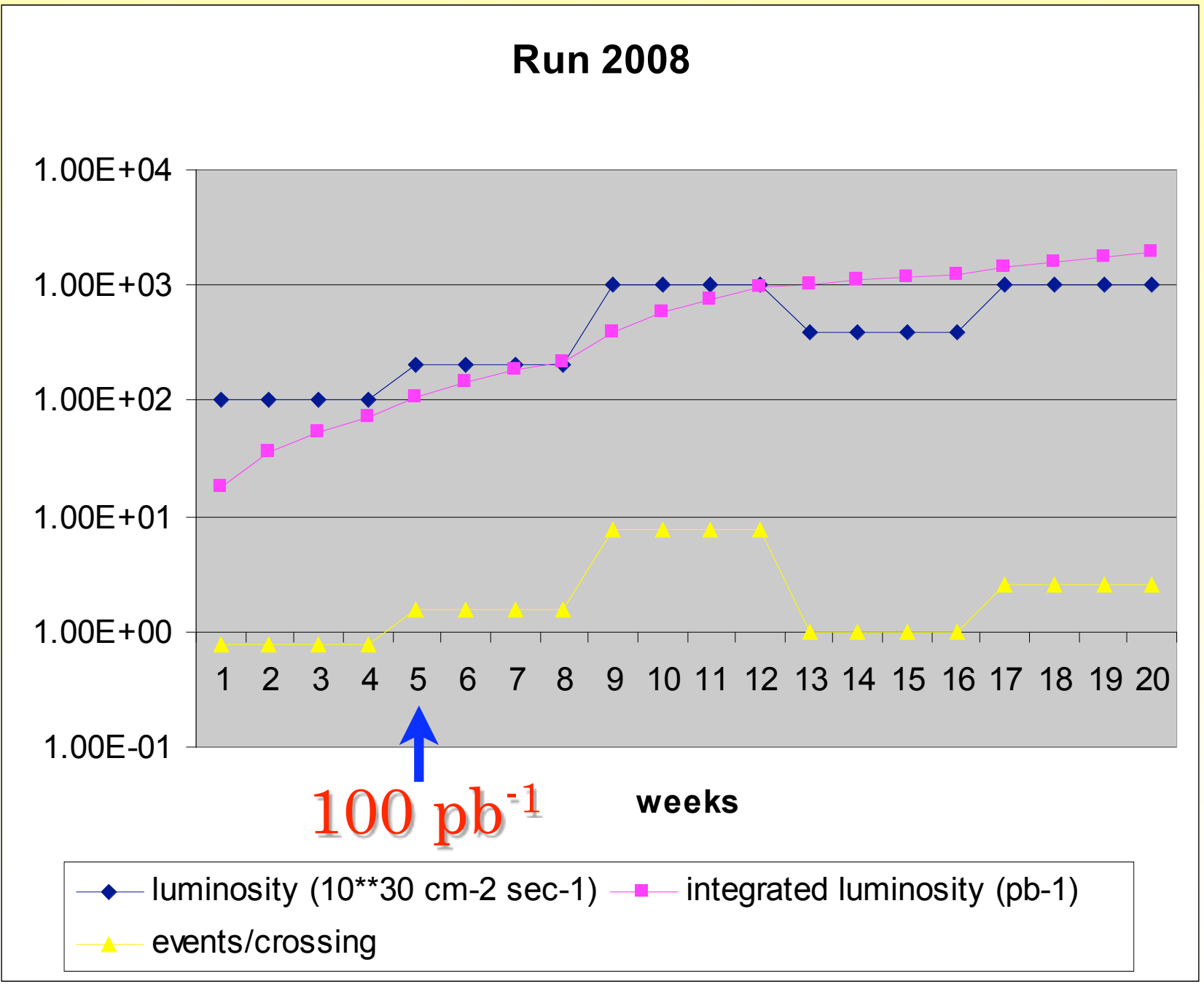


- modeling (learn from min. bias)

- tune MCs (eg. Pythia) asap

- how to subtract/merge it from/to hard scattering process ???

First 'Physics' run in 2008 !



1.9 fb^{-1}

cf. Tevatron :
~ 1 fb^{-1} today !

SM expectations :

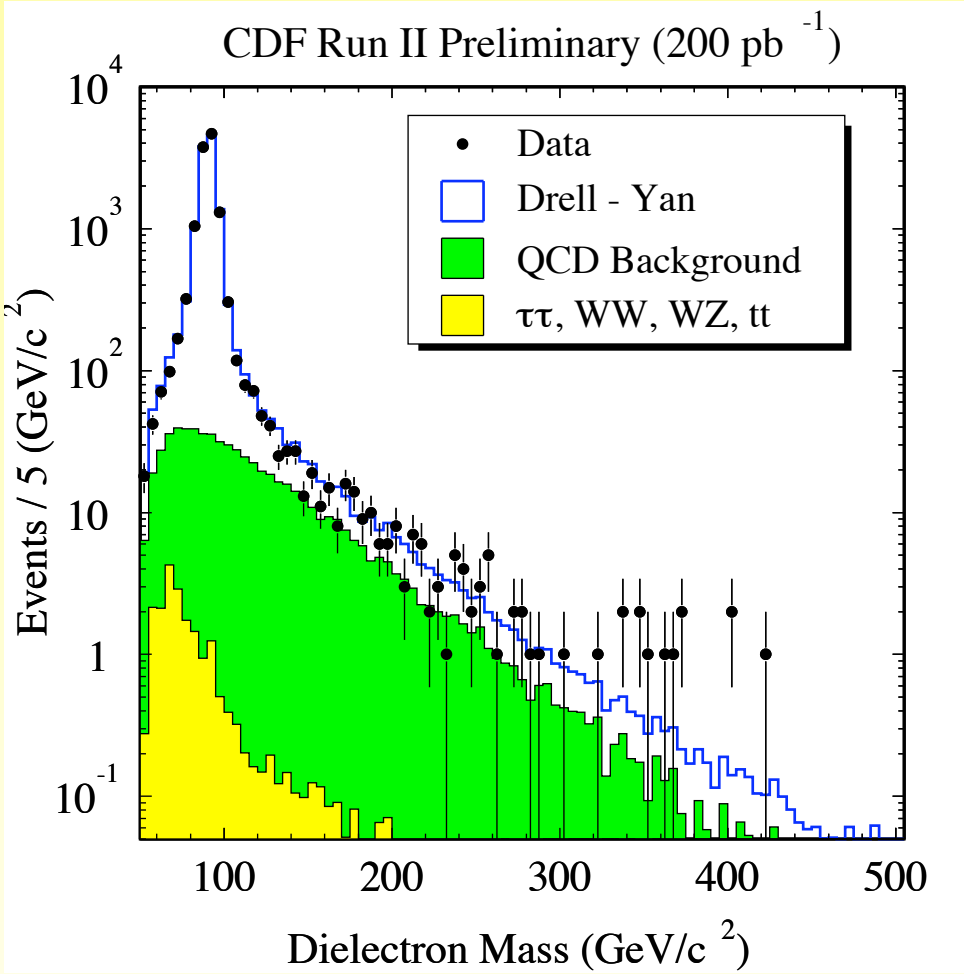
1 fb^{-1} (per exp)	Events on tape
$W \rightarrow \mu \nu$	7×10^6
$Z \rightarrow \mu \mu$	1.1×10^6
$tt \rightarrow W\ b\ W\ b \rightarrow \mu \nu + X$	8×10^4
QCD jets $p_T > 150$	$\sim 10^6$
Minimum bias	$\sim 10^6$

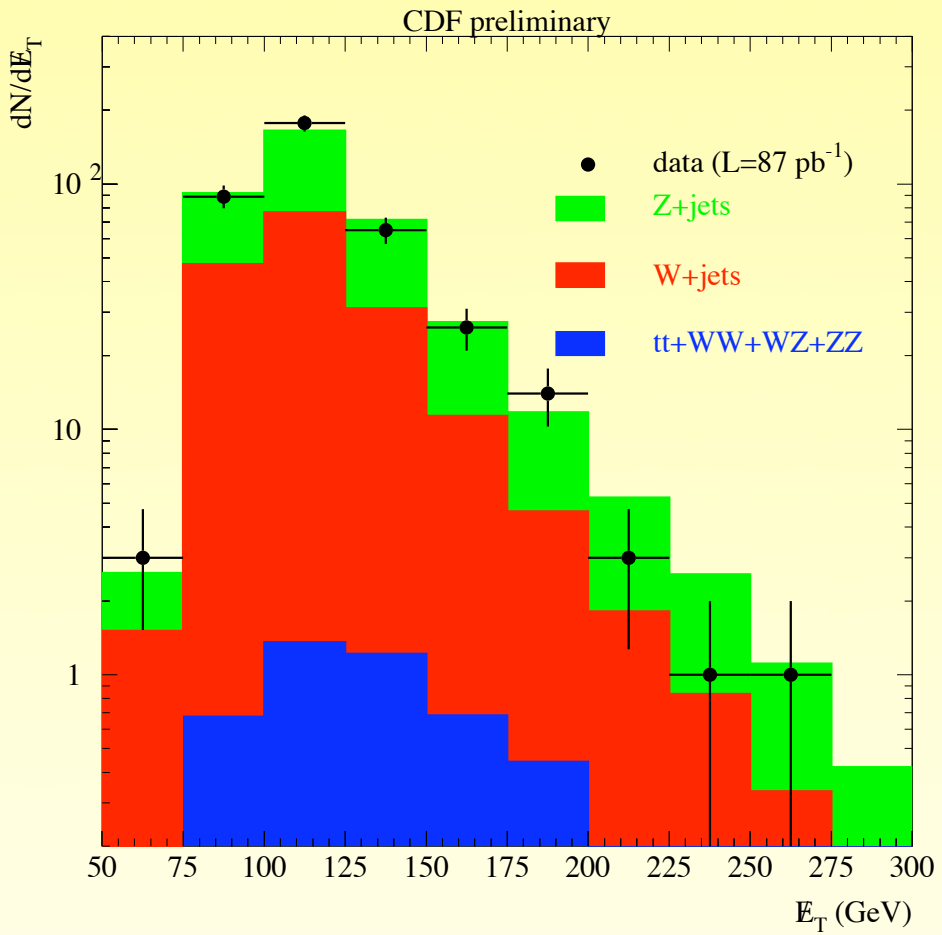
10% trigger bandwidth

what will we do with that ?

will we just check *again* the Tevatron data ???

CDF M_{ee} and $\not\!\!E_T$





Z/γ^*, $W^\pm$ Drell-Yan rate and spectrum;

jet inclusive to $p_T^j \sim 300 - 500$ GeV;

top cross sections;

b cross sections ;

LHC explores same final states as Tevatron but in a widely different partonic regime !!!

$$x_1 x_2 = \frac{M^2}{S}$$

at fixed final state ($\rightarrow$ fixed M)

$$x_1 x_2\,^{(LHC)} \simeq \frac{1}{50}\; x_1 x_2\,^{(Tevatron)}$$

In a sense, we are studying the same final state in different QCD environments !

Surprises ?

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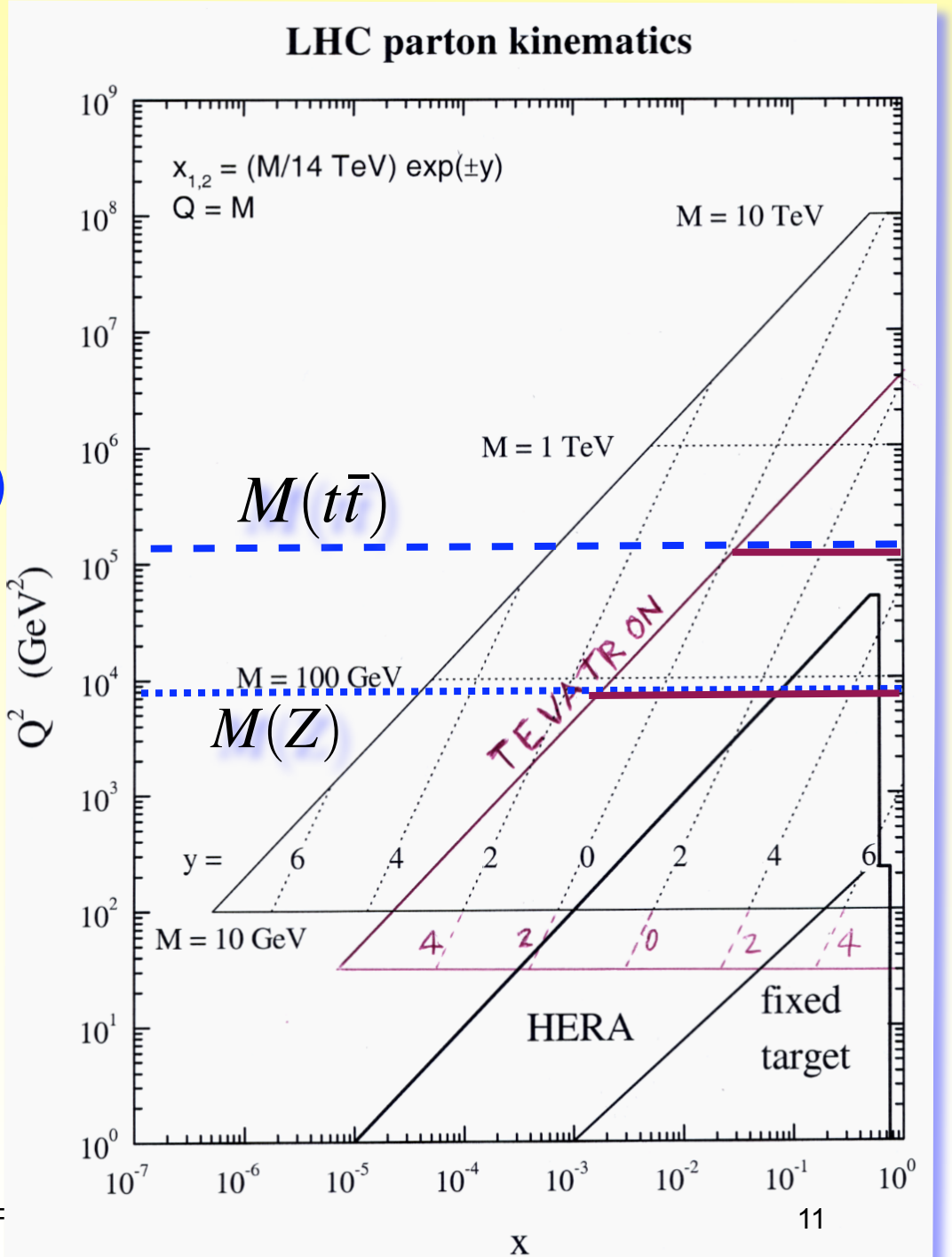
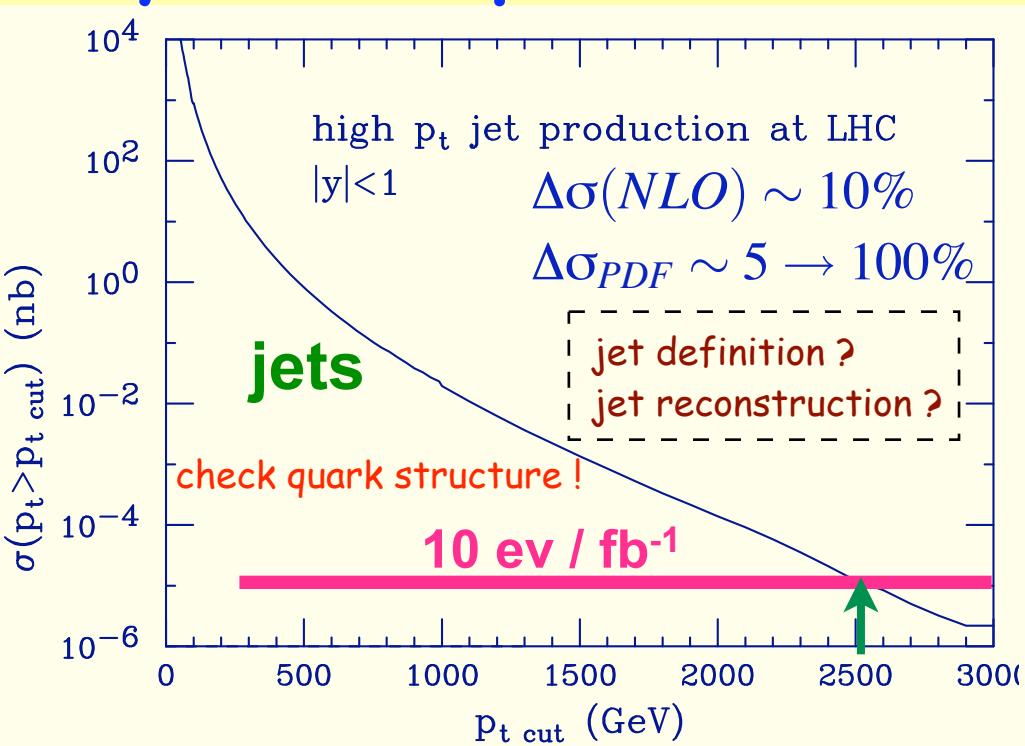
Surprises ?

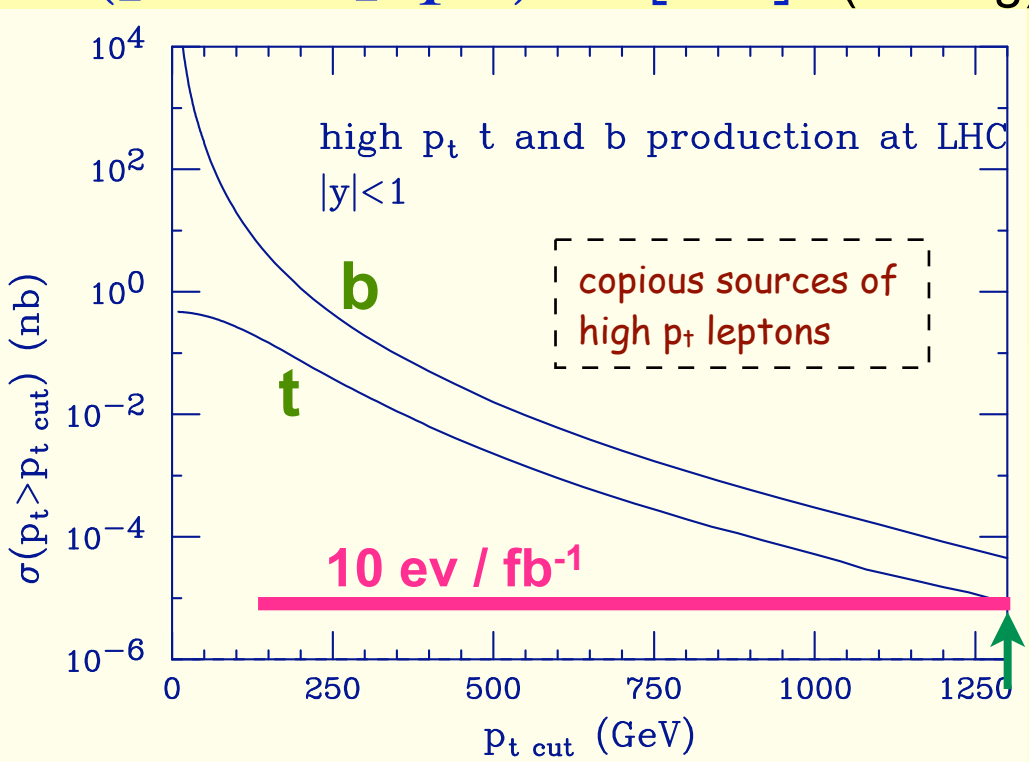
. . . of course,

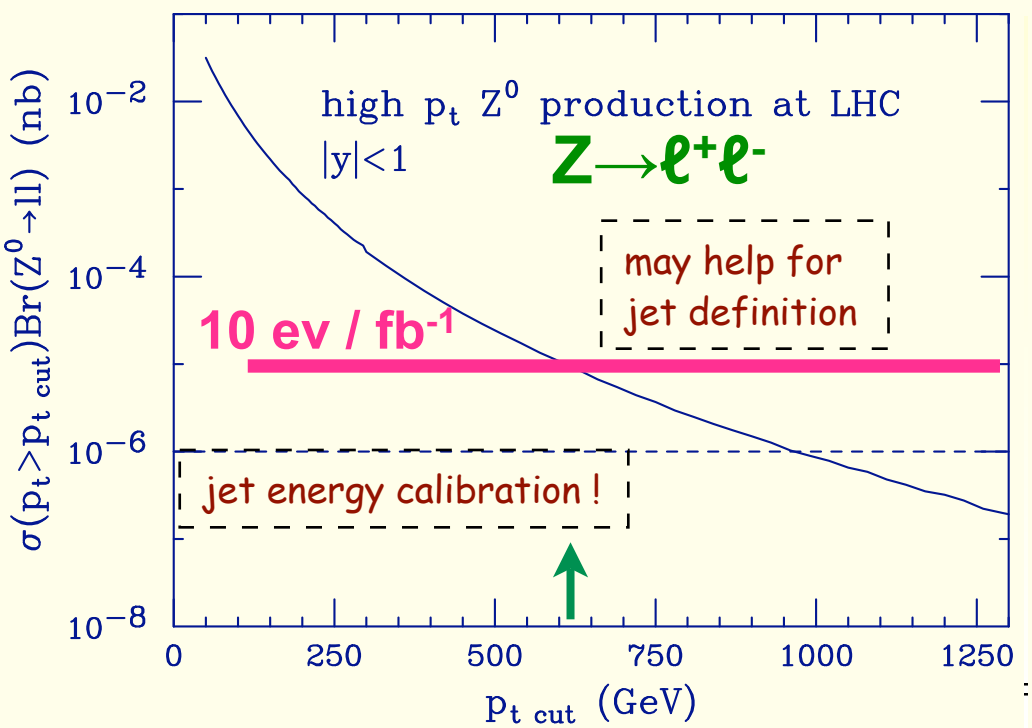
we'll also look at $Q >> M(t\bar{t})$ $\Rightarrow$

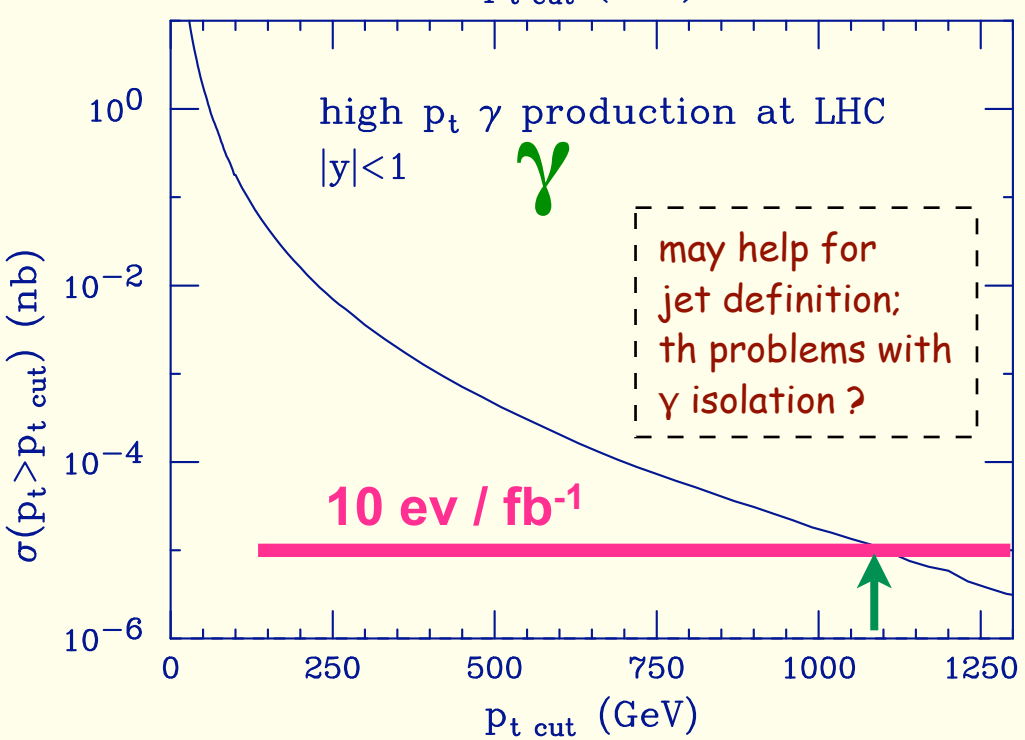


very hard processes : $\sigma(p_T > p_T^{cut})$ [nb] (Herwig)







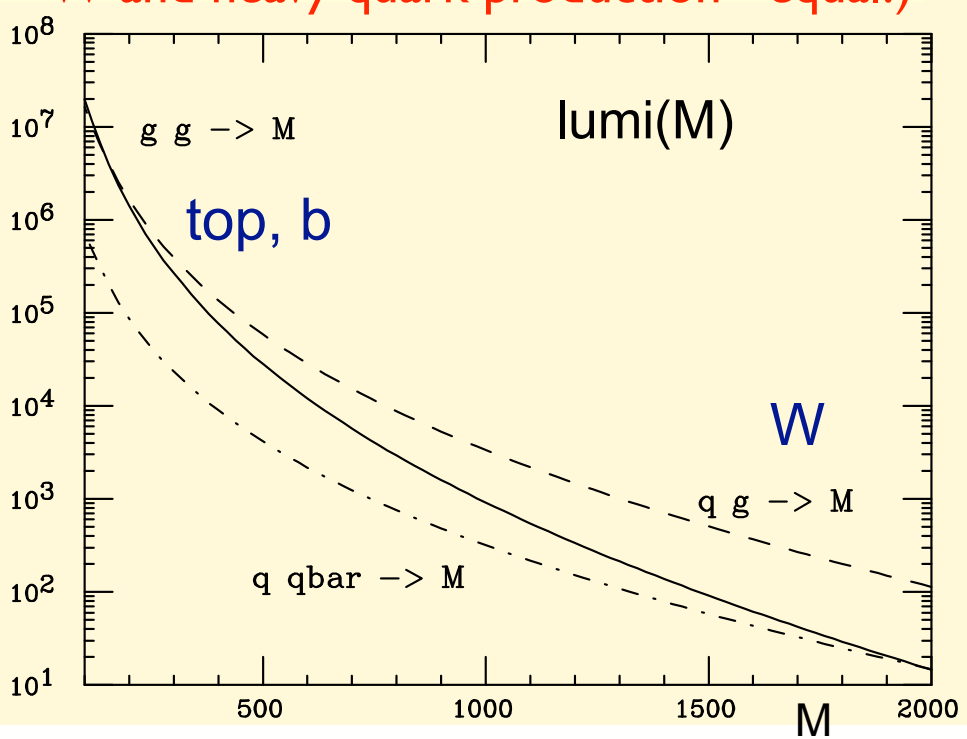


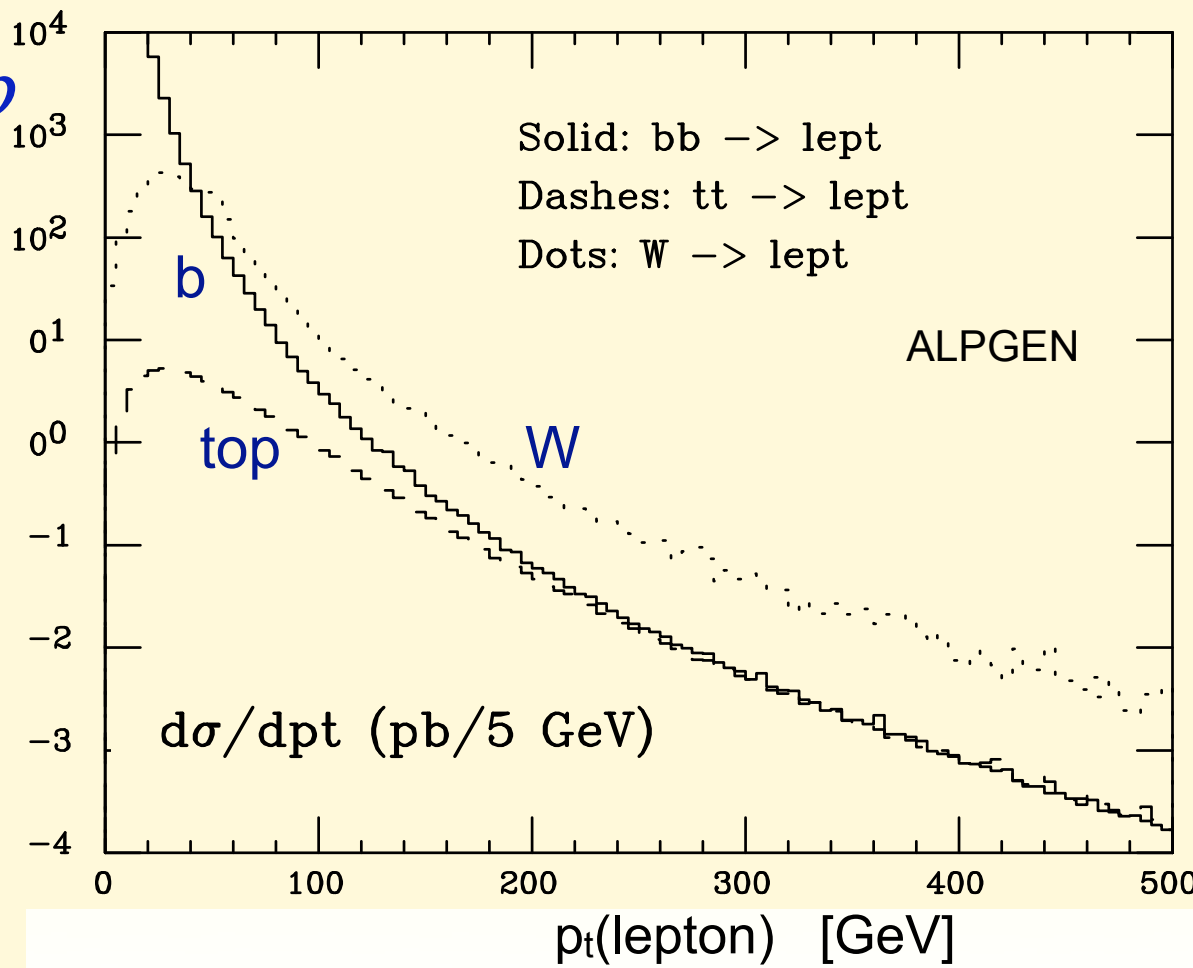
single high-p_T leptons from :

- $W \rightarrow e/\mu + \nu$
- $b \rightarrow e/\mu + X$
- $t \rightarrow Wb \rightarrow e/\mu + \nu + b$

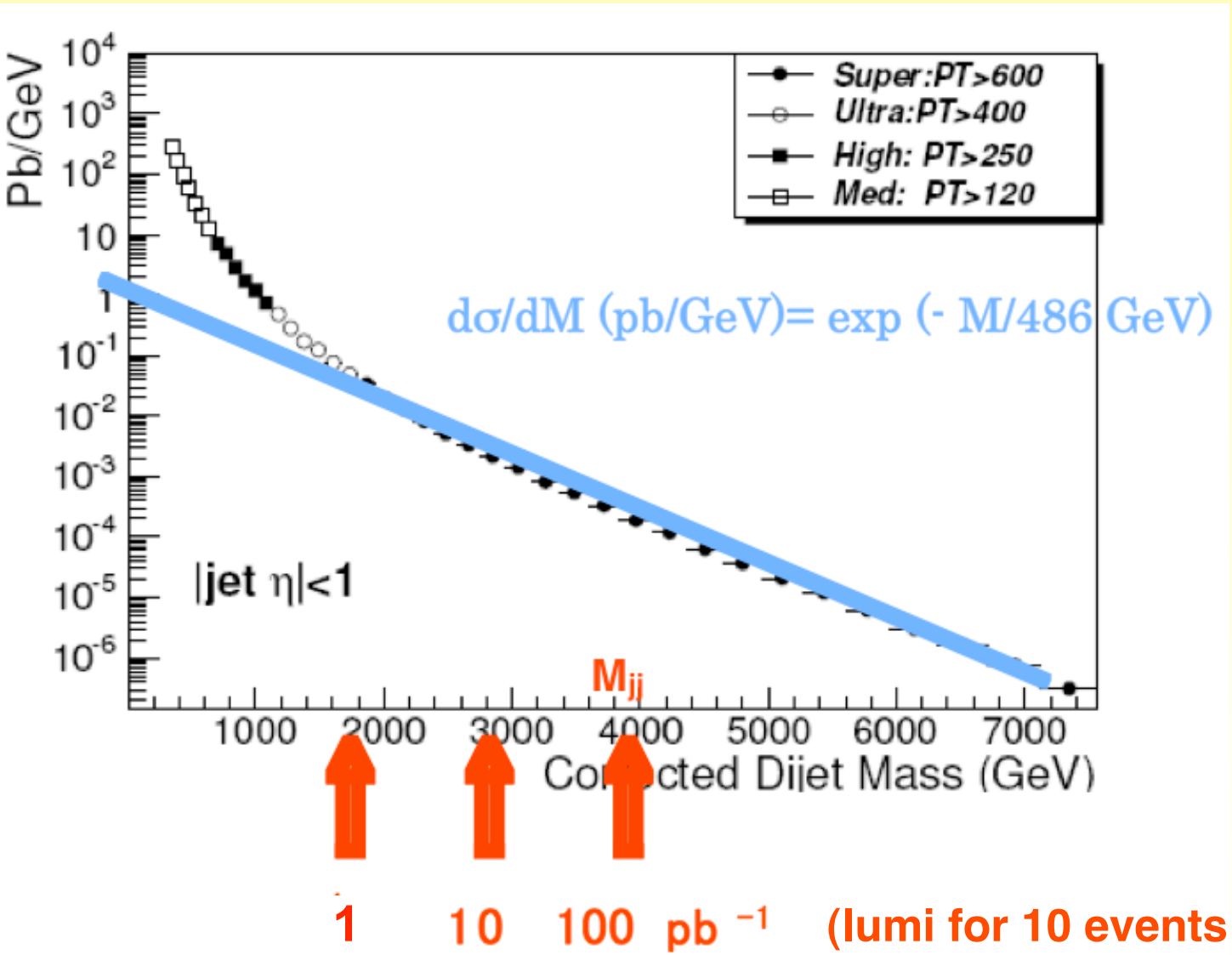
lepton spectrum can be predicted reliably !

(at large p_t , W and heavy quark production~ equal!)



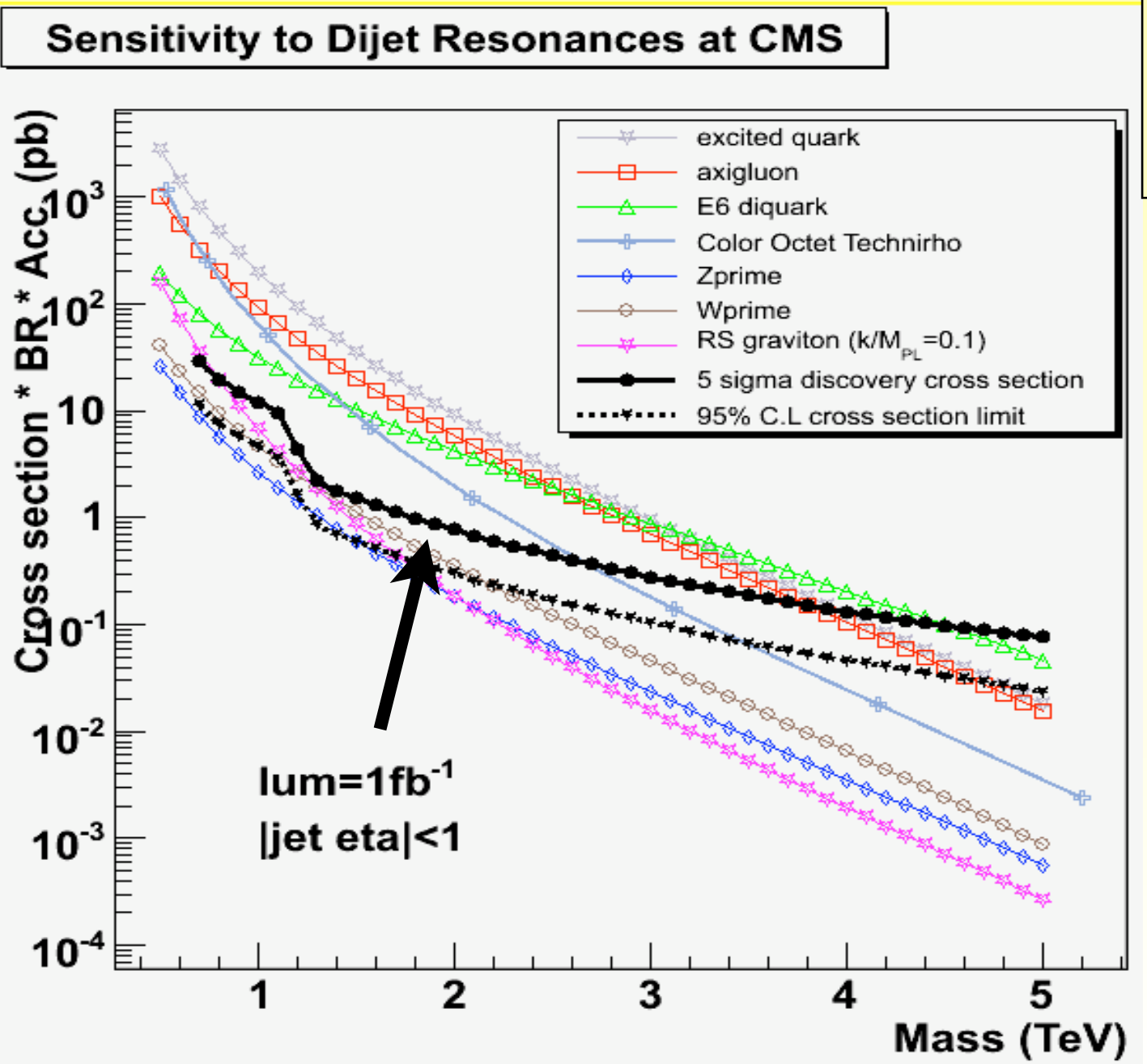


Di-Jet : high rate, jet calibration (p_T^j balance), physics interest at large m_{jj}



1 decade in lumi extends tail by 1 TeV !

Di-Jet resonances ?



σ_{QCD} (m_{jj} ~950–1050 GeV) = 26 pb

Exited quark ➡ 200 pb

σ_{QCD} (m_{jj} ~1.9 – 2.1 TeV) = 3.5 pb

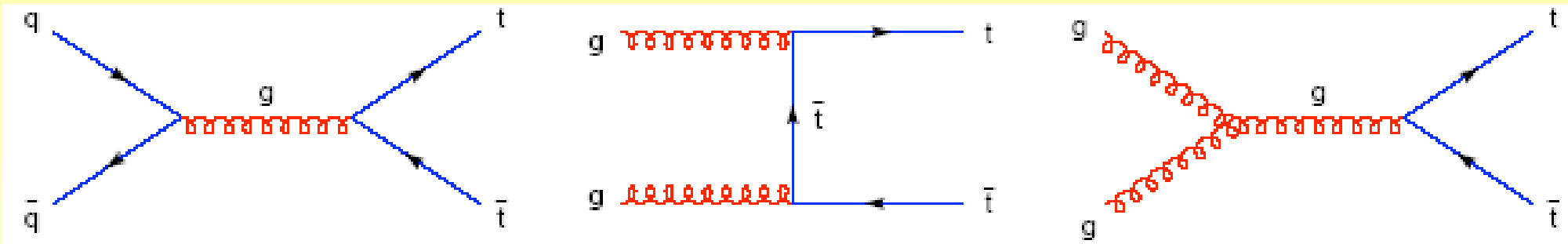
Exited quark ➡ 8 pb

CDF/D0 bounds at m_{jj} < 1TeV

LHC (10 pb^{-1}) could extend searches !

energy resolution crucial ! (narrow resonances)

plenty of Tops produced !



qq->tt: ~10%

gg->tt: ~90%

(. . . at LHC)

$\sigma_{tt}^{FNAL} = 6.5pb\ (1 \pm 5\%_{scale} \pm 7\%_{PDF})$

$\sigma_{tt}^{LHC} = 840pb\ (1 \pm 5\%_{scale} \pm 3\%_{PDF})$

(≈ 1 fb^{-1} collected on tape)

1 fb^{-1} at LHC ~ 100 x Tevatron 'today' !

	σ(tt) [pb]	σ(W+X)	σ(W+bbX) [ptb>20 GeV]	σ(W+bbjj X) [ptb,ptj >20 GeV]
Tevatron	6	20 x 10^3	3	0.16
LHC	800	160 x 10^3	20	16
Increase	x 100	x 10	x 10	x 100

Also signal/bckgd improves !

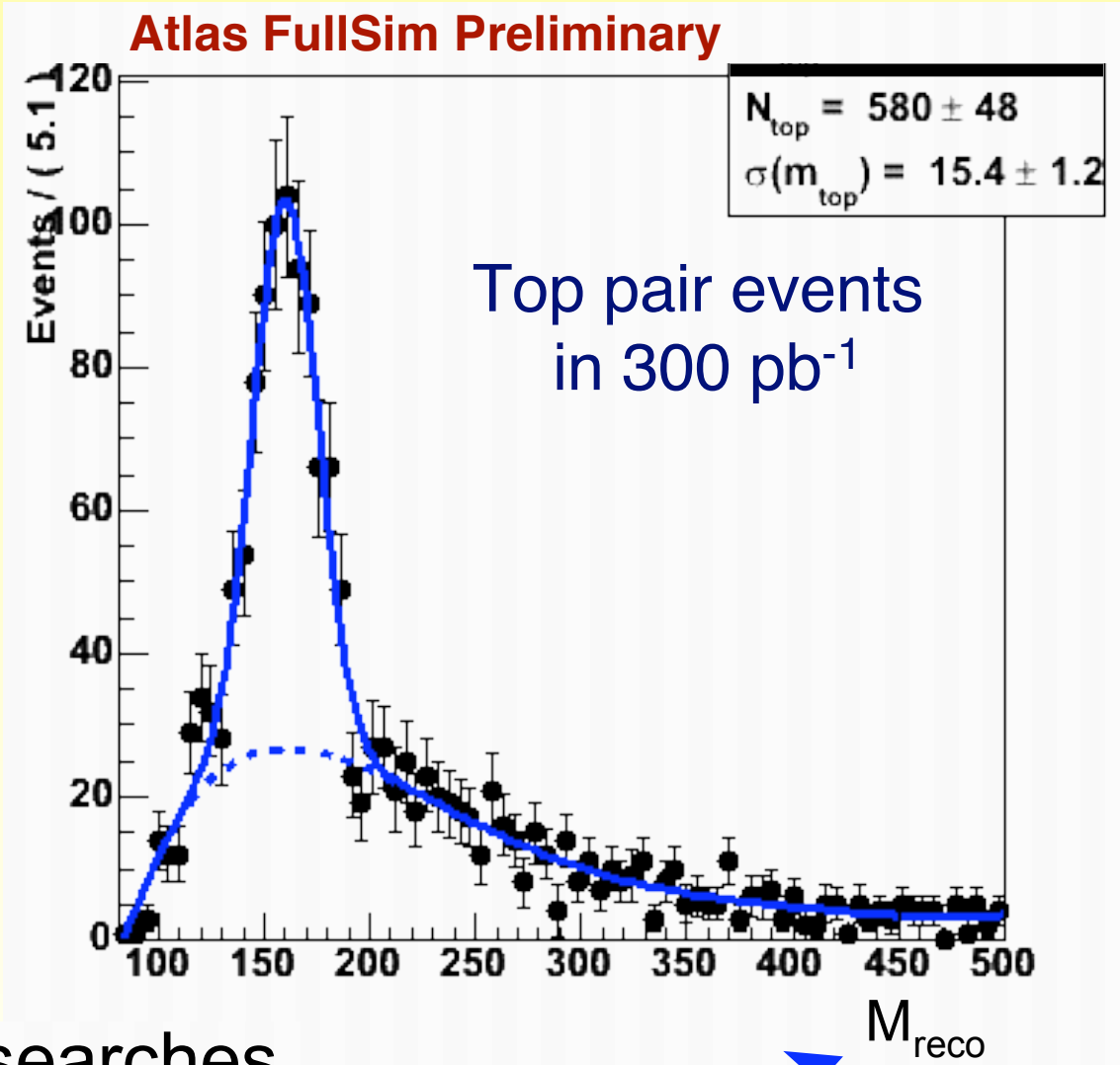
statistics is not a limit for m(top) measurements !

No b-tagging

Missing	E_T > 20 GeV
1 lepton	P_T > 20 GeV
4 jets(R=0.4)	P_T > 40 GeV

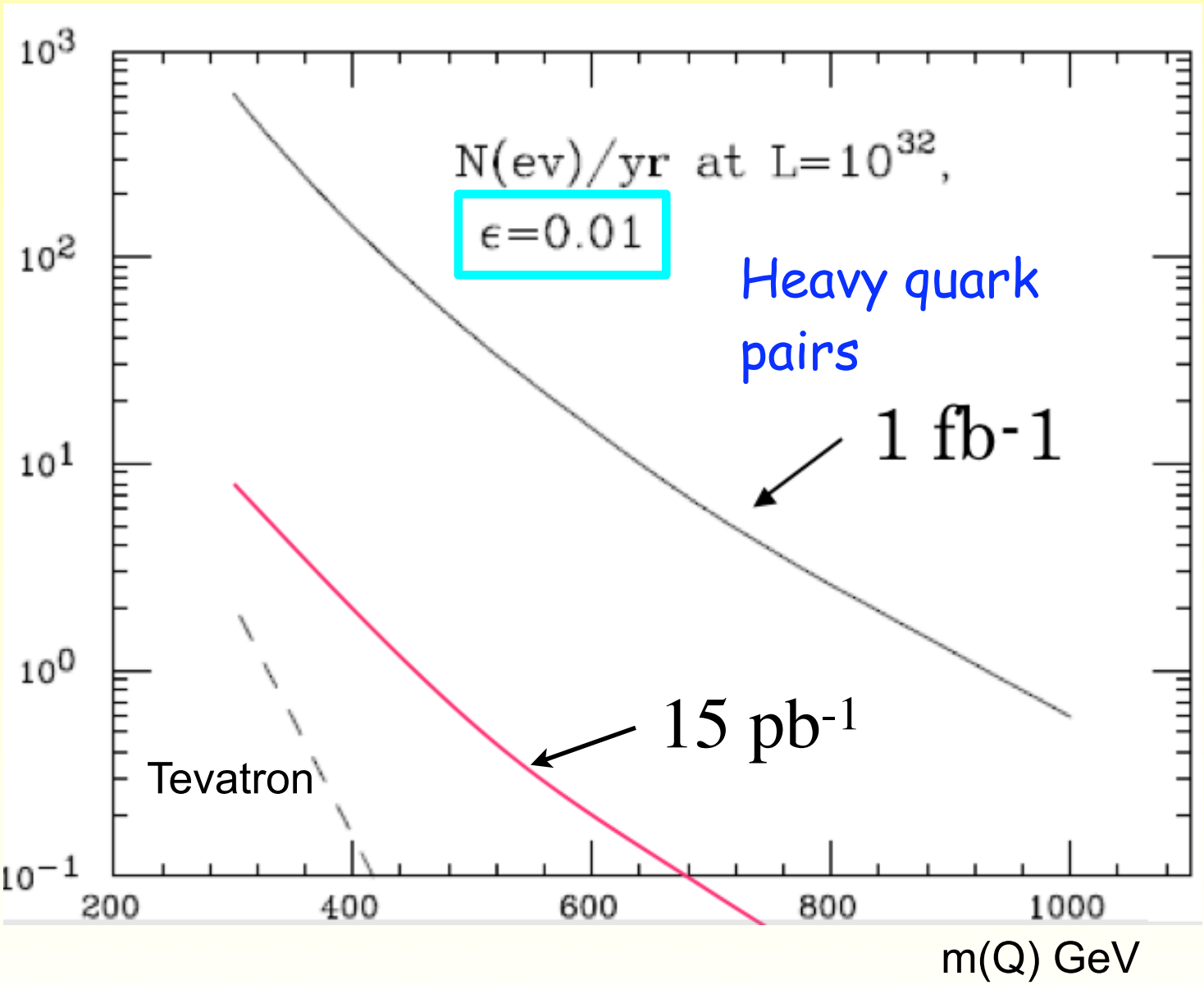
|m(jj)-m(W)|<10 GeV

→ controls W+jets bckg



- important background for searches
- Jet energy scale from W→jet jet, commission b-tagging → 1%

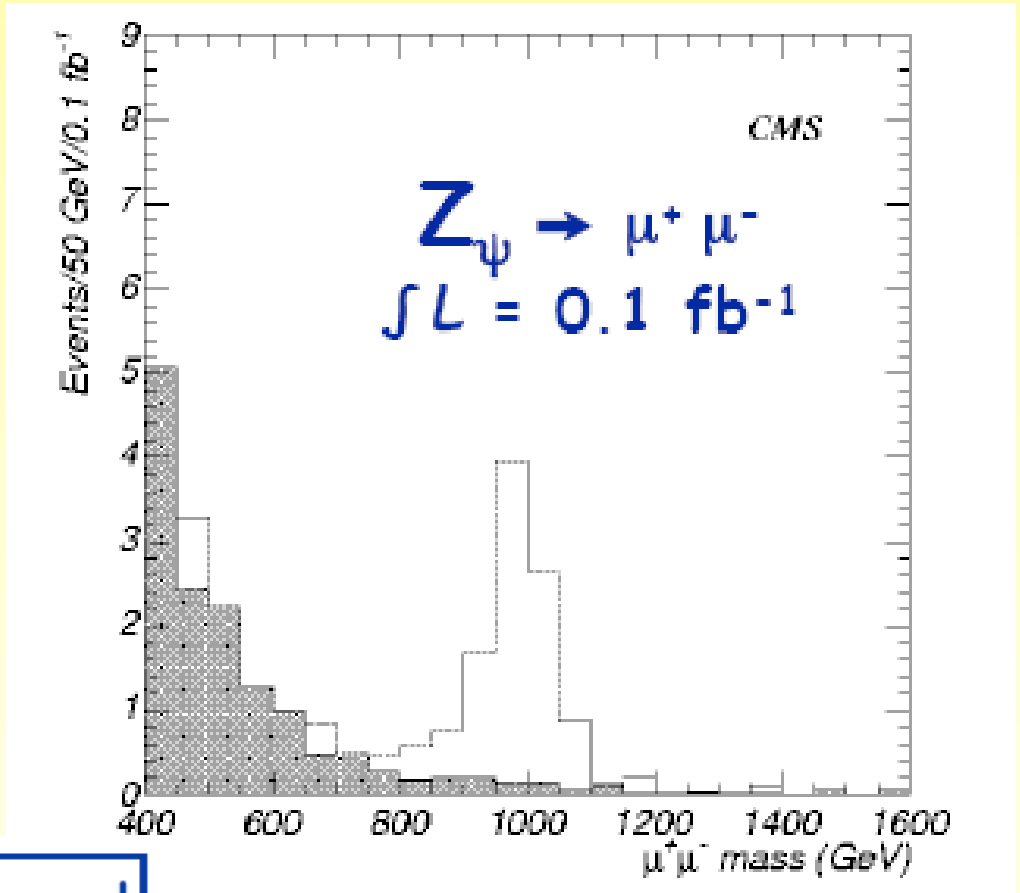
potential for new physics with 1 fb^{-1} ?

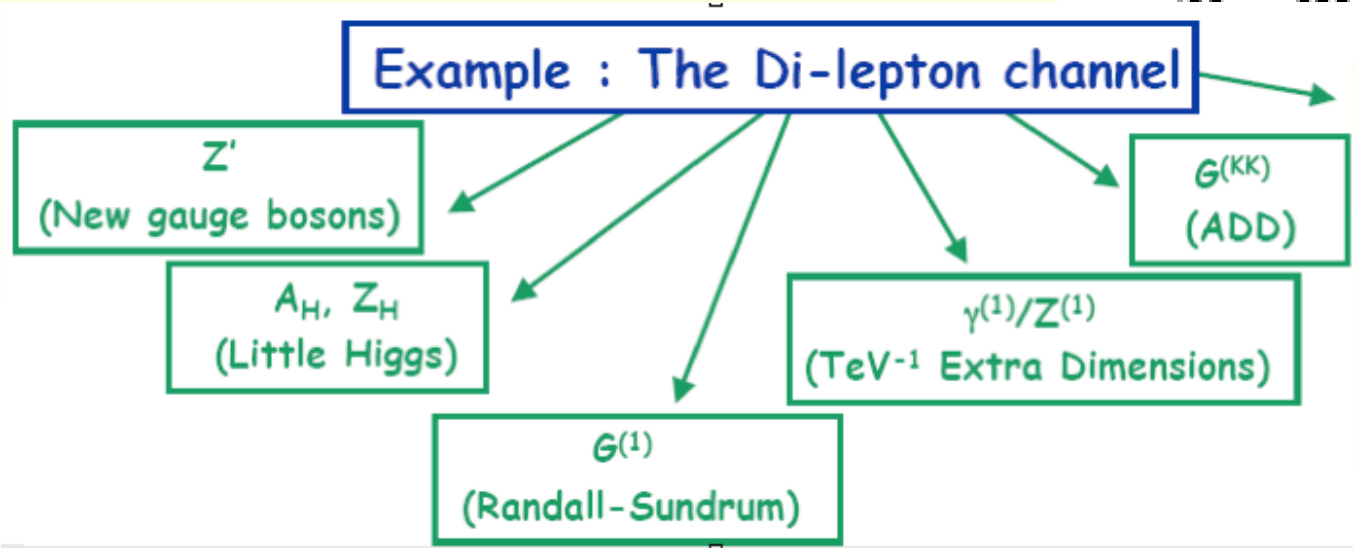


➠ squark production beyond Tevatron reach even with 10 pb^{-1}. . . !

Di-lepton resonances

May be seen very early: first weeks !





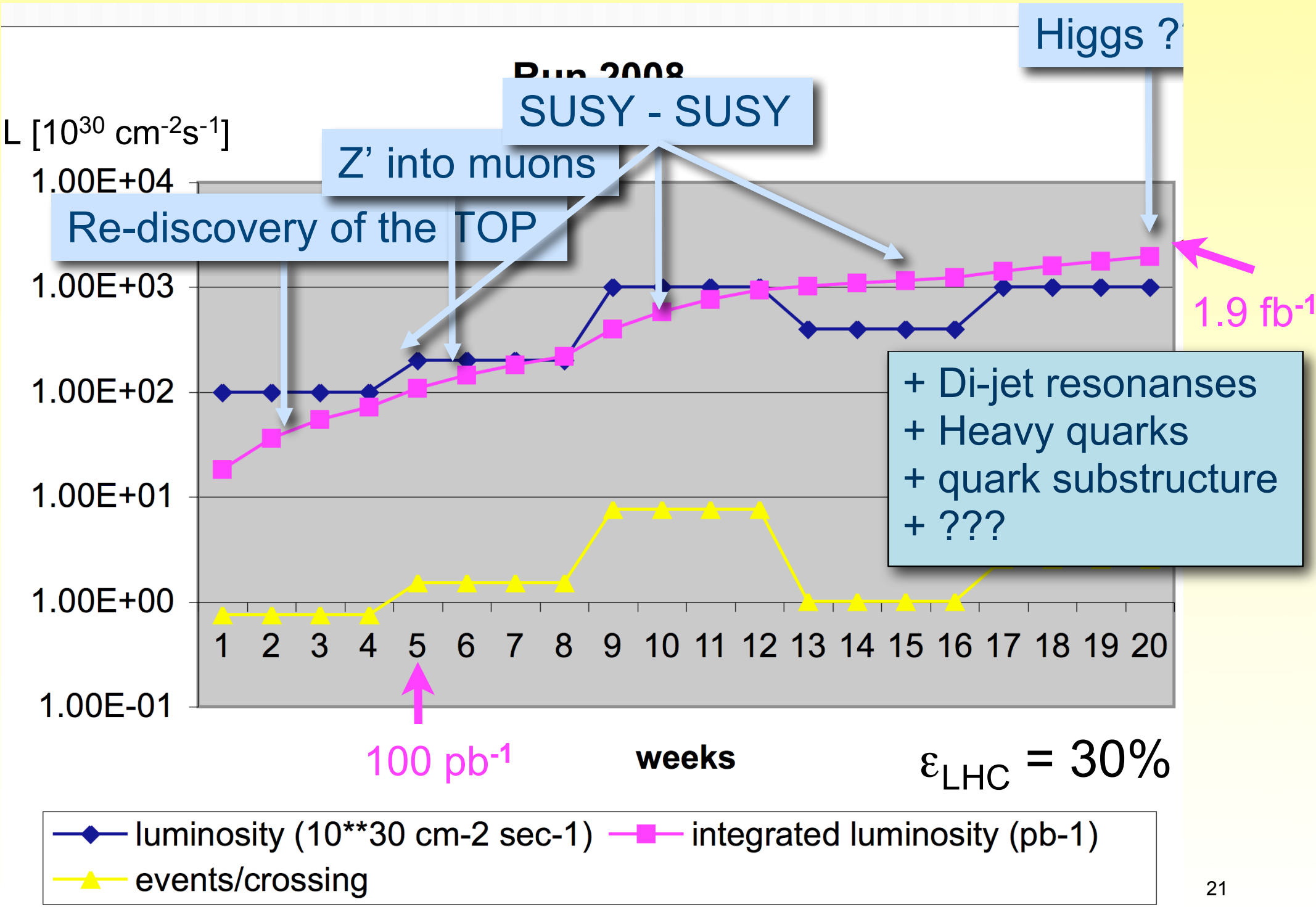
2008-run "duty" schedule vs integrated lumi

- ***after first "good" 10 pb^{-1}***
  - 20000 $W \to \ell\nu$
  - 2500 $Z \to \ell\ell$
  - 200 $t\bar{t} \to \ell\nu + jets$
    - ➠ measure rates, align and calibrate detectors better

- ***after first "good" 100 pb^{-1}***
  - *W(Z)+jets* rates well measurable
    - ➠ Jet calibration, MET calibration (for SUSY)
  - inclusive leptons, di-leptons, photons, di-photons triggers (for Higgs)

- ***from 100 pb^{-1} to 1 fb^{-1}***
  - Standard Model candles: tt production, W/Z cross sections, PDF studies, QCD studies, b-jet production
    - ➠ do extensive MC tuning
  - early Higgs boson search
    - ➠ $H \to \gamma\gamma, WW, ZZ$
  - early SUSY-BSM searches
    - ➠ MET + anything, di-jet, di-leptons, di-photons, resonances....

New Physics potential for 2008 run :



Conclusions

We could have
a very reach physics input
within one year from the first bunch
crossing ...

and that's just the start up .....