New Physics with early LHC data ?

(Supermodels !)

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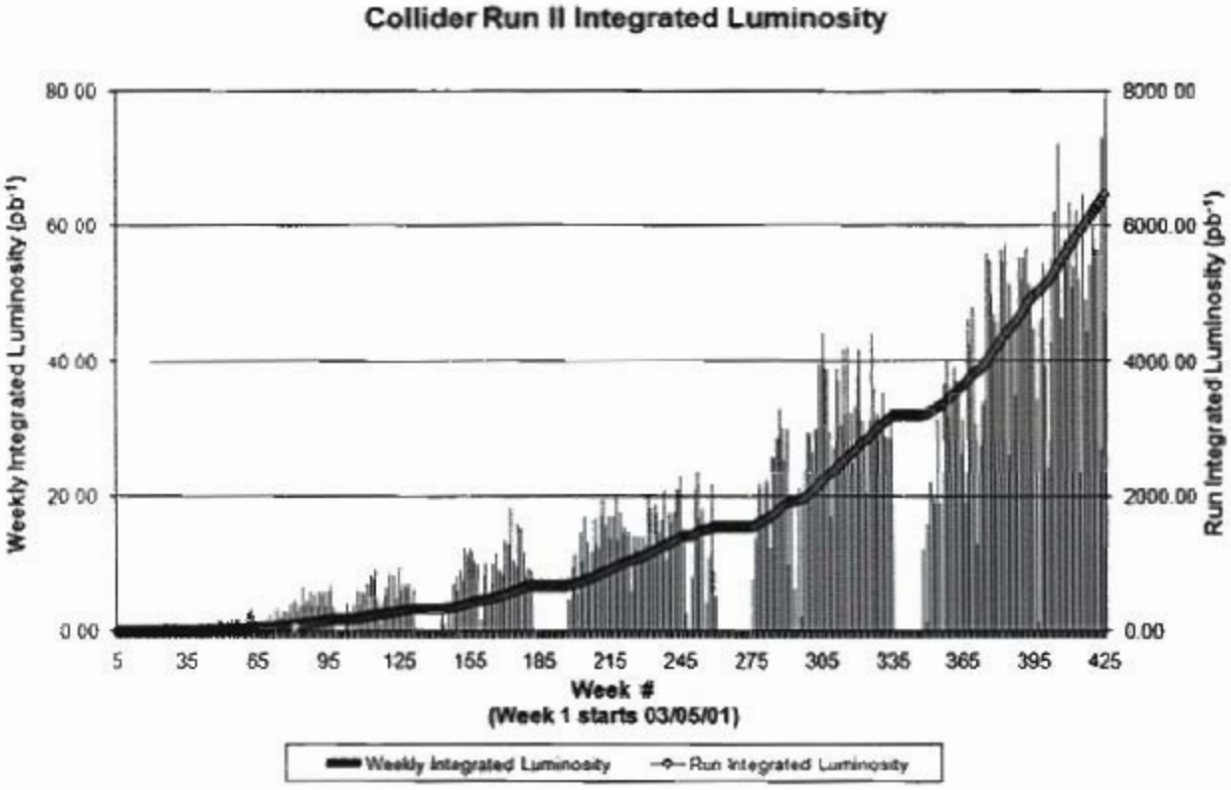
Early data ↔ "Run 1"

Sept 09 – Dec 10

10 TeV – 200 pb^{-1}

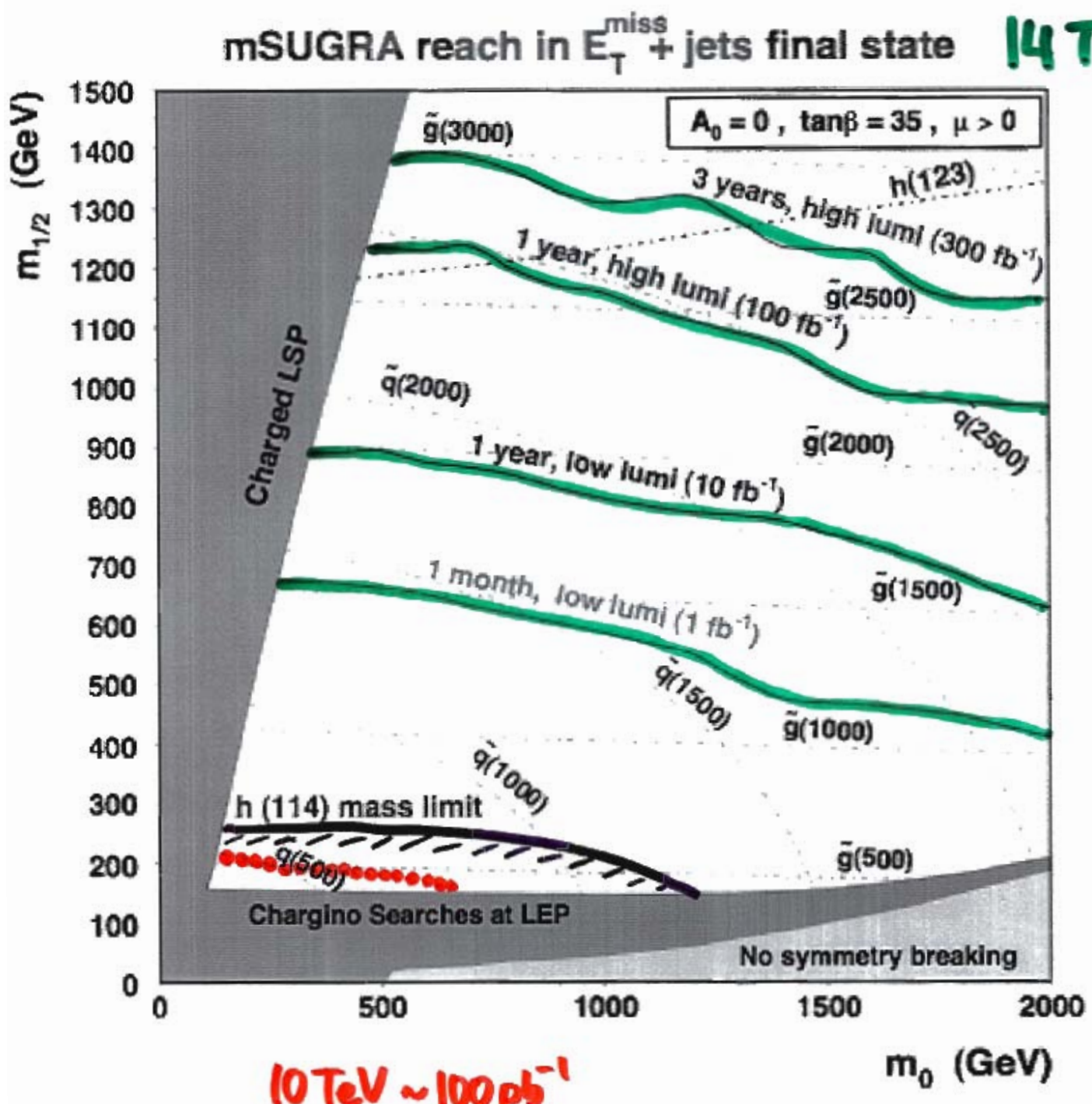
maybe only 20 pb^{-1} with delays ?

Tevatron

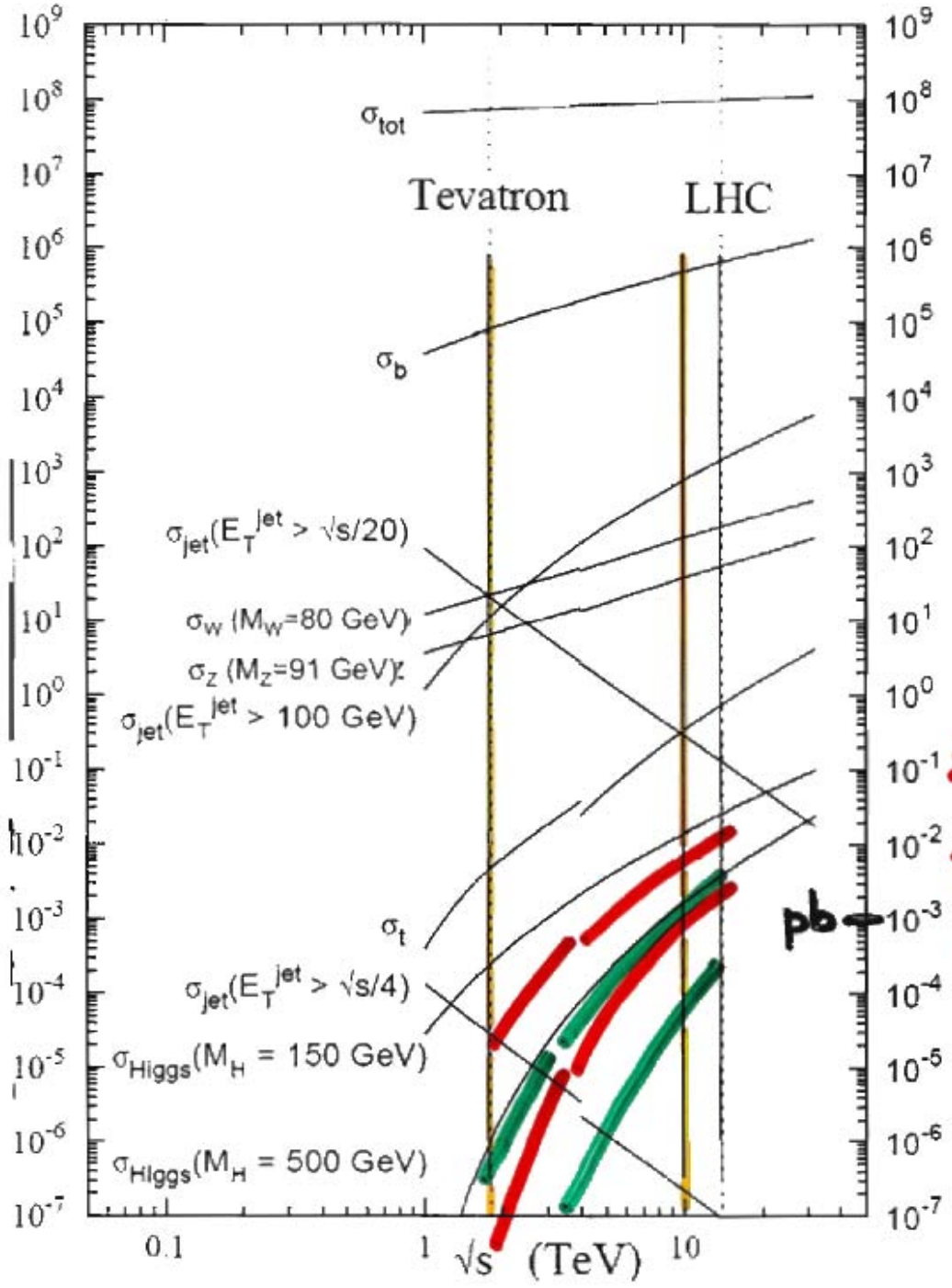


$\approx 10^4\ pb^{-1}$ by 2010

$55\ pb^{-1}$/week


mSUGRA reach in E_T^{miss} + jets final state
14 TeV
$A_0 = 0$, $\tan\beta = 35$, $\mu > 0$
$m_{1/2}$ (GeV)
m_0 (GeV)
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
0
500
1000
1500
2000
$\tilde{g}$(3000)
h(123)
3 years, high lumi (300 fb^{-1})
1 year, high lumi (100 fb^{-1})
$\tilde{g}$(2500)
$\tilde{q}$(2000)
$\tilde{g}$(2000)
$\tilde{q}$(2500)
1 year, low lumi (10 fb^{-1})
$\tilde{g}$(1500)
1 month, low lumi (1 fb^{-1})
$\tilde{q}$(1500)
$\tilde{g}$(1000)
$\tilde{q}$(1000)
h (114) mass limit
$\tilde{q}$(500)
$\tilde{g}$(500)
Charged LSP
Chargino Searches at LEP
No symmetry breaking
10 TeV ~ 100 pb^{-1}

Cross Sections



$$N_{events} = L \cdot \sigma \cdot Br$$

Early discovery requires ...

"easy" signature (leptons, ...)

A. $N^{LHC}_{events} \gtrsim 10 \Rightarrow \sigma \cdot Br \gtrsim \begin{cases} 0.05\ pb \\ 0.5\ pb \end{cases}$

B. $N^{LHC} \gtrsim N^{Tevatron}$

$\Leftrightarrow L \cdot \sigma \cdot \cancel{Br}\big|_{LHC} \gtrsim L \cdot \sigma \cdot \cancel{Br}\big|_{TeV}$

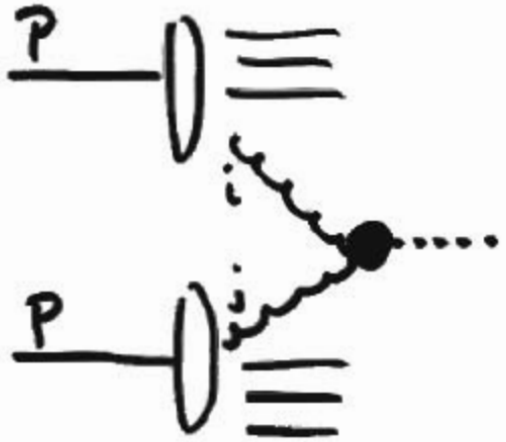
$\Leftrightarrow \frac{\sigma^{LHC}}{\sigma^{TeV}} \gtrsim \frac{L^{TeV}}{L^{LHC}} = \begin{cases} \frac{10000\ pb^{-1}}{200\ pb^{-1}} = 50 \\ \frac{10000\ pb^{-1}}{20\ pb^{-1}} = 500 \end{cases}$

a useful formula for $\frac{\sigma_{LHC}}{\sigma_{TeV}}$:

$$\frac{d\sigma}{d\hat{s}} = \sum_{ij} \hat{\sigma}_{ij}(\hat{s}) \int\int dx_i dx_j f_i(x_i) f_j(x_j)\, \delta(\hat{s} - x_i x_j s)$$

collider independent

process independent $\equiv \Omega_{ij}(s, \hat{s})$



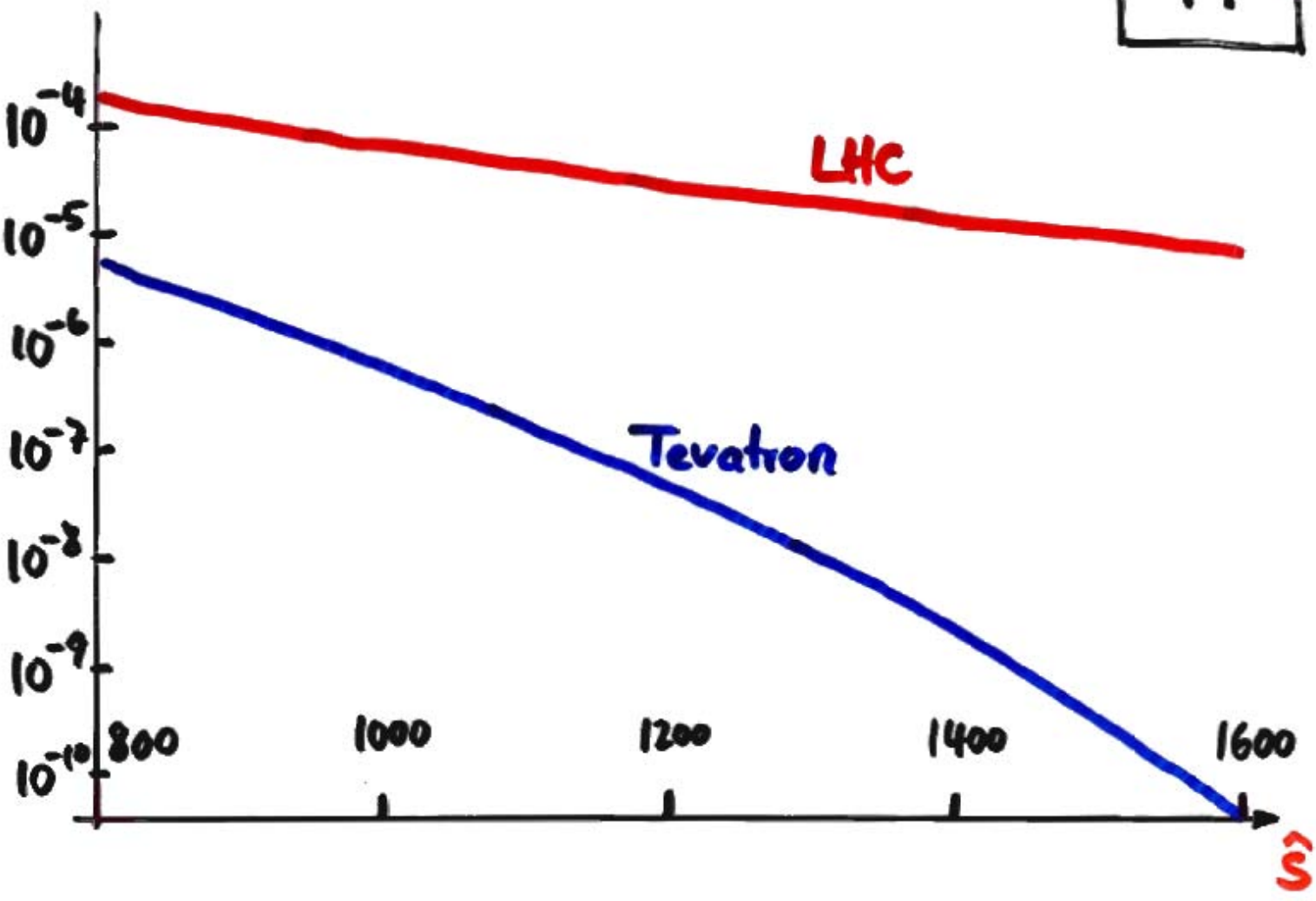
"parton parton luminosity"

$$\Rightarrow \quad \frac{\sigma_{LHC}}{\sigma_{TeV}} \approx \frac{\cancel{\hat{s}}\ \Omega_{LHC}(s, \hat{s})}{\cancel{\hat{s}}\ \Omega_{TeV}}$$

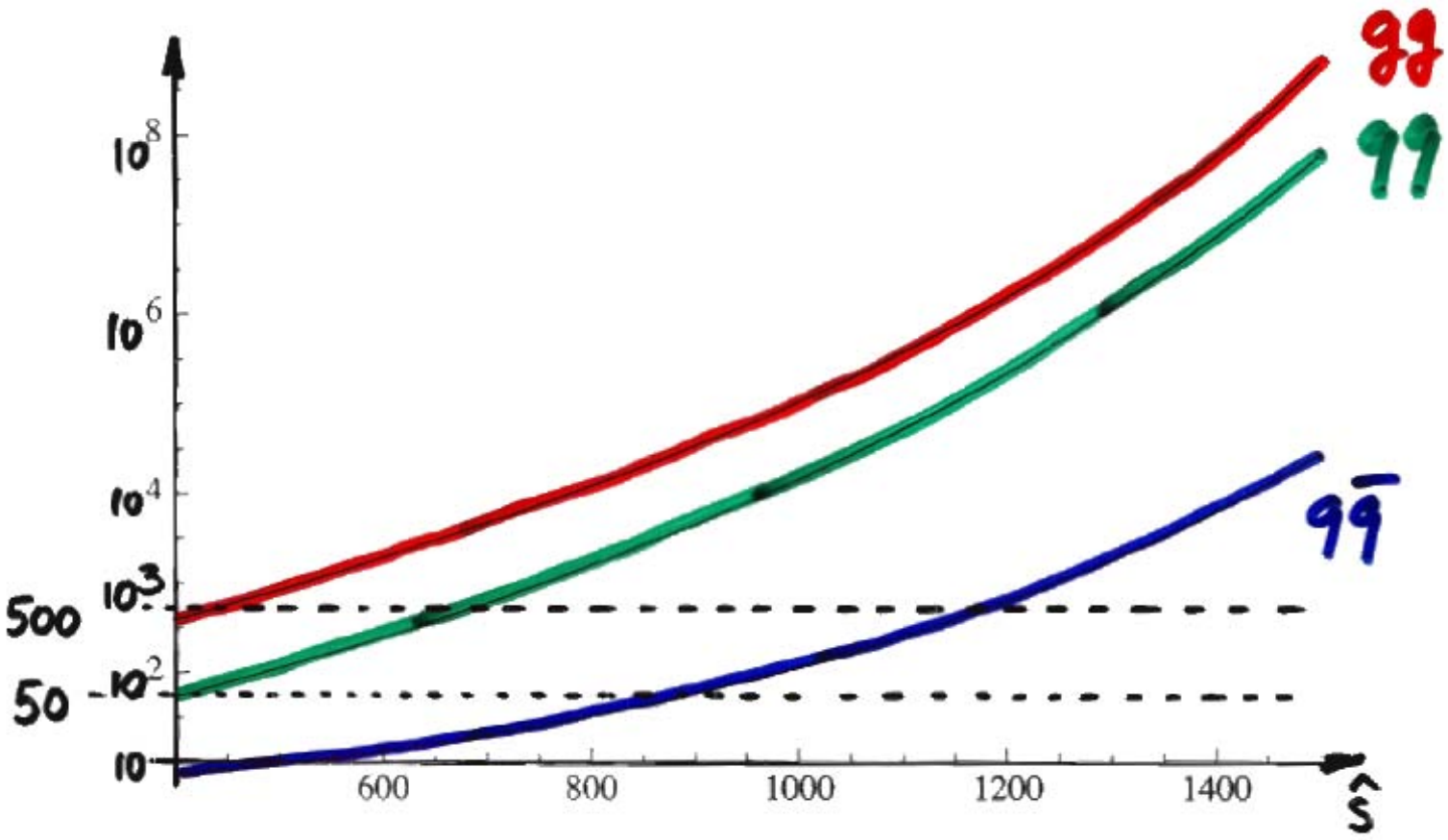
(assumed : single parton dominates, narrow $\hat{s}$ range)

$\Omega^{LHC}(10TeV, \hat{s})$ vs. $\Omega^{TeV}(\hat{s})$

$q\bar{q}$



$$\frac{\Omega^{LHC}(10\,TeV)}{\Omega^{TeV}}$$



LHC wins for

- Large mass
- gg, qq initial partons

Early discovery requires ...

"easy" signature

A. $N^{LHC} \gtrsim 10 \Rightarrow \sigma \cdot Br \gtrsim \begin{cases} 0.05\ pb \\ 0.5\ pb \end{cases}$

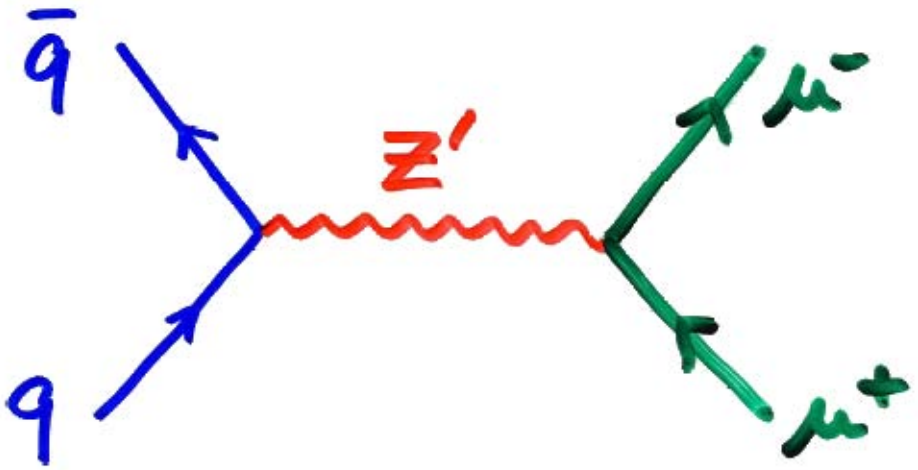
"some events"

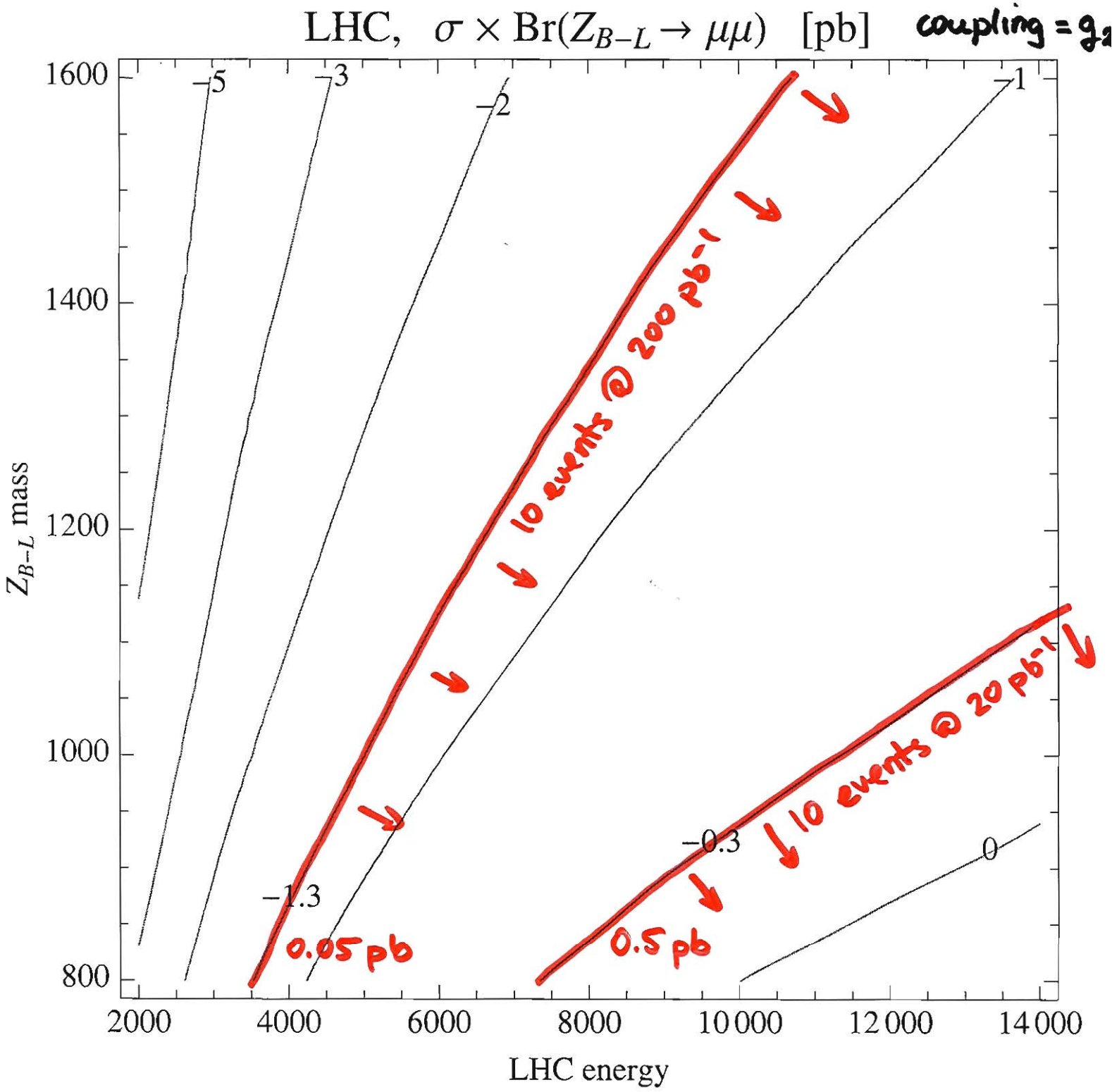
B. $N^{LHC} \gtrsim N^{Tev}$

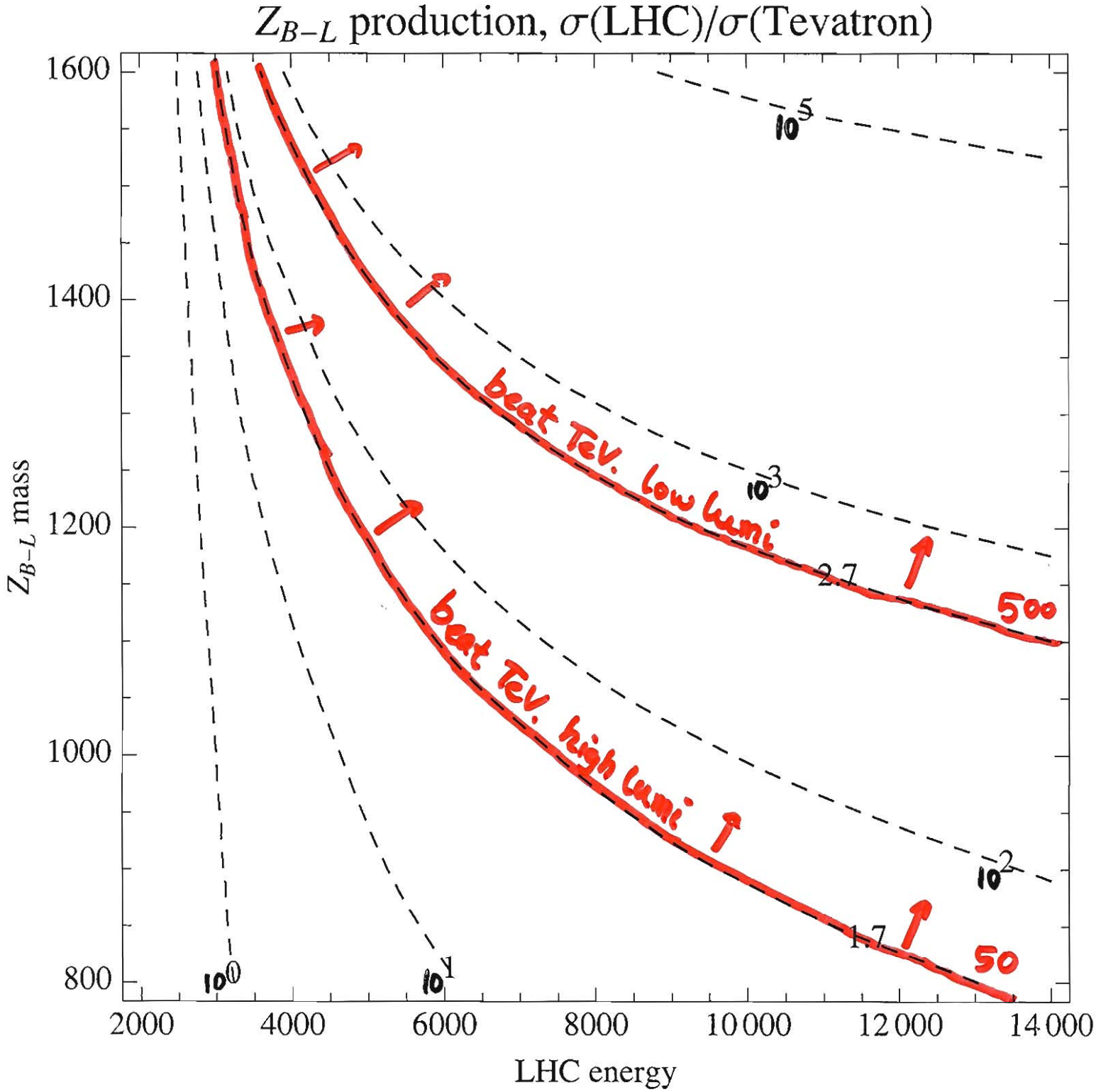
"beat Tevatron"

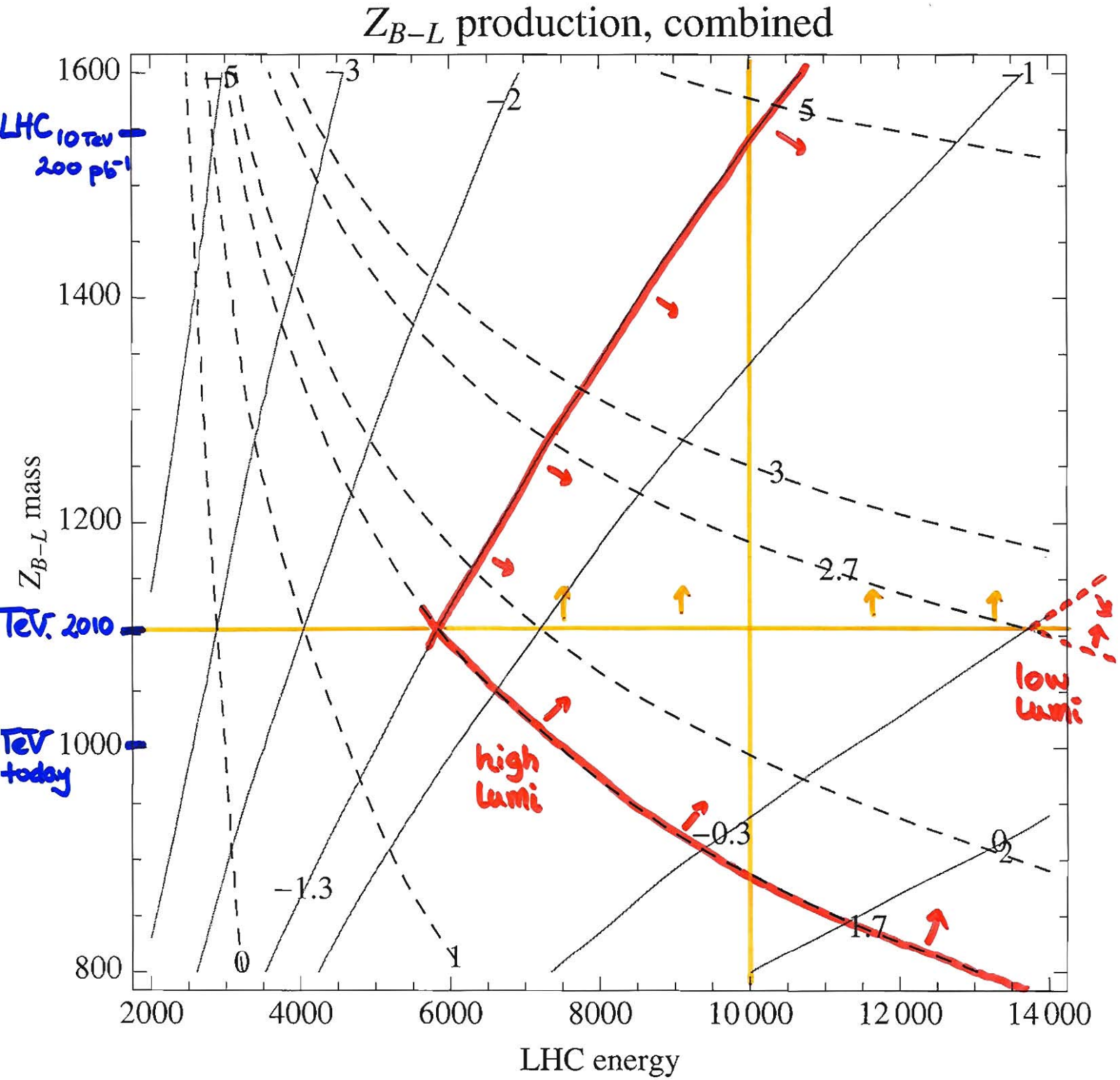
$$\Rightarrow \frac{\sigma^{LHC}}{\sigma^{Tev}} \approx \frac{\Omega^{LHC}}{\Omega^{Tev}} \gtrsim \frac{L^{Tev}}{L^{LHC}} = \begin{cases} \frac{10^4\ pb^{-1}}{200\ pb^{-1}} = 50 \\ \frac{10^4\ pb^{-1}}{20\ pb^{-1}} = 500 \end{cases}$$

Example: $Z'_{B-L} \to \mu^+\mu^-$



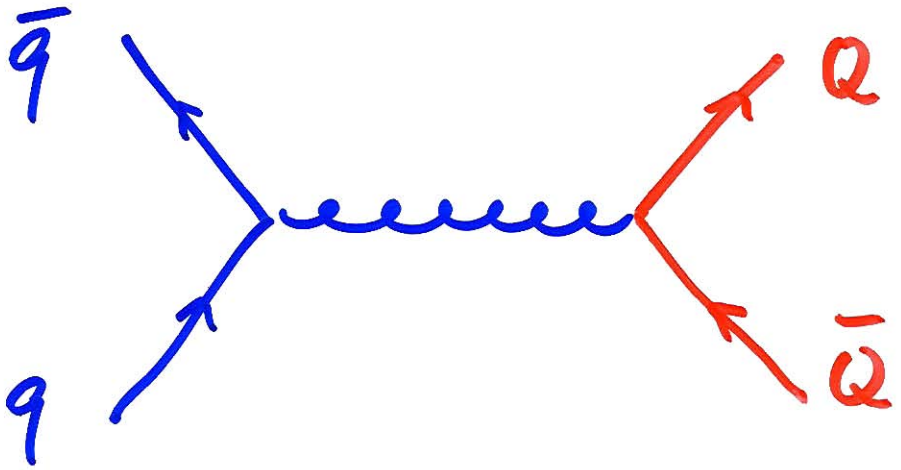

LHC, $\sigma \times \mathrm{Br}(Z_{B-L} \to \mu\mu)$ [pb]
coupling = g_{B-L}
1600
1400
1200
1000
800
Z_{B-L} mass
2000
4000
6000
8000
10 000
12 000
14 000
LHC energy
5
3
2
1
−1.3
−0.3
0
10 events @ 200 pb⁻¹
10 events @ 20 pb⁻¹
0.05 pb
0.5 pb

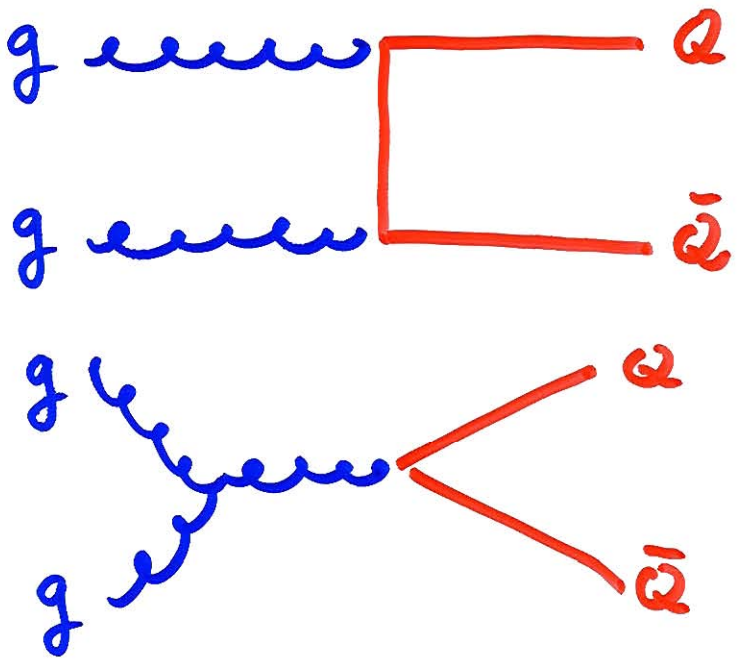

Z_{B-L} production, σ(LHC)/σ(Tevatron)
1600
1400
1200
1000
800
Z_{B-L} mass
2000
4000
6000
8000
10 000
12 000
14 000
LHC energy
10^5
10^3
10^2
10^1
10^0
beat TeV. low lumi
2.7
500
beat TeV. high lumi
1.7
50



Luminosity crucial !

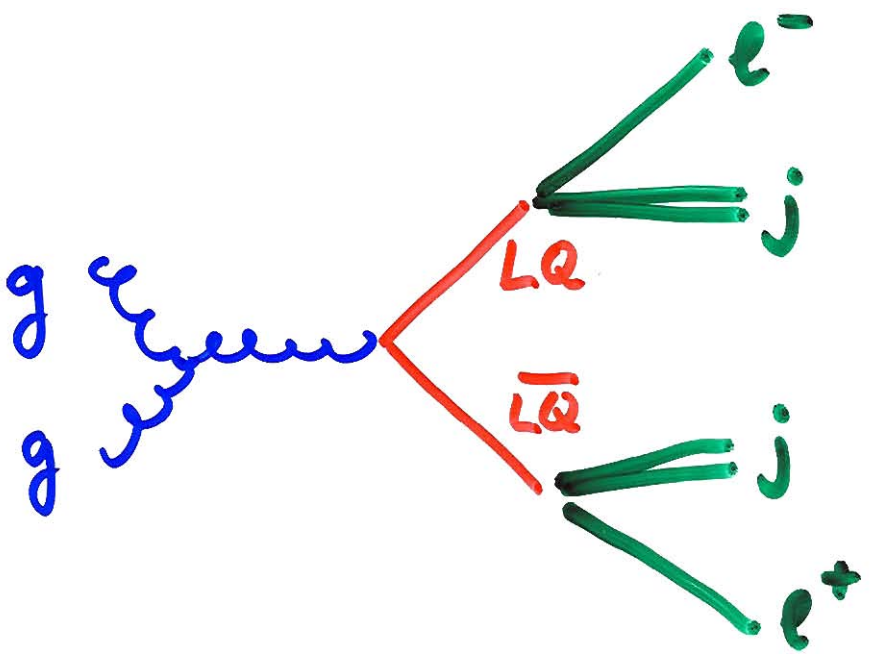
Example : "stable" new quark

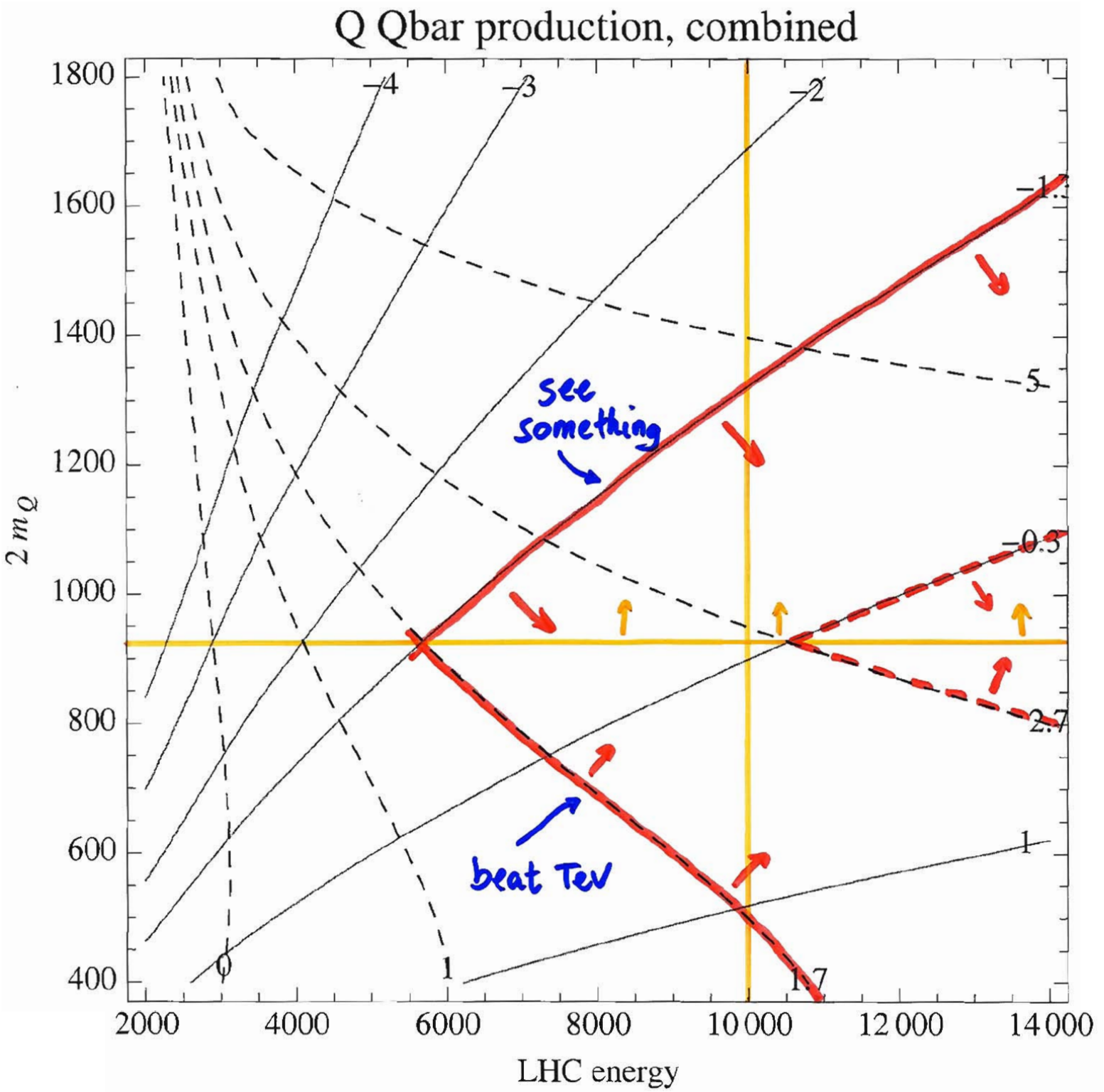




lepto-quark similar $LQ \rightarrow \mu q$

Leptoquark signature





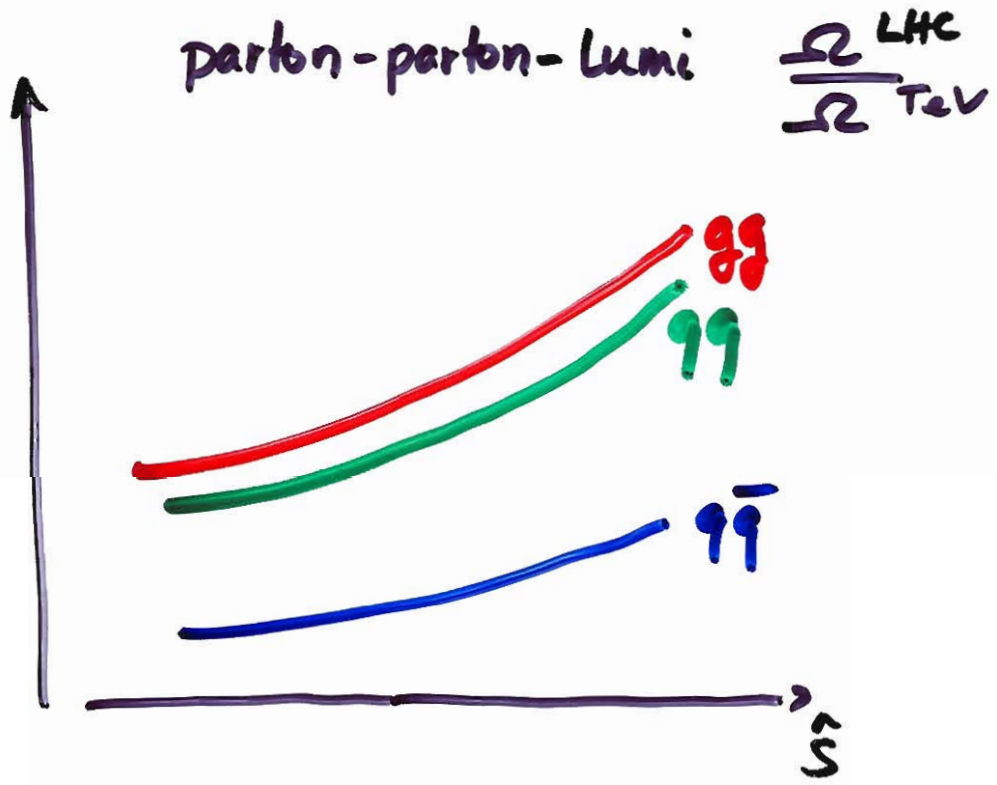
CMS, Tevatron cuts applied

Supermodels

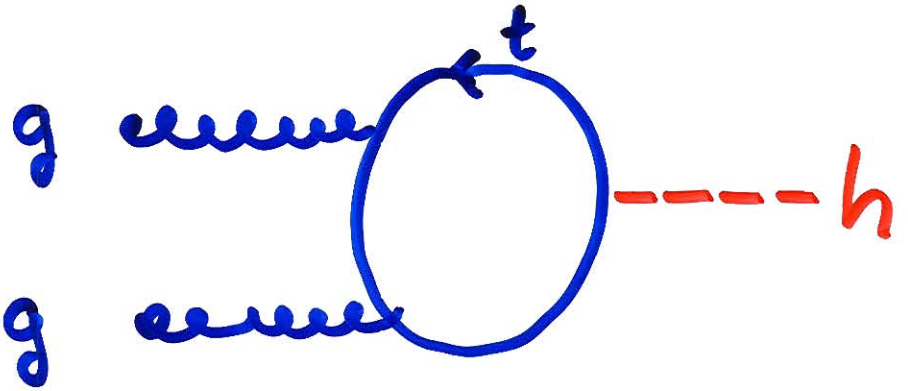
new physics which can be seen with

LHC · 10 TeV · 20 pb^{-1}

and not ruled out by Tevatron etc.



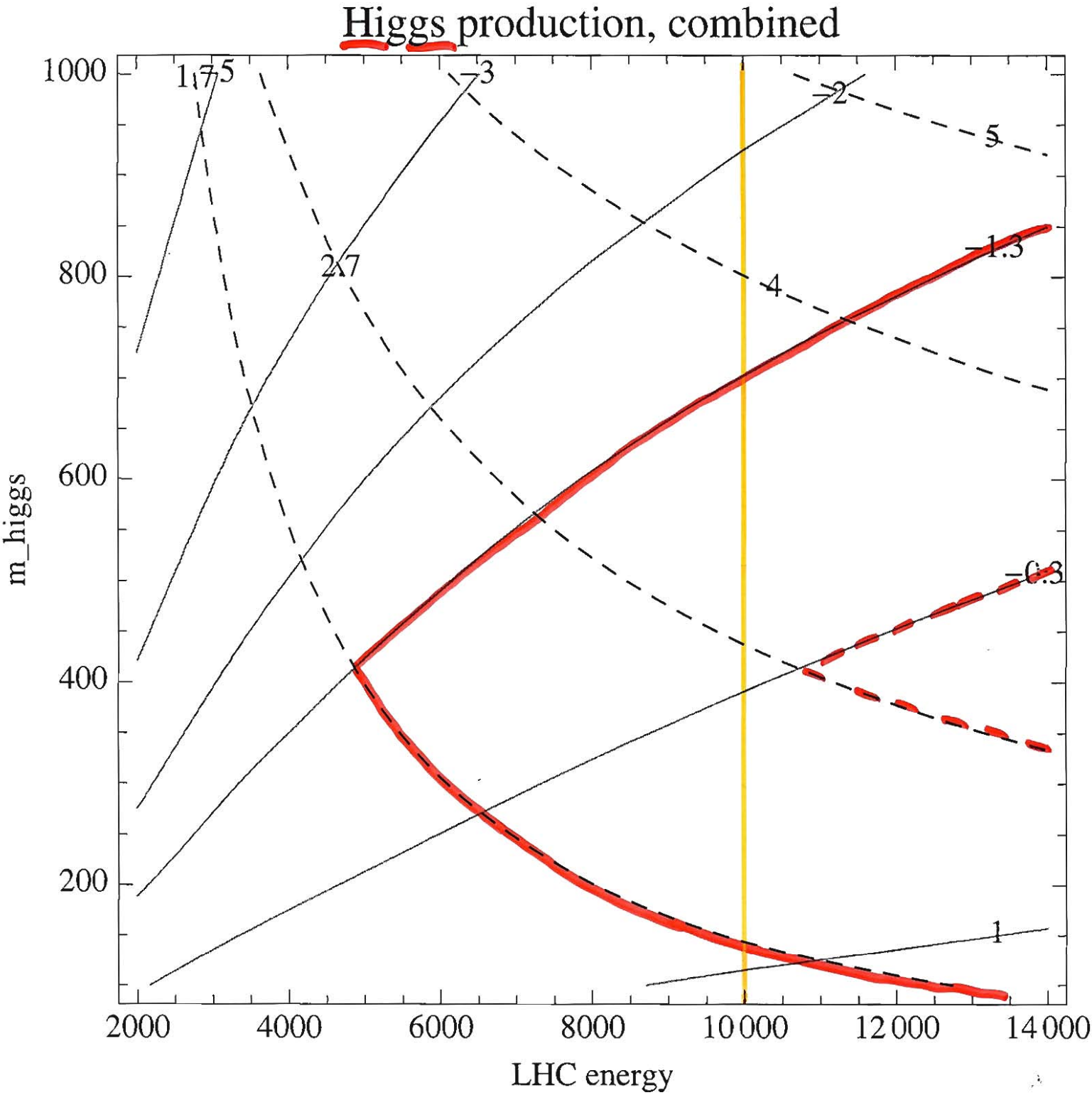
Example: $gg \longrightarrow$ Higgs



$$\sigma \sim \alpha_s^2 \left(\frac{\lambda_{top}}{m_{top}}\right)^2 \left(\frac{1}{16\pi^2}\right)^2$$

↖ loop

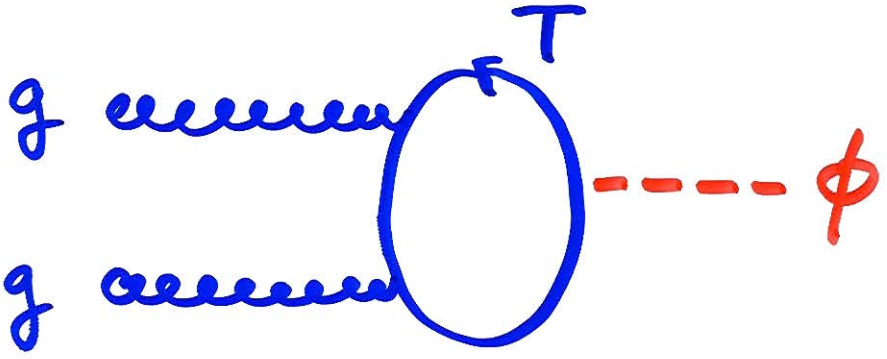
no Branching fractions / cuts



not a supermodel !

Example: Zoltan's ϕ

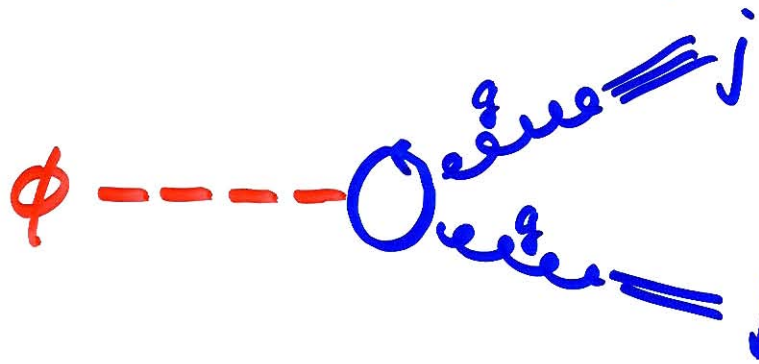
(Higgs on steroids)



$$\sigma \sim \alpha_s^2 \left(\frac{\lambda_\phi}{m_T}\right)^2 \left(\frac{1}{16\pi^2}\right)^2$$

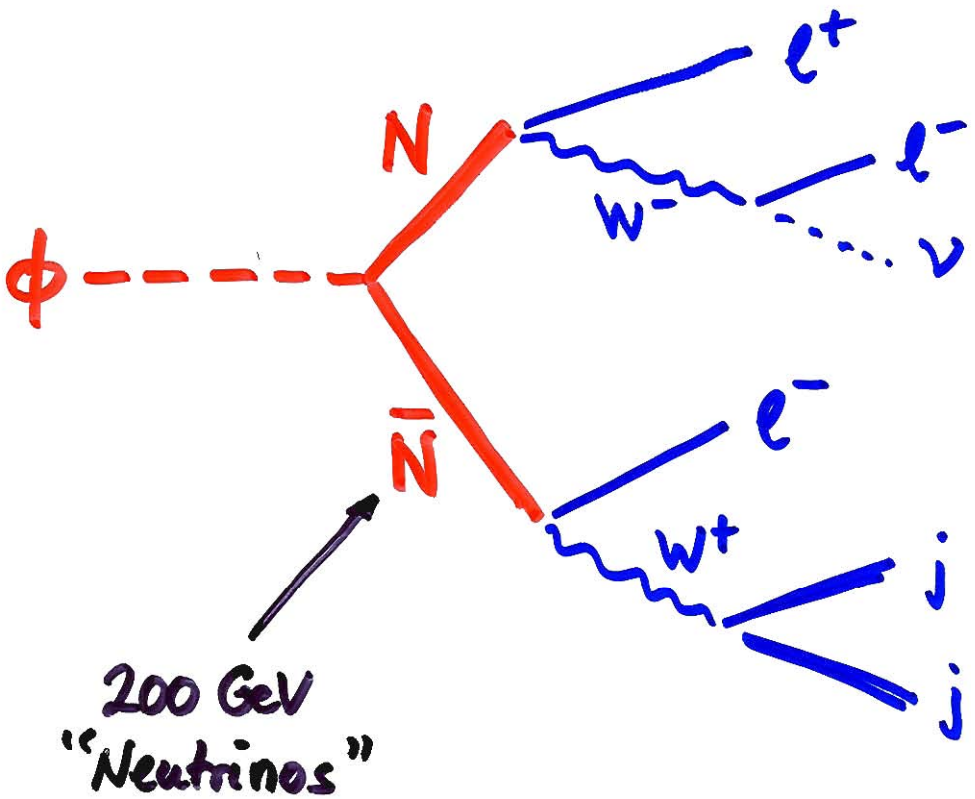
can be
10 × higgs σ

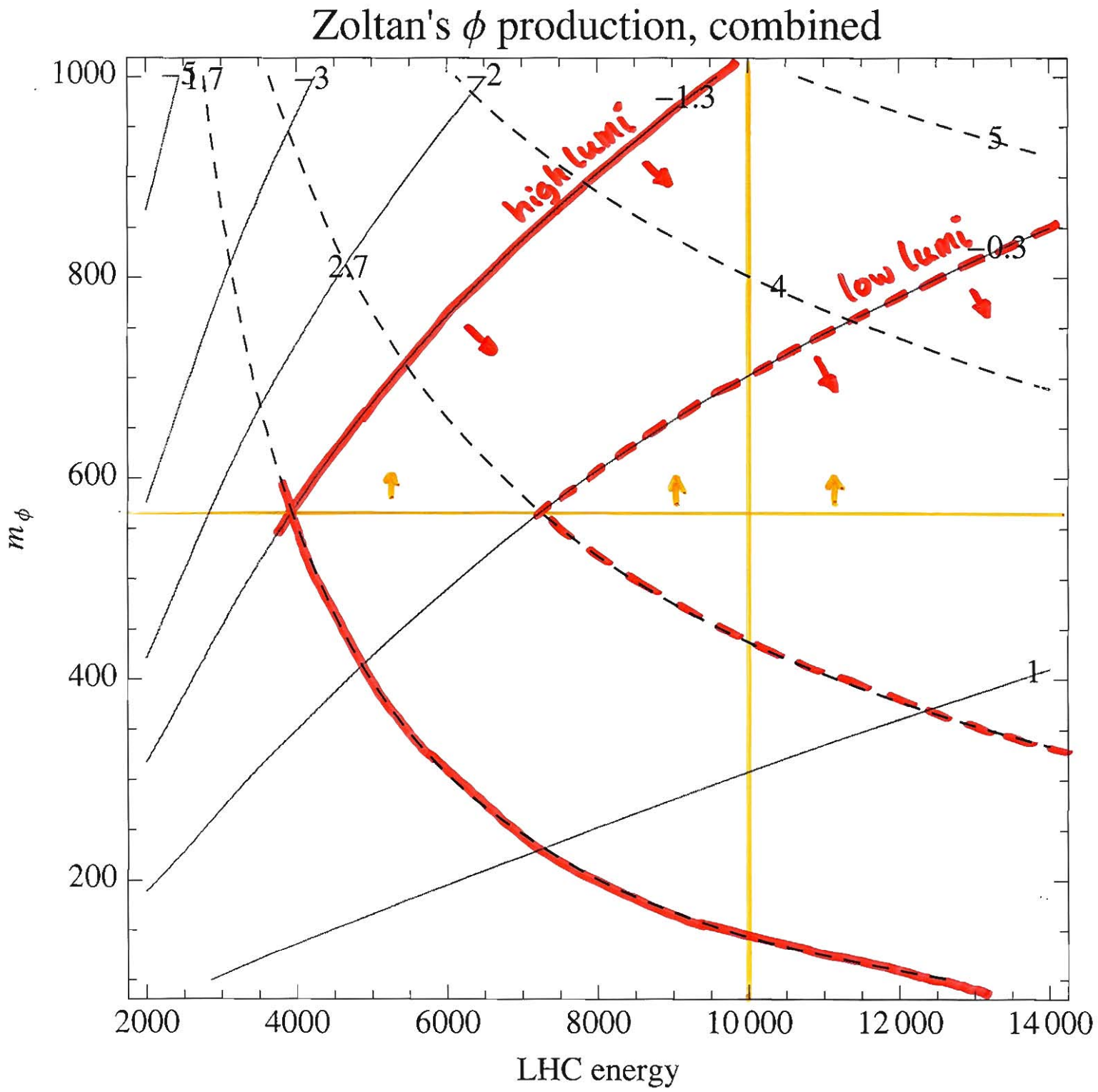
Zoltan's ϕ decays



suppressed

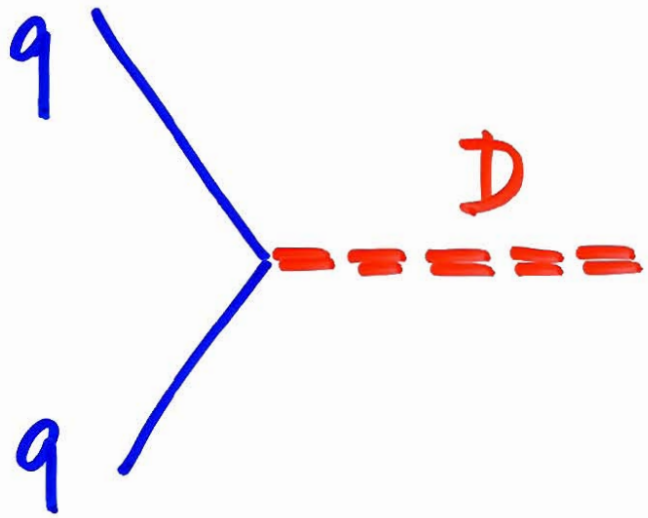
many possibilities e.g.



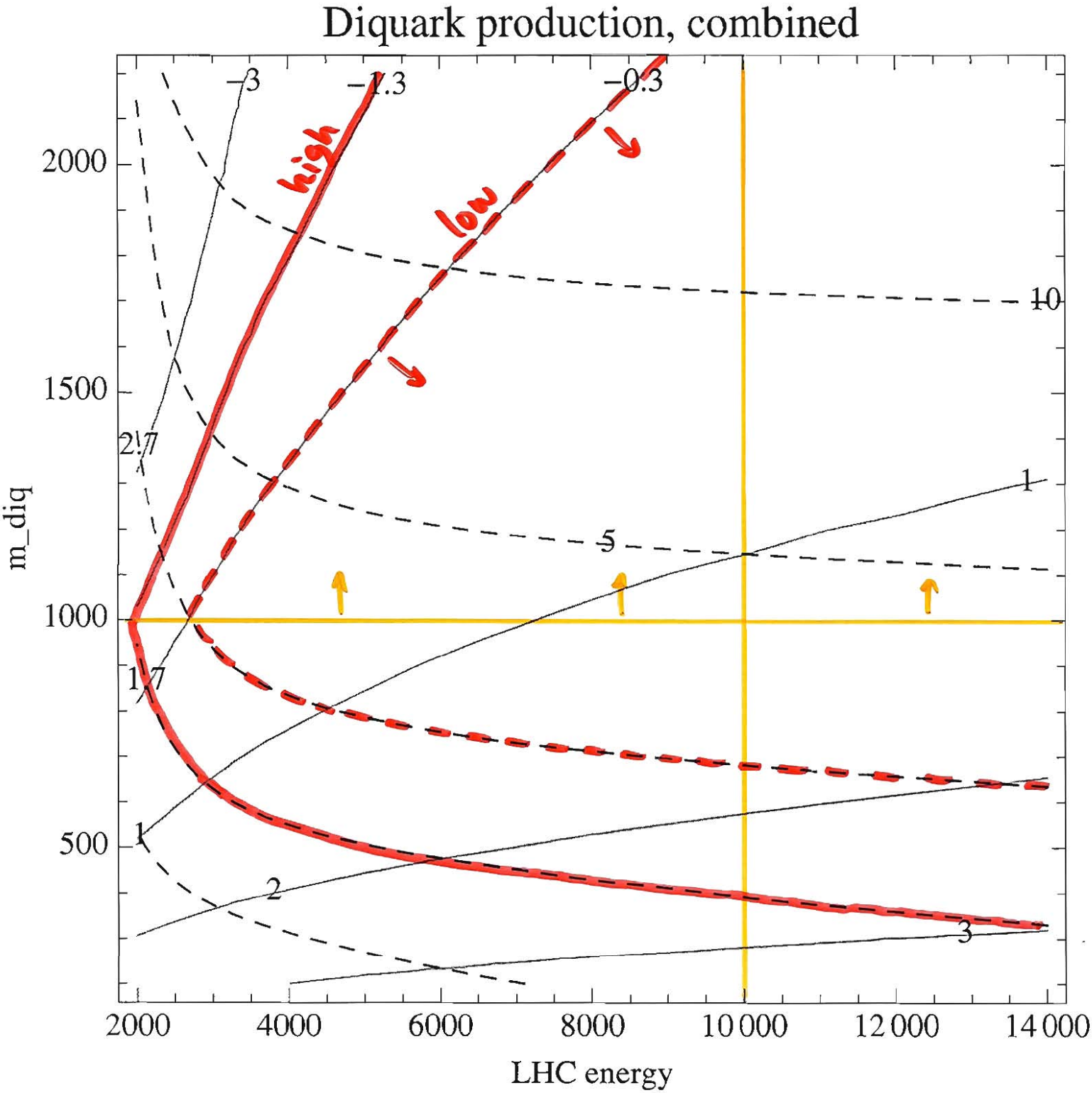


a little-super model ...

Example: super-diquark



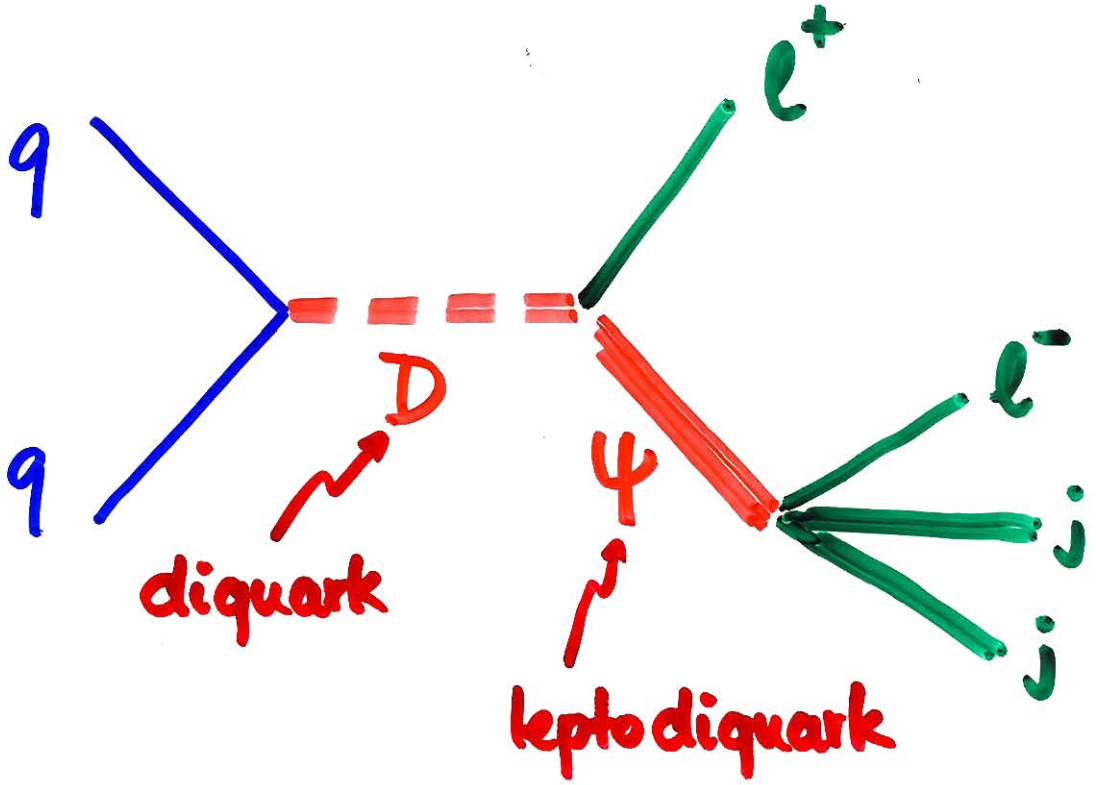
scalar or vector, colored, flavored



truly super !

(no Branching · no cuts)

Example: super-diquark

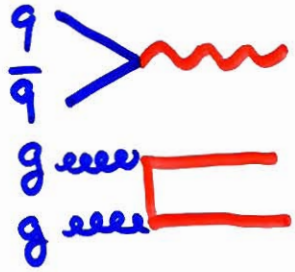


Conclusions (preliminary)

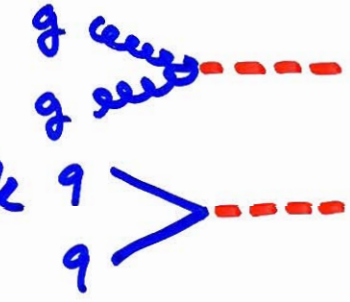
- no reach for MSUGRA, gM SUSY, Higgs, little Higgs,... even with 200 pb^{-1}
- huge difference between 200 & 20 pb^{-1}

beat Tevatron & discover with ...

- 200 pb^{-1}: Z'
  - stable quarks
  - lepto quarks



- 20 pb^{-1}: Zoltan's ϕ
  - super-diquark



(paper to appear)