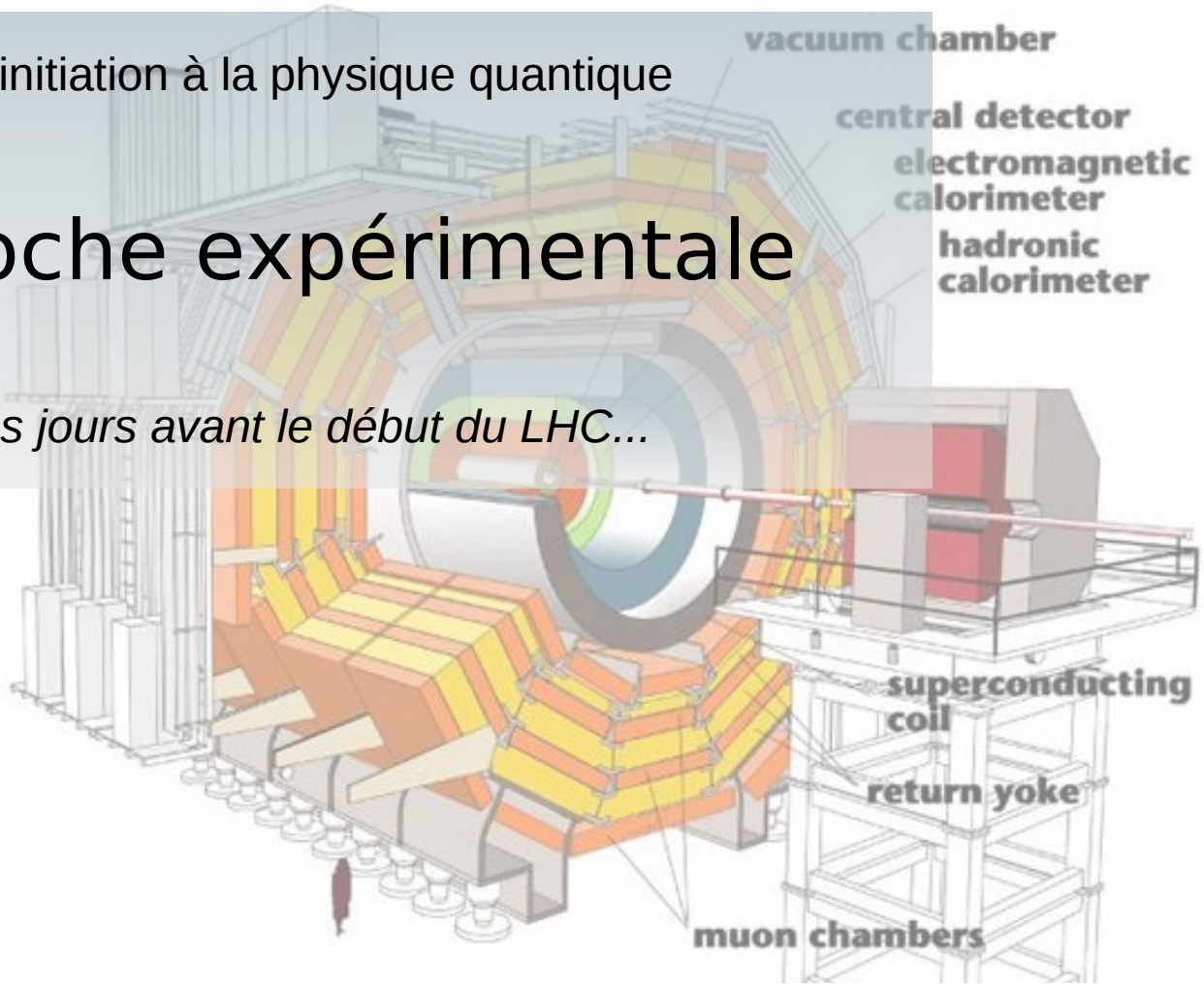
UCL
Université catholique de Louvain

Cours d'initiation à la physique quantique

Approche expérimentale

Quelques jours avant le début du LHC...



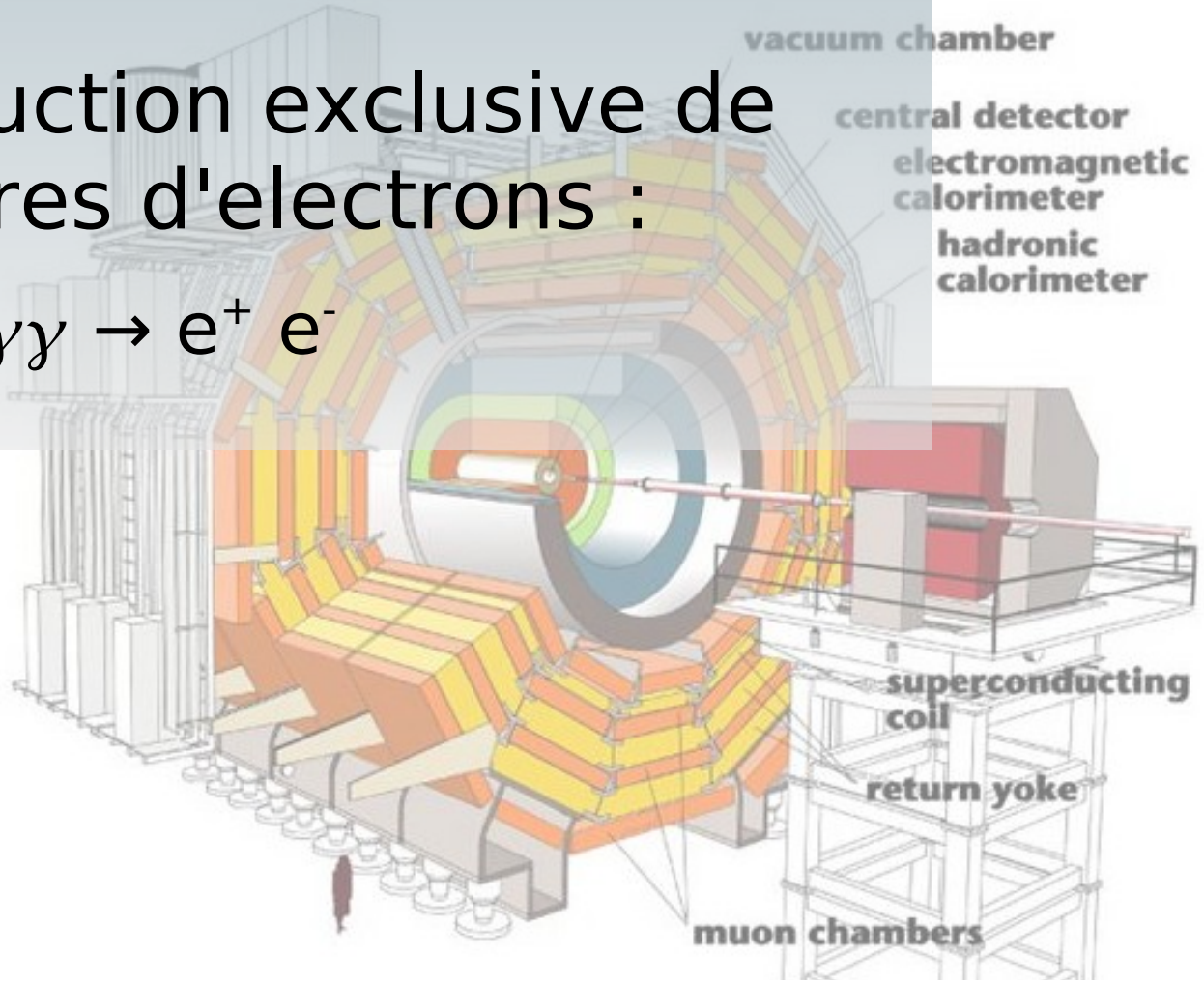
Diélectrons
Méson Upsilon
Higgs

UCL
Université catholique de Louvain

- Diélectrons
- Méson Upsilon
- Higgs

Production exclusive de paires d'electrons :

$\gamma\gamma \rightarrow e^+ e^-$



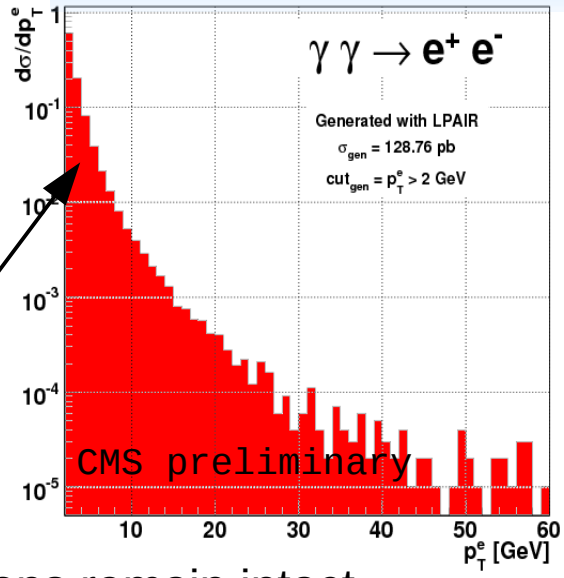
Exclusive electrons

Excl. Dielectrons
- intro
- selection
- measurement

Processus similaire à la production d'une paire de muons

$$pp(\gamma\gamma \rightarrow e^+e^-)pp$$

electron p_T



Very narrow peak at low p_T

Total cross section (LPAIR) :

7.1×10^{12} fb – no cut

10.4 fb – $p_T > 5.5$ GeV : elastic case : the protons remain intact

13.6 fb – $p_T > 5.5$ GeV : inelastic case : one proton dissociates

Like dimuons:

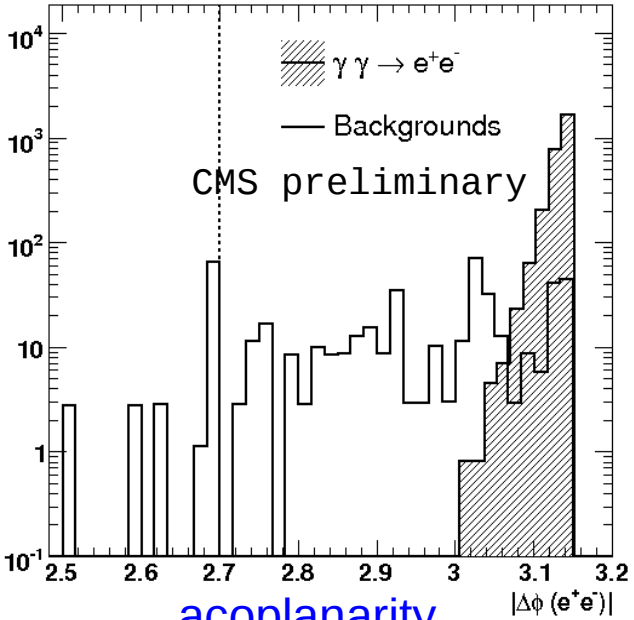
- Electrons are balanced in Δp_T and $\Delta\Phi$
- p_T distribution is really peaked at low values

Unlinke dimuons

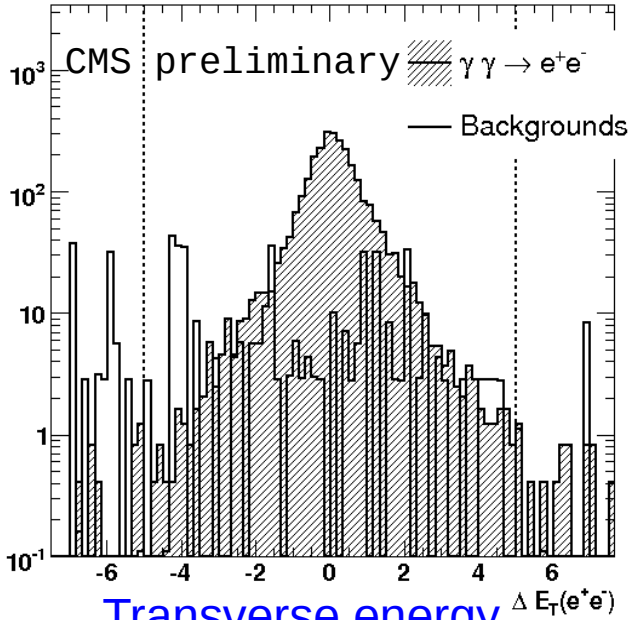
- Electrons are more difficult to reconstruct => higher thresholds

Exclusive dielectrons

- Trigger : p_T > 6 GeV + exclusivity — S. Ovyn's talk
  - Dedicated L1+HLT triggers
- Selection : similar to μ μ
  - Balance in acoplanarity and in E_T
  - Exclusivity conditions : tracking + calorimetry



acoplanarity



Transverse energy

Exclusive dielectrons

Similar process:
exclusive production of an electron-positron pair $pp(\gamma\gamma \rightarrow e^+e^-)pp$

Total cross section (LPAIR) :

7.1 x 10^{12} fb – no cut

10.4 fb – p_T > 5.5 GeV : elastic case : the protons remain intact

13.6 fb – p_T > 5.5 GeV : inelastic case : one proton dissociates

Like dimuons:

- Electrons are balanced in Δp_T and $\Delta\Phi$
- p_T distribution is really peaked at low values

Unlike dimuons

- Electrons are more difficult to reconstruct => higher thresholds

Dedicated trigger required !

Excl. Dielectrons
- intro
- **selection**
- measurement

Exclusive dielectrons

S Ovyn, X Rouby
CMS IN 2008 in preparation

Level 1 selection of $\gamma\gamma \to l^+l^-$ events

Very low luminosity phase

$\gamma\gamma \to \mu^+\mu^-$

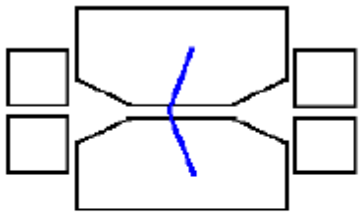
- Thresholds of the default dimuon triggers are already as low as 3 GeV (L1) and (HLT)
-

$\gamma\gamma \to e^+e^-$

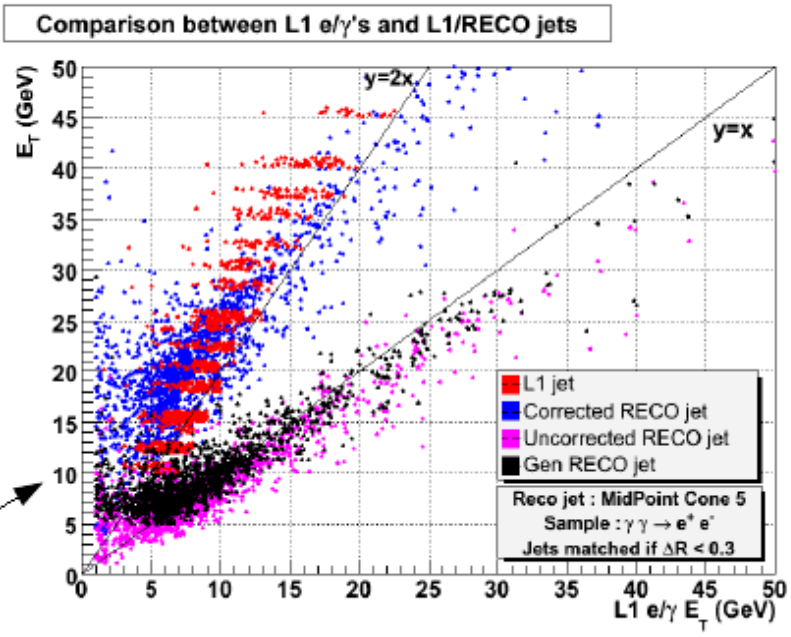
- Very low transverse momentum of the leptons
- High threshold of the defaults di-egamma trigger
- ➡ Need a special trigger

- Goals :
  - decrease the thresholds of the default level1 triggers
  - preserve the output rate

Add exclusivity requirement specific to $\gamma\gamma \to l^+l^-$



L1 e/γ are seen as jets candidates

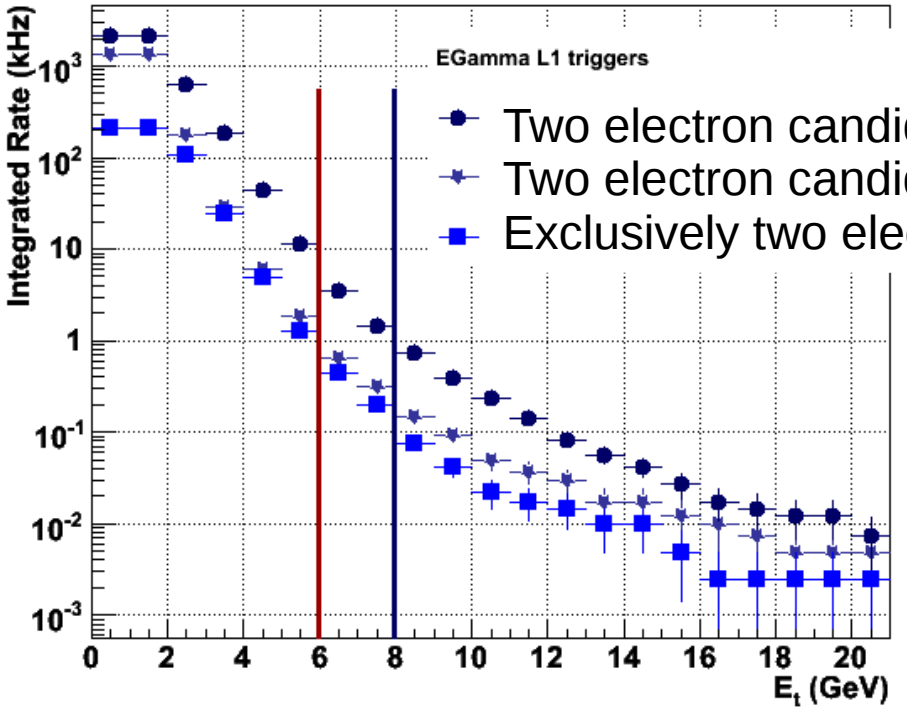


Depends on the energy scale applied on the jets

Exclusive dielectrons

Trigger conditions :

- at least 2 e/γ candidates with a p_T bigger than a threshold value
- nothing else ...



LPAIR

$p_T^e > 5.5$ GeV

Rates for 10^{32} cm^{-2} s^{-1}

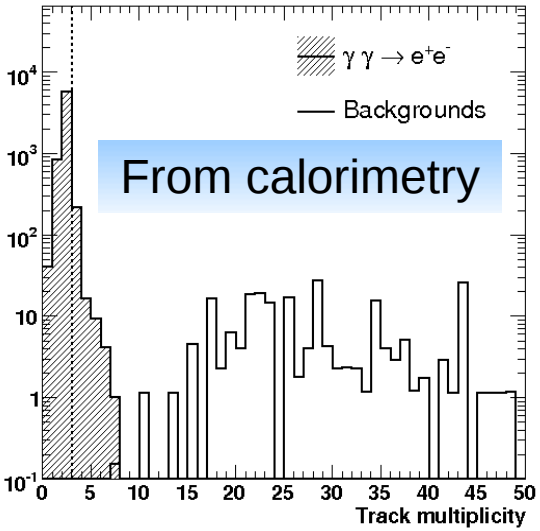
	p_T^e (GeV)	Rates (kHz)	ϵ(%)
Default trigger	8	0.73	10.99
New trigger	6	0.45	15.91

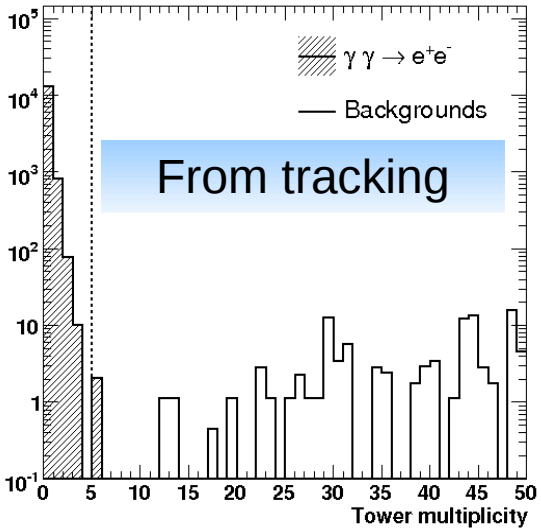
Events passing the exclusive 2 e/γ trigger must satisfy a dedicated High Level Trigger

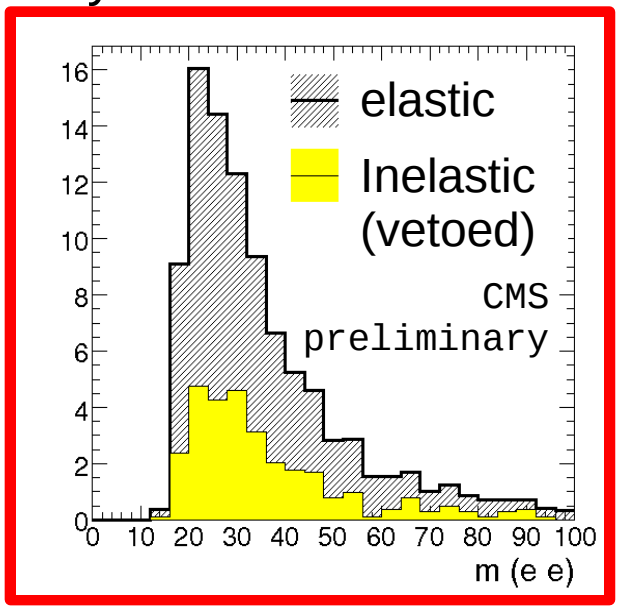
Exclusive dielectrons

- Selection (continued)
  - Balance in acoplanarity and in E_T
  - Exclusivity conditions : tracking + calorimetry

JJ Hollar, S Ovyn, X Rouby
CMS PAS DIF-07-001







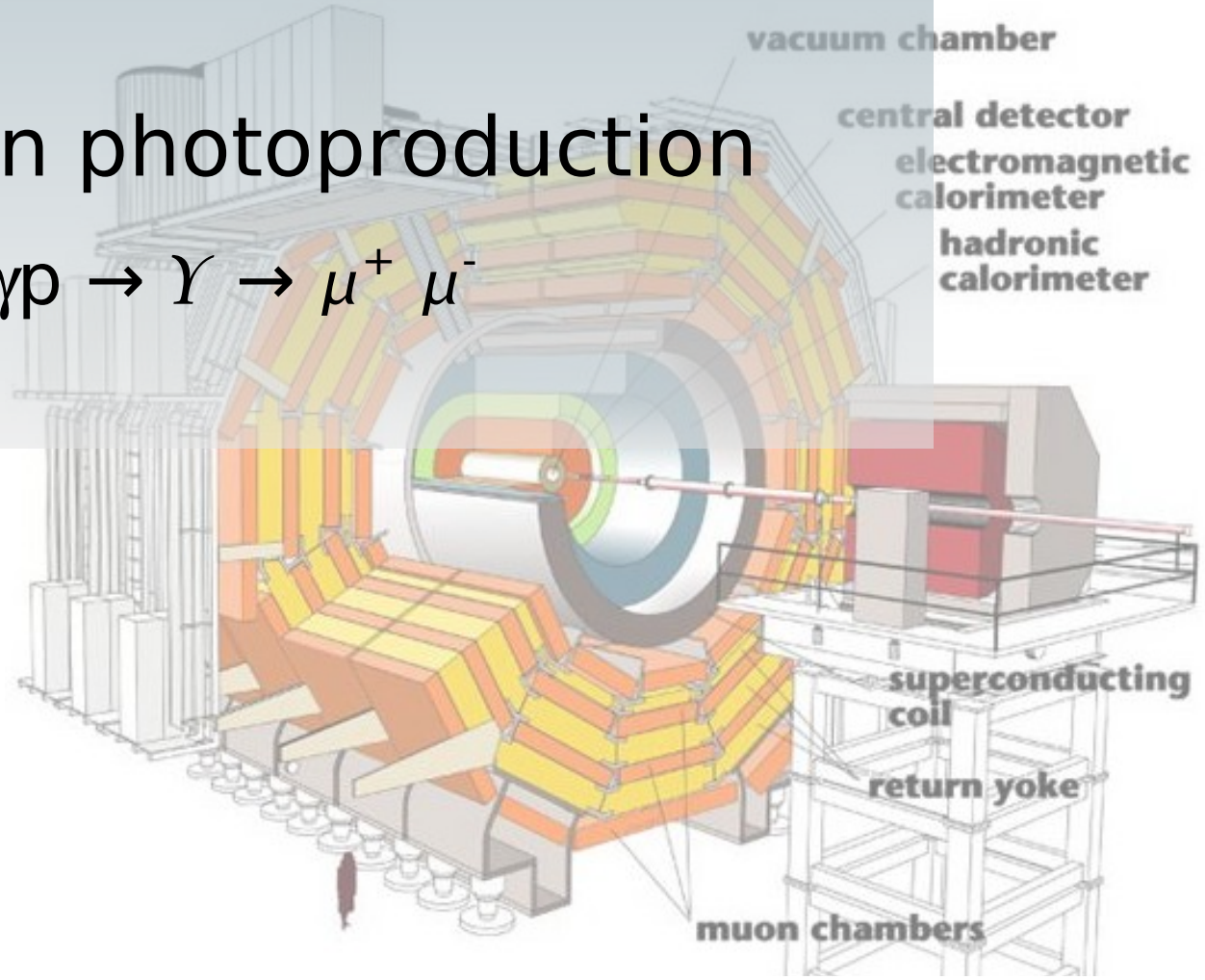
L = 100 pb^{-1}

$$N_{elastic}(\gamma\gamma \to e^+e^-) = 67 \pm 8(stat)$$
$$N_{inelastic}(\gamma\gamma \to e^+e^-) = 82 \pm 9(stat) \pm 15(model)$$
$$N^{w/veto}_{inelastic}(\gamma\gamma \to e^+e^-) = 31 \pm 6(stat) \pm 6(model)$$

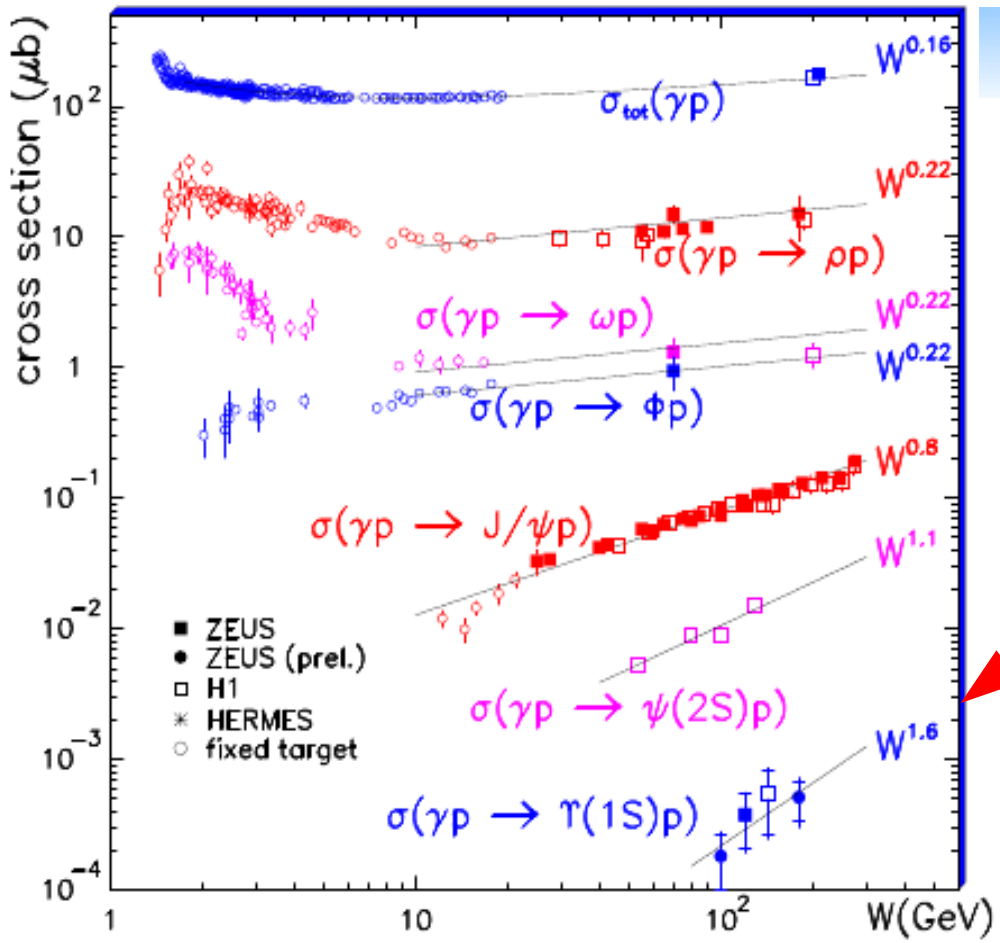
Interesting but 10x smaller sample than for dimuons

Upsilon photoproduction

$$\gamma p \rightarrow \Upsilon \rightarrow \mu^+ \mu^-$$



Upsilon photoproduction



photon – proton interaction

Mass and branching ratio

(1S) m = 9.46 GeV

BR(μμ) = 2.48%

(2S) m = 10.02 GeV

BR(μμ) = 1.93%

(3S) m = 10.36 GeV

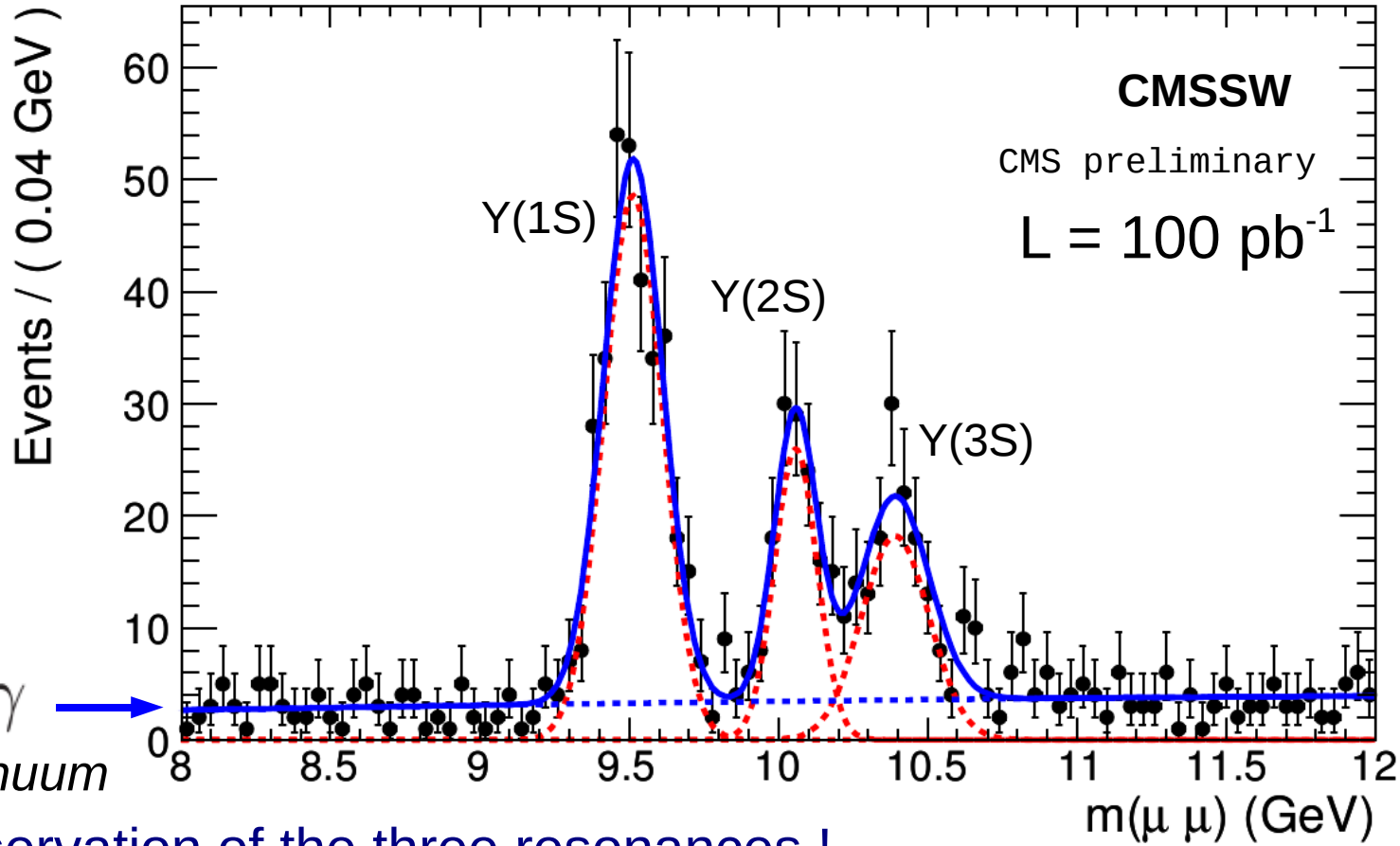
BR(μμ) = 2.18%

Process	σ_{prod} (pb)	Generator
$\gamma I\!P \to \Upsilon \to \mu^+\mu^-$	12 (1S)	PHITI
$\gamma I\!P \to \Upsilon \to \mu^+\mu^-$	39 (1S), 13 (2S), 10 (3S)	STARLIGHT

Upsilon: measurement

JJ Hollar, S Ovyn, X Rouby
CMS PAS DIF-07-001

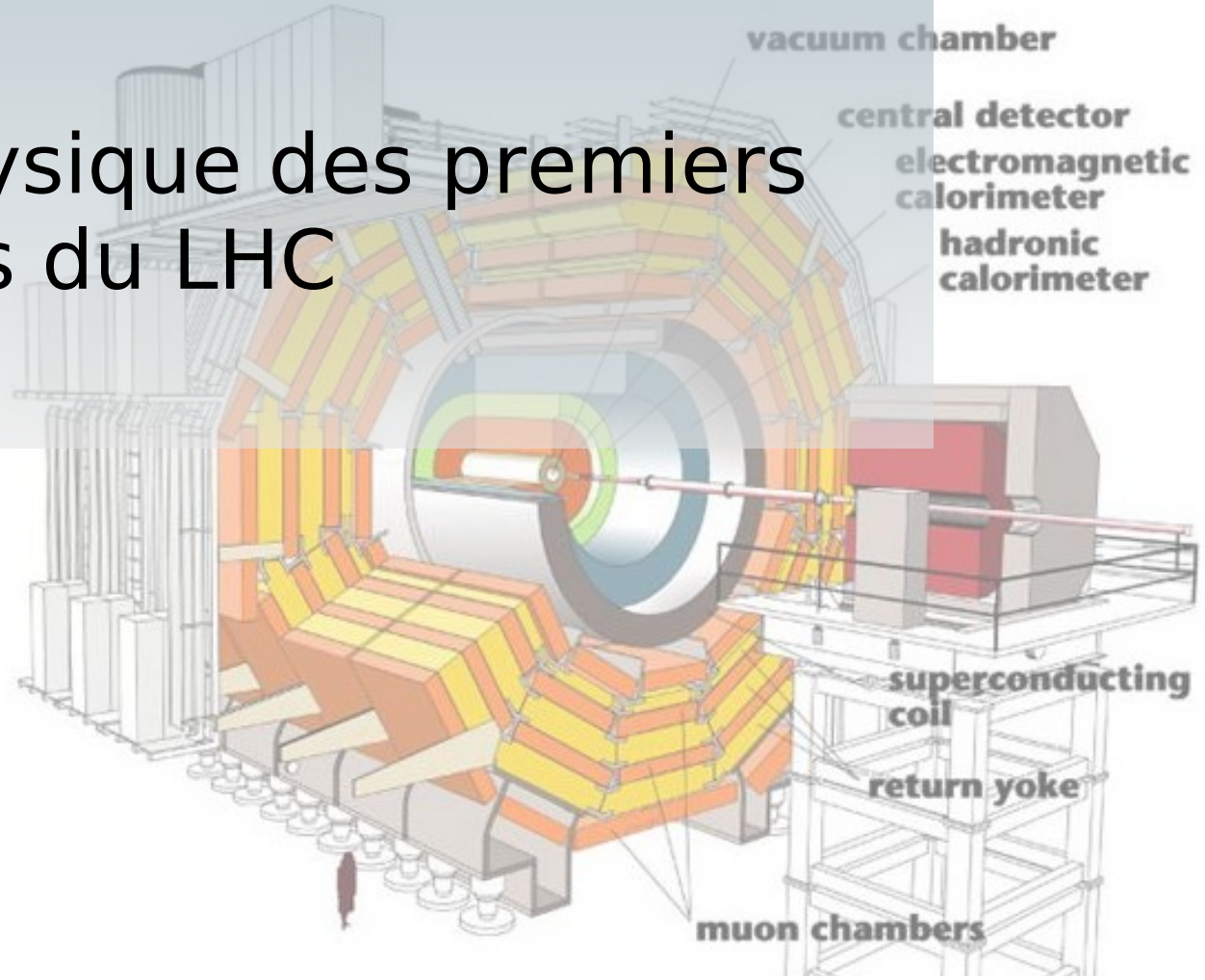
Selection of the dimuon pairs as before



Observation of the three resonances !

- low p_T track calibration
- detector alignment
- sensitivity to very low-t distributions

La physique des premiers jours du LHC



Taux d'événements

$\mathcal{L} = 2 \times 10^{33}\,\mathrm{cm}^{-2}\,\mathrm{s}^{-1}$ (en supposant 20 fb^{-1}/an)

Processus	Nombre/s	Nombre/an
$W \to e\nu$	40	$4 \cdot 10^8$
$Z \to ee$	4	$4 \cdot 10^7$
$t\bar{t}$	1.6	$1.6 \cdot 10^7$
$b\bar{b}$	10^6	10^{13}
$\tilde{g}\tilde{g}$ (m = 1 TeV)	0.002	$2 \cdot 10^4$
Higgs (m= 120 GeV)	0.08	$8 \cdot 10^5$
Higgs (m= 120 GeV)	0.08	$8 \cdot 10^5$
Higgs (m= 800 GeV)	0.001	10^4
QCD jets $p_T > 200$ GeV	10^2	10^9

Prérequis pour une analyse...

- Génération des événements (monte-carlo)
- Simulation de la réponse du détecteur
- Reconstruction
  - Trigger : sélection “en ligne”
  - Analyse : sélection “en différé”
    - Signal
    - Bruits de fond (réductible / irréductible / pile-up)
    - Erreurs systématiques

Effet du pile-up

- Section efficace inélastique ~ 80 mb.
- 40 MHz mais 2808/3584 “bunches” f_{BX}

$$p(n;\mu) = \mu^n \frac{e^{-\mu}}{n!}$$

Nombre moyen de collisions:

statistique de Poisson

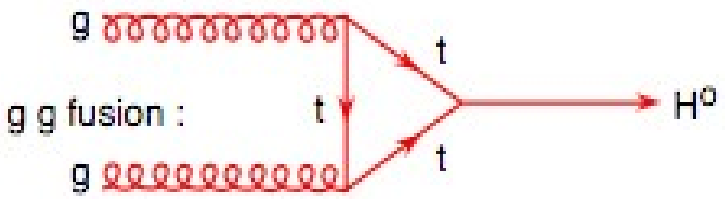
$$\boxed{\mu = \frac{\sigma \mathcal{L}}{f_{BX}}}$$

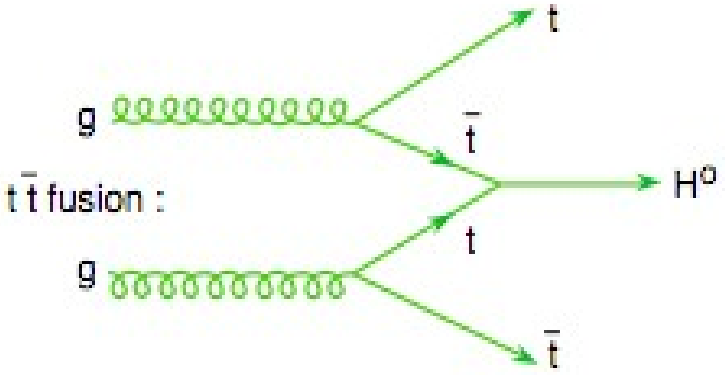
$$\mathcal{L} = 2 \times 10^{33}\,\mathrm{cm}^{-2}\,\mathrm{s}^{-1} \qquad \mu \approx 5$$

$$\mathcal{L} = 10^{34}\,\mathrm{cm}^{-2}\,\mathrm{s}^{-1} \qquad \mu \approx 25$$

Recherche du boson de Higgs

1) Production

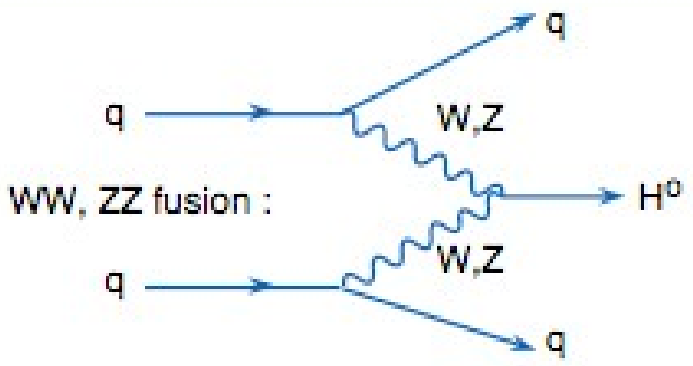




Fusion gluon gluon

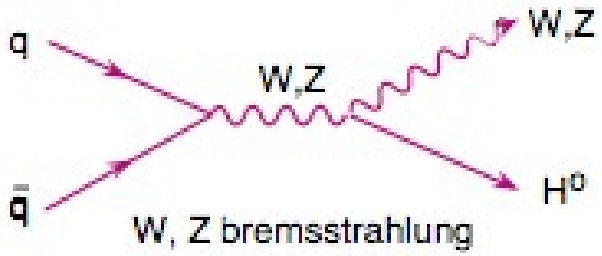
Recherche du boson de Higgs

1) Production



Vector Boson Fusion

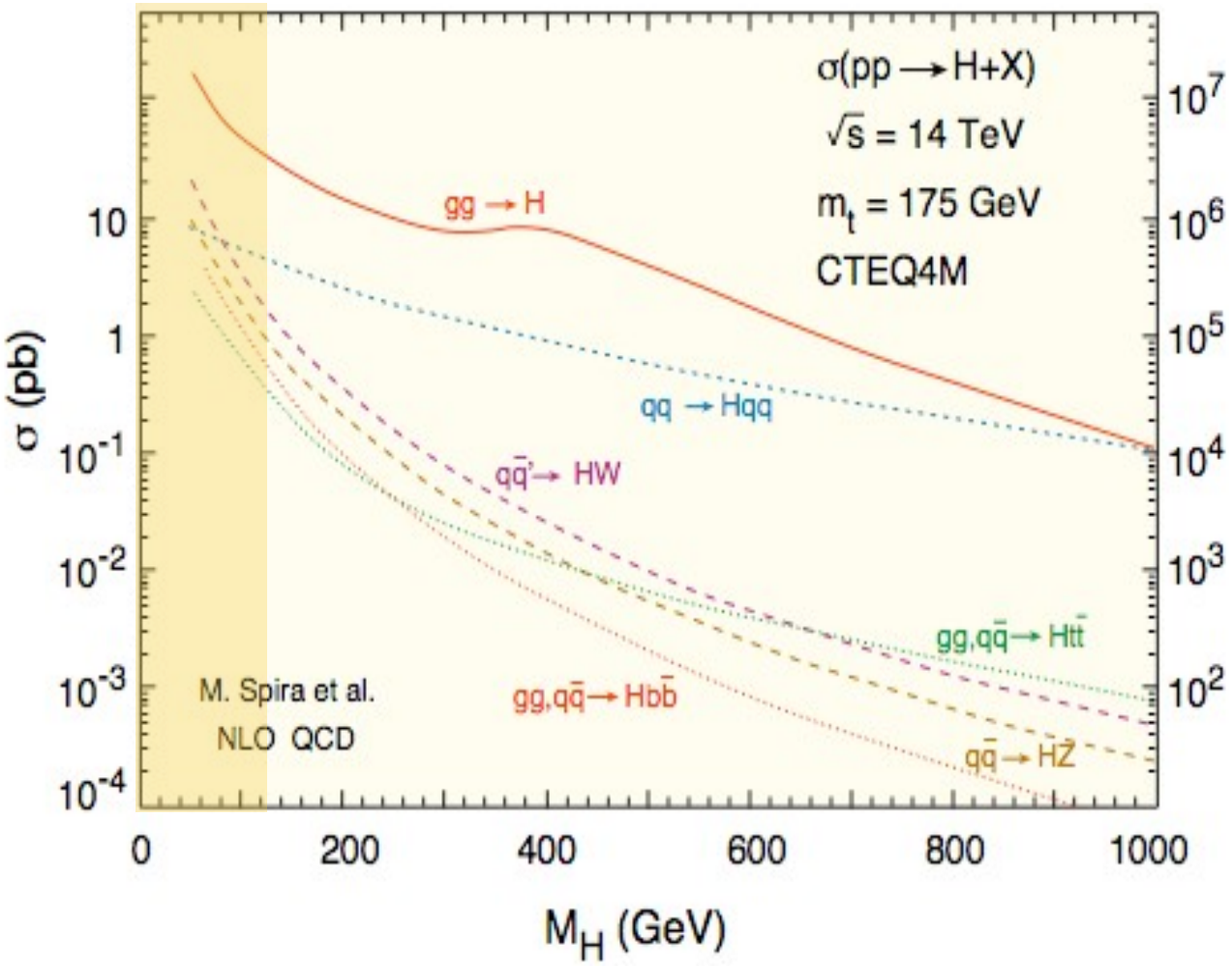
2 jets vers l'avant !
W/Z : pas d'échange de couleur



Productions associées WH ou ZH

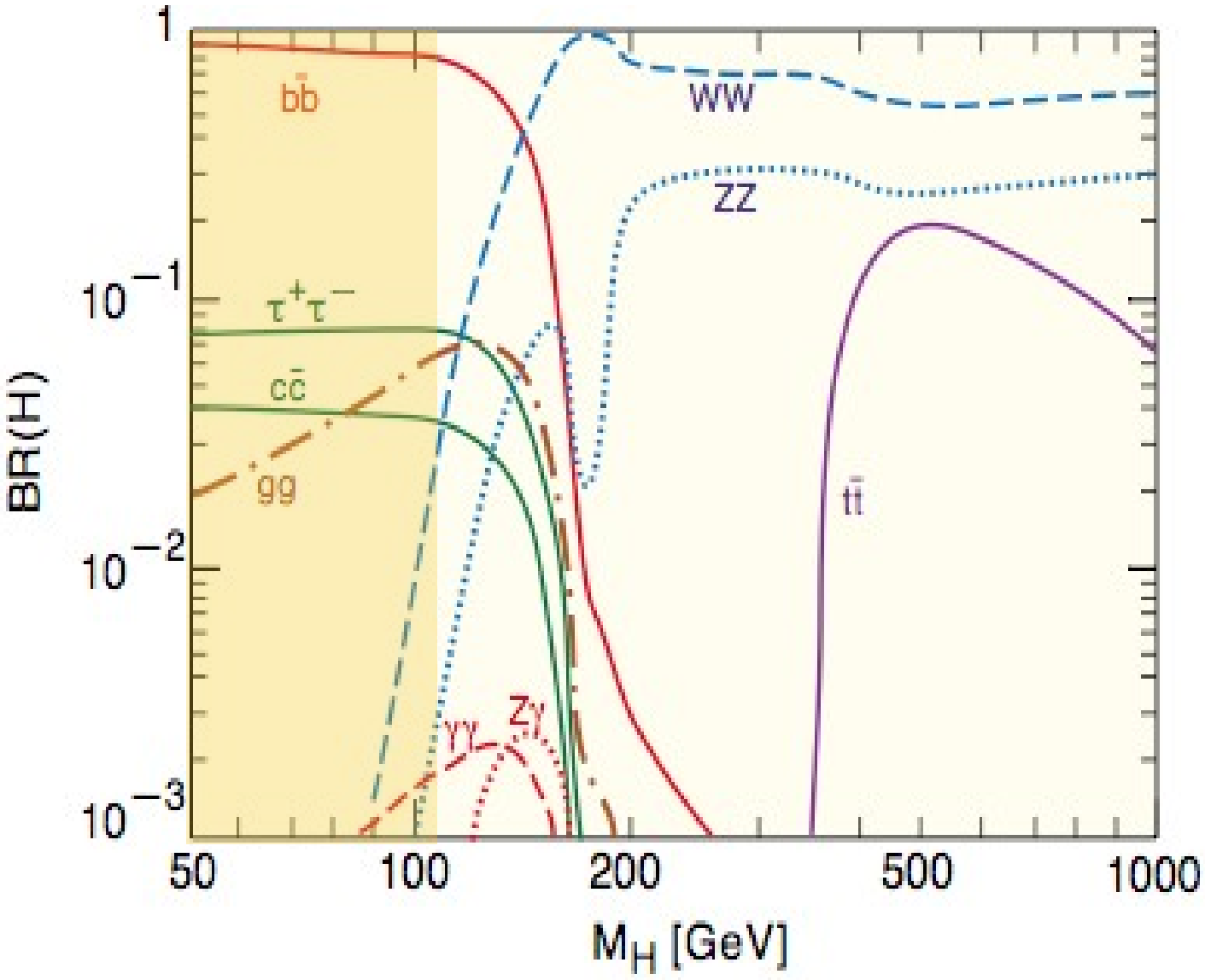
Recherche du boson de Higgs

1) Production



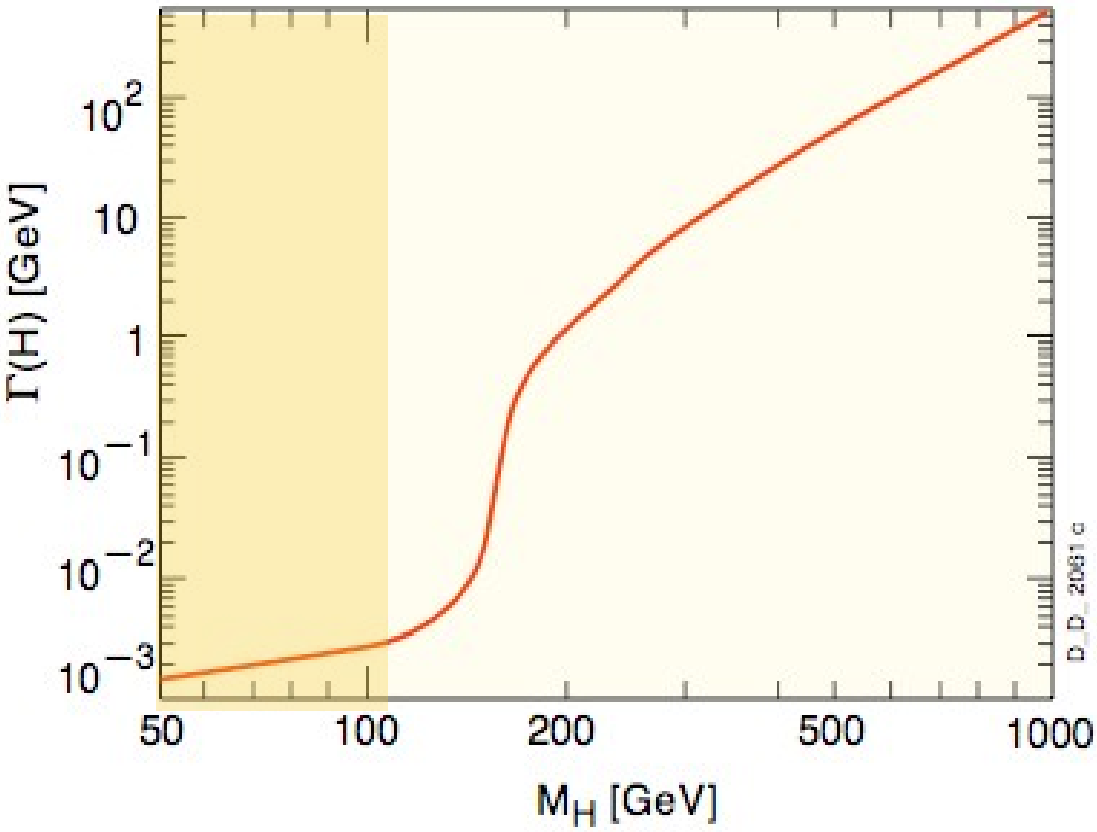
Recherche du boson de Higgs

2) Désintégration



Recherche du boson de Higgs

Largeur du Higgs



Recherche au LEP

Topologies: (*Higgs-strahlung*)

$$e^+e^- \to (h \to b\bar{b})(Z^0 \to q\bar{q})$$ 4 jets

$$e^+e^- \to (h \to b\bar{b})(Z^0 \to \nu\bar{\nu})$$ 2 jets + MET

$$e^+e^- \to (h \to b\bar{b})(Z^0 \to e^+e^-, \mu^+\mu^-)$$

2 jets + leptons

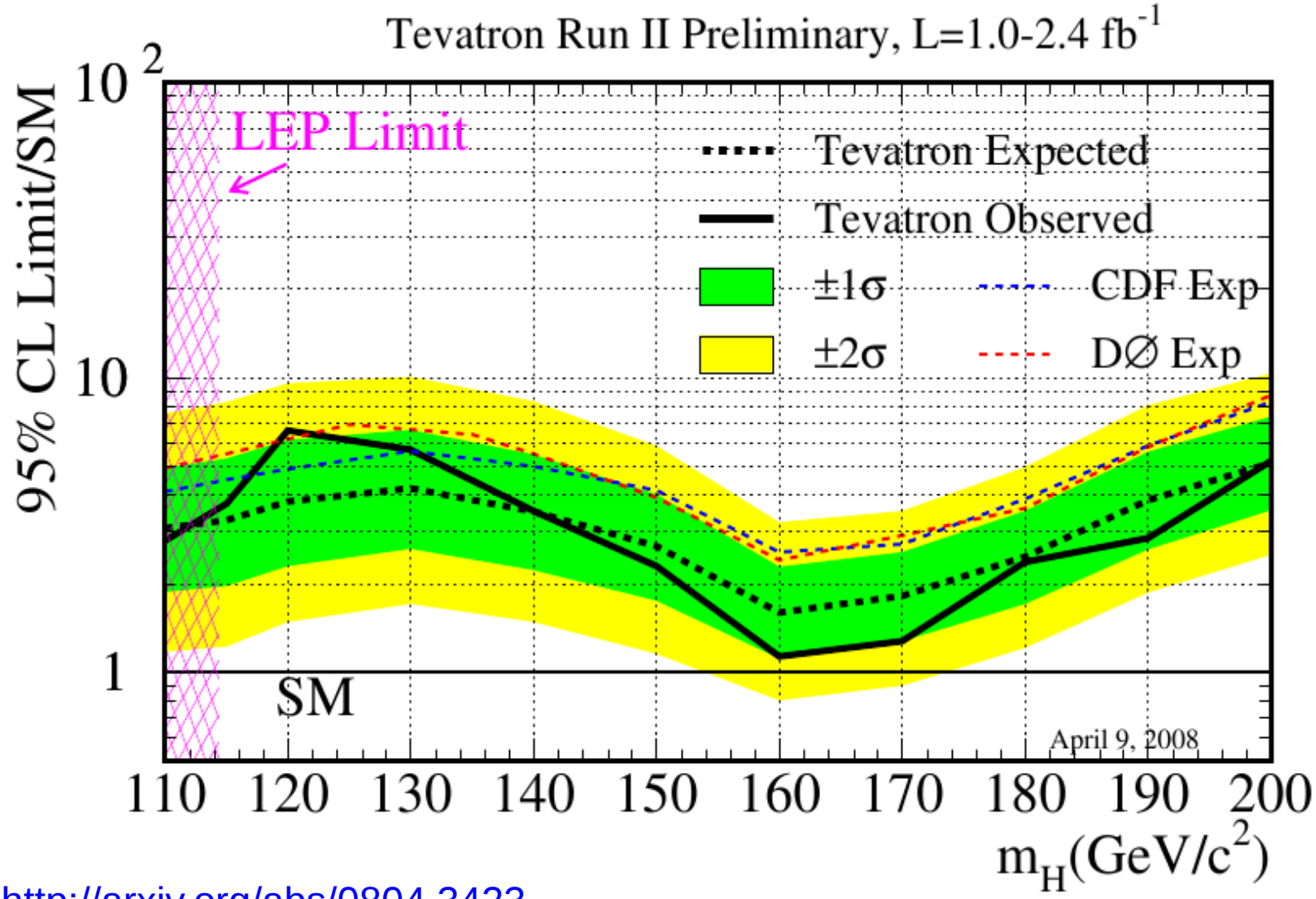
$$e^+e^- \to (h \to q\bar{q})(Z^0 \to \tau^+\tau^-)$$
$$(h \to \tau^+\tau^-)(Z^0 \to q\bar{q})$$

2 jets + 2 taus

$M_H > 114.4$ GeV (95% CL)

Recherche au Tevatron

Collisions $p\bar{p}$ à $\sqrt{s} = 1.96$ TeV



http://arxiv.org/abs/0804.3423