Irfu
Institut de recherche sur les lois fondamentales de l'Univers

Résumé des conférences d'hiver 2012

"résultats accélérateurs"

Frédéric Déliot

avec Eric Armengaud et Fabrice Couderc

séminaire Irfu/Spp - 27 avril 2012

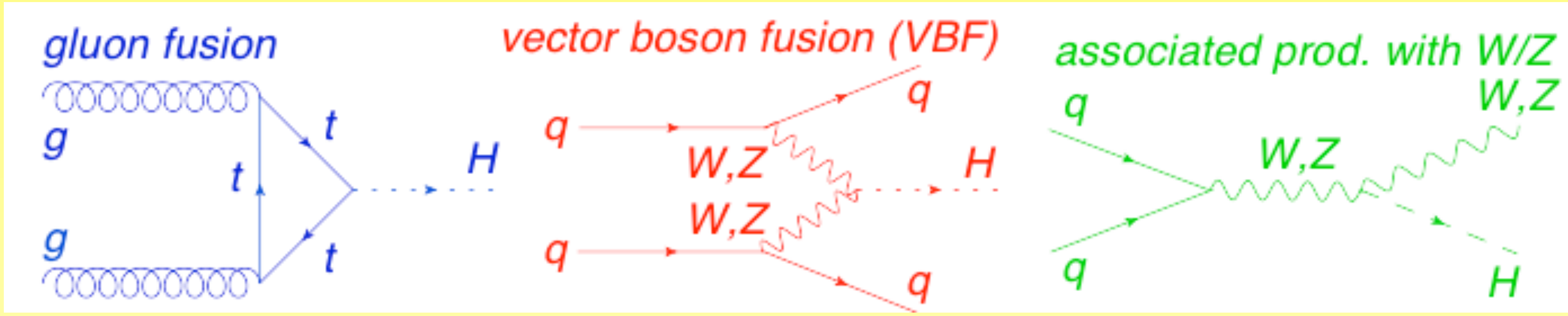
Greatest Highlights

results to take home

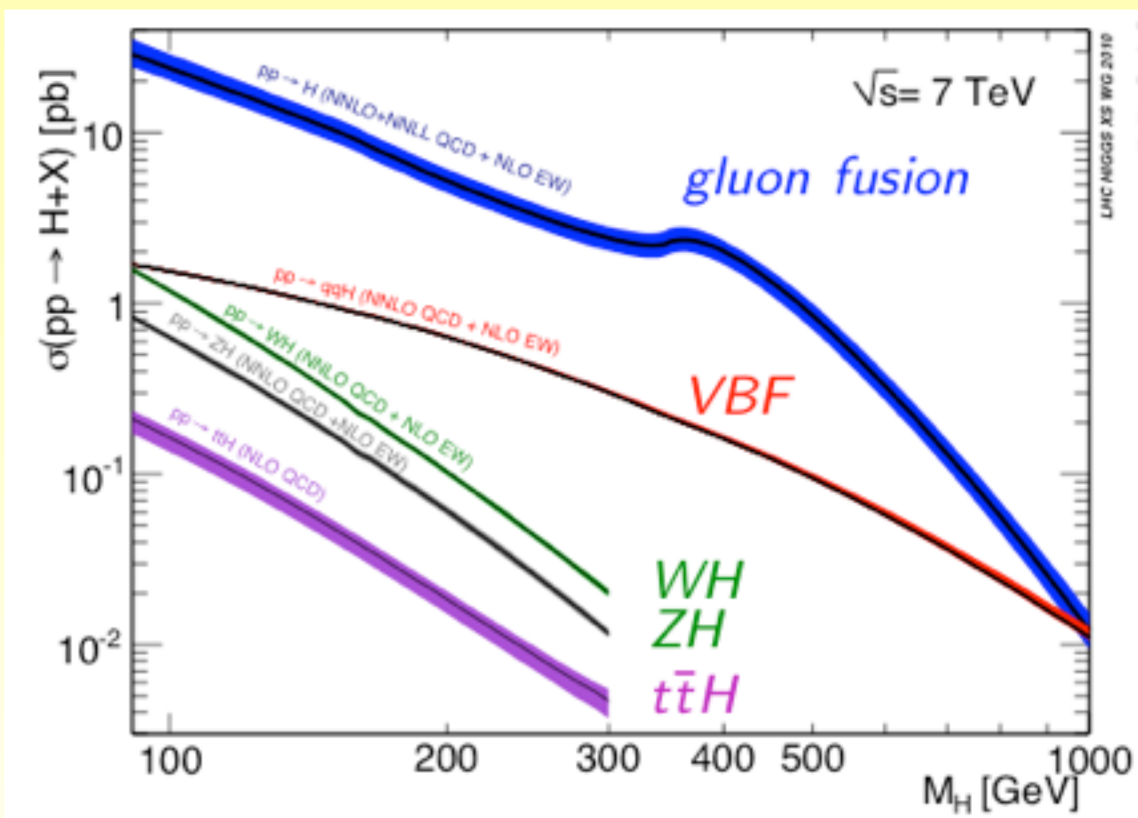
- recherche du boson de Higgs au Tevatron et au LHC
- neutrino: mesure de θ_{13}
- limite sur $B_s \longrightarrow \mu\mu$ de LHCb

Caveat: les transparents suivants ne sont qu'un copier-coller de morceaux choisis parmi les présentations de Moriond electroweak.

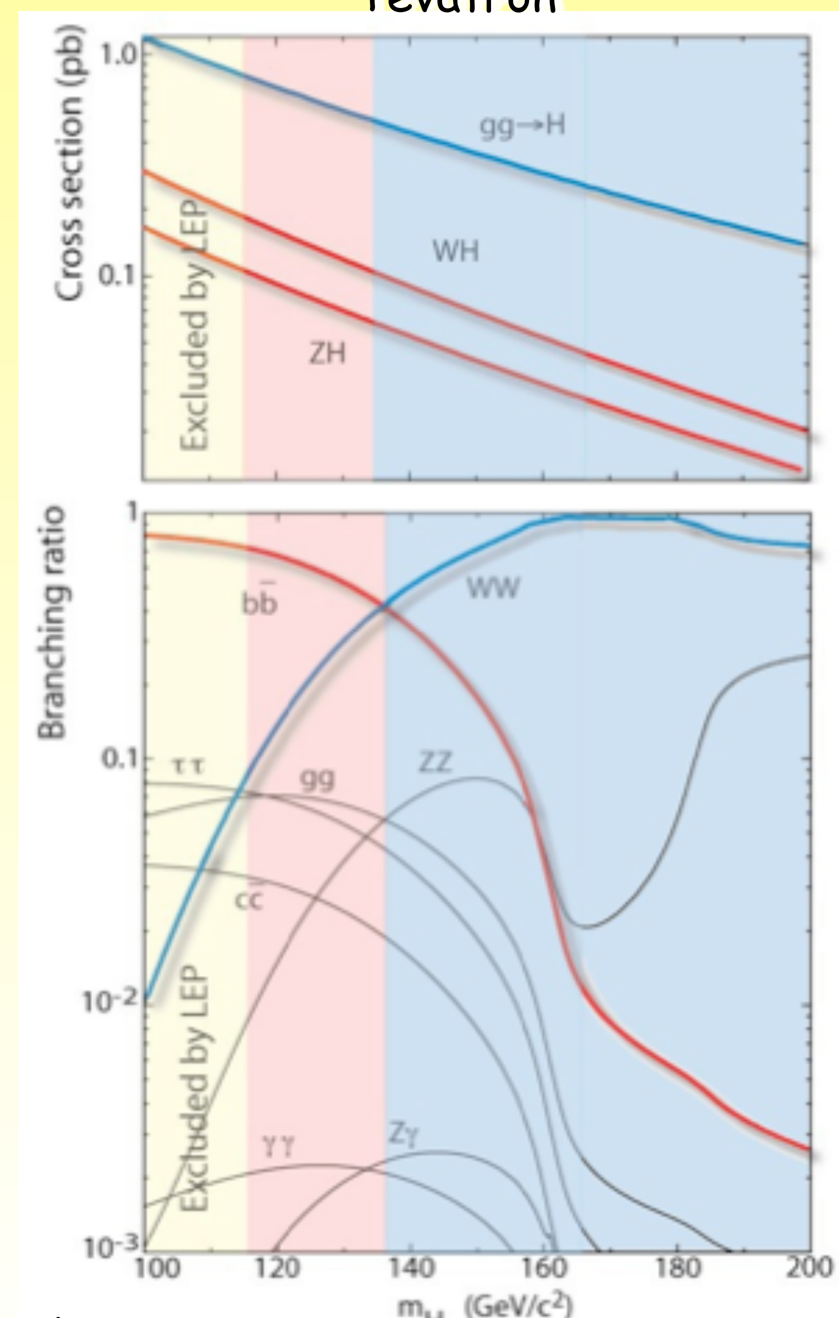
Recherche du boson de Brout-Englert-Higgs



LHC



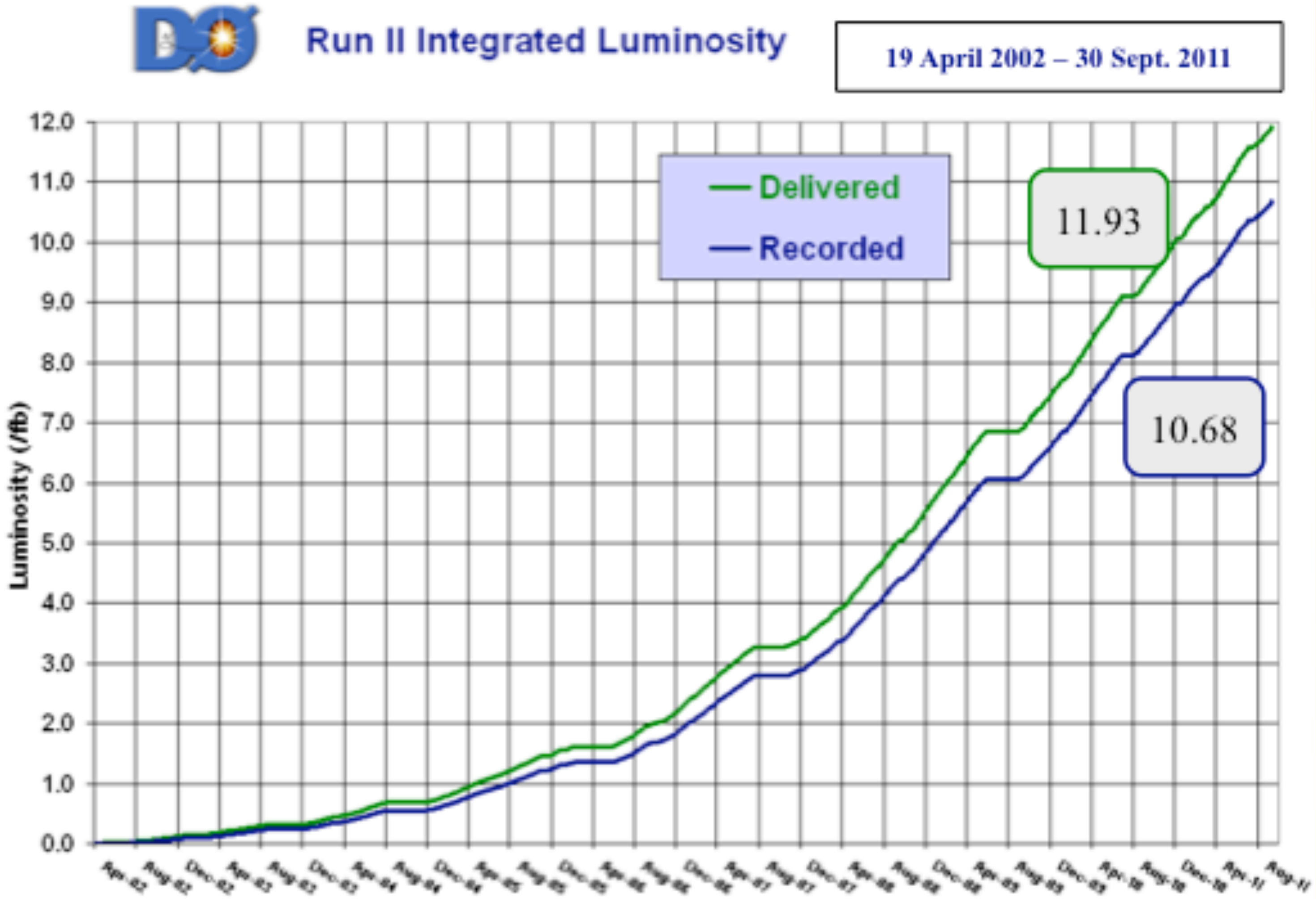
Tevatron



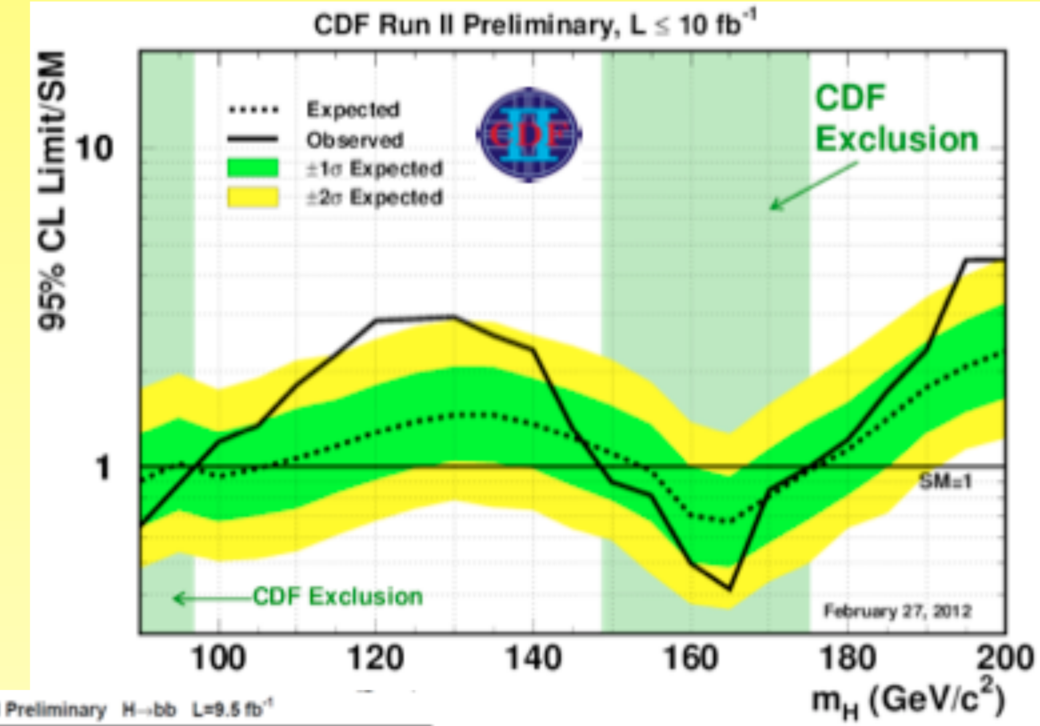
Recherche du boson de Brout-Englert-Higgs au Tevatron

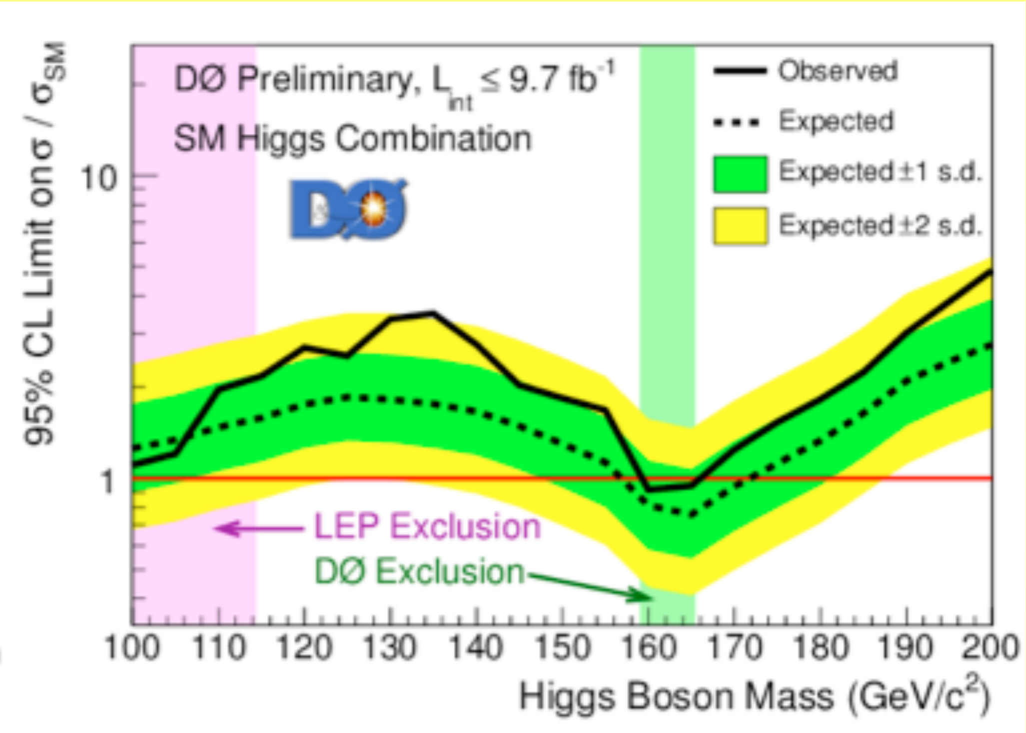
$p\bar{p}$ collider with $\sqrt{s}$ = 1.96 TeV

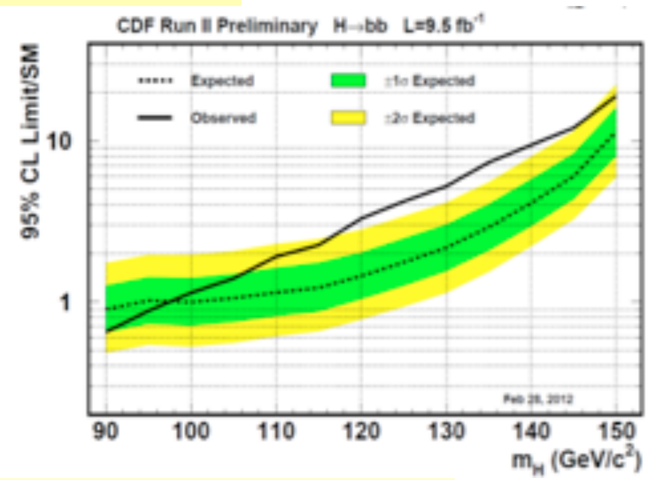
- Shutdown September 30, 2011 after 26 years of outstanding operation
- First superconducting accelerator
- Delivered ~11.9 fb^{-1}
- Recorded ~10.7 fb^{-1}
- Good Data Quality ~9.7 fb^{-1}

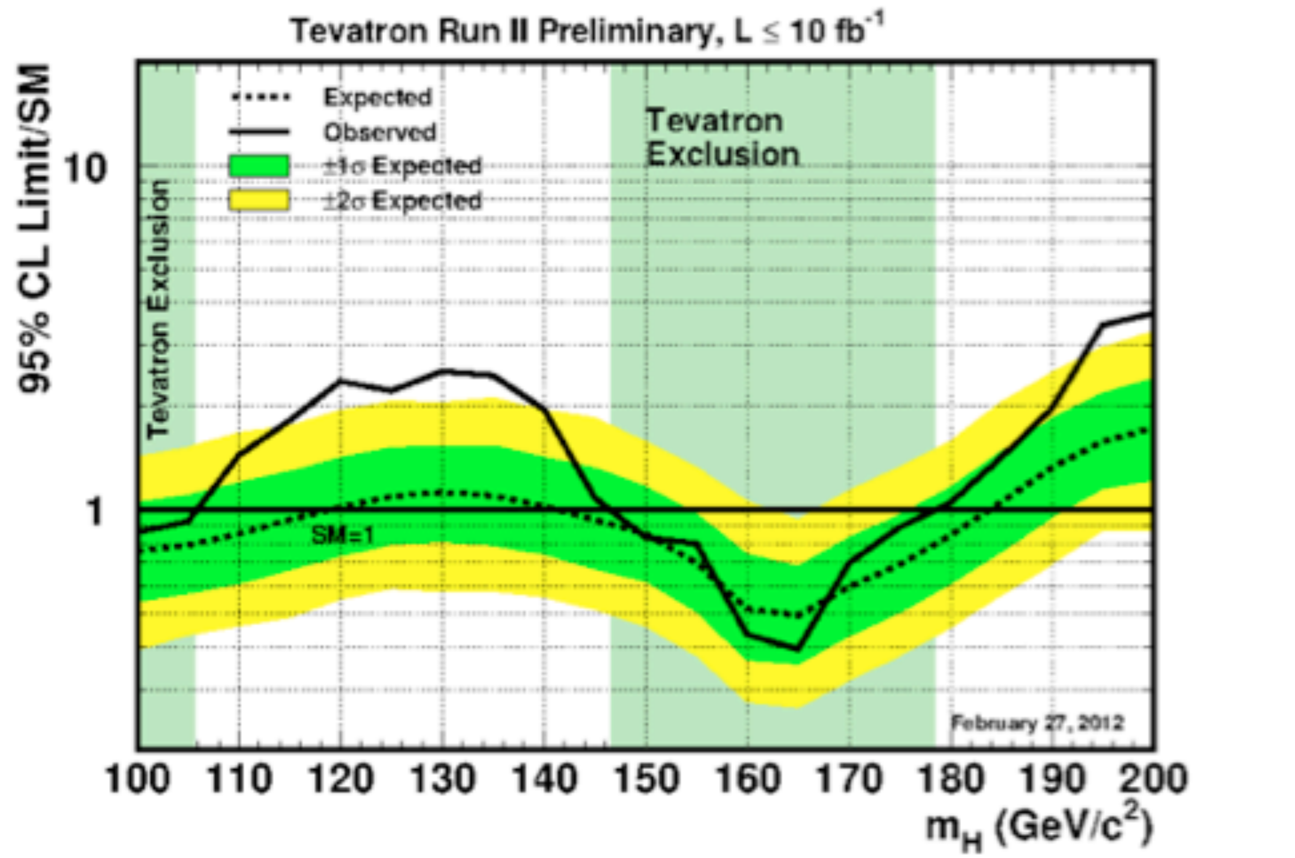


Recherche du boson de Brout-Englert-Higgs au Tevatron



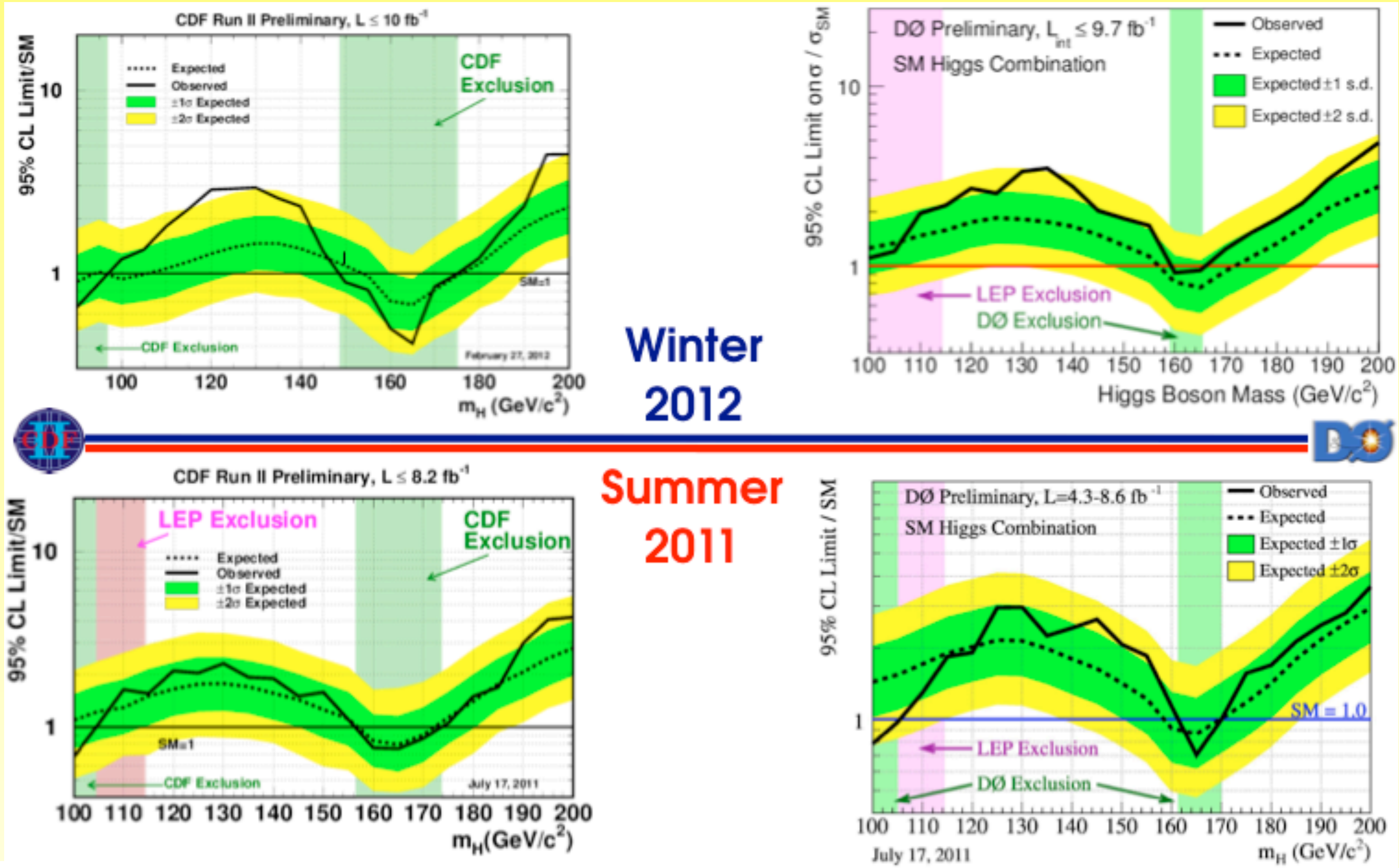






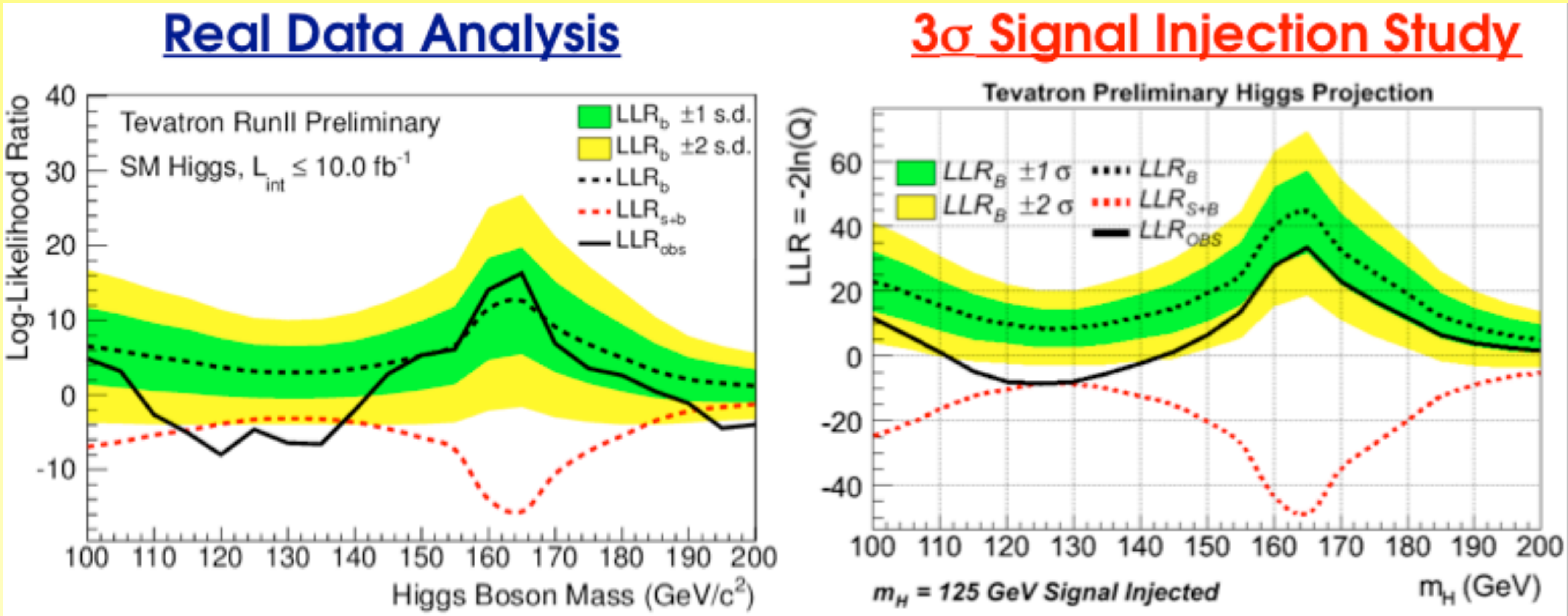
- 95% C.L. upper limits on SM Higgs boson production at the Tevatron
  - Expected exclusion: **100 < M_H < 120 GeV** 141 < M_H < 184 GeV
  - Observed exclusion: **100 < M_H < 106 GeV** 147 < M_H < 179 GeV

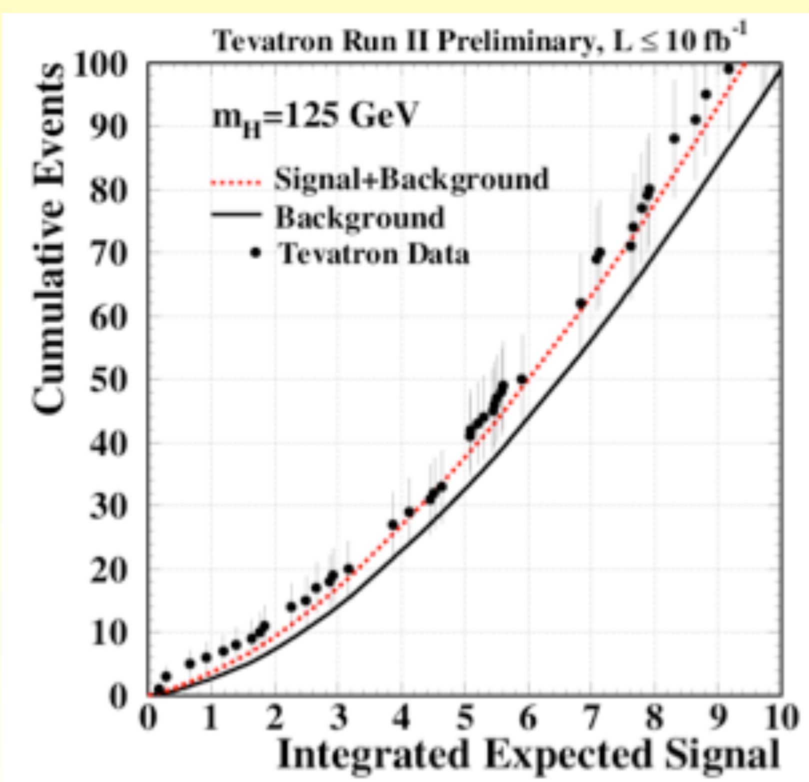
Recherche du boson de Brout-Englert-Higgs au Tevatron



- 2012: New CDF Neural Network b-tagger
  - More jets are taggable
  - For identical false-positive rates of previous taggers, b-jet efficiency:
    - Tight: 38.6→53.6%
      - False Positive: 1.4%
    - Loose: 47.1→59.3%
      - False Positive: 2.8%

Recherche du boson de Brout-Englert-Higgs au Tevatron





- The data appear to be incompatible with the background, with a global p-value of **2.2 s.d.** (2.7 local)
  - **H→bb only: 2.6 s.d.** (2.8 local)
- Higgs mass range of **115 < M_H < 135** continues to be very interesting

Recherche du boson de Brout-Englert-Higgs au LHC

Atlas:

Searches performend in 12 distinct channels using the full 2011 dataset.

Channel	m_H range (GeV)	Backgrounds	$\mathcal{L}$ (fb^{-1})	Reference
low-m_H, good mass resolution				
$H \to \gamma\gamma$	110-150	$\gamma\gamma$, γj, jj	4.9	arXiv:1202.1414
$H \to ZZ^{(*)} \to 4\ell$	110-600	$ZZ^{(*)}$, $Z+jets$, $t\bar{t}$	4.8	arXiv:1202.1415
low-m_H, limited mass resolution				
$H \to WW^{(*)} \to \ell\nu\ell\nu$	110-600	WW, $t\bar{t}$, $W/Z+jet$	4.7	CONF-2012-012
$H \to \tau\tau(ll, lh, hh)$	100-150	$Z \to \tau\tau$, $t\bar{t}$	4.7	CONF-2012-014
$VH, H \to bb$	110-130	$W/Z+jets$, $t\bar{t}$	4.7	CONF-2012-015
high-m_H				
$H \to ZZ \to \ell\ell\nu\nu$	200-600	diboson, $t\bar{t}$, $Z+jets$	4.7	CONF-2012-016
$H \to ZZ \to \ell\ell jj$	200-600	$Z+jets$, $t\bar{t}$, diboson	4.7	CONF-2012-017
$H \to WW \to \ell\nu jj$	300-600	$W+jets$, $t\bar{t}$, multijets	4.7	CONF-2012-018

CMS:

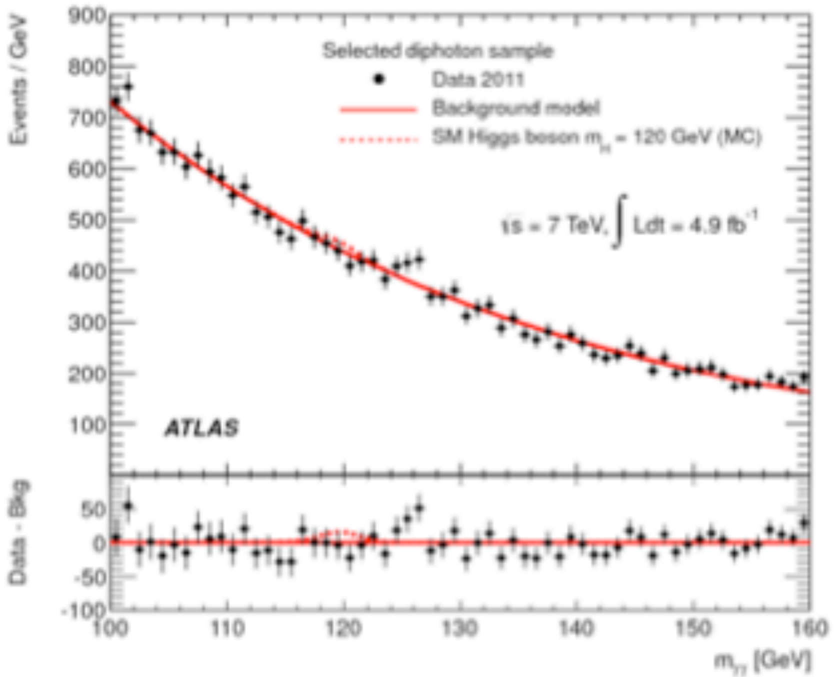
Low mass → High mass

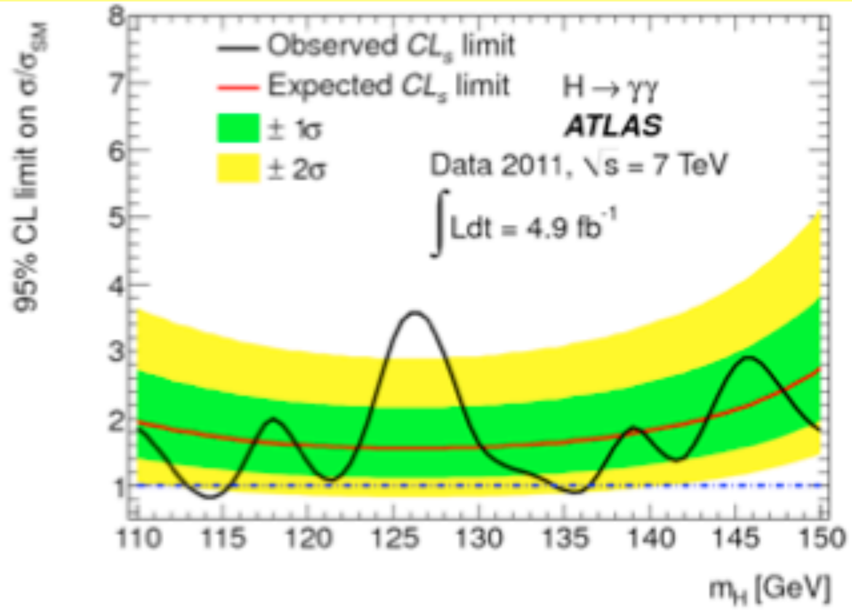
	Channel	m_H range (GeV)	Luminosity (fb^{-1})	Sub-channels	m_H resolution
new	$H \to \gamma\gamma$	110–150	4.8	2	1–2%
	$H \to \tau\tau \to e\tau_h/\mu\tau_h/e\mu + X$	110–145	4.6	9	20%
new	$H \to \tau\tau \to \mu\mu + X$	110–140	4.5	3	20%
new	$WH \to e\mu\tau_h/\mu\mu\tau_h + \nu's$	100–140	4.7	2	20%
	$(W/Z)H \to (e\nu/\mu\nu/ee/\mu\mu/\nu\nu)(bb)$	110–135	4.7	5	10%
	$H \to WW^* \to 2\ell 2\nu$	110–600	4.6	5	20%
new	$WH \to W(WW^*) \to 3\ell 3\nu$	110–200	4.6	1	20%
	$H \to ZZ^{(*)} \to 4\ell$	110–600	4.7	3	1–2%
	$H \to ZZ^{(*)} \to 2\ell 2q$	130–164 200–600	4.6	6	3% 3%
	$H \to ZZ \to 2\ell 2\tau$	190–600	4.7	8	10–15%
	$H \to ZZ \to 2\ell 2\nu$	250–600	4.6	2	7%

11 independent channels

Search mass range 110-600 GeV

Recherche du boson de Brout-Englert-Higgs dans ATLAS



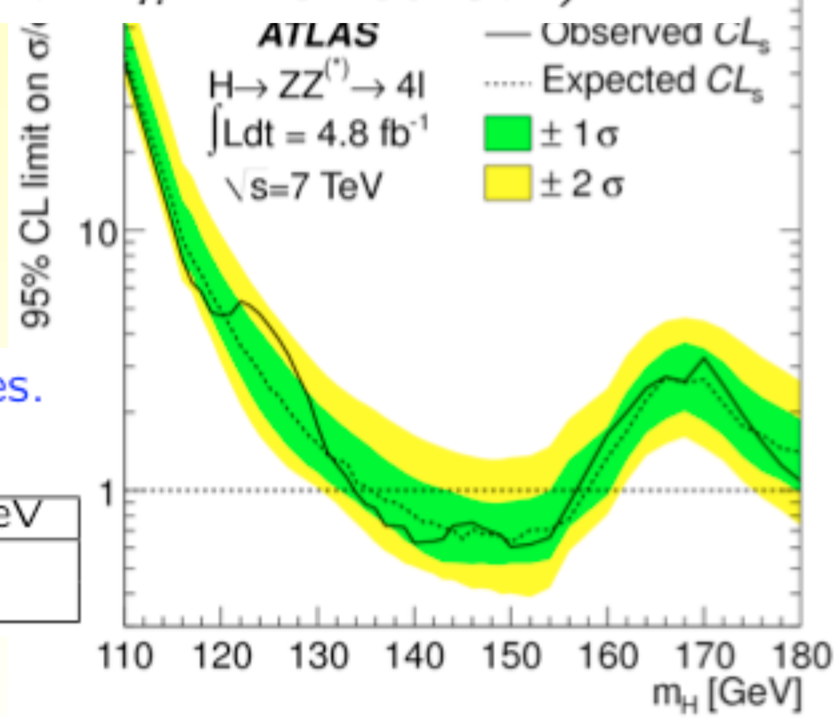


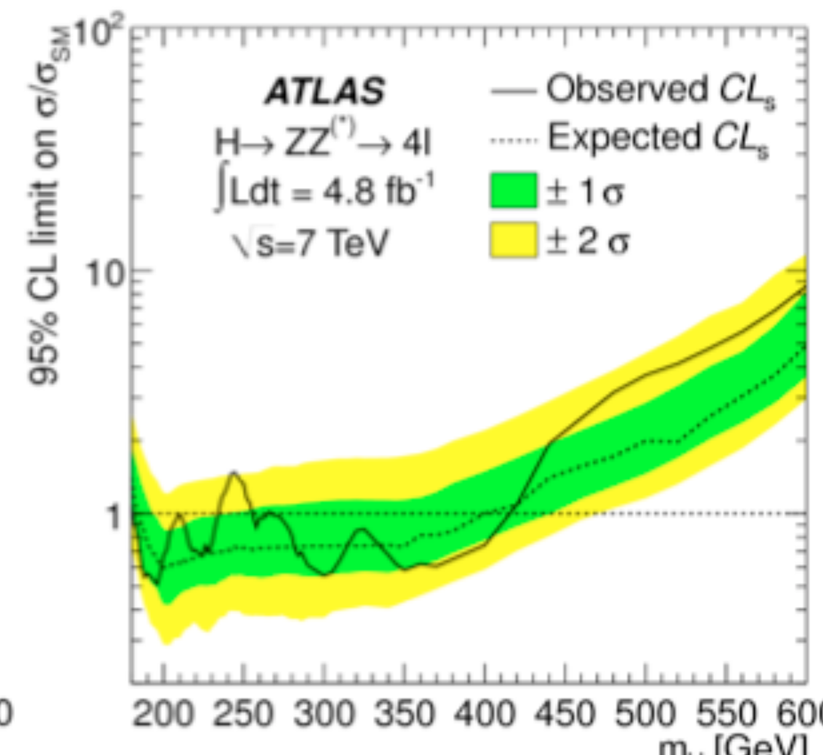
- Observed exclusion:

113-115 GeV, 134.5-136 GeV.

Largest excess of events observed at 126.5 GeV.

- Local significance: 2.8σ (Global: 1.5σ for m_H =110-150 GeV).



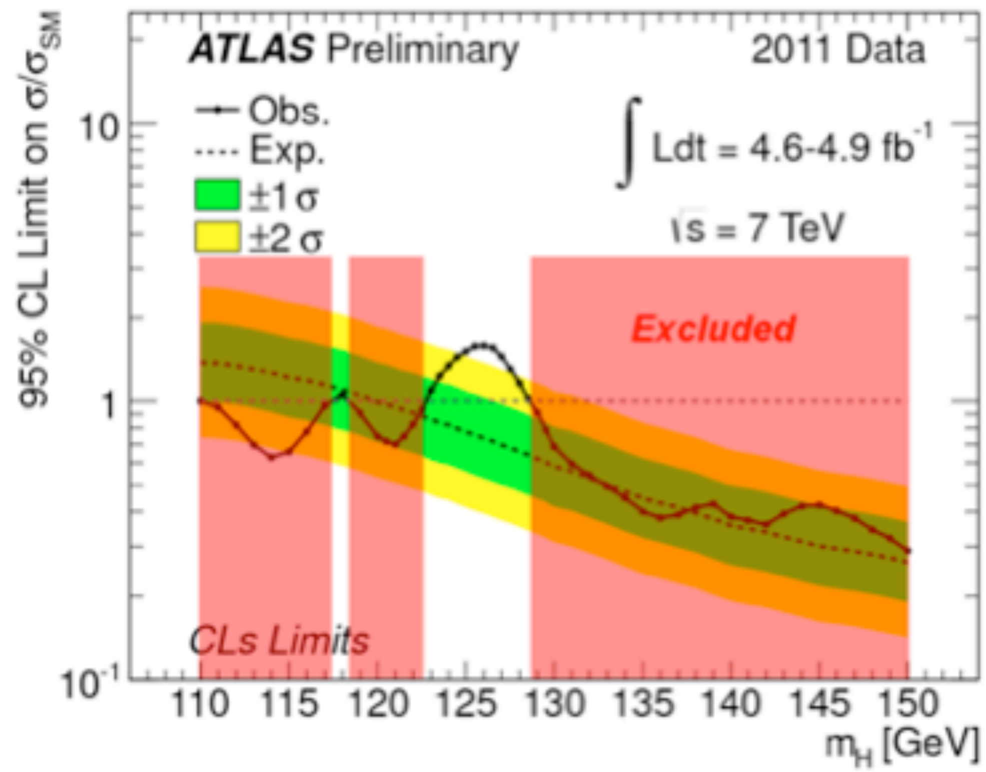


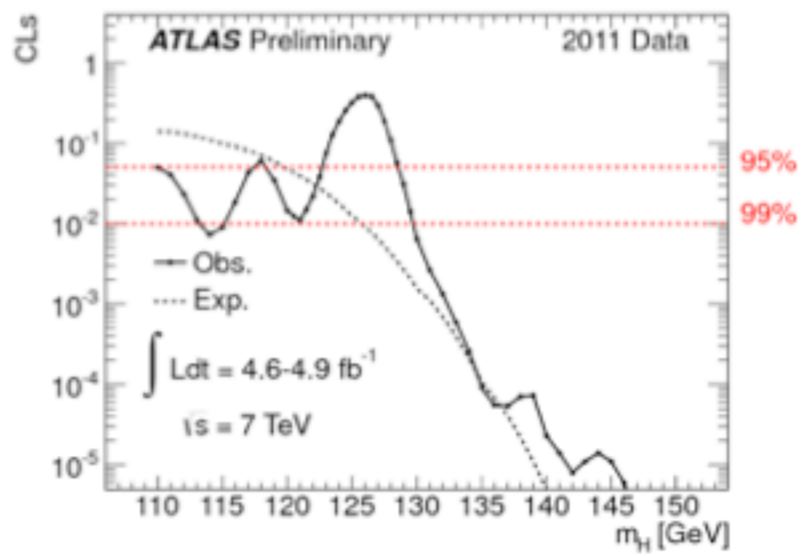
Small excesses observed around 3 mass values.

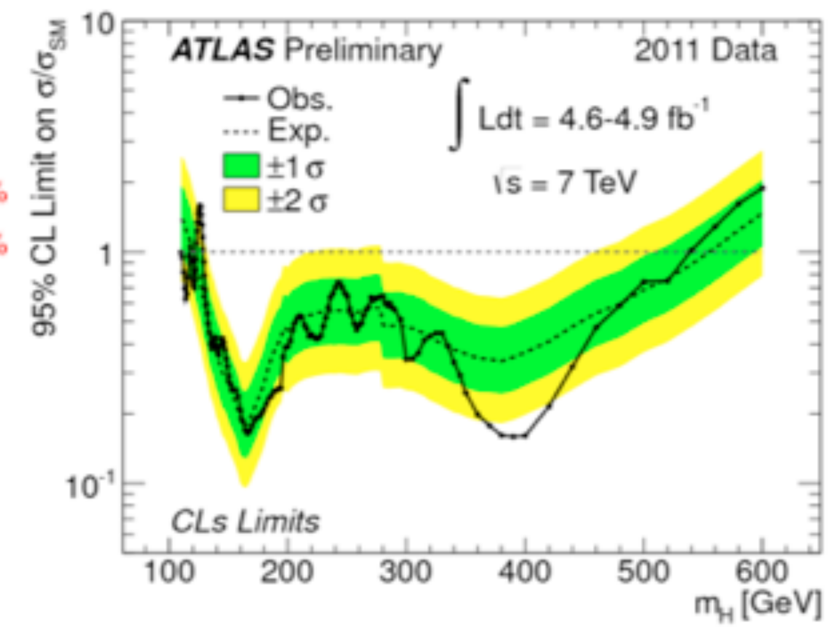
Local significance:

$m_{4\ell}$	125 GeV	244 GeV	500 GeV
Exp. w. signal	1.3σ	3.0σ	1.5σ
Observed	2.1σ	2.2σ	2.1σ

Recherche du boson de Brout-Englert-Higgs dans ATLAS



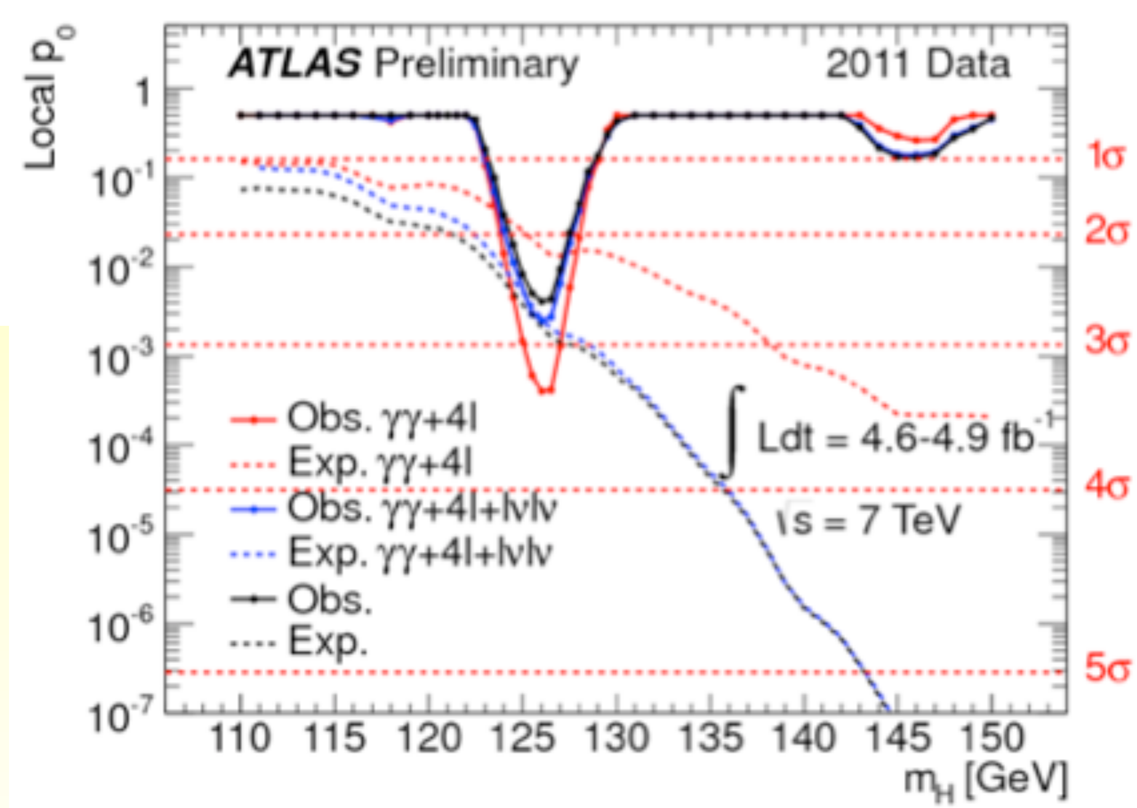




Expected exclusion at 95% CL: 120-555 GeV

Observed exclusion at 95% CL: 110-117.5, 118.5-122.5, 129-539 GeV

Observed exclusion at 99% CL: 130-486 GeV



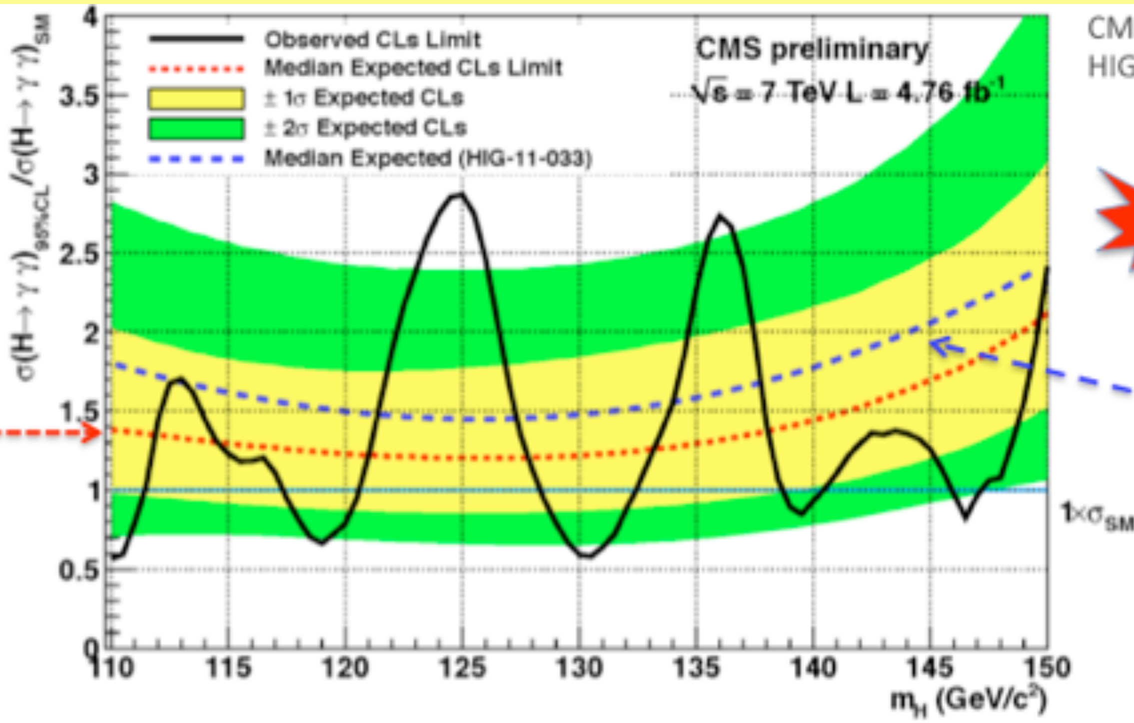
Excess is mainly observed in two high-resolution channels:

$\Rightarrow$ $H \to \gamma\gamma$ and $H \to ZZ^{(*)} \to 4\ell$ combined: 3.4σ local significance.

Recherche du boson de Brout-Englert-Higgs dans CMS

$H \rightarrow \gamma\gamma$

Expected from MVA analysis Improvement ~20%



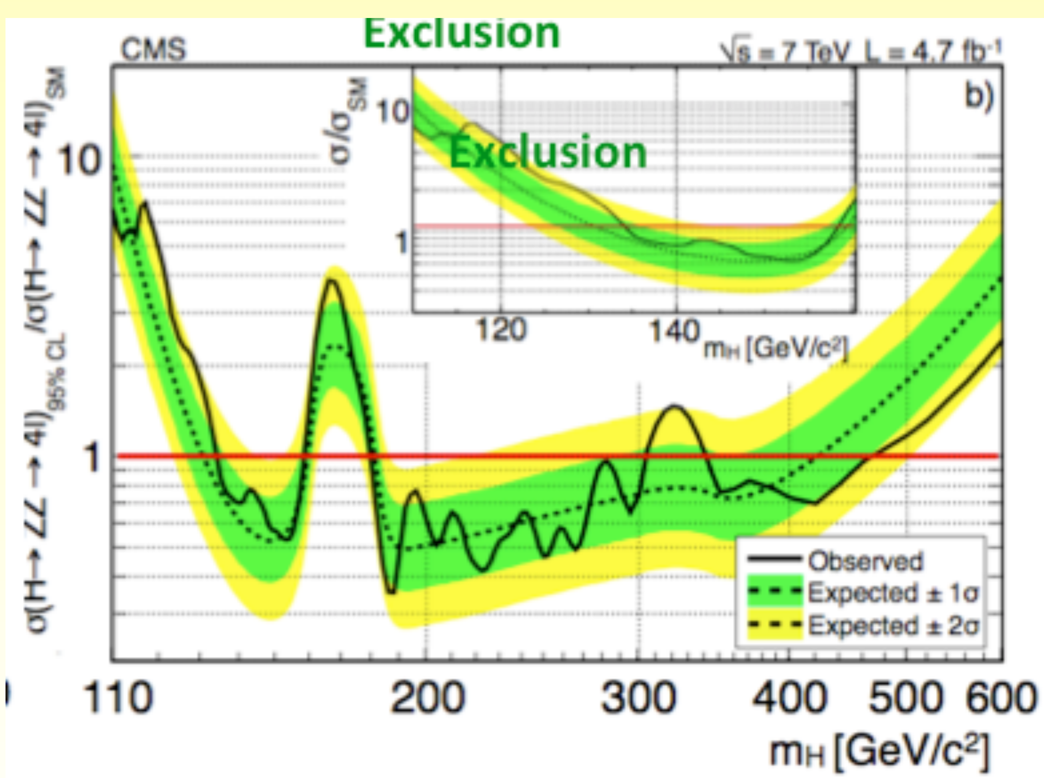
CMS document HIG-12-001

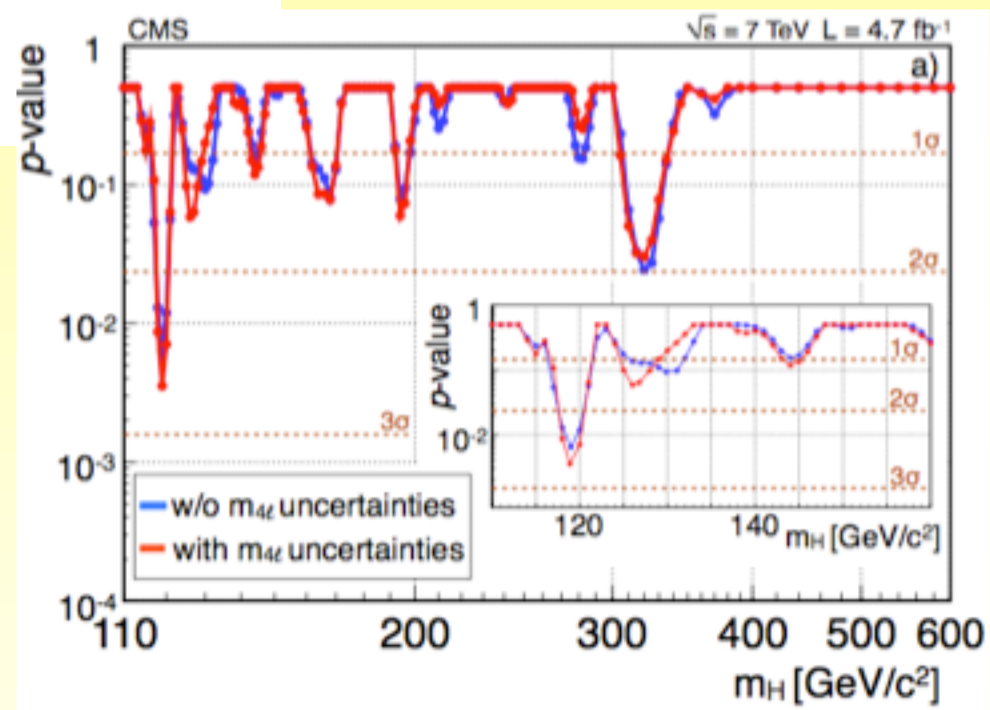
NEW

Expected from cut based analysis

- Largest excess around 125 GeV
  - Local significance 2.9 σ
  - Global significance 1.6 σ

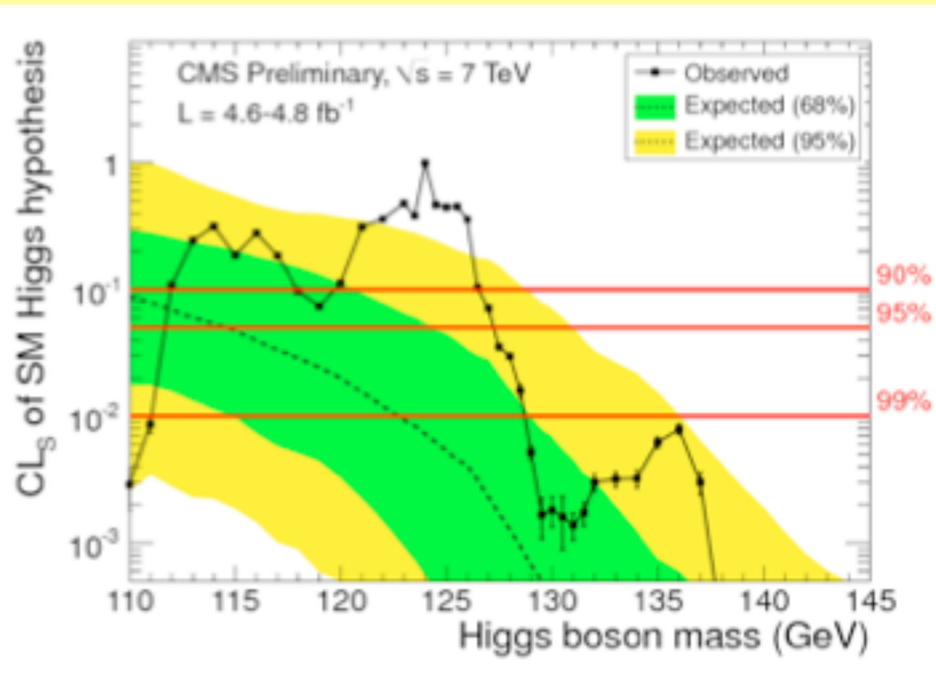
$H \rightarrow ZZ$

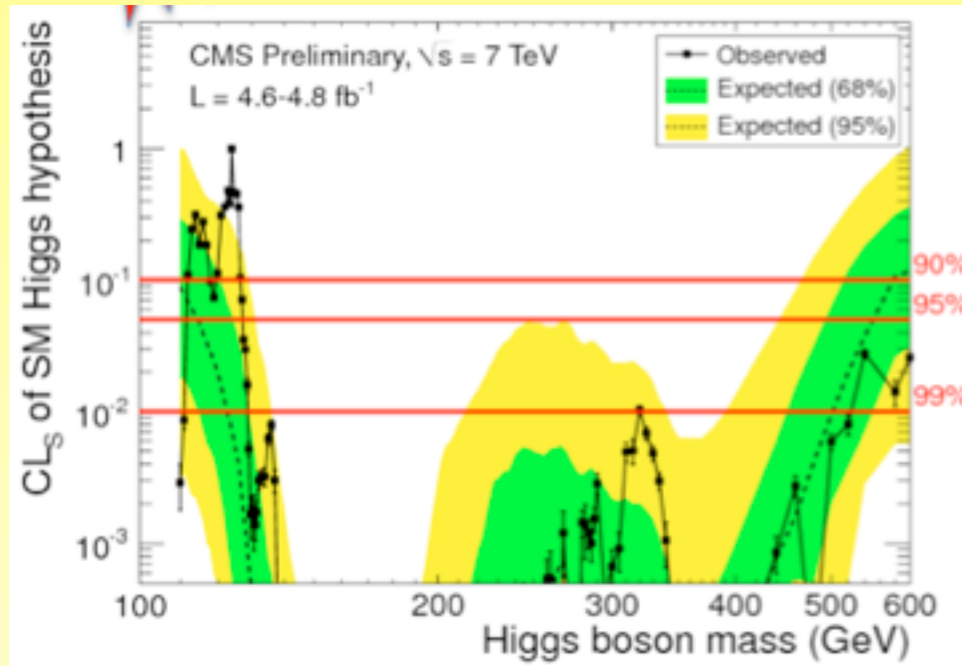


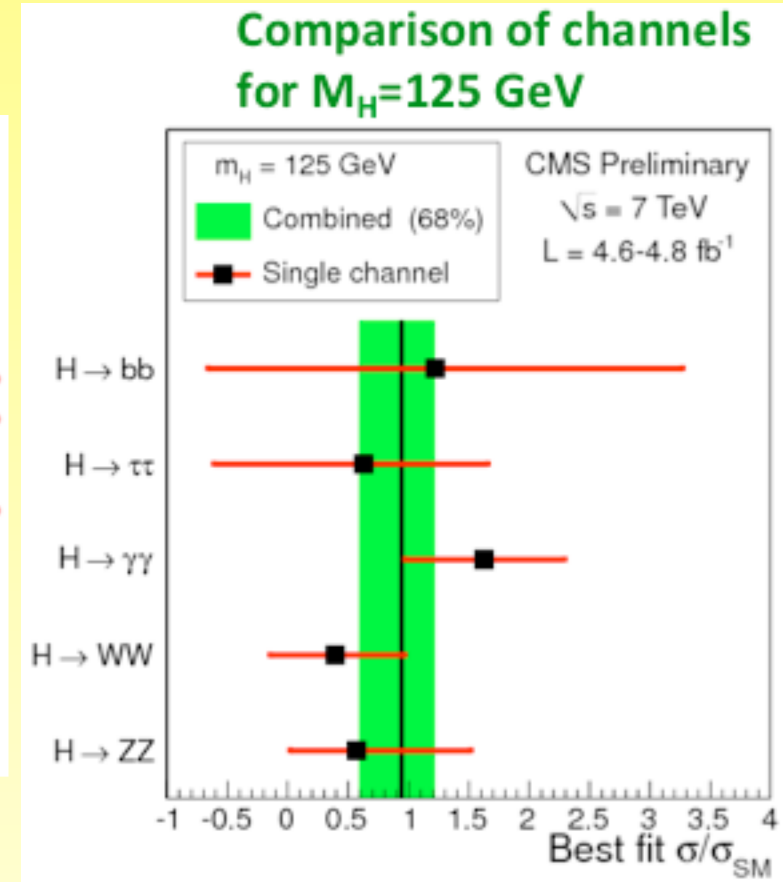


- Largest excess observed at 119.5 GeV
  - local significance 2.5 σ
  - global significance 1.0 σ in the full mass range, 1.6 in the mass range 100-160 GeV

Recherche du boson de Brout-Englert-Higgs dans CMS







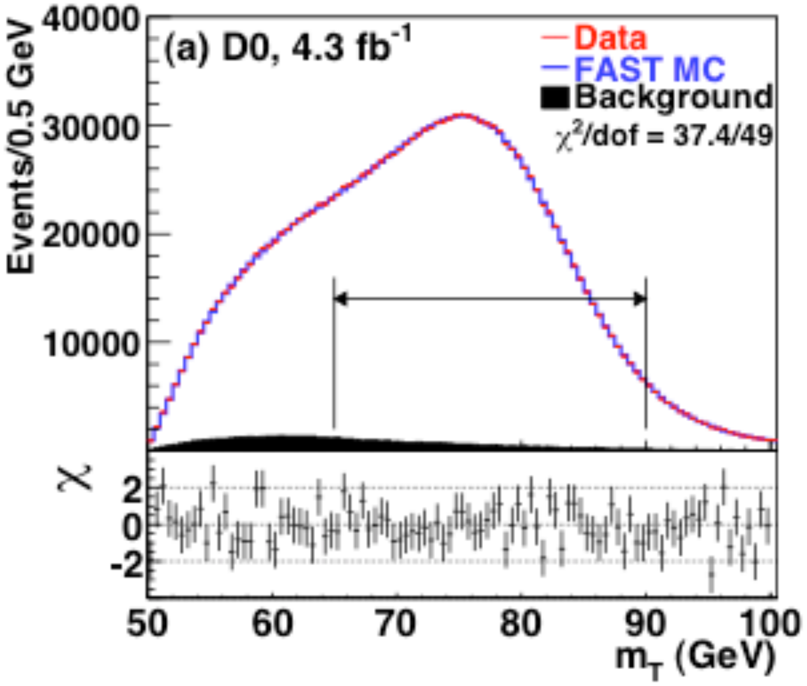
- Expected: 95% exclusion M_H in [114.5-543] GeV
- Observed: 95% exclusion M_H in [127.5-600] GeV
  99% exclusion M_H in [129-525] GeV
- 95% allowed mass range: 114.4-127.5 GeV
- Observed lower limit higher than expected because of excess in data at low mass

zone non exclue à 95% ATLAS+CMS: 117.5-118.5 GeV et 122.5-127.5 GeV

Contraintes indirectes sur le Higgs: mesure de la masse du W à D0

1.677k W events

M_T



systematic uncertainties

Source	$\sigma(m_W)$ MeV m_T	$\sigma(m_W)$ MeV $p_T(e)$	$\sigma(m_W)$ MeV $\not\!\!E_T$
Experimental			
Electron Energy Scale	16	17	16
Electron Energy Resolution	2	2	3
Electron Energy Nonlinearity	4	6	7
W and Z Electron energy loss differences	4	4	4
Recoil Model	5	6	14
Electron Efficiencies	1	3	5
Backgrounds	2	2	2
Experimental Total	18	20	24
W production and decay model			
PDF	11	11	14
QED	7	7	9
Boson p_T	2	5	2
W model Total	13	14	17
Total	22	24	29
statistical	13	14	15
total	26	28	33

the new Run II 5.3 fb⁻¹ result:

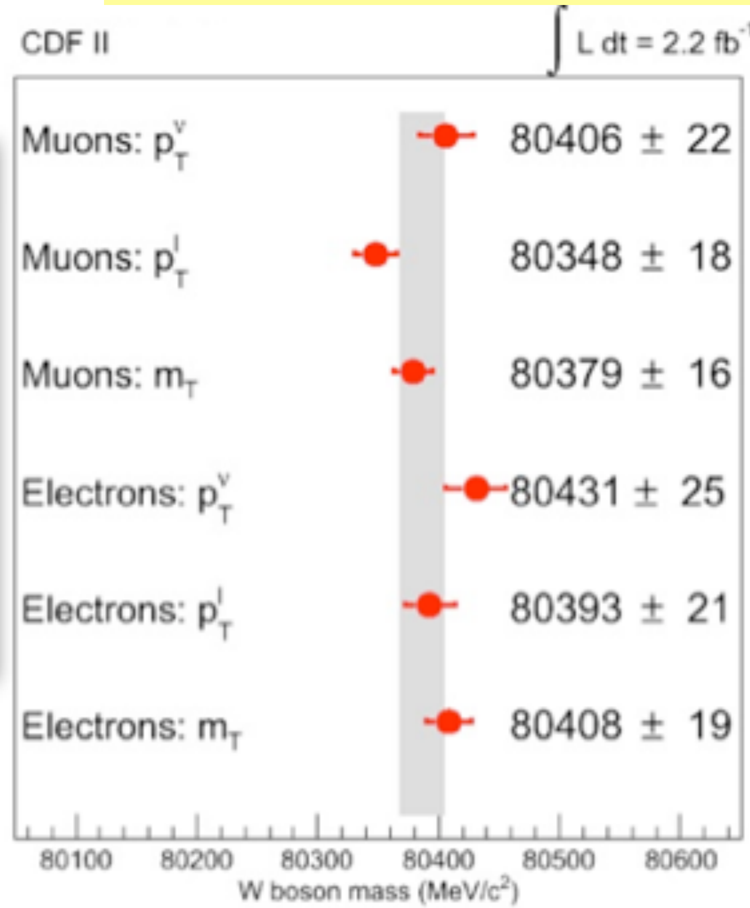
$$M_W = 80.375 \pm 0.011\ (\text{stat}) \pm 0.020\ (\text{syst})\ \text{GeV}$$
$$= 80.375 \pm 0.023\ \text{GeV}.$$

The previous world average uncertainty was just this 23 MeV.

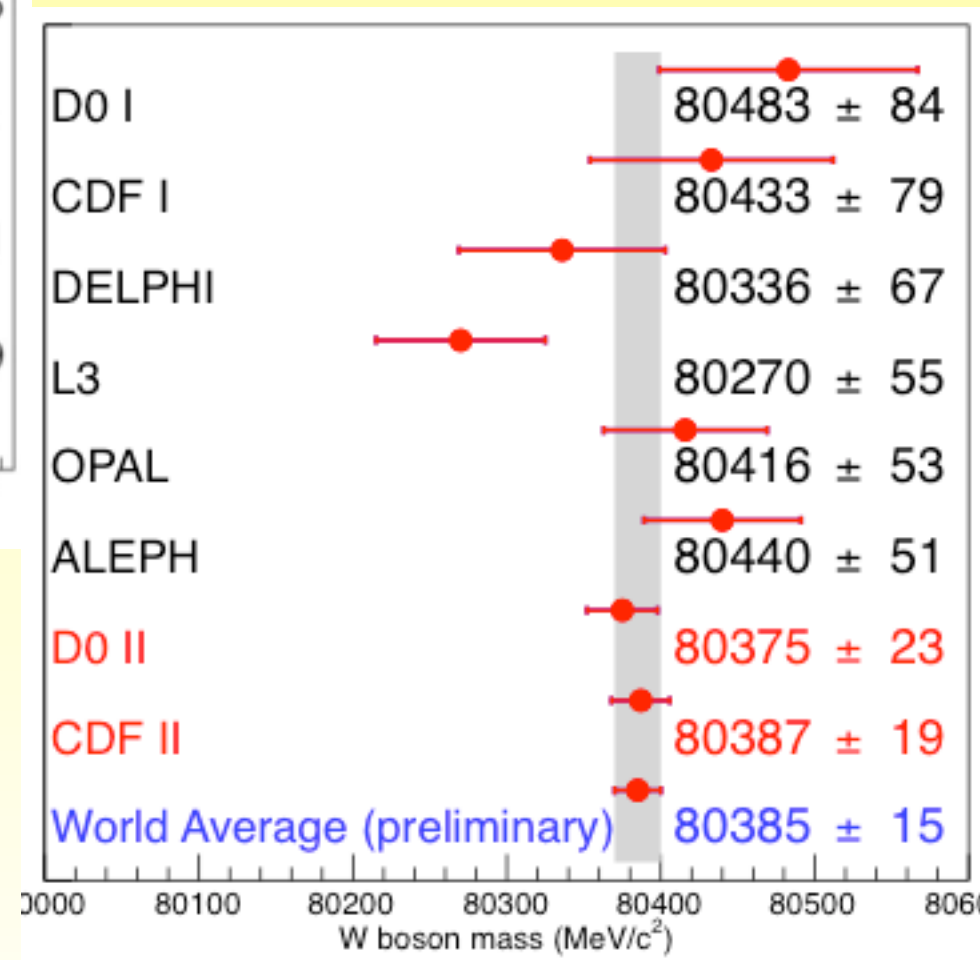
Contraintes indirectes sur le Higgs: mesure de la masse du W au Tevatron

CDF:

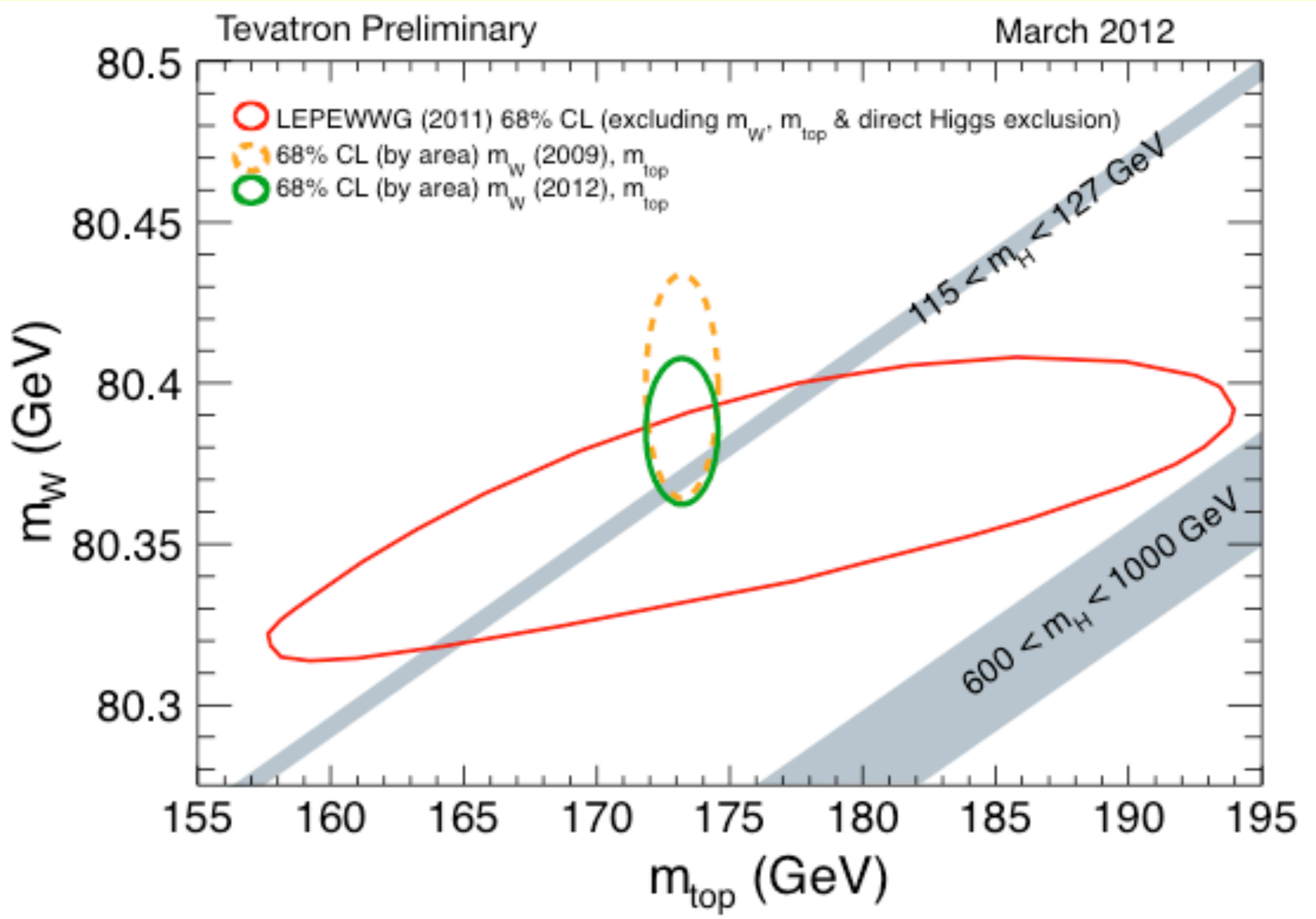
Source	Uncertainty 2.2 fb^{-1} (MeV)
Lepton energy scale	7
Lepton energy resolution	2
Recoil energy scale	4
Recoil energy resolution	4
Lepton removal	2
Backgrounds	3
p_T (W) model	5
PDFs	10
QED radiation	4
Total systematics	*15*
W statistics	12
Total	***19***



$M_W = 80387 \pm 12_{stat} \pm 15_{syst}$ MeV/c^2



Contraintes indirectes sur le Higgs



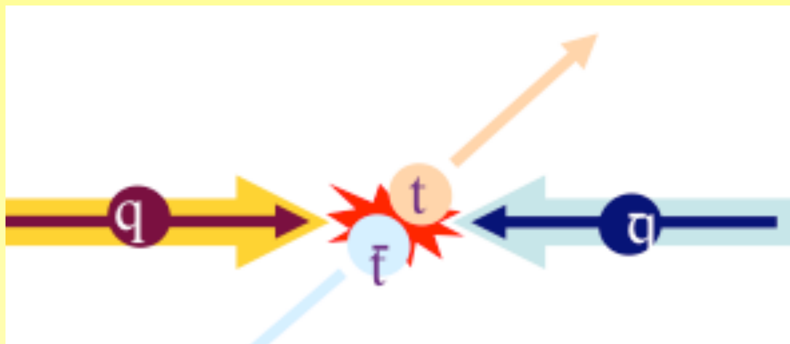
With M_W = 80385±15 MeV

$M_H = 94^{+29}_{-24}$ GeV

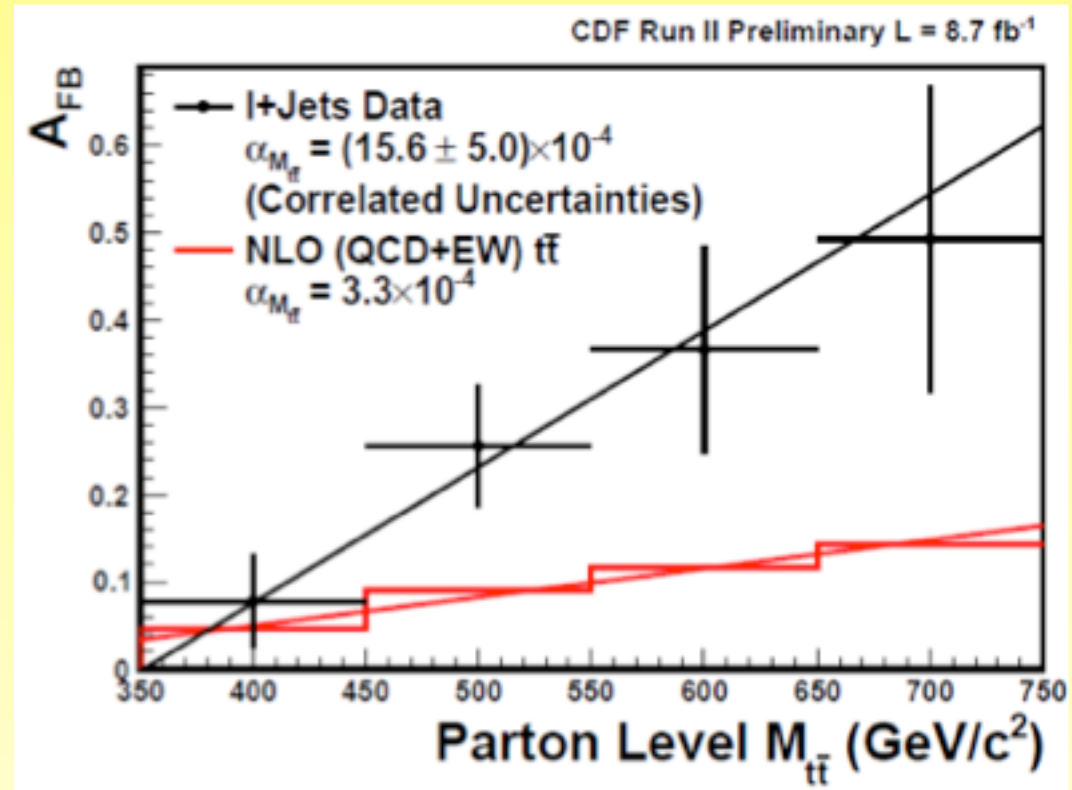
M_H < 152 GeV @95% CL

LEPEWWG/ZFitter

Top-Antitop Forward Backward Asymmetry at the Tevatron



$$A_{FB} = \frac{N(\Delta y > 0) - N(\Delta y < 0)}{N(\Delta y > 0) + N(\Delta y < 0)}$$



M_{tt} (GeV)	NLO (QCD+EW) ttbar	CDF 5.3 fb^{-1}	CDF 8.7 fb^{-1} Run II Preliminary	D0 5.4 fb^{-1}
Inclusive	0.066	0.158 ± 0.074	0.155 ± 0.048	0.196 ± 0.065
‹ 450	0.047	-0.116 ± 0.153	0.078 ± 0.054	0.078 ± 0.048 Recon. Level
› 450	0.100	0.475 ± 0.112	0.296 ± 0.067	0.115 ± 0.060 Recon. Level

NLO QCD predictions: ~ 7%

NLO QCD predictions: ~ 10 %

From Eric

Neutrinos

- Vitesse = c ? : Opera ; ICARUS
- θ_{13} est mesuré : T2K ; Double Chooz ; Daya Bay ; Reno
- Indices de neutrino stérile ?????
- Progrès en $0\nu\beta\beta$: EXO ; Kamland/ZEN...
- Neutrinos solaires : Borexino (réactions nucléaires); Amanda/IceCube (recherche de WIMPs)

- Contraintes/mesures cosmologie

IRFU
Séminaire passé
Séminaire à venir..

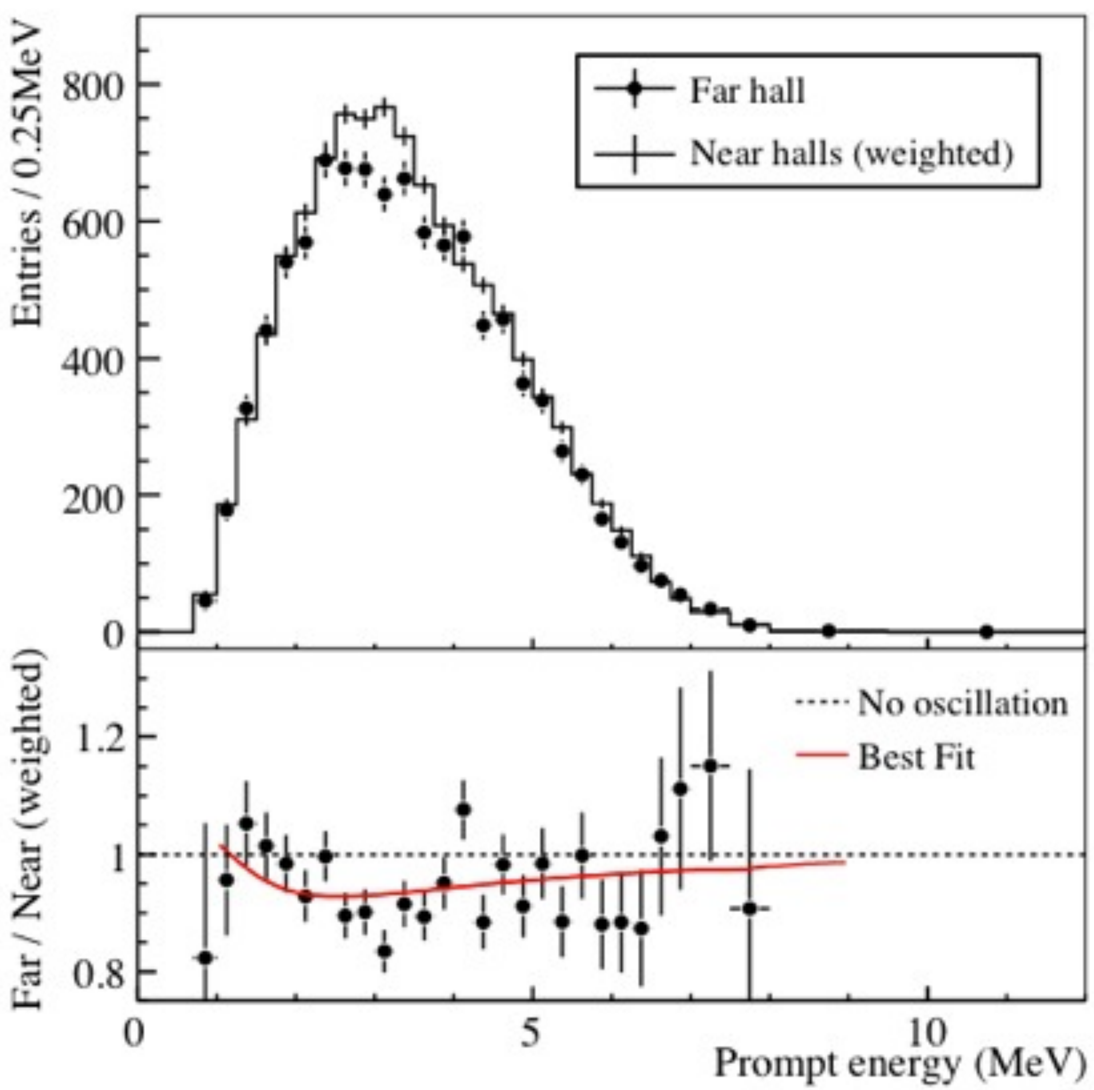
Mesure de θ_{13}

From Eric

Dernier angle non mesuré de la matrice de mélange des saveurs
Principe mesure réacteur: baisse du flux (+ forme spectre) de ve

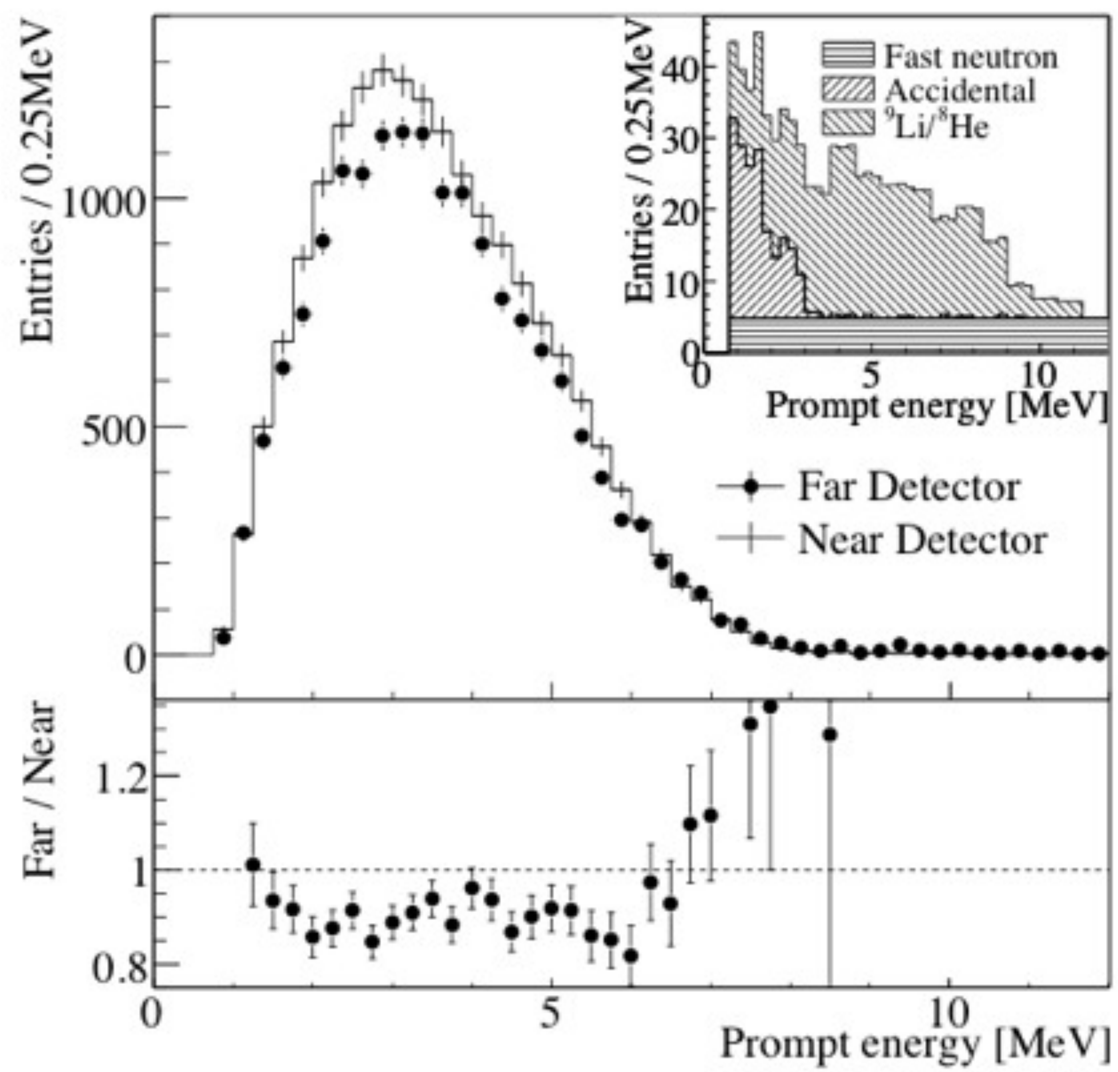
Daya Bay

(séminaire en mai)



$$\sin^2 2\theta_{13} = 0.092 \pm 0.016(\text{stat}) \pm 0.005(\text{syst})$$

Reno



$$\sin^2 2\theta_{13} = 0.113 \pm 0.013(\text{stat.}) \pm 0.019(\text{syst.})$$

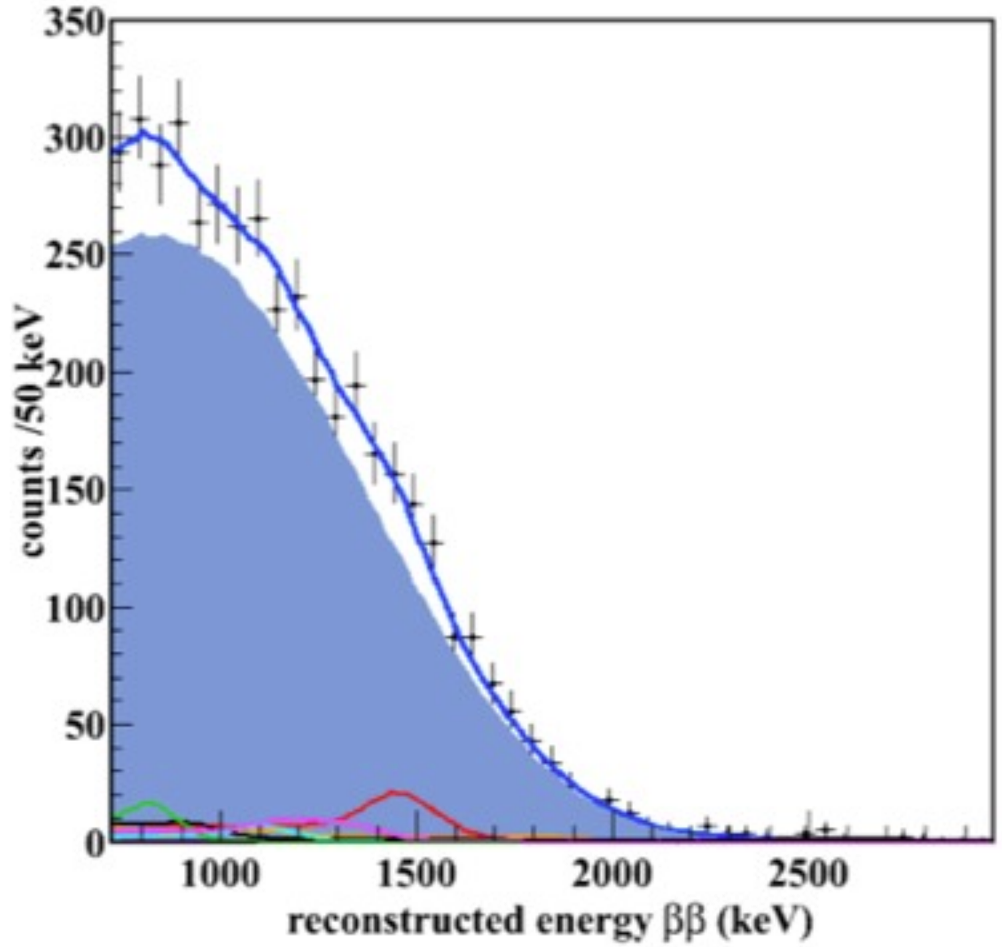
Prospective deltaCP...

Double beta sans neutrino avec TPC au 136Xe

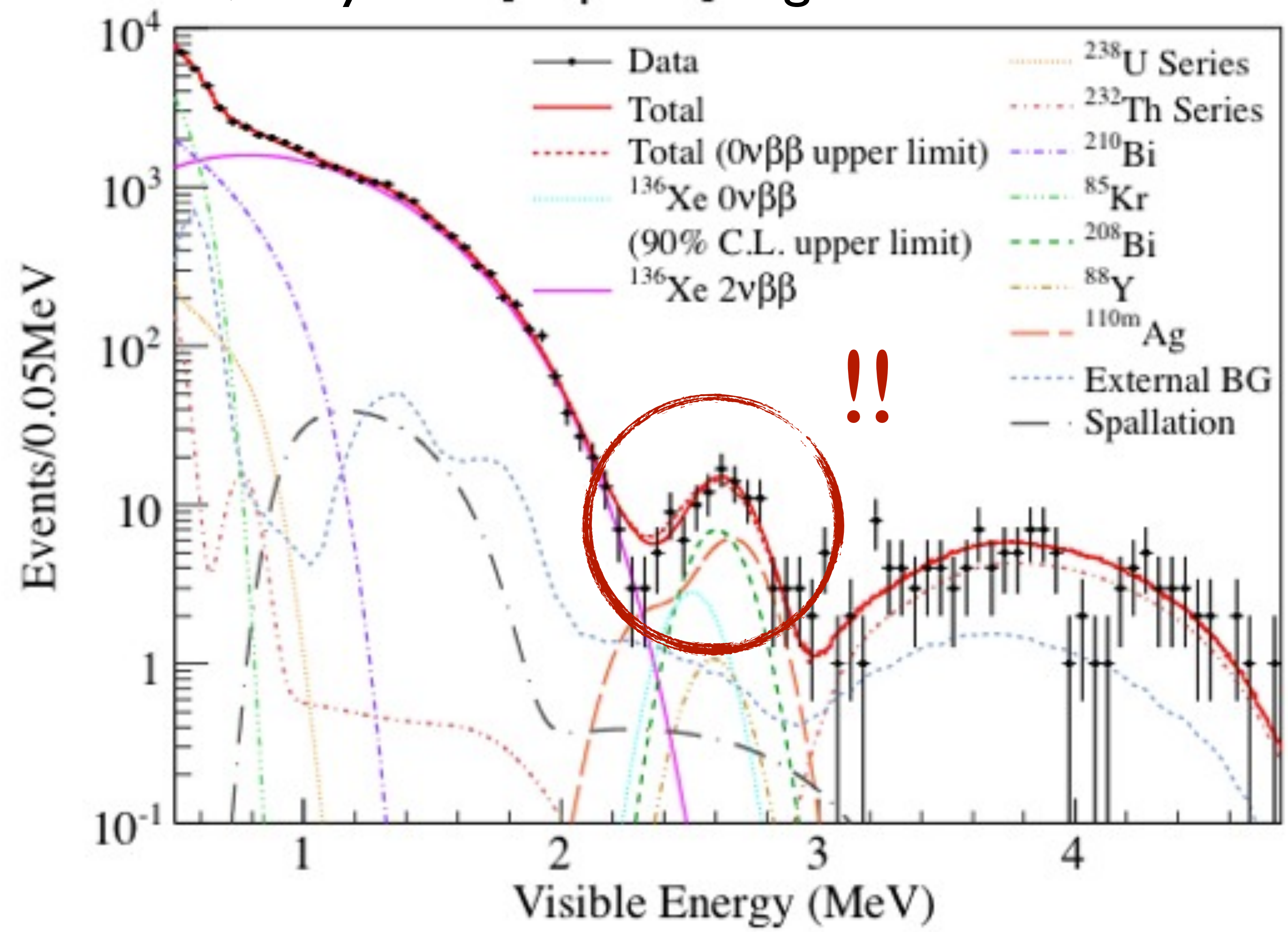
Accès à une moyenne pondérée des masses des neutrinos SI MAJORANA
Signal attendu = raie spectrale au endpoint du spectre $2\nu\beta\beta$ de certains isotopes

From Eric

EXO
31 live days - 63 kg active mass



KAMLAND-ZEN (séminaire en mai)
77,6 days livetime - 129 kg



a) mesure de $2\nu\beta\beta$ pour cet isotope:

EXO: $t_{1/2} = 2.11 \cdot 10^{21}$ yr (± 0.04 stat) yr (± 0.21 sys)

Kamland: $T^{2\nu}_{1/2}$=2.38±0.02(stat)±0.14(syst) ×10^{21} years

(DAMA result $T^{2\nu}_{1/2} > 1.0 \times 10^{22}$ yr) !!

b) limite sur le $0\nu\beta\beta$:

Kamland: $\langle m_{\beta\beta} \rangle$ <0.3~0.6 eV

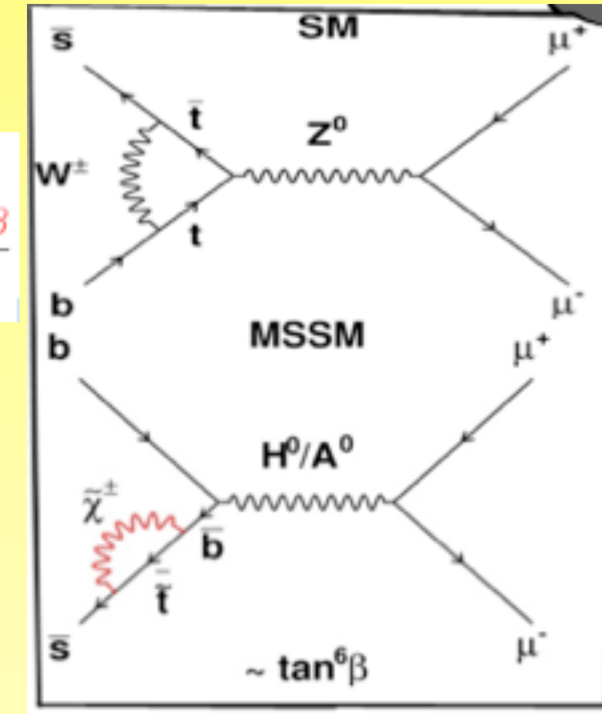
Les deux experiences font face à des bruits de fond qu'il faut réduire...

Recherche de $B_s \to \mu\mu$ à LHCb

SM $\mathcal{B}(B_s\to\mu\mu) = (3.2\pm0.2)\ 10^{-9}$ arXiv:1005.5310

SM $\mathcal{B}(B\to\mu\mu) = (0.1\pm0.01)\ 10^{-9}$ arXiv:1012.1447

- Large sensitivity to NP, eg SUSY:
  - $\mathrm{Br}_{\mathrm{MSSM}}(B_q \to \ell^+\ell^-) \propto \frac{M_b^2 M_\ell^2 \tan^6\beta}{M_A^4}$



Some excitation last year: 3σ signal from CDF

CMS+LHCb did not confirm

Similar selection for signal and normalization channels:

$B^+\to J/\psi(\mu\mu)K^+$, $B_s\to J/\psi(\mu\mu)\phi$, $B\to K\pi$

A multivariate discriminant BDT:

kinematical and geometrical variables

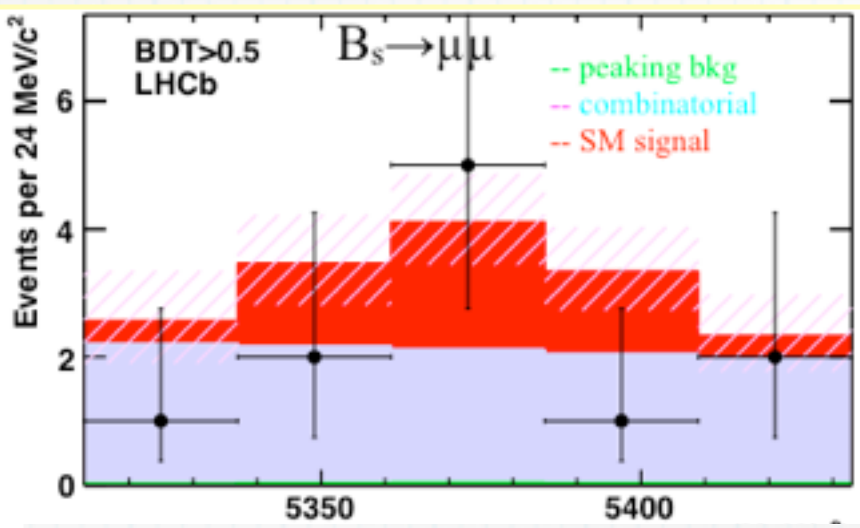
signal uniformly distributed [0,1]

trained with MC

estimated with data:

signal $B\to hh$ trigger unbias

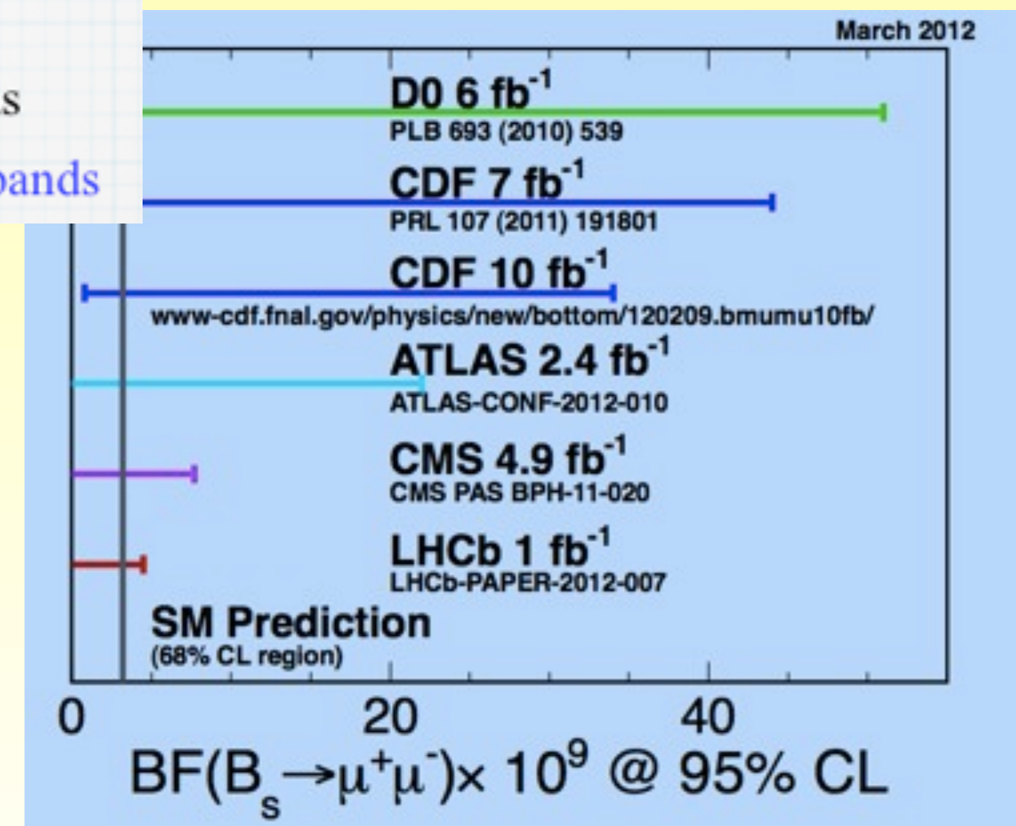
background: $Bs\to\mu\mu$ sidebands



$\mathcal{B}(B_s\to\mu\mu) < 4.5\ 10^{-9}$ at 95% CL

$\mathcal{B}(B\to\mu\mu) < 10.3\ 10^{-10}$ at 95% CL

best limit!



Sensibilité proche de la valeur prédite du modèle standard

Place très réduite pour les modèles simples de SUSY ...

CDF: no events in the last $3\mathrm{fb}^{-1}$, they do not confirm their excess

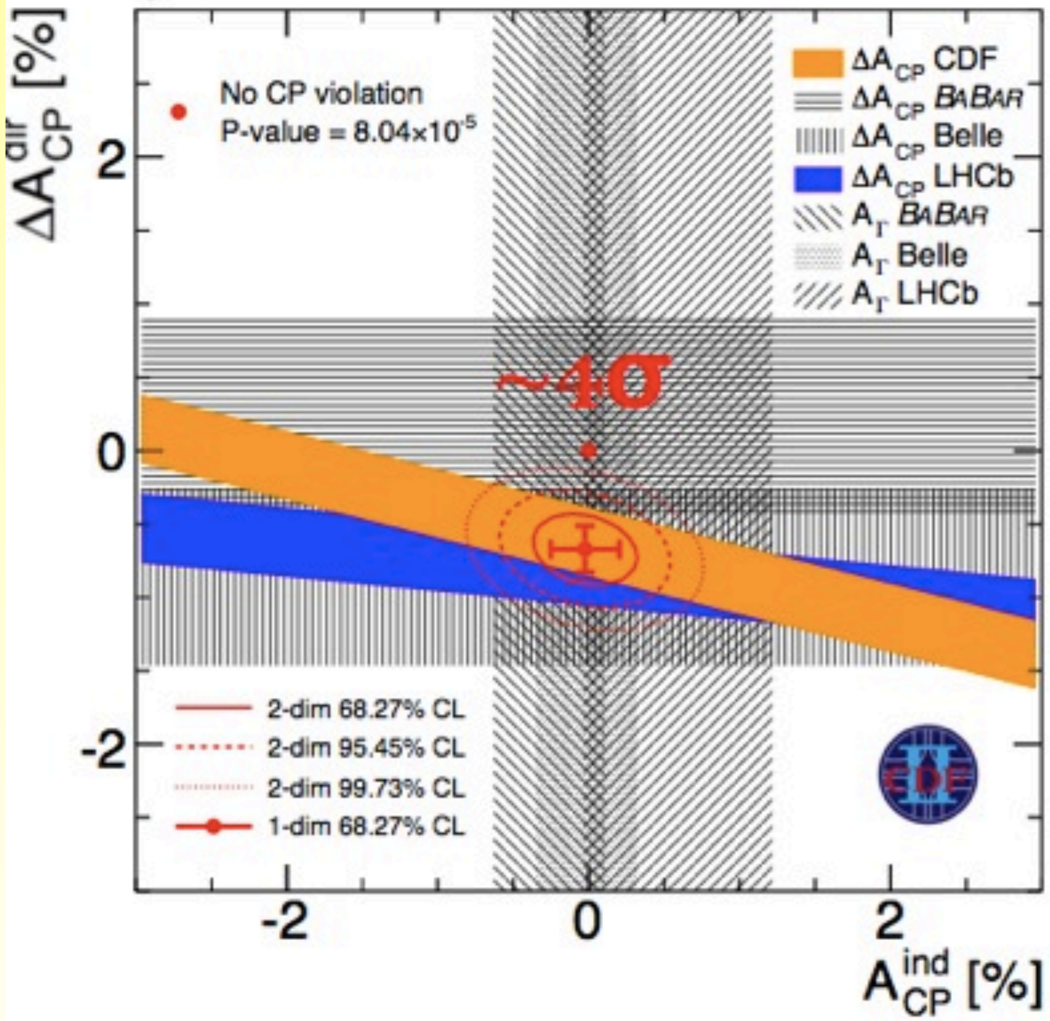
Violation de CP dans le charme

From Fabrice

- ✓ Measure direct CP violation in $D^0 \to K^+K^-$ and $D^0 \to \pi^+\pi^-$
- ✓ Expectations from U-spin symmetry: $A^{dir}{}_{CP} := A^{dir}(KK) = -A^{dir}(\pi\pi)$
- ➢ $\Delta A_{CP} = A^{dir}(KK) - A^{dir}(\pi\pi) = 2 \cdot A^{dir}{}_{CP}$

NEW $\Delta A_{CP} = (-0.62 \pm 0.21(stat) \pm 0.10(syst))\%$

CDF Note 10784



Confirm LHCb result
$\Delta A_{CP} = (-0.82 \pm 0.21 \pm 0.11)\%$

When combining à la HFAG
No CPV point is at
$\sim 4\sigma$ from zero

$\Delta A_{CP}{}^{dir} = (-0.67 \pm 0.16)\%$
$A_{CP}{}^{ind} = (-0.02 \pm 0.22)\%$

See SPP seminar from LHCb

Asymmetrie de charge dimuon à D0

From Fabrice

- Measure *CP* violation in mixing via

$$A^b_{sl} = \frac{N_b(\mu^+\mu^+) - N_b(\mu^-\mu^-)}{N_b(\mu^+\mu^+) + N_b(\mu^-\mu^-)}$$

- DØ: Evidence for anomalous dimuon charge asymmetry, (6 fb^{-1},PRL **105**, 081801 (2010))
  3.2σ deviation from $A^b_{sl}(SM) = (-0.023^{+0.005}_{-0.006})\%$

DØ Update 9.0 fb^{-1} arXiv:1106.6308, sub. to PRD

$$A^b_{sl} = (-0.787 \pm 0.172 \pm 0.093)\%$$

Now a 3.9σ deviation from SM prediction

2 same sign muons: one B meson has necessarily oscillated.
Combination of B_d and B_s asymmetry:
B_d asymmetry is zero (B factories) ⇒ hint for new physics in B_s

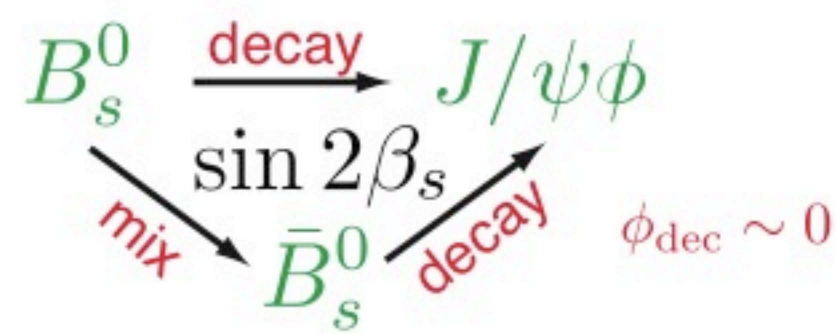
Lien avec la violation de CP dans le Bs

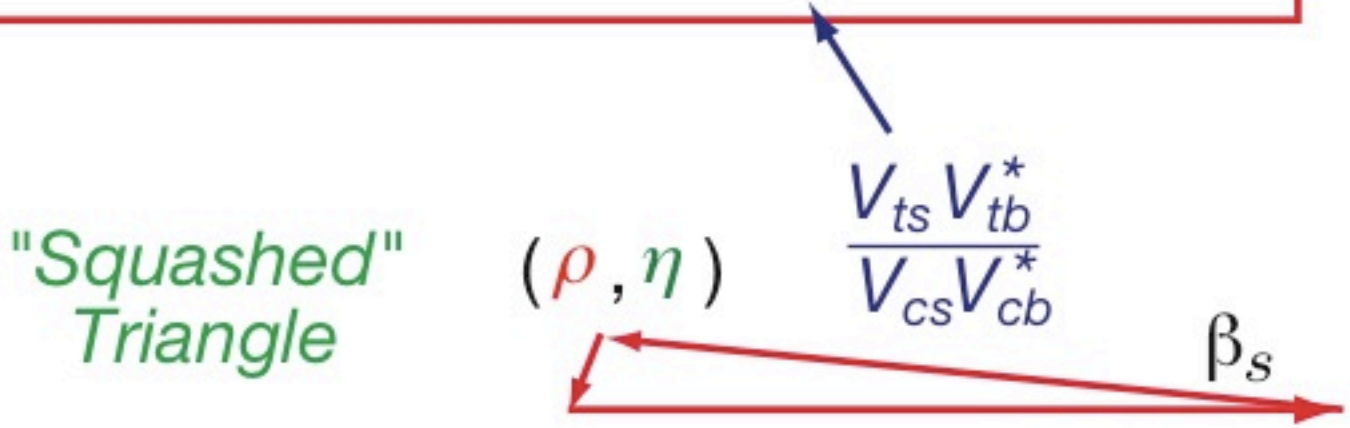
From Fabrice

$$\phi_s^{J/\psi\phi} \approx -2\beta_s = -2\beta_s^{SM} + \phi_s^{NP}$$

$-(0.038 \pm 0.002)$

Golden mode,
Hadron Colliders





CP violation through
interference of diagrams
with and w/o mixing

Link with dimuon asymmetry:

$$a_{\rm sl}^s = \frac{|\Gamma_s^{12}|}{|M_s^{12}|} \sin\phi_s = \frac{\Delta\Gamma_s}{\Delta M_s} \tan\phi_s$$

Lien avec la violation de CP dans le Bs

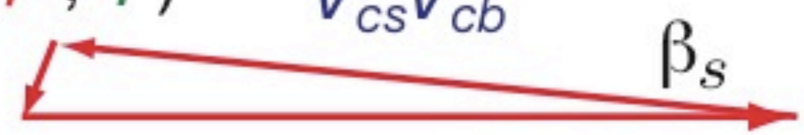
From Fabrice

$$\phi_s^{J/\psi\phi} \approx -2\beta_s = -2\beta_s^{SM} + \phi_s^{NP}$$

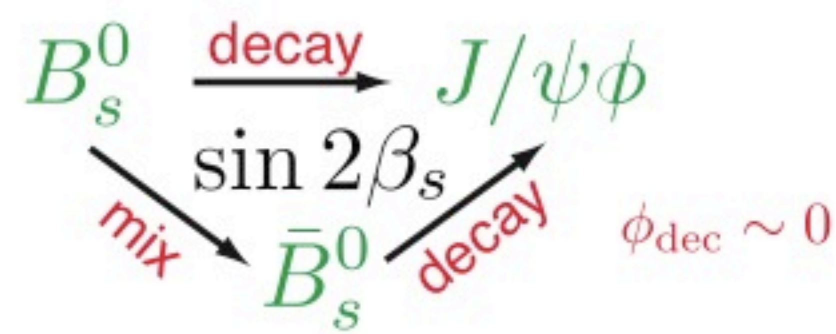
$-(0.038 \pm 0.002)$

$\frac{V_{ts}V_{tb}^*}{V_{cs}V_{cb}^*}$

"Squashed" Triangle (ρ, η)



Golden mode, **Hadron Colliders**



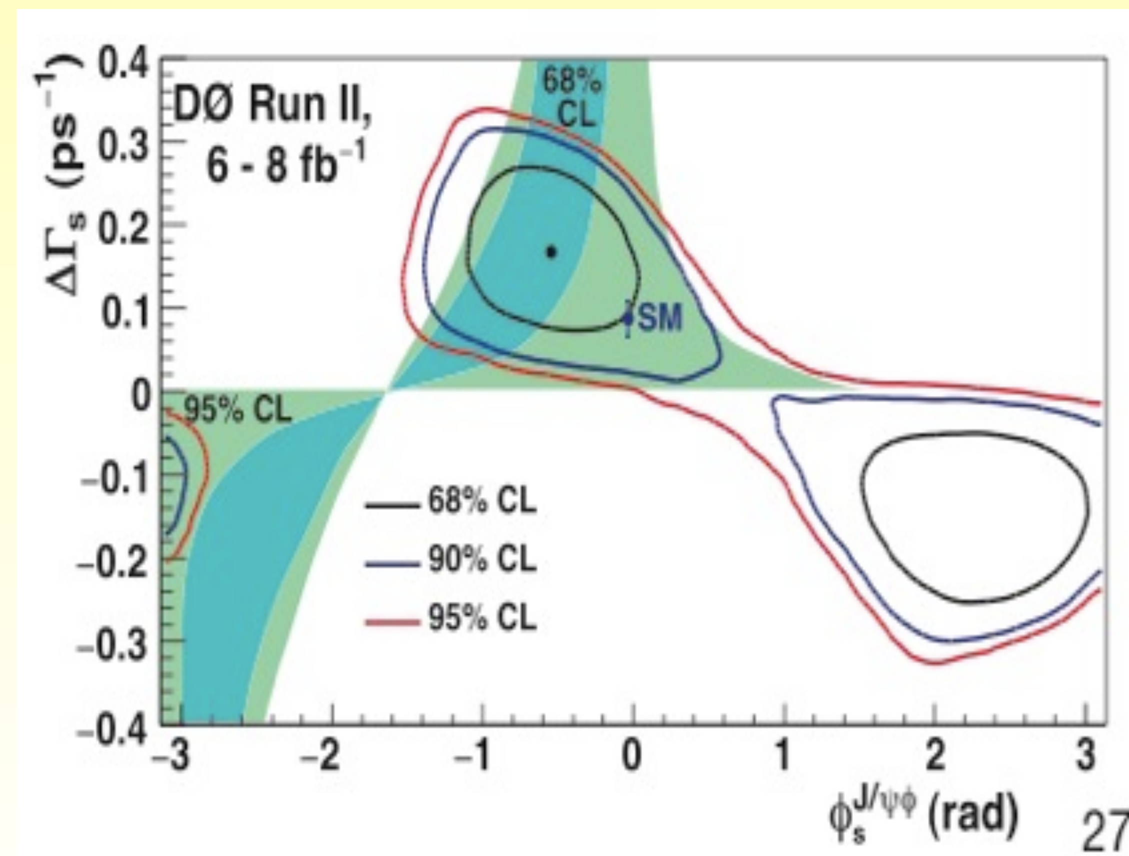
CP violation through interference of diagrams with and w/o mixing

same Φ_s

Link with dimuon asymmetry:

$$a_{\rm sl}^s = \frac{|\Gamma_s^{12}|}{|M_s^{12}|}\sin\phi_s = \frac{\Delta\Gamma_s}{\Delta M_s}\tan\phi_s$$

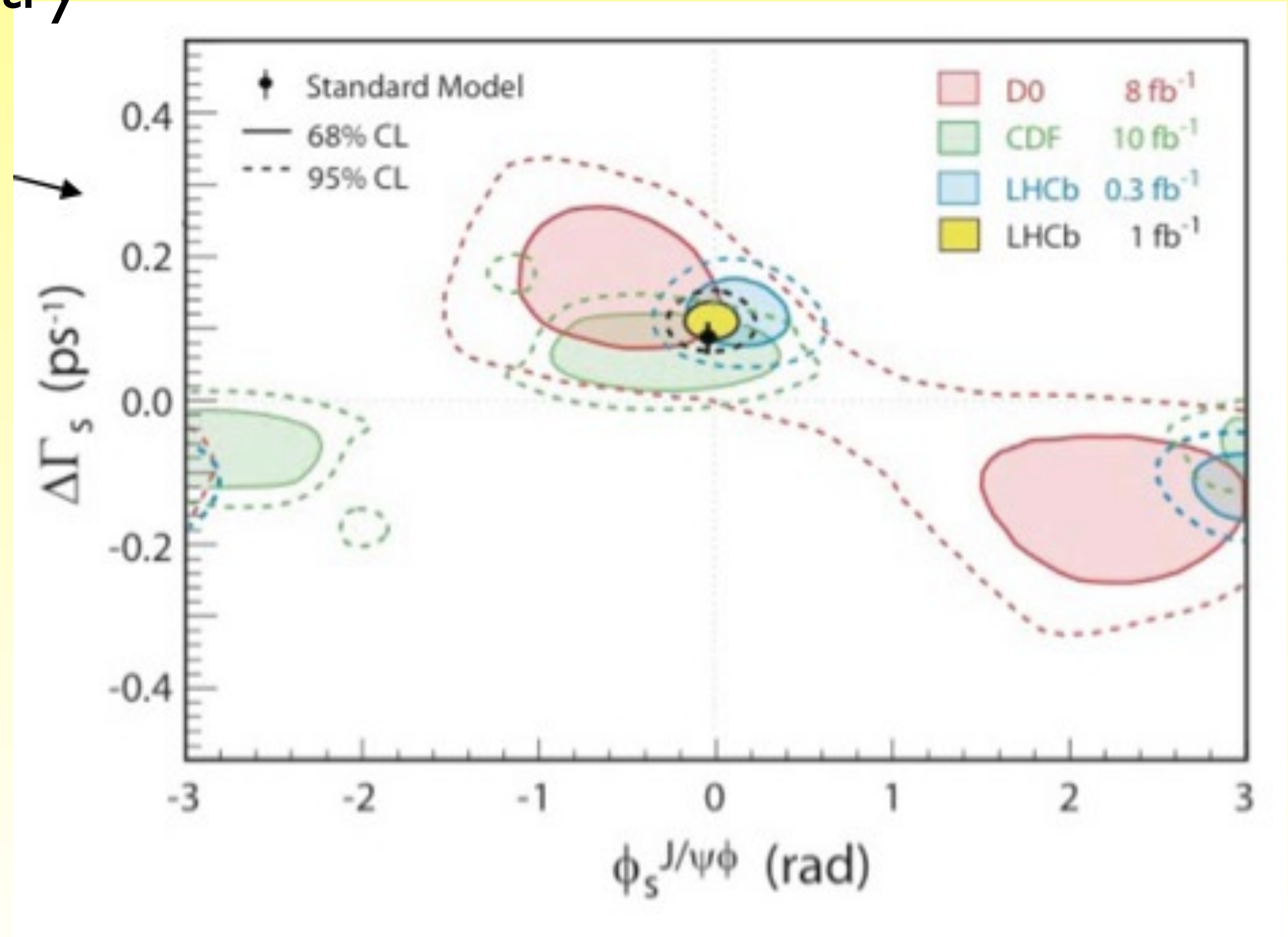
Two completely different measurements at the Tevatron deviates and point to the same corner. But here comes LHCb....



Mesure de Φs à LHCb

From Fabrice

Impressive update from LHCb, nearly rules out D0 dimuon asymmetry

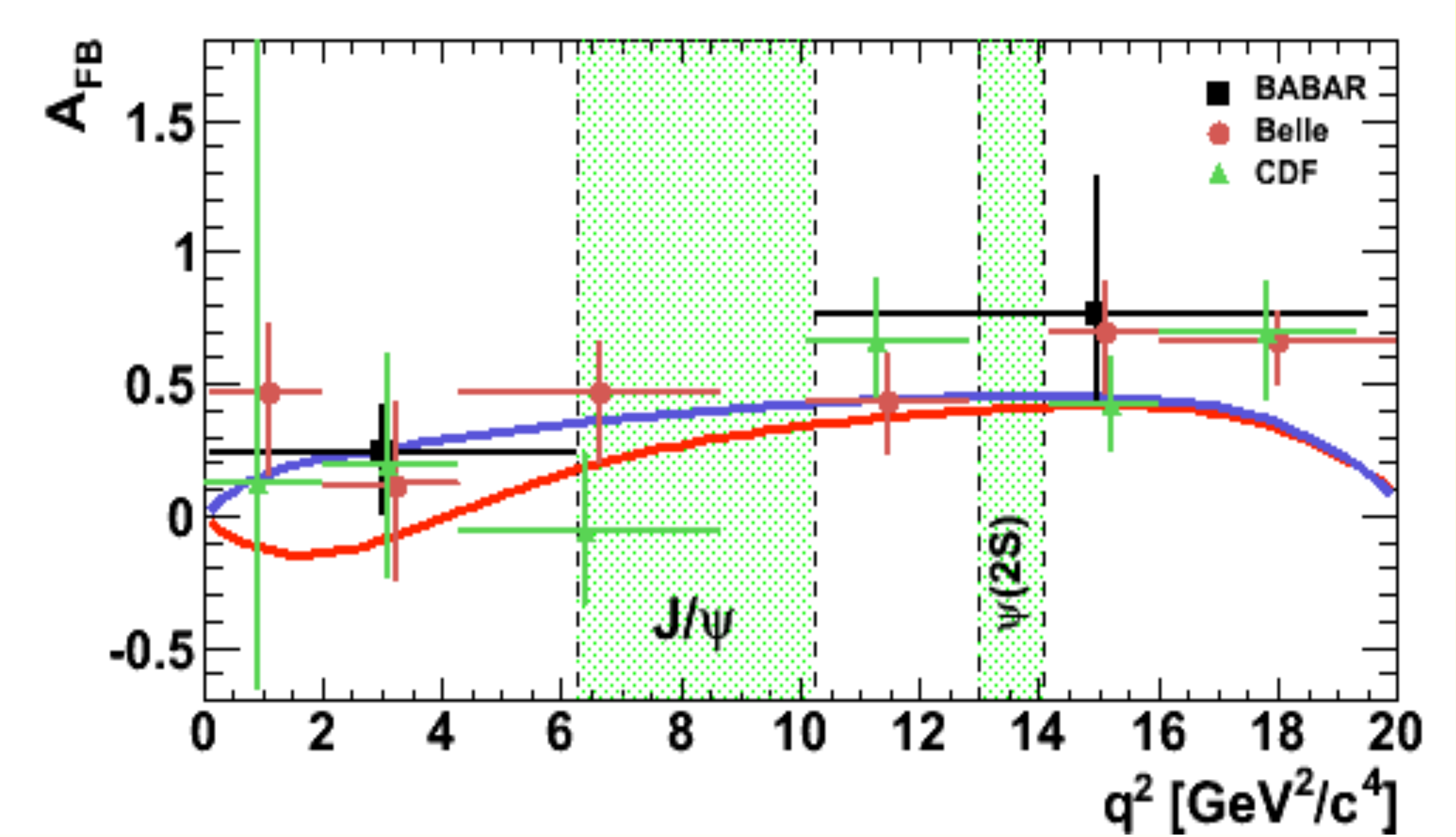


A_{FB} dans $B_d \rightarrow K^* ll$

From Fabrice

Asymmetry FB of the lepton system vs its q^2 is very sensitive to new physics.

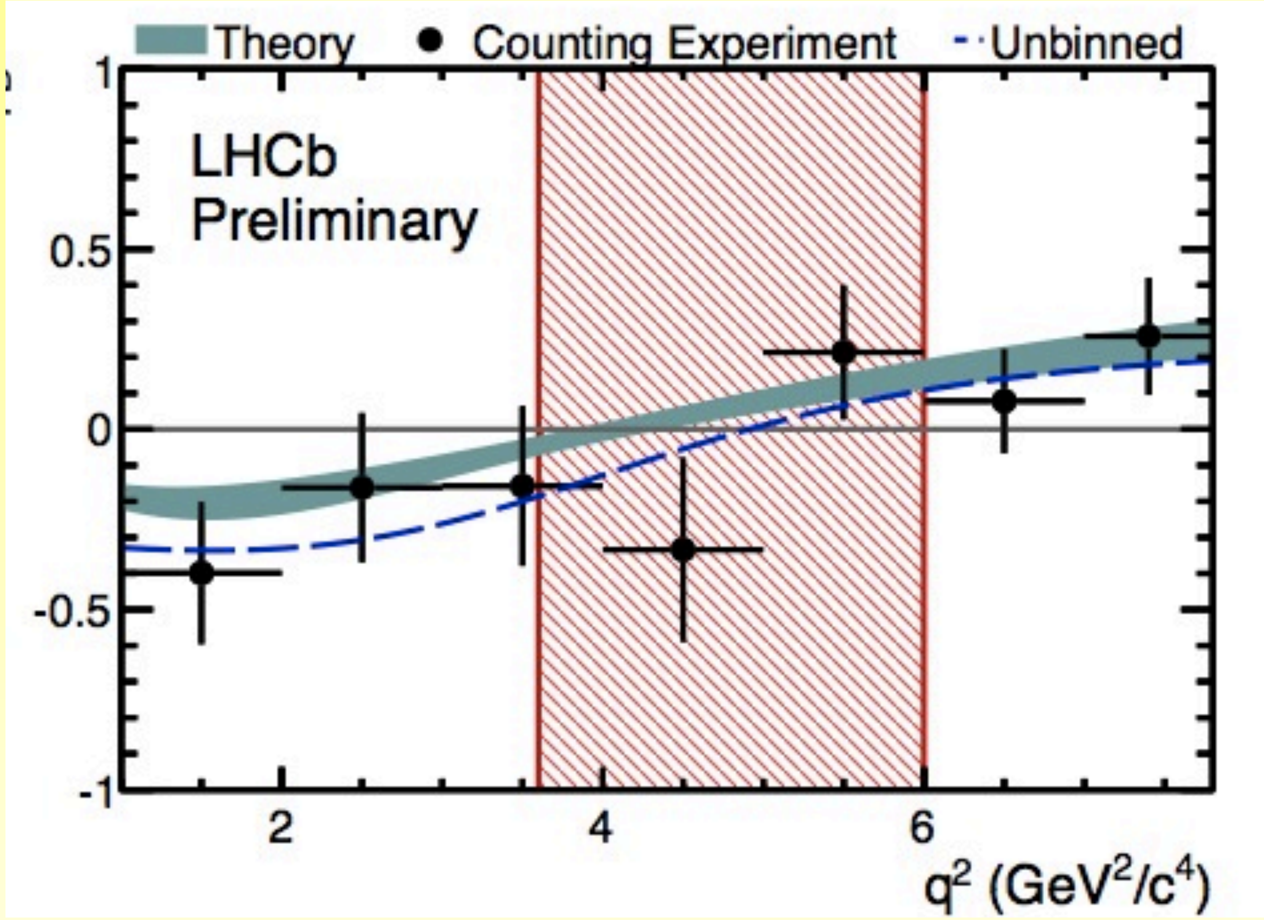
Some hints of deviations from B-factories and CDF

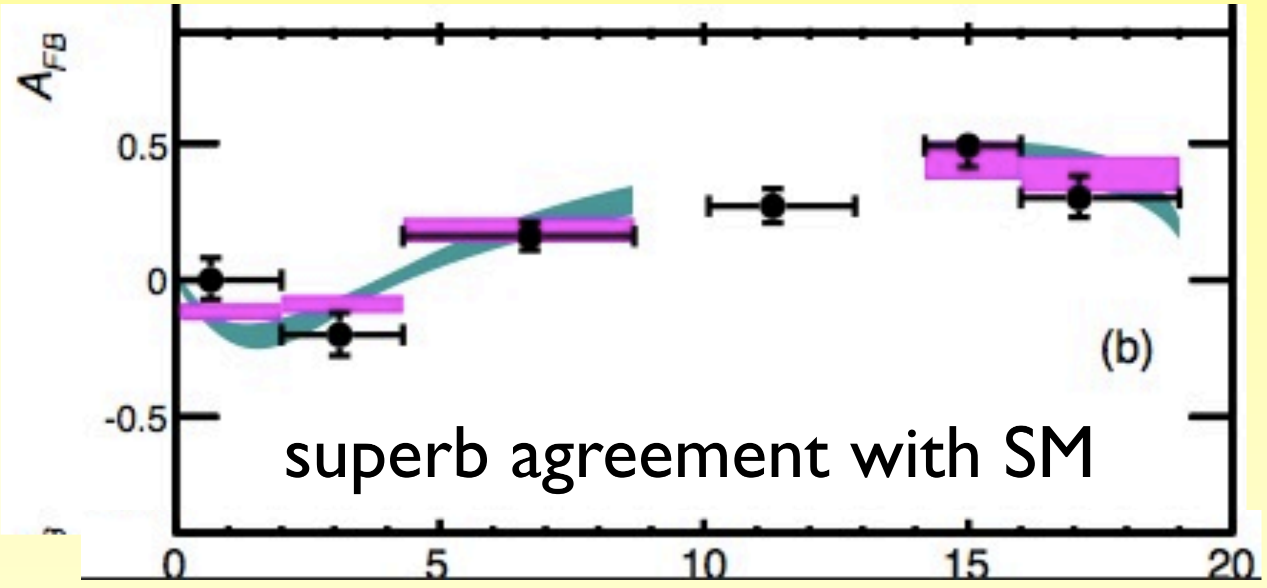


A_{FB} dans $B_d \to K^*$ ll à LHCb

From Fabrice

zero crossing point very well predicted in the SM





First Measurement

- The worlds first measurement of q_0^2, at $q_0^2 = 4.9^{+1.1}_{-1.3}$ GeV$^2/c^4$ [preliminary]
- This is consistent with SM predictions which range from $4 - 4.3$ GeV$^2/c^4$

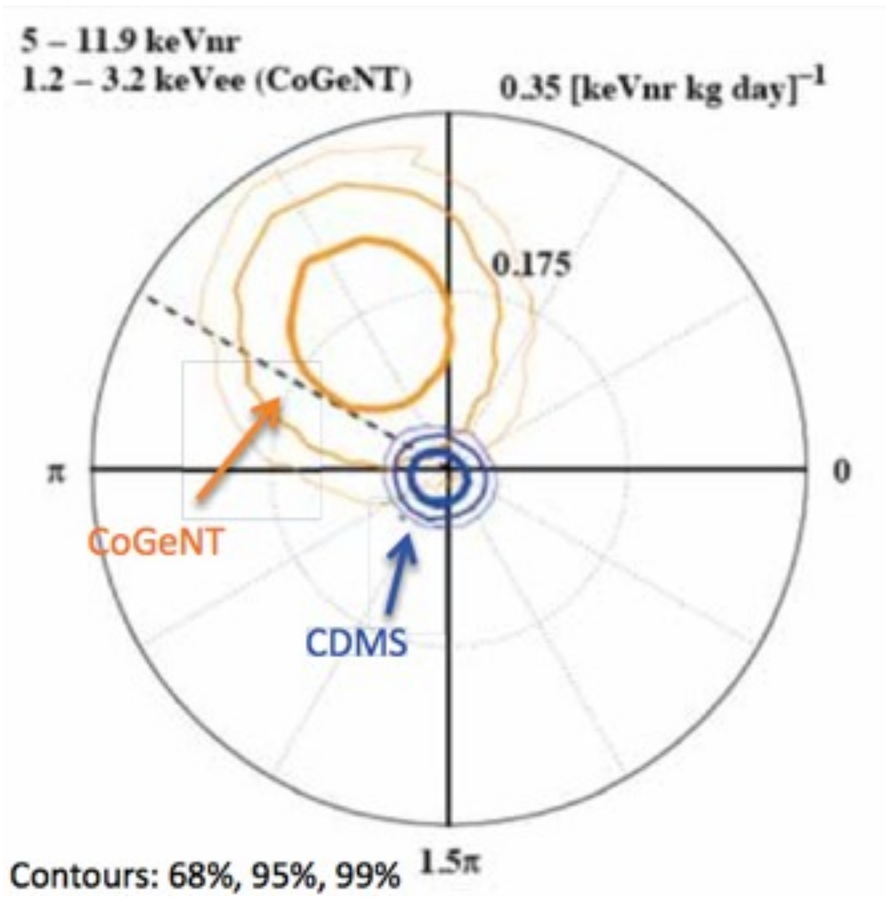
Détection directe de matière noire

From Eric

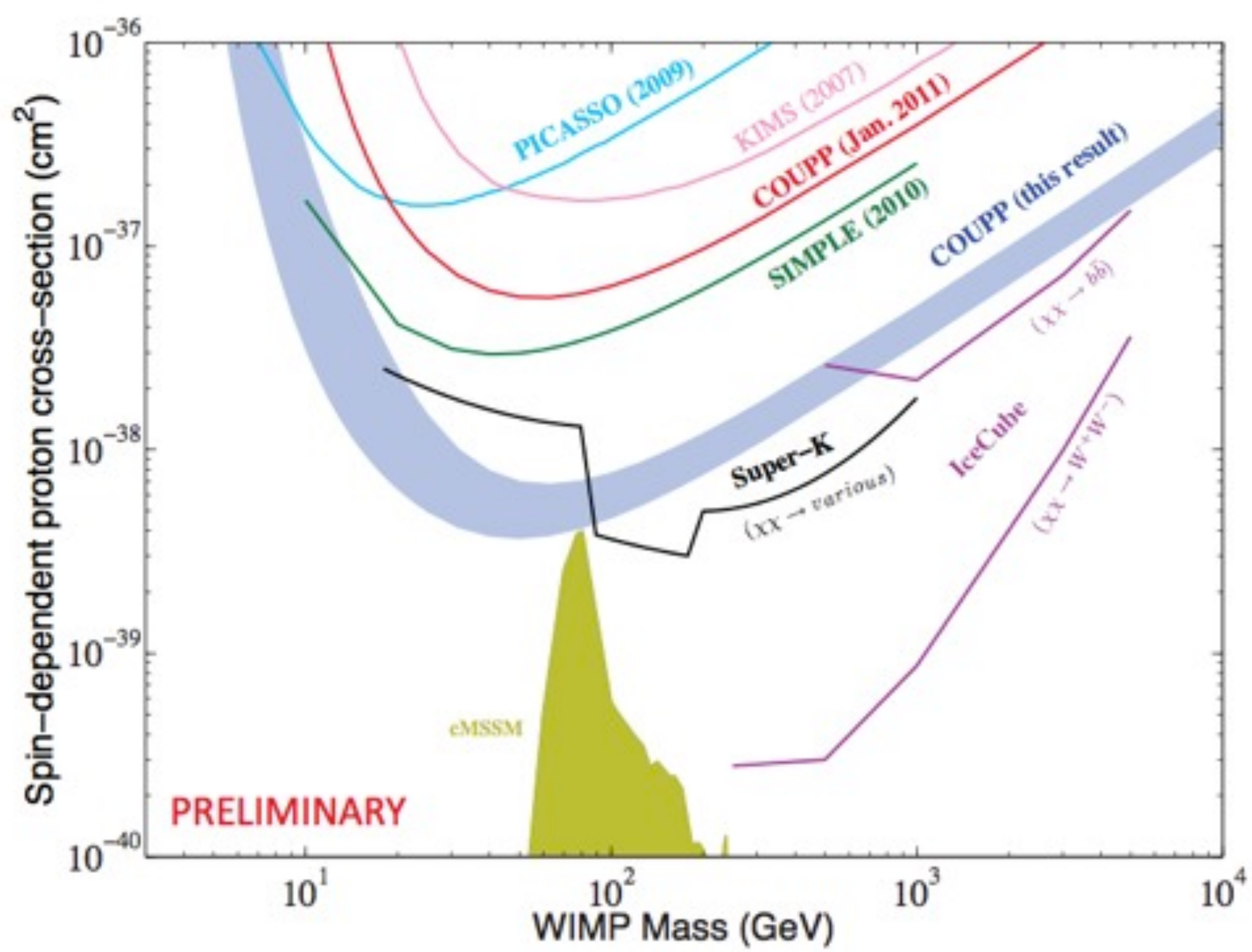
Recherche de reculs nucléaires induits dans une cible par la diffusion de WIMPs du halo galactique
Nombreuses stratégies expérimentales explorées

CDMS : recherche de modulation annuelle parmi les «candidats» WIMPs de basse énergie (réanalyse d'anciennes données)
- ne confirme pas le signal CoGeNT

Diagramme amplitude-phase



COUPP : recherche de WIMPs avec chambre à bulles 2L de CF3I
- contrainte compétitive sur la section efficace spin-dépendante
- limité par bruit de fond (20 «candidats») origine ??

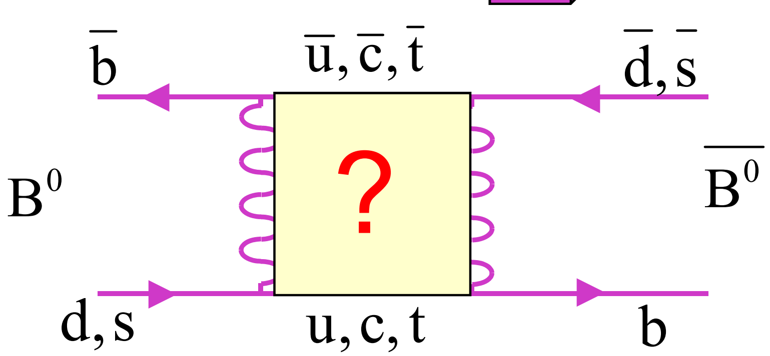


Backup

New Physics manifestations in Heavy Flavours

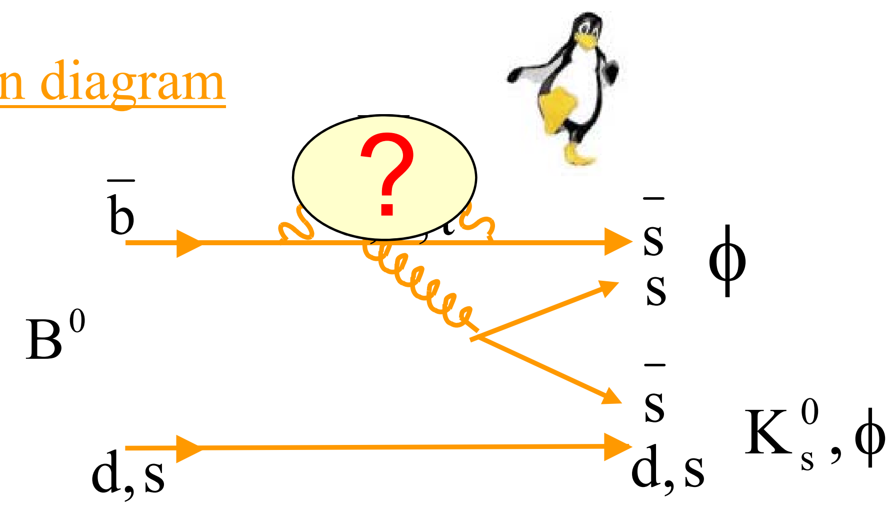
Search for deviations from Standard Model predictions due to ***virtual contributions of new heavy particles in loop processes***

Box diagram



New Physics

Penguin diagram



measure:

- ***CP violating phases*** in mixing and decay
- ***Rare Decays*** of heavy quarks

compare:

- to ***very precise predictions*** of the SM

→ discovery potential for ***New Physics*** extending to mass scales far in excess of the LHC centre-of-mass energy

$B_s \rightarrow \mu^+\mu^-$ "s-channel penguin"