

[] ?

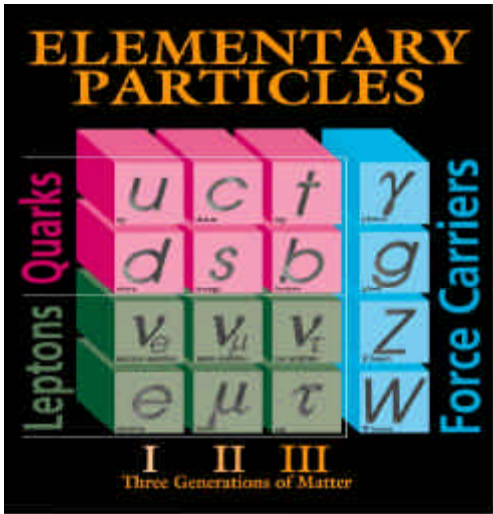
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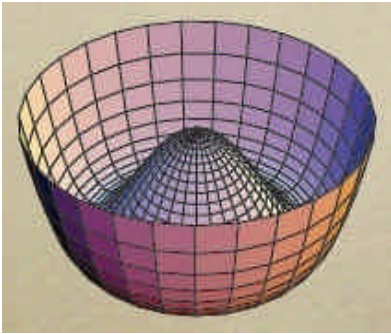
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[]

$Q(3, 2, +\frac{1}{6}), u(3, 1, +\frac{2}{3}), d(3, 1, -\frac{1}{3}),$
 $L(1, 2, -\frac{1}{2}), e(1, 1, -1)$



[]

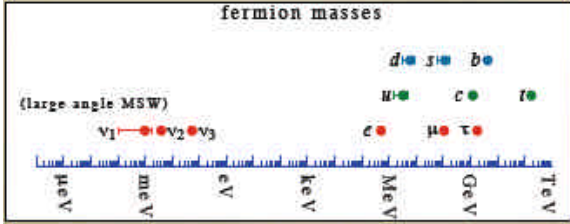


TeV @ LHC



Higgs & What Else?

[]



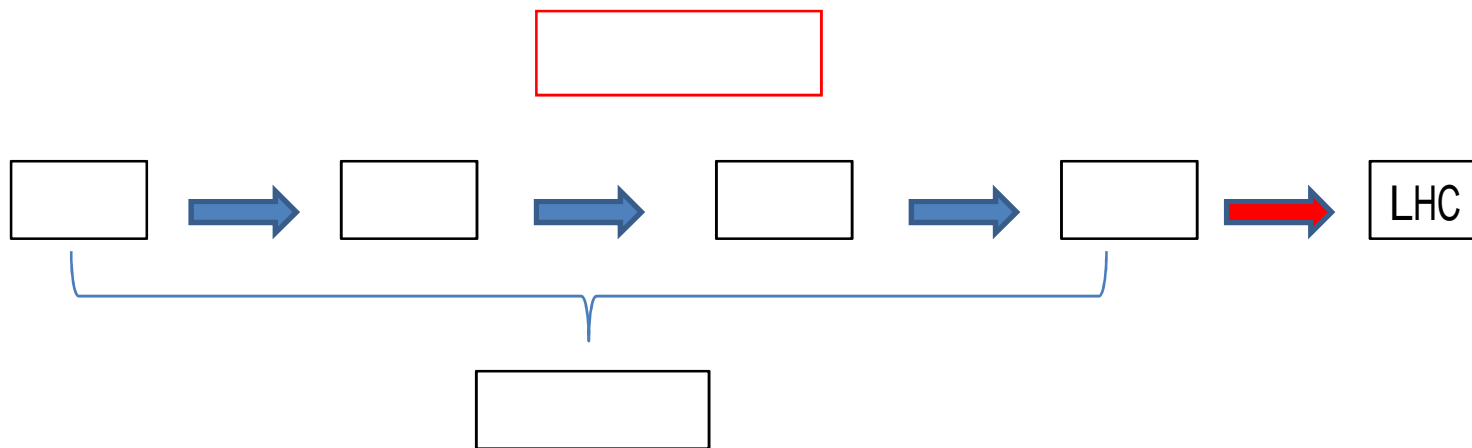


Hitoshi Murayama LP03

Quantum Universe

Particle Data Group 2008

John Ellis LHC





: ©

: © ©

$$\lambda = h/p \quad h = 6.6 \times 10^{-34} \text{ J s}$$

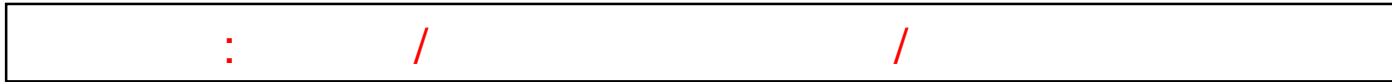
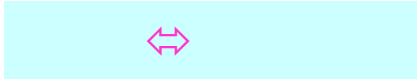
$$E^2 = p^2 c^2 + m^2 c^4 \quad c = 3 \times 10^8 \text{ m/s}$$

가 / 가 .

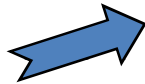
$$100 \text{ GeV} \Leftrightarrow 10^{-18} \text{ m} \Leftrightarrow 10^{-26} \text{ s}$$



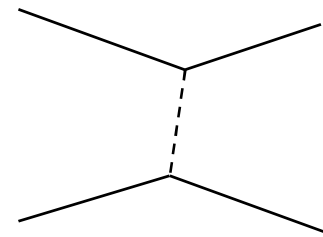
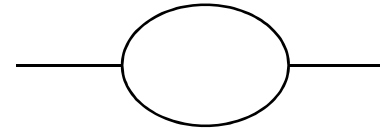
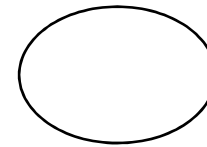
$$\text{Terascale : } 1 \text{ TeV} \Leftrightarrow 10^{-19} \text{ m} \Leftrightarrow 10^{-27} \text{ sec}$$



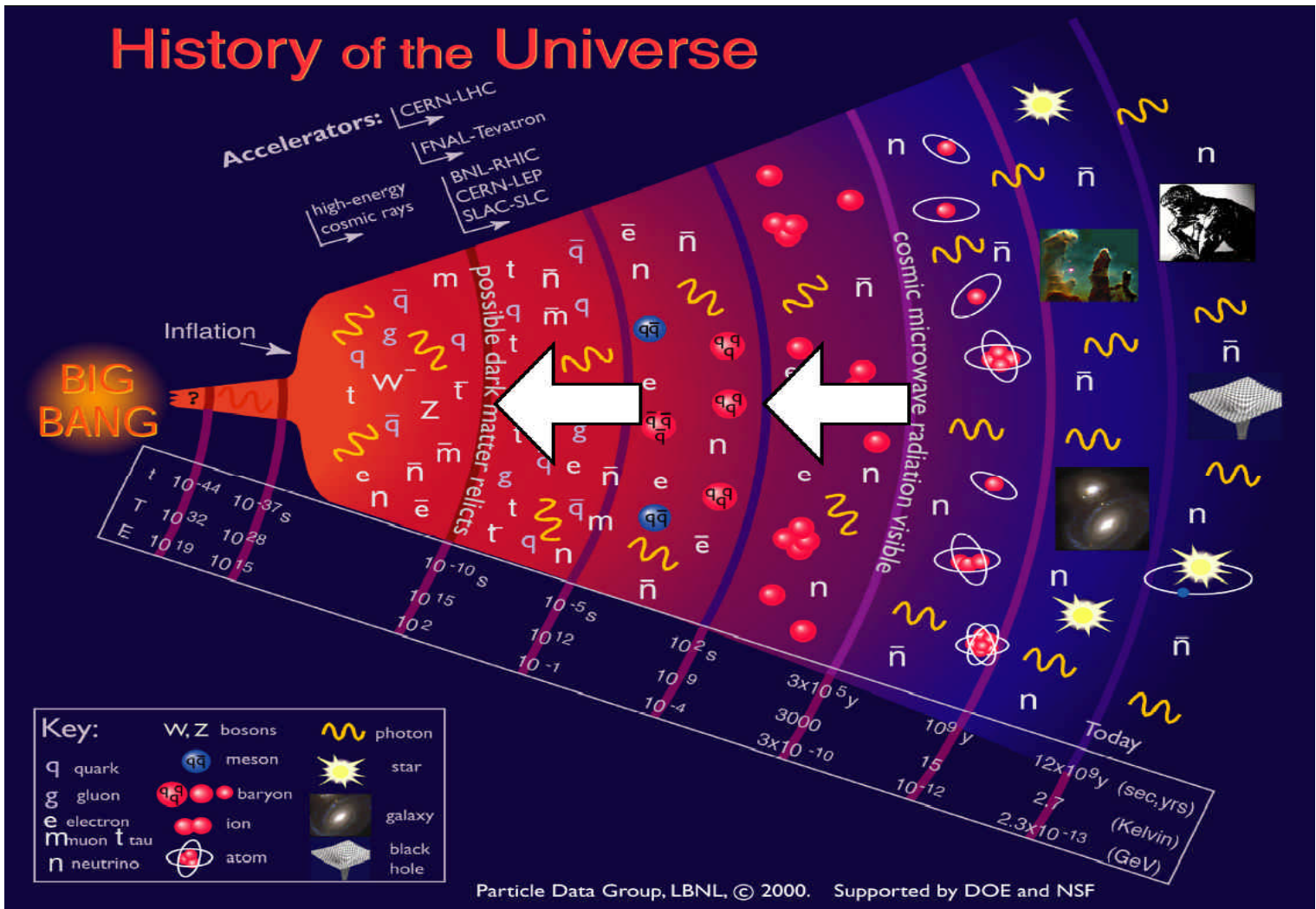
$\Delta t \sim h/\Delta E$
 $\Delta x \sim h/\Delta p$



/



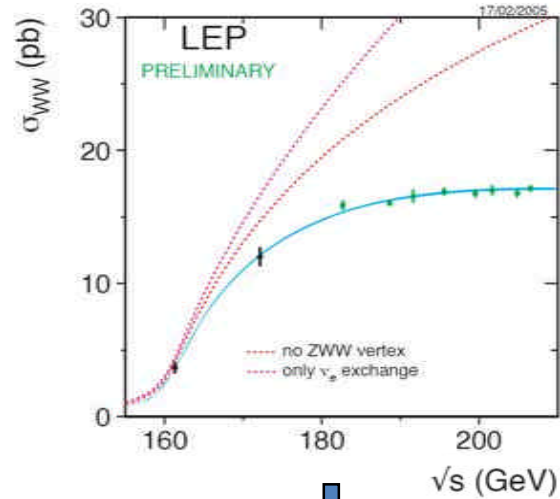
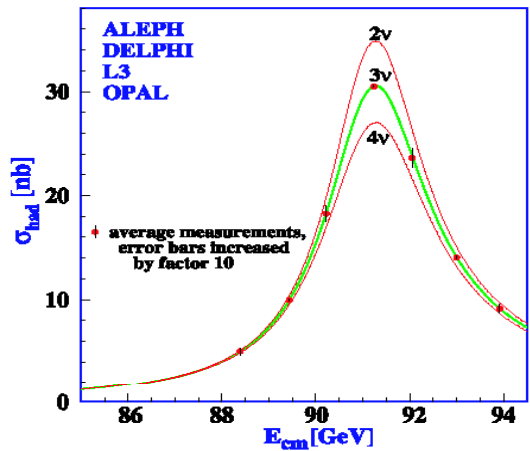
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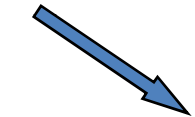
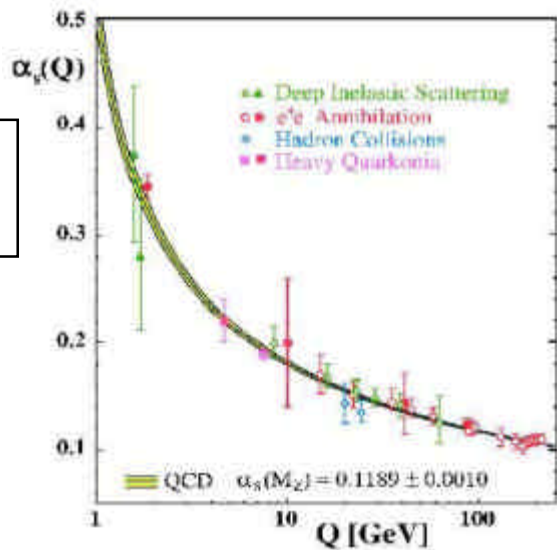
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SU(2) x U(1)

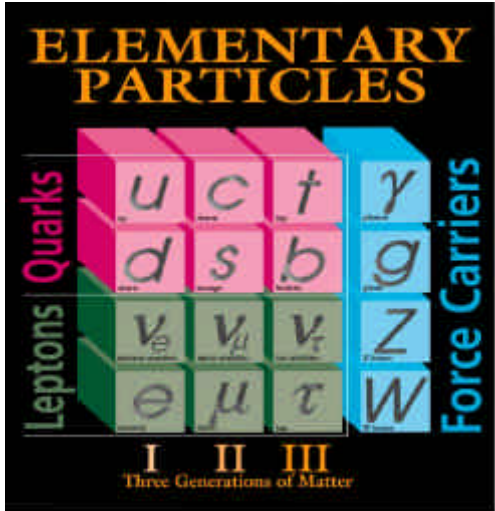
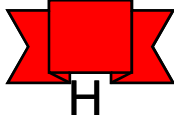
3



SU(3)

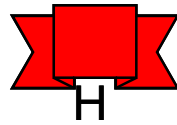
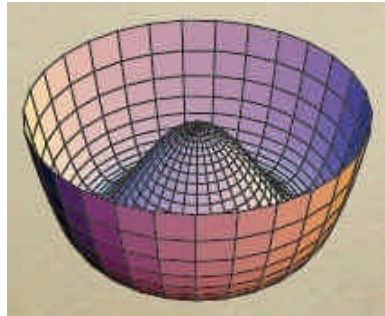
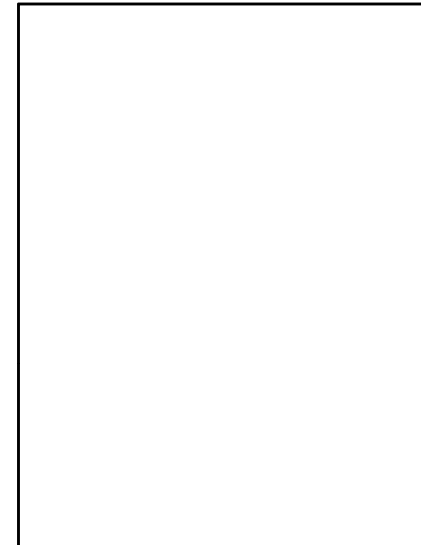
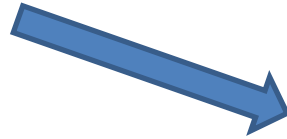
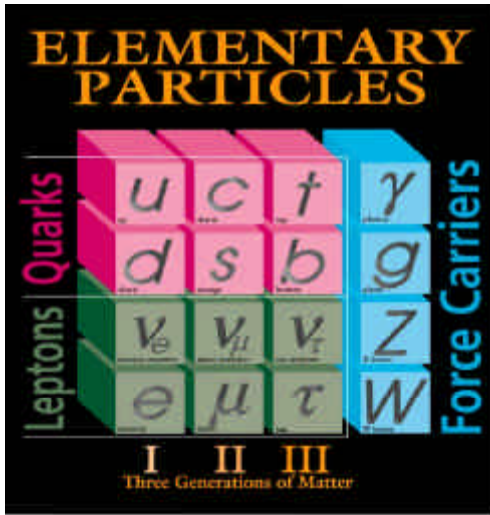


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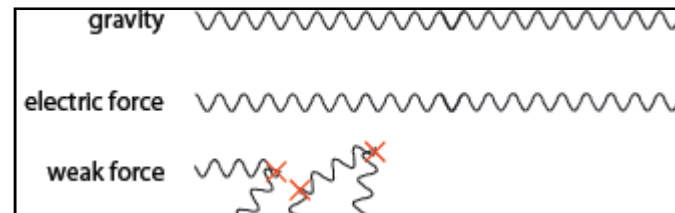


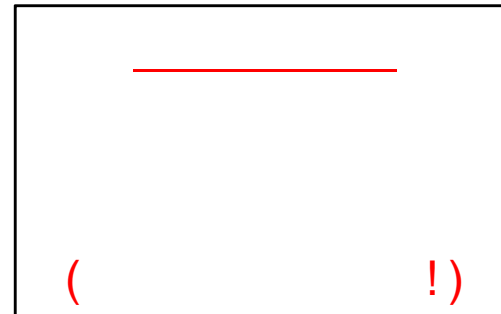
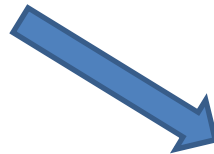
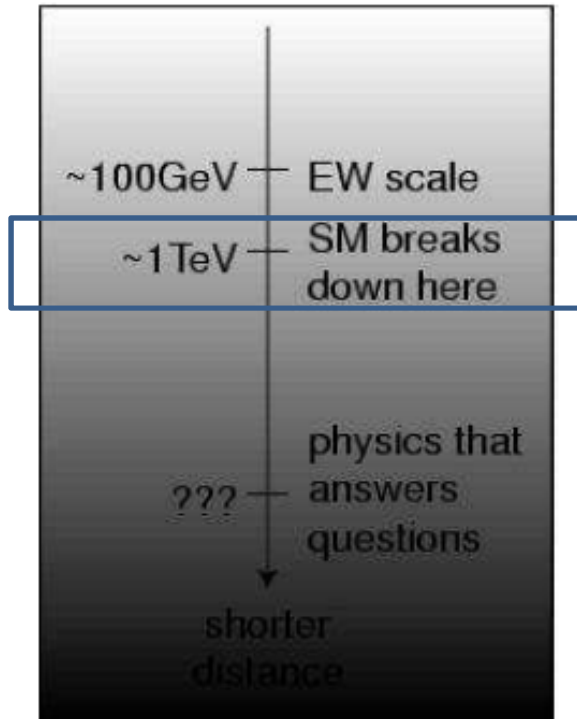


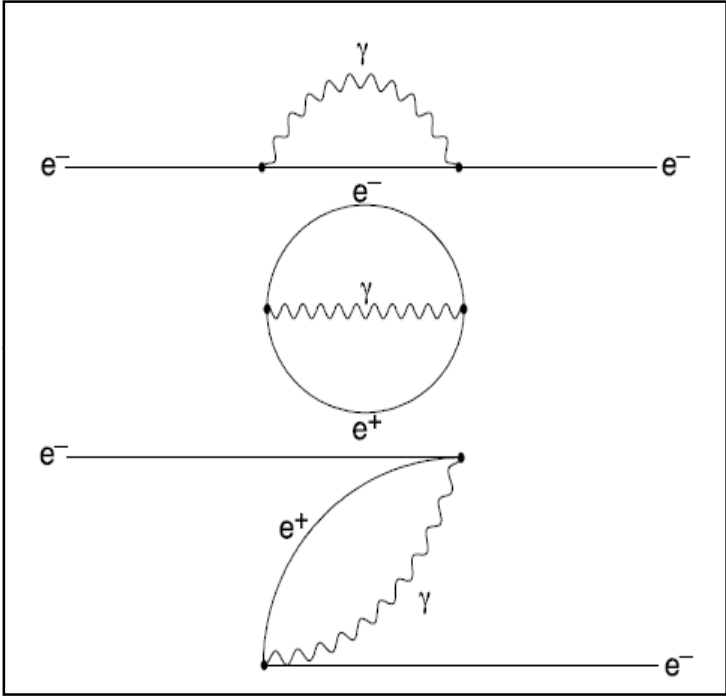
: $v = 246 \text{ GeV}$



BEC







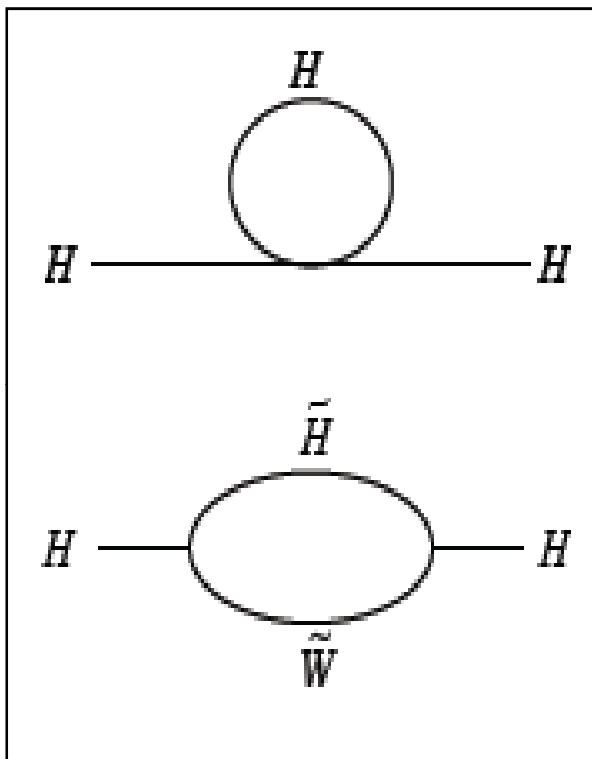
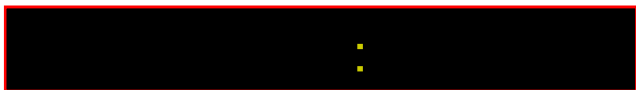
$$\Delta E \sim \frac{\alpha}{r_e} \sim 1 \text{ GeV} \frac{10^{-17} \text{ cm}}{r_e}$$



$$m_e = 0.51 \text{ MeV}$$

$$\Delta m_e c^2 \sim m_e c^2 \times \frac{\alpha}{4\pi} \log(m_e r_e)$$





$$\Delta m_H^2 c^4 \sim \left(\frac{\hbar c}{r_H}\right)^2$$

$$m_H \sim v = 246 \text{ GeV}$$

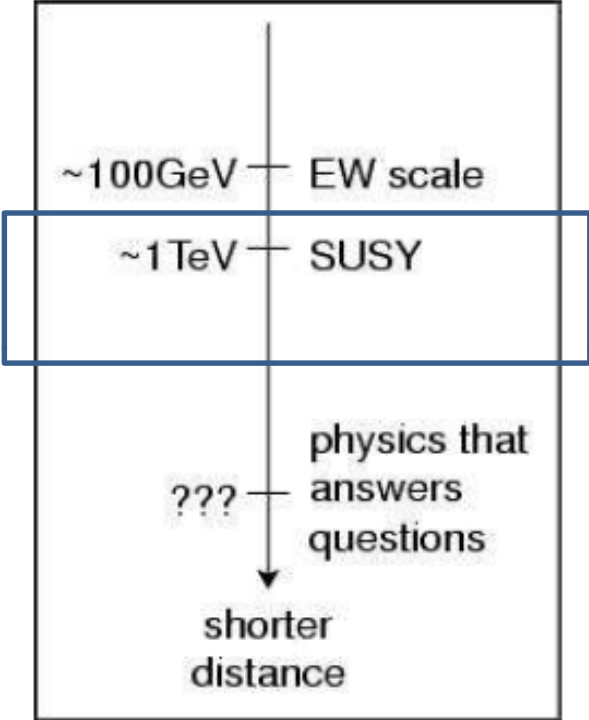


$$\Delta m_H^2 \sim \frac{\alpha}{4\pi} m_{SUSY}^2 \log(m_H r_H)$$



TeV ...

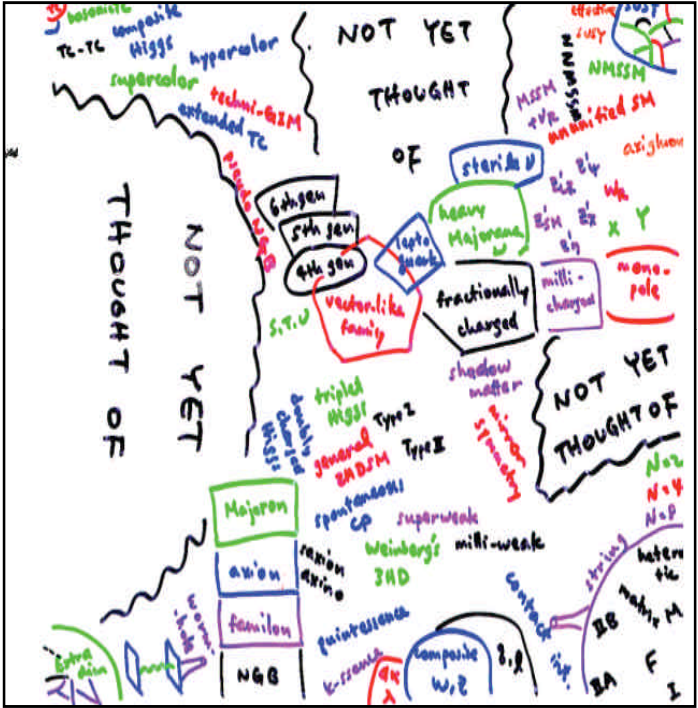
()
TeV
($v = 246 \text{ GeV}$)



가 가?

/ / ?
 (Cooper) ?
 TeV ?

(Pseudo) -
 (Little Higgs)
 KK



[Hitoshi Murayama]



Io stimo più il trovar un vero, benchè di cosa leggiera, ch'ì disputar lungamente delle massime questioni senza conseguir verità nissuna.

I attach more value to **finding a fact, even about the slightest thing**, than to lengthy disputations about the Greatest Questions that fail to lead to any truth whatever.

가 /

LHC

“The other half of the world
discovered ”



Halliday-Resnick

All observed particles have unique partners of different spin and statistics, called superpartners, that make our theory of elementary particles valid to very small distances.

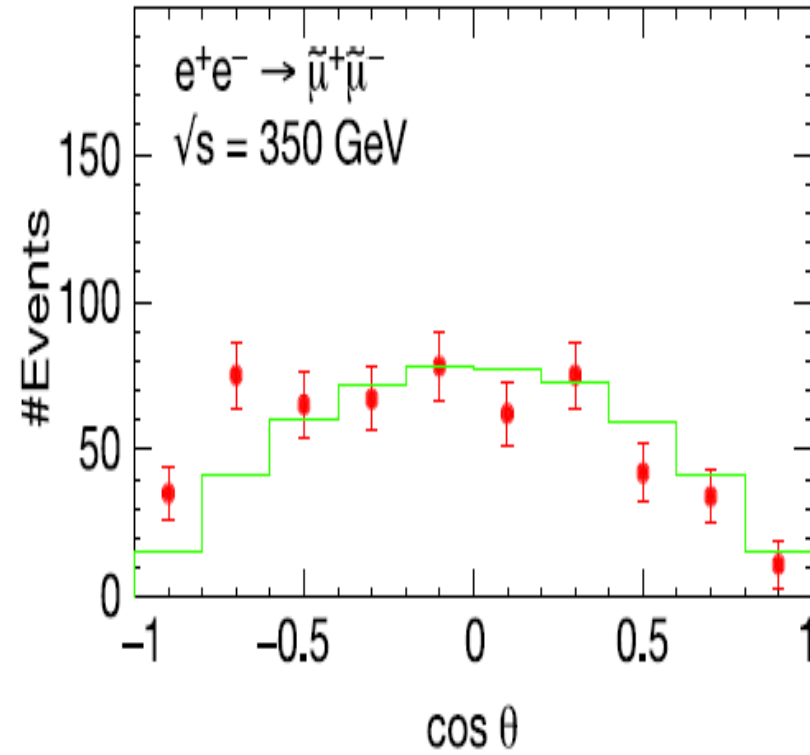
@ ILC

[www.linearcollider.org]

$\frac{1}{2}$

SU(3) x SU(2) x U(1)

= 0 ?

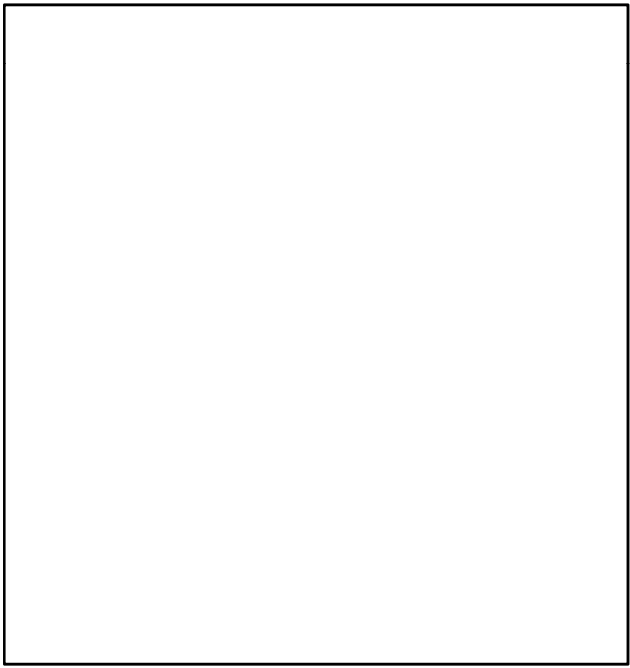
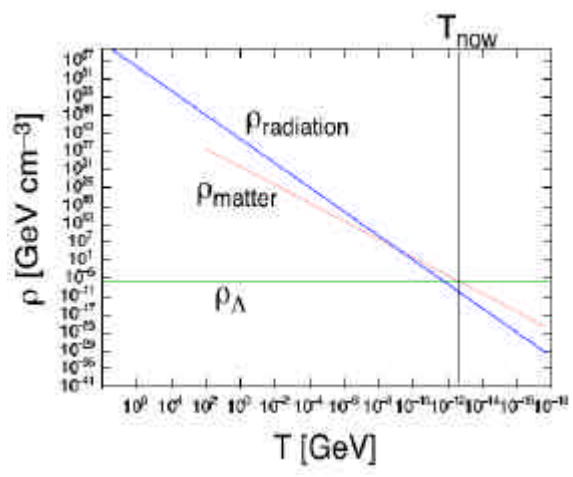
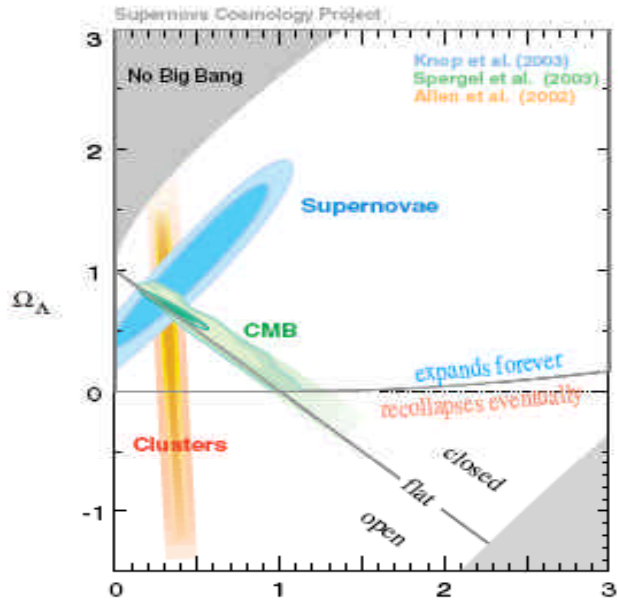


$$\Omega_{total} = 1.02 \pm 0.02$$

$$h = 0.71 \pm 0.04$$

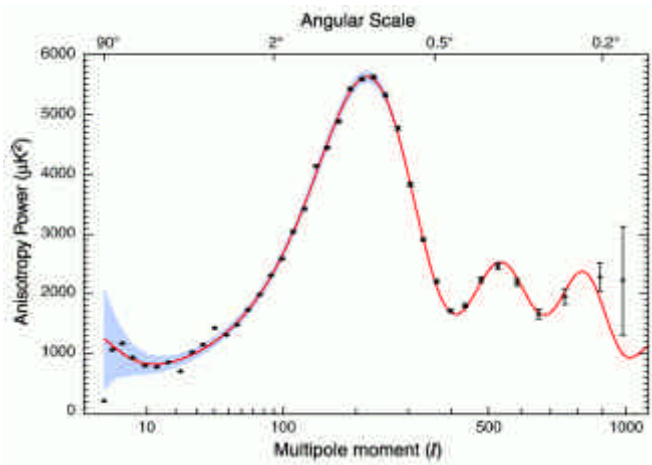
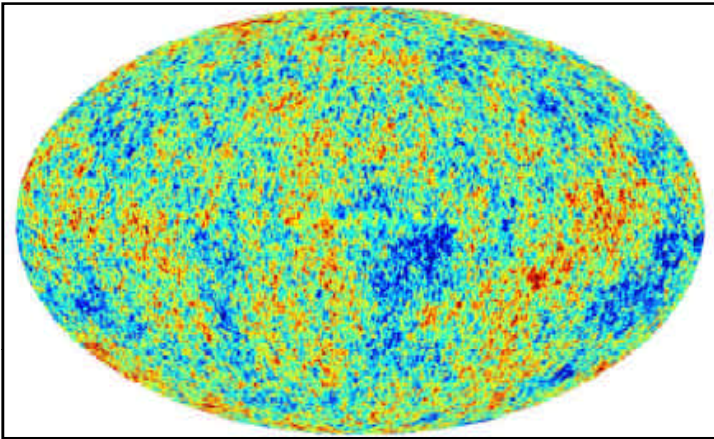


,





WMAP



$$h = 0.71 \pm 0.04$$

$$\Omega_M h^2 = 0.135 \pm 0.009$$

$$\Omega_b h^2 = 0.0224 \pm 0.0009$$

$$\Omega_{total} = 1.02 \pm 0.02$$



TeV again?

$$\Omega_M h^2 = 0.135 \pm 0.009$$



$$\Omega_M = \frac{0.756(n+1)x_f^{n+1}}{g^{1/2}\sigma_{ann}M_{Pl}^3} \frac{3s_0}{8\pi H_0^2} \approx \frac{\alpha^2 / (\text{TeV})^2}{\sigma_{ann}}$$

TeV

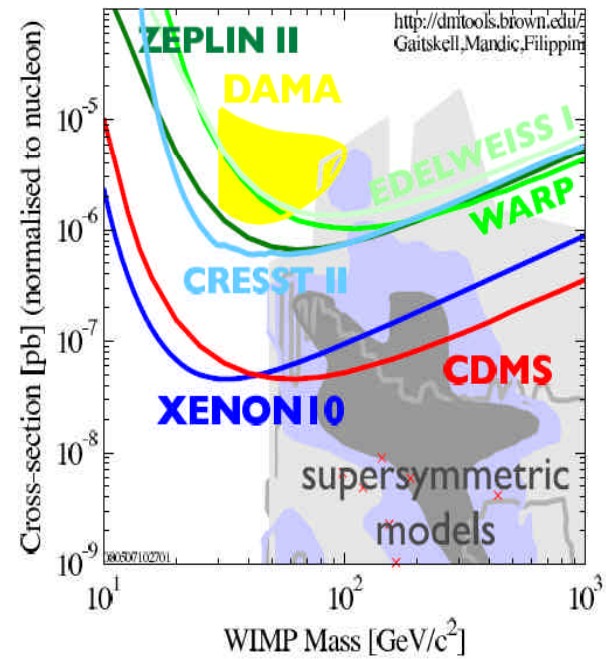
(LSP LKP LTP)

LHC

ILC

: 가

(10⁻¹²)

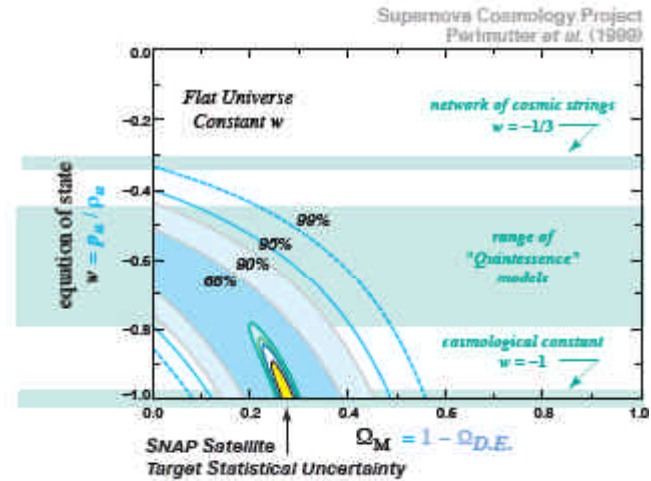
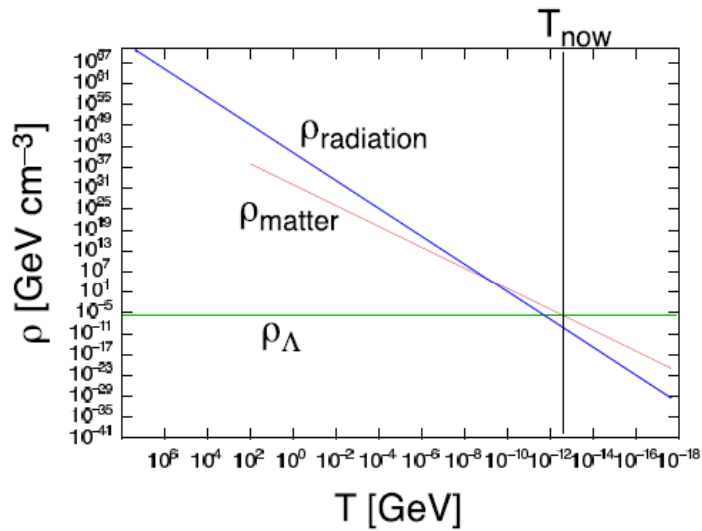


?



3

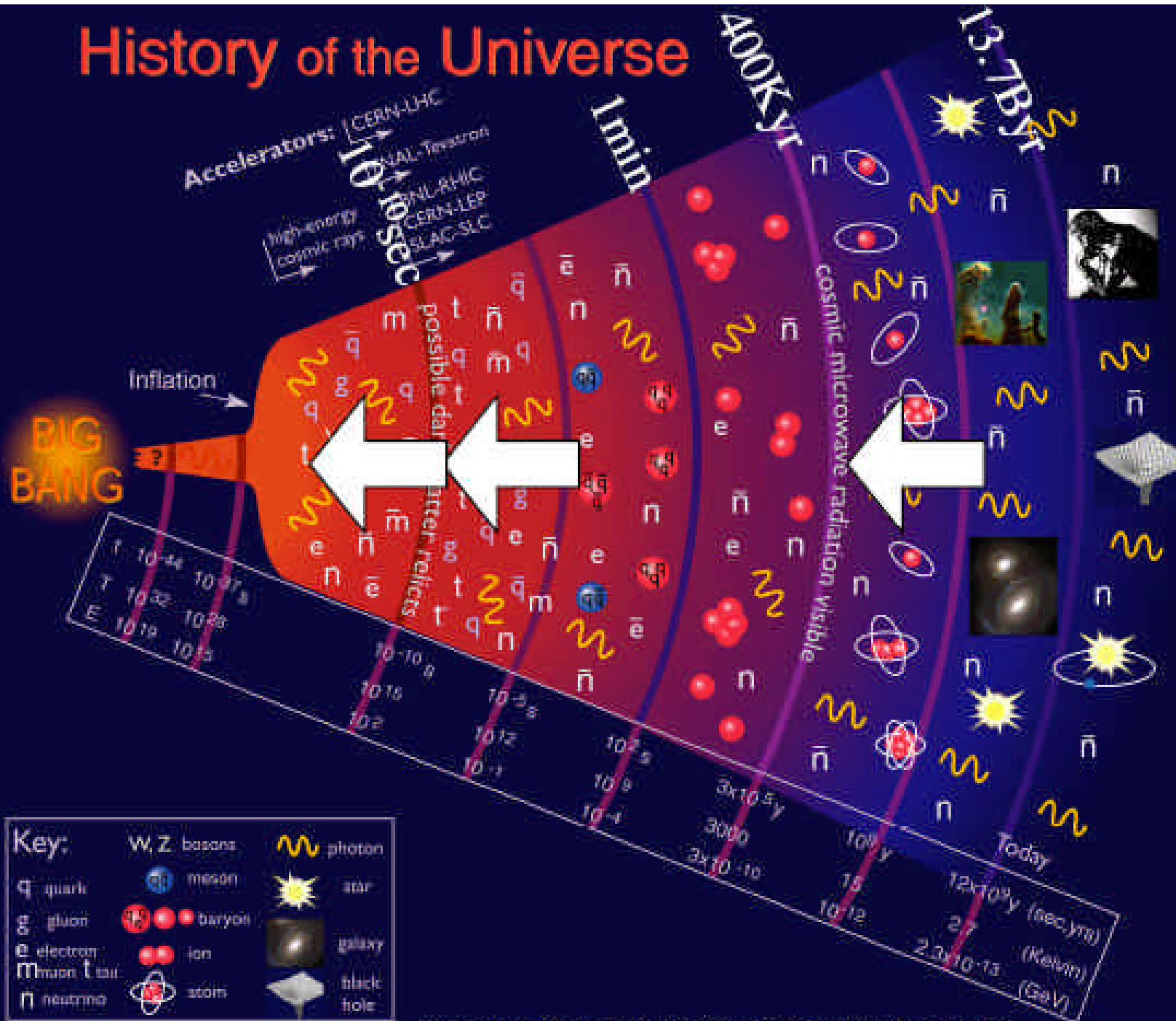
$w = -1 ?$



$$\rho_{\text{rad}} \sim T^4 \simeq \rho_M \sim \frac{m T^3}{M_{\text{Pl}}} \Rightarrow \rho_\Lambda \sim \left(\frac{\text{TeV}^2}{M_{\text{Pl}}} \right)^4 \sim (0.5 \text{meV})^4 \Leftrightarrow (2 \text{meV})^4$$

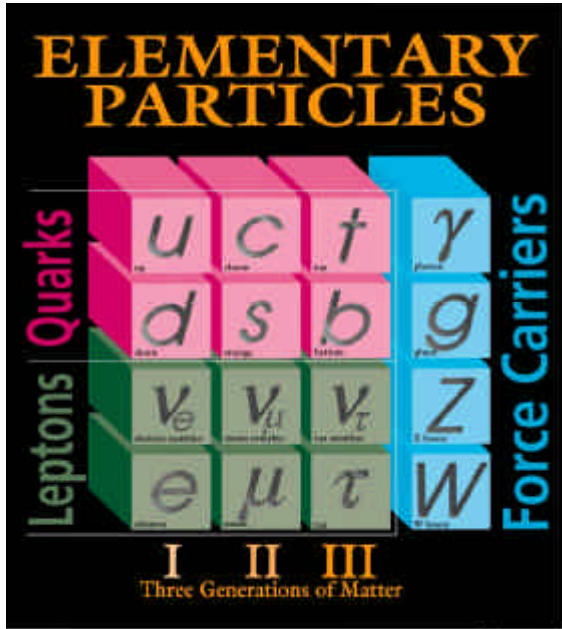
TeV again!?

History of the Universe

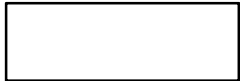




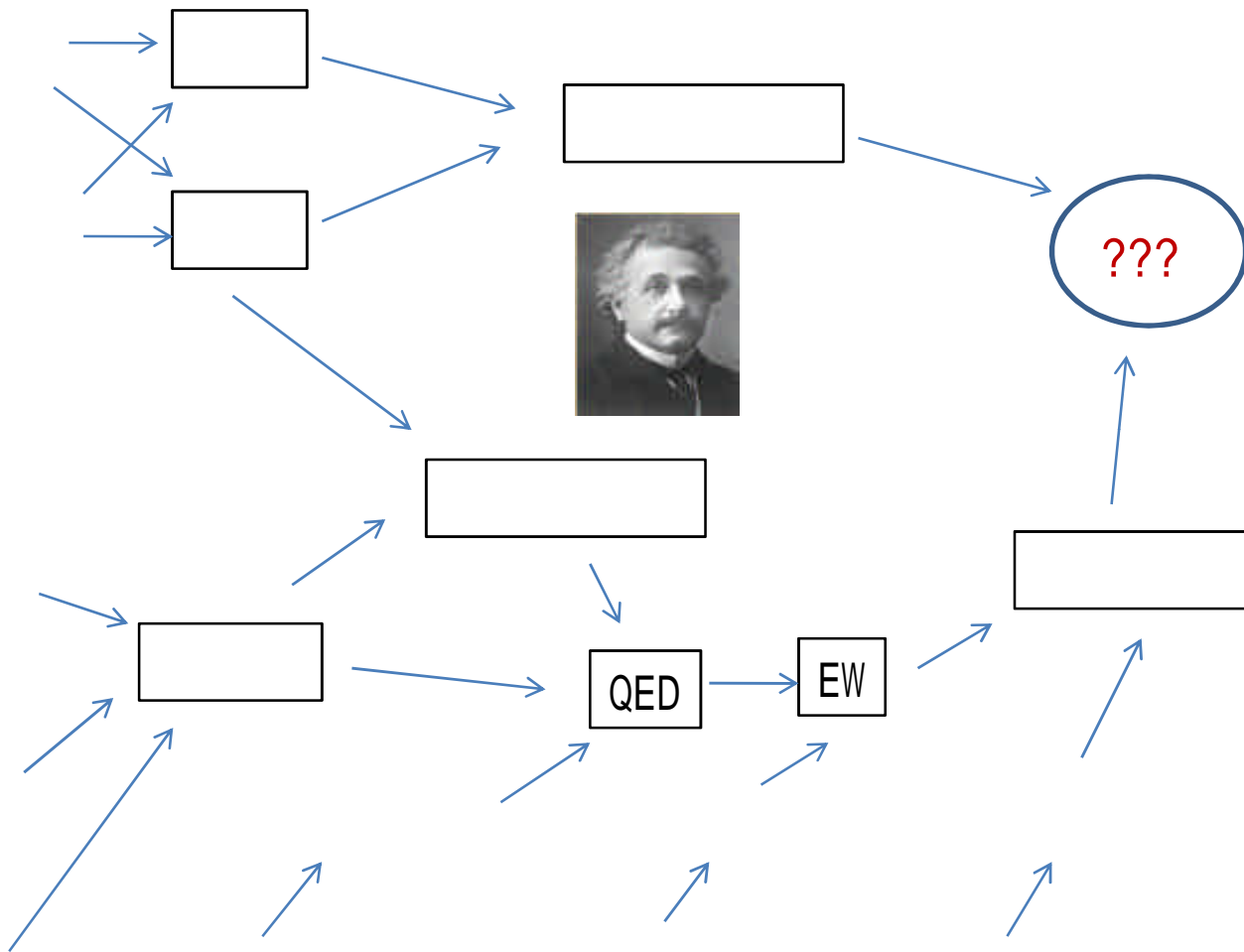
⋮



3 (+1) 가

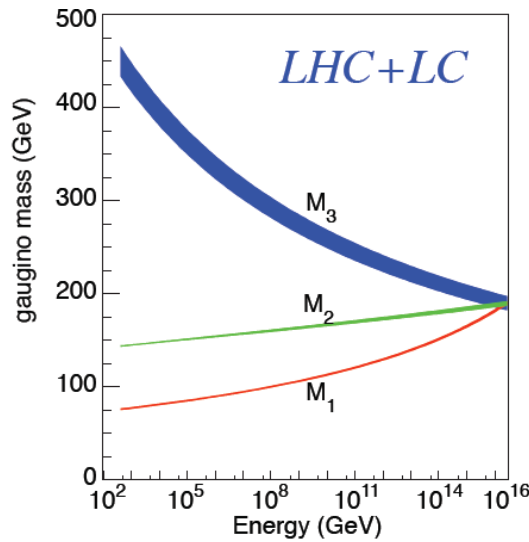
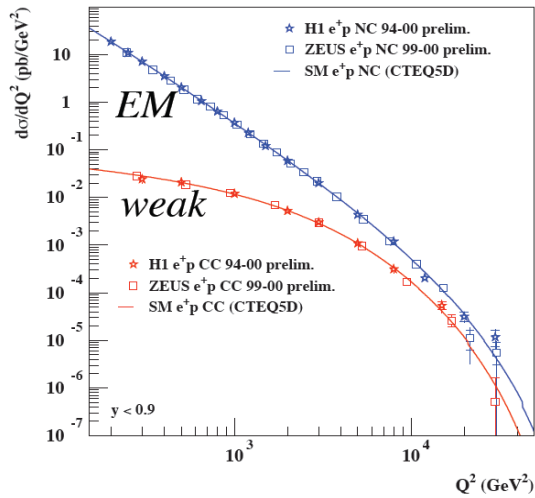


: m_W $M_{GUT} \sim 10^{16}$ GeV

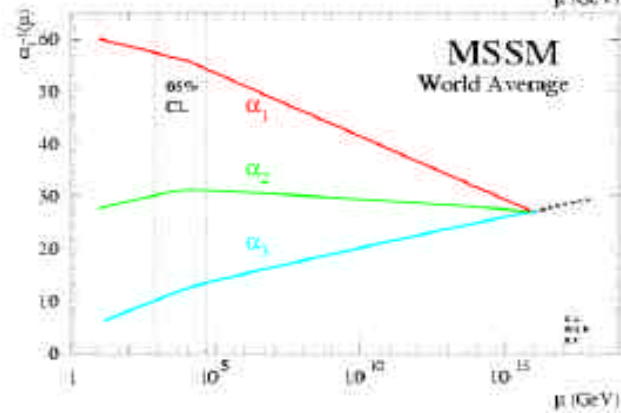
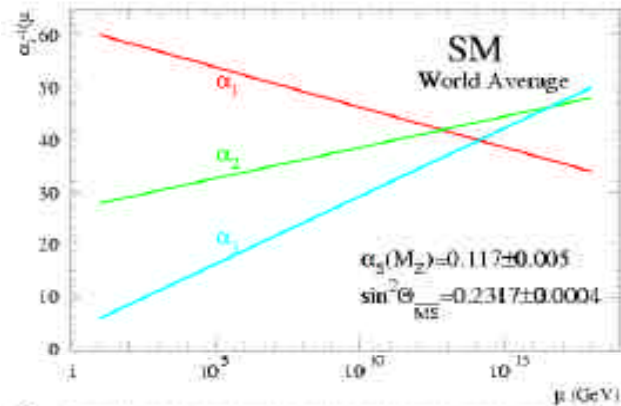




@ HERA



:



TeV again?!

:



$$\mathcal{L} = \mathcal{L}_{\text{SM}} + \frac{1}{\Lambda} \mathcal{L}_5 + \frac{1}{\Lambda^2} \mathcal{L}_6 + \dots$$

$$\mathcal{L}_5 = (LH)(LH)$$



$$\frac{1}{\Lambda} (L\langle H \rangle)(L\langle H \rangle) = m_\nu \nu \nu$$



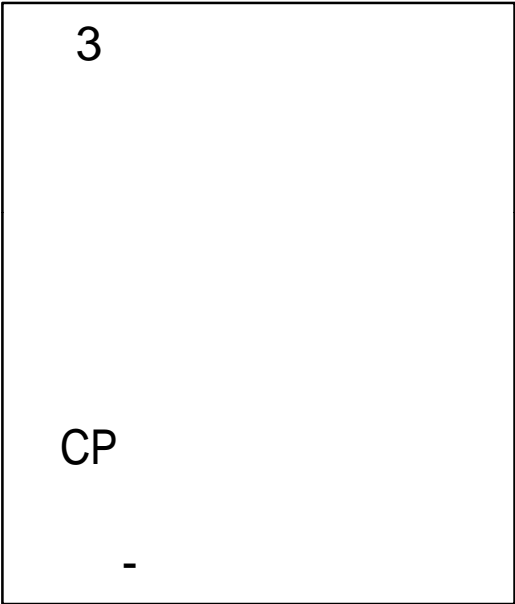
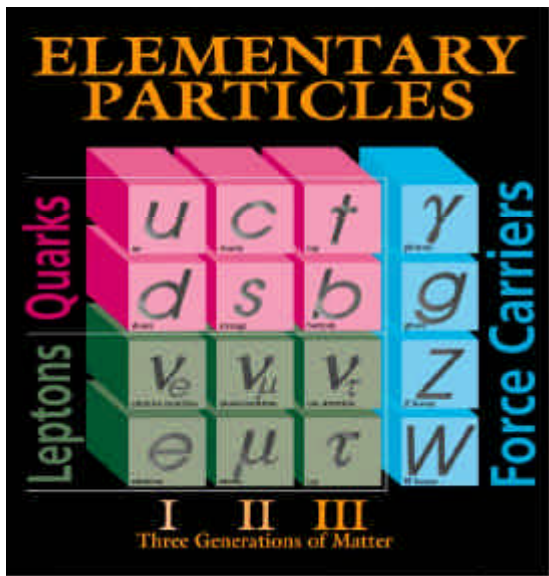
$$\Lambda \sim 10^{15} \text{ GeV!}$$

GUT !





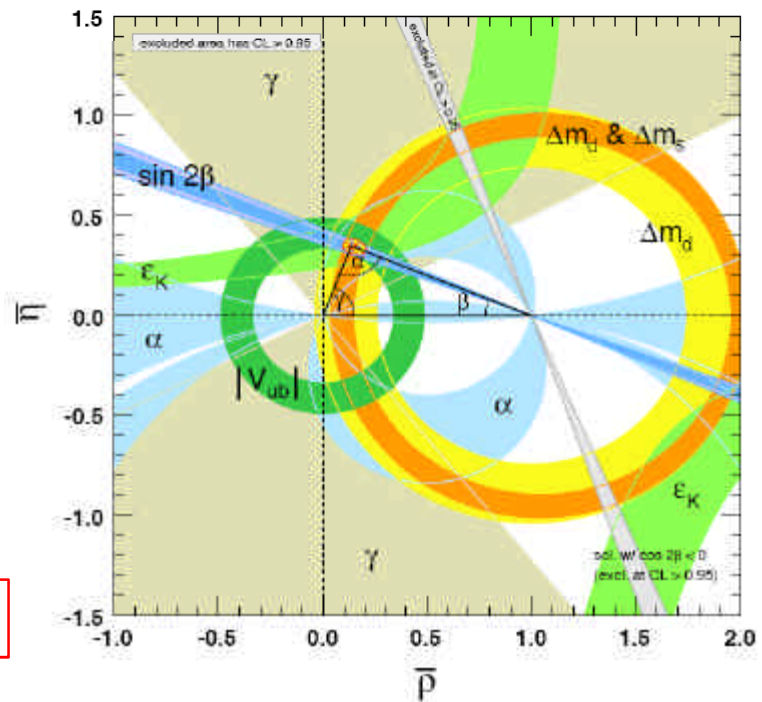
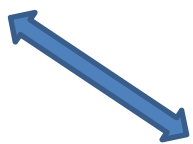
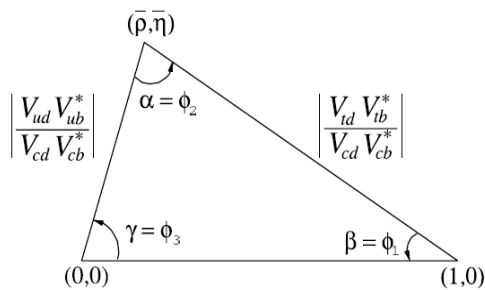
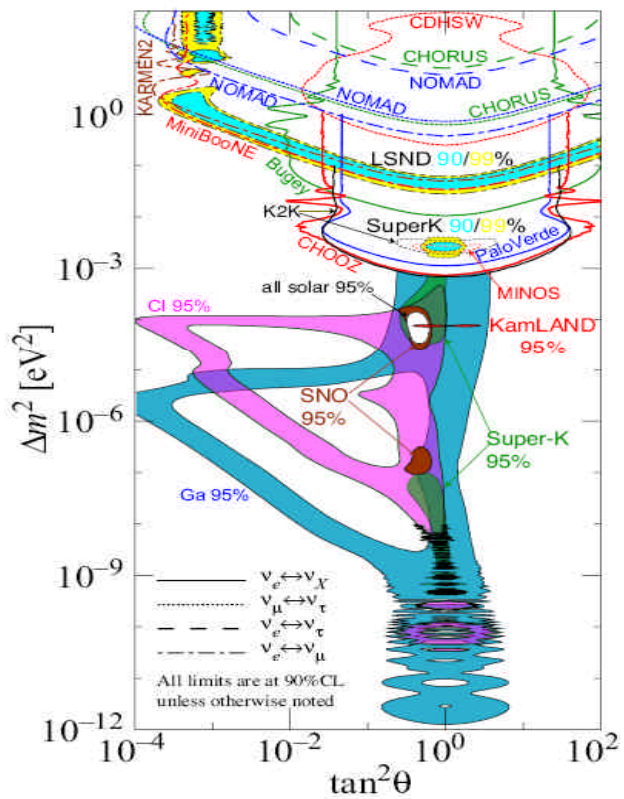
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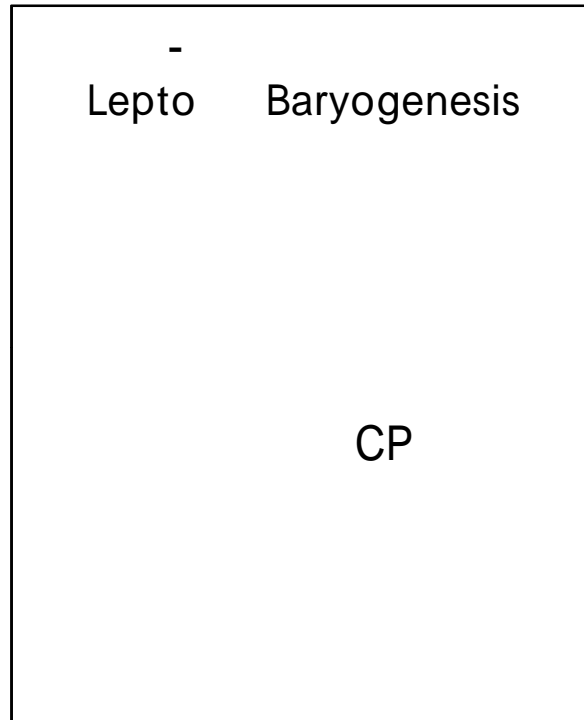
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GUT + FUT?!



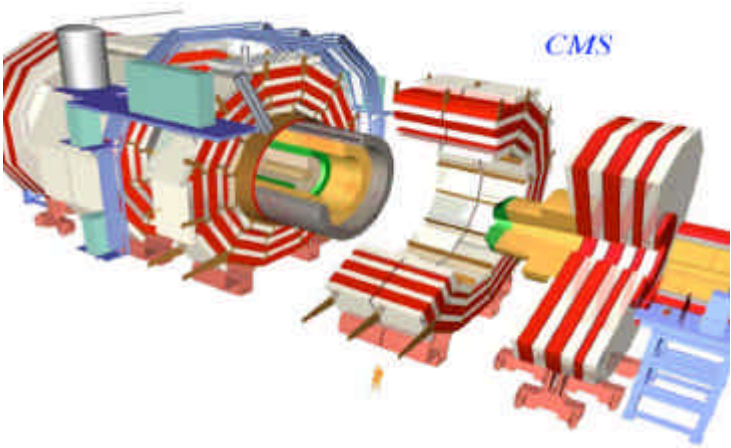
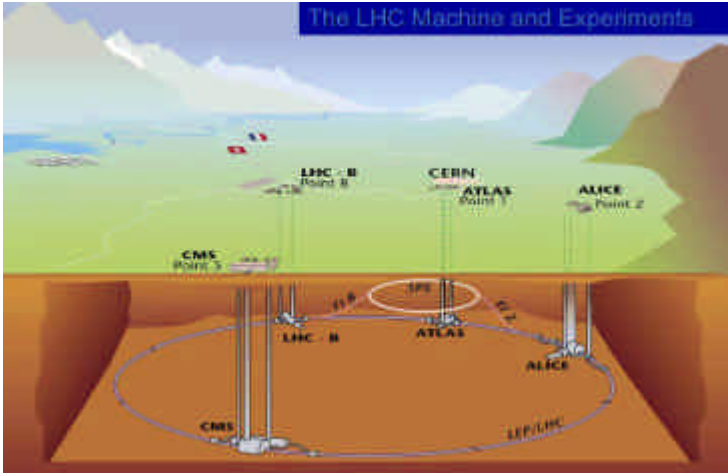
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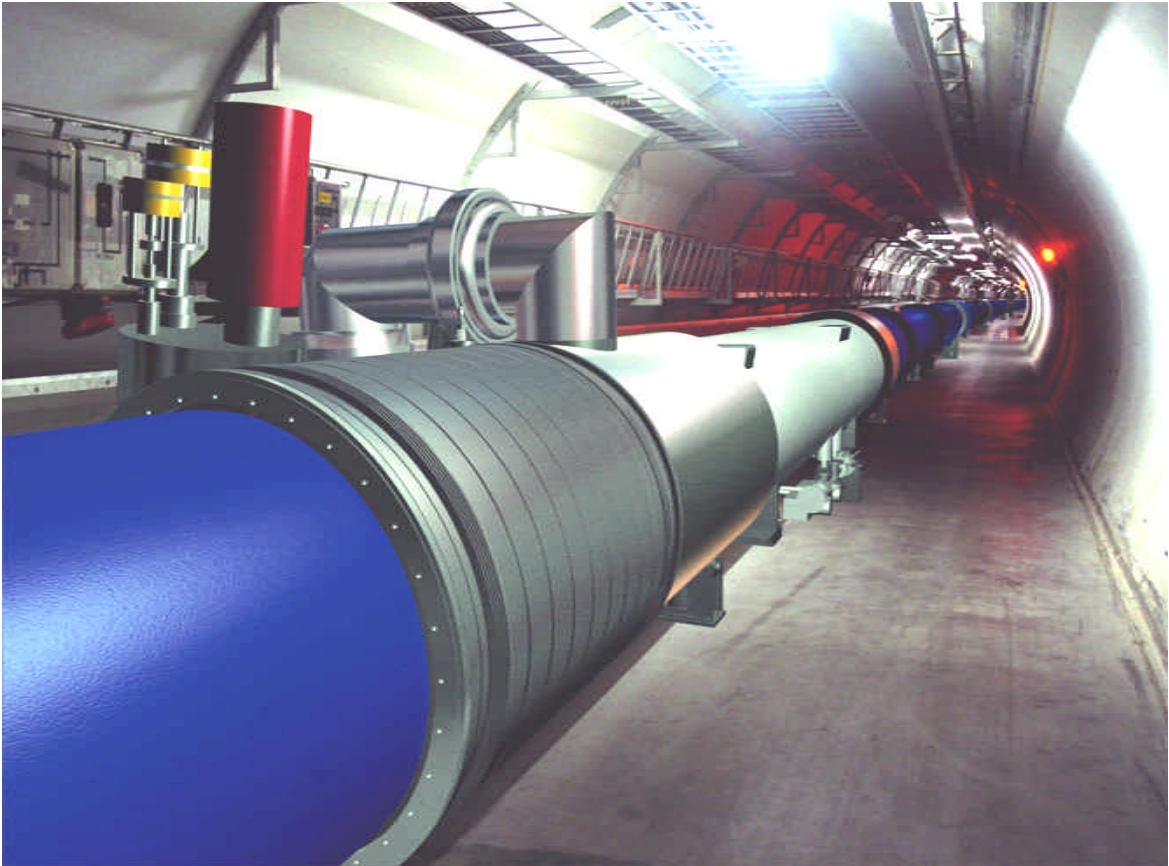
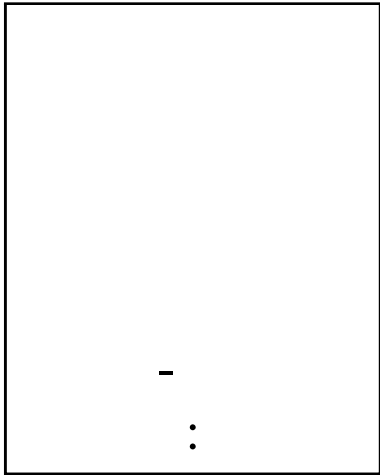
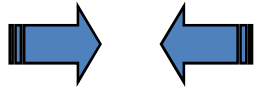
LHC = Large Hadron Collider



LHC



7 TeV + 7 TeV



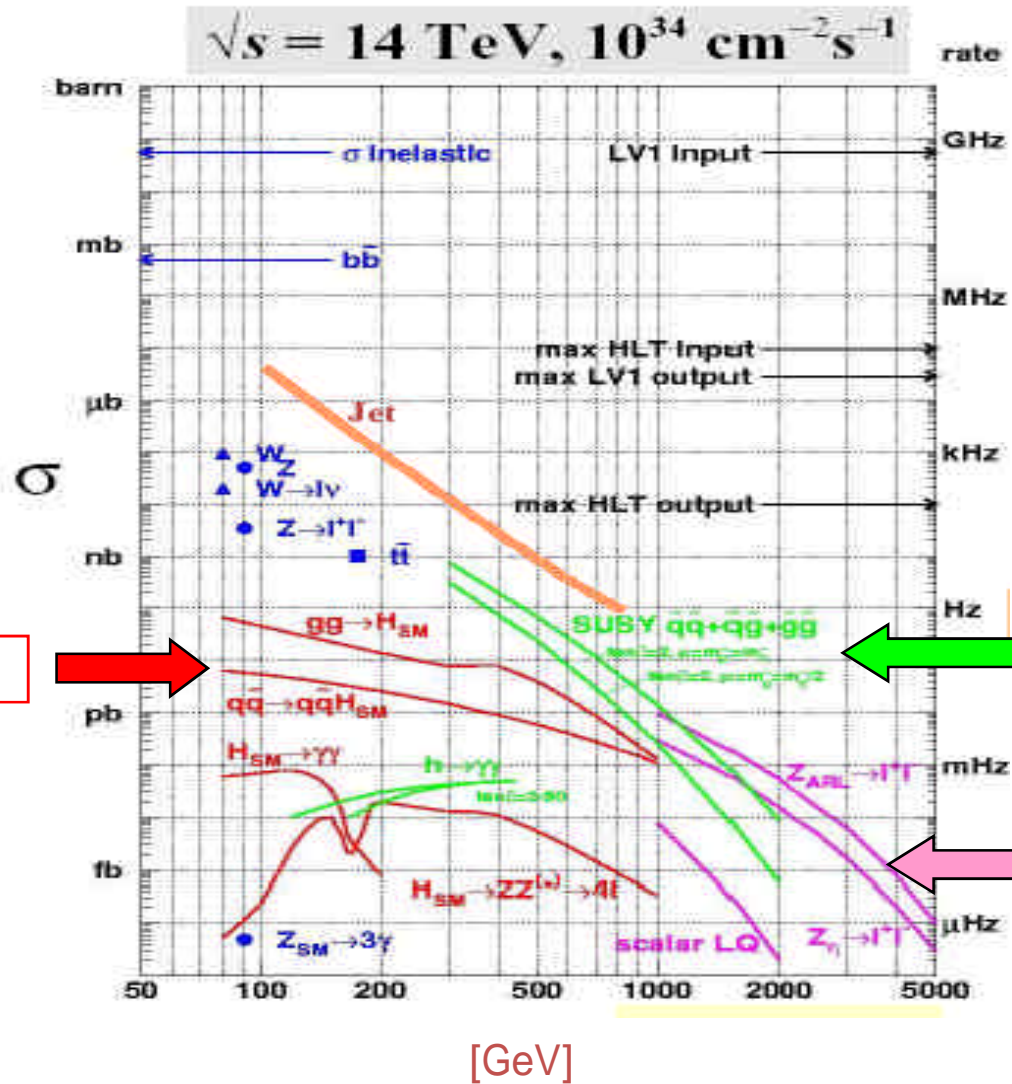


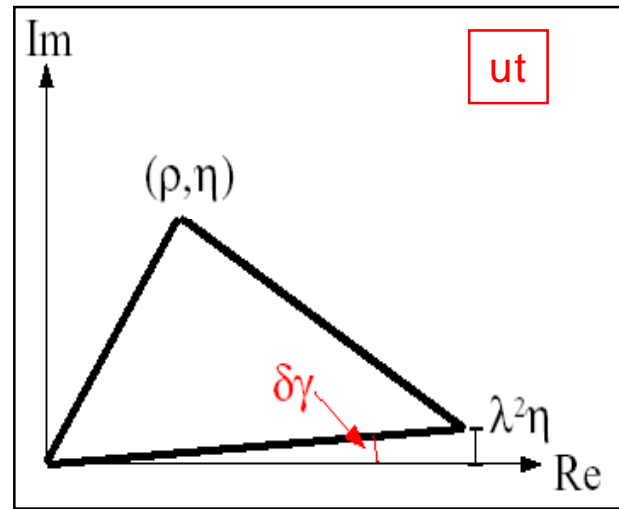
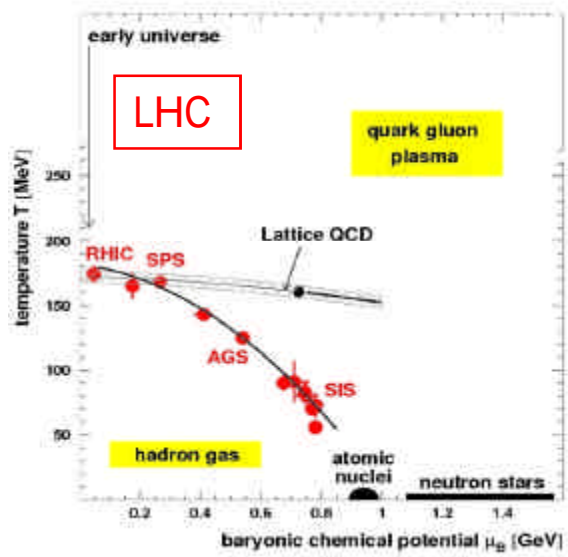
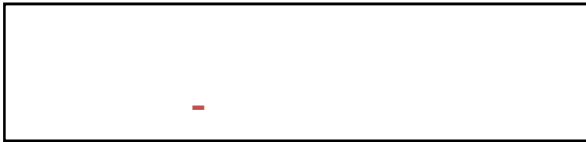
$$L = 10^{33} \text{ cm}^{-2} \text{ s}^{-1}$$

			~ 2007
$W \rightarrow e\nu$	15	10^8	10^4 LEP / 10^7 Tevatron
$Z \rightarrow ee$	1.5	10^7	10^7 LEP
$t\bar{t}$	1	10^7	10^4 Tevatron
$b\bar{b}$ LHC-b	10^6	$10^{12} - 10^{13}$	10^9 Belle/BaBar ?
H $m=130 \text{ GeV}$	0.02	10^5	?
$\tilde{g}\tilde{g}$ $m=1 \text{ TeV}$	0.001	10^4	---
Black holes $m > 3 \text{ TeV}$ ($M_D=3 \text{ TeV}, n=4$)	0.0001	10^3	---
	+		

LHC top, W/Z, Higgs, SUSY
5 TeV

LHC :



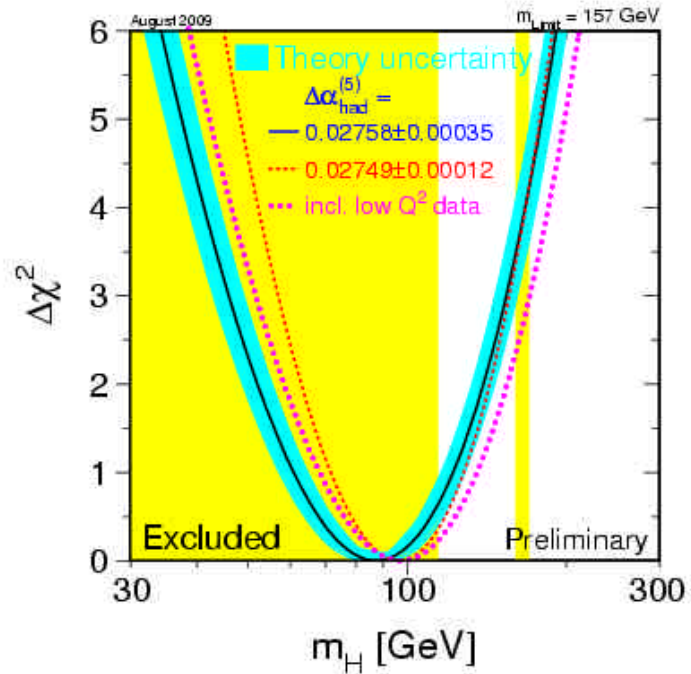
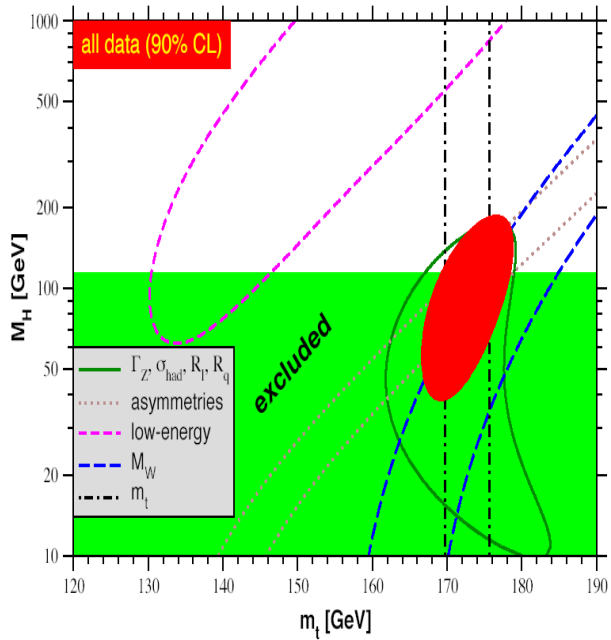




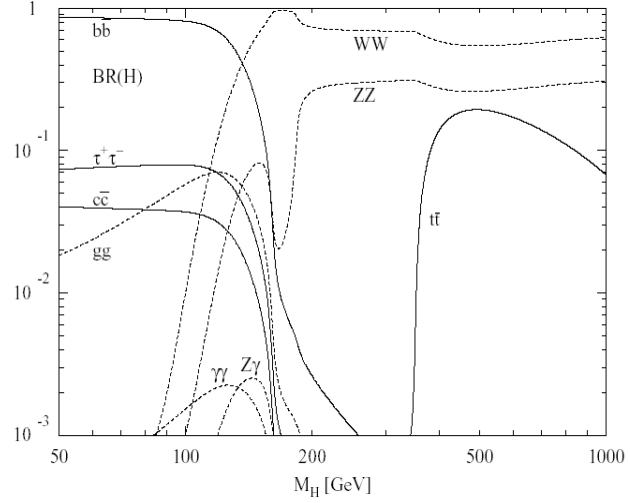
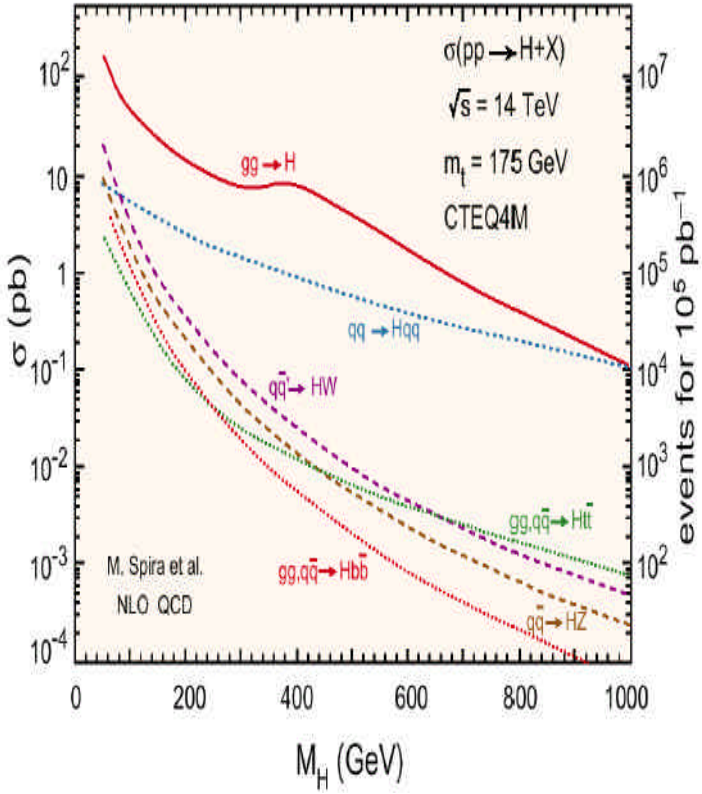
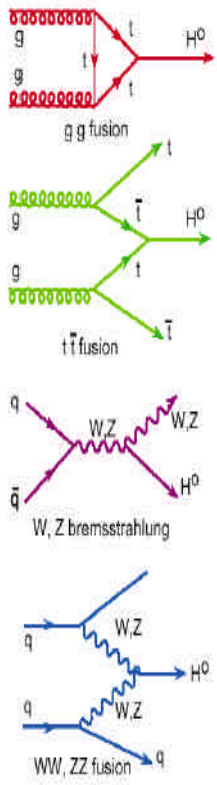
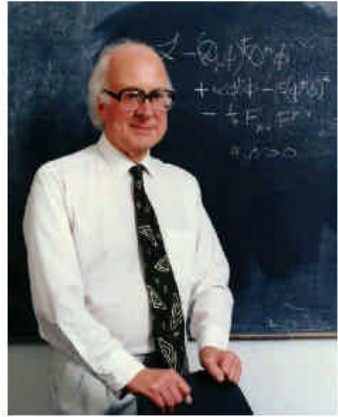
@ LEP, SLC



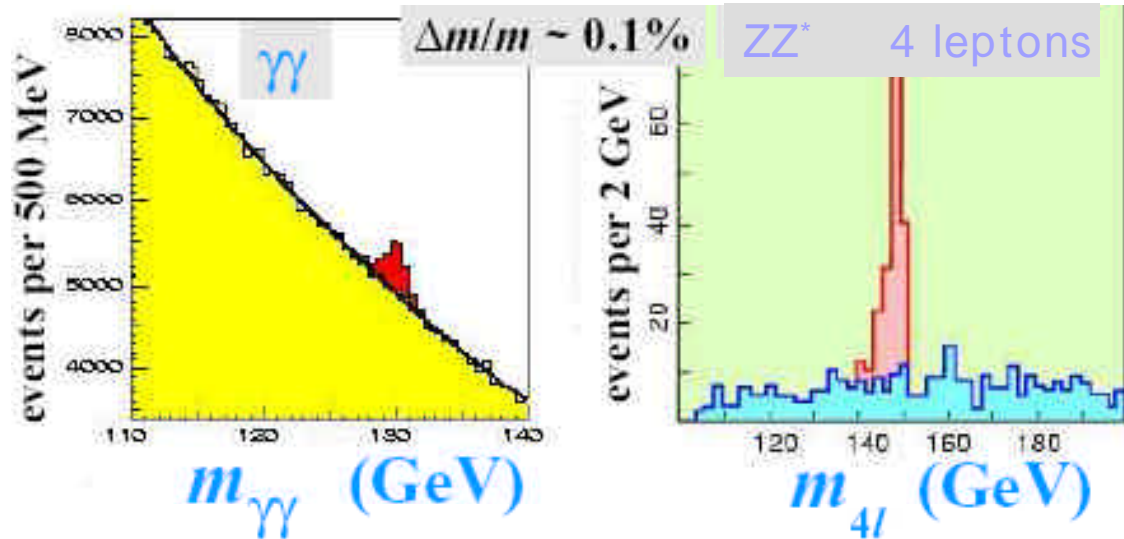
LEP
e⁺e⁻ ZH
(2000)
(95%)
114.4 < m_H < 144 GeV



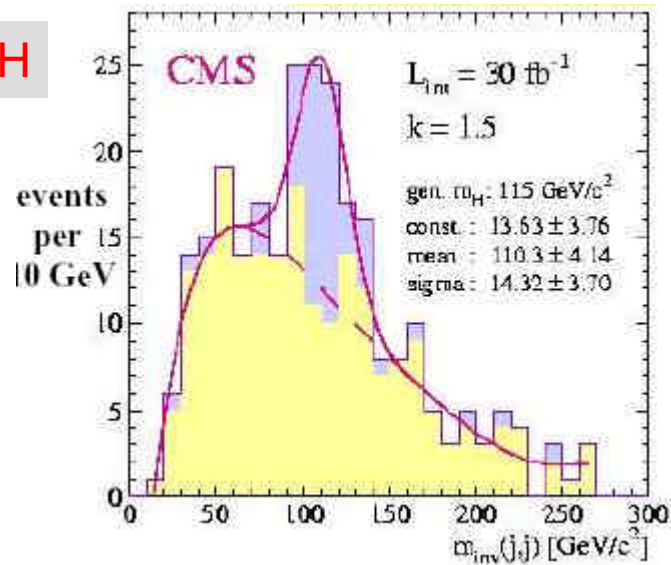
@ LHC



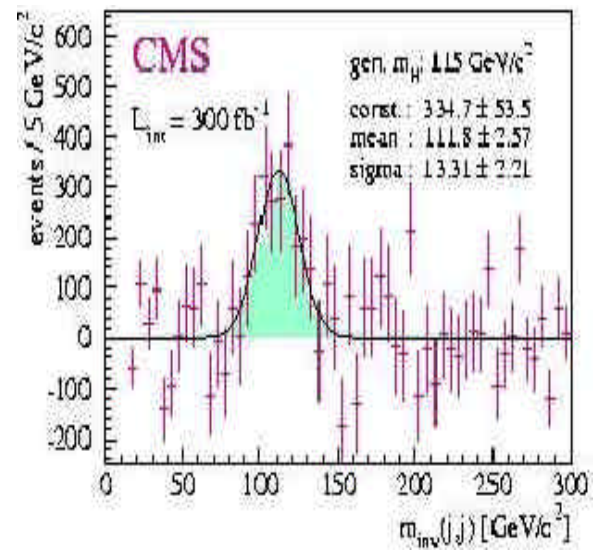
가



ttH

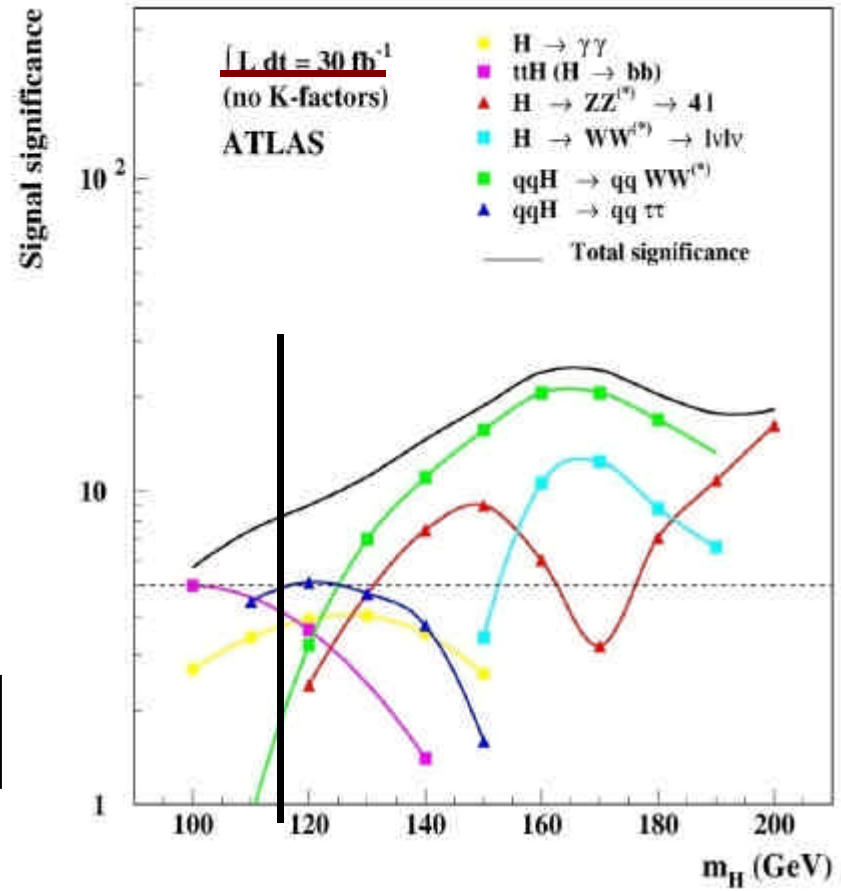
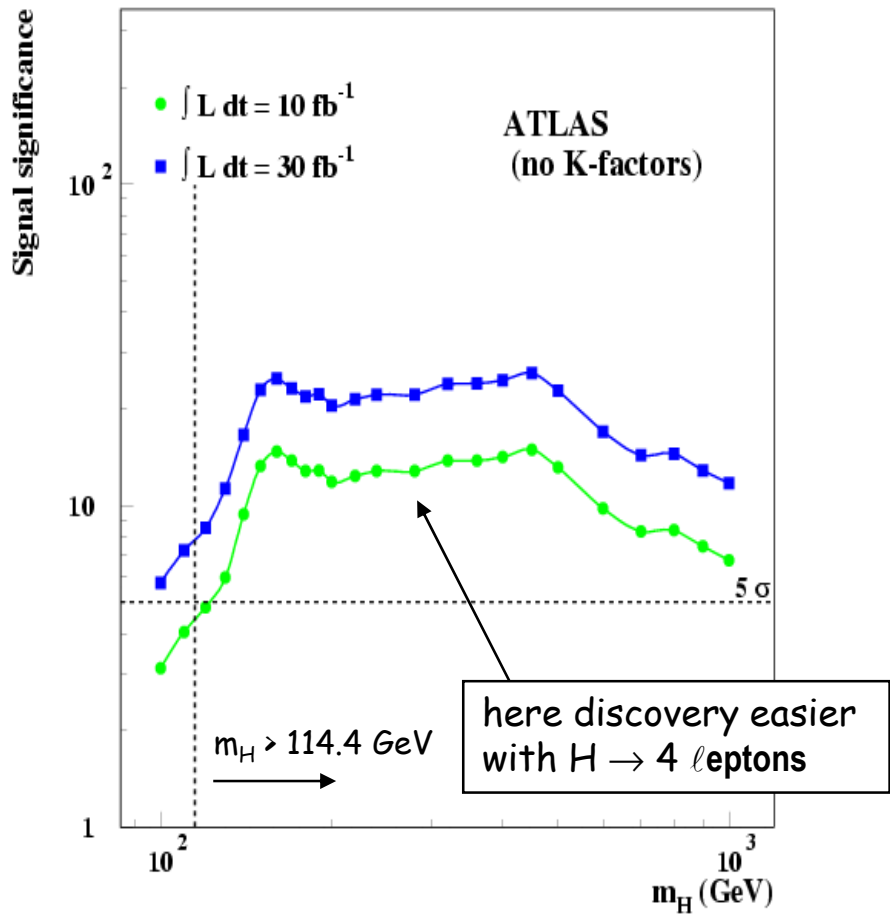


bbH





() 가

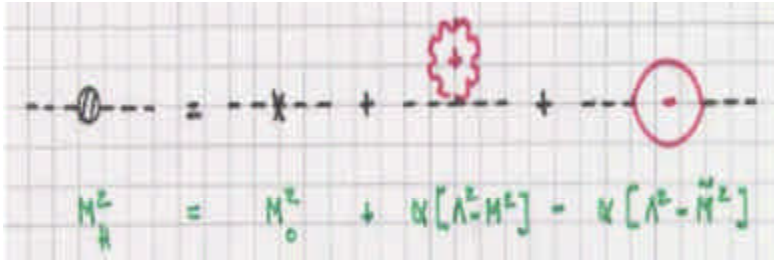


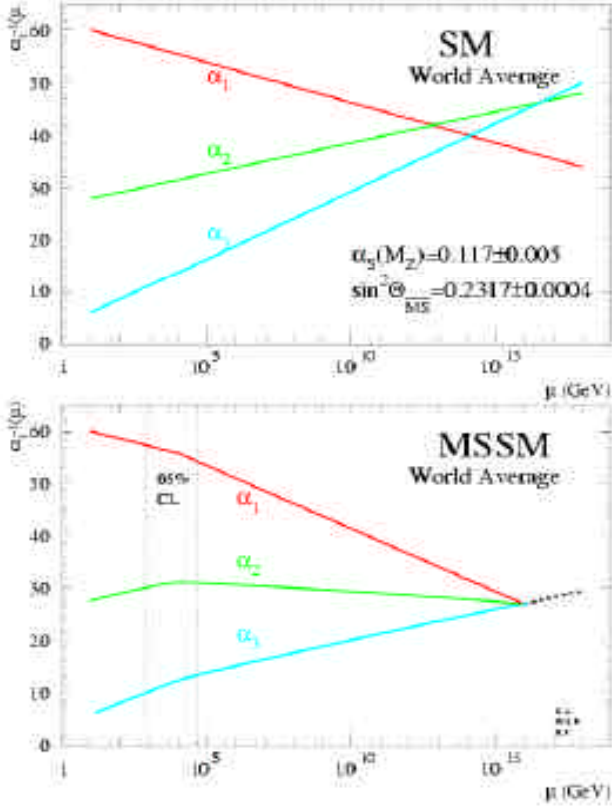
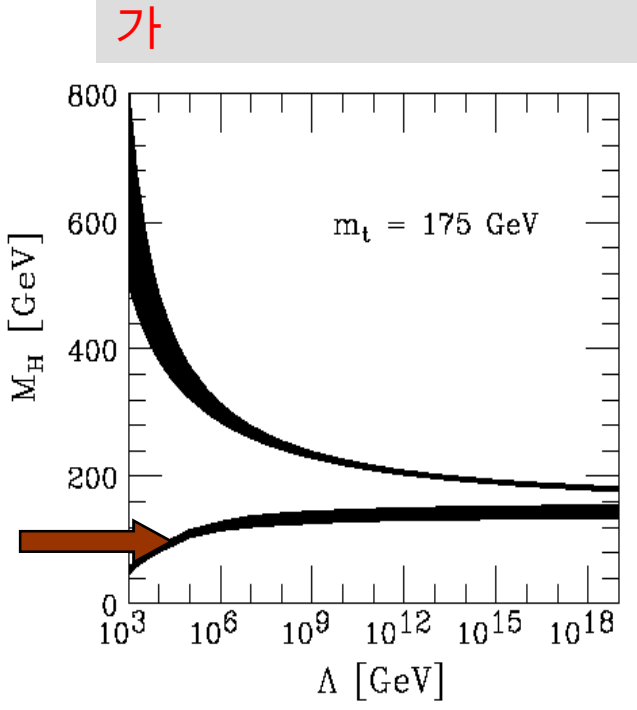
가?

$$M_W \ll M_P \sim 10^{19} \text{ GeV}$$

$$G_F = 1/M_W^2 \gg G_N = 1/M_P^2$$

$$M_{H,W}^2 = O\left(\frac{\Lambda^2}{M_P^2}\right)^2$$



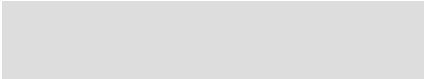
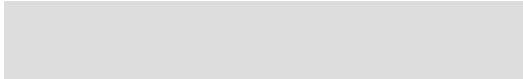
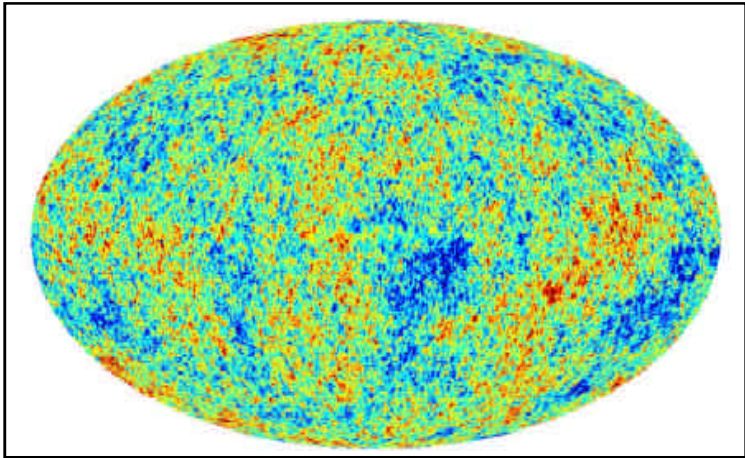
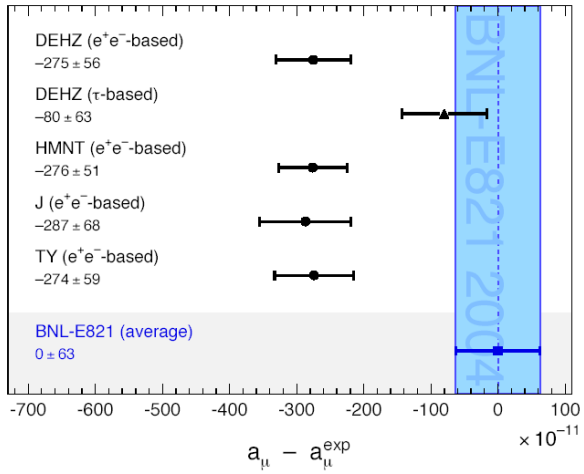




LEP , Tevatron
 , > 100 GeV
 , > 250 GeV

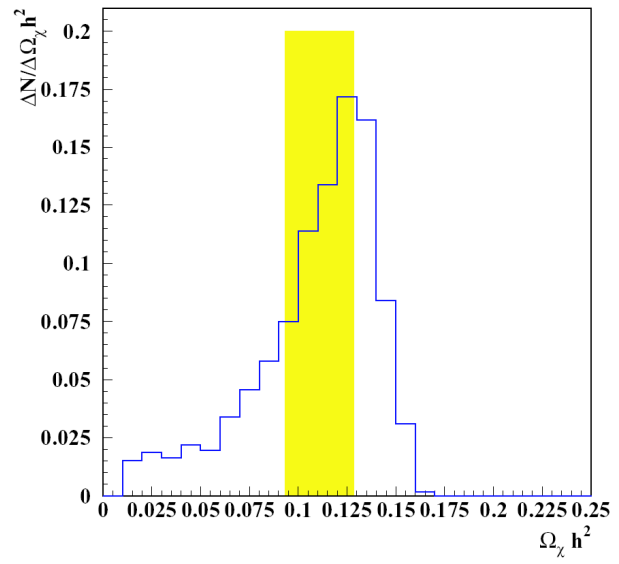
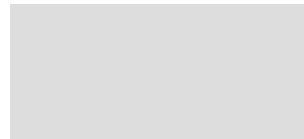
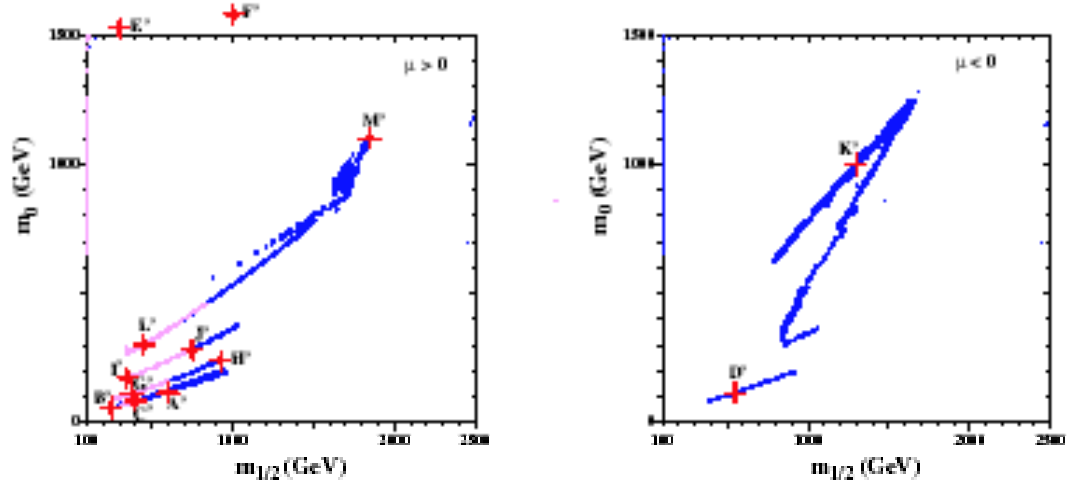
$g_\mu - 2$, $M_H > 114$ GeV, b s

가 가
 WMAP: $0.094 <$ $h^2 < 0.124$

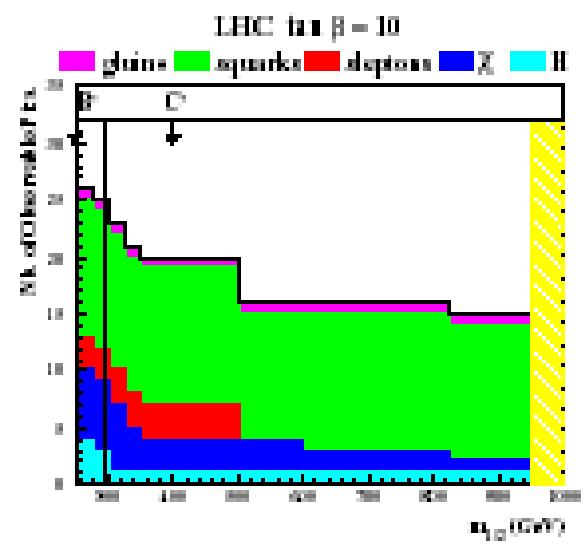




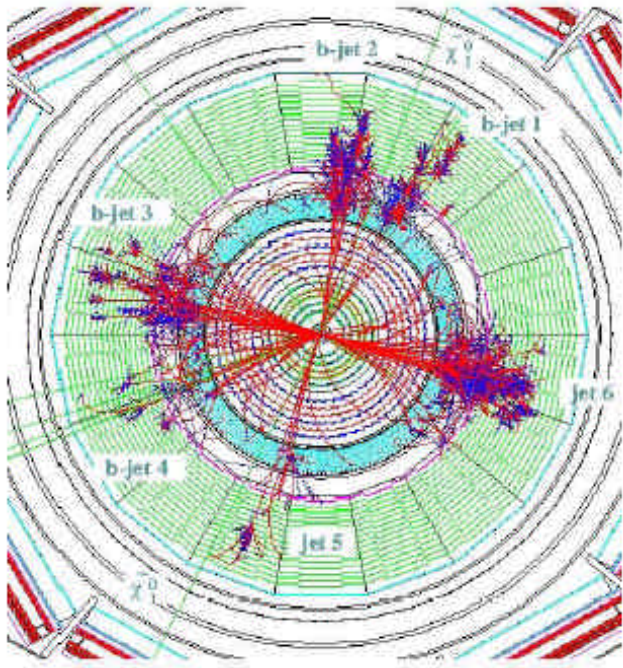
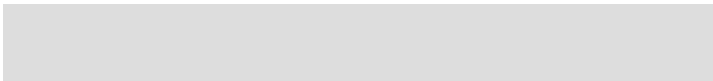
WMAP



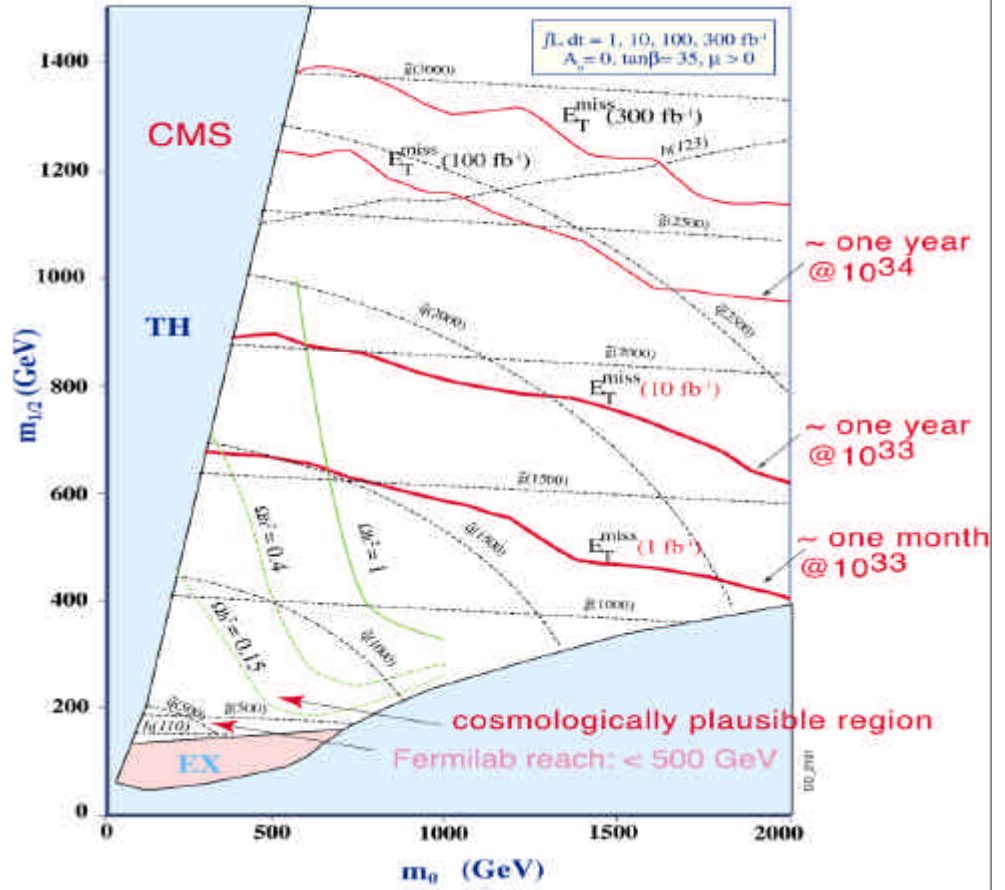
WMAP
가

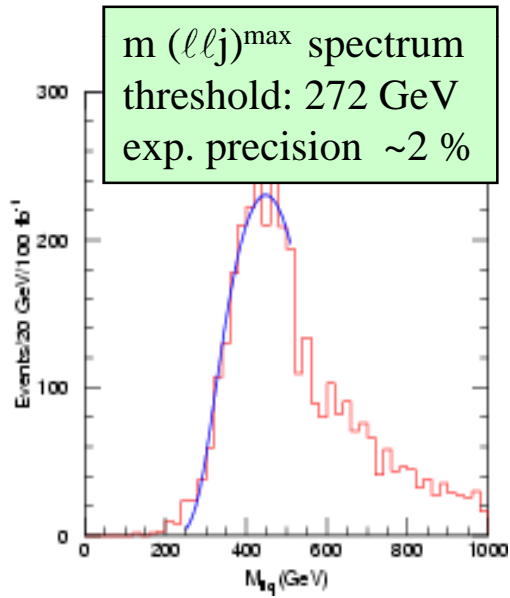
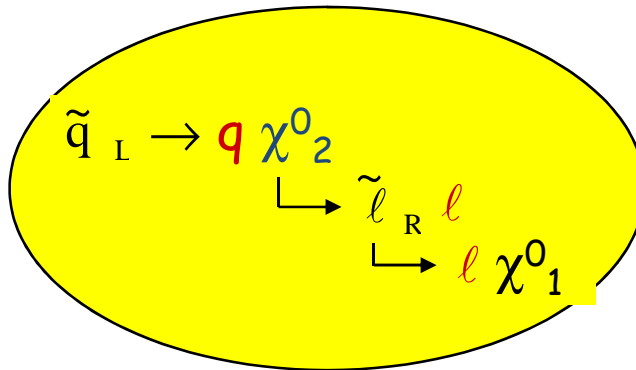
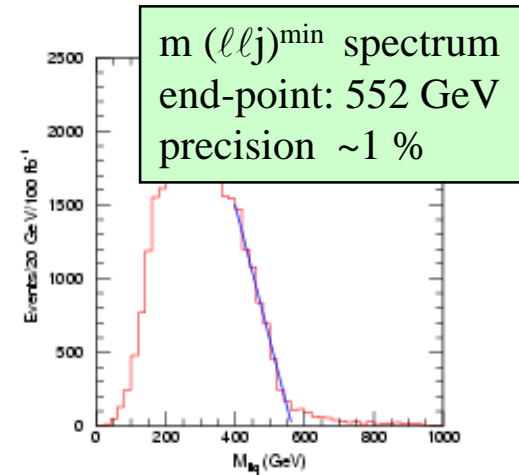
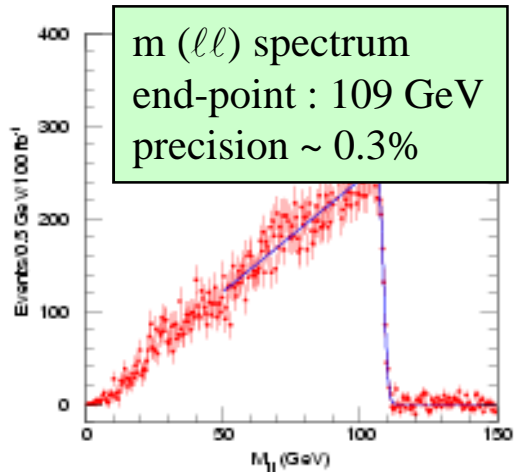


@ LHC

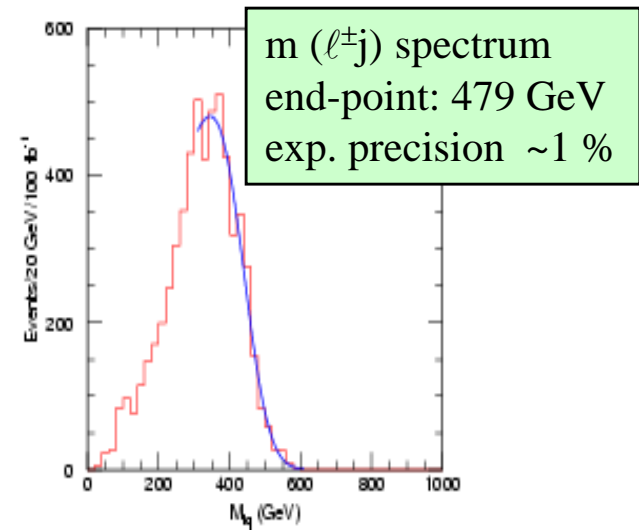


LHC





$M_{\text{squark}} = 690 \text{ GeV}$
 $M_{\tilde{\gamma}} = 232 \text{ GeV}$
 $M_{\text{slepton}} = 157 \text{ GeV}$
 $M_{\tilde{\gamma}} = 121 \text{ GeV}$



?

- @ TeV

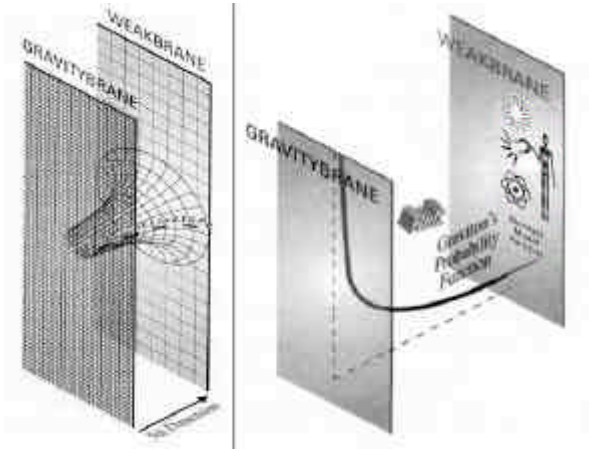
$$\frac{G_{n+3}}{R^{n+2}} = \frac{G_N}{R^2} \Rightarrow G_{n+3} = G_N R^n$$

$$M^{n+2} R^n = M_{\text{Pl}}^2 \quad (\hbar = c = 1)$$

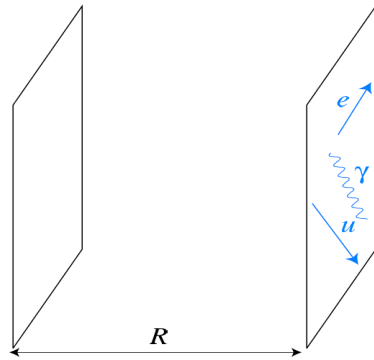


$$\frac{M}{M_{\text{Pl}}} \sim \frac{10^3 \text{ GeV}}{10^{19} \text{ GeV}} \Rightarrow R \sim \begin{cases} 10^{15} \text{ cm} & (n = 1) \\ 10^{-1} \text{ cm} & (n = 2) \\ 10^{-6} \text{ cm} & (n = 3) \\ 10^{-12} \text{ cm} & (n = 4) \end{cases}$$

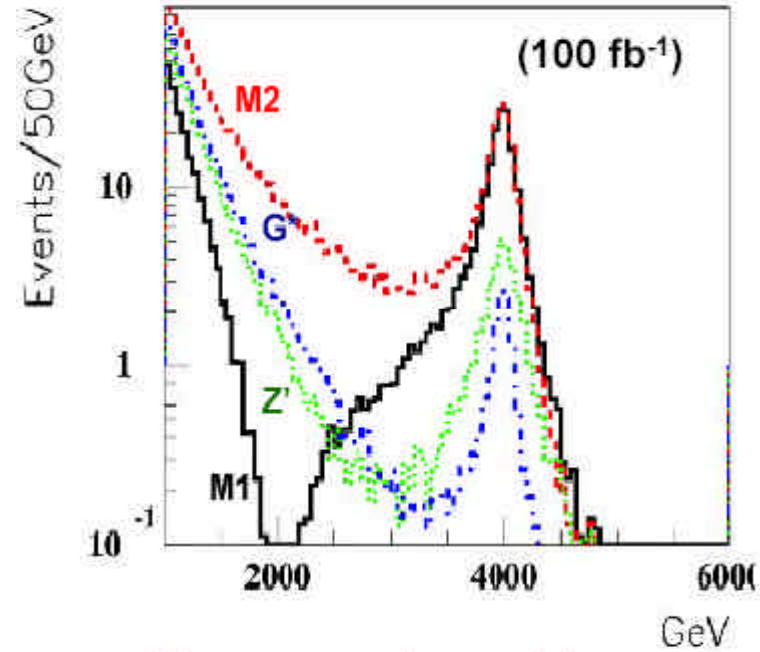
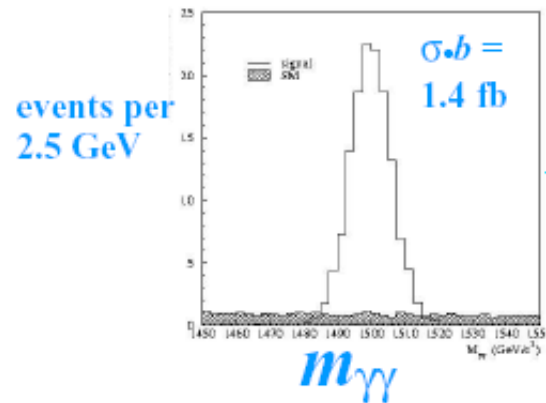
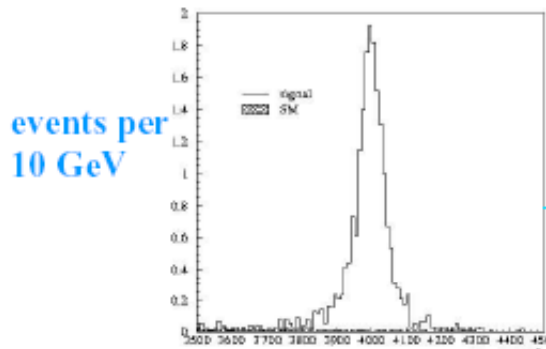
RS



ADD



가

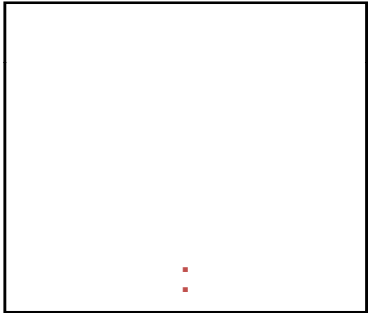
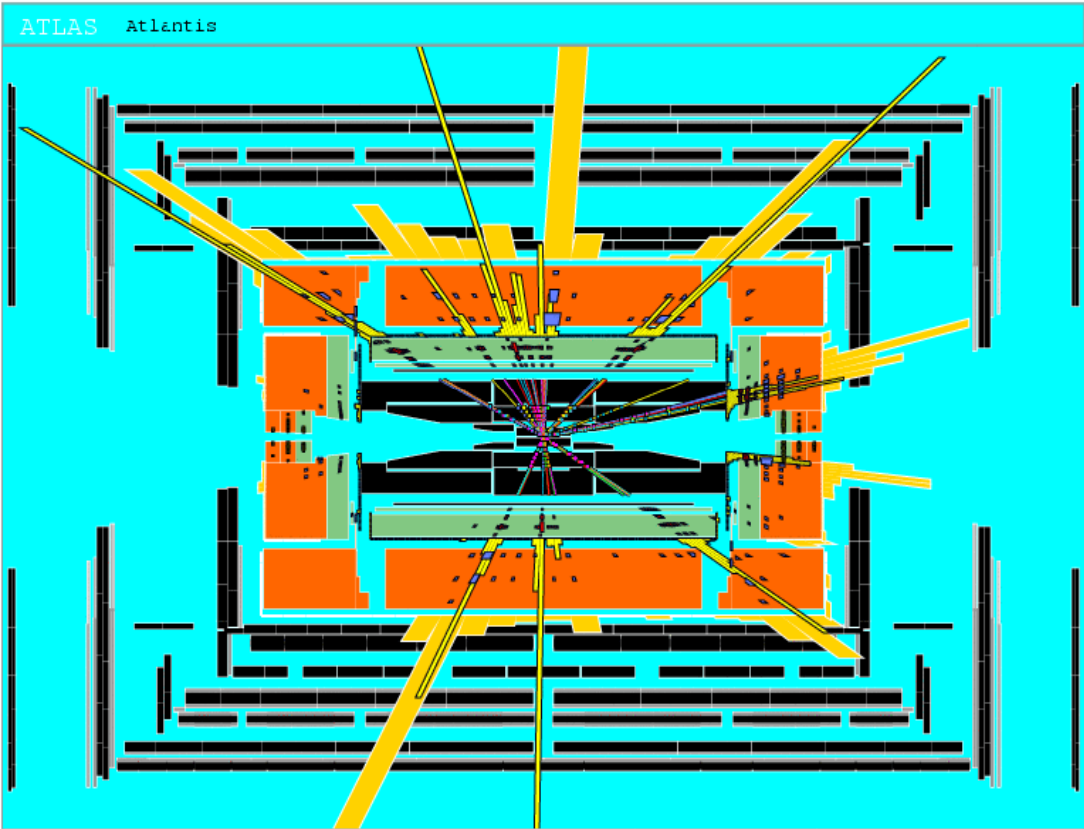


Resonance observable
Up to ~ 6 TeV with 100 fb⁻¹

...

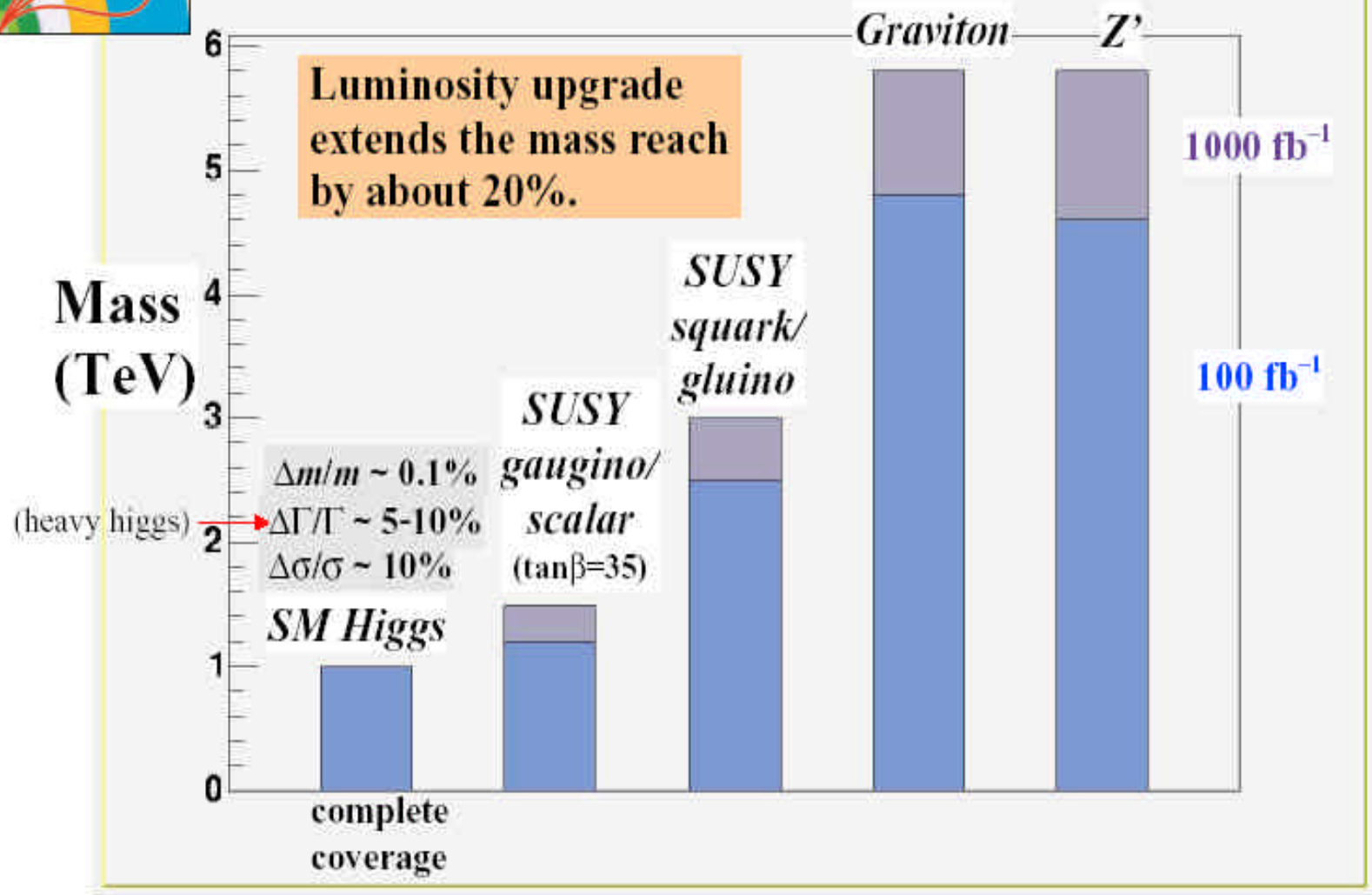


TeV @ LHC



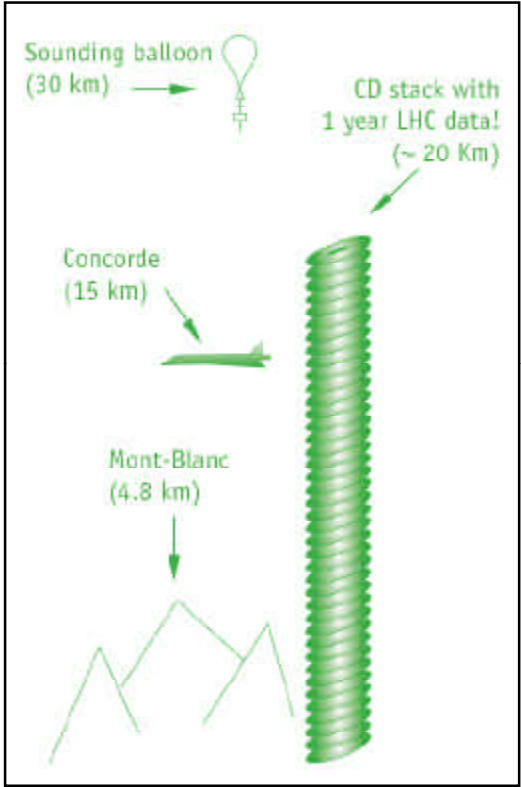


LHC 가



: LHC

~ TeV
⇔ ?
가?
가?
~ 10⁻¹²



: TeV !

(, , ,)
TeV :
LHC TeV
TeV /

?