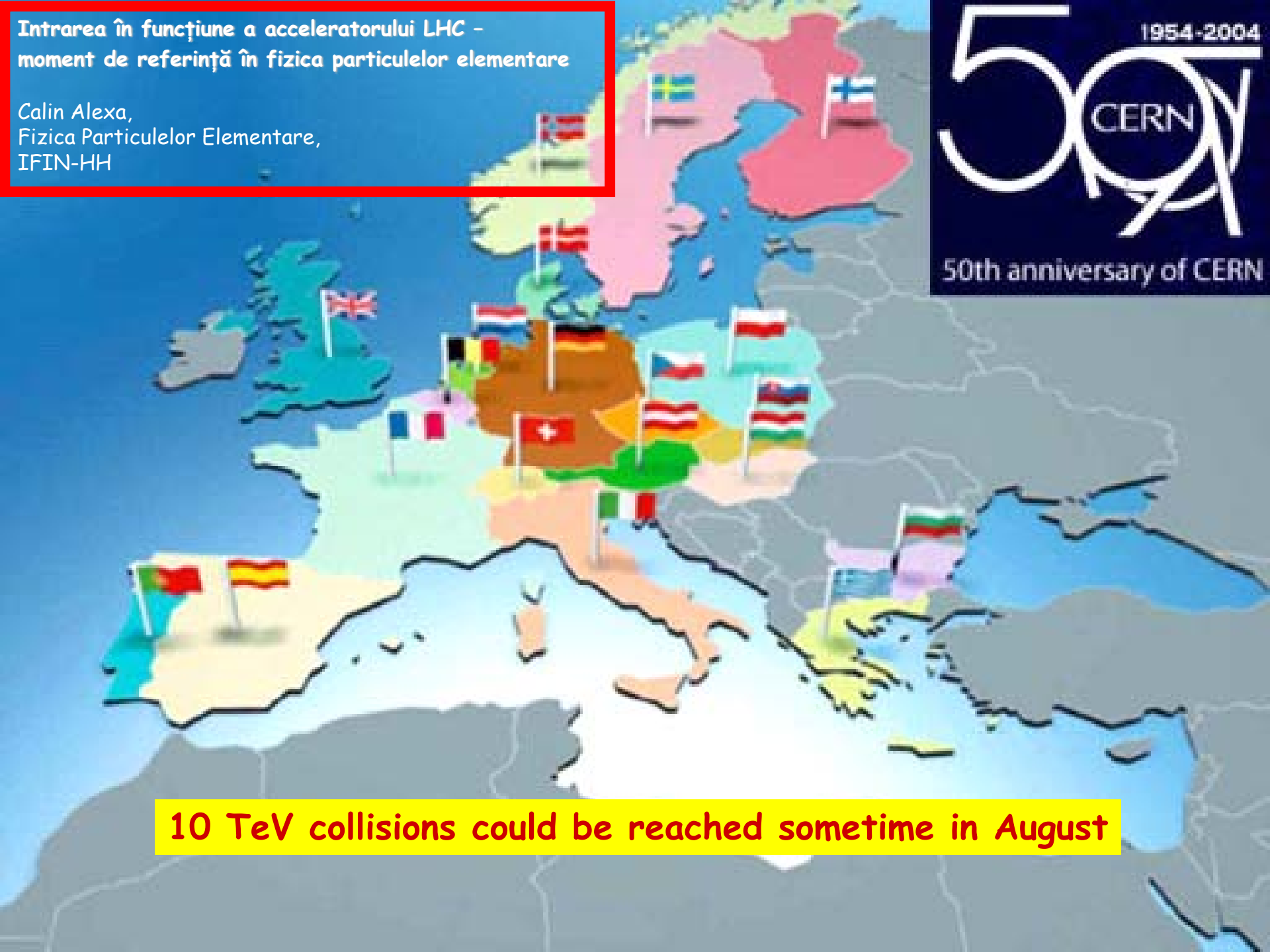
Intrarea în funcțiune a acceleratorului LHC – moment de referință în fizica particulelor elementare

Calin Alexa,
Fizica Particulelor Elementare,
IFIN-HH

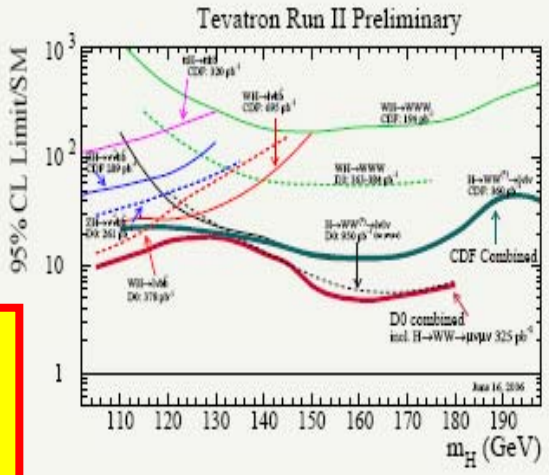


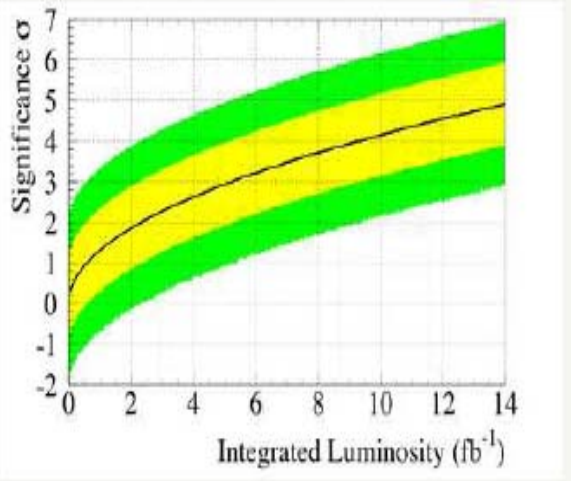
10 TeV collisions could be reached sometime in August

Before the LHC:

Summary of the SM Higgs at Tevatron

⇒ Limits and expected significance (with improvements)



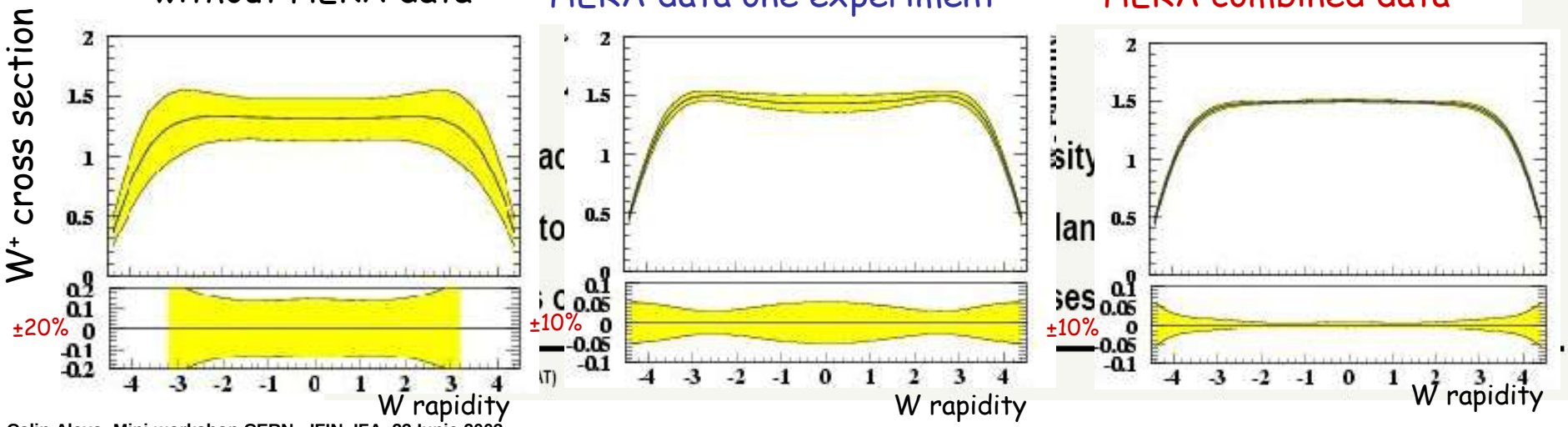


last two accelerators:
- Tevatron (2009)
- HERA (2007)

⇒ Need to work on further improvements

HERA predictions for W/Z production @ LHC: W cross section, fit uncertainty

without HERA data | HERA data one experiment | HERA combined data

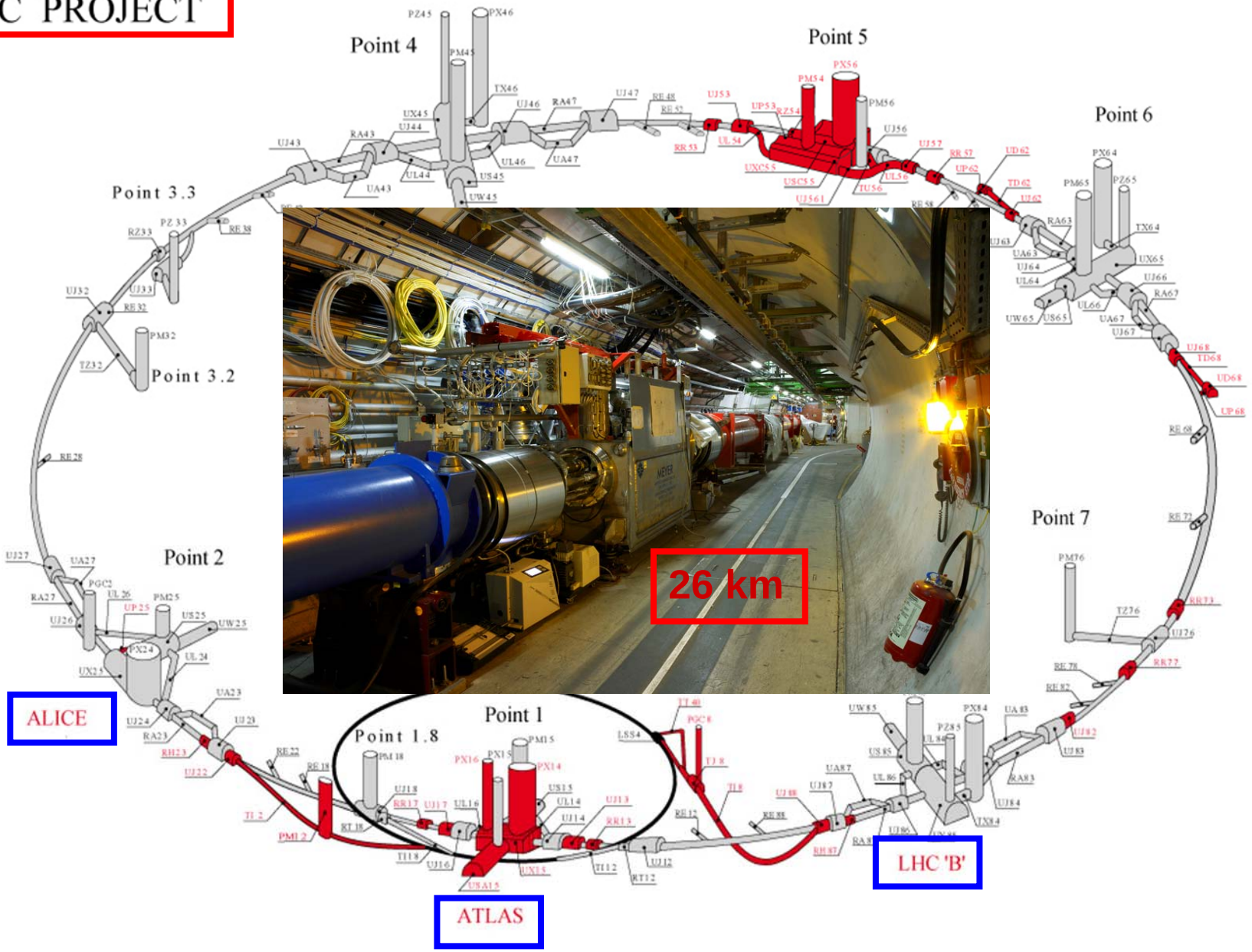


Open Questions beyond the Standard Model:

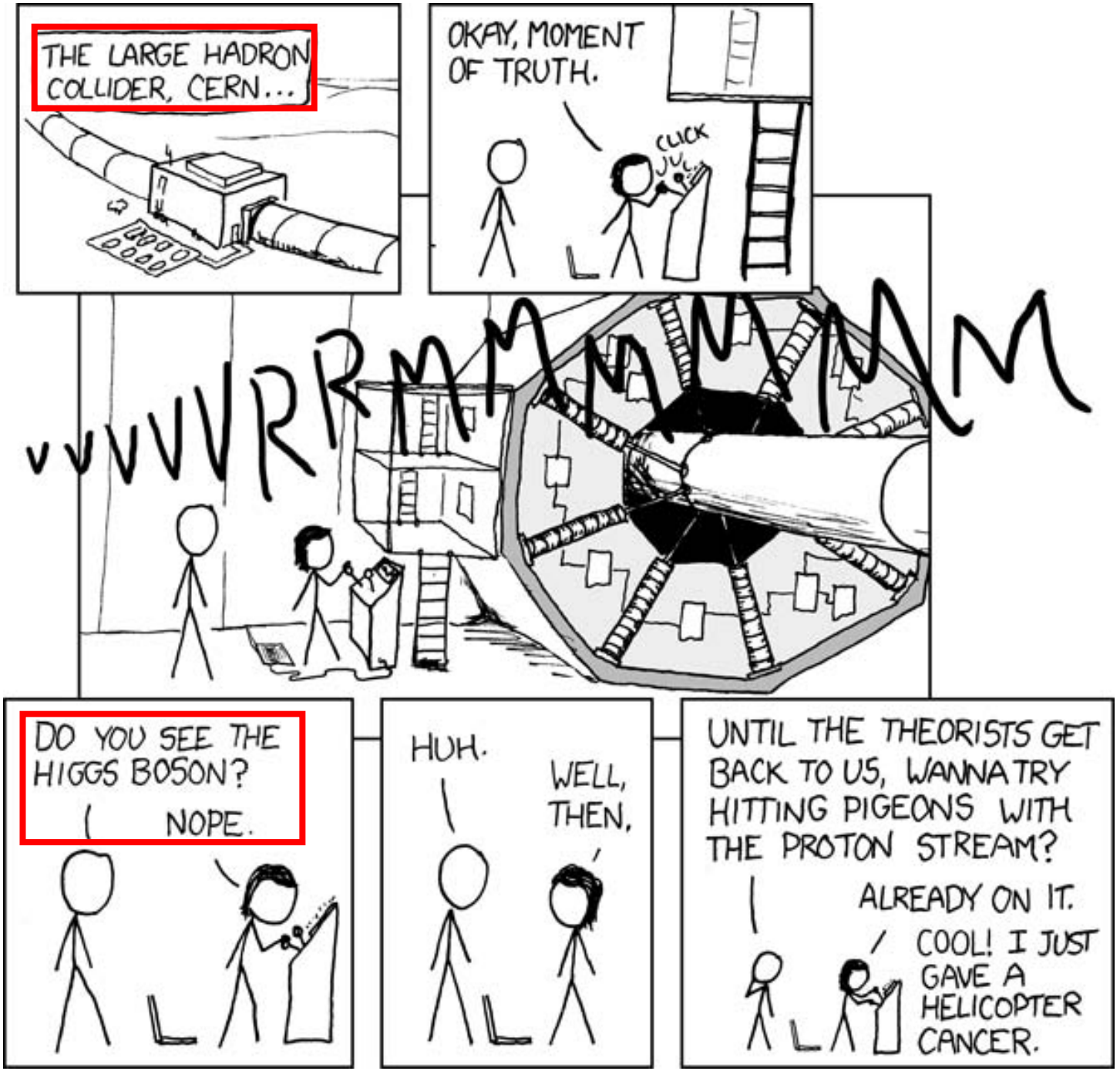
- What is the origin of particle masses?
- Why so many types of matter particles?
- Matter-antimatter difference?
- Unification of the fundamental forces?
- Quantum theory of gravity? Black holes? Dark Matter?
- New state(s) of hadronic matter

The first Higgs @ LHC … (4th April 2008)

LHC PROJECT

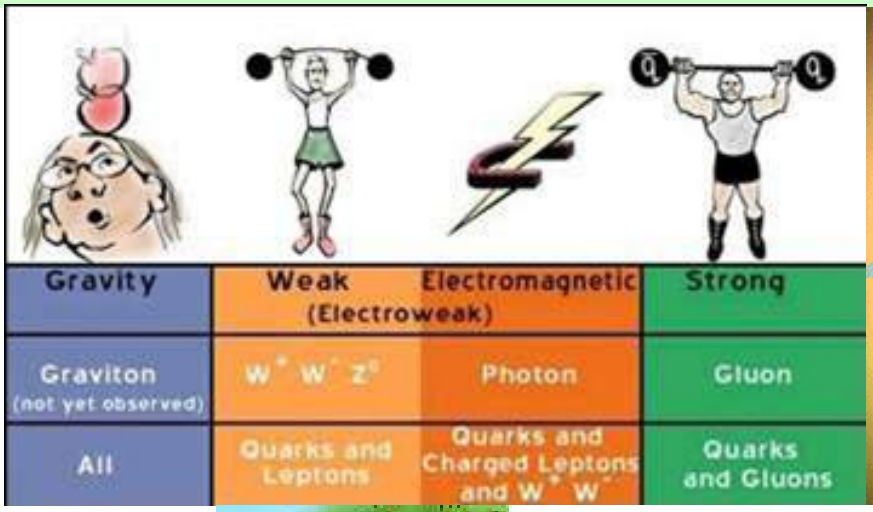


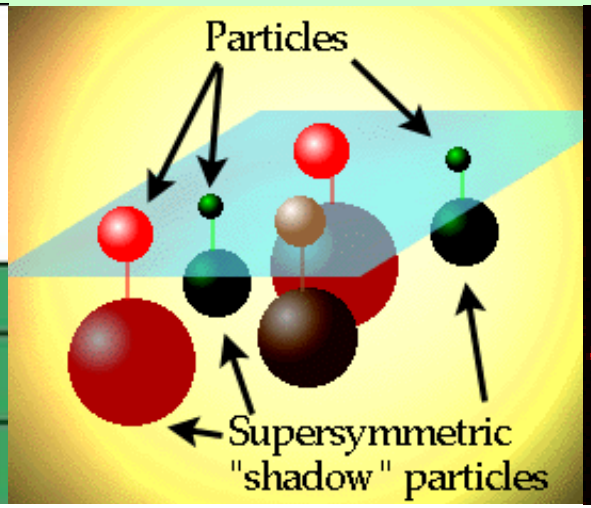
10 TeV collisions could be reached sometime in August


THE LARGE HADRON COLLIDER, CERN...
OKAY, MOMENT OF TRUTH.
CLICK
VVVVVRRMMMMMM
DO YOU SEE THE HIGGS BOSON?
NOPE.
HUH.
WELL, THEN,
UNTIL THE THEORISTS GET BACK TO US, WANNA TRY HITTING PIGEONS WITH THE PROTON STREAM?
ALREADY ON IT.
COOL! I JUST GAVE A HELICOPTER CANCER.

Physics @ LHC - main goals:

- Explore a new energy / distance scale
- Higgs boson
- Supersymmetry, Extra dimensions, …
- Heavy Ions
- Find something that the theoretical models did not expect





If M_{pl} ~ O(1 TeV) → Black Hole Production possible at LHC

N.Arkani-Hamed, S. Dimopoulos and G.R.Dvali [hep-ph/9803315]; S.Dimopoulos and G. Landsberg [hep-ph/0106295]

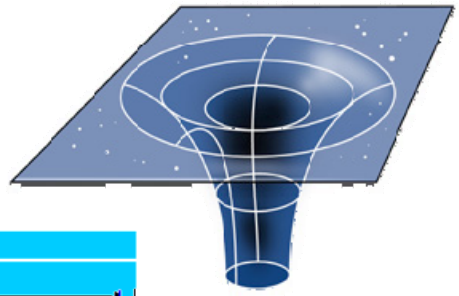
BH decays with equal probability to all particles

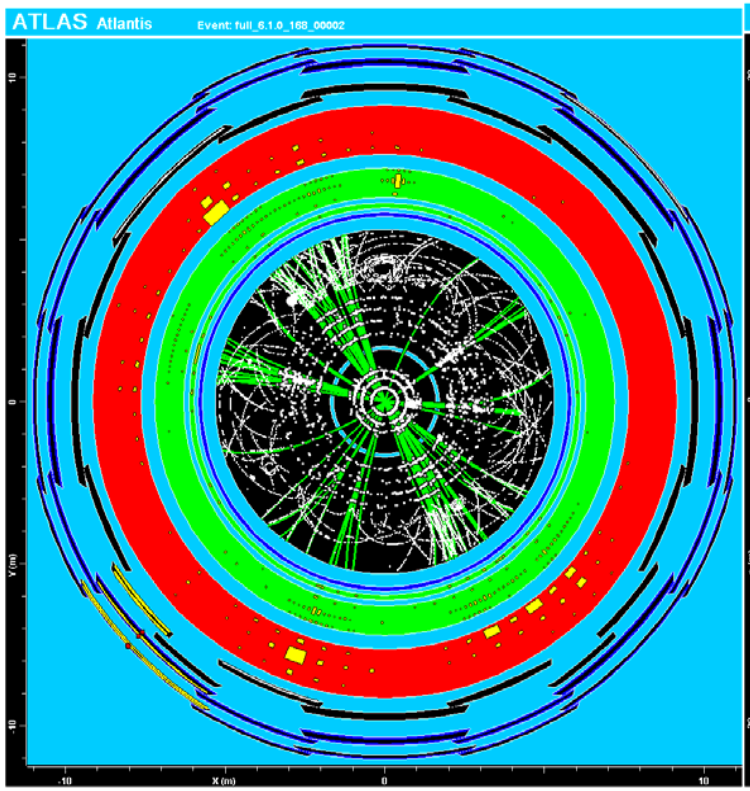
BH evaporates into (q and g : leptons : Z and W : n and G : H) =(72%:11%:8%:6%:2%:1%)
(hadron : lepton) is (5 : 1) accounting for t, W, Z and H decays

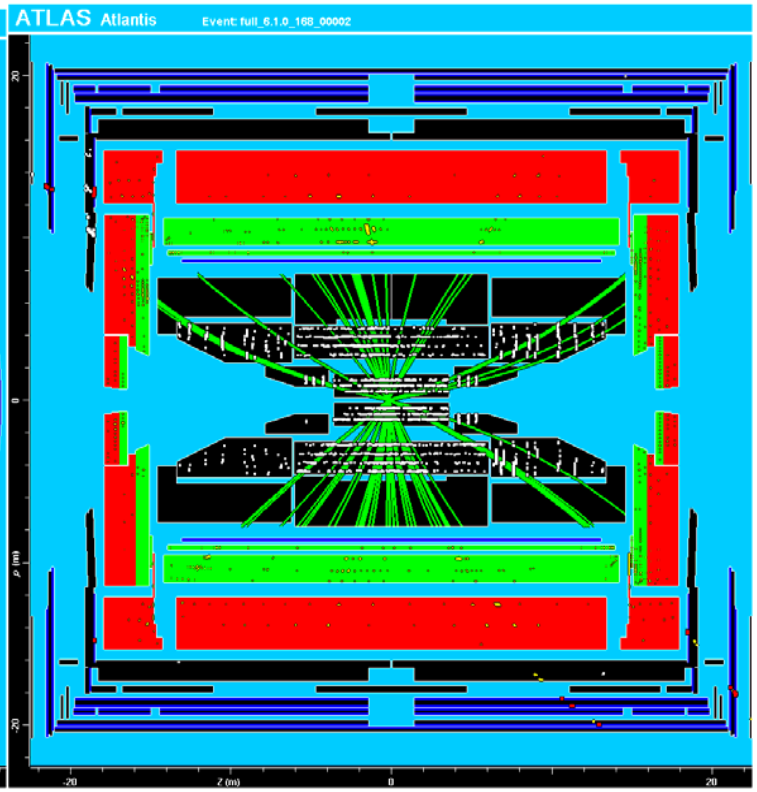
S.B. Giddings, S. Thomas, Phys.Rev.D65(2002)056010

σ ~ πRS2 ~ O(100)pb

BH lifetime ~ 10^{-27} - 10^{-25} seconds







A quantum theory of gravity?

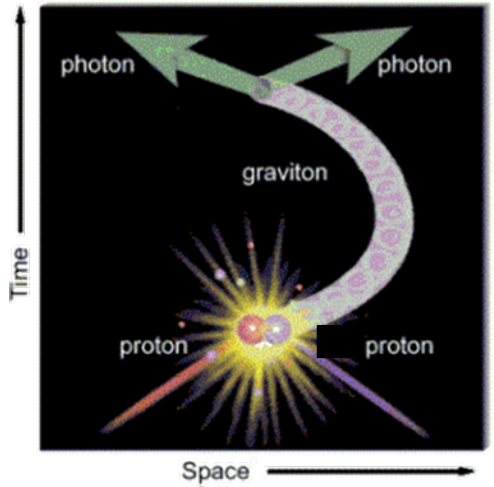
- two major problems have not been resolved yet:
the hierarchy problem and the cosmological constant problem

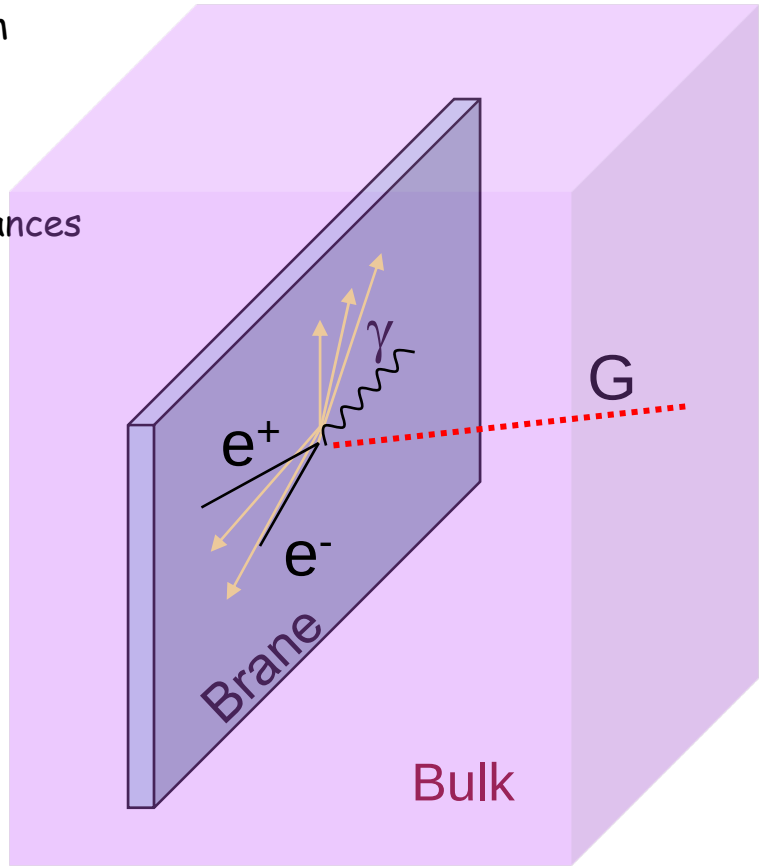
- the existence of **new dimensions** can help in the resolution of these two enigmas and might (dis)prove the fact that gravity becomes strong at **sub-millimeter** distances

- new physics phenomena can be brought to light if we consider that the fundamental Planck scale could be as low as 1TeV for "n > 1" (ADD)

- **only gravity and other non-SM fields propagate** in the full (4+n)-dimensional spacetime;
all SM fields are confined to a 3-brane extended in the non-compact dimensions

- in function of **n → deviation** of Newtonian gravity





ADD or RS

$$R \sim 10^{\frac{30}{n}-17}\ cm \times \left(\frac{1TeV}{m_{EW}}\right)^{1+\frac{2}{n}}$$

Radius of Compactified Dimensions

Number of ED

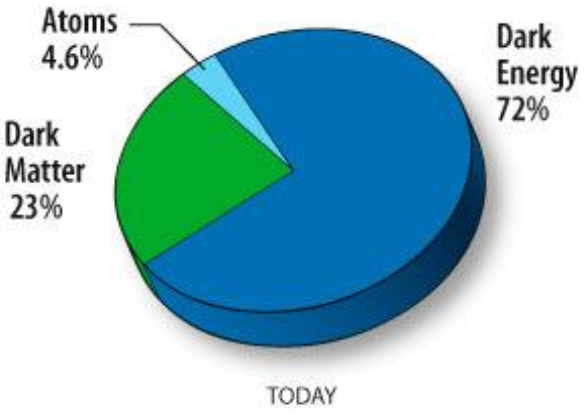
Astronomers say that most of the matter in the Universe is invisible Dark Matter

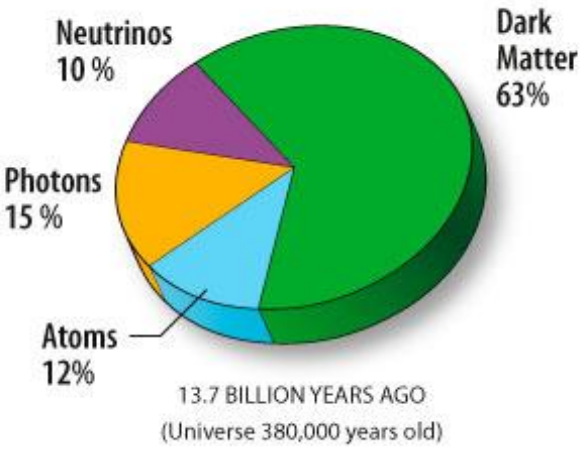
Is the Dark Matter Supersymmetric?

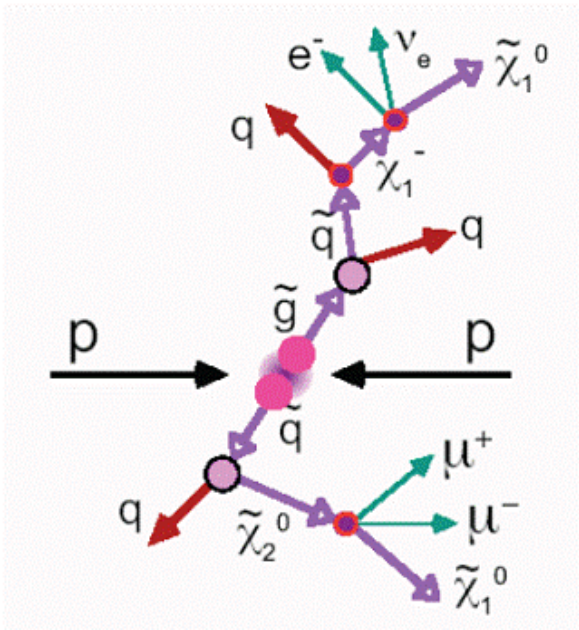
SUSY can provide plausible WIMP Dark matter candidates.

Cosmological arguments prefer WIMP mass ~ hundred GeV

Combining with Astroparticle & Cosmology measurements, would reveal the relation of the SUSY LSP to the dark matter

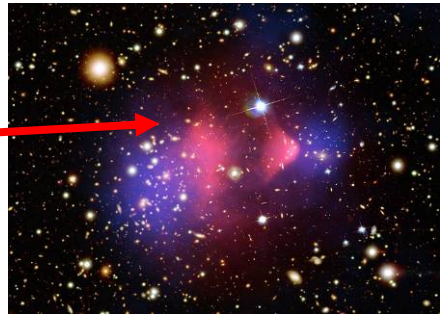




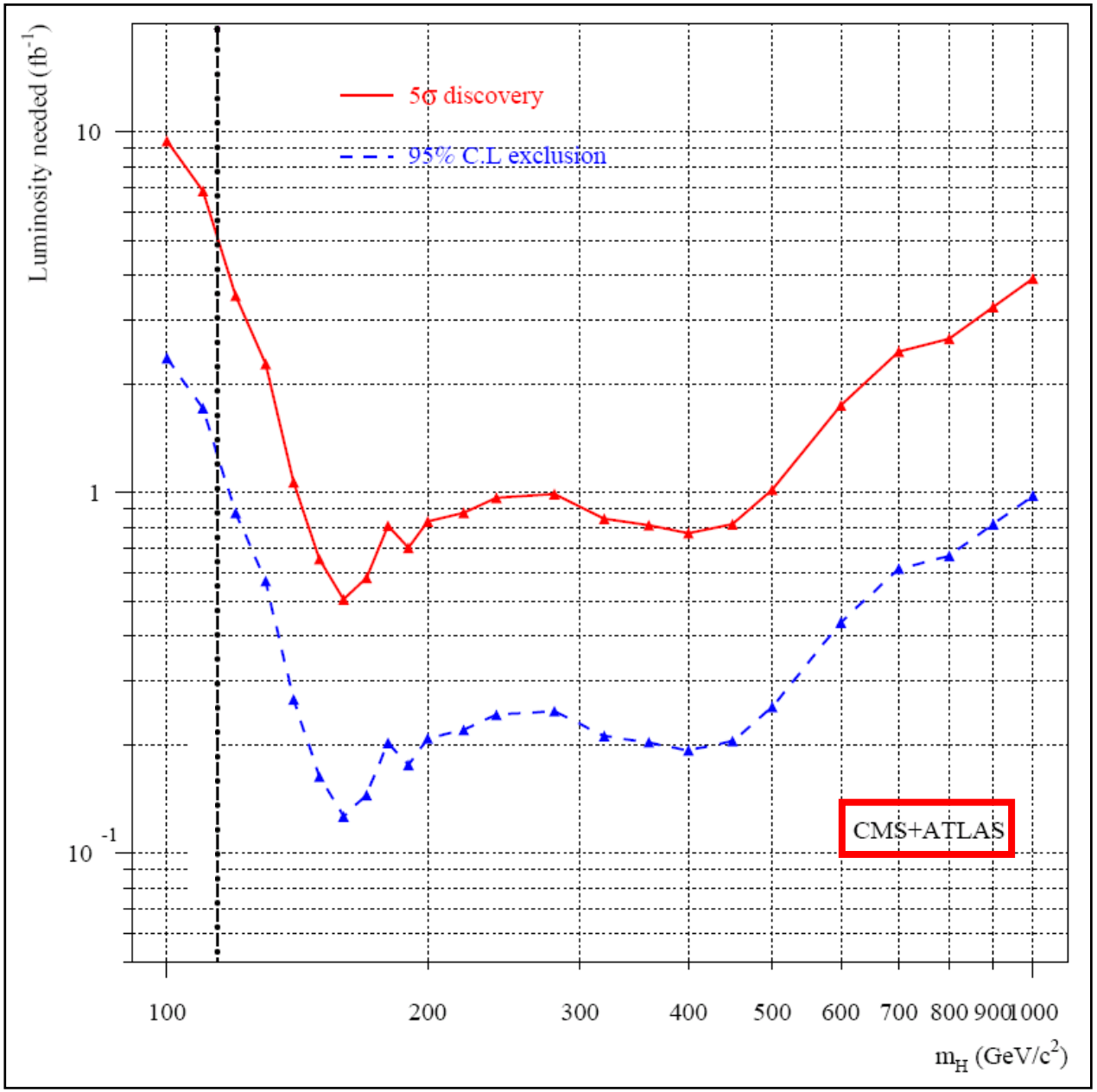


Lightest SUSY particle (LSP) cannot decay, hence potential WIMP Dark Matter candidate

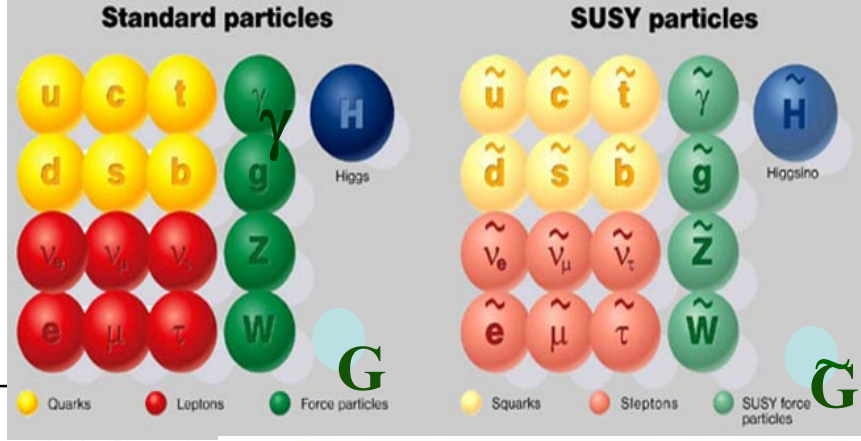
$\tilde{\chi}_1^0$



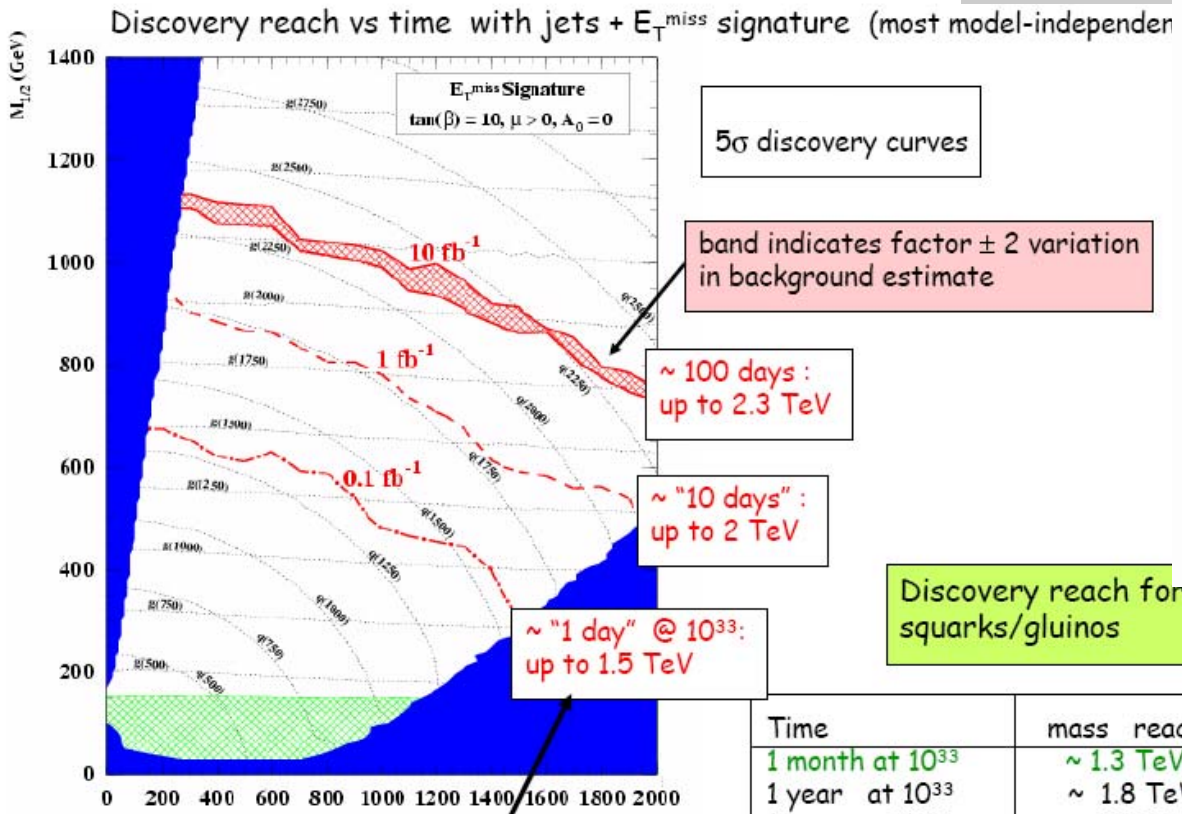
A Standard Model Higgs boson could be discovered with 5-σ significance with 5fb^{-1}, 1fb^{-1} would be sufficient to exclude a Standard Model Higgs boson at the 95% confidence level



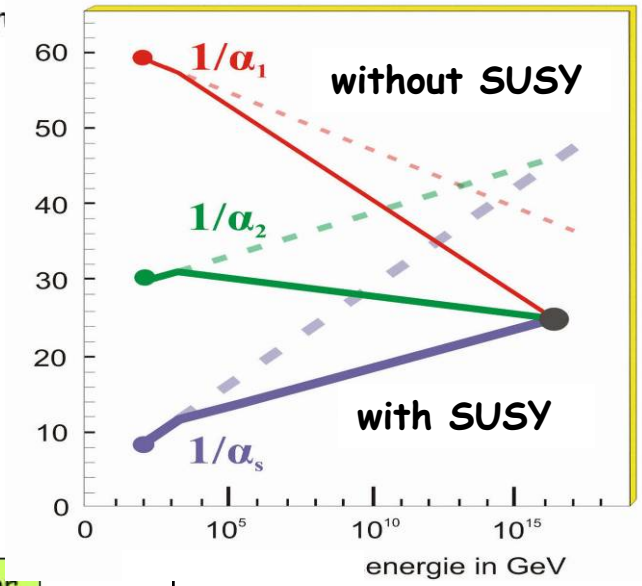
Standard Model particles have supersymmetric partners, differ by 1/2 unit in spin



Supersymmetry: early days @ LHC



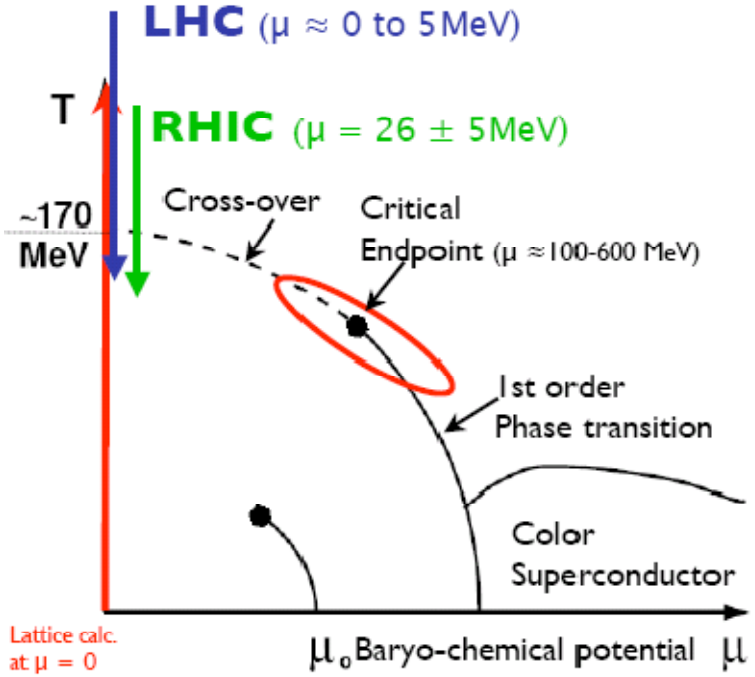
Time	mass reach
1 month at 10^{33}	~ 1.3 TeV
1 year at 10^{33}	~ 1.8 TeV
1 year at 10^{34}	~ 2.5 TeV
ultimate (300 fb^{-1})	~ 2.5-3 TeV

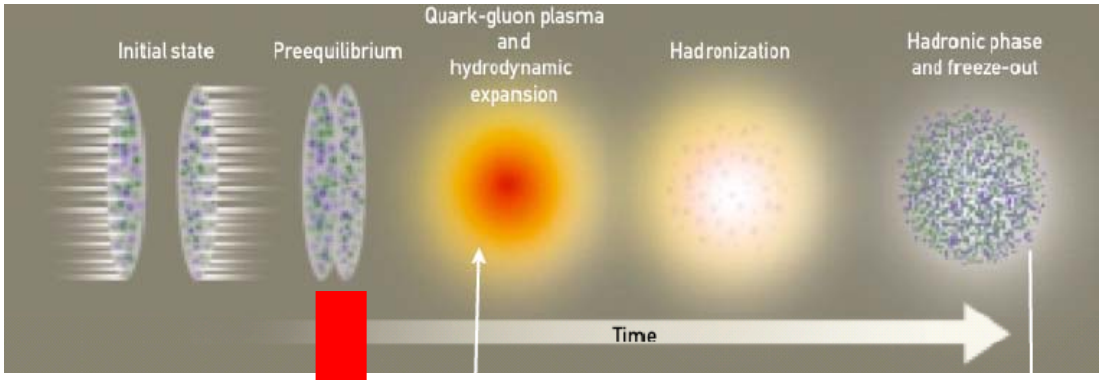


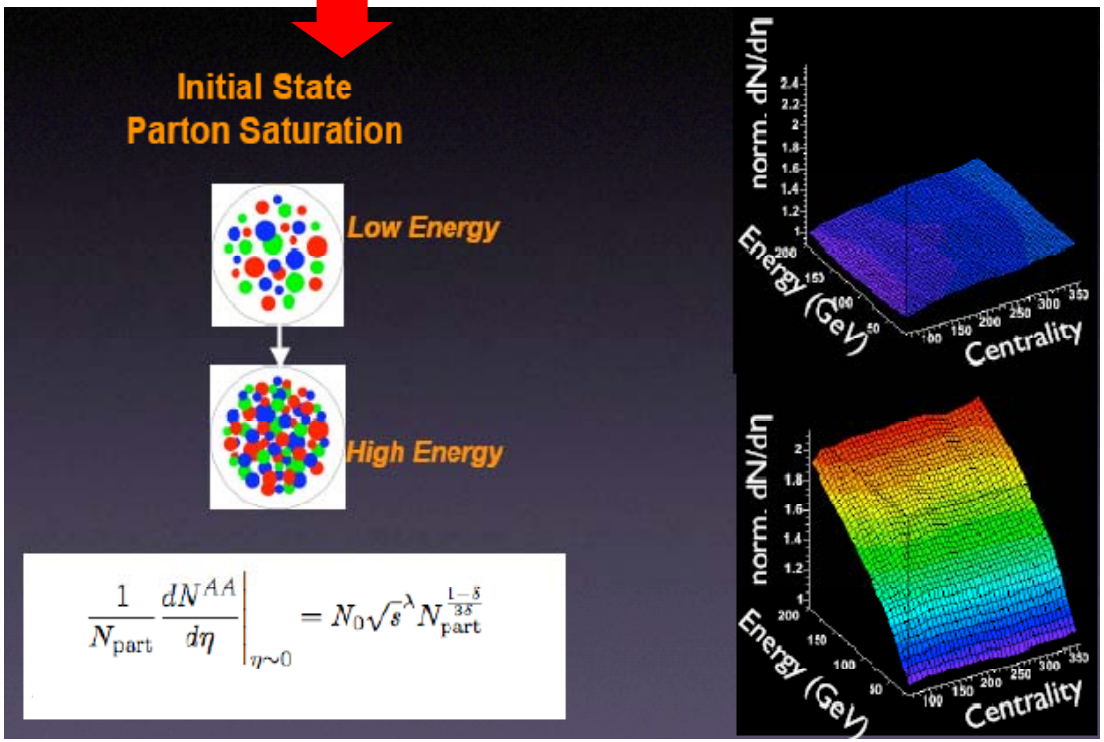
New kinematic range @ LHC

New State(s) of Hadronic Matter

Phase diagram probed in heavy-ion collisions







What we expect after the LHC?

- SLHC?
- ILC?
- CLIC?
- DLHC (double LHC energy)?
- TLHC (triple LHC energy)?

Depends on the LHC results

Answers available in '2010'