Plans for upcoming physics analysis activities of the Swiss CMS groups

Leonardo Sala, *ETHZ*

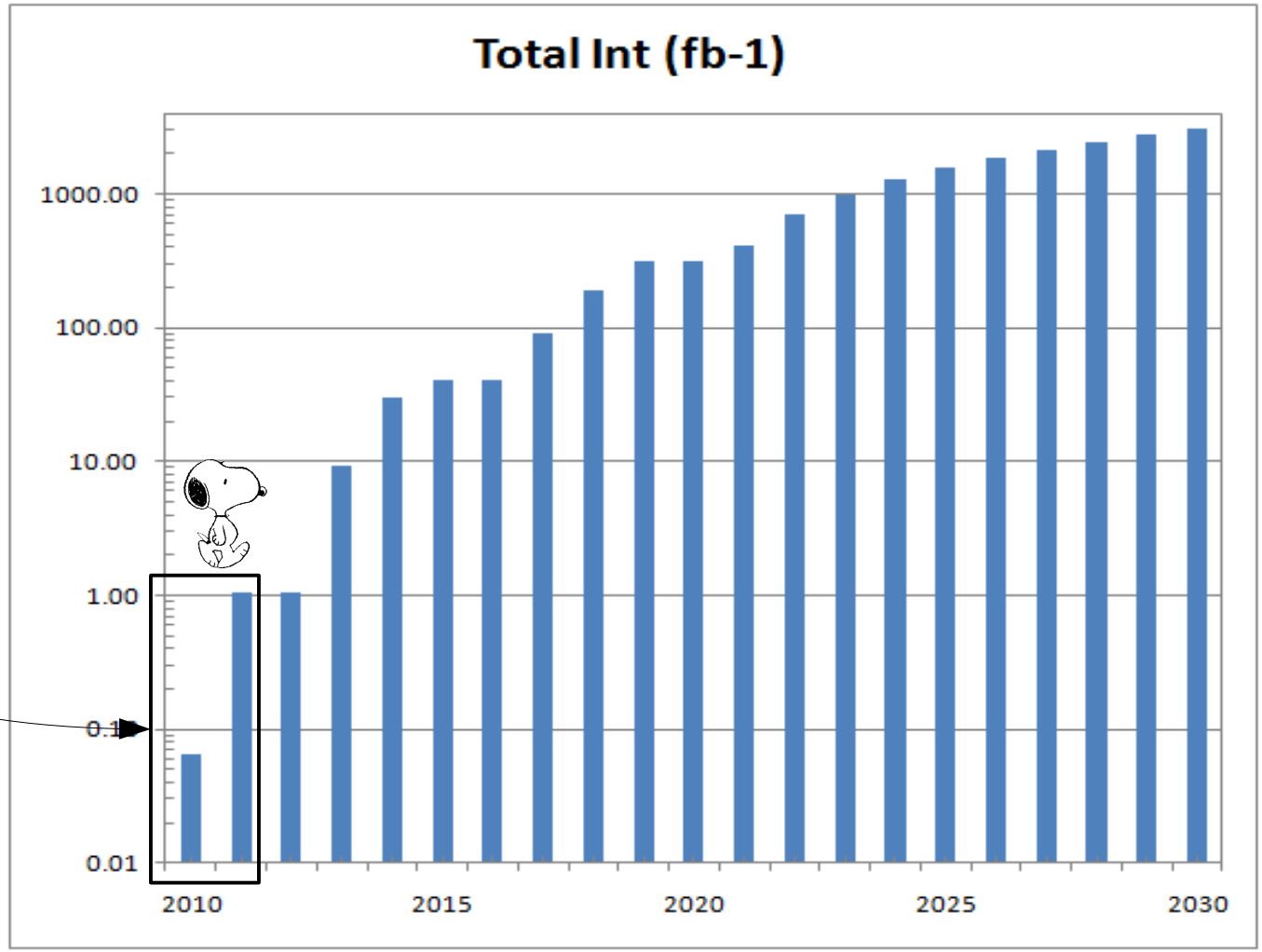
CHIPP Workshop on the High-Energy Frontier,
Physik-Institut der Universität Zürich, 1-2 Sept 2010

It's a long way to Tipperary...

QCD | B-Physics | EWK | SUSY | BSM

LHC plans

This is the time scale of this talk



See S.Myers talk at ICHEP10

Towards end of 2011

Even if we are at 7 TeV and low luminosity, we cannot get bored:

- Polina Otiougova has already shown the first ~0.5 year
- The next (0.5+1)years will allow to:
  - ➔ Further improve some measurements
  - ➔ Start to explore or pave the way to new/old physics

The presented physics plans are broken down to main areas where Swiss institutes (ETHZ, UZH, PSI) contribute:

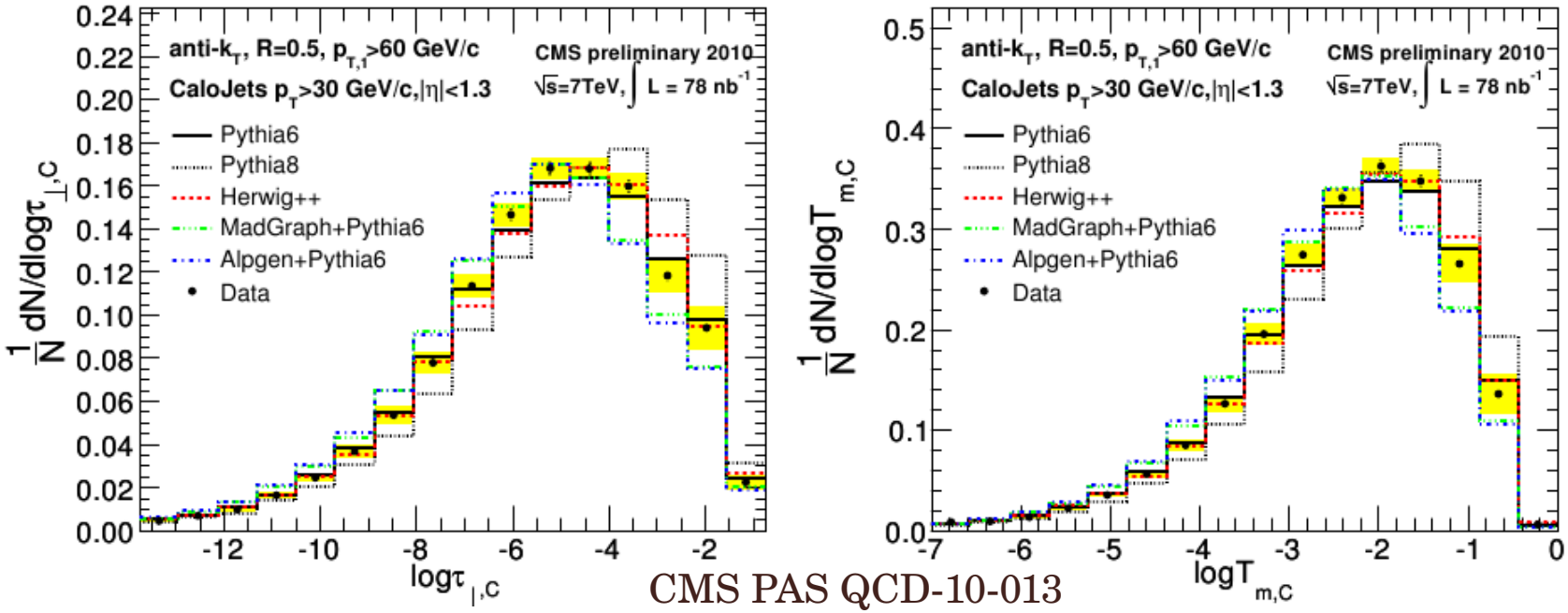
- QCD
- B Physics
- EWK
- SUSY
- Beyond the Standard Model

ETH

Event Shape results are already available to the public

Plans for the next year are:

- Focus on central event shapes: transverse thrust, thrust minor, Y_{23}
- Results will be presented after unfolding



CMS PAS QCD-10-013

B Physics

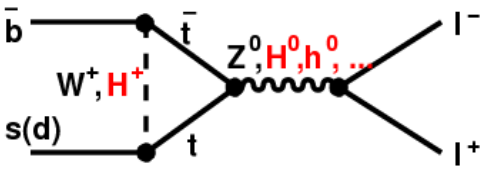
Various analyses are covered (started or to be started):

- $\Lambda_B \rightarrow J/\psi+\Lambda$ and $\Lambda+\mu\mu$ (PSI)
- $B_{s,d} \rightarrow \mu\mu$ (PSI, ETHZ)
- $B_s \rightarrow J/\psi+\phi$ (UZH)
- $B_c \rightarrow J/\psi+\pi+\pi$ (UZH)
- Search for B baryons (UZH)
- B-quarks correlations (ETHZ, UZH)

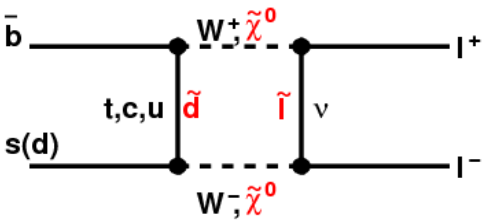
Let's focus on these ones

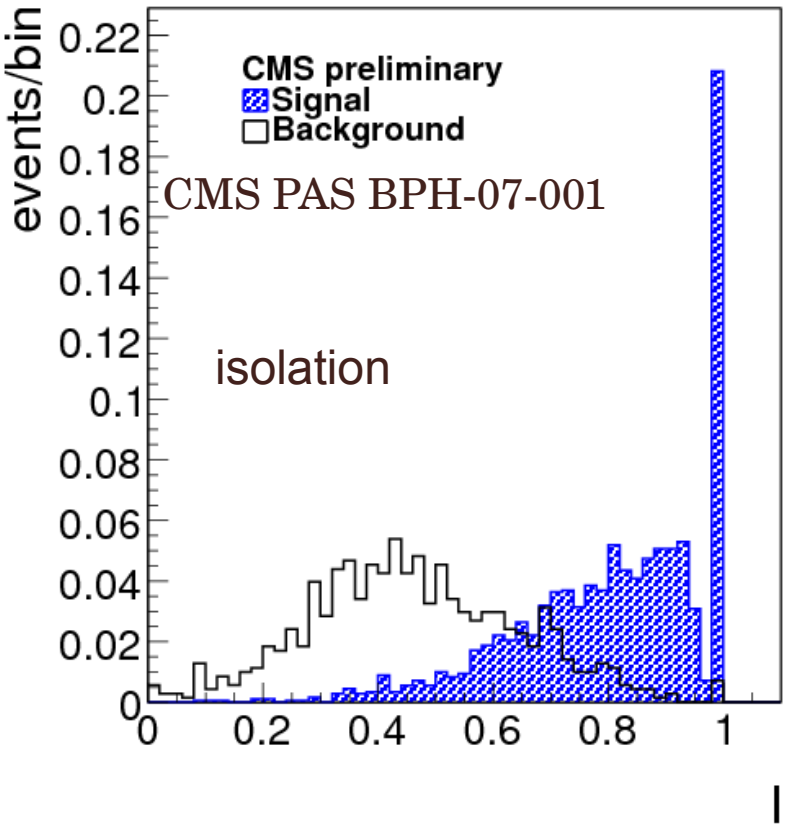
$B_{s,d} \rightarrow \mu\mu$

This decay is heavily suppressed in the SM, but can be enhanced in the MSSM at large tanβ



A normalization sample is used, namely $B^{+-} \rightarrow J/\psi\ K^{+-}$, with selections as similar as possible for the two channels





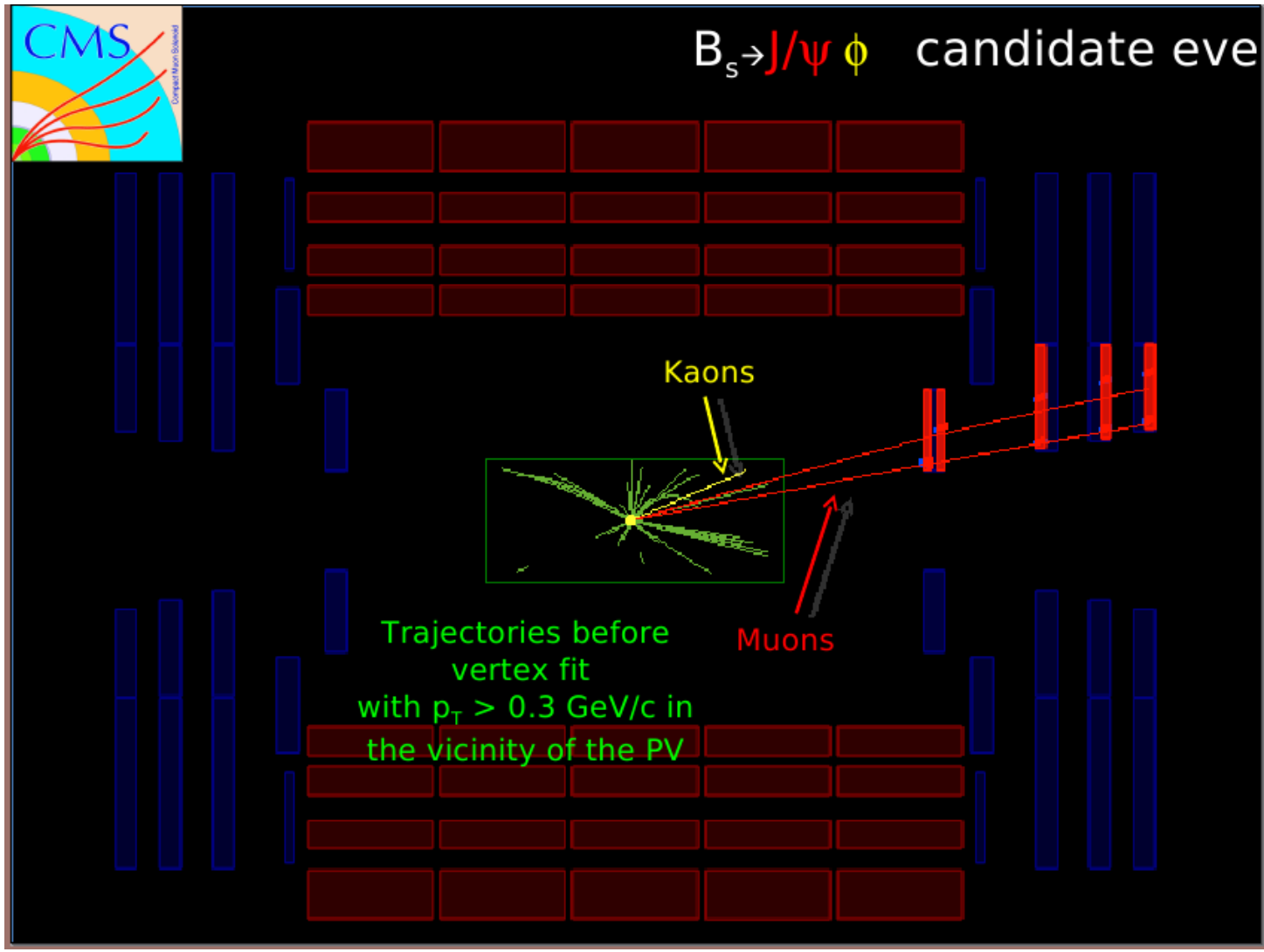
Selections are applied on :

- dimuon mass
- angle between the SV and the B_s
- Flight distance significance
- SV fit
- isolation around the B_s candidate

The predicted exclusion limit is $\leq 1.6 \times 10^{-8}$ at 90% CL for 1/fb at 14 TeV, scaling to 7 TeV ongoing

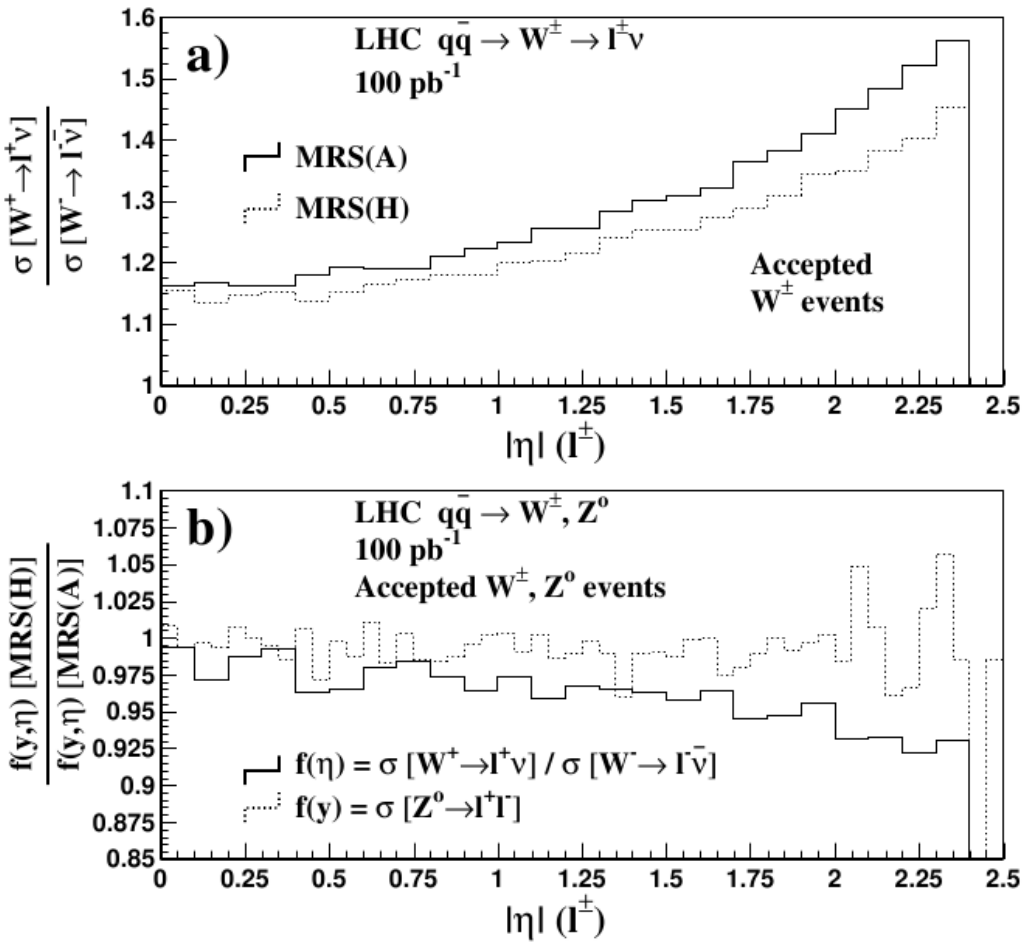
$B_s \rightarrow J/\psi\phi$

- Observation B_S → $J/\psi+\phi$ ~1/pb
- Differential cross-section, lifetime, mass and width: ~10/pb
- CP-even and CP-odd components, B_S^H-B_S^L eigenstates: >50/pb
- Extraction of the weak phase difference (CP violation) : >>100/pb



The goal is to best measure *W* and *Z* kinematic quantities (p_T, η)

Test of current *pdf* knowledge (see M.Dittmar, F.Pauss, D.Zuercher: Phys. Rev. D 56, 7284-7290 1997)



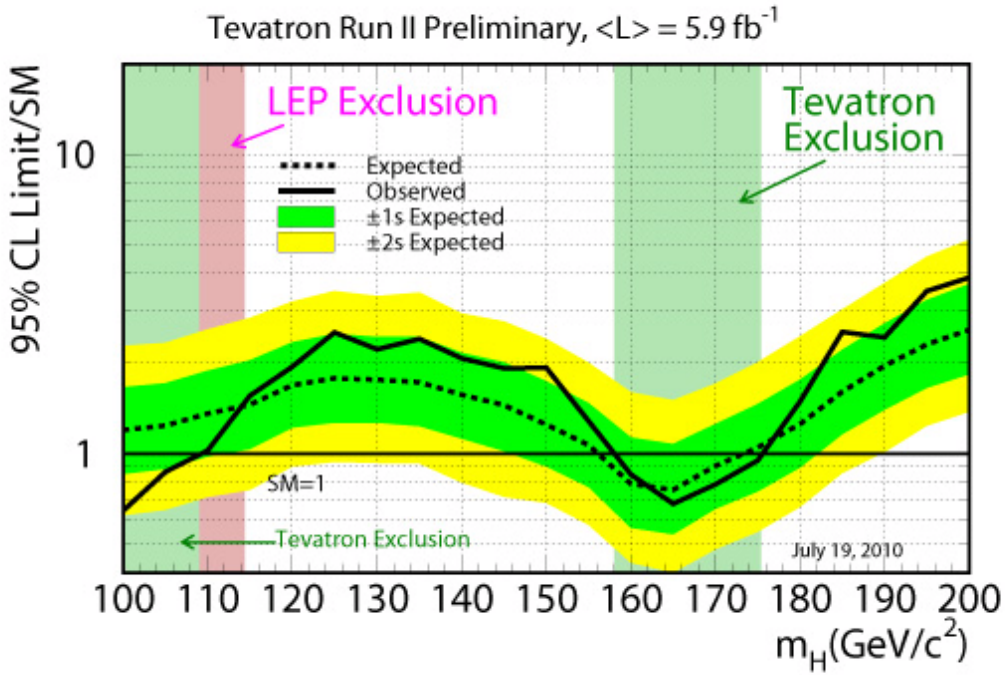
Already in the next 0.5 year, sensitivity for this measurement can be reached

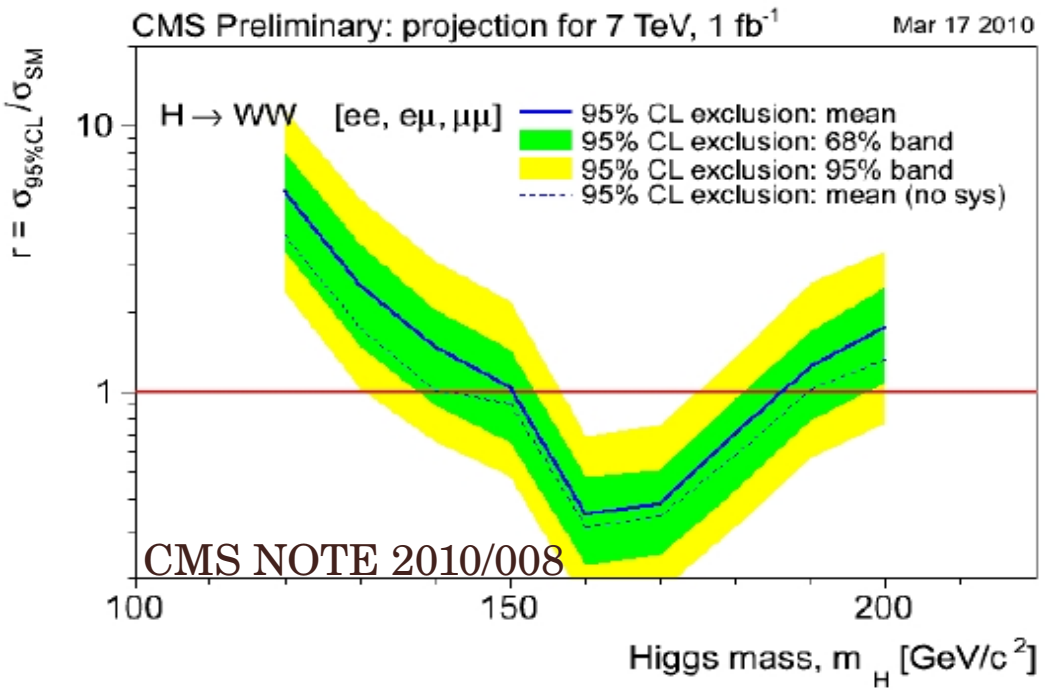
Higgs

First accessible channel: $H \rightarrow WW \rightarrow ll\nu\nu$ (M.Dittmar,H.Dreiner: Phys. Rev. D 55, 167-172 1997)

- The search is made both in the muon and the electron channels
- Backgrounds and fakes rates are checked with data
  - Backgrounds from sidebands
  - Fake rates using relaxed selections

Within the 2011, it will be probably possible to verify and improve Tevatron results



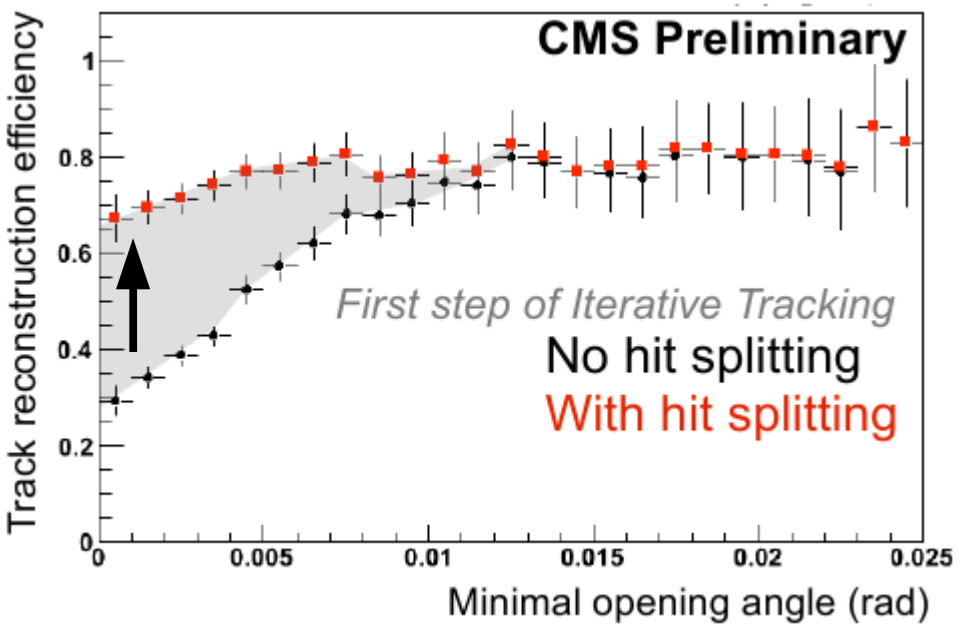


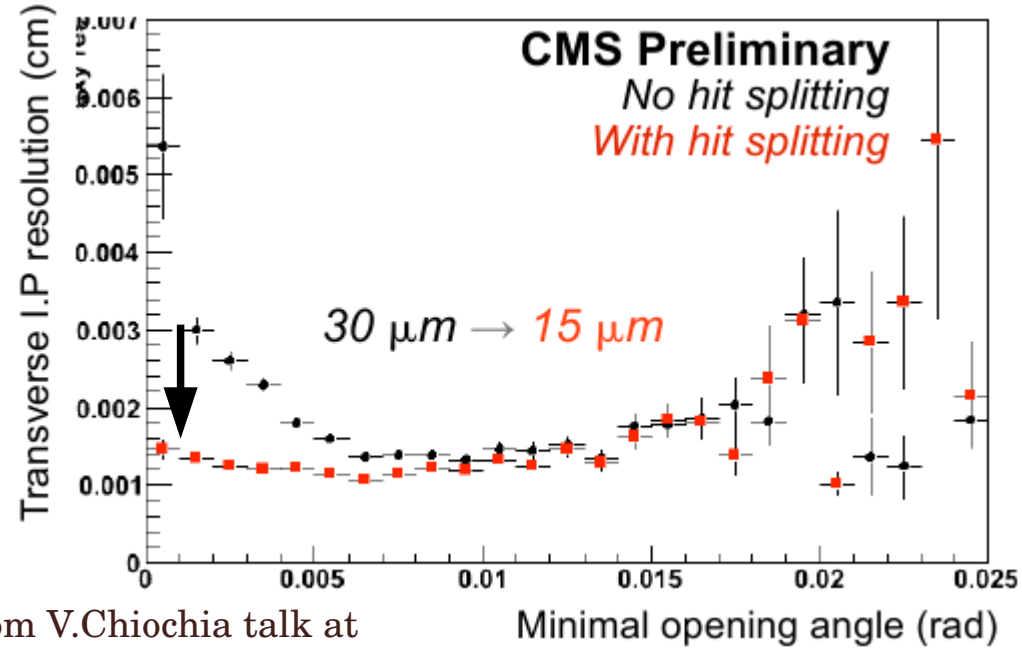
Higgs/2

$H \rightarrow \tau\tau$ from Vector Boson Fusion is out of reach in the next 1.5 years

- $Z \rightarrow \tau\tau$ studies can be already done, also to characterize the background
- Furthermore, efforts have to be put into high-p_T τs reconstruction and identification

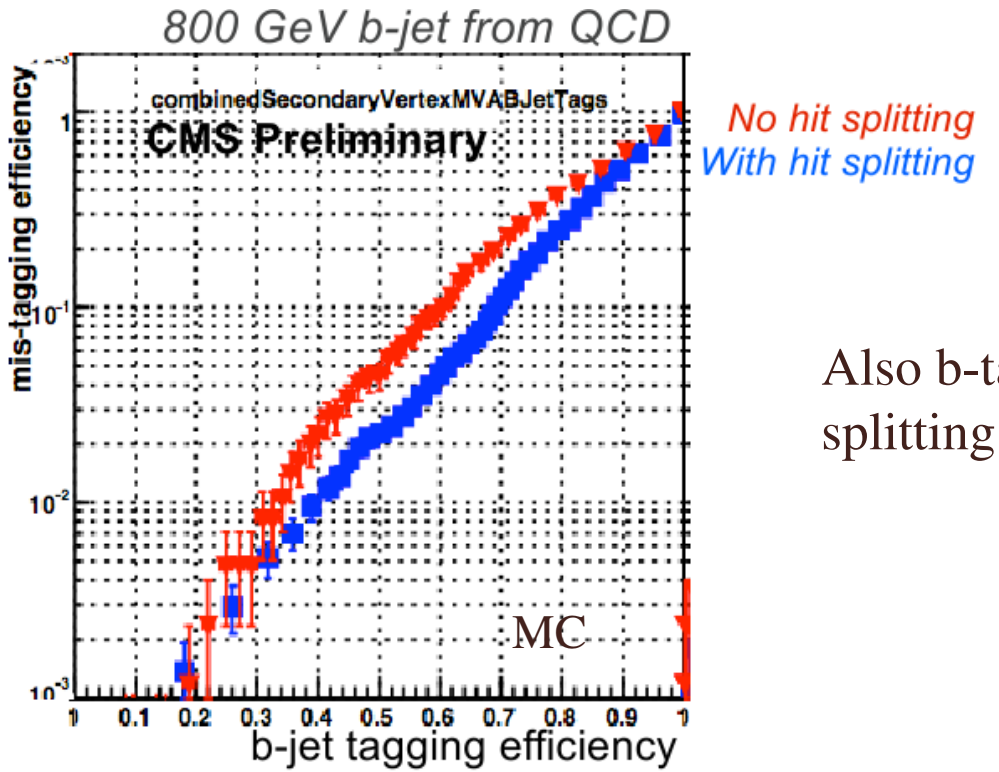
UZH is currently working in improving 3-prong high p_T decays, using pixel hit splitting based on a *template fit*





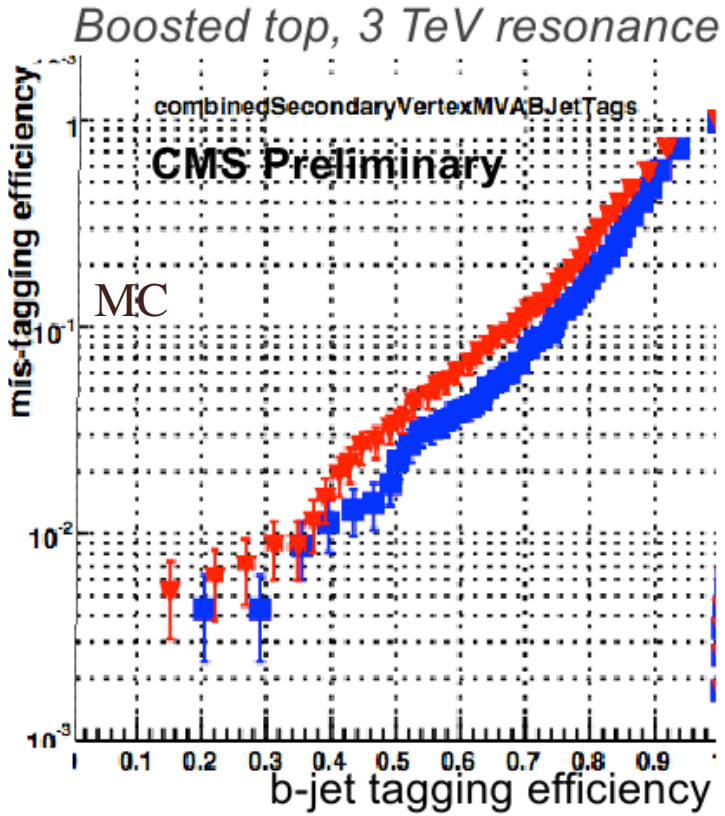
From V.Chiochia talk at DESY, March 1st 2010

Higgs/2



Also b-tagging greatly benefits from the hit splitting procedure

From V.Chiochia talk at DESY, March 1st 2010



SUSY

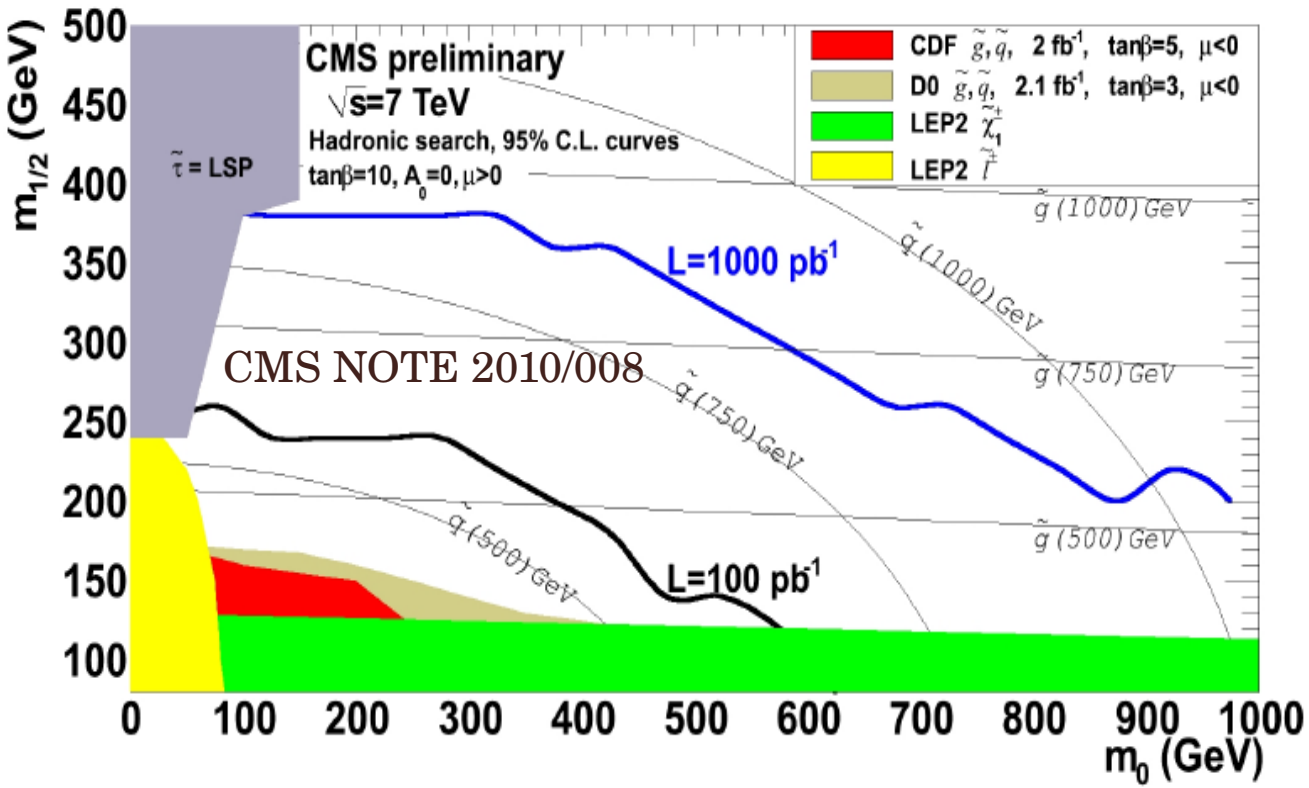
Both leptonic and hadronic channels are covered by Swiss institutions:

- Multi-jet final states (UZH)
- Dilepton + jets + E^T_{miss}: Same Sign and Opposite Sign states (ETHZ)
- Single lepton + jets + E^T_{miss} (ETHZ)

For the hadronic states, typical selections are:

- Veto on isolated leptons, at least 2 jets
- α_T used to discriminate signal/background
- High E^T_{miss} and H_T

Next step would be to add to the topological selections also b-tagging

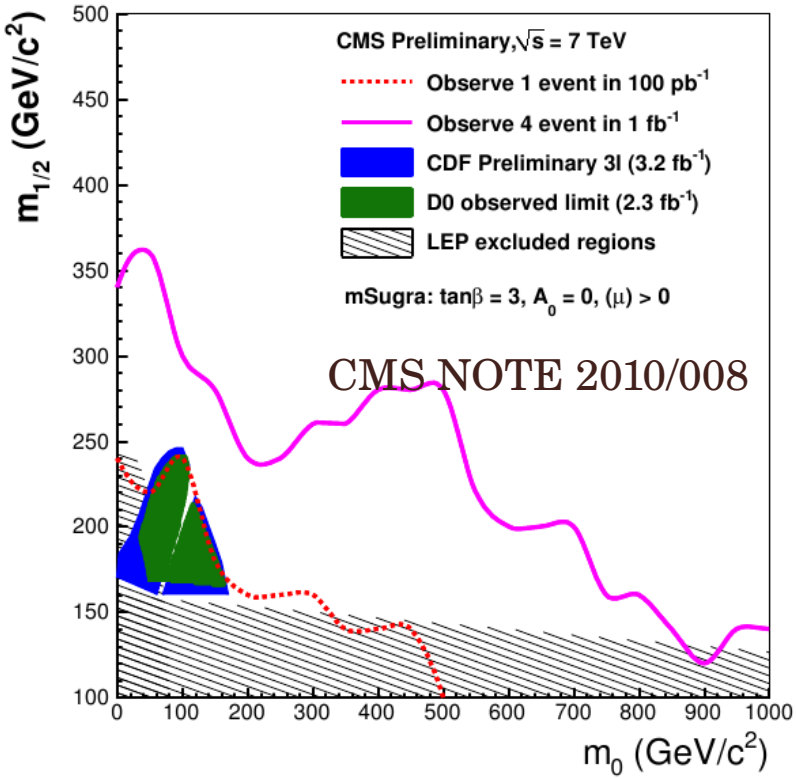


SUSY/2

For the SS dileptons, main backgrounds are due to *tt*-production

A major effort in ETHZ group is spent in the lepton fake rate measurement from data, using isolation as discriminating variable to create background enriched/depleted regions

Also here, an improvement of Tevatron results is already possible...



An OS dileptons search is also ongoing, looking in the Z+>2jets + E^T_{miss} channel, where the on-shell Z is produced by the χ_2^0.

- The Z-jet p_T balance method (SM Z+jets events should not carry E^T_{miss})
- The next 1.5y will be devoted to characterizing the imbalance and exploring sensitivity

SUSY/3

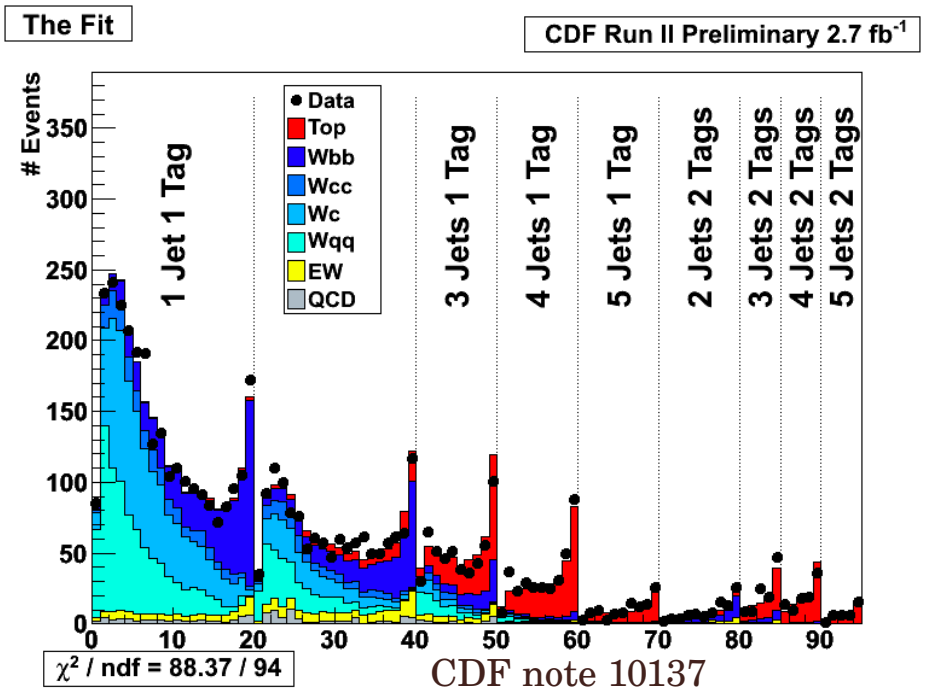
ETH

single leptons + jets + E^{T}_{miss} :

- balance discovery reach and S/B
- Add (optional) b-tag to increase sensitivity

Main backgrounds from *tt*-production and *W*+jets (and QCD)

- Both dominant backgrounds interesting in their own right
- Standard Model cross check
- Recent theoretical progress in *W*+ ≥3 jets
- *tt*-production and *W*+ jets mutual backgrounds of each other



CDF note 10137

Attempt simultaneous extraction using multi-dimensional "templates" (# jets, #b-tags, secondary vertex mass)

- Template fit to data determines relative contributions
- Reduce uncertainties by exploiting correlation
- Pioneered by CDF

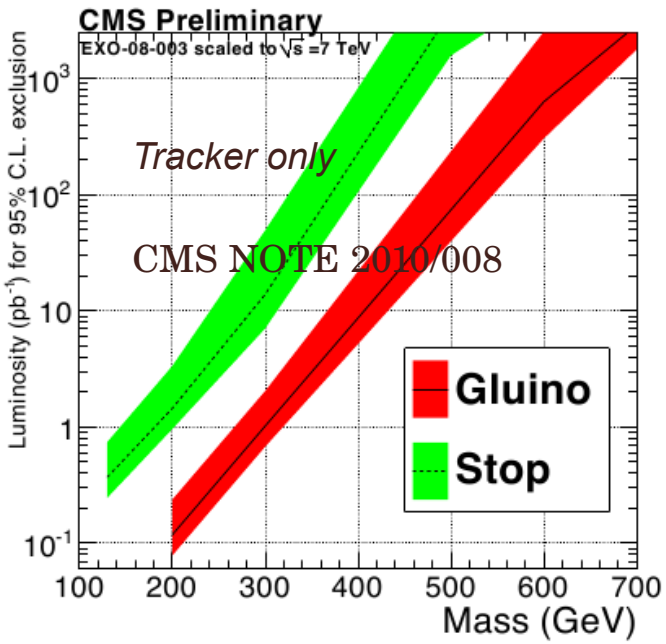
Beyond the Standard Model (and SUSY)

Some BSM models (mGMSB, UED, Split SUSY) can introduce massive charged meta-stable states: Heavy Stable Charged Particles (HSCP)

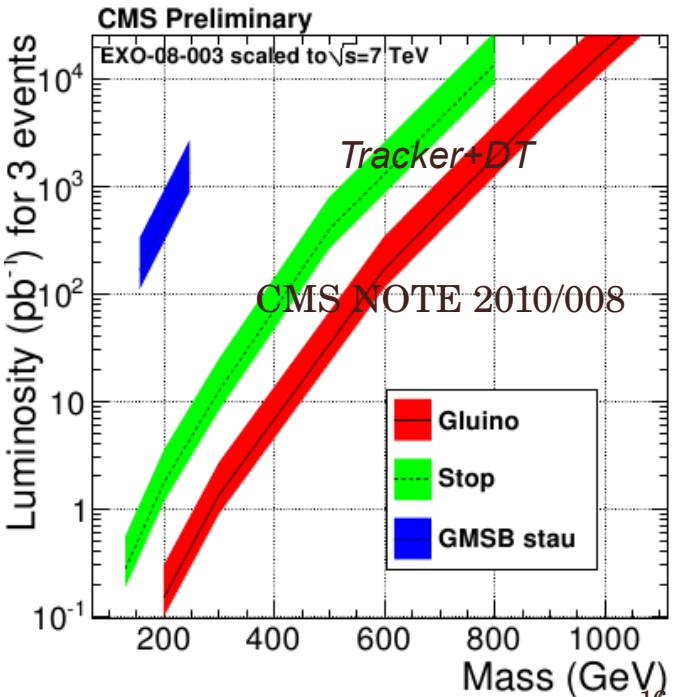
The HSCP can be:

- *Stau*
- *Stop* and *Gluino*. They hadronize in R-hadrons *gqqq* (R-baryon), *gqq* (R-meson), *gg* (gluon ball)
- τ_R^1 from UED (first KK excitation)

Charged and heavy → anomalously large *dE/dx*. The search can be done in two steps:



- Now: Using ionization in the Tracker (high x-sec models as R-hadrons from gluinos or stop)
- O(1/fb): use also the timing information from the DT muon detectors (staus, KK lepton resonances)

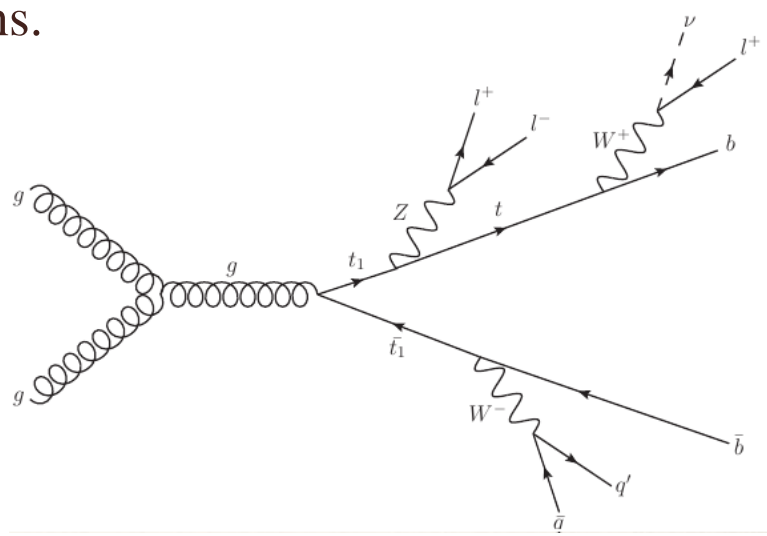


Beyond the Standard Model (and SUSY)/2

Composite Higgs model: a new strongly interacting sector gives (through breaking) origin to a Higgs doublet composed of 4 Goldstone bosons.

From the same mechanism:

- 6 top-like quarks t, t_i (i=1-5)
- 3 bottom-like quarks b, b_j (j=1,2)
- 2 Exotic charge quarks x_1, x_2



Different mass hierarchies are possible, and lepton-rich decays are available, such as:

$$t_2 \rightarrow x_1 W^+ \rightarrow t\, W^+ W^- \rightarrow b\, W^+ W^- W^+$$

Selections:

- At least two SS leptons
- At least two jets
- H_T>300 GeV and p_T(hardest jet) > 90 GeV

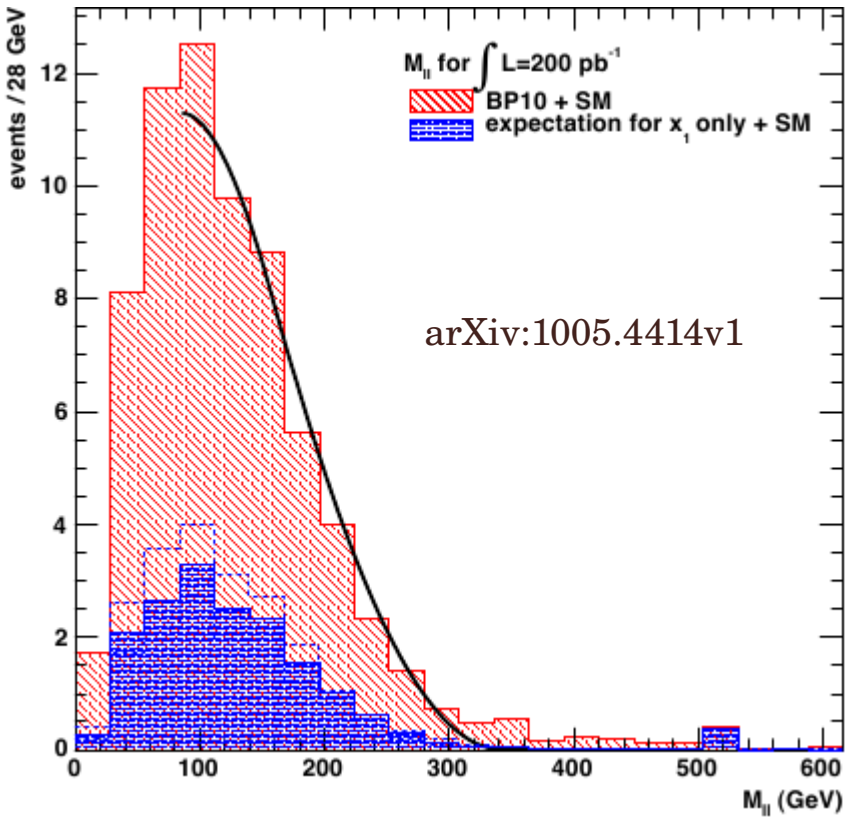
A study about Composite Higgs model discovery potential in CMS (`G.Dissertori, E.Furlan, F.Moortgat, P.Nef: arXiv:1005.4414v1`) has been performed, and shows interesting results

Beyond the Standard Model (and SUSY)/2

- 5σ reachable with 24^{+16}_{-12} /pb and 46^{+25}_{-22} /pb for the two analyzed benchmark points!

sample	preselection eff.	total selection eff.	expected # of events
Z + jets	$7.22 \cdot 10^{-5}$	$1.54 \cdot 10^{-6}$	$0.74^{+0.74}_{-0.37}$
W + jets	$2.97 \cdot 10^{-5}$	$1.63 \cdot 10^{-7}$	$0.79^{+0.79}_{-0.39}$
VV + jets	$2.19 \cdot 10^{-2}$	$6.15 \cdot 10^{-4}$	$0.59^{+0.07}_{-0.07}$
$W^{\pm}W^{\pm}jj$	$2.32 \cdot 10^{-2}$	$9.92 \cdot 10^{-3}$	$0.42^{+0.02}_{-0.02}$
$W^{+}W^{-}W^{\pm}$	$2.24 \cdot 10^{-2}$	$1.26 \cdot 10^{-3}$	$0.010^{+0.001}_{-0.001}$
$t\bar{t}$ + jets	$8.67 \cdot 10^{-4}$	$1.89 \cdot 10^{-4}$	$3.6^{+0.2}_{-0.2}$
$t\bar{t}W^{\pm}j$	$2.44 \cdot 10^{-2}$	$1.11 \cdot 10^{-2}$	$0.37^{+0.01}_{-0.01}$
$t\bar{t}Z^{\pm}$	$1.67 \cdot 10^{-2}$	$8.24 \cdot 10^{-3}$	$0.17^{+0.01}_{-0.01}$
BP 10	$3.79 \cdot 10^{-2}$	$2.87 \cdot 10^{-2}$	$61.8^{+1.1}_{-1.1}$
lBP 18	$4.97 \cdot 10^{-2}$	$3.75 \cdot 10^{-2}$	$41.4^{+0.7}_{-0.7}$

arXiv:1005.4414v1

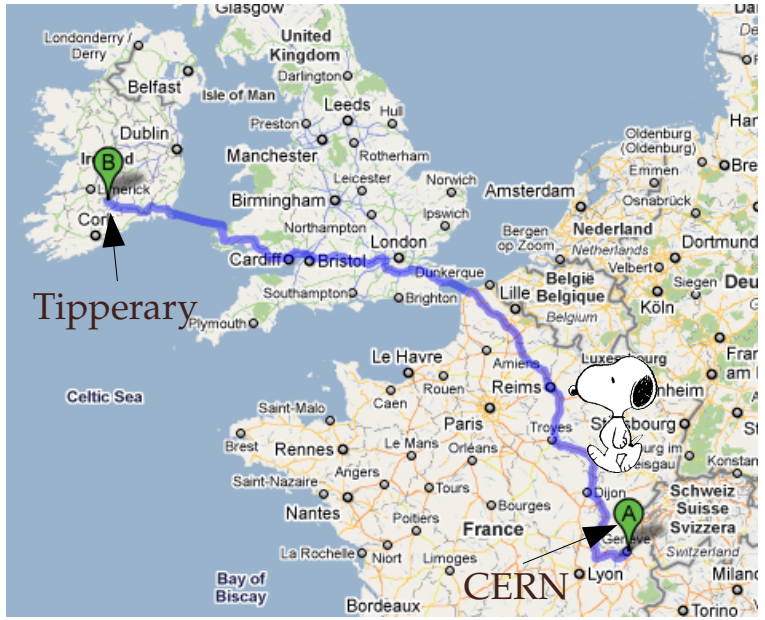


Furthermore, with a fit on the SS dilepton mass distribution tail (coming from the new quarks decays) it is possible with 200/pb to:

- Discriminate the possibility of only one 5/3 quark or e.g. there's t_1 too
- Have an estimate of the 5/3 mass

Conclusions

• By now, ~3/pb have been delivered, and we expect ~25-50/pb (1/fb) by the end of 2010 (2011)



• Interesting measurements will be available, e.g.:
  - ✔ Completion of Event Shape analysis
  - ✔ Many B physics measurements
  - ✔ First tests of *pdf* current state of art
  - ✔ Start working on the Higgs search
  - ✔ Explore SUSY parameter space
  - ✔ Update of HSCP limits and first results for Composite Higgs

• As seen, Swiss institutions play (and will play) an important role in CMS physics analyses.

• Beyond analysis, important contributions now and in the near future also in commissioning, computing and coordination