# SUSY@LHC.cern.ch

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CERN-PH


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# Outline

# Outline


**LHC in the news:**

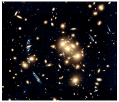
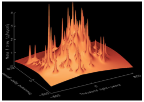
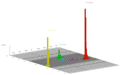
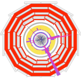
"It would be essentially impossible for the LHC to see nothing new"

Science, 27 March 2007

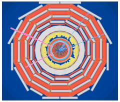
Status of the machine: Lyn Evans.

# The Physics Scope of the LHC

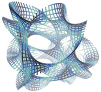
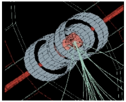
- Find and characterize the new particles that compose the dark matter of the universe (SUSY/Alternatives sessions)

- Find the Higgs particle (Karl Jakobs)



- Find new particles, forces, extra dimensions of space (SUSY/Alternatives sessions)

# ATLAS+CMS SUSY parallel Experimental talks

- SUSY searches in all-hadronic states with large MET at the LHC [Michael Tytgat (Ghent, CERN) 26.07]
- SUSY sensitivity in final states with leptons jets and MET at the LHC [ Chiorboli Massimiliano (Univ. di Catania) 26.07]
- Strategy for early SUSY searches at the LHC [Shimpei Yamamoto (Kyoto) 26.07]
- Trigger strategy for SUSY searches at the LHC [Antonella De Santo (RHUL) 26.07]
- SUSY searches in trilepton final states at the LHC [Martin Niegel (KIT) 27.07]
- R-hadron and long lived particle searches at LHC [Shikma Bressler (Israel Inst. of Technology) 28.07]
- Search for GMSB NLSPs at LHC [Piotr Zalewski (Warsaw) 28.07]
- SUSY parameters determination with ATLAS [Nurcan Ozturk (Univ. of Texas, Arlington) 28.07]

# Outline

The LHC

**Status of the LHC Experiments**

- Detectors

Besides the Standard Model

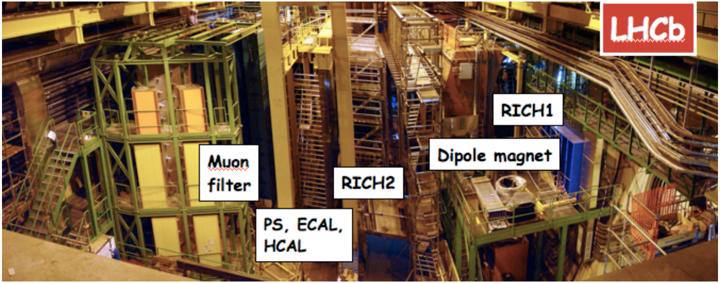
- SUSY@LHC program of work
- SUSY07 ATLAS+CMS Highlights

Top SUSY matters

Engineering the Discovery Plan

Wisdom from the Past

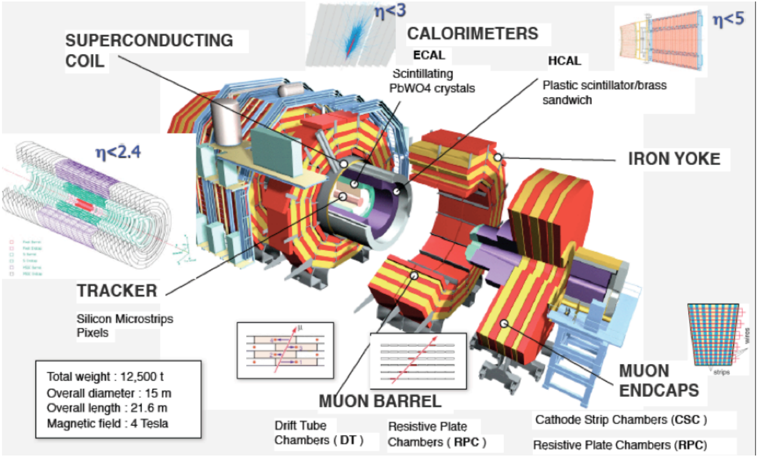
# Status of ATLAS and CMS



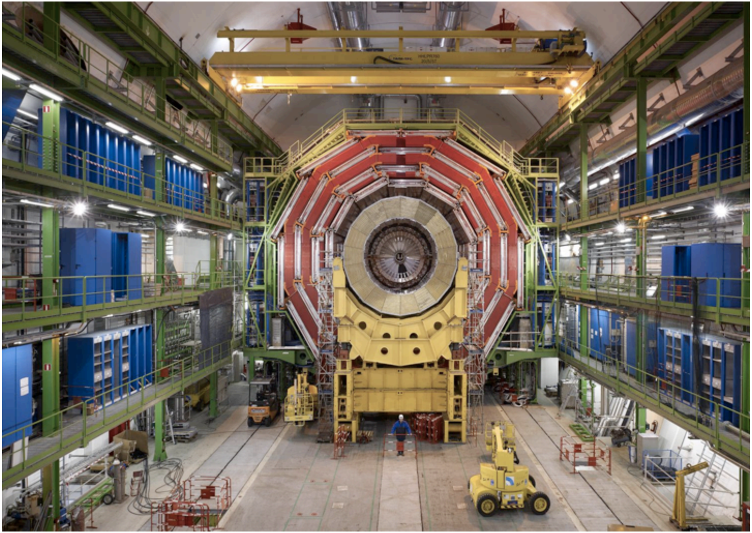


- LHCb and ALICE are on track
- status CMS (Maria/SUSY) and ATLAS (KarlHiggs)

# CMS: Compact Muon Solenoid detector at LHC



# CMS status

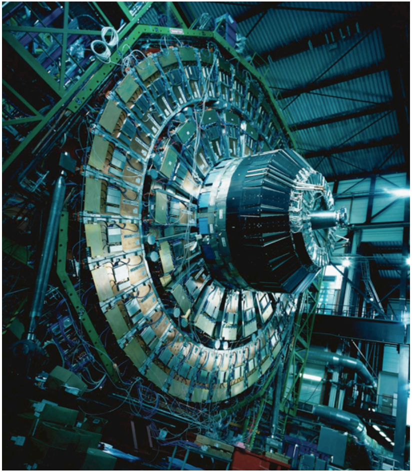


# Schedule

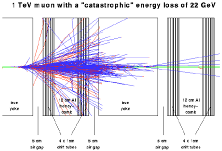
| | |
|---|---|
| May 07 and few days every end of month | commissioning/global runs/ cosmics/test data |
| Sep. 07 | CSA07 |
| Oct-Dec 07 | cosmics/integration |
| Feb 08 | beam pipe close |
| ++ | install pixels/ECAL EE (one) |
| Mar 08 | cosmics/integration |
| Apr 08 | close CMS for 14 TeV run |
| Jun 08 | 14 TeV physics run |

On the status of individual subsystems check backup slides

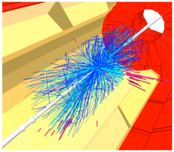
# big and challenging

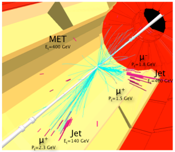


- high energy




- high luminosity



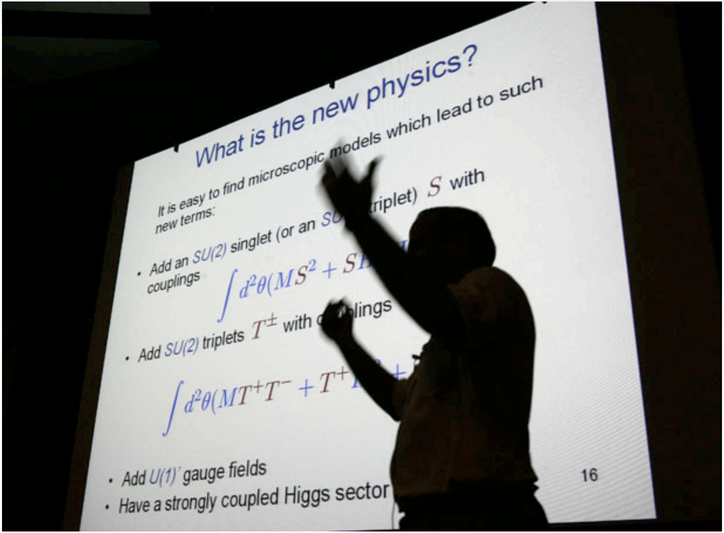



- high data rates (trigger, GRID)
- ...not a walk in the park

# Outline

*"Let me stress that I do not believe that the standard theory will long survive as a correct and complete picture of physics"*

*Shelly Glashow, Stockholm 1979*




Strings 07, (Nati assumes) The LHC will discover some of the particles in the MSSM, These include some or all of the 5 massive Higgs particles of the MSSM, No particle outside the MSSM will be discovered (and concludes) There could be measurable deviations from MSSM relations at the LHC.These could point to new higher energy physics.

# Top 2 Experimental Manifestations of New Physical Mechanisms (the known unknowns)

- the $W$ and $Z$ boson measured masses
- the dark matter

**The expectation is then that the LHC will discover a new sector of particles associated with electroweak symmetry breaking and dark matter:** $\longrightarrow$
Look for SUSY or “SUSY-mutation” in multijets+missing energy final state and 165 (value b/c of bet with Wim De Boer) GeV WIMP/neutralino dark matter candidate(s).

# Top 1 Current Experimental Hint for Low Mass SUSY

$$m_t = 171.4 \text{ GeV}$$

see also revised global fits (L.Roszkowski, R. de Austri, R.Trotta arxiv:0705.2021 and in this meeting parallel O. Buchmueller, R. Cavanaugh, A. De Roeck, S. Heinemeyer, G. Isidori, P. Paradisi, F.J. Ronga, A.M. Weberg, G. Weiglein just posted in the arXiv– also @Karl's talk)

# ATLAS/CMS program of work

## ATLAS CSC SUSY Notes

- SUSY1 : Data-driven Estimation of Z/W backgrounds to SUSY
- SUSY2 : Data-driven Estimation of top Backgrounds to SUSY
- SUSY3 : Data-driven Estimation of QCD Backgrounds to SUSY
- SUSY4 : Estimation of Heavy Flavor backgrounds and associated systematic
- SUSY5 : Searches and inclusive studies for SUSY events
- SUSY6 : Exclusive measurements for SUSY events
- SUSY7 : Gaugino direct productions
- SUSY8 : Studies for Gauge mediated SUSY

## ATLAS CSC Exotics Notes

- Black Holes
- Dibosons
- Lepton+jets
- Dileptons
- Leptons+ Etmiss

# ATLAS/CMS program of work

- Leptonic searches (SUSY) [WG1]
  - Search for SUSY in $\geq$1 lepton+$E_T^{miss}$+jets at 14 TeV in the electron and muon channels ($\mathcal{O}$(100 $pb^{-1}$)).
  - in dilepton pairs+ $E_T^{miss}$+jets at 14 TeV in the electron and muon channels ($\mathcal{O}$(100 $pb^{-1}$)).
  - Search for SUSY in trileptons + jets at 14 TeV. (1 $fb^{-1}$).
- Hadronic searches (SUSY) [WG2]
  - Search for SUSY in 0 lepton + $E_T^{miss}$+ jets at 14 TeV ($\mathcal{O}$(100) pb$^{-1}$).
  - in $b\bar{b}$ + $E_T^{miss}$ + jets at 14 TeV ($\mathcal{O}$(100) pb$^{-1}$).
  - in di-tau + $E_T^{miss}$ at 14 TeV ($\mathcal{O}$(100) pb$^{-1}$).
- HSCP and photonic searches (GMSB) [WG3]
  - Search and reconstruction of heavy stable charged particles at 14 TeV using TOF and dE/dx (500 pb$^{-1}$, model dependent).
  - Search for GMSB using prompt photons at 14 TeV (500 pb$^{-1}$).
- High Energy Pair Searches (U(1)$'$/ED/other) [WG4]
  - Search for TeV mass resonances in diEM events at 14 TeV (100 pb$^{-1}$ $\mathcal{O}$(fb$^{-1}$))
  - in dimuon events at 14 TeV (100 pb$^{-1}$)
  - in dijet events at 14 TeV ($\mathcal{O}$(fb$^{-1}$))

# Alerts and Emphases in the Past Year

- Trigger aware analyses
- Data-driven background estimates, use of control samples
- Understanding of Standard Model QCD associated production of anything at $\sqrt{s} = 14$ TeV (especially W/Z/top, see talk by Michelangelo Mangano)
- Engineering of "first data" strategies – i.e. shifting gears to the $\text{pb}^{-1}$ from the $\text{fb}^{-1}$
- Engineering of faster, simpler navigation/orientation compass in the vast parameter space

# First Data and SUSY

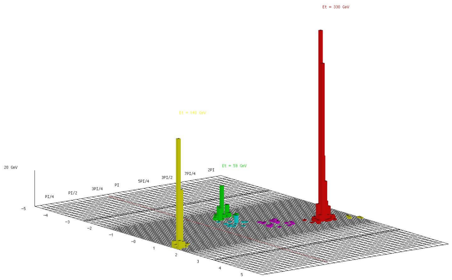
**General Stategy (SUSY06, Giacomo P. /Maria S. for ATLAS/CMS)**

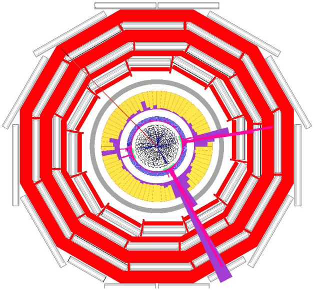
- Choose signatures identifying well defined decay chains
- Extract constraints on masses, couplings, spin from decay kinematics/rates
- try to match emerging pattern to tentative template models
- having adjusted template models to measurements, try to find additional signatures to discriminate different options

# Canonical Dark Matter Searches Using Missing Energy

Michael Tytgat, yesterday

$E_T^{miss}$=360 GeV, $E_T(1)$=330 GeV, $E_T(2)$=140 GeV, $E_T(3)$=60 GeV

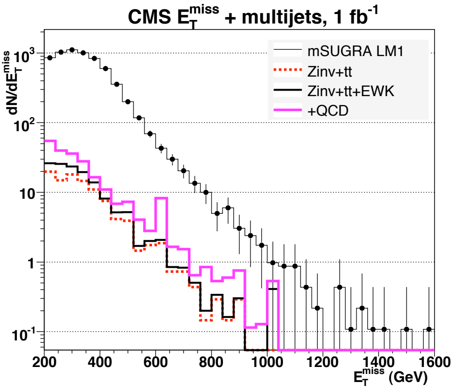




LHC can discover such events fast. Their cross section is huge : 10,000 to 1,000,000 events per year...

# Inclusive Signatures with Missing Energy

## $E_T^{miss}$ +jets, gluino=600 GeV, neutralino=100 GeV



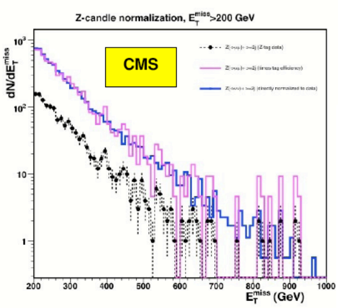

- fast-track to discovery of "low mass" SUSY $\mathcal{O}(10)$ pb$^{-1}$ b/c of signal cross section – control of systematics using SM processes (e.g. $Z$+jets, top)
- the time between $\mathcal{O}(10)$ and $\mathcal{O}(100)$ pb$^{-1}$ of well understood data will be critical for the discovery and characterization of SUSY

# Standard Model Candles and Handles

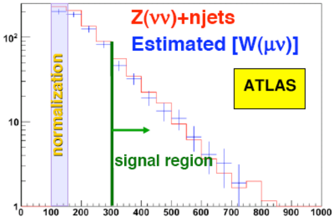
## Example

The $Z$ candle

### W/Z+jets Background




- MC to data normalization avoids systematics due to QCD scale, PDFs, ISR/FSR, jet energy scale ...




- CMS : Systematic uncertainty dominated by luminosity, measured ratio R and ρ; 5% precision expected with ~1.5 fb-1

# Triggering on SUSY

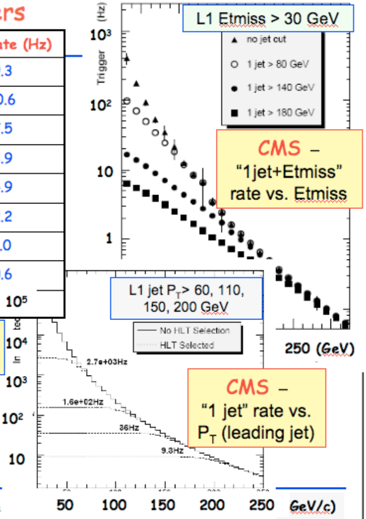
**talk by Antonella De Sando RHUL**

## CMS Jet/ETmiss Triggers

| HLT Path | Thresh'd(s) (GeV) | HLT Rate (Hz) |
|---|---|---|
| 1 jet | 200 | 9.3 |
| 2jets | 150 | 10.6 |
| 3 jets | 85 | 7.5 |
| 4 jets | 60 | 3.9 |
| Etmiss | 65 | 4.9 |
| 1 jet + Etmis | (180,60) | 2.2 |
| 2 jets + Etmiss | (125,60) | 1.0 |
| 3 jets + Etmiss | (60,60) | 0.6 |
| 4 jets + Etmiss | (35,60) | |

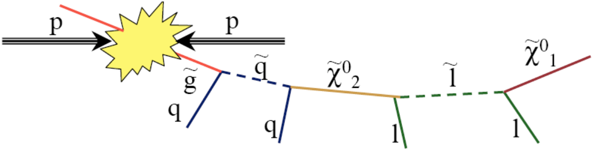
CMS HLT rates @ L=$10^{32}$ $cm^{-2}$ $s^{-1}$
(total HLT output ~150 Hz)

CMS HLT –
CERN/LHCC 2007-021



# First/Fast Mass Clues (dileptons)

**talk by Massimiliano Chiorboli (Catania), Nurcan Ozturk (UTA)**



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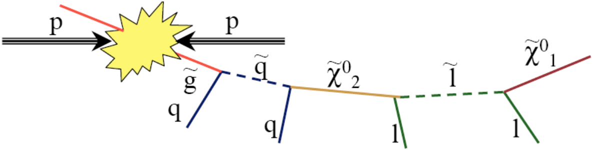
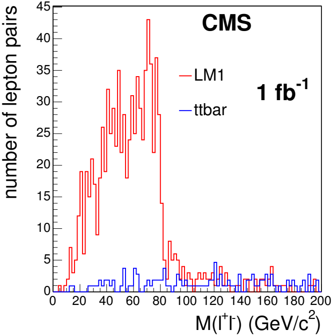
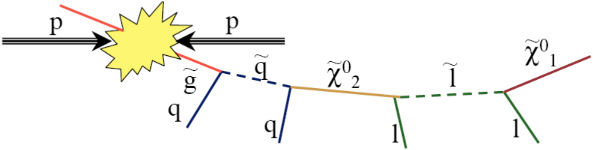


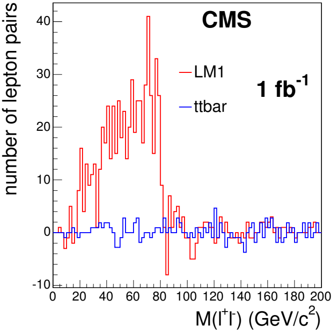




- SFOS dilepton+jets+$E_T^{miss}$
- $t\bar{t}$:$WW$+j:$Z$+j:other$\sim$ 6:1:1:1
- flavor subtraction ($e^-\mu^+ + e^+\mu^-$) to supress chargino,$W$, $t\bar{t}$, $WW$, "other"
- L1+HLT trigger path required
- overall systematic on the background 20% (JES dominated)
- $5\sigma$ discovery with $\sim$ 20 pb$^{-1}$ (of data understood as expected with 1 fb$^{-1}$).

# First/Fast Mass Clues (dileptons)

**talk by Massimiliano Chiorboli (Catania), Nurcan Ozturk (UTA)**

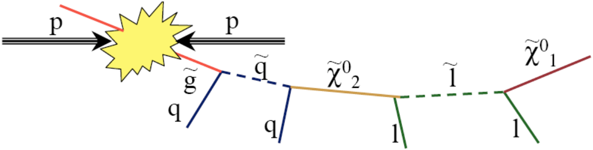


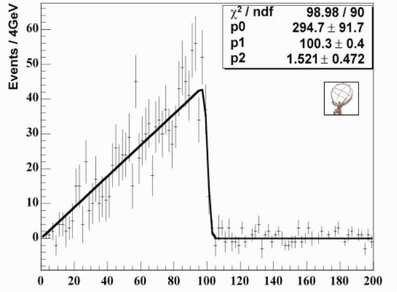




- $M_{\ell\ell}^{max} = M(\tilde{\chi}_2^0)\sqrt{1 - \frac{M^2(\tilde{\ell}_R)}{M^2(\tilde{\chi}_2^0)}}\sqrt{1 - \frac{M^2(\tilde{\chi}_1^0)}{M^2(\tilde{\ell}_R)}}$
- $M_{\ell\ell}^{max}$(meas)= $80.42 \pm 0.48$ GeV/$c^2$, *cfr* with
- expected $M_{\ell\ell}^{max}$= 81 GeV/$c^2$ [given $M(\tilde{\chi}_1^0)$ = 95, $M(\tilde{\chi}_2^0)$= 180 and $M(\tilde{\ell}_R)$ = 119 GeV/$c^2$]

# First/Fast Mass Clues (dileptons)

**talk by Massimiliano Chiorboli (Catania), Nurcan Ozturk (UTA)**




- $m_0 = 100$ GeV, $m_{1/2}$ = 300 GeV ,$A_0$ = -300 GeV, tan $\beta$ = 6 sgn($\mu$) = +1 [ATLAS SU3 test-point]
- $M_{\ell\ell}^{max}$(meas)= 100.3 $\pm$ 0.4 GeV/$c^2$ with 4.20 fb$^{-1}$ (Geant-4 based simulation, no systematics)
- ATLAS-preliminary

# towards SUSY reconstruction

## Nurcan Ozturk, UTA

## Lepton+Jet Endpoint

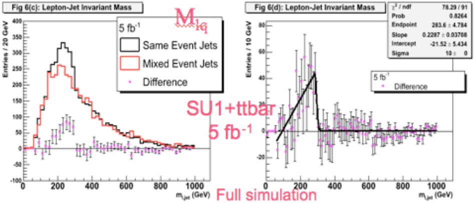
$$\tilde{q}_L \to q\tilde{\chi}_1^{\pm} \to ql^{\pm}\tilde{\nu}_l \to ql^{\pm}\nu_l\tilde{\chi}_1^0$$

$$M_{lq}^{\max} = \sqrt{\frac{(M_{\tilde{q}_L}^2 - M_{\tilde{\chi}_1^{\pm}}^2)(M_{\tilde{\chi}_1^{\pm}}^2 - M_{\tilde{\nu}_l}^2)}{M_{\tilde{\chi}_1^{\pm}}^2}}$$

Event selection:

- one lepton (electron, muon) $p_T$> 20 GeV, |η|<2.5, chi2/dof<10 for muon
- EMlikelihood > 0.95, lepton isolation cut $E_T$ < 10GeV in 0.45 cone
- Cone7 (R=0.7) jets, ΔR(lepton,jet)>0.7
- to reduce lepton+jets and dilepton ttbar background:
  - leading and second leading jet with $E_T$ > 200 GeV
  - transverse mass $M_T$ < 60GeV or $M_T$ > 100GeV
  - $E_T^{miss}$ > 250 GeV

- Use mixed event technique to subtract combinatorial jet background: randomly pair jets from a different event (satisfying same event selection) with the lepton.
- Assumptions of the technique: The jet from signal decay chain and the jet from the decay of the other squark have similar kinematic distributions. And the squarks are produced at rest so the event is roughly spherical. Both are valid for SU1 but not for ttbar.
- Subtract mixed-event-jet distributions from same-event-jets distribution to obtain an inferred "correct jet" distribution. (normalization correction applied)
- Statistical significance of discovery is 5σ with 5 $fb^{-1}$.
- Expected endpoint: 284 GeV
- Fitted endpoint: 283.6±4.8 GeV




Nurcan Ozturk    ATLAS note: Cooke et.al ATL-COM-PHYS-2007-002    July 28, 2007    10

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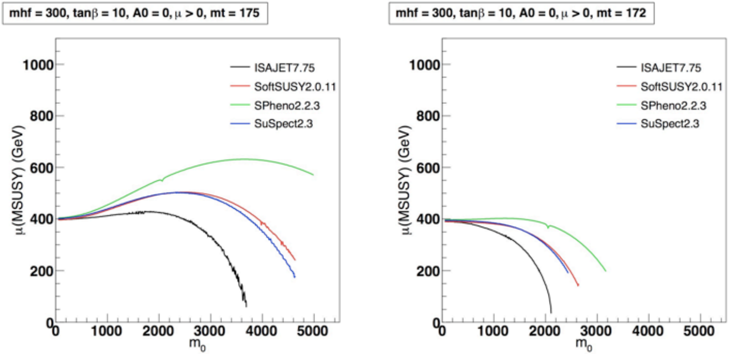
- The LHC
- Status of the LHC Experiments
  - Detectors
- Besides the Standard Model
  - SUSY@LHC program of work
  - SUSY07 ATLAS+CMS Highlights
- **Top SUSY matters**
- Engineering the Discovery Plan
- Wisdom from the Past

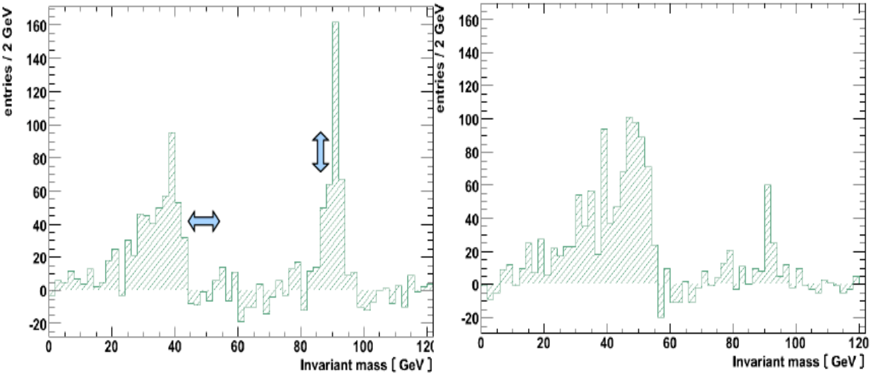
# Comparison of SUSY Calculators




Most recent comparison of SUSY spectrum calculators: S. Kraml, S. Sekmen.

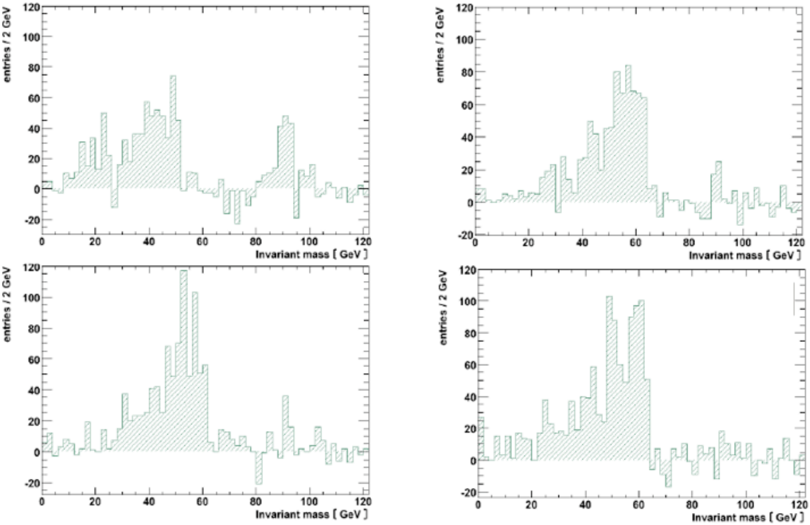
# Top mass in SUSY

Niklas Mohr, L. Feld, K. Klein, Aachen-I




1 (one) GeV difference in top mass, same calculator+SUSYHIT at large m0.

# Top mass in SUSY



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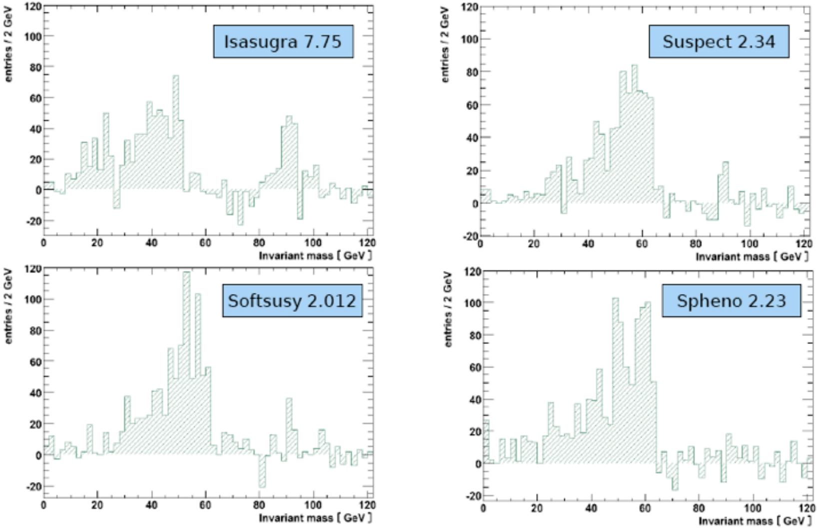

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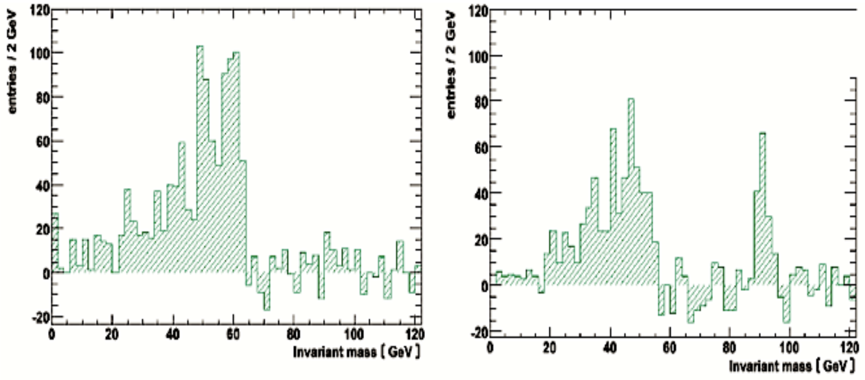
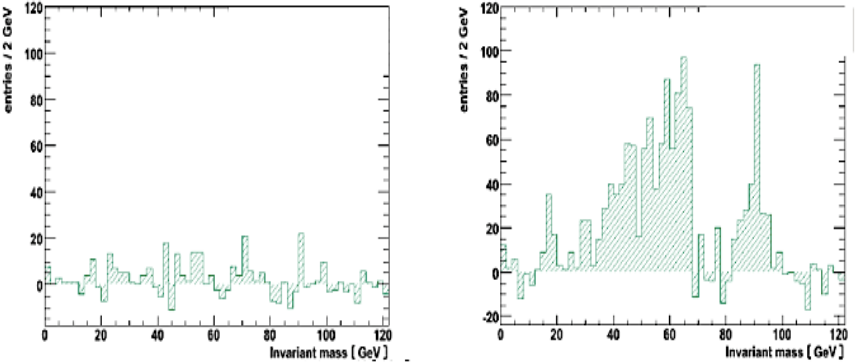



175 spheno+SUSYHIT, 172.5 spheno+SUSYHIT

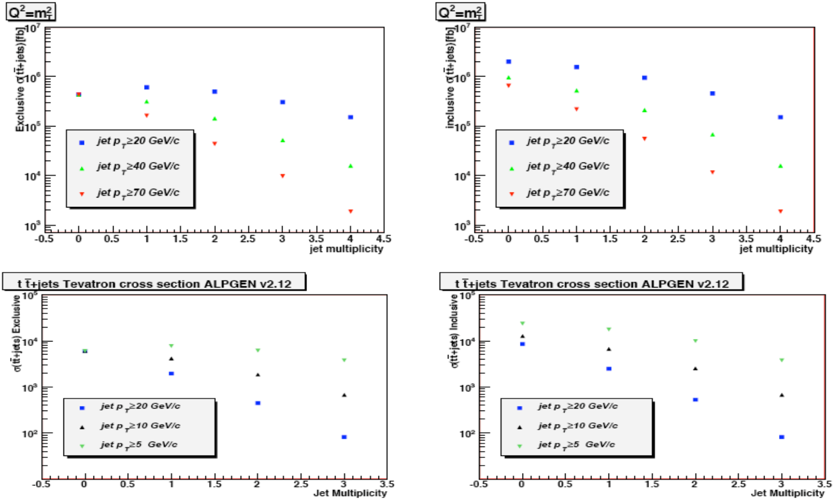
# Top mass in SUSY




172.5 isajet : no LM9 (no EWKSB) move m1/2 by 40 GeV and make LM9p ; look Lm9p between isajet and softsusy

# Top QCD Matters @LHC: non trivial

## MS, M.Pierini ALPGEN, tt+Njets... (see also MLM)



# Outline

# CMS SUSYBSM discovery plan

- Search for SUSY (Evidence for excess) in $\geq$1 lepton+$E_T^{miss}$+jets at 14 TeV in the electron and muon channels (100 $pb^{-1}$).
- Search for SUSY (Evidence for excess) in opposite sign dilepton pairs+ $E_T^{miss}$+jets at 14 TeV in the electron and muon channels (20 $pb^{-1}$)
- Search for SUSY (Evidence for excess) in same-sign dilepton pairs + $E_T^{miss}$+jets at 14 TeV in the electron and muon channels (200 $pb^{-1}$)
- Search for SUSY (Evidence for excess) in $Z^0$ leptonic decays+ $E_T^{miss}$+jets at 14 TeV in the electron and muon channels (100 $pb^{-1}$)
- Search for LVF SUSY (Evidence for excess) in $e + \mu$ final state at 14 TeV (500 $pb^{-1}$)
- Search for SUSY (Evidence for excess) in trileptons + jets at 14 TeV. ($\sim$ $fb^{-1}$)
- Search for SUSY (Evidence for excess) in $b\bar{b}$ + 1 lepton at 14 TeV.
- Search for SUSY (Evidence for excess) in 0 lepton + $E_T^{miss}$+ jets at 14 TeV (10 pb$^{-1}$)
- Search for SUSY (Evidence for excess) in $b\bar{b}$ + $E_T^{miss}$ + jets at 14 TeV (100 pb$^{-1}$)
- Search for SUSY (Evidence for excess)in top hadronic decays+ $E_T^{miss}$ at 14 TeV (200 pb$^{-1}$)
- Serach for SUSY (Evidence for excess) in opposite-sign ditau + $E_T^{miss}$ at 14 TeV (200 pb$^{-1}$)
- Search for GMSB (Evidence for excess) in prompt photon final states at 14 TeV (500 pb$^{-1}$)
- Search for GMSB (Evidence for excess) in non-pointing photons at 14 TeV (1 fb $^{-1}$)
- Search and reconstruction of heavy stable charged particles at 14 TeV using TOF and dE/dx (500 pb$^{-1}$)
- ....

# Some Discovery signatures

- canonical inclusive
  - jets+ $E_T^{miss}$ (*)includes strategies for beam halo/noise, first data
  - jets+ $\ell$ + $E_T^{miss}$
  - same-sign dimuon + $E_T^{miss}$
  - opposite-sign same flavor dielectron and dimuon + $E_T^{miss}$
  - opposite-sign same flavor hadronic ditau + $E_T^{miss}$
- higher reco object inclusive
  - $Z$ + $E_T^{miss}$
  - $t$ hadronic + $E_T^{miss}$
  - $h^0(b\bar{b})$ + $E_T^{miss}$

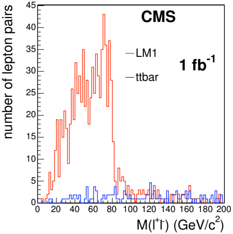
# is it an amoeba or is it Sharon Stone?

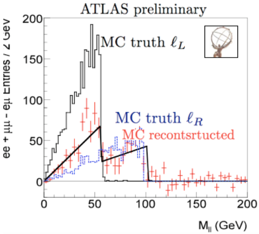
## decoding the compositions of primary constituents

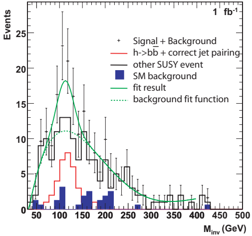


- Just like decoding DNA we have to decode the signals we will observe. And we do expect more similarities than differences, so fast discrimination will require smart and simple measurements.

# Features directly from the kinematics




- But can we also tell the twins apart? Just as DNA is “what” we are but not “who” we are, we have to find additional traits and put the pieces together in order to orient and navigate in the vast parameter spaces of the models.

# Twins and look-alikes: so far-away so close

• Question: take the example of the excess in LM1 in my jetMET channel. This was at “LM1”, a specific point, one of millions in the SUSY parameter space. Can you find another point that would give you the same answer (same final number of events passing all the analysis path)?

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- Answer: Sure thing (took less than a day)

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- Question: Can you tell them apart?

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# Twins and look-alikes: so far-away so close

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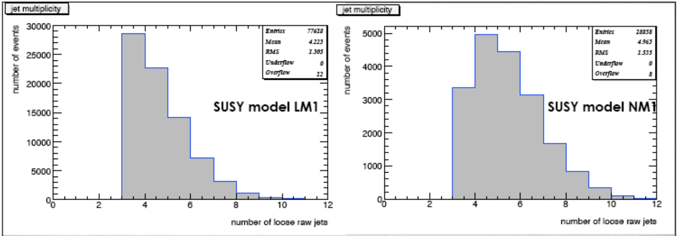
- SuperModel LM1 (CMS PTDR): squark/gluinos 600 GeV gluino, 550 GeV squark. 50pb cross section. 51% squark-gluino production 15% gluino-gluino, rest squark-squark
- SuperModel NM1 (look-alike1): light gluinos 350 GeV gluino, 1200 GeV squark. 230 pb cross section. 95% of gluino pair production
- SuperModel NM2 (look-alike2): light stops 450 GeV gluino, 550 GeV squark, 190 GeV stop. 230 pb cross section. 20% gluino pairs, 30% squark-gluino, 40% stop pairs




compute the ratio of the number of events with >3 jets to the number of events with 3 jets, after all cuts except the final HT cut:

- SUSY model LM1: 1.7
- SUSY model NM1: 4.6
- SUSY model NM2: 6.3

*MS, J. Lykken,J. Hubisz and M. Pierini to appear in hep-ph*

# Towards Systematic and Deeper Mining of the Event

Examples of the simple questions to ask and answer (fast) and recent examples of works:

- excess of SS dileptons $\rightarrow$ ?
- $++/--$ =2 $\rightarrow$ ?
- excess if OS dileptons $\rightarrow$ ?
- triangle in dilepton invariant mass $\rightarrow$ ?
- double triangle $\rightarrow$ ?
- no triangle $\rightarrow$ ?
- $Z^0$ and no triangle $\rightarrow$ ?
- $Z^0$ and triangle $\rightarrow$ ?
- ratios: $1\ell/2\ell/3\ell/4\ell$, jets
- ... more “footprint” homeworks

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- ... more "footprint" homeworks

Arkani-Hamed, Toro, Shuster et al Very clever "marmoset" solutions to the navigation problem: see Olympics and black boxes challenges

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- ... more “footprint” homeworks

Gunion et al. Mass Determination in SUSY-like events with Missing Energy: Use the full event, see parallel SUSY-pheno session

# Towards Systematic and Deeper Mining of the Event

Examples of the simple questions to ask and answer (fast) and recent examples of works:

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- ... more “footprint” homeworks

A. Bar et al, Spin Prints to distinguinsh between UED and SUSY (but with a lot of lumi), see parallel Oztrurk

# Towards Systematic and Deeper Mining of the Event

Examples of the simple questions to ask and answer (fast) and recent examples of works:

- excess of SS dileptons $\rightarrow$ ?
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- ratios: $1\ell/2\ell/3\ell/4\ell$, jets
- ... more "footprint" homeworks

A number of post-modern multivariate very sophisticated analyses with DTs, NNs, fancy statistics etc: with care and caveats

# Outline

# W-s and Z's: from 1976 to ALPGEN

PHYSICAL REVIEW D VOLUME 14, NUMBER 1 1 JULY 1976

**Intermediate-boson and dilepton production in hadronic interactions***

R. B. Palmer, E. A. Paschos, N. P. Samios, and Ling-Lie Wang
*Brookhaven National Laboratory, Upton, New York 11973*
(Received 10 November 1975)

Various relations are obtained between dilepton and intermediate-boson ($W$) production cross sections. It is pointed out that if the dilepton production obeys a scaling law, then its measurement at presently available energies can provide a lower bound for the production of $W$ bosons in future high-energy experiments. We also calculate $W$ production using a Drell-Yan model with and without color. We find that the model without color is quite successful when compared with the dilepton production data. Estimates of the leptonic and hadronic decay rates of the $W$ boson are also given.

## Extrapolating from 1975

- BNL 400 GeV collidr proposal
- $s/M_W^2$ Tevatron $\sim$500 $\rightarrow \sigma = 16$ nb
- $s/M_W^2$ LHC $\sim$30000 $\rightarrow \sigma = 12$ nb
- The Tevatron W-inclusive cross section is (measured) 8 nb
- The LHC is $\sim$ 20 nb

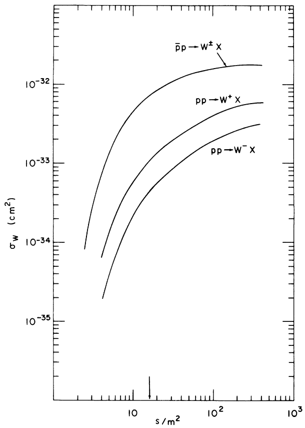
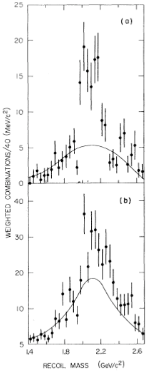



FIG. 6. Production cross section for $pp \to W^{\pm}X$ and $\bar{p}p \to W^{\pm}X$, calculated from the model given in Sec. III. The arrow points to the $s/M^2$ value corresponding to the production of a 100-GeV $W$ meson by a 200-GeV/$c$-on-200-GeV/$c$ storage machine.

# Resonances, Reflections: a non-trivial discovery example from 30 years ago (MLM digged this)




$K\pi$ and $K3\pi$ spectra 2.08.76 PRL 37 (76) 255

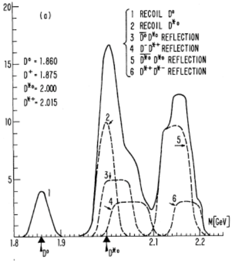
Experiment indicates[3] $M(D^0) \cong 1.86$ MeV and $M(D^{0*}) \cong 2.00$ GeV.[5] Using our estimate of ems, we tabulate available energies $Q$ and branching ratios $B$ for $D^*$ decays as follows:

$$D^{*+} \to \begin{cases} D^0\pi^+, & Q=15\text{ MeV}, \quad B\sim 90\%, \\ D^+\pi^0, & Q=5\text{ MeV}, \quad B\sim 10\%, \\ D^+\gamma, & Q=140\text{ MeV}, \quad B\sim 1\%, \end{cases}$$

$$D^{*0} \to \begin{cases} D^0\pi^0, & Q=5\text{ MeV}, \quad B\sim 90\%, \\ D^+\pi^-, & Q=-5\text{ MeV}, \quad B\sim 0, \\ D^0\gamma, & Q=140\text{ MeV}, \quad B\sim 10\%. \end{cases}$$

Although none of the masses we use are precisely determined, the point is clear: *Decays of charged or neutral $D^*$'s predominantly yield $D^0$'s and pions.*

To the extent that $\bar{D}D$, $\bar{D}D^* + \bar{D}^*D$, $\bar{D}^*D^*$ production obeys the predicted 1:4:7 ratios, the yield of neutral $D$'s is expected to be seven times greater than the yield of charged $D$'s. At higher ener-



# ...excerpts

**Observation in $e^+e^-$ Annihilation of a Narrow State at 1865 MeV/$c^2$ Decaying to $K\pi$ and $K\pi\pi\pi$ †**

G. Goldhaber,* F. M. Pierre,‡ G. S. Abrams, M. S. Alam, A. M. Boyarski, M. Breidenbach, W. C. Carithers, W. Chinowsky, S. C. Cooper, R. G. DeVoe, J. M. Dorfan, G. J. Feldman, C. E. Friedberg, D. Fryberger, G. Hanson, J. Jaros, A. D. Johnson, J. A. Kadyk, R. R. Larsen, D. Lüke,§ V. Lüth, H. L. Lynch, R. J. Madaras, C. C. Morehouse,‖ H. K. Nguyen,** J. M. Paterson, M. L. Perl, I. Peruzzi,†† M. Piccolo,†† T. P. Pun, P. Rapidis, B. Richter, B. Sadoulet, R. H. Schindler, R. F. Schwitters, J. Siegrist, W. Tanenbaum, G. H. Trilling, F. Vannucci,‡‡ J. S. Whitaker, and J. E. Wiss

*Lawrence Berkeley Laboratory and Department of Physics, University of California, Berkeley, California 94720, and Stanford Linear Accelerator Center, Stanford University, Stanford, California 94305*

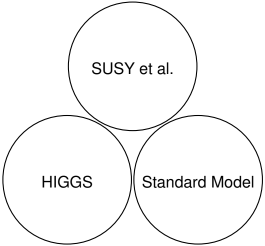
(Received 14 June 1975)

We present evidence, from a study of multihadronic final states produced in $e^+e^-$ annihilation at center-of-mass energies between 3.90 and 4.60 GeV, for the production of a new neutral state with mass $1865 \pm 15$ MeV/$c^2$ and decay width less than 40 MeV/$c^2$ that decays to $K^\pm\pi^\mp$ and $K^\pm\pi^\mp\pi^\pm\pi^\mp$. The recoil-mass spectrum for this state suggests that it is produced only in association with systems of comparable or larger mass.

*is charm found?* De Rujula, Georgi, Glashow, PRL 37,(76) 398

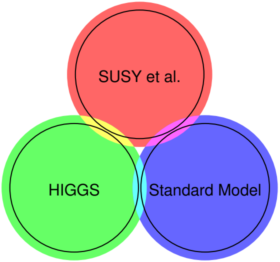
In summary, it may be fruitful to search for charmed states—both mesons and baryons—at $e^+e^-$ energies of 4–6 GeV. Peaks in invariant masses of several final hadrons are expected, accompanied by rich and energy-dependent structure in the recoil-mass spectra. Dozens of new hadrons await discovery.

We wish to thank Professor Gerson Goldhaber for discussing the data with us prior to publication.




**SUSY is marking the engineering of the discovery path of beyond the standard model signatures[which consist of more that SUSY and SUSY-like frameworks and duals]:**

- SUSY
- Heavy Stable Charged Particles
- $U(1)'$
- Technicolor
- Compositeness
- Flavor violation
- Little higgs
- Extra dimensions
- Black holes
- ...

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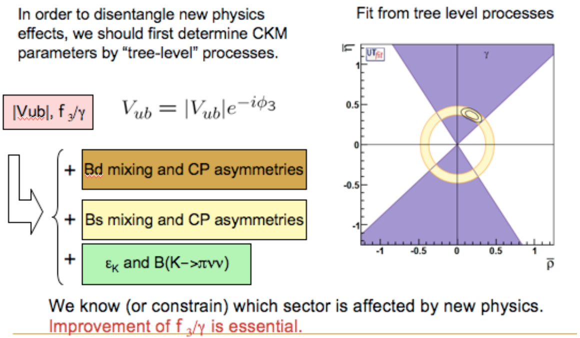
- ...

# Alternatives@LHC (parallel)

- Sensitivity of the LHC Experiments to Extra Dimensions Tracey Berry (RHUL)
- Discovery Potential of LHC for Extended Gauge Symmetries Gernoth Krobath (Munich, LMU)
- Electroweak Symmetry Breaking without Higgs Bosons at LHC Pierre-Antoine Delsart(Annecy, LAPP)
- Black Holes and ADD gravitons at LHC Sezen Sekmen (METU)
- Contact Interactions at the LHC Monica Acosta, (CERN)
- Trigger Strategy for Alternative Signatures at the LHC Tulika Bose (Brown)

# Flavor for SUSY and beyond @LHC

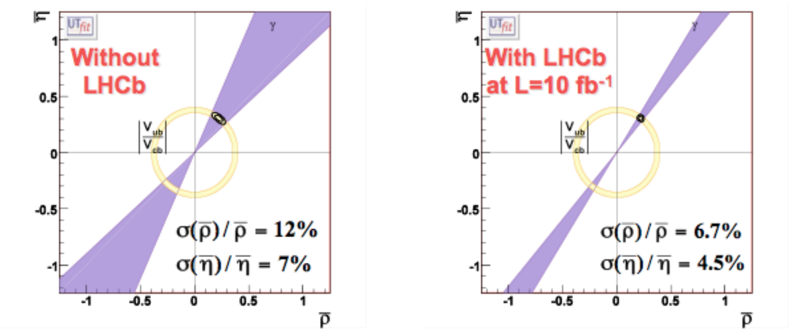
flavor has caused SUSY a lot of suffering...




More on the essential measurements for new physics searches at the B-factories and LHCb at the flavor session.

with the discovery of any new physics@LHC the role of flavor will be revised and upgraded into tool for navigation and characterization of the new physics

# LHCb and NP in the fit: 2014

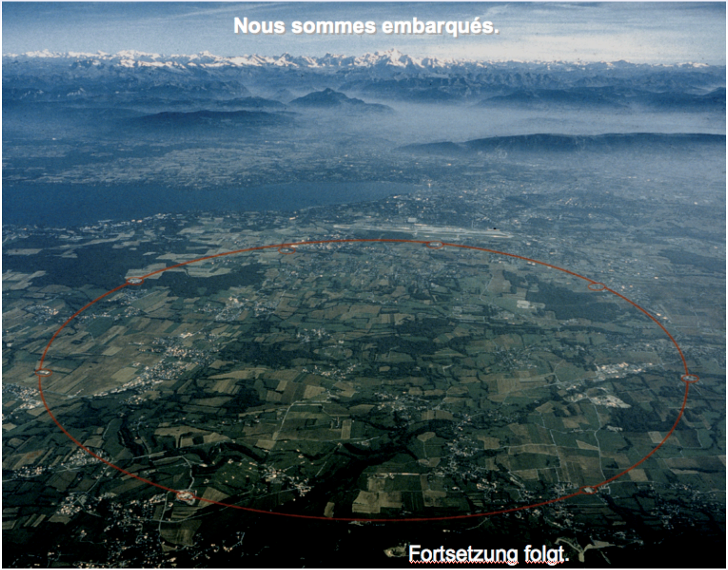



- **By allowing for arbitrary NP contributions in the mixing, the UT apex will be basically determined by the Tree-level constraints, and it will be the reference for any NP model building**
  - caveat: neglecting here NP effects in neutral D-meson mixing
- **LHCb will further constrain the apex, due to substantial improvement in the $\gamma$ measurement**

# Das Nullte Theorem der Wissenschaftgeschichte

*lautet dass eine Entdeckung (Regel,Gesetzmässigkeit, Einsicht), die nach einer Person bennant ist, nicht von dieser Person herrührt*

–E.P. Fischer, Fremde Federn, Im Gegenteil, July 24 2006, Die Zeit (from J. D. Jackson's "the first and the famous" collection) my message: Work and make the discoveries with care and respect to the data: the famous are often not the first and the first are often not famous but this is irrelevant in particular at a monumental time like the LHC one. Getting it right is important.



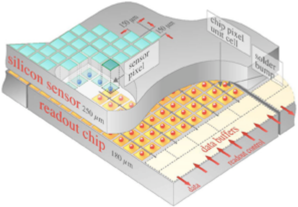

“faster, better, simpler, smarter” with the LHC data: The field needs the LHC input at the $\mathcal{O}(\text{pb}^{-1})$ time scale

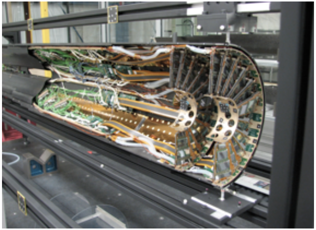
# Thanks

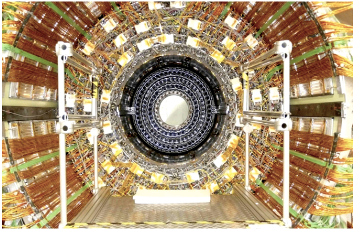
Shoji Asai and Davide Costanzo (SUSY@ATLAS conveners);
Luc Pape
Tatsuo Kawamoto and all the LHC parallel speakers who sent their slides. (if i have spelled your name wrong yell at me to correct)

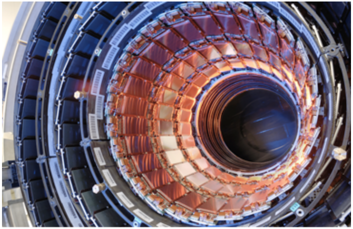
# backup

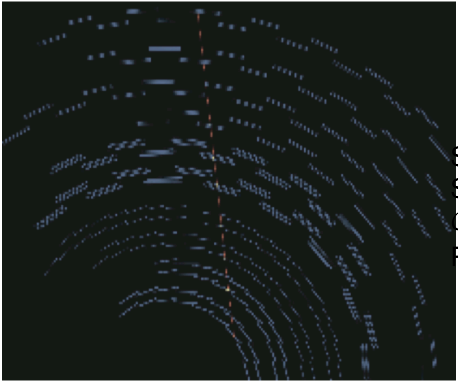
# Silicon (pixels (L), SST (R))



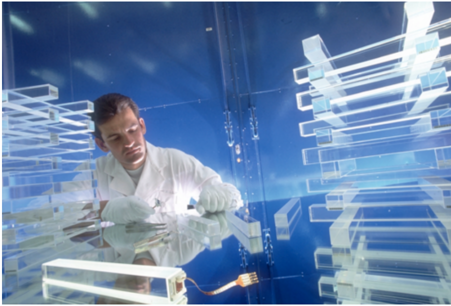






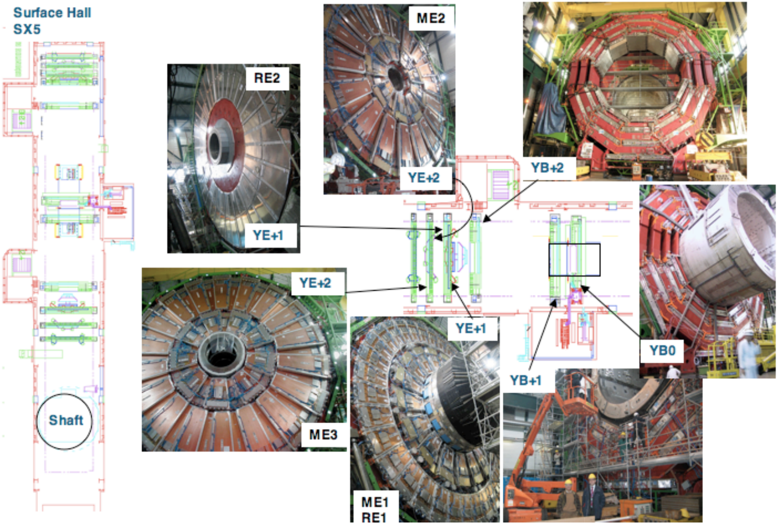
alignment goal: 30 $\mu$ 04.08
SST istallation: starting
SST cosmic commissioning:
$\mathcal{O}$(M) recorded cosmic events
Pixel installation: $<$summer 08

# CMS ECAL

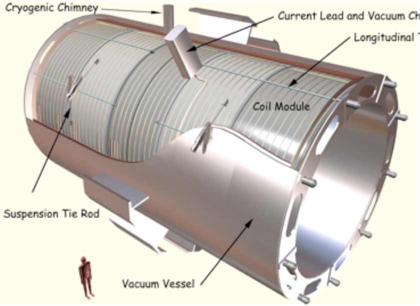


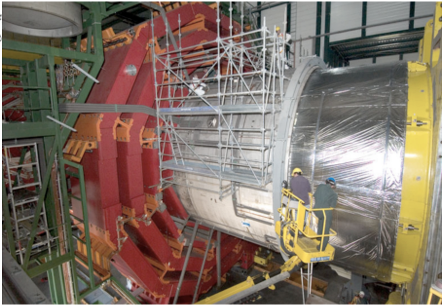
ALL 61.5k $PbWO_4$ barrel crystals have been delivered. Endcap crystal delivery from Russia and China is ongoing and foreseen to end in March 2008. First endcap Dee will be ready for insertion end of Feb. 2008. Construction of second endcap will be finished by early summer 2008.

# CMS surface assembly

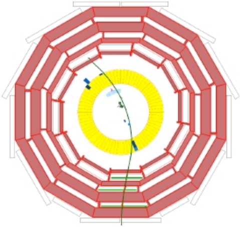


# CMS superconducting solenoid

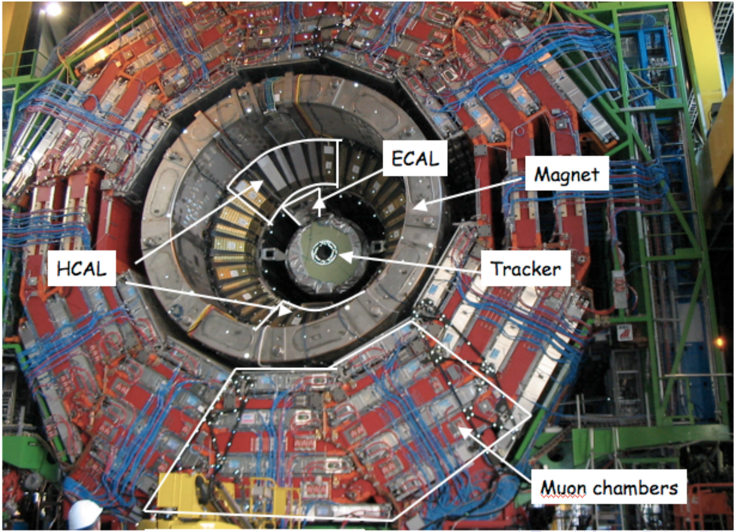


- Magnet length 12.5 m; Diameter 6 m; Magnetic field 4 T; Nominal current 20 kA; Stored energy 2.7 GJ.



# CMS surface configurations for the Magnet and Cosmic Slice Test



# CMS closing for the Magnet and Cosmic Test

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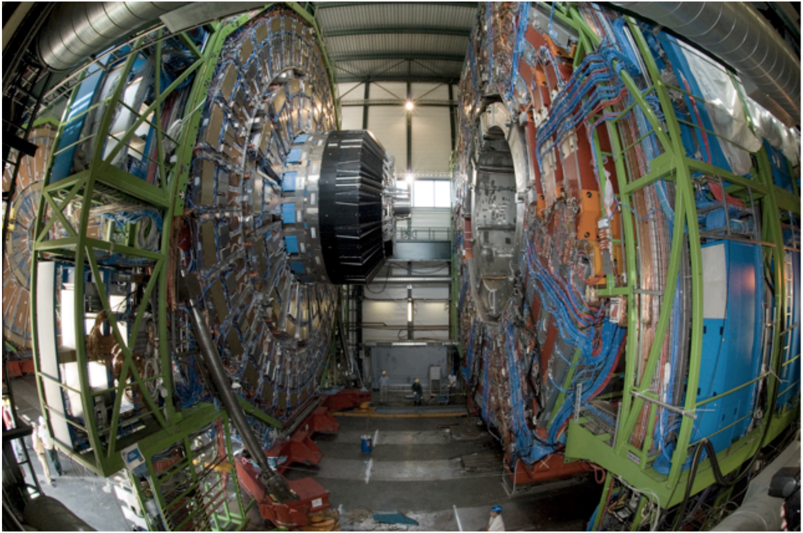
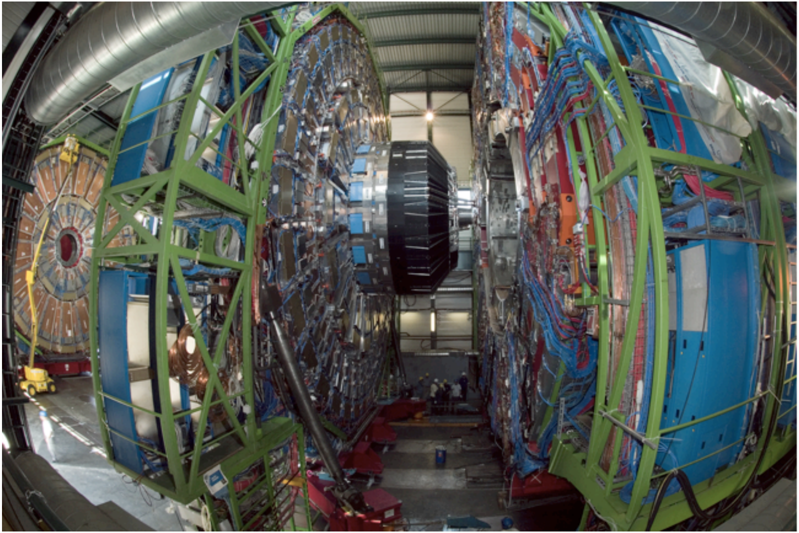
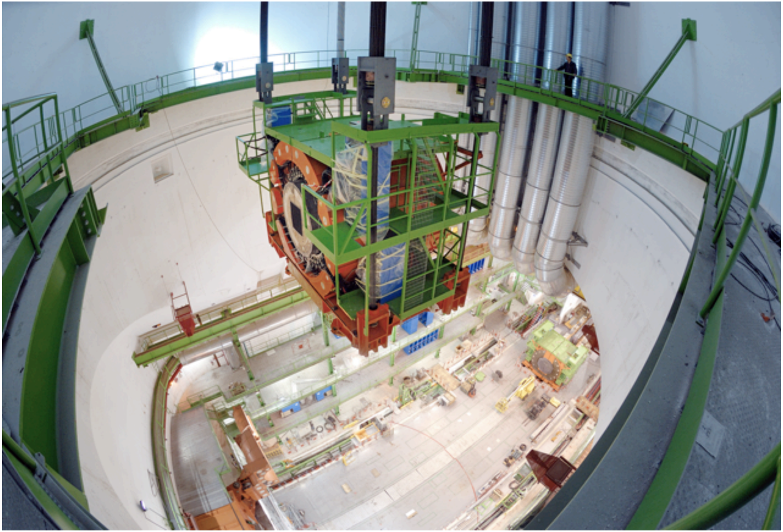


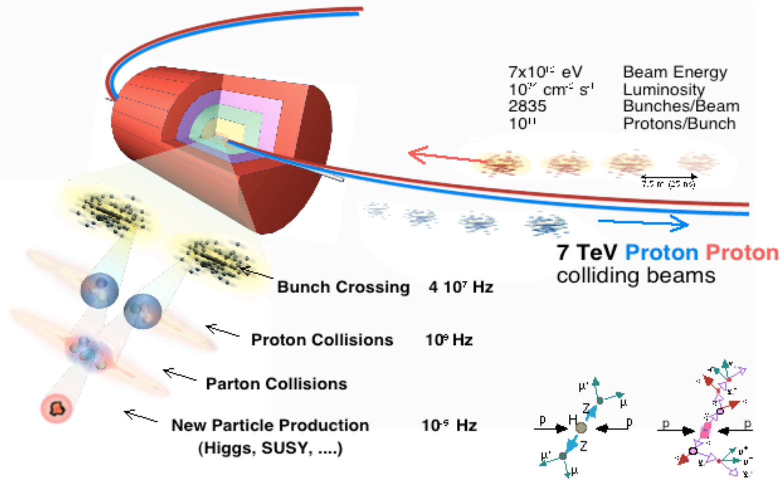
# CMS closing for the Magnet and Cosmic Test



# Lowering the Forward calorimeter

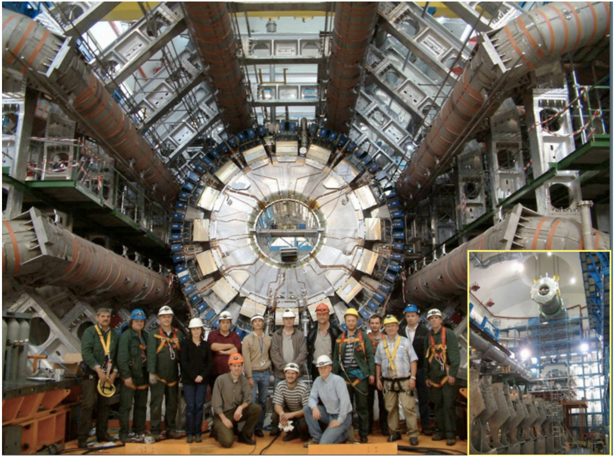


# Lowering the End Cap Disks



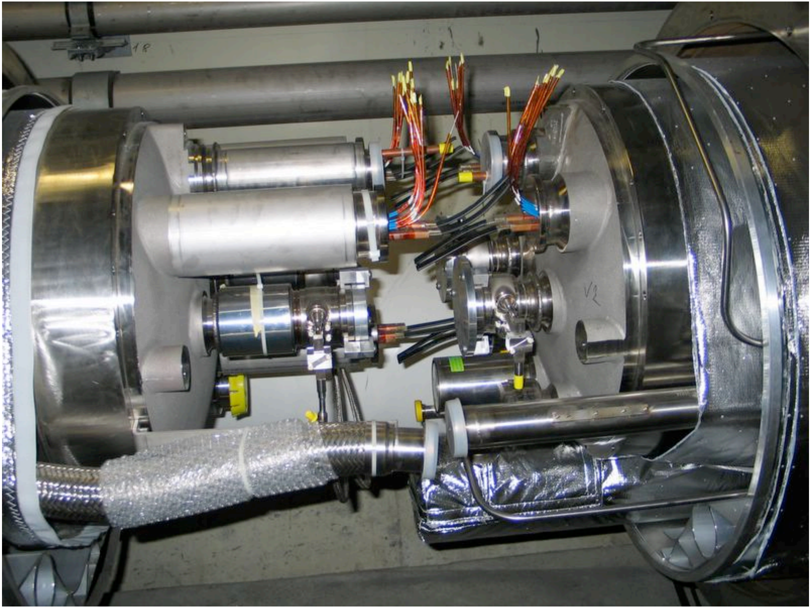

**Selection of 1 event in 10,000,000,000,000**

# ATLAS Barrel Calorimeter

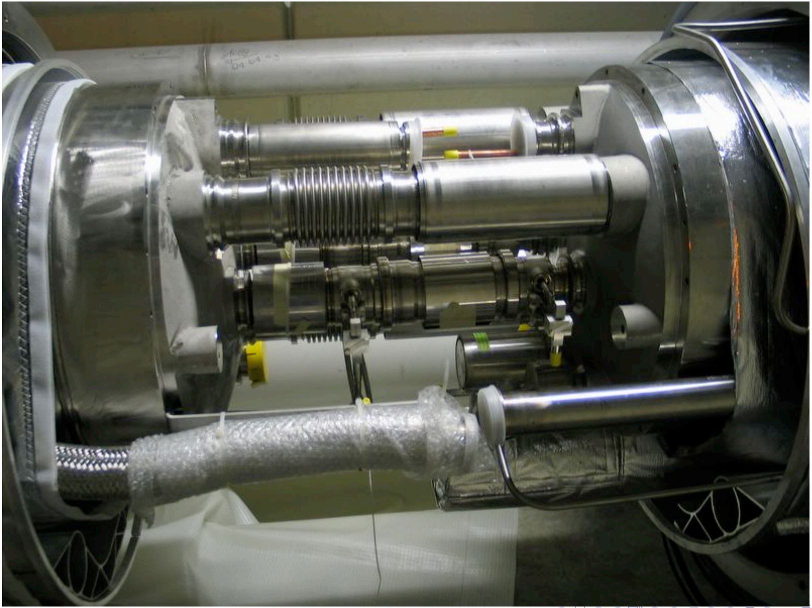


•Barrel calorimeter (EM liquid-argon + HAD Fe/scintillator Tilecal) in final position at z=0. Barrel cryostat cold and filled with Ar.

# unjoined dipoles



# Finished join



Survey marks on the tunnel floor, TCDI are the tranfer collimators

# CERN Accelerator Complex

MOVEME TO BACKUP