SUSY 06 \equiv SUSY#12

1st SUSY: 93

\[ \rightarrow ? \text{ discovery?} \]

transformed in conferences

Beyond the Standard Model

\[ \rightarrow \text{ difficulty in summary:} \]

- large number of topics
- large \( \times \) talks
- no transparencies from home
- no \( \text{"} \) speakers
- competition with World-Cup!
Briefly:

Exp. - no signs of new physics
- LHC on schedule

Th. - well prepared for "standard" physics
- Explosion of new ideas and models

⇒ Imagination or Reality?
OUTLINE

- Statistics
- Brief review of talks in groups
- Surv: motivations / history
  - advantages, problems
- Naturalness
- Getting ready for / expectations from LHC
Statistics

Talks: 30 plenary

918 parallel

2 discussion sessions

Participants: 318 $\Rightarrow >80\%$ talked!

Parallel sessions

- Collideus: 51

- Cosmology: 50

- Alternative: 38

- Models: 27

- Strings: 26

- Precision: 26

Total: 318
TOPICS (plenary sessions)

1) Experiments (colliders)
   Evans (LHC), Anastassou, Giuzay (Tevatron)
   Rosenzweig (future), Mienna (tools)
   + discussion session

2) Higgs + Susy
   Zeppenfeld (Higgs), Nojiri (susy), Barger (singlets)

3) Naturalness (landscape)
   Uafa, Dine, Giudice + discussion session

4) Strings + other
   Kochru, Trivedi, Raiden
   Nelson, Chacko
5) Non accelerator
Gonzalez-Garcia, Dedes (neutrinos)
Rospalov (EDM), Nakao (B-factories)

6) Dark Matter
Schnee (direct), Baltz (Colliders),
Moroi ($\tilde{\psi}_R$ LSP), Buchmuller (spin-$\frac{3}{2}$ LSP)
Kamionkowski

7) Cosmology
Steigman, Dlinto (UHE Cosmic $\gamma$), Bean
Grojean (EW phase transition)
Introduction of SUSY:

- Mathem. curiosity \rightarrow convinced: on the way

Advantages:

- Unification of gauge couplings
- Dark Matter candidate
- EW Radiative Breaking
- Naturalness
- Naturally from string theory

Inconveniences: "freedom" of soft terms

- Large nb of parameters
- FCNC
- $B$, $H \Rightarrow R$-parity?
- $\mu$-problem
Naturalness: became dominant motivation enhanced after EW precision data (LEP1)
ruled out conventional Technicolor
last 10 years: explosion of different theoretical ideas/approaches
  - absence of exp data
  - theoretical development in string theory
    - large extra dimensions / low scale Q Gravity
    - low string scale
    - warped dimensions ↔ AdS/CFT
      composite Higgs ideas back
- TeV^{-1} extra dimensions
- Higgs from higher dim gauge field
- Higgsless models

* LEP 2 "paradox": <1% fine-tuning
  \rightarrow "little" hierarchy problem

- Little Higgs models
- Singlet extensions revival
- Twin Higgses
- Combined models (ED+SUSY, LH+SUSY, ... )

* Dark energy, eternal inflation,
  landscape of string vacua
  \rightarrow Live with hierarchies?
Environmental selection? physics or "meta"-physics? "relevant" question or not?

"Sad" possibility for EW hierarchy but worth to explore => predictivity?

Concrete proposal: Split SUSY
scalars heavy, keep fermions light
= unification + DM candidate remain
FCNC, $\beta,\gamma$ + ... "solved"
clear signals of "fine-tuning":
- long-lived gluinos =, displaced vertices
- unification of 5 couplings at $m_{\text{susy}}$

$HWA, H^4$
1) LHC

- All key objectives been reached end 05
- Magnet installation should finish end 08.07
- Every effort is made for collisions by end 07

Evans
- LHC phenomenology begins with the SM
- Need complete description of main processes
- Discrepancies will arise in specific final states

Mrenna

EW data fit \( \Rightarrow m_H = 89^{+42}_{-30} \) GeV

+ direct search \( \Rightarrow 114.4 \leq m_H \leq 207 \) GeV
TEVATRON

Anastassov, Gruaž

Higgs discovery potential

SM : $m_h < 180$ GeV

MSSM Higgs for $m_A < 300$ GeV

New physics limits

SUSY (cMSSM):

$m_{\chi^0} > 140$  $M_{\tilde{g}} > 241$  $M_{\tilde{\phi}} > 325$ GeV

New gauge bosons:  $M_{w'} > 788$  $M_{Z'} > 850$ GeV

EDMs:  $M_{\chi} > 1.4$ TeV  $M_{R5} > 785$ GeV

- Exploring already energies above LEP
- Expect $\sim 5 fb^{-1}$ = frontier physics
2) LHC Higgs production

- dominant modes: gluon + weak-boson fusion
- multiple decay channels observable
  ⇒ great info on Higgs couplings (SM or MSSM)
- NLO QCD corrections needed for signal
  + important backgrounds: Zeppenfeld

susy production

- generic signature: new color particles decaying into a stable neutral "LSP"
- first discovery/not data ⇒ discriminate "susy-like" scenarios Nojiri
singlet extension of MSSM

solve \( \mu \)-problem

soften little hierarchy ...

light higgs can be "invisible" but still detectable

and higgs ~ 1st of MSSM

Barger
3/4) Landscape + Strings

- String landscape may be significantly reduced
  swampland = boundary of it by eff field theories mostly inconsistent

Masza

- String realizations of mechanisms of gauge mediation

Kachru

- Attractors: moduli are fixed in terms of change

on black-hole horizons

Susy and Non-Susy attractors Trivedi

- Efficient string techniques for tree and 1-loop

QCD computations improved by twistors

Roidan
9) Non accelerator

- EDM sensitivity: comparable to LHC reach
  - probe new phys in superpotential $\Rightarrow 10^9$ GeV
  - 1-loop su4 corrections $\Rightarrow$ EDM sensitivity

- Neutrinos
  - new data from terrestrial exps $\Rightarrow$
    start constructing leptonic mixing matrix

- MSSM extension with L violation $\Rightarrow$
  - calculable v-masses by radiative corrections
6/7) Dark Matter + cosmology

Problem: energy density of the universe mostly unknown

Baryons: 5%  Dark matter: 20%

Dark energy: 75%

DM solution requires detection in galaxy + study of its properties in lab

Complementary approaches: direct/indirect detection + accelerators

Baltz

Weakly interacting particles in 100 GeV - TeV range

Direct searches: no signs of WIMPS at \( \sigma \sim 10^{-7} \) pb

Expected sensitivity in 5 yrs: \( \sim 10^{-9} \) pb

Schnee
- SUSY standard scenario: neutralino LSP

- Other viable scenarios:
  
  - Right sneutrino $m_{\nu_R} \sim 100$ GeV
    Moroi
  
  - Gravitino ($1-100$ GeV)
    Buchmüller

  - Interesting collider signatures

- EW phase transition 1st order

  enhanced e.g. by $1H^2$ terms in the Higgs potential

  gravitational wave production

  in the milli Hertz frequency

  Grojean
Getting ready for LHC

Explosion of testable ideas and models

some with spectacular signatures

but only few simple cases used in standard analysis

need efficient interactions theorists - experimenters

hadronic machines: difficult for unexpected corrs

unless something clear and spectacular

→ Main questions to be answered
- Is nature natural or unnatural?
- Where is the Higgs?

Is SUSY realized in some form at "low energies"?

Is there any information on mechanism of SUSY + mediation? → New era

- Find Dark Matter WIMPS?

- Gauge unification will survive LHC data?

- Any signal of string theory at "low energies"?