News/Views from the Theory Group

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Users Executive Committee Meeting
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1) What initiatives of the theory group do you see being of most interest to the User community ?

Theory group members organize or co-organize many activities that bridge between theory and experiment:

- The Tev Connection Fest (yearly):

  to show the Latest Physics Results from CDF & D0 and related Theoretical Perspectives

- The TeV4LHC workshop 2004-2005:

  to bring together the Tevatron and LHC experimental groups and the theoretical community to make the best possible use of data and experience from the Tevatron in preparing for the LHC experimental program

- The Chicago Flavor seminar

It aims at the exchange of information and ideas among the lab's theorists and experimentalists working in B,K and D physics. It takes place irregularly, roughly bi-weekly.

- The New Phenomen Group

It meet weekly to discuss new ideas in BSM. Mostly theory oriented , sometime also with experimentalists participation

- Provide technical support to experimental program:
- MCFM - Monte Carlo for FeMtobarn processes
  John Campbell, Keith Ellis
- Useful code for lattice cluster computing
  http://lqcd.fnal.gov/useful.html
- CPsuperH: a Computational Tool for MSSM Higgs Phenomenology with Explict CP Violation
  Carena et al.
- ...
- Contribute to the education of postdocs and students and to the intelectual life of the lab.

Fermilab academic training lectures

Theory Lectures at UTeV

Seminars at CDF/DO/ Miniboone/Minos/

- Define new strategies to help interpret data
  (some very recent examples)

-- The new bbH/A (H/A→ bb) searches at DO and similar but H/A→ tau tau at CDF (to appear)

-- latest new gauge boson searches ta CDF (yesterday wine and cheese

-- Charged Higgs from top decays at CDF

-- Bs→ mu+mu- and the search for new physics

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2) What are the advantages to the lab of having a strong theory group?

Physics is interesting only if you have theory and experiment

All the experimental efforts at the lab are strongly supported by theoretical efforts with strong theory group component

The theory group has a broad scope covering basically all areas of HEP at a level of international recognition

This provides a healthy, necessary enviroment for developing new ideas, some of them triggering new directions in experimental activities at the lab

A reach program in theory and experiment is the base to provide an exciting enviroment for Users to come to Fermilab

This is particularly useful to Users at Universities with smaller HEP component, for which the diversity and strength of the lab activities adds the most. Also to physicists at nearby Universities, who nucleate big part of their research activities at the lab.

We should improve/expand this activity if possible: your input?

3) How do you see the theory group and their interaction with the Users evolving over the next few years where we move away from a Tevatron dominated community ?

-- **lattice B** phycisits (Mackenzie, Kronfeld) have developed a strong relationship with BaBar and Belle, that will evolve to include LHC-b and CMS too.
question to the UEC : after the demise of BTeV, will be anyone who is "Fermilab user/LHC-b participant"?

-- **LHC physics**: more that 50% of the theory group scientists work on physics related to LHC.

See the LHC theory initiative discussion below

-- ILC physics:
scientists and postdocs from the theory group working in collaboration with experimenters involved in the ILC R&D group at Fermilab:
example: working on issues of relevance for ILC in connection with Dark Matter and Baryogenesis

- Neutino Physic: Scientists and postdocs plus users from nearby Universities working on

Why do we need an LHC Initiative at the Theory Group

- At the start of the next decade, the LHC will be the only operating facility at the high energy frontier – and the US has already invested a quite significant portion of the HEP budget there.

- Fermilab will concentrate efforts and resources on LHC: We should move with the Lab. in this direction.

- We expect the LHC to bring new discoveries and hopefully some surprises:
$\Longrightarrow$ The Fermilab-based theory community should be in a position to play a major role in the proper understanding of LHC data
This task will be quite demanding and coordination will be very valuable.

- An LHC Theory Initiative will enhance the efforts of the US CMS Physics Center at Fermilab and will increase the synergy between theory and experiment, both ATLAS and CMS.

- The time is ripe to crystalize analysis strategies for the LHC!!
The TeV4LHC Workshop is the first step in this direction.

Main Characteristics of this effort

- **Fermilab** LHC Theory initiative with connections to both CMS and ATLAS

- Include broad spectrum of theorists: 3 groups

⋆ Collider Phenomenologists
$\Longrightarrow$feasability studies of the latest theoretical ideas in the context of the LHC collider experiments
$\Longrightarrow$ refine and extend existing studies of well established theoretical ideas
QCD and electroweak SM precision measurements
SUSY, Extra Dimensions, Strong Dynamics, Little Higgs
$\Longrightarrow$ further develop theoretical tools to match the experimental precision and maximally exploit the measurements

⋆ Experts in MC and other computational techniques
$\Longrightarrow$ implementation of best theoretical calculations in programs used in real data analysis
A synergy between some theorists and each collaboration will become necessary to bridge theory and experiment

⋆ Model Builders
$\Longrightarrow$ to bring in the latest theoretical ideas

Fermilab Theory Group

$\Longrightarrow$ perfect enviroment for this initiative

- Already has broad expertise in subjects relevant for LHC physics

- and Fermilab is the US CMS Physics Center

– The Fermilab Theory Group has its own role in Theoretical Developments and Lab. Activities $\Longrightarrow$ much broader scope: Lattice gauge theories, Perturbative QCD, Flavor Physics, Higgs Physics, Model Building, Supersymmetry, Strong Dynamics, Strings, D-Branes, Extra Dimensions, Neutrino Physics, RUN II Physics, LHC Physics and Linear Collider Physics.

– An LHC initiative will expand our efforts on LHC physics allowing us to keep/increase our weight (size!) in the LHC era

TeV4LHC Wokrshop: first step in a Collider oriented initiative

(1) Discuss Tevatron physics and implementation of new computational techniques. How will the information obtained from the Tevatron shape LHC Physics?

(2) Evaluate ongoing efforts to improve on theoretical calculations and techniques in all topics relevant for LHC

(3) Identify important areas in which further work is needed and define a strategy for theorists to contribute to it.

$\star$ A one year-long planned activity on specific topics relevant for Tevatron and LHC physics

Discuss which is the best format for our group to implement such an initiative.

- Just expand our activities in this direction without further planning?

- Create an LHC Theory Center based at Fermilab?
Fermilab by conception is a *users* oriented laboratory: perfect place to locate a HEP *users* Theory Center

- Other alternatives?

OUTLOOK ➔

At the start of the next decade, the high energy frontier will be overseas and the Fermilab, as the main US HEP Accelerator Lab, should increase efforts to continue playing a leading role in that domain.

The LHC initiative at the theory group aims to:

- help strengthen and further develop the theory program for the vast domain of hadron collider physics.

- have a positive impact on Fermilab/US LHC experimental efforts.

- add to the efforts of the US CMS analysis center in their goal to make Fermilab *the place to come to do prime LHC physics analyses*.

- Provides a possibility to get extra positions for Collider phenomenologists and Experts in computational techniques, to promote LHC physics at Fermilab and within the US $\longrightarrow$an LHC visitor program

- Need for additional space:
for Fermilab Theory Users (LHC visitor program) and to promote collaboration and interactions with experimentalists at Fermilab.

Visitors: Many possibilities

- At sabbatical level for senior researchers,
- 3-5 year positions for younger scientists.
- short term visitors.

4) What can we do to strengthen ties between the Users organisation and the theory group?

Mainly through the involvement of the theory group in the major activities of the lab. of which the Users community is/needs to keep being a major component:

Tevatron data analysis,

Neutrino Experiments: data analysis and planning,

LHC data analysis and upgrades,

Physics case for ILC to support R&D,

Astroparticle physics program

In all areas theory group has important ongoing activities

Outlook

Tevatron → LHC → ILC

Windows on to the mysteries of Dark Matter and Baryogenesis

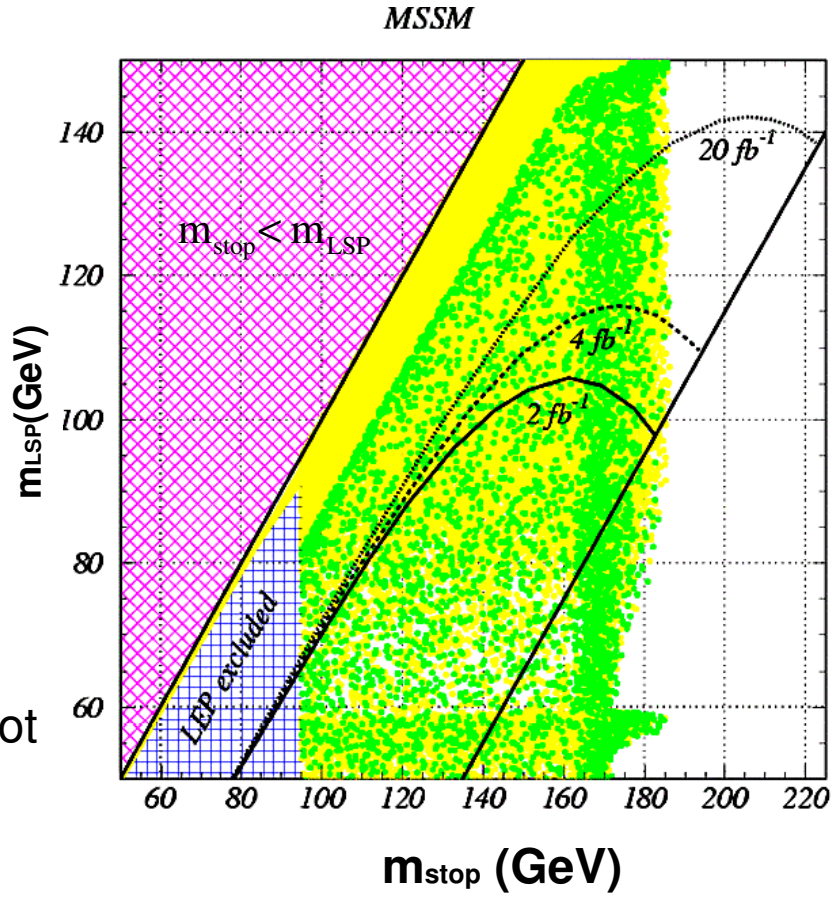
Supersymmetry with a light Higgs $m_h < 120$ GeV and a light scalar top (stop, $\tilde{t}$) $m_{stop} < m_{top}$ provides the necessary ingredients

Lightest Supersymmetric Particle (LSP) ➔ good dark matter candidate

Figure shows Tevatron reach:
Green dots show area consistent with WMAP Dark Matter density determination and with Electroweak Baryogenesis

Good News: light stop can be discovered at CDF and D0 via $\tilde{t} \longrightarrow jet + LSP$ decays.

Bad News: searches are challenging for hadron colliders when m_{stop} close to m_{LSP} due to soft jets signature. Region of parameters consistent with cosmological observations cannot be fully tested at hadron colliders.



Higgs will be discovered at the LHC (maybe at the Tevatron)

- Higgs searches:

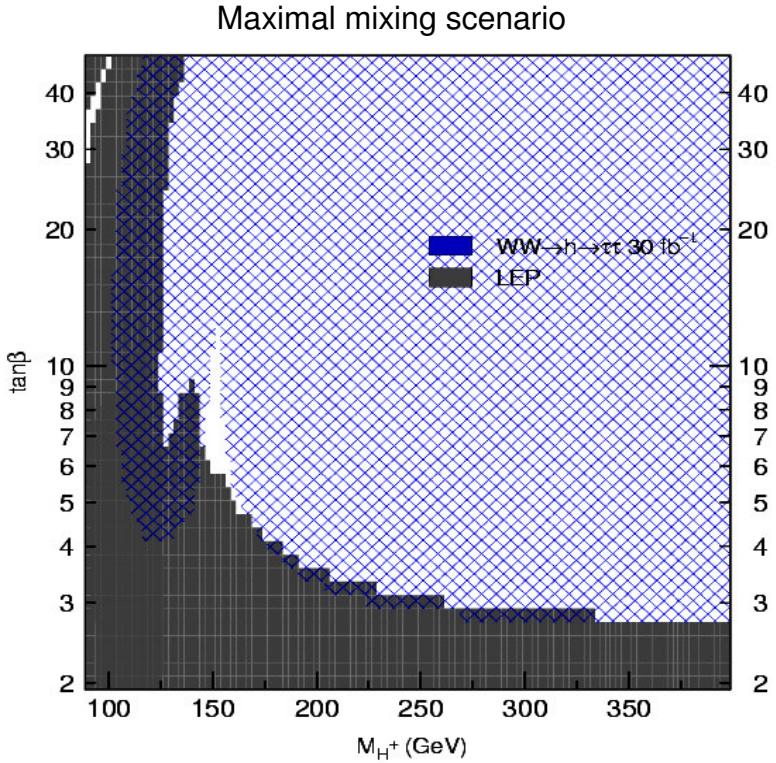
Higgs associated with electroweak symmetry breaking: Standard Model-like.
Higgs mass below 120 GeV required

1. Tevatron collider may test this possibility: 3 sigma evidence with about 4 fb^{-1}

Discovery quite challenging, detecting a signal will mean that the Higgs has relevant strong (SM-like) couplings to W and Z

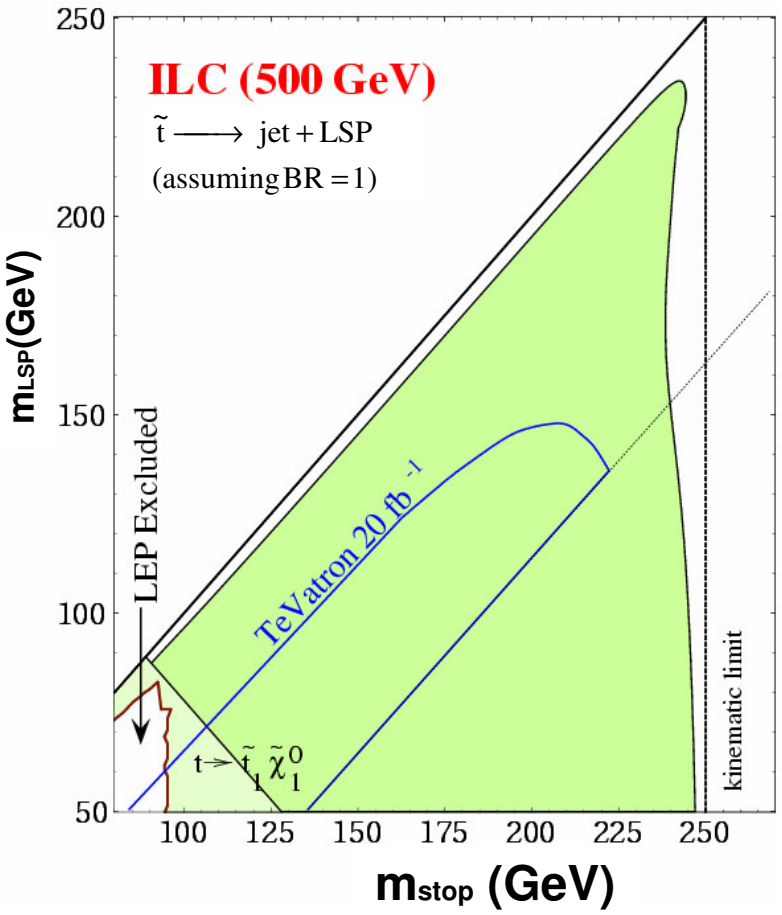
2. A definitive test of this scenario will come at the LHC with the first 30 fb^{-1} of data

$$qq \to qqV^*V^* \to qqh$$
$$\text{with } h \to \tau^+\tau^-$$



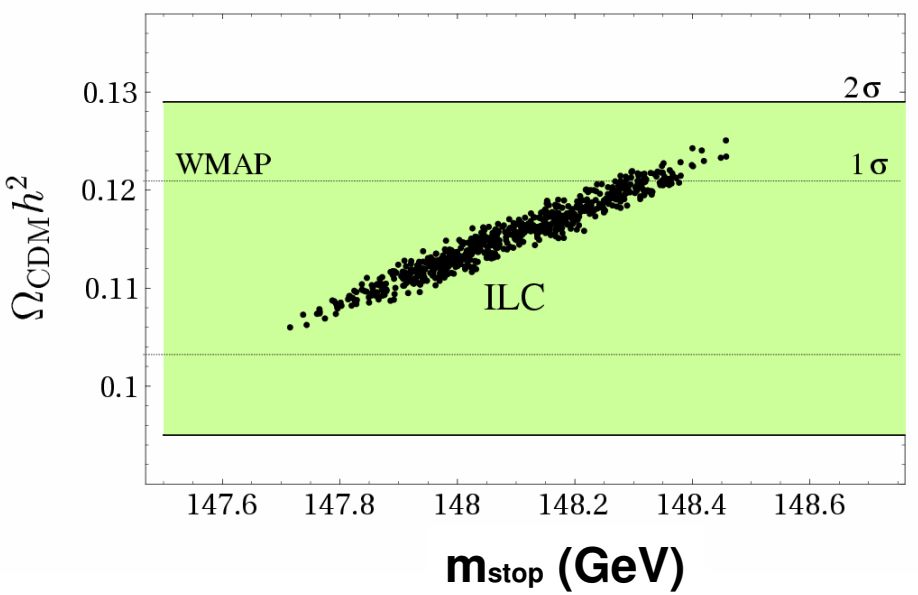
The power of the ILC

- Detect light stop in the whole regime compatible with DM and EWBG



- Measurement of SUSY parameters for Dark Matter density computation

-- stop mass and mixing angles
-- LSP mass and composition
-- Higgs properties
-- other relevant light SUSY particles



A particle physics understanding of cosmological questions!