LHC 1fb-1で物理

野尻美保子
LHC

- LHC starts from 1fb-1 and 7 TeV (level of 10nb-1 for each experiments at early June.

- Still some discovery modes

- discovery and model independent studies.

- 実験のハイライト

- pole の物理

- missing の物理
Expected physics reach with 1fb$^{-1}$

In 2010/11 we expect to record up to 1fb$^{-1}$ of integrated luminosity at 7 TeV

**Standard Model**
- $W \to l^+\nu$ (4M events)
- $Z \to ll$ (400k)
- $t\bar{t}bar \to l+\text{jets}$ (6k)
- $t\bar{t}bar$ dilepton (2.5k)

**Discovery Potential**
- Susy $5\sigma$ discovery above Tevatron limit with a few 100pb$^{-1}$
- $Z' \to \mu\mu$ : sensitive up to 1.5TeV
- Higgs: $3\sigma$ evidence in the mass range 145-180GeV

Detector Commissioning

Std Model measurements

Figure 6: The reconstructed $W$ charge asymmetry including estimated statistical and systematic uncertainties for 100pb$^{-1}$ of simulated luminosity at 10TeV from CMS (left) [42] and the forward backward asymmetry $A_{FB}$ versus the weak mixing angle $\sin^2\theta_{\text{eff}}$ at the $Z$ pole for 100fb$^{-1}$ of integrated luminosity at 14GeV from ATLAS (right) [11].
Start to feel the effect to be at high energy

Charged-particle multiplicities in pp interactions at $\sqrt{s} = 0.9$ and 7 TeV

MC shows significant excess in several GeV momentum range, also seen at 900 GeV. Large impact on modeling rate for low PT objects (EM clusters, muons, jets) in data.

Charged-particle momenta for events with $n_{ch} \geq 1$ within the kinematic range $p_T > 500$ MeV and $|\eta| < 2.5$ at $\sqrt{s} = 7$ TeV compared to MC predictions (left) and to the published results at $\sqrt{s} = 900$ GeV (right [PLB 688,1,21-42]).
Detector is working OK

CMS の E cal うまく動いている。
b-tag も問題なし。
O(100nb) になると top がみえてくる。
• E6→SO(10)×U(1)ψ  SO(10)→U(1)×SU(5)  U(1)が2つの模型

• Z_SSM is a toy model (scaled Z boson).

• model independent approach with signle U(1), next page.

Table 1: Charges of Standard Model fermions in canonical Z' models.

<table>
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<tr>
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<th>Y</th>
<th>T_{3R}</th>
<th>B - L</th>
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<th>\sqrt{\frac{22}{3}}Q_{\psi}</th>
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<td>+\frac{1}{3}</td>
<td>-3</td>
<td>-1</td>
<td>-\frac{1}{6}</td>
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mass は決まっている。
cross section は？

CMS preliminary
5 σ discovery

PAS EXO-09-006 scaled to 7 TeV

Integrated luminosity (pb^{-1})

Integrated luminosity (fb^{-1})

 CMS Preliminary
SBM-07-002, scaled to
\sqrt{s} = 7 TeV

Z' mass (TeV/c^2)

SSM Z'
Z'_{\psi}
RS grav. (0.1)
RS grav. (0.05)
single U(1) model

charge assignment

<table>
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<tr>
<th></th>
<th>$(u, d)$</th>
<th>$u^c$</th>
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Table 1: The charges of left-handed fermions controlling the electroweak neutral currents.

interaction

$$J^\mu_{Z'0} = \sum_f [g_Y Y(f) + g_{BL} (B - L)(f)] \bar{f} \gamma^\mu f$$

$$= \sum_f g_Z Q_{Z'}(f) \bar{f} \gamma^\mu f.$$ 

• yellow region (GUT prefered)

Figure 1: GUT-favored region and some representative models in the $(\tilde{g}_Y, \tilde{g}_{BL})$ plane, see the text for details.
Physics at 7 TeV 1 fb-1 (prospect not so great)

Figure 7: The LHC $5\sigma$ discovery potential in the $(\tilde{g}_Y, \tilde{g}_{BL})$ plane for $\sqrt{s} = 7$ TeV. The red and blue regions are those allowed by EWPT and Tevatron bounds respectively; the yellow region is the one not within $5\sigma$ discovery reach at the LHC. Thus the region accessible by the LHC is the one formed by points that are both in the red and blue regions but not in the yellow one. Plots in the first row refer to 50 pb$^{-1}$ of data and $M_{Z'} = 200, 500, 700$ GeV respectively; plots in the second row are for 100 pb$^{-1}$ of data and $M_{Z'} = 600$. 

Figure 8: The LHC $5\sigma$ discovery potential in the $(\tilde{g}_Y, \tilde{g}_{BL})$ plane for $\sqrt{s} = 7$ TeV. The red and blue regions are those allowed by EWPT and Tevatron bounds respectively; the yellow region is the one not within $5\sigma$ discovery reach at the LHC. Thus the region accessible by the LHC is the one formed by points that are both in the red and blue regions but not in the yellow one. Plots in the first row refer to 50 pb$^{-1}$ of data and $M_{Z'} = 200, 500, 700$ GeV respectively; plots in the second row are for 100 pb$^{-1}$ of data and $M_{Z'} = 600$. 

Things start improving as the LHC steps up in energy and luminosity. The situation with $\sqrt{s} = 10$ TeV and 200 pb$^{-1}$ of integrated luminosity is represented in Fig. 8. The region of $Z'$ masses below 400 GeV will not be accessible yet, this – 19 – Physics at 7 TeV 1 fb-1 (prospect not so great ) ԫ৭ LHC Ͱ ݟ ͑ͳ͍ͱ͜Ζ ২ ṫɹ EWPT Ͱ OK
LHC starts from 7TeV and 1fb-1

Figure 13: Estimated 95% C.L. exclusion limits for the all-hadronic SUSY search, expressed in mSUGRA parameter space.
cross section for discovery

\[ 100\text{pb}^{-1} \sim \sigma_{\text{SUSY}}>9\text{pb} \quad 1\text{fb}^{-1} \sim \sigma_{\text{SUSY}}>1\text{pb} \]
Comparing with 14 TeV

cross section は10倍になる。
luminosity も1 0倍を予定
• ISR could be a problem of the event reconstruction (especially for three body decay)

• remove one of the jet and calculate kinematical variable greatly improve

\[ pp \to \tilde{g}\tilde{g} \]
\[ \tilde{g} \to \tilde{q}^* q \to q\bar{q}\tilde{\chi}_1^0 \]

675.4 +/- 6.4 (imin. = 3 )
672.7 +/- 3.5 (for all)
at 7TeV and 1 fb$^{-1}$

- Point 3
  - $m_{\text{ul}} = 520 \text{GeV}$, $m_{\text{gl}} = 610 \text{GeV}$
  - $M_{T2\text{min}}$ (for $i \geq 3$)
  - $n_{100} \geq 1$, $n_{50} \geq 4$

- Mass difference is rather difficult to see here

- $m_{\text{ul}} = 735 \text{GeV}$, $m_{\text{gl}} = 636 \text{GeV}$
- $M_{T2\text{min}}$ (for $i \geq 3$)

- True squark/gluino mass

主な変更点* n200>2 のイベントの比率が多いときは、
3rd jet から minimization をする。
• gluino-> squark 2 high pt jet soft things from the other cascade.

• squark-> gluino (with some squark-> EW ino leading very high pt jet)

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**Diagram:**

- **Gluino**
  - Squark
  - Leading jet
  - LPS

- **Gluino**
  - Squark
  - Three body decay
  - Small but nonzero BR(sq→χ)
  - LPS
ISR effect is small for heavy squark mass because \( p_T \) of the decay products are large.

\[
mgl=558\text{GeV} \quad \text{mul}=825\text{ GeV}
\]

using global shape probably more useful.
$M_{T2}(\text{min})$ for mixed case
(14TeV, 60000 events)

$M_{T2}$ is more affected by ISR
gluino mass $\sim M_{T2}(\text{min})$ end point.
Total SUSY cross section $\leftrightarrow$ squark mass scale.
Lepton mode

- model with $m_1, m_2 \ll m_3$ ex. first two generation as NG boson. (arXiv1004.4164[hep-ph], Mandal, Nojiri, Sudano, Yanagida)
- the large third generation scalar mass $\Rightarrow$ less constraint from B decay, higgs mass,...
- DM constraint $\Rightarrow$ Higgs mass at GUT scale.
- Three DM consistent solution

- Experimental reach based on leptons are not impressive compared with jets.

- We may focus on the models with large lepton branching ratio (looking for a key under the... )
Heavy third generation

- Experimental reach based on leptons are not impressive compared with jets.

- We may have to focus on the models with large lepton branching ratio (looking for a key under the... )
Little Higgs model, UED, more toy models.

SU(2)$^2 \times U(1)^2 \rightarrow SU(2) \times U(1)$

with T partity.

fermion partners, and heavy EW gauge boson partners

- The cross section is about factor 1/4 small for same squark gluino mass.

- factor 1/10 at 7 TeV

- $\sim 600$ GeV may be accessible, but not acceptable with EW precision measurements. no gluion partner
Figure 4. Strong production of $n = 1$ KK particles at the LHC for $\sqrt{s} = 7$ TeV: (a) KK-quark pair production; (b) KK-quark/KK-gluon associated production and KK-gluon pair production. The cross sections have been summed over all quark flavors and also include charge-conjugated contributions such as $Q_1 \bar{q}_1$, $\bar{Q}_1 q_1$, $g_1 \bar{Q}_1$, etc. We use CTEQ6L parton distributions [91] and choose the scale of the strong coupling constant $\alpha_s$ to be equal to the parton level center of mass energy.
## Implemented models

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- Still many model missing/private... how to make them public..?
Exisotic
Heavy Stable Charged Particles

- Exploit distinct signature
  - low velocity, high momentum
  - use muon timing and tracker dE/dx to identify candidates
  - 10 TeV result scaled to 7 TeV
  - Probing 0.5 TeV with 100 pb$^{-1}$

- Side-note
  - dE/dx commissioned!
    - Kaons, protons and deuterons
      - the latter is not present in MC...

95% C.L. exclusion limit for HSCP searches at 7 TeV
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