Flavour in RS Models

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16 April 2009

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Beyond Part III
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Beyond Part III
Theory vs. Experiment
in our generation

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The next 25 minutes of your life

- Phenomenology
- Two examples from 2009
- Early lessons for our generation
Until very recently, “string cosmology” was the marriage of a field with no predictions with a field with no data.

- Shamit Kachru (2006)
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**The name of the Game:**
Beyond the Standard Model Phenomenology
“Phenomenology”

from XKCD.com
“Phenomenology”

from XKCD.com
“Phenomenology”

Experimentalists

Formal Theory

Experimental “interpretation”
Collider QCD; MC, simulations
Testing validity of the SM
Model-building beyond the SM
Connections to formal theory

from XKCD.com
Theory-Experiment Interface
Theory-Experiment Interface

Theory-Experiment Interface
Theory-Experiment Interface
Theory-Experiment Interface
Theory-Experiment Process

As seen by a Part III student...

“Data” \[ \rightarrow \mathcal{L} \rightarrow \text{Nobel} \]

Transverse Mass
Theory-Experiment Process

"Data" → Monte Carlo → Indirect, Precision, Exclusion, Correlation

Effective Lagrangian → BSM Model(s)

\[ L_{\text{eff}} \]
Theory-Experiment Process

"Data" → Monte Carlo → Indirect, Precision, Exclusion, Correlation → Effective Lagrangian

Non-collider data → WTF? → Build models anyway! → BSM Model(s)
Theory-Experiment Process

“Data” \[\rightarrow\] Monte Carlo \[\rightarrow\] Indirect, Precision, Exclusion, Correlation \[\rightarrow\] Effective Lagrangian

Non-collider data \[\rightarrow\] WTF? \[\rightarrow\] Build models anyway! \[\rightarrow\] BSM Model(s)

Interdisciplinary collaboration
Theory-Experiment Process

"Data" ➔ Monte Carlo ➔ blogs, leaks, rumour-mongering

Indirect, Precision, Exclusion, Correlation ➔ Effective Lagrangian

WTF? ➔ Build models anyway!

Non-collider data ➔ Interdisciplinary collaboration

BSM Model(s)

Monte Carlo

L

Effective Lagrangian

Interdisciplinary collaboration
‘HEP’ Experiments

- **Collider**: CDF/D0, ATLAS/CMS, ILC
‘HEP’ Experiments

- **Collider**: CDF/D0, ATLAS/CMS, ILC
- **Precision**: Belle, LHCb, SuperB, ...
- **Heavens**: WMAP, Fermi, ...
- **‘Hell’**: CDMS, XENON, ...

(Classification by Hitoshi Murayama)
Ex. CDF Multi $\mu$

I imagine hordes of theoretical physicists canceling flights, conferences, and courses today, making room for some serious thinking in their agendas.

(Tommaso Dorigo, A Quantum Diaries Survivor, 31 Oct 08)

- $R_{2b} = \frac{(\sigma_{b\bar{b}})_{\text{exp}}}{(\sigma_{b\bar{b}})_{\text{NLO}}} \text{ should be } \approx 1$
  - $R = 3.0 \pm 0.6$ using semileptonic decays
  - $R = 1.15 \pm 0.21$ using 2nd'ry vertex ID

- Defines a set of excess “ghost muons”
- Ghost muons have abnormally large multiplicity
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- Ghost muons have abnormally large multiplicity
Is it background?
Not a typical question from a model-builder!

- Mismeasured tracks?
  \( \mu D \) decay length consistent
- “Decay-in-flight” of K, \( \Pi \)
  Hard to account for ghosts far from beamline
- “Punch-through” of mesons into \( \mu \) chamber
  At most about 8% of ghost events
- Secondary interaction with detector?
  No spike in reconstructed vertex distance

Not likely to be normal background
Muon multiplicity

- Excess number of muons ("lepton jets")
- QCD BG: $b \rightarrow W^- c \rightarrow W^- W^+ s (W^\pm \rightarrow \mu^\pm \nu)$
- Don’t expect more than one extra muon
  - 1 additional $\mu$: see 23192, expect 7300
  - 2 additional $\mu$: see 3422, expect $\sim 0$
  - 3 additional $\mu$: see 756, expect $\sim 0$
  - 4 additional $\mu$: see 126, expect $\sim 0$
- Hard to explain with BG
Dialogue

• Lots of discussion between theorists and experimentalists on the blogosphere.
Current Status

A Quantum Diaries Survivor
private thoughts of a physicist and chessplayer

DZERO refutes CDF's multimuon signal... Or does it?  - A Quantum Diaries Survivor

March 17, 2009

Hot off the press: Mark Williams, a DZERO member speaking at Moriond QCD 2009—a yearly international conference in particle physics, where HEP experimentalists regularly present their hottest results—has shown today the preliminary results of their analysis of dimuon events, based on 900 inverse picobarns of proton-antiproton collision data. And the conclusion is:

DZERO searched for an excess of muons with large impact parameter by applying a data selection very similar, and when possible totally equivalent, to the one used by CDF in its recent study. Of course, the two detectors have entirely different hardware, software algorithms, and triggers, so there are certain limits to how closely one analysis can be replicated by the other experiment. However, the main machinery is quite similar: they count how many events have two muons produced within the first layer of silicon detector, and extrapolate to determine how many they expect to see which fail to yield a hit in that first layer, comparing to the actual number. They find no excess of large impact parameter muons.
Ex. PAMELA/ATIC

- **PAMELA**: excess in $e^+$ flux above 10 GeV
- **ATIC**: excess in $e^\pm$ above 100 GeV
Is it Dark Matter?

- Signal of dark matter annihilation?
- A few novel model-building developments:
  - Sommerfeld Enhancement
  - Kinetic mixing with hidden-sector
  - Excited/Inelastic Dark Matter
- Other signals: EGRET, CMB haze, INTEGRAL
- **Lots** of papers: plug in your favorite model.
  5 experiments $\Rightarrow 2^5$ possible papers  
  (Matt Dolan)
Astrophysics?

- Backgrounds are **astrophysical**, model-builders are **particle physicists**
- Pulsars are tricky!
- Proper studies of ‘uninteresting’ astrophysical sources only came later
- Need new set of tools, collaborators
- Remember ultra-high energy cosmic rays?
How to steal data

[47] Talk by M. Boezo at the idm08 conference [...] the preliminary data points for $e^+$, $P^-$ fluxes plotted in our figures have been extracted from a photo of the slides taken during the talk and may differ from the data that the PAMELA collaboration will officially publish

arXiv:0810.0713 [v1]
More soon

- **Fermi** to announce results 1 May 09
- Rumour-mongering: ATIC “killed”
- Model-building efforts shift to DAMA (??)
- Non-WIMP Dark Matter alive again
What’s the point?

Interest in these experiments have waned. What is the value of telling their stories?

- **Fairy tale.**
  Signal turns into a pumpkin at midnight.

- **Morality play.**
  Not literally true, but teaches us lessons.
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Brave New World

• Unconventional sources of data, new interfaces with experiment
• **Interdisciplinary**: astro/cosmo-particle, string-phenomenology
• Phenomenology is in demand
• **Web 2.0**: blogs, wikis, meta-information, VoIP
Experiments

• Unconventional sources of data, new interfaces with experiment

• Interdisciplinary: astro/cosmo-particle, string-phenomenology

Phenomenology is in demand

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April 9 at 4:12pm · via Twitter · Comment · Unlike
Be prepared

- Collider physics, astroparticle physics
- LHC Olympics, black box data challenges
- Learn to talk to experimentalists (hep, astro)
- Keep an eye out!
- In case everything goes to hell...
  ... learn string-cosmology
Lessons

• The next 20 years will be data-driven (Planck, Super-B, ILC)
• Your PhD will not be like your adviser’s.
• Things will happen quickly, be prepared
• Broader range of skills required
• Technology is on our side
• Collaboration is even more important
2008 Part III Return Conference