

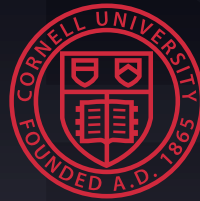


# Flavour in RS Models

*Flip Tanedo*

16 April 2009

Cornell



University



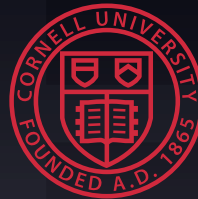
Beyond Part III

# Flavour in RS Models

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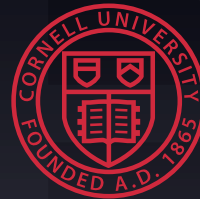
Beyond Part III

# Theory vs. Experiment in our generation

*Flip Tanedo*

16 April 2009

Cornell



University



Beyond Part III

# 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)

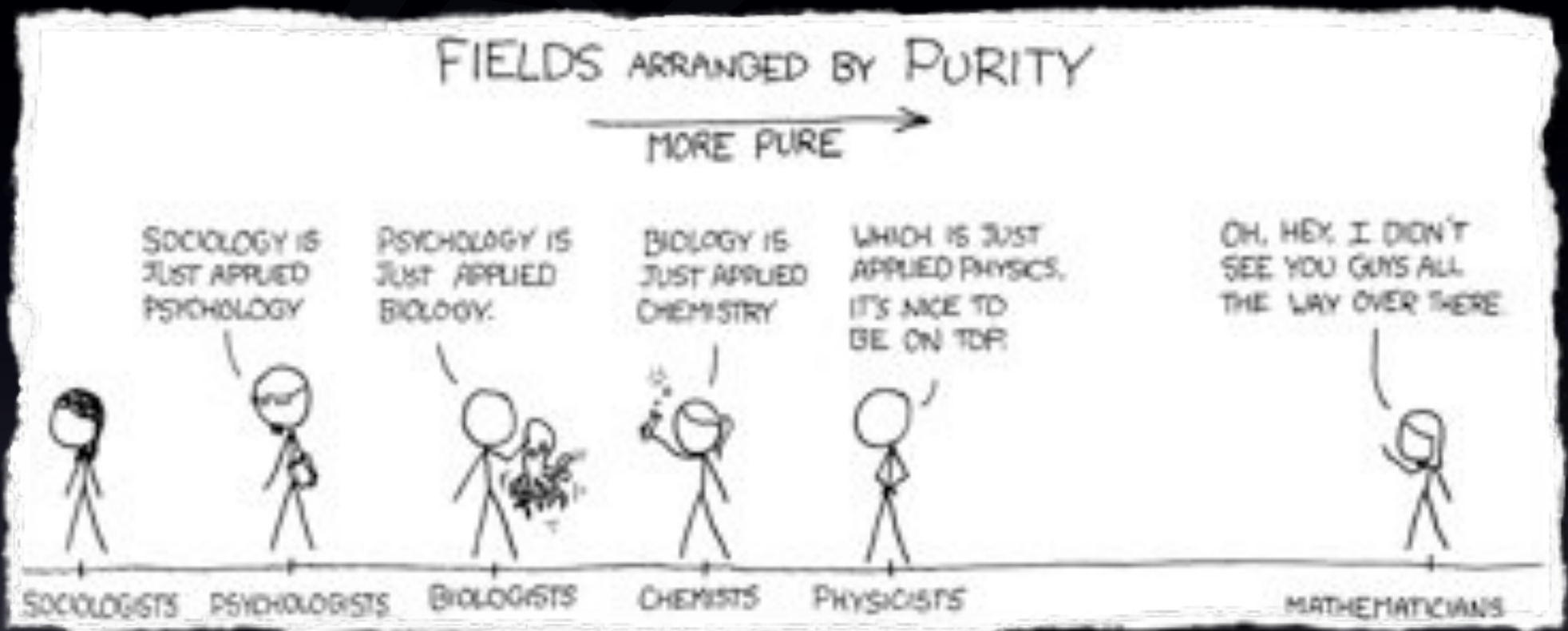
Until very recently, “**string cosmology**”  
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- Shamit Kachru (2006)

**The name of the Game:**

**Beyond the Standard Model Phenomenology**

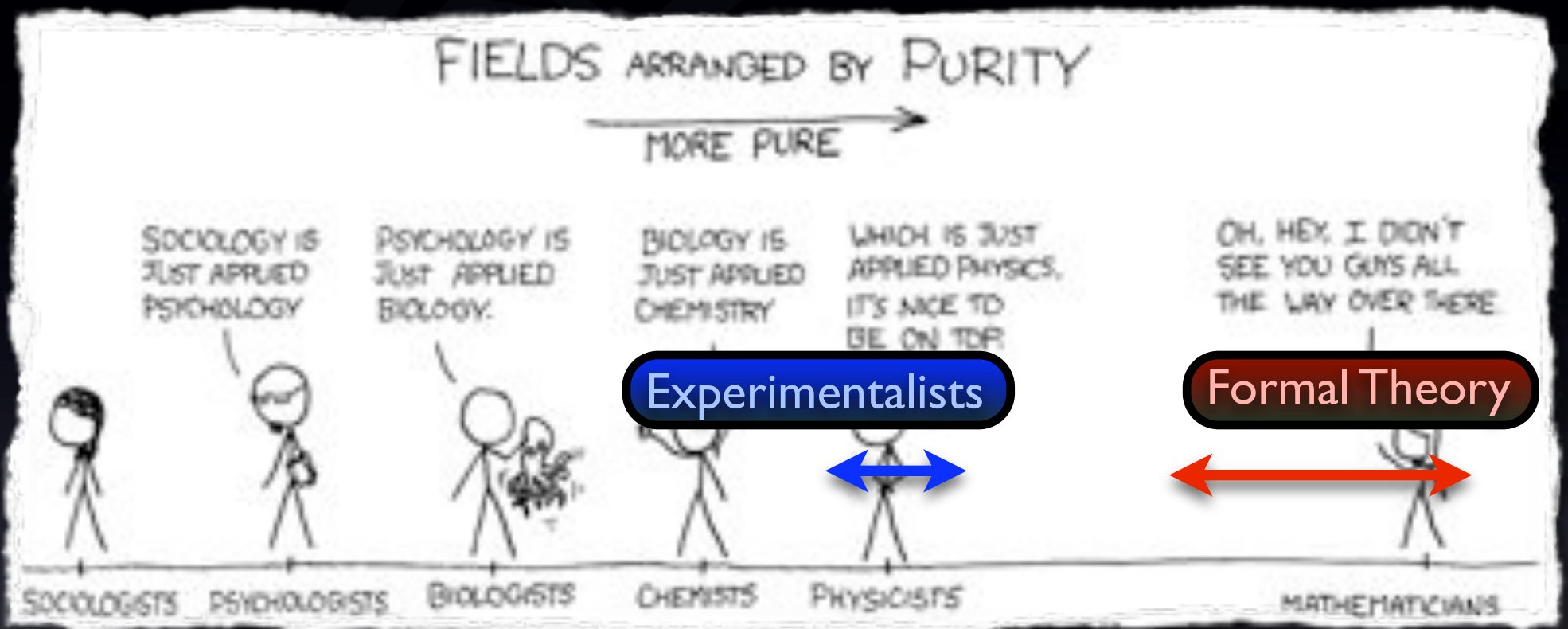
# “Phenomenology”



from XKCD.com

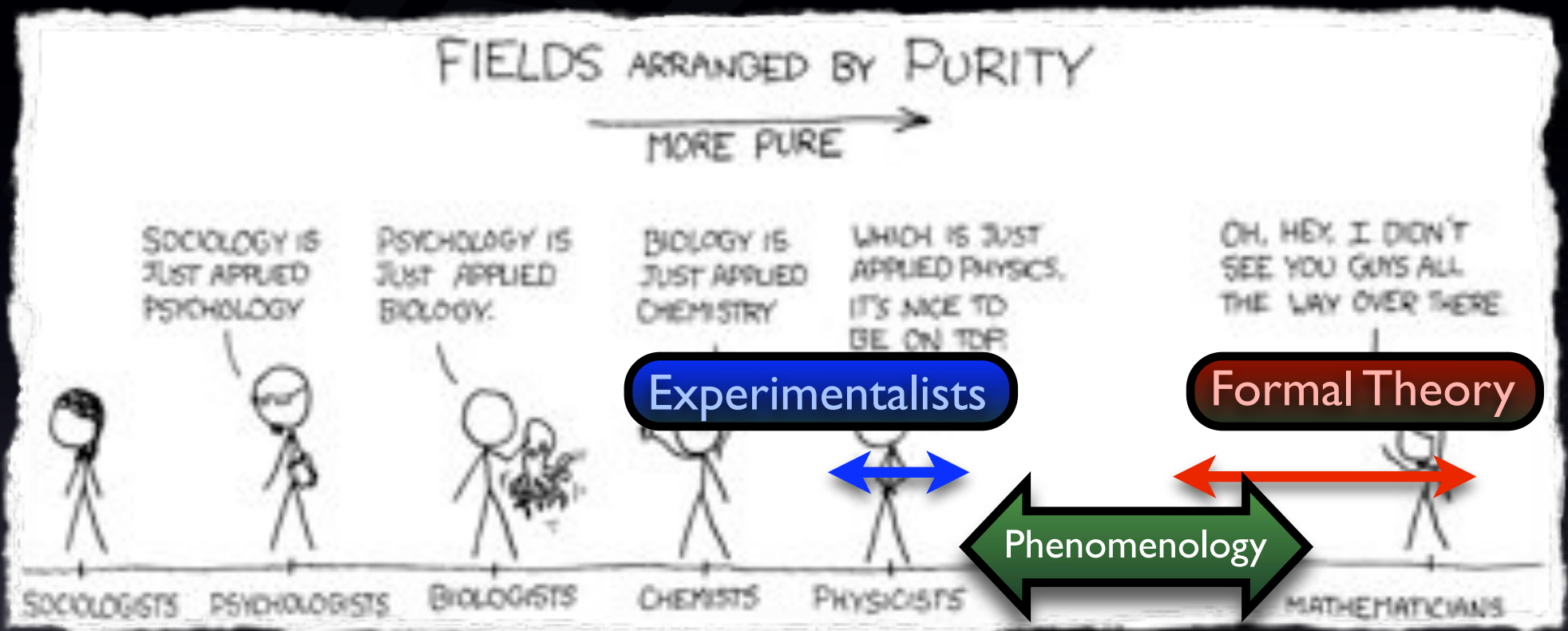


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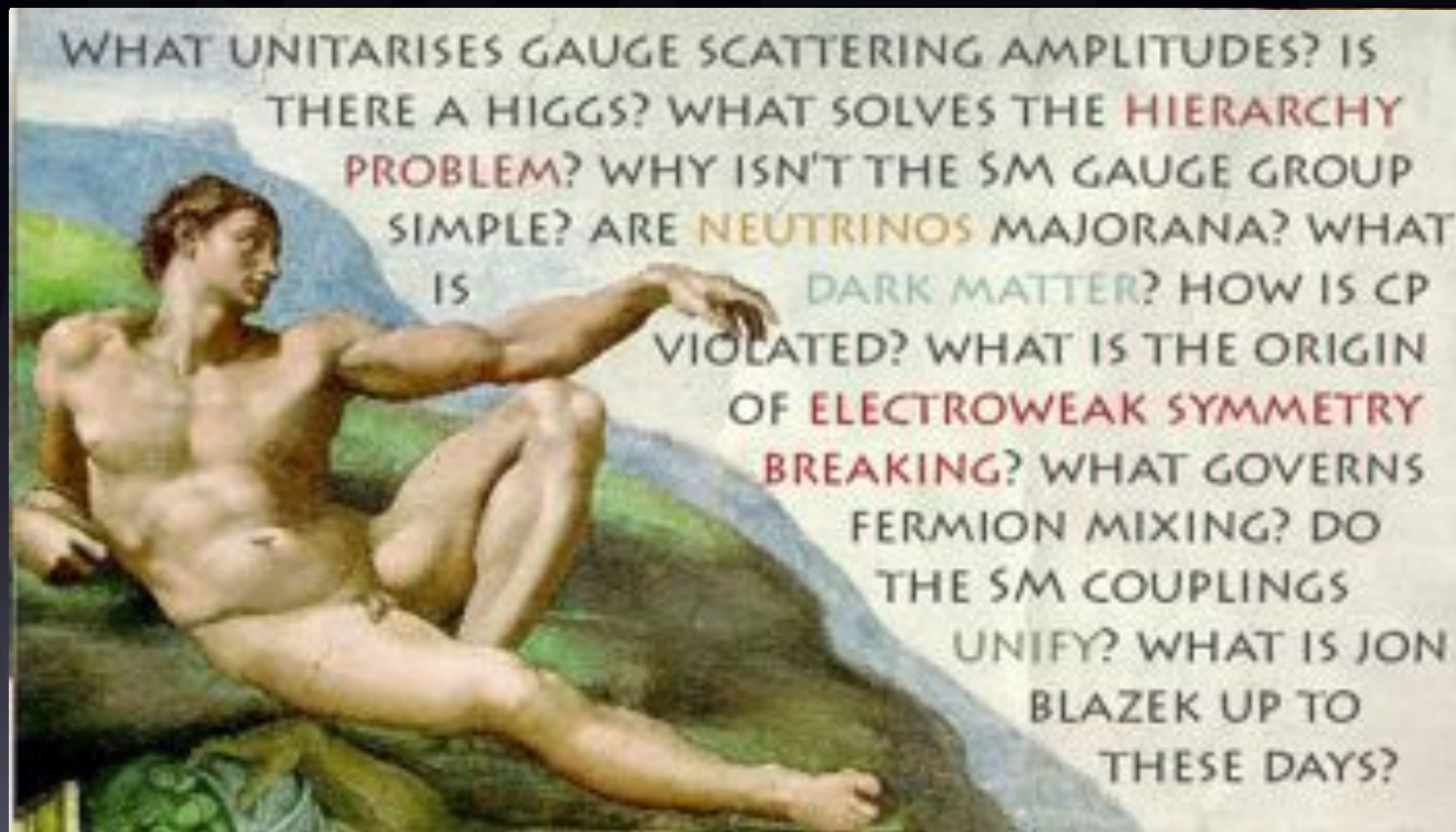
from XKCD.com

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

# Theory-Experiment Interface



# Theory-Experiment Interface



# Theory-Experiment Interface



# Theory-Experiment Interface

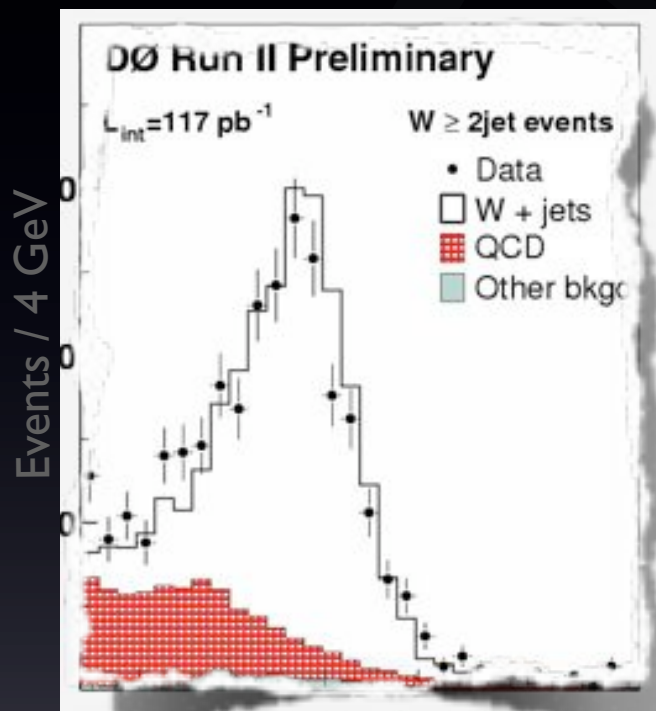


# Theory-Experiment Interface



# Theory-Experiment Process

As seen by a Part III student...



Transverse Mass

**“Data”**



$\mathcal{L}$

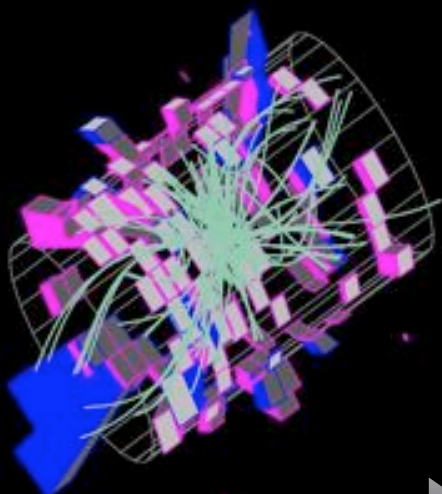


**Lagrangian**

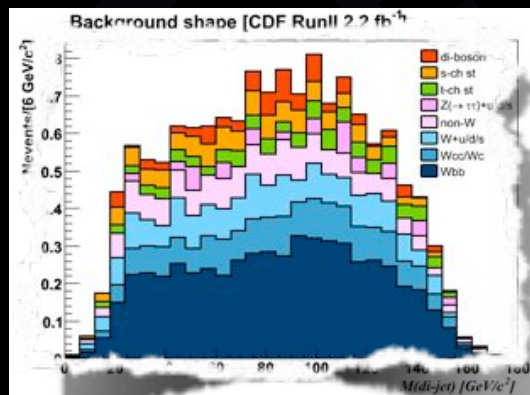
**Nobel**



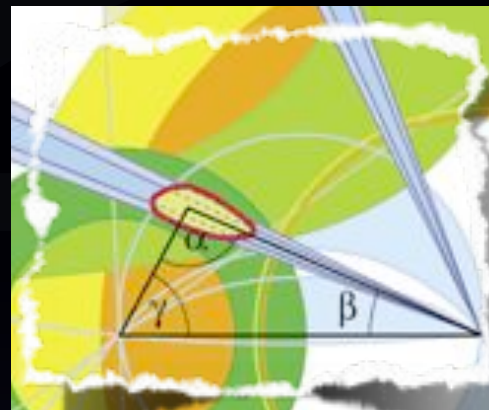
# Theory-Experiment Process



**“Data”**



**Monte Carlo**



Indirect,  
Precision,  
Exclusion,  
Correlation

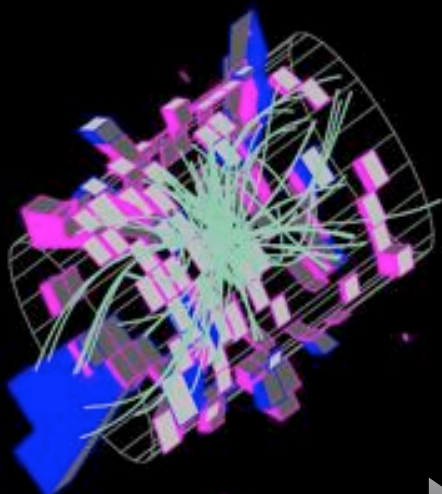
$\mathcal{L}_{eff}$

**Effective  
Lagrangian**

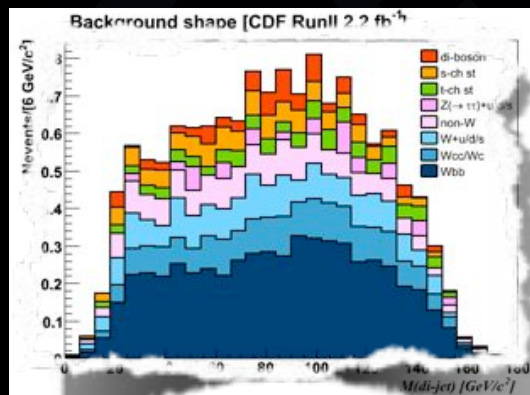
$\mathcal{L}$

**BSM Model(s)**

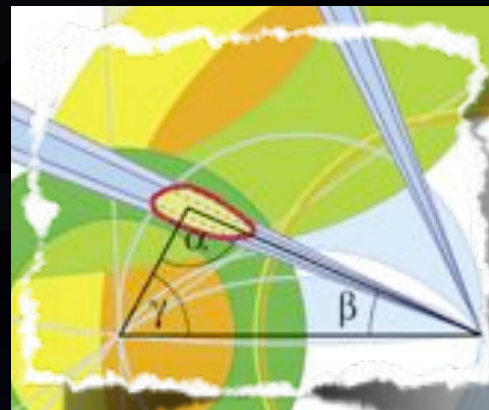
# Theory-Experiment Process



“Data”



Monte Carlo



Indirect,  
Precision,  
Exclusion,  
Correlation

$\mathcal{L}_{eff}$

Effective  
Lagrangian



Non-collider data

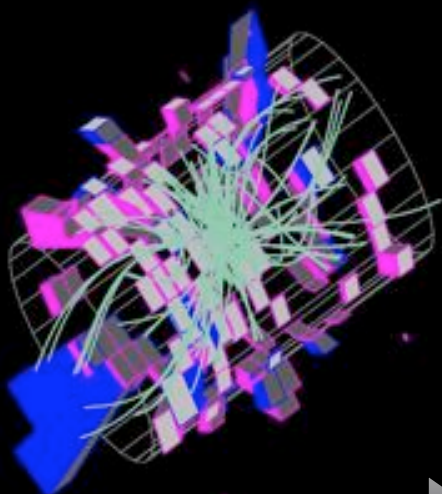
WTF?

Build  
models  
anyway!

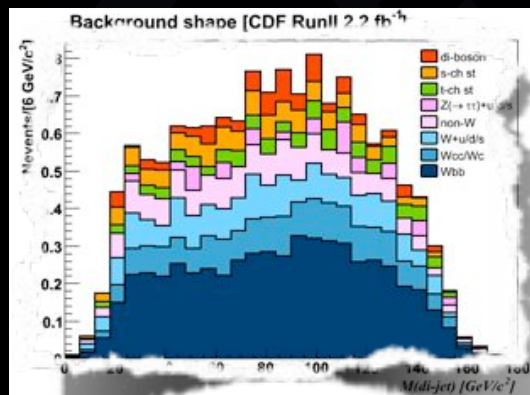
$\mathcal{L}$

BSM Model(s)

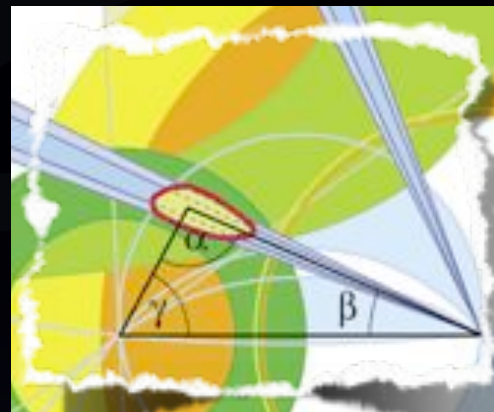
# Theory-Experiment Process



“Data”



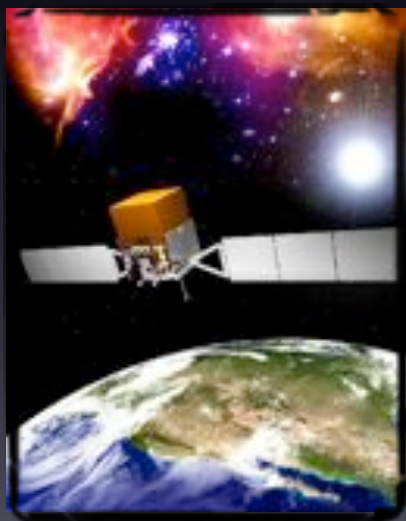
Monte Carlo



Indirect,  
Precision,  
Exclusion,  
Correlation

$\mathcal{L}_{eff}$

Effective  
Lagrangian



Non-collider data

**WTF?**

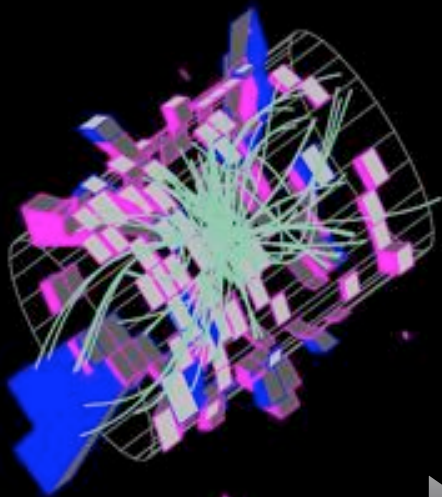
Build  
models  
anyway!

$\mathcal{L}$

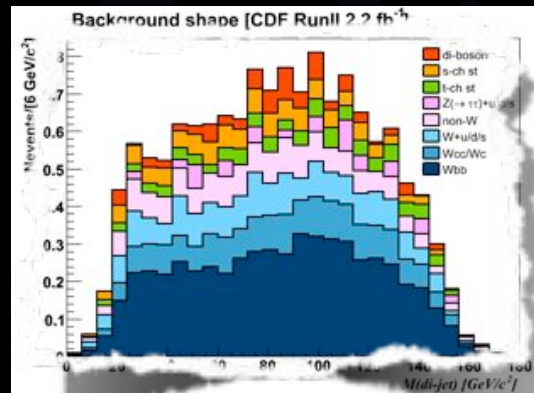
Interdisciplinary collaboration

BSM Model(s)

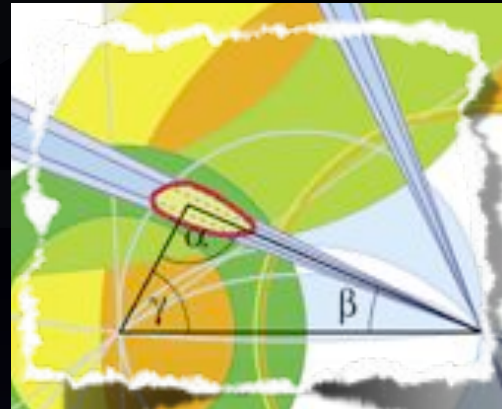
# Theory-Experiment Process



**“Data”**



Monte Carlo



Indirect,  
Precision,  
Exclusion,  
Correlation

$\mathcal{L}_{eff}$

Effective  
Lagrangian



Non-collider data

blogs, leaks,  
rumour-mongering

**WTF?**

Build  
models  
anyway!

Interdisciplinary collaboration

$\mathcal{L}$

BSM Model(s)

# '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, ...

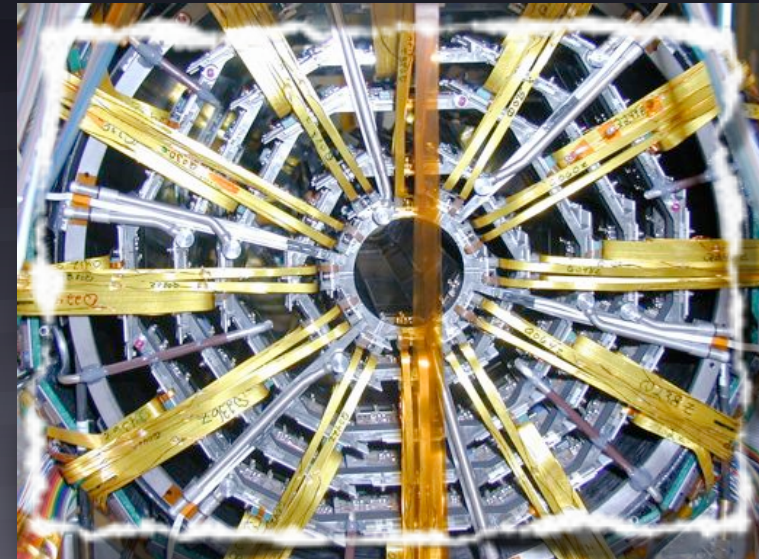
(Classification by Hitoshi Murayama)

# 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)

- $R_{2b} = (\sigma_{b\bar{b}})_{\text{exp}} / (\sigma_{b\bar{b}})_{\text{NLO}}$  should be  $\approx 1$ 
  - $R = 3.0 \pm 0.6$  using semileptonic decays
  - $R = 1.15 \pm 0.21$  using 2<sup>nd</sup>ry vertex ID
- Defines a set of excess “**ghost muons**”
- Ghost muons have abnormally large multiplicity

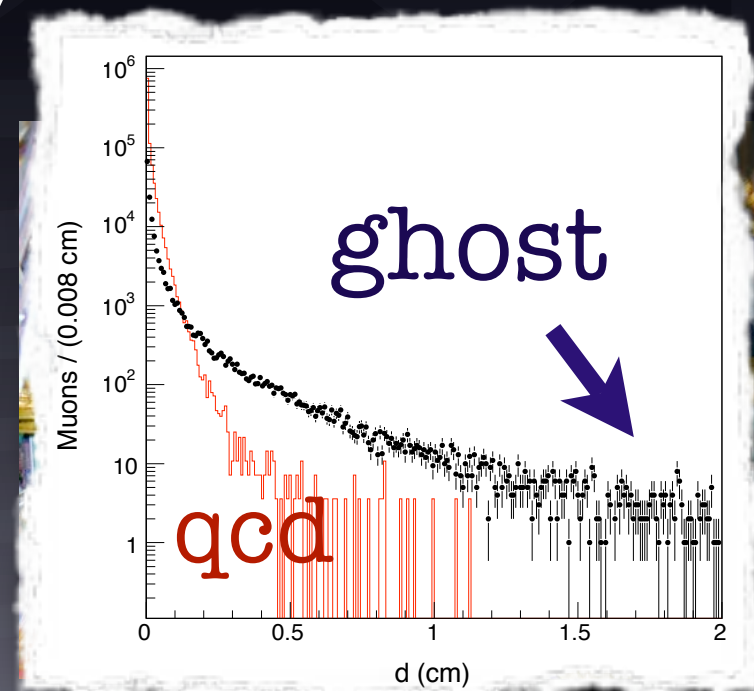


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# Is it background?

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

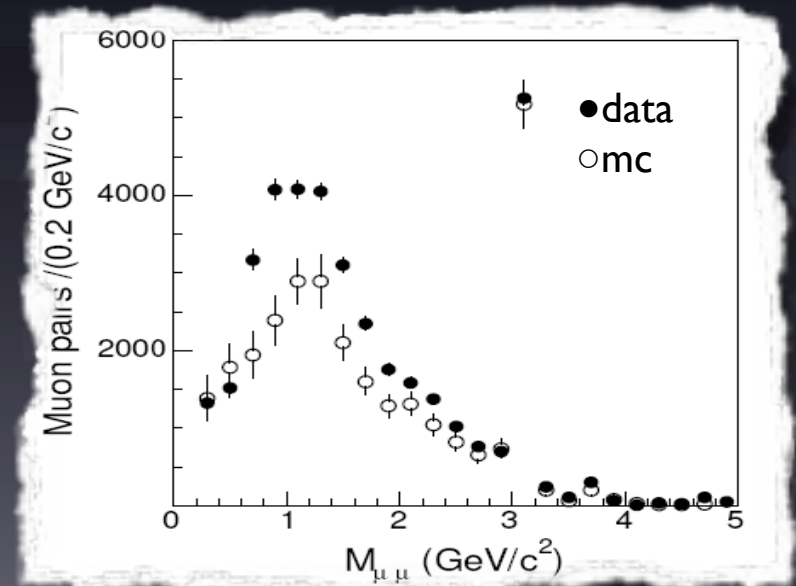
Not likely to be normal background

# 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

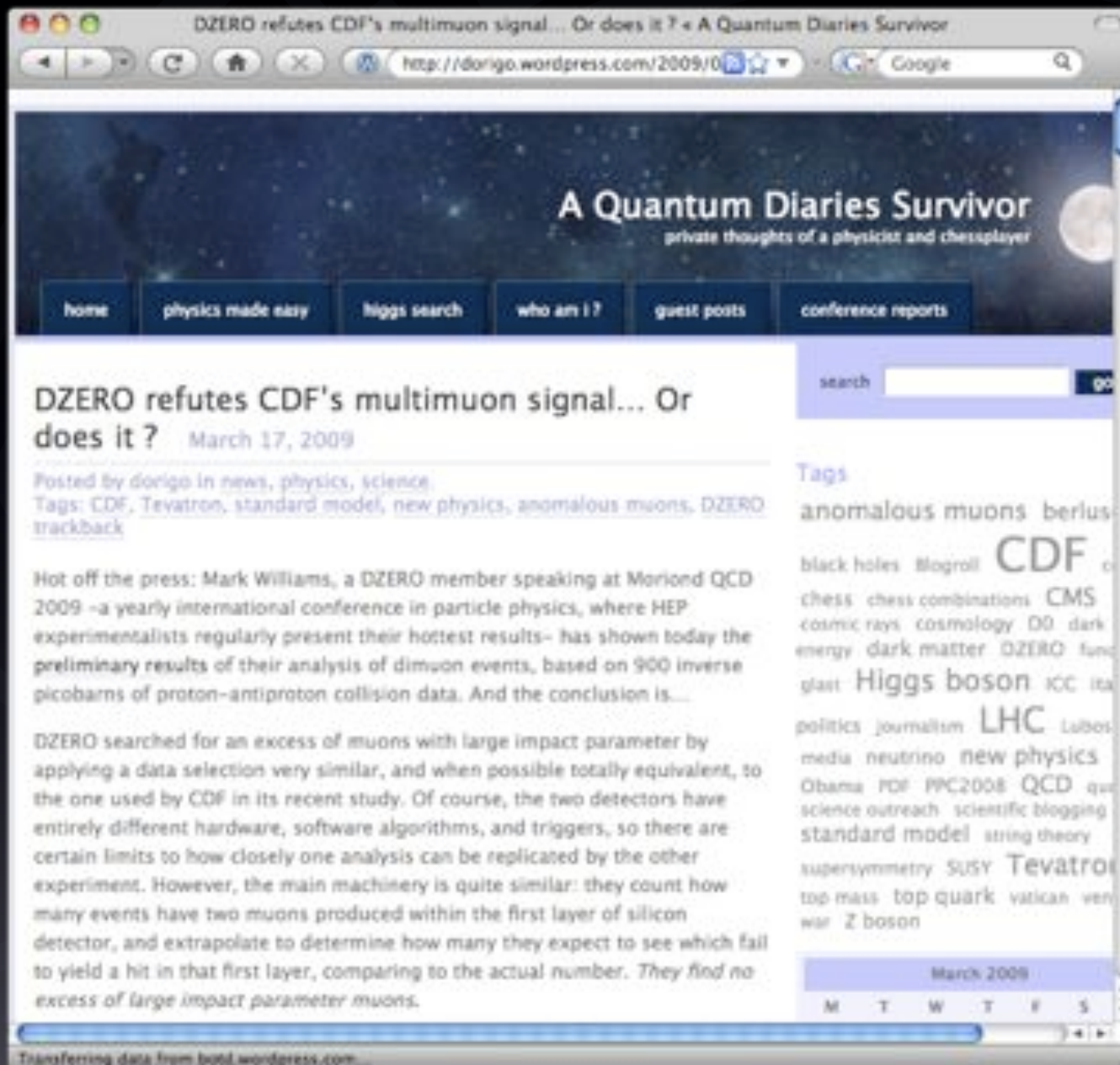


# Dialogue

- Lots of discussion between theorists and experimentalists on the **blogosphere**.

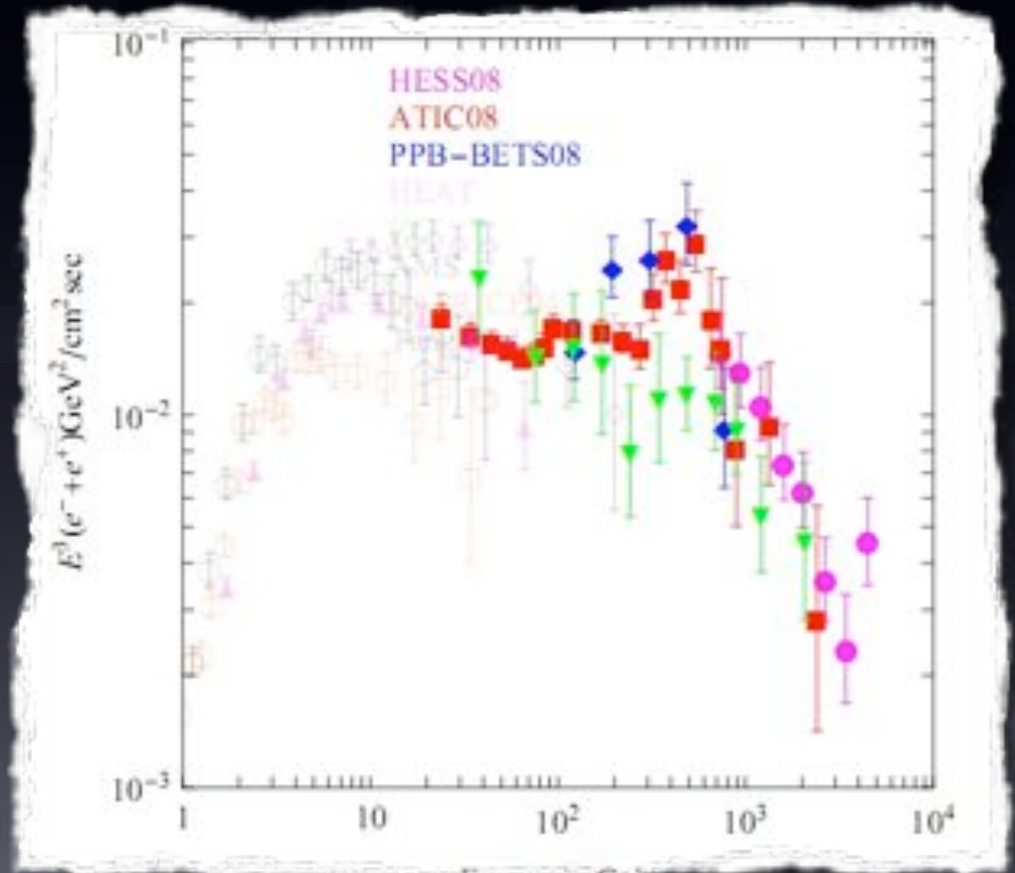
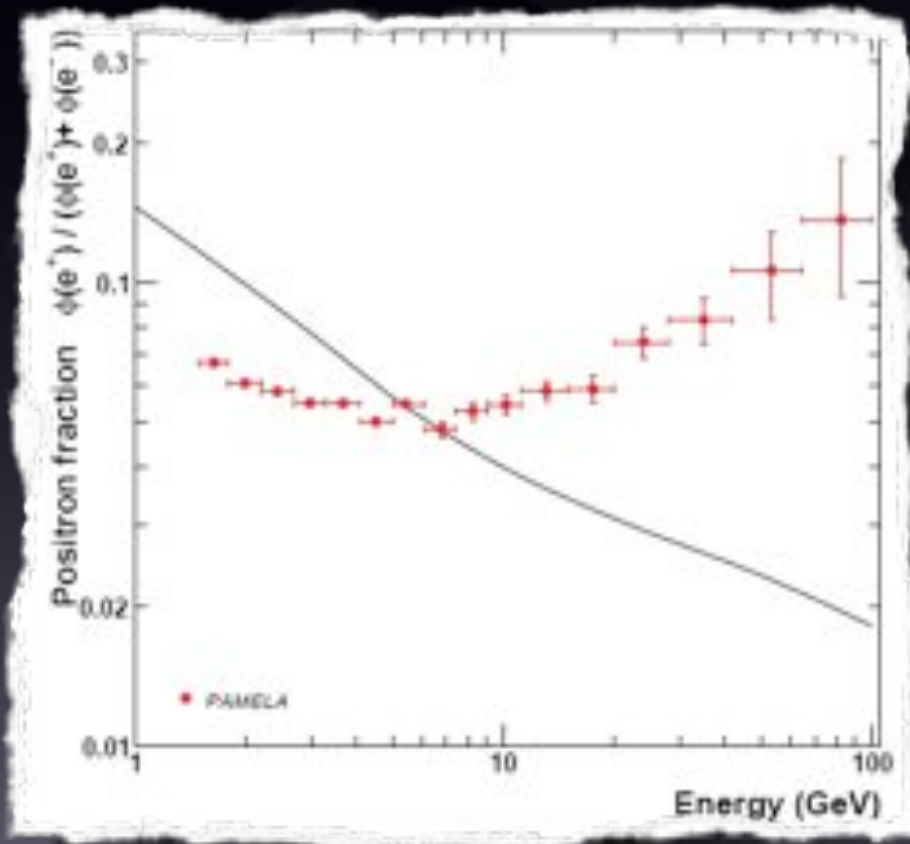
The image shows a screenshot of a blog post. The header features the title "A Quantum Diaries Survivor" with the subtitle "private thoughts of a physicist and chessplayer" and a small image of the moon. Below the header is a navigation menu with links for "home", "physics made easy", "higgs search", "who am i?", "guest posts", and "conference reports". The main content area displays the title "A few remarks on Matthew Strassler's 'Flesh and Blood with Multi-Muons'" dated November 17, 2008. The post is attributed to "dorigo" and includes tags for "anomalous muons", "arxiv", "CDF", and "new physics". The text of the post begins with a paragraph: "[I know, I know... I had promised that today I would issue a fourth installment of my multi-threaded post on the multi-muon analysis, and instead this morning (well, that depends where you're sitting) I am offering you something slightly different: instead than concrete details on the analysis, here is a review of a review of the same. I trust you understand that blogs, like newspapers or magazines, have their own priority lists...]" followed by another paragraph: "Last evening I read with a mixture of interest and surprise the paper recently appeared on the Arxiv by Matthew Strassler, a theorist from Rutgers University, and a supporter of so-called 'hidden valley' models of physics beyond the Standard Model." To the right of the main text is a search bar with a "go!" button and a list of tags including "anomalous muons", "berlusconi", "black holes", "Bloggell", "CDF", "cern", "chess", "chess combinations", "CMS", "cosmic rays", "cosmology", "D0", "dark energy", "dark matter", "DZERO", "funding", "glst", "Higgs boson", "icc", "italian", "politics", "journalism", "LHC", "lobes", "Med", "media", "neutrino", "new physics", "news", "Obama", "PDF", "PPC2008", "QCD", "quotes", "science", "outreach", "scientific", "bloggna", "standard-model", and "strag".

# Current Status



# 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.

Until very recently, “**string cosmology**”  
was the marriage of a field with *no predictions*  
with a field with *no data*.

- Shamit Kachru (2006)

# 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

Facebook | Beyond Part III

http://www.facebook.com/home

facebook Home Profile Friends Inbox Flip Tanedo Settings Logout

## Beyond Part III

Global

**Basic Info**

Type: Organizations - Academic Organizations

Description: If you are beginning a career in mathematical research you are invited from 16-18 April 2009 to the Centre for Mathematical Sciences, University of Cambridge. Our aim is to develop a stronger network between mathematics graduate communities in the UK and internationally.

The idea of Beyond Part III is that it's definitely not just for ex-Part III students. If you've never heard of Part III then we particularly want you to come! Some of our funding is specifically for those with no prior connection to Cambridge. (Part III is a one year graduate course in Cambridge - the majority of students then go on to do PhDs elsewhere).

Further details can be found on the website, where you can also register for the conference. If you plan to attend Beyond Part III, please join this group and spread the word to friends who may be interested.

**Contact Info**

Applications

Read b.static.ak.fbcdn.net

**Officers**

Richard Mycroft (Cambridge)  
Birmingham School of Mathematics rep

Chris Johnson (University of Manchester)  
University of Manchester School of Mathematics rep

 **David Simmons-Duffin** Woot! Just submitted a paper to arXiv! <http://arxiv.org/abs/0904.1584> (link live at midnight)

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

 You like this.

# 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