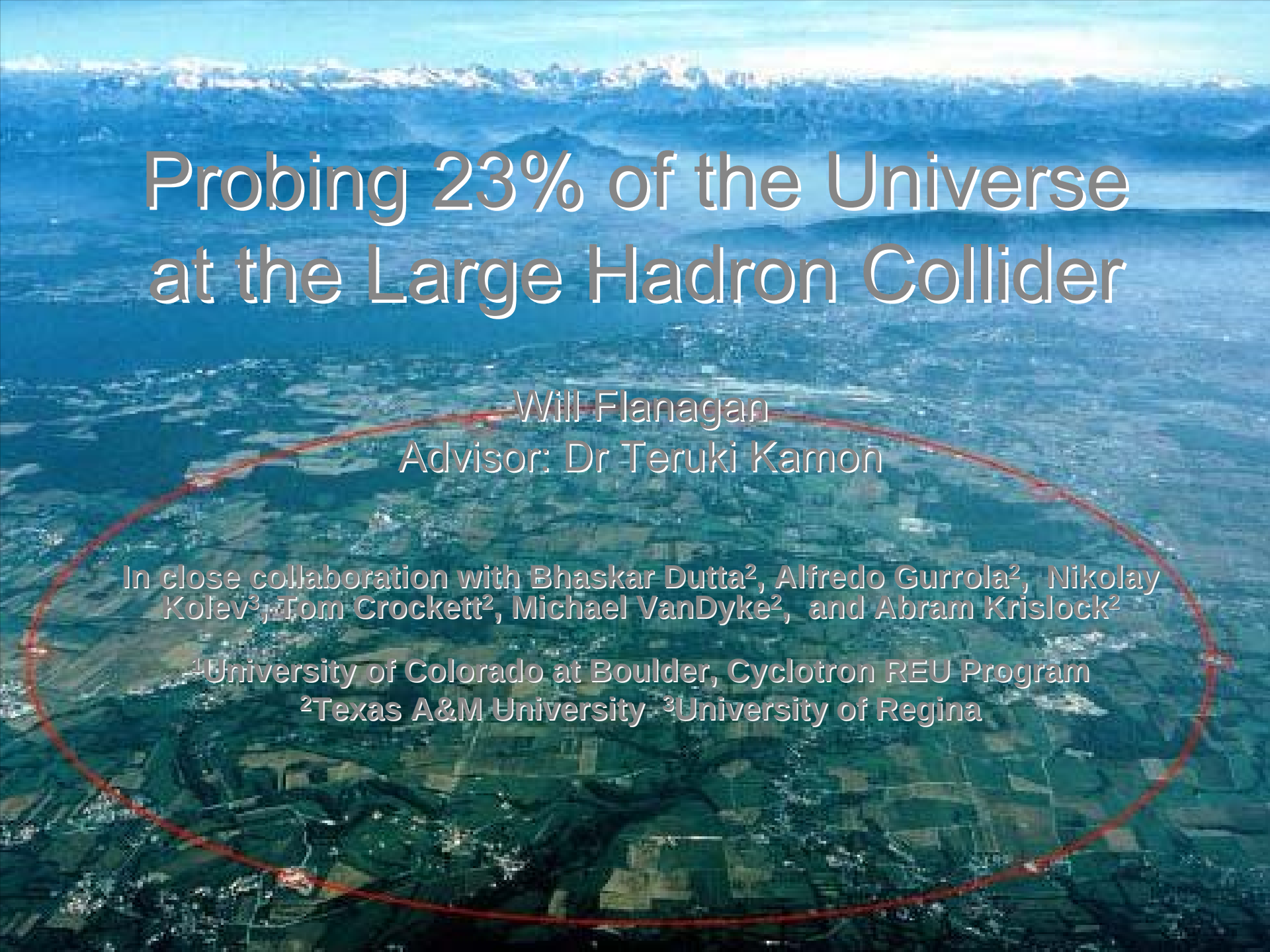


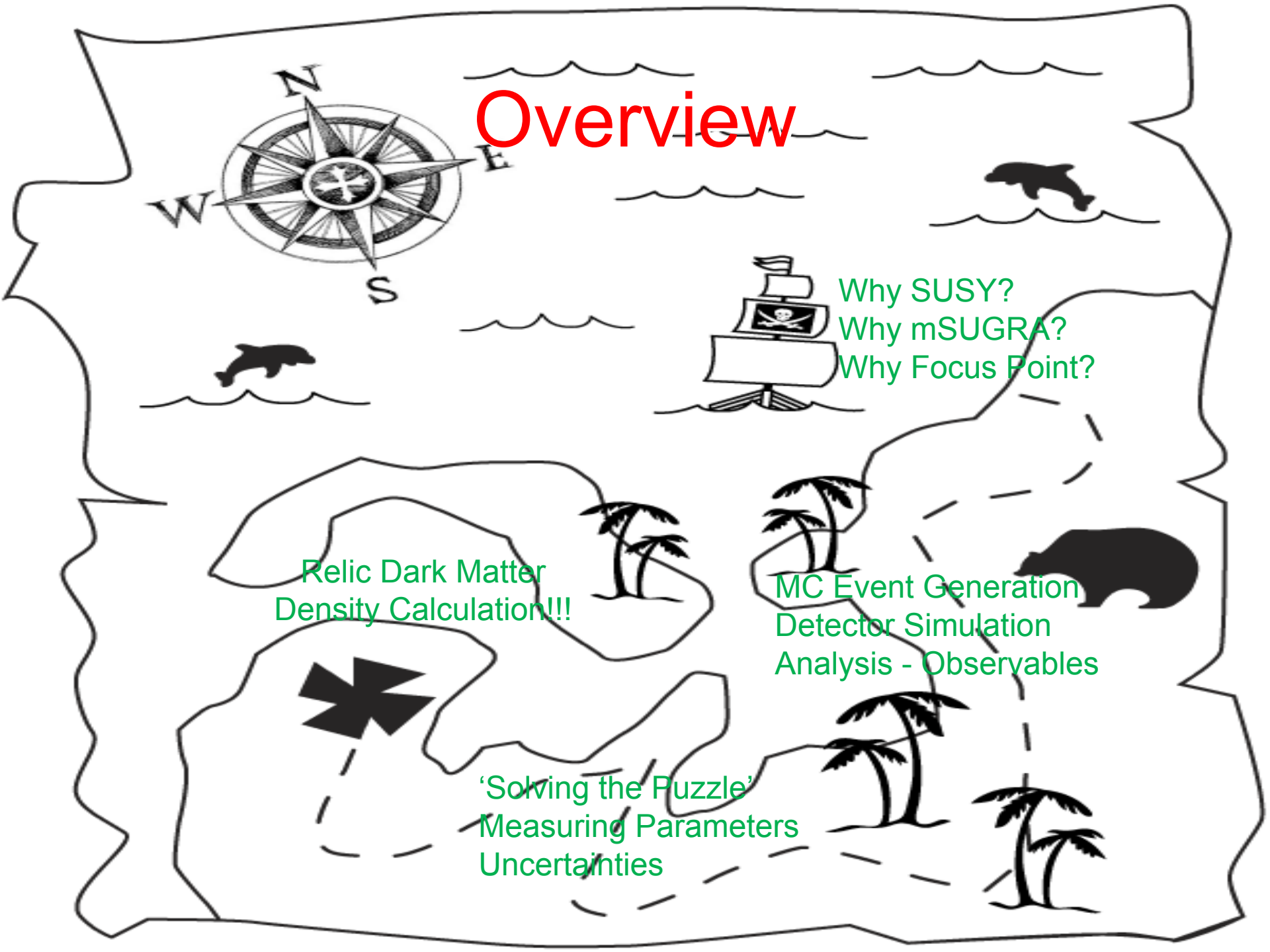
Probing 23% of the Universe at the Large Hadron Collider

Will Flanagan
Advisor: Dr Teruki Kamon

In close collaboration with Bhaskar Dutta[2], Alfredo Gurrola[2], Nikolay Kolev[3], Tom Crockett[2], Michael VanDyke[2], and Abram Krislock[2]

[1]University of Colorado at Boulder, Cyclotron REU Program
[2]Texas A&M University [3]University of Regina

Overview

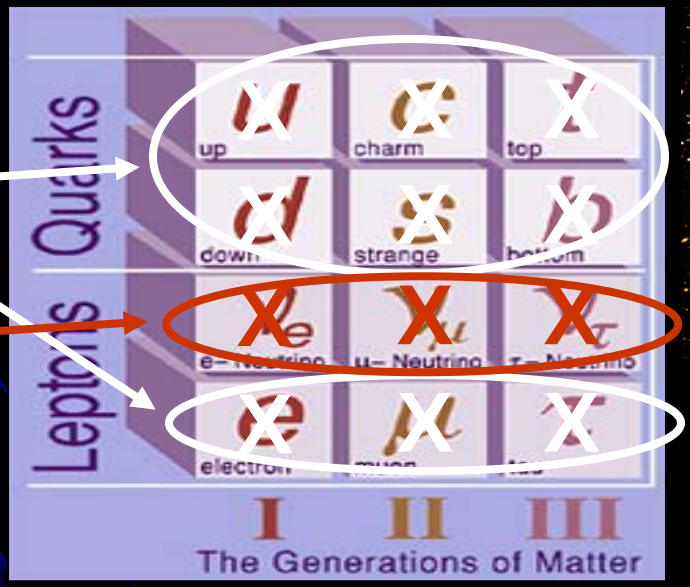

N
W
E
S
Why SUSY?
Why mSUGRA?
Why Focus Point?
Relic Dark Matter
Density Calculation!!!
MC Event Generation
Detector Simulation
Analysis - Observables
'Solving the Puzzle'
Measuring Parameters
Uncertainties

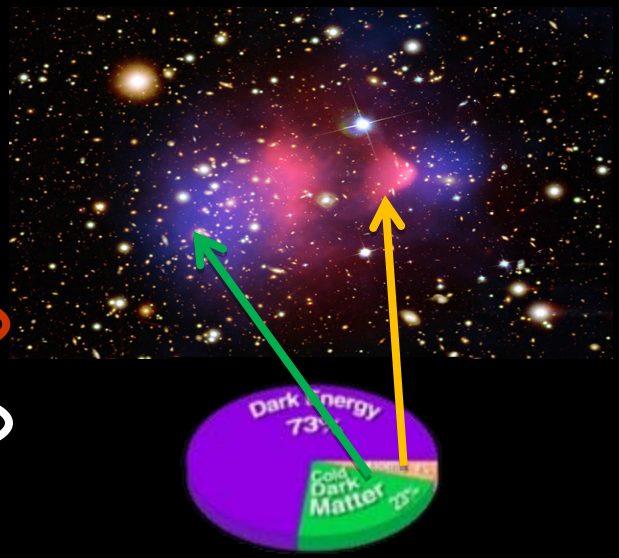
Dark Matter: The Connection Between Particle Physics and Cosmology

- Dark matter must be a particle, but the Standard Model can't provide one…

Not *dark*

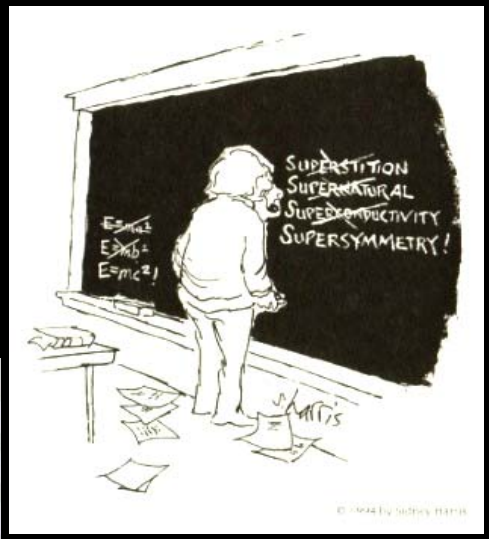
Not *heavy* enough for 'cold dark matter'



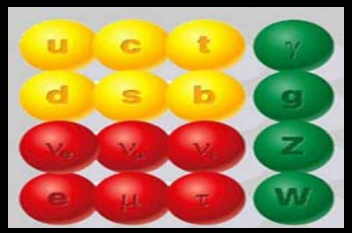


Supersymmetry to the Rescue!

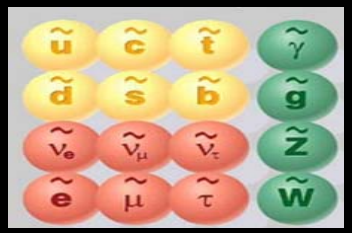
- Each Standard Model particle has a SUSY partner
- Due to R-parity conservation, the lightest supersymmetric particle, LSP, gives us a stable, heavy, and 'dark' particle



q 'quark' ⇨ $\tilde{q}$ 'squark'



⇨



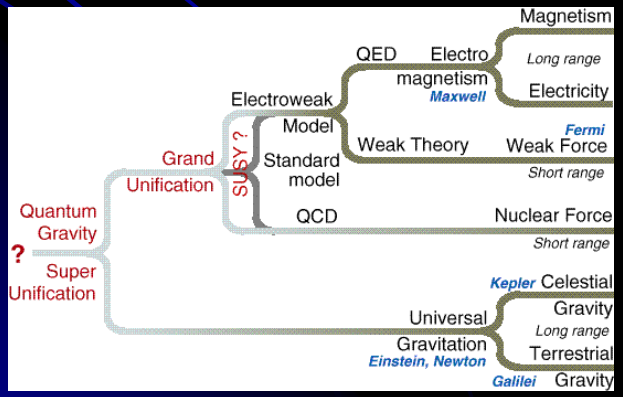
g 'gluon' ⇨ $\tilde{g}$ 'gluino'

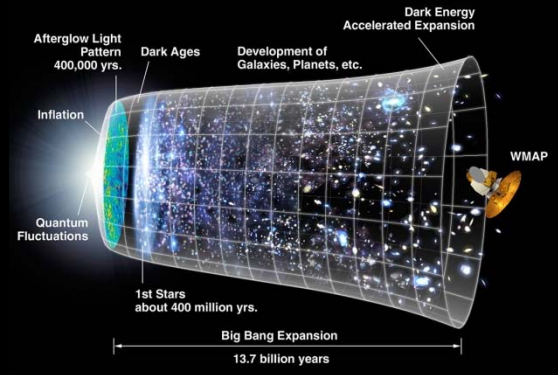
'Will' ⇨ 'Willino'

Fermions have Boson SUSY particles and vica-versa

What is mSUGRA???

- mSUGRA is ‘minimal supergravity;
- It has many interesting properties – simplicity for one with only 4 ½ (compare to Gauge Mediated SUSY)
- Also provides for Grand Unification Theory!!!



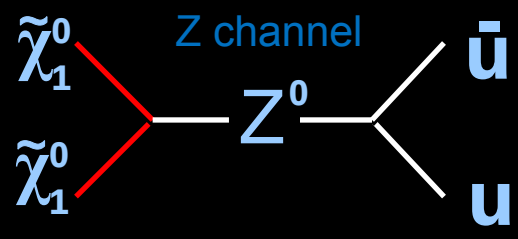


How is focus point 'cosmologically consistent'

- mSUGRA in general has a DM annihilation cross section that is too small – leading to a DM relic density that is too large – leading to a universe that is too closed!
- The LSP of focus point has a large higgsino component, opening up the 'Z channel', increasing the cross section.

$$\underbrace{\Omega_{\tilde{\chi}_1^0}}_{0.23} h^2 \sim \int_0^{x_f} \frac{1}{\langle \sigma_{ann} v \rangle} dx$$

$$\underbrace{\langle \sigma_{ann} v \rangle}_{0.9\ pb} = \frac{\pi \alpha^2}{8 M^2}$$



4 ½ Parameters…

- m_0 and $m_{1/2}$ are the unified masses at GUT scales.
- A_0 is a unified coupling parameter
- Tan(β) is the ratio of higgs doublets. In focus point we have a small value for tan(β) with interesting implications…
- Sgn(μ) – the ½ parameter. In focus point we also have a small value for μ with other interesting implications…

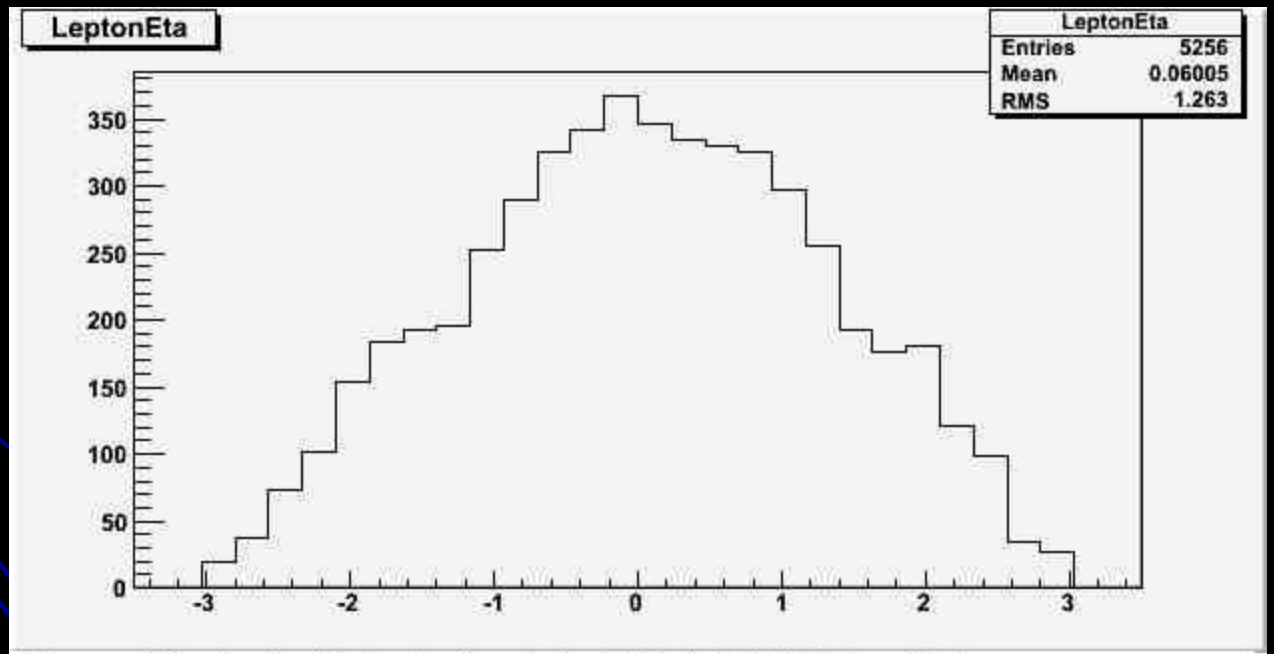
Characteristics of FP

- Small tan(β) favors e and μ production over τ production
- Small μ favors top quark production due to the large higgsino component of our neutralinos and the large mass of the top quark

Analysis

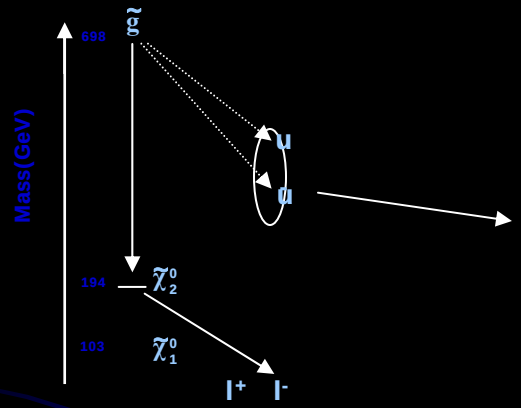
Run event level and detector level simulations. Then analyze Monte-Carlo data

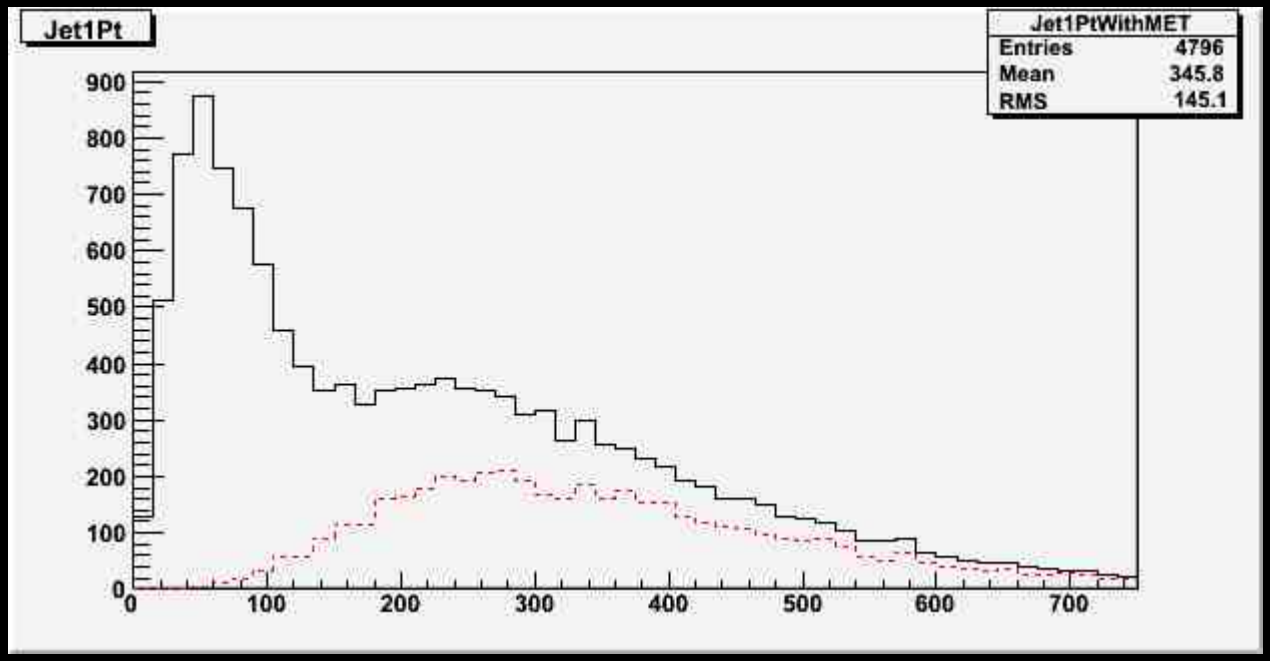
⇨

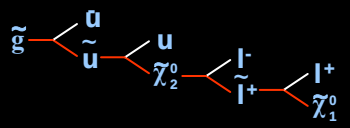


Histogram of Eta values for all leptons in all events from Nikolay's 6/19/08 (fp001.root) data.
Histogram created 6/20/08 by Tom.

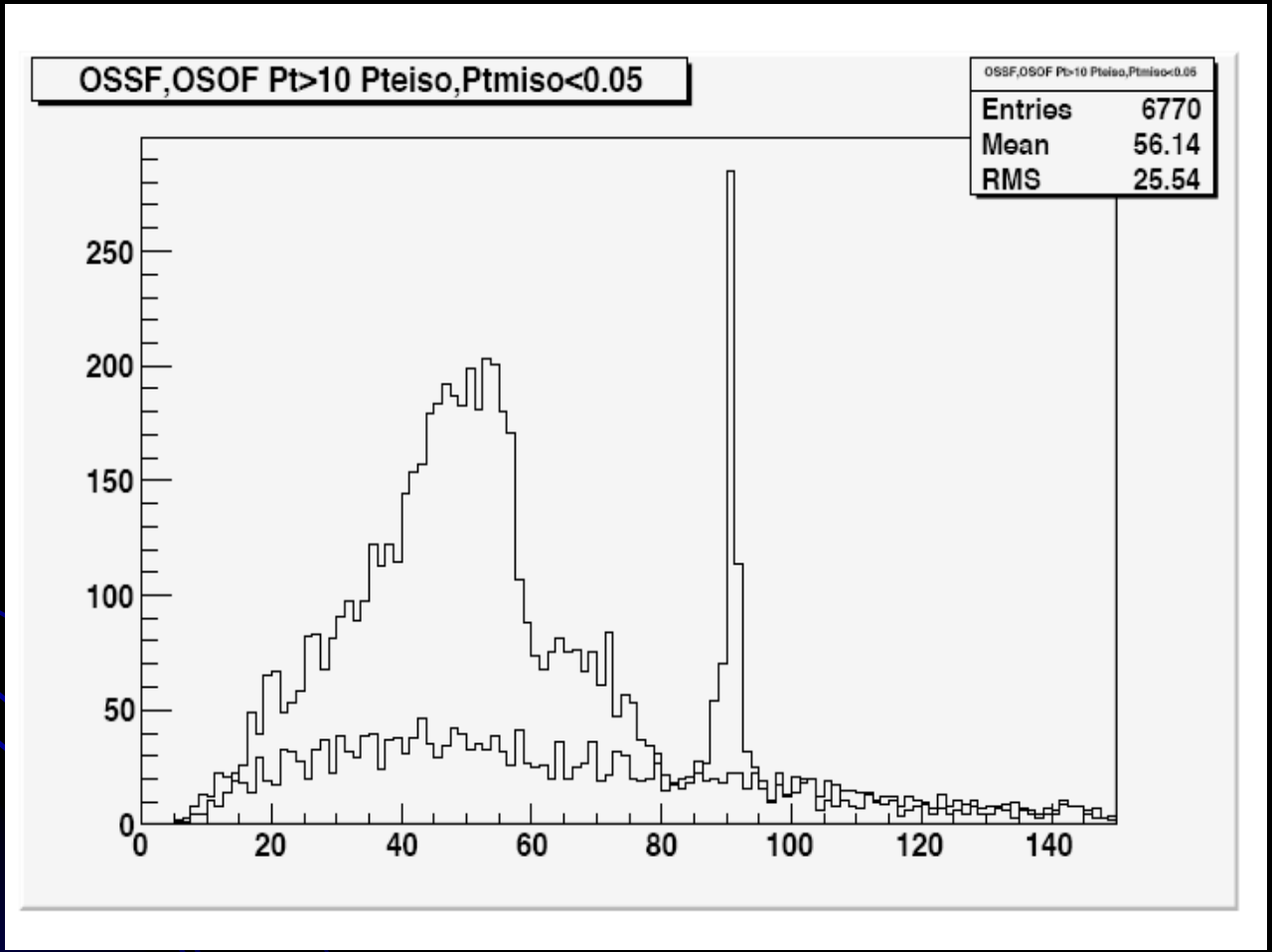
Look for energetic jets…





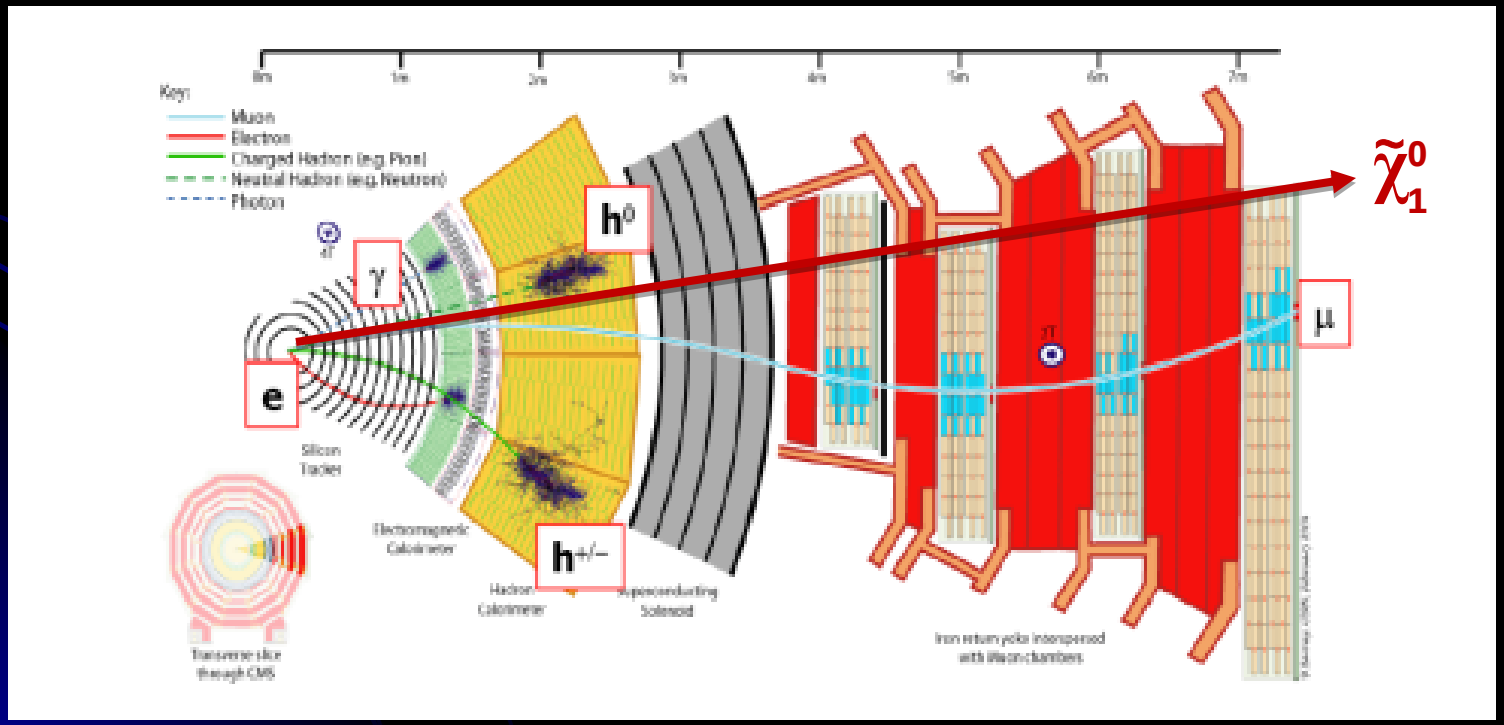


Use the dilepton edge for neutralino masses…



Efficiencies and Isolation Cuts

- We also probe efficiencies and isolation cuts in order to make sure that we are seeing ‘true electrons’ not ‘fakes’



Solve for FP Parameters

- Use the parameters extracted from our MC data to solve for FP parameters
- THEN calculate DM density

$$\underbrace{\Omega_{\tilde{\chi}_1^0} h^2}_{0.23} \sim \int_0^{x_f} \frac{1}{\langle \sigma_{\text{ann}} v \rangle} dx$$

$$\underbrace{\langle \sigma_{\text{ann}} v \rangle}_{0.9\,\text{pb}} = \frac{\pi \alpha^2}{8 M^2}$$

Parameter Space Coverage

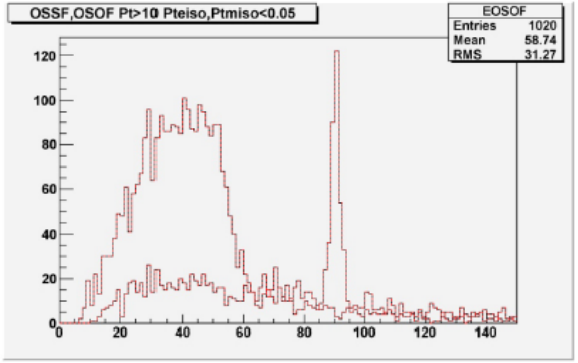
- We need to see how well we can uncover these parameters in less ideal places…

Dilepton Mass at FP2 & FP3

July 30, 2008
Will

$OSSF - OSDF\ (e^+e^- + \mu^+\mu^- - e^\pm\mu^\mp)$

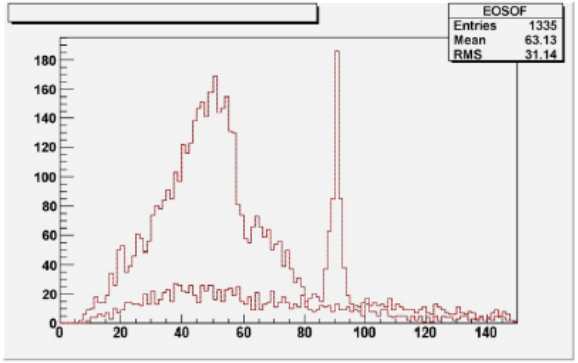
FP2 (7 GeV)



End point ~ 60 GeV

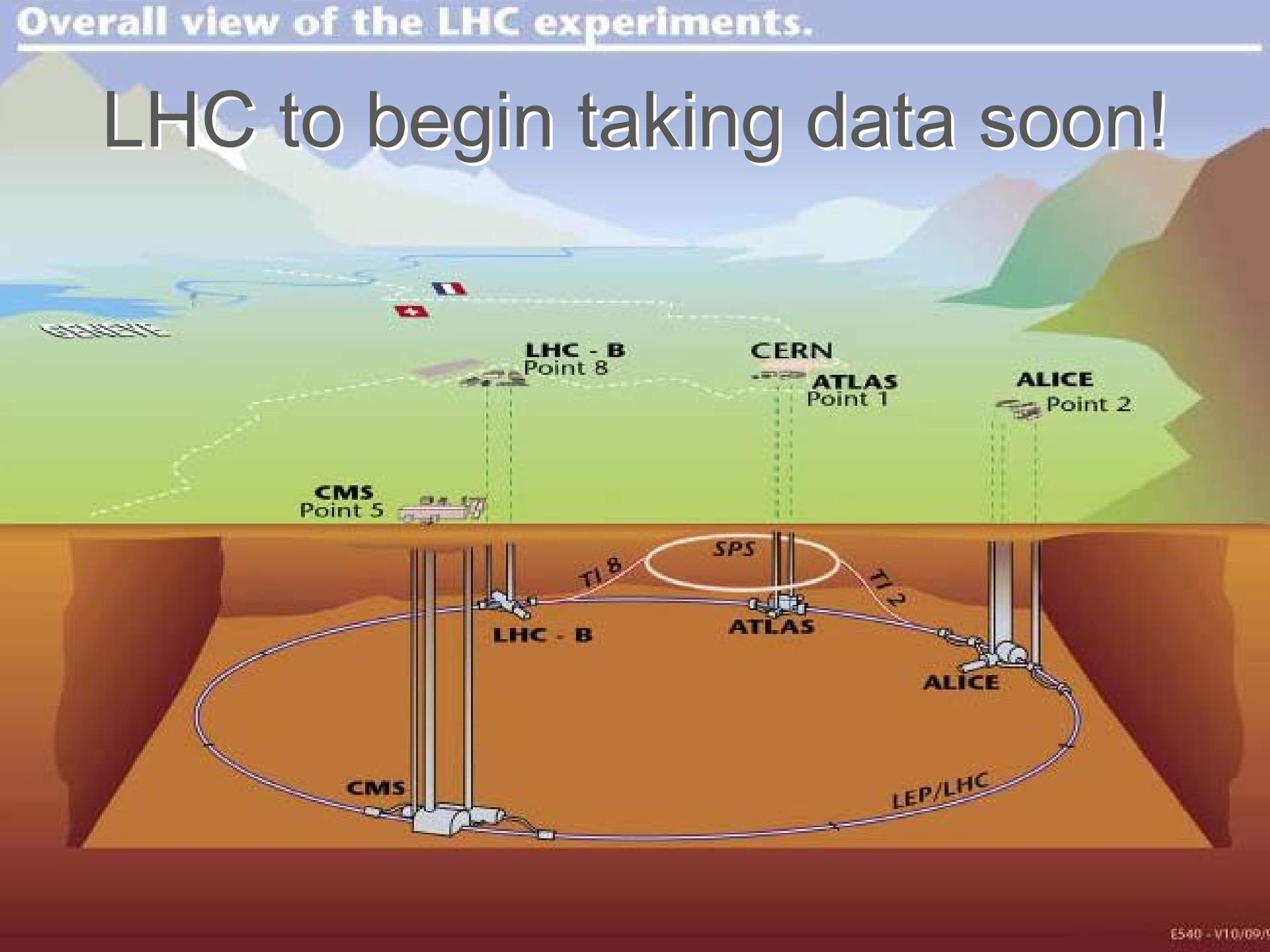
$OSSF - OSDF\ (e^+e^- + \mu^+\mu^- - e^\pm\mu^\mp)$

FP3 (22 GeV)



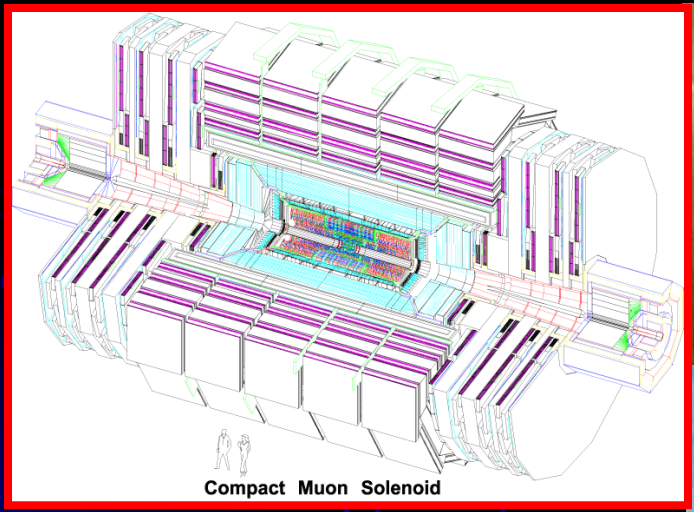
End points ~ 57 & 78 GeV

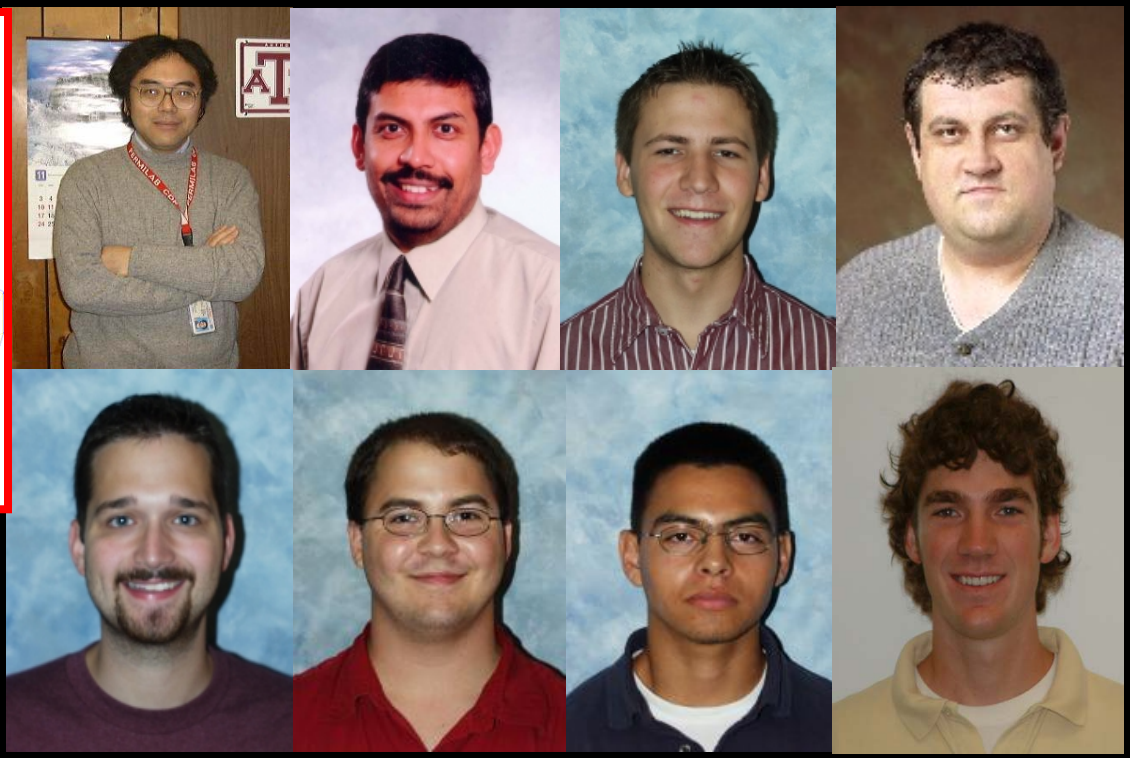
LHC to begin taking data soon!



To be continued!…

- Look for preliminary results in my presentation at the Texas APS meeting on October 17…





Much Thanks to the Cyclotron REU Program, Dr Kamon and the whole TAMU HEP Team!