DARK MATTER RELIC DENSITY AND SUPERSYMMETRY AT THE LARGE HADRON COLLIDER

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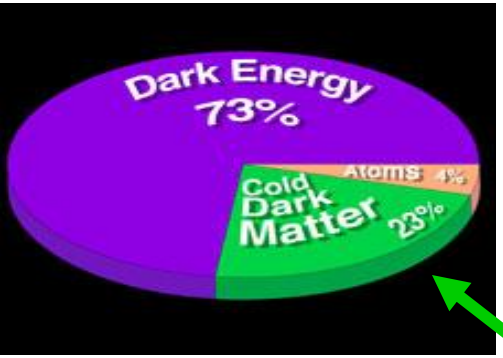
Outline for Talk (A physics and computing talk)

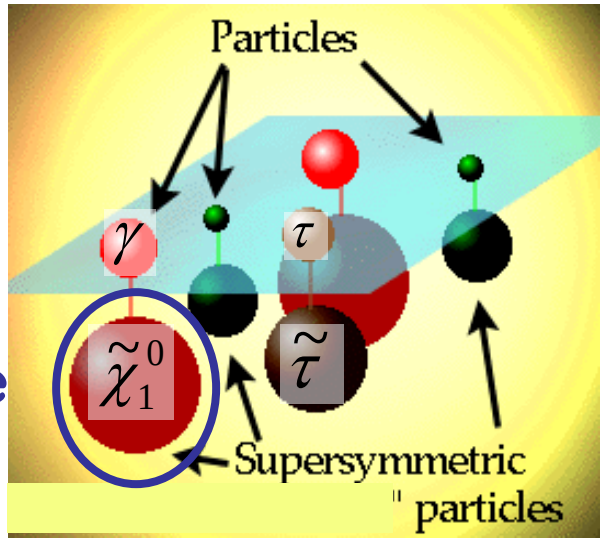
- Brief reminder of previous analysis
  - The analysis requires lower statistics to make relic density determination
- Determining one of the parameters in the previous analysis independently
  - Allows for a more accurate measurement of the dark matter relic
  - This proposed analysis will require very high statistics
  - High statistics analysis creates a computing challenge
- The Large Hadron Collider experiment itself presents a computing challenges for physics analysis
  - New idea for a tool to do scientific computing with large amounts of data

DARK MATTER AND SUSY



SUSY models give a Lightest Supersymmetric Particle that if created in the early universe would still exist today and may provide a Cold Dark Matter Candidate

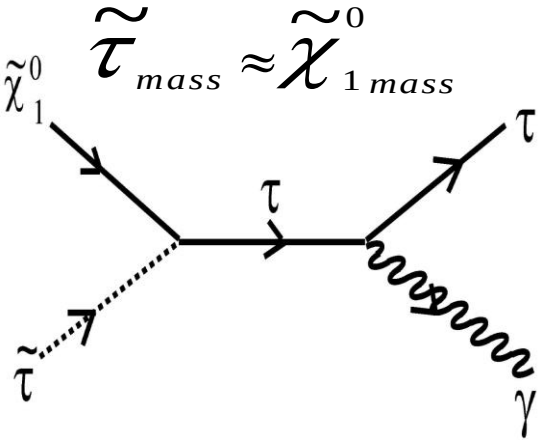
SUSY



Cosmological Observations indicate that a large fraction of the universe is Cold Dark Matter

Co-Annhilation Region

- If there is another SUSY particle with mass close to the lightest particle's mass it will have a large abundance in the early universe and annihilate with the lightest particle to reduce the density *(making predictions that agree with astronomical observations)*



Look for observables of the Co-annihilation region at the LHC

SUSY → RELIC DENSITY

Paper in preperation: Details of Analysis work done being given by Alfredo Gurrola

4 Observables as a function of 4 Unknowns

$$M_{\tau\tau}(M_{\chi_1^0}, M_{\chi_2^0}, M_{\tilde{G}}, M_{\tilde{\tau}})$$

$$M_{j\tau\tau}(M_{\chi_1^0}, M_{\chi_2^0}, M_{\tilde{G}}, M_{\tilde{\tau}})$$

$$P_t^{soft\,\tau}(M_{\chi_1^0}, M_{\chi_2^0}, M_{\tilde{G}}, M_{\tilde{\tau}})$$

$$N_{os-ls}(M_{\chi_1^0}, M_{\chi_2^0}, M_{\tilde{G}}, M_{\tilde{\tau}})$$

Invert Equations to determine masses

$M_{\chi_1^0}$
$M_{\chi_2^0}$
$M_{\tilde{G}}$
$M_{\tilde{\tau}}$

Use masses to to determine mSUGRA parameters

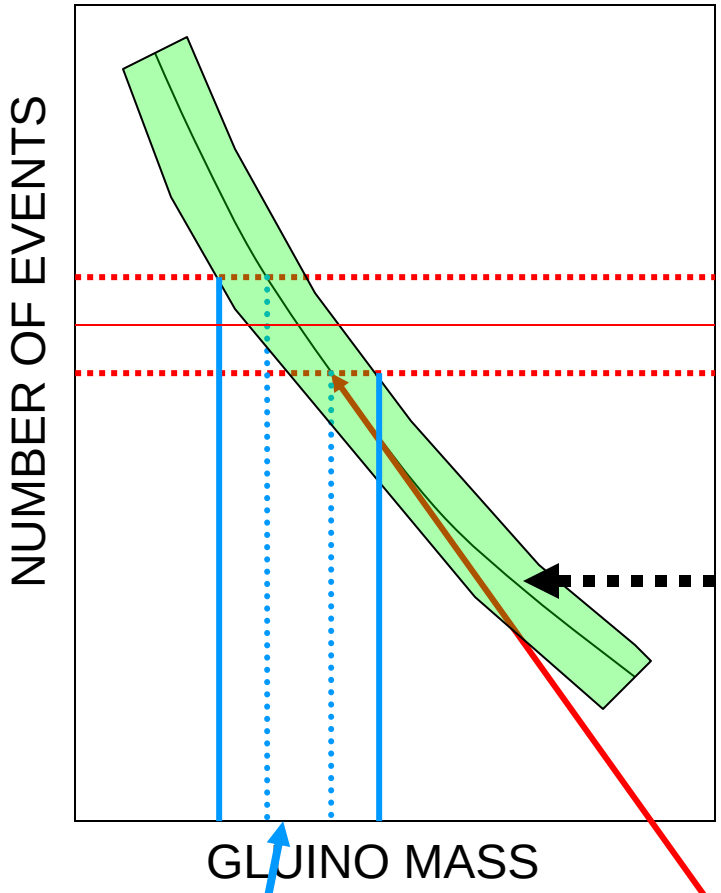
m_0
$m_{1/2}$
$\mathrm{sgn}\,\mu$
$\tan\beta$
A_0

Use these values to calculate dark matter relic density

$\Omega_{\chi_1^0} h^2$

Everywhere in this analysis tau events are used. Thus making this a low statistics measurement. To measure the gluino mass independently we will have to move away from taus. (Higher backgrounds & Higher Signal) Thus requiring high statistics!

LOOKING FOR NEW PHYSICS



- We know that the number of events we expect depends on the cross-section, Luminosity and acceptance

$$N = L \cdot \sigma \cdot A$$

- The cross-section depends inversely on the mass of the gluino

$$\sigma = C / M_{\tilde{g}}$$

$$C_1 = C \cdot A$$

- Thus the number of events expected is expected to be inversely proportional to the gluino mass

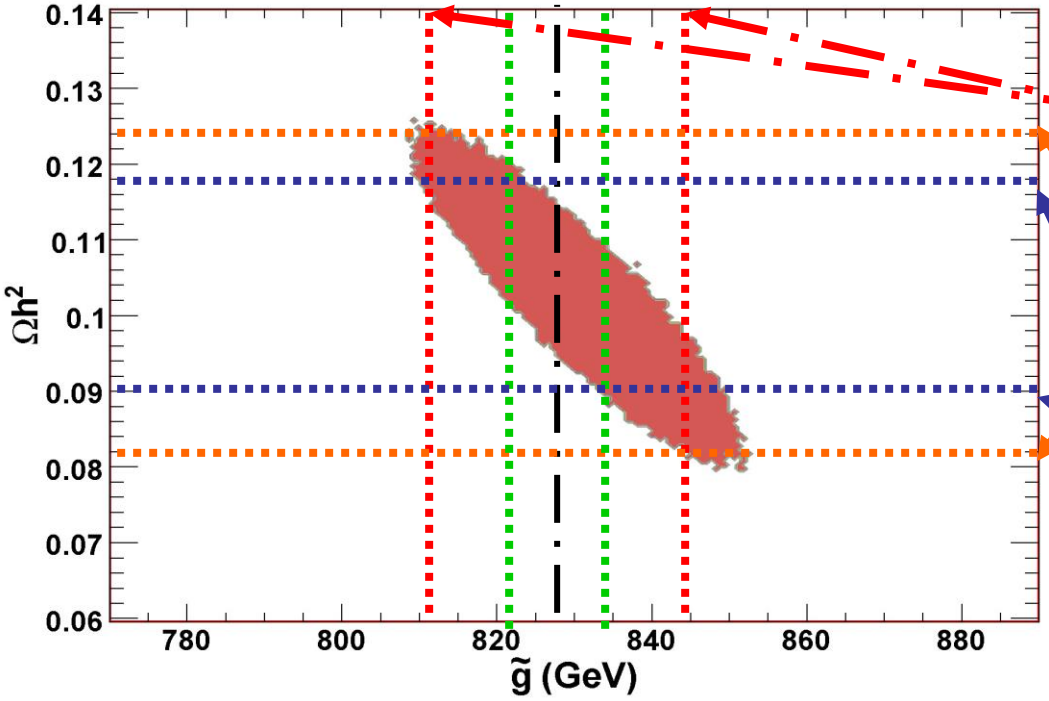
$$N = L \cdot C_1 / M_{\tilde{g}}$$

Thus if we know our measurement of N with some uncertainty…

WE CAN MAKE A MEASUREMENT OF $M_{\tilde{g}}$!!!

→ **WE ARE ANALYZING HOW SYSTEMATIC UNCERTAINTIES IN C (CONSTANT) AND L (LUMINOSITY) EFFECT OUR MEASUREMENT OF** $M_{\tilde{g}}$

Measuring Relic Density with Gluino Mass



Measurement of Gluino mass with some uncertainty

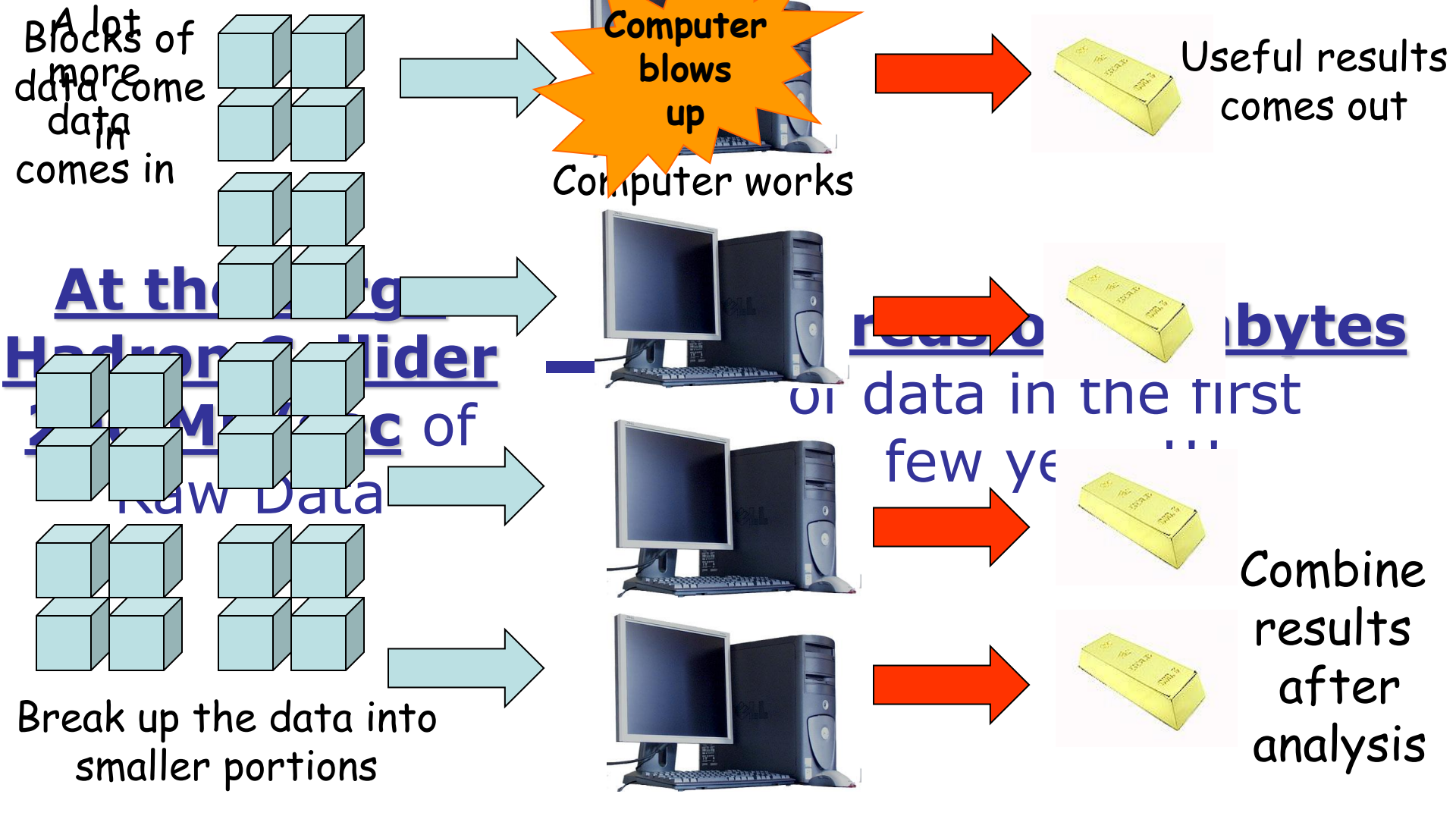
Measurement of relic density

More accuracy in the Gluino mass corresponds to a better determination of the relic density

A more accurate Gluino mass measurement will require high statistics → This requires a great deal of computer power for analysis → Propose a new computer tool to help the already existing tools deal with a high statistics analysis

SEARCH FOR NEW PHYSICS IS GOING TO REQUIRE CPU POWER

The way cool thing is "High Throughput Computing"

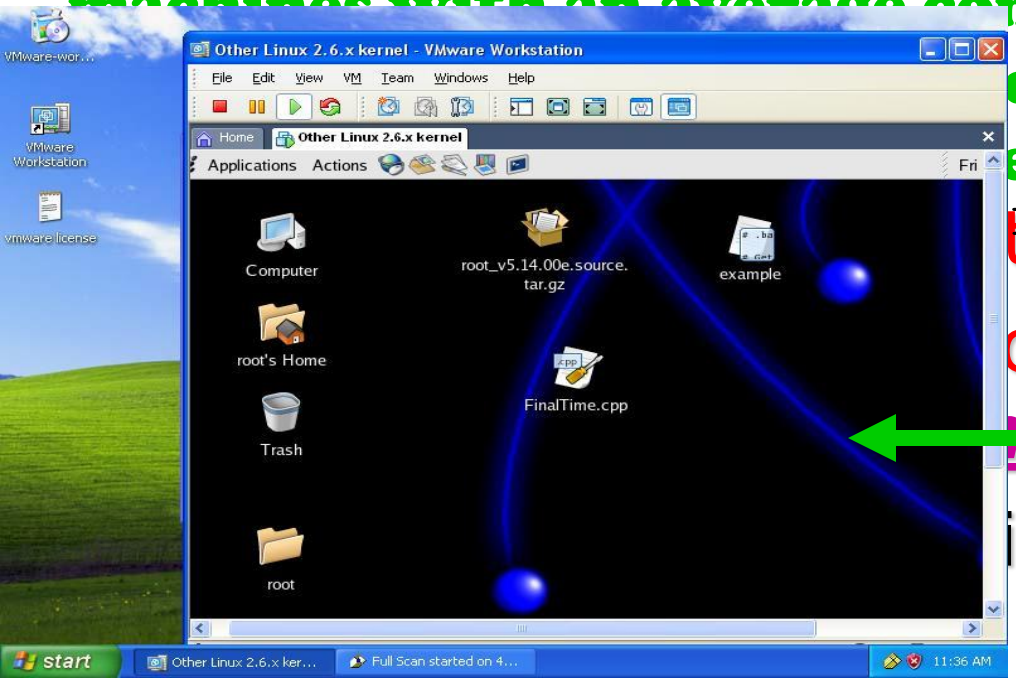


ACHIEVING HIGH-THROUGHPUT COMPUTING AT A&M

IDEA:
Scavenge unused CPU cycles from already existing computers on TAMU's campus

→ Utilize unused computing power from Student Computing Resources

Currently we have on Texas A&M'S campus ~ 1300 machines with an average computing capacity of 3 GHz



disk space

er every year!)

"Virtual Machines" run a foreign operating system as an application on a host machine

tific Linux" and

ows XP Machines

Run Scientific Linux machines"

on a Windows XP Machine

ientific Linux

Virtual Machines for High-Throughput Computing

Q: How well can we do computing in this enviroment?

A: Great!!! Using virtual machines allows us to use student computing resources with a minimal performance hit

PRELIMINARY RESULTS: *(DONE ON IDENTICAL MACHINES)*

Time for Analysis on Scientific Linux Machine:
585 seconds
Time for Analysis in a Virtual Scientific Linux Environment:
675 seconds

ONLY 13% PERFORMANCE HIT!!!!

We can utilize this powerful computing tool for our own SUSY analysis which requires high statistics and a lot of computing time

Measuring the gluino mass and the dark matter relic density Ωh_1^2 at the LHC

Conclusions

- SUSY models give rise to a cold dark matter candidate
  - Focusing on a particular model we measure SUSY mass parameters and infer a dark matter relic density
- Having an independent determination of the Gluino Mass would give further confidence to our analysis
  - The Monte Carlo work currently in progress and requires a great deal of high-throughput computing
- Searches for SUSY will create a demand for High Throughput computing
  - Through the use of Virtual Machines we can utilize already existing resources for Dark Matter searches at the LHC