Theory Space, LHC and the Inverse Problem

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INFN Monte Carlo Workshop, Frascati

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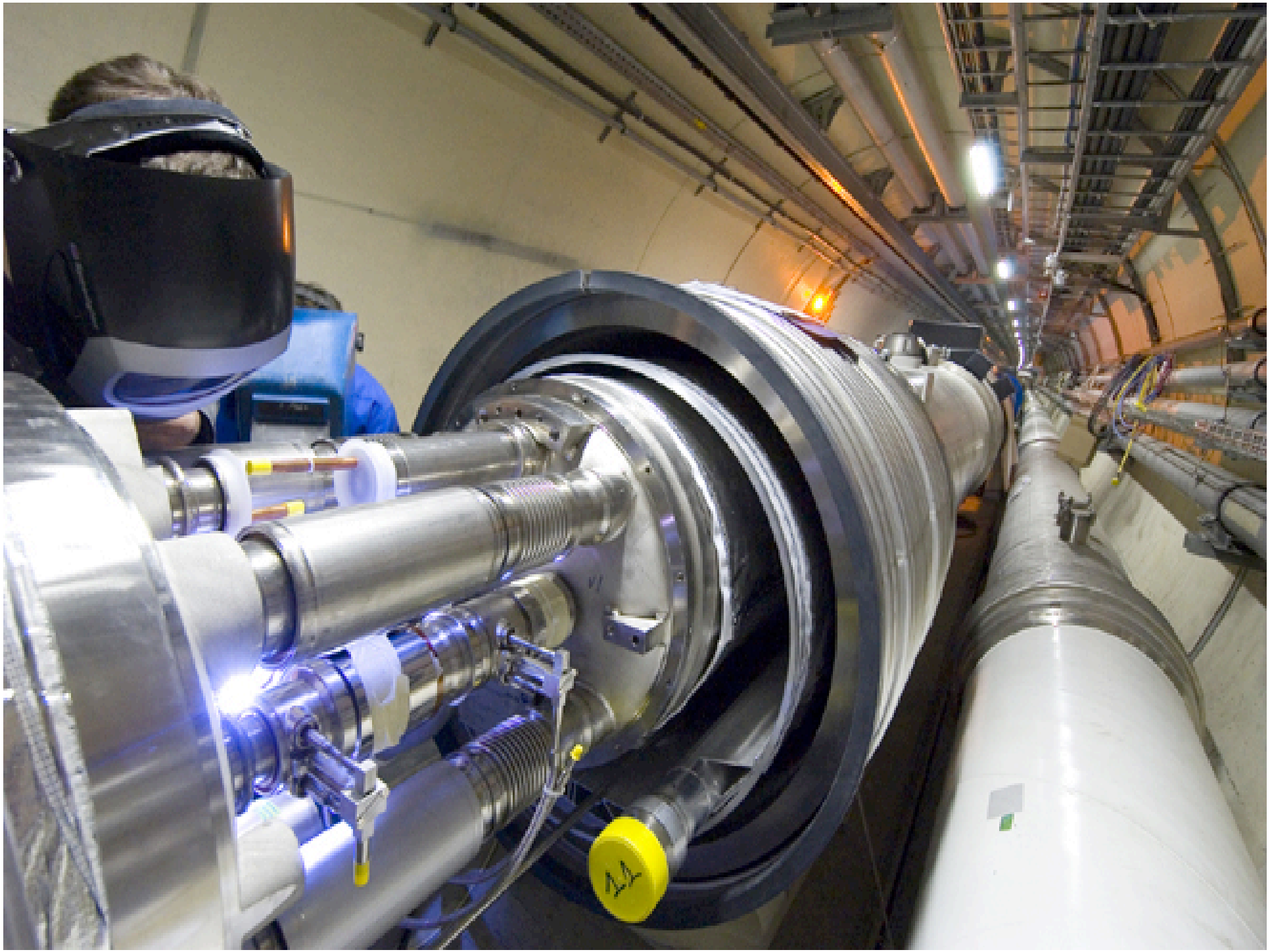


Are We Ready For the LHC?

- LHC will switch on in 18 months or so:)
- Commissioned some time ago
- Theoretical Perspective has changed:
- Does supersymmetry naturally extend the standard model?
- Many new ideas: large extra dimensions, warped extra dimensions, little Higgs, Higgsless models……
- Theory space is vast
- The String Landscape vs. Naturalness

- **We should try to be as prepared as possible for such possibilities.**
- **Hopefully this meeting will inspire some new initiatives in this direction**
- **Eg Monte Carlo's for understanding the LHC signal of `other' theories (cf comments of Fabio Maltoni)**
- **Eg if LHC spits out something unanticipated it will require a close collaboration between theorists and experimentalists.**
- **Why not start now!**

The LHC Olympics

- **Many theorists are NOT ready for the experiment which will dominate high energy physics for some years to come**

- **The LHC Olympics is a series of meetings which offers an opportunity to resolve this issue.**

The LHC Olympics Format

- http://wwwth.cern.ch/lhcOlympics/lhcolympicsII.html - online info and discussion

- Blackboxes - simulated data samples which participants can study as if real data

- Biannual meetings with talks and discussions.
- Hopefully this will help prepare us for the inverse problem…

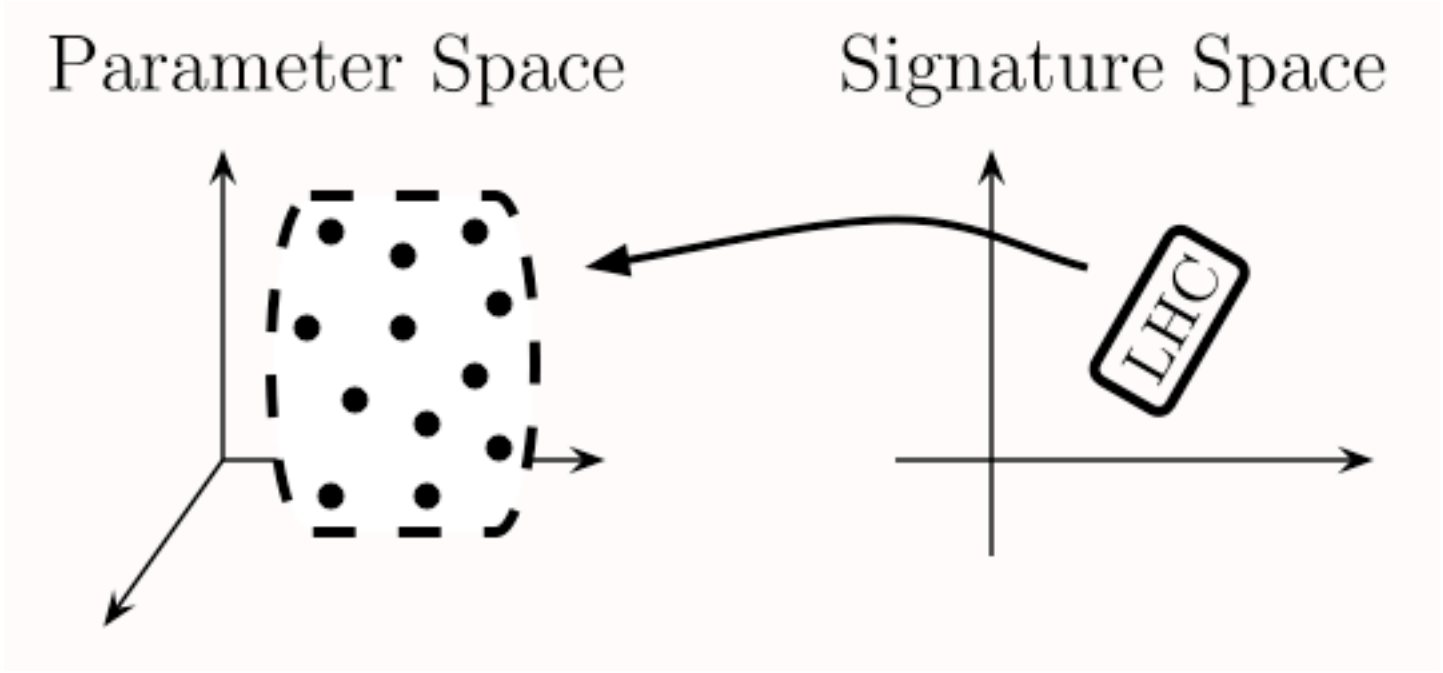
LHC Inverse Problem

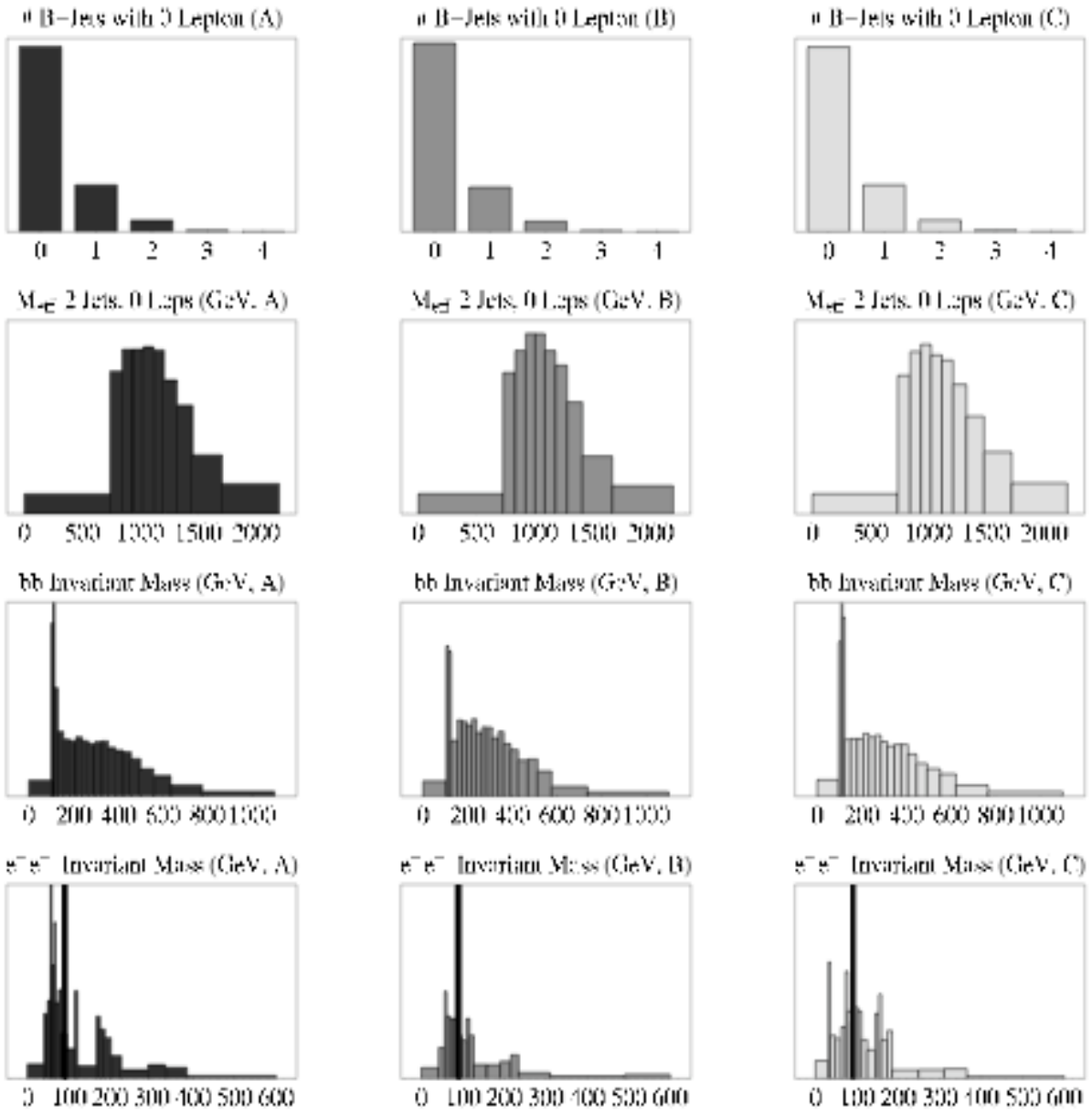
- If LHC produces a signal…….
- How can we use it to determine the TeV Lagrangian?
- What about the underlying theory?
- How will we identify the string/M theory vacuum?
- This is the LHC Inverse Problem
- A mini version of this problem is:

The SUSY LHC Inverse Problem

Arkani-Hamed, Kane, Thaler, Wang hep-ph/0512190

- **Simulated 43,026 MSSM's, 1808 observables**
- **Varied the 15 most LHC relevant parameters**
- **Found that 283 pairs of models were degenerate**
- **Determined the effective number of independent signature bins ~ 3 million ~ $(43\ 026)^2$ /283x2**
- **Found that each signal can come from from 5 - 100 different theories.**
- **Eg parameter vol/#sigs ~ 10^8 / 3 million ~ 30**


Parameter Space
Signature Space
LHC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B-Jets with 0 Lepton (B)
0 1 2 3 4
B-Jets with 0 Lepton (C)
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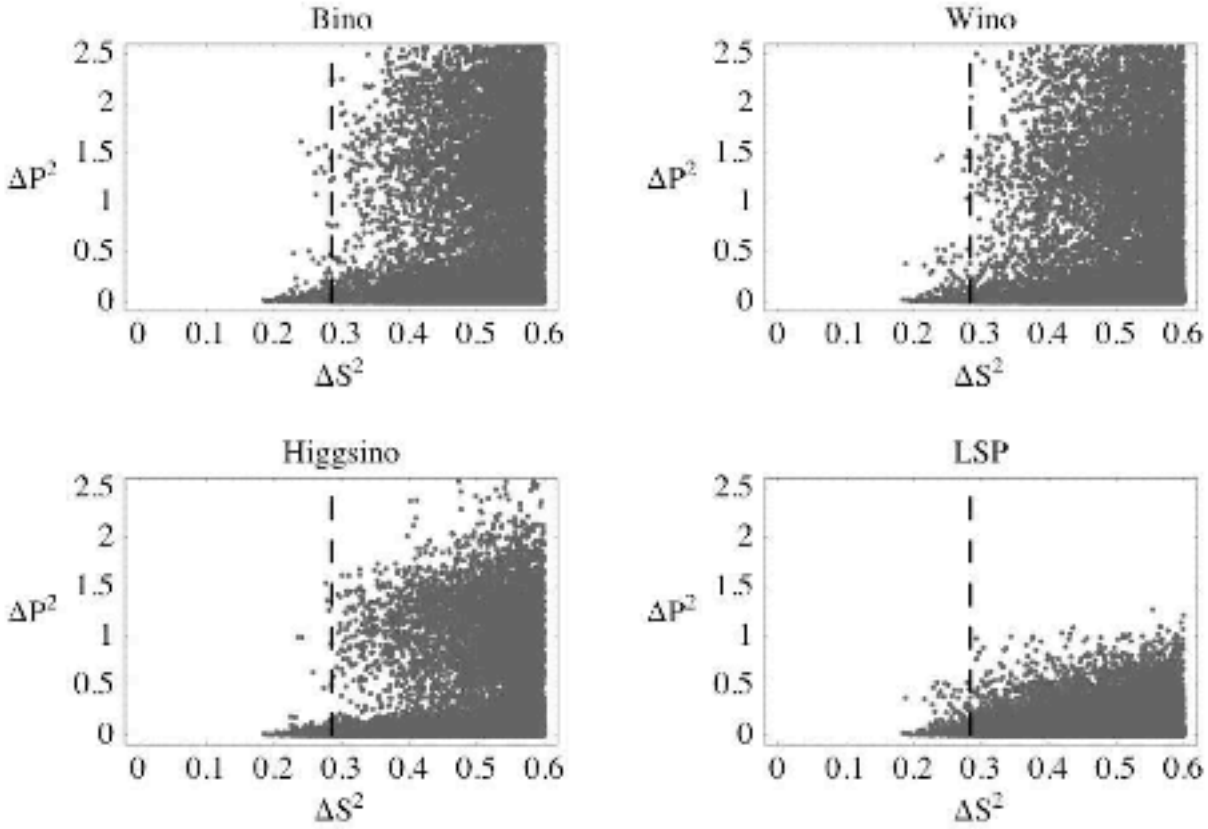
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How it was done.

- Event generation software by piping Pythia output into John Conways Pretty Good Simulator (PGS)
- Created a mathematica based data analysis package called Chameleon
- http://www.jthaler.net/olympics/software.html
- Extremely user friendly tools which are very useful for studying the hadron collider signals of any theory which can be simulated by Pythia. (eg a theorist with little experience with MC's can easily use these)
- To simulate so many models (each at $10 fb^{-1}$) used the Harvard Astro SAURON Cluster.

Conclusions

- We will have to face the LHC Inverse problem if LHC discovers any BSM physics

- These are questions for both theorists and experimentalists.
- I hope we can discuss them further.