Discovery of superpartners at Tevatron, LHC could be especially productive

--L_{soft} is determined by W, K, f, which in turn are generated as go to 4D world

-- so if we can measure L_{soft} maybe we can go the other way and learn about the 10D theory

-- also need to learn about phases since most masses in L_{soft} are complex

Further – Lagrangian masses mostly complex

- No known symmetry implies phases small – if the phases *are* small it tells us something basic
- Some phases constrained by EDMs, most not
- Phases affect superpartner masses, σxBR, higgs sector, dark matter, etc
- If set phases to zero when analyzing data can be very misleading (e.g higgs mass limit from LEP) – L. Wang, GK
- Need to develop techniques to search for existence of phases by consistency checks, looking for CPV effects in hadron collider data

So see signal

- String theorists: so what, we knew that, keep studying theory
- Just look at data and think a little?
- Not so simple!
  - Particularly at hadron collider, many obstacles
  - Usual methods cannot work!
    - Experiments measure masses of mass-eigenstates (usually mass differences), σ x BR, but those not in Lagrangian (e.g. rate for events with same sign dileptons with energies above 20 GeV and missing transverse energy above 100 GeV is 53fb)
    - At hadron colliders there are always more Lagrangian parameters than observables, so cannot in general solve for Lagrangian parameters such as soft-breaking masses (*actually best reason to want a linear collider)*
    - No general method known to measure tanβ (certain lucky situations may occur …), test gaugino mass degeneracy, etc

What was learned from LEP? Basically 3 things:

- Gauge coupling unification
- Global fit implies light fundamental higgs boson
- No deviations from SM numbers implies weakly coupled extension

-- All required major interaction of experiment and theory – none could be learned from data alone

--All suggest supersymmetric SM

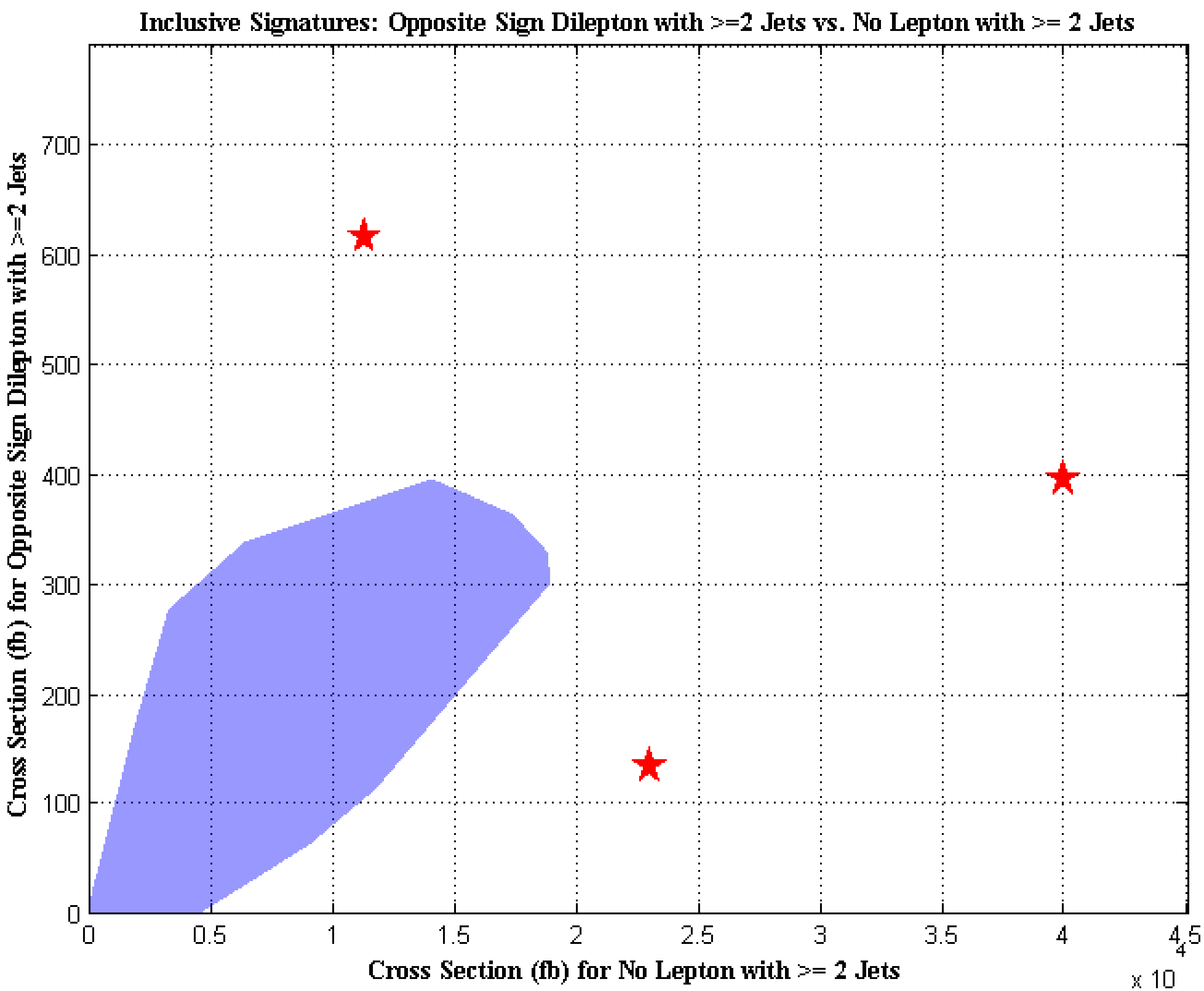
What will happen at LHC?

- First, a susy signal of some sort
- Then, like LEP – without big role of theory no clue to implications

What kind of information will experimenters report? How can we learn to interpret it?

- Show "inclusive signature" plots

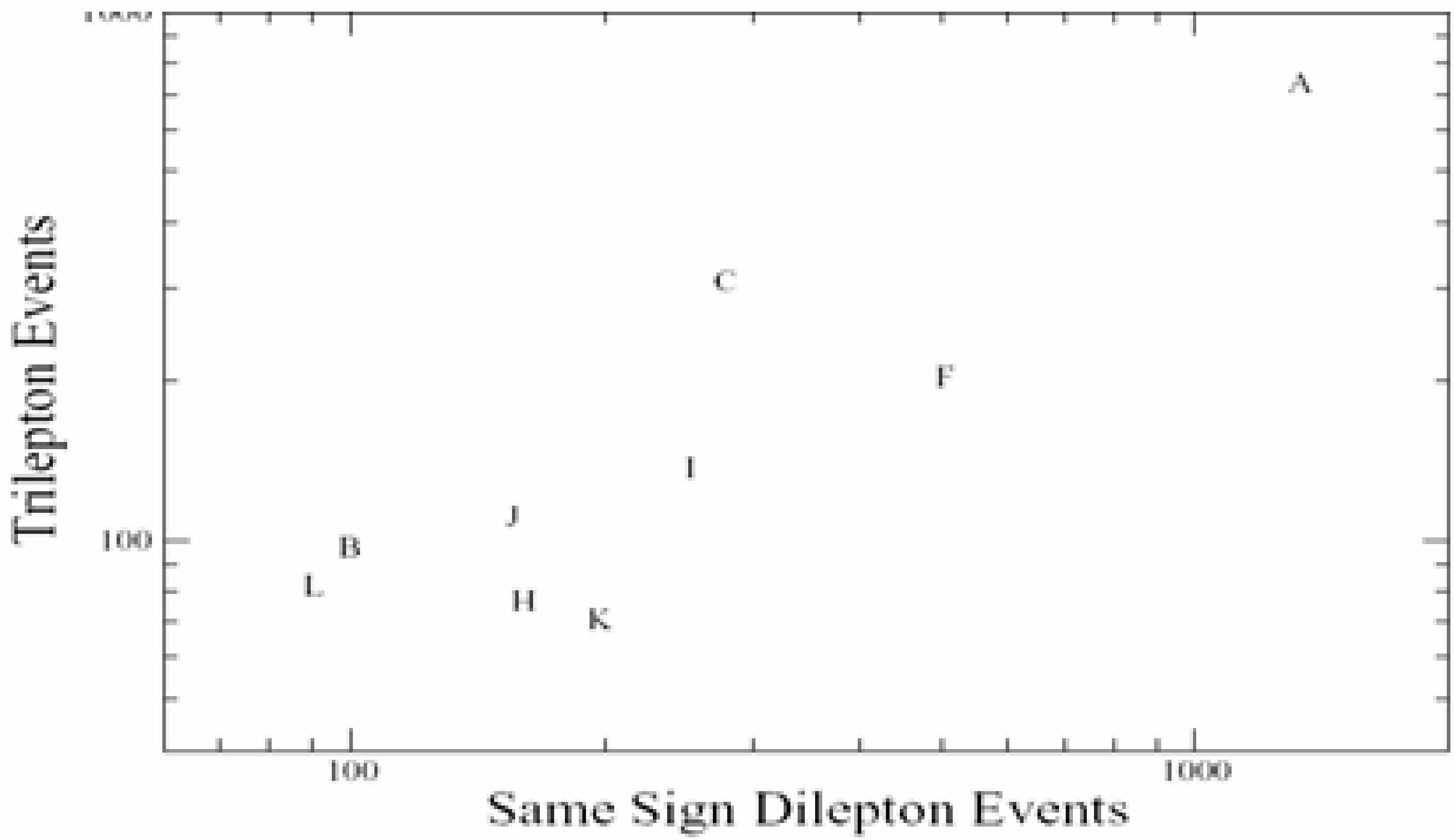
  main paper: Pierre Binetruy, GK, Brent Nelson, LianTao Wang, hep-ph/0312248, see for references
- Their pattern contains much information that usual approaches do not
- Collaborators also Jake Bourjaily, Piyush Kumar, Ting Wang
- All signatures have missing transverse energy > 100 GeV, so assume this removes all SM "background"



Inclusive Signatures: Opposite Sign Dilepton with >=2 Jets vs. No Lepton with >= 2 Jets
Cross Section (fb) for Opposite Sign Dilepton with >=2 Jets
Cross Section (fb) for No Lepton with >= 2 Jets
0
100
200
300
400
500
600
700
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
x 10^4

- mSUGRA must lie in blue region, for any parameter values
- Easy to lie outside that region – red stars are string constructions
- Make such plots for many observables – every hypothesis covers some region that does not cover area

Can get more systematic, study underlying theories (letters are string constructions)

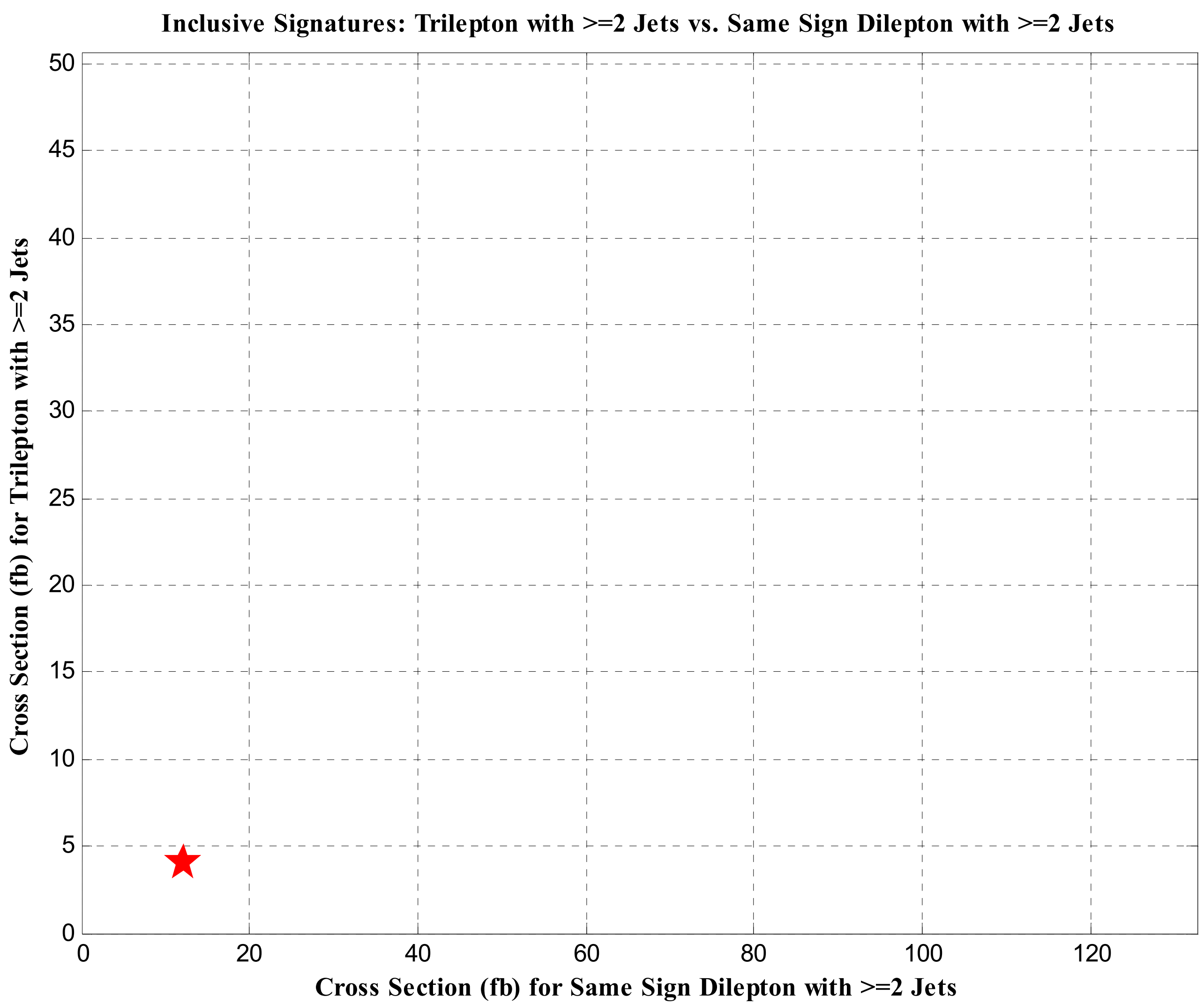


- High scale theory
- RGEs to get low scale, calculate spectrum, e.g. SUSPECT2 (Djouadi, Kneur, Moultaka)
- PYTHIA to produce events, impose cuts, etc

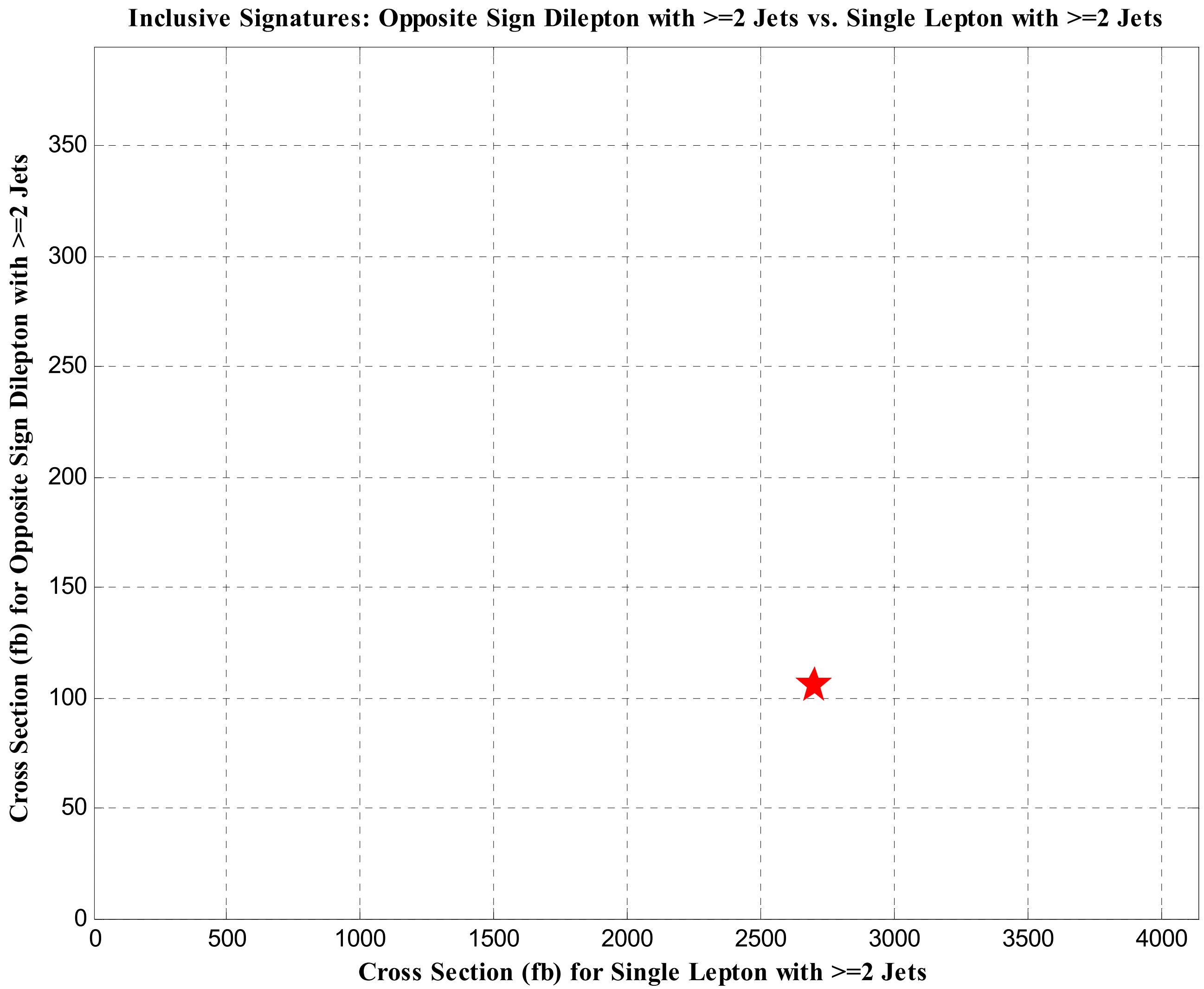
- With data, hope to reverse direction

LHC STRETCHING EXERCISE

LHC HAS RUN FOR A WHILE, NEXT WE SUMMARIZE THE INITIAL RESULTS FOR OBSERVED SIGNALS BEYOND THE STANDARD MODEL



Inclusive Signatures: Trilepton with >=2 Jets vs. Same Sign Dilepton with >=2 Jets
Cross Section (fb) for Trilepton with >=2 Jets
Cross Section (fb) for Same Sign Dilepton with >=2 Jets
0
5
10
15
20
25
30
35
40
45
50
0
20
40
60
80
100
120



Inclusive Signatures: Opposite Sign Dilepton with >=2 Jets vs. Single Lepton with >=2 Jets
Cross Section (fb) for Opposite Sign Dilepton with >=2 Jets
Cross Section (fb) for Single Lepton with >=2 Jets
0
50
100
150
200
250
300
350
0
500
1000
1500
2000
2500
3000
3500
4000

Inclusive signatures

($10\ fb^{-1}$ =1yr, $10^{33}\ cm^{-2}sec^{-1}$)

CROSS SECTION fb	2 jets	3 jets	>3 jets
0 leptons	33036	5874	373
1 lepton	2292	393	20
OS dileptons	89	16	0
SS dileptons	4	8	0
trileptons	0	4	0

- For opposite sign dilepton channels, the dilepton invariant mass distribution has its end point at 20 GeV

- For channels without leptons, the sum of missing E_T and P_T of all jets has its peak at 715 GeV

CUTS

- $\eta<3$ for jets
- $R>0.7$
- Jets have $E_T>100$ GeV
- Leptons $=e,\mu$ with $\eta<5$ and $p_T>20$ GeV
- Lepton isolation, E_T within a cone of $R=0.3<5$ GeV
- Missing $E_T>100$ GeV
- Transverse plane angle between missing E_T and closest jet $> 15^\circ$

REMEMBER

- String phenomenology is here to stay – domain should be expanded
- Learning implications of LHC data will take serious effort and thinking – start learning and thinking now