Title: LHC

Date: Mar 30, 2005 05:00 PM

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Abstract:

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 – perhaps can do that from EDMs and from studying CPV at LHC – and also from non-CPV at LHC and from DM detection

Further – Lagrangian masses mostly complex

- No known symmetry implies phases small – if the phases *are* small it tells us something basic
- Phases enter 4D effective theory via compactification geometry or complex F-term vevs
- 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

Note here masses, rates depend on phases

- Example: consider charginos

$$\mathrm{M}_{\tilde{C}} = \begin{pmatrix} M_2 e^{i\phi_2} & \sqrt{2} M_W \sin\beta \\ \sqrt{2} M_W \cos\beta & \mu e^{i\phi_\mu} \end{pmatrix}$$

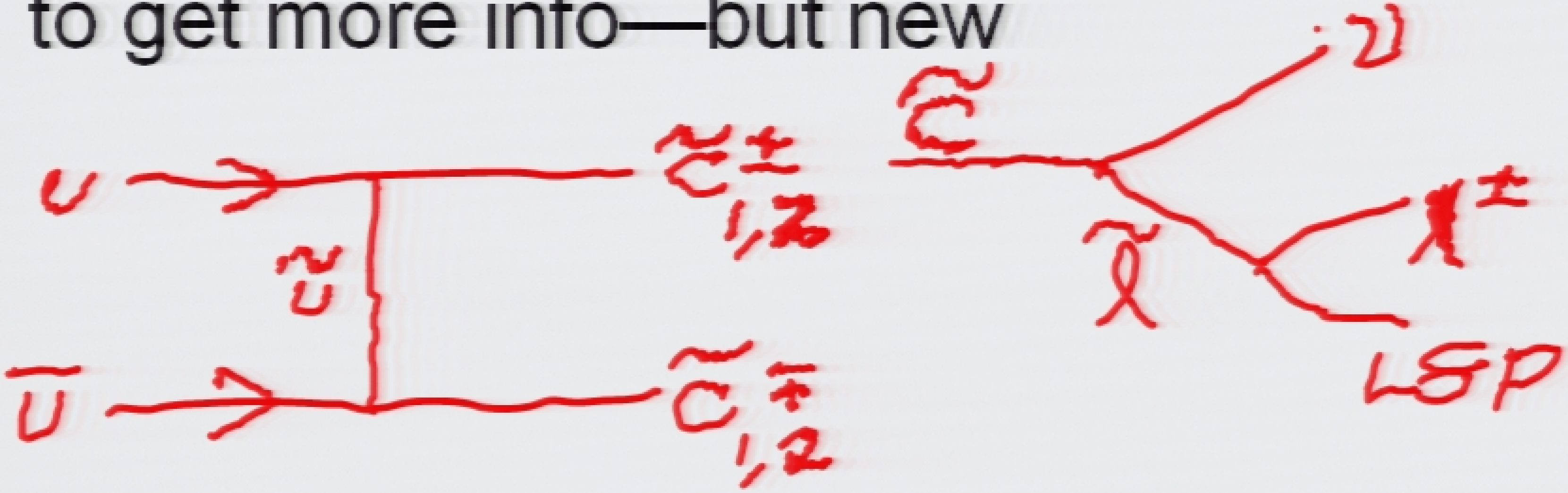
$$M^2_{\tilde{C}_1} + M^2_{\tilde{C}_2} = Tr M^\dagger_{\tilde{C}} M_{\tilde{C}} = M_2^2 + \mu^2 + 2M_W^2$$

$$M^2_{\tilde{C}_1} M^2_{\tilde{C}_2} = Det M^\dagger_{\tilde{C}} M_{\tilde{C}} =$$

$$M_2^2 \mu^2 + 2M_W^4 \sin^2 2\beta - 2M_W^2 M_2 \mu \sin 2\beta \cos(\phi_2 + \phi_\mu)$$

- Four unknowns, two observables—can't invert!
- Masses, cross sections depend on phases

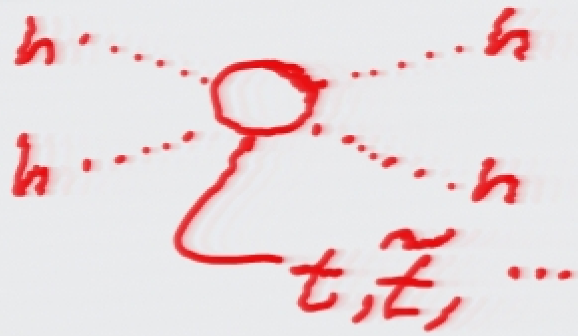
- Add cross sections for chargino production to get more info—but new



parameters enter, process does not converge

- What about Higgs sector?
- V=tree level +

$m_h < m_Z$



- → at least 7 parameters important, tanβ, μ, $m^2_{H_u}$, $m^2_{H_d}$, A_t, $\varphi_\mu - \varphi_{A_t}$, $m_{\tilde{t}}$
- So at least 7 observables needed to invert

Use *patterns* of "inclusive signatures"

	GravMSB large μ	GravMSB small μ	Gauge MSB	Dilaton DSB		
SS dileps	yes	yes	yes	yes		
Prompt γ's	no	maybe	yes (but)	no		
Trileps	yes	no	no	yes		
B-rich						
OS dileps						

Data-related major advantages of using inclusive signature approach

- Define: Inclusive Signature is one that is really measurable, summed over all ways
- Some systematic errors drop out (or get less important when comparisons of rates are plotted

  --Don't need absolute cross section normalization, so less need for knowledge of beam luminosity!

  --Corrections to jet energies less important!

  --By comparing full rates don't reduce statistics, detailed detector simulations less important

So see signal

- String theorists: so what, we knew that
- Just look at data and think a little?
- Not so simple!
  - Particularly at hadron collider, many obstacles
  - Usual methods unlikely to work!
    - Experiments measure masses of mass-eigenstates (usually mass differences), σ x BR, but those not in Lagrangian
    - 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 will happen at LHC?

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

Existing LHC studies to interpret data cover little, less than meets the eye

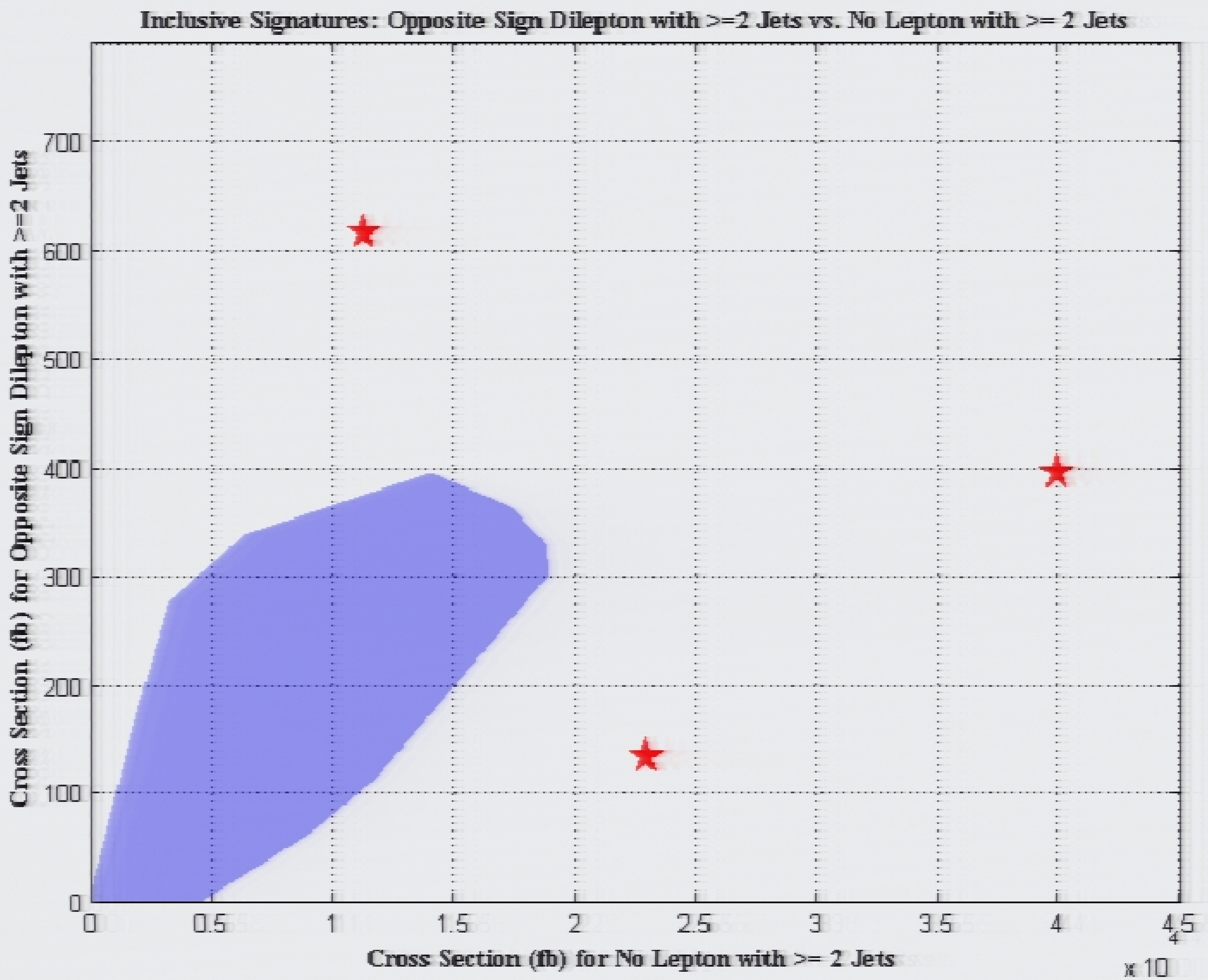
- Almost all use “mSUGRA”, with 4 real parameters $M_0, M_{1/2}, \mu, A$
  - Poorly motivated
  - Doesn’t emerge normally from high scale theory

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

- Show "inclusive signature" plots

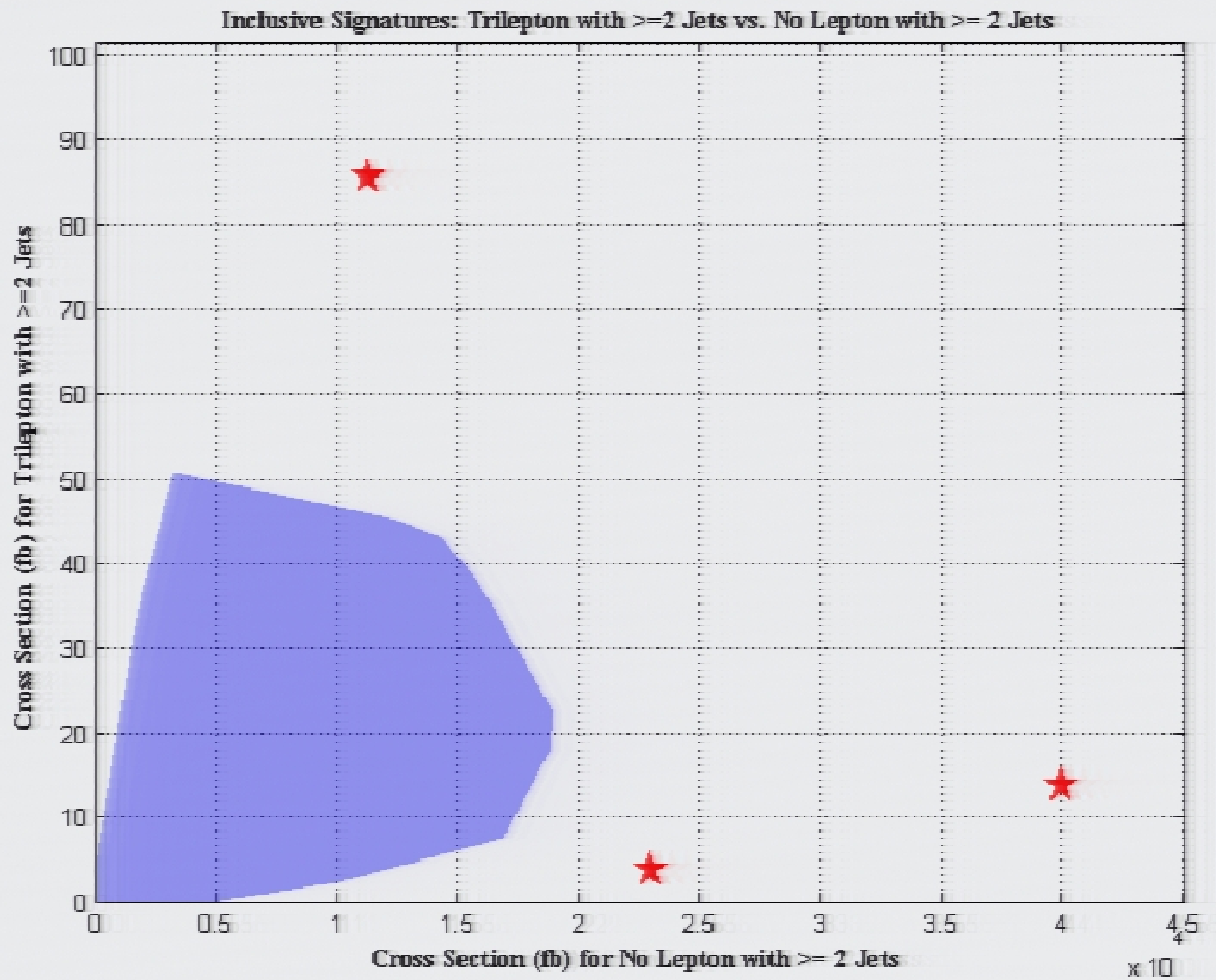
  Pierre Binetruy, GK, Brent Nelson, LianTao Wang, hep-ph/0312248

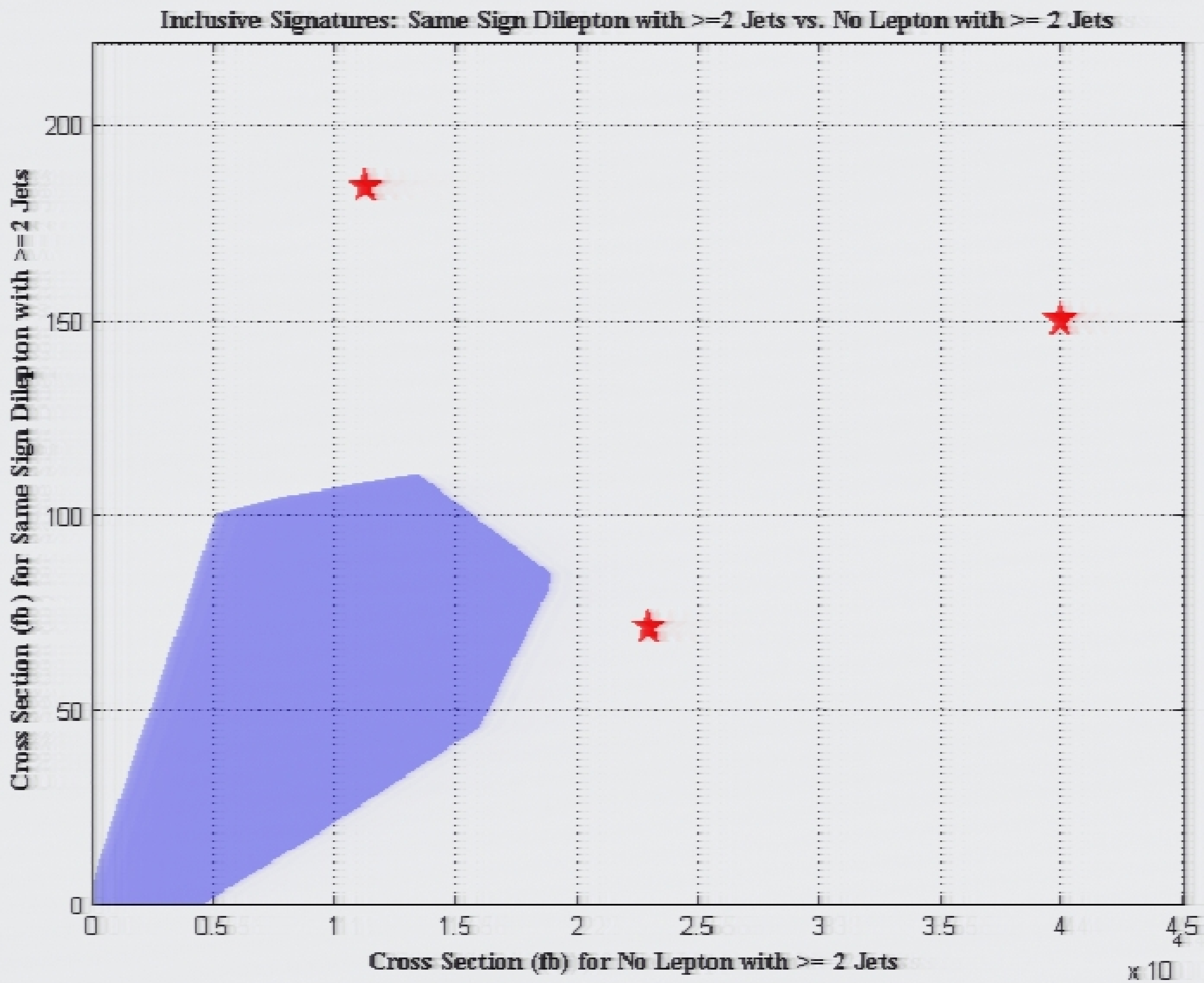
- Their pattern contains much information that usual approaches do not
- Collaborators also Jake Bourjaily, Piyush Kumar, Ting Wang
- All signatures have missing transverse energy > 100 GeV, so assume this removes all SM "background"


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

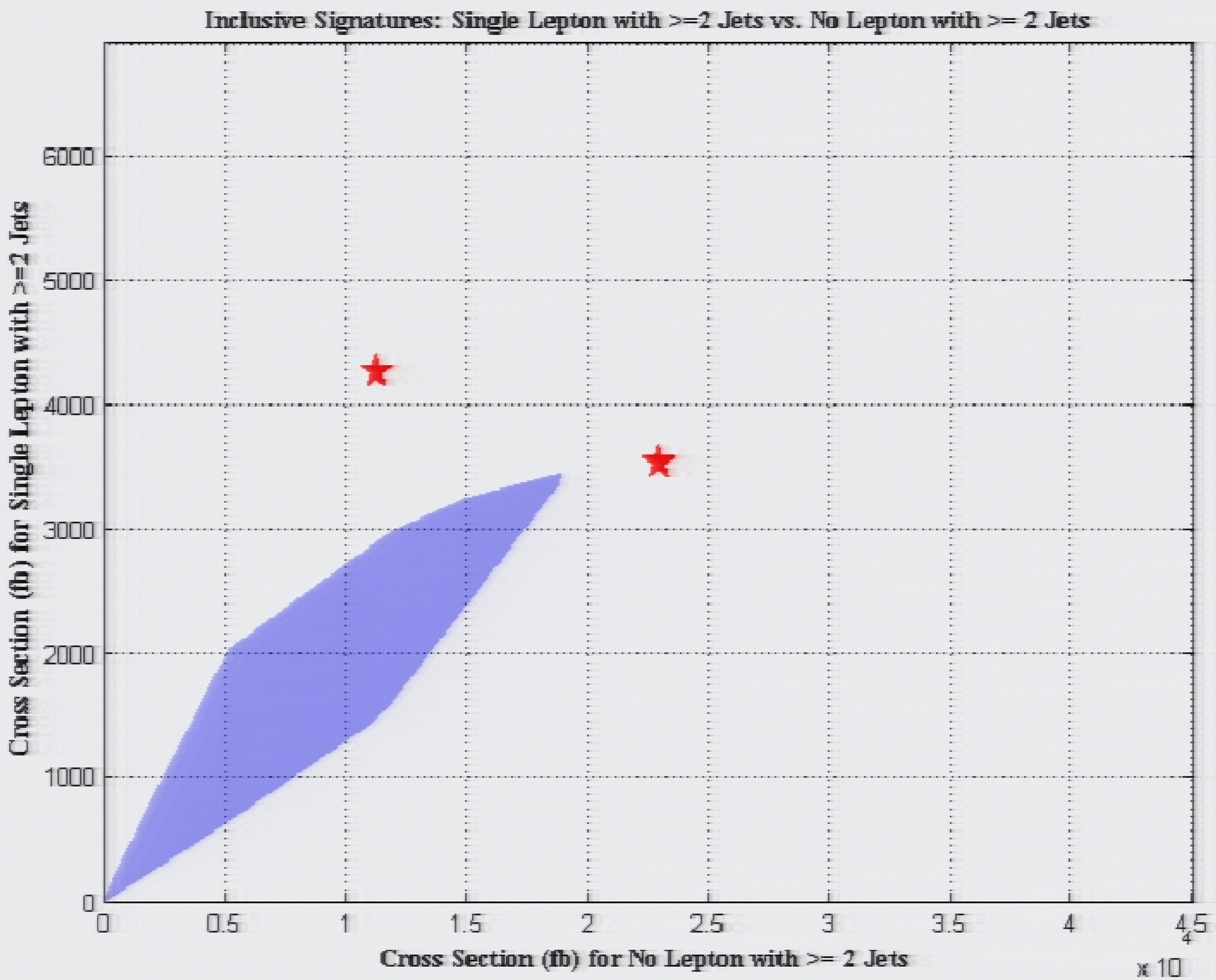
- High scale theory
- RGEs to get low scale, calculate spectrum, e.g. SUSPECT2 (Djouadi, Kneur, Moultaka)
- PYTHIA to produce events, impose cuts, etc

- Important for theorists to work on reducing obstacles to connecting low scale and high scale information


Inclusive Signatures: Trilepton with >=2 Jets vs. No Lepton with >= 2 Jets
Cross Section (fb) for Trilepton with >=2 Jets
Cross Section (fb) for No Lepton with >= 2 Jets
x 10^4
0
10
20
30
40
50
60
70
80
90
100
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5

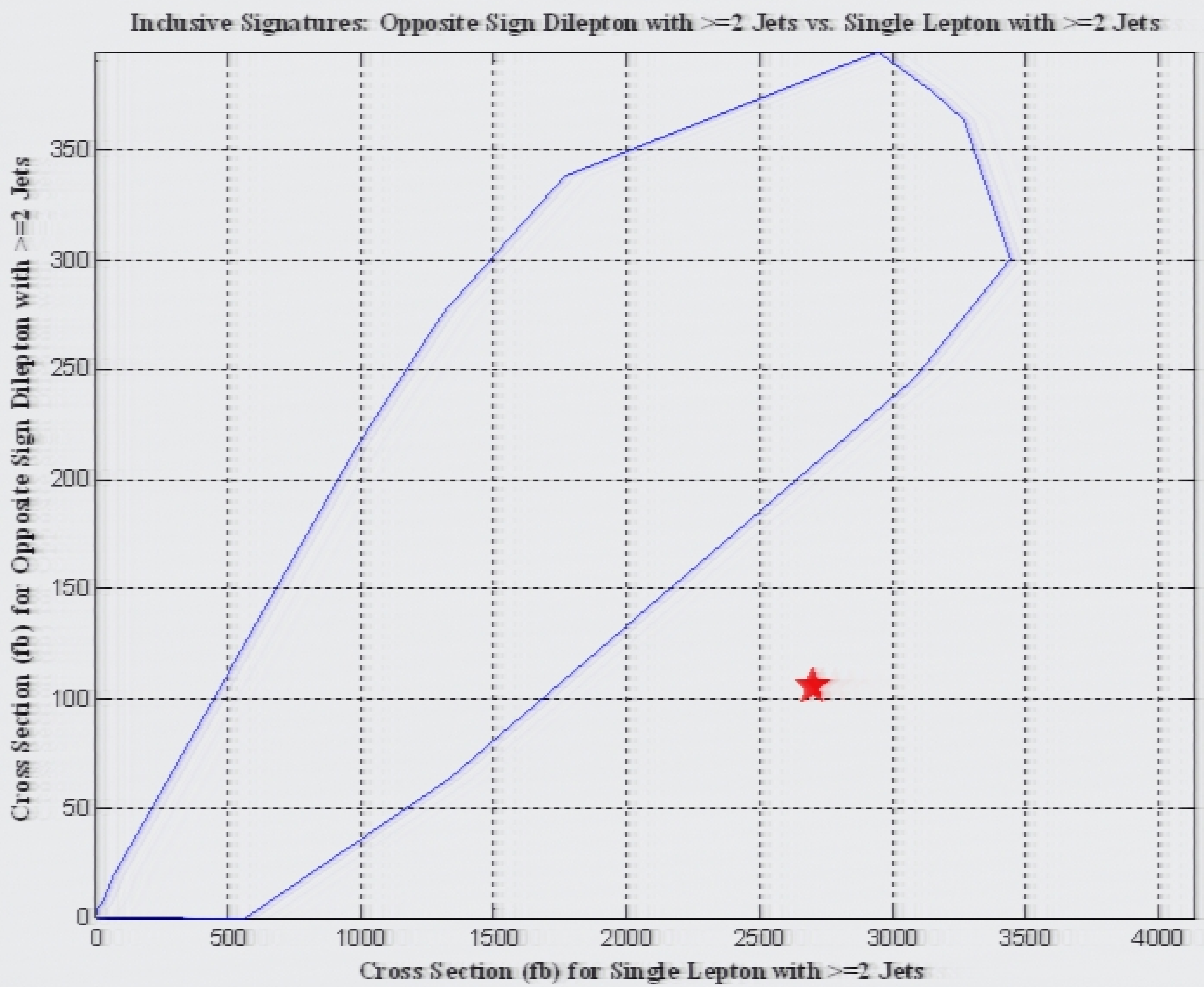


Inclusive Signatures: Same Sign Dilepton with >=2 Jets vs. No Lepton with >= 2 Jets
Cross Section (fb) for Same Sign Dilepton with >=2 Jets
Cross Section (fb) for No Lepton with >= 2 Jets
0
50
100
150
200
0.5
1
1.5
2
2.5
3
3.5
4
4.5
x 10^4


Inclusive Signatures: Single Lepton with >=2 Jets vs. No Lepton with >= 2 Jets
Cross Section (fb) for Single Lepton with >=2 Jets
Cross Section (fb) for No Lepton with >= 2 Jets
6000
5000
4000
3000
2000
1000
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
x 10^4

LHC STRETCHING EXERCISE

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

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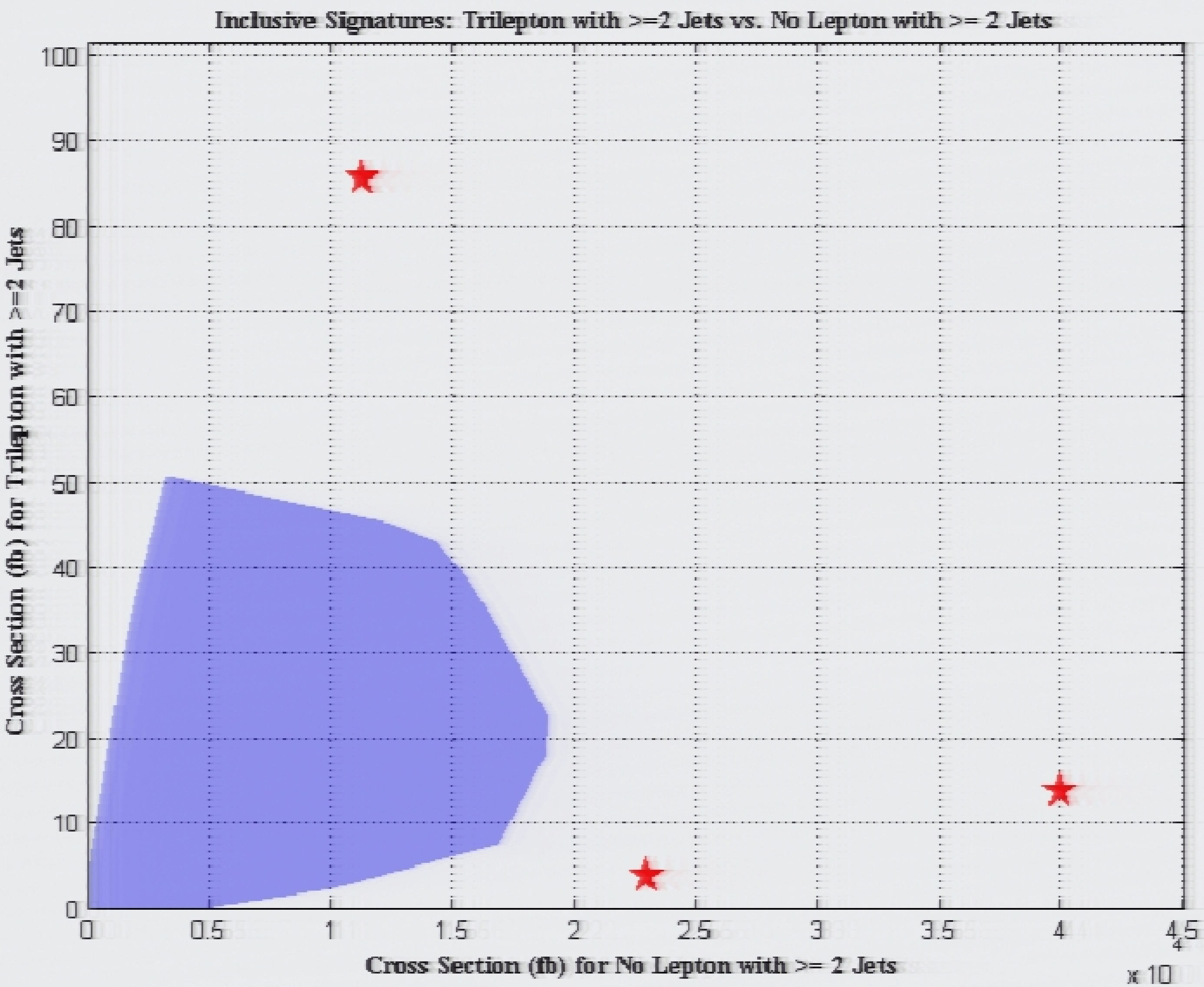

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Cross Section (fb) for Trilepton with >=2 Jets
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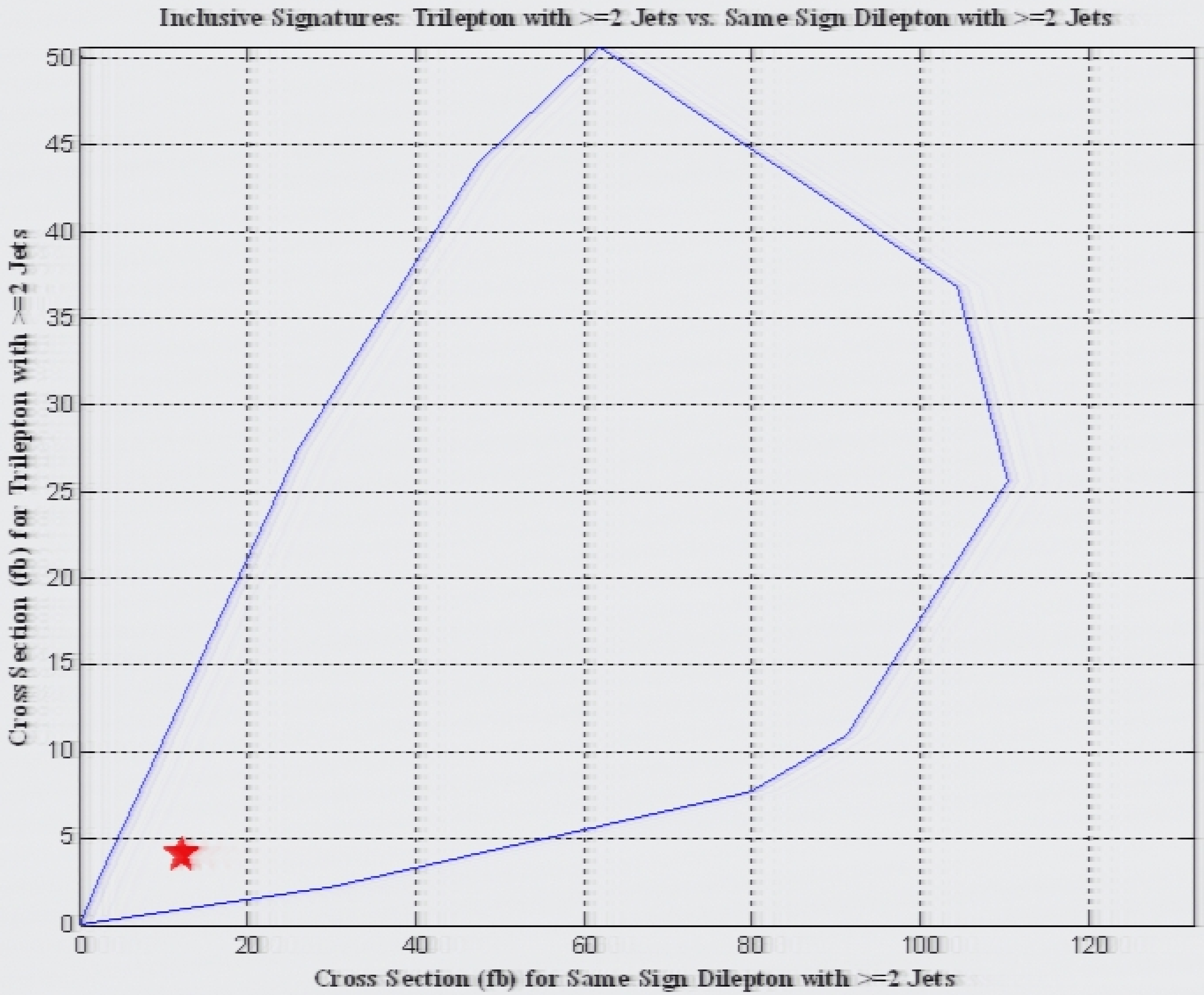
100
90
80
70
60
50
40
30
20
10
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
x 10^4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Cross Section (fb) for Trilepton with >=2 Jets
Cross Section (fb) for Same Sign Dilepton with >=2 Jets
0
5
10
15
20
25
30
35
40
45
50
0
20
40
60
80
100
120

Inclusive signatures

(10 fb =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

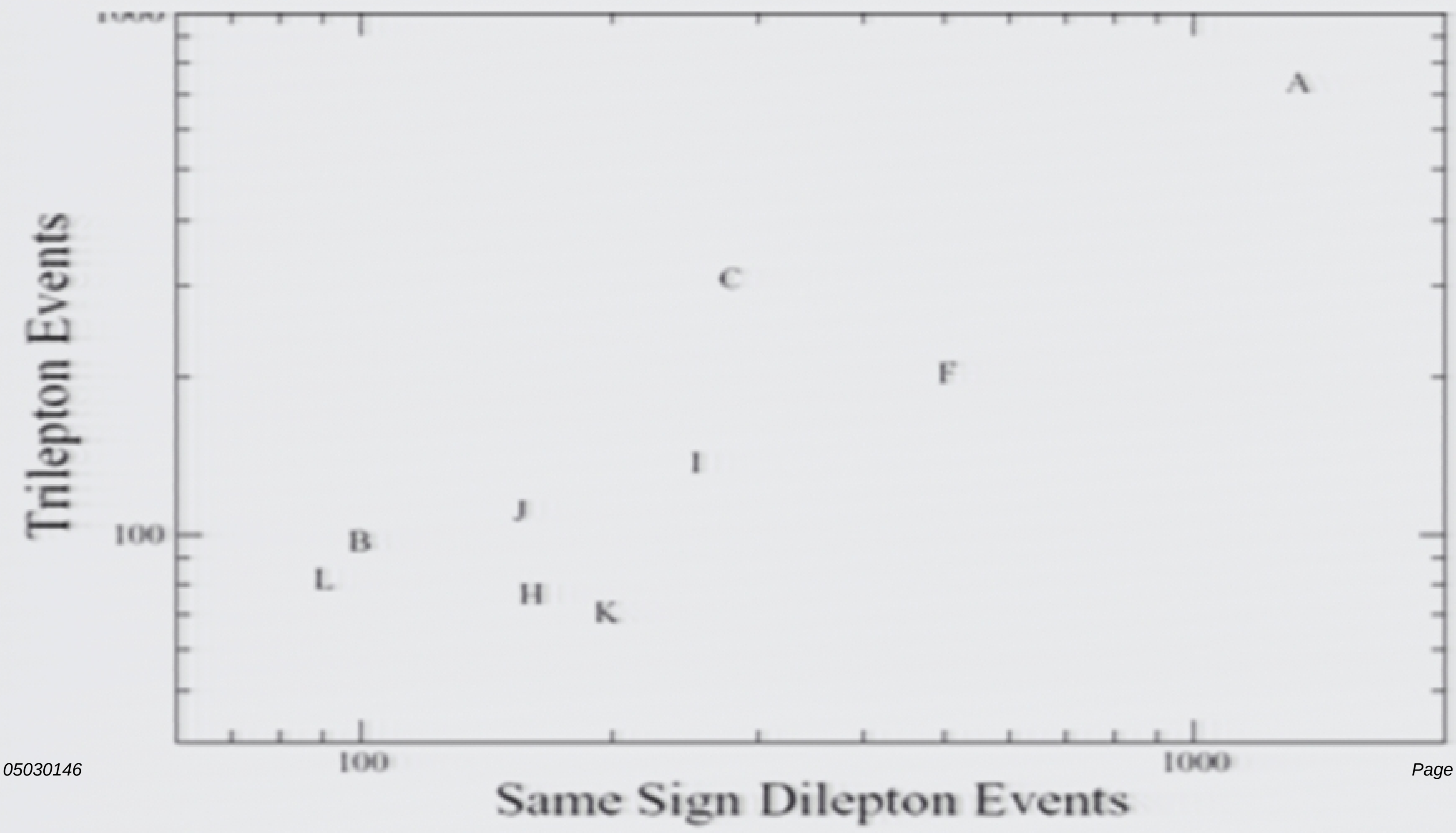
- For opposite sign dilepton channels, the dilepton invariant mass distribution has its end point at 20 GeV

- 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,μ 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°

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



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

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