Some recent activities – Gordy Kane

CERN, Aug 2009

➢ Measure gluino (or …) *spin early* by using production cross section information

➢ Test relations among high scale gaugino masses at LHC with footprint analysis, even though cannot measure individual gaugino masses

➢ 4-top signatures

➢ [Wino LSP (M~180 GeV) plus generic astrophysics describes PAMELA, Fermi data well, implies universe has non-thermal history – dwarf galaxy and LHC predictions and tests] – SEPARATE TALK

A. Measure gluino spins from production cross section with little data -- 0805.1397 GK, Petrov, Shao, Wang

-- GK, Kuflik, Shao, Wang, in progress

Discovery at LHC --***Is it supersymmetry*** (or whatever)?? – classic way to tell is to measure the spin of a partner

Use production cross section information to measure spins of larger effects – works because spin quantized and effects large

Clearly works for isolated effects – i.e. for many ways the world might be – requires few hundred pb^{-1} or less
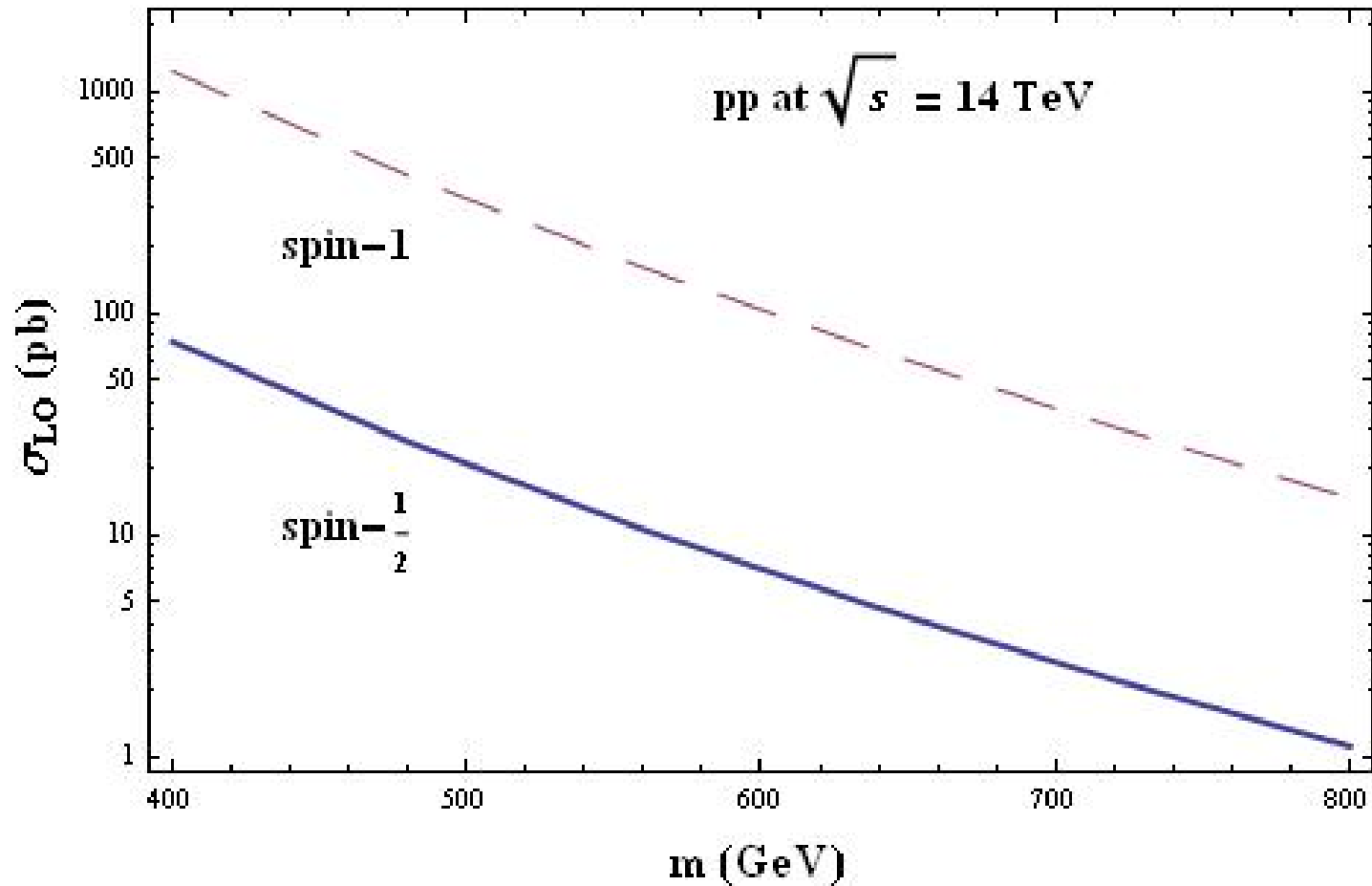
- Paper shows also works for cases where really observe mass difference, by using other data – still works for $\sim$ 1 fb^{-1}

- Currently studying effects of producing several states of similar mass, and needed luminosity in some familiar benchmark models

Works to measure top quark spin

Cross Section (pb)

$t_s \bar{t}_s$

$t\bar{t}$

D0

CDF
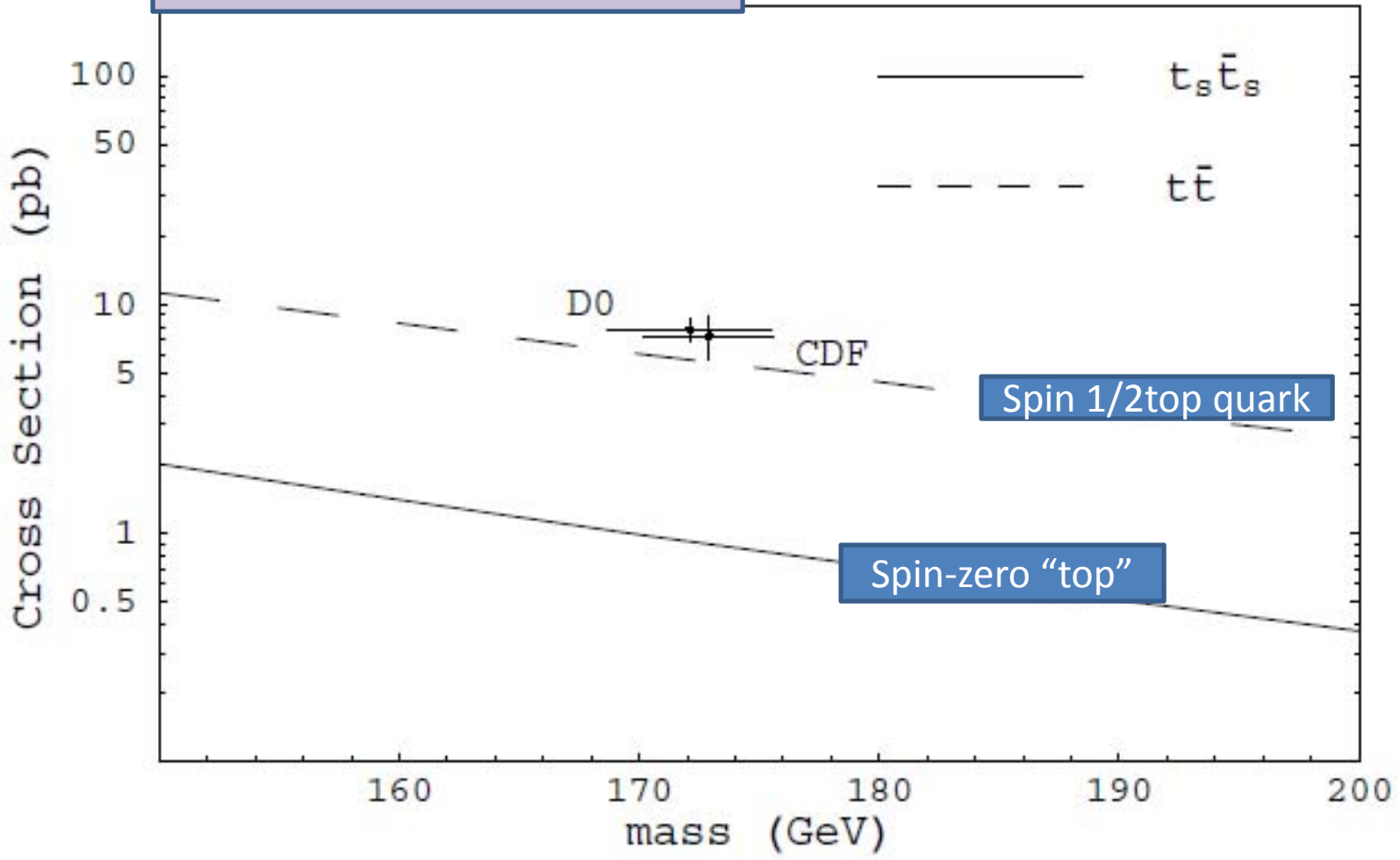
Spin 1/2 top quark

Spin-zero "top"

mass (GeV)

A plot of the cross sections for gluino (spin-half) pair production (solid line) and KK-gluon (spin-one) pair production (dashed line) at LHC. In the calculation, the masses of extra color triplet quark partners are taken to be 5 TeV.

Hierarchy:

$$m_{\tilde{g}} > m_{\tilde{u}_{L,R}}, m_{\tilde{d}_{L,R}} > m_{\tilde{W}^\pm}, m_{\tilde{W}^3} > m_{\tilde{l}}, m_{\tilde{\nu}} > m_{\tilde{B}}$$

Spectrum

$$m_{\tilde{g}} = 880 \text{ GeV} \quad m_{\tilde{q}} = 700 \text{ GeV}$$
$$m_{\tilde{W}} = 270 \text{ GeV} \quad m_{\tilde{l}} = 170 \text{ GeV} \quad m_{\tilde{B}} = 70 \text{ GeV}$$
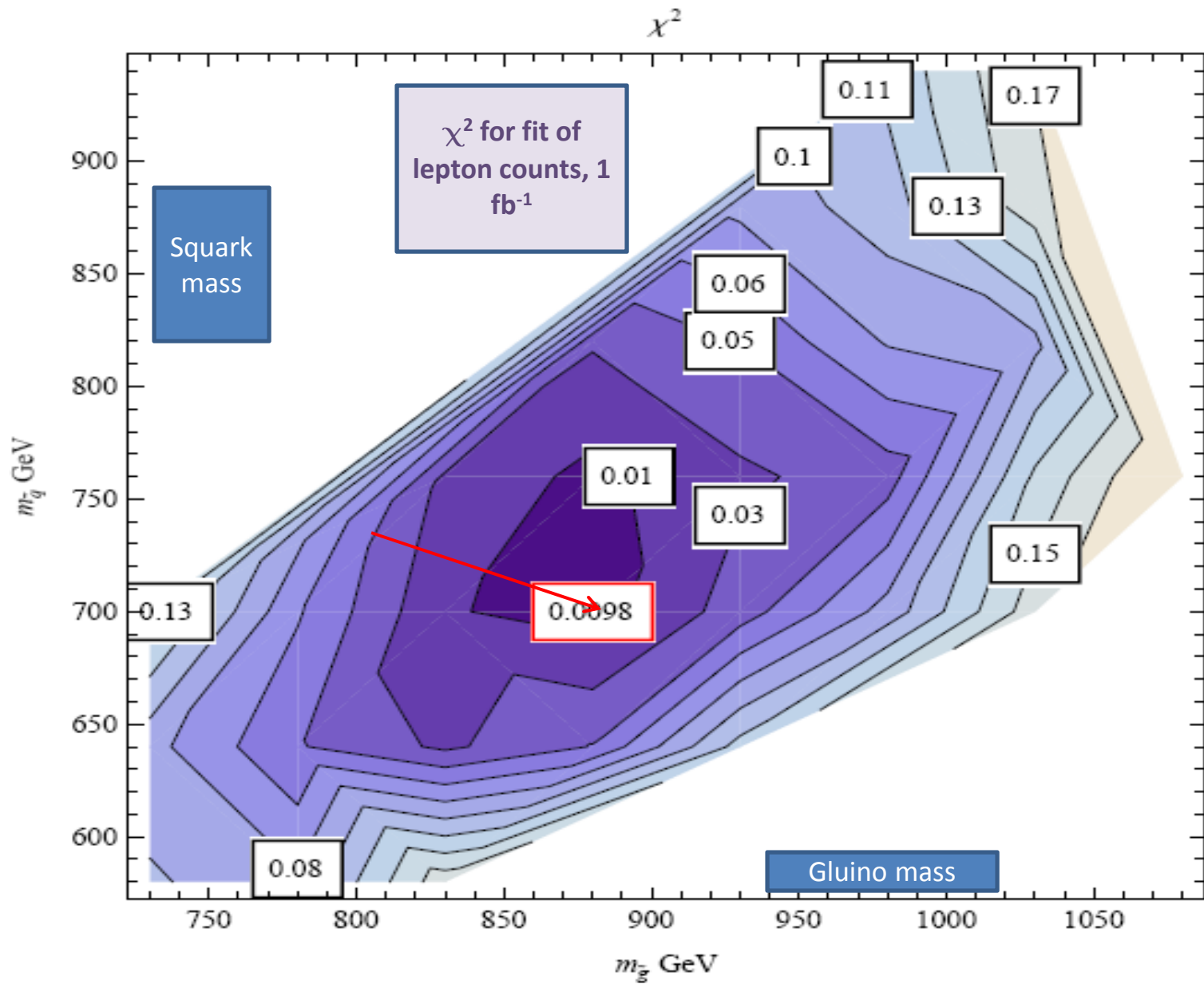
Cuts:

- $P_T > 20$ GeV on all Leptons

- Missing $P_T > 100$ GeV

- At least 2 Jets with $P_T > 50$ GeV

At 1 fb^{-1}

> *Suppose several states of same mass produced* --Assume a hierarchy, measure ratios of leptonic counting rates, look for good fit to spectrum, test consistency

	1-Lepton	2-Leptons				3-Leptons
$\tilde{g}\tilde{g}$	+: 52	OSSF: 28	SSSF+: 2	SSDF+: 2		++-: 3
	+: 51	OSSF: 3	SSSF-: 2	SSDF-: 2		- - +: 3
$\tilde{g}\tilde{q}$	+: 558	OSSF: 253	SSSF+: 23	SSDF+: 24		++-: 35
	+: 380	OSSF: 35	SSSF-: 11	SSDF-: 10		- - +: 24
$\tilde{q}\tilde{q}$	+: 385	OSSF: 181	SSSF+: 17	SSDF+: 17		++-: 33
	+: 218	OSSF: 38	SSSF-: 5	SSDF-: 5		- - +: 21

			+/1Lep	-/1Lep		
			0.605	0.395		

OSSF/2Lep	OSDF/2Lep	SSDFP/2Lep	SSDFM/2Lep	SSSFP/2Lep	SSSFM/2Lep
0.700	0.116	0.0652	0.0269	0.0656	0.0256

			+ + -/3Lep	- - +/3Lep		
			0.596	0.404		

χ^2

χ^2 for fit of lepton counts, 1 fb^{-1}

Squark mass

Gluino mass

$m_{\tilde{q}}$ GeV

$m_{\tilde{g}}$ GeV

0.11 0.17

0.1

0.13

0.06

0.05

0.01

0.03

0.15

0.13

0.0098

0.08

B. LHC high scale soft-breaking gaugino mass relations -- arXiv:0901.1145 Brent Nelson, GK, Grajek, Altunkaynak, Holmes
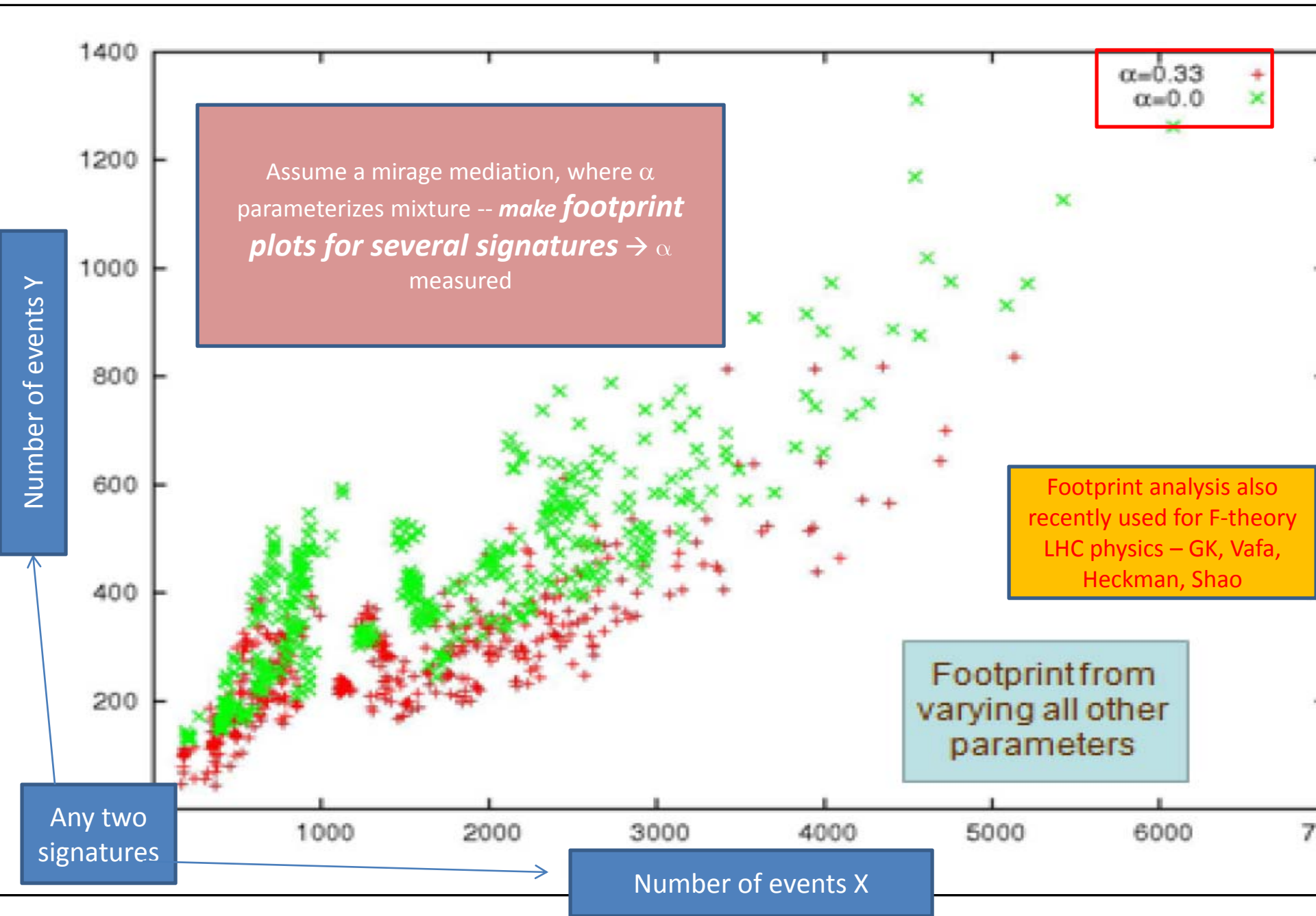
Testing hypotheses about relations among gaugino masses is of great interest once there is data
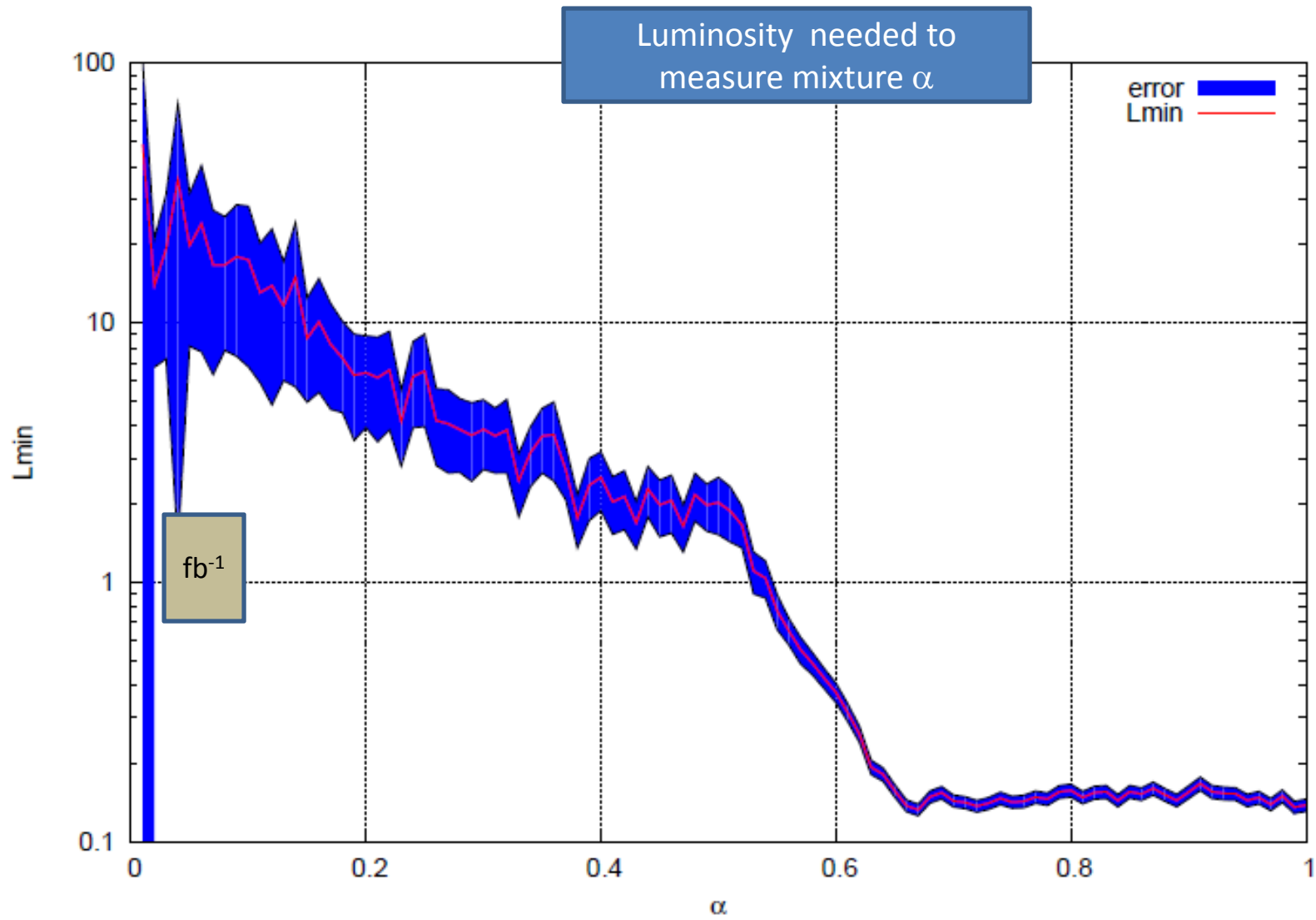
But measuring soft gaugino masses M1, M2, M3 unlikely, and measuring high scale ones very unlikely

We show that nevertheless it is not hard to test the hypotheses using footprint analyses

Method can be generalized to many issues about implications of data for underlying theory – e.g. squark mass sum rules, LSP wavefunction

Assume a mirage mediation, where α parameterizes mixture -- *make **footprint plots for several signatures** $\rightarrow$ α* measured

Footprint analysis also recently used for F-theory LHC physics – GK, Vafa, Heckman, Shao

Footprint from varying all other parameters

Any two signatures

Number of events Y

Number of events X

$\alpha=0.33$ +
$\alpha=0.0$ ×

Luminosity needed to measure mixture α

C. Four top signatures -- Some well-motivated models have produced particles that decay to tbar-t-X

[e.g. M-theory compactified on G_2 manifold →such a gluino decay has BR > 1/2]

Then generically produce a pair, and final state has 4 W's and 4 b's and large missing energy

[in G_2 case X=N2→"W"+N1, nearly real W, so 6 W's]

4-top counting and reconstruction analysis

- ***Early discovery of signal beyond the SM easy with 4 b's and 4-6 W's per event, just counting***
- SM fakes unlikely when include many jets, some leptons, large missing energy
- Same sign dilepton channel very good
- Reconstruction of tops hard, but relative decay BR of tt, tb, bb states useful to suggest multitops
- Get information on gluino mass and cross section