Early new physics with jets at the LHC

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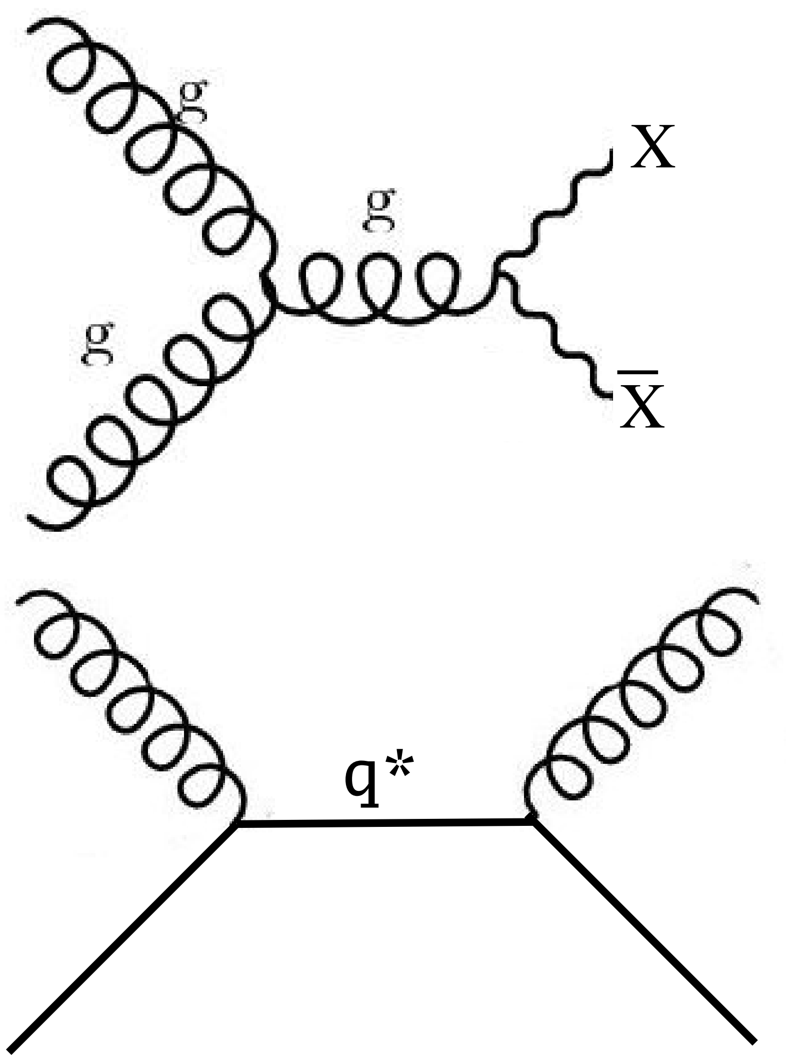
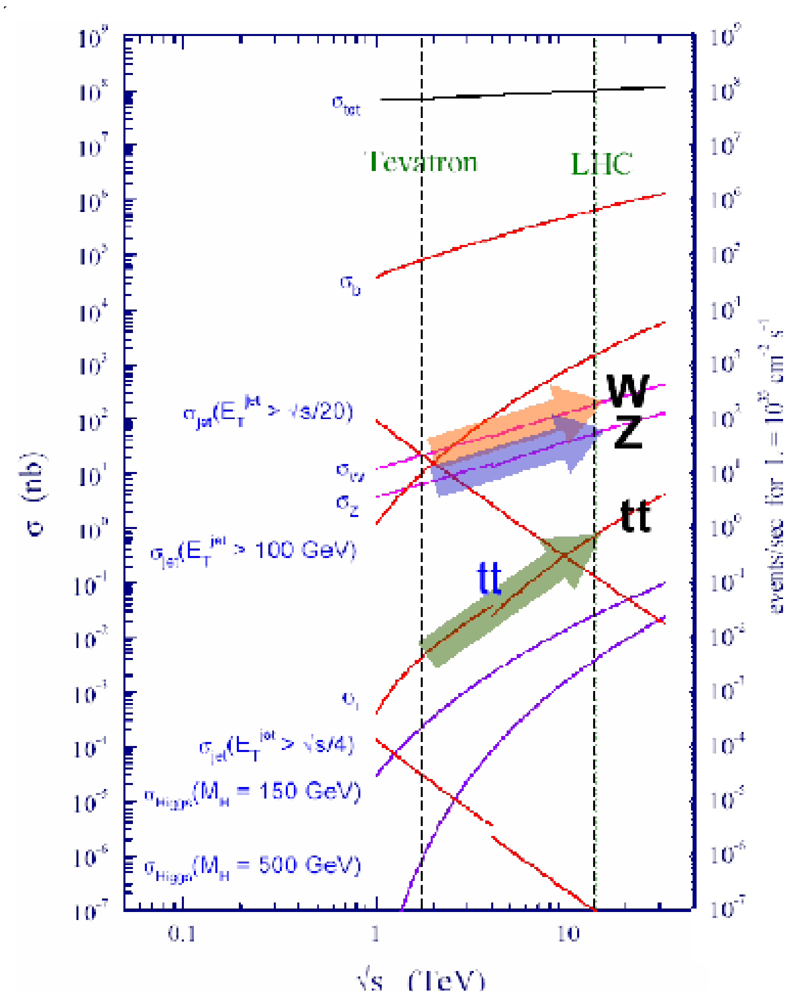
Why Jets?



Strongly coupled particles:
- Pair production
- resonances

=> high production cross sections

=> color conservation leads to jets in final state



- Large QCD/jet xsec at the LHC
- Triggering difficult for pure jet final states (only possible for high E_T final states)
- Low signal to background ratio for pure jet final states (worse at low E_t)

=> look at very high E_t

=> focus on semileptonic final states

Dijet resonance

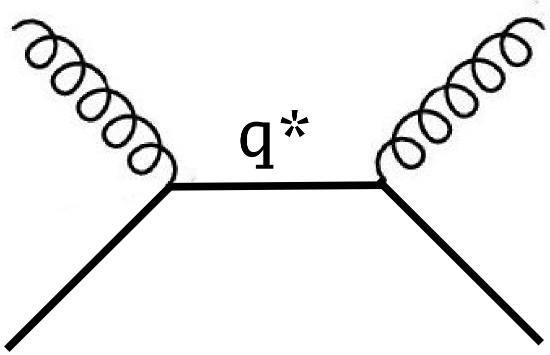
- high E_t
- no leptons

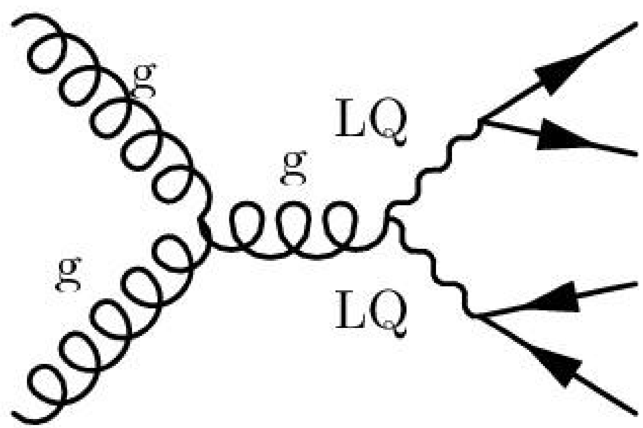
Leptoquarks

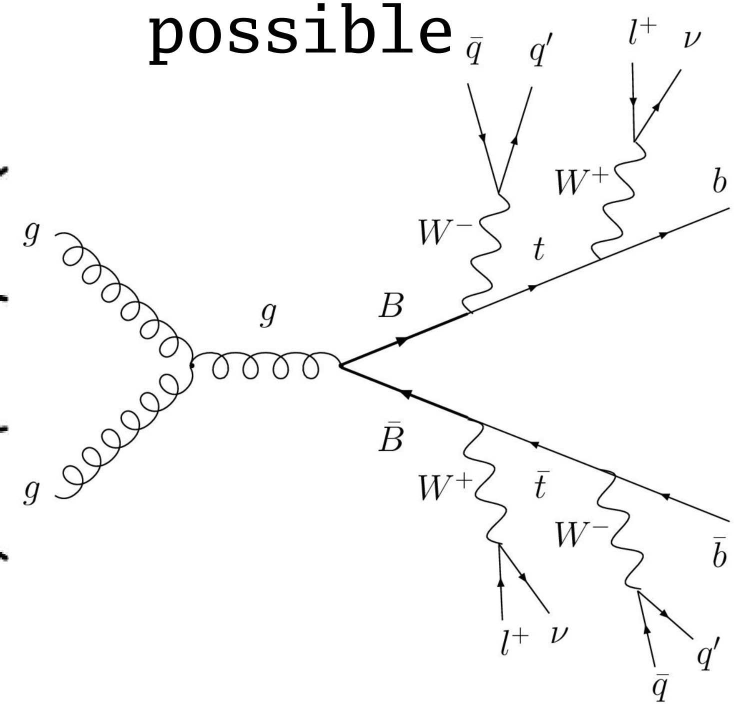
- same flavor leptons
- opposite charge leptons

4^{th} generation quarks

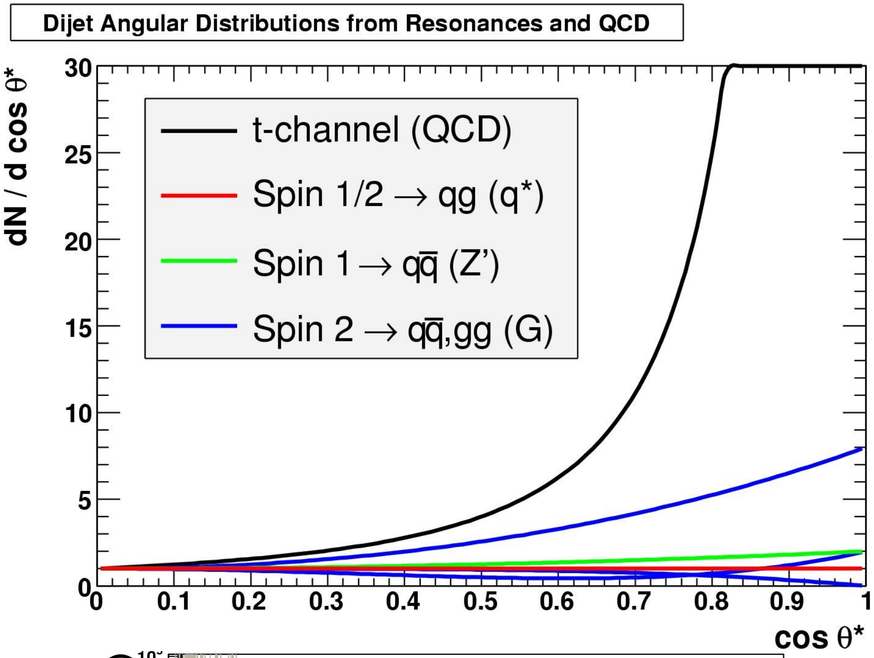
- low E_t
- mixed flavors possible
- same sign leptons possible

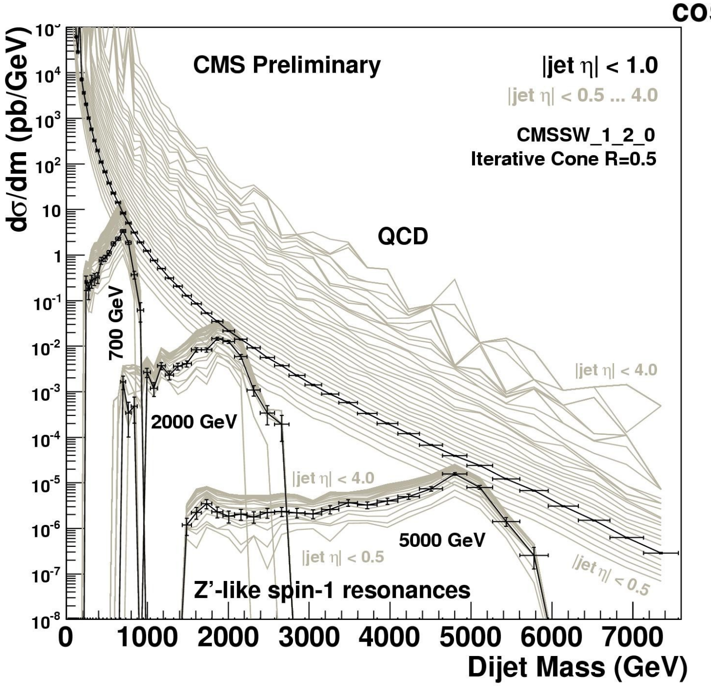






Analysis Strategy: Resonance





QCD Background:
- large
- not well known

=> use angular dist.
- QCD: forward
- Resonances: central

=> optimize fwd vs. bckwd region for best sensitivity

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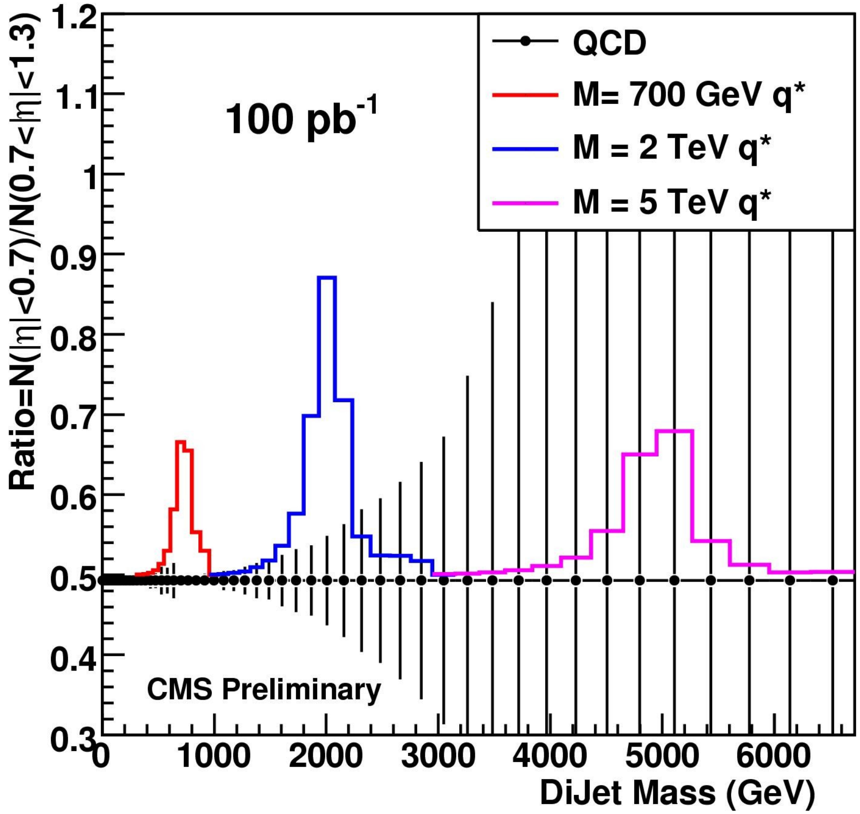
Reach: Dijet Resonance

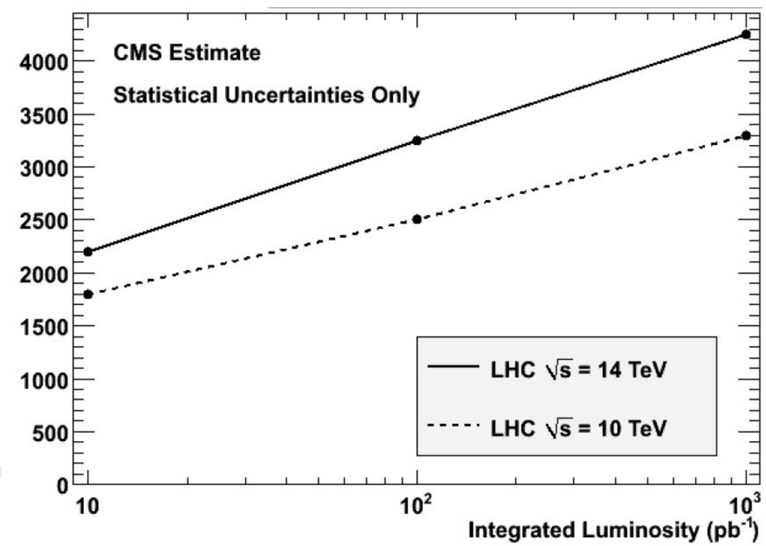


SBM-07-001

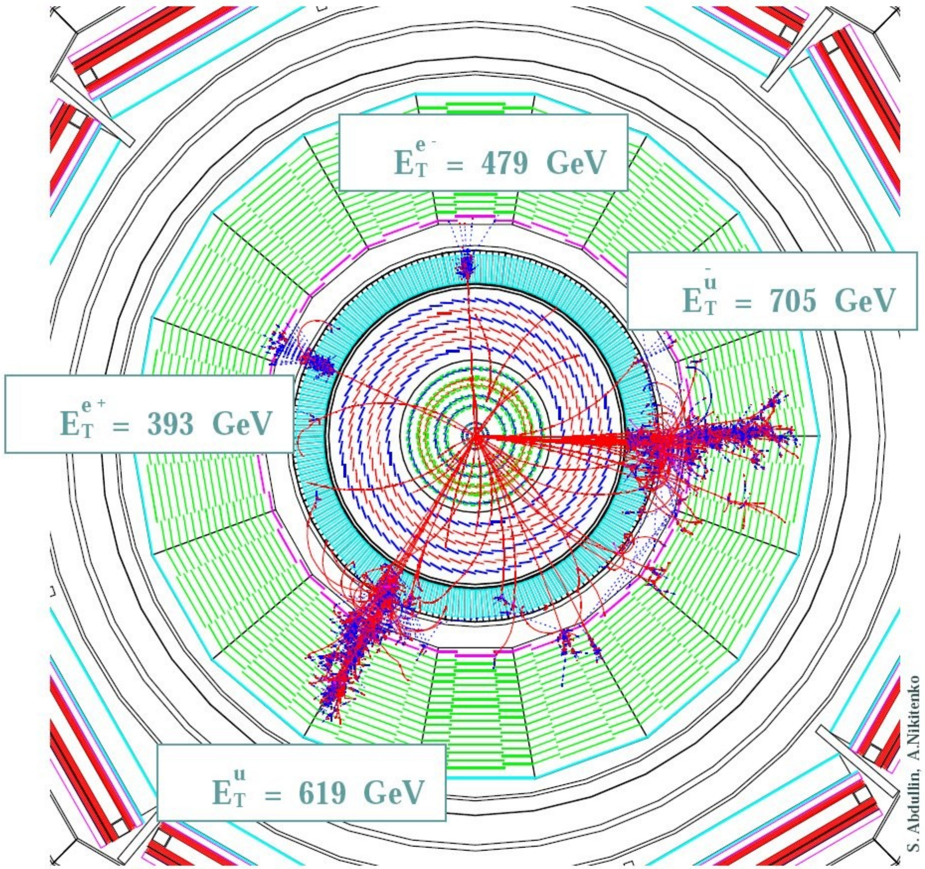
sensitive to many processes:

- q*
- Z'
- Contact interactions
- ...

Analysis for 14 TeV
=> rescale cross section to 10 TeV
=> reach reduced: ~1TeV



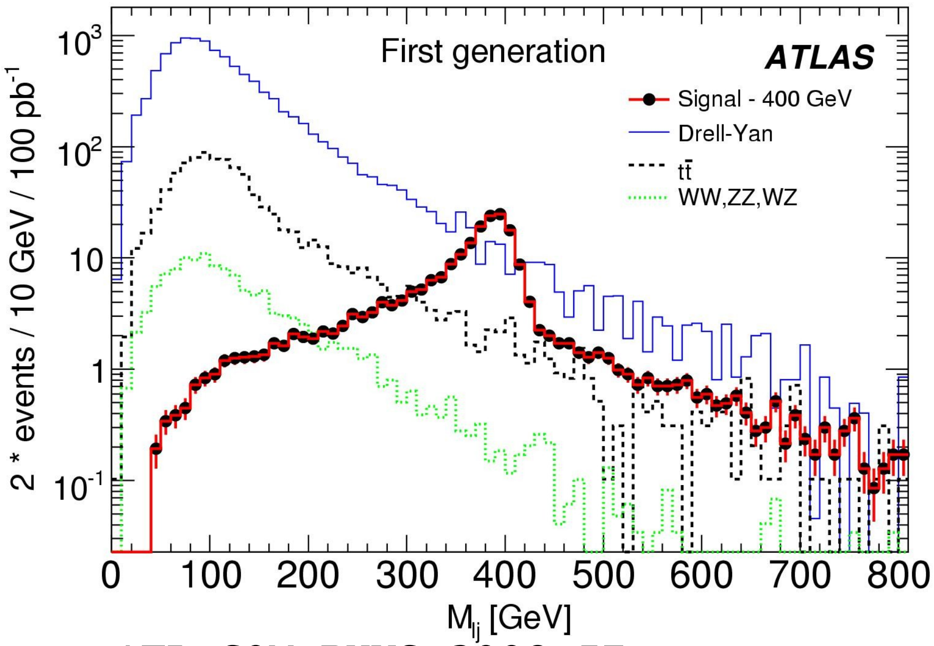
Analysis Strategy: LQ



- Select 2 leptons (same generation)
- Select 2 jets
- Suppress Background (lepton isolation, S_T)
- Estimate remaining backgrounds

EXO-2008-10 (CMS 1st gen)
EXO-2009-10 (CMS 2nd gen)
ATL-COM-PHYS-2008-57 (Atlas 1st+2nd)

Background Reduction



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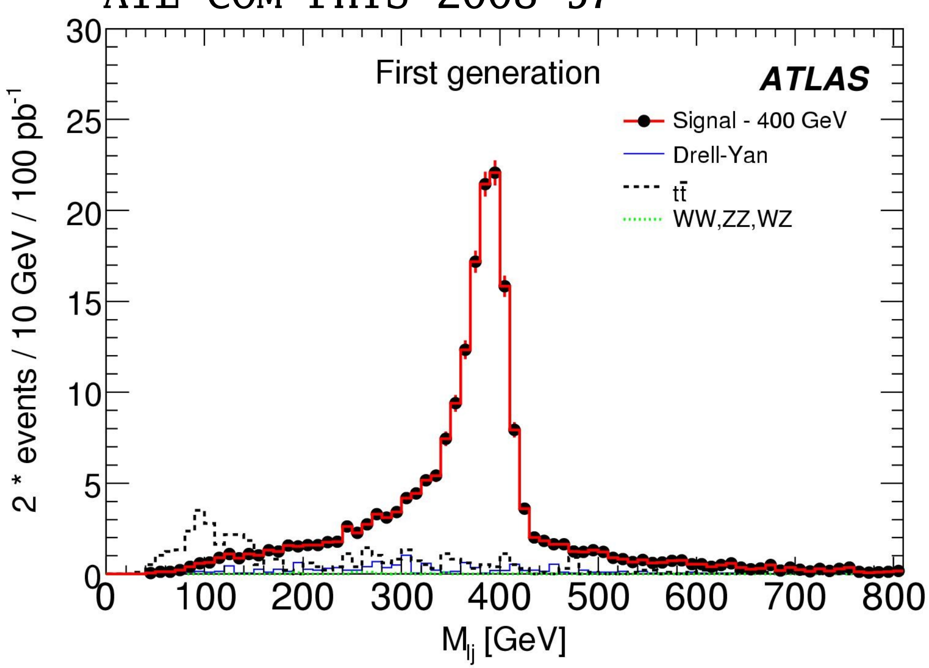


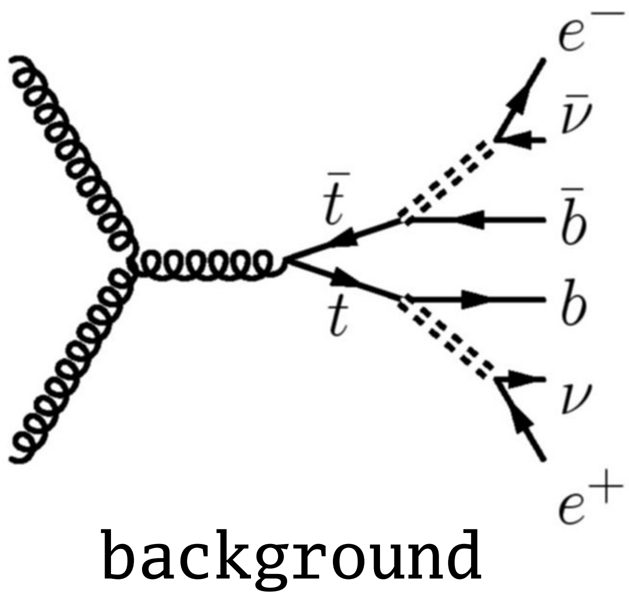
Exploit heavy primaries

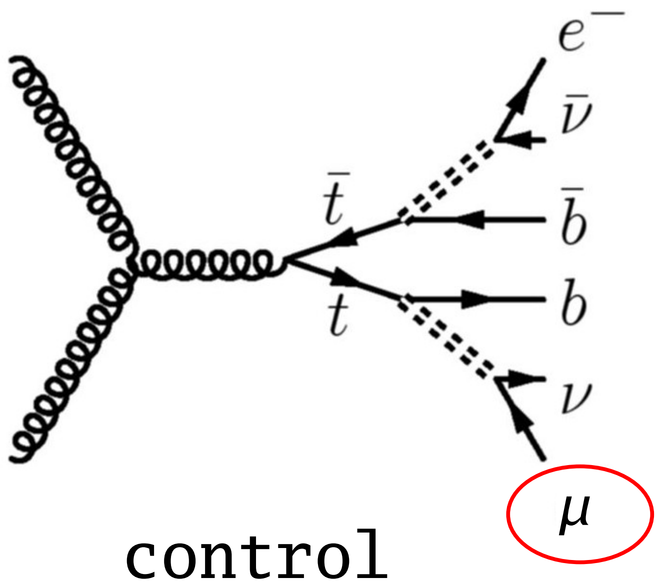
- $E_{t,l}$
- $E_{t,j}$
- $S_t = \Sigma|E_{t,j}| + \Sigma|E_{t,l}|$
- M_{ll}
- M_{lj} (closest pair)

Cuts differ by experiment and lepton flavor

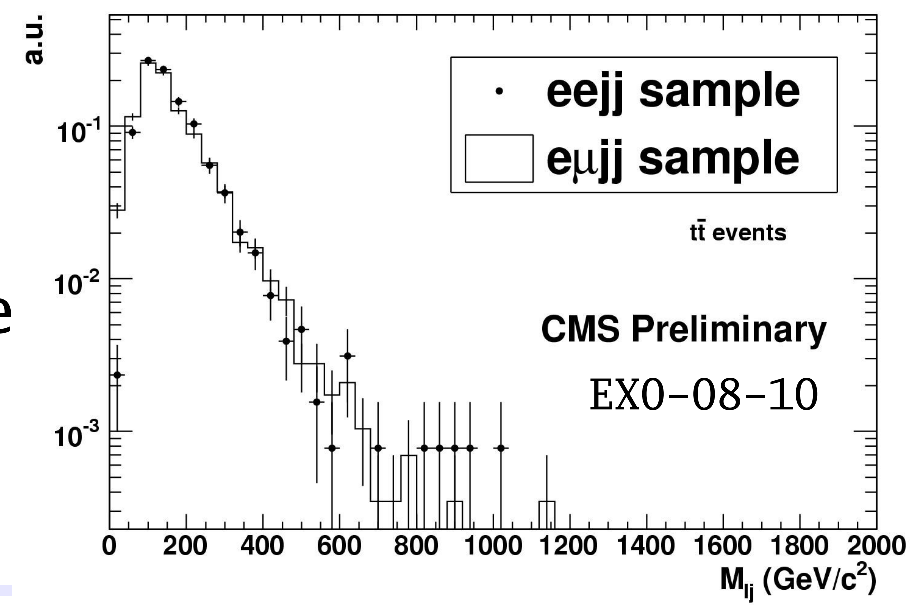
Top pairs are largest residual background

Background Control





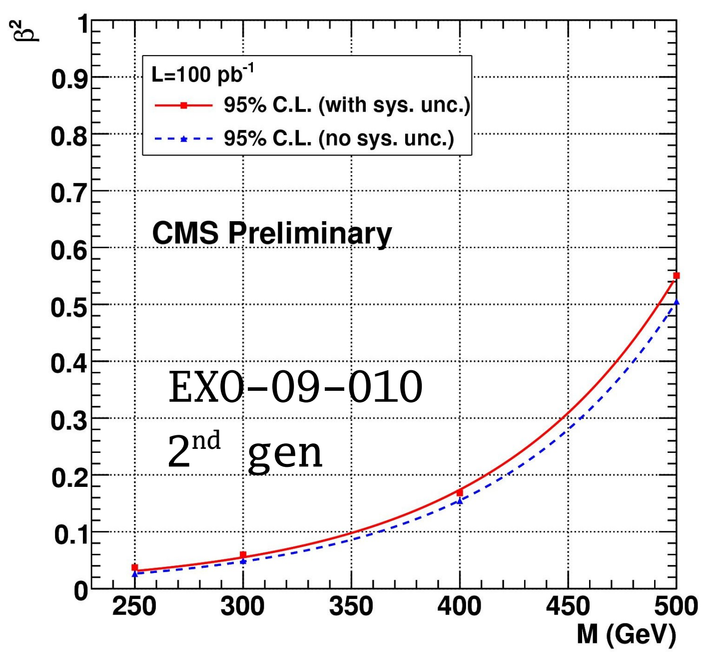
- Relative branching ratio for tt->ee and tt->eμ equals 0.5
- eμ sample reasonably pure
- Need to correct for efficiency/acceptance

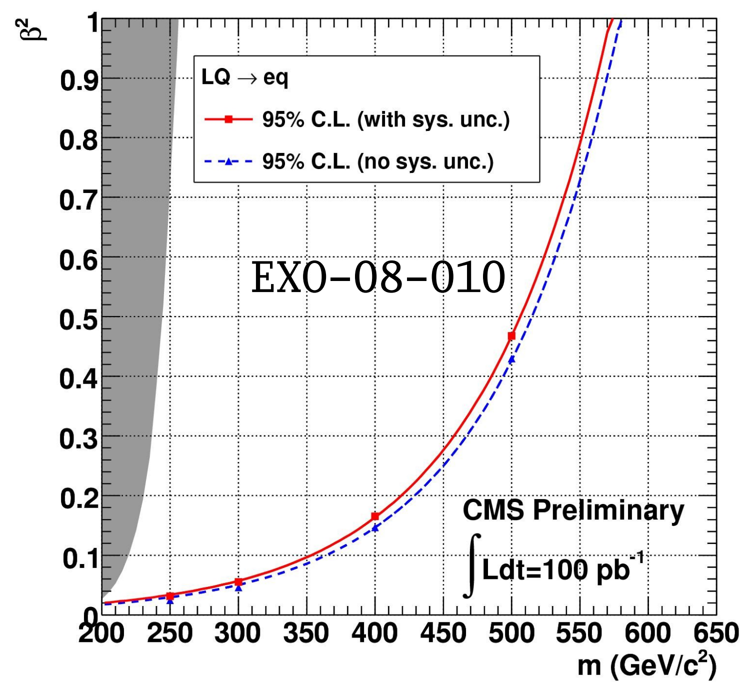


Limits: Leptoquark

Branching fraction β
of LQ->lq vs LQ->νq
not fixed by most models

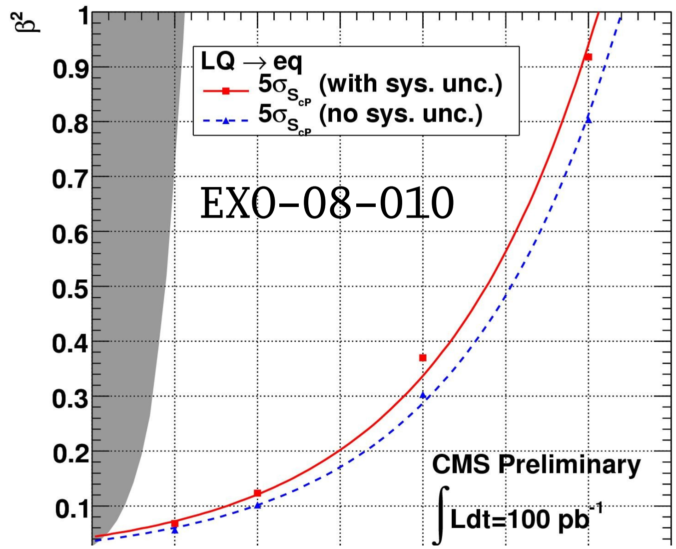
=> produce limts as
function of β

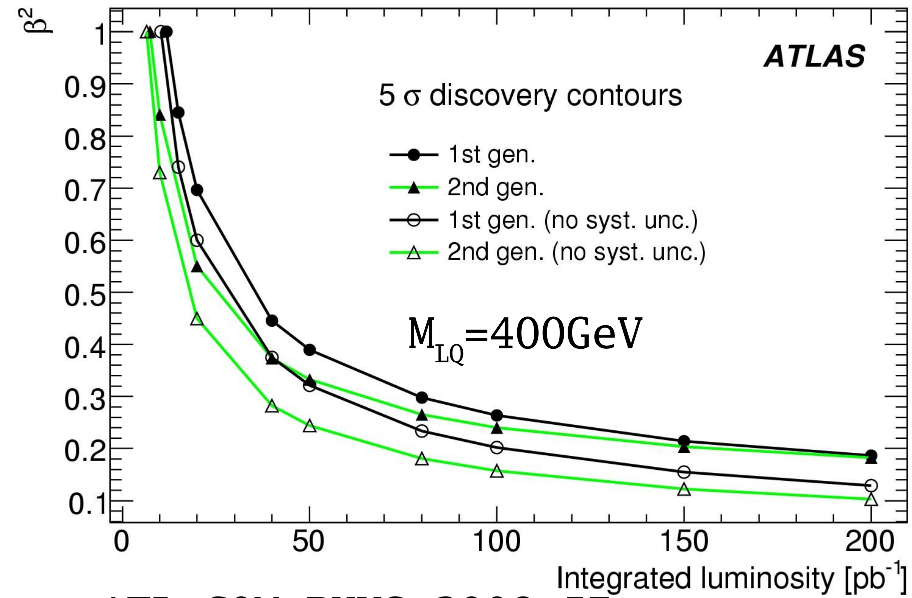




Tevatron: ~300 GeV for β=1 (needs high lumi update)

Reach: Leptoquarks





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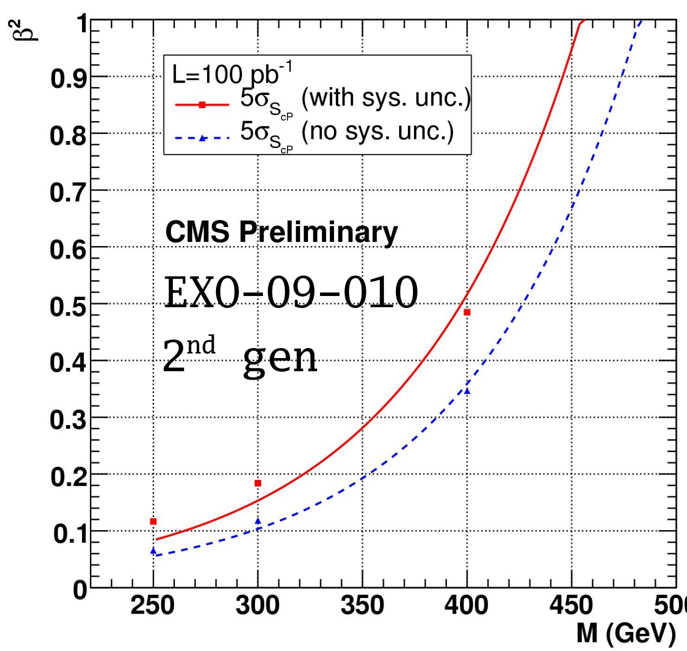
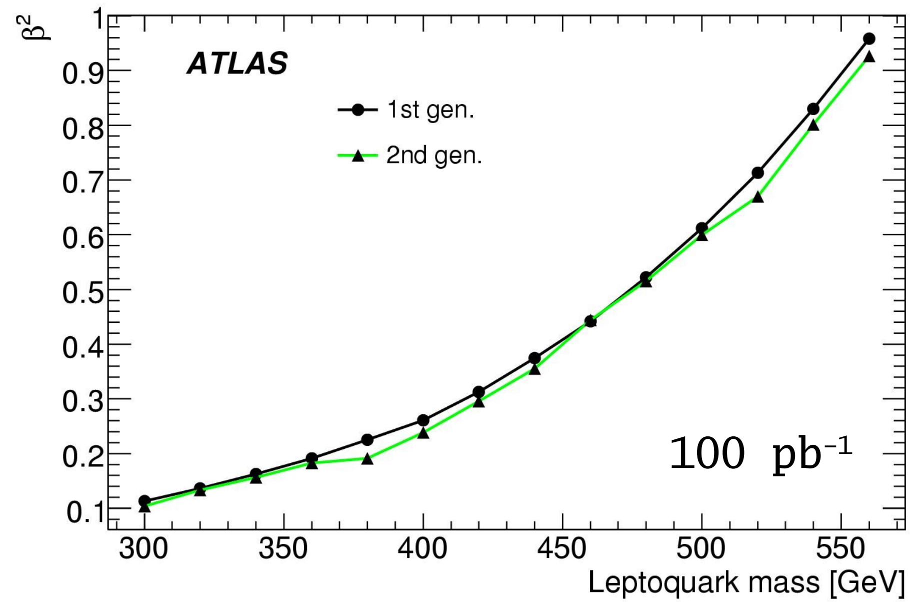
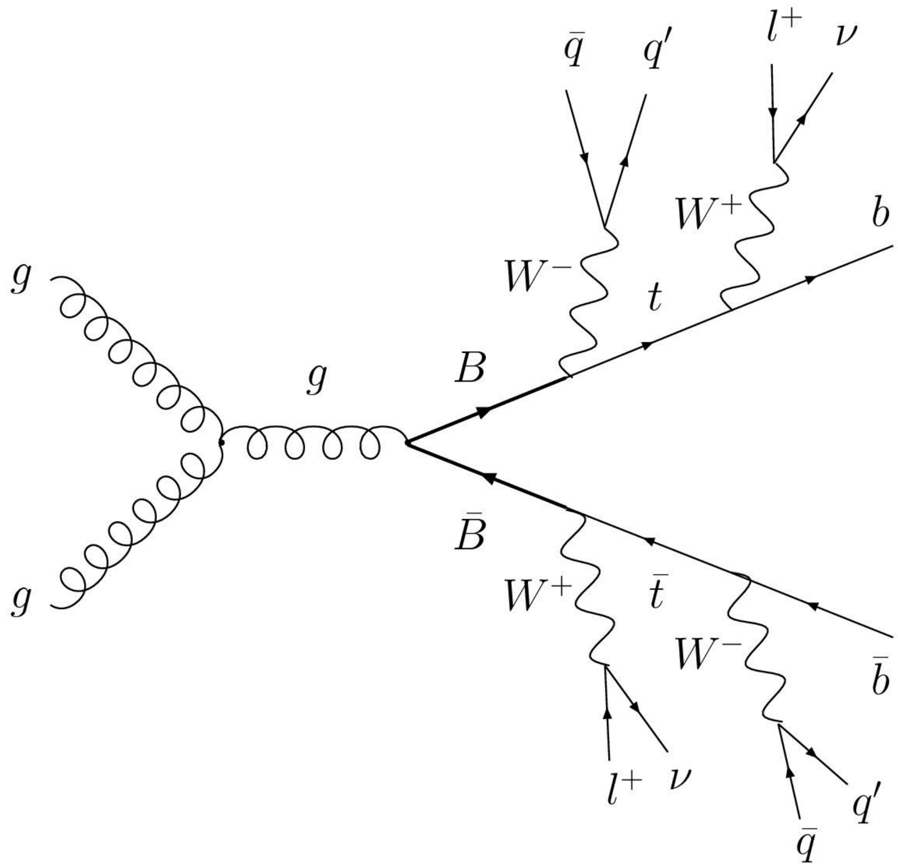




4^{th} generation quarks



- High multiplicity
- Neutrinos in final state

- Low acceptance for complete decay chain
- Kinematic reconstruction ambiguous (no mass spectrum)

- Use simple counting experiment (focus on limits)
- Background suppression and estimation crucial

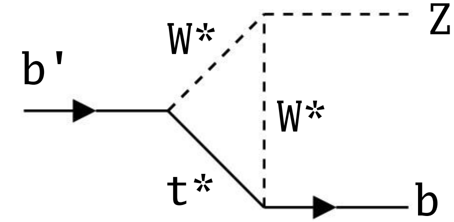
Searches by Model

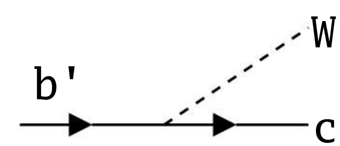
EXO-08-008	EXO-09-012	EXO-08-013
$T_{5/3}$/B (degenerate)	heavy b'	light b'
$T_{5/3}$/B->tW	b'->tW	b'->cW/bZ

With high lumi (~2fb^{-1}) $T_{5/3}$ can be completely reconstructed (inv. Mass)

Least model specific

Visible decay weak





Alternatives can be CKM suppressed

Some overlaps
(may pick up same signal)

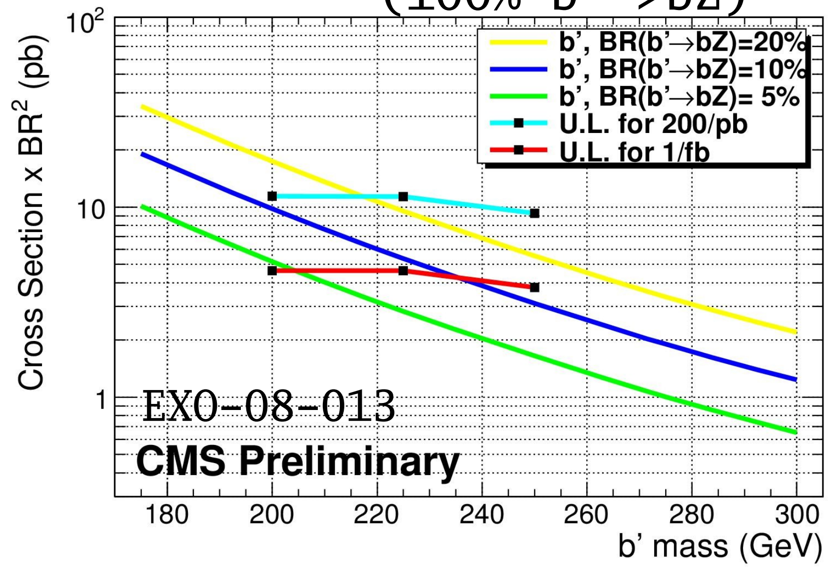
Analysis Strategy

	EXO-08-008 $T_{5/3}/B$	EXO-09-012 heavy b'	EXO-08-013 light b'
leptons	2 same sign any flavor	2 ss. Or 2 ss. + 1 opp. any flavor any flavor	2 opp. + 1 other same flavor +oth.
jets	5+ jet	4+ jets 2+ jets	2+ jets
Missing E_t	none	crosschecks/optional	optional
background	**tt** **tt+W/Z** as heavy b' **Z+X** estimate charge mis-id at Z peak	**tt** **tt+W/Z** normalize to bckg. rich control region (opp. sign leptons)	**W/Z +X** loose vs. tight selection **WZ+X** same as signal normalized MC

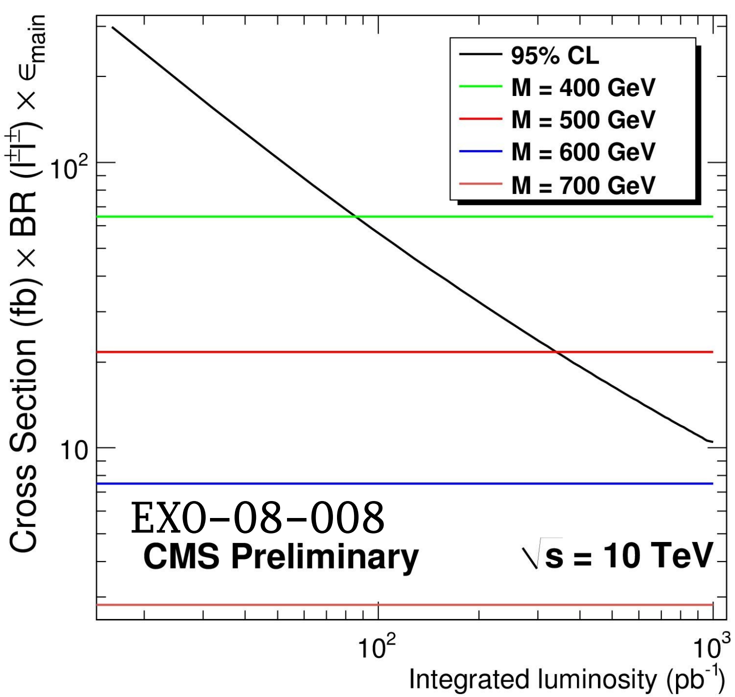
Expected Limits

Stringent limits on 4^{th} gen quarks possible.

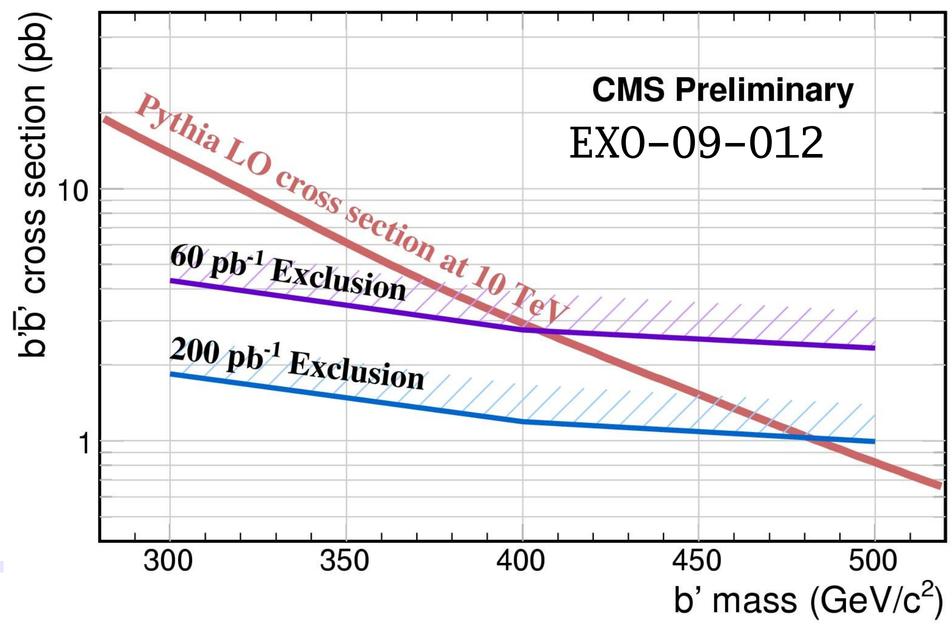
Light b' Tevatron: >270 GeV (100% b'->bZ)



$T_{5/3}$/B Tevatron: >350 GeV



Heavy b' Tevatron: >325 GeV



Summary

- Pair production of strongly interacting exotic particles has
  => high cross sections
  => final states with jets
- Pure jet final states are
  => difficult to trigger
  => contaminated with backgrounds
  => Analysis of semileptonic final states or very high E_t jets most promising

Limits can be pushed beyond Tevatron
New discoveries are possible
even at modest luminosities

Backup

Atlas Leptoquark:

- Mu isolation < 30% (R=0.2)
- JetCone: R=0.4
- DeltaR jet-e > 0.1
- lepton/jet Et > 20
- Lepton eta < 2.5
- Jet eta < 4.5

1^{st} gen	2^{nd} gen
	$P_{tmu} > 60$
	$E_{tjet} > 25$
$S_T > 490$	$S_T > 600$
$M_{ee} > 120$	$M_{mumu} > 110$
Delta M_{ej}: variable	Delta Mmuj: variable

Backup

CMS 1st gen leptoquark

- Electron eta < 2.5 (+gap)
- Electron Id (cluster shape, H/E, track match)
- Electron isolation

- $E_{te} > 30$
- $E_{tjet} > 50$
- $M_{ee} > 100$
- $S_T > f(M_{LQ})$

Backup

CMS 2nd gen leptoquark

- Muon isolation
- Muon eta < 2.0
- Jet eta < 3.0
- $E_{t,mu1} > 80$
- $E_{t,mu2} > 40$
- $E_{t,jet} > 60$
- $M_{mumu} > 100$
- $S_T > f(M_{LQ})$

Backup

T5/3

- Cone jets R=0.5
- Electron Id (cluster shape, H/E, track match))
- Lepton isolation

- 5 jets, E_t> 30, eta < 3.5
- $E_{t,jet1}$ > 100
- $E_{t,jet2}$ > 80
- 2 same sign lepton, ee,emu,mm
- Electron eta < 2.4
- $E_{t,l1}$ >50
- $E_{t,l2}$ >25
- Z-veto for ee channel

Backup

Heavy b'

- Cone jets R=0.5
- Electron Id (cluster shape, H/E, track match)
- Lepton isolation

- $E_{t.jet}$ > 35
- $E_{t,l}$ > 20
- Electron eta <2.5
- Muon eta < 2
- Two same sign leptons or two ss + 1 opp sign
- At least four jets for two leptons
  At least two jets for three leptons
- R_{ll} >0.3
- R_{lj} >0.3
- Z-veto for opposite charge leptons

Backup

Light b'

- Cone jet R=0.5
- Electron Id (cluster shaoe, H/E, track match)
- Lepton isolation

- $E_{t,jet}$ > 30
- Jet eta < 2.4
- $E_{t,l}$ > 20
- Muon eta < 2.1
- Electron eta < 2.4
- At least 2 jets
- One Z-candidate in 80-100 GeV, no other in 60-120
- One W-candidate with M_T within 30-120
- $R_{l,j}$ > 0.5

Reach plot for T5/3 once available