BSM Searches at CDF

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for the CDF Collaboration

BSM Status at CDF

... building on experience

... coordinating with other CDF work

...comprehensive set of models

...examining virtually all high-P_T final states

- W',Z'
- LED
- Technicolor
- 4th generation
- leptoquarks
- excited particles
- SUSY
- high-mass γγ, ZZ, tt, ll
- jets and MET
- dileptons, trileptons
- bosons
- tt
- long lived particles
- highly ionizing particles

http://www-cdf.fnal.gov/physics/exotic/

Signature-based Searches

The Idea

- Chose a signature
- Define a nominal selection, with variations
- Compute SM backgrounds
- Report event yields and kinematics
- Investigate discrepancies

The Why

- There are many models, very few are obviously more likely than others
- Model limits usually do not provide critical insight
- Save time – cover more signatures
- Experimental results are experimental

More and more, searches are including both model-based and signature-based search components

Recent CDF Results:

- Search in the $\gamma\gamma$ Spectrum
- Search in the $\mu\mu$ Spectrum
- Search for $QQ \rightarrow (3j)(3j)$
- Search in $l\gamma b$MET

Search for Anomalous Peaks in the $\gamma\gamma$ Mass Spectrum

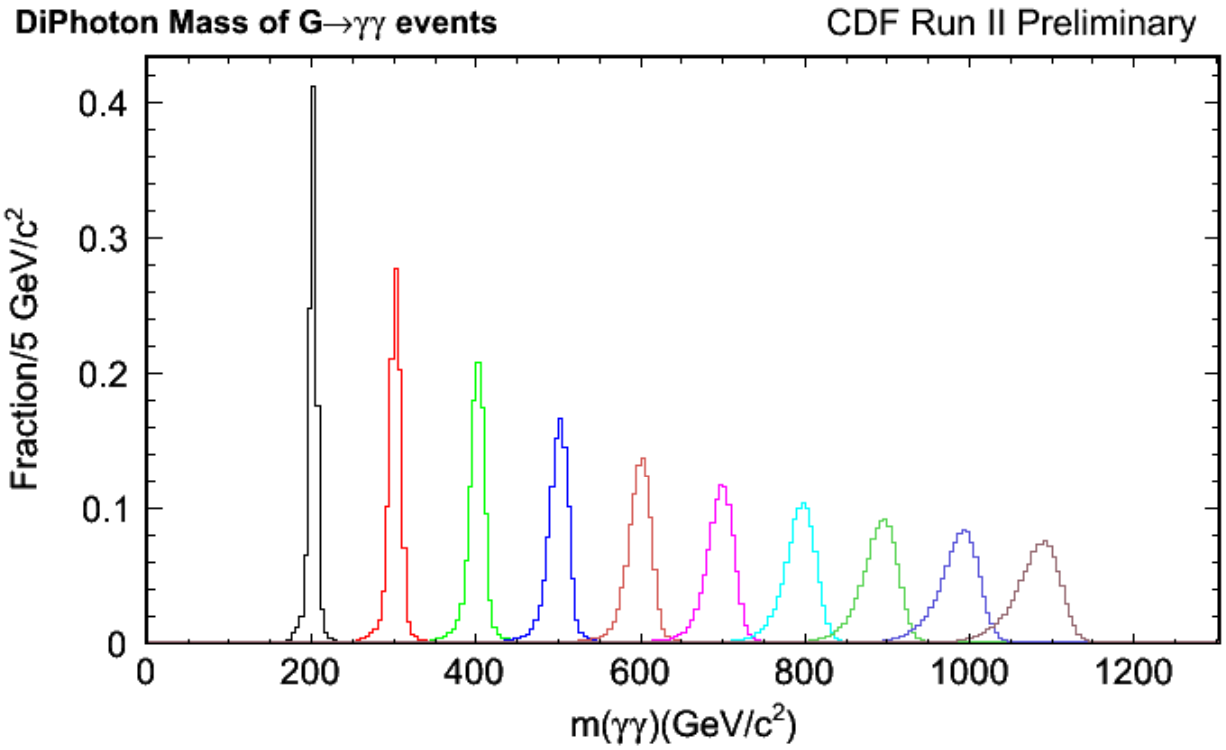
$\gamma\gamma$ Search

The Search

- Sensitive to narrow $X \rightarrow \gamma\gamma$
- Higgs,Technicolor
- other anomalous diphotons
- Set limits on LED Randall-Sundrum Gravitons

Event Selection

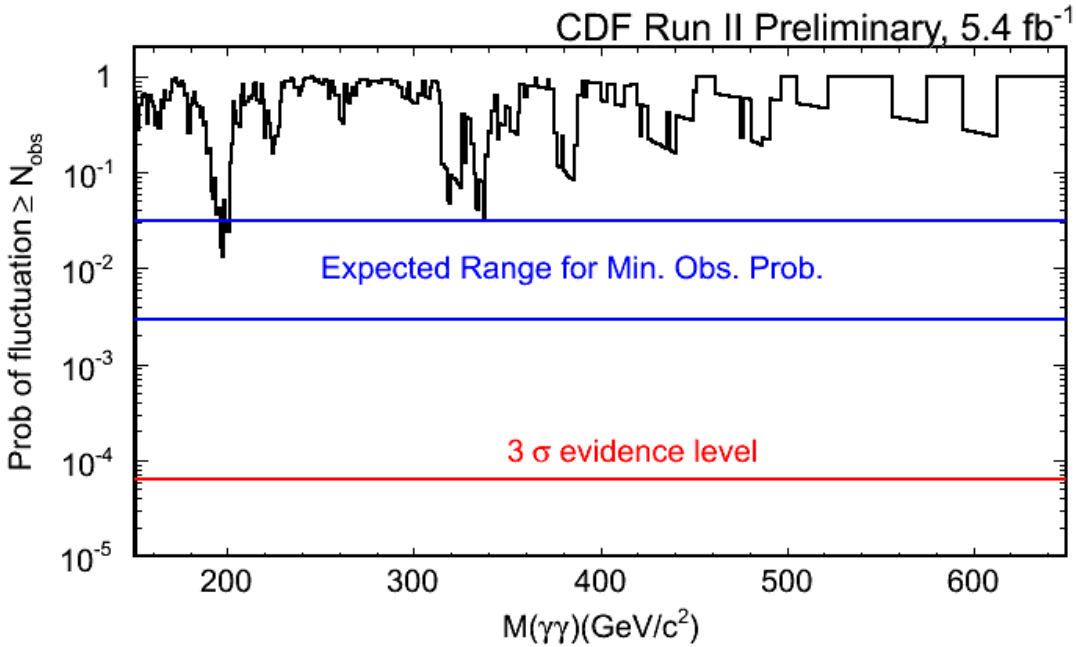
- 5.4 fb^{-1}
- Two photons
  E_T>15 GeV, $|\eta|$<1.1

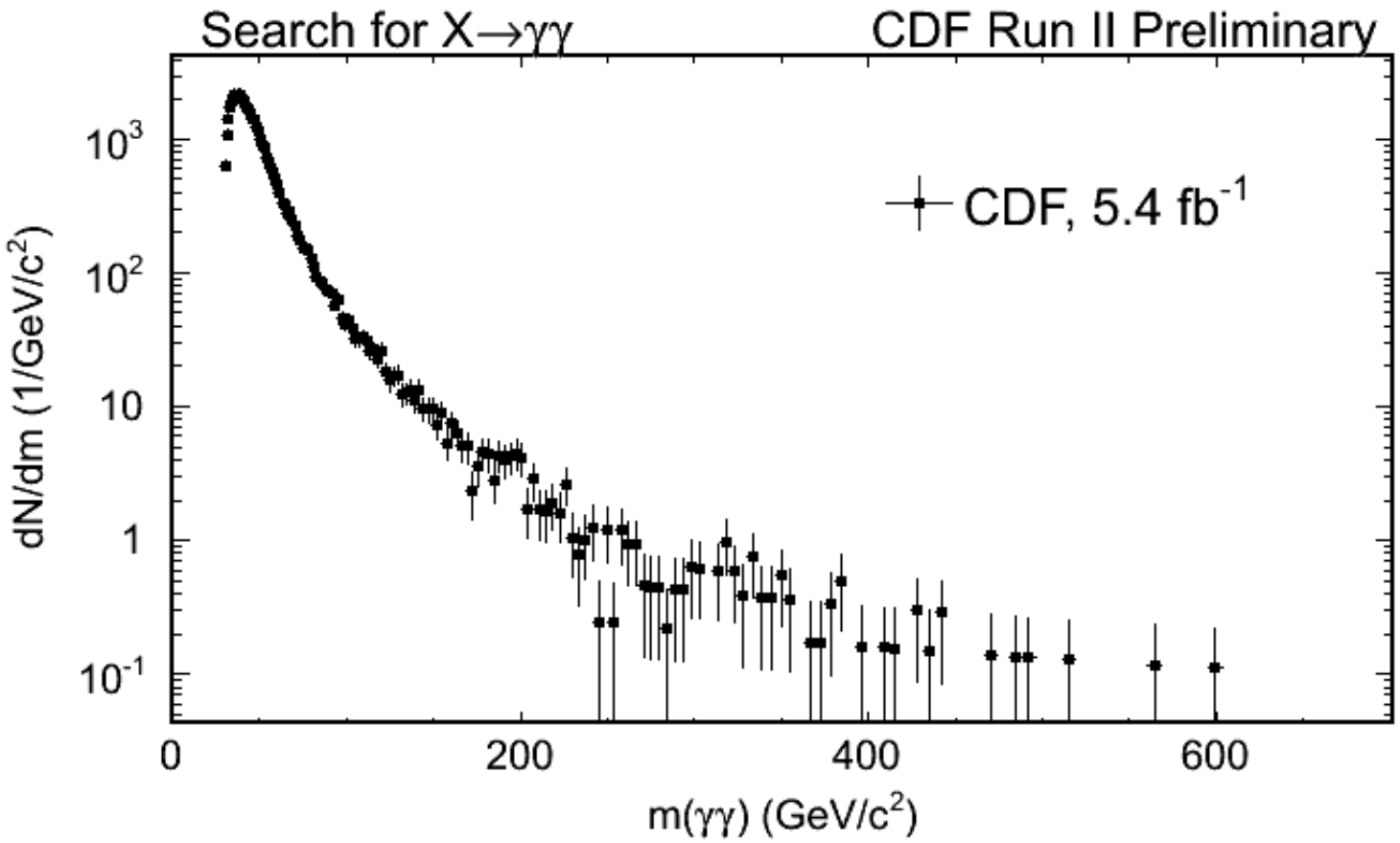


- R-S Gravitons, parameters: mass and k (coupling strength)
- calorimeter saturation not a issue

γγ Search

- spectrum in bins of resolution
- test for excesses,
  includes trials factor

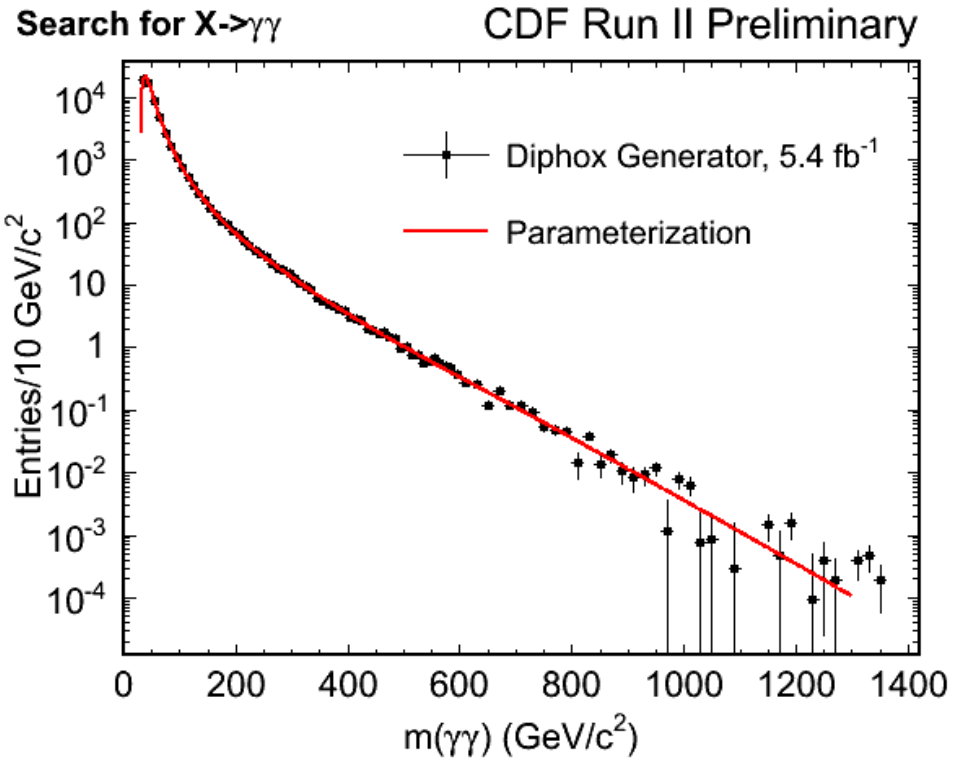


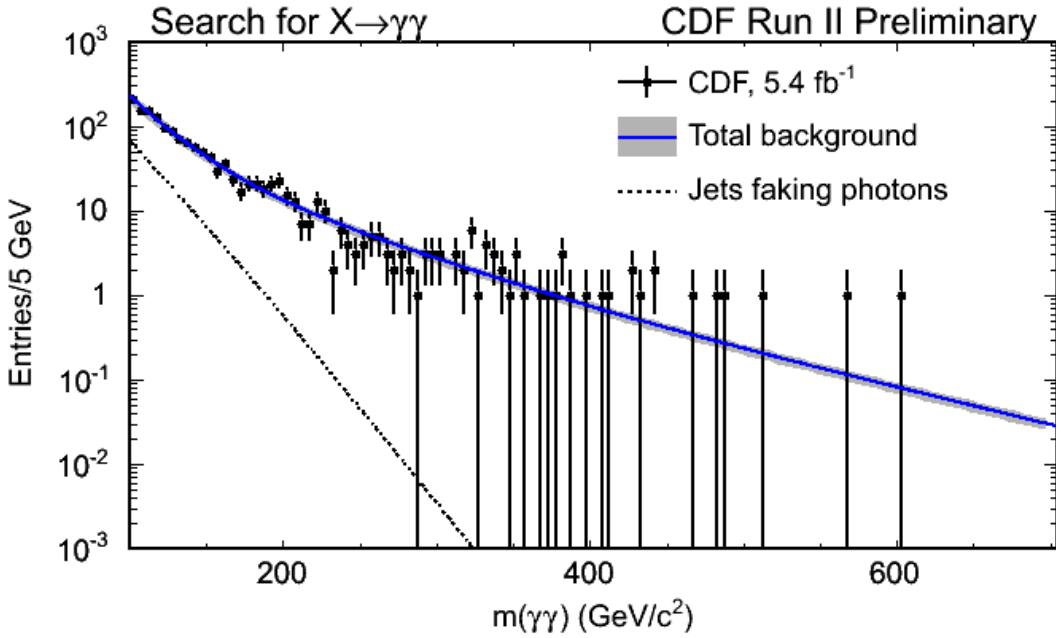


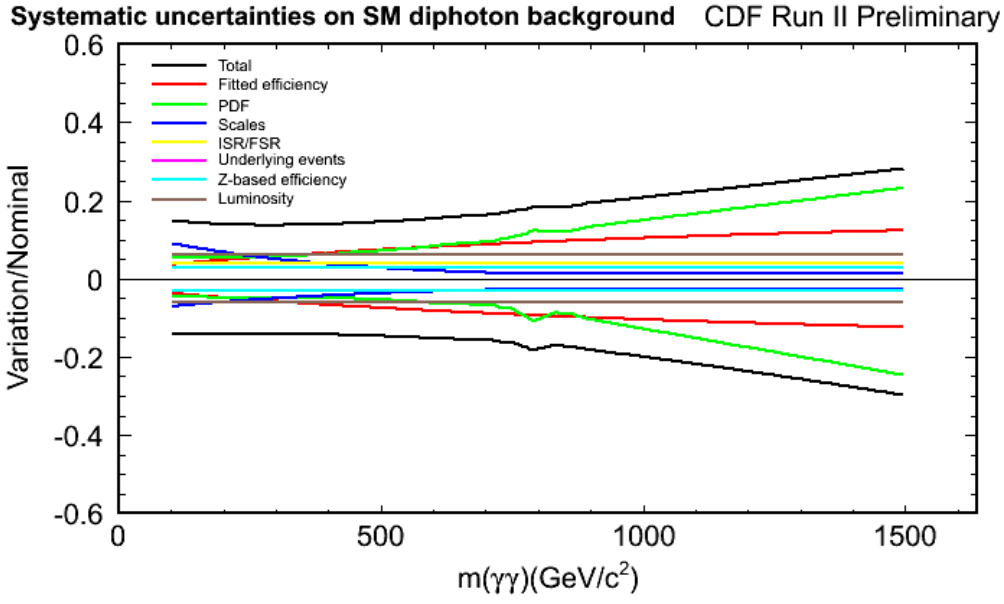
γγ Search

Background

- ♦ fit DIPHOX NLO SM γγ spectrum
- ♦ fit data to DIPHOX + fake photon exponential form
- ♦ largest systematic from PDF and efficiency







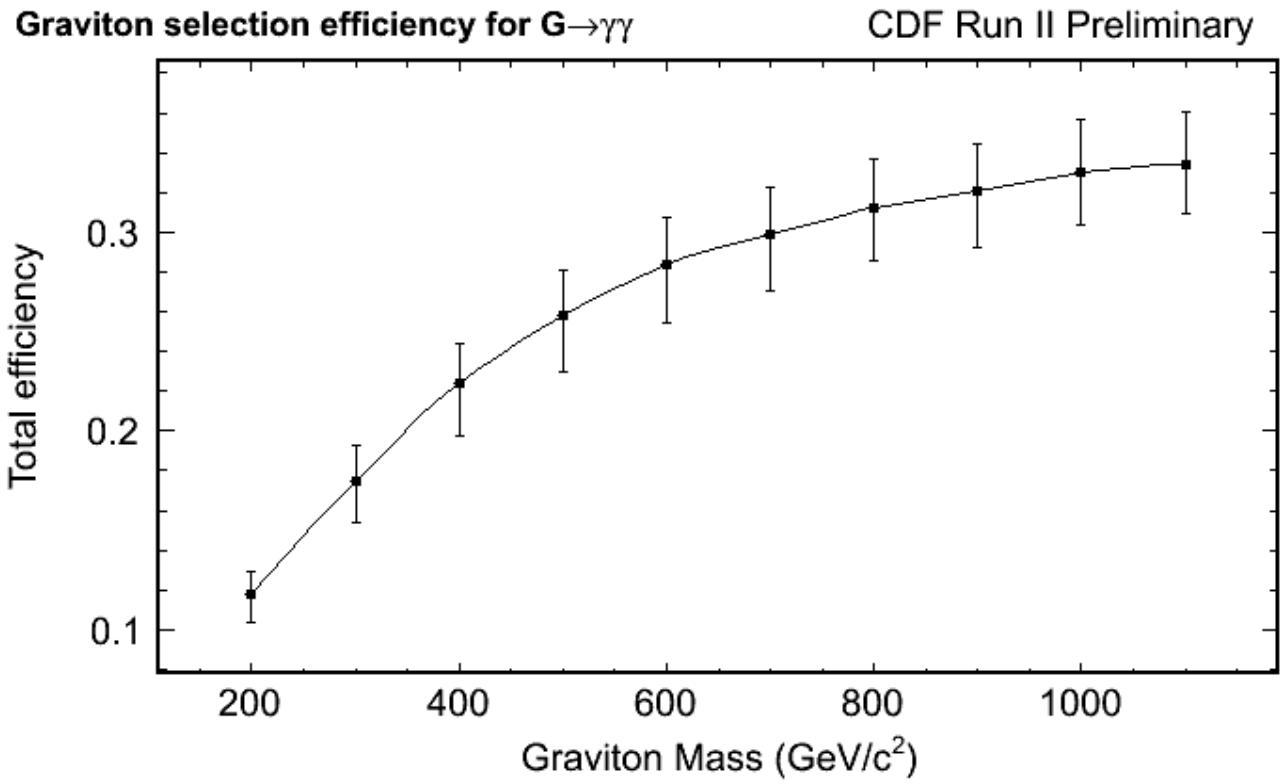
$\gamma\gamma$ Search

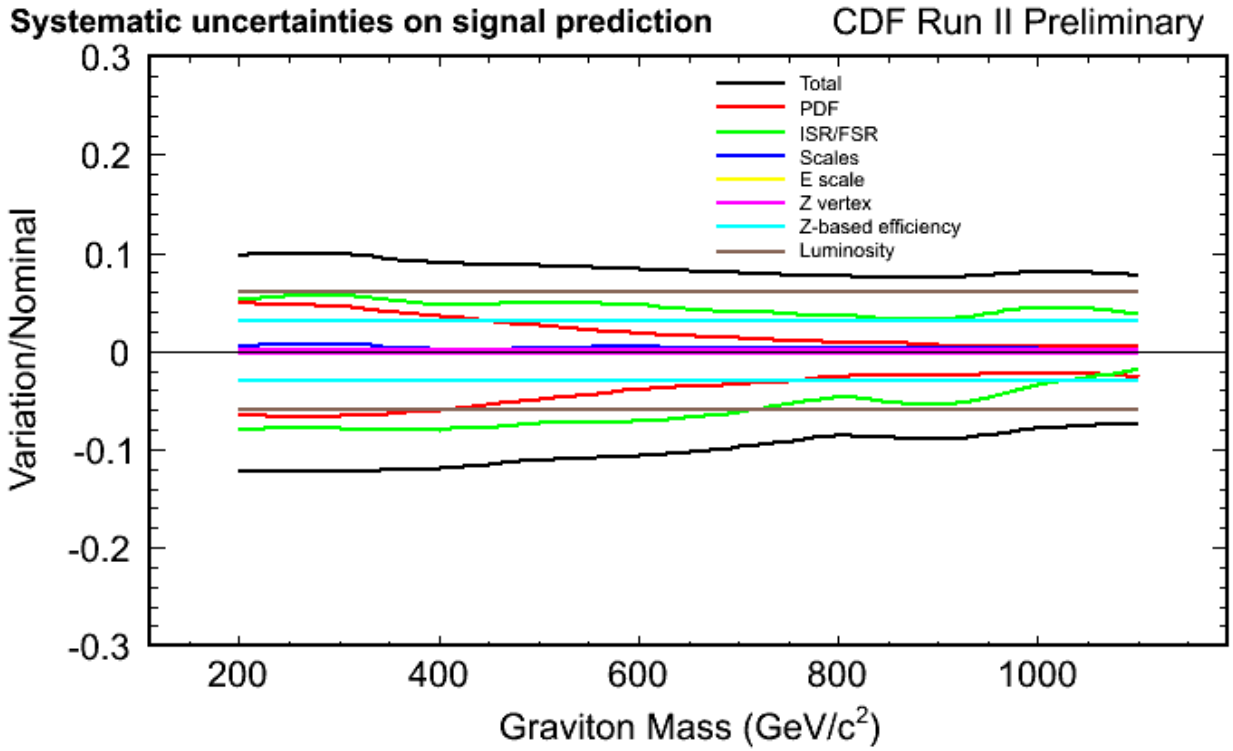
Efficiency

- R-S Gravitons
- PYTHIA and CDF GEANT
- shape driven by central acceptance
- conversions rejected

Signal Systematics

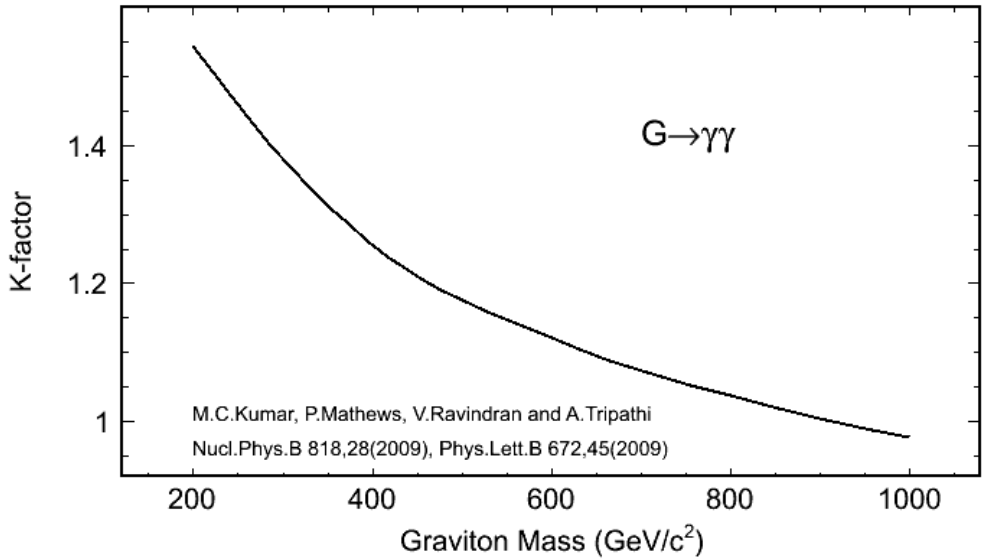
- ~ 10%
- luminosity
- PDF

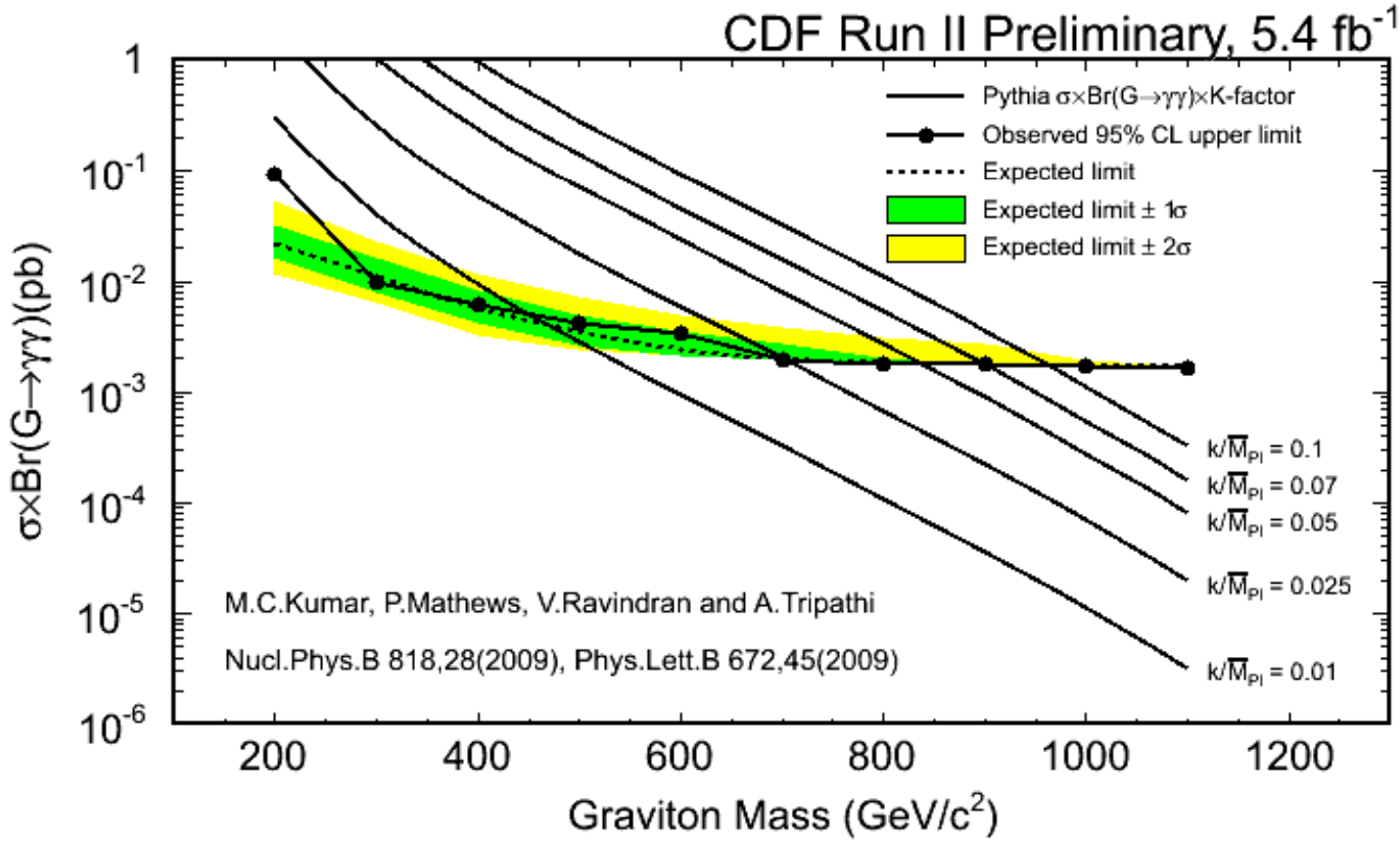




γγ Search

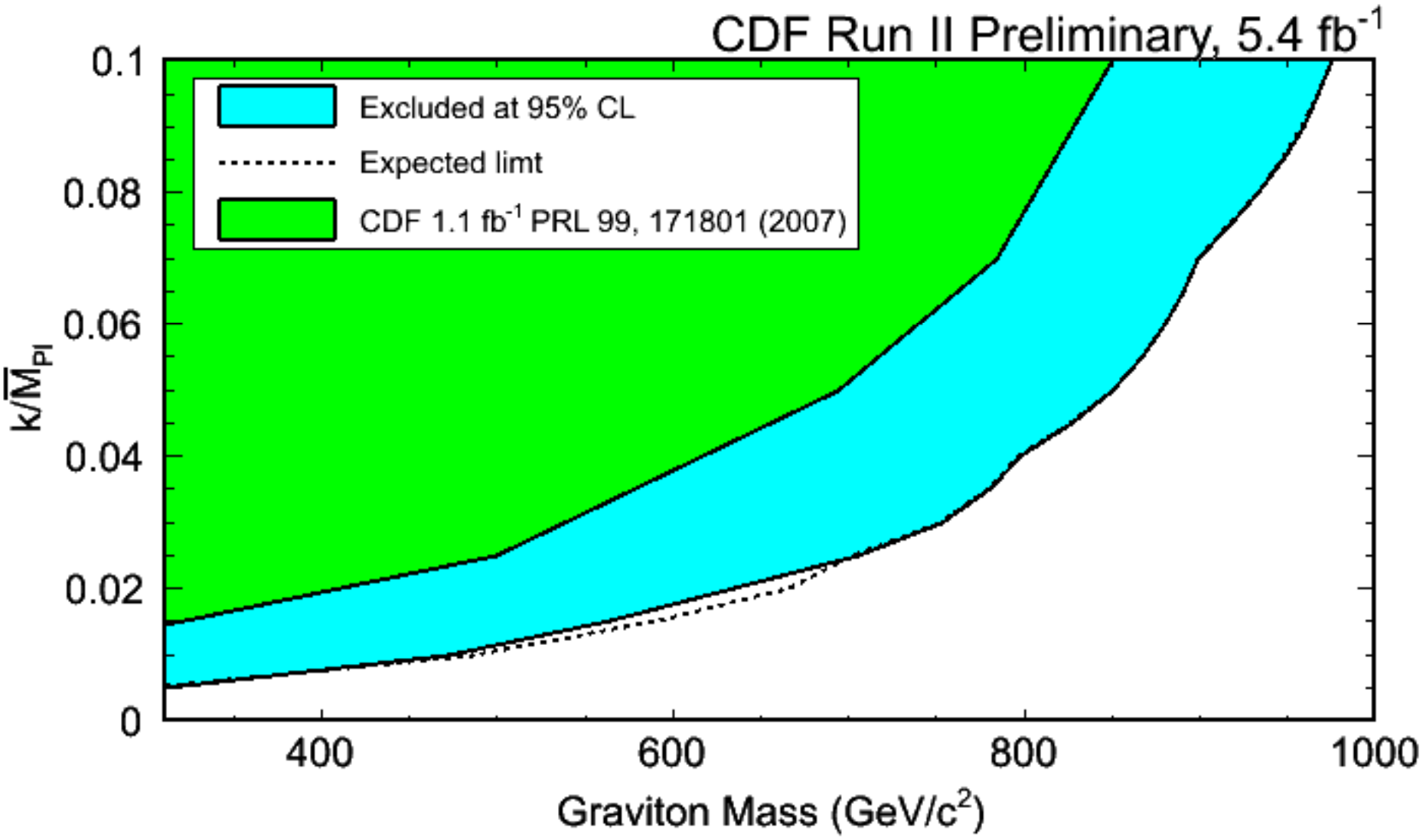
- NLO mass-dependant k-factor
- cross section limits *vs* M





$\gamma\gamma$ Search

♦ limits in k vs M plane: k/Mpl=0.1: 976 GeV



Search for Anomalous Peaks in the μμ Mass Spectrum

Dimuon Search

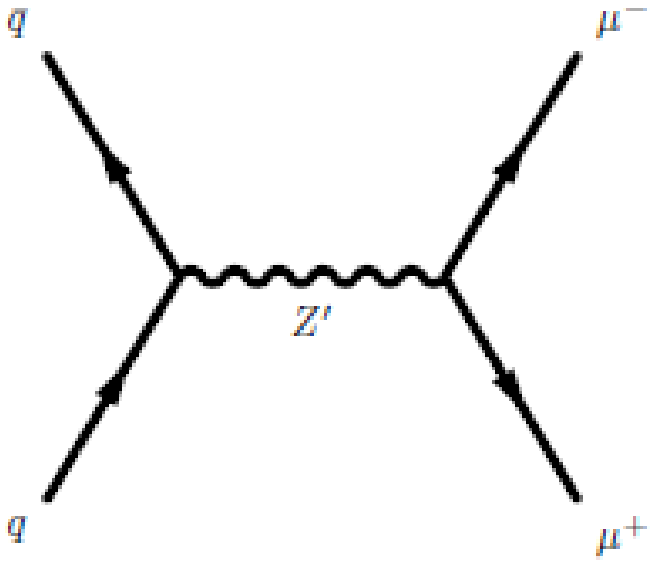
update of the CDF 2.3 pb^{-1} result to 4.6 pb^{-1}, adding improved methods

Goals

- sensitive to any dimuon mass bump
- Z'
- R-S Gravitons
- RPV ν

Event Selection

- two isolated muons
  P_T>30 GeV, |η|<1.0
- M(μμ) > 130 GeV
- cosmic rejection

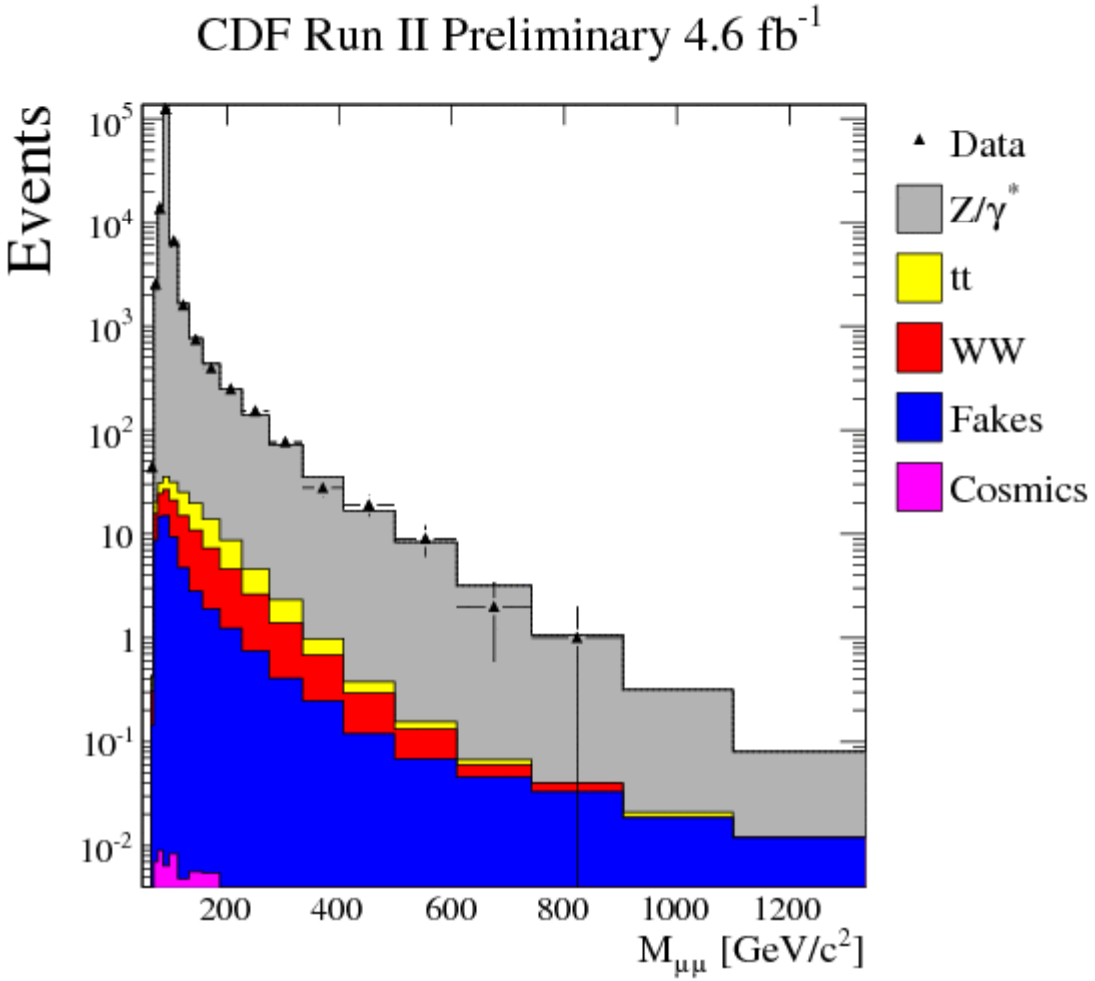


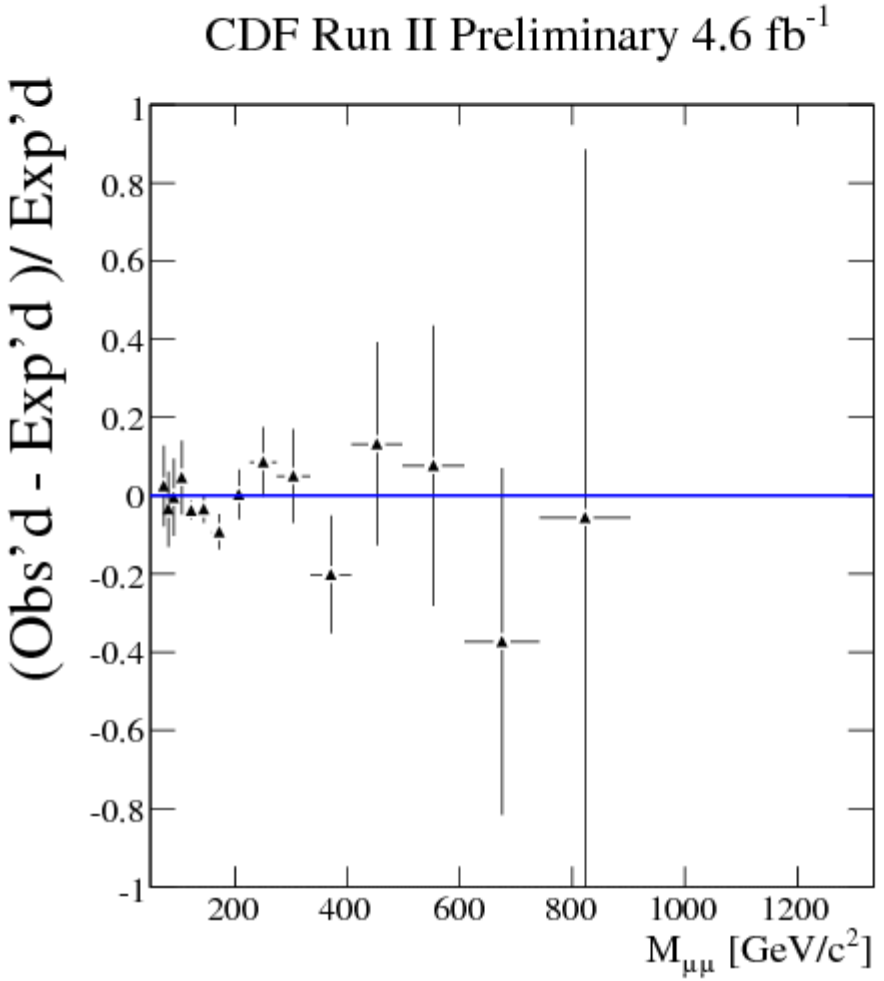
Dimuon Search

Backgrounds

- NNLO Drell-Yan – norm. to low mass
- tt and WW from MC
- fakes and cosmics from data-driven methods

For M>130:
1850±90 expected
1813 observed

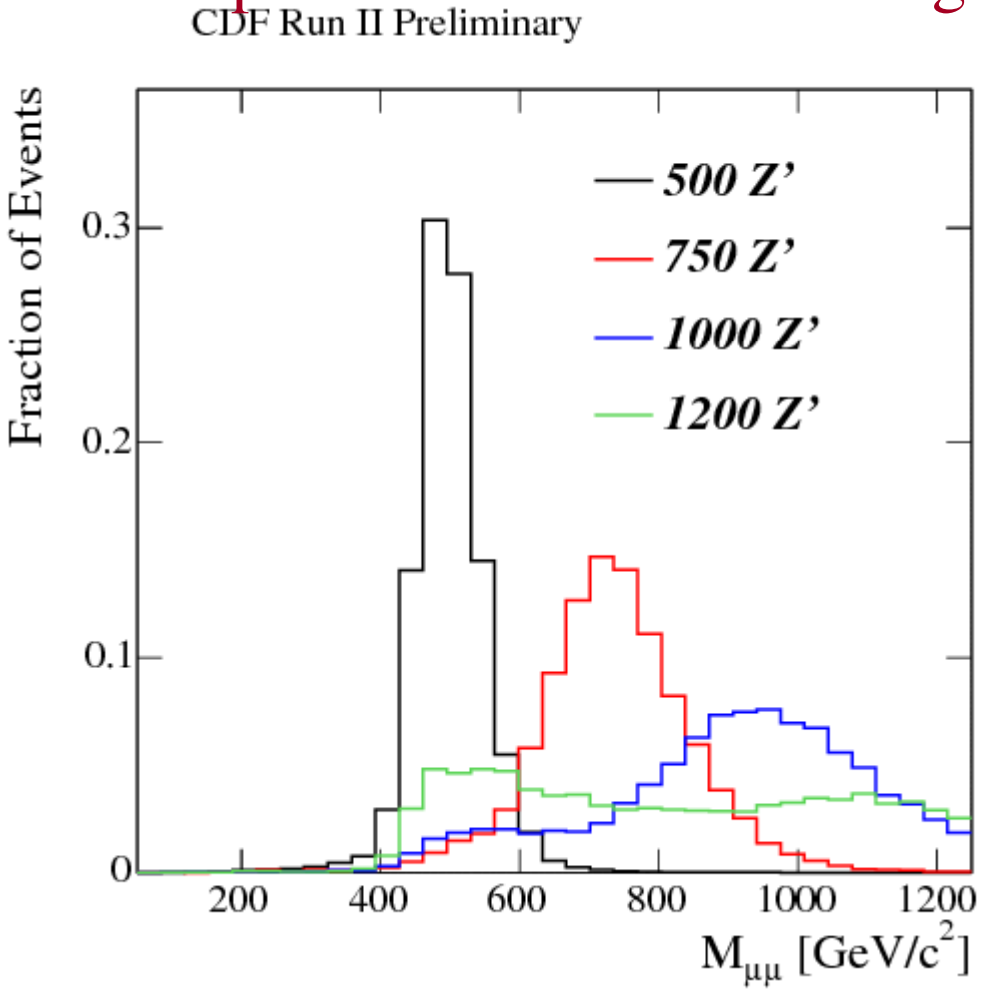


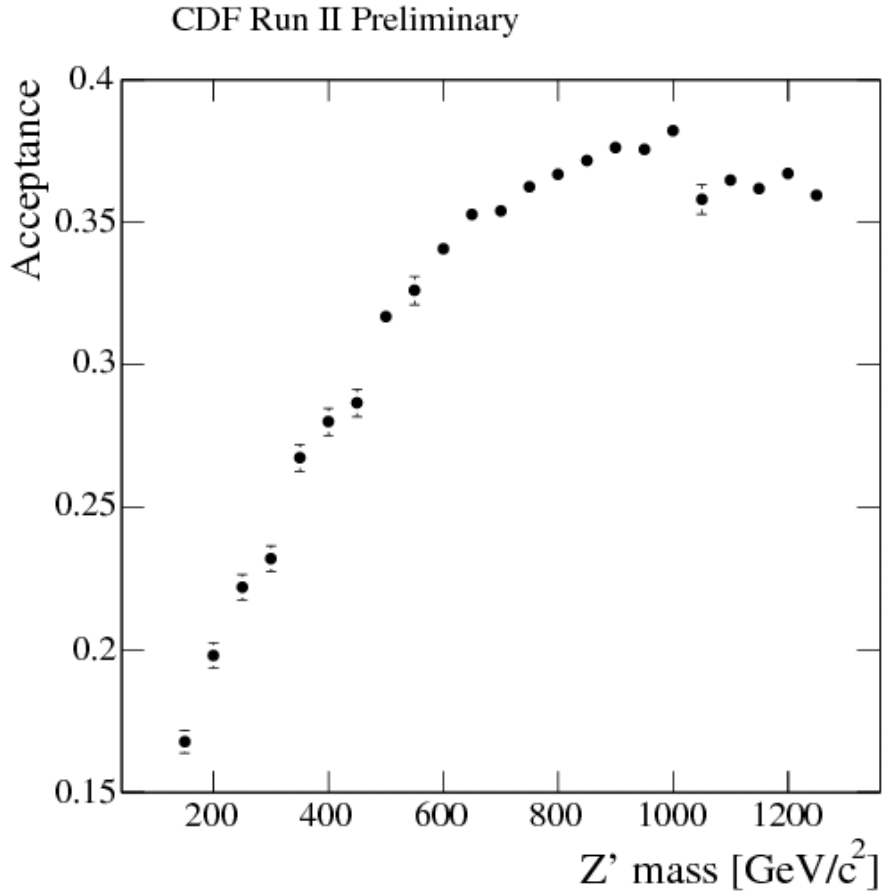


Dimuon Search

Models

- ♦ PYTHIA Z'
- ♦ largest uncertainty due to PDF
- ♦ shape distortion due to falling PDF times Z' lineshape

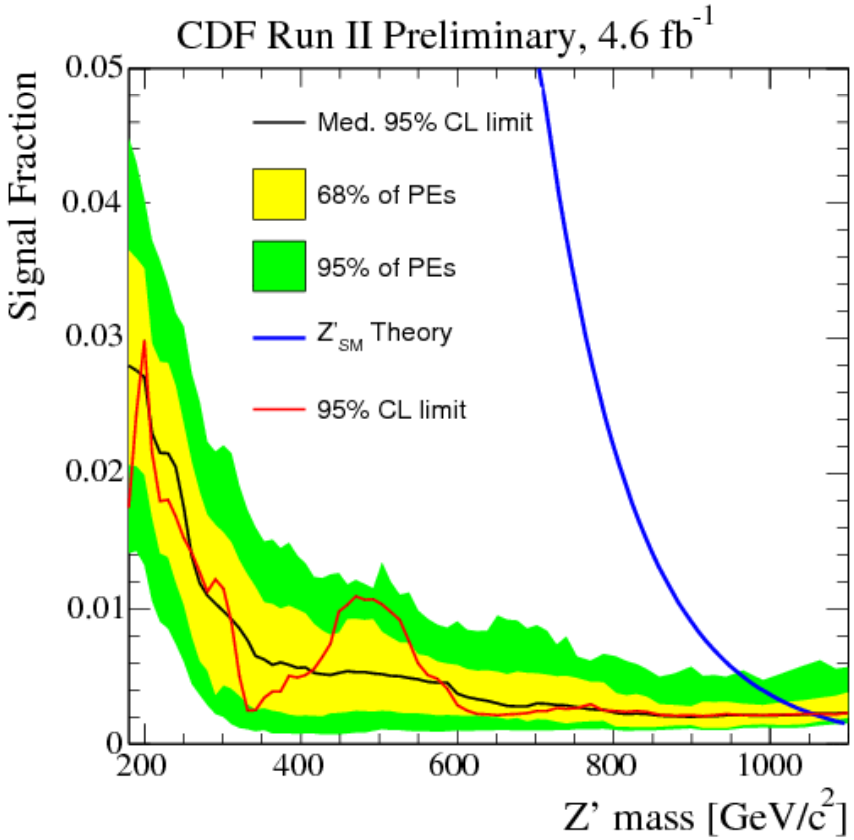


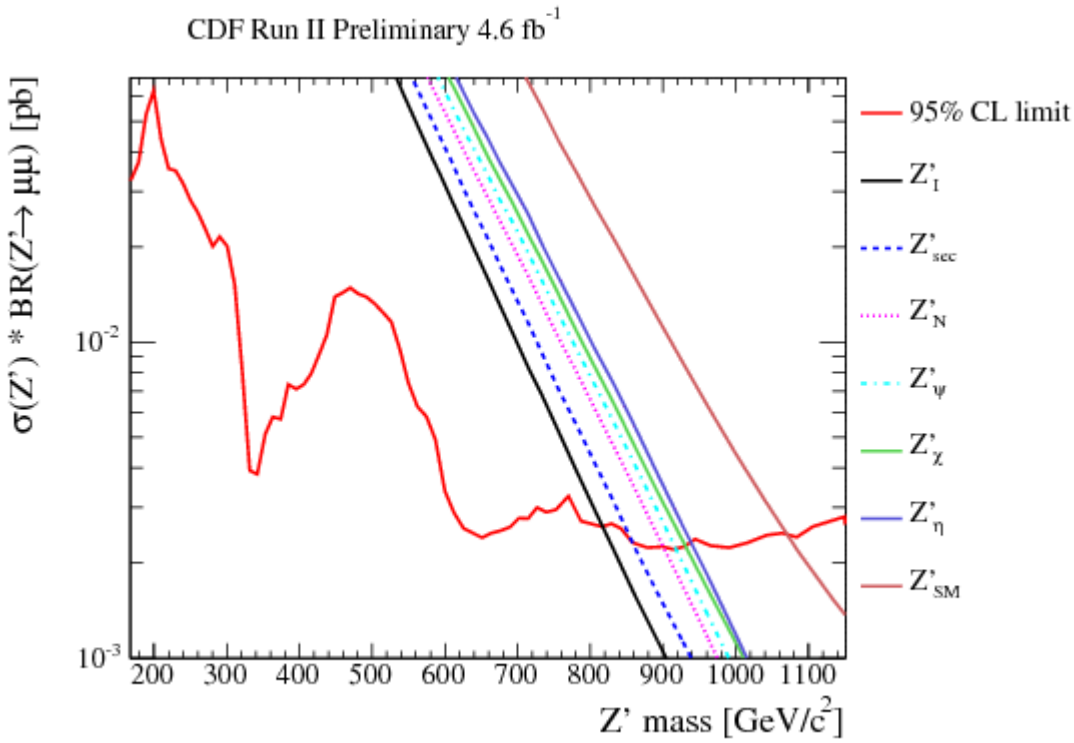


Dimuon Search

final Z' limits

Model	Mass Limit (GeV/c^2)
Z'_l	817
Z'_{sec}	858
Z'_N	900
Z'_ψ	917
Z'_χ	930
Z'_η	938
Z'_{SM}	1071





Search for Hadronic Resonances in Jet Ensembles

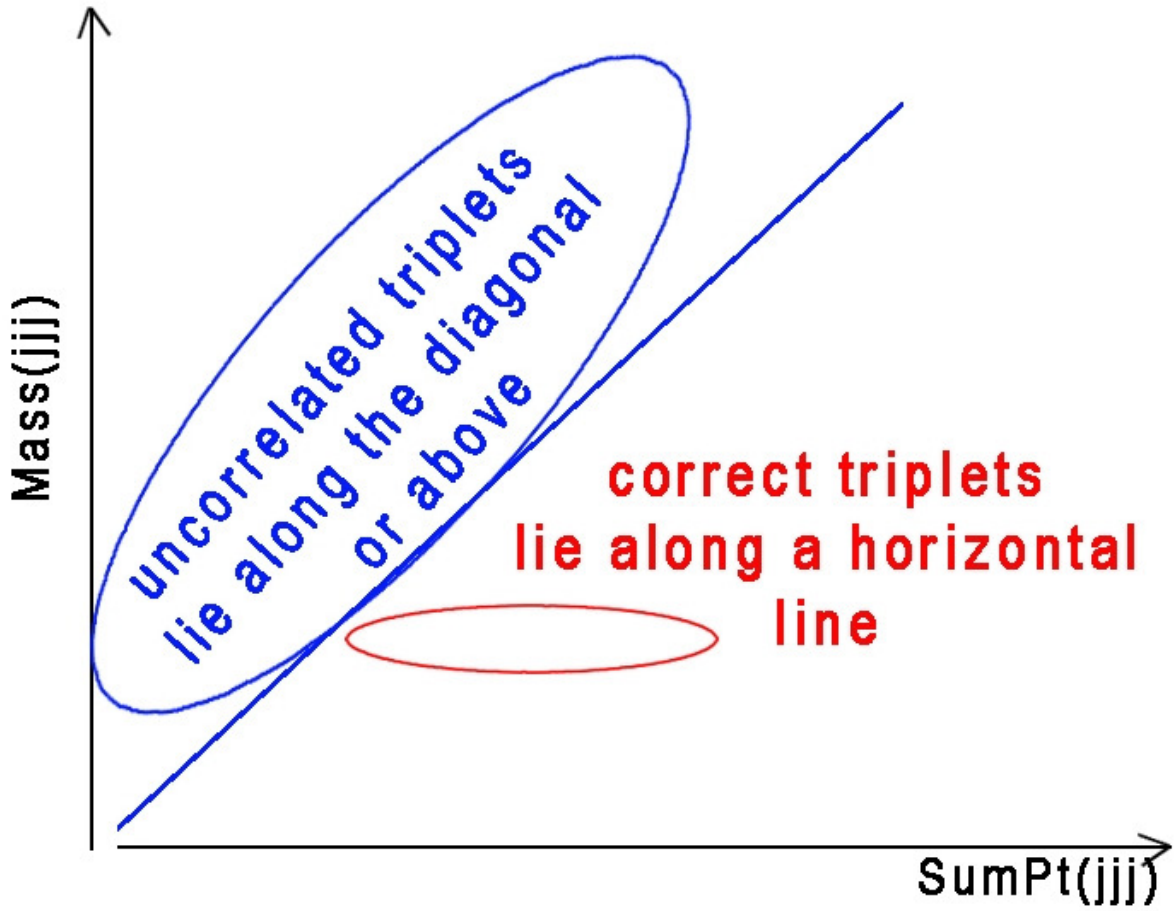
3j Resonances

The Idea

♦ pp → QQ
→(3j)(3j)

♦ Do not select on subresonances (signature-based)

♦ very similar to all-hadronic top – use as a example signal



The Challenge

♦ large QCD backgrounds

♦ features of QCD hard to get right in detail

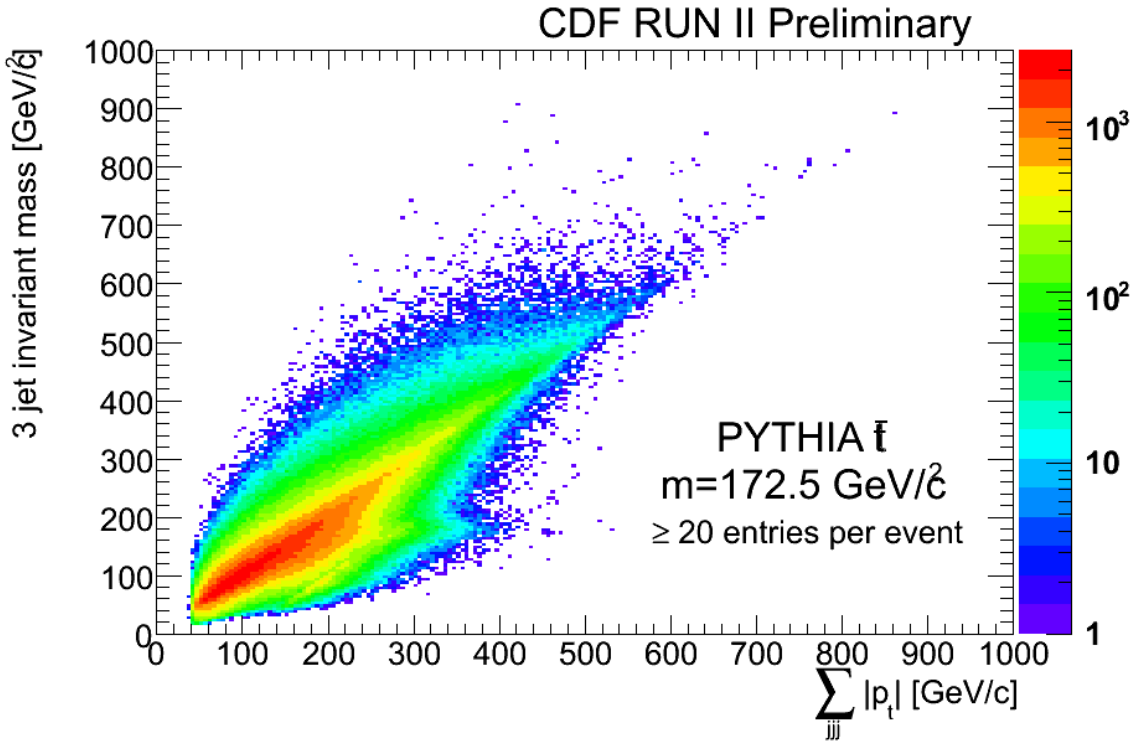
♦ on average Q →3j has higher pt than QCD

♦ plot all 3j combinations
– as sensitive as other schemes

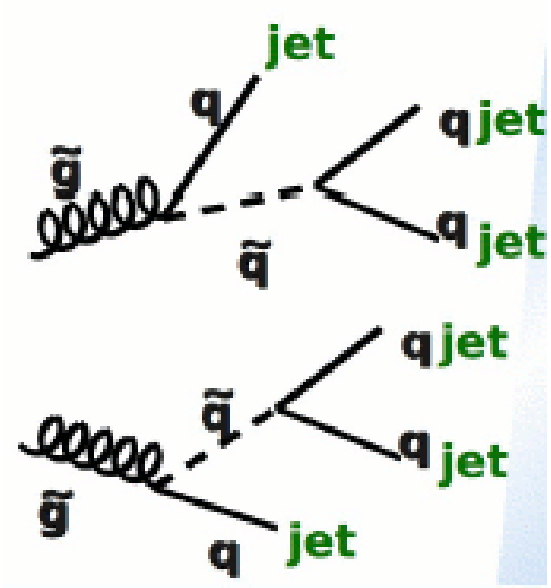
3j Resonances

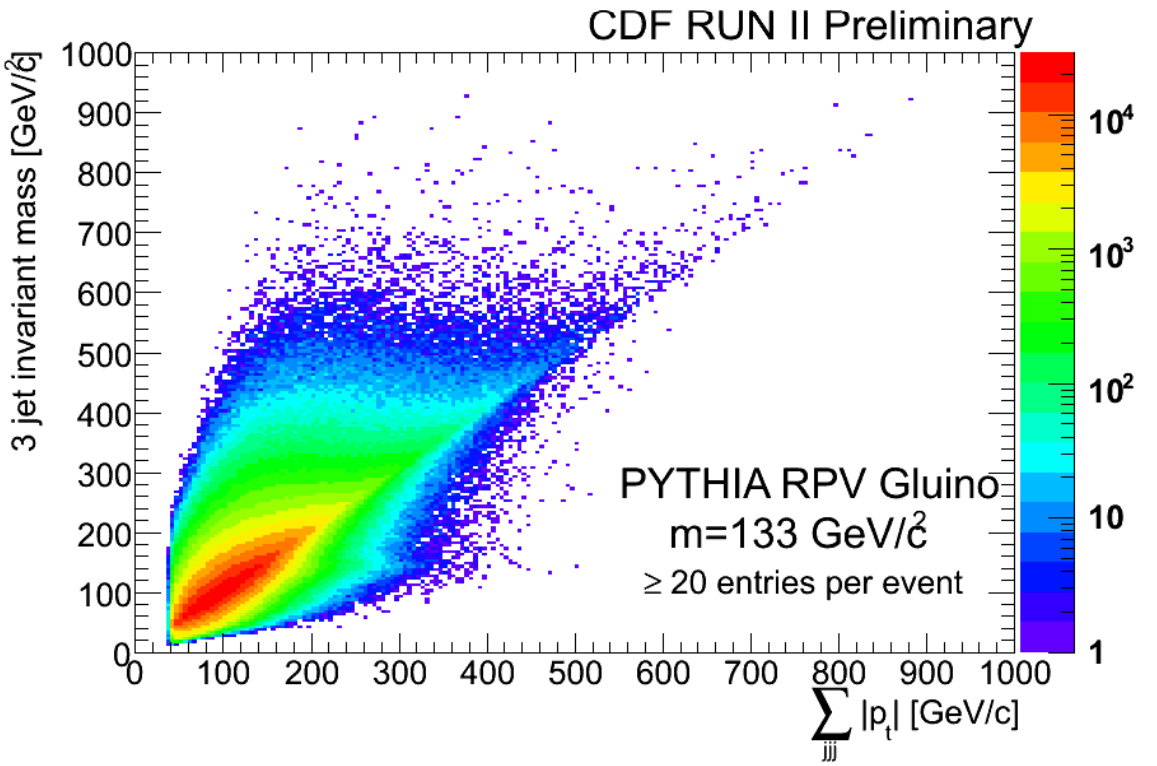
Examples of signals

- tt



- RPV gluino

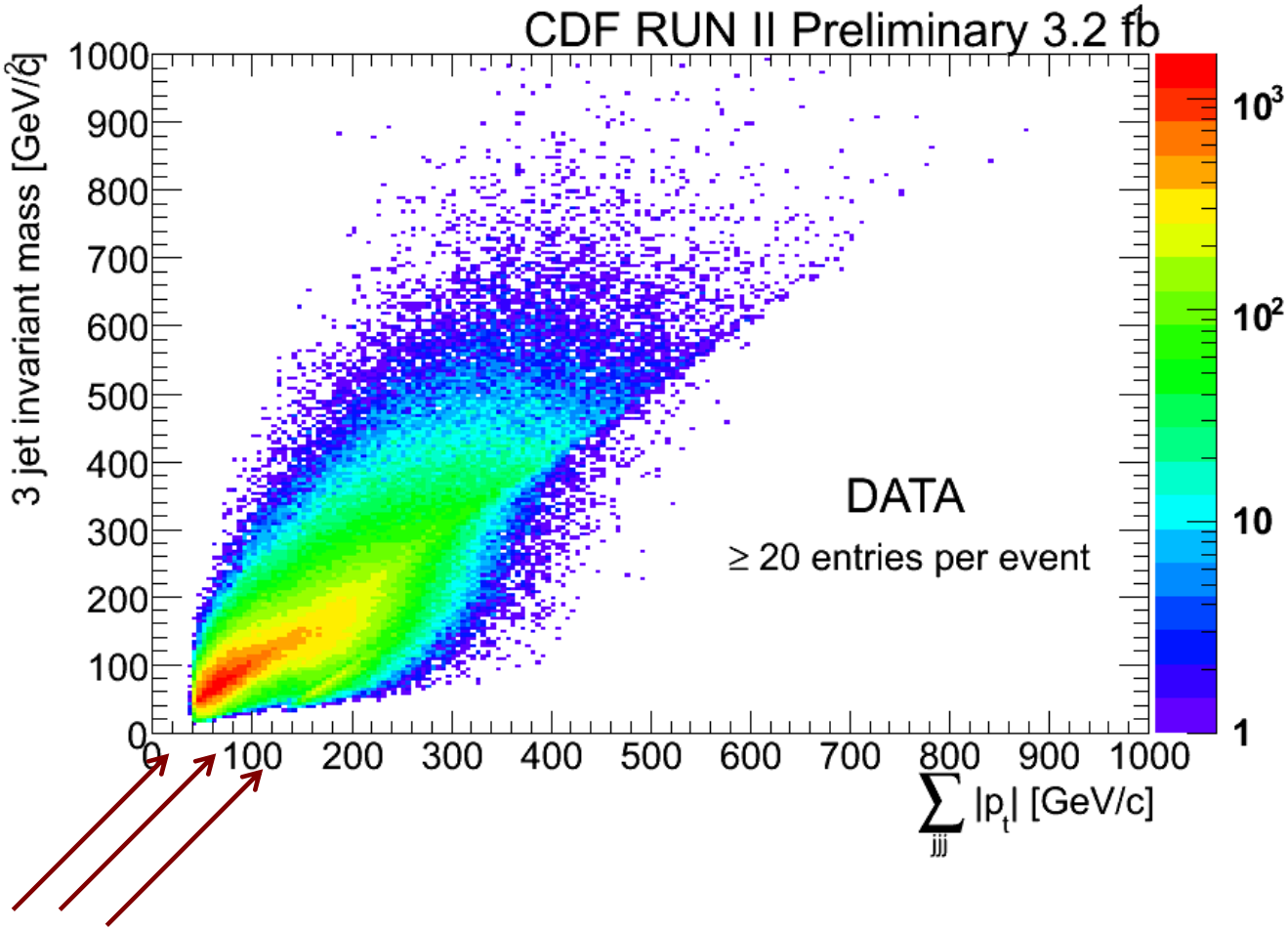




3j Resonances

Event Selection

- 3.2 fb^{-1}
- 6 jets
  E_T>15 GeV, |η|<2.5
- SumPt(6j) >250 GeV
- MET<50 GeV
- originate from one vertex



Diagonal cut

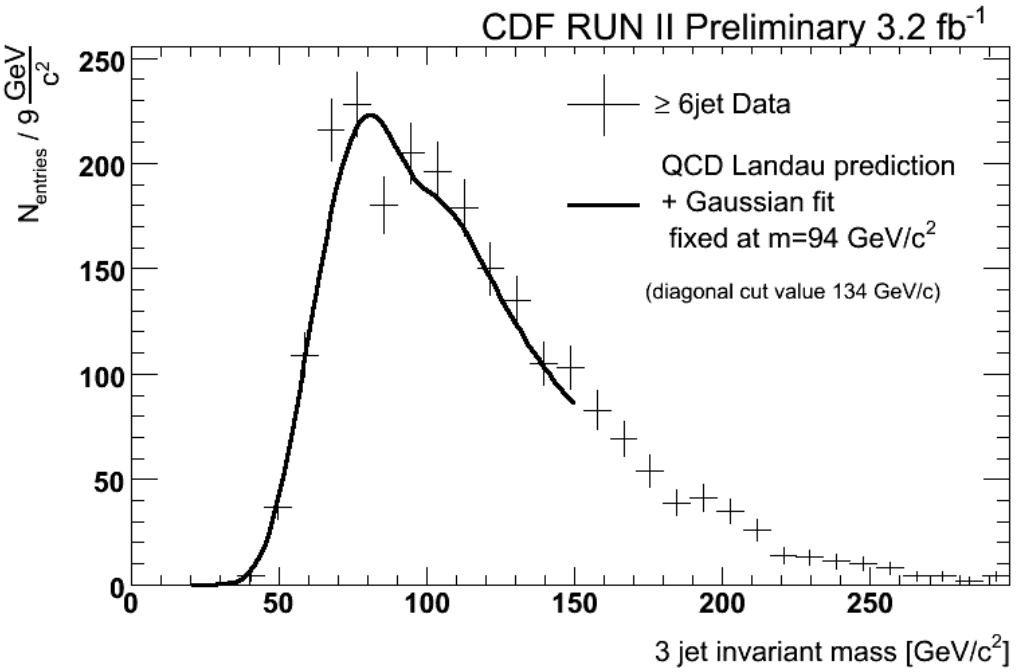
- Sum P_T(3j) > M(3j) + α
- optimized for each gluino mass,
  α is 100-200 GeV
- fit final mass plot

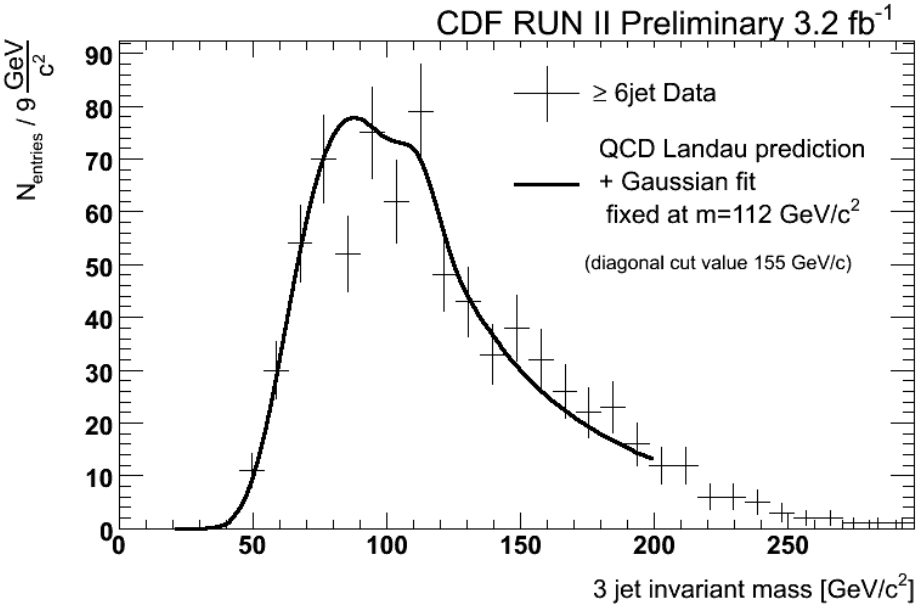
3j Resonances

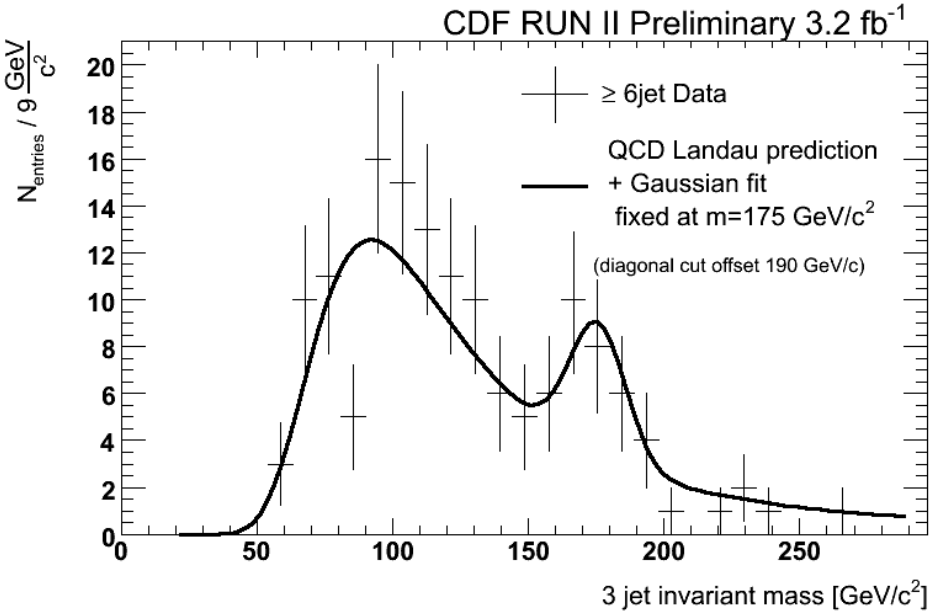
make diagonal cut, plot 3j mass

Backgrounds

- EWK negligible
- QCD shape from 3j combos in 5j data
  - scale Sum Pt to match 6j
  - plot 3j mass





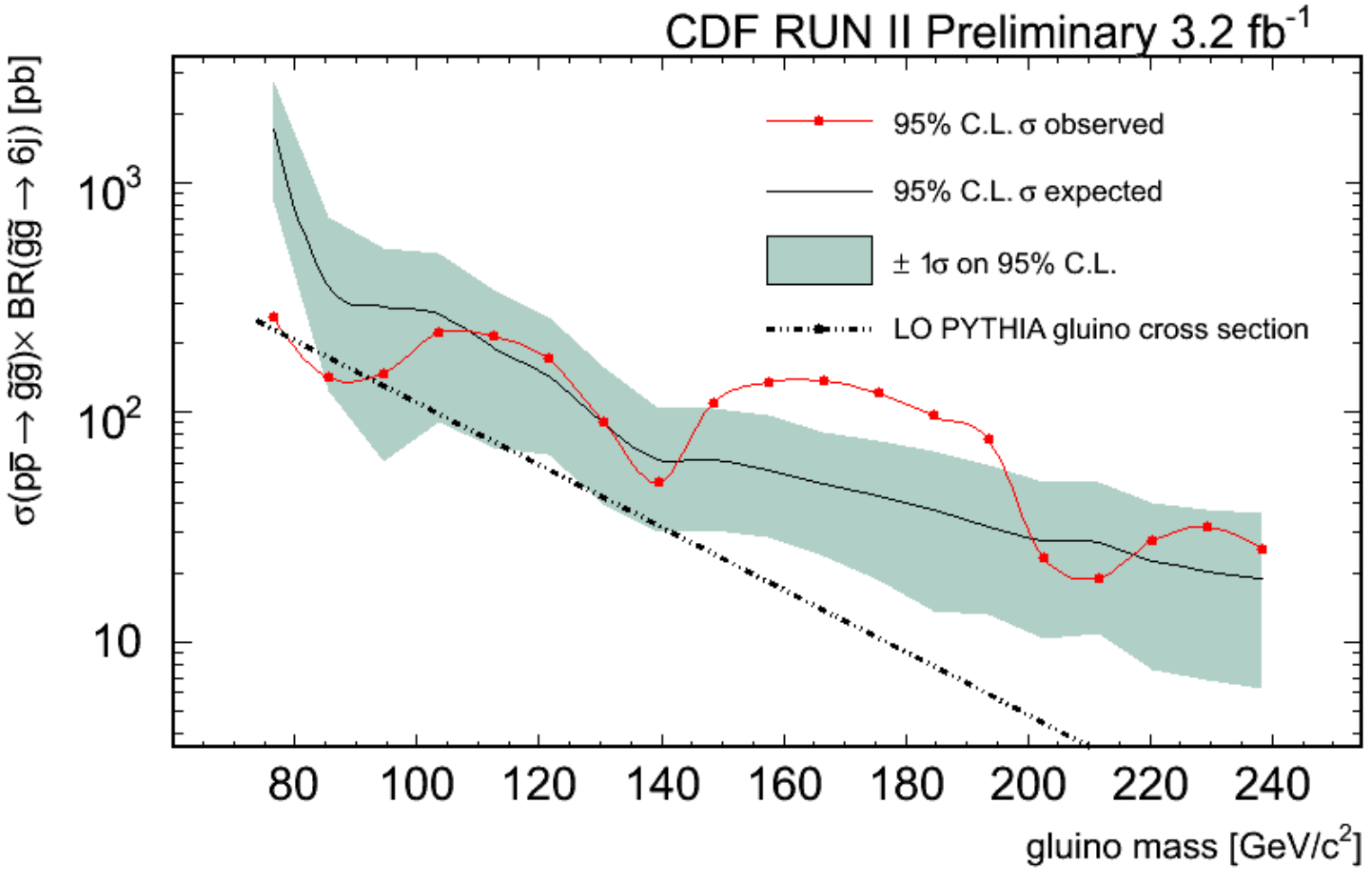


3j Resonances

Acceptance
- ~ 5%

Systematic
- PDF 10%
- ISR 20%
- jet energy scale 38%

Background systematic
- vary shapes



Search for Anomalous lbγMET and $t\bar{t}\gamma$

lbγMET Search

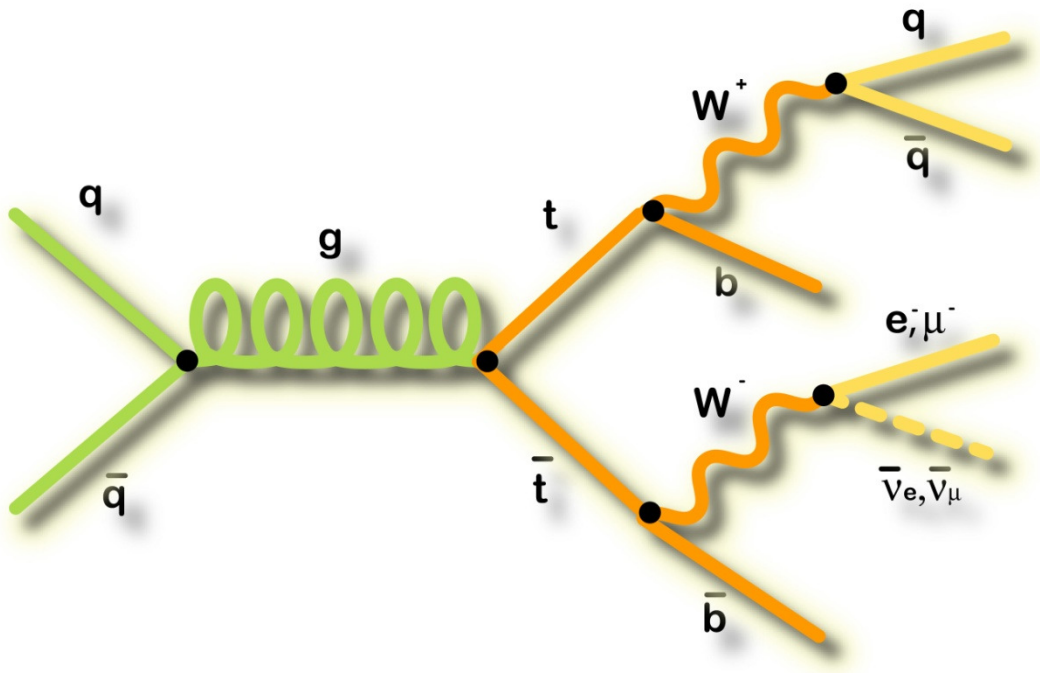
Goals

♦ signature-based search for anomalous rates or kinematics

♦ for example, GMSB can give lbγMET

♦ use top samples (w/ and w/o tags) and W/Zγ as control samples

♦ measure ttbar-γ cross section



lbγMET Search

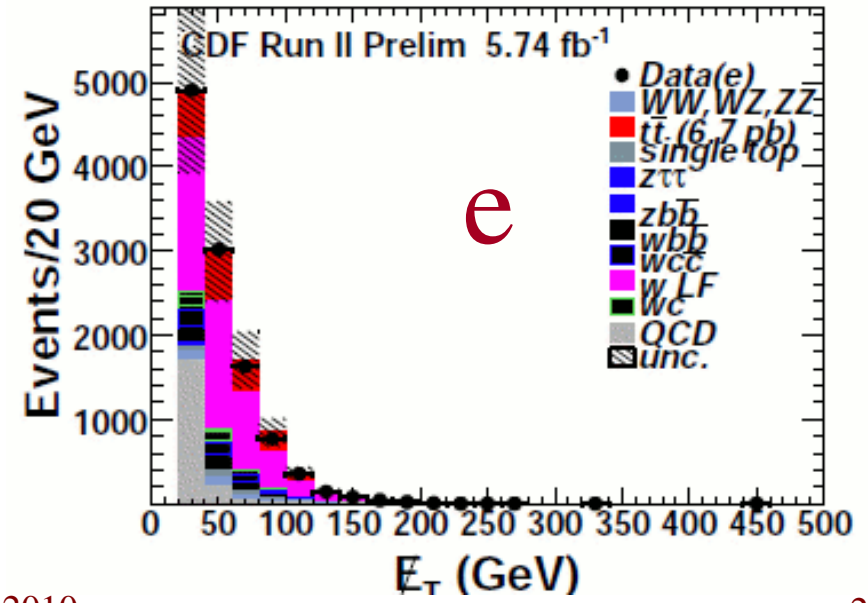
control samples

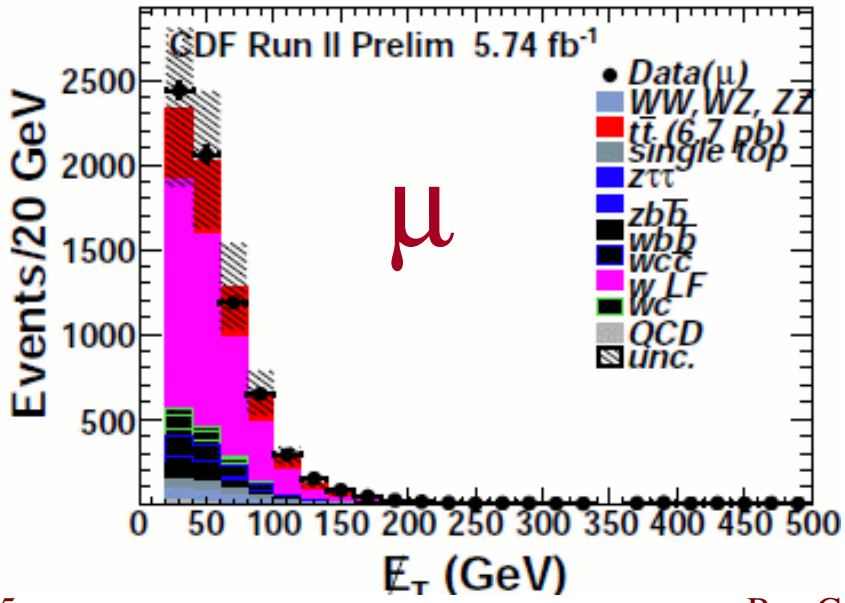
Pretagged tt Event Selection

- 5.7 fb^{-1}
- e or μ, isolated
  E_T or P_T>20 GeV, |η|<1.1
- 3 jets, E_T>15 GeV, |η|<2.0
- MET>20 GeV
- H_T>200 GeV

Backgrounds

- tt : from MC, 6.7 pb
- EWK: from MC
- QCD: use anti-electron sample, normalized to low MET





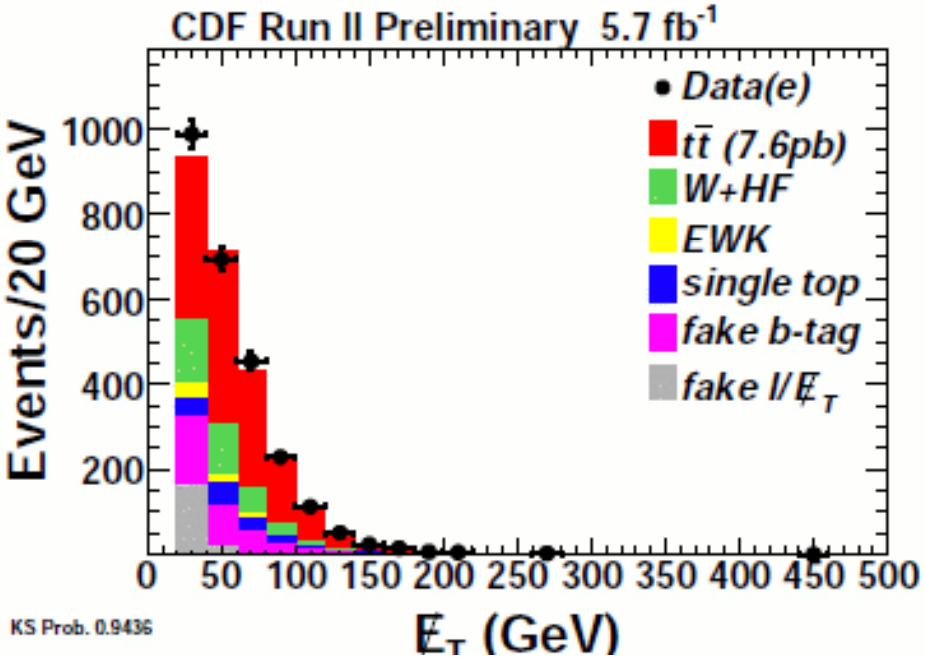
lbγMET Search

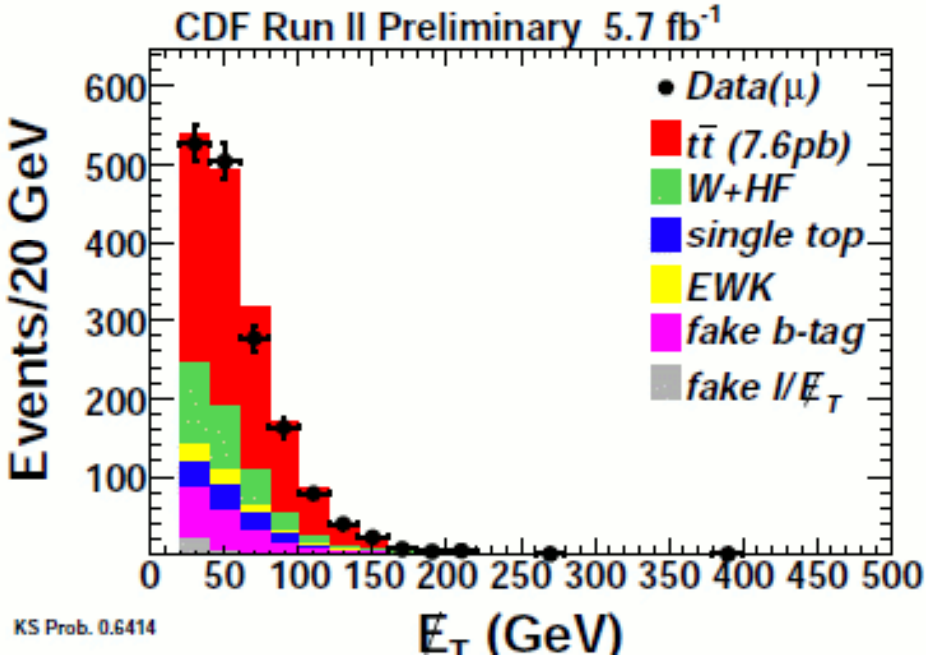
Event Selection

♦ Add one secondary-vertex (SV) loose-tagged jet

Background

♦ Add predicted mistags from the mistag matrix





♦ good agreement with previous tt cross section measurements

lbγMET Search

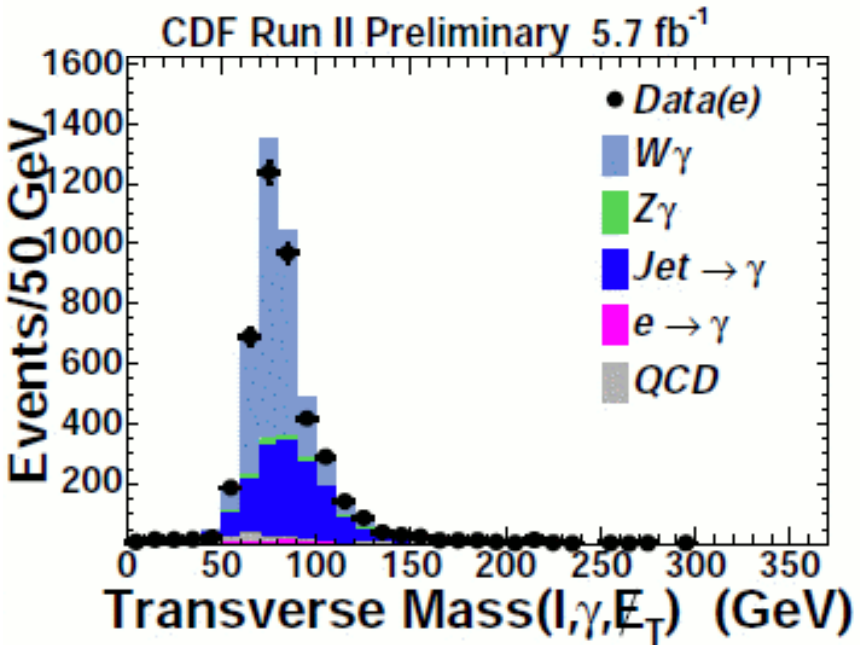
change gears – validate photon techniques on lγMET

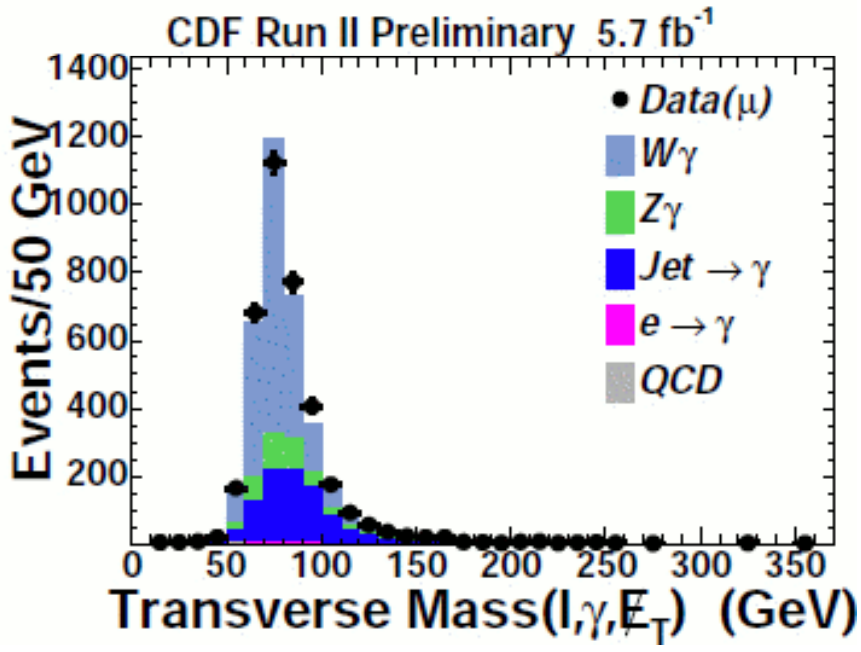
Event Selection

- lepton, MET as before
- one photon
  E_T>12 GeV, |η|<1.1

Backgrounds

- W/Z+γ form MC
- fake photons from fitting isolation





lbγMET Search

now to the search sample: lbγMET

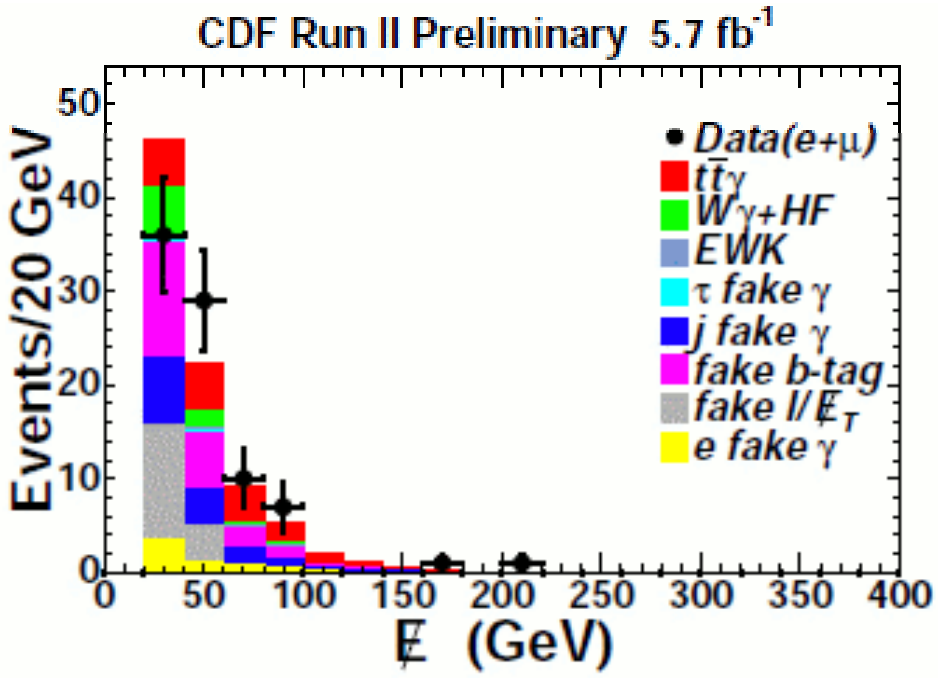
Event Selection

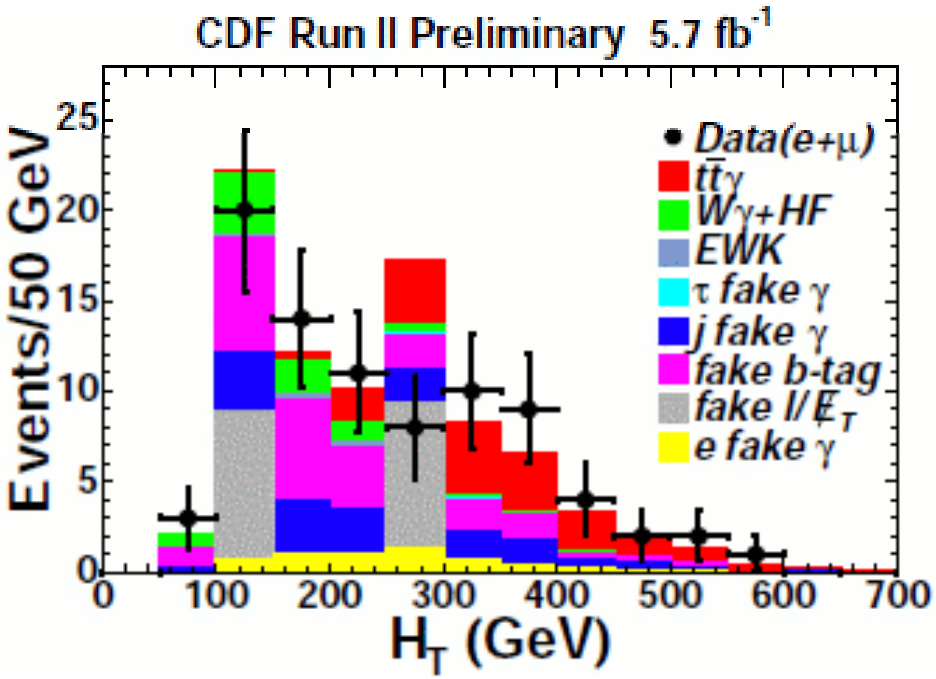
- lepton, γ, MET as before
- one jet, with loose SV tag

Event Counts

86 ±9 expected

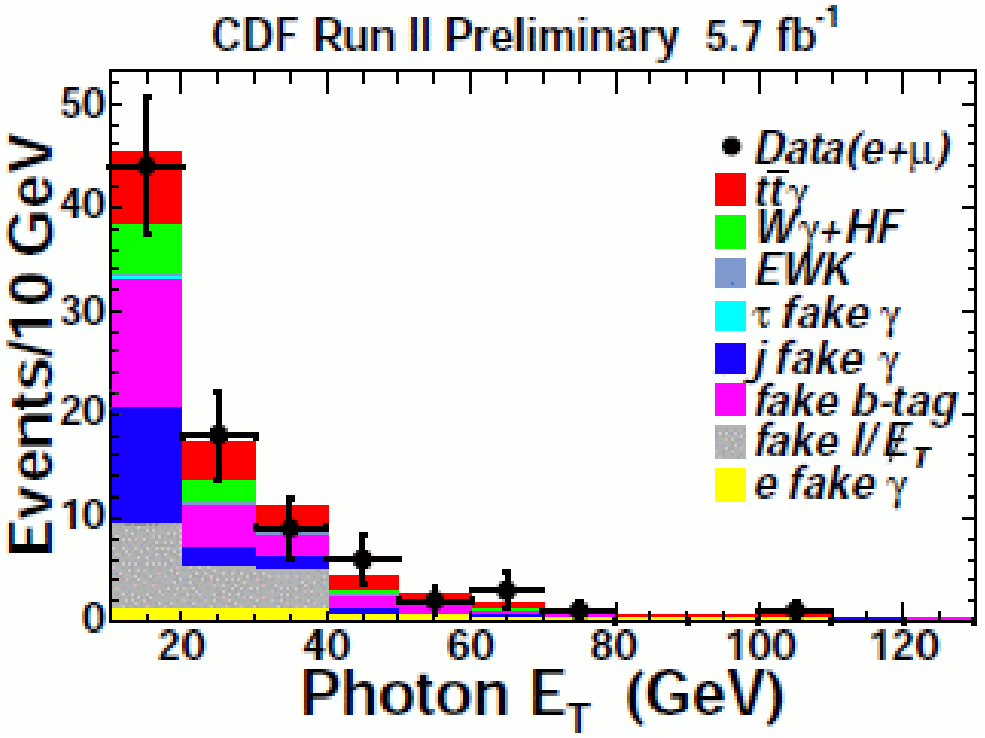
84 observed

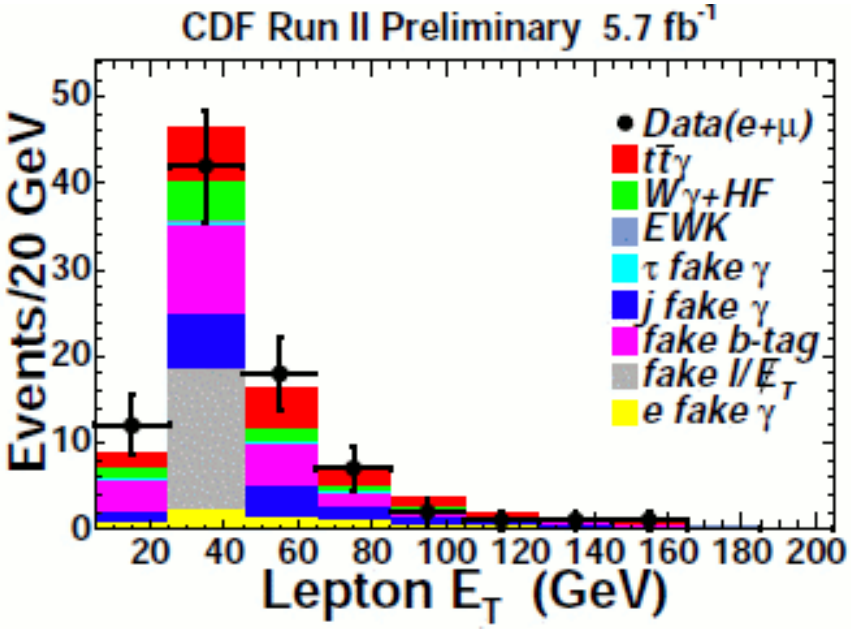


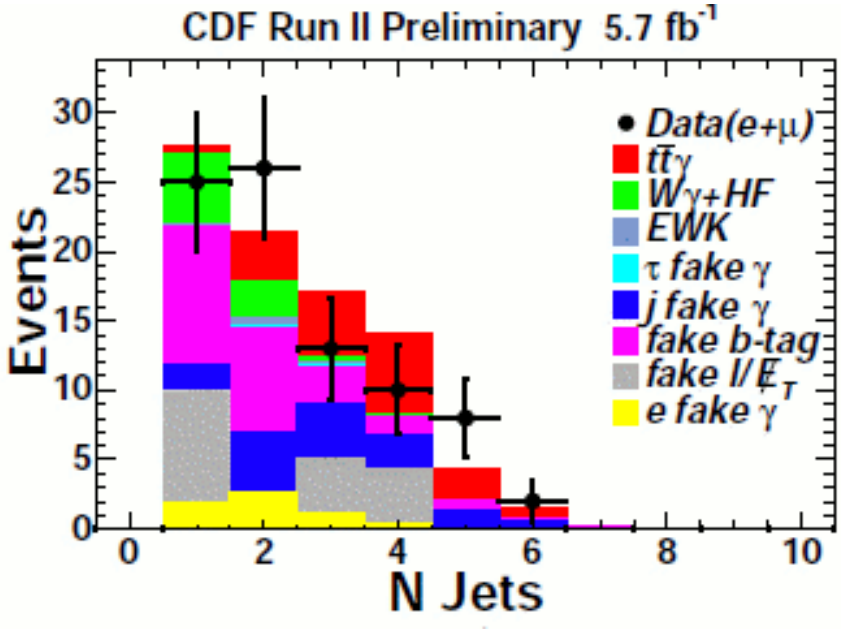


lbγMET Search

more kinematics for the search sample, lbγMET





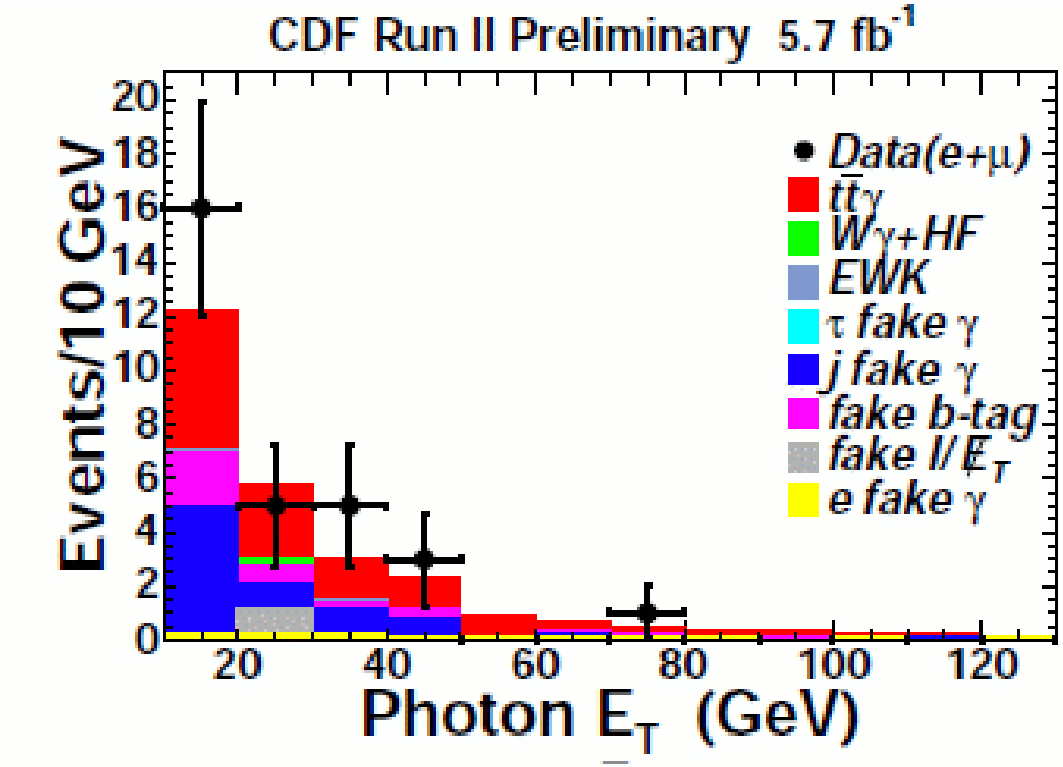


lbγMET Search

measure ttγ cross section

ttγ Event Selection

- e or μ, isolated
  E_T or P_T>20 GeV, |η|<1.1
- 3 jets, E_T>15 GeV, |η|<2.0
- one loose SV tag
- MET>20 GeV
- H_T>200 GeV
- photon E_T >12 GeV, |η|<1.1



ttγ Event Counts

13 ± 2 ttγ expected

27 ± 3 total expected

30 observed

ttγ Cross Section

0.10 ± 0.04 (stat+syst) ± 0.02 (lum) pb

0.08 ± 0.01 pb theory prediction at ~NLO

BSM Status at CDF

- LHC work is proceeding quickly, already eclipsing the Tevatron in sensitivity to excited quarks (others?)
- greatest sensitivity for all high-mass searches will pass to LHC with $<1 fb^{-1}$
- lower mass, electroweak production will not happen as fast – depends on the model
- experiencing an ongoing shift of people to LHC, but

Currently CDF is proceeding with BSM searches at a pace comparable to recent years...

Searched $\gamma\gamma$ Spectrum, RS Grav> 976 GeV

Searched $\mu\mu$ Spectrum, $Z'_{SM} > 1071$ GeV

Searched QQ $\rightarrow$(3j)(3j)

Searched lγbMET

Thank you...