Like-sign dimuon analysis on UED

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Overview

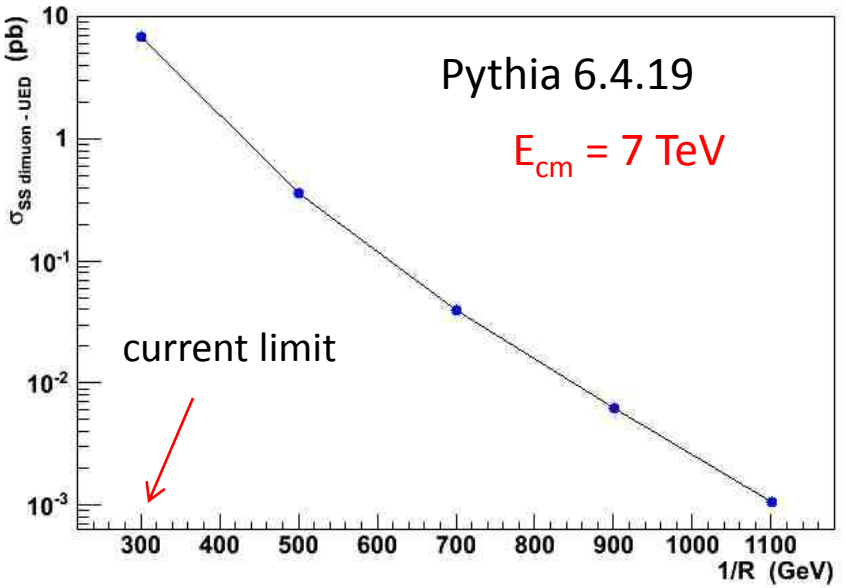
- Minimum UED Model
- Signal
- Event Selection
- Background Estimates: Monte Carlo
- Event Yields

The mUED model

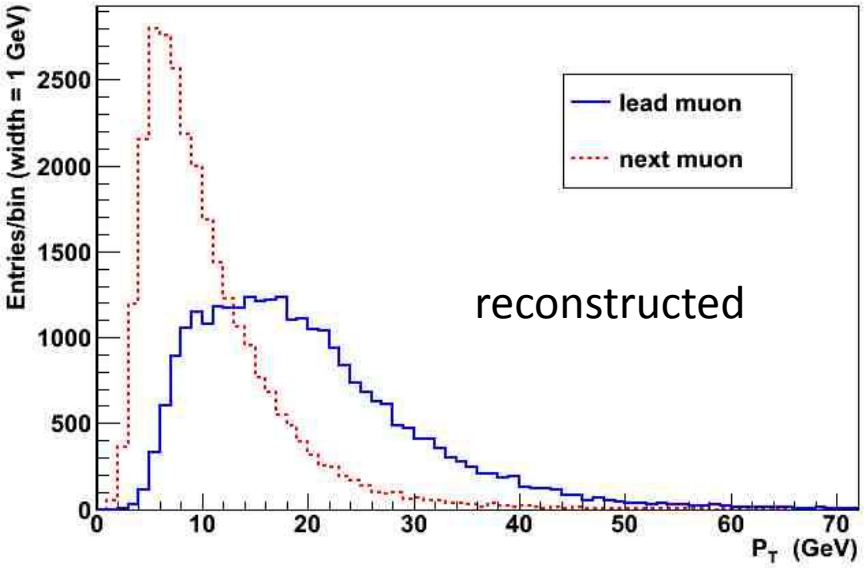
- All particles propagate in the extra dimension
- KK Parity $\leftrightarrow$ UED pair production and LKP (Dark matter candidate)
- Predicts the production of the N=1 modes at LHC energies
- Interesting phenomenology. In some aspects similar to SUSY models

The mUED model

- Parameters: 1/R, Λ
- XSection depends on 1/R
- Muons are KK daughters
- No veto on additional leptons



- P_T distributions in the low GeV range
- Trigger strategy should not cut those muons



Event Selection

- Selection based on event topology
  - Two prompt isolated muons (same sign)
  - Good dimuon vertex fit
  - Hadronic activity: number of jets
  - Missing E_T due to LKP pair
- Relatively clean and easy to reconstruct
  - Same sign requirement drastically reduces background
  - Charge assignment for muons should not be an issue
  - Cuts depend on relationship between signal and background distributions

Event Selection

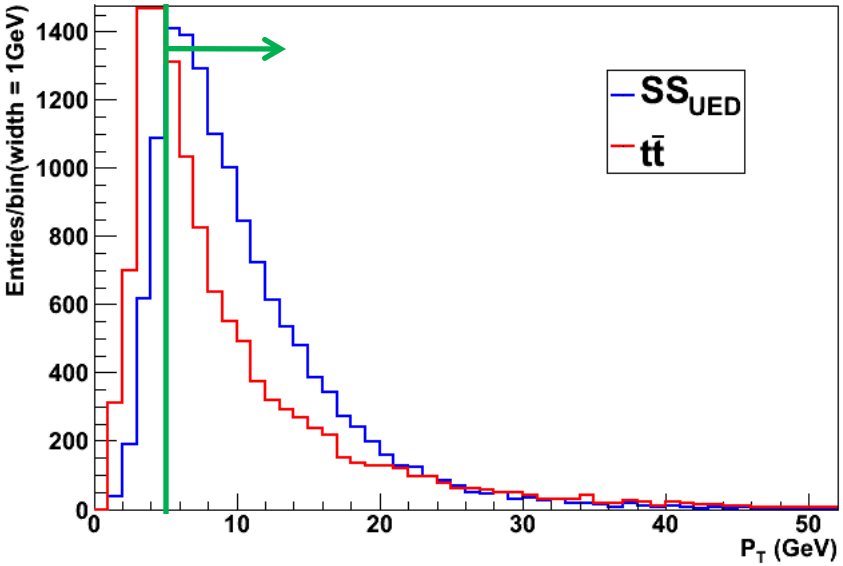
- Signal and ttbar events to obtain selection criteria
- Good sample to test background rejection
- All sorts of muons in the ttbar sample
  - high P_T ($W \rightarrow \mu\nu$)
  - hadrons (non-isolated, b-decays)
- Background cross-sections comparable with other samples
- SS dimuon fractions:
  - Signal, Z+jets: ~1%
  - ttbar: ~5%

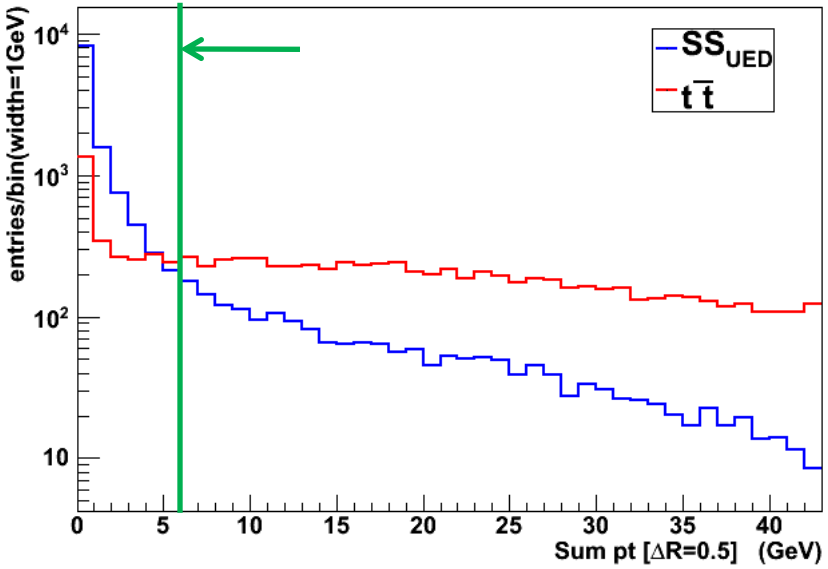
Selection variables

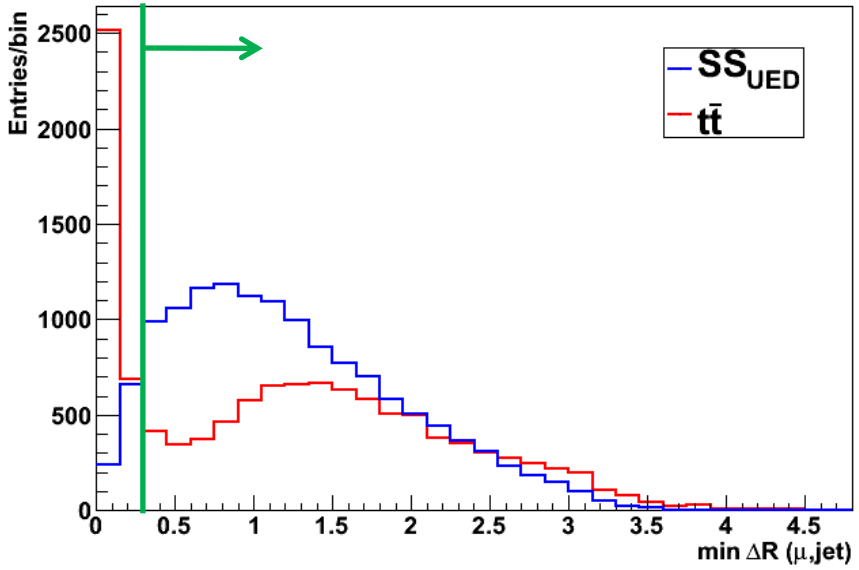
- Simplest procedure: histogram comparison
- Correlations not considered
- Number of variables to a minimum
- Cuts on: single muons, dimuon, jets

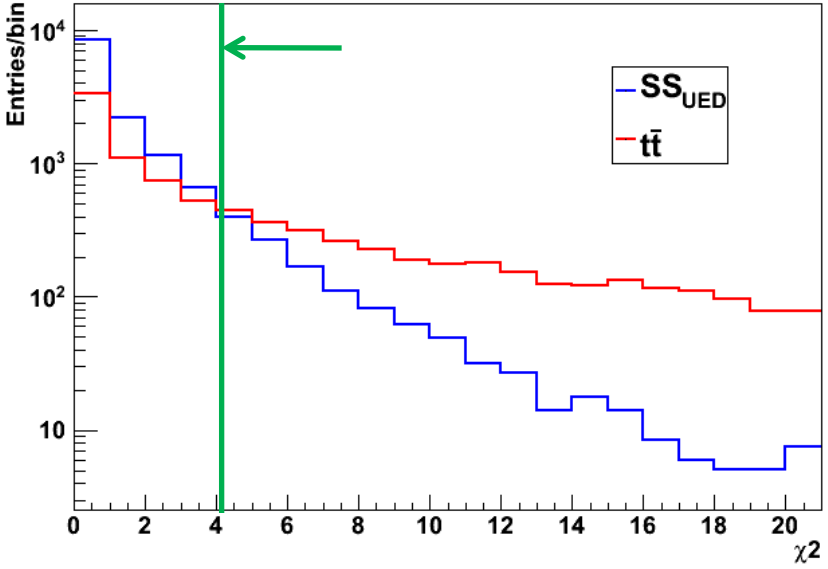
Variable	Cut
Leading μ: p_T	> 7.0 GeV, < 35.0 GeV
Leading μ: track p_T sum (ΔR=0.5)	< 6.0 GeV
Leading μ: min ΔR (μ, jets)	> 0.2
Next μ: p_T	> 5.0 GeV
Next μ: track p_T sum (ΔR=0.5)	< 8.0 GeV
Next μ: min ΔR (μ, jets)	> 0.3
Dimuon: vertex χ^2/ndof	< 4.0
Jets: n jets (p_T>25.0 GeV)	> 1

Selection variables









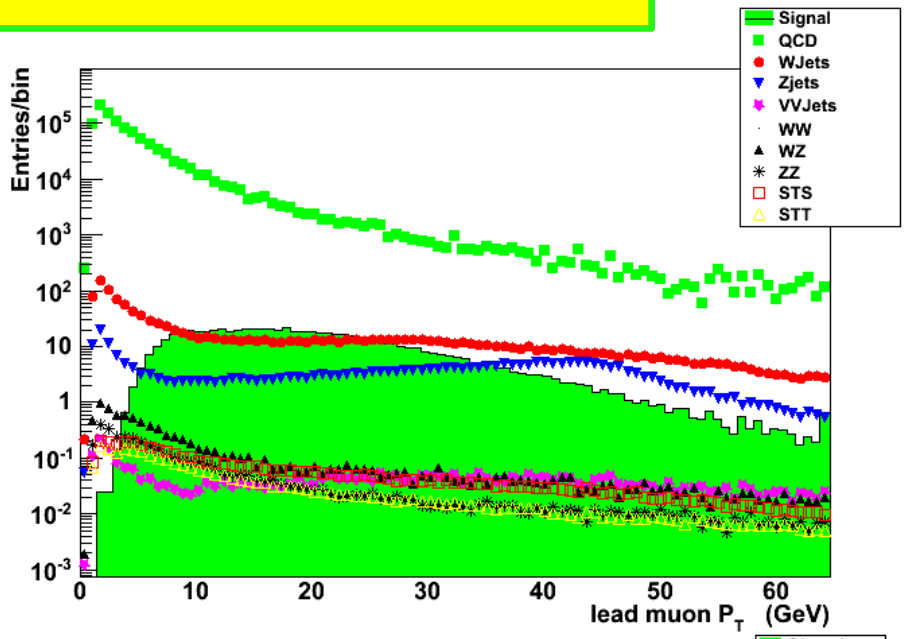
Setup

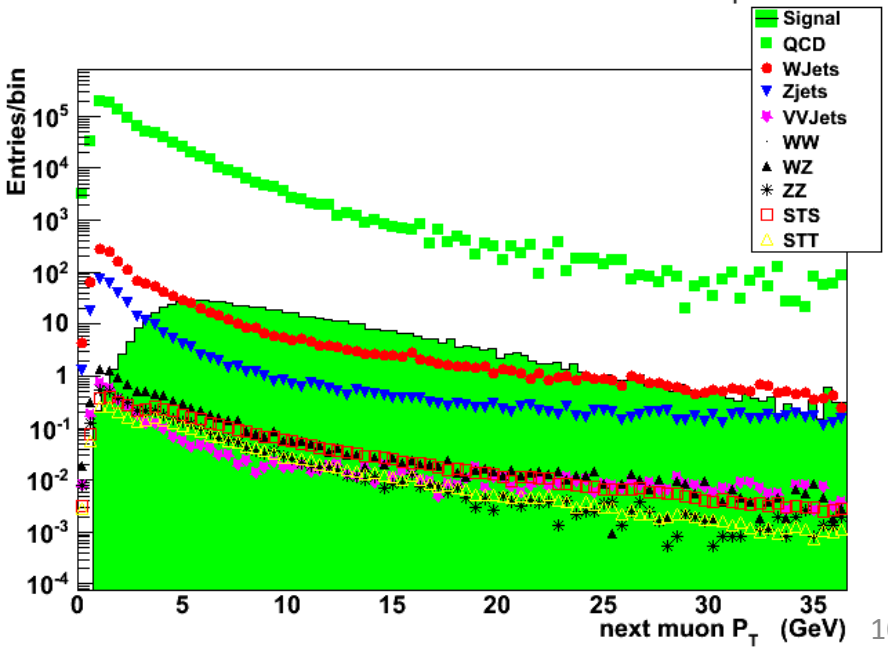
- Used CMSSW_3_5_6
- CM energy: 7 TeV (startup)
- UED ss dimuons:
  1/R: 300, 500, 700, 900, 1100
  ~35k events per point
- Various background datasets
  - V+jets, VV'+jets, QCD Multijets, TTbar+jets, Single T, Minimum bias

Background Distributions

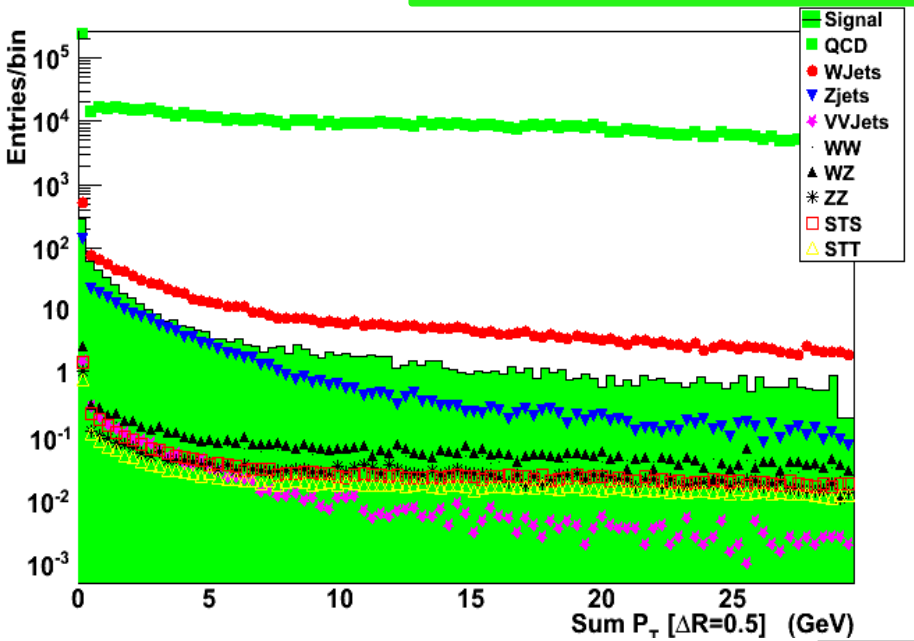
- Only same sign requirement
- Scaled to 100pb^{-1}
- Most background muons at very low P_T range
- V+Jets comparable to signal just after SS cut
- QCD dominates at this point

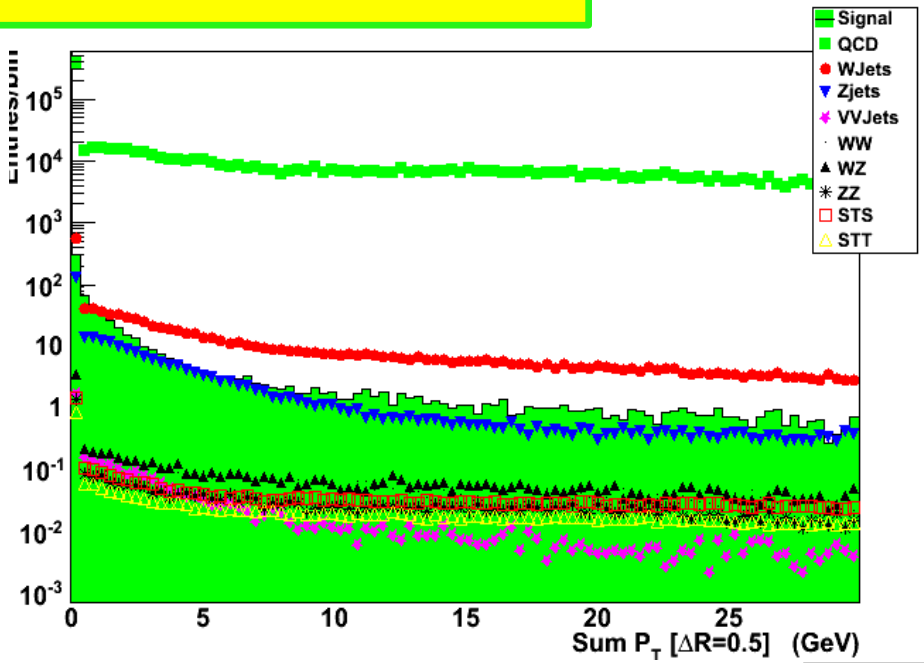
Background	SS dimuon fraction
QCD	1.7 x 10^{-3}
W+Jets	1.6 x 10^{-3}
Z+Jets	2.8 x 10^{-3}
VV+Jets	1.3 x 10^{-2}
WW	3.0 x 10^{-3}
WZ	9.1 x 10^{-3}
ZZ	9.2 x 10^{-3}
Single top s	4.5 x 10^{-2}
Single top t	2.7 x 10^{-2}

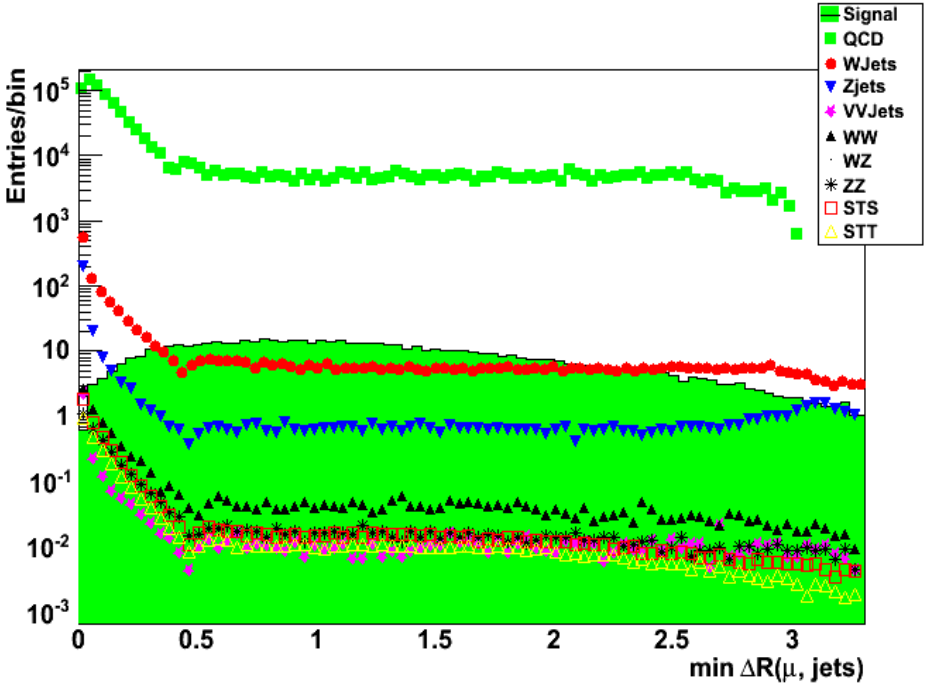


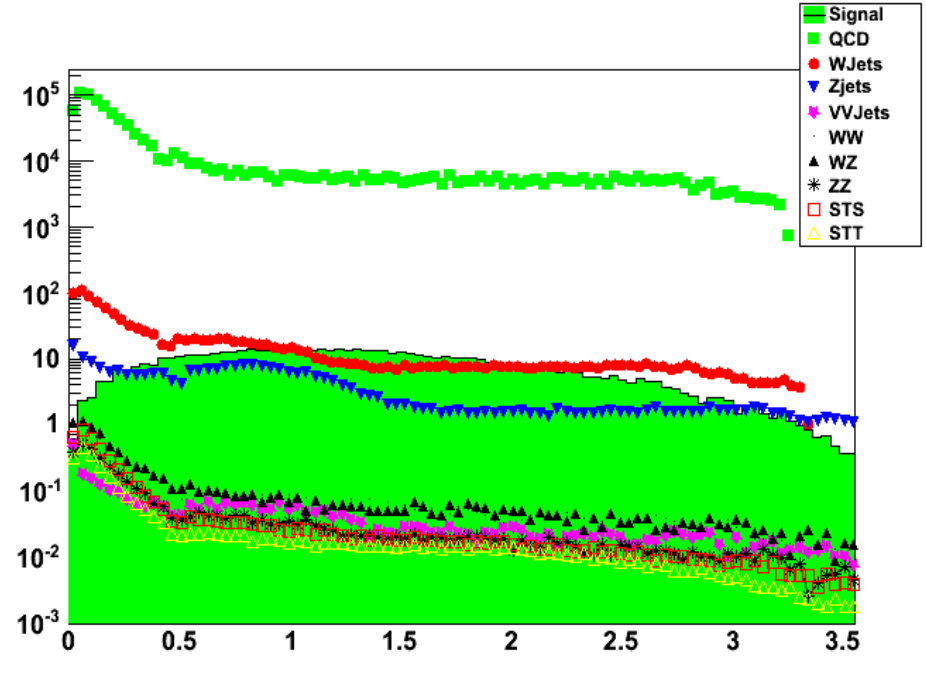


Background Distributions









Event Yields ($100pb^{-1}$)

- Only statistical uncertainties
- Signal selection

N_{sel}/N_{reco} ~250 events

- Background dominated by QCD?

Difficult to estimate via MC. Factorization? Data?

Background	Number of Events
W+Jets	19.8 ± 2.7
Z+Jets	3.4±0.6
VV+Jets	0.08±0.02
WW	0.18±0.06
WZ	0.13±0.04
ZZ	0.06±0.01
Single top s	0.028±0.003
Single top t	0.015±0.002

Cross-sections from:

https://twiki.cern.ch/twiki/bin/view/CMS/ProductionReProcessingSpring10

QCD Multijet Estimates

Background	All lead cuts	All next cuts	Dimuon cut	All cuts	Factorized cuts
QCD2_40_120	0,019	0,013	0,637	0,000	1,55E-04
QCD2_120_280	0,006	0,007	0,735	0,000	3,30E-05
QCD2_280_500	0,001	0,004	0,667	0,000	3,81E-06
QCD2_500_5000	0,000	0,001	0,633	0,000	2,64E-07
QCD3_40_120	0,021	0,038	0,671	0,000	5,37E-04
QCD3_120_280	0,013	0,022	0,693	0,000	2,03E-04
QCD3_280_500	0,002	0,008	0,705	0,000	1,12E-05
QCD3_500_5000	0,003	0,005	0,653	0,000	8,00E-06
QCD4_40_120	0,038	0,035	0,612	**0,004**	8,14E-04
QCD4_120_280	0,008	0,036	0,657	0,000	1,86E-04
QCD4_280_500	0,005	0,011	0,683	0,000	3,78E-05
QCD4_500_5000	0,001	0,007	0,643	0,000	4,60E-06
QCD5_40_120	0,022	0,051	0,635	0,000	7,11E-04
QCD5_120_280	0,015	0,029	0,657	0,000	2,84E-04
QCD5_280_500	0,007	0,009	0,670	0,000	4,23E-05
QCD5_500_5000	0,003	0,006	0,652	0,000	1,26E-05
QCD6_40_120	0,047	0,068	0,630	0,000	2,01E-03
QCD6_120_280	0,000	0,025	0,675	0,000	0,00E+00
QCD6_280_500	0,004	0,016	0,668	0,000	3,74E-05
QCD6_500_5000	0,000	0,013	0,651	0,000	0,00E+00

W+Jets

Background	Lead cuts	Next cuts	Dimuon cuts	All cuts	Factorized	Uncertainty
W1Jets_Pt0to100	0,12527	0,073013601	0,763779528	0,018	0,007	0,0023
W1Jets_Pt100to300	0,10816	0,050147493	0,710914454	0,003	0,004	0,0005
W2Jets_Pt0to100	0,16312	0,088388911	0,73965448	0,013	0,011	0,0011
W2Jets_Pt100to300	0,10526	0,068688671	0,704727921	0,004	0,005	0,0007
W2Jets_Pt300to800	0,03136	0,035637919	0,683535282	0,001	0,001	0,0001
W3Jets_Pt0to100	0,16312	0,082890071	0,719858156	0,012	0,010	0,0011
W3Jets_Pt100to300	0,07738	0,068452381	0,711309524	**0,001**	0,004	0,0003
W4Jets_Pt0to100	0,15156	0,071718539	0,700947226	0,009	0,008	0,0016
W4Jets_Pt100to300	0,11565	0,102040816	0,659863946	0,007	0,008	0,0025
W4Jets_Pt300to800	0,03974	0,033112583	0,71192053	0,003	0,001	0,0014

Other Samples

Background	All lead cuts	All next cuts	Dimuon cuts	All cuts	Factorized	Uncertainty
WW	0,122	0,073	0,729	0,020	0,007	0,007
WZ	0,085	0,203	0,678	0,014	0,012	0,004
ZZ	0,075	0,157	0,582	0,014	0,007	0,003
STS	0,136	0,125	0,394	0,006	0,007	0,001
STT	0,102	0,104	0,436	0,005	0,005	0,001

QCD Estimate

- Total of QCD events: 440±174
- Using naïve assumption
- Uses fractions obtained for each bin
- Yield is given by the sum of each bin estimate
- Uncertainties propagated from the 3 ratios
  (lead muon cuts, next muon cuts, dimuon cuts)

Summary

- UED XSections: like-sign analysis possible
- Background can possibly be controlled
- Various background channels included in the analysis
- Signal events ~250 events for 1/R=300 GeV
- Background ~460±175
- QCD might be dominant
  - Factorization looks feasible
  - Additional studies to prove (or not) if this can be done
  - Other improvements can be implemented
    - Loose cuts and check if fractions are consistent
    - Exclude dimuon cuts and swap cuts order
    - Look at data. Should be able to get some information with current luminosity
- Trigger performance studies

Backup Slides

Muon Reconstruction

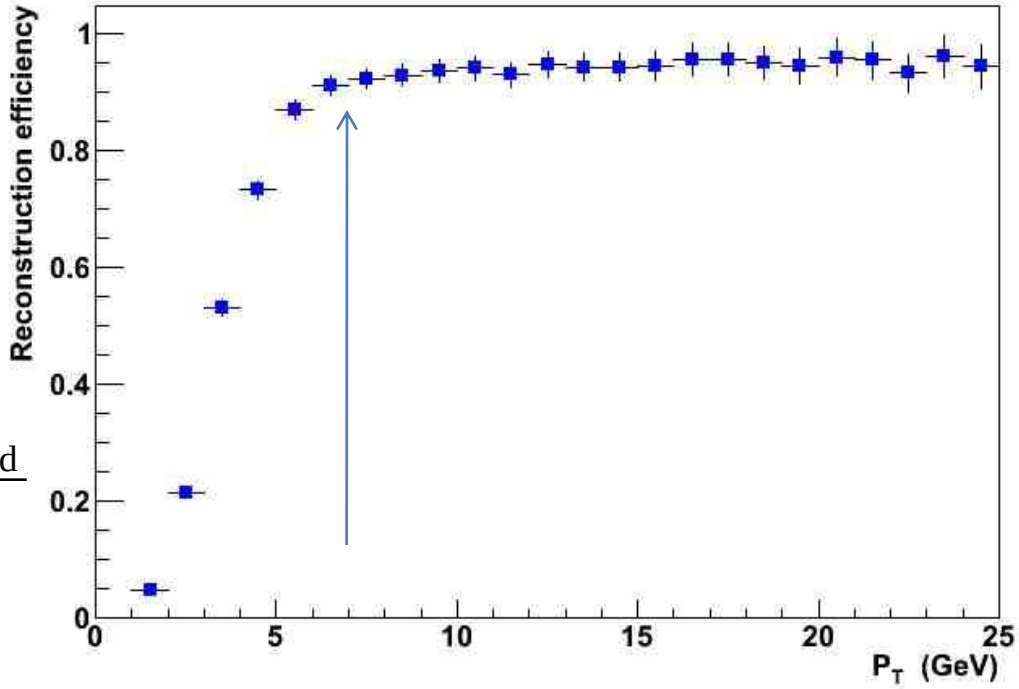
- Reconstruction efficiency as a function of P_T
- Muons at low range are already suppressed in the reconstruction

Muon requirements:

Prompt, Global,

MC matched

$$\mathrm{eff}(P_T) = \frac{\mu_{\mathrm{Reco\,\&\,Global\&\,MCMatched}}}{\mu_{\mathrm{MC}}}$$

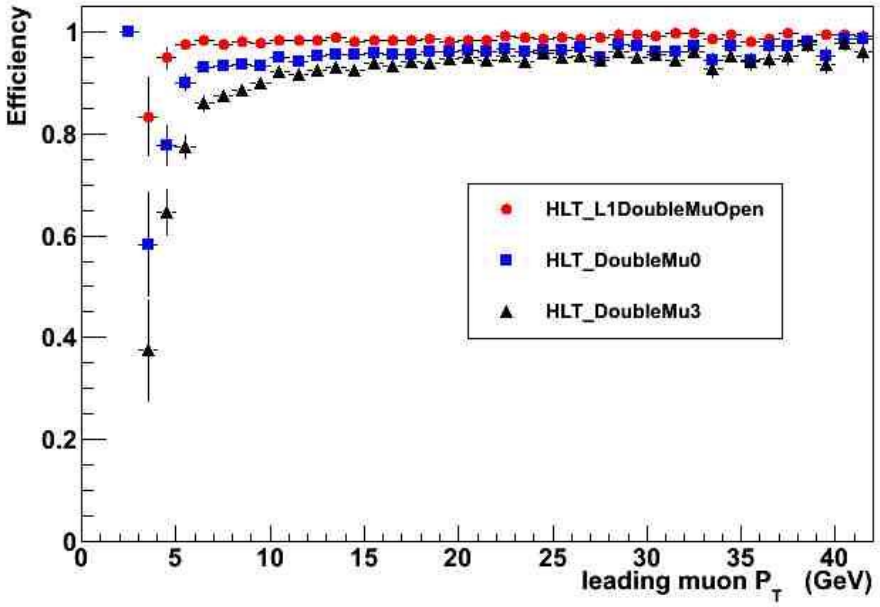


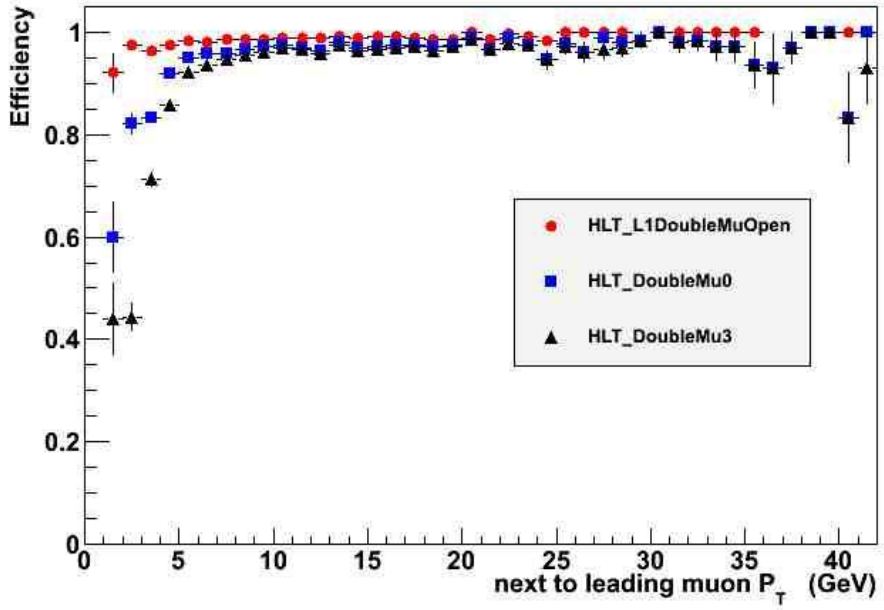
- Trigger and selection algorithms should not increase those effects above ~7GeV

Trigger – signal events

- Only Global Muons used
- Efficiency for both muons
- Both muons reconstructed:
  80% of signal kept

$$\mathrm{eff}_{\mathrm{trigger}}(P_T) = \frac{\mu's \text{ in the } P_T \text{ bin after } Trigger}{\mu's \text{ in the } P_T \text{ bin before } Trigger}$$





Trigger – ttbar events

$$\mathrm{eff}_{\mathrm{trigger}}(P_T) = \frac{\mu's \text{ in the } P_T \text{ bin after } Trigger}{\mu's \text{ in the } P_T \text{ bin before } Trigger}$$