Light-flavored Squark Production at CLIC

Frank Simon
MPI for Physics & Excellence Cluster 'Universe'
Munich, Germany

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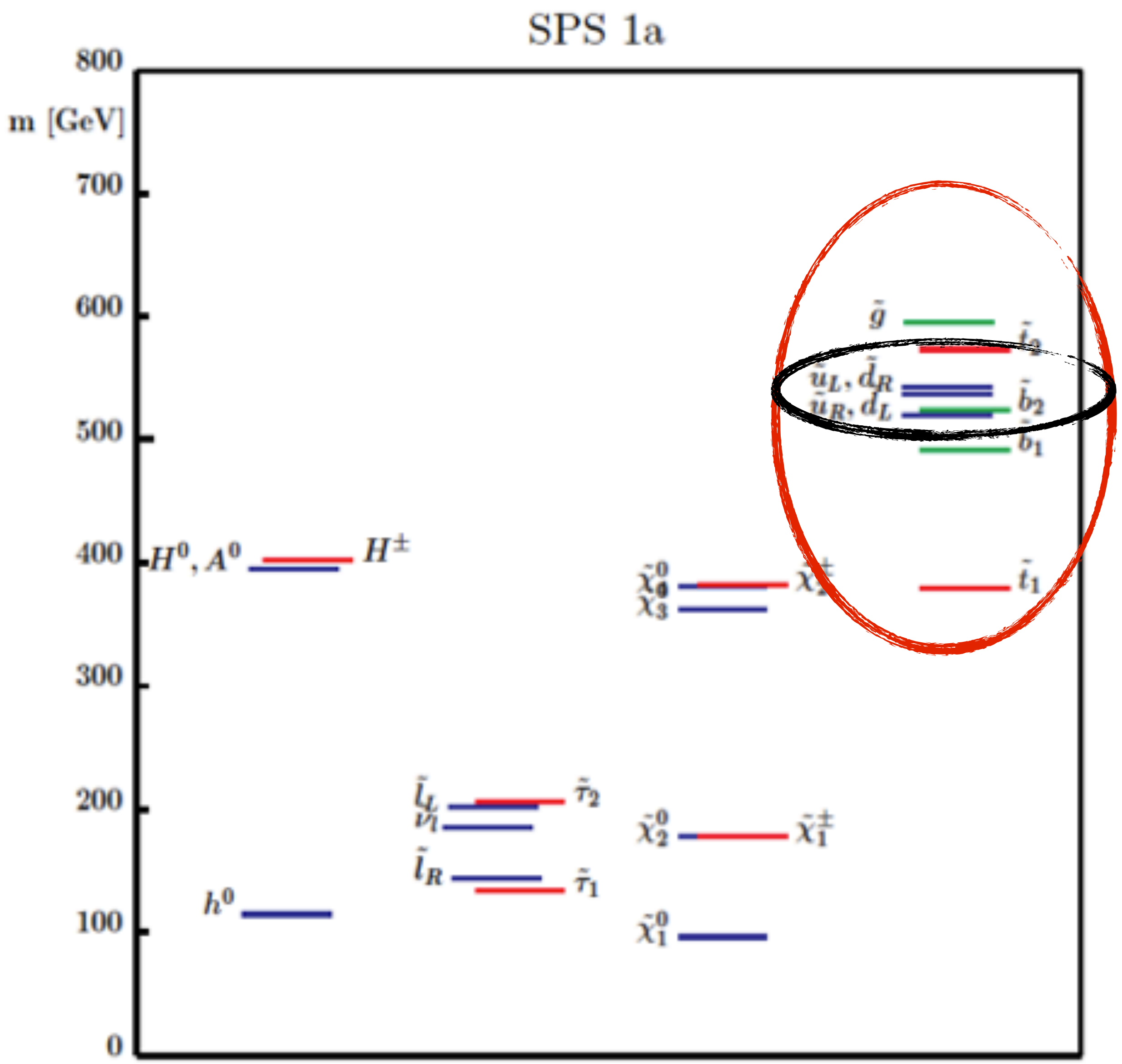
Outline

- Squark production and decay at CLIC
- Techniques for mass measurements
- Experimental challenges
    - SM background suppression
    - $\gamma\gamma \rightarrow$ hadrons background
- Summary/Outlook

SQuarks: The Domain of Multi-TeV Colliders

- In many mSUGRA models the squarks are among the heaviest sparticles
  - Requires collision energies beyond 1 TeV for pair production
  - The light-flavored quarks are special: Left and right squarks don’t mix to form two mass states

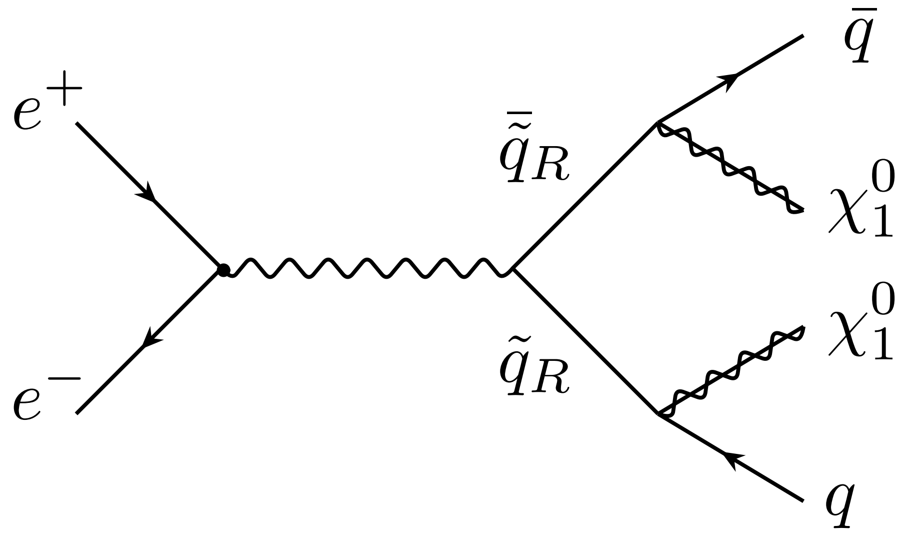


- typically no distinction between first and second generation:
  - up, charm squarks and down, strange squarks have equal masses
  - small mass difference between up-type and down-type
  - mass difference between left- and right squarks

Precise squark mass measurements are an important ingredient for SUSY spectroscopy!

Light-flavored Squark Production & Decay

- The CLIC benchmark: Light-flavored (u, d, s, c) Right-Squark mass ~ 1.12 TeV

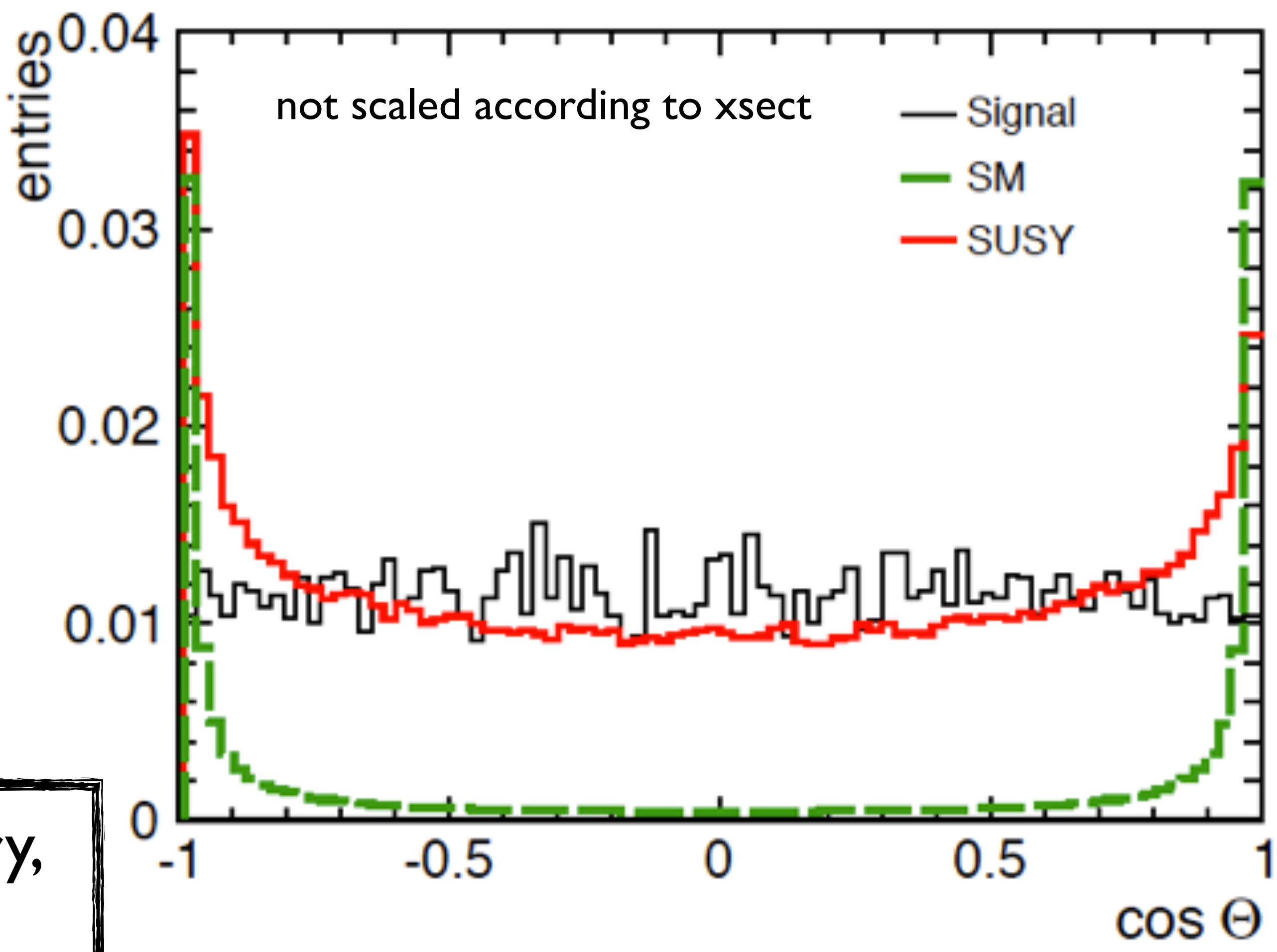


3 TeV CLIC cross section (u, d, s, c): ~ 1.7 fb

(almost) exclusive decay $\tilde{q}_R \rightarrow q\chi_1^0$

Signature: Two high-energy jets, missing energy

- Signal flat in cosθ
- Backgrounds peak forward and backward
  - Dominating background SM 4 fermion final states - xsect ~ 10 pb



➡ Particular emphasis on barrel calorimetry, tracking and particle flow

Signal, Background and Cuts

	Final State	σ (with ISR + BS)
Signal	$qq\chi\chi$ (u,d,s,c)	~ 1.7 fb
SM Background	qq	~ 2300 fb
	$qq\nu\nu$	~ 950 fb
	qqee	~ 3300 fb
	$qqe\nu$	~ 5300 fb
SUSY	$qq\nu\nu\chi\chi$	~ 1.0 fb
	$qql\nu\chi\chi$	~ 8.5 fb
	$qqll\chi\chi$	~ 0.6 fb

still under study:
qqll, $qq\nu l$ for l = μ, τ

} dominating contributions (qq, $qq\nu\nu$, qqee, $qqe\nu$)

- Reject events with two-jet invariant mass consistent with weak bosons
- cuts on N_{reco}, accoplanarity of jets, cosθ, jet invariant mass, transverse momentum relative to event thrust axis missing p_T, maximum lepton momentum in event

Mass Measurement Techniques

- Parameters of the used SUSY scenario:

$$m(\tilde{u}_R, \tilde{c}_R) = 1126\,\mathrm{GeV} \quad m(\tilde{d}_R, \tilde{s}_R) = 1116\,\mathrm{GeV} \quad m(\chi^0_1) = 328\,\mathrm{GeV}$$

- Also used for illustration purposes: SPS1b:

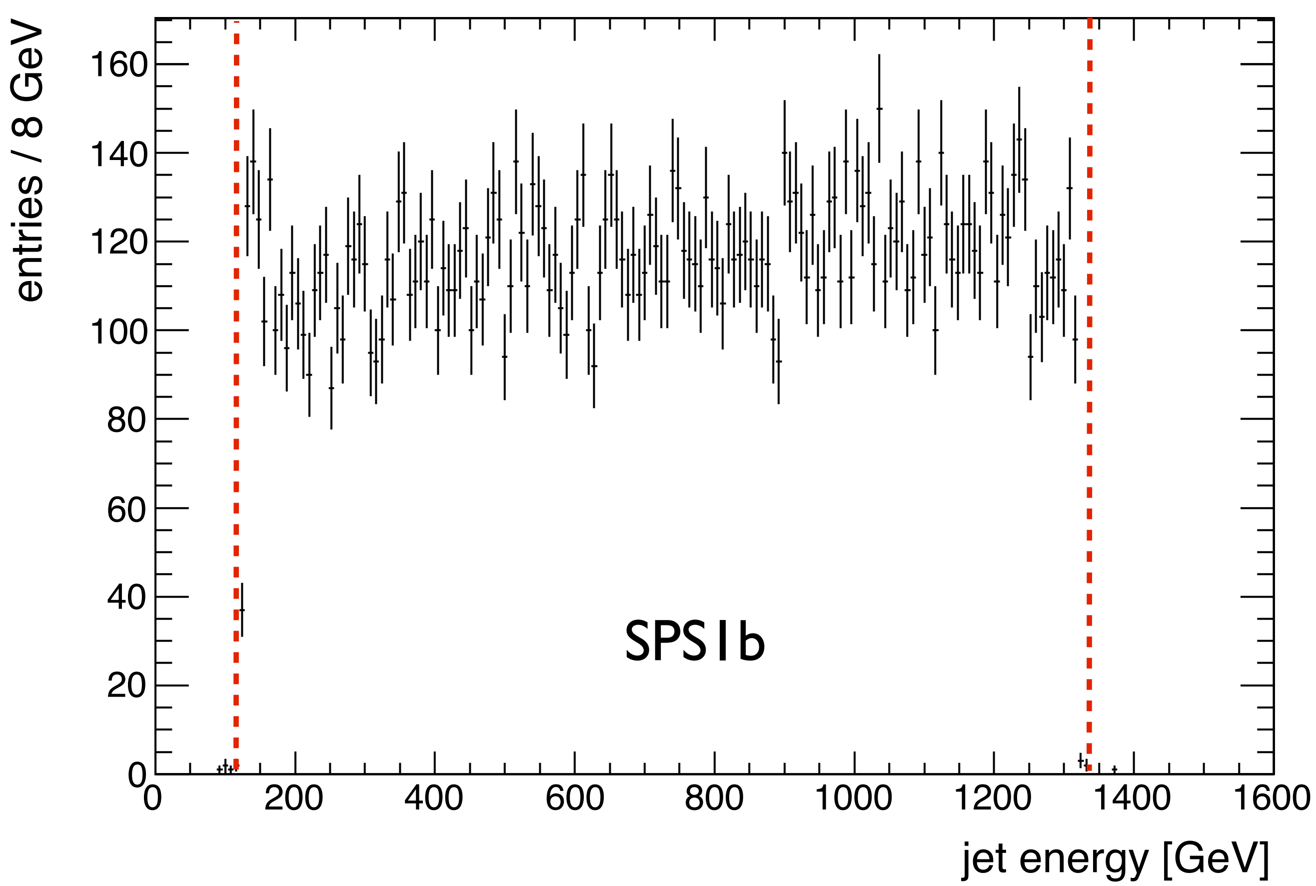
$$m(\tilde{u}_R, \tilde{c}_R) = 846\,\mathrm{GeV} \quad m(\tilde{d}_R, \tilde{s}_R) = 843\,\mathrm{GeV} \quad m(\chi^0_1) = 162\,\mathrm{GeV}$$

➩ These masses determine location of kinematic edges in distributions

The “classic” observable:

Distribution of jet energies

- Simultaneous measurement of squark and neutralino masses



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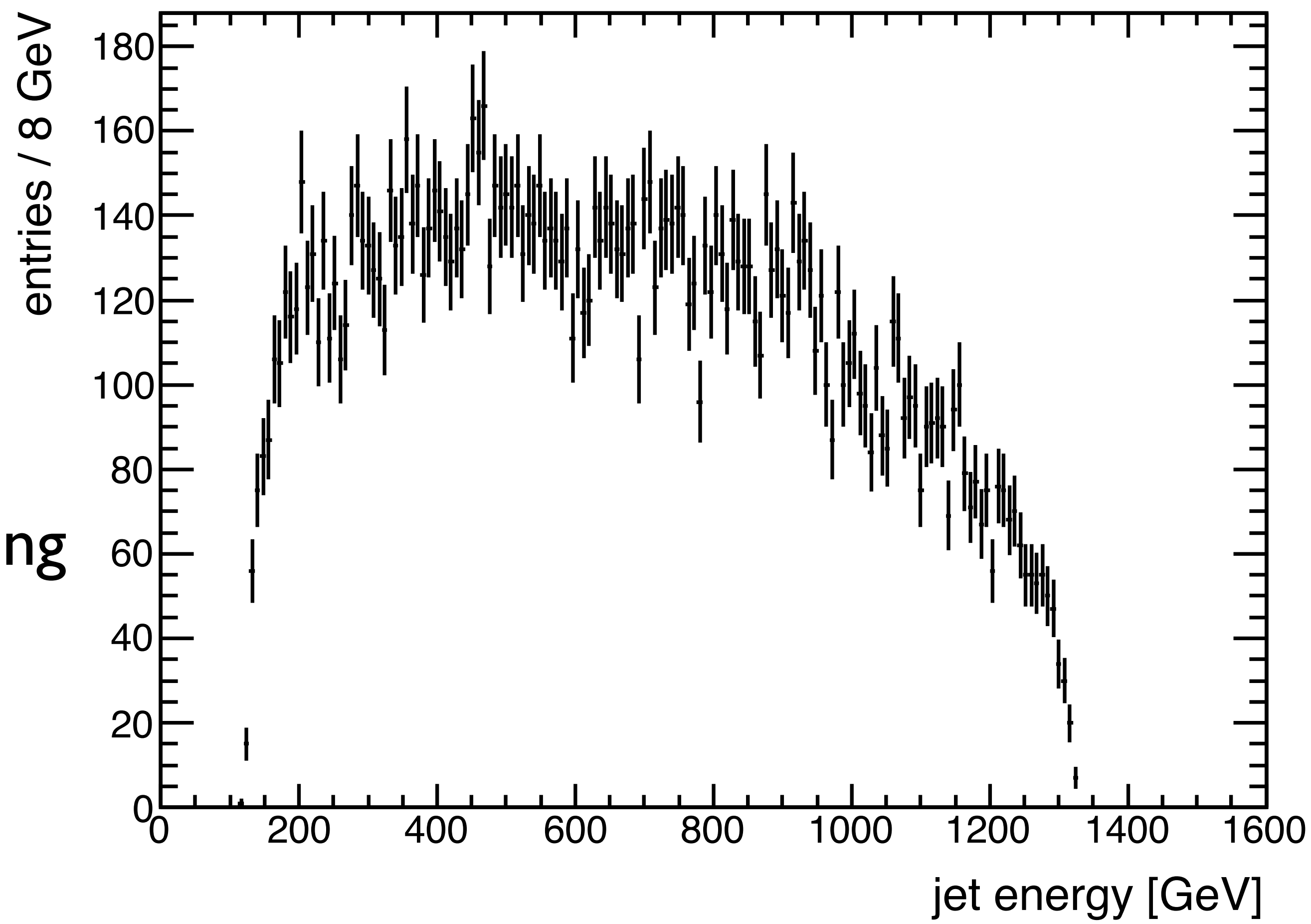
The "classic" observable:

Distribution of jet energies

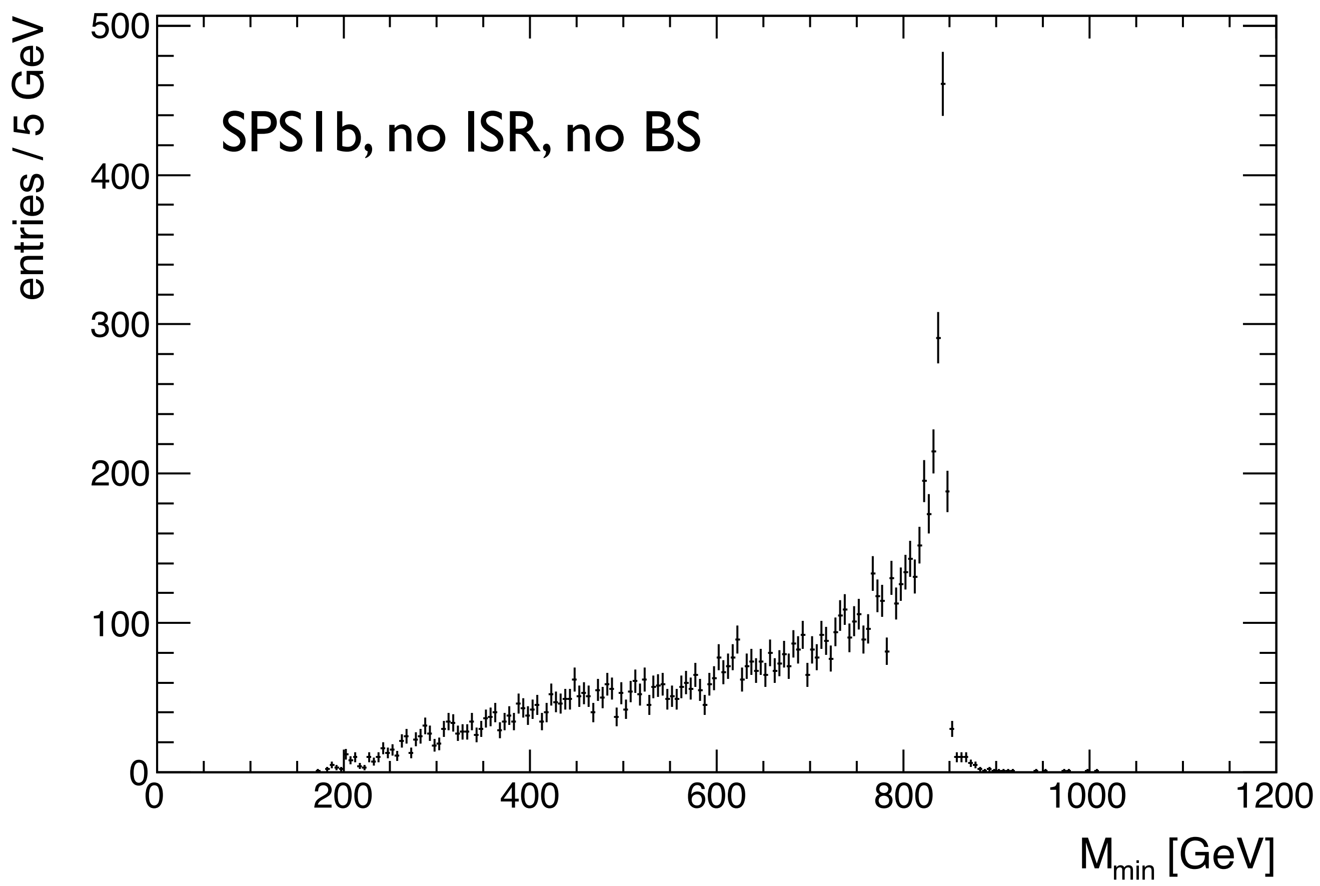
- Simultaneous measurement of squark and neutralino masses
- Strong distortions of upper edge from beam energy smearing due to beamstrahlung
- both edges suffer from SM background, γγ → hadrons background strongly affects single jet observables



Mass Measurement Techniques: Minimum Squark Mass

- Calculate the minimum squark mass allowed in an event, using
  - the measured jet three momenta (assuming massless quarks)
  - the neutralino mass (assuming it is known from other measurements)
  - the collision energy *s*

J.L Feng, D.E. Finnell, PRD 49, 2369 (1994)



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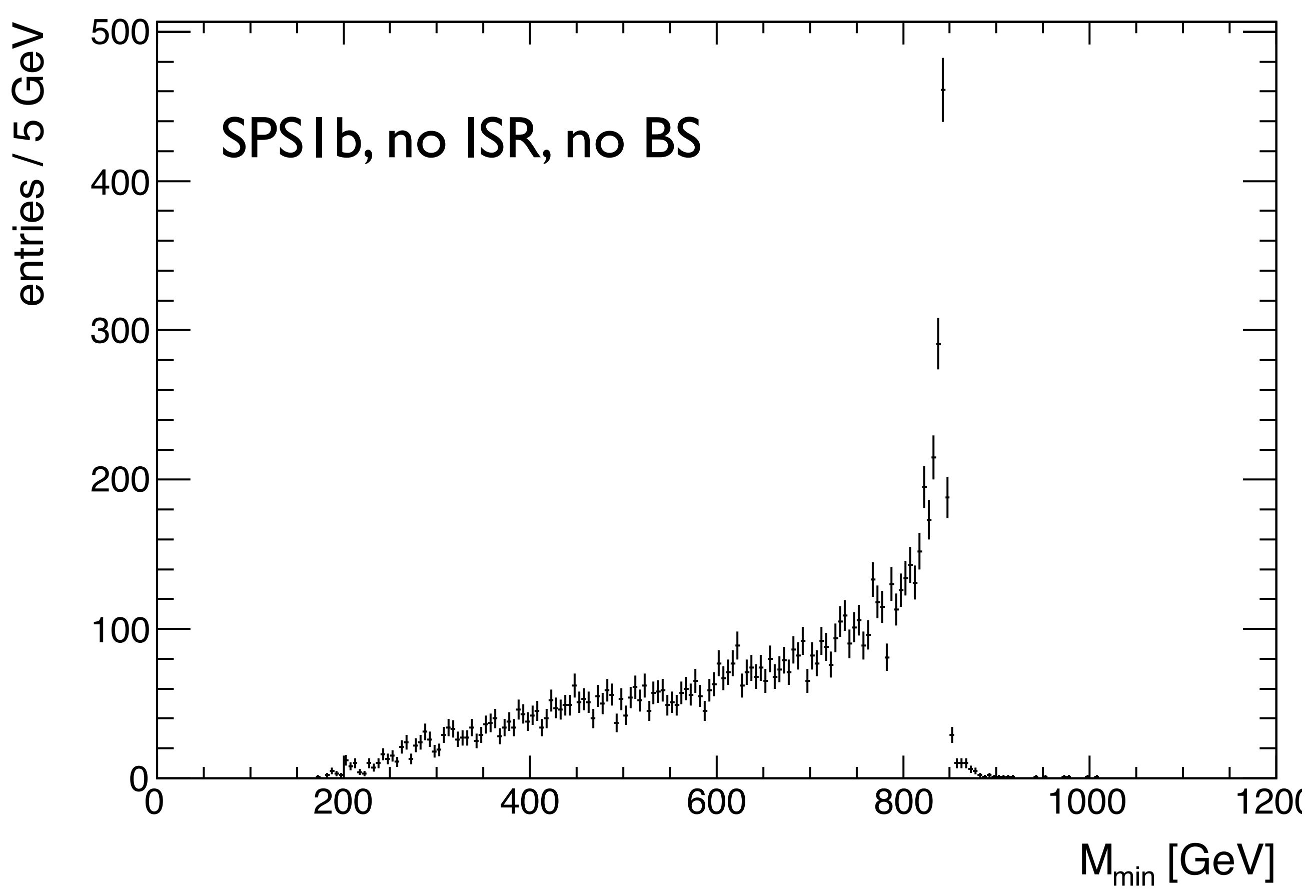
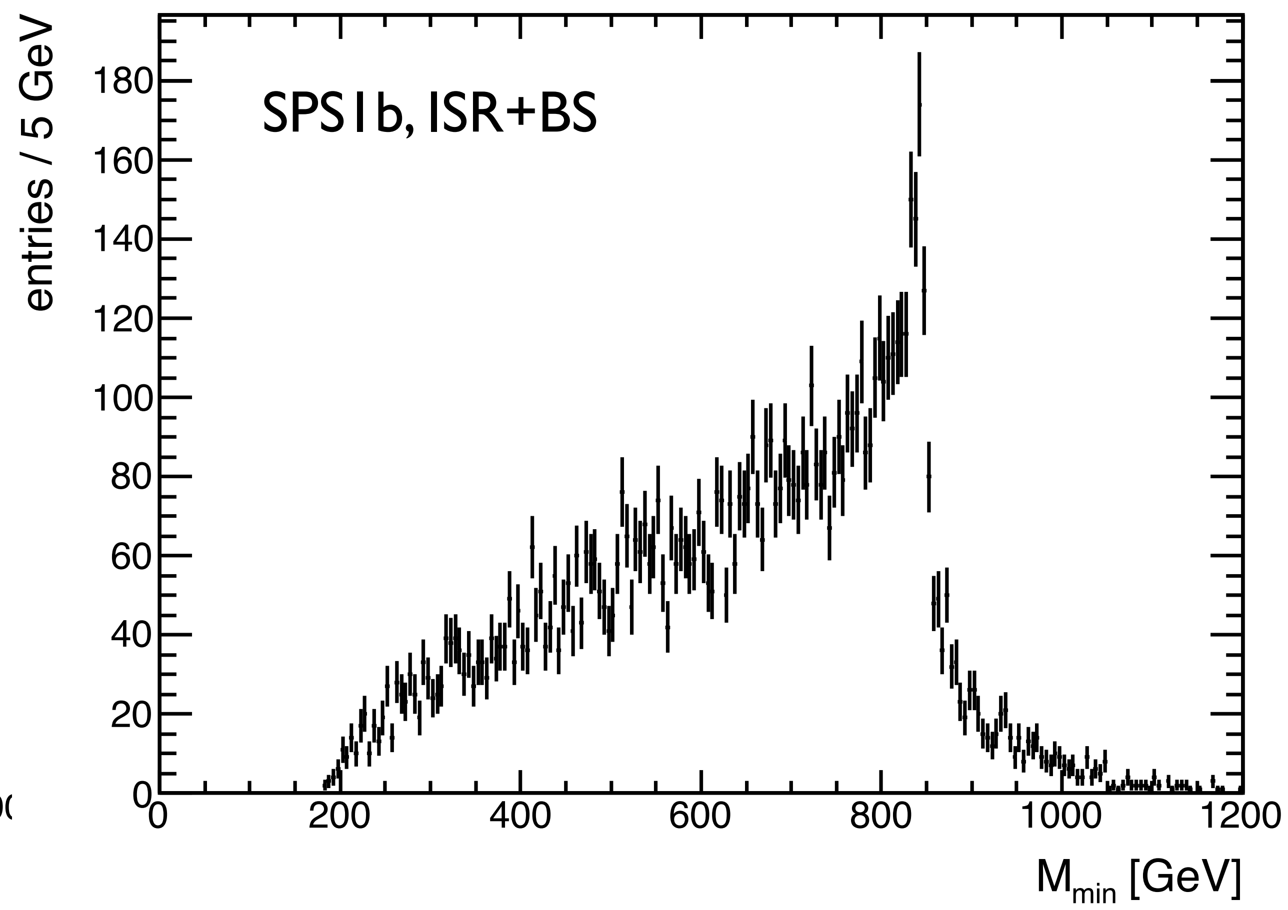




➩ peaks at true squark mass: good for low statistics

➩ reduced distortions from beamstrahlung

Mass Measurement Techniques: M_C

- Several new techniques studied for LHC: Need independence from collision energy, typically use only transverse observables
- Interesting technique: A modified invariant mass, calculated from the four momentum of one quark and the parity-transformed four momentum of the other quark

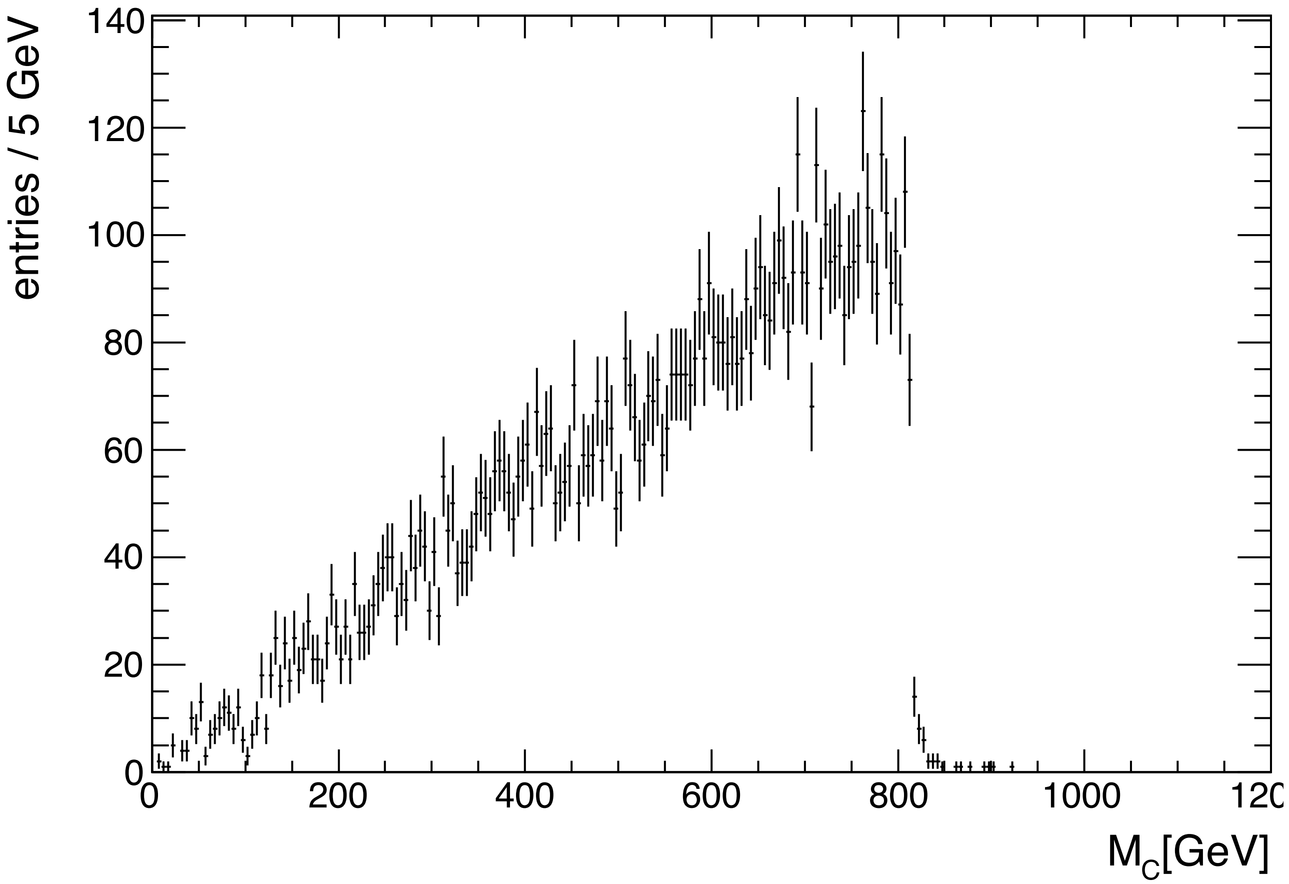
D.R. Tovey, JHEP 04, 34 (2008)

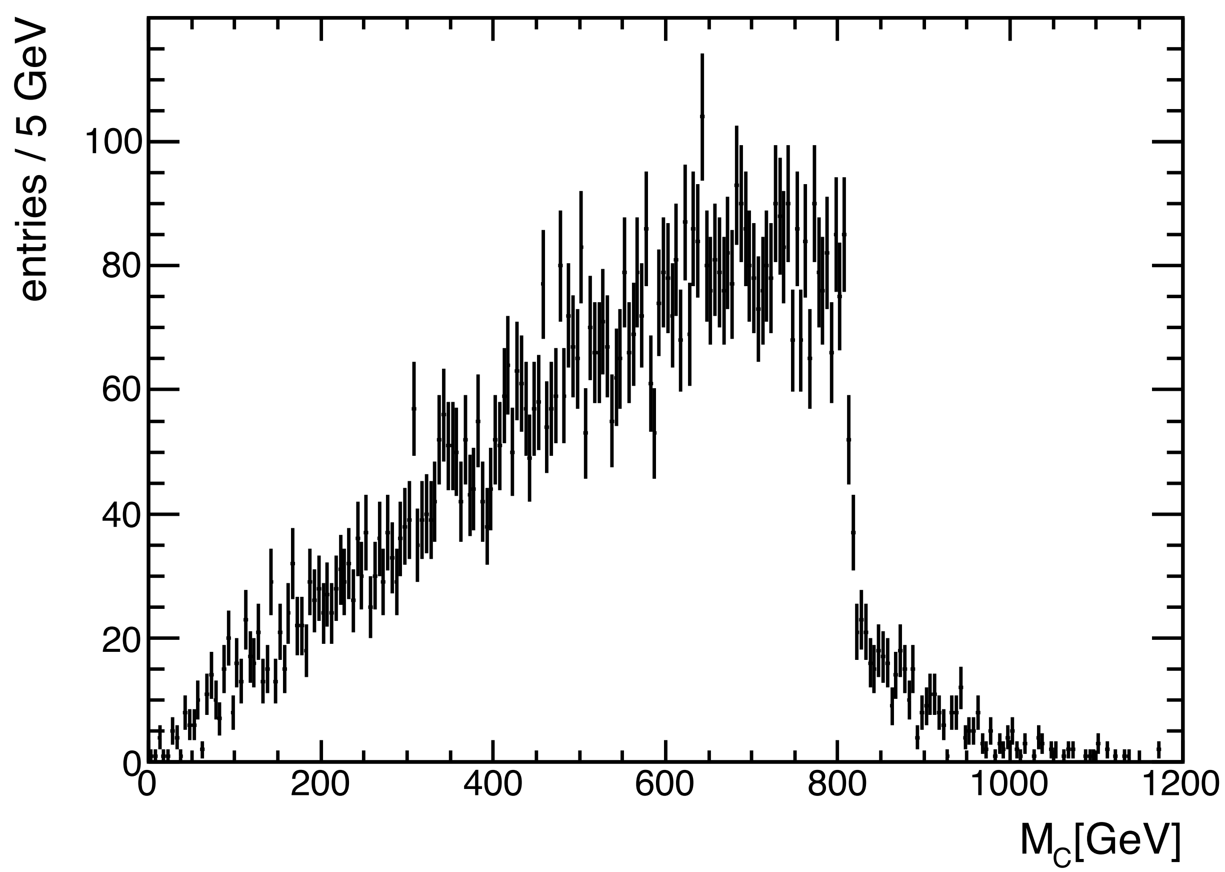
  - invariant under contra-linear boosts: works for back-to-back pair production of particles
    - at LHC, use a transverse form, use full 3D for lepton colliders
  - requires quark momenta and neutralino mass as input

upper edge of distribution given by: $$M_C^{max} = \frac{m_{\tilde{q}}^2 - m_\chi^2}{m_{\tilde{q}}}$$

Mass Measurement Techniques: M_C

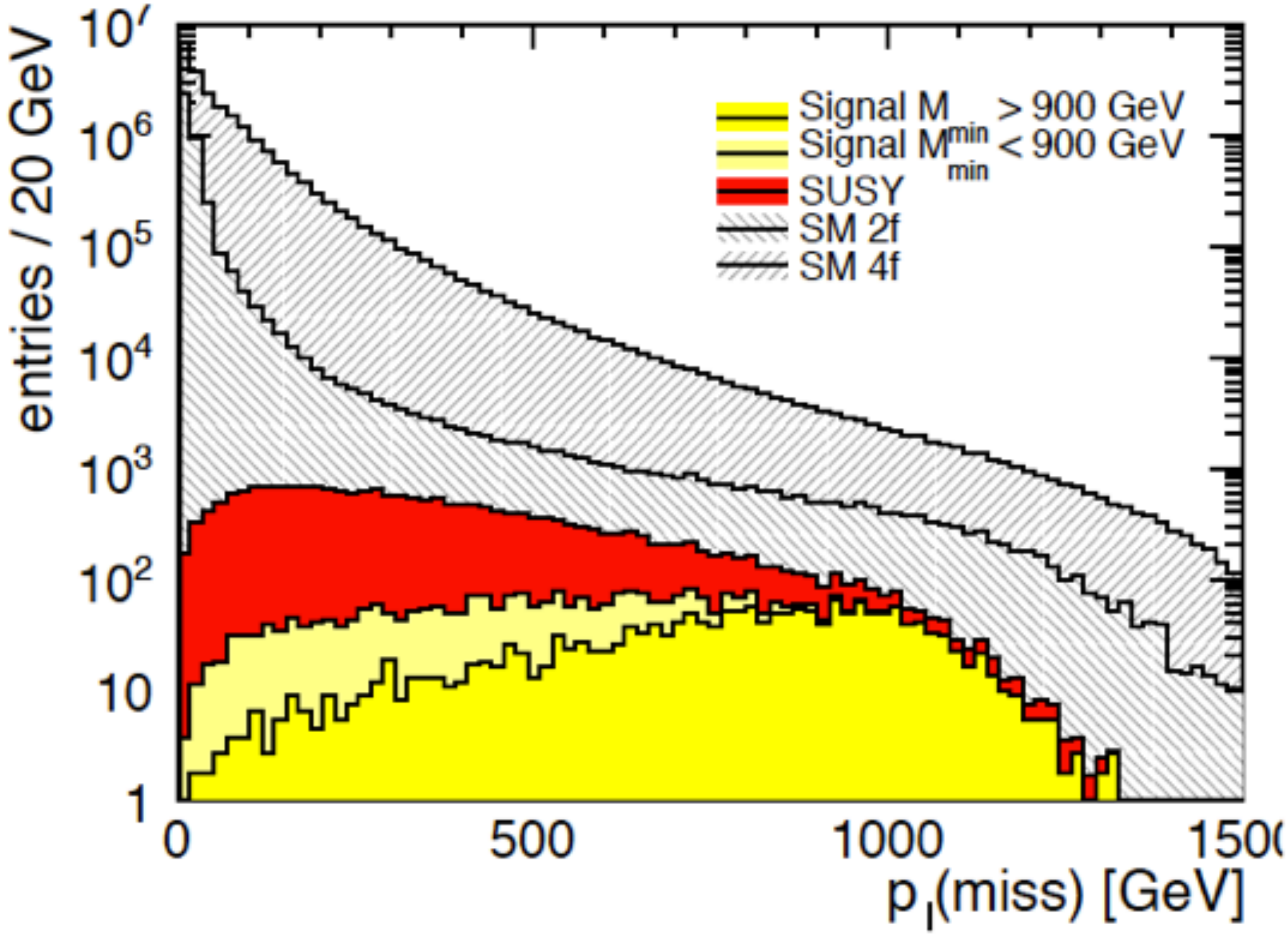
- Collision energy does not enter: Reduced sensitivity to collider energy spectrum (beamstrahlung enters due to boost along beam axis)
- Maximum at upper edge: Advantageous in environments with low statistics
- Simple tri-angular shape (without cuts and distortions): Potentially easy to fit





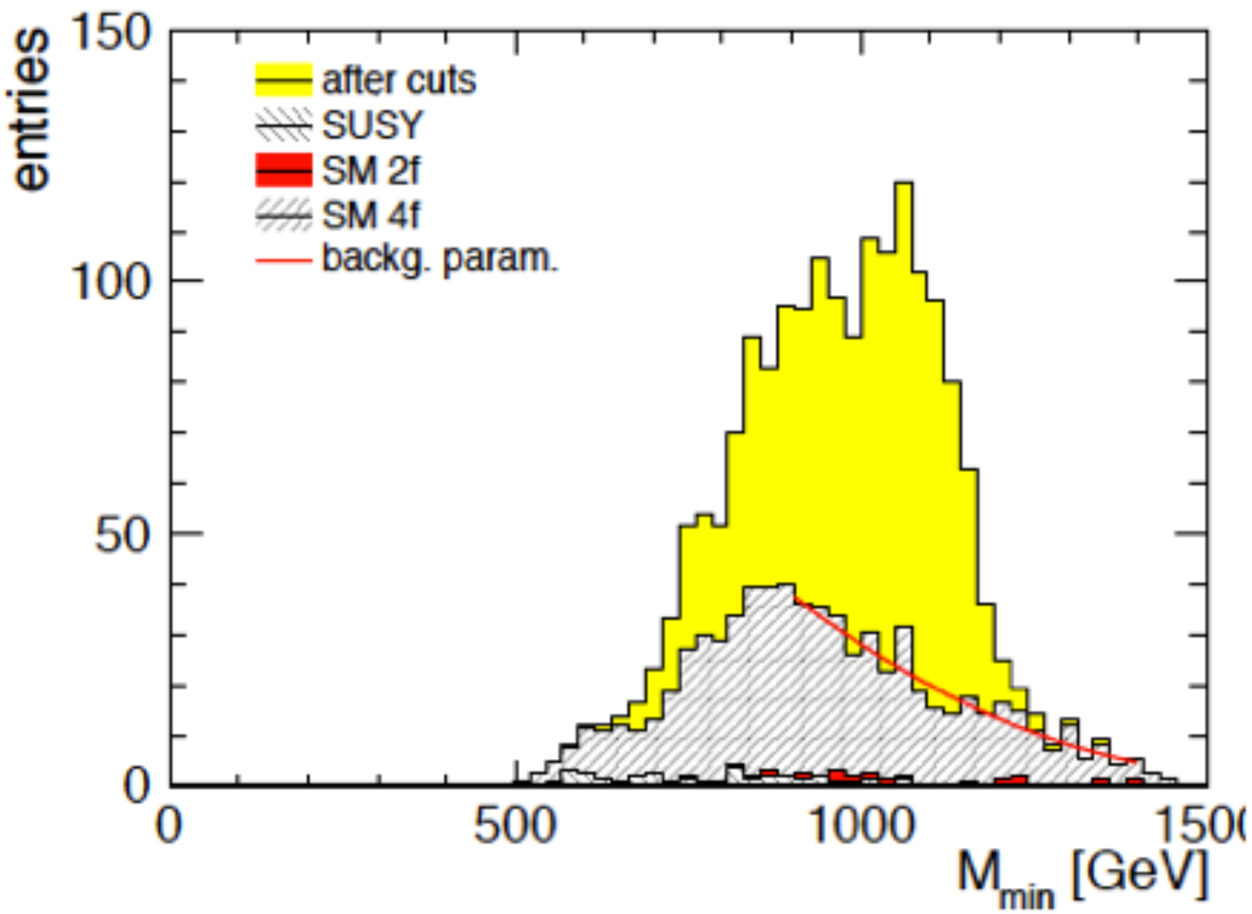
Influence of Physics Background

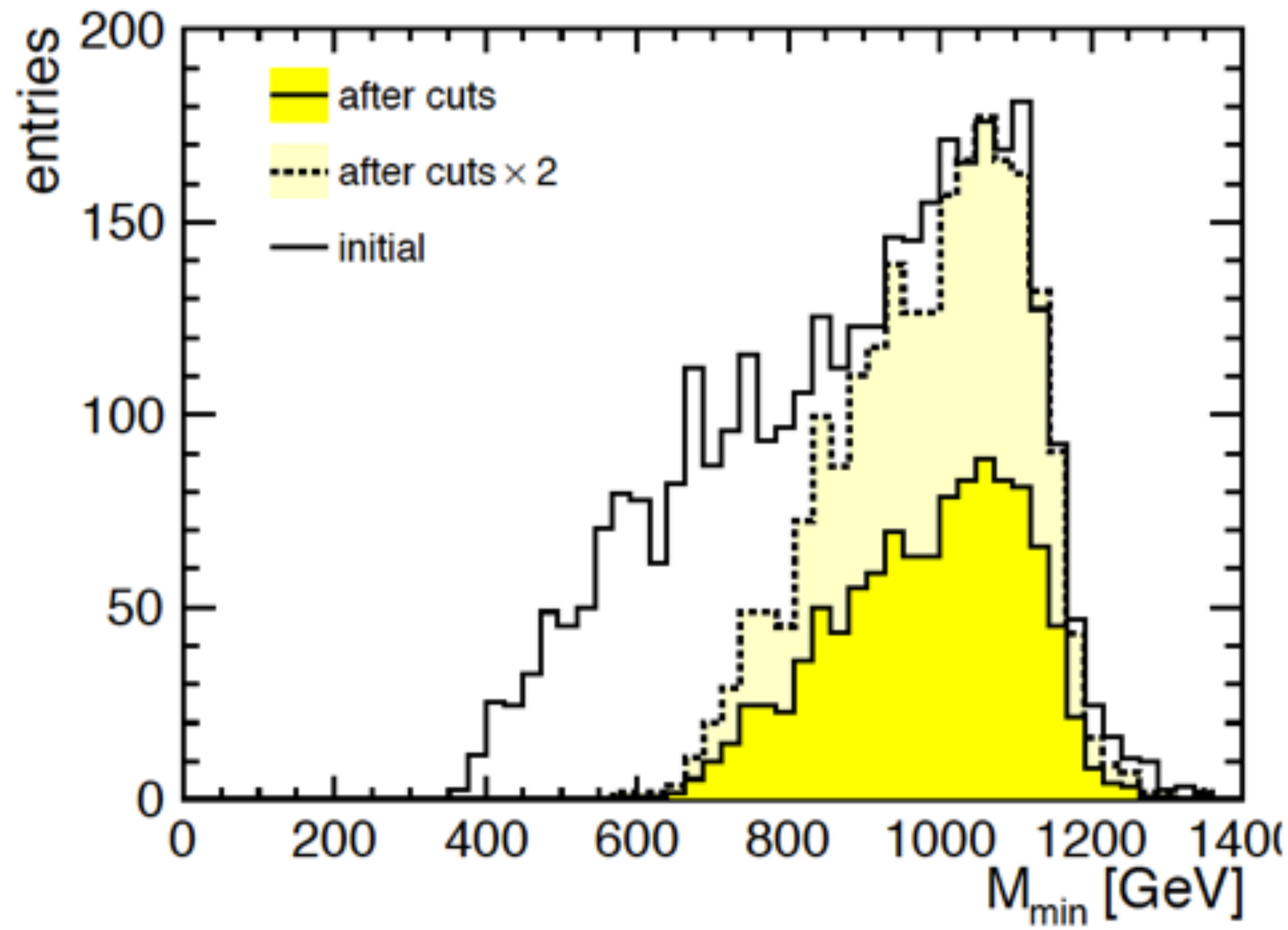
- Dominating background: SM 4 fermions



Rejection of Physics Background

- Cuts optimized to leave upper edge of distributions intact





Influence of $\gamma\gamma \rightarrow$ Hadrons Background

- Influence on distributions
- Different jet finders
- ...

Material to be included

- Effects of cuts
- Distributions of variables for fully simulated data
- Production plans