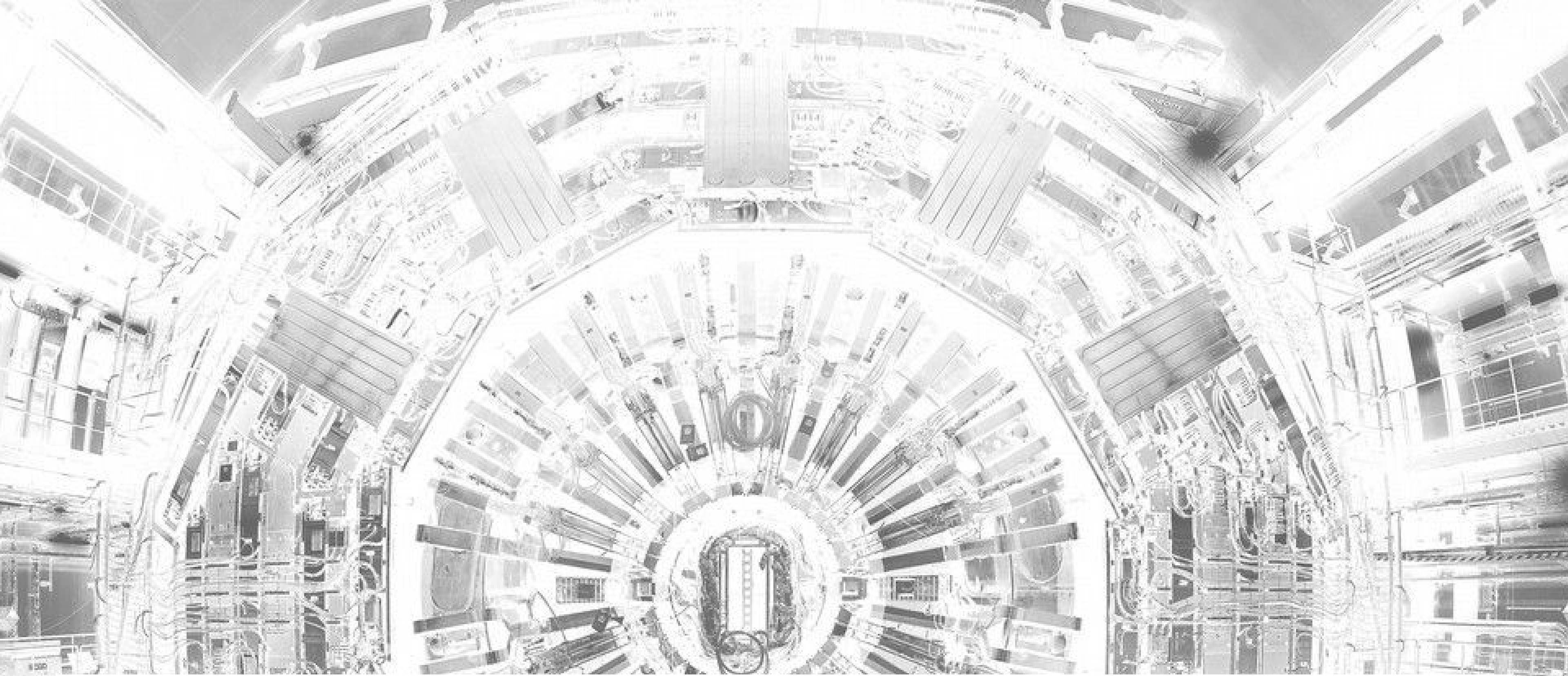

Inclusive SUSY Search in hadronic final states with M_{T2}

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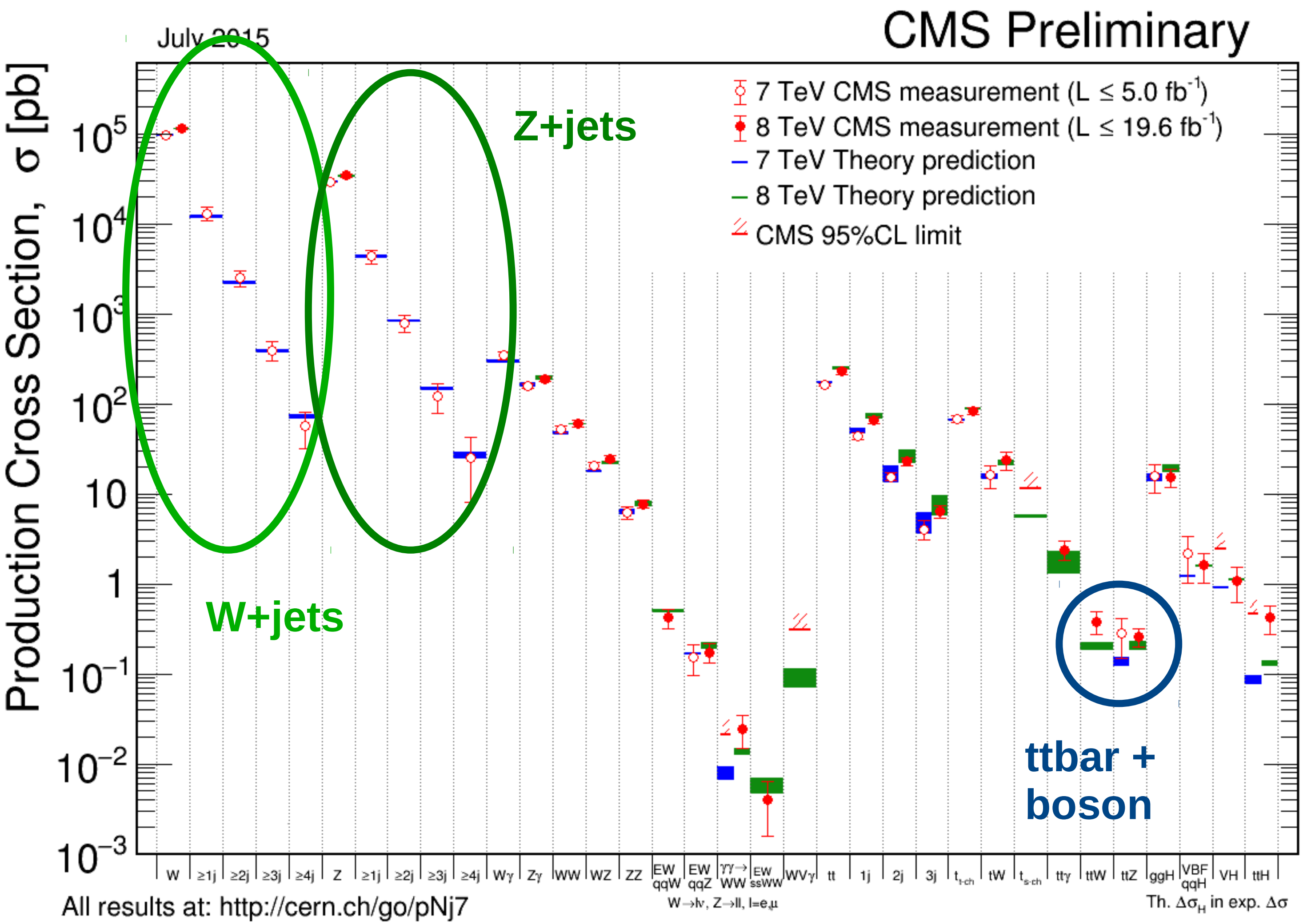
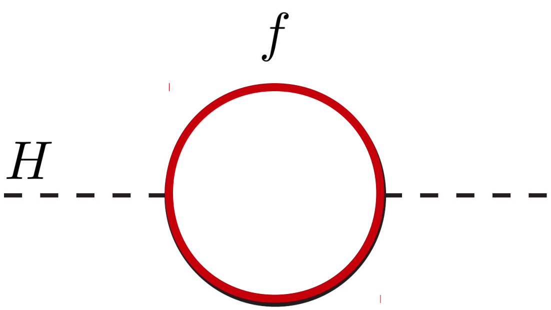
PhD Seminar 2015
27.08.2015

ETH Institute for Particle Physics

Success of the Standard Model



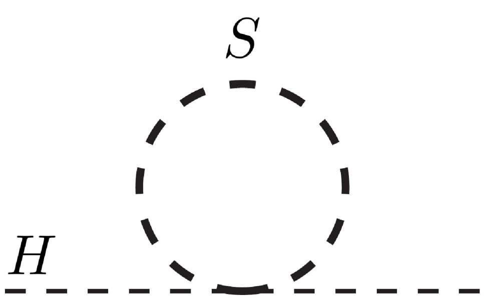
Why do we search for more?



Fine Tuning problem

$$(125\text{GeV})^2 = {m_H}^2 = {m_{H,0}}^2 + \Delta {m_H}^2$$

$$\propto \sum_f -g_f \Lambda_{UV} \leftarrow \text{can be as large as } \Lambda_{Planck}$$



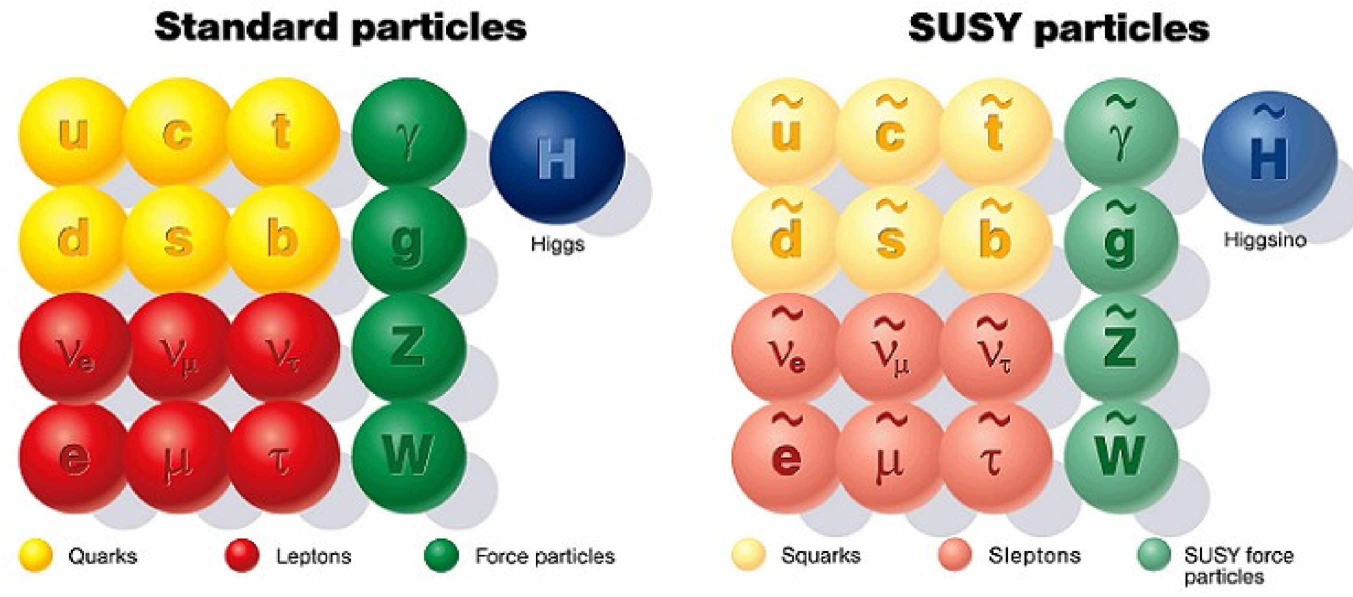
SUSY Solution:

For each fermion add a diagram with a scalar to cancel $\Delta {m_H}^2$

→introduce for each fermion a scalar

(and vice versa)

SUSY's Solution



Super Symmetry: Q |fermion⟩ = |boson⟩ & Q |boson⟩ = |fermion⟩

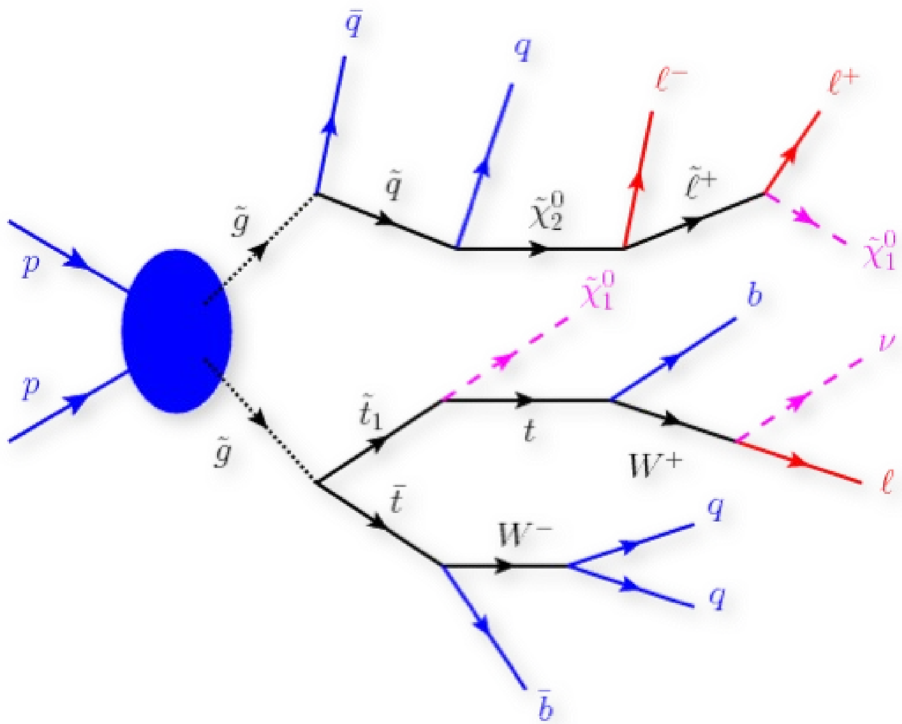
Bonuses if R Parity is conserved:

- Lightest neutralino stable

  → **dark matter candidate** neutralino χ_0

- Grand unification

Characteristics of a SUSY event

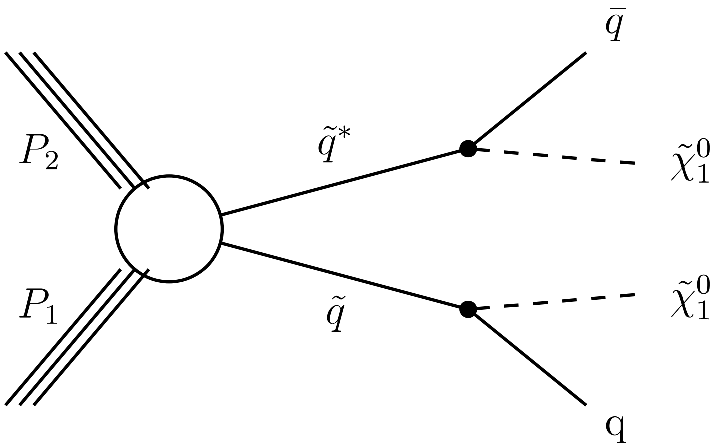


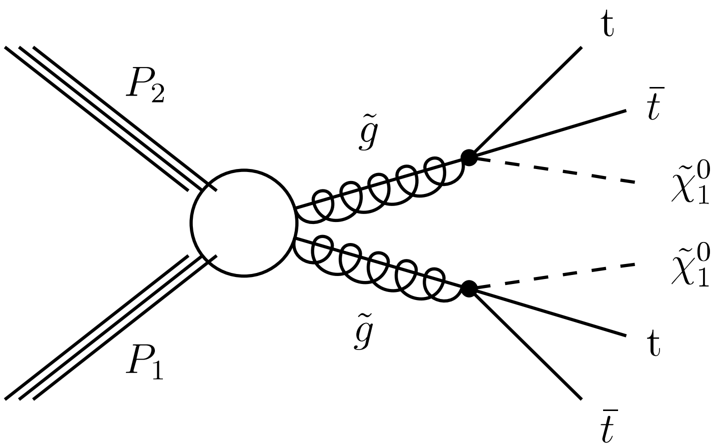
Assume **R parity** is conserved

- sparticles **produced in pairs**
- **Two neutralinos** in final state
  - → undetected
  - → missing transverse energy (ME_T)

+ a lot of activity

Looking for Jets + ME_T



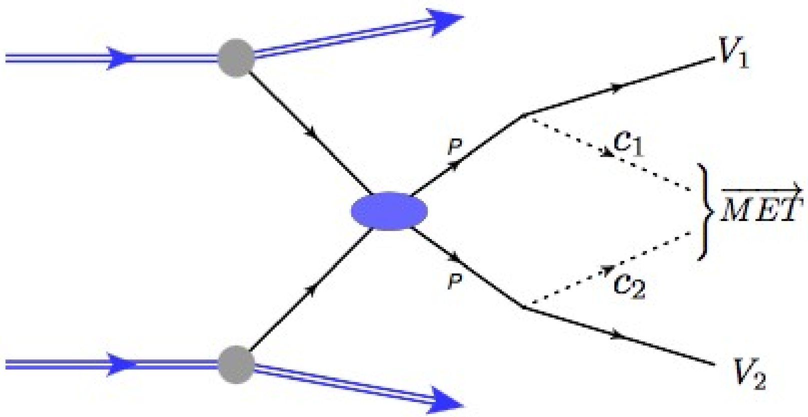


Fully hadronic inclusive search:

- Large ME_T
- Many jets
- Lepton veto
- A lot of hadronic activity

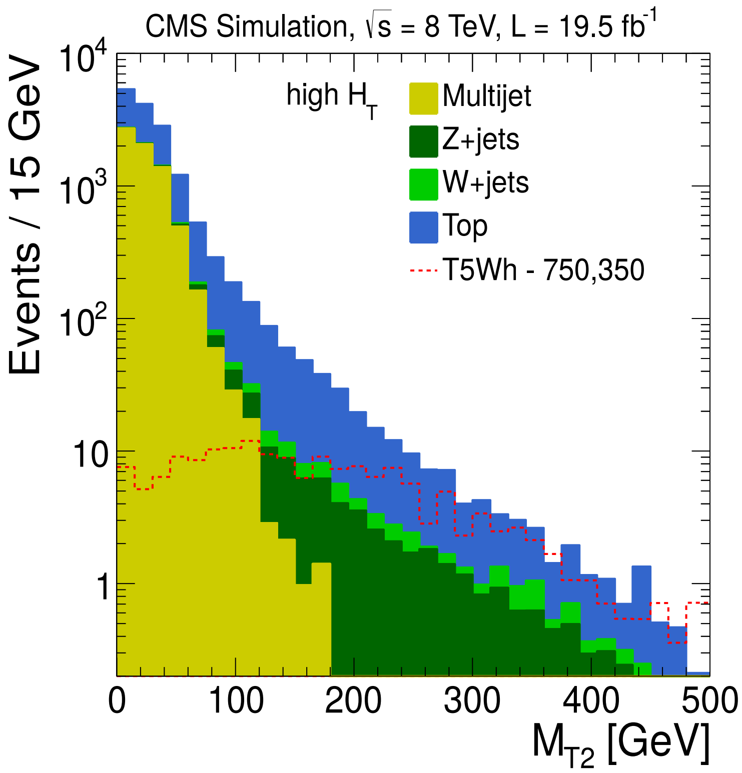
  e.g. $2 \times (\tilde{g} \to t\bar{t}) \to 12$ jets

Search Strategy



- M_{T2} is a generalized ME_T like variable for decays with 2 unobserved particles
- Fake ME_T clusters at $M_{T2} \approx 0$

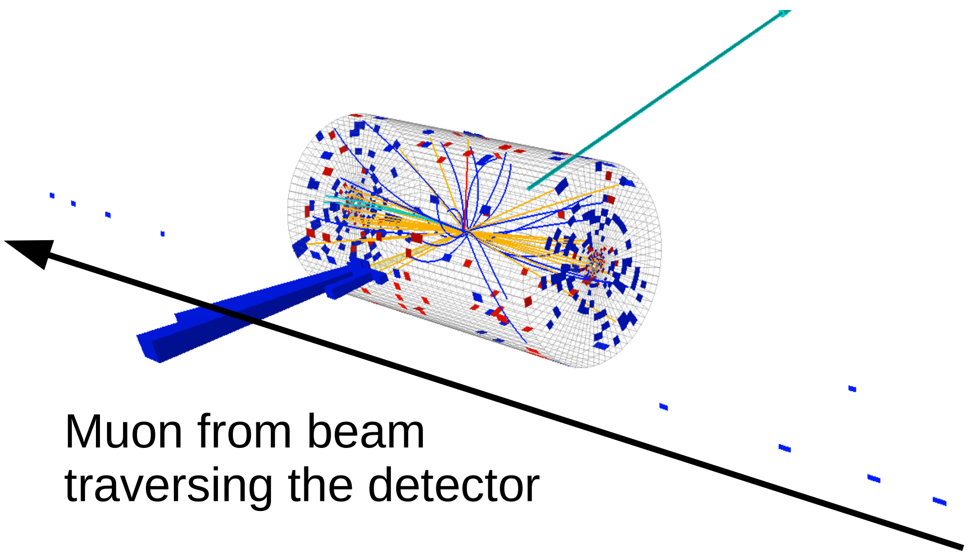
  → M_{T2} is a **QCD killer**
- And look for an **excess at high M_{T2} values where typical SUSY events lie**
- Categorize in H_T, number of Jets, number of b-Jets and M_{T2} to be as inclusive as possible



Anomalous Event Reduction in Data

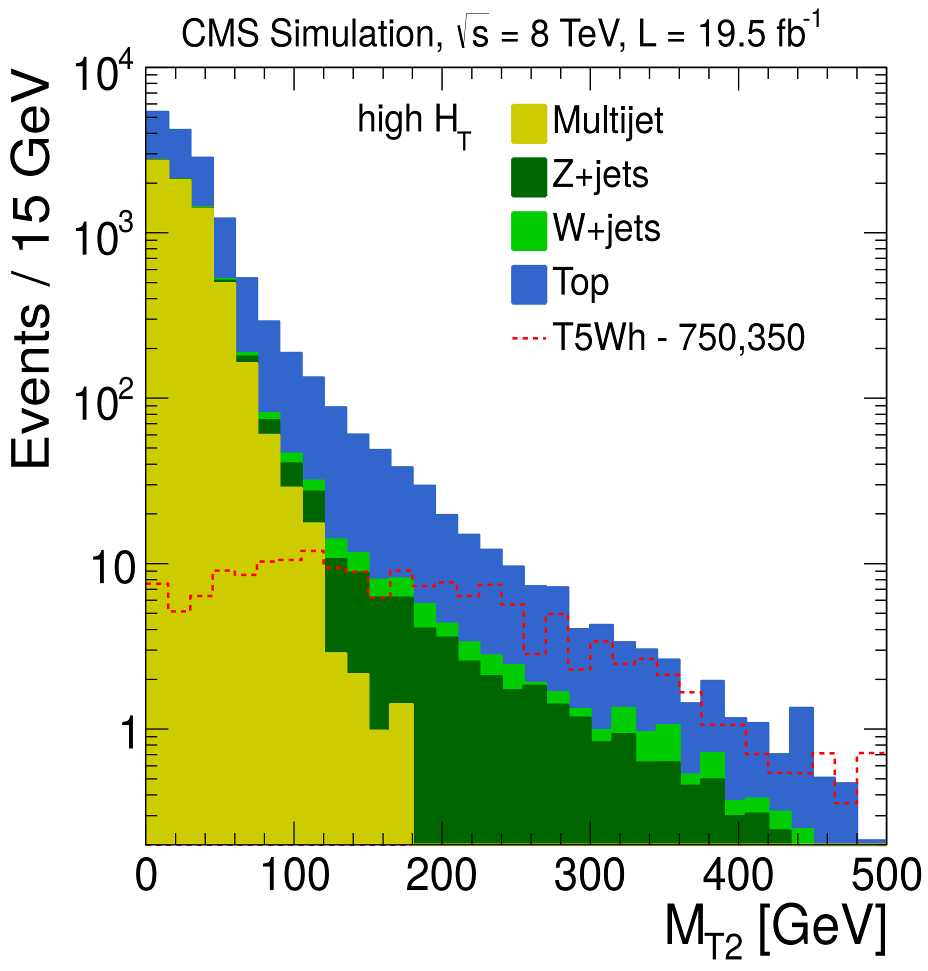
- Detector noise most visible in tails of $ME_{T,}$ where our signal lies!
- Have filters to get rid of the typical detector noise

  → filter efficiency has to be checked



Muon from beam
traversing the detector

Background Processes



QCD Multi-Jets

- mis-measurement of a jet

  → unbalanced event → ME_T

W → ℓν & Top

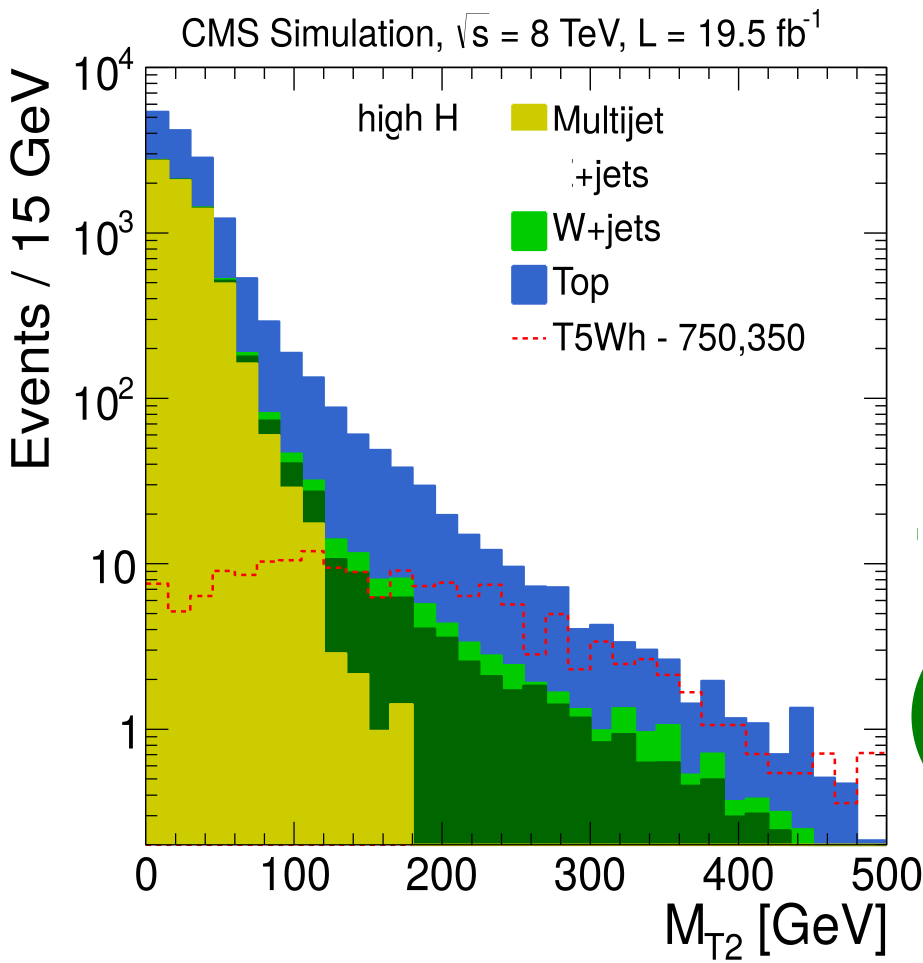
- Real ME_T from neutrino
- **Fail to identify lepton**

  → looks like ME_T+jets

Z → νν + jets

- real ME_T from neutrinos

Background Processes



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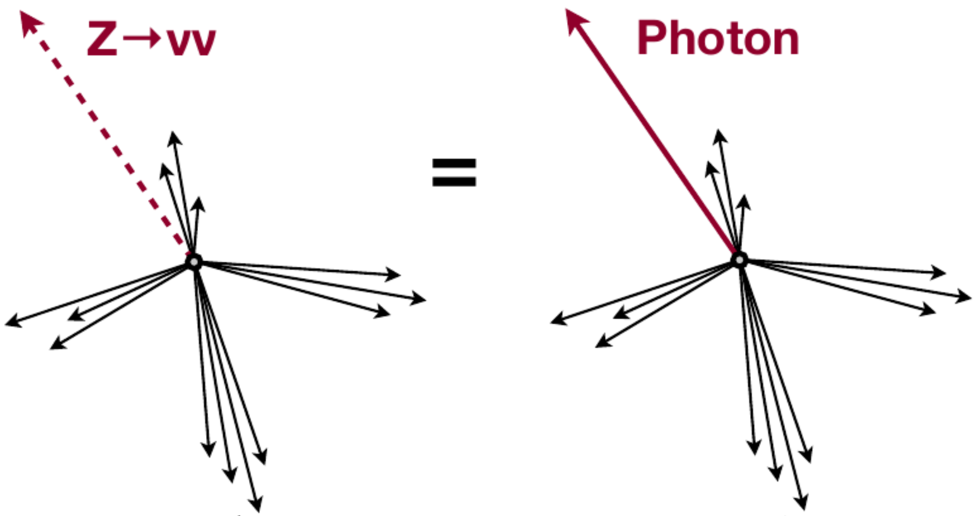
Z→νν + jets

- real ME_T from neutrinos
  → looks like signal

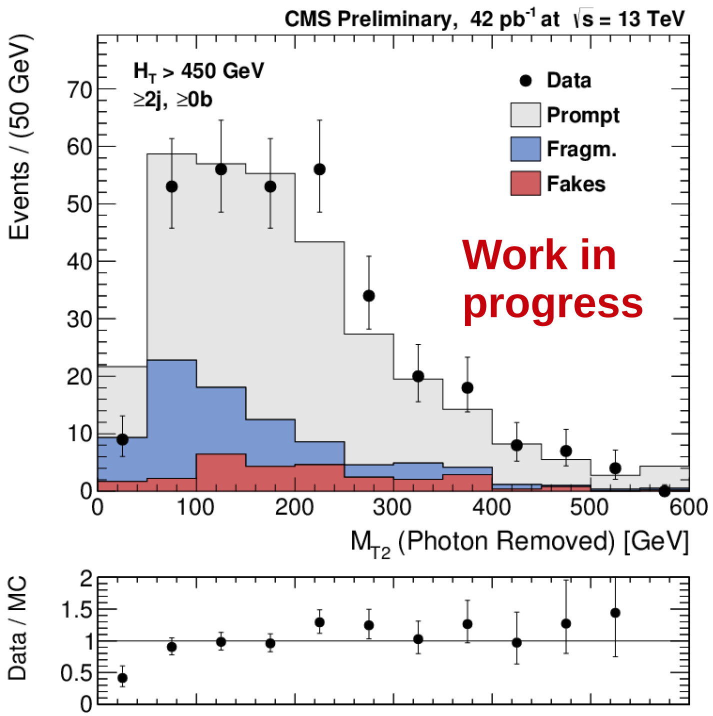
Main background & irreducible

Focus on it for this talk

Z→νν estimation from Photons



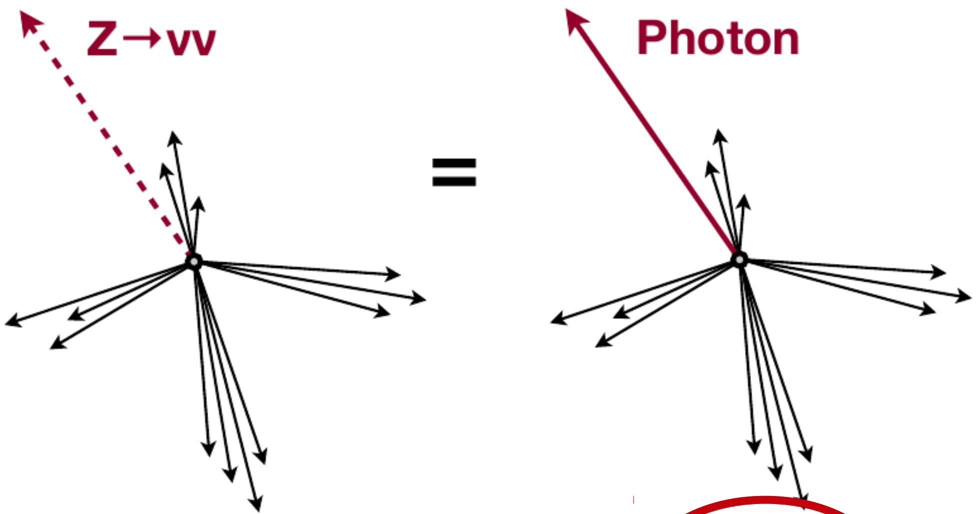
$$N_{Z\nu\nu} = N_{\gamma} \cdot R(Z/\gamma)$$



Use similarity of photons with Z for estimation

- Remove γ from event to model Z→invisible
- Scale with Z/γ ratio ← account for different mass and coupling

Z→νν estimation from Photons



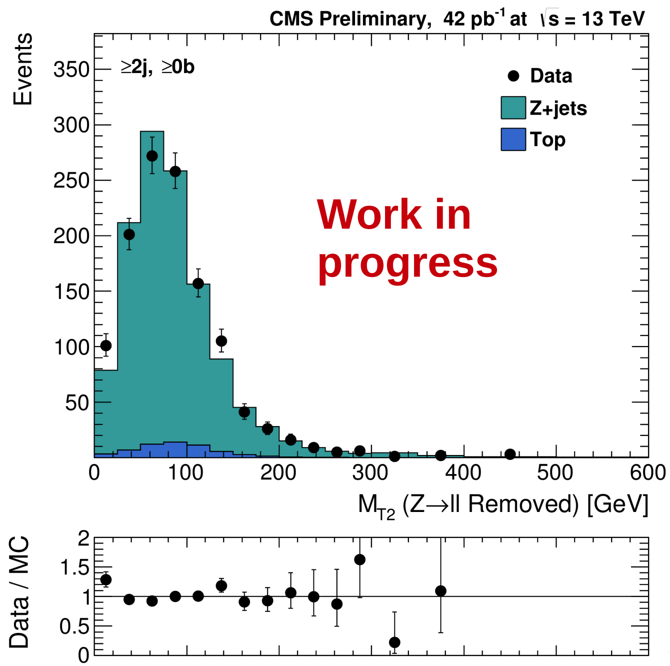
$$N_{Z\nu\nu} = N_\gamma \cdot R(Z/\gamma)$$

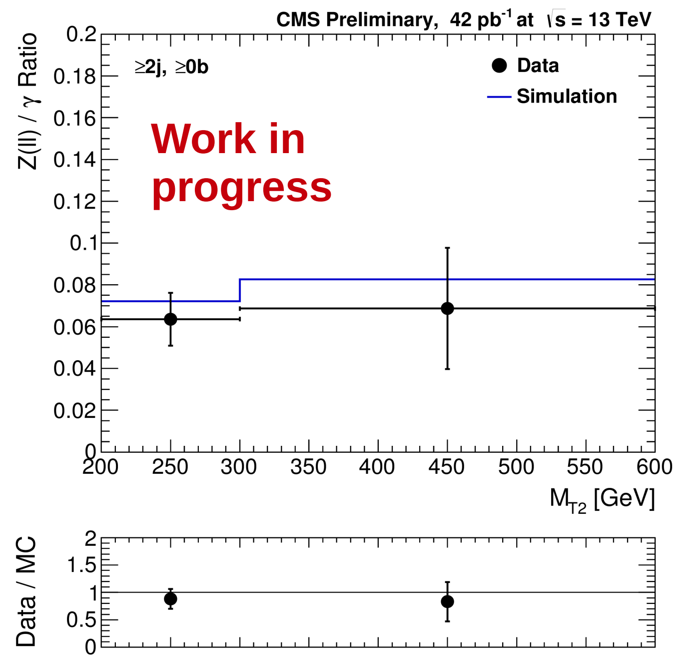
Directly from simulation
→ check with Z→ll in data

Use similarity of photons with Z for estimation

- Remove γ from event to model Z→invisible
- Scale with Z/γ ratio ← account for different mass and coupling

$Z \rightarrow e^+e^-/\mu^+\mu^-$ Control Region





Select events on Z peak

Check R(Z/γ) in data

$$N_{Z\nu\nu} = N_\gamma \cdot R(Z/\gamma)$$

Possible Discovery this Year?

- Expect about $4\mathrm{fb}^{-1}$ at the end of this year by the LHC
- Gluino mass not allowed to be too far from the EW scale
  → gluino unnatural above ~1.5TeV (Papucci, Ruderman, Weiler. arxiv: 1110.6926)
- At $4\mathrm{fb}^{-1}$ rough expected significanc $\mathrm{m}_{\tilde{g}} \approx 1500\,\mathrm{GeV}, m_{\tilde{\chi}_0} \approx 100\,\mathrm{GeV}$

Process

$$\mathrm{pp} \to \tilde{g}\tilde{g}, \tilde{g} \to t\bar{t}\tilde{\chi}_0$$
$$\mathrm{pp} \to \tilde{g}\tilde{g}, \tilde{g} \to b\bar{b}\tilde{\chi}_0$$

} Close to evidence

$$\mathrm{pp} \to \tilde{g}\tilde{g}, \tilde{g} \to q\bar{q}\tilde{\chi}_0$$

} Close to discovery

Conclusions

- SUSY fixes fine tuning problem by doubling the particles
- Gives a dark matter candidate (if R-parity conserved)

- We have a strategy to find SUSY
  - possibly already this year
  - If $\tilde{g}$~1.5TeV exists

- Looking forward to more data

More figures of the early data can be found here:
https://indico.cern.ch/event/405815/contribution/2/attachments/1141931/1638100/DPS_SUSY.pdf