Top Pair Tagging and Reconstruction in the Di-lepton Channel

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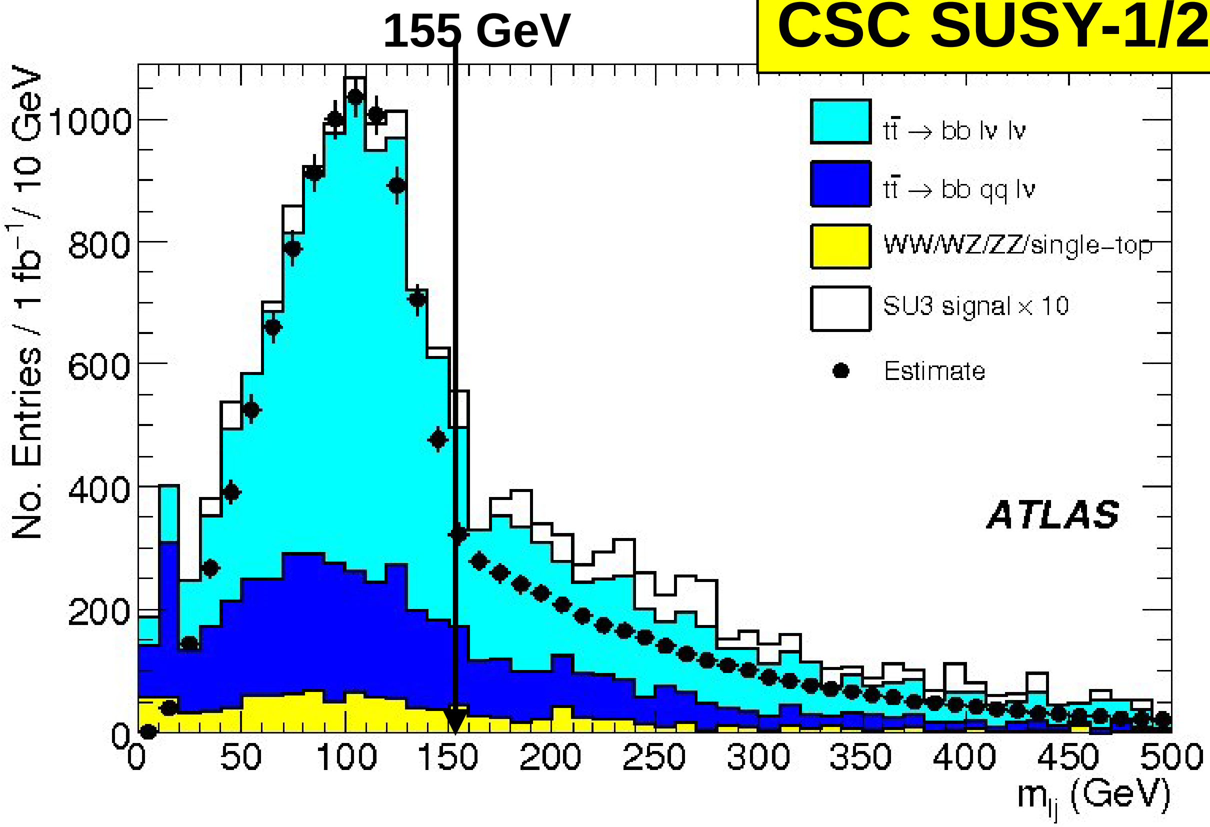
Tagging / Mass Measurement

- Expect end-point in lepton+jet invariant mass distribution at (m_b=0):

$$m_{lj}^{\max} \simeq \sqrt{m^2(\mathrm{t}) - m^2(\mathrm{W})}$$

CSC SUSY-1/2

- Release 12.0.7 (CSC) data: sample 5200
- No b-tagging assumed
- Require :
  - Online: j45+xE50
  - 2 OS leptons with p_T > 10 GeV
  - 2 jets with p_T > 20 GeV
  - E_T^{miss} > 10 GeV
  - Leptons OF || (|m(ll)-mZ|>15GeV && m(ll)>5GeV)



Contransverse Mass

- Consider identical pair-produced particles D_1 and D_2, each decaying to invisible state and a visible particle v.
- In centre-of-mass of D_1 and D_2, v_1 and v_2 momenta boosted with equal magnitude but opposite direction relative to in rest frames of D_1 and D_2.
- Invariant quantity:

$$\begin{aligned} M_C^2(v_1, v_2) &\equiv [E(v_1) + E(v_2)]^2 - [\mathbf{p}(v_1) - \mathbf{p}(v_2)]^2 \\ &= m^2(v_1) + m^2(v_2) + 2[E(v_1)E(v_2) + \mathbf{p}(v_1) \cdot \mathbf{p}(v_2)] \end{aligned}$$

- In transverse plane:

$$\begin{aligned} M_{CT}^2(v_1, v_2) &\equiv [E_T(v_1) + E_T(v_2)]^2 - [\mathbf{p_T}(v_1) - \mathbf{p_T}(v_2)]^2 \\ &= m^2(v_1) + m^2(v_2) + 2[E_T(v_1)E_T(v_2) + \mathbf{p_T}(v_1) \cdot \mathbf{p_T}(v_2)] \end{aligned}$$

- If v_1 and v_2 massless then

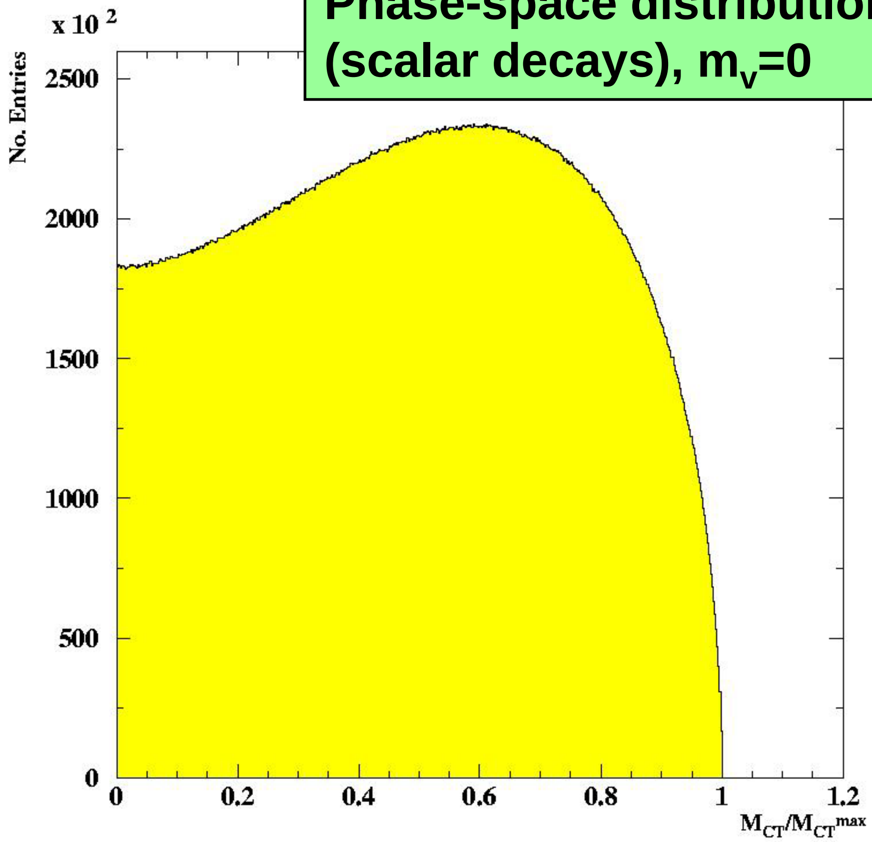
$$M_{CT}^2(v_1, v_2) = 2p_T(v_1)p_T(v_2)(1 + \cos\phi_{12})$$

- M_{CT} maximised when v_1 and v_2 co-linear

Contransverse Mass

- Q: Why is M_{CT} interesting?
  - It does not represent mass of a particle decaying to give v_1 and v_2
- A: Value in lab frame (if no transverse boost) equal to that calculated from transverse momenta measured in rest frames of D_1 and D_2.
  - These momenta constrained by the masses of the particles involved via two-body kinematics.

Phase-space distribution (scalar decays), m_v=0

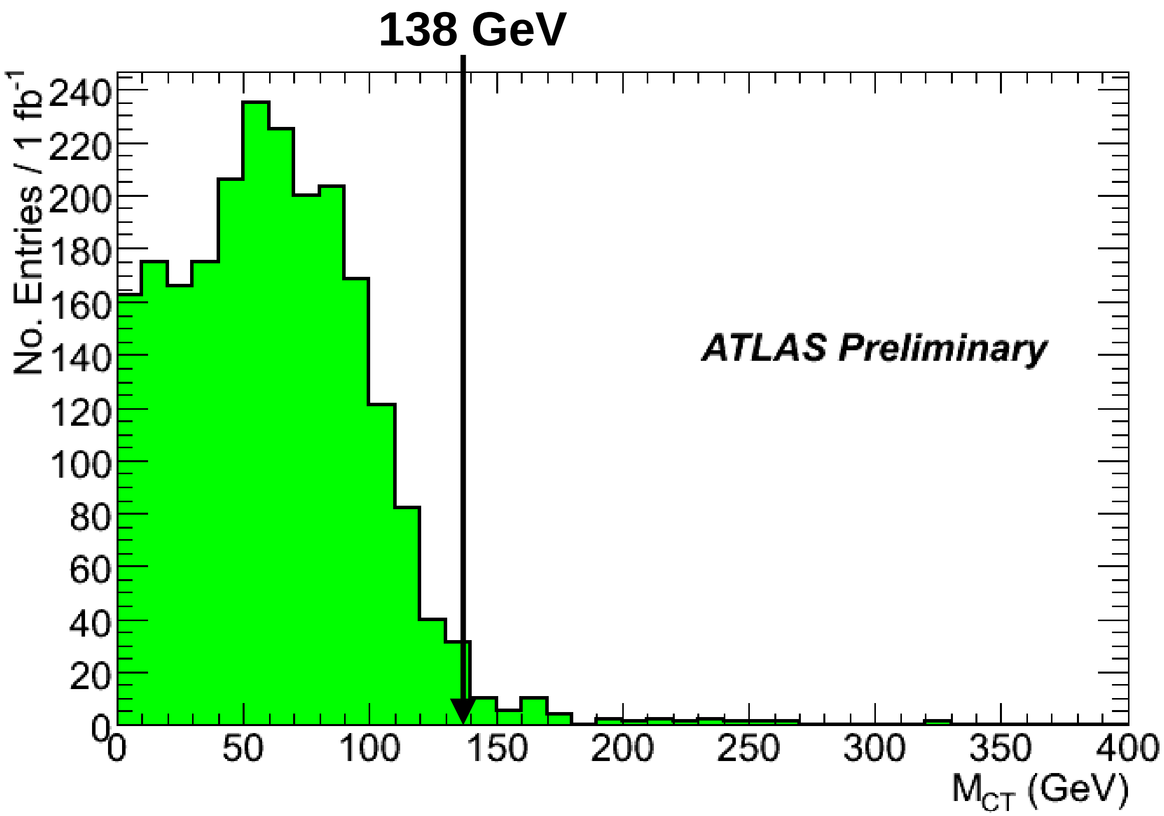


Tagging / Mass Measurement

- Expect end-point in in M_{CT} distribution at (massive b):

$$M_{CT}^{max} = \frac{m^2(\mathrm{t}) - m^2(\mathrm{W}) + m^2(\mathrm{b})}{m(\mathrm{t})}$$

- Release 12.0.7 (CSC) data: sample 5200
- No b-tagging assumed
- Require :
  - Online: e25i || 2e15i || mu20 || e15imu10
  - 2 OS leptons with pT > 10 GeV
  - E_T^{miss} > 10 GeV
  - Leptons OF || (|m(ll)-mZ|>5GeV && m(ll)>5GeV)
  - min(ΔR(l,j))>0.4
  - ISR boost < 20 GeV



Top Reconstruction

- **Solve constraints to reconstruct tops**
- **Require one and only one lepton+jet combination with both m(lj) < 155 GeV (m_t=175 GeV)**
- **Solve 6 constraints for p(ν)**
  - **Take Re(soln) if complex**

$$m_W^2 = (p_{l1} + p_{\nu 1})^2$$
$$m_W^2 = (p_{l2} + p_{\nu 2})^2$$
$$m_t^2 = (p_{l1} + p_{\nu 1} + p_{b1})^2$$
$$m_t^2 = (p_{l2} + p_{\nu 2} + p_{b2})^2$$
$$E_x^{miss} = p_{(\nu 1)x} + p_{(\nu 2)x}$$
$$E_y^{miss} = p_{(\nu 1)y} + p_{(\nu 2)y}$$

$$p_{l1} \cdot p_{\nu 1} = \frac{1}{2} m_W^2$$
$$p_{l2} \cdot p_{\nu 2} = \frac{1}{2} m_W^2$$
$$p_{b1} \cdot p_{\nu 1} + p_{b1} \cdot p_{l1} = \frac{1}{2}(m_t^2 - m_W^2)$$
$$p_{b2} \cdot p_{\nu 2} + p_{b1} \cdot p_{l1} = \frac{1}{2}(m_t^2 - m_W^2)$$
$$\hat{x}.(p_{\nu 1} + p_{\nu 2}) = E_x^{miss}$$
$$\hat{y}.(p_{\nu 1} + p_{\nu 2}) = E_y^{miss}$$

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