Search for New Physics in fully hadronic final states with the ATLAS detector at the LHC

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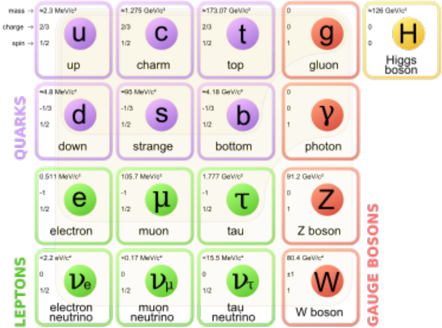
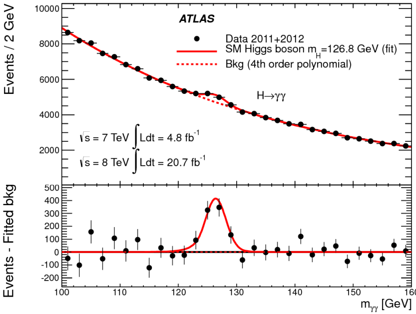
Standard Model



Standard Model



H discovered in 2012 with mass

$m_H = 125$ GeV at ATLAS

SM is not perfect

Standard Model weaknesses

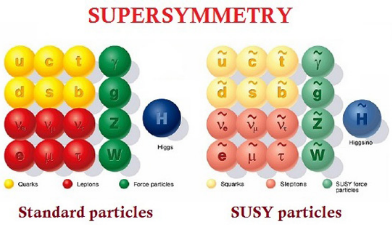
- Hierarchy problem?
- Unification problem?
- Dark matter?
- origin of matter-antimatter asymmetry in our universe?

...

• We need Beyond Standard Model!

• One of the extensions of SM is Minimal Supersymmetric Standard Model (MSSM).

Supersymmetry Model (SUSY)



Supersymmetry Model

Motivation:

- Largest space-time symmetry.
- LSP as candidate of DM.
- Solve the Higgs mass correction problem.
- Possible QT of gravity.

Superpotential of MSSM

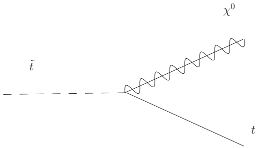
$$W_{RpC} = U^c y_u Q H_u - D^c y_d Q H_d - E^c y_e L H_d + \mu H_u H_d,$$

$$W_{RpV} = \lambda_{ijk} L_i L_j E^c_k + \lambda'_{ijk} L_i Q_j D^c_k + \mu'_i L_i H_u + \lambda''_{ijk} U^c_i D^c_j D^c_k$$

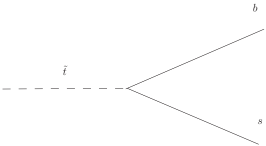
R-parity

R-parity

$$R = (-1)^{2S+3(B-L)}$$



RpC vertex

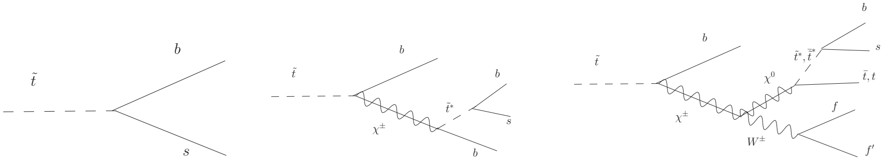


RpV vertex

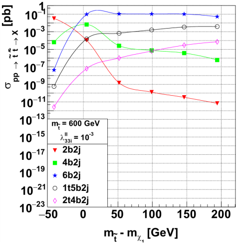
- Sparticles are in pair at vertex.
- Lightest supersymmetric particle (LSP) as dark matter candidate.
- Large missing energy.
- Conserve B and L.

- Sparticles are single at vertex.
- LSP is not dark matter candidate.
- Missing energy is not large.
- Violate B and L.

Stop decay channels

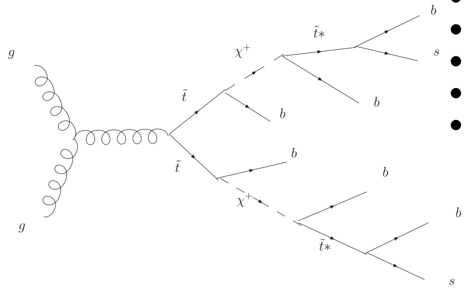


Left: 2 jets Middle: 4 jets Right: 6 jets



stop-anti-stop production and decay cross-section at $\sqrt{s} = 14\ TeV$ versus $m_{\tilde{t}} - m_{\chi^+}$, $m_{\tilde{t}=}$ 600 GeV

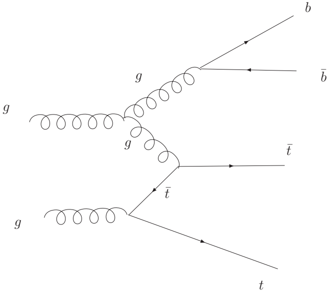
RpV Signal diagram



RpV Signal

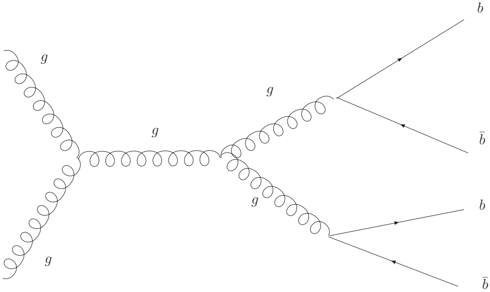
- Cross section: 0.072 pb.
- stop mass: 603.44 GeV.
- chargino mass: 504.45 GeV.
- neutralino1 mass: 501.89 GeV.
- neutralino2 mass: 508.61 GeV.
- Higg mass: 125.03 GeV.

ttbb background and bbbb background



ttbb

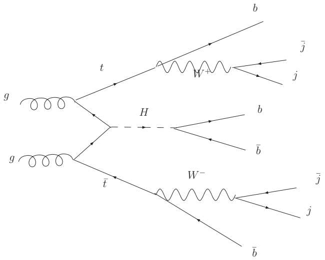
- Cross section: 5.1 pb.



bbbb

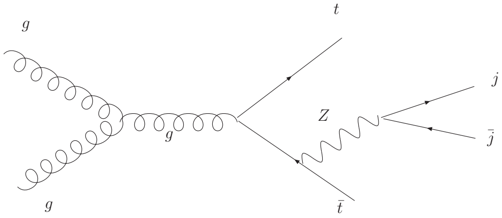
- Cross section: 4185 pb.

ttHTobb background and ttZtojj background



ttHTobb

- Cross section: 0.12398 pb.



ttZtojj

- Cross section: 0.09168 pb.

Jet labeling

Look for components of a jet - Use MC information

- Access to truth levels.
- Look for all MC particles whose:.

- $|\text{PDGID}| \in [\ 1\ ,\ 5\ ]$
- statuscode = 3 or statuscode $\in [\ 40\ ,\ 60\ ]$
- $\Delta R < 0.4$

- PYTHIA 6

- statuscode = 3: Partons that are used in the matrix element calculation.

- PYTHIA 8

- statuscode $\in [\ 40\ ,\ 60\ ]$: particles produced by initial (final)-state-showers.

Labeling condition

- Contains a b-quark, label as b-jet.
- Contains a c-quark and no b-quark, label as c-jet.
- Contains no b-quark and no c-quark, label as light-jet.

Selection condition

Kinematic selection

- at least 5 jets whose PT $>$ 55 GeV.
- $|\eta| < 2.5$.

b-tagging efficiency

- $\epsilon_b = 77\%$
- $\epsilon_c = 5\%$
- $\epsilon_{light} = 0.5\%$

Probabilities to have N b-tag jet (N=0,1,2,...)

$$P_{=0} = \prod_{i=1}(1-\epsilon_i),$$

$$P_{=1} = \sum_{j=1}\left(\epsilon_j \prod_{i\neq j}(1-\epsilon_i)\right),$$

$$P_{=2} = \sum_{j=1}\sum_{l=j+1}\left(\epsilon_j\epsilon_l \prod_{i\neq j,l}(1-\epsilon_i)\right),$$

$$P_{\geq 1} = 1 - P_{=0},$$

$$P_{\geq 2} = 1 - P_{=0} - P_{=1},$$

$$P_{\geq 3} = 1 - (P_{=0} + P_{=1} + P_{=2}),$$

Number of event

1. Number of event at MC level

Signal
- nevent= 10000
- njrec5= 9252

ttbbar
- nevent= 109990
- njrec5= 17335

ttHtobb
- nevent= 101229
- njrec5= 26441

ttZtojj
- nevent= 36378
- njrec5= 9713

bbbb
- nevent= 92048
- njrec5= 415

1. Number of event with 6-jets at final state $n' = \frac{\sigma \times L}{N_{event}} \times n_{MC}$

b-tag	signal	ttbbar	ttHtobb	ttZtojj	bbbb
3	41	3137	262	91	177444
4	35	374	93	30	58521
5	12	11	6	1	4221
≥ 6	1	0.07	0.1	0.01	20

Number of event

1. Number of event with 7-jets at final state

b-tag	signal	ttbbar	ttHtobb	ttZtojj	bbbb
3	113	5482	416	137	164760
4	139	1081	168	51	55391
5	77	64	14	3	3229
≥ 6	13	1	0.6	0.07	28

1. Number of event with at least 8-jets at final state

b-tag	signal	ttbbar	ttHtobb	ttZtojj	bbbb
3	542	11419	1007	304	132975
4	902	3651	480	135	49959
5	803	383	64	16	7092
≥ 6	374	28	6	0.7	119

Transverse hadronic energy distribution

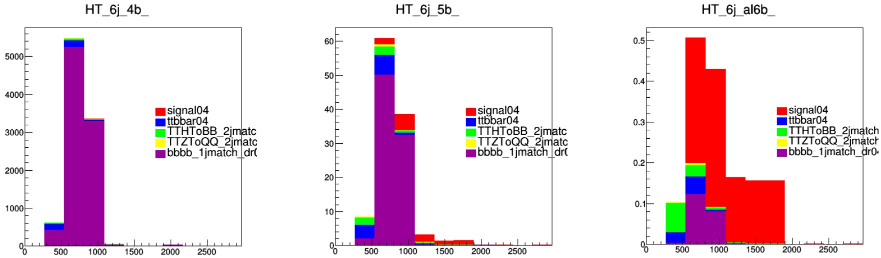


Figure : Left: HT with 6 jets and 4 b-tag Middle:HT with 6 jets and 5 b-tag Right: HT with 6 jets and 6 b-tag

Transverse hadronic energy distribution

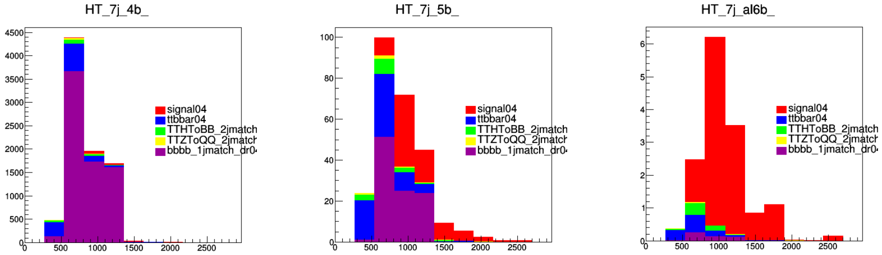


Figure : Left: HT with 7 jets and 4 b-tag Middle:HT with 7 jets and 5 b-tag Right: HT with 7 jets and at least 6 b-tag

Transverse hadronic energy distribution

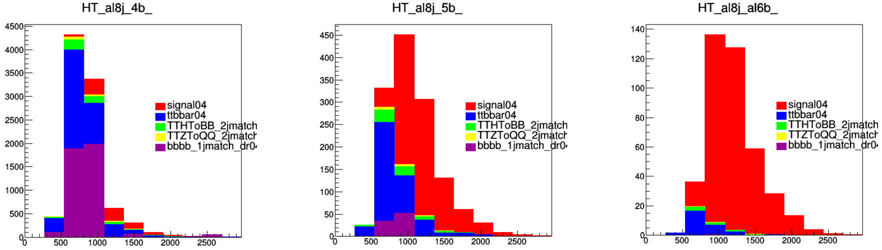


Figure : Left: HT with at least 8 jets and 4 b-tag Middle:HT with at least 8 jets and 5 b-tag Right: HT with at least 8 jets and at least 6 b-tag

Number of b,c and light jets in 7 jets event

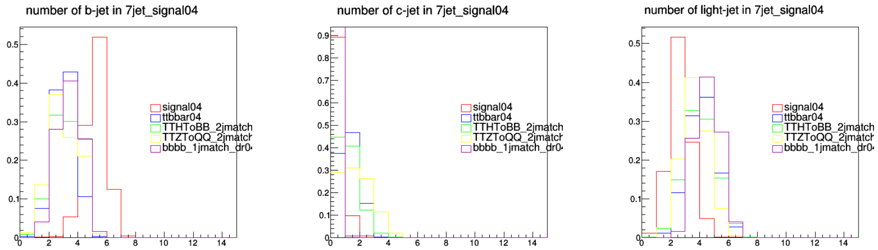


Figure : Left: Number of b-jet in 7 jets Middle: Number of c-jet in 7 jets Right: Number of light-jet in 7 jets

Number of b,c and light jets in at least 8 jets event

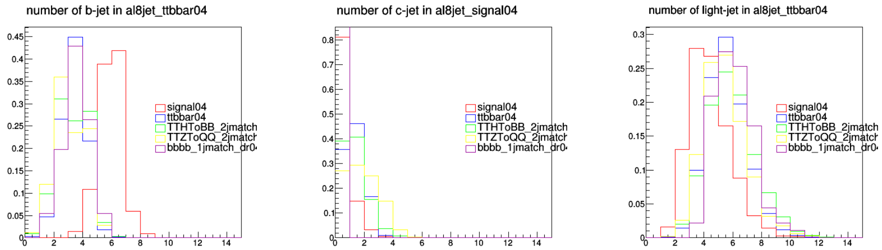


Figure : Left: Number of b-jet in 7 jets Middle: Number of c-jet in 7 jets Right: Number of light-jet in 7 jets

Invariant mass of chargino

- Chargino MC mass: 504.4 GeV.

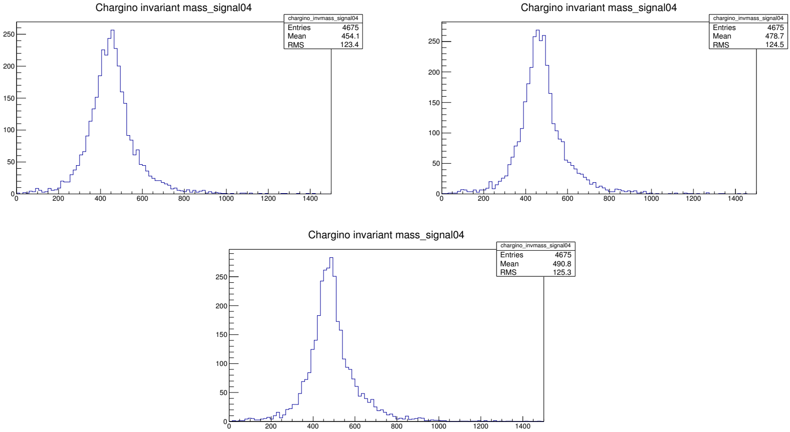
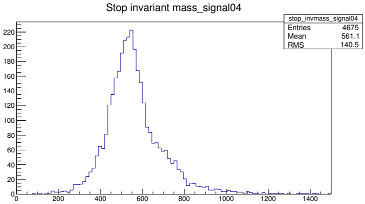
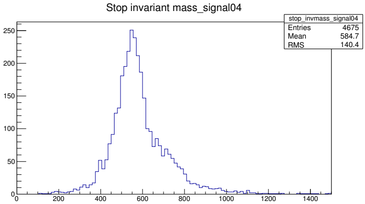


Figure : Upper left: $m_{\tilde{\chi}^+} = 454.1\ GeV$ without ν_e, ν_μ, μ Upper right: $m_{\tilde{\chi}^+} = 478.7\ GeV$ with ν_μ, μ Middle: $m_{\tilde{\chi}^+} = 490.8\ GeV$ with ν_μ, μ, ν_e

Invariant mass of stop

- Stop MC mass: 603.4 GeV.





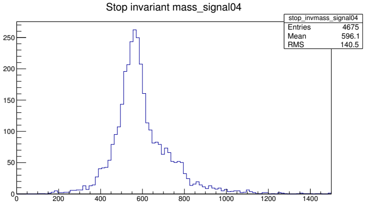


Figure : Upper left: $m_{\tilde{t}} = 561.1\ GeV$ without ν_e, ν_μ, μ Upper right: $m_{\tilde{t}} = 584.7\ GeV$ with ν_μ, μ Middle: $m_{\tilde{t}} = 596.1\ GeV$ with ν_μ, μ, ν_e

Conclusions

- Analyze RpV signal, ttbb background, ttHtobb background ttZtojj background and bbbb background.
- Create tables of number of event with different jet numbers at final state with 4, 5 and at least 6 of b-tagging.
- Plot histograms of transverse hadronic energy distribution.
- Check the invariant mass of chargino and stop.
- Next step: Apply b-tagging algorithm using CalibrationDataInterface.

BACK UP

Probabilities of b-tagging of signal

- Signal.

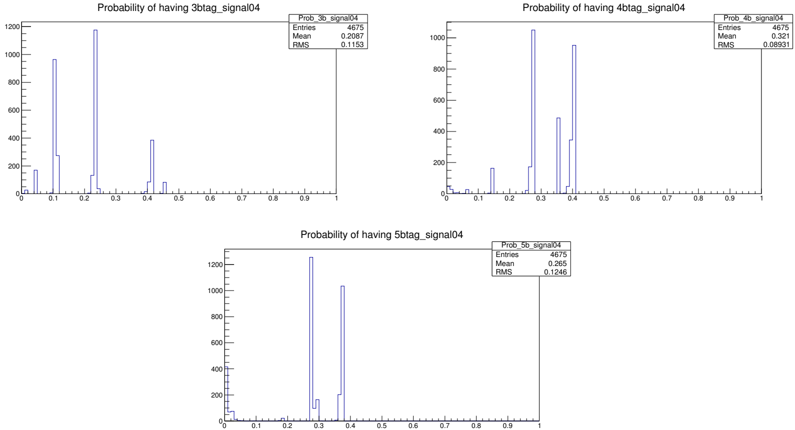


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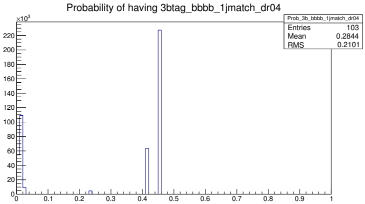
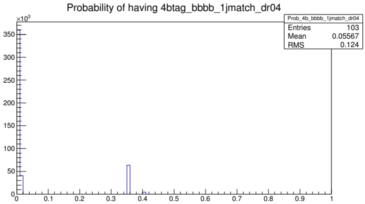
Figure : Upper left: Probability of having 3 b-tagging Upper right: 4 b-tagging Middle: 5 b-tagging

Probabilities of b-tagging of background

- bbbb background.





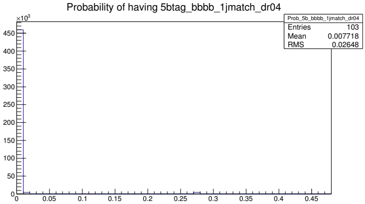
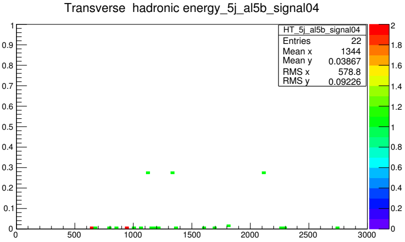


Figure : Upper left: Probability of having 3 b-tagging Upper right: 4 b-tagging Middle: 5 b-tagging

Next steps

- Apply b-tagging algorithm using CalibrationDataInterface.
- Probability versus hadronic transverse energy.



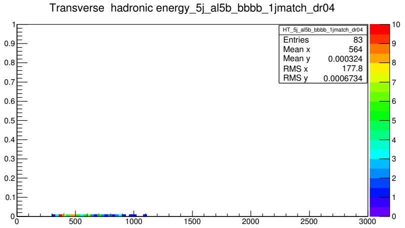
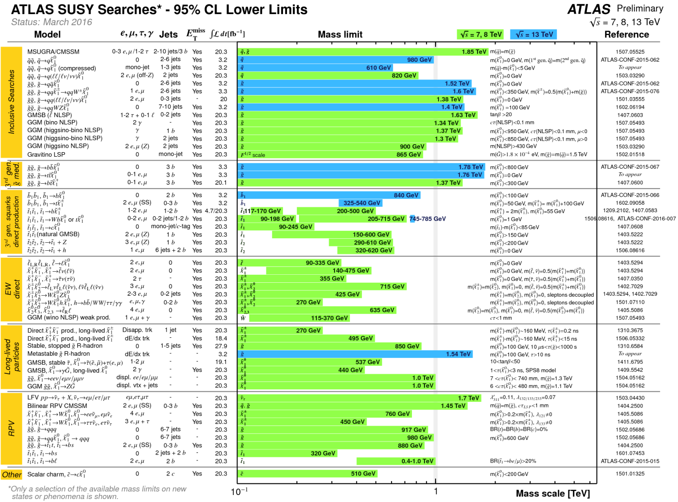


Figure : Probability of having 5 b tagging in 5 jets event - hadronic transverse energy, LEFT: signal , RIGHT: bbbb backgound

ATLAS SUSY Summary



ATLAS SUSY Summary

Stop to bs (RpV) arxiv 1601.07453

Transverse hadronic energy distribution (old)

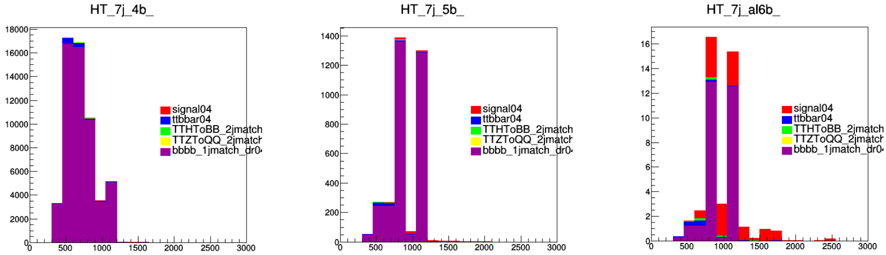


Figure : Left: HT with 7 jets and 4 b-tag Middle:HT with 7 jets and 5 b-tag Right: HT with 7 jets and at least 6 b-tag

Transverse hadronic energy distribution

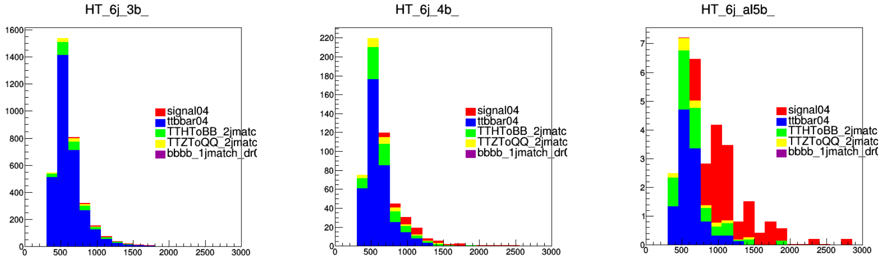
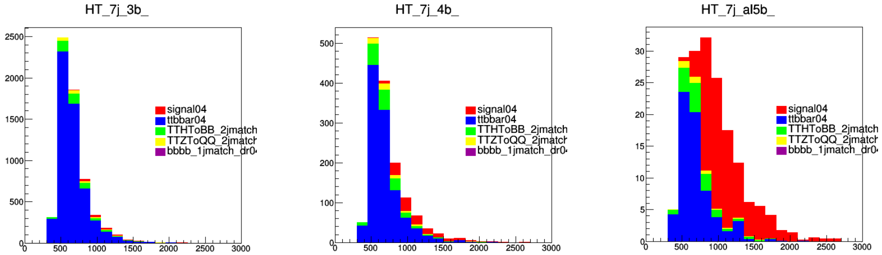


Figure : Left: HT with 6 jets and 3 b-tag Middle:HT with 6 jets and 4 b-tag Right: HT with 6 jets and at least 5 b-tag

Transverse hadronic energy distribution



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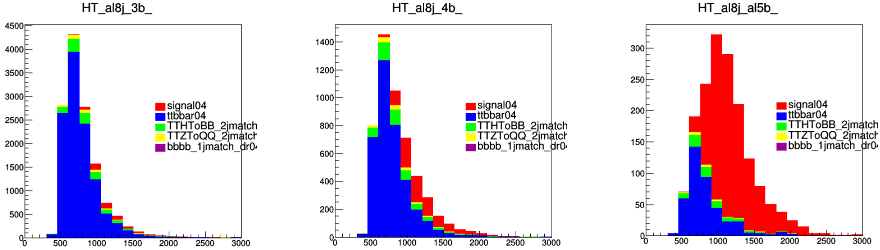
Transverse hadronic energy distribution



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