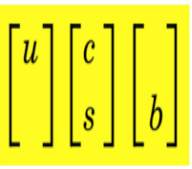
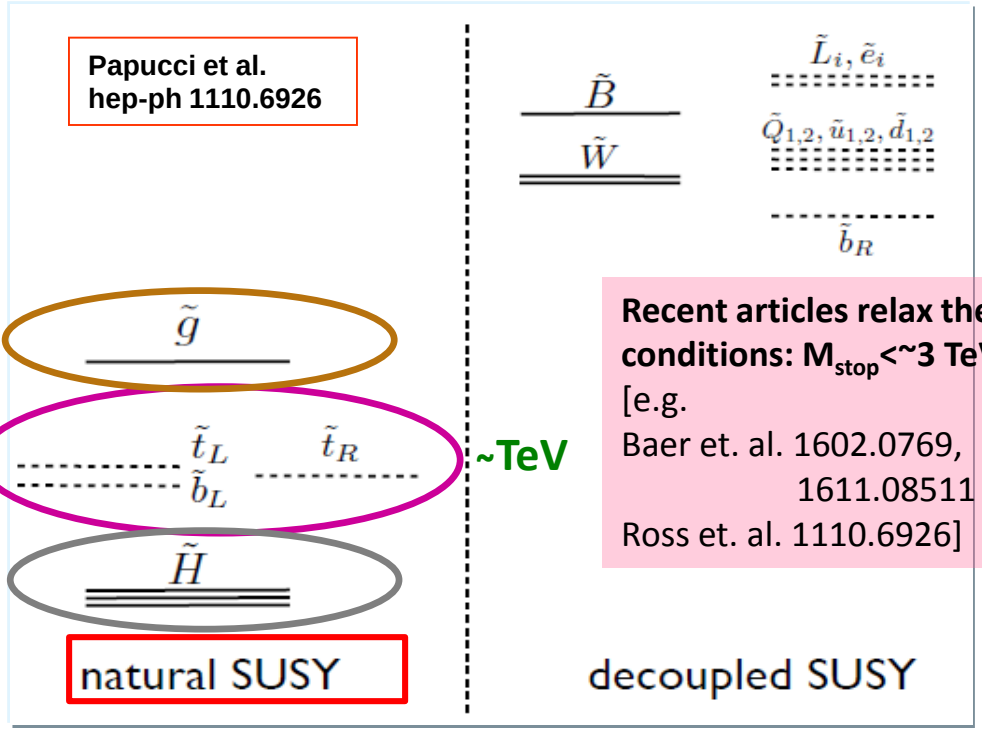


Initial studies on SUSY top squark searches at FCC-hh [100 TeV]

Owen Colegrove, **Loukas Gouskos**, Joe Incandela

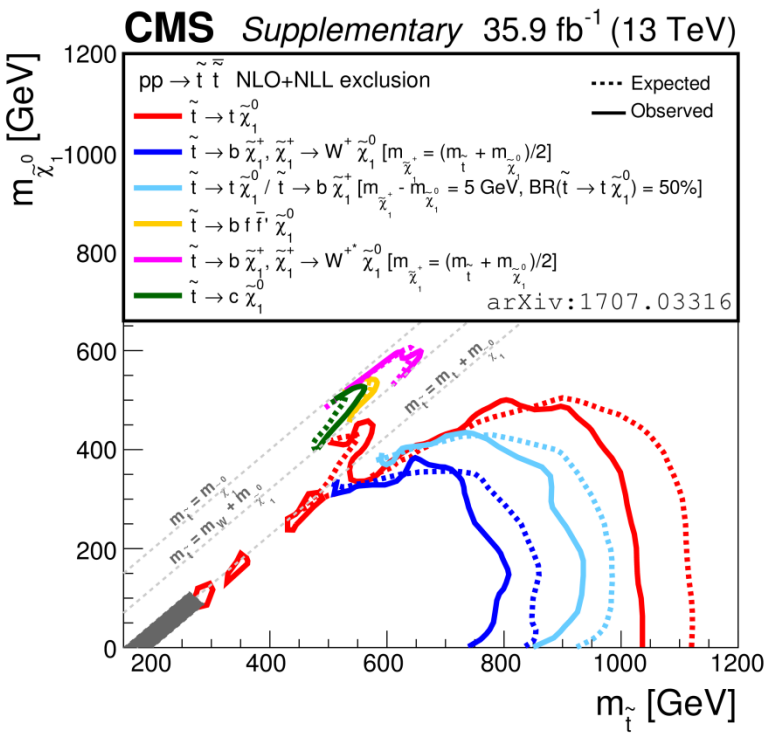
Introduction

- SUSY: one of the most extensively studied BSM theories
  - An excellent answer to: hierarchy problem, Dark Matter, unification of couplings



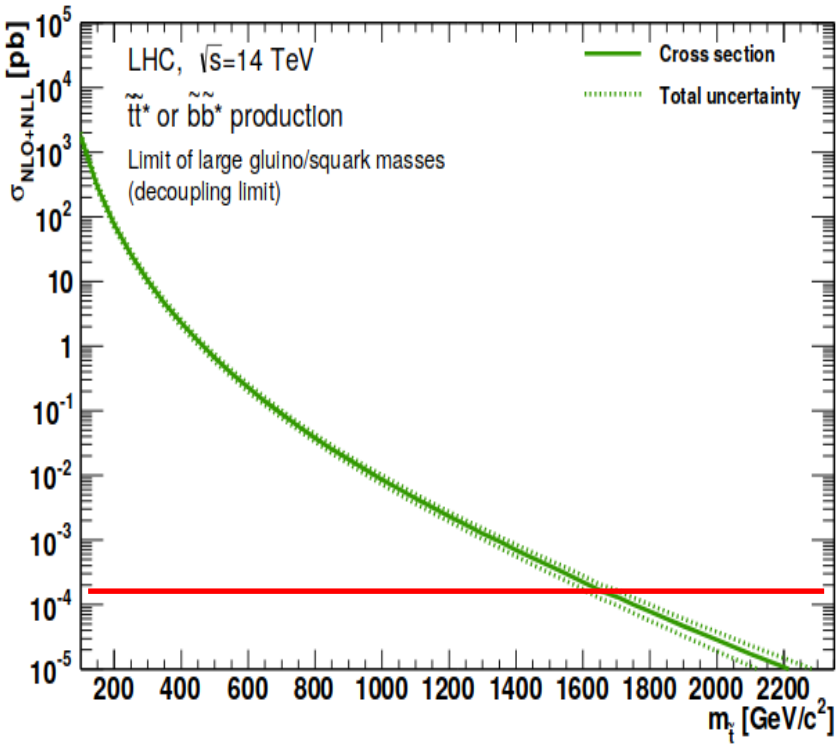
Recent articles relax these conditions: M_{stop}<~3 TeV
[e.g.
Baer et. al. 1602.0769, 1611.08511
Ross et. al. 1110.6926]

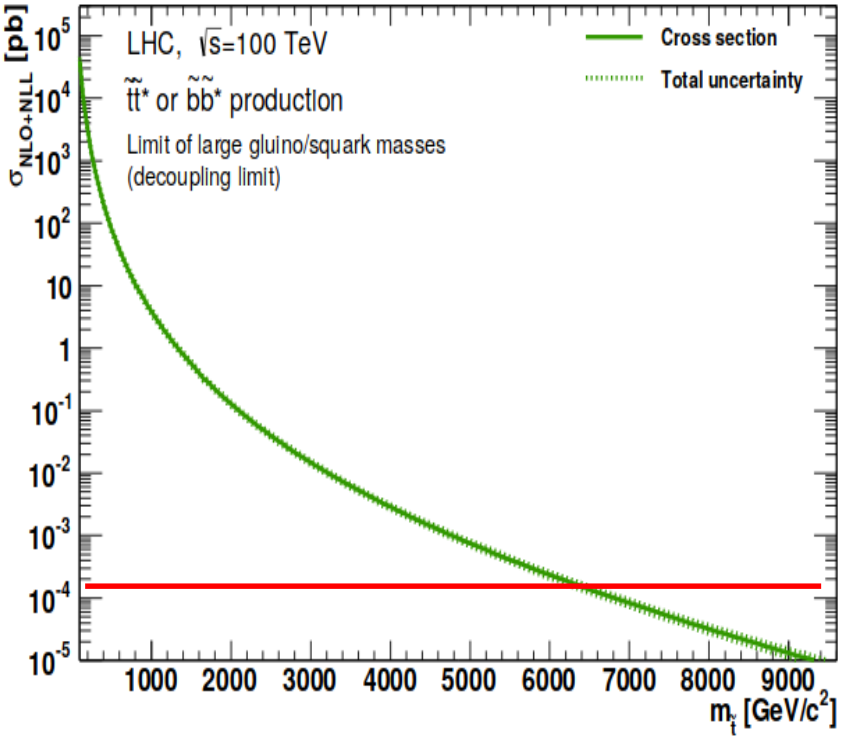
Current status



Introduction (2)

- FCC-hh @ 100 TeV:
  - Significant increase in the production cross section:

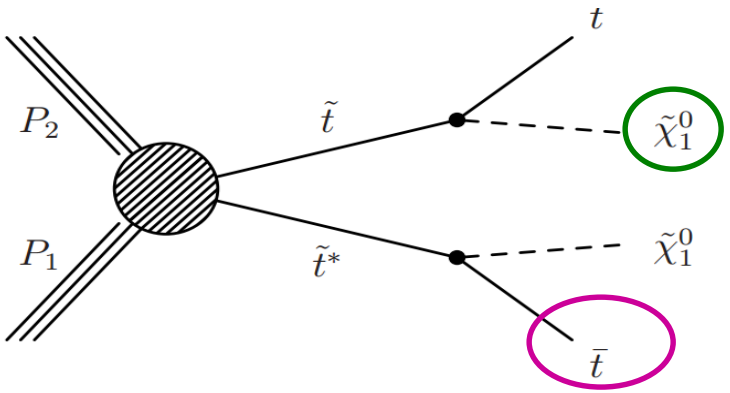




- More details on physics motivation:
  - FCC-Lecture from M. Mangano [slides]

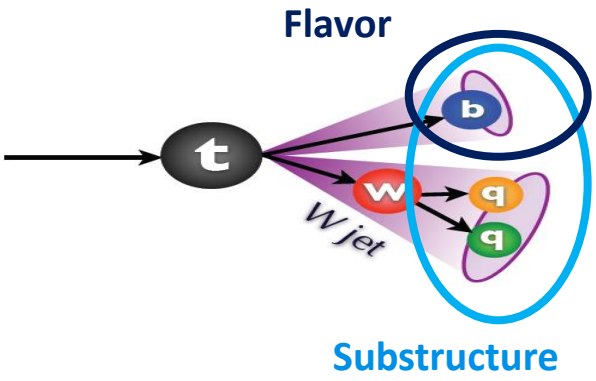
Signal characteristics

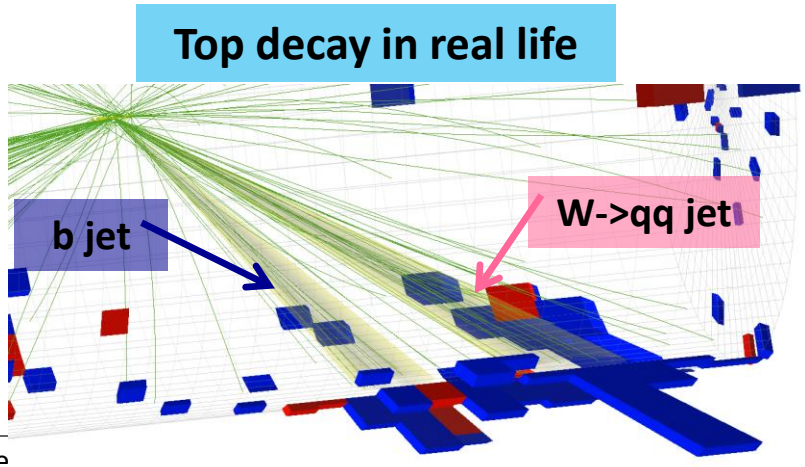
- Top squark decays: very distinct signature!



- Multiple jets
- 2 b-jets
- On-shell top quarks
- Large MET [from the two LSPs]

- Key player of top squark searches: **top tagging**
  - Identification of hadronically decaying Lorentz boosted top quarks provides a powerful handle to suppress many of the SM backgrounds





Technical details

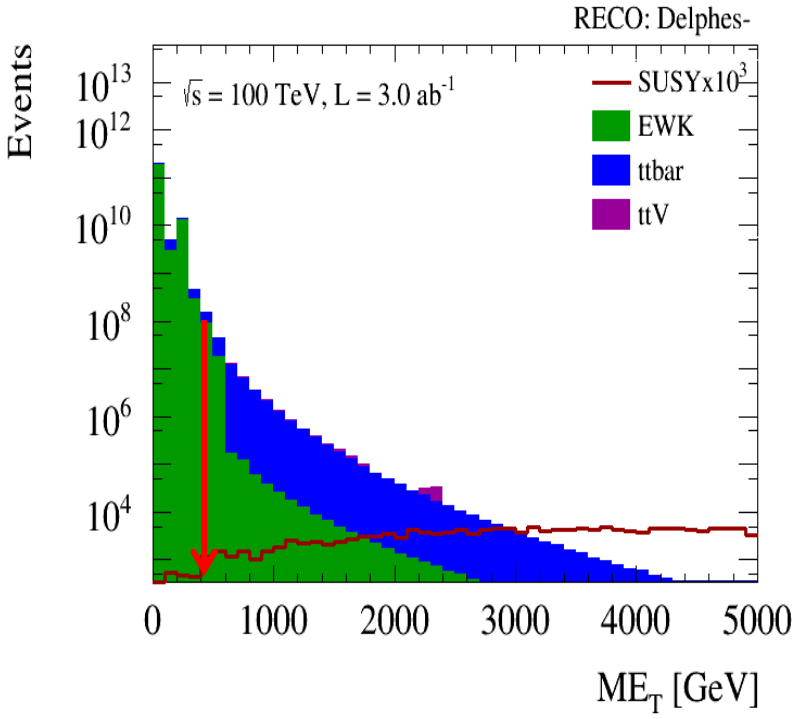
- Scope of this talk: Put in place all necessary pieces [i.e. code/structure] to carry out a search for top quarks @ 100 TeV
  - Develop dedicated analysis methods for this energy regime
  - Explore various object identification approaches tailored for 100 TeV

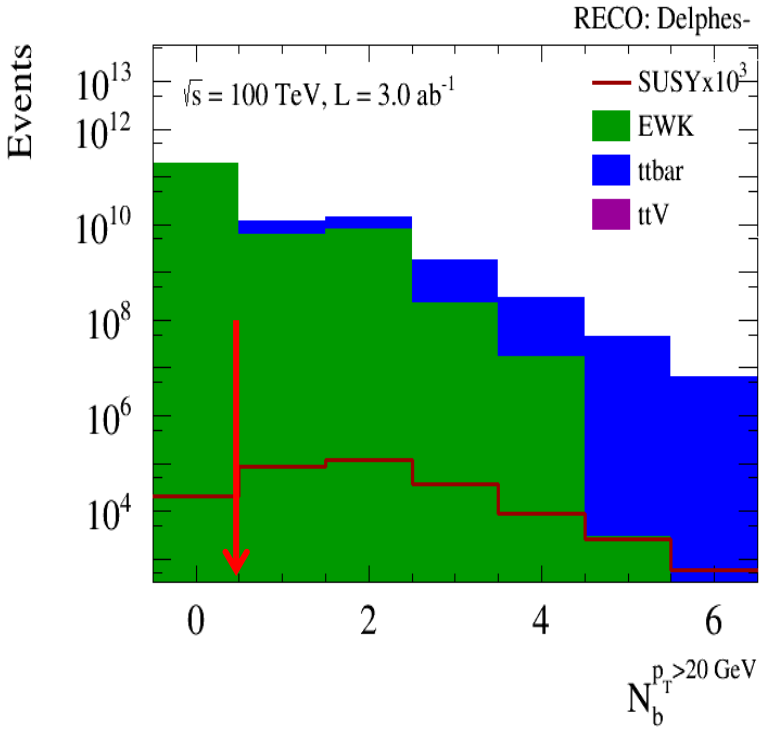
- Use "FCCSW" for lhe and ntuple production and "heppy" for analysis
  - FCC_v01 detector configuration
  - Produced a top squark signal model: m_{stop}=9000 GeV, m_{LSP}=1 GeV, xsec~10^{-5} pb
    - BKG samples: from Clemens
  - Top squark analysis directory under heppy
  - gen particle matching module for top-tagging developments
    - Might be useful in other analyses too.

- Use a cut-based analysis [ala. CMS-SUS-16-029] using a simple top-tagging algorithm based on jet substructure [softdrop and n-jettiness]

Baseline analysis

- All-hadronic final state:
  - **N_j(pT>100 GeV) >= 2** [j: anti-kt jet with R=0.4]
  - **N_{fj}(pT>200 GeV) >=1** [fj: anti-kt jet with R=0.8]
  - **Dphi($j_{1,2,3}$;MET)> 0.5** [QCD killers]



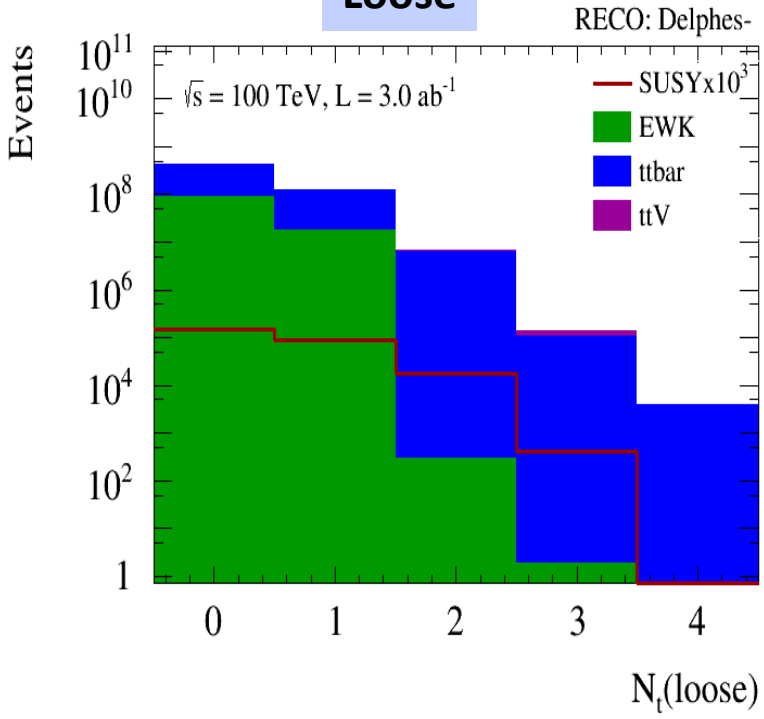


- MET traditionally powerful ; Nb useful to reduce EWK backgrounds

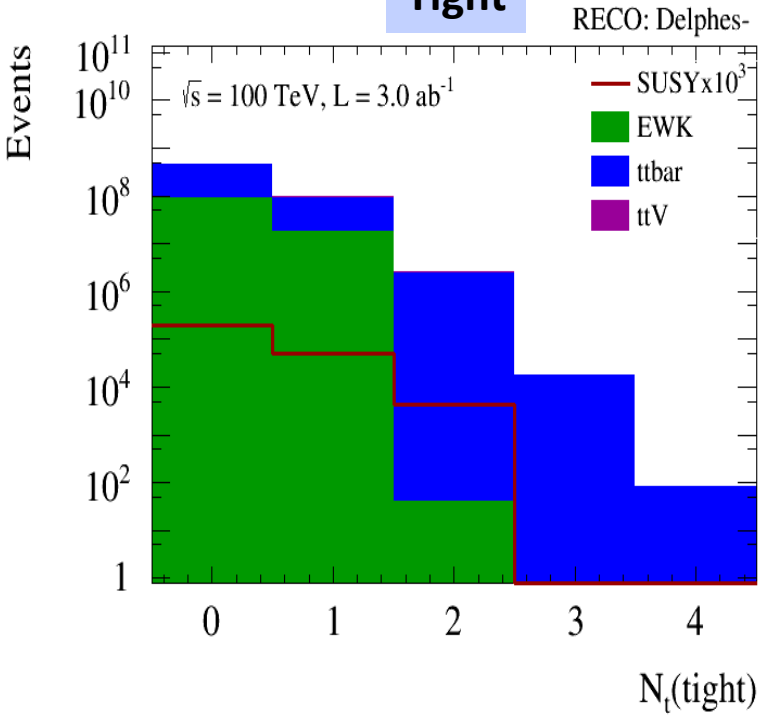
Baseline analysis (2)

- Simple top-quark identification based on softdrop (SD) & n-jettiness
  - **105<M_{SD}<220 GeV** and **tau3/tau2 < 0.67 (0.57)** Loose (Tight)
- Distributions after: baseline + MET>250 GeV + Nb>=1

Loose



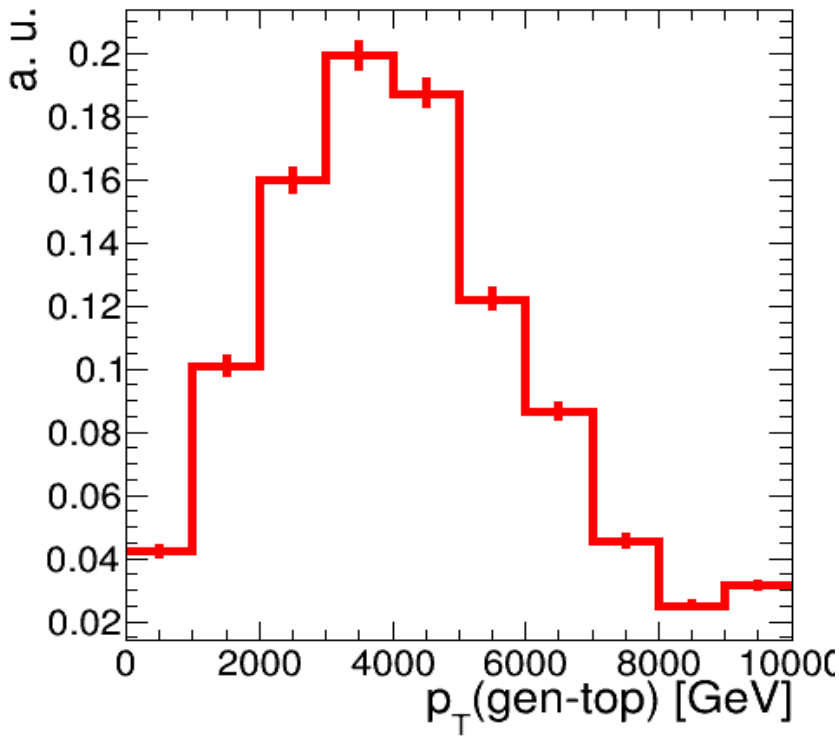
Tight

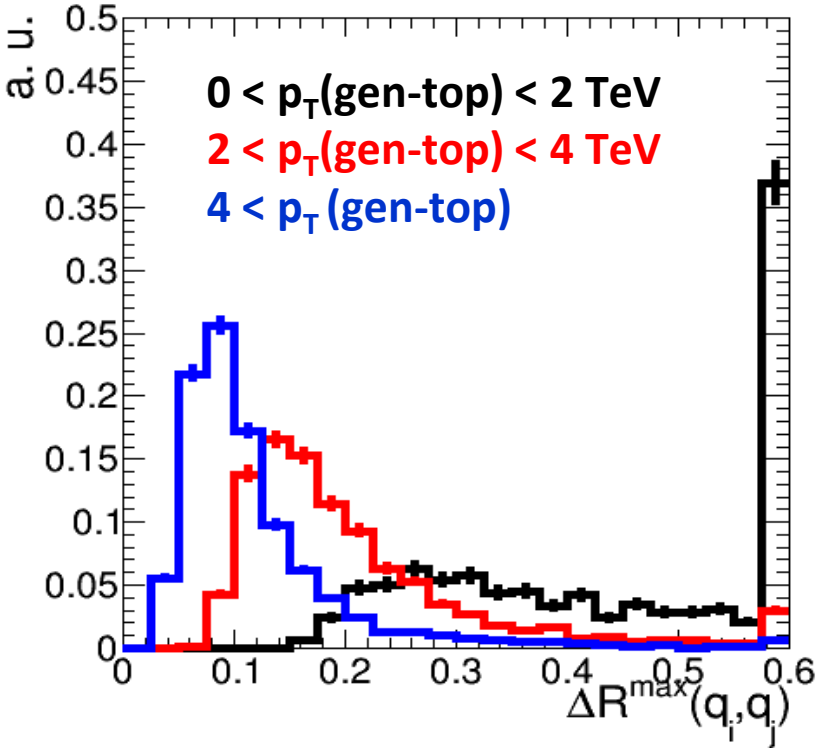


- Top-tagging not as powerful as @13 TeV

Top squarks @ 100 TeV

- Reminder: signal model with m_{stop}=9000 GeV, m_{LSP}=1 GeV



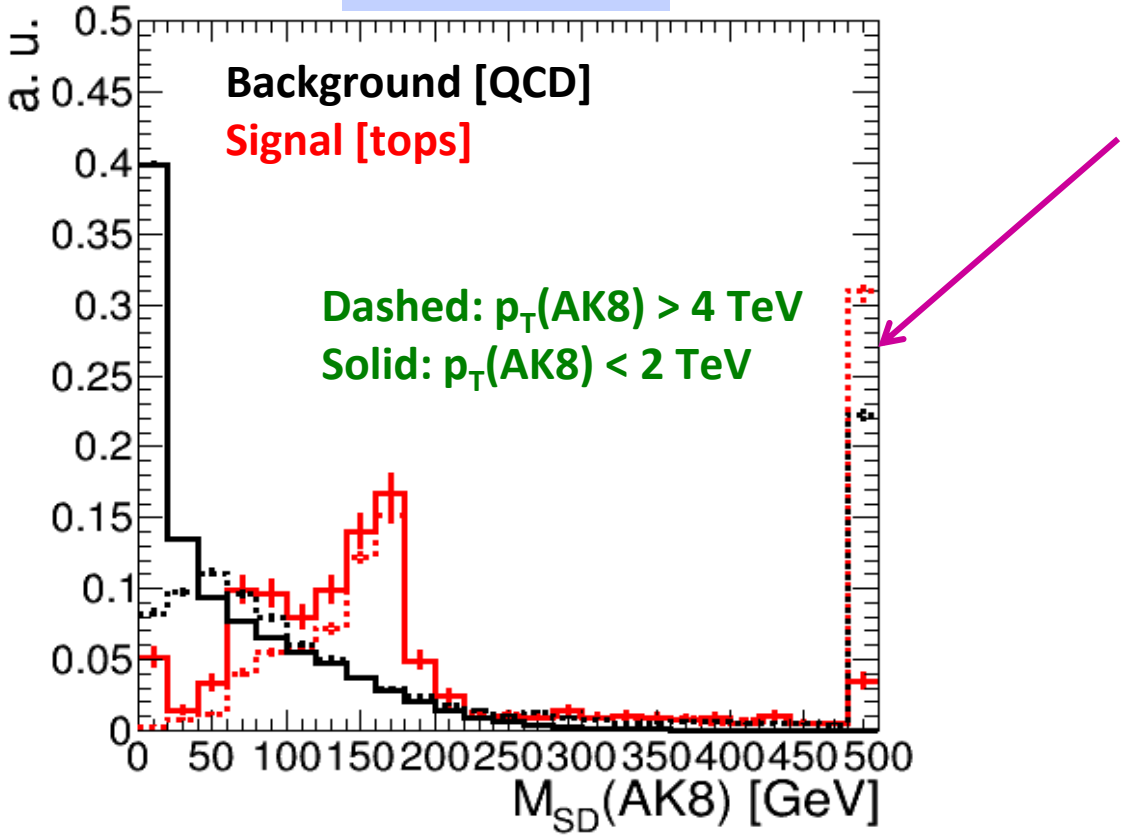


3-4 TeV stop in DR~0.1-0.15
Very different from what we are used at LHC

Detectors with high granularity essential

Tagging of very-high-p_T tops

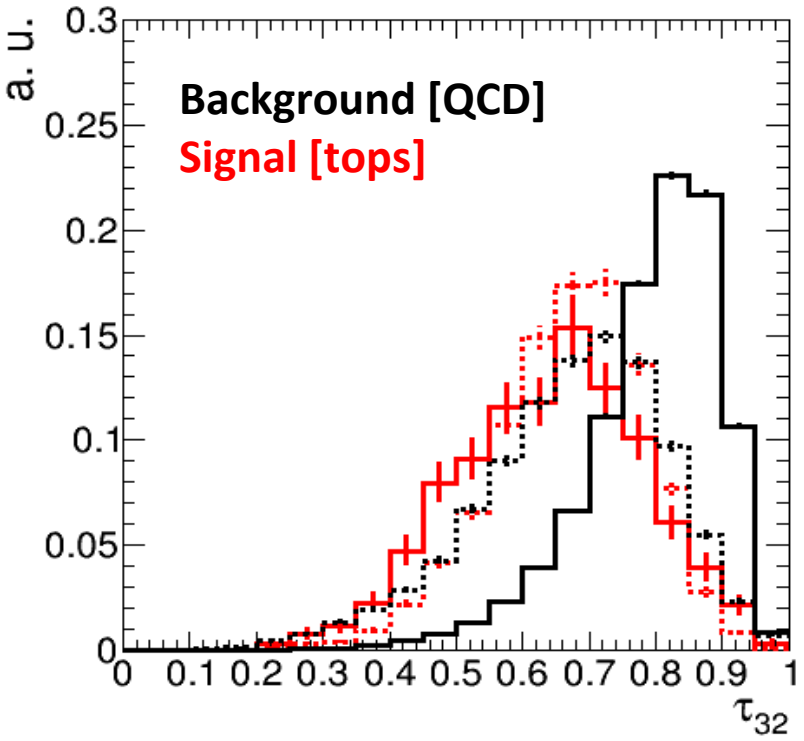
Softdrop mass



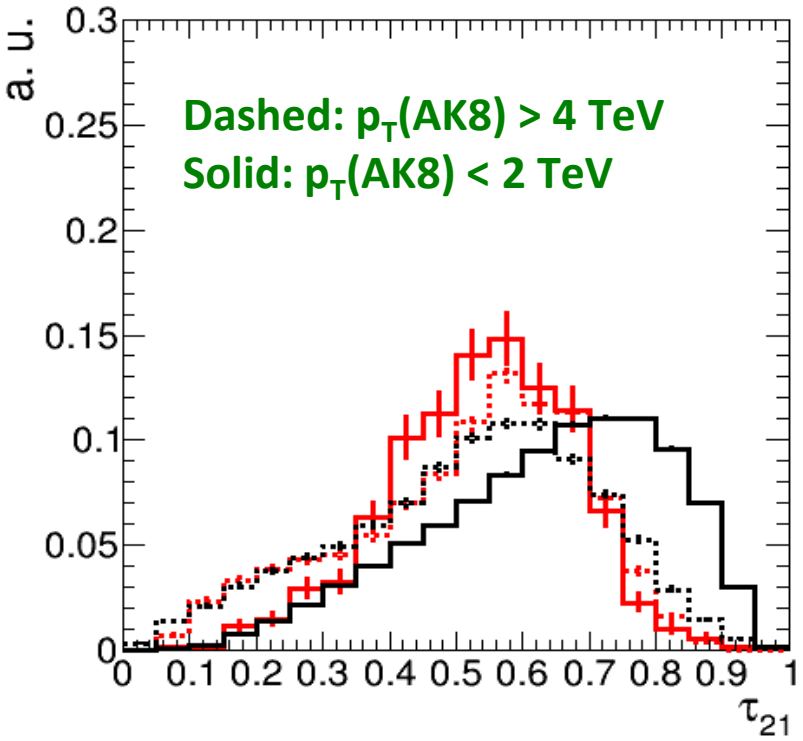
- High-p_T tops: AK8 not optimal
  - pT-dependent distance parameter ?

Tagging of very-high-p_T tops (2)

tau3/tau2



tau2/tau1

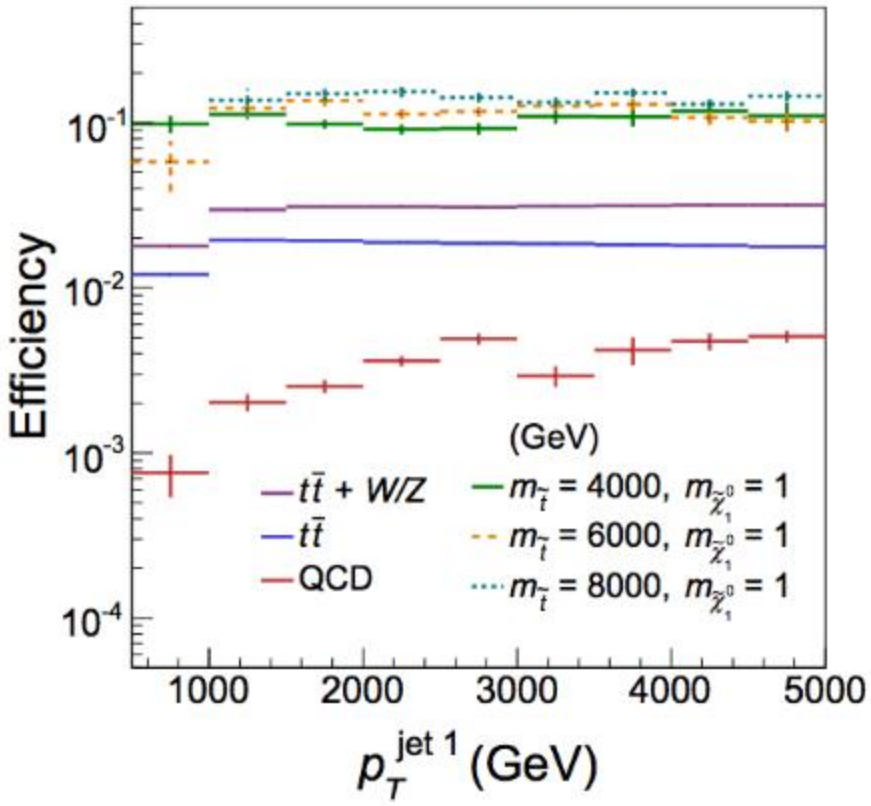


- Standard approach [with the FCC detector configuration] does not work.
- For very boosted tops we need improved methods
  - Investigate with different detector configurations

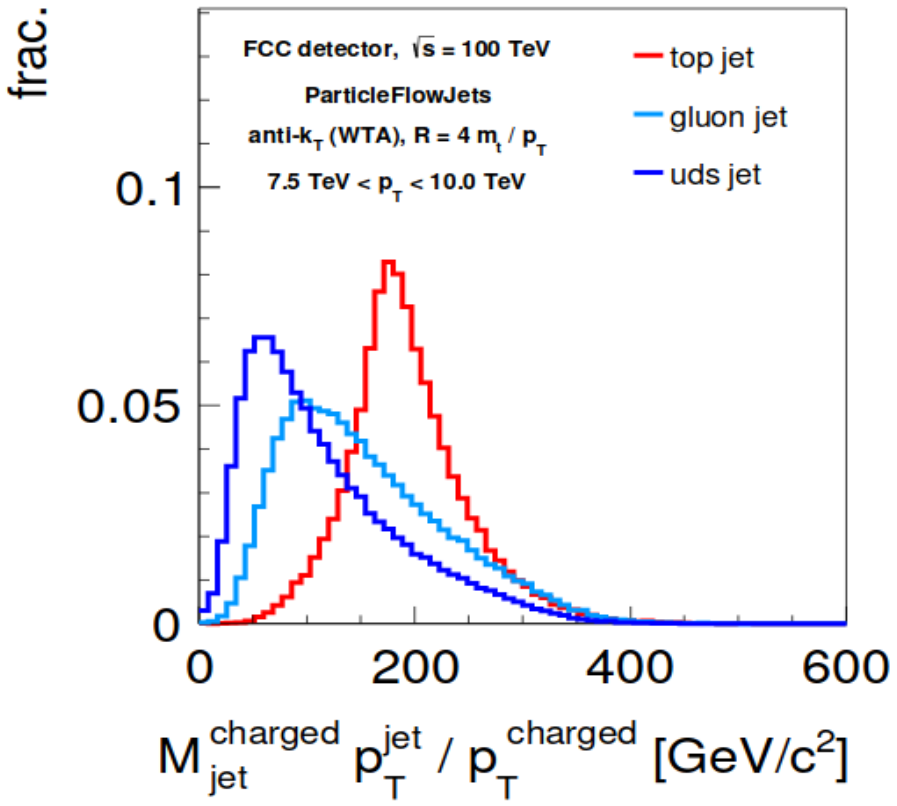
Next steps

- Investigate alternative top-tagging approaches, eg.:

Muonic-top tagging



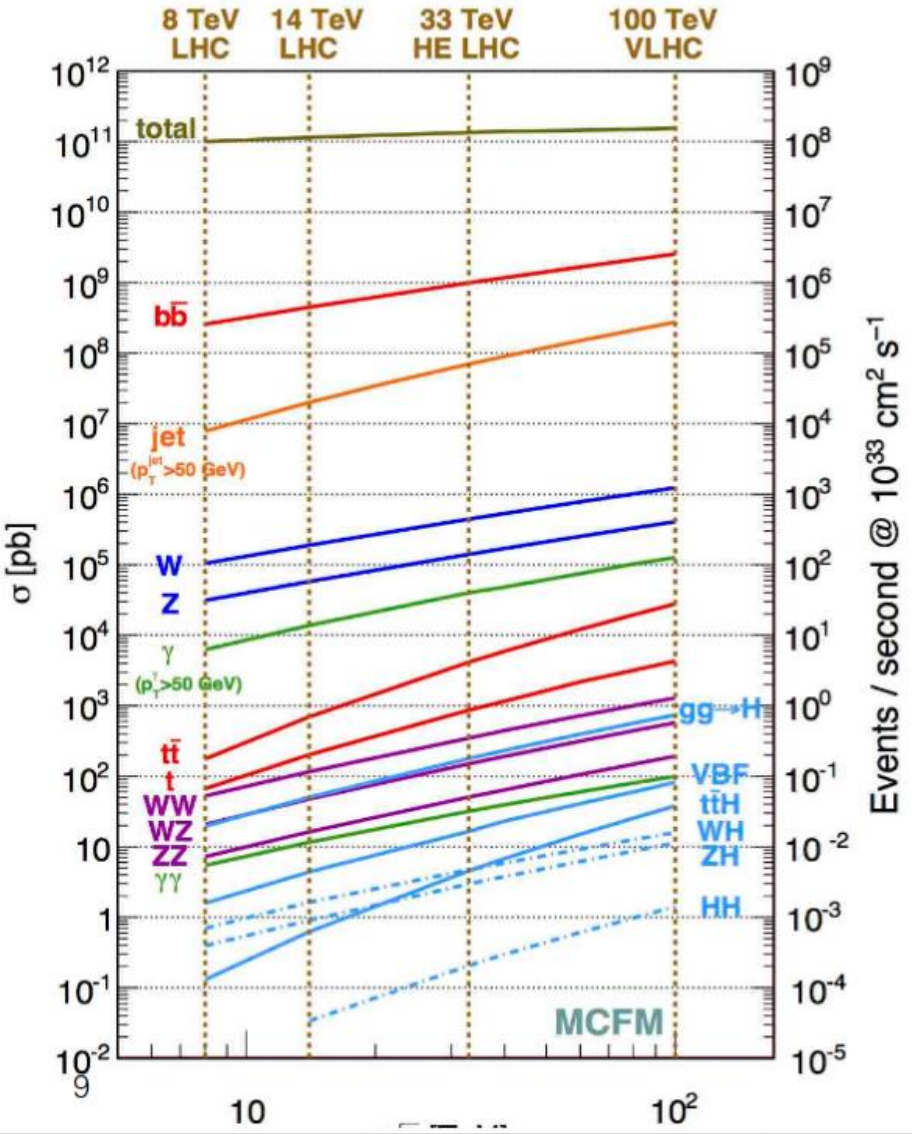
Track-based top-tagging



- …and others

Next steps (2)

- Top-tagging will always be a key player in top squark searches
- However: need to improve on analysis techniques too:
- "Rare" backgrounds [e.g. ttV] become important at 100 TeV
  - With a very similar final state as signal: **2xtops + 2xbottoms + MET**



Summary

- A first example of a top squark search using FCCSSW & heppy in place based on a simplified version of an LHC analysis
- Object reconstruction and analysis techniques developed for LHC@13-14 TeV not sufficient for FCC-hh @100 TeV
  - But can serve as a reference
- Machinery in place to explore alternative methods in both object reconstruction and search design
- Stay tuned – more updates in the next FCC-hh meeting!
- Many thanks to Michele Selvaggi, Clement Helsens and Valentin Volkl for their help!