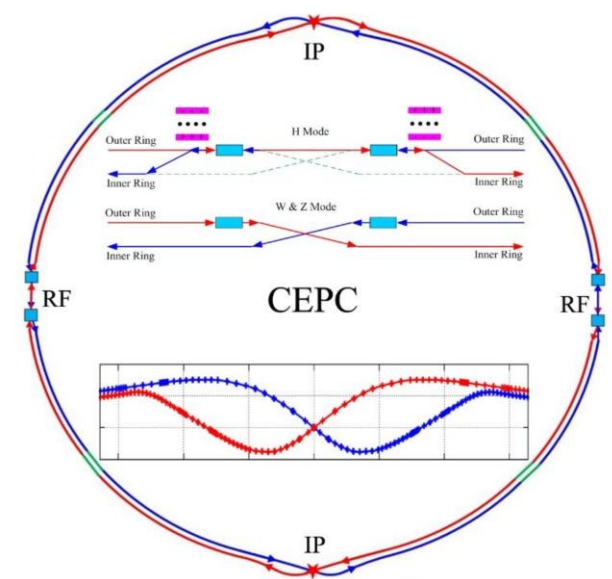




$t + jets + MET$

$b/c$ -jet tagging at CEPC



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“EF09 - General BSM” & “EF10 - DM@Collider”  
Snowmass 2021 Joint Meeting

Aug. 21<sup>st</sup>, 2020

# Outline

- Why  $t + jets + MET$
- A sample analysis in SUSY
- Jet tagging at CEPC

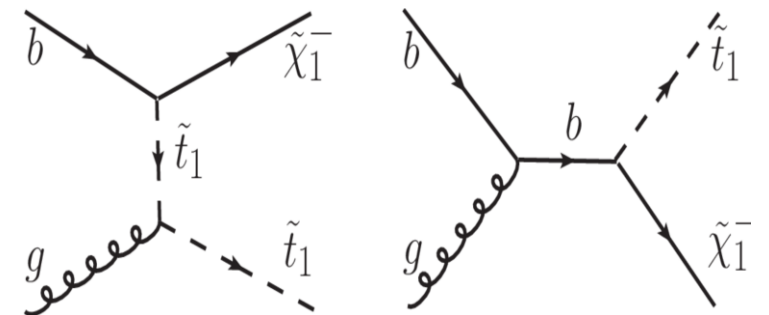
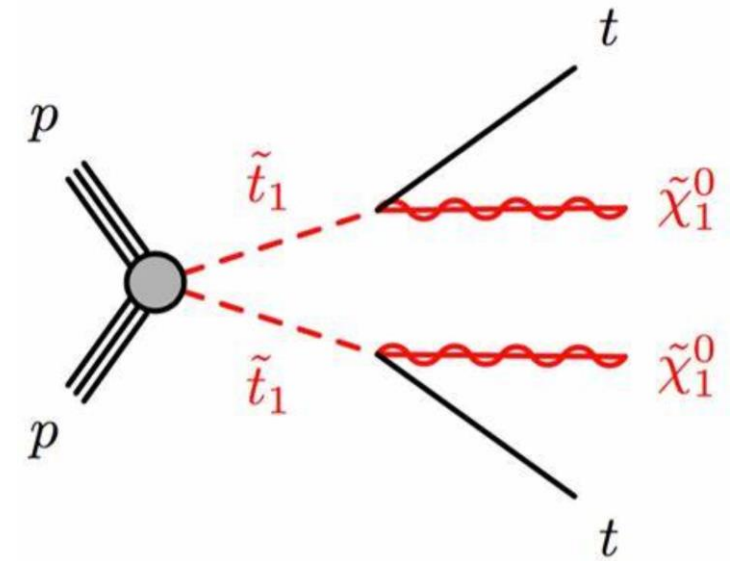
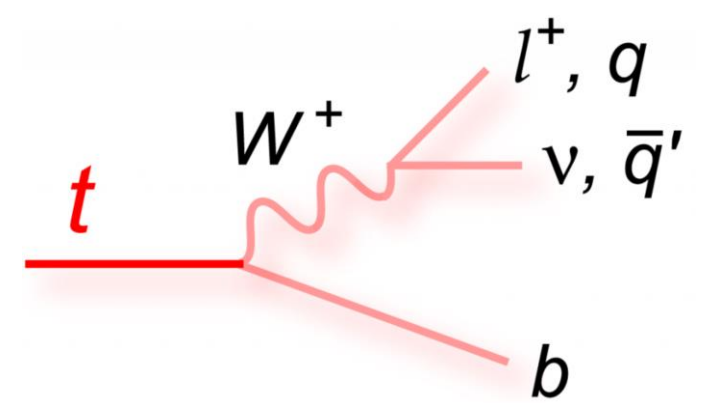
# Interests in heavy flavors

15	EF03	EW Physics: Heavy flavor and top quark physics	
16	EF03.1	Rare B decay channel study, e.g. $b \rightarrow sll$ , $b \rightarrow c l \nu$ and so on	
17	EF03.2	Z and Higgs flavor violating decay	
18	EF03.3	Tau in the Jet: $B_c \rightarrow \text{Tau} \nu$	
19	EF03.4	Lepton in the Jet: B/C meson Leptonic decay	
20	EF03.5	$\pi^0$ : $Z \rightarrow \tau\tau$ , $\text{Br}(\tau \rightarrow X)$	
21	EF03.6	MET at Jet: leptonic decay of Heavy Flavor Mesons, $B_s \rightarrow \text{Phi} + \nu\bar{\nu}$	
22	EF03.7	CKM $\phi_s$ measurement, $B_s \rightarrow J\psi \phi$	Mingrui Zhao
23	EF03.8	$t\bar{t}$ threshold scan	
24	EF03.9	$t\bar{t}$ top-EW couplings, EFT interpretation	
25	EF03.10	top FCNC	Peiwen Wu

48	EF10	BSM: Dark Matter at colliders	
49	EF10.1	Dark Matter: mono-V/H/Scalar (should be in EF08 or here?)	Shu Li
50	EF10.2	Dark Matter: Dijet + Missing Energy	Zhao Li
51	EF10.3	Dark Matter: top + jet + Missing Energy	Peiwen Wu
52	EF10.4	Dark Matter: Dark QCD Search	Mengchao Zhang
53	EF10.5	Dark Matter: Higgs portal	Xin Shi

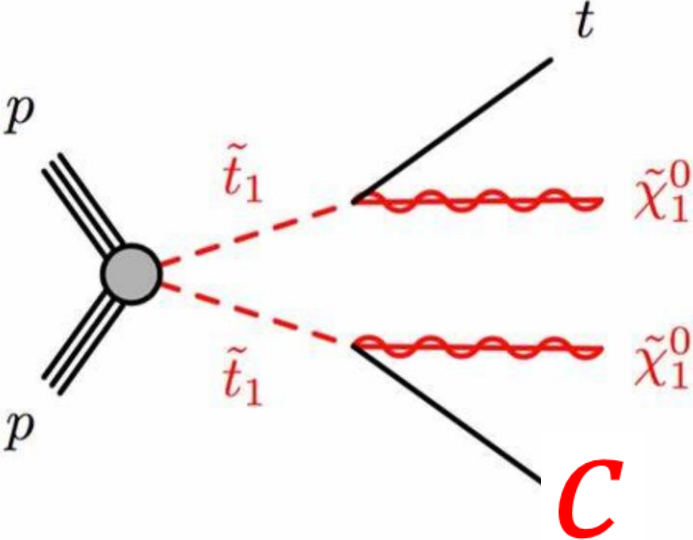
# Why $t + jets + MET$

- $t\bar{t}$  : important SM backgrounds
  - producing leptons, jets, MET
- Searches for **pure flavor** SUSY squarks
- $t\bar{t} + MET$  : pair production of  $\tilde{t}_{1,2}$
- $t + MET$ : single production of  $\tilde{t}_{1,2}$

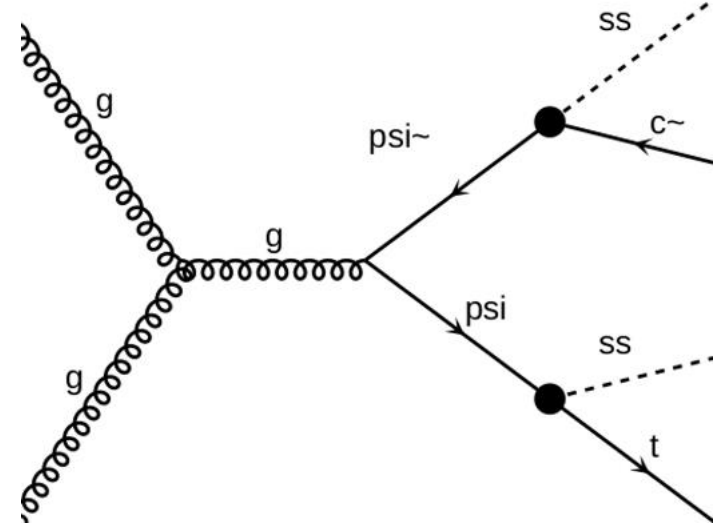
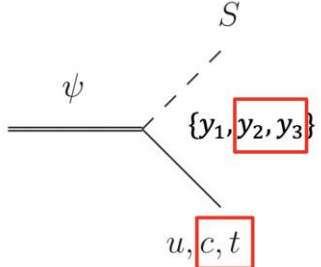


# Mixed flavor mediators

- SUSY: **flavor mixing** may exist in squarks
  - Reducing the current bounds on  $\tilde{t}_{1,2}$
  - Interplay between  $MET + t\bar{t}$  &  $c\bar{c}$

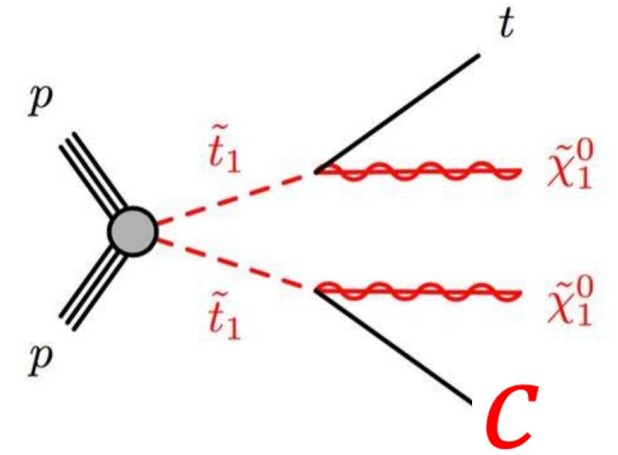


- Other BSM:
  - dark matter  $S$ : a real scalar
  - mediator  $\psi$ : a vector-like fermion
  - DM couplings: right-handed  $\{c_R, t_R\}$



# A sample analysis at LHC

arXiv: 1808.07488



## Flavour-violating decays of mixed top-charm squarks at the LHC

Amit Chakraborty<sup>1a</sup>, Motoi Endo<sup>1b</sup>, Benjamin Fuks<sup>2,3c</sup>, Björn Herrmann<sup>4d</sup>, Mihoko M. Nojiri<sup>1,5,6e</sup>, Priscilla Pani<sup>7f</sup> and Giacomo Polesello<sup>8g</sup>

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<sup>6</sup> Kavli IPMU (WPI), University of Tokyo, Kashiwa, Chiba 277-8583, Japan

<sup>7</sup> CERN, Experimental Physics Department, CH-1211 Geneva 23, Switzerland

<sup>8</sup> INFN, Sezione di Pavia, Via Bassi 6, 27100 Pavia, Italy

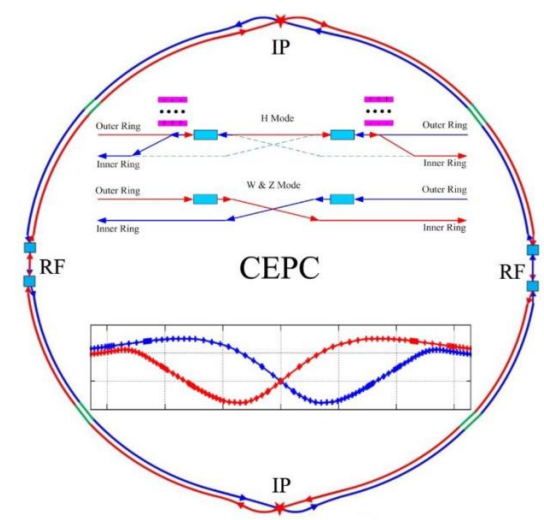
# CEPC potential

- Advantages

- cleaner QCD background: helpful for jet identification
- electron beams: full re-construction of 3-D  $\vec{p}$  for final states
- better tagging capability of  $b, c$ -flavor jets

- Challenges

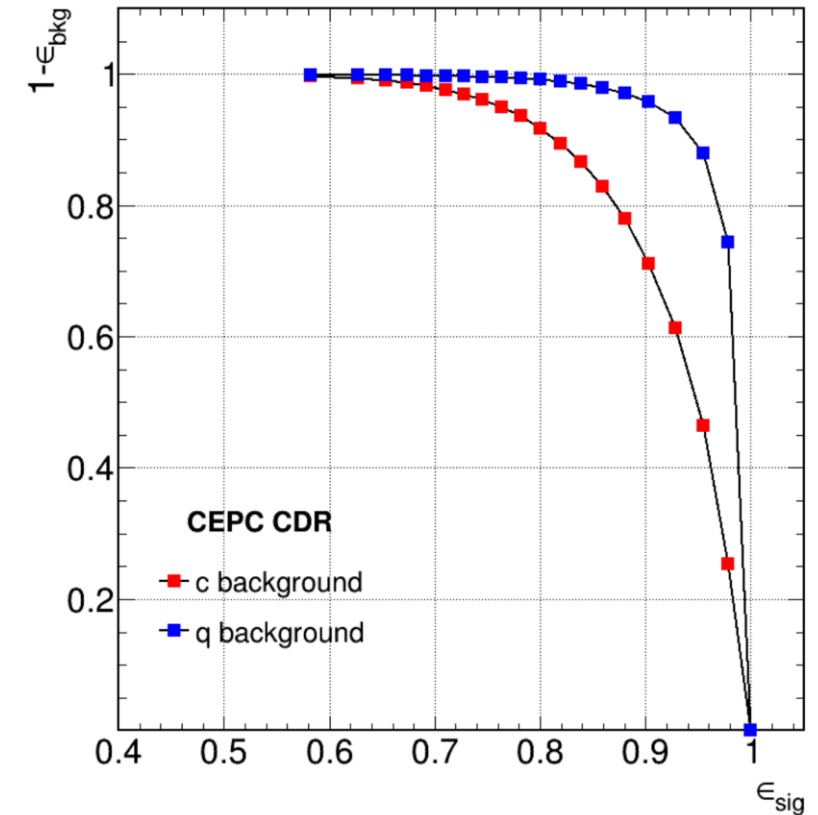
- $\sqrt{s} \sim 240$  GeV
- heavy BSM **mediators** are produced **off-shell**, indirect detection





# $b/c$ -jet tagging at CEPC

particles identified by ARBOR. It combines more than 60 discriminant variables to calculate the  $b$ -likeliness ( $L_B$ ) and  $c$ -likeliness ( $L_C$ ) using a Boosted Decision Tree [16] method. Compared with the  $b$ -jet tagging,  $c$ -jet tagging is particularly challenging as charm hadrons have shorter lifetimes than bottom hadrons and therefore suffers more from backgrounds from light-quark and gluon jets. Benefiting from the high precision vertex system, the CEPC detector provides reasonable separation of  $c$ -jets from other flavor jets. Figure 10.13 shows the  $b$ -jet tagging efficiencies for different rejections of background jets, measured from a  $Z \rightarrow q\bar{q}$  sample of the  $Z$  factory operation. For this sample,  $b$ -jets can be tagged with an efficiency of 80% and a purity of 90%. Similarly, an efficiency of 60% and a purity of 60% can be achieved for the  $c$ -jet tagging. Purities can be improved by tightening the tagging requirements at the expense of reduced efficiencies. Figure 10.14 is a demonstration of the  $b/c$ -likeliness distributions of the  $b$ ,  $c$  and gluon jets from the  $H \rightarrow b\bar{b}/c\bar{c}/gg$  decays, showing good separations between jets of different flavors.



**Figure 10.13:** Efficiencies for tagging  $b$ -jets versus rejection of background jets, determined from an inclusive  $Z \rightarrow q\bar{q}$  sample at the  $Z$  factory operation.



# Signals, Backgrounds

- signal:  $(t \rightarrow bl\nu) + j + MET$

- 1 isolated  $\ell(e, \mu) + jets + MET$

- BG: 1 or 2  $\ell$  from

- $W \rightarrow \ell \bar{\nu}_\ell$
- $Z \rightarrow \ell \bar{\ell}$
- $\tau \rightarrow \ell \bar{\nu}_\ell \nu_\tau$

typical BGs:

- $t\bar{t}$ ,  $t\bar{t}W$ ,  $t\bar{t}Z$ ,  $tWZ$
- $tW$ ,  $tZ$ ,  $WW$ ,  $WZ$ ,  $ZZ$
- $W/Z + jets$

# Summary

- $t + jets + MET$  are present in BSM models
  - requiring better  $b/c$ -jet tagging
- CEPC are advantageous for jet-tagging
  - more potential for BSM searches
- Strategies/details to be analyzed for specific BSM models