ILD Analysis/Software Meeting
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Single top production at the ILC

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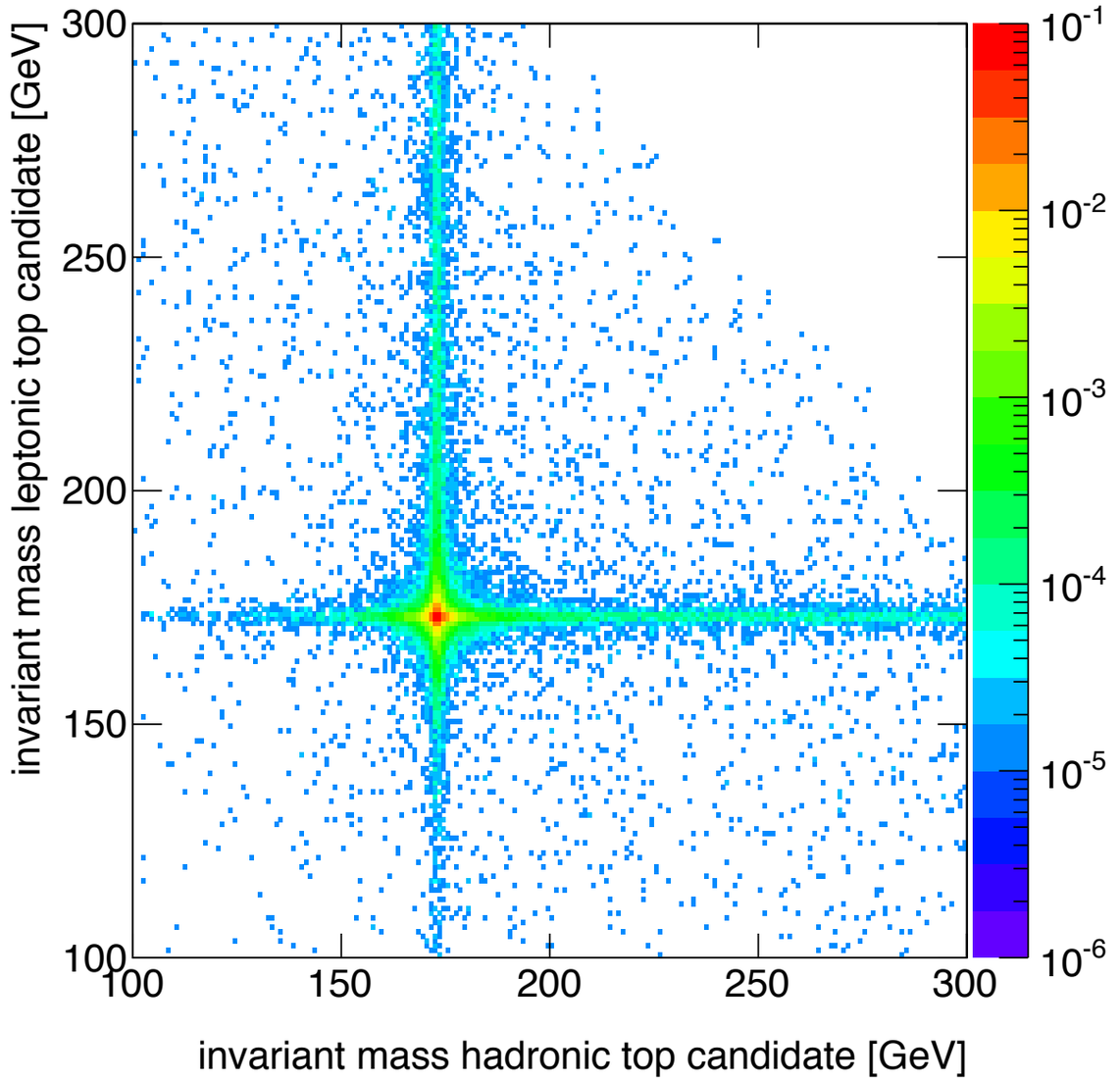
Introduction

- This talk is focused in the article arXiv:1411.2355
- The **top quark has never been produced in e^+e^- machines**
- The study of **top quark properties** is therefore one of the most **exciting prospects** for a future linear collider
- **Single top production**, trough $e^+e^- \to W^-t\bar{b}, W^+\bar{t}b$ **is abundant at e^+e^- colliders** that operate at $\sqrt{s} > 300$ GeV
- *In this work we investigate the impact of single top events in a few published analysis*

Distinguishing single top from $t\bar{t}$ production

- Question: **how can one distinguish single top form $t\bar{t}$?**
- Answer: **No algorithm can ever separate them fully -> interference between the production diagrams**
- $e^+e^- \to t\bar{t} \to W^+bW^-\bar{b}$ events generated using **MADGRAPH** at $\sqrt{s} = 500$ GeV without ISR
- So we consider a mass window to separate partially single and double-top events



$$|m_{Wb} - m_t^{MC}| < 15 \text{ GeV}$$

Experimental study at $\sqrt{s}$ = 500 GeV

- IFIC/LAL study of ILC lepton+jets tt @ 500 GeV [arXiv:1307.8102]

- We have checked at truth level the composition of this sample of input events, using the mass **window of 15 GeV**

  ✓ $t\bar{t}$ **events:** 89%
  ✓ **single top:** 10%
  ✓ **non-top:** 1%

The fraction of single-tops is non-negligible and may have a significant impact on the measurement of top quark properties

Experimental study at $\sqrt{s}$ = 500 GeV

Impact of the single top

	WbWb	single t	$t\bar{t}$
ϵ_1	51.6%	50.3%	51.8%
ϵ_2	27.2%	13.5%	29.0%

$\in_1$: kinematical and identification cuts

$\in_2$: $\chi 2$ cut formed by the M_{top}, E_{beam} and E_b*

$$d^2 = \left(\frac{m_{cand.} - m_t}{\sigma_{m_t}}\right)^2 + \left(\frac{E_{cand.} - E_{beam}}{\sigma_{E_{cand.}}}\right)^2 + \left(\frac{p_b^* - 68}{\sigma_{p_b^*}}\right)^2$$

- The selected sample contains a **5.6%** of single top after selection cuts -> **increase in the measured cross-section**

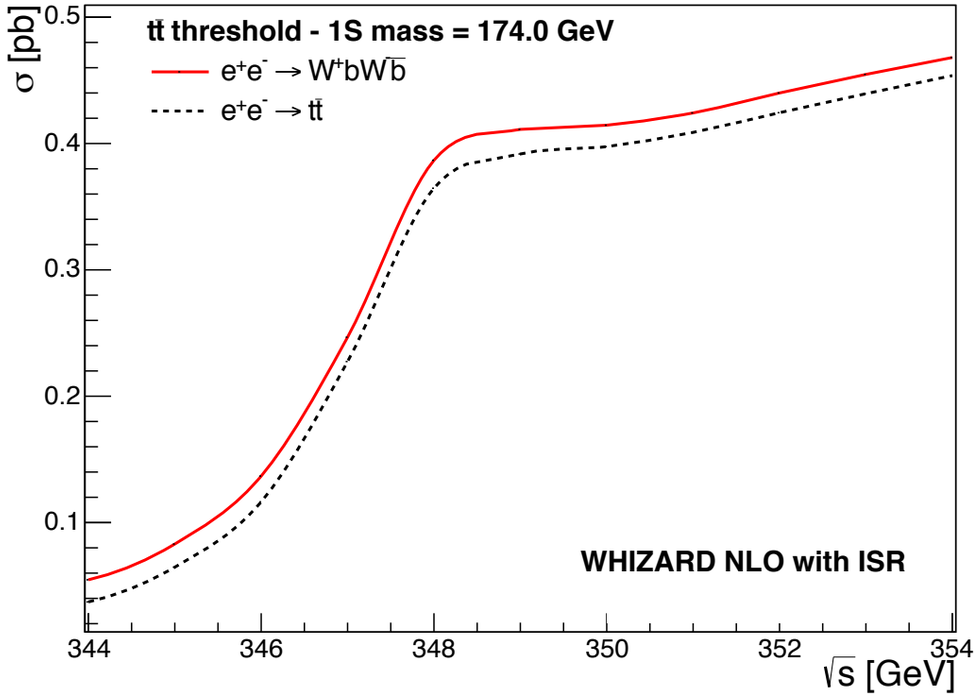
- The **forward-backward asymmetry** is even more sensitive -> we obtain a value of **0.24 instead of the expected 0.34**

Analysis of top mass at threshold

- We also review the study [arXiv:1303.3758v3, Katja Seidel, Frank Simon et al.]

- **NLO** calculations for $W^+bW^-\bar{b}$ process in **WHIZARD** around the double-top production **threshold** (MC top mass 174 GeV)
- Content of single top and non-top events in the $W^+bW^-\bar{b}$

$\sqrt{s}$ (GeV)	e^-e+ (LO)	$e^-_L e^+_R$ (LO)	e^-e+ (NLO)
344	23%	36%	32%
345	19%	30%	22%
346	13%	26%	15%
347	9%	19%	9%
348	7%	14%	6%
349	5%	10%	5%

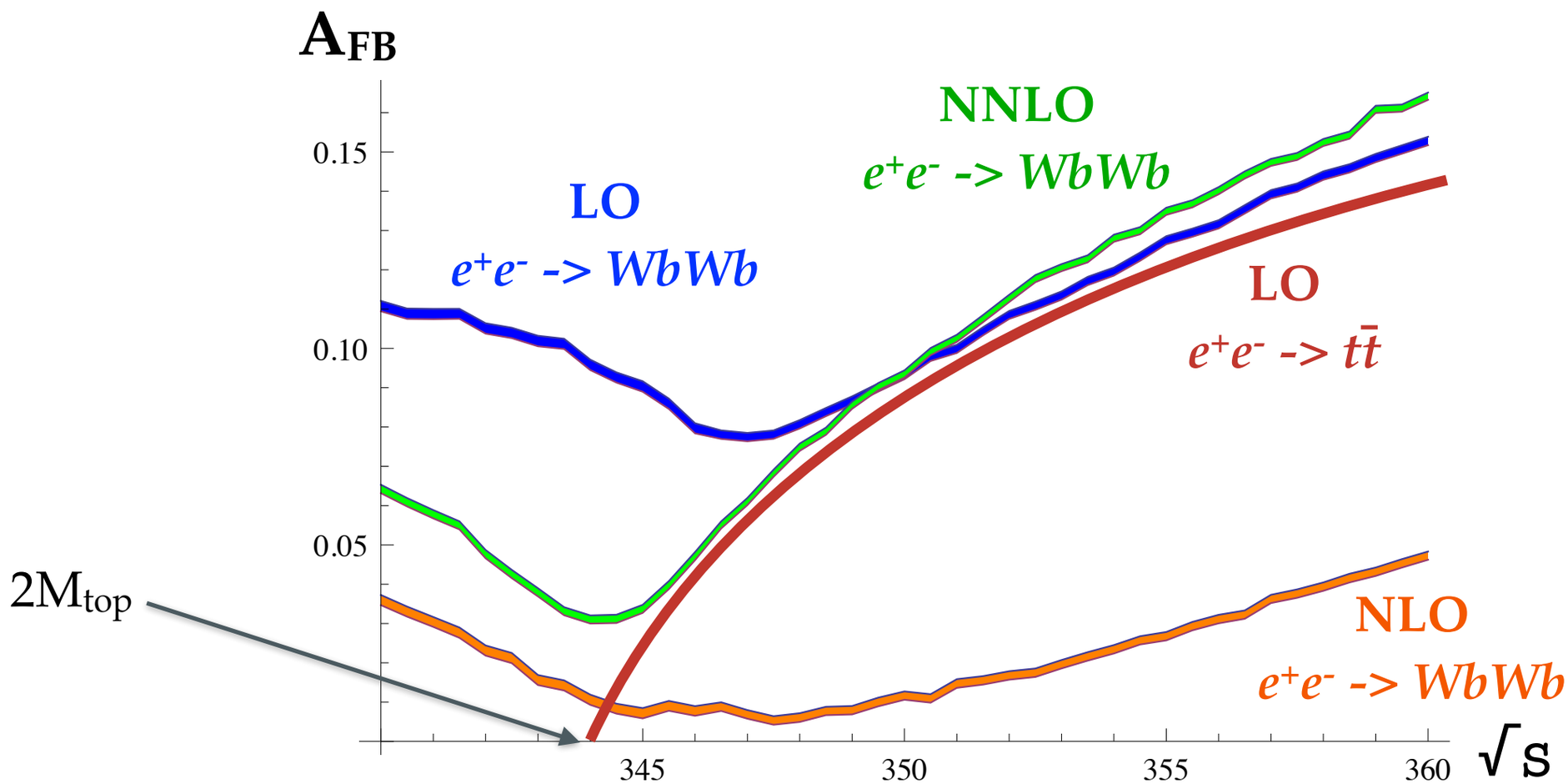


The presence of single top events modifies significantly the cross-section in the threshold region

Analysis of top forward-backward asymmetry at threshold

- **WHIZARD M1S$_{top}$ = 172 GeV**

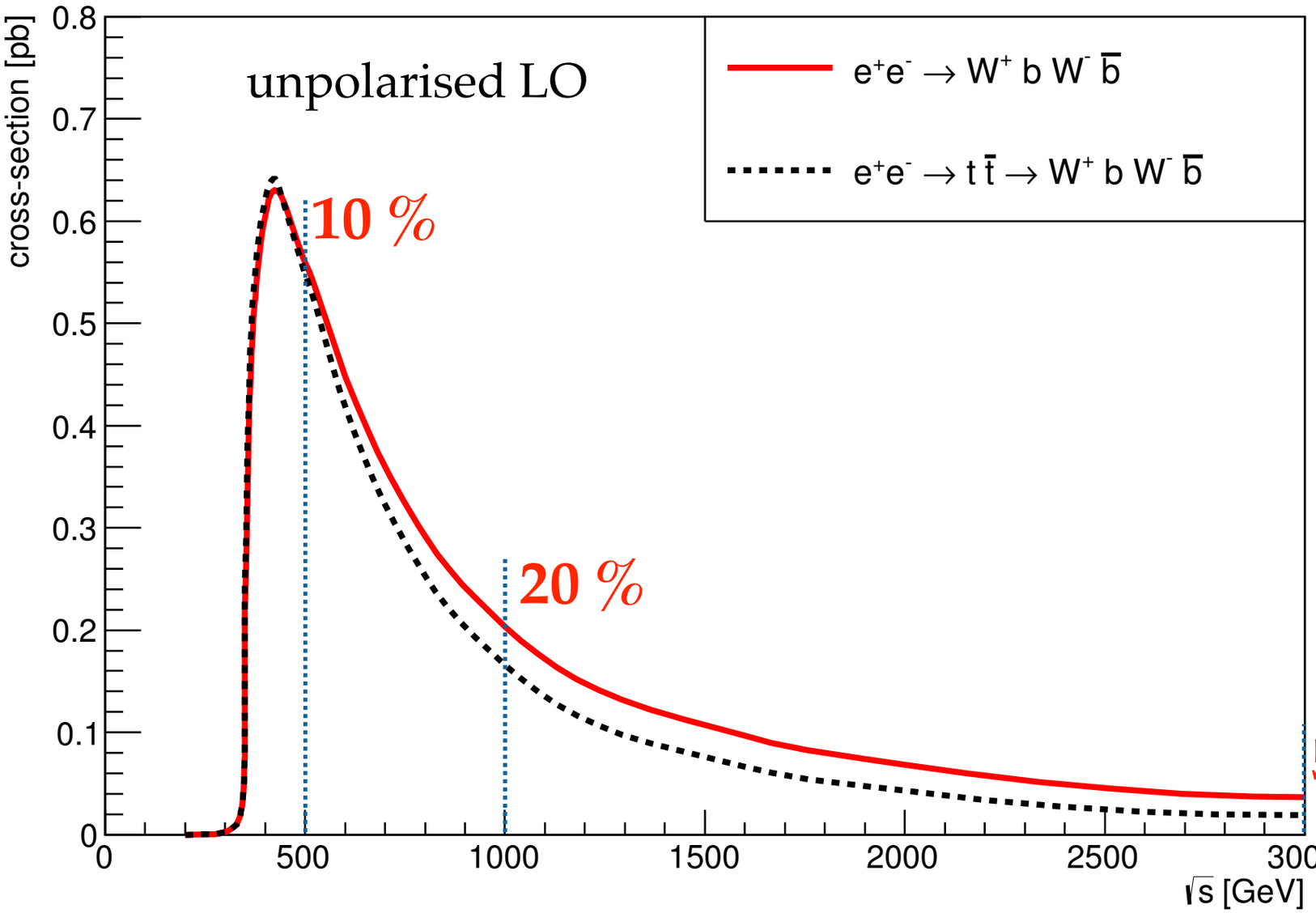
Thanks to Fabian Bach



It has no sense to calculate $e^+e^- \to tt$ to higher orders

Energy dependence

- The composition of $W^+bW^-\bar{b}$ is energy dependent



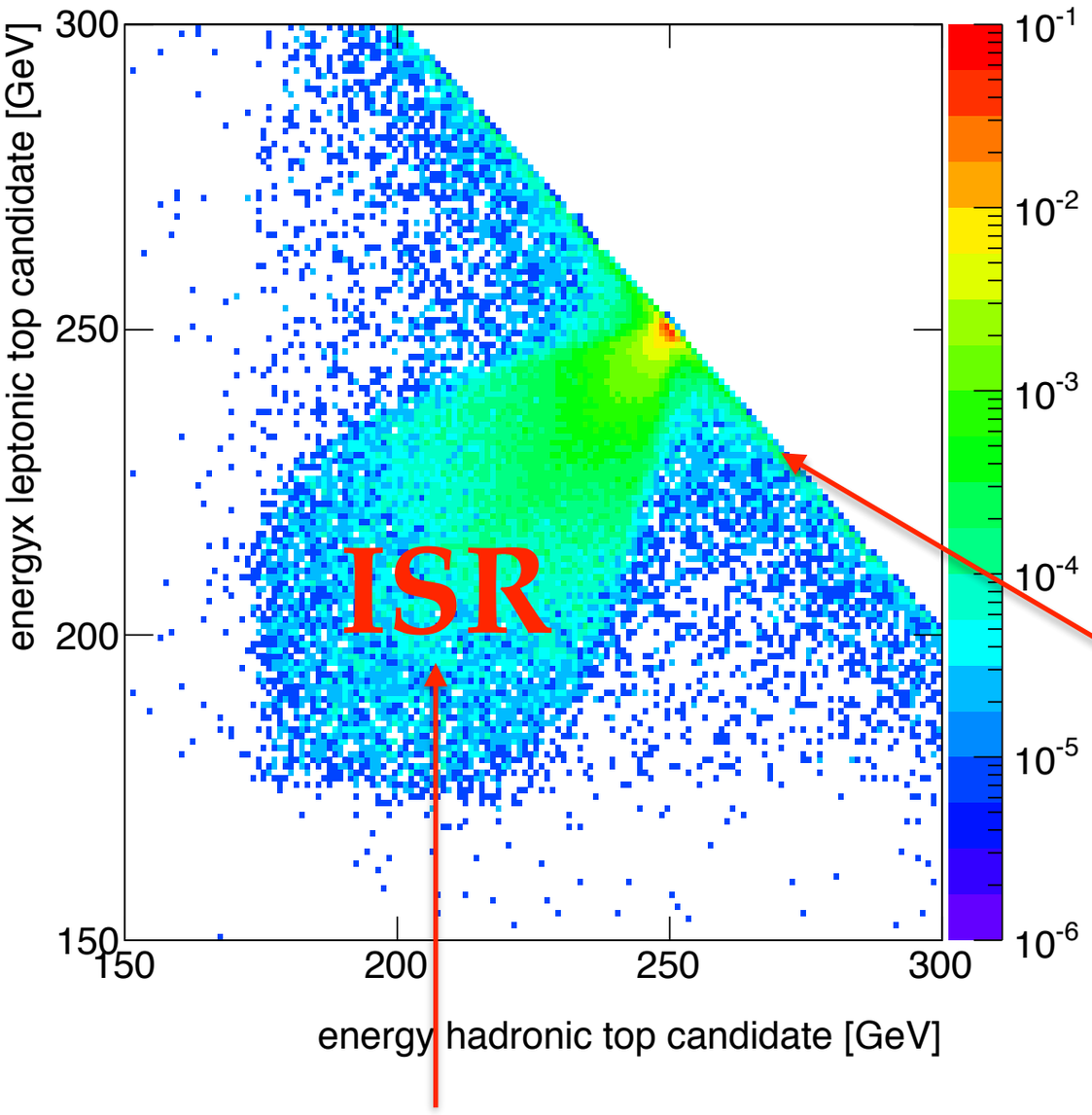
The rate for the e^+e^- -> tt drops at very large centre-of-mass energy, single top and non-top increase rapidly.

Conclusions

- **Single top is very important in e^+e^- —> $t\bar{t}$ analysis**
- **Single top events cannot be separated form $t\bar{t}$ final states**
- **We recommend calculate e^+e^- -> $WbWb$ to high orders (NLO, NNLO, etc…) instead of e^+e^- -> $t\bar{t}$**

THANK YOU FOR YOUR ATENTION

Distinguishing single top from $t\bar{t}$ production



$E_{lep}+E_{had}+E_{ISR}=\sqrt{s}$

- We also generated $e^+e^- \rightarrow W^+bW^-\bar{b}$ events with **WHIZARD** at √s = 500 GeV including ISR
- Only **semi-leptonic decays** are selected
- Significant fraction of events in the diagonal —> **Mostly single top events**

$E_{lep}+E_{had}=\sqrt{s}$

Potential criterium for the partial separation of single and double-top events