

# Search for Supersymmetry in Events with Two Leptons Including a Tau

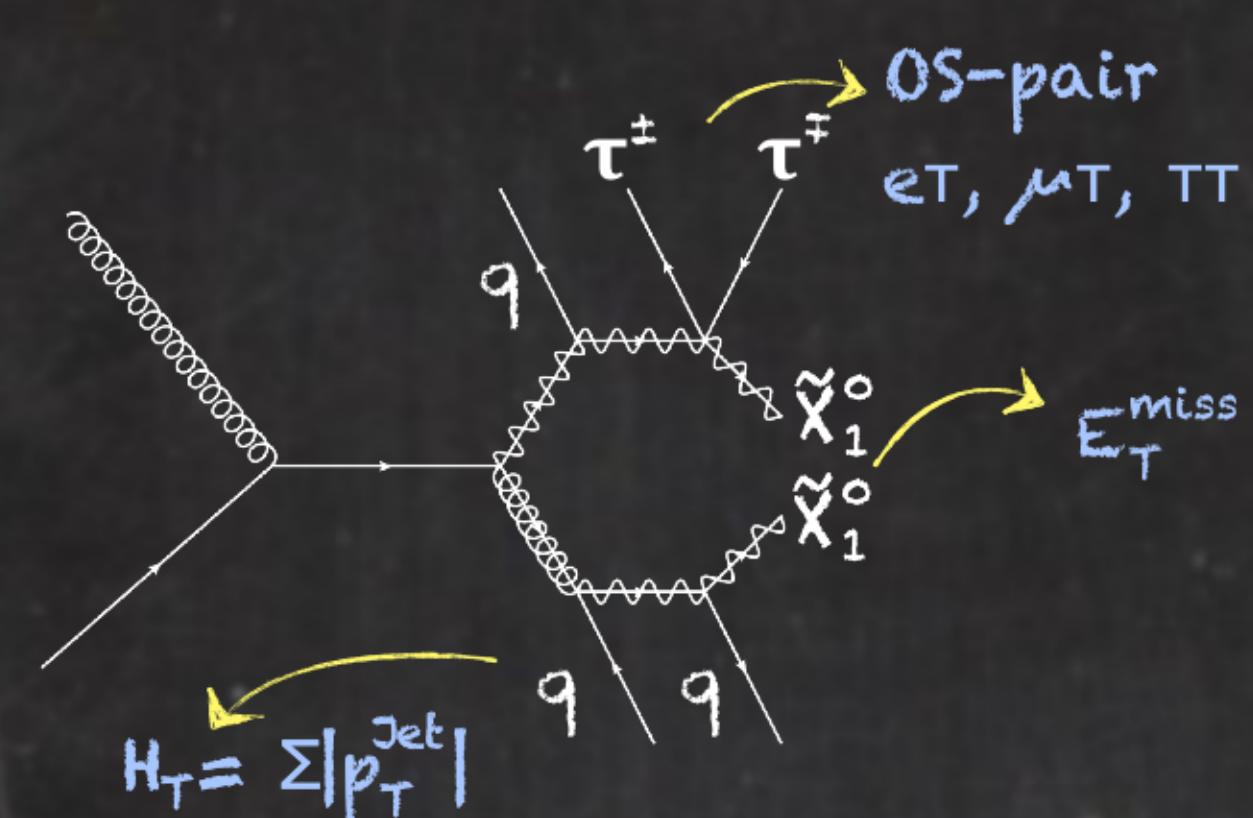
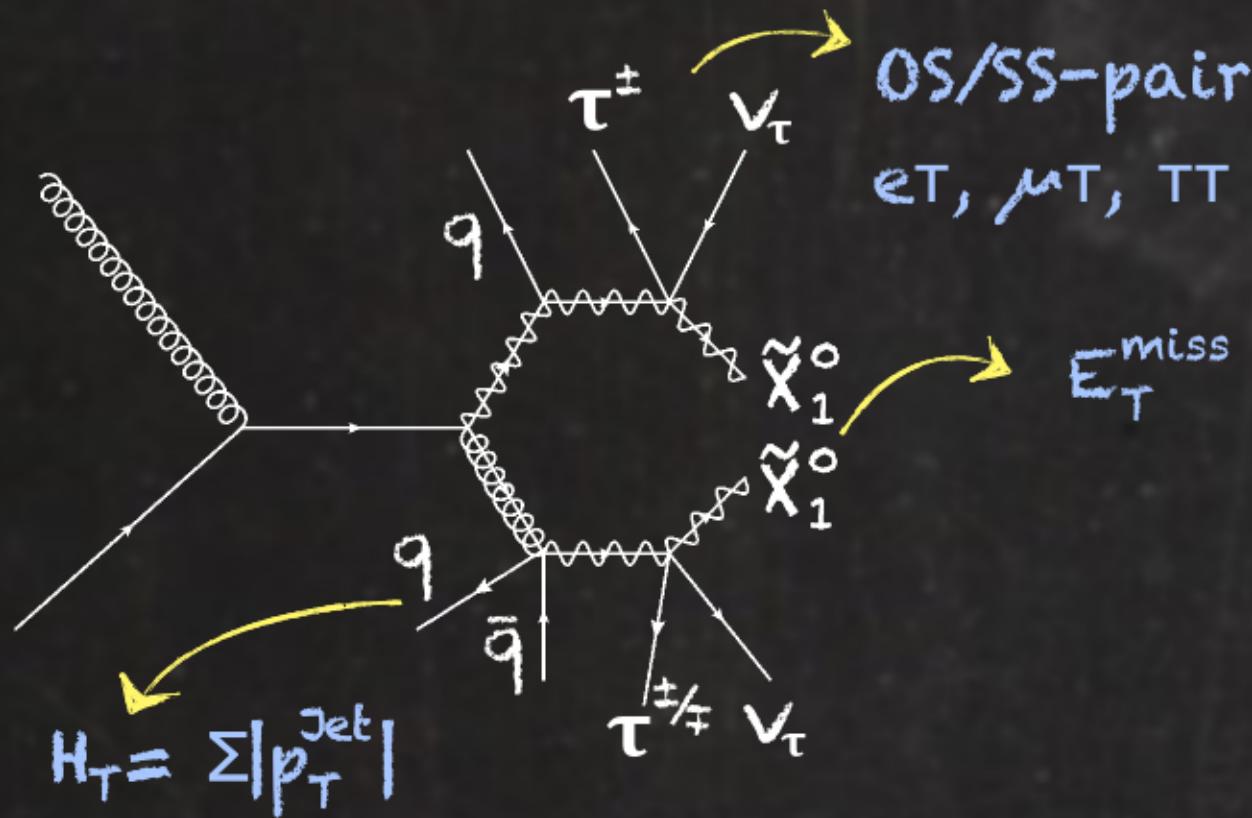


Matthias Edelhoff on behalf of the CMS Collaboration

## Introduction

### Scope

- Recent CMS results from BSM searches performed in events with two leptons in the final states, in particular combinations  $\text{ET}$ ,  $\text{MT}$  and  $\text{TT}$ .
- Data taken in 2011 corresponds to about  $L_{\text{int}} = 1 \text{ fb}^{-1}$ .



### Signature

- BSM models, especially SUSY, including the CMSSM, predict significant cross-sections containing leptons.
- SM QCD interactions are strongly suppressed for isolated lepton signatures.
- Astronomical measurements favor models including a heavy, weakly interacting particle (e.g. via R-Parity) escaping detection  $\Rightarrow$  Large  $E_T^{\text{miss}}$
- In  $p$ - $p$  collisions BSM cross-sections are dominated by the production via colored particles.  $\Rightarrow$  multiple high energetic jets

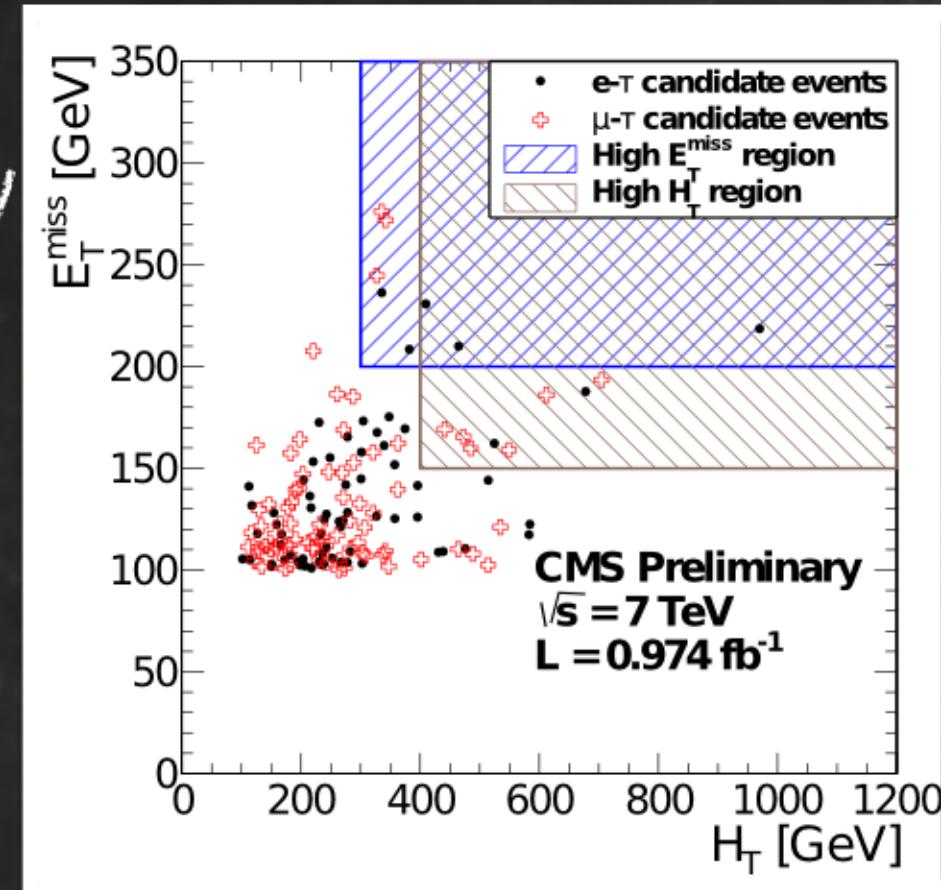
## Opposite Sign

### Selection ( $\text{ET}, \text{MT}$ )

Trigger: Based on two leptons

High  $H_T$  ( $E_T^{\text{miss}}$ ):  $H_T^{\text{miss}} > 400$  (300) GeV ( $p_T^{\text{jet}} > 30$  GeV)  
 $E_T^{\text{miss}} > 150$  (200) GeV  
 $n_{\text{jet}} \geq 2$

OS Leptons:  $p_T^{\text{lept}} > 20$  GeV  
 $|p_T^{\text{lept}}| < 2.1$   
 $e, \mu$  rel. iso.  
HPS loose iso.



### Selection ( $\text{TT}$ )

Trigger: Based on  $H_T^{\text{miss}}$

Event:  $n_{\text{jet}} \geq 2$  ( $p_T^{\text{jet}} > 100$  GeV)  
 $H_T^{\text{miss}} = -\sum p_T^{\text{jet}} > 200$  GeV

OS Leptons:  $p_T^{\text{lept}} > 15$  GeV,  $|p_T^{\text{lept}}| < 2.1$   
HPS very loose isolation

### SM - Backgrounds ( $\text{ET}, \text{MT}$ )

- After analysis cuts top pair production is the only relevant background process
- Estimated from data using  $p_T(\text{LL})$ -Method (see box "Top Pairs")

- Other contributions are neglected

### Backgrounds Due to Misidentification ( $\text{ET}, \text{MT}$ )

- Quark or gluon jet misidentified as hadronic tau decay.
- Estimated from data using "tight-to-loose-ratio" (see box "Fakes")

### Fully Hadronic Backgrounds ( $\text{TT}$ )

- Quark or gluon jet misidentified as hadronic tau decay.
- Top pair decays with two hadronically decaying  $\tau$
- Estimated from data using sidebands:
- Relax  $\tau$  isolation and select sideband where background dominates
- Extrapolate to signal region using simulation and "tight-to-loose-ratio"

CMS Physics Analysis Summary [SUS-11-007]

## Summary

OS		High $H_T$		High $E_T^{\text{miss}}$	
$\text{ET}, \text{MT}$					
Top Pairs		$7.2 \pm 1.6 \text{ stat.} \pm 2.7 \text{ syst.}$		$5.9 \pm 1.5 \text{ stat.} \pm 1.9 \text{ syst.}$	
Mis-ID		$2.9 \pm 0.7 \text{ stat.} \pm 0.4 \text{ syst.}$		$1.6 \pm 0.6 \text{ stat.} \pm 0.2 \text{ syst.}$	
Total Observed		$10.1 \pm 1.7 \text{ stat.} \pm 2.7 \text{ syst.}$		$7.5 \pm 1.6 \text{ stat.} \pm 1.9 \text{ syst.}$	
		11		8	

OS		Predicted/ Observed	
$\text{TT}$		$\text{ET}$	$\text{MT}$
QCD		$0.58 \pm 0.02 \text{ stat.} \pm 0.41 \text{ syst.}$	
W+Jets		$0.00 \pm 1.20 \text{ stat.} \pm 0.10 \text{ syst.}$	
Top Pairs		$2.18 \pm 2.18 \text{ stat.} \pm 0.35 \text{ syst.}$	
Z $\nu\nu + \text{Jets}$		$0.00 \pm 0.16 \text{ stat.} \pm 0.02 \text{ syst.}$	
Total Observed		$2.76 \pm 2.50 \text{ stat.} \pm 0.55 \text{ syst.}$	
		3	

### Limits and Interpretations

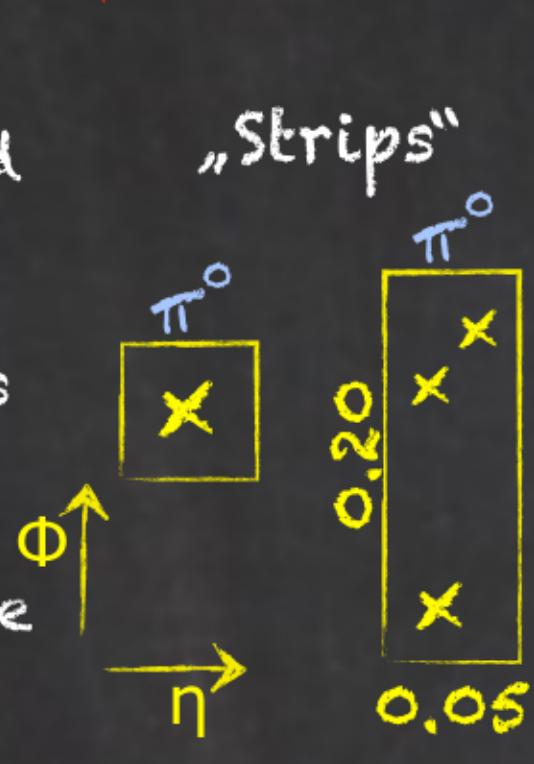
- No evidence for signal observed, 95% CL UL for signal set using  $\text{CL}_s$
- For OS, an upper limit for signal cross-sections in CMSSM benchmark-points is set:

$(m_0, m_{1/2}, A_0, \tan\beta)$	LM1	LM2	LM13
$O_{\text{model}}^{\text{NLO}}$	(60, 250, 0, 10)	(185, 350, 0, 35)	(270, 218, -553, 40)
	6.6	0.8	9.8
High $H_T^{\text{miss}}$ (meas., exp.)	(2.9, 2.5 $\pm$ 1.5)	(0.7, 0.6 $\pm$ 0.3)	(1.5, 1.2 $\pm$ 1.0)
High $E_T^{\text{miss}}$ (meas., exp.)	(2.8, 2.4 $\pm$ 1.4)	(0.6, 0.6 $\pm$ 0.3)	(1.5, 1.2 $\pm$ 1.0)

\* For SS an upper limit for signal yields is set at 5.8

## Tau- $\bar{\tau}$ ID

### Decay - Modes



### Hadrons Plus Strips (HPS)

- Combine information from all sub-detectors to build particle candidates (Particle Flow)
- Cluster particles to jets using AK.5 clustering algorithm
- Reconstruct neutral pions as "Strips"
- Combines charged and neutral pions to tau candidates for different decay modes
- Define degree of isolation in working points (here: very loose and loose)

## Same Sign

### Selection

Trigger: Based on  $H_T$ ,  $H_T^{\text{miss}} = -\sum p_T^{\text{jet}}$

and two leptons ( $\text{ET}$ ,  $\text{MT}$ , or  $\text{TT}$ )  
Event:  $H_T > 350$  GeV,  $n_{\text{jet}} \geq 2$  ( $p_T^{\text{jet}} > 40$  GeV)  
 $E_T^{\text{miss}} > 80$  GeV

SS Leptons:  $p_T^e > 10$  GeV,  $p_T^\mu > 5$  GeV,  $p_T^{\tau} > 15$  GeV  
 $|p_T^e|, |p_T^\mu| < 2.4$   
rel. isolation for  $e, \mu$   
HPS loose isolation

### Selection ( $\text{TT}$ )

Trigger: Based on  $H_T^{\text{miss}}$

Event:  $n_{\text{jet}} \geq 2$  ( $p_T^{\text{jet}} > 100$  GeV)  
 $H_T^{\text{miss}} = -\sum p_T^{\text{jet}} > 200$  GeV

OS Leptons:  $p_T^{\text{lept}} > 15$  GeV,  $|p_T^{\text{lept}}| < 2.1$   
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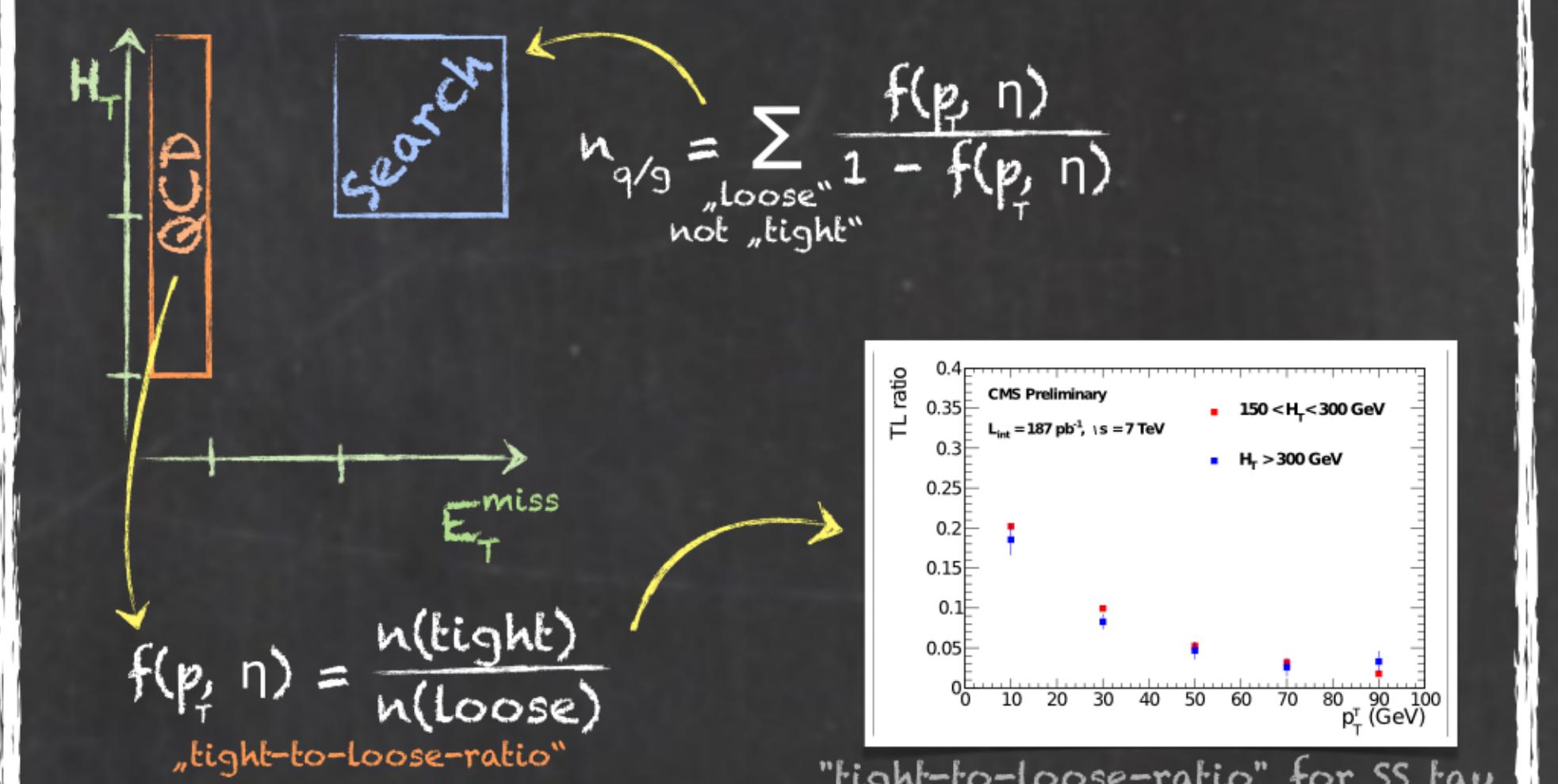
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### Fakes

### OS & SS

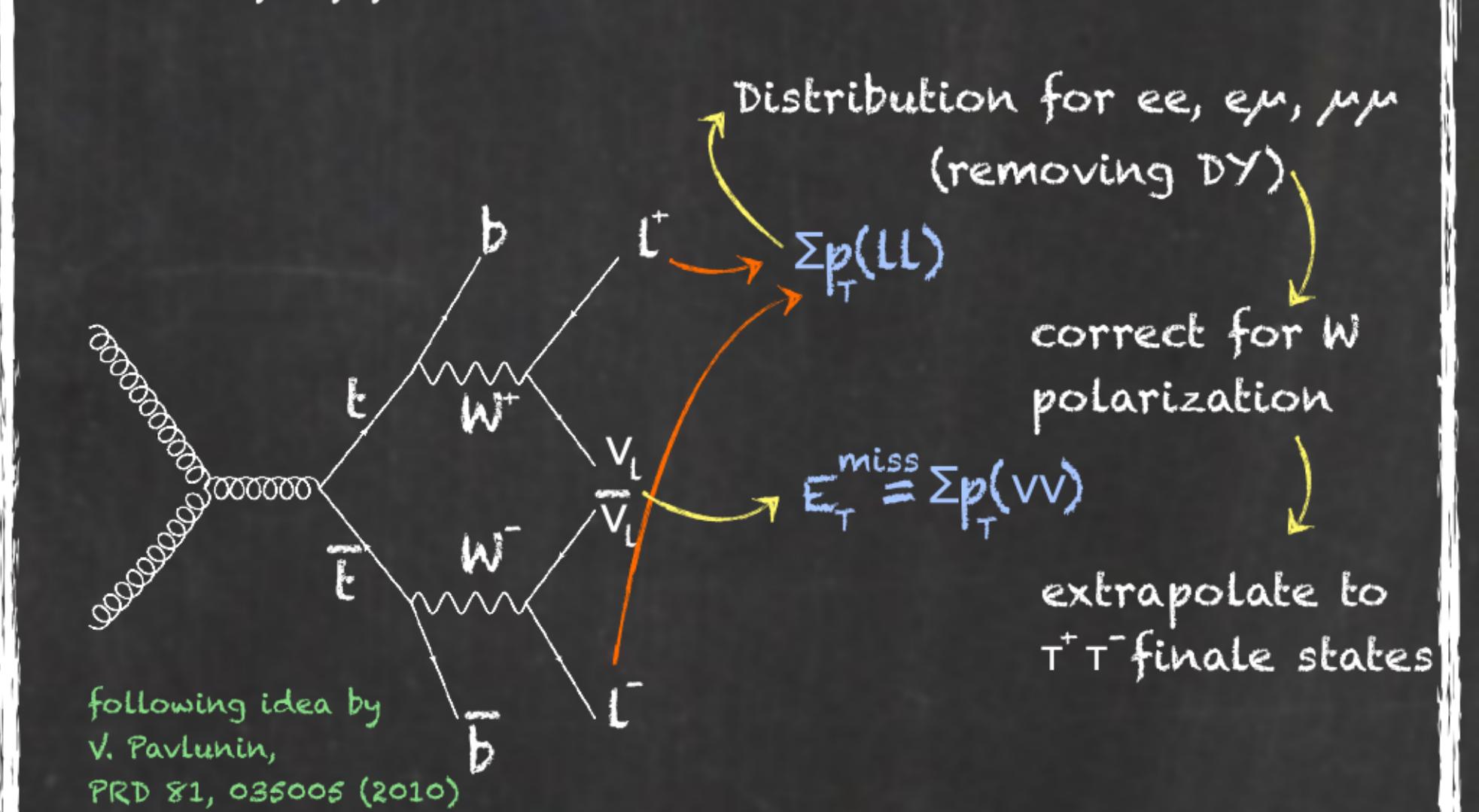
- Measure probability for tau candidate to pass both the loose and tight isolation requirements on an independent multijet sample
- Apply ratio on loose candidates in the signal region



## Top Pairs

### OS

- $E_T^{\text{miss}}$  in dileptonic  $t\bar{t}$  decays originates in two neutrinos.
- Use well understood  $W^\pm$ -polarisation to model  $E_T^{\text{miss}}$  with  $p_T$  of the charged leptons
- Extrapolated from light lepton channels  $ee, e\mu, \mu\mu$  to tau channels



## Charge mis - ID

### SS

- $Z \rightarrow \tau\tau \rightarrow \mu\tau$  Selection
- Invariant mass of  $\mu\tau$  pairs (does not include undetected neutrinos)
- Opposite sign (left) and same-sign (bottom) combinations are

