Search for top FCNC in single top

Overview of IPHC analyses

Introduction

- Single top FCNC channel investigated so far :
  - tZq anomalous couplings : **3 leptonic channel**,
  - tHq anomalous couplings : single lepton-bb, **same sign dileptons**, 3 leptonic and >=4 leptons channels.
  - tgammaq : **single lepton channel.**
  - tgluonq : **single lepton channel**, in the caroTop mode (pp->t).

- Tools for automatic cross-section calculation, optimization, plotting and MVA training ready and used.

- All sample are ready with a decent statistic (sometime more events needed).
- (Almost) All ingredients needed for the analyses ready.

Search for caroTop

Caro

Selection

Based on ATLAS paper and then optimized (*), my **selection** is :

- = 1 lepton pT>30 GeV (no other lepton pT>20),
  but the optimization recommends pT>45 GeV*

- ≥ 1 jets* with pT(j1)>35 GeV*, other jets with pT>20 GeV*,
  all with |η|<2.4

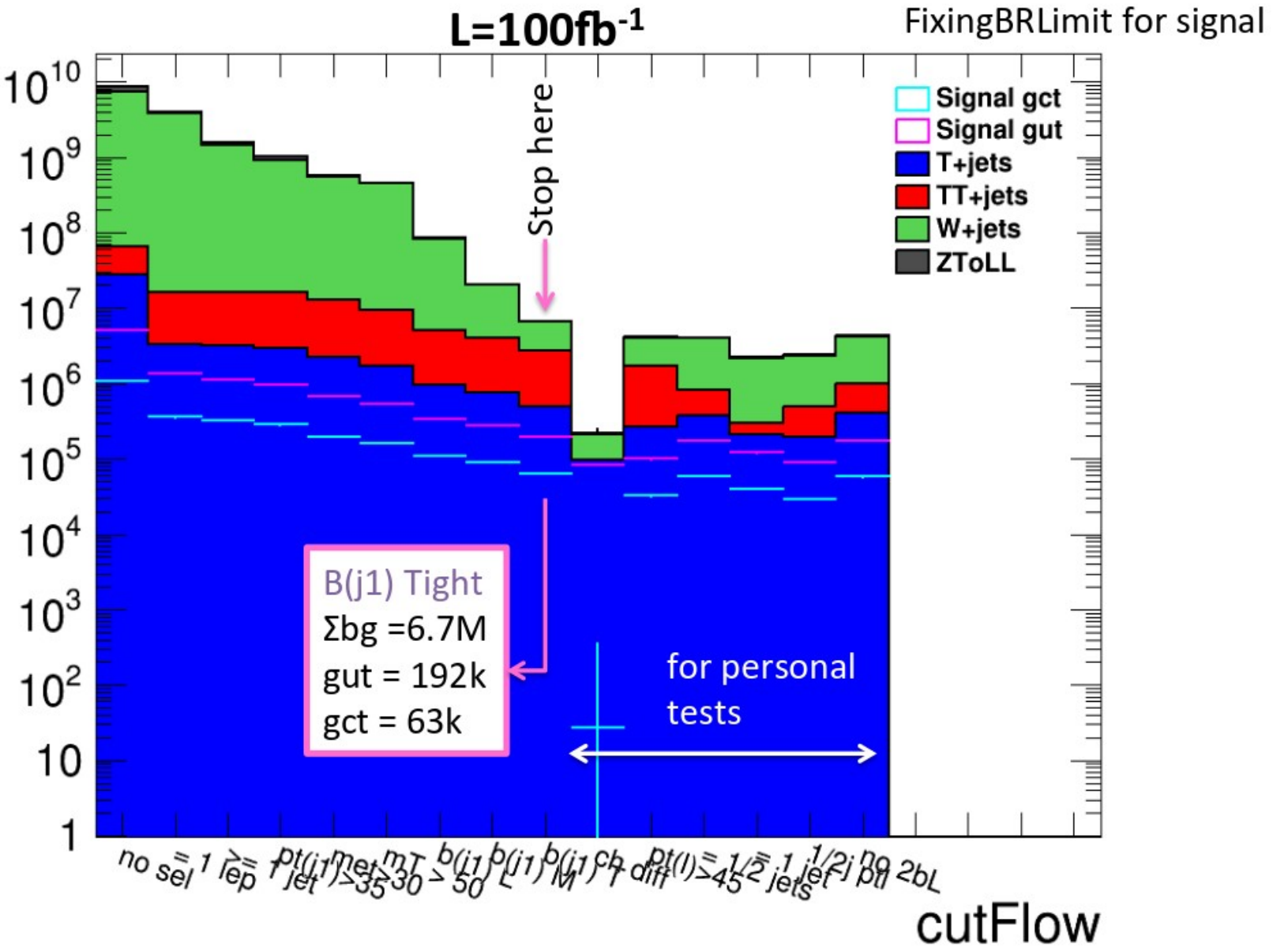
- MET>30 & M_T(W)>50 GeV from ATLAS paper, optimization recommends no cut but better to keep for multijet suppression.

- b-tagging : Tight* criteria for j1.

→ Selection more or less finalized

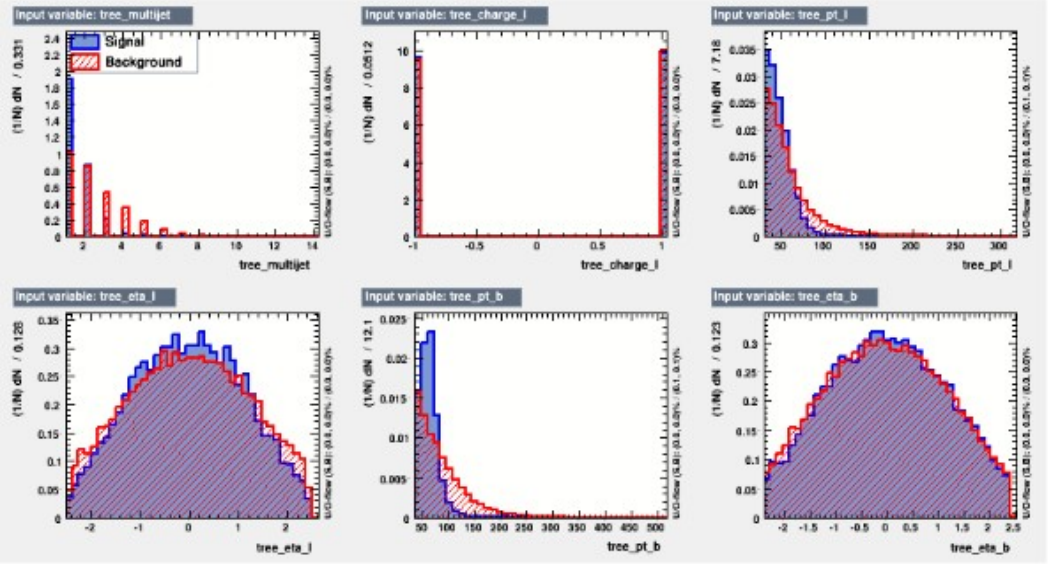
remark: ____ means different with respect to previous cuts

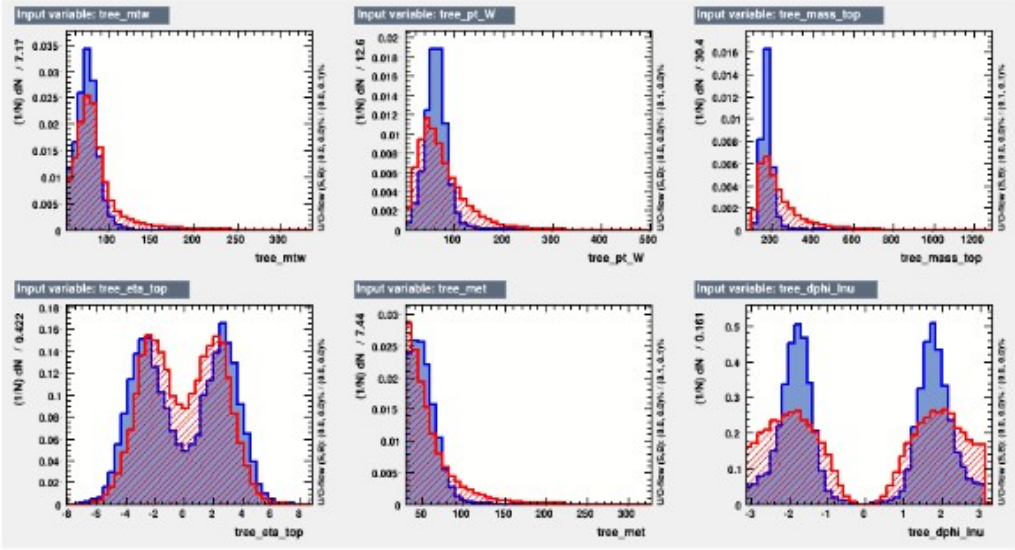
CutFlow

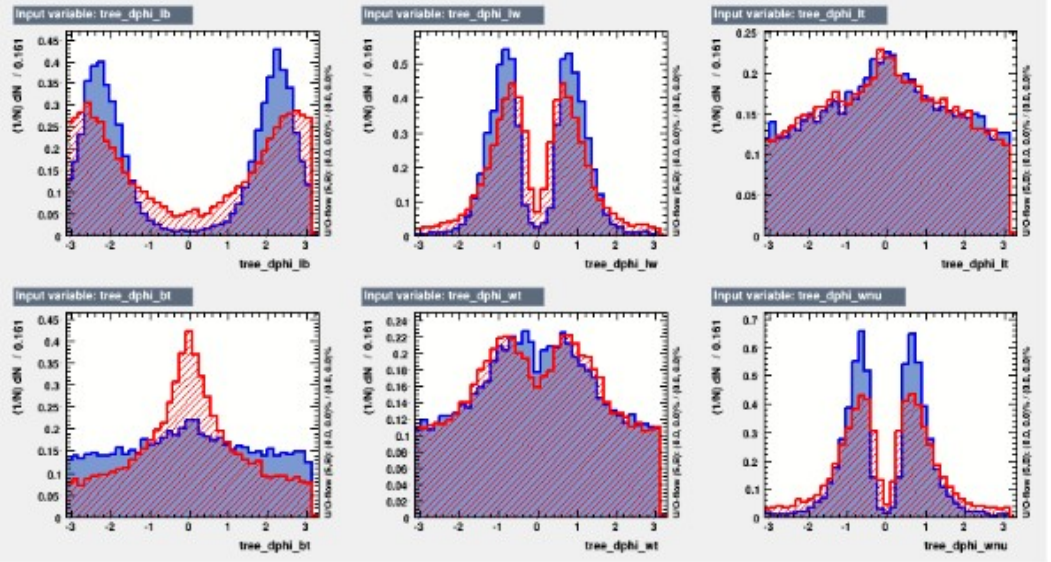

L=100fb-1
FixingBRLimit for signal
Signal gct
Signal gut
T+jets
TT+jets
W+jets
ZToLL
Stop here
B(j1) Tight
Σbg =6.7M
gut = 192k
gct = 63k
for personal tests
cutFlow

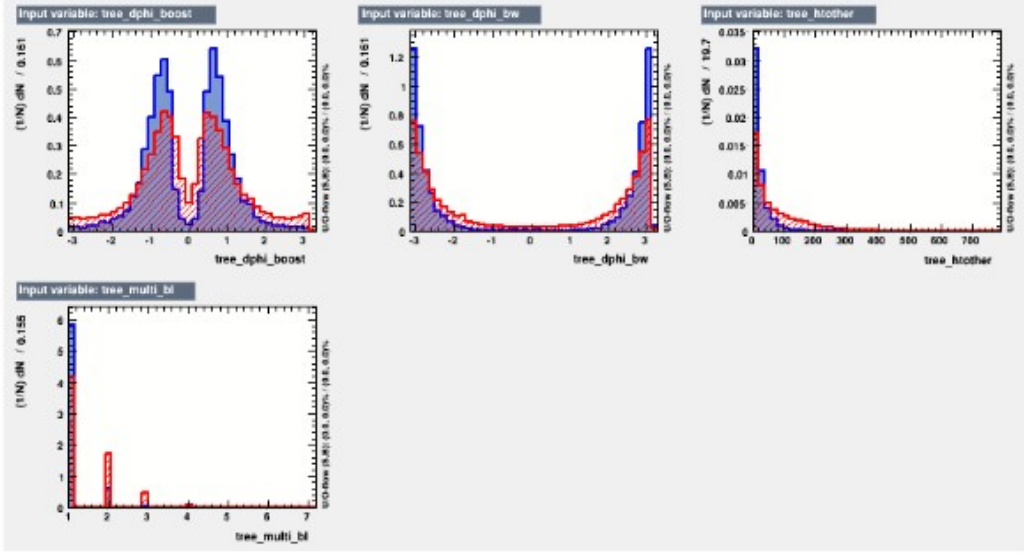
Study all the variables I think about

Plotted with signal = gct



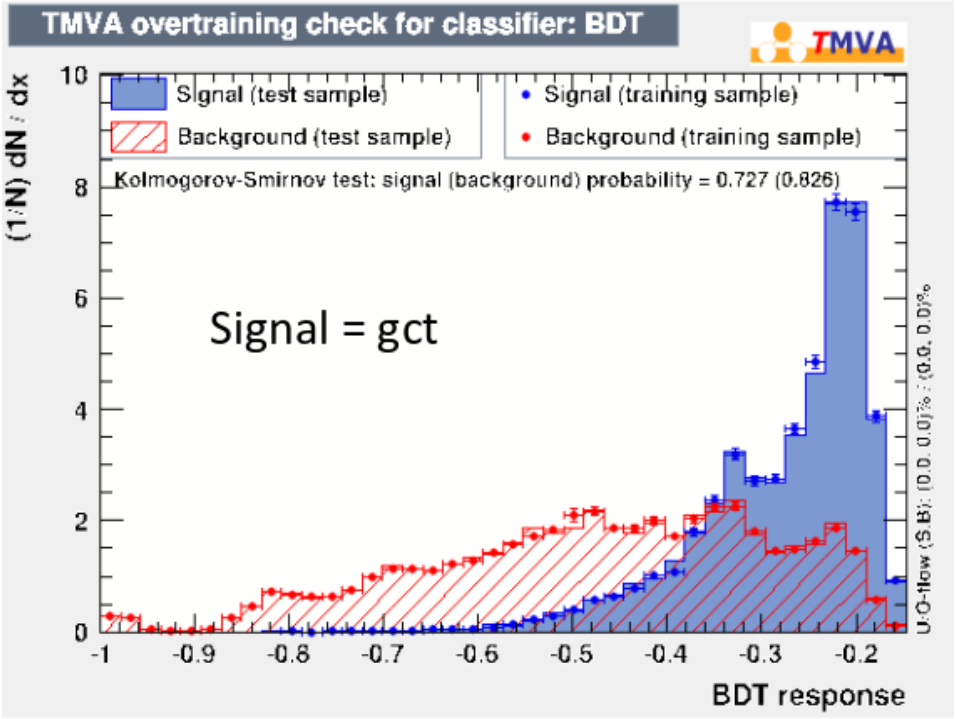


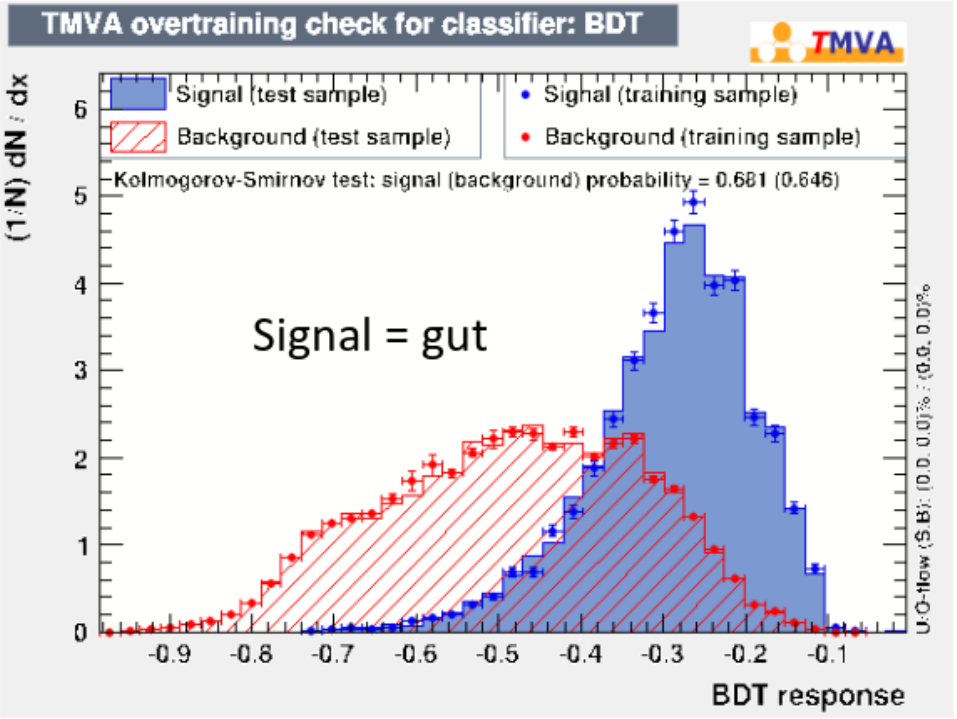




Restricted variable list

Aim: decrease the number of variables, and avoid strong correlations





Varlist = η(l), M(top), MT(W),
Δϕ(l,ν), Δϕ(b,W), Σp_T(j) (2->n),
#b(Loose)

Varlist = η(b), Q(l), M(top), M_T(W),
Δϕ(l,ν), Δϕ(b,W),Σp_T(j) (2->n),
#b(Loose)

Good results with a reasonable number of variable (7 for gct and 8 for gut)

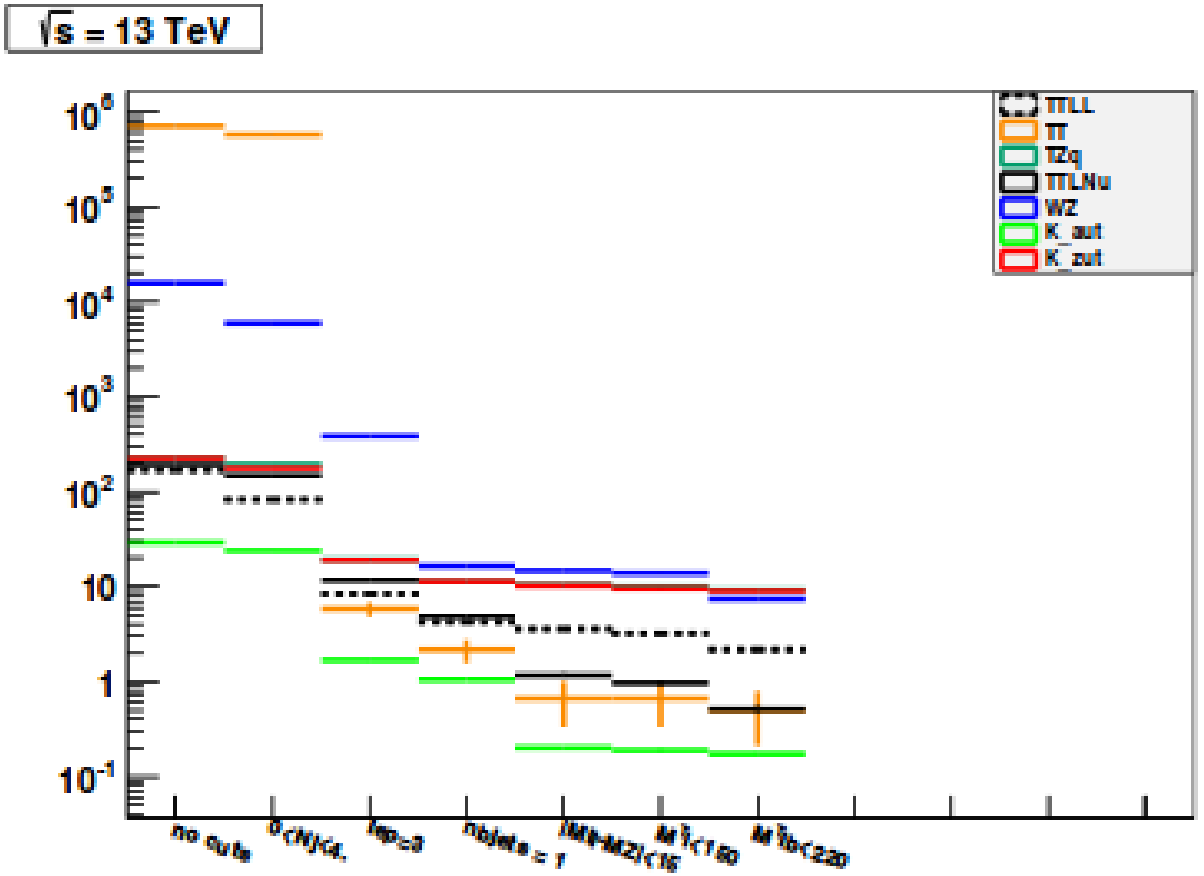
Search for tZ in 3 leptons

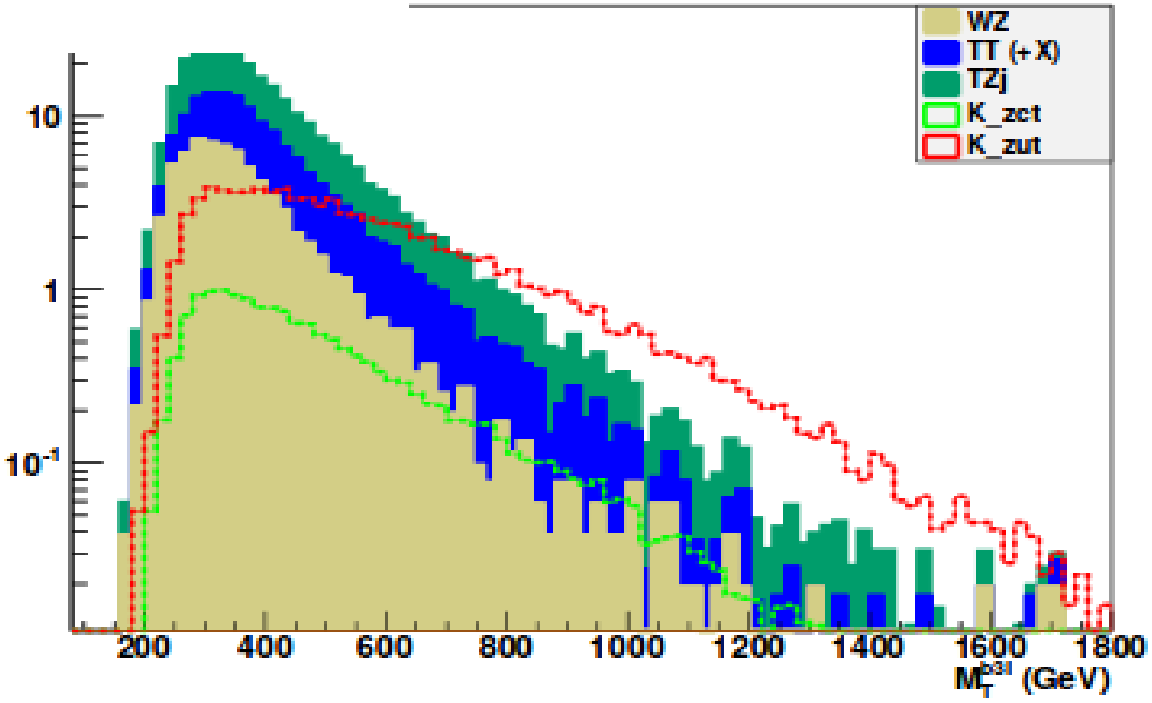
$TZ \to 3\ell$ @ $\mathcal{L} = 100$ fb^{-1}

Lorenzo

$K_{tZu} \simeq 2 \cdot 10^{-4}$ (the best limit)

- $p_\ell^T > 20$ GeV, $p_j^T > 40$ GeV, CVSM b-tagging
- isolation: CONE03 with threshold $= 0.1$ (kills $t\bar{t}$ and DY)
- $N_b \equiv 1$, $1 \leq N_J \leq 3$ ($J =$ light and b jets)
- Z candidate as pair of $e^+e^-(\mu^+\mu^-)$ closest to M_Z
- W and top mass reconstructed with tansverse mass (sharper)
- Cuts optimised with Kevin's macro
  - $|M_{\ell^+\ell^-} - 91| < 15$ GeV
  - $10 < M_{\ell_3}^T < 150$
  - $M_{b\ell_3}^T < 220$
- Attempt to use TMVA (BDT)


√s = 13 TeV
TTLL
TT
TZq
TTLNu
WZ
K_aut
K_zut
no cuts
0<Nj<4,
lep=3
nbjets = 1
|Mll-MZ|<15
M3l<180
M3lb<220


WZ
TT (+X)
TZj
K_zct
K_zut
200
400
600
800
1000
1200
1400
1600
1800
M_T^3l (GeV)

MVA: BDT Variables

Variables for training:

- $M^T(b\,3\ell)$
- $p^T(\ell_1+\ell_2)/M^T(b\,3\ell)$
- $\Delta\varphi(\ell_1,\,\ell_2)$
- $\Delta\varphi(t,\,Z)$
- $\Delta R(b,\,\ell_W)$
- $p^T_{J_1}/M^T(b\,3\ell)$
- $\Delta\varphi(Z,\,\not{p}^T)$
- $\Delta\eta(Z,\,\ell_W)$
- $\Delta\eta(b,\,\ell_W)$
- $\Delta\eta(\ell_1,\,\ell_2)$
- $\Delta\varphi(Z,\,\ell_W)$
- $p^T_{\ell_1}/M^T(b\,3\ell)$
- η_Z
- η_{top}
- $\Delta\eta(t,\,Z)$
- $\Delta\varphi(b,\,\ell_W)$
- η_j^{max}

After suitable cut (M_{tZ} or BDT output) to maximise significance:

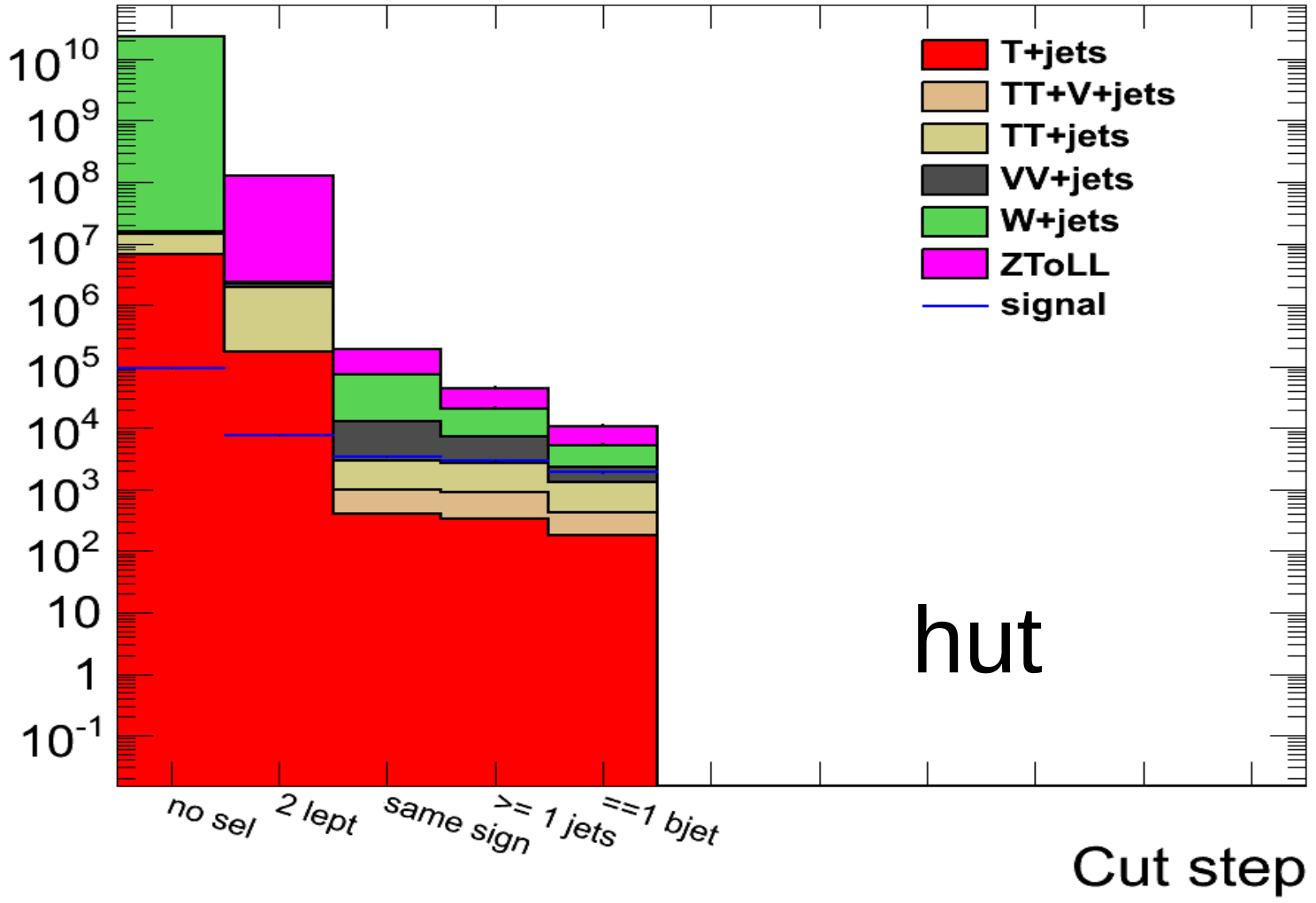
Analysis		K_{tZu}	K_{tZc}	$M_{T'}=0.8$ TeV	$M_{T'}=1.0$ TeV	$M_{T'}=1.2$ TeV
C&C	S (ev.)	67.9	15.7	17.6	12.3	7.10
	B (ev.)	122.6	287.0	10.4	5.74	2.04
	σ	4.9	0.9	3.33	2.90	2.35
MVA	σ	6.5	1.1	3.40	2.99	2.40

Search for tH in ssdl

Object and event selection

- Lepton selection :
  - pT > 10 GeV, |eta|<2.5,
  - Combined isolation (cone of 0.4) < 0.2 for both electrons and muons.
- Jet selection :
  - pT>30 GeV, |eta|<2.5, EEoverHE<0.3,
  - Remove selected leptons from the jet collection.
  - Btagging : loose WP.
- Charge mis-reconstruction of electrons 0.3 % in the endcap, 0.03 % in the barrel (from ttH CMS paper).
- Event selection :
  - Exactly 1 selected leptons,
  - Same signe leptons, leading lepton pT > 20 GeV, other lepton pT > 10 GeV, Mll>12.
- At last one selected jet.
- Exactly one b-tagged jet.

Cutflows
couplings at current limits



Search for tH in 4-5 leptons

Selection of 4 isolated leptons

Dataset	nevt for 100fb-1	rel. incert.
TTdilep_ZToLL_madspin	63.0726547241	1.13%
tHToZZ-Kappa-hct	49.5499572754	4.28%
tHToZZ-Kappa-gct	43.3671455383	4.58%
tHToZZ-Kappa-gut	31.8213348389	5.35%
tHToZZ-Kappa-hut	24.4570350647	6.10%
TTsemilep_ZToLL_madspin_2	9.49560928345	4.20%
TTsemilep_ZToLL_madspin_1	9.07546901703	4.30%
ZHToWW	5.71080827713	18.26%
ZHToZZ	1.60994207859	12.04%
HToZZ	1.22739052773	100.00%
WHToZZ	0.694424569607	25.00%
TTdilep_WWToLLNuNu_madspin	0.462979376316	1.54%
TTdilep_WZToLLLNu_madspin	0.162783518434	0.86%
TTsemilep_WZToLLLNu_madspin_1	0.113158412278	1.06%
TTsemilep_ZZToLLLL_madspin_2	0.0560129694641	0.86%
TTsemilep_ZZToLLLL_madspin_1	0.0549993366003	0.86%
TTdilep_ZZToLLLL_madspin	0.048358399421	0.64%
WZToLLLNu	0.0382276326418	70.71%
TTsemilep_WWToLLNuNu_madspin_2	0.0145742138848	12.50%
TTsemilep_WWToLLNuNu_madspin_1	0.0120702413842	13.74%

Selection of 5 isolated leptons

signal (xs = 1pb)

Dataset	nevt for 100fb-1	rel. incert.	nlep max
tHToZZ-Kappa-hct	4.1821	14.74%	5
tHToZZ-Kappa-gct	4.0912	14.91%	5
tHToZZ-Kappa-gut	3.0912	17.15%	5
tHToZZ-Kappa-hut	1.9092	21.82%	5
ZHToZZ	0.0466	70.71%	6
WHToZZ	0.0434	100.00%	5
TTdilep_WZToLLLNu_madspin	0.0273	2.10%	5
TTdilep_ZZToLLLL_madspin	0.0159	1.11%	6
TTsemilep_ZZToLLLL_madspin_1	0.0115	1.88%	5
TTsemilep_ZZToLLLL_madspin_2	0.0114	1.89%	5
TTdilep_ZToLL_madspin	0.0080	100.00%	4
TTdilep_WWToLLNuNu_madspin	0.0001	100.00%	4
TTsemilep_WZToLLLNu_madspin_1	2.5e-05	70.71%	4

xs with BR limit

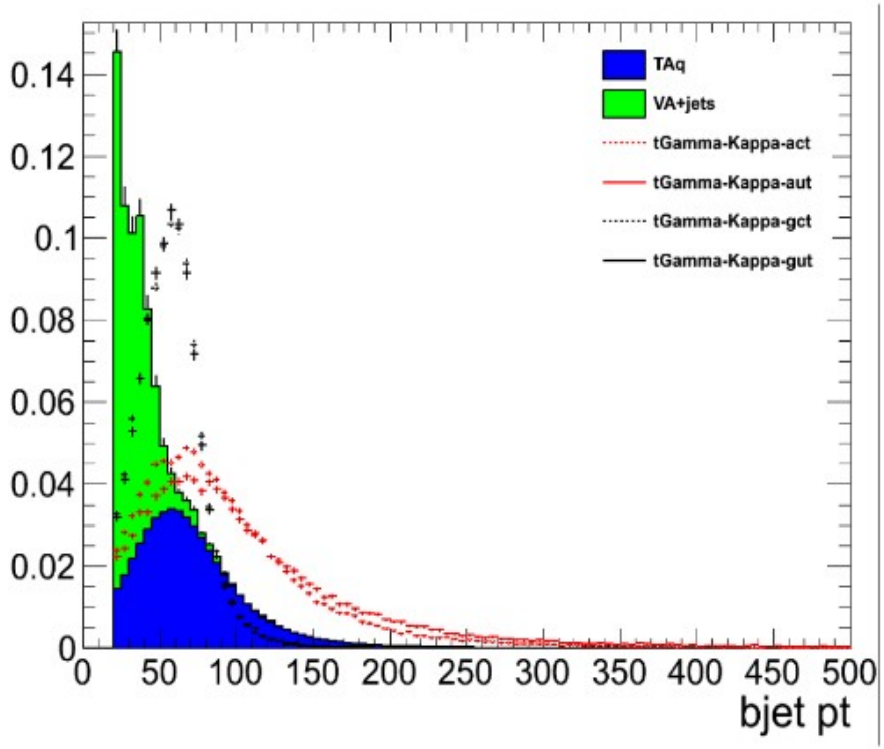
Signal	xs with BR limit [pb]	nevt for 100fb-1
tHToZZ-Kappa-hct	0.0145	0.0605
tHToZZ-Kappa-gct	0.00021	0.0009
tHToZZ-Kappa-gut	0.00165	0.0051
tHToZZ-Kappa-hut	0.1170	0.2232

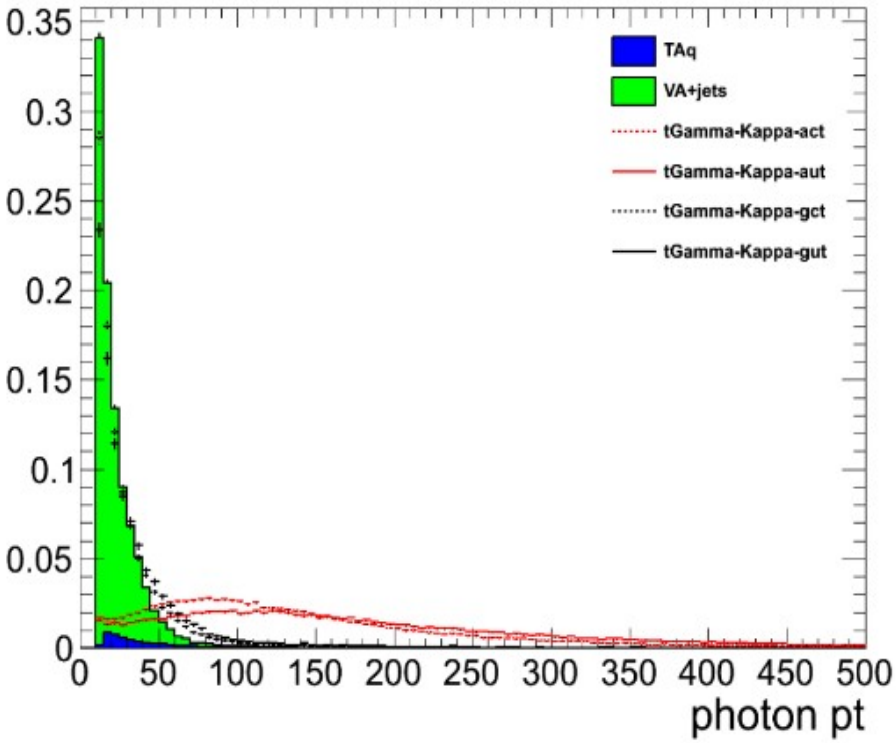
Search for tGamma

Object definition

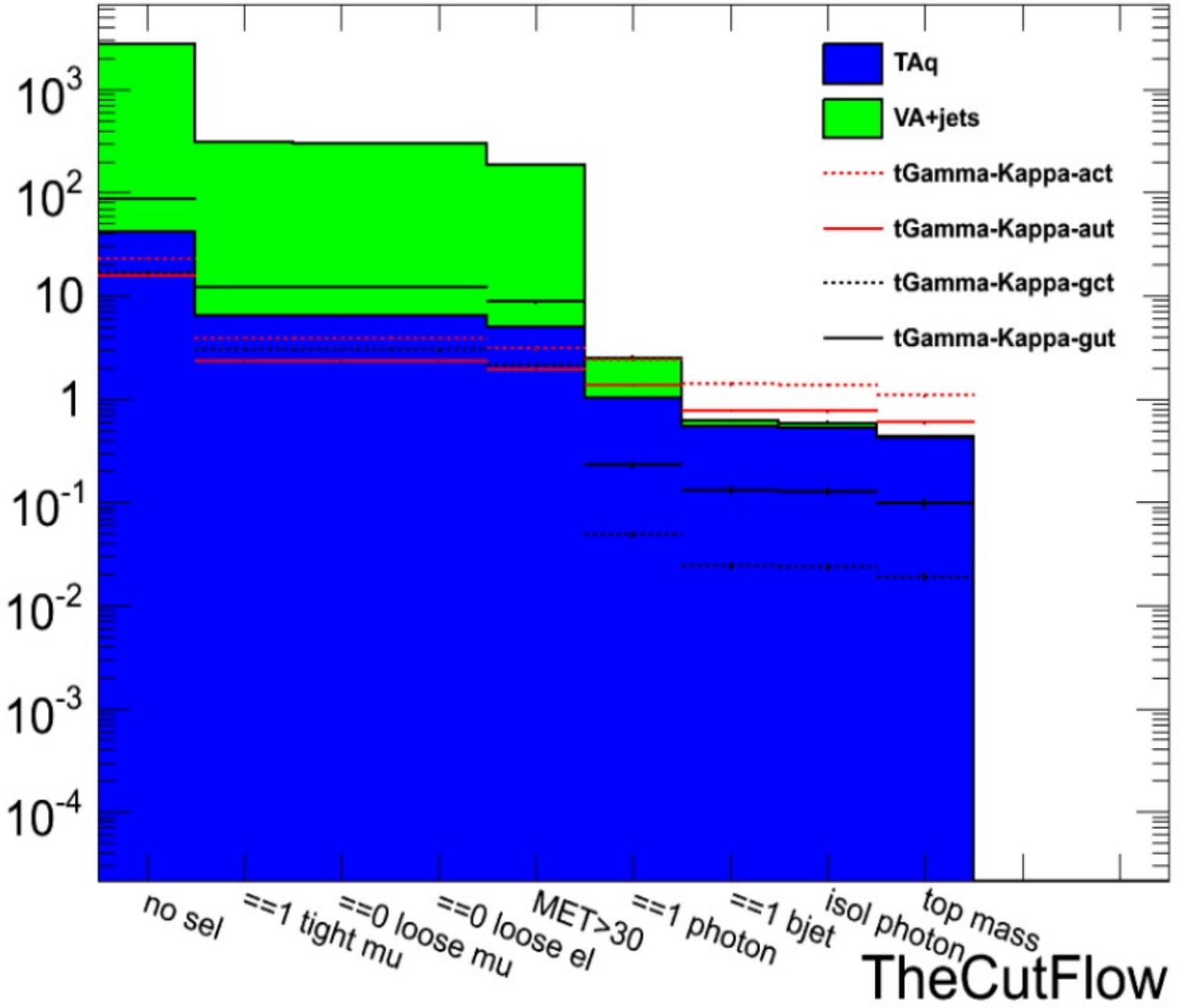
Eric

- **Tight muon**: pT > 26 GeV, eta < 2.1, Pflow relative isolation < 0.12 with DR=0.4
- **Loose muon**: pT > 10 GeV, eta < 2.1, relative isol < 0.2
- **Loose electron**: pT>20 GeV, eta < 2.5
- **Photon**: pT > 50 GeV , eta < 2.5 , Pflow isolation with DR=0.4
- **b-quark jet** : eta < 2.5 , pT > 30 GeV





Selection


TAq
VA+jets
tGamma-Kappa-act
tGamma-Kappa-aut
tGamma-Kappa-gct
tGamma-Kappa-gut
10^3
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
no sel
==1 tight mu
==0 loose mu
==0 loose el
MET>30
==1 photon
==1 bjet
isol photon
top mass
TheCutFlow

Conclusion and to do list

- Most advanced analyses
  - CaroTop almost finished, final MVA cut and contour plots.
  - tZ almost finished. MVA finalized, and contour plot implemented and tested.

- Analyses that requires some more work :
  - tH in same signe dilepton : same-sign background, lepton optimization, MVA construction, contour plots.
  - tgamma : some generation needed, check of delphes simulation for photons + finalize analysis.

- tH in >=4 leptons, not enough signal statistic ?
- tH in lepton bb, not started yet.

Other issues and timescales

- Single top FCNC production has to be redone :
  - With additional jets...
  - Overlap between single top and ttbar => not easy...
    - tZ+1jet contains ttbar, but also other diagrams => how to disentangle ?
    - Inclusive treatment single top + ttbar at the same time? much more easy.
  - Possible solution :
    - Do “single top+ttbar”, but account for a signal cross section uncertainty (30%),
    - Do ttbar only, less statistic but no (or very small) uncertainty on ttbar cross section. Potentially, ratio to ttbar cross section.

- Timescales :
  - We are expecting to finish all analyses within about a month.
  - We should be able to start writing a paper draft around Christmas.

- One or two papers ?