Limits on FCNC couplings in single top events
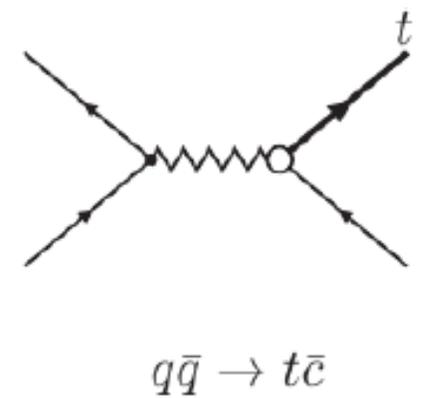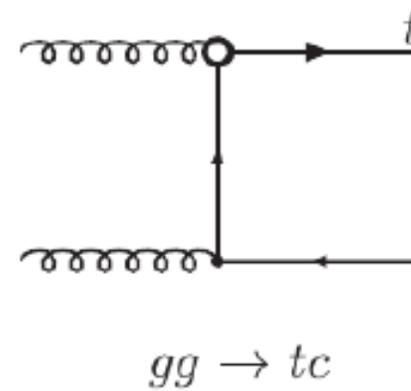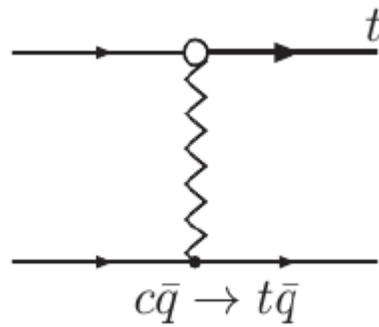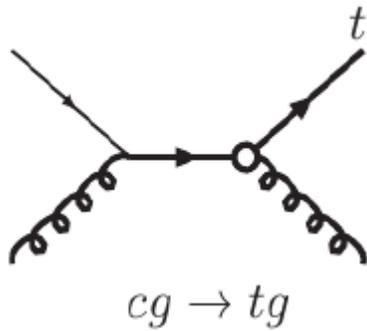
IGOR MYAGKOV

SINP MSU, ON BEHALF OF CMS COLLABORATION

FCNC vertex in single top: *tug & tcg*

Wbj channel (representative diagrams):

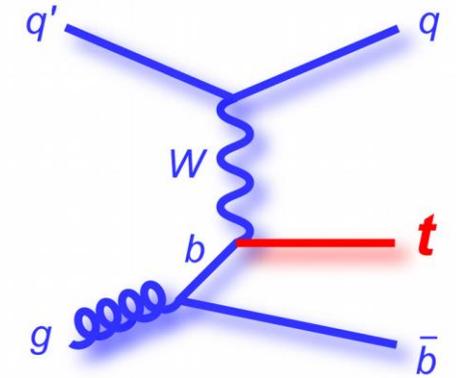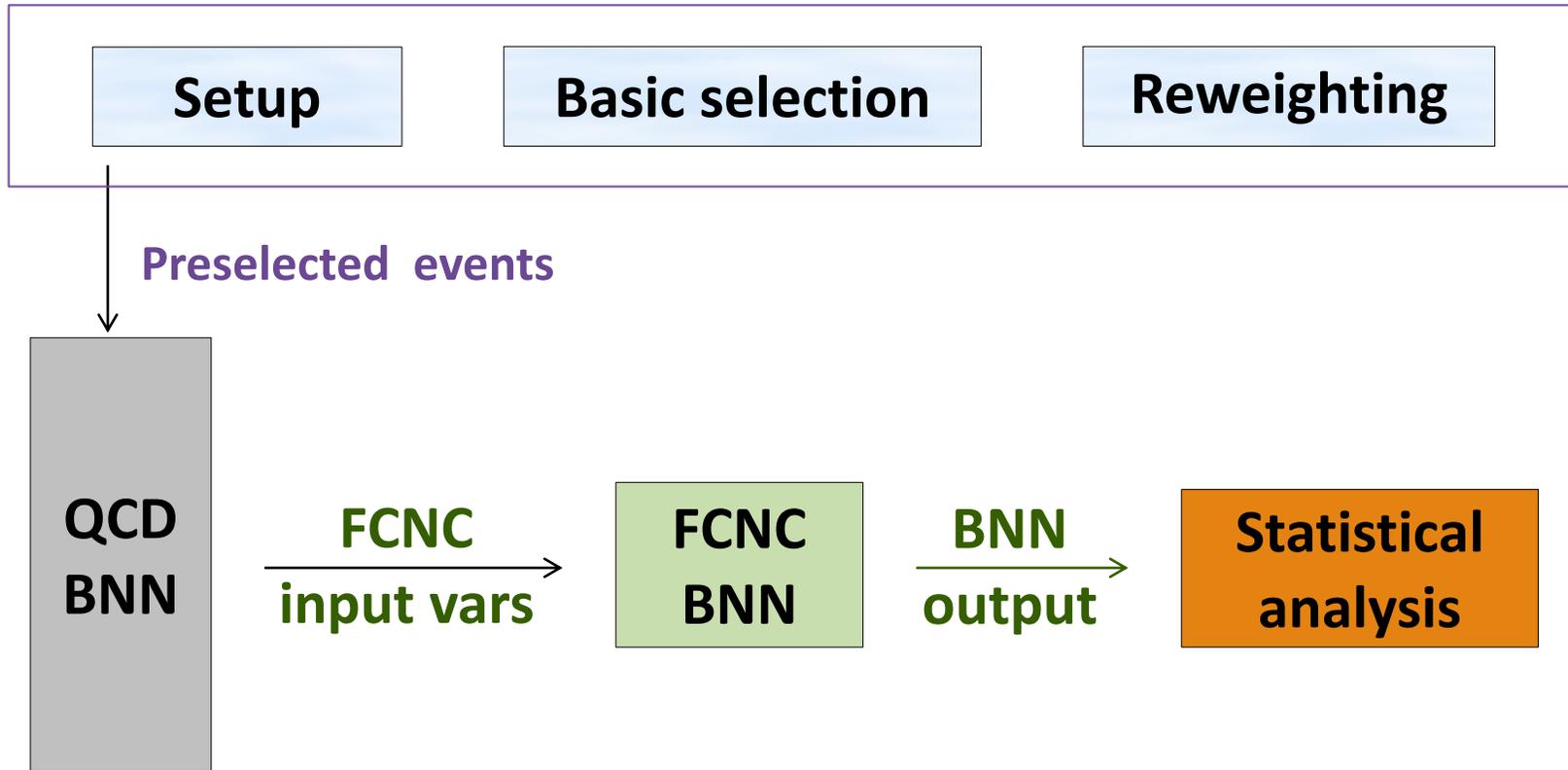$$cg \to tg \qquad c\bar{q} \to t\bar{q} \qquad gg \to tc \qquad q\bar{q} \to t\bar{c}$$

- Monte-Carlo generated with CompHEP:

$$\frac{k_u}{\Lambda} = 0.03\ TeV^{-1} \qquad \frac{k_c}{\Lambda} = 0.03\ TeV^{-1}$$

$$\frac{k_f}{\Lambda} g_s \bar{f} \sigma^{\mu\nu} \frac{\lambda^a}{2} t G^a_{\mu\nu}$$

- All necessary diagrams

Strategy

Setup	Basic selection	Reweighting

Preselected events

QCD
BNN

→ FCNC input vars →

FCNC
BNN

→ BNN output →

Statistical analysis

FCNC Limits

Published as CMS-PAS-TOP-14-007

Analysis setup, event selection & reweighting

Setup:
- Int. luminosity $5\,fb^{-1}$ @ $7\,TeV$
- Only μ channel considered

Selection:
Object definitions follow CMS Top Group recommendation
- Quality criteria for primary vertex
- Only one *"tight"* lepton:

    μ: $p_T > 26\,{}^{GeV}/_c$, $|\eta| < 2.1$, $RelIso < 0.12$
- No more additional *"loose"* leptons:

    μ: $p_T > 10\,{}^{GeV}/_c$, $|\eta| < 2.4$, $RelIso < 0.2$
- Two or three Jets:

    J: $p_T > 30\,{}^{GeV}/_c$, $|\eta| < 4.7$, $p_T^{(J1,J2)} > 40\,{}^{GeV}/_c$
- At least one b-tagged jet according to CSVT
- At least one untagged jet according to CSVT

Triggers:
- HLT_IsoMu17_v*
- HLT_IsoMu24_v*
- HLT_IsoMu24_eta2p1_v*

MC reweighting:
- Pile-Up

    Standard reweighting based on *"true"* number
    of interaction
- B-tagging

    Recommended Rizzi recipe

    Scale factors provided by BtagPOG
- Triggers and muon ID/Iso

    8 TeV SF provided by MuonPOG

    7 TeV SF measured by working group
- PDF

Systematics

Sources of systematic uncertainties:

- **Finite MC statistics**
- **Luminosity**

Marginalized:
- Xsections
- JEC
- JER
- Unclustered MET
- PileUp
- B-tag /mistag
- Triggers SF
- Lepton Id
- Lepton Iso

Unmarginalized:
- Generator choise
- Scale
- Matching
- PDF

Unmarginalized uncertaintites are estimated with toys. Pseudodata are constructed with a best-fit value for t-channel x-section, not SM value.
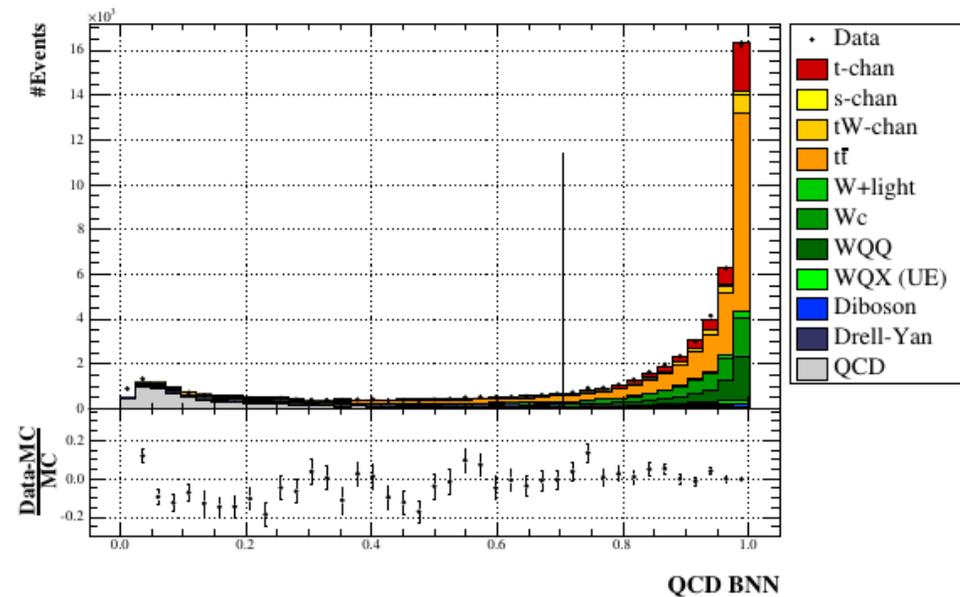
Bayesian Neural Networks

QCD suppression

◦ Estimation

- ◦ Multijet QCD background is estimated from data
- ◦ Modified event selection
- ◦ "*Cleaning*" procedure for jets

◦ Suppression

- ◦ Special BNN for QCD removal
- ◦ BNN output > 0.7
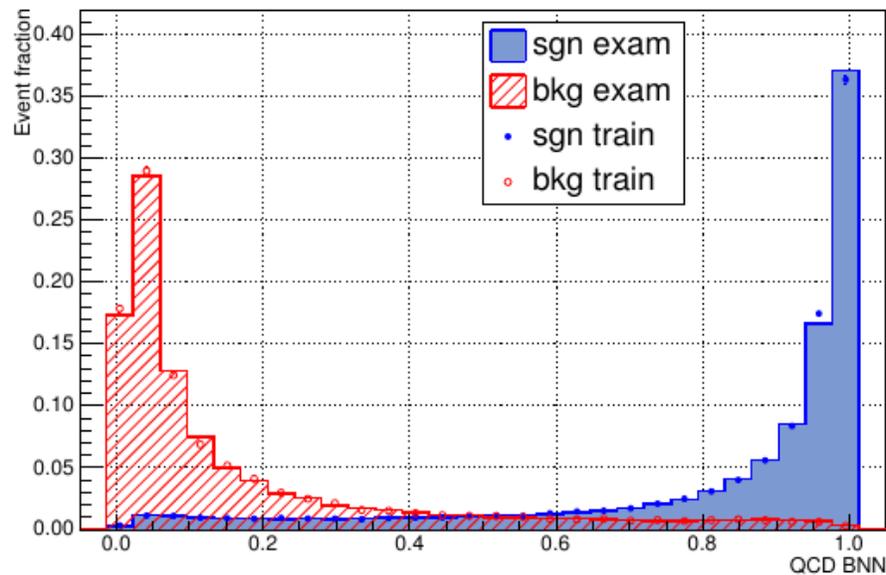
FCNC limits

$$\frac{k_f}{\Lambda} g_s \overline{f} \sigma^{\mu\nu} \frac{\lambda^a}{2} t G^a_{\mu\nu}$$

BNNs trained to separate *tug* and *tcg* processes from SM.

Input variables:

- Optimal variables method: Feynman diagram structure analysis.
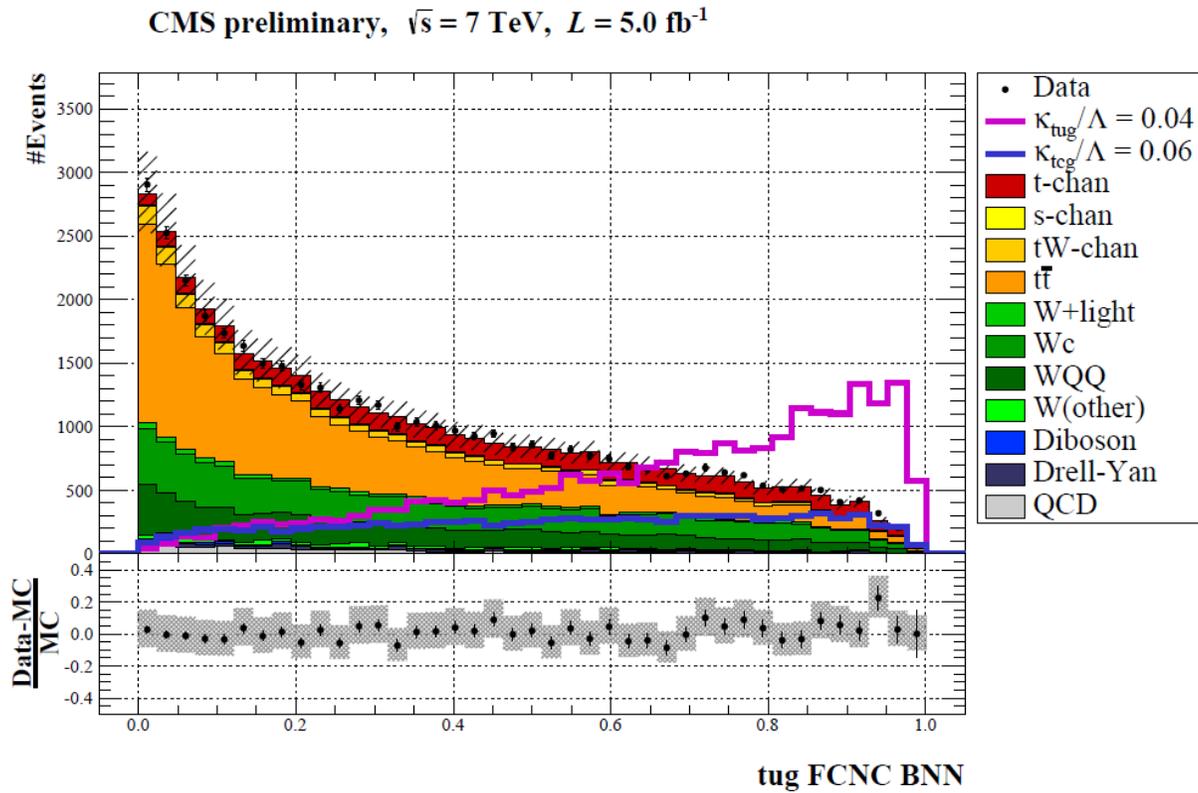
Signal:

- Events with FCNC

Background:

- All SM processes

Scenarios:

- *tug* – 1-dimensional, $\frac{k_c}{\Lambda} = 0$

- *tcg* – 1-dimensional, $\frac{k_u}{\Lambda} = 0$

- *tug + tcg* – 2-dimensional

One-dimensional tug scenario

CMS preliminary, $\sqrt{s}$ = 7 TeV, L = 5.0 fb^{-1}

Legend:
- Data
- $\kappa_{tug}/\Lambda = 0.04$
- $\kappa_{tcg}/\Lambda = 0.06$
- t-chan
- s-chan
- tW-chan
- $t\bar{t}$
- W+light
- Wc
- WQQ
- W(other)
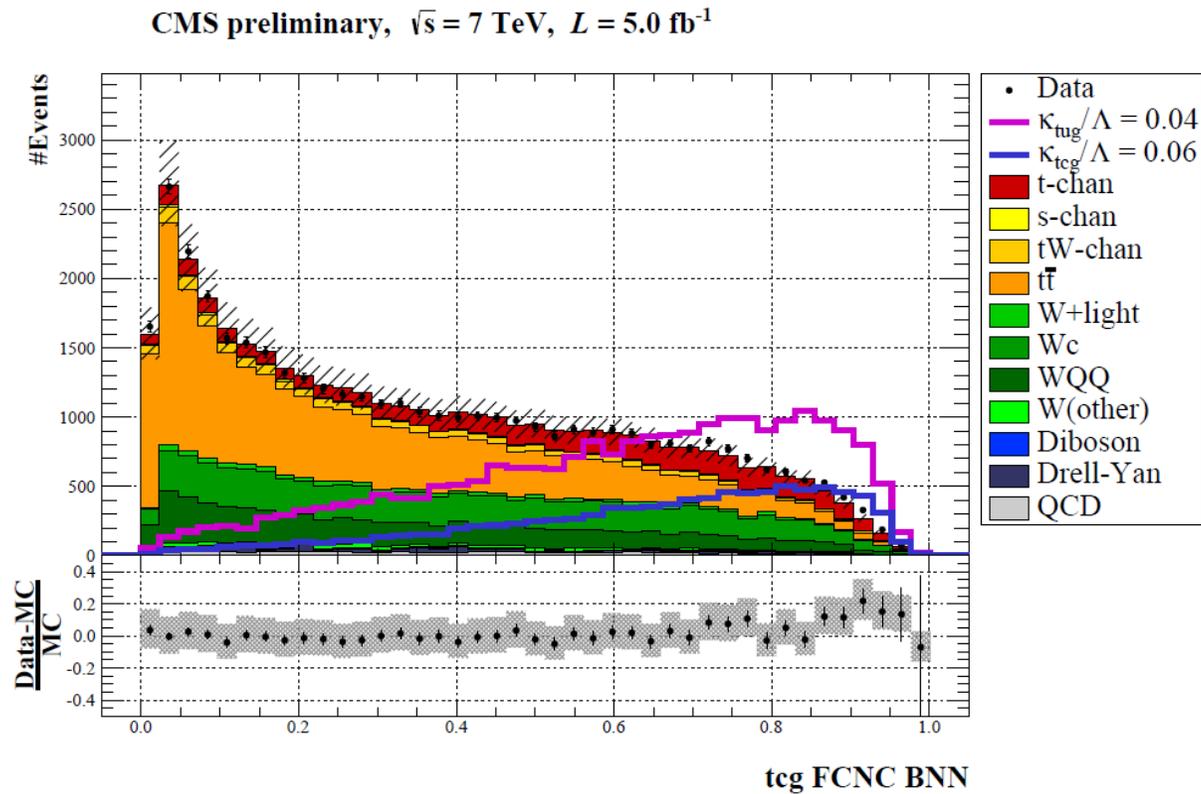- Diboson
- Drell-Yan
- QCD

tug FCNC BNN

Observed (expected)
1D limit @ 95% C.L.:

- $\frac{k_u}{\Lambda} < 1.8 \cdot 10^{-2} \; (1.2 \cdot 10^{-2}) \; TeV^{-1}$

In terms of branching fraction:

- $Br(t \to u + g) < 3.55 \cdot 10^{-4} \; (1.58 \cdot 10^{-4})$

One-dimensional tcg scenario
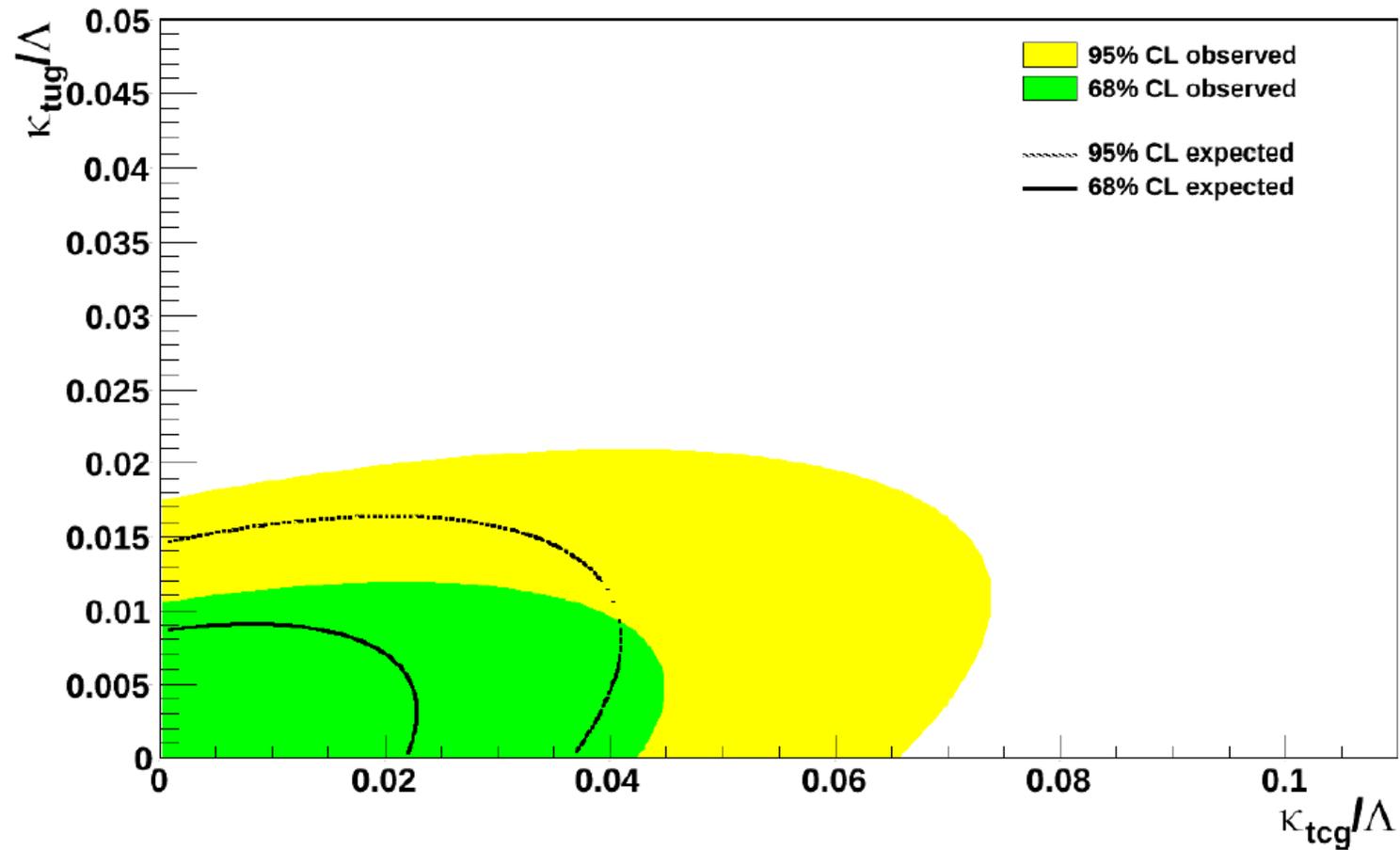

Observed (expected)
1D limit @ 95% C.L.:

- $\dfrac{k_c}{\Lambda} < 5.6 \cdot 10^{-2} \ (3.1 \cdot 10^{-2}) \ TeV^{-1}$

In terms of branching fraction:

- $Br(t \rightarrow c + g) < 3.44 \cdot 10^{-4} \ (1.05 \cdot 10^{-4})$

Two-dimensional scenario

CMS preliminary, $\sqrt{s}$ = 7 TeV, L = 5.0 fb^{-1}

95% CL observed
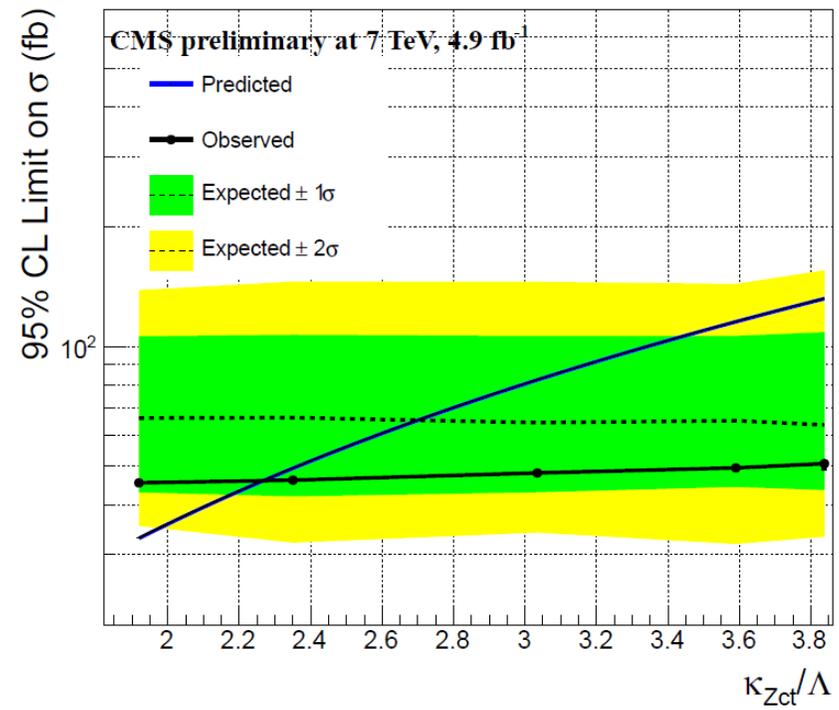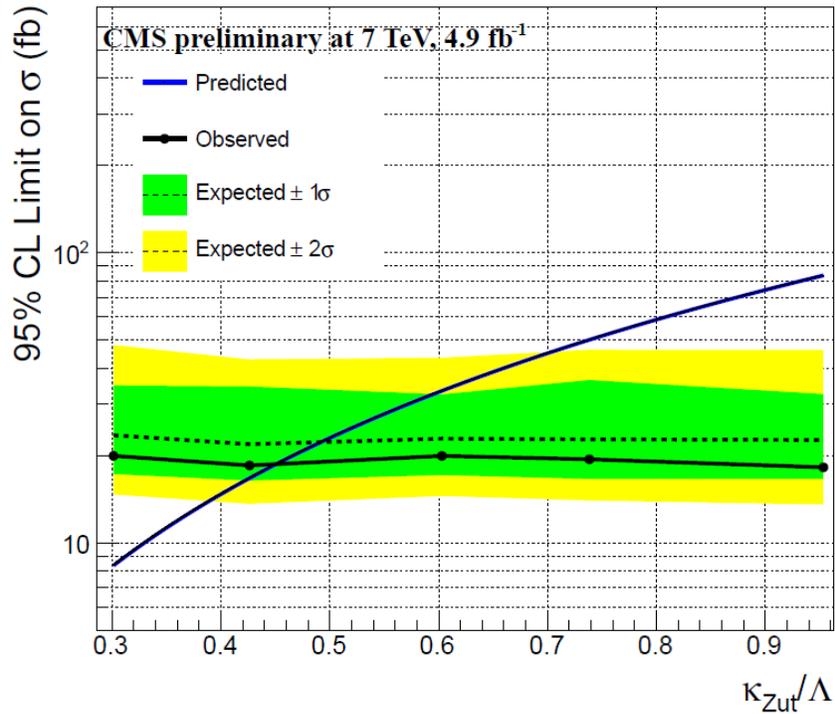68% CL observed
95% CL expected
68% CL expected

Alternative analyzes

FCNC in single top in association with Z @ 7TeV:

CMS PAS TOP-12-021

| couplings	Expected	Observed	$\mathcal{BR}(t \to gq/Zq)$
κ_{gut}/Λ	0.096	0.096	0.56 %
κ_{gct}/Λ	0.427	0.354	7.12 %
κ_{Zut}/Λ	0.492	0.451	0.51 %
κ_{Zct}/Λ	2.701	2.267	11.40 %

Alternative analyzes

Single top in association with γ:

CMS PAS TOP-14-003

	Exp. limit (LO)	Obs. limit (LO)	Exp. limit (NLO)	Obs. limit (NLO)
$\sigma_{tu\gamma} \times Br(W \to l\nu_l)$	0.0404 pb	0.0234 pb	0.0408 pb	0.0217 pb
$\sigma_{tc\gamma} \times Br(W \to l\nu_l)$	0.0411 pb	0.0281 pb	0.0410 pb	0.0279 pb
$\kappa_{tu\gamma}$	0.0367	0.0279	0.0315	0.0229
$\kappa_{tc\gamma}$	0.113	0.094	0.0790	0.0652
$Br(t \to u\gamma)$	0.0279%	0.0161%	0.0205%	0.0108%
$Br(t \to c\gamma)$	0.261%	0.182%	0.193%	0.132%
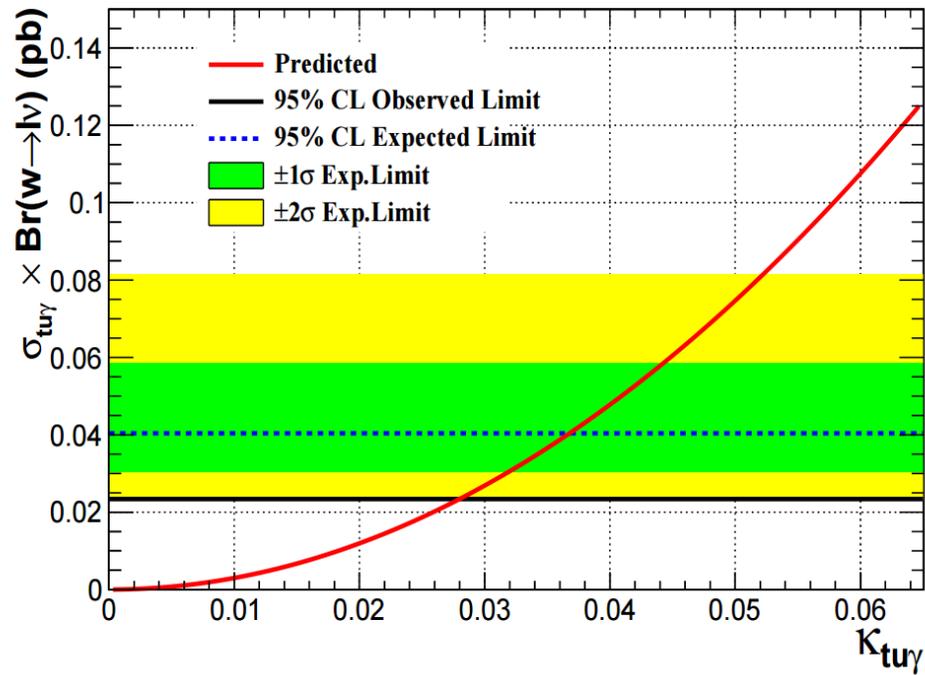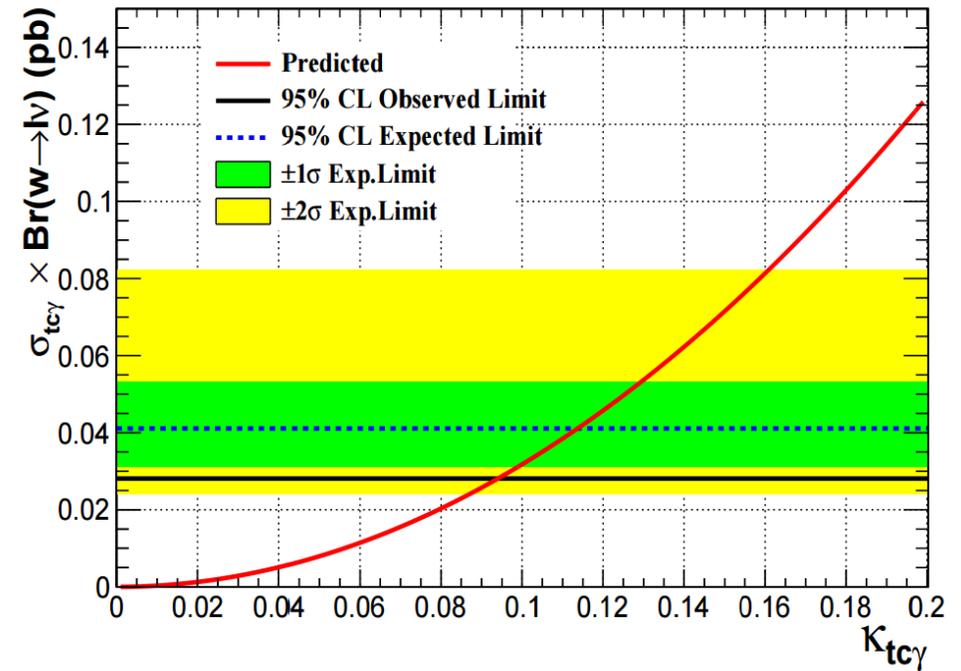
Summary

- Obtained 1D limits on $\frac{k_u}{\Lambda}$ and $\frac{k_c}{\Lambda}$ FCNC couplings

- As well as 2D limits from simultaneous fit

- CMS-PAS-TOP-14-007 is published

- Updated results with 7+8 TeV full datasets are being prepared for publication as CMS-TOP-14-007 paper

Thank you for your attention!