# FCNC @ LHC/CMS

**Chonbuk National University – May 30th, 2015**

# FCNC @ LHC/CMS

**"Eguisheim University" – Jan 21ˢᵗ-22ⁿᵈ, 2016**

# Main differences…

25 ºC



-5 ºC

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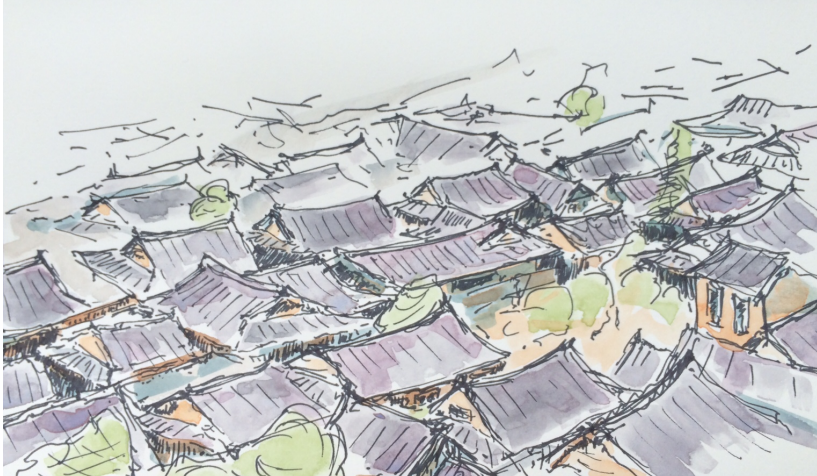eat with chop-sticks

-5 ⁰C
eat with fork & knife

25 ºC
eat with chop-sticks
huge city

-5 ºC
eat with fork & knife
smallest village

<div style="columns: 2;">

25 ºC
eat with chop-sticks
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sake wine
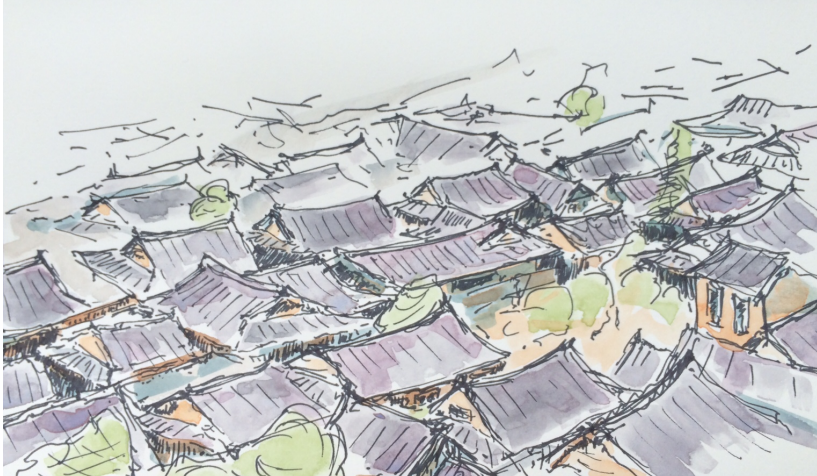
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eau-de-vie Mirabelle

</div>

# Very much equal…

no FCNC top observed

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no FCNC top observed

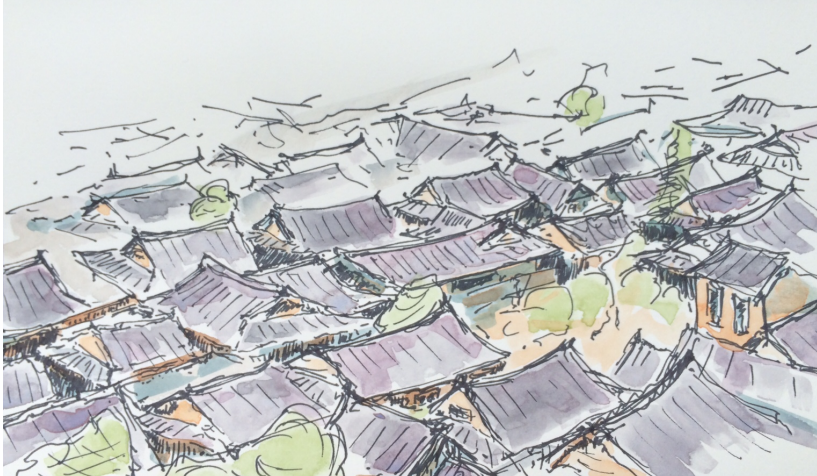food & physics & friendship

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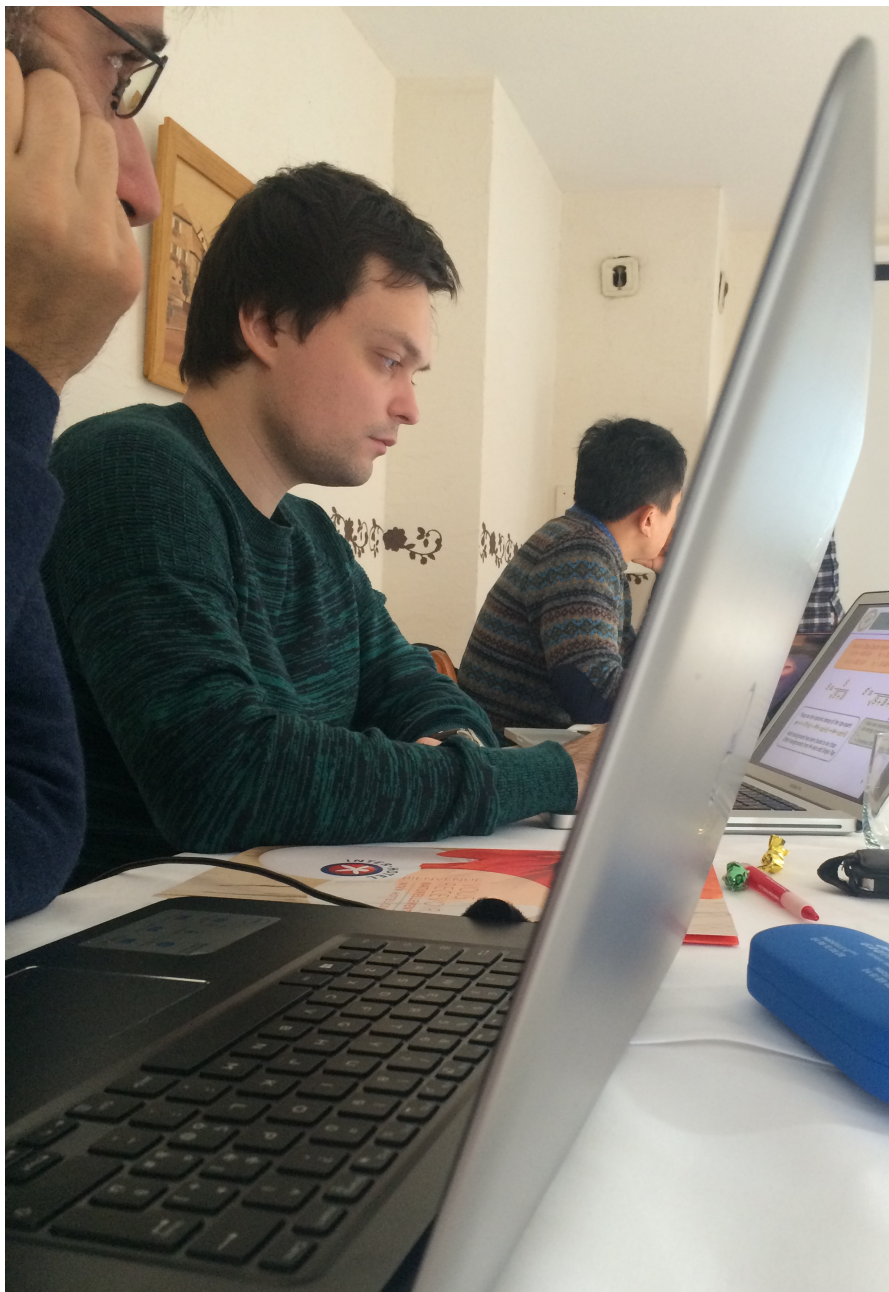
**Many thanks to**

**Kirill & Jeremy**
**and the whole Strasbourg team**

**for the perfect organization of the**
**FCNC workshop at Eguisheim**

Important wine producers in Eguisheim
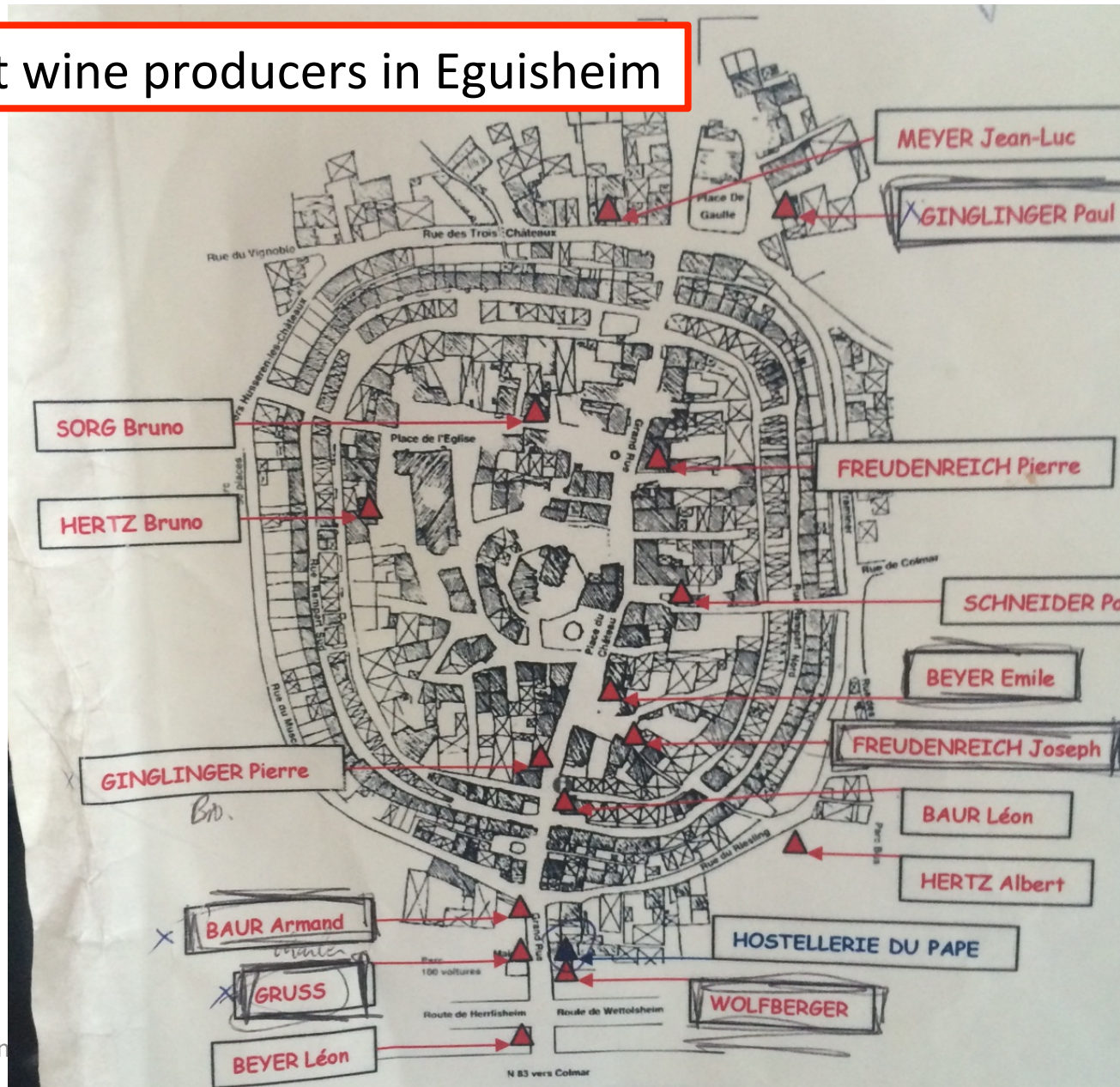
To discuss how to search for top quark related FCNC

# Why are we here ?

The discuss how to search for top quark related FCNC

… but why only ~15 participants ?

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**We only set limits ... ☹**

# Where are we in the FCNC study

Discover with 100/fb @ 13 TeV a FCNC just below the current limits?
(a factor of ~15 compared to 8 TeV with 20/fb, hence significance
increase with sqrt(15)~4... need sign=6-8 for 100/fb at 13 TeV... <u>roughly!</u>)

| coupling | "single-top" selection | "top pair" selection | comments |
|---|---|---|---|
| gqt | sign ~ 18 (u) - 30 (c )<br>sign gone when incl syst | - | *train N(jet)= 1 and 2 separate* |
| Zqt (Z->ll) | sign ~ 7-9<br>include tau decays<br>to include syst | sign ~ 4 (incl syst)<br>BDT equal power as 2 kin. variables<br>test u/c difference with c-tagging ? | *check fake-lepton tool* |
| Hqt (H->WW) | sign ~ 28<br>BDT 4 variables<br>to include syst | sign ~ 2 (incl syst)<br>check u/c rates (simulate inclusive) | *check fake-lepton tool*<br>*include inclusive signal* |
| Hqt (H->bb) | sign ~ 10-13<br>to include syst<br>need b/c-tagging discr. | sign ~ 2 (incl syst, Hct)<br>check some recent CMS analyses<br>need b/c-tagging discriminator<br>include single-top FCNC signal | *MVA not much power*<br>*"top pair" signal dominated* |
| γqt | sign to be done<br>need 100/fb vs 100/pb<br>finalize photon reconstruction | sign ~ 4 (incl syst from Run-1) | *synchronize the photon object* |

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# Key elements for CMS study

- Cannot compare our "pheno obtained" expected limit on the BR with the ATLAS/CMS obtained results at 8 TeV
- In general: SIGNAL = single-top + top pair FCNC

| coupling | "single-top" selection | "top pair" selection | comments |
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| **gqt** | BDT & template fit<br>control the multi-jet bck | not needed | *Caroline*<br>*but who on 13 TeV data ?* |
| **Zqt (Z->ll)** | tri-lepton (WZ & ttZ domi. Bck)<br>data-driven "fake" lepton bck<br>train MVA vs WZ & ttZ separate | similar, but with extra u/c jet<br>c-tagging for kin reconstruction<br>check MEM & kin fit | *Isis, Mara, Jeremy,*<br>*Nicolas, Mar, Eric* |
| **Hqt (H->WW)** | same-sign leptons (#jets & #b-jets)<br>check tri-lepton final state<br>data-driven "fake" lepton bck | similar, but with extra u/c jet | *Shimaa* |
| **Hqt (H->bb)** | MVA to the limit …<br>include c-tagging information | similar, MVA towards the limit …<br>b/c-tagging information | *Kirill, Kevin* |
| **Hqt (H->γγ)** | fit on γγ-mass spectrum<br>optimize #B vs sensitivity | similar, fit on γγ-mass spectrum | *Taejeong* |
| **γqt** | BDT<br>training with "fake" photons | similar | *Eric* |
| **tXq (X=inv)** | mono-top like (mainly c) | u/c → c-tagging & lepton charge | *Seth* |

*combination* (spanning Hqt rows)

**At the end of 2016 about 30/fb @ 13 TeV**

# Where can we go from here?

**Can we aim for a CMS publication at the end of 2016?**

yes we can

**One combined paper or separate papers?**
**(common MVA approaches)**

to be discussed

**Can we split u/c couplings (common c-tagging working point)?**

to be studied

**How much overlap with other BSM analyses in CMS?**

to be checked/studied

**Do we cover all processes?**

no, help and diversity is needed

**How much data-driven we can be in the analyses?**

as much as possible (and needed) ... test on 2015 data

**Do we hit an integrated luminosity where the extra data cannot improve our search for top related FCNC?**
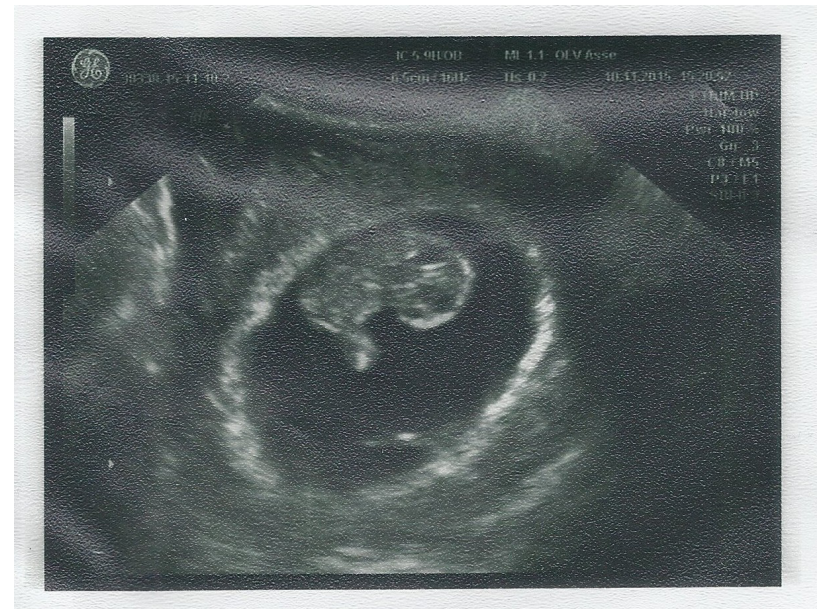
lets hope not

# Lessons learned…

FCNC is a fertile research ground….

Congratulations Jeremy & Kevin
                    … and all the best!

And soon a FCNC pheno paper …



… expected by Spring 2016

No top related FCNC yet observed…

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① initial or baseline event selection ready for most FCNC channels
② need a coherent set of FCNC signal samples & cross-sections
③ need to check the contribution of other FCNC signals in your favorite selected final state
④ need to agree how to deal with "single-top" & "top pair" signal
⑤ MVA/kinematic-fit/MEM exploration ongoing
⑥ c-tagging is ready: check the usefulness in FCNC analyses
⑦ a coherent template fitting tool for all analyses could help the overall combination and interpretation
⑧ there is overlap with other non-FCNC analyses in CMS …
⑨ pheno: opportunity to re-evaluate the FCNC BR's that might be expected from MSSM, quark singlets, technicolor, …
⑩ pheno: links between FCNC couplings and other phenomena in the top quark sector (eg. anomalous couplings)

# Lessons learned… (in the CMS frame)

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**These workshops are excellent milestones for our research !!**