Analyses de Physique (SM et BSM) Phase 1

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Run-I short summary

Analyses(papers) where members of the group have leadership/editorial role

Example of the most cited papers

1000+

Observation of a new boson at a mass of 125 GeV with the CMS experiment at the LHC
Phys. Lett. B 716 (2012) 30 - Cited by 5847 records

500+

Combined results of searches for the standard model Higgs boson in pp collisions at √s =7 TeV
Phys.Lett. B 710 (2012) 26-48 - Cited by 775 records

250+

Measurement of the properties of a Higgs boson in the four-lepton final state
Phys. Rev. D 89 (2014) 092007 - Cited by 376 records

Study of the Mass and Spin-Parity of the Higgs Boson Candidate via Its Decays to Z Boson Pairs
Phys. Rev. Lett. 110 (2013) 081803 - Cited by 305 records

100+

Performance of electron reconstruction and selection with the CMS detector in pp collisions at √s = 8 TeV
JINST 10 (2015) P06005 - Cited by 149 records

Constraints on the Higgs boson width from off-shell production and decay to Z-boson pairs
Phys. Lett. B 736 (2014) 64) - Cited by 138 records

Search for the standard model Higgs boson in the decay channel H→ZZ→4ℓ at 7 TeV
Phys. Rev. Lett. 108 (2012) 111804 - Cited by 133 records

Constraints on the spin-parity and anomalous HVV couplings of the Higgs boson in pp collisions at 7 and 8 TeV
Phys. Rev. D 92 (2015) 012004 - Cited by 114 records

… and lots of other preliminary results on physics and objects

Run-II effort

In the following **just the ongoing** (2015/2016) LLR Run-II analyses are highlighted

✓ For some of them we have already produced preliminary results for Moriond2016 (2.7/fb @13 TeV)

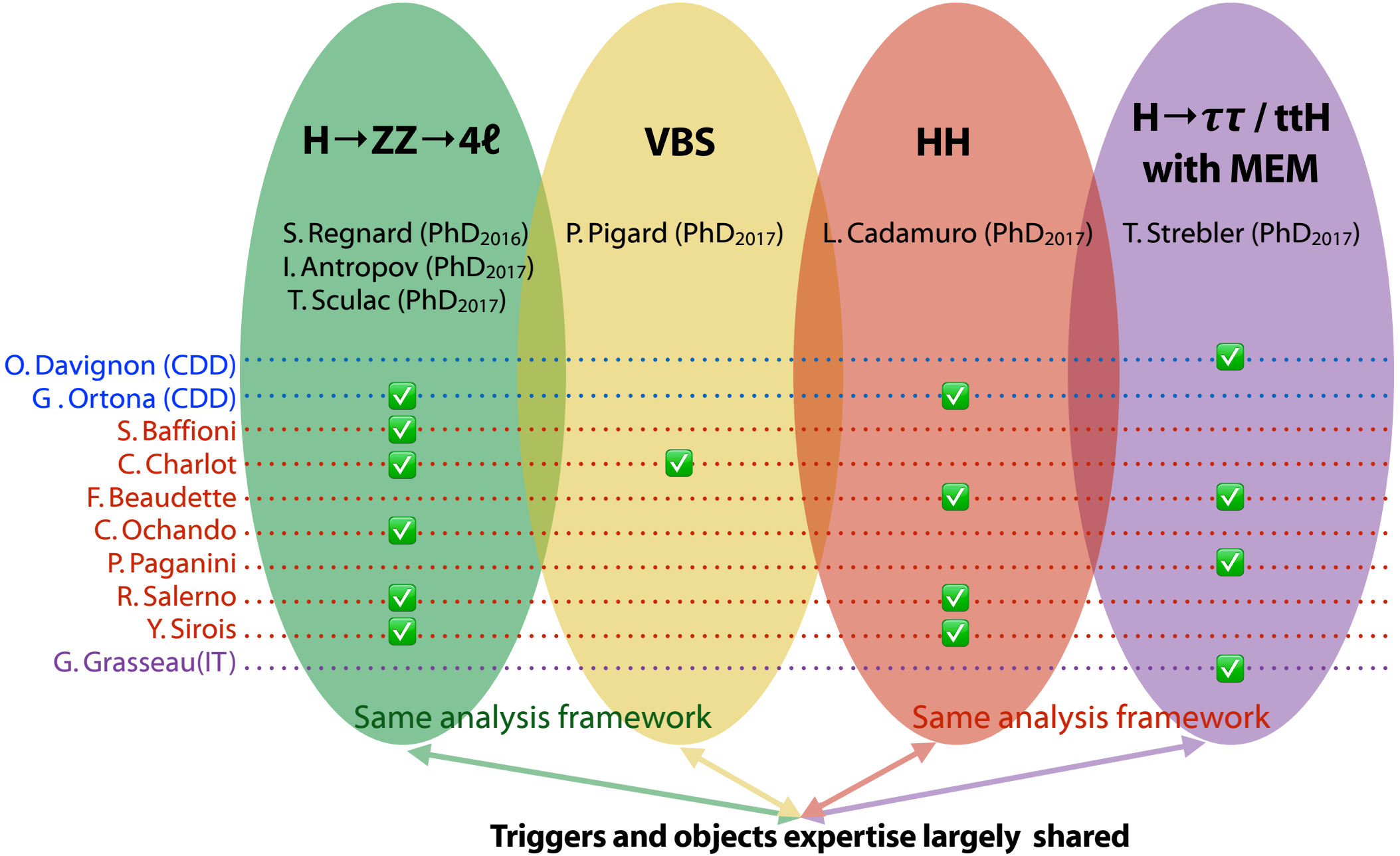
Only 1% of the final LHC Phase1 dataset was used

✓ For all of them we are targeting ICHEP2016 (~10/fb) and/or the end of the year (~30/fb)

the Run-I results be will largely superseded, it will be a turnaround for HEP (the X(750) resonance?)

Coherent effort to completely understand the EWSB

Understand the EWSB @ LLR



$H \rightarrow ZZ \rightarrow 4\ell$

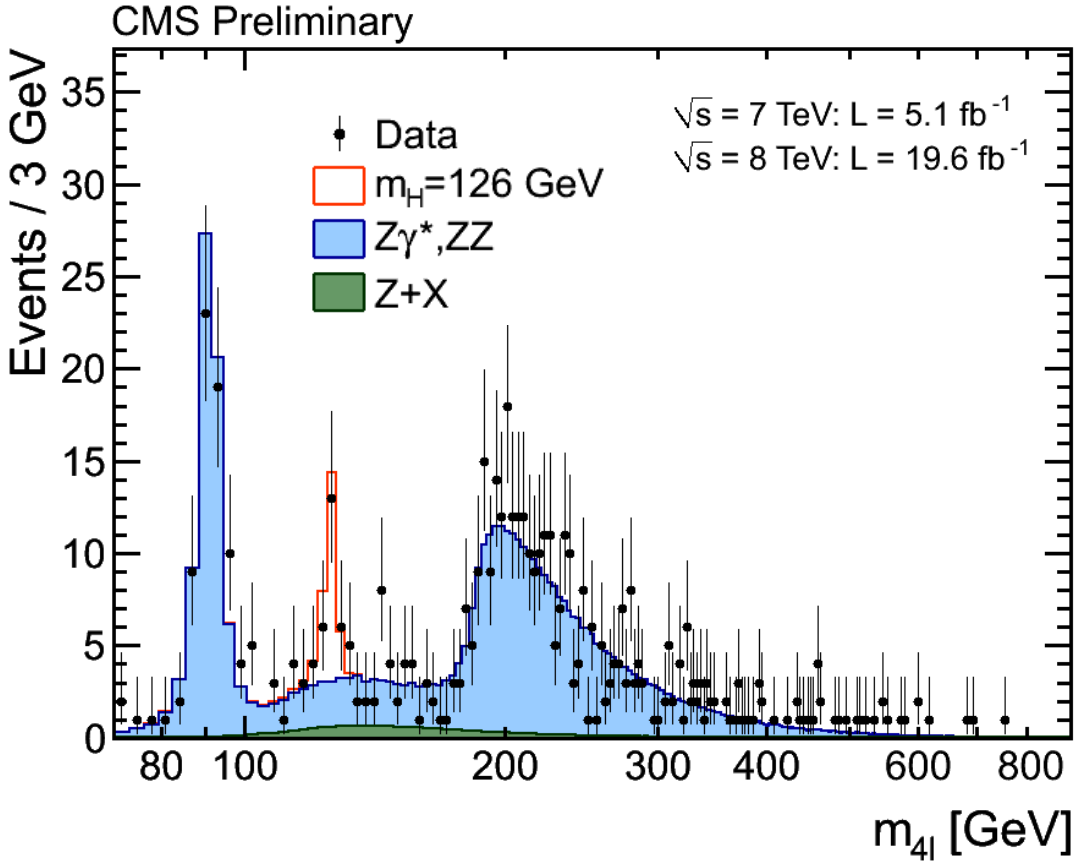
Clean experimental signature: narrow resonance of four primary and isolated leptons in the invariant mass spectrum

The most

performing channel on the whole mass range for the **exclusion**, **discovery**, and **properties measurement** of the Higgs boson and new resonances...

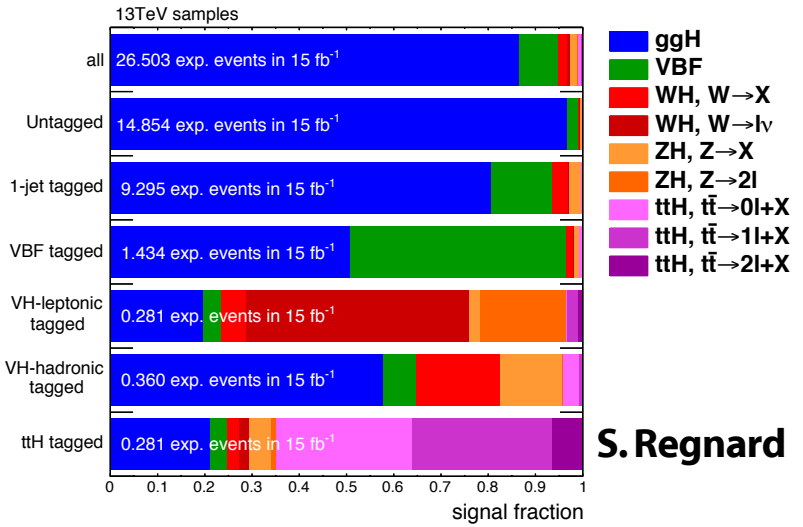
... but:

an extremely demanding channel for selection, it requires the **highest** possible **efficiencies** (e.g lepton ID/Isolation)



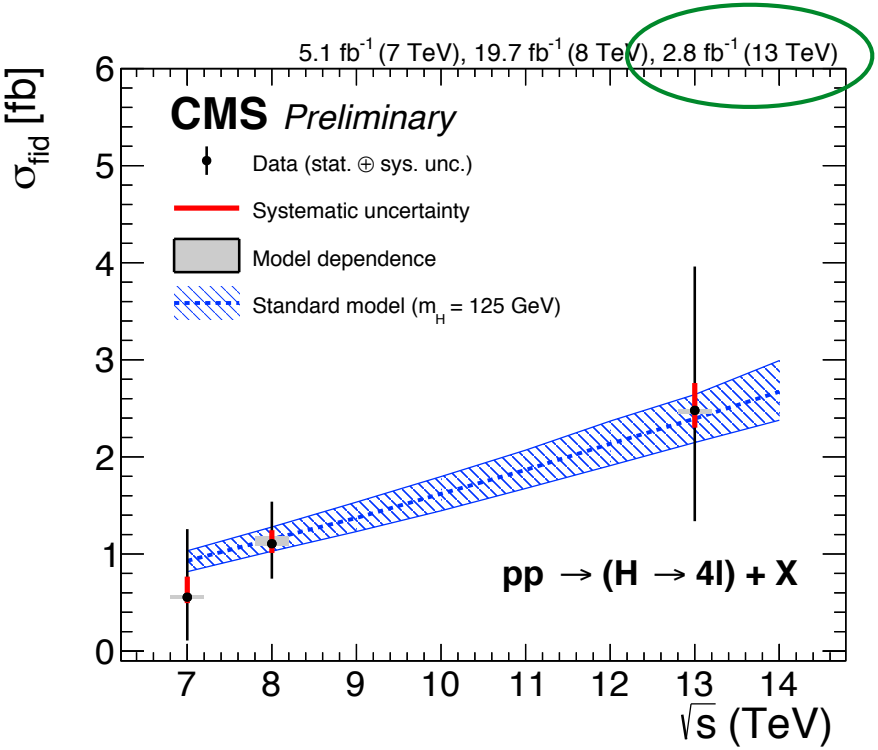
$H \rightarrow ZZ \rightarrow 4\ell$

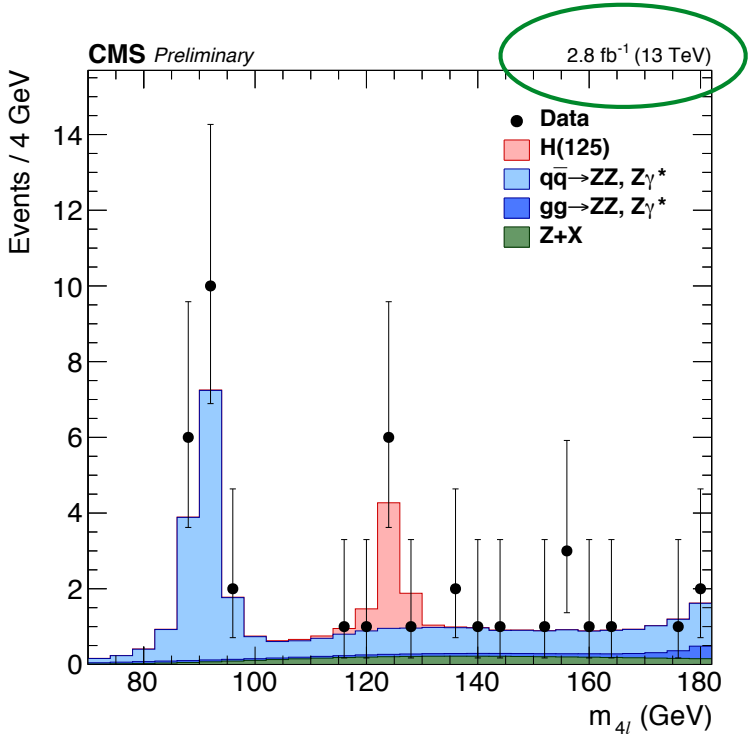
Improve the categorisation to observe $H \rightarrow ZZ \rightarrow 4\ell$ in all the exclusive production modes



S. Regnard

First results at 13 TeV already shown at Moriond16, the Higgs boson is still there





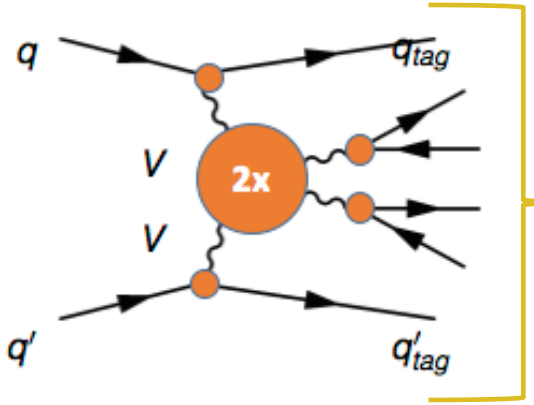
S. Regnard (PhD) : editor of 13 TeV $H \rightarrow ZZ \rightarrow 4l$ first preliminary results

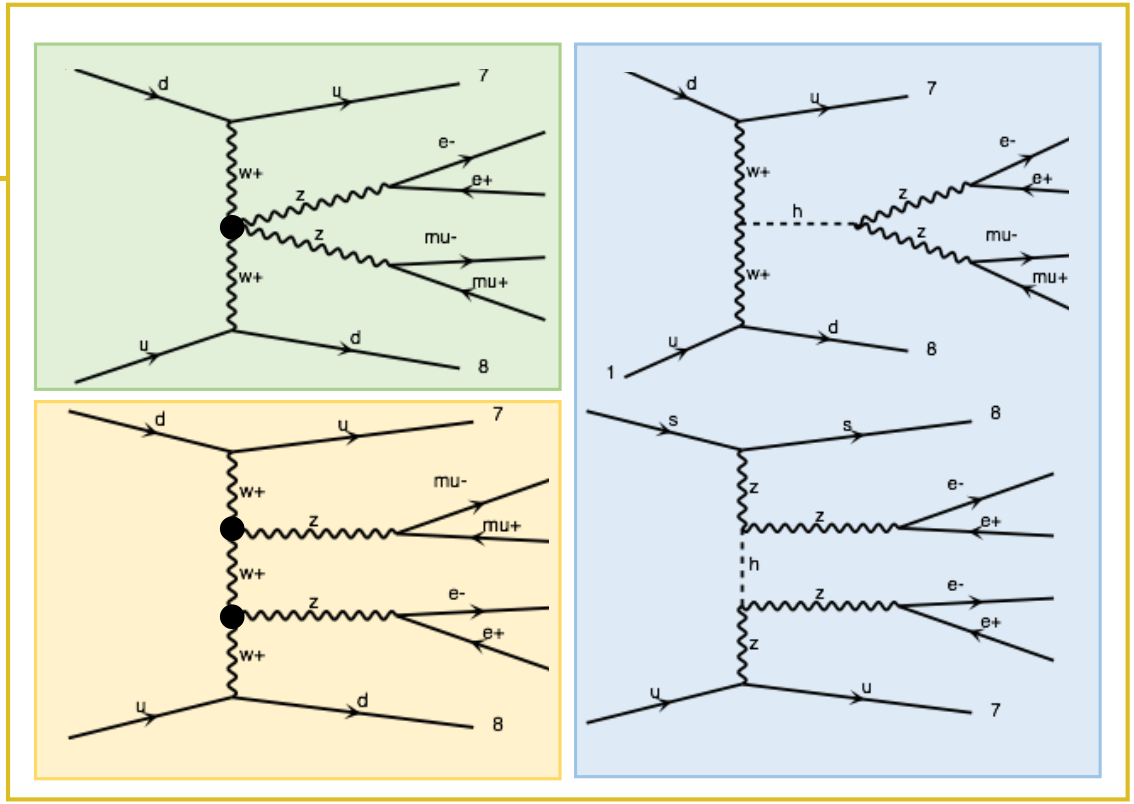
Coming conference talk : ICHEP2016 (SR)

Vector Boson Scattering

In the SM without the Higgs boson, VBS processes violate unitarity in the longitudinal polarization mode at the TeV scale. The unitary is ensured by the destructive interference between VBS and Higgs diagrams

If BSM physics is present in the electroweak sector, VBS offers a promising approach by its impact on gauge boson couplings via the probing of anomalous triple (**aTGC**) and quartic gauge couplings (**aQGC**)





As a purely electroweak process the cross-section is of order α^6_{EWK}

Multiple production mechanisms:

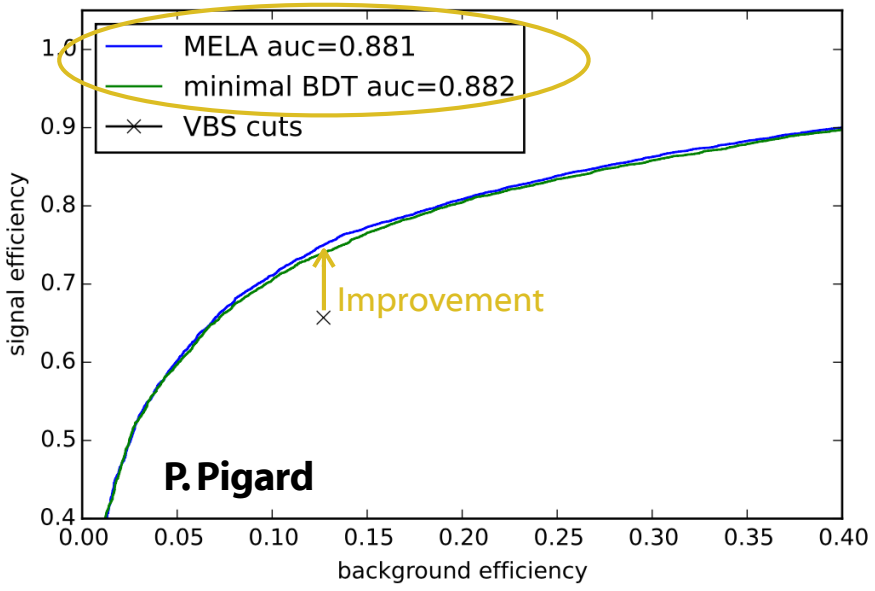
- Quartic Gauge Coupling (QGC)
- Double Triple Gauge Coupling (TGC)
- Higgs exchange in s- and t-channel

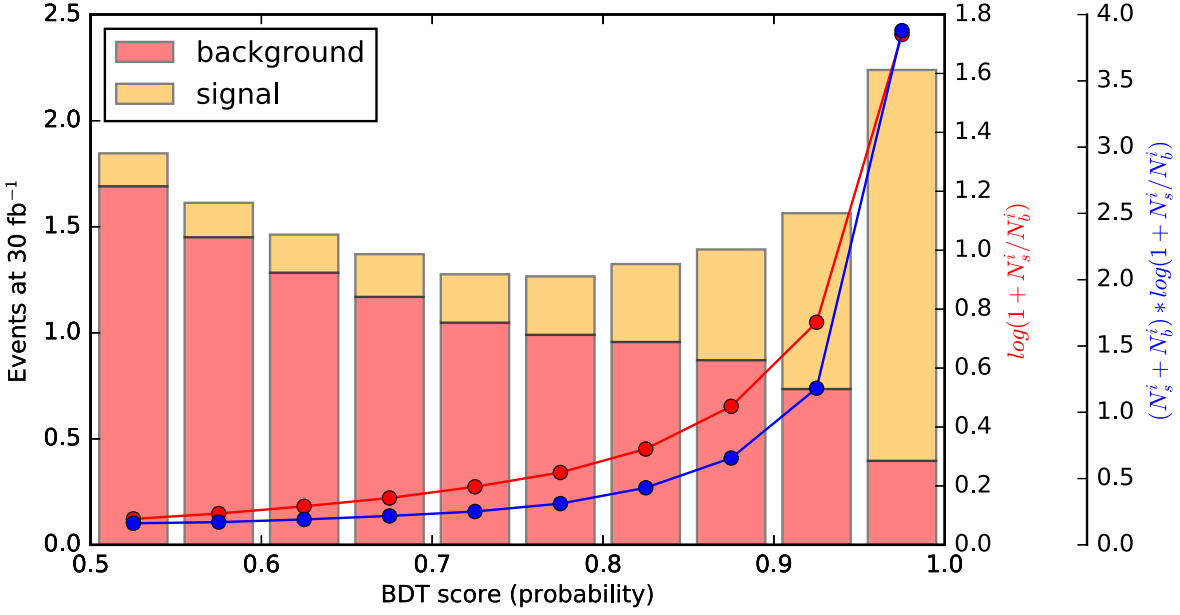
Vector Boson Scattering

@LLR

Focus on the the ZZjj→4ℓjj final states
work side-by-side with H→ZZ→4ℓ group

Improving on the QCD ZZjj background rejection using either a **"minimal" BDT** (which only exploits kinematics) or **Matrix Element Method** approach





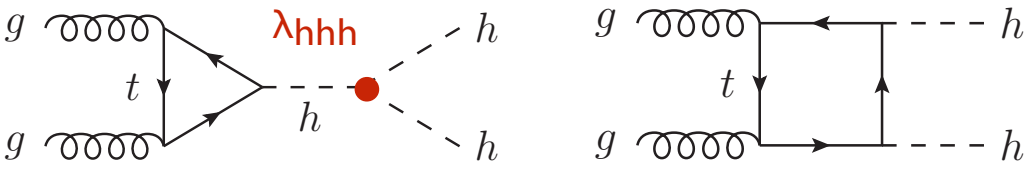
Signal extraction by a shape analysis
The expected significance for **30 fb^{-1} is 2.3σ**
Expected ~6 signal events after selection cuts

In track to release the first ever LHC analysis on VBS with ZZjj final state by the end of the year

Higgs boson pair production

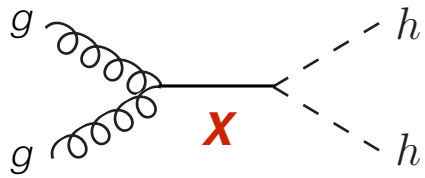
The non-resonant Higgs boson pair production is the principal way to extract the Higgs boson trilinear coupling (λ_{hhh}) to probe EWSB and measure the shape of the Higgs potential

The resonant Higgs boson pair production ($X \rightarrow hh$) is a key channel to observe BSM physics and to fully cover the MSSM Higgs sector



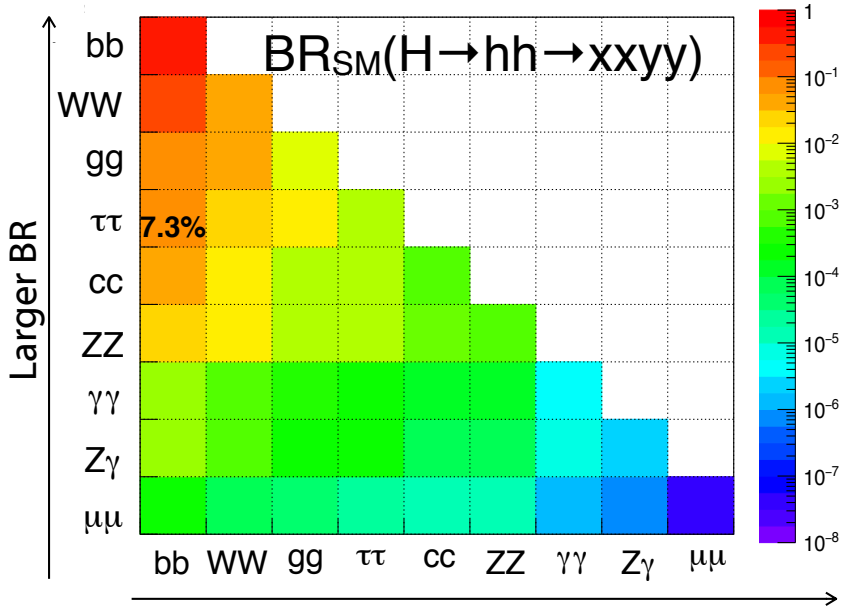
non-resonant

$\sigma^{SM}_{hh}(13TeV) = 37.9fb$



resonant

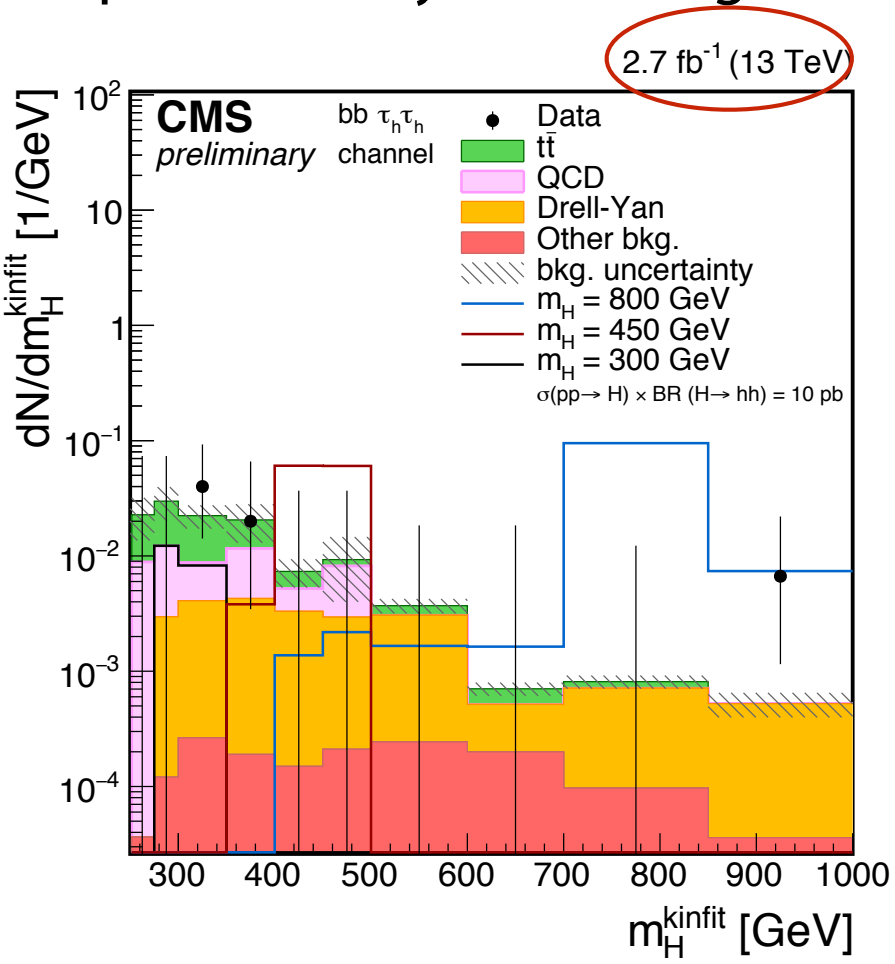
Focus on the **bbττ final state** : quite high BR (7.3%) and a relatively small background contamination

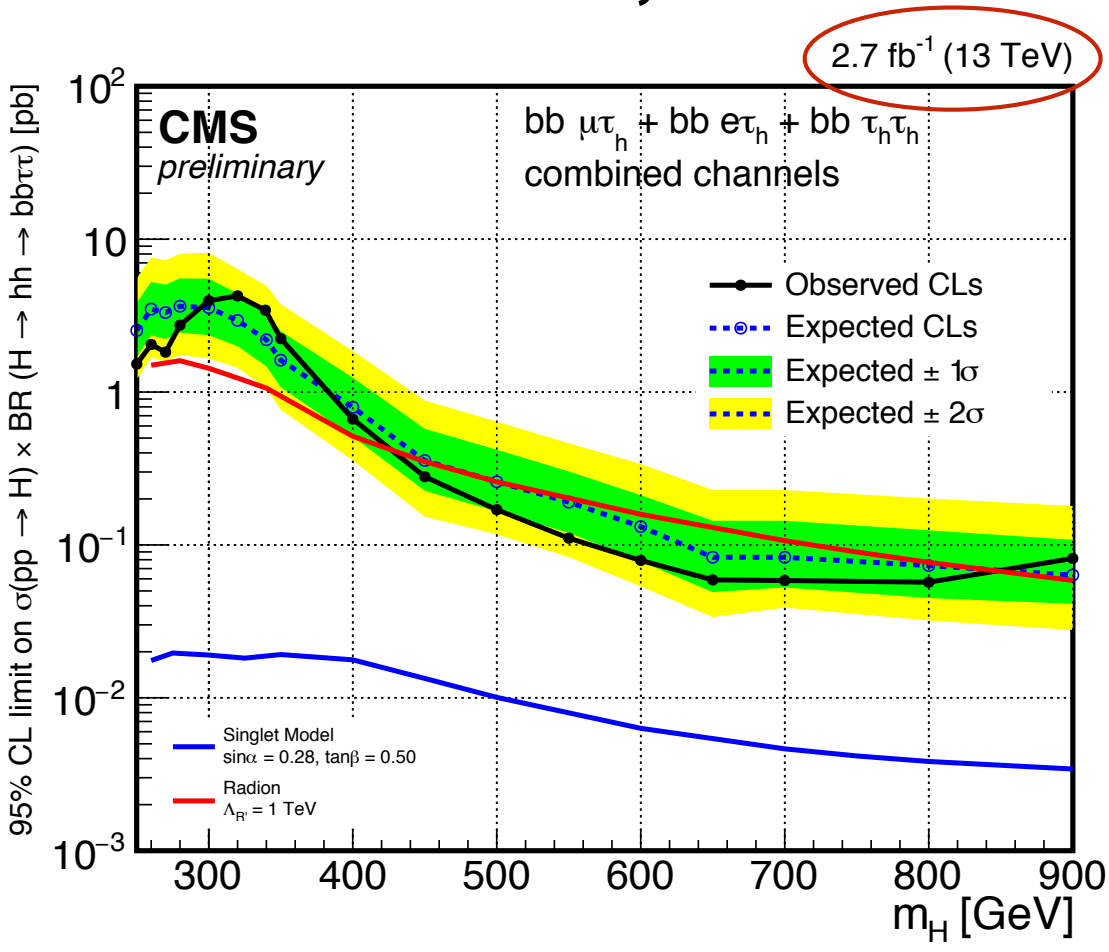


Higgs boson pair production

@LLR

The **first 13 TeV CMS** resonant and non-resonant Higgs boson pair production result have been shown at Moriond2016
Improved analyses are target for ICHEP and the end of the year



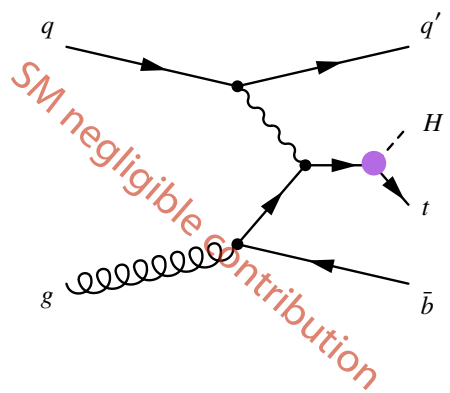


L. Cadamuro (PhD) : editor of 13 TeV resonant analysis / G. Ortona (CDD) : editor of the 13 TeV non-resonant analysis

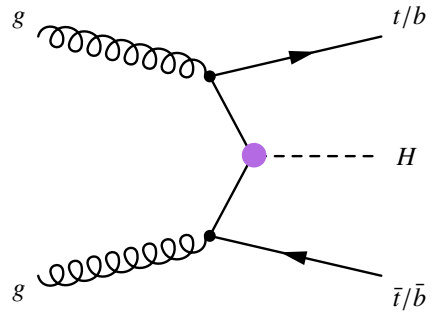
Coming conference talks : PHENO2016 (LC) - ICHEP2016 (GO)

H→ττ and/or ttH with MEM

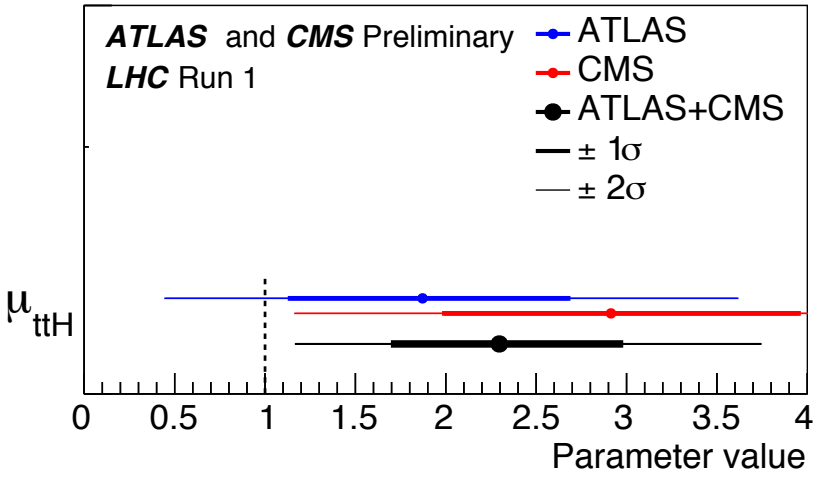
In SM the top-Higgs Yukawa coupling is strongest one ($Y_T \propto m_T/v \approx 1$)
The top-Higgs vertex (●) is only directly accessible when H is produced in association with one or more top quarks



$\sigma(pp \rightarrow tH)$ { 0.019 pb @ 8 TeV; 0.074 pb @ 13 TeV }



$\sigma(pp \rightarrow ttH)$ { 0.133 pb @ 8 TeV; 0.507 pb @ 13 TeV }



Knowledge from Run-I : 25% accuracy

The comparison of the precise direct measurement of Y_T with the one inferred by other cross section measurements can constrain contributions from new physics to the gluon fusion loop

LLR is focusing on **ttH(ττ)** asking the presence of at least 1 τ_h in the final state

H→ττ and/or ttH with MEM

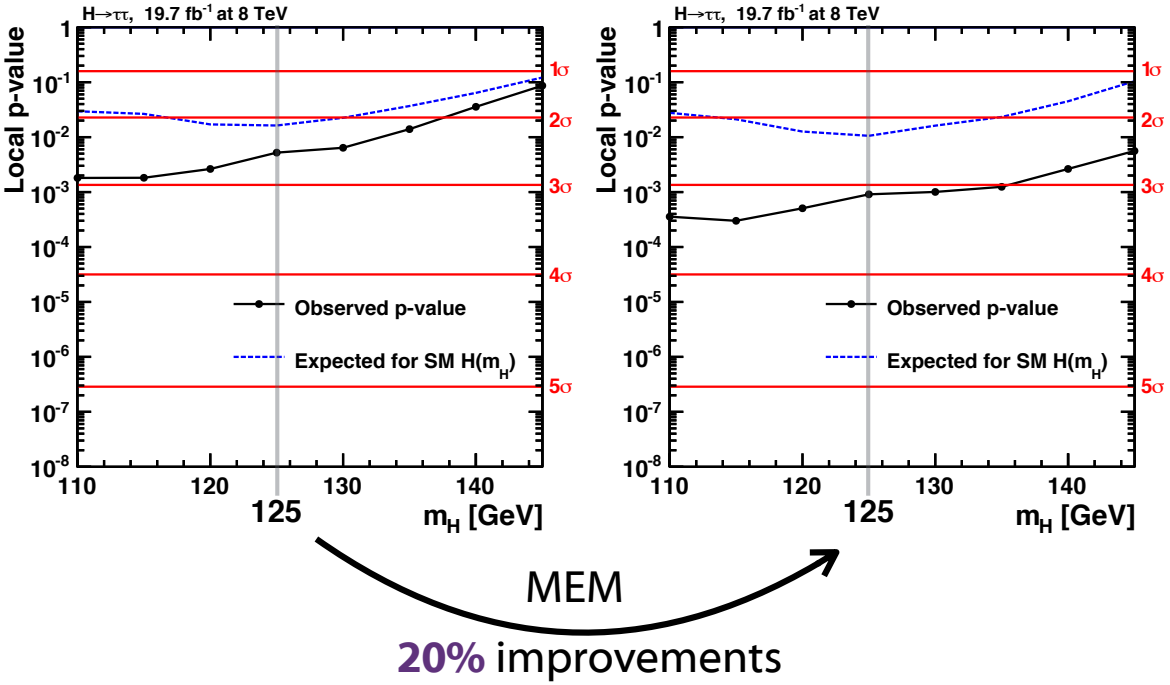
Improve the performance using the Matrix Element Method approach

$$w_i(\mathbf{y}) = \frac{1}{\sigma_i}\sum_p \int dx_a dx_b \frac{f(x_a,Q)f(x_b,Q)}{x_a x_b s}\delta^2(x_a P_a + x_b P_b - \sum p_k)|\mathcal{M}_i(\mathbf{x})|^2 W(\mathbf{y}||\mathbf{x})d\mathbf{x}$$

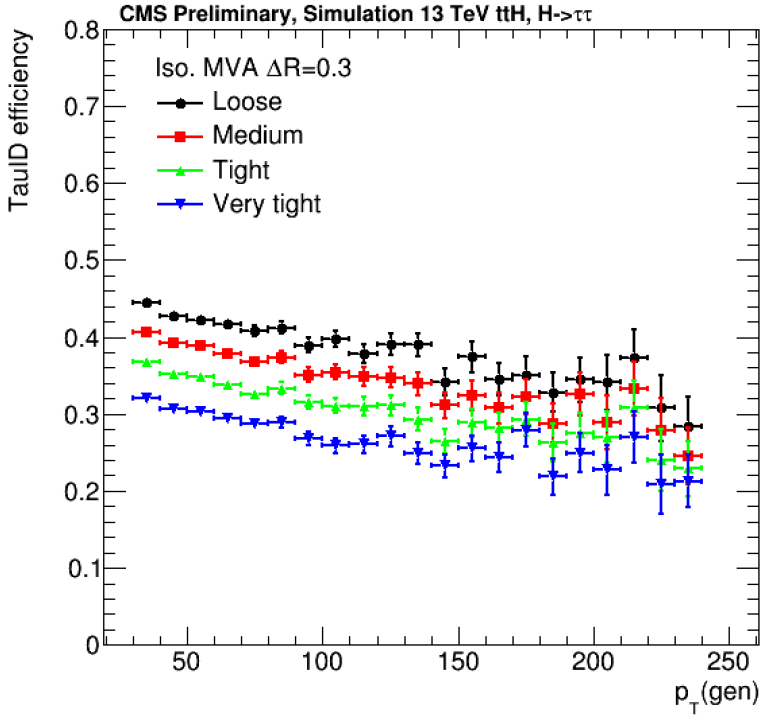
Event weight

Using Run-1 data :

LLR pioneering work to apply the MEM to $H\rightarrow\tau\tau\rightarrow\mu\tau^{had}$

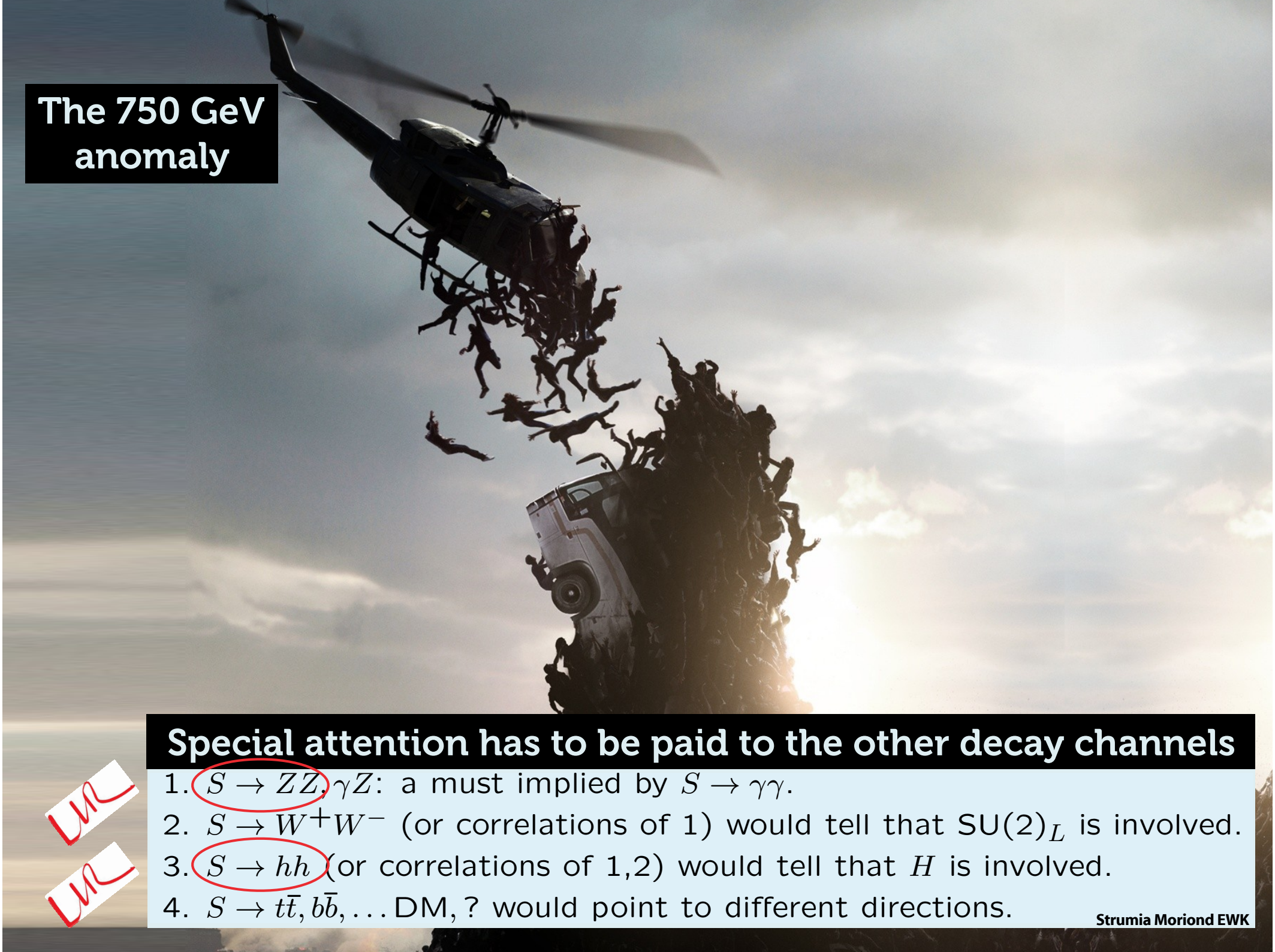


For the ttH Run-II, investigating different τ selection criteria to further optimise the analysis



T. Strebler

In track to release the first ttH($\tau\tau$) analysis with MEM by the end of the year



The 750 GeV anomaly

Special attention has to be paid to the other decay channels

1. $S \to ZZ, \gamma Z$: a must implied by $S \to \gamma\gamma$.
2. $S \to W^+W^-$ (or correlations of 1) would tell that SU(2)$_L$ is involved.
3. $S \to hh$ (or correlations of 1,2) would tell that H is involved.
4. $S \to t\bar{t}, b\bar{b}, \ldots$ DM, ? would point to different directions.