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Bin-By-Bin Uncertainty Pruning (based on Moriond results)

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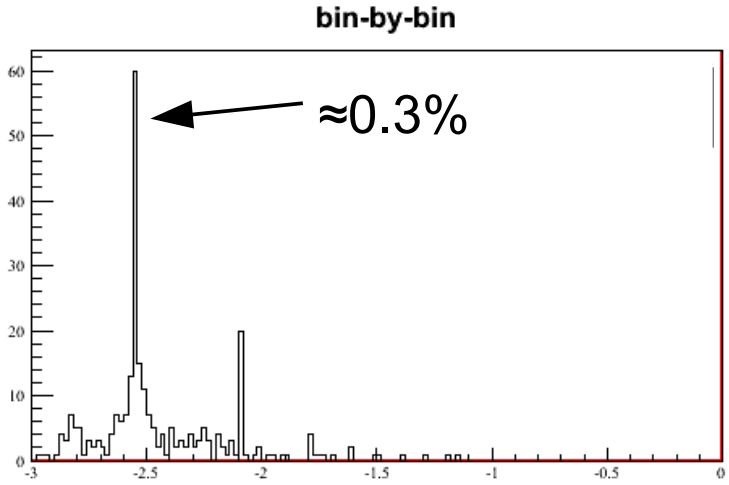
Introduction

- Adding bin-by-bin uncertainties adds up 689 addititonal nuisance parameters to the combined datacard
  - Used here: Moriond analyses = eμ + eτ + μμ + μτ + ττ
- Maximum likelihood fit takes ~12h
  - Time does NOT increasae linearly with number of nuisance parameters
- Tool in HiggsToTauTau package to prune number of bin-by-bin uncertainties (and only those): *prune_bbb_errors.py*
  - Check usage from SWGuideHiggs2TauLimits

Pruning Methods

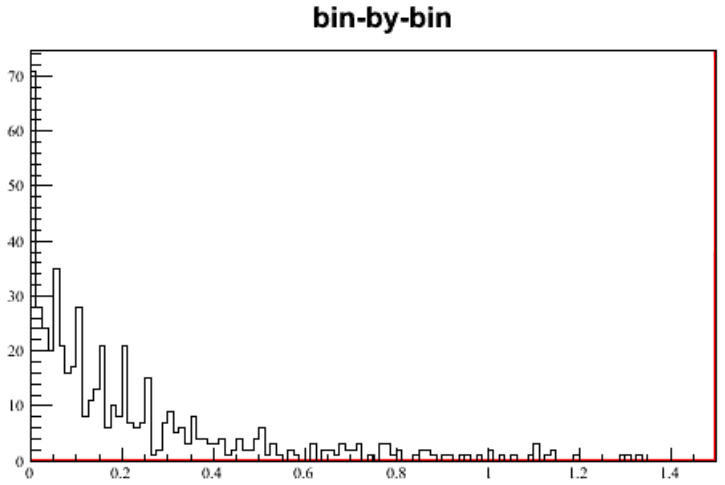
- Three ways of bin-by-bin uncertainty pruning implemented:

- --byLimit (using tools of HCG[1)]):
  Neglect bin-by-bin uncertainties that have only small effect on asymptotic limit (only feasible if split by channel).



log10(rel. effect on the limit).

- --byPull:
  Neglect bin-by-bin uncertainties that are pulled by less than a certain threshold (feasible on combined datacards).



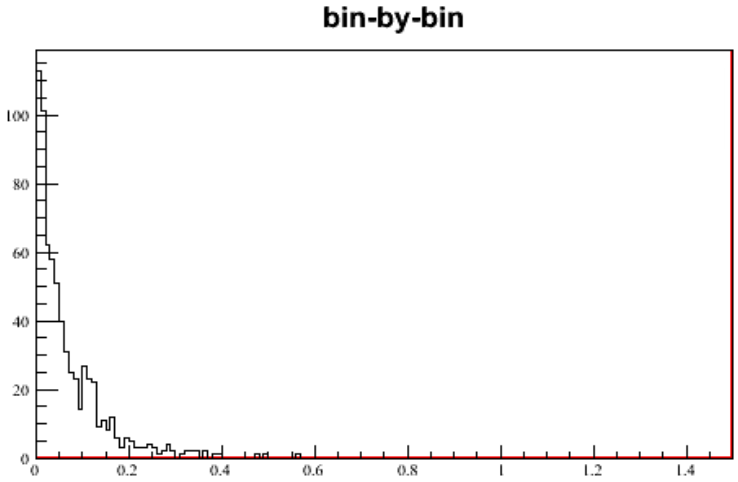
Pull by max-likelihood fit (in σ).

[1)] HCG=Higgs Combination Group

Pruning Methods

- Three ways of bin-by-bin uncertainty pruning implemented:

- --byShift:
  Neglect bin-by-bin uncertainties that are shifted by less than a certain threshold (feasible on combined datacards).



Relative shift by max-likelihood fit

- --shield-bins:
  Additional option to save bin-by-bin uncertainties of bins „in the signal region“ from being pruned.
  Current implementation: mass window of ±30% around 125 GeV (87.5 GeV to 162.5 GeV).

Pruning --byLimit

- Run asymptotic CLs with *combine* with all bin-by-bin uncertainties and with each bin-by-bin uncertainty excluded (i.e. „690 times“).
- Check effect of bin-by-bin uncertainties on asymptotic limit.
  Chose between effect on *exp*, *obs* or *all*:max(*exp*, *obs*).
- Very computing intensive. Therefore only feasible if datacards splitted in channels and determined channel-wise.
- Does it make sense to have the limit itself decide wheter to accept the nuisance parameter or not?
- Is the limit the right metric? E.g. uncertainties have bigger effect on significance.

Pruning --byPull

- Run Maximum Likelihood fit with *combine* with all bin-by-bin uncertainties included (i.e. „once“).
- Check pull of bin-by-bin uncertainties .
  Chosse between pull on *b-only*, *s+b* or *all*:max(*b-only*, *s+b*).
- Feasible to run on combined datacards.
- Problem: Small pulls for large uncertainties do not necessarly mean small effects on the results.

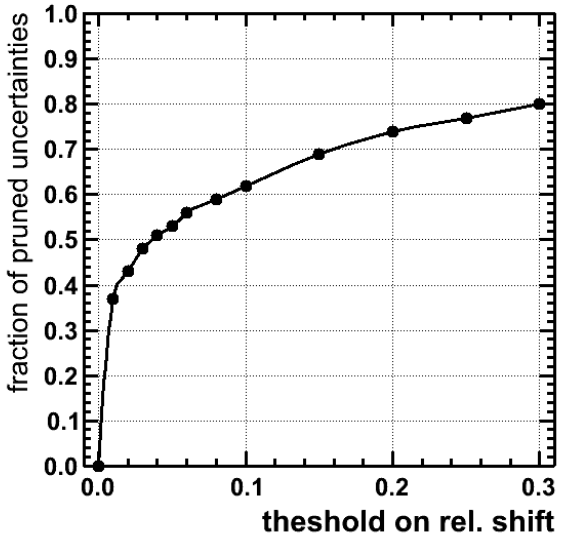
Pruning --byShift

- Run Maximum Likelihood fit with *combine* with all bin-by-bin uncertainties included (i.e. „once“).
- Check pull of bin-by-bin uncertainties • size of the original uncertainy (corresponds to relative shift).
  Chosse between pull on *b-only*, *s+b* or *all*:max(*b-only*, *s+b*).
- Feasible run on combined datacards.
- Better measure of effect on results (small shift → small effect on limits)
- Proper threshold to be defined. Minimize influence on significance and limit.

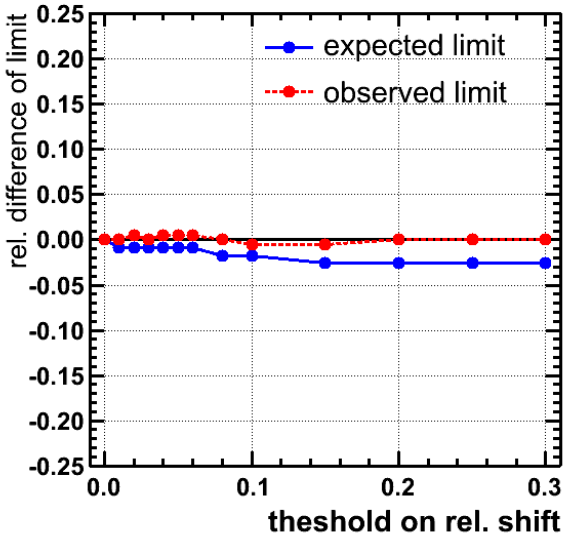
Test of --byShift implementation (w/o 'shielding')

- Checking effects on Limit and (Bayesian) Significance

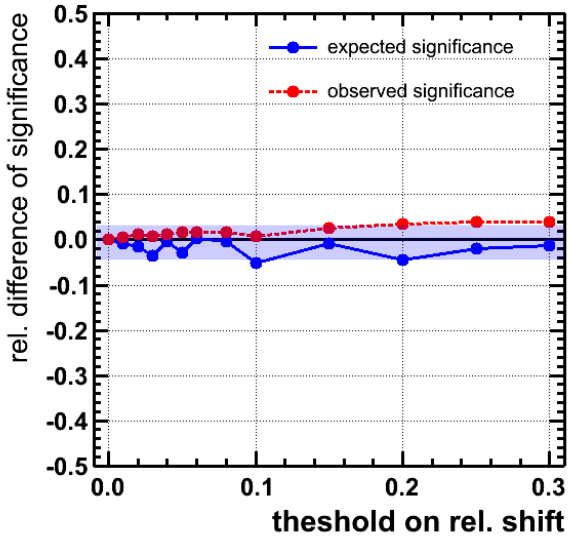
From 689 uncerts.



Limit



Significance



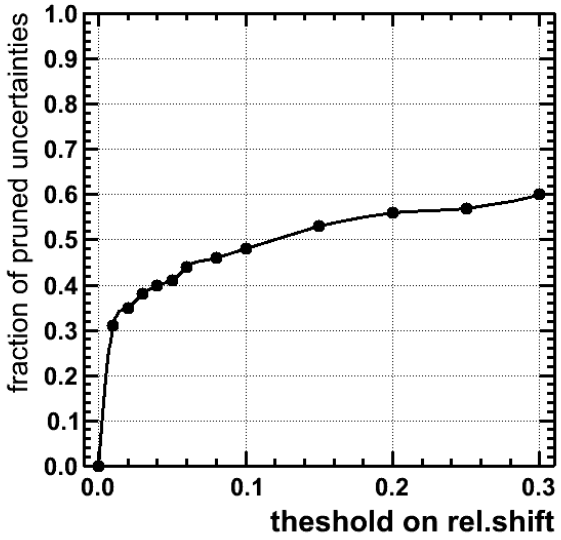
App. ±3.2% stat. uncertainty from 1000 independent toys.

Effects < 3% shifts on limit, < 5 % in significance

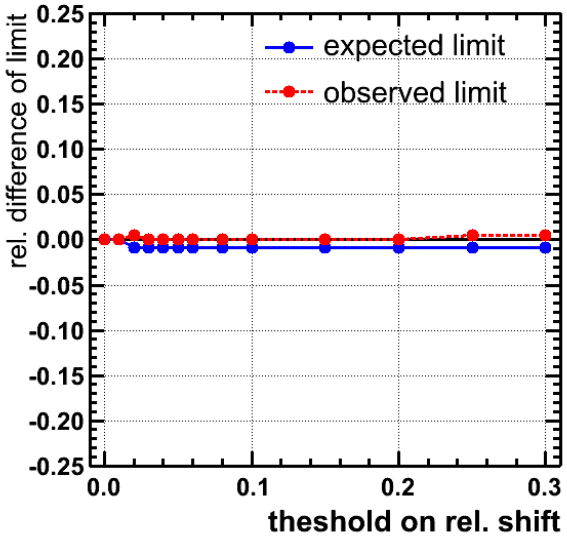
Test of --byShift implementation (w/ 'shielding')

- Checking effects on Limit and (Bayesian) Significance

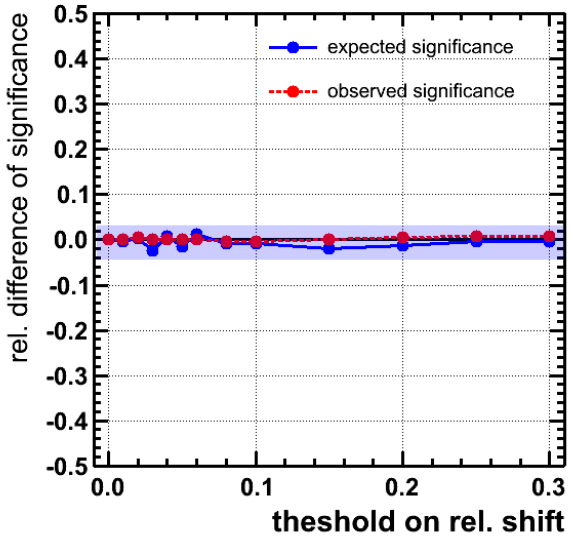
From 689 uncerts.



Limit



Significance



App. ±3.2% stat. uncertainty from 1000 independent toys.

Effects < 1% shifts on limit, < 3 % in significance

Conclusions and actual Status Quo

- Three ways to prune bin-by-bin uncertainties have been implemented and tested.
- Chose pruning --byShift. Biases in the order of 3-5%. „Shielding“ of bins in the signal region does reduce biases on obs. and exp. limit or significance to 1-3%.
- Could go with a fairly high threshold, but it improves the computing performance already a lot to prune just those 10-20% of the nuisance parameters, which do have only a small shift in the fit.

- **Status Quo** (= done for Moriond):
  - Go with --byShift
  - „Shielding“ of 125GeV ±30% window
  - Threshold of 0.3
    - → number of bin-by-bin uncertainties reduces from 689 to 276
    - → Maximum Likelihood fit takes ~2h (down from ~12h)

BACKUP

Bin-by-bin Uncertainties to Hττ Analysis

- For each bin of a histogram add a shape uncertainty by scaling that bin up and down by its statistical error (all other bins stay as they are)
  - 2 additional histograms UP and DOWN
  - Add bin-by-bin if stat uncertainty >10% (>1% for ττ)

- Renormalize the UP and DOWN histograms in respect to the central value histogram

- Tool in HiggsToTauTau package to add bin-by-bin uncertainties: *add_bbb_errors.py* (makes use of add_stat_shapes.py)
  - Check usage from SWGuideHiggs2TauLimits