Signal modeling study for Higgs boson decay to a Z boson and a photon Analysis

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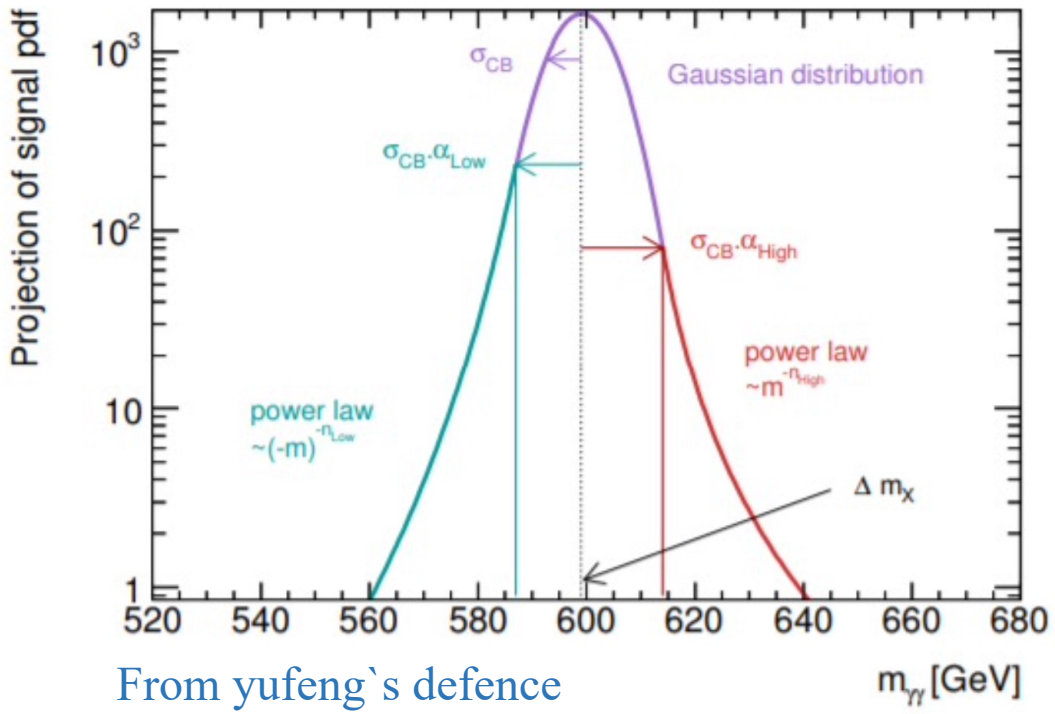
Signal modeling in H to Zγ Analysis

The signal mass distribution for the Higgs boson decay into Zγ is well modelled by a double-sided Crystal Ball (DSCB) function (a Gaussian function with power-law tails on both sides).
The peak position and width of the Gaussian component are represented by μ_{CB} and σ_{CB}, respectively.



From yufeng`s defence

name	Name that identifies the PDF in computations.
title	Title for plotting.
x	The variable of the PDF.
x0	Location parameter of the Gaussian component.
sigmaLR	Width parameter of the Gaussian component.
alphaL	Location of transition to a power law on the left, in standard deviations away from the mean.
nL	Exponent of power-law tail on the left.
alphaR	Location of transition to a power law on the right, in standard deviations away from the mean.
nR	Exponent of power-law tail on the right.

PDF implementing the generalized Asymmetrical Double-Sided Crystall Ball line shape.

$$f(m; m_0, \sigma, \alpha_L, n_L, \alpha_R, n_R) = \begin{cases} A_L \cdot (B_L - \frac{m-m_0}{\sigma_L})^{-n_L}, & \text{for } \frac{m-m_0}{\sigma_L} < -\alpha_L \\ \exp\left(-\frac{1}{2} \cdot \left[\frac{m-m_0}{\sigma_L}\right]^2\right), & \text{for } \frac{m-m_0}{\sigma_L} \leq 0 \\ \exp\left(-\frac{1}{2} \cdot \left[\frac{m-m_0}{\sigma_R}\right]^2\right), & \text{for } \frac{m-m_0}{\sigma_R} \leq \alpha_R \\ A_R \cdot (B_R + \frac{m-m_0}{\sigma_R})^{-n_R}, & \text{otherwise,} \end{cases}$$

times some normalization factor, where

$$A_i = \left(\frac{n_i}{|\alpha_i|}\right)^{n_i} \cdot \exp\left(-\frac{|\alpha_i|^2}{2}\right)$$

$$B_i = \frac{n_i}{|\alpha_i|} - |\alpha_i|$$

Definition at line 13 of file RooCrystalBall.h.

Signal modeling process in HGamCore Framework

```
SignalFunctionalForm:           DoubleCB
# The input file
ResonanceMass:                  125000
InputFile:                      /eos/home-l/liuk/ZgammaAnalysis/run/hist-sample.root
MCtype: mc21a
# Name of the sample (e.g. "ggH", "VBF",... or "SM"). Doesn't affect running.
SampleName:                     ggH
# The analysis luminosity, in pb-1, for normalization of the sample:
Luminosities:                   3200
MassBranchUnits:                GeV
VariableBins:                   0.0 100000000.
CategoryNames:                  Inclusive
#DefinedParams:                 muCBNom sigmaCBNom alphaCB nCB alphaCBLo nCBLo alphaCBHi alphaCBHi nCBHi sigmaG
A fracCB
DefinedParams:                  alphaCBLo
Param_alphaCBLo:                [1.0, 0.1, 5.0]
Param_alphaCBHi:                [1.0, 0.1, 5.0]
```

Signal modeling is performed by HGamCore/HGamTools/util/createSingleSignal.cxx

```
3736    // Double Crystal Ball-specific parameters:
3737    else if (function.Contains("DoubleCB")) {
3738      result.push_back("muCBNom");
3739      result.push_back("sigmaCBNom");
3740      result.push_back("alphaCBLo");
3741      result.push_back("alphaCBHi");
3742      result.push_back("nCBLo");
3743      result.push_back("nCBHi");
3744    }
```

- Signal sample: ggH, H->Z(ll)y
  mc21_13p6TeV.601709.PhPy8EG_PDF4LHC21_ggH_MINLO_Zllgamma.recon.AOD.e8472_s3873_r13829

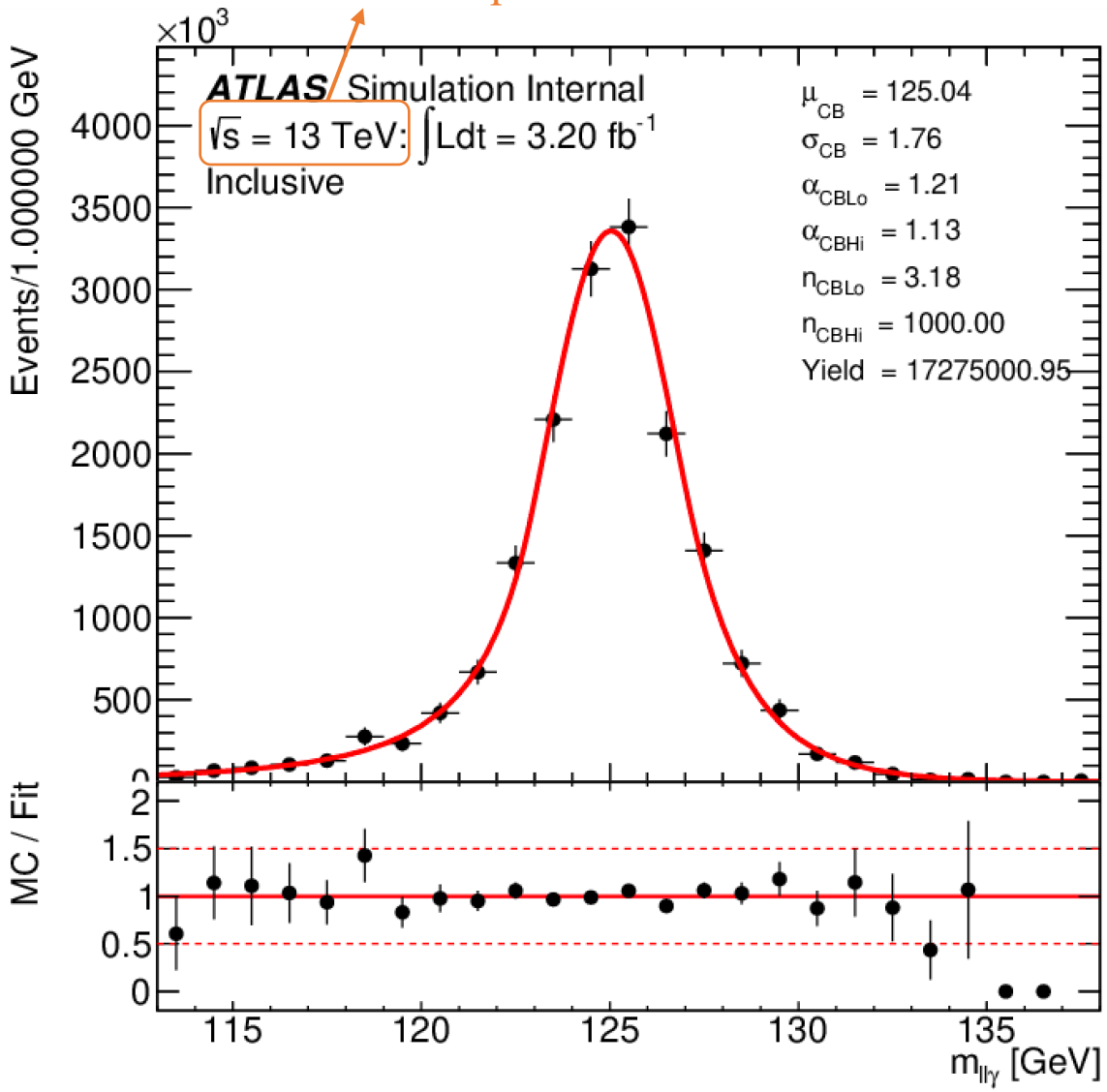
Signal modeling

```
createSingleSignal: Printing parameters for cat 0, mH = 125 GeV
SigParam: Get PDF variables in category = 0 and mass = 125
        alphaCBHi = 1.12577
        alphaCBLo = 1.21037
        muCBNom = 125.035
        nCBHi = 1000
        nCBLo = 3.1802
        sigmaCBNom = 1.7586
createSingleSignal: Removing local copies of inputs.
createSingleSignal: Printing Summary
        Fits that succeeded (1 total)
                mass=125.00 GeV in category 0
        Fits that failed (0 total)
The inclusive signal yield at mH=125 GeV is: SigParam: Get total yield at
 mass = 125
SigParam: Get yield in category = 0 at mass = 125
SigParam: point yield
1.7275e+07 for 3.2 fb-1
```

Output

```
latexTable.txt
plot_singleRes_m125.00_c0.pdf
res_ggH_DoubleCB_workspace.root
resonance_paramList.txt
resonance_yieldList.txt
```

Should be update to 13.6 TeV



Summary and To-Do list

Summary

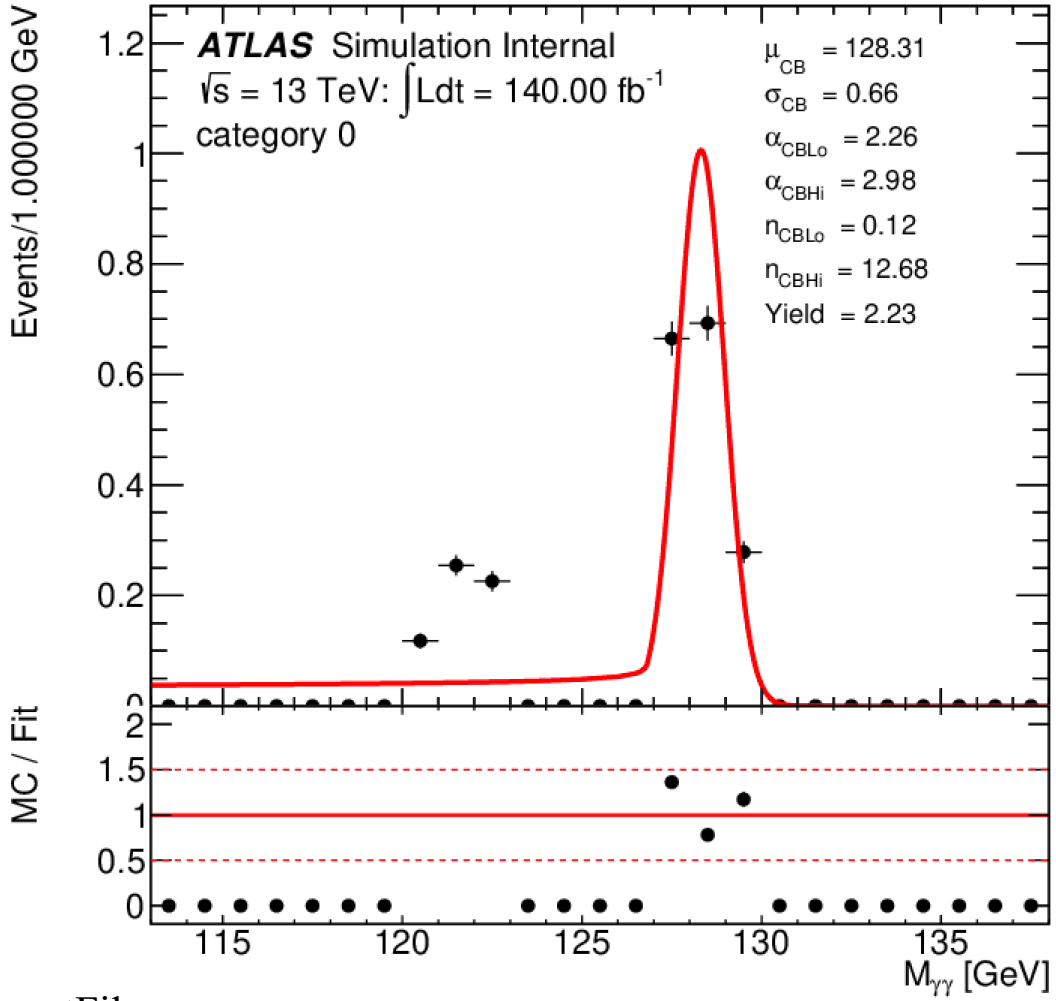
- I have run through the signal modeling code in HGamCore framework.
- Just one ggF ntuple be used to make a fitting attempt.
- Currently, the parameters in cfg only initialize alphaCBHi and alphaCBLo.

To-do list

- Continue to familiarize myself with the fitting code and add more parameters in cfg.
- Fitting the complete ggF MC21 ntuple.

backup

$M_{\gamma\gamma}$ Fitting Test




```
wt 0
mResonance 5005
functionName 0
m_yy_m125000_c0 128.807
m_yy_m125000_c1 125.864
muCBNom_SM_ggZH125_m125000_c0 128.313
sigmaCBNom_SM_ggZH125_m125000_c0 0.658607
alphaCBLo_SM_ggZH125_m125000_c0 2.25919
alphaCBHi_SM_ggZH125_m125000_c0 2.97984
nCBLo_SM_ggZH125_c0 0.122231
nCBHi_SM_ggZH125_c0 12.6757
sigYield_SM_ggZH125_m125000_c0 2.23456
muCBNom_SM_ggZH125_m125000_c1 125.333
sigmaCBNom_SM_ggZH125_m125000_c1 1.15412
alphaCBLo_SM_ggZH125_m125000_c1 2.49695
alphaCBHi_SM_ggZH125_m125000_c1 2.98991
nCBLo_SM_ggZH125_c1 77.348
nCBHi_SM_ggZH125_c1 48.4871
sigYield_SM_ggZH125_m125000_c1 13.5812
```

InputFile:
/eos/atlas/atlascerngroupdisk/physhiggs/HSG1/MxAOD/h029/mc21a/Nominal/mc21a.PhPy8EG_PDF4LHC21_ggZH125_Zincl.MxAODDetailedNoSkim.e8472_s3873_r13829_p5441_h029.root