(CMS France)
Diphotons and resolution

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Context & Outline

Higgs → GammaGamma

Difficult, background-dominated analysis

$\sigma_{Hgg}/\sigma_{QCD} \sim 10^{-9}$
$\sigma_{Hgg}/\sigma_{DIPHOTON} \sim 10^{-4}$

(CMS MC Production at 7 TeV)

High photon energy resolution required to identify small signal peak
→ Steps towards optimisation of the **energy resolution**

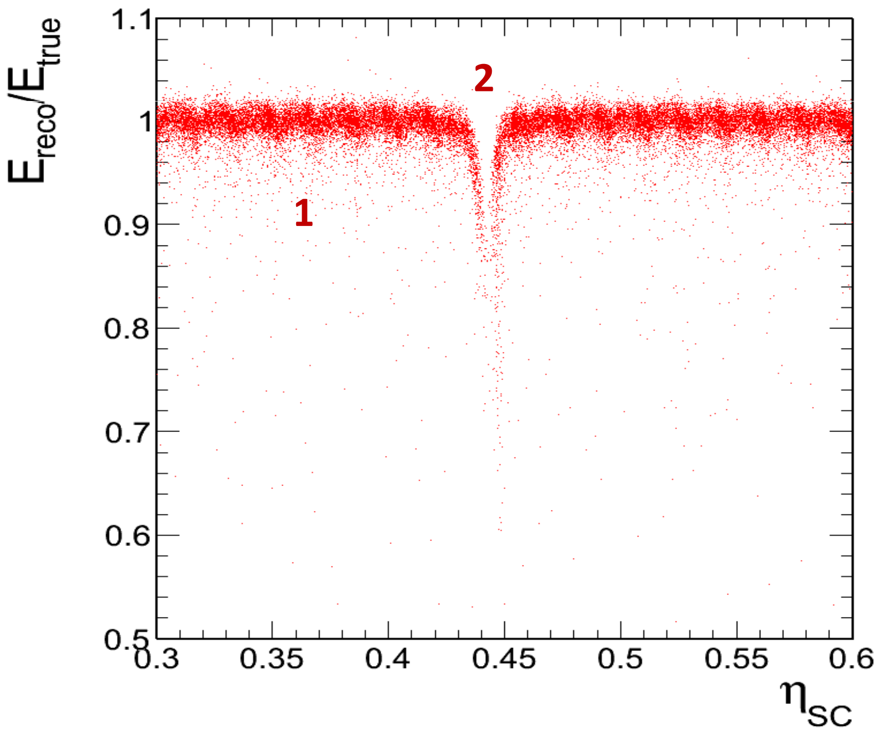
Starts as a diphoton analysis
- Two types of background (prompt diphotons, neutral mesons faking photons) to be studied
- Range of analyses to be performed (SUSY, RS, QED at high energies)

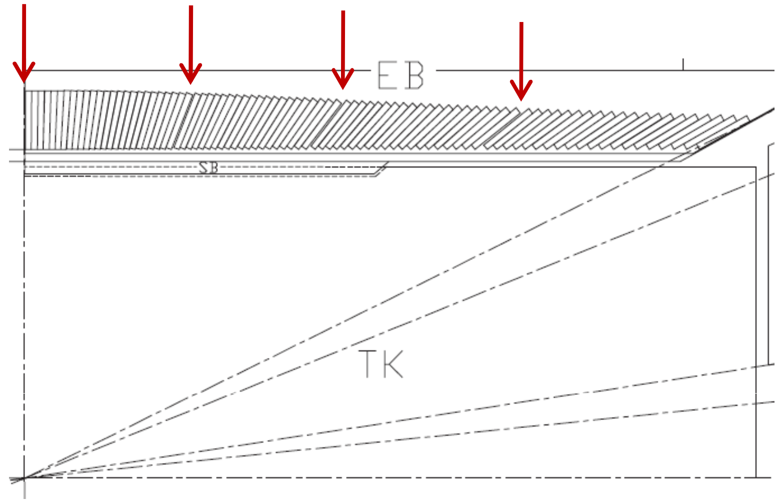
→ Elements of a **diphoton analysis** in CMS

Resolution optimisation

Energy loss

For **unconverted** photons in the **barrel**
Due to :
- intermodule cracks (~7 mm) 1
- variation of the local shower containment of a 5x5 matrix 2





One has:

→ Energy is locally underestimated
→ **Deterioration** of the photon energy resolution

Now:
Suggesting a correction algorithm valid in the **ECAL barrel**

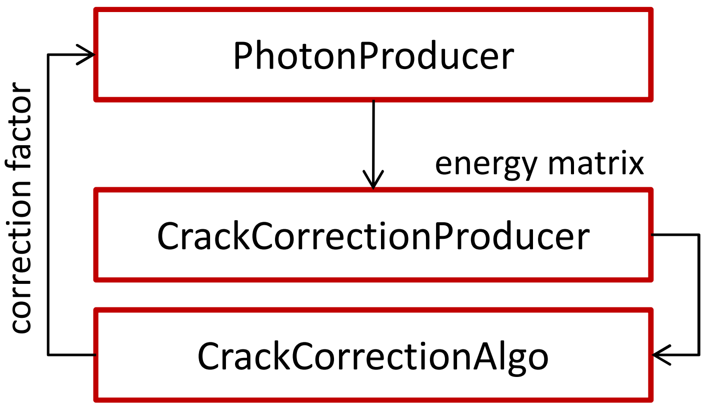
Resolution optimisation

Correction method

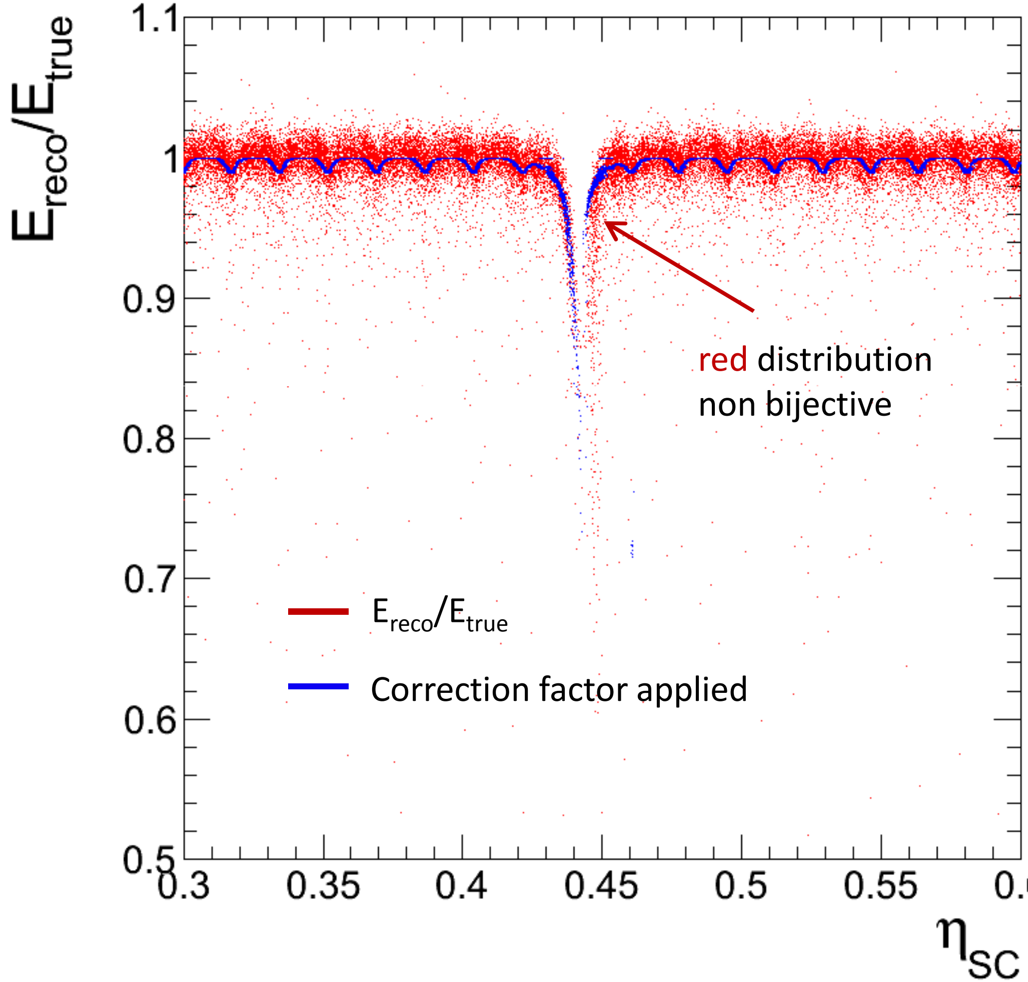
Based on CMS IN2004/007 by E. Locci

- Correction of cracks in η and ϕ are treaded separately
- Impact point is **parametrised** as function of a ratio of crystal energies
- Corrected with a polynomial function fitted on **test beam data and MC**

Implemented in **CMSSW**



NB. Difficulty correcting the right side of the crack.



Resolution optimisation

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Results

Working with photons from
/DiPhotonBox_Pt10to25/Summer09-MC_31X_V3_7TeV_TrackingParticles-v1/GEN-SIM-RECO
Pythia Box Diphotons
pt_hat > 25

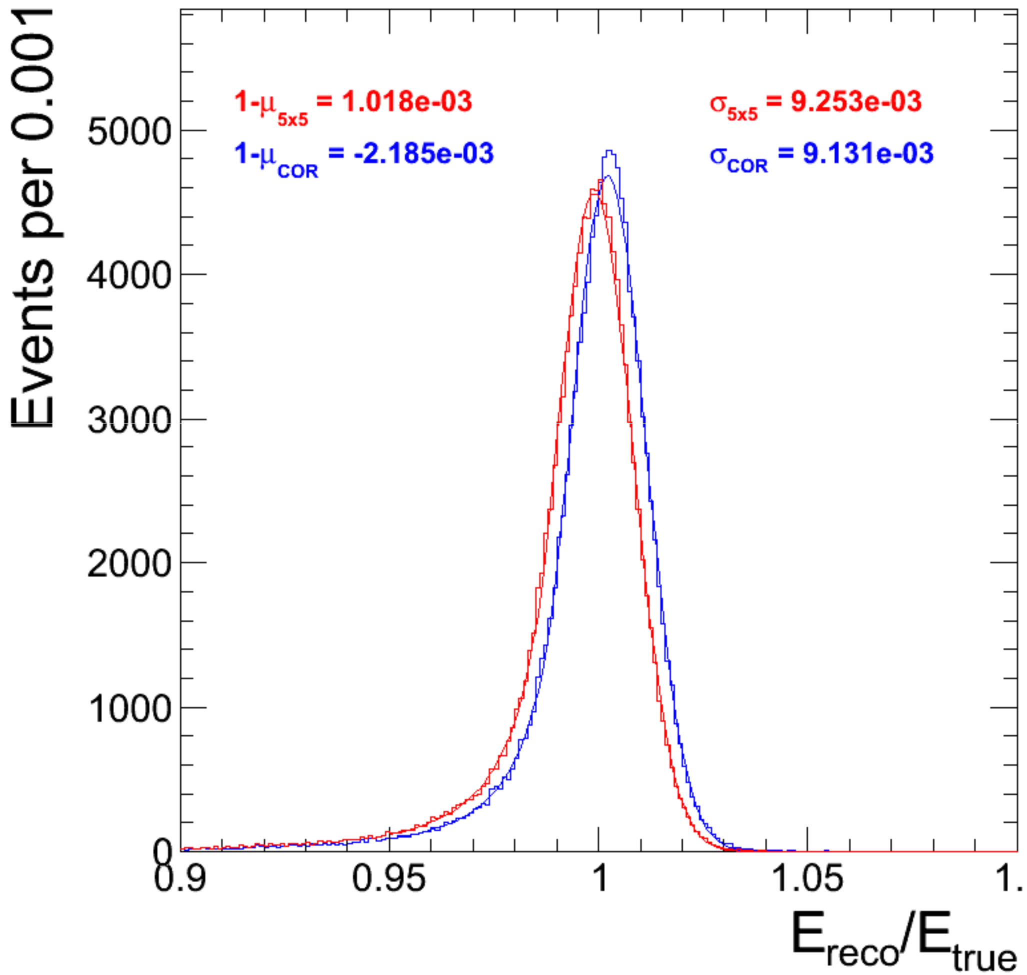
Resolution function before and after correction.

- Improvement not overwealming
(low energy ~25 GeV photons, average on all unconverted photons in the barrel)

- Larger effect within the crack

- CMSSW implementation will be released soon to be tested on a larger scale

→ Final steps in collaboration with Elizabeth and the Lyon group

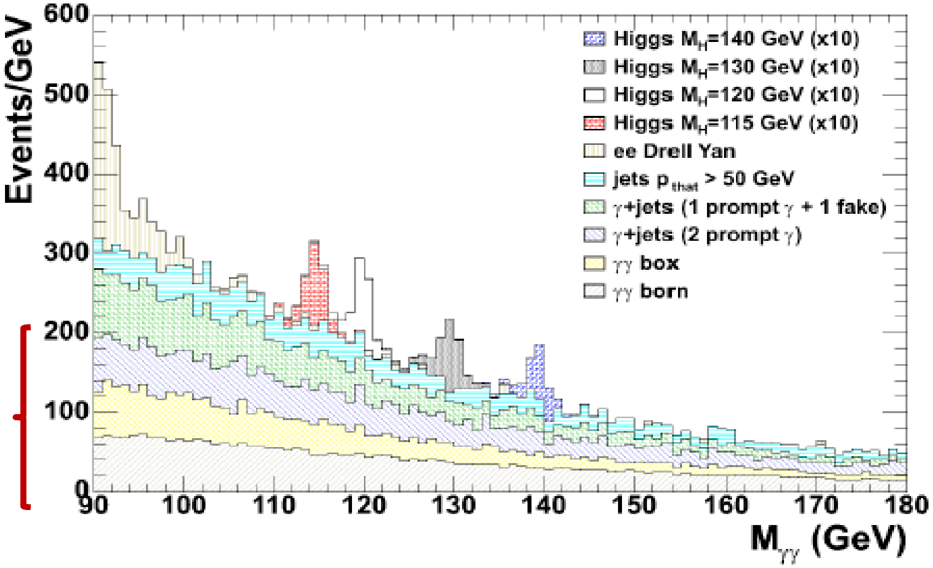


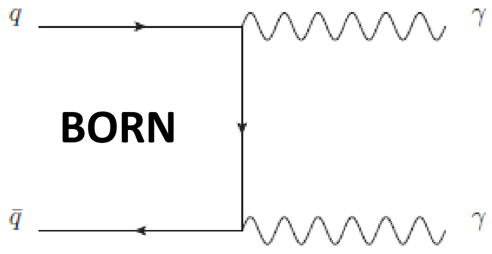
Diphotons

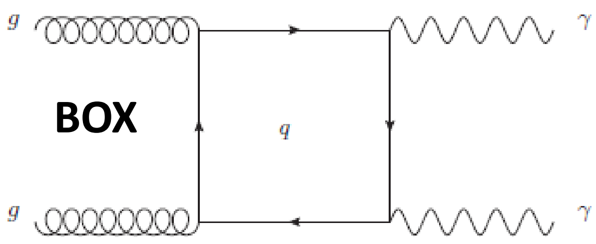
Analysis introduction

Performed within **Suzanne Gascon-Shotkin's** group in QCD Photons
→ Measuring the inclusive cross-section of isolated diphoton events.

In the context of the HtoGammaGamma analysis, the irreducible background.







(FRAGMENTATION)
not treated for the moment

NB.	At the Tevatron	BORN >> BOX
	At the LHC	BORN ~ BOX

Diphotons

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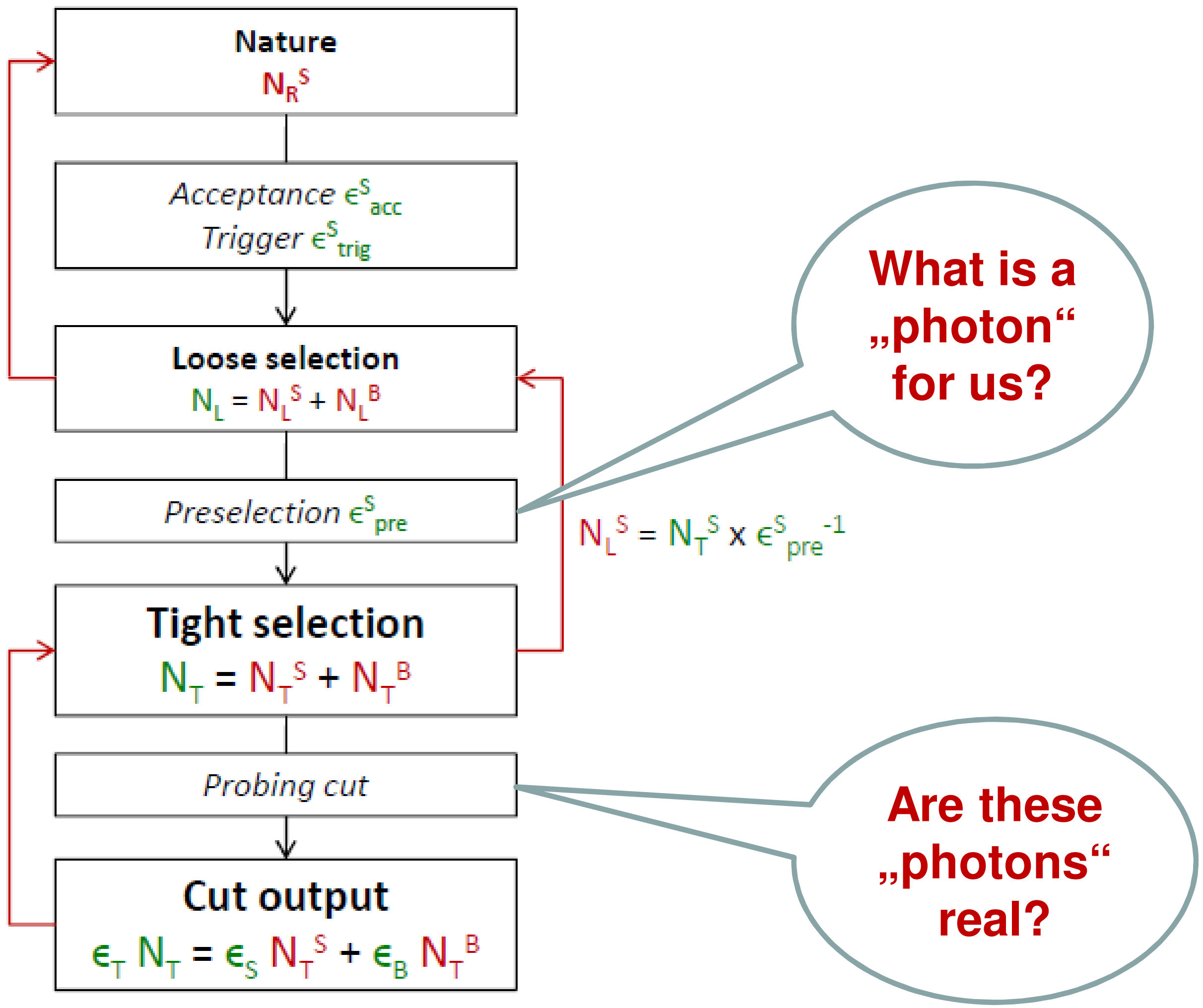
Workflow

ANALYSIS STEPS

Green : know
Red : unknown

$N_R^S = N_L^S \times \epsilon^S_{trig}{}^{-1} \times \epsilon^S_{acc}{}^{-1}$

$$N_T^S = N_T \frac{\epsilon_T - \epsilon_B}{\epsilon_S - \epsilon_B}$$



Diphotons

Errors

$$N_R^S = \frac{N_T}{\epsilon_{pre}^S \times \epsilon_{trig}^S \times \epsilon_{acc}^S} \times \frac{\epsilon_T - \epsilon_B}{\epsilon_S - \epsilon_B}$$

- N_R^S: what we are looking for
- N_T: selected events
- ϵ_T: cut efficiency on selected event (measured)
- ϵ_B: cut efficiency on background (from flipCut)
- ϵ_S: cut efficiency on signal (from tag&probe)
- ϵ_{pre}^S: preselection efficiency (from tag&probe)
- ϵ_{trig}^S: trigger efficiency (from tag&probe)
- ϵ_{acc}^S: acceptance efficiency (from MC)

$$\frac{\delta N_R^S}{N_R^S} = \frac{\delta \epsilon_T}{\epsilon_T - \epsilon_B} \oplus \frac{\delta \epsilon_B}{\epsilon_T - \epsilon_B} \oplus \frac{\delta \epsilon_S}{\epsilon_S - \epsilon_B} \oplus \frac{\delta \epsilon_B}{\epsilon_S - \epsilon_B} \oplus \frac{\delta \epsilon_{pre}^S}{\epsilon_{pre}^S} \oplus \frac{\delta \epsilon_{trig}^S}{\epsilon_{trig}^S} \oplus \frac{\delta \epsilon_{acc}^S}{\epsilon_{acc}^S}$$

contradictory goals, maximising

ϵT - ϵB tight preselection

ϵS - ϵB loose preselection

Preselection: where to place it?

What variables can we select on?

- Isolation variables

ecalIsolation	ecalRecHitSumEtConeDR04
trackIsolation	trkSumPtHollowConeDR04
hcalIsolation	hcalTowerSumEtConeDR04
HoverE	hadronicOverEm

- Showershape variables

sigmaIetaIeta	sigmaIetaIeta
R9	e_{3x3}/e_{SC}

- Other

  angle between photon and second closest jet
  preshower energy (in the endcap)

→ First photon and second photon distributions are **uncorrelated**
→ For the probing, one need variables with **high discrimination power** and **small correlation** to the other variables

Diphotons

Examples of cuts

ANALYSIS STEPS

Green : know
Red : unknown

$N_R^S = N_L^S \times \epsilon^S_{trig}{}^{-1} \times \epsilon^S_{acc}{}^{-1}$

Nature
N_R^S

Acceptance ϵ^S_{acc}
Trigger ϵ^S_{trig}

$|\eta|<2.5$
$E_t > 20$ GeV

such that efficiency is 1
HLT_doublePhoton10 ?

Loose selection
$N_L = N_L^S + N_L^B$

Asking for
2 photons with E_t>20
trkIso<2 ecalIso<3
r9>.92 HoverE<0.001

Preselection ϵ^S_{pre}

$N_L^S = N_T^S \times \epsilon^S_{pre}{}^{-1}$

Tight selection
$N_T = N_T^S + N_T^B$

$$N_T^S = N_T \frac{\epsilon_T - \epsilon_B}{\epsilon_S - \epsilon_B}$$

Probing cut

Using:
hcalIso
sigmaEtaEta

Cut output
$\epsilon_T N_T = \epsilon_S N_T^S + \epsilon_B N_T^B$

Diphotons

Selection

With two datasets
one for **TRAINING** (using MC truth, estimate efficiencies)
and one for **TESTING** (applying est. efficiencies on S&B mixtures)

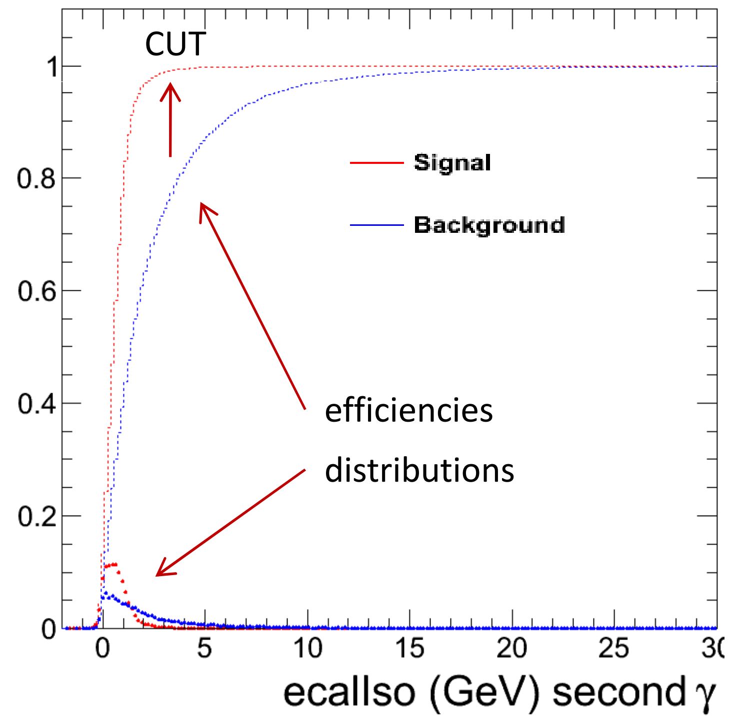
	TRAINING	Eff (%)	deltaEff (%)
nGen	3250		
nTrig	3095	95.2	0.3
nPresel (S)	1075	34.7	0.6
	MC truth	**Pur (%)**	**deltaPur (%)**
nPres (B)	7031	13.3	2.0

	TESTING
nPresel (S+B)	7201
nPresel (Signal)	955 ± 141
nGen (prediction)	2891 ± 426
nGen (MC truth)	3182

Compatible.

SAMPLES USED (Summer09 @ 7 TeV)
- Diphotons BOX
- Diphotons BORN
- Gamma + Jet
- QCD EM Enriched

ECAL ISO as example of selection variable



Conclusions

Example

CDF 2005 diphoton paper
With 207 pb^{-1} at 1.96 TeV
Final 427 ± 59 signal events
We expect ~1000 signal events
Analysis can be performed with 100 pb^{-1}

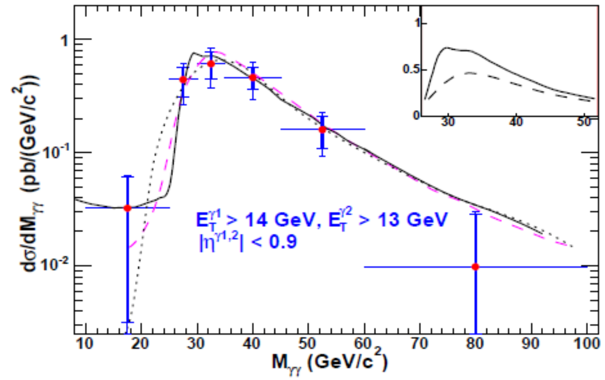


FIG. 1: The $\gamma\gamma$ mass distribution from the CDF Run II data, along with predictions from DIPHOX (solid), ResBos (dashed), and PYTHIA (dotted). The PYTHIA predictions have been scaled by a factor of 2. The inset shows, on a linear scale, the total $\gamma\gamma$ cross section in DIPHOX with (solid)/without (dashed) the gg contribution.

Real data

7 TeV data – run 132 440 (4 μb^{-1})
MC predictions: ~70 M in 100pb^{-1} 3 in 4 μb^{-1}
Events found: 0 events
→ Poisson probability of 5 %

Outlook

Lot of work ahead
- Study of fragmentation photons from QCD processes
- Commisionning of the data-driven efficiency searches (Suzanne's presentation)
- Systematic uncertainties
- Differential cross-section: eta, inv. mass, deltaPhi, cosTheta, p_T