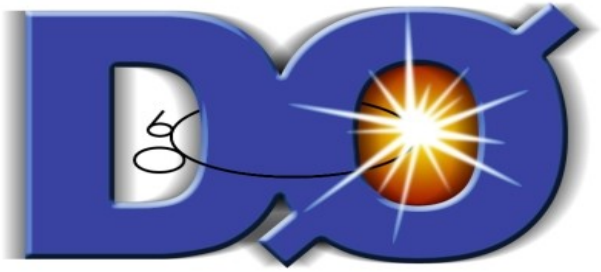


Search for LED in the mono-photon final state with 1 fb^{-1}

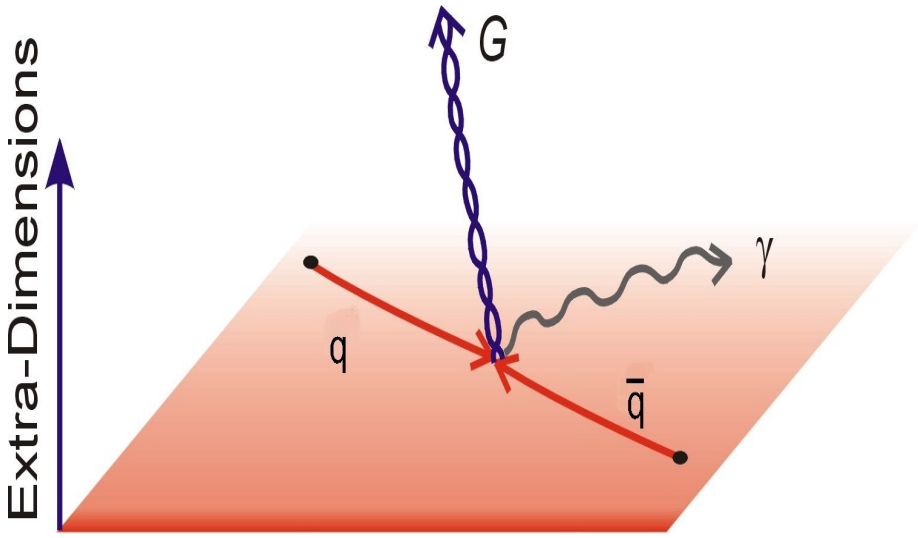
Pheno Symposium

04/29/2008

Edgar Carrera

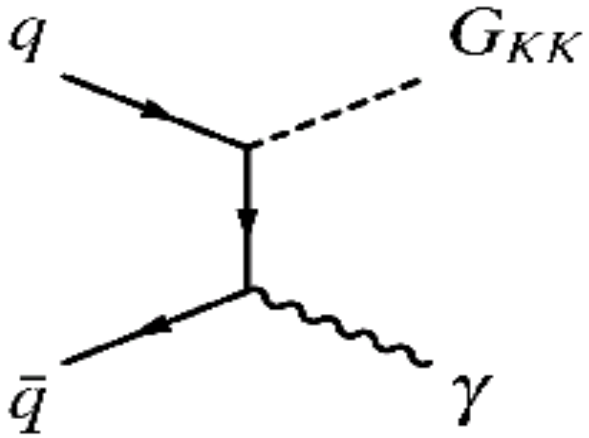
Florida State University

Introduction



- Gravity can be **diluted** in the bulk (compactified extra dimensions).
- The momenta of the gravity field are **quantized**. (Kaluza-Klein modes).

We search for LED studying the exclusive **photon + missing transverse energy** channel.



The distance hierarchy

$$M_{Pl}^2 = 8\pi M_D^{n+2} R^n$$

R = size of extra dimensions
M_{Pl} = effective Planck scale in the 4D space-time
M_D = fundamental Planck scale in the (4+n)D space time

The hierarchy problem is solved (or actually, recast into a distance hierarchy problem)

For M_D = 1 TeV:

n = 1, R ~ 10^{13} cm (solar system)
n = 2, R ~ 1 mm
n = 3, R ~ 1 nm
n = 7, R ~ 1 fm (proton)

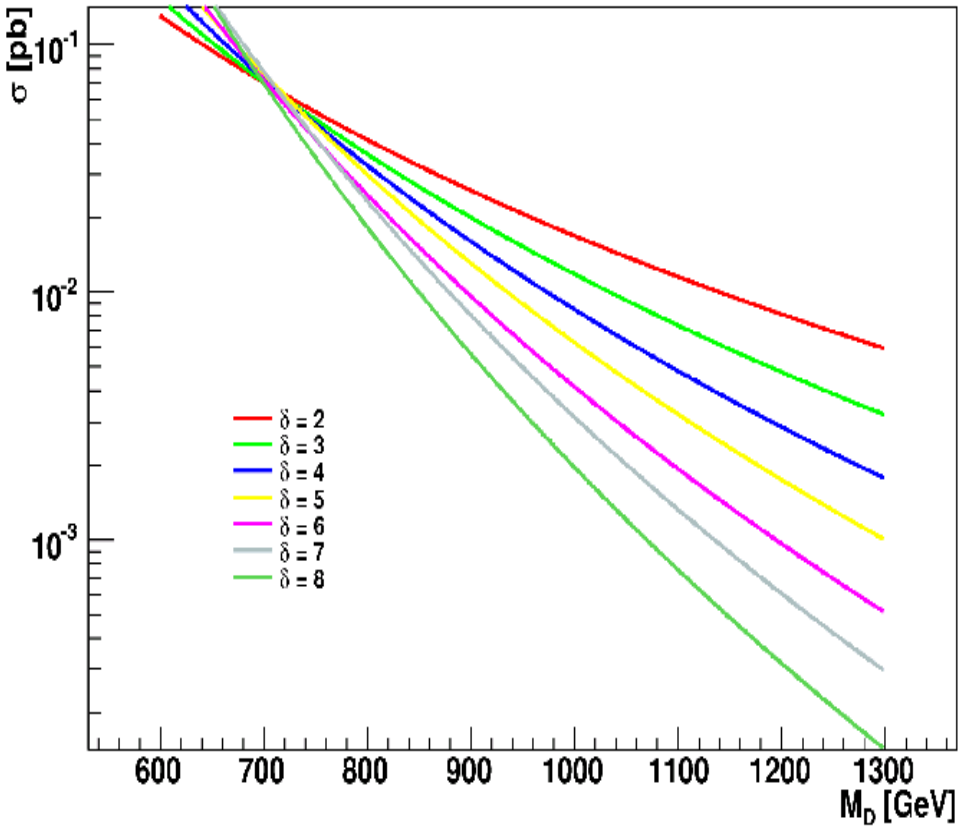
1 TeV^{-1} ~ 10^{-19} m

Signal MC

Signal process:

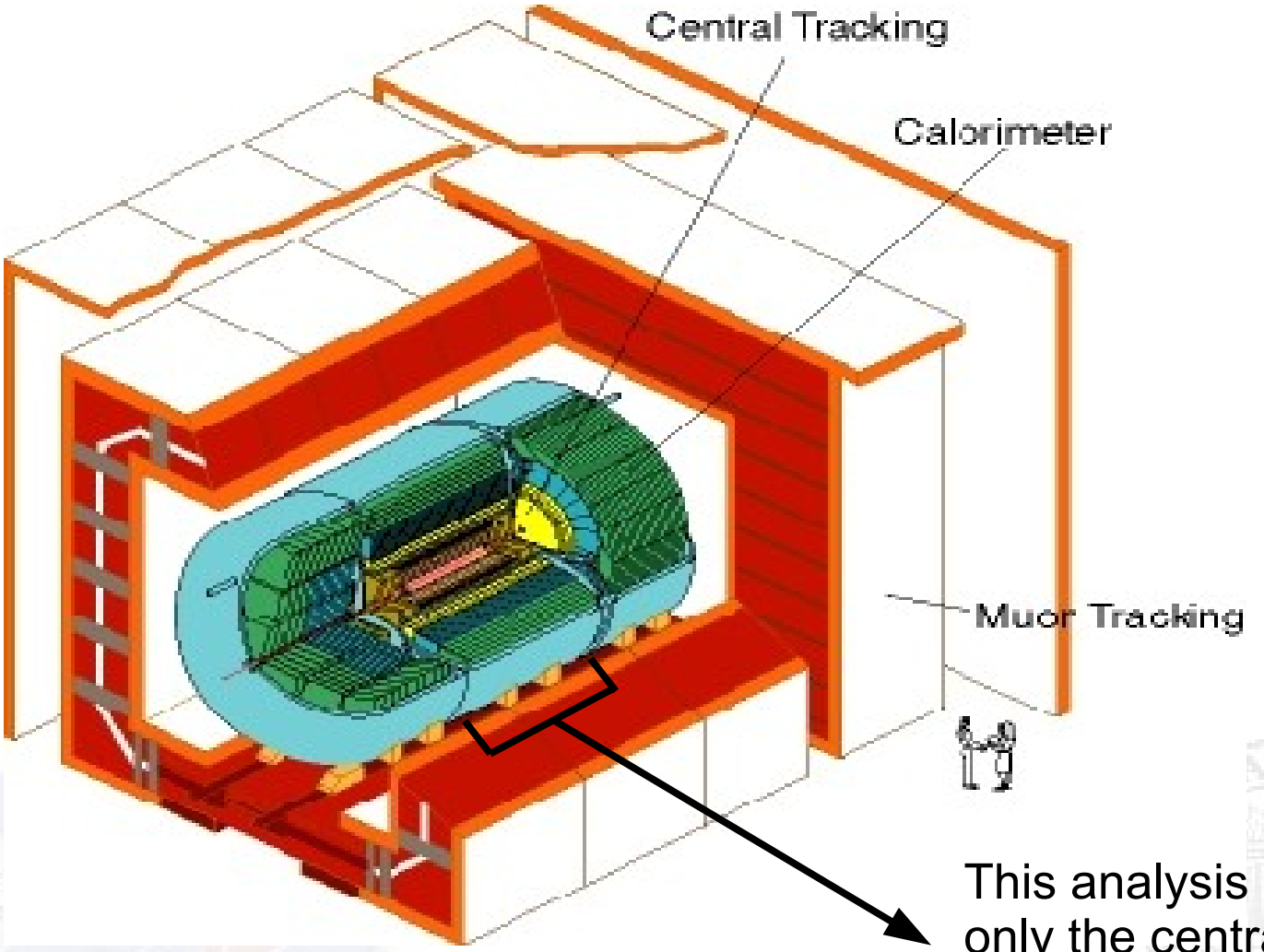
$$q\bar{q} \rightarrow \gamma + G_{KK}$$

- Generated using PYTHIA* for n = 2 to n =8, at M_D = 1.5 TeV.
- Kinematics independent of M_D for a fixed number of extra dimensions.
- The cross section in this case scales as $1/M_D^{n+2}$



* Stephen Mrenna, private communications.

D0 Detector



This analysis uses only the central region $|\eta| < 1.1$

Background sources and data samples

Physics Background: $Z+\gamma \rightarrow \nu\bar{\nu}+\gamma$

An excess in events could also indicate the presence of anomalous ZZγ couplings.

Instrumental Backgrounds:

large cosmic muons + halo particles background (non−collision)

$W \rightarrow e\nu$	*Electron misidentified as a photon*
$W+\gamma \rightarrow l\nu+\gamma$	*Lepton is lost*
W/Z + jet production	*Jet misidentified as a photon*

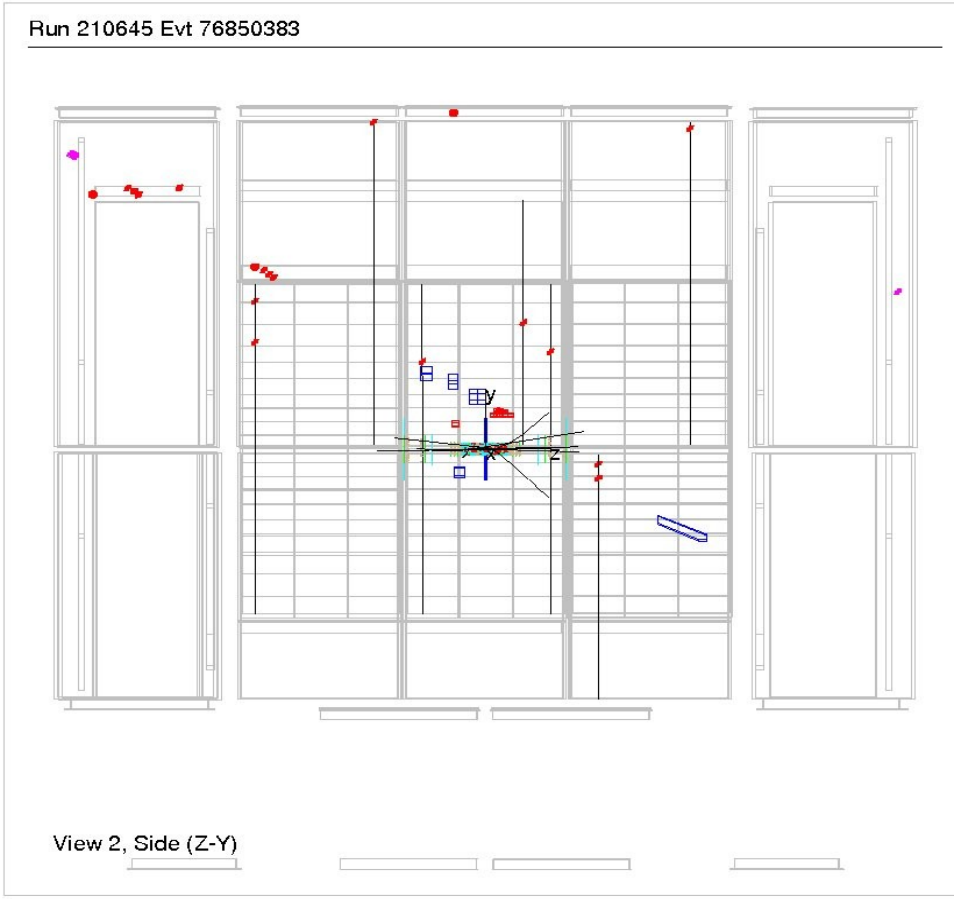
Selection:

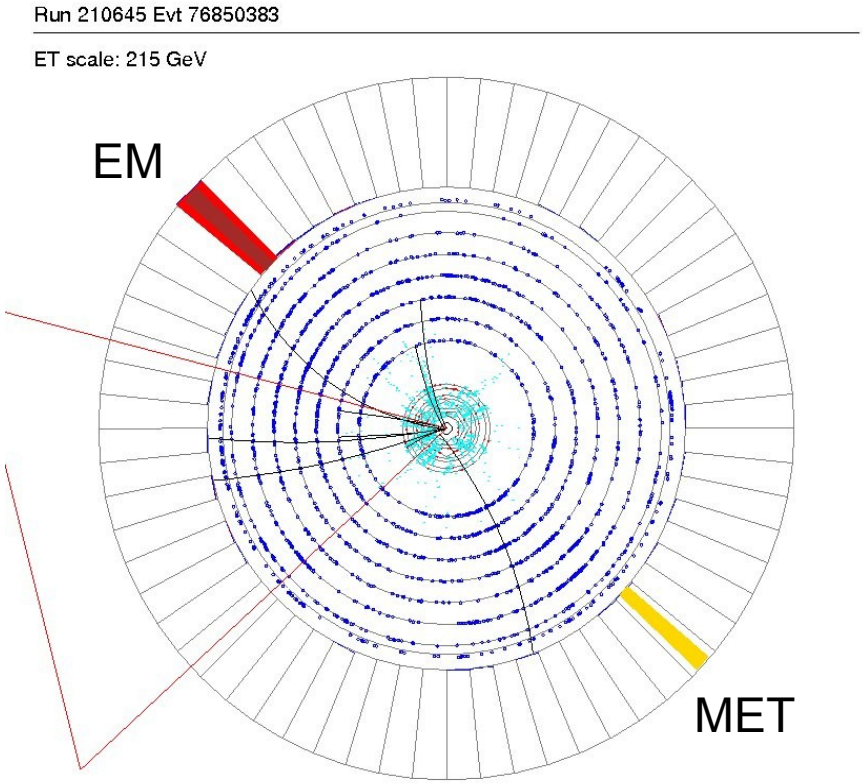
We prepare the ***PHOTON SAMPLE*** by selecting events with:

- Only one central photon with **pT > 90 GeV** (cluster isolated in the calorimeter and tracker, no track matched to it; topological cuts applied to reduce non-collision background.)
- Missing transverse energy **MET > 70 GeV** (no multijet background)
- No jets with **pT_{jet} > 15 GeV**.
- No events with reconstructed muons, with cosmic ray muons, or energetic isolated tracks.

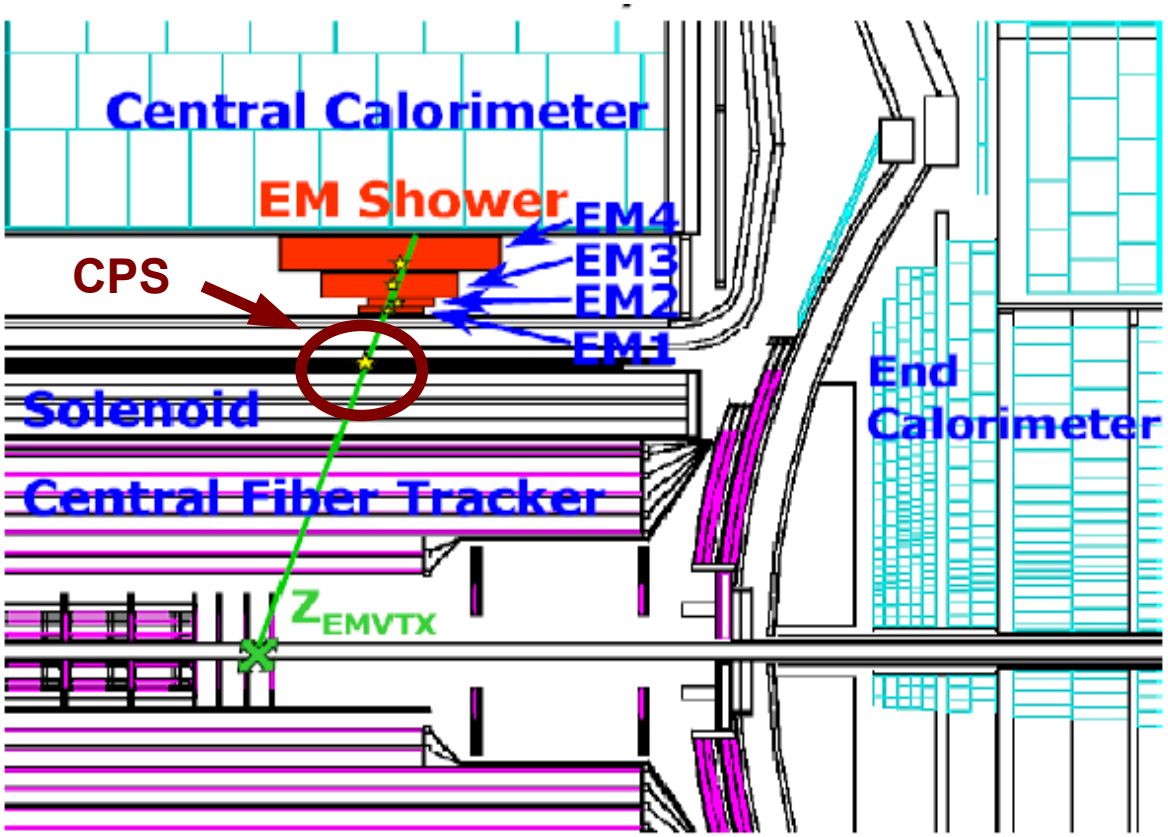
"FAKES" SAMPLE: the isolation in the tracker is reversed

Event display of a cosmic ray event





EM Pointing Algorithm

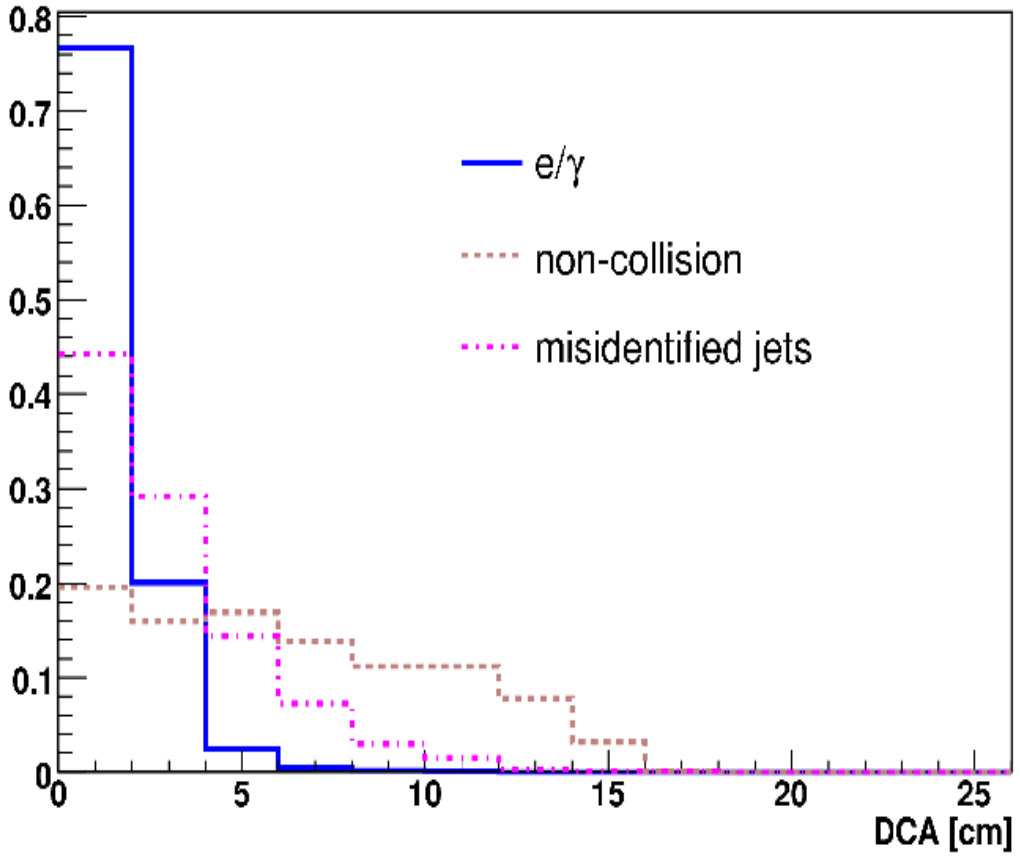


POINTING: calculation of the direction of the EM shower based solely on the central preshower (CPS) and EM calorimeter clusters.

POLAR plane: **z position of vertex**
AZIMUTHAL plane : distance of closest approach to the beam line (**DCA**)

Template construction for additional contributions

- **non-collision template:** (cosmics + halo) extracted from a sample with same kinematic cuts as for photon sample but requiring cosmics ray muons + events with no primary vertex or that have number of tracks < 3
- **misidentified jets template:** extracted from the fake photon sample
- **e/γ template:** extracted from a real data sample of isolated electrons and clean photons from data.



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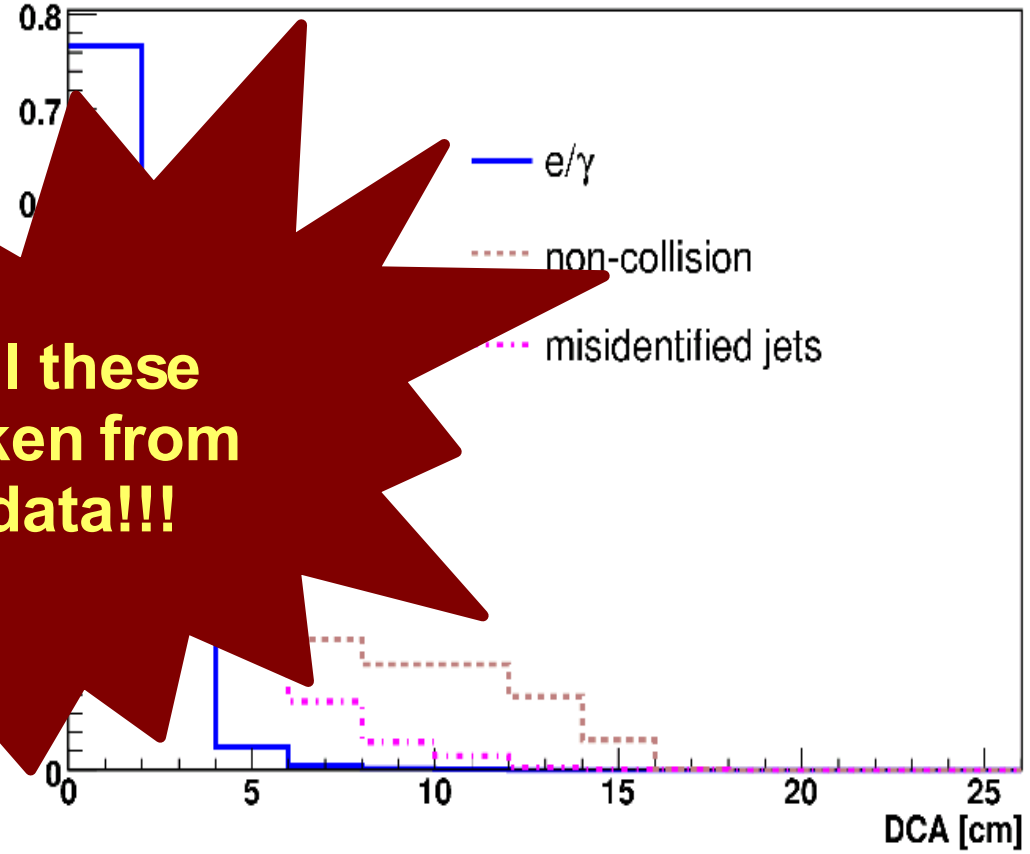
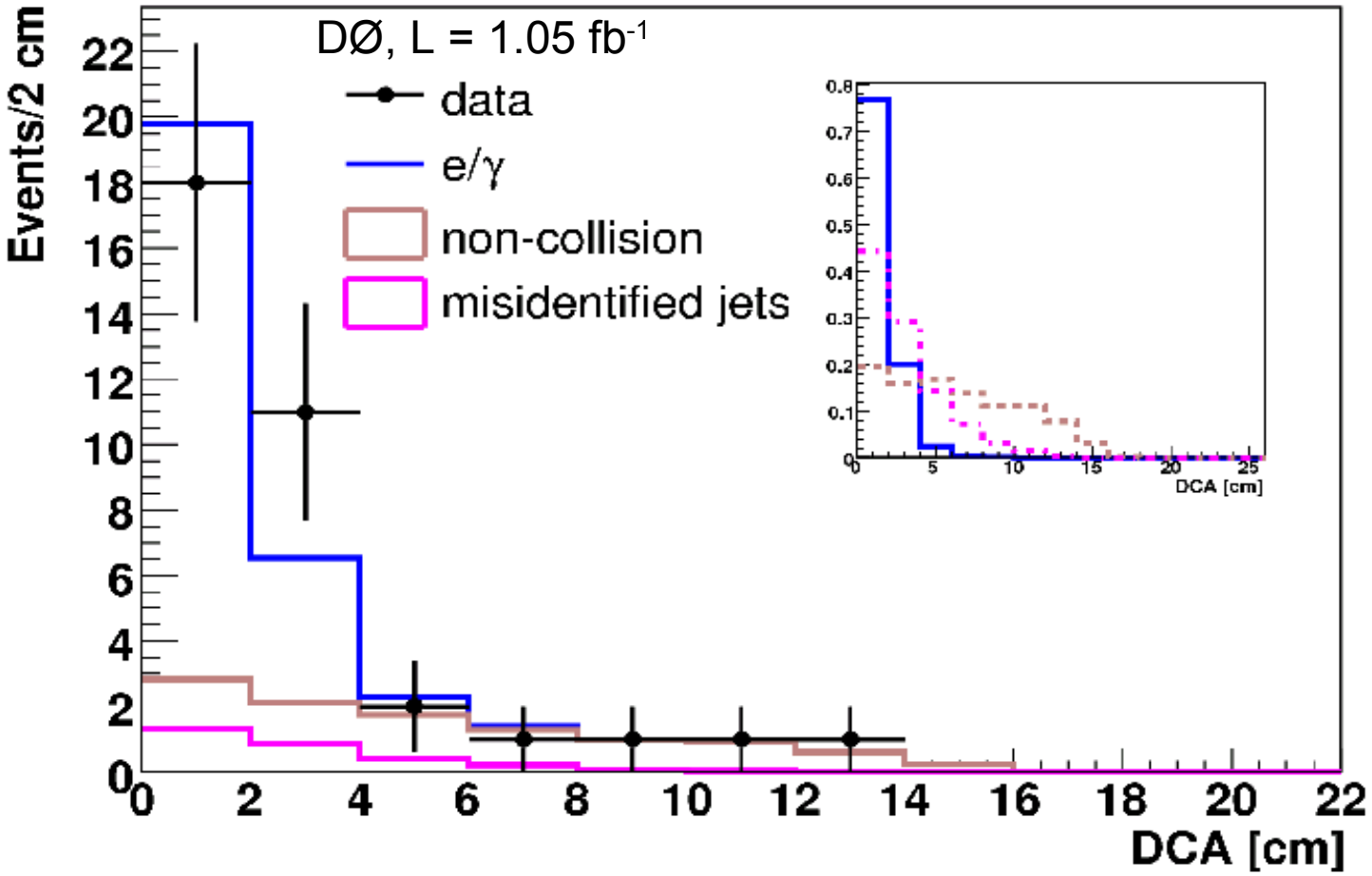


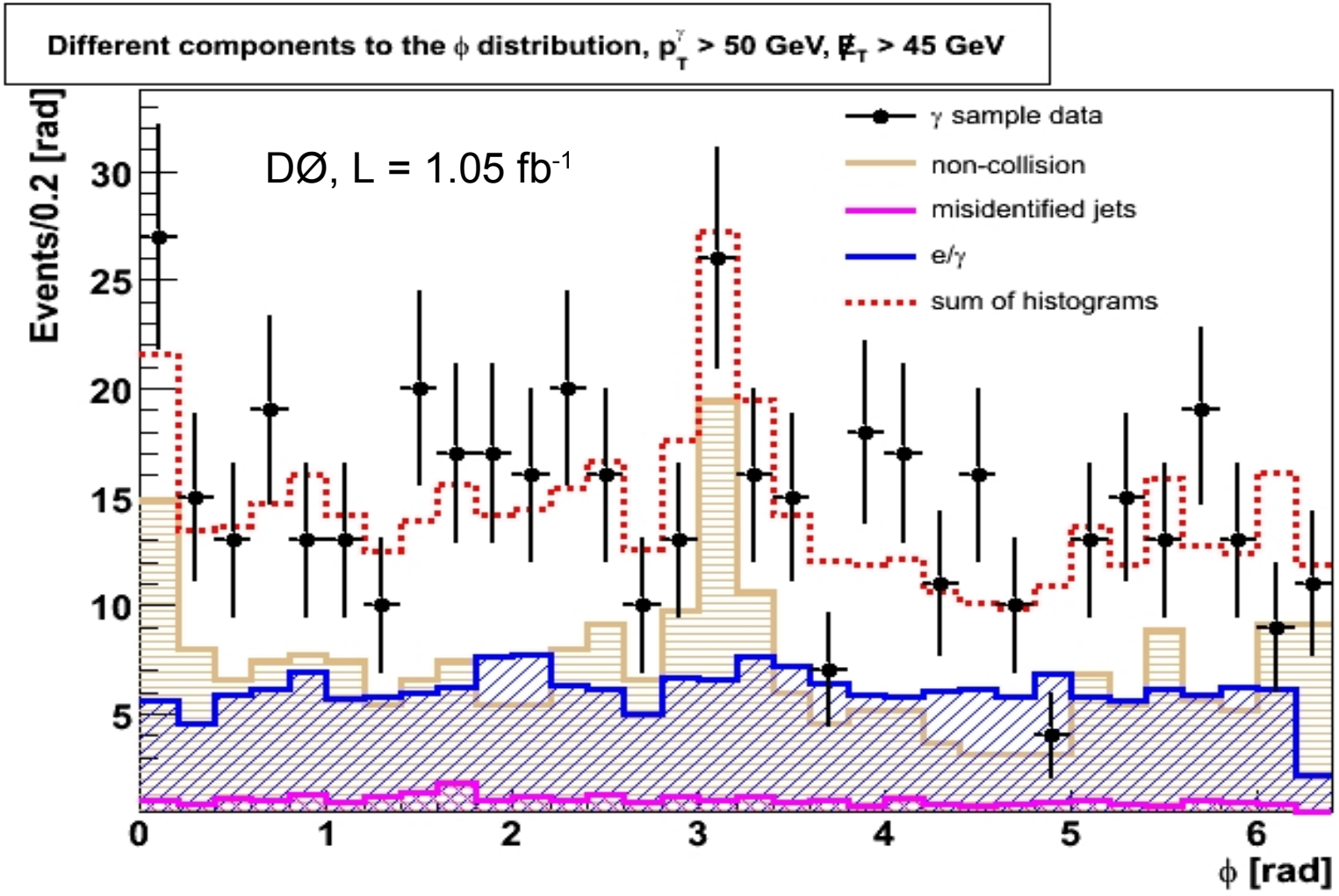
All these taken from data!!!

DCA template fit

We fit the photon sample DCA distribution to a linear sum of the three templates fixing the contribution of misidentified jets from the rate of these objects in a photon + jet events, and determine the e/γ and non-collision contributions.



Photon Sample – Azimuthal distribution



Final counts and systematics

These numbers are **based on the first 2 bins in the DCA fit** plot which practically contain all prompt photons.

TABLE I: Data and estimated backgrounds.

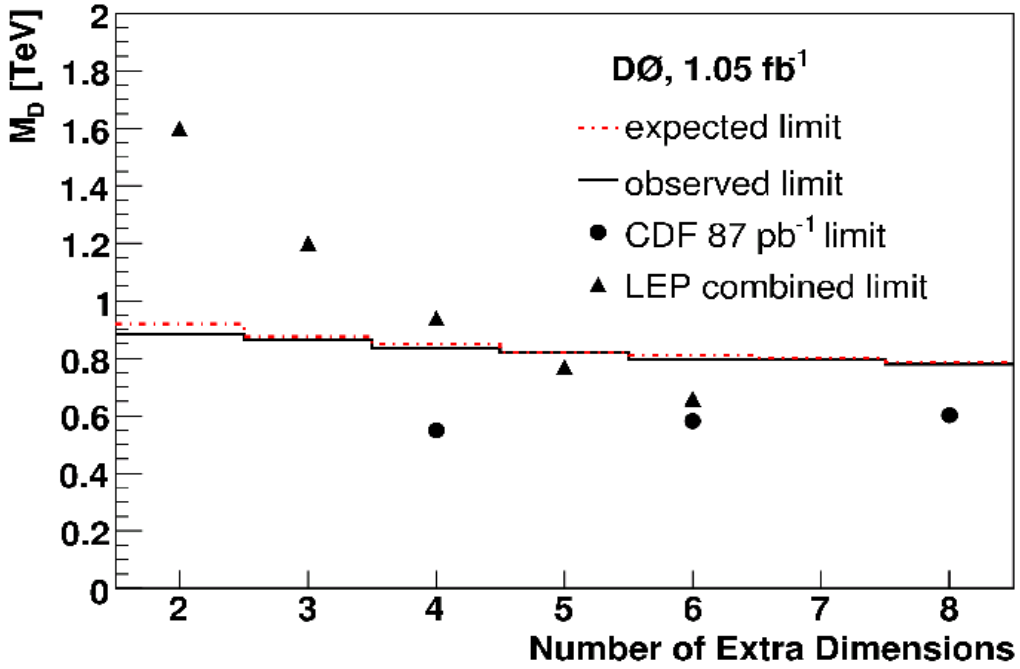
Background	Number of expected events	
$Z + \gamma \rightarrow \nu\overline{\nu} + \gamma$	12.1 ± 1.3	from MC
$W + \gamma$	1.5 ± 0.2	
$W \rightarrow e\nu$	3.8 ± 0.3	from DATA
Non-collision	2.8 ± 1.4	
Misidentified jets	2.2 ± 1.5	
Total Background	22.4 ± 2.5	
Data	29	

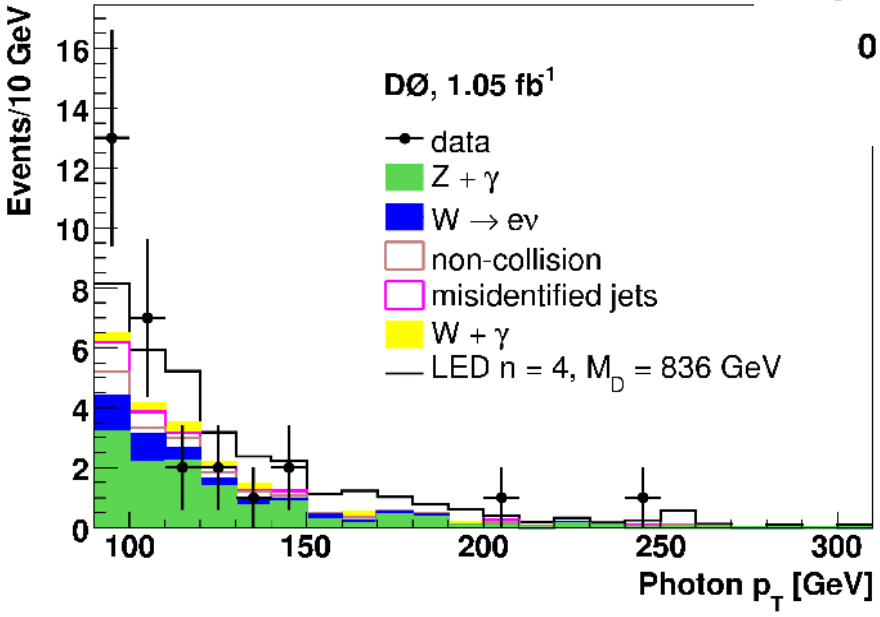
Signal ACCEPTANCE x EFFICIENCY: ~ 50%

SYSTEMATICS: dominated by
- 5% **photon ID**,
- 6.1% **total integrated luminosity,**
- 4% **PDF** uncertainty.
- For MC SM backgrounds, 7% **k-factors**.

Limits

We use a method based on log-likelihood ratio test statistic (modified frequentist approach) to calculate the limits on M_D. We use the binned photon pT distribution.





Photon pT distribution for the final candidate events, after all the applied requirements. The LED signal is stacked on top of the SM backgrounds.

Summary and Conclusions

• Data and SM agree. We do not see any significant excess of events.

• No Large Extra Dimensions discovery :-(

• We set limits on the reduced Planck scale for number of dimensions 2 to 8. We improve latest CDF published limits (n > 4) and LEP combined limits for n > 5.

• arXiv:0803.2137v1 [hep-ex], submitted to PRL.

• This analysis is being updated to include more data.

Backup slides

Misidentifed jets (fakes) normalization

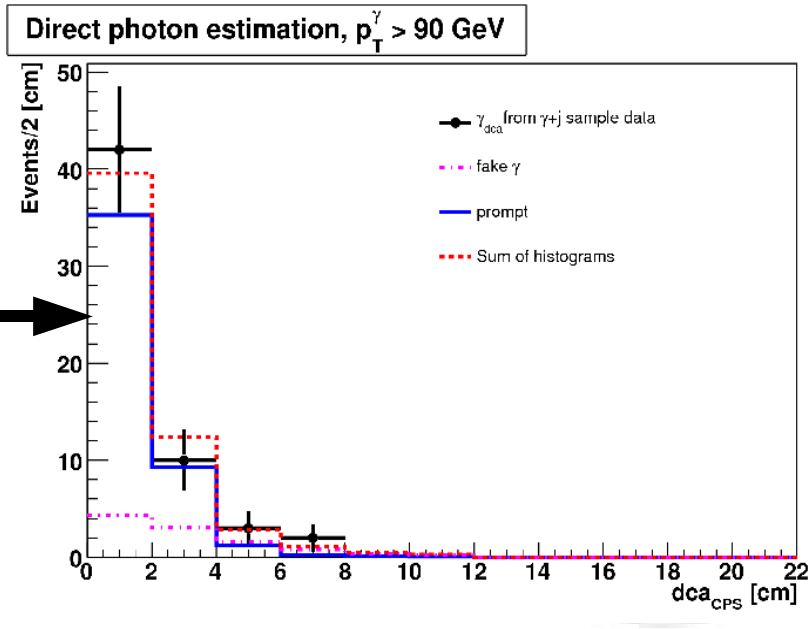
- photon sample: has background events from misidentified jets ($\mathbf{N_{fake}}$)

- fakes sample (inverted track isolation): known number of events $\mathbf{N_0}$

EM + jet

fakes (inverted trk isolation) + jet: $\mathbf{N_1}$

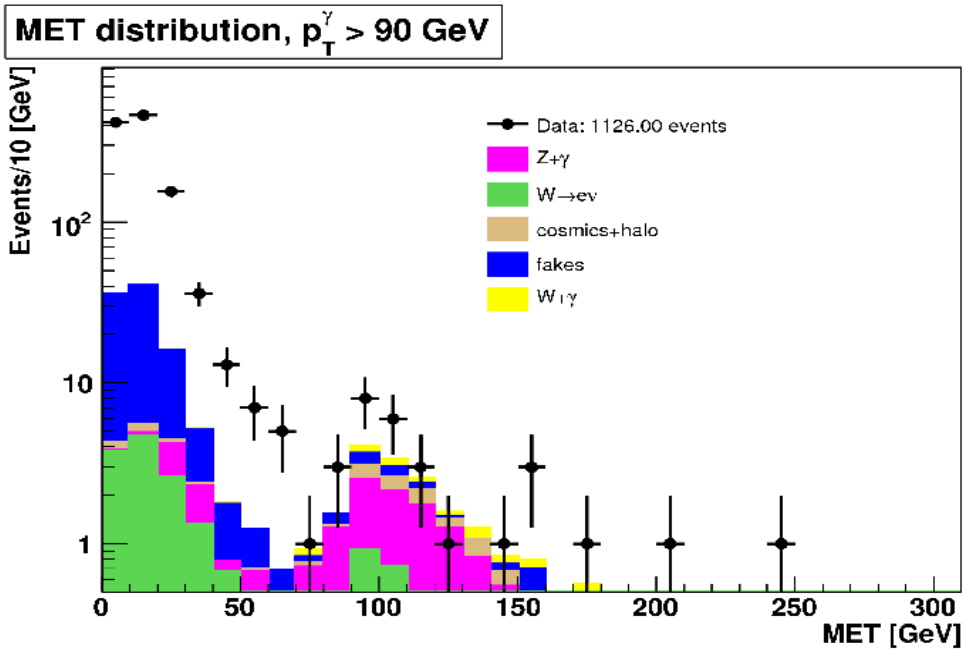
photon + jet: **misid jets $\mathbf{N_2}$?**

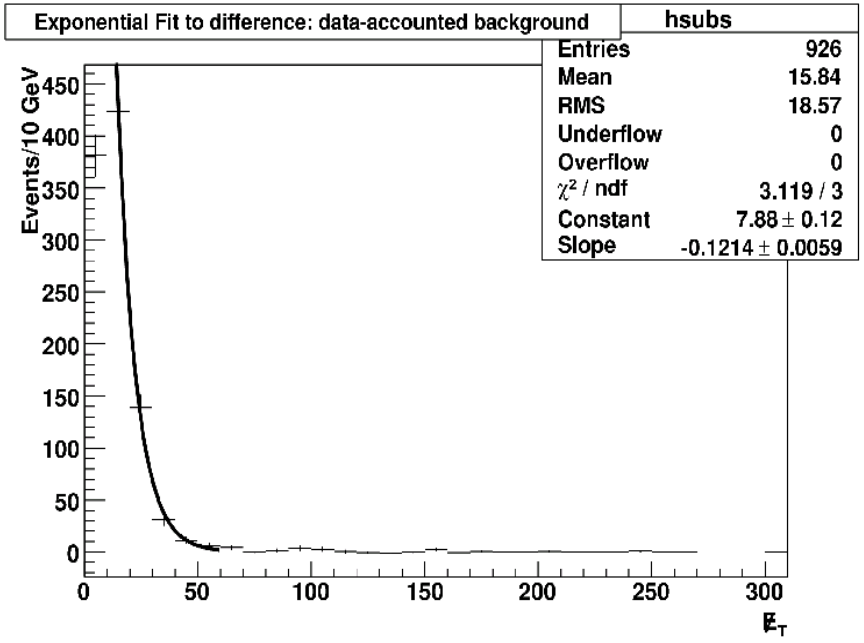


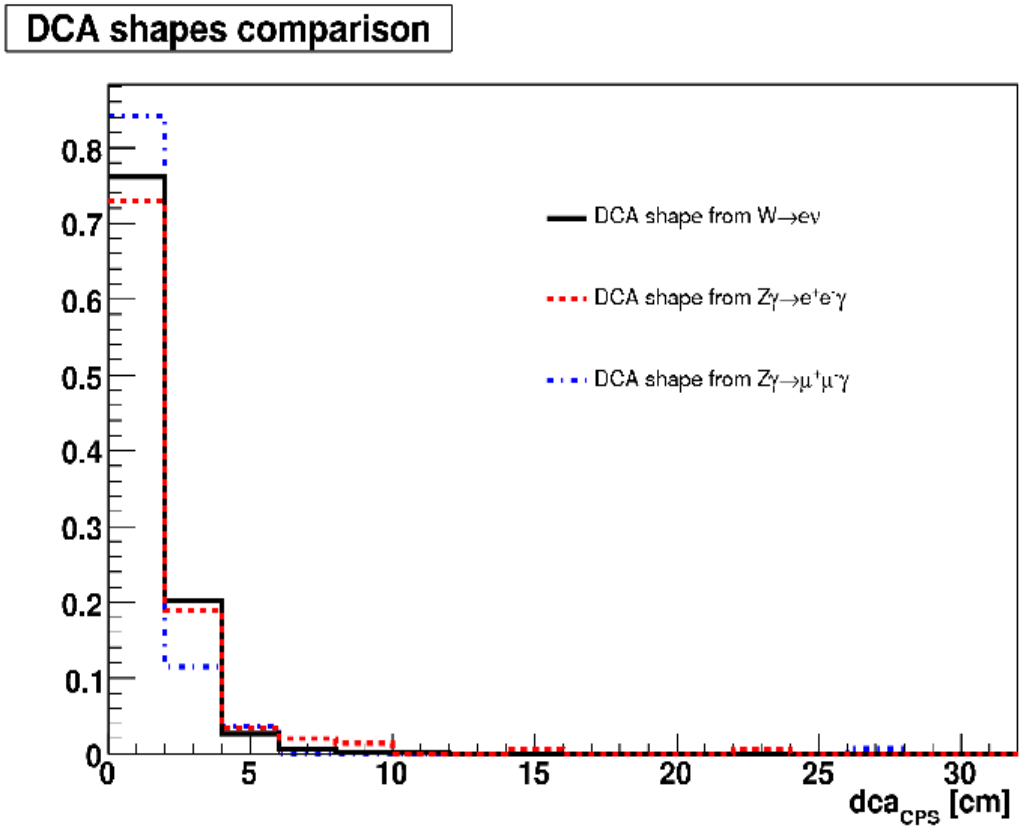
$$N_{fake} = N_0 \times (N_2/N_1)$$

QCD background

• We discard QCD or any other source of background for events with MET>70 GeV by performing an exponential fit on the difference: data – accounted background, after releasing the MET cut in the analysis.





There are no extra backgrounds after requiring MET > 70 GeV.

Shapes comparison