

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

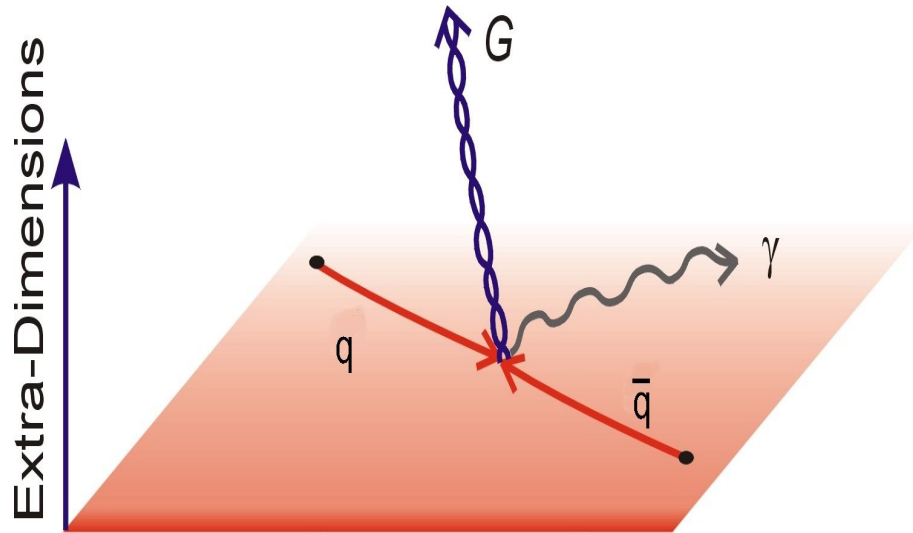
APS April Meeting

04/14/2008

Edgar Carrera

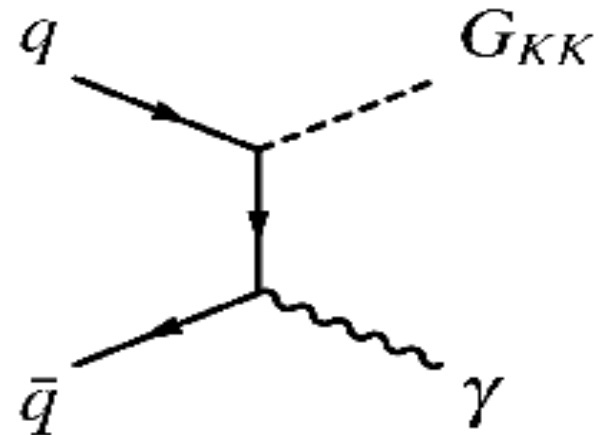


Introduction



- 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} = Planck scale in the 4D space-time
 M_D = Planck scale in the (4+n)D space time

For $M_D = 1$ TeV:

$n = 1$, $R \sim 10^{13}$ cm (solar system)

$n = 2$, $R \sim 1$ mm

$n = 3$, $R \sim 1$ nm

$n = 7$, $R \sim 1$ fm (proton)

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

$$1 \text{ TeV}^{-1} \sim 10^{-19} \text{ m}$$

Background sources and data samples

Signal process: $q\bar{q} \rightarrow \gamma + G_{KK}$

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

An excess in events could also indicate the presence of anomalous $ZZ\gamma$ 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

$W/Z + \text{jet production}$

Jet misidentified as a photon

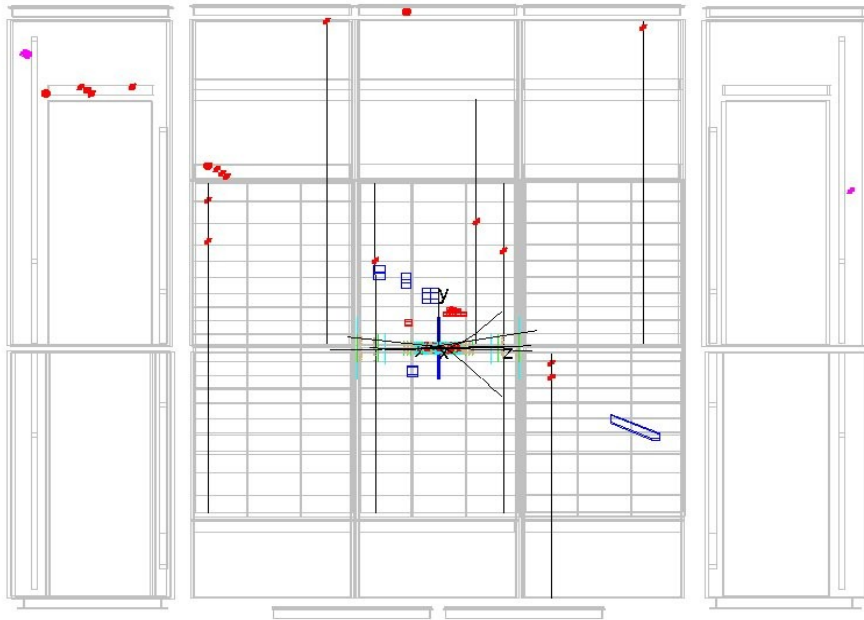
We prepare the **PHOTON SAMPLE** by selecting events with:

- Only one photon (isolated cluster in the calorimeter and tracker, with no track matched) with **pT > 90 GeV**
- Missing transverse energy **MET > 70 GeV** (no multijet background)
- No jets with pT > 15 GeV.
- No events with reconstructed muons, with cosmic ray muons, or energetic isolated tracks.

The **“FAKES” SAMPLE** has the track isolation reversed

Event display of a cosmic ray event

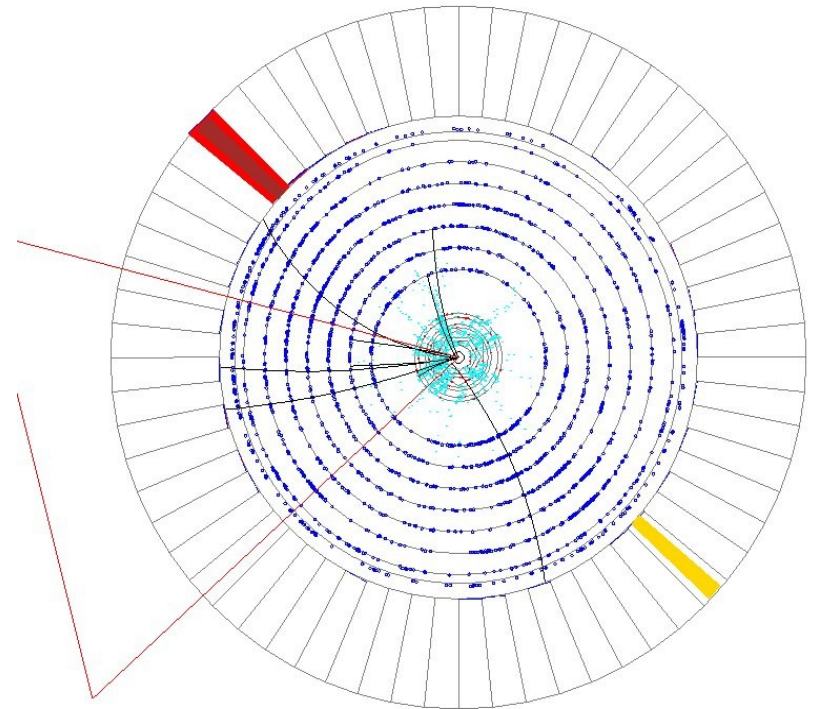
Run 210645 Evt 76850383



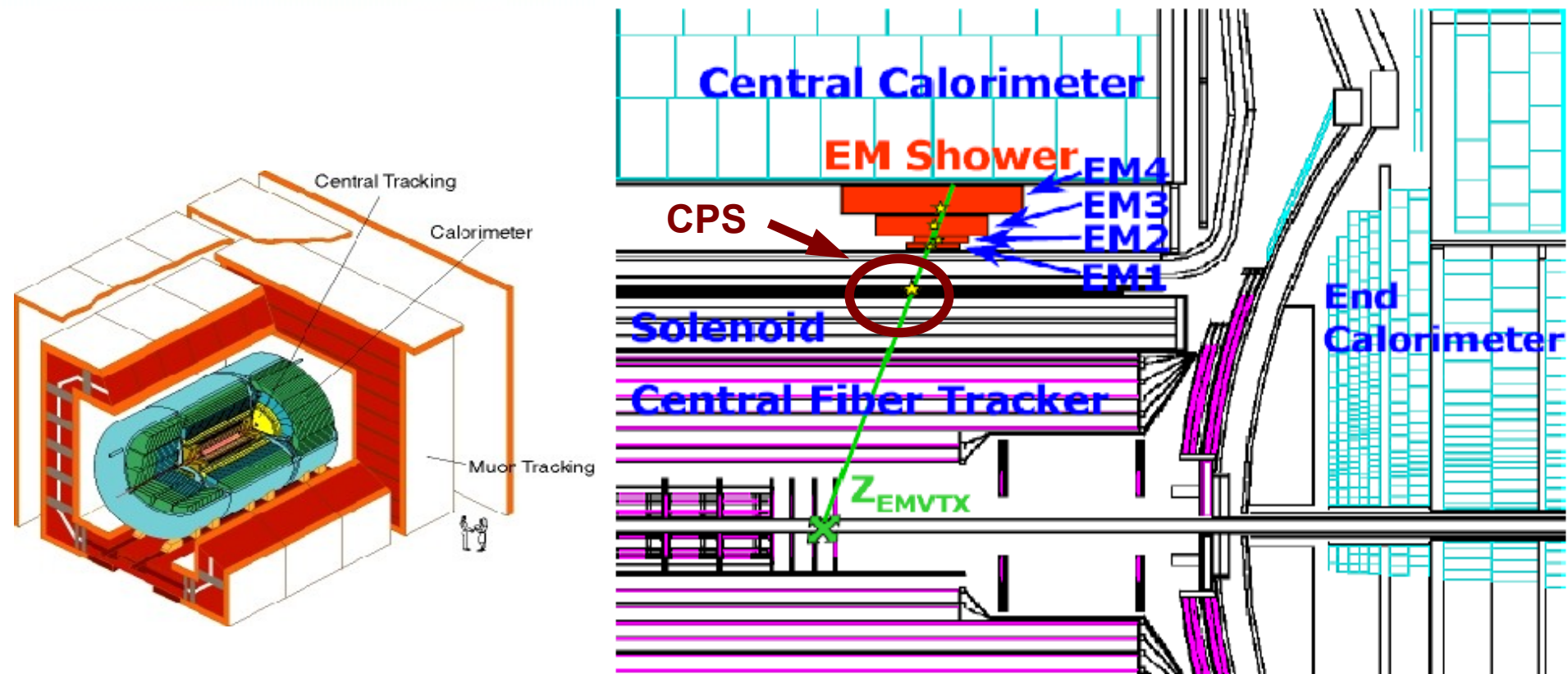
View 2, Side (Z-Y)

Run 210645 Evt 76850383

ET scale: 215 GeV



EM Pointing Algorithm



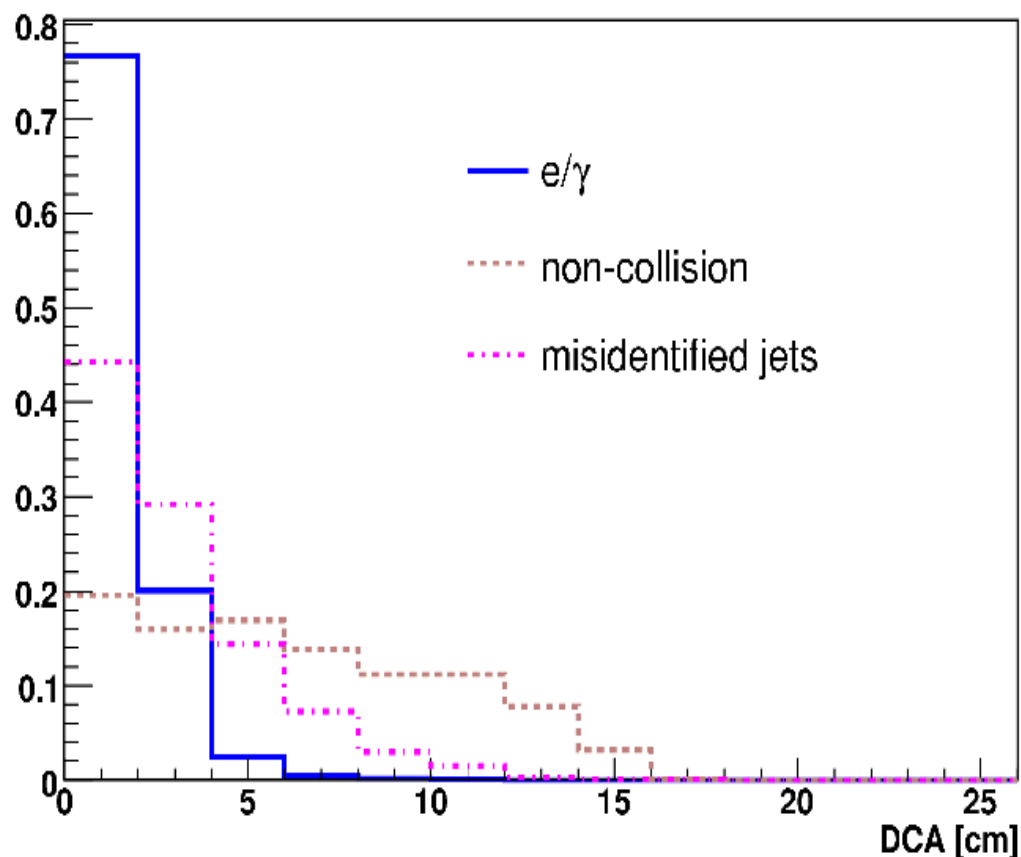
POINTING: calculation of the direction of the EM shower based solely on the central preshower (CPS) and EM calorimeter clusters.

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.



Template construction for additional contributions

- **non-collision template:**

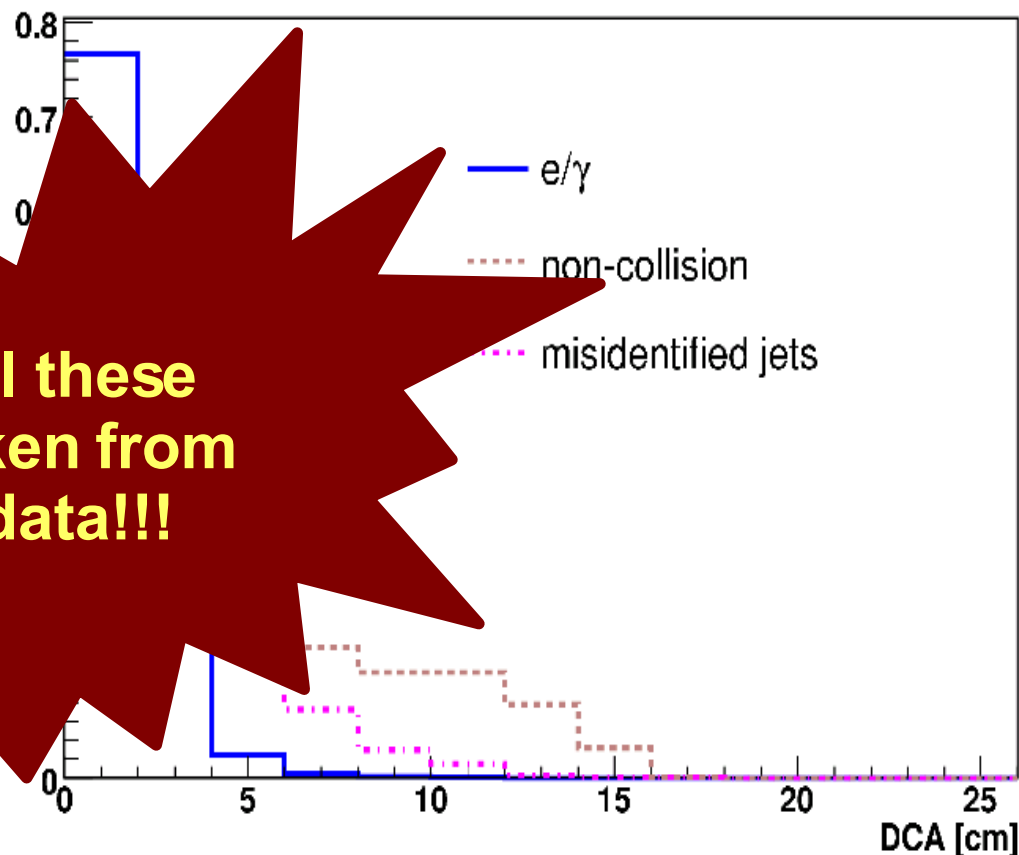
(cosmics + halo)
extracted from a sample with same kinematic cuts as for photon sample but requiring cosmics ray muons + events with no primary vertex or that have number of tracks $<$

- **misidentified jets template:**

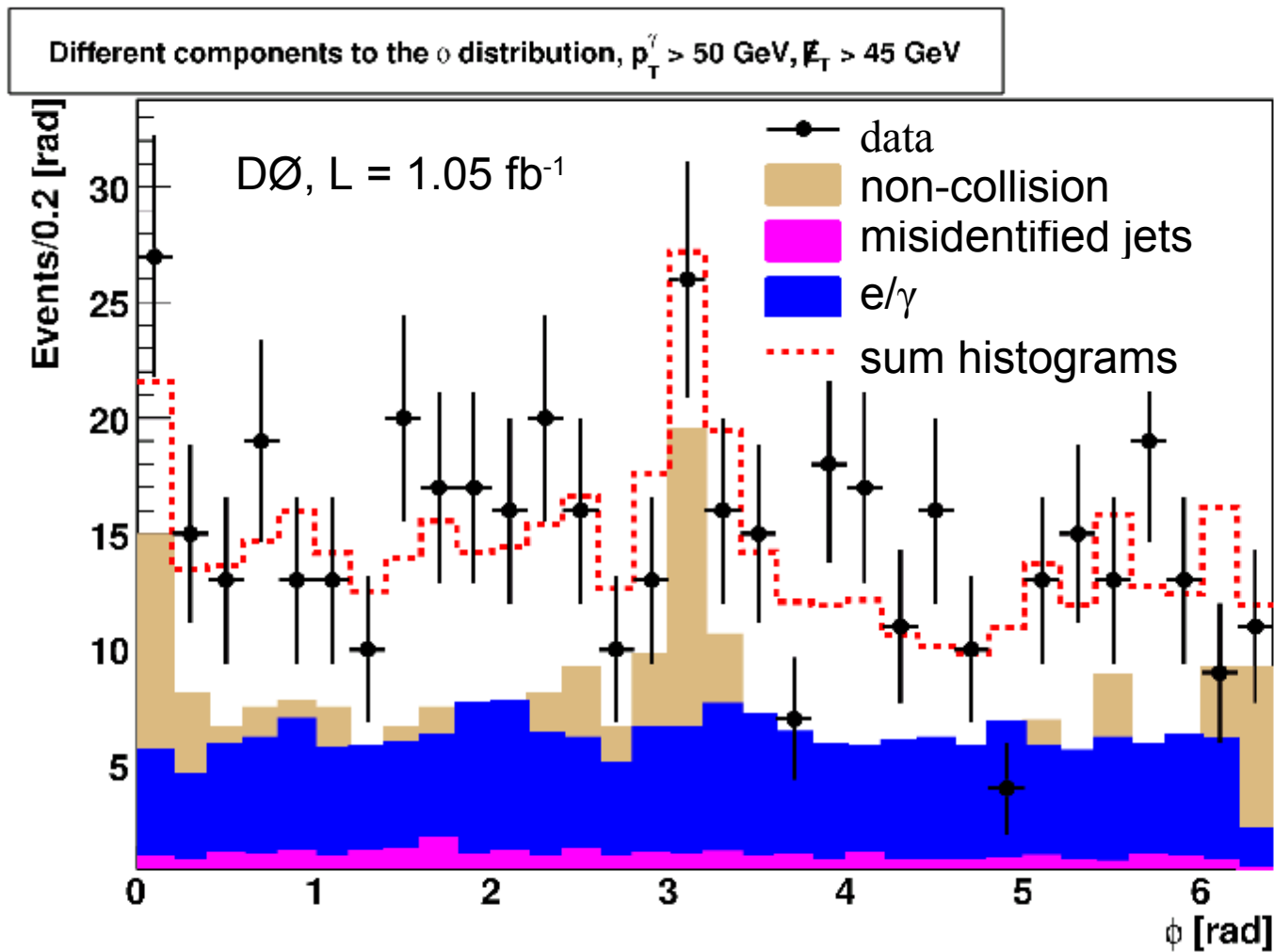
extracted from the false photon sample

- **e/γ template:**

extracted from a real data sample of isolated electrons and clean photons from data.

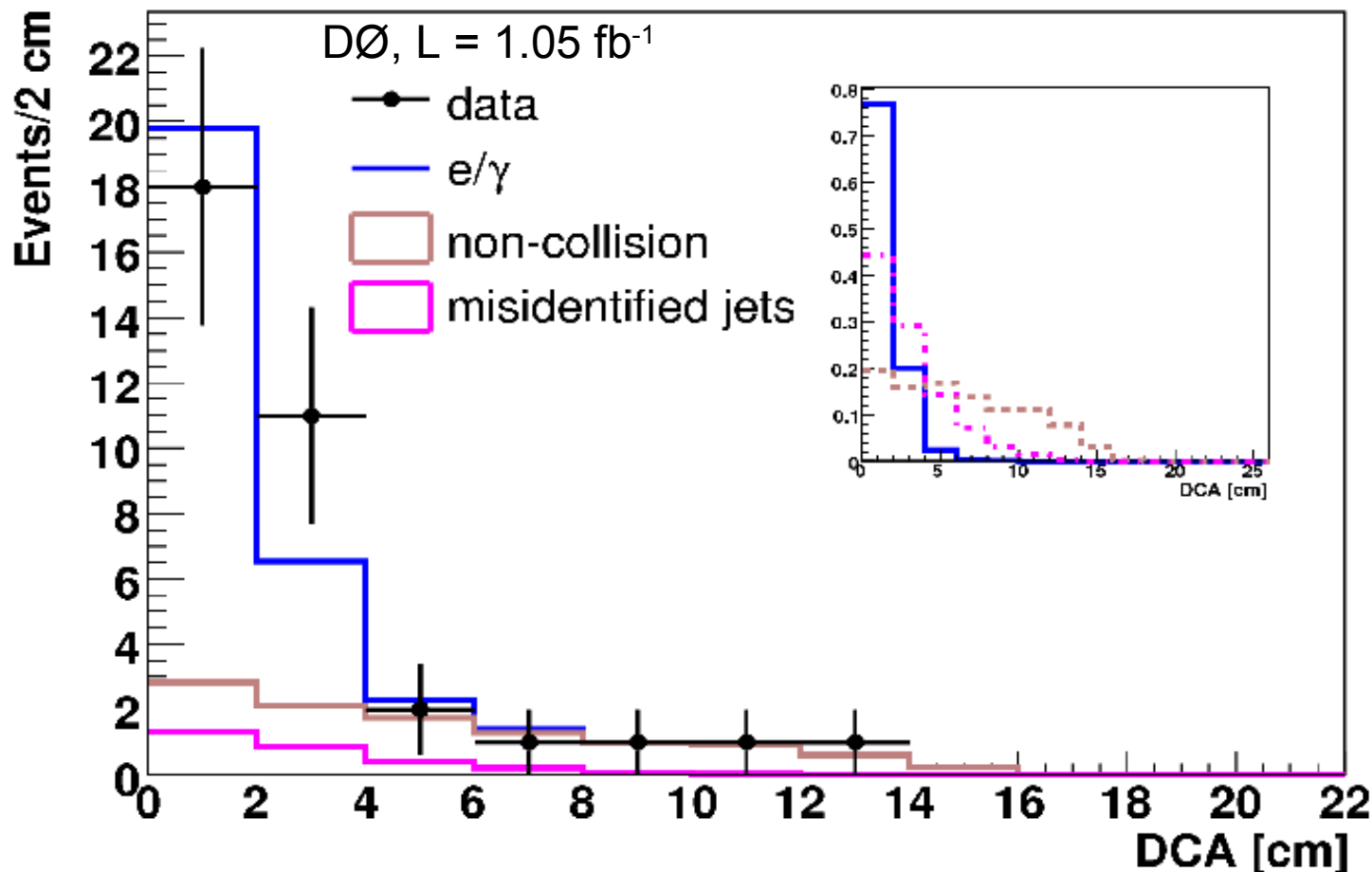


Photon Sample – Azimuthal distribution



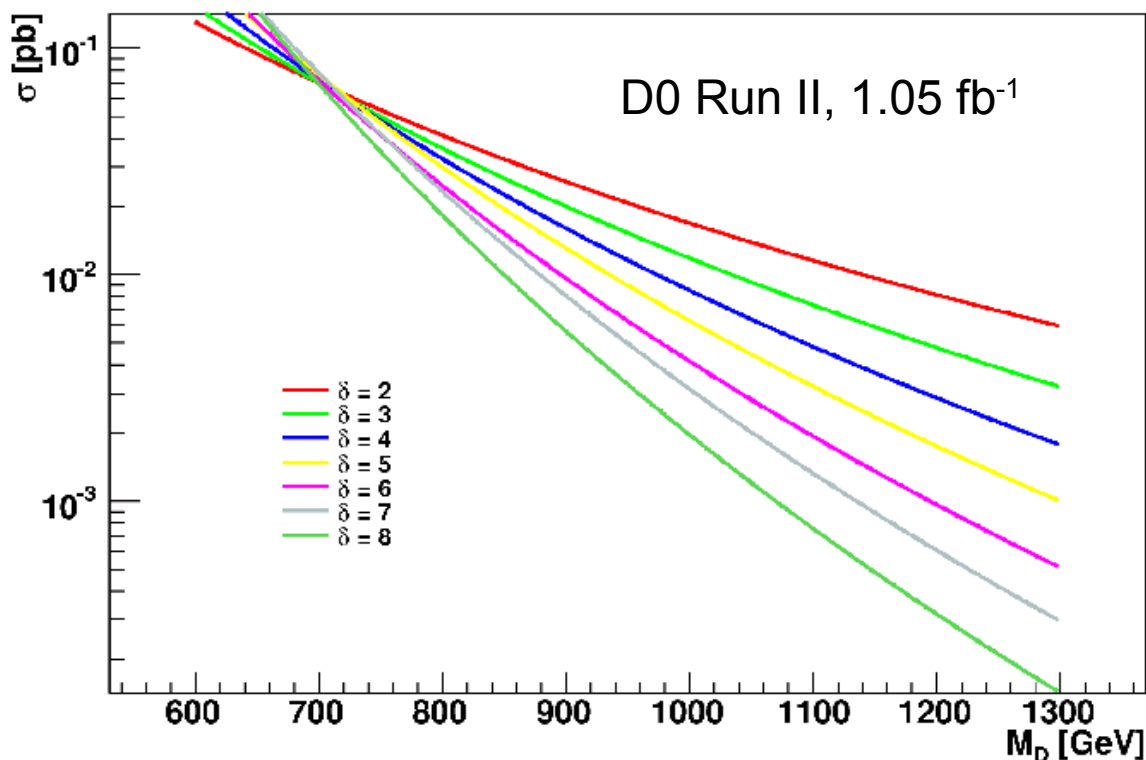
DCA template fit

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.



Signal MC

- 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 $1/M_D^{n+2}$
- The average efficiency is 50%



* Stephen Mrenna, private communications.

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	
$Z + \gamma \rightarrow \nu\bar{\nu} + \gamma$	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	

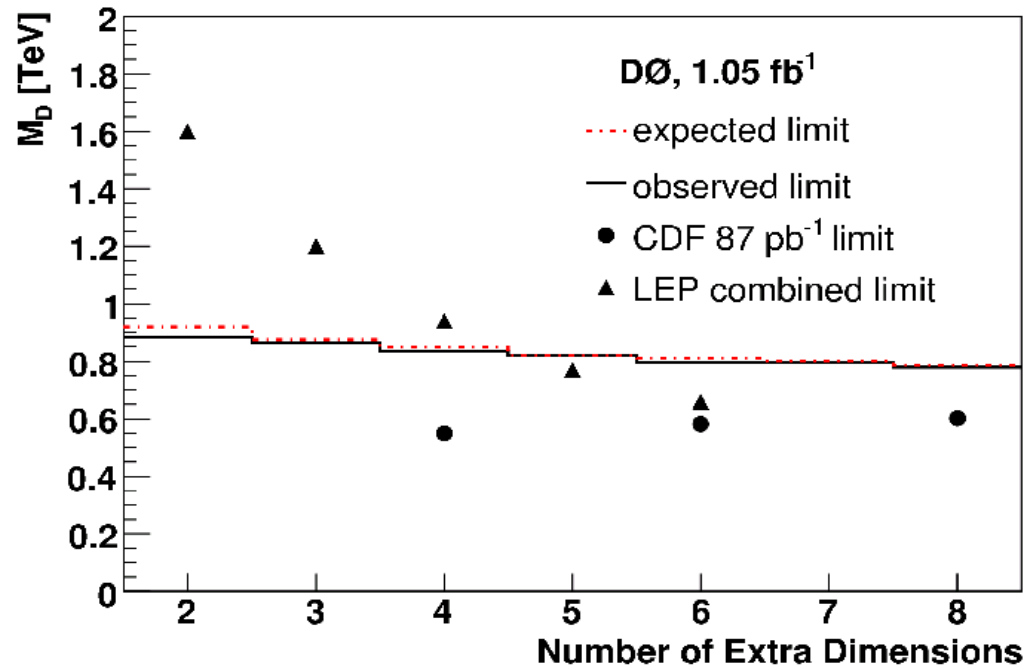
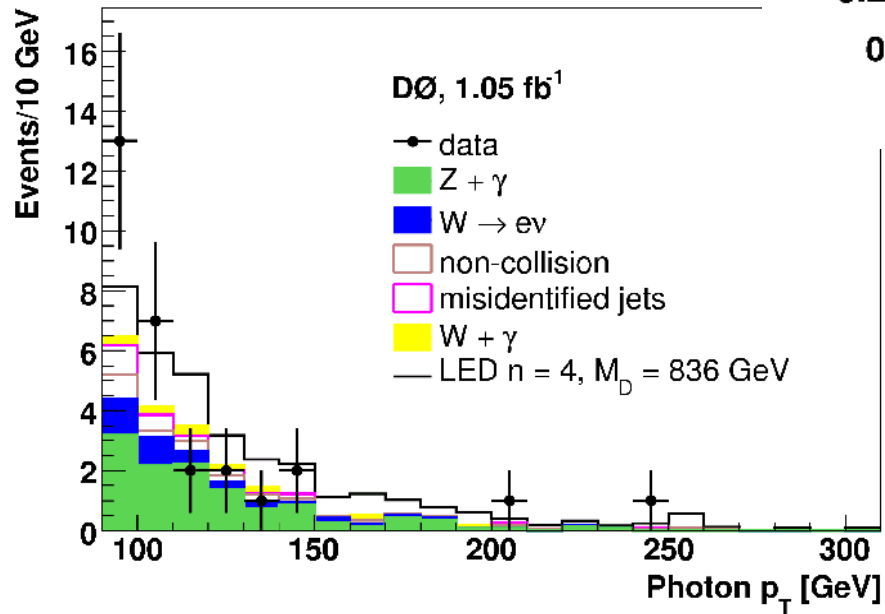
SYSTEMATICS: dominated by

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

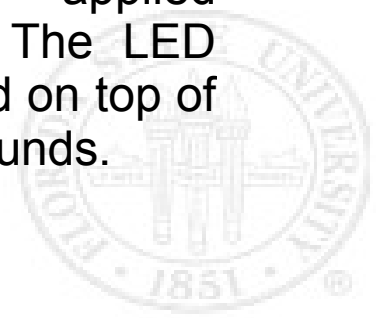


Limits

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 p_T distribution.



Photon p_T 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 LED 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.

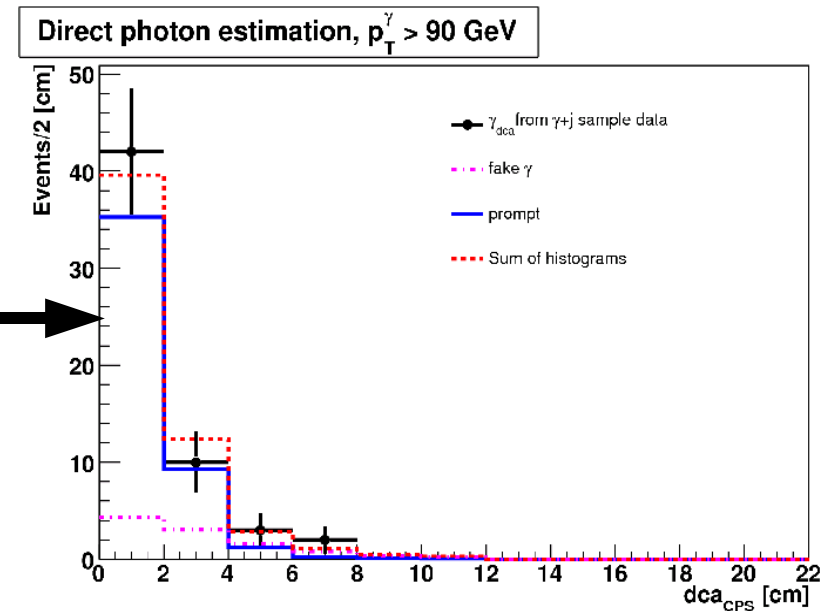
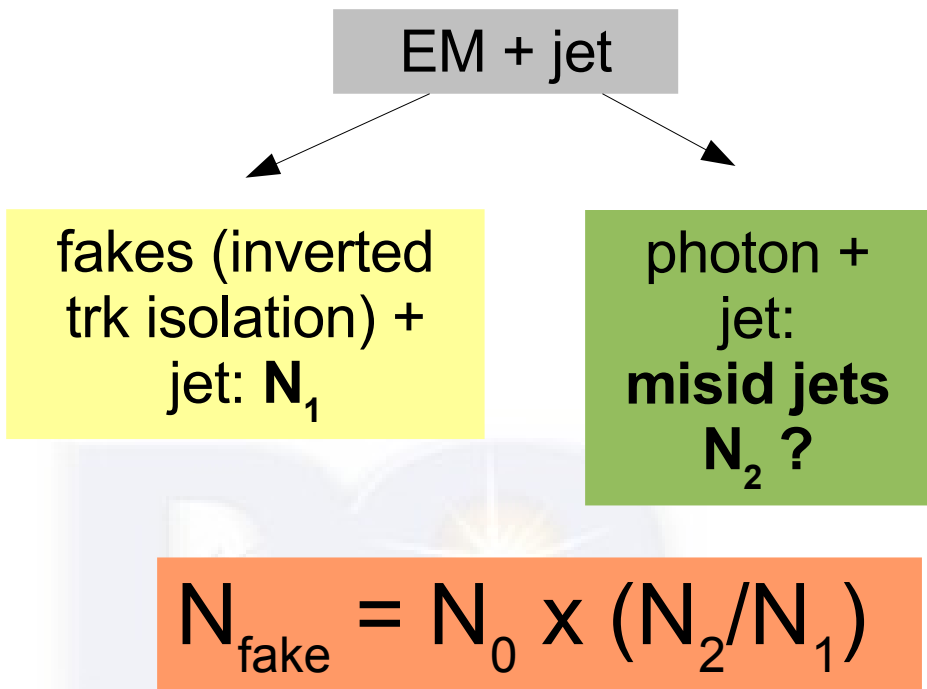


Backup slides



Misidentified jets (fakes) normalization

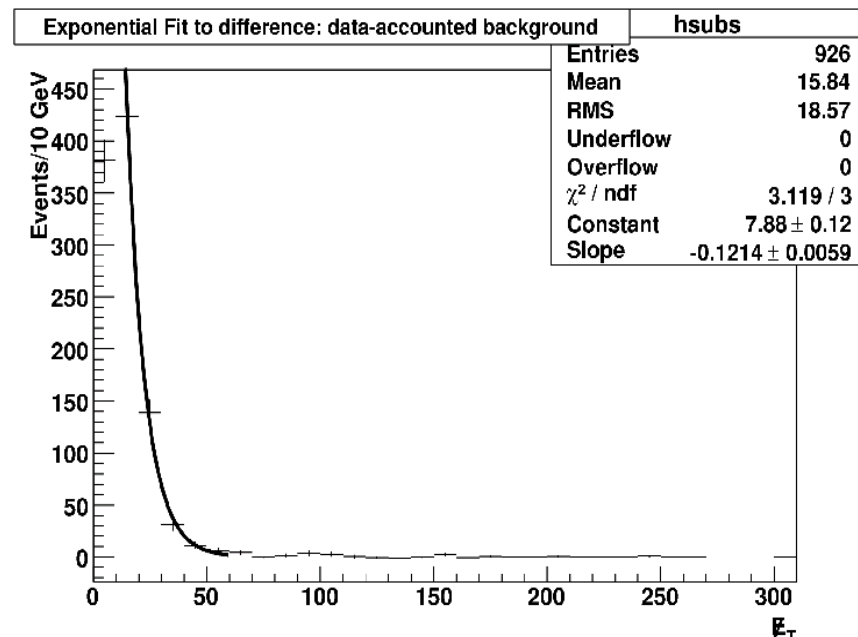
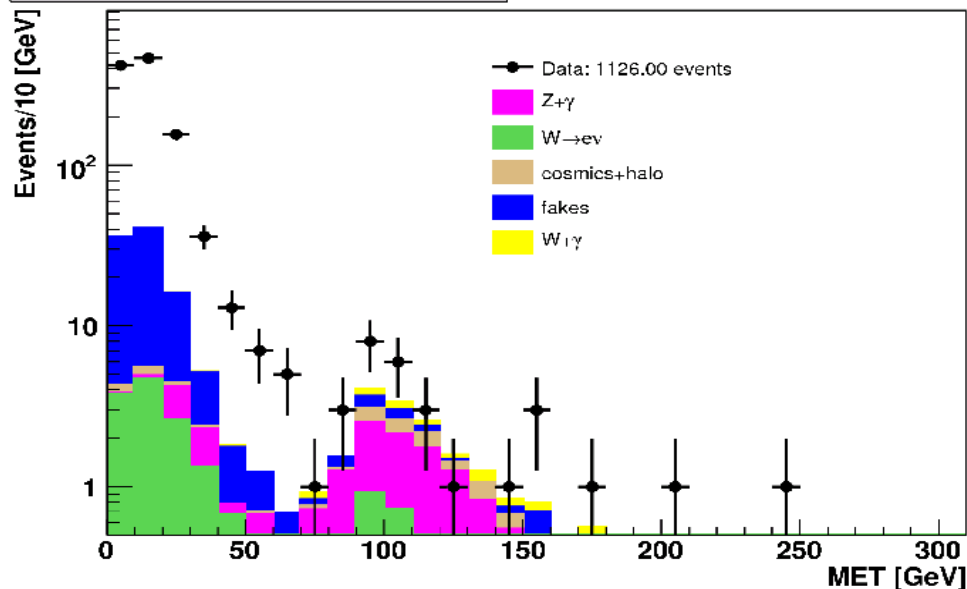
- photon sample: has background events from misidentified jets (N_{fake})
- fakes sample (inverted track isolation): known number of events N_0



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.

MET distribution, $p_T^\gamma > 90$ GeV



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

Shapes comparison

DCA shapes comparison

