Search for diphoton events with large missing transverse energy at D0

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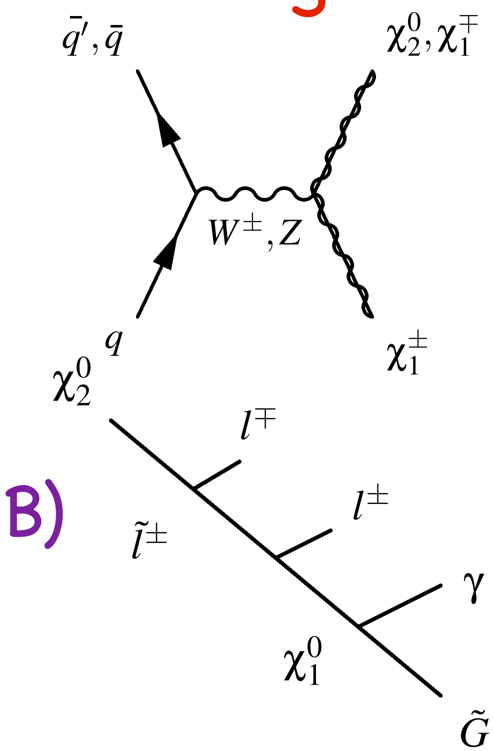
for D0 collaboration

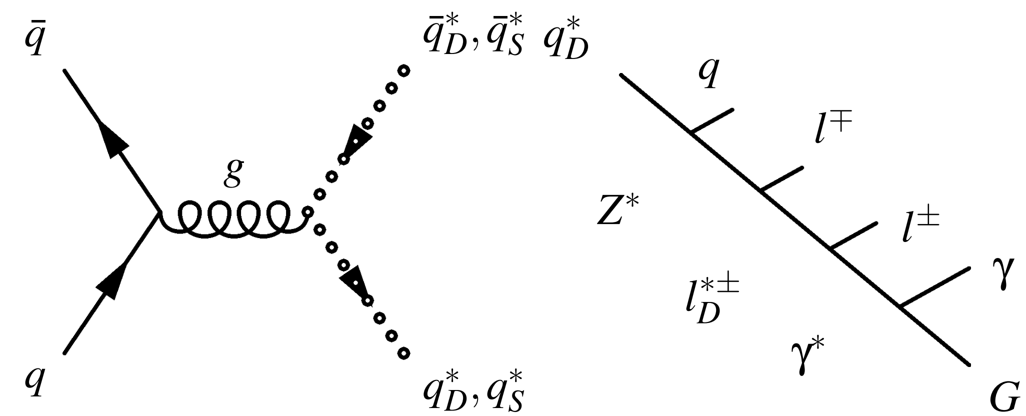
Outline

- Introduction
- Experimental Apparatus
- Event Selection
- Background Estimation
- Results
- Conclusions

Introduction

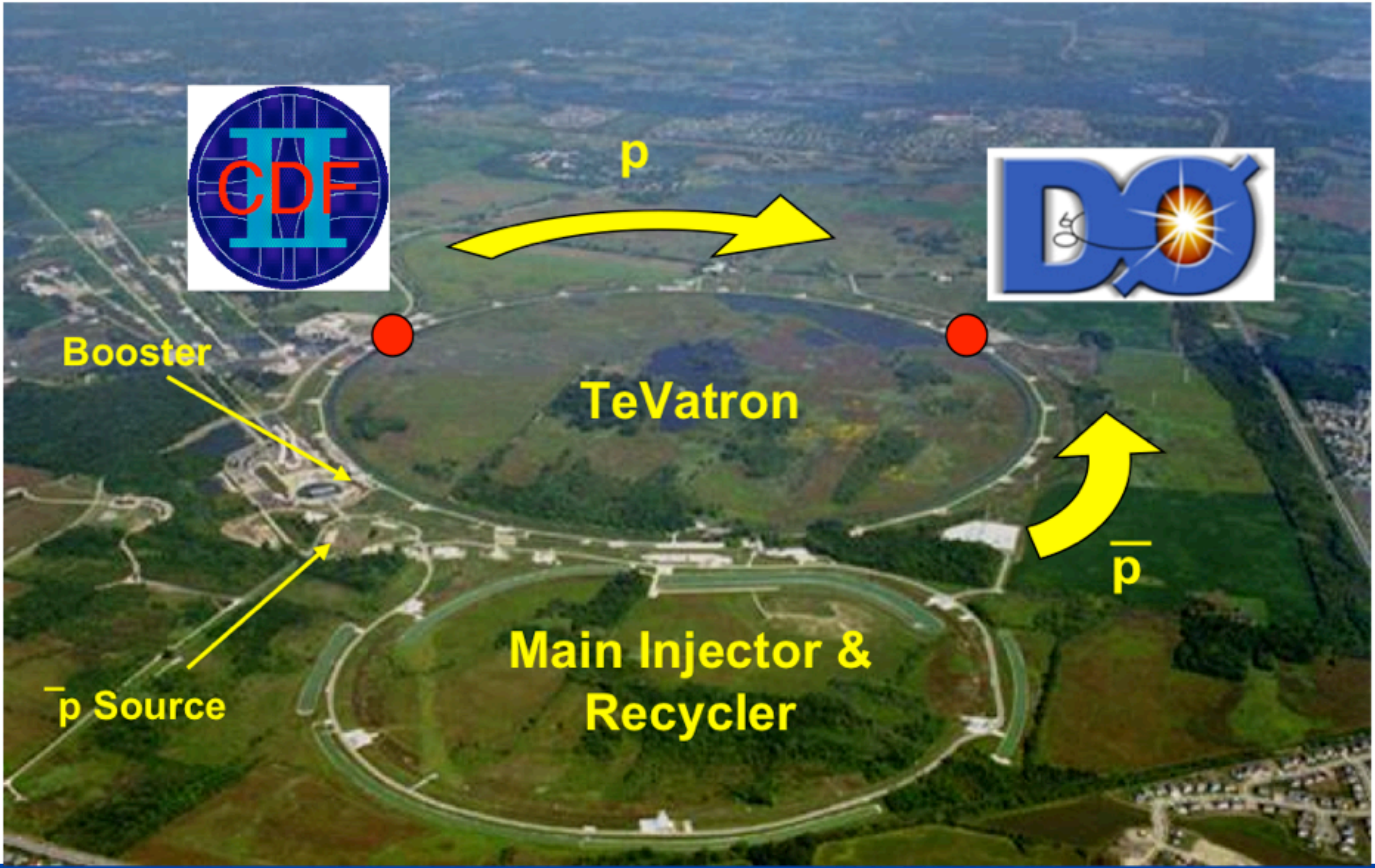
- Standard Model (SM) predicts low rate for high p_T $\gamma\gamma$ with large Missing Transverse Energy (MET)
- A sensitive channel to probe new physics beyond SM
- Two benchmark models are explored
  - Gauge Mediated Supersymmetry (SUSY) Breaking (GMSB)
    - ✓ SPS8 is used, effective SUSY breaking scale Λ
    - ✓ the next-to-lightest SUSY particle (NLSP) is the lightest neutralino, which decays to a photon and massless gravitino
  - Universal Extra Dimensions (UED)
    - ✓ a single UED compactified with radius R_C
    - ✓ the lightest Kaluza-Klein (KK) particle (LKP) is the KK photon, which decays to a photon and a graviton
  - both resulting in the final state $\gamma\gamma$+MET+X





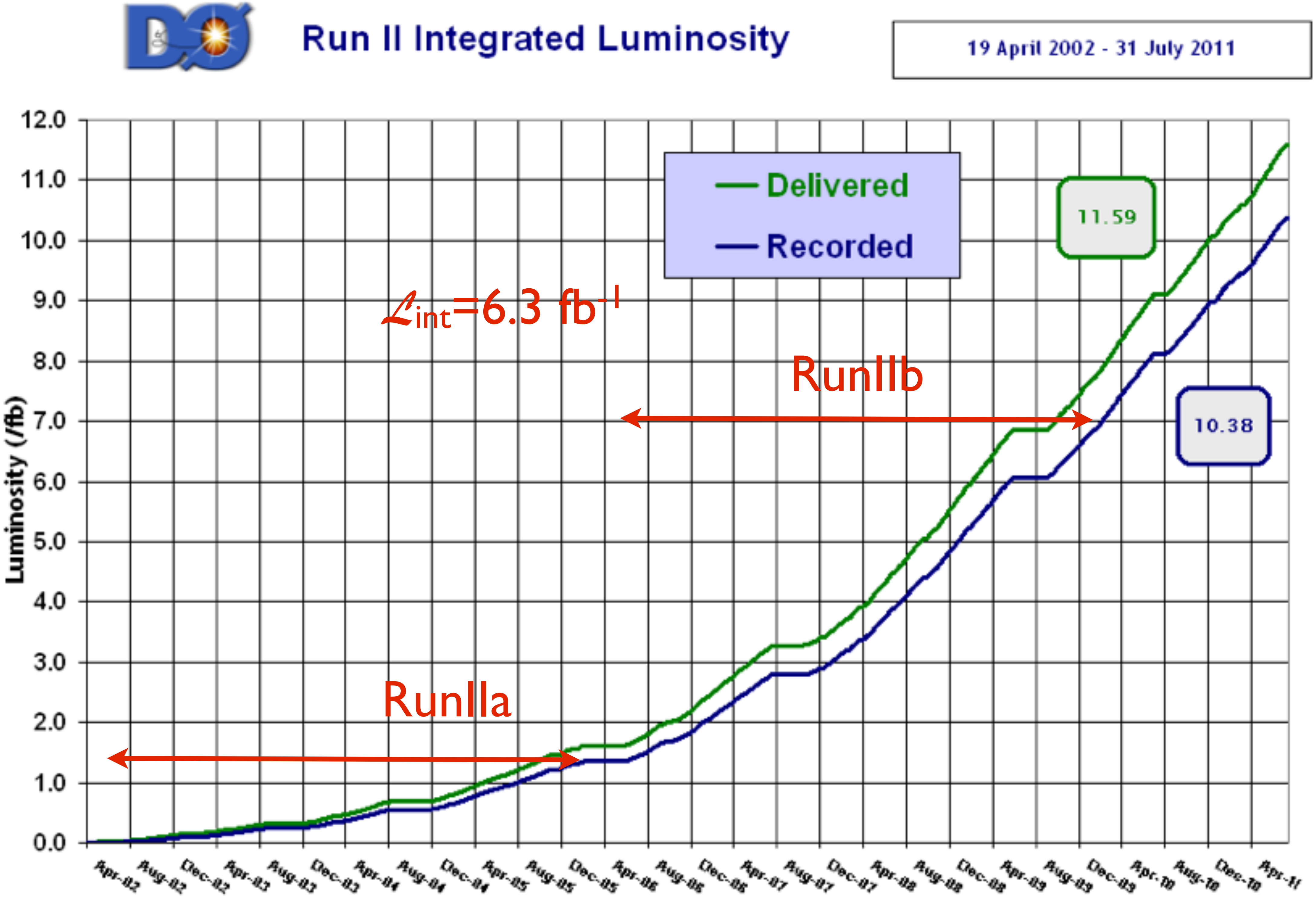
Tevatron @ Fermilab

- Tevatron: $p\bar{p}$ collider with c.o.m. = 1.96 TeV

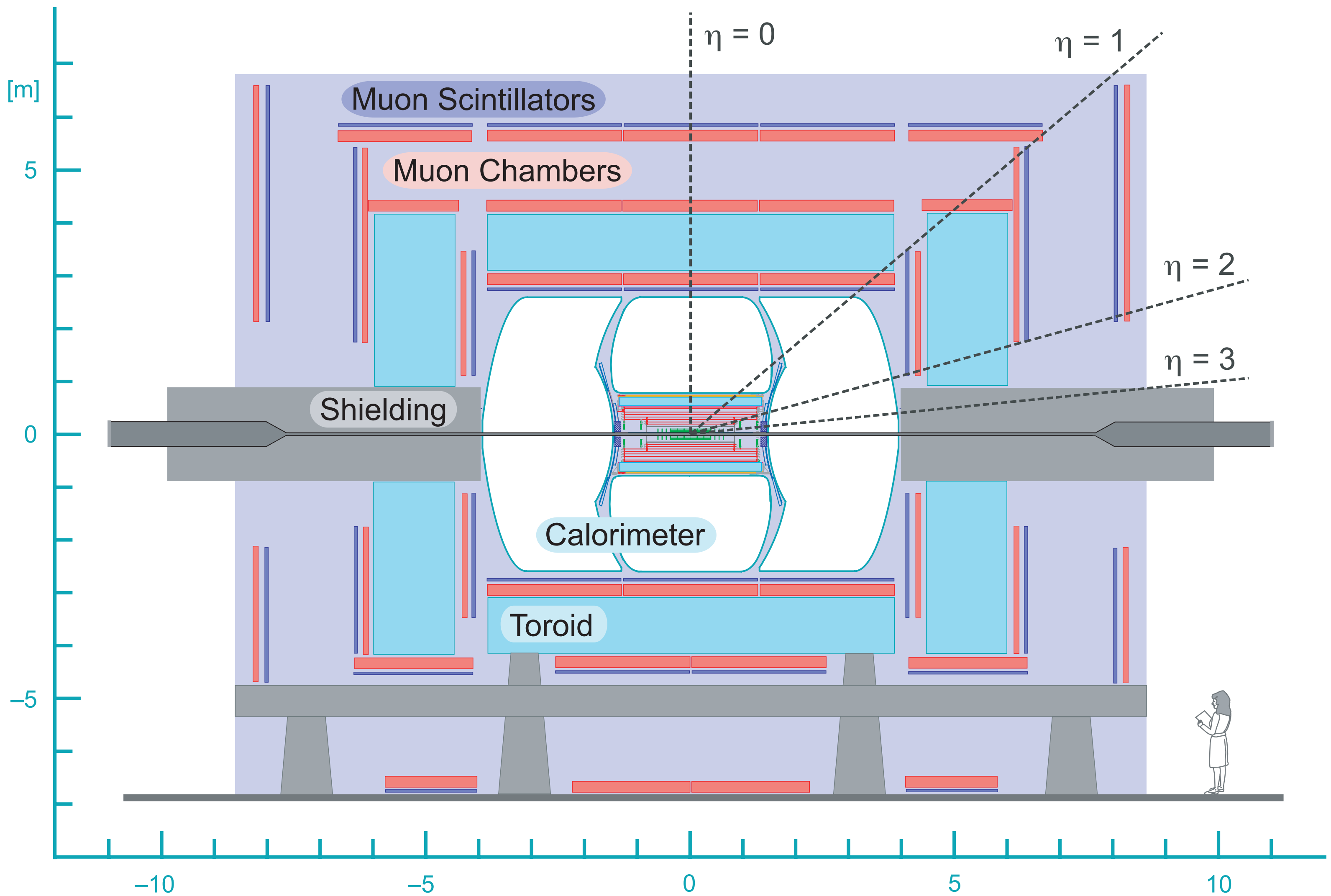


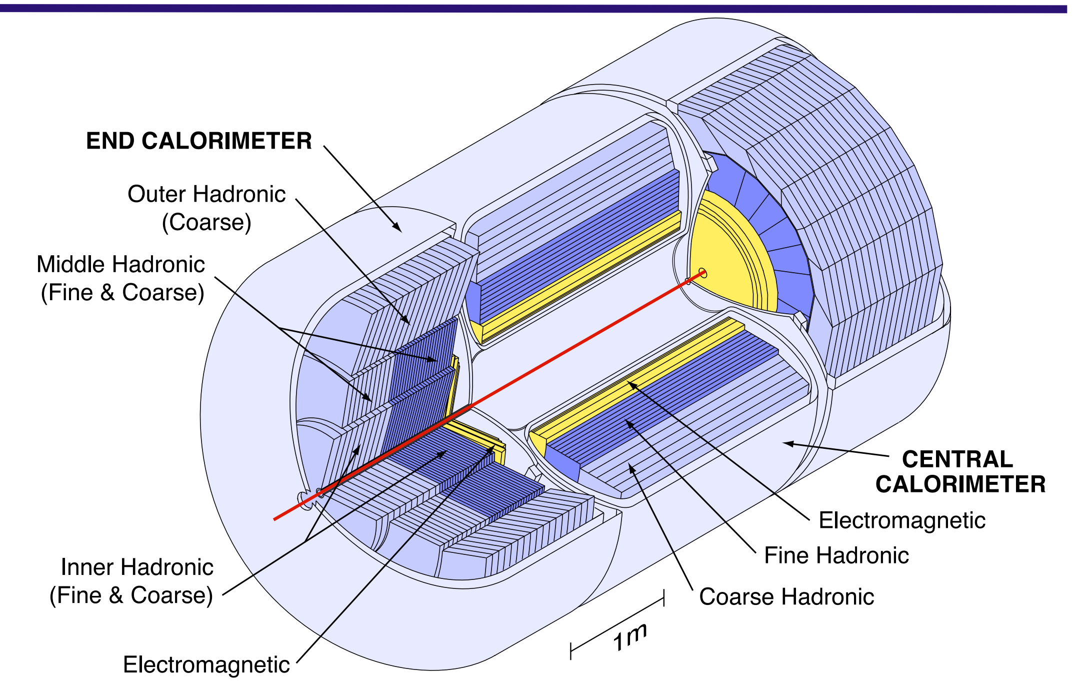
Tevatron and DO Detector

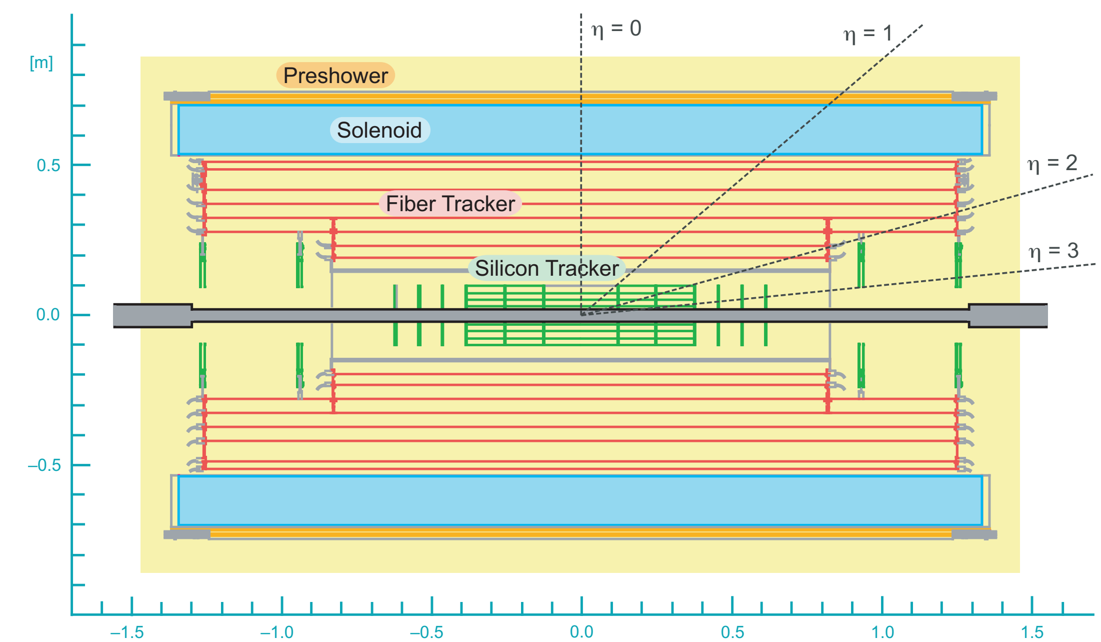
- Thanks Accelerator Division (AD) for the large dataset!



DO Detector







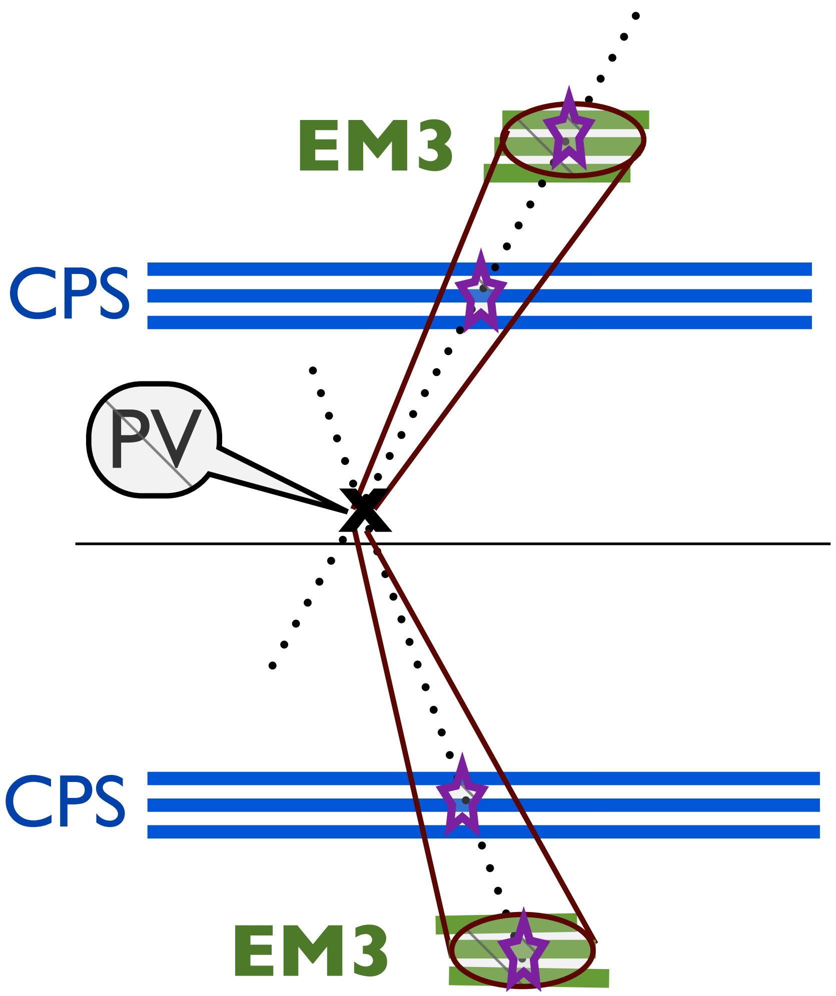
- A general multi-purpose detector
- Central tracking system: determines Primary Vertex (PV)
- Calorimeter: detects photon objects and measures MET
- Central Preshower (CPS) detector helps both PV and γ

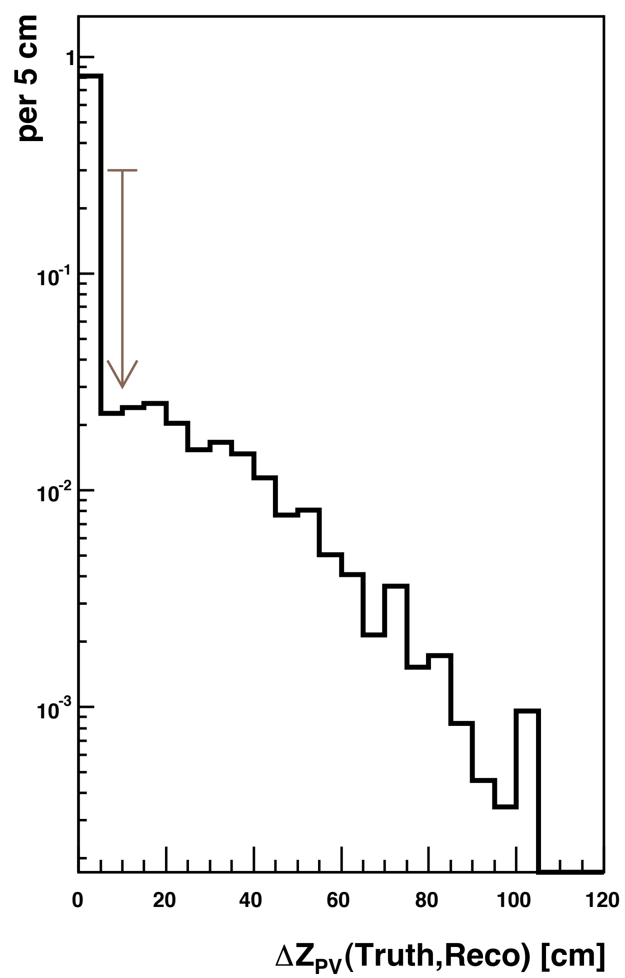
Event Selection

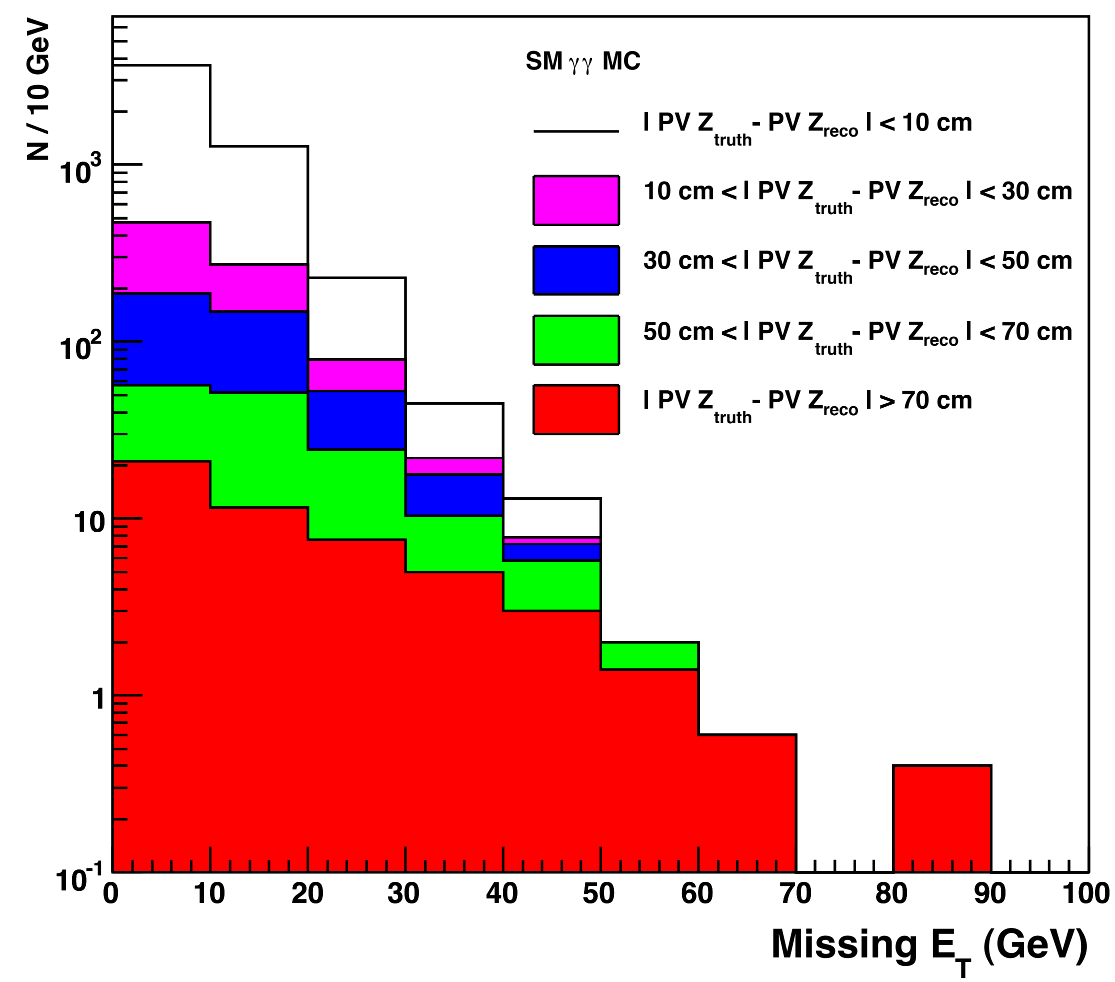
- Signal Monte Carlo (MC) samples are generated and simulated with GEANT for detector response
- Selection criteria:
  - Events with at least two photon candidates satisfying:
    - ✓ E_T > 25GeV in Central Calorimeter (CC)
    - ✓ > 95% energy deposited in EM layers
    - ✓ isolated in both calorimeter and tracking system without matched track
    - ✓ shower shape consistent with an EM shower
    - ✓ NN output to discriminate from jets
  - MET > 50 GeV
    - ✓ correction from EM objects, jets, and p_T of the muons

MET Measurement

- PV identification is crucial
  - ΔZ(PV, CPS of EM) < 10 cm to reduce the misidentified PV
- $\Delta\phi$ requirements to reduce instrumental sources of MET
  - $\Delta\phi$(MET, leading jet) < 2.5; $\Delta\phi_{min}$(MET, γ) > 0.2; $\Delta\phi(\gamma, \gamma)$ > 0.1

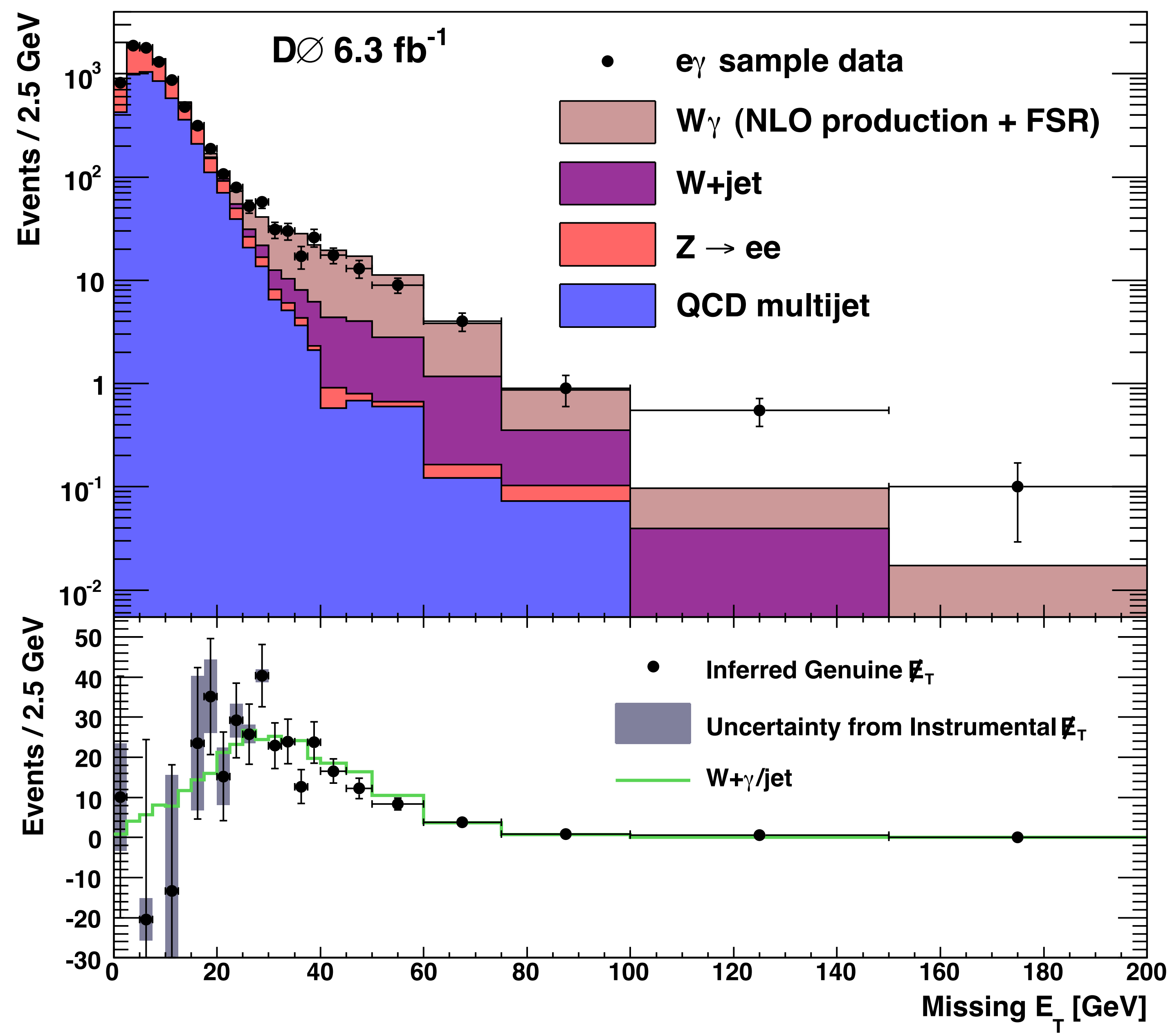






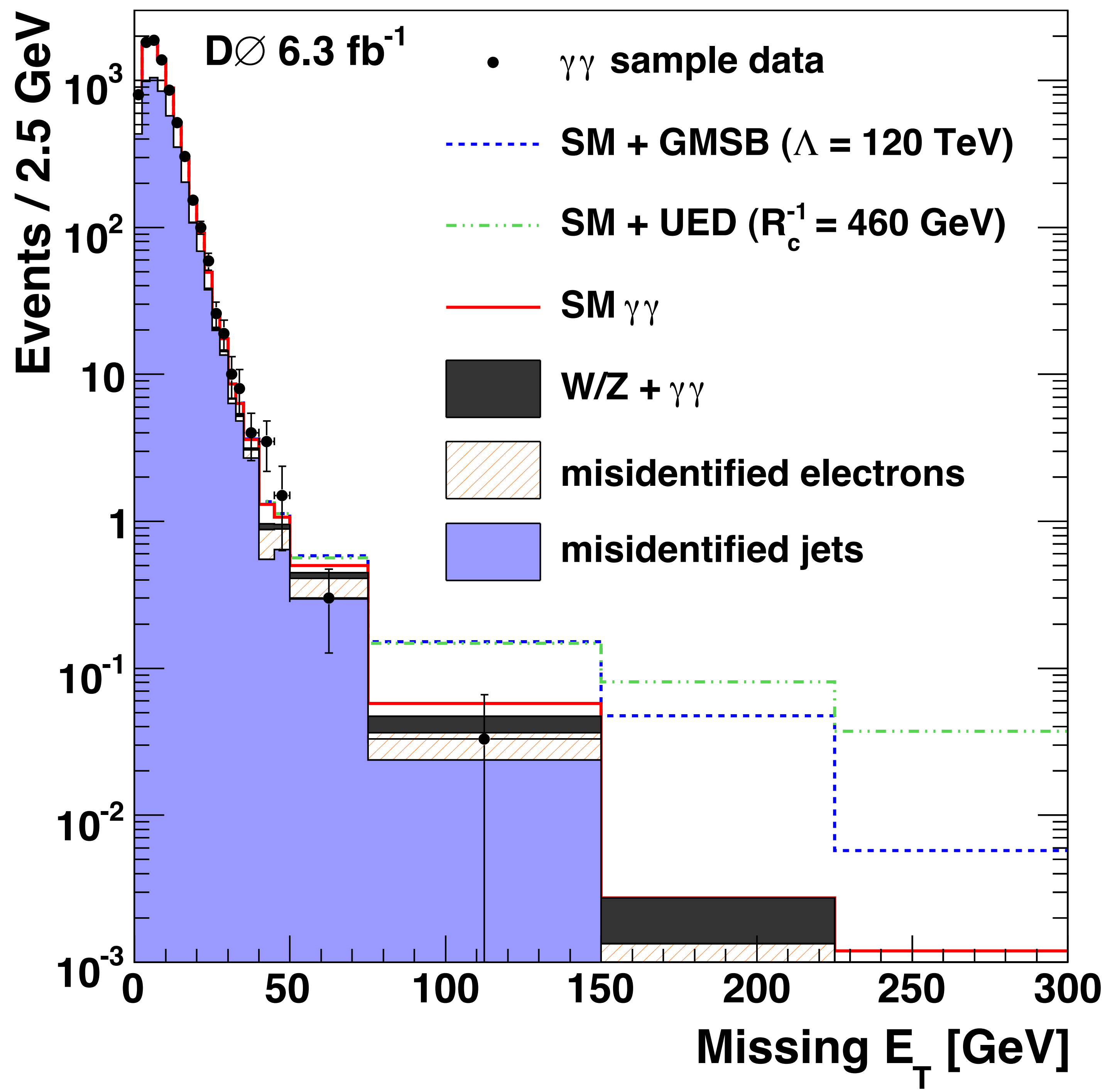
Background Estimation -- I

- Backgrounds with inherent MET
  - SM (W→eν) with electron misidentified as γ
    - ✓ electron faking photon rate is measured in real data
    - ✓ estimated from eγ data after removing possible contaminations
  - SM γγ+MET events like γγ events produced with W/Z
    - ✓ estimated using MC



Background Estimation - II

- SM events with instrumental MET
  - two types:
    - ✓ SM γγ events
    - ✓ events with at least one jet misidentified as γ so called misID jet events
    - ✓ estimated with data and normalized to control region data (MET < 10 GeV)



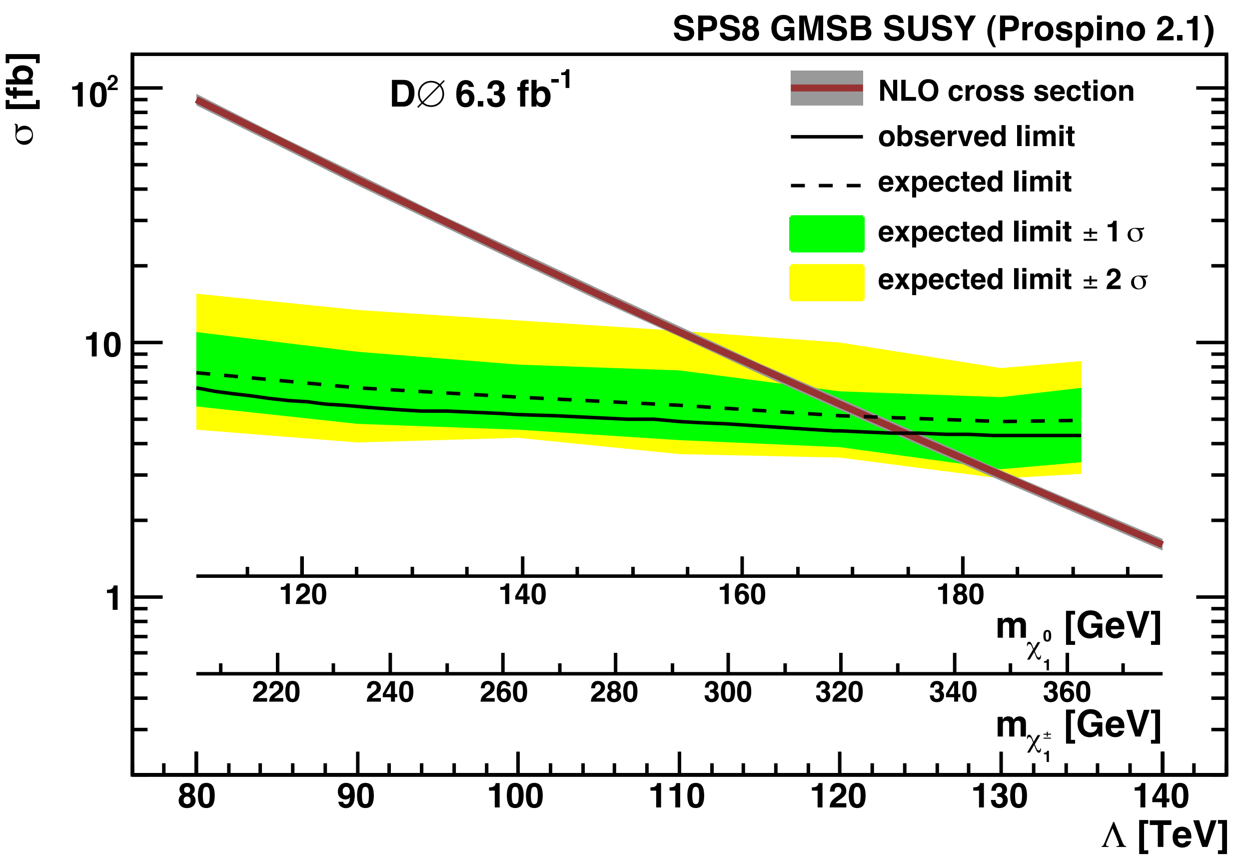
Systematic Uncertainties

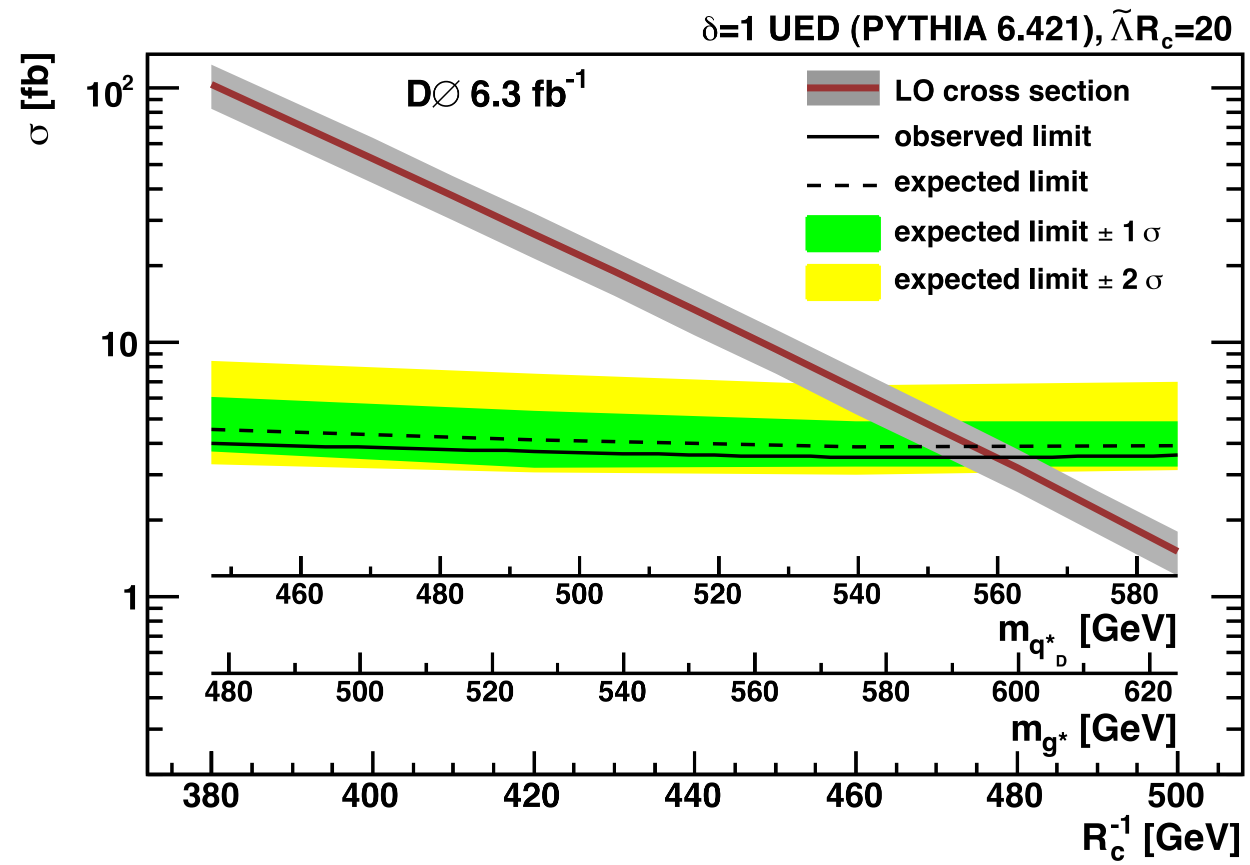
- All the systematic uncertainties as shown in the table

Component	Systematic	Type
Instrumental $\not{E}_T$ ($\gamma\gamma$ + jet misID)	$\gamma\gamma$ $\not{E}_T$ distribution - *ee* data vs. $\gamma\gamma$ MC	Shape
	jet misID $\not{E}_T$ distribution	Shape
	purity uncertainty	Shape
ele misID	uncertainty in residual from instrumental $\not{E}_T$	Shape
	normalization uncertainty (25%) from $e \to \gamma$ fake rate	Flat
$W/Z+\gamma\gamma$	luminosity (6.1%)	Flat
	CPS-PV scale factor (3%)	Flat
	PhotonID (3% per photon)	Flat
	Trigger (2%)	Flat
GMSB and UED Signal	luminosity (6.1%)	Flat
	CPS-PV scale factor (3%)	Flat
	PhotonID (3% per photon)	Flat
	Trigger (2%)	Flat
	PDFs (5% GMSB, 20% UED)	Flat

Results

- No evidence for BSM is observed
- GMSB: Λ < 124 TeV ($m_{\chi_0^1}$< 175 GeV) excluded at 95% C.L.
- UED: R_c^{-1}< 477 GeV excluded at 95% C.L.





$\not\!\!E_T$ Interval, GeV	Observed Events	SM Background Events: Instr. $\not\!\!E_T$	SM Background Events: Genuine $\not\!\!E_T$	SM Background Events: Total	Expected Signal Events: GMSB $\Lambda = 100$ TeV	Expected Signal Events: GMSB $\Lambda = 120$ TeV	Expected Signal Events: UED $R_c^{-1} = 420$ GeV	Expected Signal Events: UED $R_c^{-1} = 460$ GeV
$35-50$	18	9.6 ± 1.9	2.3 ± 0.5	11.9 ± 2.0	1.8 ± 0.1	0.3 ± 0.1	1.4 ± 0.1	0.3 ± 0.1
$50-75$	3	3.5 ± 0.8	1.5 ± 0.3	5.0 ± 0.9	4.1 ± 0.3	0.8 ± 0.1	2.9 ± 0.2	0.6 ± 0.1
>75	1	1.1 ± 0.4	0.8 ± 0.1	1.9 ± 0.4	14.3 ± 1.1	4.4 ± 0.4	24.7 ± 2.0	6.4 ± 0.5

Conclusions

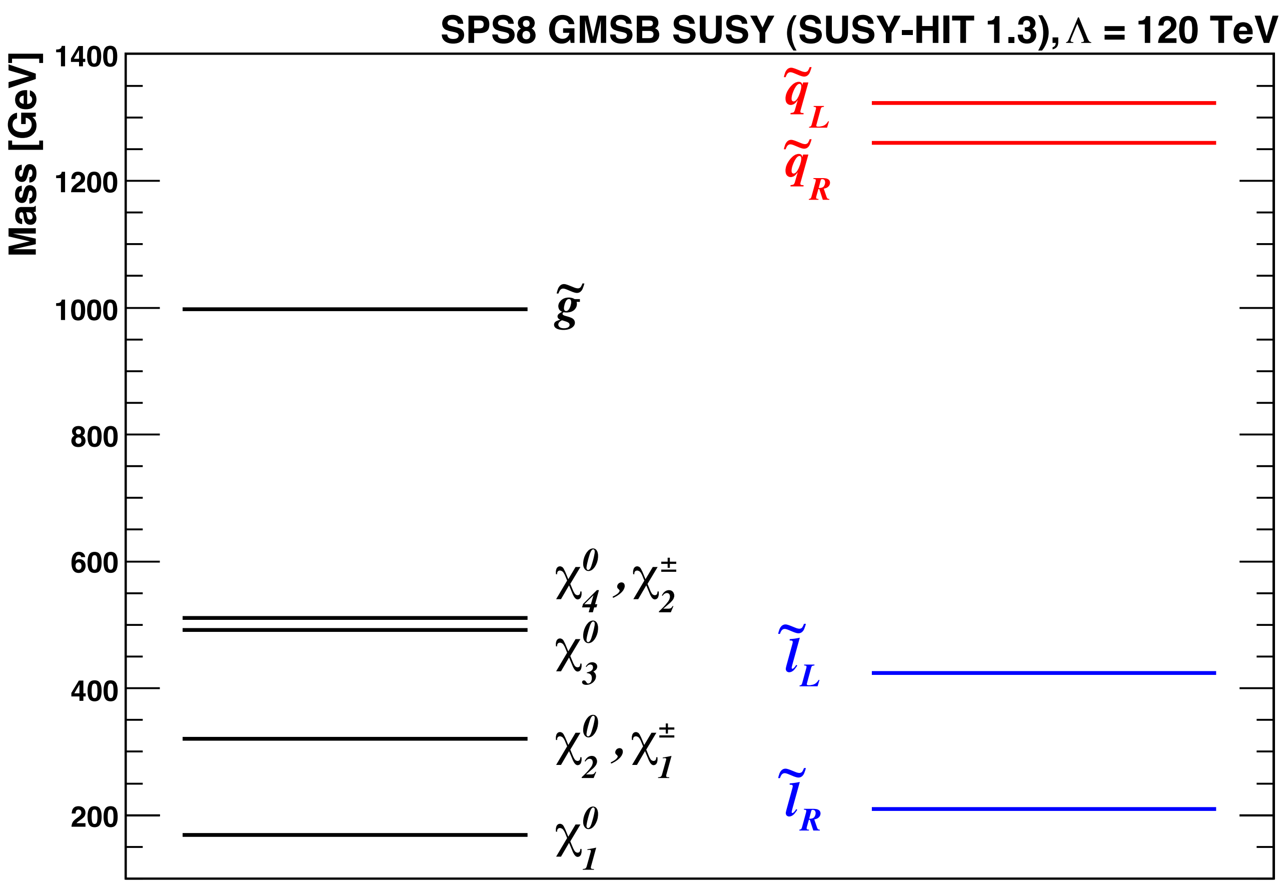
- No evidence for BSM is observed in γγ+MET+X samples
- Results are interpreted with two benchmark models
  - SPS8 GMSB:
    - ✓ Λ < 124 TeV excluded at 95% C.L.
    - ✓ $m_{\chi_0^1}$ < 175 GeV excluded at 95% C.L.
  - UED:
    - ✓ R_c^{-1} < 477 GeV excluded at 95% C.L.
- Published on PRL 105, 221802 (2010) also available @arxiv: 1008.2133

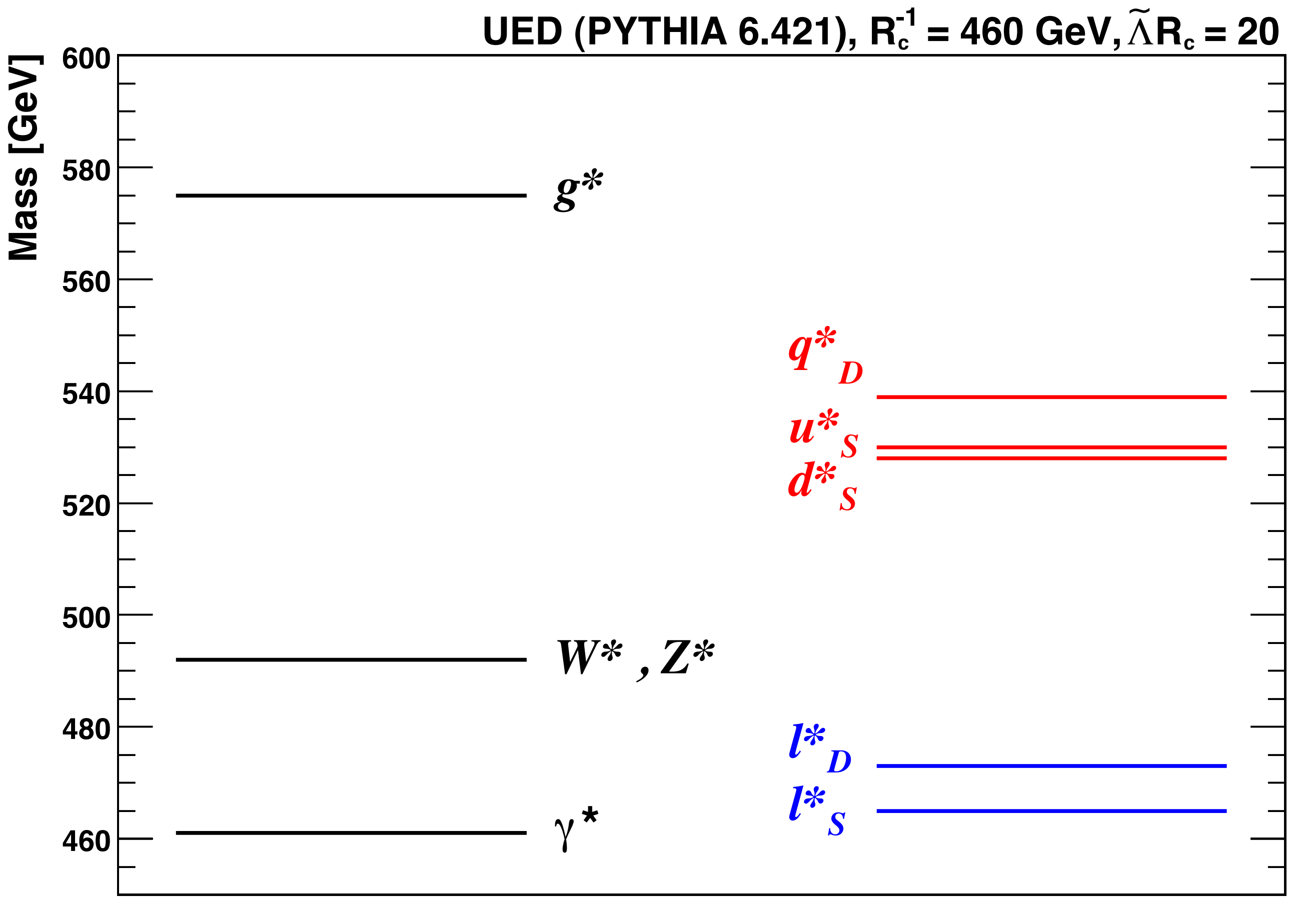
Thank you!

Backup Slides

Models

- The GMSB model parameters:
  - SPS8 :
    - ✓ $M_{mes} = 2\Lambda$, $N_{mes} = 1$, $\tan\beta = 15$, $sgn(\mu)>0$, and Λ is free





CPS confirmed PV

- Use CPS associated with the photon to confirm the PV identification