Photon + b jet studies

Motivation

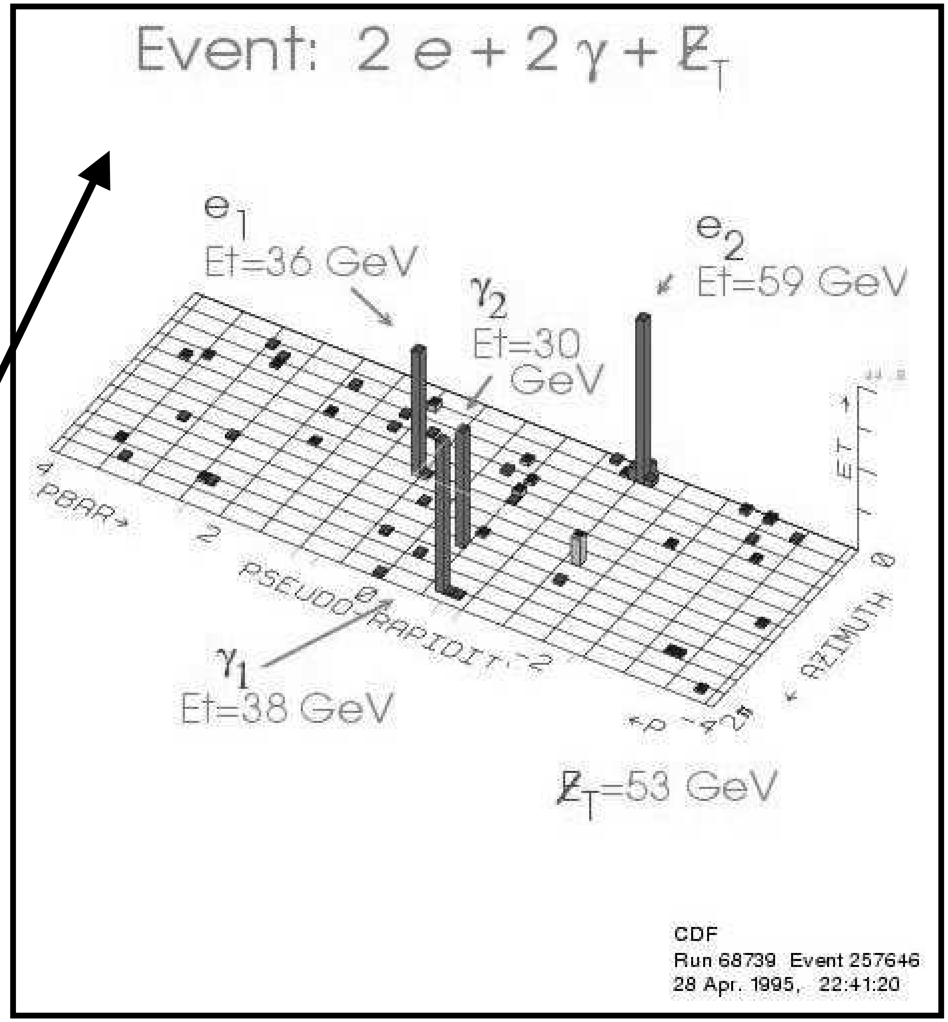
Finding photons

Finding b jets

Summary and work plan

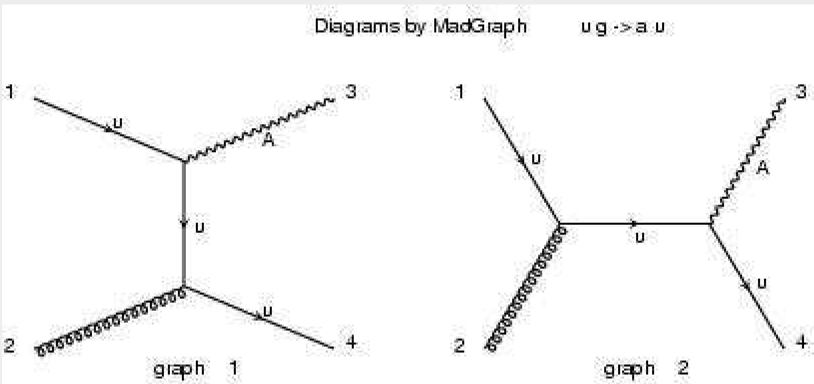
Motivation

- Topological search sensitive to "new physics"
  - Require γ, b jet, Et
  - Can look for μ, e, τ, jets in addition
- Search originally motivated by Run 1 ee$\gamma\gamma$Et event

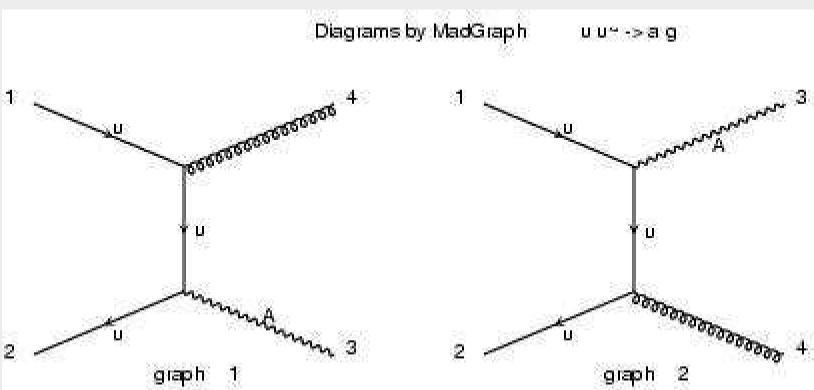


Production of γ + jet events

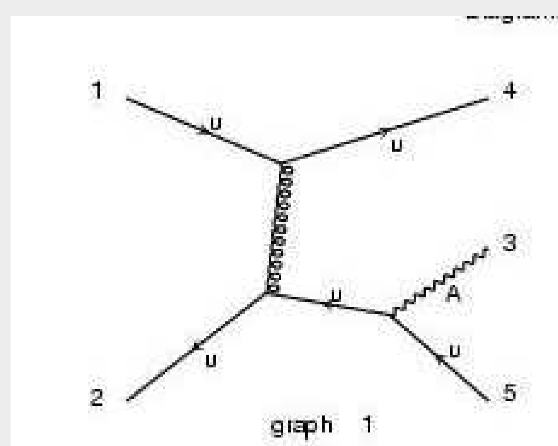
Compton scattering:

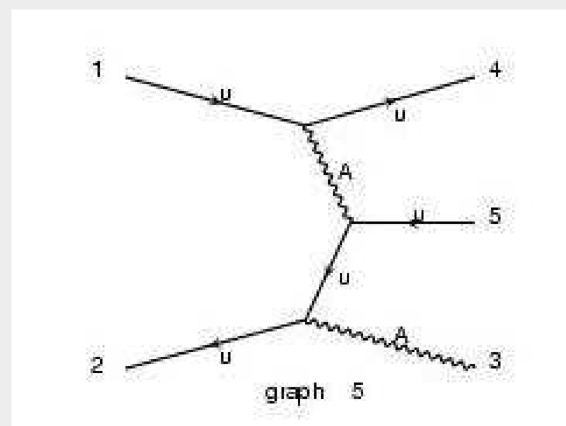


qq annihilation:

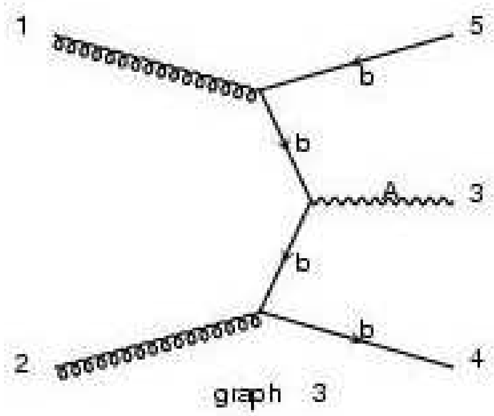


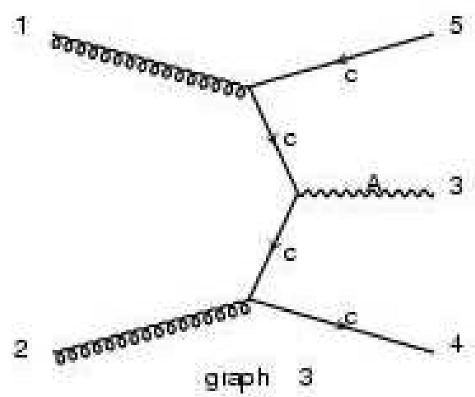
Bremstrahlung:





Production of γ + **b** jet events





Note: γ **couples as q^2**

$\boldsymbol{\sigma(\gamma bbX) \sim 0.25 * \sigma(\gamma ccX)}$

This is unlike dijet production:

$\boldsymbol{\sigma(bbX) \sim 10^{-3} * \sigma(qqX)}$

New Physics contributions

SUSY

- **MSSM**: chargino + neutralino $\chi^+_i\chi^0_2$

$\boxed{\chi^0_2\text{->}\gamma\chi^0_1,\ \chi^+_1\text{->}tb}$

  - Direct production
  - Production through squark, gluon

- **GMSB:** neutralino decay

$\boxed{\chi^0_1\text{->}hG,\ h\text{->}bb}$

  - if LSP mostly higgsino

Technicolor

$\boxed{\omega_T\text{->}\ \gamma\,\pi_T\ \text{->}\ \gamma\ b\ jet}$

Model independent

- Inclusive search for anything non SM ->γ b Et

How would we find new physics?

- We only have estimate of SM production
- New physics can be inferred through
  - Excess in number of events obs. / exp.
  - Difference in event properties
  - Heavy particle production implies higher pt decay products than SM
  - Certain models predict large branching ratios to γ, b jets cf. SM
  - LSP => larger missing Et than SM

Survey of previous measurements

Run 1 CDF γ + b jet:

- 85 pb-1 data
- Observed 1175 γb
- expected 1040+-186

Limits:

- MSSM:

  m(gluino)>250 GeV

  $\sigma(\chi^0_2\chi^+_2)$>7-10 pb
- GMSB:

  $\sigma(\chi^0_1$->γG)>0.3-1.0 pb
- Technicolor:
  - 175< m(ω_T) <275 if 40<m(π_T)<100 (excluded)

Other limits:

ω_T : m(ω_T)< 203 GeV (excluded) D0:Run 1

Gluino: > 195 - 300 GeV (CDF Run1: jets +Et)

>190 – 260 GeV (D0)

Why γ + b jet good for Run 2

Tevatron improvements:

- Higher cm energy (1.8 ->1.96 TeV)
- Potentially more delivered lumi (110 pb-1 -> 2 fb-1??)

CDF improvements:

- Improved tracking coverage
- Greater calorimetry coverage

New physics:

- Run 1 event not yet explained
- Beate's eggmet event
- (after $2fb^{-1}$) "we would expect 70 background and 200 SUSY events" (CDF4155)

How to do it

- Follow Run 1 analysis
  - Cross check results with independent data sample
  - Gives feeling for quality / composition of data
  - Learn about everything!

- Think of clever things
  - B tagging
    - same as top .. Could try 3d, tertiary vertex search (Anant ..)
    - Better distinguish c and uds from b (from data?)
  - Photon id
    - Extend coverage?
    - Better way to estimate fake rate at high Et?

Data samples

Data:

- cph108 data sample
  - Em trigger Et>22 GeV
  - Em iso + Et>50 GeV
- Require good COT, SVX, Calor, SMX status
- Approx. 45 pb-1

Monte Carlo:

- Pythia

  γ + jet
- Madgraph

  γ + jet (jet)

  γ + b bar

  γ + c cbar
- Needed:
  - Wγ, Zγ + n jets
  - dijets

Photon selection

Photon characteristics:

- Ecal deposit
- No tracks

- Distinguish from e
  - Associated track
- Distinguish from jet
  - Isolated
  - Energy deposition characteristics (shape, had vs em)

- Main background:

  $\pi^0 \to \gamma\gamma$

- Prob jet fluctuating to π^0 ~ 10-4

  σ (jet) / σ (γ) ~ 1e4

Studies of isolated γ selection

Generate single particle samples:

- 10 000 each of γ , e, π+, π^0
- Et flat 22 – 75 GeV
- Eta flat –3 -> +3 (only +- 1 used in Run 1)

Study:

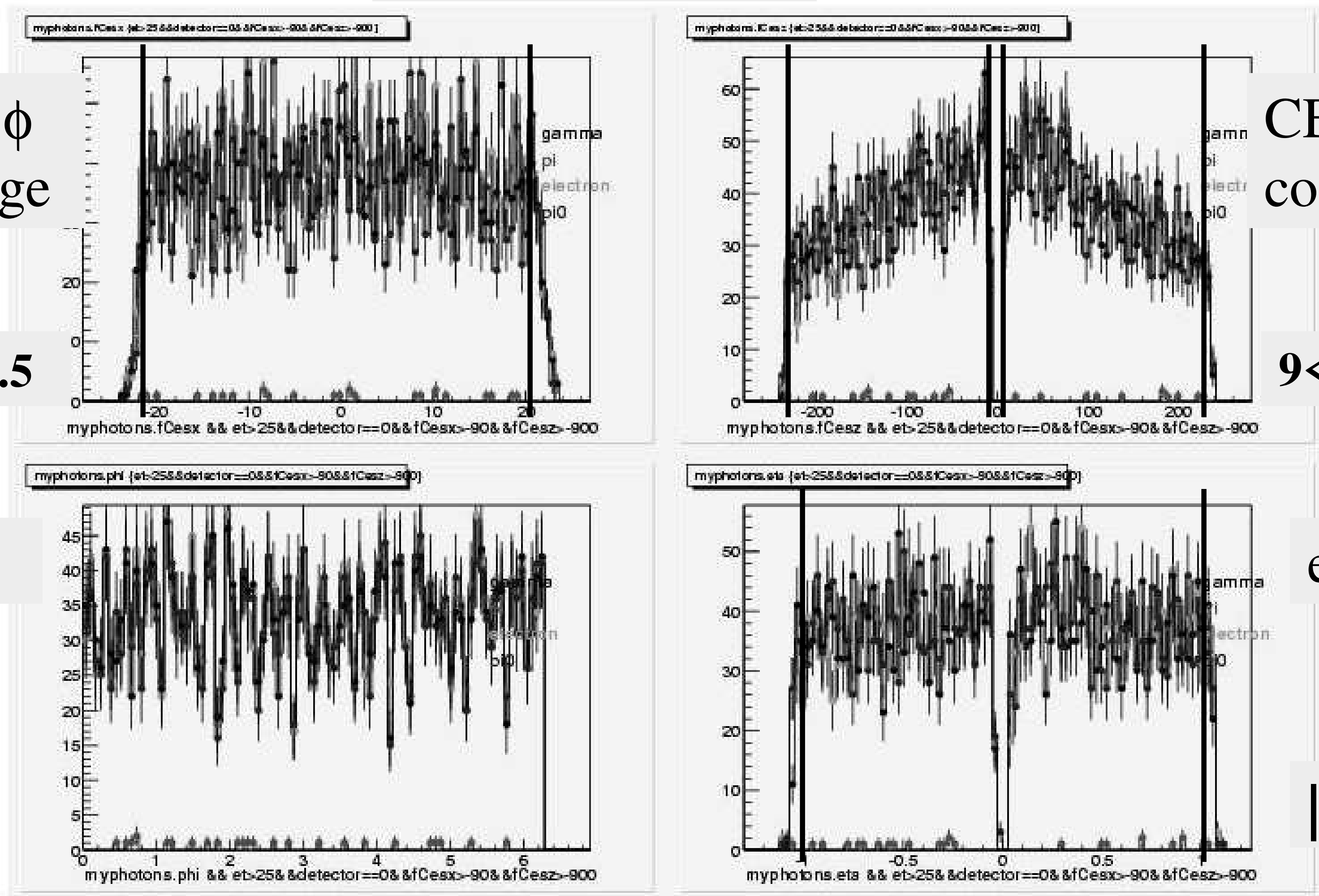
- Efficiency of run 1 cuts
- Performance as fn. Et
- How photon, π^0 distinguished

Photon variables: fiducials

Single γ, π, e, π^0

CES r-ϕ coverage

CES z coverage



$|r\text{-}\phi| < 21.5$

$9<|z|<230$

ϕ

eta

$|\eta|<1$

Photon variables: Had/em, iso, 2^{nd} CES cluster

Single γ, π, e, π^0

Had / EM E

<0.055 + 0.00045*E

Isolation

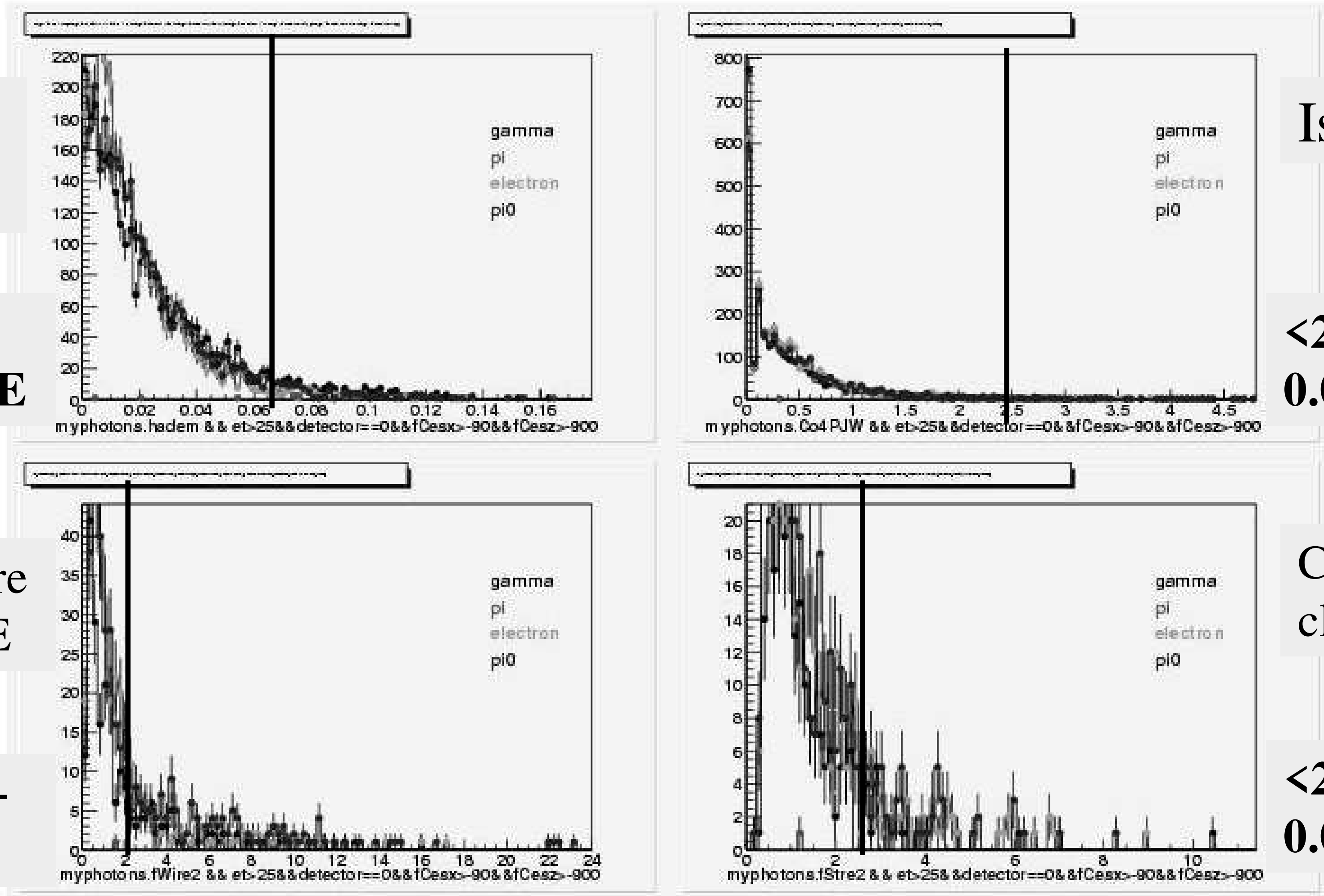
<2.0 + 0.02*Et

CES wire cluster E

<2.39 + 0.01*E

CES strip cluster E

<2.39 + 0.01*E



Photon variables: deposition, tracks

Single γ, π, e, π^0

CES χ^2

$0<\chi^2<20.$

Lshare

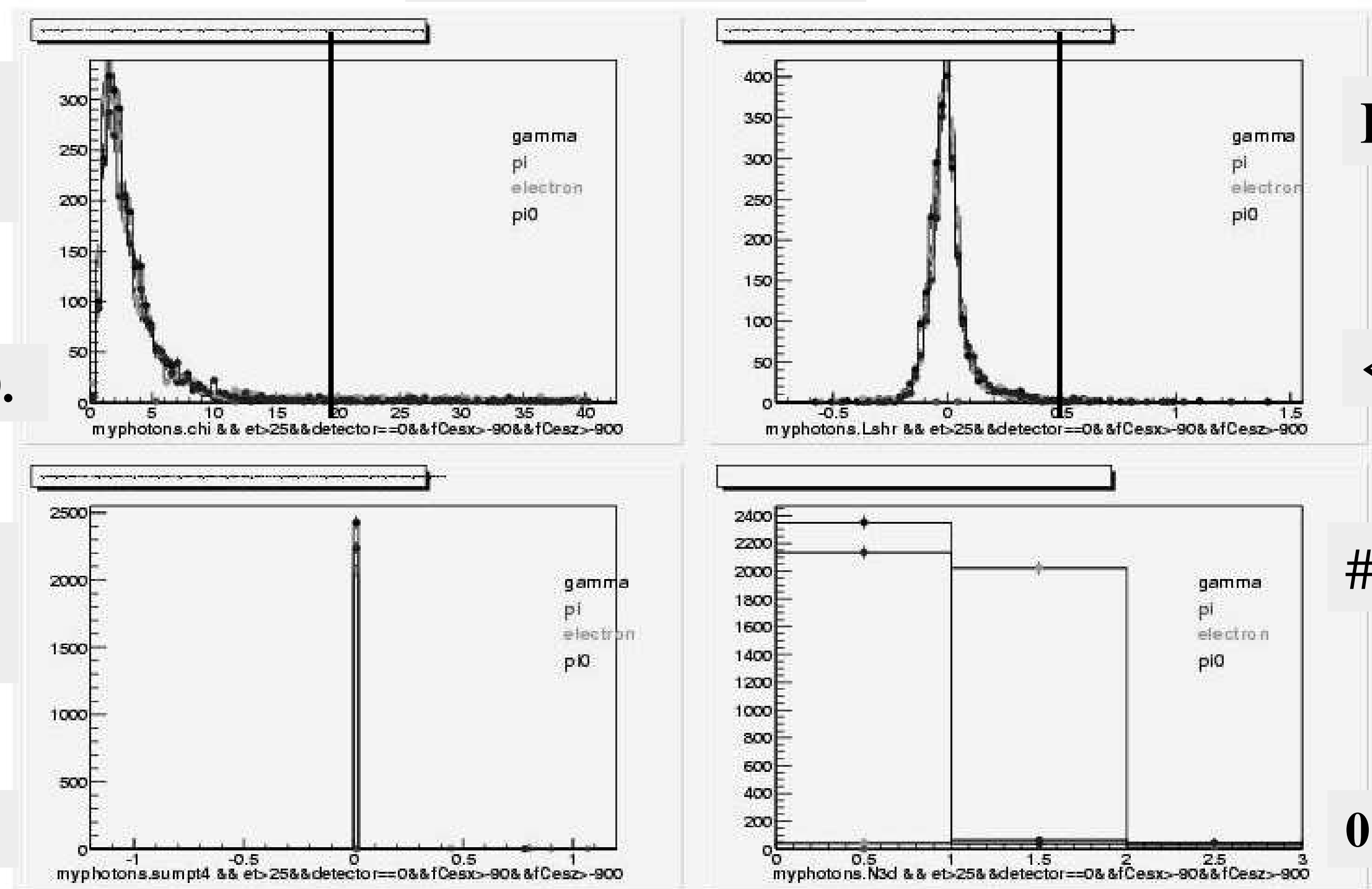
<0.5

Σ pt (0.4)

<5.

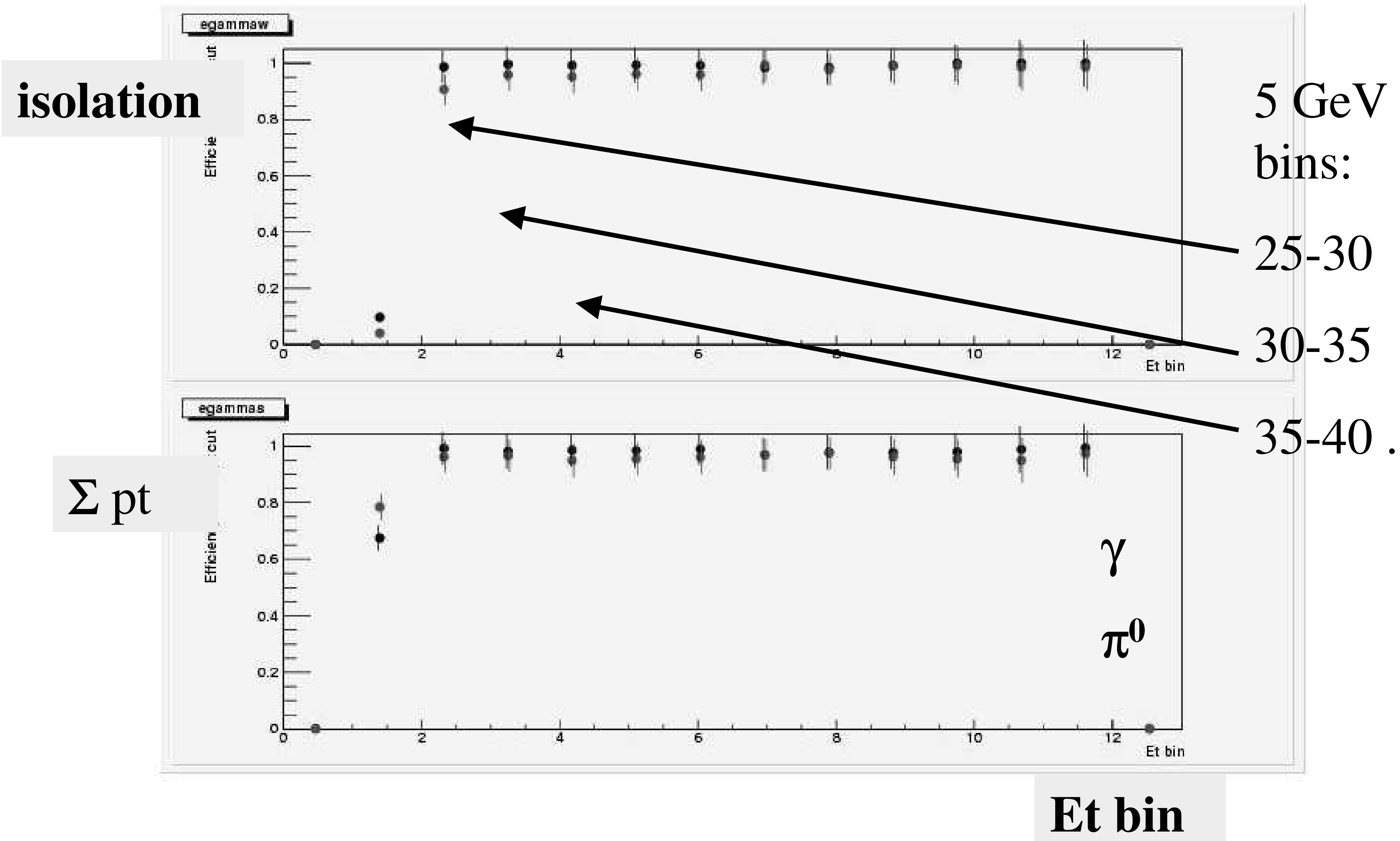
tracks

0 || pt<1.

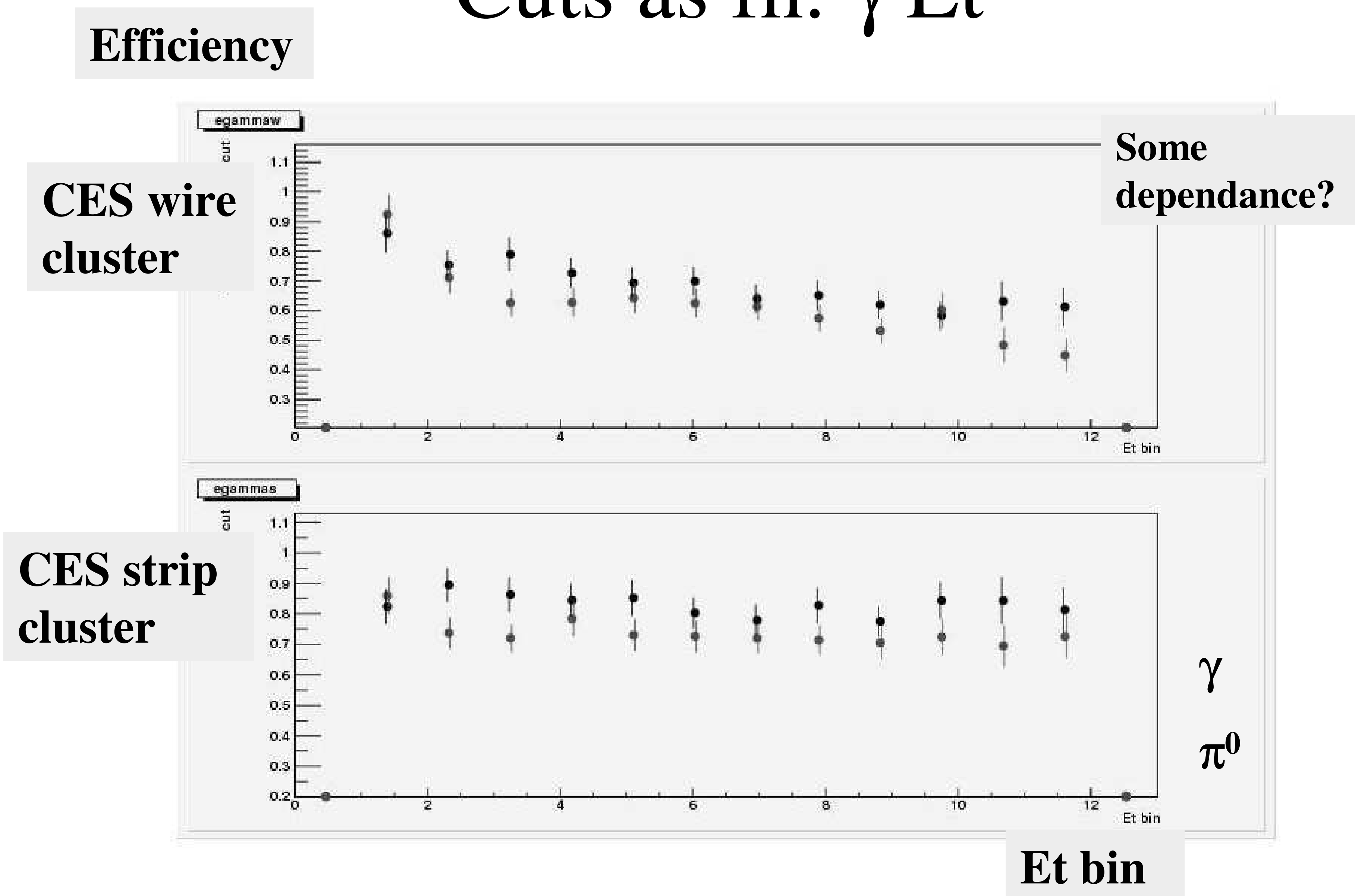


Cuts as fn. γ Et

Efficiency

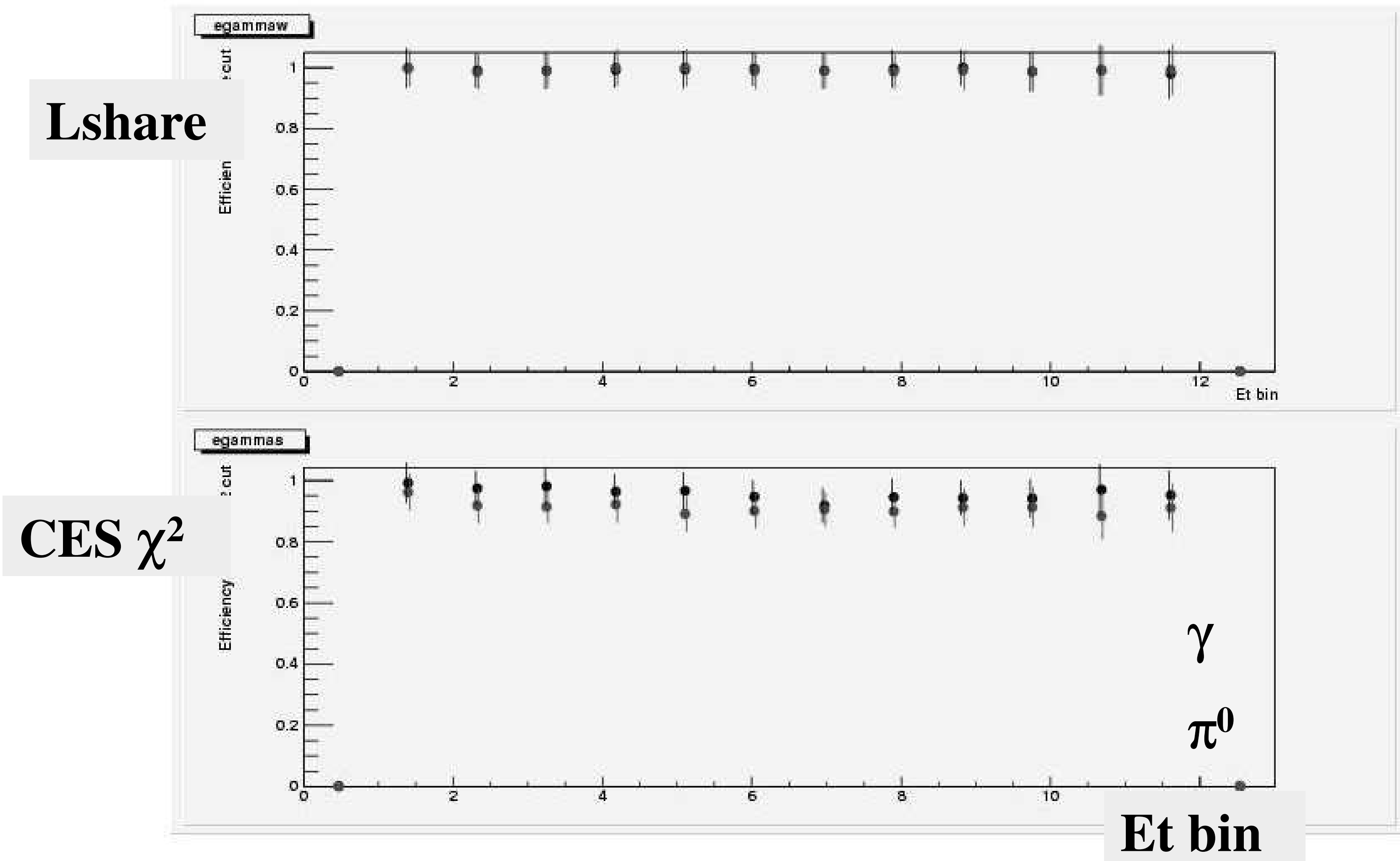


Cuts as fn. γ Et



Cuts as fn. γ Et

Efficiency

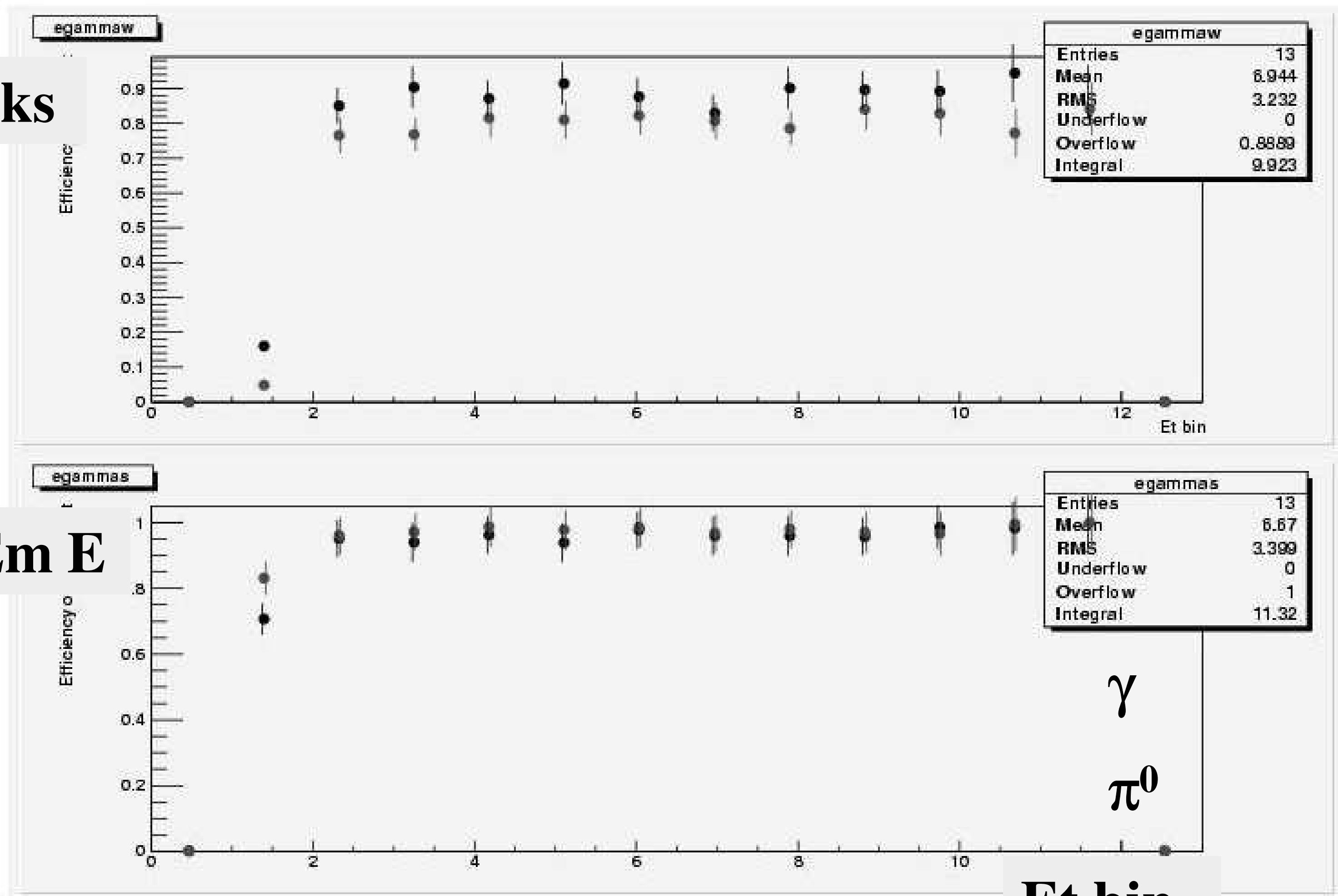


Cuts as fn. γ Et

Efficiency

 # tracks

Had/Em E



γ

π^0

Et bin

γ / π^0 discrimination

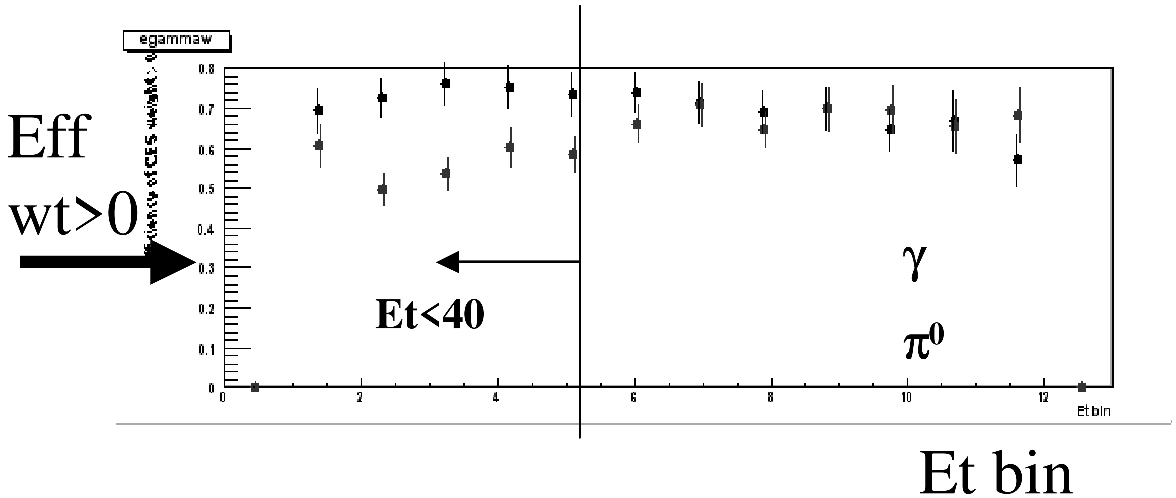
2 methods considered:

CES: based on CES χ^2;

Smaller χ^2=> narrower cluster

π^0 -> $\gamma\gamma$; lower Et, wider cluster

Valid to Et<40 GeV



CPR: based on energy dep. from conversions

π^0 - 2 chances

γ – 1 chance

Not yet commissioned for Run 2

Run 1: for 25 GeV γ

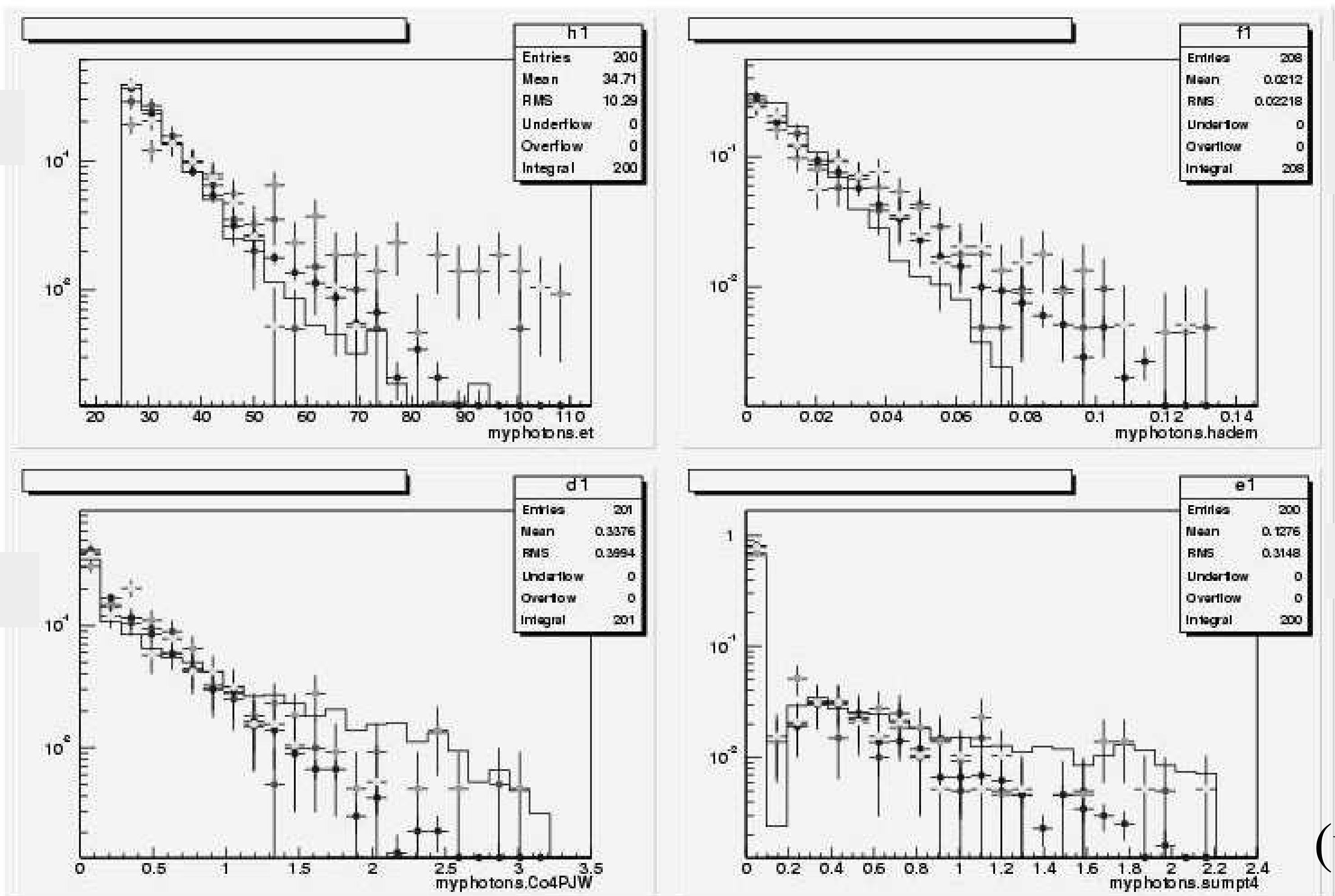
Eff(bkgrd) ~ 80%,

Eff(γ) ~ 60%

Agreement MC / data plots

γ Et

Had / em E



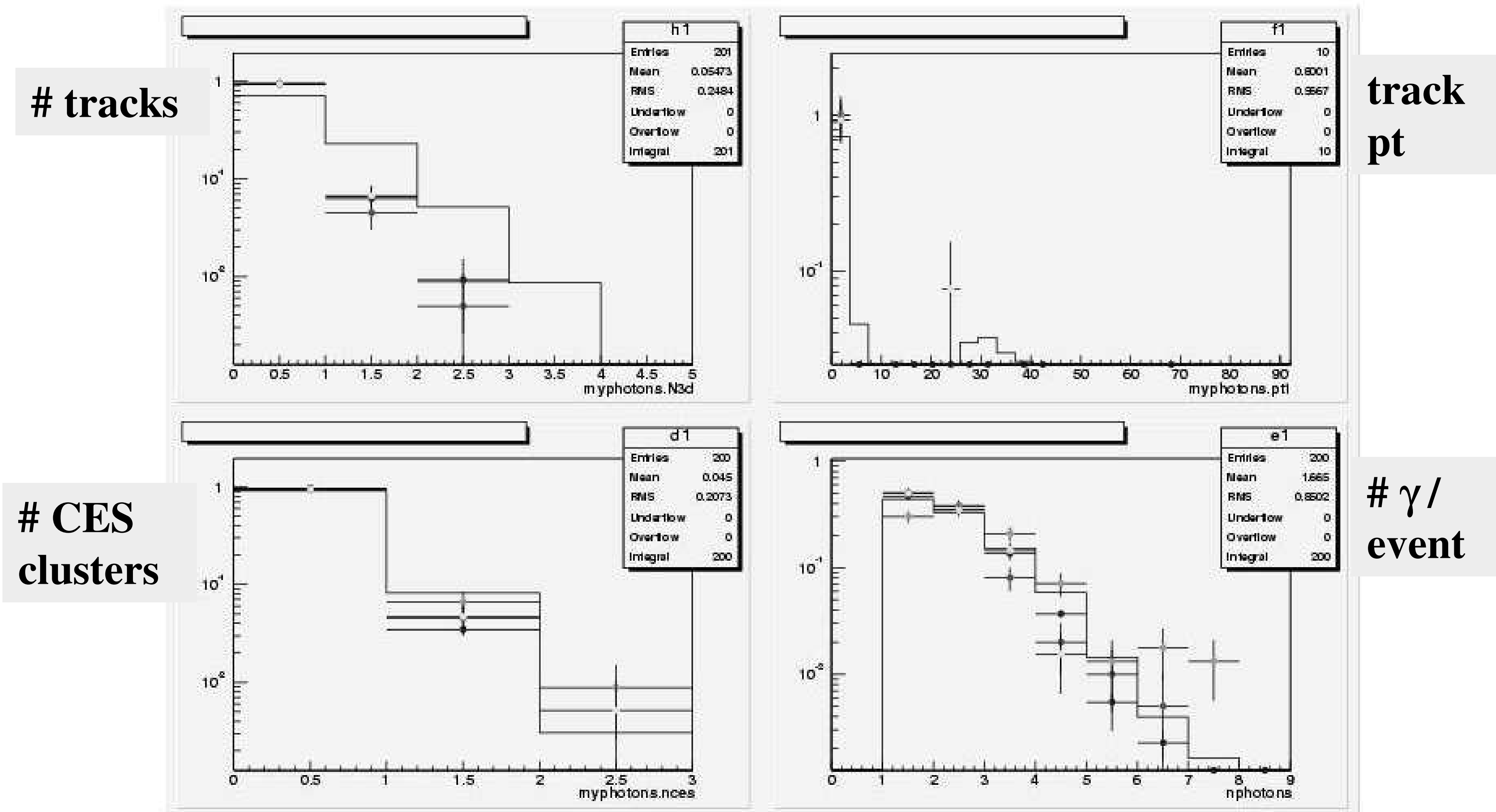
isolation

Σ pt

(unit area)

Data, Pythia γ+jet, Madgraph γ+jet, γ+jet jet

MC / data comparison

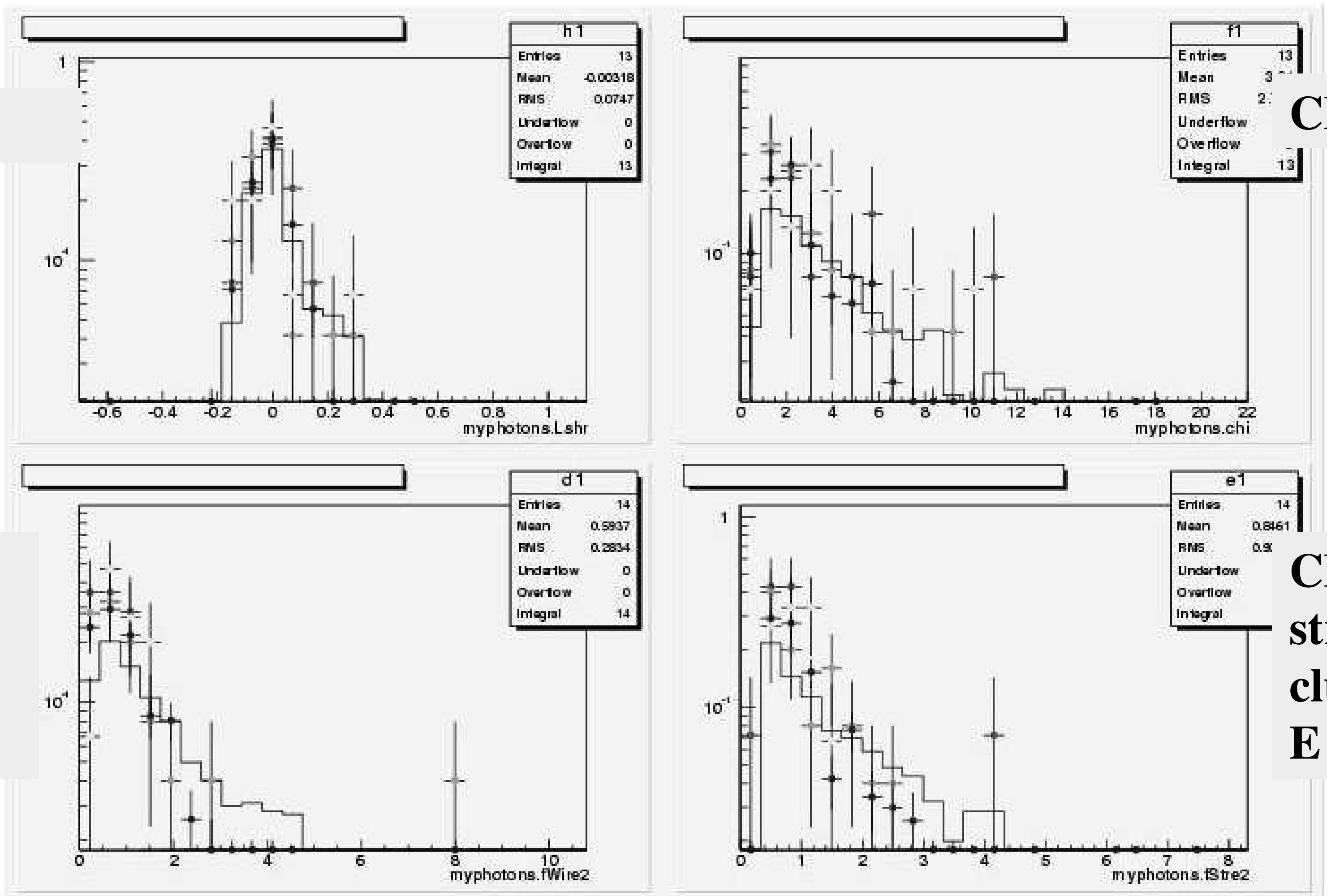


Data, Pythia γ+jet, Madgraph γ+jet, γ+jet jet

MC / data comparison

Lshare

CES χ2



CES wire cluster E

CES strip cluster E

Data, Pythia γ+jet, Madgraph γ+jet, γ+jet jet

Cut efficiencies

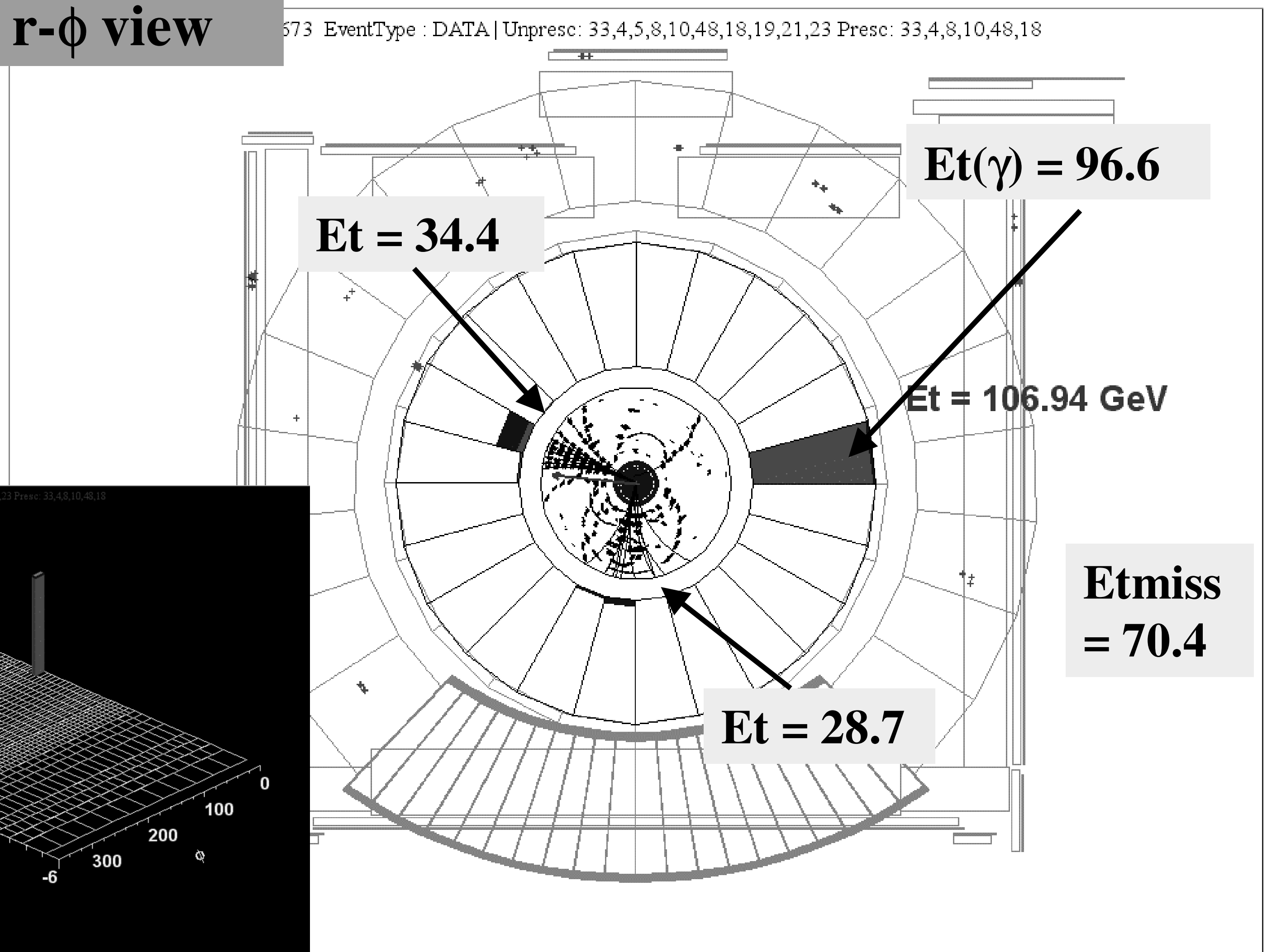
cut	γ	π^0	e	π	γ+jet	data
Central γ, Et>25	3070	3072	3096	99	13410	
Fiducial	2843	2874	2882	23	11914	
Had/em E	2737	2808	2847	5	11371	
2^{nd} CES cluster	2586	2504	2678	4	10597	
isolation	2567	2434	2640	2	10373	
CES χ2	2464	2282	2460	2	10171	
Lshare	2444	2261	2449	2	10146	
Σpt	2427	2242	2079	1	9841	
#tracks	2350	2139	44	1	9759	147595
efficiency	76.5 +- 0.7 %	69.6 +- 0.8%	1.42 +- 0.21%	1.0+-1.0 %	72.8 +- 0.4%	

Typical event

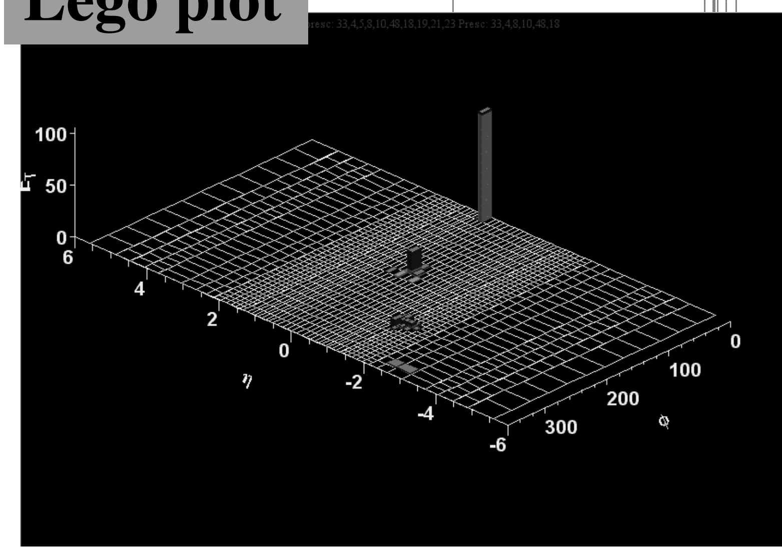
Run 144673

Event 746494

r-ϕ view



Lego plot



B jet selection

- Identify b via long lifetime => finite decay distance
  - Anant (more expl.)
  - Anyes (alternative)

- Jets are tagged using standard CDF algorithms
  - require +ve decay distance
  - require Jet Et > 15 GeV

Main backgrounds:

- Charm
  - Charm lifetime ~ 0.25 b lifetime
  - Photon couples to charm ~ 4x cf. b
- uds
  - Random combinations
  - Lambda, kshort rej.
  - Large uds cross-section

Secvtx performance

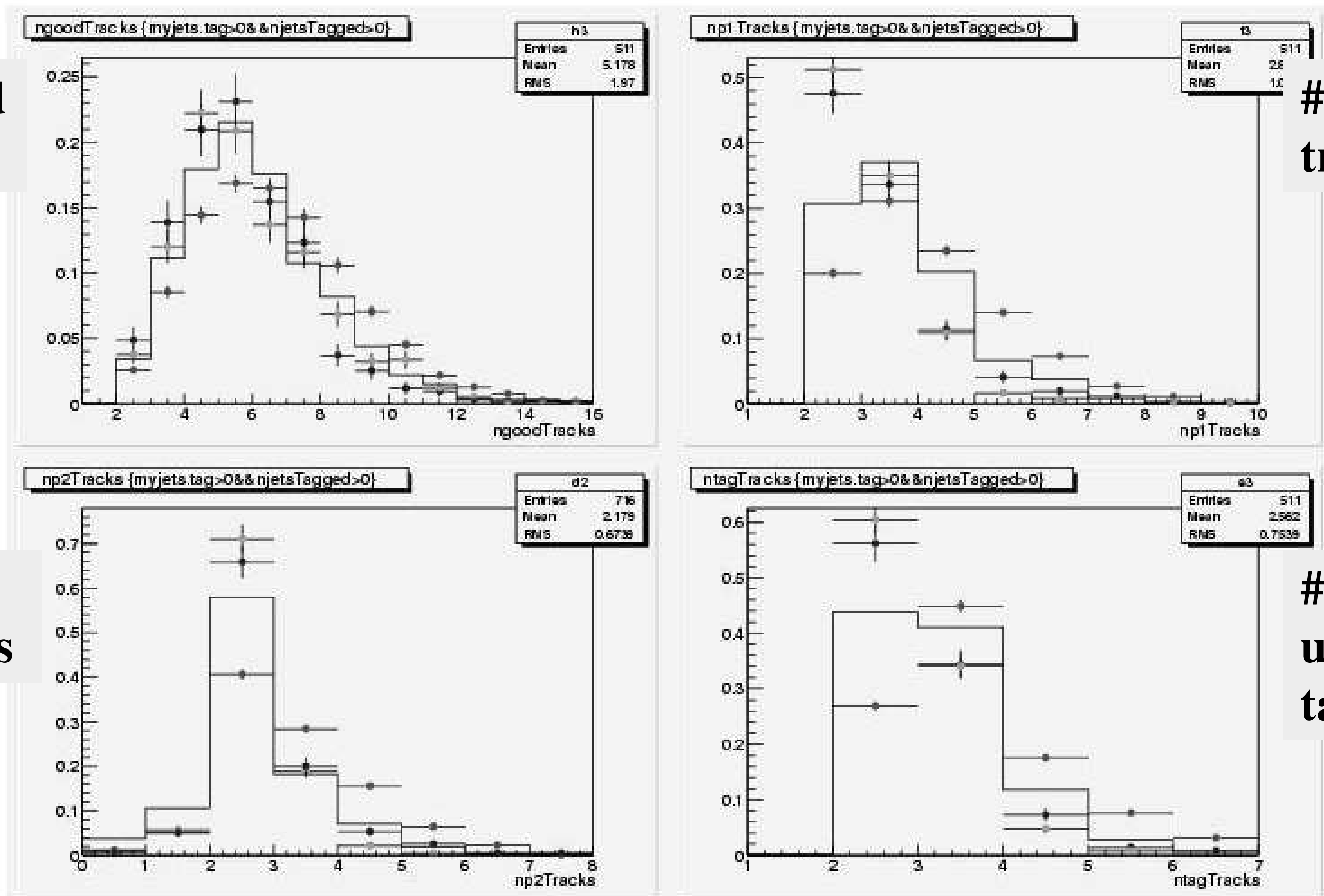
Use Madgraph γbb , γcc, Pythia γ+jets:

- Compare tagged jet properties to data
  - # tracks / vertex
  - Decay length distributions
  - Mass of secondary, χ^2, jet Et
  - Compare madgraph with Pythia!
- Count # +ve, -ve tags in MC / data

Data / MC comparison

good tracks

p1 tracks



p2 tracks

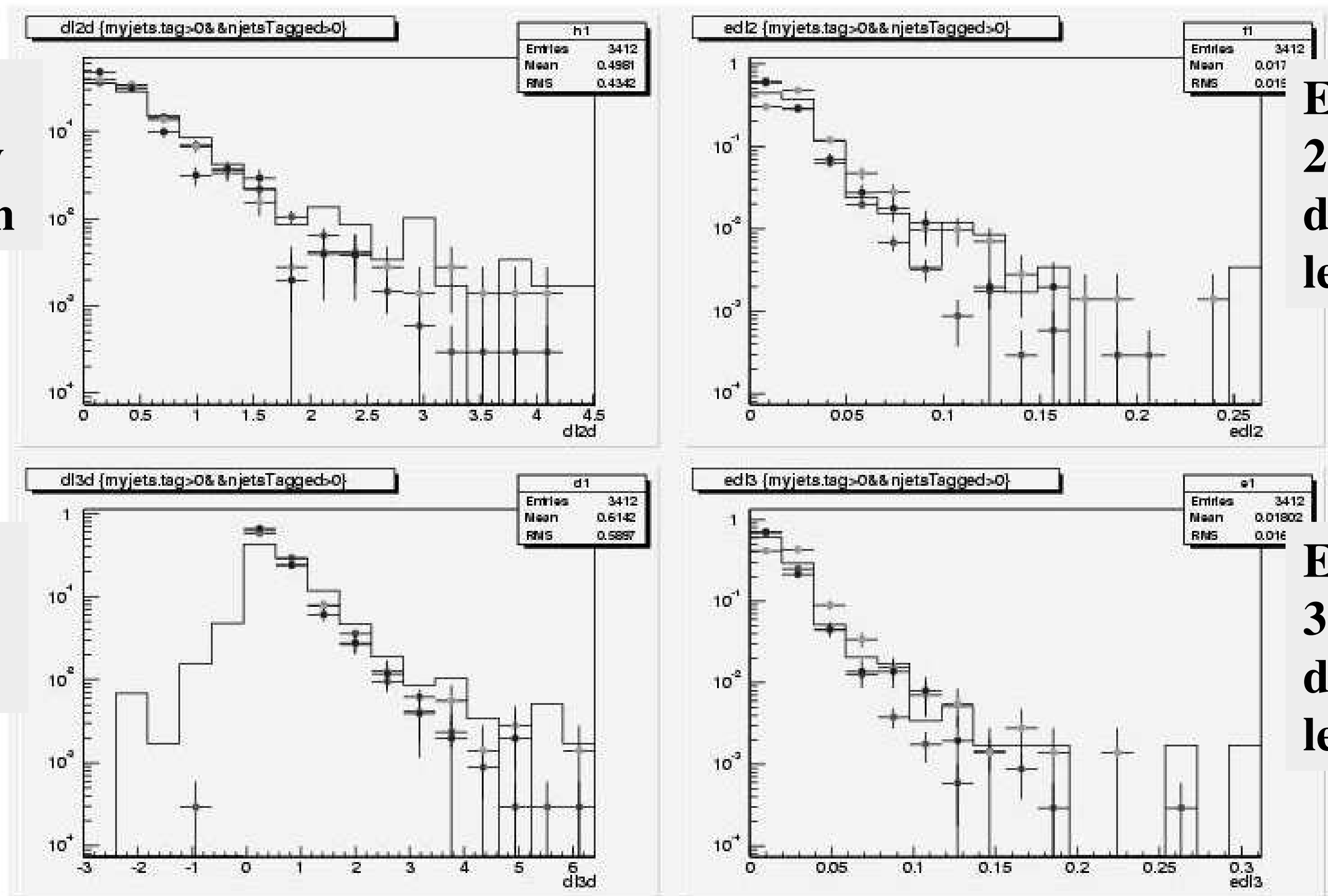
tracks used in tag

Data, Pythia γ+jet, Madgraph γ+bb, γ+cc

Data / MC comparison

2d decay length

Error 2d decay length



3d decay length

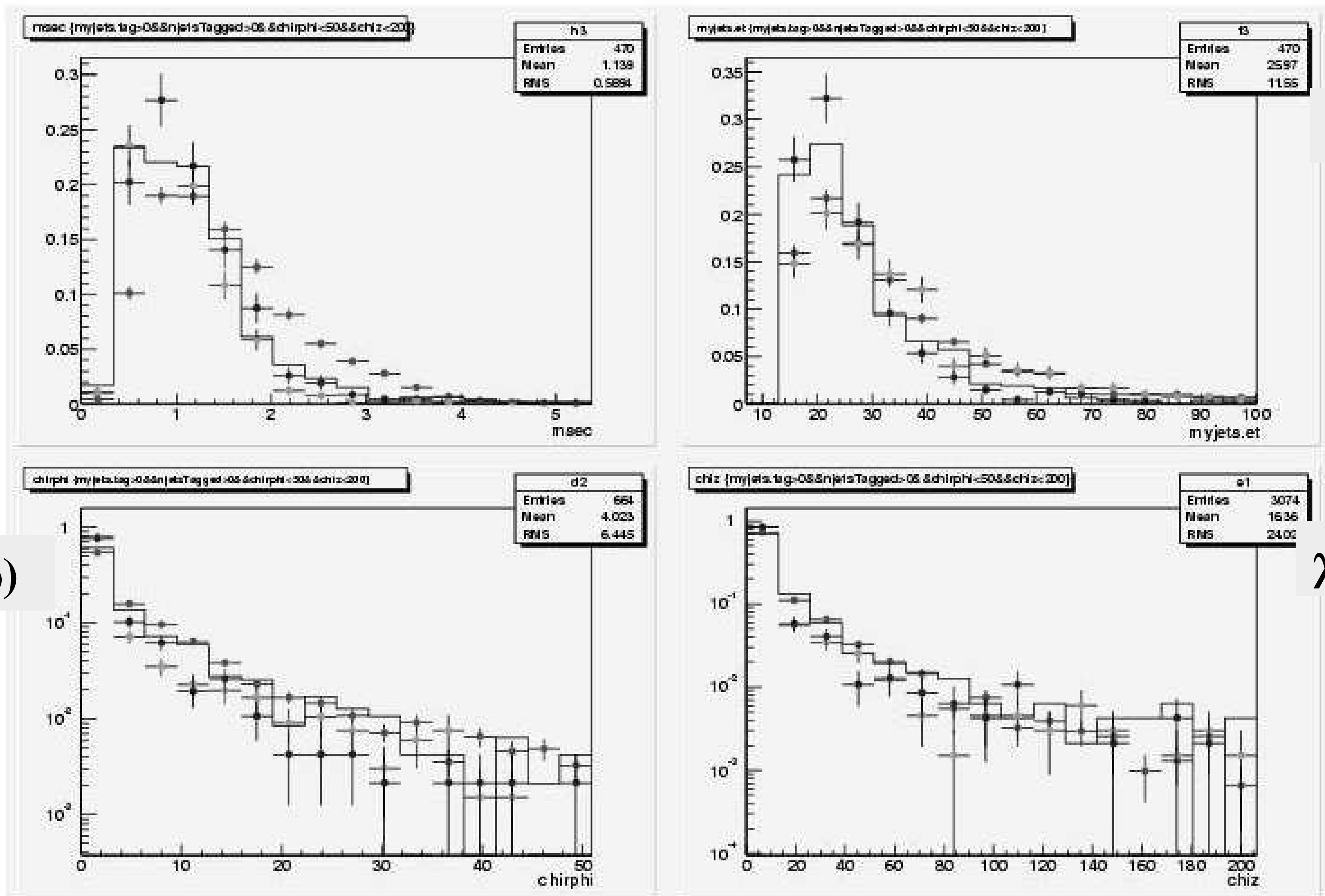
Error 3d decay length

Data, Pythia γ+jet, Madgraph γ+bb, γ+cc

Data / MC comparison

Mass of 2ndry

Jet Et



χ^2 (r-ϕ)

χ^2 (z)

Data, Pythia γ+jet, Madgraph γ+bb, γ+cc

Data / MC comparison

- Some difference expected between b, c, uds
  - Multiplicity
  - Mass of secondary
- Most distributions **similar** data/MC and madgraph/Pythia
  - More tracks in data?
  - Harder jets in Pythia?

- Known problems not yet addressed / modelled:
  - beamspot
  - alignment
  - track reconstruction
  - dead areas of silicon
  - some inconsistent data processing

Results

	# +ve tags	# -ve tags	Total sample	Eff (+ve tag)
Mad γbb	3412	100	14469	0.236+-0.004
Mad γcc	716	29	12896	0.056+-0.002
Pythia γ+jet	511 159 bb 291 cc 61 uds	56 6 bb 17 cc 33 uds	89635 1864 bb 10847 cc 76924 uds	0.006+-0.0003 0.085+-0.006 0.027+-0.002 0.0008+-0.0001
data	654	145	147595	

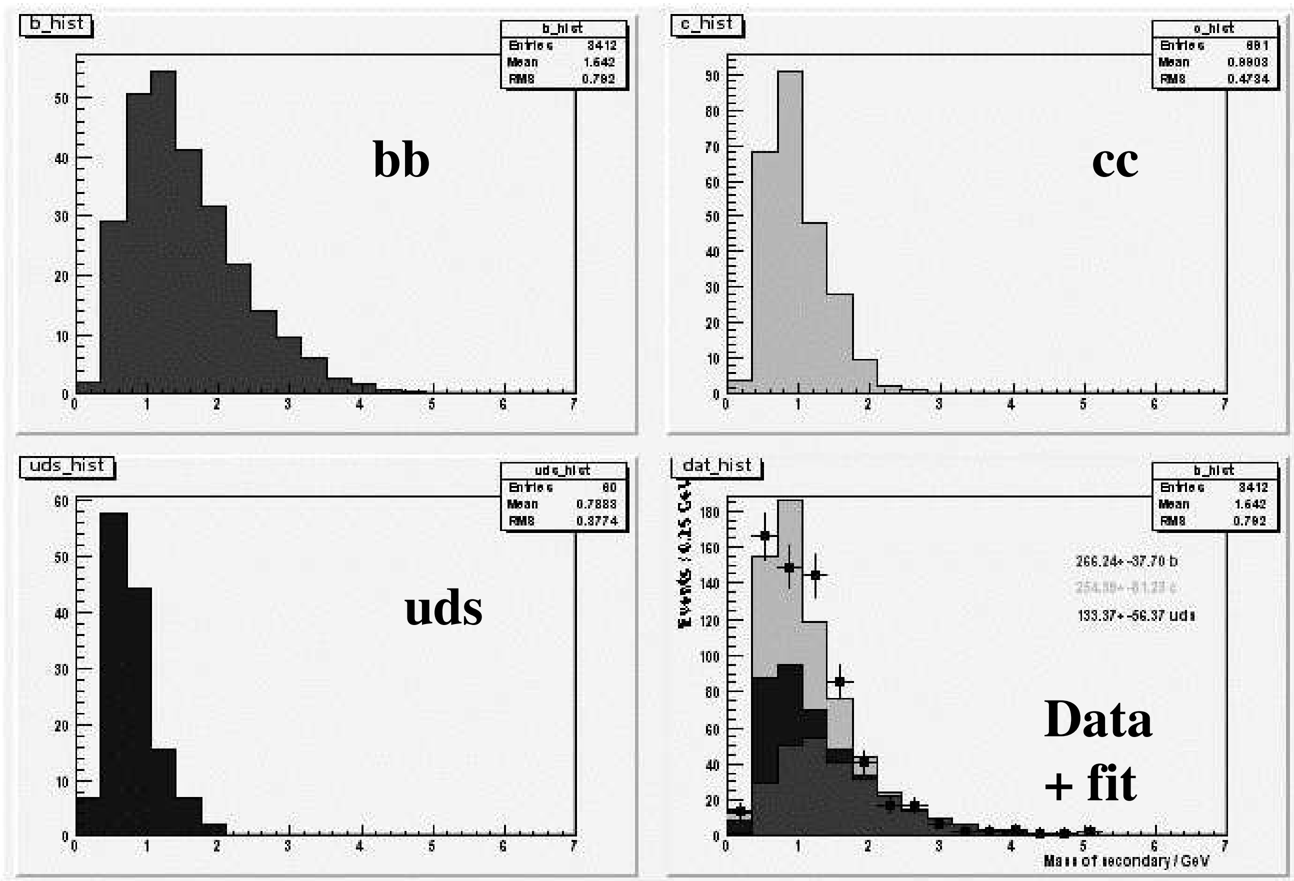
CDF code version differences?

Generator level cut differences?

Aside …(for the future)

Difference in msec, ntracks in tag between bb, cc, uds

Could fit data to MC shapes and let normalisation float

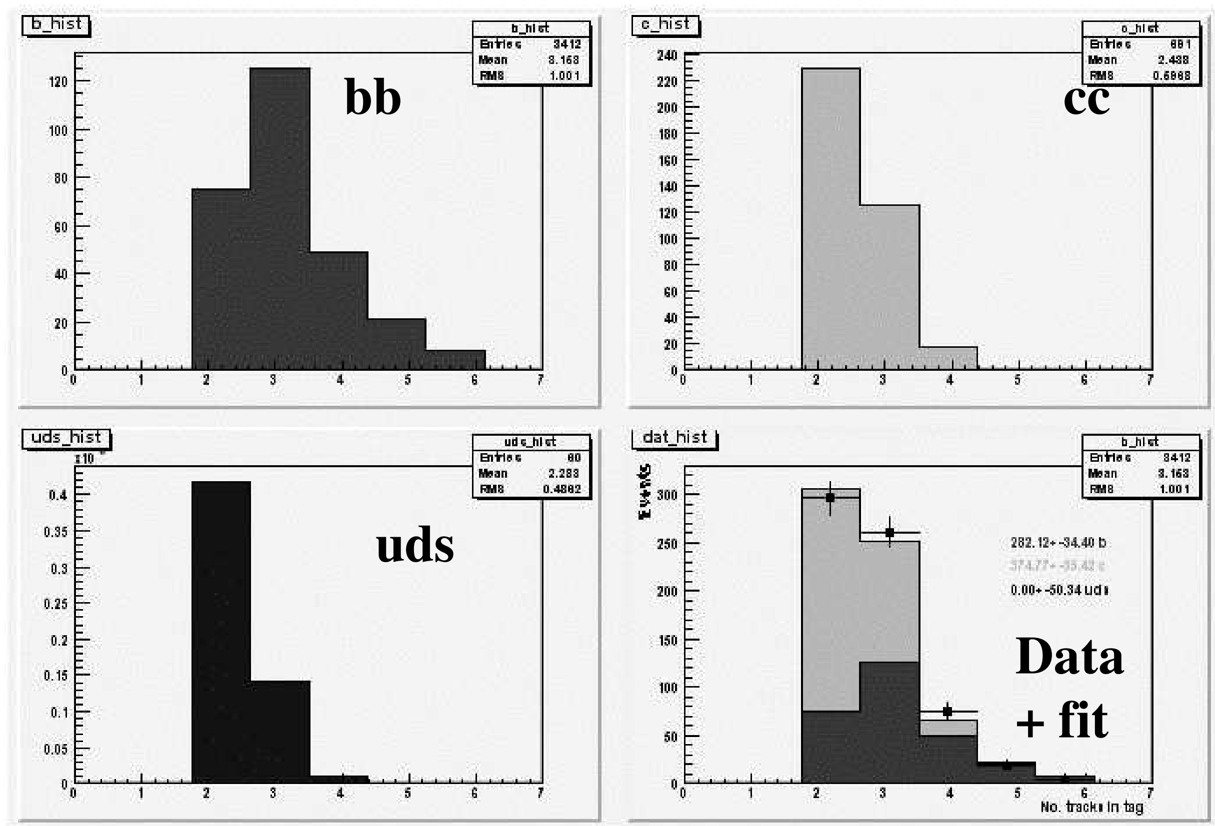


Mass of secondary

Aside …(for the future)

Sensitive more to bb fraction (cc, uds similar)

bb fraction consistent with before



 # tracks in tag

Sources of error (so far)

Photon id:

- Fake photon estimate
- Data not as isolated as MC, extra bkg contributions?

Missing Et:

- Not really yet examined, known not to be well modelled at high values (Run 1)

B tagging:

- Beamspot, alignment, tracking (->more tags)
- Tracking errors (? – parametrised in code)
- Dead areas of Si affect tracking/tagging in data (->less tags)
- MC estimate: jet Et cut off, other generator cuts, processing (?)

Summary, work plan

Done:

- Applied Run 1 photon selection to Run 2 data
- Applied Run 2 b tag to Run 2 data
- compared MC distributions to data

To do:

- Understand discrepancies
- Estimate / understand photon fake rate
- Quantify systematics