Γ_{ee} Hadronic Efficiency Measurement Completed!

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Draft CBX: `/nfs/papers/drafts/gamma_ee_efficiency.pdf`

Technique: need to know hadronic efficiency of 9 cuts (first is trigger)

- Put Monte Carlo through first six cuts, count survivors for efficiency; overlay data and estimate systematic errors

- Put background-subtracted data through last three, count survivors for efficiency

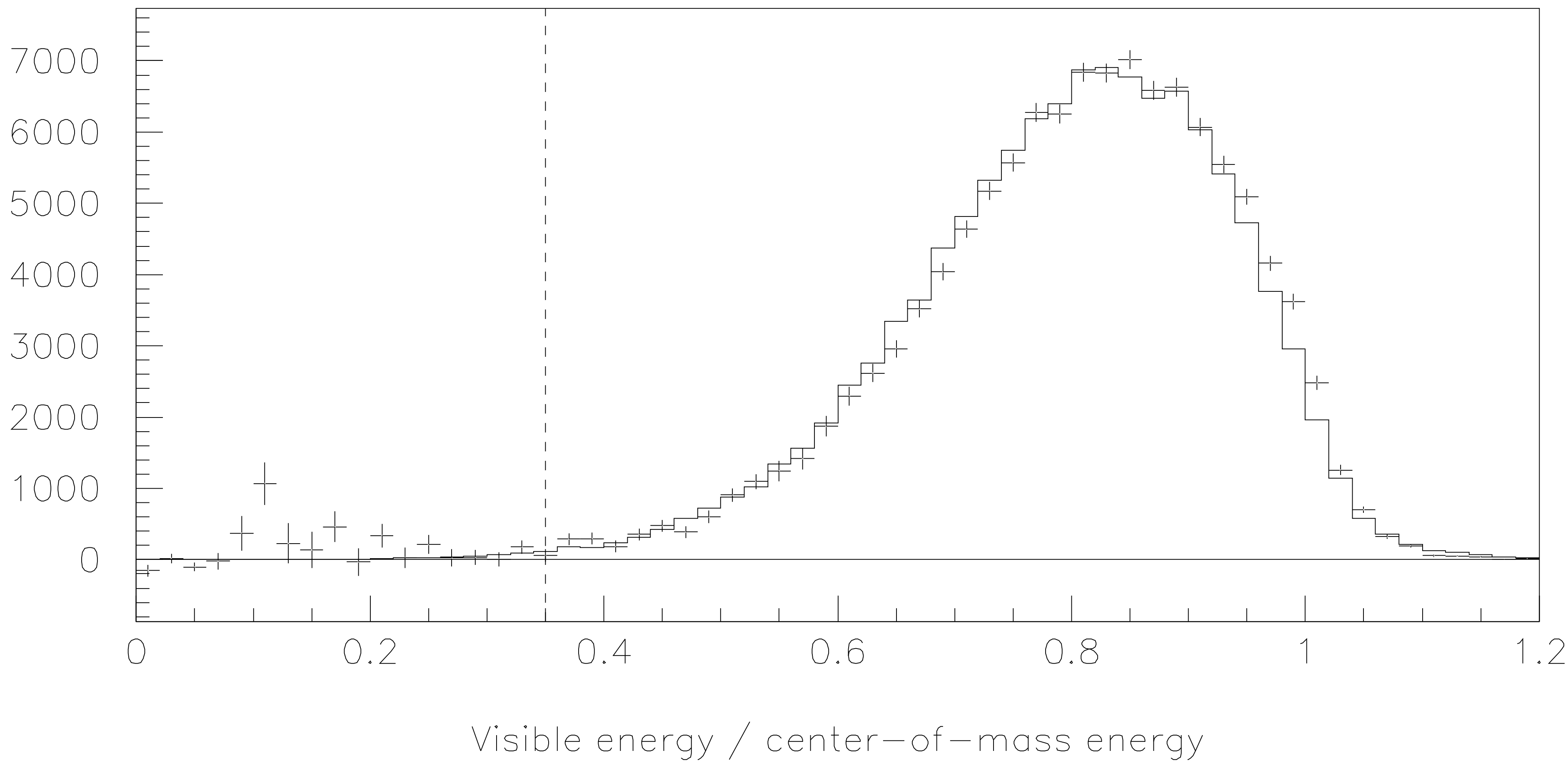
	$\Upsilon(1S)$	$\Upsilon(2S)$	$\Upsilon(3S)$
Cuts #1 – #6 (MC)	$98.9\% \pm 0.5\%$	$97.2 \pm 0.7\%$	$98.2\% \pm 0.7\%$
Cuts #7 – #9 (data)	$100.1\% \pm 0.2\%$	$99.8 \pm 0.3\%$	$98.6\% \pm 0.4\%$
	$99.1\% \pm 0.6\%$	$97.0 \pm 0.8\%$	$96.8\% \pm 0.8\%$

Example: Cut # 6: Visible energy > 35% of center-of-mass energy

Central value for efficiency comes from the Monte Carlo

but what uncertainty should be assigned?

Below: background-subtracted data (points) and Monte Carlo (histogram) for $\Upsilon(2S)$ (cuts #1 – #5 have been applied: leptons, beam-gas, and cosmic rays are gone)



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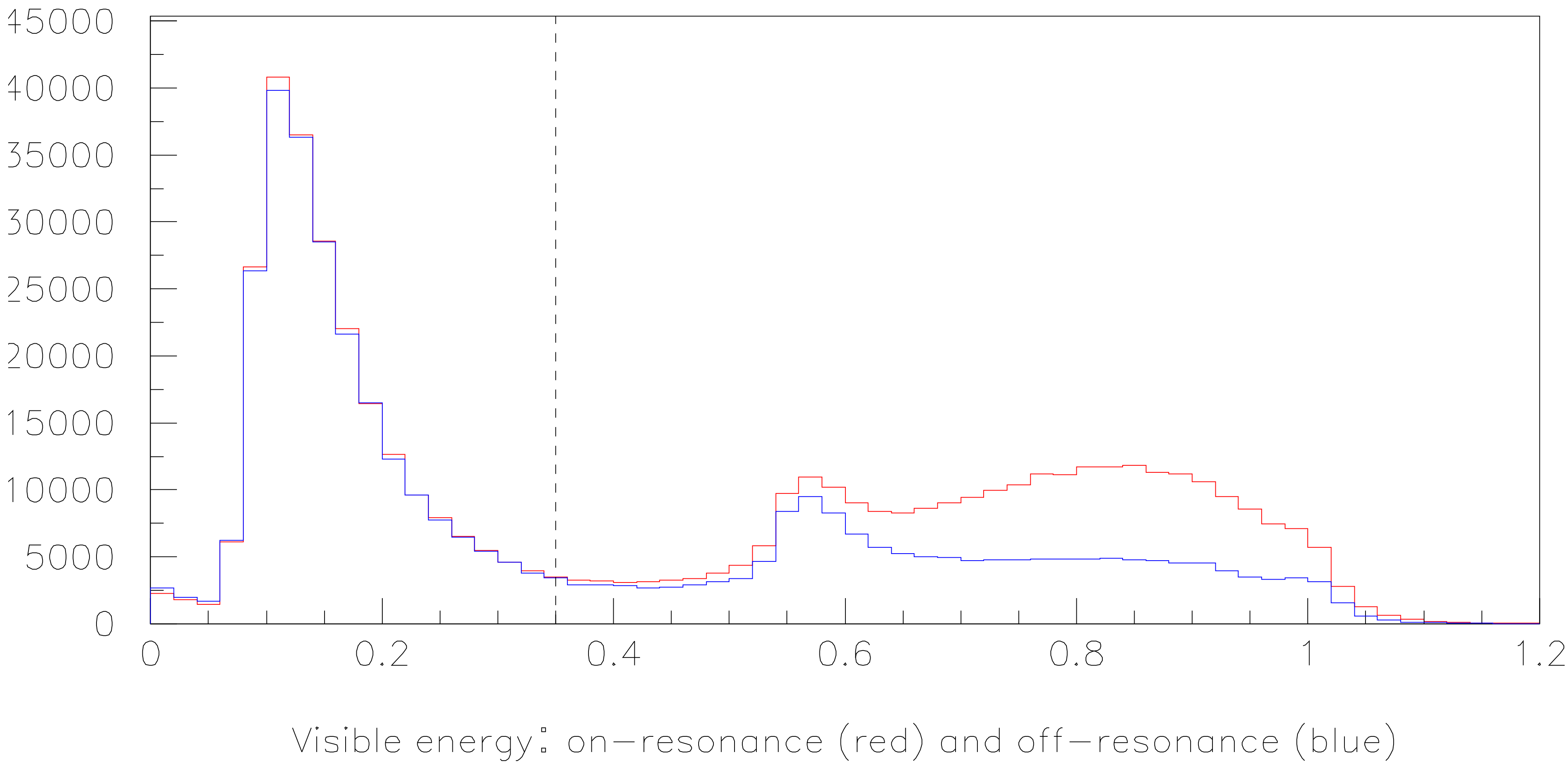
Data before background subtraction has a large peak of mostly two-photon fusion

Continuum scale factor is

$$\frac{\mathcal{L}_{\text{on-res}}}{\mathcal{L}_{\text{off-res}}}\left[\frac{s_{\text{off-res}}}{s_{\text{on-res}}}(\text{non-}2\gamma\text{ fraction})+\log\left(\frac{s_{\text{on-res}}}{s_{\text{off-res}}}\right)(2\gamma\text{ fraction})\right]$$



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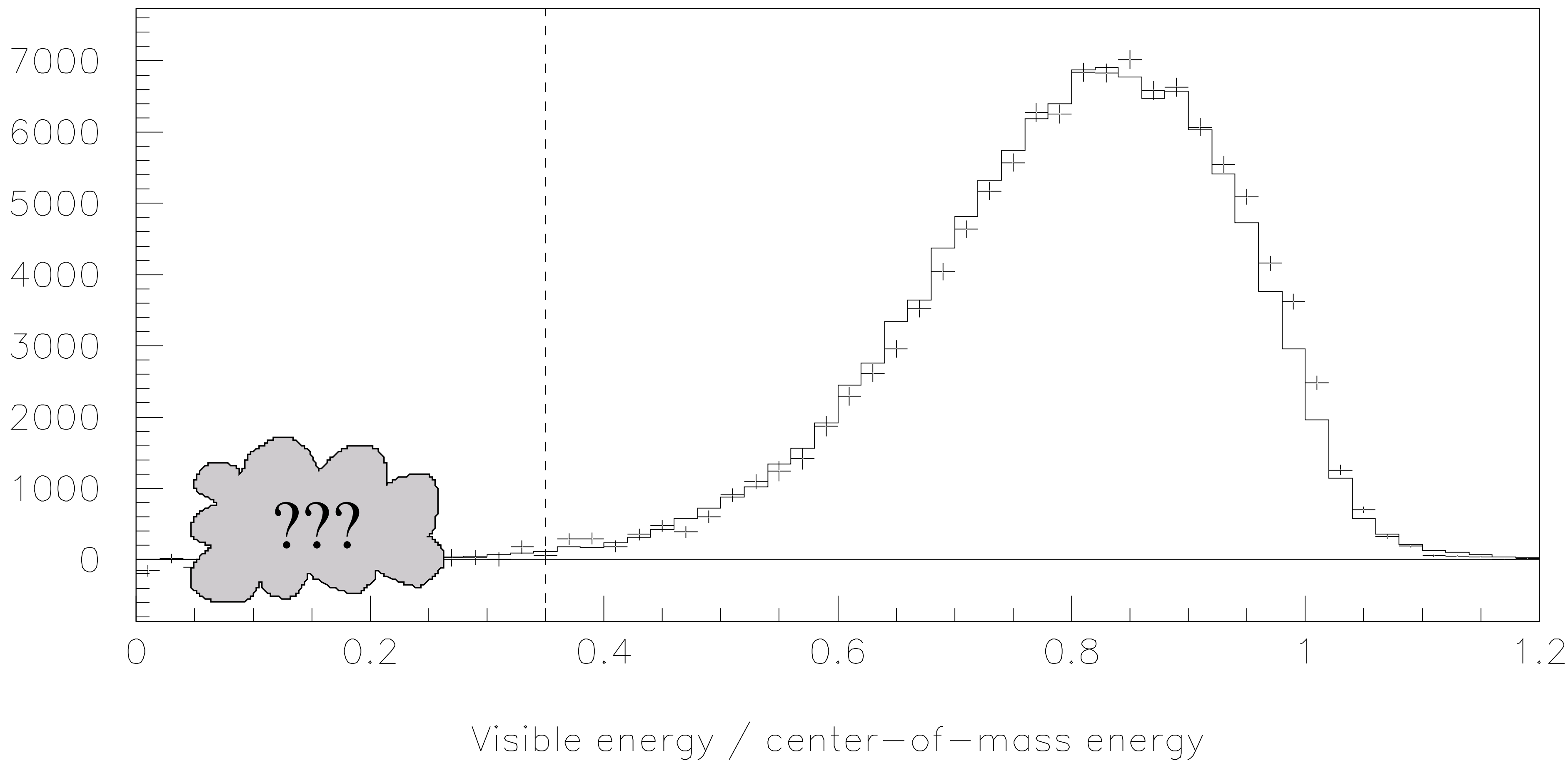
Subtraction of large peak *and* uncertainty in two-photon fraction makes data inconclusive at low visible energy.

	$\varepsilon_{\Upsilon(1S)}$	$\varepsilon_{\Upsilon(2S)}$	$\varepsilon_{\Upsilon(3S)}$
Ignore Monte Carlo, take data uncertainty	$\pm 1.2\%$	$\pm 1.5\%$	$\pm 2.0\%$
Trade assumtions for precision	$\pm 0.6\%$	$\pm 0.8\%$	$\pm 0.8\%$



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Why don't I trust Monte Carlo?

1. Explicit decay modes are okay, but real ggg, $q\bar{q}$, and $gg\gamma$ hadronize via QCD; Monte Carlo approximates with Jetset 7.4.

2. Real Υs might also decay to a final state not in the Monte Carlo (given the way I defined my signal, this would be signal).

New explicit assumtion (answers objection #2):

Υs decay only to:

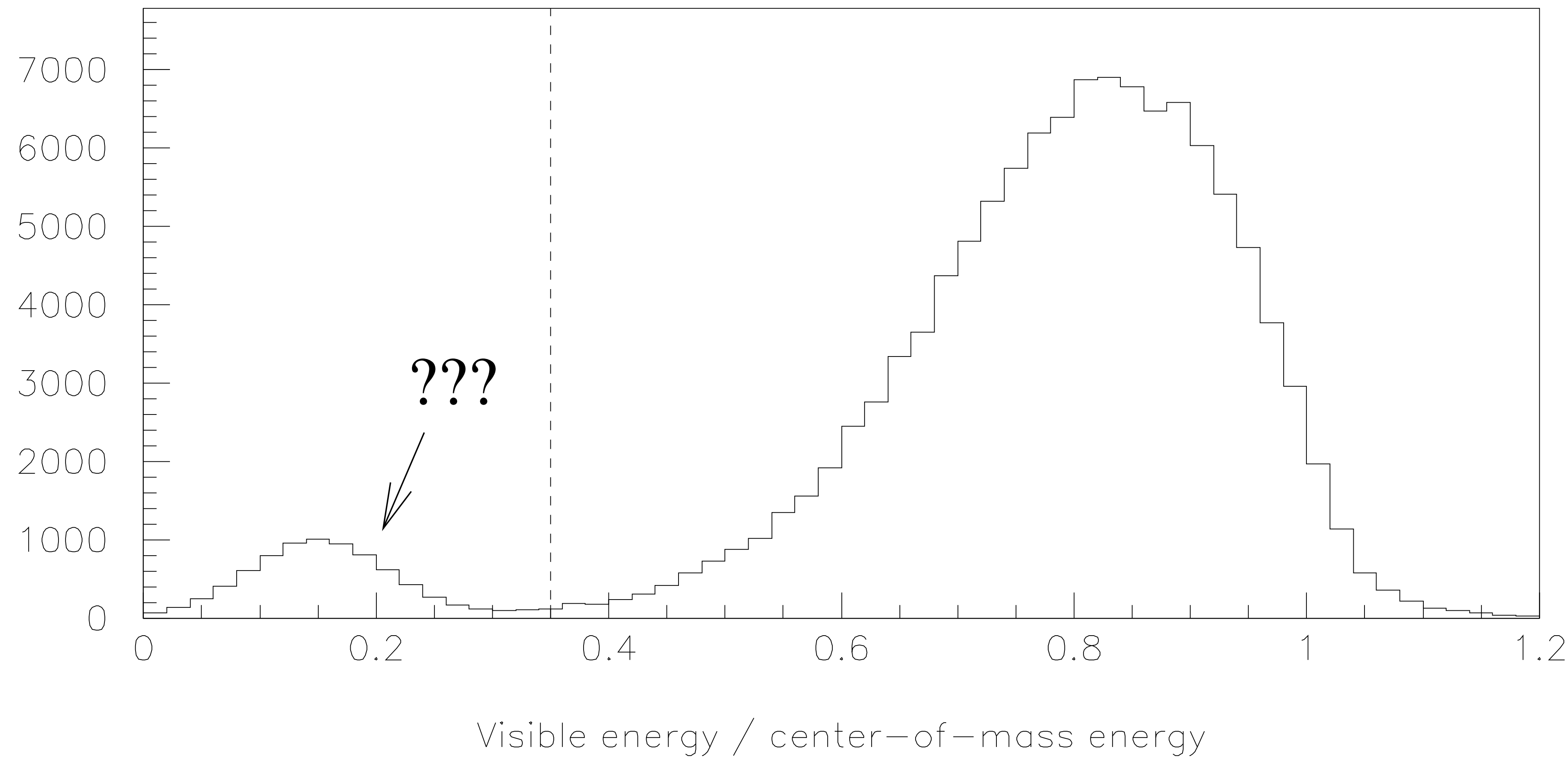
- ggg, $q\bar{q}$, and $gg\gamma$, which hadronize (signal)
- Cascades to lower Υ with $\pi\pi$ or $\gamma\gamma$ (signal)
- Radiative decays to χ_b (signal)
- $e^+e^-(\gamma)$, $\mu^+\mu^-(\gamma)$, and $\tau^+\tau^-(\gamma)$ (not signal)

Example: Cut # 6: Visible energy > 35% of center-of-mass energy

What can still go wrong? (Objection #1, previous slide)

Suppose Υ decays to a final state which *usually* has lots of missing energy, and this final state is enhanced by some QCD resonance.

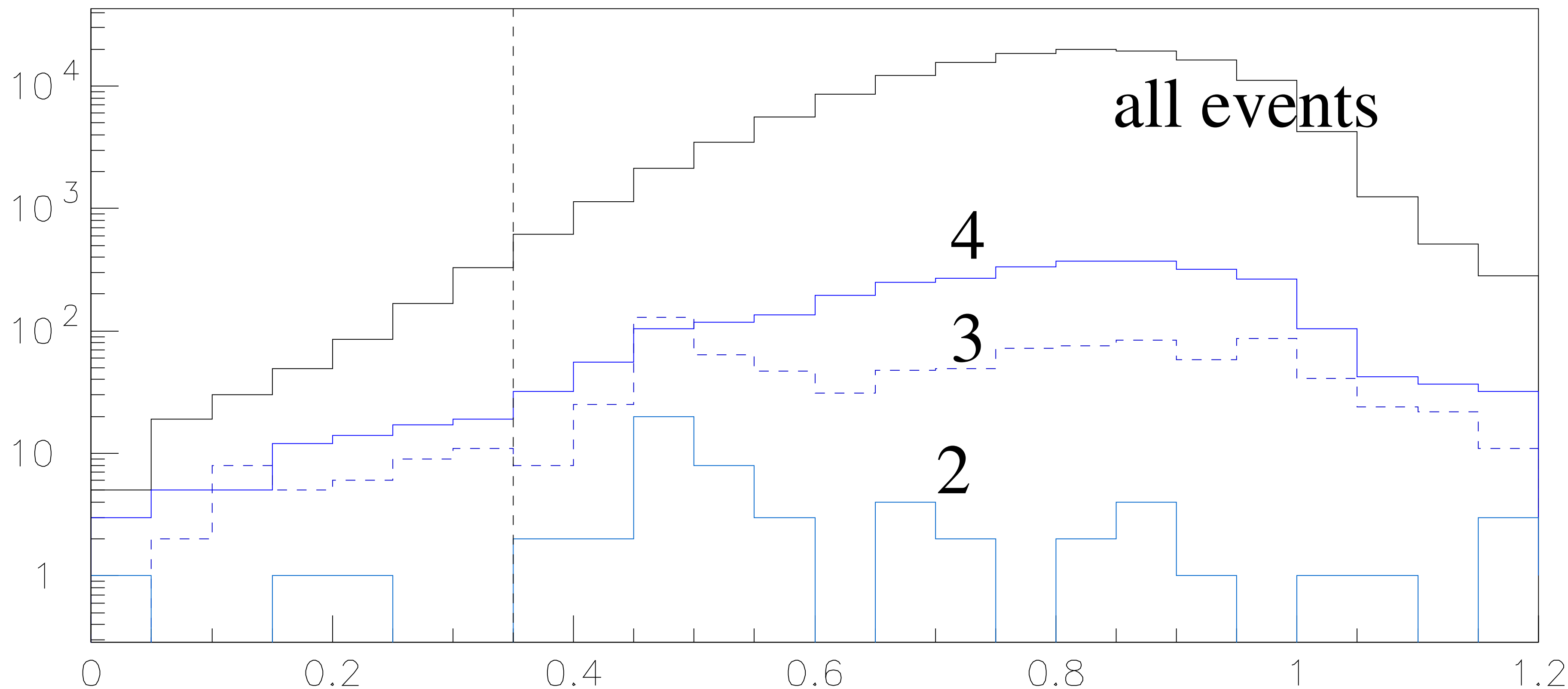
Monte Carlo sometimes generates the final state, but doesn't enhance it because Jetset doesn't know about the resonance.



Example: Cut # 6: Visible energy > 35% of center-of-mass energy

Such a final state would most likely be low multiplicity (2- or 3-body) to manage to hide most of its energy most of the time.

- Back-to-back down the beamline
- Pairs of long-lived strange particles which decay in the detector (tracks beyond 3 cm are not counted!)

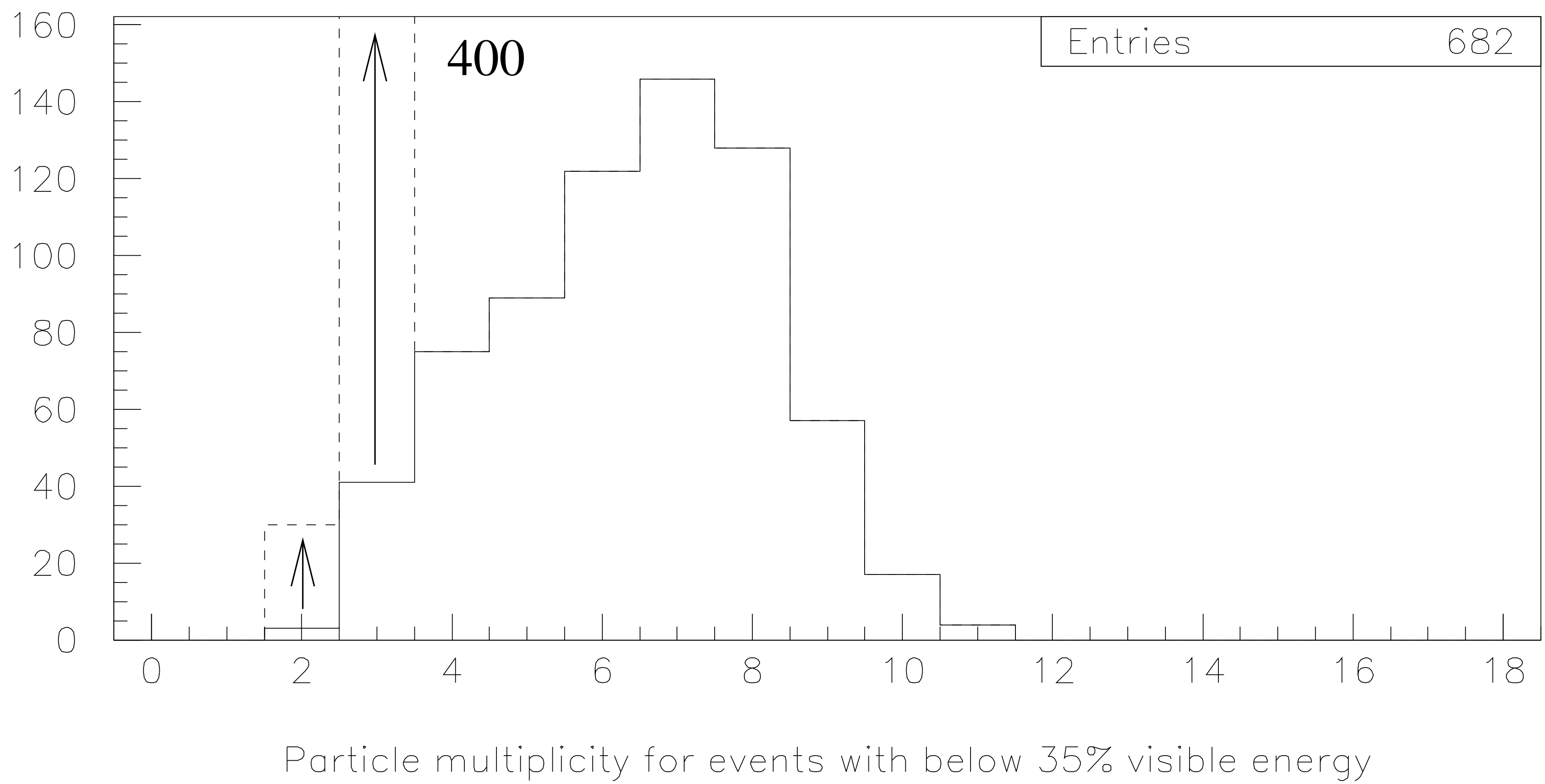


Visible energy: all events (black), 2–, 3–, 4–particle decays (blues)

Example: Cut # 6: Visible energy > 35% of center-of-mass energy

Assume it does the most damage possible: 2- and 3-body decays below threshold are a factor of 10 more common than Monte Carlo thinks.

$\Longrightarrow$ Inefficiency of 0.3% acquires uncertainty bound of 0.2%



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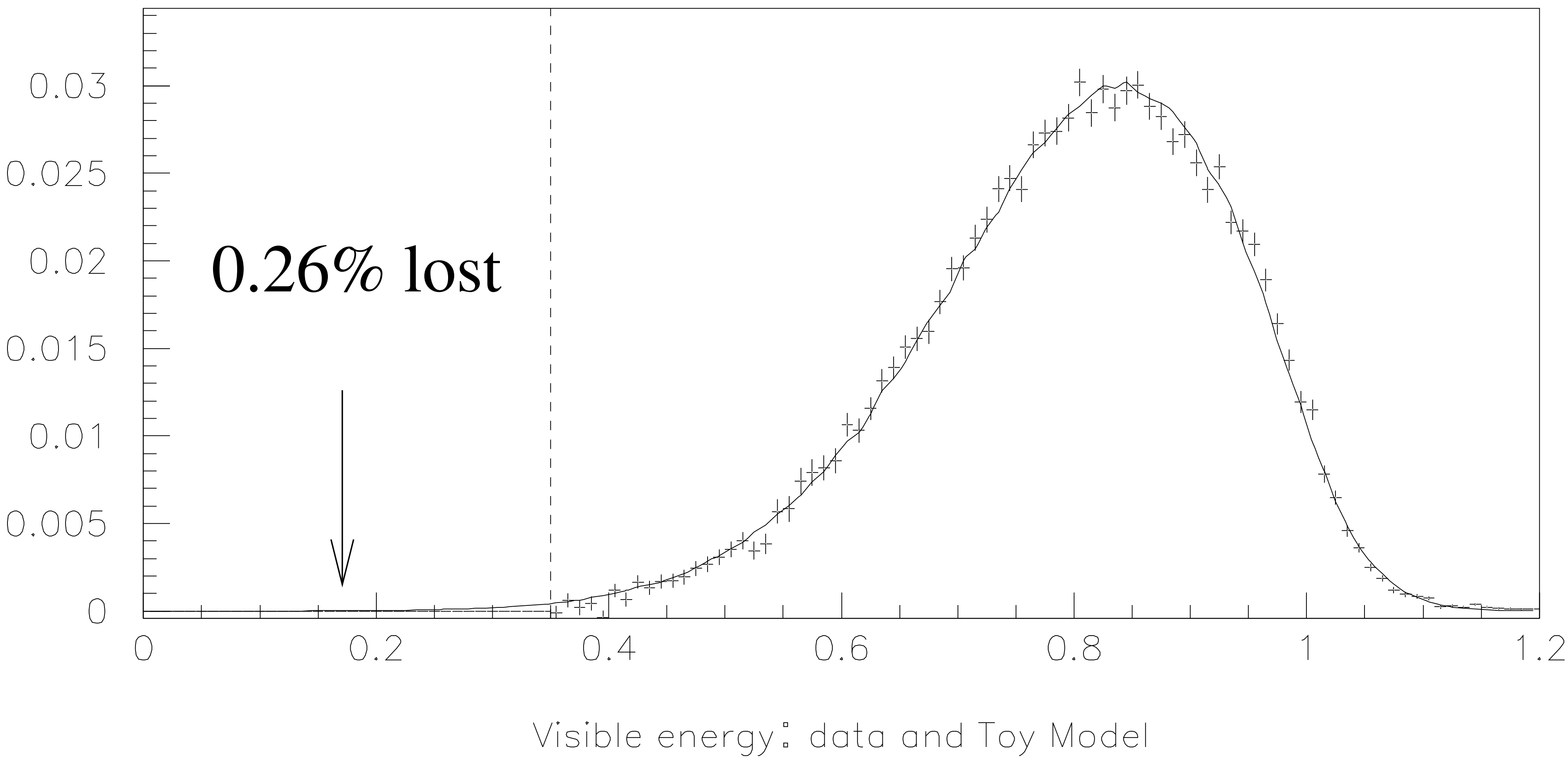
Uncertainty in detector response? Simplify Monte Carlo so I can vary parameters:

- Event is divided into N particles (average energy $\lambda = 1.85$ GeV / 10 GeV).
- A particle is lost with probability $p = 20\%$.
- And reconstructed with $\Delta E = 120$ MeV / 10 GeV.

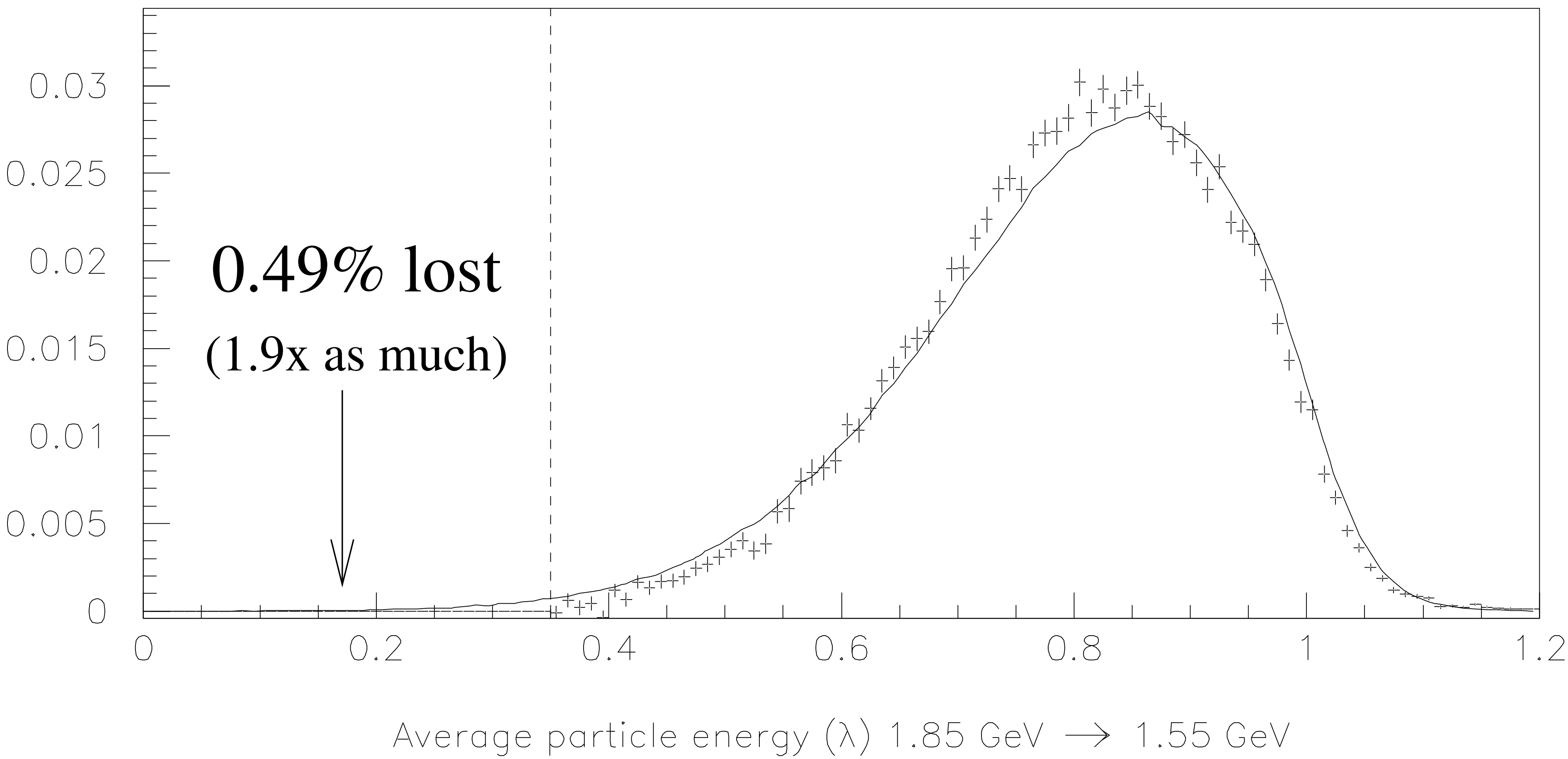
(Agrees with data and Full Monte Carlo.)



Example: Cut # 6: Visible energy > 35% of center-of-mass energy

Vary parameters until Toy Model does not agree with data.

Events that fail cut at most double.



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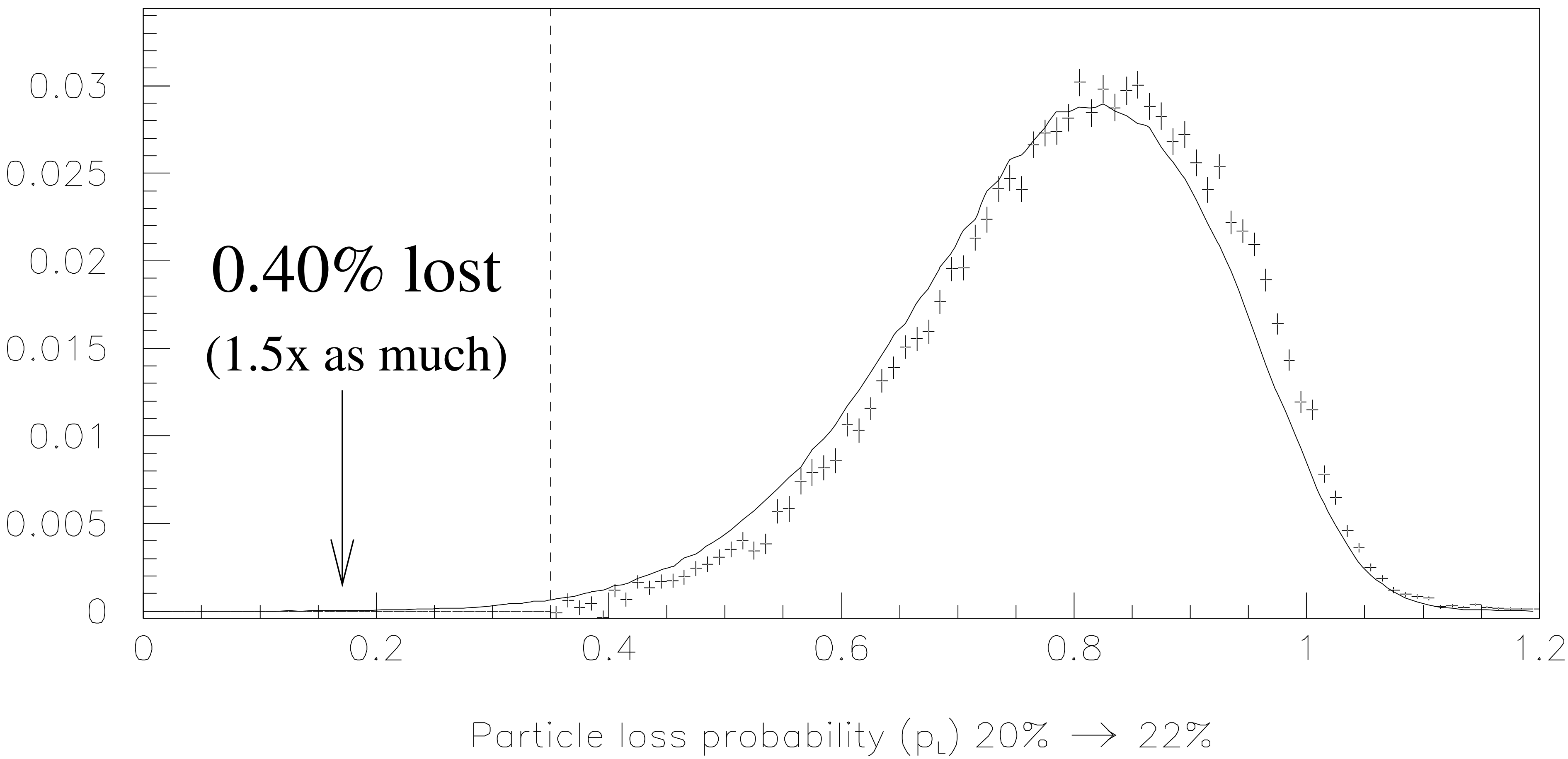

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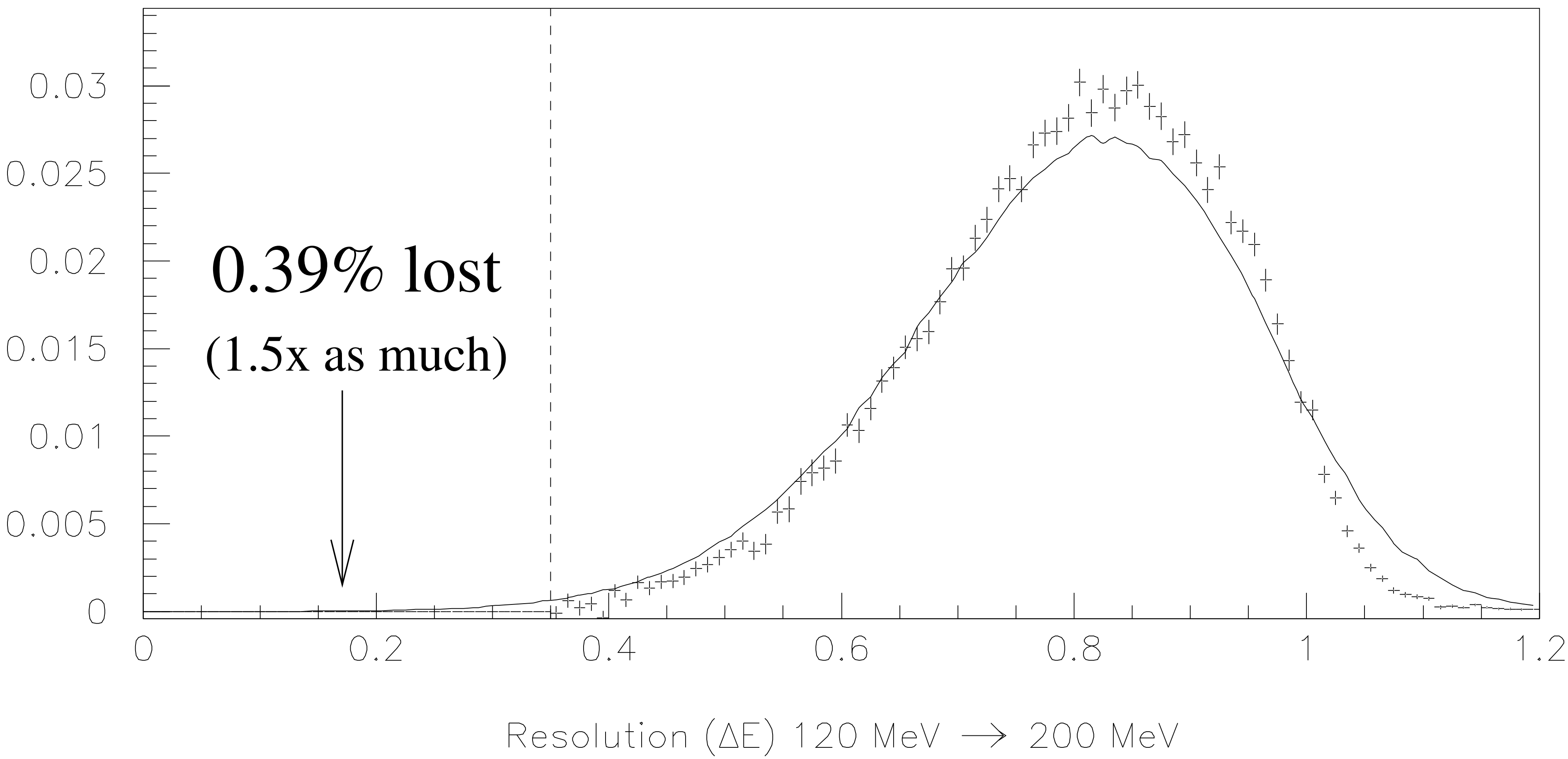
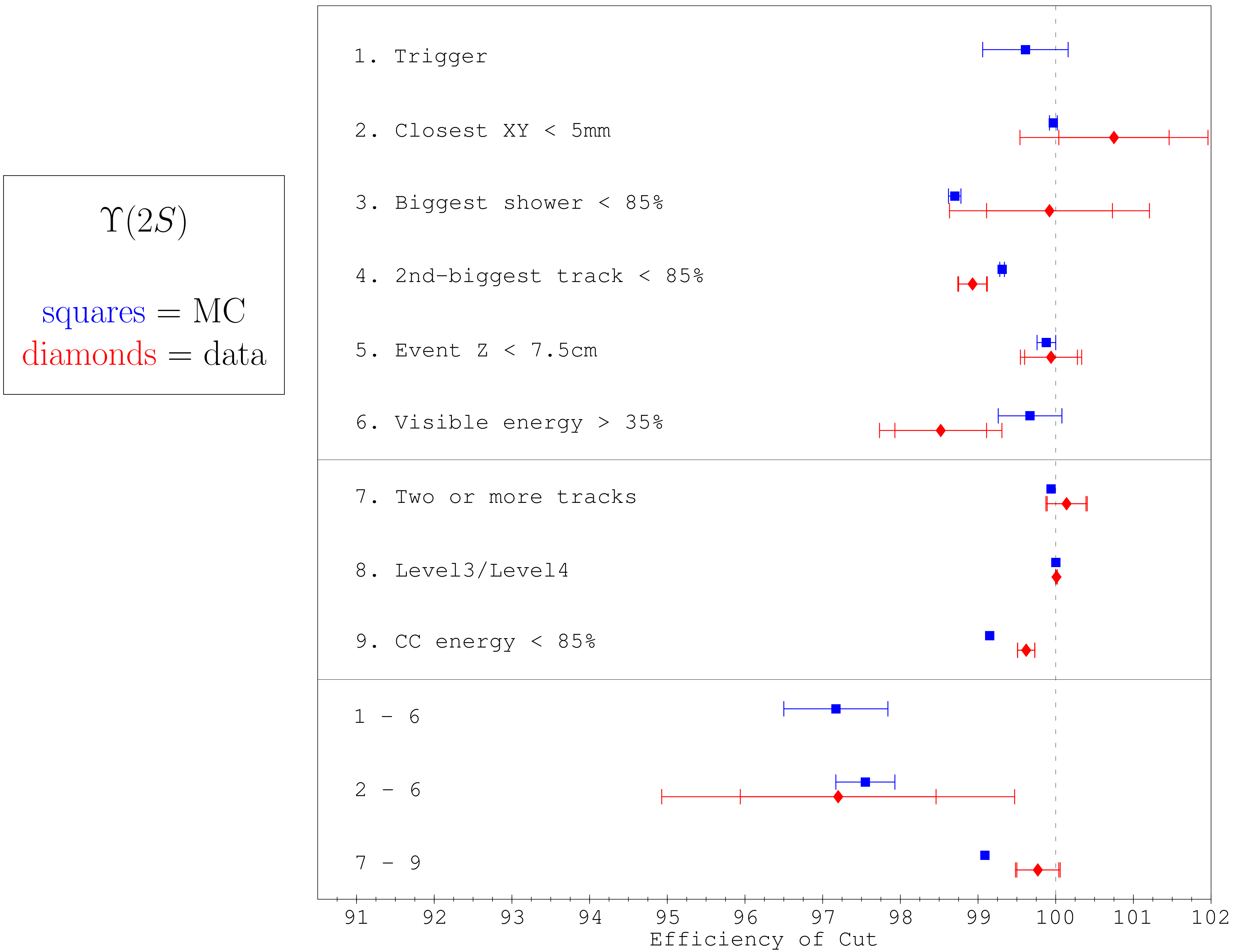
Vary parameters until Toy Model does not agree with data.

Events that fail cut at most double. $\Longrightarrow$ another 0.3% uncertainty.



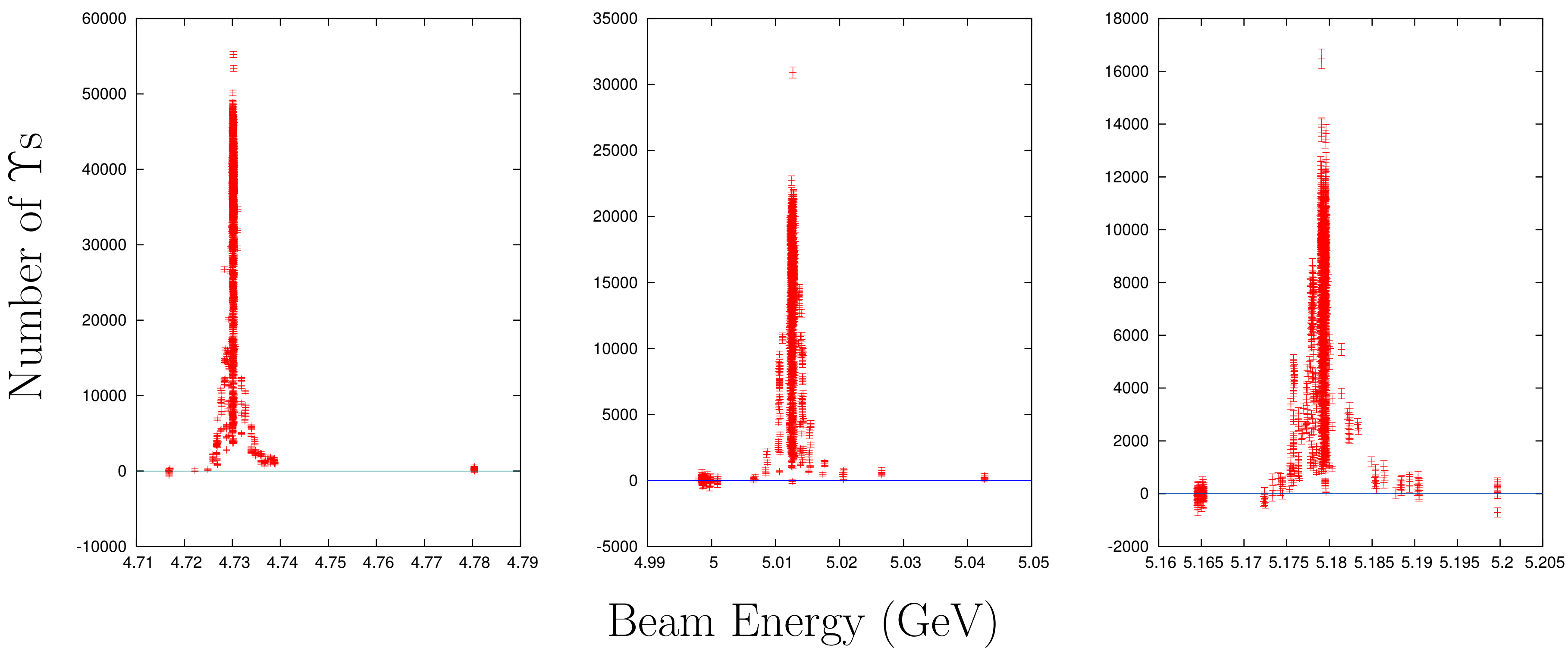


$\Upsilon(2S)$
squares = MC
diamonds = data
1. Trigger
2. Closest XY < 5mm
3. Biggest shower < 85%
4. 2nd-biggest track < 85%
5. Event Z < 7.5cm
6. Visible energy > 35%
7. Two or more tracks
8. Level3/Level4
9. CC energy < 85%
1 - 6
2 - 6
7 - 9
91 92 93 94 95 96 97 98 99 100 101 102
Efficiency of Cut

All Υs in CLEO-III have been counted on a run-by-run basis with 1.5% systematic errors.

(Backgrounds and luminosity systematics have been given rough upper limits of 0.5% and 1.1%, respectively.)

`http://www.lepp.cornell.edu/~mccann/upsilons_in_cleo3.dat`
`http://www.lepp.cornell.edu/~mccann/upsilons_in_cleo3.explaination`



What's left for Γ_{ee}?

1. ~~Lineshape Studies~~ 6 months
2. ~~Hadronic Efficiency~~ 2.75 years
3. Backgrounds (with the new cuts) $\sim$ few weeks
4. Luminosity $\gamma\gamma$-only: 3–6 months? bhabhas also: longer…
5. Beam energy stability: $<$ 1 month

*This contains forward-looking statements that are subject to risks, uncertainties and other factors that could be deemed forward-looking and could cause actual results to differ materially from those referred to in the forward-looking statements. All statements other than statements of historical fact are statements that could be deemed forward-looking statements.