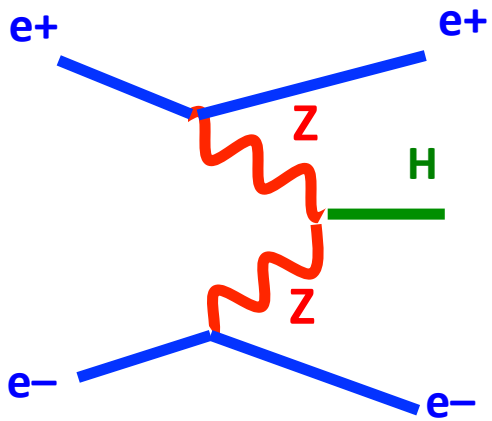
Higgs production in ZZ fusion at 1.4TeV



Aidan Robson
Dan Protopopescu

2 October 2013

University of Glasgow | Experimental Particle Physics

Introductions

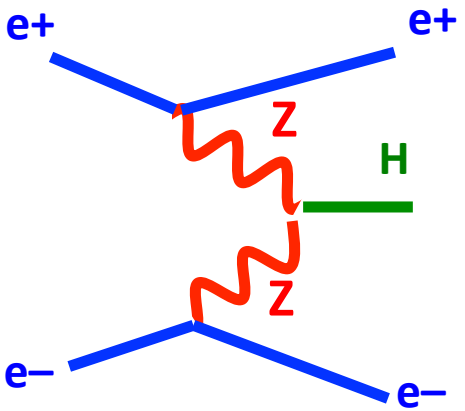
Aidan Robson
from CDF / ATLAS

Dan Protopopescu
from CLAS/PANDA/…
now NA62/PiENU

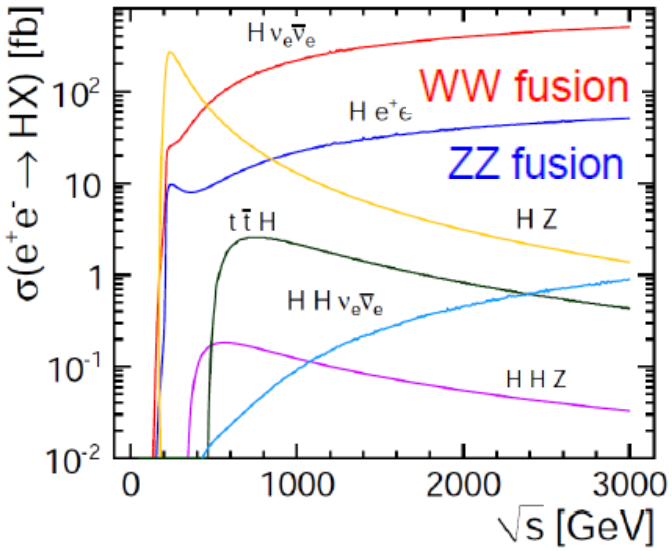
+ Strong silicon detector effort (Medipix collab)
Richard Bates, Dima Maneuski, Andy Blue

University of Glasgow | Experimental Particle Physics

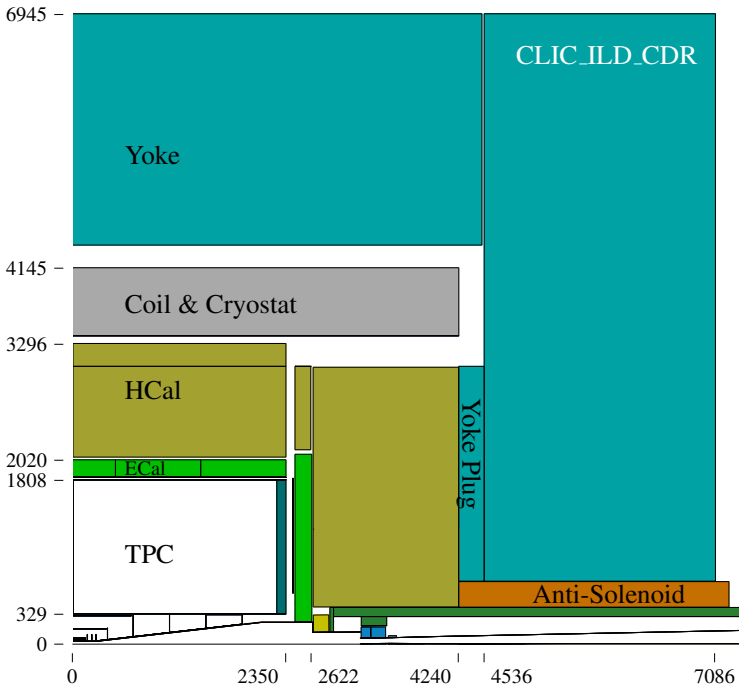
Introduction



- Fusion process $e^+e^- \rightarrow e^+e^-H$
  Cross-section at 1.4TeV ~ 24.5fb
  10% of leading production process
  $e^+e^- \rightarrow \nu\nu H$
  but access to HZZ vertex



- Using CLIC-ILD detector, good forward coverage – important here



Summary

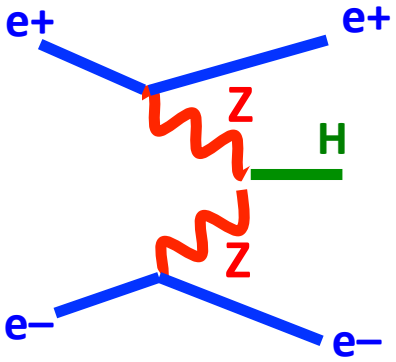
Since last update:

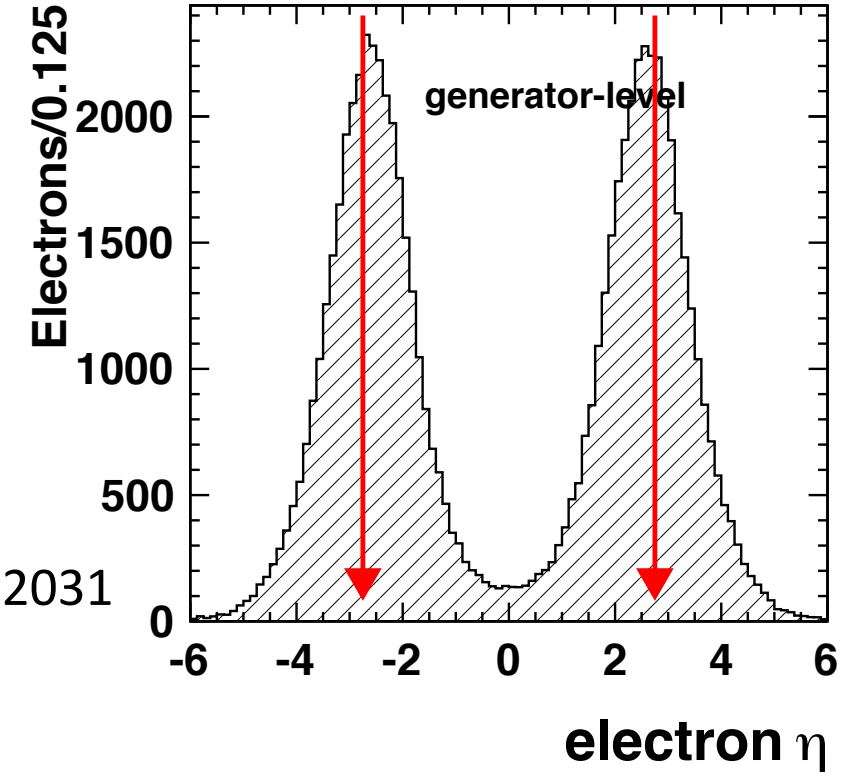
- studied main backgrounds
- developed likelihood separation
- studied final state and implemented LCFI b-tagging
- obtained good signal : background
- included photon radiation in electron reco

Characterising the signal

- Signature: 2 forward electrons, plus Higgs decay

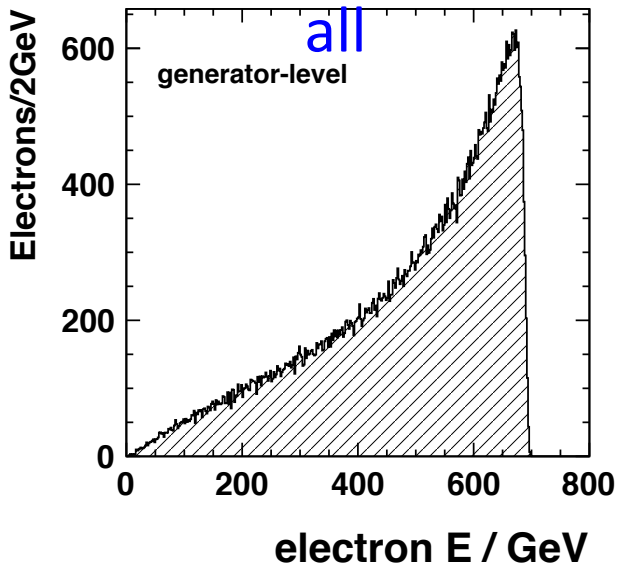
Scattered beam electrons at gen.-level:

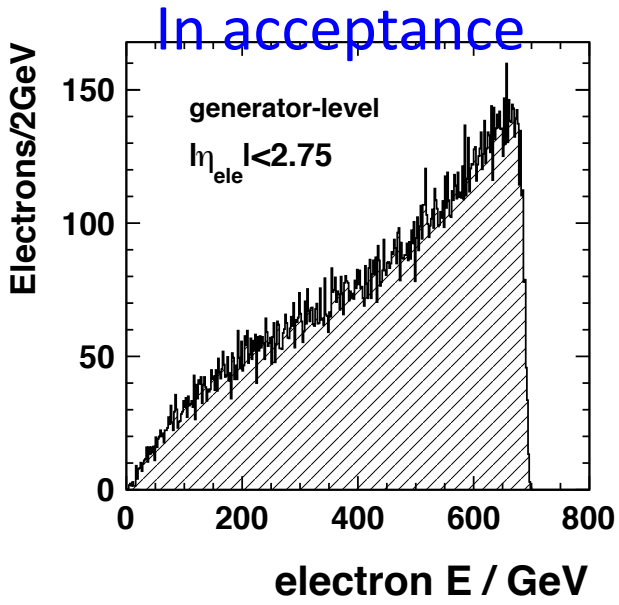




dataset 2031

Red arrows show detector acceptance

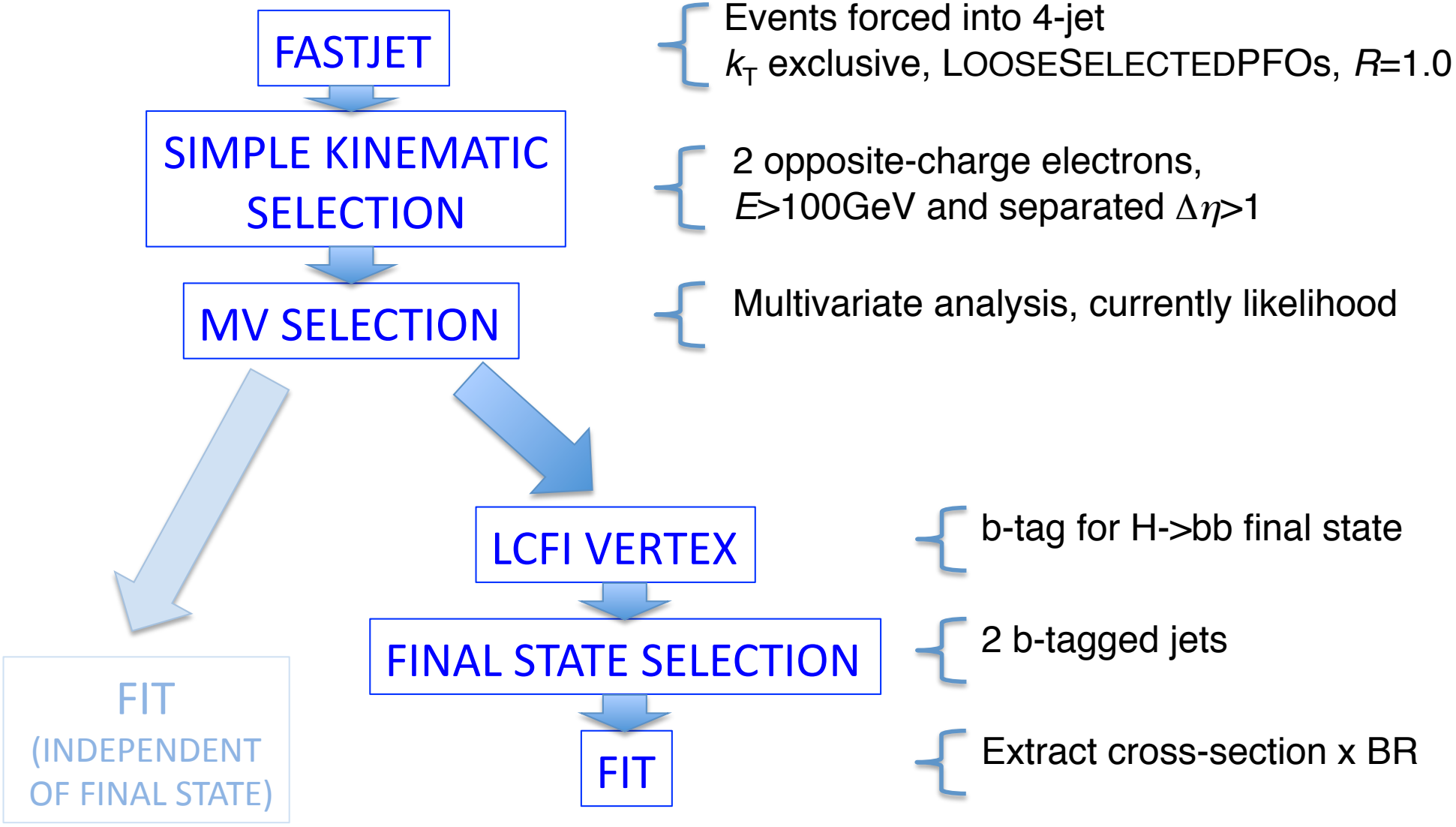




Plots all normalised to 1.5/ab

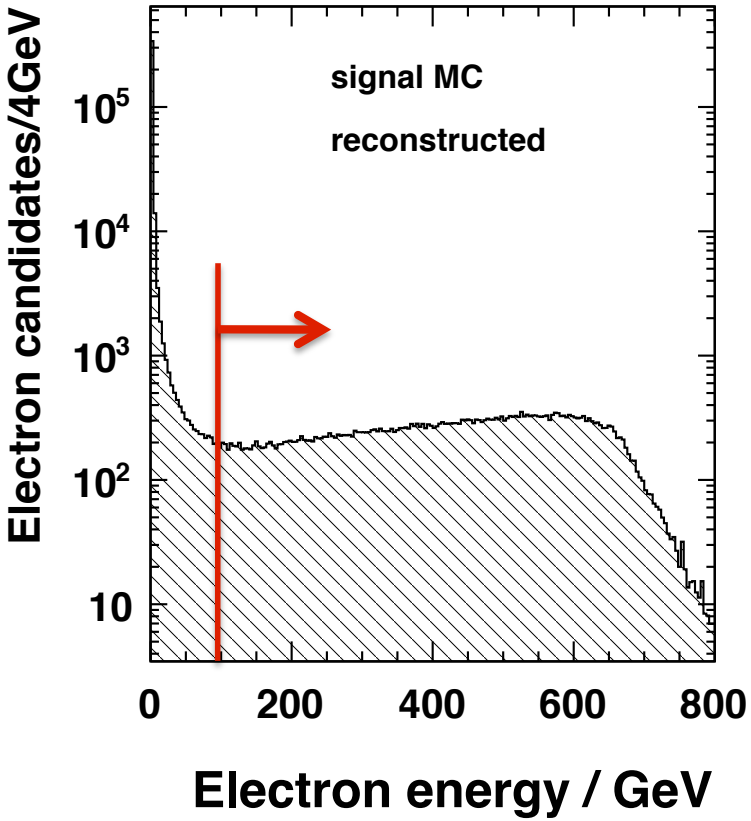
Analysis strategy

- Analysis largely in place, except for final fit:

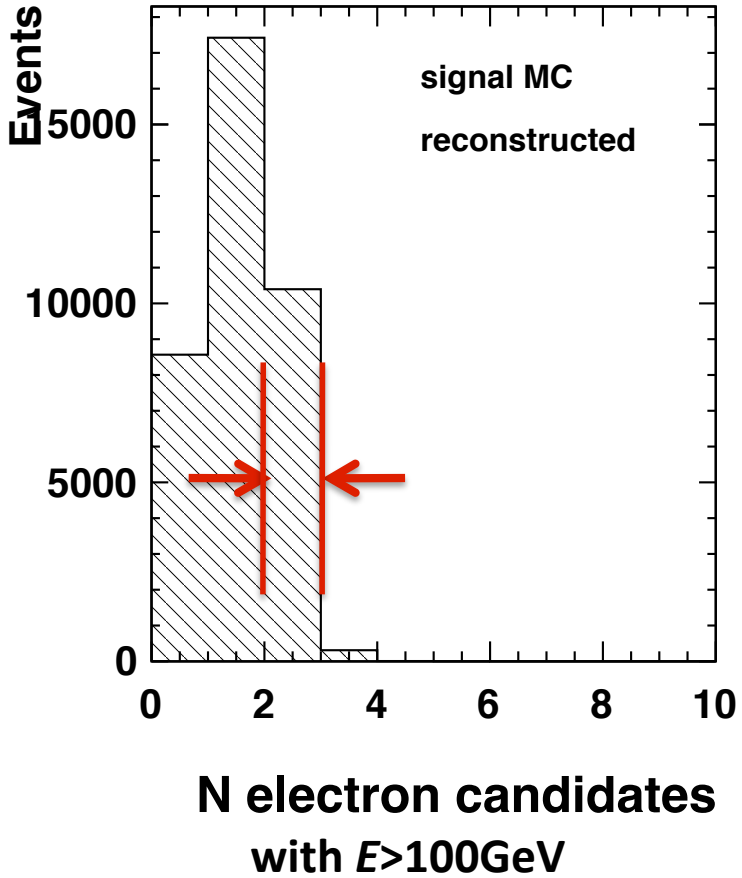


Kinematic preselection

- Look at energies of all reconstructed electron candidates



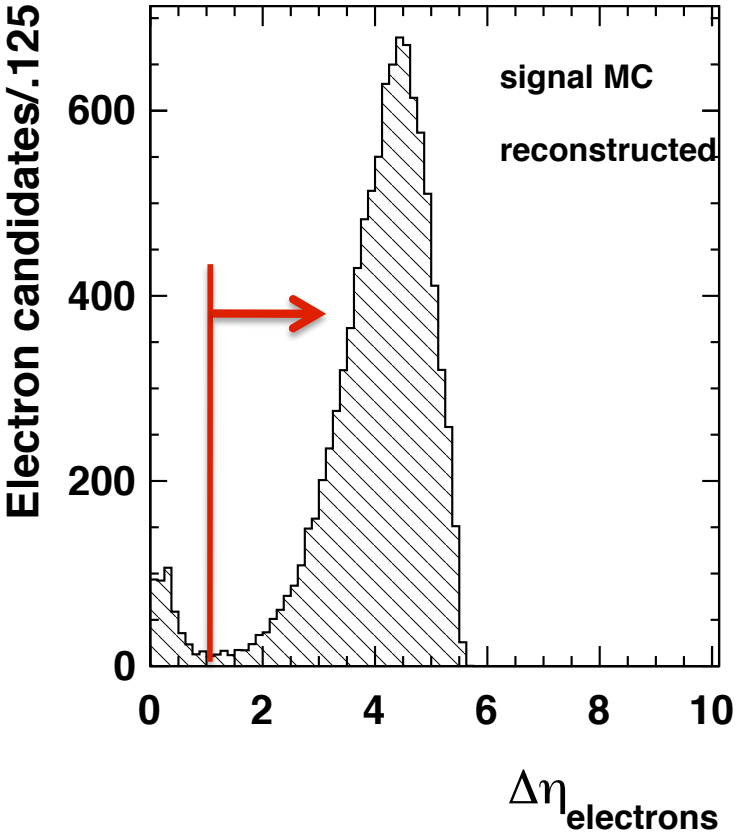
- Count reconstructed electron candidates having *E*>100GeV



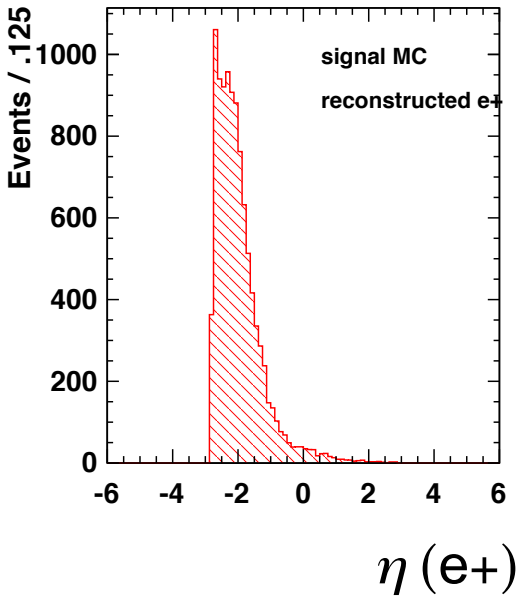
- Select *n*=2 bin

Kinematic preselection

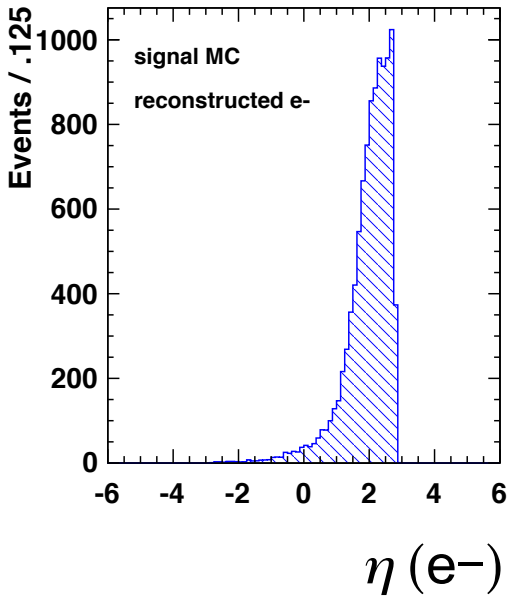
- Look at separation of electron candidates in $\Delta\eta$



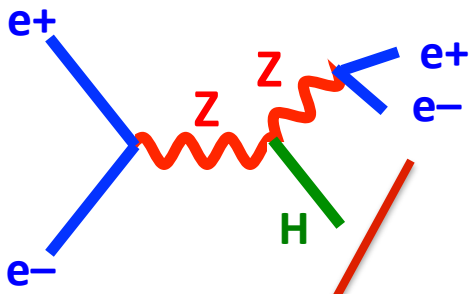
Reconstructed e+



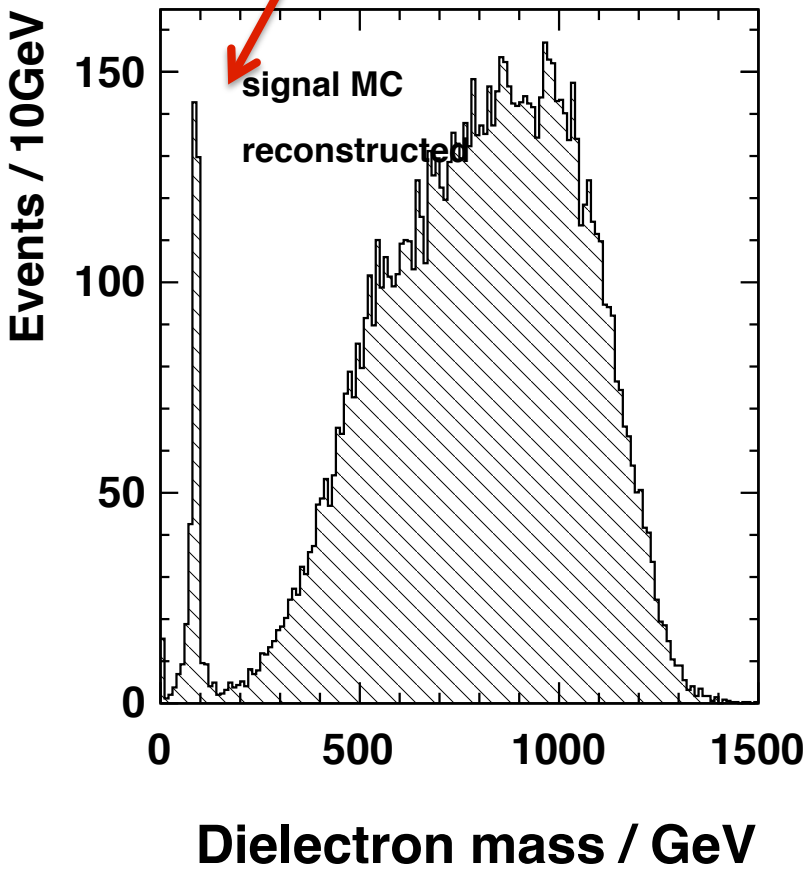
Reconstructed e–

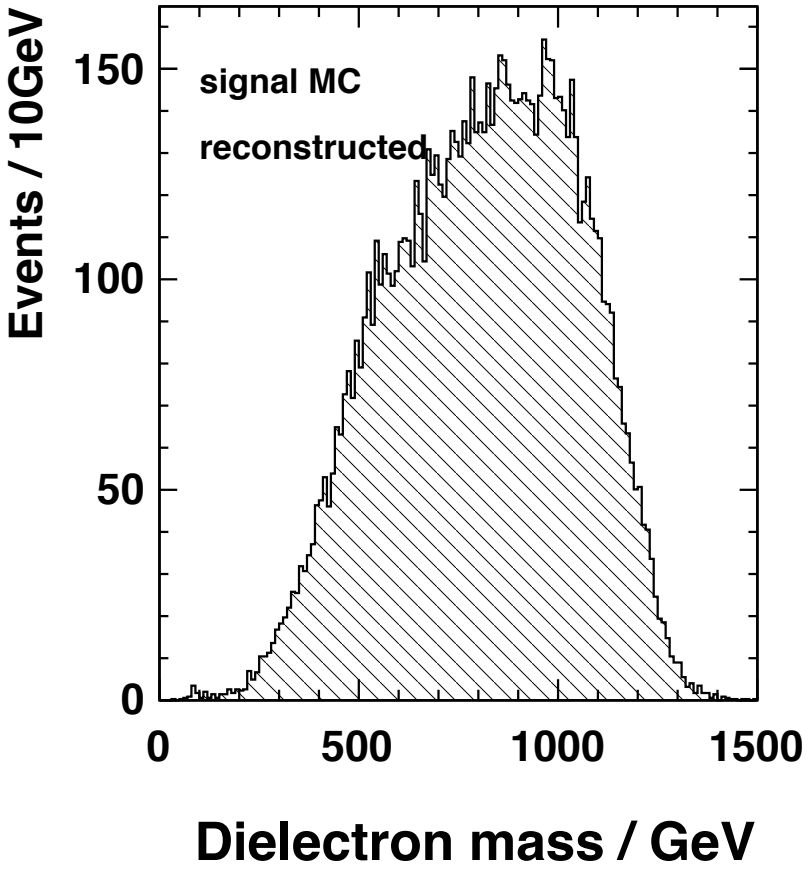


Kinematic preselection



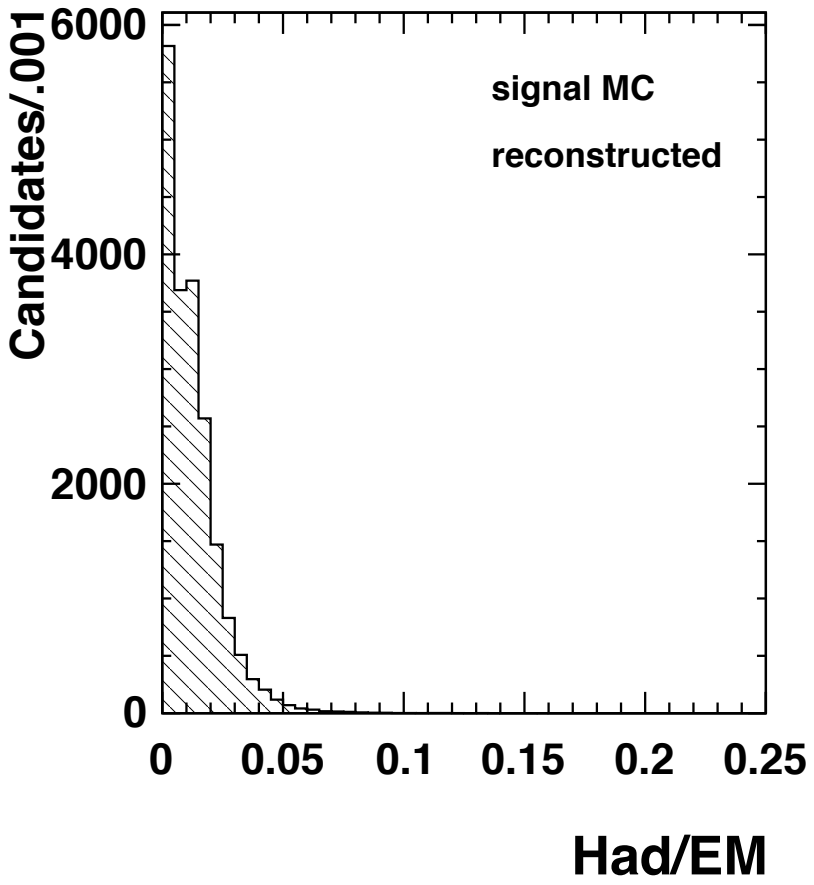
- $\Delta\eta > 1$ cut removes H-strahlung contribution

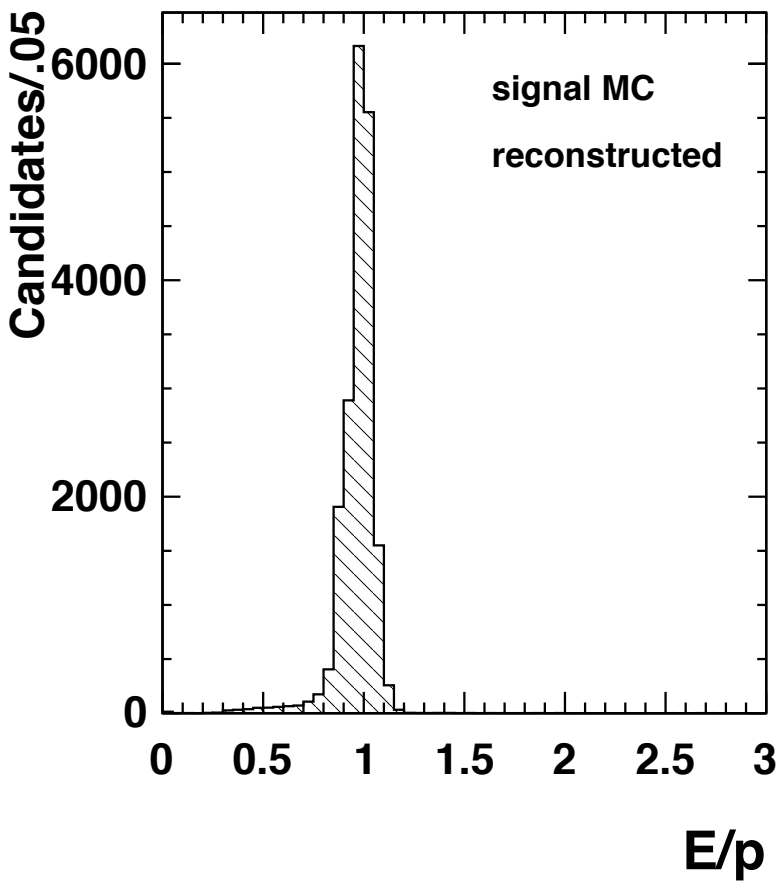




Electron reconstruction checks

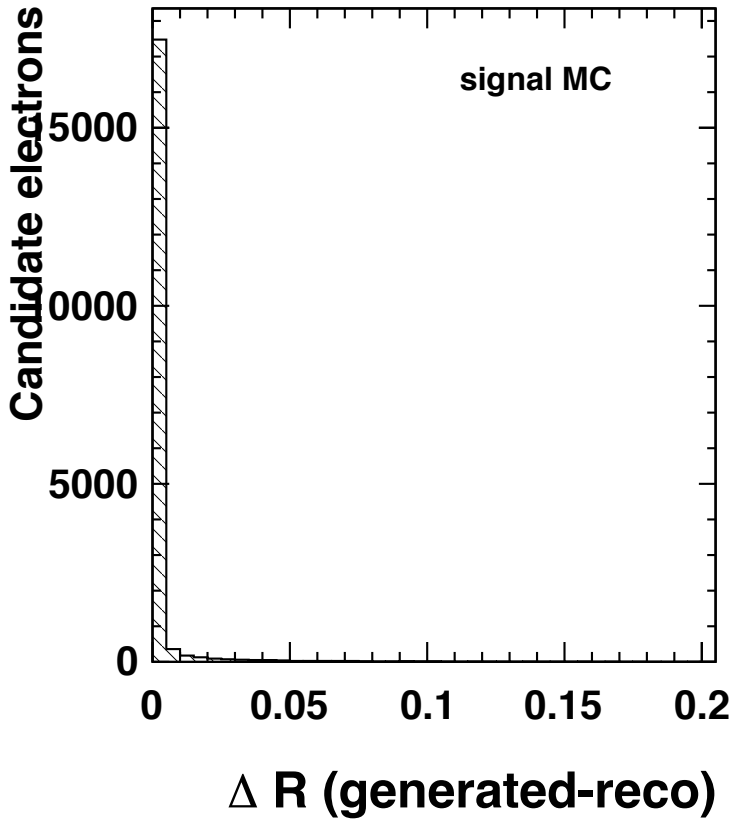
- Check that electron candidate PFOs seem sensible:

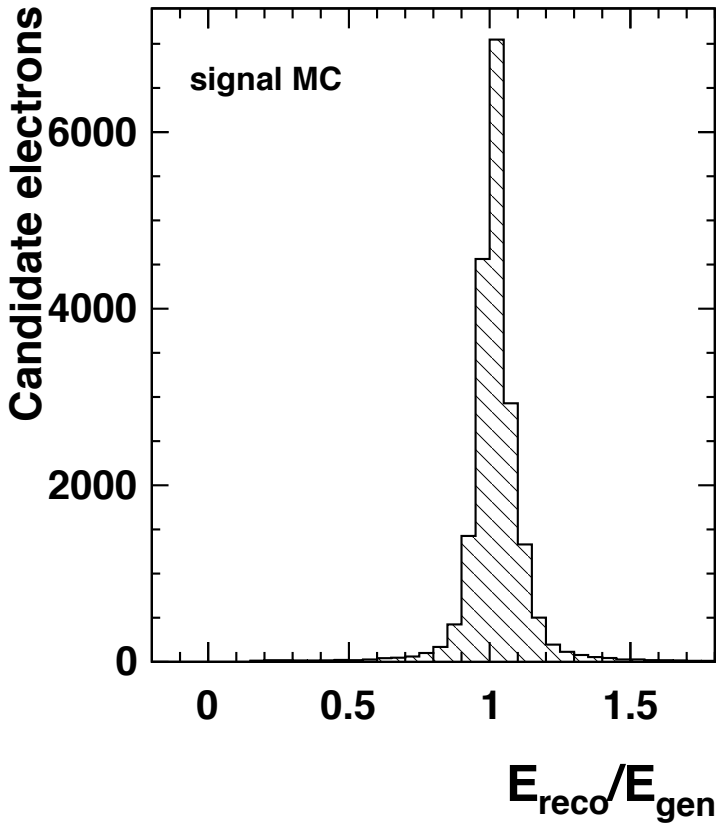




Electron reconstruction checks

- Check that electron candidate PFOs are a reasonable match to the generator-level electrons:





(Hugely improved over last versions shown – I had misunderstood PFO usage, now fixed…

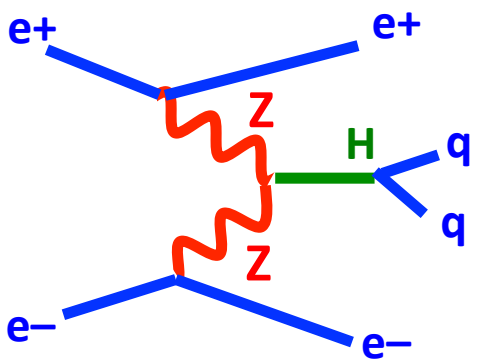
Cutflow for initial selection

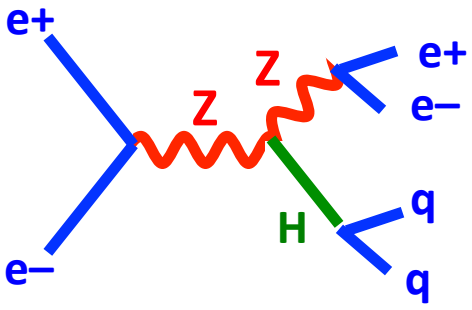
eeH signal dataset 2031	surviving	xs/fb
All events		24.47
>= 2elecron cands, E>100GeV	29.2%	7.14
==2 electron cands, E>100GeV	28.3%	6.93
opposite charge	27.7%	6.79
DeltaEta>1	26.5%	**6.49**

geometrical acceptance

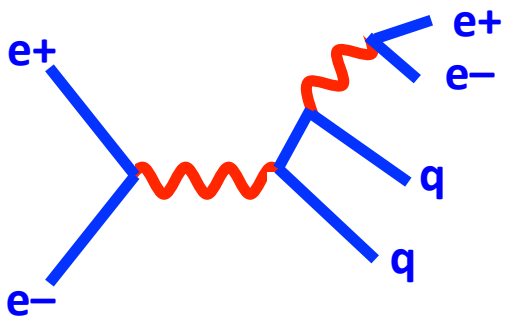
ie, 9375 events in 1.5/ab

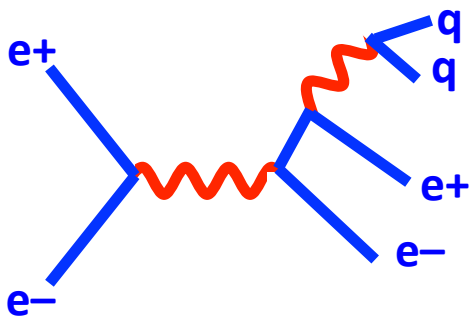
Backgrounds

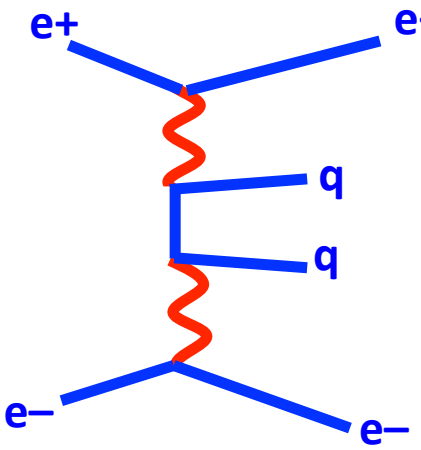




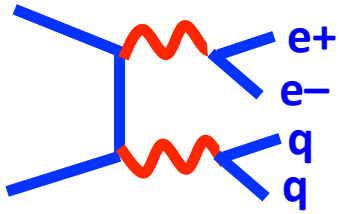
possible to remove with ΔR(electrons)>1

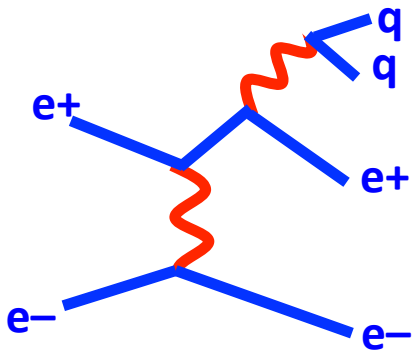






continuum





dataset 2645

Leading background

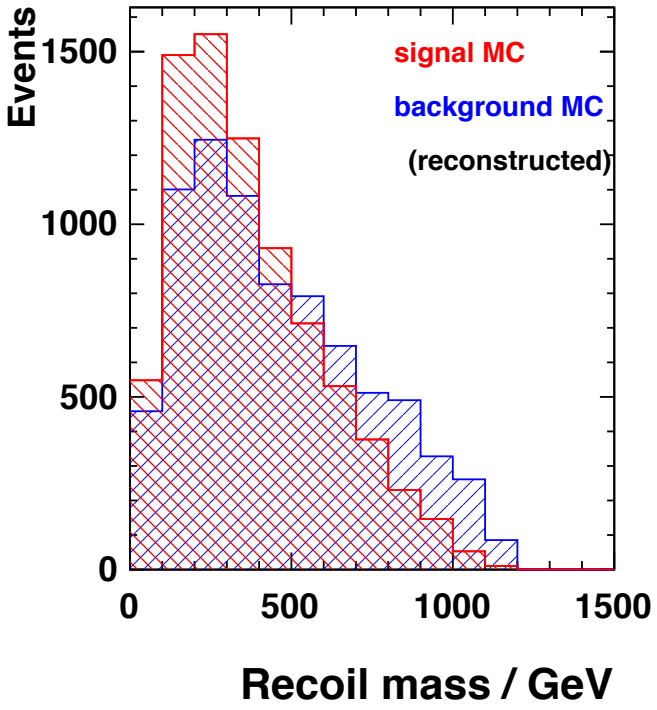
	dataset 2031 **eeH signal**		**qqll** dataset 2645 **background**	
	surviving	**xs/fb**	surviving	**xs/fb**
All events		24.47		2726.7
>= 2elecron cands, E>100GeV	29.2%	7.14	2.1%	58.02
==2 electron cands, E>100GeV	28.3%	6.93	2.1%	56.86
opposite charge	27.7%	6.79	2.0%	54.41
DeltaEta>1	26.5%	**6.49**	1.8%	**48.12**

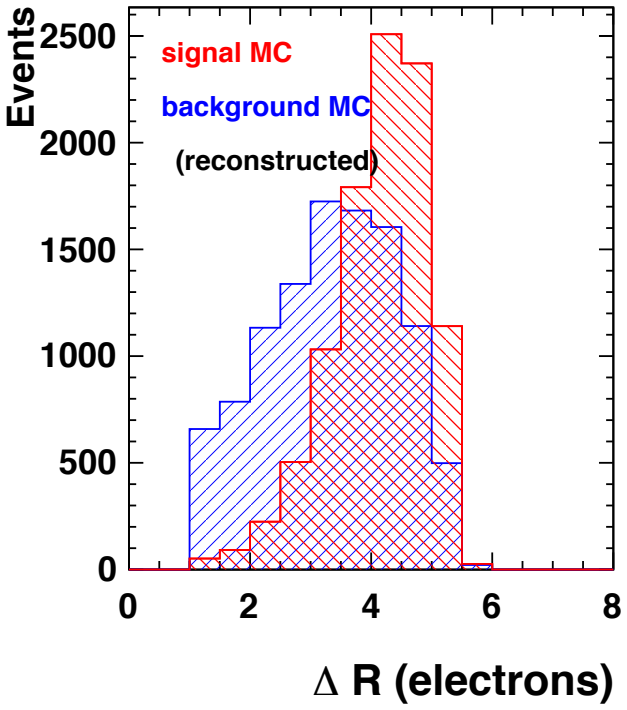
- Backgrounds well-suppressed – but still 8x signal

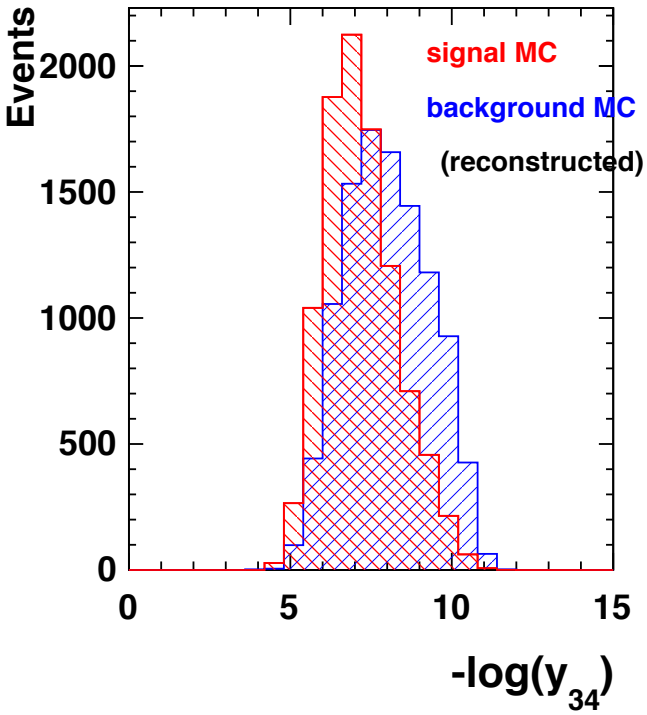
Separating signal from backgrounds

- Look for event variables to characterise signal
  - separation between electrons ΔR
  - recoil mass
  - y_{34} to characterise final state shape

fairly model-independent



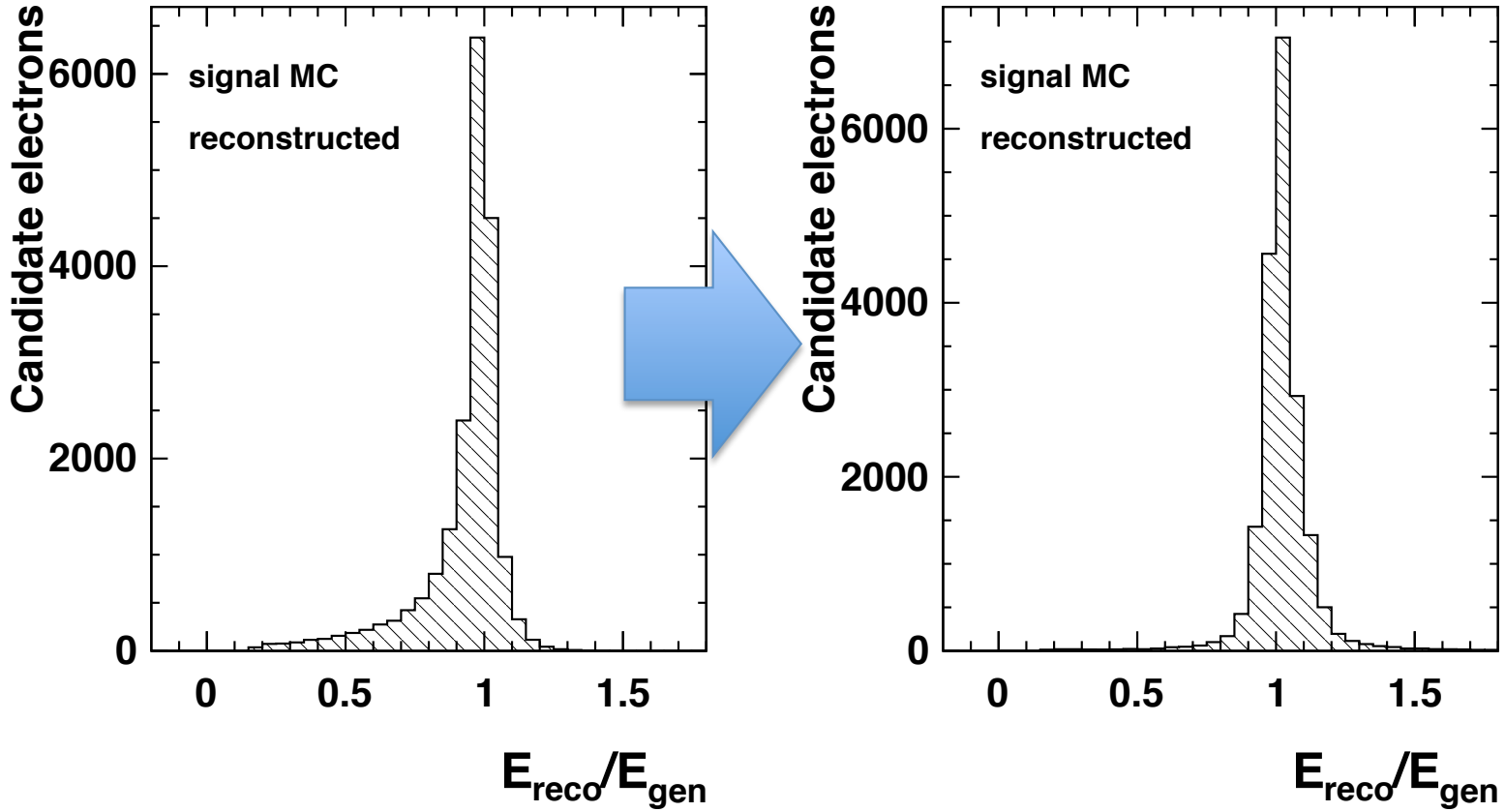




Background normalised to **signal** here

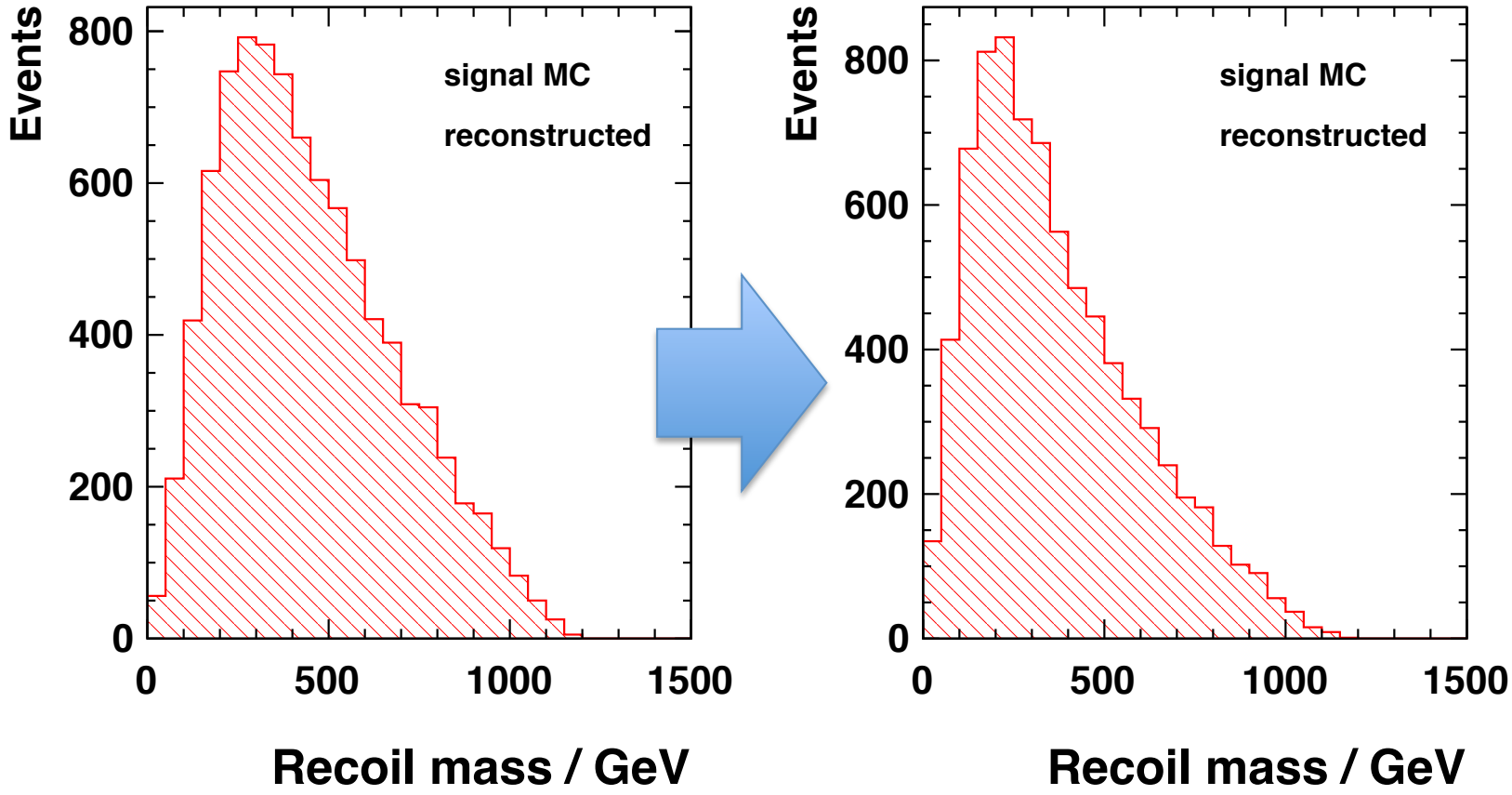
[Aside on including photon radiation]

- When trying to understand recoil shape
  - started including PFO photons within $\cos\theta > 0.9$ of electron candidates
    - improved resolution



[Aside on including photon radiation]

- including photon radiation changes recoil mass disbn



Likelihood

Using event variables

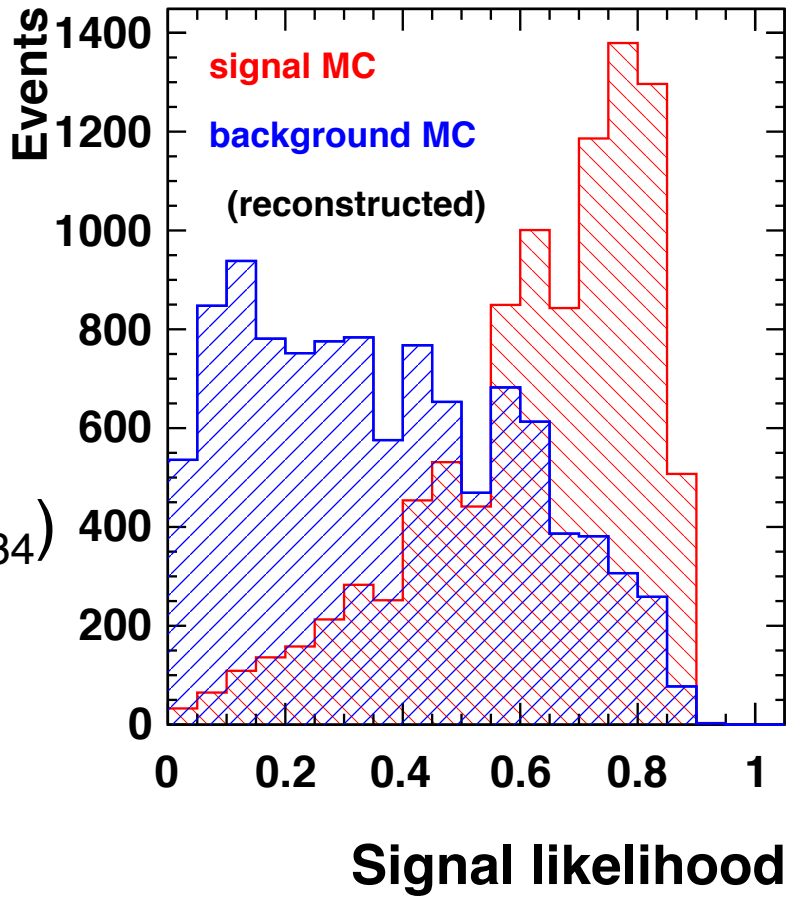
- electron ΔR
- recoil mass
- y_{34}

Construct probabilities

$$L_{sig} = P_{sig}(\Delta R) \times P_{sig}(m_{recoil}) \times P_{sig}(y_{34})$$

Signal likelihood:

$$\mathcal{L}_{sig} = \frac{L_{sig}}{L_{sig} + L_{bck}}$$

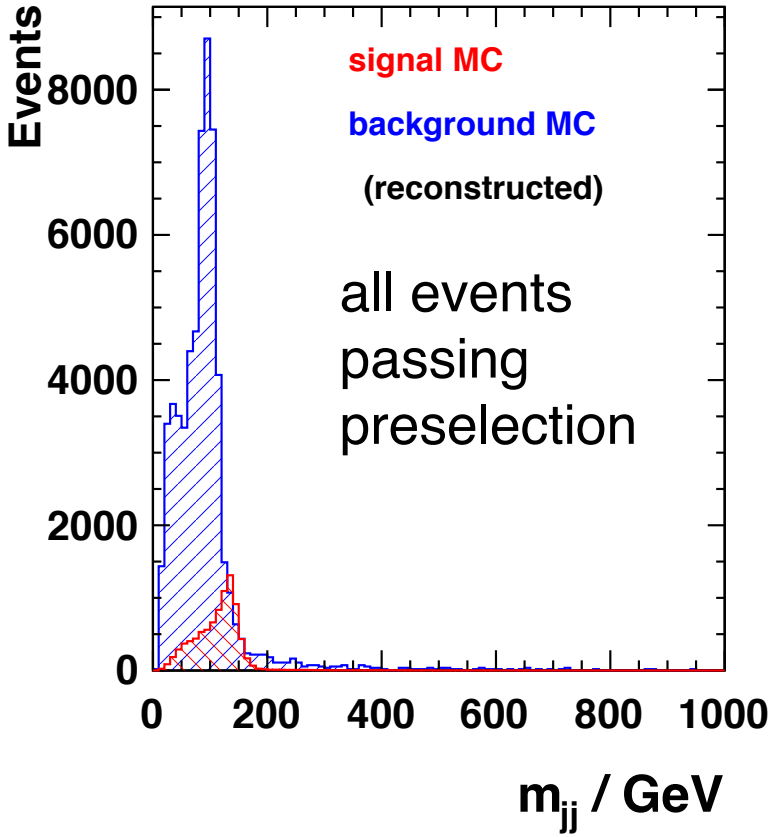


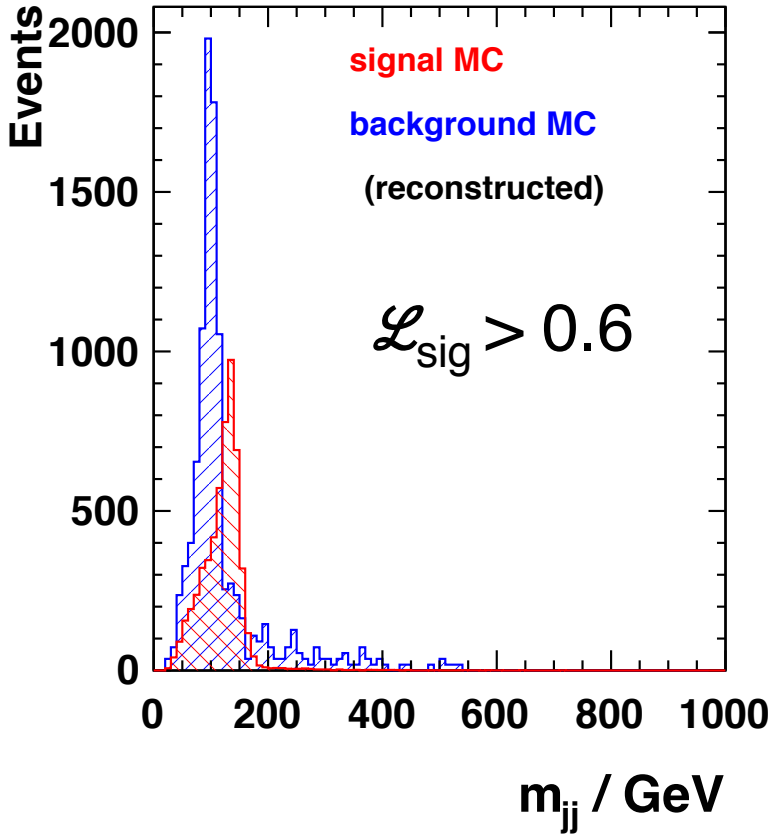
Background normalised to signal here

Background is actually ~8 x signal here

Final state

- look at m_{jj} for the two jets not matching the electron candidates:

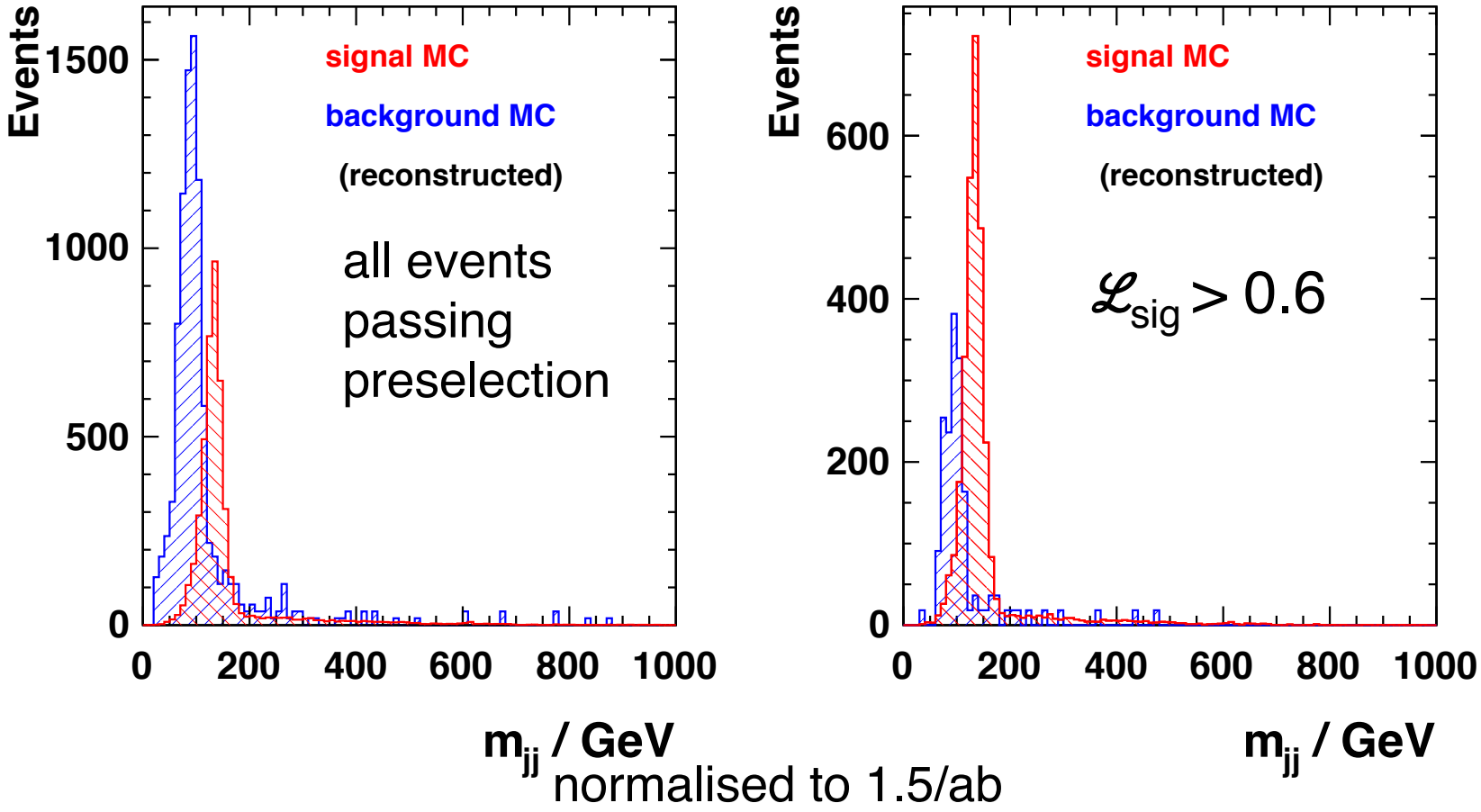




normalised to 1.5/ab

Final state

- require both jets to have truth b-tag (TrueAngularJetFlavourProcessor) [LCFI coming in a few slides]



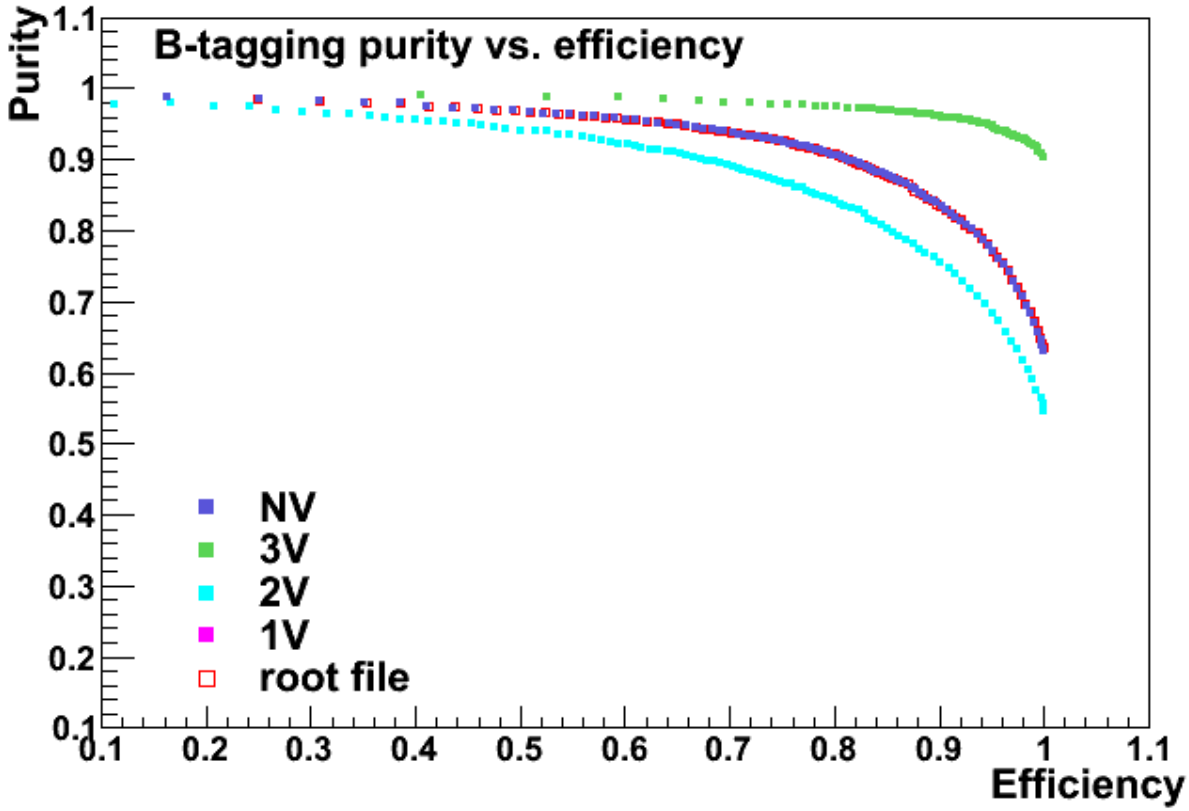
Final state

	dataset 2031 **eeH signal**		dataset 2645 **qqll background**	
	surviving	**xs/fb**	surviving	**xs/fb**
All events		24.47		2726.7
>= 2elecron cands, E>100GeV	29.2%	7.14	2.1%	58.02
==2 electron cands, E>100GeV	28.3%	6.93	2.1%	56.86
opposite charge	27.7%	6.79	2.0%	54.41
DeltaEta>1	26.5%	6.49	1.8%	48.12
4-jet topology has 2 jets matching electron cands	23.3%	5.70	1.4%	39.18
2 (truth) b-tags	12.5%	**3.06**	0.2%	**6.26**

ie, 4590 events in 1.5/ab

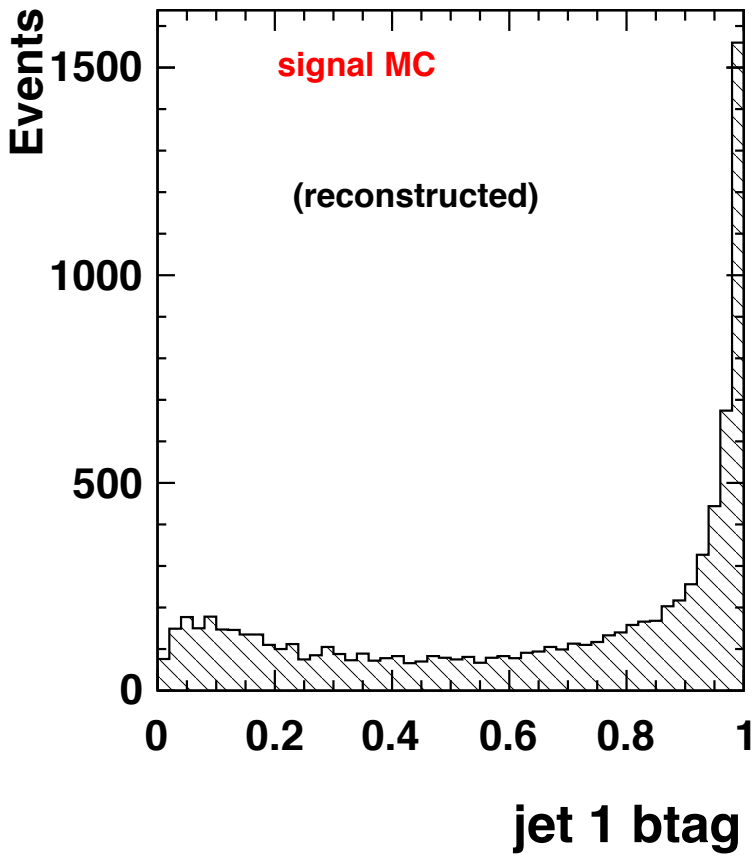
LCFI b-tagging

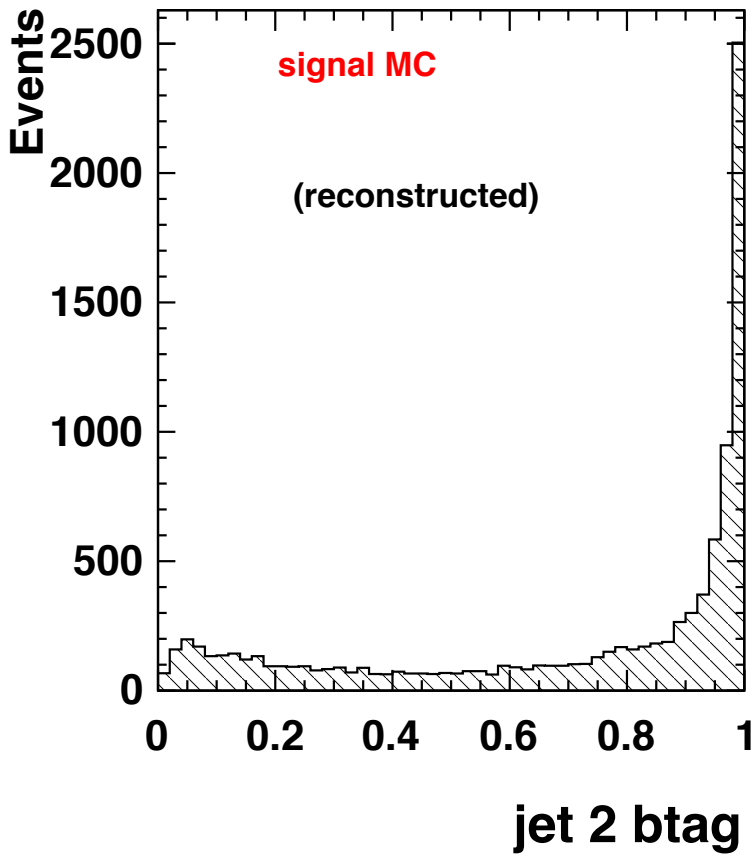
- Used LCFI tools to train flavour tagger with eeH (ds 2035) and qqll (ds 2645) events



LCFI b-tagging

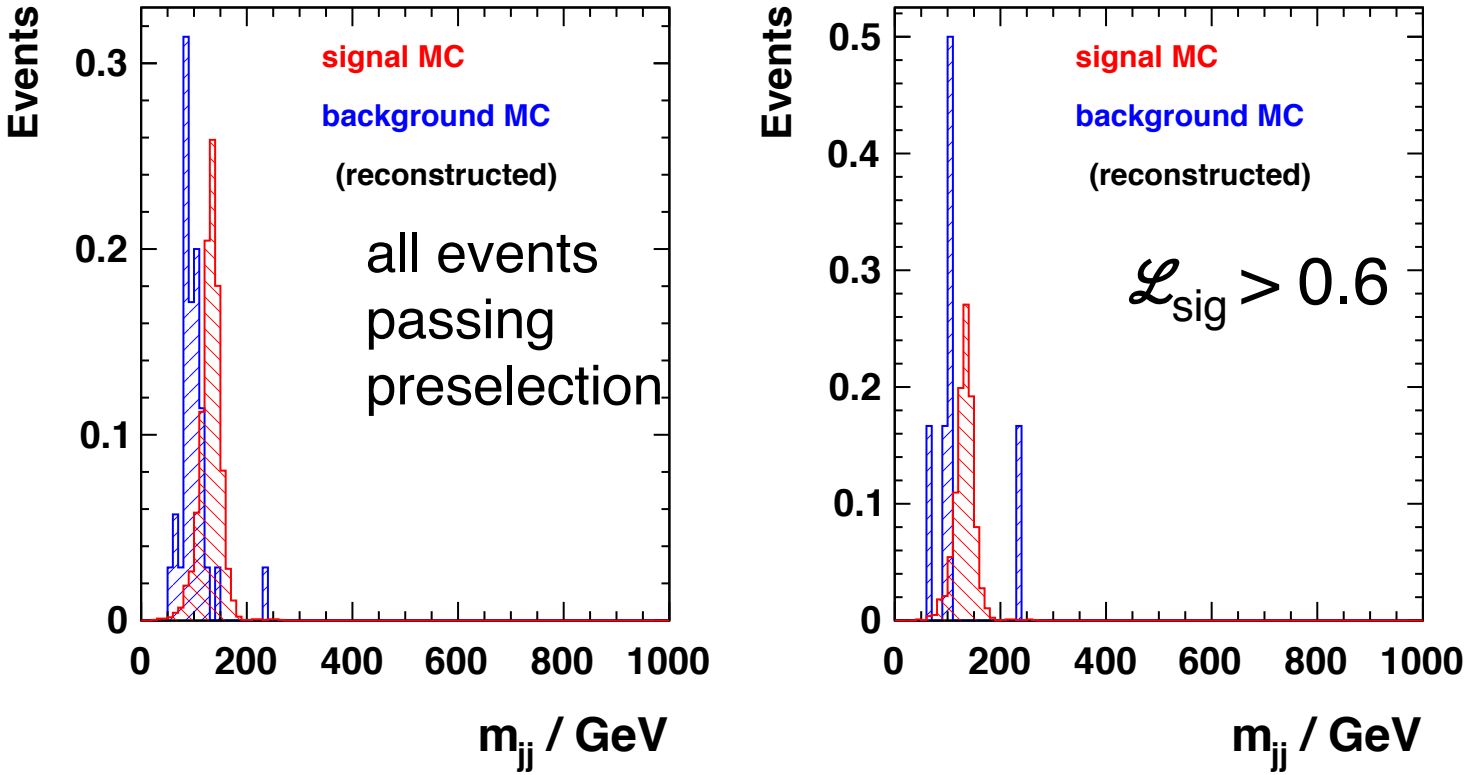
- Tag values seem reasonable (all H decays are present)





LCFI b-tagging

- Required both jets to have btag>0.7
  Not full dataset yet (takes time to vertex)
  yields seem smaller than expected – something to fix
  but qualitatively as expected from truth-tagging:

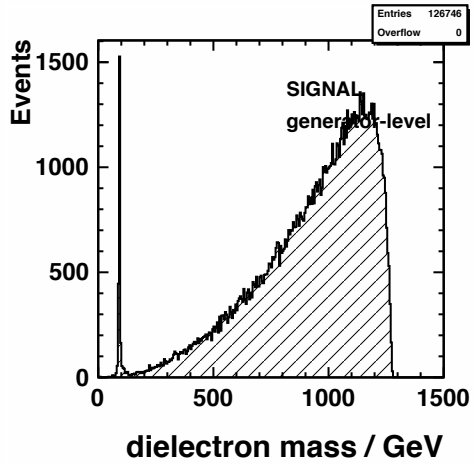


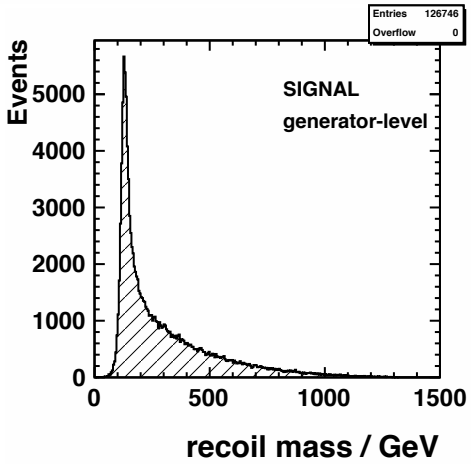
(normalised to 1 – btag yields still to be understood)

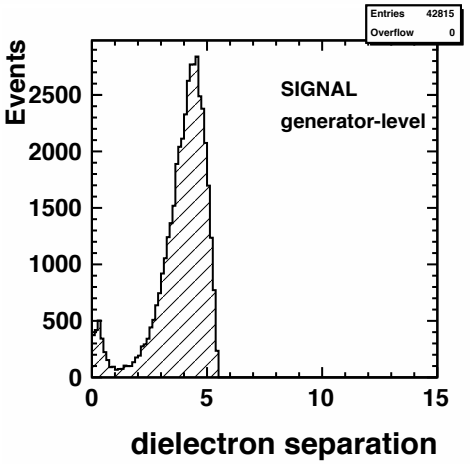
Other backgrounds

Other backgrounds with two electrons, two jets: eg top

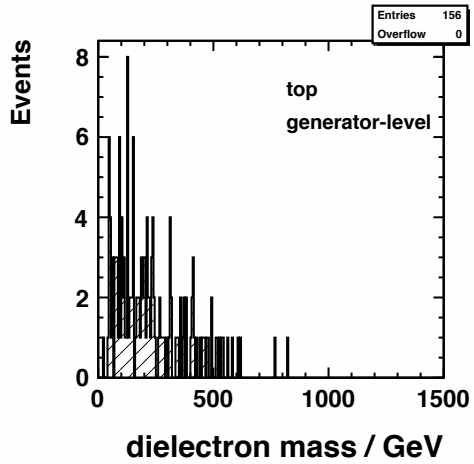
signal

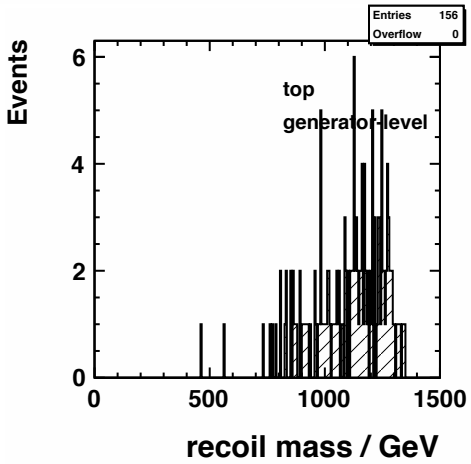


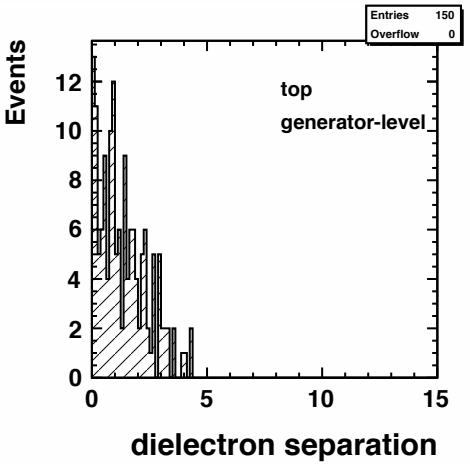




top







-> separation straightforward

- Still to look at eγ and γγ-induced backgrounds

Extracting physics

- Had hoped to avoid selecting final state so that sensitivity would be to g_{HZZ} (and Γ_H) only
- Also bad: selecting bb final state increases statistical uncertainty from ~1% to ~1.5% in 1.5/ab.
- Systematic uncertainty on cross-section measurement fairly large because detector acceptance truncates electron η distribution.
- Ratio of σ(ee→eeH).Br(H→bb) to σ(ee→$\nu\nu$H).Br(H→bb) gives the ratio g_{HZZ}/g_{HWW} without g_{Hbb} or Γ_H
  – but large acceptance systematic doesn't cancel
- Not clear that lcal / bcal help, since want electron energy measurement not just tag.

Summary

Since last update:

- studied main backgrounds
- developed likelihood separation
- studied final state and implemented LCFI b-tagging
- obtained good signal : background
- included photon radiation in electron reco

Need to:

look at γ-induced backgrounds
understand recoil shape
 -> try smarter final-state-indep approach
fix LCFI yield