Search for the SM Higgs boson in the $H \rightarrow WW$ channel (ATLAS)

Optimization of the cut-based analysis with 2011 data and MC

Victor A. Rodriguez
(The University of Texas at Austin)

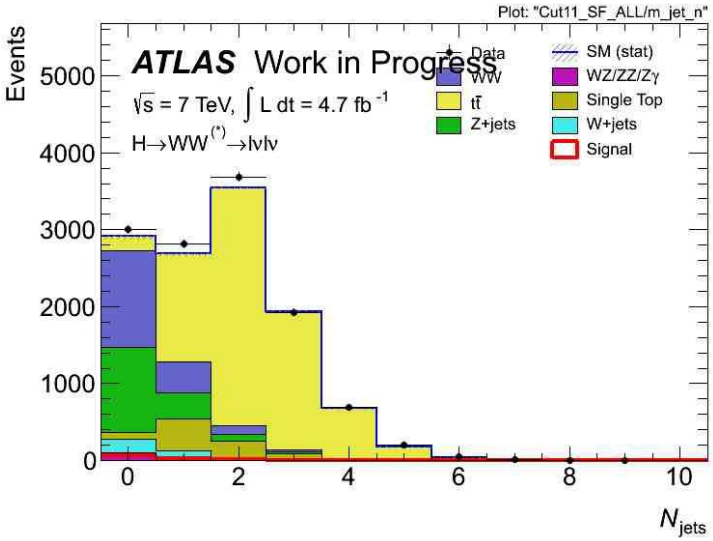
University of Michigan – CERN REU

Strategy

- Optimize, one-by-one or simultaneously, each of the 0jet cuts
- Optimization was done by maximizing:

$$R = \frac{signal\ count}{\sqrt{background\ count}}$$

(scaled event yield after each cut)



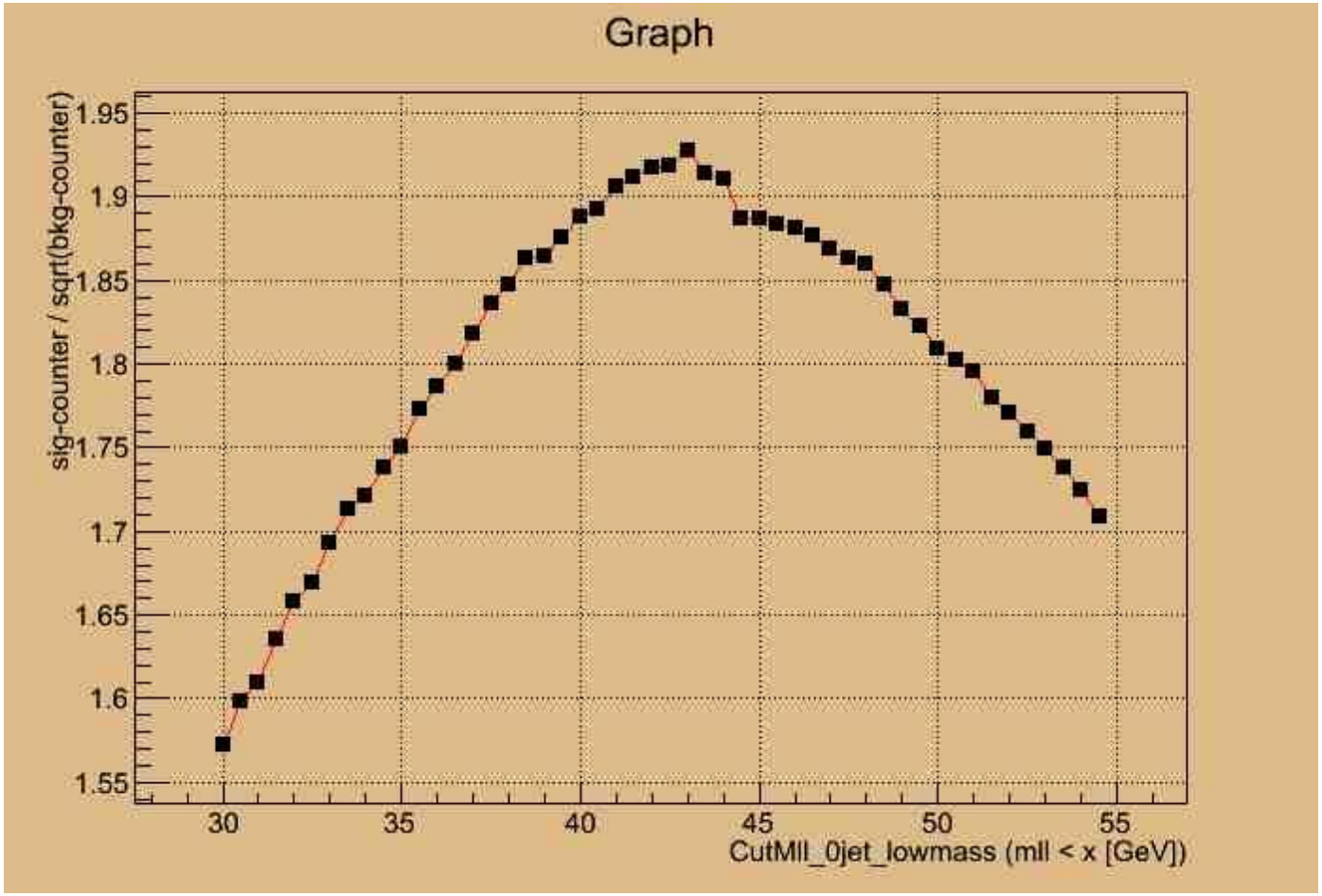
0–jet cuts (nominal, after pre-selection)

- Dilepton invariant mass
  - $m_{ll} < 50\ GeV$
- Transverse momentum of the dilepton system (suppress Drell-Yan background)
  - $\boldsymbol{p}_T{}^{ll} > 45\ GeV\ (ee\mu\mu)\ and\ 30\ GeV\ (e\mu)$
- Dilepton opening angle in transverse plane (spin 0 correlation in the H->WW system)
  - $\Delta\phi_{ll} < 1.8\ rads$

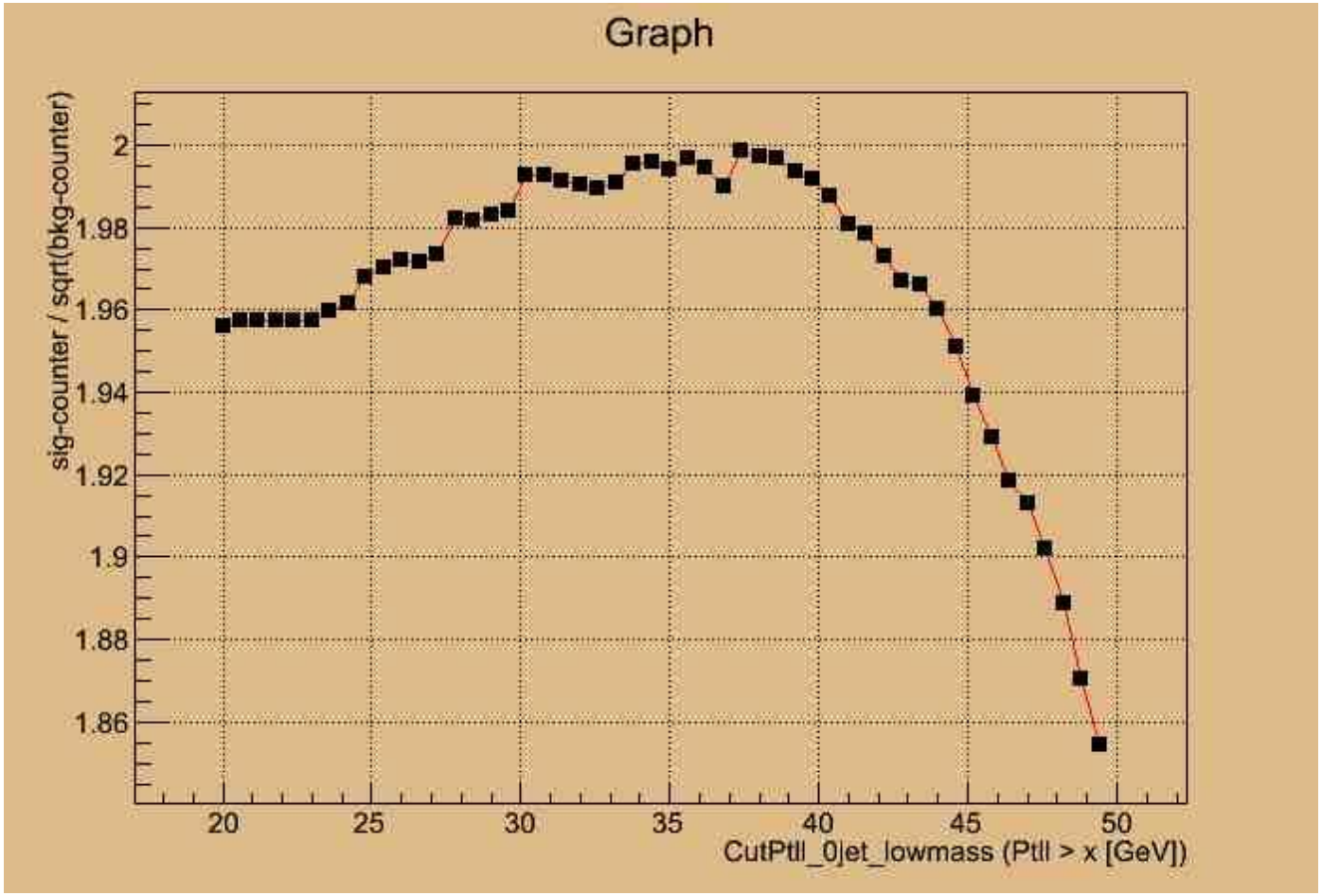
Cut Sweep 1

- Sweep over a given range for each cut and maximize R
- Sweeps:
  - Mll cut — [30, 55] GeV, 50 steps
  - Ptll cut (ee,mm) — [20, 50] GeV, 50 steps
  - Ptll cut (em) — [15, 45] GeV, 50 steps
  - Δφll cut — [.6, 3.0] rads, 50 steps

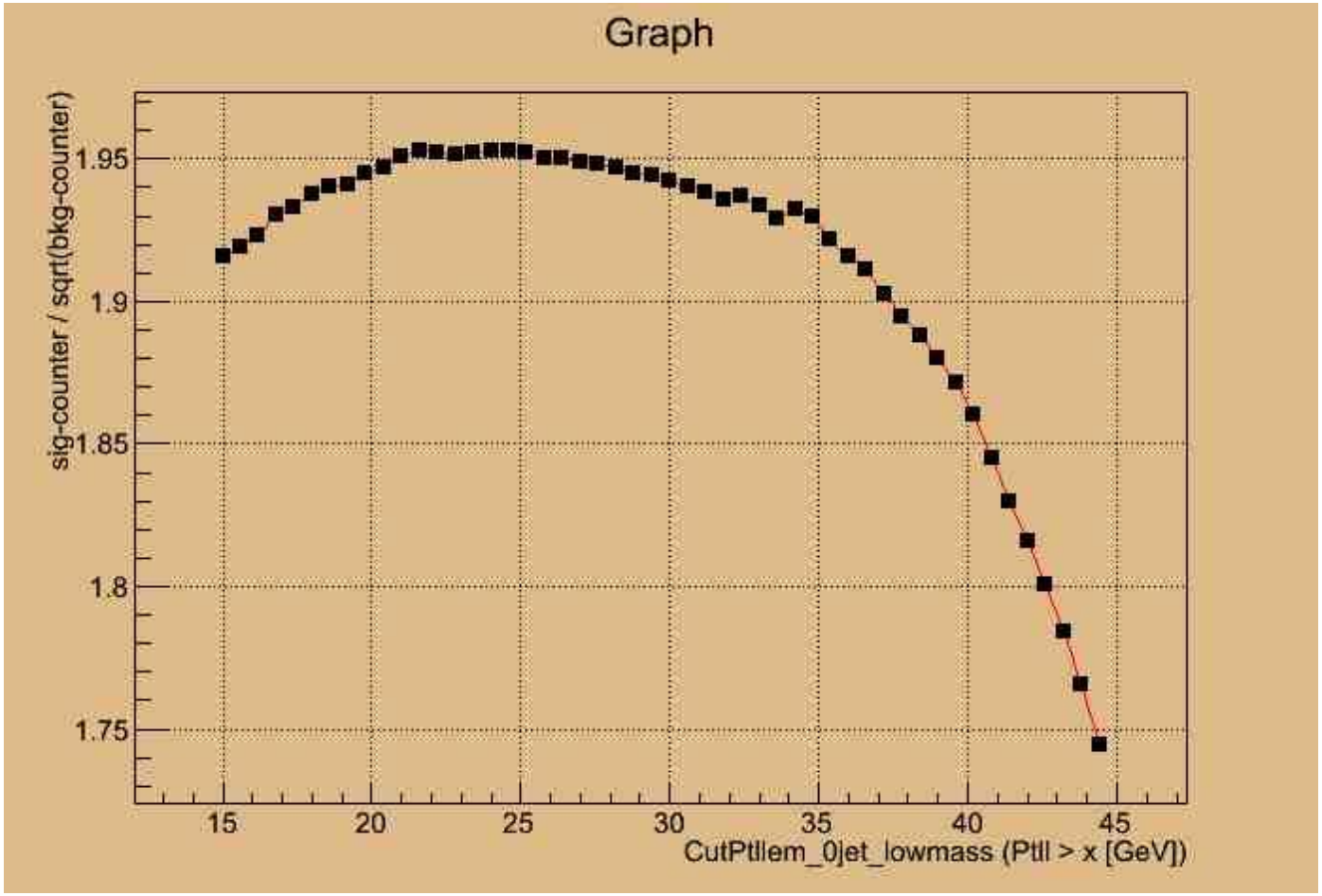
Mll Cut


Graph
sig-counter / sqrt(bkg-counter)
1.95
1.9
1.85
1.8
1.75
1.7
1.65
1.6
1.55
30
35
40
45
50
55
CutMll_0jet_lowmass (mll < x [GeV])

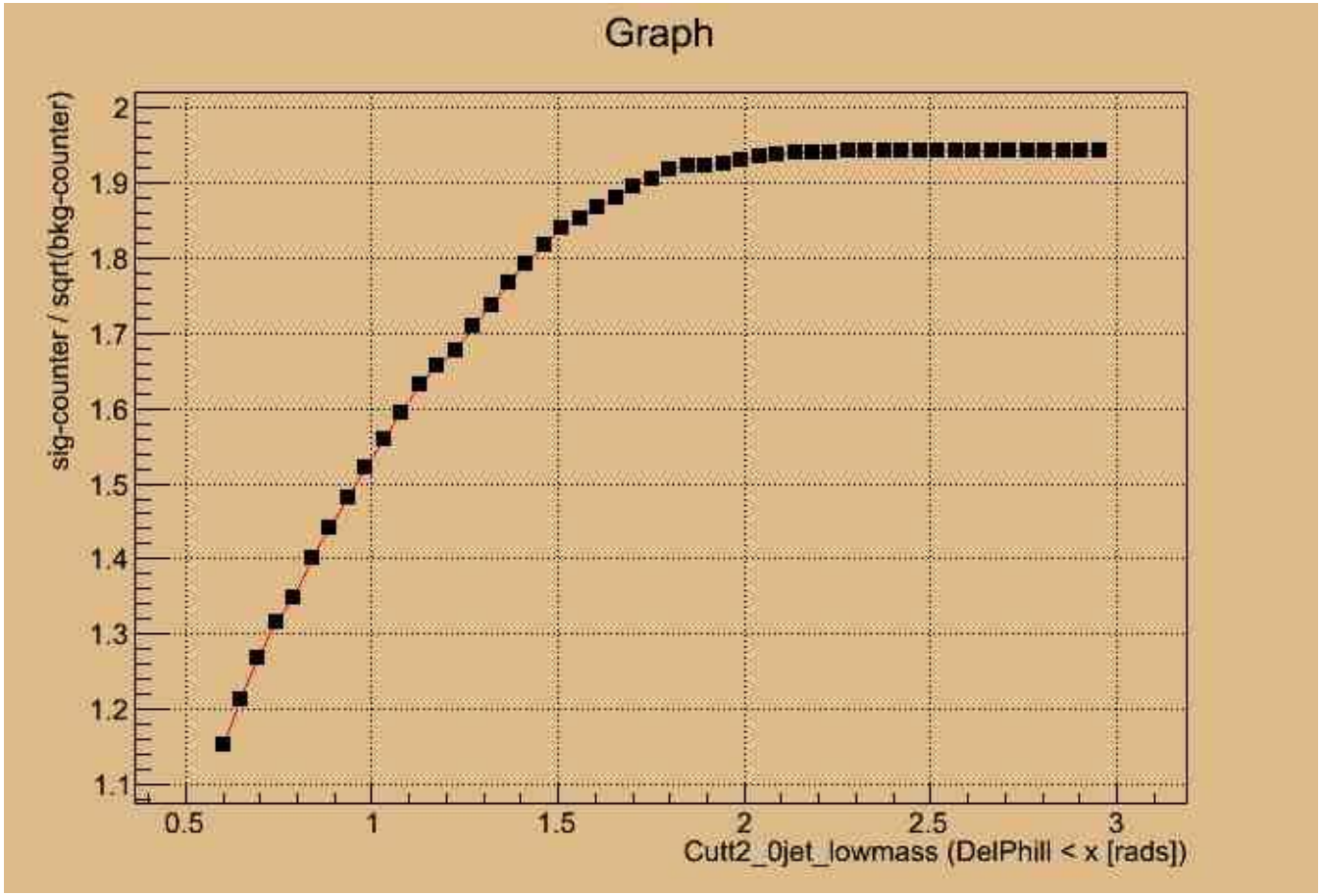
Ptll Cut (ee,mm)



Ptll Cut (em)


Graph
sig-counter / sqrt(bkg-counter)
1.95
1.9
1.85
1.8
1.75
15
20
25
30
35
40
45
CutPtllem_0jet_lowmass (Ptll > x [GeV])

Δϕll Cut


Graph
sig-counter / sqrt(bkg-counter)
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
0.5
1
1.5
2
2.5
3
Cutt2_0jet_lowmass (DelPhill < x [rads])

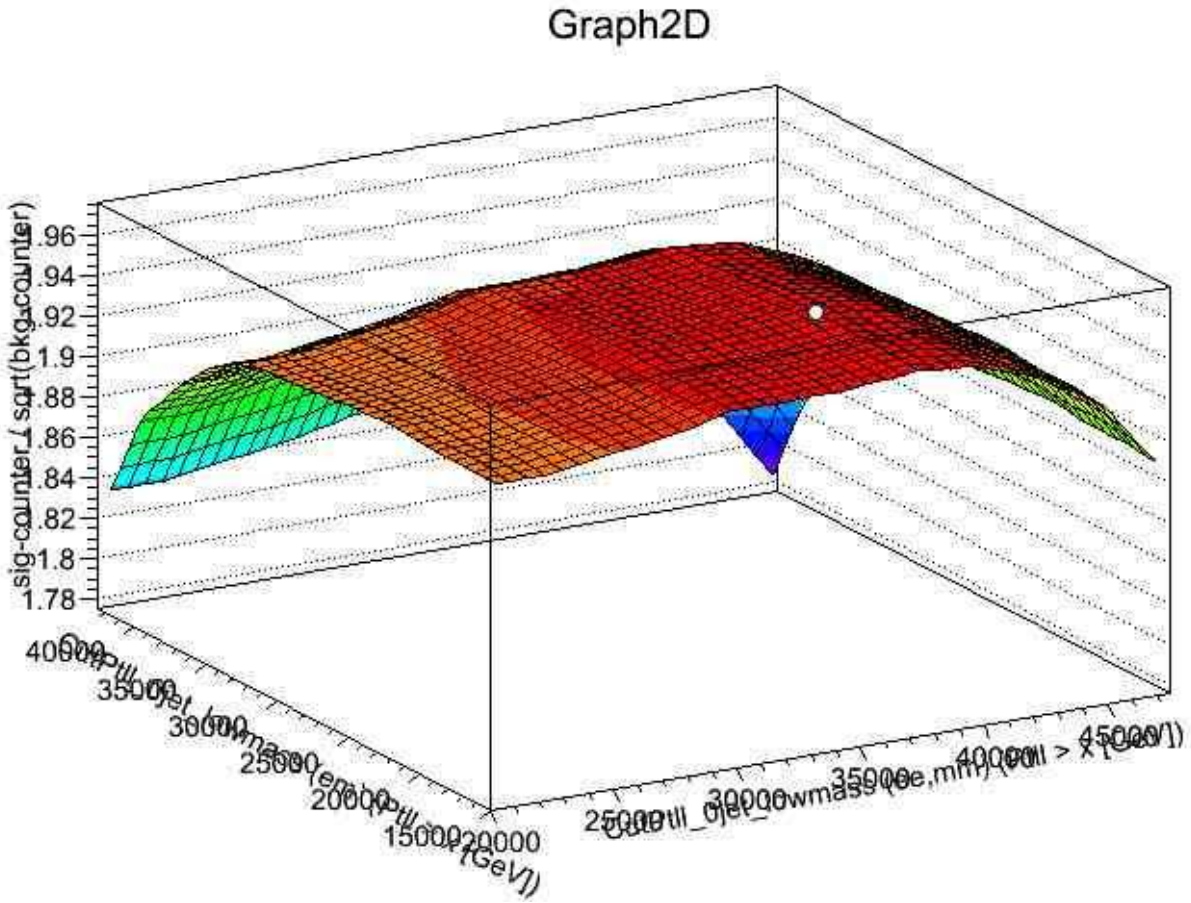
Results

- Best Mll Cut:
  - Mll < **43 GeV**
- Using this cut value, continue to optimize the following cuts in successive order
- The Δφll cut seems to be OK; no need for optimization of the cut value

Ptll Cut 1

- Sweeps:
  - Mll cut — 43 GeV
  - Ptll cut (ee,mm) — [20, 50] GeV, 12 steps
  - Ptll cut (em) — [15, 45] GeV, 12 steps

Ptll Cut 1 (same)



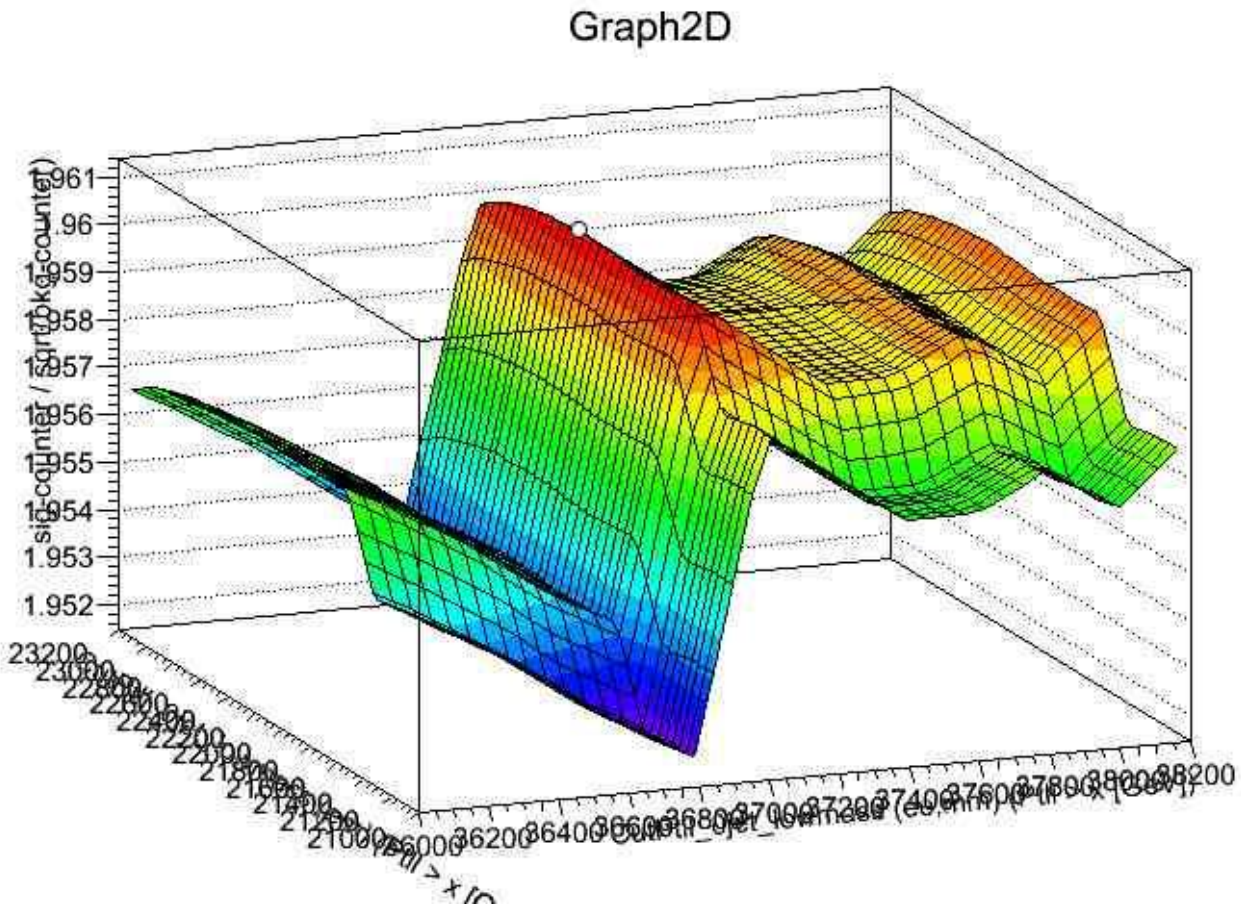
Ptll Cut, Results 1

- Best Ptll Cuts:
  - Ptll > 37.5 GeV (ee,mm)
  - Ptll > 22.5 GeV (em)

Ptll Cut 3

- One last run with finer steps
- Sweeps:
  - Mll cut — 43 GeV
  - Ptll cut (ee,mm) — [36,38.4] GeV, 12 steps
  - Ptll cut (em) — [21,23.4] GeV, 12 steps

Ptll Cut 3


Graph2D
1.961
1.96
1.959
1.958
1.957
1.956
1.955
1.954
1.953
1.952
23200
23000
22800
22600
22400
22200
22000
21800
21600
21400
21200
21000
36200
36400
36600
36800
37000
37200
37400
37600
37800
38000
38200

Ptll Cut, Results 3

- Best Ptll Cuts:
  - Ptll > 37 GeV (ee,mm)
  - Ptll > 22.4 GeV (em)

  - (Mll < 43 GeV)
  - (Δφll < 1.8 rads)

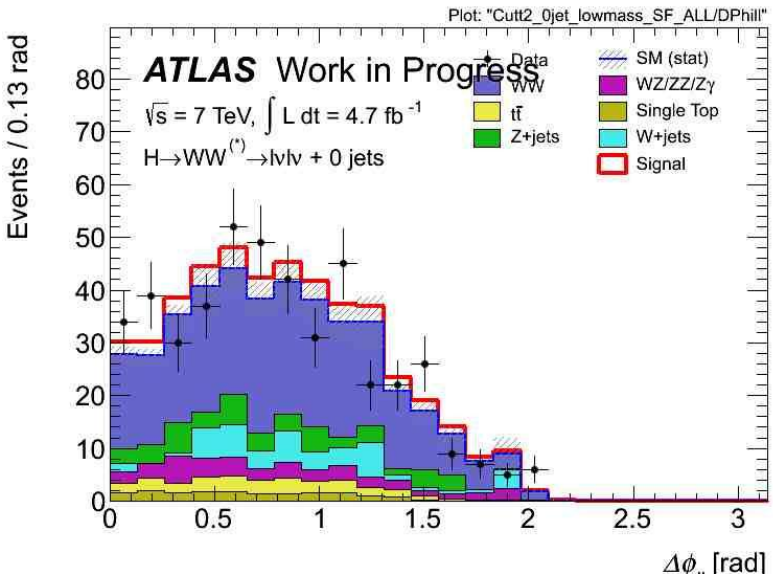
Run Analysis Results

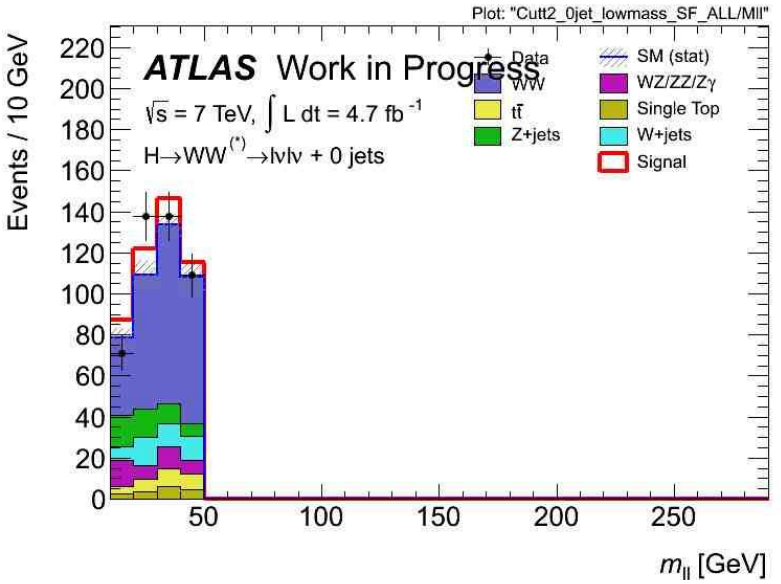
- After these cuts we obtain the following event yields:
  - **Total background — 358 ± 10**
  - **Total signal — 36.9 ± 0.2**
  - **Data observed — 384**
- Compare to the 2011 paper cutflow:
  - **Total background — 425 ± 26**
  - **Total signal — 39.0 ± 0.2**
  - **Data observed — 429**

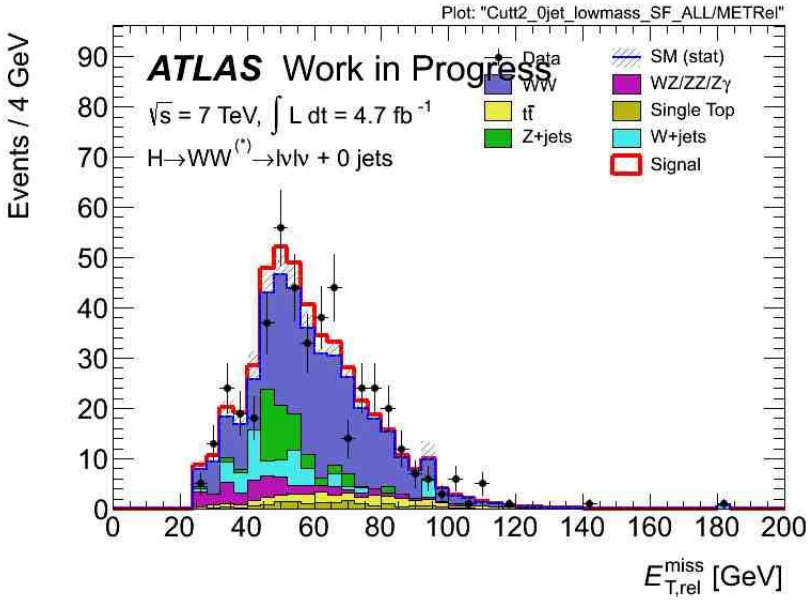
Optimize ALL simultaneously

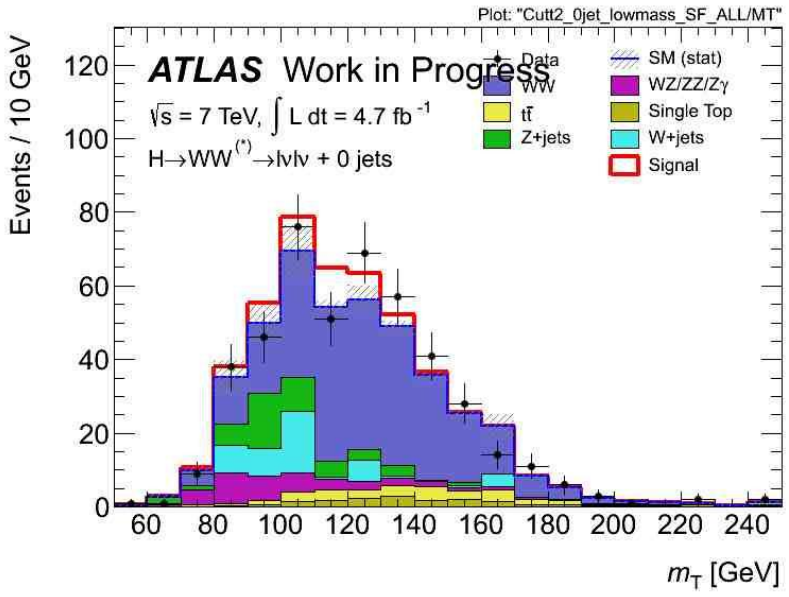
- Best Cut Values:
  - **Mll < 47 GeV**
  - **Ptll > 37 GeV (ee,mm)**
  - **Ptll > 23 GeV (em)**
  - **Δφll < 2.1**
- Max Ratio = 1.99 ~ 2.0
- Event yields:
  - **Total background — 430 ± 12**
  - **Total signal — 41.2 ± 0.2**
  - **Data observed — 456**

After Δϕll cut









Next

- Try to do the same optimization algorithms to the 2012 MC simulation data
- Learn some statistics (theory, software) to produce exclusion and p-value plots
- See if these “more efficient” cuts have a noticeable impact on actual results