sdfds

sdfsd

Introduction

- **I'll show the latest KF MC momentum smearing study results**
  - Moller mass width in data and MC agree pretty well
  - All MC samples now updated with momentum smearing, have corrected mass resolution
- Then look at the ABCD background estimation method
- **We compare expected background to N Observed for different ABCD mass sideband and search window sizes**
- How big do sidebands need to be to give a good bkg estimate?
- Does the sideband size correlate to the search window size?
- Assuming the background estimate is "good"...do we gain sensitivity by shrinking/growing the search window?
- **We will look at how significance of MC signal injected data changes with the search window size**
- This is a severely qualitative study...
- We get a broad idea about the size of the ABCD sidebands we can use
- The search window looks like anything between 1.5-2.5σ gives comparable sensitivity
- Background estimate does a little better if the search window is smaller

KF MC Momentum Smearing

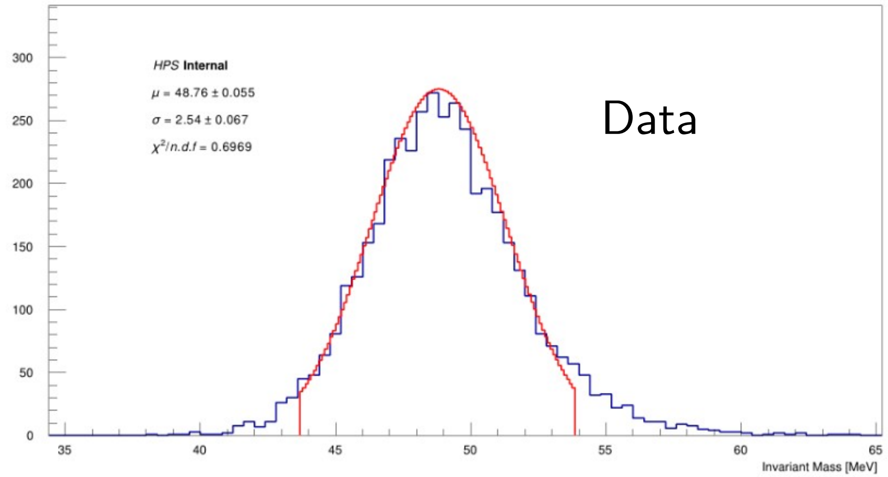
And

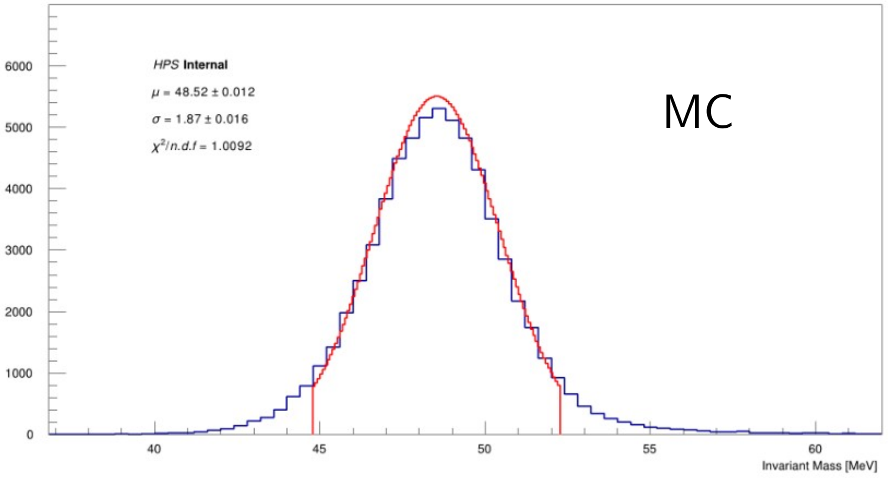
Mass Resolution

MC Data Moller Mass Discrepency

- Moller mass resolution too narrow in MC compared to data
- 2.54 vs 1.87 MeV

- Correct using momentum smearing
- Need to calculate smearing coefficients split into Top/Bot + Nhits



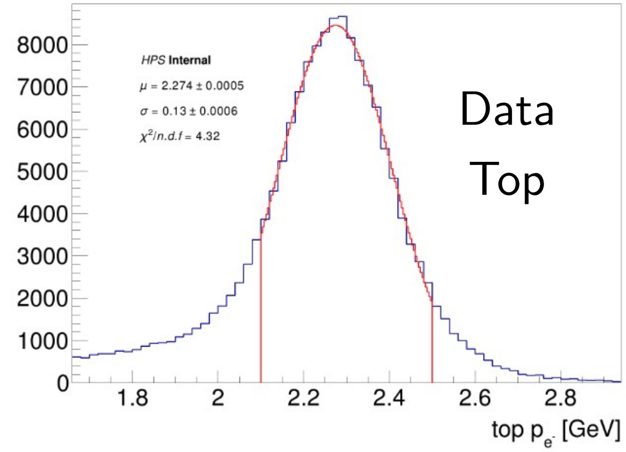


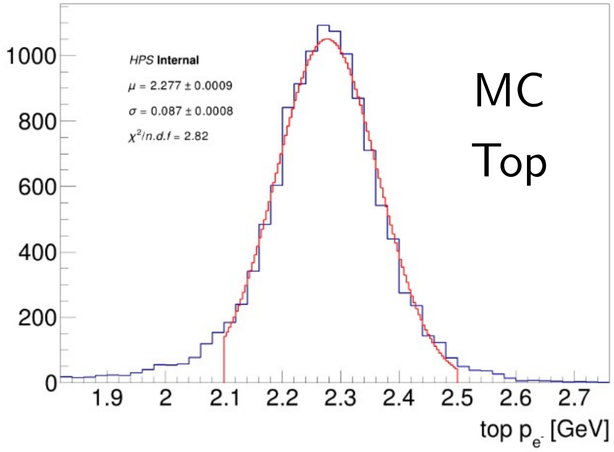
Fee Momentum Fits

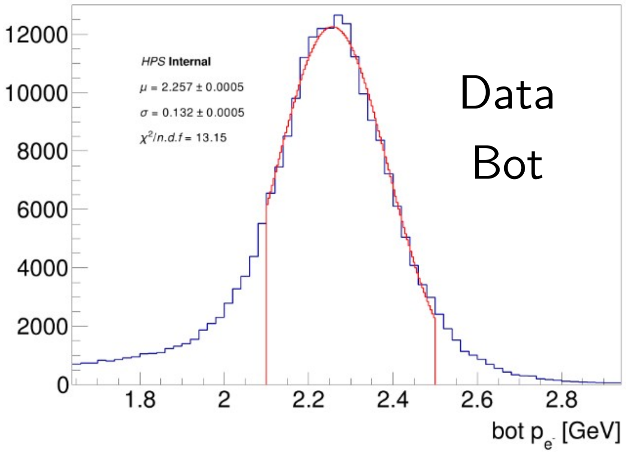
- Fit FEE peaks as a function of 10,11, 12 hits on track
- Calculate smearing factors based on FEE width

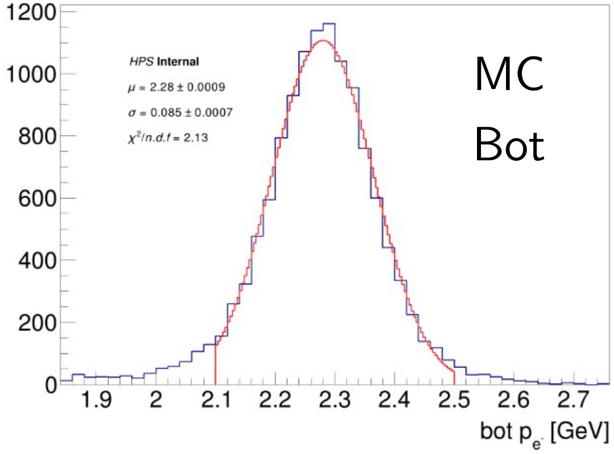
$$\Sigma_{smear} \equiv \frac{\sigma_{smear}}{P_{mc}} = \sqrt{\left(\frac{\sigma_{data}}{\mu_{data}}^2\right) - \left(\frac{\sigma_{MC}}{\mu_{MC}}\right)^2}$$

$$P_{smear} = P_{reco} + \mathcal{X}\Sigma^{smear} P_{reco}$$









Smearing Factor Summary

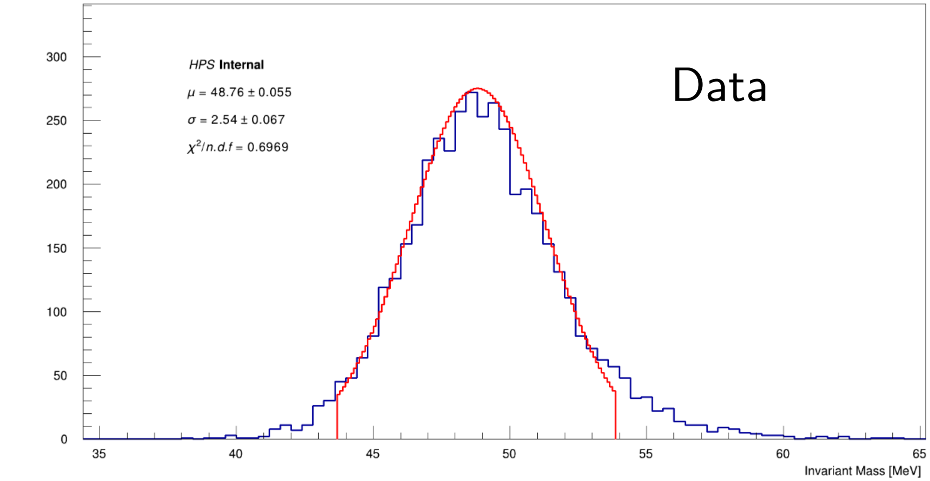
KF Tracking

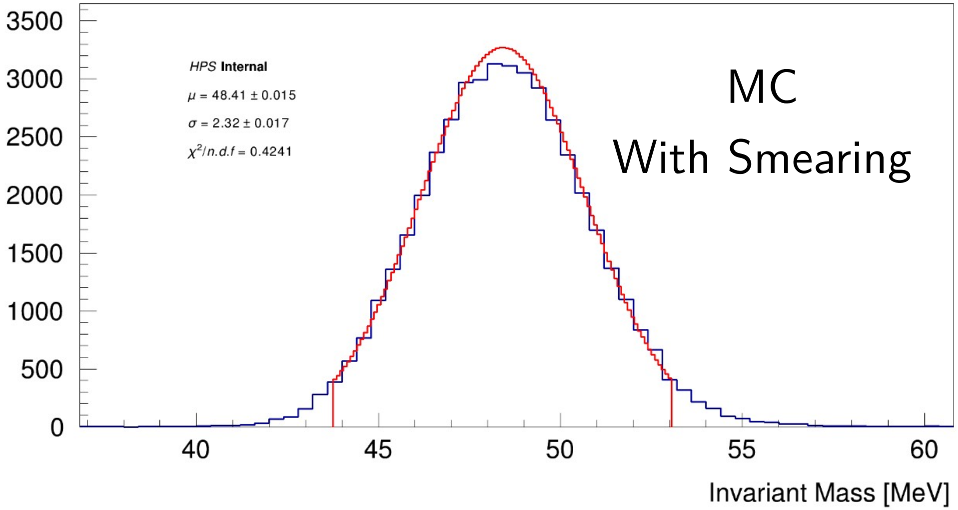
Variable/Category	Data	MC
$\mu_{Top12hits}$ GeV	2.274 $\pm$ 0.0005	2.277 $\pm$ 0.0009
$\mu_{Bot12hits}$ GeV	2.257 $\pm$ 0.0005	2.28 $\pm$ 0.0009
$\mu_{Top11hits}$ GeV	2.247 $\pm$ 0.002	2.271 $\pm$ 0.004
$\mu_{Bot11hits}$ GeV	2.271 $\pm$ 0.0016	2.78 $\pm$ 0.0036
$\mu_{Top10hits}$ GeV	2.23 $\pm$ 0.0026	2.276 $\pm$ 0.0037
$\mu_{Bot10hits}$ GeV	2.29 $\pm$ 0.0017	2.276 $\pm$ 0.0037
$\sigma_{Top12hits}$ GeV	0.13 $\pm$ 0.0006	0.087 $\pm$ 0.0006
$\sigma_{Bot12hits}$ GeV	0.132 $\pm$ 0.0005	0.085 $\pm$ 0.0007
$\sigma_{Top11hits}$ GeV	0.174 $\pm$ 0.0025	0.122 $\pm$ 0.0044
$\sigma_{Bot11hits}$ GeV	0.167 $\pm$ 0.0023	0.115 $\pm$ 0.0039
$\sigma_{Top10hits}$ GeV	0.163 $\pm$ 0.0028	0.106 $\pm$ 0.0031
$\sigma_{Bot10hits}$ GeV	0.161 $\pm$ 0.0026	0.112 $\pm$ 0.0038
$\Sigma^{smear}_{Top12hits}$ GeV	N/A	0.0427
$\Sigma^{smear}_{Bot12hits}$ GeV	N/A	0.0448
$\Sigma^{smear}_{Top11hits}$ GeV	N/A	0.0554
$\Sigma^{smear}_{Bot11hits}$ GeV	N/A	0.0535
$\Sigma^{smear}_{Top10hits}$ GeV	N/A	0.0561
$\Sigma^{smear}_{Bot10hits}$ GeV	N/A	0.0504

Seedtracker+GBL

Variable \ Data Sample	Data	MC
μ_{Top}5hits [GeV]	2.262 $\pm$ 0.0022	2.246 $\pm$ 0.0022
μ_{Top}6hits [GeV]	2.285 $\pm$ 0.00071	2.255 $\pm$ 0.00081
μ_{Bot}5hits [GeV]	2.251 $\pm$ 0.0020	2.245 $\pm$ 0.0022
μ_{Bot}6hits [GeV]	2.254 $\pm$ 0.00072	2.260 $\pm$ 0.00069
σ_{Top}5hits [GeV]	0.182 $\pm$ 0.0033	0.099 $\pm$ 0.0016
σ_{Top}6hits [GeV]	0.130 $\pm$ 0.00089	0.083 $\pm$ 0.00065
σ_{Bot}5hits [GeV]	0.170 $\pm$ 0.0027	0.099 $\pm$ 0.0017
σ_{Bot}6hits [GeV]	0.131 $\pm$ 0.00079	0.082 $\pm$ 0.00057
Σ^{smear}_{Top}5hits [%]	N/A	6.733 $\pm$ 0.1632
Σ^{smear}_{Top}6hits [%]	N/A	4.358 $\pm$ 0.0485
Σ^{smear}_{Bot}5hits [%]	N/A	6.156 $\pm$ 0.1415
Σ^{smear}_{Bot}6hits [%]	N/A	4.556 $\pm$ 0.0431

Moller Peaks with Momentum Smearing





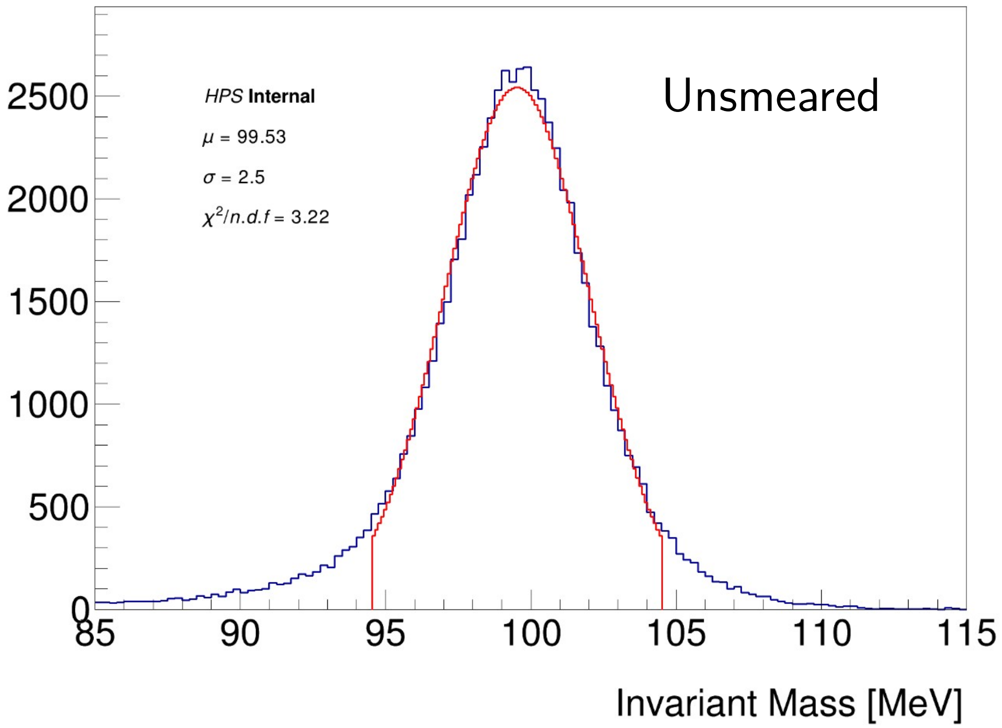
Unconstrained Vtx KF Tracking

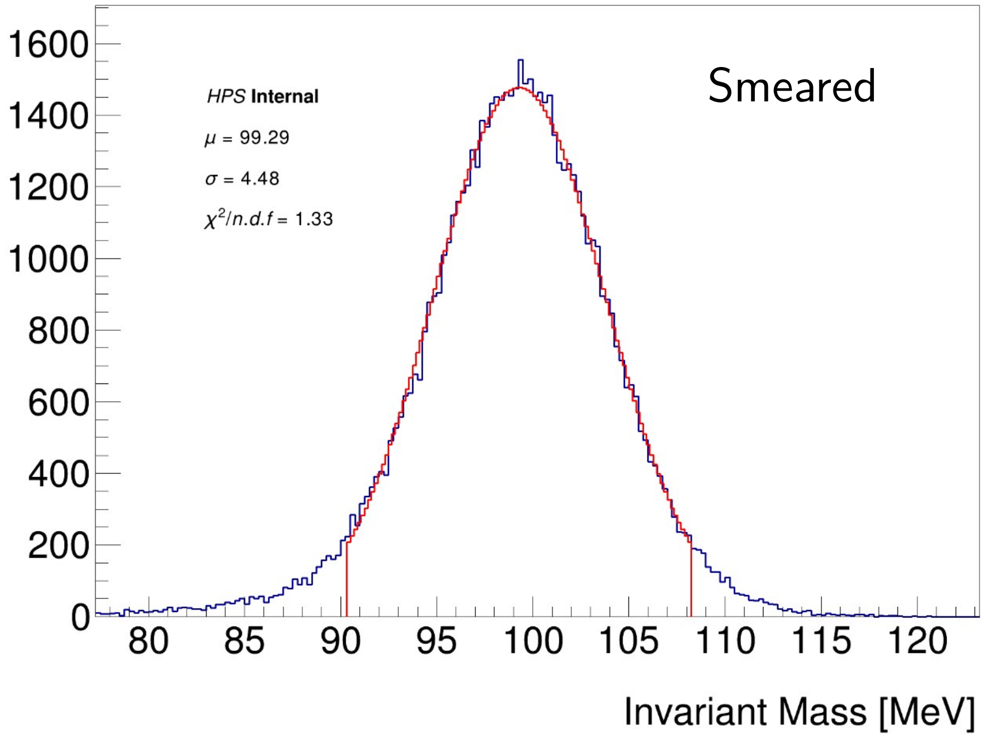
	μ [MeV]	σ [MeV]	σ_{err} [MeV]
Data	48.76	2.54	0.067
MC	48.52	1.87	0.016
$MC_{smeared}$	48.41	2.32	0.017

Constrained Vtx Seedtracker+GBL

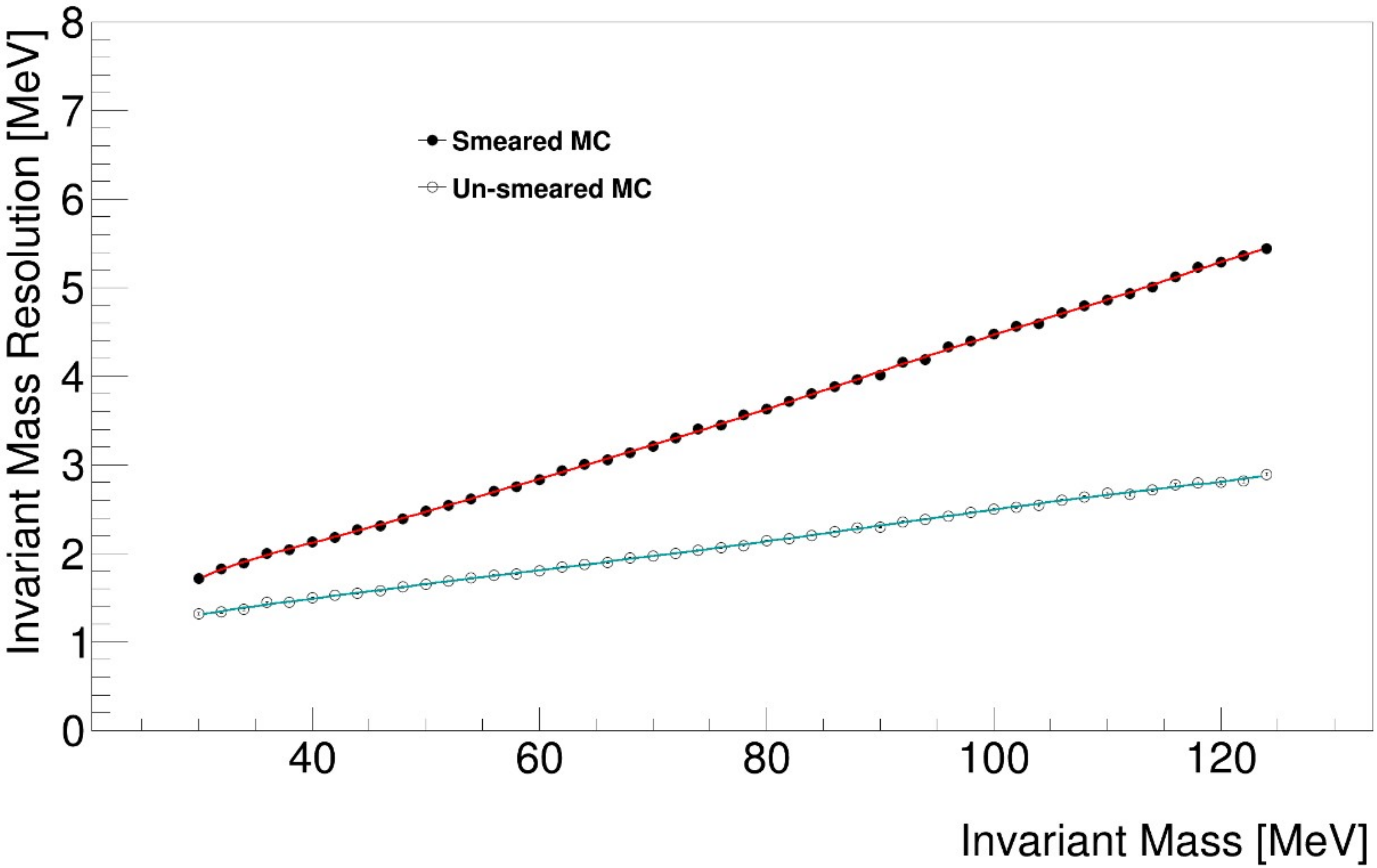
	μ [MeV]	σ [MeV]	σ_{err} [MeV]
Data	48.93	2.06	0.012
MC unsmeared	48.43	1.	0.0033
MC smeared	48.35	1.93	0.0026

MC Signal with Smearing – 100 MeV Example





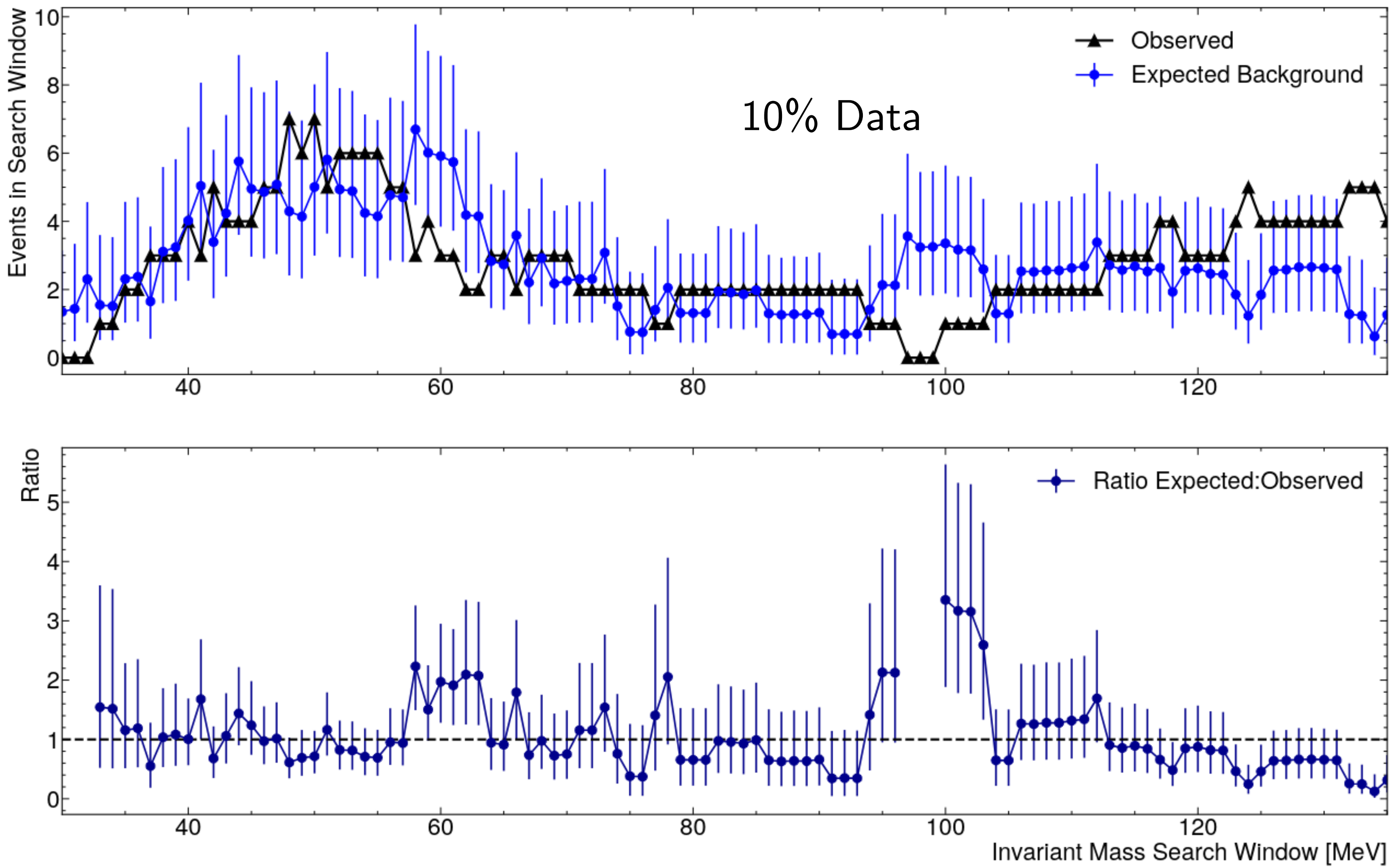
Smeared MC Mass Resolution



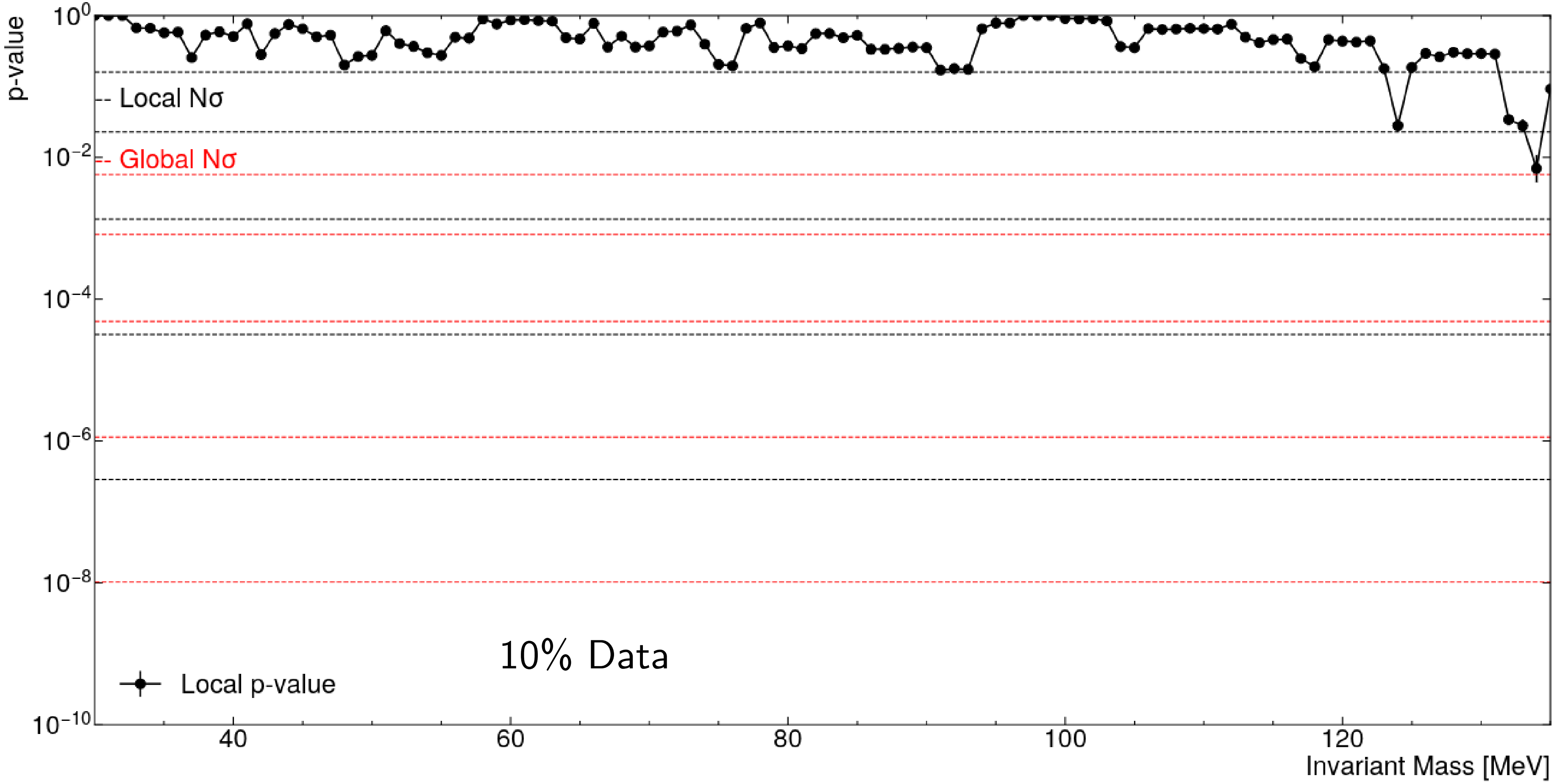
ABCD Background Estimation

Signal Window +-2 sigma

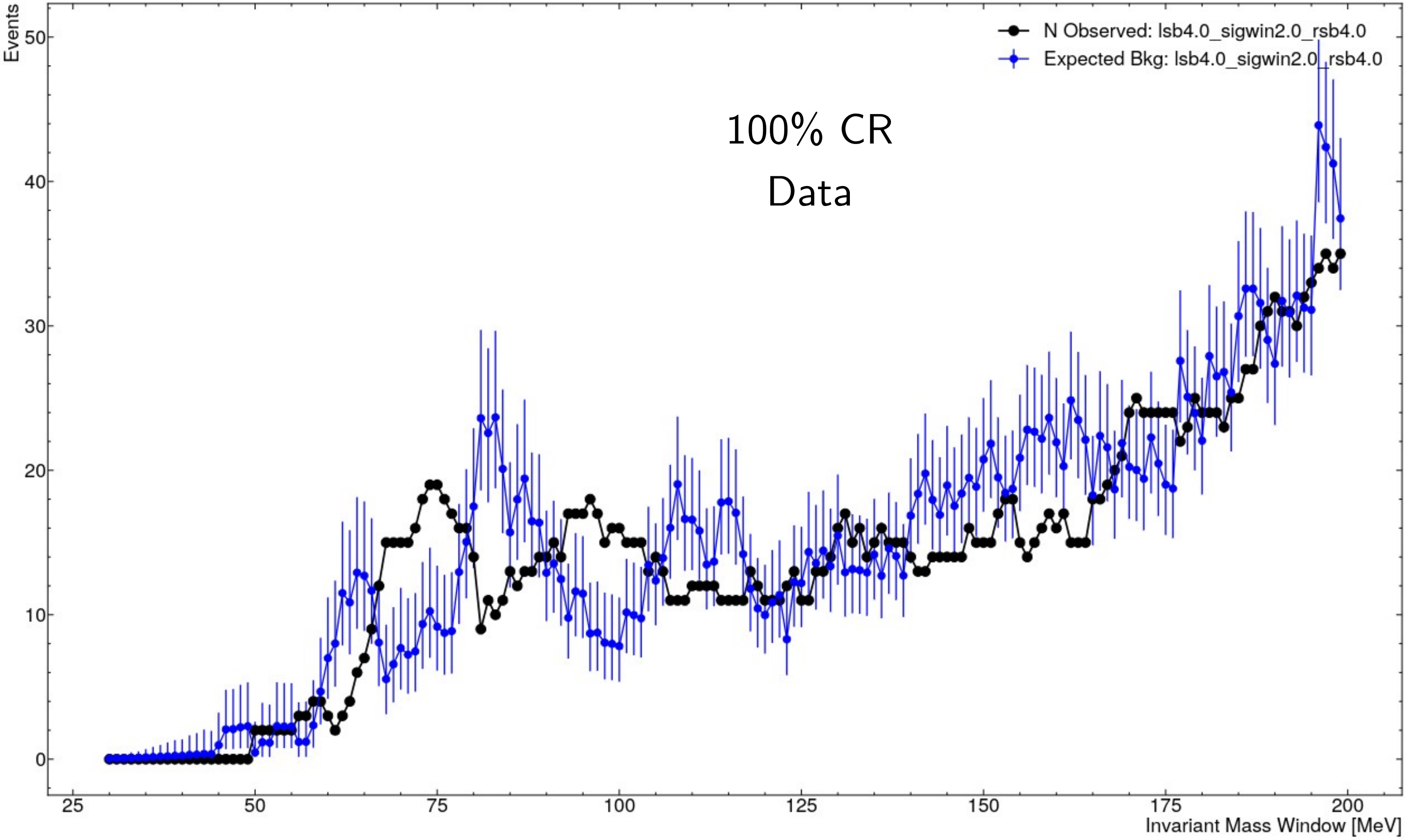
Expected Background – 10% Data



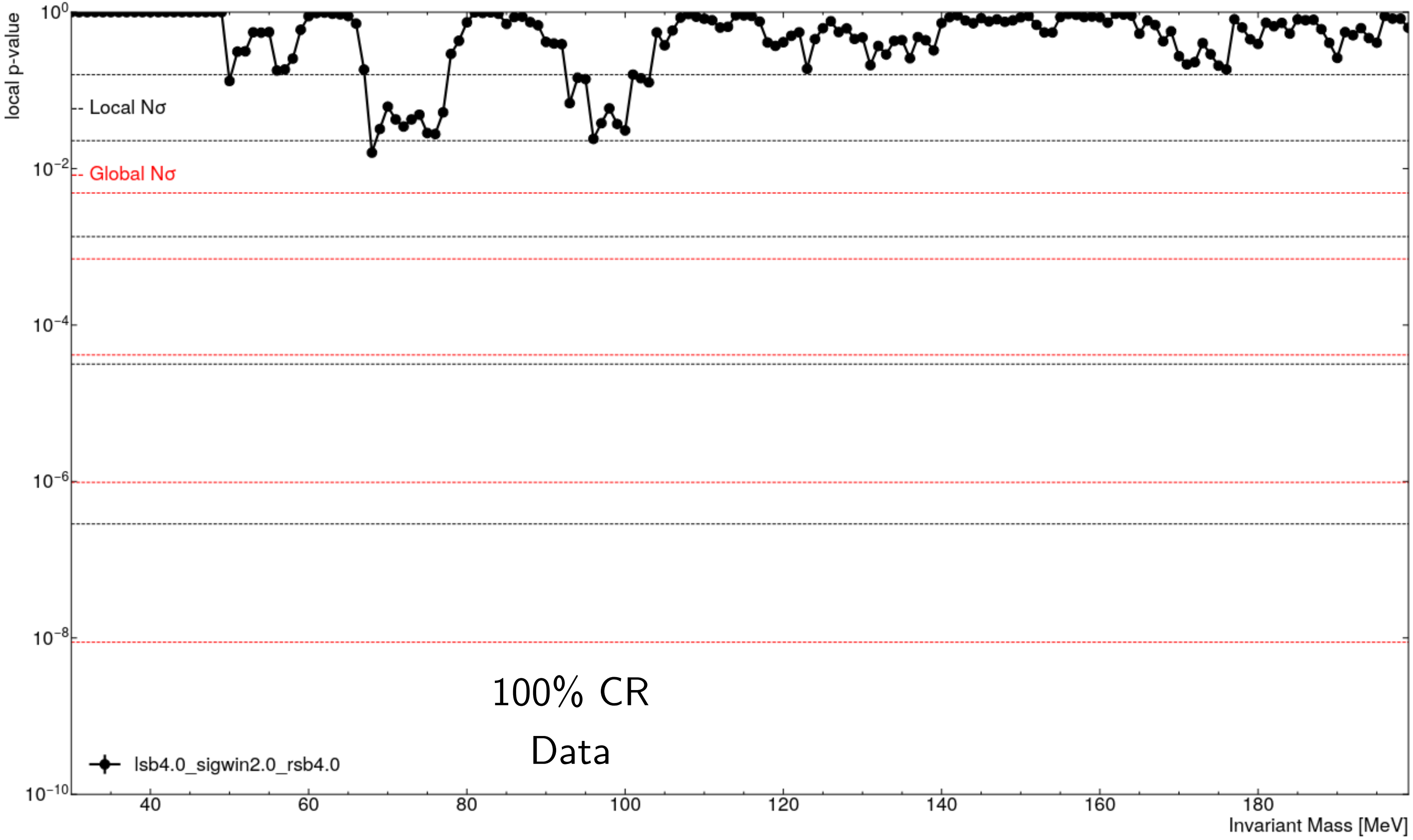
PValues – 10% Data



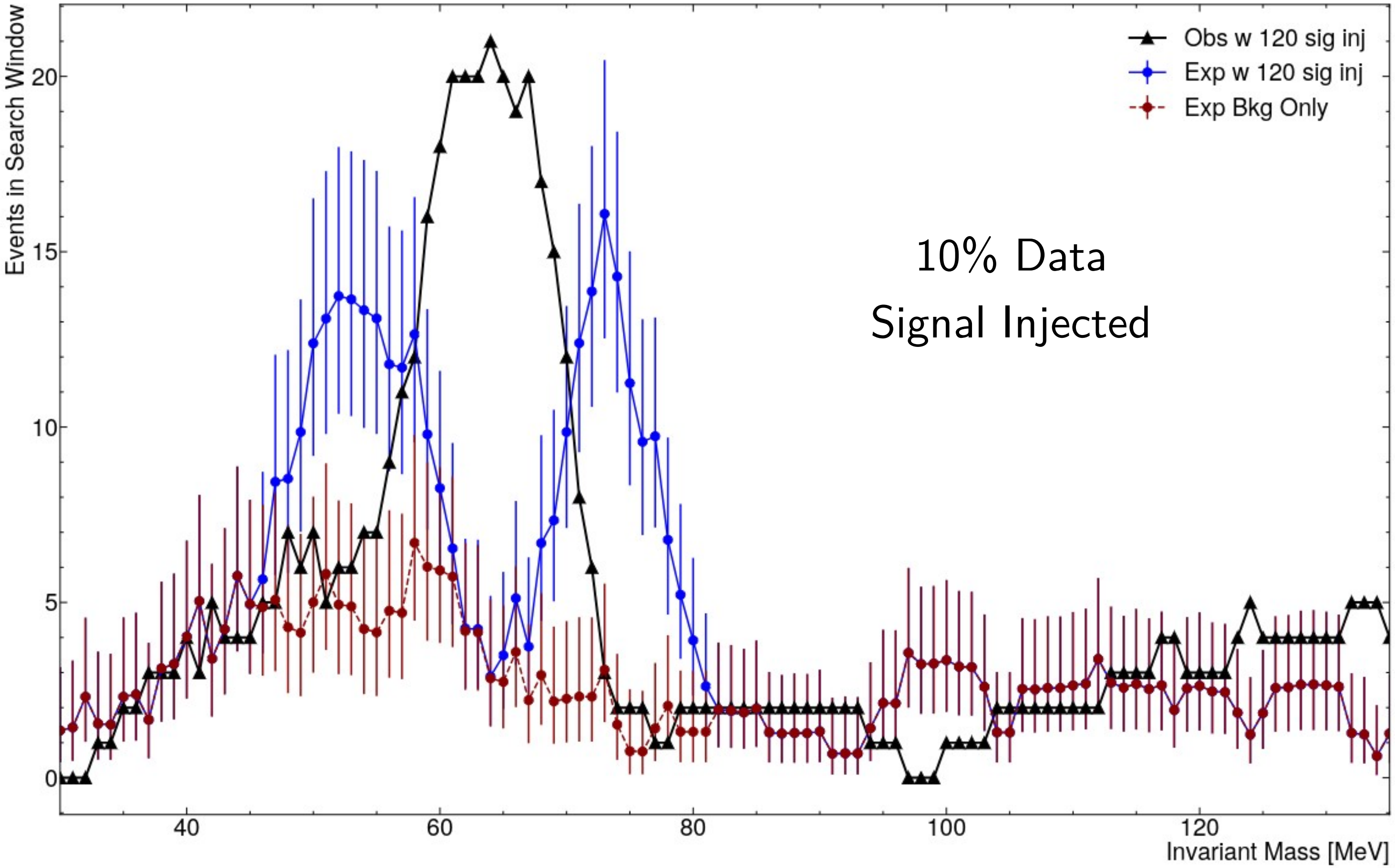
Expected Background – 100% CR Data



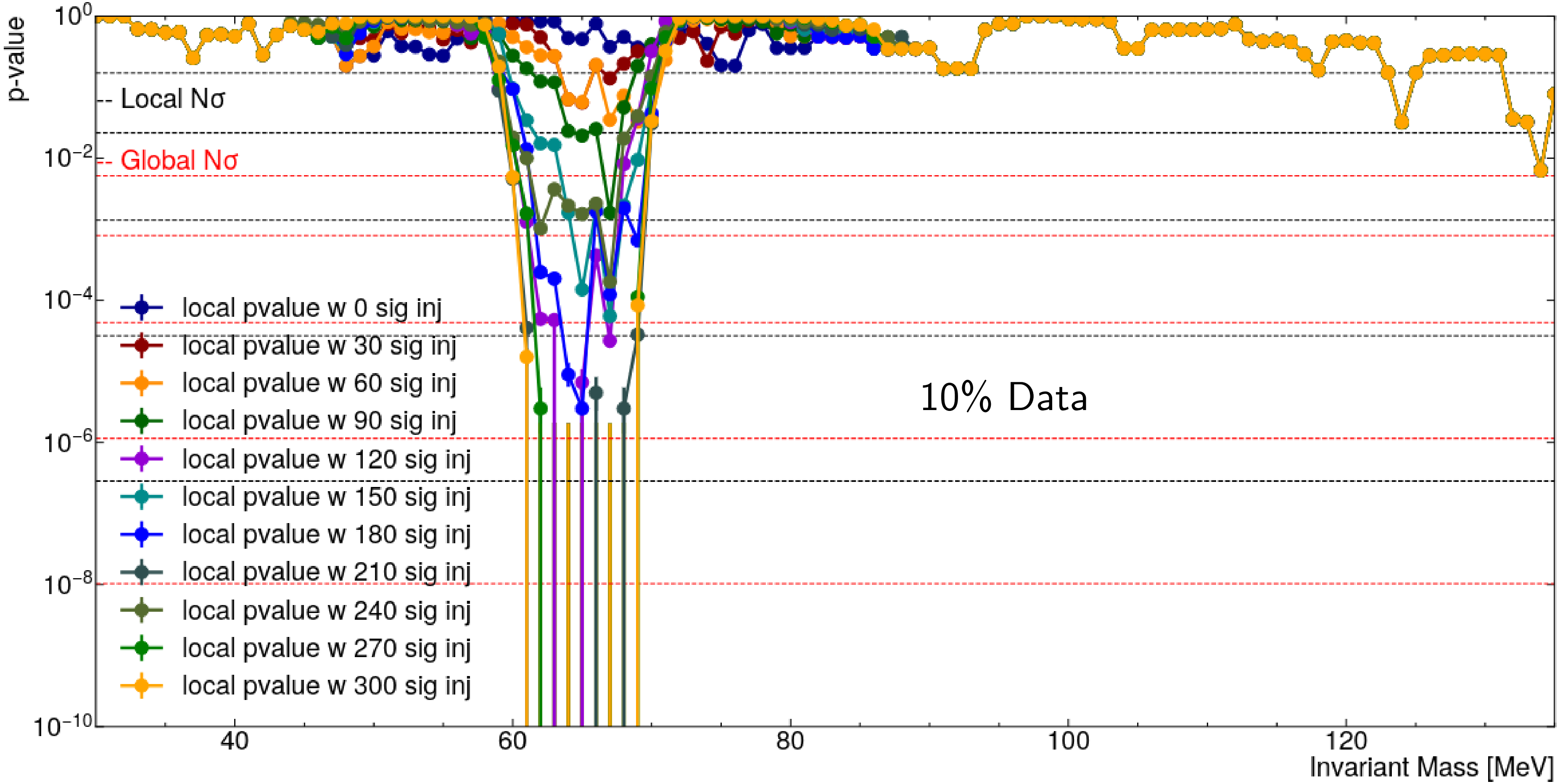
PValues – 100% CR Data



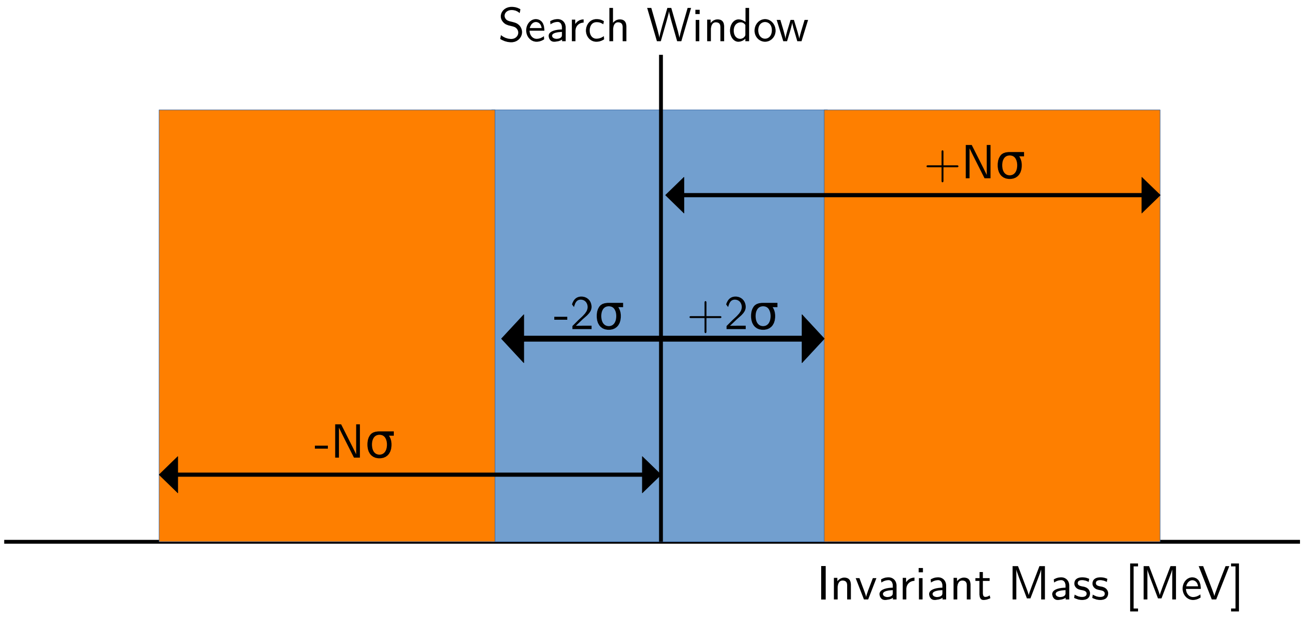
Signal Injection – 10% Data



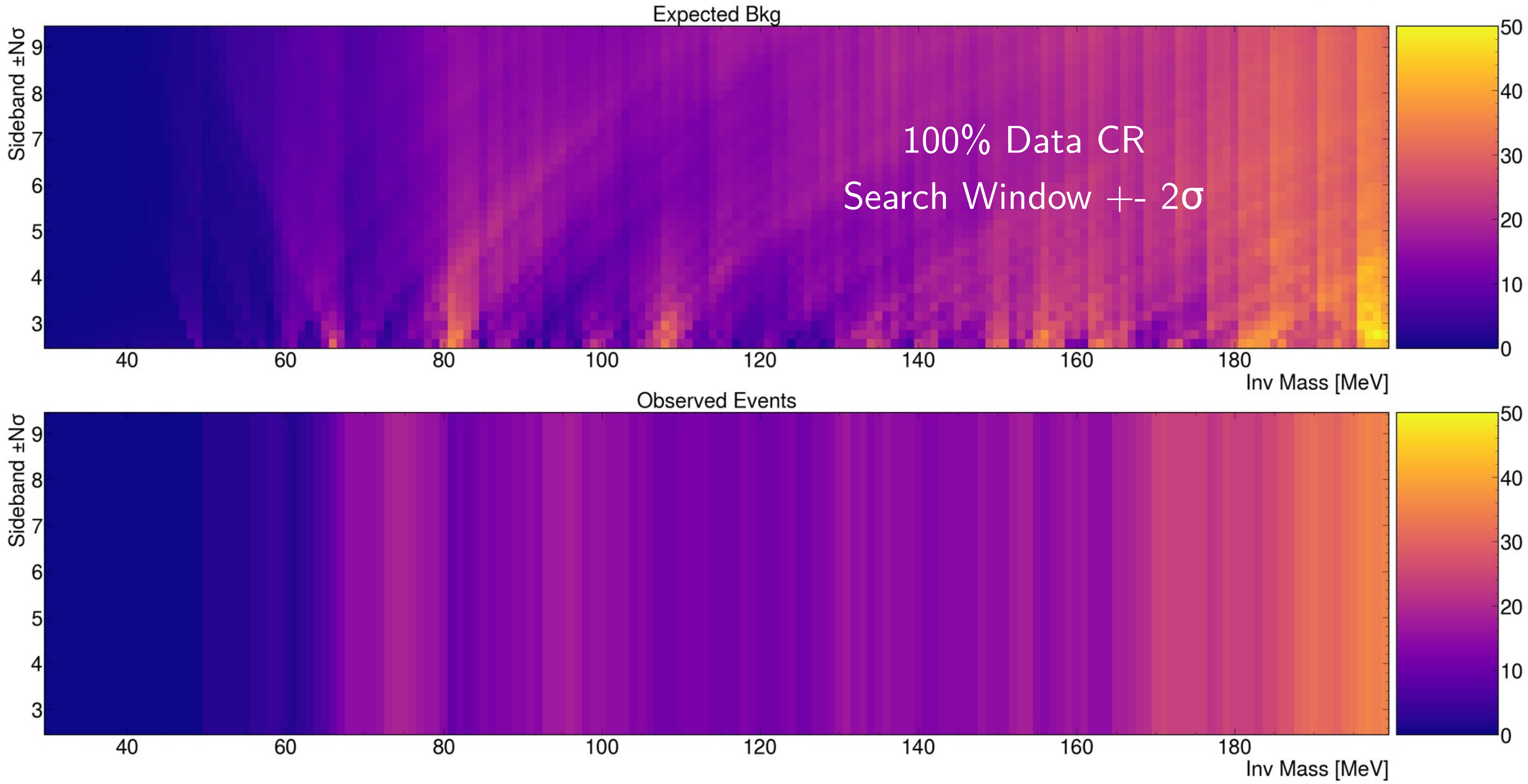
PValues – 10% Data with Signal Injected



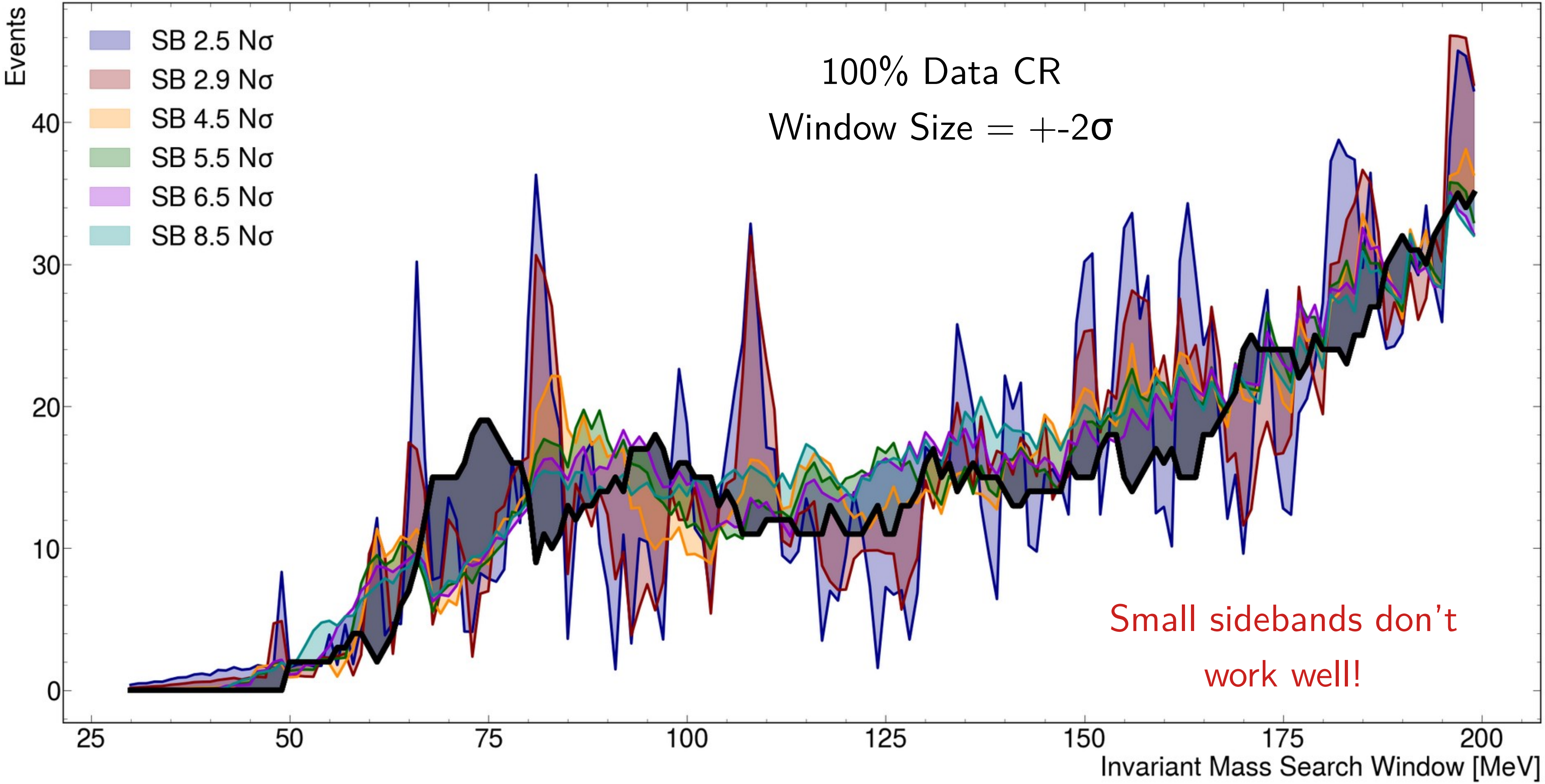
Optimize ABCD Sideband Sizes for $\pm 2\sigma$ Search Window



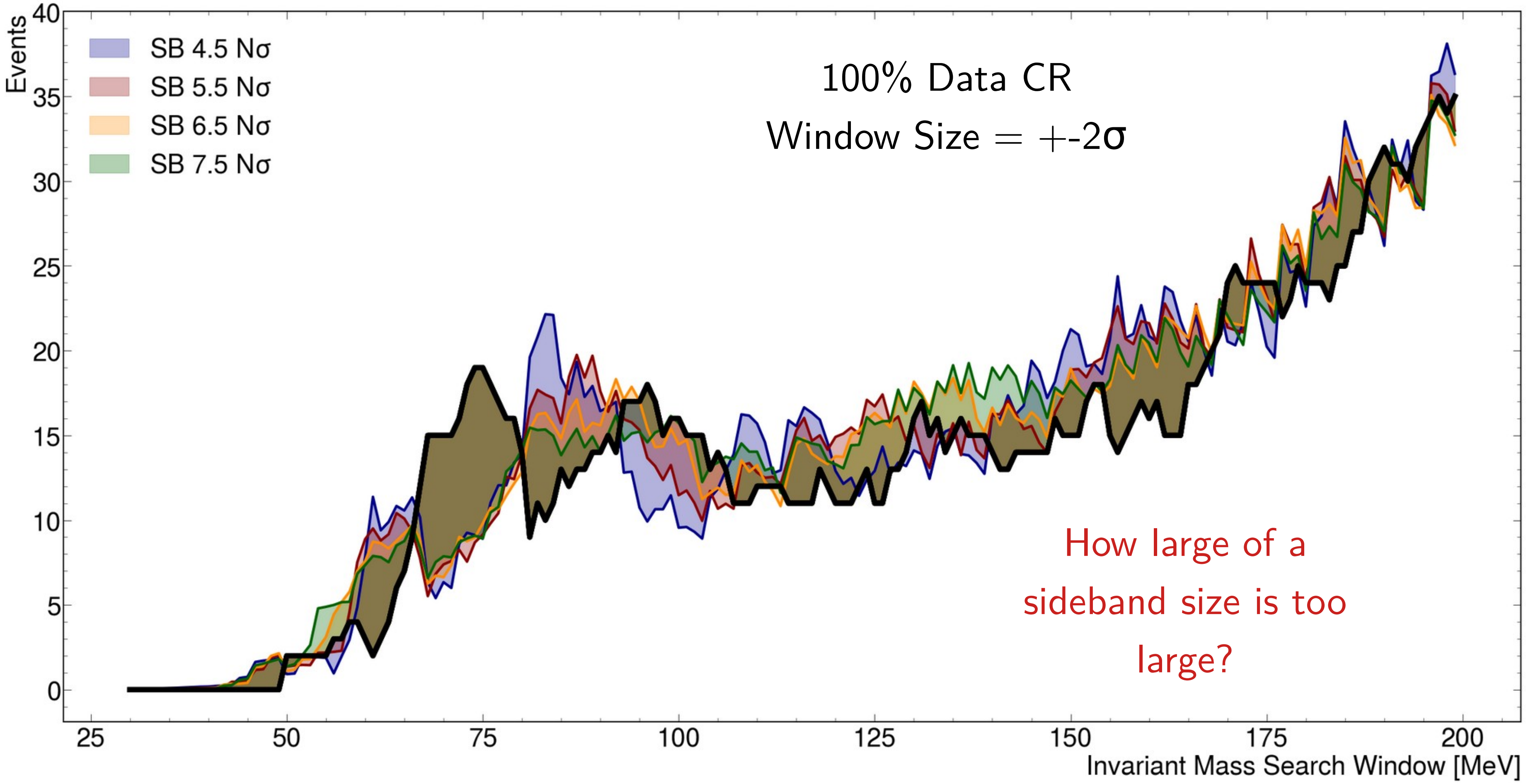
ABCD Mass Sidebands – 100% CR Data



ABCD Mass Sidebands – 100% CR Data

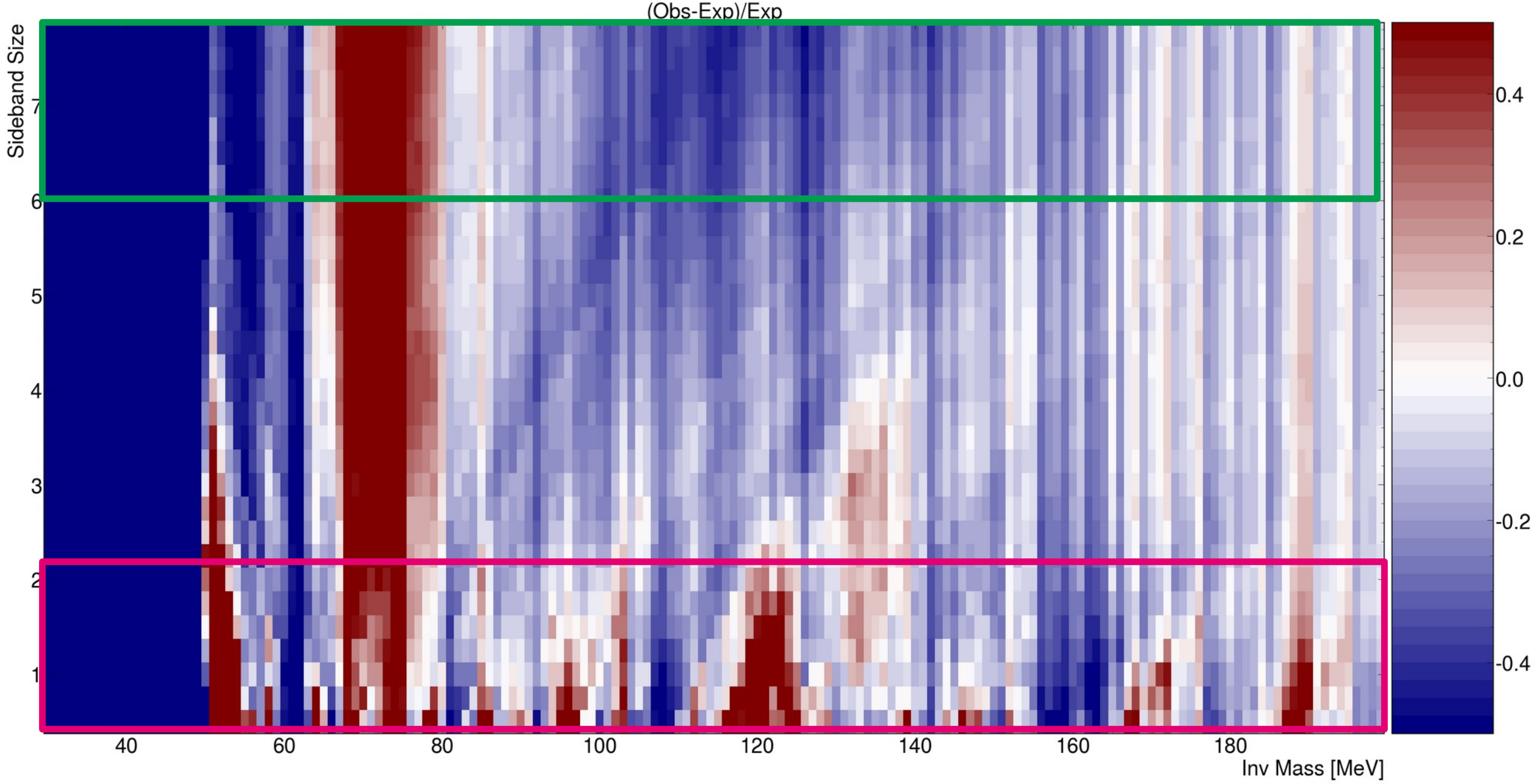


ABCD Mass Sidebands – 100% CR Data



How large of a sideband size is too large?

ABCD Mass Sidebands – 100% CR Data

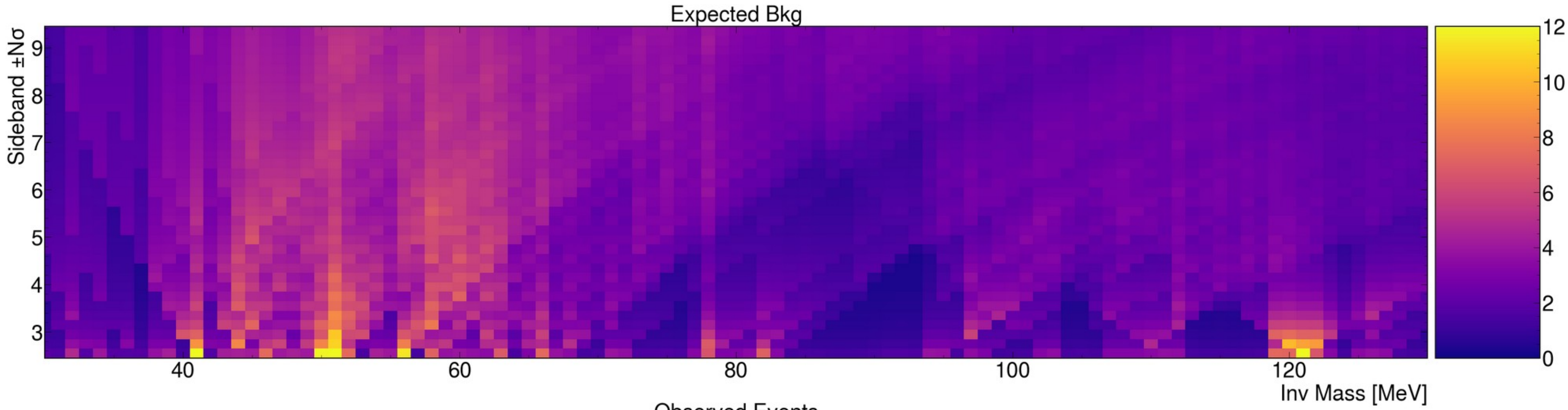


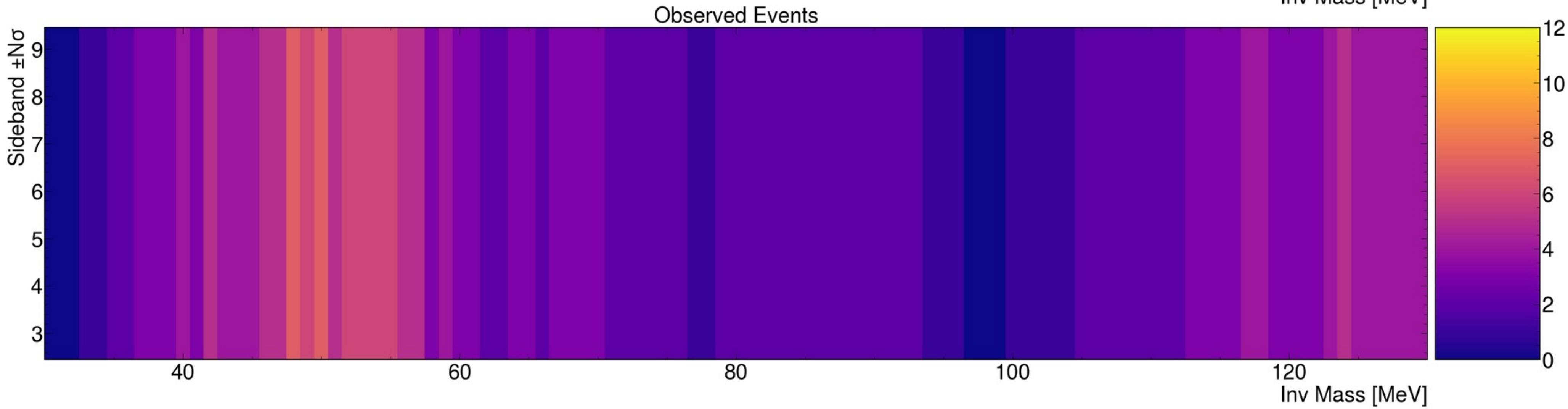
Sideband Width < 2σ results in large underestimates

Sideband Width > 6σ results in systematic overestimate

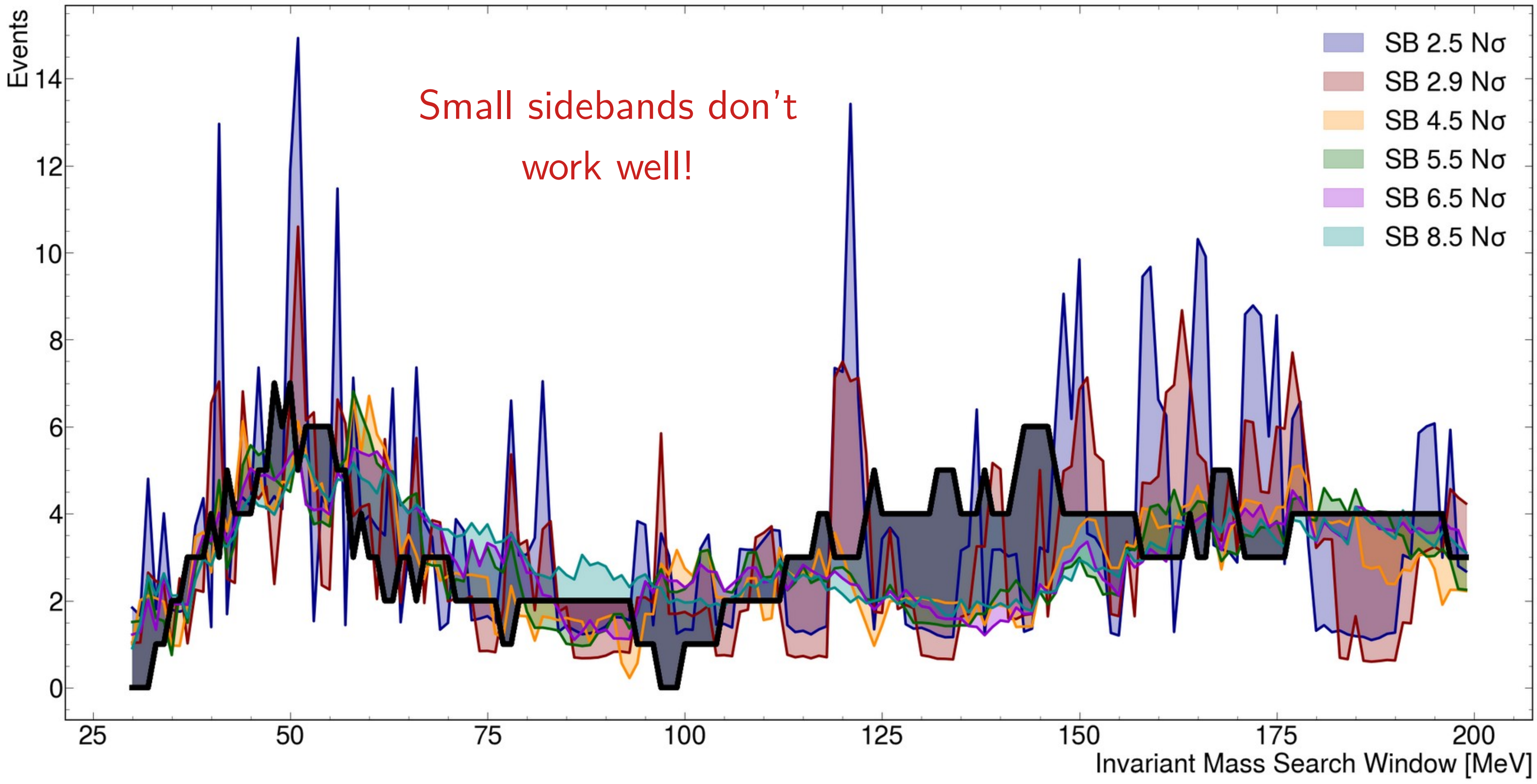
10% Data

ABCD Mass Sidebands – 10% Data

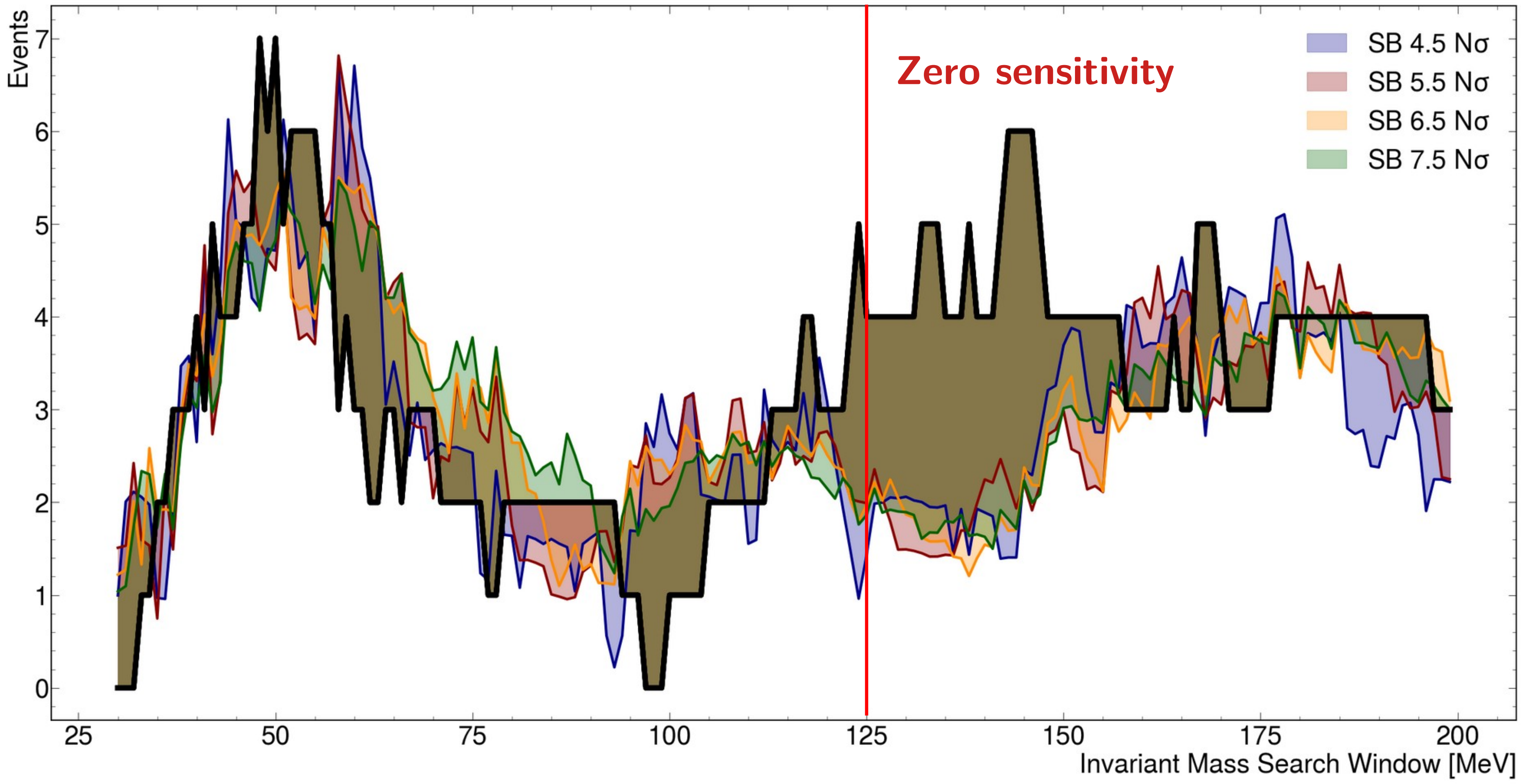




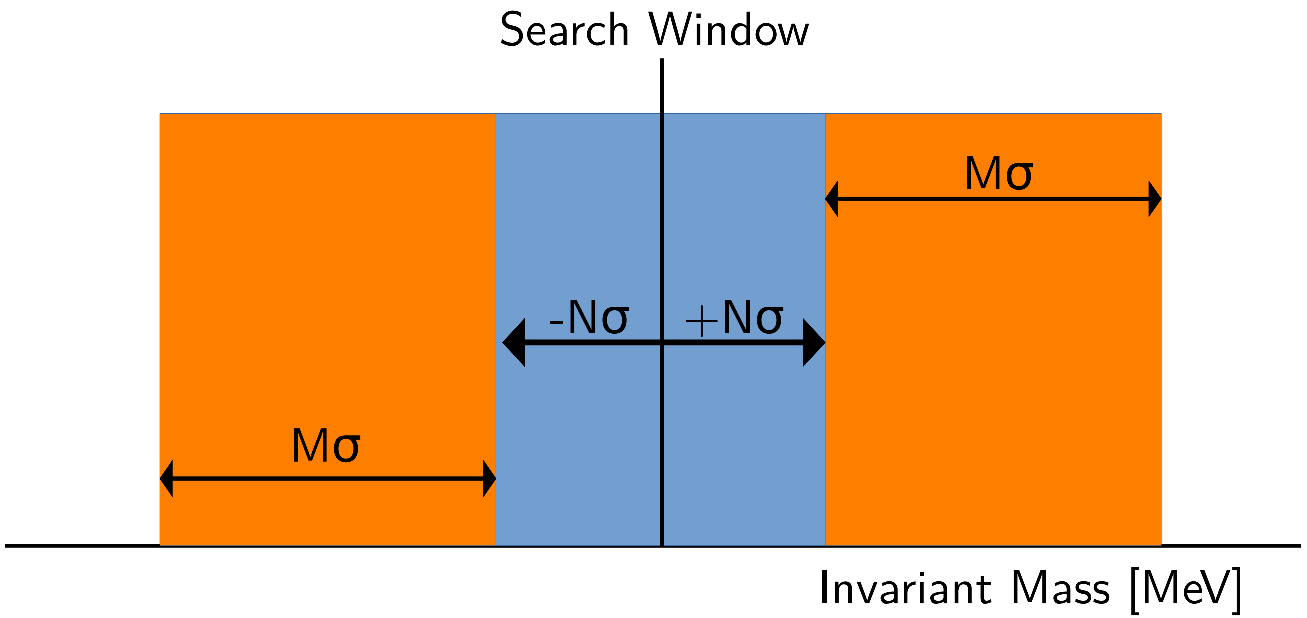
ABCD Mass Sidebands – 10% Data



ABCD Mass Sidebands – 10% Data

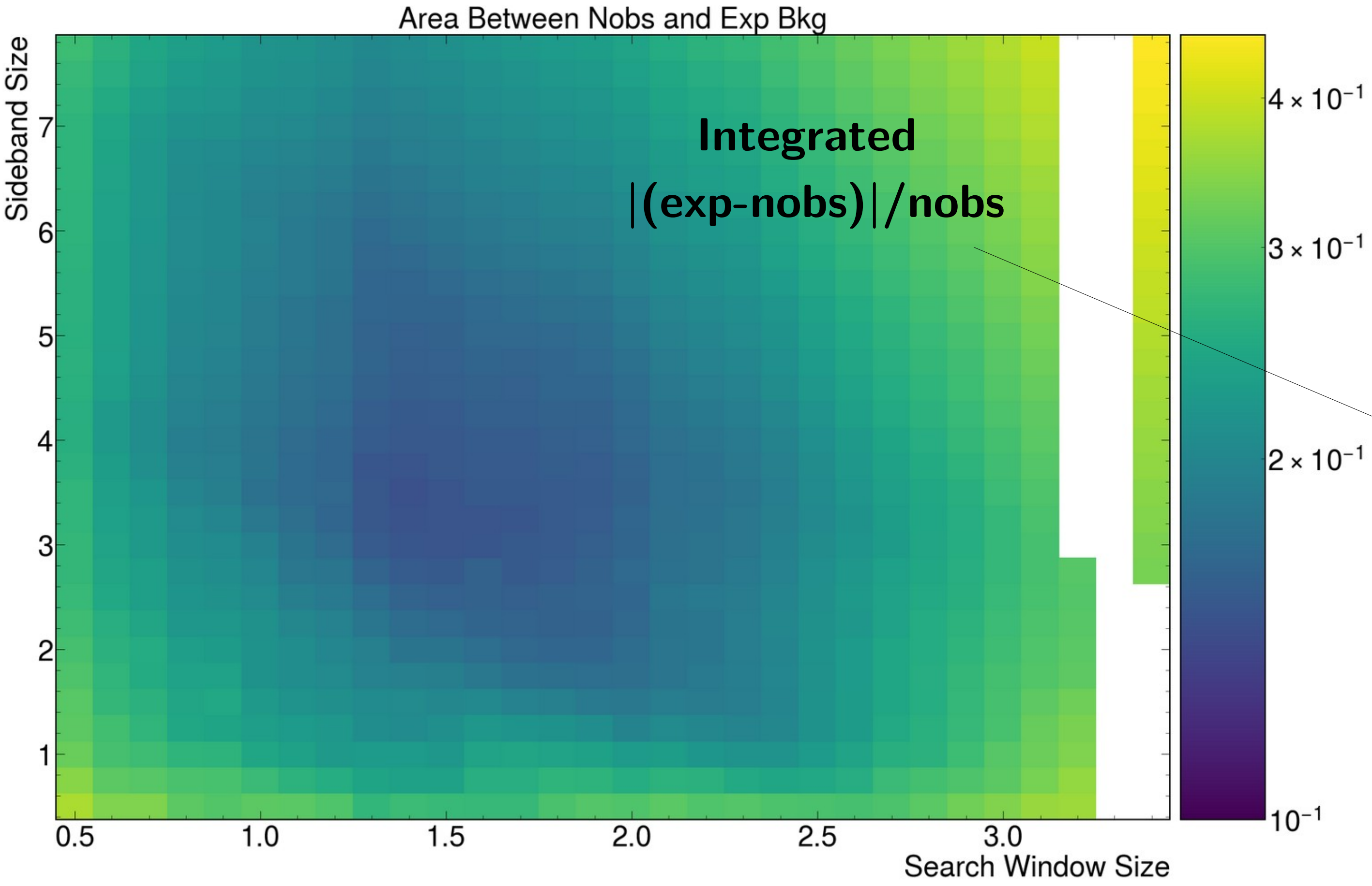


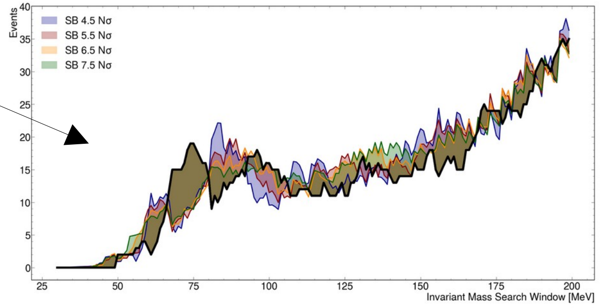
Scan Signal Window Size
AND
Sideband Size



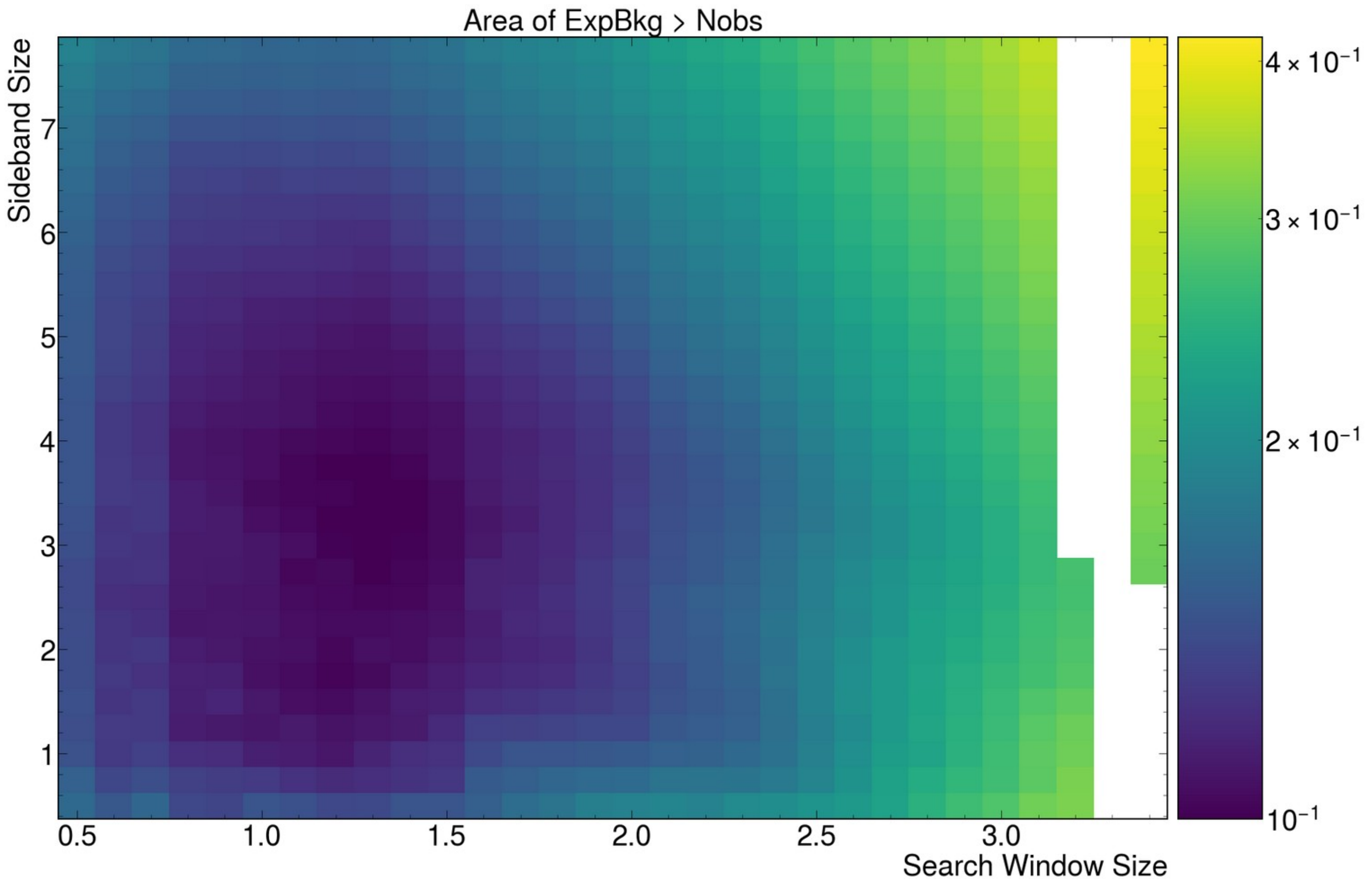
100% CR Data Plots

Scaled Area Between Observed and Expected

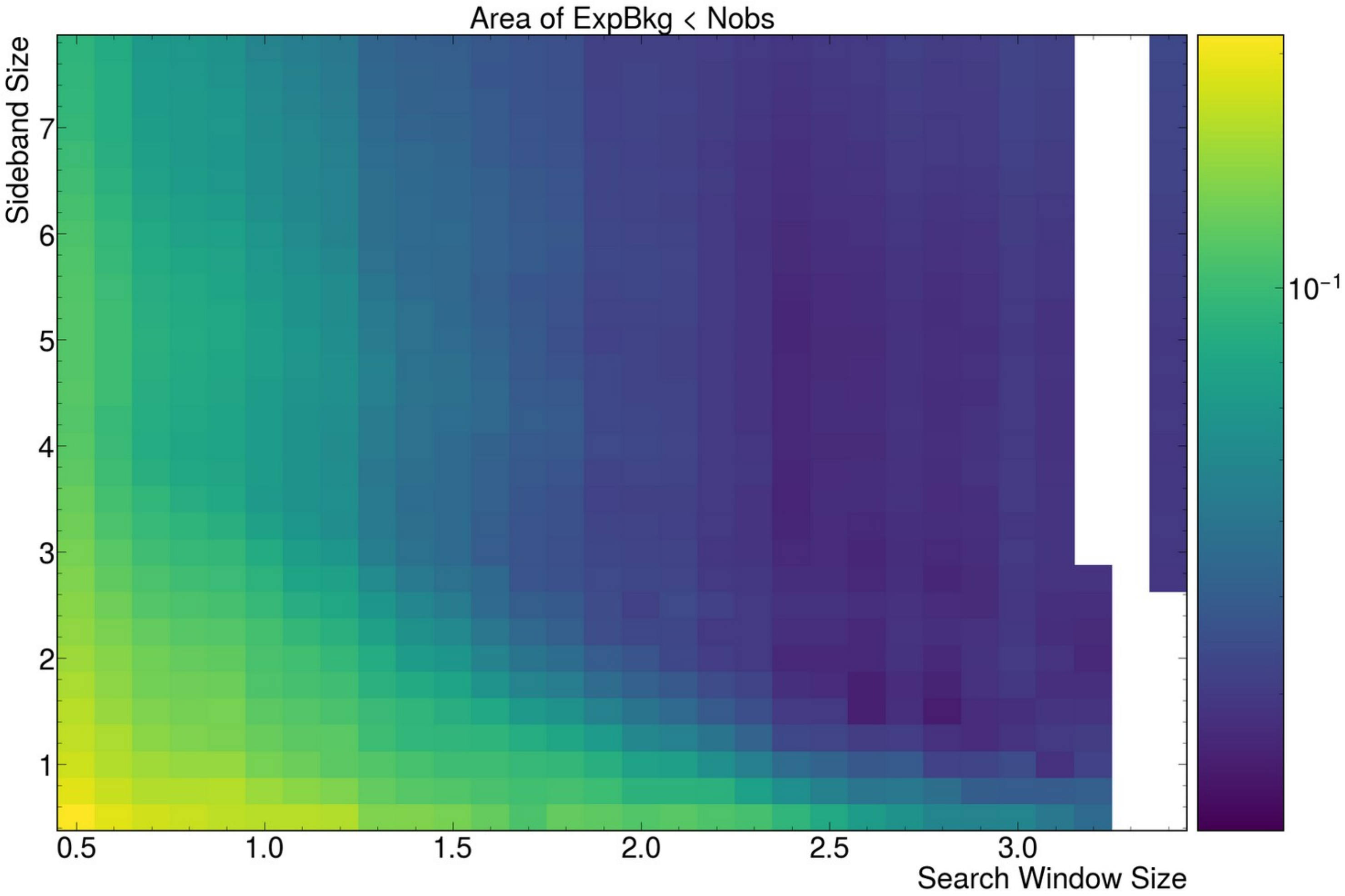




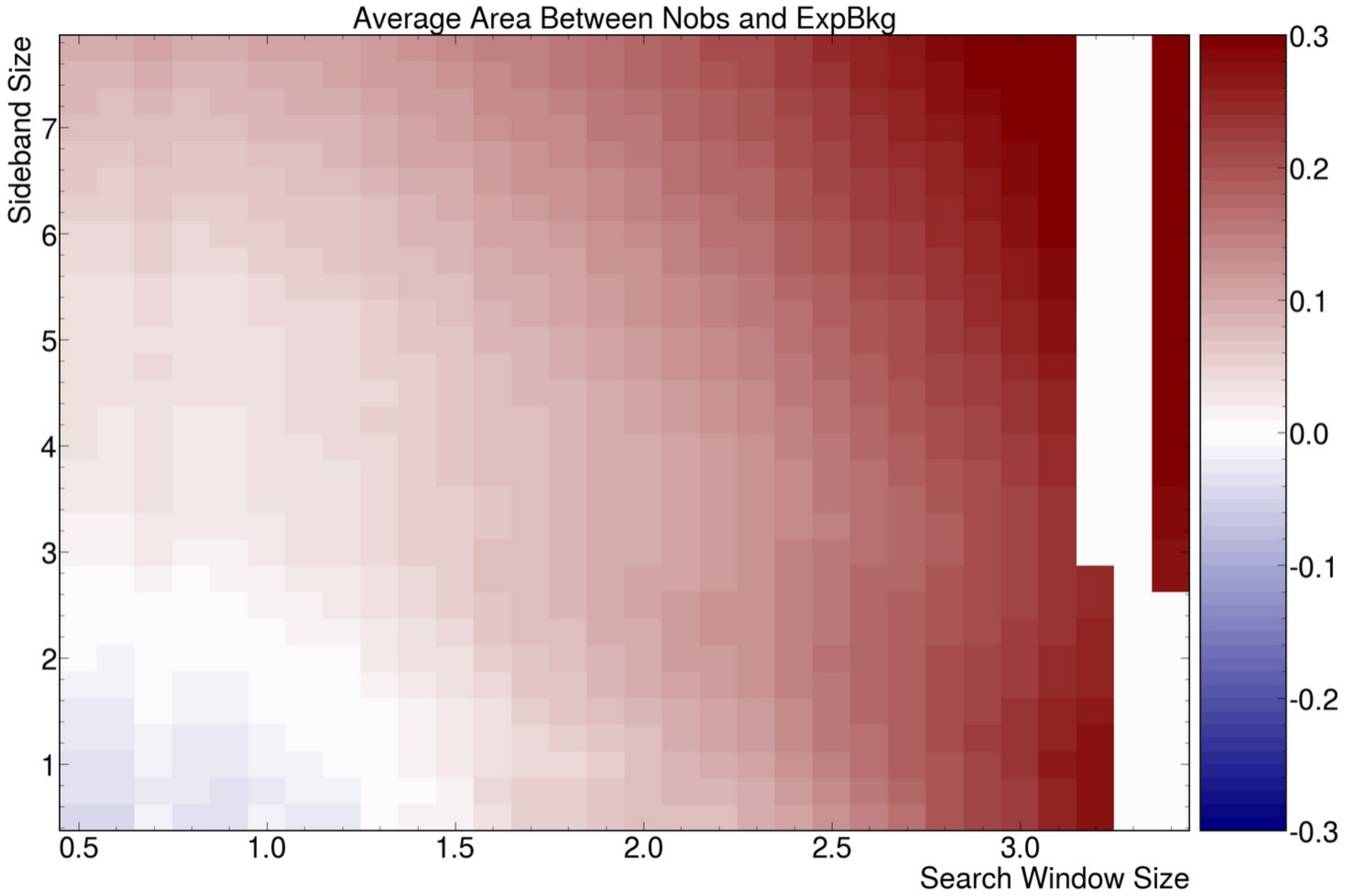
Scaled Area Expected > Nobs

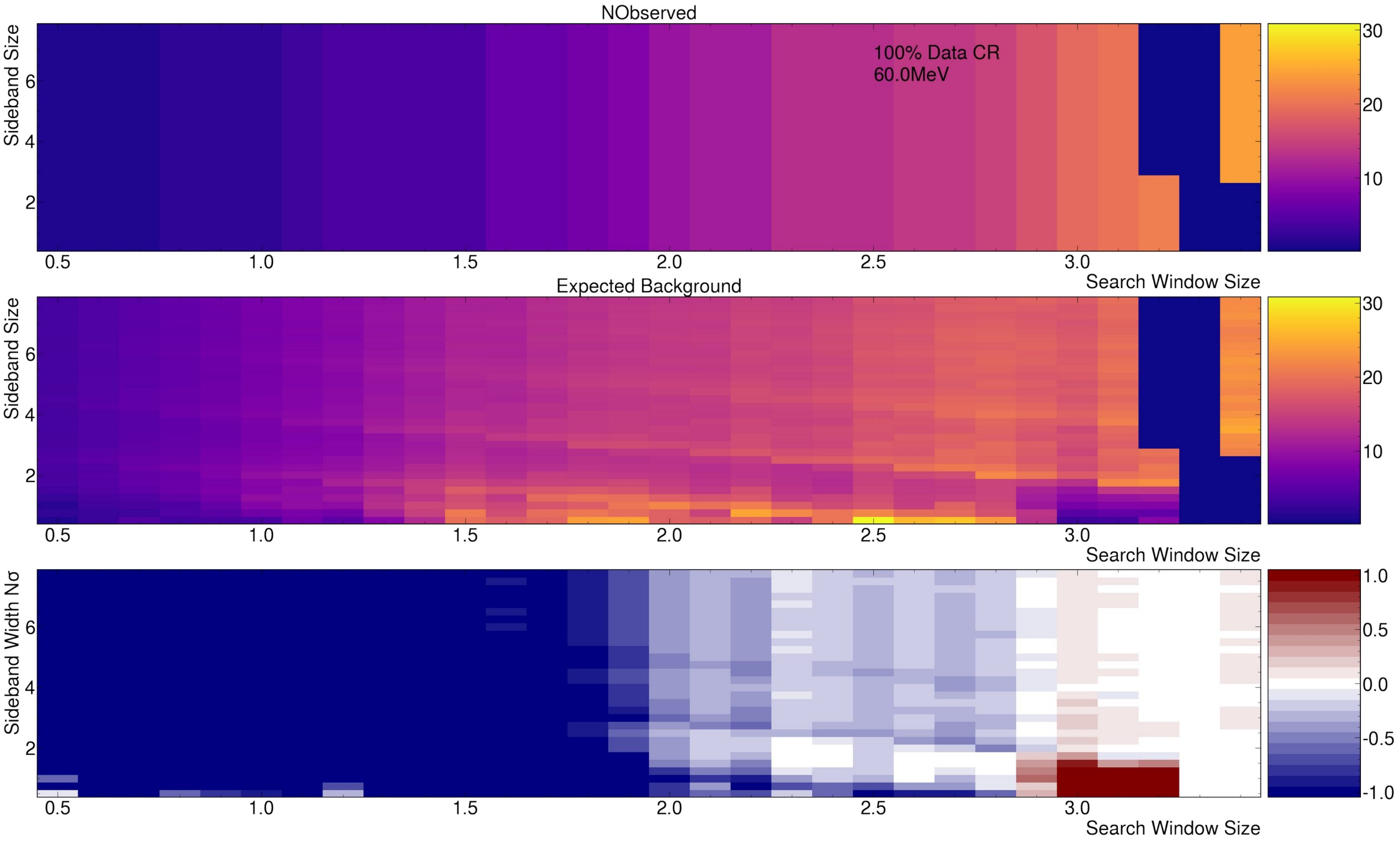


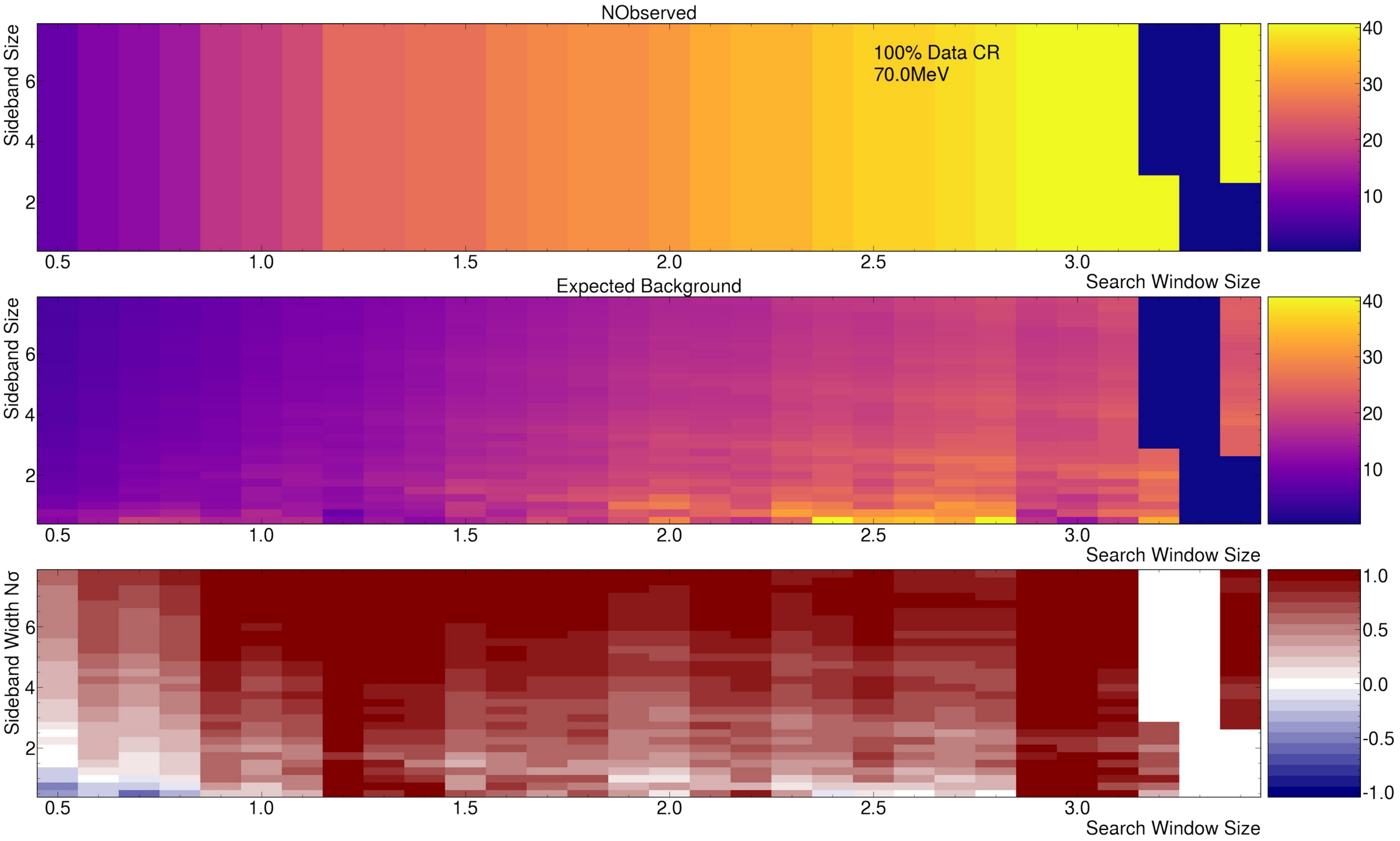
Scaled Area Expected < Nobs

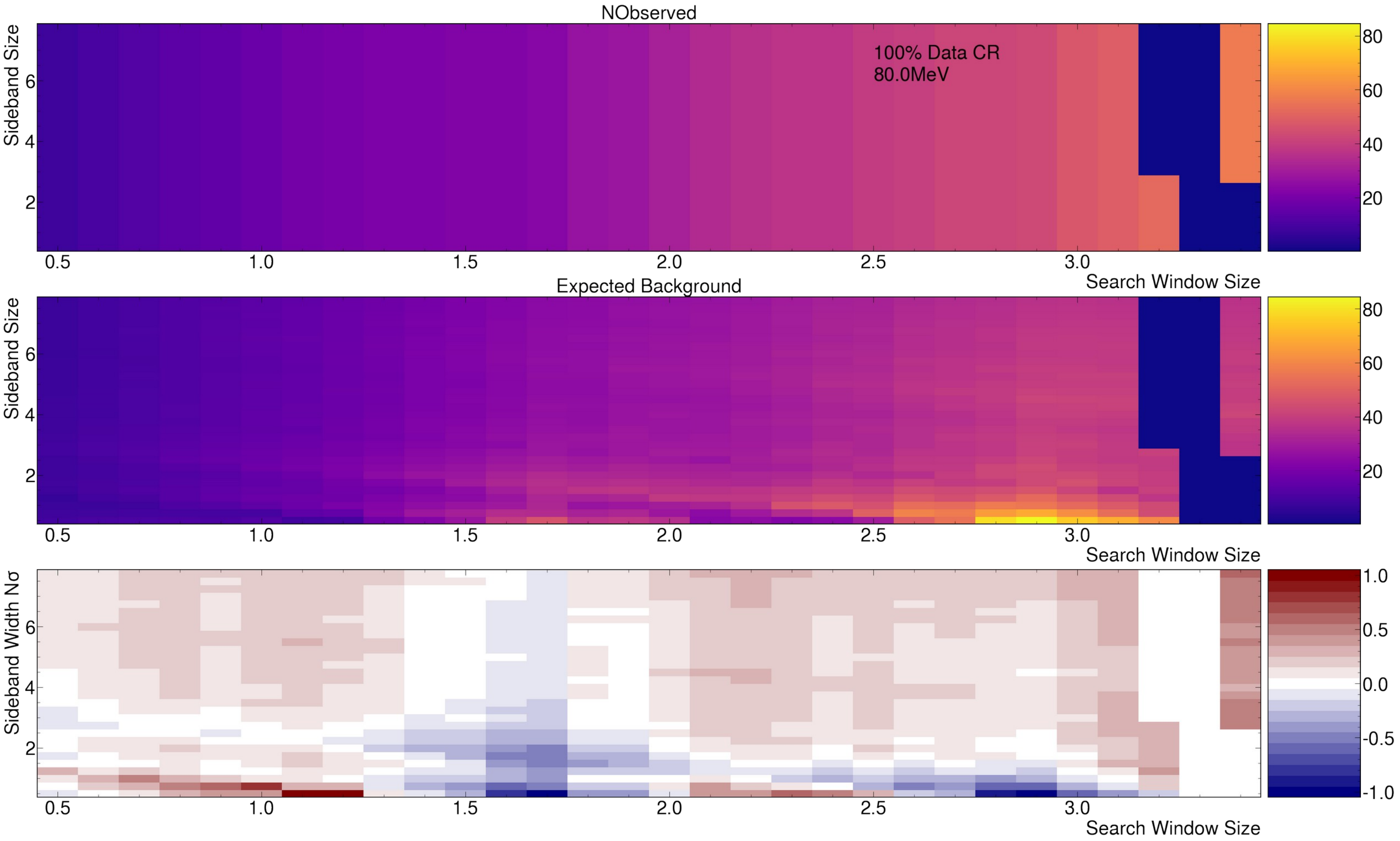


Scaled Averaged Area Above and Below

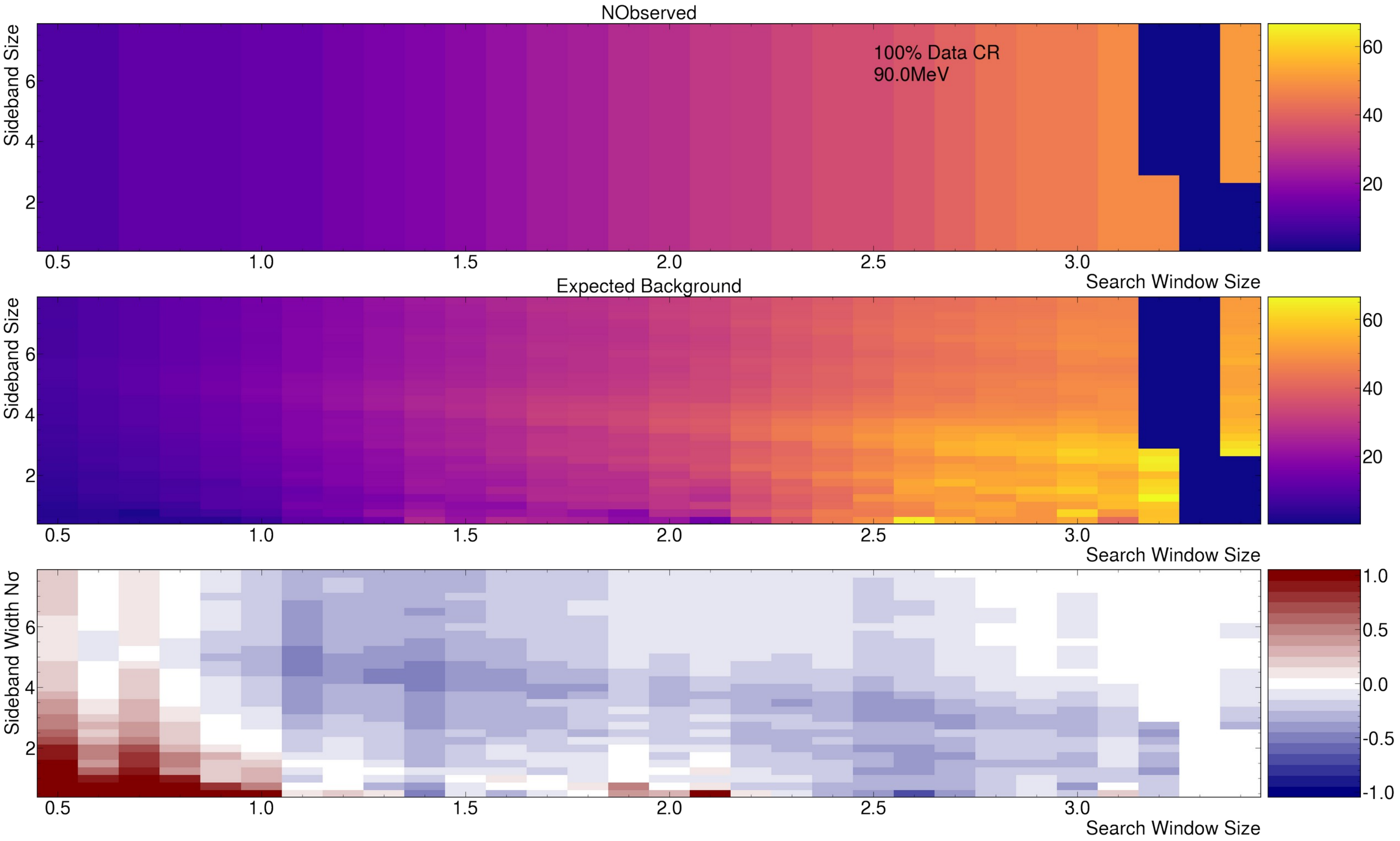


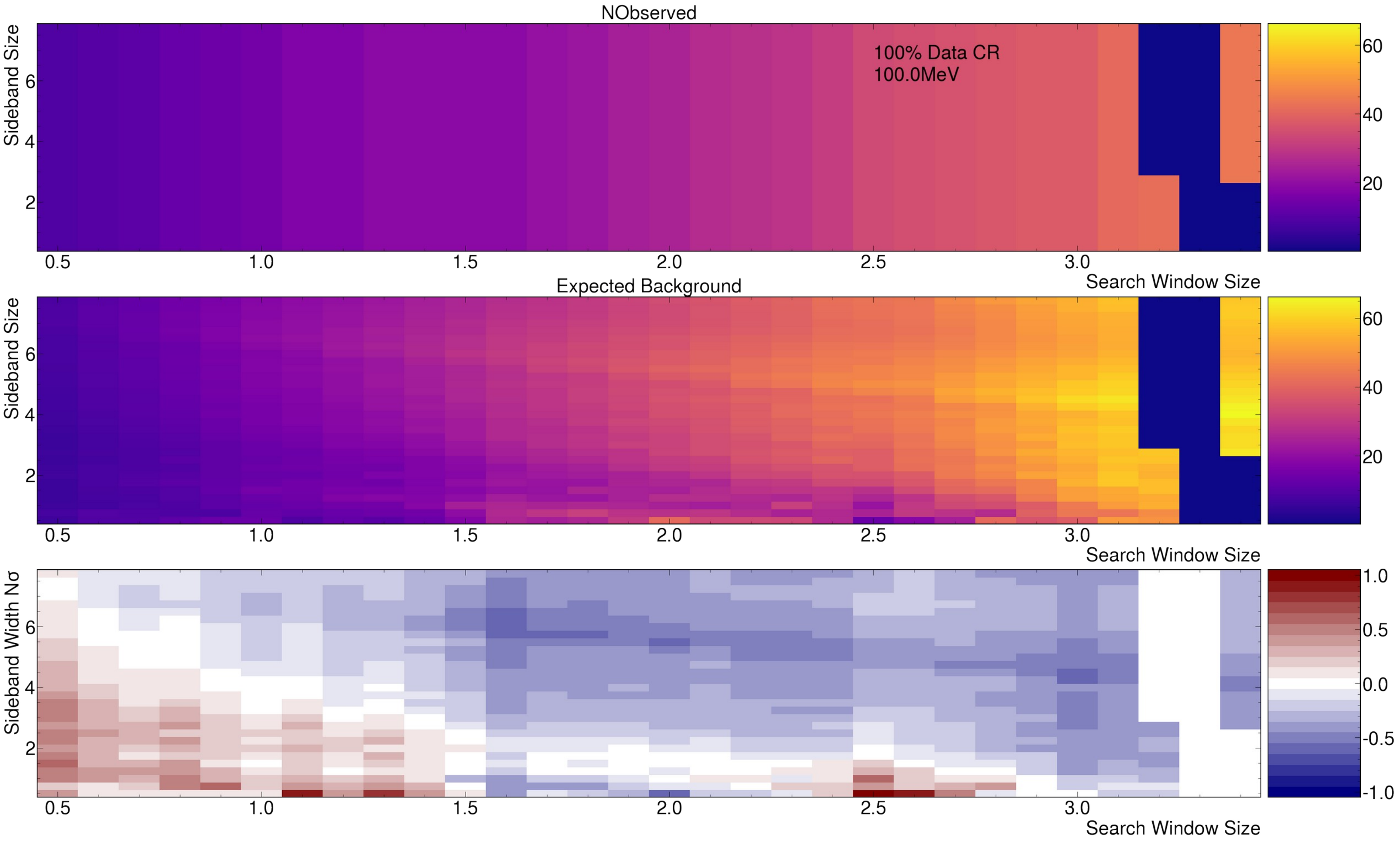

NObserved
100% Data CR
60.0MeV
Sideband Size
Search Window Size
Expected Background
Sideband Size
Search Window Size
Sideband Width Nσ
Search Window Size
0.5
1.0
1.5
2.0
2.5
3.0
10
20
30
-1.0
-0.5
0.0
0.5
1.0


NObserved
100% Data CR
70.0MeV
Sideband Size
Search Window Size
Expected Background
Sideband Size
Search Window Size
Sideband Width Nσ
Search Window Size

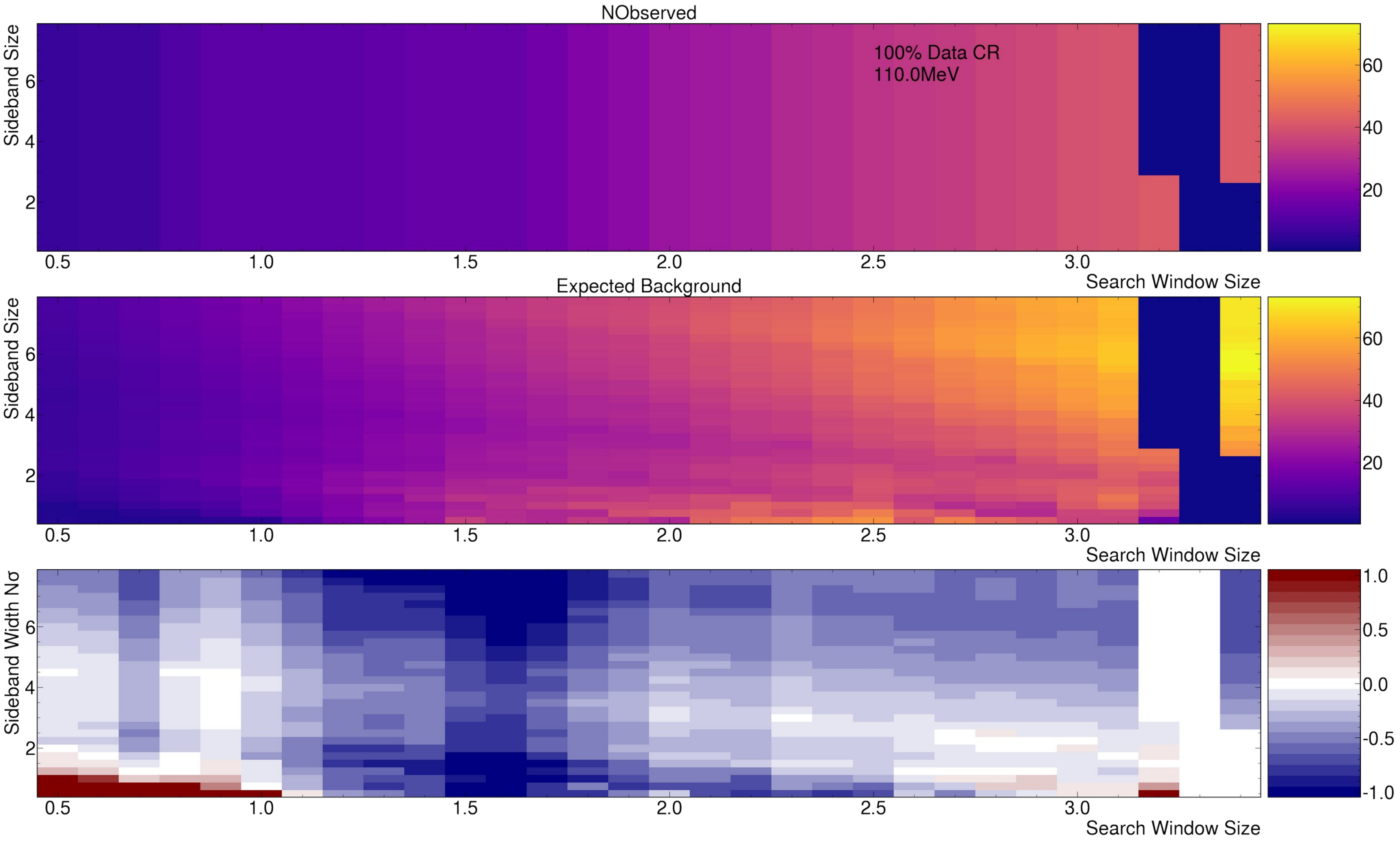


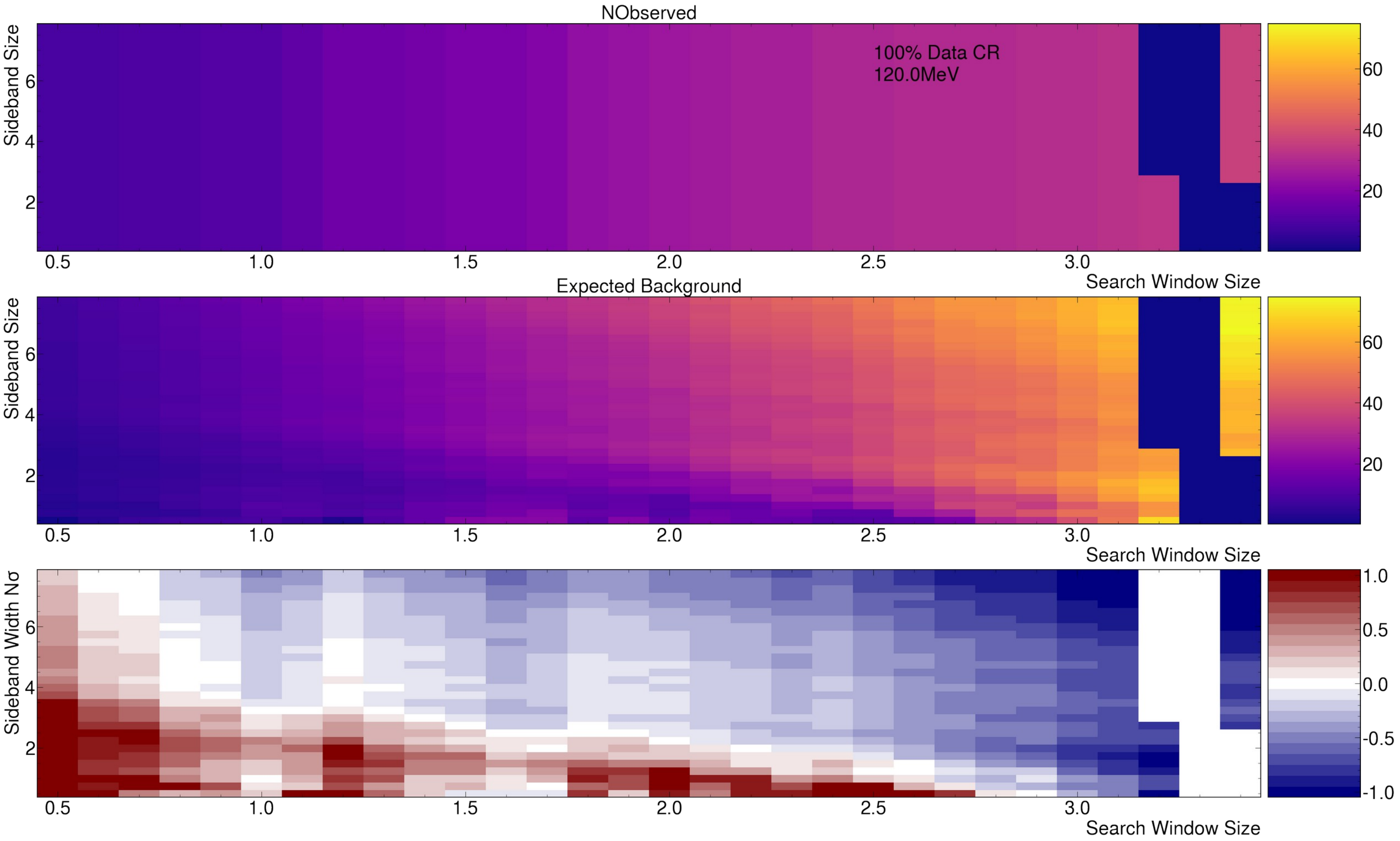
NObserved
100% Data CR
80.0MeV
Sideband Size
Search Window Size
Expected Background
Sideband Size
Search Window Size
Sideband Width Nσ
Search Window Size


NObserved
100% Data CR
90.0MeV
Sideband Size
Search Window Size
Expected Background
Sideband Size
Search Window Size
Sideband Width Nσ
Search Window Size

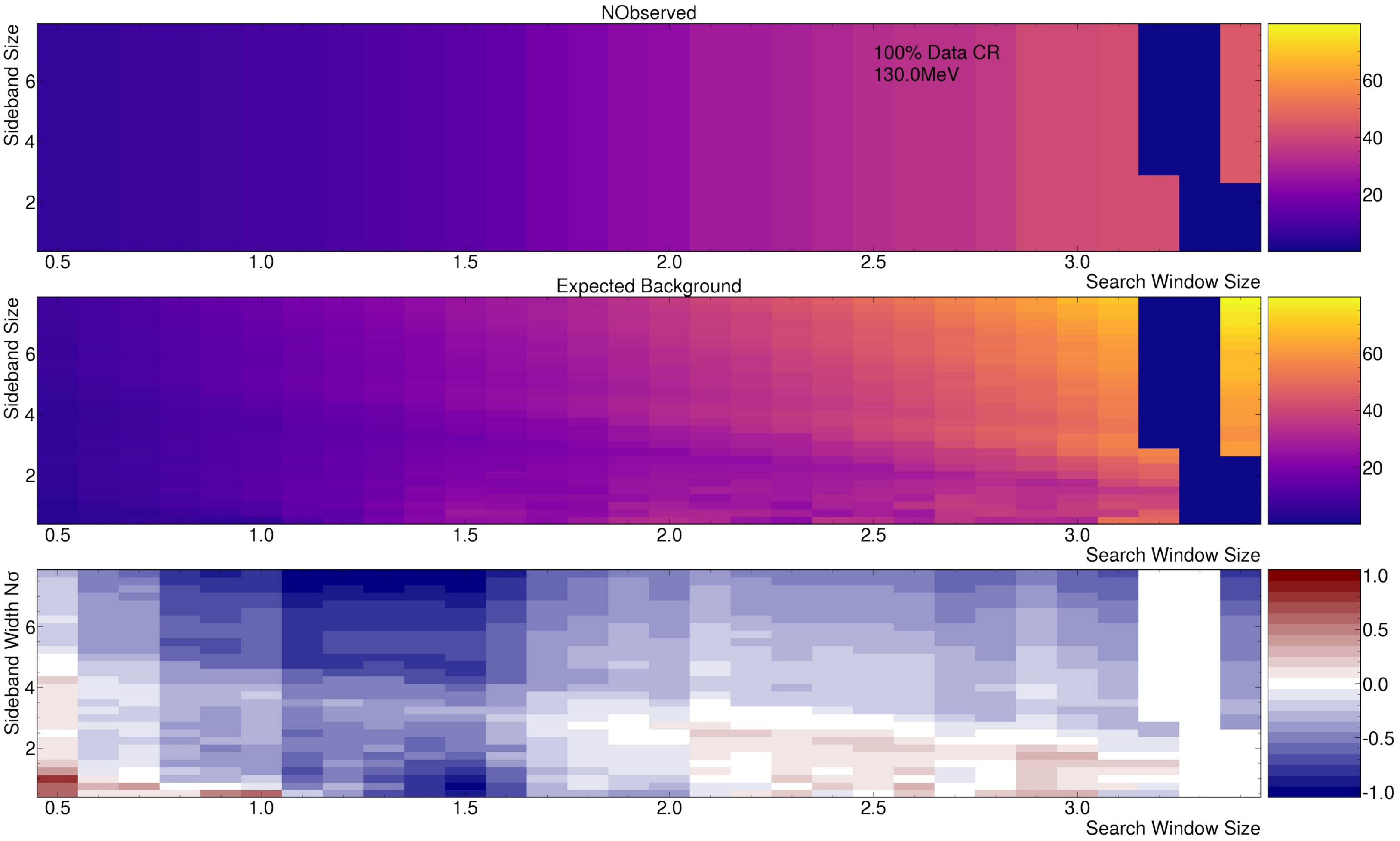


NObserved
100% Data CR
100.0MeV
Sideband Size
Search Window Size
Expected Background
Sideband Size
Search Window Size
Sideband Width Nσ
Search Window Size

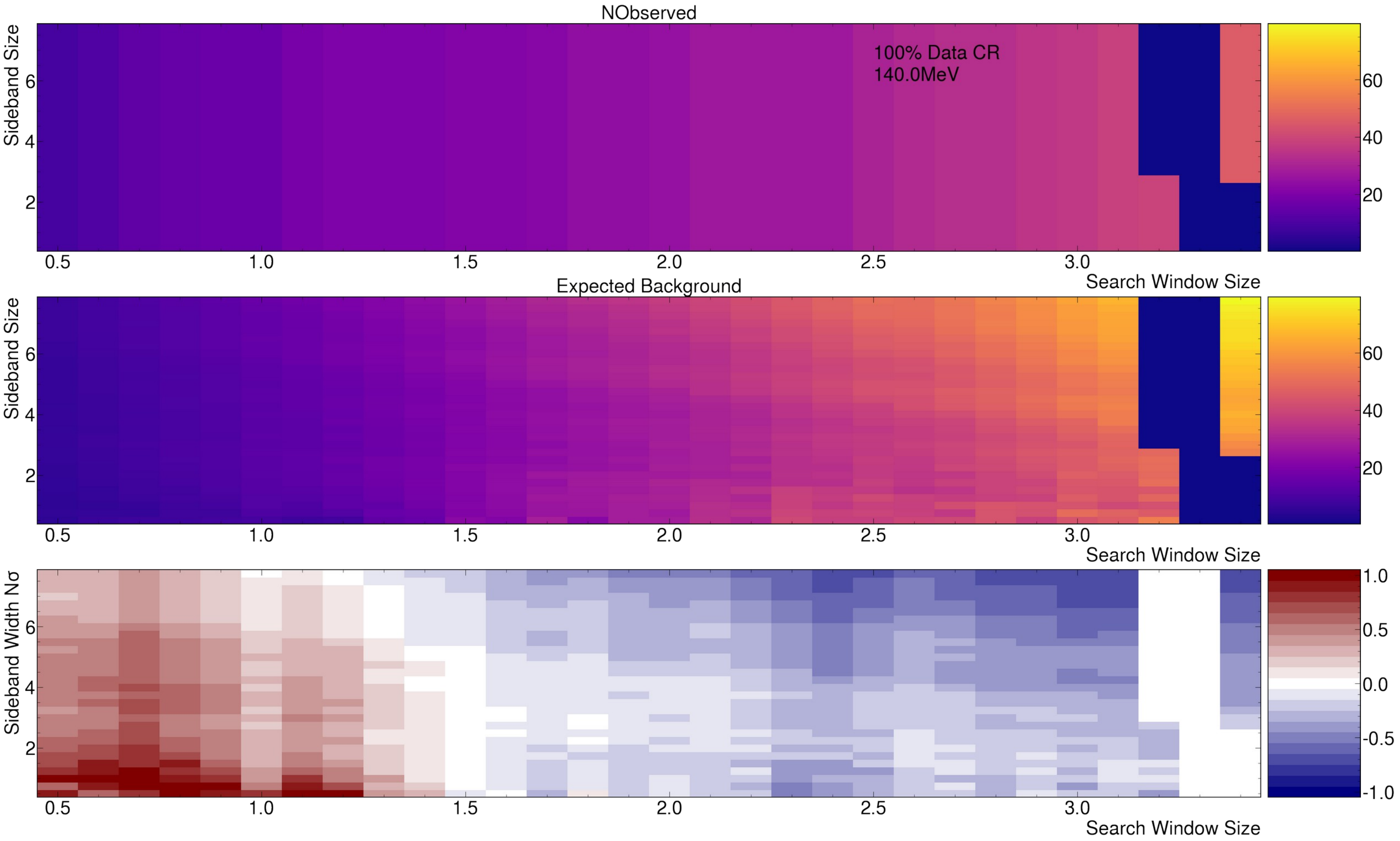

NObserved
100% Data CR
110.0MeV
Sideband Size
Search Window Size
Expected Background
Sideband Size
Search Window Size
Sideband Width Nσ
Search Window Size



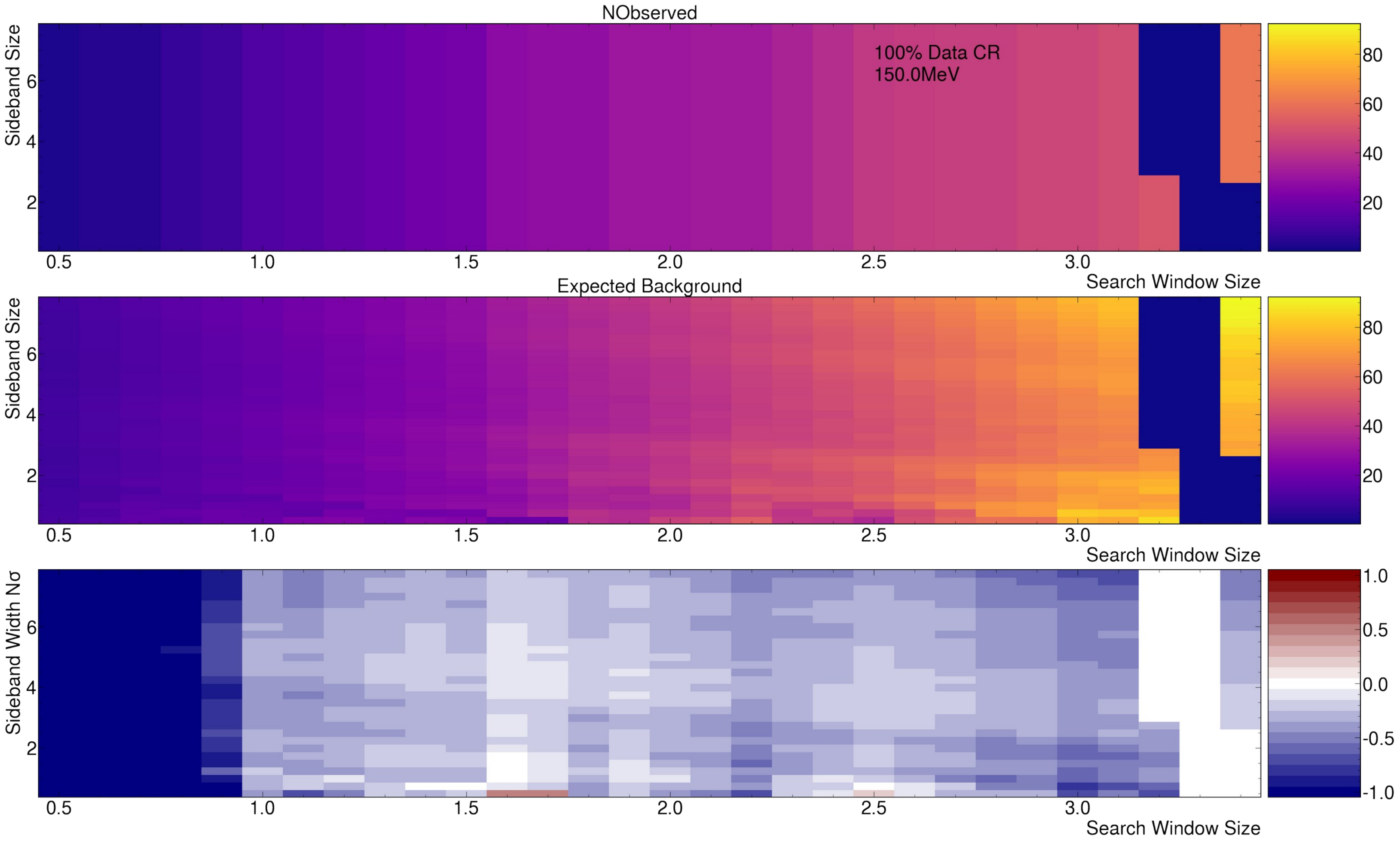
NObserved
100% Data CR
120.0MeV
Sideband Size
Search Window Size
Expected Background
Sideband Size
Search Window Size
Sideband Width Nσ
Search Window Size

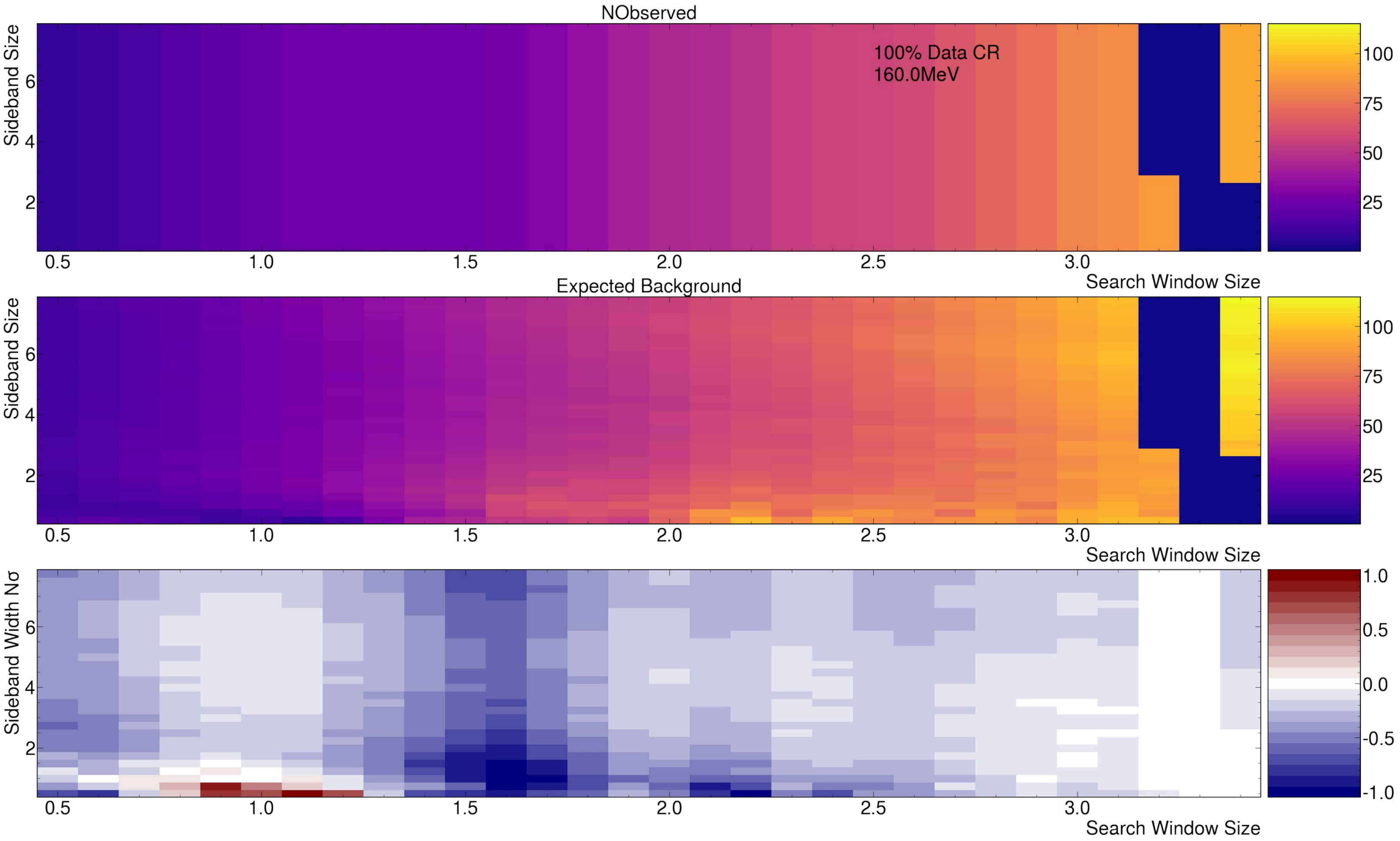


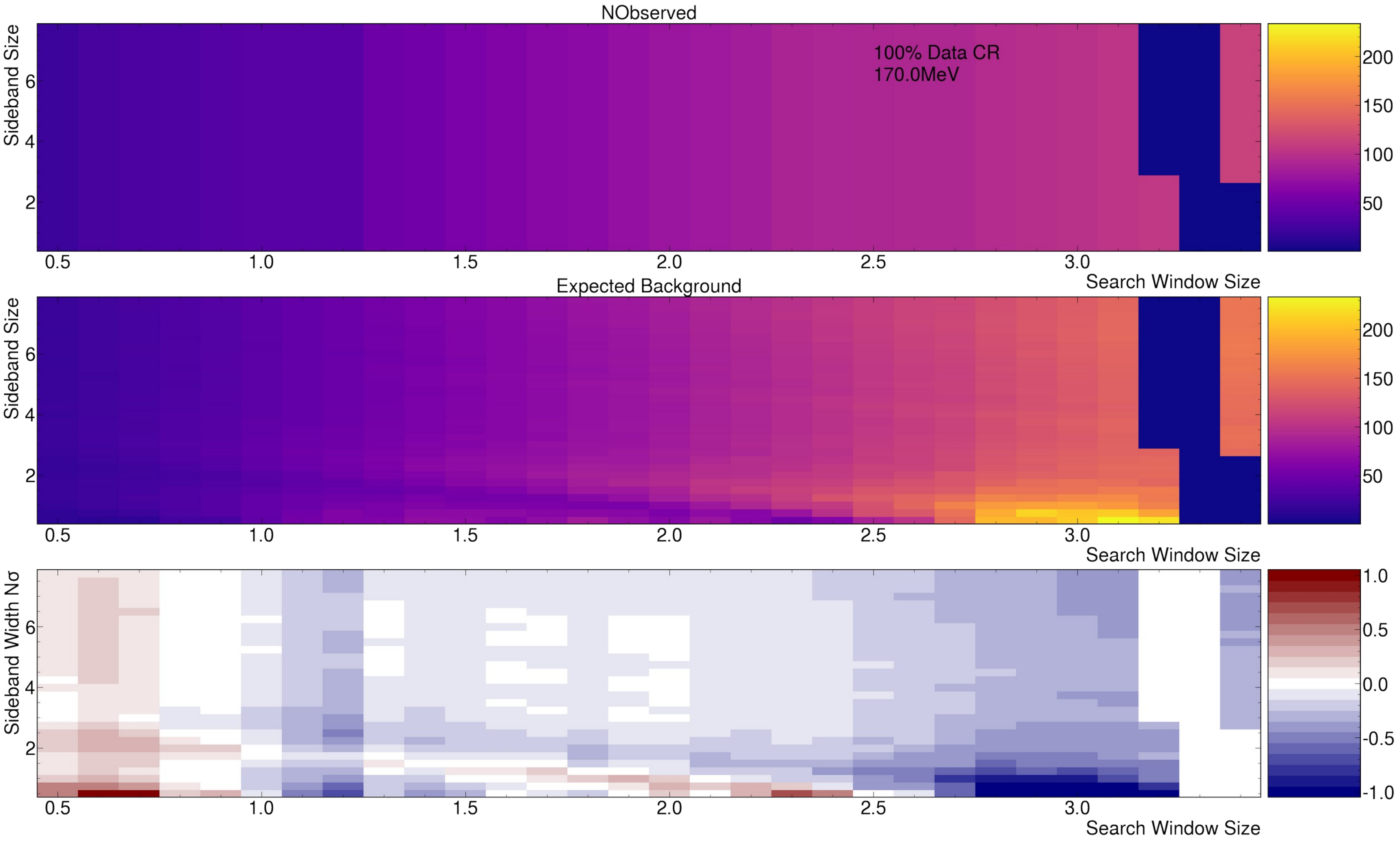
NObserved
100% Data CR
130.0MeV
Sideband Size
Search Window Size
Expected Background
Sideband Size
Search Window Size
Sideband Width Nσ
Search Window Size

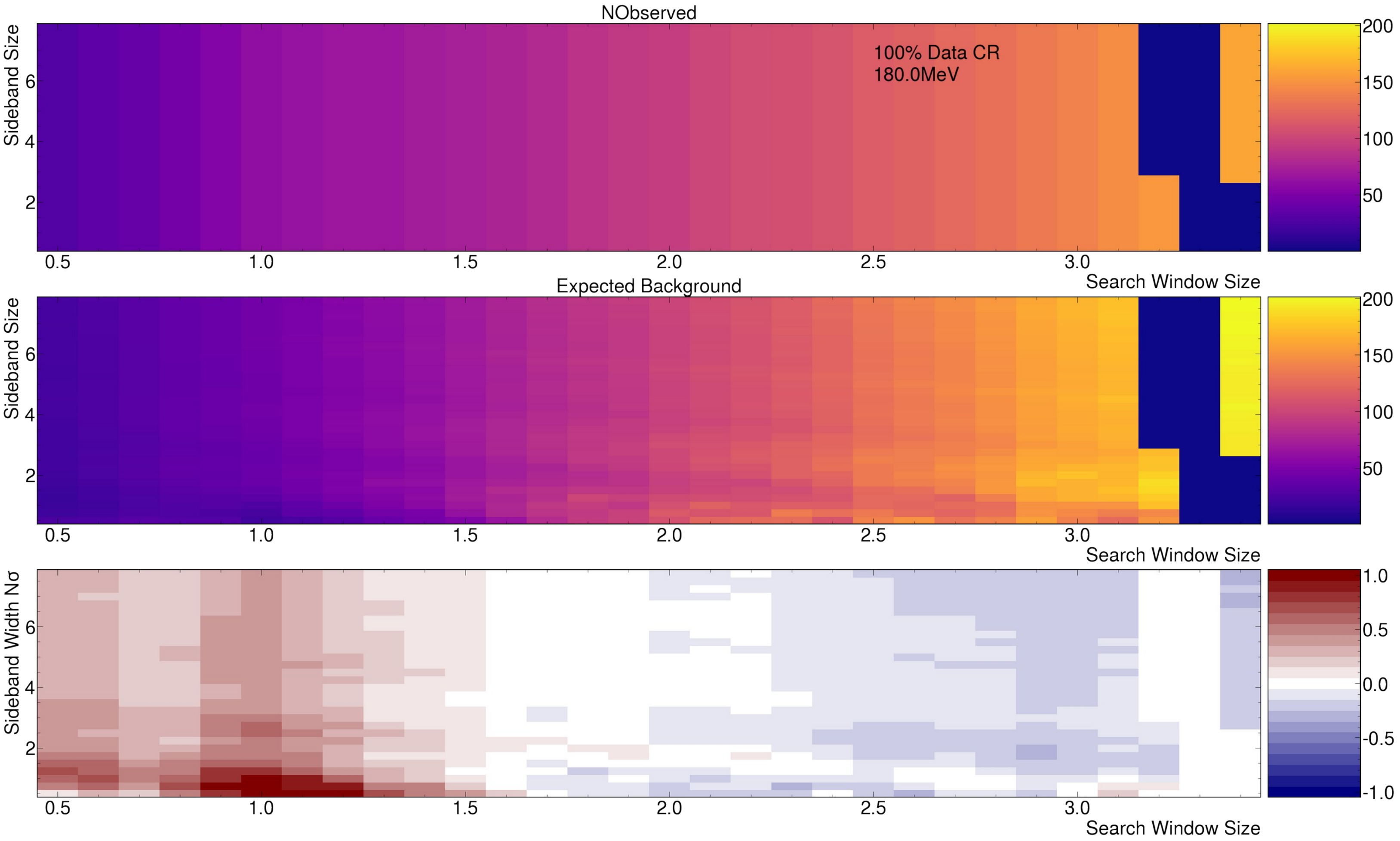


NObserved
100% Data CR
140.0MeV
Sideband Size
Search Window Size
Expected Background
Sideband Width Nσ

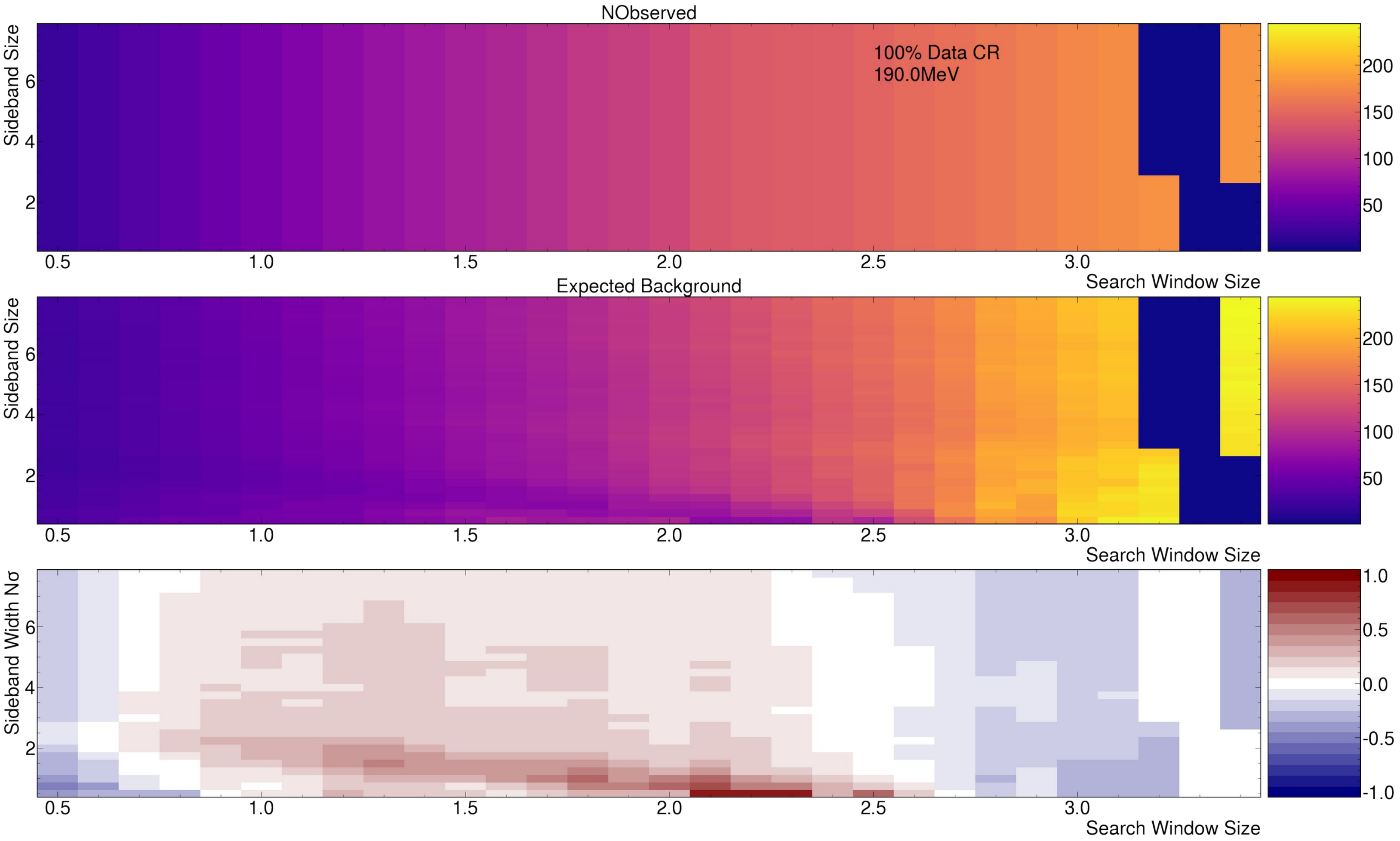

NObserved
100% Data CR
150.0MeV
Sideband Size
Search Window Size
Expected Background
Sideband Size
Search Window Size
Sideband Width Nσ
Search Window Size
0.5
1.0
1.5
2.0
2.5
3.0
2
4
6
20
40
60
80
1.0
0.5
0.0
-0.5
-1.0


NObserved
100% Data CR
160.0MeV
Sideband Size
Search Window Size
Expected Background
Sideband Size
Search Window Size
Sideband Width Nσ
Search Window Size


NObserved
100% Data CR
170.0MeV
Sideband Size
Search Window Size
Expected Background
Sideband Size
Search Window Size
Sideband Width Nσ
Search Window Size



NObserved
100% Data CR
180.0MeV
Sideband Size
Search Window Size
Expected Background
Sideband Size
Search Window Size
Sideband Width Nσ
Search Window Size
0.5
1.0
1.5
2.0
2.5
3.0
200
150
100
50
1.0
0.5
0.0
-0.5
-1.0



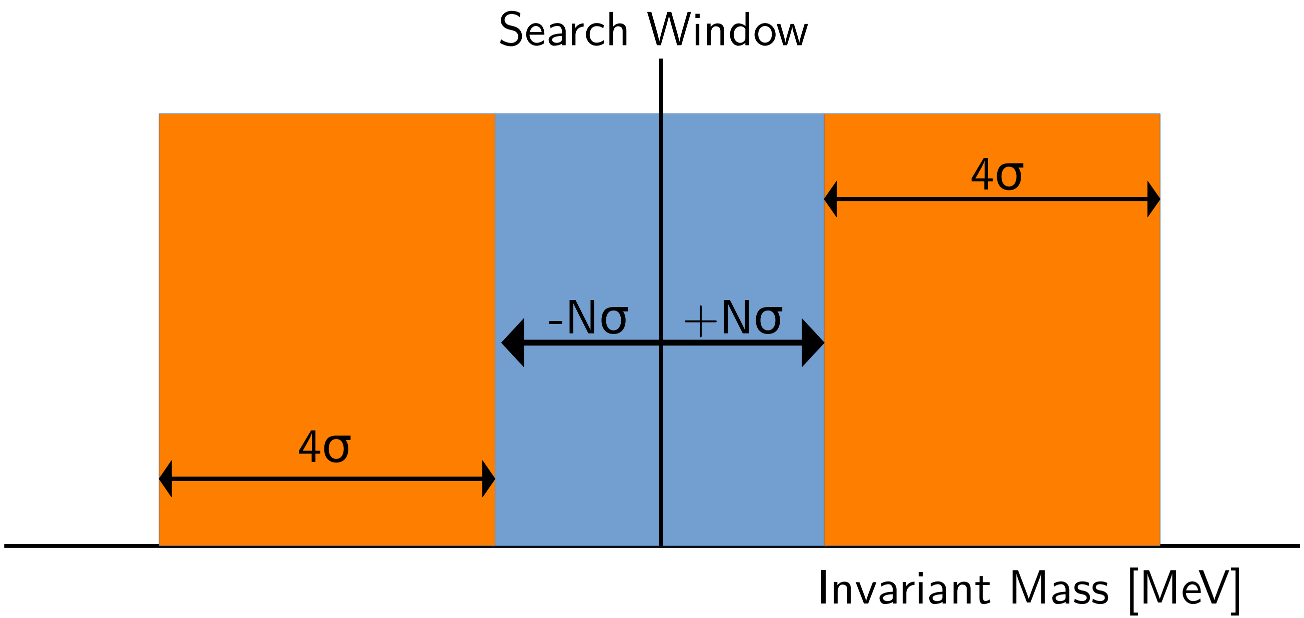
NObserved
100% Data CR
190.0MeV
Sideband Size
Search Window Size
Expected Background
Sideband Size
Search Window Size
Sideband Width Nσ
Search Window Size
0.5
1.0
1.5
2.0
2.5
3.0
50
100
150
200
1.0
0.5
0.0
-0.5
-1.0

END

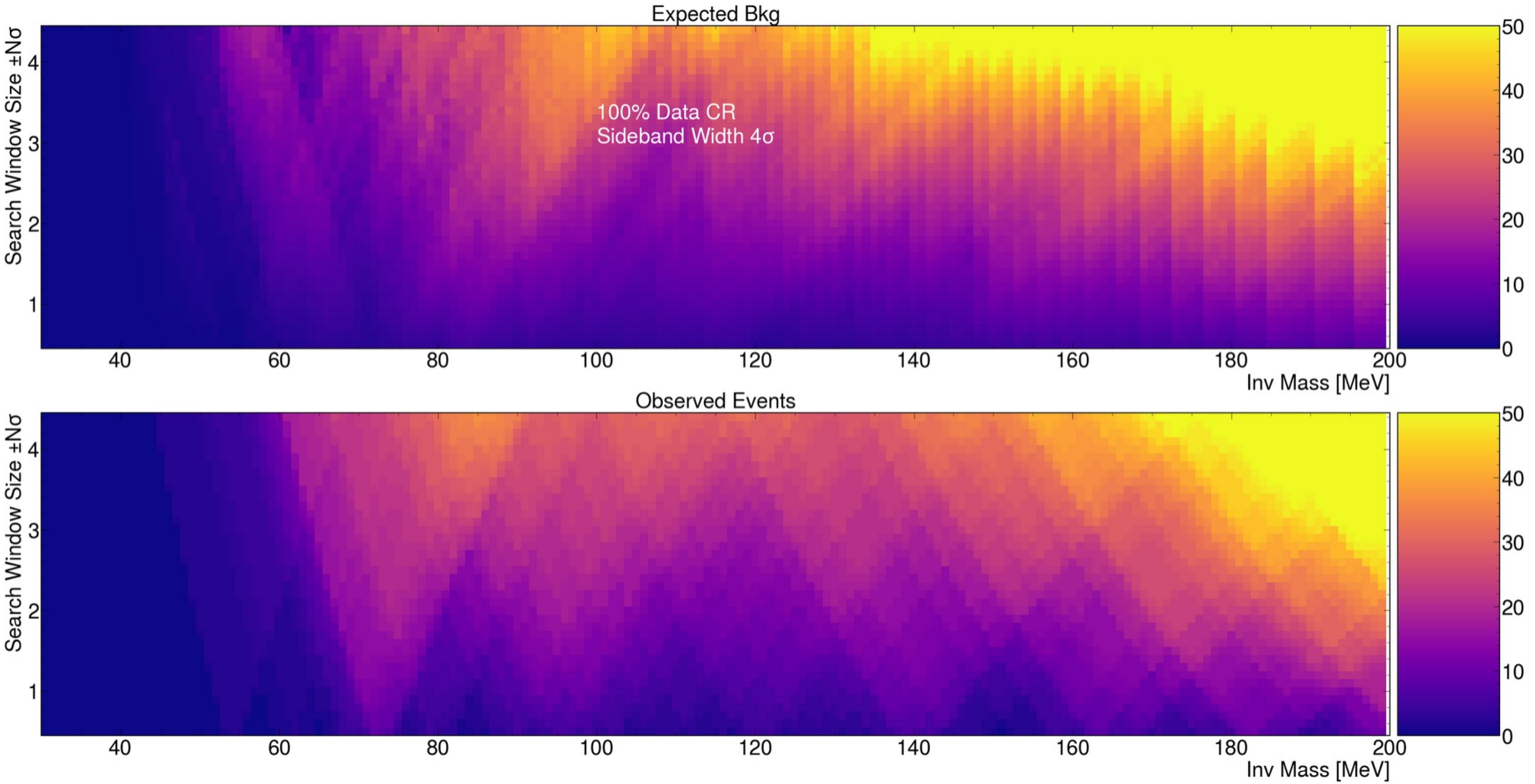
100% CR Data Plots

Sideband Size = 4σ

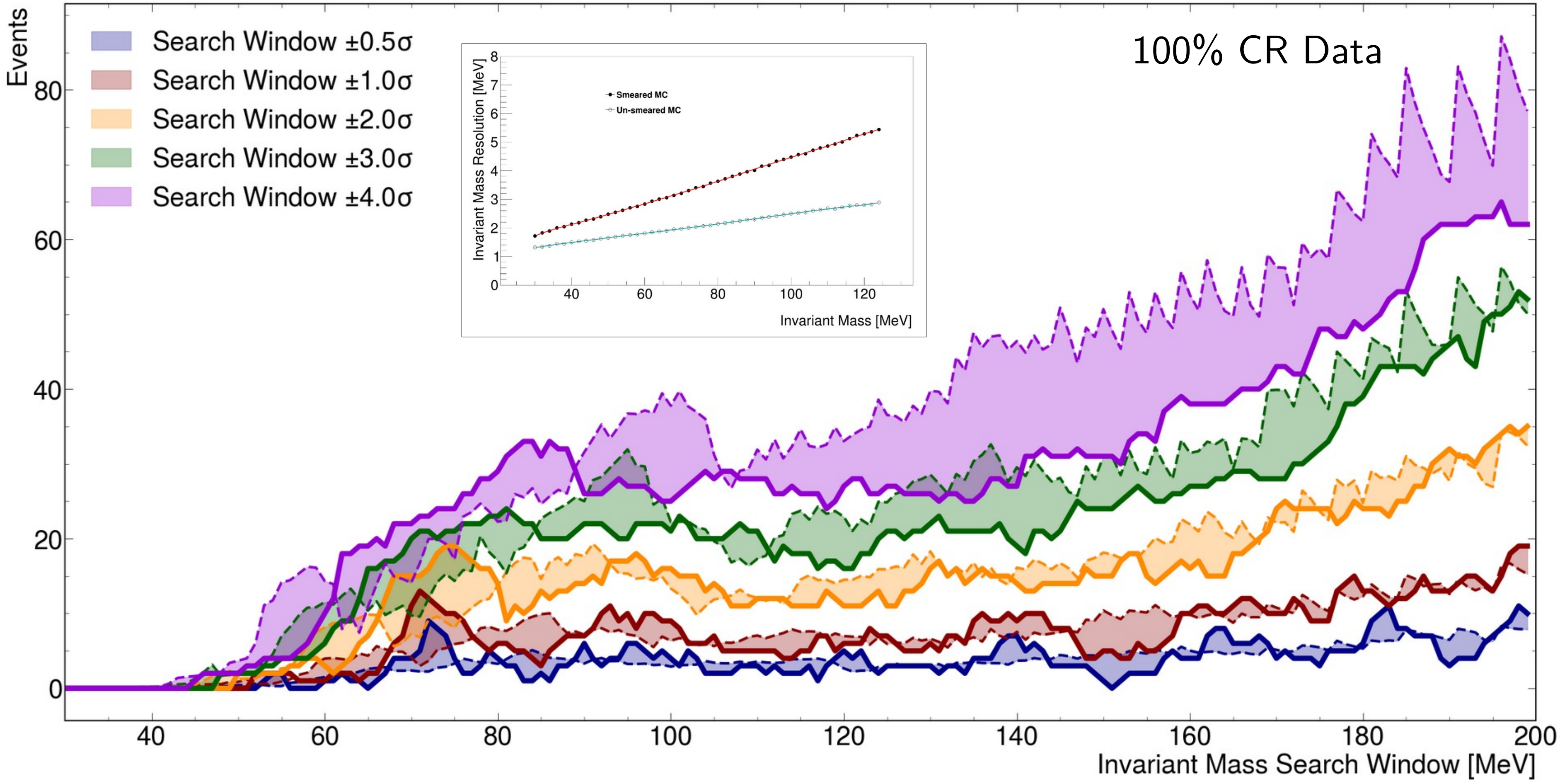
Scan Signal Window



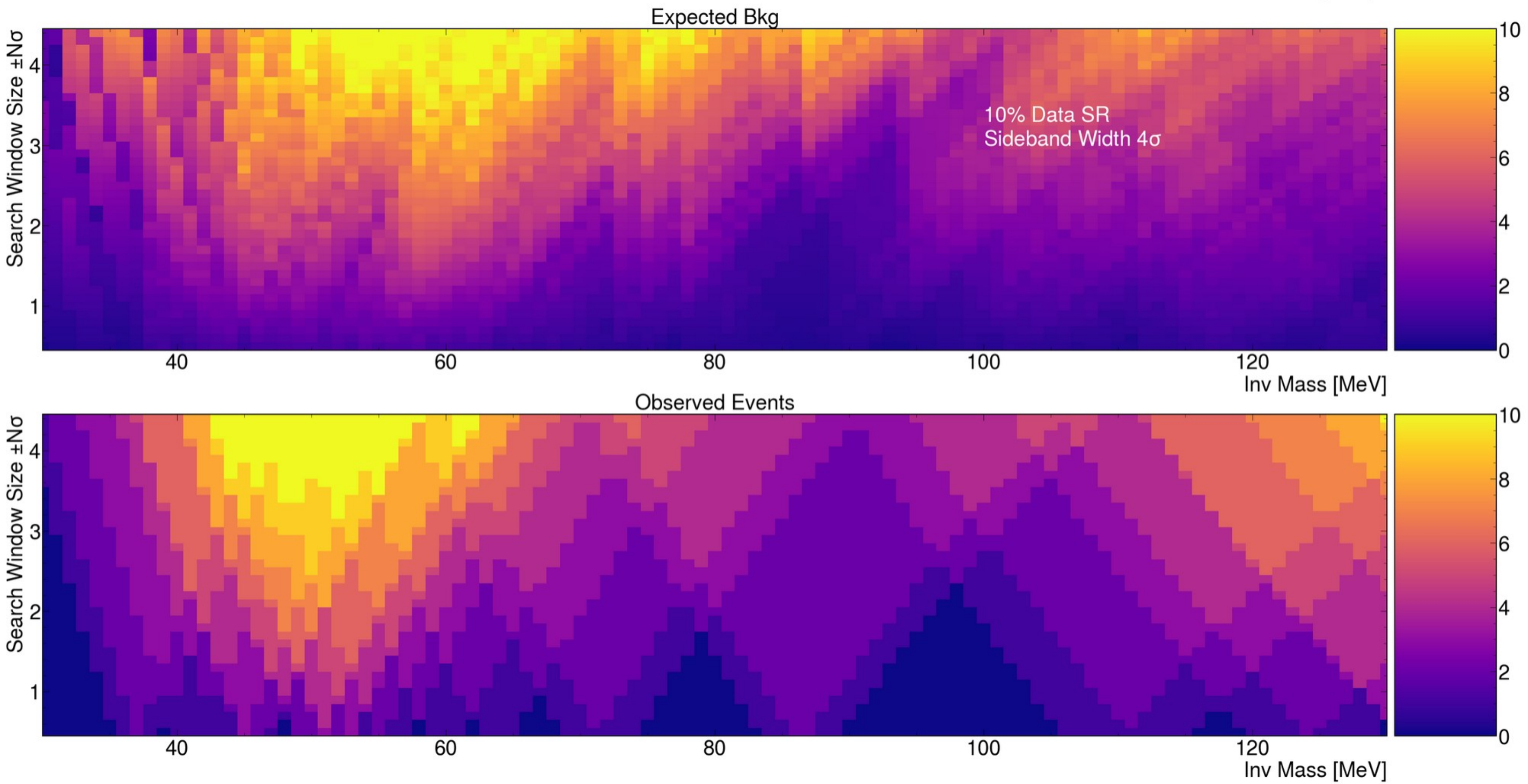
Scan Signal Window – 100% CR Data



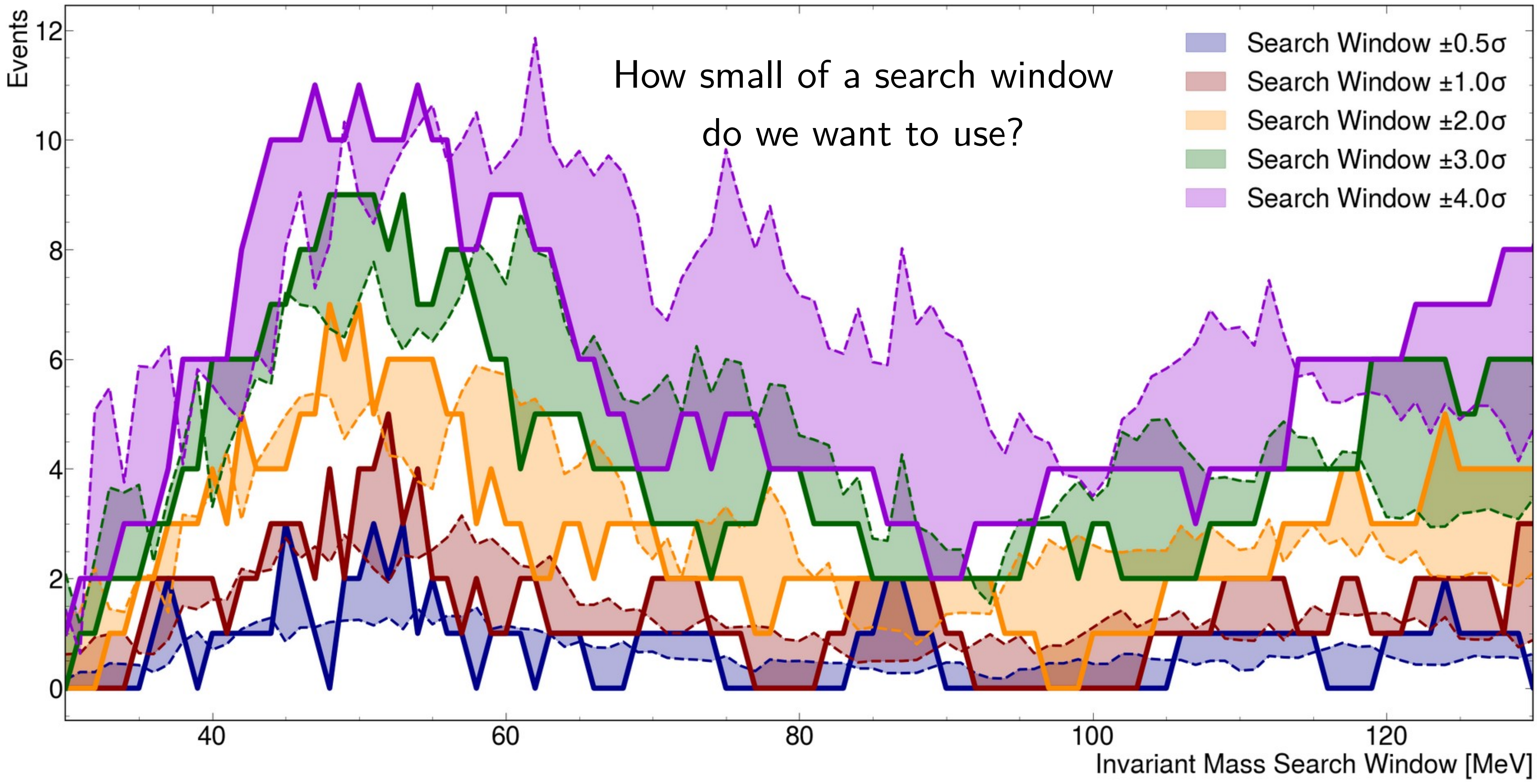
Scan Signal Window – 100% CR Data



Scan Signal Window – 10% Data



Scan Signal Window – 10% Data

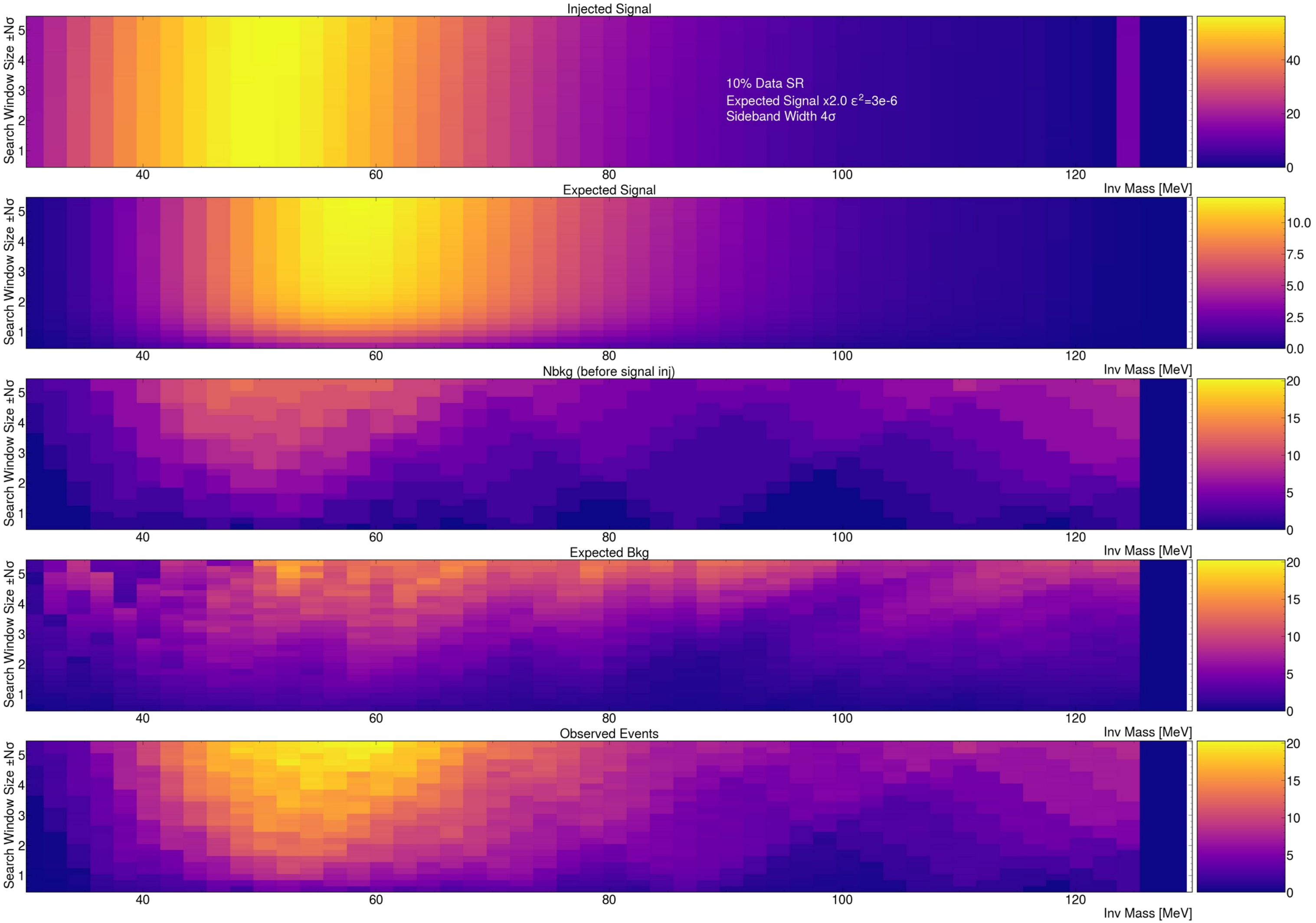


Inject MC Signal into 10% Data

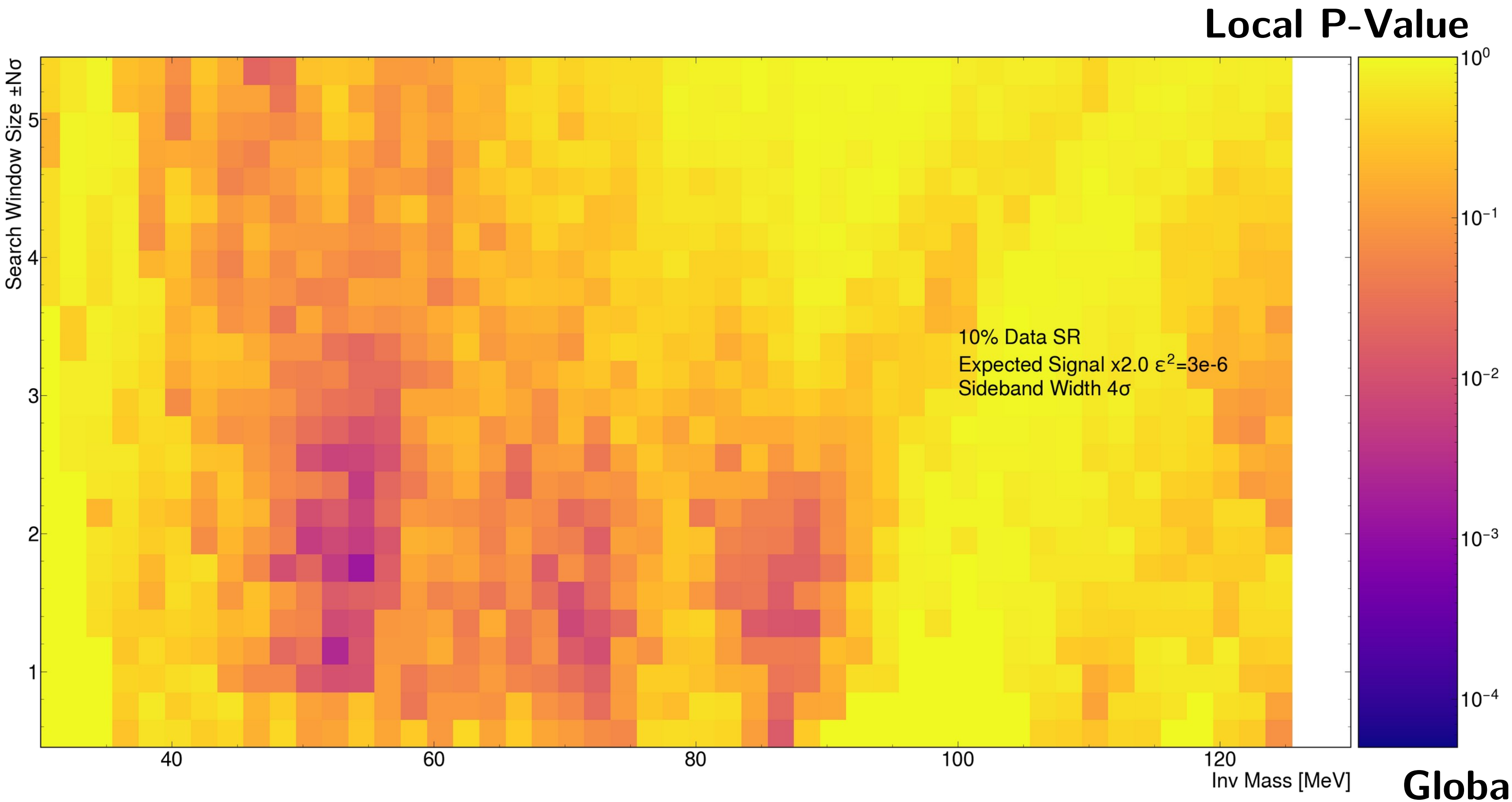
Scan Search Window Size

Measure P-Value

MC Injected Signal – 10% Data

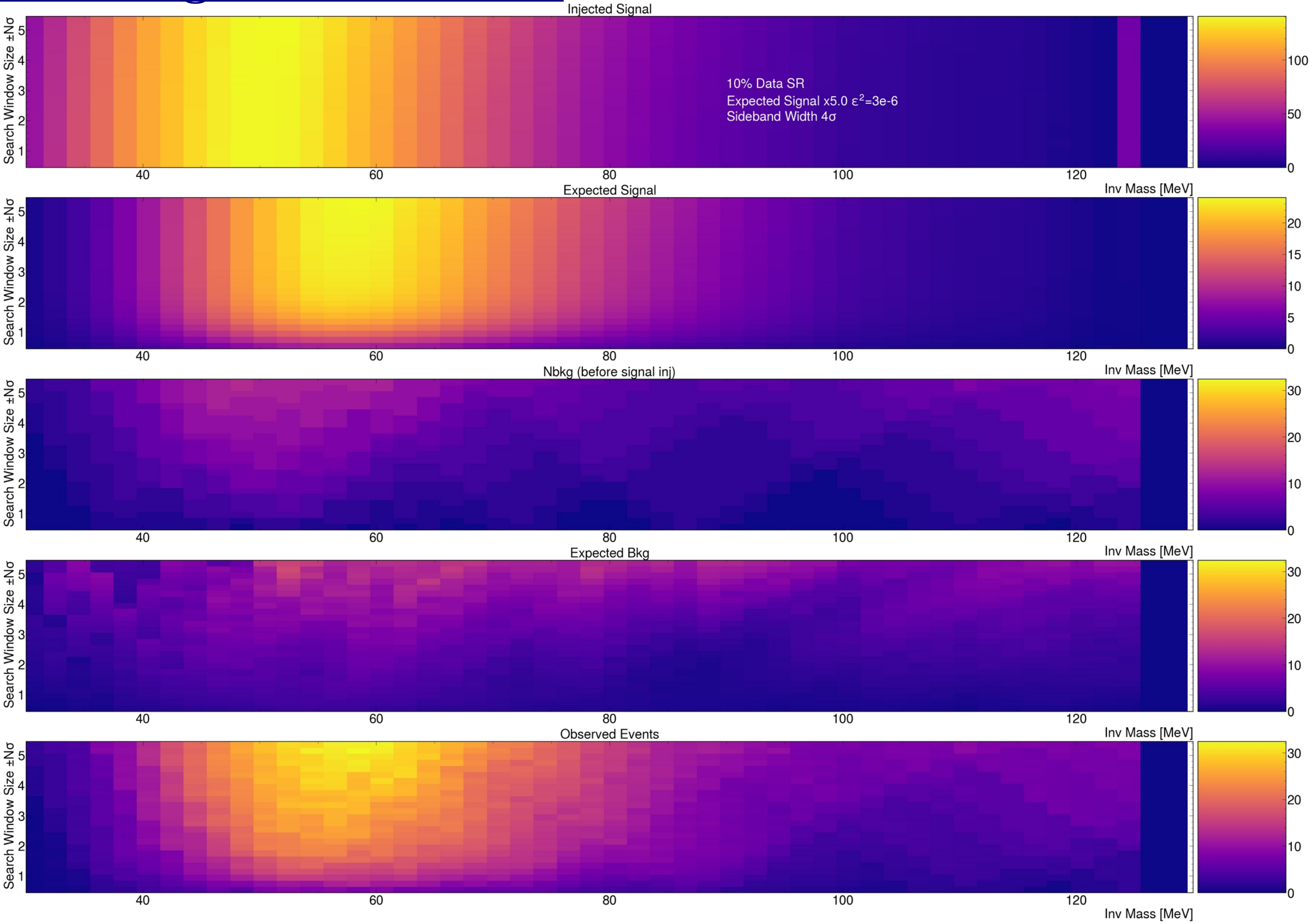


MC Injected Signal – 10% Data



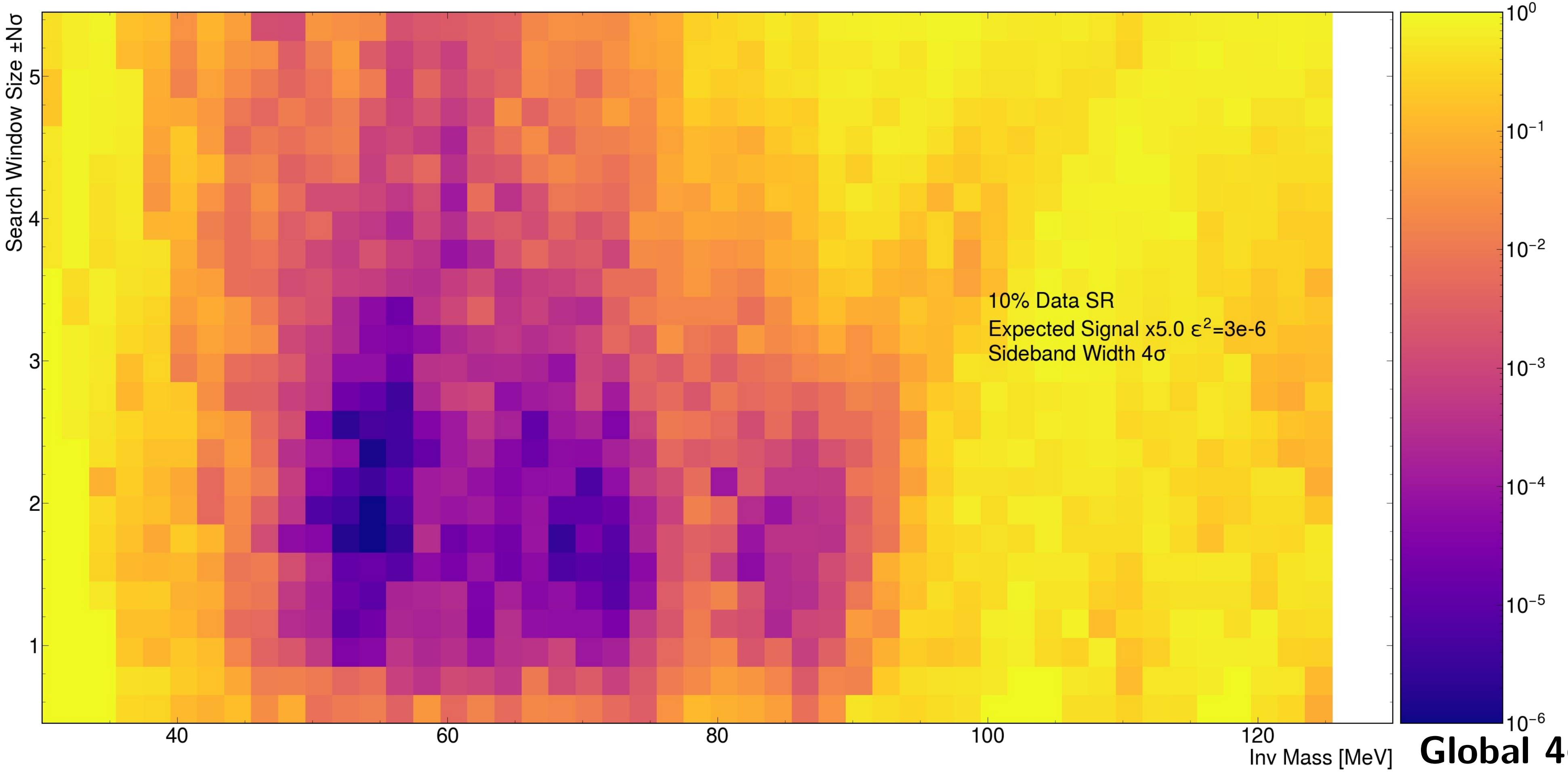
Global 3σ

MC Injected Signal – 10% Data



MC Injected Signal – 10% Data

Local P-Value

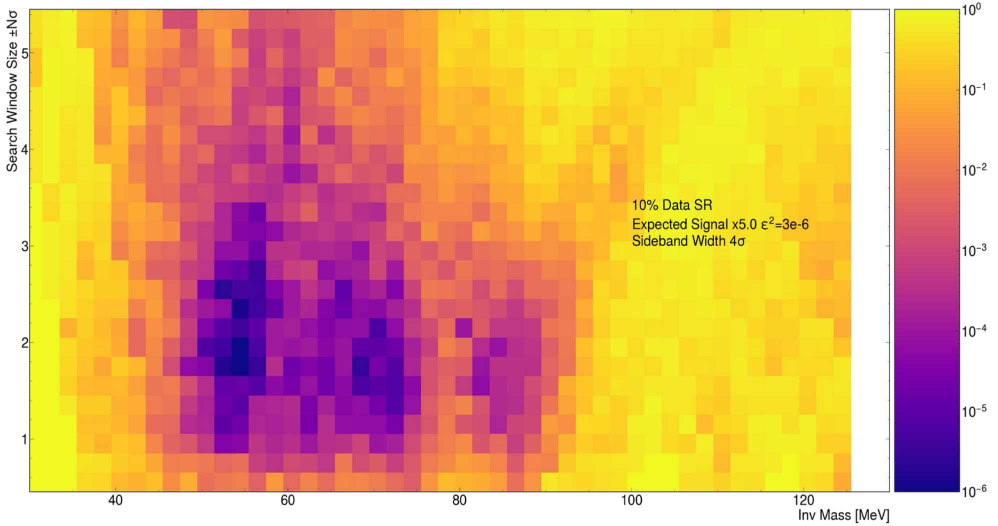


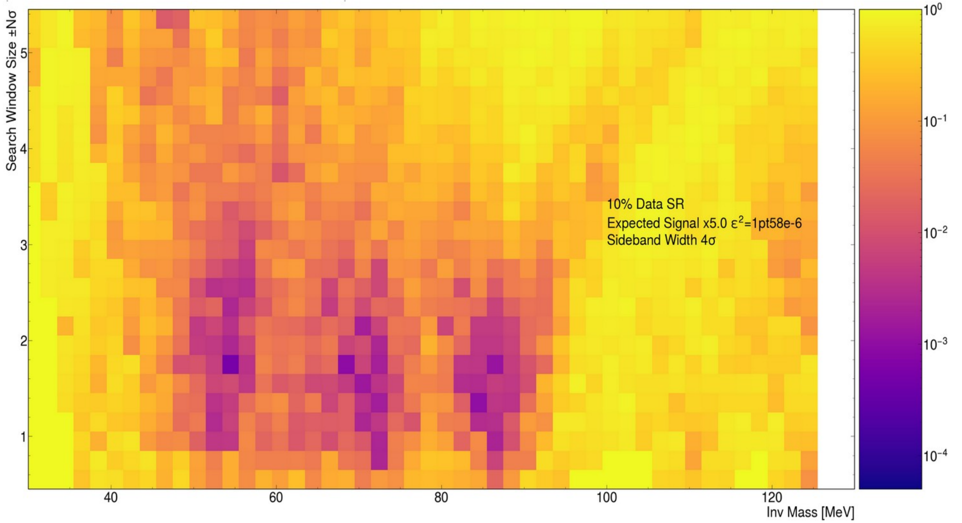
Global 4σ

MC Injected Signal – 10% Data

- Search window range 1.5-2.5σ results in similar sensitivity
- Confirmed for different values of ε^2

- We've also confirmed that the background estimates for this search window range are roughly equivalent, if the sidebands are 2-6σ wide…

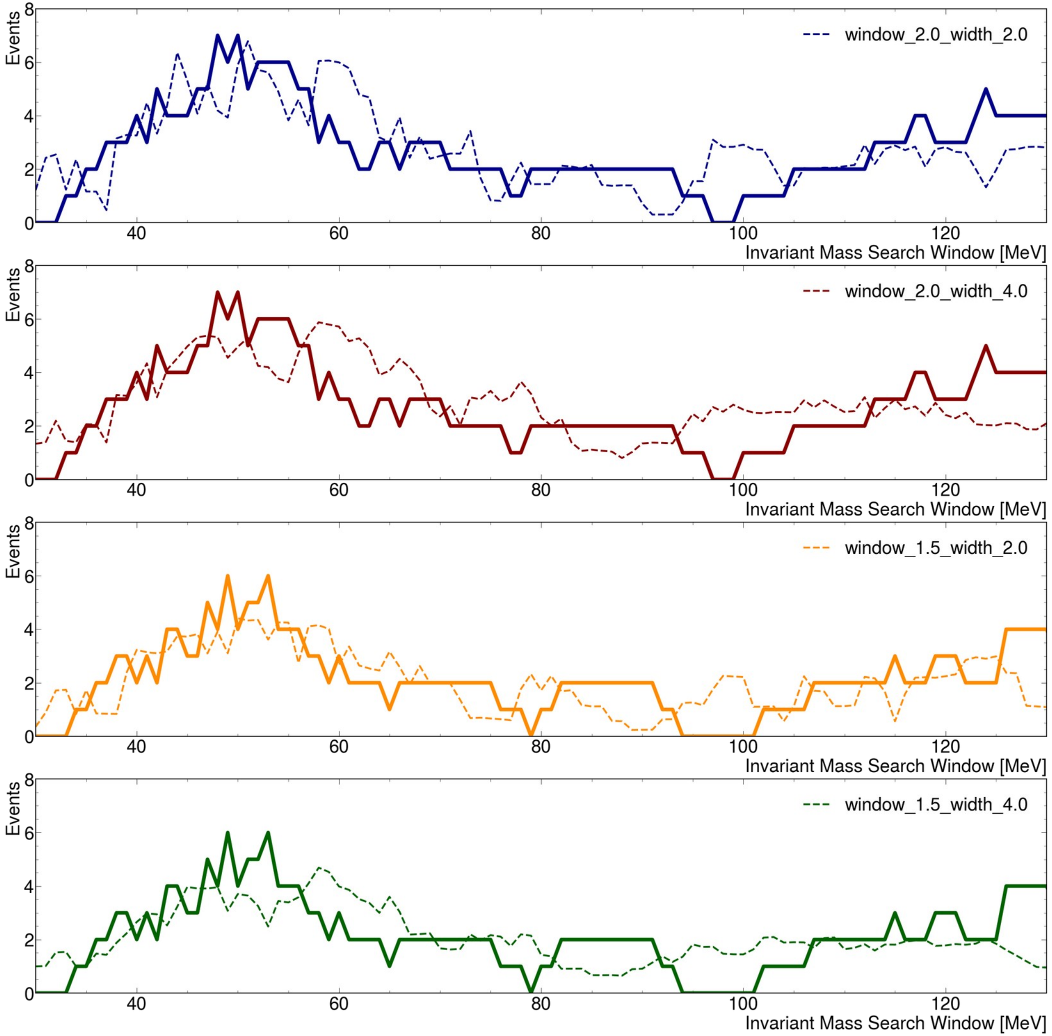




Background Estimate – 10% Data

- The background estimates for search window sizes 1.5-2.0σ, with sideband sizes 2.0-4.0σ all seem pretty reasonable…

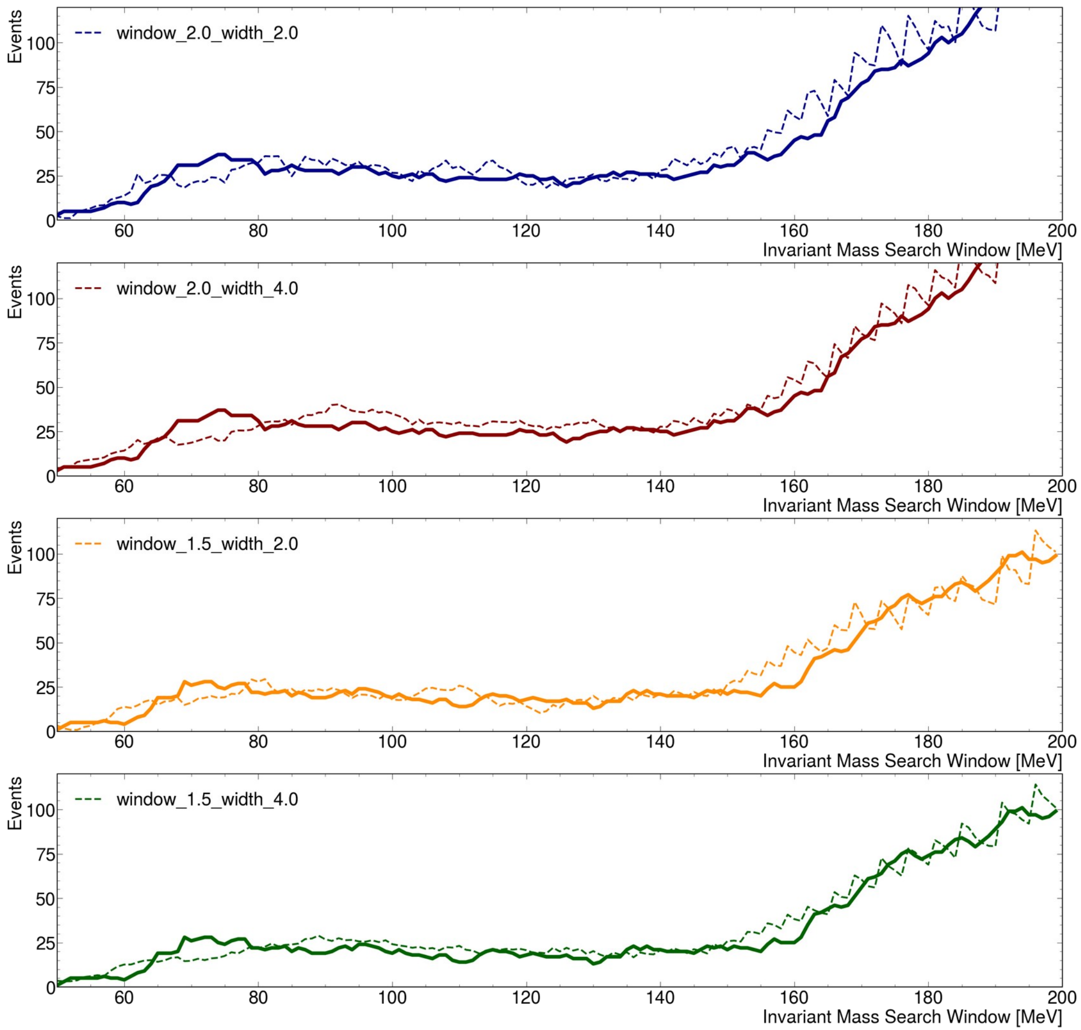
- How to choose?
- The final result seems fairly insensitive over a broad range of signal search window and mass sideband sizes



Background Estimate – 100% CR Data

- The background estimates for search window sizes 1.5-2.0σ, with sideband sizes 2.0-4.0σ all seem pretty reasonable…

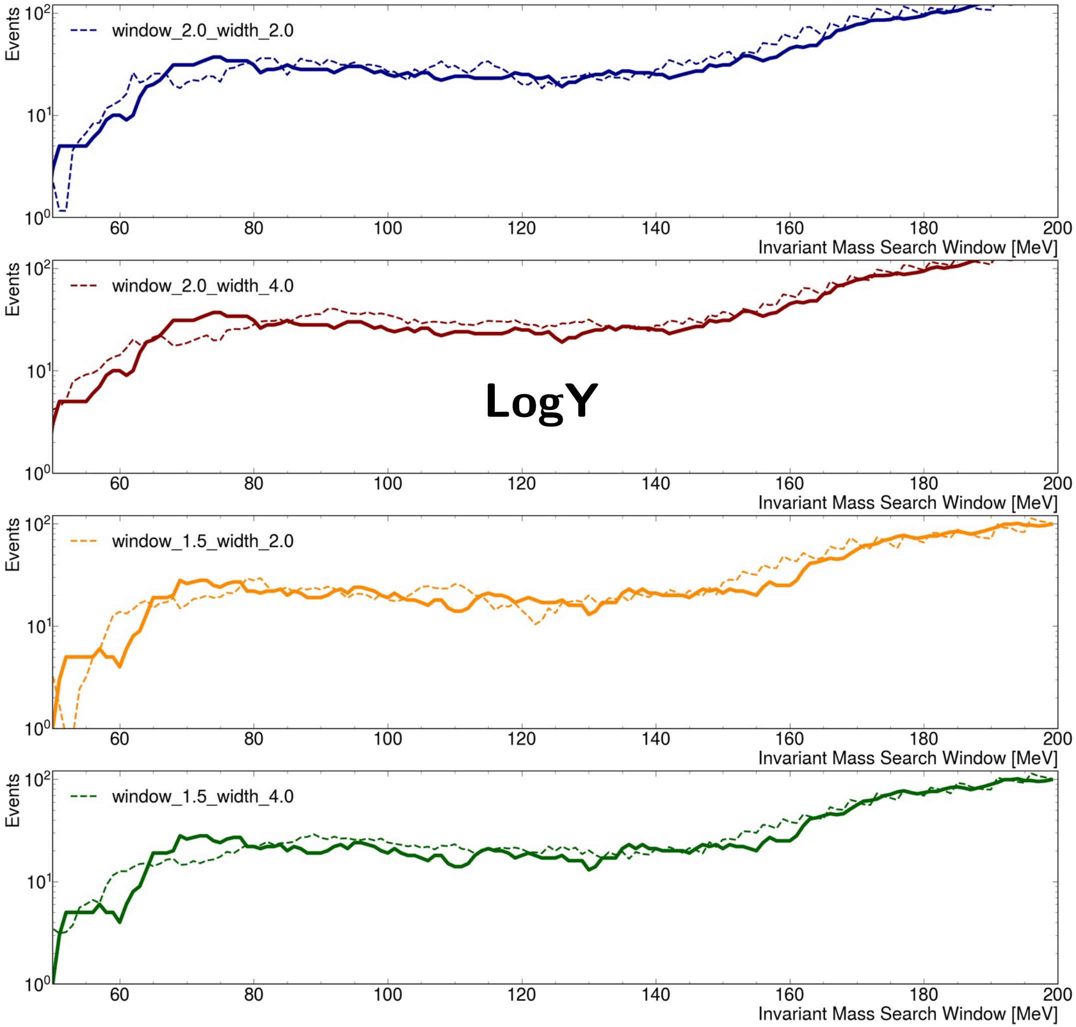
- How to choose?
- The final result seems fairly insensitive over a broad range of signal search window and mass sideband sizes



Background Estimate – 100% CR Data

- The background estimates for search window sizes 1.5-2.0σ, with sideband sizes 2.0-4.0σ all seem pretty reasonable…

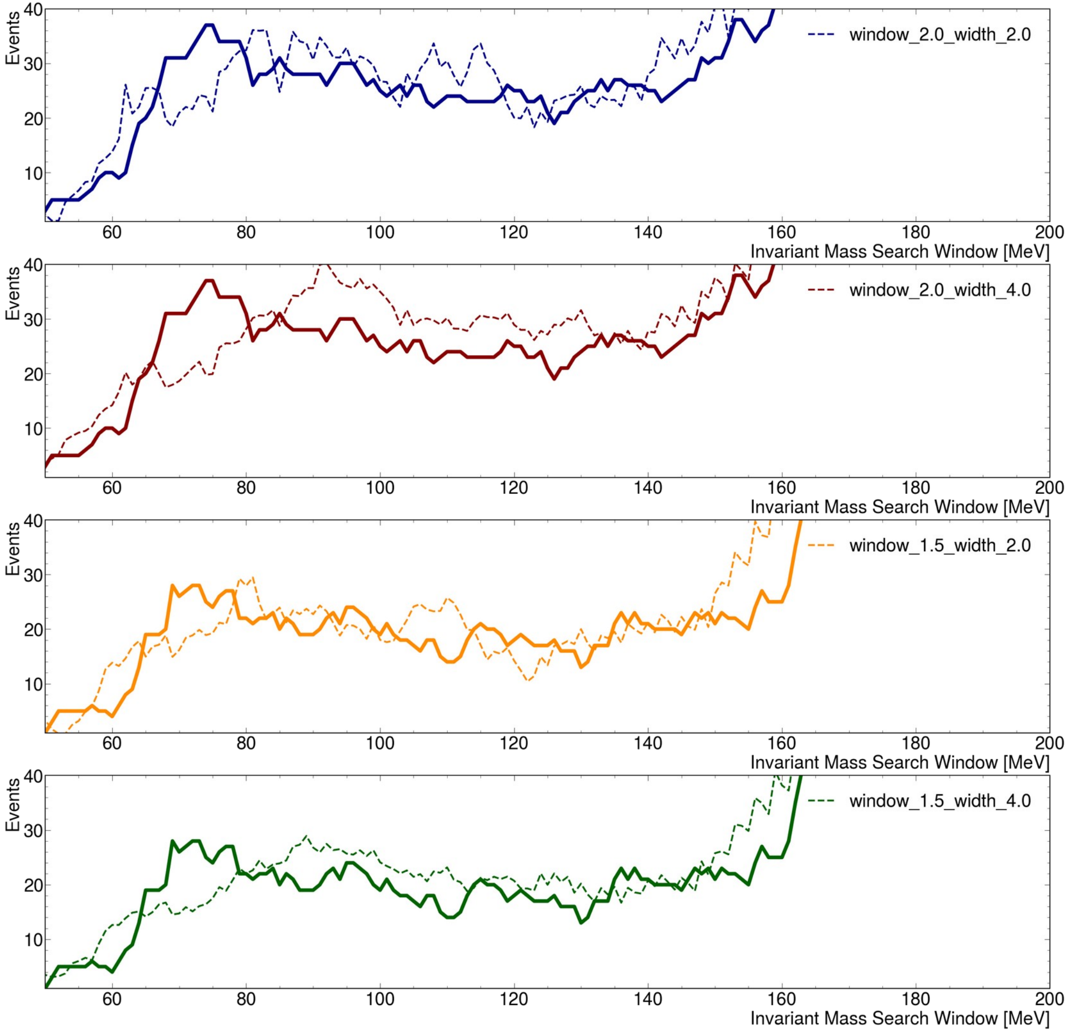
- How to choose?
- The final result seems fairly insensitive over a broad range of signal search window and mass sideband sizes

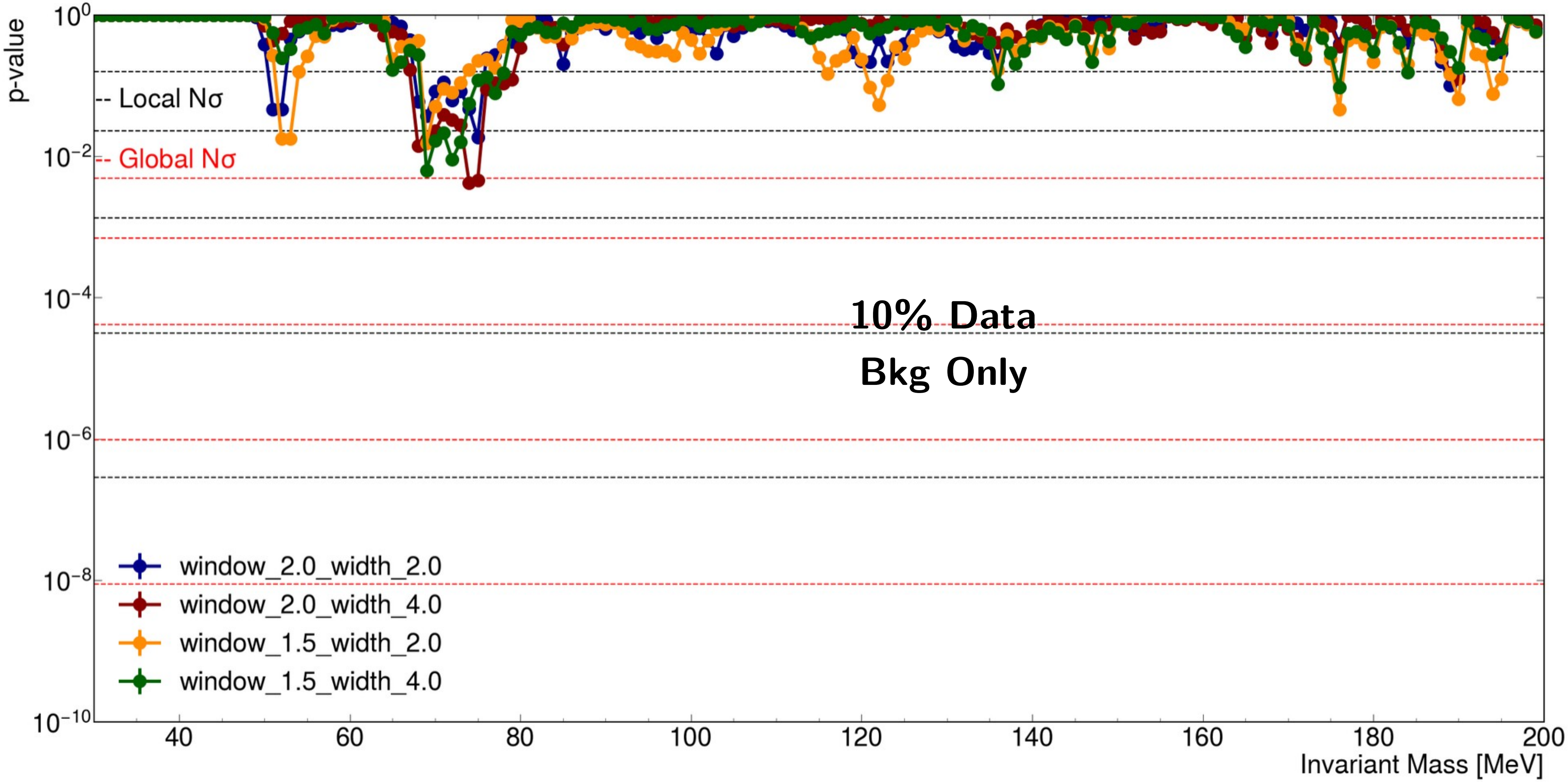


Background Estimate – 100% CR Data

- The background estimates for search window sizes 1.5-2.0σ, with sideband sizes 2.0-4.0σ all seem pretty reasonable…

- How to choose?
- The final result seems fairly insensitive over a broad range of signal search window and mass sideband sizes





p-value
-- Local Nσ
-- Global Nσ
10% Data
Bkg Only
window_2.0_width_2.0
window_2.0_width_4.0
window_1.5_width_2.0
window_1.5_width_4.0
Invariant Mass [MeV]