3LAC COUNTERPARTS TO ICECUBE NEUTRINOS ABOVE 100 TEV

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INSTITUUT

Motivation

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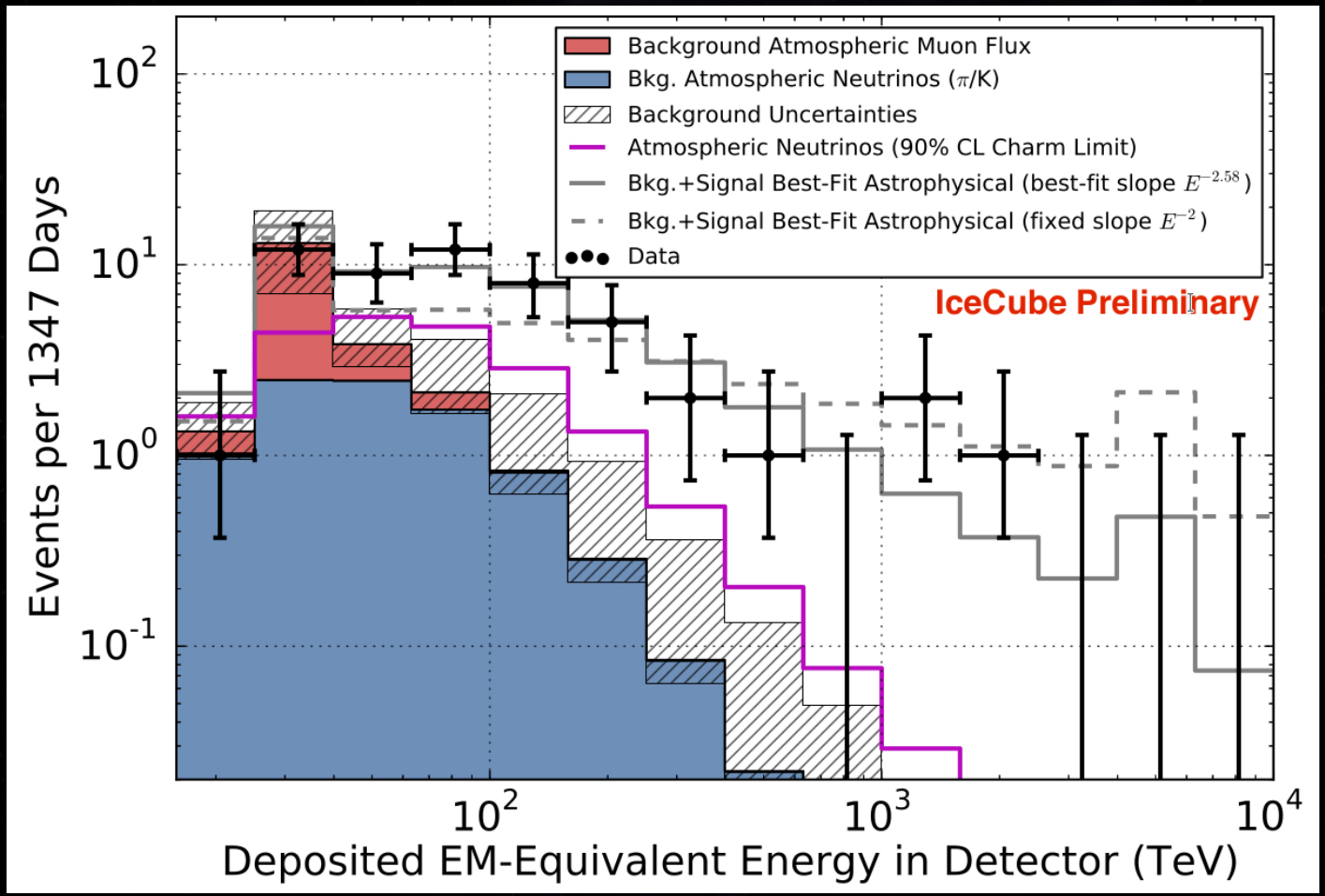
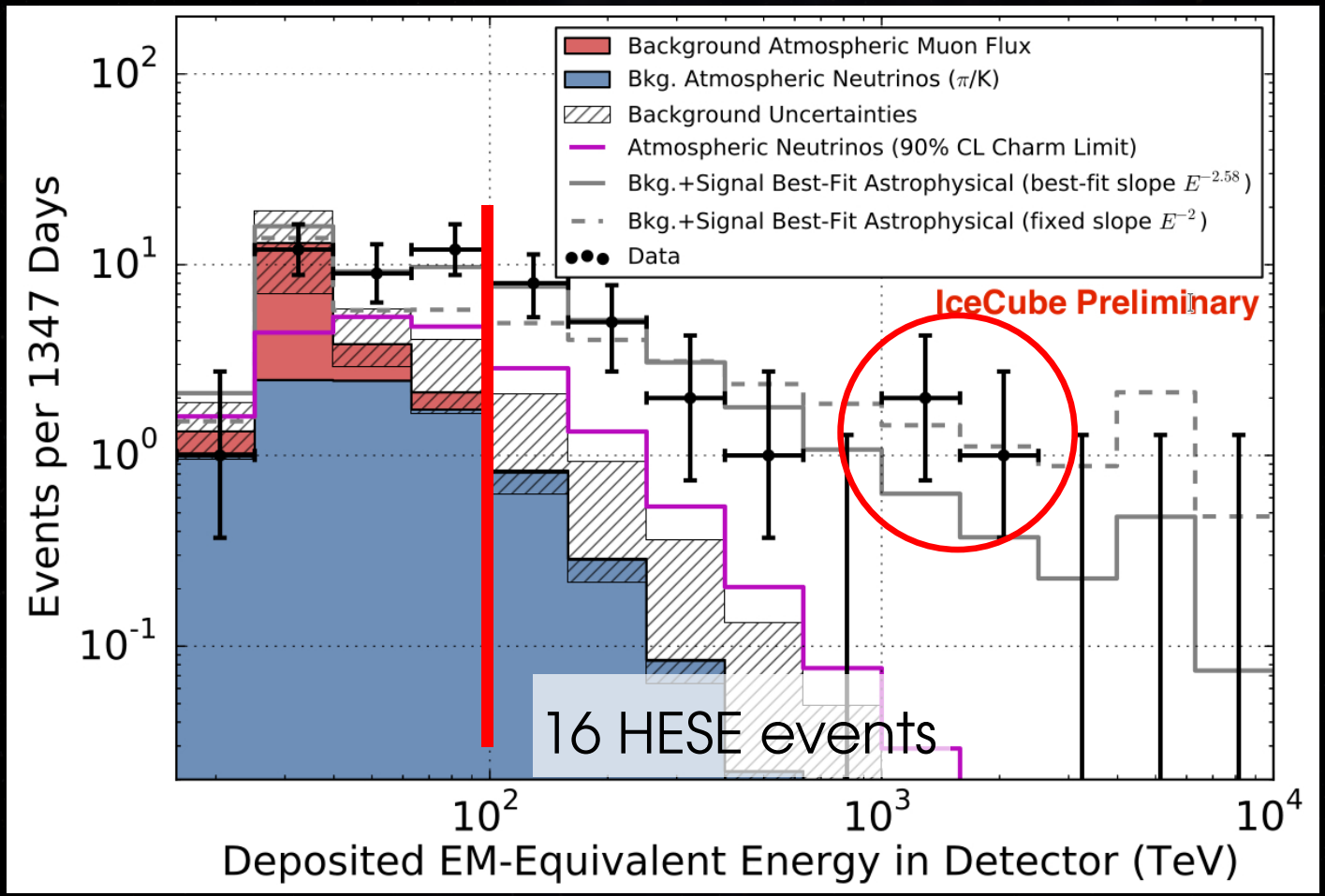


IceCube Collaboration (2013, 2013, 2014, 2015)

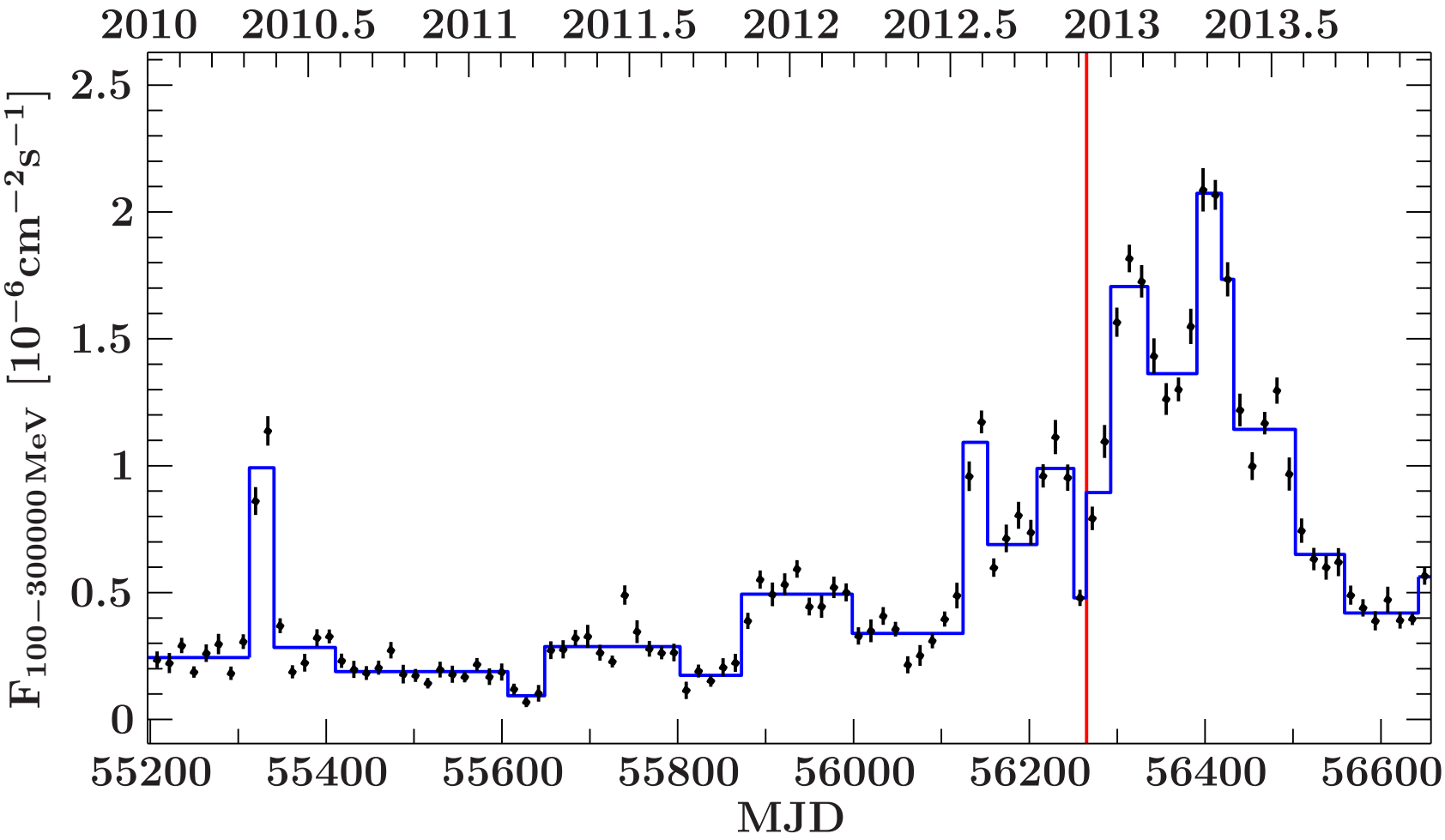
Motivation



IceCube Collaboration (2013, 2013, 2014, 2015)

Motivation

- Previous: Blazar as a class can explain PeV neutrinos (Krauß et al. 2014)
- Blazar flares promising tool for associations: IC 35 ("Big Bird") & PKS 1424−418 Kadler, Krauß et al., 2016



Kadler, Krauß et al., 2016

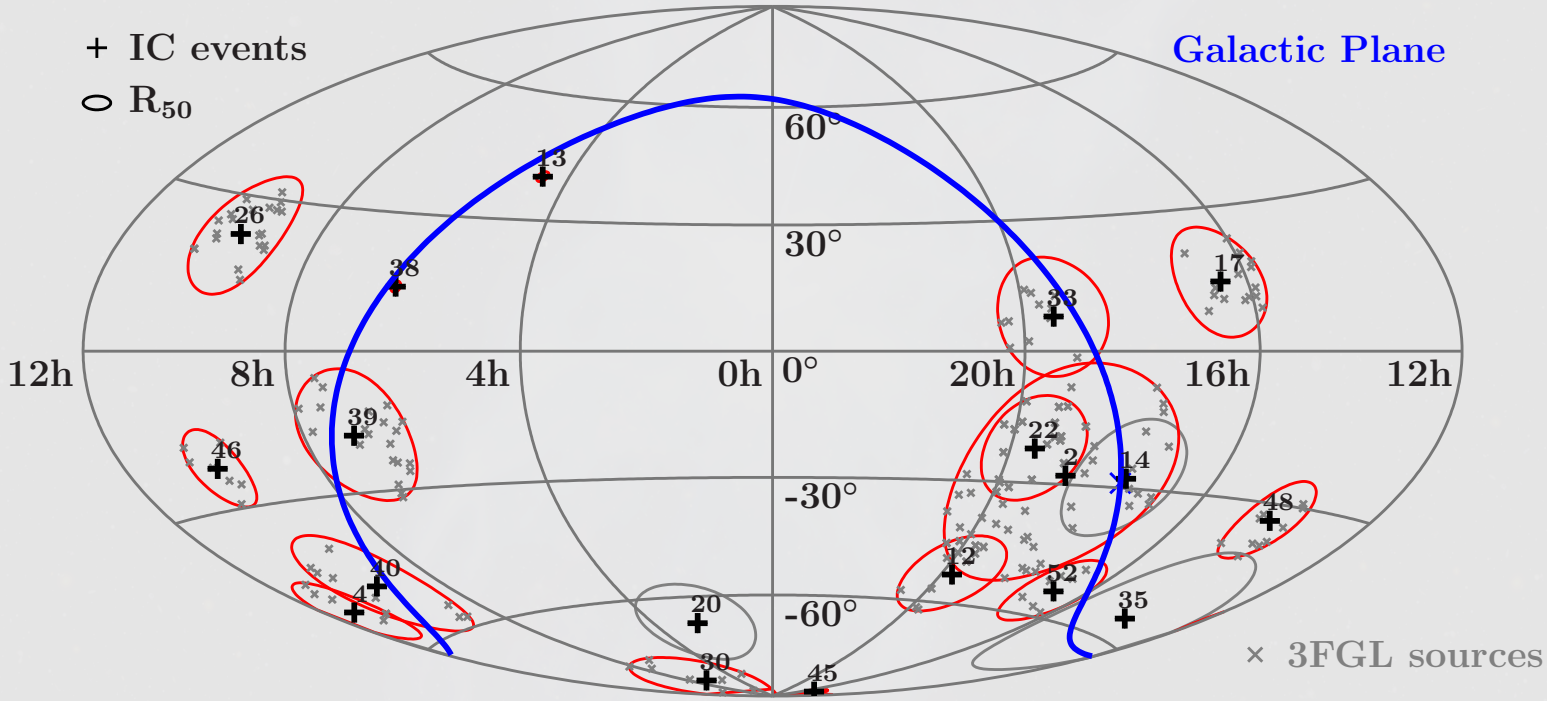
Motivation

- Blazar contribution to neutrino spectrum above 100 TeV?
- Non-detection of bright blazars consistent with blazar hypothesis?
- How hadronic do sources need to be?

Method

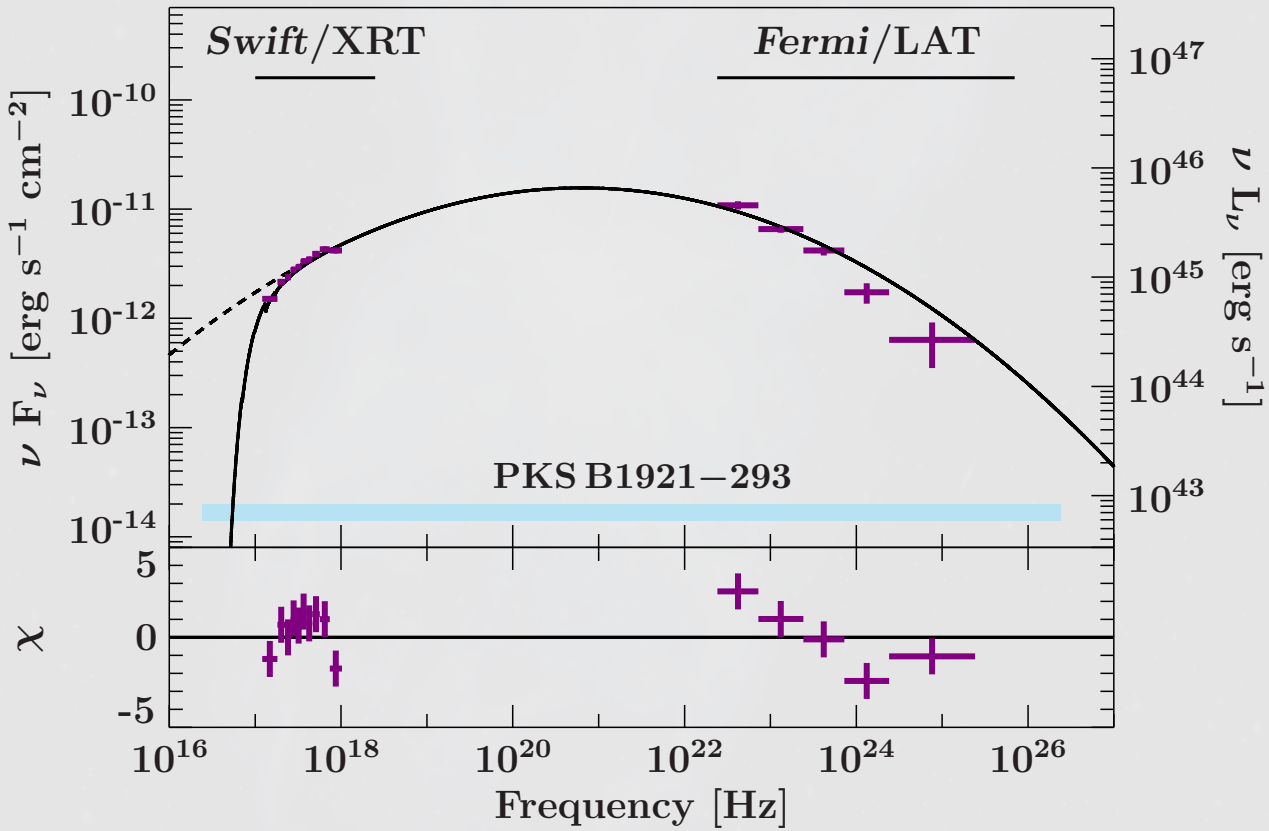
- Identify 3LAC blazars in uncertainty regions
- Estimate neutrino emission (HE emission from $\pi^0 \rightarrow \gamma + \gamma$)

Sources: 179 3LAC sources



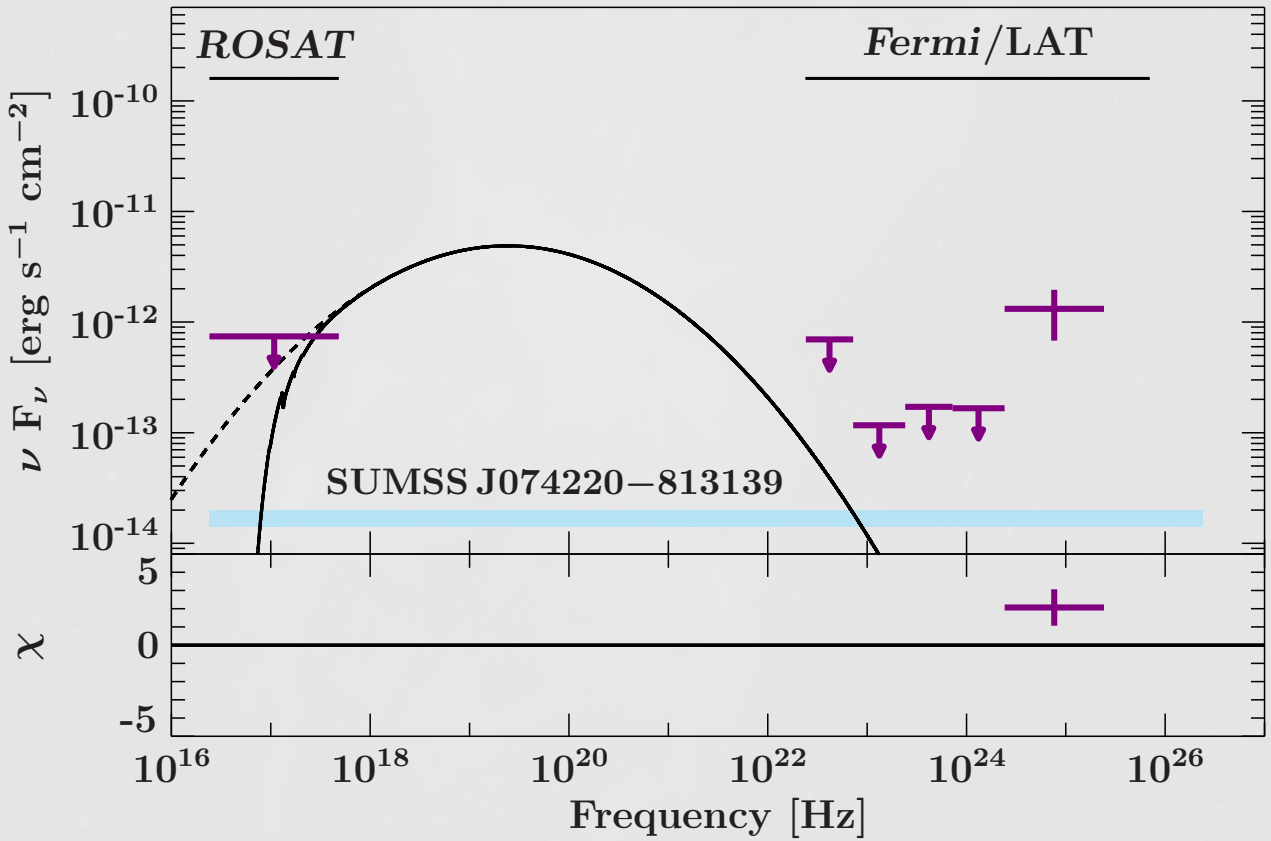
Krauß et al., submitted

COMPILE 179 HE SEDS



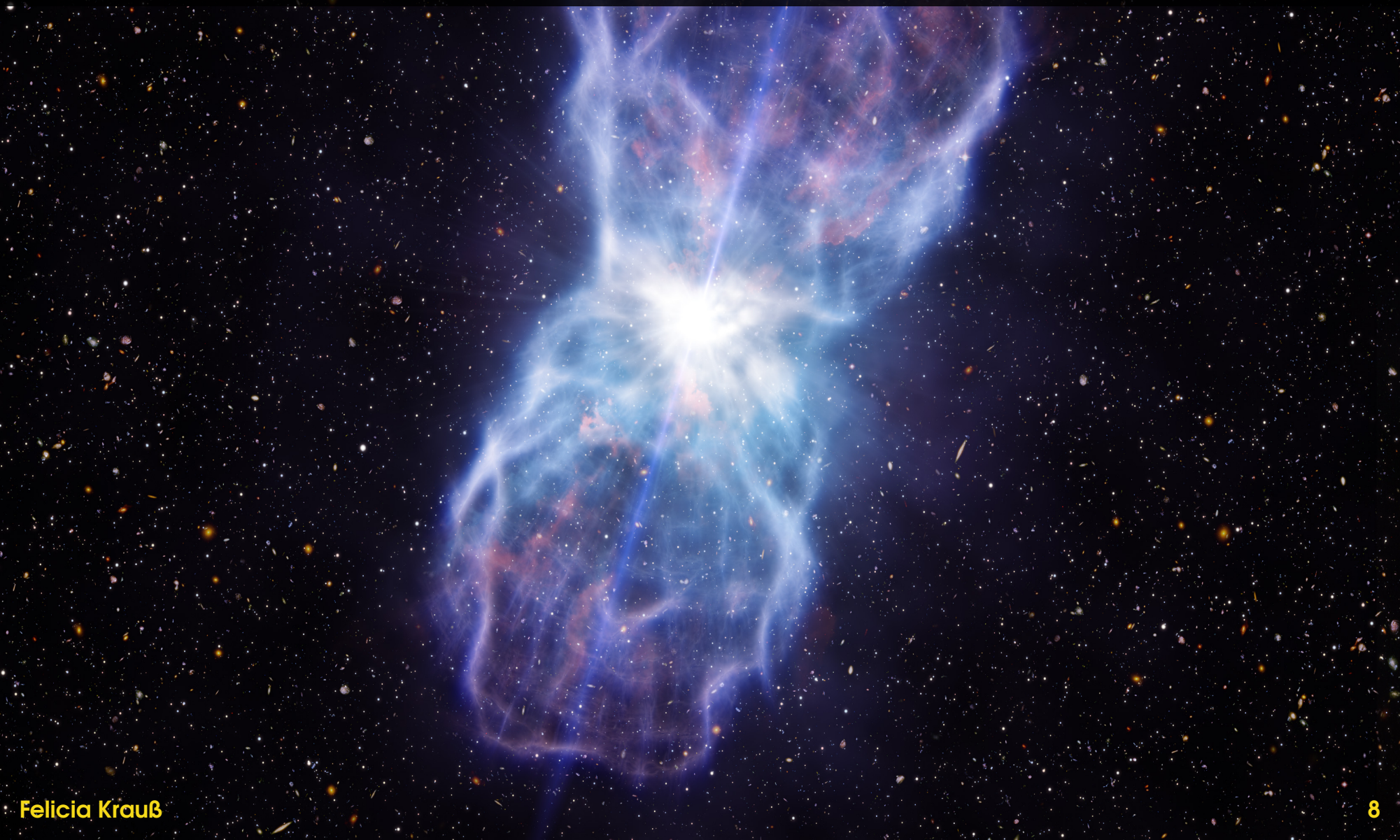
Krauß et al., submitted

Compile 179 HE SEDs

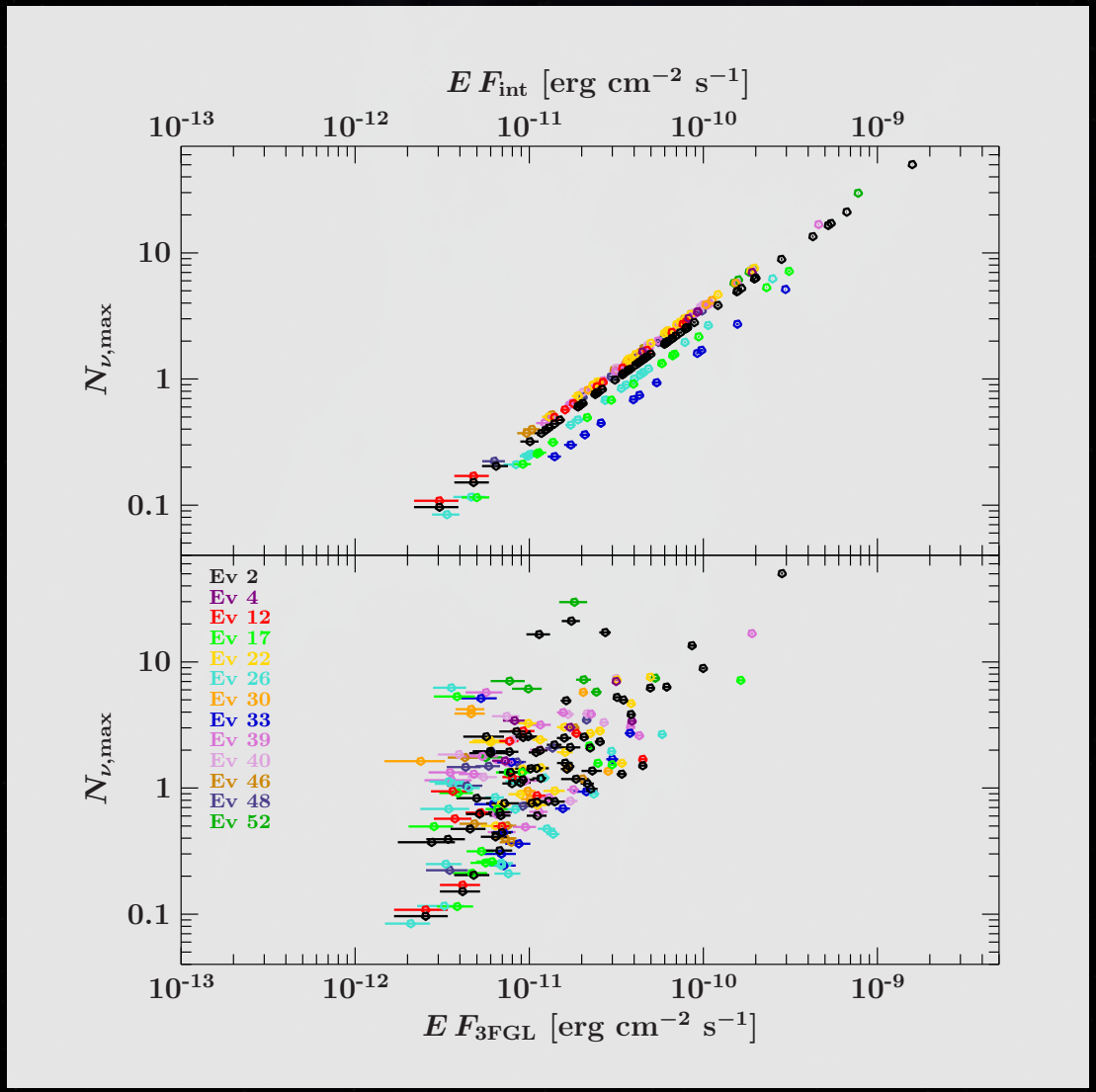


Krauß et al., submitted

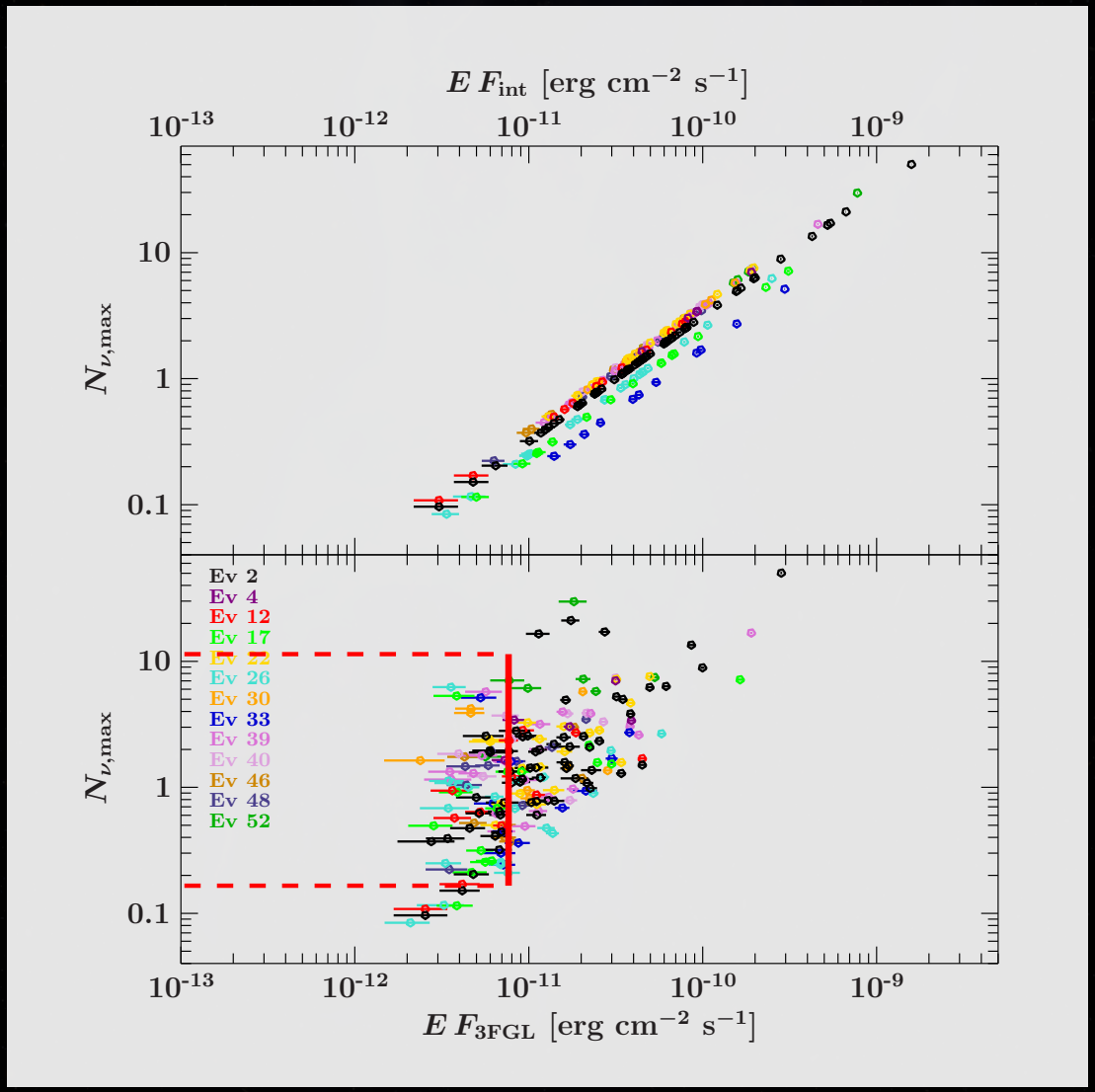
Results



Results


$E\,F_{\rm int}$ [erg cm^{-2} s^{-1}]
10^{-13}
10^{-12}
10^{-11}
10^{-10}
10^{-9}
10
1
0.1
$N_{\nu,\rm max}$
Ev 2
Ev 4
Ev 12
Ev 17
Ev 22
Ev 26
Ev 30
Ev 33
Ev 39
Ev 40
Ev 46
Ev 48
Ev 52
$E\,F_{\rm 3FGL}$ [erg cm^{-2} s^{-1}]

Results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$E\,F_{\rm 3FGL}$ [erg cm^{-2} s^{-1}]

Results

$N_{\nu,\mathrm{max,all}} = 493$
$N_{\nu,\mathrm{spec,all}} = 97$
$N_{\nu,\mathrm{f,all}} = 24.13$

6 cosmic events (/16): 25% of emission hadronic

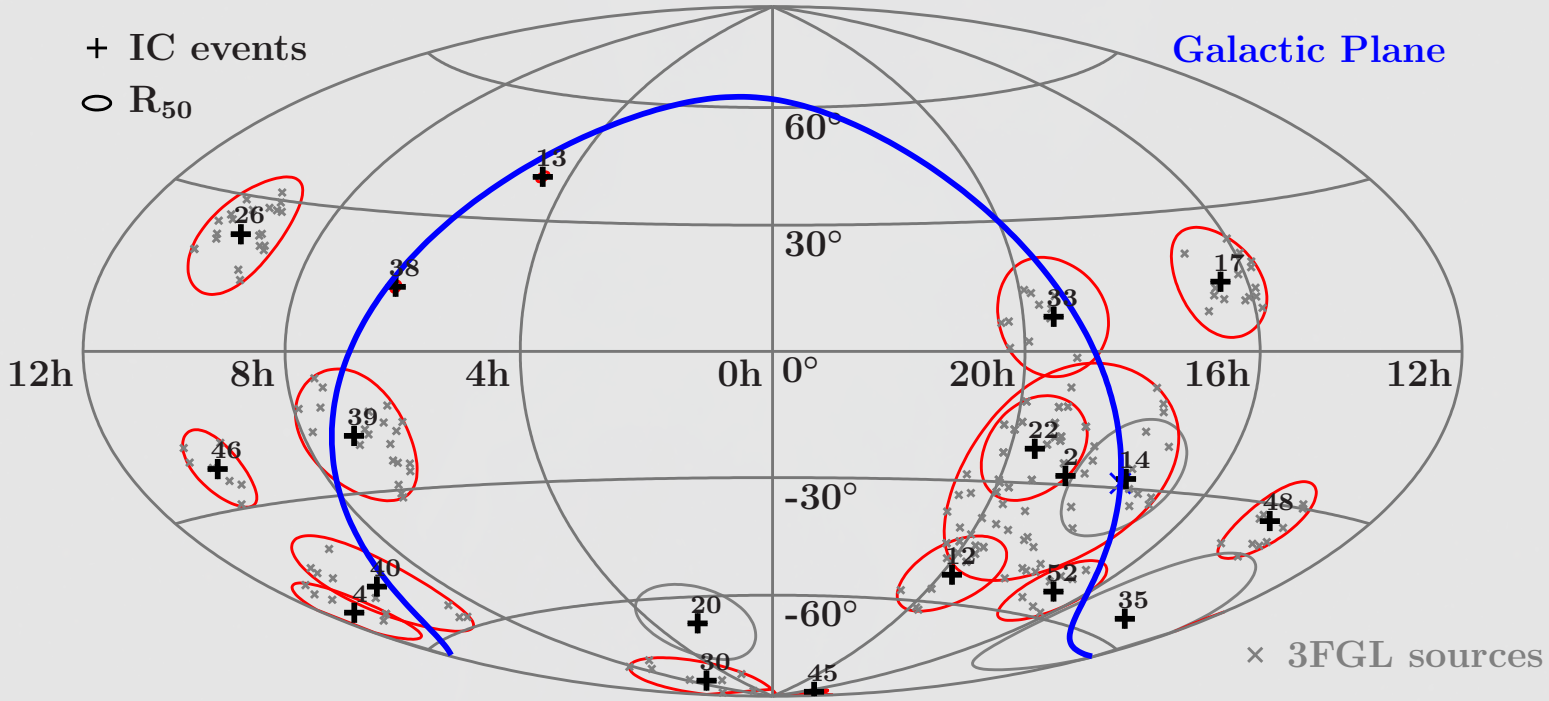
Highest expected # neutrino: PKS 1830−211: 2.7
Only 2 sources above 1 ν

Results

Full sky approximation

Results

Full sky approximation



5590.88 deg^2/41253 deg^2 = 0.136

Results

Full sky approximation

$N_{\nu,\text{max,fullsky}} = 3637$
$N_{\nu,\text{spec,fullsky}} = 712$
$N_{\nu,\text{f,fullsky}} = 178$

6 cosmic events (/16): 3.4% of emission hadronic

Approach underestimates hadronic contribution

Conclusion

- *Fermi*-LAT/EM flux not good proxy for neutrino flux
- Blazars can easily explain IceCube neutrinos
- Sources expected to be mostly leptonic ($\sim$ 3 – 25% hadronic)

Backup

IC	$E_{\text{deposited}}$ (TeV)	MJD	$\alpha_{\text{J2000.0}}$ (°)	$\delta_{\text{J2000.0}}$ (°)	ang. res.	morphology
2	$117^{15.4}_{-14.6}$	55351.4659661	282.6	-28	25.4	Shower
4	$165.4^{19.8}_{-14.9}$	55477.3930984	169.5	-51.2	7.1	Shower
12	$104.1^{12.5}_{-13.2}$	55739.4411232	296.1	-52.8	9.8	Shower
13	$252.7^{25.9}_{-21.6}$	55756.1129844	67.9	40.3	<1.2	Track
14	$1040.7^{131.6}_{-144.4}$	55782.5161911	265.6	-27.9	13.2	Shower
17	$199.7^{27.2}_{-26.8}$	55800.3755483	247.4	14.5	11.6	Shower
20	$1140.8^{142.8}_{-132.8}$	55929.3986279	38.3	-67.2	10.7	Shower
22	$219.5^{21.2}_{-24.4}$	55941.9757813	293.7	-22.1	12.1	Shower
26	$210.0^{29.0}_{-25.8}$	55979.2551750	143.4	22.7	11.8	Shower
30	$128.7^{13.8}_{-12.5}$	56115.7283574	103.2	-82.7	8	Shower
33	$384.7^{46.4}_{-48.6}$	56221.3424023	292.5	7.8	13.5	Shower
35	$2003.7^{236.2}_{-261.5}$	56265.1338677	208.4	-55.8	15.9	Shower
38	$200.5^{16.4}_{-16.4}$	56470.1103795	93.3	14	<1.2	Track
39	$101.3^{13.3}_{-11.6}$	56480.6617877	106.2	-17.9	14.2	Shower
40	$157.3^{15.9}_{-16.7}$	56501.1641008	143.9	-48.5	11.7	Shower
45	$429.9^{57.4}_{-49.1}$	56679.2044683	219	-86.3	<1.2	Track
46	$158.0^{15.3}_{-16.6}$	56688.0702948	150.5	-22.3	7.6	Shower
48	$104.7^{13.5}_{-10.2}$	56705.9419933	213	-33.2	8.1	Shower
52	$158.1^{16.3}_{-18.4}$	56763.5448147	252.8	-54	7.8	Shower