Crab Pulsar studies with non-sumtrigger data

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Outline

Regular (L1) observations of the Crab Nebula might display a detectable pulsed emission.
A search in the 2007 - 2009 data has been performed and Taka's proposed emission model is tested.

- Preliminary Data Selection & Checks
- Trial Cuts on Data
- Effective Area and Flux calculations
- Phasograms and Results
- Spectrum / UL
- Conclusion

Data Selection

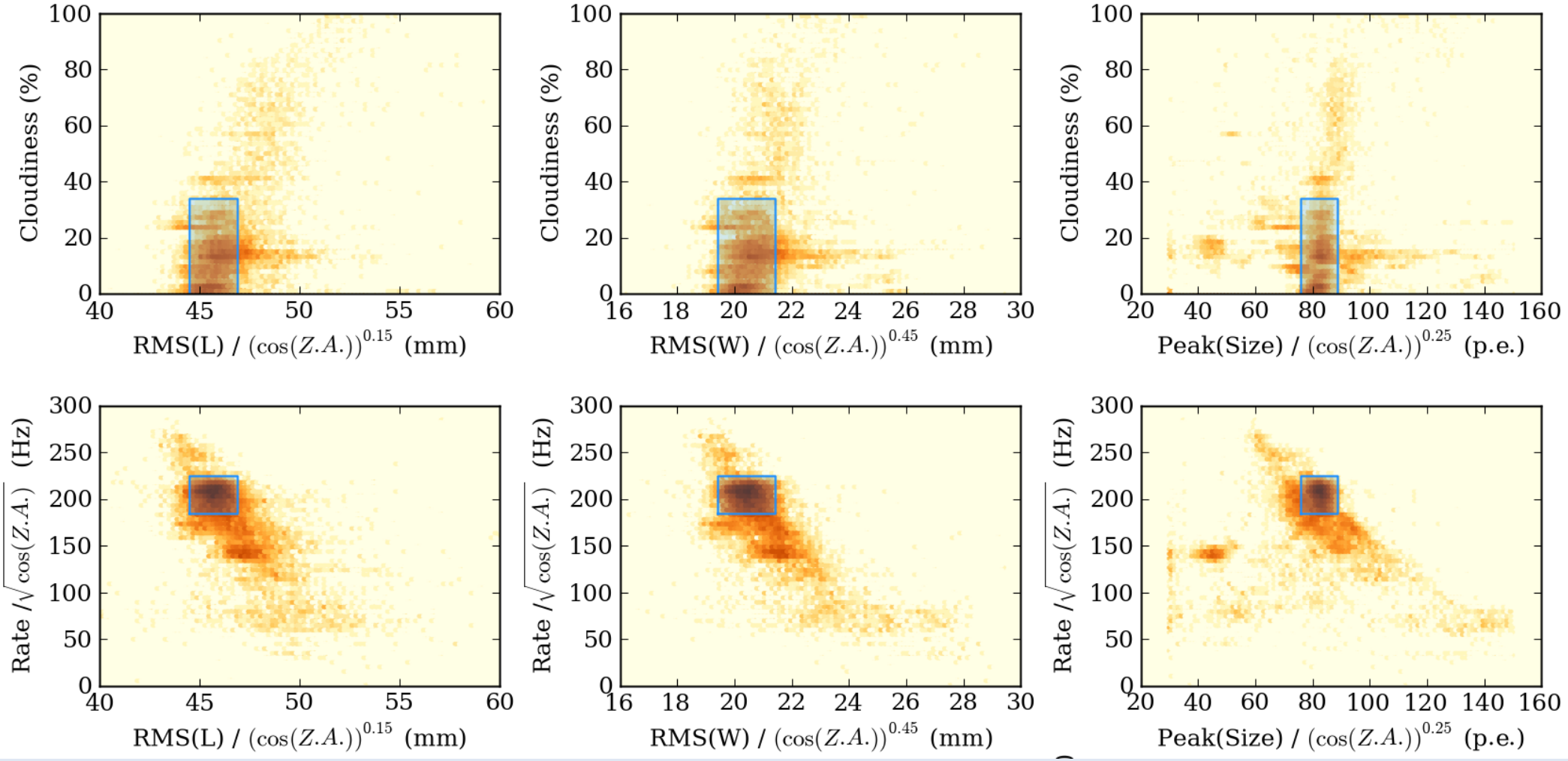
- Data Timespan: Feb. 2007 – Mar 2009
- Preselection (Observation parameter cuts):
  - Zenith<35 deg
  - SrcPosCam-Dev<0.04

The idea then is to select single runs based on their image distribution parameters, which are found to be correlated to the detector performance:

Detector performance		**Image distribution**
• Cloudiness		• RMS (Width)
• Rate		• RMS (Length)
		• Peak (Size)

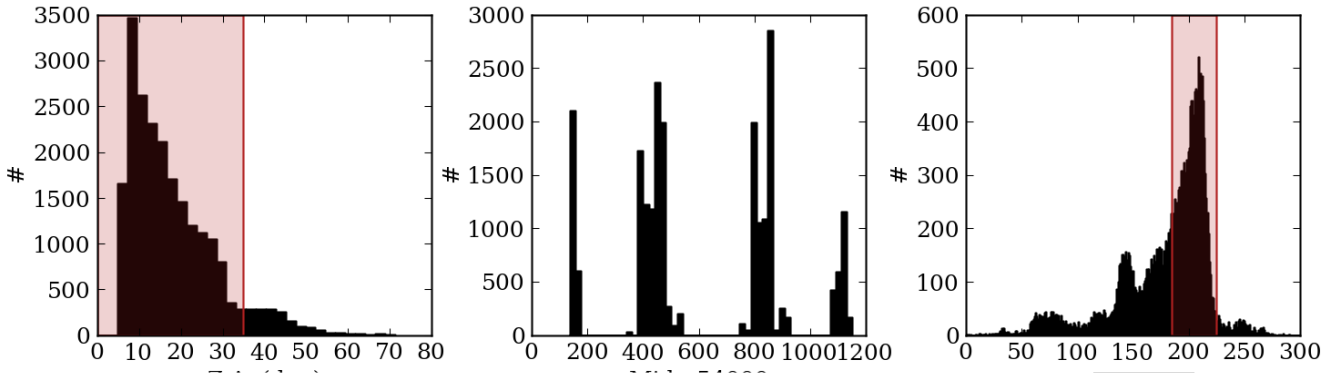
Rate, RMS (Width), RMS (Length), Peak (Size) are scaled to $\cos(\text{Z.A.})^{-\alpha}$, α in [0 - 0.5]

Data Selection



Rate, Cloudiness **vs** RMS (Width), RMS (Length), Peak (Size)
Blue boxes are selections.
See wiki: **`Crab_Pulsar_Above_60_GeV`**

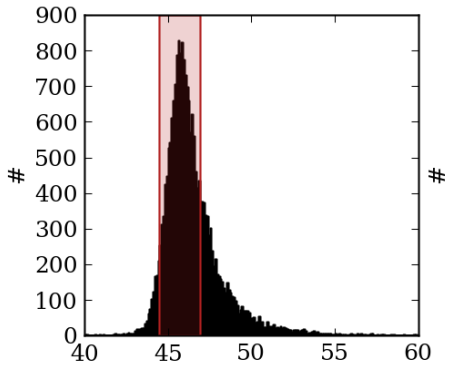
Data Selection



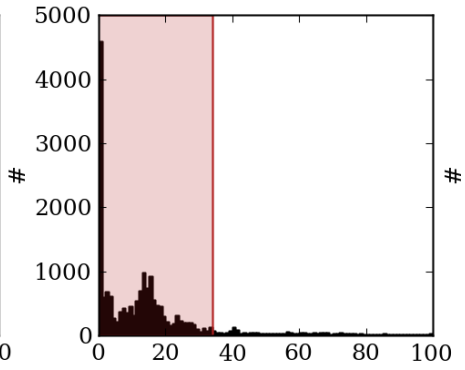
ZA < 35

Mjd > 54000

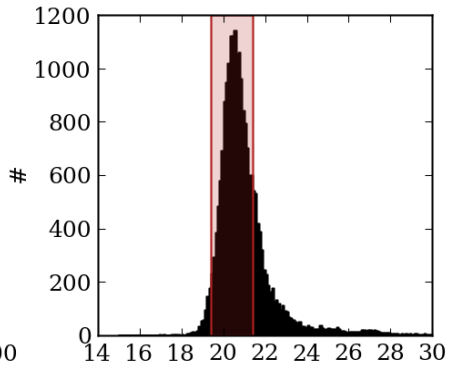
185 < Rate < 225



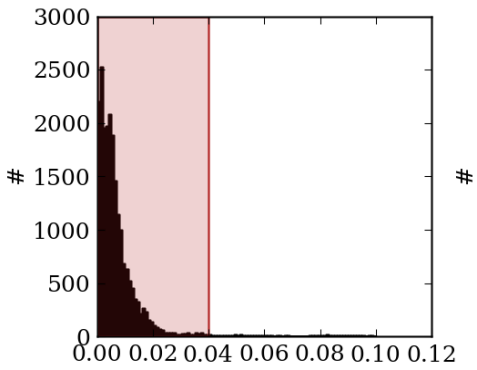
44.5 < RMS$_L$ < 46.9



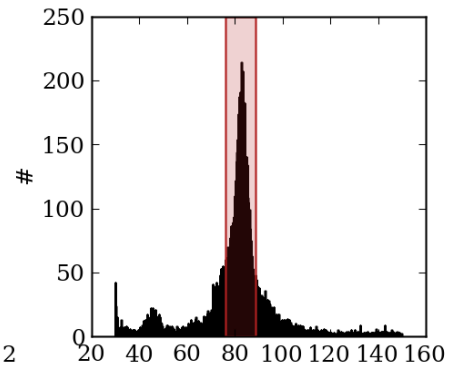
Cloudin < 34



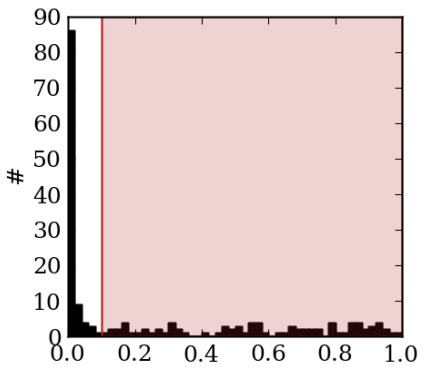
19.4 < RMS$_W$ < 21.4



Offset < 0.04



76 < Peak$_s$ < 88.9



Good R > 0.1

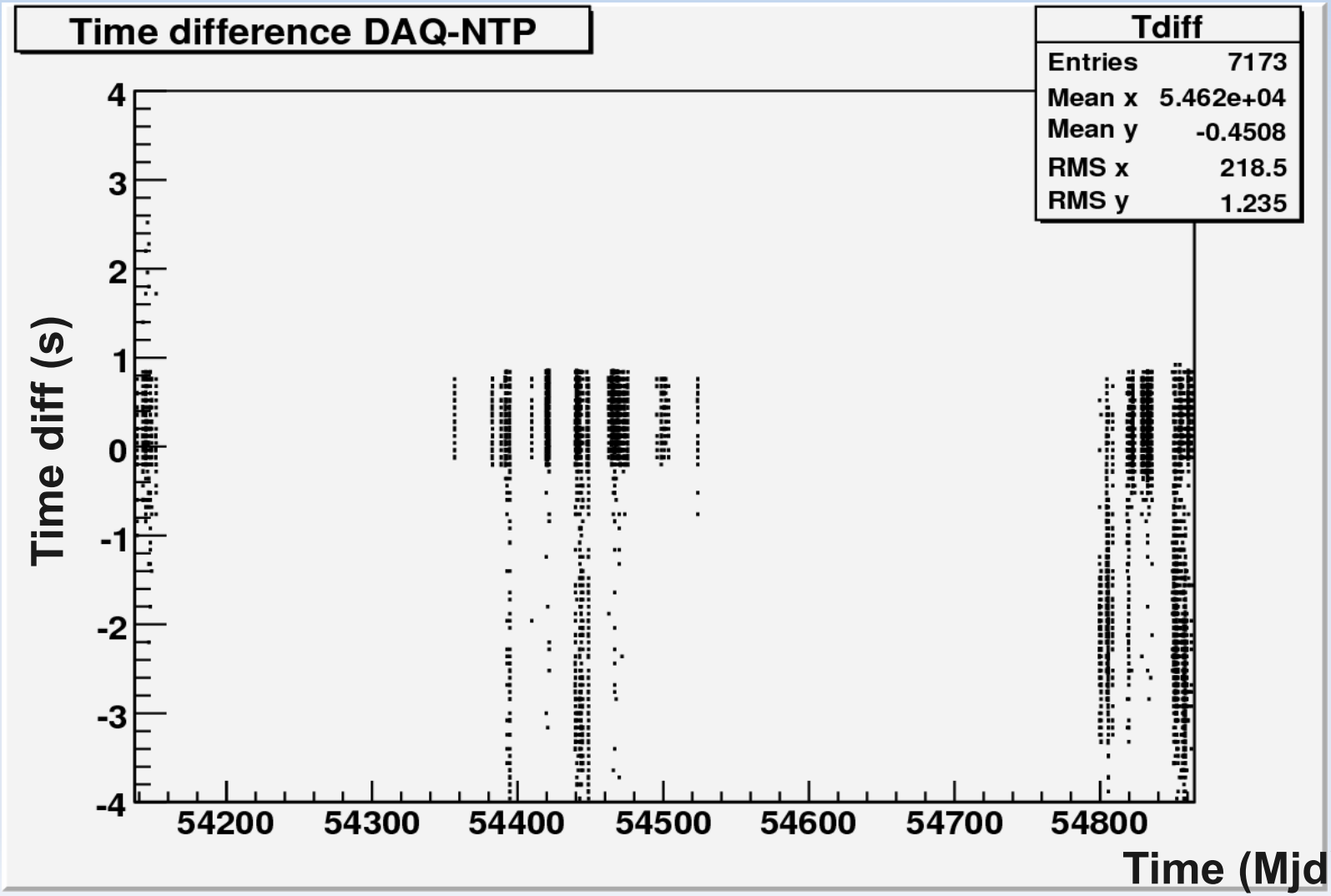
Rate, Peak(Size) are by far the most stringent cuts found.

At the end selected events:

Days : 187 (**84**)
Files : 27147 (**7580**)
Hours: 293 / (**91**)
Ev: 178213744 (**65810266**)

Additional Checks

- **<u>Rubidium Clock – GPS synchronization:</u>** checked with 1st timestamp DAQ-NTP differ.



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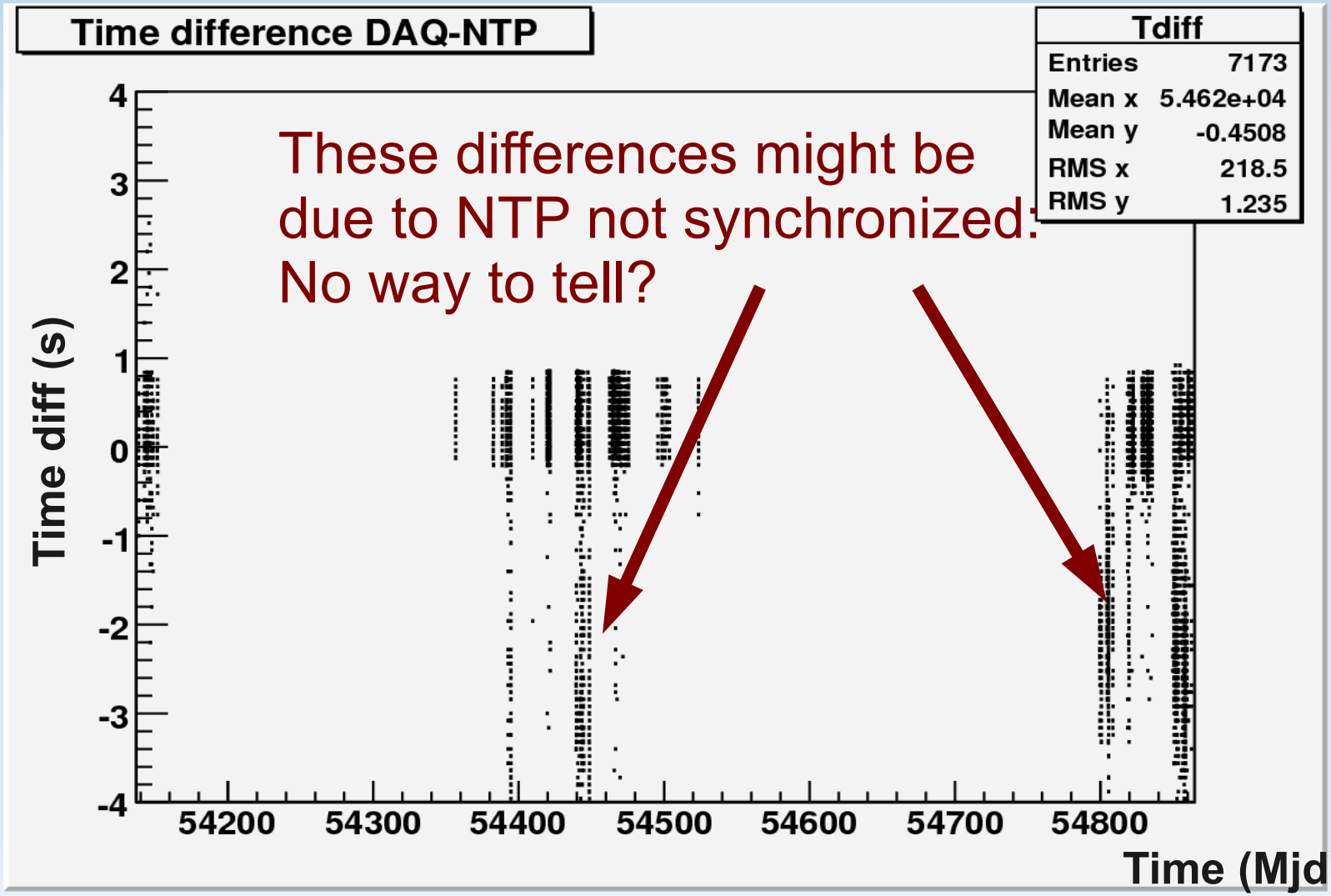


Trial Cut Sets

To have the most possible number of gammas, cuts were performed in:

- **Size**
- **Alpha**
- **Dist**
- **Zenith**

4 “HE” data cuts

- **80 < SIZE < 300**
- ALPHA (< 18 / DYN)
- DIST (NO / < 264)
- NO ZENITH CUT

2 “LE” data cuts

- **SIZE < 300**
- ALPHA (< 18)
- DIST < 264
- ZENITH (< 20 / NO)

“HE” Effective Areas

- Effective areas from untuned MC.
- Flux from Taka:

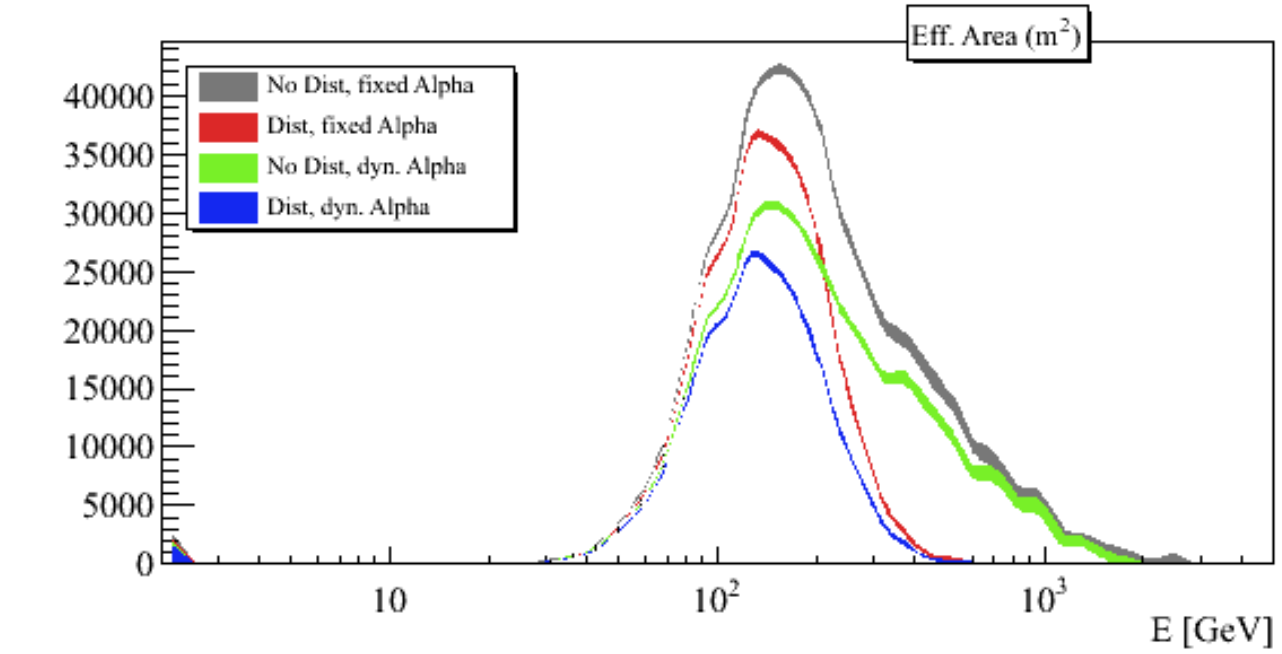
  PL with

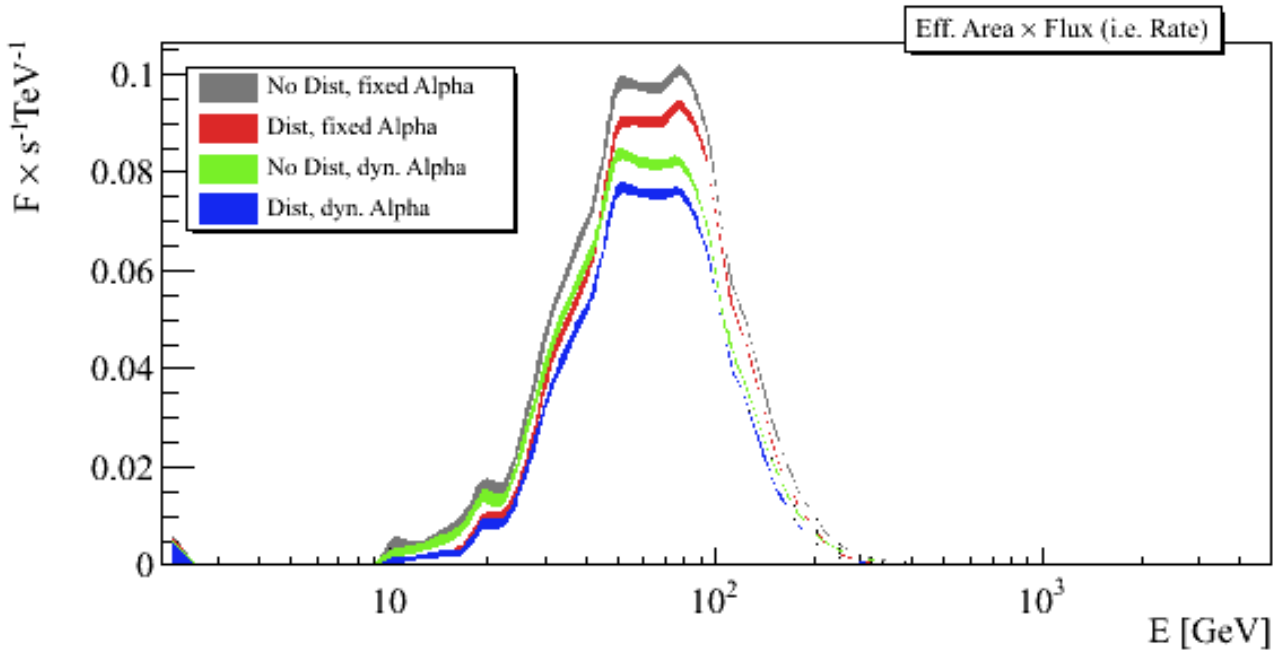
N = 14.9e-5 m^{-2} s^{-1} TeV^{-1}

Ec = 30 GeV

Index = -3.35

- Diff. Rate peaks at 50-100 GeV





“LE” Effective Areas

- Effective areas from untuned MC.
- Flux from Taka:

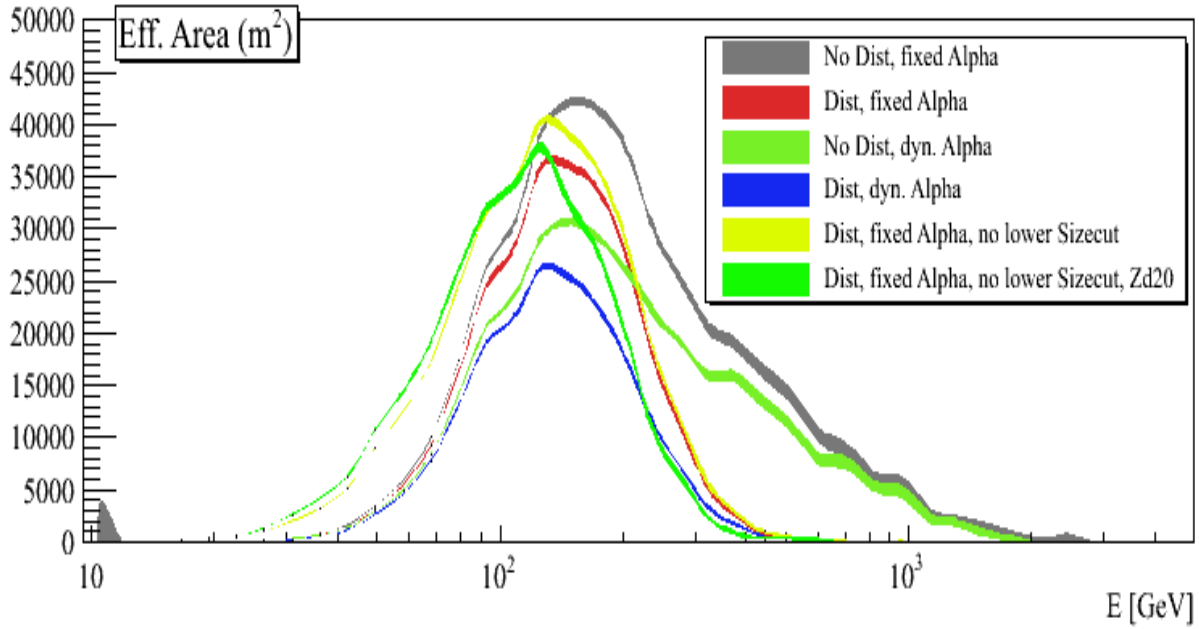
  PL with

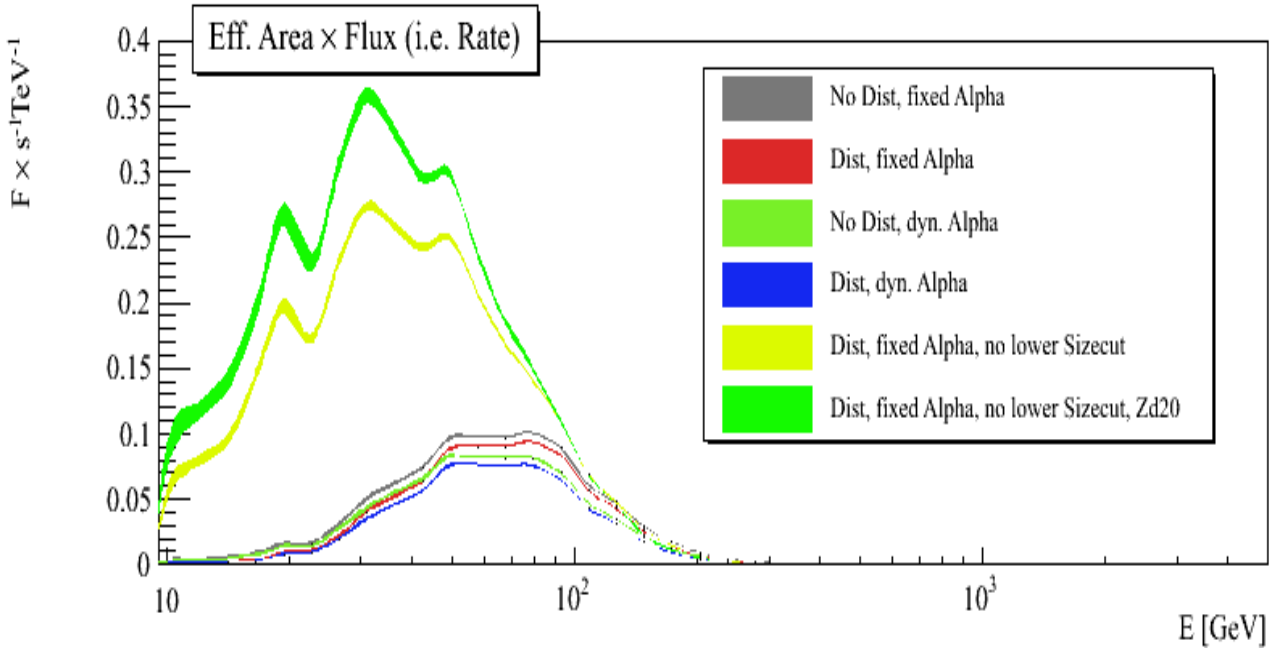
N = 14.9e-5 m^{-2} s^{-1} TeV^{-1}

Ec = 30 GeV

Index = -3.35

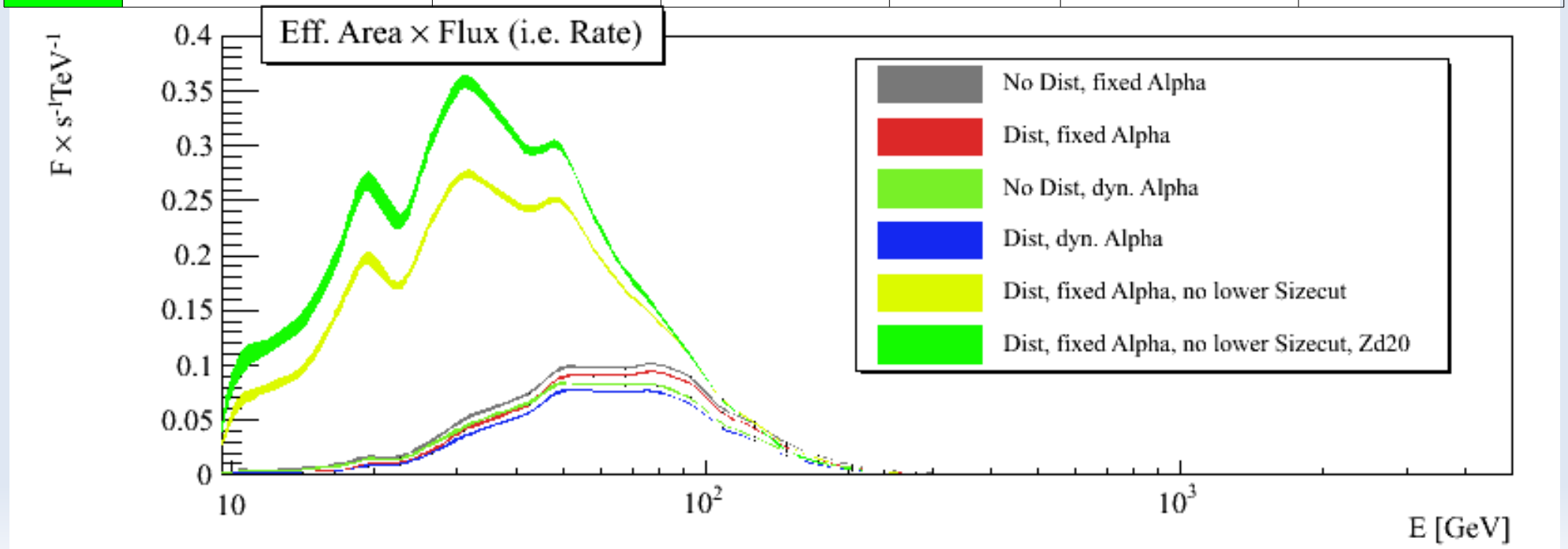
- Diff. Rate peaks at <50 GeV





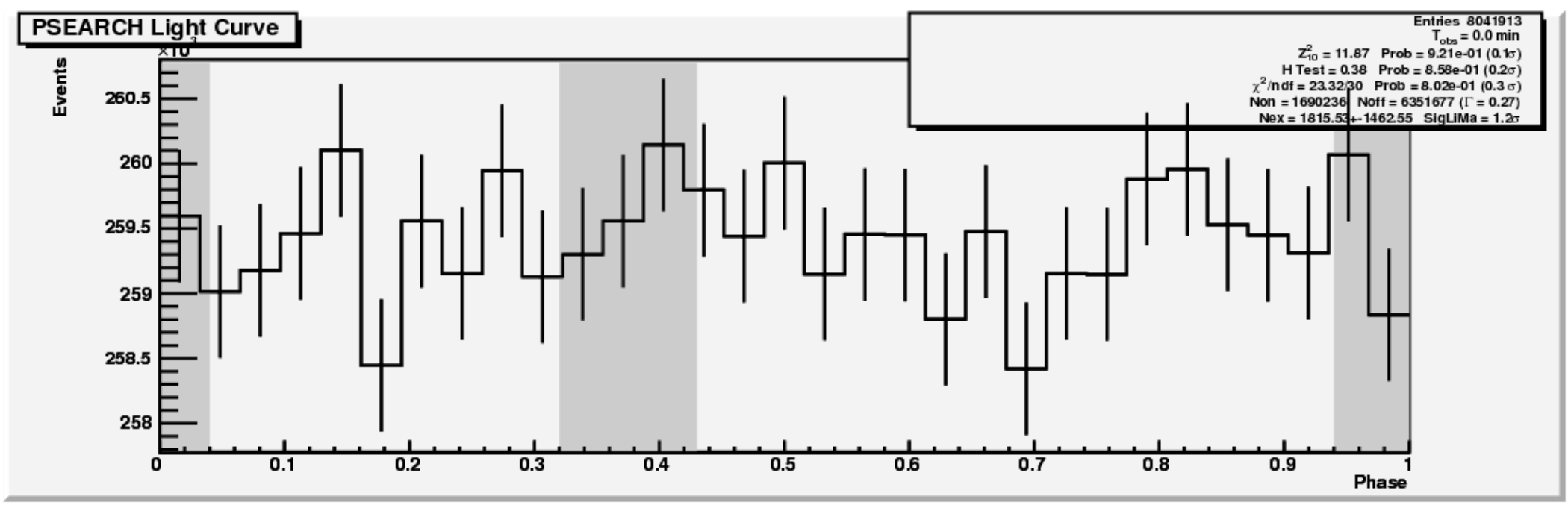
Expected Excess:

	SIZE LOW	SIZE HI	ALPHA	DIST	ZENITH	EXCESS
	80	300	<18	NO	NO	3363
	80	300	<18	< 264	NO	2936
	80	300	DYN	NO	NO	2690
	80	300	DYN	< 264	NO	2323
	0	300	<18	< 264	NO	6429
	0	300	<18	< 264	< 20	4892



Results: no dist, alpha < 18

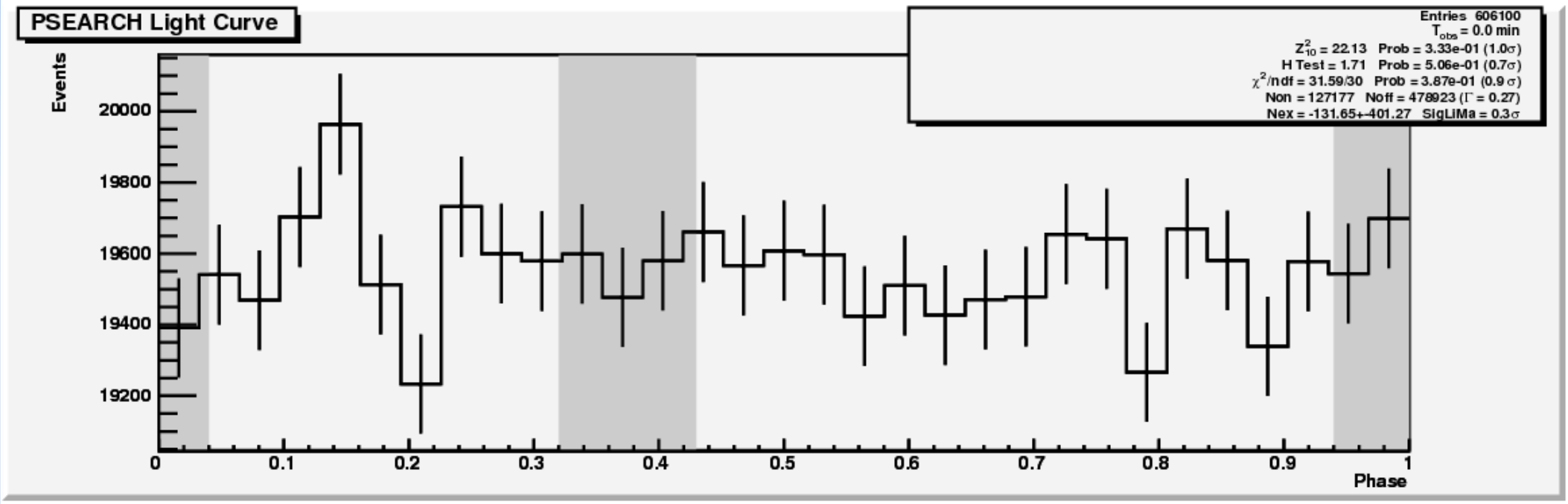
ALL Data



N. Events	8041913
N. On	1690236
N. Off	6351677
N. Excess	1815 +- 1462
H. Sign. (sigma)	0.2
Li Ma Sign. (sigma)	1.2

Results: no dist, alpha < 18

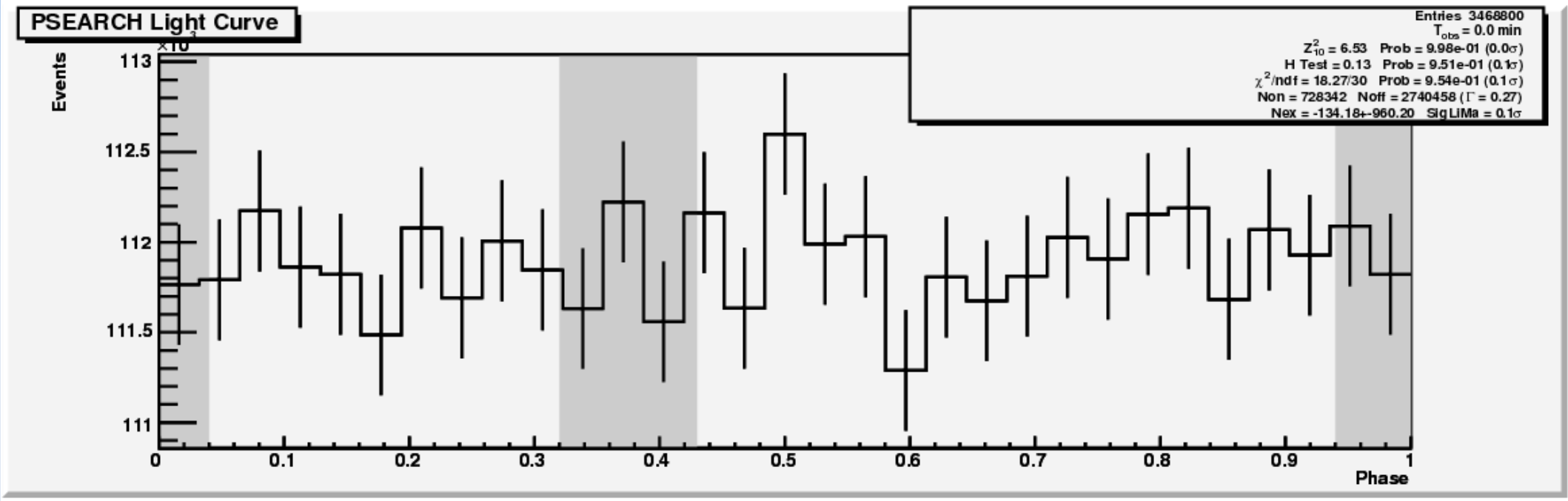
Winter 2006-2007 Data



N. Events	606100
N. On	127177
N. Off	478923
N. Excess	-132 +- 401
H. Sign. (sigma)	0.7
Li Ma Sign. (sigma)	0.3

Results: no dist, alpha < 18

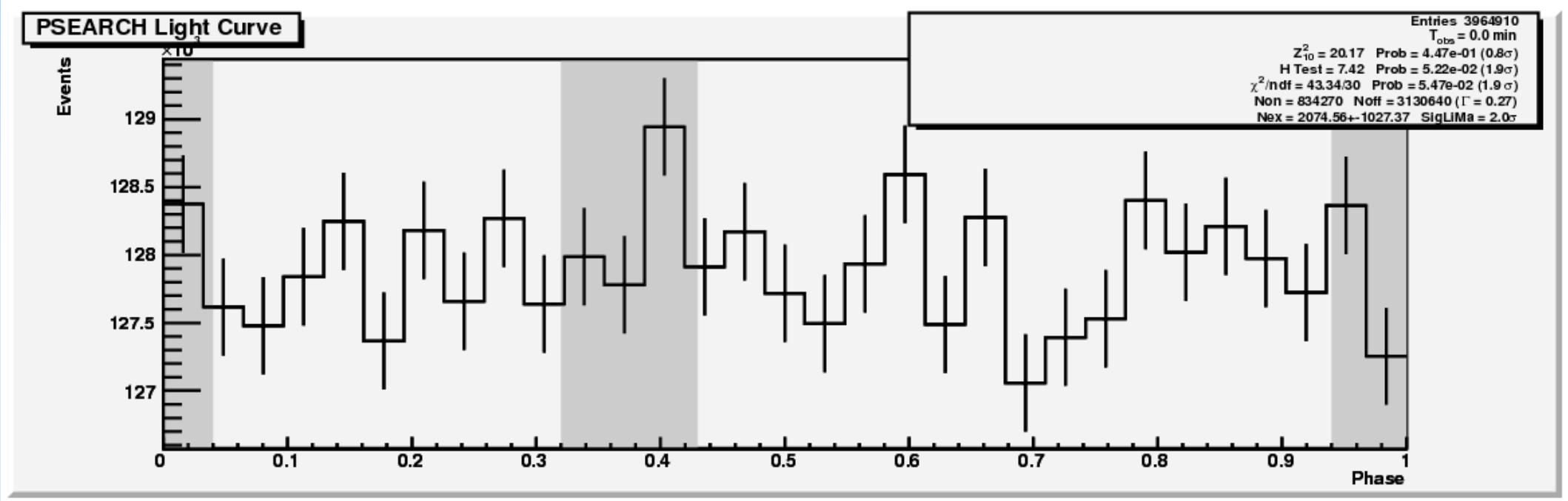
Winter 2007-2008 Data



N. Events	3468800
N. On	728342
N. Off	2740458
N. Excess	-134 +- 960
H. Sign. (sigma)	0.1
Li Ma Sign. (sigma)	0.1

Results: no dist, alpha < 18

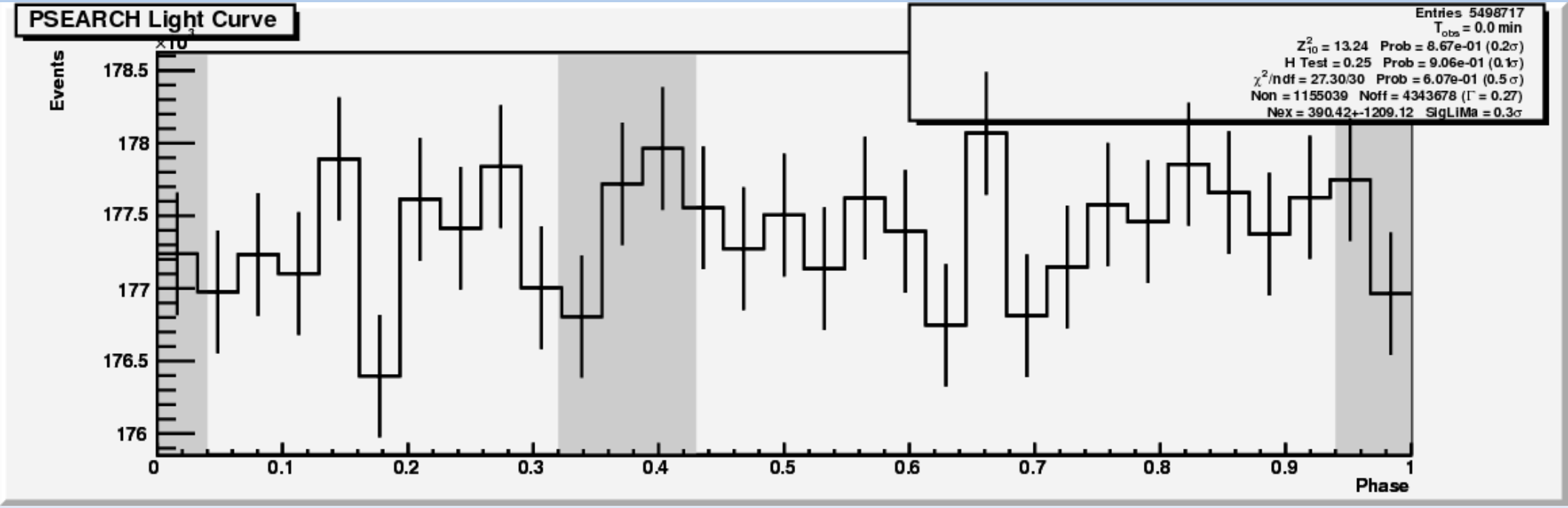
Winter 2008-2009 Data



N. Events	3964910
N. On	834270
N. Off	3130640
N. Excess	2074 +- 1027
H. Sign. (sigma)	1.9
Li Ma Sign. (sigma)	2.0

Results: dist < 264, alpha < 18

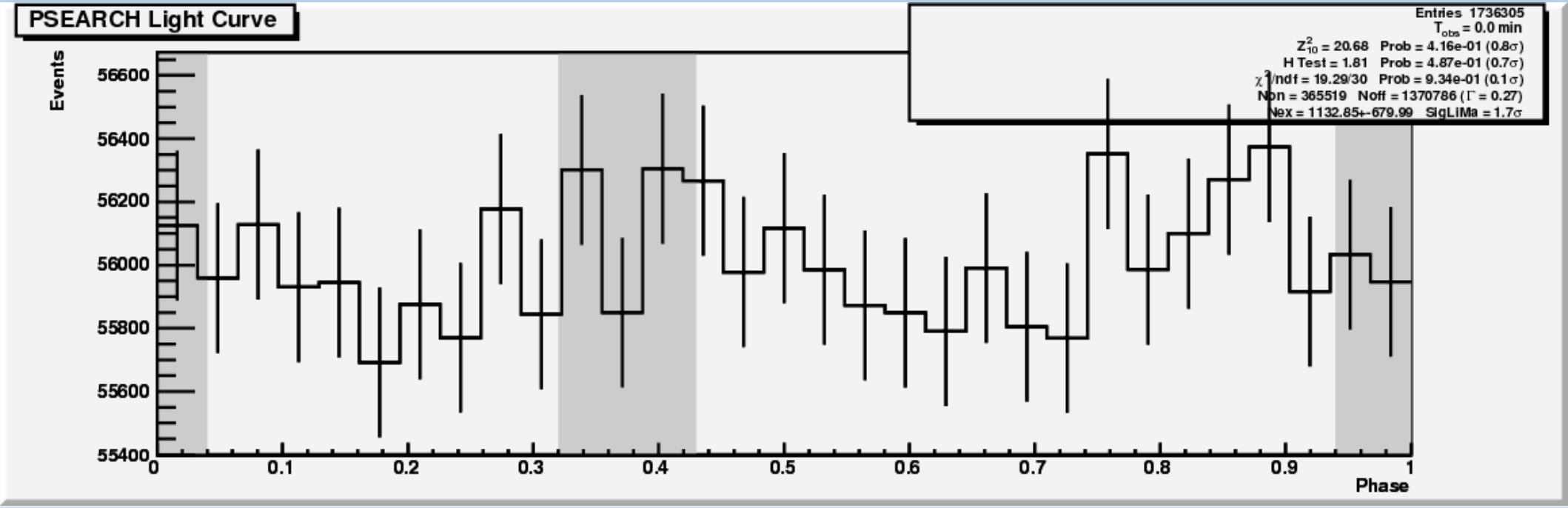
ALL Data



N. Events	5498717
N. On	1155039
N. Off	4343678
N. Excess	390 +- 1209
H. Sign. (sigma)	0.1
Li Ma Sign. (sigma)	0.3

Results: no dist , alpha dyn

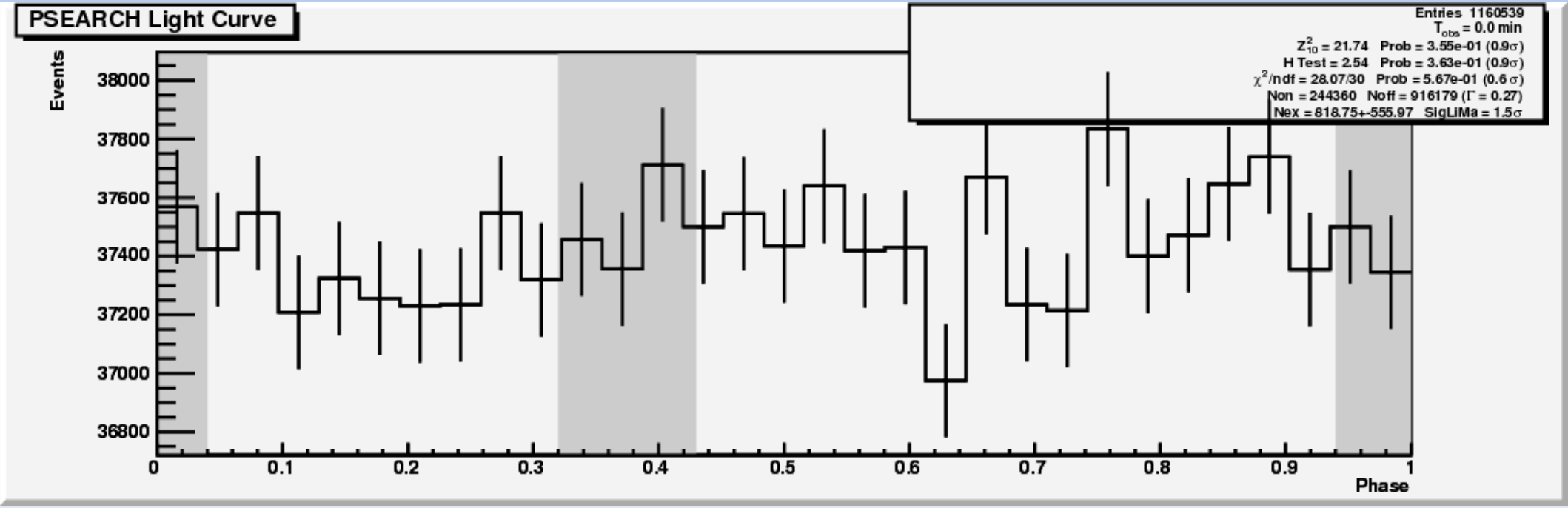
ALL Data



N. Events	1736305
N. On	365519
N. Off	1370786
N. Excess	1132 +- 680
H. Sign. (sigma)	0.7
Li Ma Sign. (sigma)	1.7

Results: dist < 264 , alpha dyn

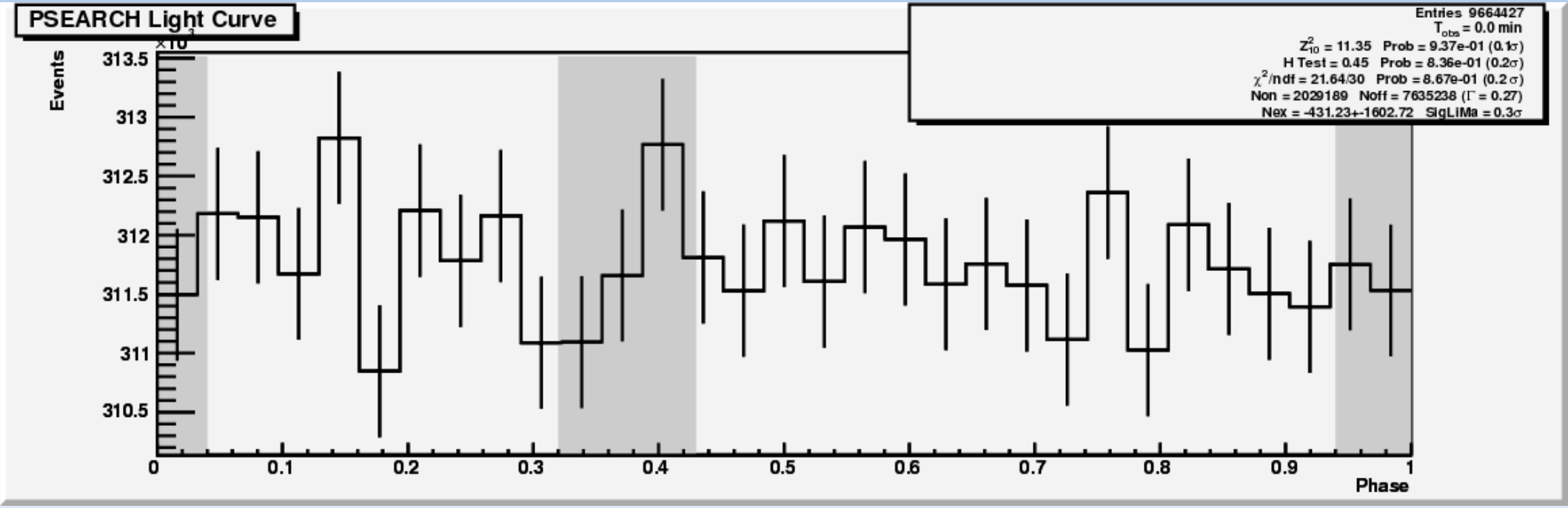
ALL Data



N. Events	1160539
N. On	244360
N. Off	916179
N. Excess	819 +- 556
H. Sign. (sigma)	0.9
Li Ma Sign. (sigma)	1.5

Results: dist < 264 , alpha < 18, no lower size cut

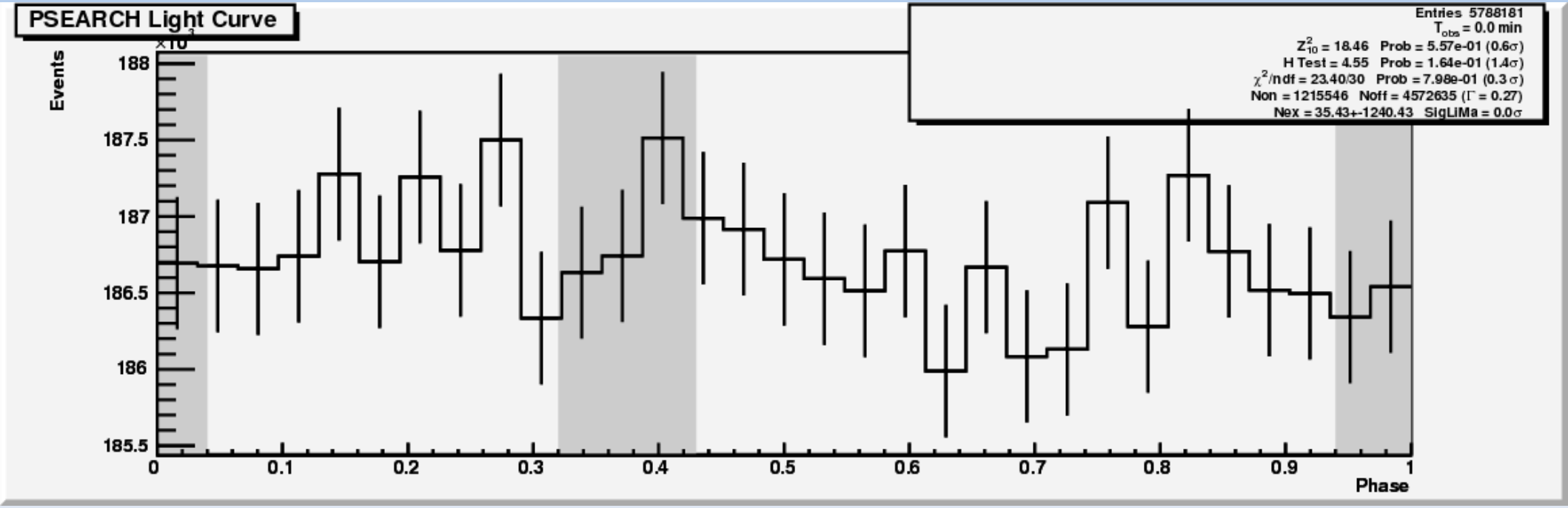
ALL Data



N. Events	9664427
N. On	2029189
N. Off	7635238
N. Excess	-431 +- 1602
H. Sign. (sigma)	0.2
Li Ma Sign. (sigma)	0.3

Results: dist < 264 , alpha < 18, no lower size cut, zenith < 20

ALL Data



N. Events	5788181
N. On	1215546
N. Off	4572635
N. Excess	-35.43 +- 1240
H. Sign. (sigma)	1.4
Li Ma Sign. (sigma)	0.0

Upper limits

Upper Limits on the excess events, from ALL Data

Trial	Expectation	UL 90%	UL 95%
No dist, alpha < 18	3363.41	5451.52	6697.3
Dist < 264, alpha < 18	2936.48	2842.73	3559.69
No dist, alpha dyn	2689.86	3003.78	3679.98
Dist < 264, alpha dyn	2323.34	2279.45	2795.44
No lower, alpha < 18, dist < 264	6429.58	2551	3306.36
No lower, alpha < 18, Dist < 264, zenith < 20	4892.09	2416.82	3071.17

- The present “HE” data can't exclude at 95% C.L. Taka's model. If we take into account the “LE” data, it can.
- Two of the “HE” trial cut sets can exclude it at 90% C.L.
- Errors in the testing model were not considered.

Conclusion

- A search for a pulsed emission from the Crab Pulsar in the MAGIC L1 data has been performed.
- The relatively well-understood energy range above 50 GeV, and the lowest energies were searched for separately.
- The data has been selected from the standard data sets, using cuts on rate and mean image parameters file by file.
- Different sets of cuts were tried, however no significant periodicity was found.
- The upper limits found however do not pose a very strict constraint on Taka's Power Law model.
- Proper MC might be needed to constrain it.

Additional Checks

- **Phasing of the events:** checked with TEMPO2

Phase diff PSEARCH - TEMPO2