
Study of 2007 and 2008 data for a point source search
Aart Heijboer, Nikhef.

files, versions, lifetimes

everything reconstructed with Calrealv2r3

atmospheric muons:

mupage v3r2

do Triggerefficiency myself for: (L05-3pe), L09-3pe, L10-3pe, L12-10pe

neutrinos:

/in2p3/mc/neutrino/mu/*/dic08/te*/up

data:

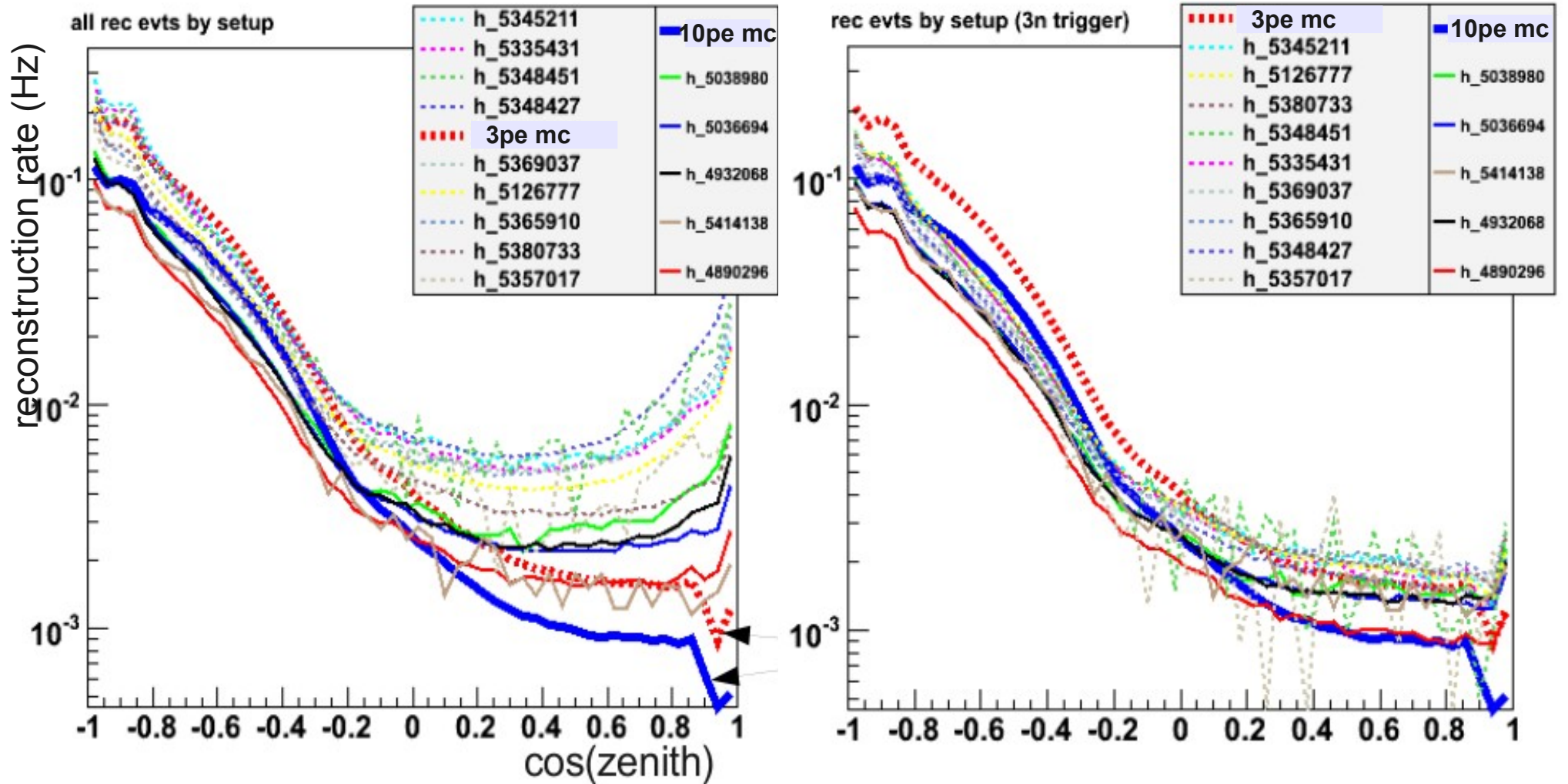
Ag runs between 25700 and 38216 (inclusive)

<i>live-times</i>		
L05	167 days	(→ 164 due to 'all sampling 2')
L09	48 days	
L10	54 days	
L12	70 days	

2007 & 2008 data in detail

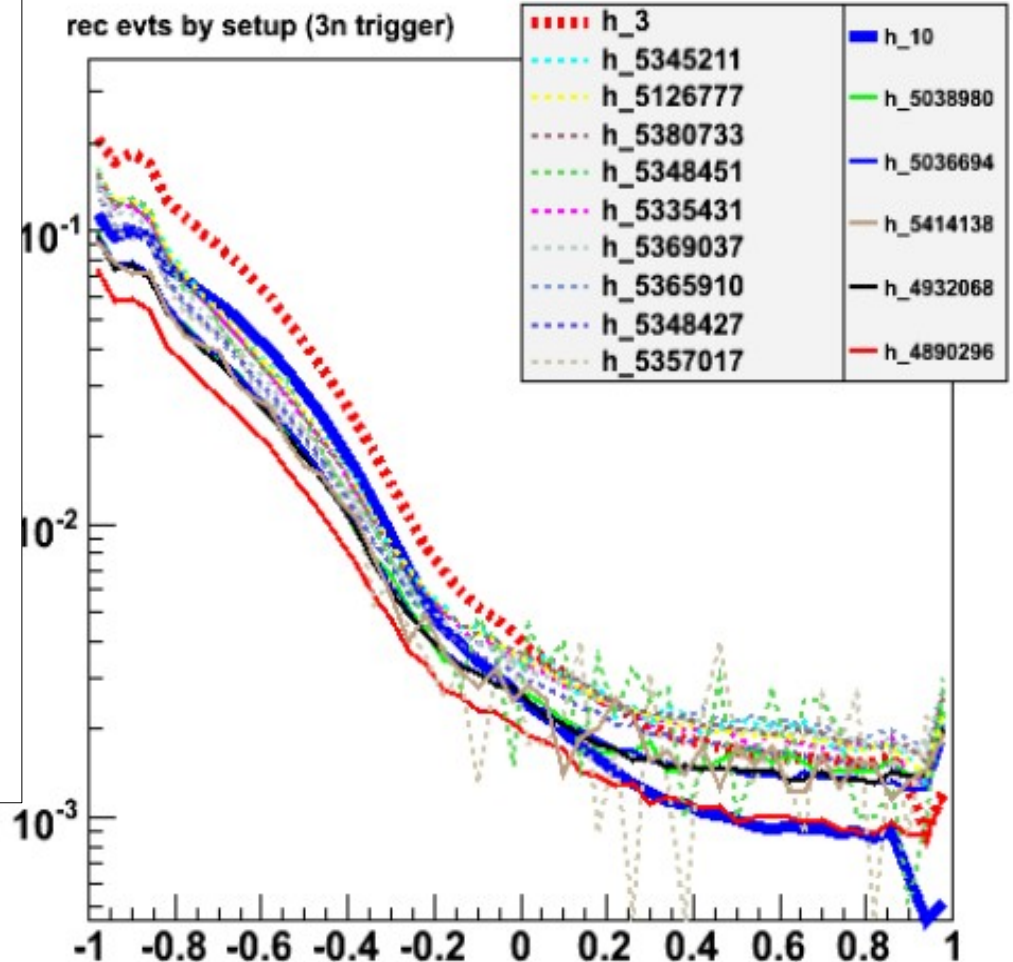
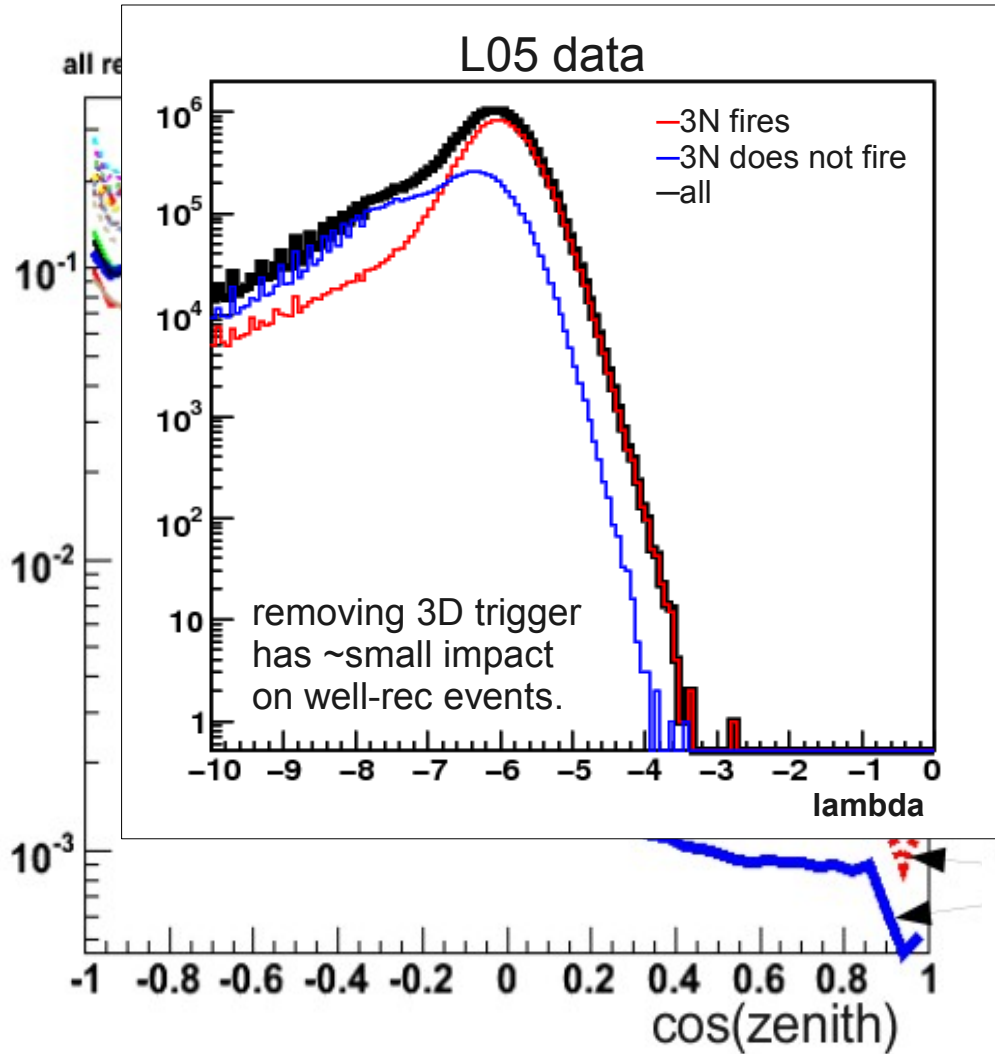
period	runsetup	comment	agruns	1st run	last run	T3	HighThr
Line5	4890296	(thr=40,allsampling=1,HRV=500kHz)	47	Feb 9 2007	Mar 17 2007	-	10.0
Line5	4932068	(thr=40,allsampling=2,HRV=500kHz)	55	Jan 31 2007	Mar 11 2007	-	10.0
Line5	5036694	(thr=tuned, allsamp=1, HRV=500kHz)	177	Mar 27 2007	May 29 2007	-	10.0
Line5	5038980	(thr=tuned, allsamp=2, HRV=500kHz)	27	Mar 22 2007	May 5 2007	-	10.0
Line5	5126777	(L0th=0.3,L1th=3,alls=1,HRV=500)	183	May 10 2007	Jul 20 2007	-	3.0
Line5	5335431	(L0th=0.3,L1th=3,alls=1,HRV=500,+)	14	Jul 20 2007	Jul 23 2007	-	3.0
Line5	5345211	(L0=.3,L1=3,HRV=800,GC)	6	Jul 23 2007	Jul 24 2007	-	3.0
Line5	5348427	(L0=.3,L1=3,HRV=500,+GC) 2007/07/	260	Jul 24 2007	Nov 5 2007	-	3.0
Line5	5348451	(L0=.3,L1=3,HRV=800,CG) 2007/07/2	1	Jul 24 2007	Jul 24 2007	-	3.0
Line5	5357017	(L0=.3,L1=3,PSD,+GC) 2007/08/07 S	1	Aug 24 2007	Aug 24 2007	-	3.0
Line5	5365910	(L0=.3,L1=3,HRV=500,NoGC) 2007/08	19	Aug 30 2007	Sep 3 2007	-	3.0
Line5	5369037	(L0=.3,L1=3,HRV=500,+GC,minGcClus	95	Aug 14 2007	Nov 23 2007	-	3.0
Line5	5380733	(L0=0.3,L1=3,HRV=500,GC=off)	52	Sep 3 2007	Dec 3 2007	-	3.0
Line10	5414138	(L1=10,HRV=500,-GC)	19	Dec 4 2007	Dec 10 2007	-	10.0
Line10	7241194	global tune	55	Dec 7 2007	Dec 19 2007	-	10.0
Line10	7537005	(L1=3,HRV=400) SCAN	23	Dec 19 2007	Jan 12 2008	-	3.0
Line10	7594391	(L1=3, HRV=700)	37	Dec 22 2007	Jan 16 2008	-	3.0
Line10	7714485	Threshold and HV SCAN	38	Jan 18 2008	Feb 3 2008	-	3.0
Line10	8075458	tuned threshold and HV	153	Jan 31 2008	Feb 27 2008	-	3.0
Line9	10282144	(3Dscan+2T3)	304	Feb 27 2008	Apr 25 2008	1	3.0
Line9	10701435	(3N+2T3+ExtSumm) SCAN	88	Mar 11 2008	May 23 2008	1	3.0
Line12	10764491	(th2 10 p.e.)	353	May 23 2008	Oct 7 2008	1	10.0
Line12	13034964	(th2 3 p.e.)	200	Jun 9 2008	Oct 30 2008	1	3.0
Line12	15900745	trig0th and HV SCAN	30	Jun 22 2008	Sep 16 2008	1	10.0
Line12	16718567	(th2 3pe, old L0 thresholds)	72	Oct 7 2008	Oct 13 2008	1	3.0
Line12	17144211	- Noisy channels treated	302	Nov 4 2008	Dec 29 2008	1	3.0
Line12	17149551	(3N+1T2) SCAN	2	Nov 15 2008	Nov 21 2008	1	3.0
Line12	17247711	- Noisy channels treated + Galac	29	Dec 11 2008	Dec 30 2008	1	3.0

five-line data



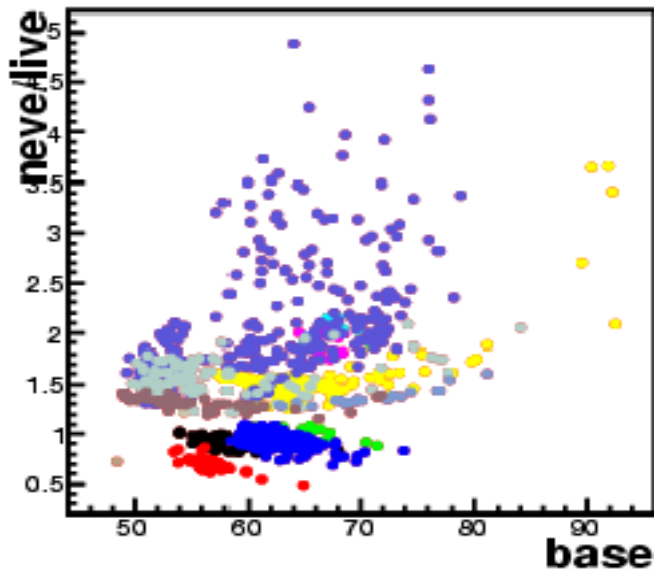
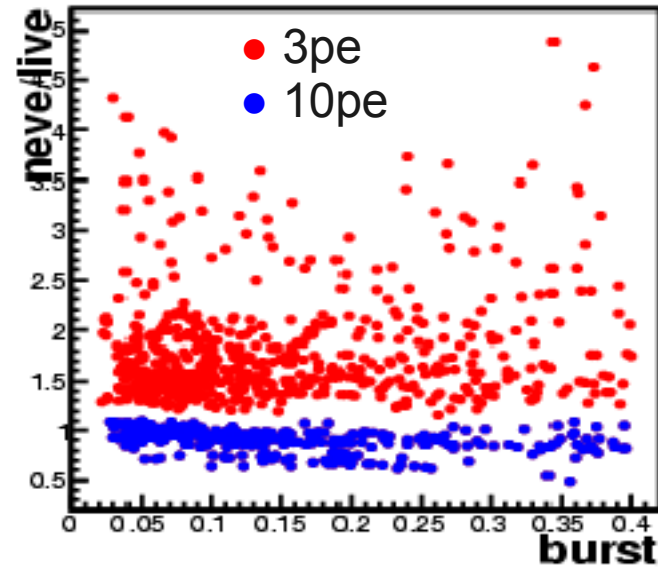
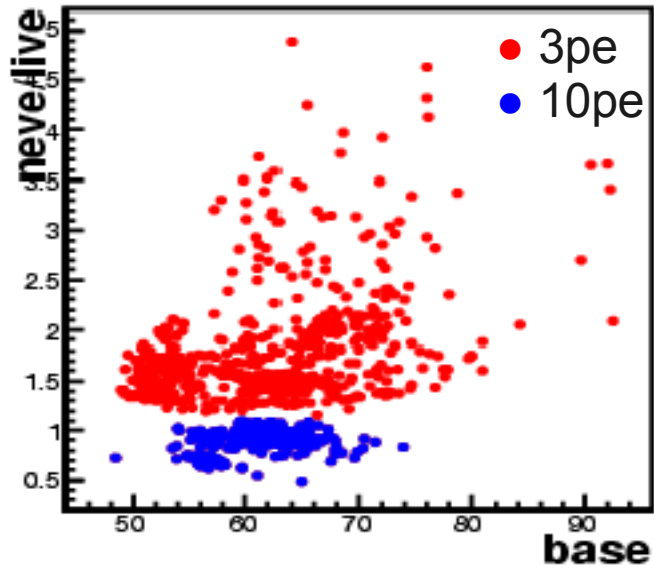
3D trigger in data, but not in MC
remove 3D: better agreement in shape,
worse agreement in rate \rightarrow factor 2

five-line data



3D trigger in data, but not in MC
 remove 3D: better agreement in shape,
 worse agreement in rate \rightarrow factor 2

five-line data

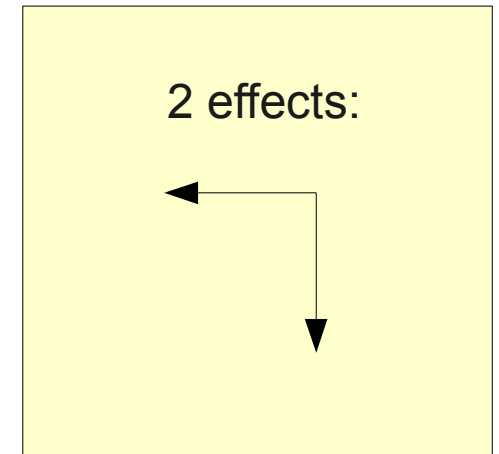
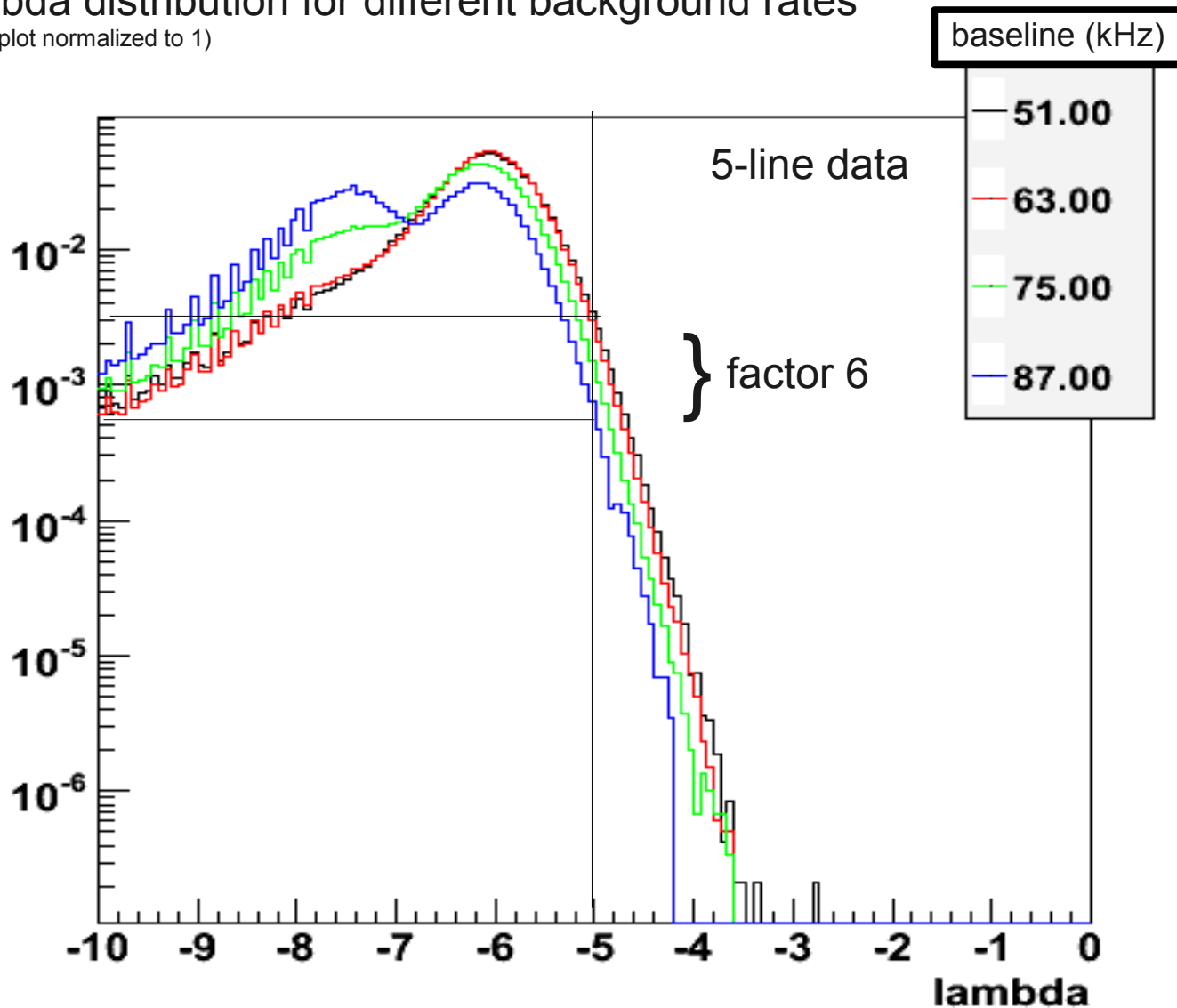


Large variation in reconstruction rate

- high-threshold has big influence on rec. rate
count rates have marginal influence
(but see next slide)
- strong dependency on runsetup
 - not clear why (hv settings ?)

five-line data

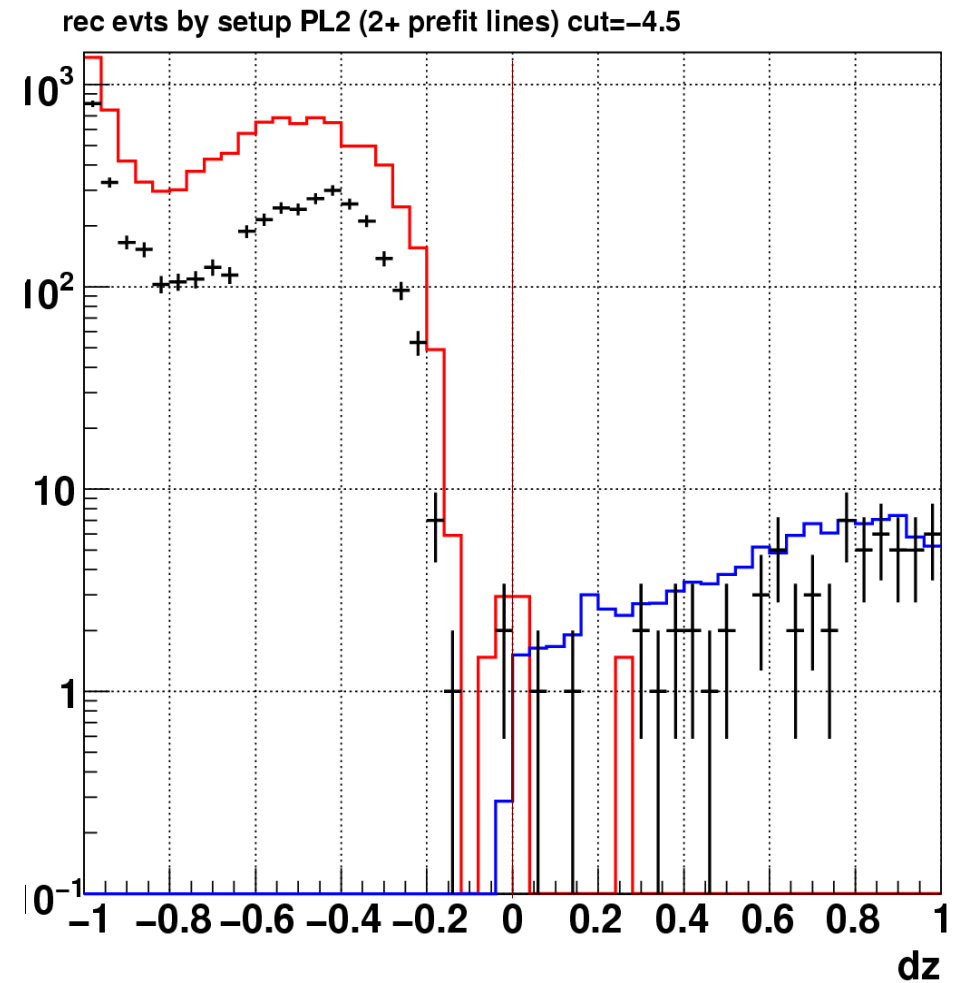
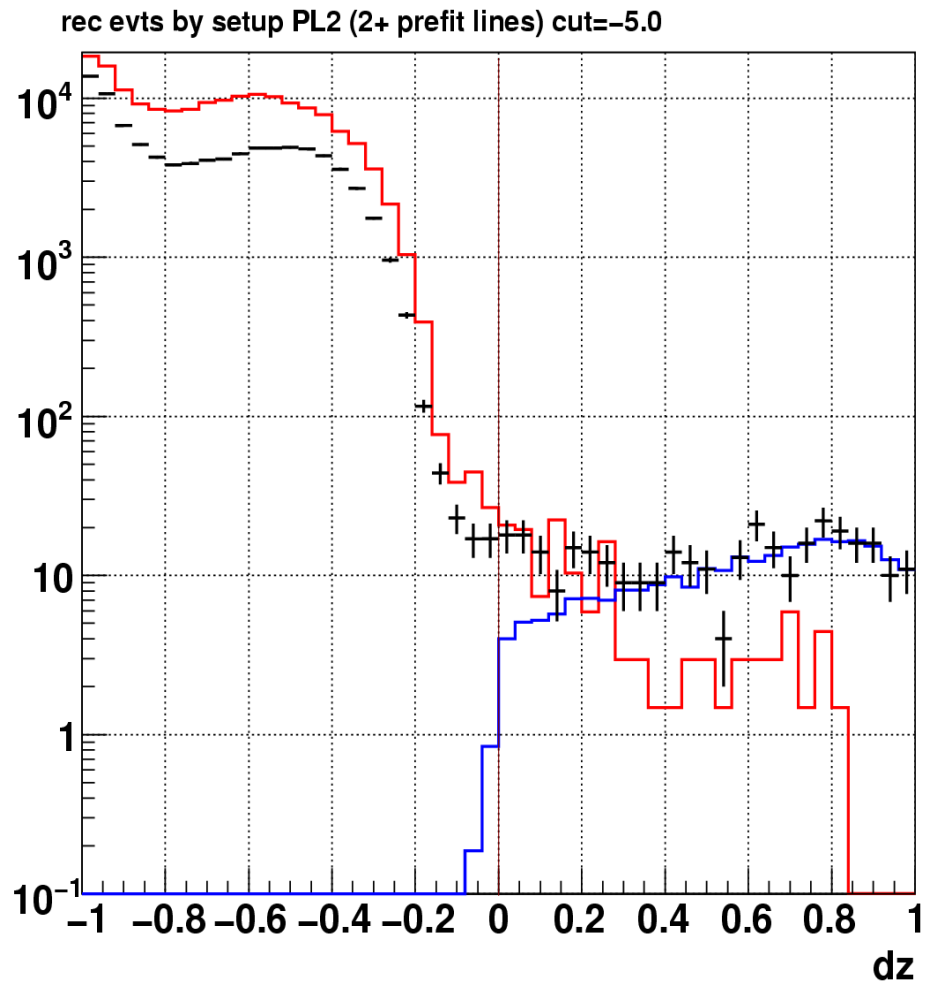
lambda distribution for different background rates
(each plot normalized to 1)



conclusion:

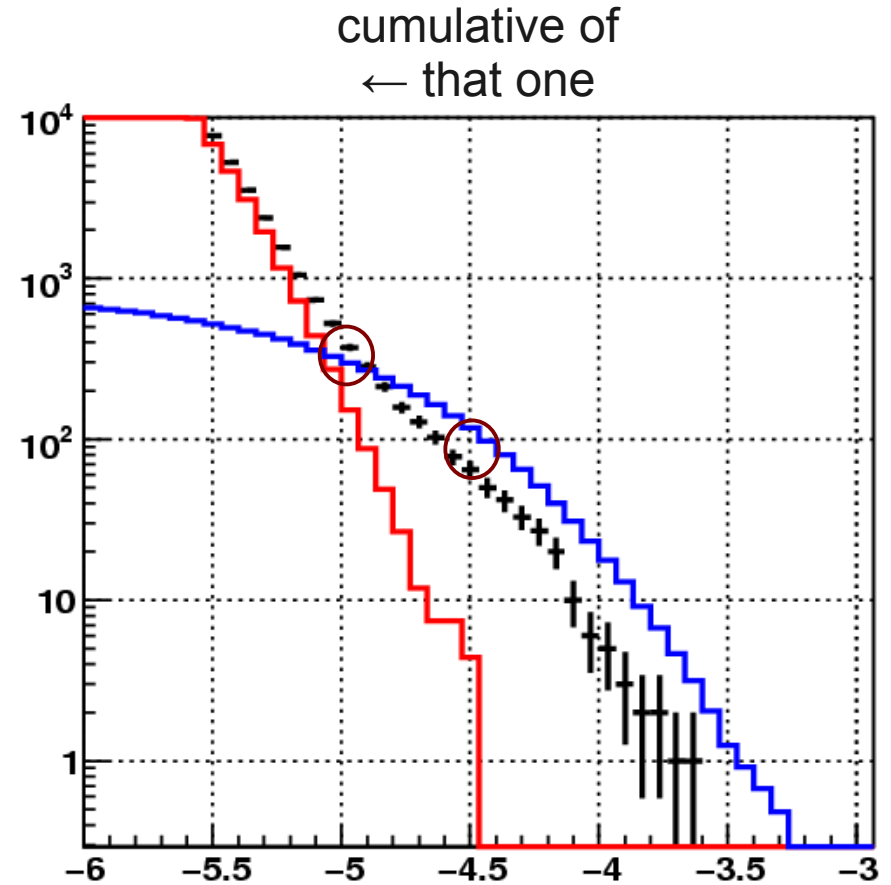
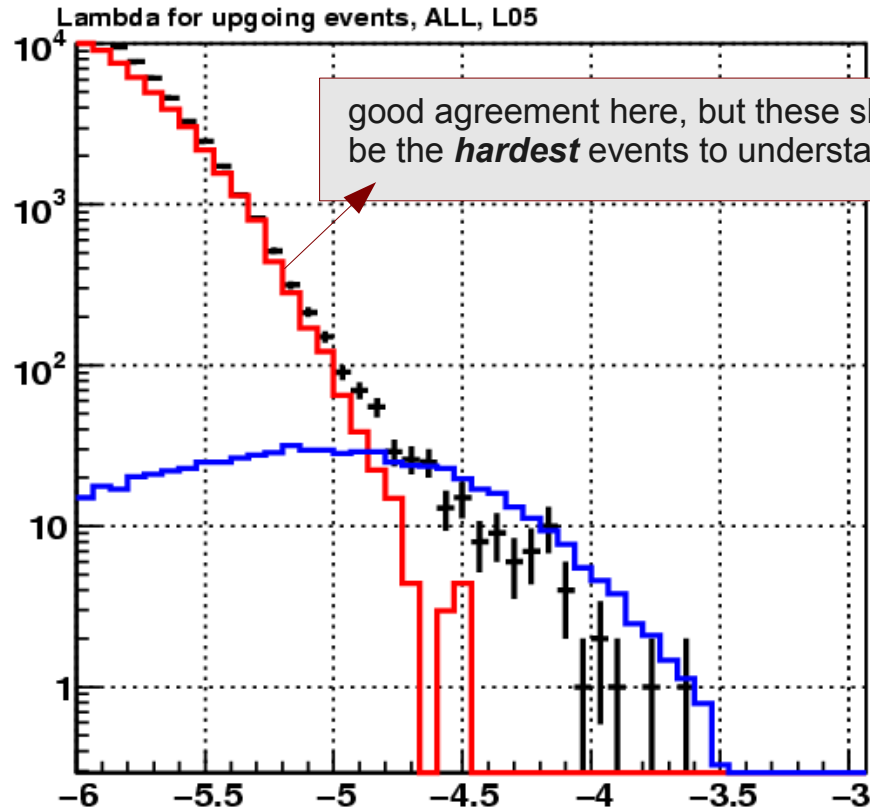
- run-by-run mc would be *great*.
- revisit lambda (?)

five-line data



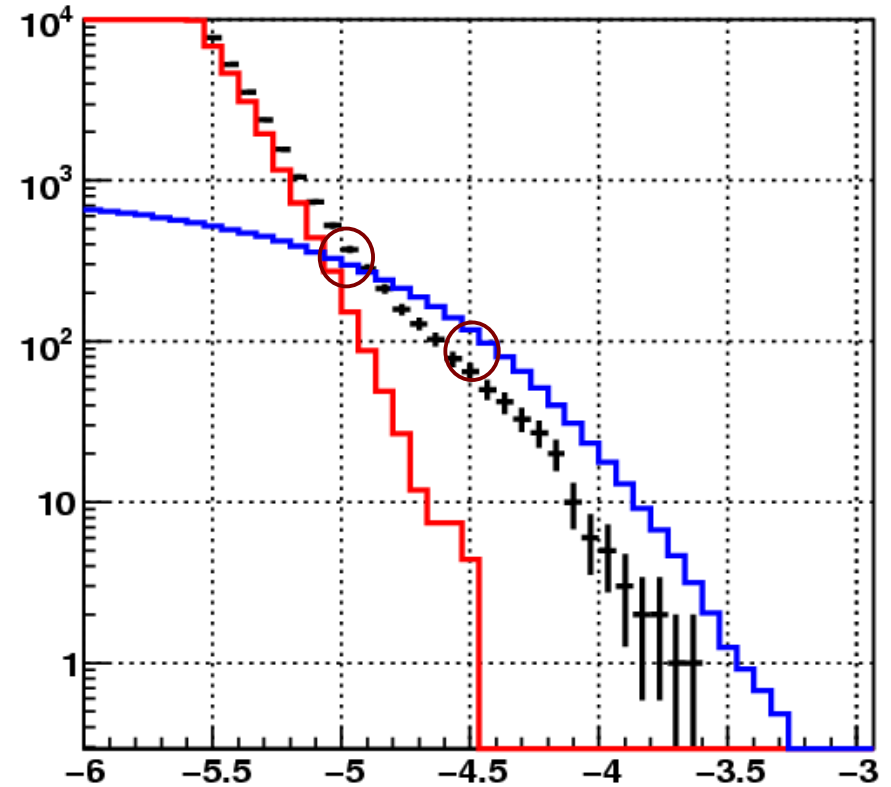
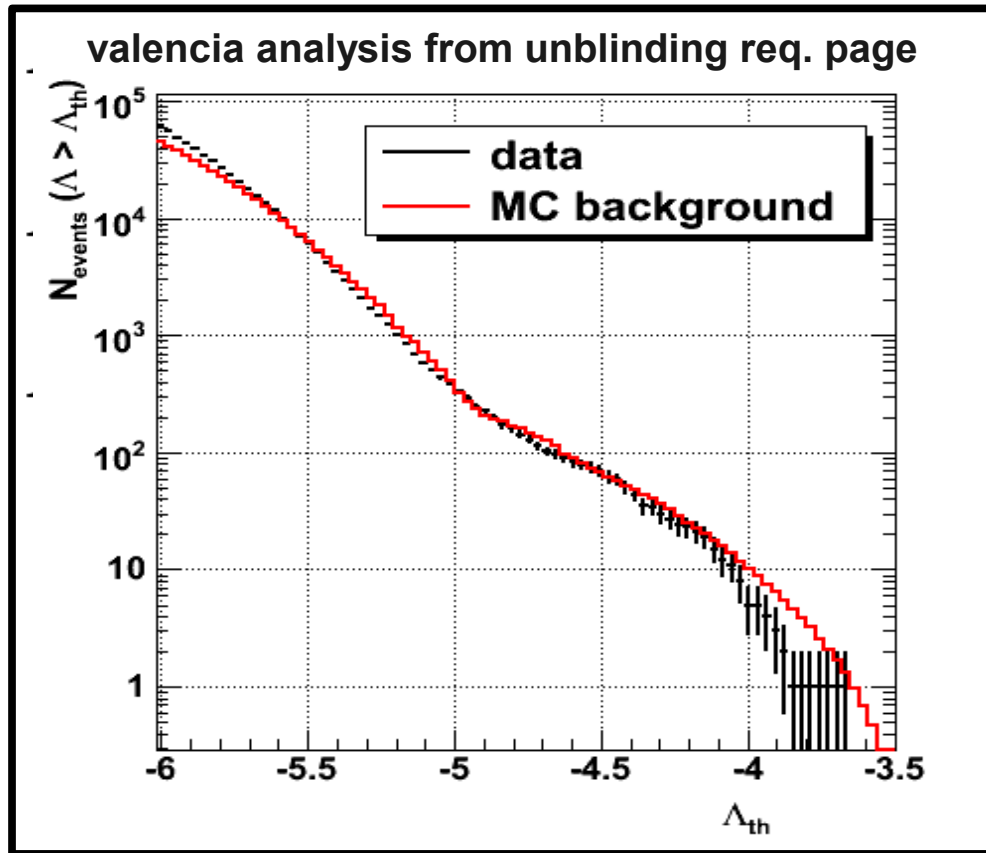
discrepancy at high likelihood values

five-line data



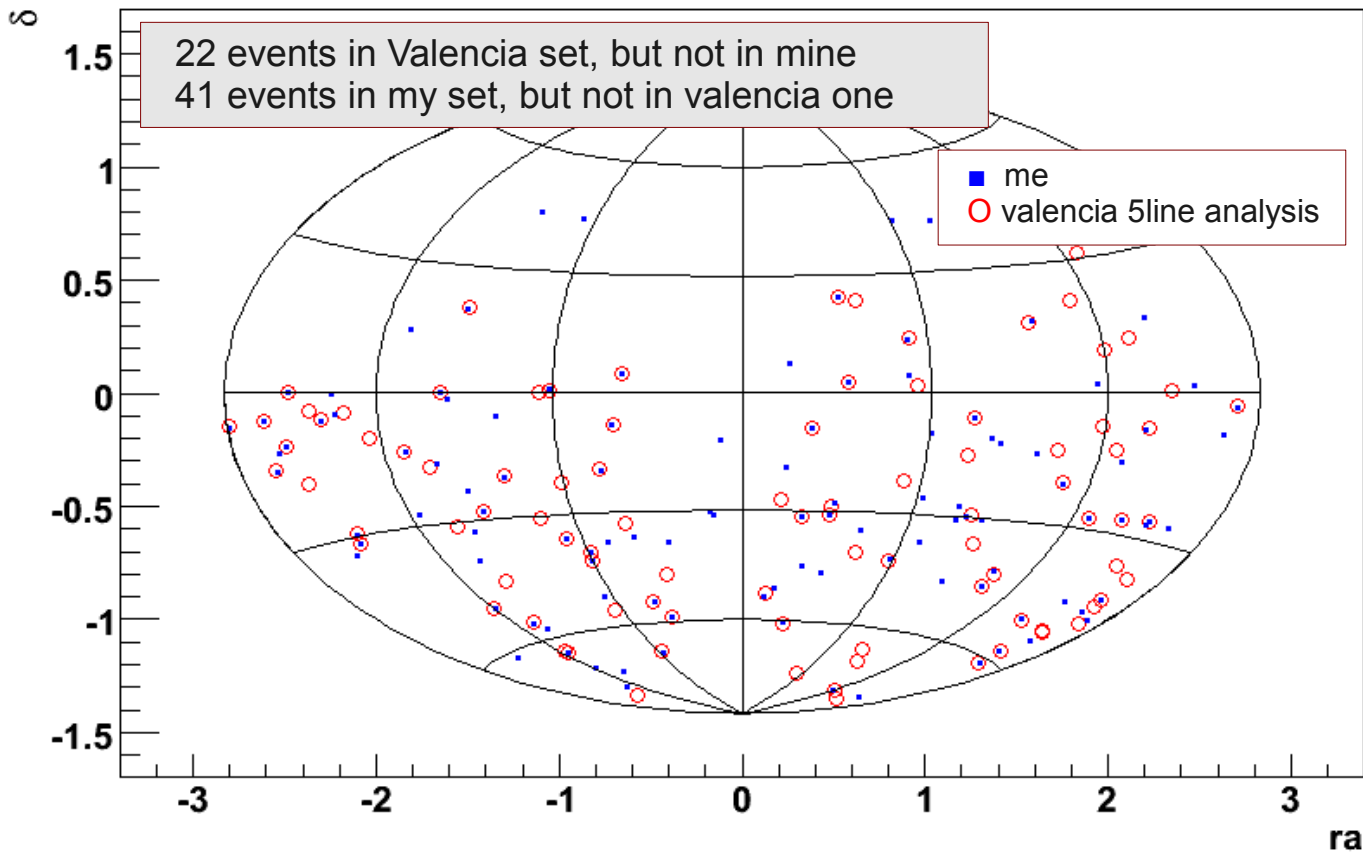
- data ~agree with Valencia analysis (more on that later)
- mupage MC gives ~good description of mu-bg in this plot
- large discrepancy of neutrino MC with data

five-line data



- data ~agree with Valencia analysis (more on that later)
- mupage MC gives ~good description of mu-bg in this plot
- large discrepancy of neutrino MC with data
and with Valencia neutrino MC → under investigation

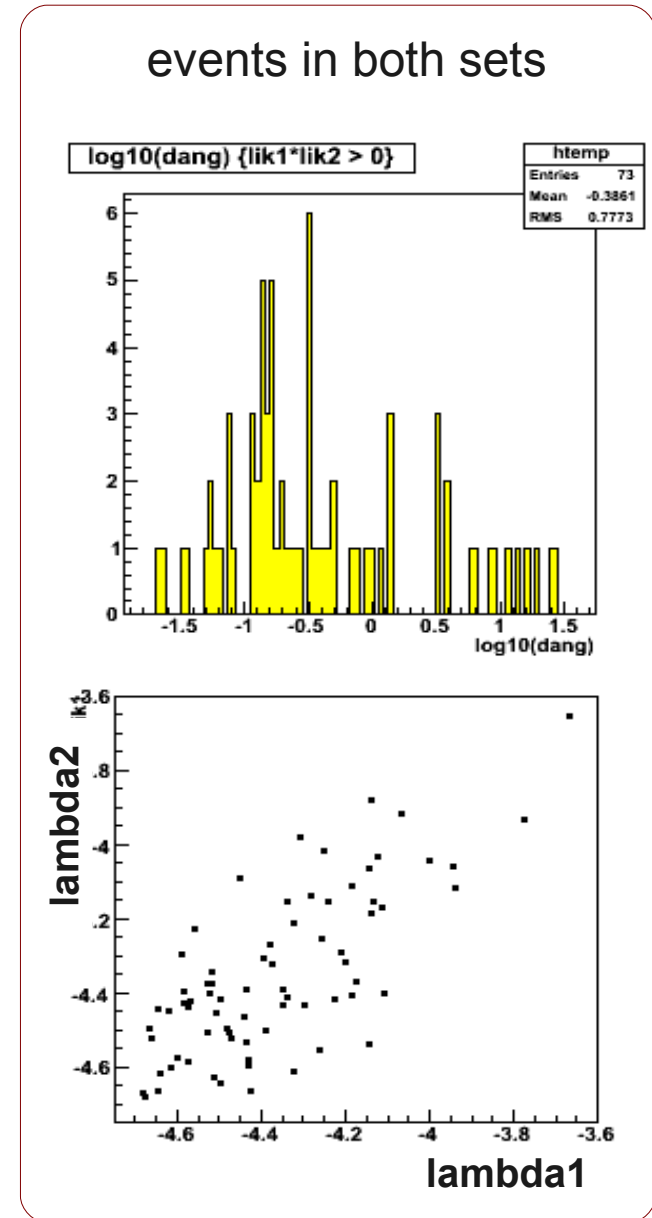
five-line data : skyplot for $\Lambda > -4.7$



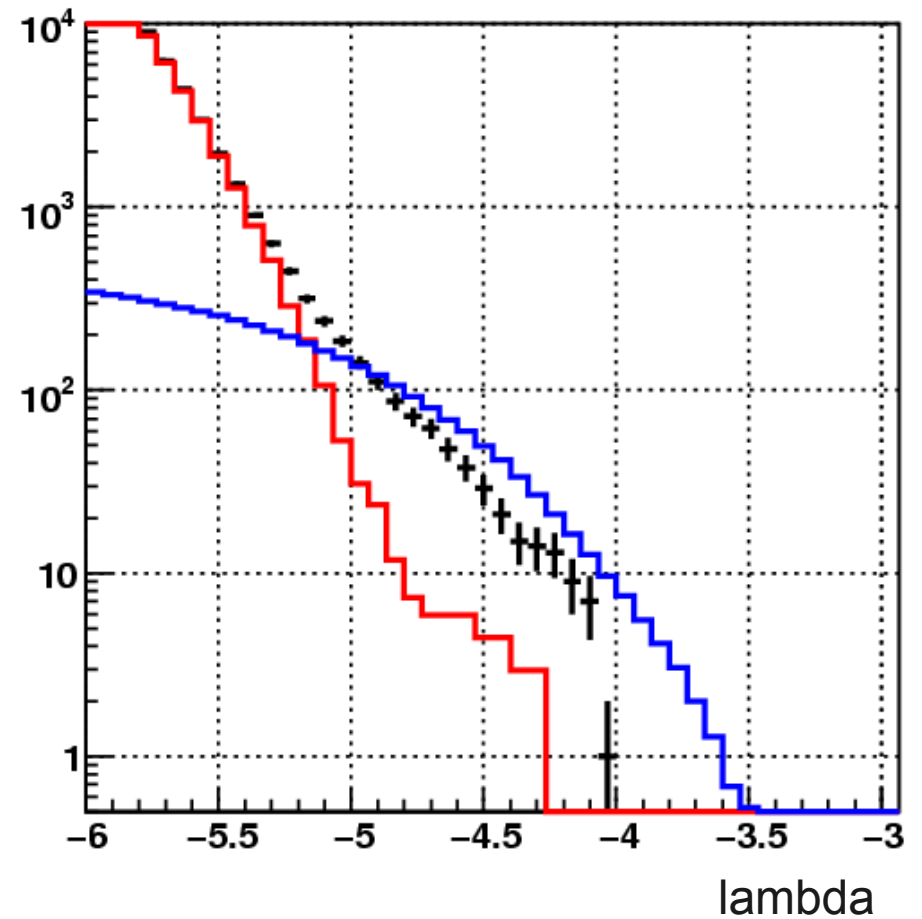
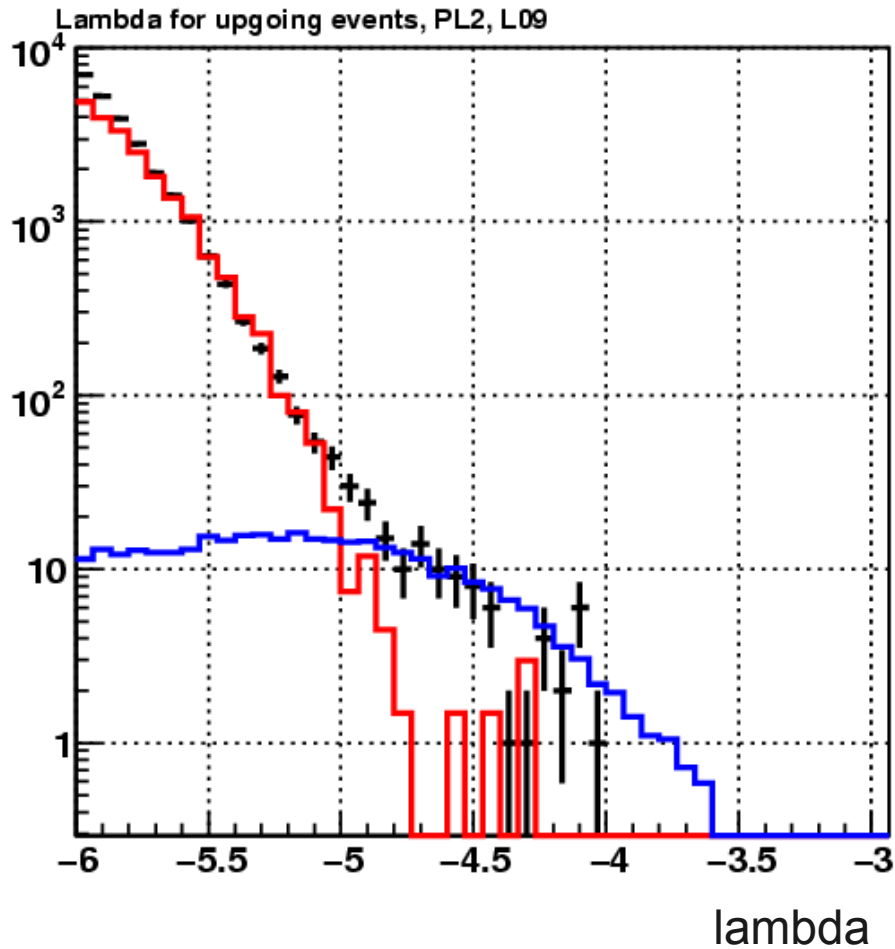
with loose (-5.5) lambda cut:

3 events from valencia set still not found in mine

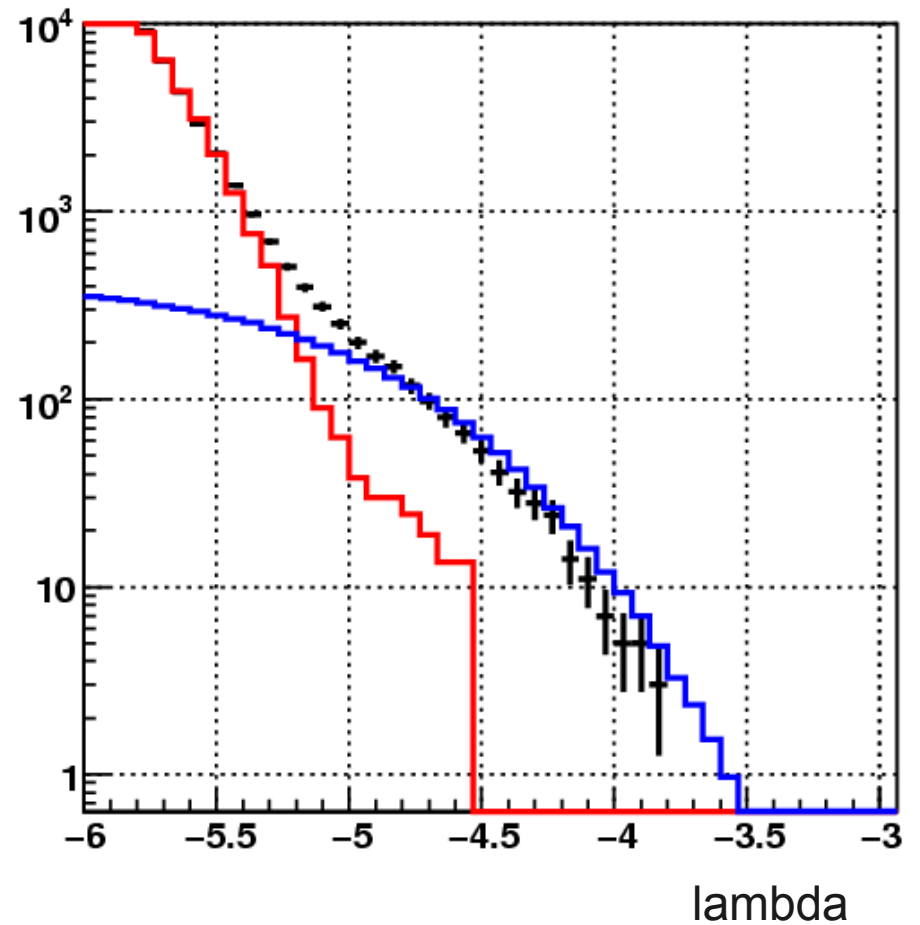
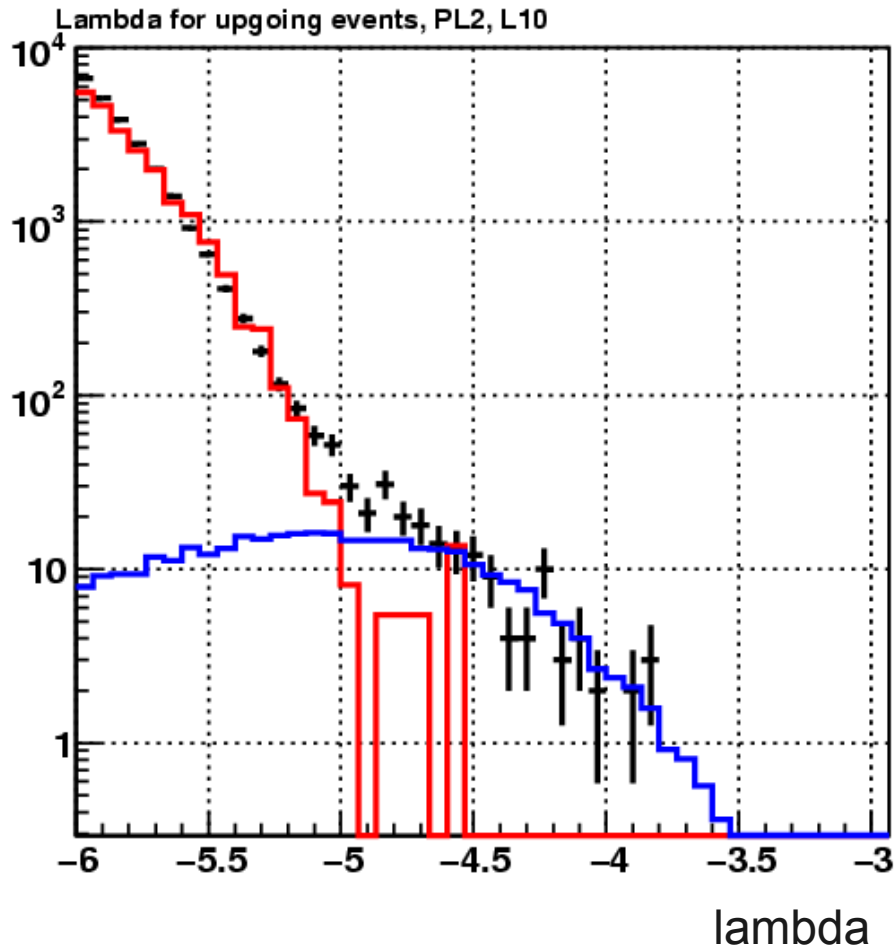
→ coordinate calculations agree, but difference in reconstruction do to calreal/calibration (?) version



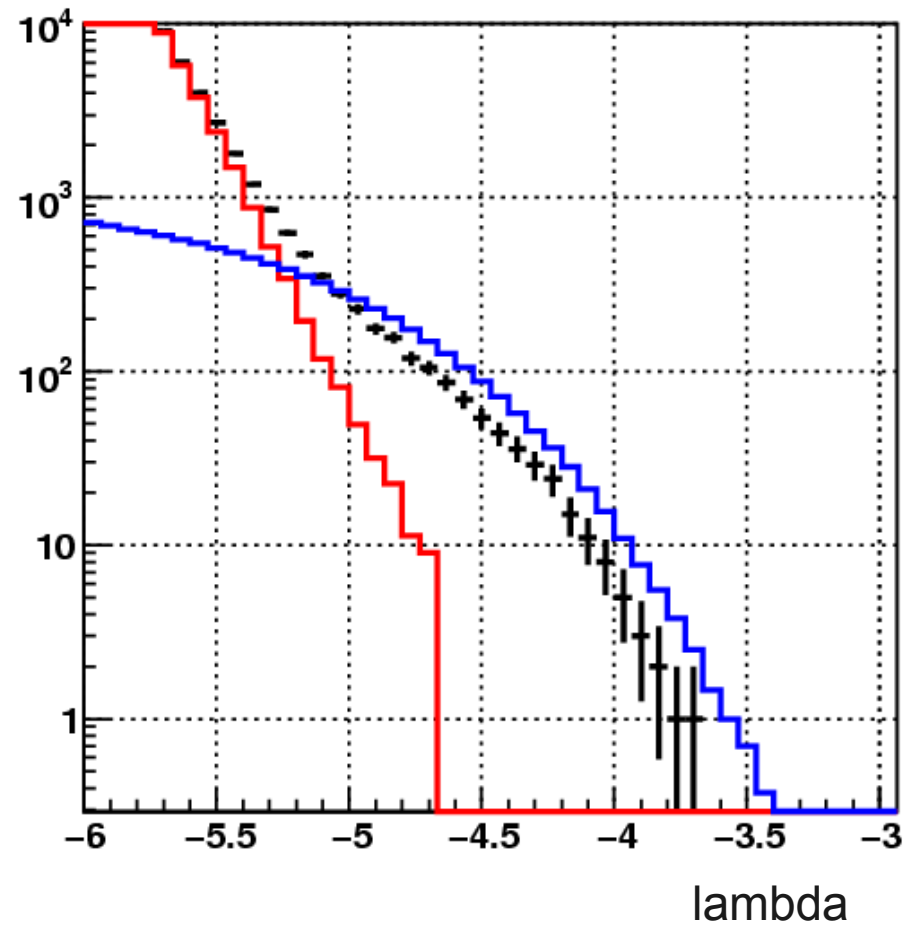
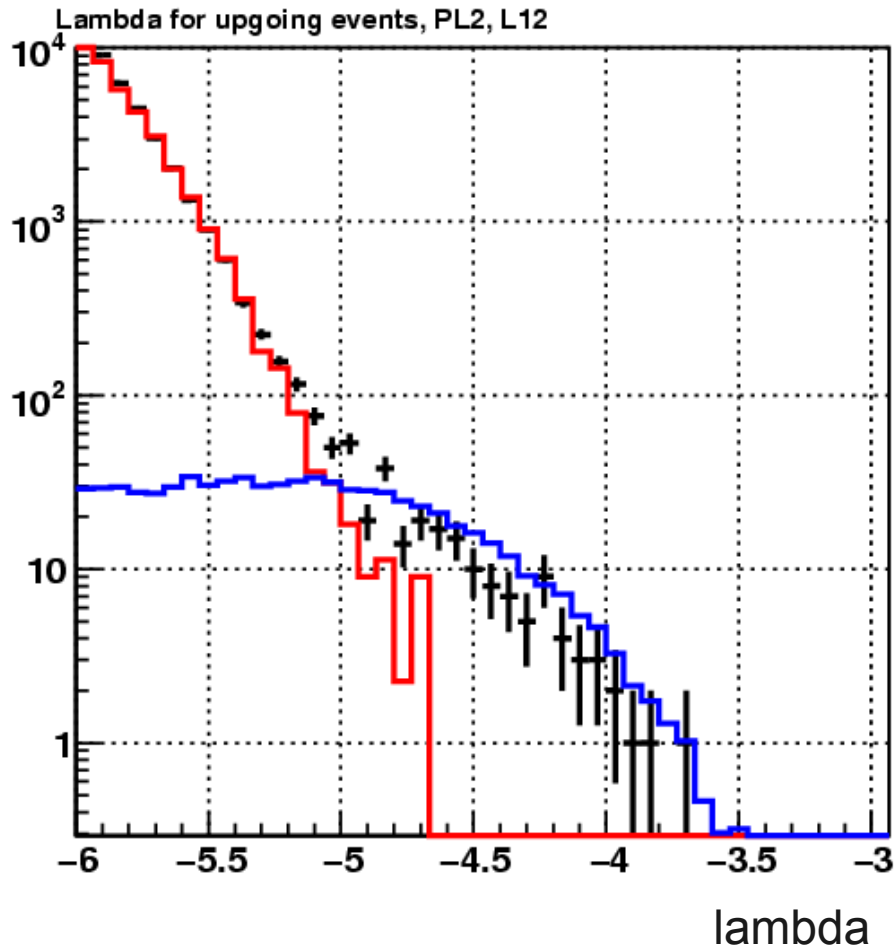
upgoing lambda plot : 9-line data



upgoing lambda plot : 10-line data



upgoing lambda plot : 12-line data

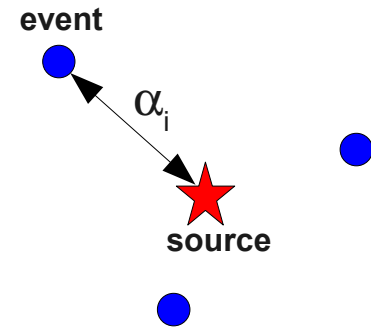


Search Algorithm

simplest possible unbinned likelihood-ratio method

$$\mathcal{L}_{s+b} = \prod_i P_{\text{sig}}(ra_i, \delta_i | \text{source}) + P_{bg}(\delta_i)$$

$$P_{\text{sig}} = N_{\text{sig}} \times PSF(\alpha_i)$$



Three/one free parameters:

- coordinates of the true source
- intensity of the source

Three ingredients:

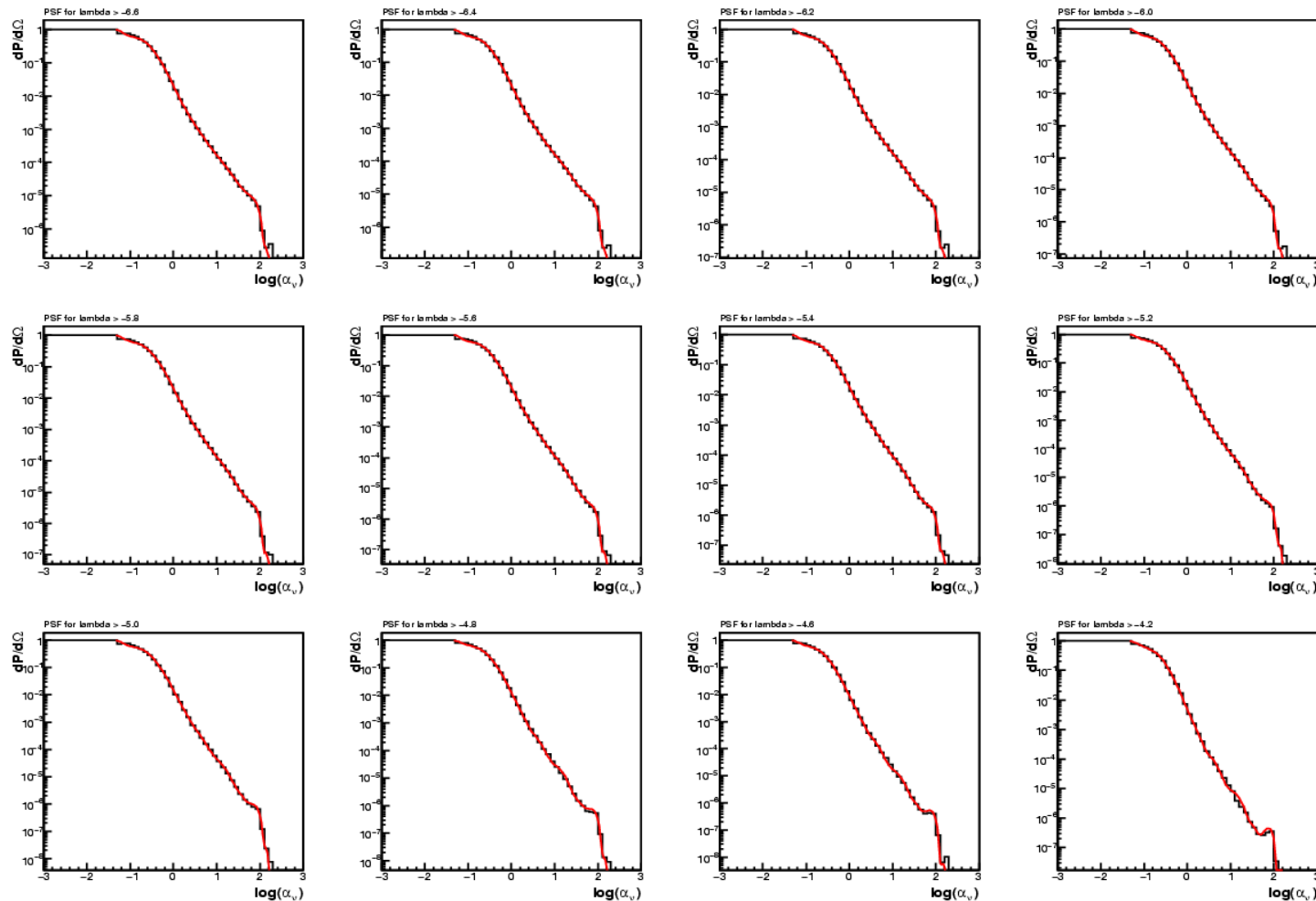
- Point spread function
- Background rate
- Acceptance (only to relate N_{sig} to a flux)

- pre-clustering to increase speed
 - for fixed point: fit is done on all events in 20 deg cone
- all angles computed by dot-product → no troubles at $\delta=-90$ or $ra=+/- 180$

Ingredients : PSF

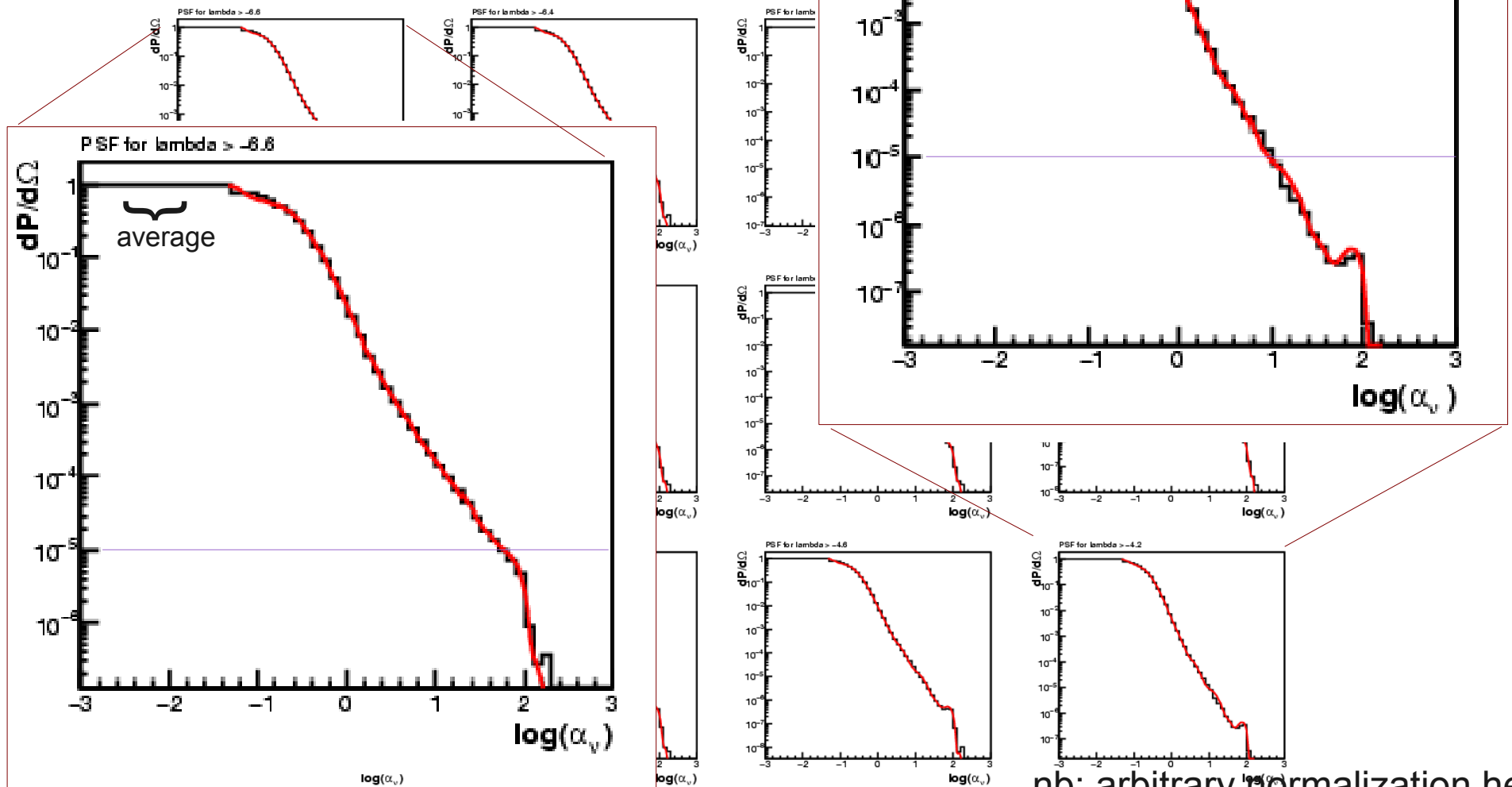
used:

- for generating pseudo-experiments
- in computing the likelihood for signal: need smooth function \rightarrow spline fit



Ingredients : PSF

take care of smooth behaviour near $a = 0$
 → no sharp peaks in likelihood func. (differentiable)

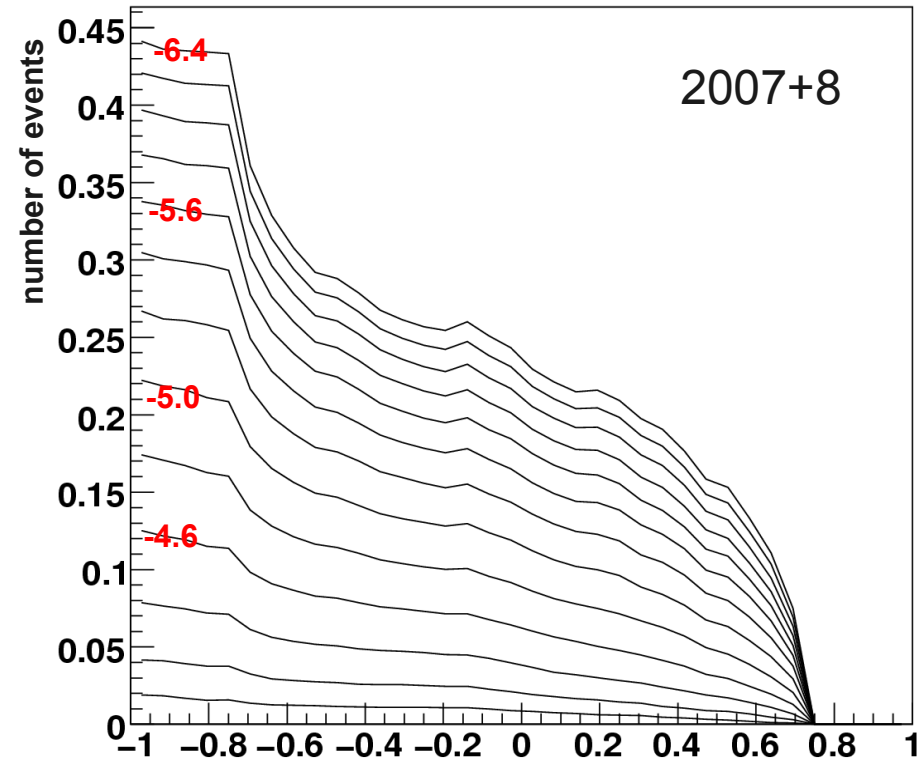
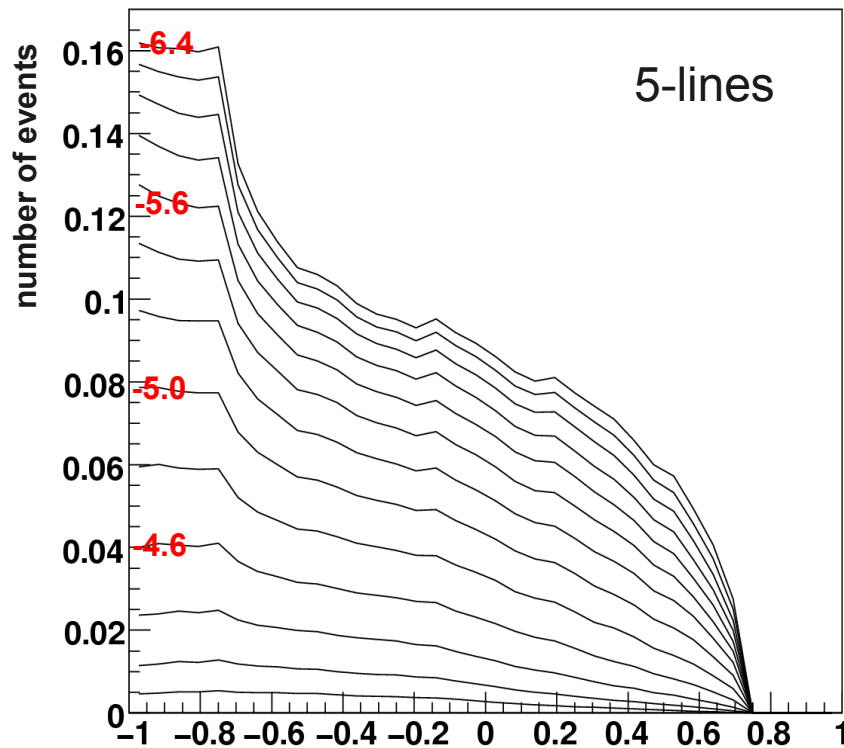


nb: arbitrary normalization here

Ingredients: Acceptance / effective area

number of detected events for flux (50-50 mix of ν and $\bar{\nu}$):

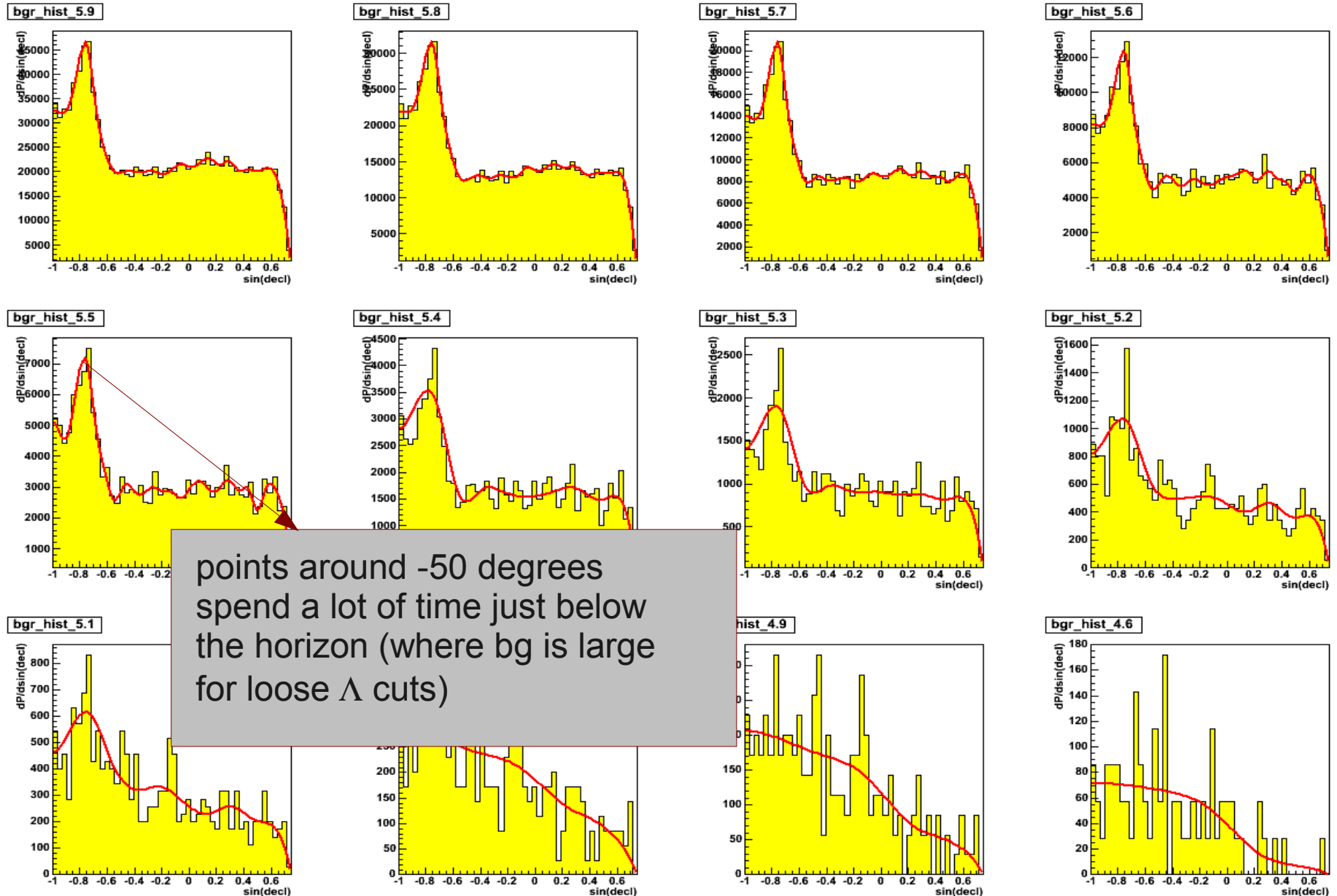
$$\frac{d\Phi_\nu}{dE} + \frac{d\Phi_{\bar{\nu}}}{dE} = 10^{-8} (E/\text{GeV})^{-2} \text{GeV}^{-1} \text{cm}^{-2} \text{s}^{-1}$$



from limit on #events, flux limits follow from simple scaling.

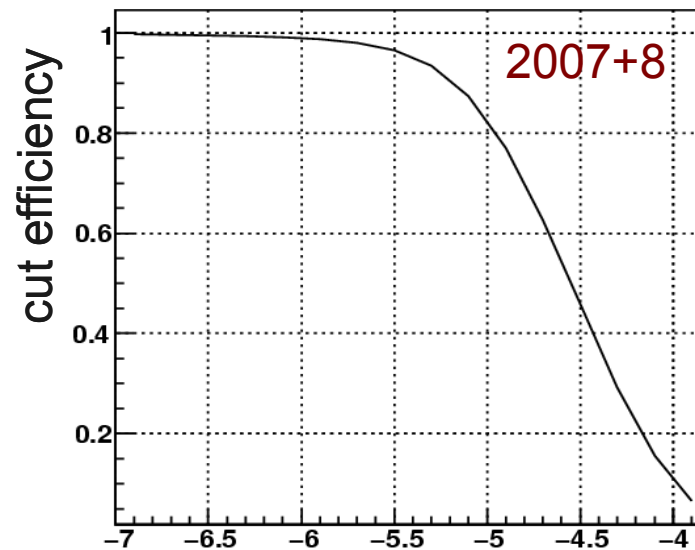
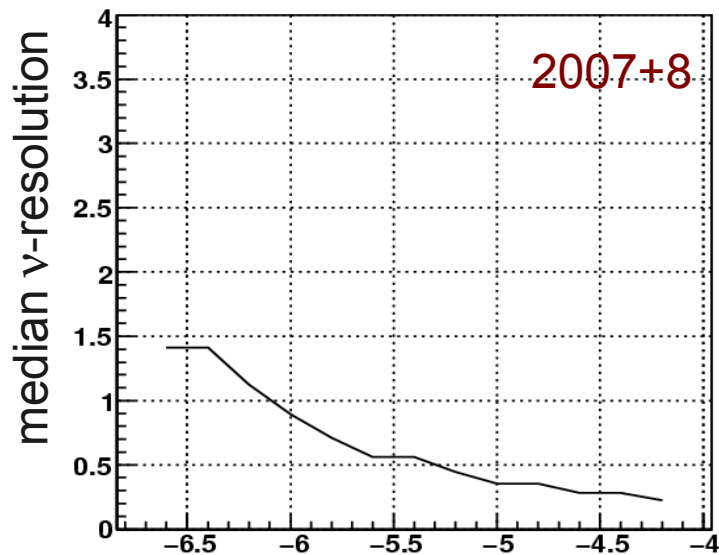
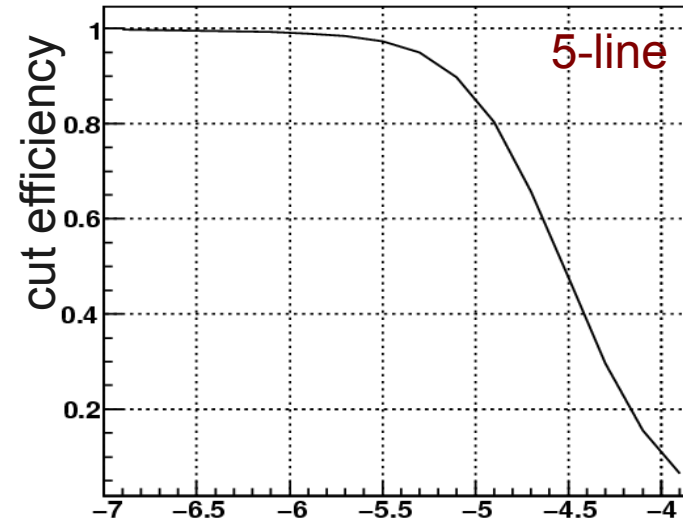
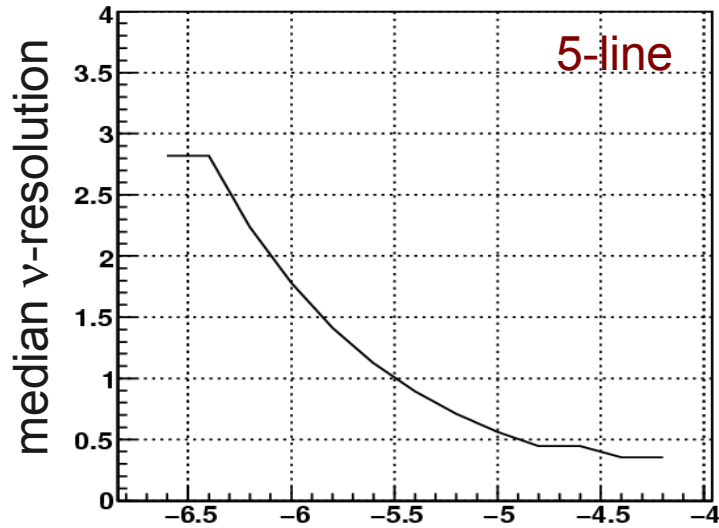
Ingredients: Background model

spline fit to data
low granularity for stringent Λ cuts



points around -50 degrees
spend a lot of time just below
the horizon (where bg is large
for loose Λ cuts)

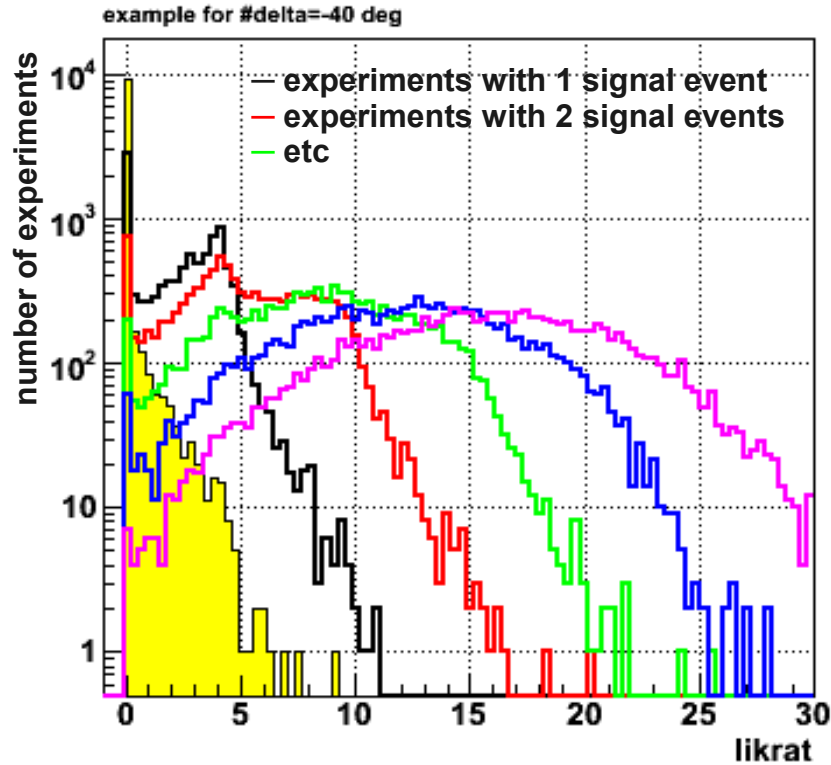
Performance (E^{-2} spectrum)



Λ

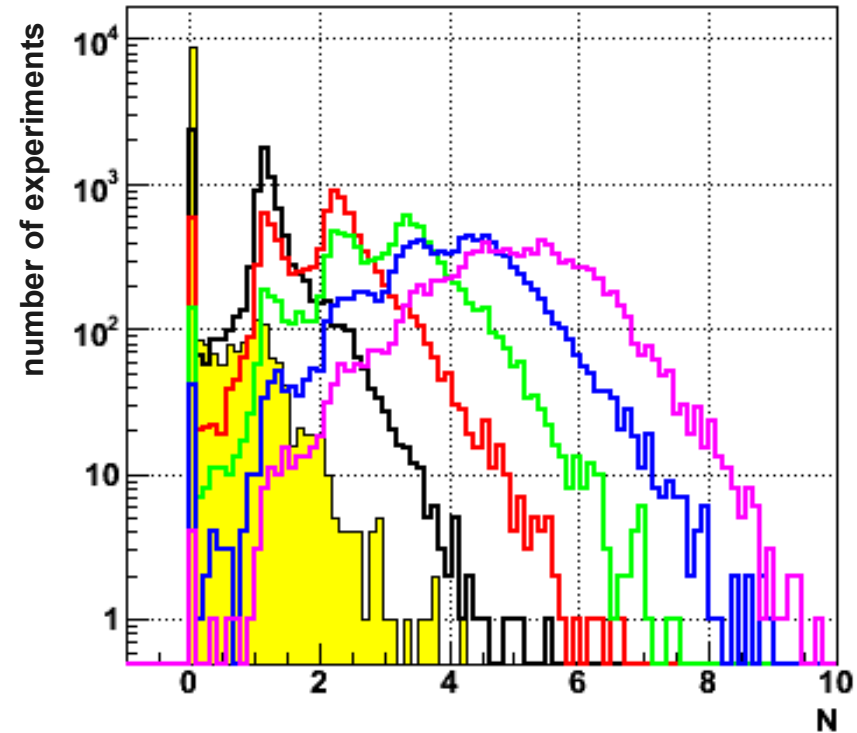
Search Algorithm

example: L05 experiments for $\delta = -40$, $\Lambda > -5.0$



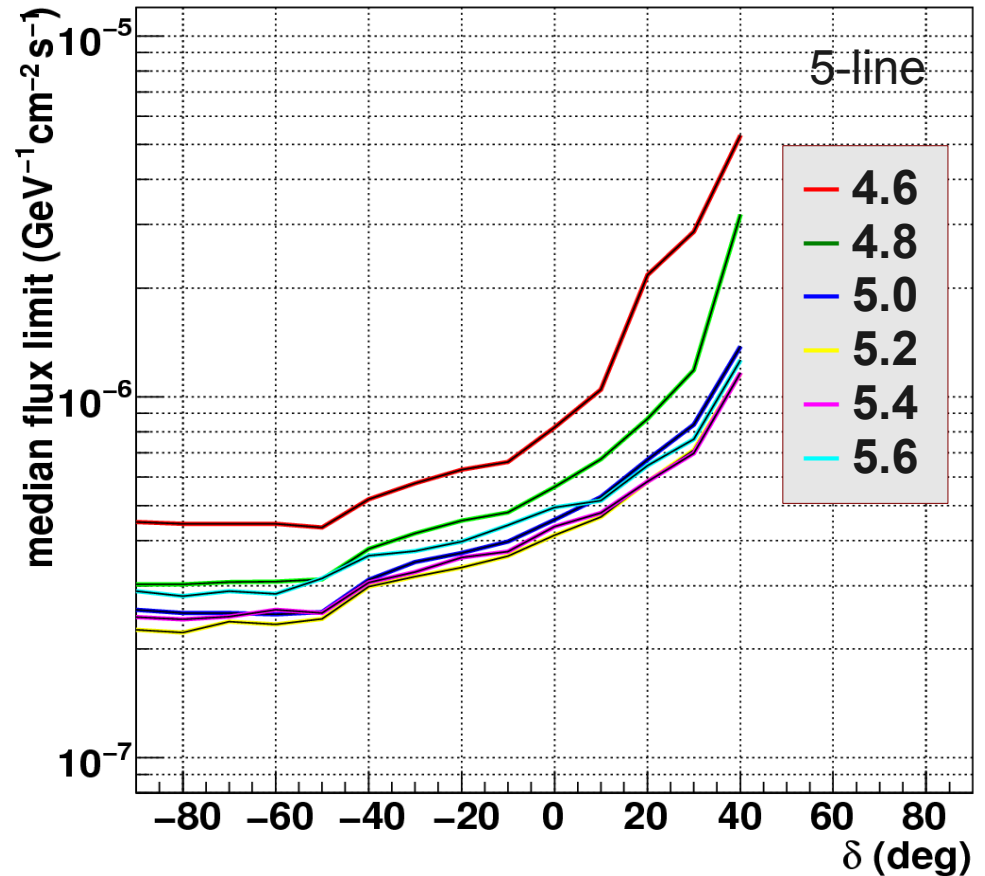
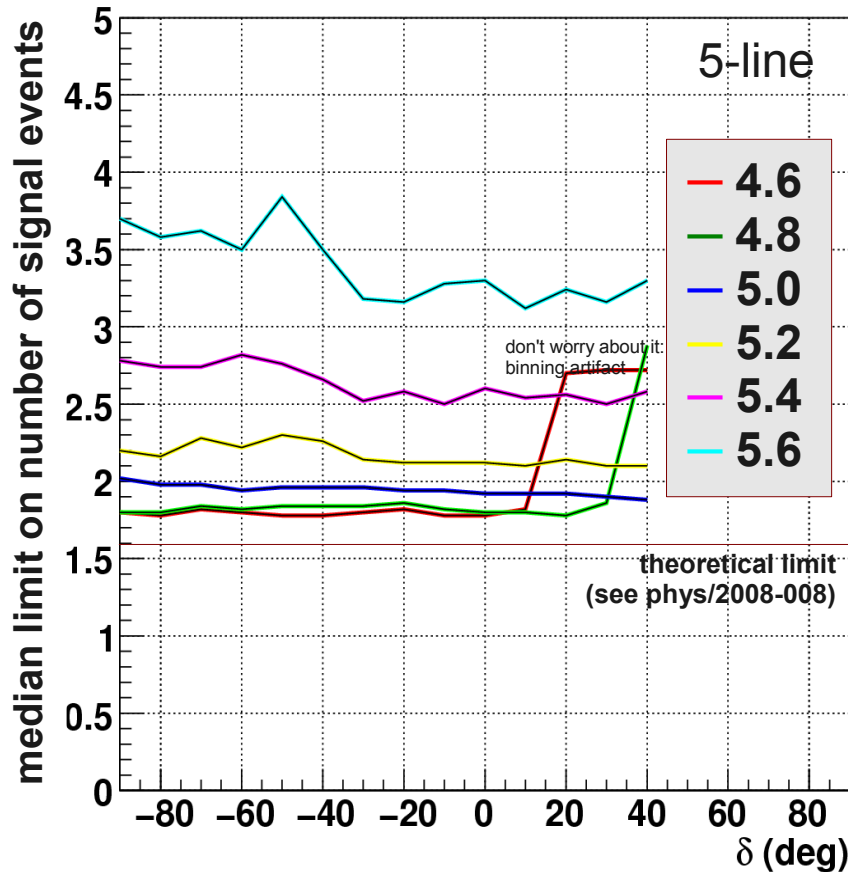
$$\text{likrat} = \log \left(\frac{\mathcal{L}_{s+b}}{\mathcal{L}_b} \right)$$

used as test statistic



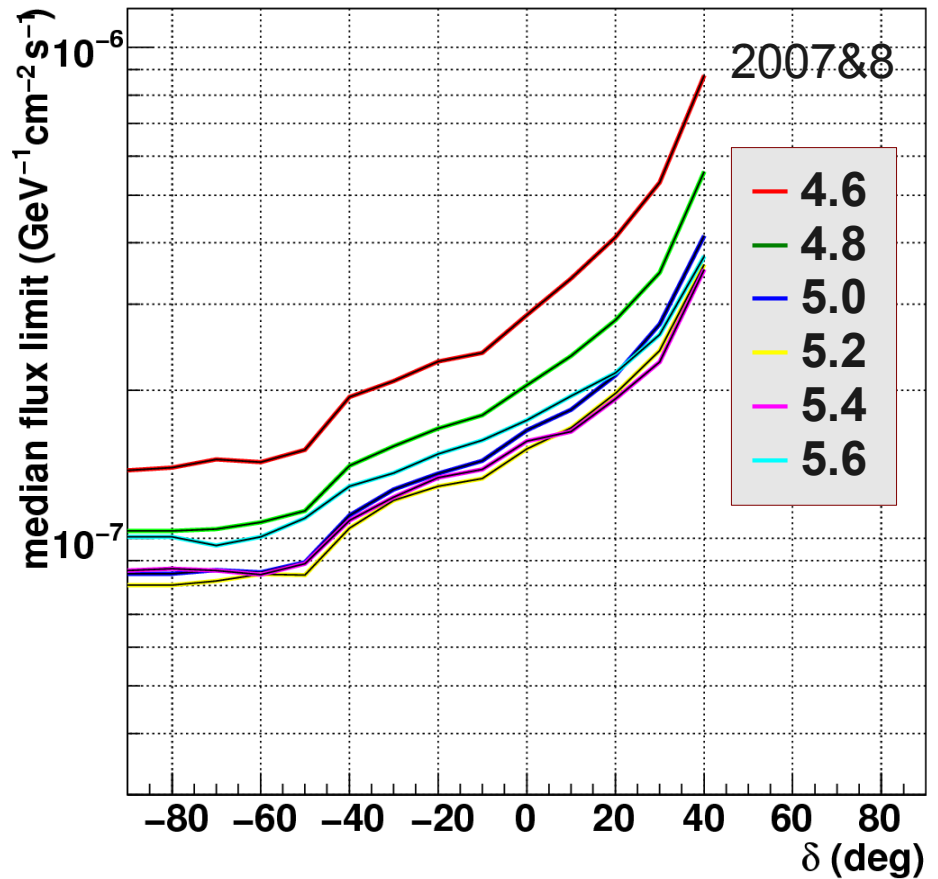
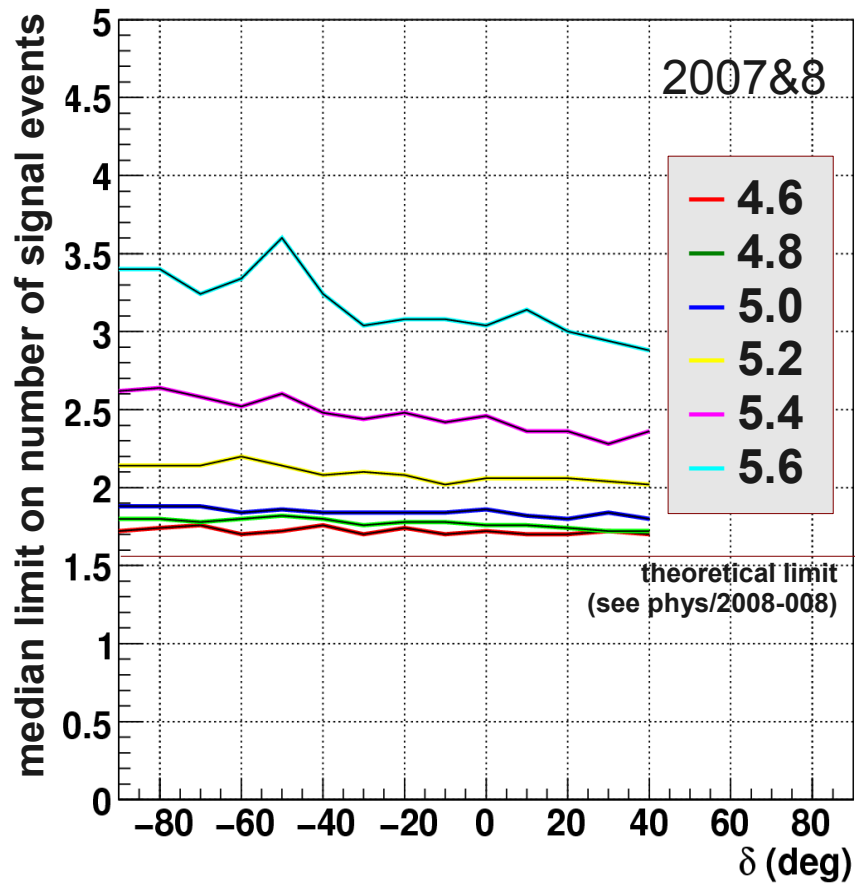
fitter finds correct number of signal events

Sensitivity / expected limit



- Good agreement with Valencia analysis
- Can get 20% better limits by optimizing Λ cut, **and**
e.g: cut at -5.4 is factor 2 more efficient for E^{-2} neutrinos... (1.5 for $\alpha_\nu < 1$ deg)

Sensitivity / expected limit



optimal cut ~same as 5-line data

Summary / Plans

- Machinery for point source search fully set up
- Todo (short term):
 - further understand data/mc (dis)agreement
 - add systematics in limit computation
 - include effect of signal leaking into background model (important at pole)
 - study discovery potential / full sky search