Sensitivities with 2 and more PID bins

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KM3NeT Group meeting

2019-02-14 (Valentines ♡)

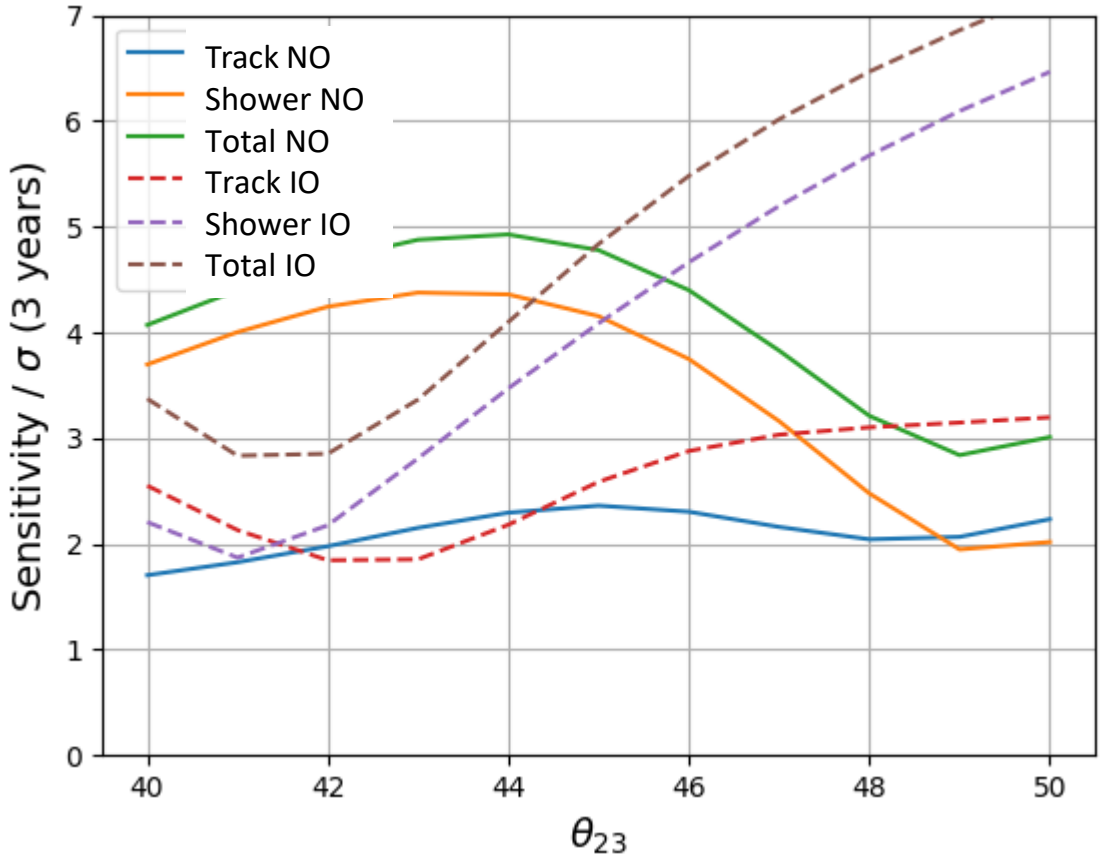
Asimov Sensitivity

"How well can we reject the other hypothesis?“

1. Model(Th12, Th13, Th23, Dm21sq, Dm31sq, Dcp) of #Evts in (E,ct)
2. Use PDG central values for the parameters
3. Evaluate Model(NO-central values) --> This is 'asimov data' or exp.val.
4. Constrain Model to fit only in IO-parameter space and start at IO-central values, fitted parameters: **Dm31sq, Th23**
5. Evaluate Model(IO-fitted values) --> This is what we would see if IO was true, 'fitted data' or exp.val.
6. Calculate Chi2(asimov data, fitted data) --> Sensitivity

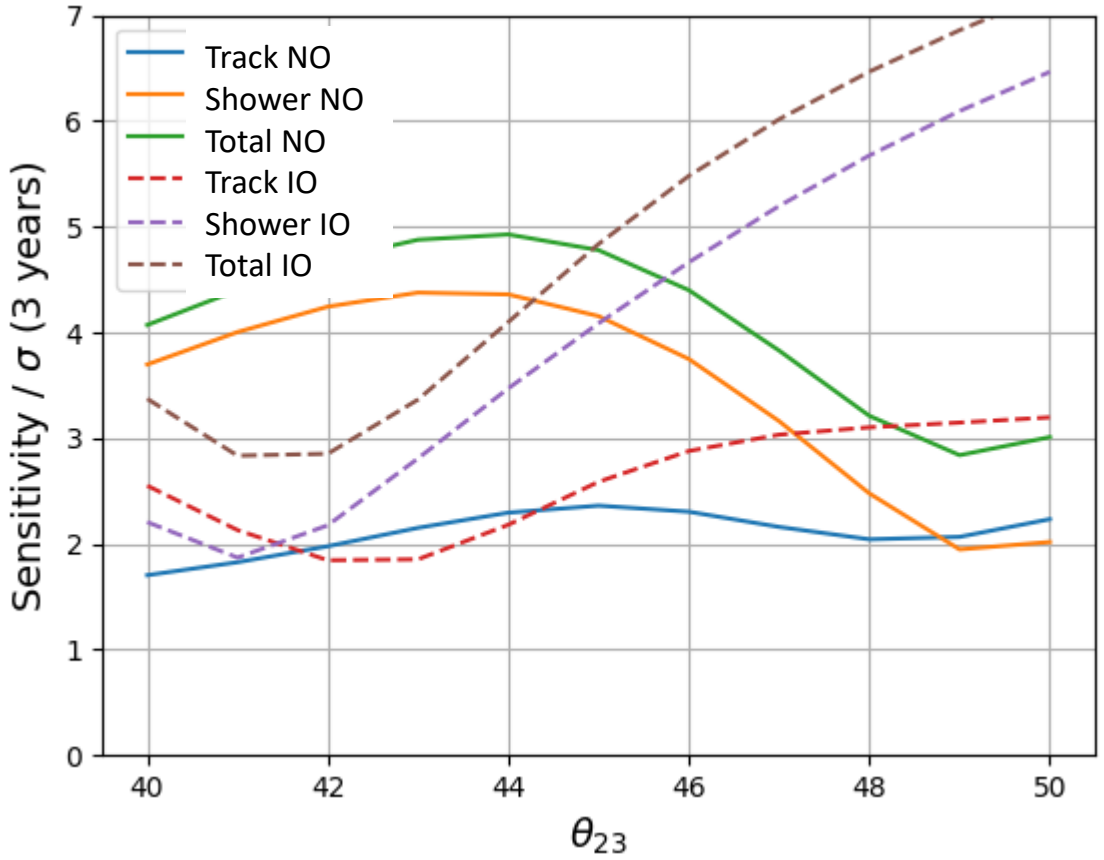
- NB: In the figures, 'NO' means Model fitted in NO parameter space, etc.

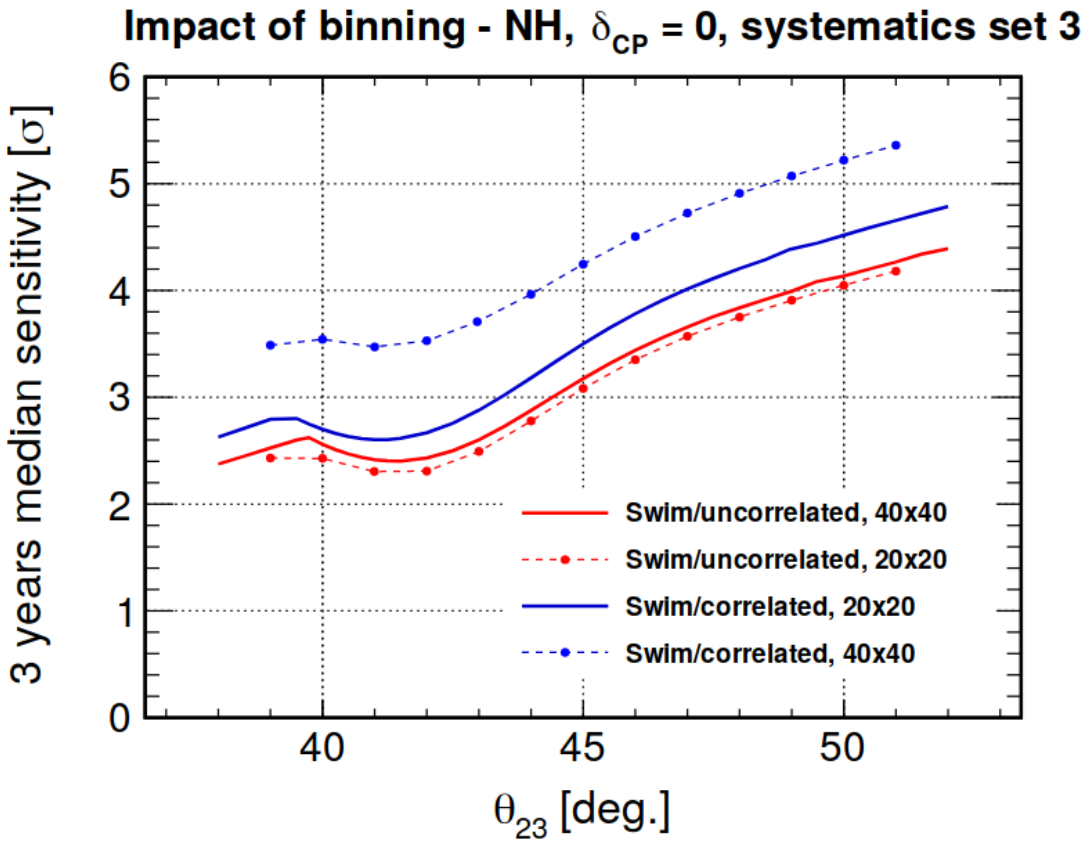
Sensitivity plot 2 pid bins: track and shower
Fit: chi2



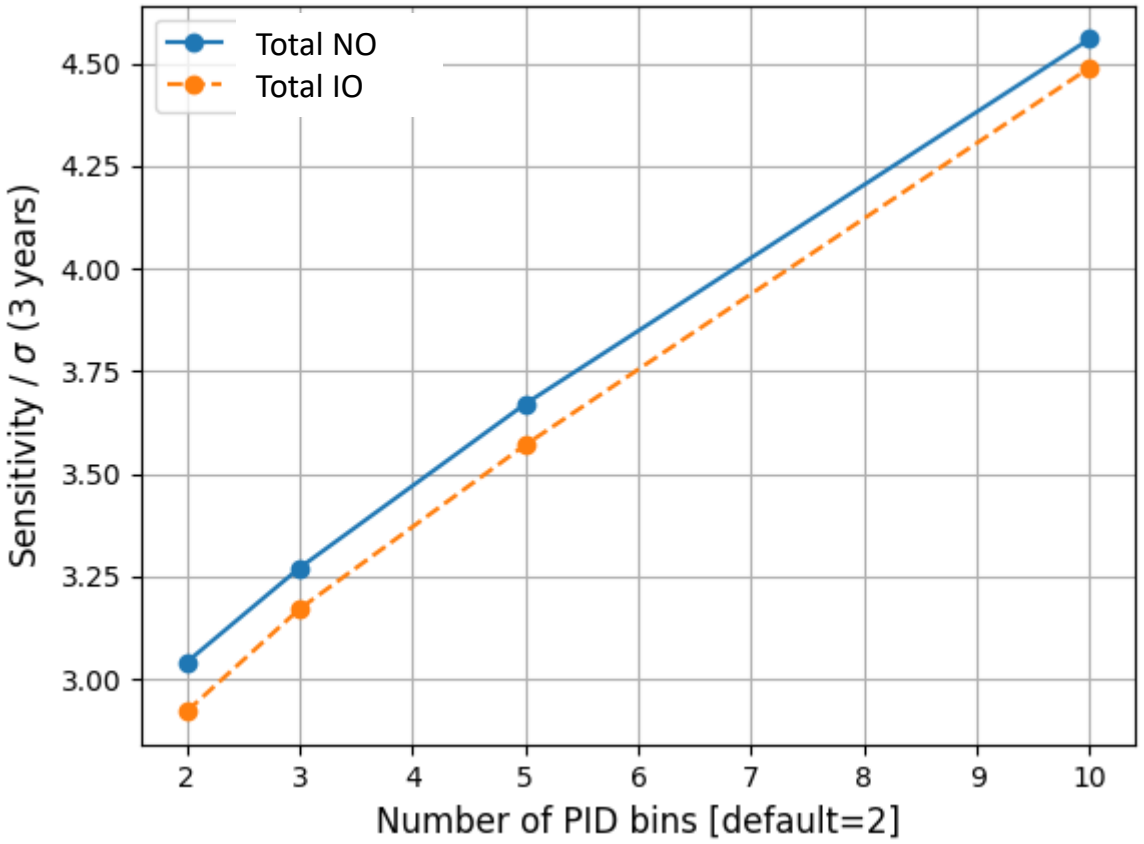
Sensitivity plot 2 pid bins: track and shower
Fit: chi2

Sensitivity SWIM w/ systematics
elog.km3net.de/Analysis/271





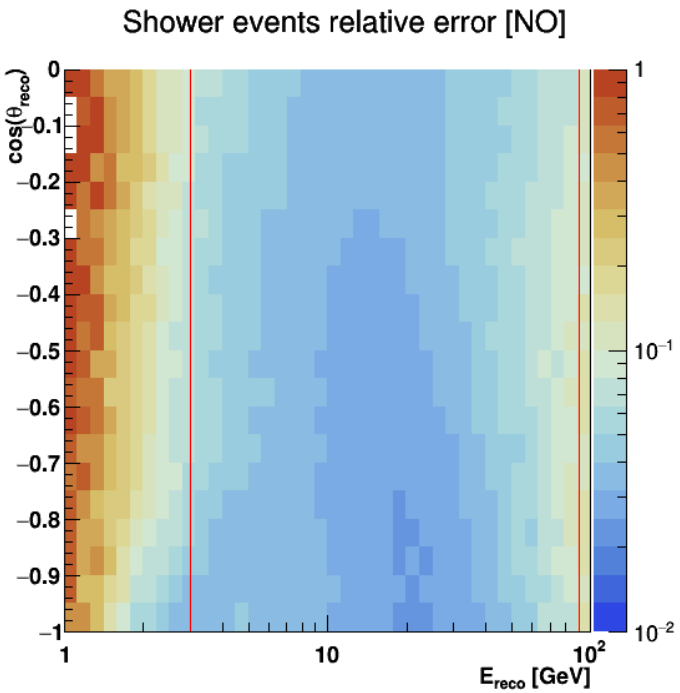
Sensitivity as function of #PID bins

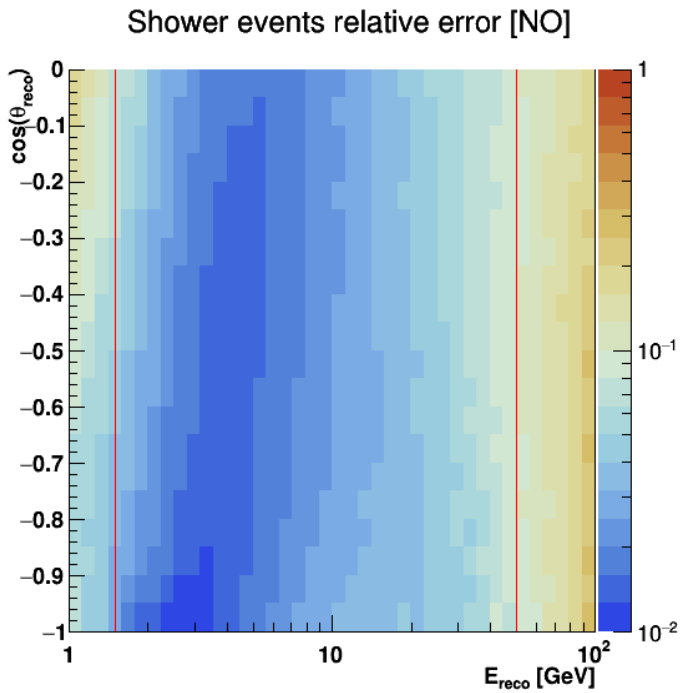


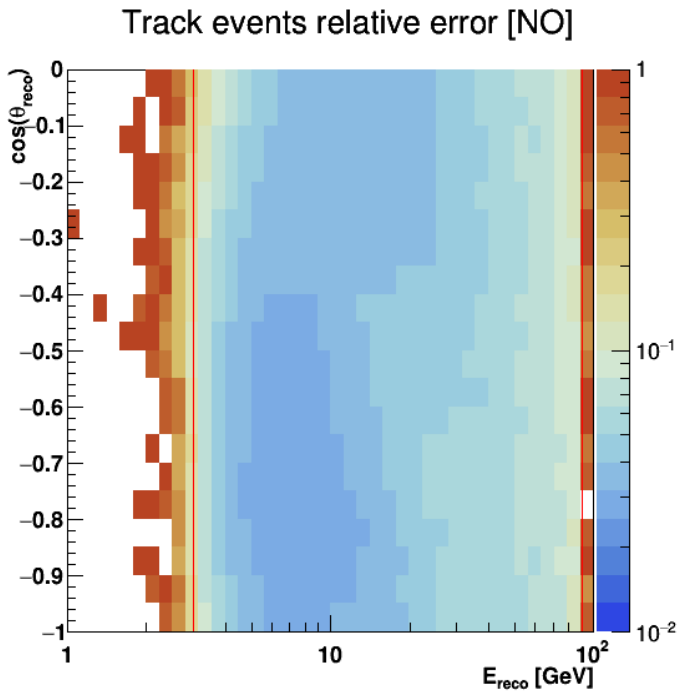
But what if the MC statistics of the #Evts becomes to low?

Relative MC uncertainty 3 PID bins

Edges: q = [0.0, 0.2, 0.6, 1.0]

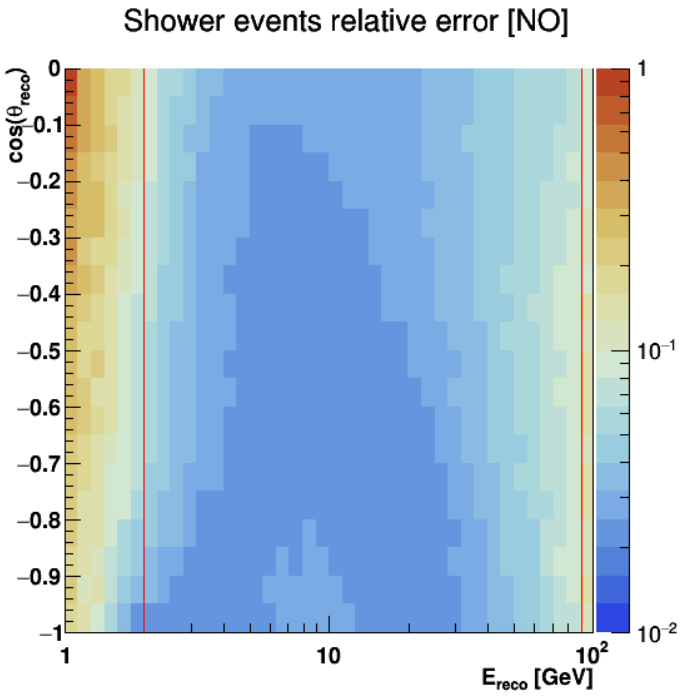


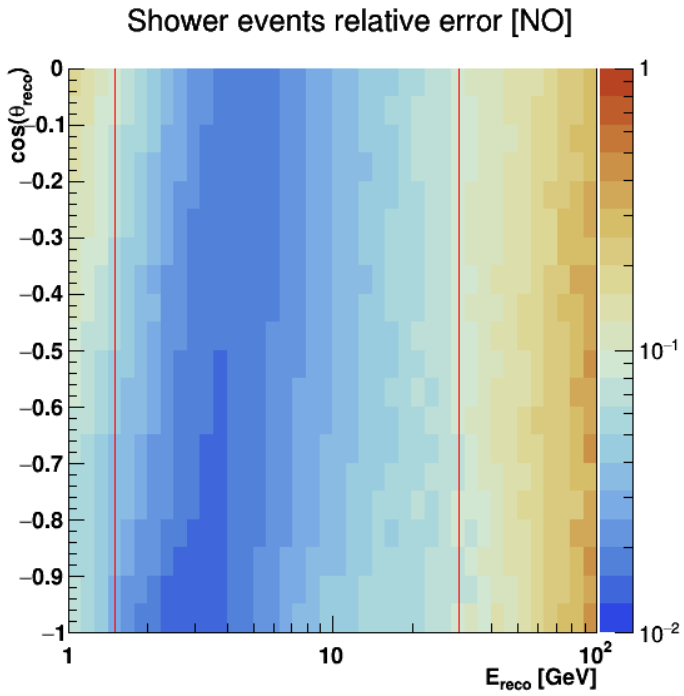


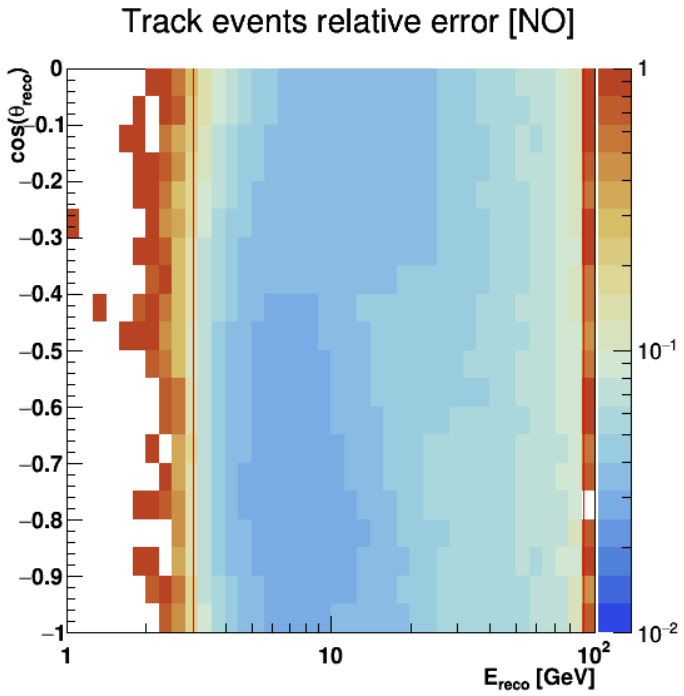


Relative MC uncertainty 3 PID bins

Edges: q = [0.0, 0.3, 0.6, 1.0]

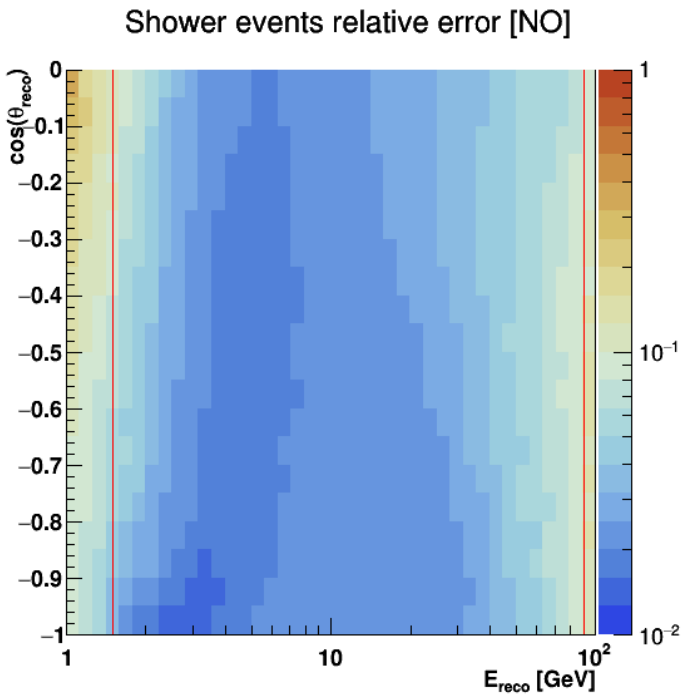


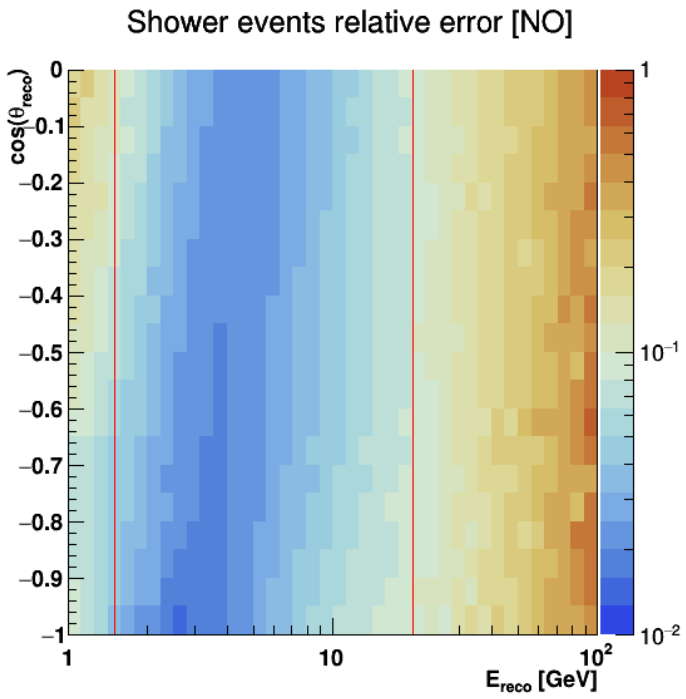


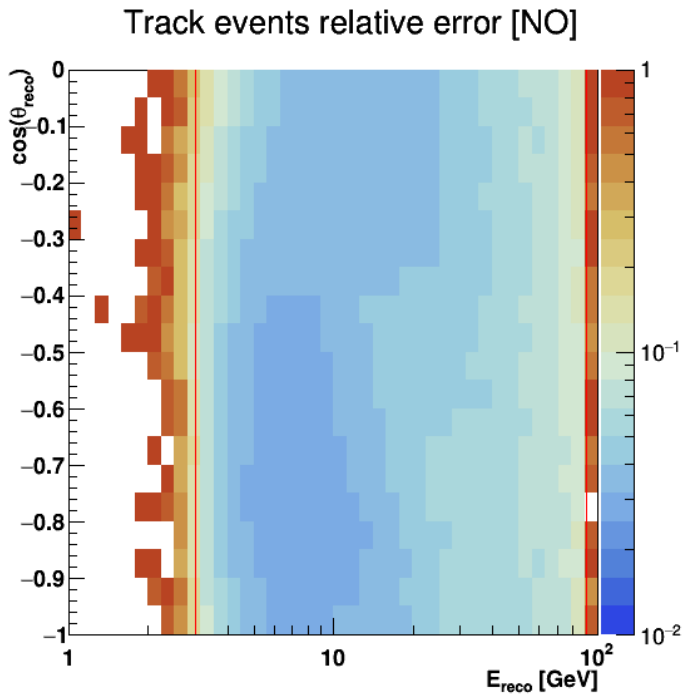


Relative MC uncertainty 3 PID bins

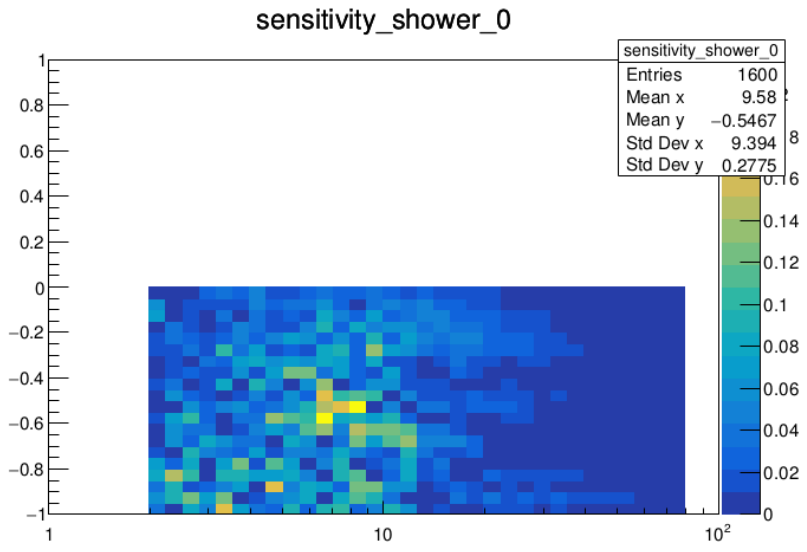
Edges: q = [0.0, 0.4, 0.6, 1.0]

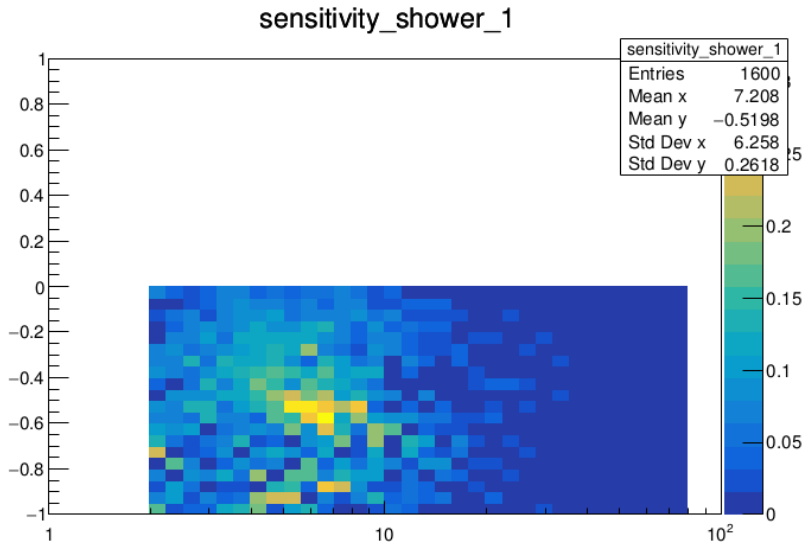


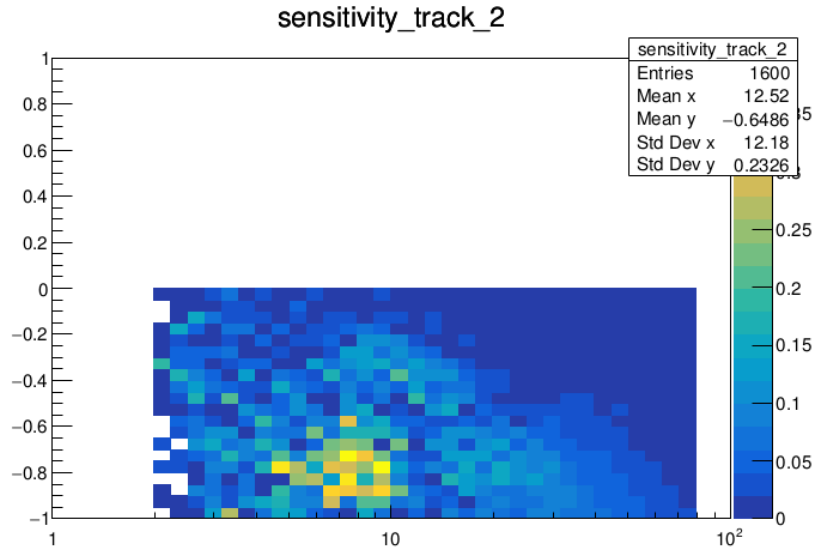




Where is the sensitivity located? (In (E, ct) space)

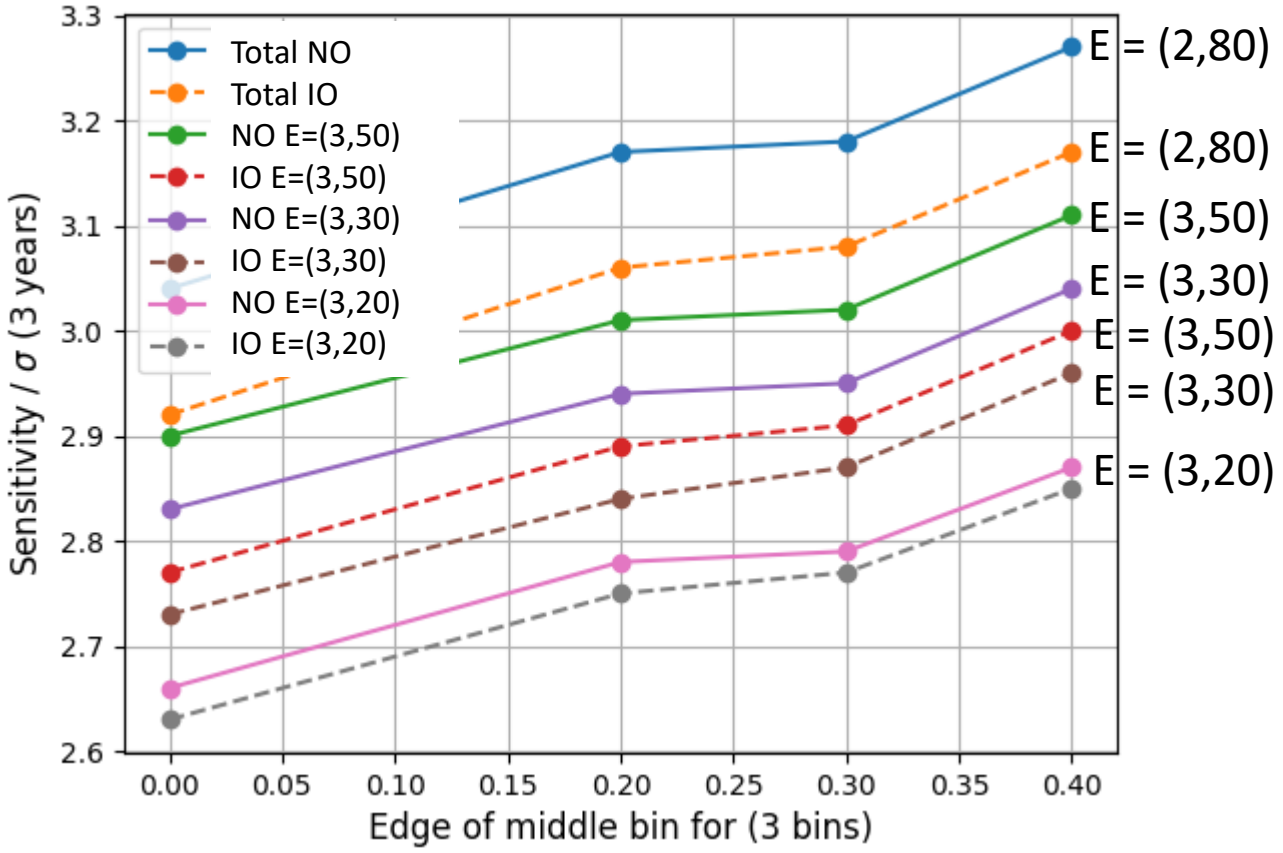




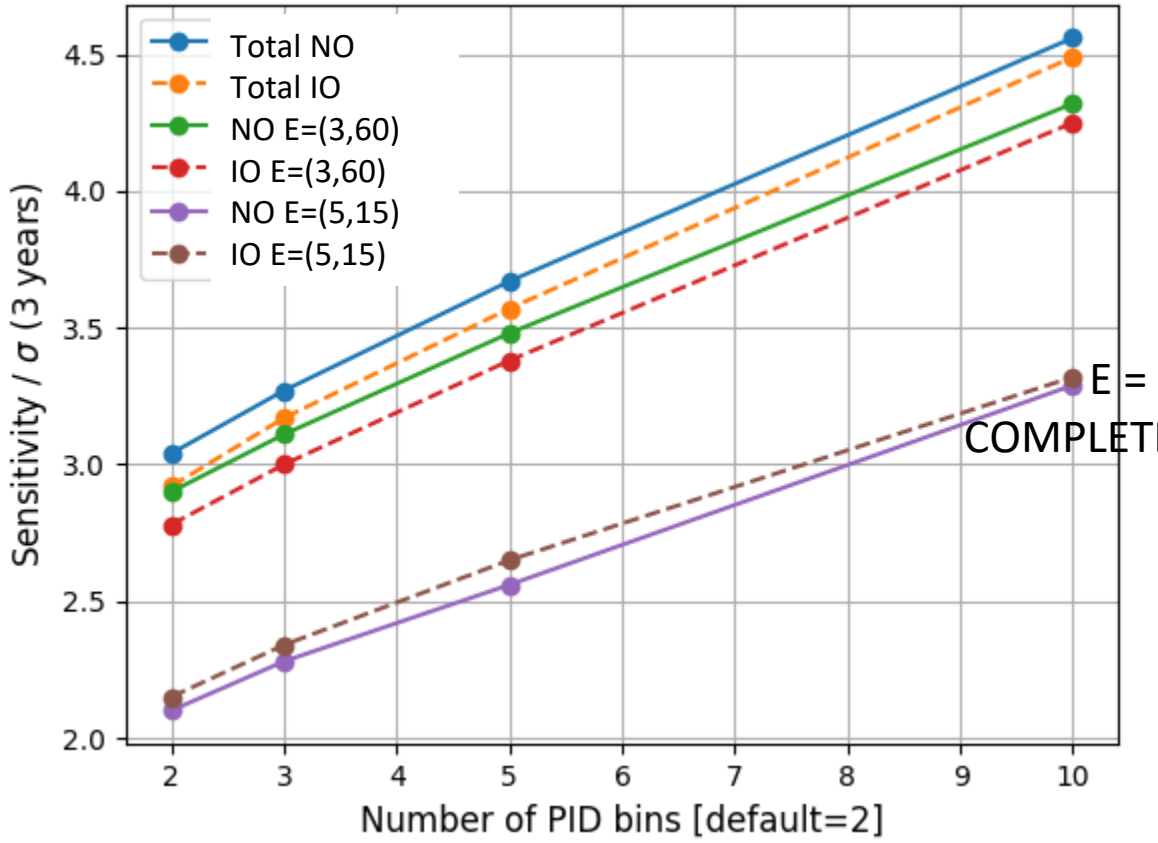


Let’s apply some energy cuts to the Sensitivity for 3 bins

Sensitivity for 2 and 3 bins
Energy cuts, shower-like-bin edge



Sensitivity when using Energy cuts



E = (5,15)
COMPLETELY MENTAL

Backup: Numbers for sensitivity in different situations

First fit results: default binning vs multiple binned fit of track and shower

Fit: fit shower and track simultaneously for 1 pid bin: free parameters are Th23, Dm31
Binned fit: fit shower and track simultaneously with N bins. Below q=0.6 use shower model and data, above q=0.6 use track model and data
The model is fitted on E=(2,80), the Sensitivity is calculated on E=(2,80)

*Fit took 3x longer than OH/OO

	SinSqTH23	**Dm31Sq**	**S**
Central Value NO	0.425	0.00256	
Central Value IO	0.589	-0.002466	
Fit, model NO	0.417	0.00257	3.04
Fit, model IO	0.579	-0.00244	2.92
Binned Fit: 3 bins, model NO	0.421	0.00257	3.27 +7.5%
Binned Fit: 3 bins, model IO	0.581	-0.00244	3.17 +8.5%
Binned Fit: 5 bins, model NO*	0.422	0.00258	3.67 +20%
Binned Fit: 5 bins, model IO	0.583	-0.00244	3.57 +22%
Binned Fit: 10 bins, model NO*	0.421	0.00258	4.56 +50%
Binned Fit: 10 bins, model IO	0.583	-0.00244	4.49 +53%

First fit results: default binning vs multiple binned fit of track and shower

Fit: fit shower and tr[illegible]sly for 1 pid bin: free parameters are Th23, Dm31

Binned fit: fit showe[illegible]taneously with N bins. Below q=0.6 use shower model and data, above q=0.6 use track mod[illegible]

The range on the fitter **does not** matter

The model is fitted on E=(**3,60**), the Sensitivity is calculated on E=(**3,60**)

*Fit took 3x longer than OH/OO

	SinSqTH23	**Dm31Sq**	**S**
Central Value NO	0.425	2.56e-3	
Central Value IO	0.589	-2.466e-3	
Fit, model NO	0.421	0.00258	2.90
Fit, model IO	0.578	-0.00244	2.78
Binned Fit: 3 bins, model NO	0.421	0.00258	3.11 +7.2%
Binned Fit: 3 bins, model IO	0.581	-0.00244	3.00 +7.9%
Binned Fit: 5 bins, model NO*	0.422	0.00258	3.48 +20%
Binned Fit: 5 bins, model IO	0.583	-0.00244	3.38 +21%
Binned Fit: 10 bins, model NO*	0.421	0.00258	4.32 +48%
Binned Fit: 10 bins, model IO	0.582	-0.00244	4.25 +52%

First fit results: default binning vs multiple binned fit of track and shower

Fit: fit shower a pid bin: free parameters are Th23, Dm31

Binned fit: fit sl sly with N bins. Below q=0.6 use shower model and data, above q=0.6 use track

The range on the fitter **does** matter: On (2,80) the numbers were different, but the increases are the same

The model is fitted on E=(**5,15**), the Sensitivity is calculated on E=(**5,15**) **LETS GO COMPLETELY MENTAL**

	SinSqTH23	**Dm31Sq**	**S**
Central Value NO	0.425	2.56e-3	
Central Value IO	0.589	-2.466e-3	
Fit, model NO	0.429	0.00259	2.10
Fit, model IO	0.590	-0.00243	2.15
Binned Fit: 3 bins, model NO	0.429	0.00259	2.28 +8.5%
Binned Fit: 3 bins, model IO	0.590	-0.00243	2.34 +8.8%
Binned Fit: 5 bins, model NO	0.431	0.00259	2.56 +21%
Binned Fit: 5 bins, model IO*	0.593	-0.00243	2.65 +23%
Binned Fit: 10 bins, model NO	0.429	0.00258	3.29 +56%
Binned Fit: 10 bins, model IO*	0.592	-0.00243	3.32 +54%

*Fit was 2x faster than normal

Fit result: 3 bins in different Q-cuts, no energy cut

- We use 3 different bin edges into 3 PID bins:
  - Q = [0, 0.2, 0.6, 1.0] --> This gives 50 GeV as upper limit, as in the middle bin the upper limit gets quite low quite fast
  - Q = [0, 0.3, 0.6, 1.0] --> Makes number of reco events more equal between the shower bins: 40k vs 90k
  - Q = [0, 0.4, 0.6, 1.0] --> 'Default' 3 bin approach, same as Liam
- Energy cut: The model is fitted on E=(2,80), the Sensitivity is calculated on E=(2,80)

	SinSqTH23	**Dm31Sq**	**S**
Central Value NO	0.425	2.56e-3	
Central Value IO	0.589	-2.466e-3	
Fit, model NO	0.421	0.00257	3.04
Fit, model IO	0.582	-0.00244	2.92
Binned Fit: 3 bins, model NO, qB=0.2	0.421	0.00258	3.17 +4.2%
Binned Fit: 3 bins, model IO, qB=0.2	0.582	-0.00244	3.06 +4.7%
Binned Fit: 3 bins, model NO, qB=0.3	0.421	0.00257	3.18 +4.6%
Binned Fit: 3 bins, model IO, qB=0.3	0.582	-0.00244	3.08 +5.3%
Binned Fit: 3 bins, model NO, qB=0.4	0.421	0.00257	3.27 +7.5%
Binned Fit: 3 bins, model IO, qB=0.4	0.581	-0.00244	3.17 +8.5%

Fit result: 3 bins in different Q-cuts, **with energy cut**

- We use 3 different bin edges into 3 PID bins:
  - Q = [0, 0.2, 0.6, 1.0] --> This gives 50 GeV as upper limit, as in the middle bin the upper limit gets quite low quite fast
  - Q = [0, 0.3, 0.6, 1.0] --> Makes number of reco events more equal between the shower bins: 40k vs 90k
  - Q = [0, 0.4, 0.6, 1.0] --> 'Default' 3 bin approach, same as Liam
- Energy cut: The model is fitted on E=(**3,50**), the Sensitivity is calculated on E=(**3,50**)

	SinSqTH23	**Dm31Sq**	**S**
Central Value NO	0.425	2.56e-3	
Central Value IO	0.589	-2.466e-3	
Fit, model NO	0.420	0.00258	2.90
Fit, model IO	0.581	-0.00244	2.77
Binned Fit: 3 bins, model NO, qB=0.2	0.421	0.00258	3.01 +3.7%
Binned Fit: 3 bins, model IO, qB=0.2	0.581	-0.00244	2.89 +4.3%
Binned Fit: 3 bins, model NO, qB=0.3	0.421	0.00258	3.02 +4.1%
Binned Fit: 3 bins, model IO, qB=0.3	0.581	-0.00244	2.91 +5.0%
Binned Fit: 3 bins, model NO, qB=0.4	0.421	0.00258	3.11 +7.2%
Binned Fit: 3 bins, model IO, qB=0.4	0.580	-0.00244	3.00 +8.3%

Fit result: 3 bins in different Q-cuts, **with energy cut**

- We use 3 different bin edges into 3 PID bins:
  - Q = [0, 0.2, 0.6, 1.0] --> This gives 50 GeV as upper limit, as in the middle bin the upper limit gets quite low quite fast
  - Q = [0, 0.3, 0.6, 1.0] --> Makes number of reco events more equal between the shower bins: 40k vs 90k
  - Q = [0, 0.4, 0.6, 1.0] --> 'Default' 3 bin approach, same as Liam
- Energy cut: The model is fitted on E=(**3,30**), the Sensitivity is calculated on E=(**3,30**)

	SinSqTH23	**Dm31Sq**	**S**
Central Value NO	0.425	2.56e-3	
Central Value IO	0.589	-2.466e-3	
Fit, model NO	0.421	0.00258	2.83
Fit, model IO	0.582	-0.00243	2.73
Binned Fit: 3 bins, model NO, qB=0.2	0.421	0.00258	2.94 +3.8%
Binned Fit: 3 bins, model IO, qB=0.2	0.582	-0.00243	2.84 +4.0%
Binned Fit: 3 bins, model NO, qB=0.3	0.422	0.00258	2.95 +4.2%
Binned Fit: 3 bins, model IO, qB=0.3	0.581	-0.00244	2.87 +5.1%
Binned Fit: 3 bins, model NO, qB=0.4	0.421	0.00258	3.04 +7.4%
Binned Fit: 3 bins, model IO, qB=0.4	0.581	-0.00244	2.96 +8.4%

Fit result: 3 bins in different Q-cuts, **with energy cut**

- We use 3 different bin edges into 3 PID bins:
  - Q = [0, 0.2, 0.6, 1.0] --> This gives 50 GeV as upper limit, as in the middle bin the upper limit gets quite low quite fast
  - Q = [0, 0.3, 0.6, 1.0] --> Makes number of reco events more equal between the shower bins: 40k vs 90k
  - Q = [0, 0.4, 0.6, 1.0] --> 'Default' 3 bin approach, same as Liam
- Energy cut: The model is fitted on E=(**3,20**), the Sensitivity is calculated on E=(**3,20**)

	SinSqTH23	**Dm31Sq**	**S**
Central Value NO	0.425	2.56e-3	
Central Value IO	0.589	-2.466e-3	
Fit, model NO	0.424	0.00259	2.66
Fit, model IO	0.586	-0.00243	2.63
Binned Fit: 3 bins, model NO, qB=0.2	0.425	0.00259	2.78 +4.5%
Binned Fit: 3 bins, model IO, qB=0.2	0.586	-0.00243	2.75 +4.5%
Binned Fit: 3 bins, model NO, qB=0.3	0.425	0.00259	2.79 +4.8%
Binned Fit: 3 bins, model IO, qB=0.3	0.586	-0.00243	2.77 +5.3%
Binned Fit: 3 bins, model NO, qB=0.4	0.425	0.00259	2.87 +7.8%
Binned Fit: 3 bins, model IO, qB=0.4	0.585	-0.00243	2.85 +8.3%