Detector systematic errors estimation

Outline:

First ideas and context
How it is estimated so far (brief summary)
Our proposed method
Results
Conclusion and perspectives

Detector systematic errors estimation

First idea : context of the T2K/SK Joint analysis

—> Have a consistent estimation of detector uncertainties between the 2 experiments, evaluated together, long term

For now: not possible to redo things that belong to SK side (only take their inputs)

—> working only on T2K detector systematics (on cut selection) with SK MC

Goal: a more global method, maybe less refined at least at first

—> See if this is something that could be used in the analysis or at least to get a better understanding of some effects or correlations

Detector systematic errors estimation

How it is done

T2K : (different inputs) (*TNs 399, 326*)

- Position/direction : stopping cosmic muons, MC/data width difference -> 2 extreme cases—> error in nb of events
- Decay e- : tagging efficiency studies
- PID and ring counting: MCMC with shifting and smearing of Likelihoods (data) *TN 318*

SK: Shifting and smearing of cut likelihoods (according to Roger Wendell's slides)

T2K/SK joint : Short term —> Adrien's work : toys throws in SK's inputs to build a binned covariance matrix

Detector systematic errors estimation

Our proposed method

Apply a pair of shifting/smearing parameters on underlying variables (see next slide)
Use a Metropolis-Hastings MCMC that builds the analysis samples at each step to :

- constrain the distributions of those parameters with binned likelihood built against nominal distributions
- Retrieve the number of events (and fractional difference with nominal) in each sample —> Build a global covariance or correlation matrix

Why ? Builds selection detector errors as a whole, for all samples at the same time and taking into account shifts but also shape changes in the underlying distribution, that could arise from detection effects

Detector systematic errors estimation

Samples and variables

3 T2K samples : 1Re, 1Rmu, 1Re1de

T2K Cut Flow (9 cuts) :

7 cuts on continuous variables

- **Wall**
- **To wall**
- **Electron momentum**
- Nb rings —> discrete variable
- **E/mu separation**
- **Momentum**
- Nb of decay electrons —> discrete variable
- **Separation with pion**
- **Reconstructed energy**

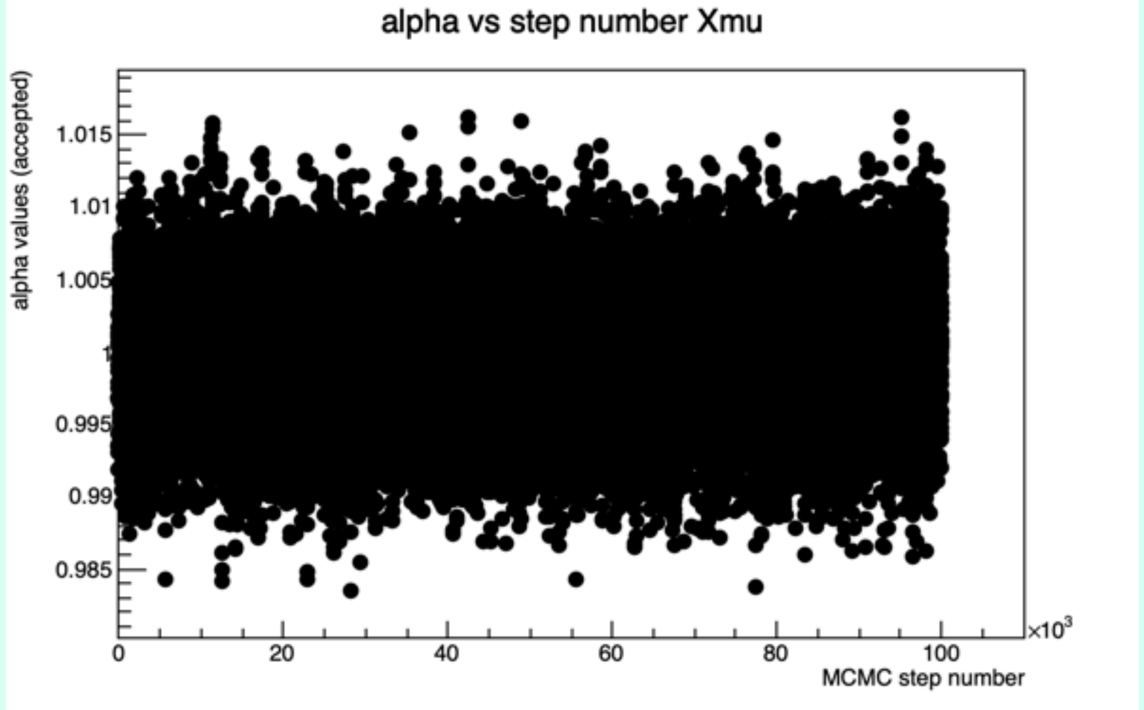
Continous variables involved (6) :

19 α/β pairs

- **fq1rpos** *3components *2PID
- **fq1rdir** *3components *2PID
- **fq1rmom** *2PID
- **fq1rnll** *3PID
- **fqpi0nll**
- **fqpi0mass**

β is the shifting parameter
α is the smearing parameter

Detector systematic errors estimation

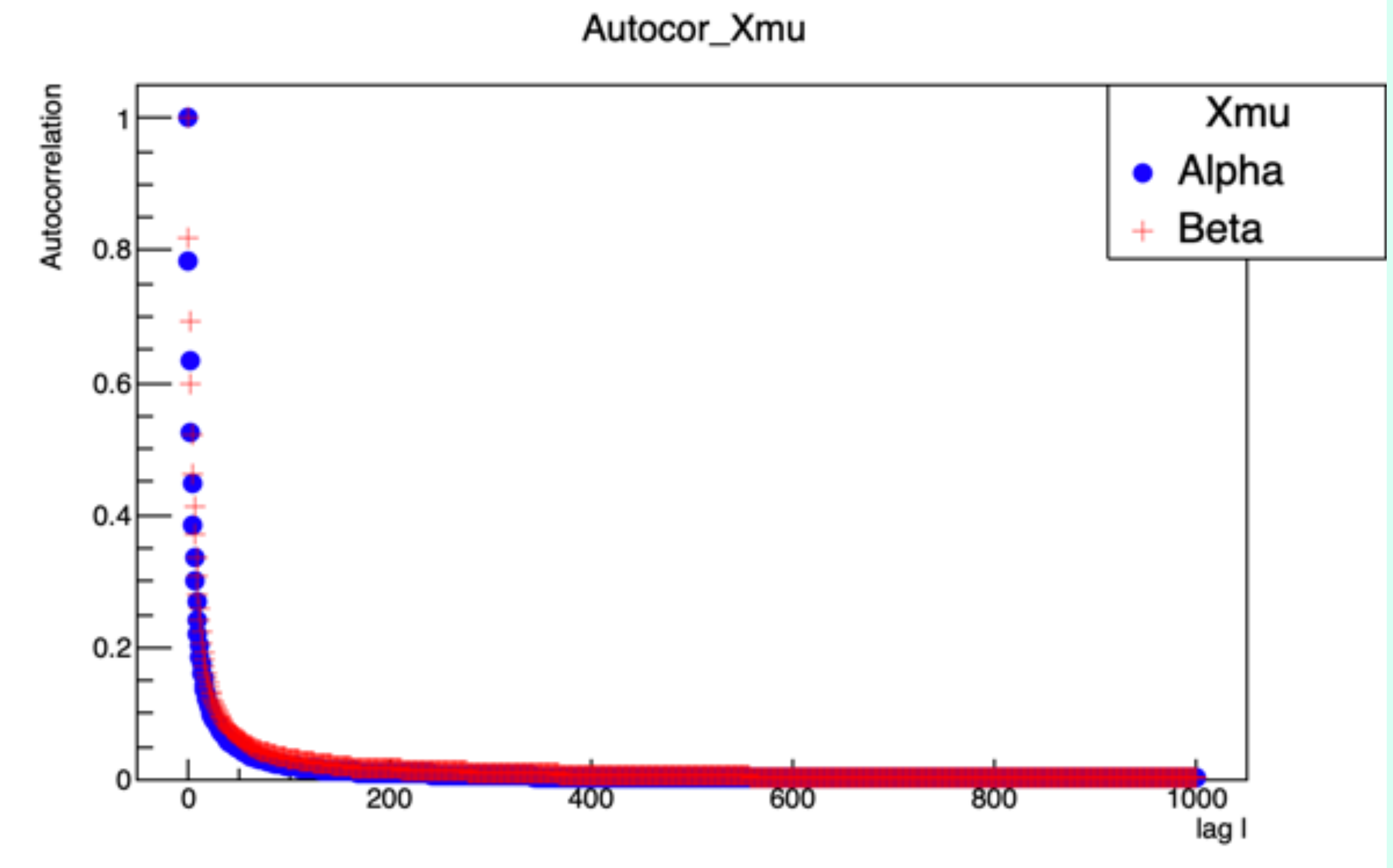


Results

First run with only an α/β pair on fq1rmom[0][2] ~ Xmu

39% acceptance
~3h30 run time for 100000 steps
But only 3% effective samples

Autocorrelation ok
Time series ok

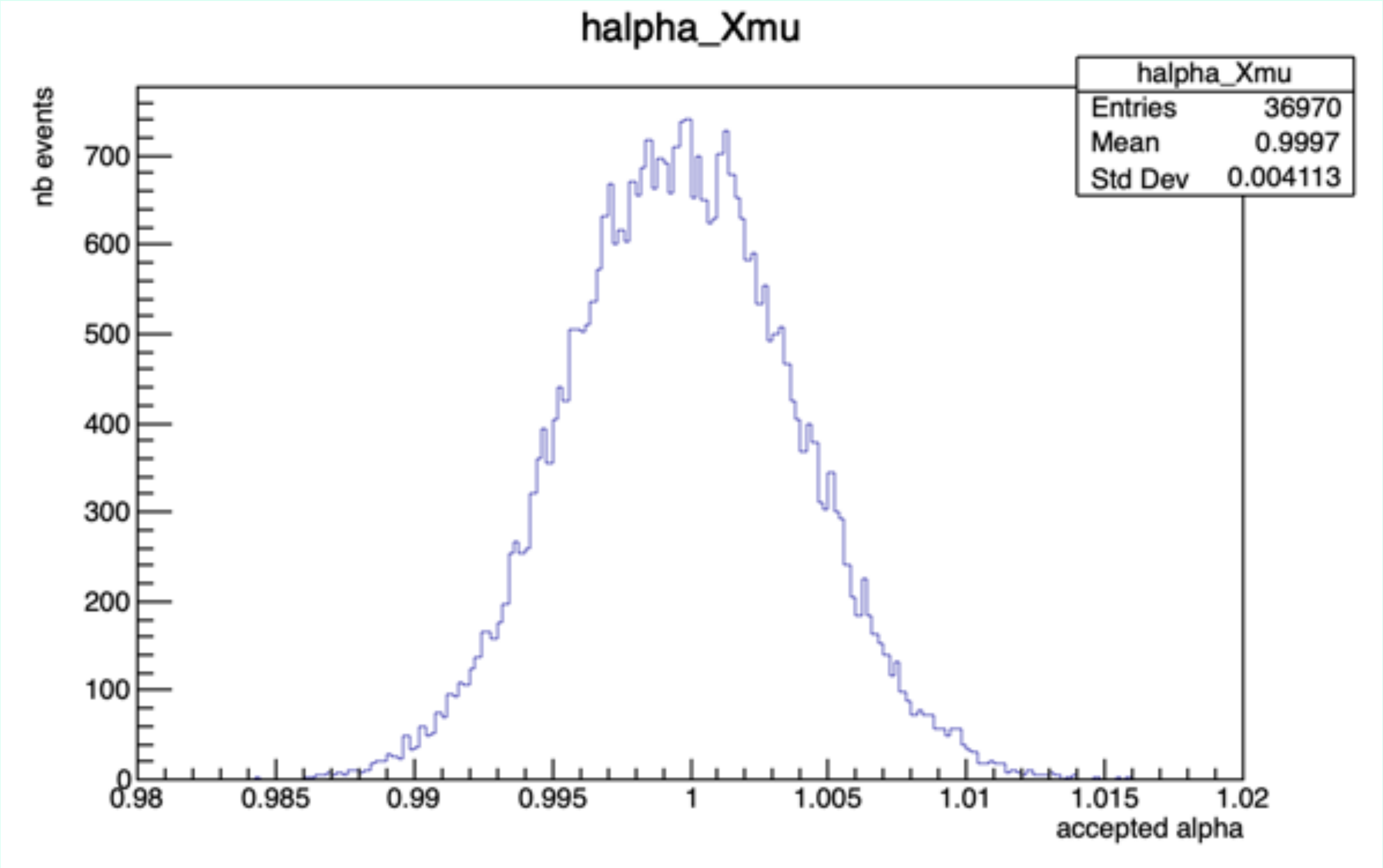


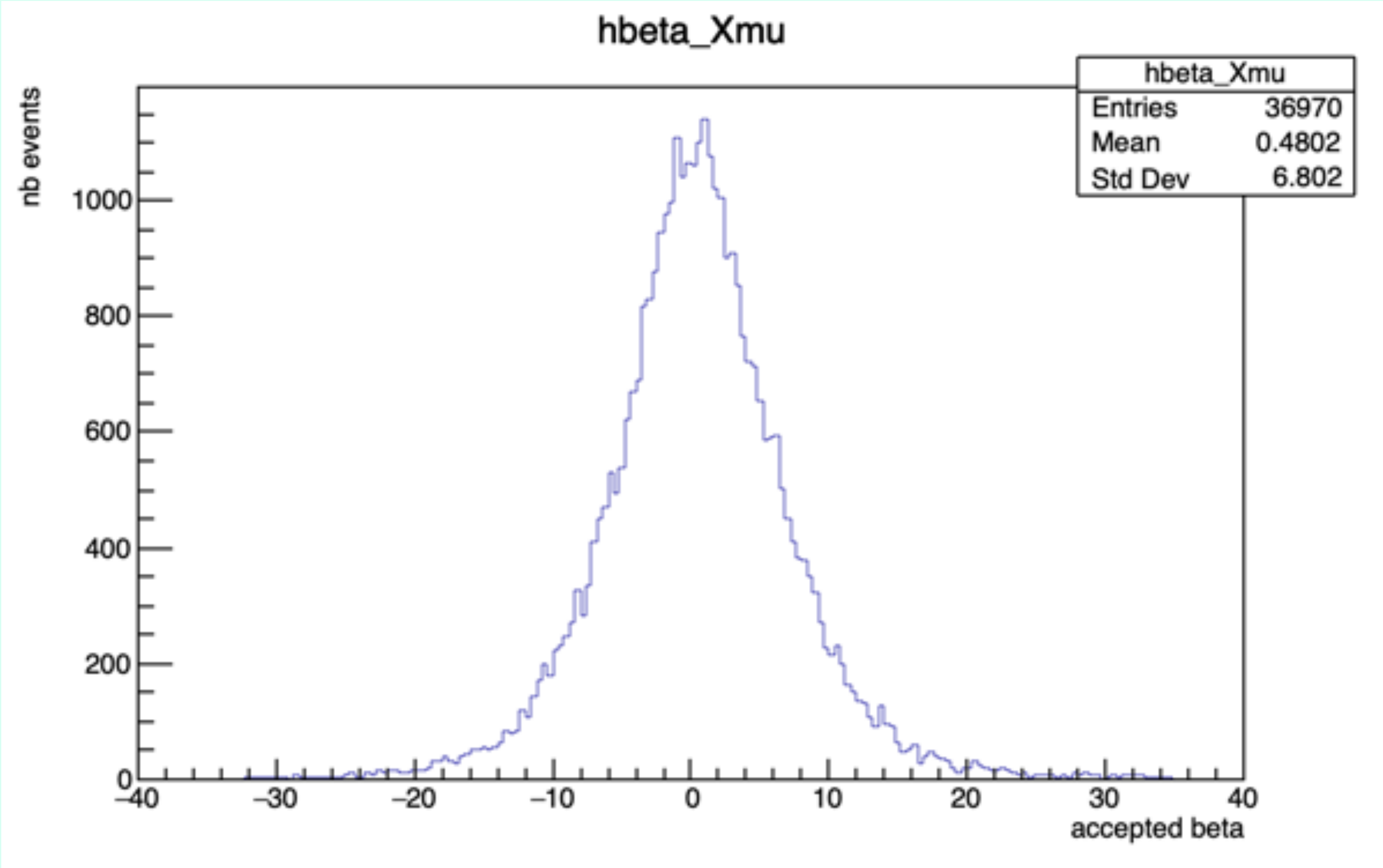
Detector systematic errors estimation

Results

First run with only an α/β pair on fq1rmom[0][2] ~

α more constrained than β

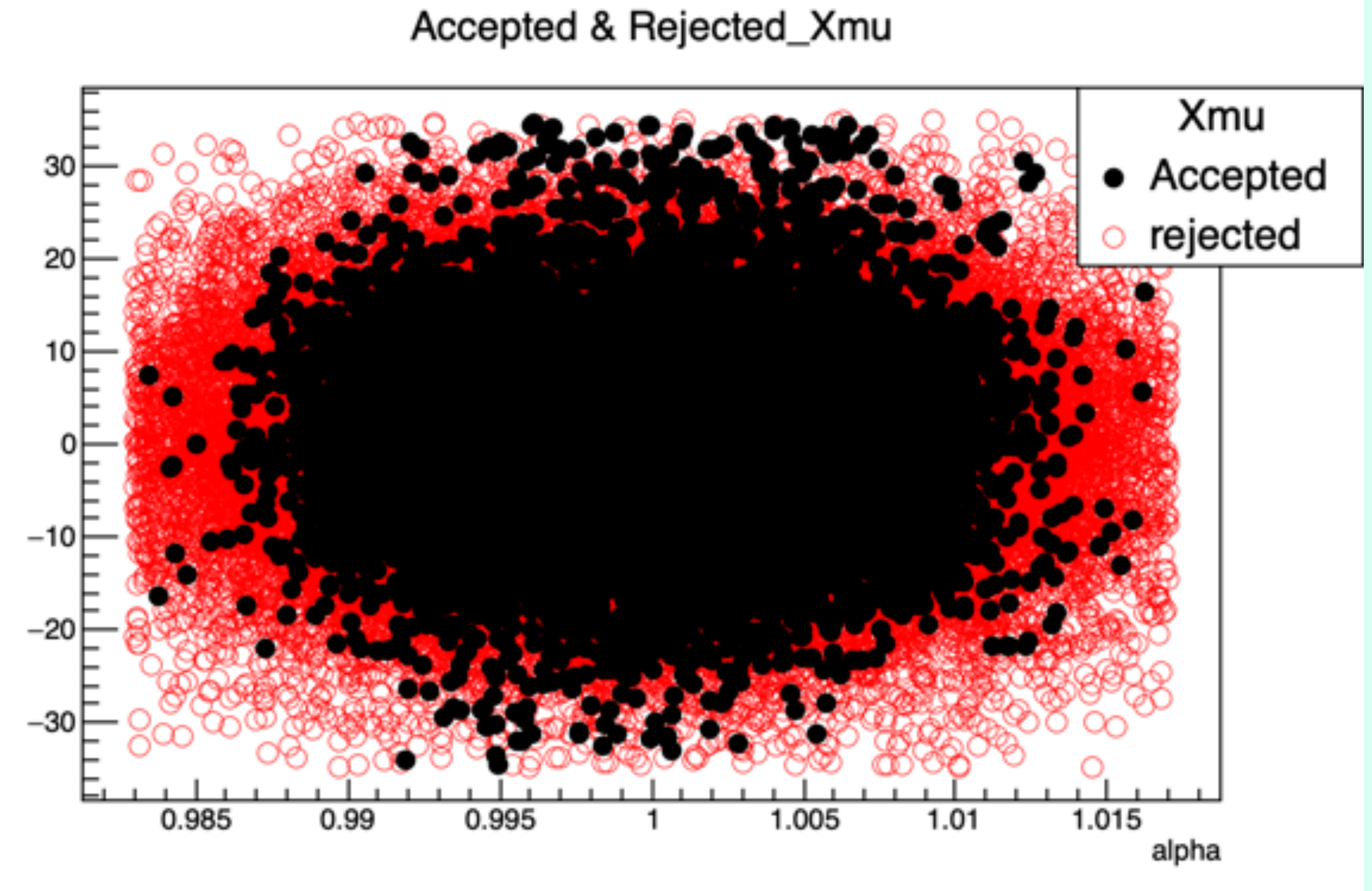


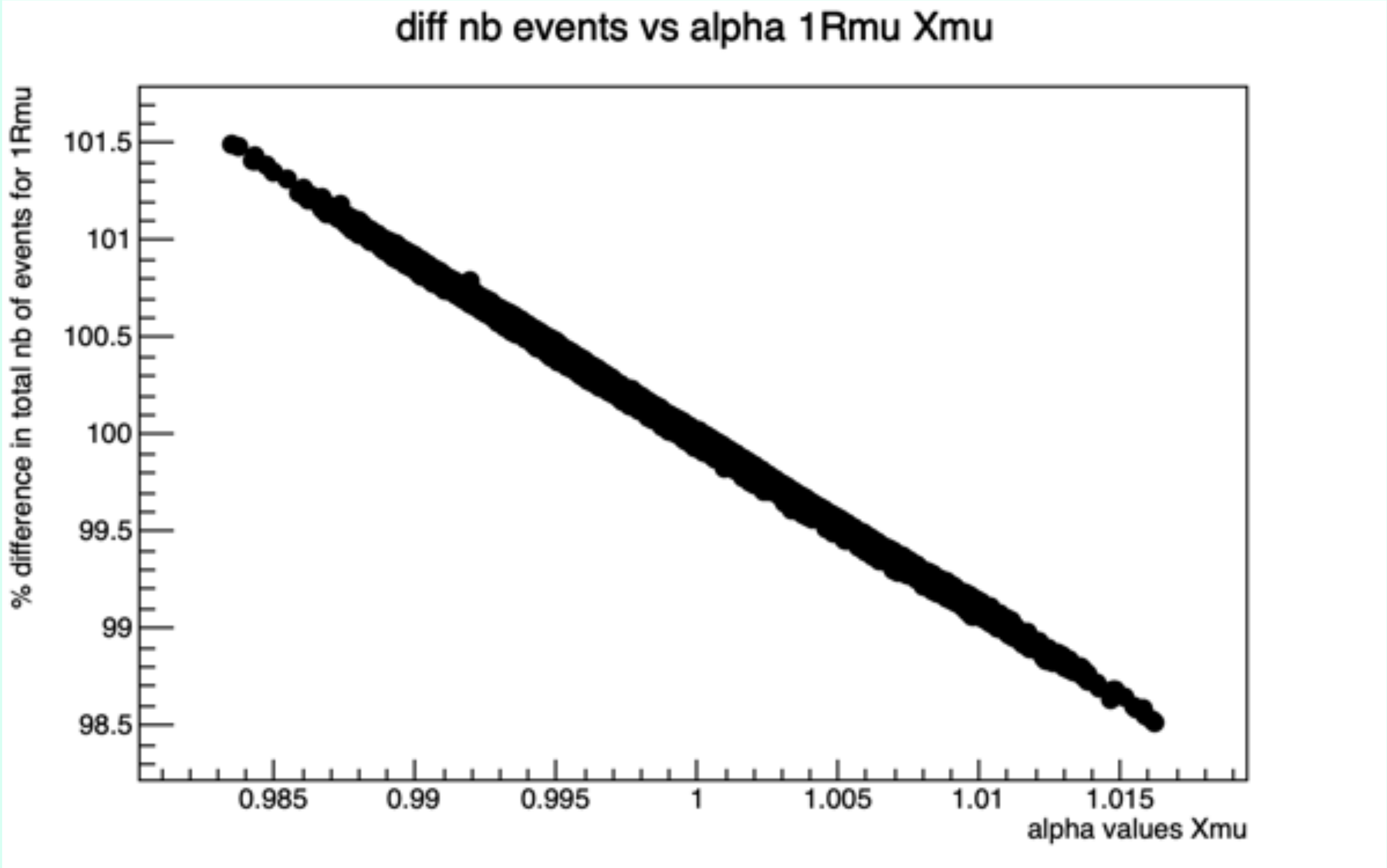


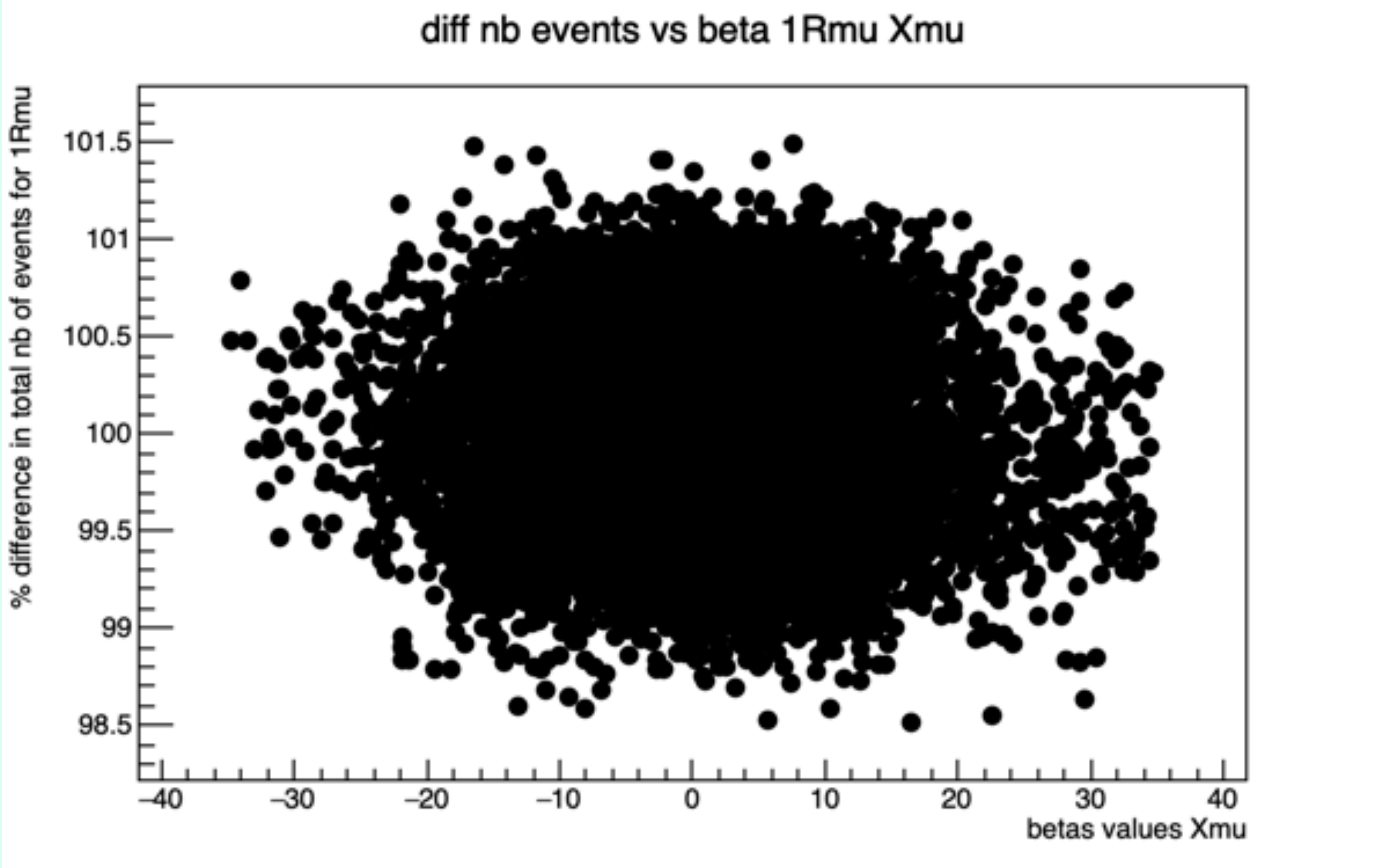
Detector systematic errors estimation

Results

First run with only an α/β pair on fq1rmom[0][2] ~ Xmu







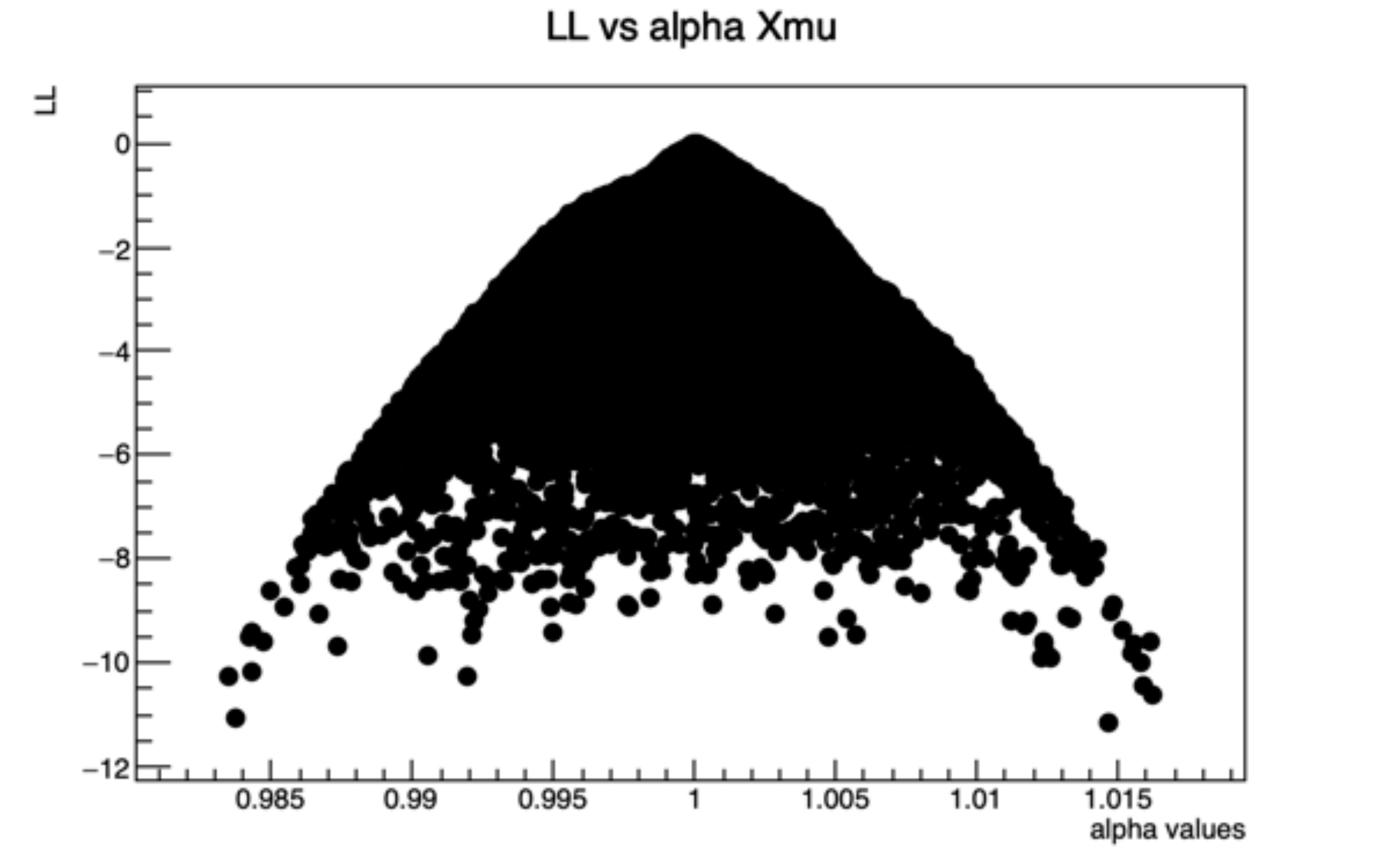
Here also, α has a more significant impact on the number of events than β

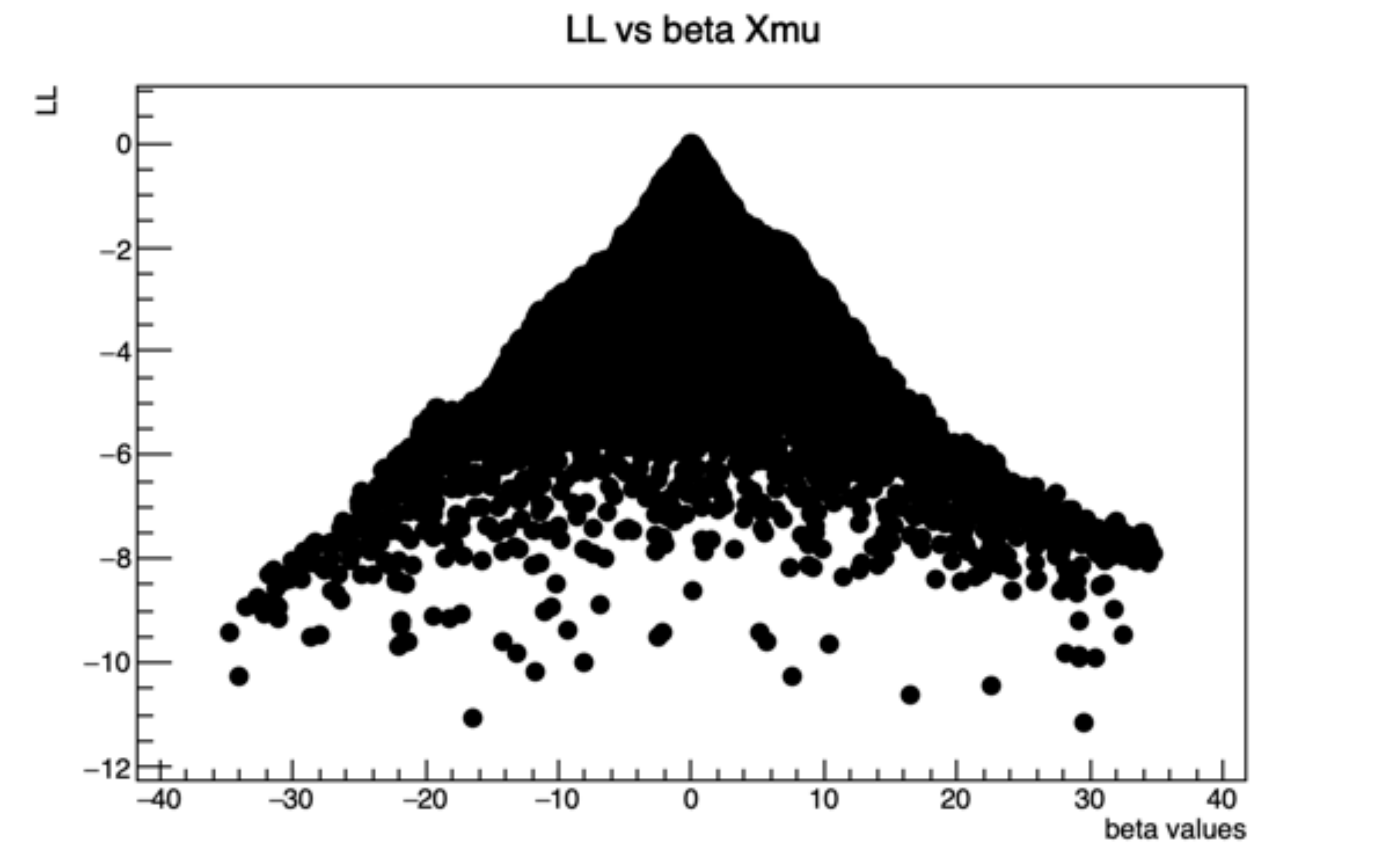
-> no α/β correlation

Detector systematic errors estimation

Results

First run with only an α/β pair on fq1rmom[0][2] ~ Xmu





Likelihoods vs α or β

if gaussian -> LLmin (=0) -1/2 —> good constraint

Detector systematic errors estimation

Results

First run with only an α/β pair on fq1rmom[0][2] ~ Xmu

—> No covariance or correlation between samples since Xmu can only impact 1Rmu

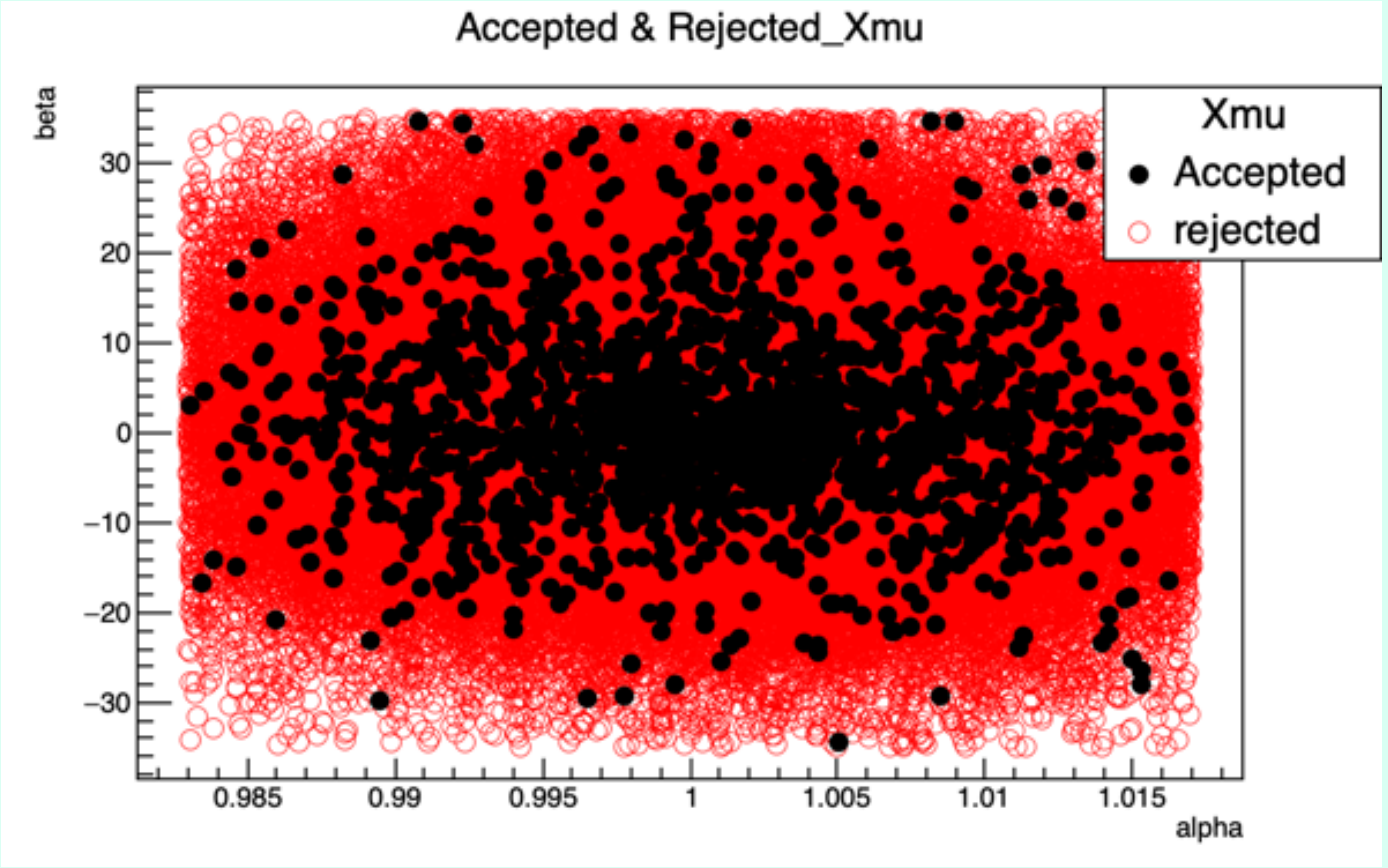
Detector systematic errors estimation

Results

First run with only α/β pairs on all 6 position variables fq1rmom[I][j]

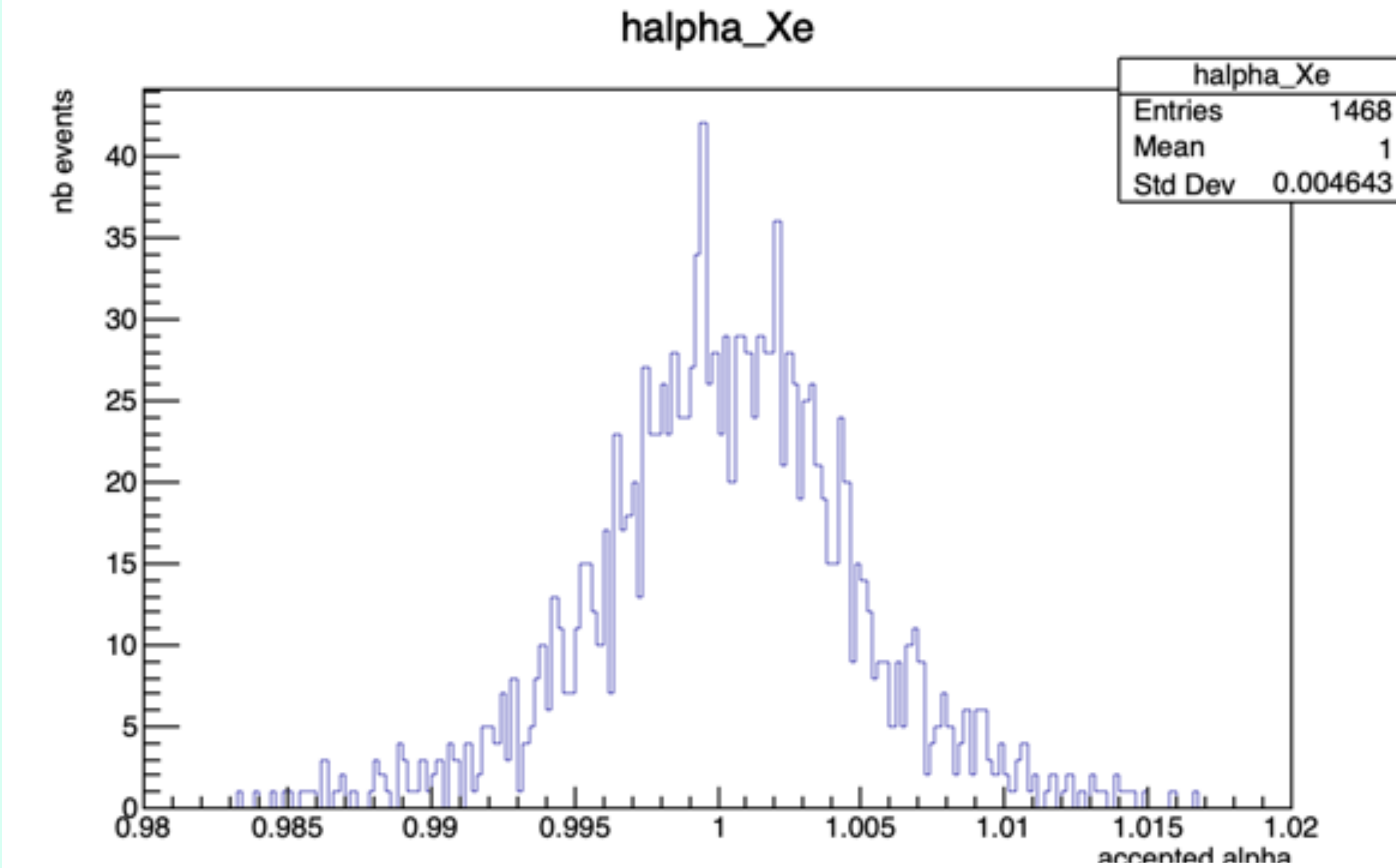
Drop in performance :
1.468% acceptance
But only 0.03% effective samples

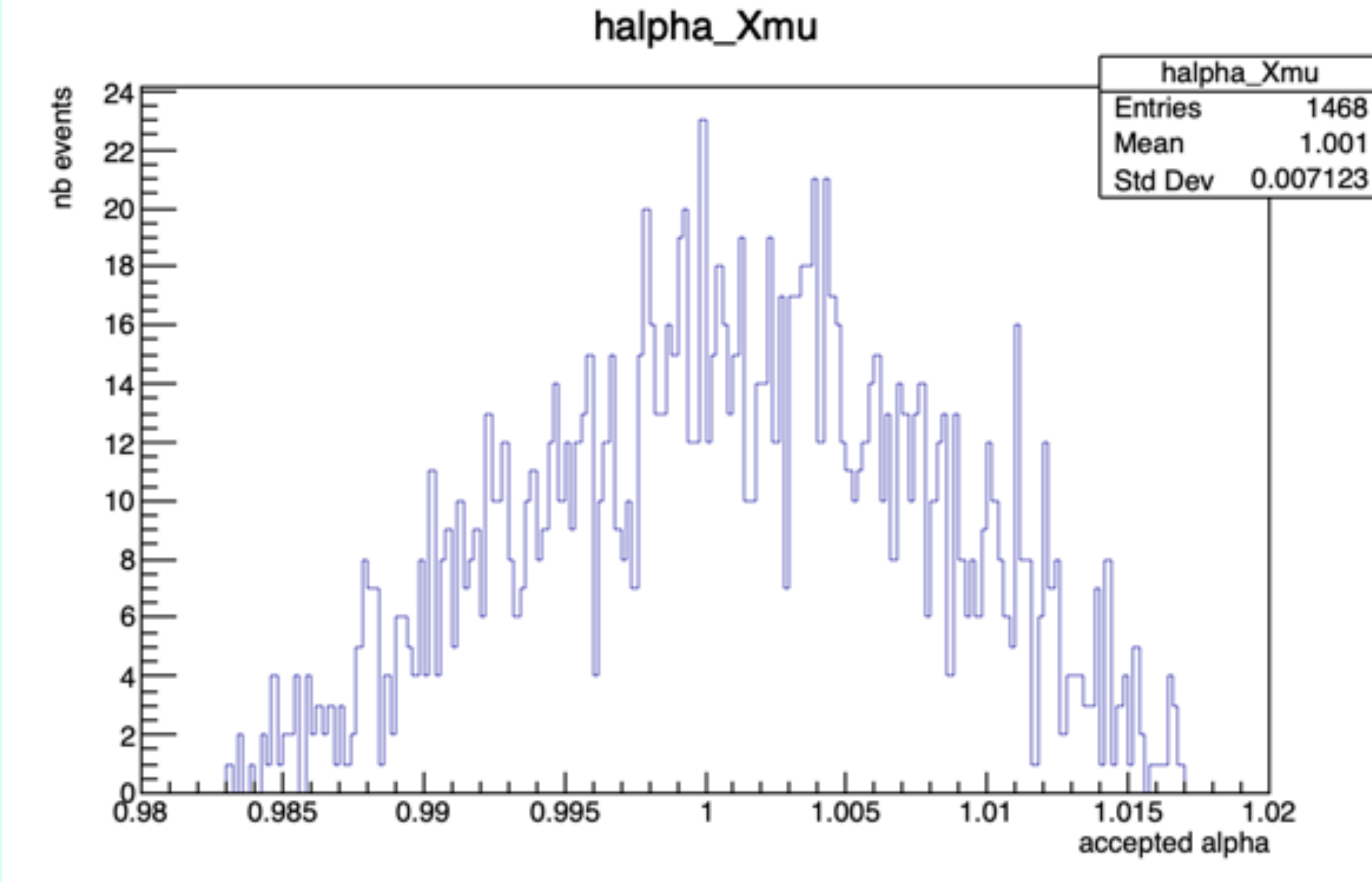
Autocorrelation ok
Time series ok
Same run time



More dimensions —> need more steps to constrain them all + compensations between variables

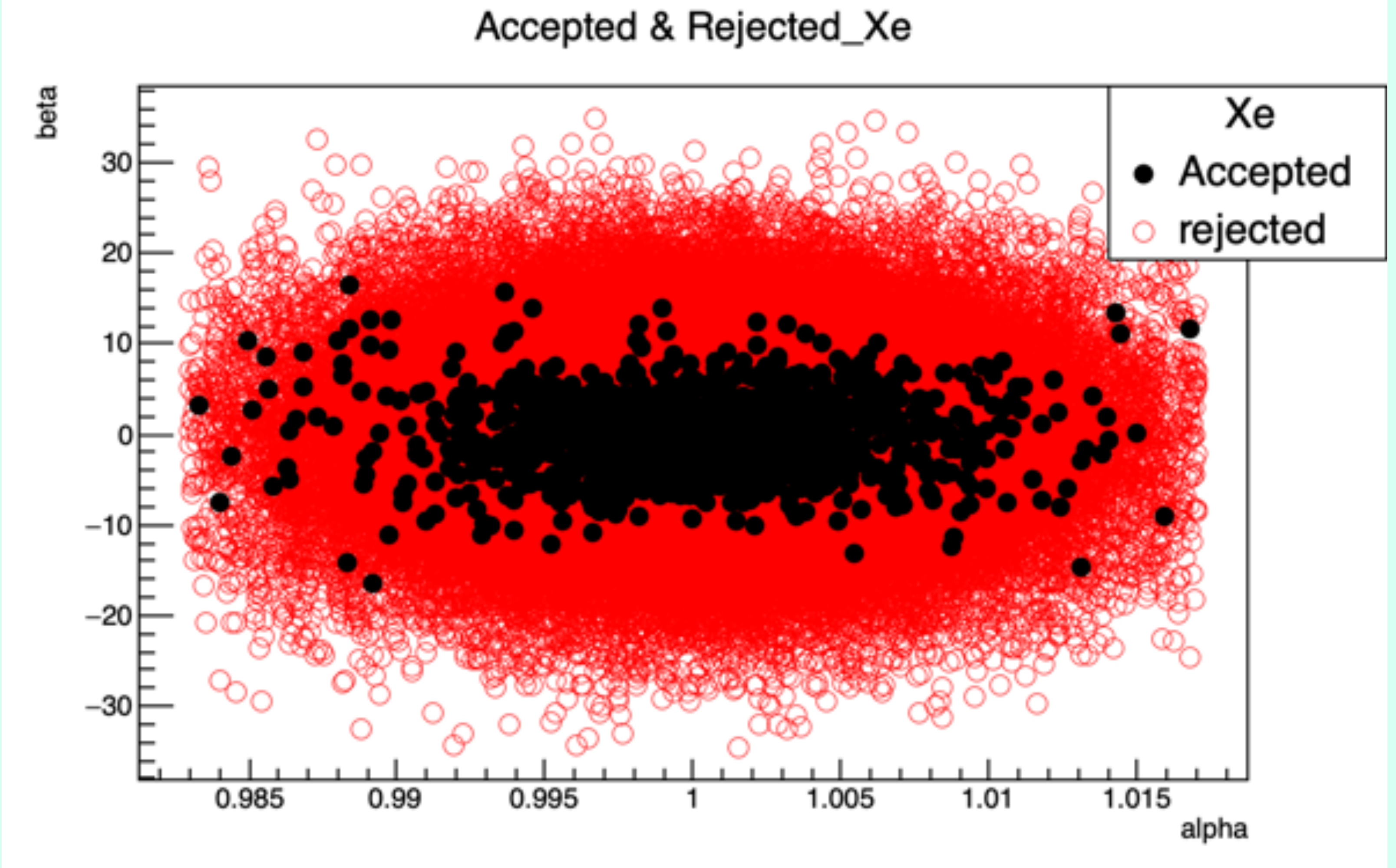
Detector systematic errors estimation

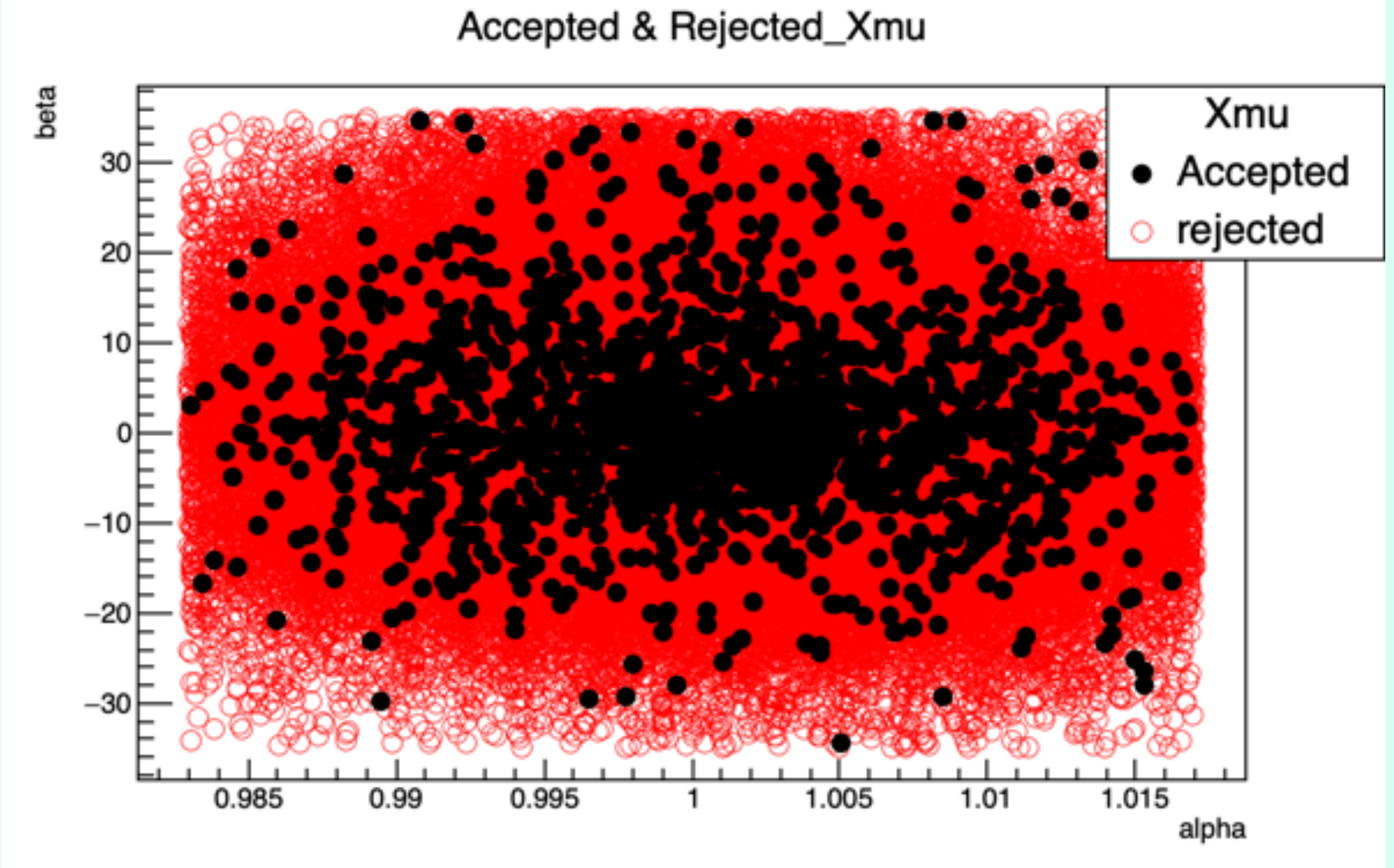




Results

First run with only α/β pairs on all 6 position variables fq1rmom[i][j]



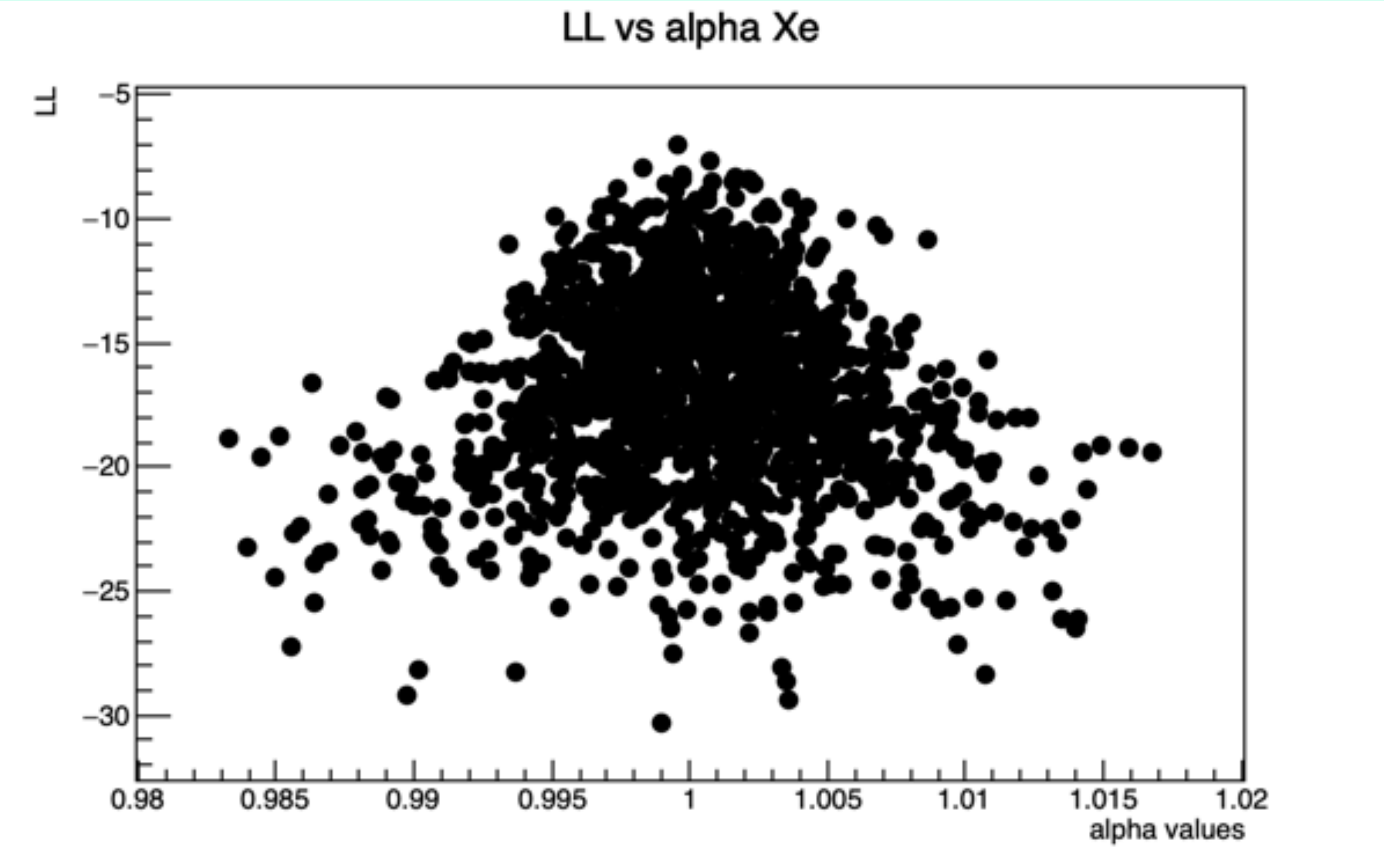


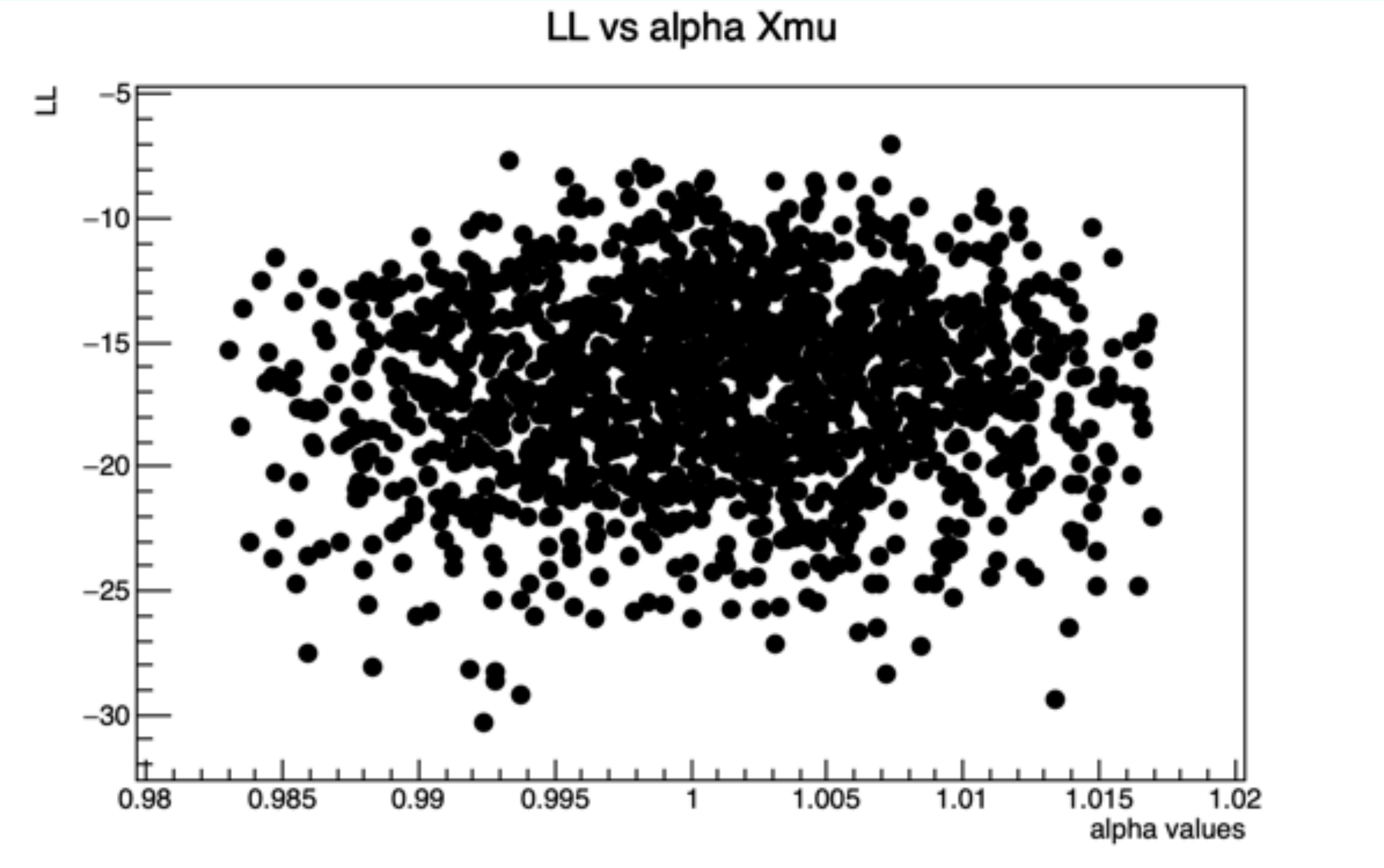
Xe more constrained than Xmu—> involved in more samples

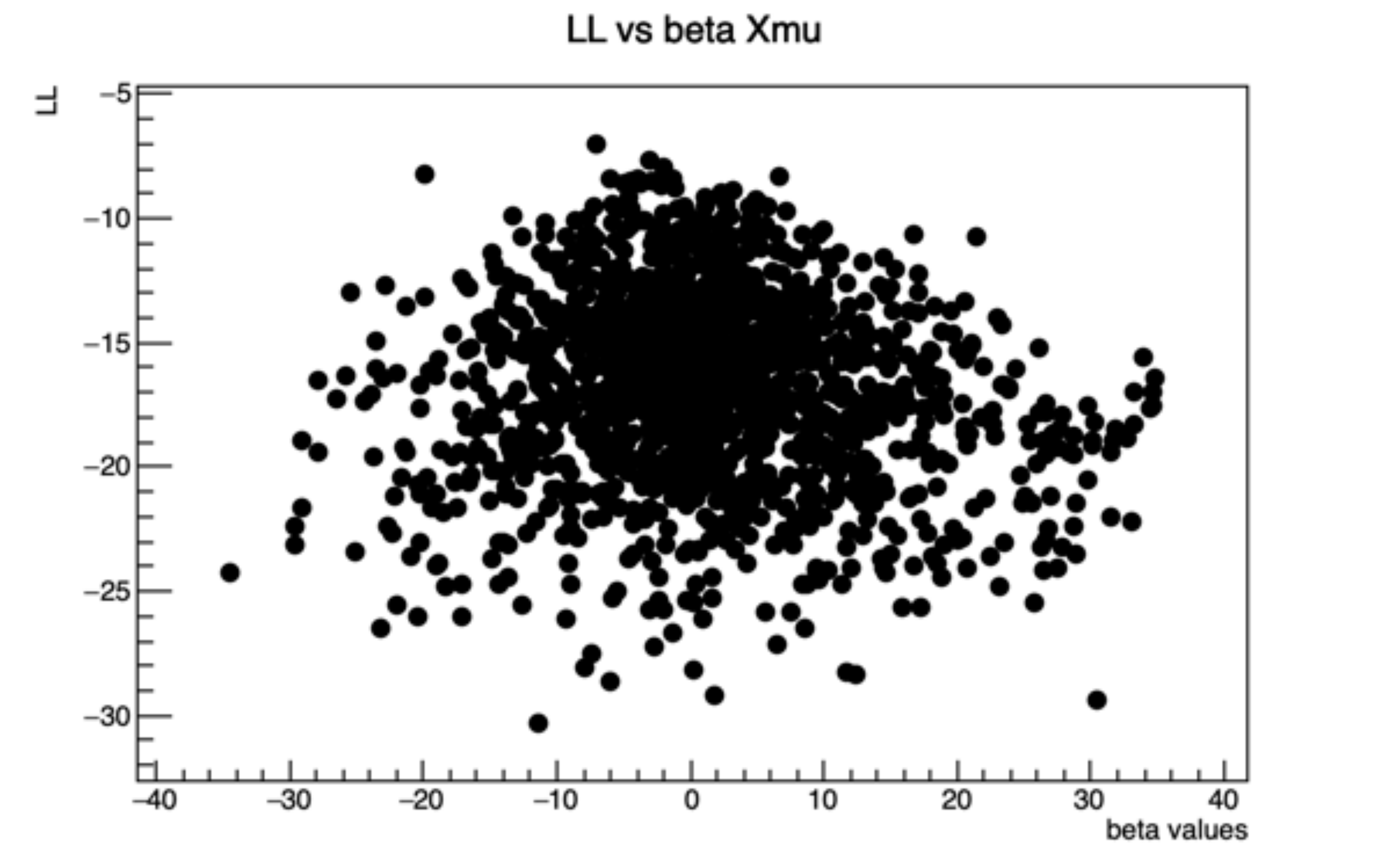
Detector systematic errors estimation

Results

First run with only α/β pairs on all 6 position variables fq1rmom[i][j]



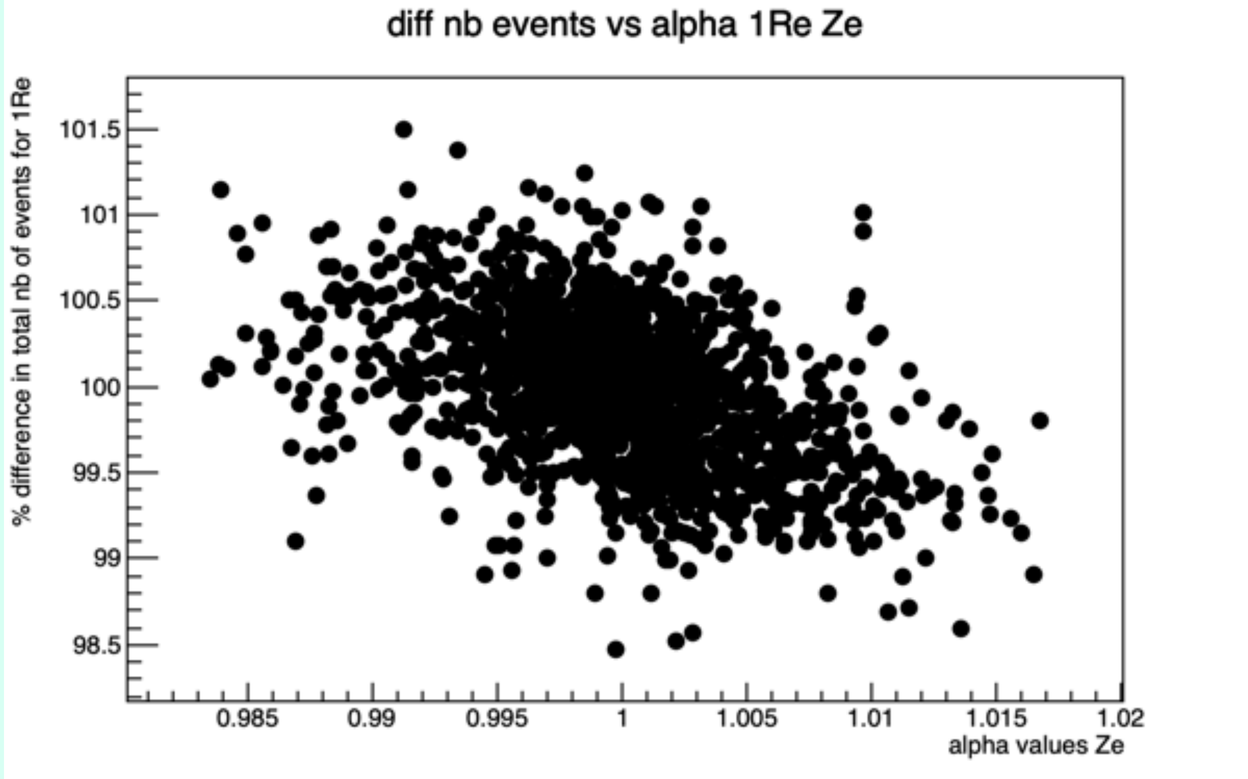


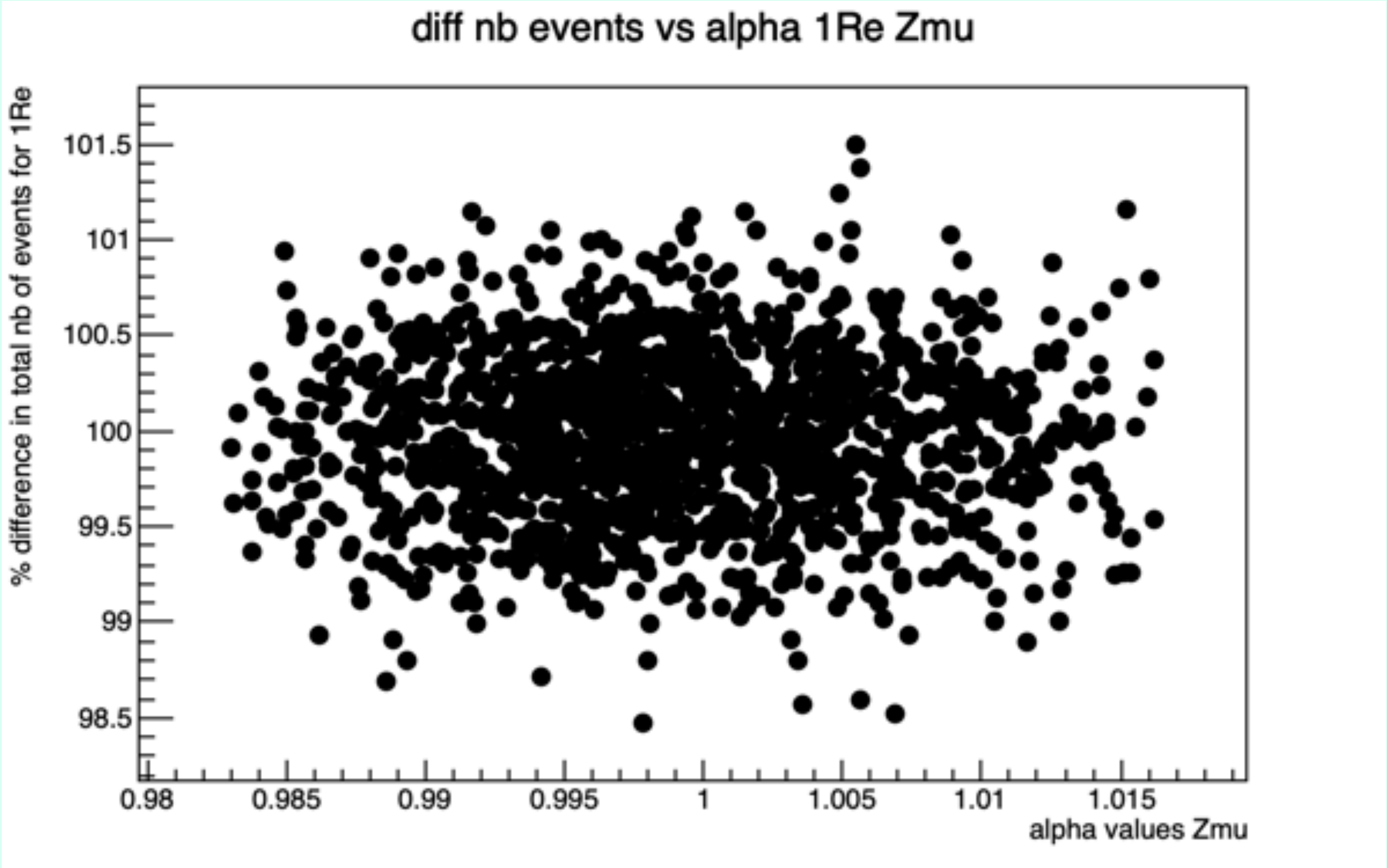


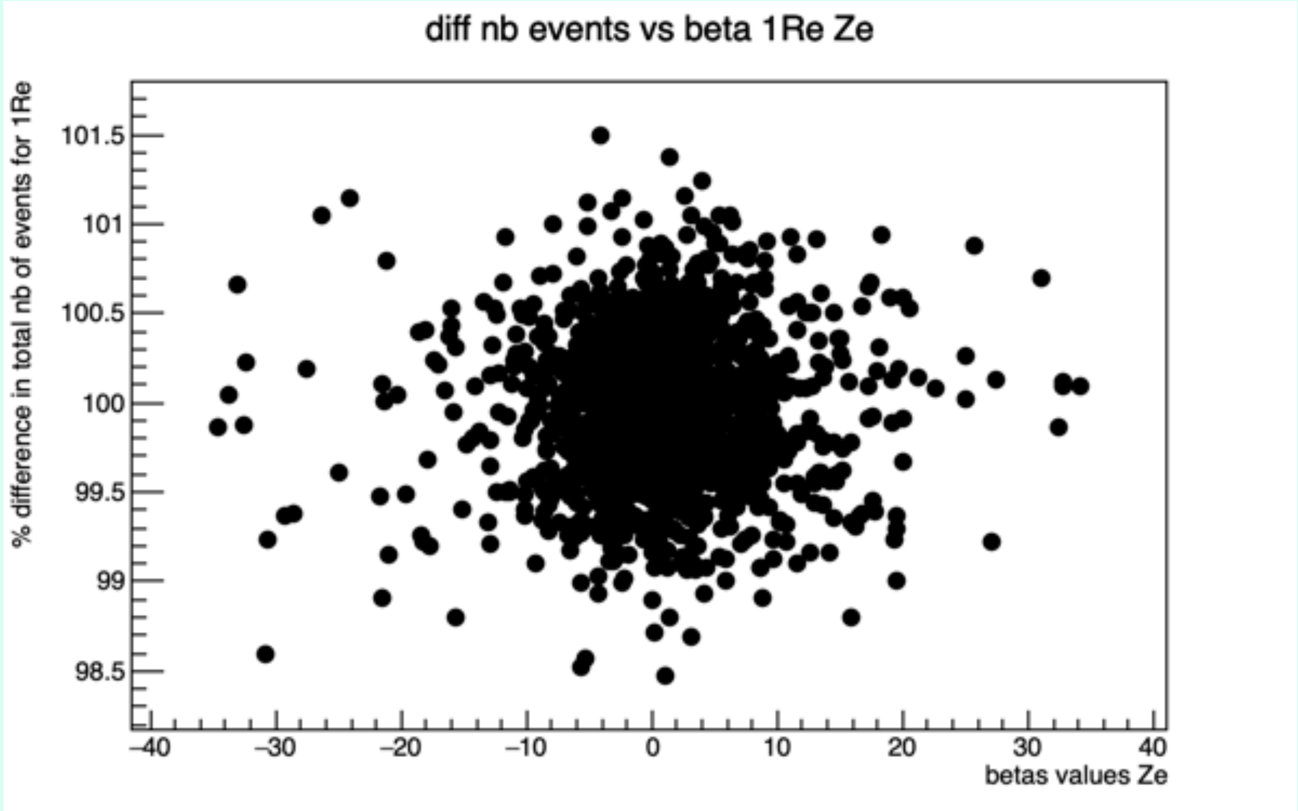
Detector systematic errors estimation

Results

First run with only α/β pairs on all 6 position variables fq1rmom[i][j]







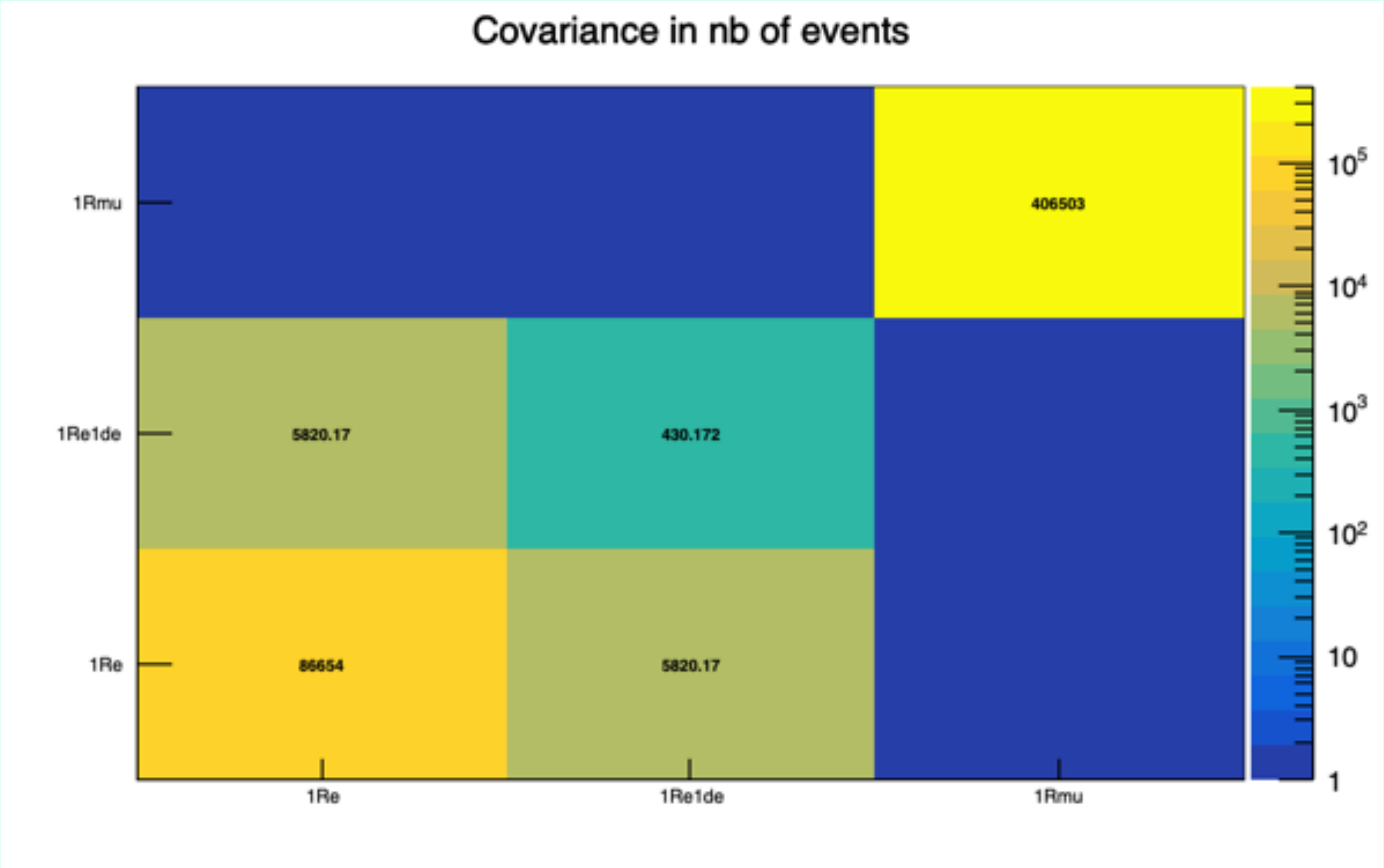
As expected, a electron variables has impact on 1Re and not muon variable

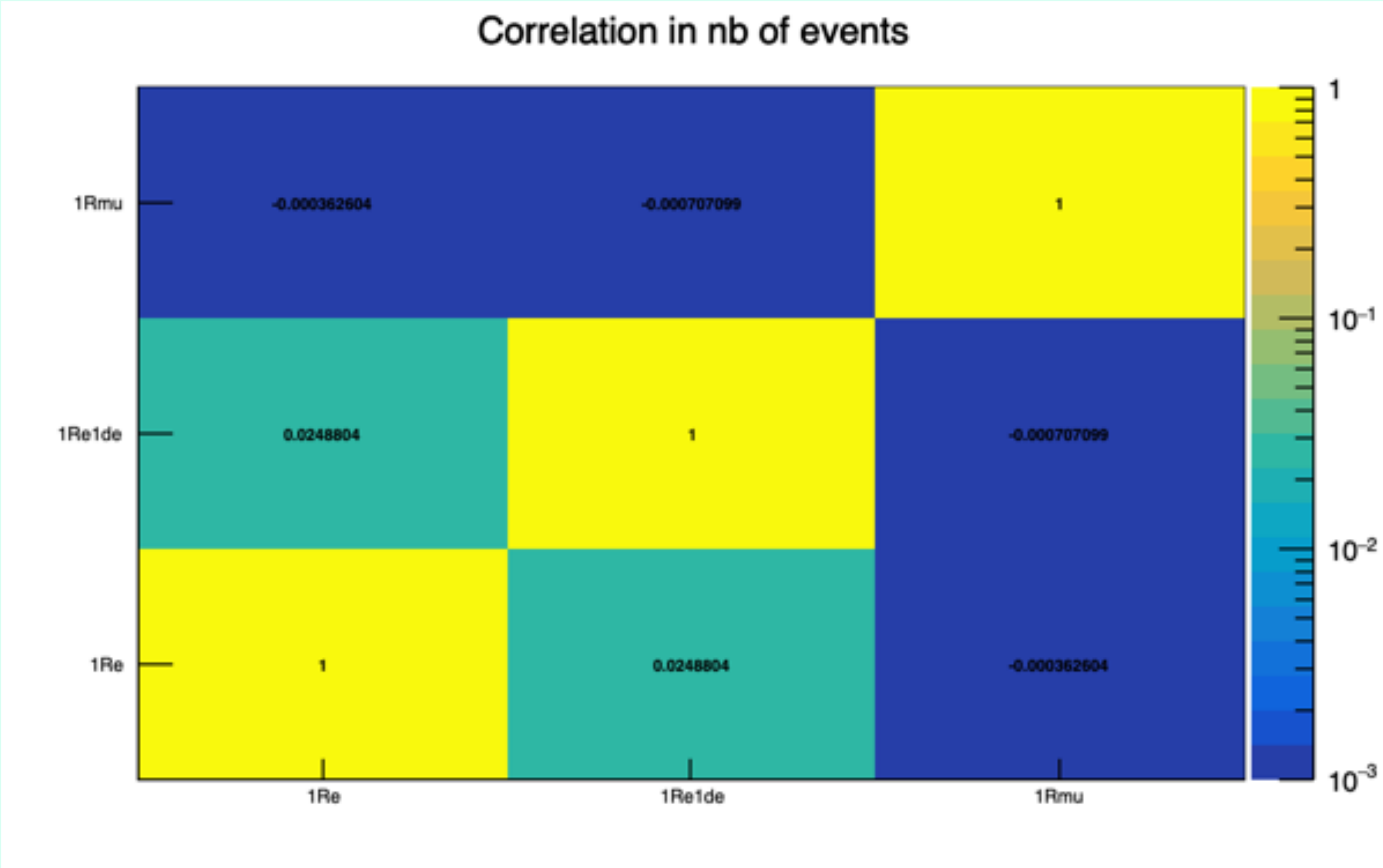
Moreover, α seems to have an impact on number of events but not β

Detector systematic errors estimation

Results

First run with only α/β pairs on all 6 position variables fq1rmom[I][j]





As expected, 1Re and 1Re1de are somewhat correlated but not with 1Rmu as we have NOT yet applied α/β pairs on variables involved in PID

Detector systematic errors estimation

Results

First run with only α/β pairs on all 6 position variables fq1rmom[I][j]

—> Seems to be working as expected but needs optimization and more MCMC steps

Detector systematic errors estimation

Conclusion

Framework is written and seems to be working as expected
Work in progress to test different variables and optimize

Next steps : produce a covariance matrix binned in analysis bins and samples taking all 19 identified variables into account

Longer term : test another MC algorithm, another parametrization, discuss which variables should really be taken into the study from a physics point of view, apply it to SK samples as well, etc…