

# IFAE Neutrino Group Meeting

Sebastian Pina-Otey 02/04/2020



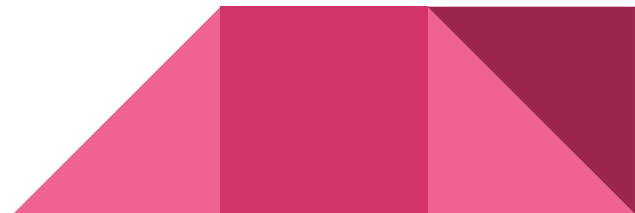
GRUPO **AIA**



**Institut de Física d'Altes Energies**

# Overview

- Likelihood-free inference Paper submission.
- Sequential weighted density estimation.





# Likelihood-free inference

## Paper submission

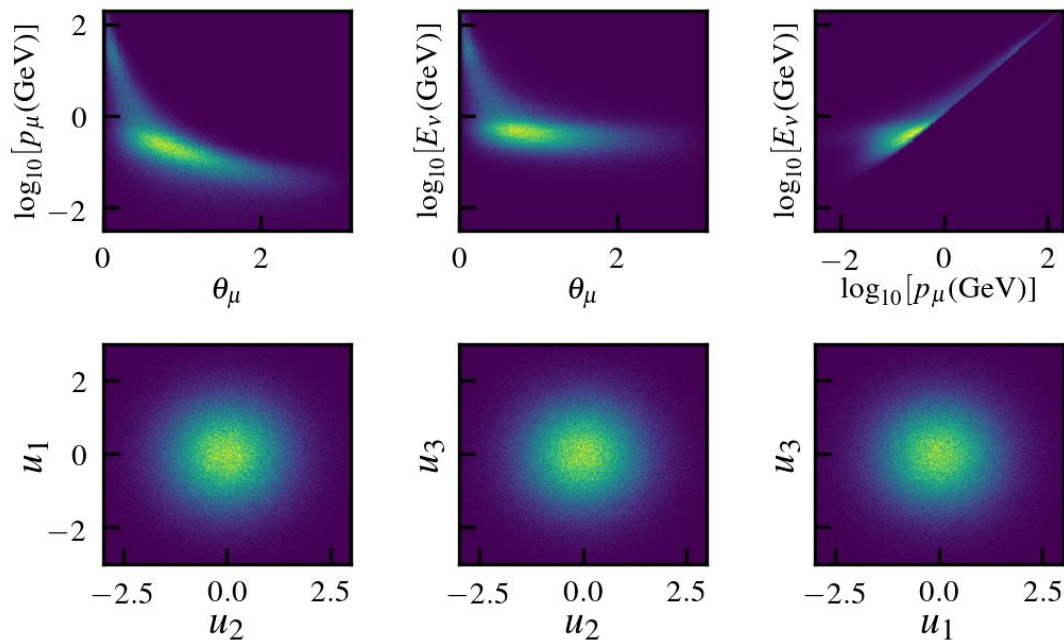
# Answering to the reviewer

- Discussion with Asher about how to incorporate in the future nuisance parameters.



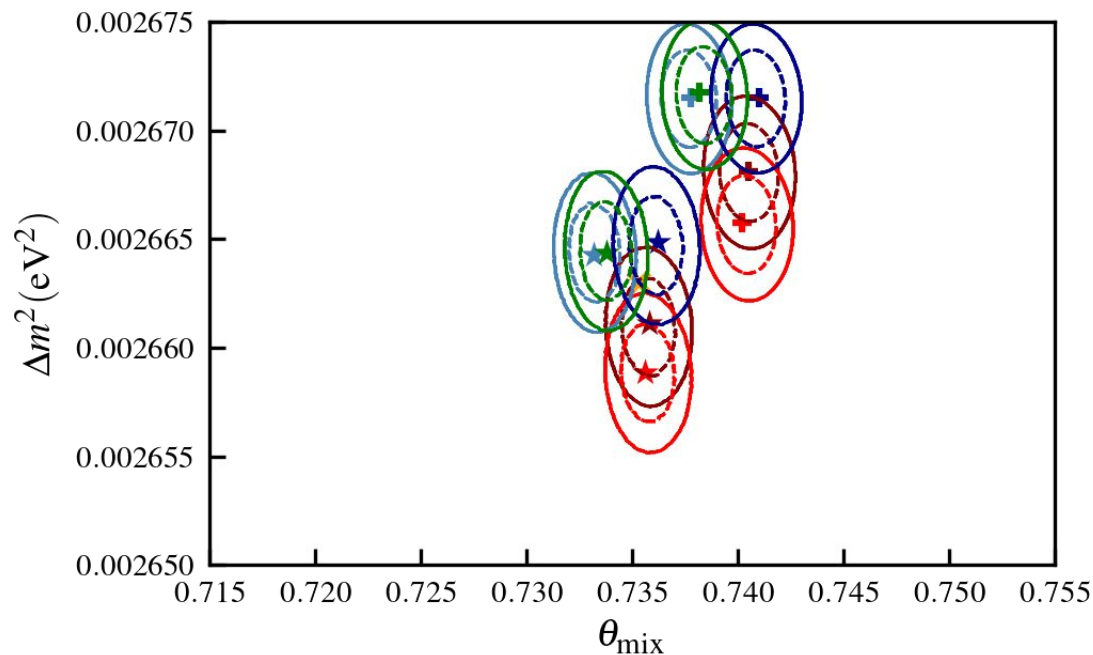
# Answering to the reviewer

- $\chi^2$  test to assess normality of transformed data.



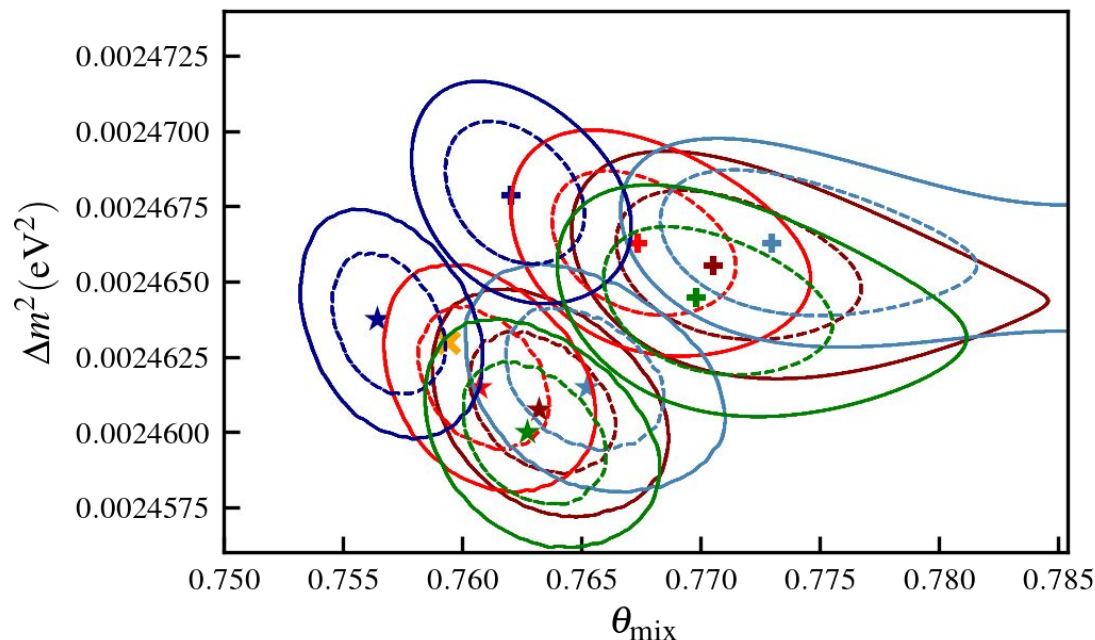
# Answering to the reviewer

- Define bias of the methods (interpolated histogram method vs NN):



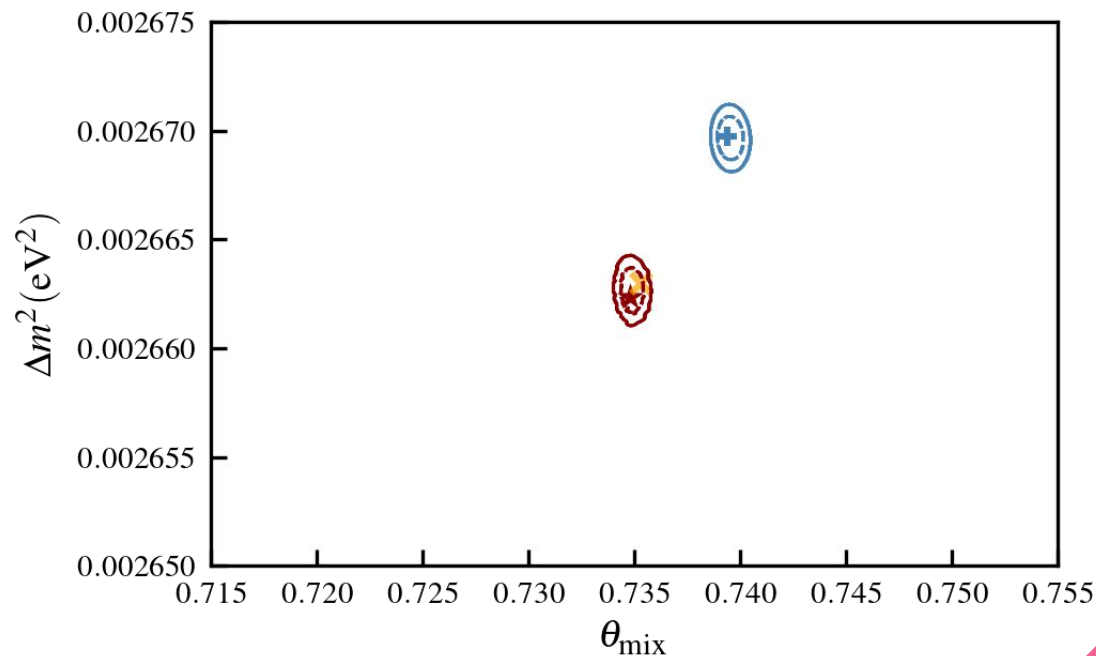
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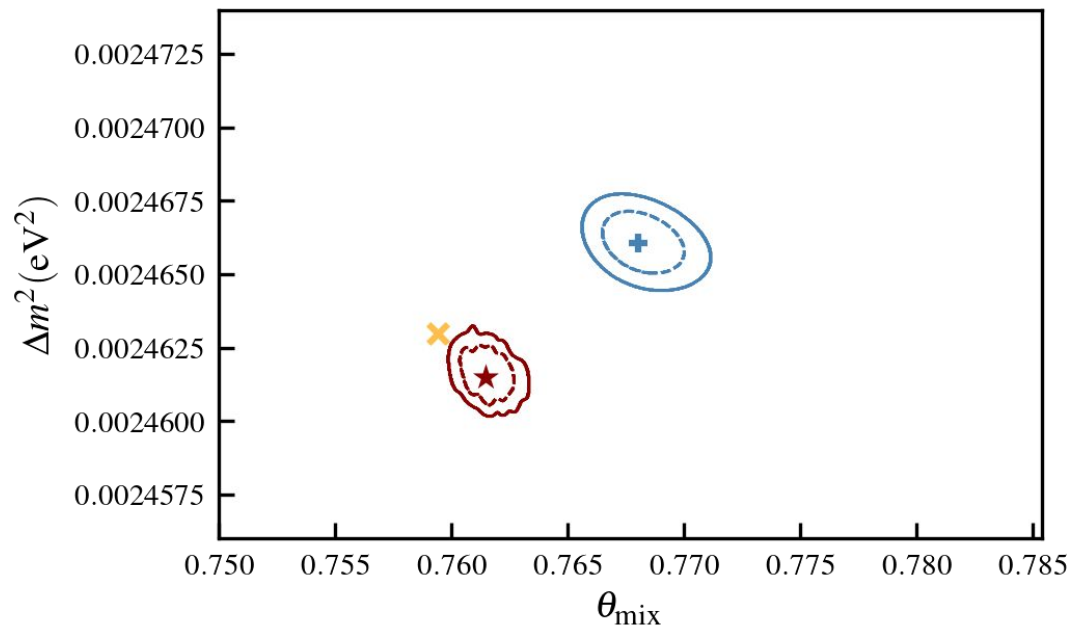
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# Answering to the reviewer

- Define bias of the methods (interpolated histogram method vs NN):





# Sequential weighted density estimation

# Theoretical background

Given a density  $p(x)$ , we want to fit  $q_\phi(x)$  using

$$\operatorname{argmin}_\phi D_{KL}(p(x) \parallel q_\phi(x)) =$$

$$\operatorname{argmin}_\phi - \int p(x) \log q_\phi(x) dx.$$

$p(x)$  is only available analytically, but we are not able to generate from it. We can use an auxiliary density  $f(x)$  which can be evaluated and also sampled from to obtain:

$$\operatorname{argmin}_\phi - \int p(x) \log q_\phi(x) dx =$$

$$\operatorname{argmin}_\phi - \int f(x) \frac{p(x)}{f(x)} \log q_\phi(x) dx =$$

$$\operatorname{argmin}_\phi - \int f(x) w(x) \log q_\phi(x) dx \approx$$

$$\operatorname{argmax}_\phi \frac{1}{n} \sum_i^n w(x_i) \log q_\phi(x_i),$$

$$x_i \sim f(x) \text{ and } w(x_i) = p(x_i)/f(x_i)$$

The stability and convergence of the method depends on how close we choose  $f(x_i)$ , i.e. on the variance in scale of  $w(x)$ .

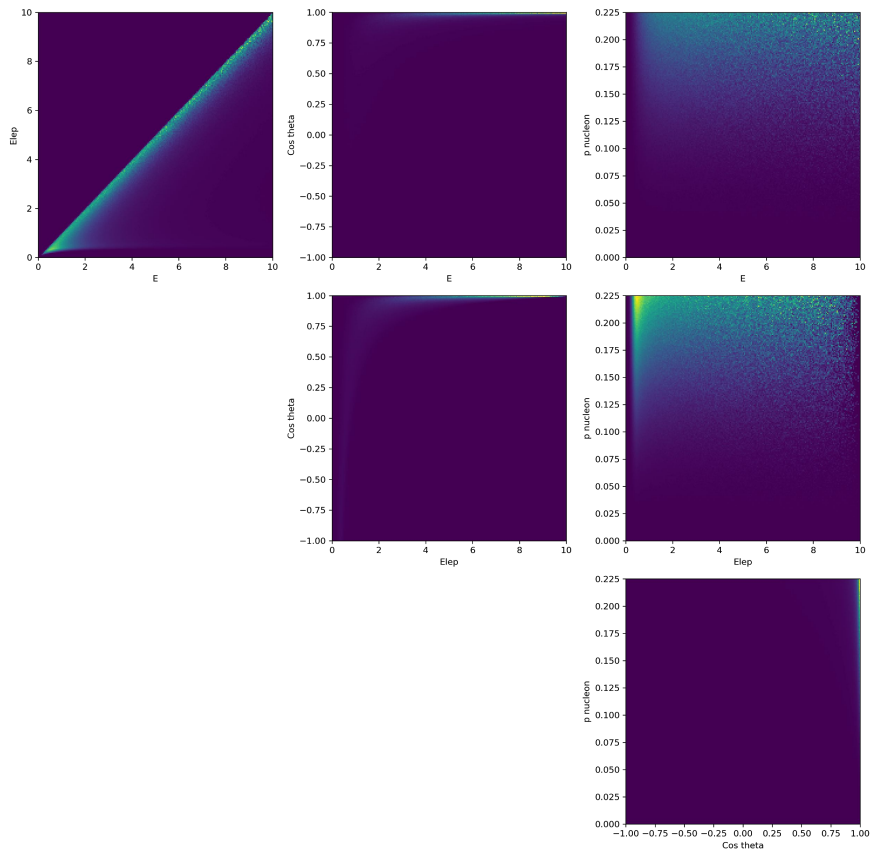
**Idea:** use  $q_\phi(x)$  as  $f(x)$  after training a bit:

- Train  $q_\phi(x)$  on a *bad*  $f(x)$  in a warm up period.
- Use  $q_\phi(x)$  as  $f(x)$  iteratively, obtaining better and better weights in each iteration.



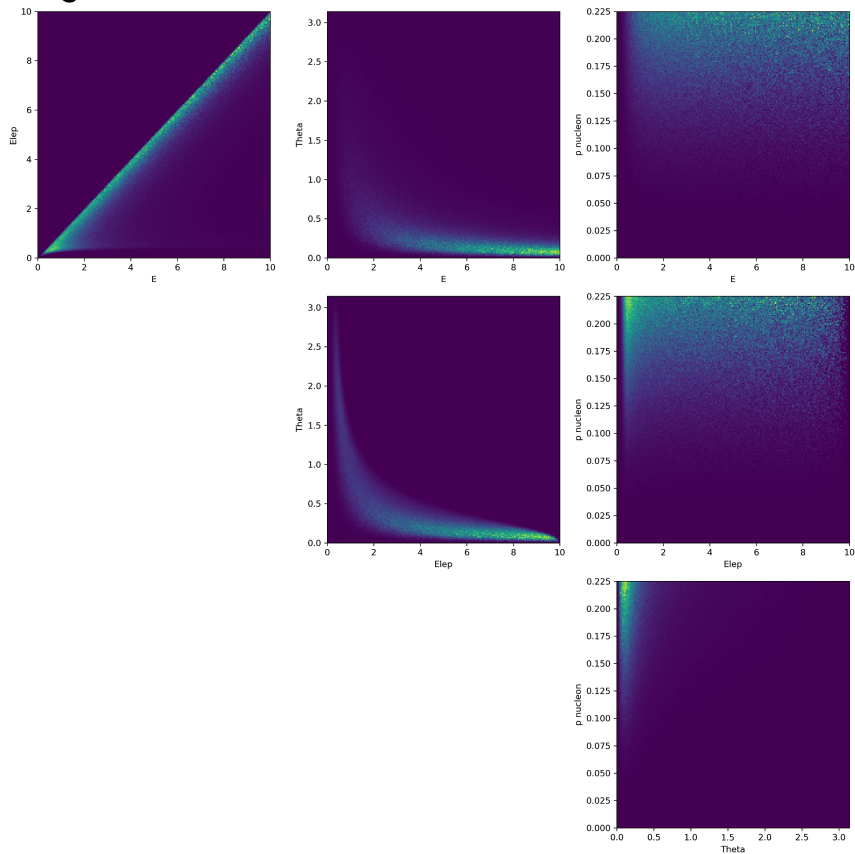
# Practical test: CCQE interaction

4 variables:  $E_{\text{neutrino}}$ ,  $E_{\text{lepton}}$ ,  $\cos \theta$  and  $p_{\text{nucleon}}$ .



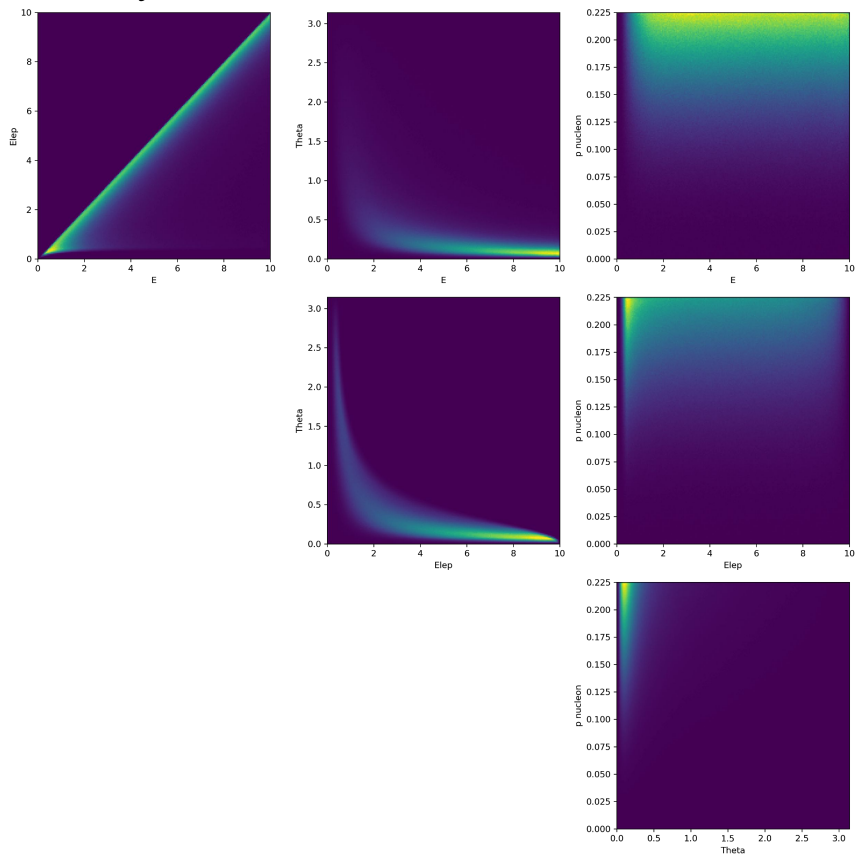
# Practical test: CCQE interaction

Changed Cos Theta to Theta. It was too condensed:



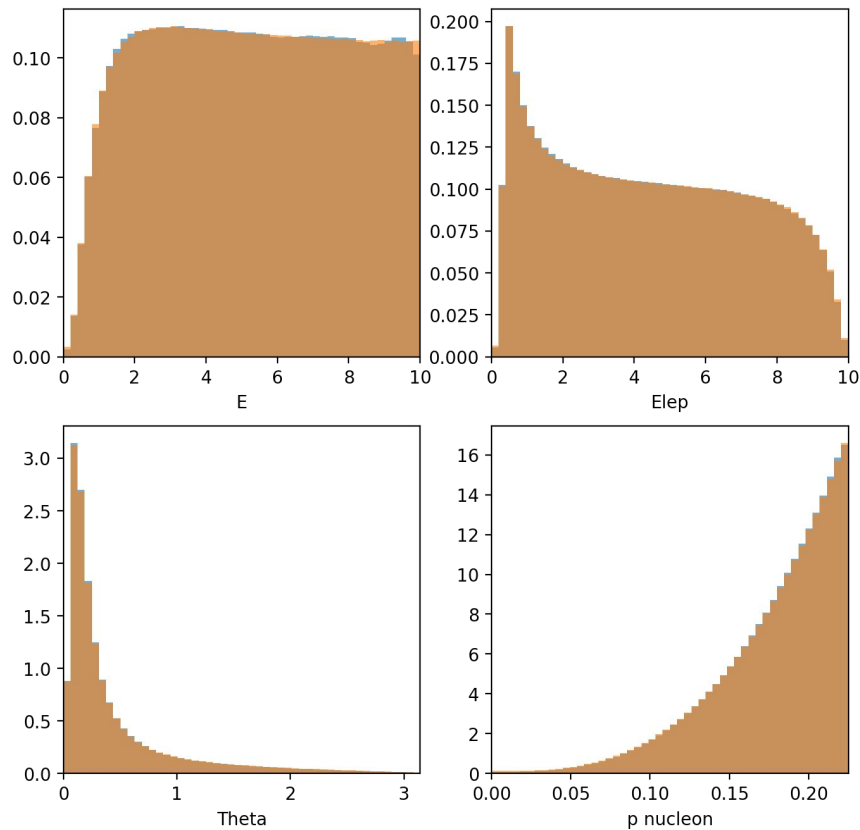
# Practical test: CCQE interaction

Learned by the NN



# Practical test: CCQE interaction

Learned by the NN 1D vs Real:



# Practical test: CCQE interaction

Final weights distribution

