νe appearance@nuPRISM

update on the sensitivity studies

Javier Caravaca, **Stefania Bordoni**, Federico Sánchez, John Vo

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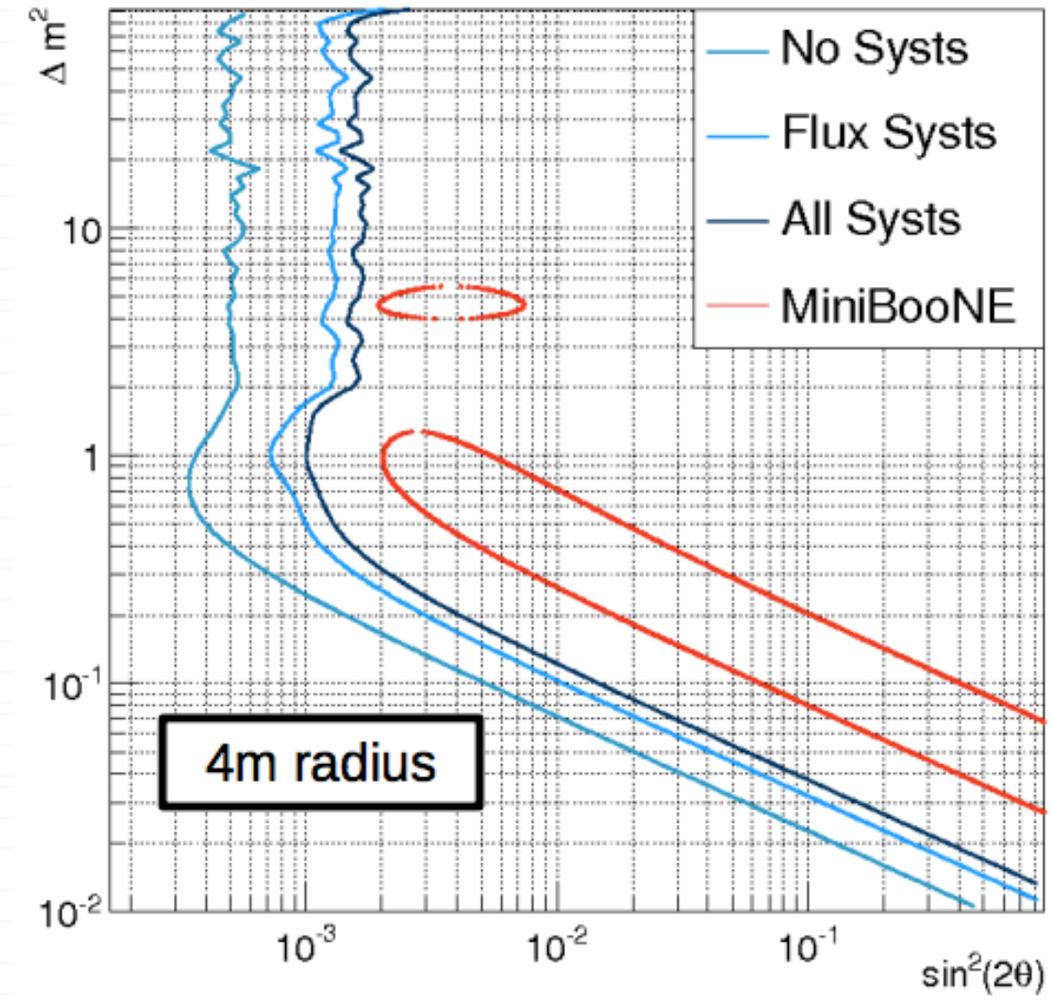
Short reminder

- We studied the nuPRISM sensitivity to to sterile neutrinos oscillations (**ν**e appearance) with the 3+1 model

- The latest results shown an improvement of the nuPRISM sensitivity while considering:
  - a detector of 4m radius (instead of 3m)
  - a shape + rate analysis based on both the reconstructed energy and the off-axis
  - signal events are calculated by re-weighting the **ν**e background according to the ν_e/ν_μ flux ratio

- nuPRISM can exclude the MiniBooNE allowed region for a 3+1 sterile model

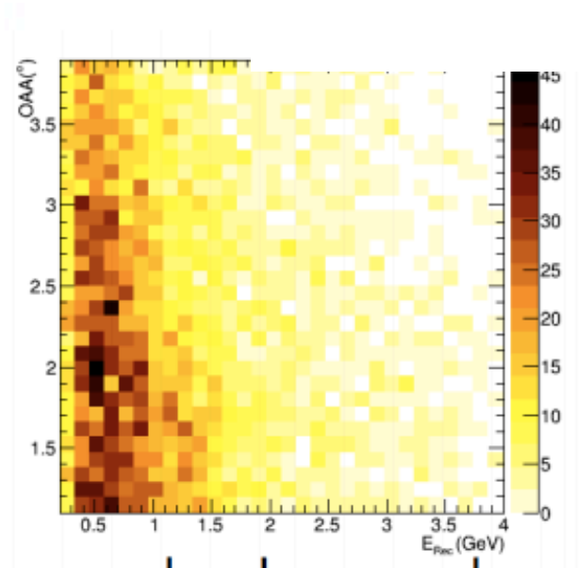


reminder: ν_e-signal template

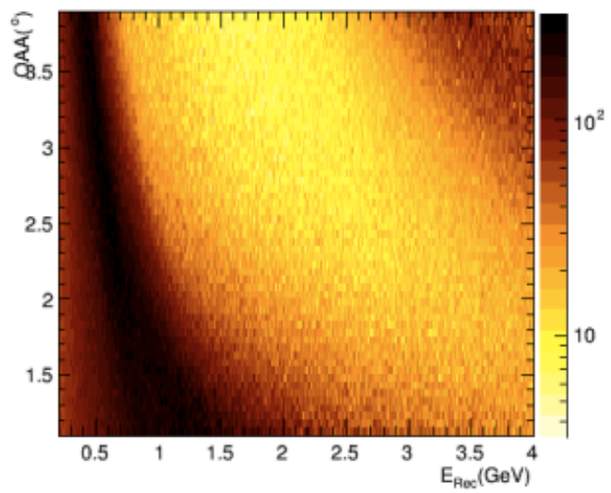
1. Select νe background sample of events by requiring :
   - at least 2m between the reconstructed vertex position and the wall of nuPRISM
   - at least 200MeV of visible energy
   - at least 3.2m distance to the nuPRISM wall in the lepton direction
2. Re-weight the νe background sample to the νμ flux
3. Apply the 3+1 oscillation probability

$$P(\nu_\mu \to \nu_e) = P(\nu_e \to \nu_\mu) = 4|U_{e4}|^2|U_{\mu 4}|^2 \sin^2\left(1.27\,\Delta m^2_{41}\frac{L}{E}\right)$$

$$\sin^2(2\theta_{e\mu}) = 4|U_{e4}|^2|U_{\mu 4}|^2$$



X



X $P(\nu_\mu \to \nu_e)$

ν_e background

ν_μ/ν_e

Unoscillated ν_e events in FV

Reminder: analysis strategy

- The analysis is done in a 10 Erec x 10 OAA plane with :
  Erec = (0.2 GeV , 4 GeV) and OAA = (1.1° , 3.9°)

- Build of a χ^2 estimator for correlated Gaussian distributions with a covariance matrix :

$$\chi^2 = (signal)^T \; V^{-1} \; (signal)$$

  - the covariance matrix is a **linear sum** of the **statistical** and **flux** and **cross-section** components
  - the signal is a 100 elements vector depending on the oscillation parameters

- The nuPRISM sensitivity is then obtained by computing the value of the χ^2 for each point of the ($\sin^2 2\vartheta$, Δm^2) phase space (100 x 100 bins)

What is new today

- Javier defended his thesis (congratulations!). I am taking over from him, ensuring with John and Federico the continuity on this analysis

- We studied the nuPRISM sensitivity considering as oscillation parameters the MiniBooNE best fit point (Erec>200MeV) for anti-neutrinos:

  $(\sin^2 2\vartheta, \Delta m^2) = (0.0061, 4.42\ eV^2)$

  - We studied the sensitivity for two cases :
    - vs. reconstructed energy (30 bins)
    - vs. reconstructing energy and off-axis angle (10 x 10 bins)

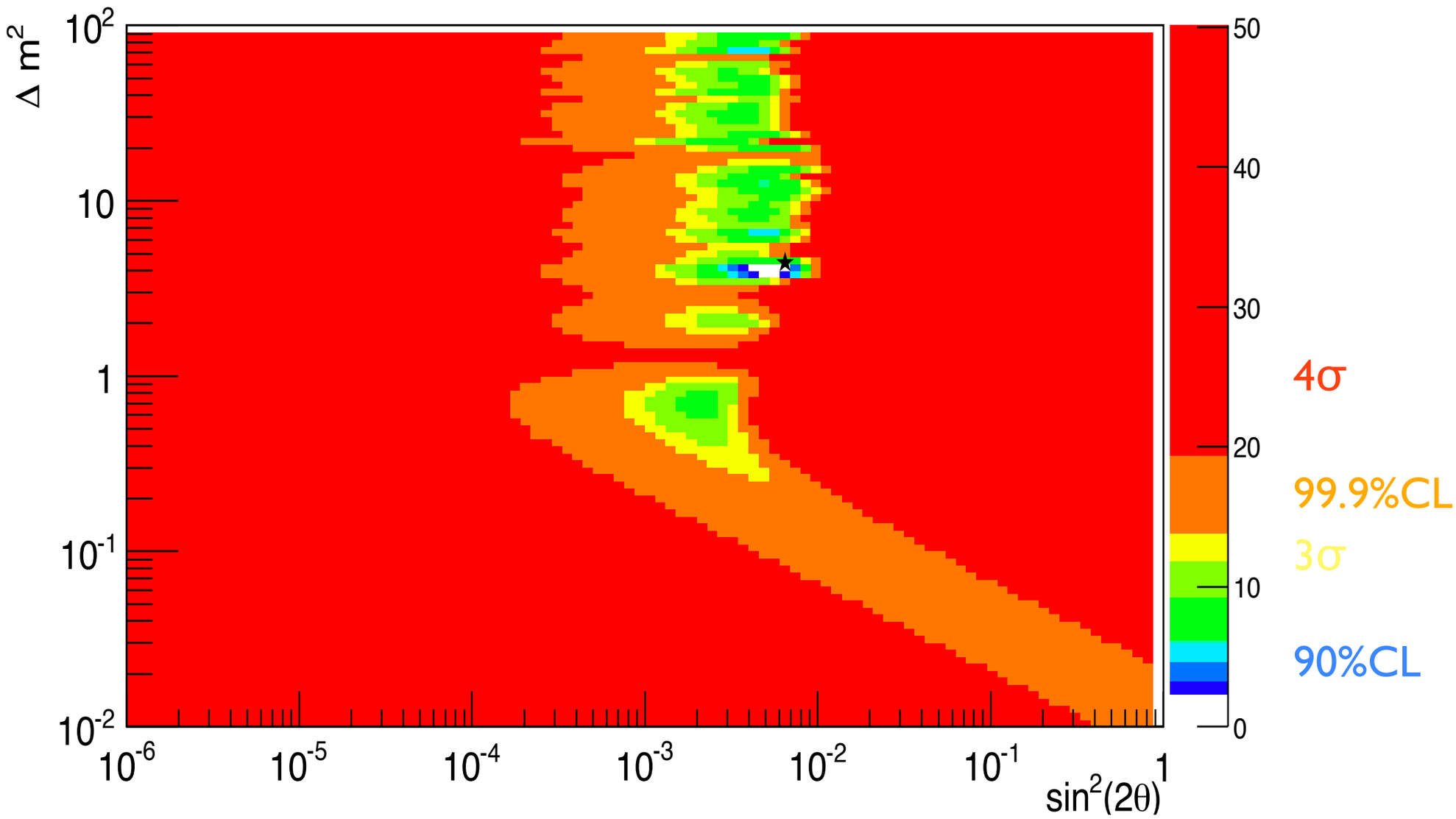
- We studied the nuPRISM sensitivity with respect to ν_e/ν_μ ratio (instead of νe-signal only) to reduce the effects due to the systematics

The results presented in the following slides are for an exposure of 4.6 10^{20} POT

Study of the NuPRISM sensitivity considering oscillations at the MiniBooNE best fit point

NuPRISM sensitivity with MB input

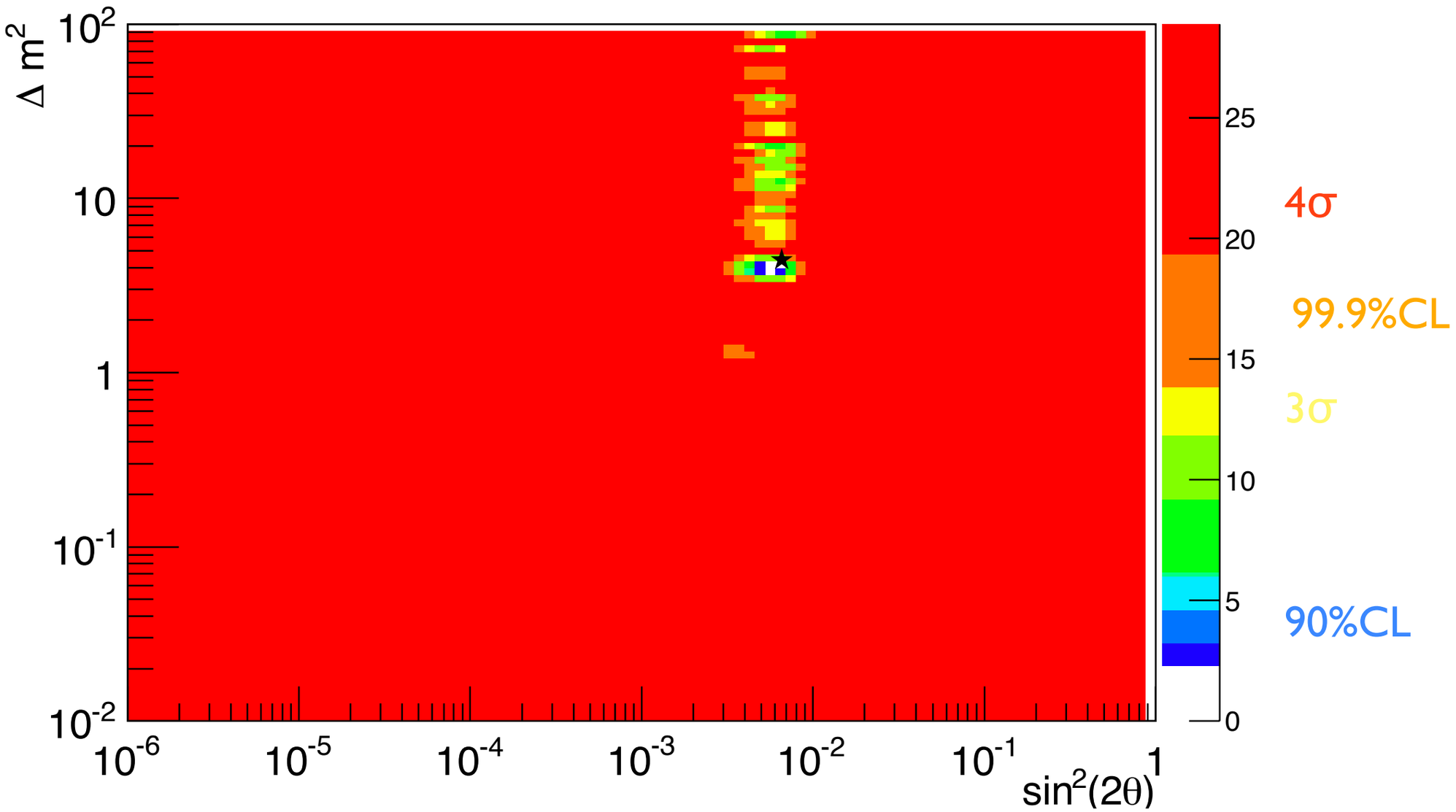
- We consider oscillations for $\sin^2 2\vartheta = 0.0066$ and $\Delta m^2 = 4.42\ eV^2$ (MiniBooNE best fit point)
- **30 bins in Erec** (0.2 GeV, 4 GeV)
- Confidence intervals drawn for several levels (90%CL, 3σ, 99.9%CL, 4σ)



★ MiniBooNE best fit point

NuPRISM sensitivity with MB input

- We consider oscillations for $\sin^2 2\vartheta = 0.0066$ and $\Delta m^2 = 4.42\ eV^2$ (MiniBooNE best fit point)
- **10 bins in Erec** (0.2 GeV, 4 GeV) and **10 bins in OAA** (1.1° , 3.9°)
- Confidence intervals drawn for several levels (90%CL, 3σ, 99.9%CL, 4σ)



★ MiniBooNE best fit point

Study of the nuPRISM sensitivity considering ν_e/ν_μ ratio

Covariance matrix

- In parallel to the ν_e background template we select a ν_μ template using criteria very closed to the ones applied to the ν_e:
  - at least 1m between the reconstructed vertex position and the wall of nuPRISM
  - at least 30MeV of visible energy
  - at least 2.0m distance to the nuPRISM wall in the lepton direction
  - at least 200MeV in momentum

- Analysis performed for **10 Erec x 10 OOA** bins

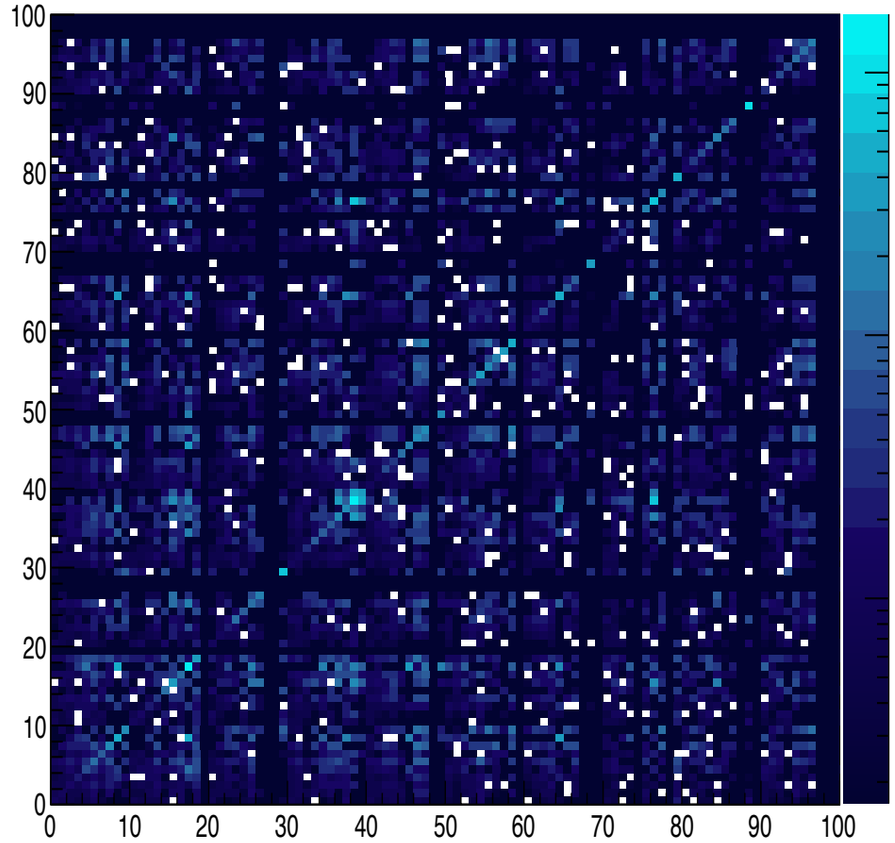
- Build of a χ^2 estimator for correlated Gaussian distributions, with a covariance matrix :

$$\chi^2 = \left(\frac{signal}{\nu_\mu}\right)^T \; V^{-1} \; \left(\frac{signal}{\nu_\mu}\right)$$

- V (stat) is the statistical error of (signal+bkg)/ν_μ

- The nuPRISM sensitivity is then obtained by computing the value of the χ^2 for each point of the ($\sin^2 2\vartheta$, Δm^2) phase space (100 x 100 bins)

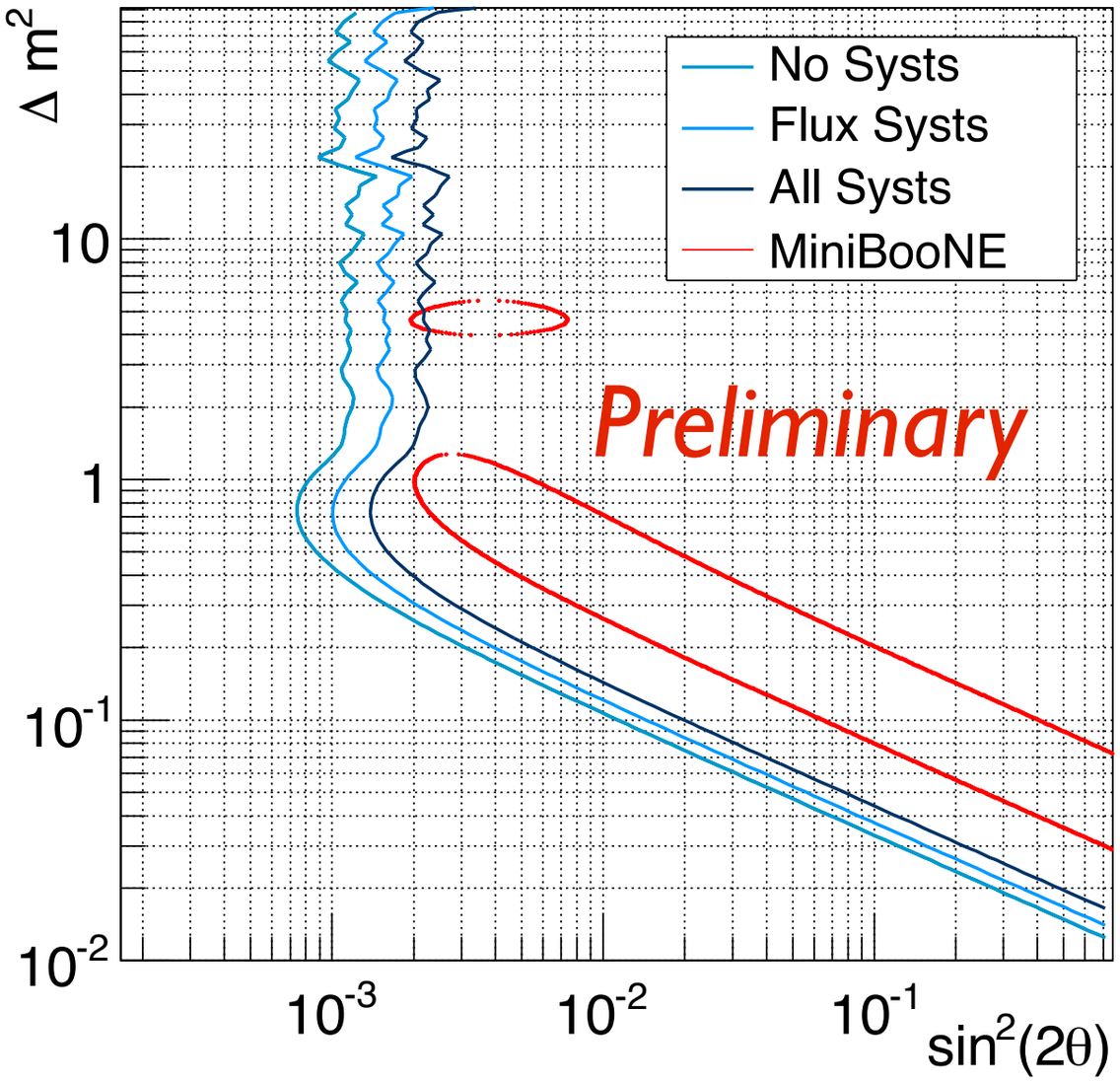
Total covariance matrix (3m)



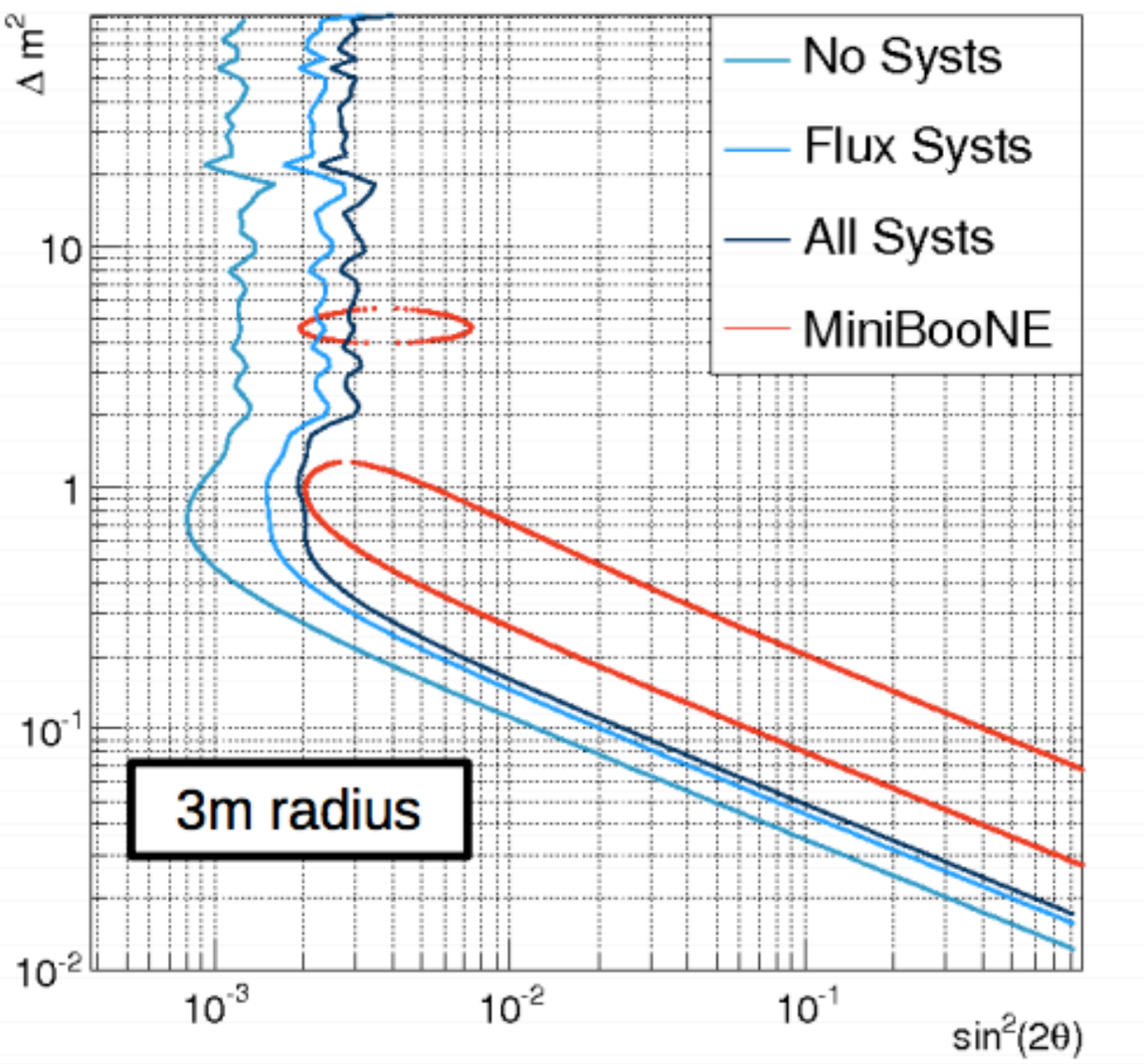
Sensitivity

nuPRISM radius 3m

ν_e/ν_μ ratio



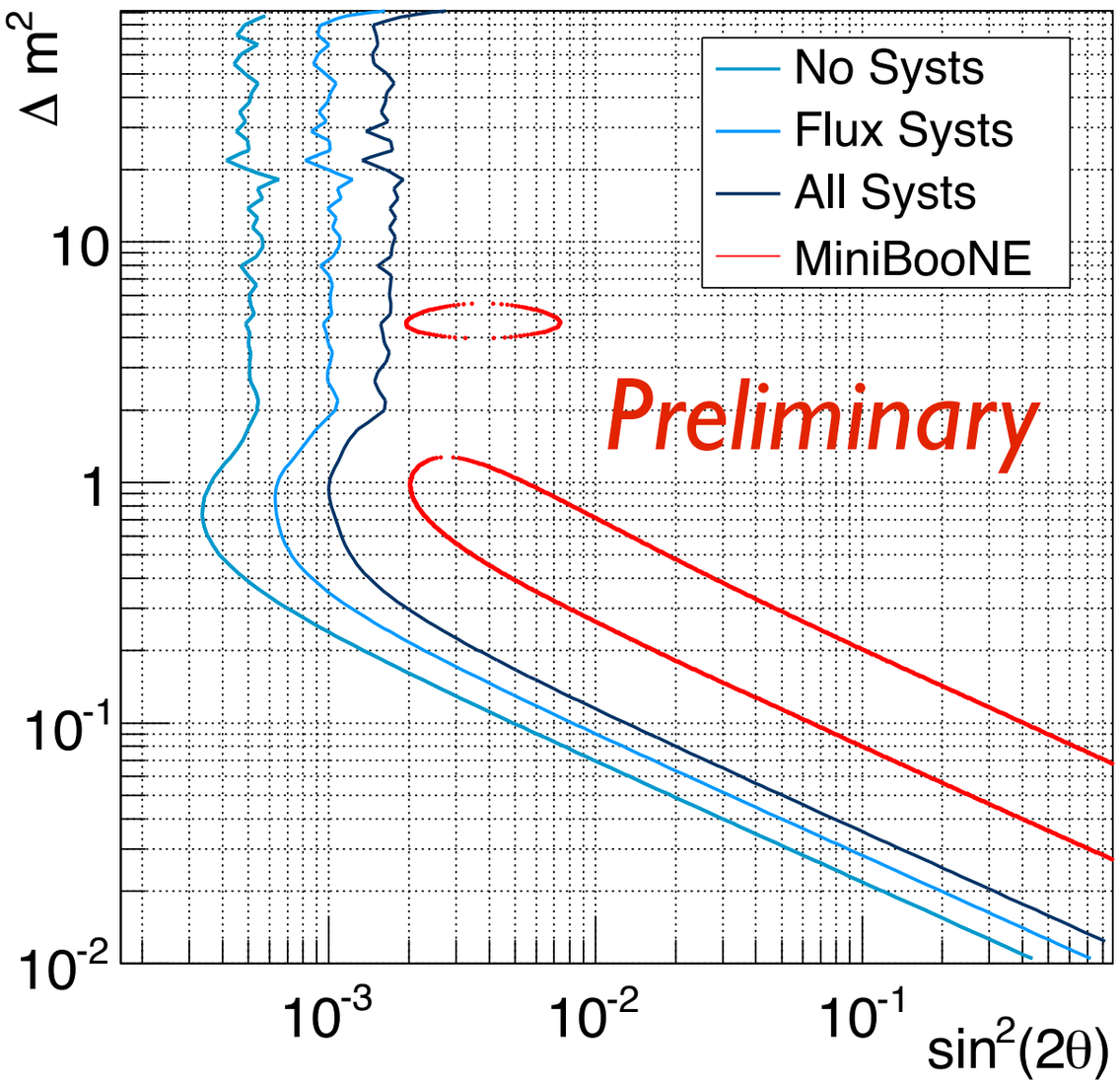
ν_e signal alone (EoI results)



Sensitivity

nuPRISM radius 4m

ν_e/ν_μ ratio



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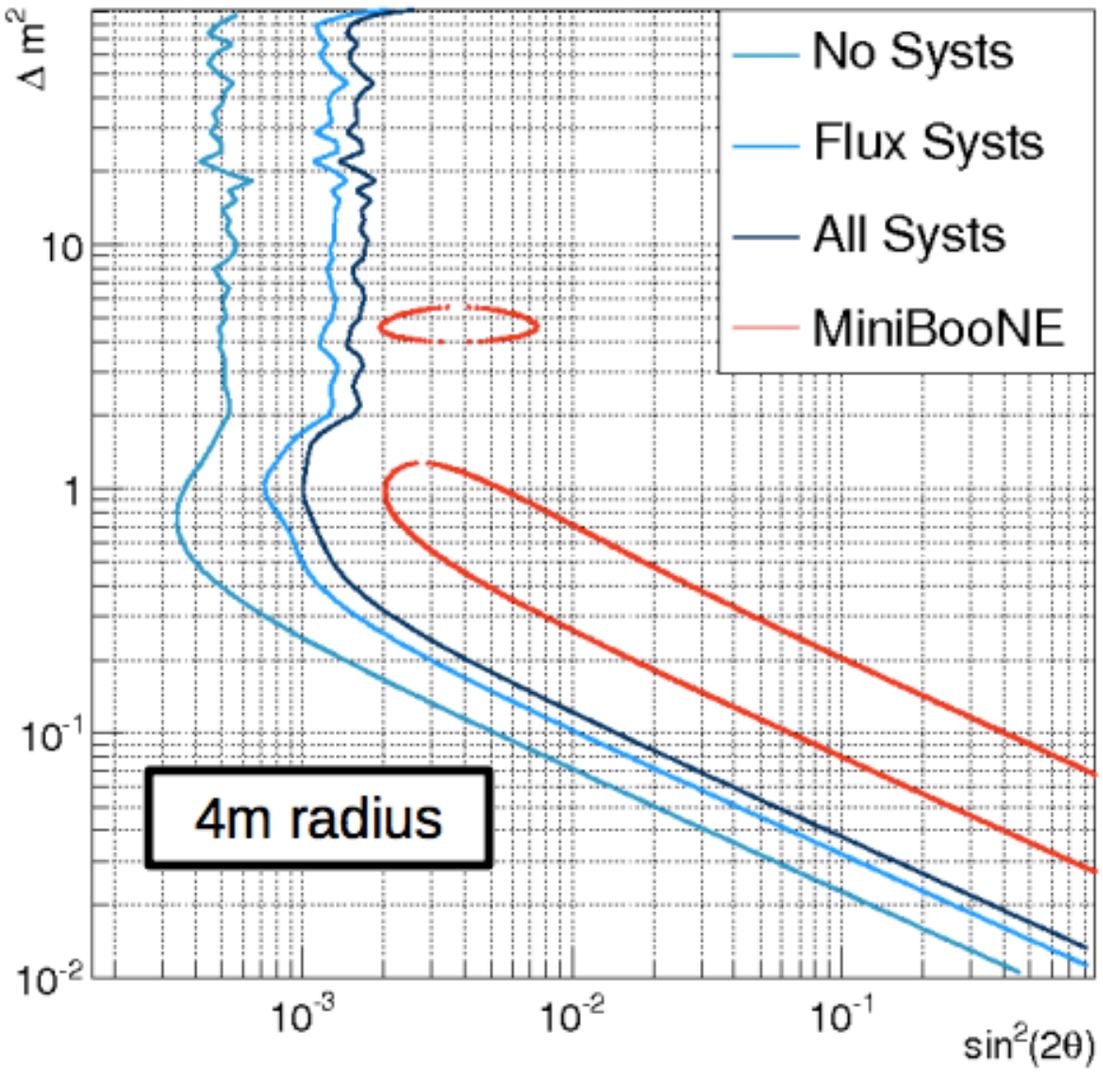


Conclusions

- The results on the nuPRISM sensitivity to the ν_e appearance previously presented and included in the EoI are promising
  - considering a **3m** (4m) radius nuPRISM can **quasi-totally** (totally) **exclude the MiniBooNE allowed region**

- We considered the case of short baseline oscillations with oscillation parameters closed to the MiniBooNE best fit point. In that case nuPRISM would be able to **reject** the **non-oscillation hypothesis** at 4σ

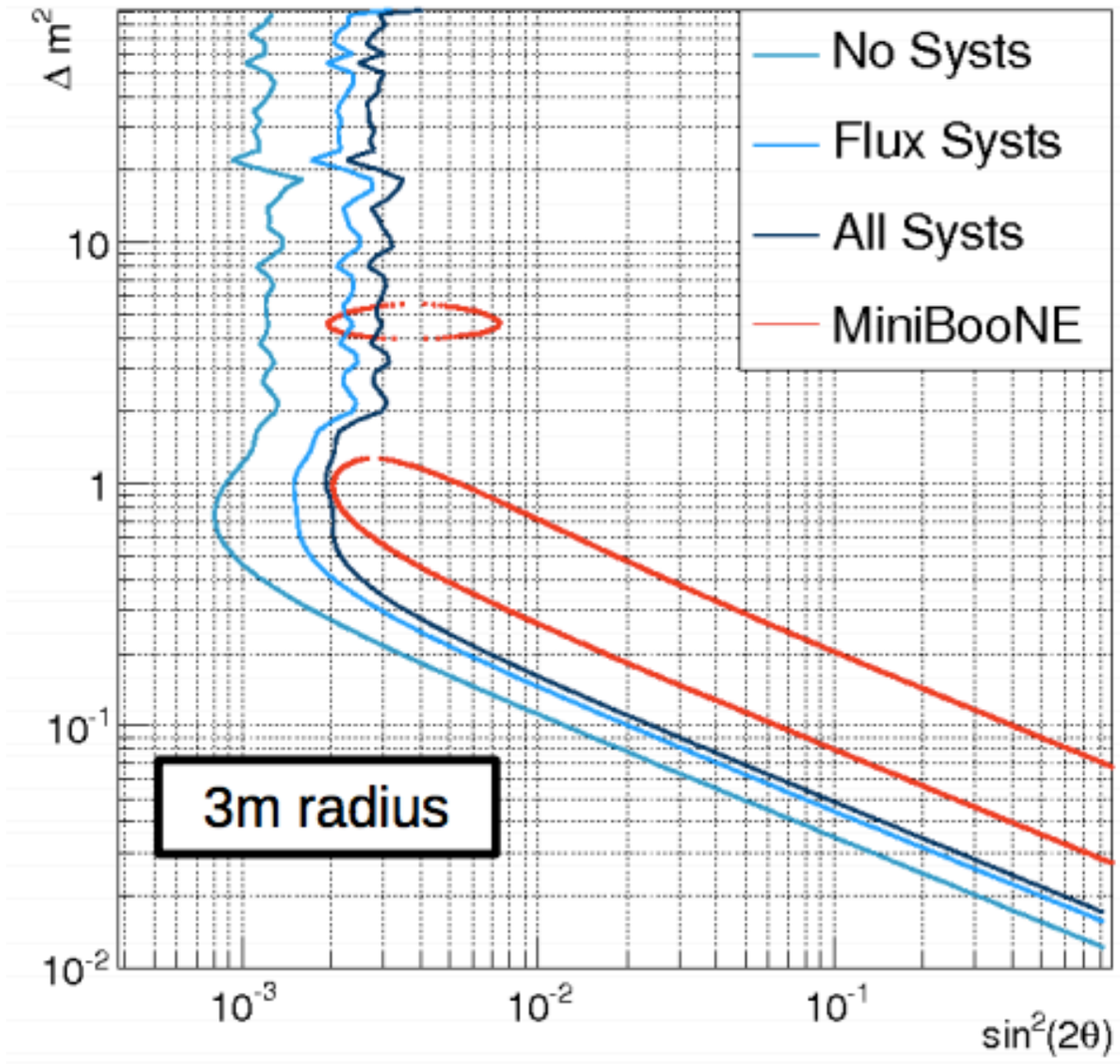
- The **analysis** as a function of the ν_e/ν_μ **ratio** have been implemented
  - Preliminary results for the nuPRISM sensitivity have been presented performing the analysis with 10Erec x 10 oaa bins for both the cases of a 3m or 4m detector radius
  - The impact due to the flux systematics is reduced. Smaller reduction are observed for the cross-section systematics

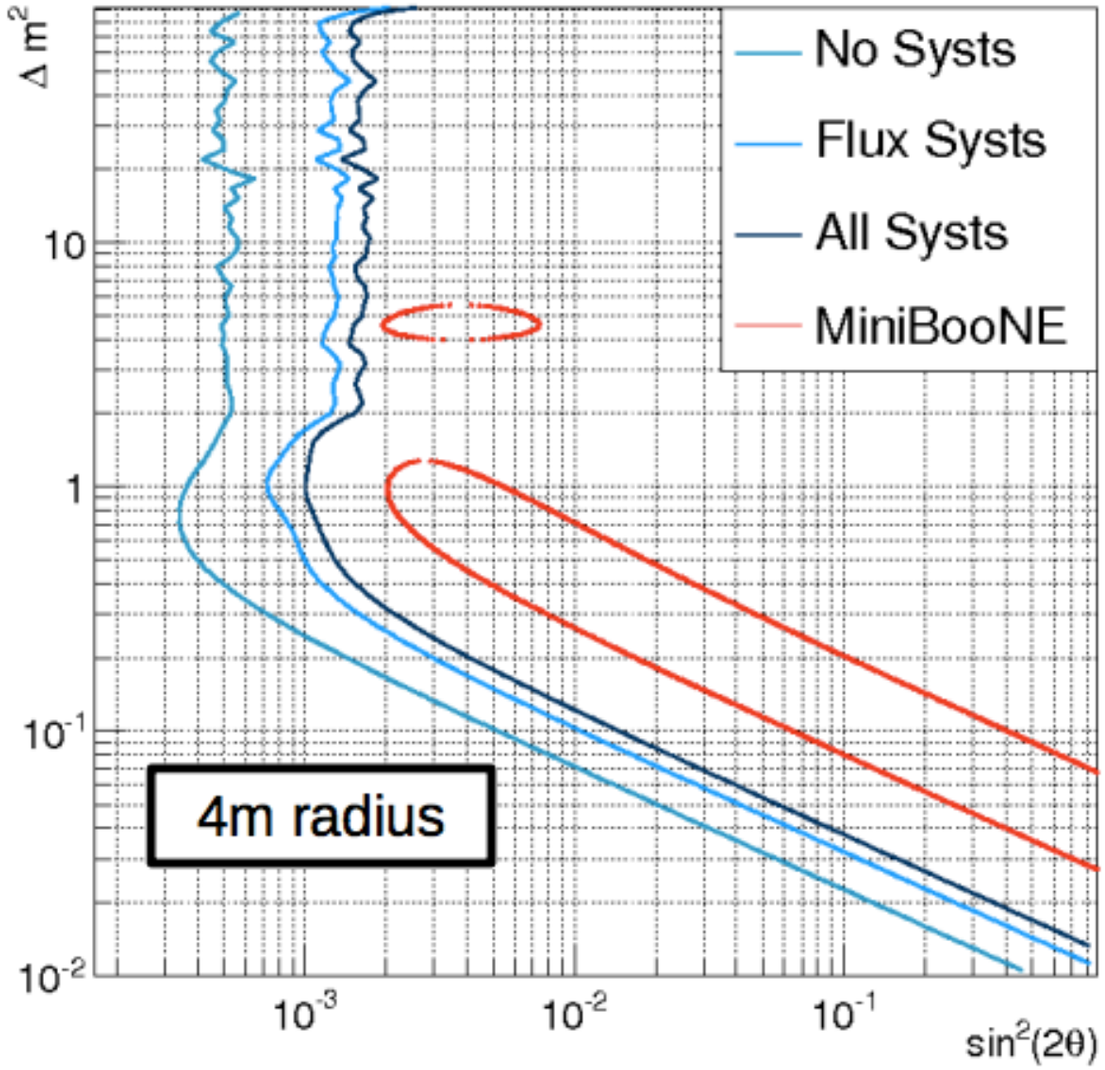
- We would like to have a publication from these results. How to proceed ?

backup

Sensitivity

ν_e signal alone (EoI results)





Sensitivity

ν_e/ν_μ ratio