SOX with likelihood ratio (… Studies on the sensitivity in progress)

CeSOX meeting

5-7/2/2014

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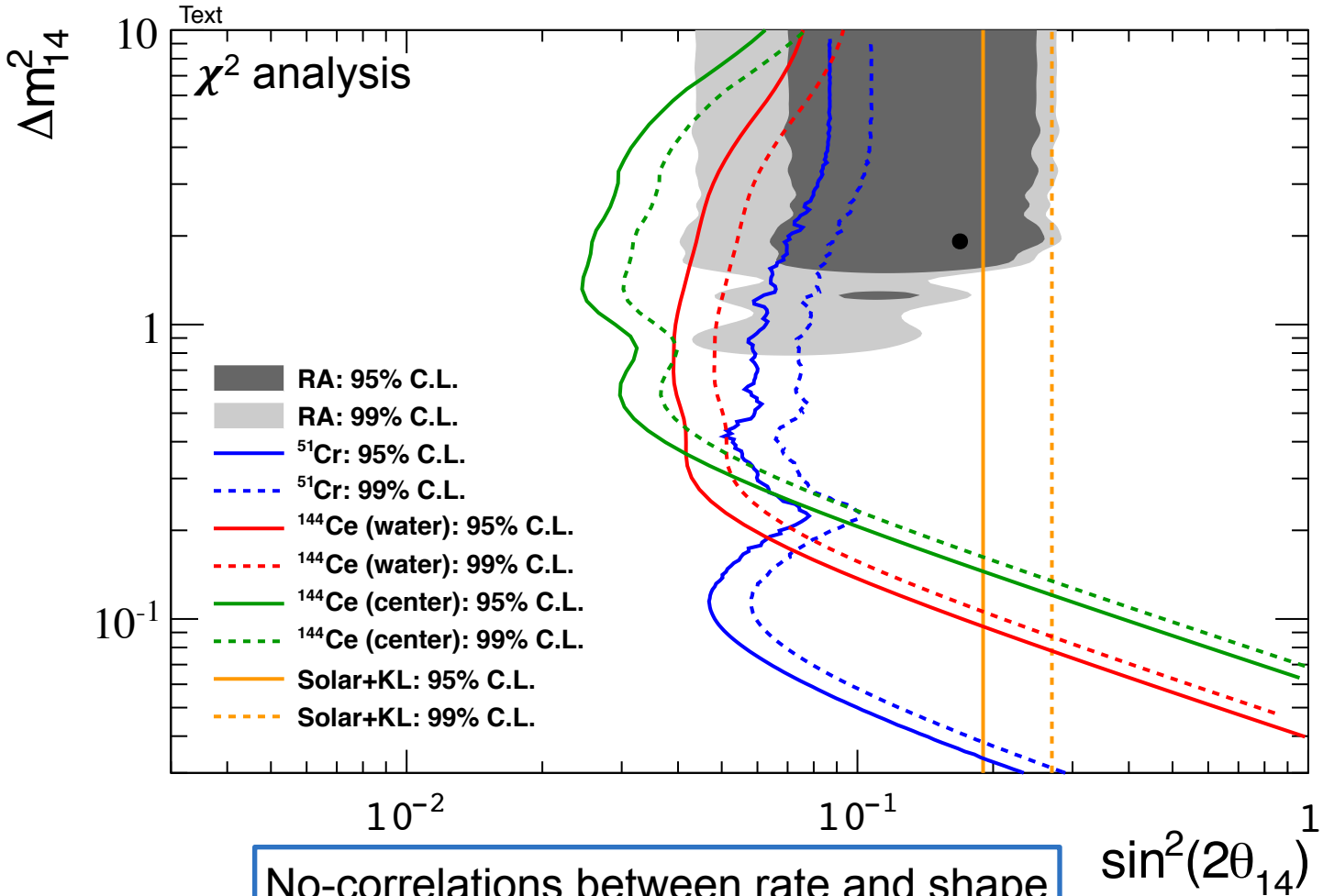
How was it?

Rate Only + Shape Only

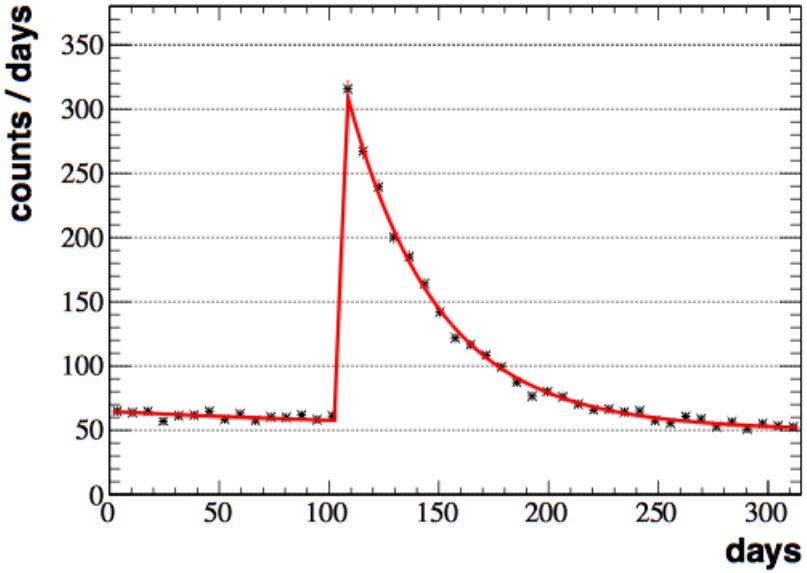


No-correlations between rate and shape
Systematics included

^{51}Cr analysis: what's new?

New analysis based on:

- **rate** + **shape** at the same time
- three variables: **energy** - **time** - **distance**
- **bg knowledge** from pre-source period: fiducial volume does not affect bg knowledge
- **no alpha/beta**: systematics at the percent level

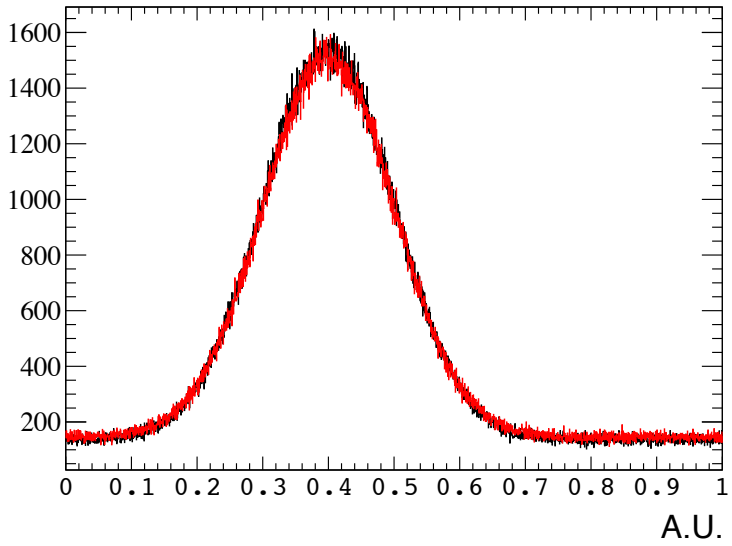


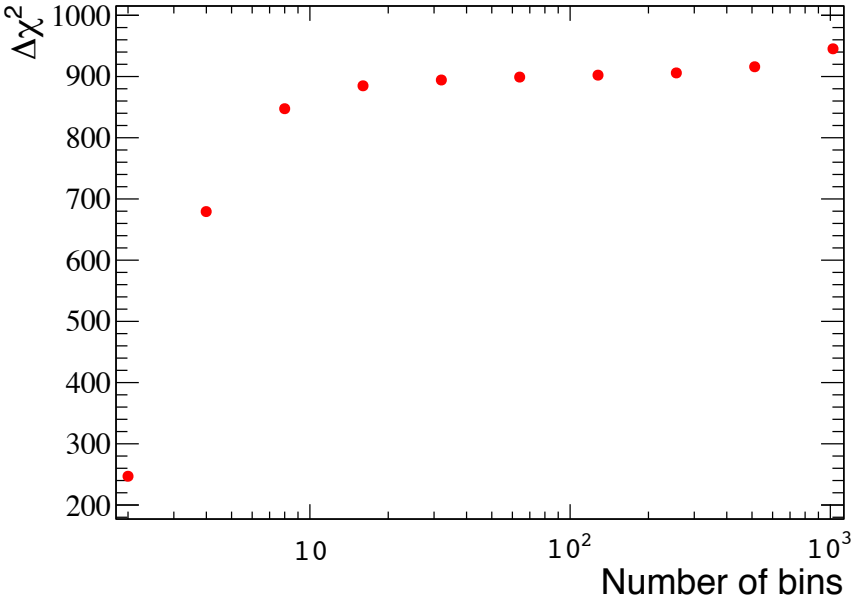
Goal: sensitivity and potential conflicts with purification
- what's happen if ^{210}Po increases?
- what's the minimum acceptable period between purification and source data taking?
- what's the impact of systematics on ^{210}Po fluctuations?

A simple consideration

- Sterile neutrino analysis: 2 parameters
- Minimum: $\sum \chi^2_{min} \sim$ NDF = Nbins - 2
- $\sum \chi^2 \gtrsim$ Nbins - 2
- If there is a **shape feature**, increasing Nbins, **$\Delta\chi^2$ increases**, while sensitivity thresholds from the Wilks theorem are constant
- Best case: **extended unbinned likelihood** or **small bin size binned likelihood**

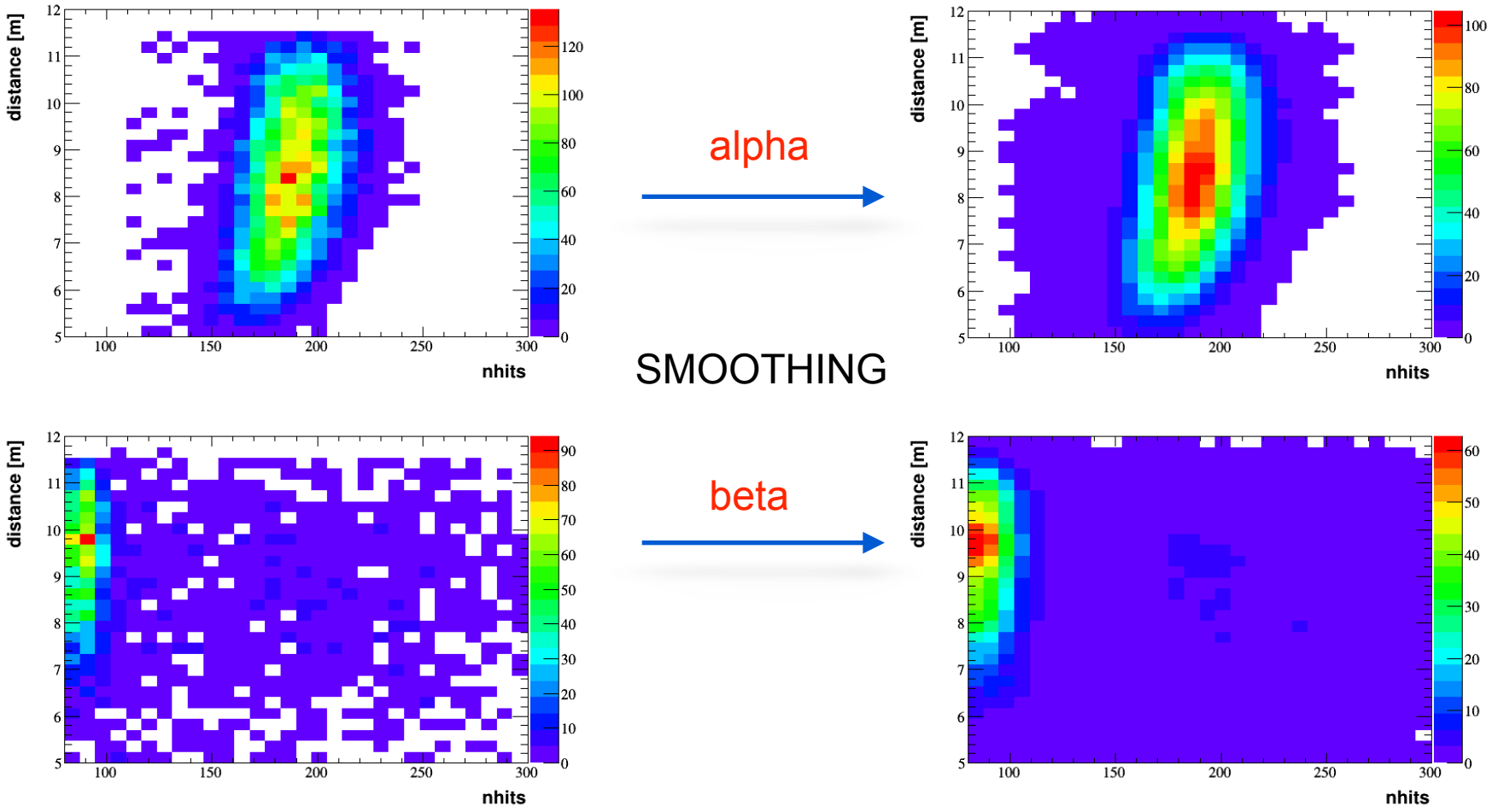
Simple example (statistics 1E6 events and 100 pseudo-experiments):
True (black): 0.70 x signal (gaussian) + 0.30 x bg (flat)
Test (red): 0.72 x signal (gaussian) + 0.28 x bg (flat)





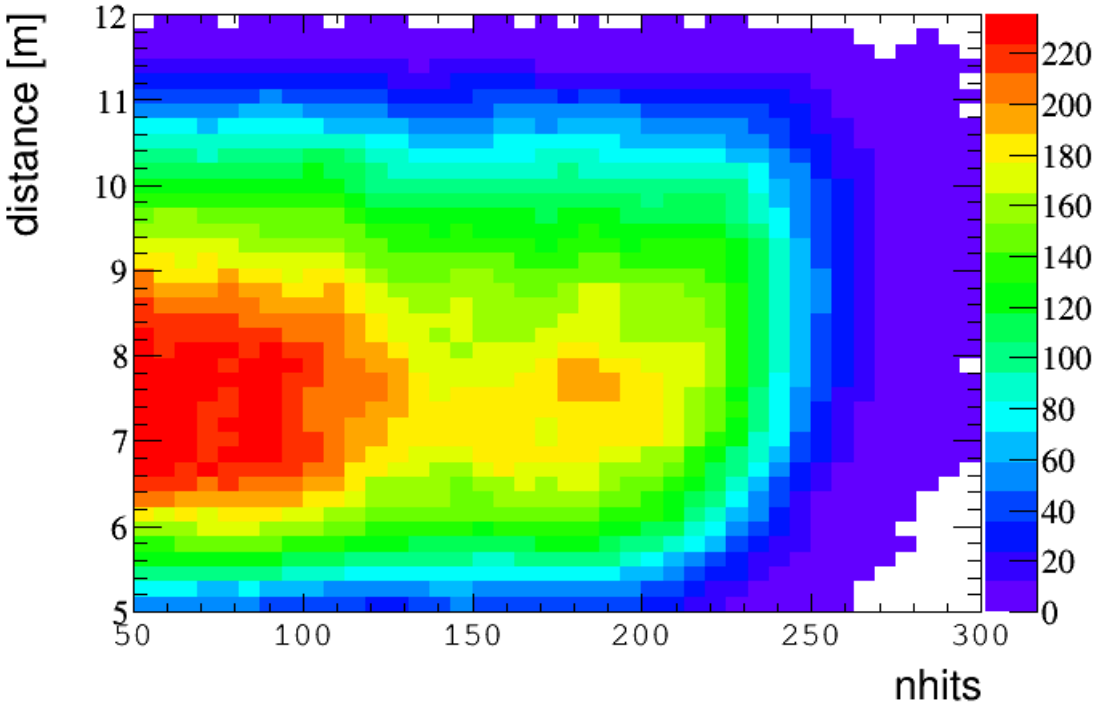
The Toy Monte Carlo

Background events from data
Two years of data… but not enough statistics because of alpha/beta for modeling the background



The Toy Monte Carlo

Neutrino events from G4Bx



Variables: Energy - Distance - Time
Small bin size: most of the bins with p(0 ev) + p(1 ev) ~ 1

Null Hypothesis Rejection

Definitions:

H0: non oscillation hypothesis
H1(x1,x2): oscillation hypothesis with x1,x2 oscillation parameters
H0 = H1(0,0), hence **nested** hypothesis
H0, H1 dependent on two **nuisance** parameters: f_v and f_{bg}

Y0: data set in case of non oscillation
Y1(x1,x2): data set in case of oscillation depending on x1,x2

(1) **Samples Y0** based on **H0** (non oscillation)

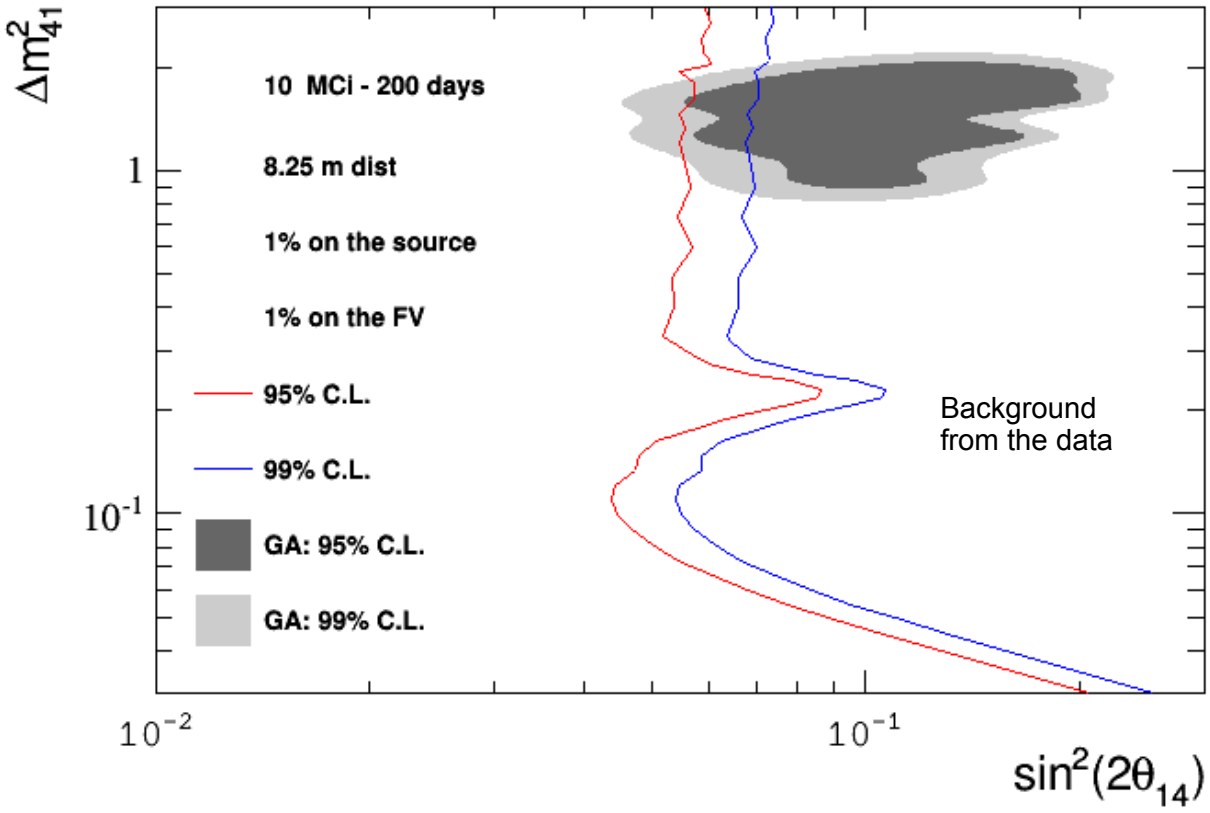
(2) PDF's generated via **MC**

(3) **marginalizing the 2 nuisance parameters**: amplitudes of signal and bg

(4) 2 x logL difference between **max P(H1(x1,x2)|Y0)** and **min P(H1(x1,x2)|Y0)**

$$-2 \times \log L = 2x\sum_i [\log pdf(y_i)] - (N_0 - N)^2 / N_0 - ((f_v - 1)/\sigma_v)^2$$

Null Hypothesis Rejection



GA
Lavader and Giunti, arXiv:1310.7478
global analysis of all anomalies

Discovery Potential

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(2) PDF's generated via **MC**

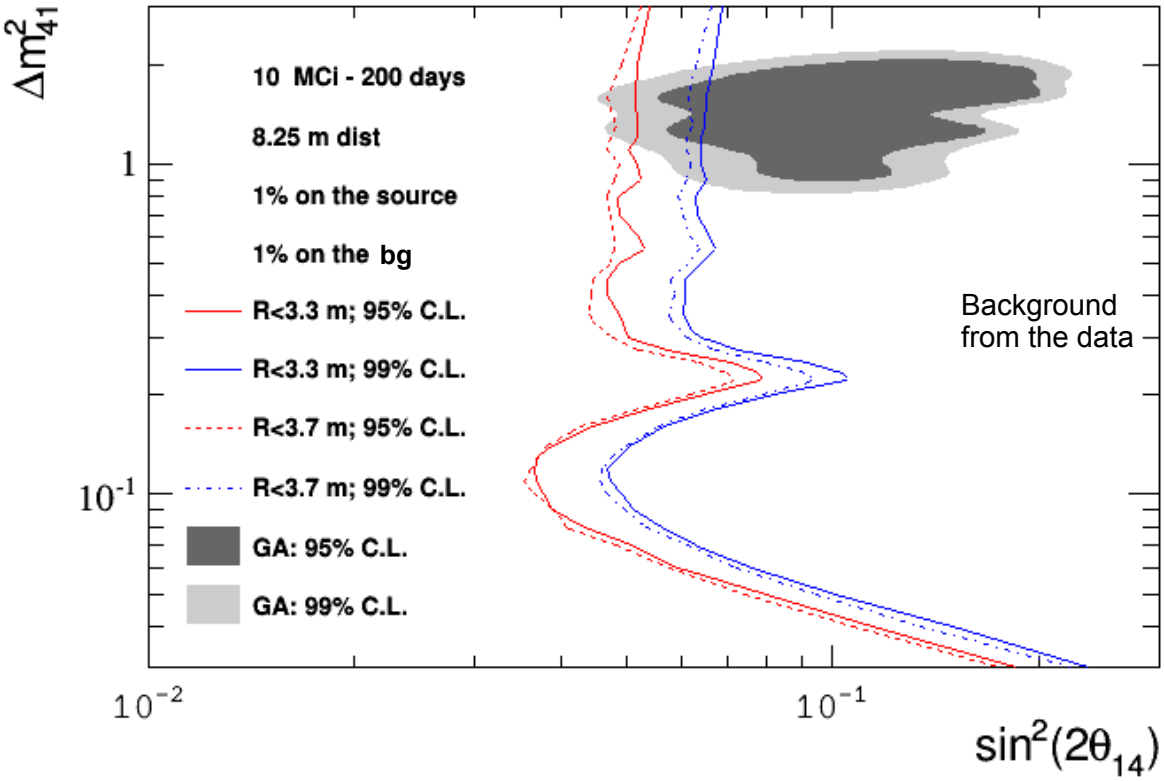
(3) **marginalizing the 2 nuisance parameters**: amplitudes of signal and bg

(4) 2 x logL difference between **min P(H1(x1,x2)|Y1)** and **P(H0|Y0)**

$$-2 \times \log L = 2x\sum_i \log(pdf(y_i)) - ((f_v - 1)/\sigma_v)^2 - ((f_{bg} - 1)/\sigma_{bg})^2$$

Discovery Potential

3.3 and 3.7 m radii
1% source error
1% FV error



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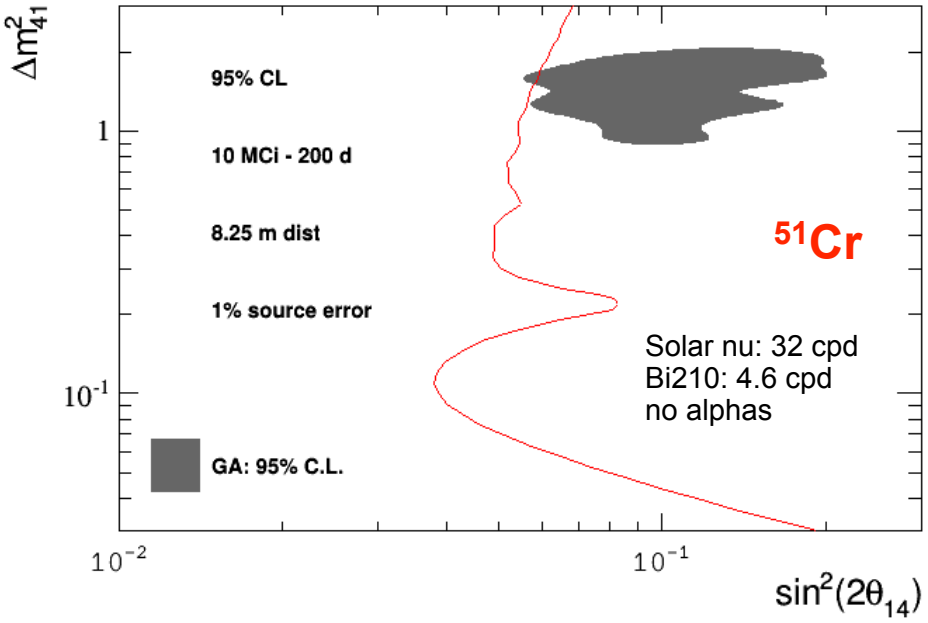
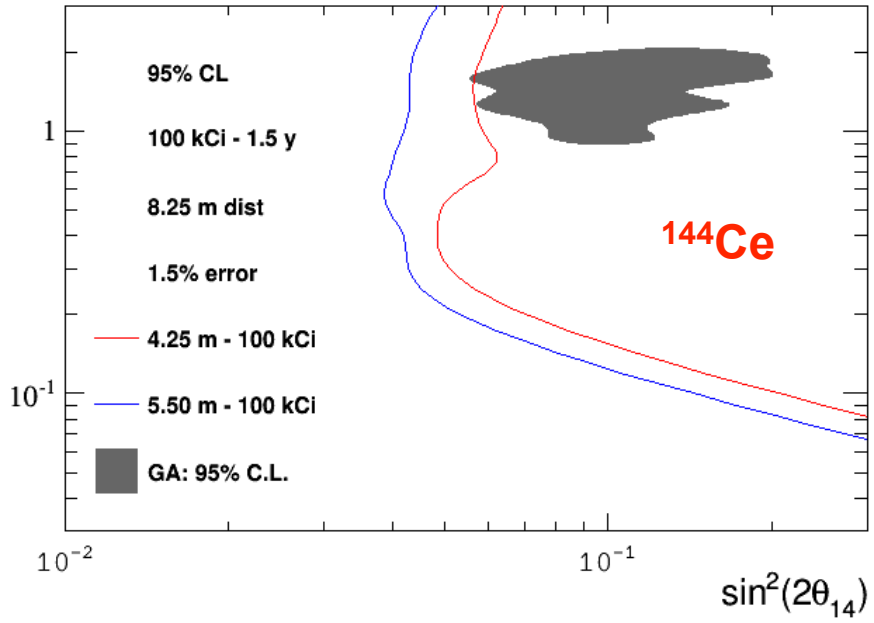
^{144}Ce and ^{51}Cr χ^2 analysis

By Gioacchino





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What's next

Preliminary results:
next week we will meet to compare the codes

Best test statistics:
extended unbinned likelihood (or small bin size binned likelihood)

Best approach:
Null Hypothesis Rejection (or Discovery Potential)

^{51}Cr Goals:
- studying the sensitivity as function of the bg
- studying potential interference between SOX and purifications

To be implemented for the ^{144}Ce case