DUNE as the Next-Generation Solar Neutrino Experiment

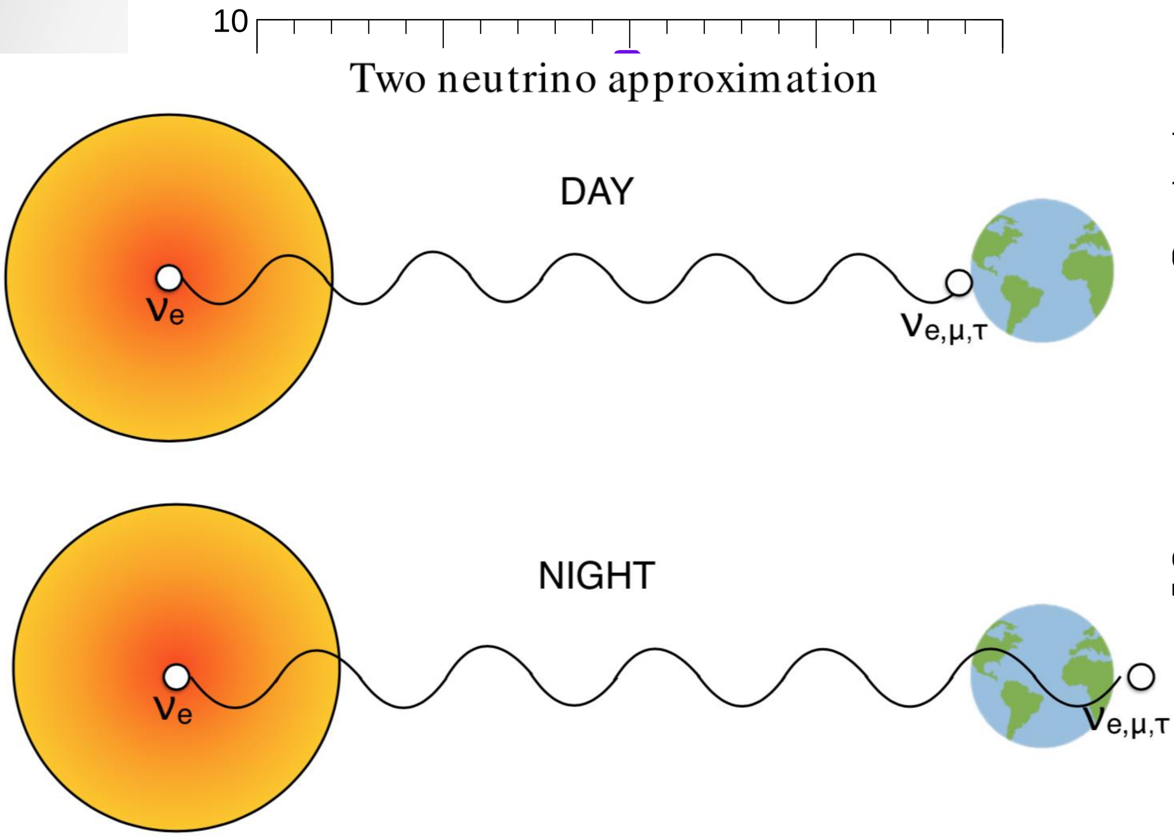
Shirley Li
SLAC

SUSY, May 2019

Tension in current data

Data from SK 2016

Solar ν vs. reactor ν



Reactor: vacuum oscillation

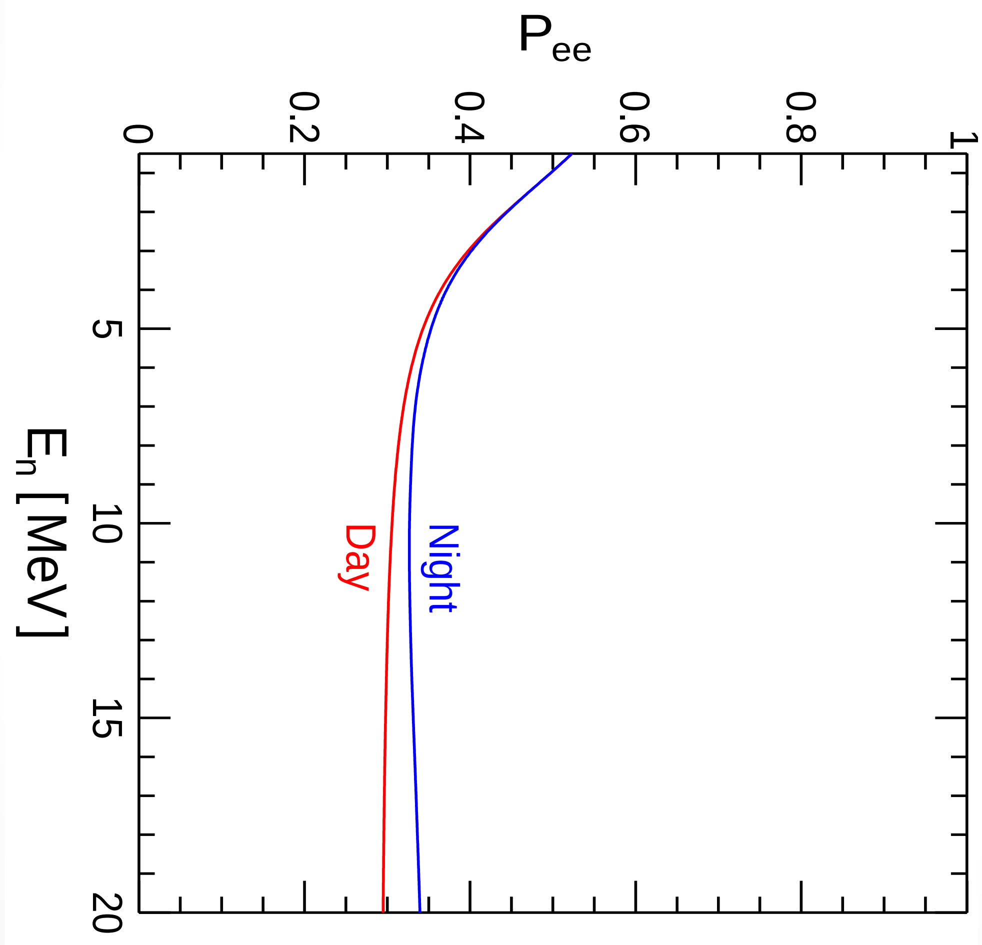
Solar: matter effect

Figure credit: F. Capozzi

Tension driven by day-night effect

Solar neutrino oscillation

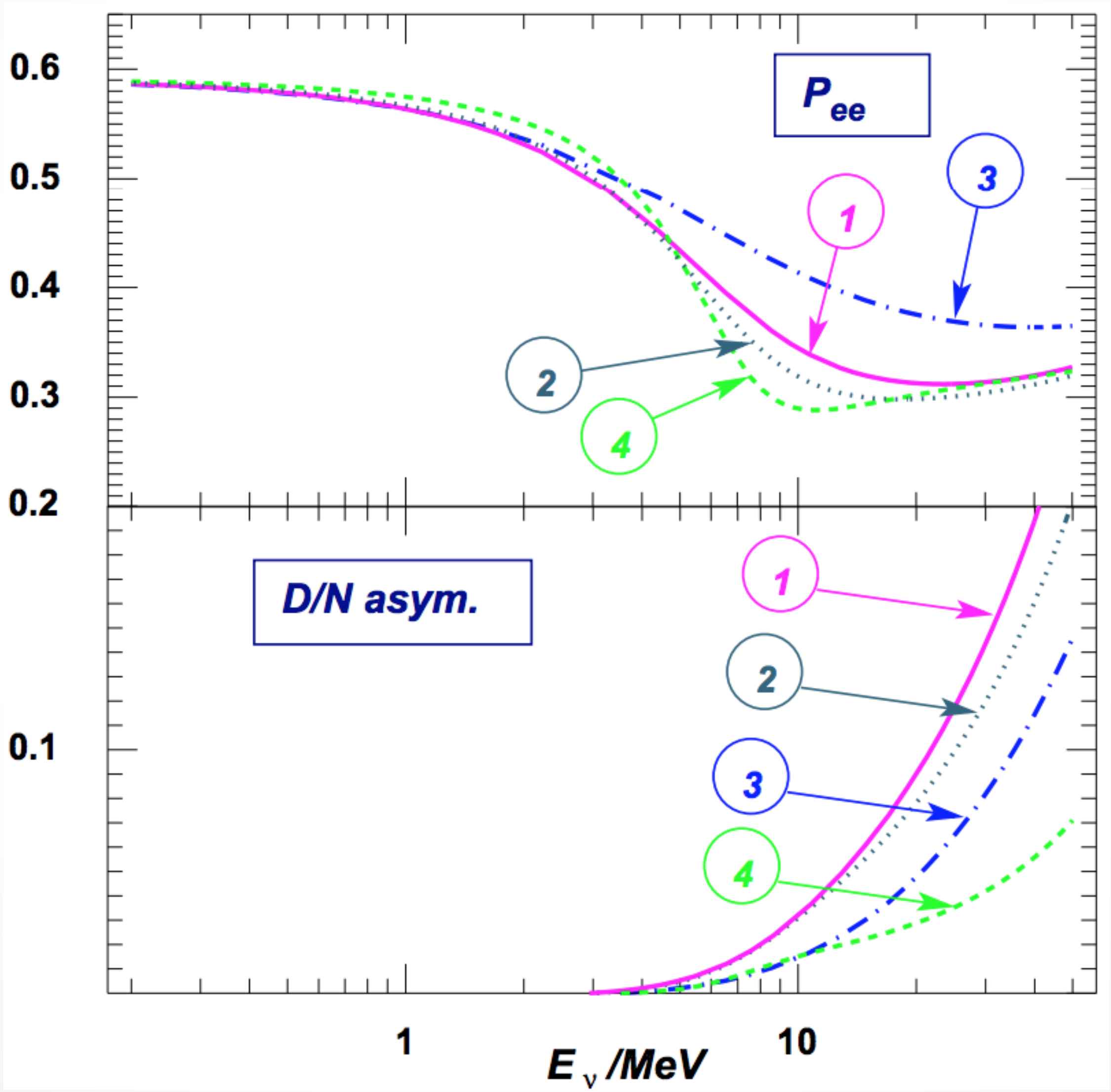
The survival probability



Capozzi et al, 2018

New physics?

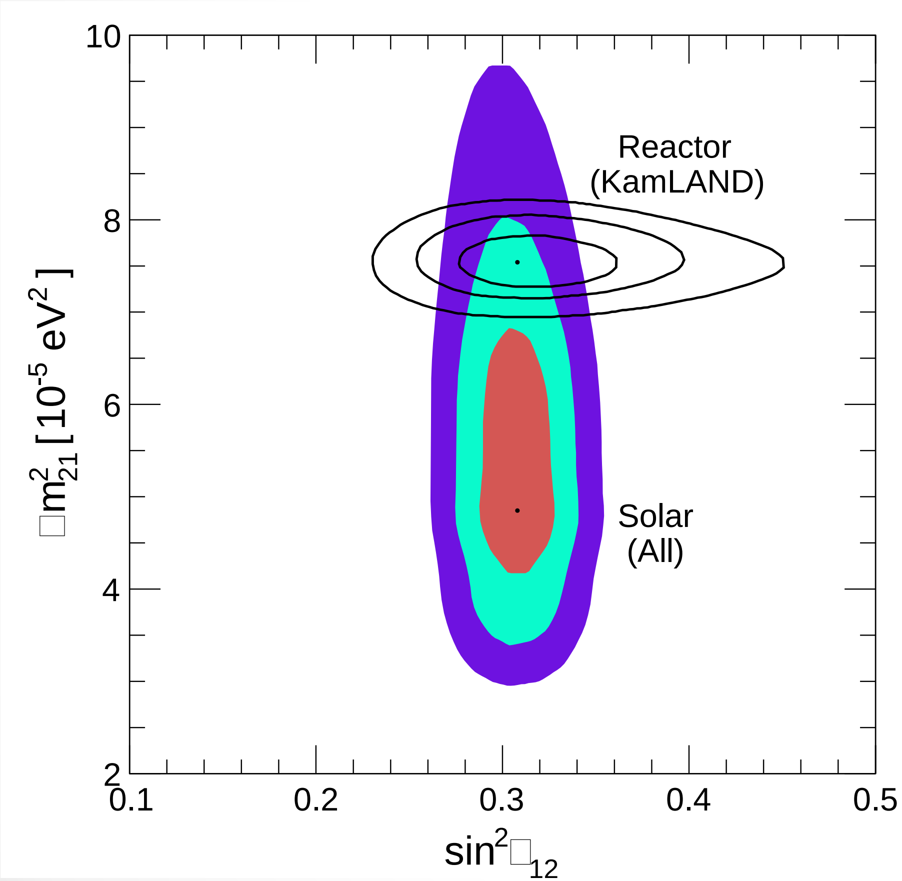
Friedland, Lunardini & Pena-Garay, 2004



Tension in current data

Data from SK 2016

Solar ν vs. reactor ν



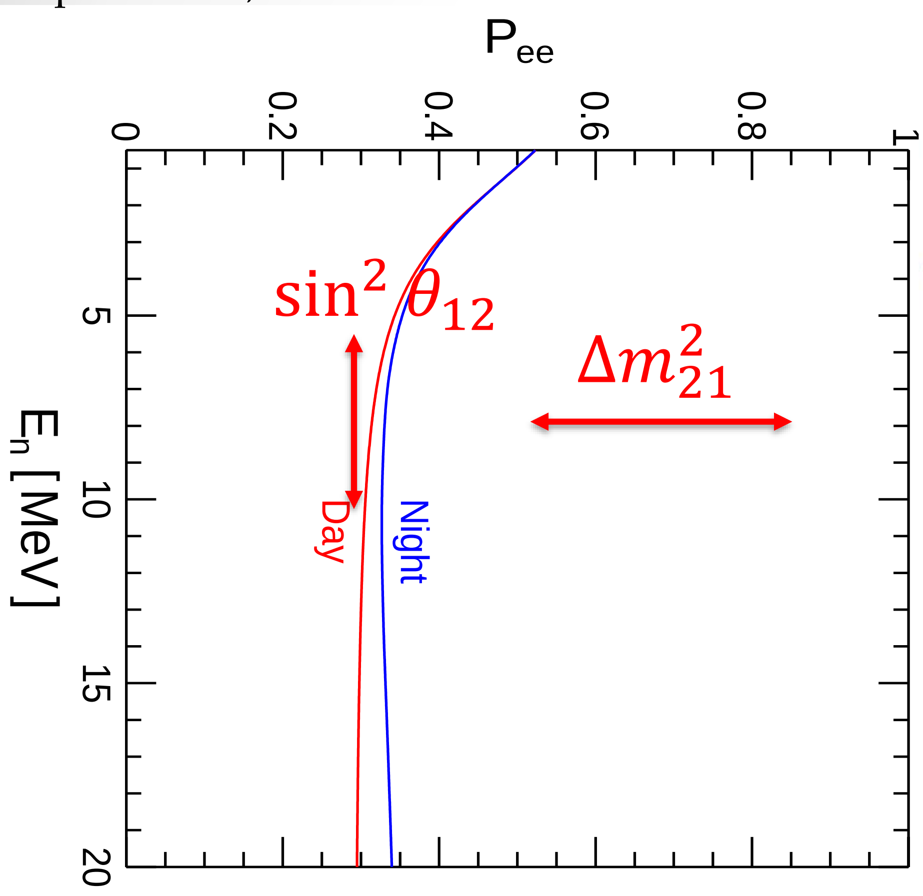
Reactor: vacuum oscillation

Solar: matter effect

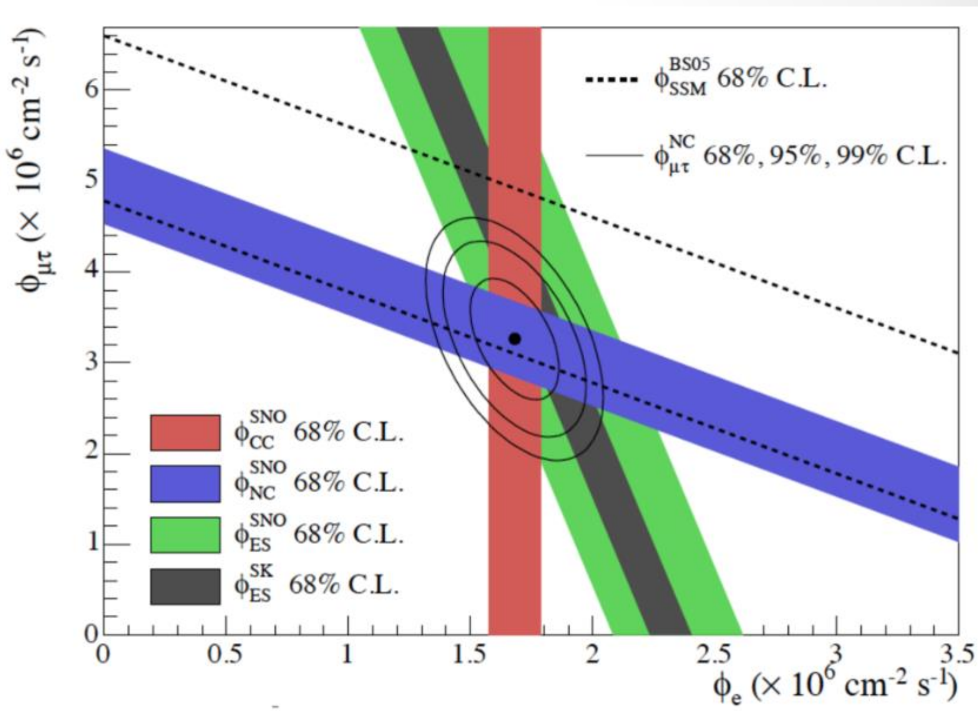
Tension driven by day-night effect

What we want to measure

Capozzi et al, 2018



sno.phy.queensu.ca

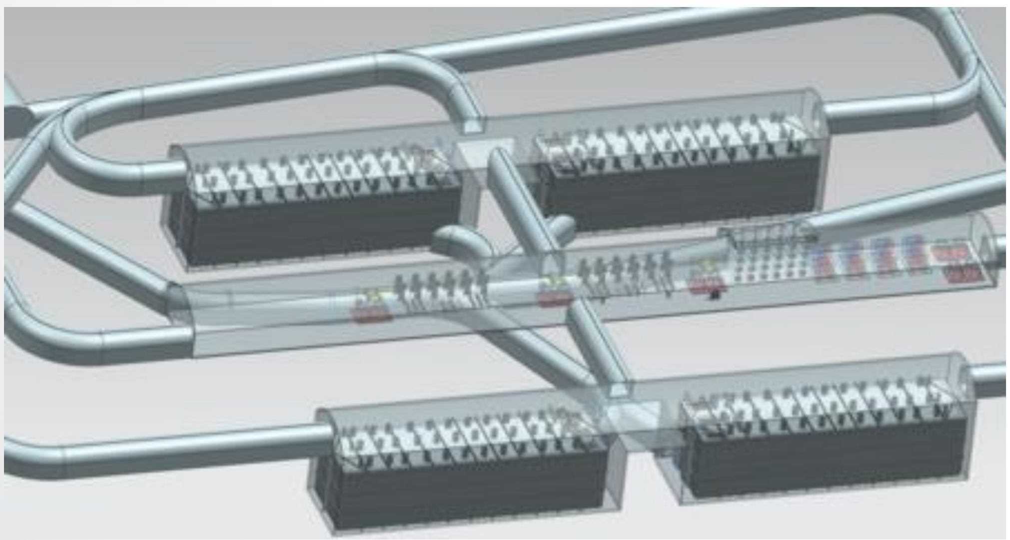


ϕ_e / ϕ_{total} as a function of E_ν

DUNE - MeV

4 10-kton liquid argon TPC module

sciencemag.org



- Trigger
- $T_e > 5$ MeV
- Energy resolution 7%
- Angular resolution 25°

Unique advantage of DUNE

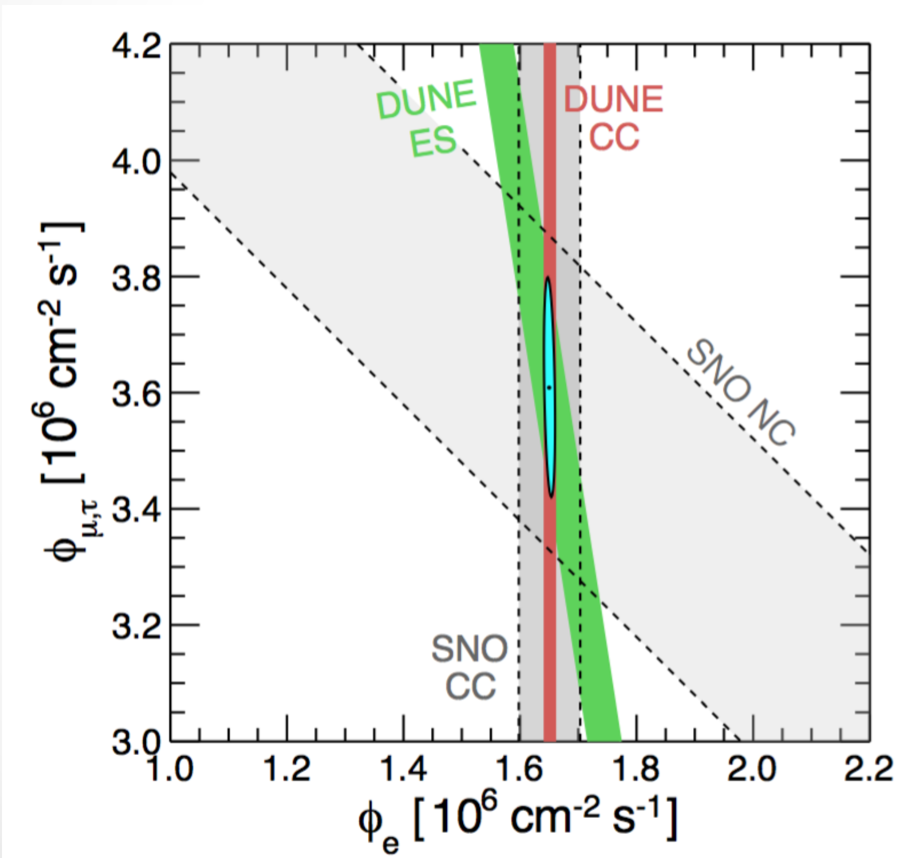
CC channel: $\nu_e + \text{Ar} \rightarrow e + \text{K}^*$ --- ϕ_e

ES channel: $\nu_x + e \rightarrow \nu_x + e$ --- $\phi_e + 1/6(\phi_\mu + \phi_\tau)$

Unique advantage of DUNE

CC channel: $\nu_e + \text{Ar} \rightarrow {\color{red}e} + \text{K}^*$ --- ϕ_e

ES channel: $\nu_x + e \rightarrow \nu_x + {\color{red}e}$ --- $\phi_e + 1/6(\phi_\mu + \phi_\tau)$

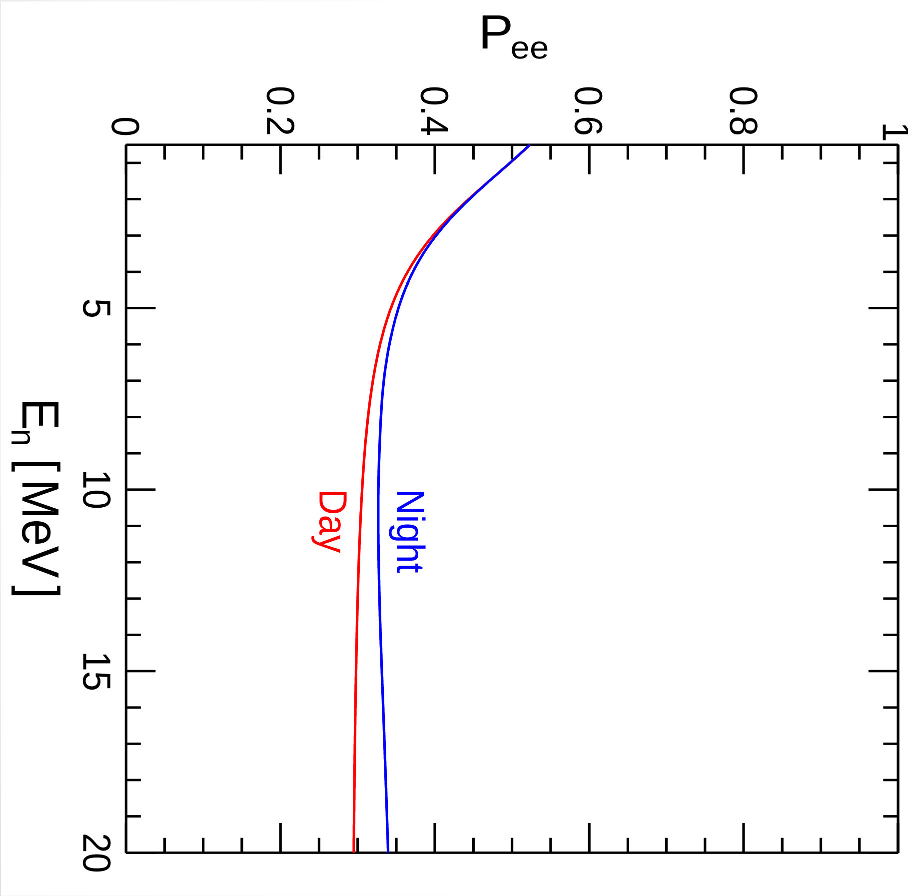


Improve on <u>$\sin^2\theta$</u>

Capozzi et al, 2018

Unique advantage of DUNE

CC channel: $\nu_e + \text{Ar} \rightarrow e + \text{K}^*$



Good energy reconstruction:

$$E_e = E_\nu - Q - \Delta\text{E}$$

Difficult channel:

$$\nu_x + e \rightarrow \nu_x + e$$

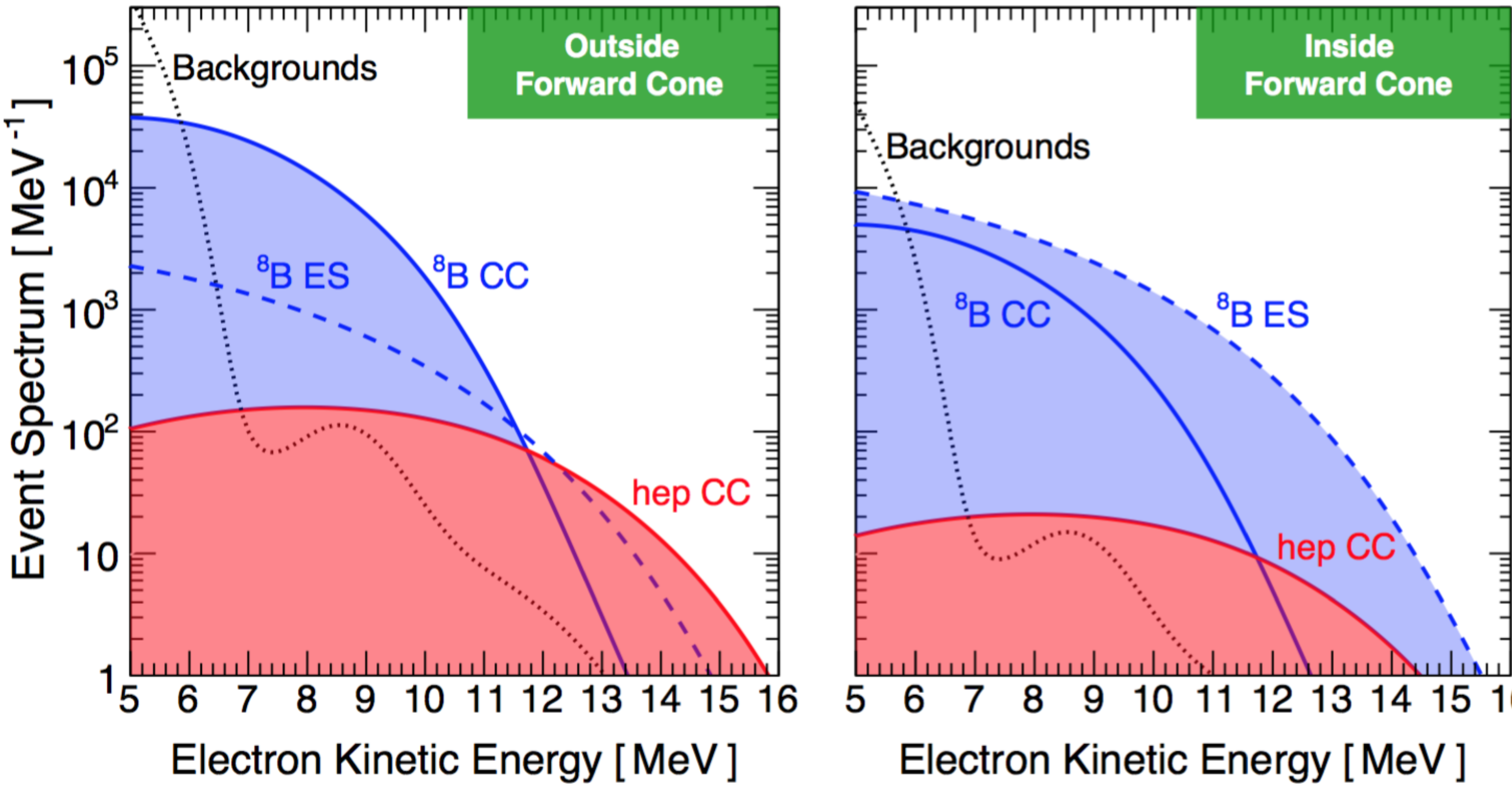
Improve on $\underline{\delta m^2}$

Capozzi et al, 2018

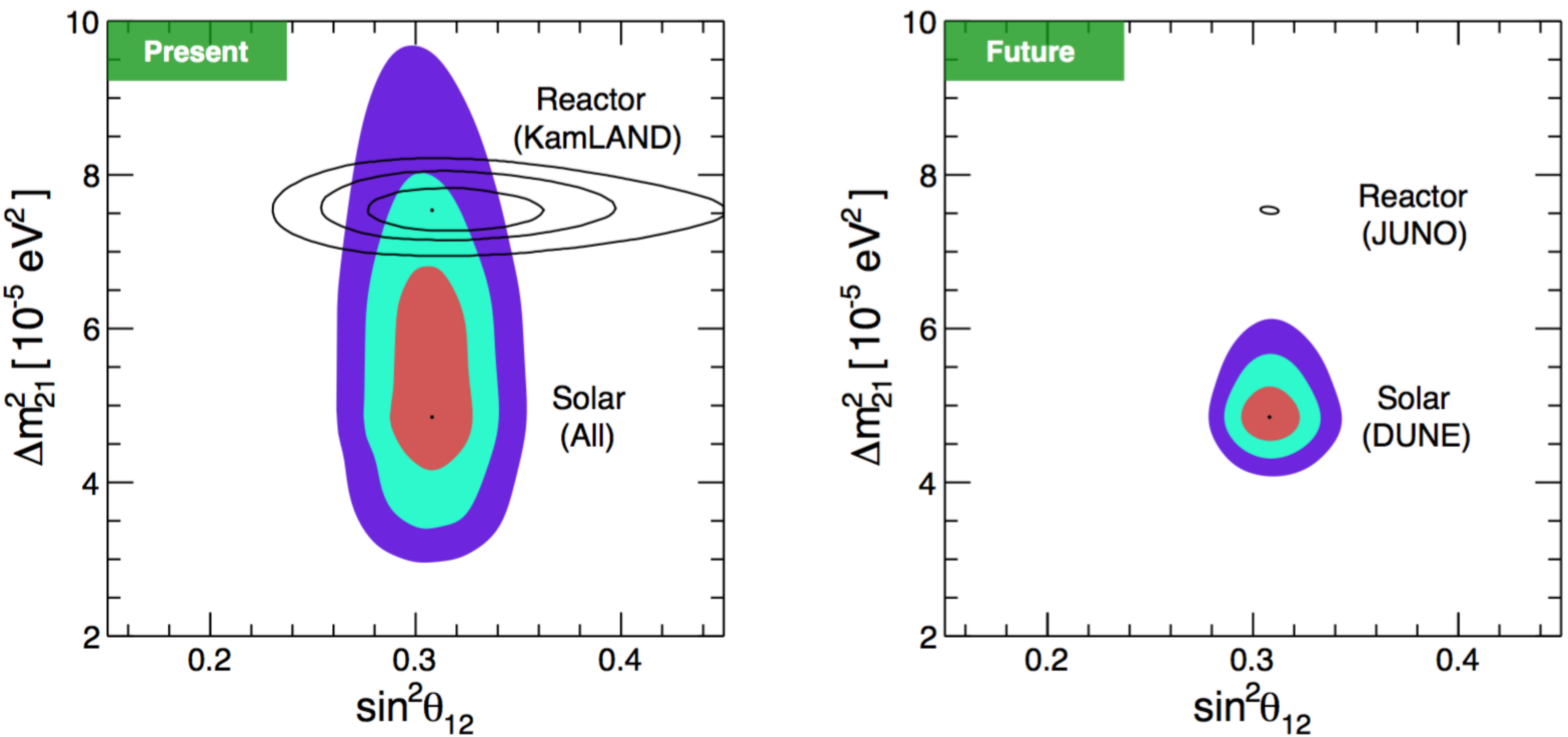
Event rate in DUNE

100 kton-year exposure

Capozzi et al, 2018



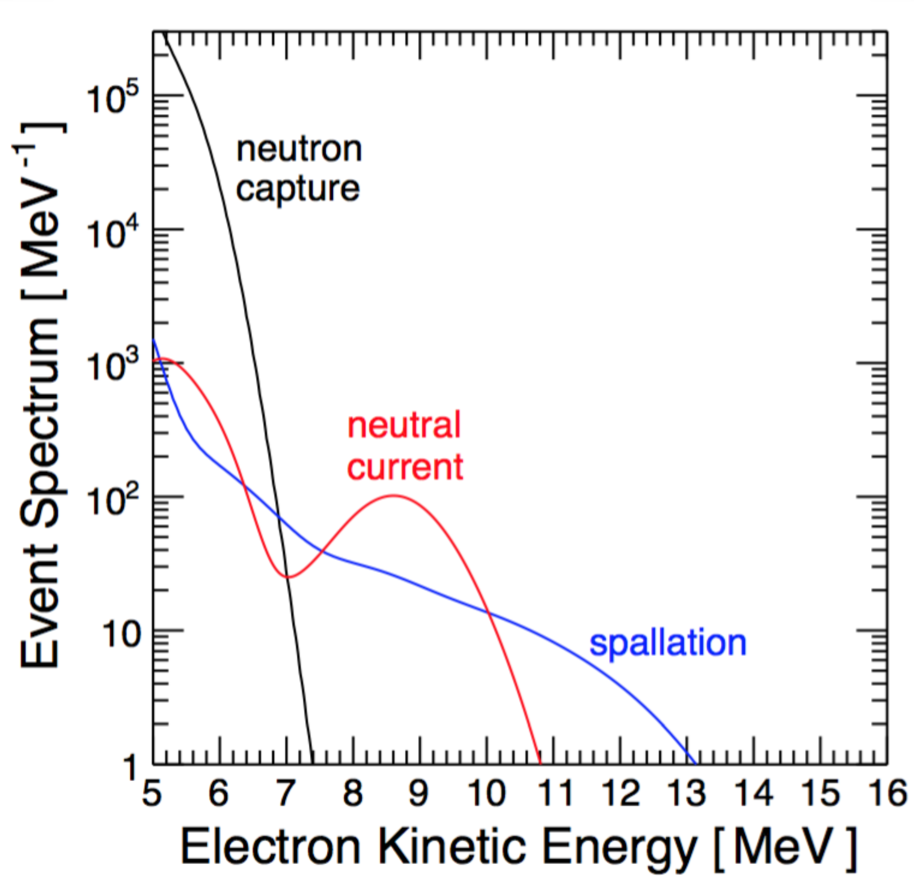
Results



Capozzi et al, 2018

In addition, ^{8}B flux 2.5%, hep flux 10%

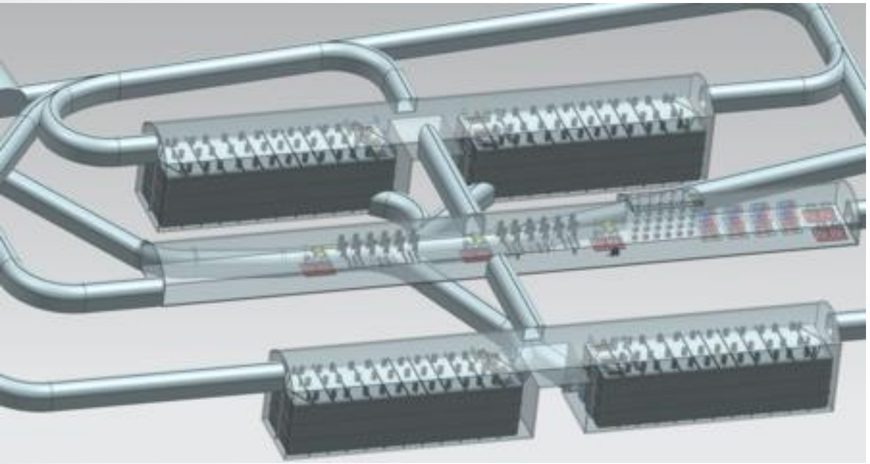
Backgrounds

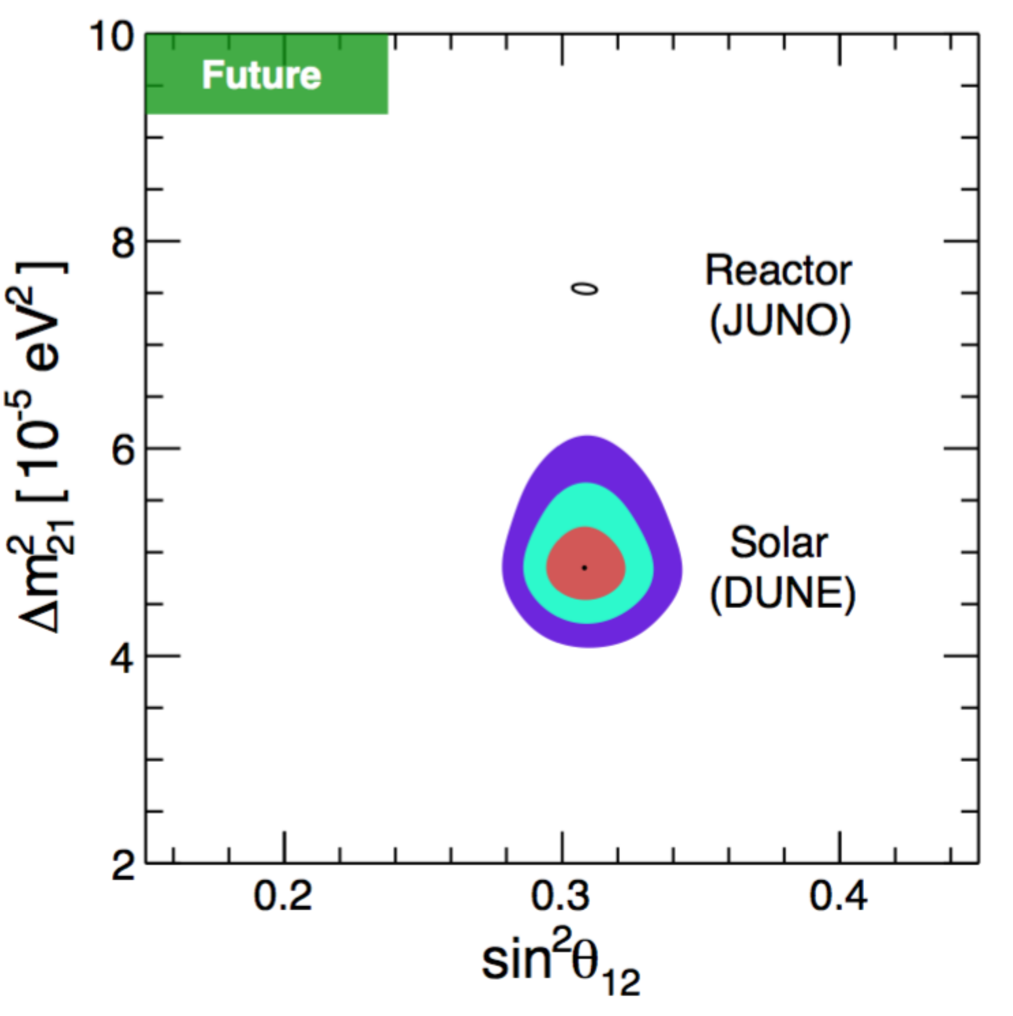


Capozzi et al, 2018

Requires ~ 40 cm of water / plastic shielding
or double the exposure

Conclusions





Back up

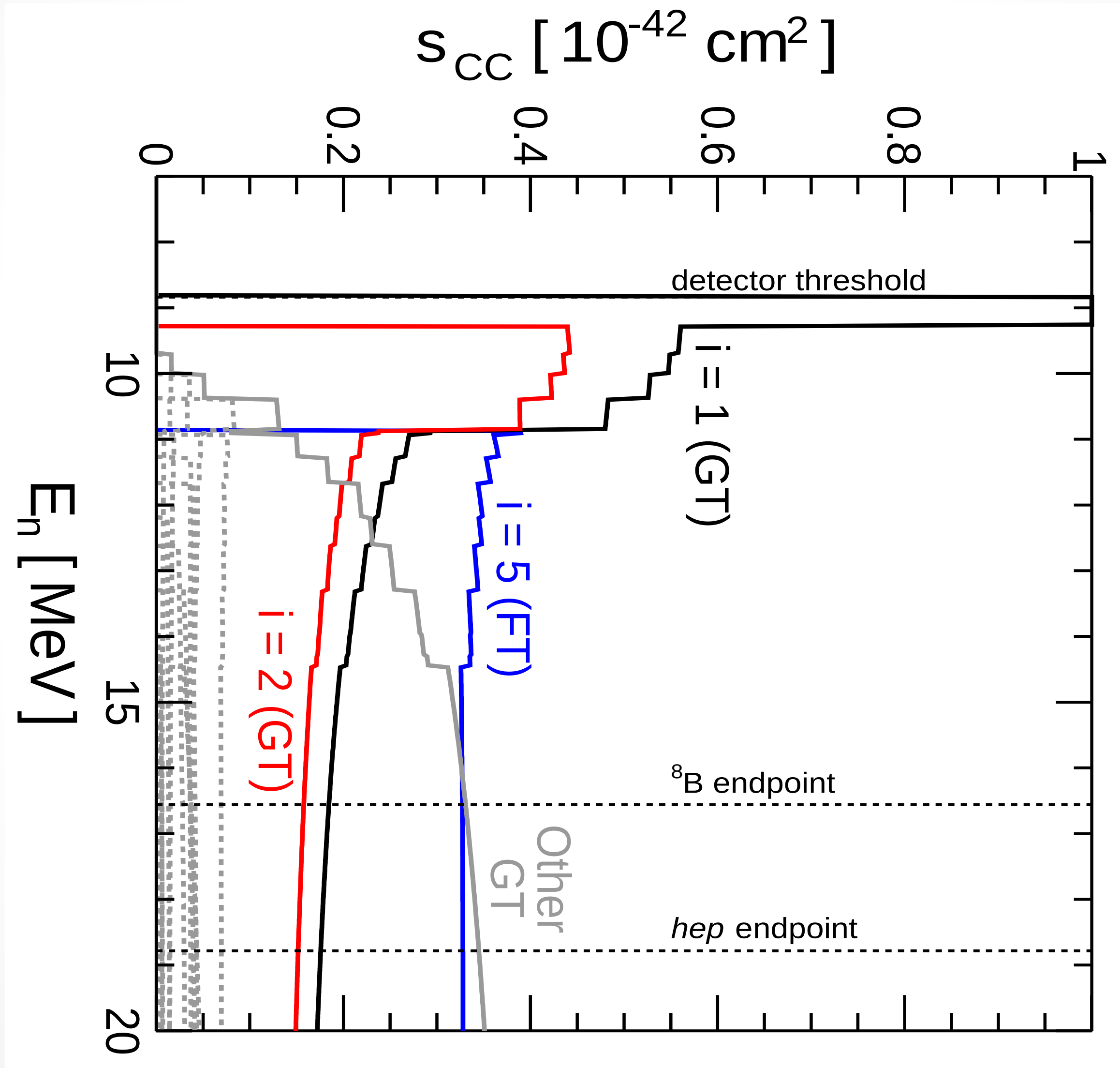
Measured metallicities

Element	GS98	AGSS09met
C	8.52 ± 0.06	8.43 ± 0.05
N	7.92 ± 0.06	7.83 ± 0.05
O	8.83 ± 0.06	8.69 ± 0.05
Ne	8.08 ± 0.06	7.93 ± 0.10
Mg	7.58 ± 0.01	7.53 ± 0.01
Si	7.56 ± 0.01	7.51 ± 0.01
S	7.20 ± 0.06	7.15 ± 0.02
Ar	6.40 ± 0.06	6.40 ± 0.13
Fe	7.50 ± 0.01	7.45 ± 0.01
$(Z/X)_\odot$	0.02292	0.01780

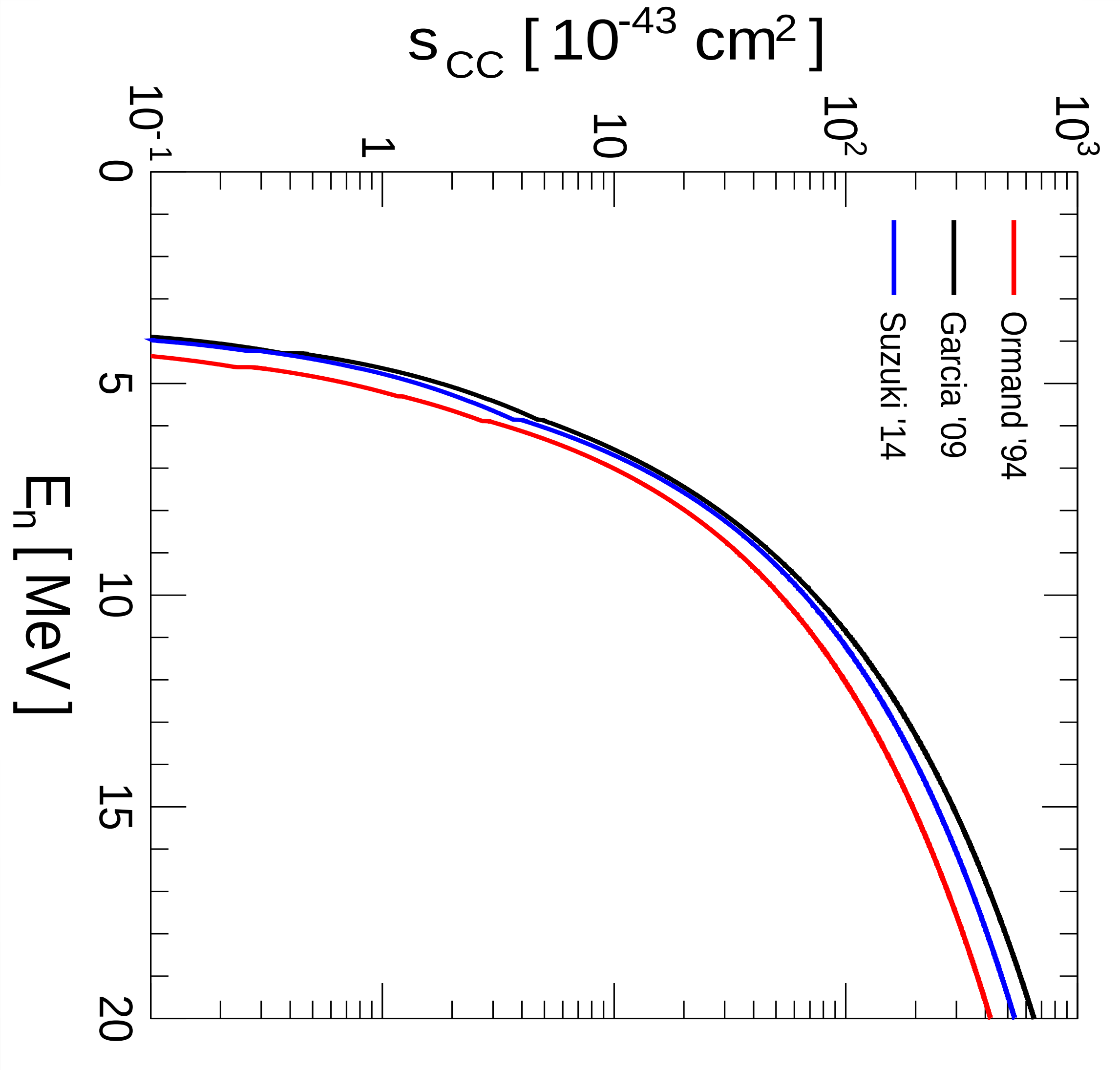
Cross section

i	ΔE_i [MeV]	B_i(F)	B_i(GT)
1	2.333		1.64
2	2.775		1.49
3	3.204		0.06
4	3.503		0.16
5	3.870		0.44
6	4.384	4.00	
7	4.421		0.86
8	4.763		0.48
9	5.162		0.59
10	5.681		0.21
11	6.118		0.48
12	6.790		0.71
13	7.468		0.06
14	7.795		0.14
15	7.952		0.97
total		4.00	8.29

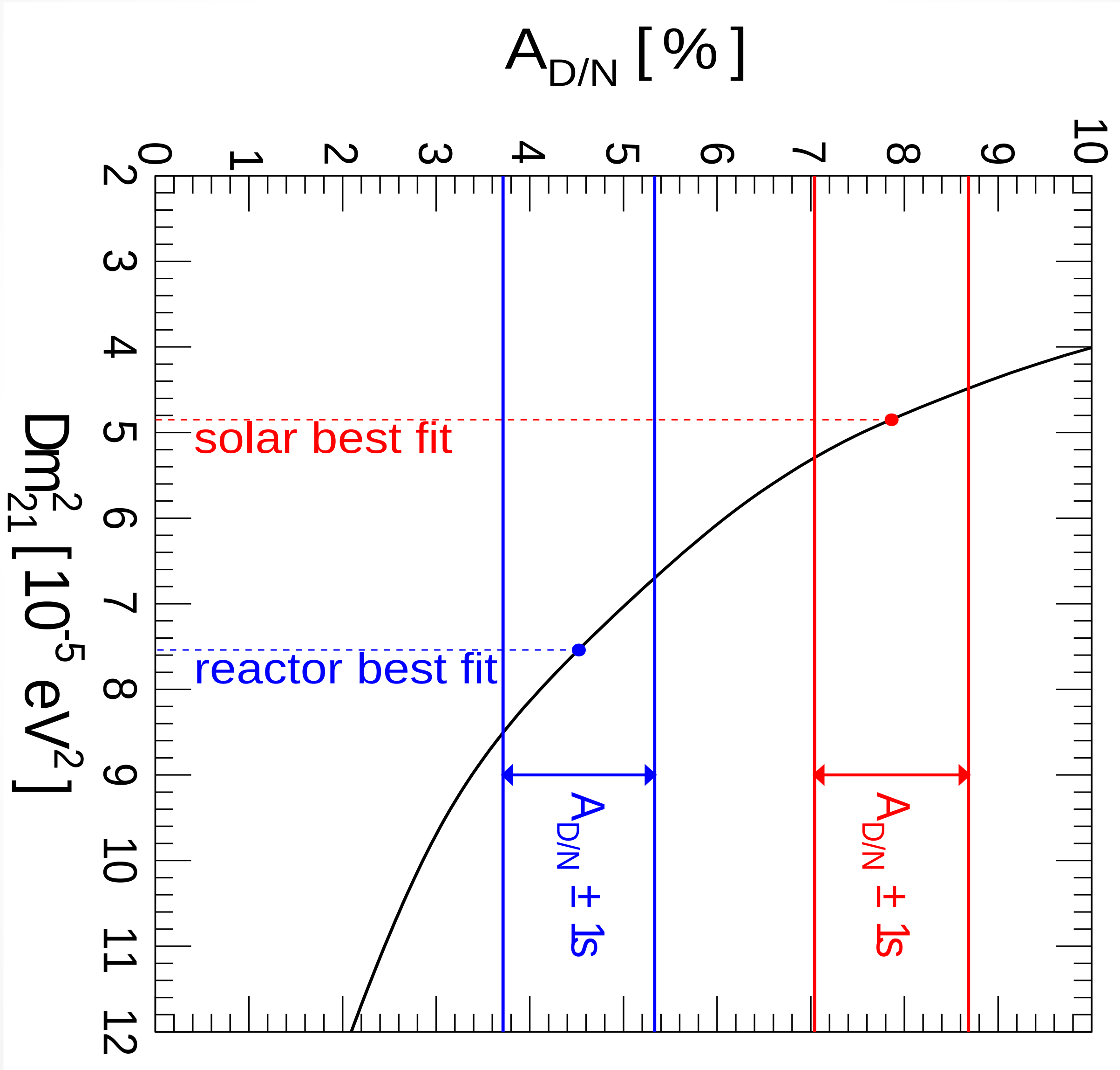
Cross section



Cross section

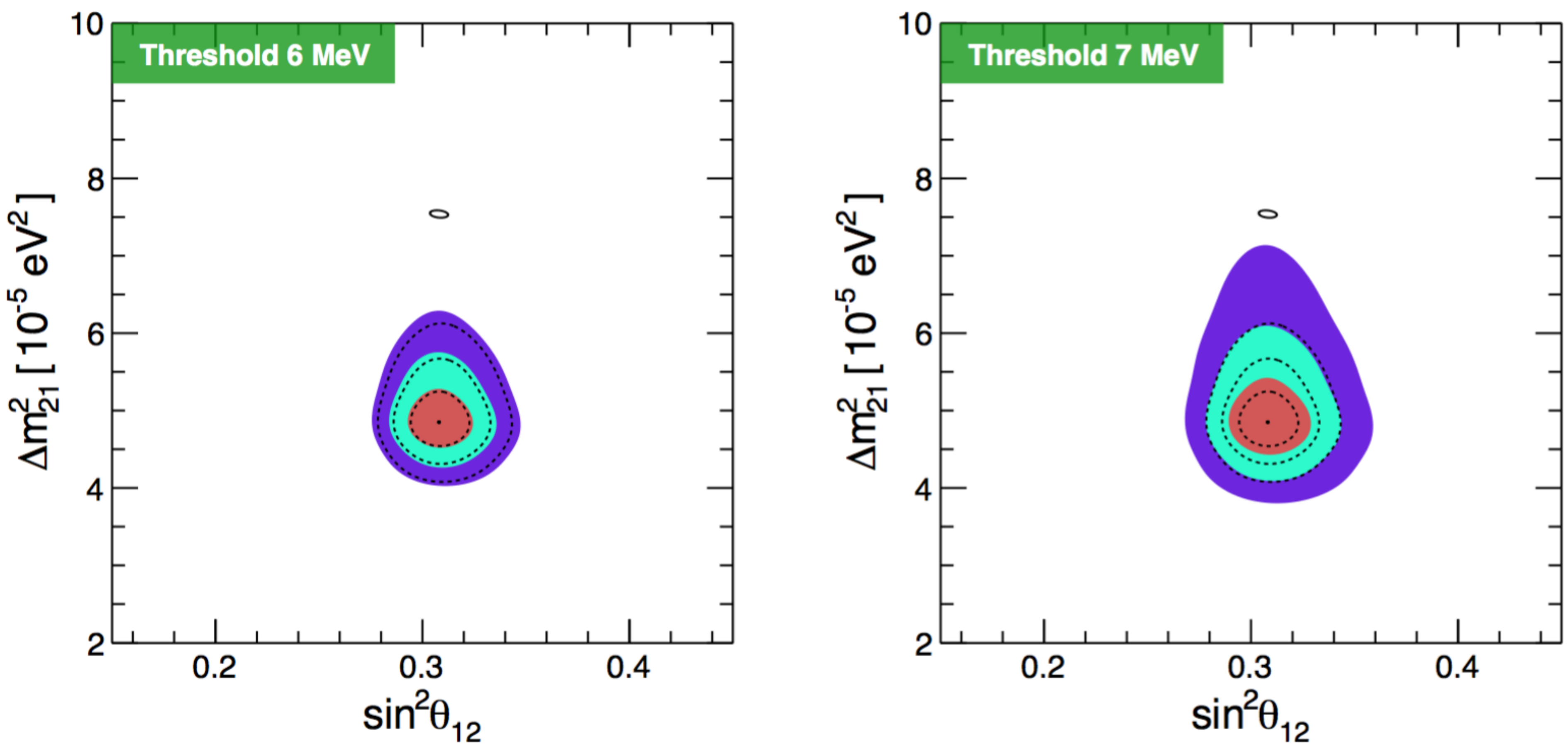


Mass square sensitivity



Threshold

Depends on reconstruction & background level

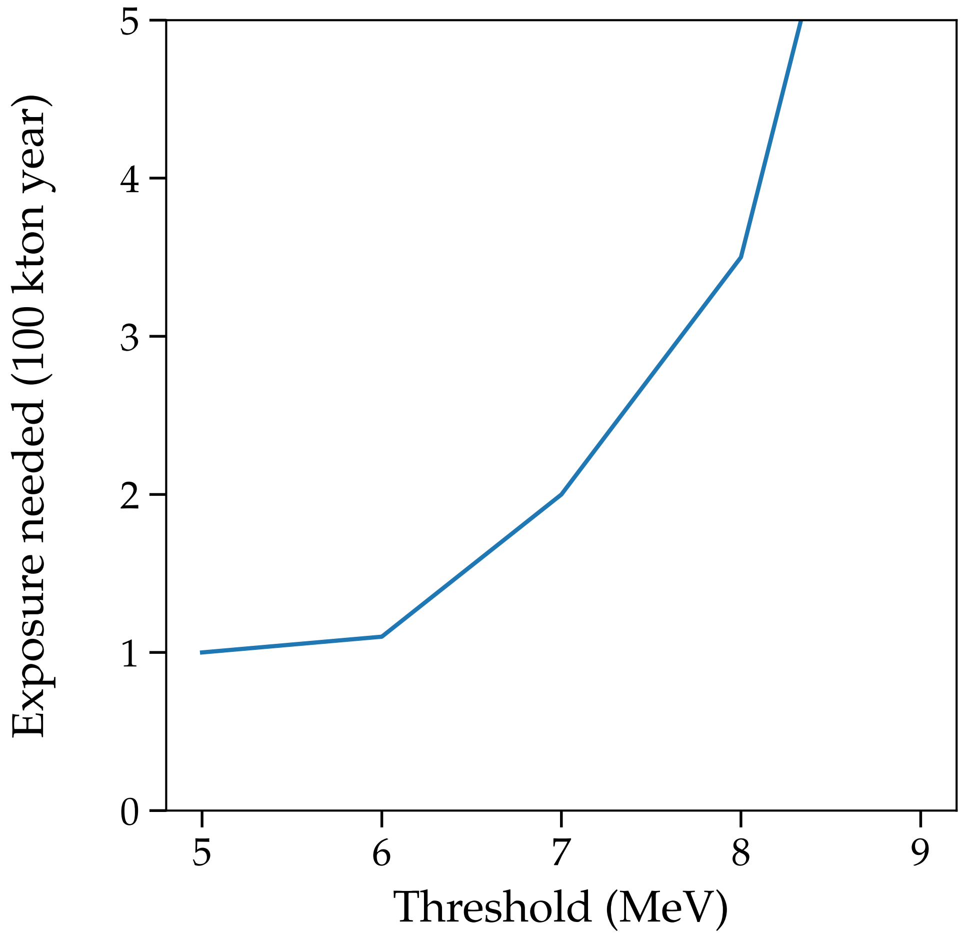


Capozzi et al, 2018

Sensitivity loss due to statistics

Threshold

It can be compensated by larger exposure



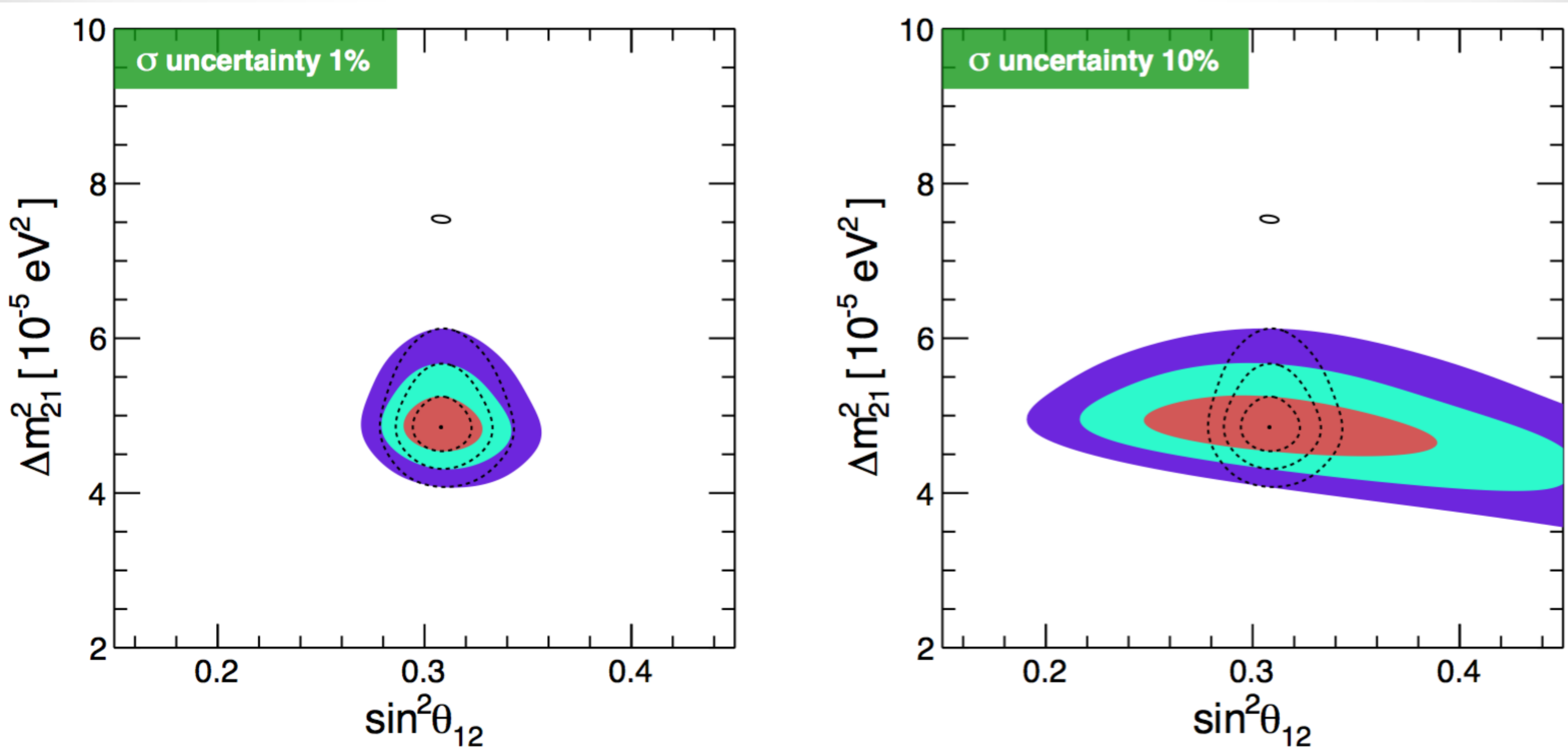
Capozzi et al, 2018

Up to >~ 8 MeV

Cross section

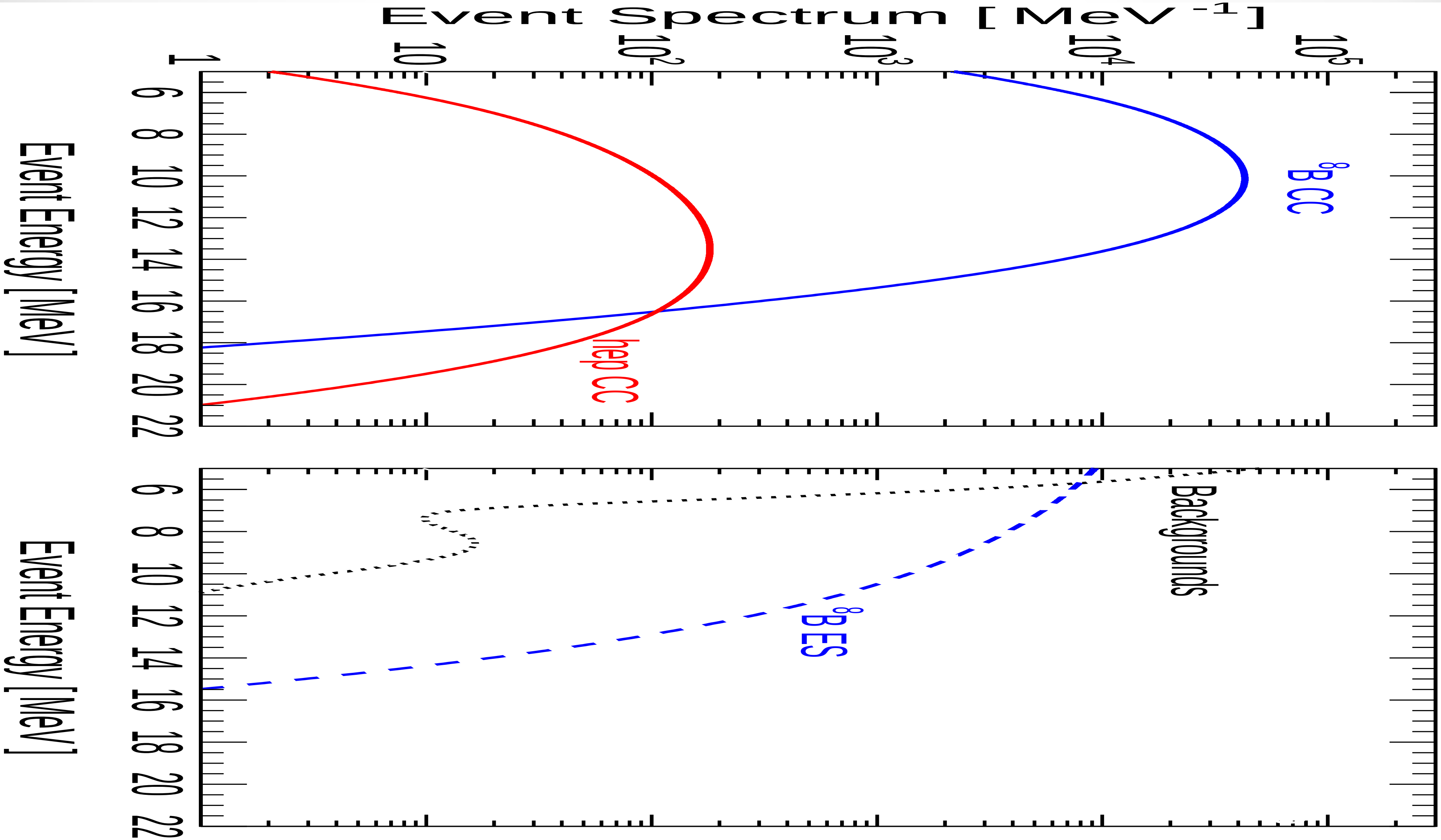
Capozzi et al, 2018

Current uncertainty: a few %



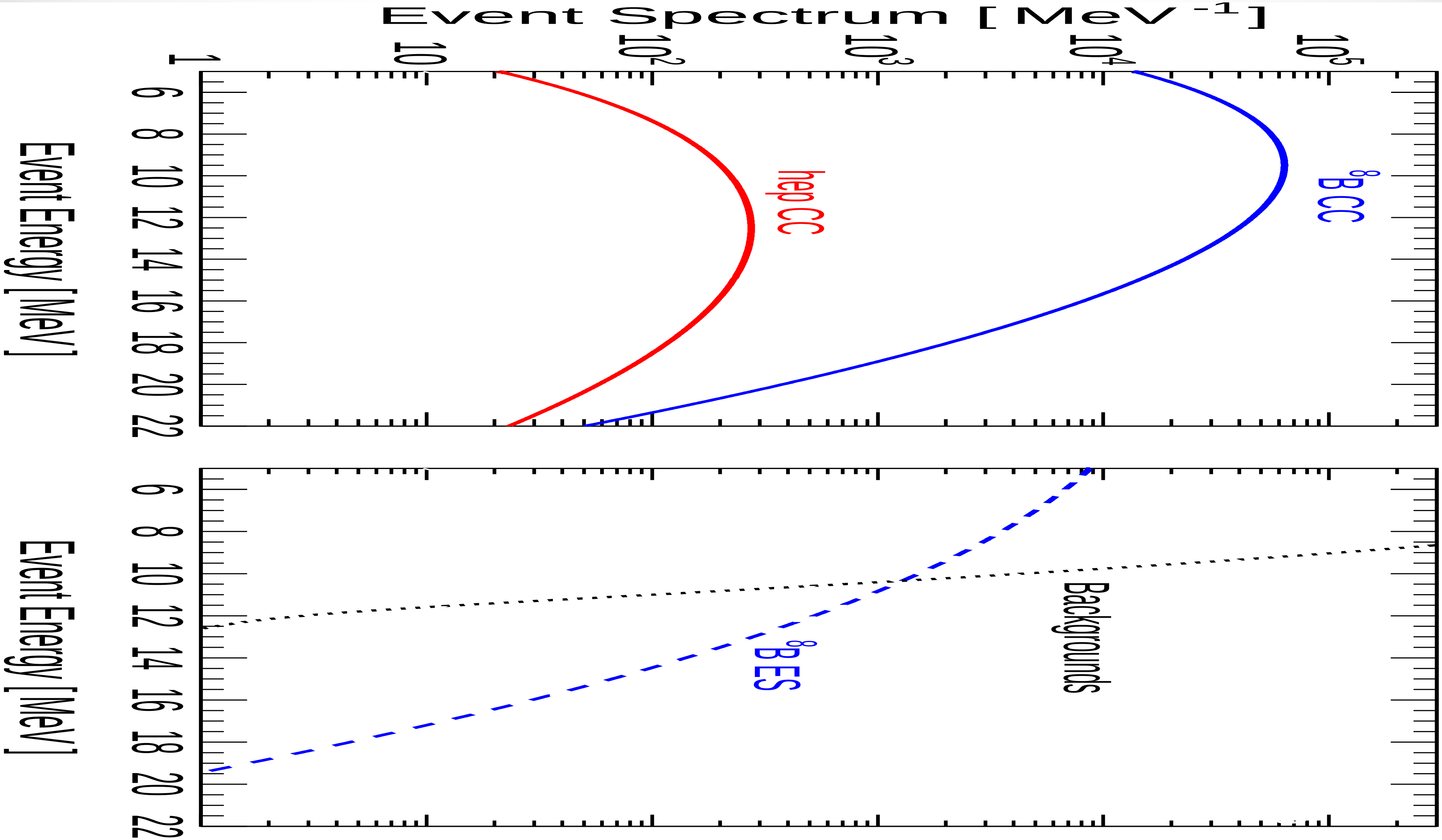
Reconstruct neutrino energy

Capozzi et al, 2018



Worse energy resolution

Capozzi et al, 2018



Backgrounds

Capozzi et al, 2018