Exploring the Potential of Short-Baseline Physics at Fermilab

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08/16/2018

NuFact 2018

Phys.Rev. D97 (2018) no.9, 095026

Arxiv: hep-pheno/1802.02133

Short-Baseline may hide lots of New Physics!

The Fermilab short-baseline program:

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(1) Running/Under Construction

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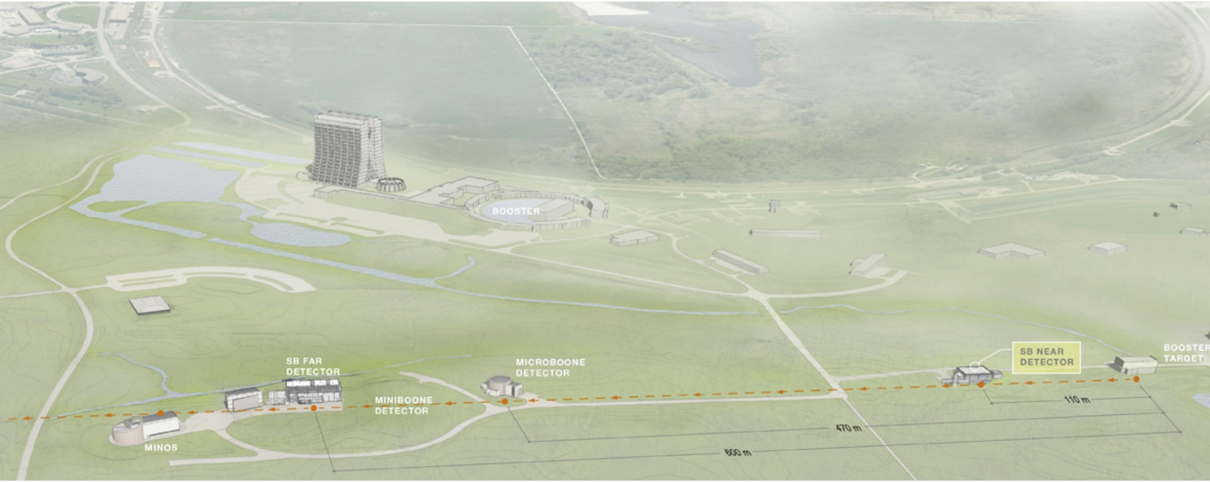

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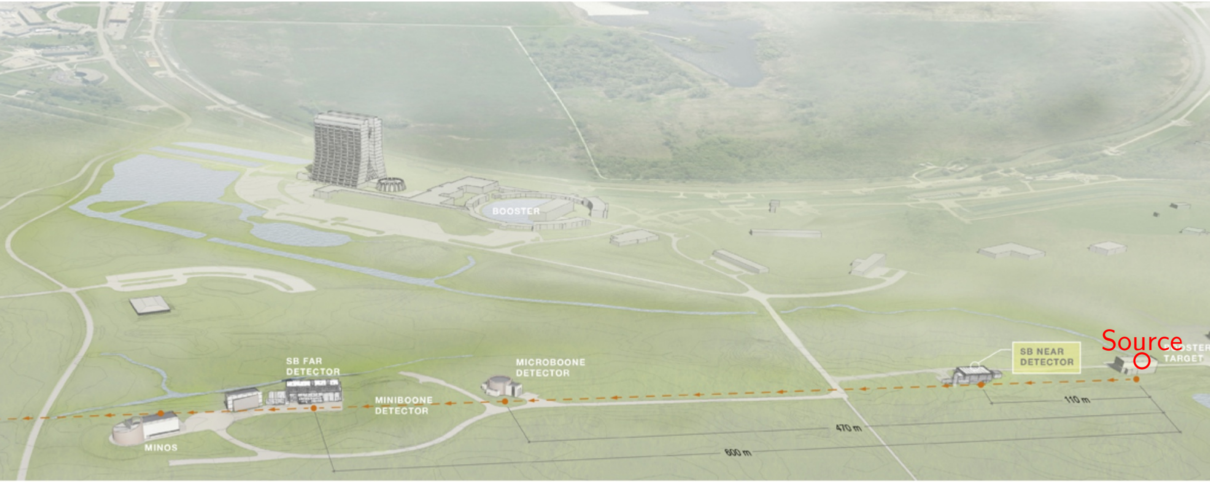

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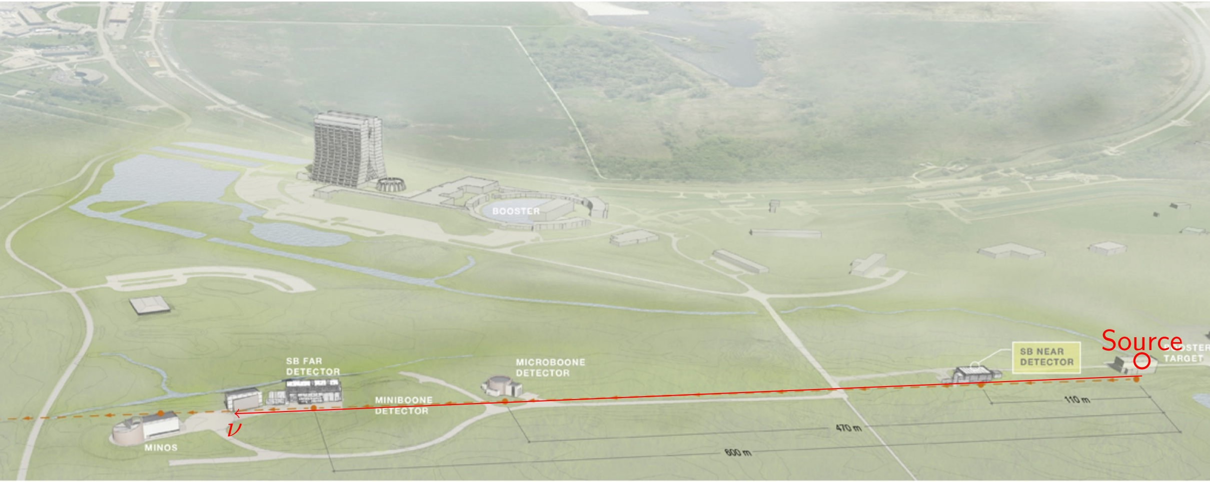

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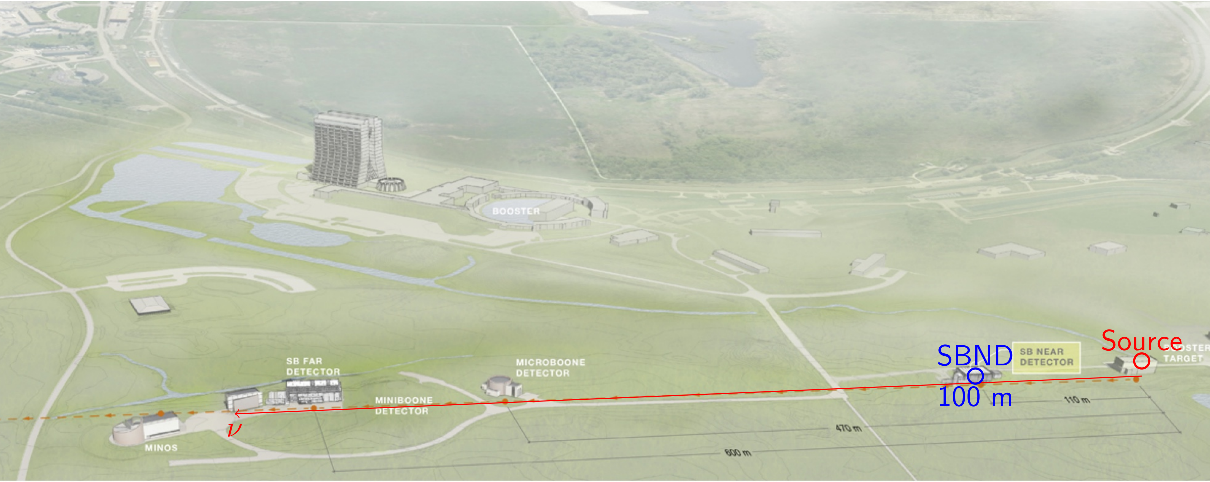

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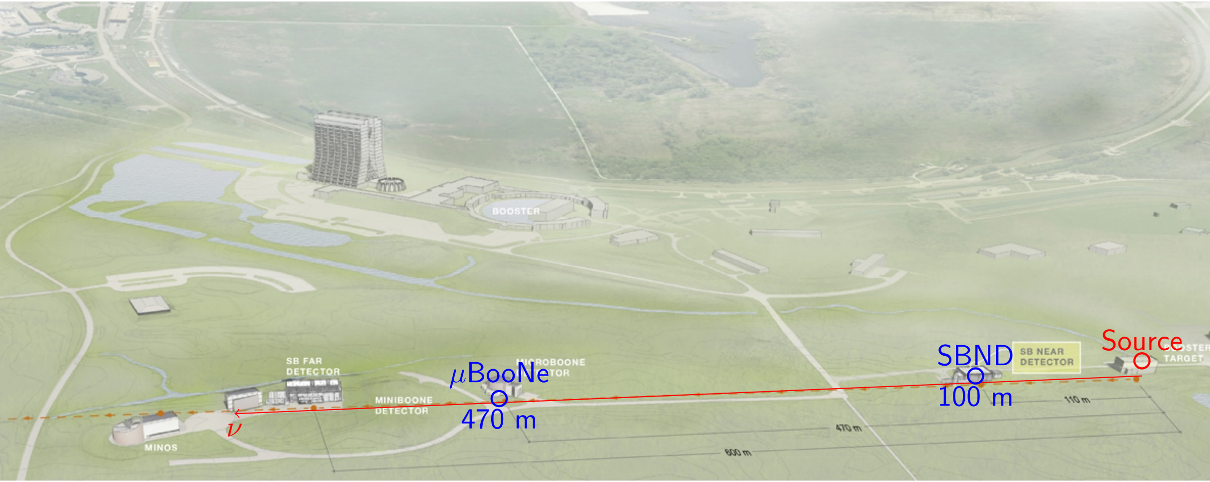

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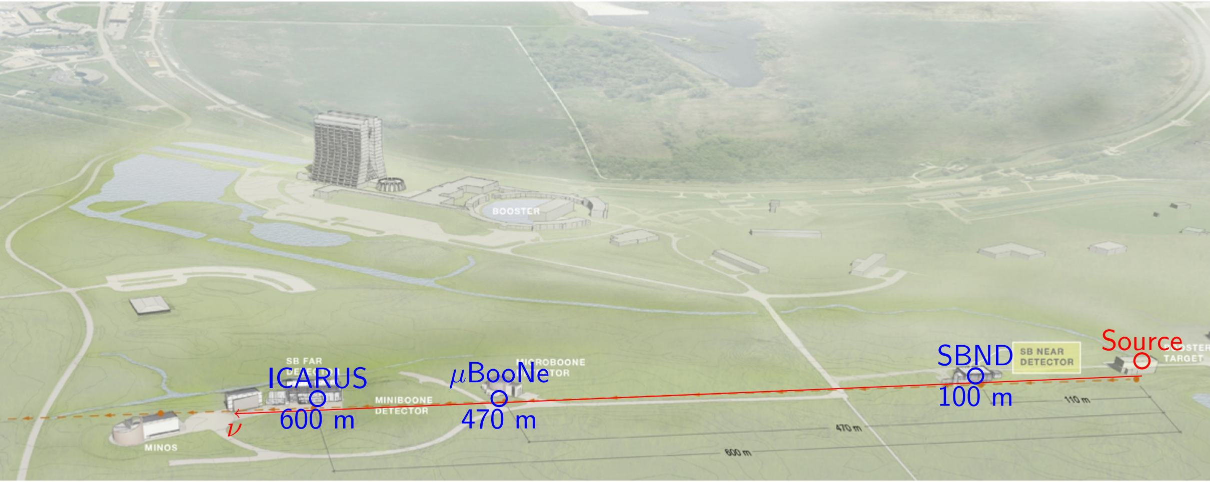

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Short Beseline Neutrino (SBN) Experiment (arxiv:1503.01520)

Detector	Active Size	Distance
SBND	112 t	110 m
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DUNE/LBNF near detector

arXiv:1512.06148

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Detector	Active Size	Distance
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around	~ 500 t	~ 600m

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Near Detec-
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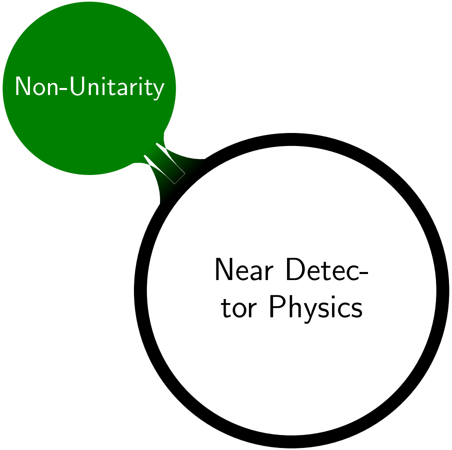

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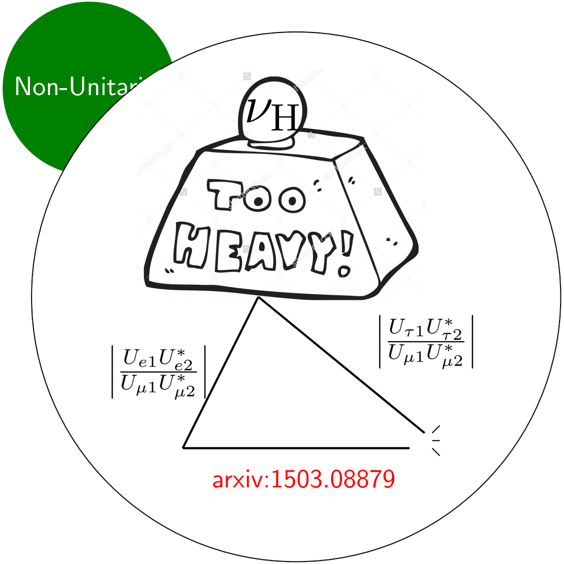

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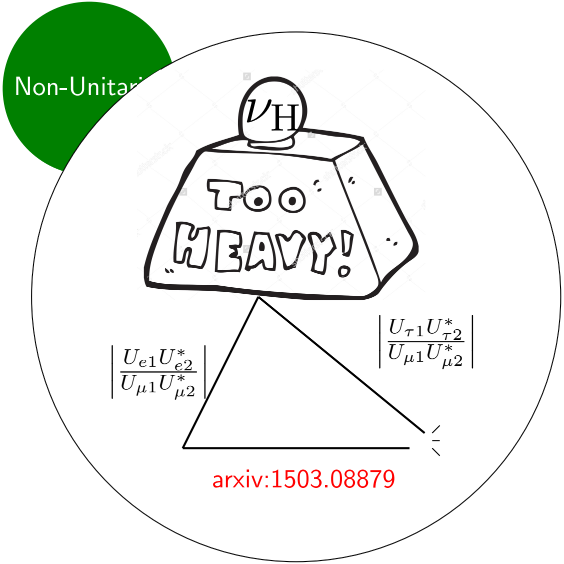

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If number of $\nu > 3$

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The (unitary) mixing matrix $N_{n\times n}$ is

$$N_{n\times n} = \begin{pmatrix} N_{11} & N_{12} & N_{13} & N_{14} & \dots \\ N_{21} & N_{22} & N_{23} & N_{24} & \dots \\ N_{31} & N_{32} & N_{33} & N_{34} & \dots \\ \vdots & \vdots & \vdots & \vdots & \end{pmatrix}$$

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Unitary

Not accessible if $E_{exp} < M_{\nu_i}$

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Unitary

Not Unitary

Not accessible if $E_{exp} < M_{\nu_i}$

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$$N_{3\times 3} = \begin{pmatrix} \alpha_{11} & 0 & 0 \\ \alpha_{21} & \alpha_{22} & 0 \\ \alpha_{31} & \alpha_{32} & \alpha_{33} \end{pmatrix} .U_{\mathrm{PMNS}}$$

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Regulates $\nu_\mu \to \nu_e$ transitions

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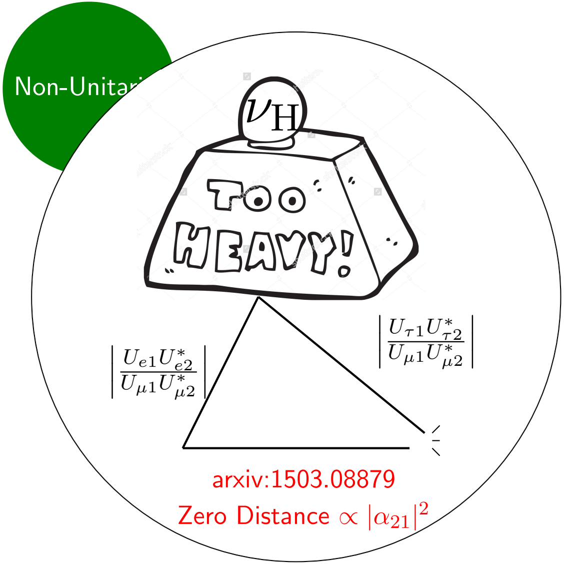

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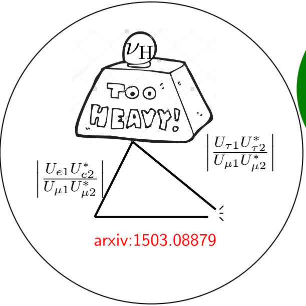

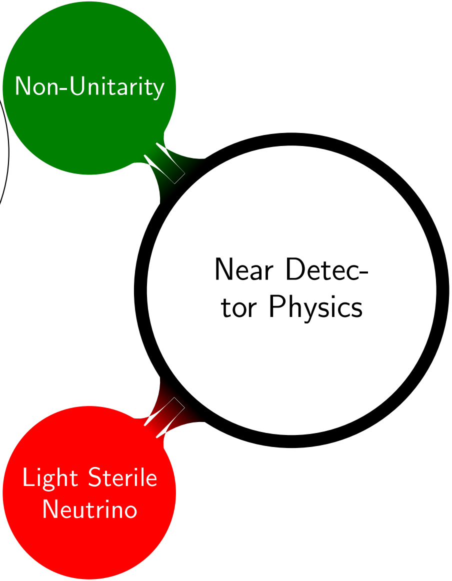

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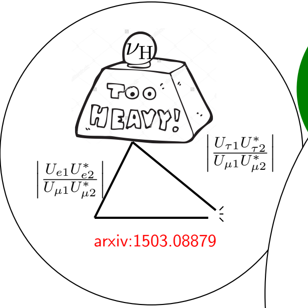

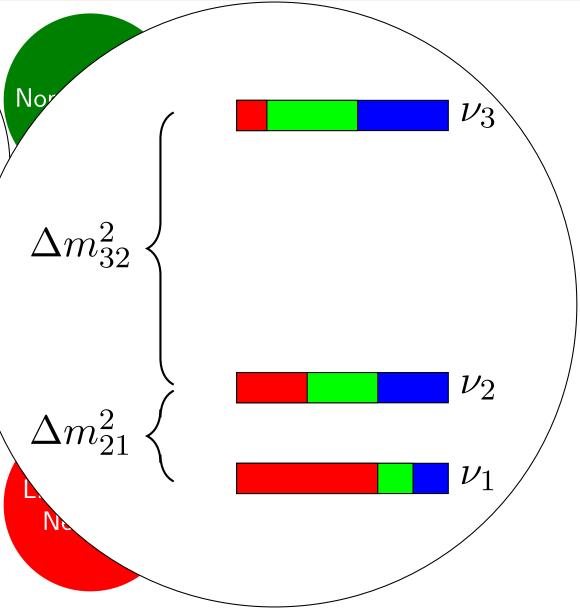

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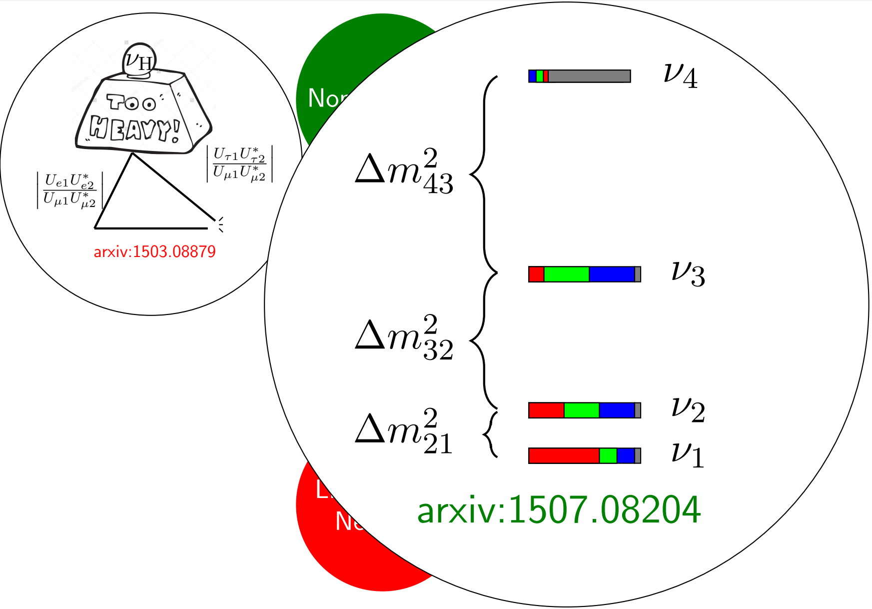

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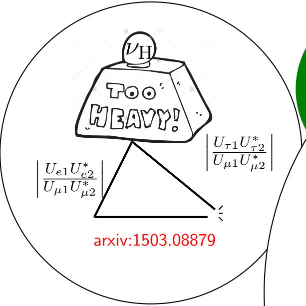
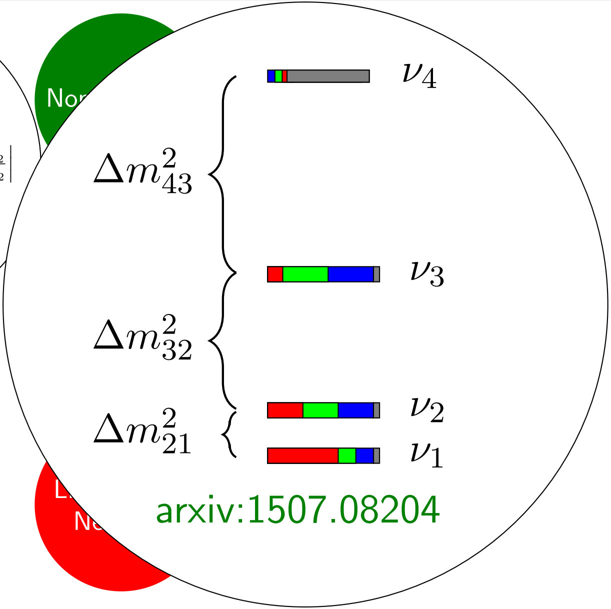
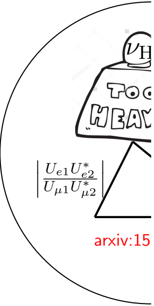




Short-



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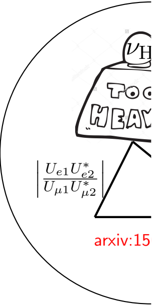
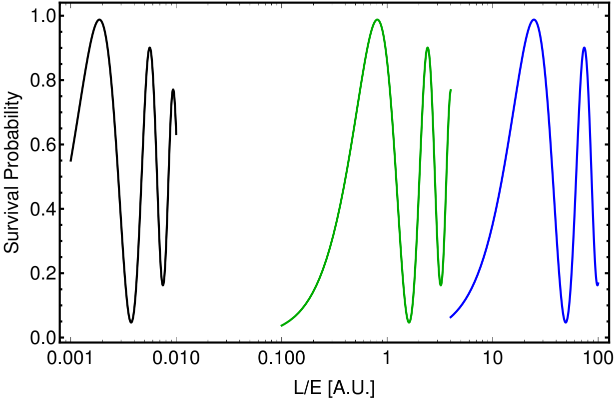
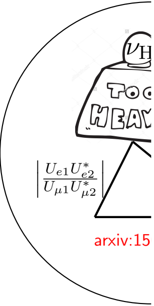


$\left|\frac{U_{e1}U_{e2}^*}{U_{\mu 1}U_{\mu 2}^*}\right|$
arxiv:15

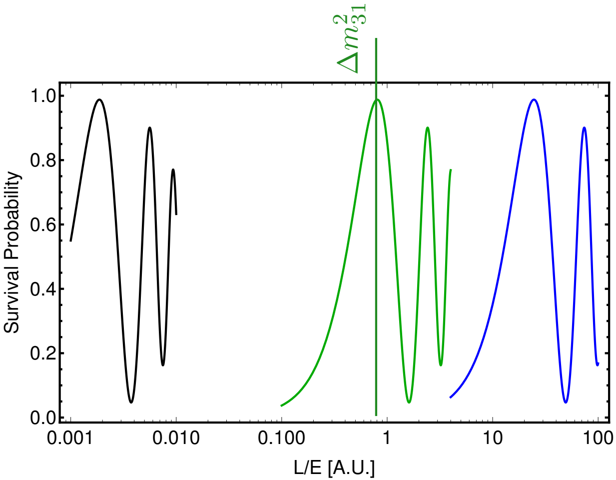


Survival Probability
1.0
0.8
0.6
0.4
0.2
0.0
0.001
0.010
0.100
1
10
100
L/E [A.U.]

Short-B

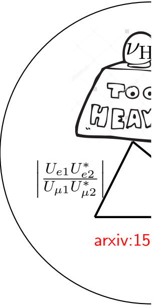


ν_H
TOO HEAV
$\left|\frac{U_{e1}U_{e2}^*}{U_{\mu1}U_{\mu2}^*}\right|$
arxiv:15



Δm_{31}^2
Survival Probability
1.0
0.8
0.6
0.4
0.2
0.0
0.001
0.010
0.100
1
10
100
L/E [A.U.]

Short-



$\left|\frac{U_{e1}U_{e2}^*}{U_{\mu1}U_{\mu2}^*}\right|$
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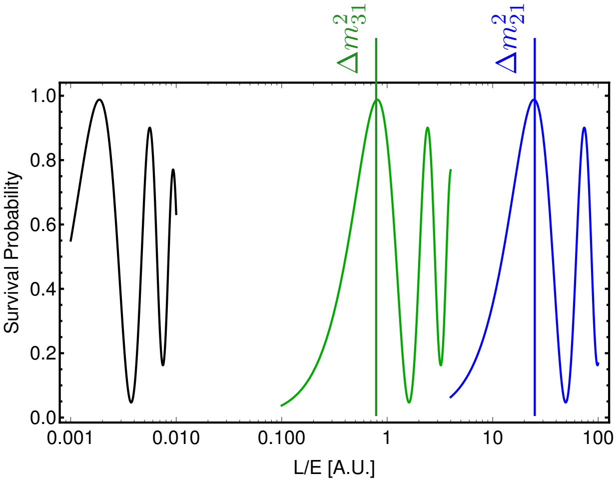
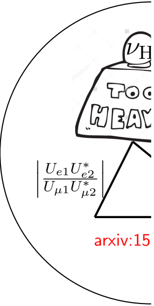
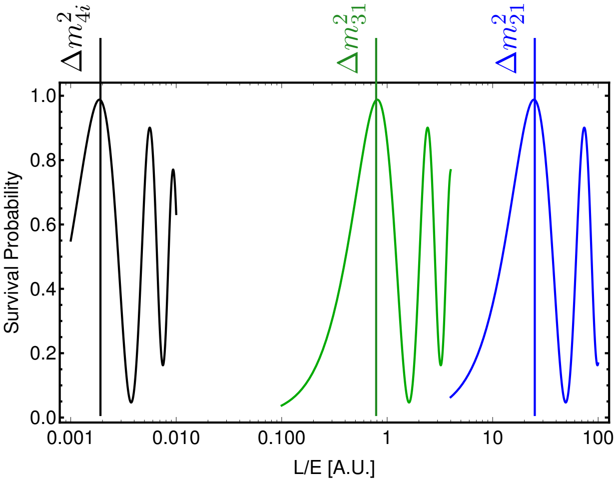


Δm^2_{31}
Δm^2_{21}
Survival Probability
1.0
0.8
0.6
0.4
0.2
0.0
0.001
0.010
0.100
1
10
100
L/E [A.U.]


ν_H
TOO
HEAV
$\left|\frac{U_{e1}U^*_{e2}}{U_{\mu1}U^*_{\mu2}}\right|$
arxiv:15


Δm^2_{4i}
Δm^2_{31}
Δm^2_{21}
Survival Probability
1.0
0.8
0.6
0.4
0.2
0.0
0.001
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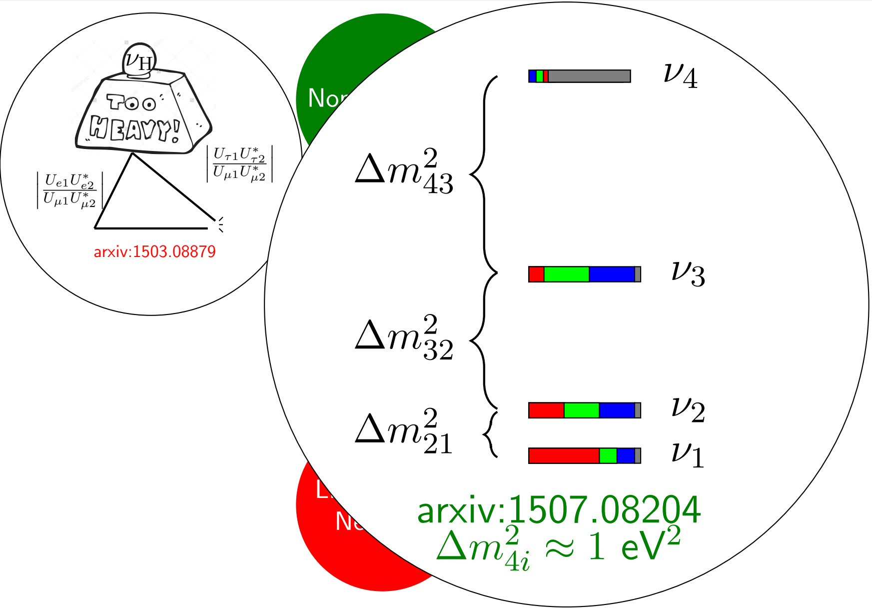

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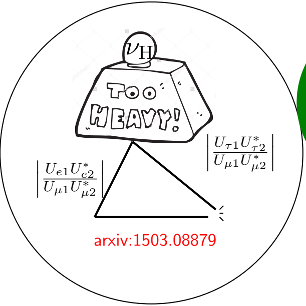

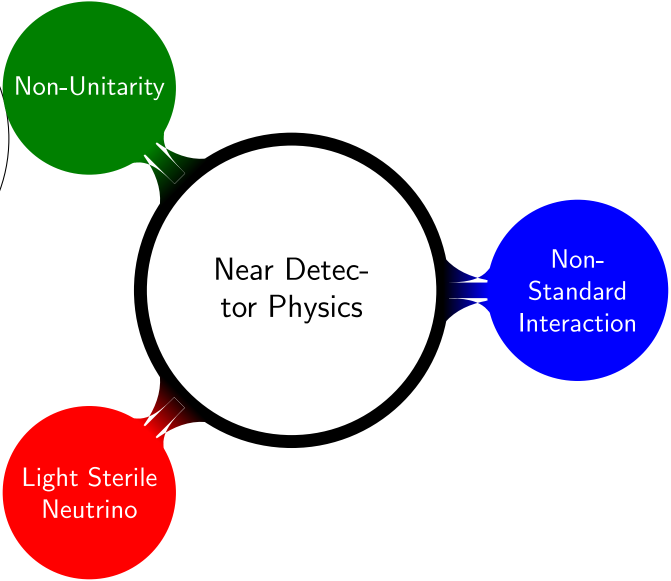

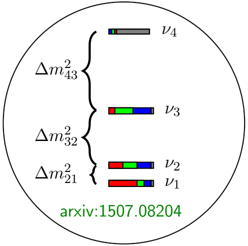

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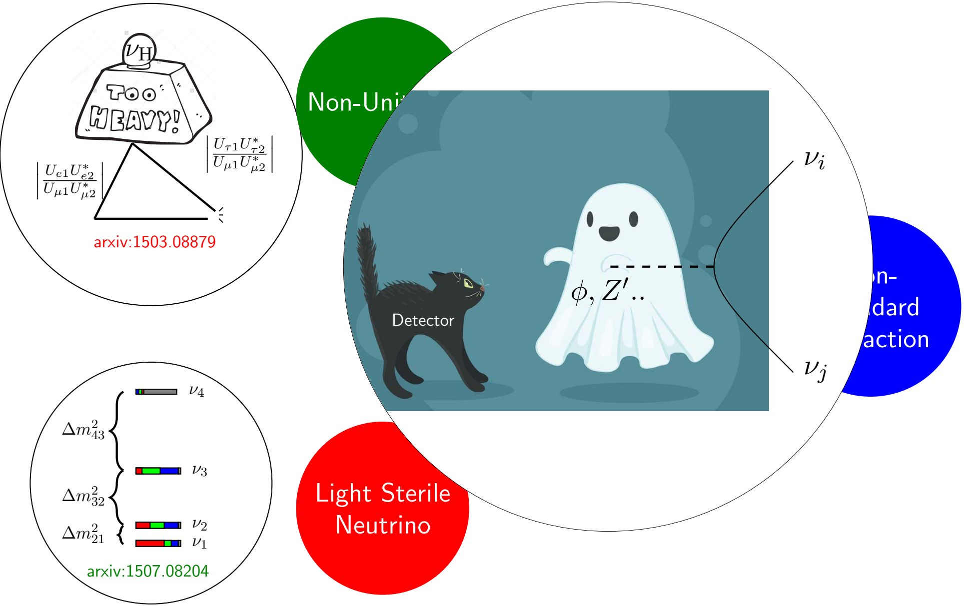

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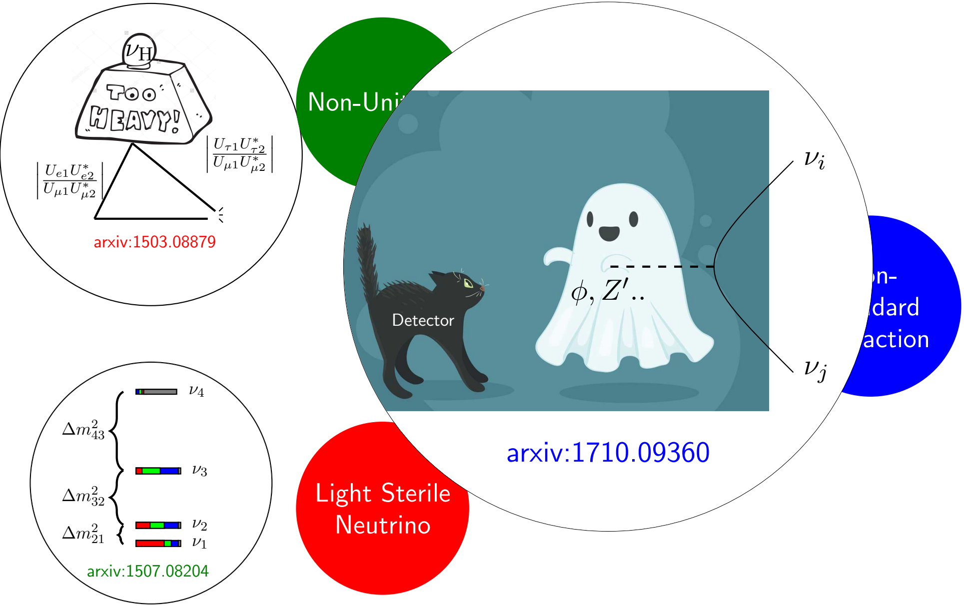

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	production: Decay	Propagation: Matter	Detection: Charge Current
Standard			
Non-Standard			

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Propagation: Matter

Detection: Charge Current

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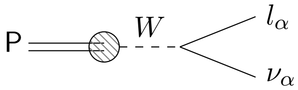

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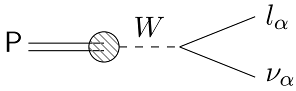

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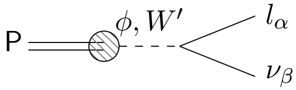

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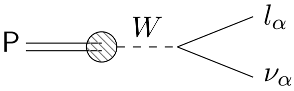

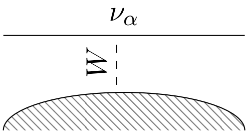

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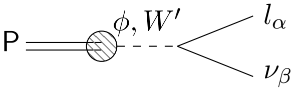

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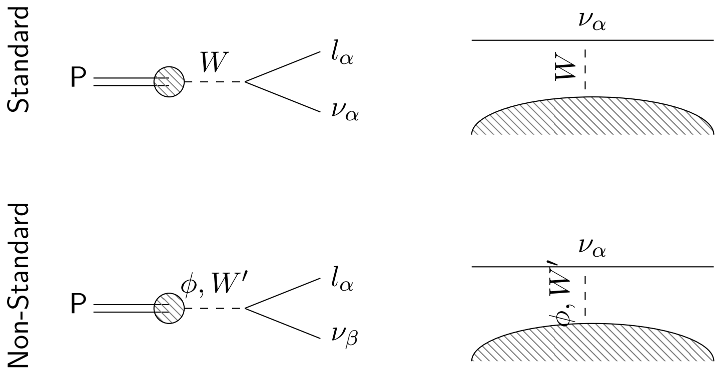

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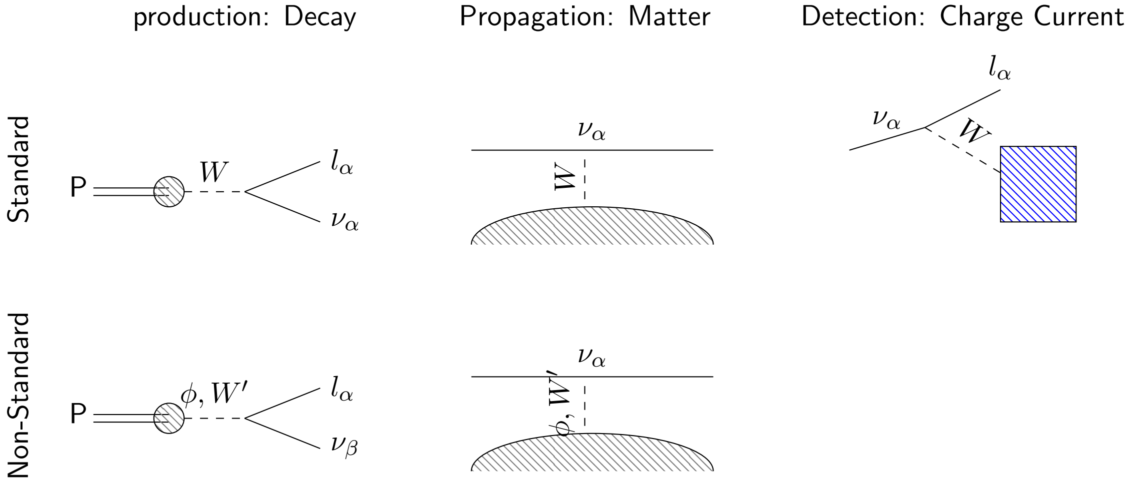

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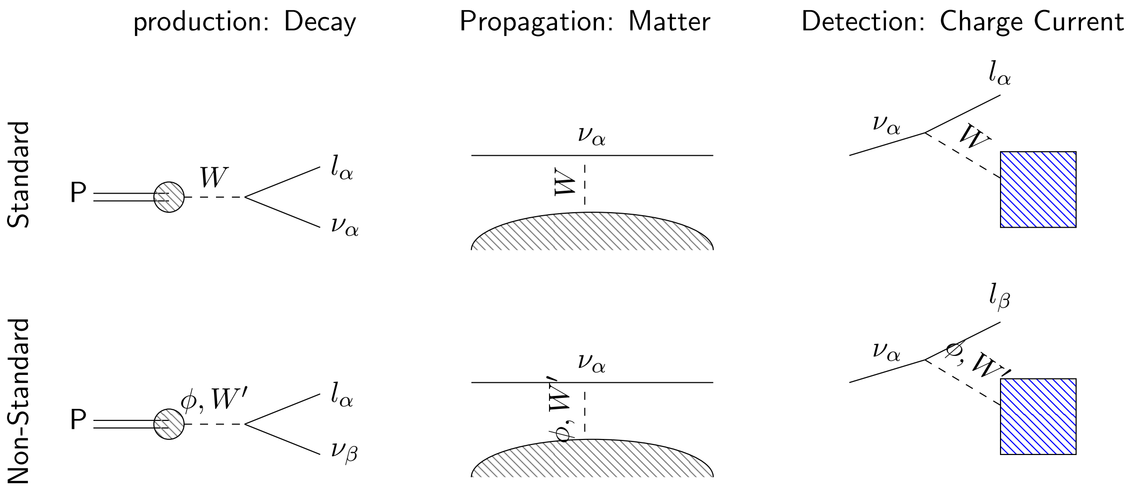

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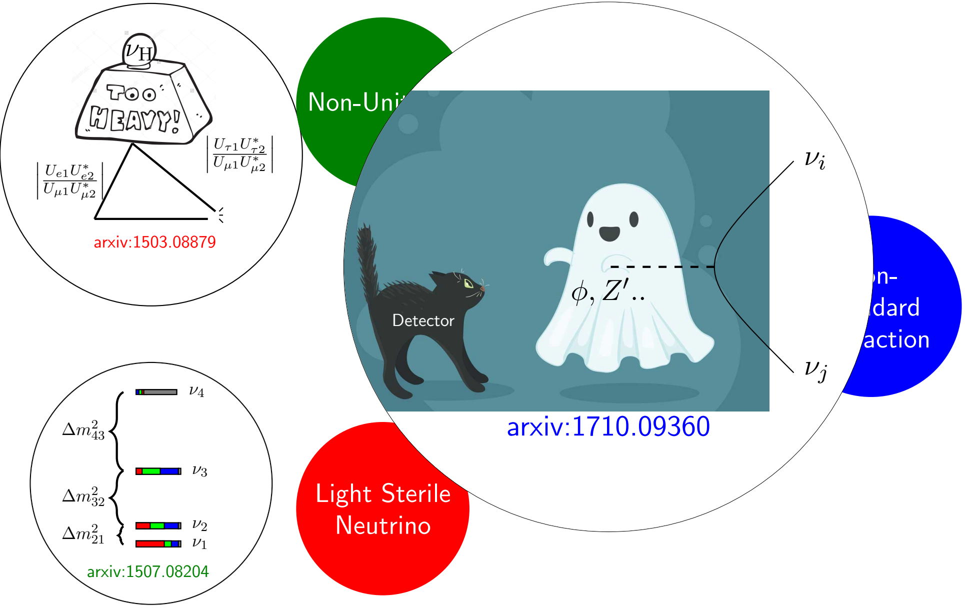

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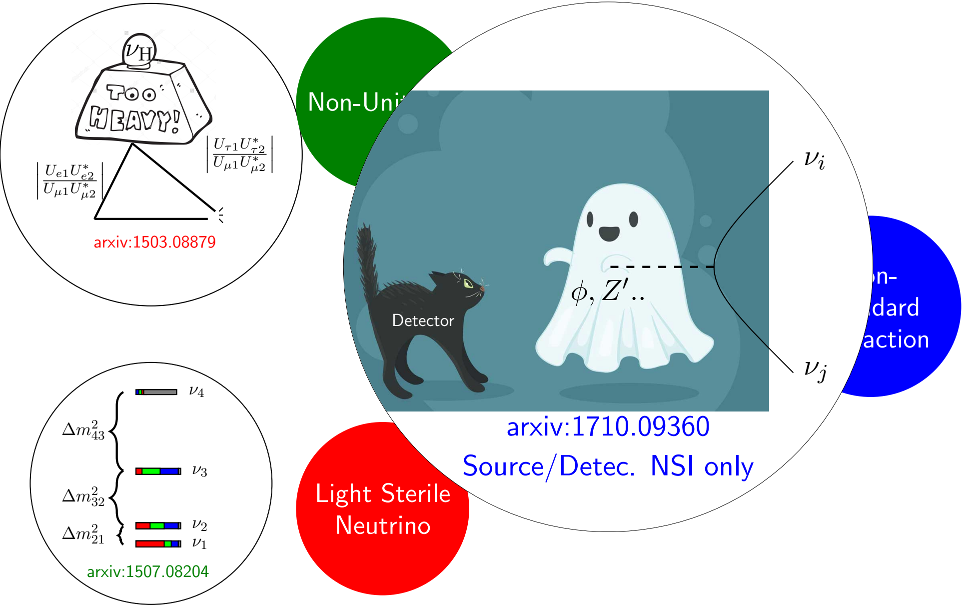

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Non-Unitarity	NSI	Sterile Neutrino
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Thus, $N_e \sim \phi_e + P_{\mu e}^{NEW} \phi_\mu$

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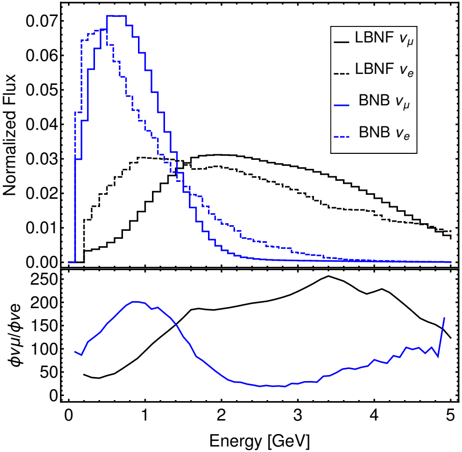

Nor ino

$P^N_{\mu e}$ $2\theta_{\mu e}$

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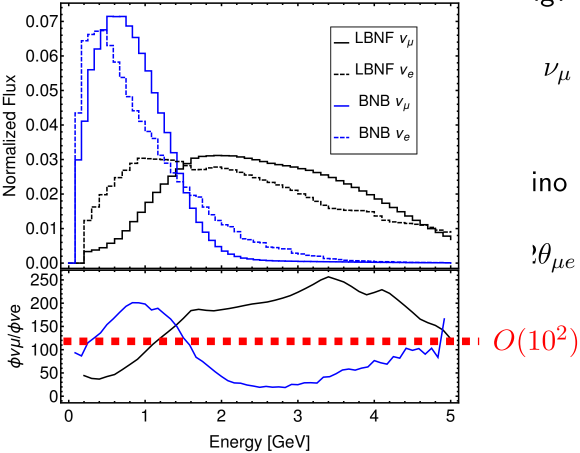
Noi ino

$P^N_{\mu e}$ $\theta_{\mu e}$



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$$\text{SBNE} = \text{SBND} + \mu\text{BooNE} + \text{ICARUS}$$

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LBNF beam with: protoDUNE and ICARUS as ND

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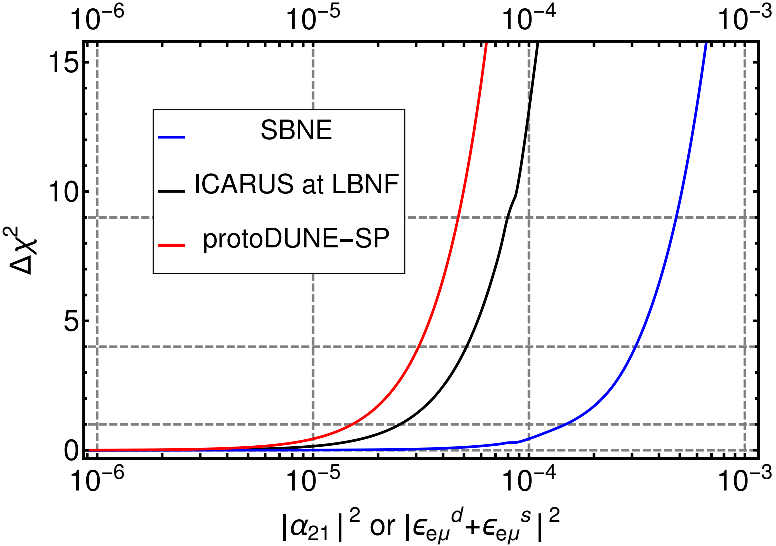

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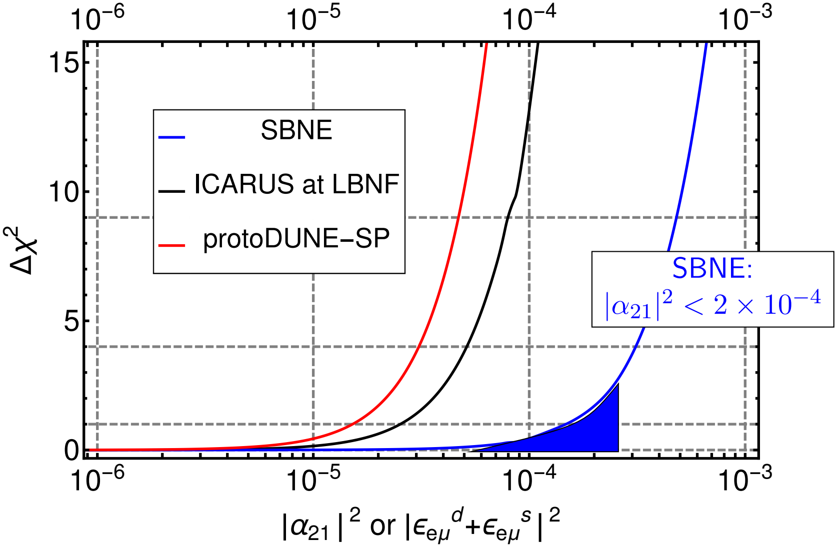

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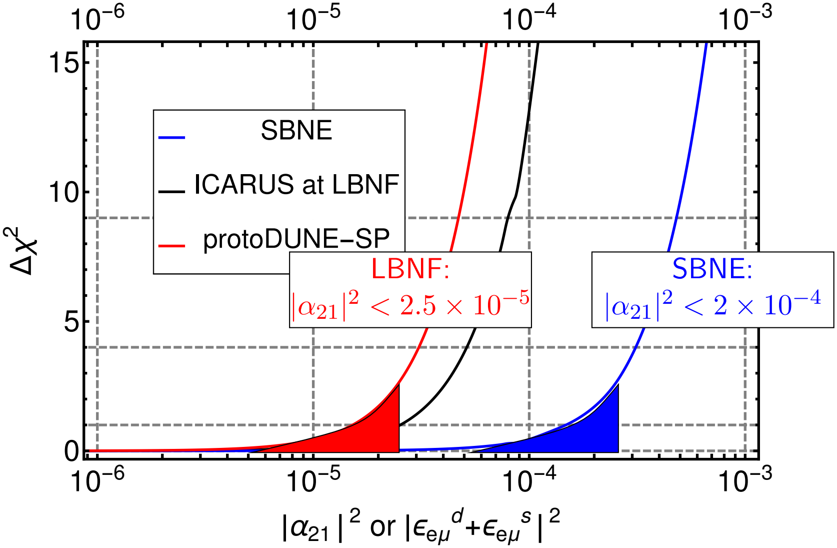

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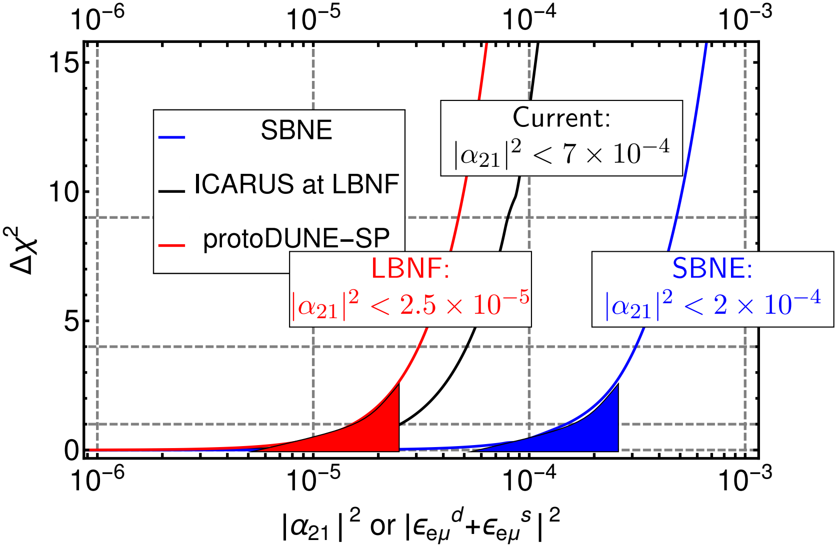

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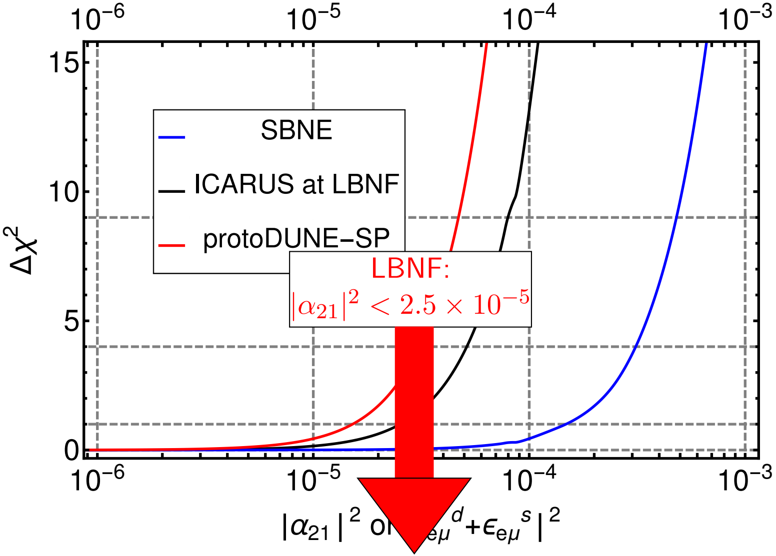

Can we really reach this level?

We need to know the expected flux precisely!

This New Physics changes ν spectrum,

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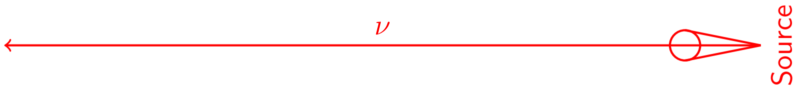

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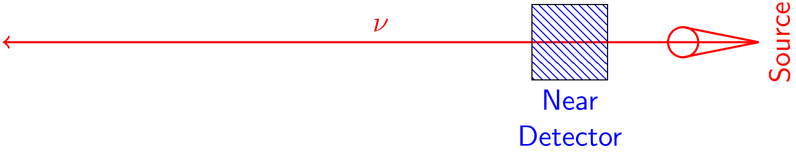

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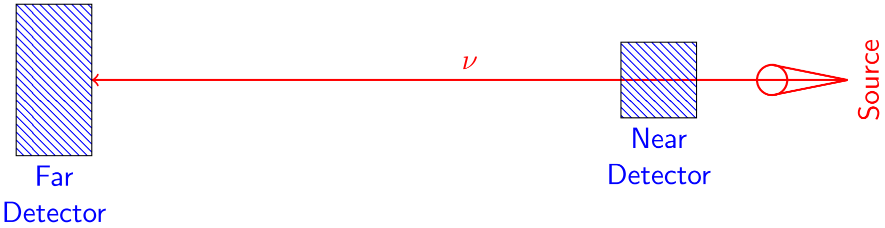

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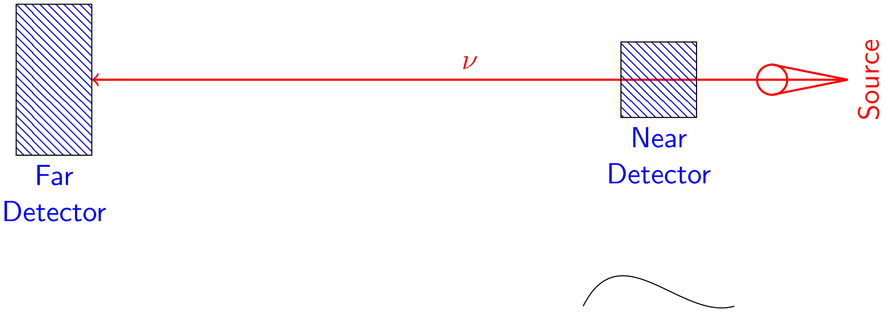

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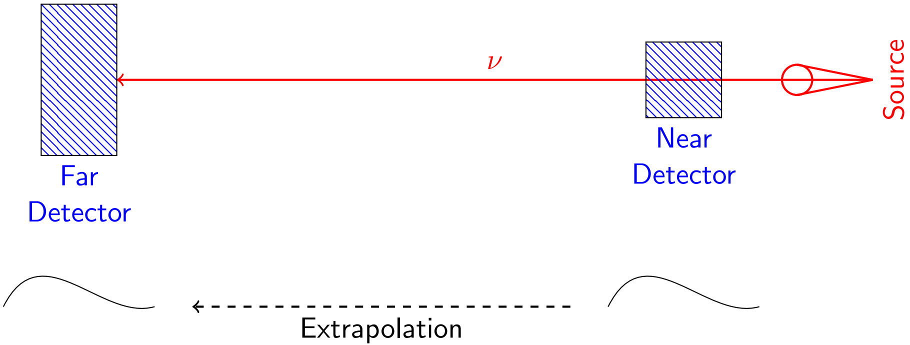

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→ Need to understand detector very well and is hard to measure E dependency

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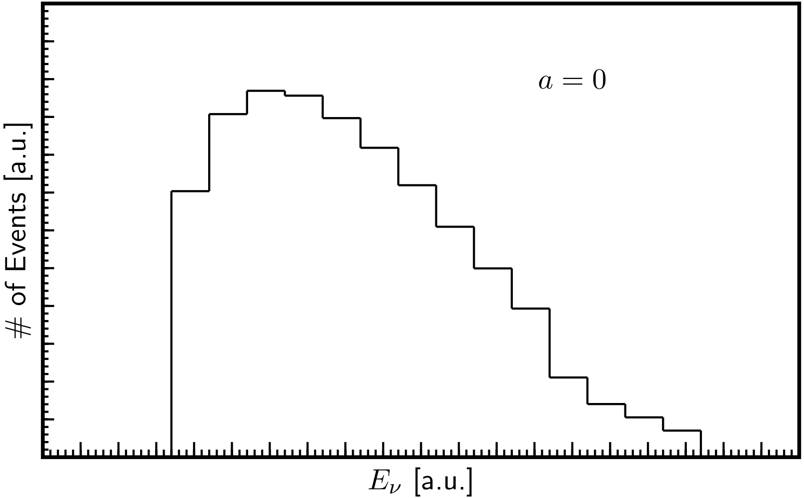

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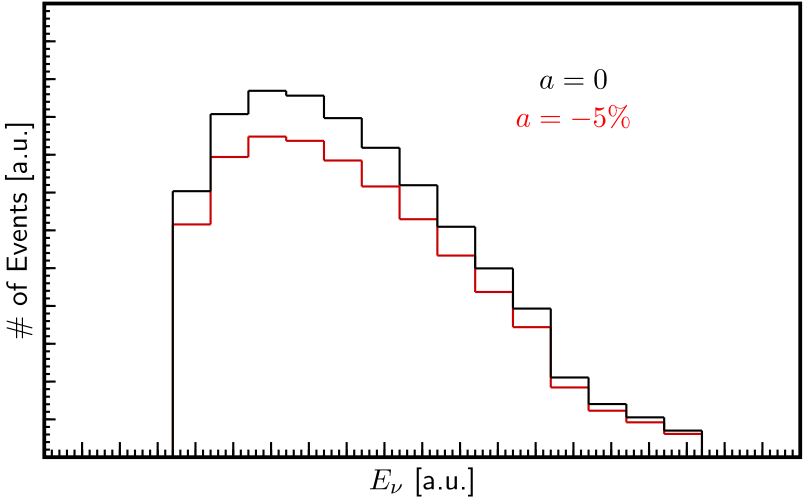

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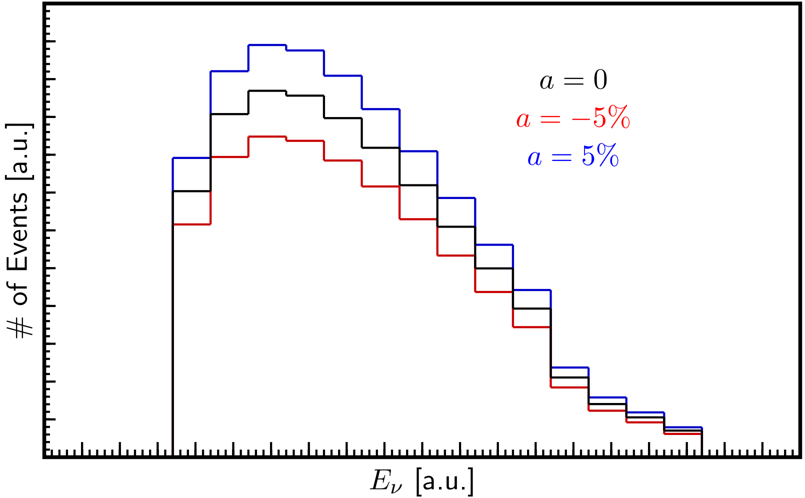

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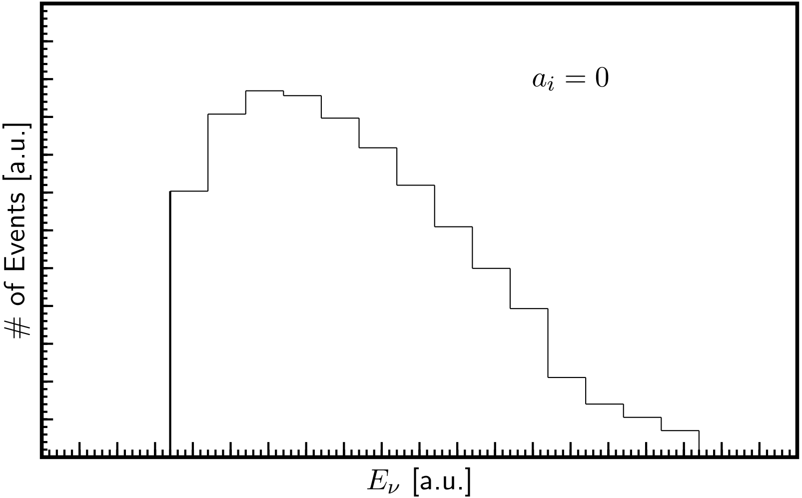

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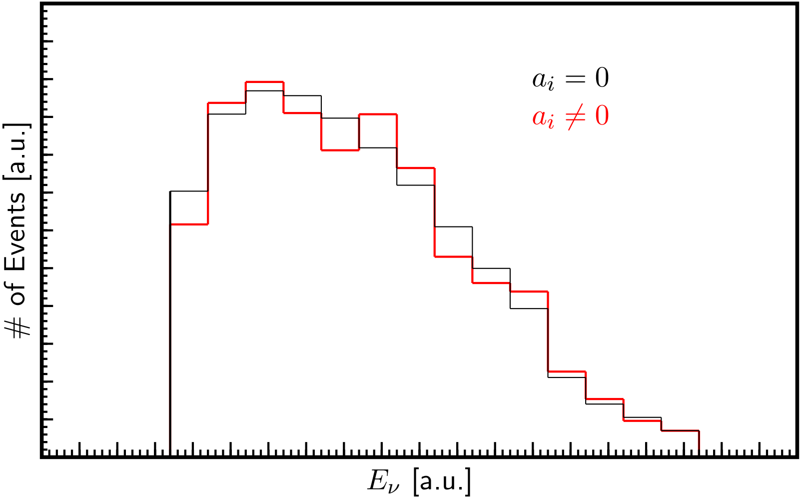

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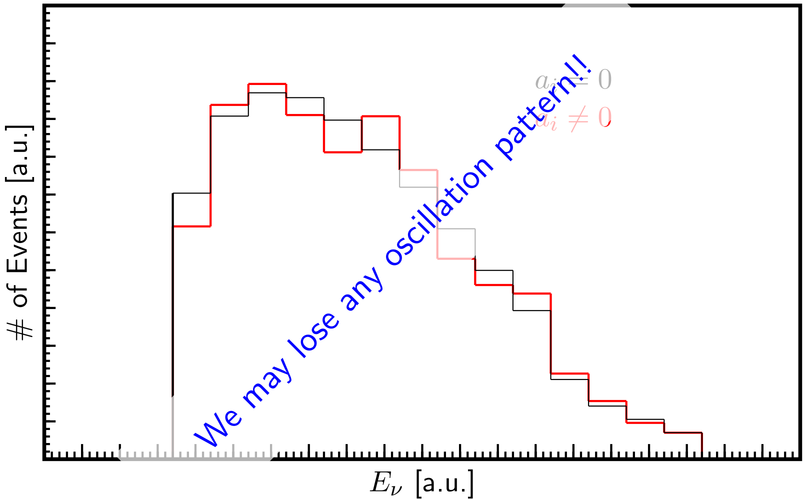

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$\sigma_{sa} = \sigma_{sb} = \sigma_s$ Spectrum error

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Notice, if $\sigma_i \to \infty$ one looses sensitivity ($\chi^2 \to 0$)

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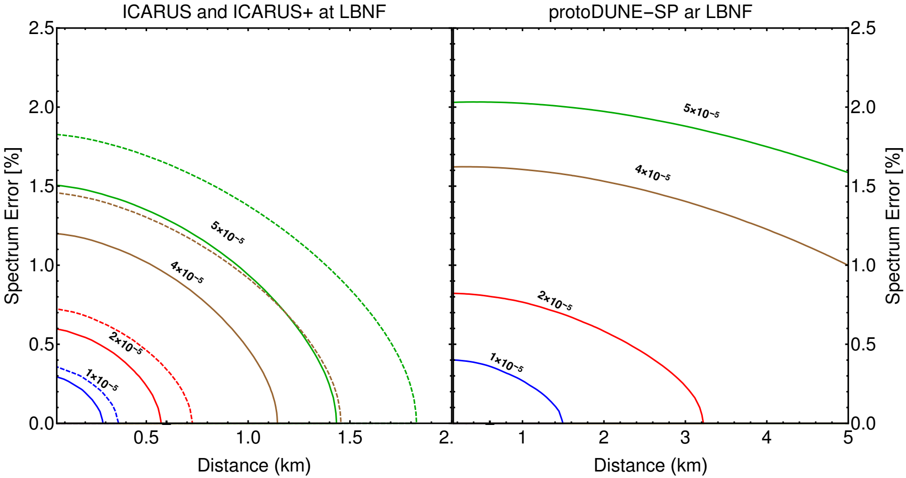

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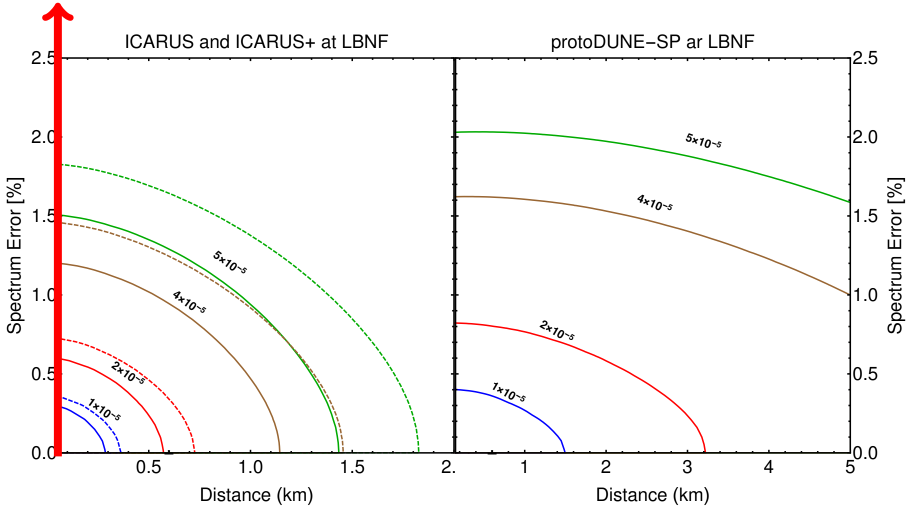

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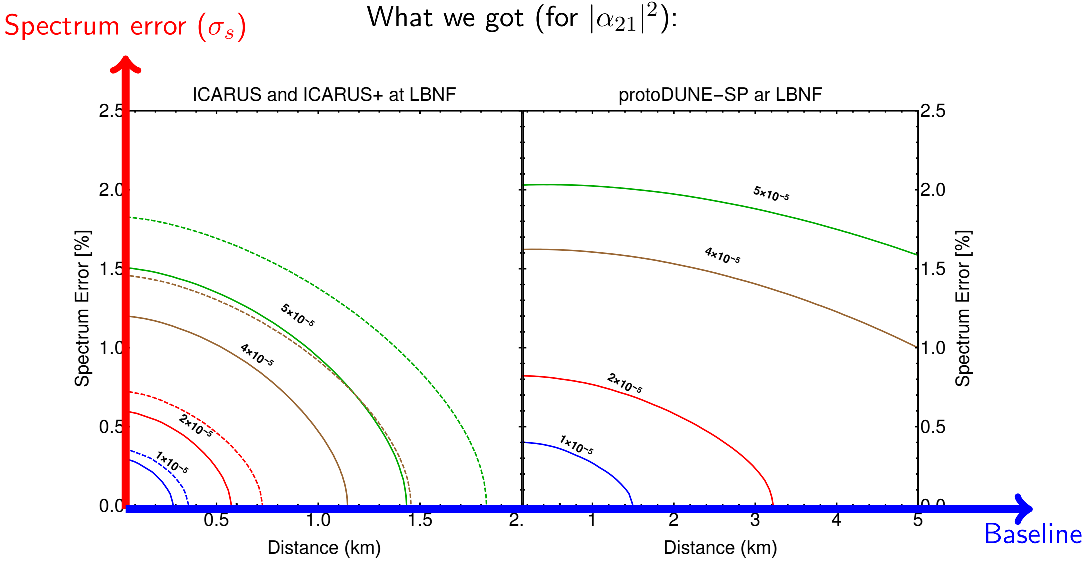

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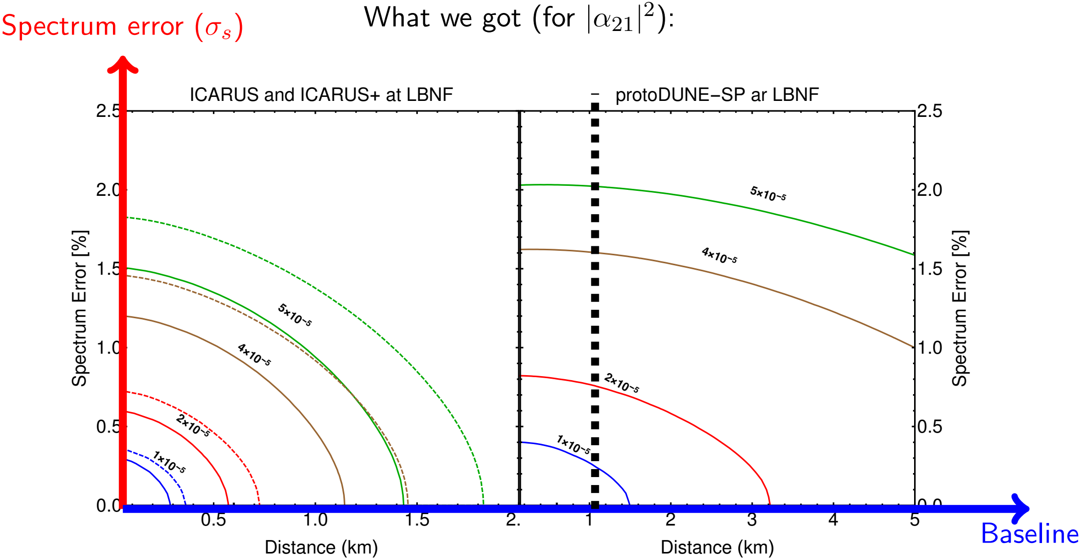

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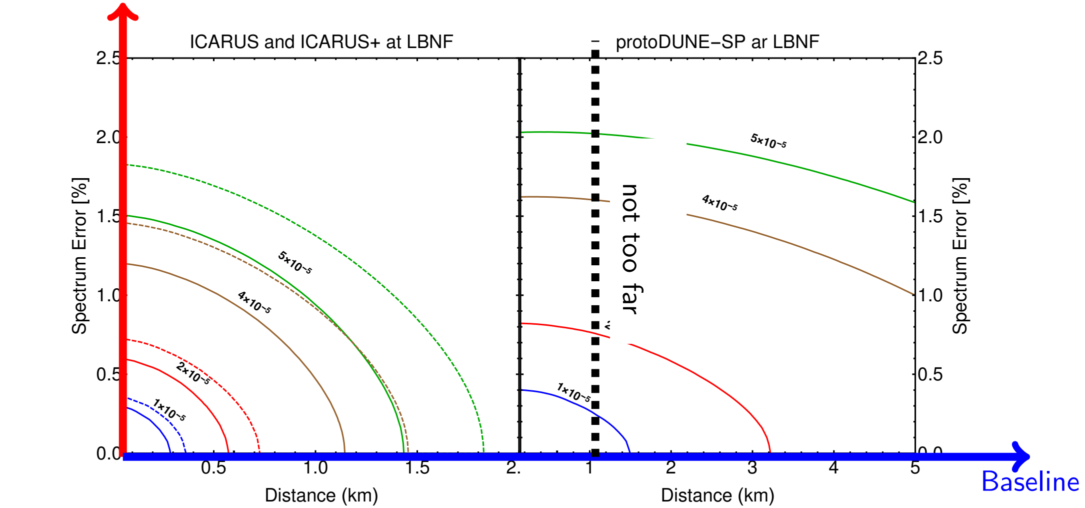

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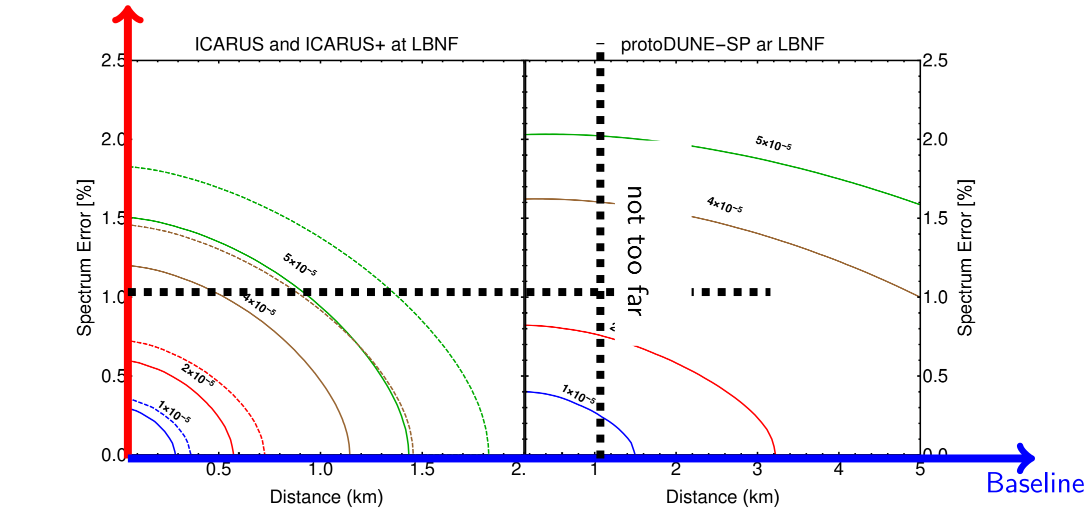

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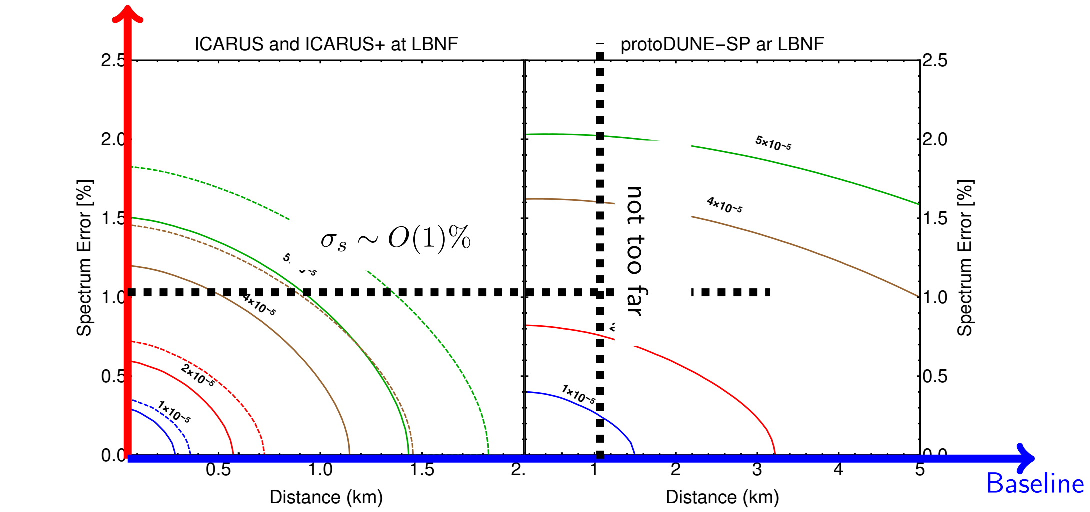

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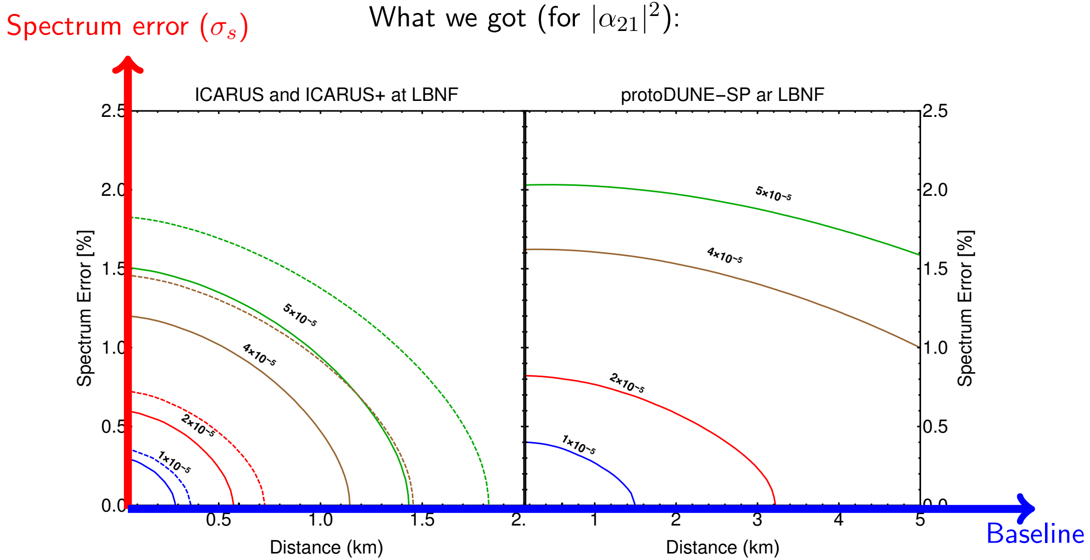

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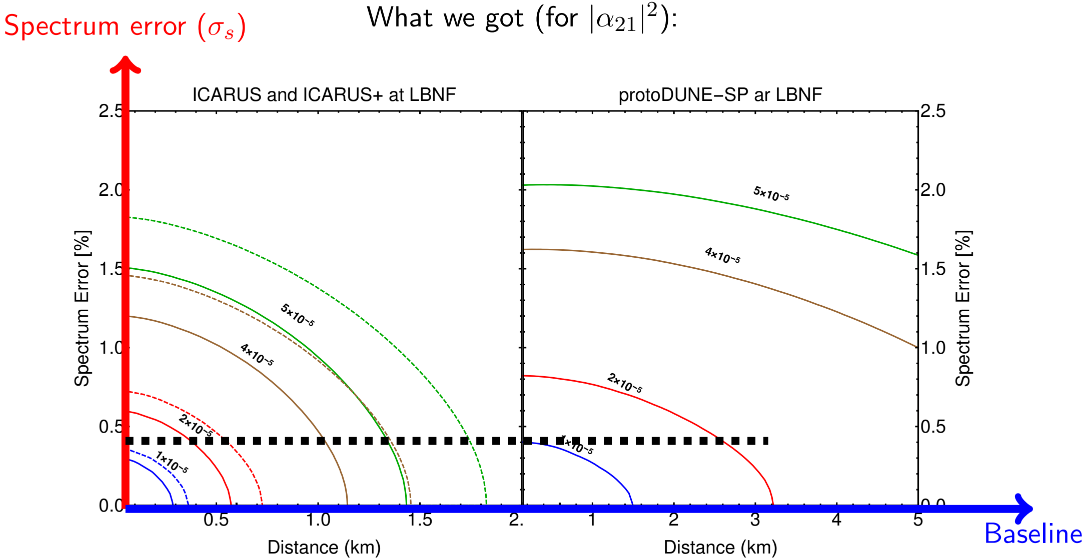

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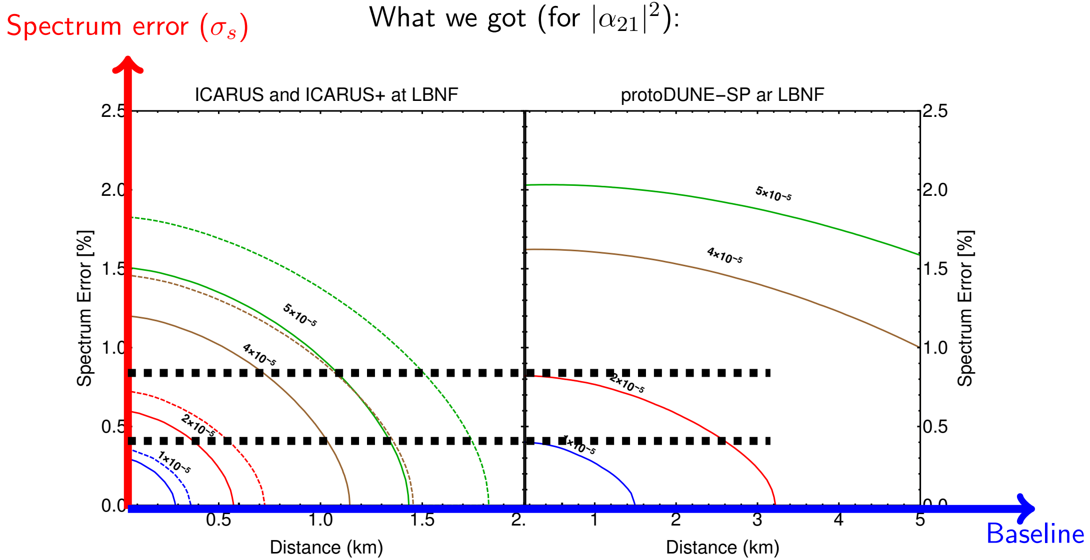

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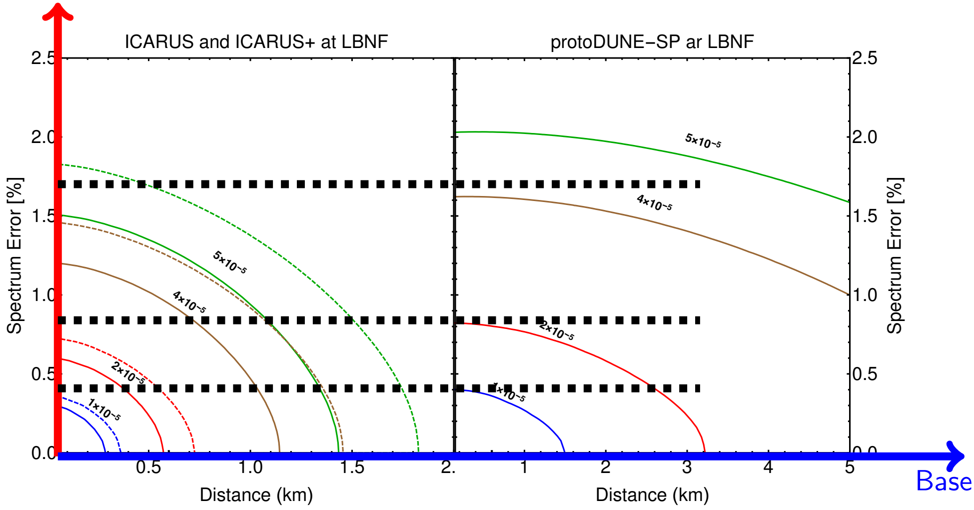

Baseline

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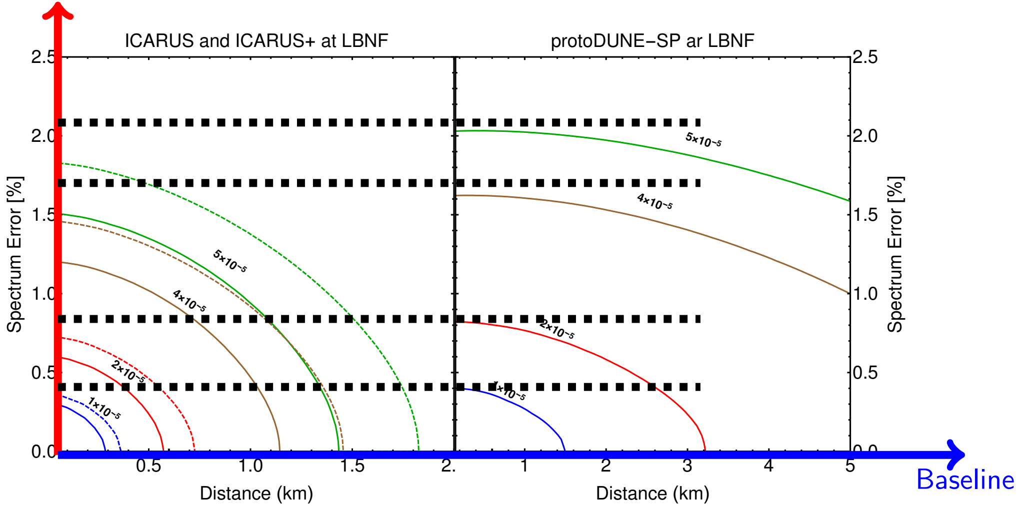
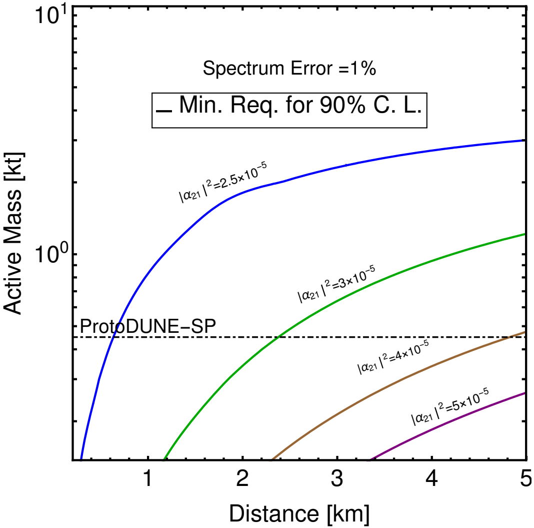


Setting a σ_s goal, we can get minimum requirements



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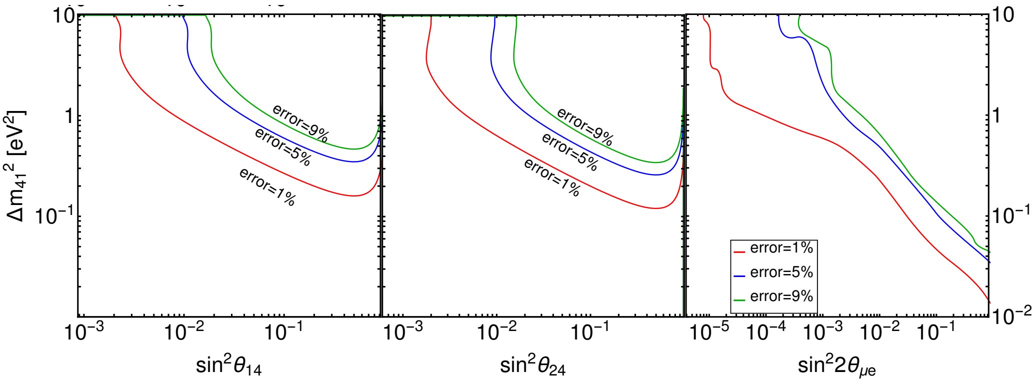

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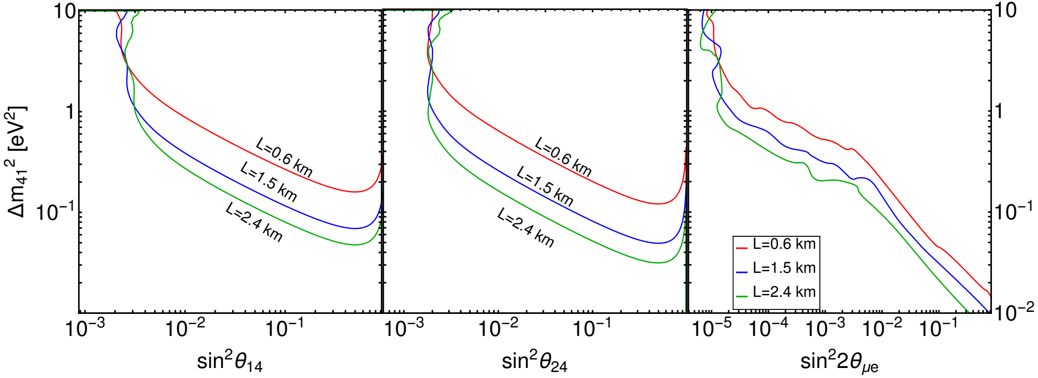
The sensitivity is reasonable good if $L \sim 1$km



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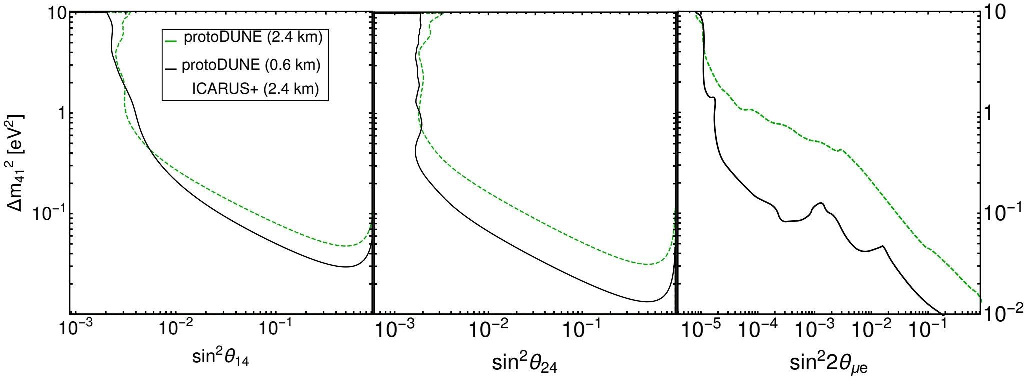

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Similar for sterile neutrino

Thanks for the supporters

Thanks

G. V. Stenico for SBN codes

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Fundo de Apoio ao Ensino, à Pesquisa e à Extensão

Generalitat Valenciana

CAPES

Ramón y Cajal

CONACyT and SNI (Mexico).

The Brazilian Physics Society (SBF) and the American Physical Society (APS)

jointly announce the

SBF-APS São Paulo School of Advanced Science on Experimental Neutrino Physics

December 3-14, 2018, University of Campinas (Unicamp), Campinas, SP, Brazil

Lecturers

Ettore Segreto, UNICAMP, Brazil (Scientific Coordinator)

Roberto Acciarri, FERMILAB, USA	Marcelo Guzzo, UNICAMP, Brazil
Jonathan Asaadi, UTA, USA	Ernesto Kemp, UNICAMP, Brazil
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Mary Bishai, BNL, USA	Franciole Marinho, UFSCAR, Brazil
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Ines Gil Botella, CIEMAT, Spain	Luciano Pandola, INFN-LNS, Italy
Flavio Cavanna, FERMILAB, USA	Laura Paulucci, UFABC, Brazil
Justin Evans, Manchester, UK	Kate Scholberg, Duke University, USA
Renata Funchal, USP, Brazil	Michelle Stancari, FERMILAB, USA
Douglas Galante, LNLS, Brazil	Andrzej Szelc, Manchester, UK
Diego Garcia-Gamez, Manchester, UK	Francesco Vissani, INFN-LNGS, Italy

All lectures will be held in English

Deadline for registration: September 28, 2018

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Additional information and Applications:

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Travel and lodging support available for up to 100 selected students/post-docs (50 from Brazil, 50 from abroad).

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Funding: São Paulo Research Foundation (FAPESP), APS, UNICAMP