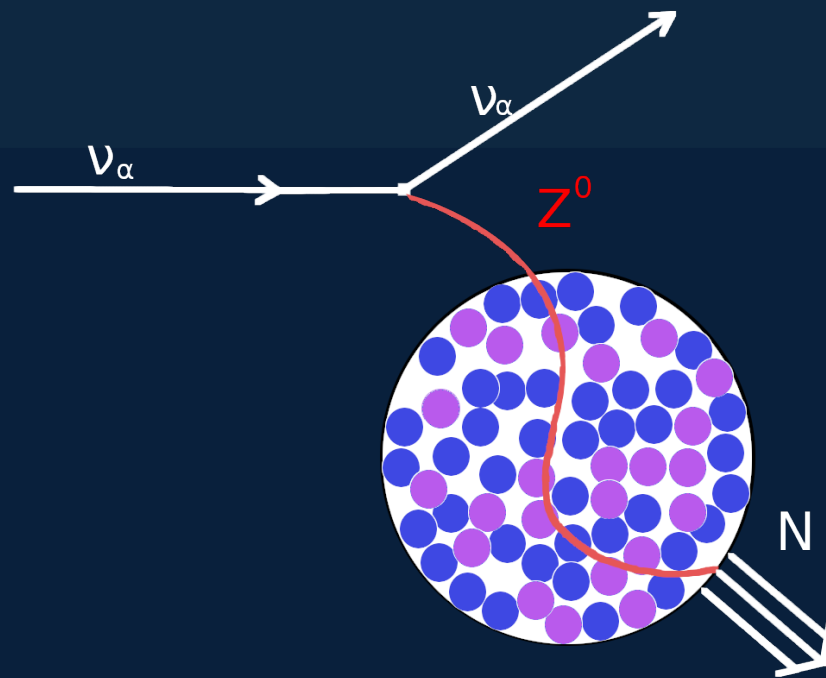


Beyond the Standard Model investigations at CONUS+

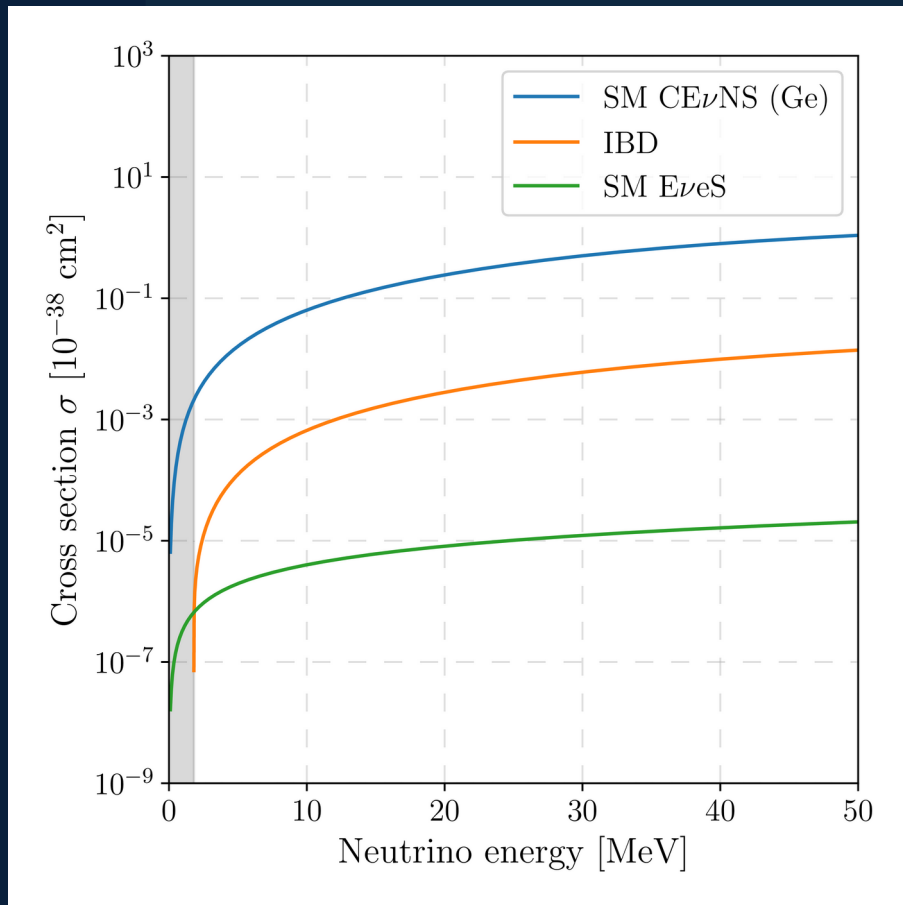
D a r i o P i a n i for the CONUS collaboration

PASCOS Sheffield, 23 June 2026

Coherent Elastic ν -Nucleus Scattering (CE ν NS)



Standard Model channel to probe low-energy ν -physics



+ Small detectors

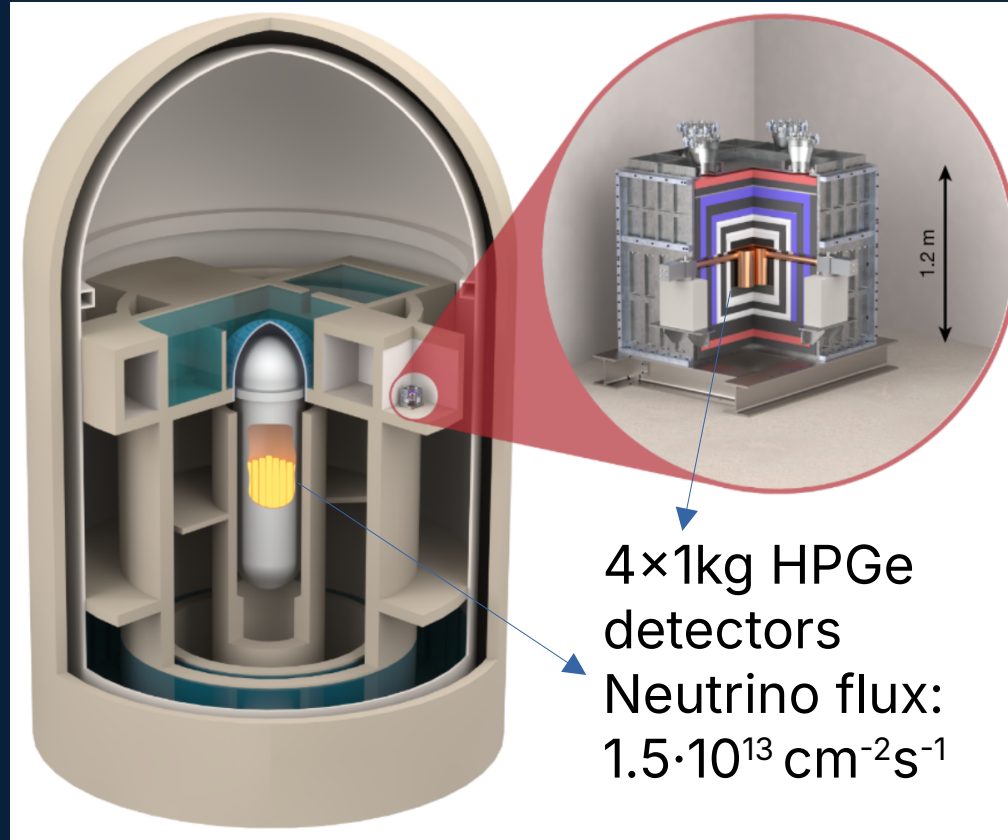
Coherent enhancement: $\frac{d\sigma}{dT_A} \propto N^2$

– Low energy threshold

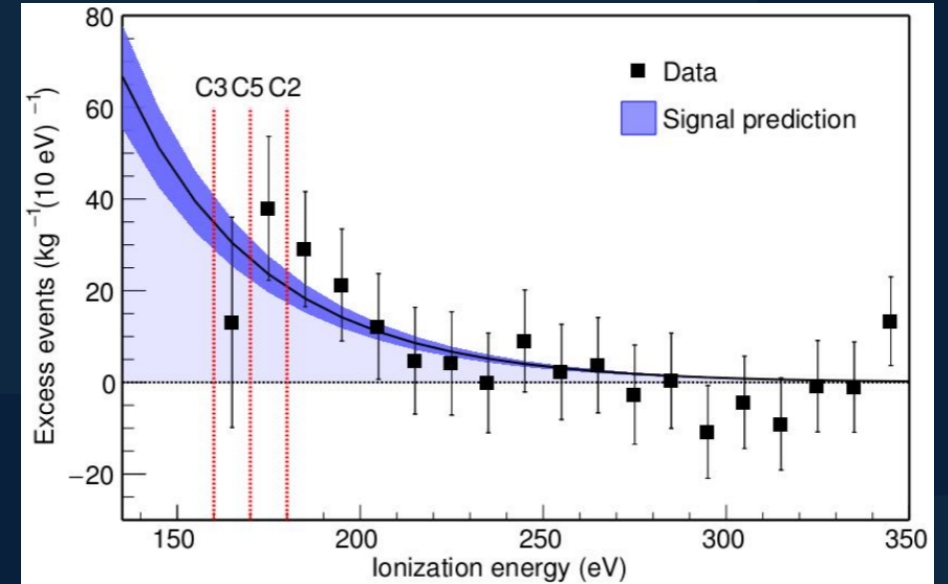
$$T_{A,max} \propto \frac{1}{M}$$

First detection at nuclear reactor!

CONUS+



Nature, 643, pages 1229–1233 (2025)



Measured events: (395 ± 106)
Predicted events: (347 ± 59)

Why Go Beyond the Standard Model?

Dark Matter



Neutrino masses

ν - ν - ν

Collider complementarity



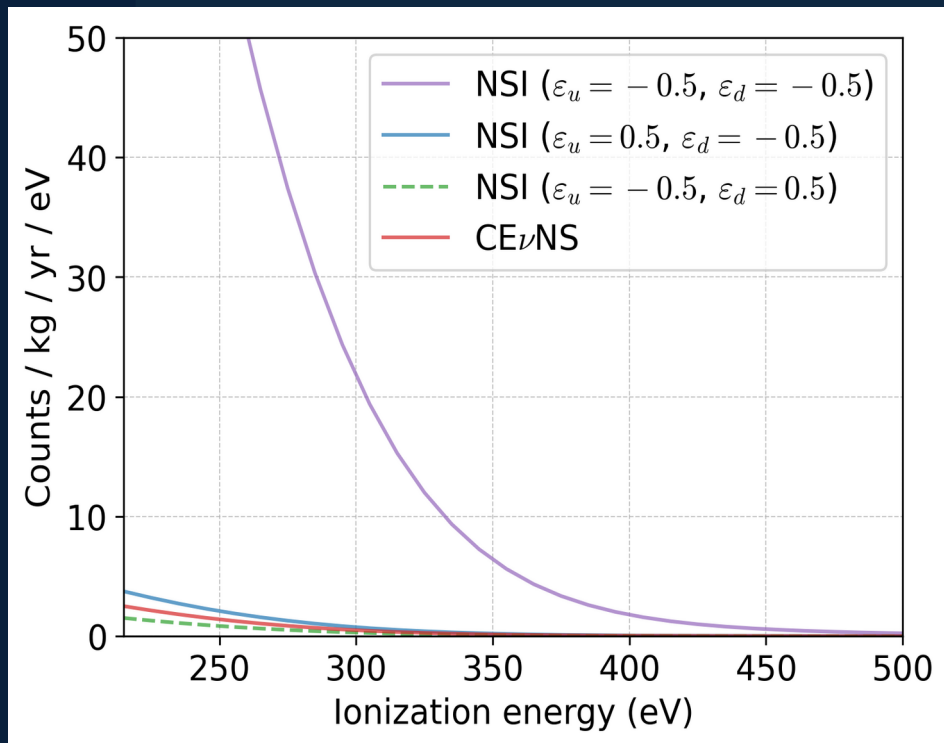
My work: look for BSM signatures!

Models: ***Non-Standard Interactions, light mediators, ν -EM properties, sterile ν , DM...***

BSM MODELS

Vector NSI

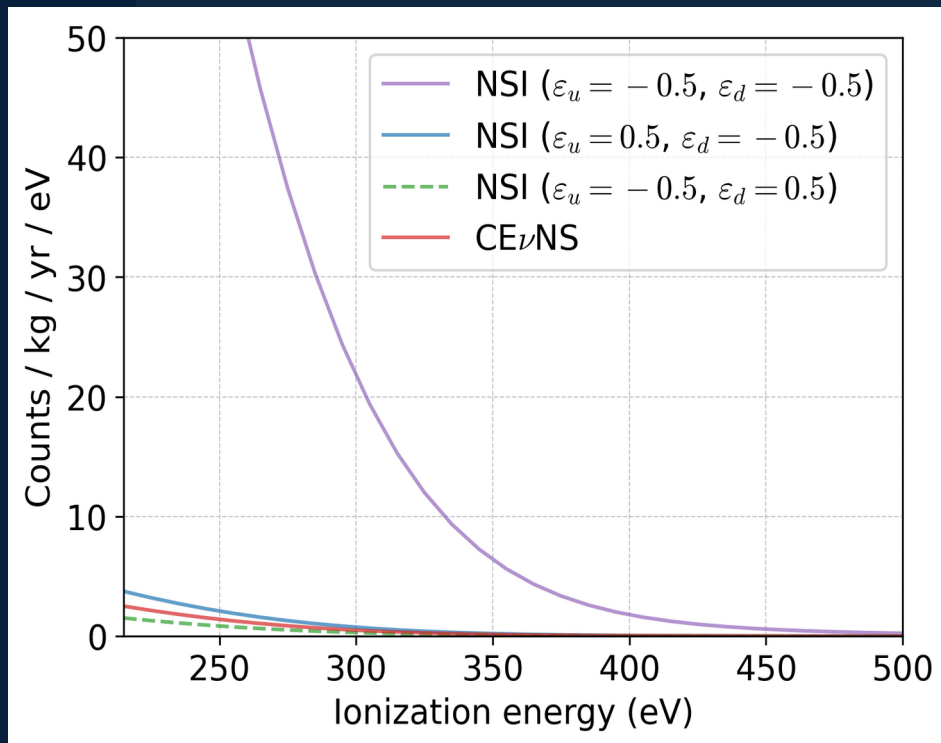
- Heavy new physics
- $\Delta Q = (2\varepsilon_{\alpha\alpha}^{uV} + \varepsilon_{\alpha\alpha}^{dV})Z + (\varepsilon_{\alpha\alpha}^{uV} + 2\varepsilon_{\alpha\alpha}^{dV})N$



BSM MODELS

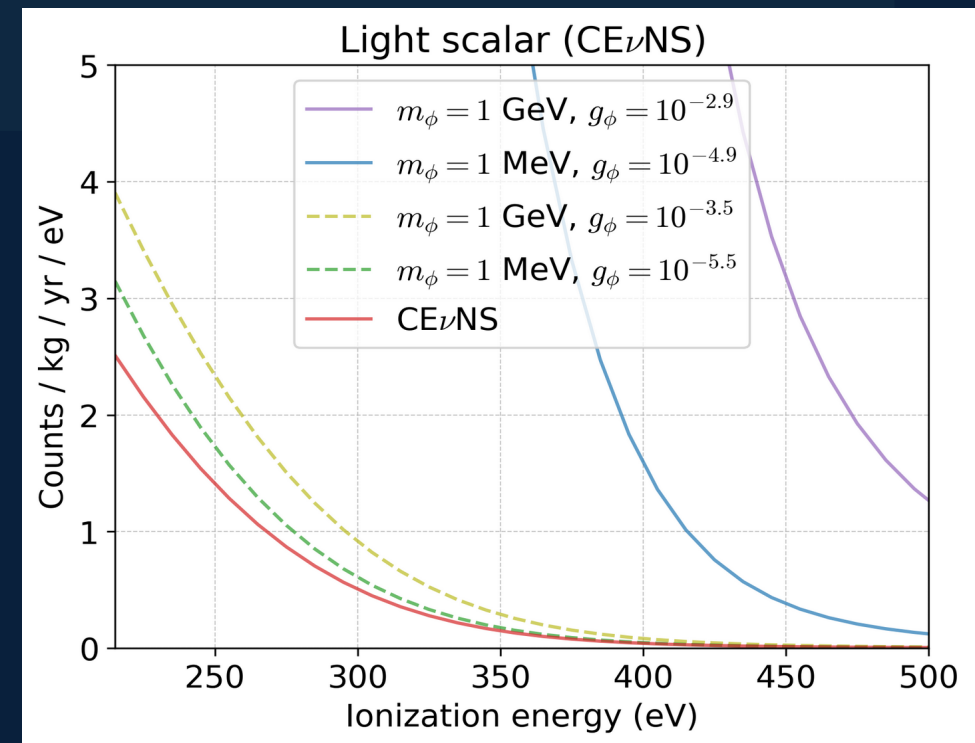
Vector NSI

- Heavy new physics
- $\Delta Q = (2\varepsilon_{\alpha\alpha}^{uV} + \varepsilon_{\alpha\alpha}^{dV})Z + (\varepsilon_{\alpha\alpha}^{uV} + 2\varepsilon_{\alpha\alpha}^{dV})N$



Light scalar

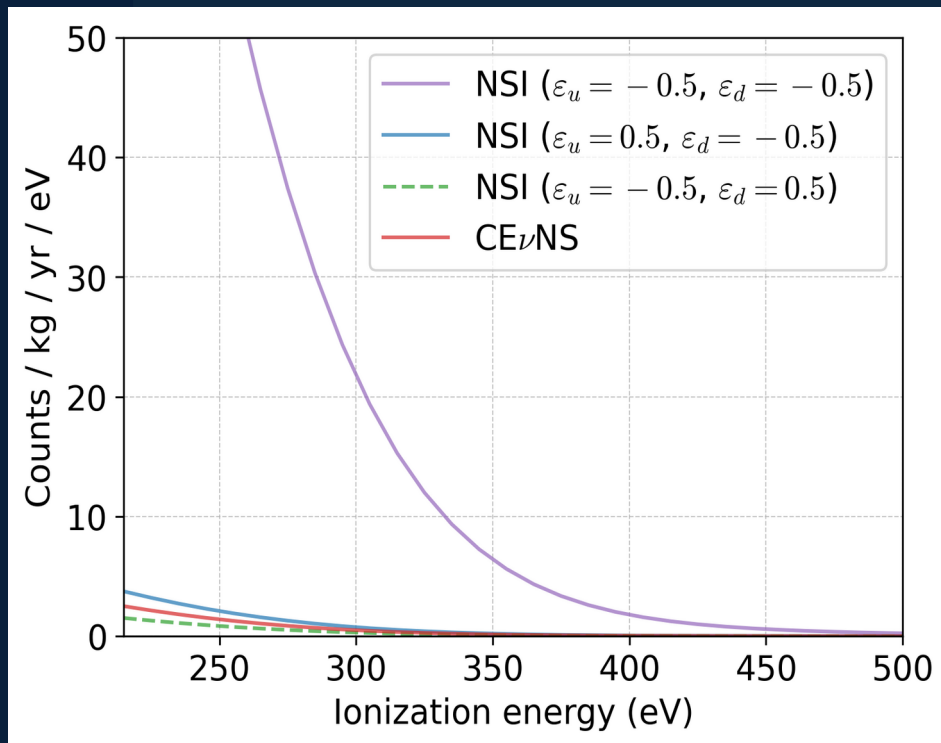
- New light mediator
- $g_{\phi}^{eS} = g_{\phi}^{\nu S} = g_{\phi}^{qS}$



BSM MODELS

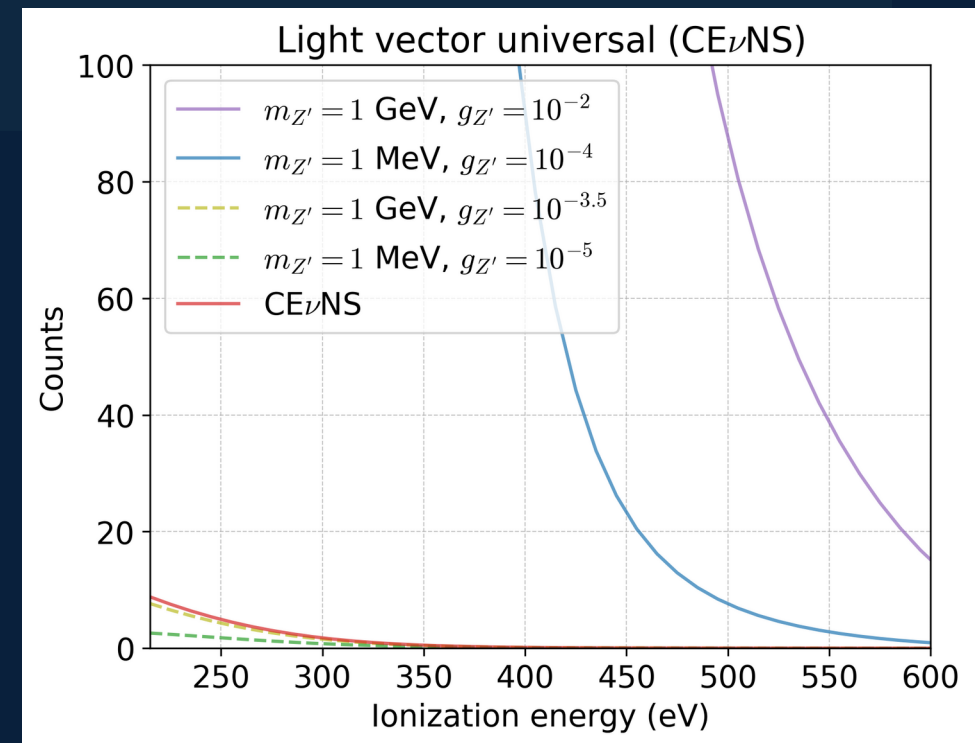
Vector NSI

- Heavy new physics
- $\Delta Q = (2\varepsilon_{\alpha\alpha}^{uV} + \varepsilon_{\alpha\alpha}^{dV})Z + (\varepsilon_{\alpha\alpha}^{uV} + 2\varepsilon_{\alpha\alpha}^{dV})N$



Light Vector universal

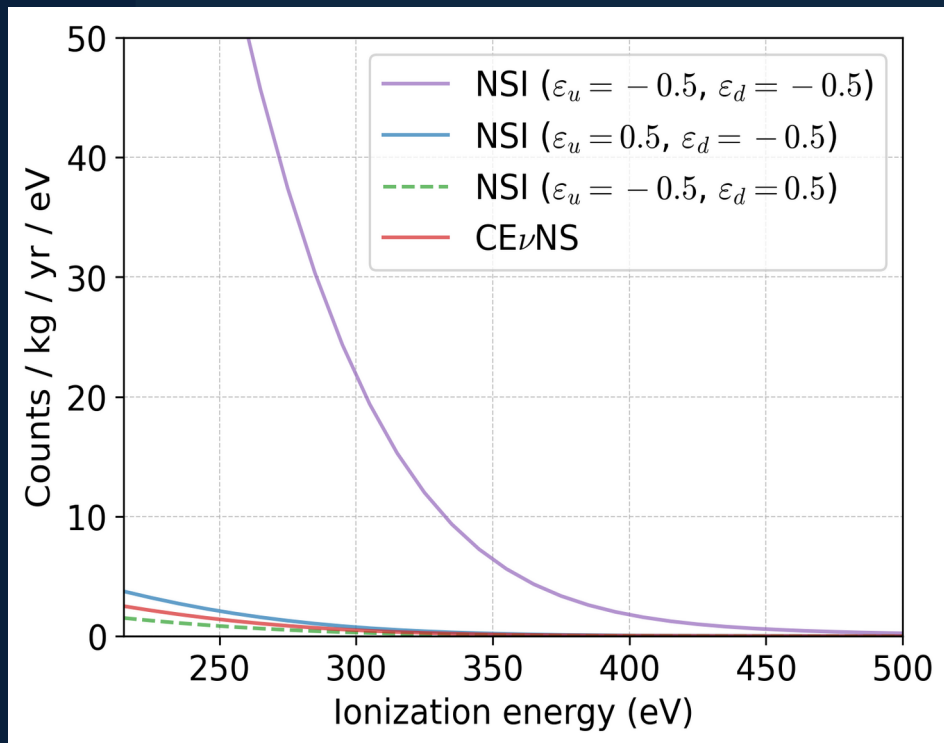
- New light mediator
- $g_{Z'}^{eS} = g_{Z'}^{vS} = g_{Z'}^{qS}$



BSM MODELS

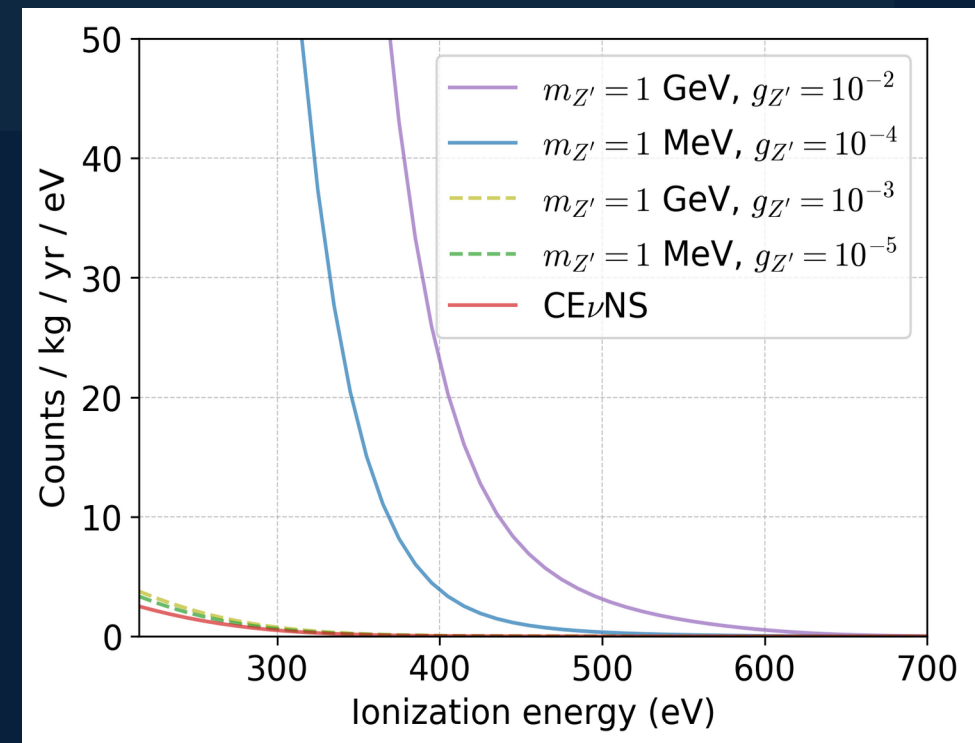
Vector NSI

- Heavy new physics
- $\Delta Q = (2\varepsilon_{\alpha\alpha}^{uV} + \varepsilon_{\alpha\alpha}^{dV})Z + (\varepsilon_{\alpha\alpha}^{uV} + 2\varepsilon_{\alpha\alpha}^{dV})N$



Light Vector B-L

- New light mediator
- $g_{Z'}^{eV} = g_{Z'}^{\nu V} = -3g_{Z'}^{qV}$



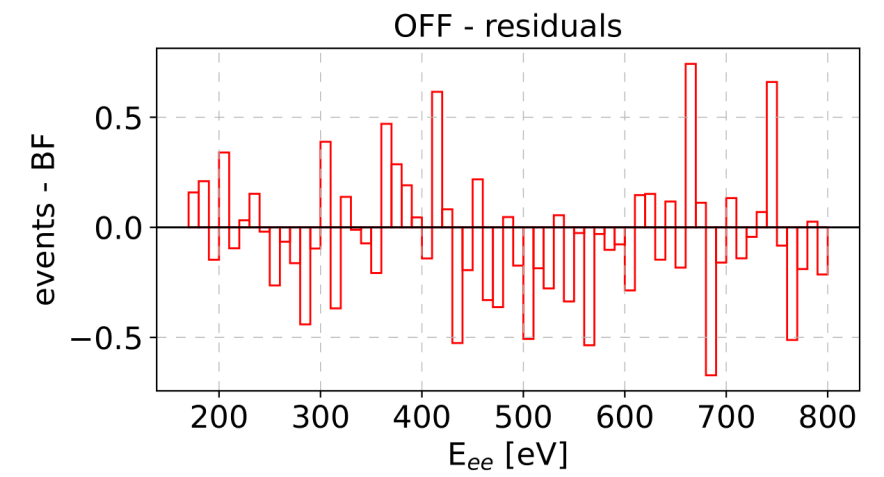
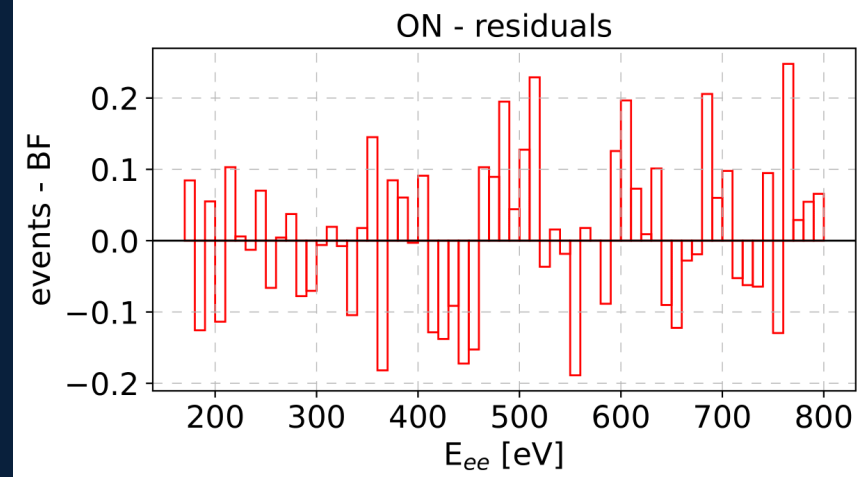
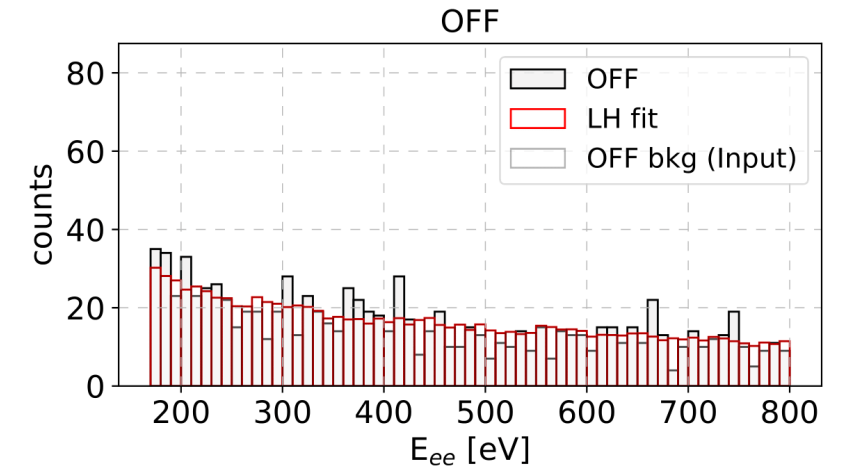
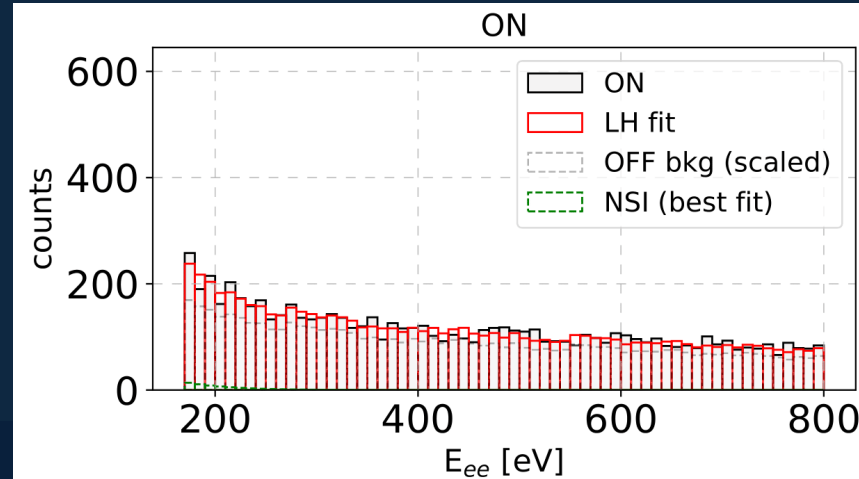
ANALYSIS STRATEGY

Likelihood fit:

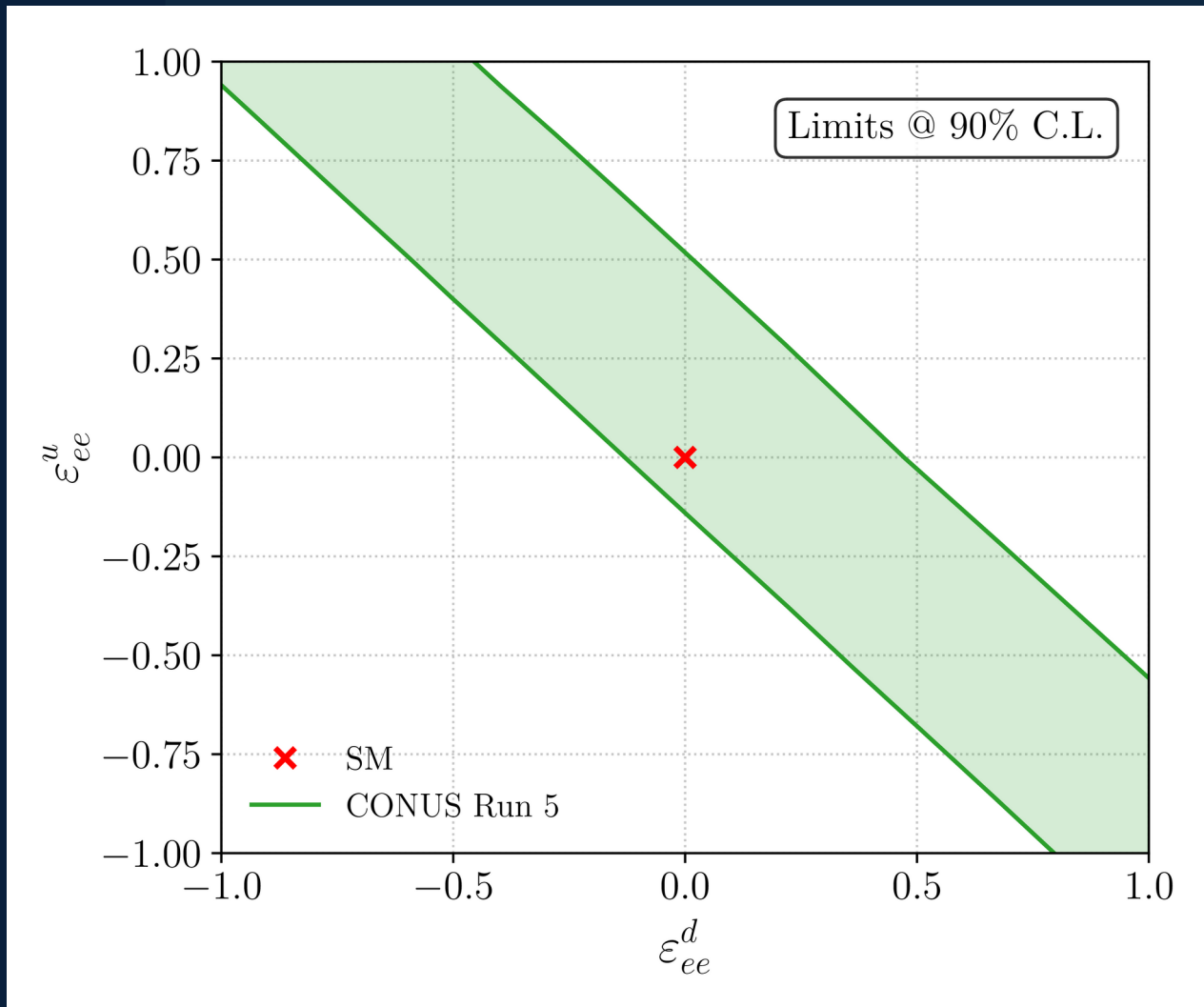
- Two energy regions
- **ON** and **OFF**

simultaneously

- Full knowledge of **systematics**



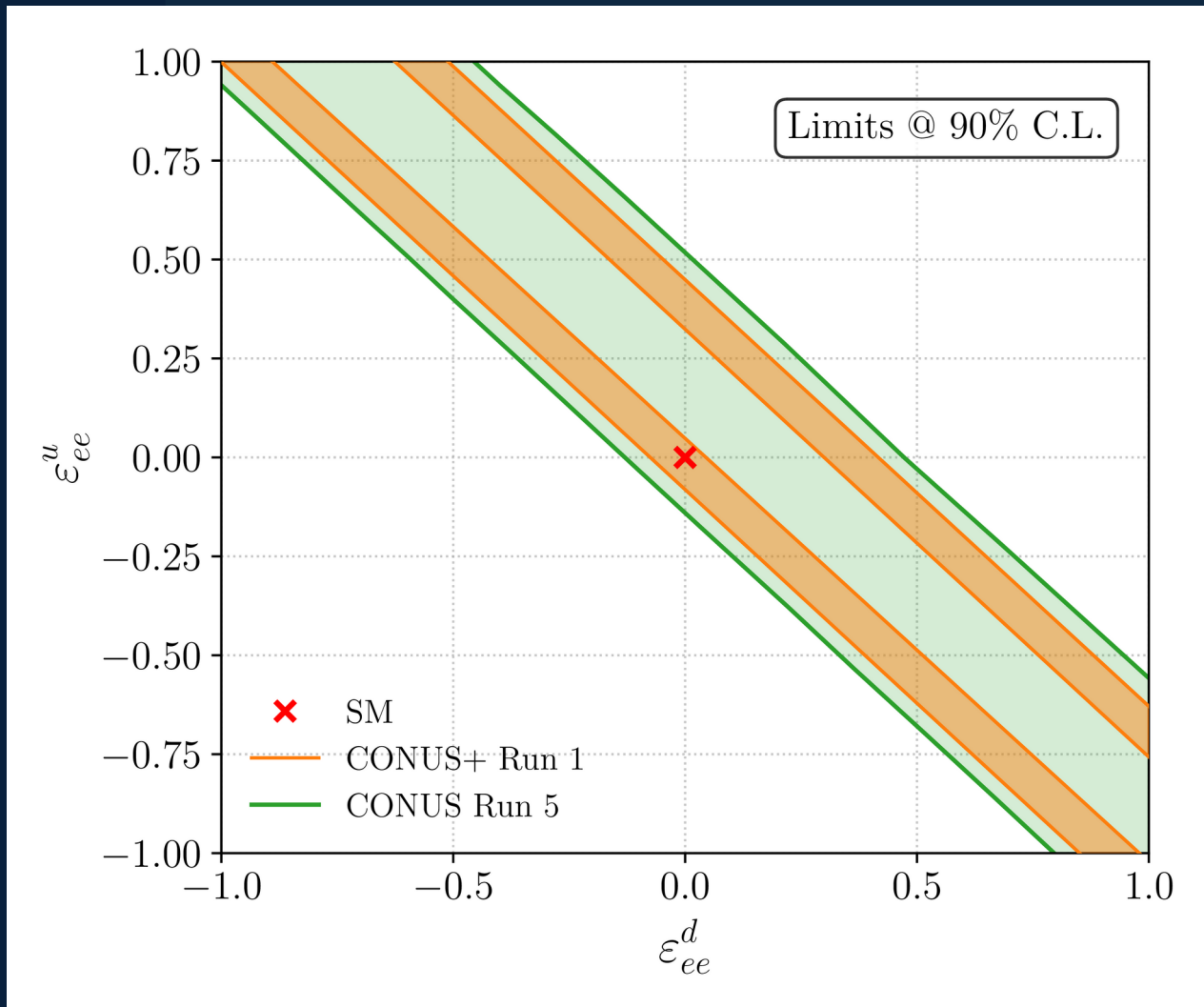
RESULTS I



Vector NSI

- New scale sensitivity: 140 GeV!
- Best limits for reactor experiments

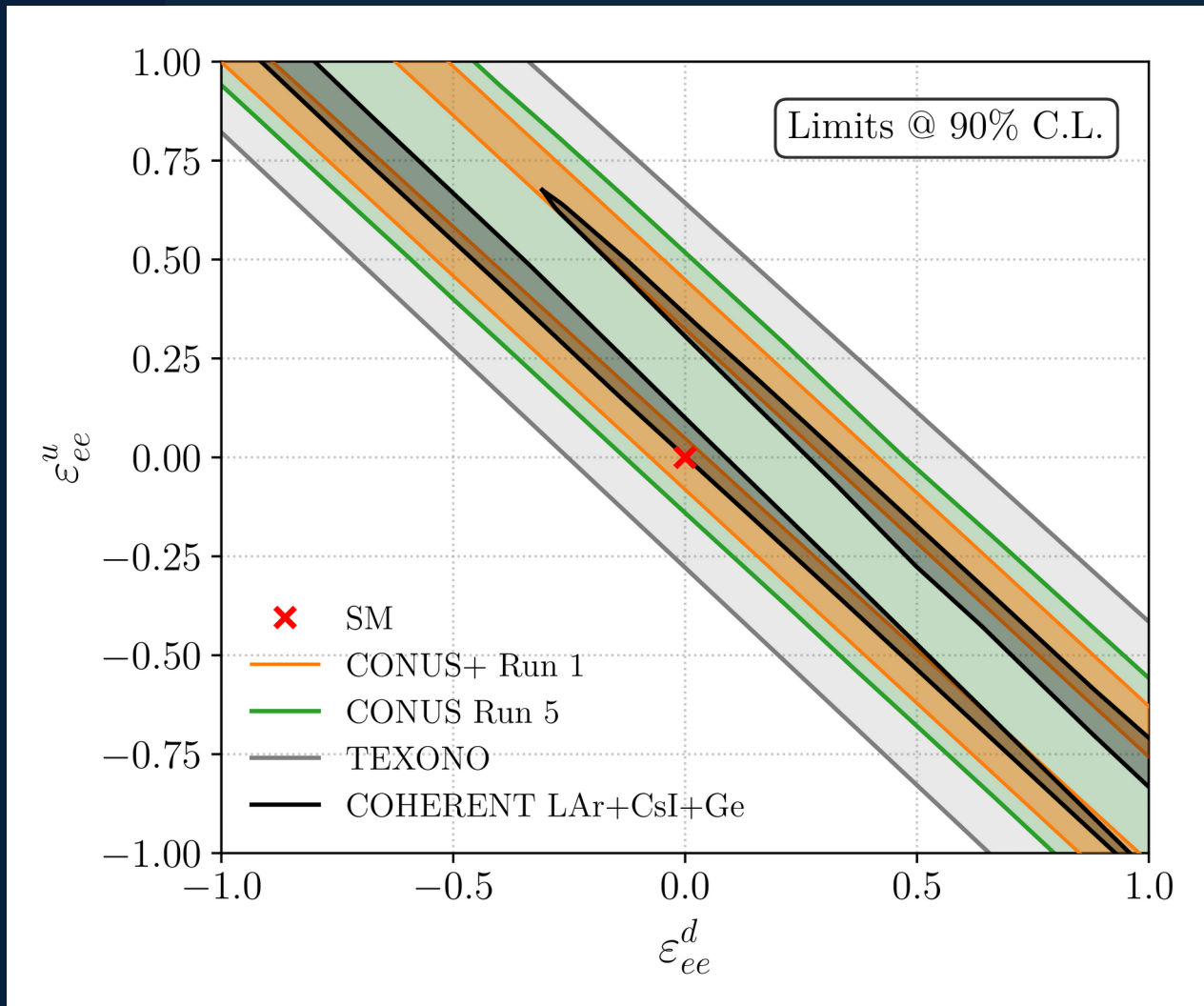
RESULTS I



Vector NSI

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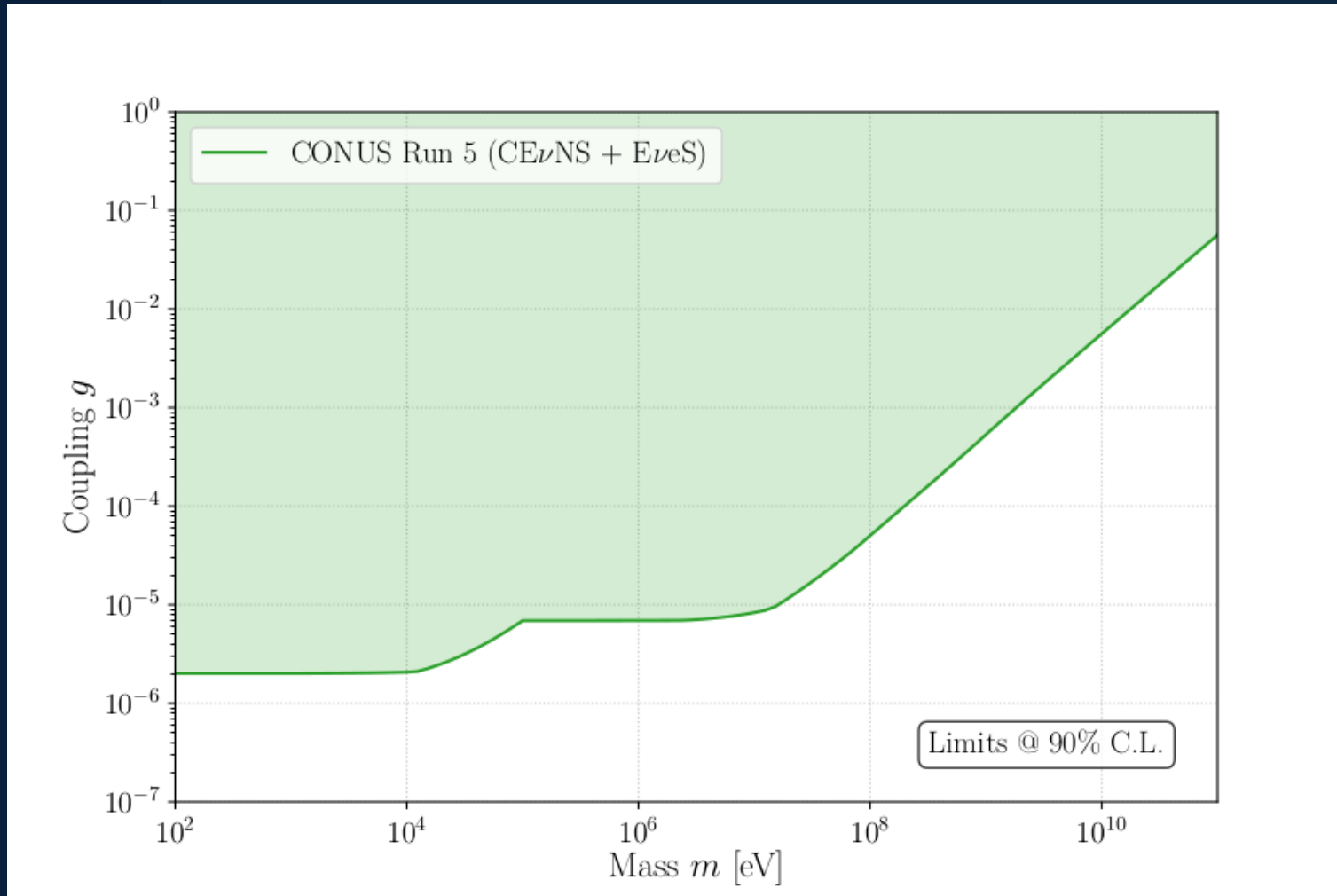
RESULTS I



Vector NSI

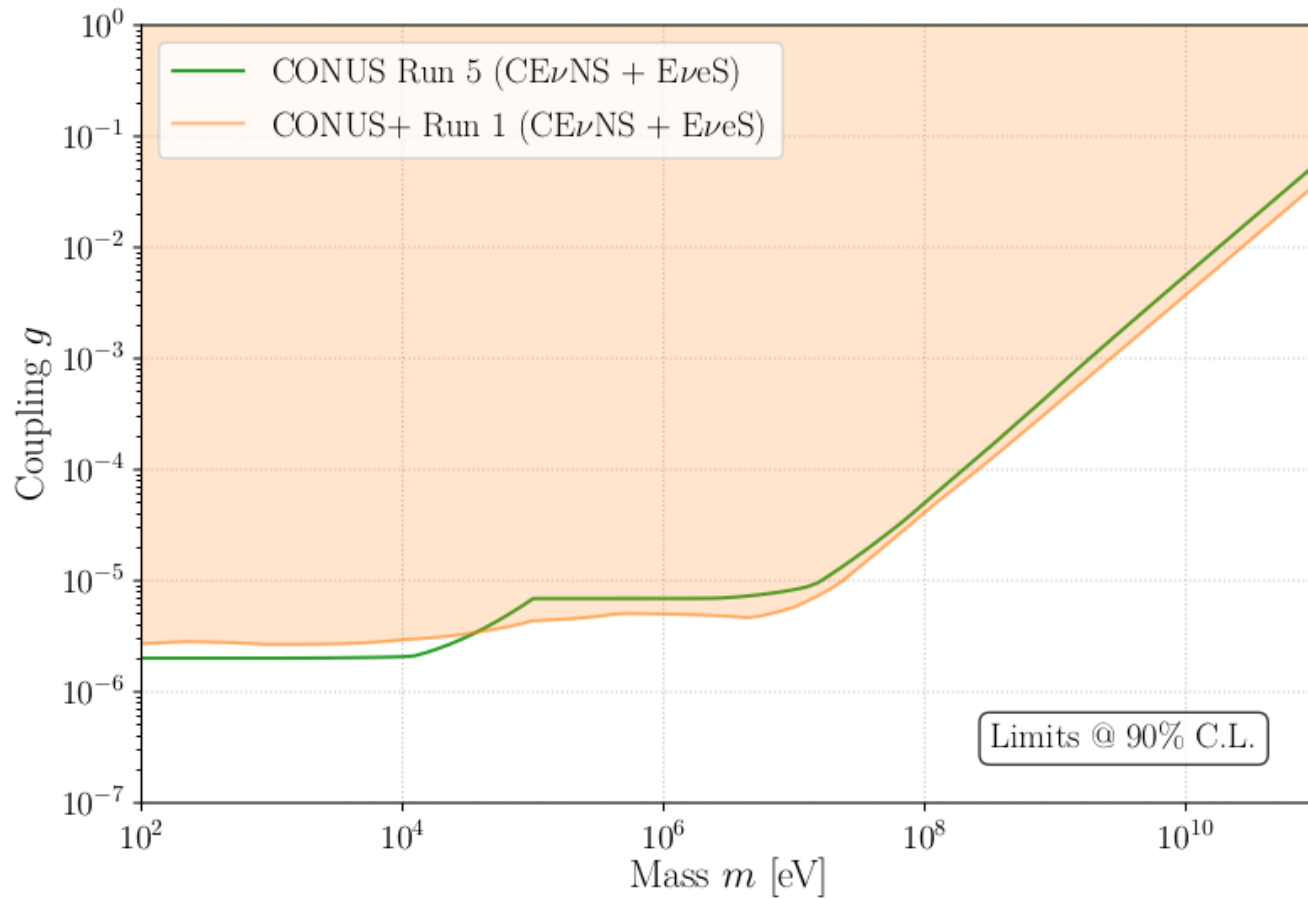
- New scale sensitivity: 140 GeV!
- Best limits for reactor experiments

RESULTS II



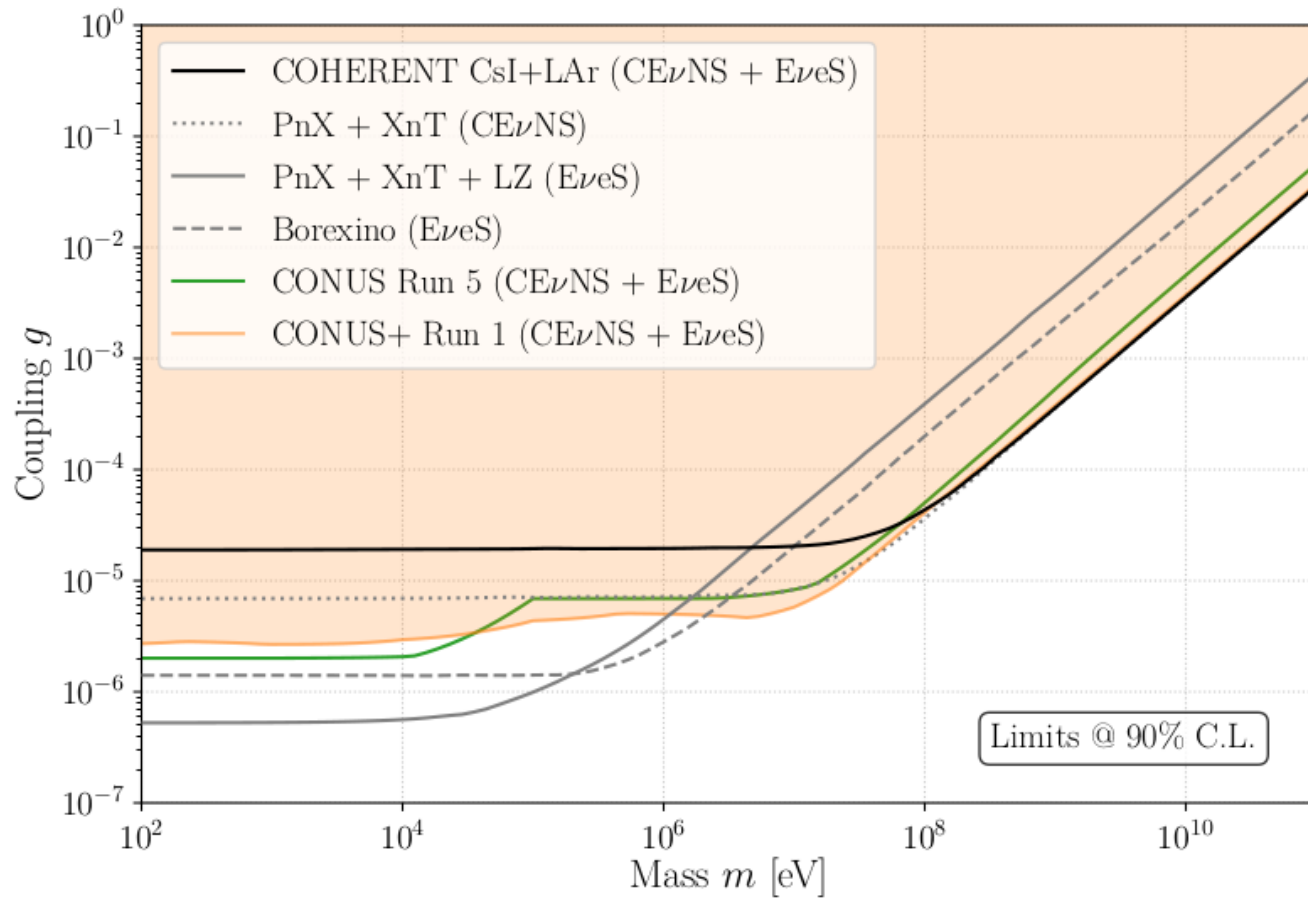
Light Scalar

RESULTS II



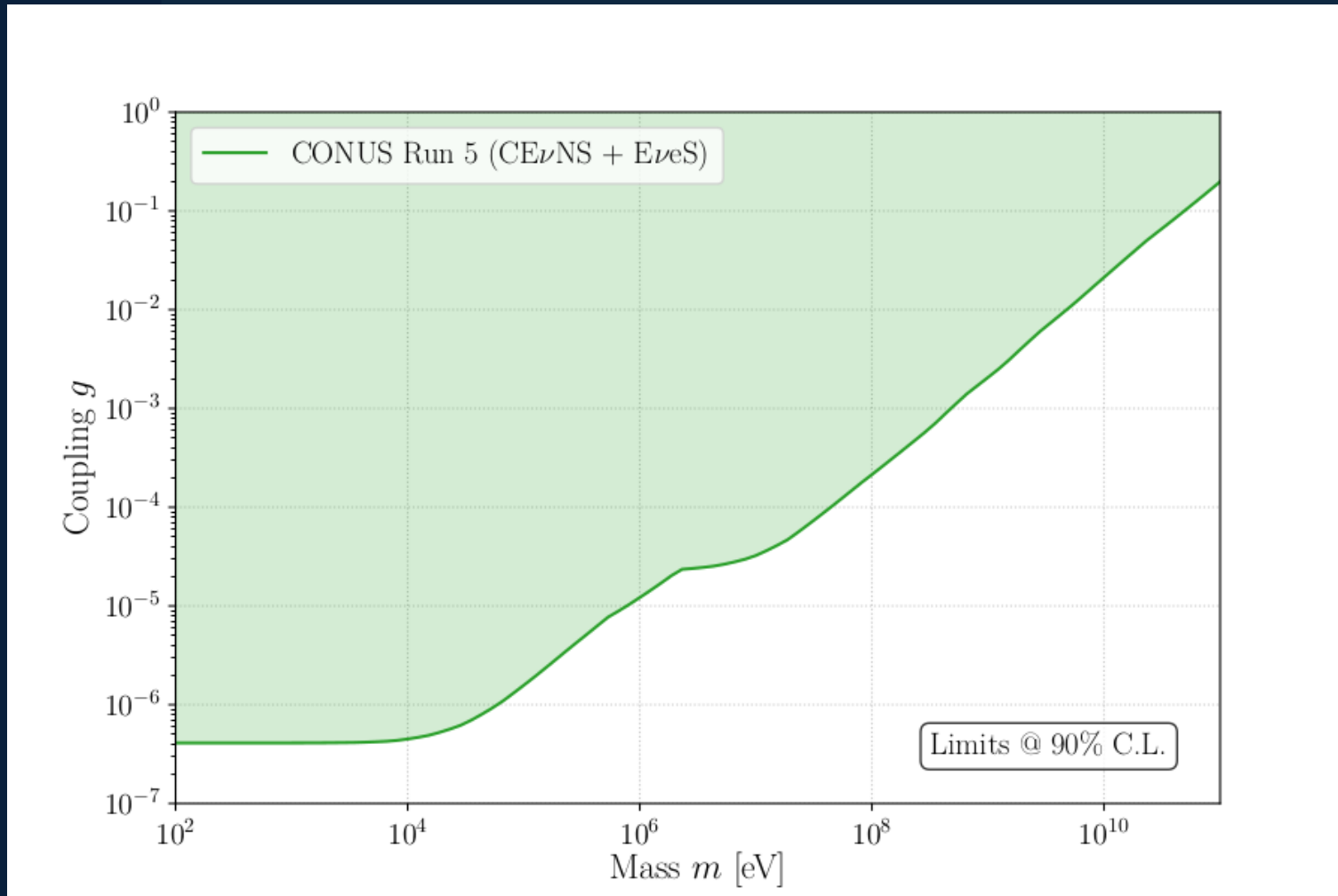
Light Scalar

RESULTS II



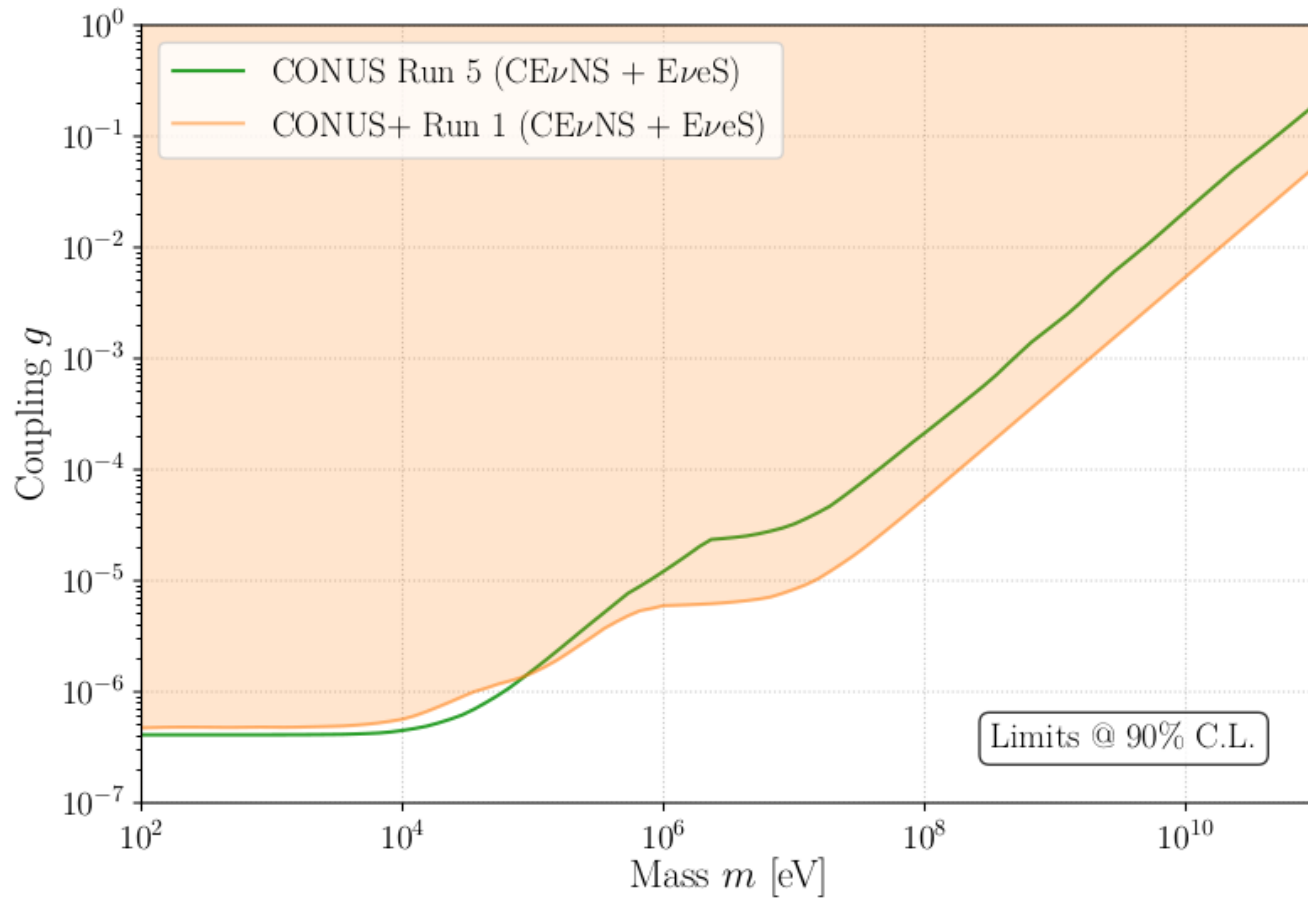
Light Scalar

RESULTS II



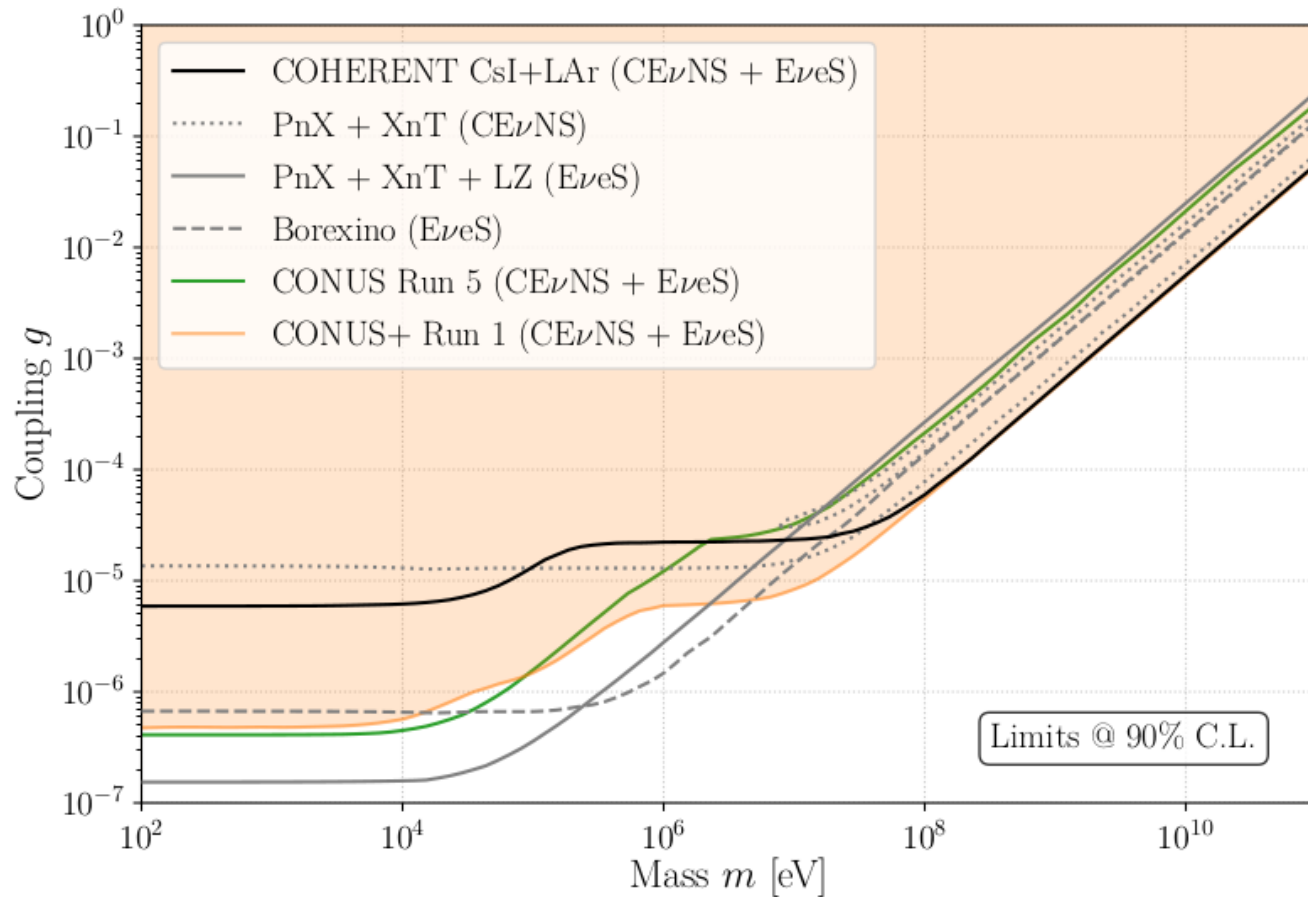
Light Vector
Universal

RESULTS II



Light Vector
Universal

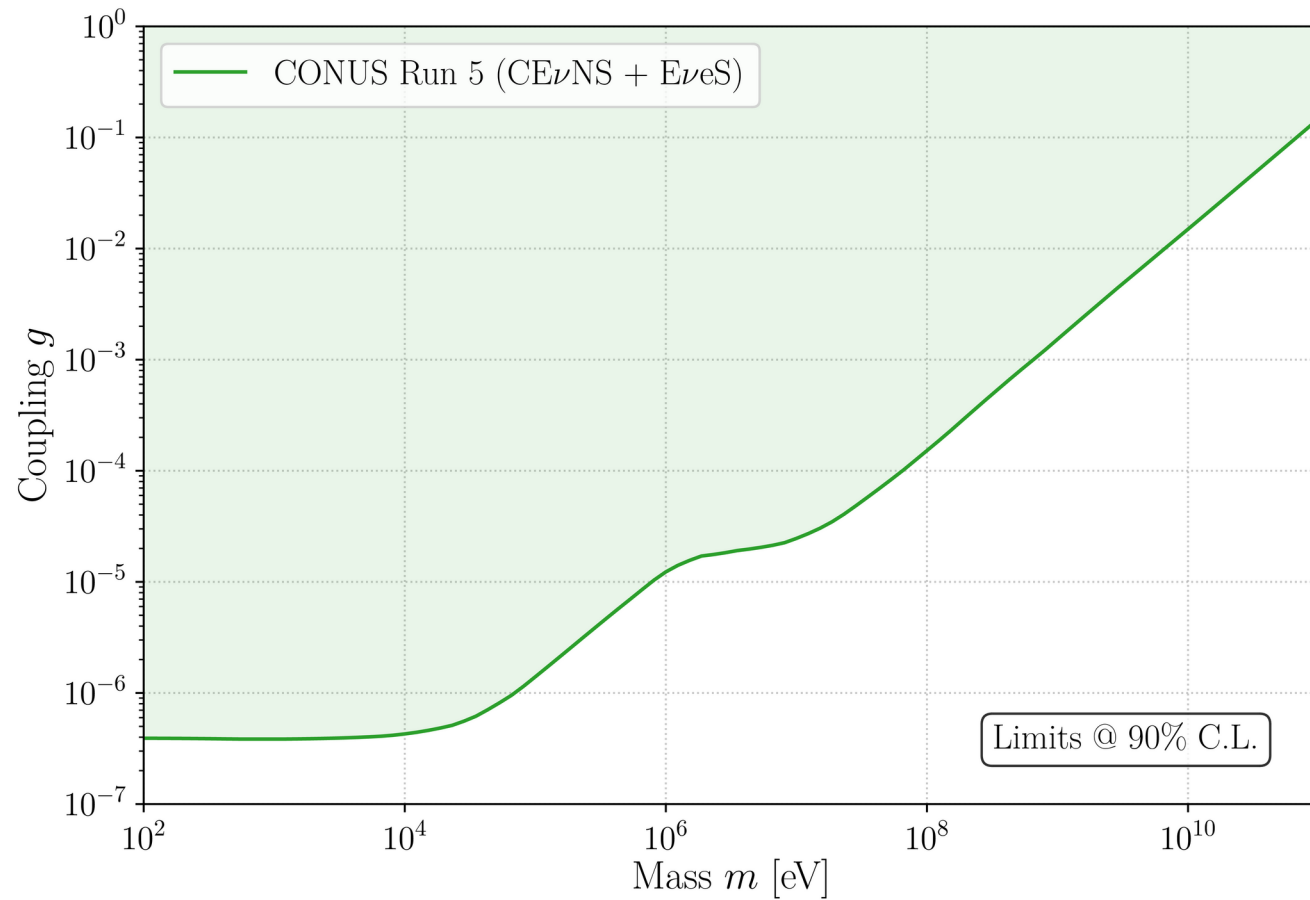
RESULTS II



Light Vector
Universal

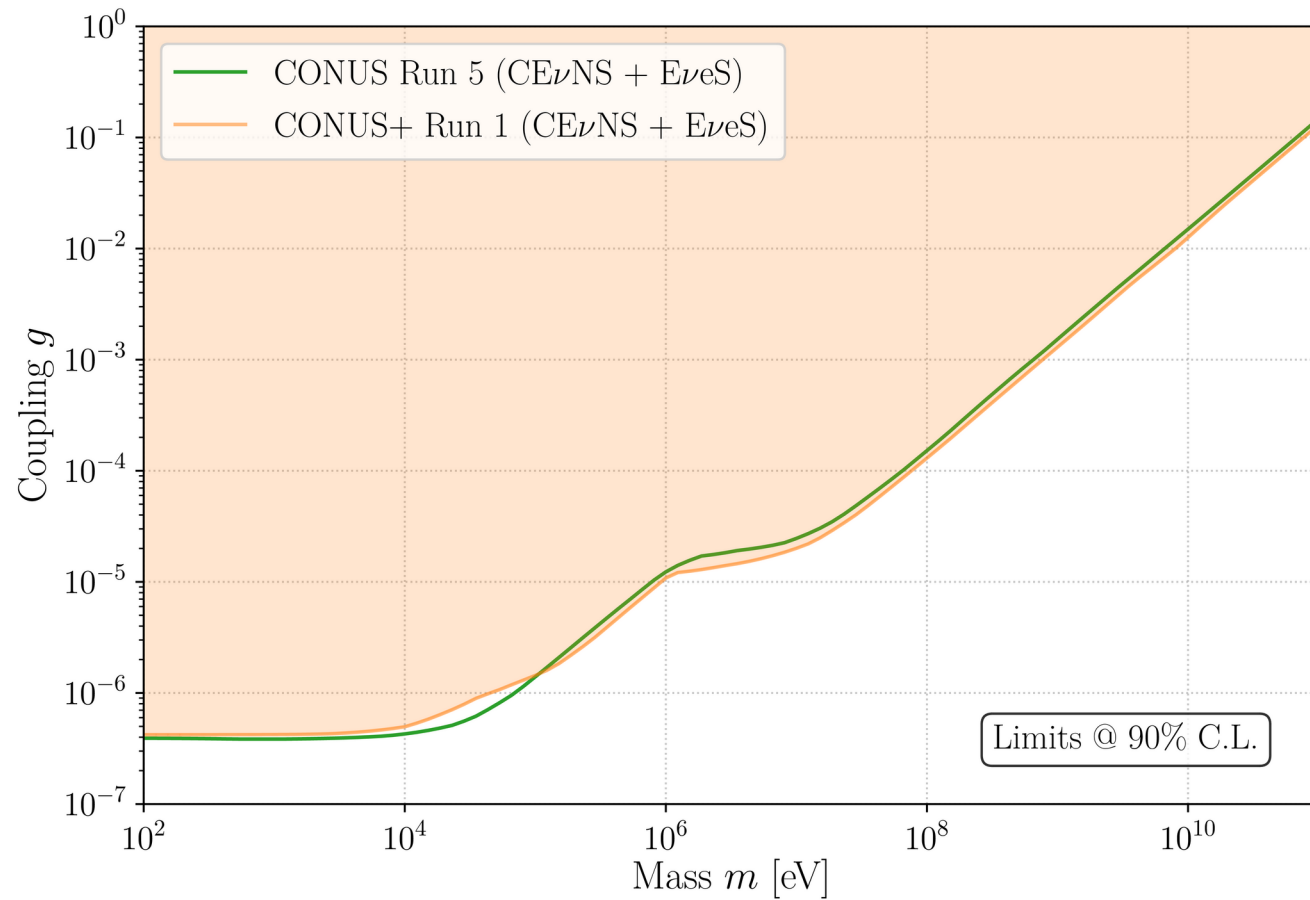
RESULTS II

Light Vector B-L



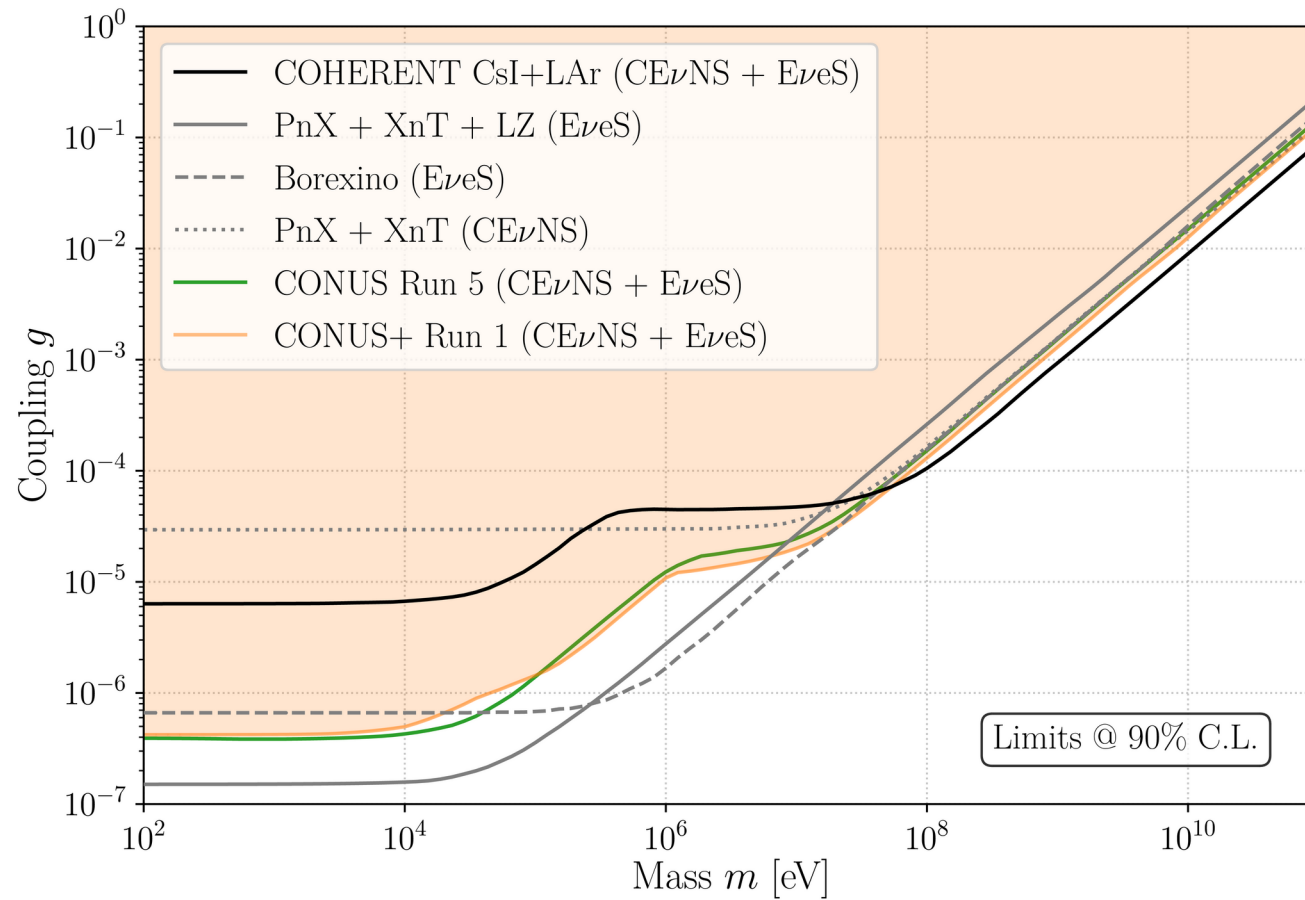
RESULTS II

Light Vector B-L

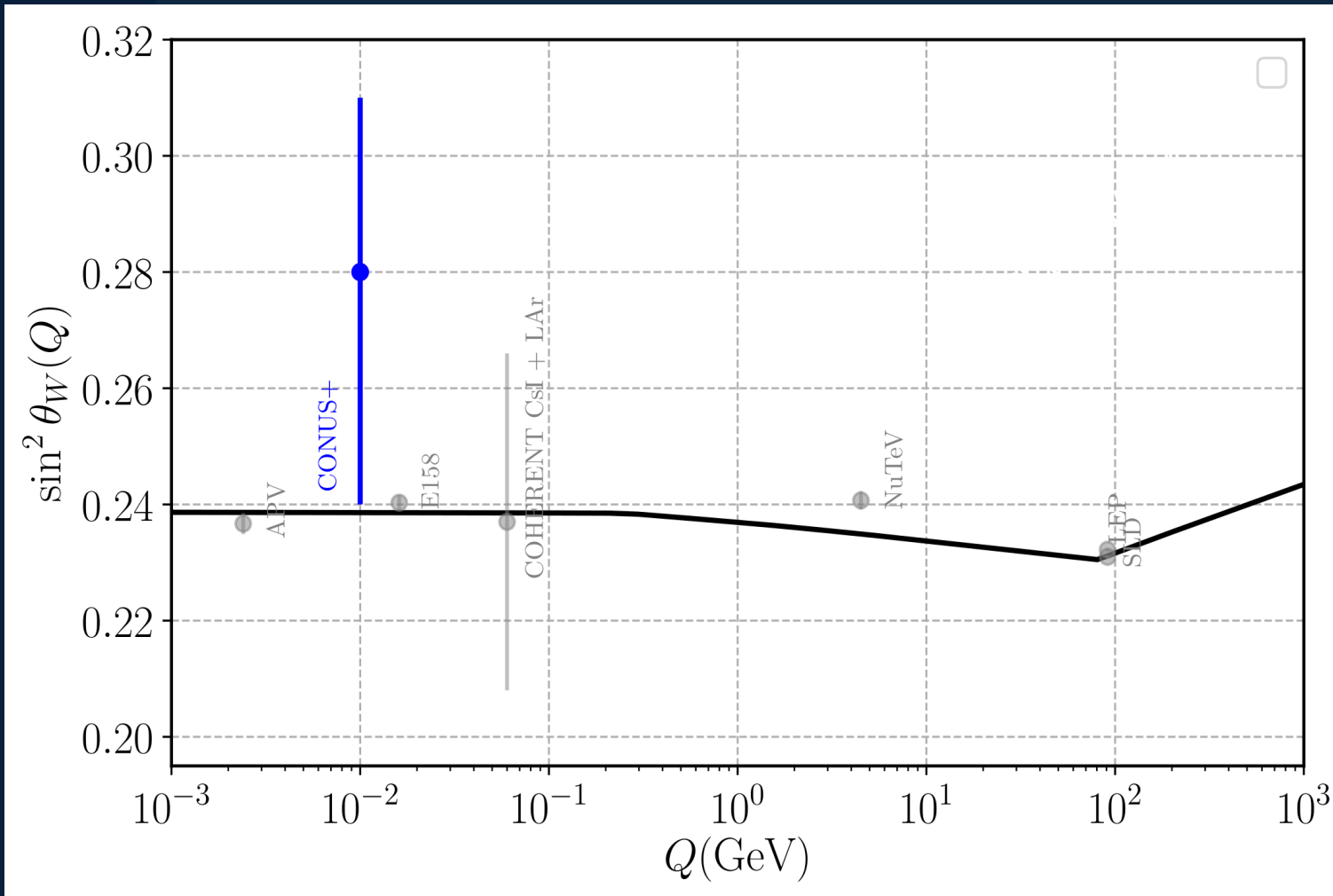


RESULTS II

Light Vector B-L



RESULTS II



Weinberg investigation

Summary

- CEvNS: new channel probing low energy ν -physics
- Compact neutrino detectors
- Competitive limits on BSM scenarios
- Data from run 2 incoming with improved setup and exposure

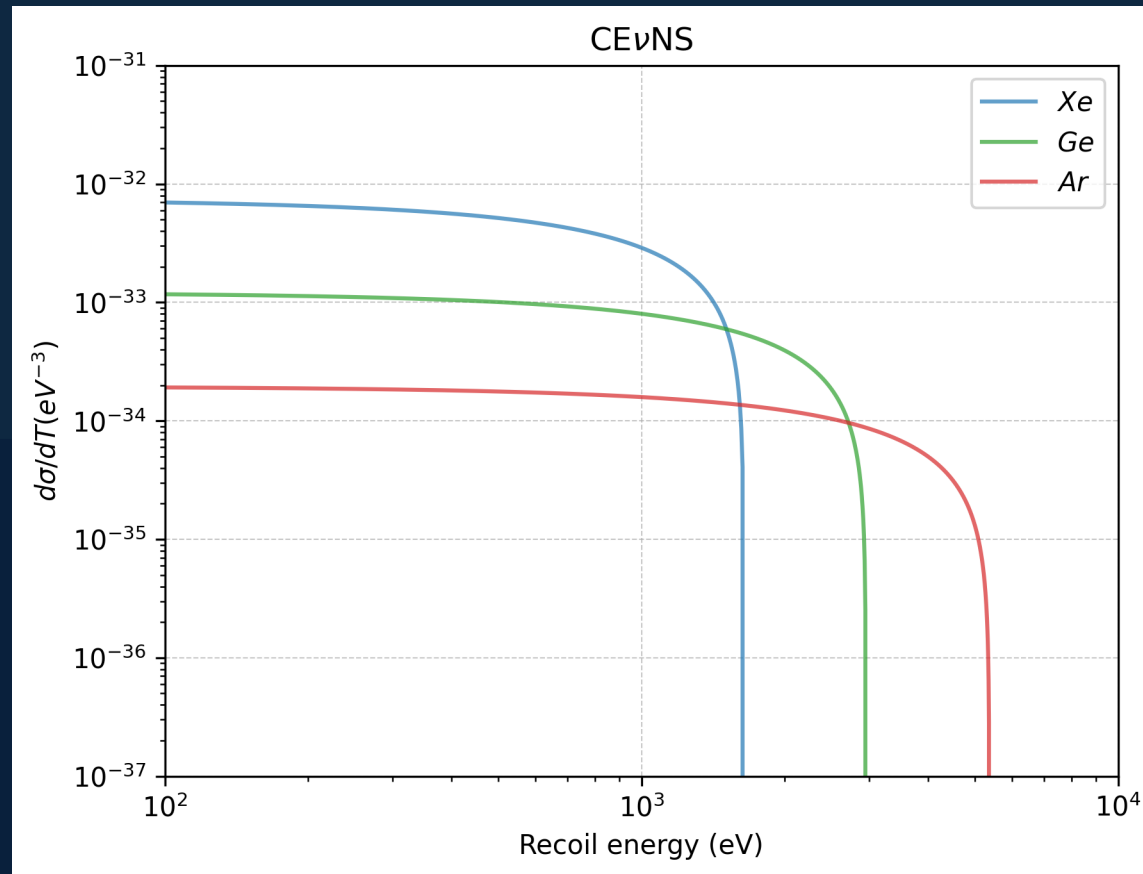
arxiv: 2605.22815

Thank You

For your attention!

Now... Questions!

Backup (Targets)



Backup (SM/BSM Models)

SM

$$\frac{d\sigma}{dT_A} = \frac{G_F^2 M}{8\pi} Q_W^2 \left(2 - \frac{MT_A}{E_\nu^2} \right)$$

$$Q_W = N - (1 - 4 \sin^2 \theta_W) Z \approx N$$

$$T_{A,max}(E_\nu) = \frac{2E_\nu^2}{M+2E_\nu}$$

Vector NSI

$$\mathcal{O}_{NSI}^{qV} = (\bar{\nu}_\alpha \gamma^\mu L \nu_\beta) (\bar{q} \gamma_\mu P q) + h.c.$$

$$\frac{d\sigma}{dT_A} = \frac{G_F^2 M}{2\pi} \frac{Q_{NSI}^2}{4} \left(2 - \frac{MT_A}{E_\nu^2} \right)$$

Backup (BSM Models)

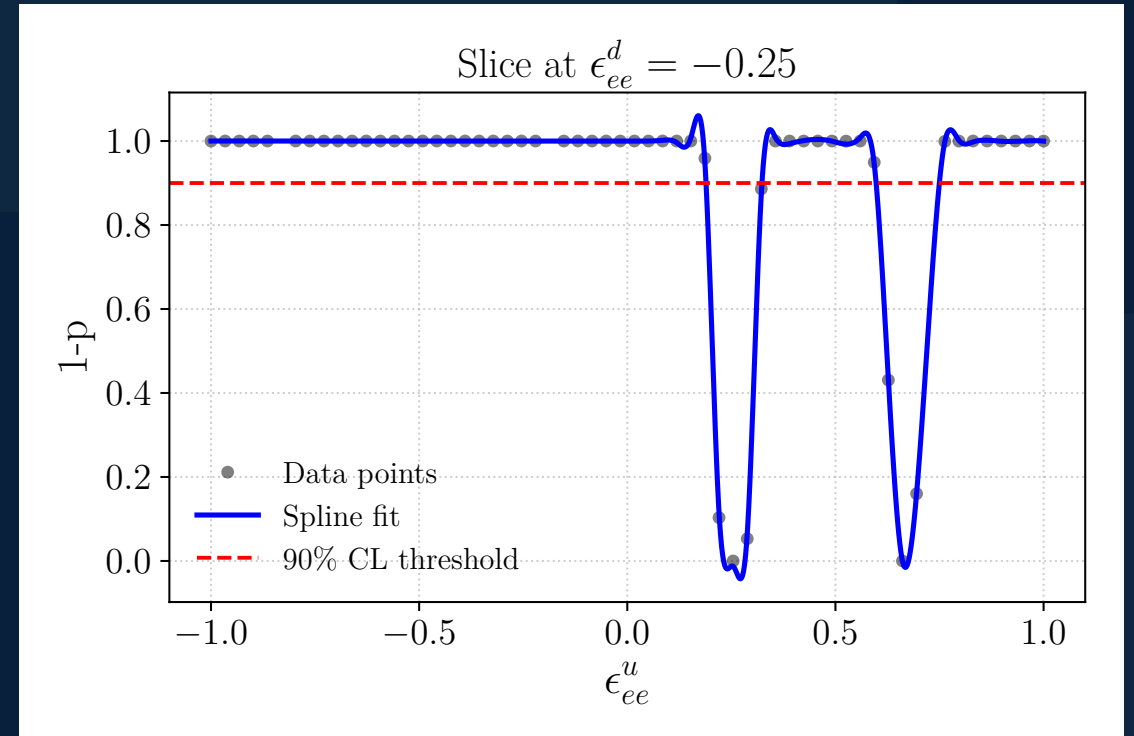
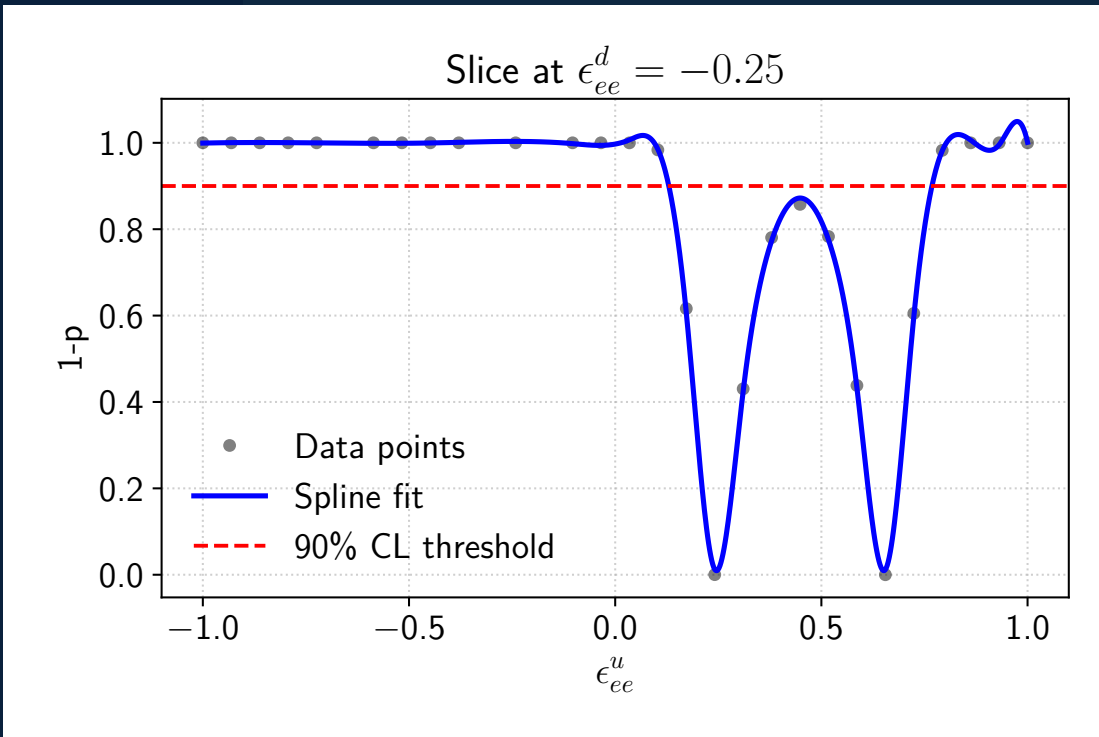
Light Vector B-L

$$\left(\frac{d\sigma}{dT_A}\right)_{CE\nu NS+Z'} = \mathcal{G}_{Z'}^2(T_A) \left(\frac{d\sigma}{dT_A}\right)_{CE\nu NS}$$

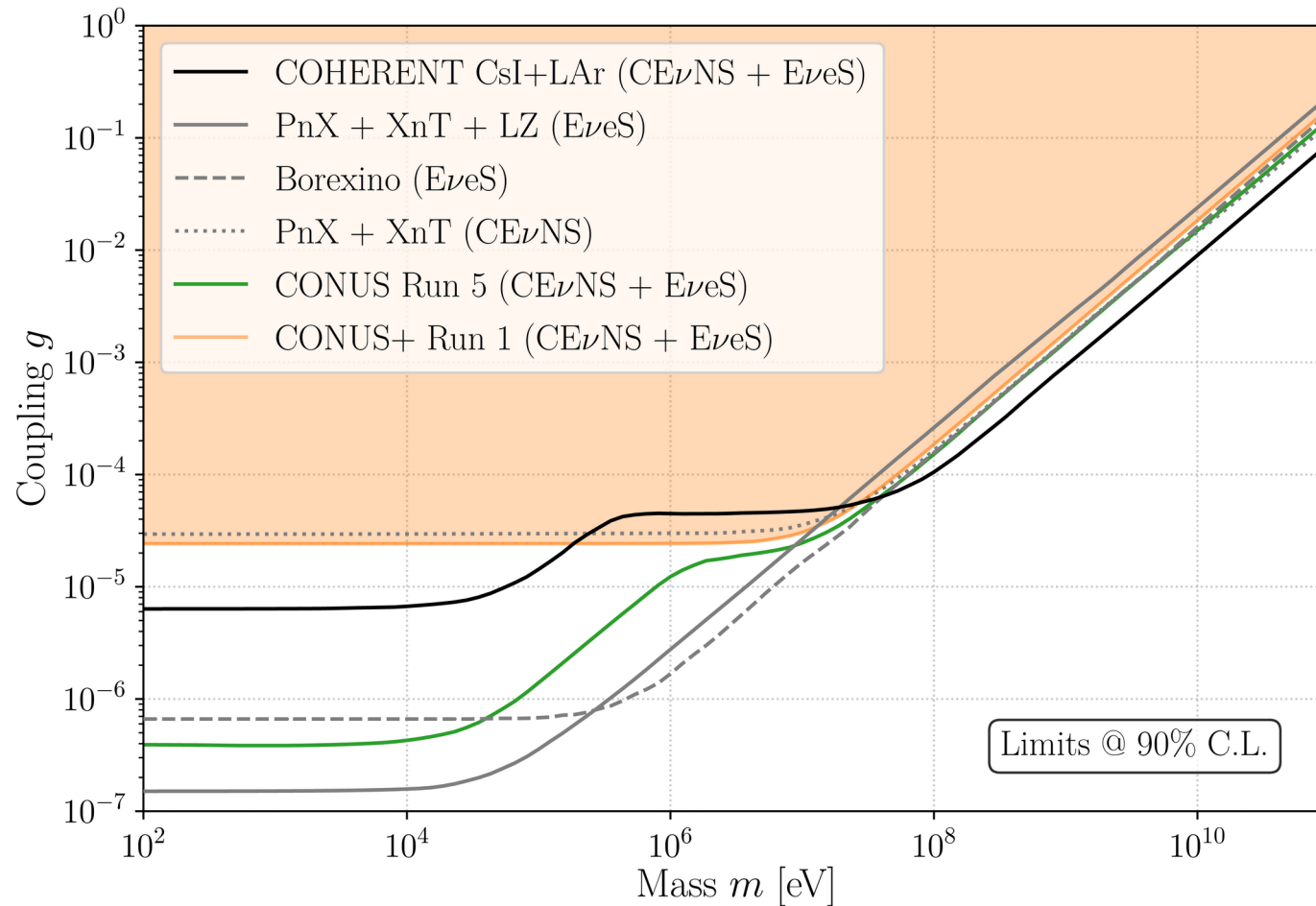
$$\mathcal{G}_{Z'}(T_A) = 1 + \frac{g_{Z'}^{\nu V}}{\sqrt{2}G_F} \frac{Q_{Z'}}{Q_W} \frac{1}{2m_A T_A + m_{Z'}^2}$$

$$\left(\frac{d\sigma}{dT_e}\right)_{E\nu e S+Z'} = \left(\frac{d\sigma}{dT_e}\right)_{E\nu e S} + \frac{\sqrt{2}G_F m_e g_V g_{Z'}^{\nu V} g_{Z'}^{eV}}{\pi(2m_e T_e + m_{Z'}^2)} + \frac{m_e (g_{Z'}^{\nu V} g_{Z'}^{eV})^2}{2\pi(2m_e T_e + m_{Z'}^2)^2}$$

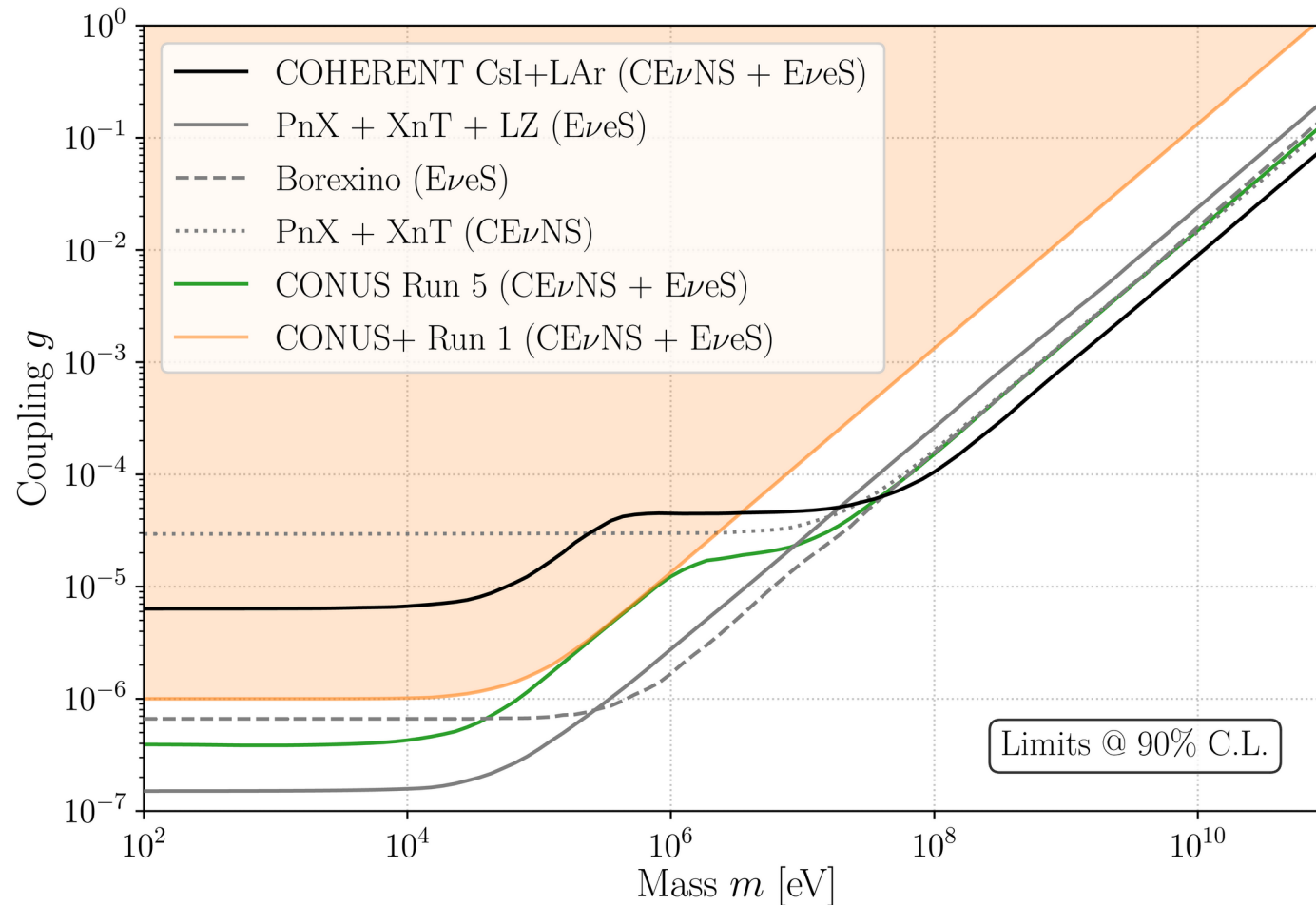
Backup (NSIs)



Backup (Light Vector CEvNS)

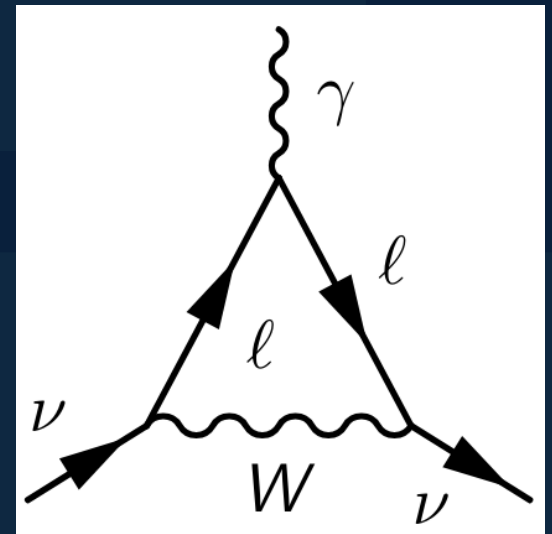


Backup (Light Vector EveS)



Backup (EM properties)

- In SM neutrinos have no electromagnetic properties
- Neutrino masses allow through loop diagrams the generation of magnetic moment (NMM) and electric millicharge (NMC)
- CONUS sensitive to effective magnetic moment
- Combined analysis of Run 1,2 and 5 from CONUS:
 $\mu_\nu < 4.39 \cdot 10^{-11} \mu_B$



Backup (Inference)

$$-\log \mathcal{L} = -\log \mathcal{L}_{ON} - \log \mathcal{L}_{OFF} + 2 \sum_i \frac{(\Theta_i - \Theta_i^*)^2}{2\sigma_i^2}$$

Negative logLH procedure

Systematic knowledge included via Gaussian pull terms

Likelihood ratio as test statistic to discriminate hypotheses:

$$T = -2 \ln \frac{\sup_{\eta} \mathcal{L}(\theta = \tilde{\theta}, \eta | N^{obs})}{\sup_{\theta, \eta} \mathcal{L}(\theta, \eta | N^{obs})}$$

θ : model parameters

η : nuisance parameters