Magnificent CEνNS *2023*
Munich 22-24/03/2023

Updated constraints on light mediators from CEνNS data

Speaker: Mattia Atzori Corona
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Outline of the talk

i. Coherent Elastic ν-Nucleus Scattering (CEνNS)
ii. Light mediators in CEνNS
iii. Limits on new light mediators using COHERENT data
iv. Future perspectives

Presentation based on

JHEP

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Probing light mediators and $(g-2)_\mu$ through detection of coherent elastic neutrino nucleus scattering at COHERENT

M. Atzori Corona,[a,b] M. Cadeddu,[b] N. Cargioli,[a,b] F. Dordei,[b] C. Giunti,[c] Y.F. Li,[d,e] E. Picciau,[a,b] C.A. Ternes[c] and Y.Y. Zhang[d,e,1]

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CEνNS Cross Section

JHEP 09 (2022) 164
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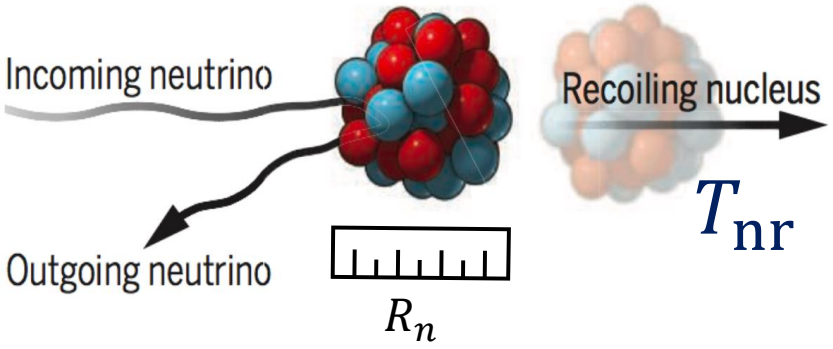

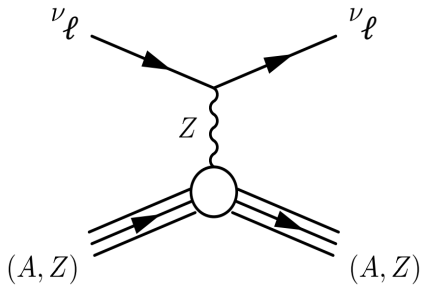

Mass of the nucleus
Z protons, N neutrons

Fermi constant

$$\frac{d\sigma^{\mathrm{SM}}_{\nu_\ell - N}}{dT_{\mathrm{nr}}}(E_\nu, T_{\mathrm{nr}}) = \frac{G_F^2 M}{\pi}\left(1 - \frac{M T_{\mathrm{nr}}}{2E_\nu^2}\right)\left[g_V^p(\nu_\ell) Z F_Z(|\bar{q}|^2) + g_V^n N F_N(|\bar{q}|^2)\right]^2 + ..$$

Nuclear Recoil Energy

Neutrino Energy

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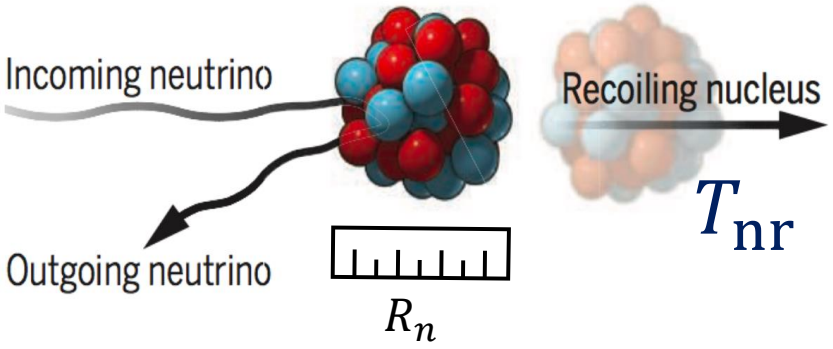

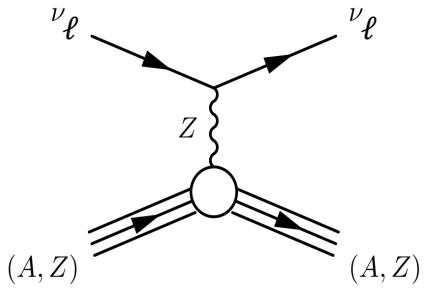

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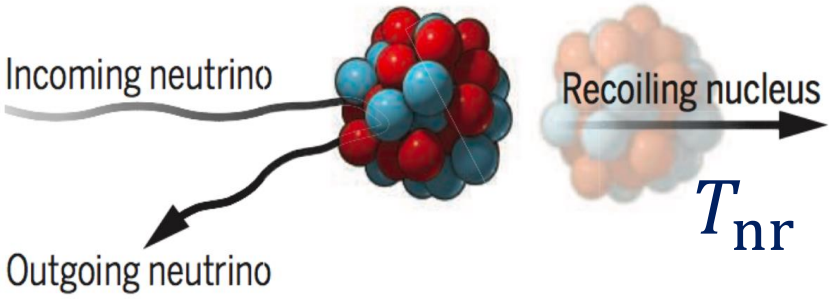

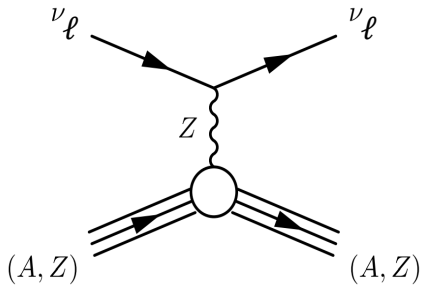

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Nuclear Recoil Energy

Tree level:

$g_V^p = \frac{1}{2} - 2\sin^2\theta_W$

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With radiative Corrections:

$g_V^p(\nu_e) \simeq 0.0382$

$g_V^p(\nu_\mu) \simeq 0.0300$

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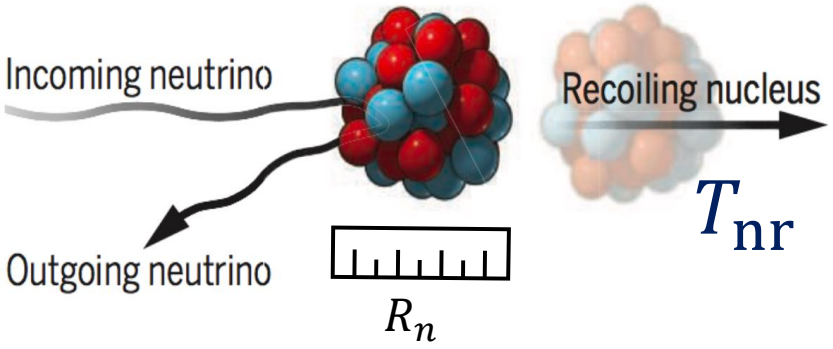

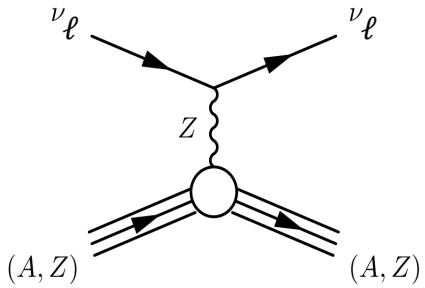

Nuclear (and EW) physics

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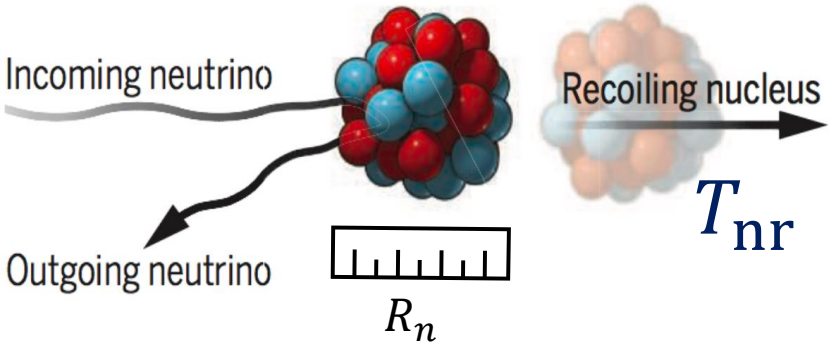

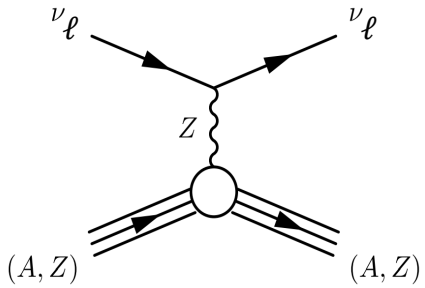

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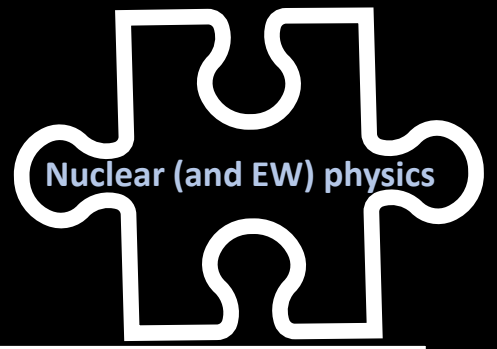

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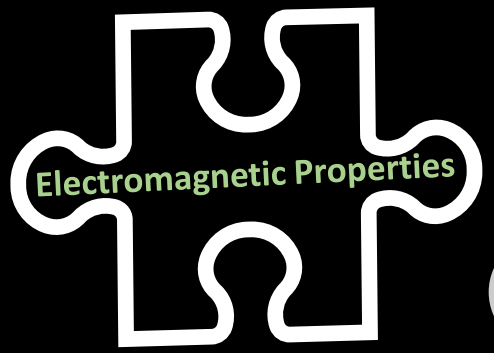

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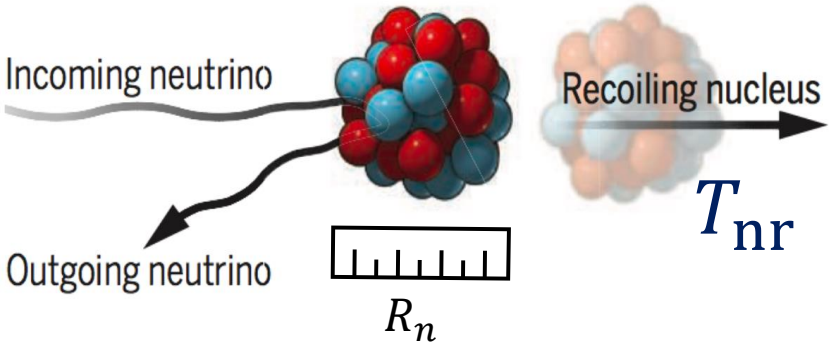

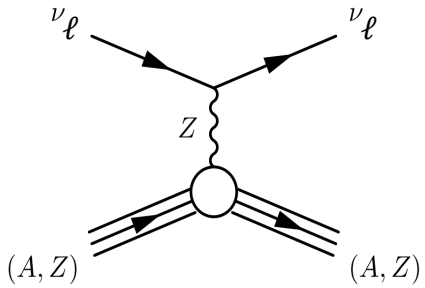

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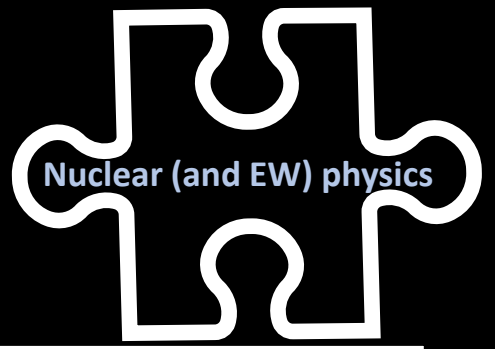

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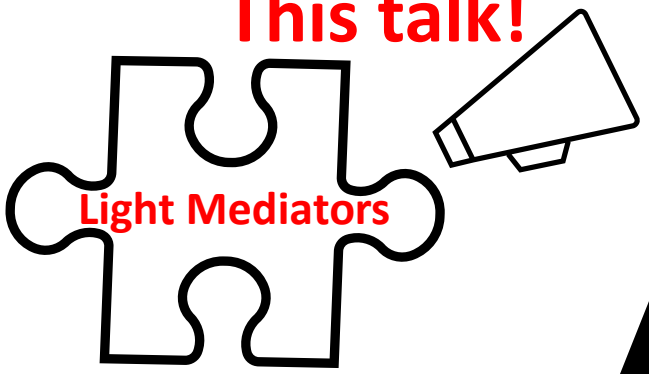
This talk!



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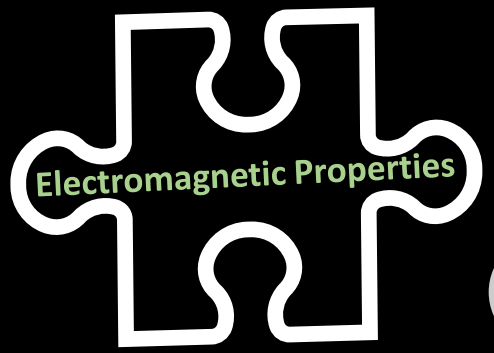

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Light mediators from U(1)' extension of the SM: **vector-boson case**

i. CEνNS is a **pure weak neutral current** process mediated by a Z **boson.**

ii. Search for **anomaly free** extensions of the SM (connection with Dark Sectors, Hidden Sectors..)

iii. Light mediators $\sim$ MeV – few GeVs

Rev.Mod.Phys. 81 (2009) 1199-1228

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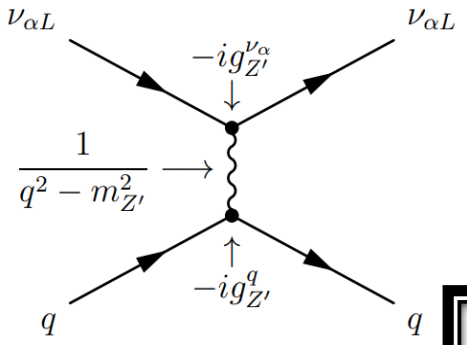

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JHEP 02, 082 (2019)

The universal model is not anomaly free

These models are anomaly free if the SM is extended with right-handed neutrinos

Anomaly-free

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universal	1	1	1	1	1
$B-L$	1/3	1/3	−1	−1	−1
$B-3L_e$	1/3	1/3	−3	0	0
$B-3L_\mu$	1/3	1/3	0	−3	0
$B-2L_e-L_\mu$	1/3	1/3	−2	−1	0
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$B_y+L_\mu+L_\tau$	1/3	1/3	0	1	1
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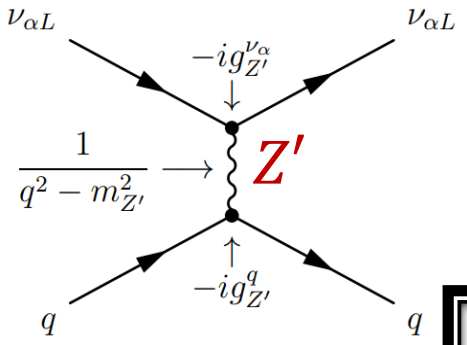

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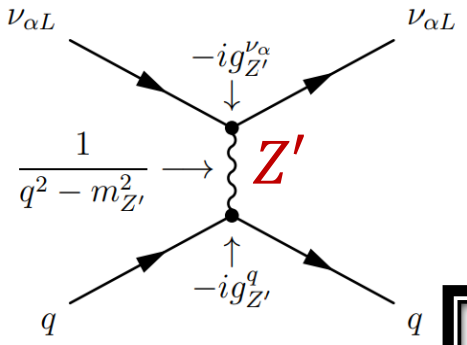

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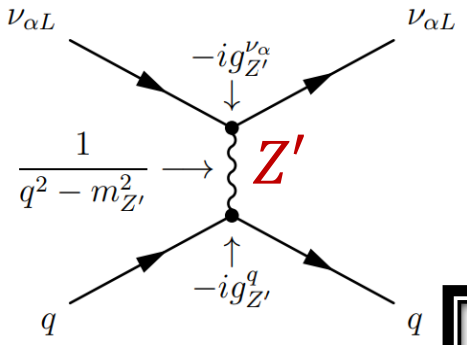

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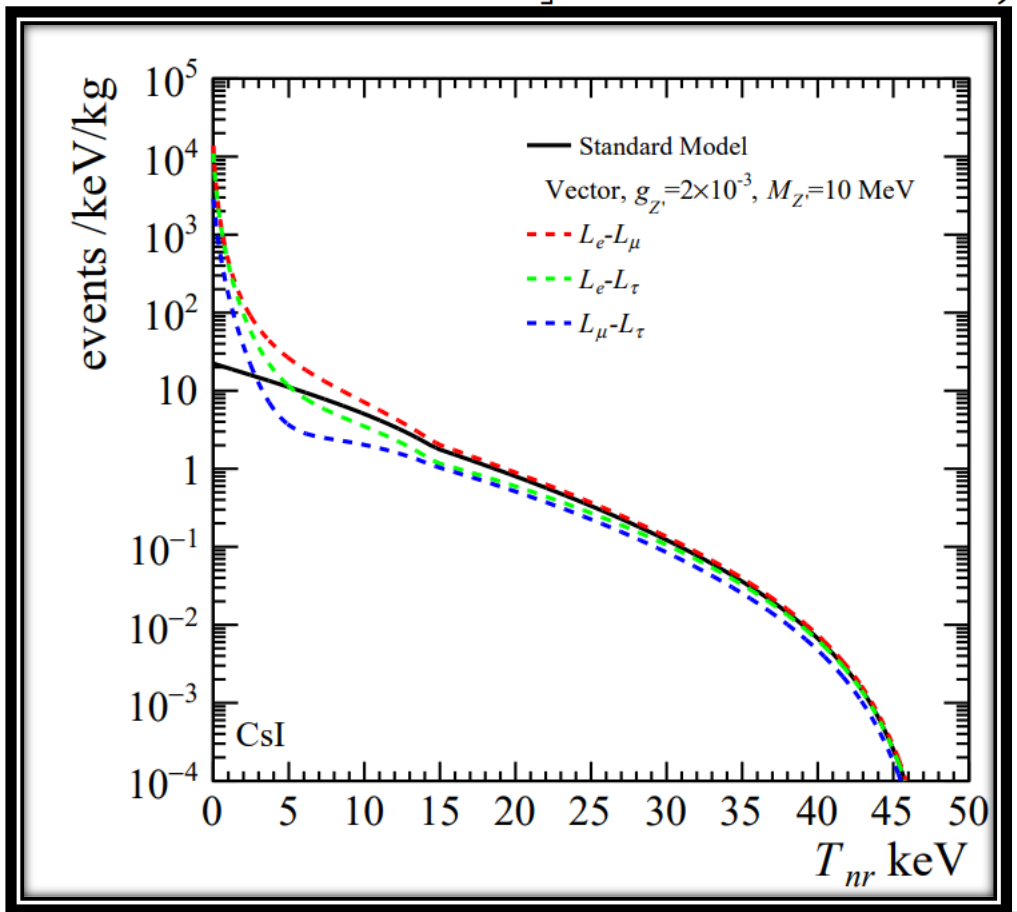
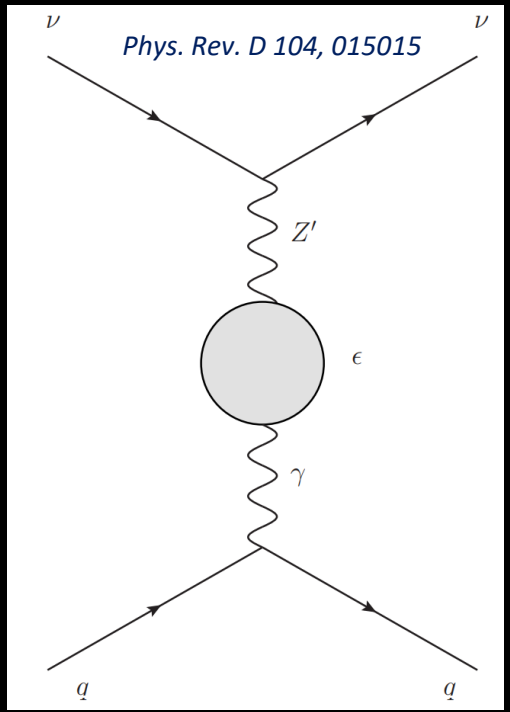
Leptophilic models

In the $\boldsymbol{L_\alpha - L_\beta}$ (where α and β are two leptons flavors) models there is **no direct coupling** between a $L_\alpha - L_\beta$ gauge boson and quarks

$$\left(\frac{d\sigma}{dT_{\rm nr}}\right)^{\nu_\ell-\mathcal{N}}_{L_\alpha-L_\beta}(E,T_{\rm nr}) = \frac{G_F^2 M}{\pi}\left(1-\frac{MT_{\rm nr}}{2E^2}\right)$$
$$\times\left\{\left[g_V^p(\nu_\ell)+\frac{\sqrt{2}\alpha_{\rm EM}g_{Z'}^2\left(\delta_{\ell\alpha}\varepsilon_{\beta\alpha}(|\vec{q}|)+\delta_{\ell\beta}\varepsilon_{\alpha\beta}(|\vec{q}|)\right)}{\pi G_F\left(|\vec{q}|^2+M_{Z'}^2\right)}\right]ZF_Z(|\vec{q}|^2)+g_V^n NF_N(|\vec{q}|^2)\right\}^2$$



The coupling between neutrinos and quark is due to 1-loop effects



Leptophilic models

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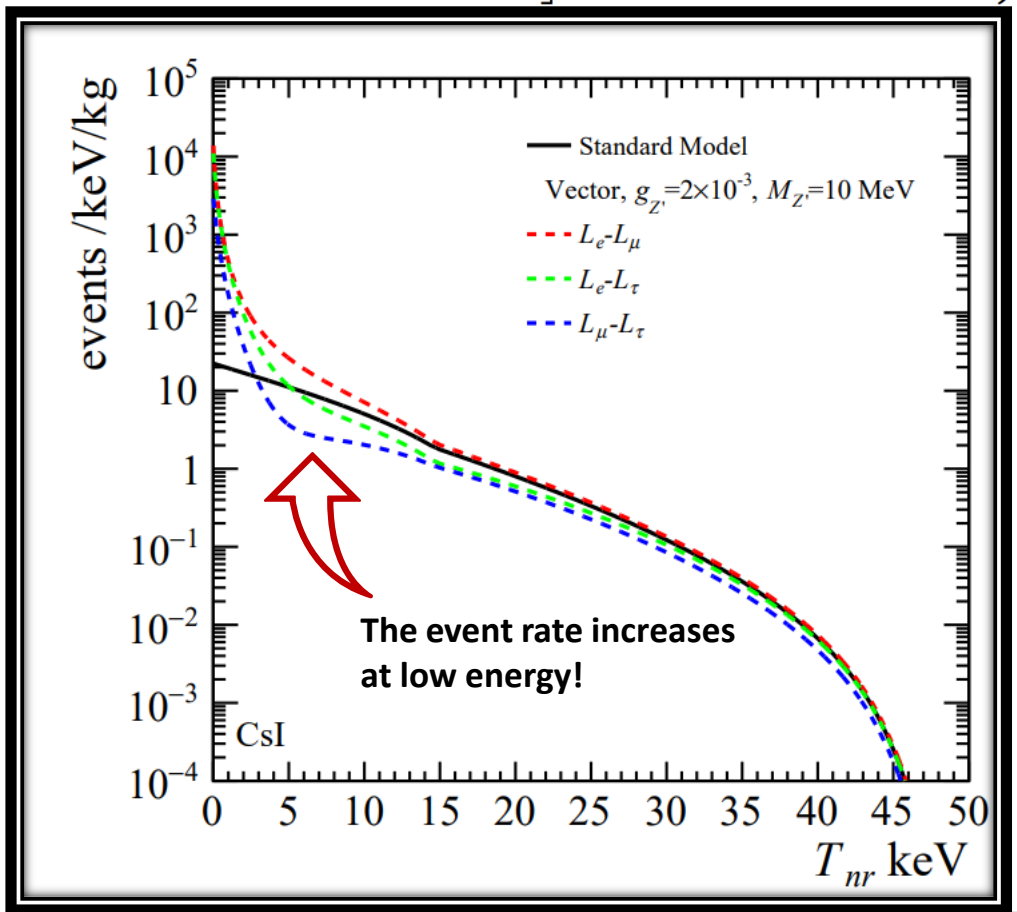
$$\times\left\{\left[g_V^p(\nu_\ell)+\frac{\sqrt{2}\alpha_{\rm EM}g_{Z'}^2\left(\delta_{\ell\alpha}\varepsilon_{\beta\alpha}(|\vec{q}|)+\delta_{\ell\beta}\varepsilon_{\alpha\beta}(|\vec{q}|)\right)}{\pi G_F\left(|\vec{q}|^2+M_{Z'}^2\right)}\right]ZF_Z(|\vec{q}|^2)+g_V^n NF_N(|\vec{q}|^2)\right\}^2$$



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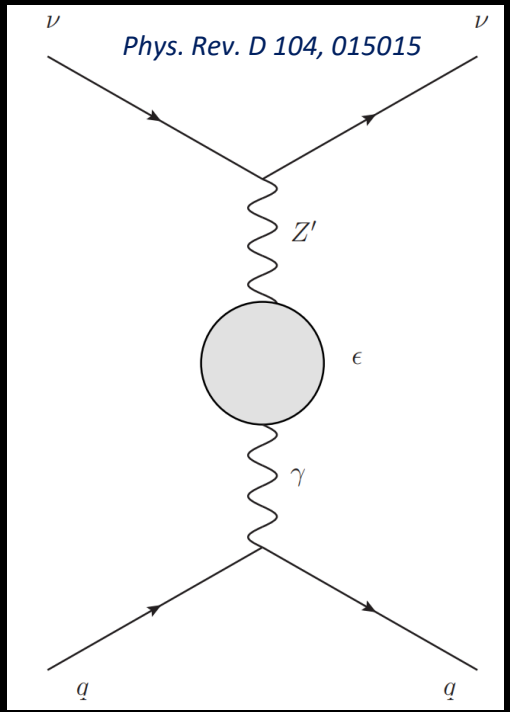
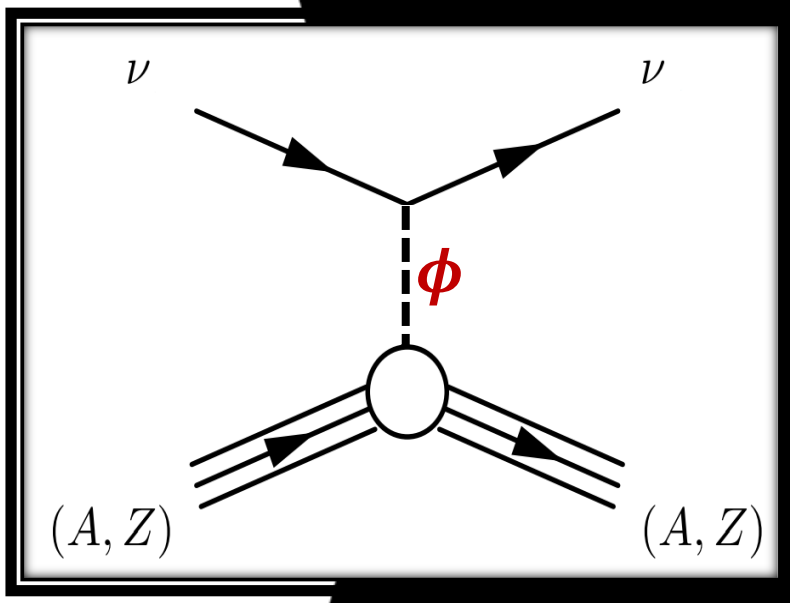


The scalar mediator case

- The interaction can be mediated by a scalar field ϕ
- We assume a scalar boson with $g_\phi^d = g_\phi^u \doteq g_\phi^q$ and $g_\phi^{\nu_e} = g_\phi^{\nu_\mu} \doteq g_\phi^{\nu_\ell}$
- The contribution of the scalar boson to CEνNS is incoherent

JHEP 05 (2018) 066

$$\frac{d\sigma_{\nu_\ell\text{-}\mathcal{N}}}{dT_{\rm nr}} = \left(\frac{d\sigma_{\nu_\ell\text{-}\mathcal{N}}}{dT_{\rm nr}}\right)_{\rm SM} + \left(\frac{d\sigma_{\nu_\ell\text{-}\mathcal{N}}}{dT_{\rm nr}}\right)_{\rm scalar}$$



$$\left(\frac{d\sigma_{\nu_\ell\text{-}\mathcal{N}}}{dT_{\rm nr}}\right)_{\rm scalar} = \frac{M^2 T_{\rm nr}}{4\pi E^2}\,\frac{\tilde{g}_\phi^4}{(|\vec{q}|^2 + M_\phi^2)^2}\left(\frac{\sigma_{\pi N}}{\overline{m}_{ud}}\right)^2_{\rm ref}\left[Z F_Z(|\vec{q}|^2) + N F_N(|\vec{q}|^2)\right]^2$$

Reference value of $\sim 17{,}3$ *Phys. Rev. Lett. 115, 092301*
Particle Data Group, PTEP 2022, 083C01 (2022)

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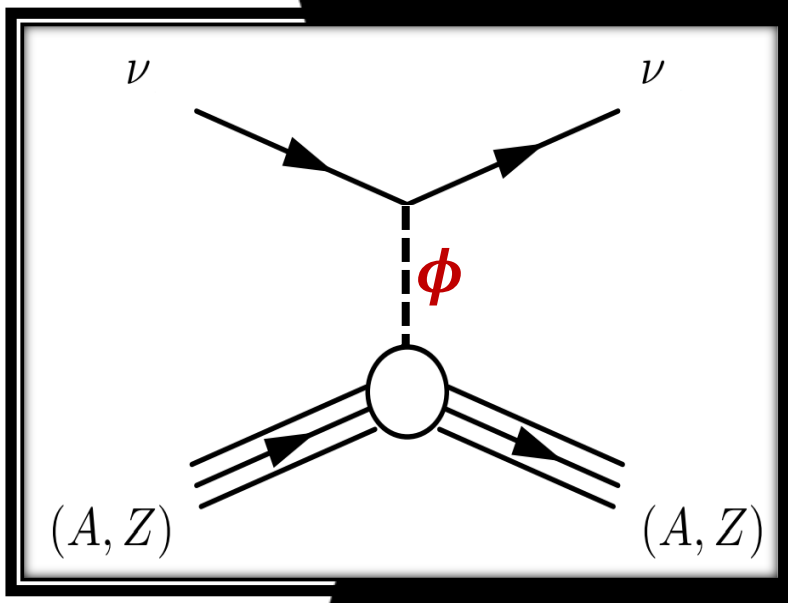

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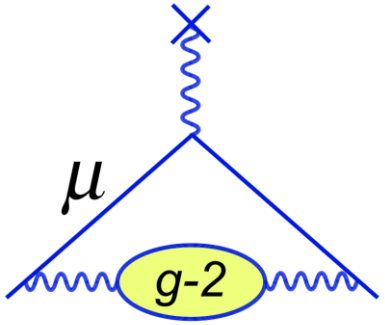
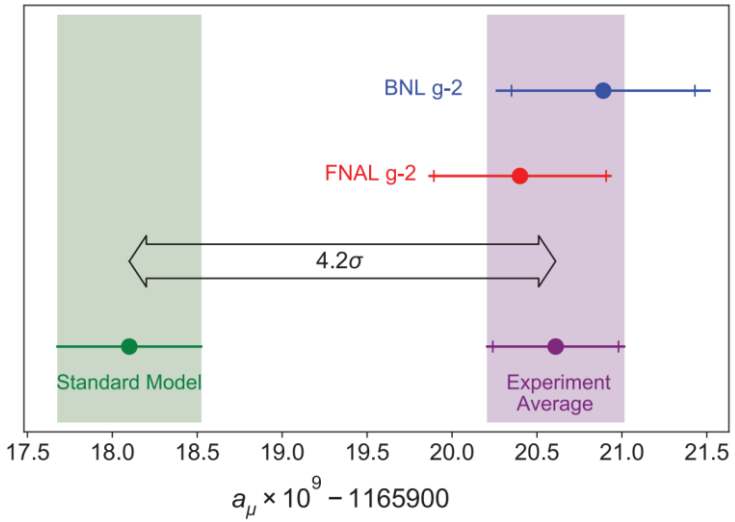
Motivation

Muon anomalous magnetic moment $(g-2)_\mu$

- Muon g-2 experiment (FNAL) confirmed in 2021 the longstanding deviation of the experimental determination of a_μ (BNL in 2004) *(Muon g−2 Collaboration), Phys. Rev. Lett. 126, 141801 (2021)*
  Phys. Rev. D 73, 072003
- World average gives $\Delta a_\mu = 251(59) \times 10^{-11}$

$$a_\mu = (g-2)_\mu/2$$





Possible explanation with additional Z' boson

- A neutral gauge boson with mass M_B that couples with the muon (coupling g_B) contributes to the muon anomalous magnetic moment through

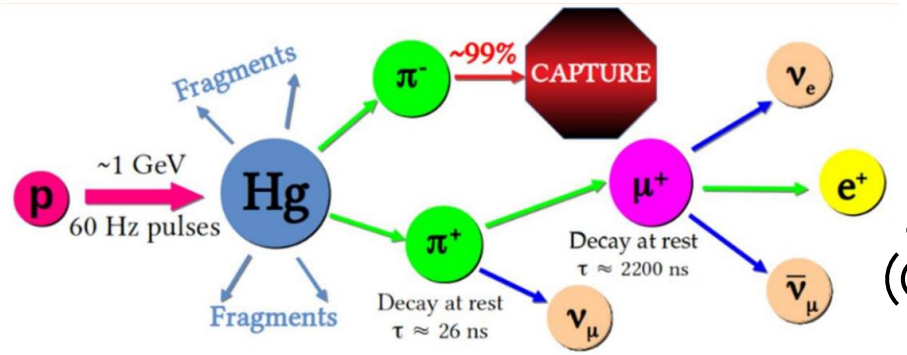
Phys.Rev.D 104 (2021) 1, 011701

$$\delta a_\mu^B = \frac{g_B^2}{8\pi^2} \int_0^1 dx \, \frac{Q(x)}{x^2 + (1-x)\, M_B^2/m_\mu^2}$$

$$Q(x) = \begin{cases} x^2\,(2-x) & \text{(scalar)} \\ 2x^2\,(1-x) & \text{(vector)} \end{cases}$$

The COHERENT Experiment

Neutrino produced by pion decay the SNS. Pulsed beam → improved background rejection!



delayed

prompt

See Jason Newby talk!

Located in Tennessee - USA

COHERENT SNS

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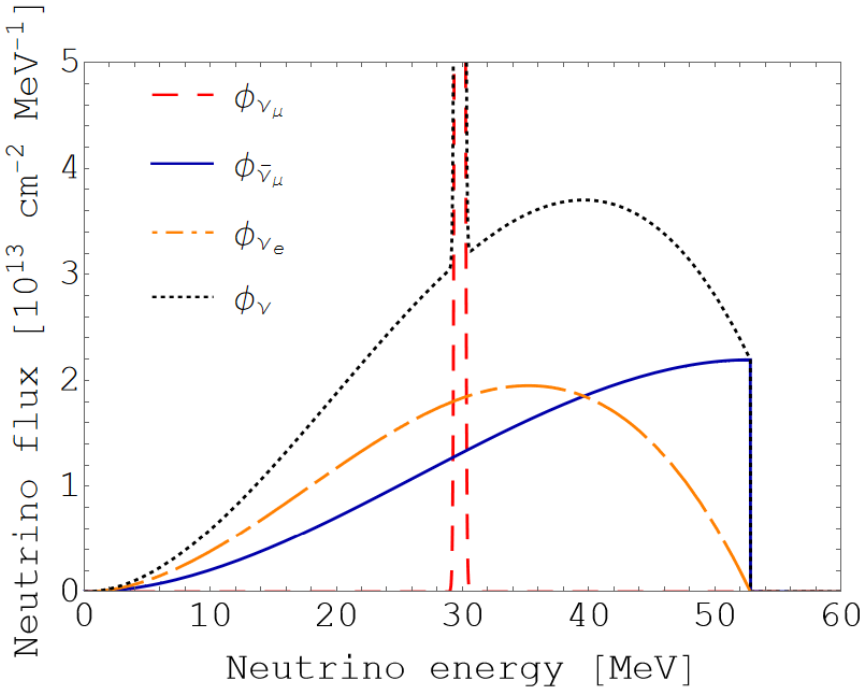
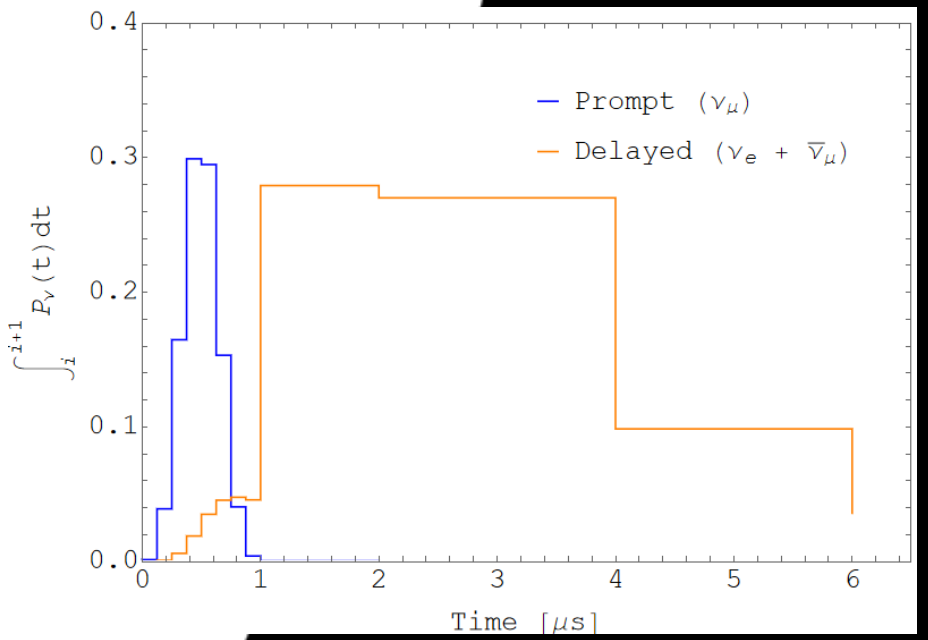


Number of proton-on-target $N_{POT} = 3.198 \times 10^{23}$
$P_{beam} = 1.4$ MW
Proton beam energy $E_p = 0.984$ GeV

Both energy and time informations!



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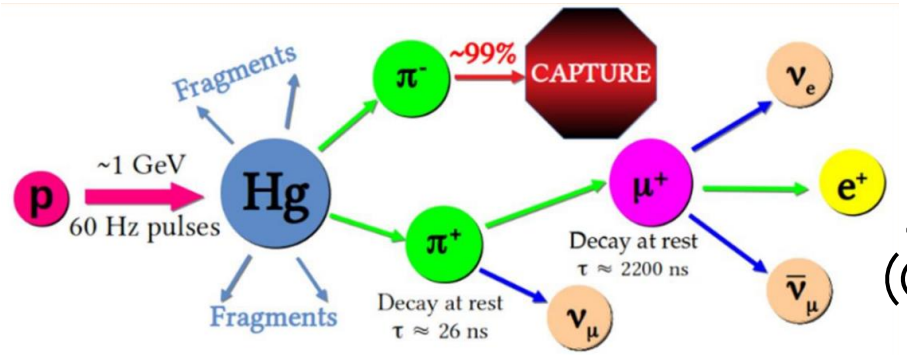

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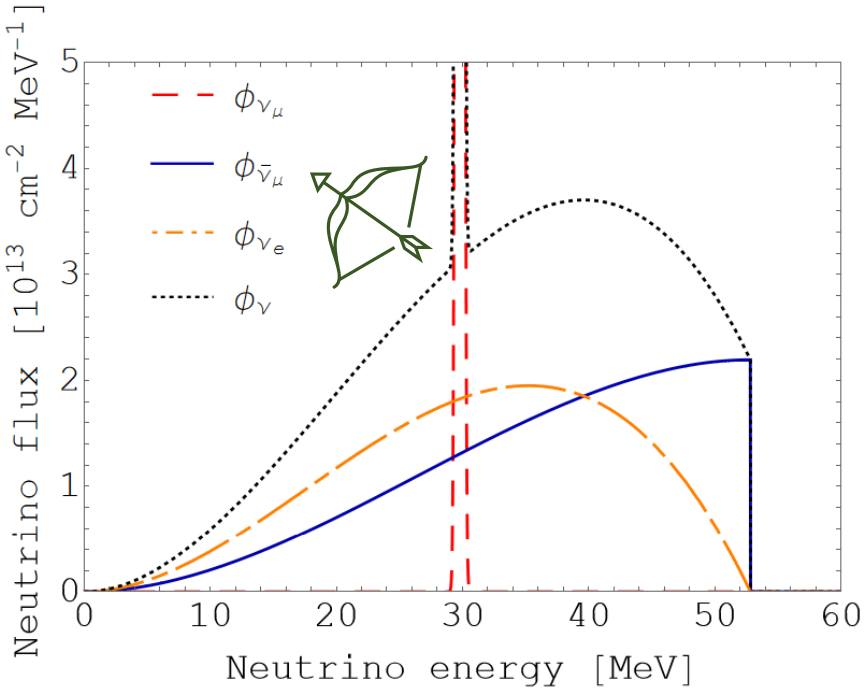

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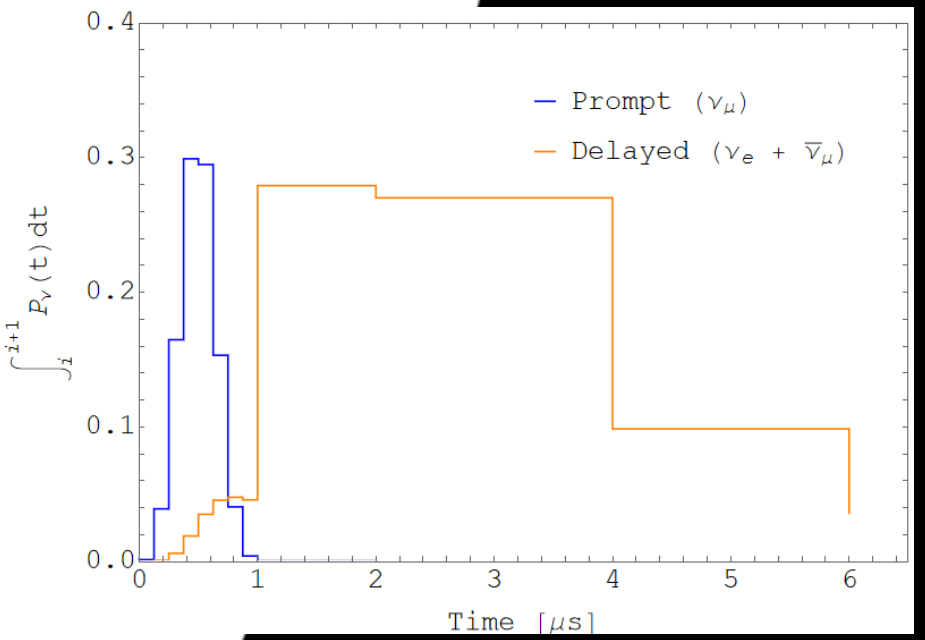

The COHERENT Experiment

Methods and data

Phys.Rev.Lett. 129 (2022) 8, 081801

CsI data

- **14.6 kg** cesium-iodide (CsI) low-threshold detector ($\sim 6\ \mathrm{keV_{nr}}$) **19.6 m** from the SNS target observed **for the first time** CEνNS in **2017**. *Science 357 (2017) 6356*
- **October 2021** new data release of the CsI detector **with twice the statistics**, **new quenching factor**, and. **new determination of arrival time distribution.**
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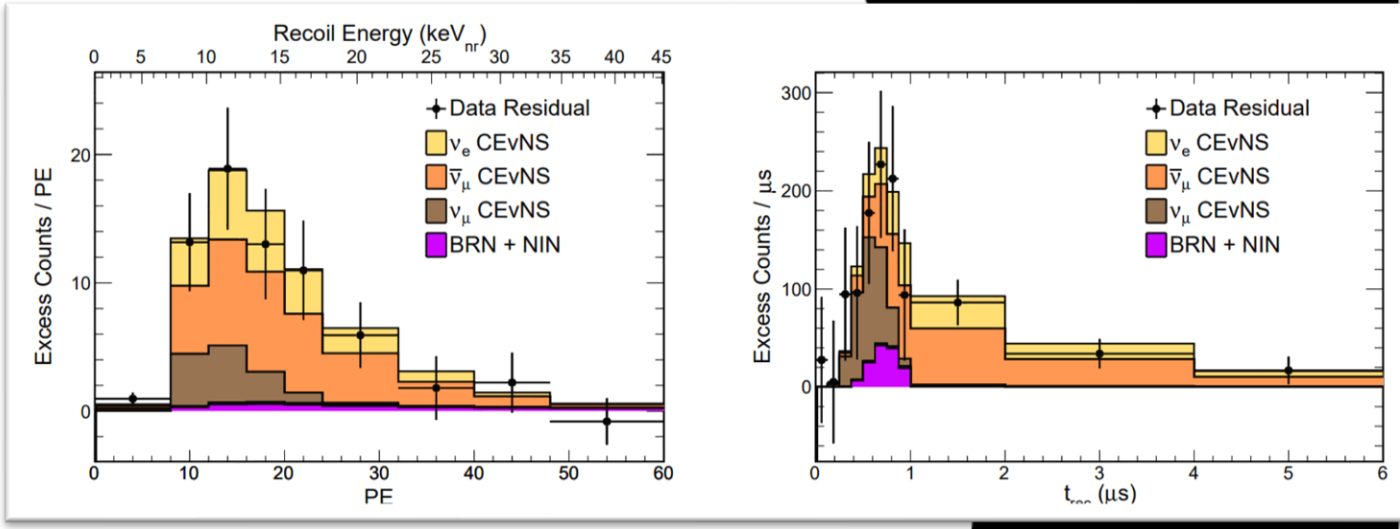
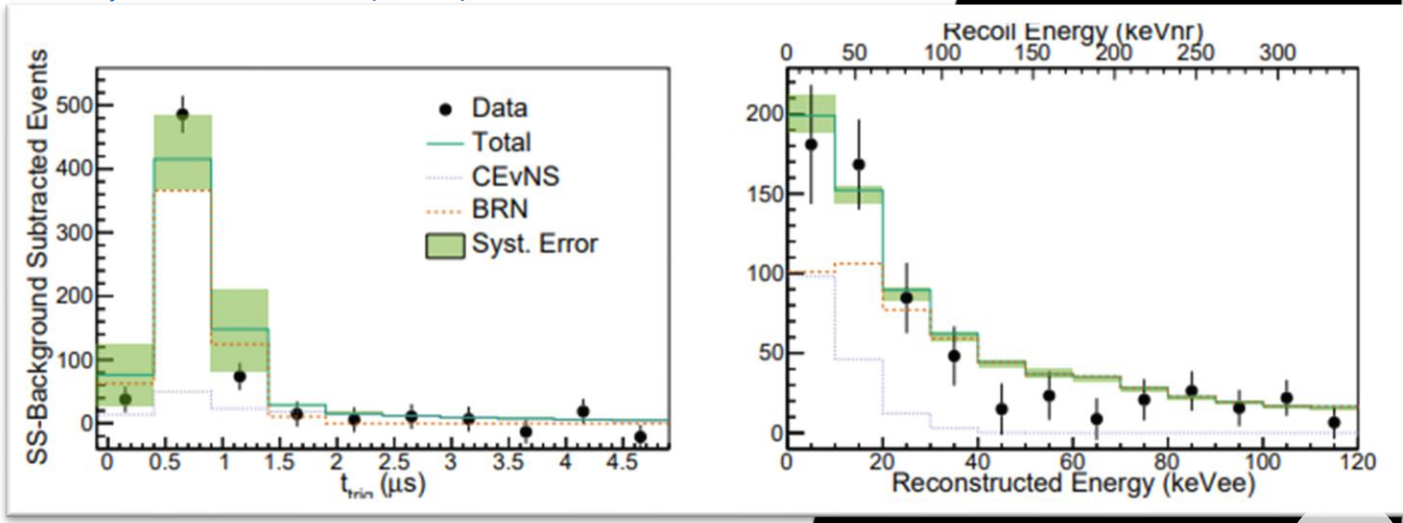
- Data fitted with a **Poissonian definition** of the least square function



LAr data

Phys.Rev.Lett. 126 (2021) 1, 01200213



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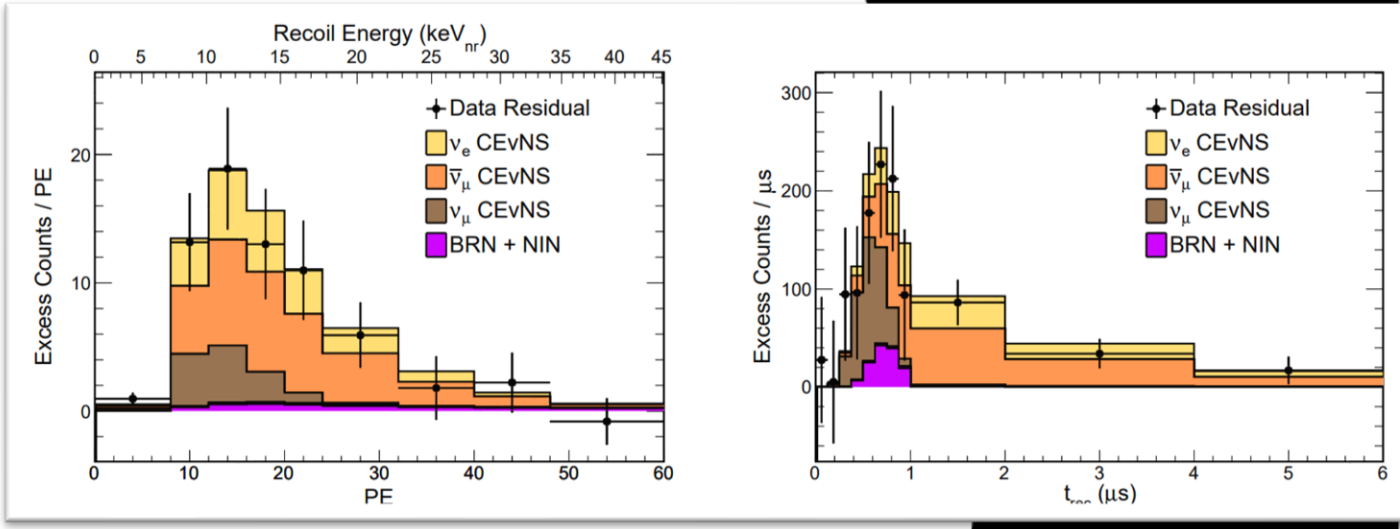
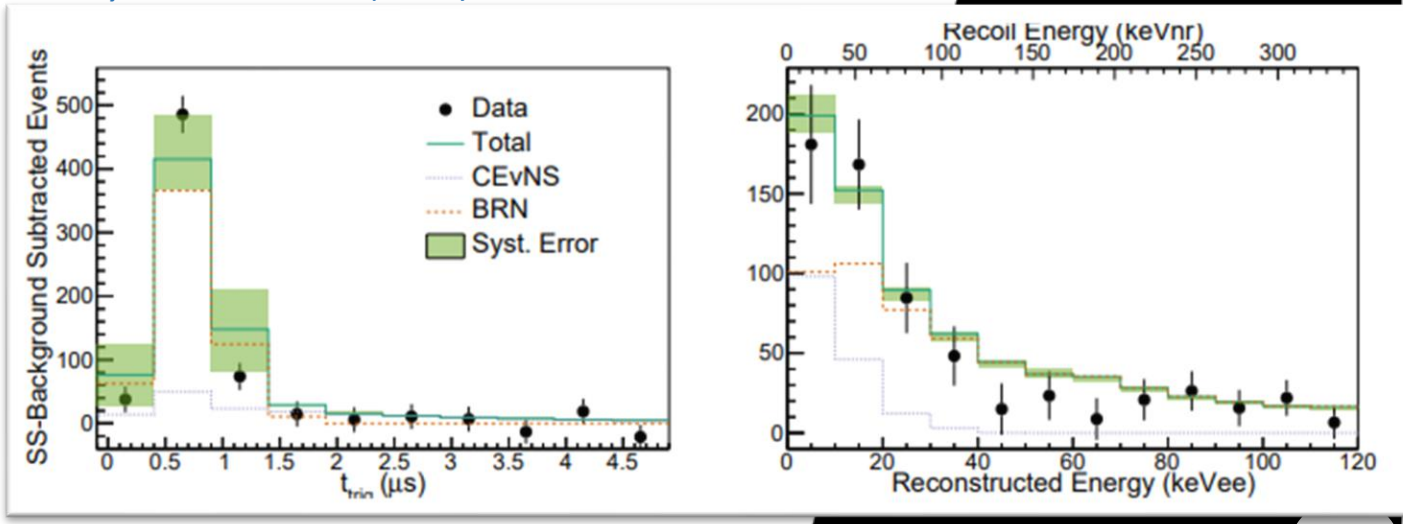


Phys.Rev.Lett. 126 (2021) 1, 01200213

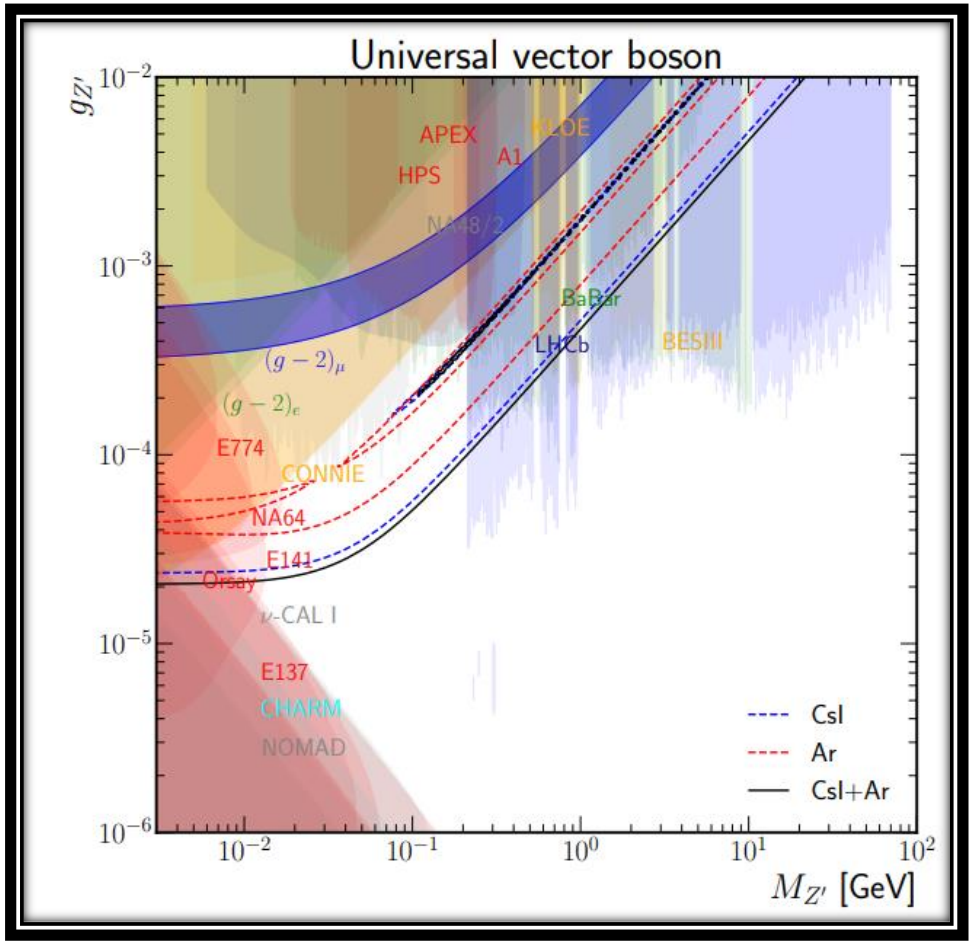
LAr data

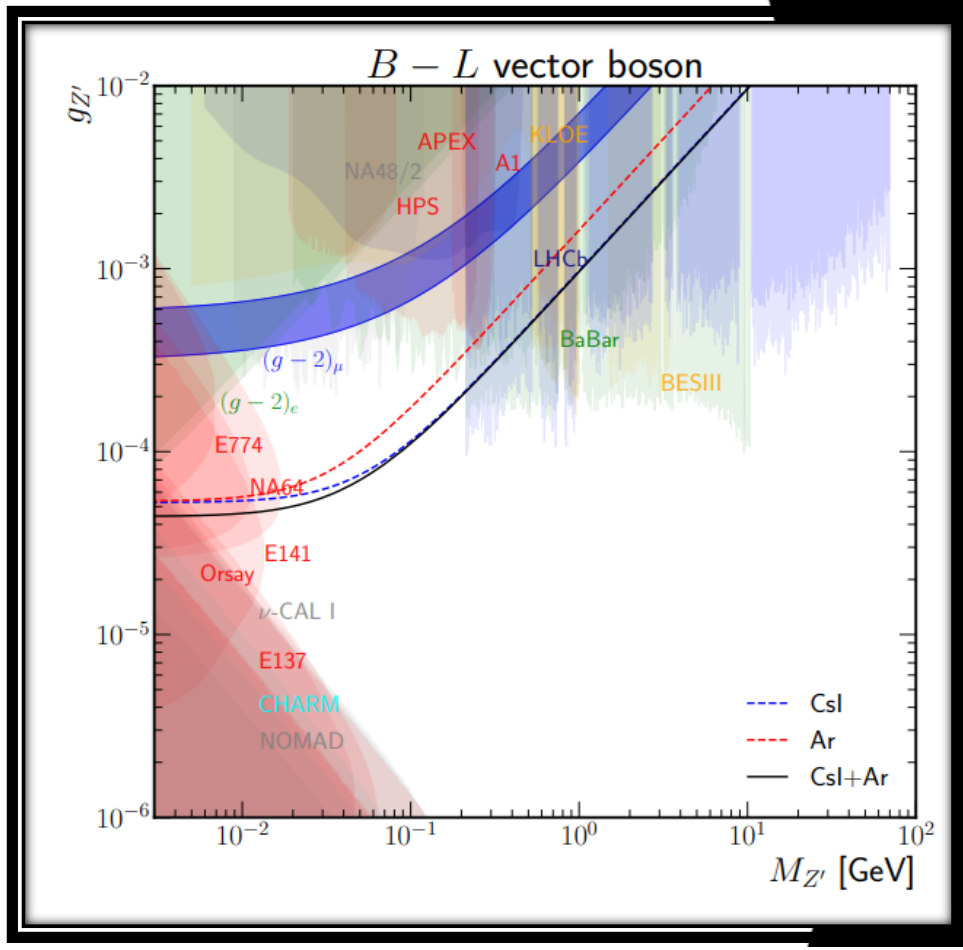
- Observation of CEνNS in **2020** with **24 kg LAr** detector **27.5 m** from SNS target
- Single phase detector with $20\ \mathrm{keV_{nr}}$ threshold
- $\mathbf{3.5}\ \boldsymbol{\sigma}$ significance
- Data fitted using the prescription provided in https://zenodo.org/record/3903810#.ZBNRmHbMIQ8
- New data expected soon!



Constraints on light mediators from COHERENT data

10.1007/JHEP05(2022)109





See JHEP 04 (2020) 054 (JHEP 05 (2022) 085) for the CONNIE (CONUS) limits

Universal model

- **Same coupling** to all SM fermions
- Improved constraints for $20<M_{Z'}<200$ MeV and $2\times10^{-5}<g_{Z'}<10^{-4}$
- $(\boldsymbol{g-2})_{\boldsymbol{\mu}}$ excluded

B-L

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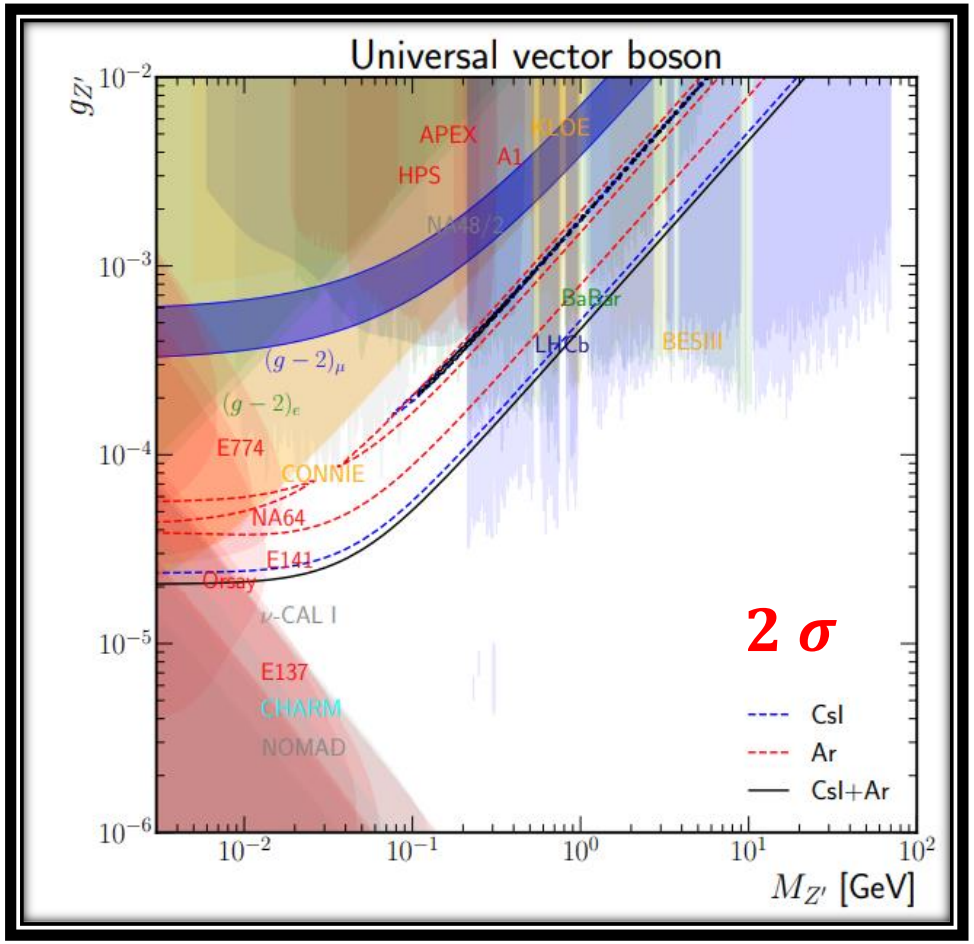

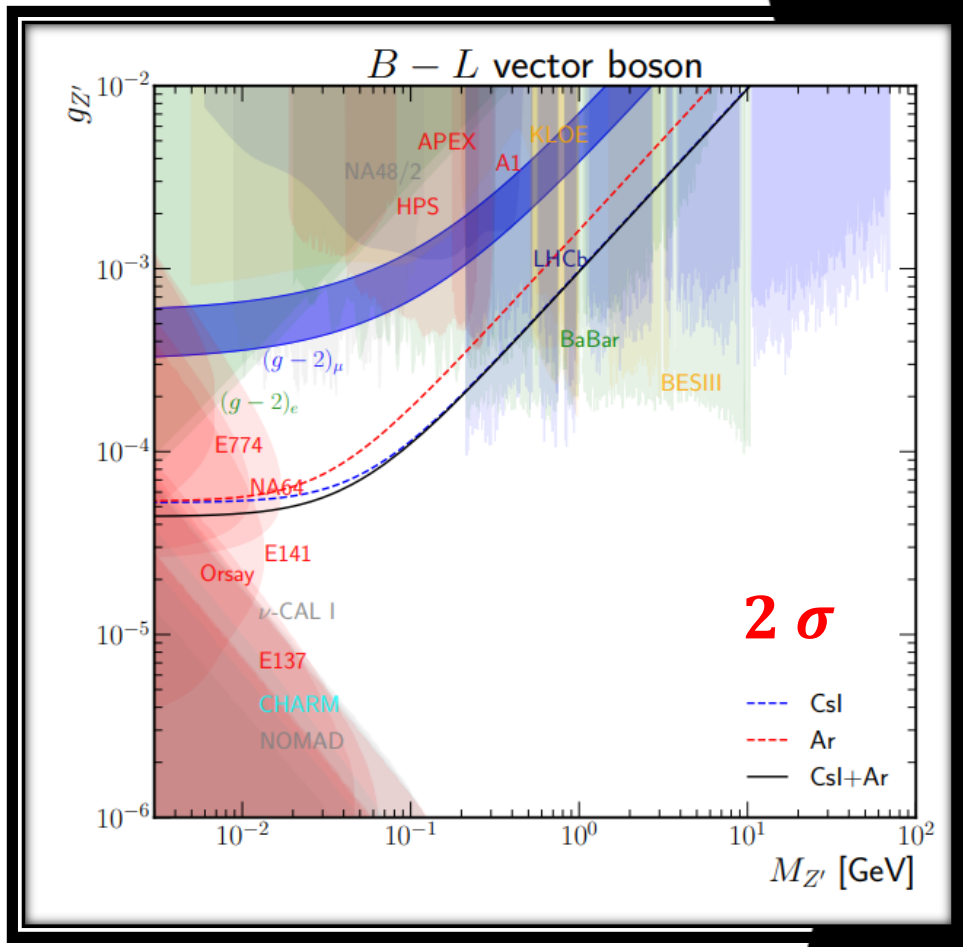

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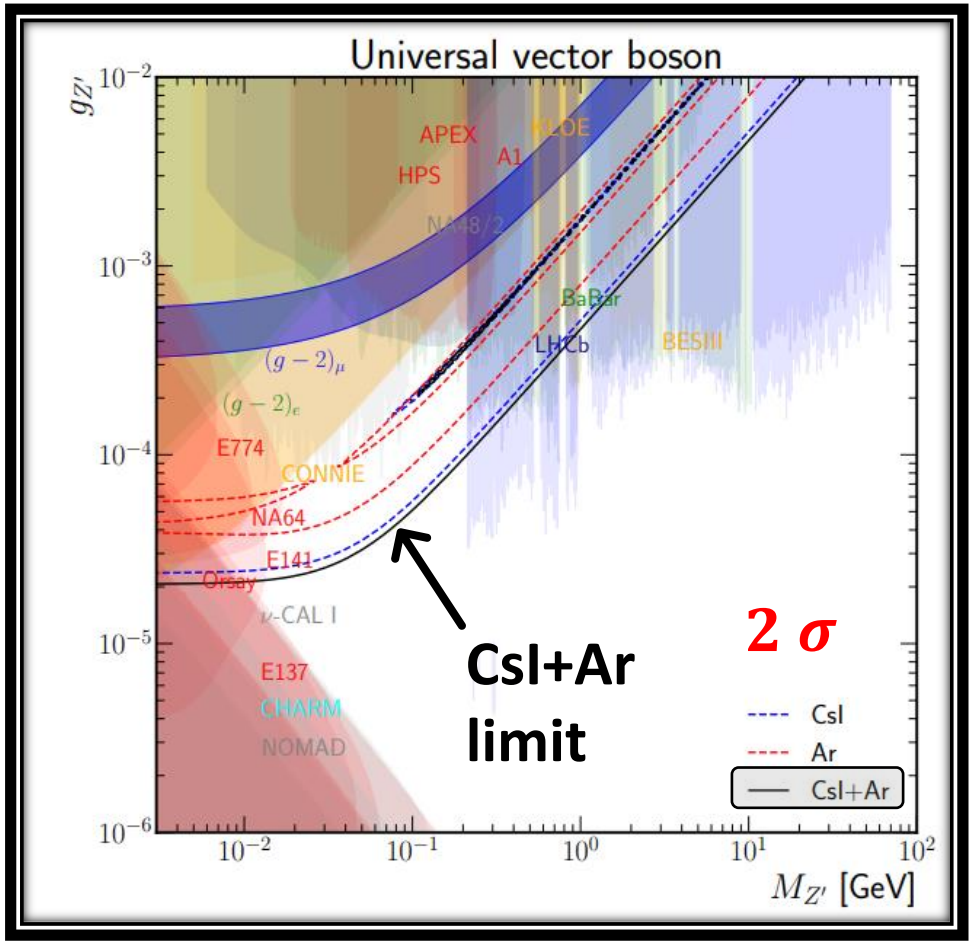

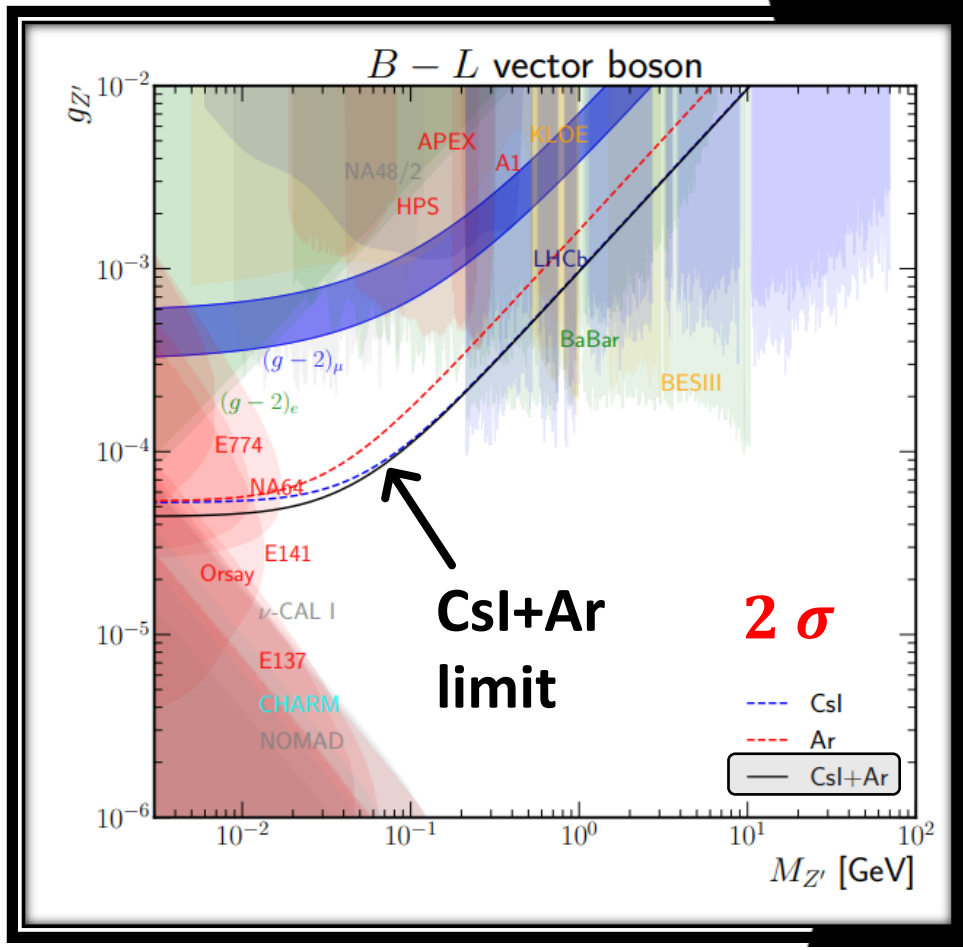

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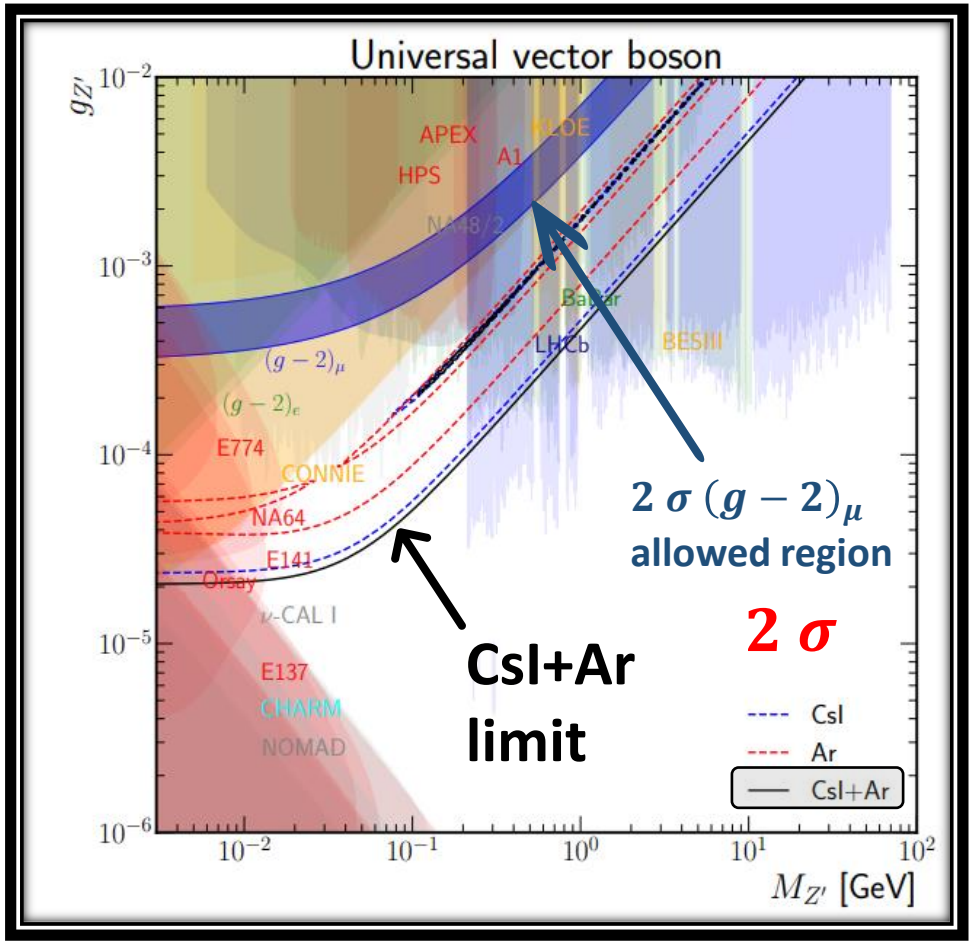

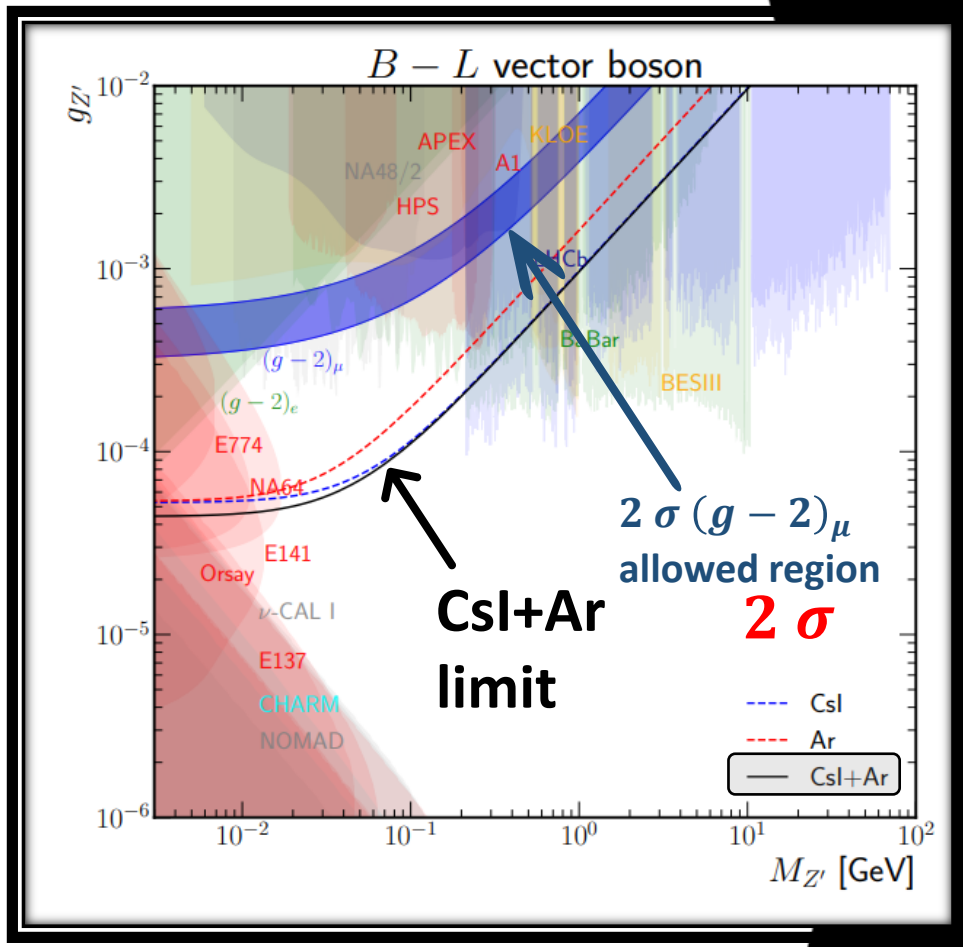

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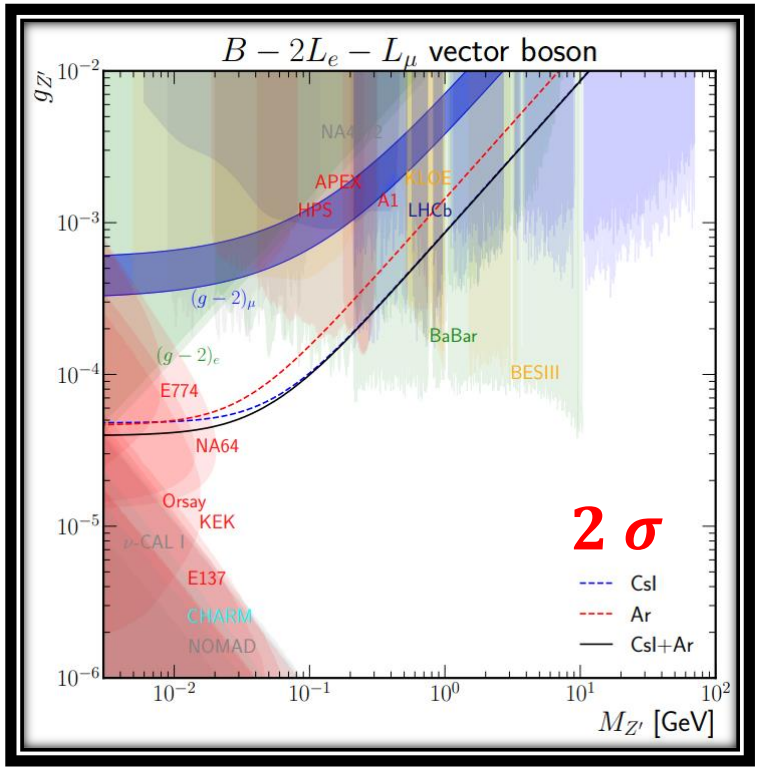

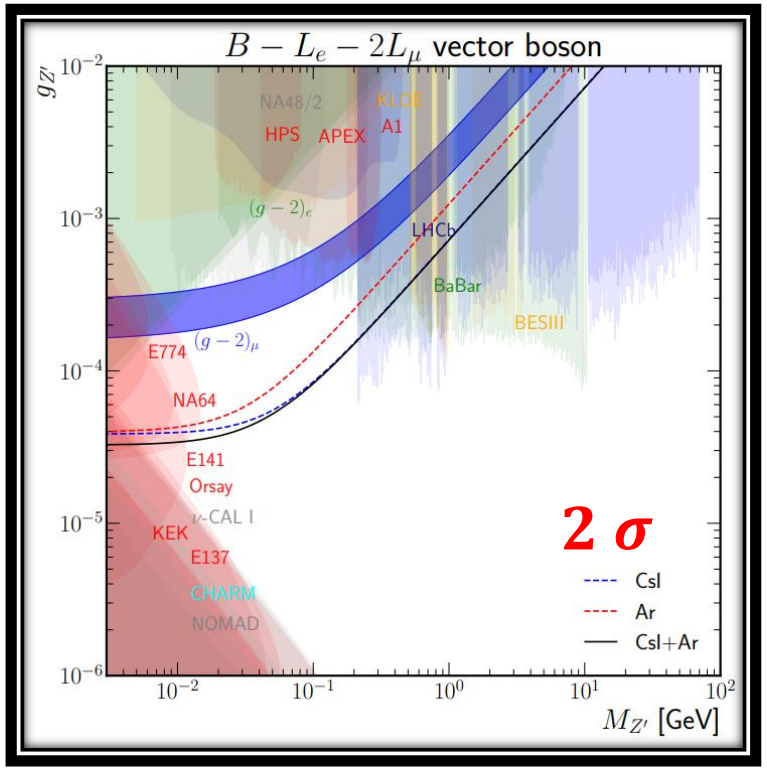

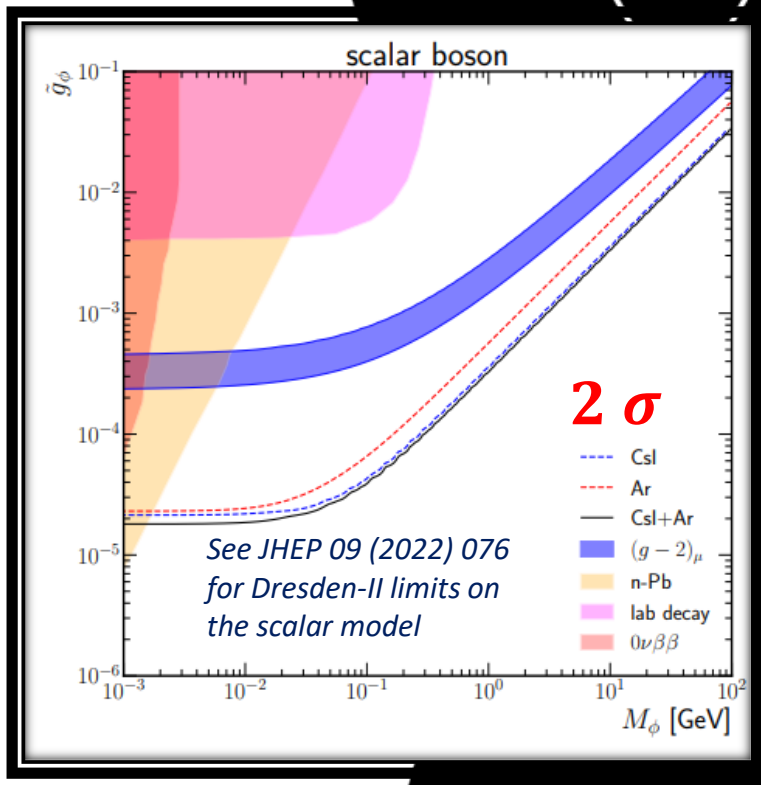

$B-2L_e-L_\mu$

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- $(g-2)_\mu$ excluded

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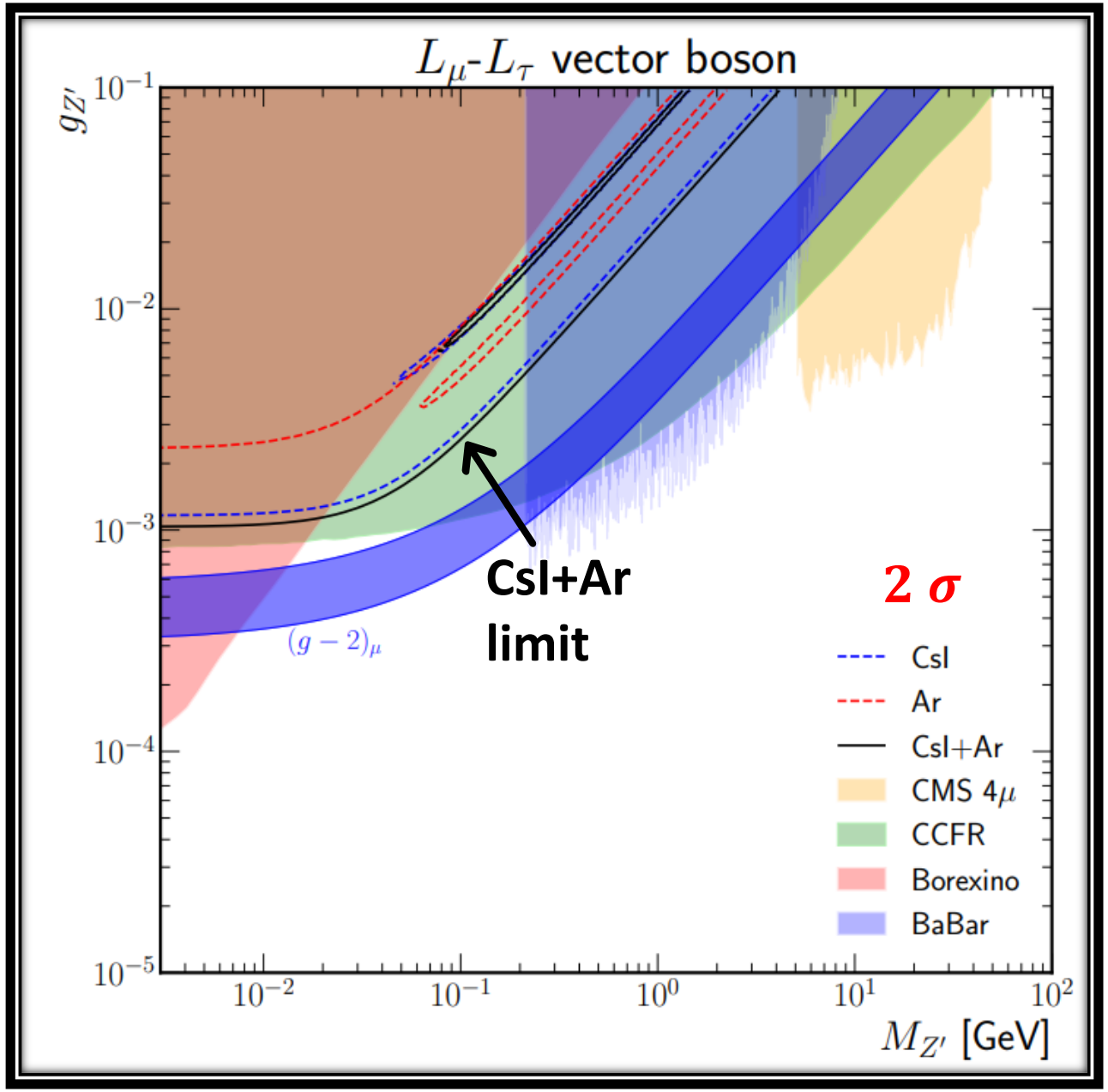
Scalar mediator

- Very strong limits with CEνNS for $M_\phi > 2$ MeV
- $(g-2)_\mu$ excluded

Constraints on light mediators from COHERENT data



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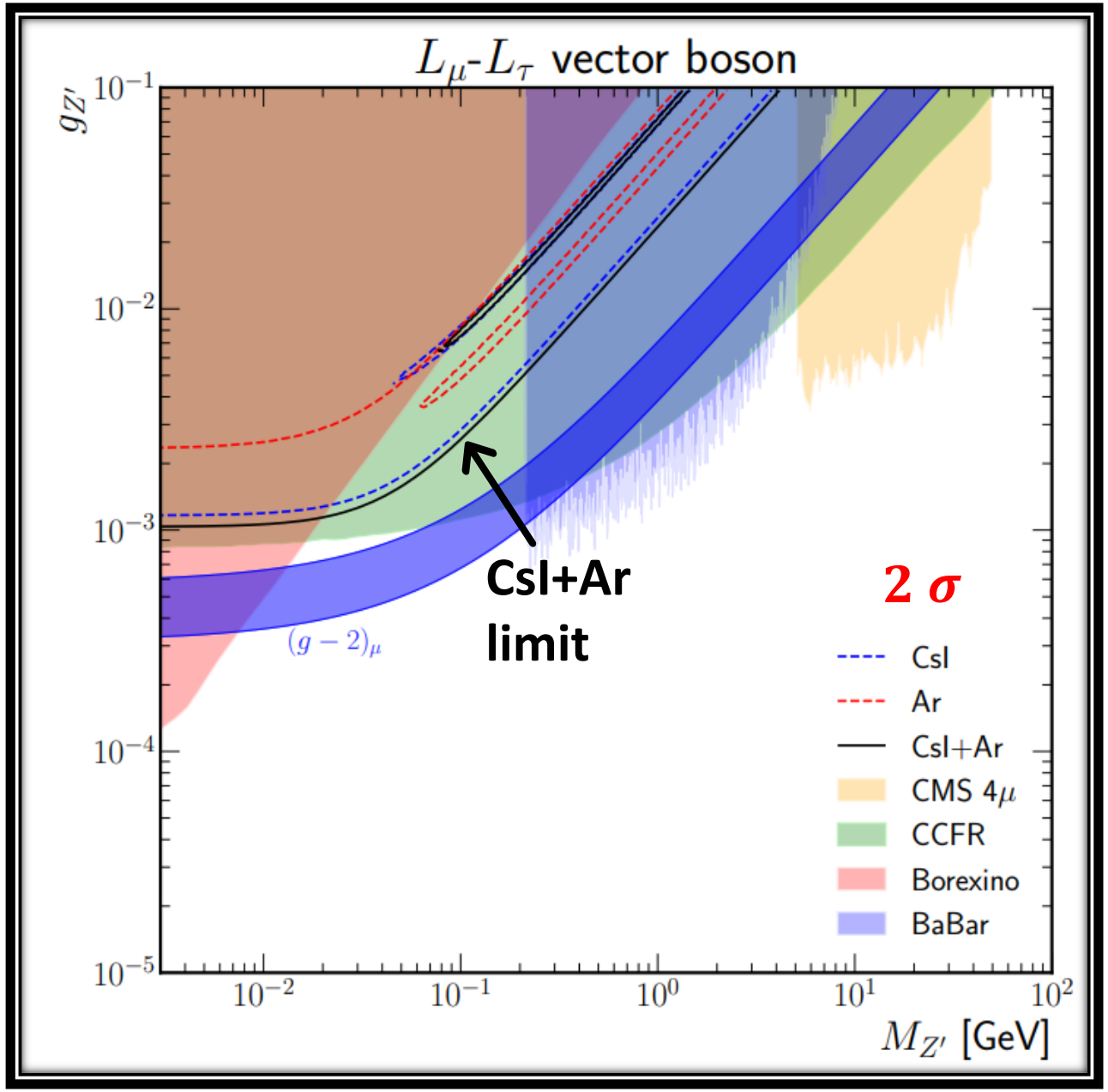
The COHERENT Experimental Program arXiv:2204.04575

JHEP 03 (2019) 071
E.P.J. C 82, 480 (2022)
arXiv:2104.15136
arXiv:2302.03571
arXiv:2303.09751

Constraints on light mediators from COHERENT data



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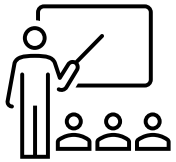

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See also Jason Newby's talk and Keyu Ding's poster for more details on the future of COHERENT!

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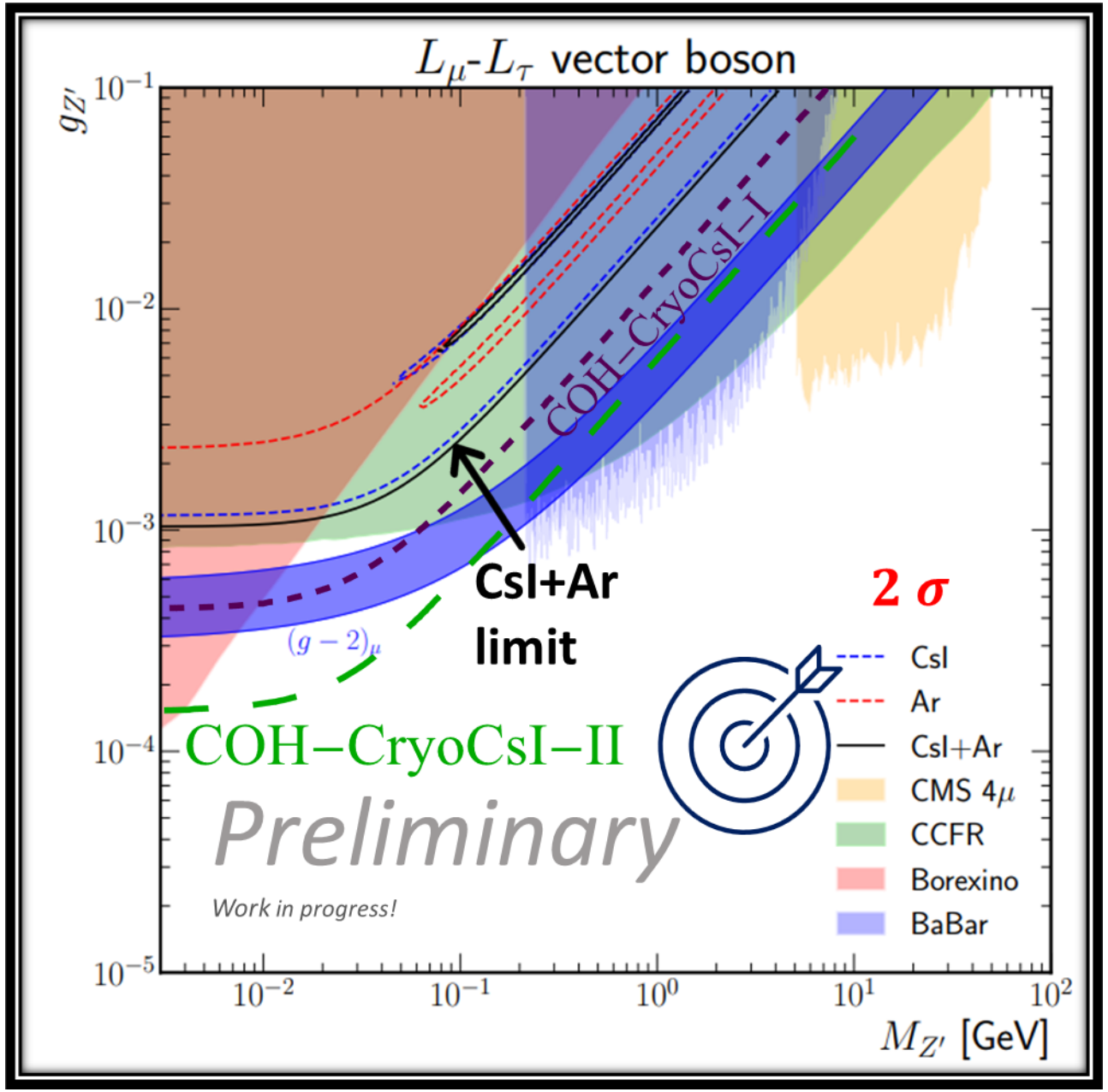

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The COHERENT Experimental Program arXiv:2204.04575

JHEP 03 (2019) 071
E.P.J. C 82, 480 (2022)
arXiv:2104.15136
arXiv:2302.03571
arXiv:2303.09751

See also Jason Newby's talk and Keyu Ding's poster for more details on the future of COHERENT!

Conclusions and future perspectives

- We present a review on the constraints on light mediator models obtained from the analysis of the latest **COHERENT LAr** and **CsI** data obtained in **JHEP 05 (2022) 109**

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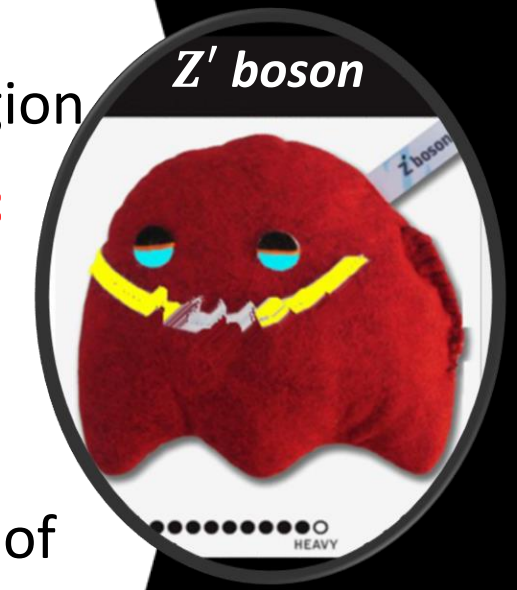

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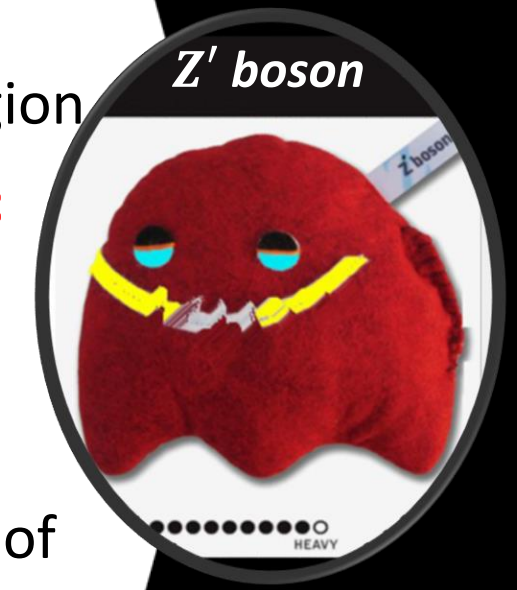
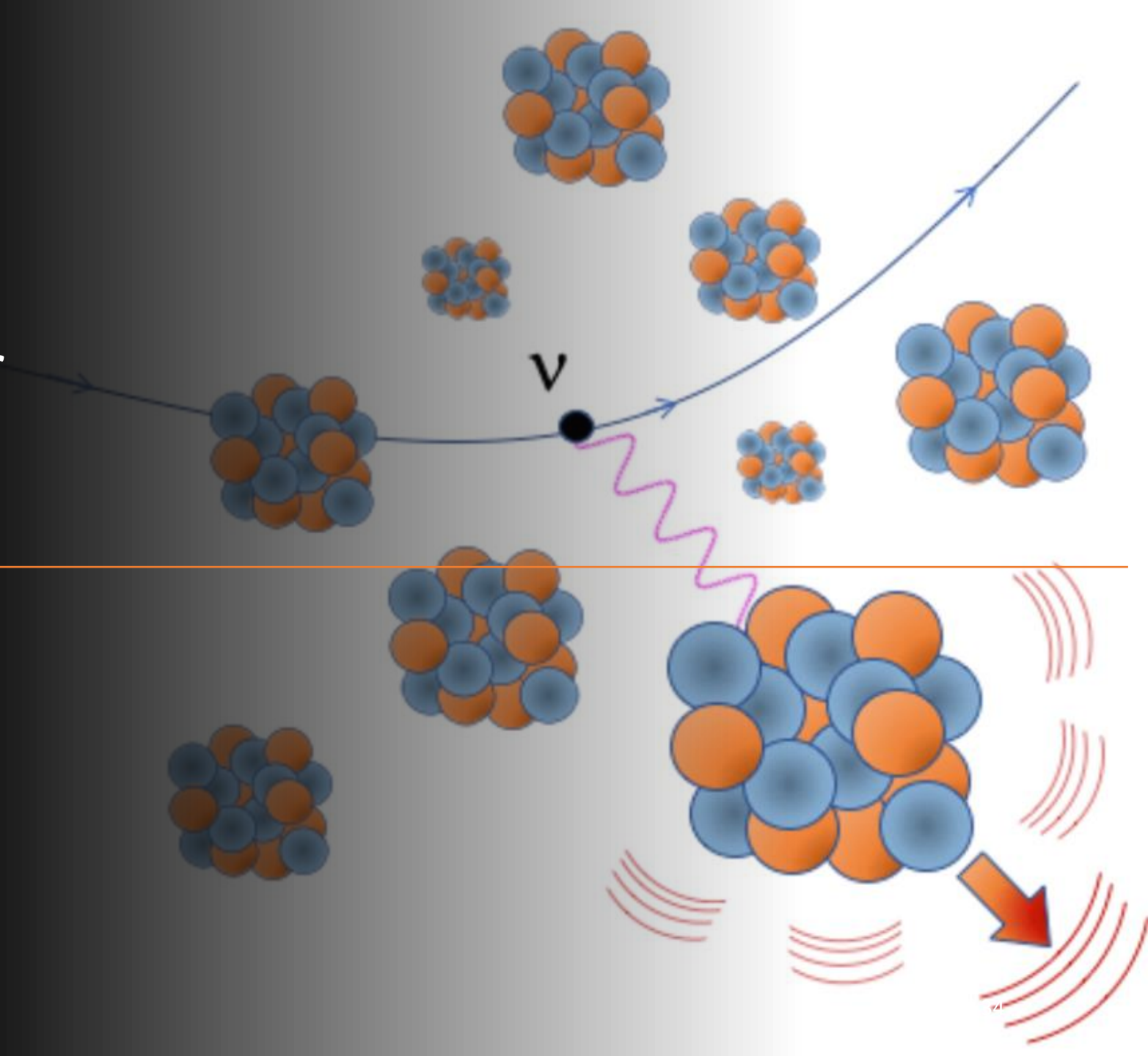
- We foresee that the complementarity with **CEνNS reactor experiments** will be crucial to test some of these models.



Thanks for your attention!



Backup Slides

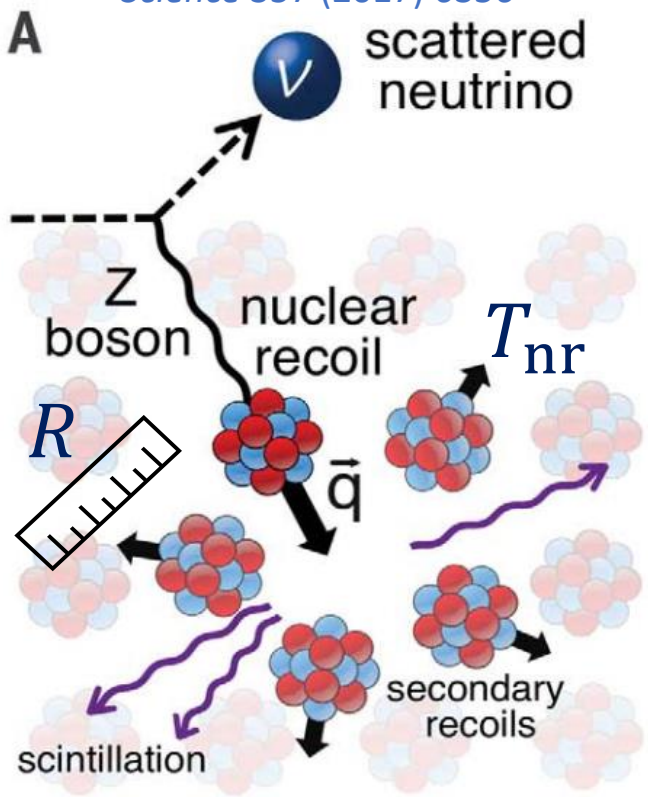
Coherent Elastic ν-Nucleus Scattering

PHYSICAL REVIEW D VOLUME 9, NUMBER 5 1 MARCH 1974

Coherent effects of a weak neutral current

Daniel Z. Freedman†
National Accelerator Laboratory, Batavia, Illinois 60510
and Institute for Theoretical Physics, State University of New York, Stony Brook, New York 11790

Science 357 (2017) 6356



- The neutrino interacts **coherently** with the nucleus as a whole $|q|R \ll 1$
- **Very challenging to detect** due to the small nuclear recoils (few keVs).
- CEνNS cross section ∝ # nucleons squared → big cross section!
- **Observed** by the **COHERENT** Collaboration in 2017.

Science 357 (2017) 6356

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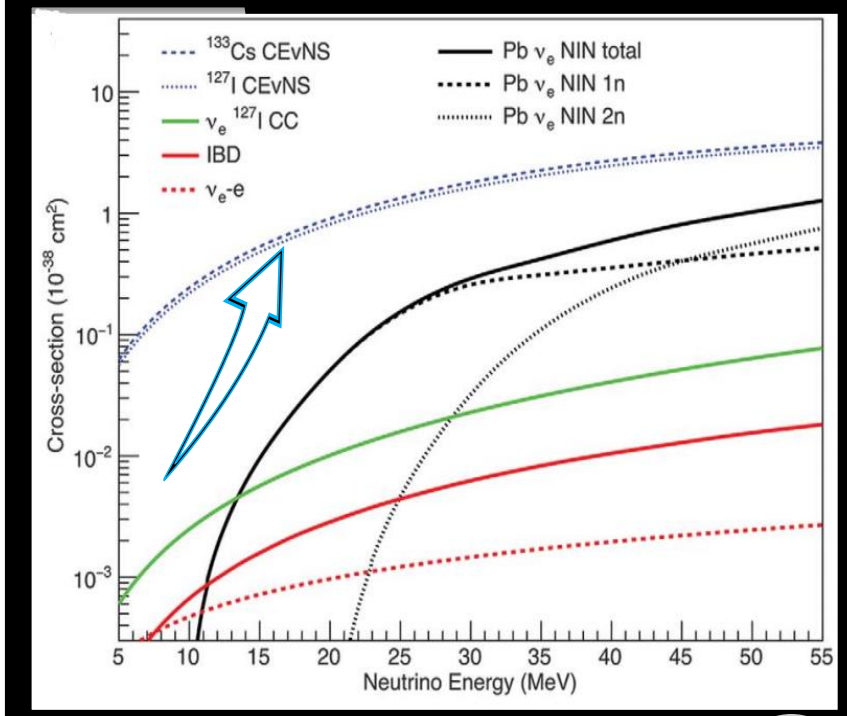


Radiative corrections for CEνNS

In our analyses we adopted the $\overline{\mathrm{MS}}$ scheme to compute the more accurate values of the couplings g_V^p and g_V^n.

Prog. Part. Nucl. Phys. 71, 119 (2013)

$$g_V^{\nu_\ell p} = \rho\left(\frac{1}{2} - 2\hat{s}_0^2\right) + 2\boxtimes_{WW} + \square_{WW} - 2\varnothing_{\nu_\ell W} + \rho(2\boxtimes_{ZZ}^{uL} + \boxtimes_{ZZ}^{dL} - 2\boxtimes_{ZZ}^{uR} - \boxtimes_{ZZ}^{dR})$$

$$g_V^{\nu_\ell n} = -\frac{\rho}{2} + 2\square_{WW} + \boxtimes_{WW} + \rho(2\boxtimes_{ZZ}^{dL} + \boxtimes_{ZZ}^{uL} - 2\boxtimes_{ZZ}^{dR} - \boxtimes_{ZZ}^{uR})$$

Neutrino Charge Radius (Flavour dependent!) $\varnothing_{\nu_\ell W} = -\frac{\alpha}{6\pi}\left(\ln\frac{M_W^2}{m_\ell^2} + \frac{3}{2}\right)$

$$g_V^p(\nu_e) \simeq 0.0382$$
$$g_V^p(\nu_\mu) \simeq 0.0300$$
$$g_V^n \simeq -0.5117$$

WW-box

$$\square_{WW} = -\frac{\hat{\alpha}_Z}{2\pi\hat{s}_Z^2}\left[1 - \frac{\hat{\alpha}_s(M_W)}{2\pi}\right]$$

WW crossed-box

$$\boxtimes_{WW} = \frac{\hat{\alpha}_Z}{8\pi\hat{s}_Z^2}\left[1 + \frac{\hat{\alpha}_s(M_W)}{\pi}\right]$$

ZZ-box $\boxtimes_{ZZ}^{fX} = -\frac{3\hat{\alpha}_Z}{8\pi\hat{s}_Z^2\hat{c}_Z^2}(g_{LX}^{\nu_\ell f})^2\left[1 - \frac{\hat{\alpha}_s(M_Z)}{\pi}\right]$

Z' couplings for vector boson mediators

Vector part of the Standard model weak neutral-current Lagrangian

$$\mathcal{L}_Z^V = -\frac{g}{2\cos\vartheta_W} Z_\mu \left[2g_V^\nu \sum_{\ell=e,\mu,\tau} \overline{\nu_{\ell L}}\gamma^\mu \nu_{\ell L} + \sum_{q=u,d} g_V^q \, \overline{q}\gamma^\mu q \right]$$

with $g_V^\nu = \frac{1}{2}, \quad g_V^u = \frac{1}{2} - \frac{4}{3}\sin^2\vartheta_W, \quad$ and $\quad g_V^d = -\frac{1}{2} + \frac{2}{3}\sin^2\vartheta_W$

Lagrangian for the interaction of a Z' vector boson with neutrinos and quarks

$$\mathcal{L}_{Z'}^V = -Z'_\mu \left[\sum_{\ell=e,\mu,\tau} g_{Z'}^{\nu_\ell V} \, \overline{\nu_{\ell L}}\gamma^\mu \nu_{\ell L} + \sum_{q=u,d} g_{Z'}^{qV} \, \overline{q}\gamma^\mu q \right]$$

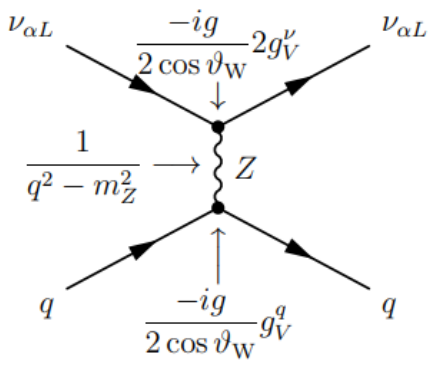
Confronting the two Lagrangians, one can see that the Z' vector interation of the left-handed neutrinos with quarks is obtained from the vector part of the Standard Model neutral-current interaction with the substitutions

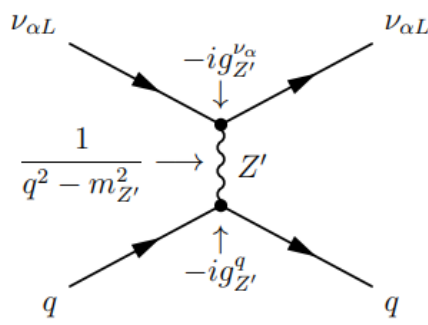
$$\frac{g}{2\cos\vartheta_W} 2g_V^\nu \to g_{Z'}^{\nu_\ell V}, \quad \frac{g}{2\cos\vartheta_W} g_V^q \to g_{Z'}^{qV}, \quad \text{and} \quad m_Z \to m_{Z'}$$

The total amplitude is given by the sum of the two diagrams

$$A \propto \frac{g^2}{4\cos^2\vartheta_W} \frac{2g_V^\nu g_V^q}{q^2 - m_Z^2} + \frac{g_{Z'}^{\nu_\ell V} g_{Z'}^{qV}}{q^2 - m_{Z'}^2}$$

For $q^2 \ll m_Z^2$ $\quad A \propto g_V^q + \frac{g_{Z'}^{\nu_\ell V} g_{Z'}^{qV}}{\sqrt{2} G_F \left(q^2 - m_{Z'}^2\right)}$





Conditions for anomaly freedom for $U(1)'$ vector boson mediators

If the SM is extened with RH neutrinos there is an infinite set of anomaly-free $U(1)'$ gauge groups generated by

$$G(c_1, c_2, c_3, c_e, c_\mu, c_\tau) = c_1 B_1 + c_2 B_2 + c_3 B_3 - c_e L_e - c_\mu L_\mu - c_\tau L_\tau$$

Baryon numbers of the three generations

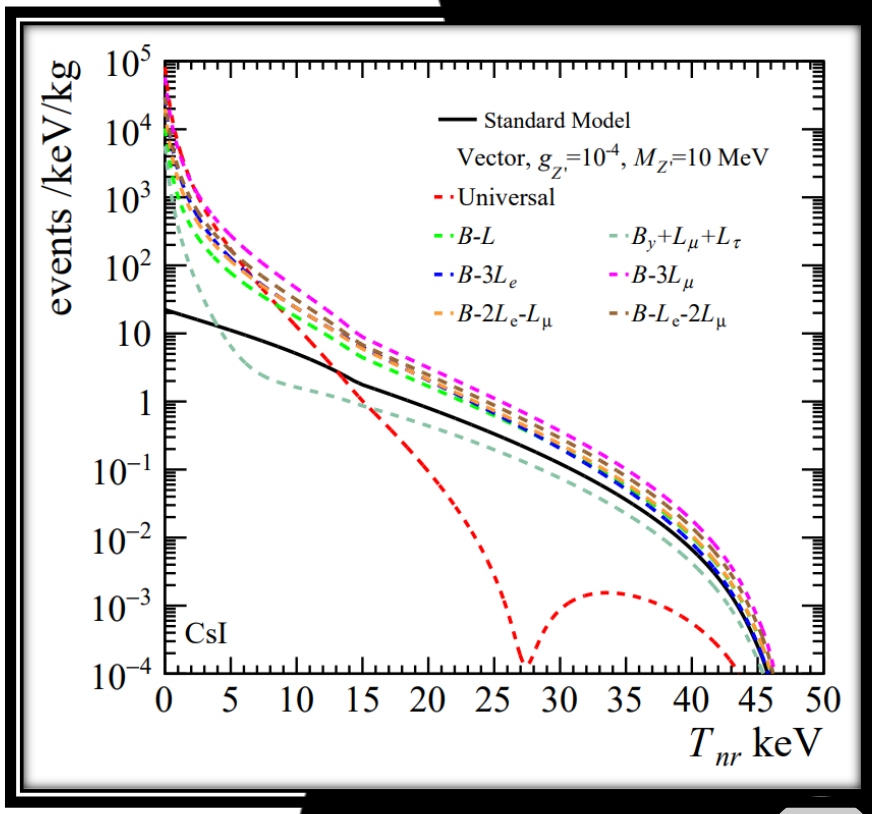
Lepton number for different flavors

The condition for anomaly freedom is $c_1 + c_2 + c_3 - c_e - c_\mu - c_\tau = 0$

To avoid unobserved flavor changing neutral currents in the quark sector it is always assumed that $c_1 = c_2 = c_3 \doteq c_B$.
The condition for anomaly freedom is

$$3c_B - c_e - c_\mu - c_\tau = 0$$

$B = B_1 + B_2 + B_3$ is the usual baryon number



Additional information on the scalar model

$$\mathcal{L}_\phi^S = -\phi\left[\sum_{\ell=e,\mu,\tau} g_\phi^{\nu_\ell}\,\overline{\nu_\ell}\,\nu_\ell + \sum_{q=u,d} g_\phi^q\,\bar{q}\,q\right]$$

The **helicity-flipping** interactions mediated by a scalar boson contribute incoherently to CEvNS $\left(\frac{d\sigma_{\nu_\ell\text{-}\mathcal{N}}}{dT_{\rm nr}}\right)_{\rm scalar} = \frac{M^2 T_{\rm nr}}{4\pi E^2}\frac{(g_\phi^{\nu_\ell})^2\mathcal{Q}_\phi^2}{(|\vec{q}|^2+M_\phi^2)^2}$

In this model, the **weak charge** of the nucleus is given by $\mathcal{Q}_\phi = ZF_Z(|\vec{q}|^2)\sum_{q=u,d} g_\phi^q\langle p|\bar{q}q|p\rangle + NF_N(|\vec{q}|^2)\sum_{q=u,d} g_\phi^q\langle n|\bar{q}q|n\rangle$

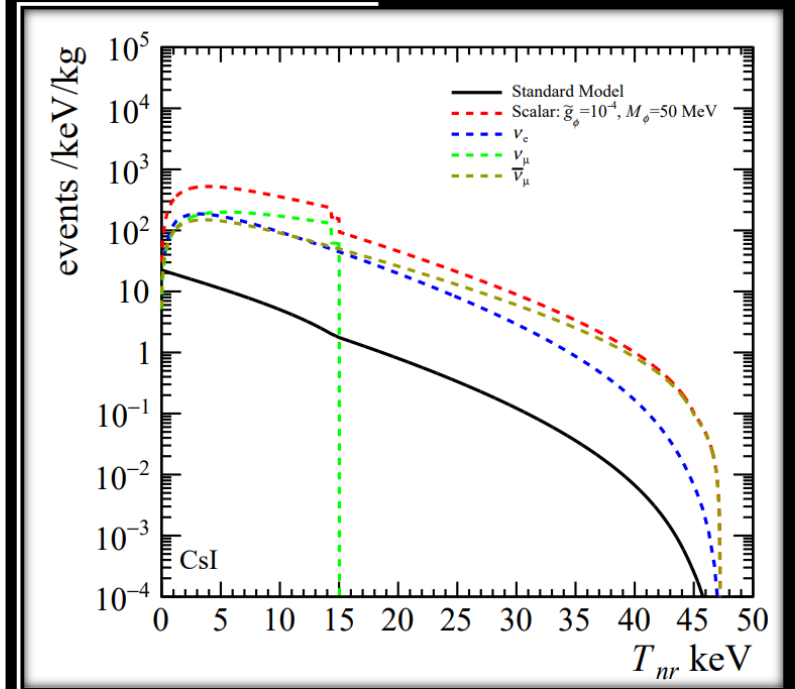
Under the **assumptions** that $g_\phi^u = g_\phi^d \doteq g_\phi^q$ $\mathcal{Q}_\phi = g_\phi^q\left[ZF_Z(|\vec{q}|^2)\langle p|\bar{u}u+\bar{d}d|p\rangle + NF_N(|\vec{q}|^2)\langle n|\bar{u}u+\bar{d}d|n\rangle\right]$

Under the **isospin approximation**: $\langle p|\bar{u}u+\bar{d}d|p\rangle = \langle n|\bar{u}u+\bar{d}d|n\rangle = \langle N|\bar{u}u+\bar{d}d|N\rangle = \frac{\sigma_{\pi N}}{\overline{m}_{ud}}$

$$\tilde{g}_\phi^2 = g_\phi^{\nu_\ell} g_\phi^q \frac{\sigma_{\pi N}/\overline{m}_{ud}}{(\sigma_{\pi N}/\overline{m}_{ud})_{\rm ref}} \qquad \overline{m}_{ud} = (m_u+m_d)/2$$

After all these approximations we obtain the scalar contribution to the cross section as

$$\left(\frac{d\sigma_{\nu_\ell\text{-}\mathcal{N}}}{dT_{\rm nr}}\right)_{\rm scalar} = \frac{M^2 T_{\rm nr}}{4\pi E^2}\frac{\tilde{g}_\phi^4}{(|\vec{q}|^2+M_\phi^2)^2}\left(\frac{\sigma_{\pi N}}{\overline{m}_{ud}}\right)^2_{\rm ref}\left[ZF_Z(|\vec{q}|^2)+NF_N(|\vec{q}|^2)\right]^2$$



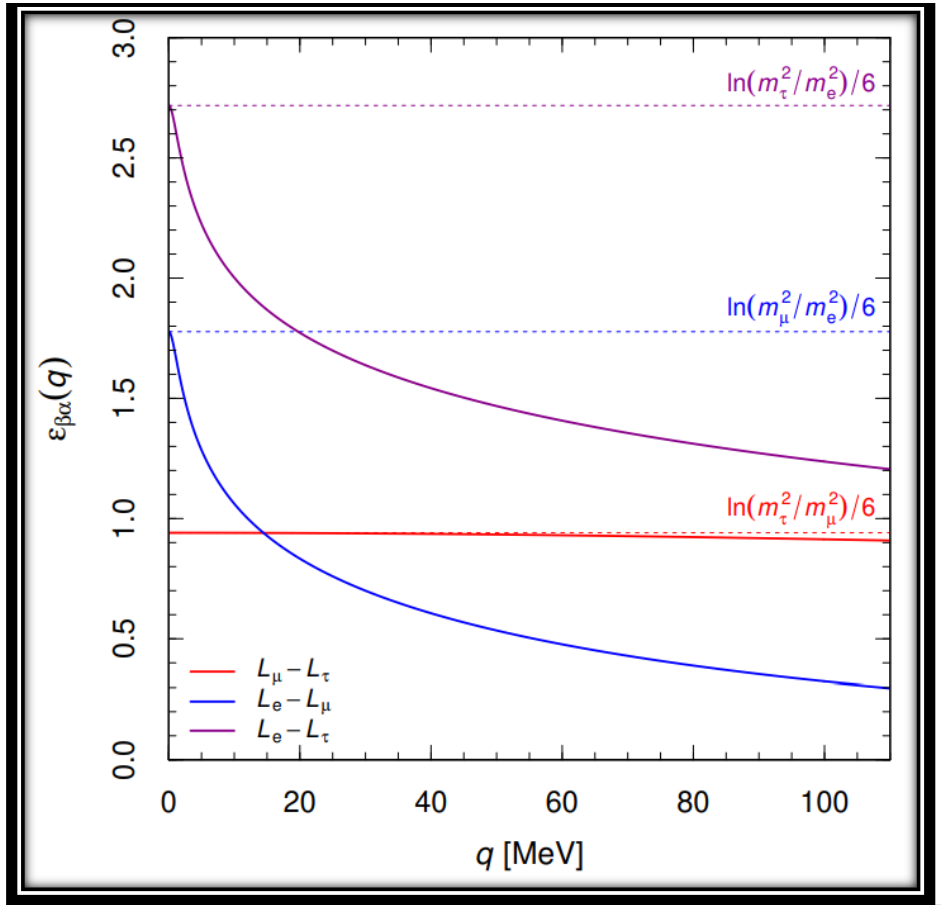
*$\sigma_{\pi N}$ is the pion nucleon σ-term that has been determined in literature (pionic atoms and pion-nucleon scattering, lattice calculations)

Leptophilic models

In the $L_\alpha - L_\beta$ (where α and β are two leptons flavors)models there is **no direct coupling** between a $L_\alpha - L_\beta$ gauge boson and quarks

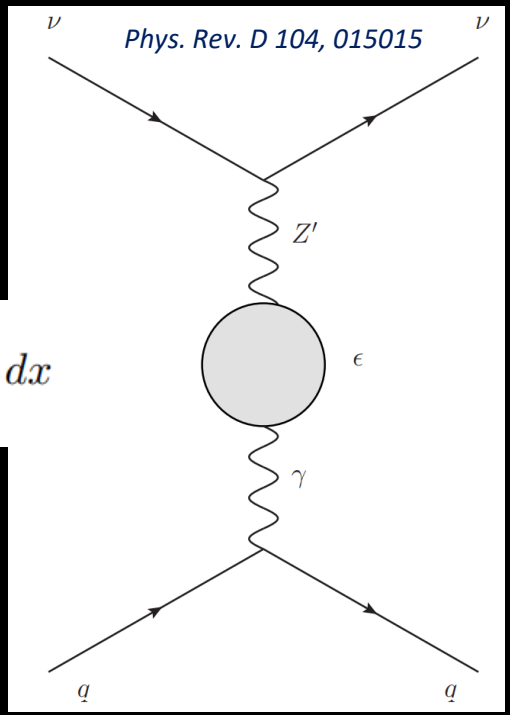
$$\left(\frac{d\sigma}{dT_{\rm nr}}\right)^{\nu_\ell - \mathcal{N}}_{L_\alpha - L_\beta}(E, T_{\rm nr}) = \frac{G_F^2 M}{\pi}\left(1 - \frac{MT_{\rm nr}}{2E^2}\right)$$

$$\times \left\{\left[g_V^p(\nu_\ell) + \frac{\sqrt{2}\alpha_{\rm EM} g_{Z'}^2 \left(\delta_{\ell\alpha}\varepsilon_{\beta\alpha}(|\vec{q}|) + \delta_{\ell\beta}\varepsilon_{\alpha\beta}(|\vec{q}|)\right)}{\pi G_F\left(|\vec{q}|^2 + M_{Z'}^2\right)}\right] Z F_Z(|\vec{q}|^2) + g_V^n N F_N(|\vec{q}|^2)\right\}^2$$



$$\varepsilon_{\beta\alpha}(|\vec{q}|) = \int_0^1 x(1-x)\ln\left(\frac{m_\beta^2 + x(1-x)|\vec{q}|^2}{m_\alpha^2 + x(1-x)|\vec{q}|^2}\right)dx$$

The coupling between neutrinos and quark is due to 1-loop effects



Statistical analysis

We computed the theoretical CEνNS event number in each NR bin as

$$N_i^{\mathrm{CE\nu NS}} = N(\mathcal{N}) \int_{T_{\mathrm{nr}}^i}^{T_{\mathrm{nr}}^{i+1}} dT_{\mathrm{nr}} A(T_{\mathrm{nr}}) \int_0^{T_{\mathrm{nr}}'^{\max}} dT'_{\mathrm{nr}}\, R(T_{\mathrm{nr}}, T'_{\mathrm{nr}}) \int_{E_{\min}(T'_{\mathrm{nr}})}^{E_{\max}} dE \sum_{\nu=\nu_e,\nu_\mu,\bar{\nu}_\mu} \frac{dN_\nu}{dE}(E) \frac{d\sigma_{\nu-\mathcal{N}}}{dT_{\mathrm{nr}}}(E, T'_{\mathrm{nr}})$$

Neutrino Flux

Energy Acceptance

Energy Resolution

$\mathcal{N}$ stands for the nucleus (i.e. Cs,I, Ar)

Time bin

Energy bin

CsI data

$$\chi^2_{\mathrm{CsI}} = 2 \sum_{i=1}^{9} \sum_{j=1}^{11} \left[\sum_{z=1}^{4} (1+\eta_z) N_{ij}^z - N_{ij}^{\mathrm{exp}} + N_{ij}^{\mathrm{exp}} \ln \left(\frac{N_{ij}^{\mathrm{exp}}}{\sum_{z=1}^{4} (1+\eta_z) N_{ij}^z} \right) \right] + \sum_{z=1}^{4} \left(\frac{\eta_z}{\sigma_z} \right)^2$$

Poissonian definition of the χ^2

$z = 1,2,3,4$ stands for the CEνNS theoretical prediction, beam related neutrons (BRN), neutrino induced neutrons (NIN), steady state (SS) backgrounds.

$\sigma_{\mathrm{CE\nu NS}} = 0.12$
$\sigma_{\mathrm{BRN}} = 0.25$
$\sigma_{\mathrm{NIN}} = 0.35$
$\sigma_{\mathrm{SS}} = 0.021$

Statistical analysis

We computed the theoretical CEνNS event number in each NR bin as

Neutrino Flux

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Energy Acceptance

Energy Resolution

$\mathcal{N}$ stands for the nucleus (i.e. Cs,I, Ar)

Energy bin

Time bin

LAr data

$$\chi^2_{\mathrm{Ar}} = \sum_{i=1}^{12} \sum_{j=1}^{10} \left(\frac{N_{ij}^{\mathrm{exp}} - \sum_{z=1}^{4} (1 + \eta_z + \sum_l \eta_{zl,ij}^{\mathrm{sys}}) N_{ij}^z}{\sigma_{ij}} \right)^2 + \sum_{z=1}^{4} \left(\frac{\eta_z}{\sigma_z} \right)^2 + \sum_{z,l} (\epsilon_{zl})^2$$

Statistical uncertainty

$z = 1,2,3,4$ stands for the CEνNS theoretical prediction, SS, prompt BRN (PBRN), delayed BRN (DBRN) backgrounds.

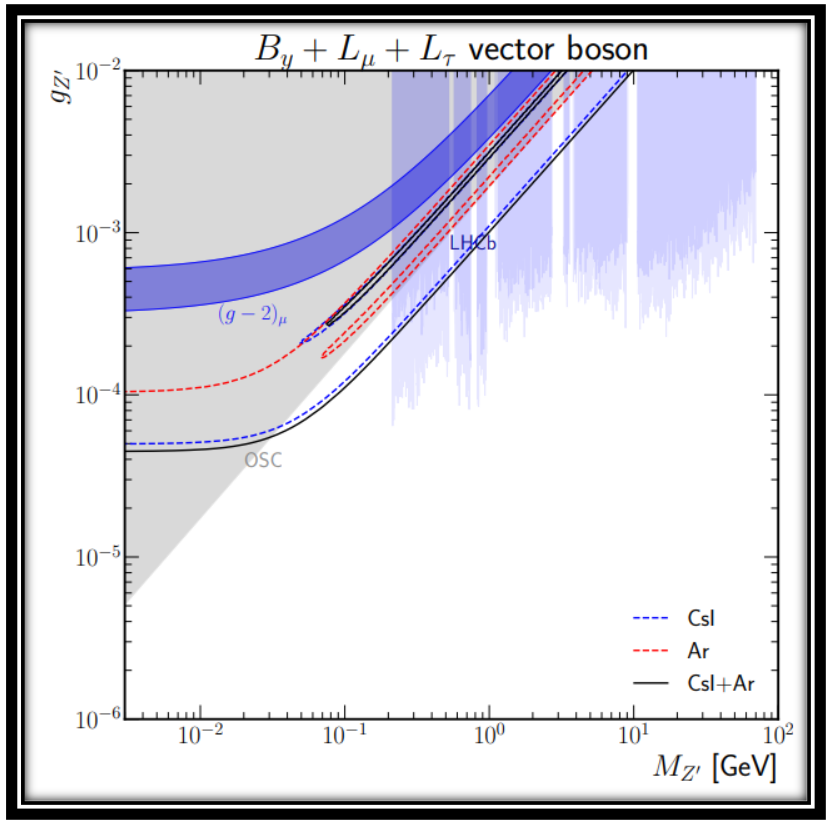
See COHERENT Collaboration data release from the first detection of coherent elastic neutrino-nucleus scattering on argon for more informations.

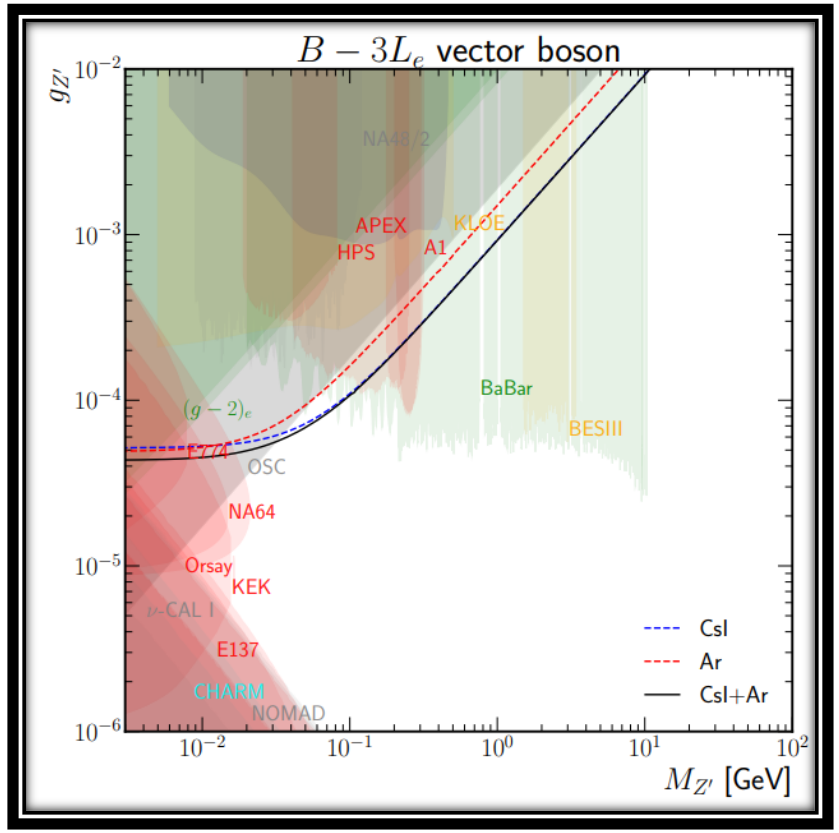
$$\eta_{zl,ij}^{\mathrm{sys}} = \epsilon_{zl} \frac{N_{zl,ij}^{\mathrm{sys}} - N_{zl,ij}^{\mathrm{CV}}}{N_{zl,ij}^{\mathrm{CV}}}$$

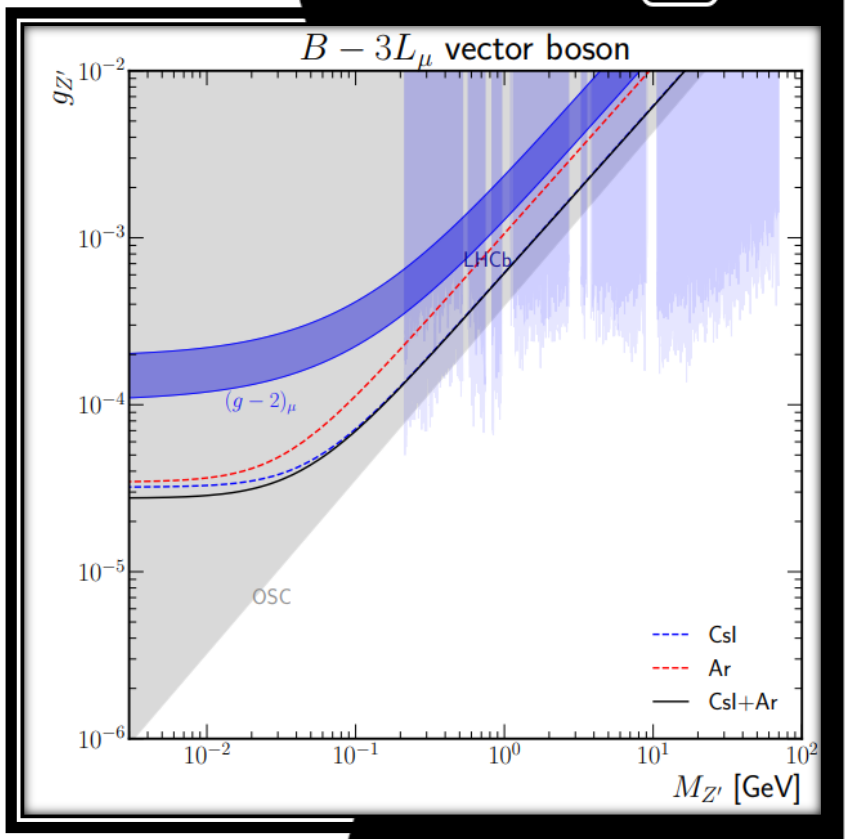
$\sigma_{\mathrm{CE\nu NS}} = 0.13$
$\sigma_{\mathrm{PBRN}} = 0.32$
$\sigma_{\mathrm{DBRN}} = 1$
$\sigma_{\mathrm{SS}} = 0.0079$

Additional constraints on light mediators

10.1007/JHEP05(2022)109







$B_y + 2L_\mu + L_\tau$

- Improved constraints for 30<$M_{Z'}$<200 MeV and 7×10^{-5}<$g_{Z'} < 3 \times 10^{-4}$
- $(g-2)_\mu$ excluded

$B - 3L_e$

- Improved constraints for 30<$M_{Z'}$<100 MeV and 5×10^{-5}<$g_{Z'} < 10^{-4}$
- No possible explanation of $(g-2)_\mu$

$B - 3L_\mu$

- Constraints not improved

Additional constraints on light mediators

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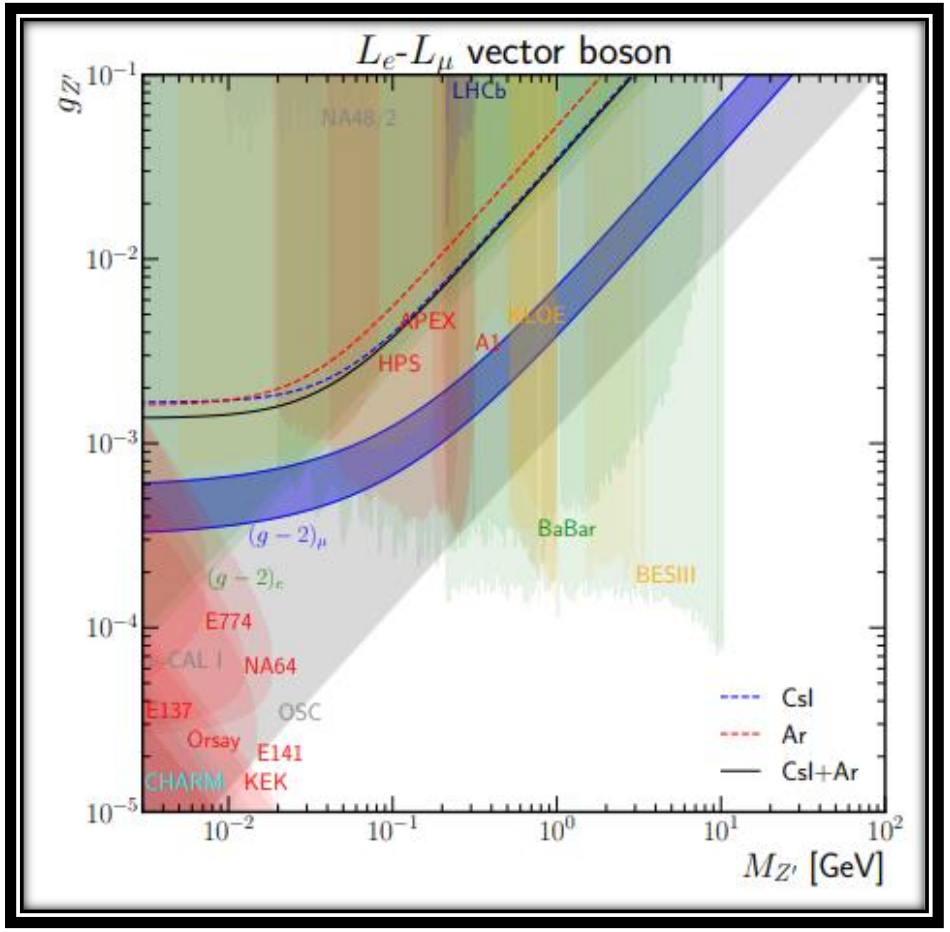
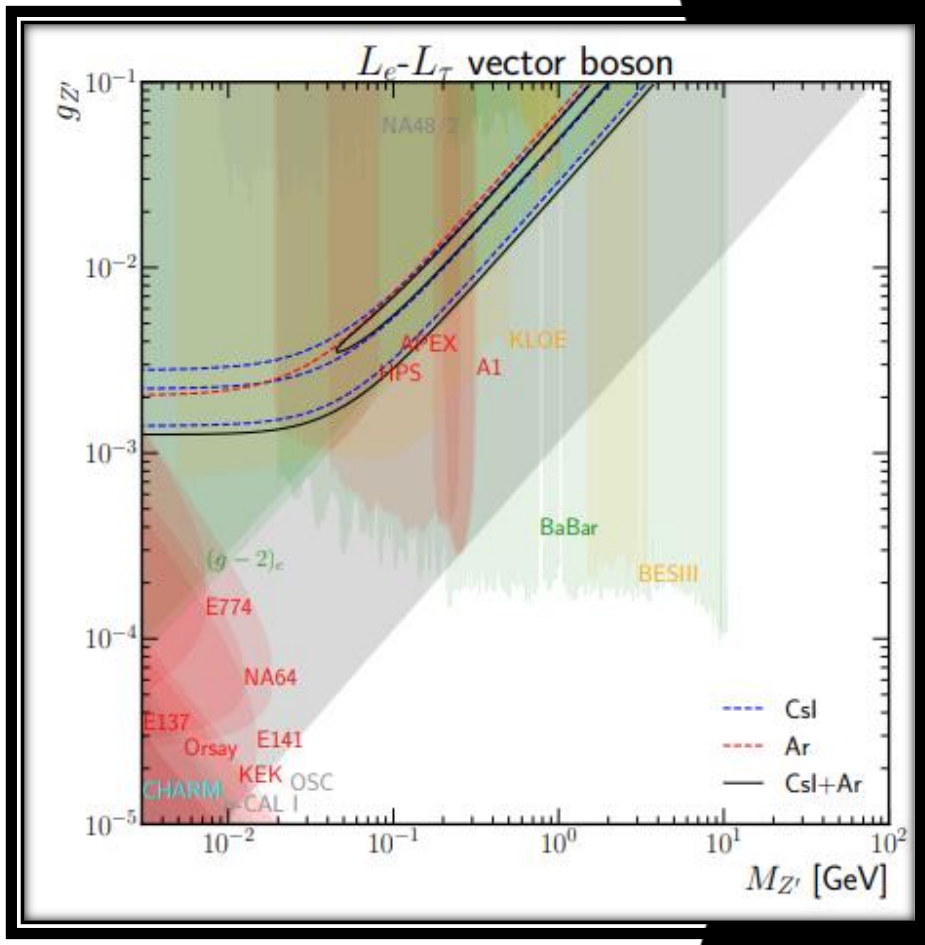




$L_e - L_\mu$

- No Improved constraints
- $(g-2)_\mu$ excluded

$L_e - L_\tau$

- No Improved constraints
- No possible explanation explanation of $(g-2)_\mu$

Summary of constraints

2 σ constraints for the low and high mass approximations

- Low mass $\propto g'$
- High mass $\propto g'/M$

10.1007/JHEP05(2022)109

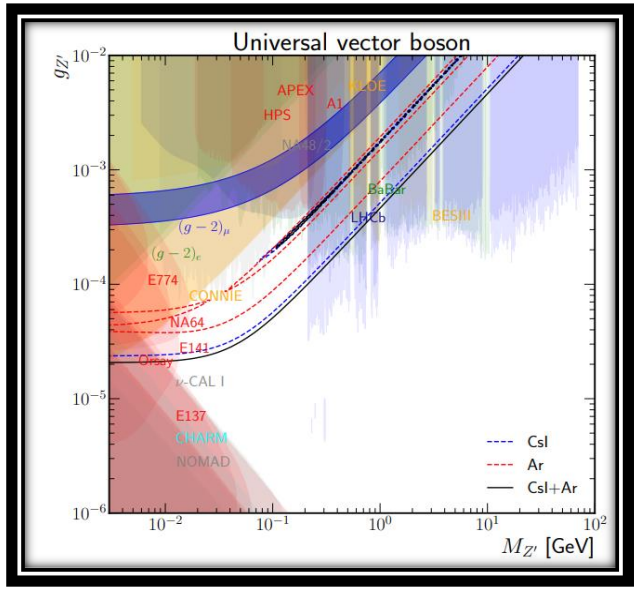
model	Ar		CsI		CsI+Ar	
	$g_{Z'}$(low $M_{Z'}$)	$\frac{g_{Z'}}{M_{Z'}}$(high $M_{Z'}$)	$g_{Z'}$(low $M_{Z'}$)	$\frac{g_{Z'}}{M_{Z'}}$(high $M_{Z'}$)	$g_{Z'}$(low $M_{Z'}$)	$\frac{g_{Z'}}{M_{Z'}}$(high $M_{Z'}$)
universal	3.91×10^{-5}	0.82×10^{-3}	2.36×10^{-5}	0.53×10^{-3}	2.07×10^{-5}	0.48×10^{-3}
$B-L$	5.35×10^{-5}	1.67×10^{-3}	5.27×10^{-5}	1.00×10^{-3}	4.42×10^{-5}	0.99×10^{-3}
$B_y + L_\mu + L_\tau$	10.4×10^{-5}	3.58×10^{-3}	4.97×10^{-5}	1.14×10^{-3}	4.47×10^{-5}	1.04×10^{-3}
$B-3L_e$	4.91×10^{-5}	1.55×10^{-3}	5.16×10^{-5}	0.96×10^{-3}	4.34×10^{-5}	0.95×10^{-3}
$B-3L_\mu$	3.45×10^{-5}	1.09×10^{-3}	3.21×10^{-5}	0.64×10^{-3}	2.76×10^{-5}	0.63×10^{-3}
$B-2L_e-L_\mu$	4.62×10^{-5}	1.48×10^{-3}	4.79×10^{-5}	0.89×10^{-3}	3.95×10^{-5}	0.88×10^{-3}
$B-L_e-2L_\mu$	3.97×10^{-5}	1.28×10^{-3}	3.86×10^{-5}	0.75×10^{-3}	3.26×10^{-5}	0.74×10^{-3}
L_e-L_μ	161×10^{-5}	54.2×10^{-3}	166×10^{-5}	36.1×10^{-3}	137×10^{-5}	34.9×10^{-3}
L_e-L_τ	204×10^{-5}	71.1×10^{-3}	140×10^{-5}	29.9×10^{-3}	125×10^{-5}	26.6×10^{-3}
$L_\mu-L_\tau$	234×10^{-5}	80.9×10^{-3}	116×10^{-5}	26.6×10^{-3}	103×10^{-5}	24.2×10^{-3}
	$\tilde{g}_\phi$(low M_ϕ)	$\frac{\tilde{g}_\phi}{M_\phi}$(high M_ϕ)	$\tilde{g}_\phi$(low M_ϕ)	$\frac{\tilde{g}_\phi}{M_\phi}$(high M_ϕ)	$\tilde{g}_\phi$(low M_ϕ)	$\frac{\tilde{g}_\phi}{M_\phi}$(high M_ϕ)
scalar	2.30×10^{-5}	0.58×10^{-3}	1.80×10^{-5}	0.31×10^{-3}	1.68×10^{-5}	0.30×10^{-3}

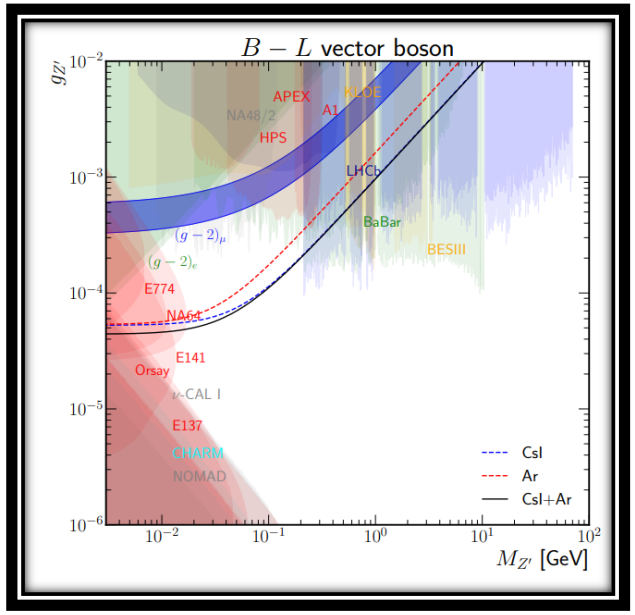
TABLE II. The 2σ (95.45% C.L.) upper bounds on the coupling of the new boson mediator obtained from the separate and combined analyses of the Ar and CsI COHERENT CEνNS data for low and high values of the boson mass in the models considered in this paper. $g_{Z'}/M_{Z'}$ and $\tilde{g}_\phi/M_\phi$ are in units of GeV^{-1}.

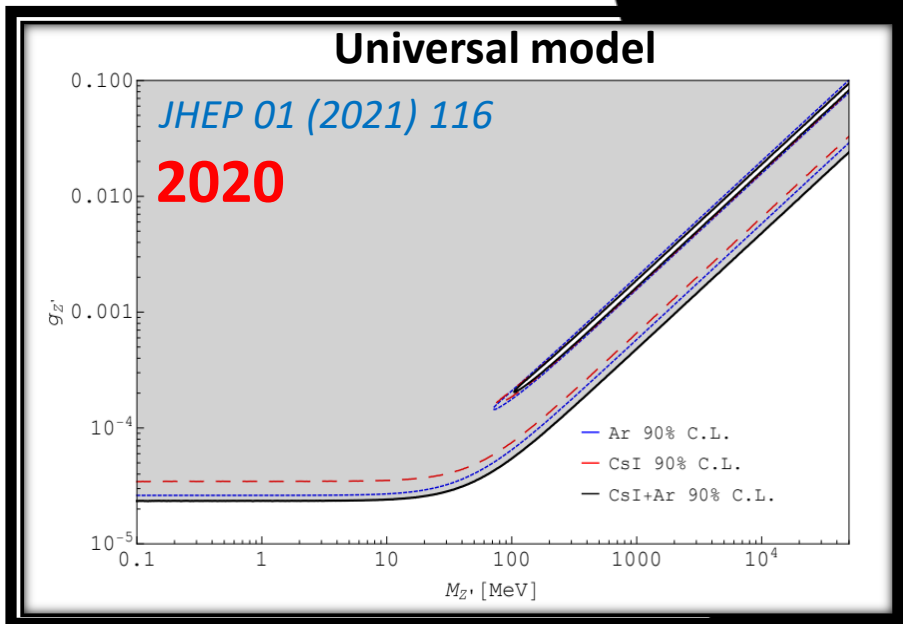
Comparison with previous constraints

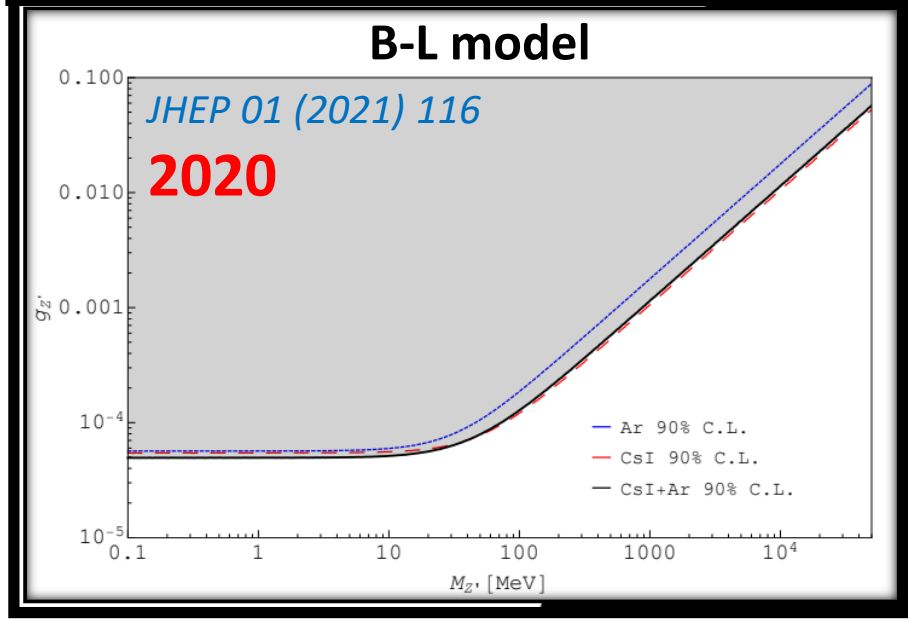
Here we compare the limits discussed in this talk with those obtained in *JHEP* 01 (2021) 116 combined LAr and the first CsI data release.

This talk

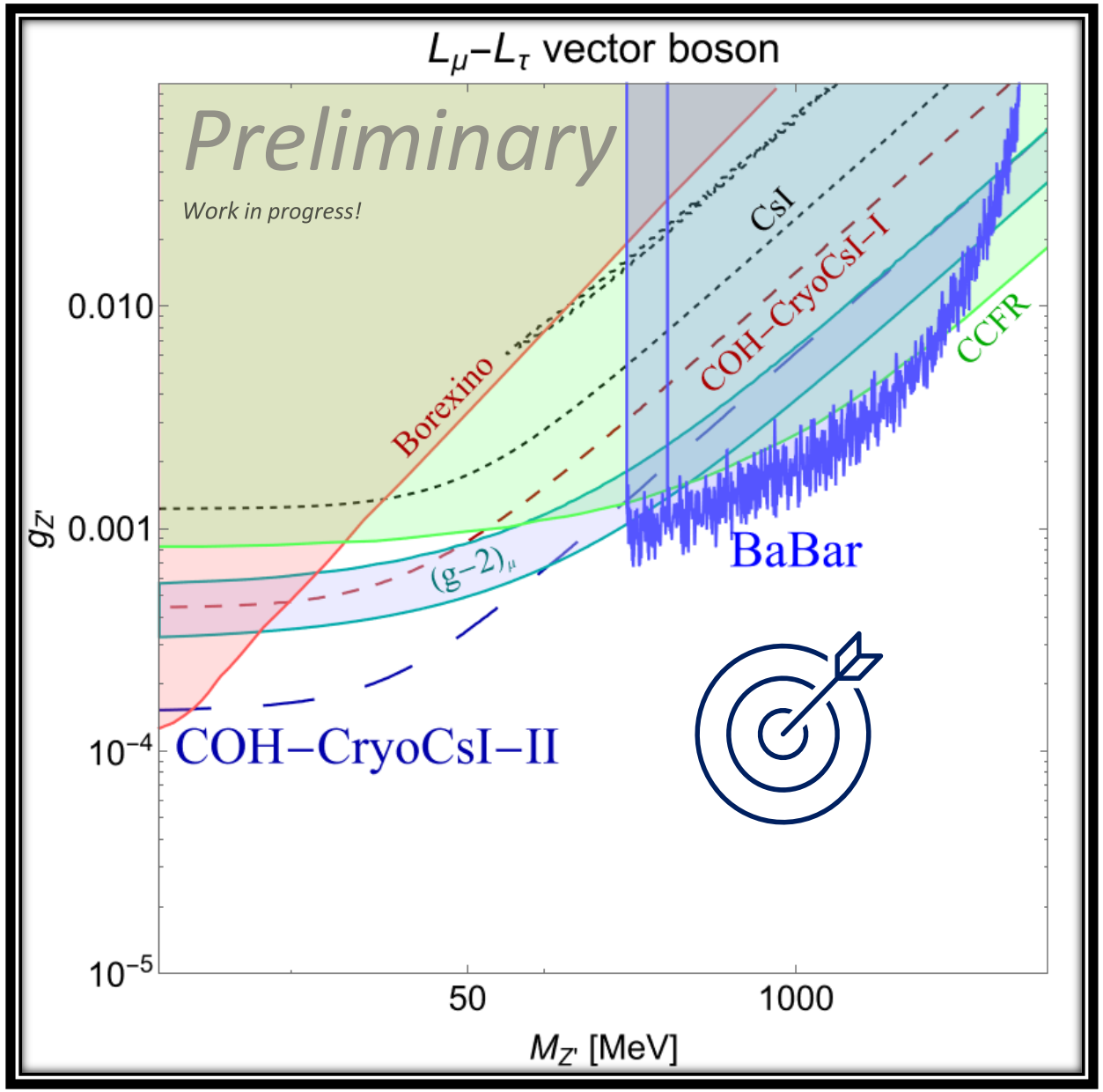








Future perspectives



Upgrade of the SNS in 2025 and 2030

- Proton beam energy $E_p = 1.3$ GeV (wrt $E_p = 0.984$ GeV)
- Beam power $P_{\text{beam}} = 2$ MW (wrt $P_{\text{beam}} = 1.4$ MW) in 2025 and $P_{\text{beam}} = 2.8$ MW
- D_2O detector will allow to measure neutrino flux. The statistical uncertainty will approach **4.7(2)%** after **2(5)** SNS-years of operation

The COHERENT Experimental Program arXiv:2204.04575

$$N_{\text{POT}} = t_{\text{exp}} \frac{P_{\text{beam}}}{E_p}$$

Cryo-CsI-I detector

- Threshold 1.4 keV_{nr}
- Mass ~ 10 kg
- 3 years of data taking
- Will explore **an interesting region** of the parameter space!

Cryo-CsI-II detector

- Threshold 1.4 keV_{nr}
- Mass ~ 700 kg
- 3 years of data taking
- **Will almost completely exclude or confirm $L_\mu - L_\tau$!**