HEP, HEP-06

Charged Lepton Flavour Violation

- searching for indirect signals of new physics

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- searching for indirect signals of new physics

Yoshitaka Kuno
Department of Physics
Osaka University

2019 Joint workshop of
TYL /FJPPL and FKPPL
Jeju, Korea
May 10th, 2018

HEP, HEP-06
Charged Lepton Flavour Violation
- searching for indirect signals of new physics

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Outline

- Aim
- People
- Highlights
- Plan 2019-2020

People

- French side
  - Sacha DAVIDSON (LUPM)
  - Ana M. TEIXEIRA (LPC)
  - Albert SAPORTA (IPNL)
  - Chandan HAITI (LPC)
  - Jonathan KRIEWALD (LPC)
- Japanese side
  - Yoshitaka KUNO (Osaka)
  - Joe SATO (Saitama)
  - Masato Yamanaka (Osaka City)
  - Yuichi Uesaka (Saitama)

Thanks

We thank the committee for the budget that our French team obtained in 2018.

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Ana Teixeira visited Saitama U., J-PARC and Osaka U. to discuss the next projects.

Charged Lepton Flavour Violation (CLFV)

μ→e Conversion

μ→e Conversion

Lepton flavour

	electron number	muon number	tau number
e generation	1	0	0
μ generation	0	1	0
τ generation	0	0	1

μ→e Conversion

Lepton flavour

	electron number	muon number	tau number
e generation	1	0	0
μ generation	0	1	0
τ generation	0	0	1

muon to electron conversion in a muonic atom

$$\mu^- + N \to e^- + N$$

(CLFV = charged lepton flavour violation)

Why CLFV?

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Neutral lepton flavour violation has been observed.

Lepton mixing in the SM has been known.

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Lepton mixing in the SM has been known.

Why CLFV ?

SM Contribution of Lepton Mixing to CLFV

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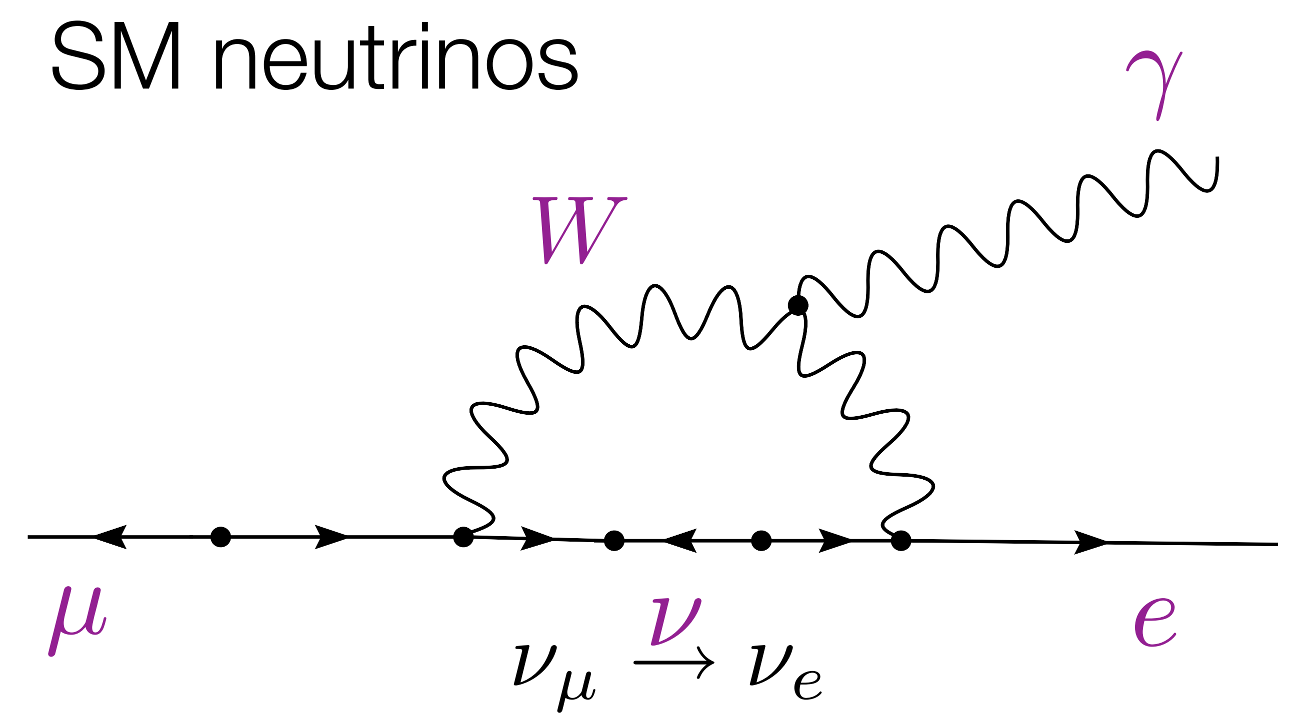
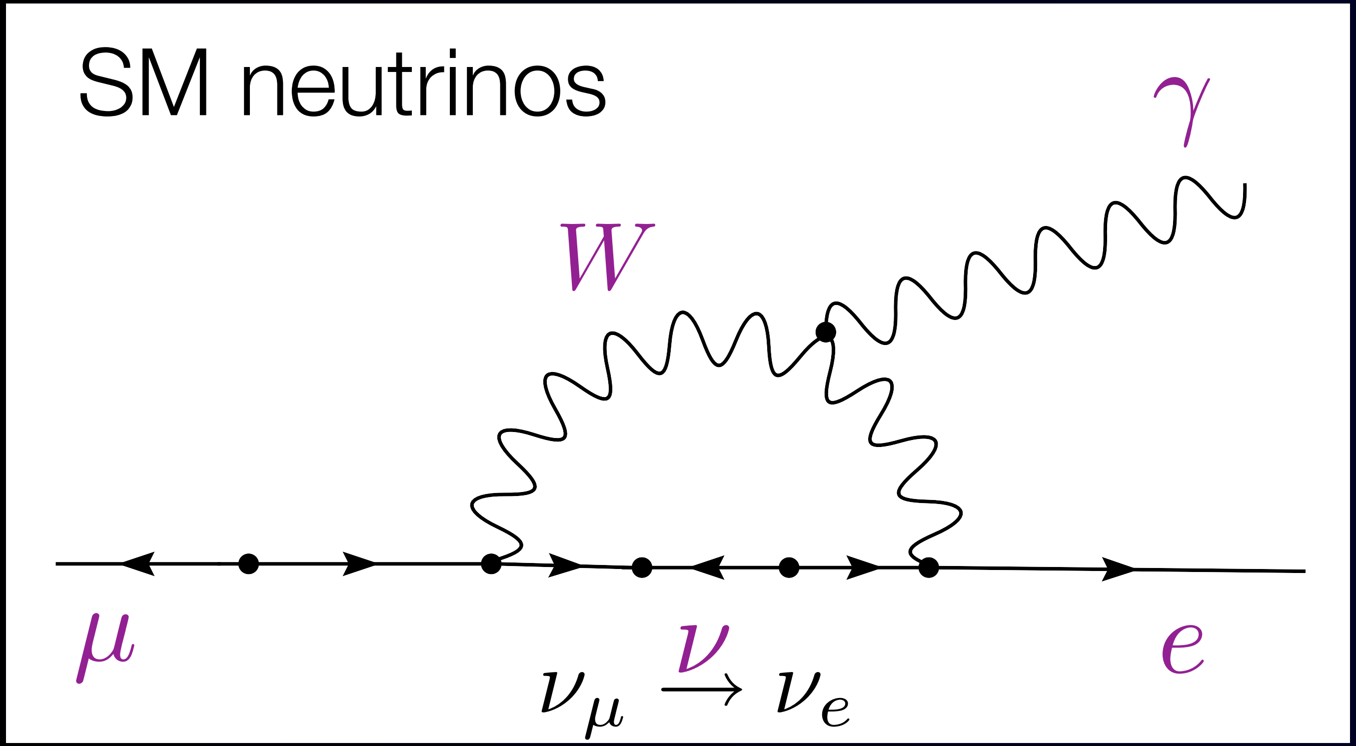


$$B(\mu \to e\gamma) = \frac{3\alpha}{32\pi}\left|\sum_l (V_{MNS})^*_{\mu l}(V_{MNS})_{el}\frac{m^2_{\nu_l}}{M^2_W}\right|^2$$

S.T. Petcov, Sov.J. Nucl. Phys. 25 (1977) 340

SM Contribution of Lepton Mixing to CLFV



BR~O(10^{-54})

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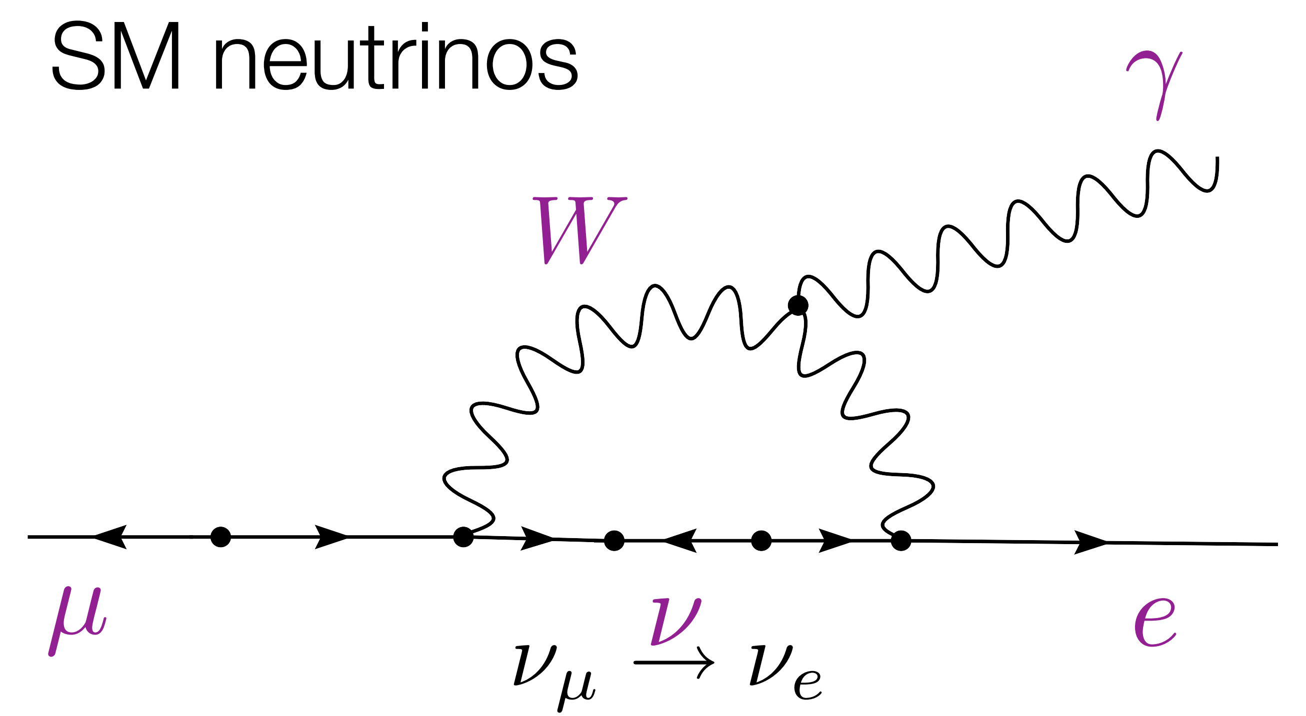
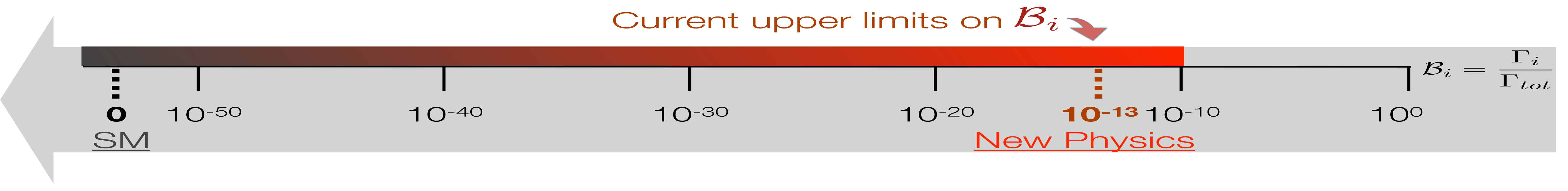
SM Contribution of Lepton Mixing to CLFV


SM neutrinos

BR~O(10^{-54})

$$B(\mu \to e\gamma) = \frac{3\alpha}{32\pi}\left|\sum_{l}(V_{MNS})^{*}_{\mu l}(V_{MNS})_{el}\frac{m^2_{\nu_l}}{M^2_W}\right|^2$$

S.T. Petcov, Sov.J. Nucl. Phys. 25 (1977) 340



Search for
New Physics Beyond the SM

Search for
New Physics Beyond the SM

Effective Field Theory Approach

$$\mathscr{L}_{eff} = \mathscr{L}_{\mathrm{SM}} + \sum_{d>4} \frac{C^{(d)}}{\Lambda^{d-4}}$$

Λ is the energy scale of new physics
$C^{(d)}$ is the coupling constant.

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New Physics Beyond the SM

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$C^{(d)}$ is the coupling constant.

from $\mathrm{BR}(\mu \rightarrow e\gamma) < 4.2\times10^{-13}$

$$\frac{C^6}{\Lambda^2}\mathscr{O}^6 \rightarrow \frac{C^6}{\Lambda^2}\bar{e}_L\sigma^{\rho\nu}\mu_R\Phi F_{\rho\nu}$$

⇨

$$\Lambda \sim \mathscr{O}(10^3)\ \mathrm{TeV}$$

Search for New Physics Beyond the SM

Effective Field Theory Approach

$$\mathscr{L}_{eff} = \mathscr{L}_{\mathrm{SM}} + \sum_{d>4} \frac{C^{(d)}}{\Lambda^{d-4}}$$

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Future planned improvements by an additional factor of 10,000 would probe

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Future planned improvements by an additional factor of 10,000 would probe $\Lambda \sim \mathscr{O}(10^4)\ \mathrm{TeV}$

sensitive to high energy scale that accelerators cannot reach!

Future Experimental Prospects

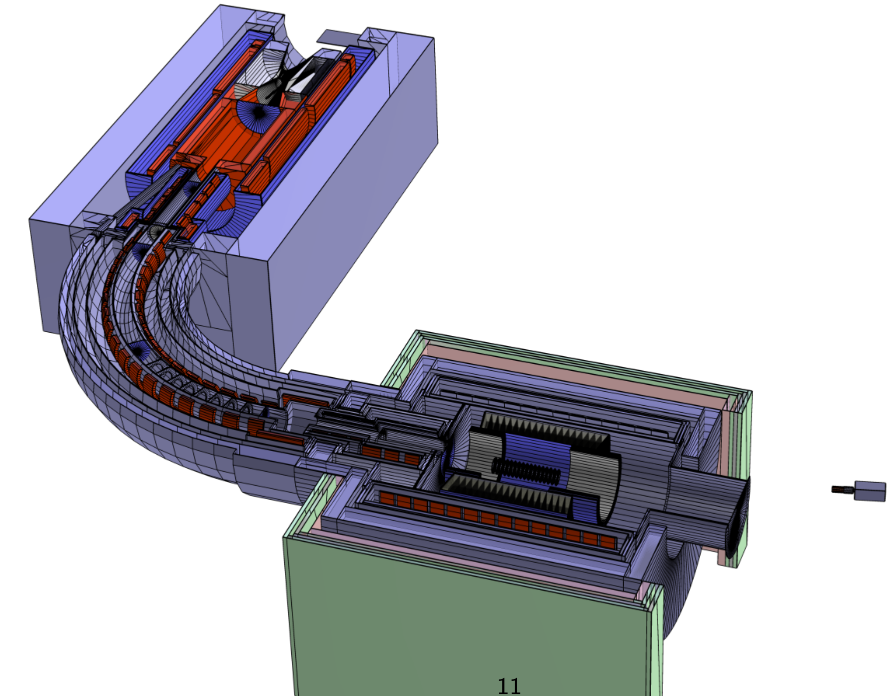
next talk!

Future Experimental Prospects

next talk!

Sensitivity:
X100

COMET
Phase-I



Future Experimental Prospects

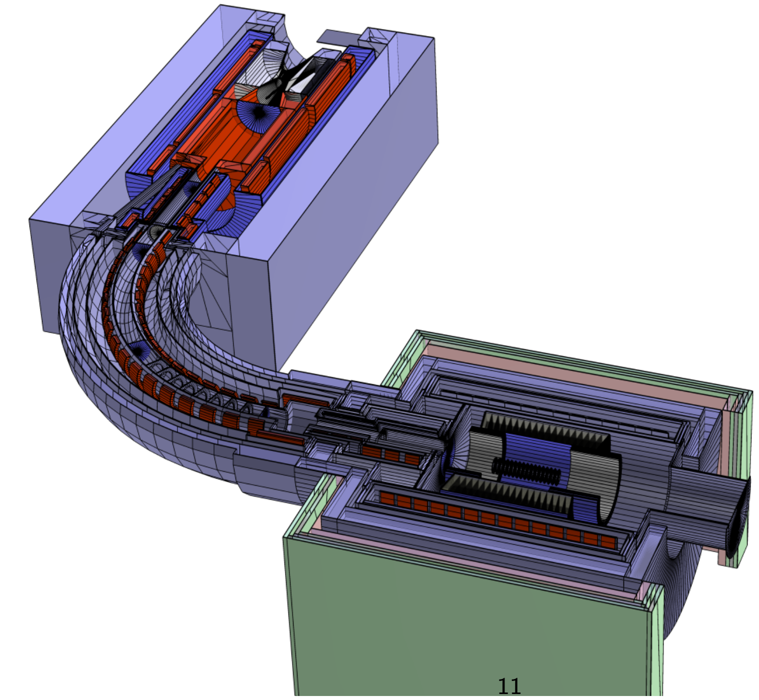
next talk!

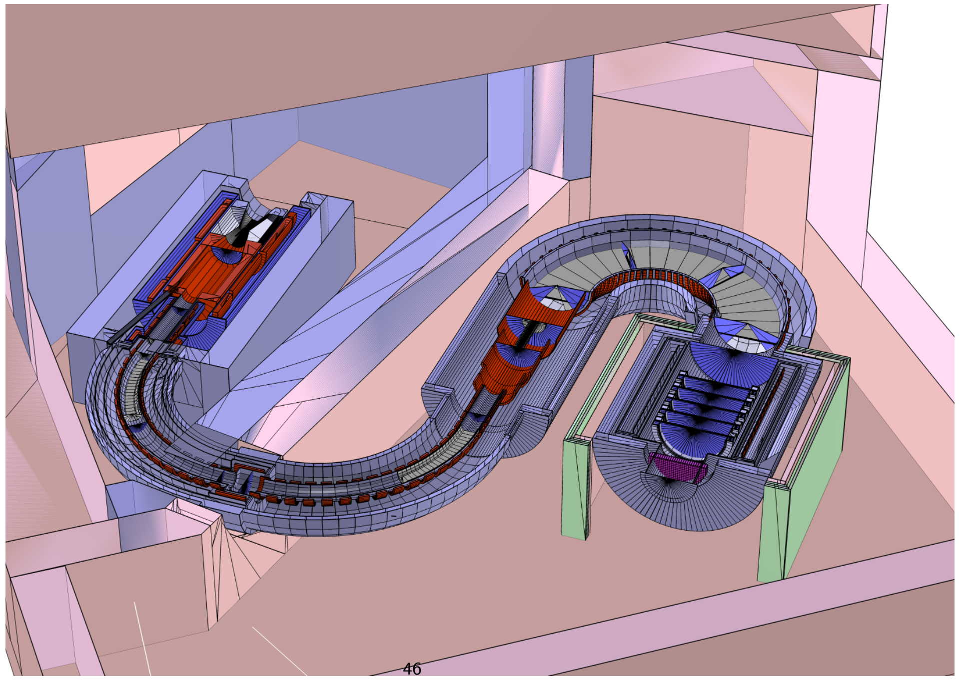
Sensitivity:
X100

COMET
Phase-I

Sensitivity:
X100,000

COMET
Phase-II





Future Experimental Prospects

next talk!

Sensitivity:
X100

COMET
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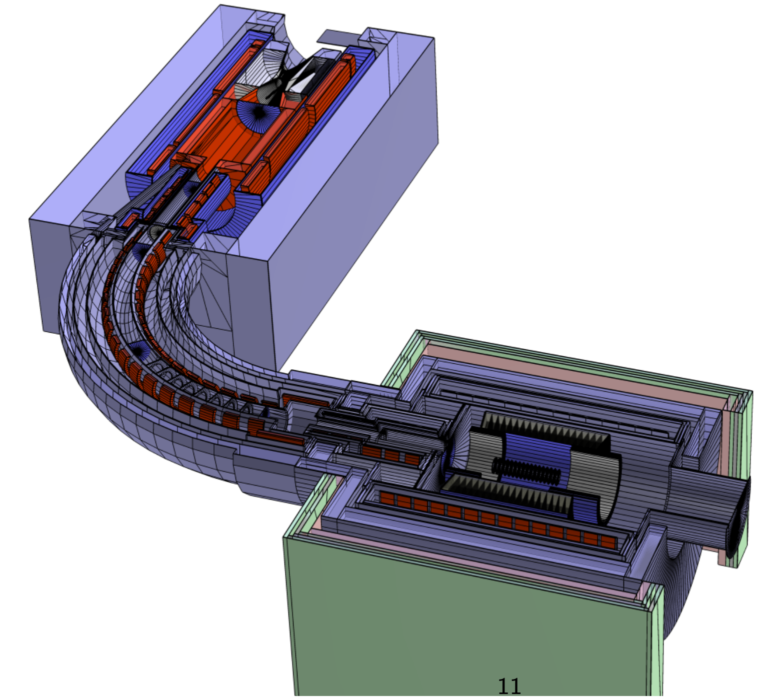
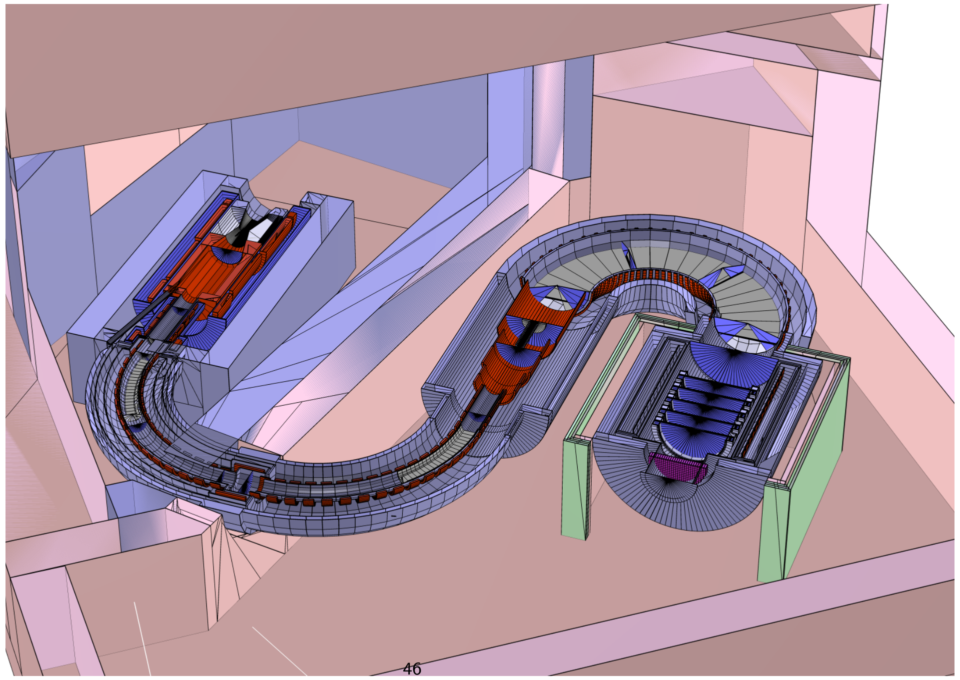


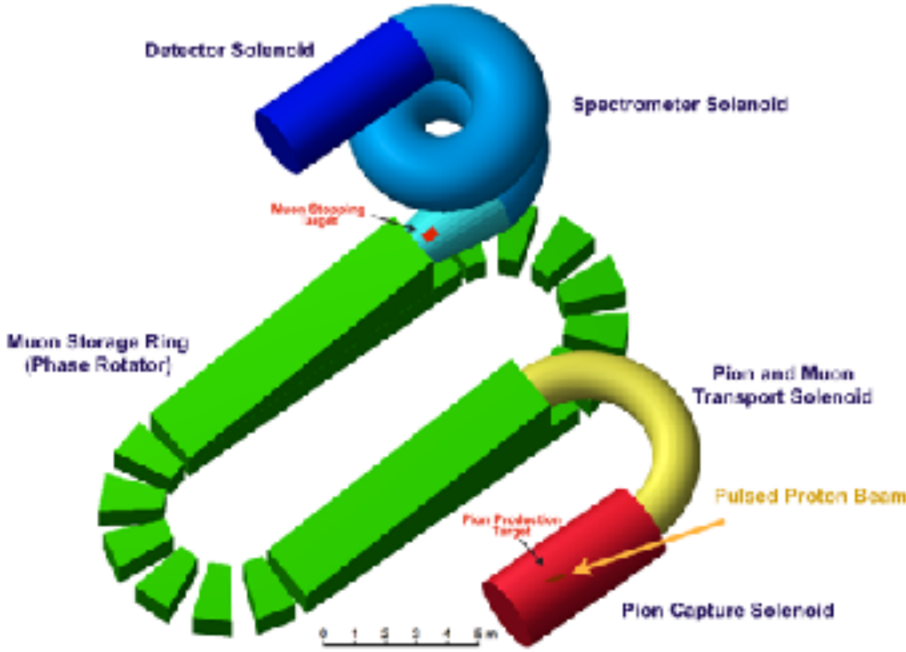
Sensitivity:
X100,000

COMET
Phase-II



Sensitivity:
X1,000,000

PRISM/PRIME



Highlights

EFT approach for μ→e conversion

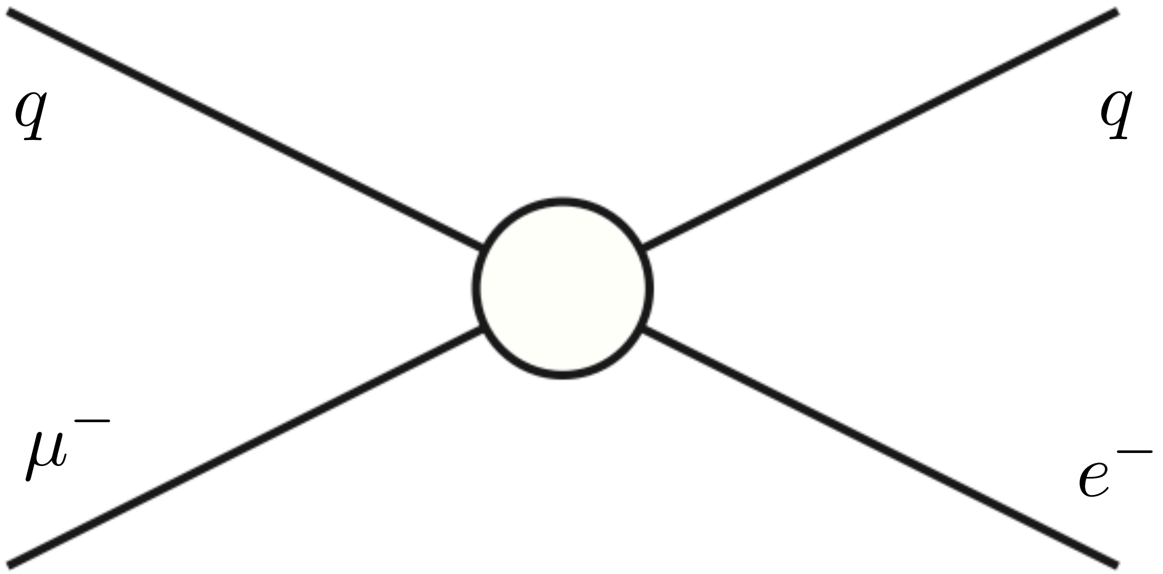
EFT approach for μ→e conversion

$$\mu^- + q \to e^- + q$$

EFT approach for μ→e conversion

$$\mu^- + q \to e^- + q$$

contact interaction



$$(\overline{e}\Gamma P_Y \mu)(\overline{q}\Gamma q) \quad , \quad q \in \{u, d, s\}$$

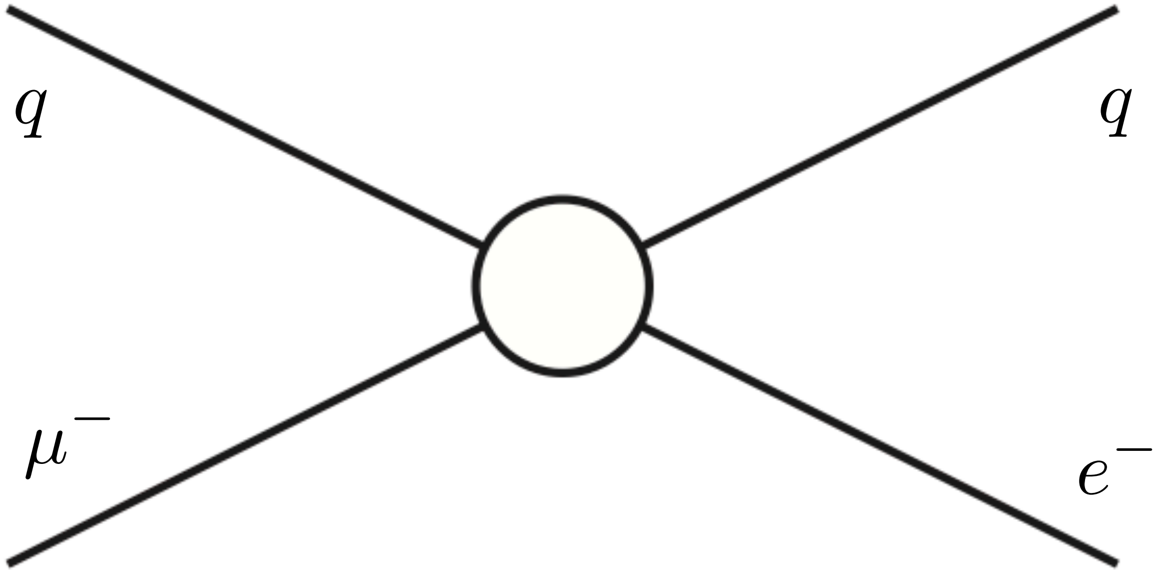
$$\Gamma = \{I, \gamma_5, \gamma, \gamma\gamma_5, \sigma\}$$

S, P, V, A, T

EFT approach for μ→e conversion

$$\mu^- + q \to e^- + q$$

contact interaction



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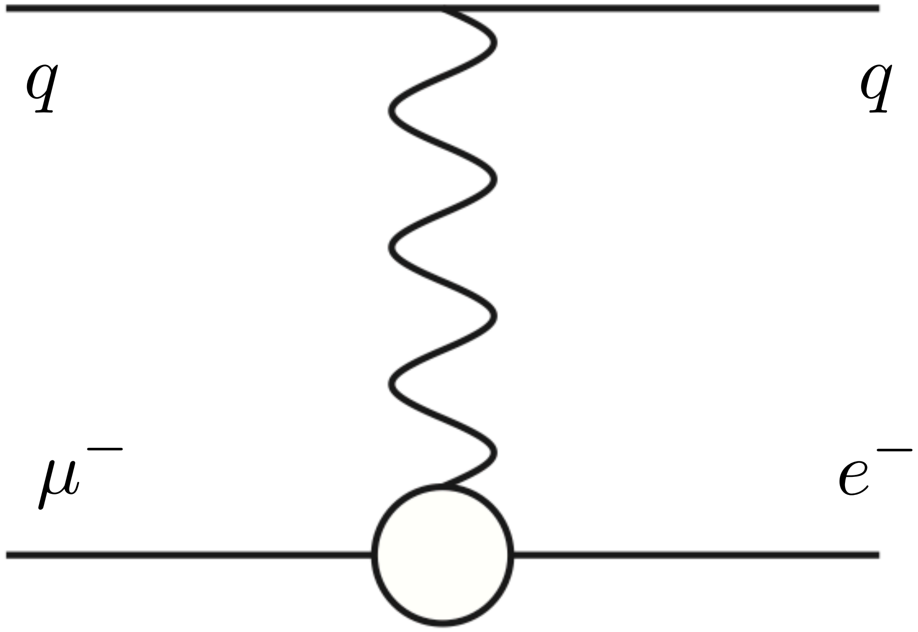
S, P, V, A, T

dipole interaction



dipole (D)

Effective Field Theory for μ→e Conversion

two-lepton and two nucleon operators and dipole operators

$$
\begin{aligned}
& \mathcal{L}_{\mu A\to eA}(\Lambda_{expt}) = -\frac{4G_F}{\sqrt{2}}\sum_{N=p,n}\Big[m_\mu\left(C_{DL}\overline{e_R}\sigma^{\alpha\beta}\mu_L F_{\alpha\beta}+C_{DR}\overline{e_L}\sigma^{\alpha\beta}\mu_R F_{\alpha\beta}\right) && \text{dipole}\\
& \text{scalar} \quad +\left(\widetilde{C}_{SL}^{(NN)}\overline{e}P_L\mu+\widetilde{C}_{SR}^{(NN)}\overline{e}P_R\mu\right)\overline{N}N \\
& \text{pseudo-scalar} \quad +\left(\widetilde{C}_{P,L}^{(NN)}\overline{e}P_L\mu+\widetilde{C}_{P,R}^{(NN)}\overline{e}P_R\mu\right)\overline{N}\gamma_5 N \\
& \text{vector} \quad +\left(\widetilde{C}_{VL}^{(NN)}\overline{e}\gamma^\alpha P_L\mu+\widetilde{C}_{VR}^{(NN)}\overline{e}\gamma^\alpha P_R\mu\right)\overline{N}\gamma_\alpha N \\
& \text{axial-vector} \quad +\left(\widetilde{C}_{A,L}^{(NN)}\overline{e}\gamma^\alpha P_L\mu+\widetilde{C}_{A,R}^{(NN)}\overline{e}\gamma^\alpha P_R\mu\right)\overline{N}\gamma_\alpha\gamma_5 N \\
& \text{(derivative)} \quad +\left(\widetilde{C}_{Der,L}^{(NN)}\overline{e}\gamma^\alpha P_L\mu+\widetilde{C}_{Der,R}^{(NN)}\overline{e}\gamma^\alpha P_R\mu\right)i(\overline{N}\overleftrightarrow{\partial}_\alpha\gamma_5 N) \\
& \text{tensor} \quad +\left(\widetilde{C}_{T,L}^{(NN)}\overline{e}\sigma^{\alpha\beta}P_L\mu+\widetilde{C}_{T,R}^{(NN)}\overline{e}\sigma^{\alpha\beta}P_R\mu\right)\overline{N}\sigma_{\alpha\beta}N+h.c.\Big] \quad .
\end{aligned}
$$

Effective Field Theory for μ→e Conversion

two-lepton and two nucleon operators and dipole operators

$$
\begin{aligned}
& \mathcal{L}_{\mu A\to eA}(\Lambda_{expt}) && = -\frac{4G_F}{\sqrt{2}}\sum_{N=p,n}\Big[m_\mu\left(C_{DL}\overline{e_R}\sigma^{\alpha\beta}\mu_L F_{\alpha\beta}+C_{DR}\overline{e_L}\sigma^{\alpha\beta}\mu_R F_{\alpha\beta}\right) \quad \text{dipole} \\
& \text{scalar} && + \left(\widetilde{C}^{(NN)}_{SL}\bar{e}P_L\mu+\widetilde{C}^{(NN)}_{SR}\bar{e}P_R\mu\right)\overline{N}N \\
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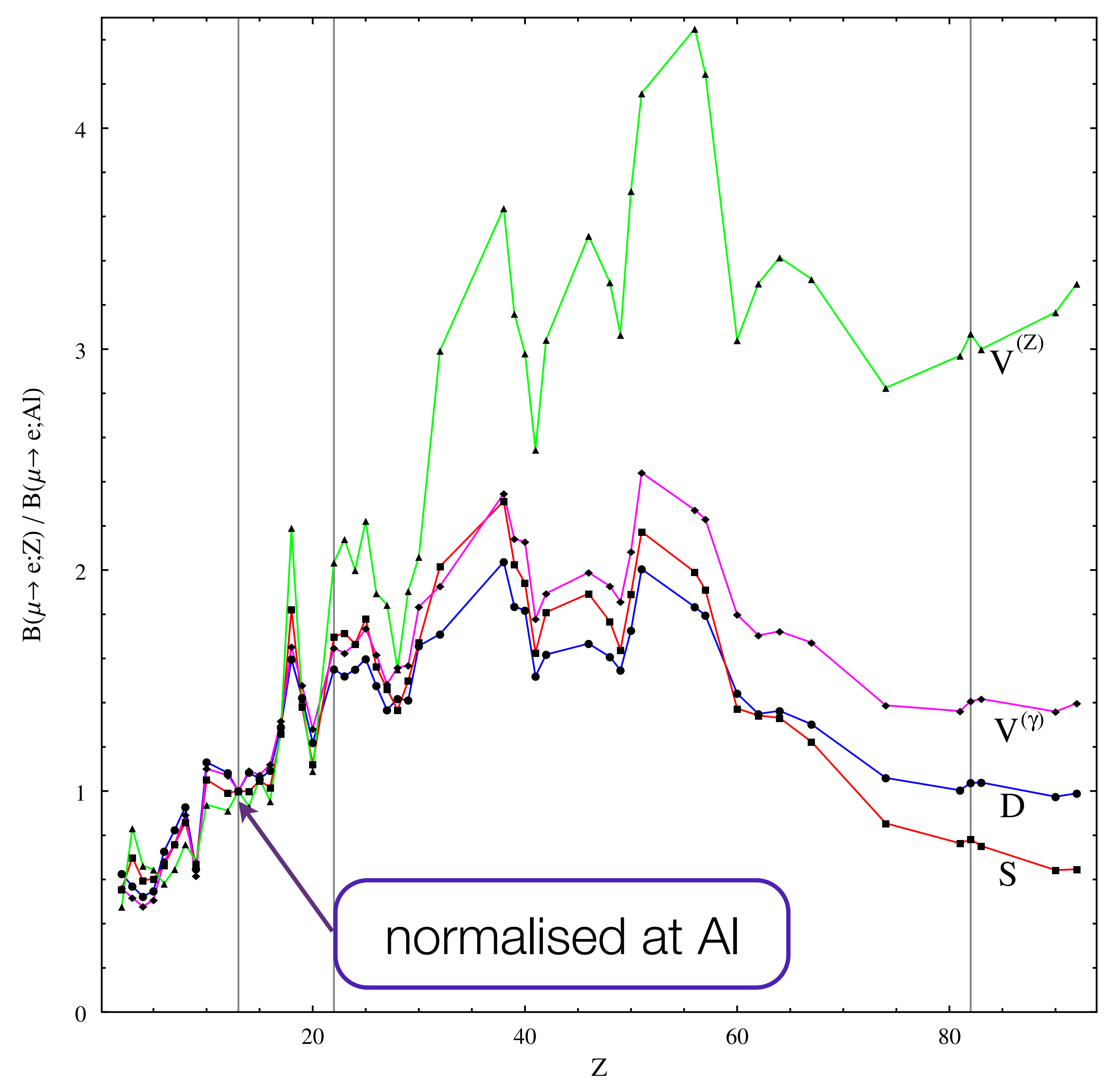
& \text{tensor} && + \left(\widetilde{C}^{(NN)}_{T,L}\bar{e}\sigma^{\alpha\beta}P_L\mu+\widetilde{C}^{(NN)}_{T,R}\bar{e}\sigma^{\alpha\beta}P_R\mu\right)\overline{N}\sigma_{\alpha\beta}N+h.c.\Big] \quad .
\end{aligned}
$$

22 coeff. = 2 (dipole) + 2 (left/right) x 2 (proton/neutron) x 5 (interaction)

Discrimination of the interactions by different targets



normalised at Al

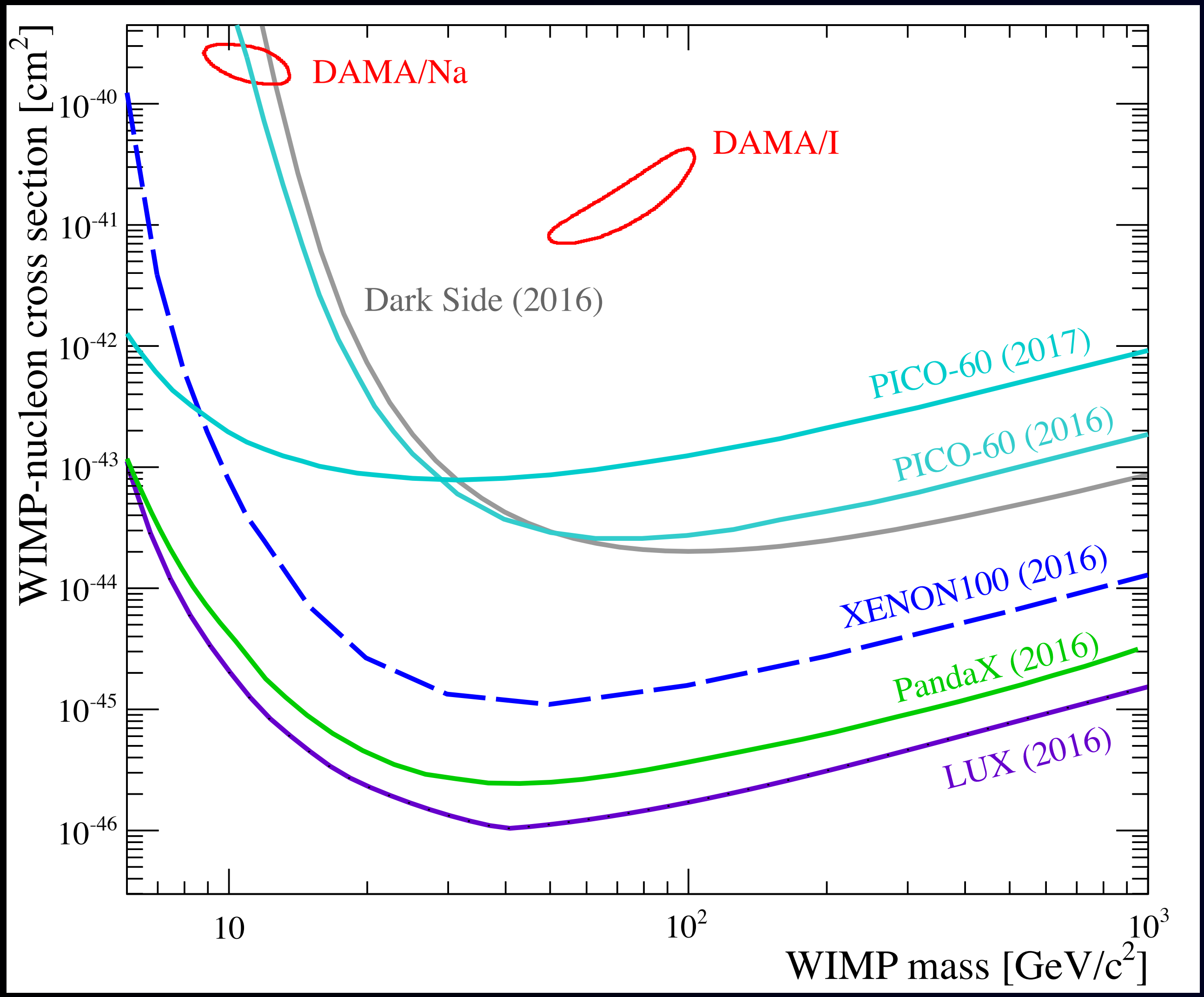
vector interaction (with Z boson)	with Z penguin
vector interaction (with photon - charge radius)	left-right models
dipole interaction	SUSY-GUT
scalar interaction	SUSY seesaw

R. Kitano, M. Koike and Y. Okada, Phys.Rev. D66 (2002) 096002; D76 (2007) 059902

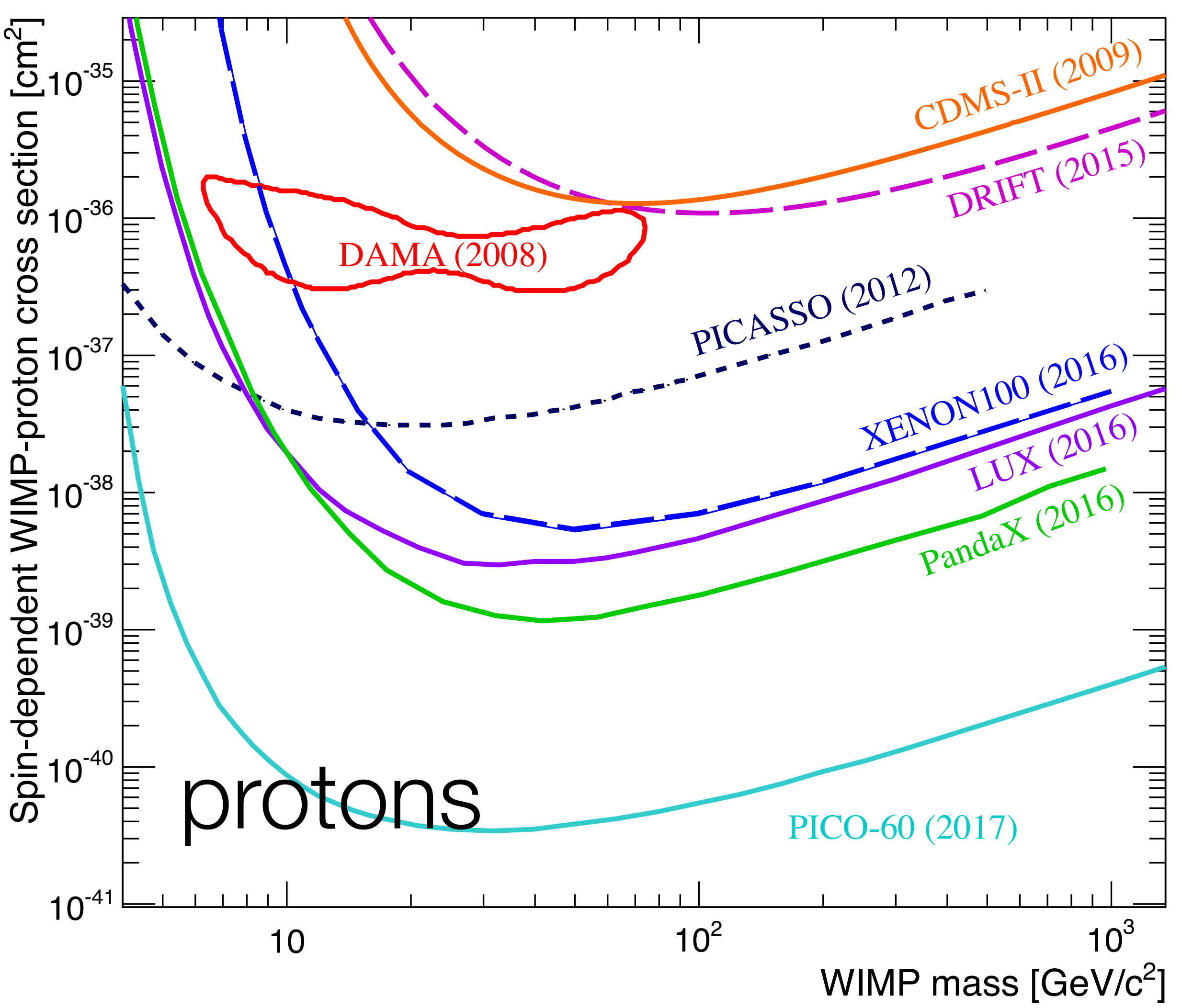
V. Cirigliano, R. Kitano, Y. Okada, and P. Tuzon, Phys. Rev. D80, 013002 (2009)

WINP Searches
Spin-Independent and Spin-dependent

WINP Searches
Spin-Independent and Spin-dependent



spin-independent cross section
scalar, vector interaction



spin-dependent cross section
pseudo-scalar, axial-vector,
tensor interactions

Spin-independent and Spin-dependent μ→e Conversion

Spin-independent and Spin-dependent μ→e Conversion

scalar interaction

vector interaction

dipole interaction

Spin-independent
μ-e Conversion
(coherent)

Spin-independent and Spin-dependent μ→e Conversion

scalar interaction

vector interaction

dipole interaction

Spin-independent
μ-e Conversion
(coherent)

Pseudo-scaler interaction

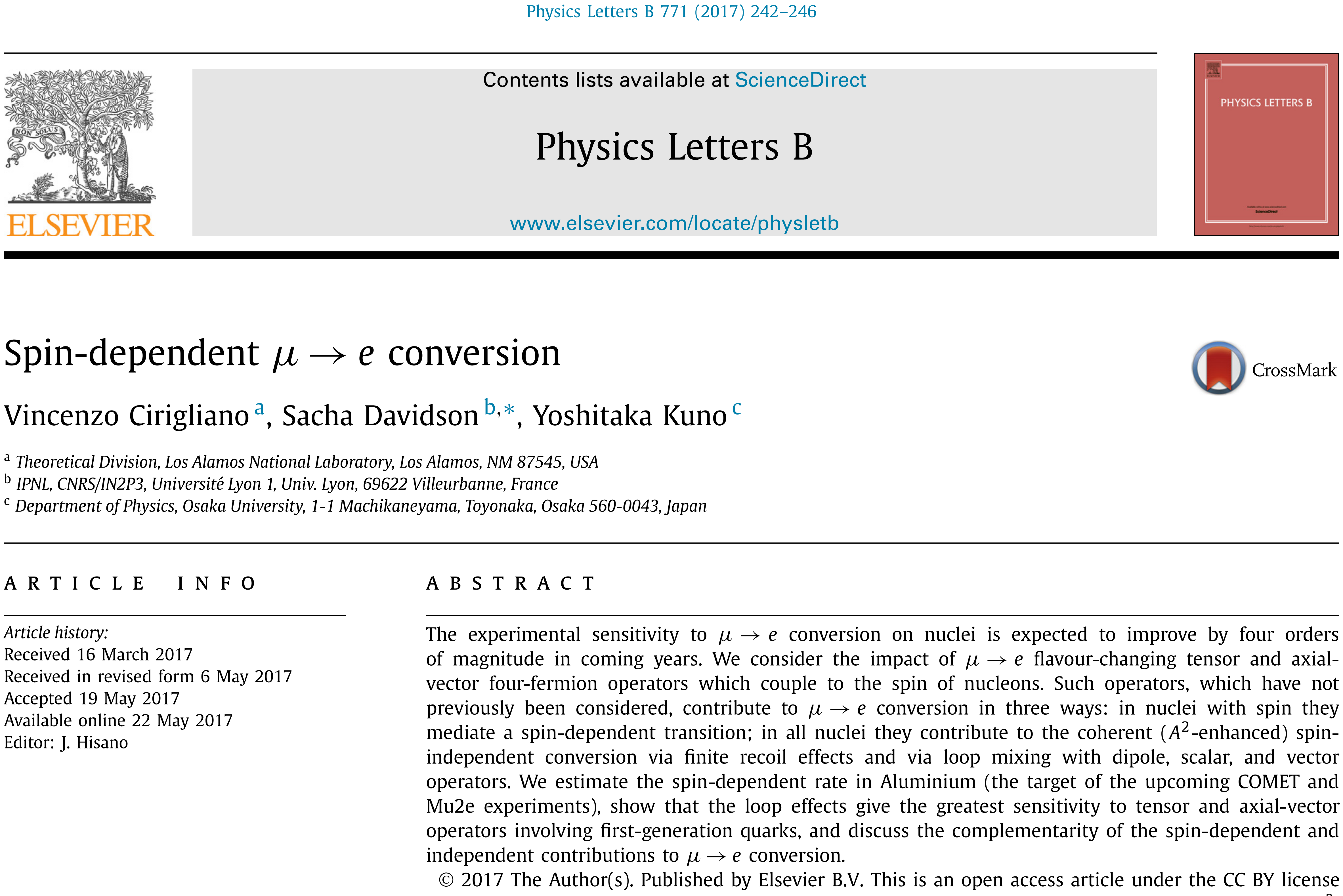
axial vector interaction

tensor interaction

Spin-dependent
μ-e Conversion
(incoherent)

analogy to WINP searches

Publication 1 (2017)



Physics Letters B 771 (2017) 242–246

Contents lists available at ScienceDirect

Physics Letters B

www.elsevier.com/locate/physletb

Spin-dependent $\mu \to e$ conversion

Vincenzo Cirigliano [a], Sacha Davidson [b,*], Yoshitaka Kuno [c]

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[b] *IPNL, CNRS/IN2P3, Université Lyon 1, Univ. Lyon, 69622 Villeurbanne, France*
[c] *Department of Physics, Osaka University, 1-1 Machikaneyama, Toyonaka, Osaka 560-0043, Japan*

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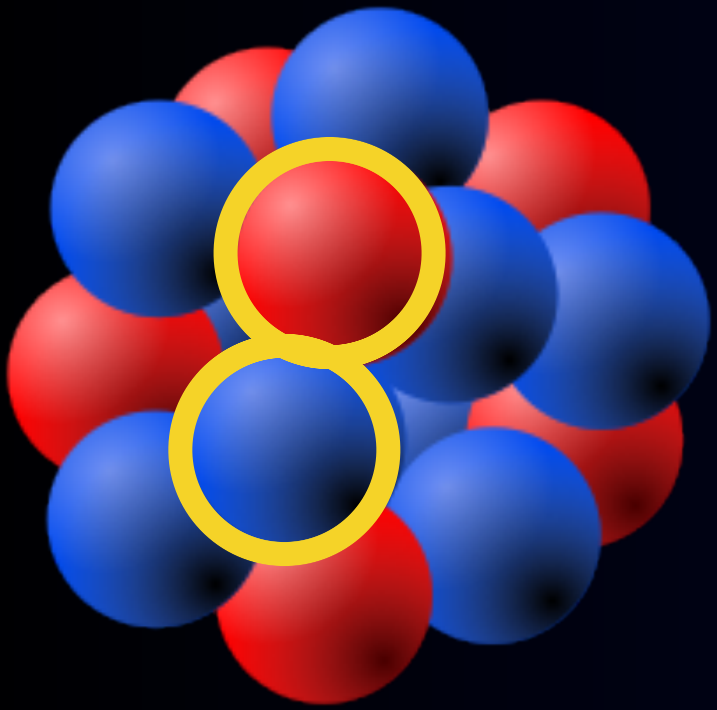
ABSTRACT

The experimental sensitivity to $\mu \to e$ conversion on nuclei is expected to improve by four orders of magnitude in coming years. We consider the impact of $\mu \to e$ flavour-changing tensor and axial-vector four-fermion operators which couple to the spin of nucleons. Such operators, which have not previously been considered, contribute to $\mu \to e$ conversion in three ways: in nuclei with spin they mediate a spin-dependent transition; in all nuclei they contribute to the coherent (A^2-enhanced) spin-independent conversion via finite recoil effects and via loop mixing with dipole, scalar, and vector operators. We estimate the spin-dependent rate in Aluminium (the target of the upcoming COMET and Mu2e experiments), show that the loop effects give the greatest sensitivity to tensor and axial-vector operators involving first-generation quarks, and discuss the complementarity of the spin-dependent and independent contributions to $\mu \to e$ conversion.

Coherent and Incoherent : Pros and Cons

Coherent and Incoherent : Pros and Cons

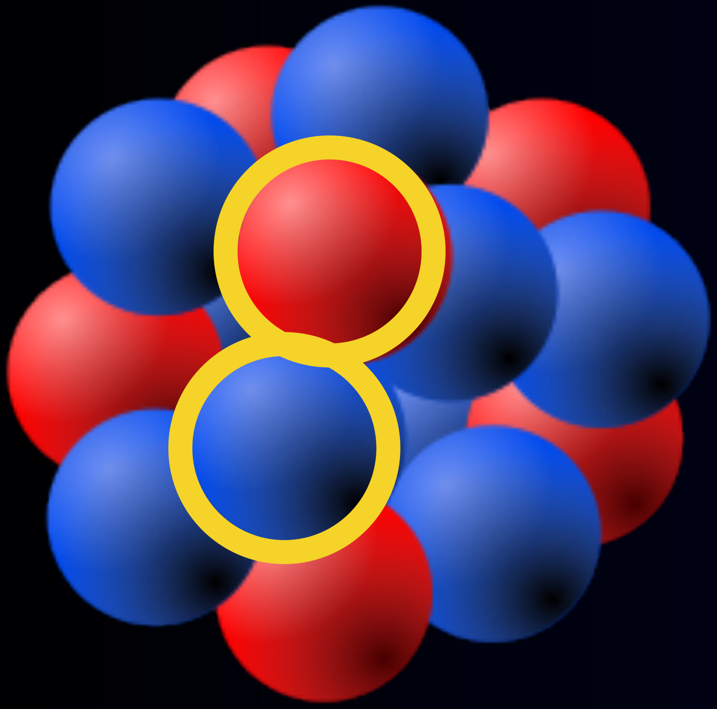
Coherent
μ-e Conversion
(spin independent)



$$|\Sigma_i N_i|^2 \propto A^2$$

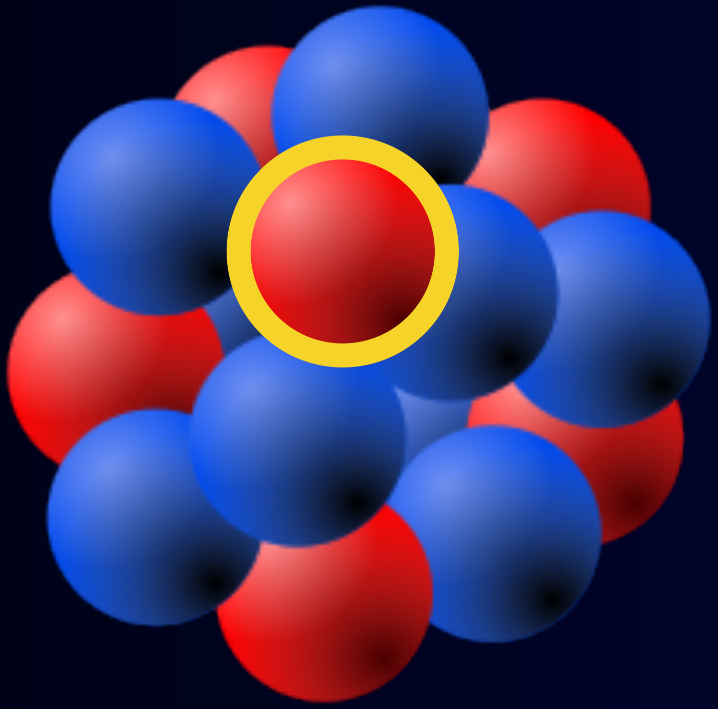
Coherent and Incoherent : Pros and Cons

Coherent
μ-e Conversion
(spin independent)



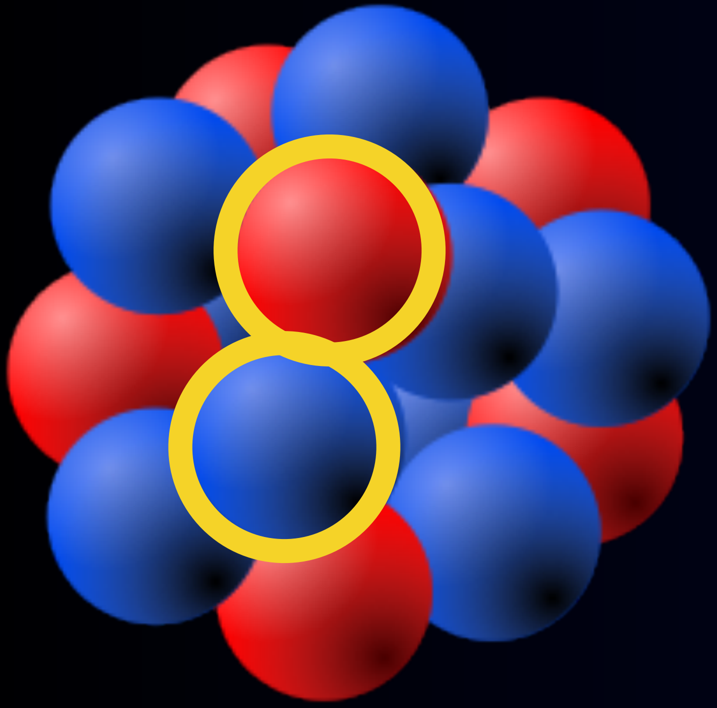
$$|\Sigma_i N_i|^2 \propto A^2$$

nuclear muon
capture



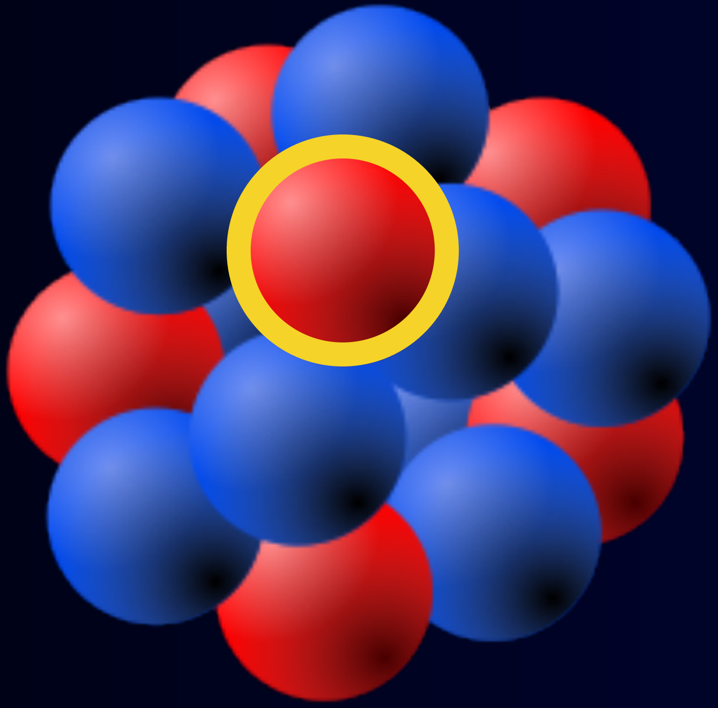
$$\Sigma_i |N_i|^2 \propto Z$$

Coherent and Incoherent : Pros and Cons



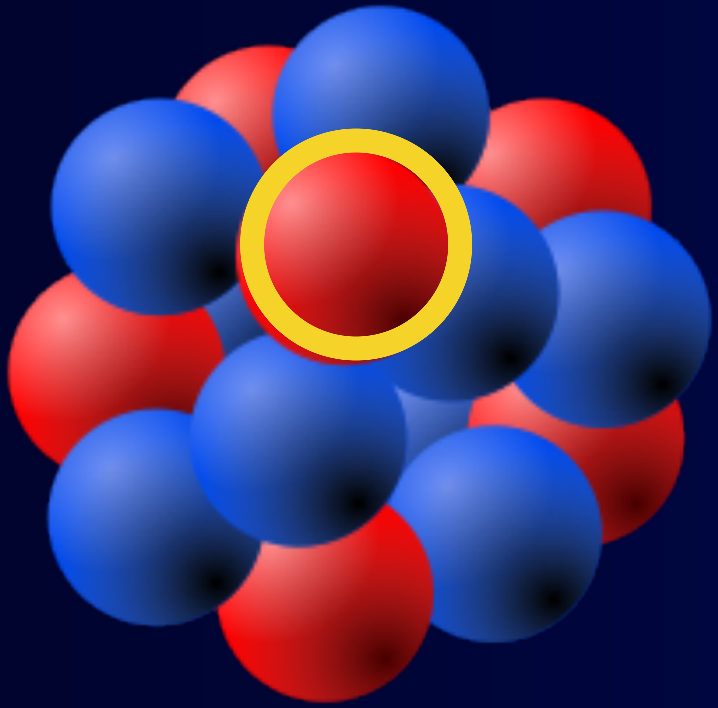
Coherent
μ-e Conversion
(spin independent)

$$|\Sigma_i N_i|^2 \propto A^2$$



nuclear muon
capture

$$\Sigma_i |N_i|^2 \propto Z$$



Incoherent
μ-e Conversion
(spin dependent)

$$|N_i|^2 \propto 1$$

Publication 2 (2018)

Eur. Phys. J. C (2018) 78:109
https://doi.org/10.1140/epjc/s10052-018-5584-8

THE EUROPEAN
PHYSICAL JOURNAL C

CrossMark

Regular Article - Theoretical Physics

“Spin-dependent” $\mu \rightarrow e$ conversion on light nuclei

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[2] Université Claude Bernard Lyon 1, Villeurbanne, France
[3] Université de Lyon, 69622 Lyon, France
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Received: 25 October 2017 / Accepted: 23 January 2018 / Published online: 6 February 2018

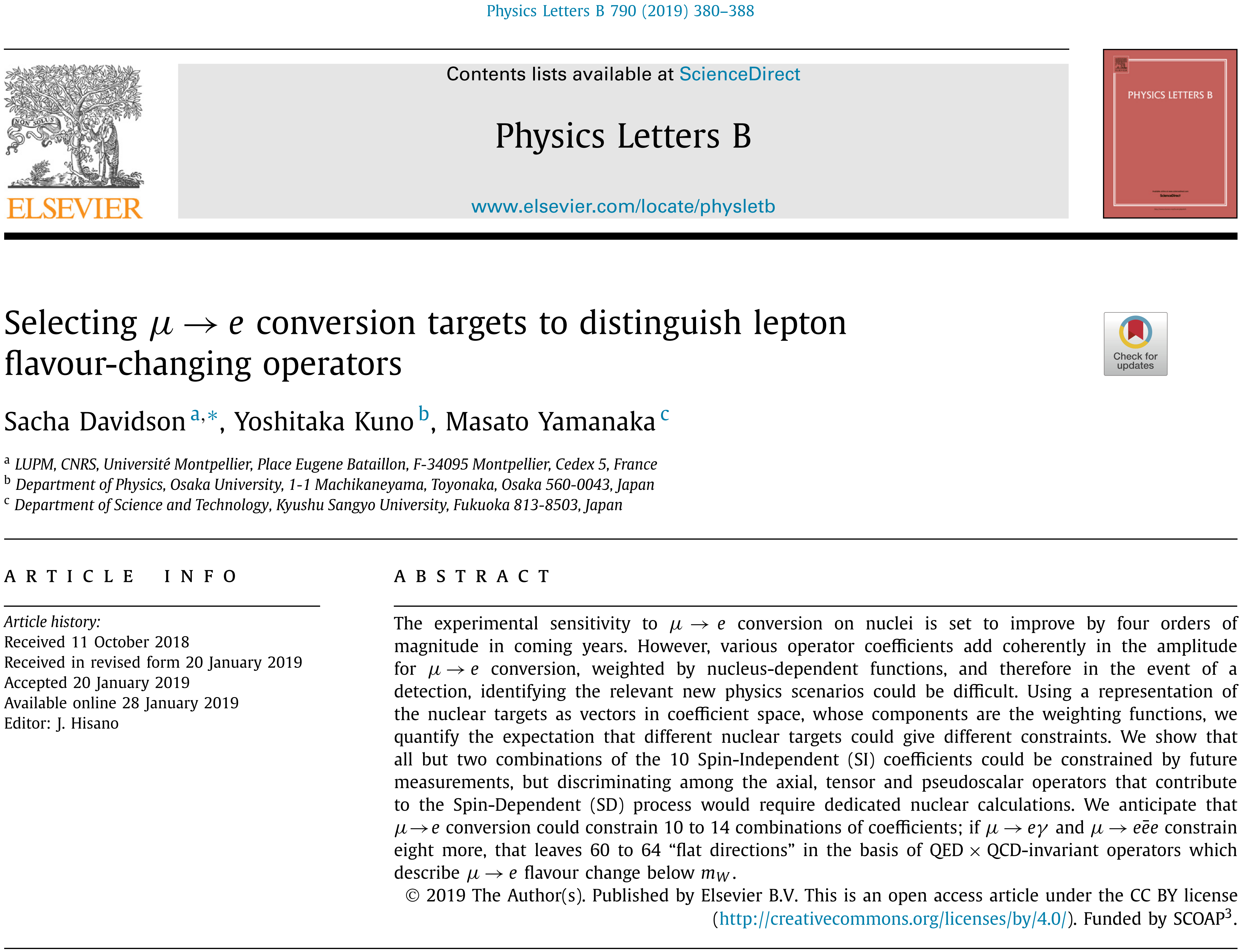
Abstract The experimental sensitivity to $\mu \rightarrow e$ conversion will improve by four or more orders of magnitude in coming years, making it interesting to consider the “spin-dependent” (SD) contribution to the rate. This process does not benefit from the atomic-number-squared enhancement of the spin-independent (SI) contribution, but probes different operators. We give details of our recent estimate of the spin-dependent rate, expressed as a function of opera-

the μ is captured by a nucleus, and can convert to an electron while in orbit. The COMET [7] and Mu2e [8] experiments, currently under construction, plan to improve the sensitivity by four orders of magnitude, reaching a branching ratio $\sim 10^{-16}$. The PRISM/PRIME proposal [9] aims to probe $\sim 10^{-18}$. These exceptional improvements in experimental sensitivity motivate our interest in subdominant contributions to $\mu \rightarrow e$ conversion.

Publication 2 (2018)

- Describes the details of the spin-dependent (SD) calculation with prospects for disentangling SD from SI processes by changing targets.
- detailed estimation in light nuclei
- comparison of different targets
    - different isotopes with spin-zero and spin-non-zero
- leptoquark models

Publication 3 (2019)



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Selecting $\mu \to e$ conversion targets to distinguish lepton flavour-changing operators

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ABSTRACT

The experimental sensitivity to $\mu \to e$ conversion on nuclei is set to improve by four orders of magnitude in coming years. However, various operator coefficients add coherently in the amplitude for $\mu \to e$ conversion, weighted by nucleus-dependent functions, and therefore in the event of a detection, identifying the relevant new physics scenarios could be difficult. Using a representation of the nuclear targets as vectors in coefficient space, whose components are the weighting functions, we quantify the expectation that different nuclear targets could give different constraints. We show that all but two combinations of the 10 Spin-Independent (SI) coefficients could be constrained by future measurements, but discriminating among the axial, tensor and pseudoscalar operators that contribute to the Spin-Dependent (SD) process would require dedicated nuclear calculations. We anticipate that $\mu \to e$ conversion could constrain 10 to 14 combinations of coefficients; if $\mu \to e\gamma$ and $\mu \to e\bar{e}e$ constrain eight more, that leaves 60 to 64 "flat directions" in the basis of QED × QCD-invariant operators which describe $\mu \to e$ flavour change below m_W.

Publication 3

- prospects to constrain and identify different spin-independent (SI) coefficients which interfere in the amplitude
- results: three targets (2 light, 1 heavy) could constrain 6 of the 8 Scalar and Vector processes.

EFT for μ→e Conversion

$$
\begin{aligned}
&\mathcal{L}_{\mu A\to eA}(\Lambda_{expt}) &=\;& -\frac{4G_F}{\sqrt{2}}\sum_{N=p,n}\Big[m_\mu\left(C_{DL}\overline{e_R}\sigma^{\alpha\beta}\mu_L F_{\alpha\beta}+C_{DR}\overline{e_L}\sigma^{\alpha\beta}\mu_R F_{\alpha\beta}\right) \quad \text{dipole}\\
&\text{scalar} && +\left(\widetilde{C}^{(NN)}_{SL}\overline{e}P_L\mu+\widetilde{C}^{(NN)}_{SR}\overline{e}P_R\mu\right)\overline{N}N\\
&\text{pseudo-scalar} && +\left(\widetilde{C}^{(NN)}_{P,L}\overline{e}P_L\mu+\widetilde{C}^{(NN)}_{P,R}\overline{e}P_R\mu\right)\overline{N}\gamma_5 N\\
&\text{vector} && +\left(\widetilde{C}^{(NN)}_{VL}\overline{e}\gamma^\alpha P_L\mu+\widetilde{C}^{(NN)}_{VR}\overline{e}\gamma^\alpha P_R\mu\right)\overline{N}\gamma_\alpha N\\
&\text{axial-vector} && +\left(\widetilde{C}^{(NN)}_{A,L}\overline{e}\gamma^\alpha P_L\mu+\widetilde{C}^{(NN)}_{A,R}\overline{e}\gamma^\alpha P_R\mu\right)\overline{N}\gamma_\alpha\gamma_5 N\\
&\text{(derivative)} && +\left(\widetilde{C}^{(NN)}_{Der,L}\overline{e}\gamma^\alpha P_L\mu+\widetilde{C}^{(NN)}_{Der,R}\overline{e}\gamma^\alpha P_R\mu\right)i(\overline{N}\overset{\leftrightarrow}{\partial}_\alpha\gamma_5 N)\\
&\text{tensor} && +\left(\widetilde{C}^{(NN)}_{T,L}\overline{e}\sigma^{\alpha\beta}P_L\mu+\widetilde{C}^{(NN)}_{T,R}\overline{e}\sigma^{\alpha\beta}P_R\mu\right)\overline{N}\sigma_{\alpha\beta}N+h.c.\Big] \quad .
\end{aligned}
$$

EFT for μ→e Conversion

$$\mathcal{L}_{\mu A\to eA}(\Lambda_{expt}) = -\frac{4G_F}{\sqrt{2}}\sum_{N=p,n}\Big[m_\mu\left(C_{DL}\overline{e_R}\sigma^{\alpha\beta}\mu_L F_{\alpha\beta}+C_{DR}\overline{e_L}\sigma^{\alpha\beta}\mu_R F_{\alpha\beta}\right)$$

dipole

scalar

$$+\left(\widetilde{C}^{(NN)}_{SL}\bar{e}P_L\mu+\widetilde{C}^{(NN)}_{SR}\bar{e}P_R\mu\right)\overline{N}N$$

pseudo-scalar

$$+\left(\widetilde{C}^{(NN)}_{P,L}\bar{e}P_L\mu+\widetilde{C}^{(NN)}_{P,R}\bar{e}P_R\mu\right)\overline{N}\gamma_5 N$$

vector

$$+\left(\widetilde{C}^{(NN)}_{VL}\bar{e}\gamma^\alpha P_L\mu+\widetilde{C}^{(NN)}_{VR}\bar{e}\gamma^\alpha P_R\mu\right)\overline{N}\gamma_\alpha N$$

axial-vector

$$+\left(\widetilde{C}^{(NN)}_{A,L}\bar{e}\gamma^\alpha P_L\mu+\widetilde{C}^{(NN)}_{A,R}\bar{e}\gamma^\alpha P_R\mu\right)\overline{N}\gamma_\alpha\gamma_5 N$$

(derivative)

$$+\left(\widetilde{C}^{(NN)}_{Der,L}\bar{e}\gamma^\alpha P_L\mu+\widetilde{C}^{(NN)}_{Der,R}\bar{e}\gamma^\alpha P_R\mu\right)i(\overline{N}\overset{\leftrightarrow}{\partial}_\alpha\gamma_5 N)$$

tensor

$$+\left(\widetilde{C}^{(NN)}_{T,L}\bar{e}\sigma^{\alpha\beta}P_L\mu+\widetilde{C}^{(NN)}_{T,R}\bar{e}\sigma^{\alpha\beta}P_R\mu\right)\overline{N}\sigma_{\alpha\beta}N+h.c.\Big]\quad .$$

let us make an argument simplified…

5 coeff. - dipole, scalar (p), vector (p), scalar (n), vector (n)

Vector presentation in multi-dimension space (5-dim.)

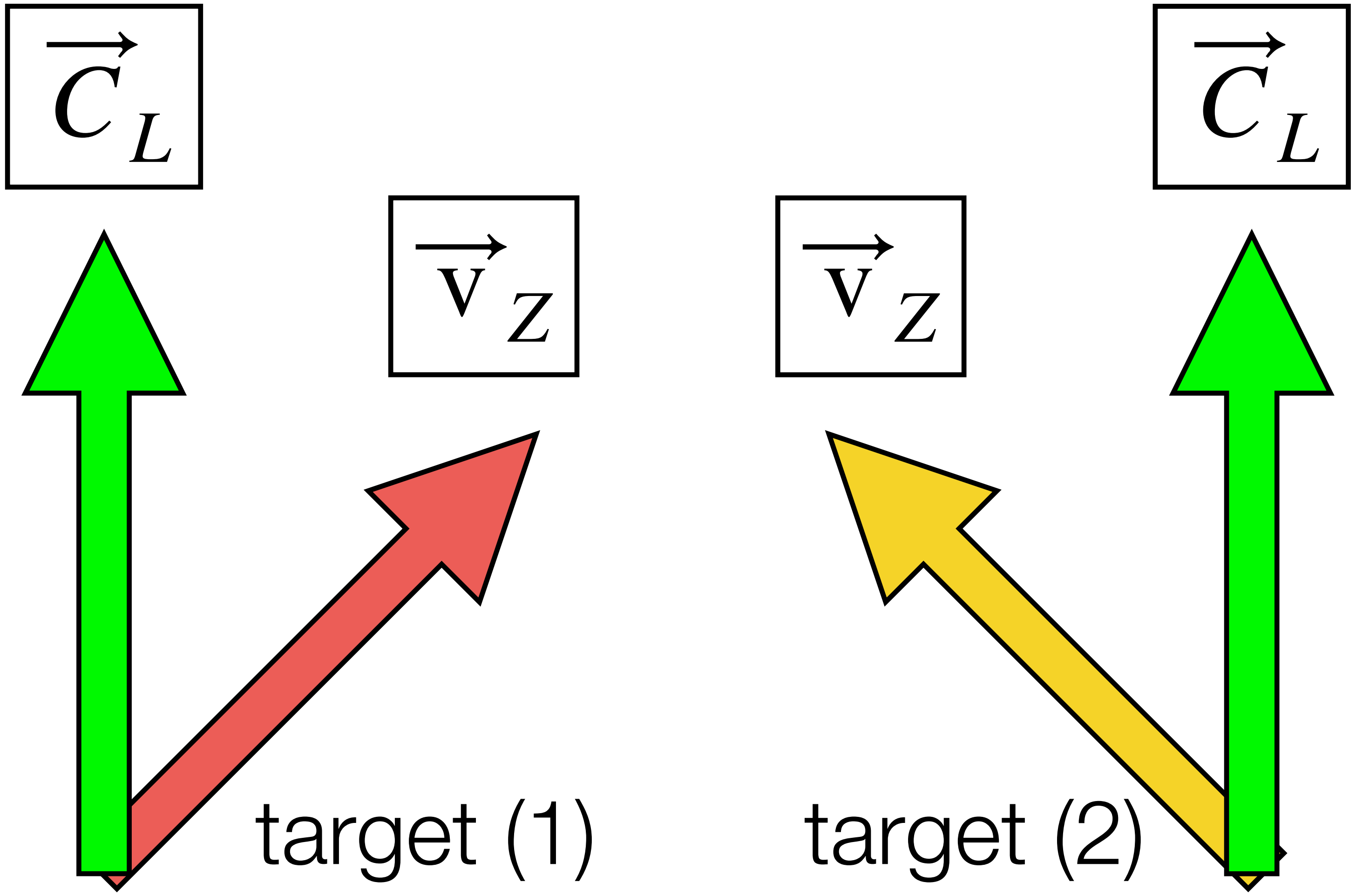
$$BR = B_Z \left[|\vec{v}_Z \cdot \vec{C}_L|^2 + |\vec{v}_Z \cdot \vec{C}_R|^2 \right]$$

$$\vec{C}_L = (\widetilde{C}_{D,R}, \widetilde{C}^{pp}_{V,L}, \widetilde{C}^{pp}_{S,R}, \widetilde{C}^{nn}_{V,L}, \widetilde{C}^{nn}_{S,R})$$ new physics

$$\vec{v}_Z = \left(\frac{D_Z}{4}, V_Z^{(p)}, S_Z^{(p)}, V_Z^{(n)}, S_Z^{(n)} \right)$$ nuclear form factor

Nuclear form factors, including
overwrap of muon wave function and nucleus
calculated by nuclear physics
(estimated by WINP searches)

Misalignment is needed....



$\vec{C}_L$

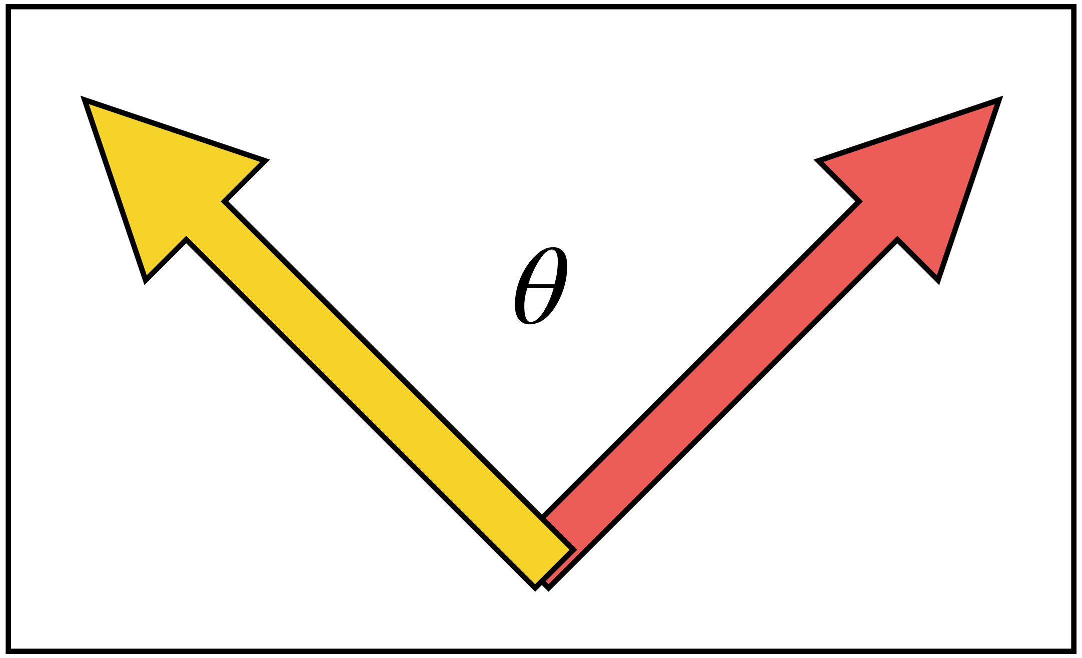
$\vec{v}_Z$

target (1)

$\vec{v}_Z$

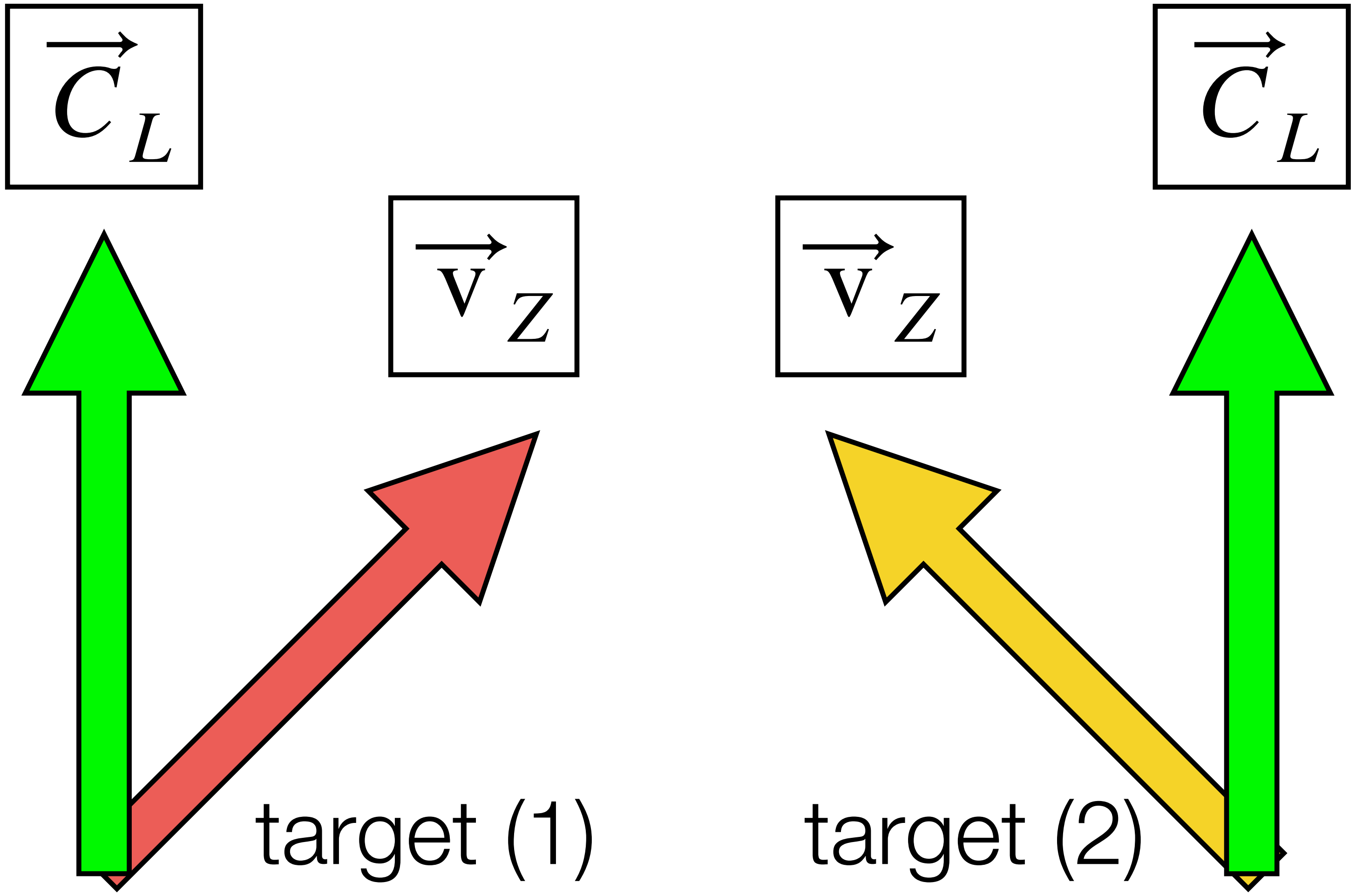
$\vec{C}_L$

target (2)

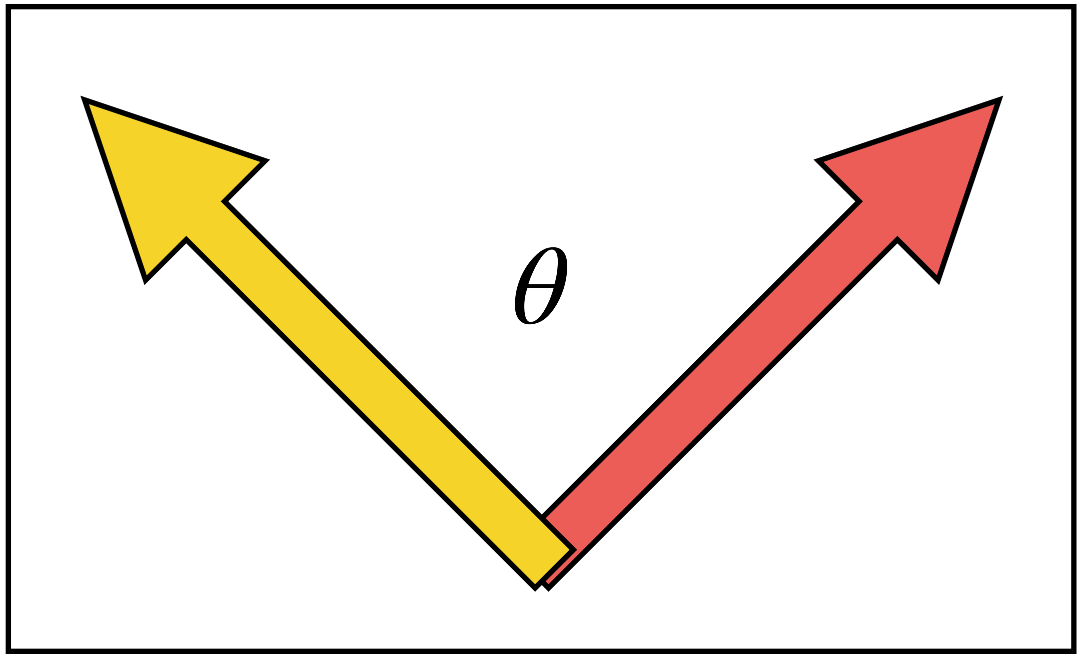


θ

Misalignment is needed....



misalignment of target
vectors provide
more information on couplings



Spin dependent μ-e conversion (Model Independent) - second preprint

Titanium

Lead

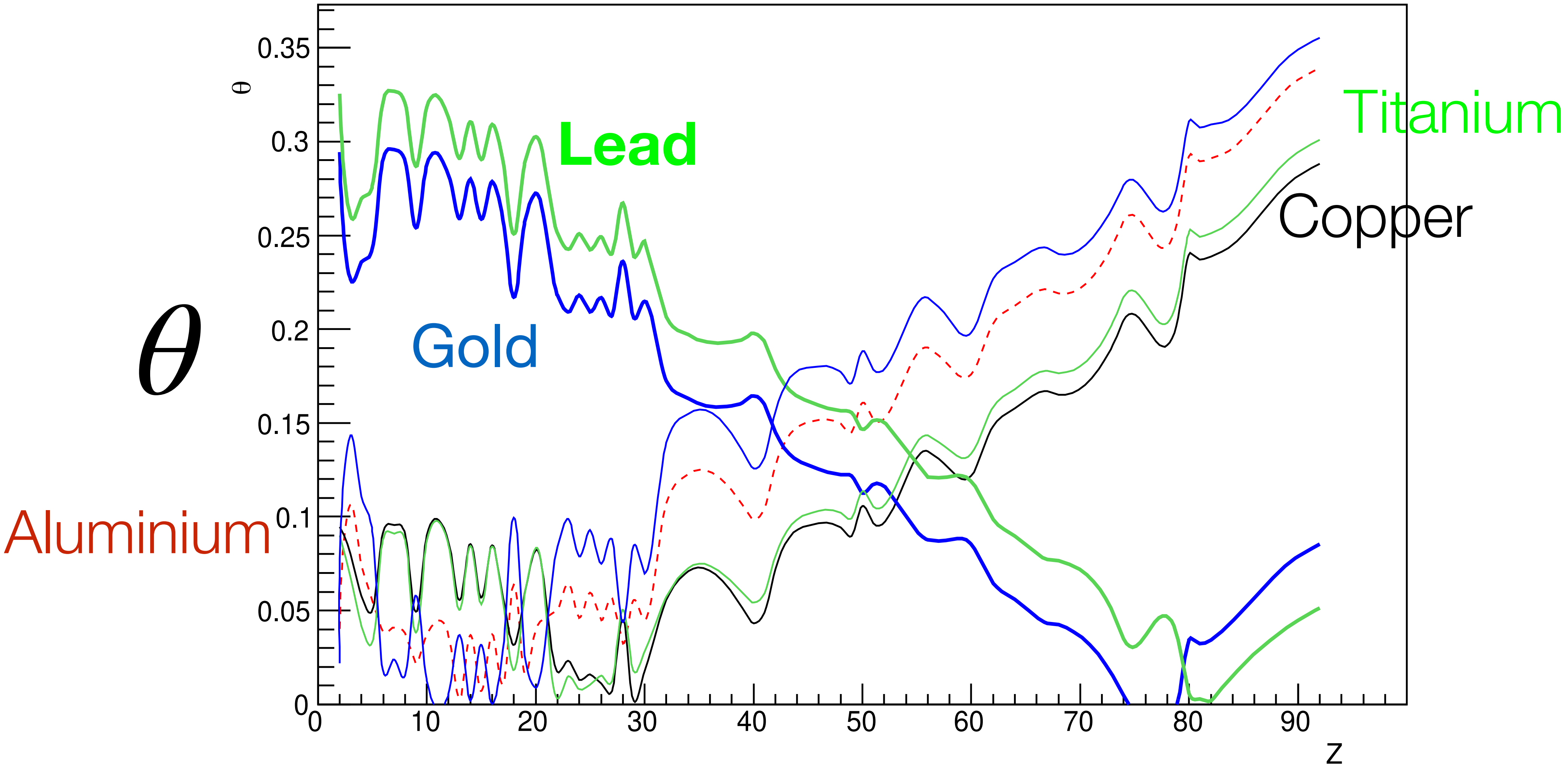
Copper

Gold

Aluminium

solid lines : existing data

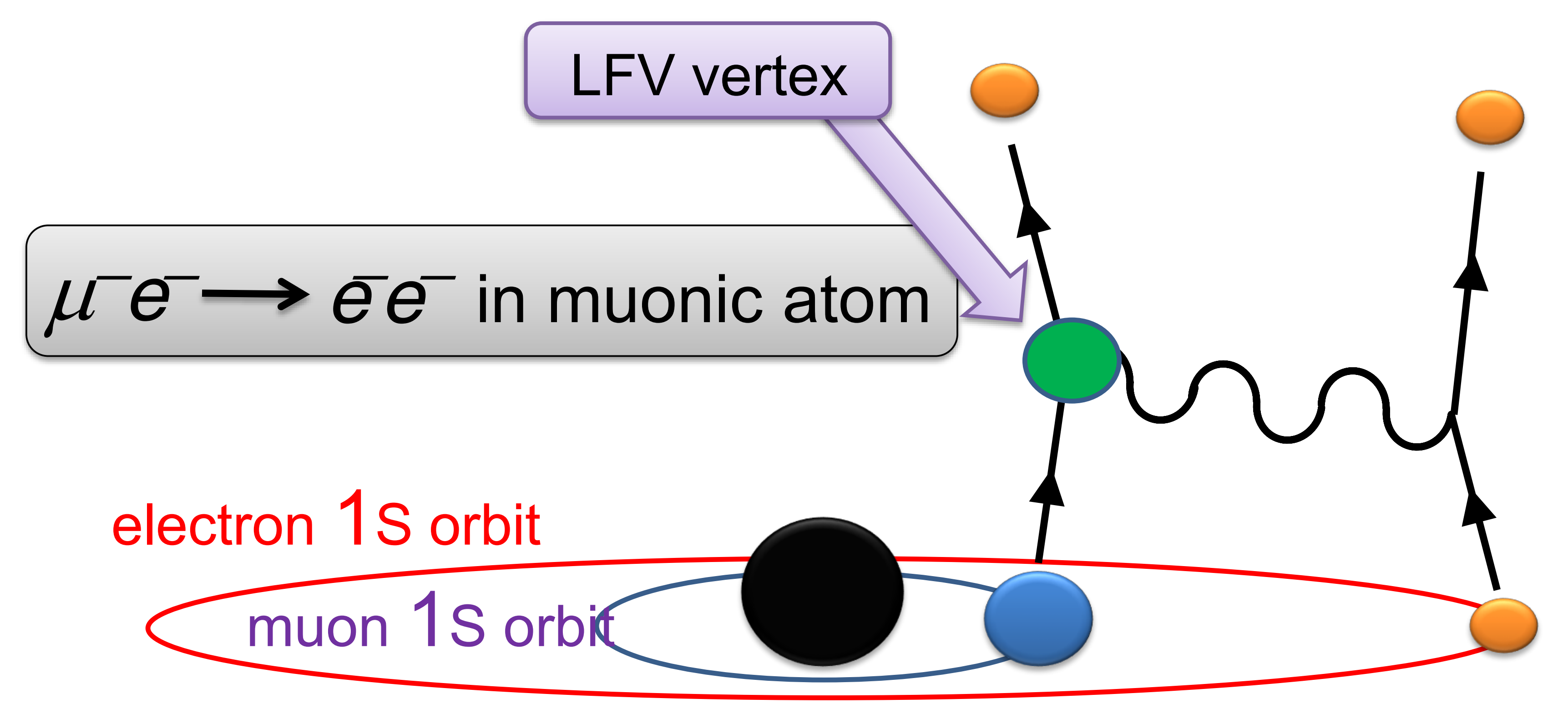
Spin dependent μ-e conversion (Model Independent) - second preprint



solid lines : existing data

Figure 2: Angle θ between a target vector (eg dashed red = Aluminium) and other targets labelled by Z. The angle is obtained as in eqn (9), with all the dipole coefficients set to zero. The solid lines represent the targets for which there is currently data (see table 1). From smallest to largest value of θ at large Z, they are: thick green = Lead, thick blue = Gold, black = Copper, thin green = Titanium, dashed red = Aluminium, and thin blue is Sulfur. We assume that two targets can probe different coefficients if their misalignment angle is $\theta \gtrsim 0.2$ radians (or 0.1).

$\mu^- + e^- \to e^- + e^-$ in a muonic atom



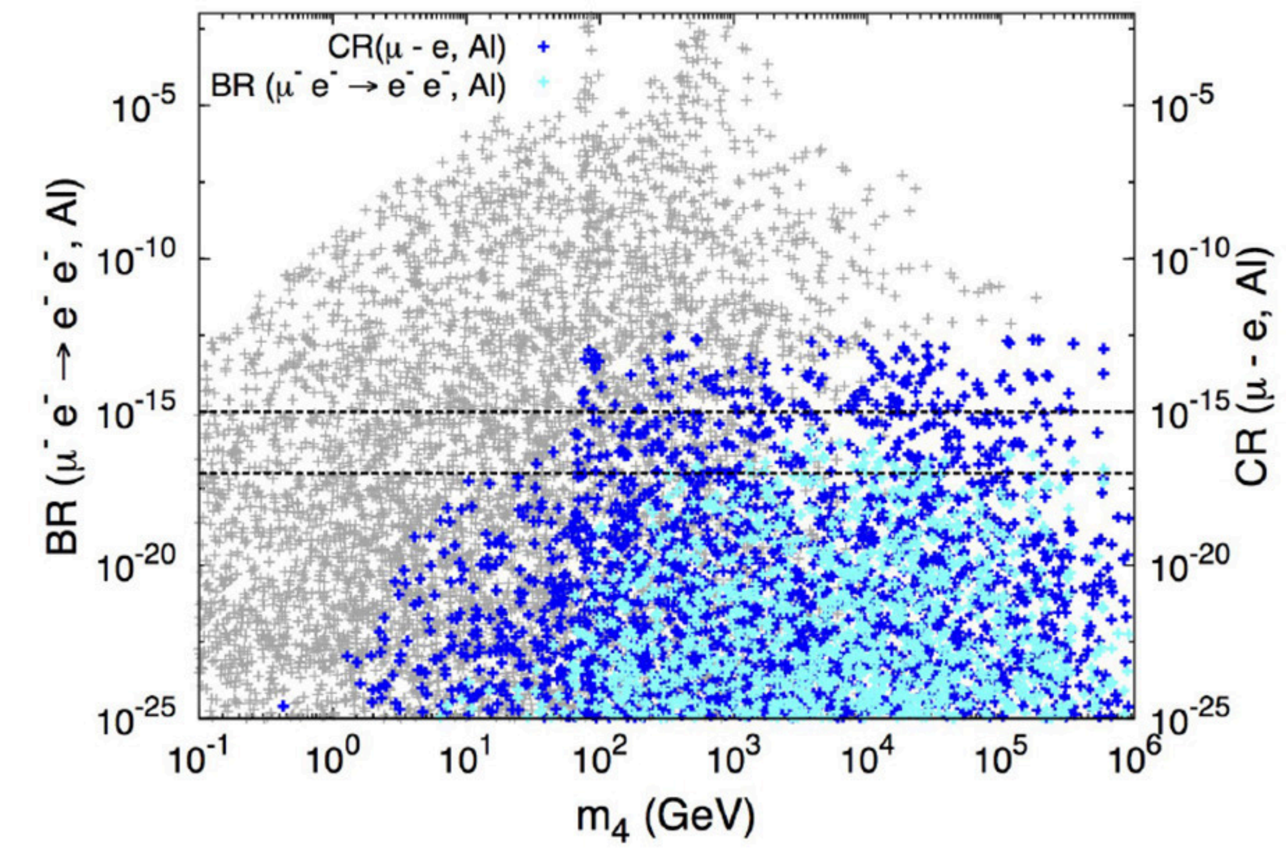
$\mu^- e^- \to e^- e^-$ has the overwrap of μ^- and e^- which is proportional to Z^3. (almost compatible to $\mu^+ \to e^+ e^+ e^-$)

Experimentally a pair of e^- and e^- in the final state is measured.

- Original idea
  M. Koike, YK, J. Sato and M. Yamanaka, Phys. Rev. Lett. 105 (2010)
- Study of contact interaction with different Z targets
  Y. Uesaka, YK, J. Sato, T. Sato and M. Yamanaka, Phys. Rev. D93 (2016) 076006
- Study of long-distance dipole interaction with different Z targets
  Y. Uesaka, YK, J. Sato, T. Sato and M. Yamanaka, Phys. Rev. D97 (2018) 015017
- one more paper under preparation.

Heavy Neutral Lepton (HNL) Models for $\mu^- + e^- \to e^- + e^-$ in a muonic atom

(3+1) model

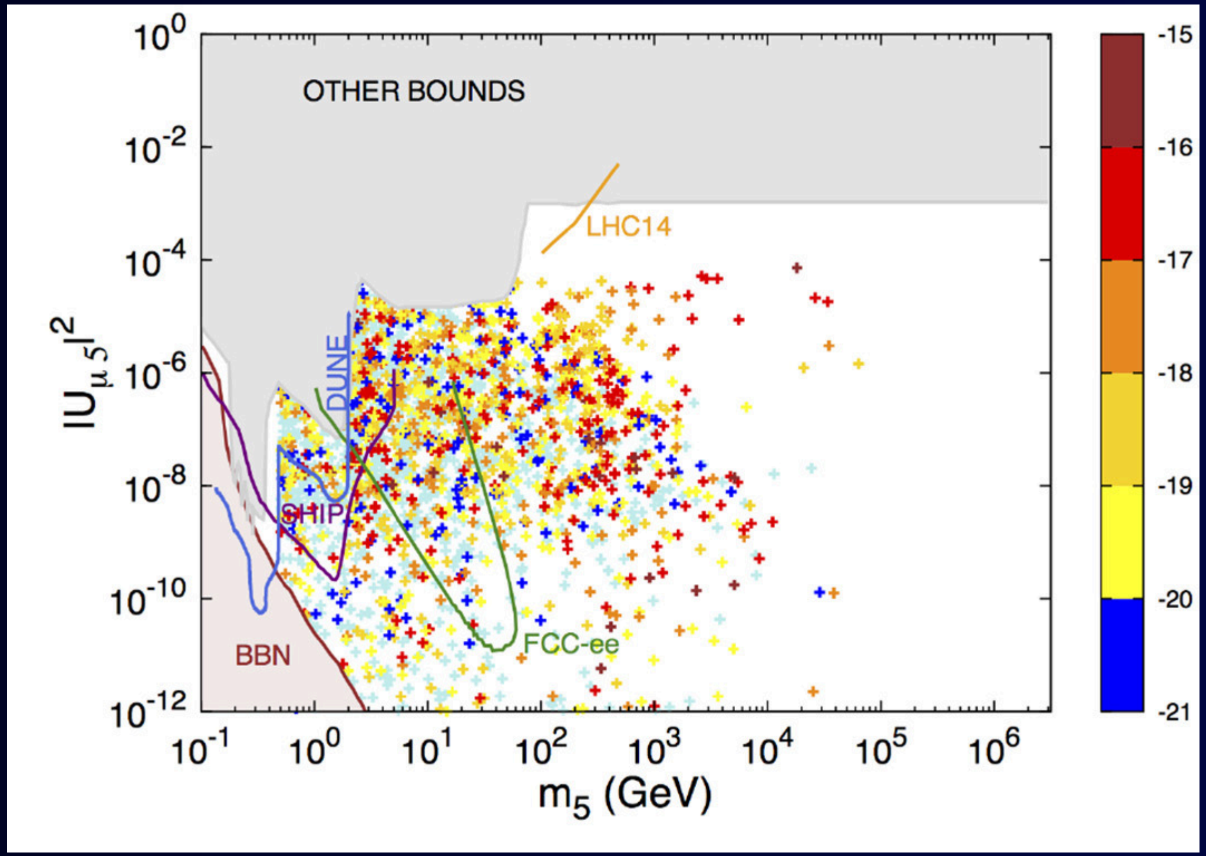


m_4 : HNL mass

cyan points : $\mu^- + e^- \to e^- + e^-$

blue points : $\mu^- + \mathrm{Al} \to e^- + \mathrm{Al}$

(3+2) model



m_5 : HNL mass

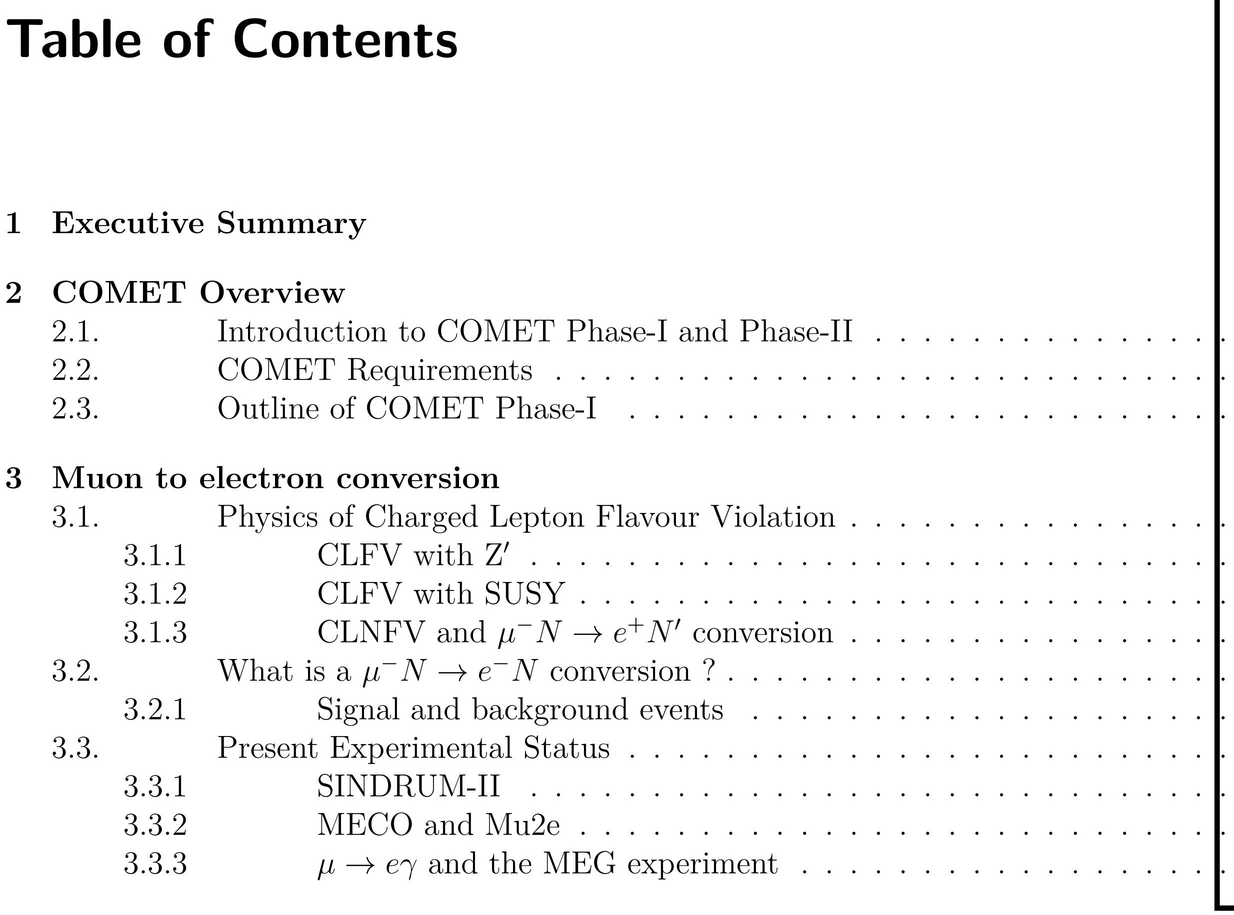
colored points : $\mathrm{Br}(\mu^- + e^- \to e^- + e^-)$

A. Abada, V. De Romeri, A.M. Teixeira, JHEP 02 (2016) 083)

More Highlights

COMET Phase-I TDR

- Contributions to the theory chapter of the Technical Design Report (TDR)
  - **Joe Sato** (Saitama) and **Ana Teixeira** (LPC)
  - submitted to PTEP.



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COMET Phase-I TDR

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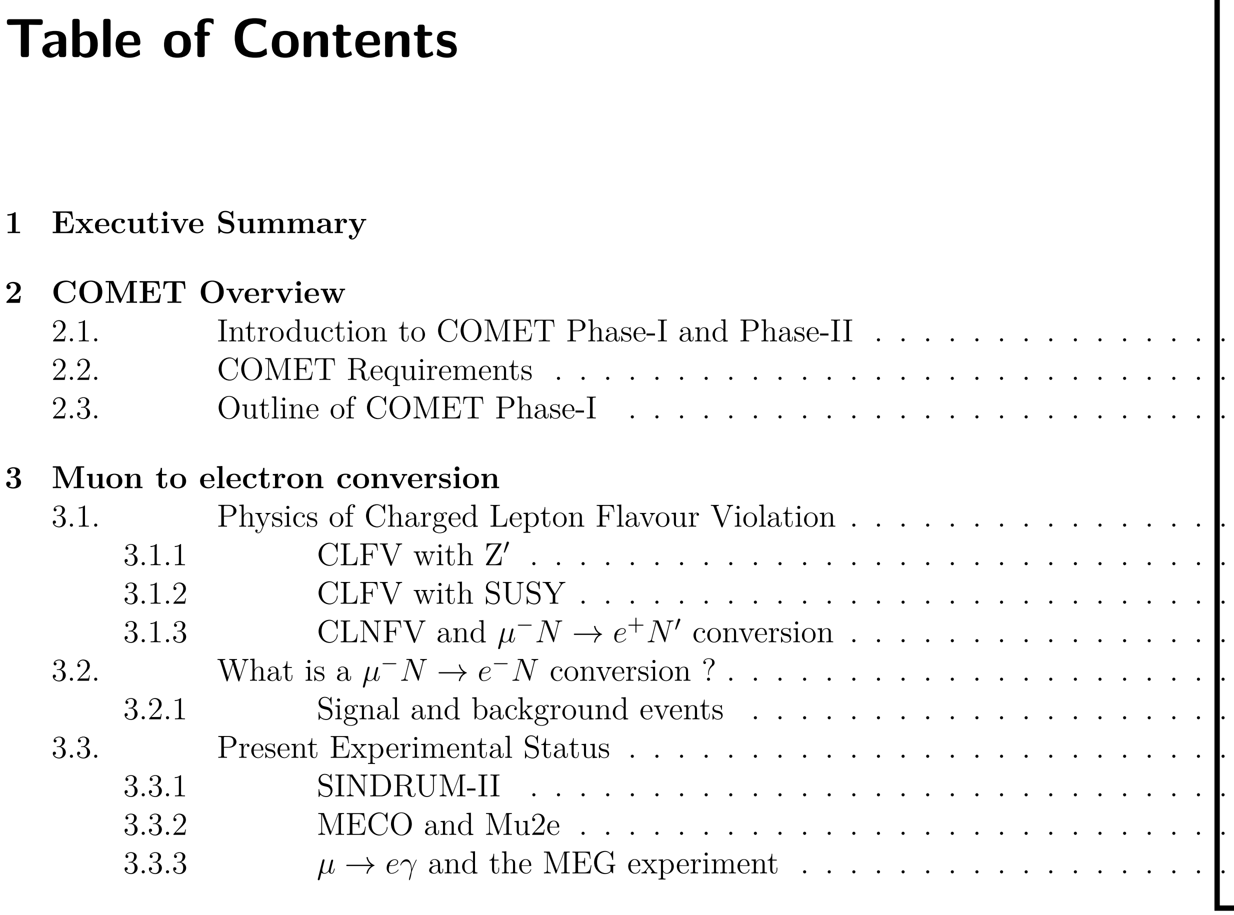

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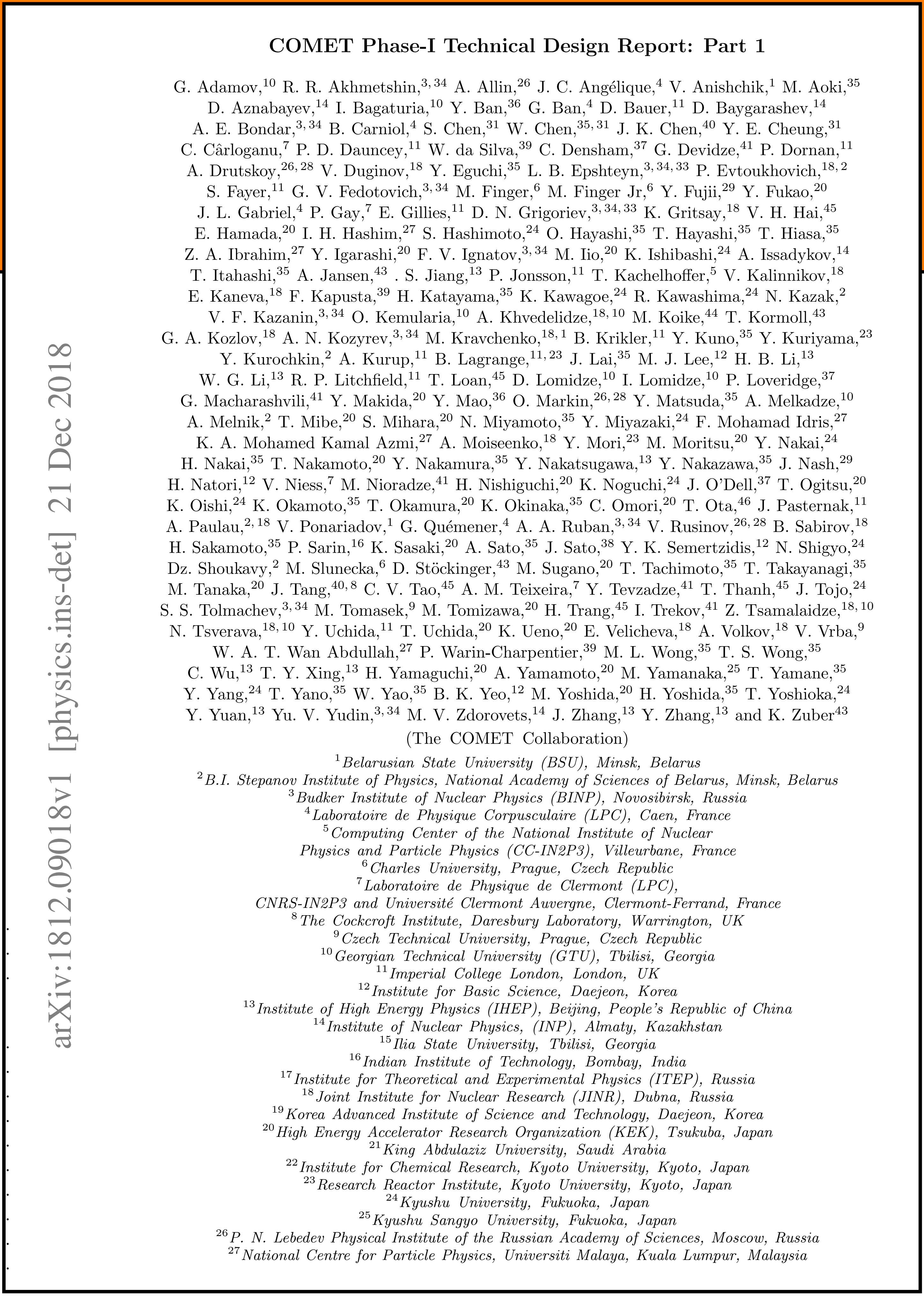

COMET Phase-I Technical Design Report: Part 1

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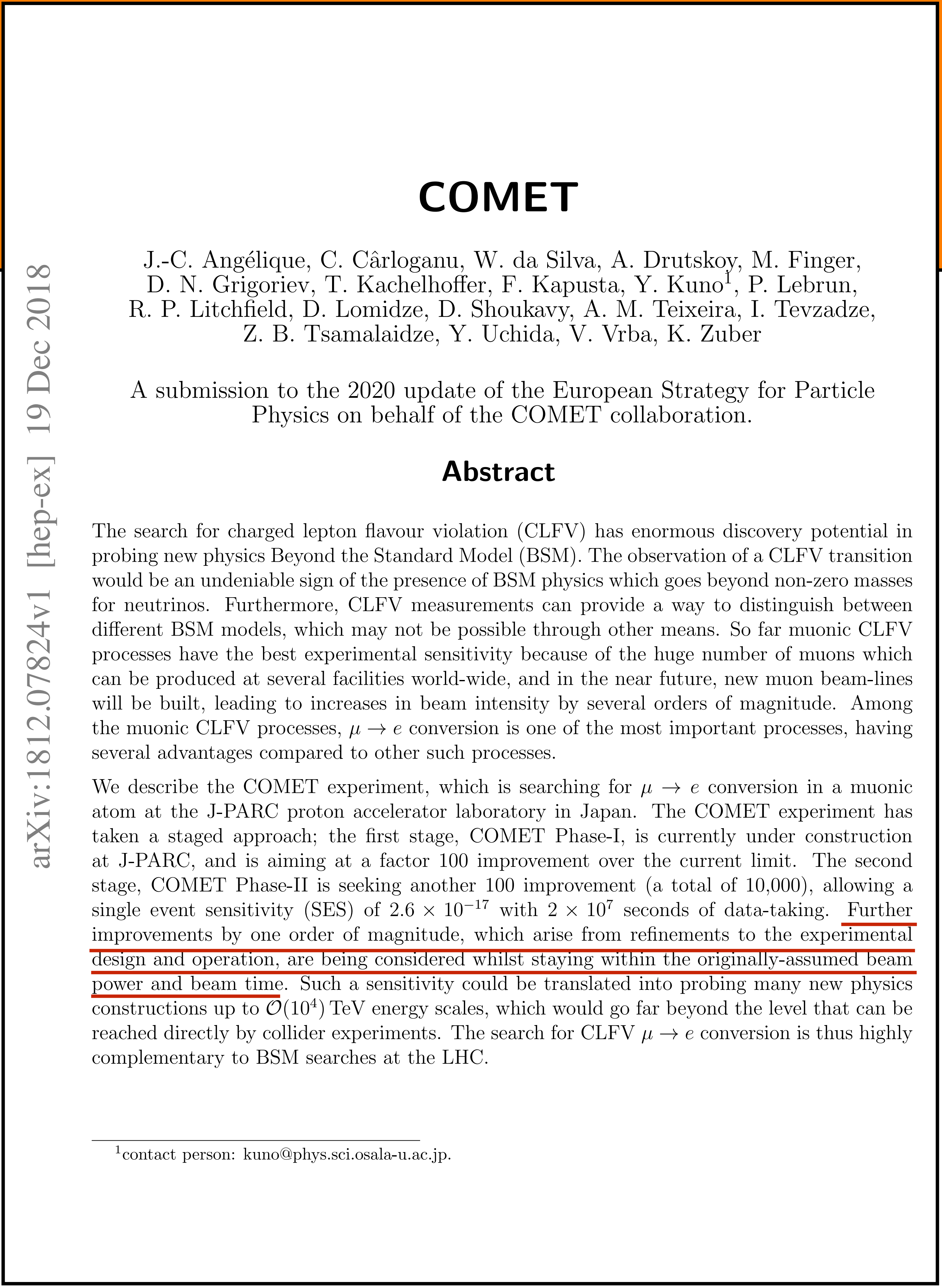
White Paper: COMET

COMET white paper to the 2020 update of the European Strategy for Particle Physics, by COMET collaborations.

- Scientific context
- Methodology
  - COMET Phase-II
  - Phase-I
  - PRISM
- European Contribution
- Summary



arXiv:1812.07824v1 [hep-ex] 19 Dec 2018

COMET

J.-C. Angélique, C. Cârloganu, W. da Silva, A. Drutskoy, M. Finger,
D. N. Grigoriev, T. Kachelhoffer, F. Kapusta, Y. Kuno[1], P. Lebrun,
R. P. Litchfield, D. Lomidze, D. Shoukavy, A. M. Teixeira, I. Tevzadze,
Z. B. Tsamalaidze, Y. Uchida, V. Vrba, K. Zuber

A submission to the 2020 update of the European Strategy for Particle Physics on behalf of the COMET collaboration.

Abstract

The search for charged lepton flavour violation (CLFV) has enormous discovery potential in probing new physics Beyond the Standard Model (BSM). The observation of a CLFV transition would be an undeniable sign of the presence of BSM physics which goes beyond non-zero masses for neutrinos. Furthermore, CLFV measurements can provide a way to distinguish between different BSM models, which may not be possible through other means. So far muonic CLFV processes have the best experimental sensitivity because of the huge number of muons which can be produced at several facilities world-wide, and in the near future, new muon beam-lines will be built, leading to increases in beam intensity by several orders of magnitude. Among the muonic CLFV processes, $\mu \to e$ conversion is one of the most important processes, having several advantages compared to other such processes.

We describe the COMET experiment, which is searching for $\mu \to e$ conversion in a muonic atom at the J-PARC proton accelerator laboratory in Japan. The COMET experiment has taken a staged approach; the first stage, COMET Phase-I, is currently under construction at J-PARC, and is aiming at a factor 100 improvement over the current limit. The second stage, COMET Phase-II is seeking another 100 improvement (a total of 10,000), allowing a single event sensitivity (SES) of 2.6×10^{-17} with 2×10^{7} seconds of data-taking. Further improvements by one order of magnitude, which arise from refinements to the experimental design and operation, are being considered whilst staying within the originally-assumed beam power and beam time. Such a sensitivity could be translated into probing many new physics constructions up to $\mathcal{O}(10^4)$ TeV energy scales, which would go far beyond the level that can be reached directly by collider experiments. The search for CLFV $\mu \to e$ conversion is thus highly complementary to BSM searches at the LHC.

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[1] contact person: kuno@phys.sci.osala-u.ac.jp.

Planning 2018-2019

New Projects

New Projects

- more projects under disucssions
  - rates in polarised targets ??
  - coherency in different interactions ??
  - exotic muon CLFV processes ??

New Projects (2)

New Projects (2)

- Review article on CLFV in progress
  - Ana Teixeira (LPC), Asmaa Abada (U. Paris Sud), Lorenzo Calibbi (ITP) and YK

Budget Request Summary

- French side
  - Travel support of one researcher, 10 days
  - Request to IN2P3 for 2500 euros

- Japanese side
  - Travel support of one researcher, 10 days (for young researcher)
  - Request to KEK for 200 k Japanese yen
  - Additional request to Osaka University for 100 k Japanese yen

Conclusion

- This project forms some framework to strengthen the collaboration between French and Japanese physicists interested in charged lepton flavor violation.
- Face-to-face meeting provide open discussion to create innovative idea.
- In 2018-2019, studies of μ→e conversion (in particular spin-dependent) were carried out.
- In 2019-2020, we are planning to do more works related to CLFV in the collaboration between French and Japanese physicists.

Conclusion

Osaka University

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my dog, IKU

Thank you for your attention!