Electro-magnetic probes for DBD isospin NMEs

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DBD NME RCNP Oct. 2022.
Thanks the organizers for the invitation.

1. Electro-magnetic probes for DBD NMEs .
2. EM from IAS in intermediate DBD nuclei.
3. E1 NMEs with isospin dipole NMEs.
4. Impact on DBD experiments and on DBD NMEs.
5. Concluding remarks

1. H. Ejiri, et al, Phys. Rev. Lett. 21, 373 1968
2. H. Ejiri, A. Titov, at al., Phys. Rev. C. 88, 054610 2013
3. H. Ejiri, J. Suhonen, K. Zuber, Phys. Rep. 797, 1 (2019).
4. H. Ejiri, Frontiers in Physics 9, 650421 (1921).

ELECTRIC DIPOLE TRANSITION FROM THE $2f_{7/2}$ ISOBARIC ANALOG RESONANCE TO THE $2d_{5/2}$ GROUND STATE IN ^{141}Pr †

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Electric dipole γ rays from the $2f_{7/2}$ isobaric analog state $(2T_0)^{-1/2}T_-|i\rangle$ to the $2d_{5/2}$ ground state $|f\rangle$ in ^{141}Pr were measured with a Ge(Li) crystal. The matrix element of the $E1$ γ transition, $|\langle f|m_\gamma T_-(2T_0)^{-1/2}|i\rangle|$, and that of the analogous first forbidden β transition, $|\langle f|m_\beta|i\rangle|$, were obtained.

A measurement of electric dipole γ rays from isobaric analog states (IAS) in heavy nuclei is interesting since it provides information on the IAS and the low-lying states[1-4] as well as the matrix element $\langle\vec{r}\rangle$ for the $E1$ γ decay $\langle m_\gamma\rangle$, and for the analogous first forbidden β decay[1-3] $\langle m_\beta\rangle$ (Fig. 1).

These matrix elements are related by

$$\langle f|m_\beta|i\rangle = \langle f|[m_\gamma, T_-]|i\rangle$$

$$\approx (2T_0)^{1/2}\langle f|m_\gamma|\mathrm{IAS}\rangle,$$

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Neutrino-nuclear response and photonuclear reactions

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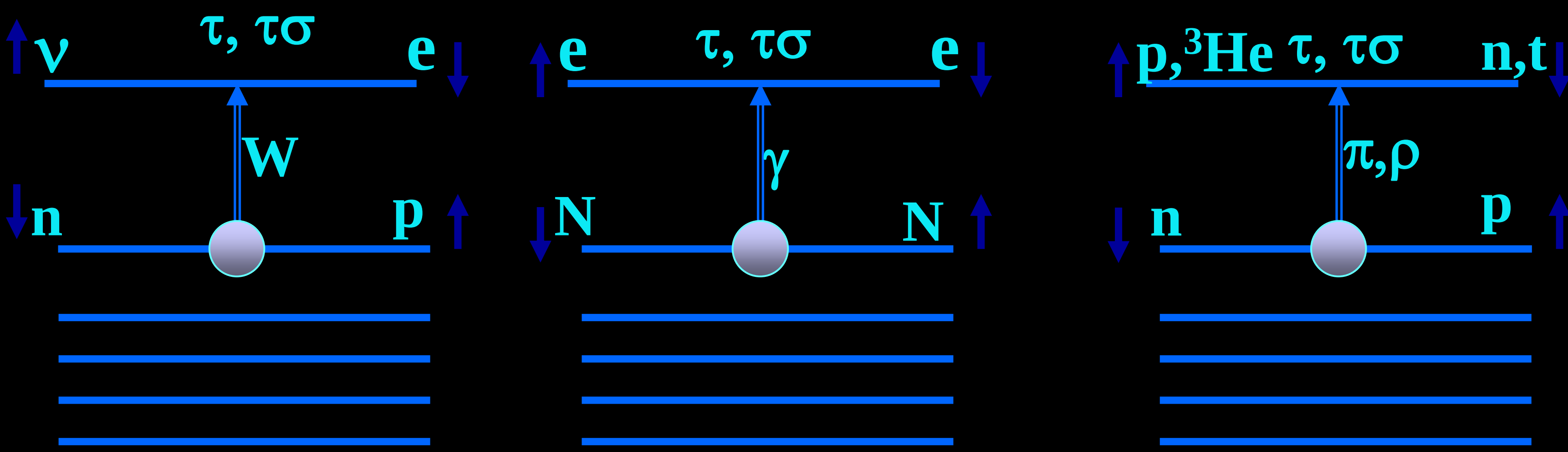
Nuclear τσ and τ responses for ν in β &ββ

Weak probe | **EM –probe** | **Nuclear Probe**



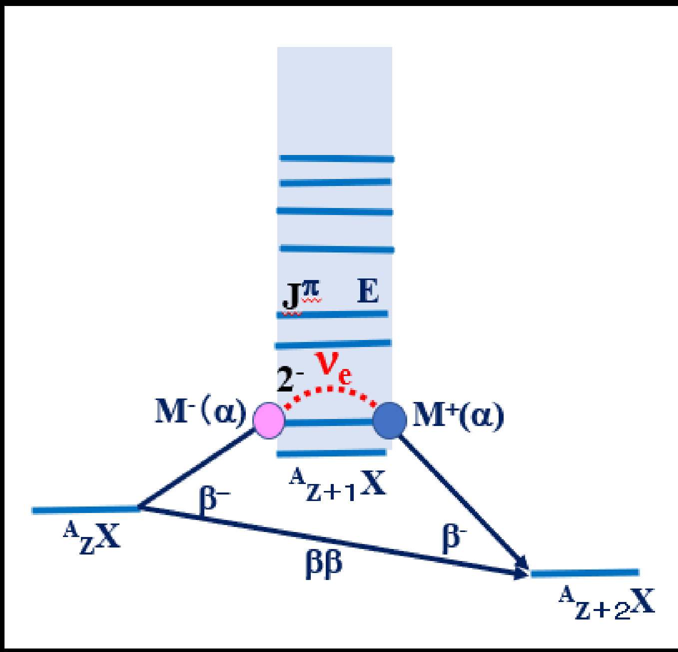
β-decay,
e capture
ν, μ probe
J-PARC SNS

γ-capture,
e scattering
γ from
Spring-8 HIGS

CER ^{3}He,t
t,^{3}He d,^{2}He
N RCNP,
MSU, KVI

1. DBD NME and SD

$$M^{0\nu} = \left(\frac{g_A^{\mathrm{eff}}}{g_A}\right)^2 \left[M_{\mathrm{GT}}^{0\nu} + \left(g_V/g_A^{\mathrm{eff}}\right)^2 M_{\mathrm{F}}^{0\nu} + M_{\mathrm{T}}^{0\nu}\right],$$



Quenching due to effects not in model

Model NMEs

$$M_{\mathrm{GT}}^{0\nu} = \sum_k \langle t_\pm \boldsymbol{\sigma} h_{\mathrm{GT}}(r_{12}, E_k) t_\pm \boldsymbol{\sigma} \rangle$$

$$M_{\mathrm{F}}^{0\nu} = \sum_k \langle t_\pm h_{\mathrm{F}}(r_{12}, E_k) t_\pm \rangle,$$

$$M_{\mathrm{T}}^{0\nu} = \sum_k \langle t_\pm h_{\mathrm{T}}(r_{12}, E_k) S_{12} t_\pm \rangle ,$$

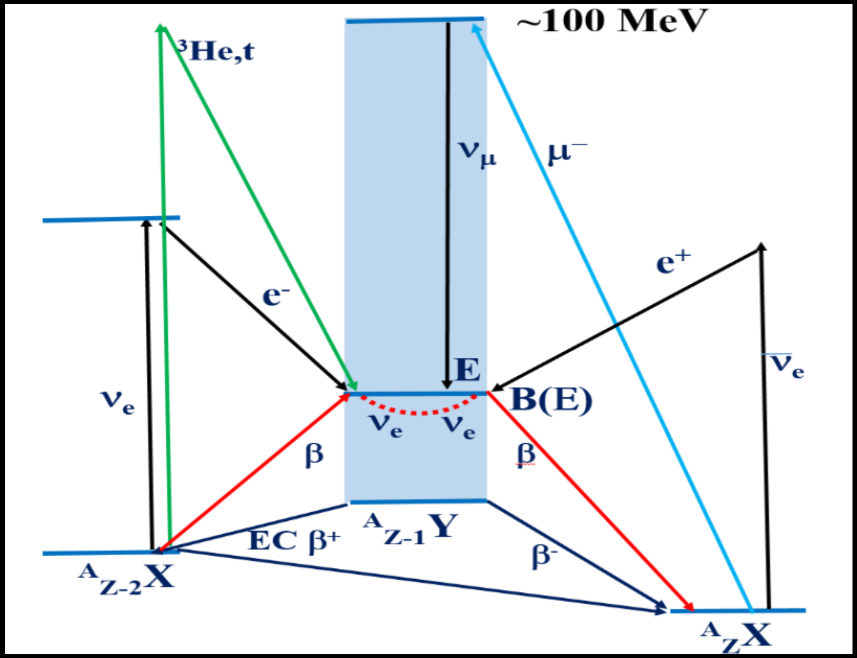
M(GT) Axial vector NMEs by preferential τσ nuclear excitation

M(F) vector NMEs by preferential E1 τ gamma excitation

So far Nuclear CERs and Muon CERs

$M^{0\nu}_{GT}$ 1+, 2-, 3+ states NMEs by（^{3}He,t）(RCNP,（d,2He）

SCER With E/A ~ 0.1-0.3 GeV V(τσ)>> V(τ)



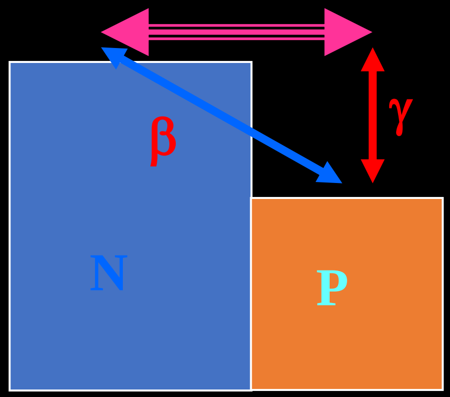
Present Photon γ

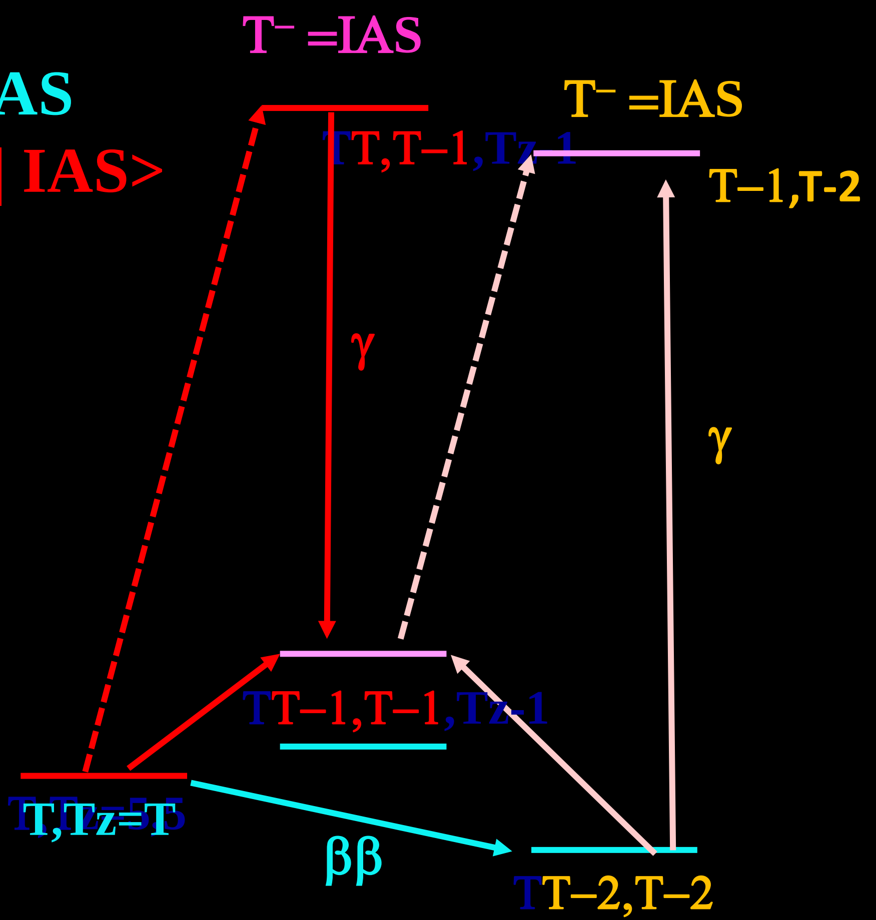
$M^{0\nu}_{GT}$ 1-, 2+ states NMEs by (IAS γ)

T,Tz-1 γ

Isospin rotation for
charged current responses via IAS

$$\langle f \,|\, g\, M_\beta \,|\, i \rangle = g/e\,(2T)^{1/2} \langle f \,|\, em_\gamma \,|\, IAS \rangle$$





H. Ejiri PRL 21 '68, H. Ejiri PR 38 '78

A: H. Ejiri et al 1968 Phys. Rev. Lett, 1968

IAS by proton capture

Gamma by Ge detectors

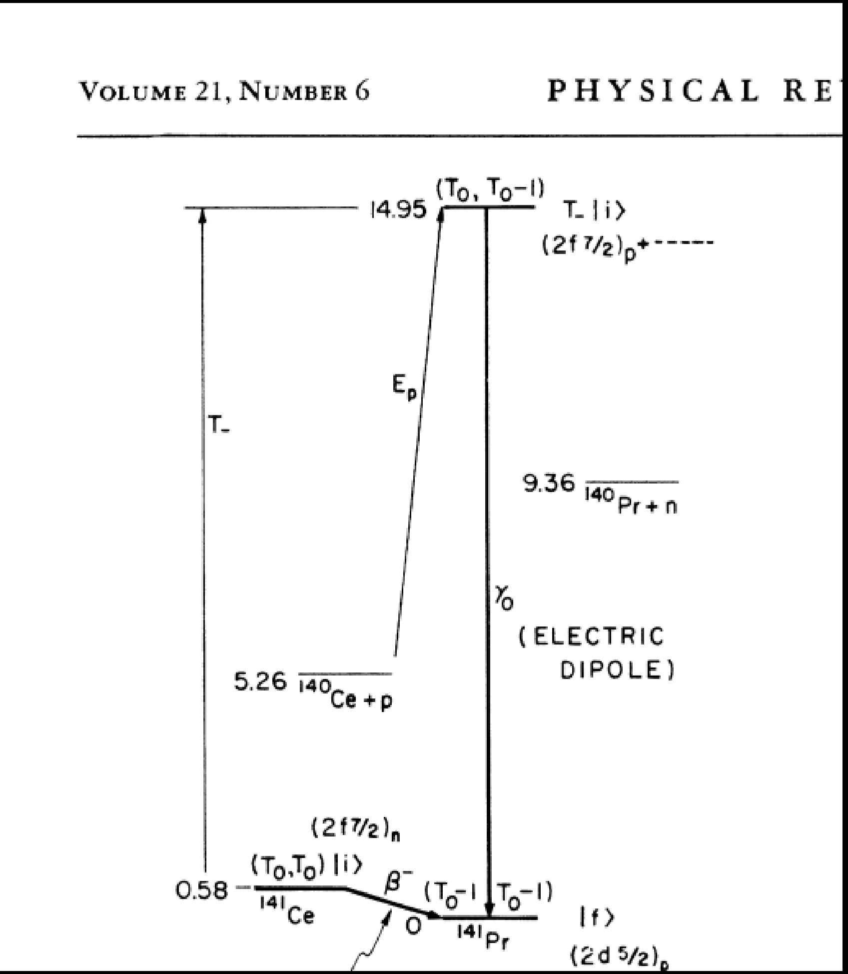
$M(E1) \sim g_V^{eff}/g_V\ M(QP)$,

$g_V^{eff}/g_V \sim 0.25$

ττ correlations not in QP model

M(g) provides the <r> component

among <β>.



(^{3}He,t γ) reaction via IAS .

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Gamma by Ge or Nai

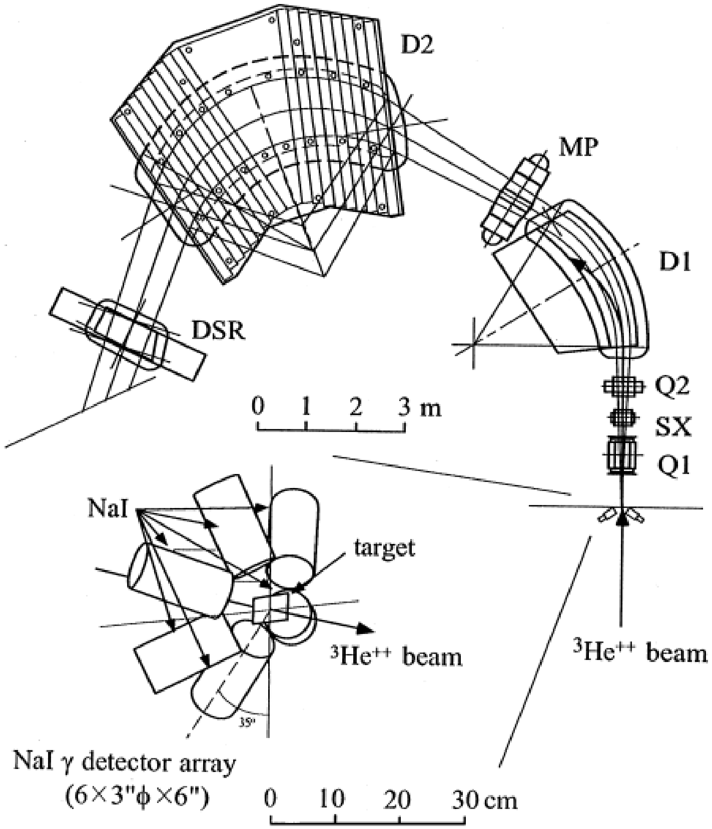


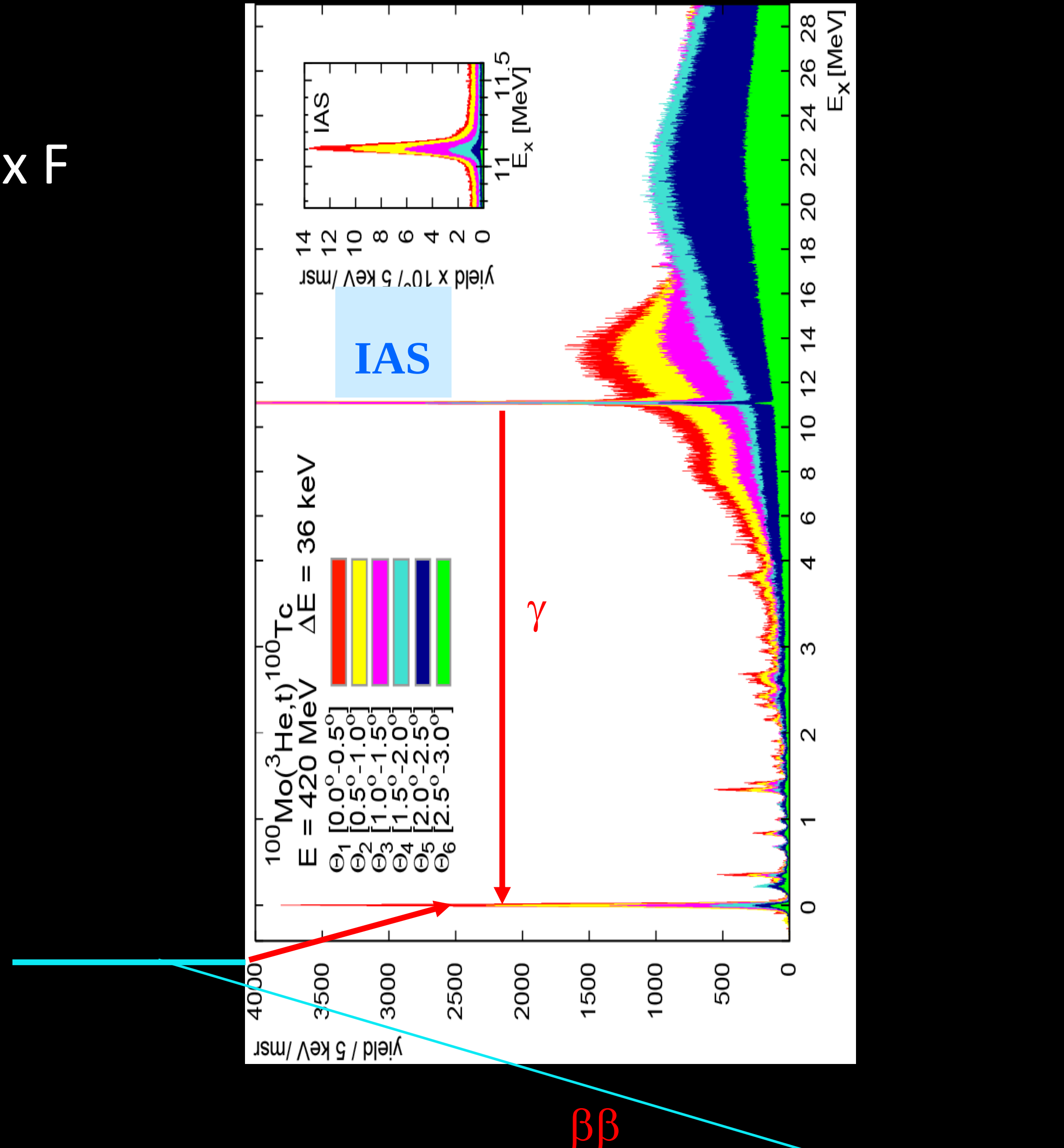
Fig. 12. The measured cm cross-sections of the (d, ^{2}He) reactions at 0° as a function of the GT strengths deduced from β-decay or (p,n) reaction studies. The solid line is a linear fit to the data [244].

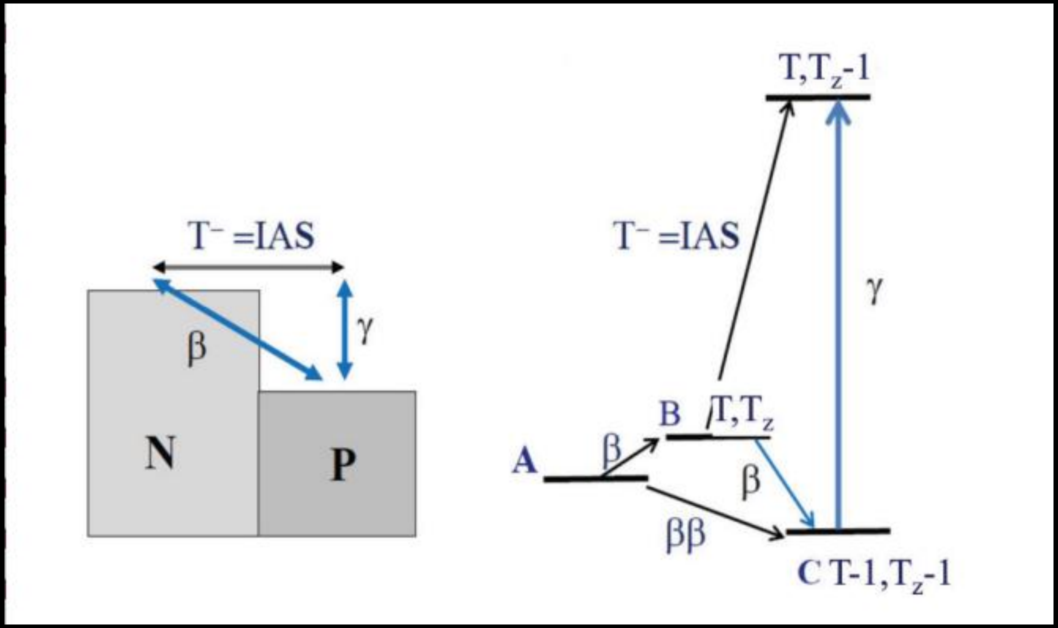
Cross section

=^{3}He,t cross section x F

F=$\Gamma(\gamma)/\Gamma(t)$

F = 1 eV/100 keV = 10 $^{-5}$





In medium and heavy nuclei, the IAS is observed as an isobaric analog resonance (IAR) in the medium-excitation region. The photonuclear cross section via the IAR with J^{π} is expressed as

$$\sigma(\gamma, n) = \frac{S(2J+1)\pi}{k_\gamma^2} \frac{\Gamma_\gamma \Gamma_n}{(E - E_R)^2 + \Gamma_t^2/4}, \qquad (10)$$

where Γ_γ, Γ_t, and Γ_n are the γ capture width, the total width, and the neutron decay width, S is the spin factor, and k_γ is the incident photon momentum.

The integrated photonuclear cross section is given by

$$\int \sigma(\gamma, n) dE = \frac{S(2J+1)2\pi^2}{k_\gamma^2} \frac{\Gamma_\gamma \Gamma_n}{\Gamma_t}. \qquad (11)$$

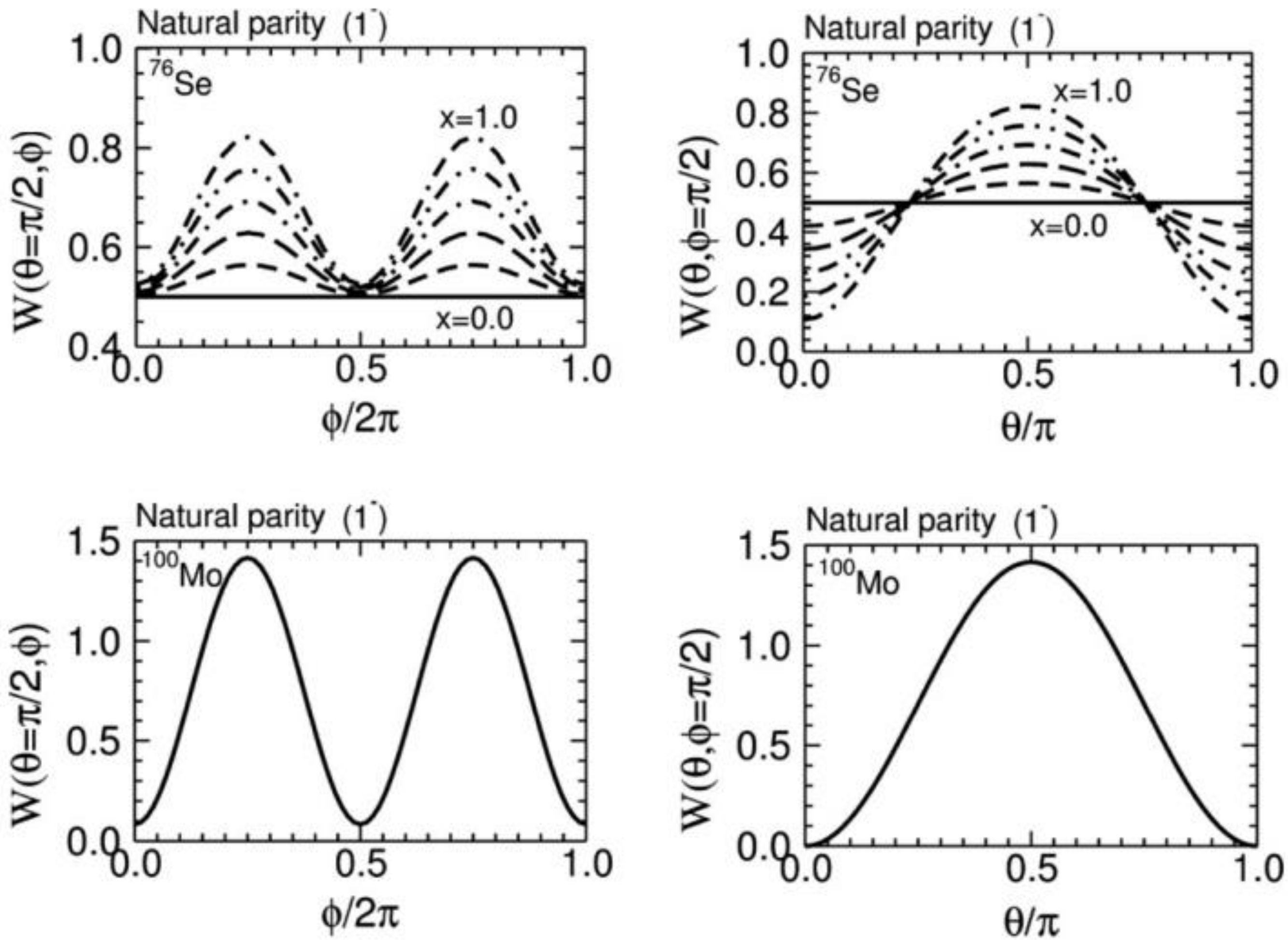


FIG. 3. Top: Azimuthal (left) and polar (right) angular distributions (relative) of the neutron from the 1^- photonuclear excitation on ^{76}Se with x being the fraction of the d configuration (see text). Bottom: The angular distributions for ^{100}Mo.

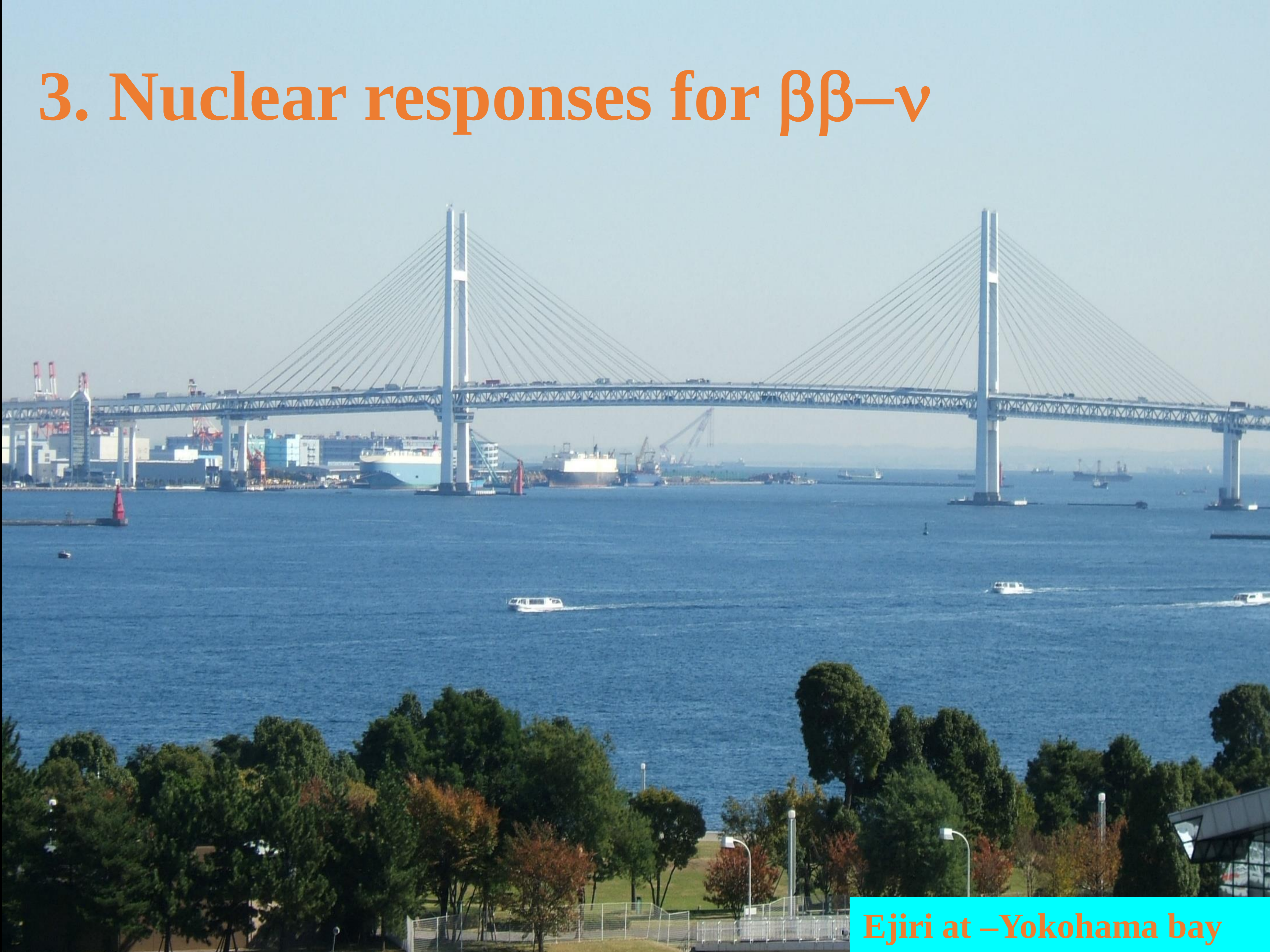

Thank you for your attention
Ejiri-weekend house at Shounan

4. Nuclear responses for solar–ν.

A view from the Ejiri-Yokohama

Thanks for your attention.

3. Nuclear responses for ββ–ν



Ejiri at –Yokohama bay

J-PARC

ν probes $p + X = n\,\pi \quad \pi = \nu_\mu + \mu \quad \mu = \nu_\mu + \nu_e + e$