SOLAR NEUTRINO CAPTURE CROSS-SECTION FOR ^{76}Ge NUCLEI *

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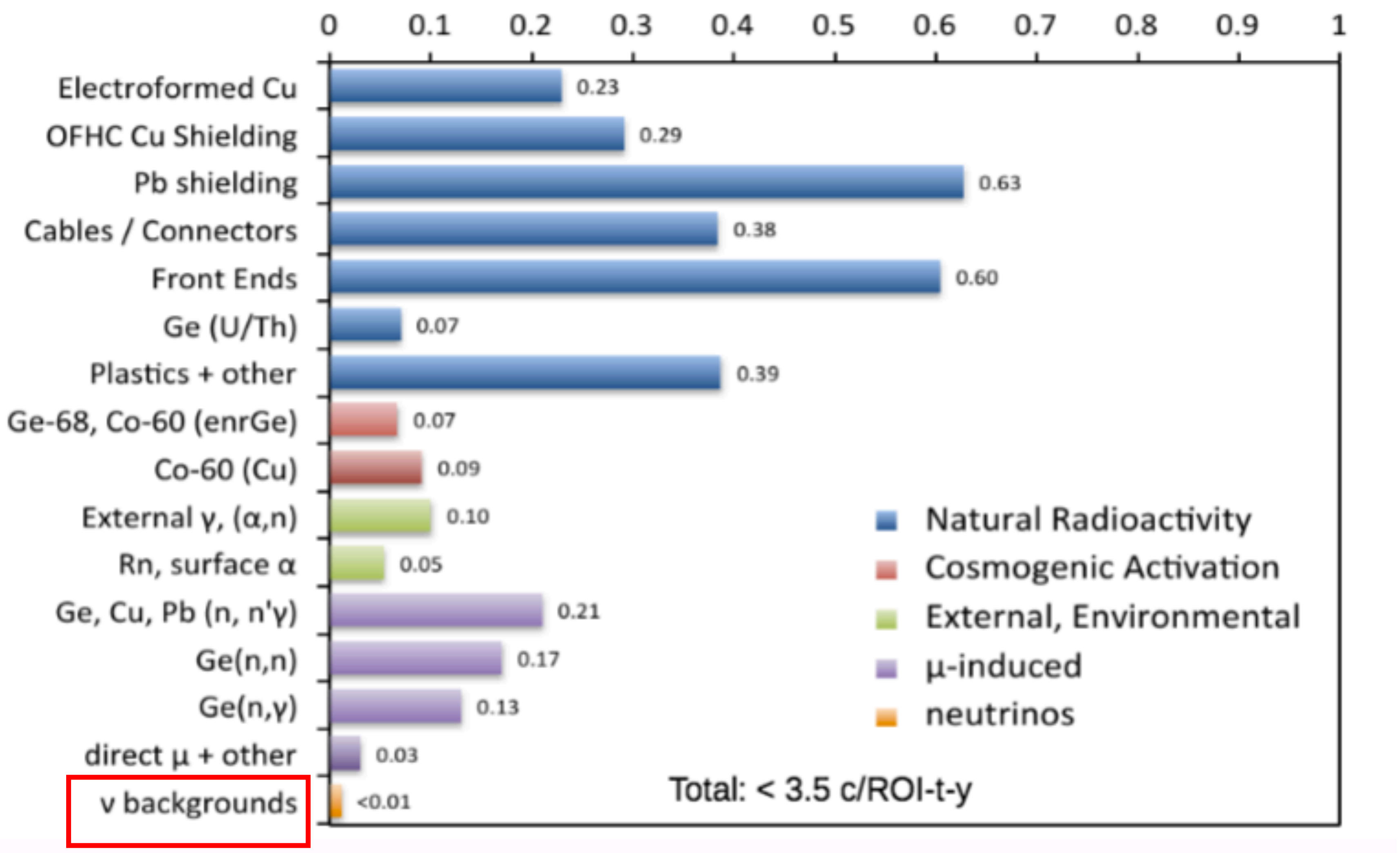
MAJORANA experiment

GERDA experiment

$0\nu\beta\beta$ *decay*: $\quad {}^{76}_{32}Ge \rightarrow {}^{76}_{34}Se + 2e^{-}, \quad Q_{0\nu\beta\beta} = 2039\ keV$

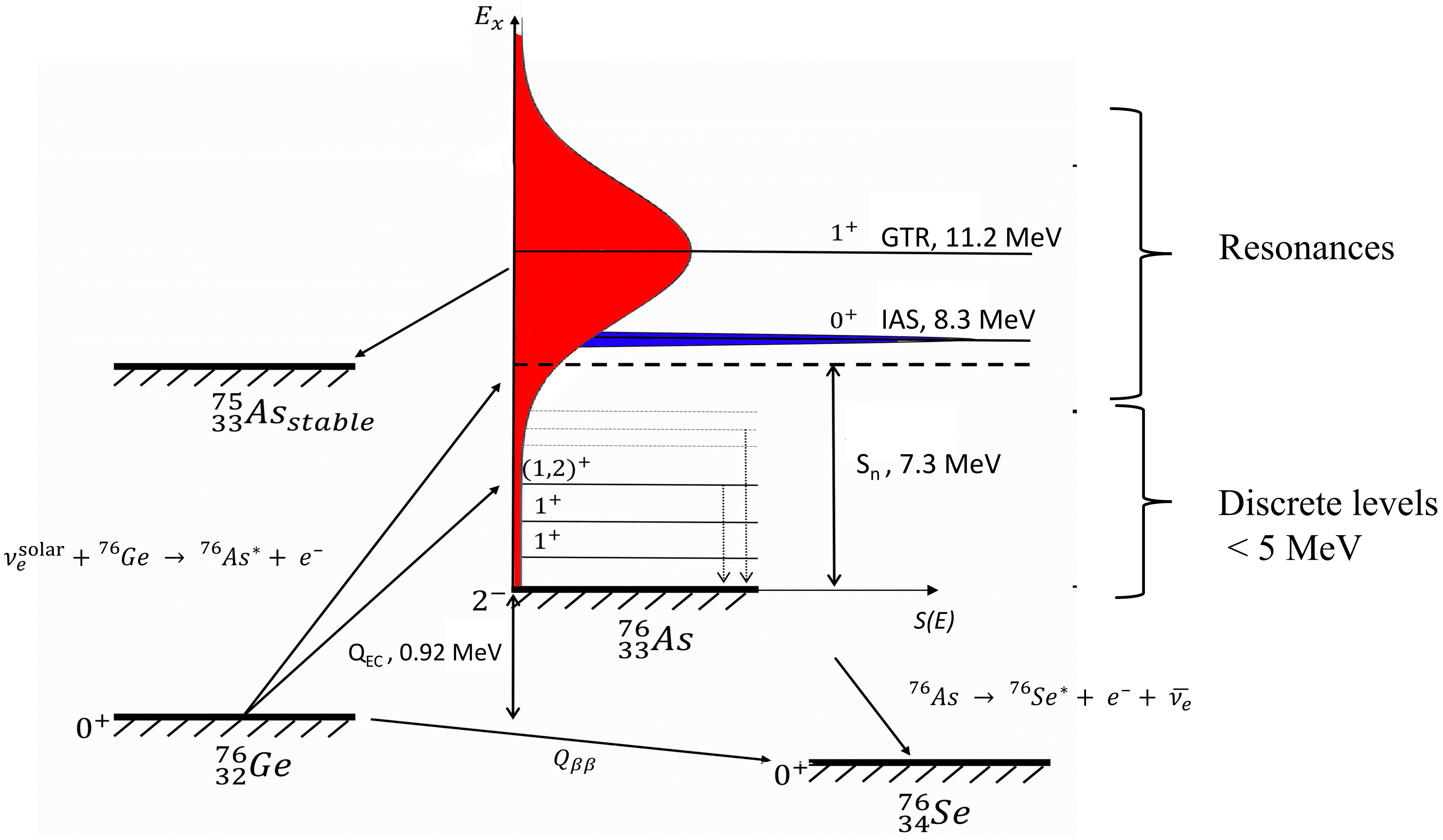
ν *backround*: $\quad \nu_e^{\text{solar}} + {}^{76}Ge \rightarrow {}^{76}As + e^{-} + n\gamma$

$${}^{76}As \rightarrow {}^{76}Se + e^{-} + \overline{\nu_e} + m\gamma$$

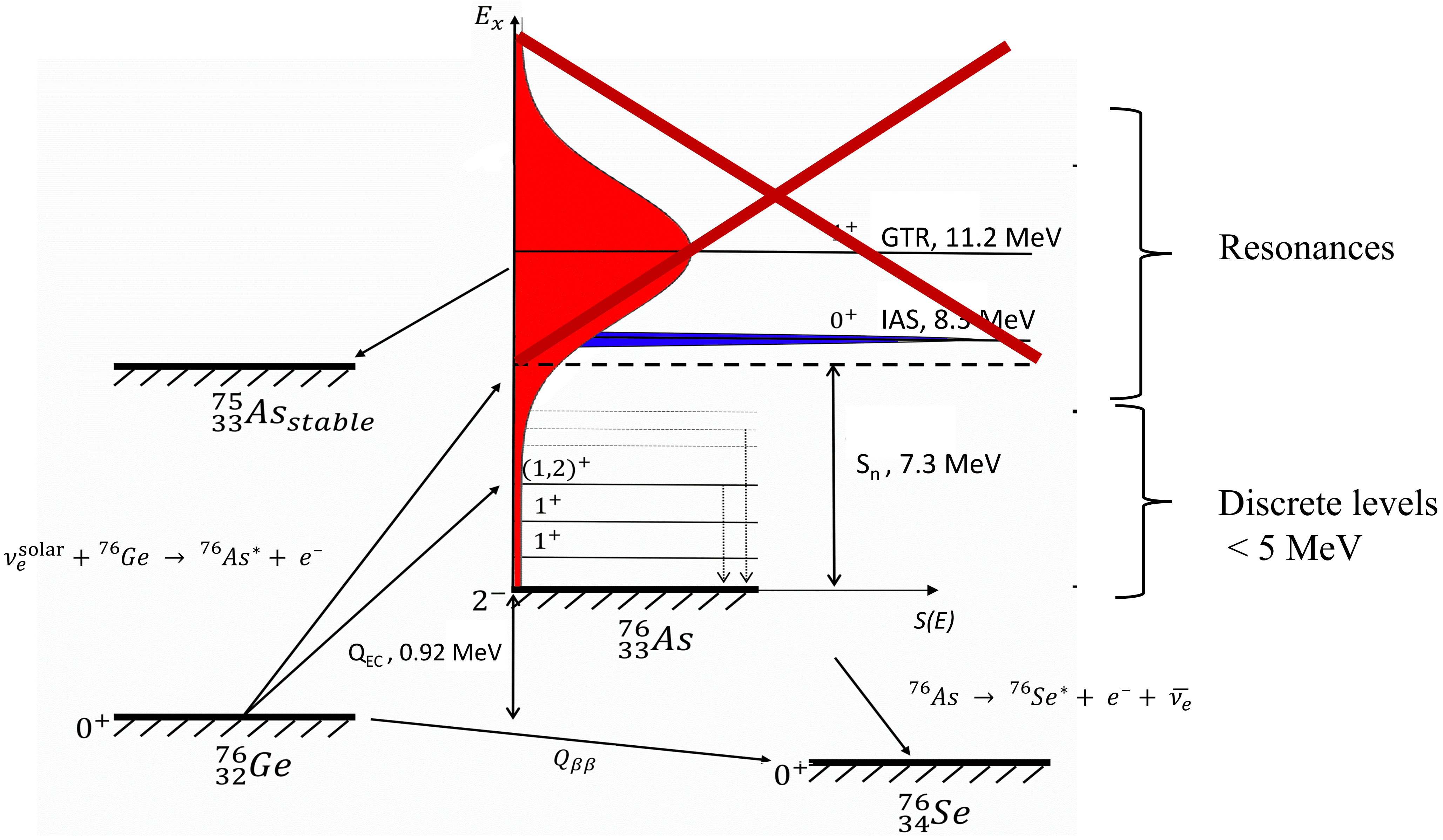


background events in MAJORANA experiment (2017)

MAJORANA, GERDA → LEGEND



Scheme of transitions



Scheme of transitions

$$\sigma_{total}(E_\upsilon) = \sigma_{\substack{discrete \\ levels}}(E_\upsilon) + \sigma_{resonances}(E_\upsilon) \quad (= 0,\ if\ E_\upsilon \leq Q_{EC}) \tag{1}$$

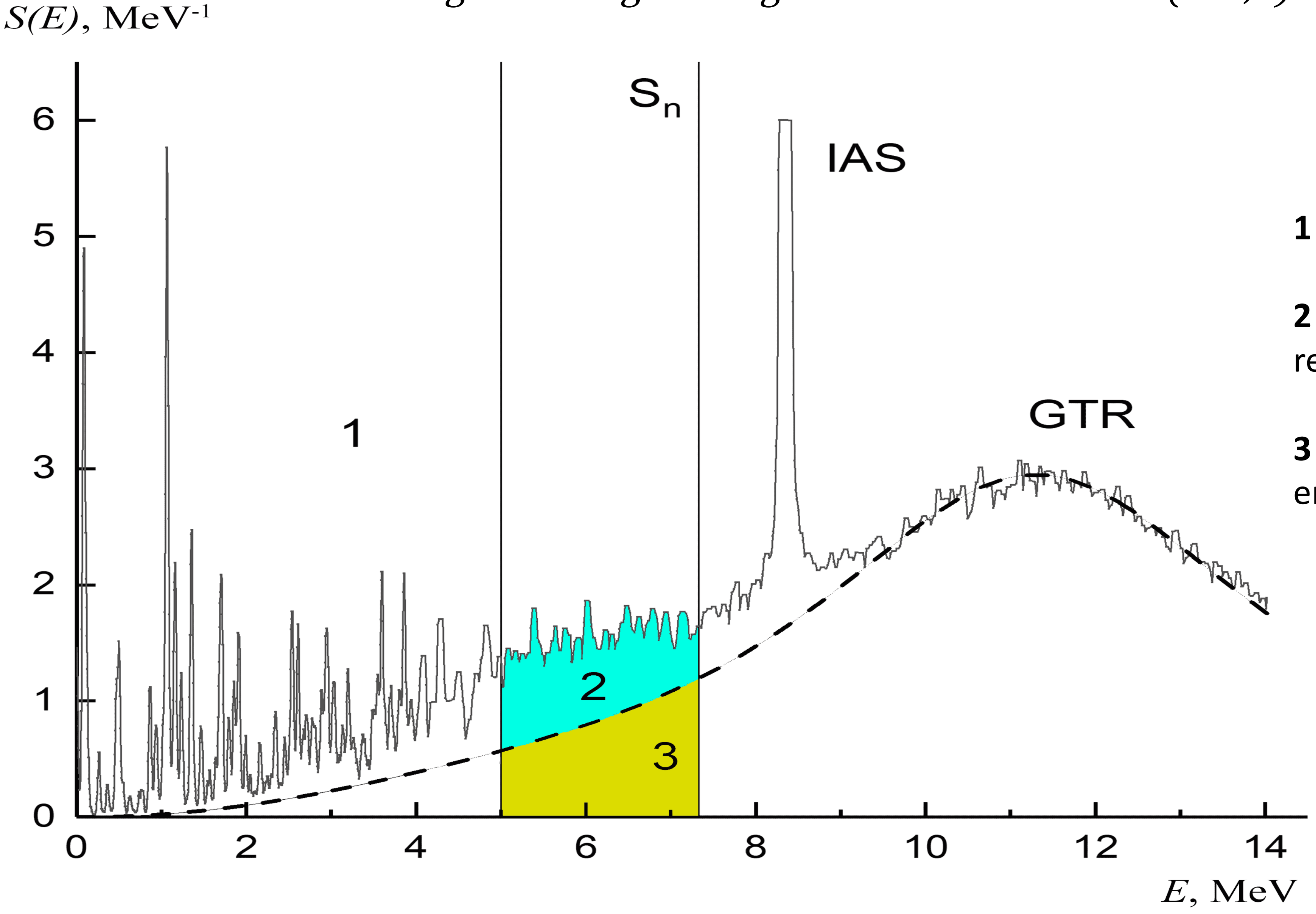
$$\sigma_{\substack{discrete \\ levels}}(E_\upsilon) = \sum_k \frac{G_F^2 cos^2\theta_c}{\pi} p_e E_e F(Z, E_e)\left[B(F)_k + \left(\frac{g_A}{g_V}\right)^2 B(GT)_k\right] \tag{2}$$

$$\sigma_{\text{res}}(E_\nu) = \frac{1}{\pi}\int_{\varepsilon_{\text{min}}}^{\varepsilon_{\text{max}}} G_{\text{F}}^2 \, cos^2\theta_{\text{C}} \, p_e \, E_e \, F(Z, E_e) S(E) \, dE \tag{3}$$

G_F – the weak coupling constant, θ_c – the Cabibbo angle
p_e/E_e – the outgoing electron momentum / total energy
$F(Z, E_e)$ – the Fermi function
$\frac{g_A}{g_V}$ – the ratio of the axial vector and vector coupling constants
$B(F)_k$, $B(GT)_k$ – the Fermi (Gamow-Teller) response *k*-th excited state of ${}^{76}_{33}As^*$
$S_\beta(E)$ – nuclear beta strenght function
E_{sep} – neutron separation energy, E_{sep} = 7.3 MeV
ε_{min} = 5 MeV, $\varepsilon_{max} = E_{sep}$

$$\nu_{e\ solar} + {}^{76}_{32}Ge \rightarrow {}^{76}_{33}As^* + e^-$$

Charge-exchange strength function of the $^{76}Ge(^{3}He, t)\,^{76}As$ reaction S(E)

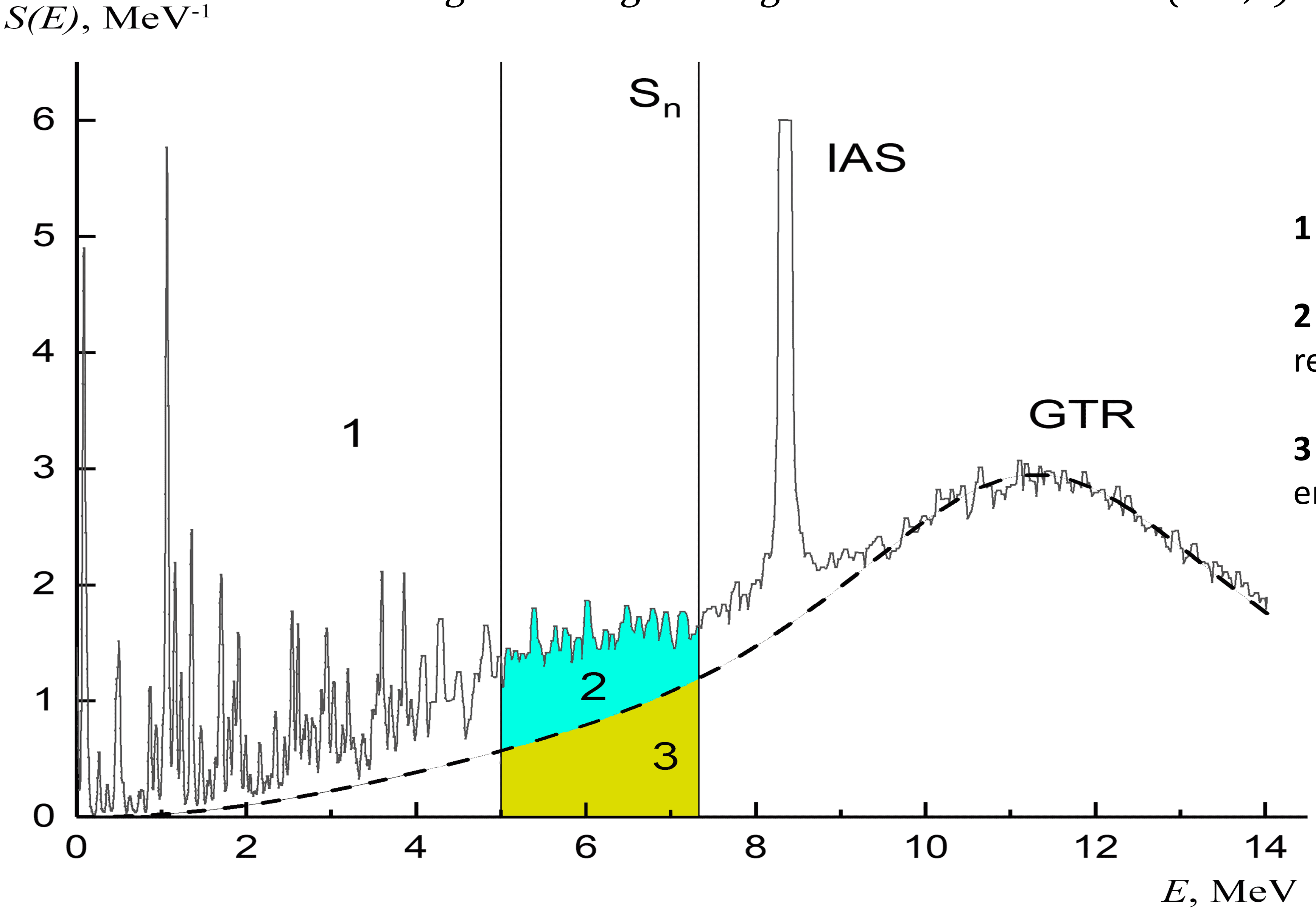


1 - below 5 MeV, discrete levels;

2 - continuous excited states without GTR resonance;

3 - tail of the GTR resonance in the energy range from 5 MeV to S_n (7.3 MeV).

Charge-exchange strength function of the $^{76}Ge(^3He, t)\,^{76}As$ reaction $S(E)$



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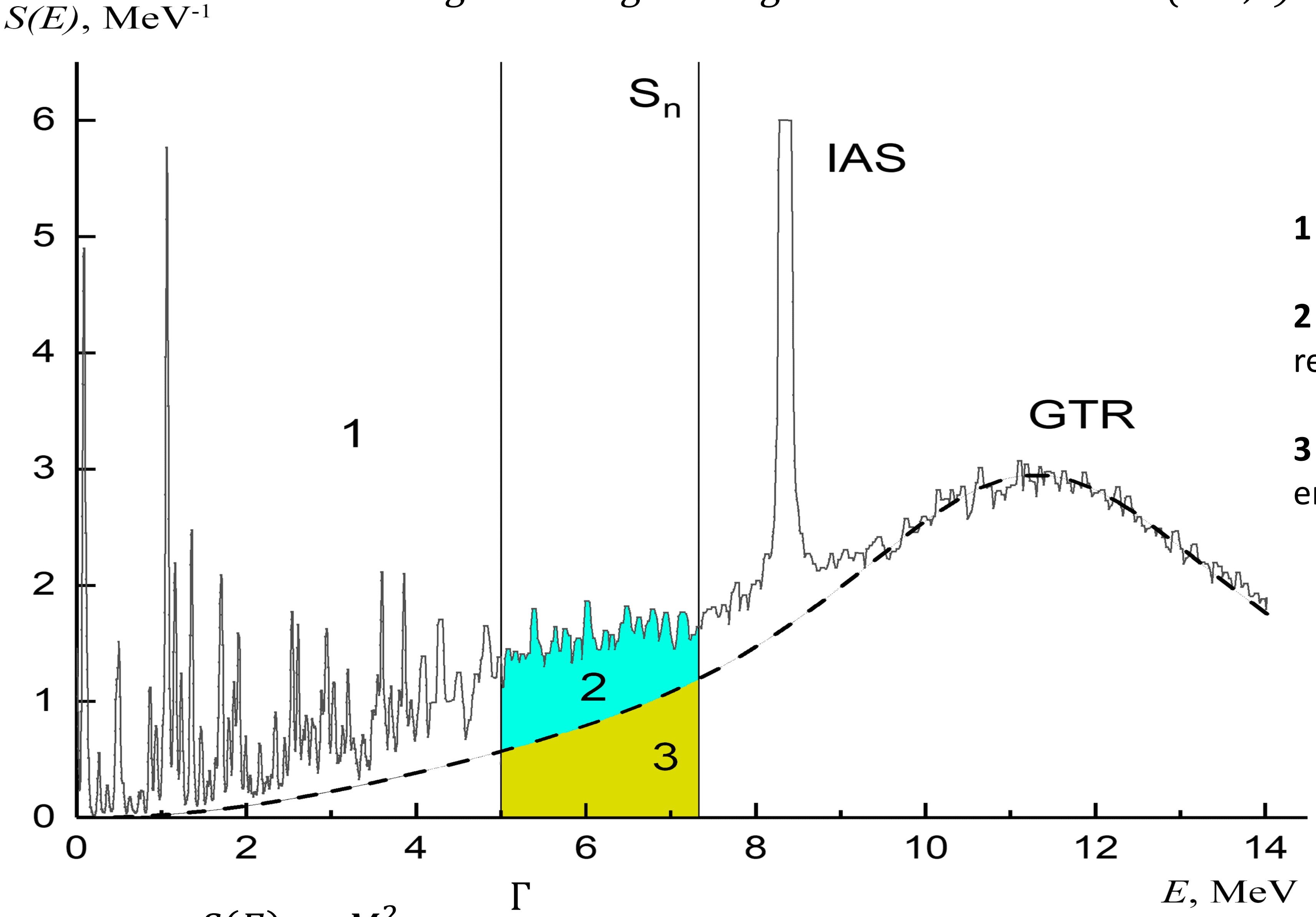
$$\sum M_i^2 = \sum_k B(GT)_k + \int_{\Delta_{min}}^{\Delta_{max}} S(E)\,dE = 3\,(N-Z) = 36,$$

$\Delta_{min} = 5$ MeV,
$\Delta_{max} = 28$ MeV,
$\sum_k B(GT)_k = 1.6$

Charge-exchange strength function of the $^{76}Ge(^{3}He, t)\,^{76}As$ reaction $S(E)$



$$S(E) = M_i^2 \frac{\Gamma}{(E-\omega_i)^2+\Gamma^2}$$

Γ = 3.3 MeV

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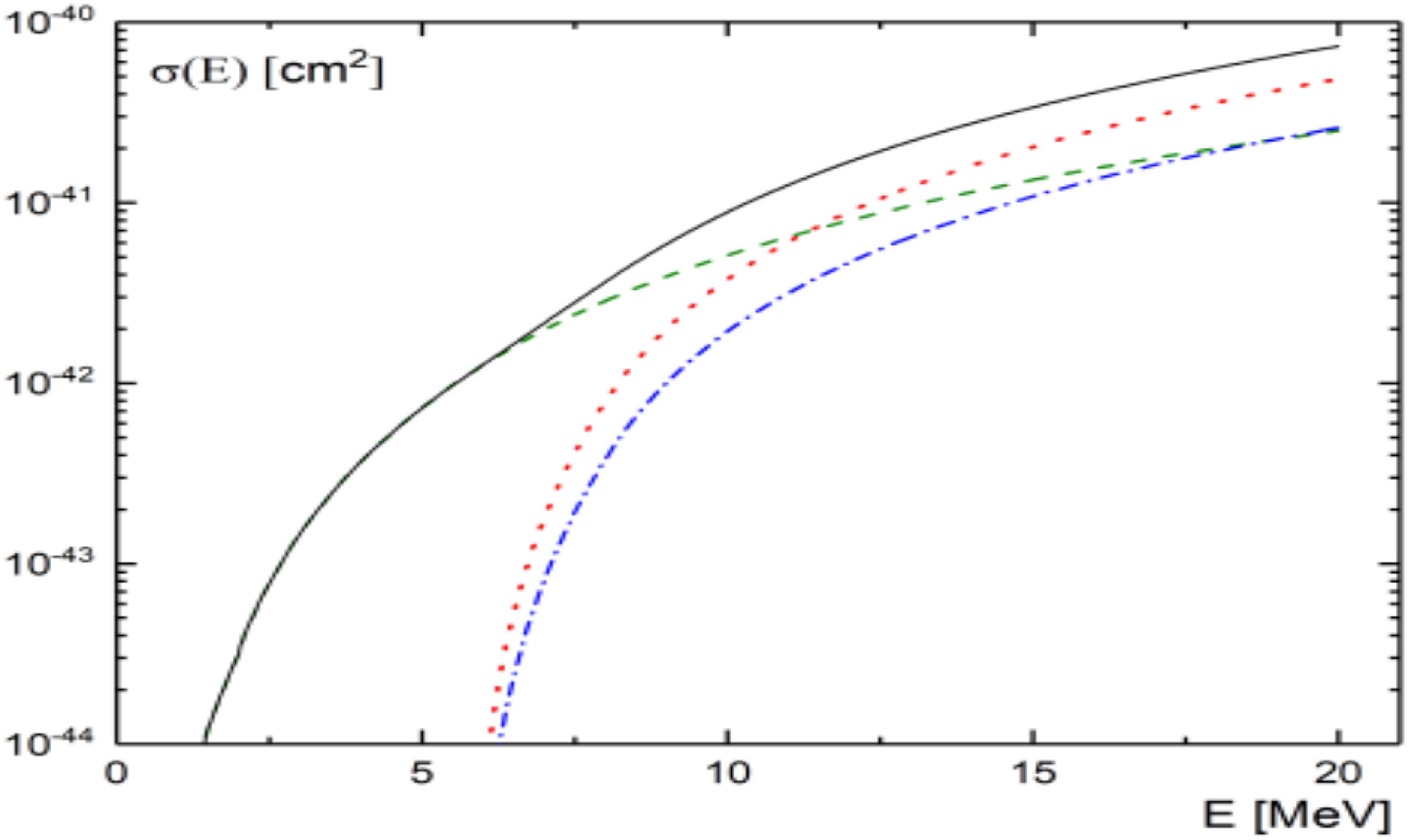
Cross-sections for $^{76}Ge(\nu_e, e)^{76}As$ reaction



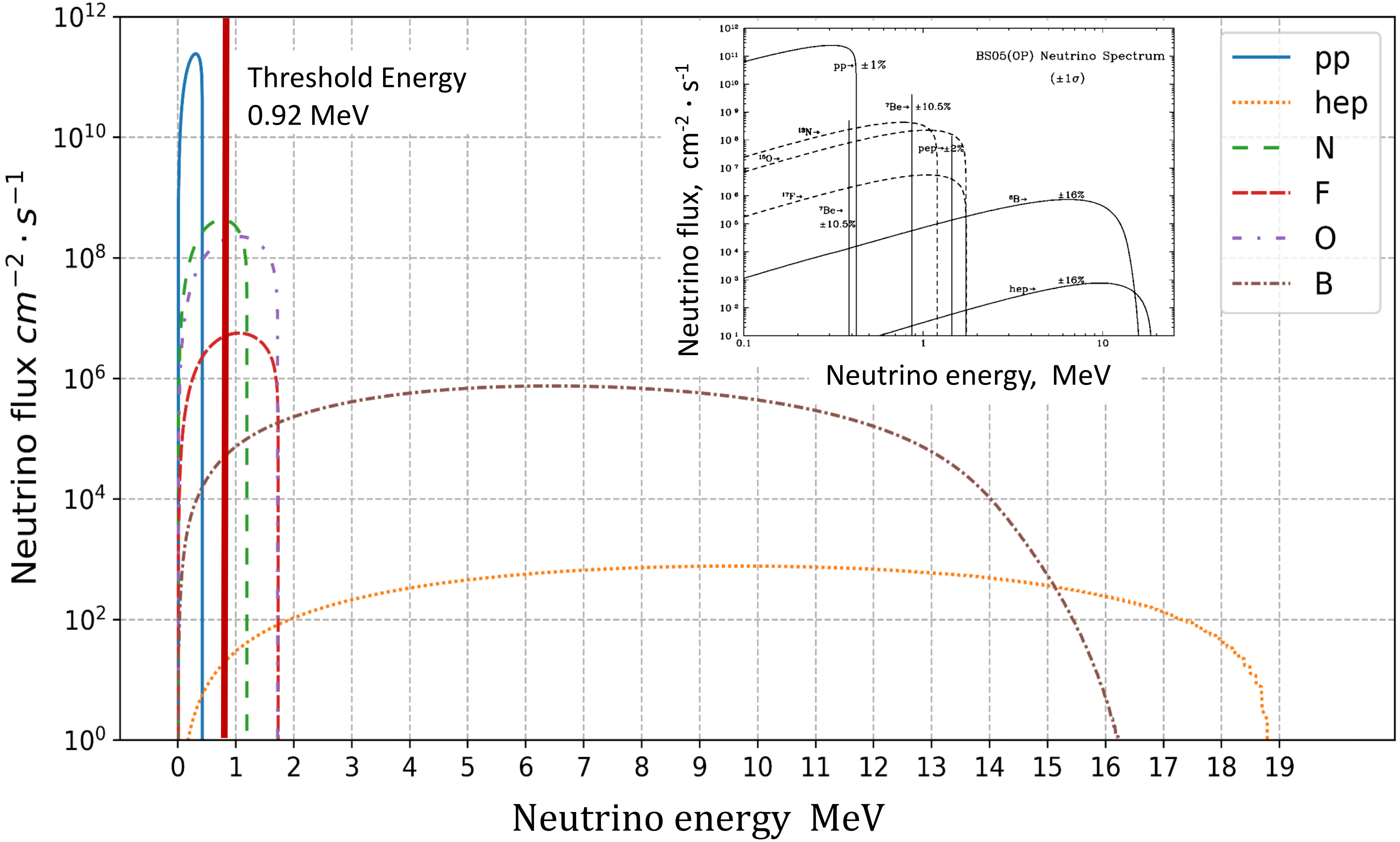
continuous excited states with E: 5 MeV < E < S_n

GTR with E: 5 MeV < E < S_n

discrete states

total

Flux density of incident neutrinos (BS05 model)



$$R = \int_0^{Emax} \rho_{solar}(E_\nu)\, \sigma_{total}(E_\nu)\, dE_\nu$$ – capture rate, $E_{max} = 18.79$ MeV

Rate of solar neutrino capture

Capture rate of solar neutrinos [*SNU]	pep	hep	$^{13}\mathbf{N}$	$^{17}\mathbf{F}$	$^{15}\mathbf{O}$	$^{7}\mathbf{B}$	Total capture rate
$\mathbf{R_{discr}}$	1.369	0.0451	0.102	0.021	0.828	13.54	15.9
$\mathbf{R_{total}}$	1.369	0.090	0.102	0.021	0.828	21.17	23.58
$\mathbf{R_{discr} + R_{GTR}}$	1.369	0.070	0.102	0.021	0.828	17.46	19.85
$\mathbf{R_{GTR}} / \mathbf{R_{total}}$	0%	28%	0%	0%	0%	19%	17%
$\mathbf{R_{cont}} / \mathbf{R_{discrete}}$	0%	99%	0%	0%	0%	56%	48%

*SNU = $10^{-36} \frac{1}{nucleon \cdot s}$

Summary:

- $\sigma(E_\nu)$ were determined using S(E) for discrete and continuous states
- The effect of resonance structure on $\sigma(E_\nu)$ was investigated
- 17% - contribution of only GTR
- Account of continuous states increases R by up 50%

It is planned to:

- Consider other types of resonances and states behind S_n
- Consider neutrino oscillations
- Calculate the contribution of the secondary process $^{76}\mathrm{As} \rightarrow {}^{76}\mathrm{Se} + e^{-} + \bar{\nu}_e$

(account the design of detecting elements)

THANK YOU FOR YOUR ATTENTION!