New Reactor antineutrino spectrum on base of Double Chooz experimental data

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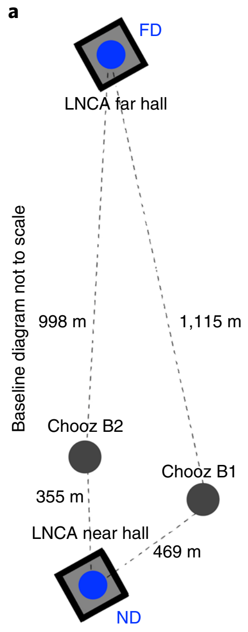
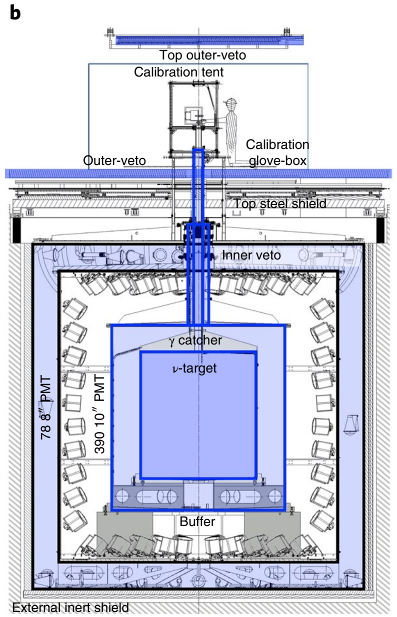
Plan of the talk

- Experimental site
- Data accumulated by the detector
- Subtraction of backgrounds
- Monte Carlo simulation of positron spectrum registration
- Transformation of measured positron spectrum to antineutrino one
- Splitting experimental $\overline{\nu_e}$ spectrum on components
- Fitting of components by calculation
- New antineutrino spectra
- Cross sections of spectra and Double Chooz experimental cross section
- Conclusion

Double Chooz experimental site

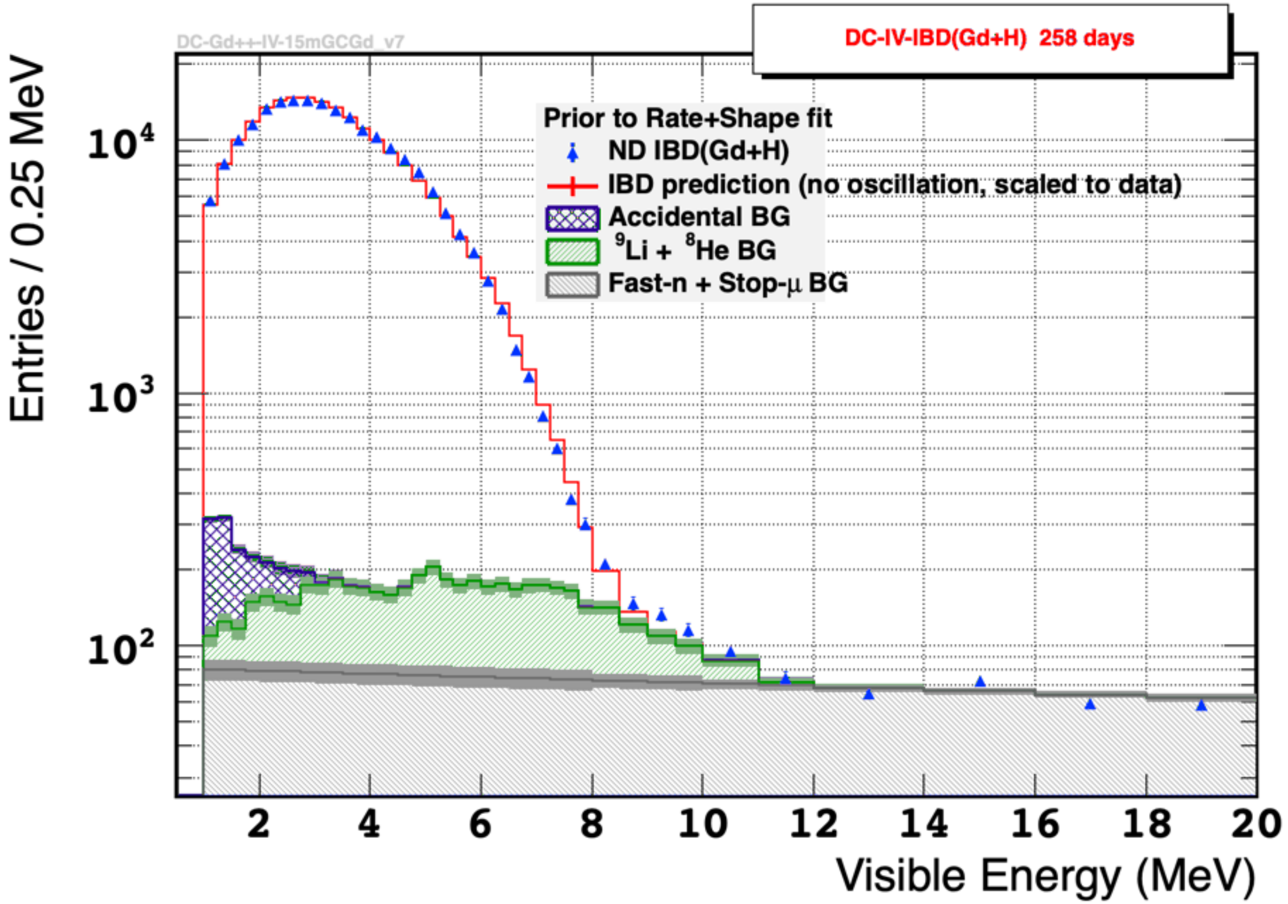


Detector positions from top view



Each Detector construction

Experimental data taken by near detector



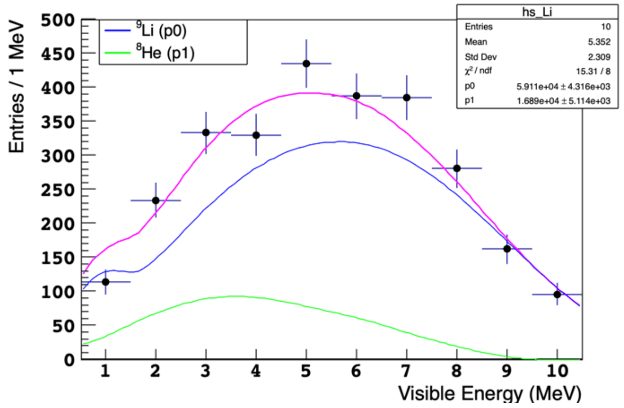
~200 000 events in the spectrum

To get positron spectrum one needs to subtract backgrounds:

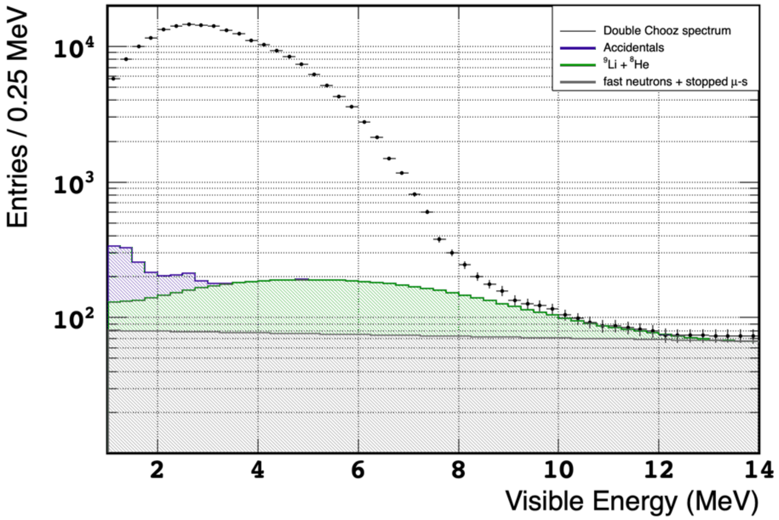
- Accidentals
- ^{9}Li-^{8}He cosmogenic
- Fast neutrons and stopped muons

Nature Physics, (2020) 16, 558–564. doi: 10.1038/s41567-020-0831-y
Arxiv:1901.09445 [hep-ex]

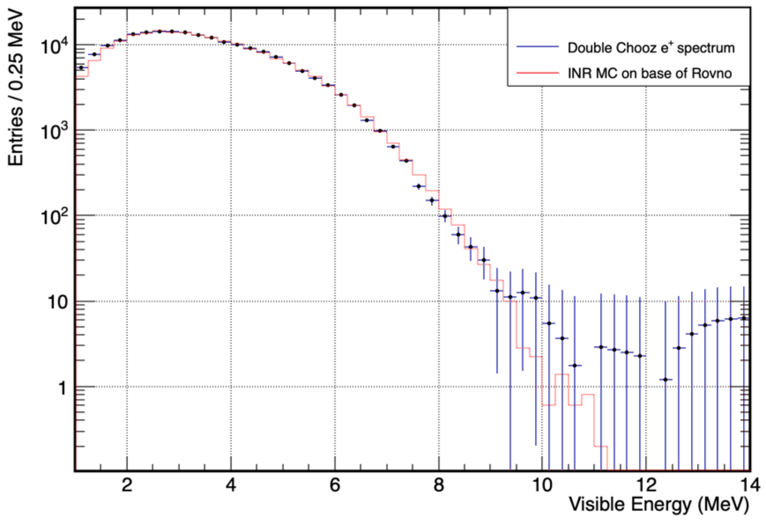
Treatment of experimental spectrum



Experimentally measured beta-spectrum produced by cosmogenic isotopes ^{9}Li and ^{8}He.



Normalized ^{9}Li and ^{8}He beta-spectrum on measured counting rate of these events in near detector.



Pure positron spectrum after background subtraction.
Red line – Monte Carlo simulation on base of Rovno spectra.

Positron and antineutrino spectra

$$\frac{dN_e}{dT}(T) = \int_{E_{thr}}^{E_{max}} \frac{dN_e}{dE}(E) \cdot \sigma_{\nu p}(E) \cdot R(E,T)dE$$

Positron spectrum

Positron kinetic energy

Antineutrino spectrum

Antineutrino energy

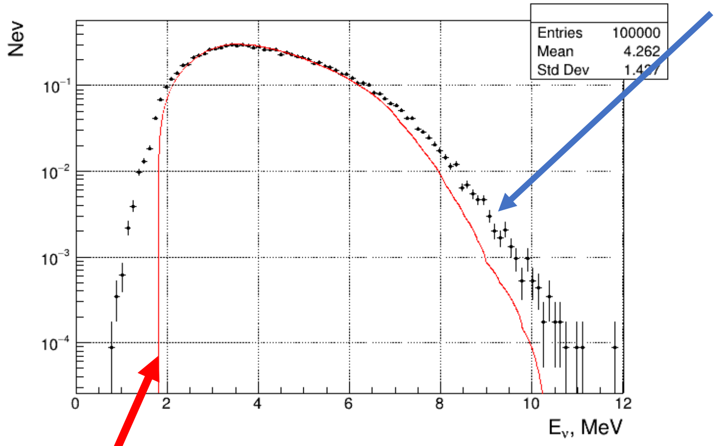
Antineutrino cross section

Detector response function

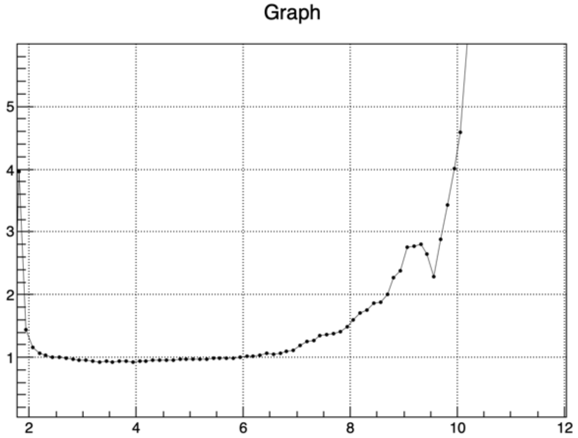
Cross section: Strumia and F. Vissani, Phys. Lett. B 564, 42-54 (2003) doi:10.1016/S0370-2693(03)00616-6 [arXiv:astroph/0302055 [astro-ph]].
G. Ricciardi, N. Vigniaroli, F. Vissani, JHEP 08 (2022) 212 doi:10.1007/JHEP08%282022%29212 [arXiv:2206.05567 [hep-ph]].

Monte Carlo transformation function calculation

Monte Carlo simulated spectrum shifted on 0.85 MeV



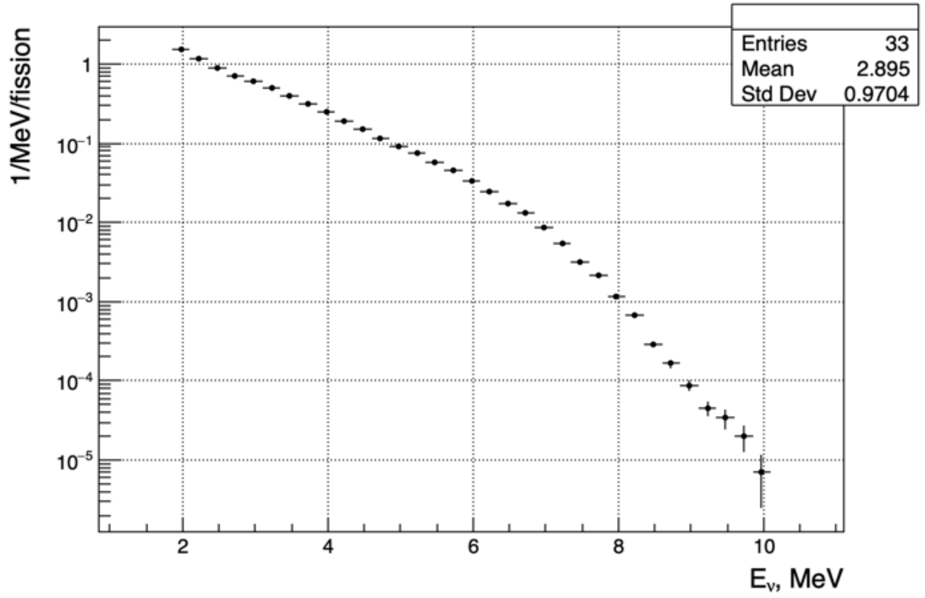
Ideal spectrum $\frac{dN_\nu}{dE}(E)\sigma_{\nu p}(E)$



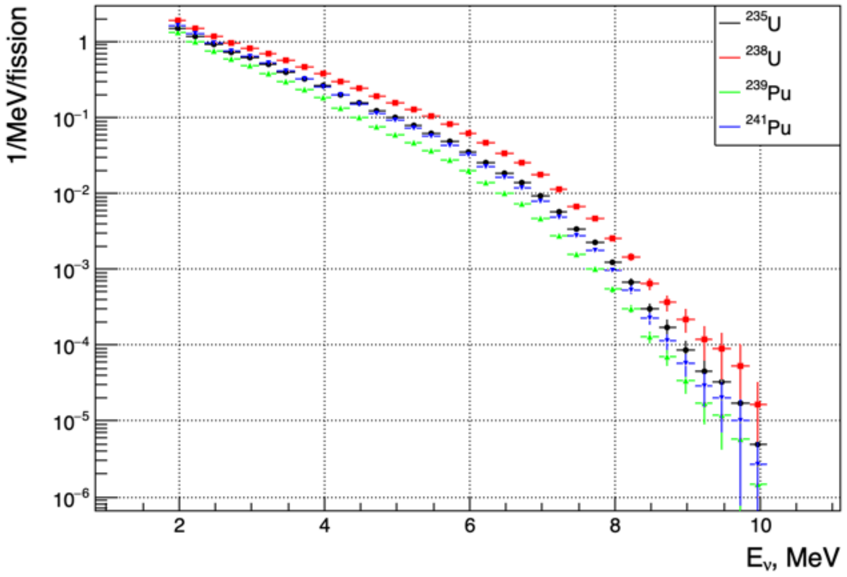
E_ν, MeV

Transformation function

Experimental antineutrino spectrum



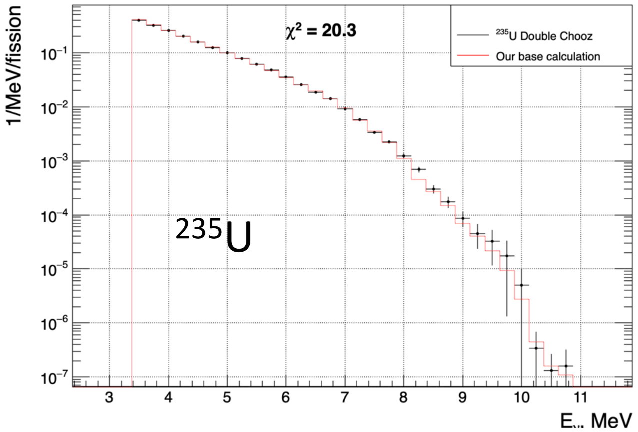
Experimental antineutrino spectrum as a result of division experimental ideal spectrum by transformation function

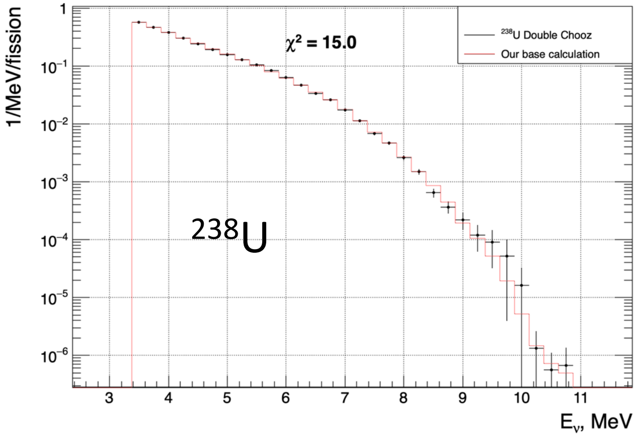


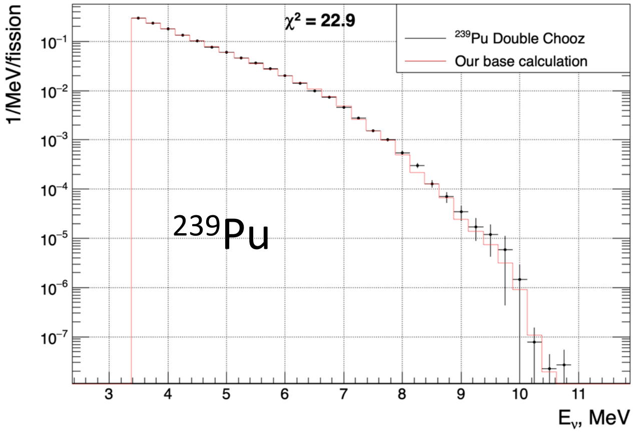
^{235}U, ^{238}U, ^{239}Pu, ^{241}Pu experimental antineutrino spectra as a result of splitting experimental spectrum according to their parts

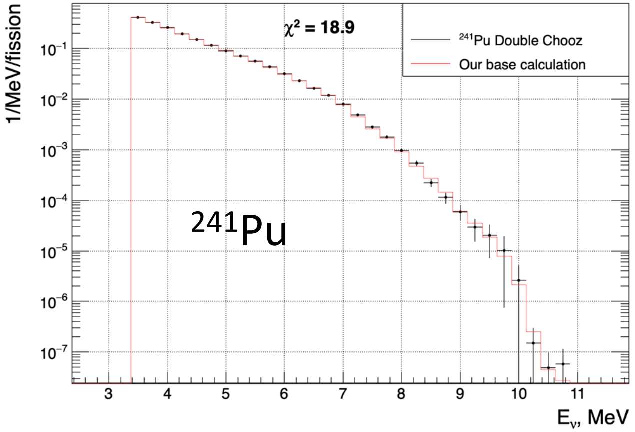
^{235}U – 0.52, ^{238}U – 0.087, ^{239}Pu – 0.333, ^{241}Pu – 0.06

Fitting of experimental spectra by calculated ones









Cross sections of calculated spectra [$\times 10^{-43}$ cm^2/fission]

	^{235}U	^{238}U	^{239}Pu	^{241}Pu	DC
Эта работа	5.992	9.066	4.113	5.839	5.63
Rovno	6.241	9.089	4.269	5.948	5.815
ILL	6.395	8.903	4.185	5.768	5.840
Vogel	6.498	9.135	4.508	6.520	6.066
MEPhI	6.404	9.267	4.383	6.489	5.985
Huber & Mueller	6.658	10.08	4.364	6.031	6.154
Kopeikin et al.	6.308	9.395	4.33*	6.01*	5.900

Experimental Double Chooz $\sigma_f = (5.71 \pm 0.06) \cdot 10^{-43}$ cm^2/fission

Calculation of other experiments cross sections using INR spectra

experiment	Core content				${}^{i}\sigma_f$ x10^{43} [cm^2/fission]	${}^{INR}\sigma_f$ x10^{43} [cm^2/fission]	R
	^{235}U	^{238}U	^{239}Pu	^{241}Pu			
DC	0.520	0.087	0.333	0.060	5.71 ± 0.06	5.63	1.015
Bugey-4	0.538	0.078	0.328	0.056	5.752 ± 0.081	5.61	1.026
Daya Bay	0.561	0.076	0.307	0.056	5.91 ± 0.12	5.64	1.048

Conclusion

- New ^{235}U, ^{238}U, ^{239}Pu, ^{241}Pu antineutrino spectra are performed on base of Double Chooz measurement
- Superposition of cross sections per fission satisfy to most exact experimental cross section (Double Chooz)
- Systematically smaller values of calculated cross sections in compare with experimental ones can be explained by not accounting of spent fuel emission