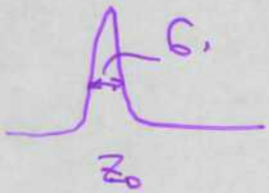
Измерение массы нейтрино (ν)

Из распадов Z_0 установлено $\exists$ $3^х$ типов ν

$$\begin{pmatrix} \nu_e \\ \nu_\mu \\ \nu_\tau \end{pmatrix} \rightsquigarrow \begin{pmatrix} e \\ \mu \\ \tau \end{pmatrix}$$

$Z_0 \to \nu\bar{\nu}$.



- Масса нейтрино в СМ не фиксирована (свободный параметр)
- Диапазон предсказаний из ССМ $(0 \div 50)$ эВ.
- Скрытая масса Вселенной $\left(1м^3 - 1p + \frac{300\,\nu}{см^3}\right)$ достаточна $m_\nu \simeq 10 \div 30$ эВ.
- Недостаток Солнечных нейтрино. Осцилляции m_ν – ? < 1 эВ.

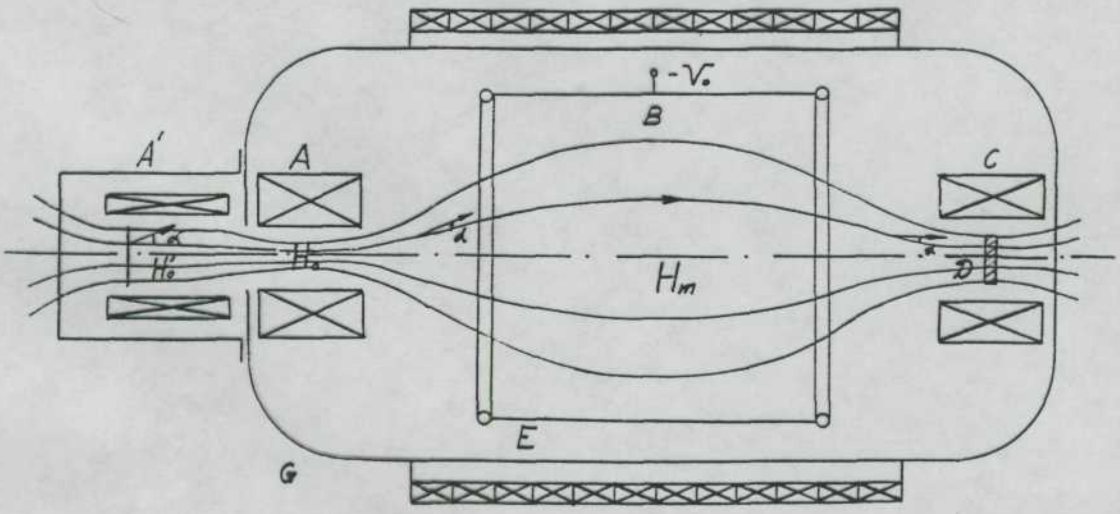
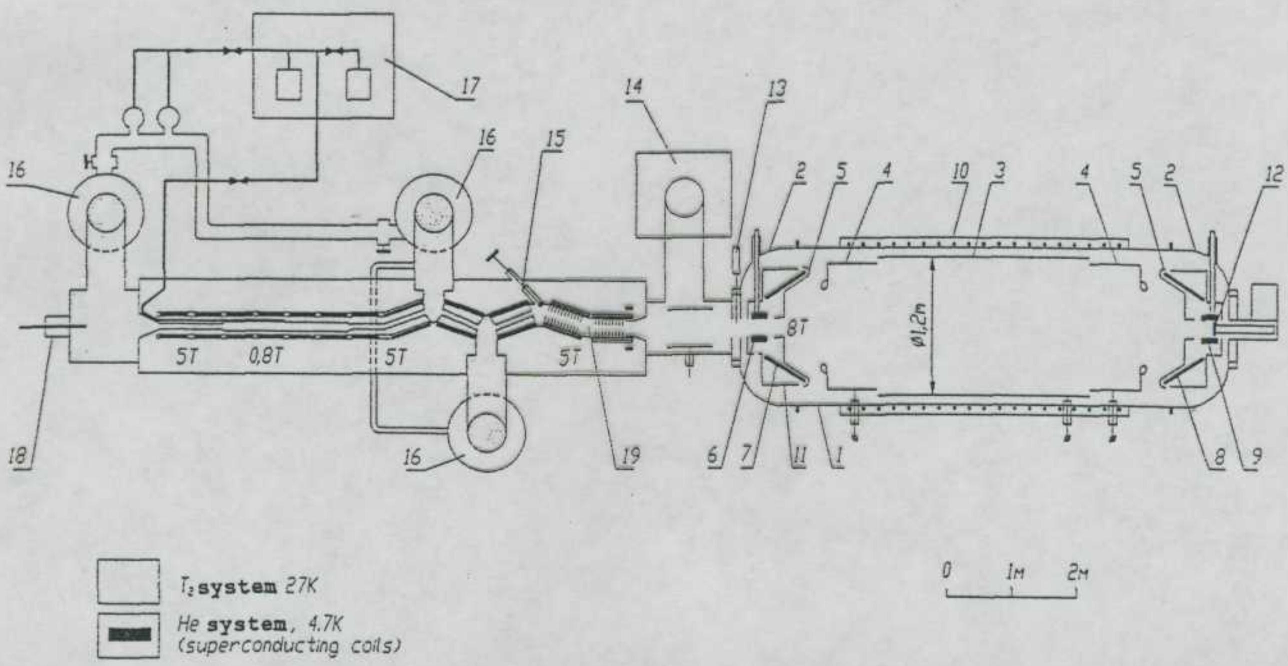


Fig. 1. Schematic diagram of the spectrometer and configuration of the magnetic field. H_0', H_0 and H_m are
strengths. D is the detector; E is the electrostatic analyzer. Only some of the solenoids setting up a magnetic field

$$\sin^2\alpha / H = \mathrm{const} \quad \text{– инвариант}$$

$$\sin\alpha_{max} = \sqrt{H_m/H_0}\ ; \quad p_\perp = \mathrm{const}\ ; \quad p_\parallel \to 0.$$

$$\Delta E = E_0 \cdot \sin^2\alpha_m = E_0 \cdot \frac{H_m}{H_0}$$



ig. 1. Experimental setup. (1), (2) vacuum tank; (3), (4) electrostatic analyzer; (5) grounded electrode; (6), (7), (8), (9) superconducting
olenoids; (10) warm coil; (11) liquid-N_2 jacket; (12) detector; (13) fast shutter; (14) Ti-pump; (15) cold valve; (16) Hg diffusion pump;
17) T_2 purification system; (18) electron gun; (19) argon pump.

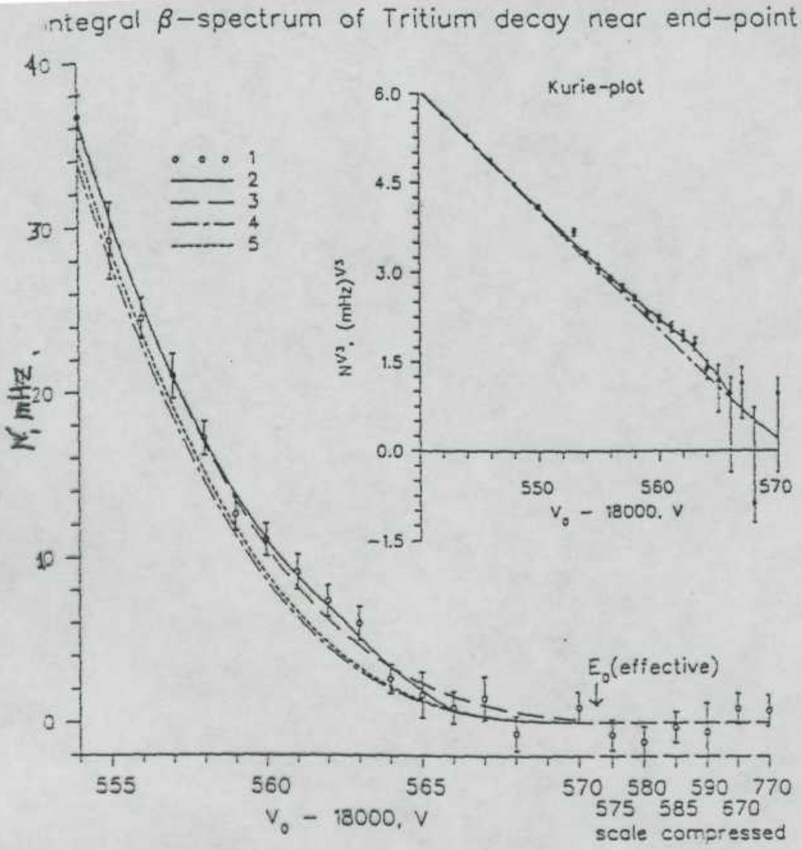


Fig. 2. Part of the tritium spectrum (a) and of the Kurie-plot (b) near the end point. V_0 is the spectrometer voltage; N1 is the experimental spectrum. N2–N5 are the calculated spectra with different variables: N2 is standard + m_ν^2 and $\Delta N_{\rm step}$; N3 is standard + m_ν^2; N4 is the N2 spectrum with step function subtracted; N5 is standard with fixed background. Measuring time is 4.4–5.4 $\times 10^4$ s/point. Background is 22–30 mHz.

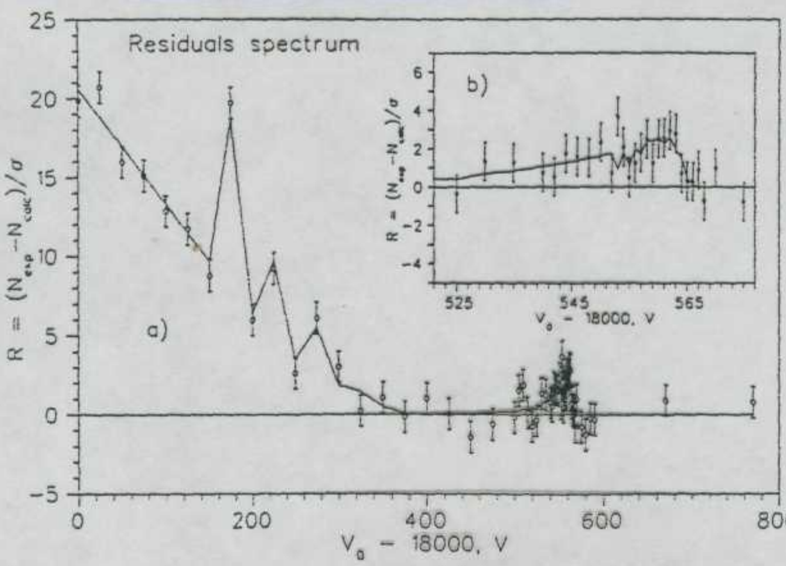


Fig. 3. Residuals from the fit of the tritium spectrum. The residual for each point is the difference between the measured value and the calculated one divided by the corresponding error. The zero line is the standard spectrum ($m_\nu^2 = 0$) fitted with fixed background and $E_{\rm low} = 18350$ eV and extrapolated to 18000 eV. The solid line is fitted spectrum with variation of m_ν^2, $\Delta N_{\rm step}$, $EM_0^{\rm C}$, $P^{\rm MC}$ and of standard parameters. Jumps in the curve are due to the difference in measurement times of different points.

Table 1
Experimental limits (95% CL) on the mass of electron neutrinos from tritium beta decays as reported in reviewed papers. New, improved limits have been published by the Troitsk group in conferences in 1997 (see text).

publication	m_ν^2 (eV^2)	$m_\nu/eV \leq$
Belesev et al. [1]	-22 ± 4.8	4.35
Stoeffl et al. [2]	$-130 \pm 20 \pm 15$	7.0
Weinheimer et al. [3]	$-39 \pm 34 \pm 15$	7.2
Robertson et al. [6]	$-147 \pm 68 \pm 41$	9.3
Holzschuh et al. [7]	$-24 \pm 48 \pm 61$	11.7
Kawakami et al. [8]	$-65 \pm 85 \pm 65$	13.1
Hiddeman et al. [9]	313 ± 5994	15^{+32}_{-15}

→ Любимов в 1980 г
$M_\nu = 27 \div 42$ эВ
↓
35 эВ !

Table 2
Experimental limits on the mass of ν_3 from tau decays.

publication	limits on m_ν (MeV)
ALEPH [15]	24 (95% CL)
ARGUS [13]	31 (95% CL)
CLEO [14]	32.6 (95% CL)
OPAL [16]	74 (95% CL)

(18.2), 1999 г.

ARGUS: $\tau \to 5\pi^\pm \nu_\tau$, (20 соб)

CLEO II: $\tau \to 5\pi^\pm \nu_\tau$, (60 соб)
+ $\tau \to 3\pi^\pm 2\pi^0 \nu_\tau$, (53 соб)

ALEPH: $\tau \to 5\pi^\pm (\pi^0) \nu_\tau$
+ $\tau \to 5\pi^\pm \nu_\tau$
$\tau \to 3\pi^\pm 2\pi^0 \cdot \nu_\tau$