На установке КАТРИН получено лучшее в мире ограничение на массу электронного антинейтрино

TAUP-2019 – 16th International Conference on Topics in Astroparticle and Underground Physics
(arXiv.org> hep-ex> arXiv:1909.06048)

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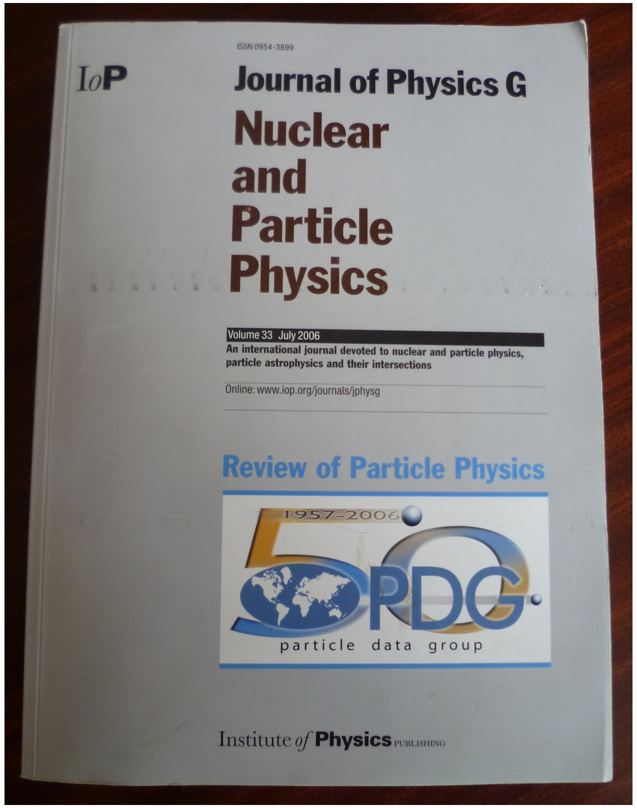
17 сентября 2019г.



From 2003:

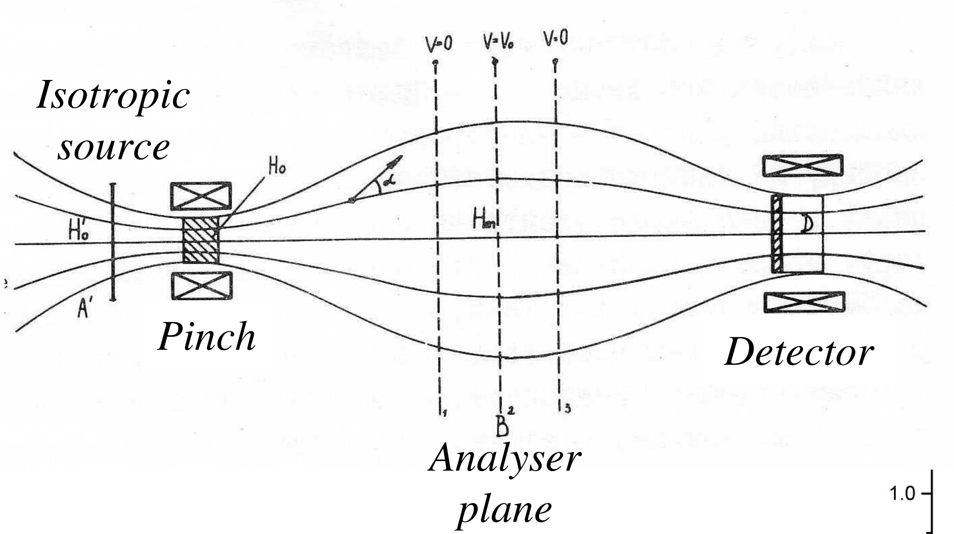
Citation: C. Patrignani *et al.* (Particle Data Group), Chin. Phys. C, **40**, 100001 (2016) and 2017 update

Neutrino Properties

See the note on "Neutrino properties listings" in the Particle Listings.

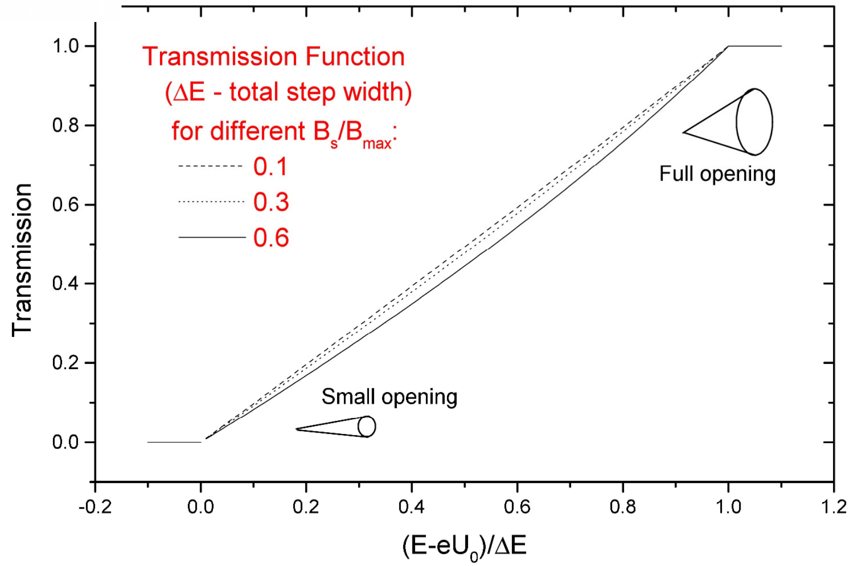
Mass $m <$ 2 eV (tritium decay)
Mean life/mass, $\tau/m >$ 300 s/eV, CL = 90% (reactor)
Mean life/mass, $\tau/m >$ 7×10^9 s/eV (solar)
Mean life/mass, $\tau/m >$ 15.4 s/eV, CL = 90% (accelerator)
Magnetic moment $\mu < 0.29 \times 10^{-10}\ \mu_B$, CL = 90% (reactor)

Электростатический спектрометр с адиабатической магнитной коллимацией
Принцип работы



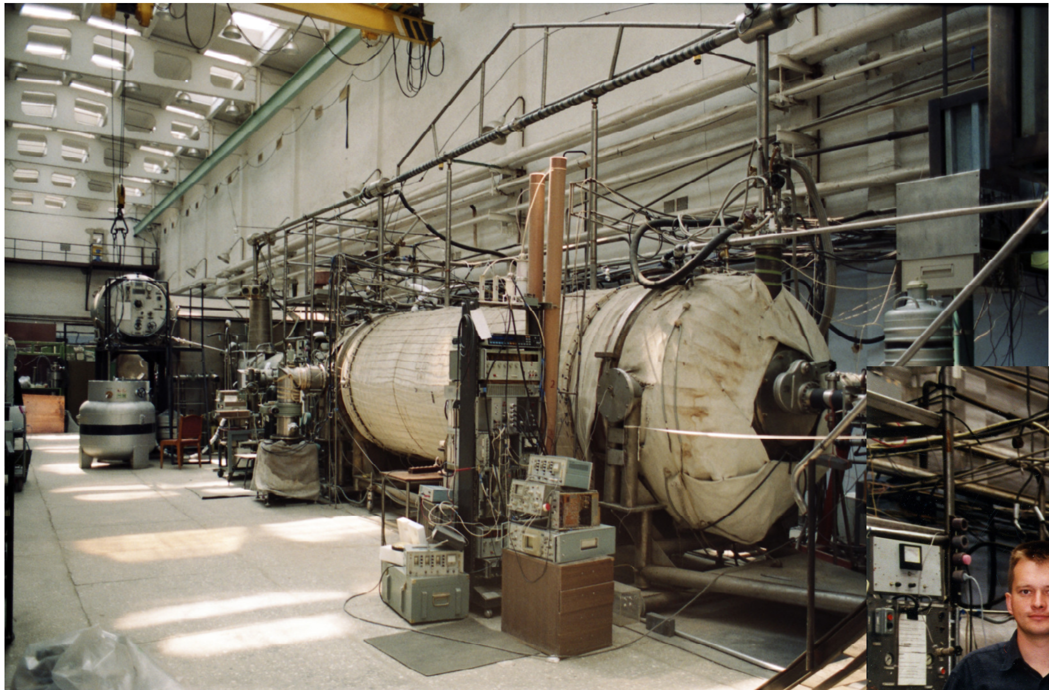
$$\Delta E = |\, eU_0 \,| \frac{B_{analyser}}{B_{pinch}}$$

Высокое разрешение спектрометра *не зависит* от размера источника



Установка «Троицк ню-масс

Спектрометр
длина 6,5 м
диаметр электрода 1,2 м
разрешение 3,7 эВ
Диаметр источника 20 мм
толщина $1 \cdot 10^{17}$ мол/см^2,
активость 0,3 GBk (8 mCi)



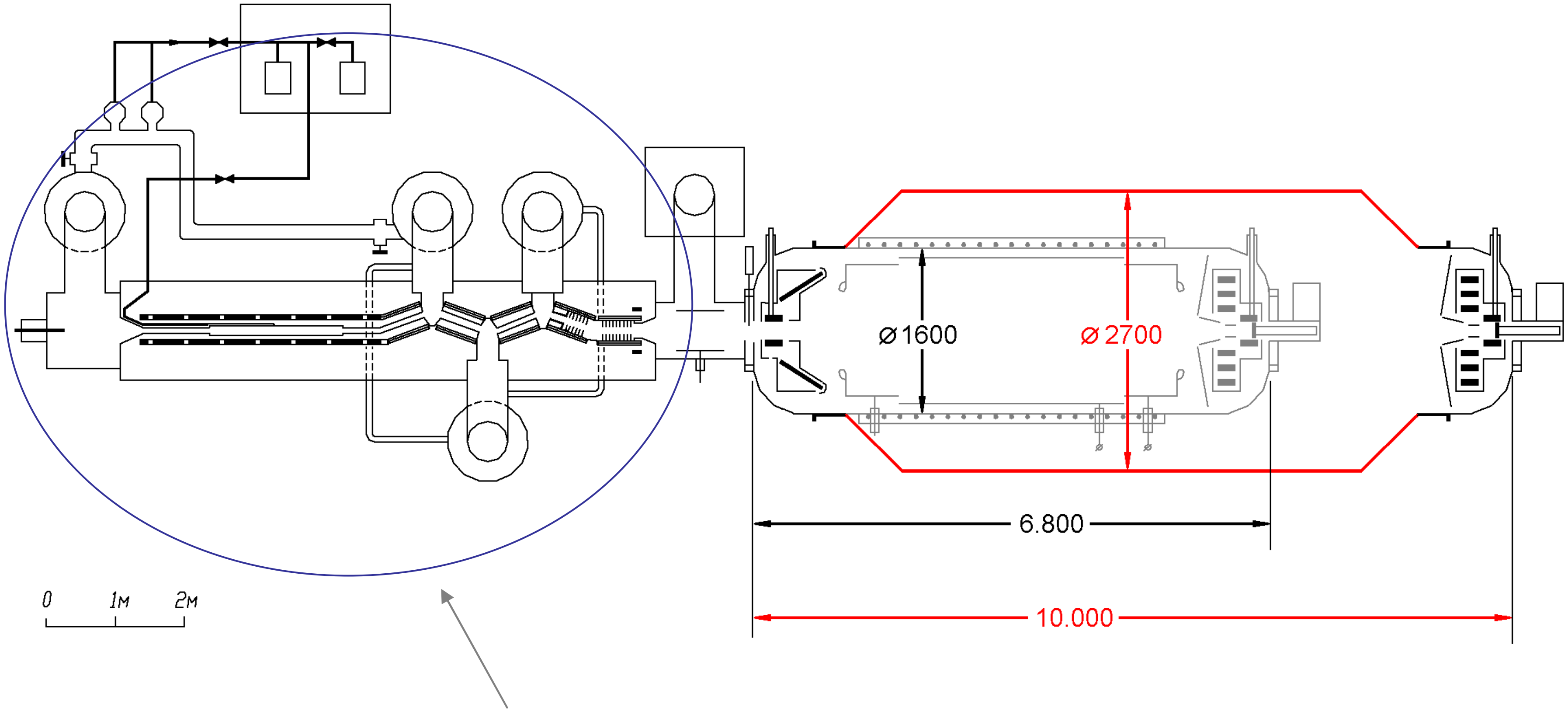
Первые данные
опубликованы в 1994г:

Paper presented at XXVII Int. Conf. on High Energy Physics.
Glasgow, UK, 20–27 July 1994

Завершен набора данных в 2003г.

Троицк ню-масс:

Спектрометр с адиабатической магнитной коллимацией и безоконный газовый источник молекулярного трития.



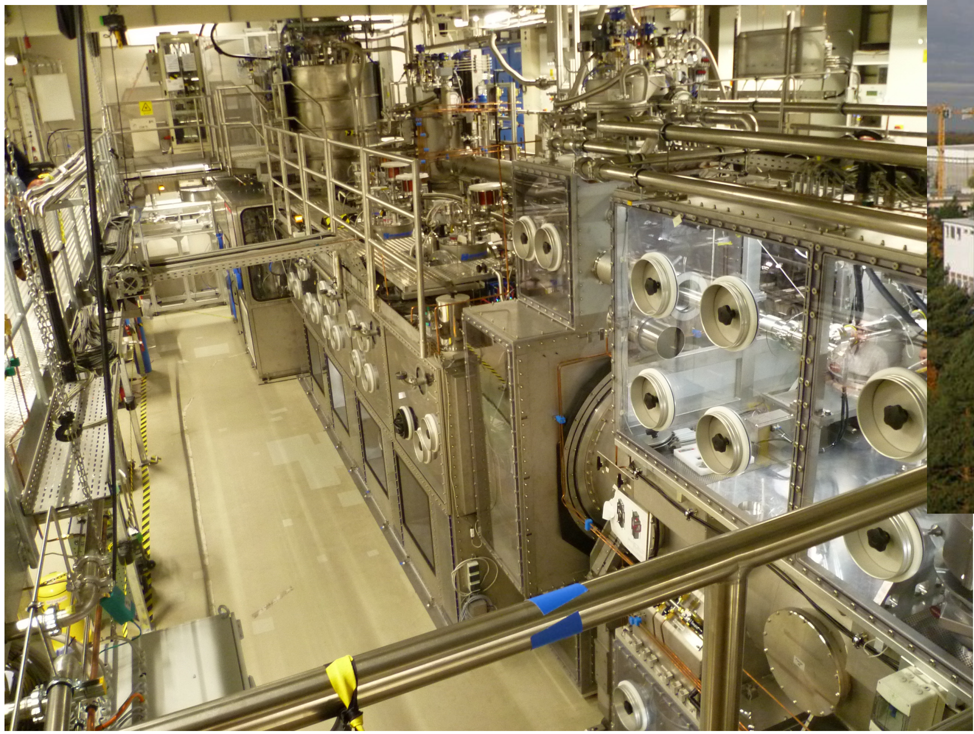
Windowless Gaseous Tritium Source,

similar configuration as in KATRIN

Karlsruhe Institute for technology
(former Forschungszentrum Karlsruhe)

Tritium laboratory with license for 40g of Tritium
($3{,}6*10^{14}$ Bq = 10 kCi)

Project started at 2001



First Tritium in
the set-up - 2018

KATRIN project

Main parameters

Total installation length 70 m

Spectrometer diameter 10 m

Inner source diameter 90 mm

Source column density $5\cdot 10^{17}$ mol/см^2

Total source activity ≈ 30 GBq (0,8 Ci)

Resolution $\Delta E = 0.9$ eV at 18 keV

Neutrino mass sensitivity

(after 3/5 years of data taking):

$m_\nu < 0.2$ eV/c^2 (90%C.L.)

Запуск установки – июнь 2018

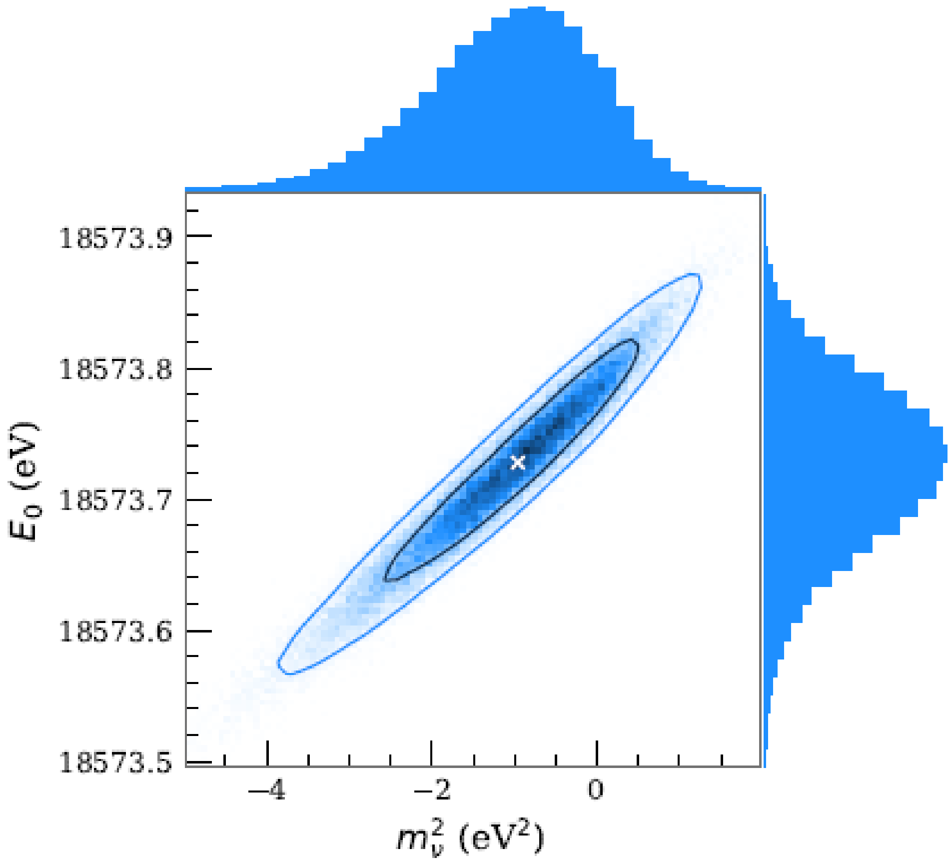


FIG. 4. Scatter plot of fit values for the mass square m_ν^2 and the effective β-decay endpoint E_0 together with 1-σ (black) and 2-σ (blue) error contours around the best fit point (cross). It follows from a large set of pseudo-experiments emulating our experimental data set and its statistical and systematical uncertainties.

We report on the neutrino mass measurement result from the first four-week science run of the Karlsruhe Tritium Neutrino experiment KATRIN in spring 2019. Beta-decay electrons from a high-purity gaseous molecular tritium source are energy analyzed by a high-resolution MAC-E filter. A fit of the integrated electron spectrum over a narrow interval around the kinematic endpoint at 18.57 keV gives an effective neutrino mass square value of $(-1.0\,^{+\,0.9}_{-\,1.1})$ eV^2. From this we derive an upper limit of 1.1 eV (90% confidence level) on the absolute mass scale of neutrinos. This value coincides with the KATRIN sensitivity. It improves upon previous mass limits from kinematic measurements by almost a factor of two and provides model-independent input to cosmological studies of structure formation.

$$m^2_\nu = \left(-1.0\,^{+\,0.9}_{-\,1.1}\right)\ \mathrm{eV}^2$$

m_ν < 1.1 eV (90% C.L. –Lokhov&Tkachev)

Спасибо за внимание!

KATRIN set-up

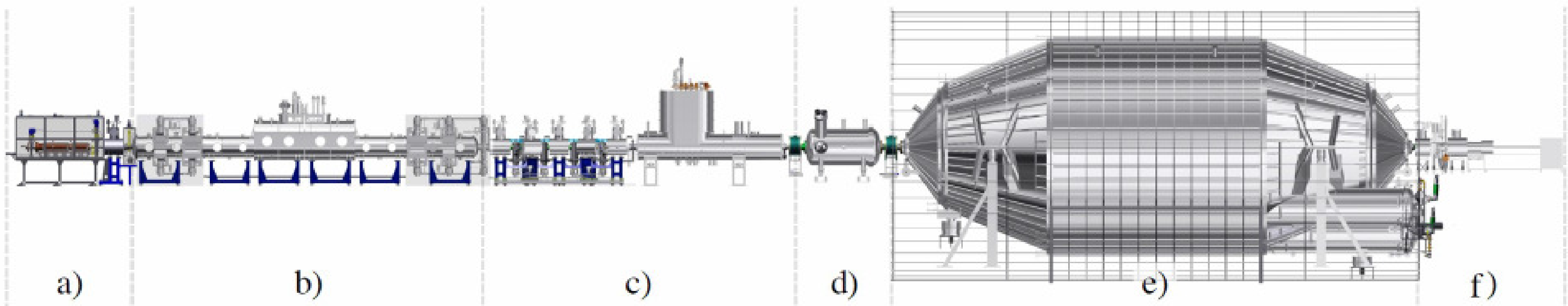


FIG. 1. The major components of the KATRIN beam line consist of a) the Rear Section for diagnostics, b) the windowless gaseous tritium source WGTS, c) the pumping section with the DPS and CPS cryostats, and a tandem set-up of two MAC-E-filters: d) the smaller pre-spectrometer and e) the larger main spectrometer with its surrounding aircoil system. This system transmits only the highest-energy β-decay electrons onto f) the solid-state detector where they are counted.

TABLE I. 1-σ systematic uncertainties (σ_{syst}) for m_ν^2 in eV^2, averaged over positive and negative errors, using the method of MC propagation.

Effect	relative uncertainty	$\sigma(m_\nu^2)$ in eV^2
Source properties		
$\rho d \cdot \sigma$	0.85%	0.05
energy loss $\varepsilon(\delta E)$	$\mathcal{O}(1\%)$	negligible
Beamline		0.05
B_{WGTS}	2.5 %	
B_{min}	1 %	
B_{max}	0.2 %	
Final state distribution	$\mathcal{O}(1\%)$	0.02
Fluctuations in scan k		0.05
HV stacking	2 ppm	
ρd variation	0.8%	
isotopologue fractions	0.2%	
Background		
background slope	1.7%/keV	0.07
non-Poisson background	6.4%	0.30
Total syst. uncertainty		**0.32**