Lev Mitrofanovich Barkov

90th anniversary

Talk by Dmitry Budker

Helmholtz Institute
JGU Mainz

UC Berkeley Physics
NSD LBNL

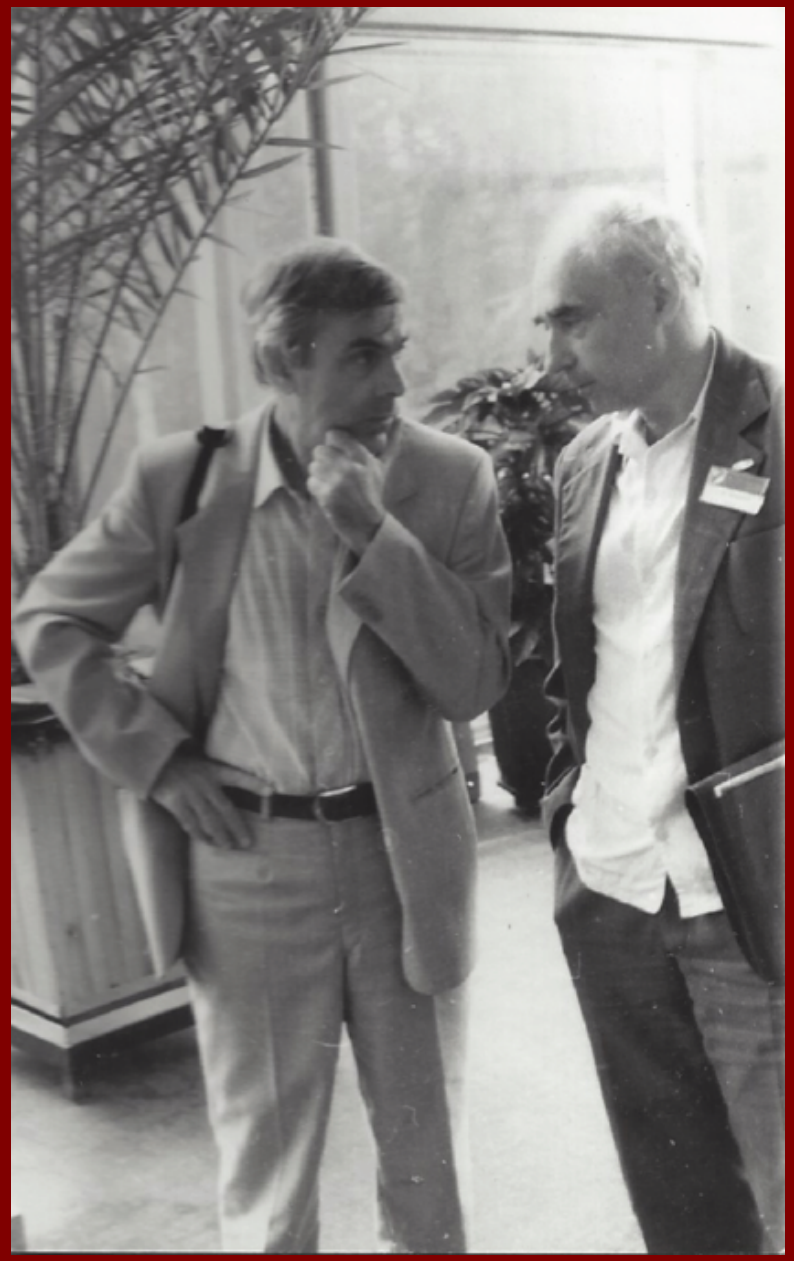
BINP, Novosibirsk (via teleconference); October 24, 2018

How I remember him

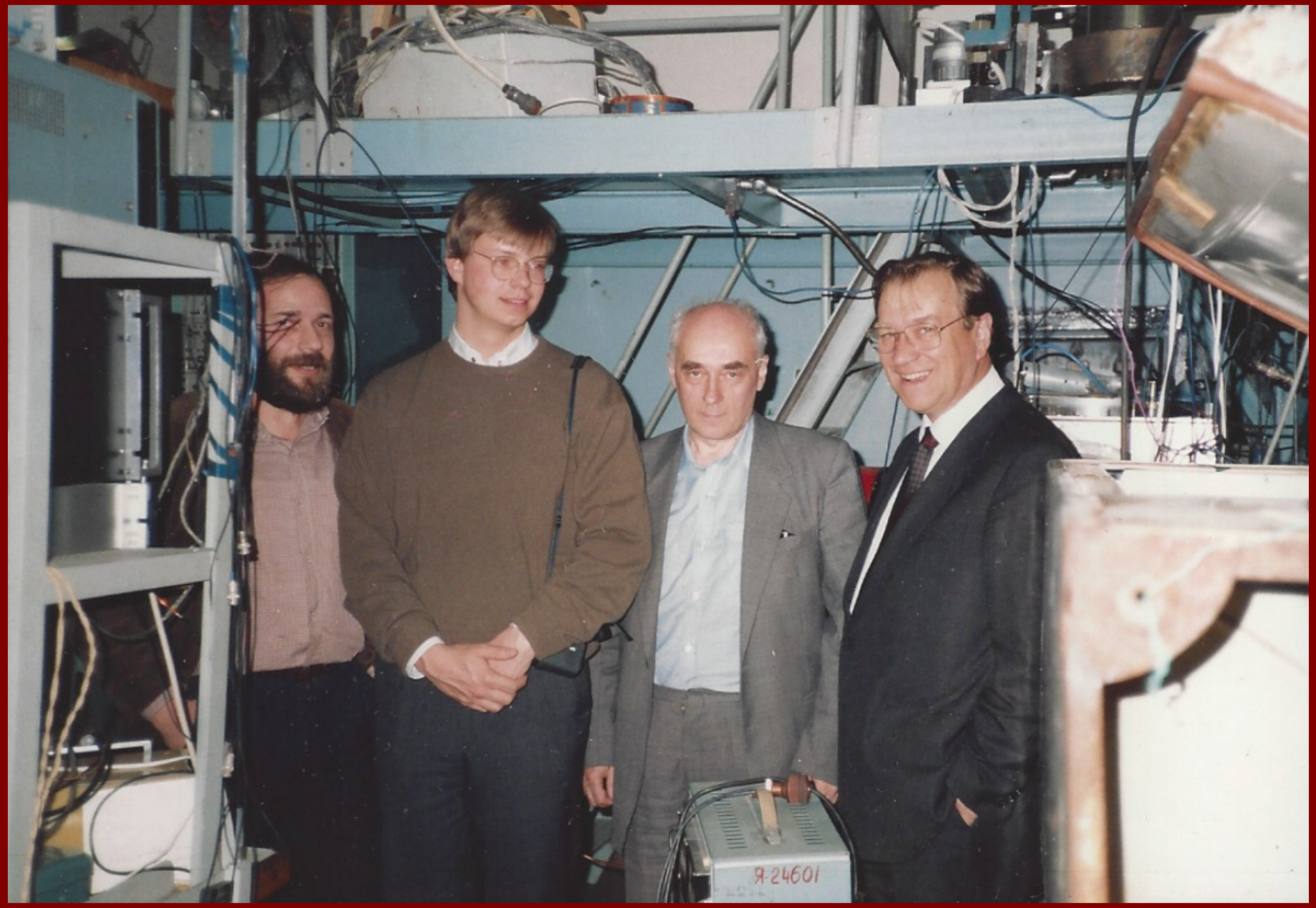
- Moscow → Novosibirsk flight, early 1970 (I was 6)
- Professor of Atomic Physics (~1983)
- Co-advisor and boss (1983-1988)
- No contact for about 20 years after I left for US
- Cell-phone call (2008)

Как скалькулируешь, так и будет!

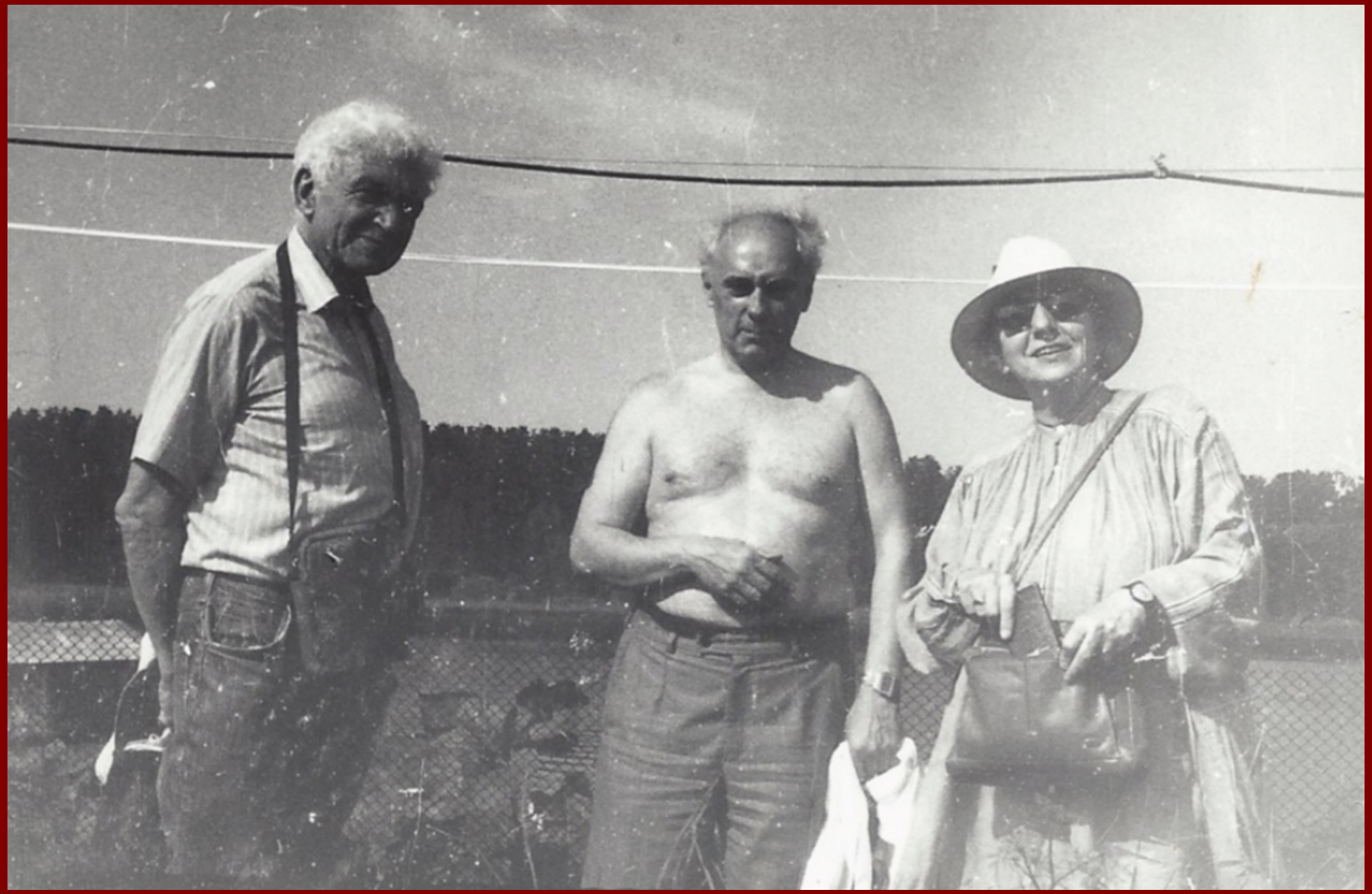
Л. М. Барков



Lev B. Okun′ and Lev M. Barkov
August 1986



Max Zolotorev, Jasper zu Putlitz, L. M. Barkov, Gisbert zu Putlitz, March 1988



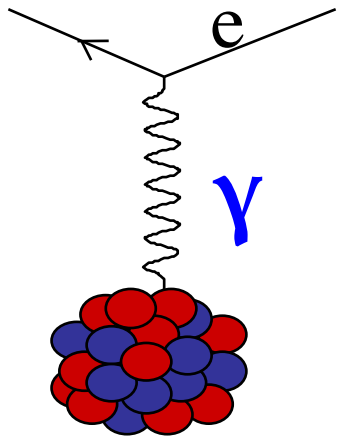
Vernon Hughes, L. M. Barkov, Mrs. Hughes, July 1987

October 24, 1988; L. M. Barkov @ 60

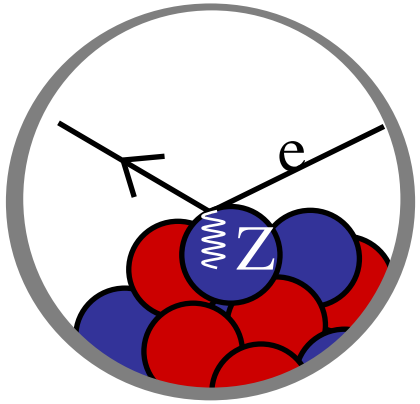
Laserstrahl

ATOMIC PARITY VIOLATION

- Main Source: Z exchange



Electromagnetic interaction (conserves parity)



Weak interaction (violates parity)

- P-odd, T-even correlation $\vec{\sigma} \cdot \vec{p}$

Atomic PV landmarks

- 1959 **Ya. B. Zel'dovich:**

PNC (Neutr. Current) ⇒ Opt. Rotation in atoms

- 1974 **M.-A. & C. Bouchiat**

Z^3 enhancement ⇒ PV observable in **heavy** atoms

- 1978-9 **Novosibirsk, Berkeley**

discovery of PV in OR(Bi) and Stark-interf.(Tl)

- …1995 **Boulder, Oxford, Seattle, Paris**

PV measured to 1-2% in Cs, Tl, Bi, Pb

- 1997 **Boulder**

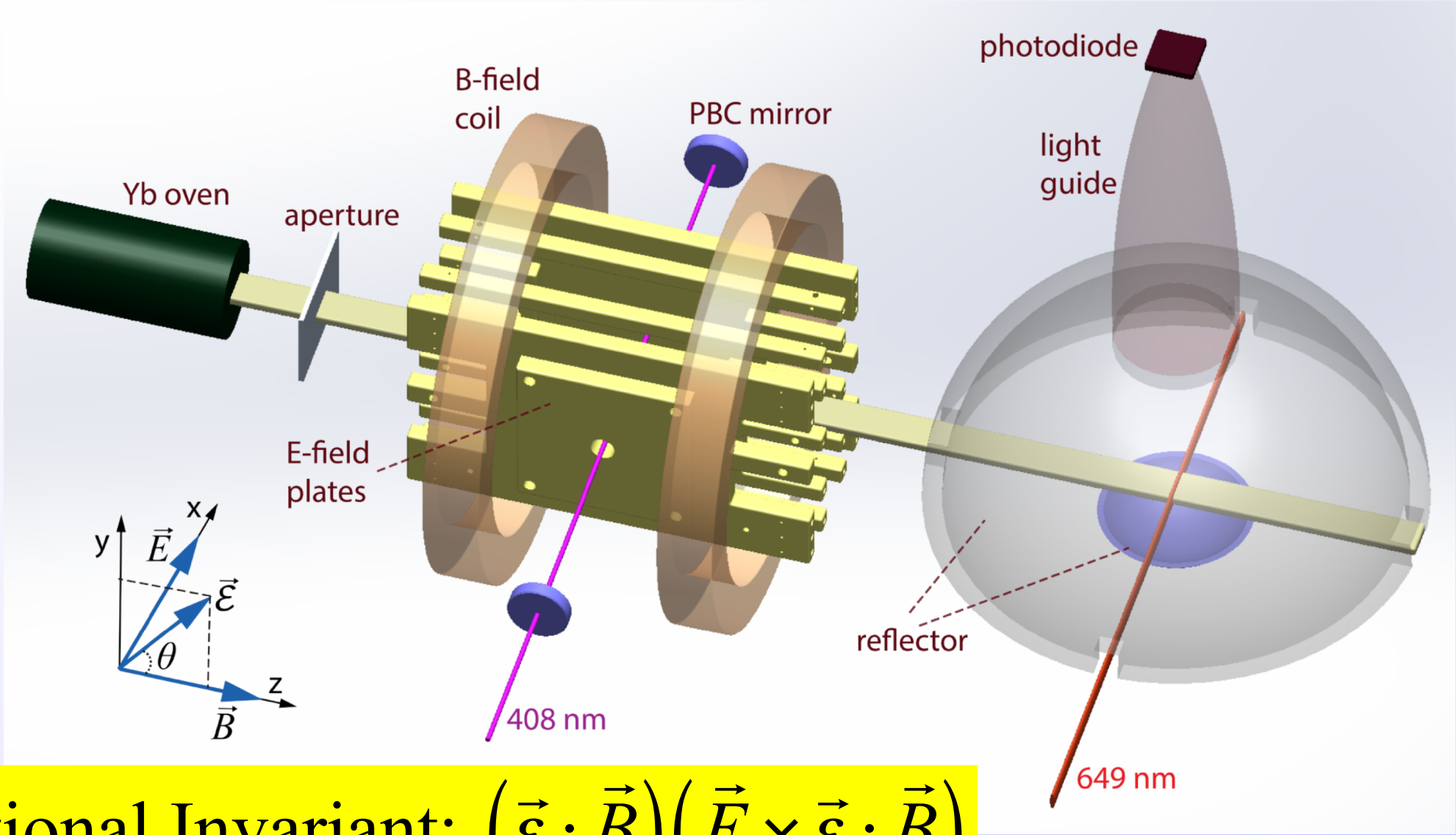
0.35% measurement, discovery of anapole moment

- 2009 **Berkeley** Large APV in Yb (personal landmark)

Marie-Anne and Claude Bouchiat

26 years

Yb atomic beam apparatus

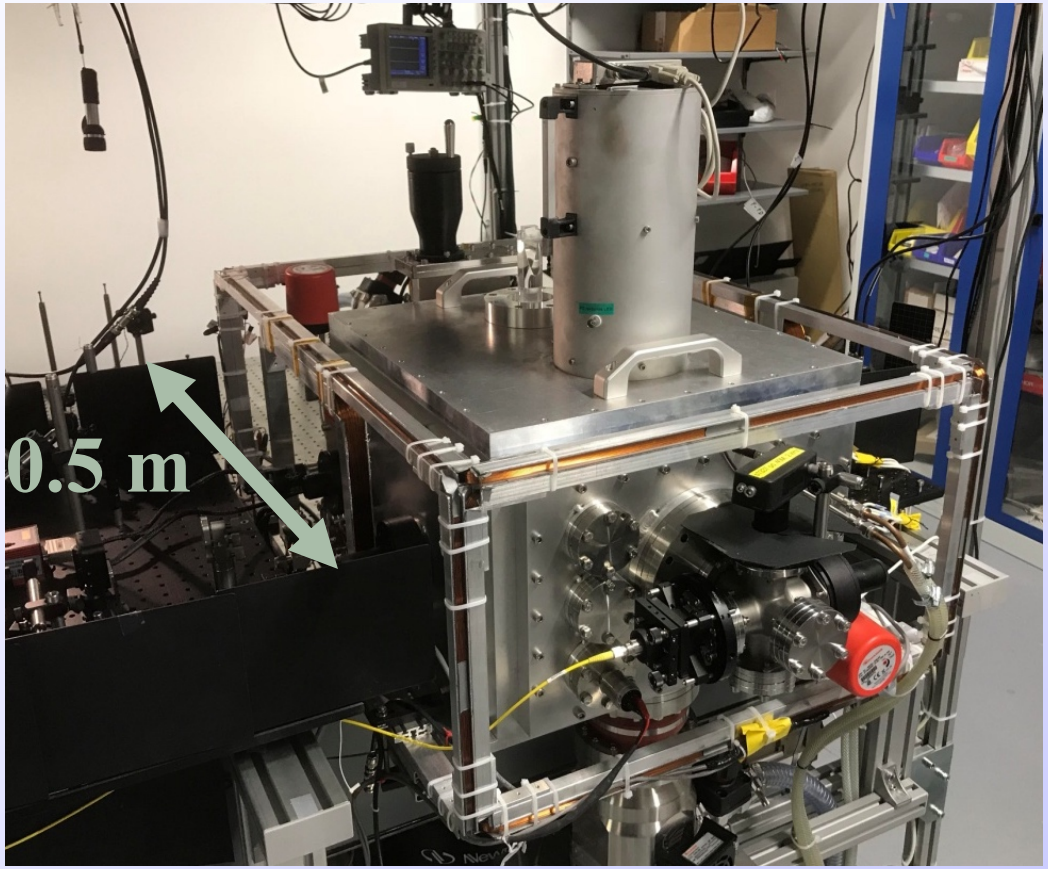


Rotational Invariant: $\left(\vec{\varepsilon}\cdot\vec{B}\right)\left(\vec{E}\times\vec{\varepsilon}\cdot\vec{B}\right)$

Yb reincarnation in Mainz

New apparatus

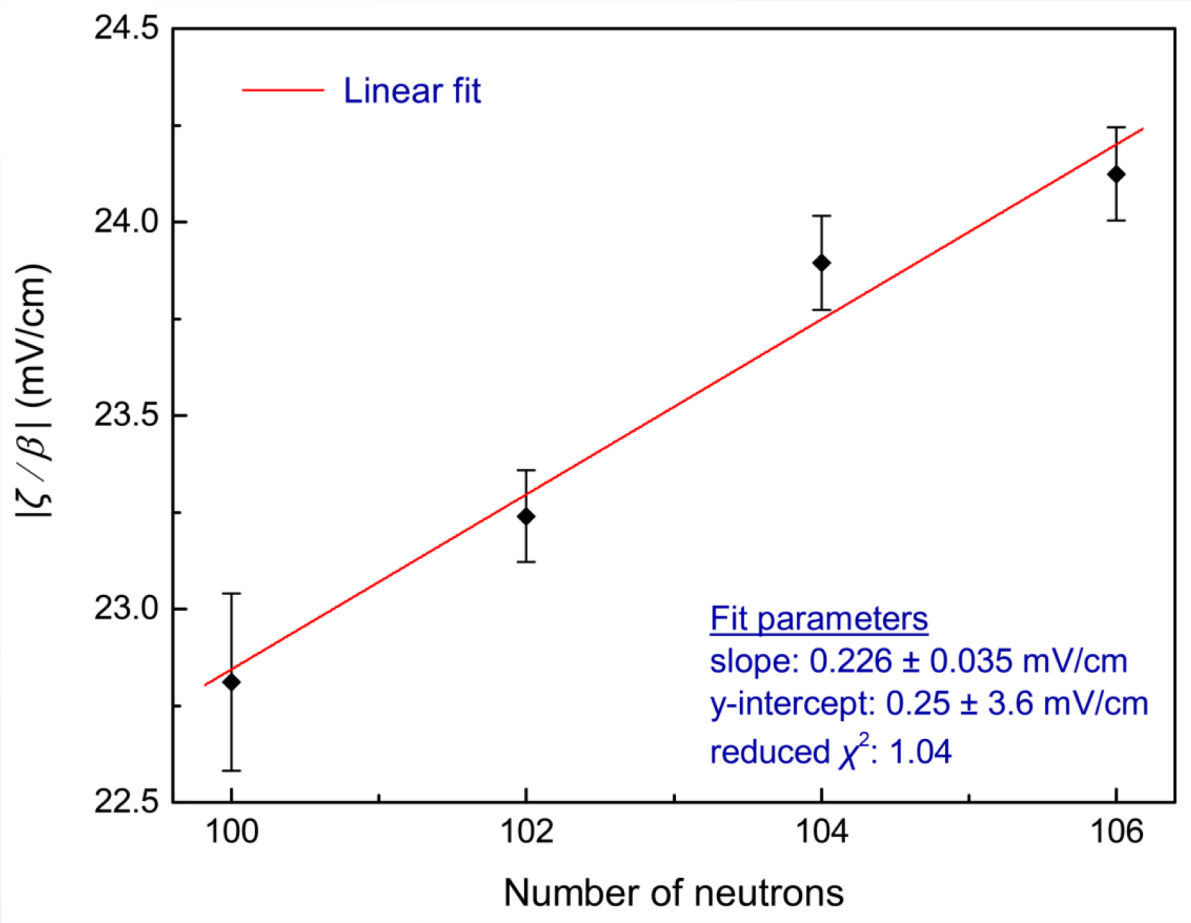
- Newly built vacuum system
- More powerful and frequency stable laser system
- More precise control of fields applied in interaction region
- 20 times better SNR



Mainz Roadmap

- Verify expected isotopic dependence of PV (0.5% accuracy) ✓
- Probe spin-dependent PV (sub-0.1 %)
- Neutron distributions/new physics (sub-0.1%)

First observation of isotopic variation of atomic PV



0.5% single isotope accuracy

SM: $Q_W \approx -N+Z(1-4\sin^2\theta_W) \rightarrow$ 1% change per neutron around N=103

Observation: 0.96(15) % change per neutron

Implication for light mediators (V.V. Flambaum)

$$\mathcal{L} = Z'_\mu \sum_{f=e,p,n} \overline{f}\gamma^\mu (g_f^V + \gamma_5 g_f^A) f$$

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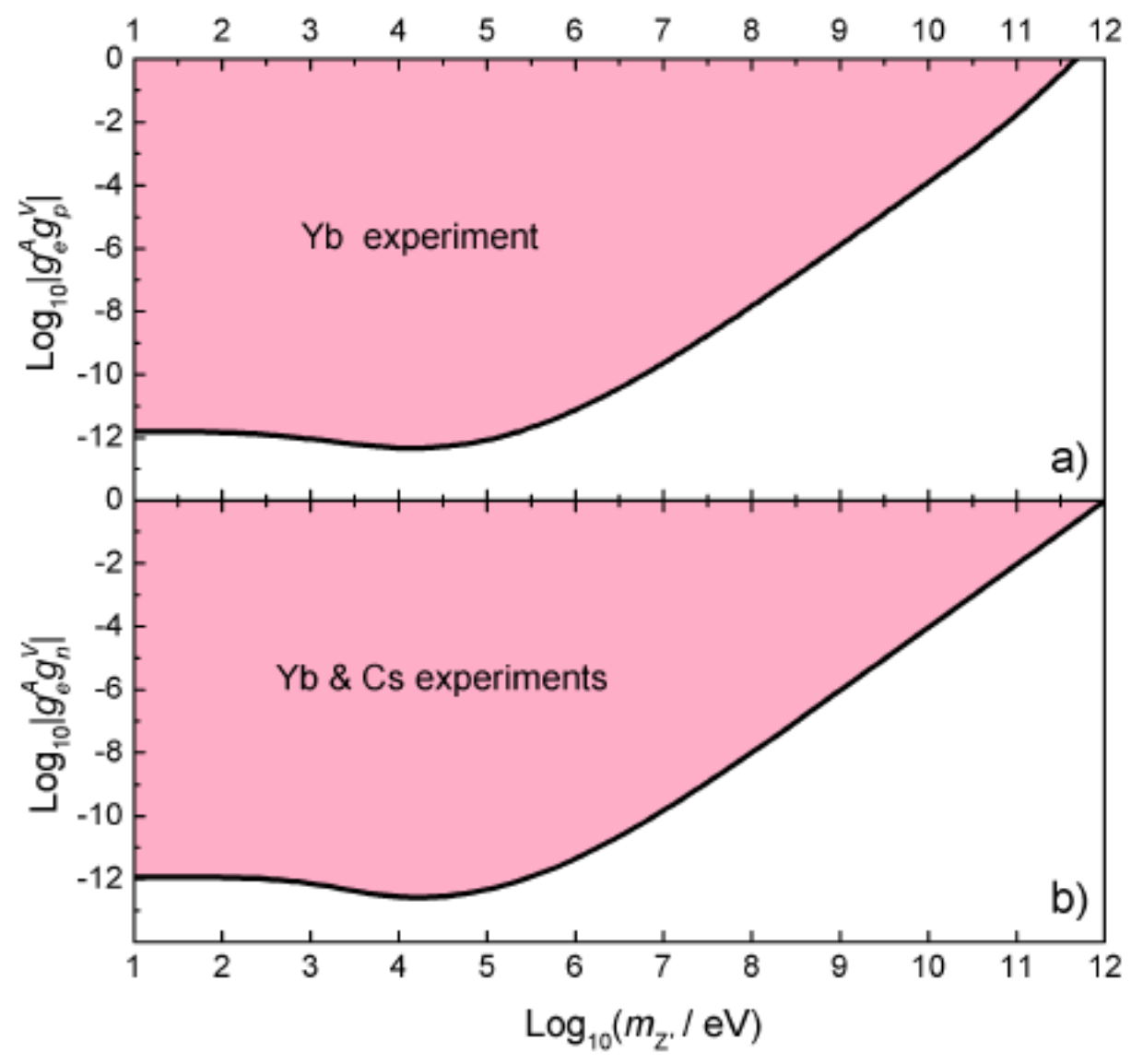
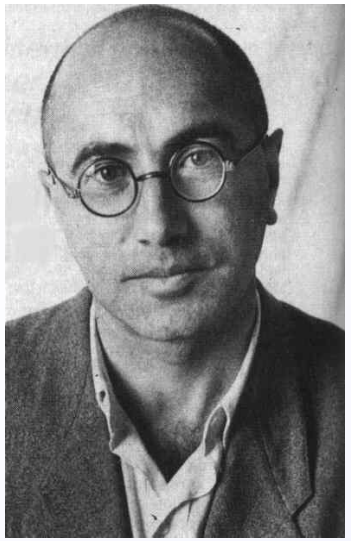
Probing Low-Mass Vector Bosons with Parity Nonconservation and Nuclear Anapole Moment Measurements in Atoms and Molecules

V. A. Dzuba,[1] V. V. Flambaum,[1,2] and Y. V. Stadnik[2]

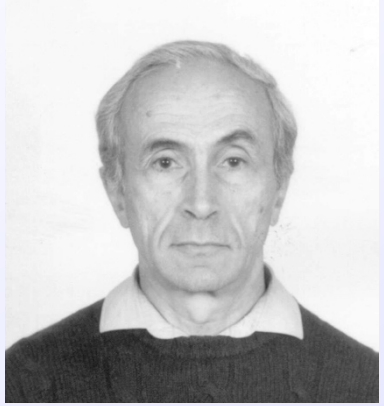


Reference

D. Antypas, A. Fabricant, J.E. Stalnaker, K. Tsigutkin, V. V. Flambaum, and D. Budker
Isotopic variation of parity violation in atomic ytterbium
arXiv:1804.05747; accepted to Nature Physics



Anapole Moments



- 1959 **Ya. B. Zel'dovich, V. G. Vaks**

  AM first introduced

- 1980-84 **V.V. Flambaum, I.B. Khriplovich & O.P. Sushkov**

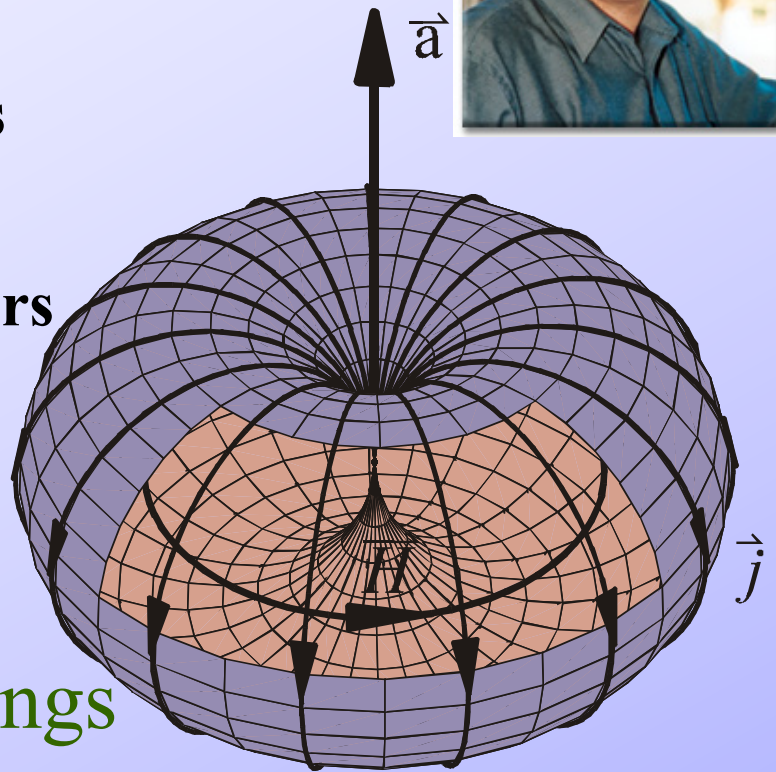
  Nuclear AM detectable in atoms

- 1995 **E.N.Fortson and co-workers**

  Tl AM – small…

- 1997 **C. E. Wieman and co-workers**

  Cs AM detected !

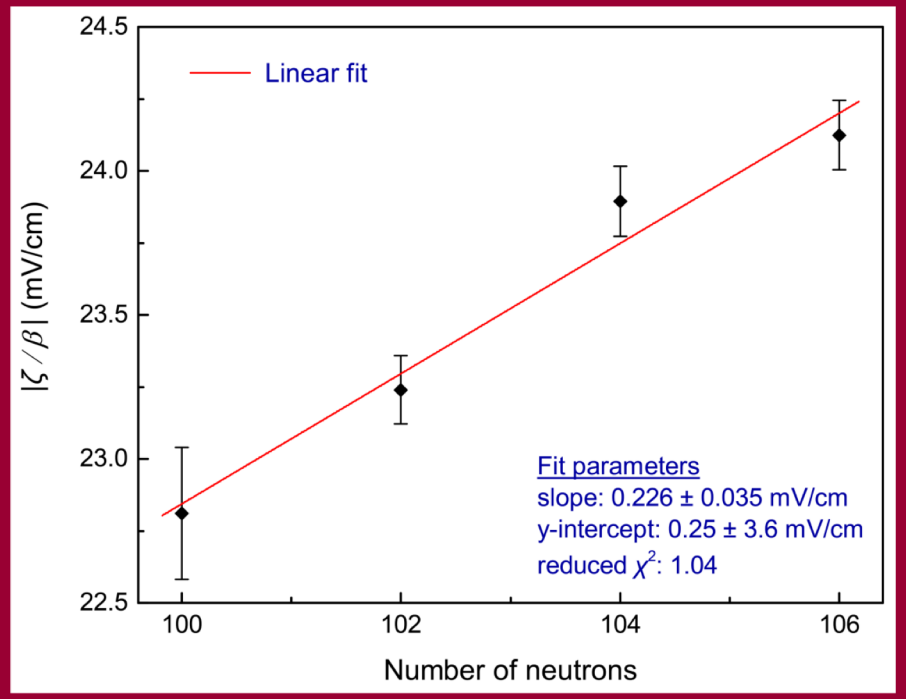


PNC *within* nucleus !

➔probe of weak meson couplings

Summary (PV in Yb)

- Measured PV on a chain of isotopes
- 0.5% accuracy per isotope
- Next stop: anapole moments of ^{171}Yb& ^{171}Yb



D. Antypas

A. Fabricant

J. Stalnaker

K. Tsigutkin

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Search for new physics with atoms and molecules

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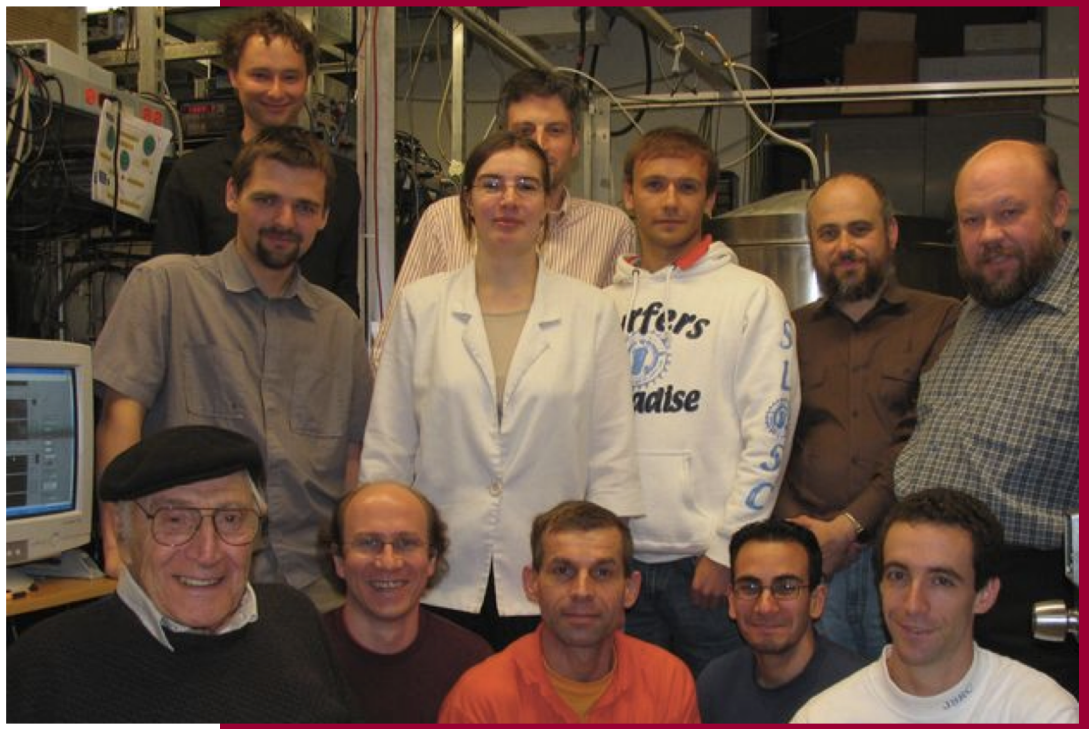

Marianna Safronova with Erwin L. Hahn and the Budker Group, Berkeley, 2006

Personal opinions…

- BSM vs. BBSM physics
- Merger of particle physics, astronomy, cosmology,… in non-collider physics
- Discoveries are around the corner!
- Adopt new technologies or perish

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Low-energy Tests of Fundamental Physics

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