# Status report PERKEO III

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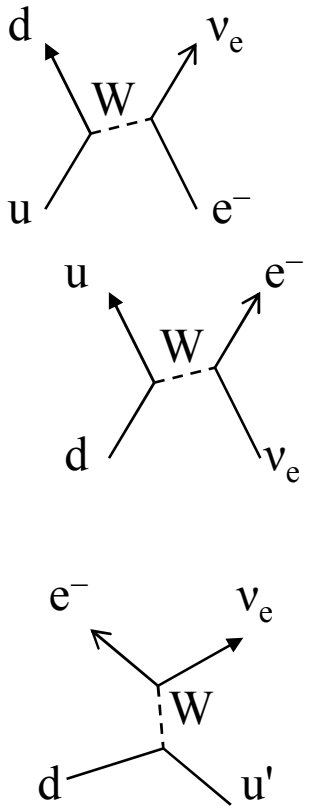
# Neutron decay data are useful ...

... because many processes have the same
Feynman diagram as neutron decay:

| | | |
|---|---|---|
| Primordial element formation | $n + e^+ \leftrightarrow p + \nu'_e$ | $\sigma_\nu \sim 1/\tau$ |
| ($^2$H, $^3$He, $^4$He, $^7$Li, … ) | $p + e^- \leftrightarrow n + \nu_e$ | $\sigma_\nu \sim 1/\tau$ |
| | $n \leftrightarrow p + e^- + \nu'_e$ | $\tau$ |
| Solar cycle | $p + p \leftrightarrow {}^2H + e^+ + \nu_e$ | |
| | $p + p + e^- \leftrightarrow {}^2H + \nu_e$ etc. | $\sim (g_A/g_V)^5$ |
| Neutron star formation | $p + e^- \leftrightarrow n + \nu_e$ | |
| Pion decay | $\pi^- \leftrightarrow \pi^0 + e^- + \nu'_e$ | |
| Neutrino detectors | $\nu'_e + p \leftrightarrow e^+ + n$ | |
| Neutrino forward scattering | $\nu_e + n \leftrightarrow e^- + p$ etc. | |
| W and Z production | $u' + d \leftrightarrow W^- \leftrightarrow e^- + \nu'_e$ etc. | |




… precision data of weak interaction parameters today only from neutron decay

# Only few Standard Model parameters in n-decay …

3 parameters needed:

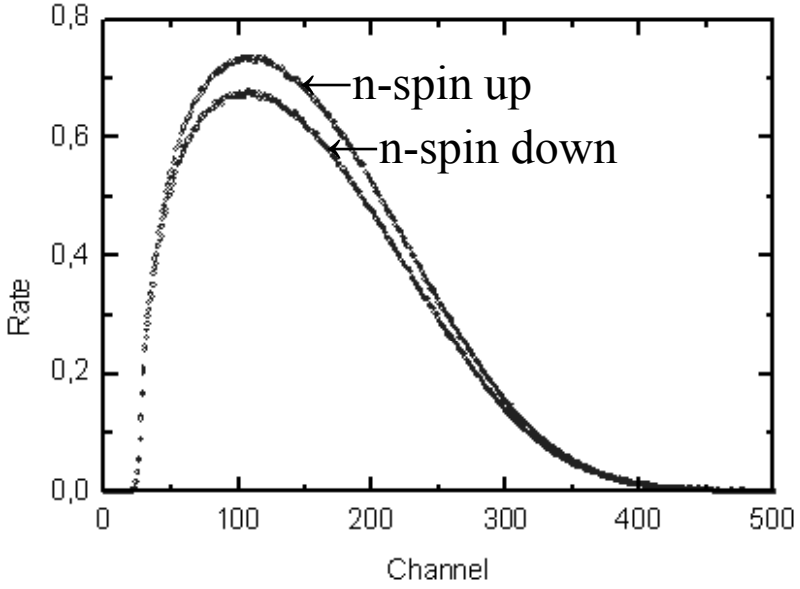
- CKM matrix element $V_{ud}$,
- ratio of coupling constants $\lambda = g_A/g_V$
- T-violating phase $\varphi$

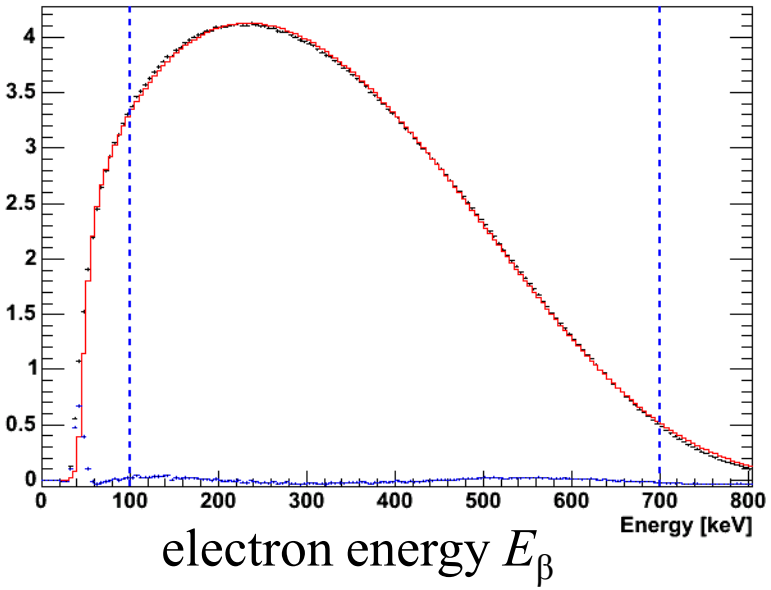
# … but many n-decay observables:

| | | |
|---|---|---|
| measured: | lifetime | $\tau$ |
| | e-ν correl. | $a$ |
| | β-asym. | $A$ |
| | ν-asym. | $B$ |
| | p-asym. | $C$ |
| limits: | triple-correl. | $D$ |
| | | $G$ |
| | | $R$ |
| in reach: | weak magn. … | $f_2, g_2, b, \ldots$ |

# problem is overdetermined: many tests of Standard Model

# β-spectra PERKEO II - 2006



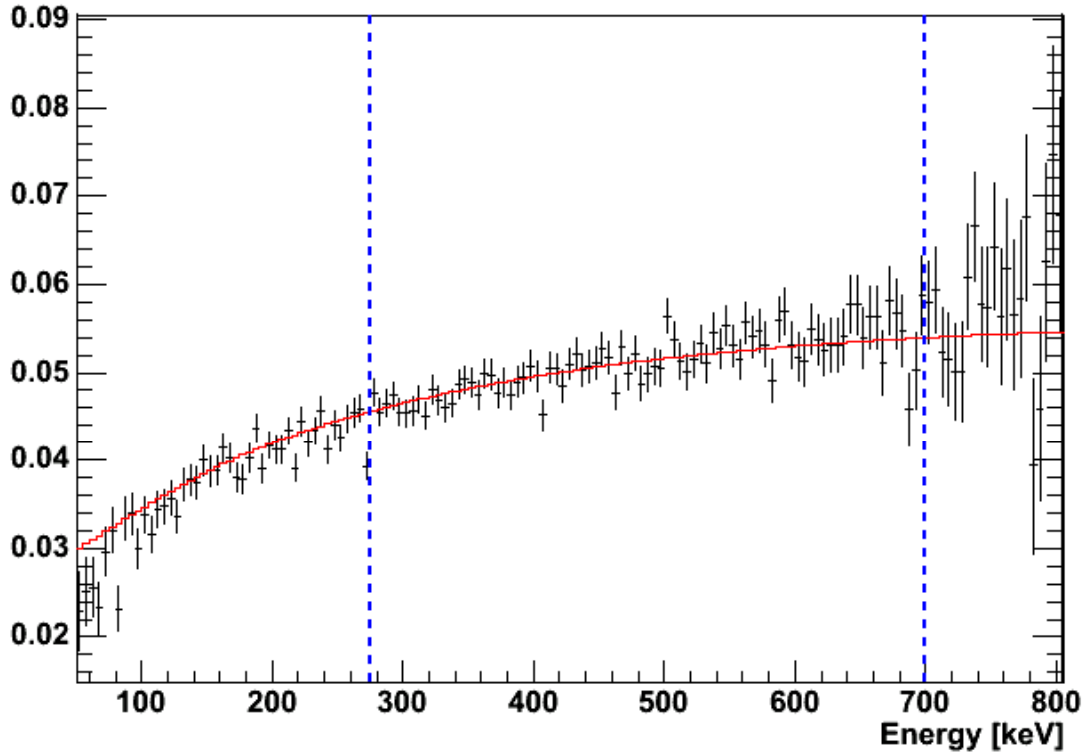

electron energy $E_\beta$

H. Abele et al.

# β-asymmetry $A$:

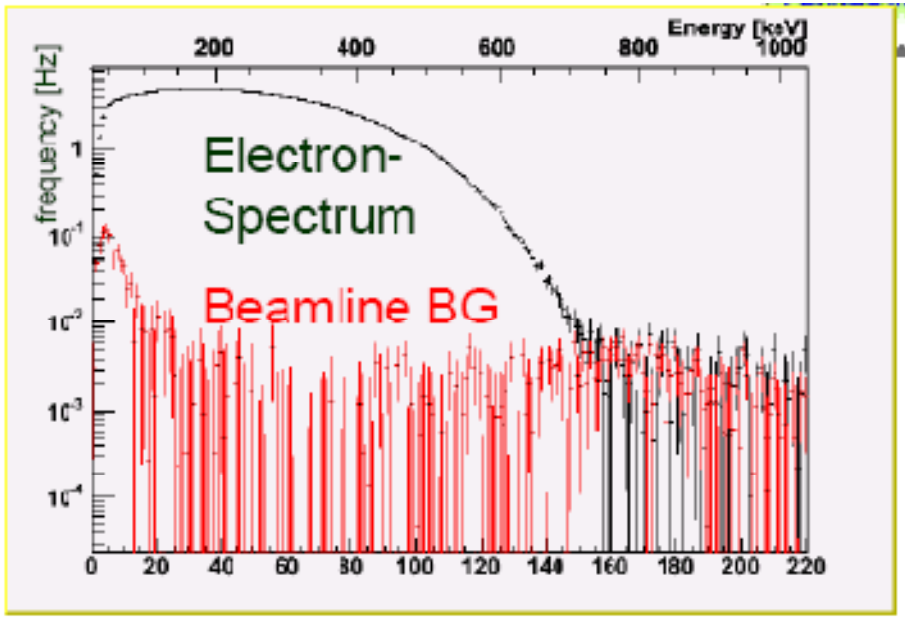
$A_{exp} =$

$½(v_\beta/c)\, A$




electron energy $E_\beta$

# Beam related background




in-beam: 1 of $10^7$ neutrons decay in spectrometer;

uncompensated background < $10^{-3}$

# PERKEO II results

| | | |
|---|---|---|
| β-asymmetry: | $A = -0.11933(34)$ | thesis Mund 2006 |
| ν-asymmetry: | $B = +0.9821(40)$ | thesis Schumann 2007 |
| proton-asymmetry | $C = -0.2377(26)$ | thesis Schumann 2007 |
| n-polarization | $P_n = 0.997(1)$ | thesis Kreuz 2005 |

# PERKEO III team:

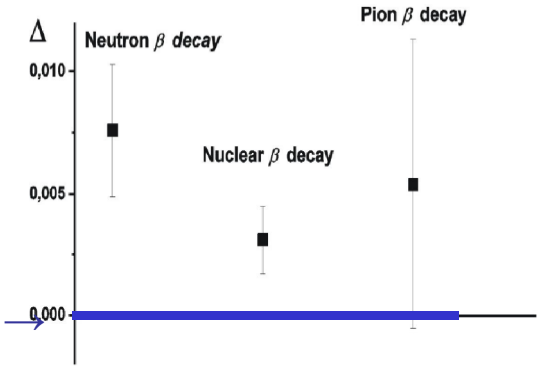
H. Abele, D. Dubbers, B. Märkisch, H. Mest,
A. Petoukhov, T. Soldner, X. Wang

# CKM Unitarity

unitarity test of CKM-matrix $V_{ud}^2 + V_{us}^2 + V_{ub}^2 - 1 \equiv \Delta = 0$ ?

$\sim 0.95 + 0.05 + 0$

2005:




Standard Model →

2005:

all data combined: $\Delta = 0.0040 \pm 0.0012$

2009:

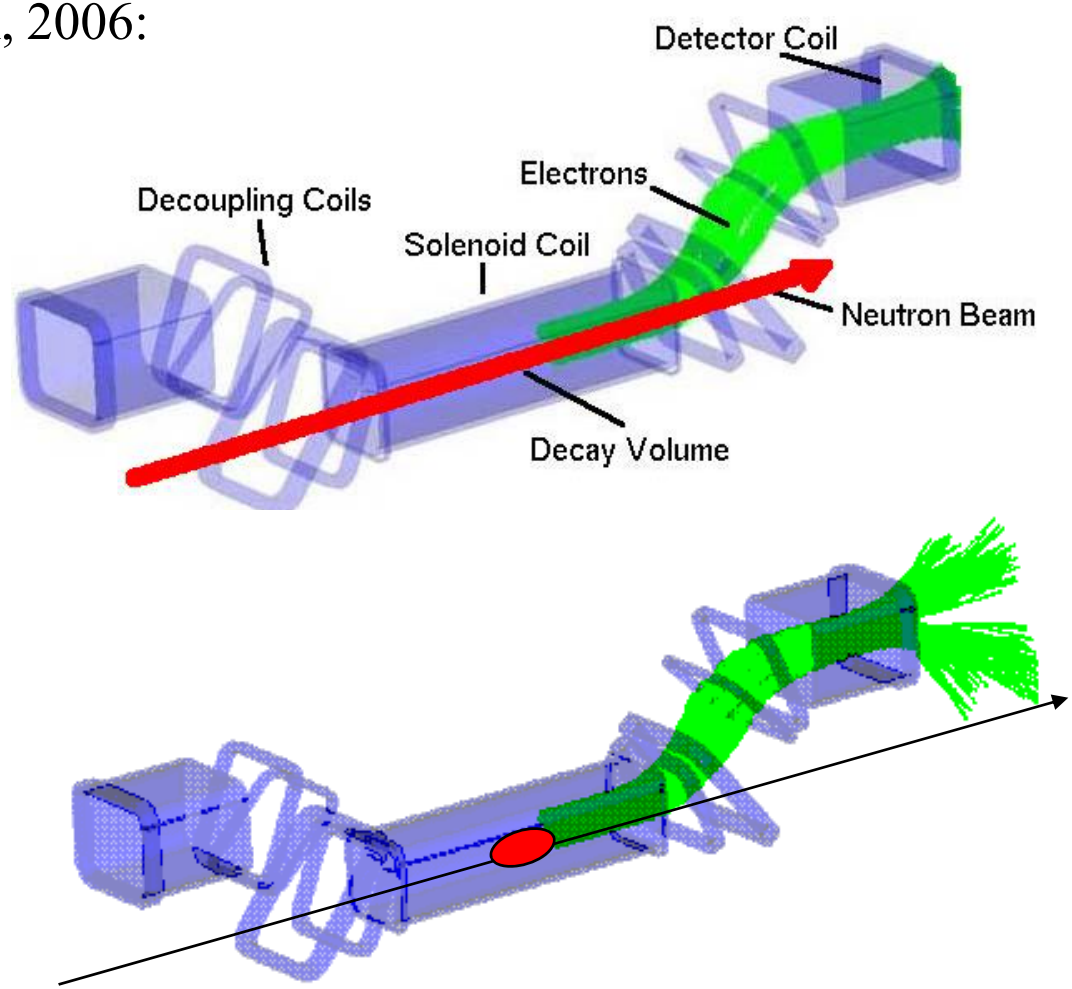
New CKM element $V_{us}$, new neutron lifetime $\tau_n$:

New $V_{us}$ reestablishes unitarity when using old $\tau_n$,

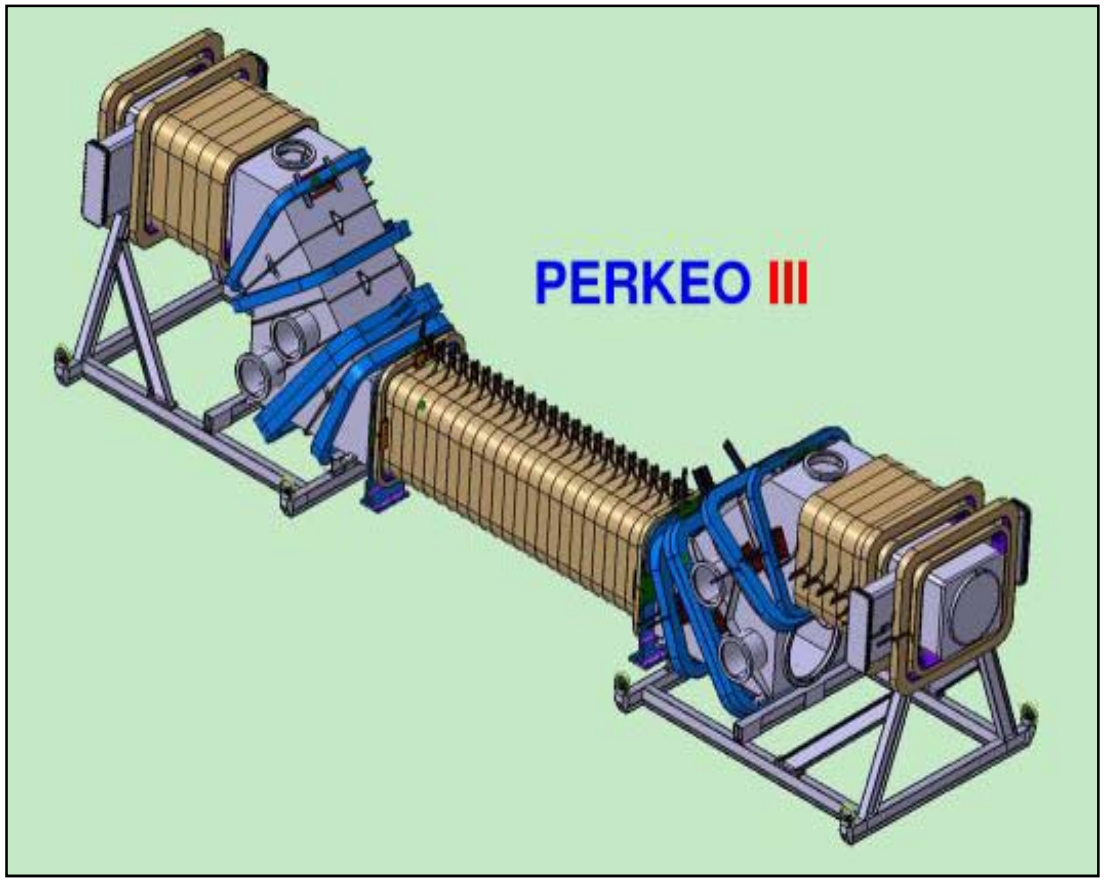
New $\tau_n$ reestablishes unitarity when using old $V_{us}$.

# New Perkeo instrument

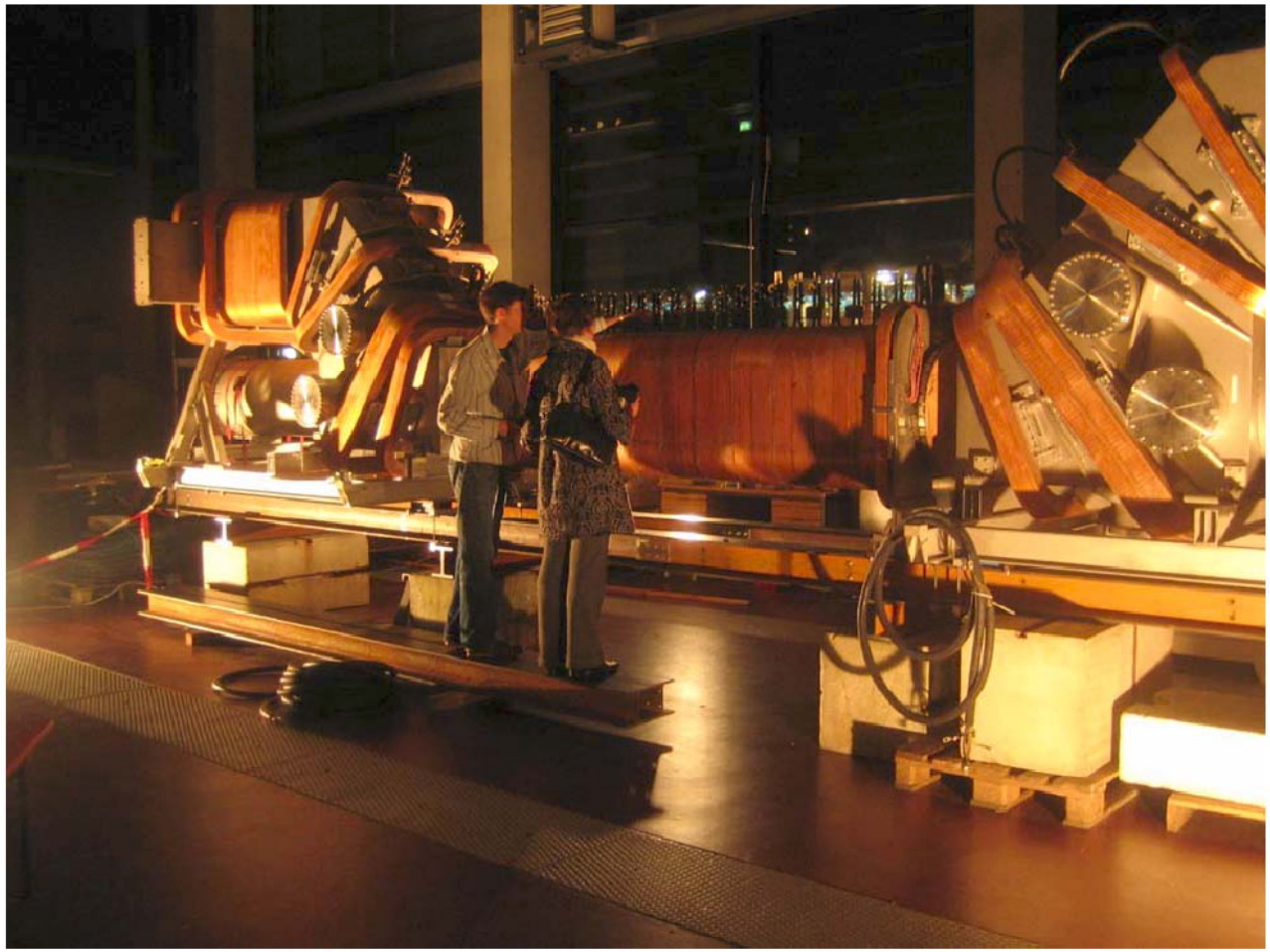
thesis B. Märkisch, 2006:



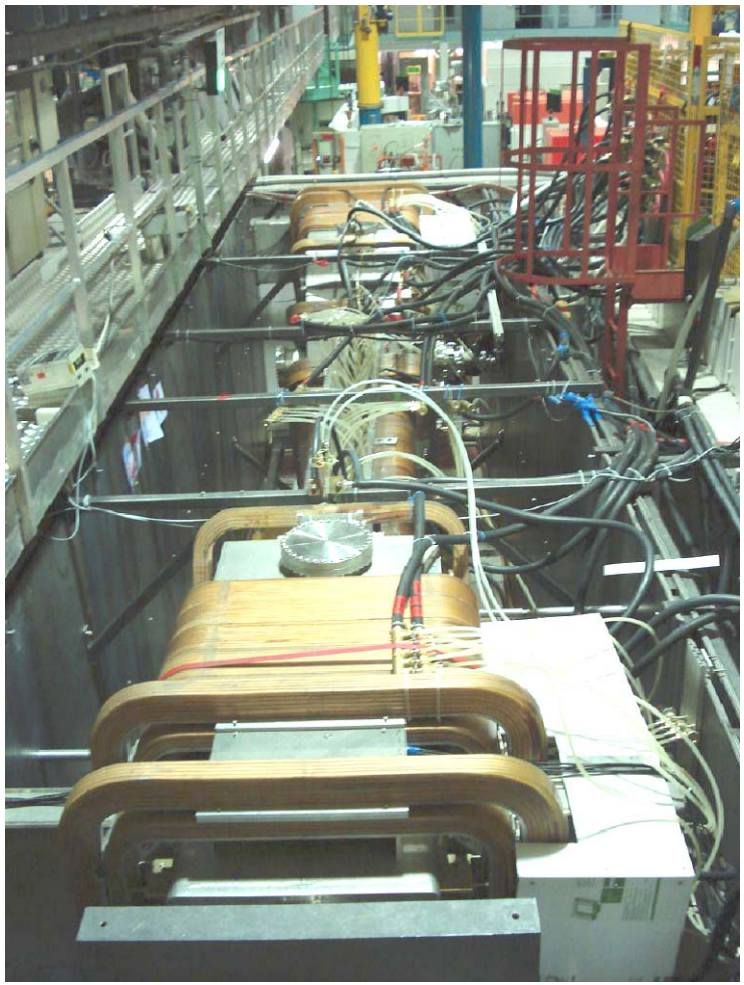
# PERKEO 2006: In the design phase



# In the test phase



# First run of New PERKEO 2007

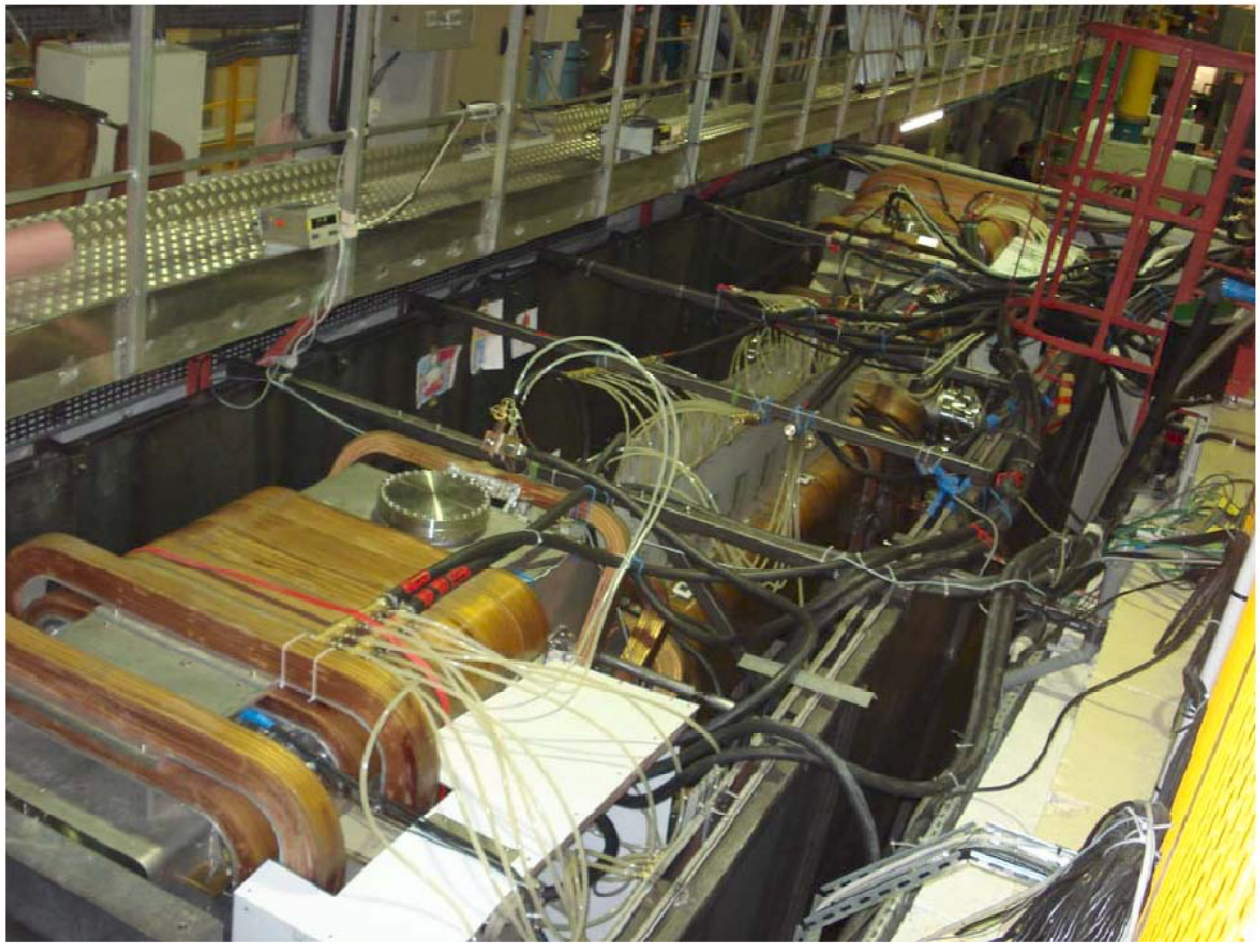


count rate:
60 000 n-decays/sec.

Planned measurement:
weak magnetism in n-decay
$\sim \mu_n - \mu_p$
(~ 1% effect in β-asymmetry)

Next run: March 2009 to June 2009

# 2009: PERKEO III with pulsed n-beam



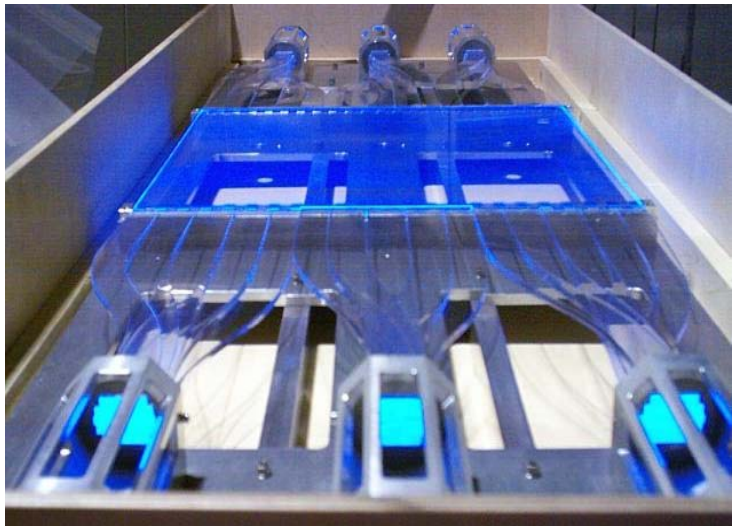
# Current Beam Time

**Changes to 2007 beamtime:**

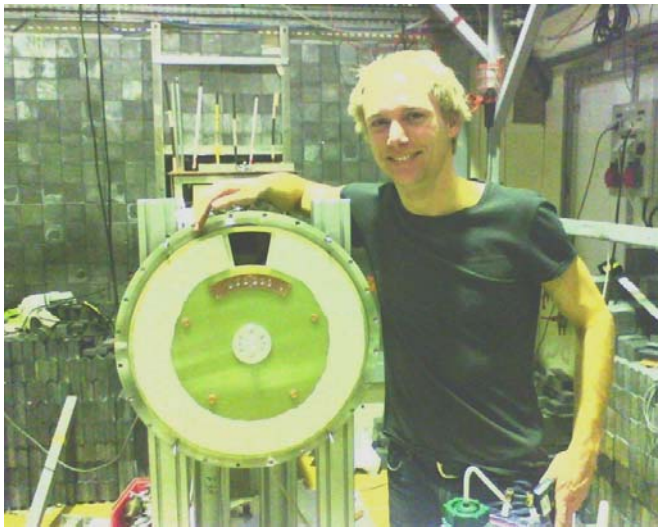
- velocity selector $\bar{\lambda} = 5A, \quad \Delta\lambda / \lambda \approx 12\%$
- LiF chopper, frequency 100 Hz
- new plastic scintillator detectors
- improved background shielding
- revised/new data acquisition

mean event rate ~150 1/s
1% / day

polarization $P_n > 98\%$



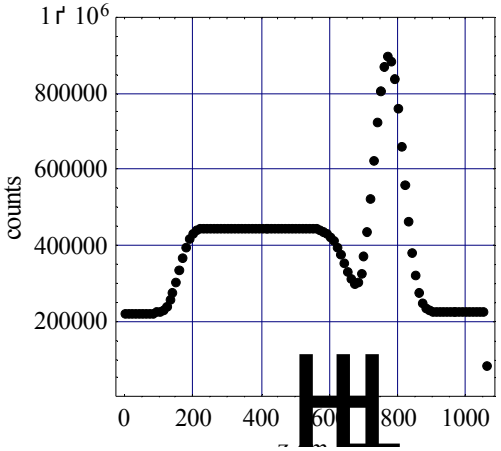
Plastic Scintillator Detector

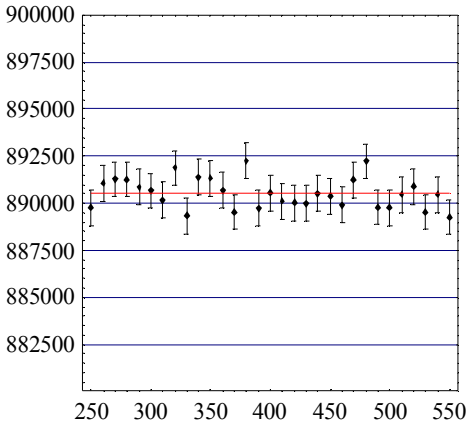


LiF Chopper

# tof-spectra after close of n-chopper

β-counts

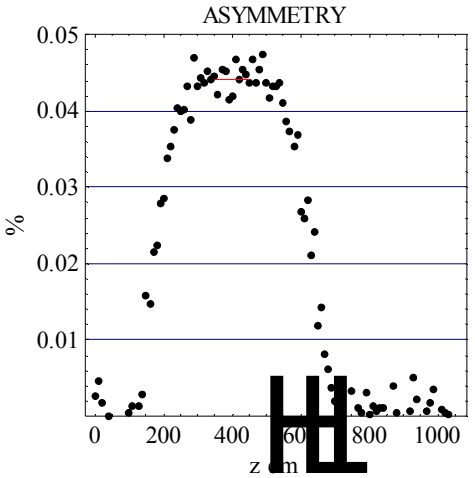


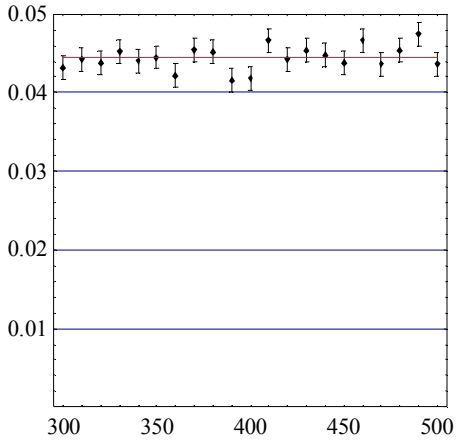




890526. ± 4504.26

chi$^2$ = 22.3318 dof = 29

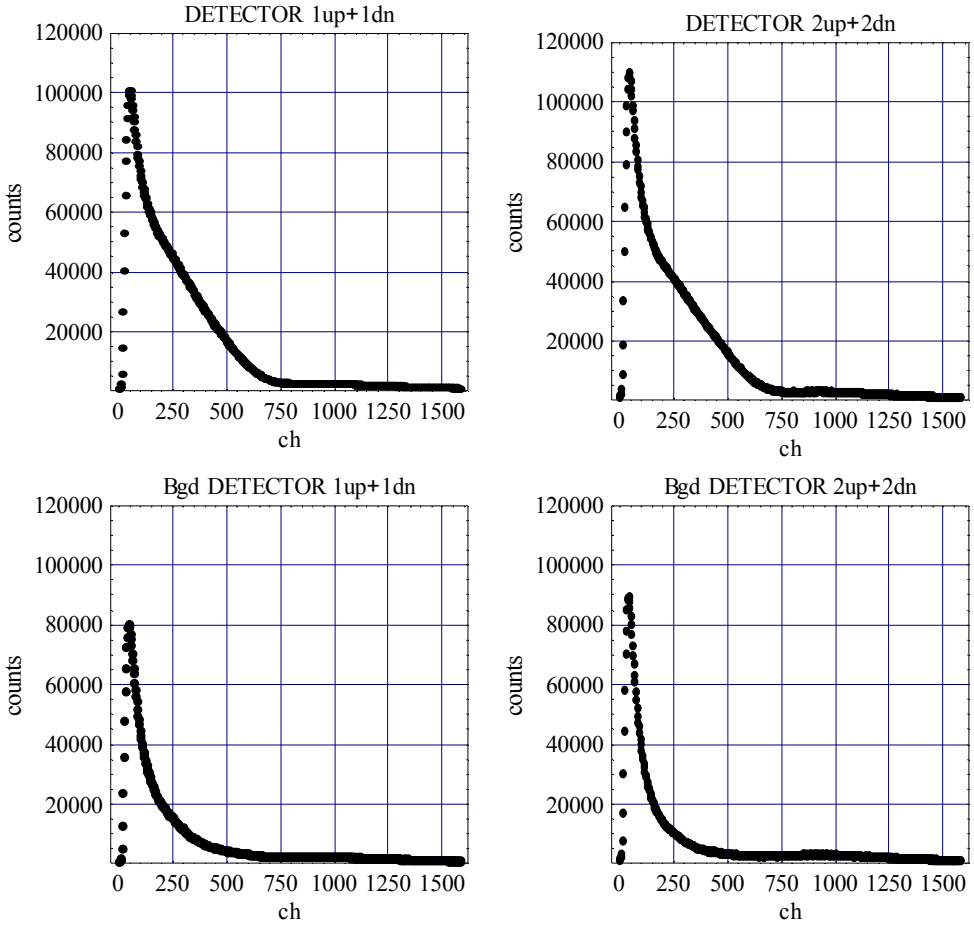
β-asymmetry

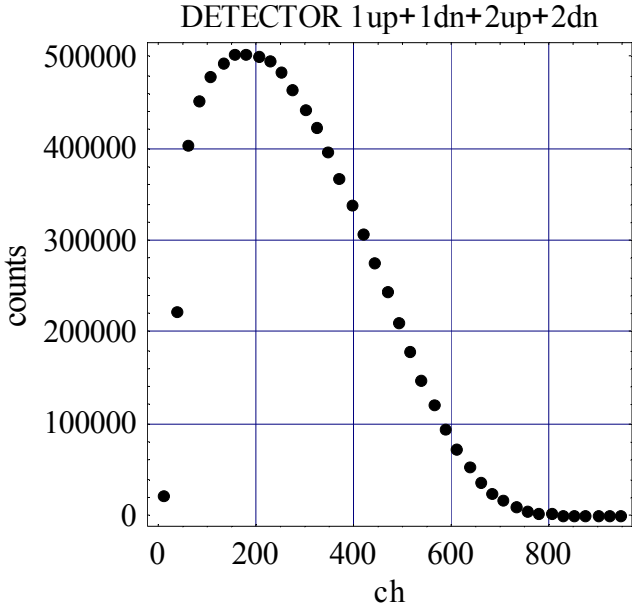


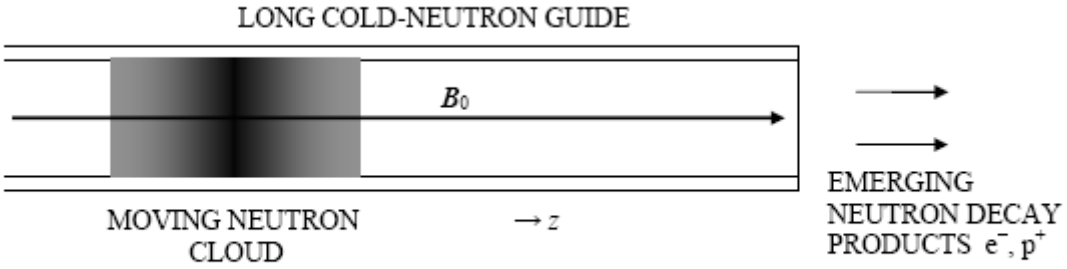

4.44088% ± 0.0327022%

chi$^2$ = 21.1309 dof = 19


DETECTOR 1up+1dn
DETECTOR 2up+2dn
Bgd DETECTOR 1up+1dn
Bgd DETECTOR 2up+2dn
counts
ch
0 250 500 750 1000 1250 1500
20000 40000 60000 80000 100000 120000


DETECTOR 1up+1dn+2up+2dn
counts
ch
0 200 400 600 800
0 100000 200000 300000 400000 500000

# PERC Project




**A clean, bright, and versatile source of neutron decay products**

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D. Dubbers, H. Abele, S. Baeßler, B. Märkisch, M. Schumann, T. Soldner and O. Zimmer