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CERN Strategy Group Meeting, Zeuthen May 2, 2006

Particle Physics Experiments and Technology Transfer at Paul Scherrer Institut

Ralph Eichler

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Main topics

1. Detector development (pixel detectors, avalanche photo diodes, APD)
2. Particle physics:
   - (i) $\mu \rightarrow e$ conversion, $\mu \rightarrow e\,\gamma$
   - (ii) pion beta decay,
   - (iii) $\pi \rightarrow e\,\nu$
6. Neutron physics
   - (i) ultra cold neutron (UCN) source development
   - (ii) nEDM, neutron lifetime, ...
   - (iii) liquid metal target development

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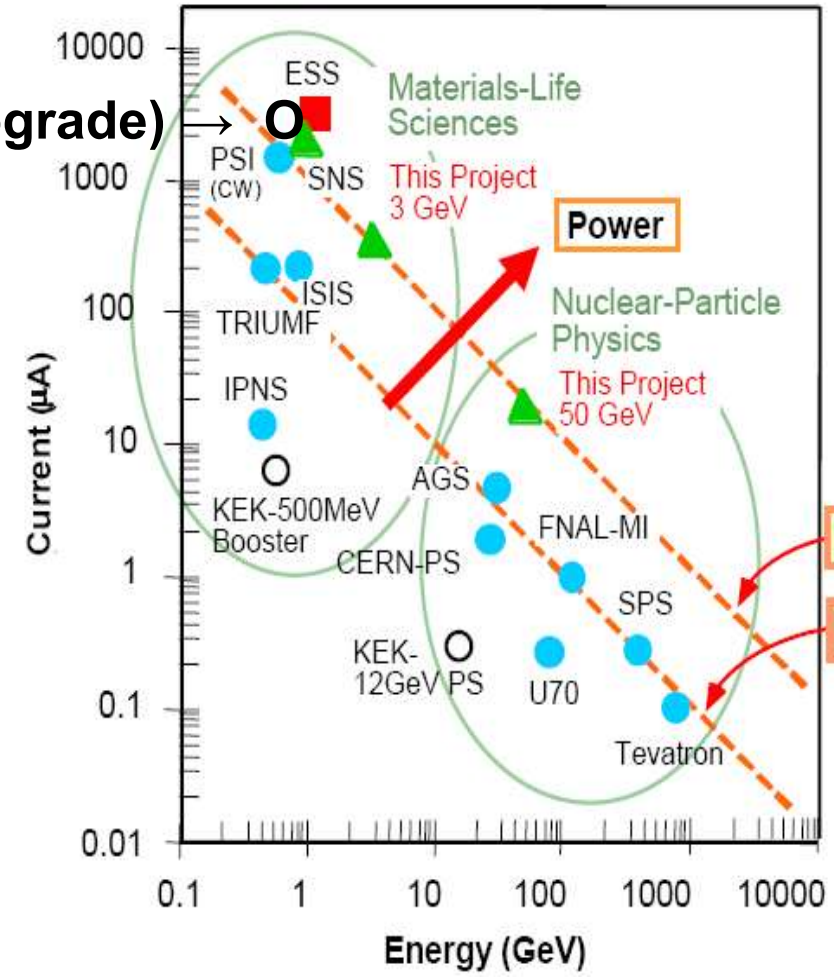
PSI

Comparison of High Power Accelerators

PSI (upgrade) → O



To MW class in 21st century!!

PSI secondary beams:
$2\ 10^{8}\ \mu^{+}/s$
$2\ 10^{11}\ \pi^{+}/s$

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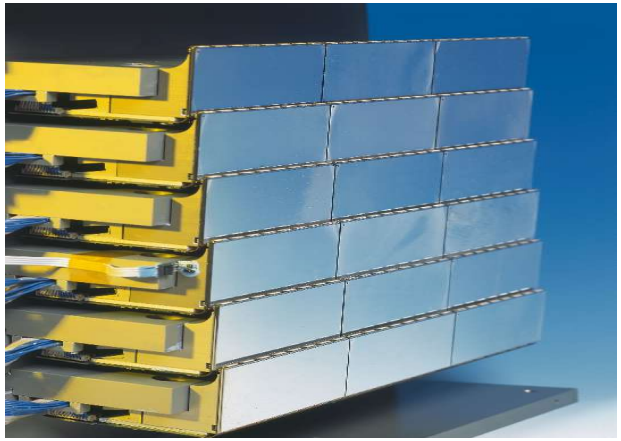
Running Experiments

τ_μ	Accuracy	10^{-6} in 2006
$n_{pol} \rightarrow e_{pol}\, p\nu_e$	T-Violation?	in 2006
$\mu \rightarrow e\gamma$	Sensitivity	10^{-14} in 2008
edm(n):	Sensitivity	10^{-27} ecm in 2010

Single Photon Counting with Hybrid Pixel Detectors

Spin-Off of pixel detector for CMS at LHC to protein crystallography



PILATUS 6M Parameters at PSI

DQE	**75% @ 12 keV, 100% @ 8keV**
Size	**2588 x 2498 pixels**
Spatial resolution	**0.172 x 0172 mm^2**
Dynamic range:	**20 bits, rate limit 1 MHz/pixel**
Readout time	**2 ms**
Frame rate	**10 Hz**

Properties:

Energy range 4 – 30 keV
No dark current and readout noise
Excellent point spread function
Short readout times: ms
Suppression of fluorescent background
Very good signal/noise ratio
Radiation hard

Future trends:

Higher count rates
Faster framing
Correlation of X-rays
Smaller pixel size

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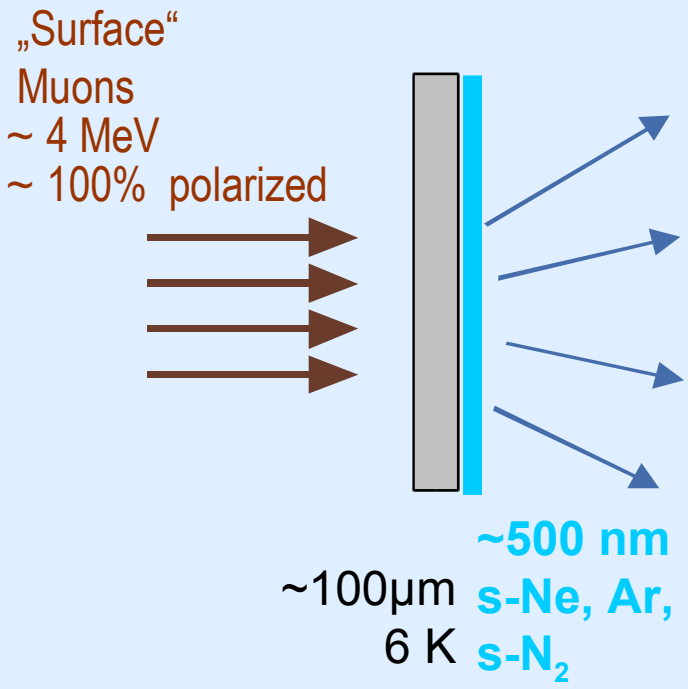
License contracts

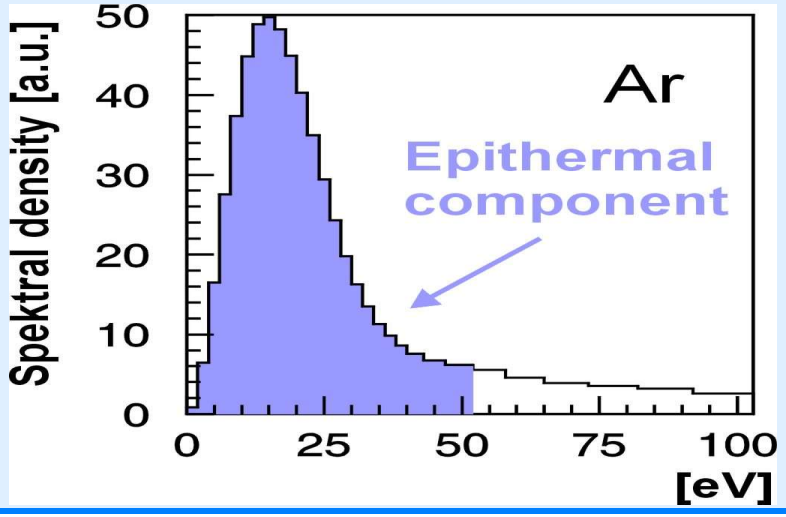
- Digital controled power supplies
- Pixel detectors for applications in synchrotron radiation experiments
- Wave form digitizers
- Constant fraction discriminator

Generation of Polarized Epithermal Muons by Moderation

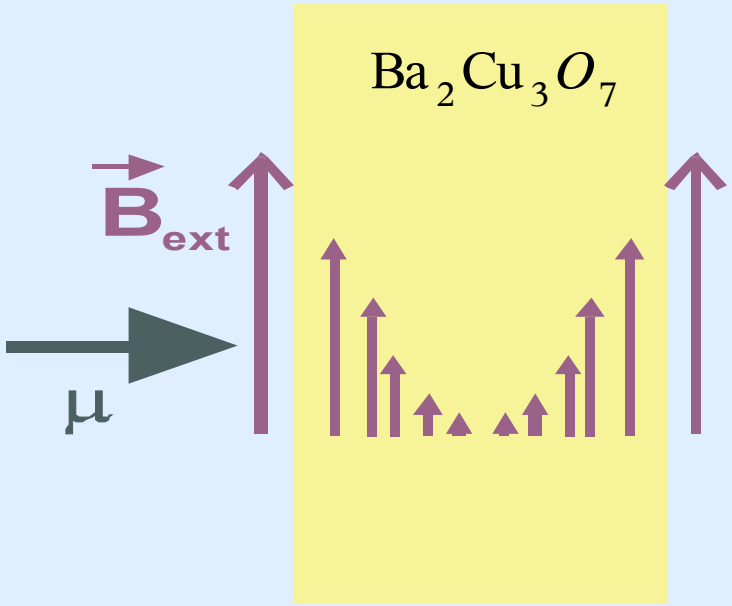


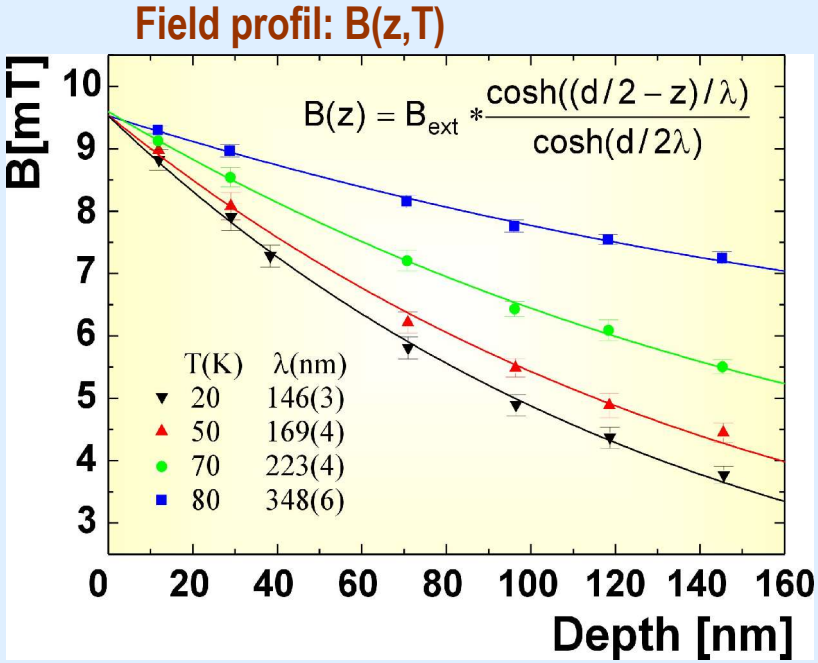
LE-muons source:

- peak energy: ~15 ± 10 eV
- ~ 100% polarized
- moderation efficiency 10^{-4}-10^{-5}
- escape depth : 15-250 nm
- angular distribution: dN ~cosθdΩ



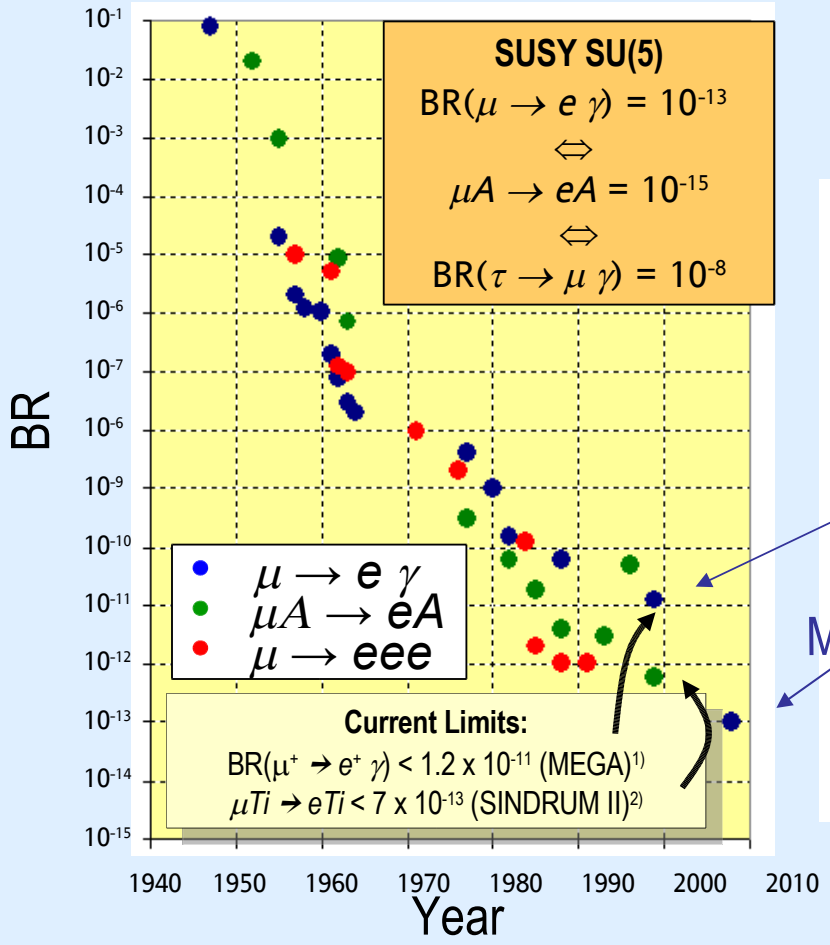
Penetration Depth of a Magnetic Field into Superconductor



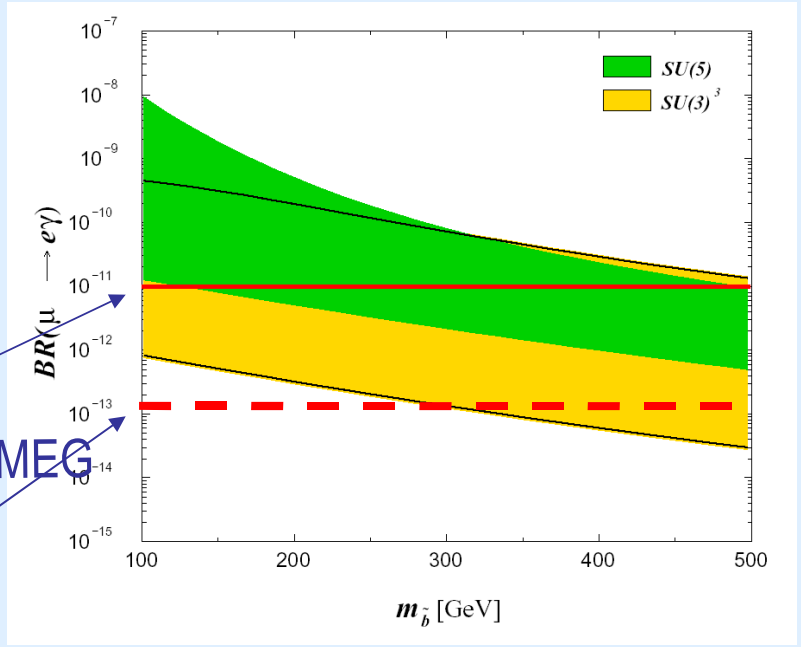


With very low energy muons we probe nanometer thick magnetic layers

Summary of Lepton Flavour Violating experiments



"Supersymmetric parameterspace accessible by LHC"



1) hep-ex/9905013 2) A. van der Schaaf, priv. comm.

W. Buchmueller, DESY, priv. comm.

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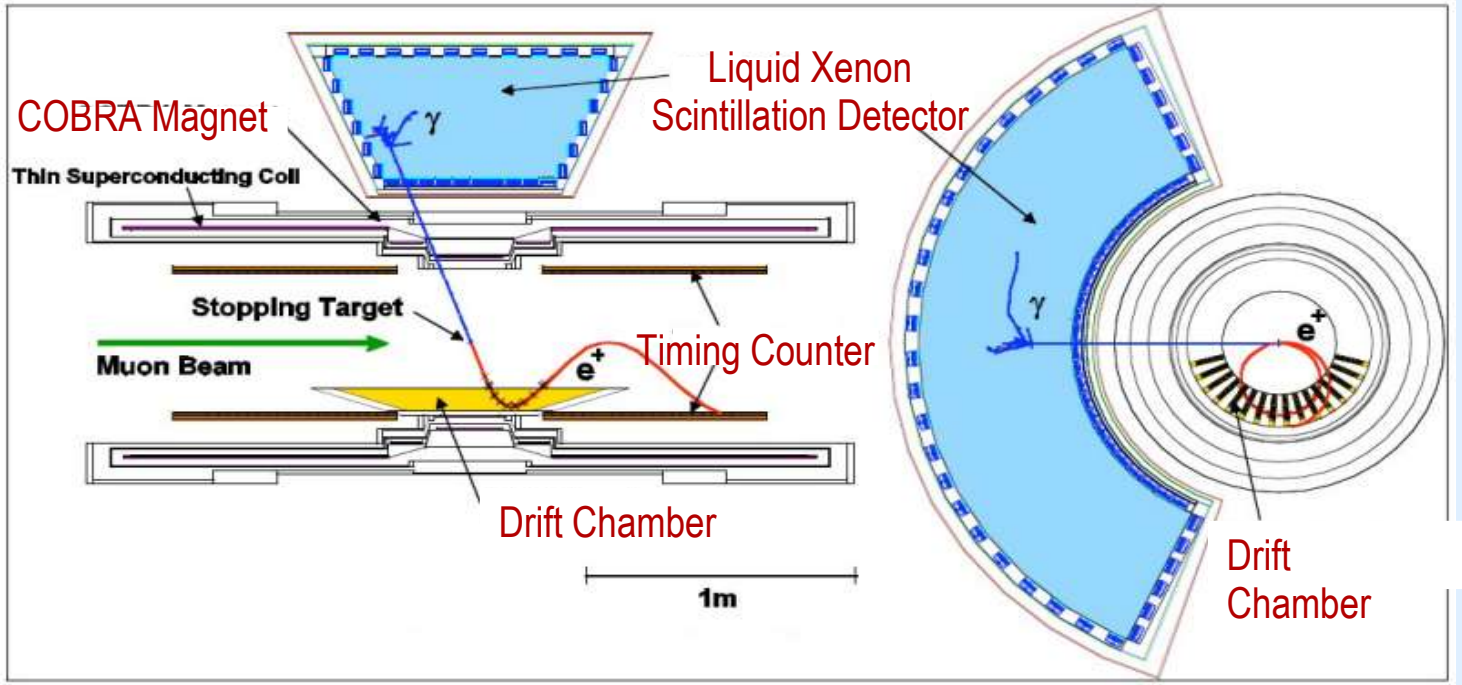
The MEG Detector

Japan, Italy, Russia (JINR, Novosibirsk), Switzerland



- Solenoidal magnetic spectrometer
- LXe for efficient γ detection
- Drift Chamber for Positron detection
- Timing Counter for time measurement

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Pion Betadecay at PSI

Arizona, JINR, PSI, Tbilisi, Swierk, Virginia, Zagreb

- **First phase: 0.8% accuracy**
- **Stopped pion experiment: 10^6 π/s * 1 y beam time, *relative measurement***

$$BR_{\pi\beta} = \frac{BR_{\pi\to e\nu}}{N_{\pi\to e\nu}} \cdot \frac{N_{\pi\beta}}{BR_{\pi^\circ\to\gamma\gamma}} \cdot \text{corrections}$$

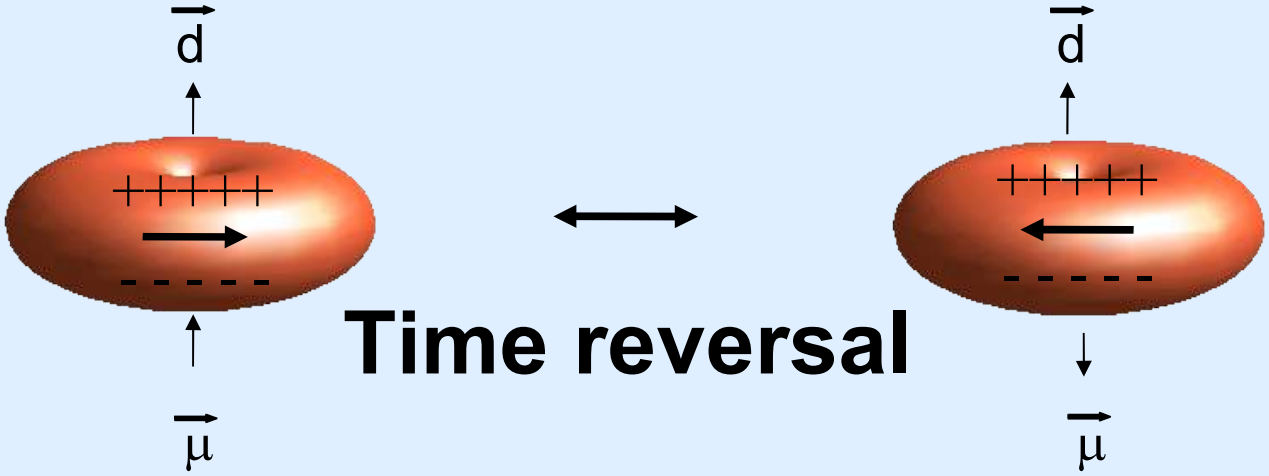
$$BR_{\pi\beta} = 1.034 \pm 0.004 \pm 0.007 \; 10^{-6} \text{ (experiment)}$$
$$= 1.039 \pm 0.002 \; 10^{-6} \text{ (prediction)}$$

$$V_{ud} = 0.9716 \pm 0.0039 \text{ (experiment)}$$
$$= 0.9734 \pm 0.0008 \text{ (PDG)}$$

$$F_A = 0.0262 \pm 0.0015$$

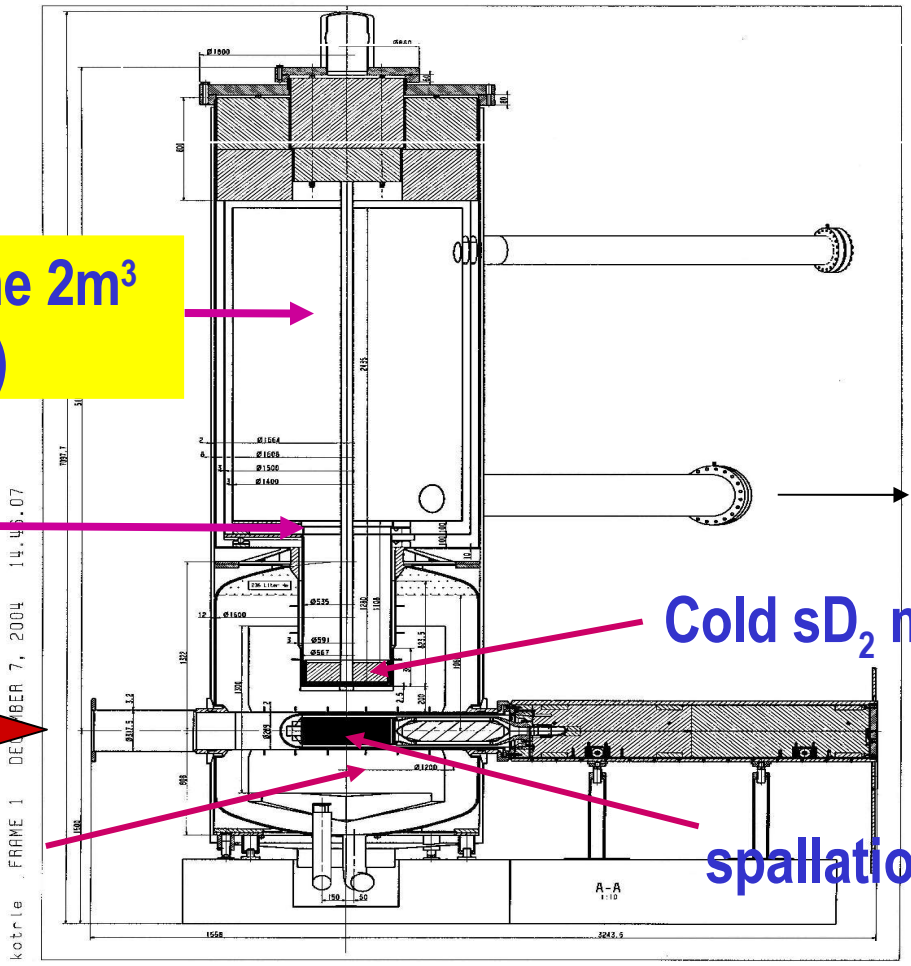
$$F_V = 0.0118 \pm 0.00035$$

Ultra-cold Neutrons



- Ratio of matter to radiation in the universe is $n(B)/n(\gamma)=10^{-9}$ observed, but 10^{-20} predicted
- At the big bang time reversal symmetry was violated and therefore matter dominates over antimatter and the neutron should have an electric dipole moment

1 MW p-beam for 8 s (fill bottle), 10 min beam off (do experiments)



UCN storage volume $2m^3$ ($\sim$2000 UCN/cm^3)

UCN shutter

to experiments

Cold sD_2 moderator

p beam

D_2O moderator

$\tau\sim$5ms, s~10m

spallation neutron target

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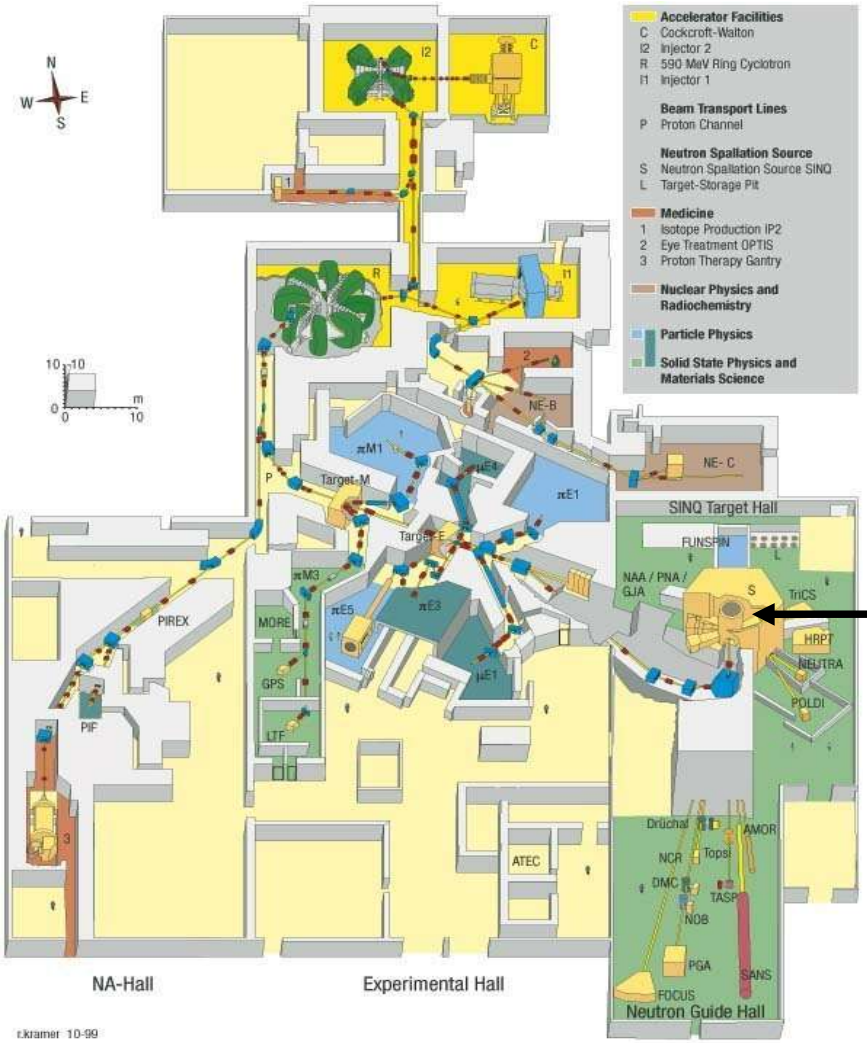
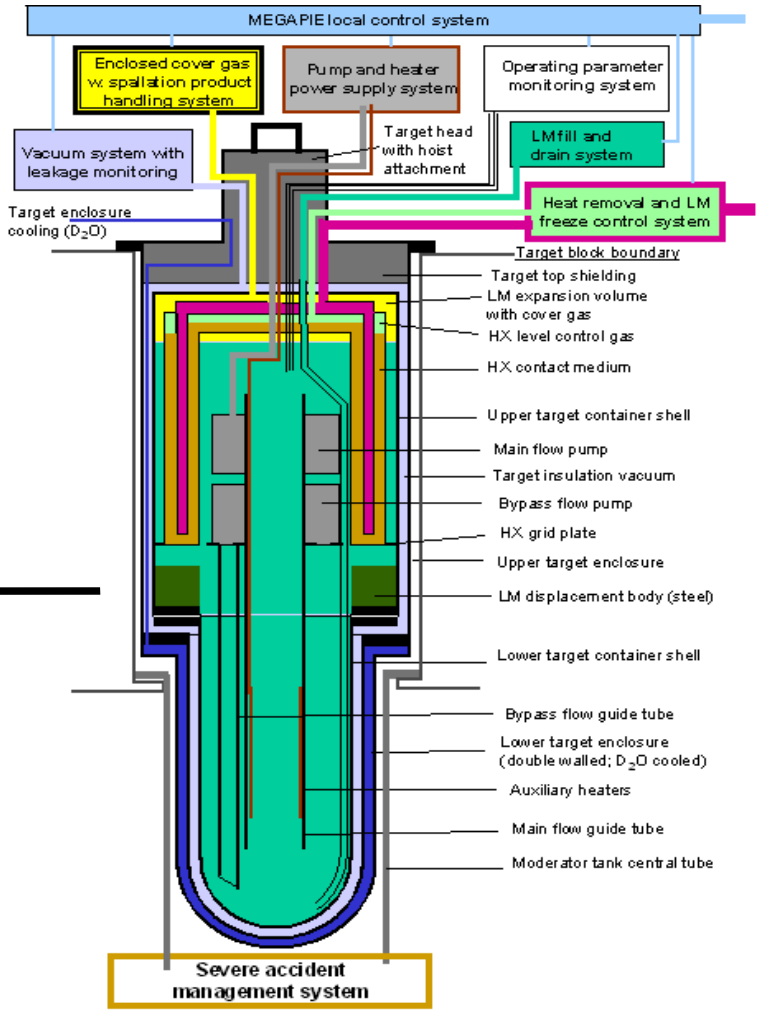
Irradiation of a liquid Pb-target with 1 MW beam in 2006





New Medical Area for Tumor Therapy