PAUL SCHERRER INSTITUT

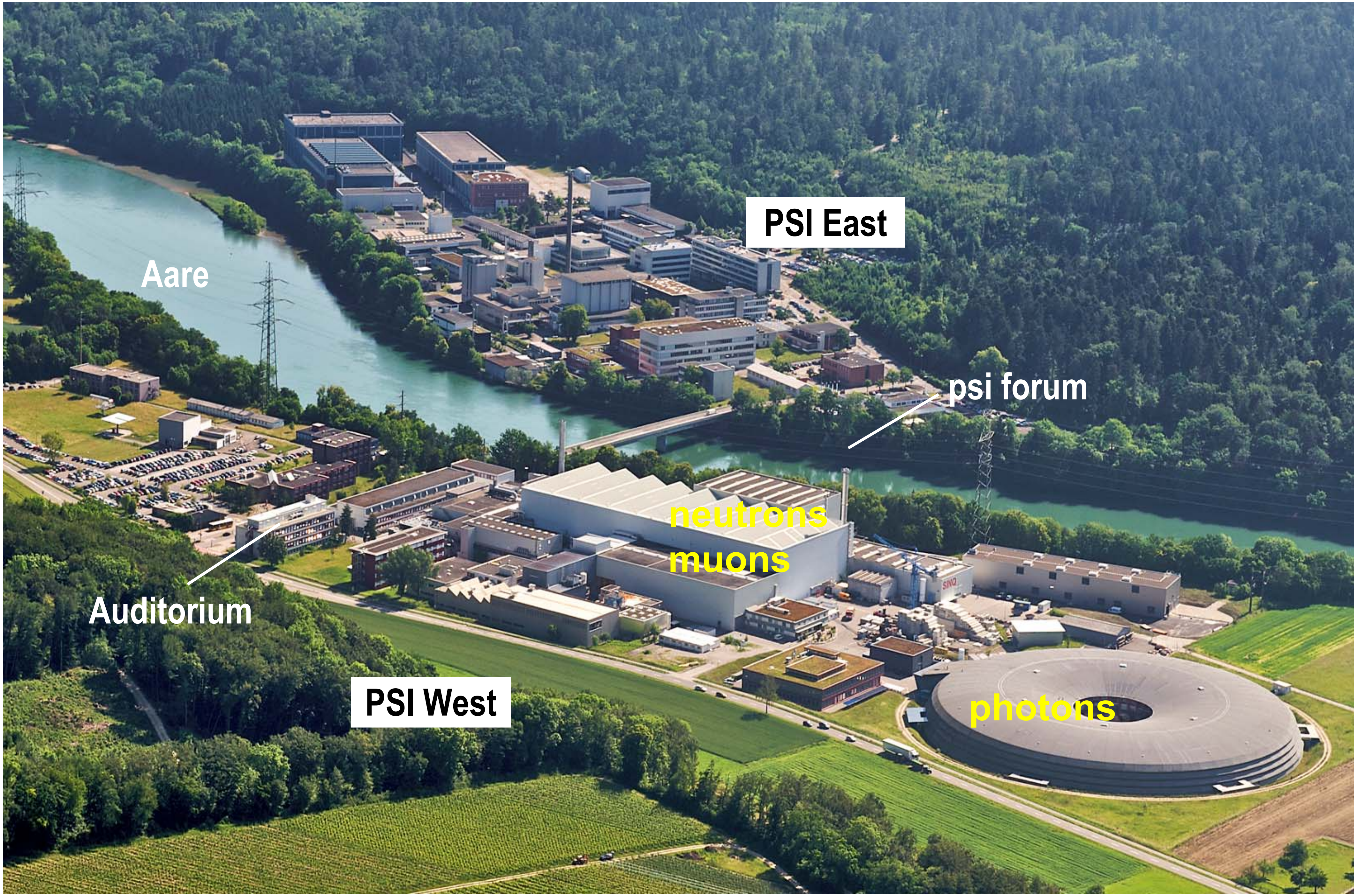
PSI

Wir schaffen Wissen – heute für morgen

SμS: Swiss Muon Source

E. Morenzoni

representing the
Laboratory for Muon Spin Spectroscopy @ PSI
with input from
A. Amato, R. Khasanov, T. Prokscha, Z. Salman, K. Sedlack,
R. Scheuermann, A. Suter

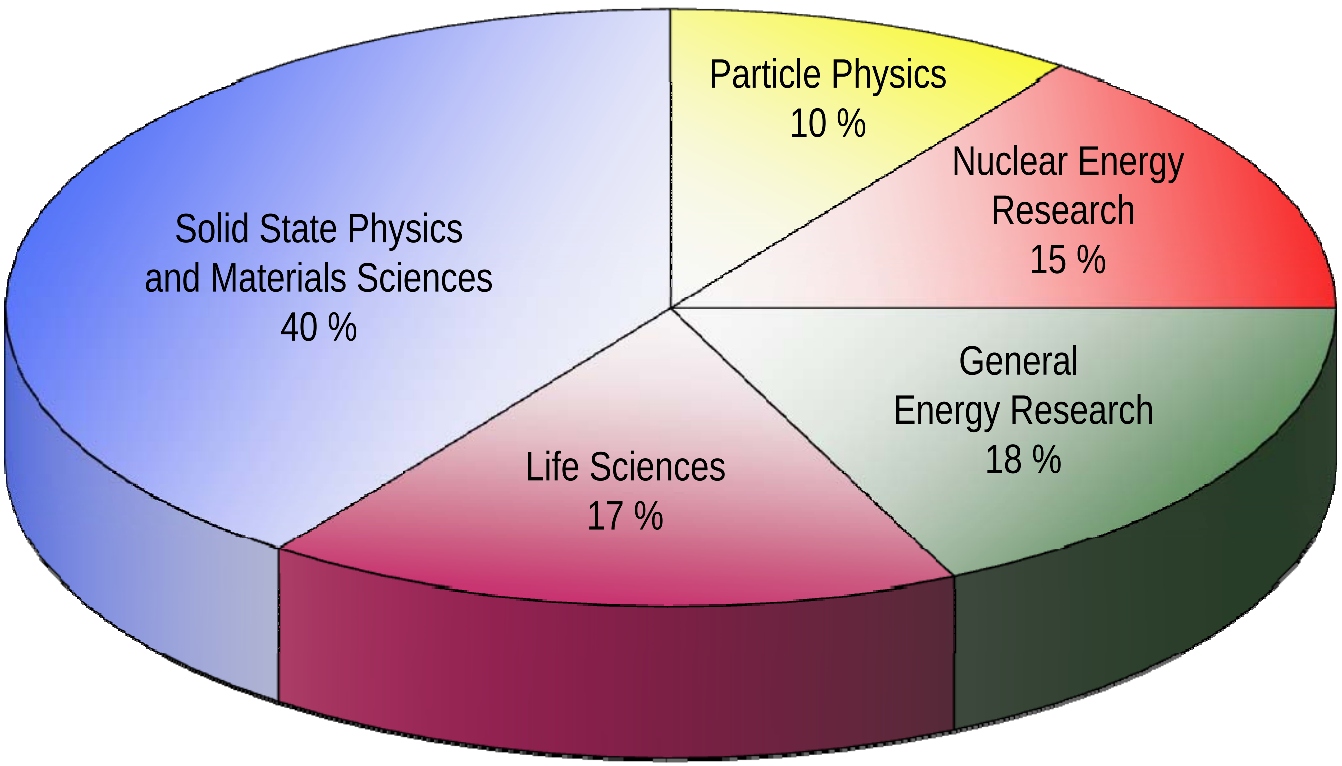

PSI East
Aare
psi forum
neutrons
muons
Auditorium
PSI West
photons

Budget 2011

1 € = 1.32 CHF

1 US$ = 0.9 CHF

Distribution by activities; 320 MCHF (PSI and third-party contributions)



People @ Laboratory for Muon Spin Spectroscopy

Bulk μSR:

Alex Amato (GL) **GPS**

Christopher Baines **LTF**

Markus Bendele (PhD. St., UZH)

Matthias Elender (Techn.)

Alexander Maisuradze (PDF) **GPD**

Zurab Shermadini (PhD)

Rustem Khasanov **GPD**

Robert Scheuermann **HF**

Jose Rodriguez (PDF) **HF**

Kamil Sedlak (PDF) **Dolly/ALC**

Low Energy Muons:

Thomas Prokscha (GL) **LEM**

Andreas Suter **LEM**

Zaher Salman **LEM**

Evelyn Stilp (Ph. D.)

Hans Peter Weber (Techn.)

Hubertus Luetkens **GPS/LEM**

Gwendoline Pascua (Ph D.)

Hassan Saadaoui (PDF)

Matthias Thede (Ph. D.)

Andrea-Raeto Raselli (Computing, LDM)

SμS: The Swiss Muon Source

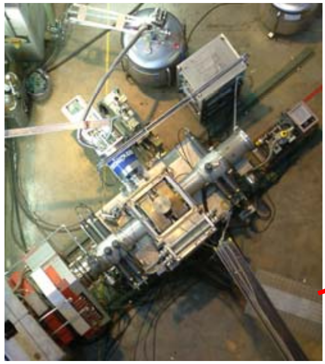
ALC
Avoided Level Crossing Resonance Instrument
Muon energy: **4.2 MeV** (μ^+)

5 T (TI-LF), 2 T (TD-TF), 4 K

(From 2012 High Field μSR)

GPS
General Purpose Surface Muon Instrument
Muon energy: **4.2 MeV** (μ^+)

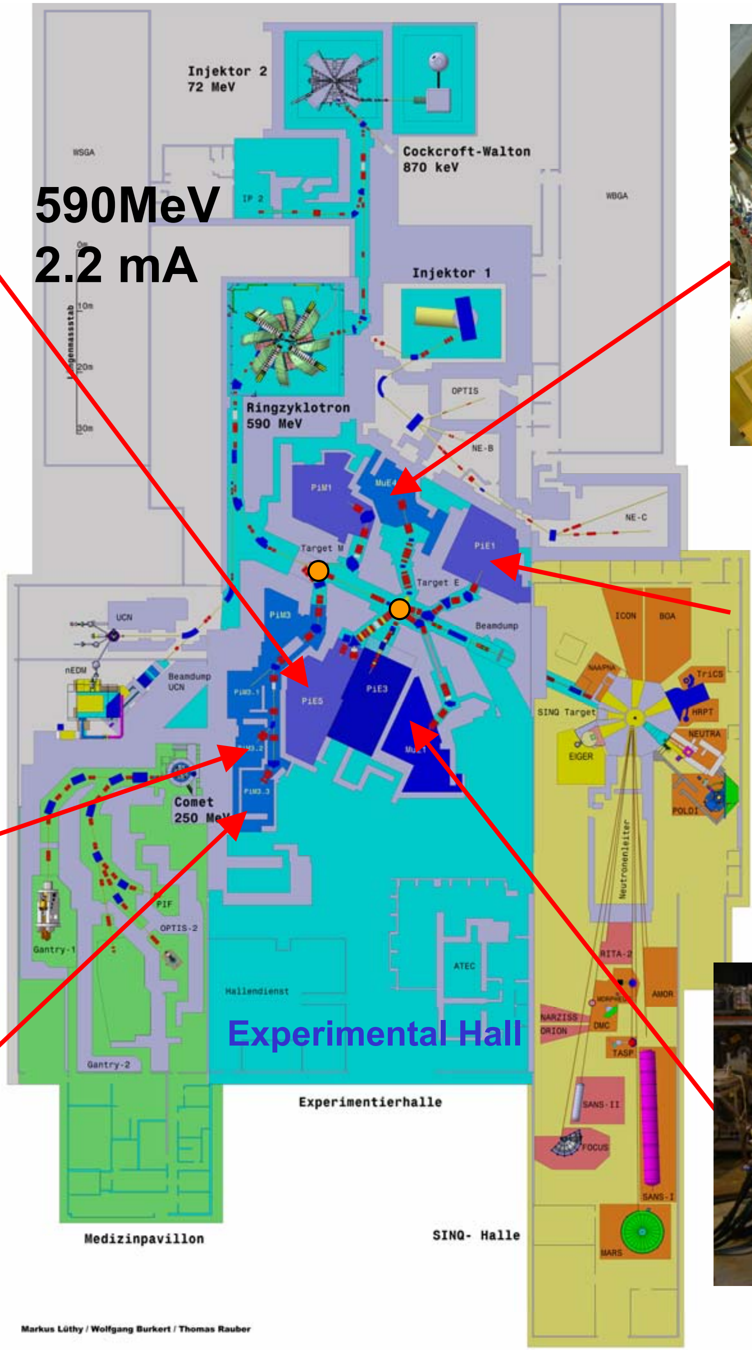
0.6 T, 1.8 K

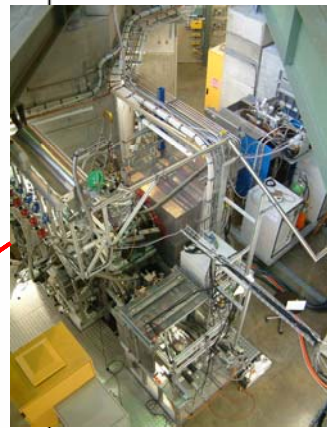


Shared Beam Surface Muon Facility

LTF
Low Temperature Facility
Muon energy: **4.2 MeV** (μ^+)

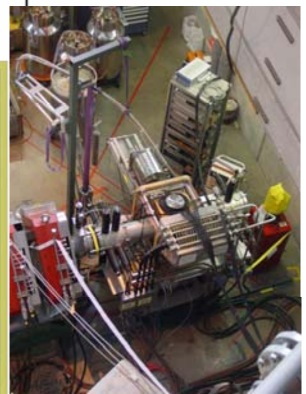
3 T, 20mK- 4 K





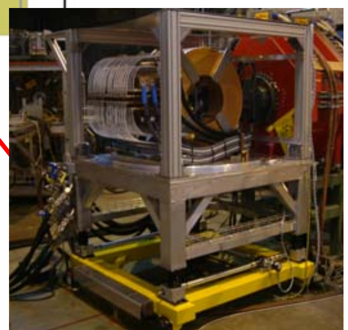
LEM
Low-energy muon beam and instrument, tunable energy (**0.5-30 keV**, μ^+), *thin-film, near-surface and multi-layer studies (1-300 nm)*

0.3 T, 2.5 K



DOLLY
General Purpose Surface Muon Instrument
Muon energy: **4.2 MeV** (μ^+)

0.5 T, 300 mK

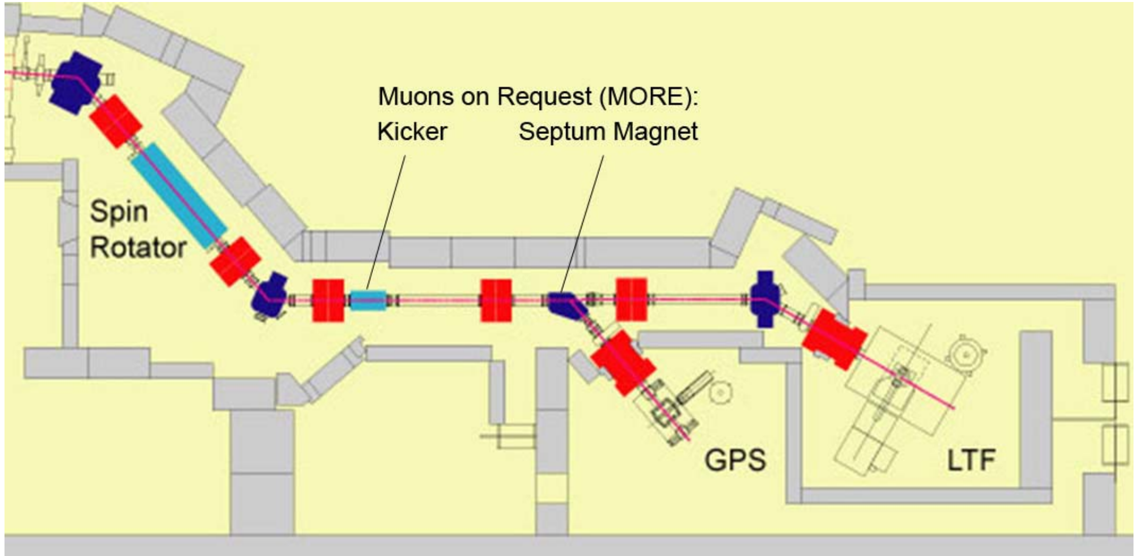


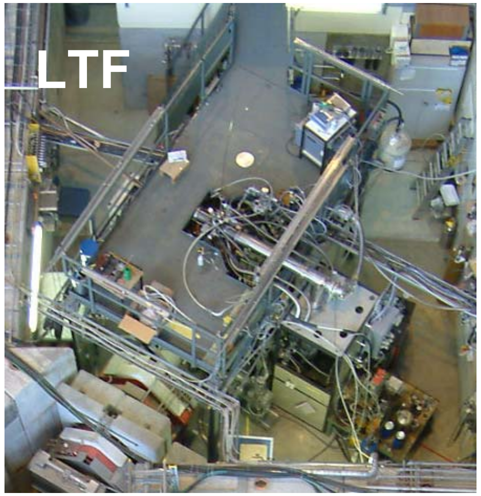
GPD
General Purpose Decay Channel Instrument
Muon energy: **5 - 60 MeV** (μ^+ or μ^-)

0.5 T, 300 mK

Surface Muon Instruments – GPS/LTF

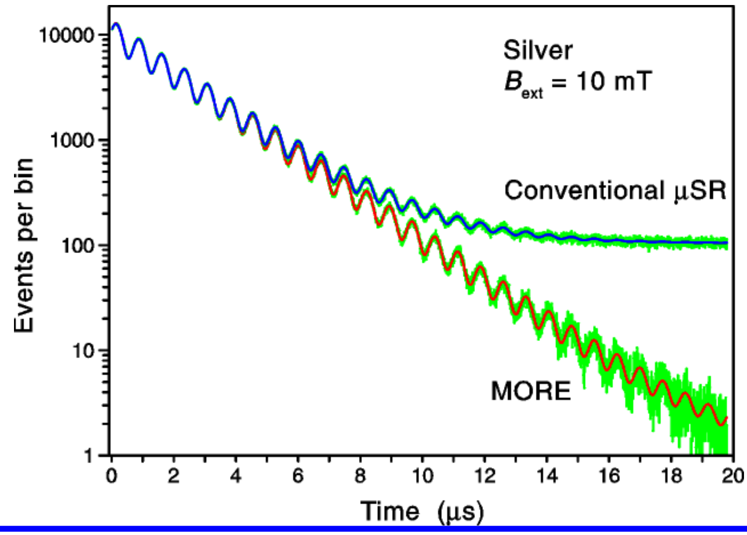
πM3 Dedicated Shared-Beam Surface Muon Facility: GPS and LTF





- 4 MeV μ^+, 100% polarized
- B_{ext}: GPS: 0 - 0.6 T
  LTF: 0 - 3 T
- T : GPS: 1.8 - 1200 K
  LTF: 0.02 - 4.2 K

Worldwide Unique:
Muons on Request, MORE



Surface Muon Instruments – Dolly

πE1 Beamline with Spin Rotator: DOLLY

- 4 MeV μ^+, 100% polarized
- B_{ext}: 0 - 0.5 T
- T: 0.3 - 300 K

Surface Muon Instruments – GPS/LTF and DOLLY

Recent Upgrades/Plans

GPS:

- New **beam line power supplies and control (EPICS)** and vacuum control.
- New data acquisition (VME, software handling of coincidences and vetos)
- Top-loading 4-Kelvin CCR
- Replacement of main Helmholtz coils

DOLLY:

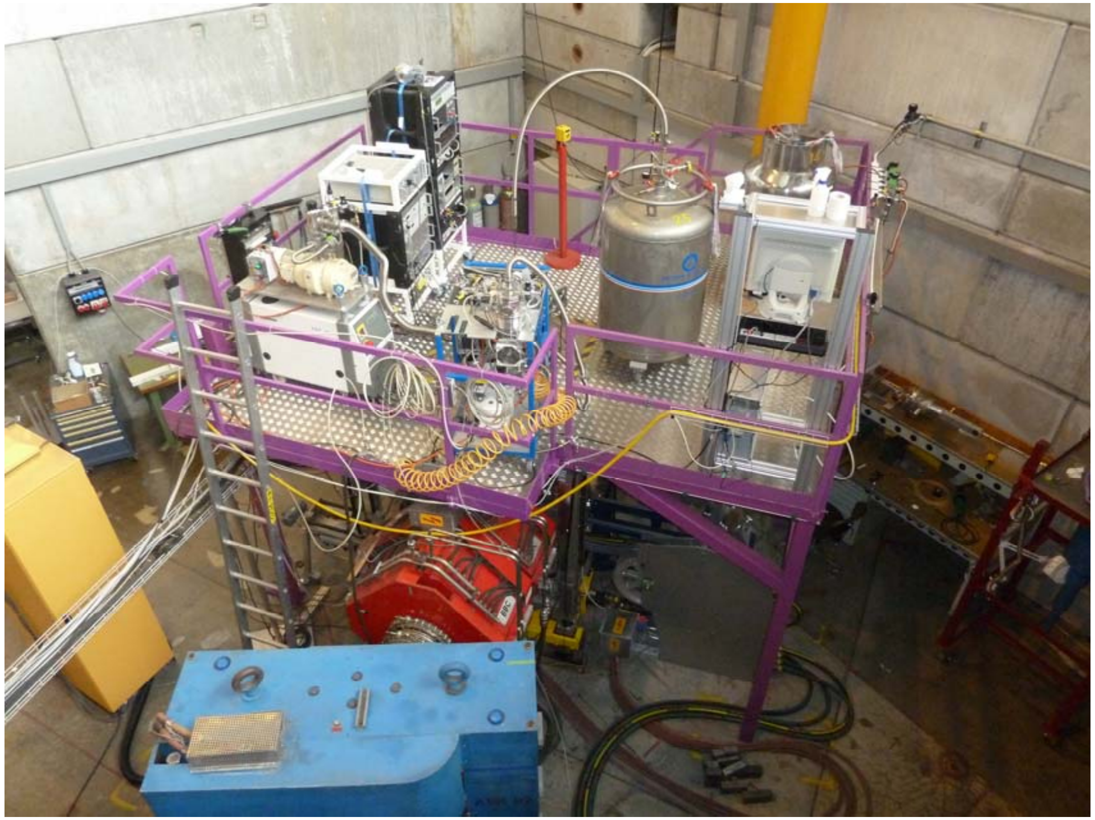
- New data acquisition (VME, software handling of coincidences and vetos)
- New cold valve control with feedback loop
- New temperature control (no more LabView application)
- **Possibility to use ^{3}He or DR insert**

LTF:

- New data acquisition (VME, software handling of coincidences)
- New beamline power supplies and control (EPICS) and vacuum control
- Automatic zero-field compensation
- **Concept for entire replacement at the end of 2011**

High Energy Muon Instrument – GPD

μE1 Superconducting Decay Channel Beamline



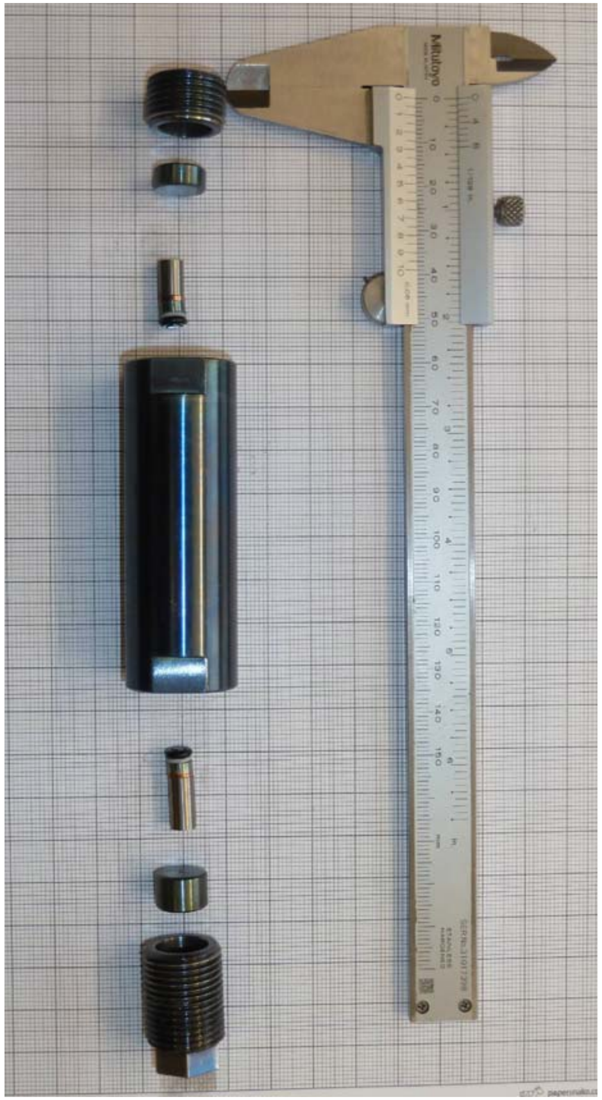
- 10 - 60 MeV μ^+ or μ^-
- B_{ext}: 0 - 0.6 T
- T : 0.3 - 475 K
- Large sample chamber for pressure cells (diameter up to 40 mm)

Recent Upgrades/Plans

- New collimation system
- New data acquisition (VME, software handling of coincidences and vetos)
- New top-loading 10K-CCR
- Additional G-APD based detectors to decrease **background** based on MuSRSim(Ana) – s

⟶Poster #67

High Energy Muon Instrument – GPD

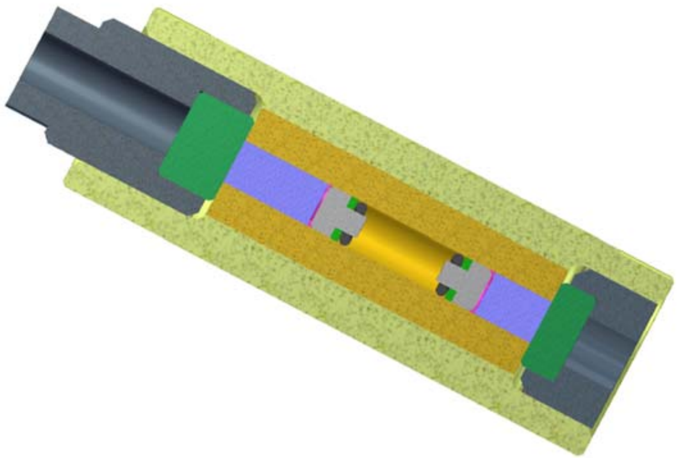


High Pressure Cells

New pressure cells
(double-wall, open on both side)

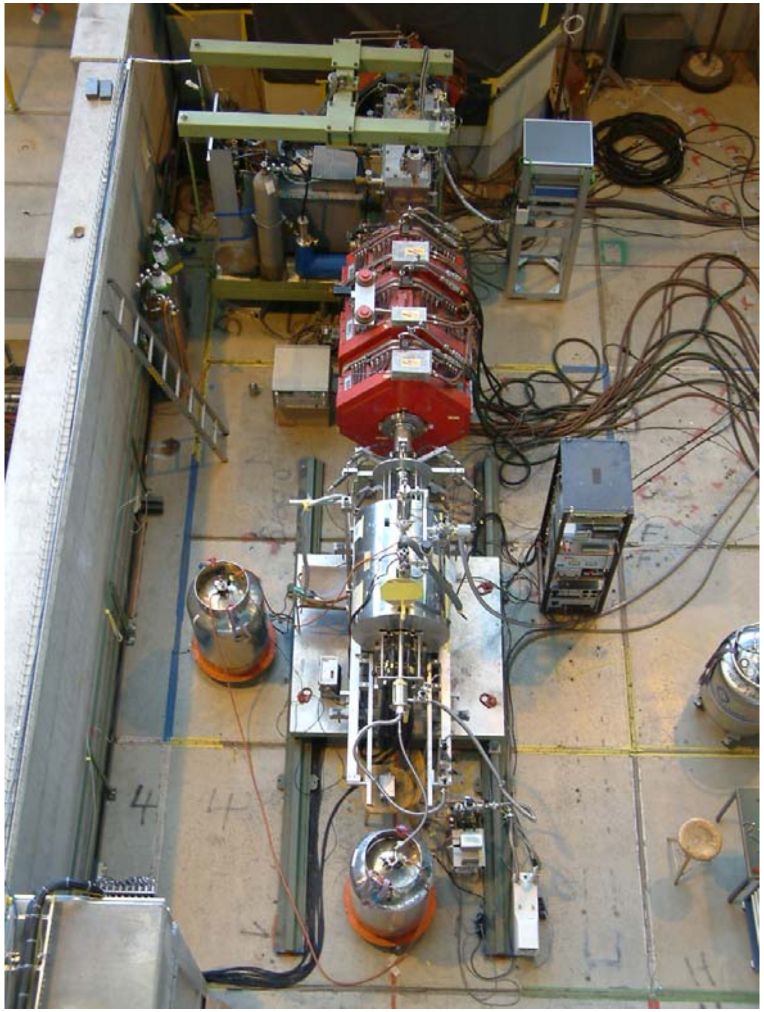
MP35N/MP35N, MP35N/CuBe

Tested: 28 kbar down to 0.25K



Integral μSR Instrument: Avoided Level Crossing – ALC

πE3 Surface Muon Beamline (from 2012 dedicated for High Field μSR)



- 4 MeV μ^+, 100% polarized
- B_{ext}: 0 - 5 T longitudinal (Superconducting solenoid)
- T: 4.2 - 500 K

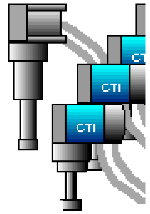
Recent Upgrades/Plans

- New G-APD based detectors (prototype for new High Field instrument)
- New He-flow cryostat
- Possibility to perform **Δt experiments**
- New "Standard" Qt GUI Interface for integral measurements:
  → same "feel and touch" as time differential GUI interface
  → fast switching between Δt and integral measurements
  → full autorun control

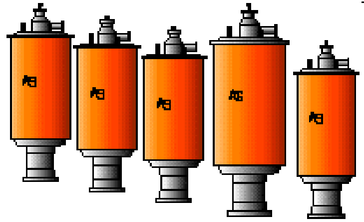
SµS Sample Environment (bulk)

Temperature: 0.02 - 1200 K

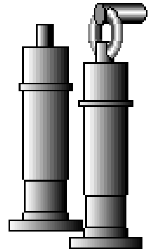
2 Closed Cycle Refrigerators



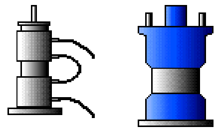
7 He-Cryostats



1 Dilution Cryostat, 1 ^{3}He Insert

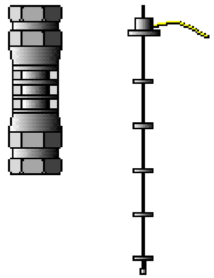


2 Furnaces

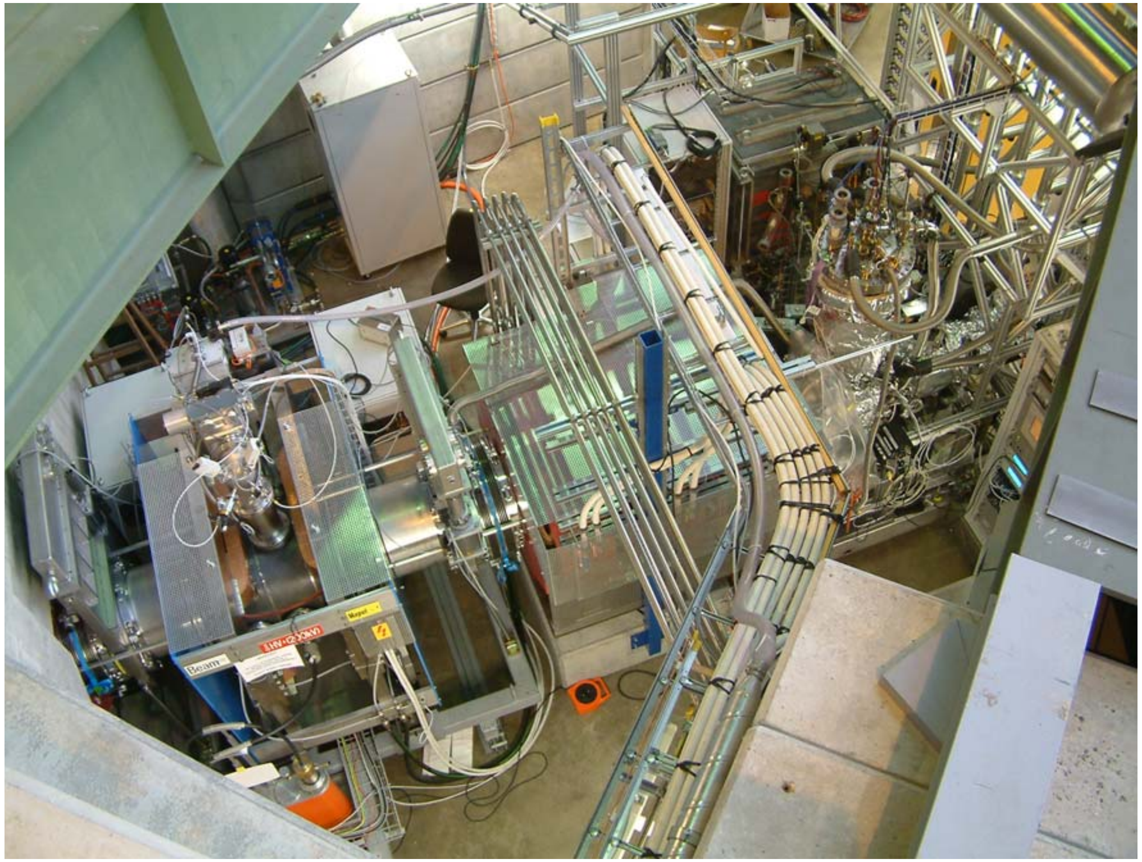


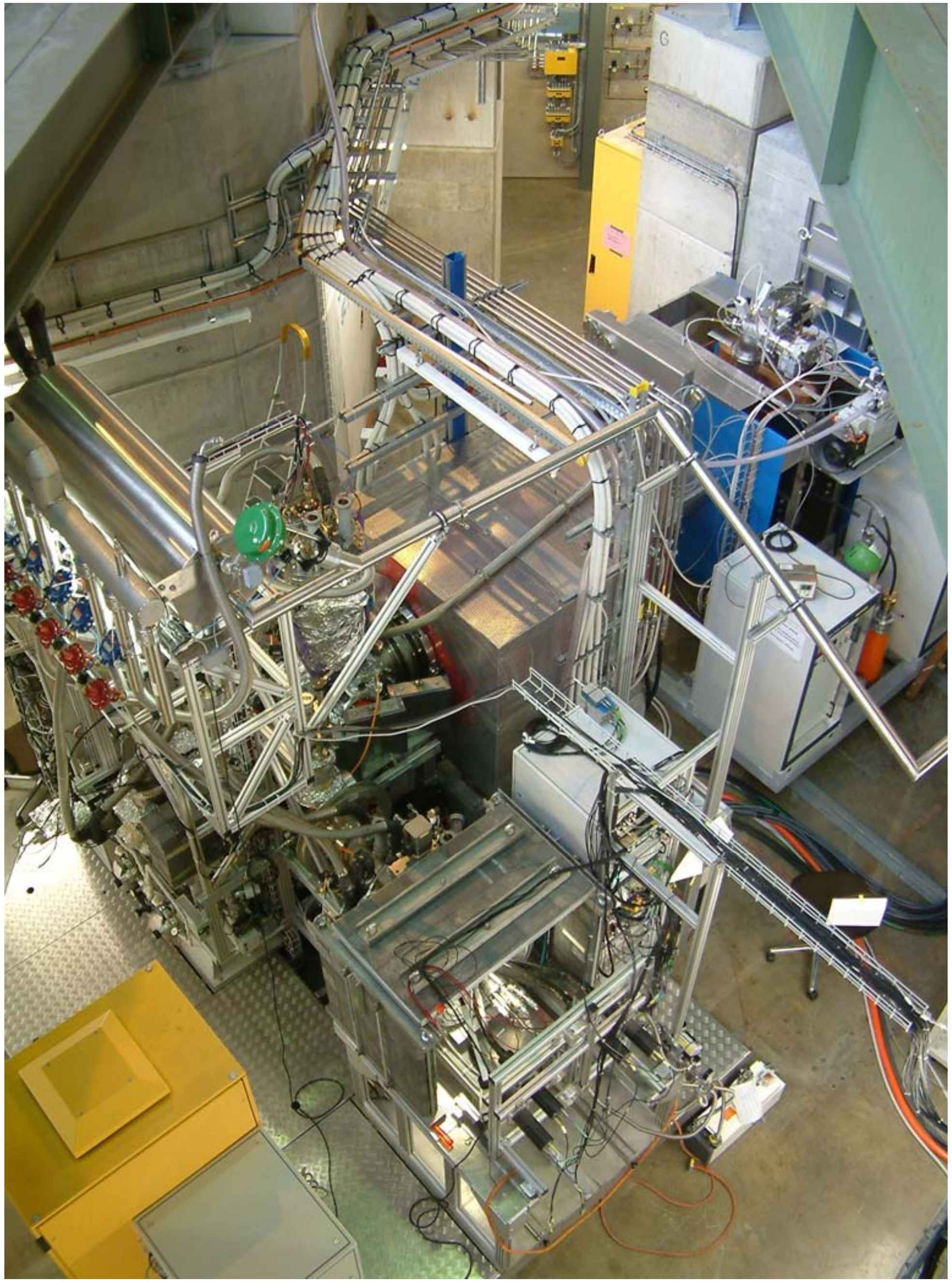
Magnetic Field: 5 T longitudinal (ALC), 3 T transverse (LTF)
0.6 T longitudinal or transverse (standard)

Pressure: 28 kbar hydrostatic



LE-μ^+ Apparatus @ μE4





~6.5 •10^8 μ^+/s total

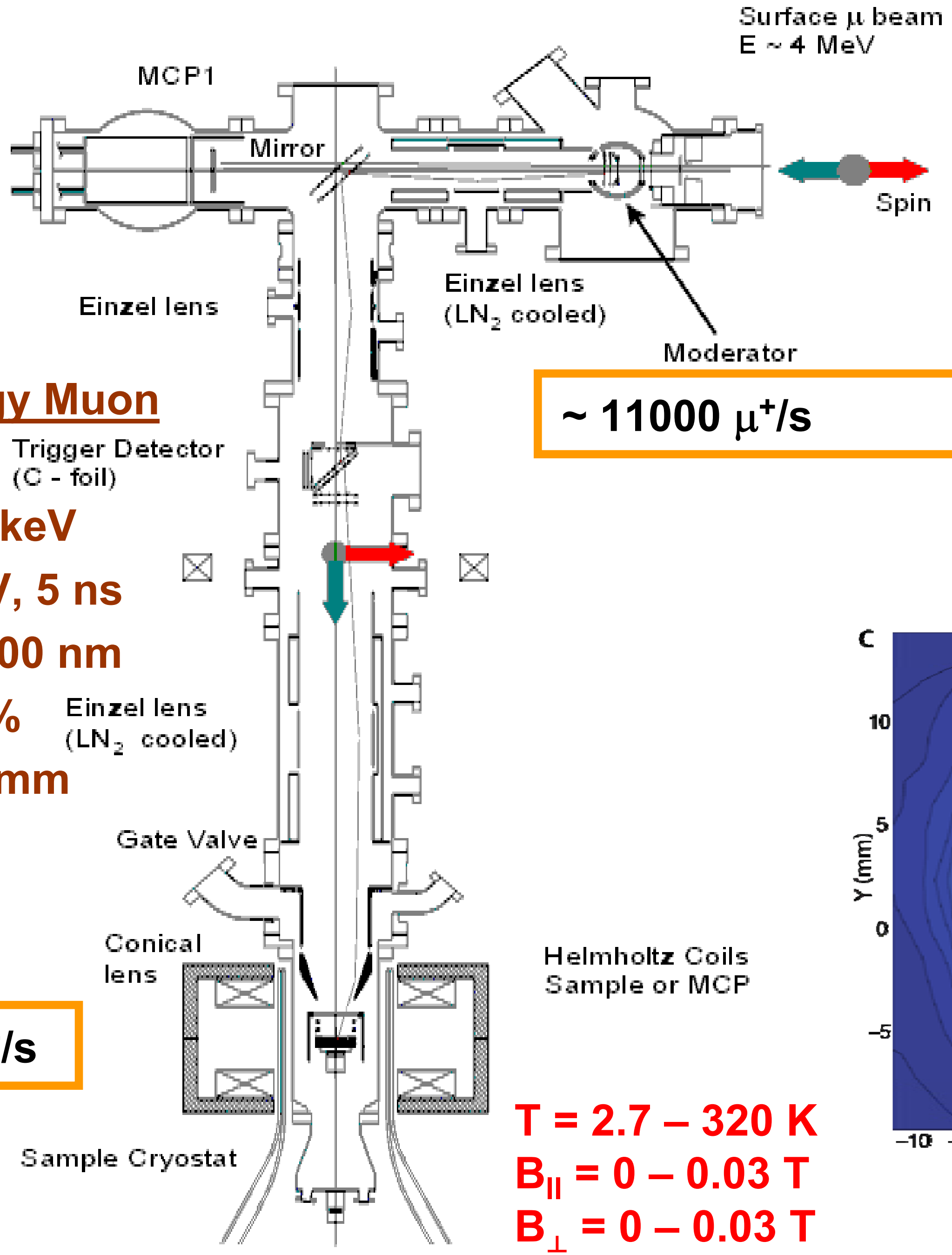
~1.9 •10^8 μ^+/s on LEM source

Th. Prokscha, E. Morenzoni, K. Deiters, F. Foroughi, D. George, R. Kobler, A. Suter and V. Vrankovic
Physica B 374-375, 460-464 (2006)
and Nucl. Instr. Meth. **A 595** 317 (2008)

Low energy μ^+ beam and set-up for LE-μSR

~1.9 •10^8 μ^+/s

μE4 beam line



~ 11000 μ^+/s

- All transport elements

LN_2 cooled

-10^{-9}-10^{-10} mbar (UHV)

Polarized Low Energy Muon Beam

Energy: 0.5-30 keV

ΔE, Δt : 400 eV, 5 ns

Depth: ~ 1 – 300 nm

Polarization ~ 100 %

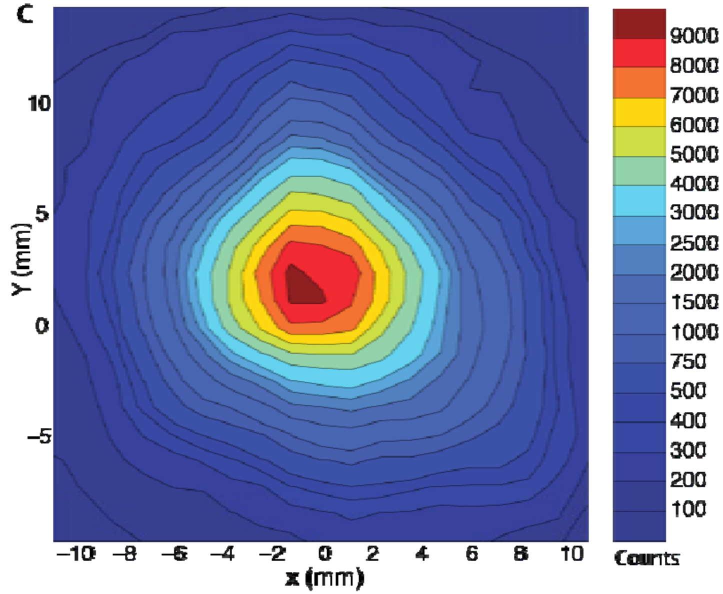
Beam Spot: 10-20 mm

~ 4500 μ^+/s

T = 2.7 – 320 K

$B_{||}$ = 0 – 0.03 T

$B_{\perp}$ = 0 – 0.03 T



LE-μSR sample environment

Sample cryostats:

- 2 Konti cryostats (CryoVac, Germany), 4-320 K

- 2 Konti cryostats for development and light experiments

- 1 low-Temp cryostat (PSI/Univ. Birmingham), 2.7-300 K

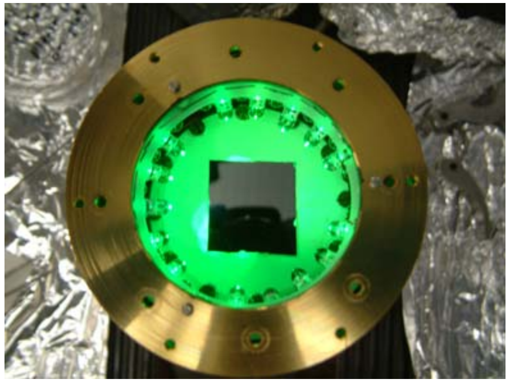
Special sample environment:

- Floating Ohm Meter (FOM, Univ. Fribourg/PSI), currents 1 nA – 1 mA, 0 - 50 V, floating between -12 and +12kV

- Floating application of electric fields (PSI, currently testing)

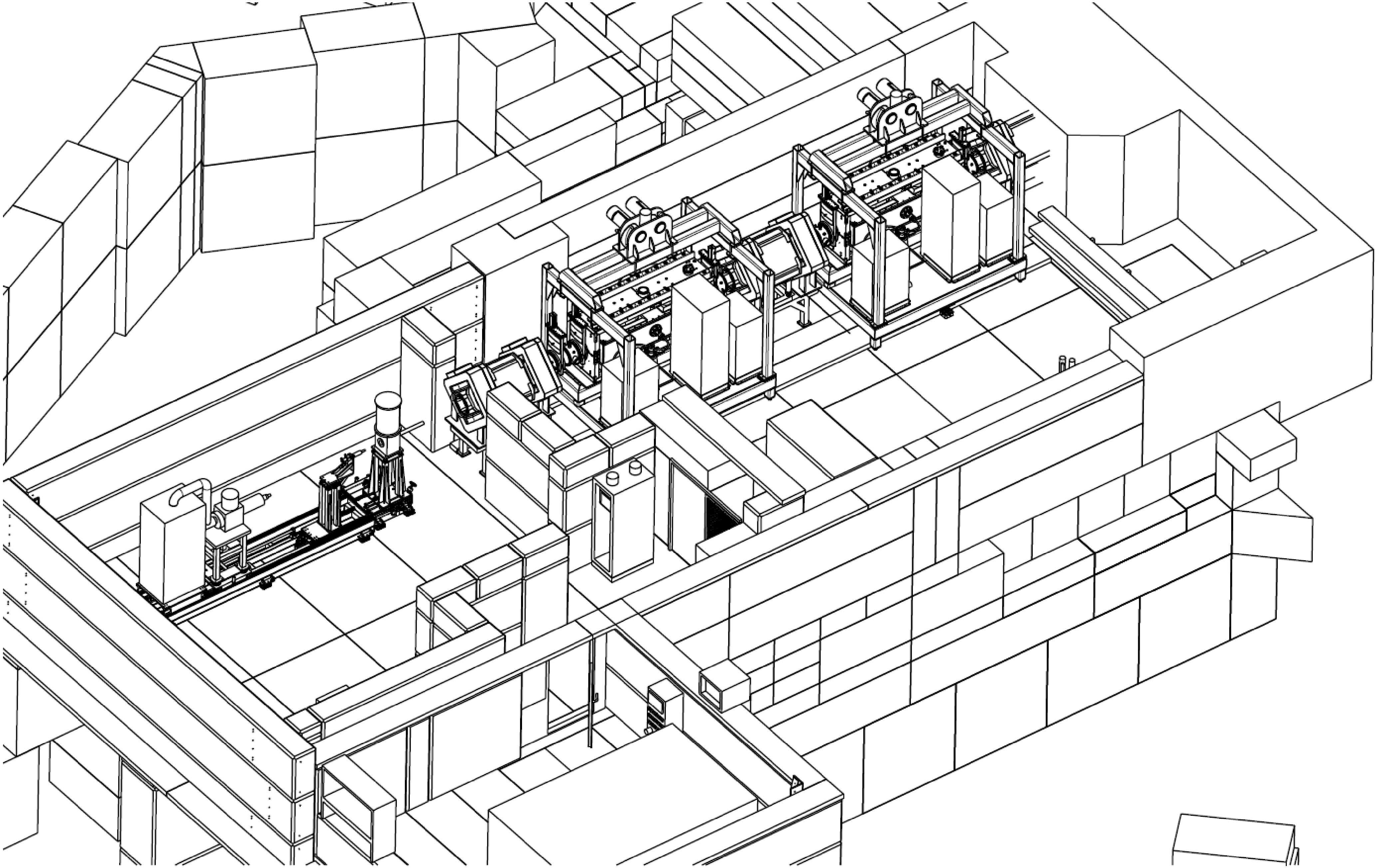
- μSR under light stimulus (LED, laser under development)

⟶Poster #42



- Floating resistivity measurements under illumination (PSI, under construction)

High Magnetic Field µSR Instrument



High Field μSR ~10T, ~20mK

R. Scheuermann, J. Rodriguez, T. Konter, K. Sedlak

A. Stoykov, M. Bartkowiak, A. Amato, K. Deiters, T. Rauber, ………

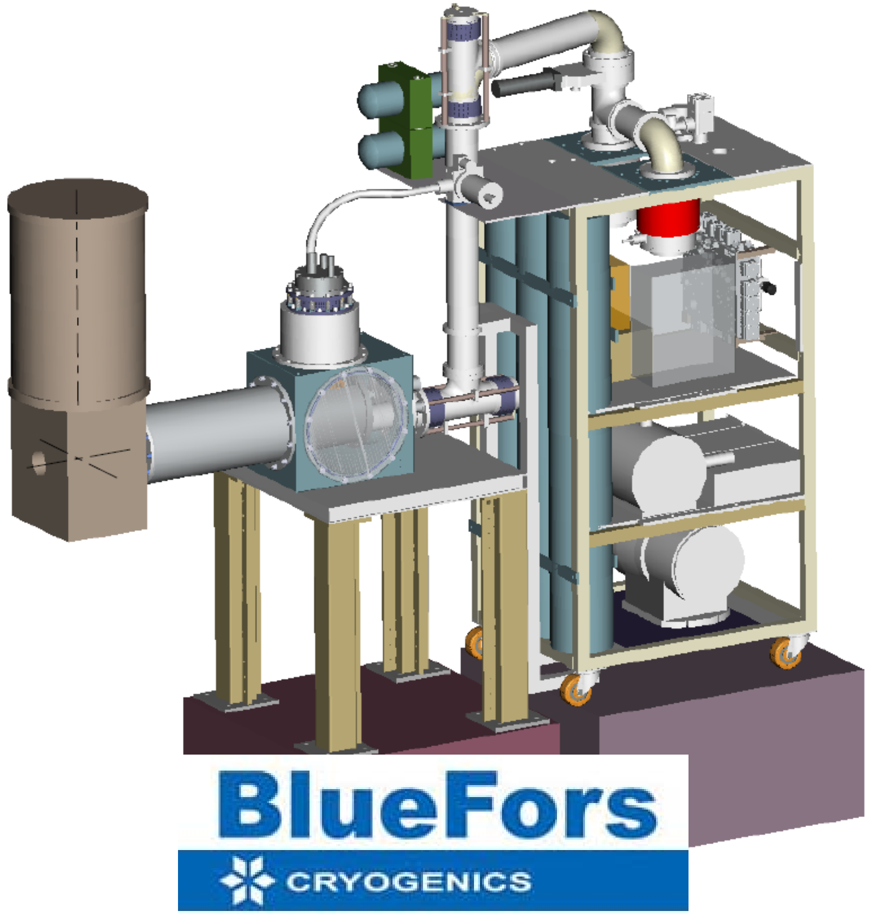
→Poster #32

@ PSI

9.5 T with recondensing System

Horizontal DR 20mK

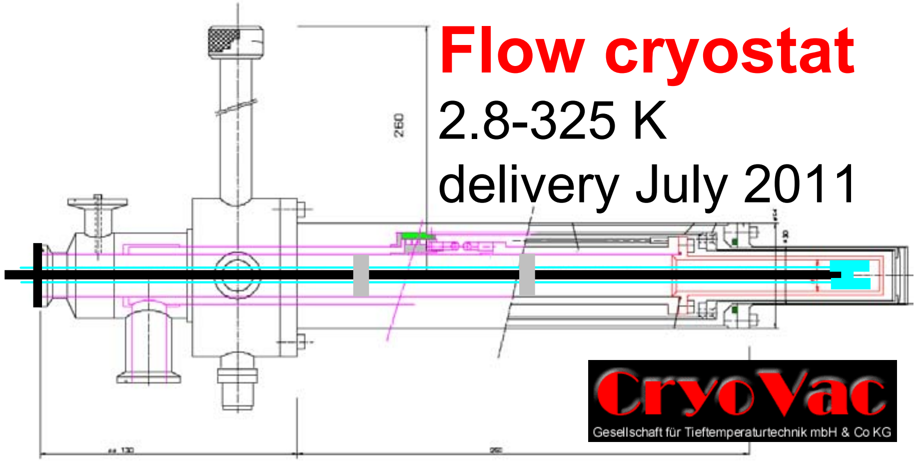
in production, delivery July 2011



Flow cryostat

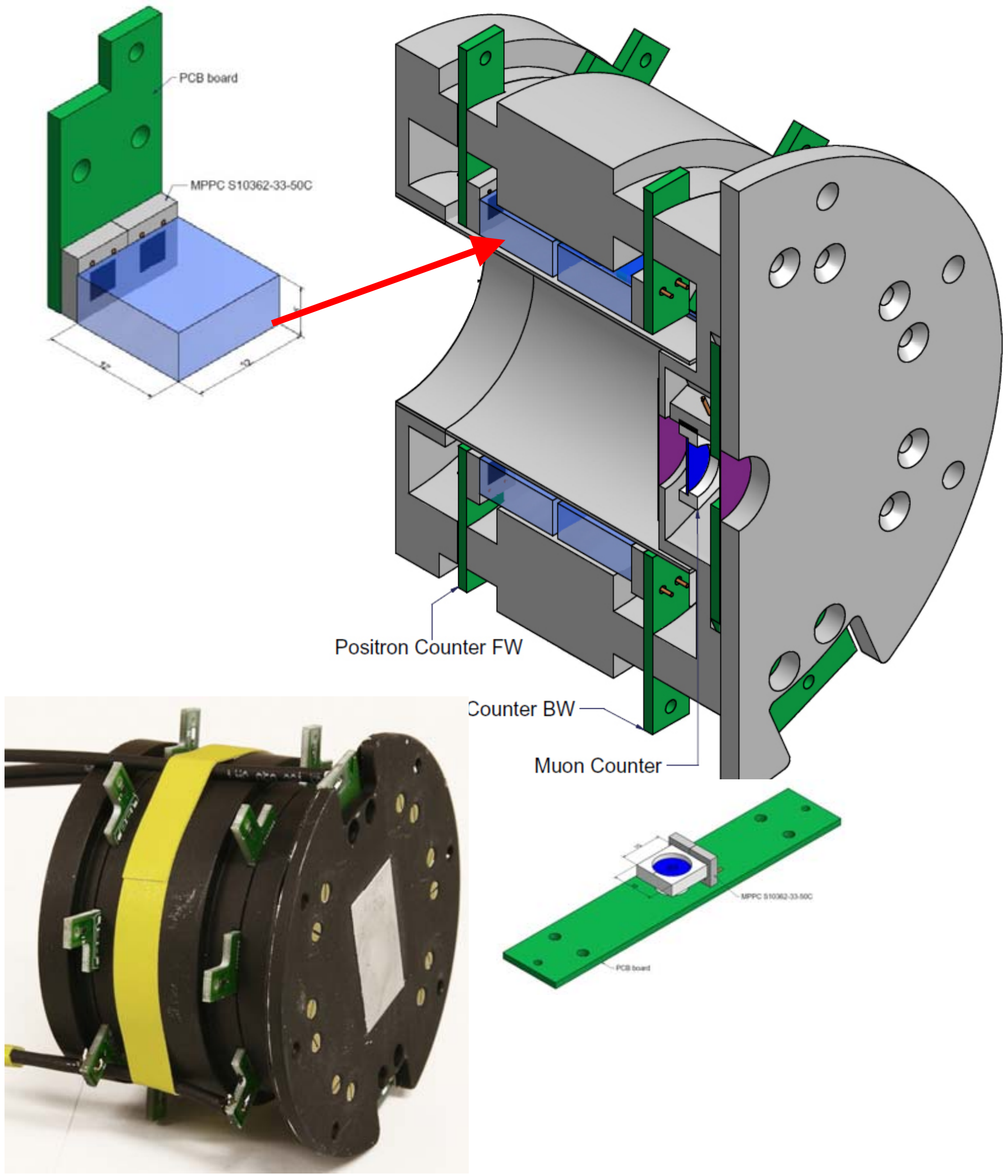
2.8-325 K

delivery July 2011



Detectors

APD‘s (Avalanche Photo Diodes)

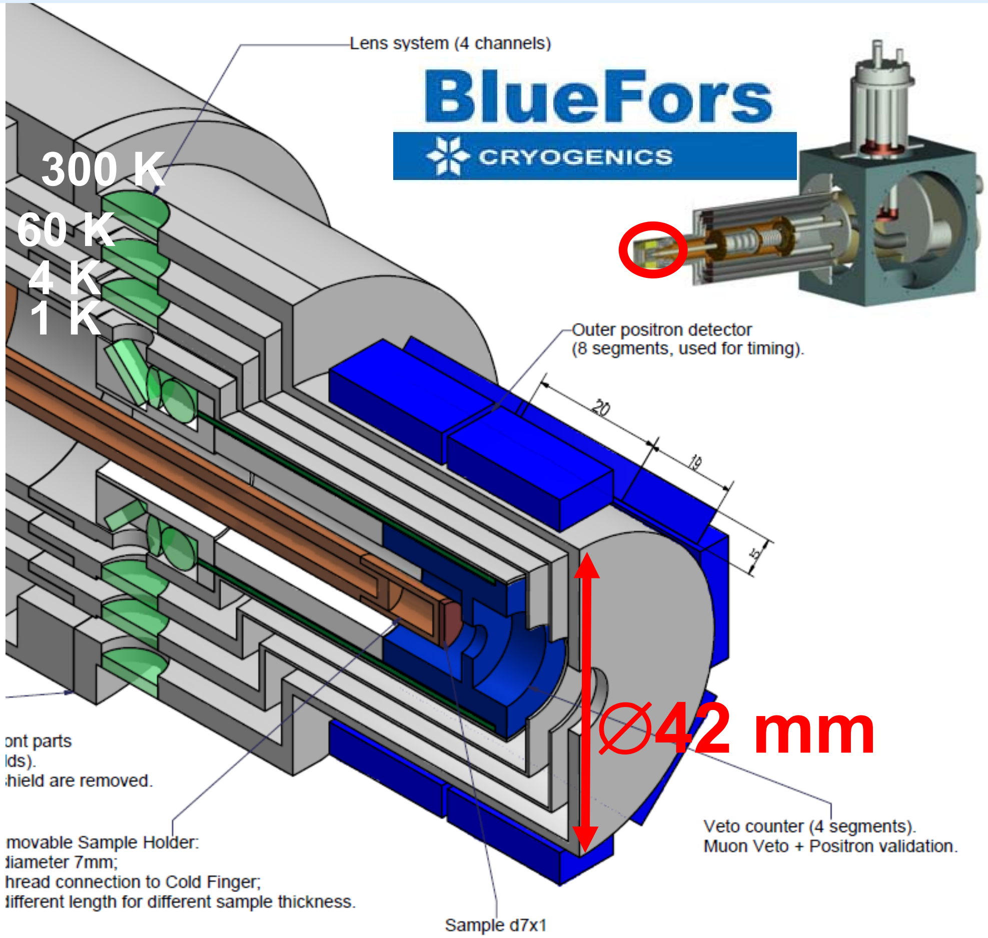


Setup with DR

Veto/validation detector @ 1 K shield,

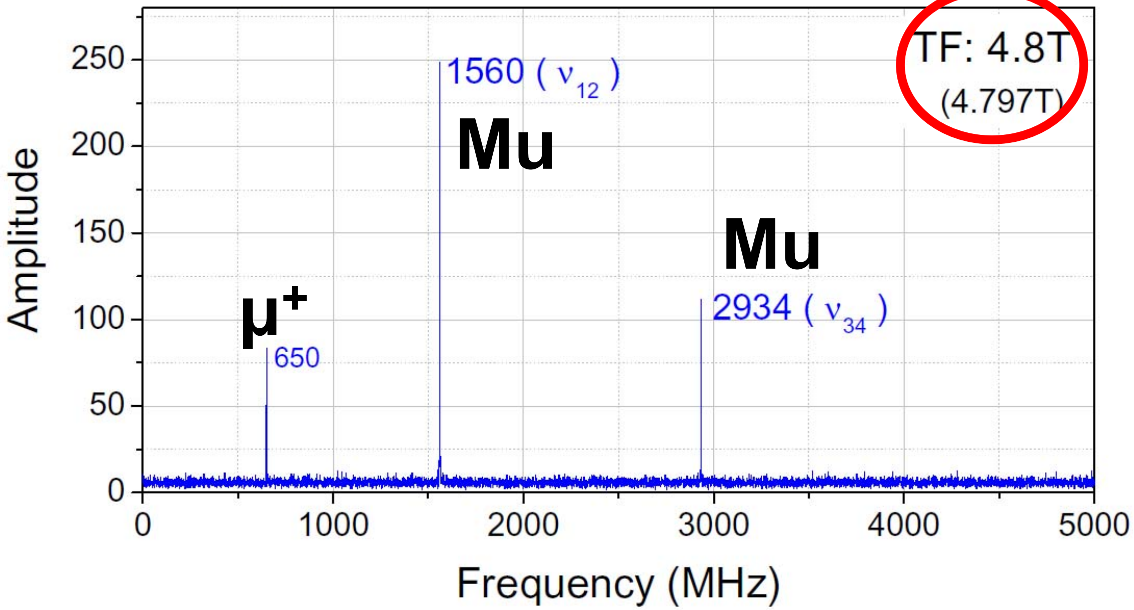
readout by WLS & lens system,
photodetector outside

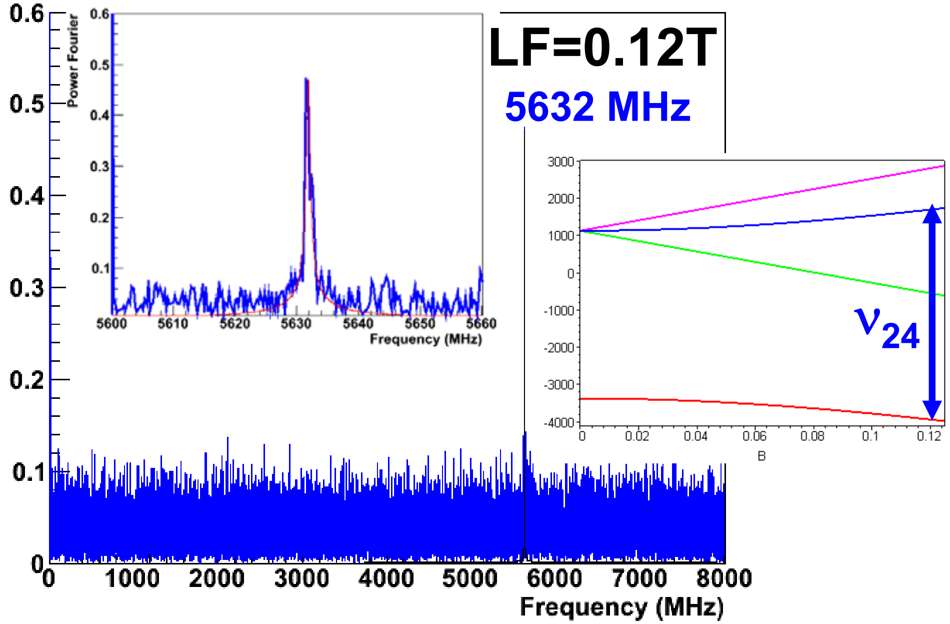
http://arxiv.org/abs/1101.3254



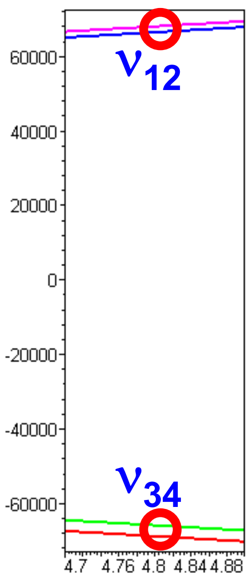
APD's Timing Detector Tests

μSR measurements: Mu in cryst. quartz (A_{iso}=4495 MHz)

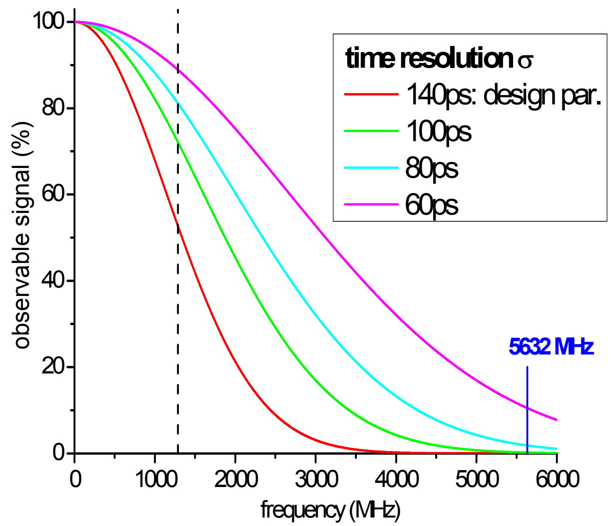




Such a **high frequency** μSR signal in such a **high magnetic** field has **never** been measured before!



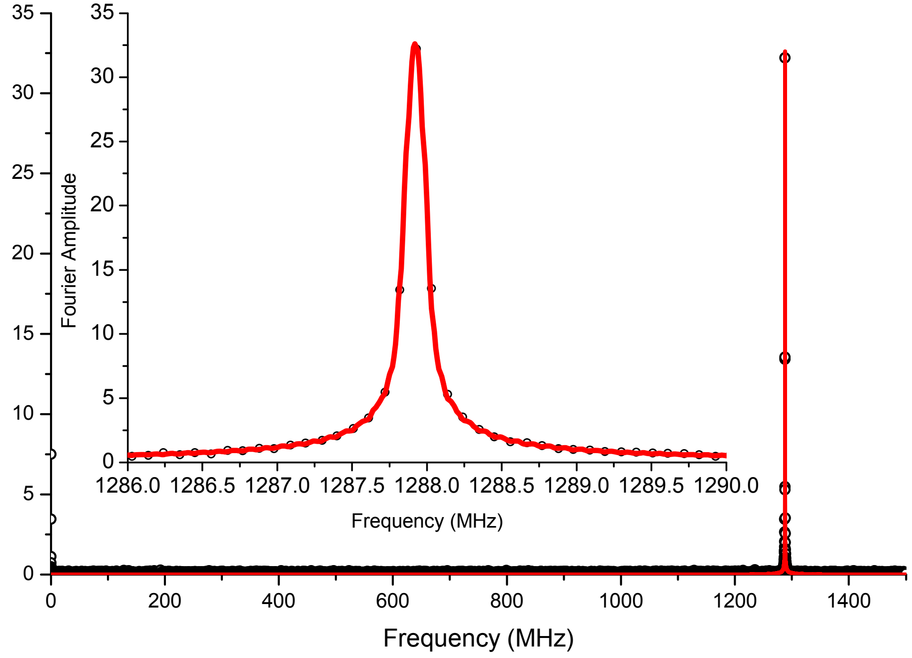
⟶Poster #33

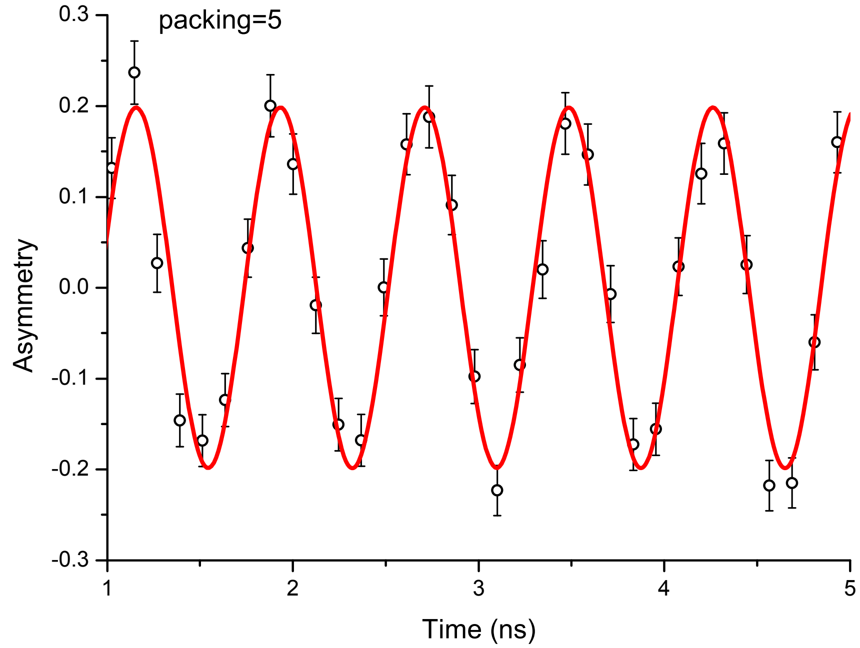


Time resolution σ=80ps:

>80% μ^+ prec. ampl. at max. field

First Data at 9.5 T on Ag sample (11.05.2011)



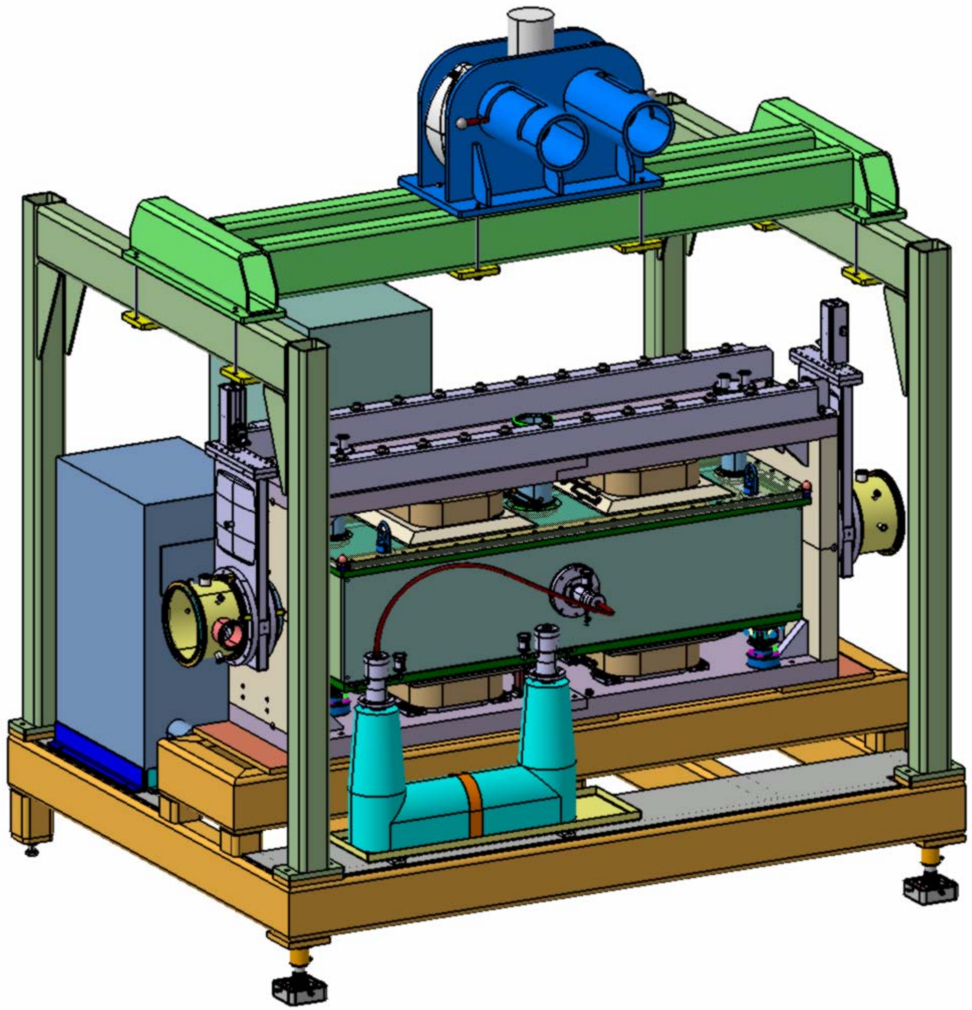


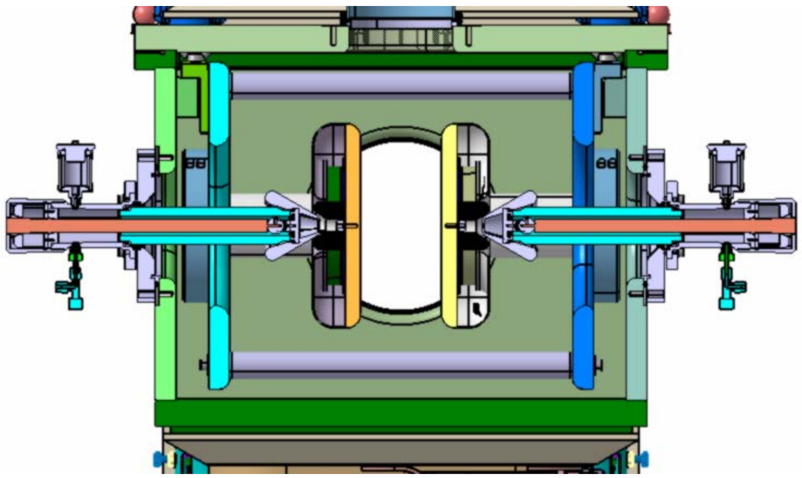
Fitparameters: freq = (1287.92215 ± 0.00016) MHz

asym = (0.19849 ± 0.00039)

sigma = (0.0694 ± 0.0021) μs^{-1} (< 0.8 G)

Spin Rotators:





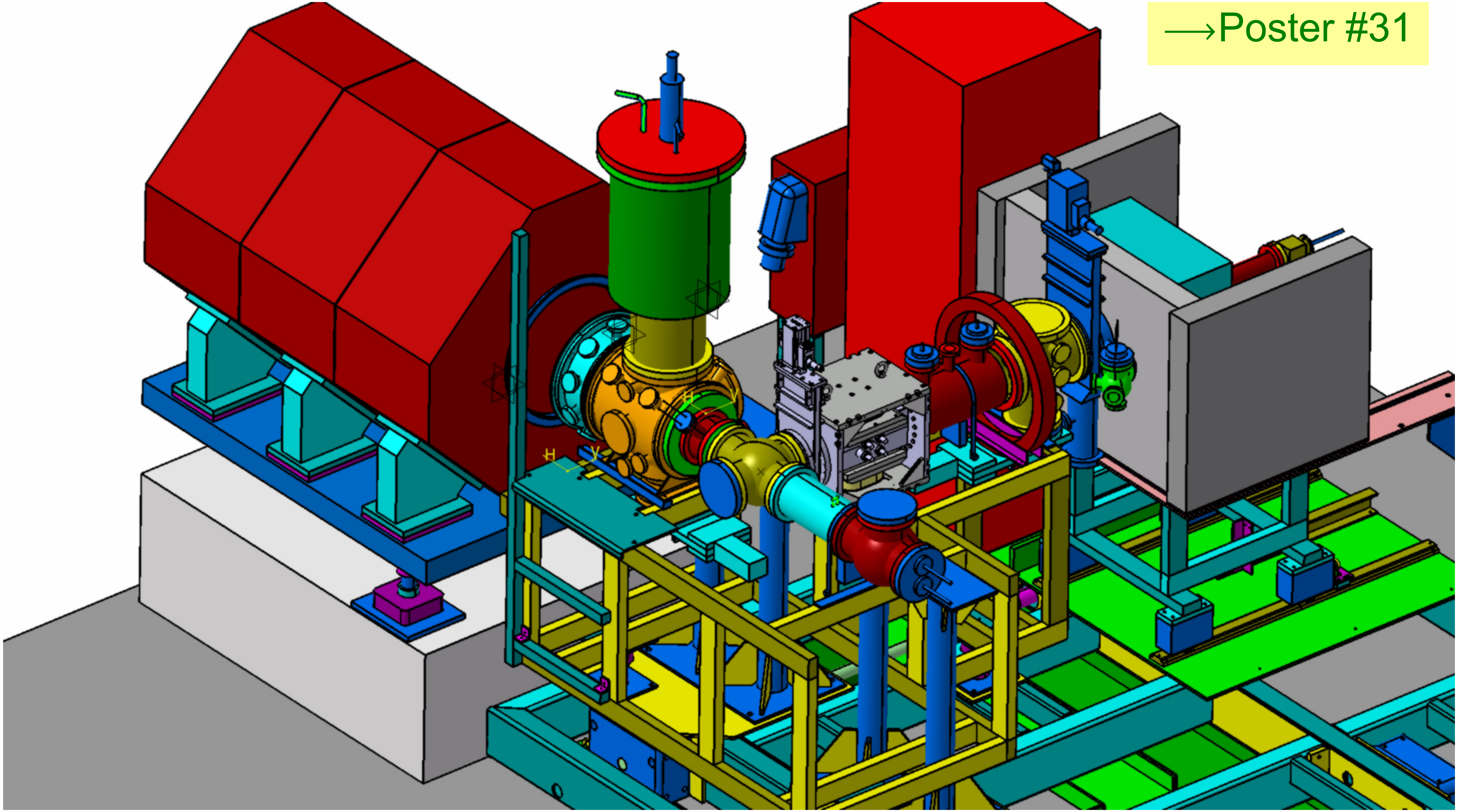
HV=+/- 200 kV, max. 80 kV/cm
180cm length, 12 cm gap, B=380 G
in production, target date: end of Mai 2011
installation in πE3, ready for use: October 2011

Time scale High Field instrument:

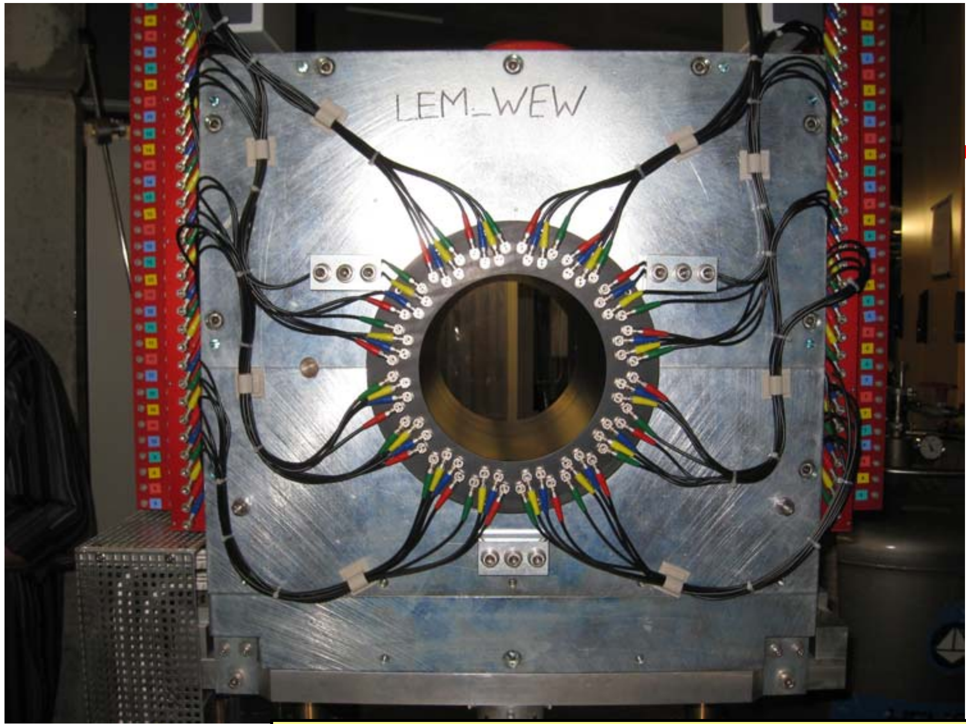
End 2011-Spring 2012: commissioning of instrument and beam line

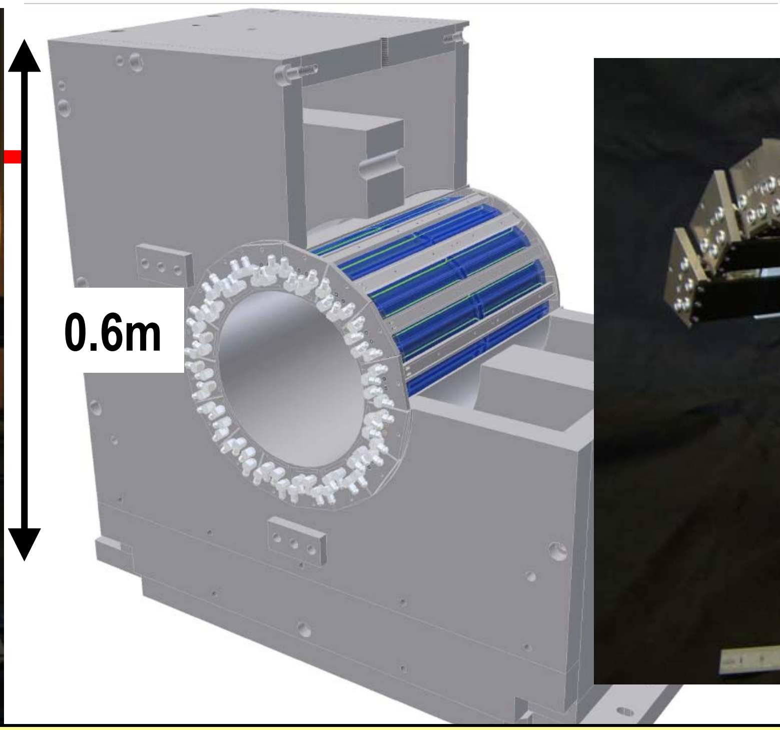
From Summer 2012: Expert user operation

LEM with Spin Rotator (from 2012)→ LF/TF

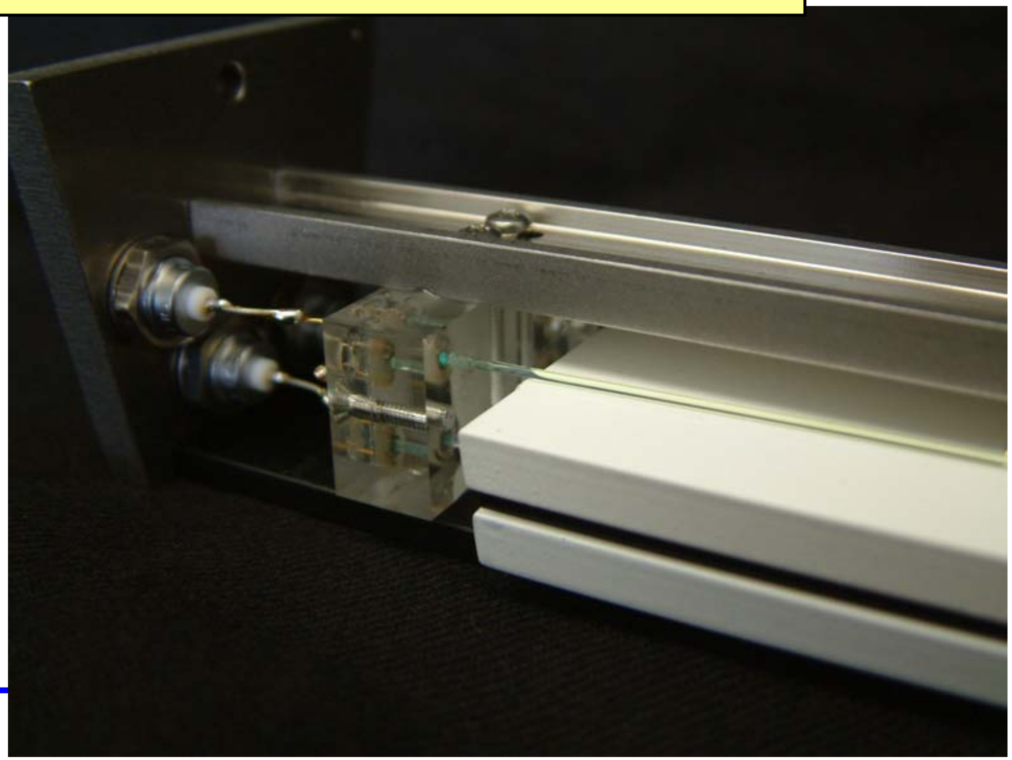


→Poster #31





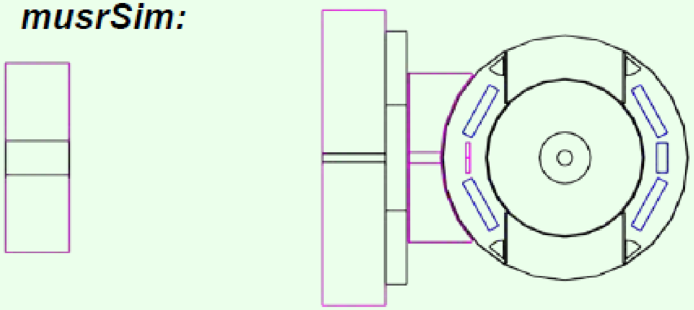
LEM: new positron spectrometer with APD readout

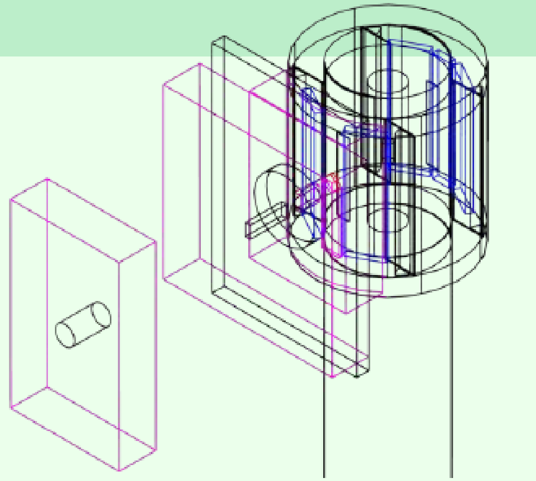


Software: Instrument simulation

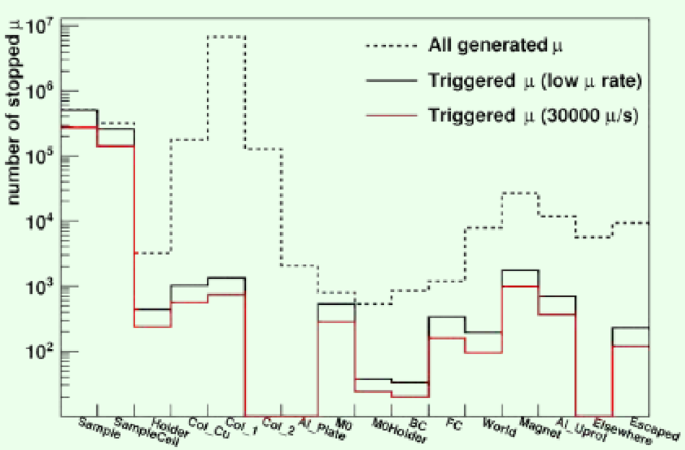
Example – GPD instrument at PSI

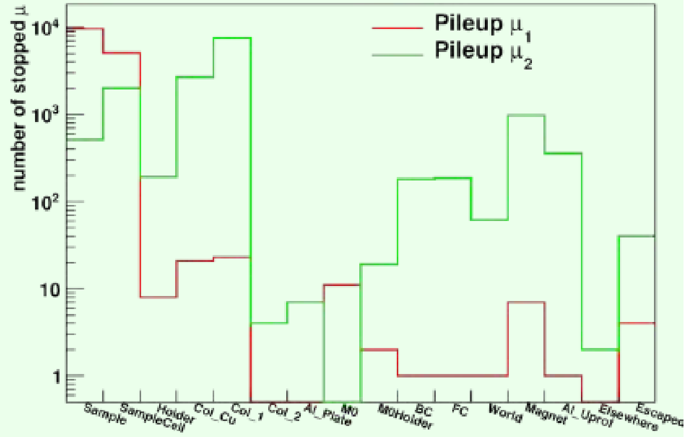
musrSim:





musrSimAna:





Left – illustration of where the muons stop and decay. Majority of them stops in collimators (dashed line), however only few of such events give rise to the signal in the M-counter (full lines), mainly due to the decay positron passing through the M.

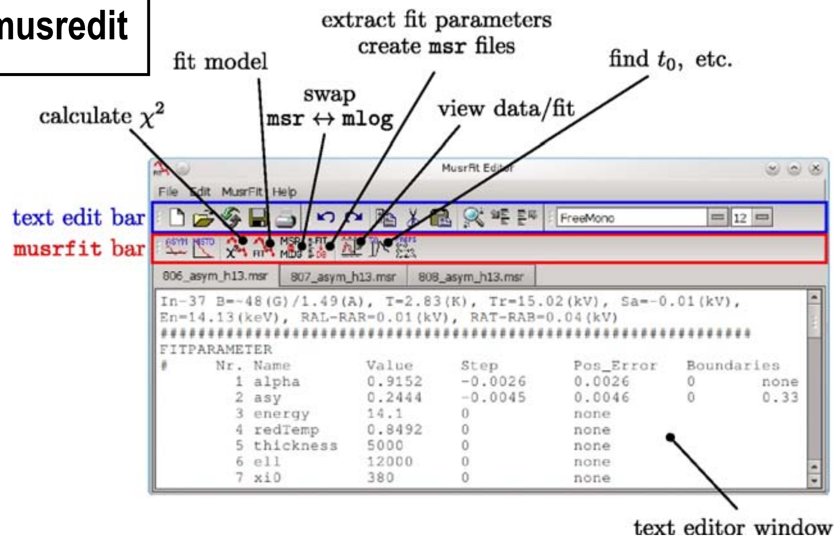
⟶Poster #67

musrfit – a free framework for μSR data analysis

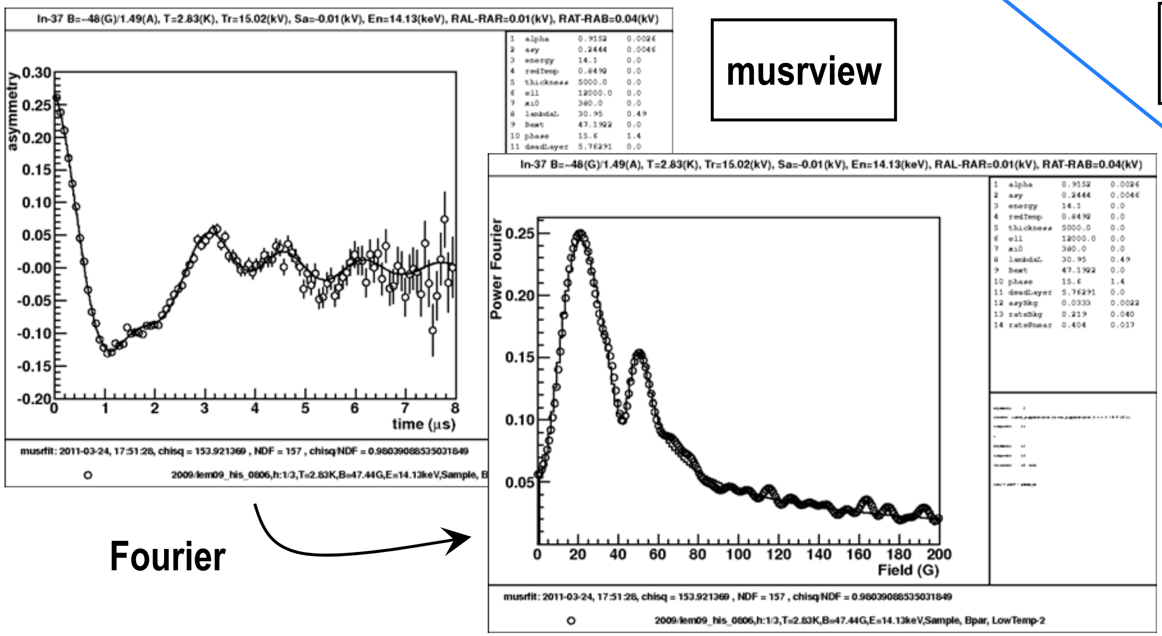
- CERN/ROOT – Minuit2 based
- controlled via ascii text file (similar but much more user friendly than msr-fit)
- platform independent (Linux, MacOS, „MS Windows“)
- free software (GPL/LPGL)
- reads PSI-BIN, PSI-ROOT, MUD, NeXus, …
- user-functions can be added via plug-in mechanism
- easy collection of fitting parameters
- online help available

⟶Poster #72

musredit

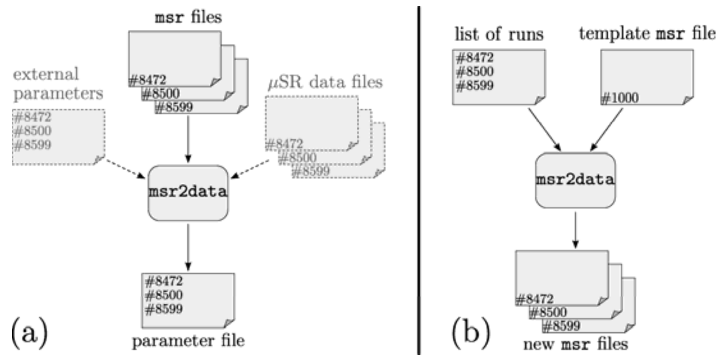


musrview

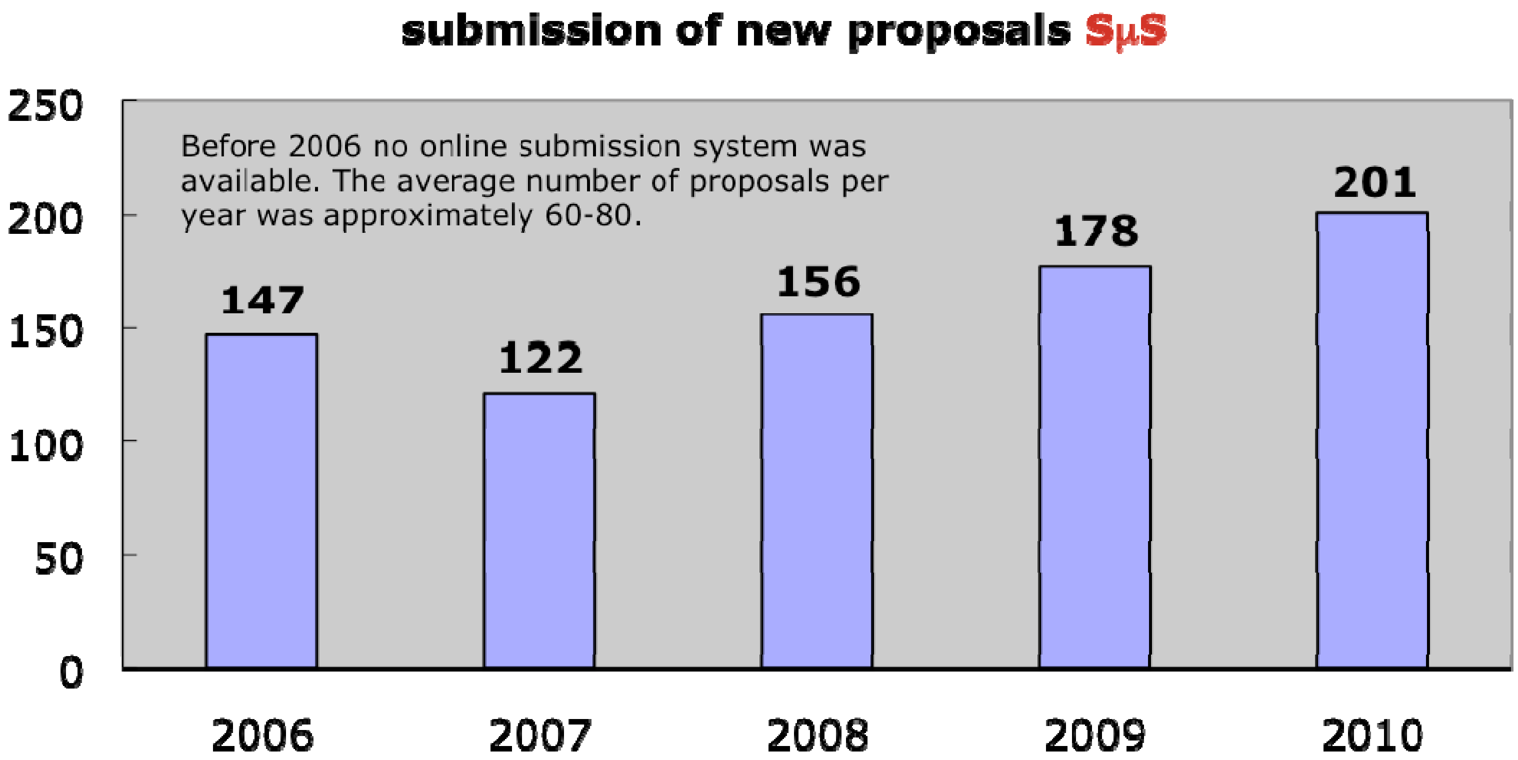


msr2data

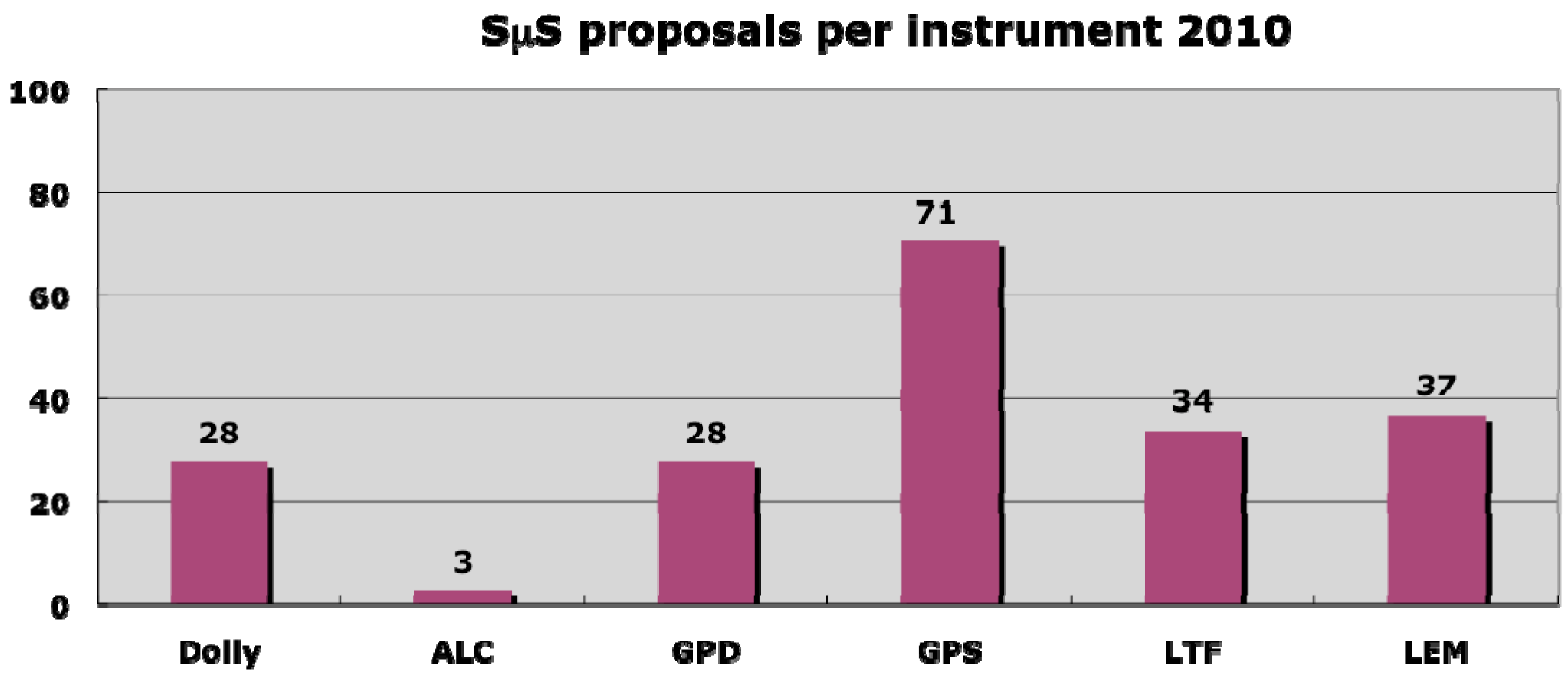
- msr-file input generation
- parameter file extractor
- generate global msr-fit-files
- adding external parameters to the fitting ones
- …



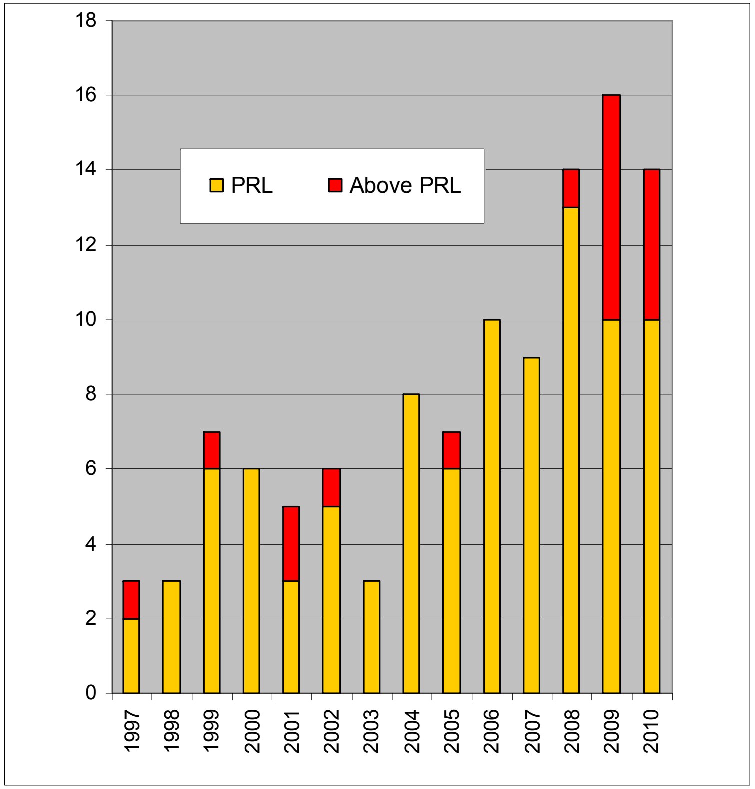
see: http://lmu.web.psi.ch/facilities/software.html



Proposal submission



SμS - Scientific publications in 2009 and 2010



1 Nature
3 Nature Materials
2 J. of the American Chemical Soc.
10 Physical Review Letters
2 Chemical Comm.
20 Physical Review B
….

109 Publications in total (μSR2008)

2 Nature Materials
1 J. of the American Chemical Soc.
1 Angew. Chemie
10 Physical Review Letters
30 Physical Review B
….

59 Publications in total