Paul Scherrer Institute: Swiss Muon Source SμS

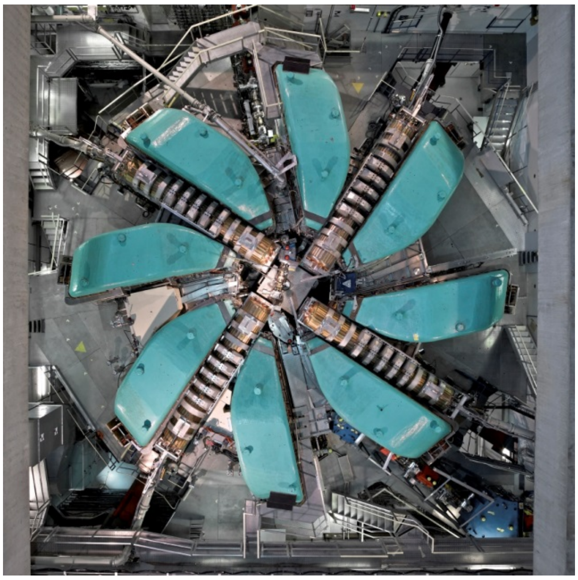
General Information: http://www.psi.ch/smus

SμS key numbers user operation 2013
User operations: started in **1989**

User Operation	2013
Visitors (badge requests)	289
Individual Users	170
Experimental days	633
Number of Experiments	219
New Proposals	233
Number of Publications (in total)	60
High Impact Publications (≥ 7.1 (PRL))	11

PSI proton accelerator HIPA:

590 MeV, 2200 μA ring cyclotron.



Muon Spin Spectroscopy (μSR) at SμS

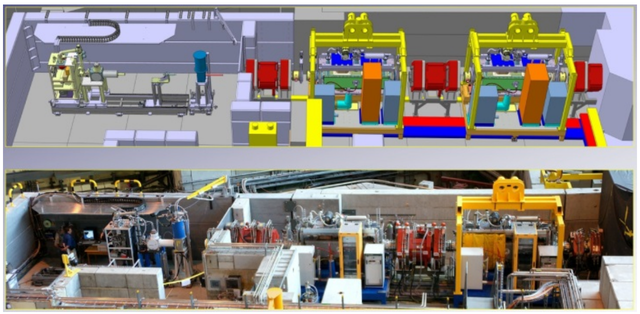
The Swiss Muon Source (SμS) – powered by the PSI 1.4 MW High Intensity Proton Accelerator (**HIPA**) is the world's most intense continuous beam muon source. The proton beam hits two graphite targets, before reaching the spallation neutron source SINQ. Attached to those are seven beam lines for muon (or pion) extraction, one of them is equipped with a superconducting decay channel. Of these ***5 beam lines*** are used for μSR activities.

SμS operates ***6 state-of-the-art μSR instruments*** covering a large range of experimental parameters as temperature (0.01K - 1200K), pressure (≤ 2.5GPa) or magnetic field (≤ 9.5T). The available muon energies range from 0.5 keV to 60 MeV.

The ***Low-Energy Muon Beam*** for the study of thin films, layers and surfaces, and the Extraction of ***Muons On Request*** for high frequency resolution and slow relaxation measurements are Worldwide unique facilities.

A new ***high-field instrument*** (HAL-9500) equipped with a 9.5 Tesla magnet and a dilution cryostat capable of reaching 0.02 K has been recently put in operation.

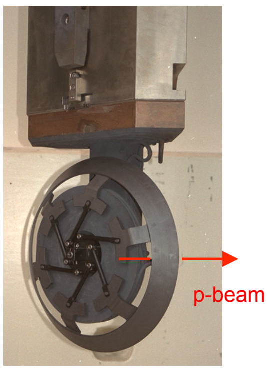
HAL-9500 instrument for high-field μSR



Target E

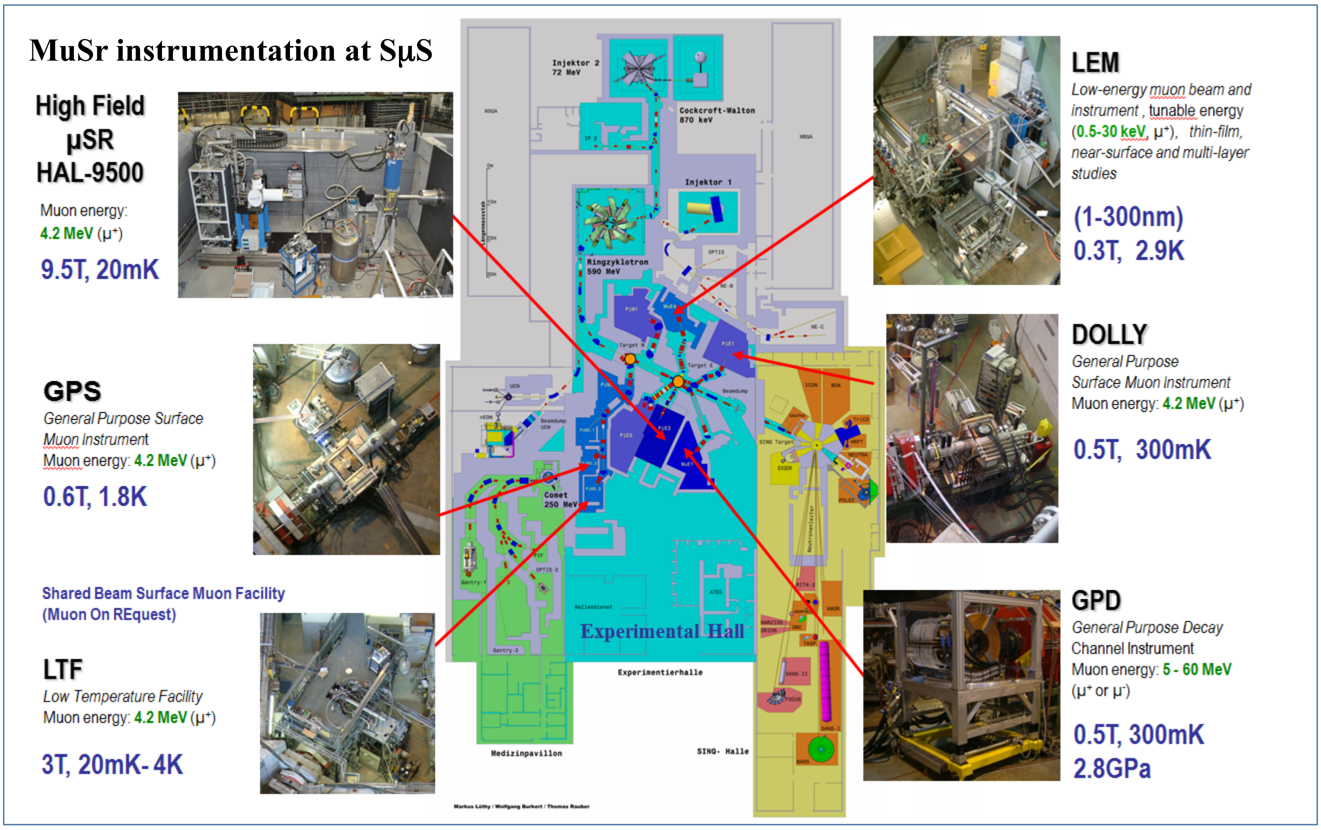
Rotating Graphite Muon target (4 cm) providing the Worlds most intense continuous surface Muon beams:

~5 10^8 μ^+/s

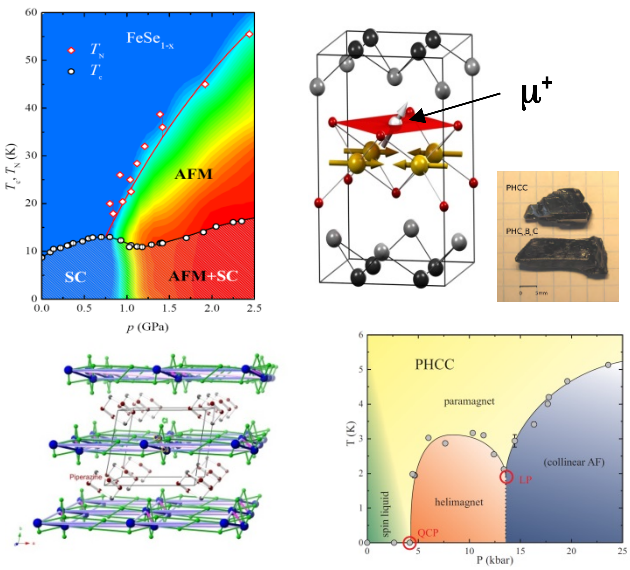


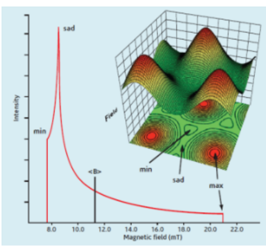
Swiss Muon Source SμS

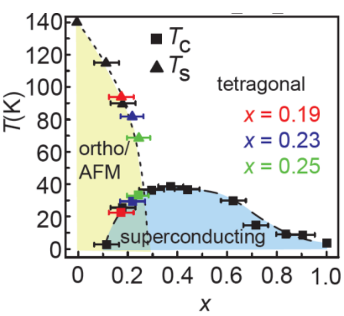
Current Activities



μSR is a very sensitive local magnetic probe and is applied to study a wide range of topics including condensed matter physics, materials and molecular sciences, chemistry and biology. SμS is being intensively used to study novel strongly correlated magnetic and superconducting systems (e.g. Fe based superconductors, cuprates and other oxides or layered materials), but also low dimensional, frustrated or organic magnetic materials. Material science studies range from materials for energy storage, through ionic conductors to semiconductors, where the muon mimics the behavior of a very important impurity such as hydrogen.





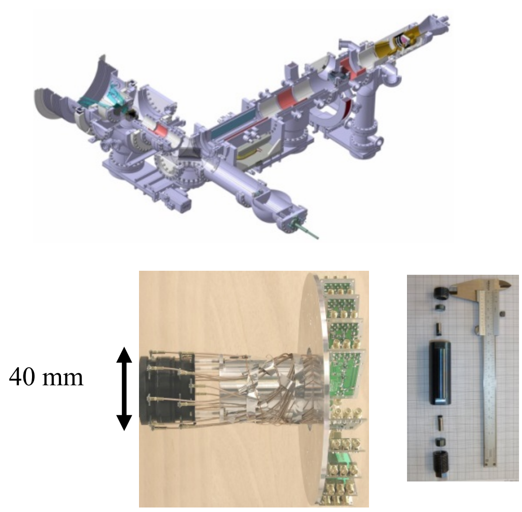


Example of MuSr studies: Microscopic investigations of the vortex state in unconventional superconductors. Mapping phase diagrams. Quantum magnetism in low dimensional systems.

Swiss Muon Source SμS

Developments and Future Perspectives

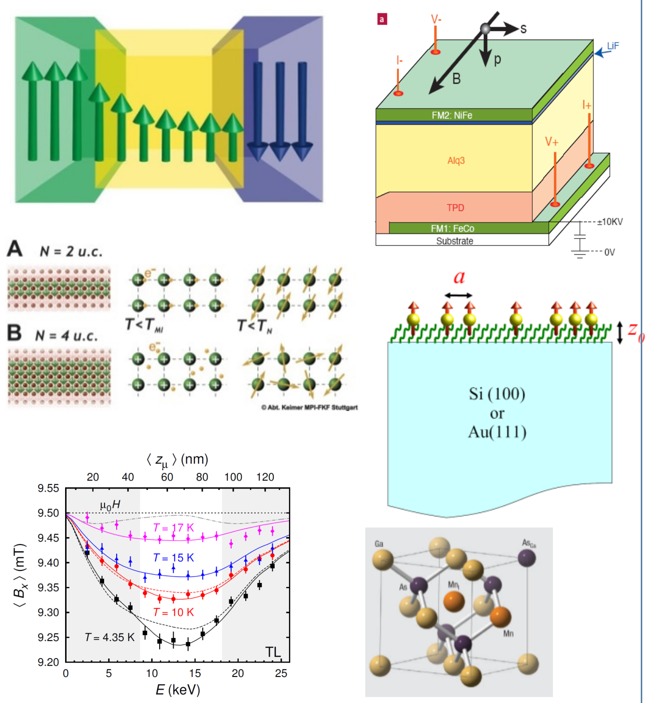
The SμS is presently the worldwide most advanced muon source. In order to defend this position, the Laboratory for Muon Spin Spectroscopy is constantly developing cutting-edge technologies to improve instrument performance and provide new research opportunities. For example the need for high pressures, coupled with extremely low temperatures, is covered by an ongoing development of two-walls pressure cells compatible with sub-Kelvin temperatures.
Similarly, the demand of high magnetic field has necessitated the in-house development of solid-state compact detectors based on avalanche photo diodes. Such high-performance detectors provide a step-like increase of performances with picoseconds time resolution. The LE-muon beam is being provided with various tools for external stimuli (photo illumination by laser, pulsed electric fields,..)



Example of recent developments: Low energy muon beam line. High performance compact spectrometer for μSR in high magnetic fields. Double wall pressure cells.

Studies aimed at further increase in the muon intensity, is ongoing – the goal is to develop the next generation muon beams such as a high intensity muon microbeam.

A unique asset of SμS is the **LE-μSR** instrument, where polarized muons of tunable energy between 0.5 and 30 keV can be implanted at variable depth between 1 and 200 nm. This allows to study depth dependent phenomena of thin films, heterostructures but also near surface studies of crystals. Recent results include studies of spin injection in organic spin valves, dimensional effects in nickelates or cuprate superlattices, and also on spintronics materials which can be grown only as thin films, such as the magnetic semiconductor (GaMn)As.



Example of **nanoscale studies** (from top to bottom): Spin injection in an organic spin valve. Dimensional control of electronic states. Dynamics of monolayers of molecular magnets. Proximity effects in cuprate heterostructures. Spintronics materials.

Contact and Proposal Deadlines

Laboratory for Muon Spin Spectroscopy
Prof Elvezio Morenzoni, elvezio.morenzoni@psi.ch
Proposals: http://www.psi.ch/useroffice/