# Developments in High Pressure Clamp Cells for Neutron Scattering at the MLZ

Andreas Eich[1,2], Karen Friese[1], Martin Meven[2,3], Micha Hölzle[1], Yixi Su[3], T. Müller[3], Vladimir Hutanu[4], Muni K. B. Poli[2], Robert Georgii[5], Lukas Beddrich[5], Andrzej Grzechnik[2]

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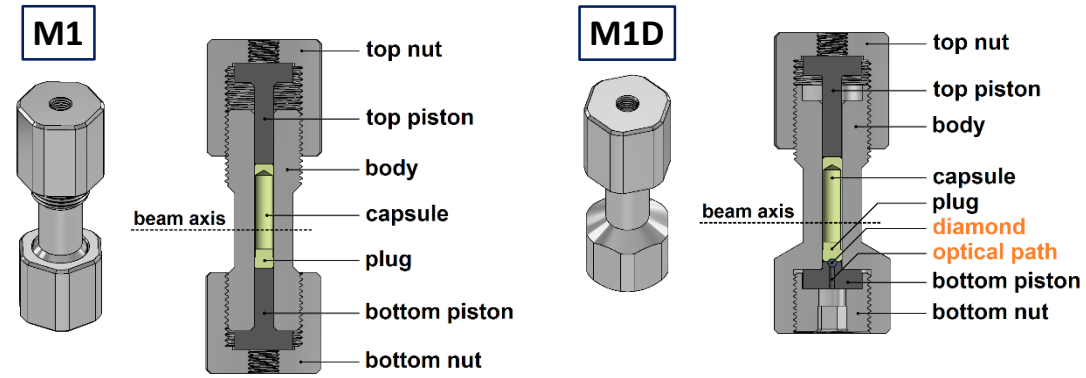
## Cell Designs and Specifications




| | $p_{max}$ | | | | |
|---|---|---|---|---|---|
| **type** | **CuBe** | **NiCrAl** | $l_{max}$ | $\varnothing_{max}$ | **sample space** |
| **M1** | 1.1 GPa @ 300 K | 1.5 GPa @ 300 K | 86 mm | 32 mm | ⌀4×L10 mm³ |
| **M1D** | | | 77.5 mm | 32 mm | ⌀4×L10 mm³ |

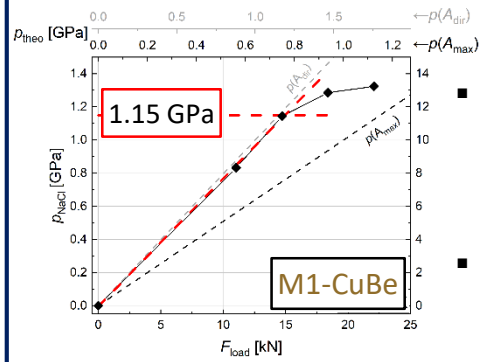
The cells are specifically developed to fit into the existing closed-cycle cryostats and high-field magnets on the following beamlines at **Heinz Maier-Leibnitz Zentrum**:

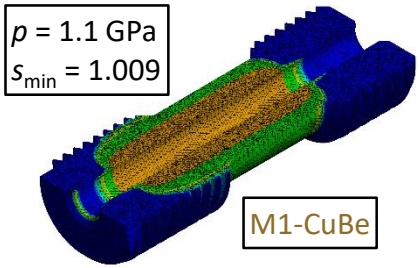
- **DNS**: a diffuse scattering neutron time-of-flight spectrometer
- **MIRA**: a cold three-axes spectrometer with polarization analysis
- **POLI**: a double focusing polarized hot neutron diffractometer

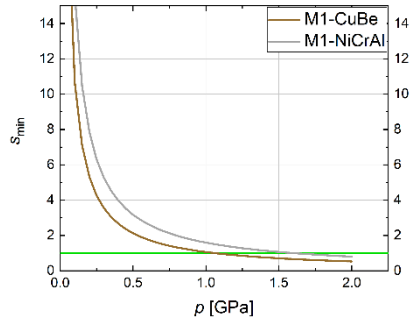
As the pressure is applied and fixed („clamped“) *ex situ*, the clamp cells can be used independently in various setups.

Ultimately, these cells are intended for high-pressure experiments at ultra-low temperatures and in combination with applied high magnetic fields.

## Pressure Limit and Calibration




- The pressure inside the cell is determined by the change in lattice parameter of a single crystal of NaCl.
- The load is applied with a standard laboratory hydraulic press.
- A 1:1 FC770–FC75 Fluorinert mixture was used as pressure-transmitting medium.
- The simulation shows that plastic deformation of the M1-CuBe cell sets in at 1.1 GPa, where the safety factor *s* goes below 1.
- For the M1-NiCrAl, the simulation yields a pressure limit of about 1.5 GPa.

BMBF Grant 05K19PA2

DFG Grant GE9711/5-2

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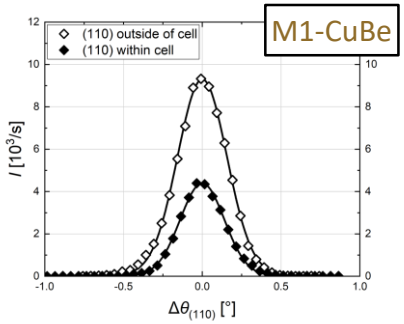
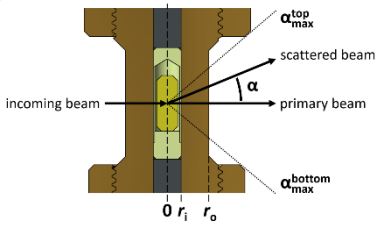
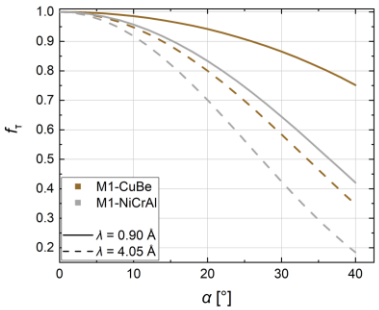
## Neutron Transmission and Transmission Loss Correction

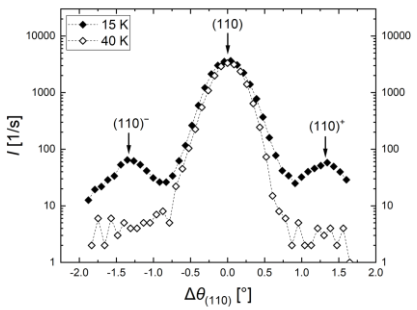


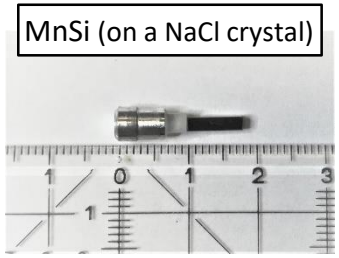




- The experimental neutron transmission for the M1-CuBe was determined by the maximum neutron count ratio of a MnSi Bragg reflection to 47(1)% at $\lambda$ = 4.05 Å.
- To account for the angular dependence of the neutron transmission loss in the cell, a simple geometrical model can be used to calculate a correction factor for the intensity.

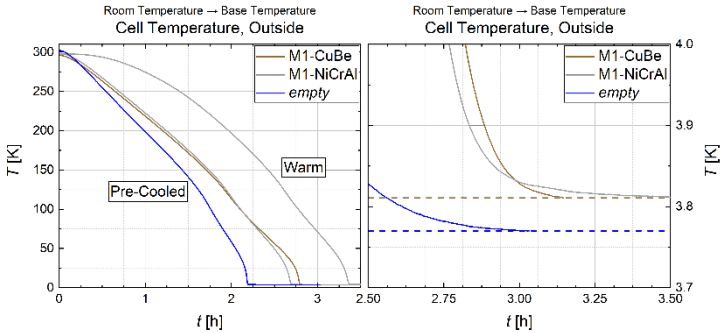
## Magnetic Reflections



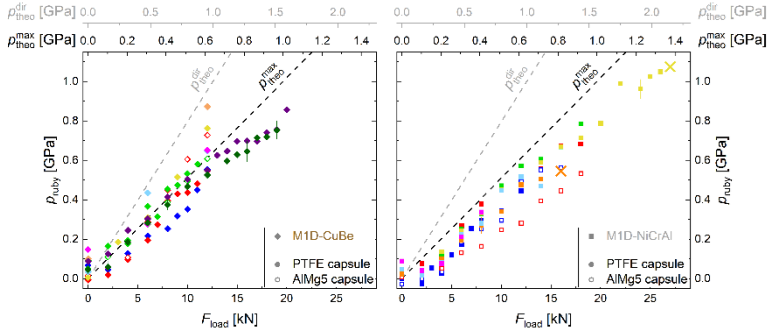

- MnSi was used to tests the suitability of the M1-CuBe for the measurement of magnetic reflections.
- MnSi has a small ordered moment (0.4 $\mu_B$/Mn) and large helix pitch (180 Å), yet satellites are clearly visible.

## Thermal Response

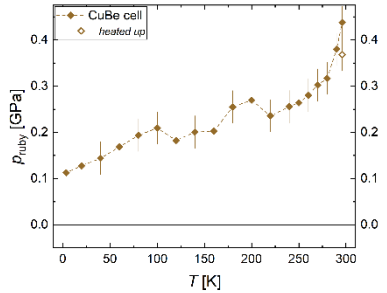



- With the cryostat pre-cooled, the cell increases the cooling time by approximately 30 min.
- The base temperature is not significantly affected.

## Ruby Luminescence Option: Load/Pressure Calibration and Pressure Drop




- To assess the reproducibility of the cell loading, multiple tests with both M1D variants and two capsule materials (PTFE, AlMg5) are performed.




- The pressure drop at low temperatures is determined by cooling down a cell loaded to 0.45 GPa.

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