EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH
Proposal to the ISOLDE and Neutron Time-of-Flight Committee

Development of new rare-earth-free hard magnetic materials

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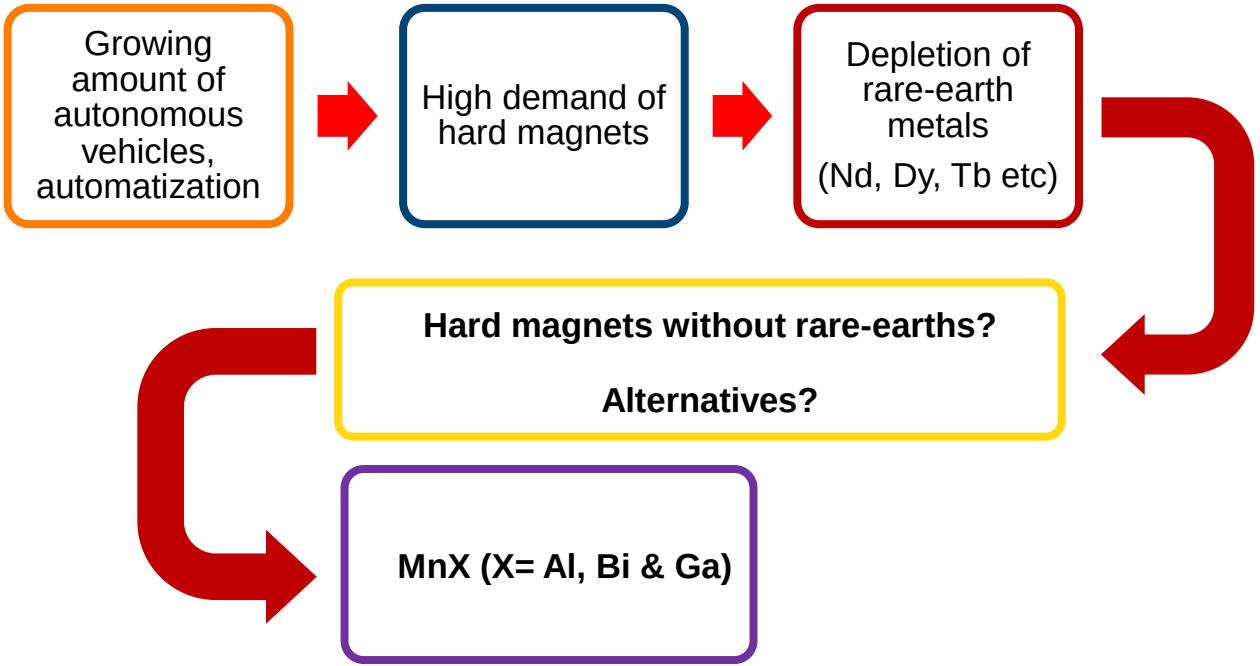
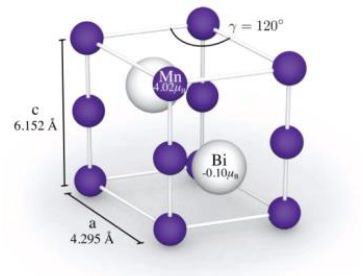
New hard magnets?



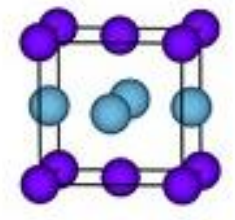
Candidates



hex.- MnBi

Not a single phase

- Segregation of Mn?
- Doping theoretically may lead to high magnetization

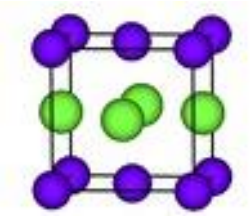


$L1_0$- MnAl

Metastable

- Where is surplus of Mn? Which site?
- Doping? Deteriorates magnetic properties!
- Fe-doped is stable, what about dilute concentrations?

Candidates



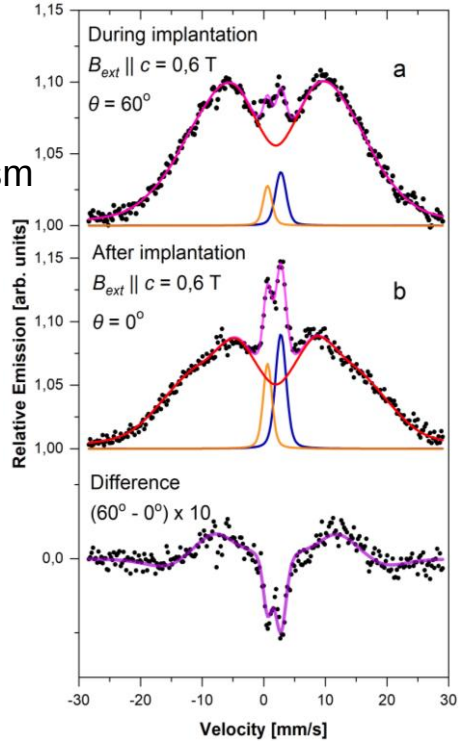
$L1_0$- MnGa

- Reveal the interplay between structure/strain and magnetism
- Origin of the unexpected large hyperfine field at Ga sites

Expected: negligible hyperfine fields with In at Ga sites

Observed: huge hyperfine fields with ^{119}In

LS2 did not allow to finalize the studies



In/Sn measured at angles of 60 and 0 under 0.6T during (a) and after (b) implantation.

Feasibility

WHAT?

MnAl, **MnBi** & **MnGa** by electron beam and magnetron sputtering

[**TU Ilmenau**]

Implantation depth [TRIM est. at 40 keV]:

- **19/13 nm** [^{57}Mn/ ^{119}In] into **MnAl**
- **22/16 nm** [^{57}Mn/ ^{119}In] into **MnBi**
- **15/10 nm** [^{57}Mn/ ^{119}In] into **MnGa**

HOW?

As a function of

- Sample **stoichiometry**
  - Mn_xAl [x=49-60]
  - Mn_xBi [x=49-60]
  - Mn_xGa [x=0.7-1.9]
- Annealing and measuring **temperature**
- **Magnetic field**

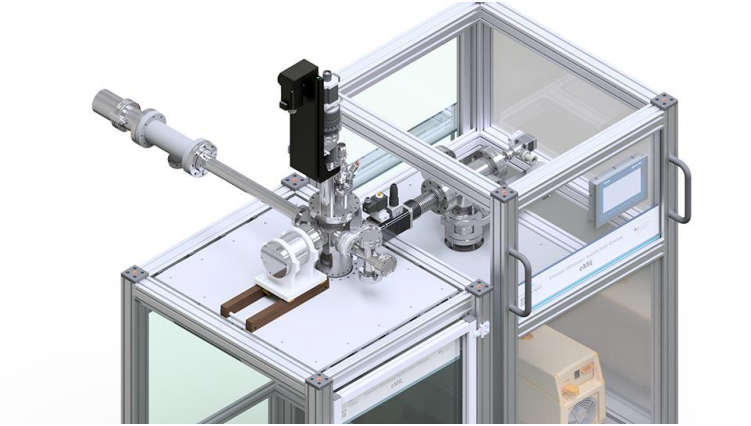
[**ISOLDE/CERN**]

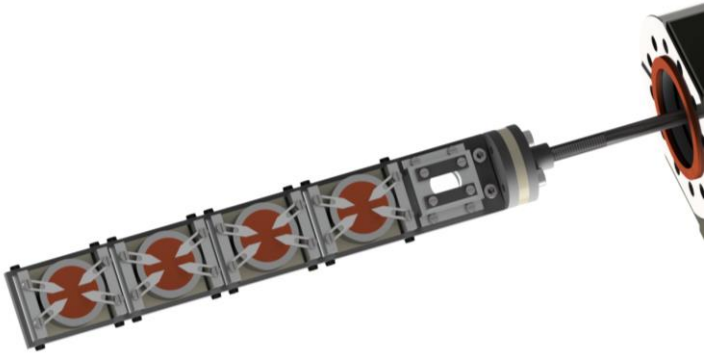
Feasibility

Emission Mössbauer spectroscopy

- Probe-host & probe-defect interaction
  - Valence, site symmetry, magnetic interactions, diffusion, spin relaxation, binding properties
- Dilute concentration (~10^{-4} at.%)
- Short spectra collection time

eMIL



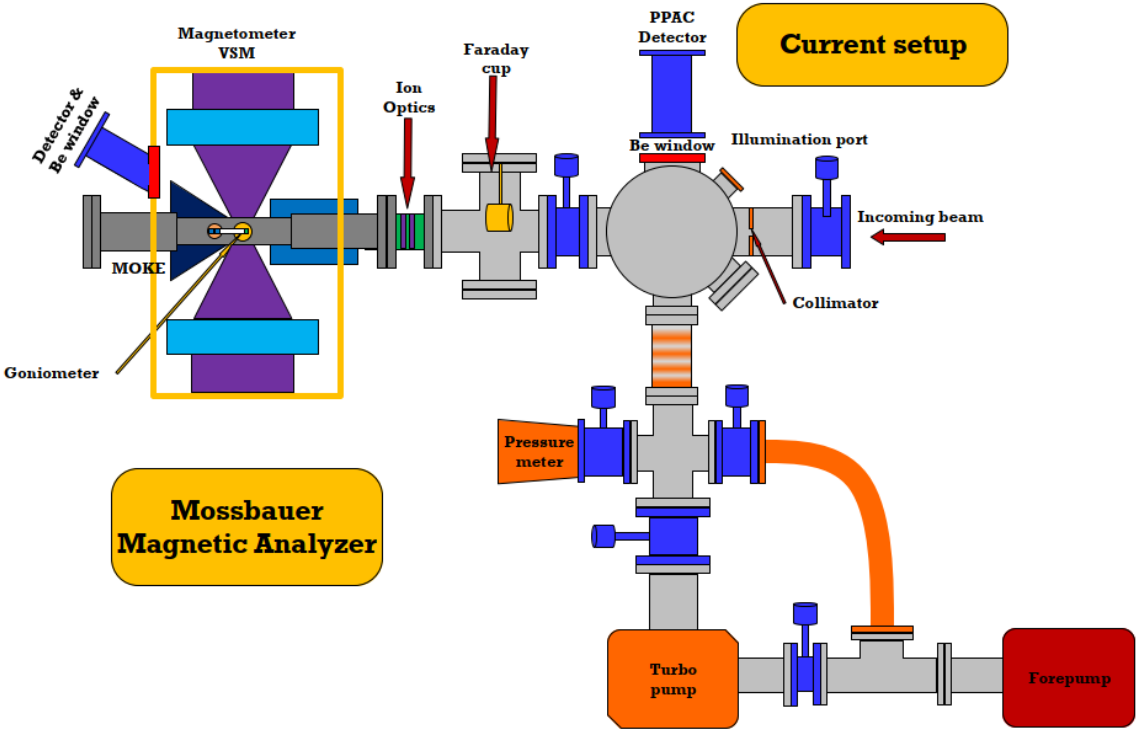


- Annealing up to 1100 K
- Time-delayed measurements
- Angular dependence
- Solid Base for future modifications
- Cryogenic measurements

Zyabkin *et al*. Nucl. Instrum. Methods Phys. Res A.968 (2020)

eMIL + eMMA

- Magnetic field up 2.2 T
- Off/On-line usage
- Heating & possible cooling



- Promising platform for investigation of magnetic materials

BEAM TIME REQUEST

Isotope	Minimum intensity	Beam energy	Shifts	Target	Ion source
^{57}Mn (1.5min)	(1-3) x 10^8	≥ 40 keV	**10**	UC_x	Mn RILIS
^{119}In (2.1min)	(2-3) x 10^8	≥ 40 keV	**5**	UC_x	In RILIS

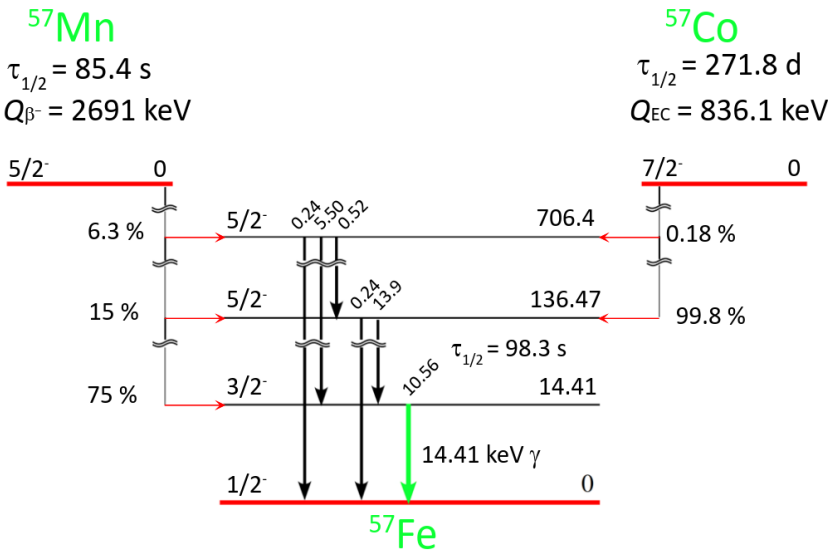
FUNDING INVOLVED

BMBF
Bundesministerium für Bildung und Forschung

Erforschung kondensierter Materie mit Großgeräten
Ausbau und Unterhalt der Einrichtungen an ISOLDE/CERN
Germany, contract: 5K19SI1

Thank you for your attention!

$^{57}Mn/^{57}Fe$


57Mn
τ1/2 = 85.4 s
Qβ- = 2691 keV
57Co
τ1/2 = 271.8 d
QEC = 836.1 keV
5/2- 0
7/2- 0
6.3 %
5/2- 0.24 5.50 0.52 706.4
0.18 %
15 %
5/2- 0.24 13.9 136.47
99.8 %
τ1/2 = 98.3 s
75 %
3/2- 10.56 14.41
14.41 keV γ
1/2- 0
57Fe