PAUL SCHERRER INSTITUT PSI

Wir schaffen Wissen – heute für morgen

Possible unmagnetisable materials to modify the sample area

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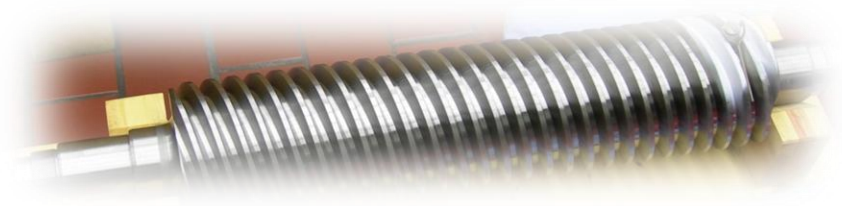
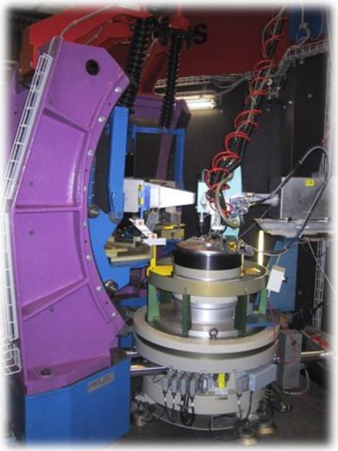
Overview



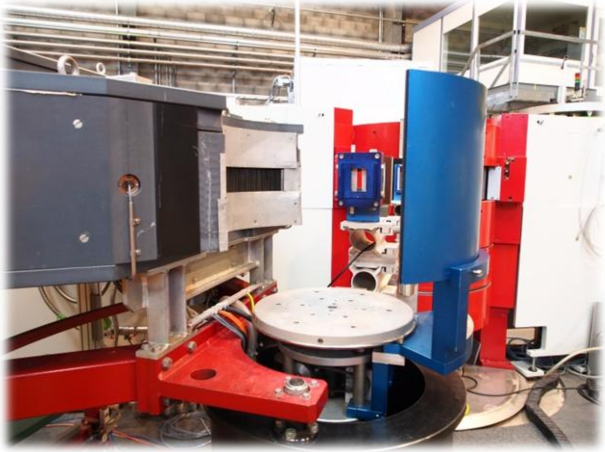
Introduction

PSI has neutron instruments which were built during different time-decades. The first day SINQ-equipment were done in the early ninety and some older units were moved from the old reactor Saphir (PSI) and from Risø (DK).

Focus built 1996



Trics built 1996

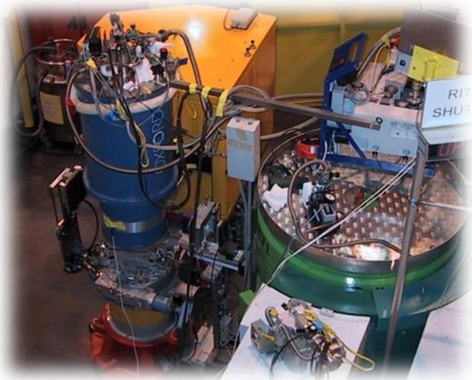


DMC built 1983 for Saphir reactor
moved to SINQ 1996

SANS-II built from Risø
moved to SINQ 2002

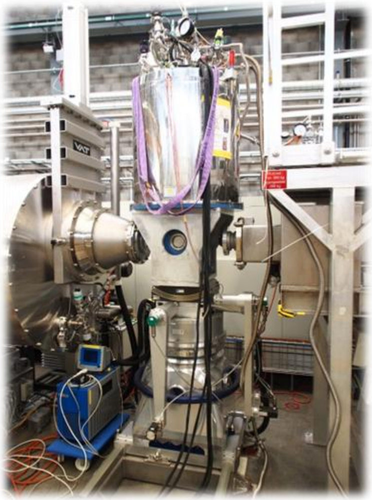
Introduction

High magnetic fields used on the sample tables increased a lot, since then.

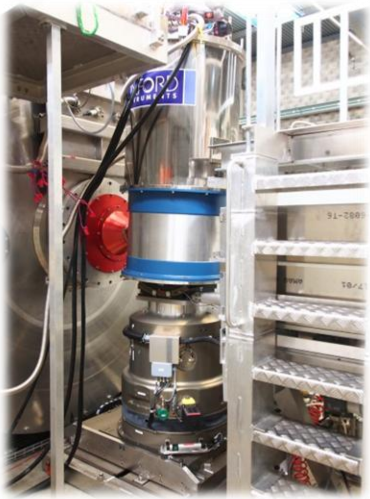


Rita-II

This means we are in a process of modifying these old equipment to more unmagnetisable, since several years.



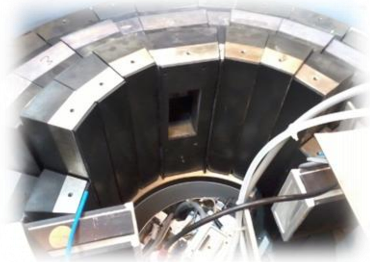
SANS-II



SANS-I

Critical Components

The critical components by use close to magnetic fields are the following mechanical and electro-mechanical items:


individual machine items


shieldings


screws


bolts


gears


housings & flanges


bearings

pneumatics


spindles


guidings


encoders

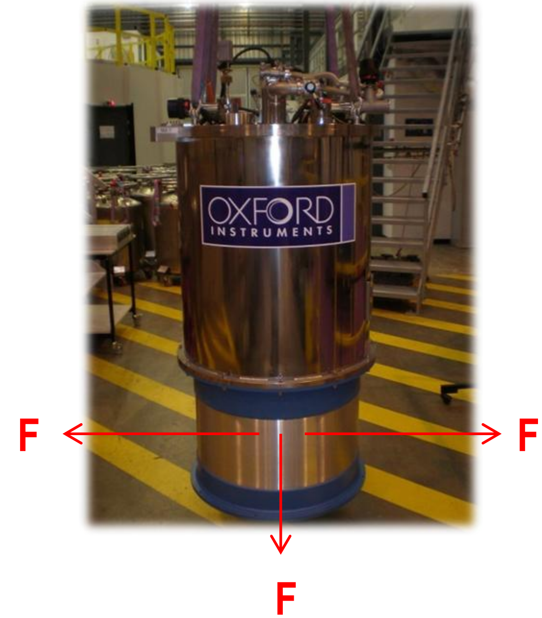

motors

Critical Components

The influences of the magnetic field are:

-Force from the magnet to the sample table items

F = usually limited in area of 500 – 1000 N



-Risk of quenching the magnet

overheating of super conductor
because of coil touch wall

Critical Components

By using our 14.9 T vertical magnet we will reach the following fields

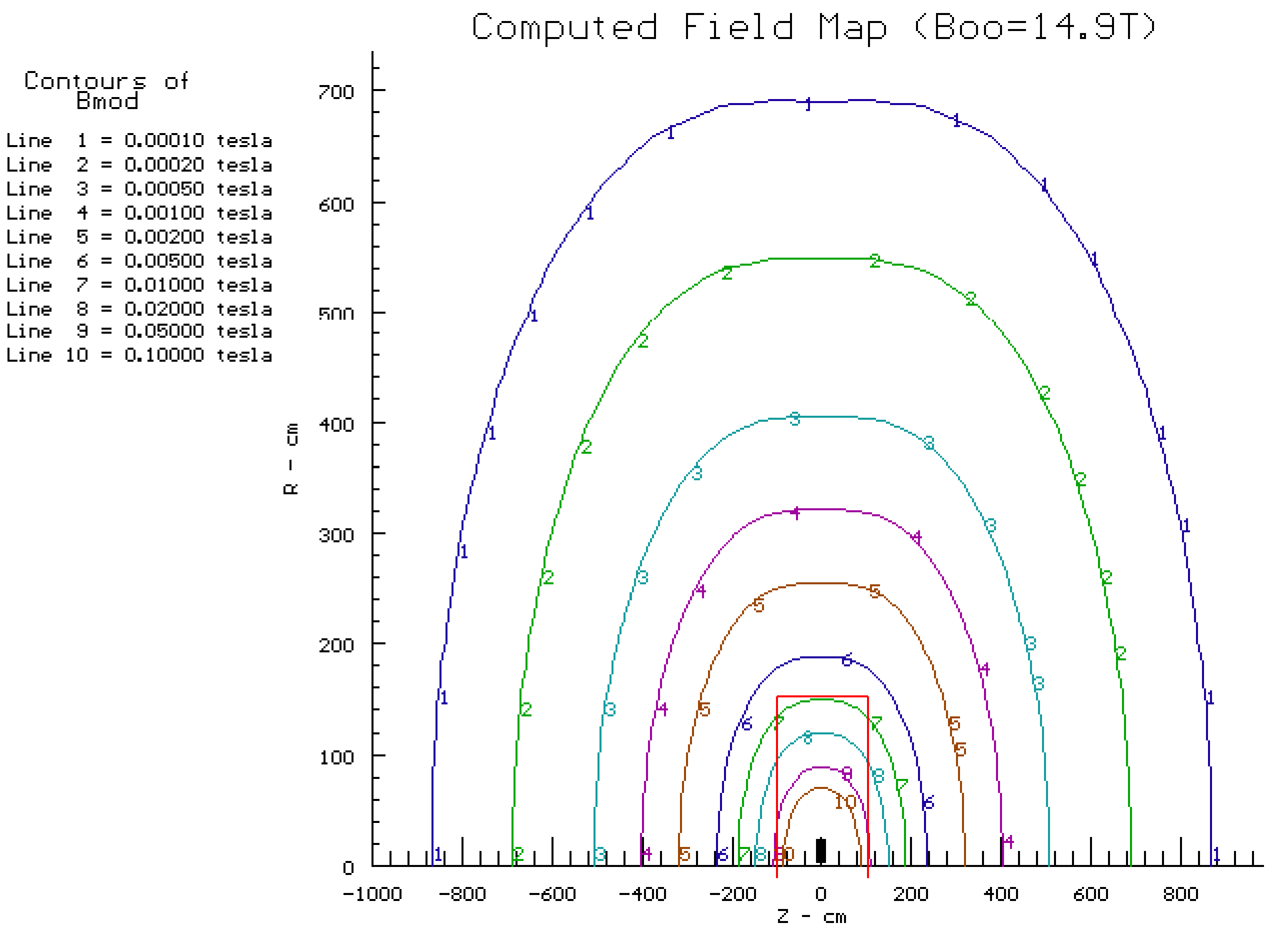


Figure from Oxford Instruments

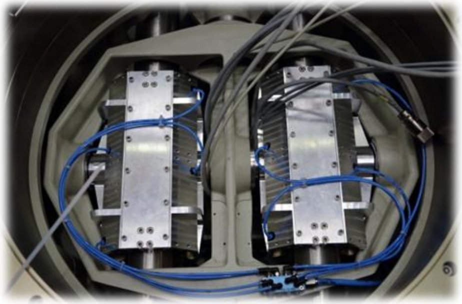
at a distance of ~1.5 - 2m from the magnet centre the influence of magnetisable items are negligible

Standard Materials

Because of optimized costs and simple handling old instrument parts are often made of carbon steel.

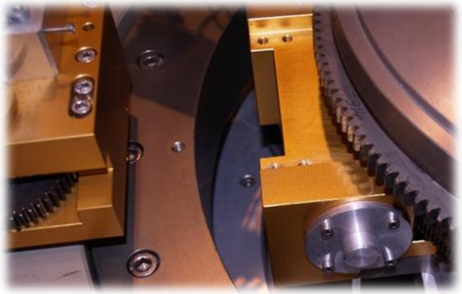
Easy replacements materials are usually:

-Stainless steel



clamping system (A2 – sample position

-Aluminium



gearbox casings

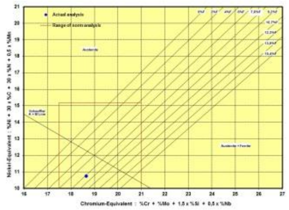
-others: brazen, …

Standard Materials

Stainless Steel

-"Low permeability" (depending on quality batch)

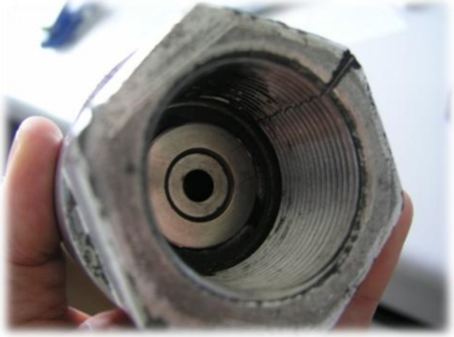
minimal permeability numbers ~1.05 – 1.1



-On some steels the permeability increase after welding

-Soft surface

-By friction use risk of sticking (cold shut)



Standard Materials

Aluminium

-Very low permeability (depends on contamination)

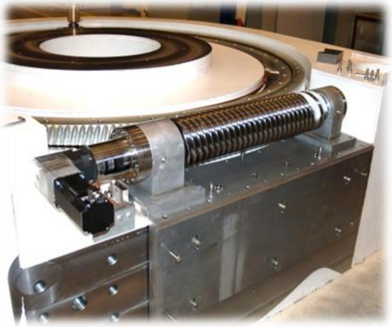
-Easy to machine

-Very soft surface

Hard Materials

Many of the individual machine parts need hard surfaces!

- -gears



- -guiding

- -bearings

- -spindles

- -bolts

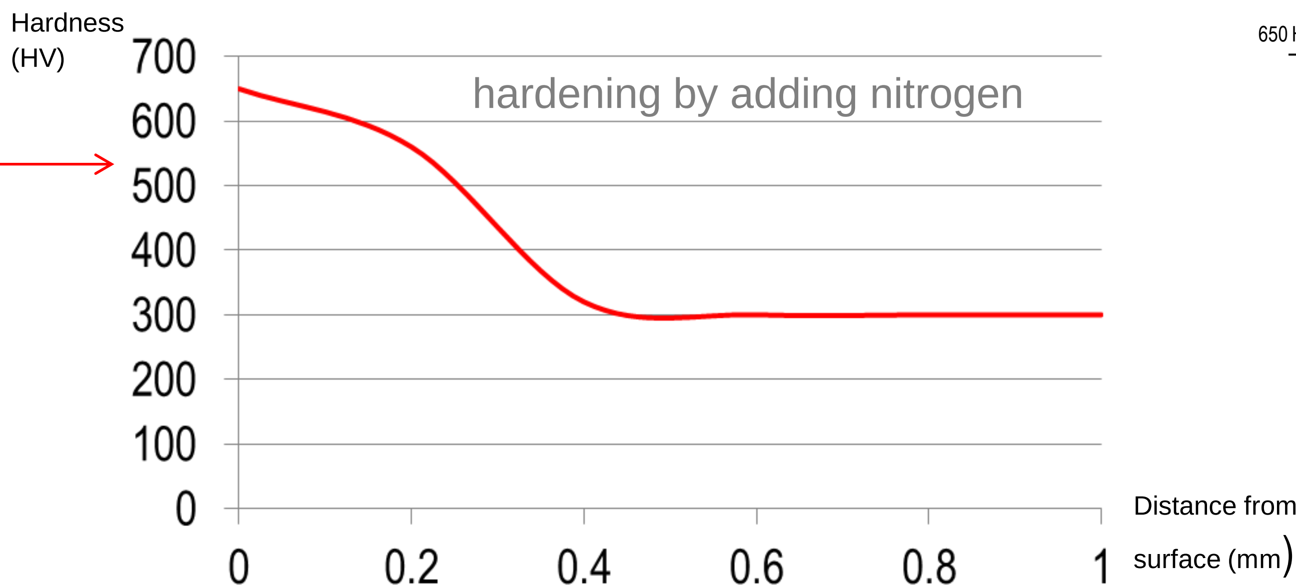
Over a period of several years we modified plenty of such systems with unmagnetisable materials.

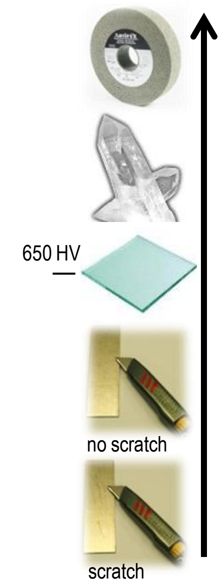
During these processes we got in touch with a few different hard surface materials.

Stainless steel

Hardened stainless steels with ferrite microstructure are available.

Hardness of manganese (also dental enamel, just to scratch by a knife)





Advantages:

- harder surface
- harder core
- hard layer thickness 0.1 – 1mm
- machining possible (grinding, ..)

Disadvantages:

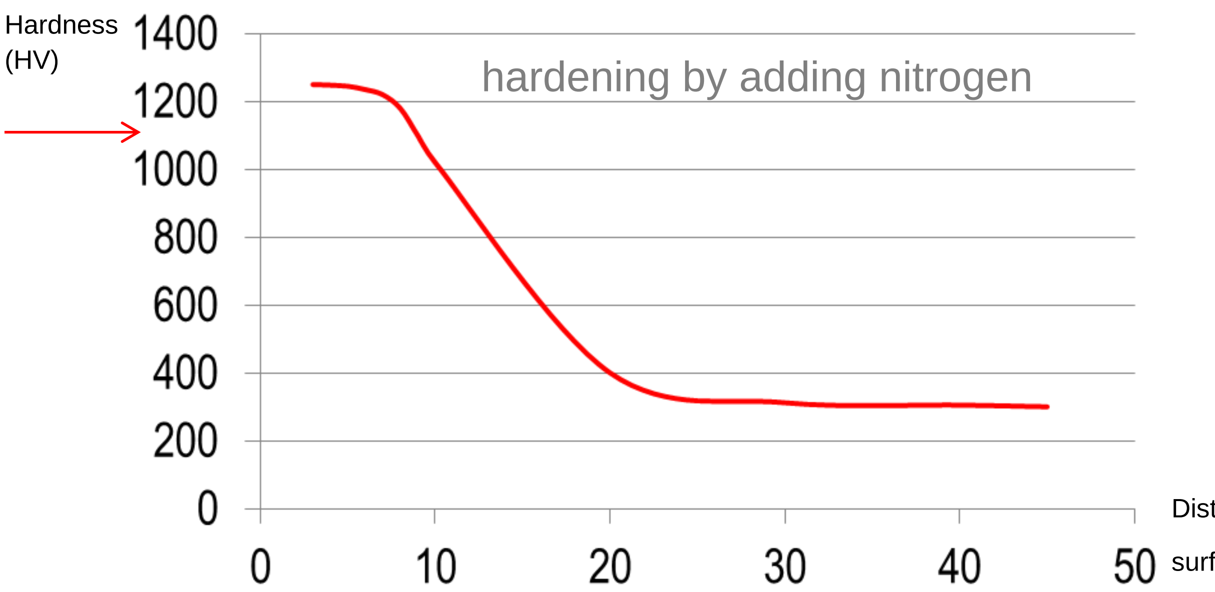
-change of magnetically properties

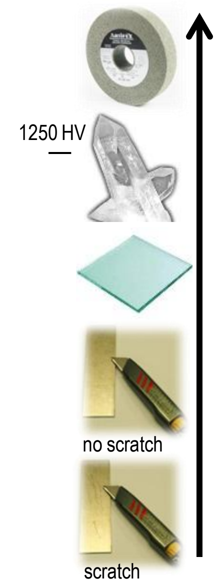
-dimensional changes

Hard Materials

Surface hardening of austenite microstructure are possible.

Hardness of quartz (possible to scratch a glass with)





Advantages:

- very hard surface
- no change of magnetically properties
- marginal dimensional changes

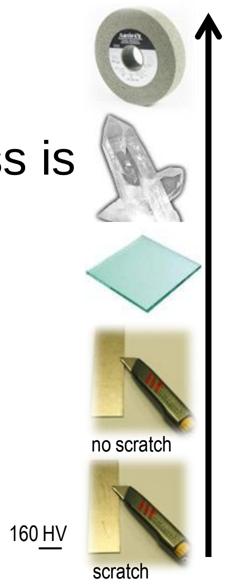
Disadvantages:

-layer thickness only 0.01 – 0.02mm

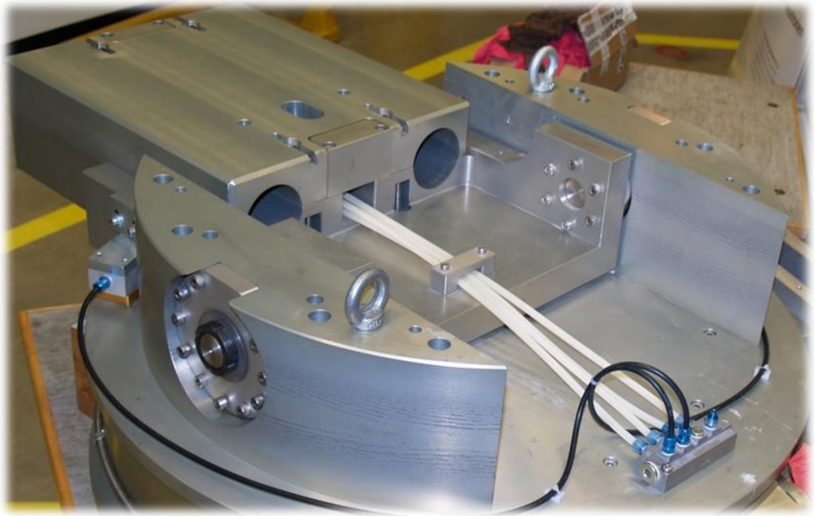
-no more machining possible

Aluminium

Hardened aluminium increase the tensile strength. But the surface hardness is to soft.



Alloy 7075
-tensile strength up to 540N/mm^2 (standard aluminium has 170N/mm^2)
-surface hardness up to 160 HV (easy to scratch by a knife)
(standard aluminium has 40HV)
-alloy contains copper (radiation)

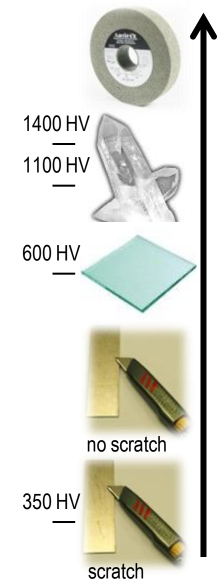


Alloy 7075
AlZn5.5MgCu

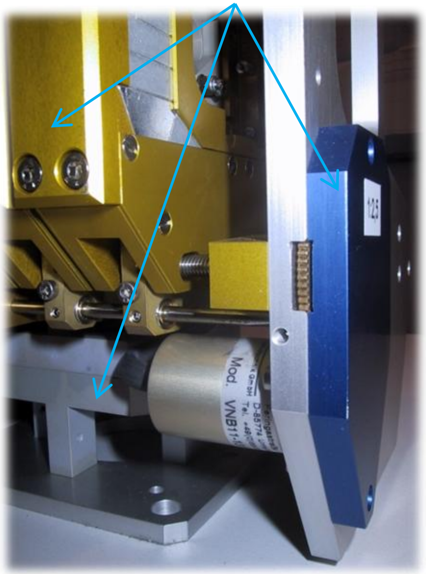
Hard Materials

Alternative there are different coatings possible. The most famous is **anodisation** (surface-oxidation) 350 HV.

Others are:
-ematal (oxidation with titanium adding) ~ 1100 HV
-hardematal (oxidation with titan adding) ~ 1400 HV
-hardanodisation (surface-oxidation) ~ 600 HV
-hard chromium plating (galvanic) ~ 1100 HV

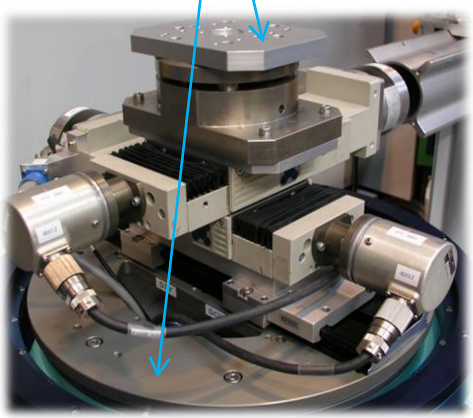


anodisation

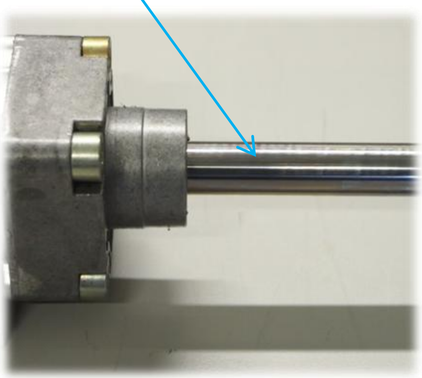


hardanodisation

hardematal



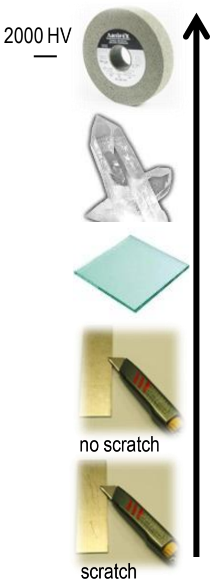
hard chromium plating



Hard Materials

Sintered tungsten carbide

-very hard up to 2000 HV
-pressed green body simple to machine (before sintering)
-after sintering volume-shrinking of several %
-after sintering grindable
-90 – 94% tungsten carbide (rest cobalt or nickel)




rail system items

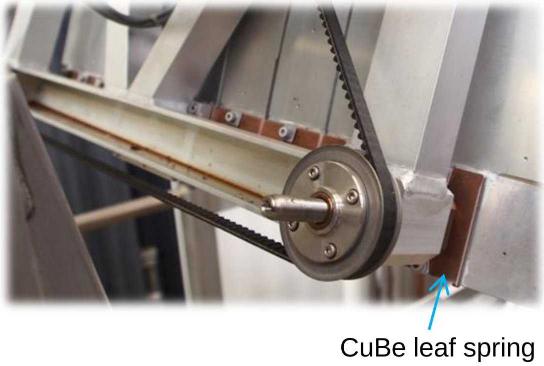

worm shaft

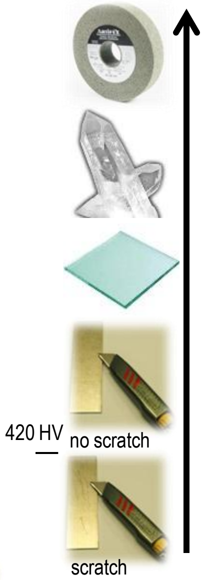

ball socket

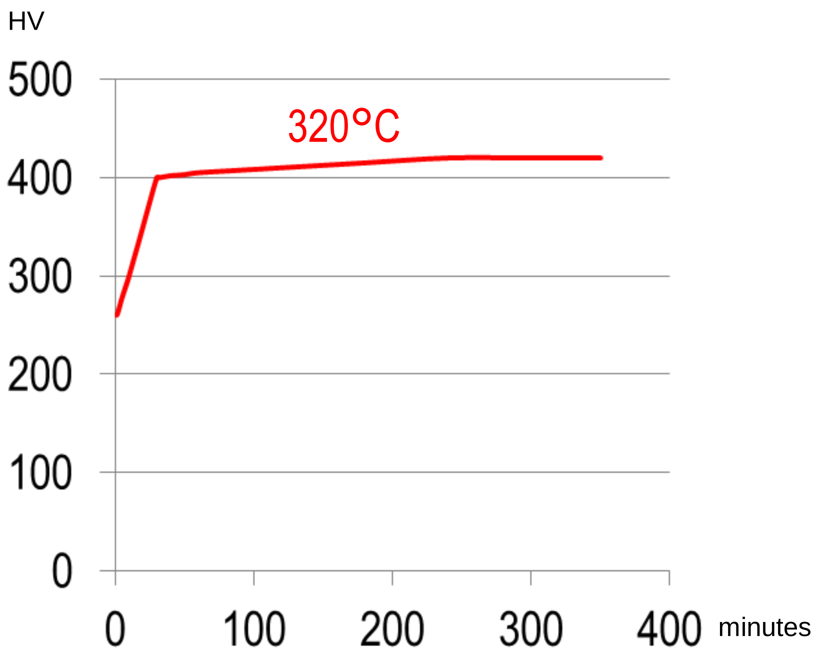
Hard Materials

CuBe

- -In soft state simple to machine
- -easy hardening (~2 hours by 320°C)
- -hardness up to 420 HV
- -contains copper (radiation)
- -contains 2% Beryllium (safety regulations)



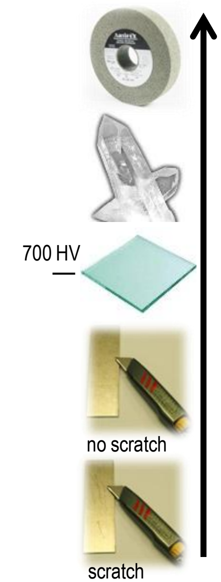




Hard Materials

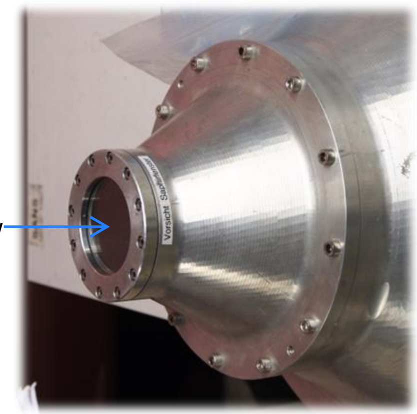
Glass

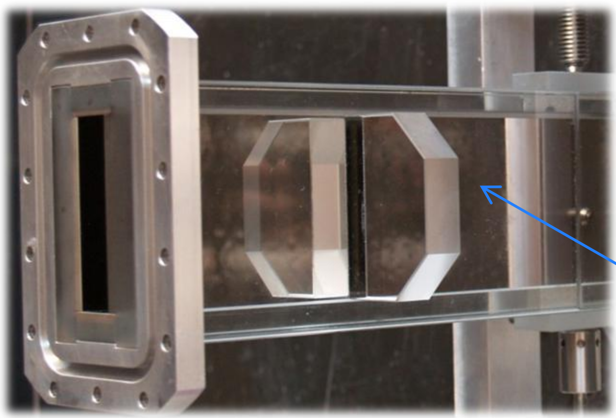
Their are glasses available with plenty of different properties beside the unmagnetisable idea. Till now, we used the following:



- -Boronsilicate, 7 – 13% B_2O_3
  (neutron shielding and temperatures up to 500°C)
- -Lead glass, ~24% PbO (x-ray shielding)
- -Soda-lime glass, (standard-glass, house-windows, ..), 600 – 700 HV
- -Quartz glass, SiO_2 (neutron windows)
- -Sapphire glass, Al_2O_3 (neutron window and filter)
- -Glass ceramic Zerodur, lithium-aluminium-silicon oxide (0±0.02ppm/K)

sapphire window



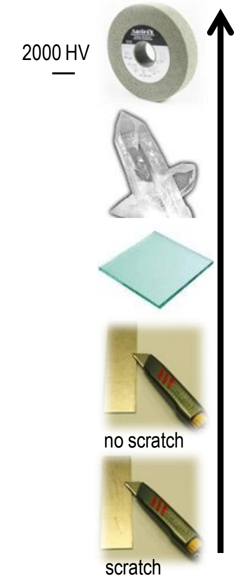


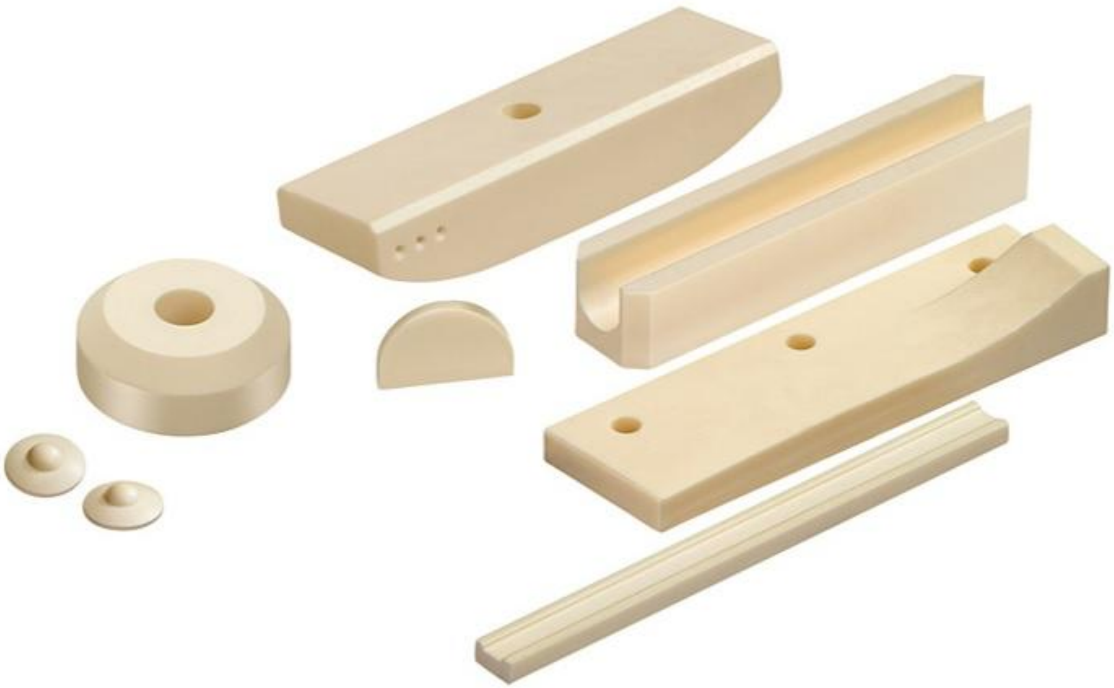
Borosilicate glass
neutron guide MARS

Hard Materials

Aluminium oxide ceramic

-very hard up to 2000 HV
-pressed green body possible to machine (before sintering)
-after sintering volume-shrinking
-after sintering grind able
-maximal temperature 1700°C





Hard Materials

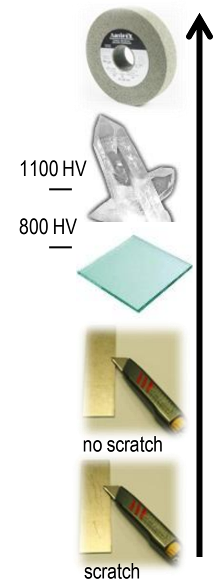
Zircon oxide ceramic (ZrO_2)

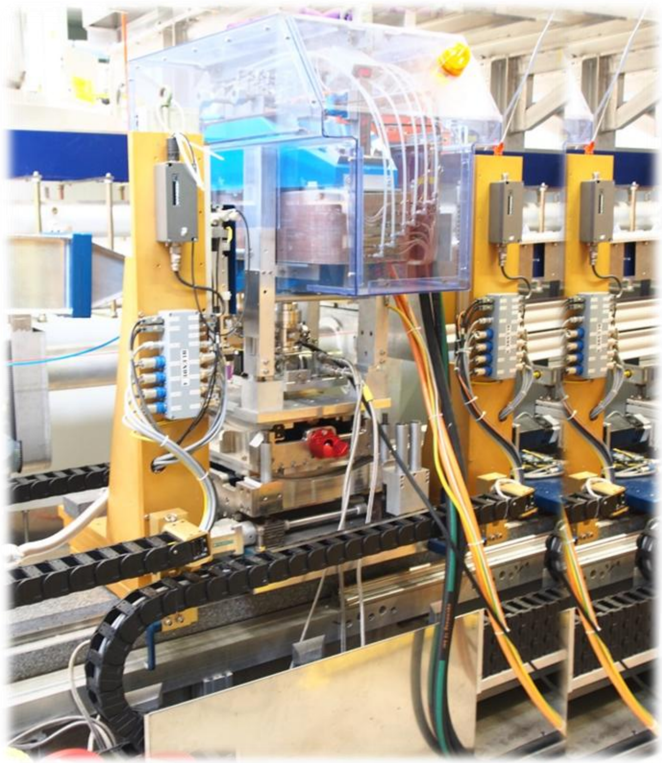
-hardness up to 1150 HV
-very high bending strength
-pressed green body possible to machine (before sintering)
-after sintering volume-shrinking
-after sintering grindable
-maximal temperature 1000°C

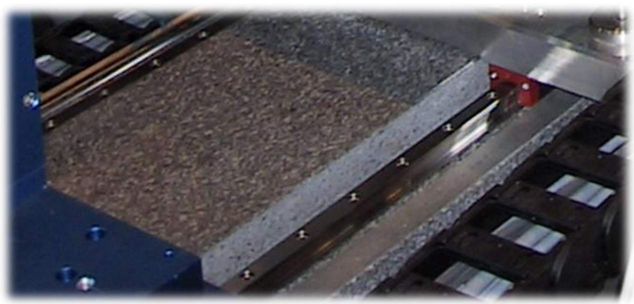
Film by DOCERAM

Granite

-main minerals quartz & feldspar
-hardness-mixture of different minerals: Quartz 1100 HV & feldspar 800 HV
-machining only by grinding
-natural radiation



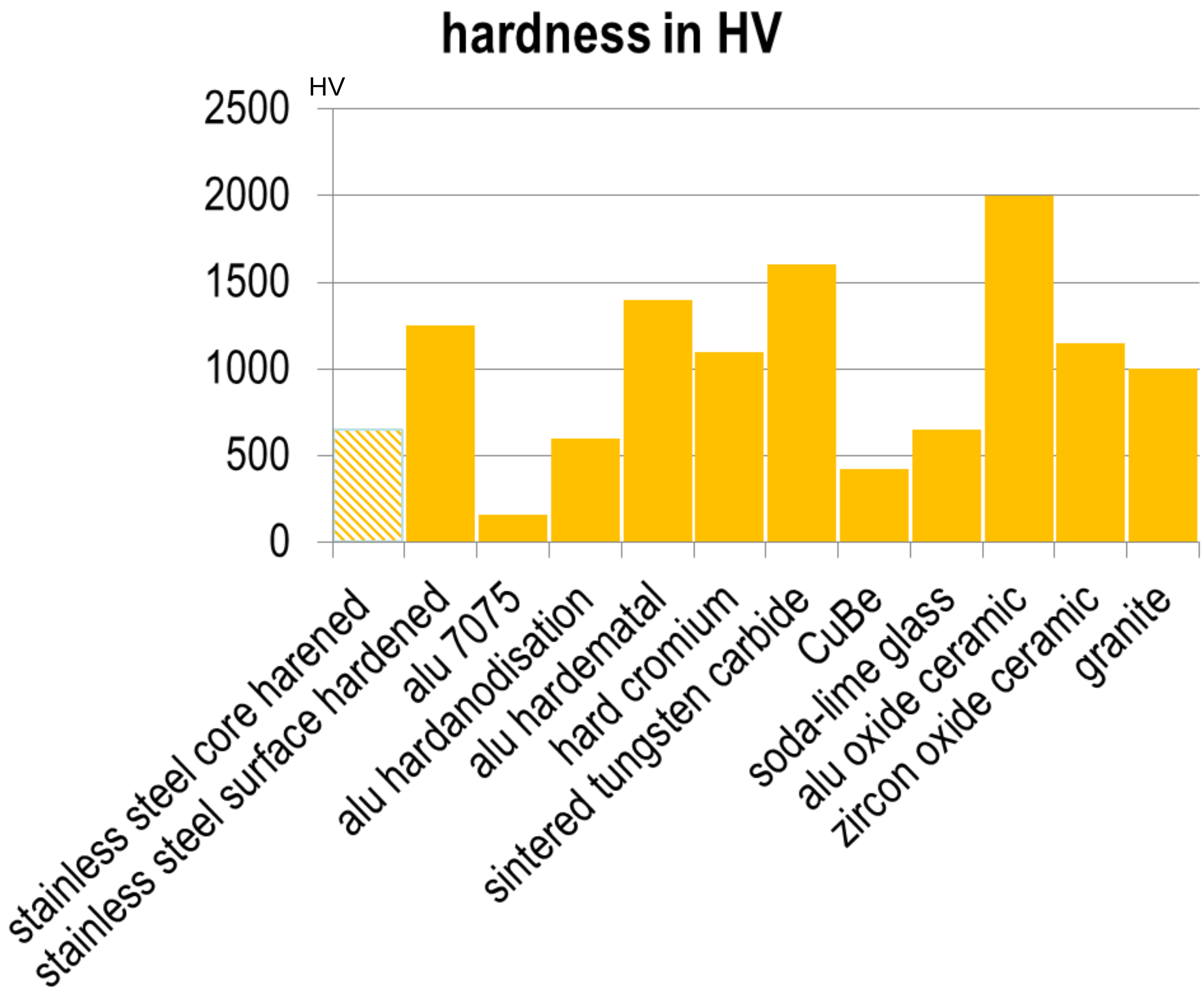




AMOR reflectometer sample table

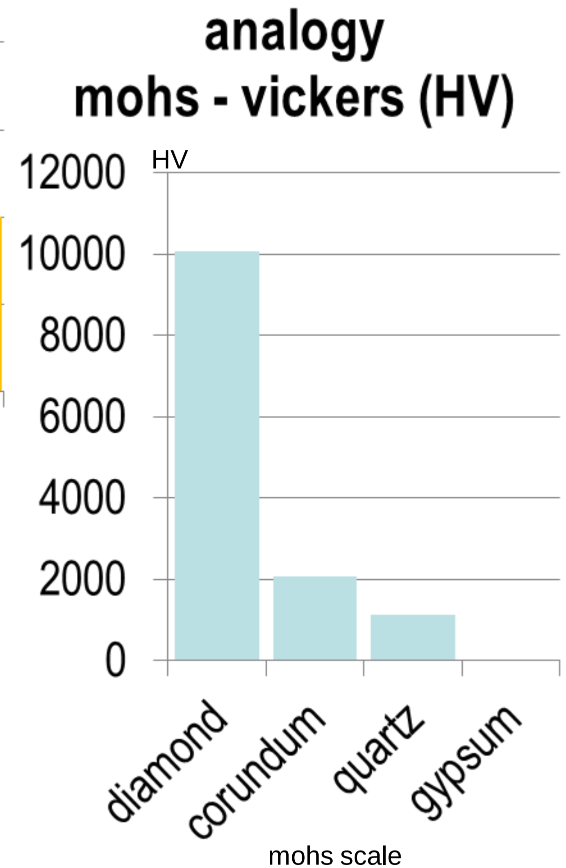
Hard Materials

Summary of hardness of the explained materials



Standard-materials:

- carbon steel ~ 120 HV
- carbon steel hardened ~ 840 HV
- AL Mg ~ 40 HV



Other Materials

Beside of changing carbon steel by “standard” and “hard” materials there are several other materials.

Most of them are based on plastic or concrete. Since these applications more or less well known I will not talk much more about this.

There is just one development we did in this respect:

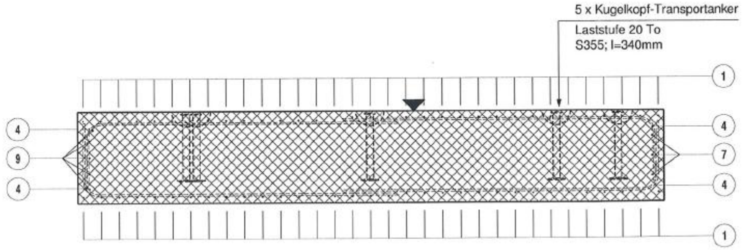
borated unmagnetisable heavy concrete

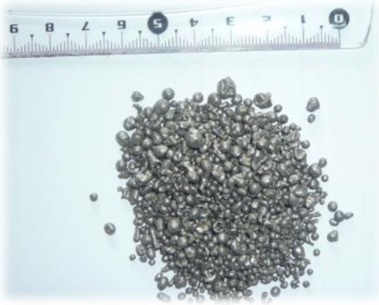
EIGER monochromator-shielding

Other Materials

borated unmagnetisable heavy concrete

-density 5.2 Kg/dm^3
-contains 5% boron carbide
-stainless steel grain1.4301
-SCC-concrete (Self Compacting Concrete)



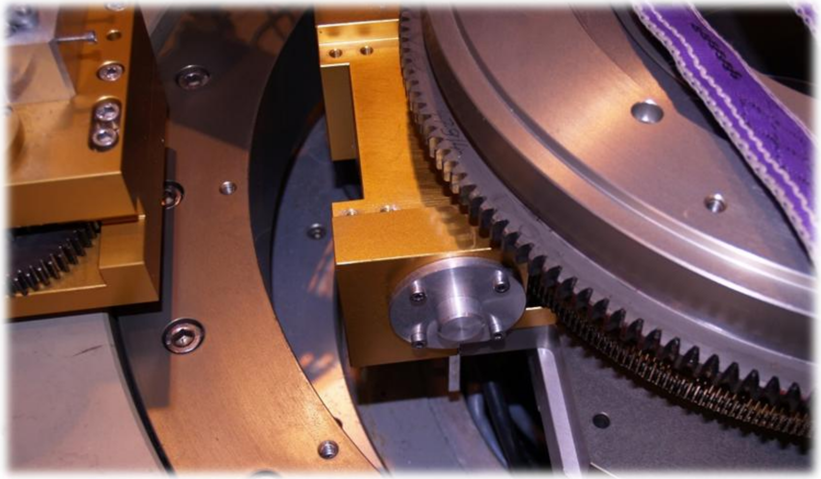


Design Samples

Sintered tungsten carbide

Until today we modified several worm shaft gears of rotation stages and goniometers by swapping the shaft material.

All these systems working until today without any problems and it seems they are at least as durable as the hardened carbon steel solution!

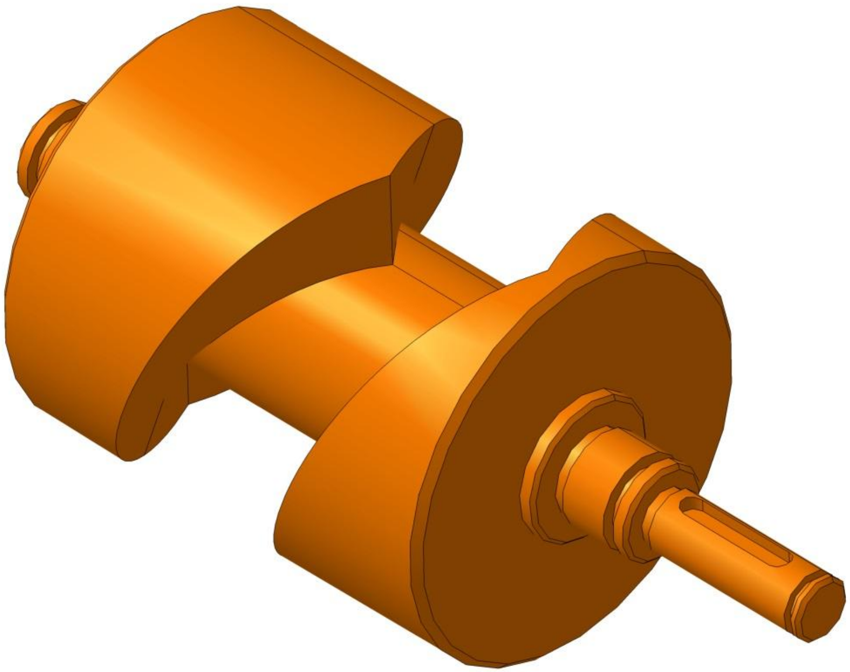


TASP sample table

Design Samples

CuBe

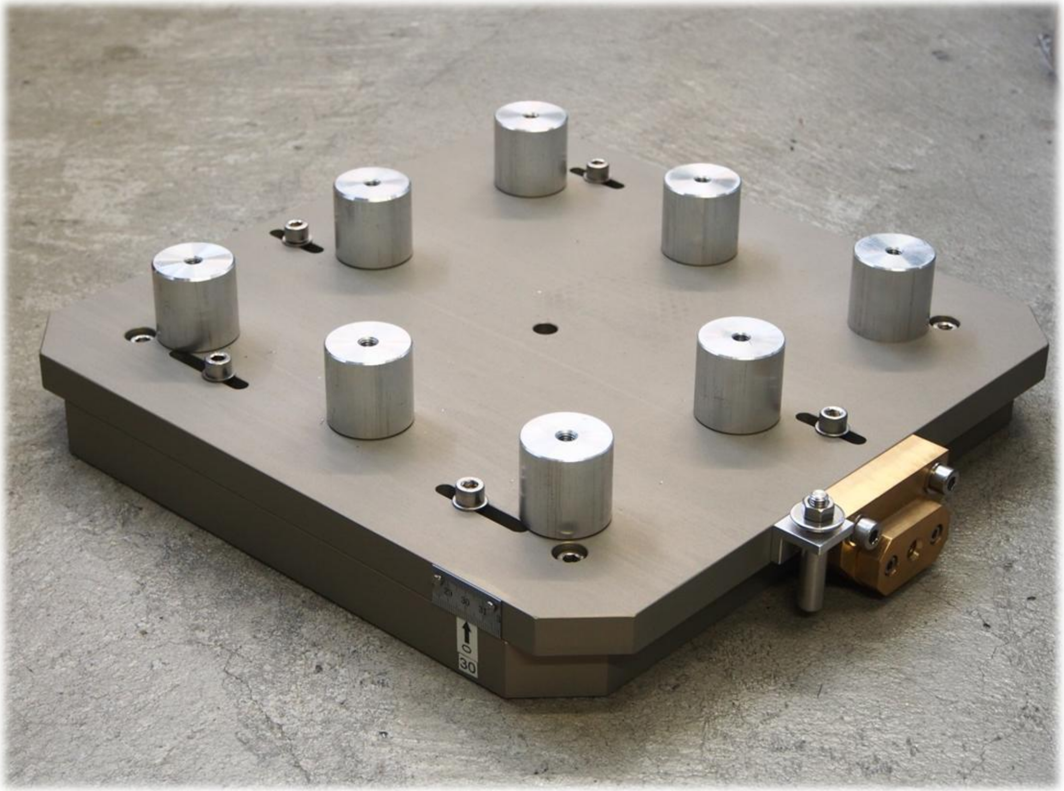
Replacement of a coated stainless steel shaft by a CuBe-shaft



FOCUS radial collimator
camshaft

Hardanodisation

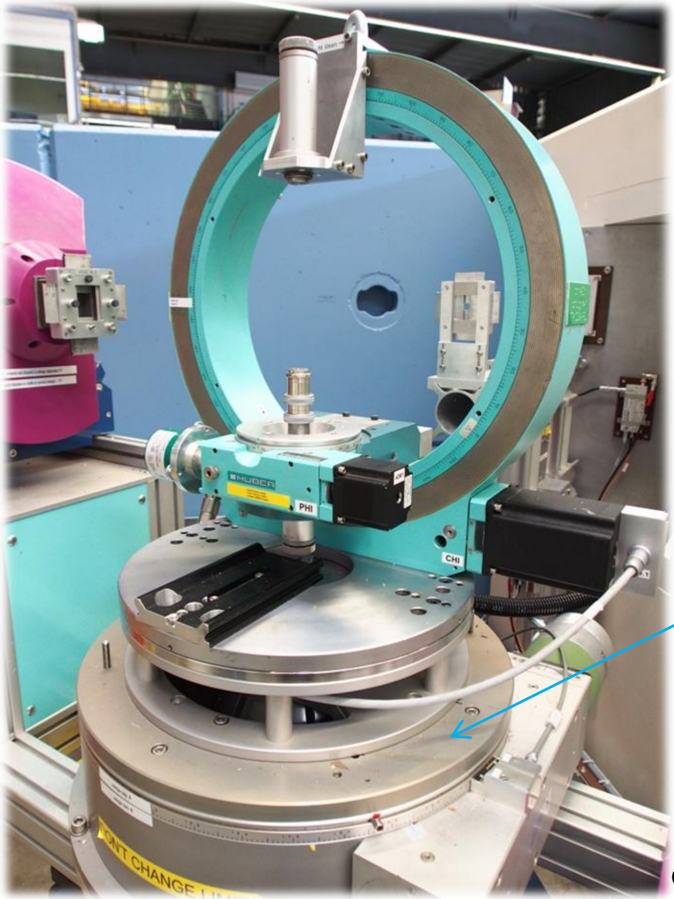
Simple translation to move a cryostat.



Design Samples

Hardematal

Hard-wearing surface to put sample environment on.

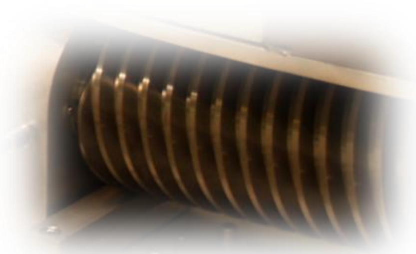


hardematal

Orion sample table

Summary

Experiences



positive

-We got very good results by building worm shaft gears with sintered tungsten carbide.
-Hard coated aluminium plates are a good way to protect friction-surfaces.

negative

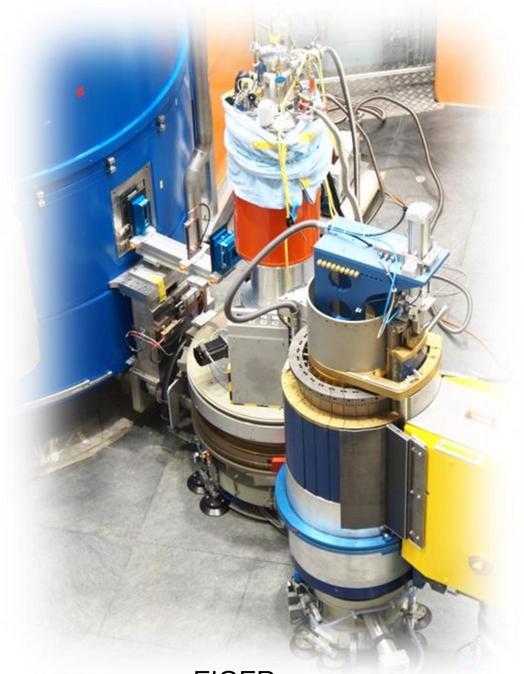
-Hard coated stainless steel parts were often not long resistant.
-Slider of ceramics very often destroyed the touching piece.

Summary

Perspectives

In the area of solid-spindles and -rails we see many future solutions by using hardened CuBe.

Glass could be a very interesting material to built hard unmagnetisable systems which are additional protect radiation and have a low thermal expansion.



EIGER

Questions?