PAUL SCHERRER INSTITUT

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Shielding of EIGER-Monochromator production

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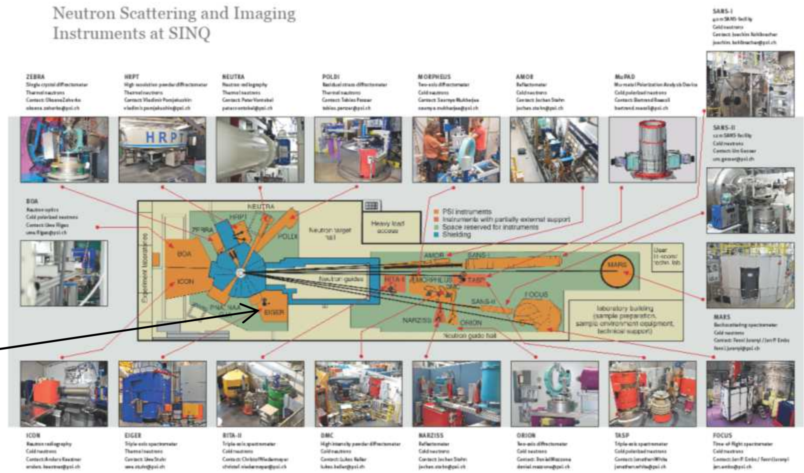
picture by courtesy of C.Kägi

Introduction

EIGER is a triple axis instrument which belongs to the permanent spallation source SINQ at the Paul Scherrer Institute in Switzerland. The monochromator sit within a thermal beam-channel.

- ❑ Neutron flux of SINQ: 10^{14} n/cm^2/s
- ❑ very fast neutrons > 1 MeV

EIGER



picture by courtesy of S.Janssen

Introduction

Parameters Properties of EIGER

picture by courtesy of C.Kägi

component	properties	values
monochromator	double focusing 15x9 pieces PG 20x20mm^2 each	Alignment: <+/-0.1° 30° mosaicity
virtual source	10mm<width<40mm	
shielding	non-magnetic	
beam size at sample	double focusing condition	40x40mm
filter	PG (37 or 70mm)	
analyser	PG horizontal focusing	
detector	^{3}He-tube	
collimation	20’, 40’ or 80’ available	
usable magnet	15 Tesla vertical	
A2-stage	worm gear	17° - 90°

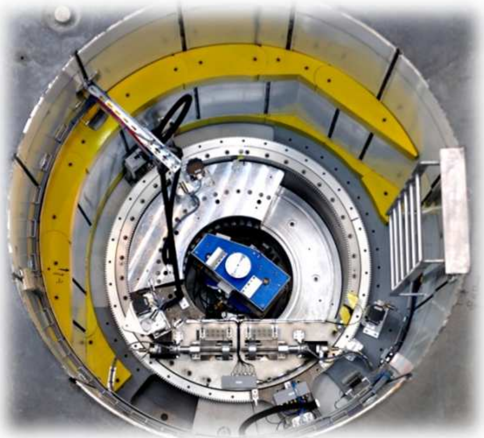
Project aim

The aims were:

- ❑ Design of a shielding which stops a major amount of the fast neutrons

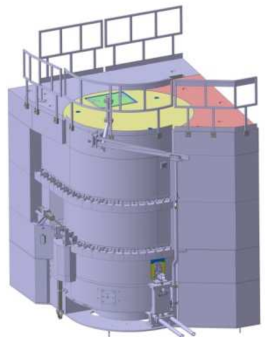
- ❑ The process of choosing the part-materials should take care about the future plans to use of a 15 Tesla sample magnet.

- ❑ Good signal to noise ratio



pictures by courtesy of C.Kägi

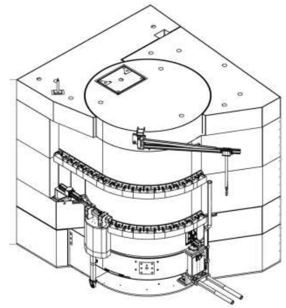
Shielding materials



CATIA-model
by courtesy of D.Graf

used major shielding materials:

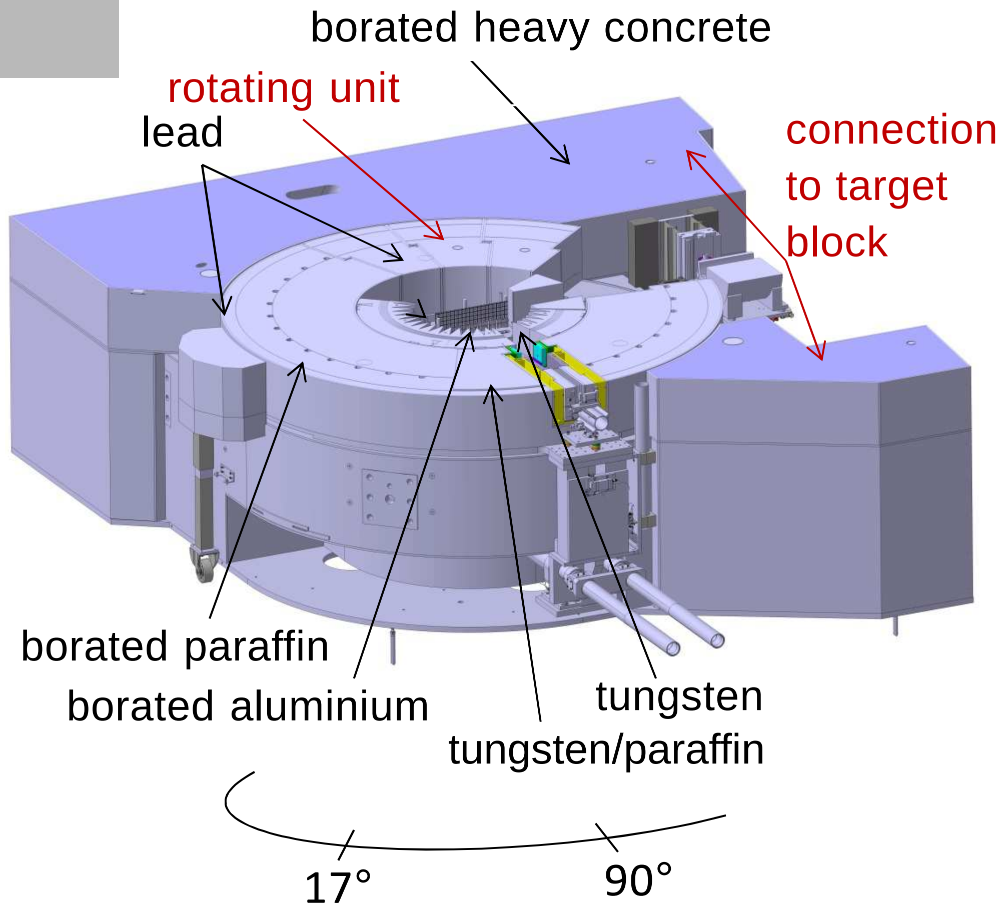
- ❑ lead → main shielding
- ❑ tungsten → slits
- ❑ tungsten/paraffin → direct beam
- ❑ stainless steel → casings
- ❑ carbon steel → casings
- ❑ borated heavy concrete (unmagnetisable) → main shielding
- ❑ borated heavy concrete (magnetisable) → main shielding
- ❑ borated light concrete → top and bottom shielding
- ❑ borated aluminium → scattered beam
- ❑ borated stainless steel → to shim gaps
- ❑ borated paraffin → main shielding

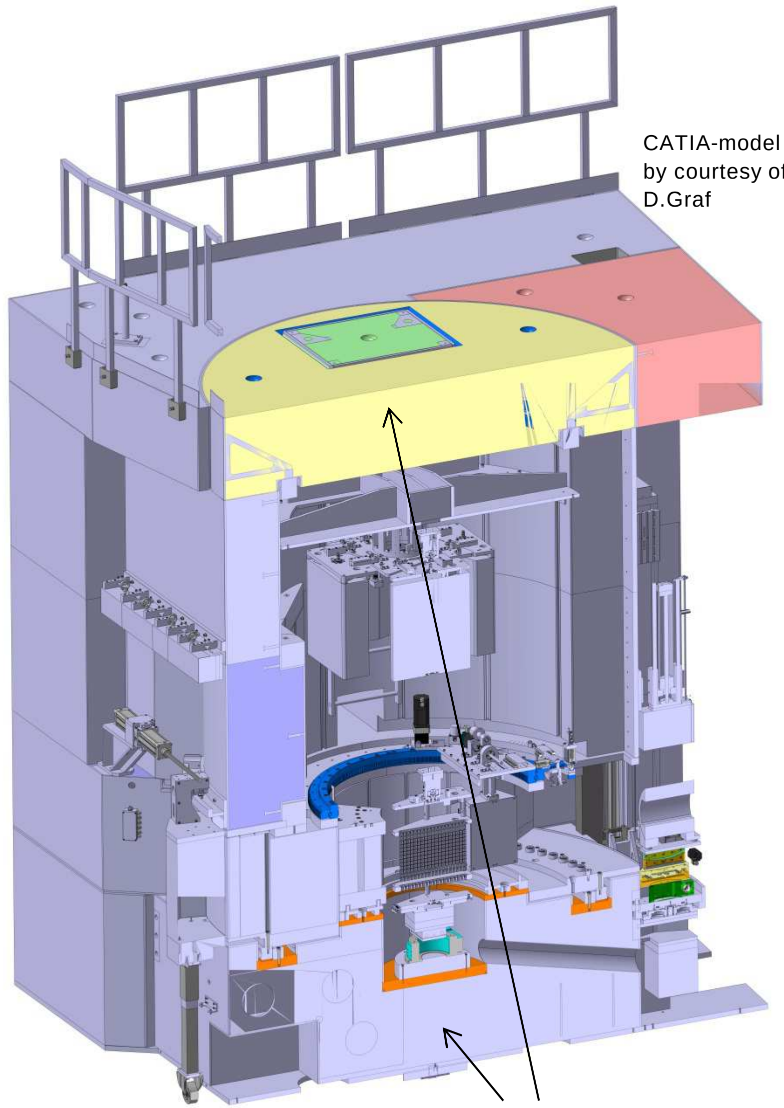


Shielding materials

shielding weight ~ 250 t

height ~ 3.5m





15 T magnet use

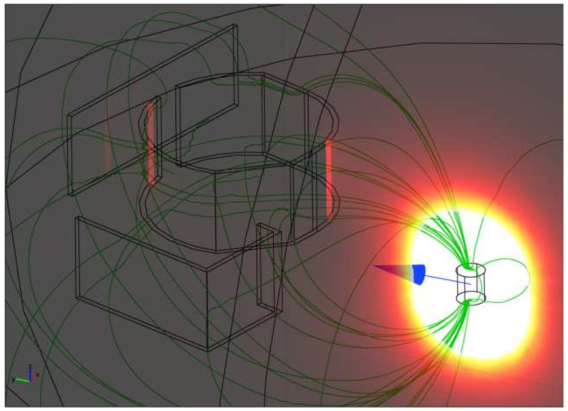
Force from the magnet to the sample table items

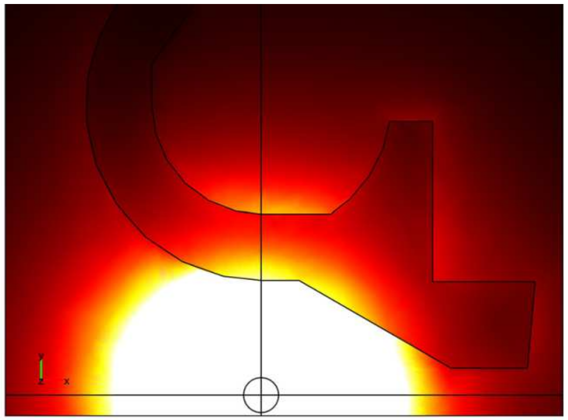
Fmax = limited to 500 N

15 T magnet use

During the project prices of stainless steel increased much.

- We simulated all major pieces in case of their magnetically force.
- By observing the magnetically force on the sample table we choose partly carbon steel instead of stainless steel.
- Result was a mixture of pieces made of magnetisable and unmagnetisable materials.





COMSOL-simulation figures
by courtesy of L.Holitzner

Concrete pieces

Specification target was:

- ❑ density higher then 5.0 Kg/dm^3
- ❑ 5% boron carbide (2.5 Kg/dm^3)
- ❑ unmagnetisable

pictures by courtesy of D.Graf

machining on the final piece

steel casing

birchwood

we studied following heavy concrete compositions

- ❑ Magnetite (Fe_3O_4); density of 5.2 Kg/dm^3

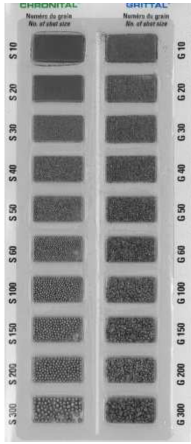
- ❑ Hematite (Fe_2O_3); density of 5.3 Kg/dm^3

- ❑ Barite ($BaSO_4$); density of 4.5 Kg/dm^3

Concrete pieces

Specification:

- density up to 5.3 Kg/dm^3
- 5% boron carbide
- stainless steel grains
- steel casings



stainless steel grains (surface blasting)

pictures by courtesy of D.Graf

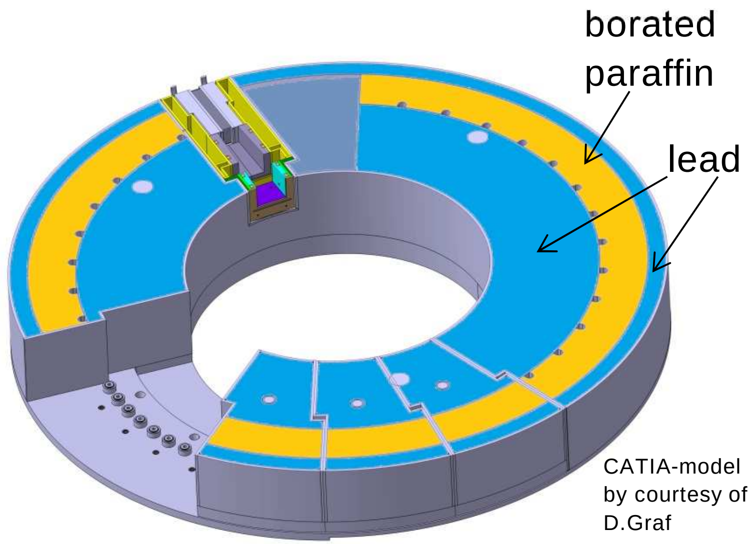
steel grains during pouring

instead of sand we used boron carbide

stainless steel   carbon steel

Lead shielding

pictures by courtesy of D.Graf



CATIA-model by courtesy of D.Graf

Lead shielding

lead

borated paraffin

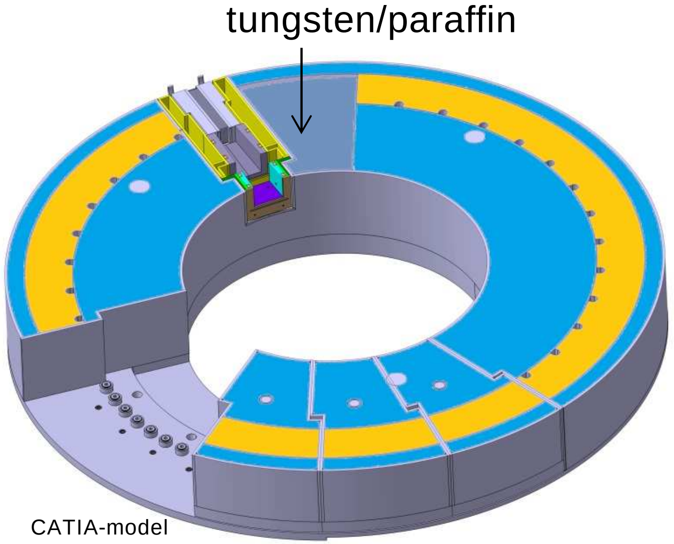
lead

pictures by courtesy of D.Graf

Tungsten parts

Specification tungsten/paraffin

- tungsten powder mesh 100 – 400 micron
- paraffin granulate (used by candle-maker)
- mixture 60% tungsten (weight %)
- density 11.6 Kg/dm^3



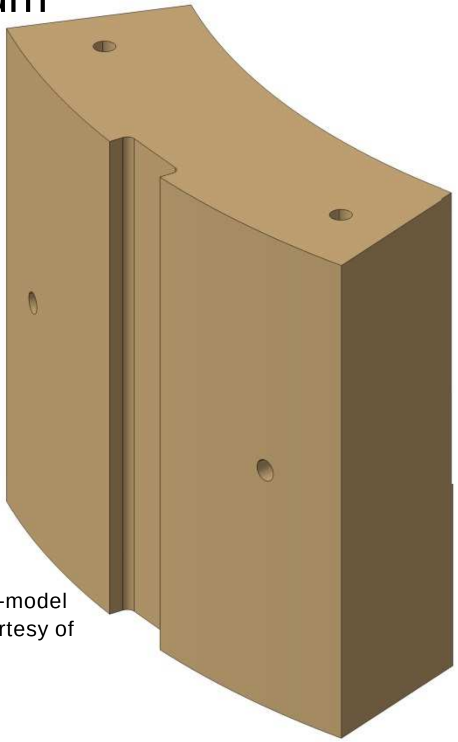
CATIA-model by courtesy of D.Graf

pictures by courtesy of C.Kägi

Tungsten parts

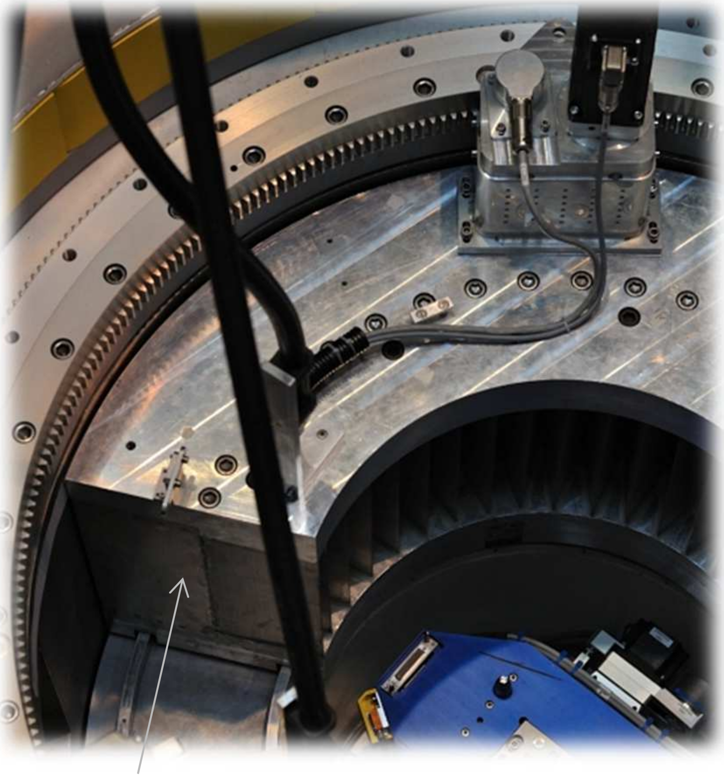
Specification solid tungsten

- ❑ Densimet D180
- ❑ sintered tungsten
- ❑ 95% tungsten
- ❑ rest FeNi
- ❑ density 18 Kg/dm^3



CATIA-model by courtesy of D.Graf

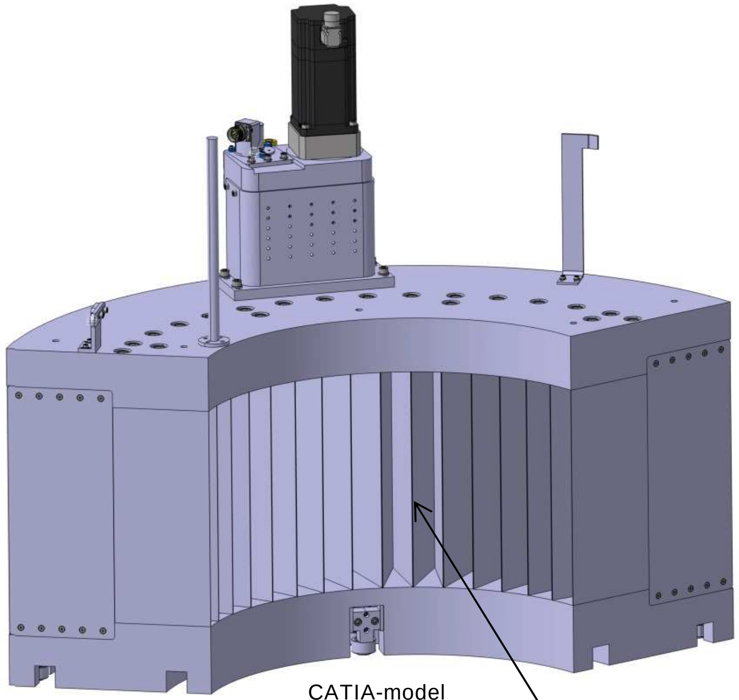
picture by courtesy of C.Kägi



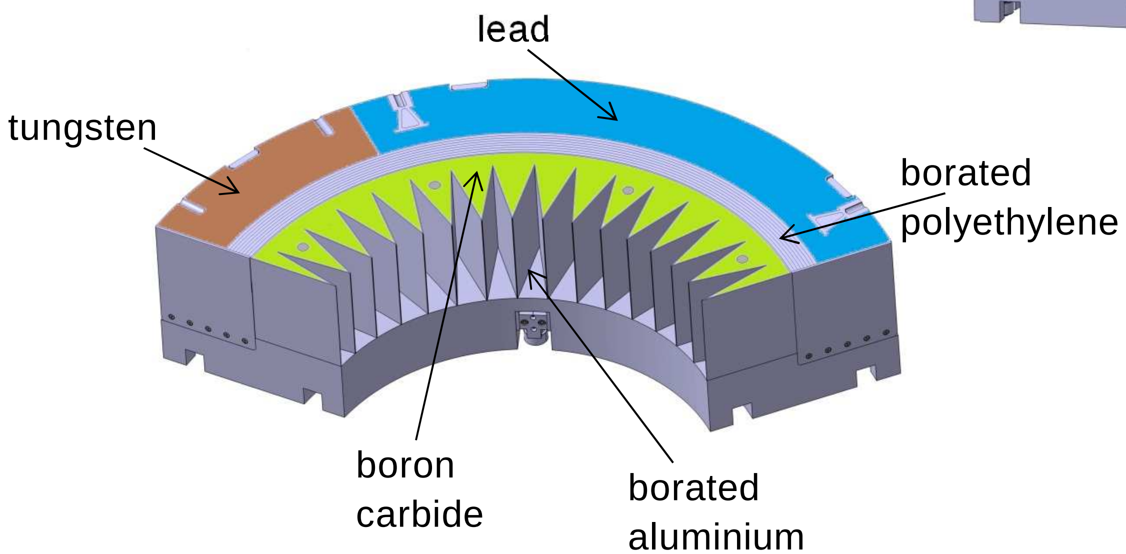
solid tungsten block

Beam trap

picture by courtesy of C.Kägi



CATIA-model
by courtesy of
D.Graf



Assembly

pictures by courtesy of C.Kägi

neutron guide, sapphire filter & shutter

Starting with a flat base plate

- putting the base plate straight
- metrology checking
- pouring concrete underneath

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Assembly

unaccesable crane areas
- balances
- special hangers

gallery

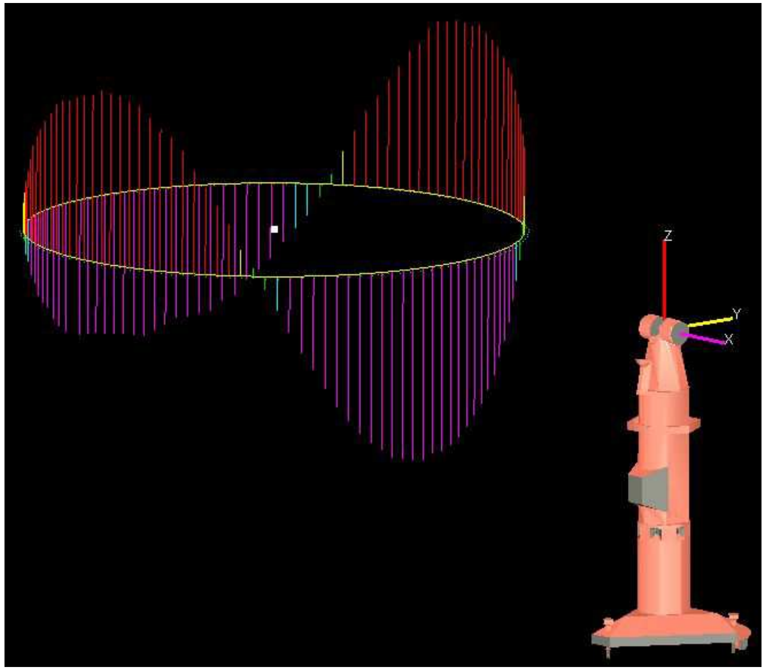
pictures by courtesy of C.Kägi

Assembly

Picture by courtesy of C.Kägi

Total RMS Error: 0.521 [mm]

	Planar Deviation Summary:	Radial Deviation Summary:	
Minimal:	-0.806	-0.116	[mm]
Maximal:	0.748	0.220	[mm]
Range:	1.555	0.336	[mm]
RMS:	0.517	0.066	[mm]



figures by courtesy of K.Dreyer

Measured tolerances of the worm-wheel base on the shielding were not okay!

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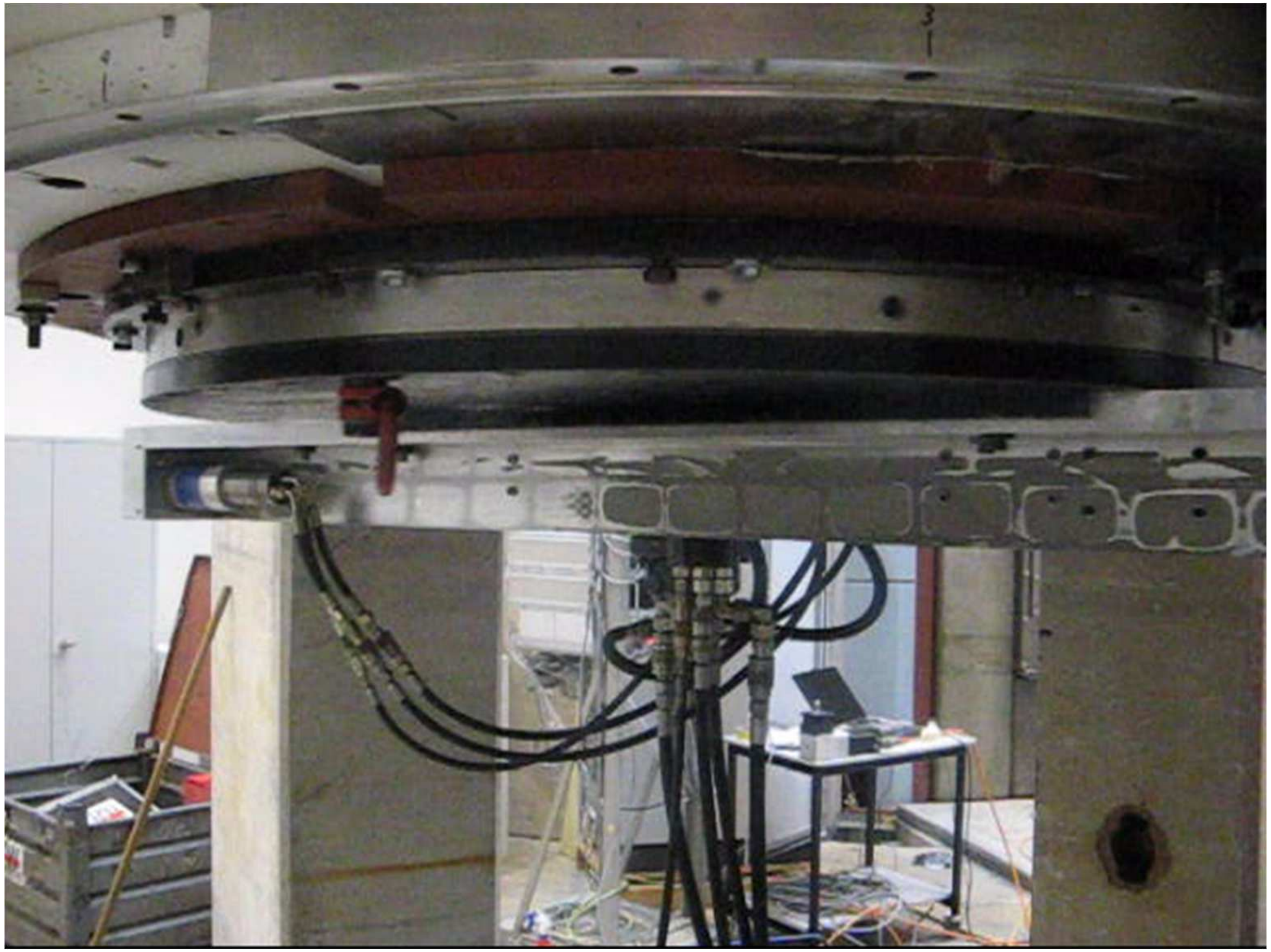
Assembly



video by courtesy of C.Kägi

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Summary

During the process of material-choosing and production we learned much about shielding-building technics.

Specially the various material optimising and development took us much more time as suspected.

Steel casings are relatively expensive and do not provide the believed flatness and tolerances.

Finally measurements of radiation showed us values as simulated. Magnetic forces on the sample-kryomagnet were also close to the calculated numbers.

My thanks go to

- Dieter Graf; PSI; design shielding
- Alex Bollhalder; PSI; design monochromator
- Christian Kägi; PSI; assembly
- Karsten Dreyer; PSI; metrology
- Lothar Holitzner; PSI; simulation magnet field
- Uwe Filges; PSI; simulation radiation shielding
- Uwe Stuhr: PSI; instrument responsible
- Severian Gvasaliya; ETHZ; former instrument respons.
- Henrik Rønnow; EPFL; former instrument responsible

Providing main companies:

- Hinneburg; production lead & steel
- Alphabeton; production concrete
- Wissel & Wissner GmbH; special machining

Questions?