Marco Negrazus :: Magnet Section :: Paul Scherrer Institute

Magnets for the up-grade of the Storage Ring at PSI

IMMW 21 24.-28. June 2019

Magnets for SLS 2

1. Electro Magnets
2. Permanent Magnets
3. Time schedule and resource plan

Magnets for SLS 2

Conventional electro magnets:

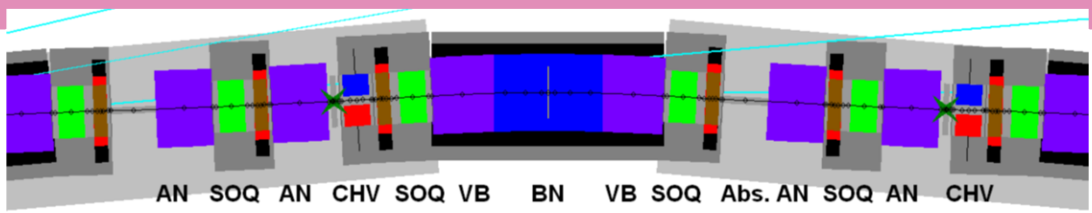
- 96 – 105 Quadrupoles (1 Type)
- 288 Sextupoles (magnetic 1 type, mechanic 2 Types)
- 288 Octupoles/Quad/SkewQuad (2 Types)
- 216 Correctors (h/v)

888 – 897 Magnets, 4 Types

Permanent magnets:

- 60 BN (LGB)
- 144 VB (Dipol + Quadrupole)
- 144 AN / ANM (Quadrupole + Antibend) (2 Types)
- 24 BEV (Dipole + Quadrupole)
- 24 BEH (Dipole)
- 24 BES (Dipole)

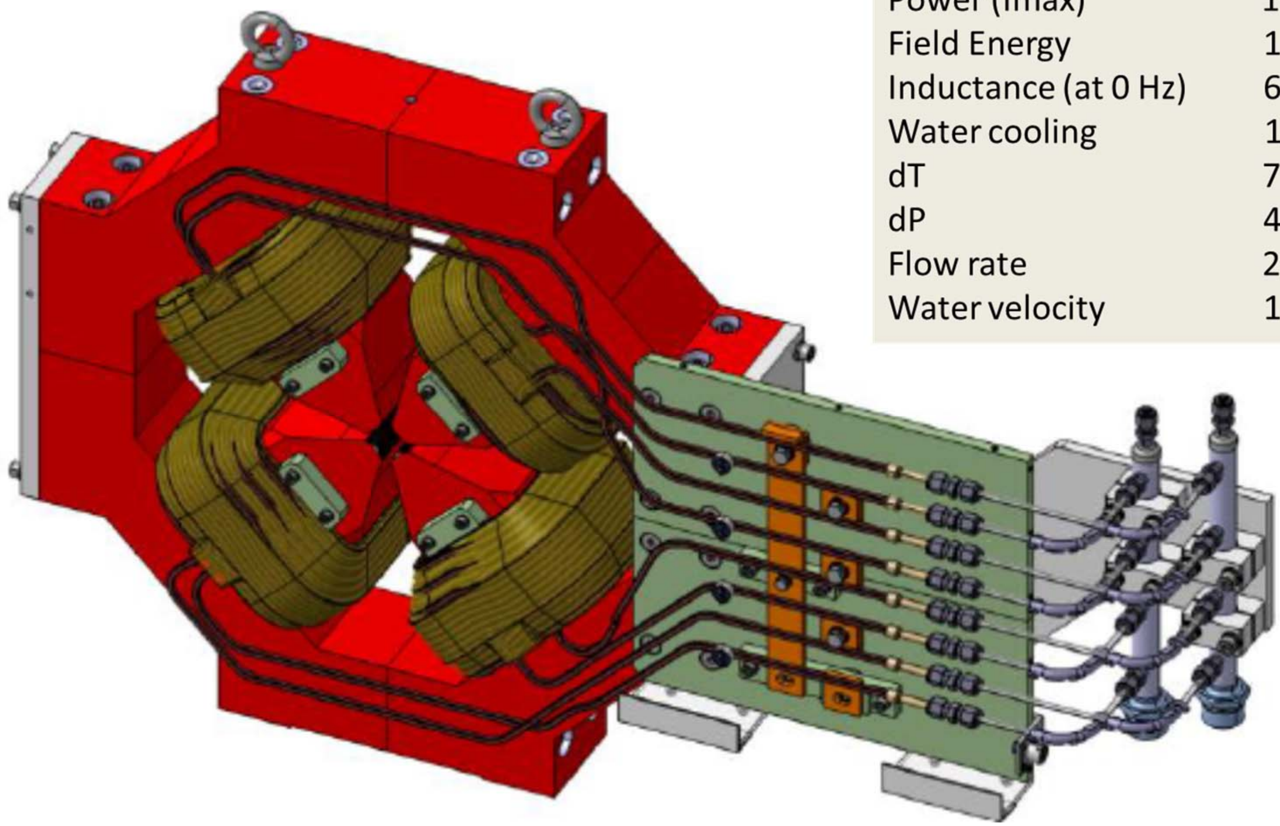
420 Magnets, 7 Types



Electro Magnets

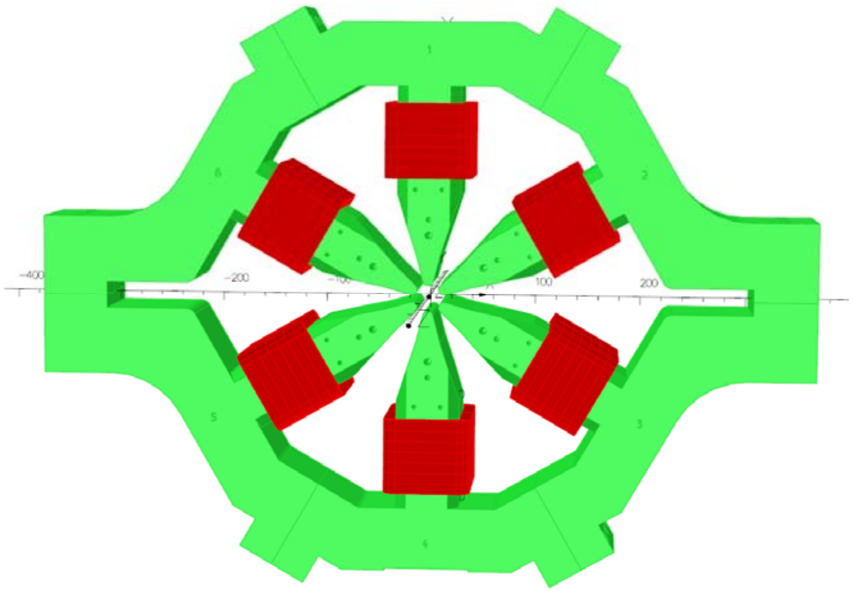
Quadrupole

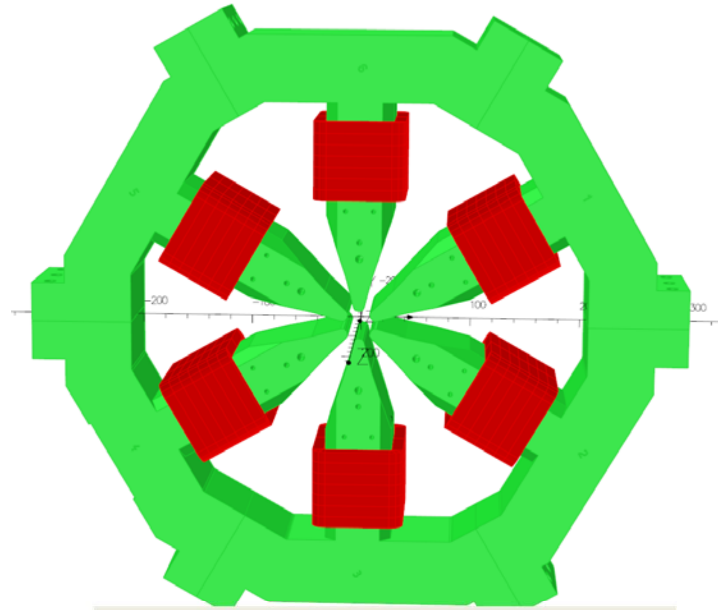
Aperture	24 mm
Number	4
Conductor	5x5x3
Windings per coil	75
Gradient	78 T/m at 66 A
Imax	70 A
R	0.20 Ohm
Voltage (Imax)	14.0 V
Power (Imax)	1020 W
Field Energy	150 J (at I = 64 A)
Inductance (at 0 Hz)	61.0 mH
Water cooling	1 circuit per coil
dT	7.2°
dP	4 bar
Flow rate	2.0 l/min
Water velocity	1.14 m/s



Electro Magnets

Sextupole (2 Types)

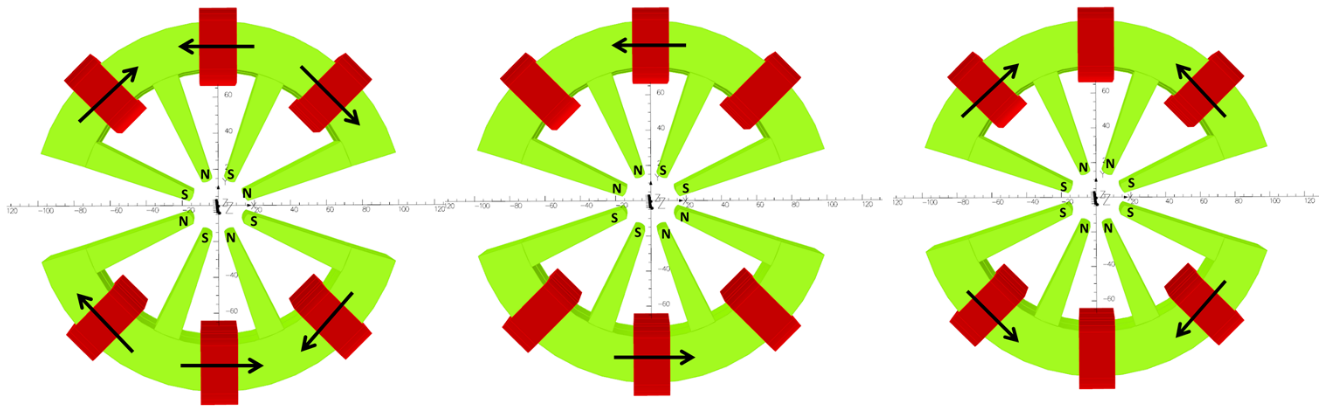


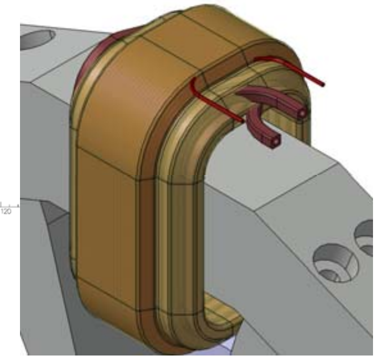


Aperture	25 mm
Number	6
Conductor	5x5x3 length: 124 m
Windings per coil	48
Gradient	4000 T/m^2 at 45.8 A
Imax	50 A
R	0.139 Ohm
Voltage (Imax)	6.96 V
Power (Imax)	348 W
Inductance (at 0 Hz)	44 mH
Water cooling	1 circuit per 3 coils
dT	6.2°
dP	4 bar
Flow rate	0.8 l/min
Water velosity	0.95 m/s

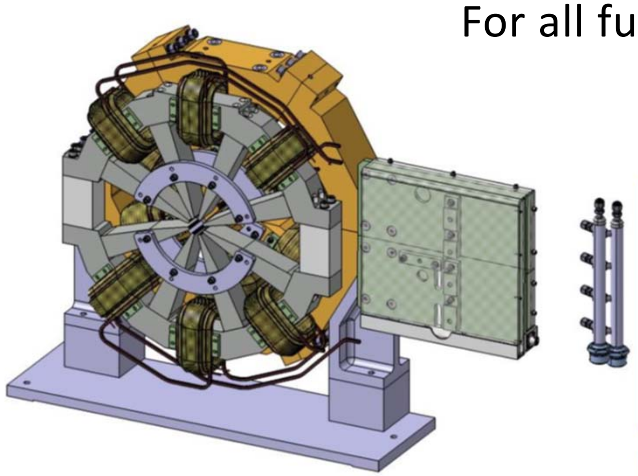
Electro Magnets

Octupole / Quad / SkewQuad combination





For all functions 12 coils with 3 PS are needed



Sextupole-Octupole

Field Quality of Quad and Skew Quad

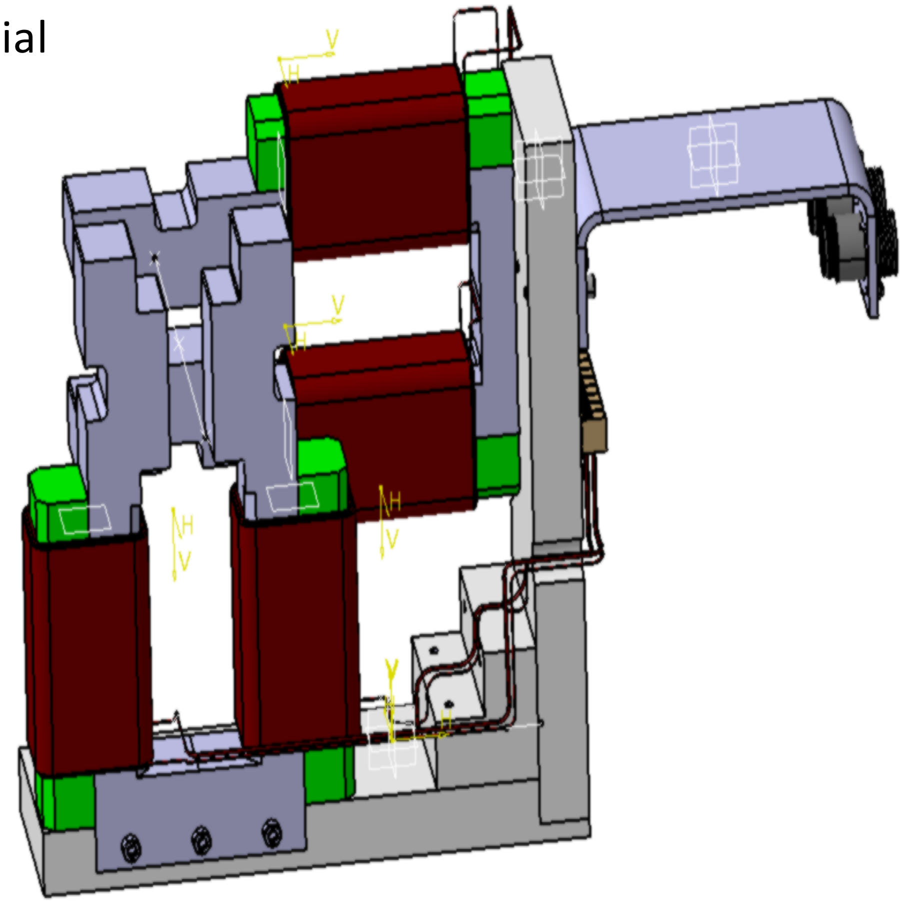
Axis alignment of SP and OP

Space problem (215 mm length)

Magnetic length	50 mm
Gross length	90 mm
Aprture radius	15.2 mm
Octupole strength	45000 T/m3
Quad + skew quad strength	2.5 T/m
Pole Tip Field OP/QP/Skew	0.16 / 0.04 / 0.04 T
OP conductor	4x4x3 water cooled
QP conductor	1.5 mm round wire air cooled
OP coil	6 coils,24 windings per coil
QP/skew coils	2 coils / 4 coils
Current OP/QP/skew	50 / 5 / 5 A
Resistivity OP/QP/skew	110 / 800 /1600 mOhm
Voltage OP/QP/skew	5.6 / 4.1 / 8.2 V
Power OP/QP/skew	280 / 20 / 40 W
Cooling OP dP	3 bar, six coils in series
dT	10°

Electro Magnets

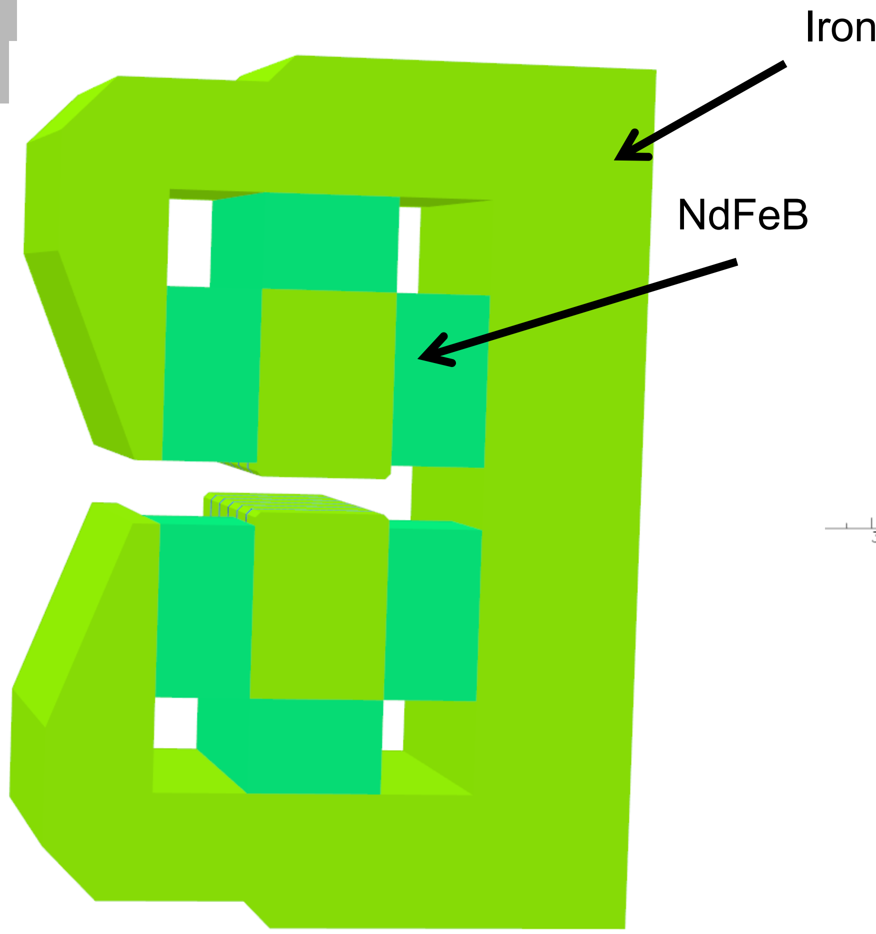
CHV Steerer, laminated yoke material

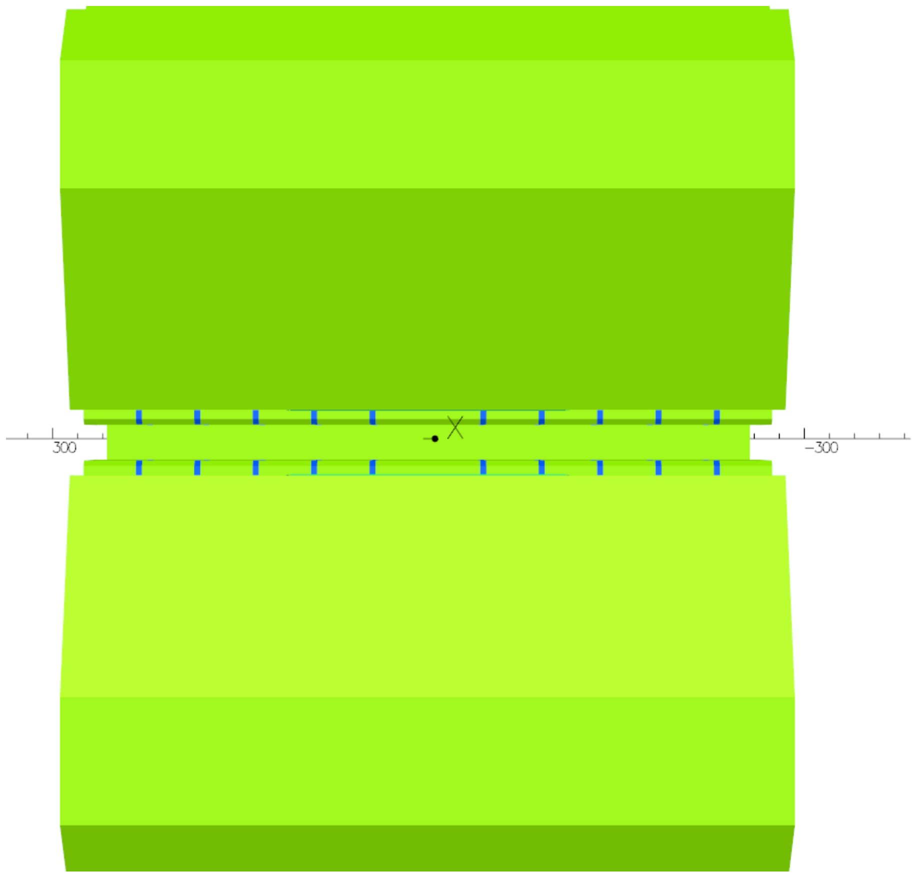


Data:	
Angle	0.4 mRad
Gap	24 mm
Length	120 mm
Fl	3.34 T mm
B0	0.049 T
R	0.7 Ohm
Windings	2 x 139
Power	2 x 16 W
Conductor	round wire 1.2 mm

Permanent Magnets

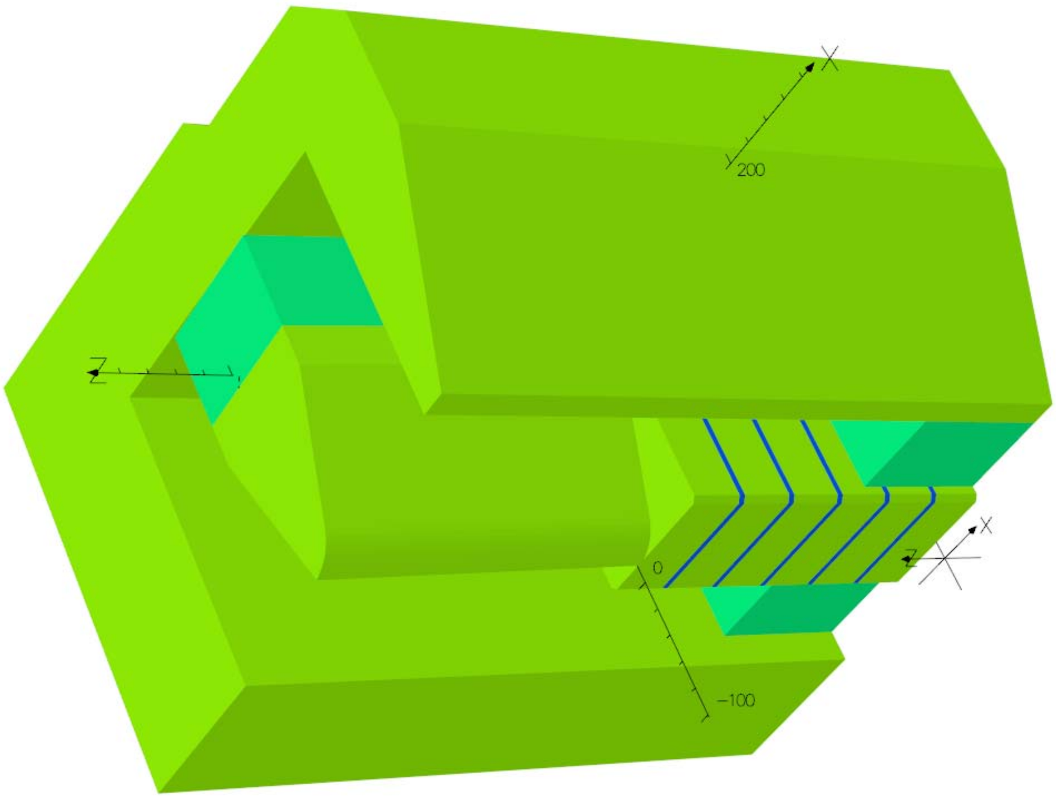
BN LGB magnet with slits in the pole, C- Type magnets





Permanent Magnets

VB BN VB combination, one quarter of the magnet shown



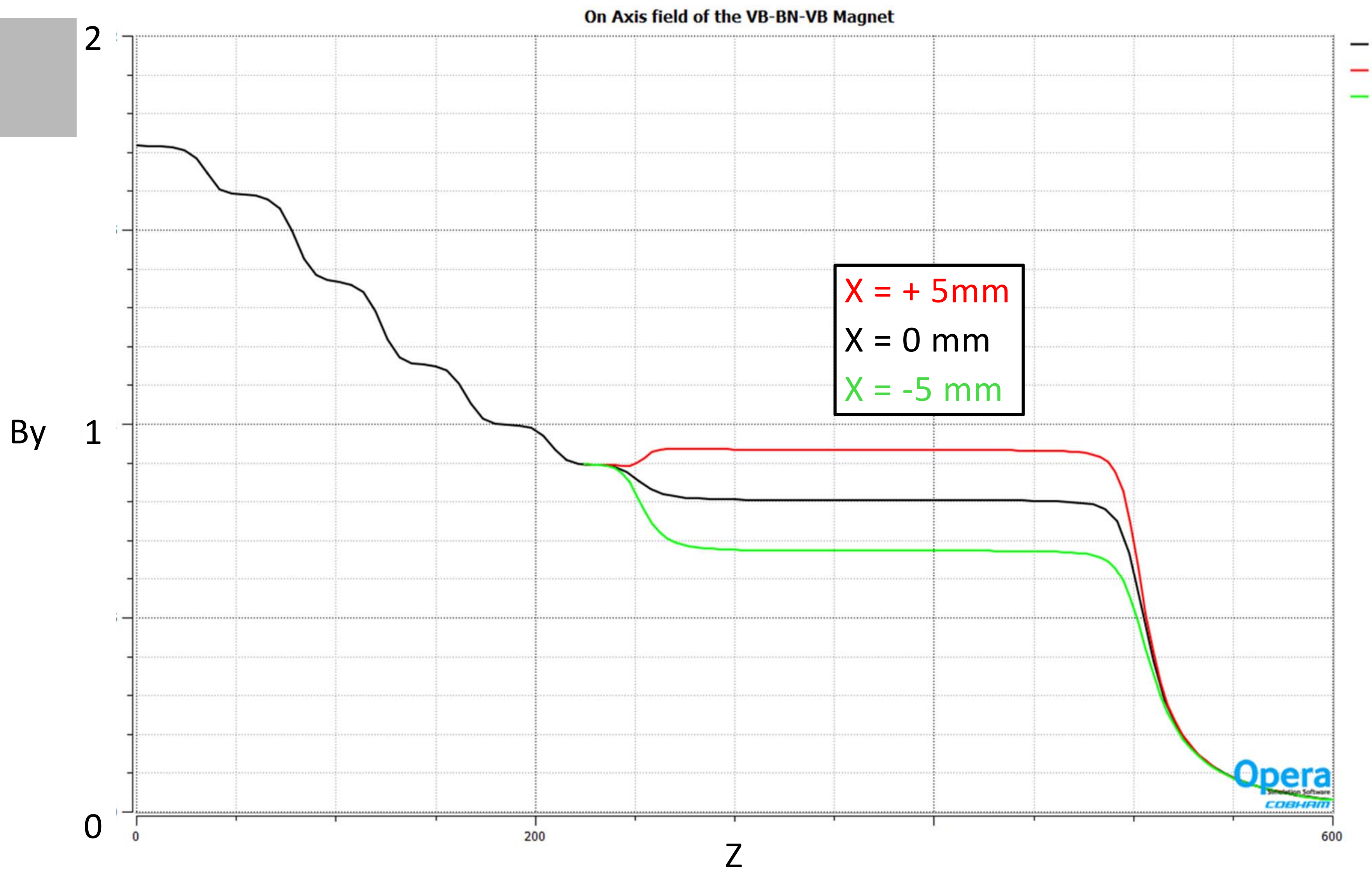
Open Question:

Straight or curved magnets ?

PM material

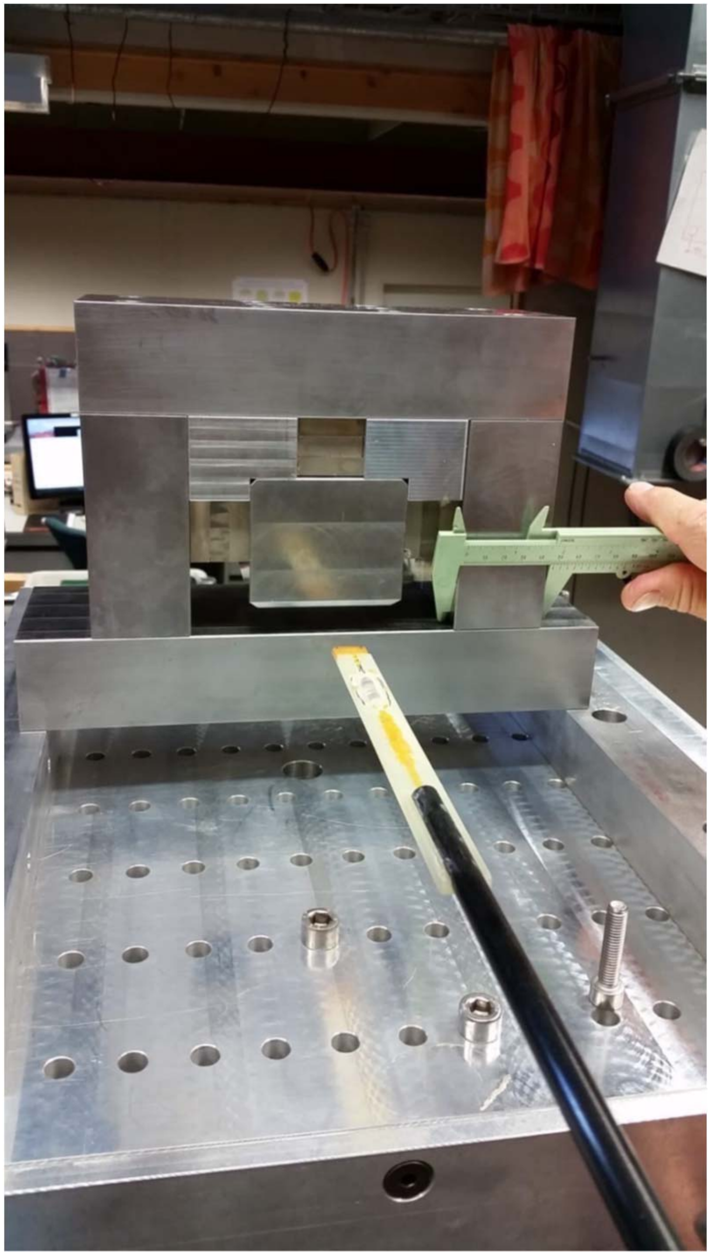
Measurement and optimization

B Field of the VB BN VB combination



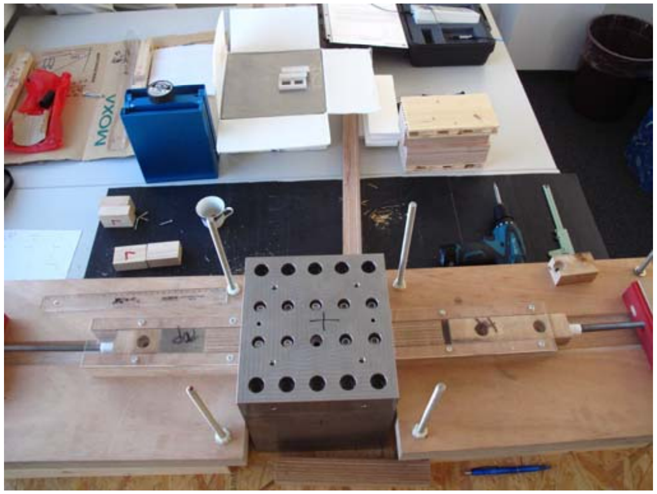
Permanent Magnets

Assembly exercise
Half dipole with towers of 3 PM blocks
9.5 mm x 32 mm x 40 mm
Br 1.1 T

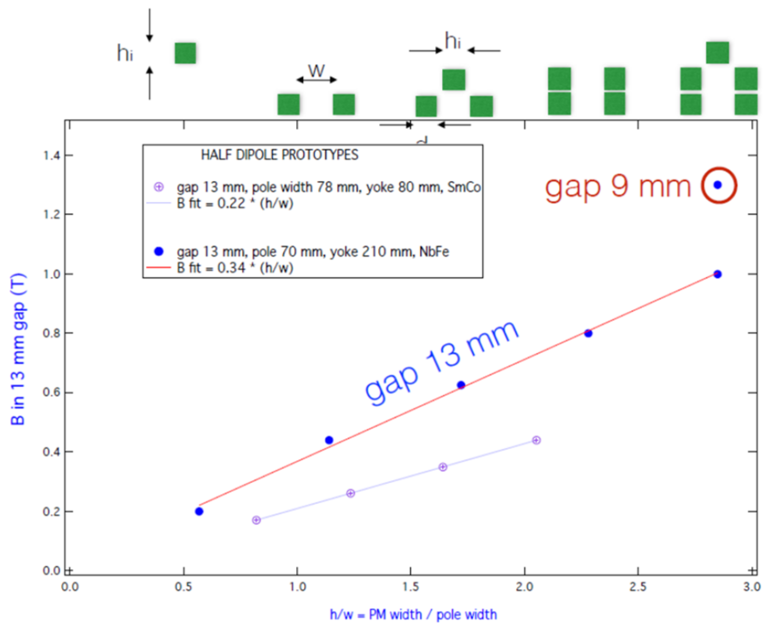


Main Goal is to learn how to handle PM blocks and insert them in the setup, developing of tools, and compare simulations and measurements.

Permanent Magnets



Dipole test setup using Br 1.26 T
70 mm x 30 mm x 40 mm NdFeB blocks
B = 1.3 T was reached (with small Gap)



Moving wire measuring bench

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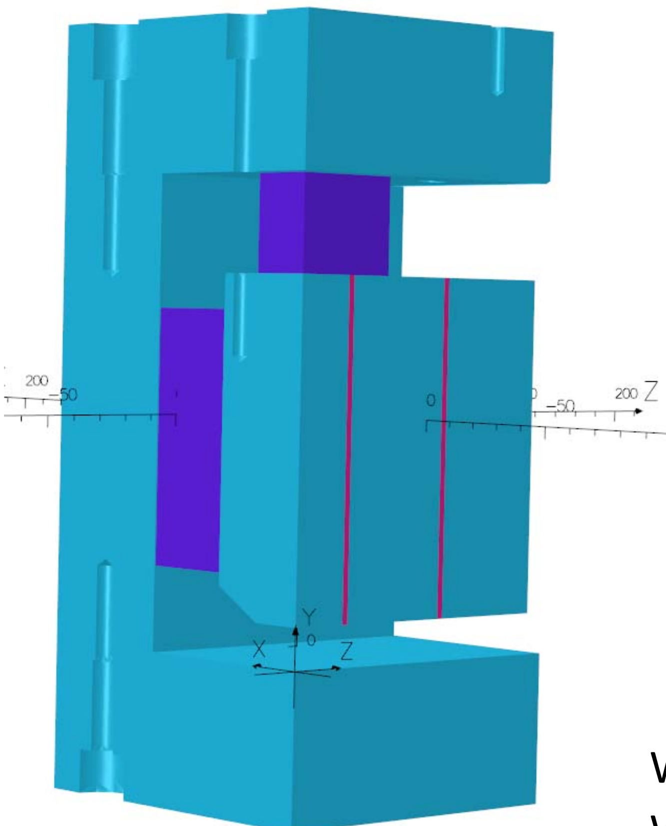
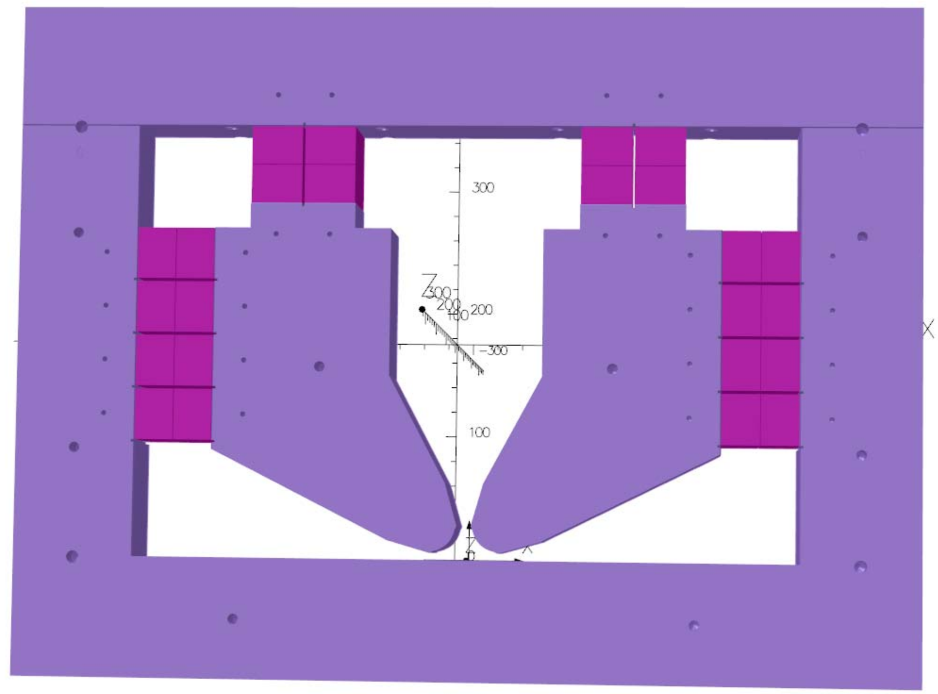
Permanent Magnets

Next test magnets in preparation with Br = 1.26 T blocks

LGB test



AN «Prototype»



With a magnet length of 210 m and 150 PM blocks
We can reach the Lattice B specs of 52 T/m for AN.
But we only have 49 blocks. → magnet length 70 mm
→ G = 36 T/m

Tentative Resource Plan

Uncertainty: Segmentation of work packages between PSI and industry for the permanent magnets

Resource plan for electromagnets (production by industry)

• QP (Design, construction, measurement, mechanics)	20 PM
• SP-OP	35 PM
• CHV	10 PM

Resource plan for permanent magnets (assembly included)

• Concept validation, prototyping, material acquisition	31 PM
• BN(BEH …)-VB	70 PM
• AN(ANM)	50 PM

Sum 216 PM

Tentative Time Schedule

Uncertainty:

- Segmentation of work packages between PSI and industry for the permanent magnets
- Specifications ready soon ?

Magnet	Call for Tender	first magnet ready	last magnet ready
QP	1.9.2019	1.3.2021	28.2.2022
CHV	20.2.2020	30.7.2020	23.12.2020
SP/OP	5.11.2019	31.5.2021	9.1.2023
BN (BEH …) VB	17.9.2020	2.8.2021	15.6.2023
AN (ANM)	29.10.2020	5.7.2021	23.12.2022

Dark Time start 3.4.2023

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Summary

- The design and construction for the electromagnets is almost ready; Adaptation to new specifications required
- The permanent magnets are conceptually designed
  - Open questions: PM material ? , curved magnets ? , aperture, measurements and optimization
- The electro magnets will be manufactured by industry
- The permanent magnets assembly in collaboration with industry
- Estimated resources for PSI: 216 PMs for 4 years

My thanks go to

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