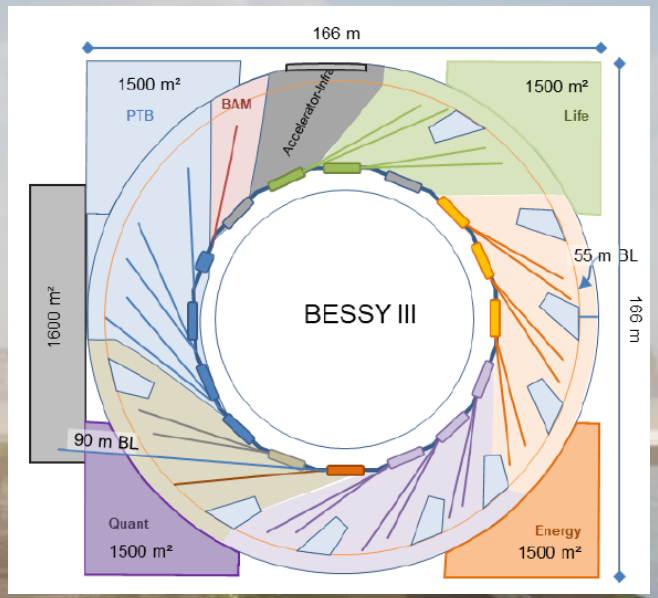
HZB Helmholtz Zentrum Berlin

DECREASING THE FOOTPRINT FOR A NEW SR FACILITY - BESSYIII

Decreasing the footprint for a new SR facility

Jens Völker - HZB

7th ESSRI workshop 2024 Madrid



BESSYIII

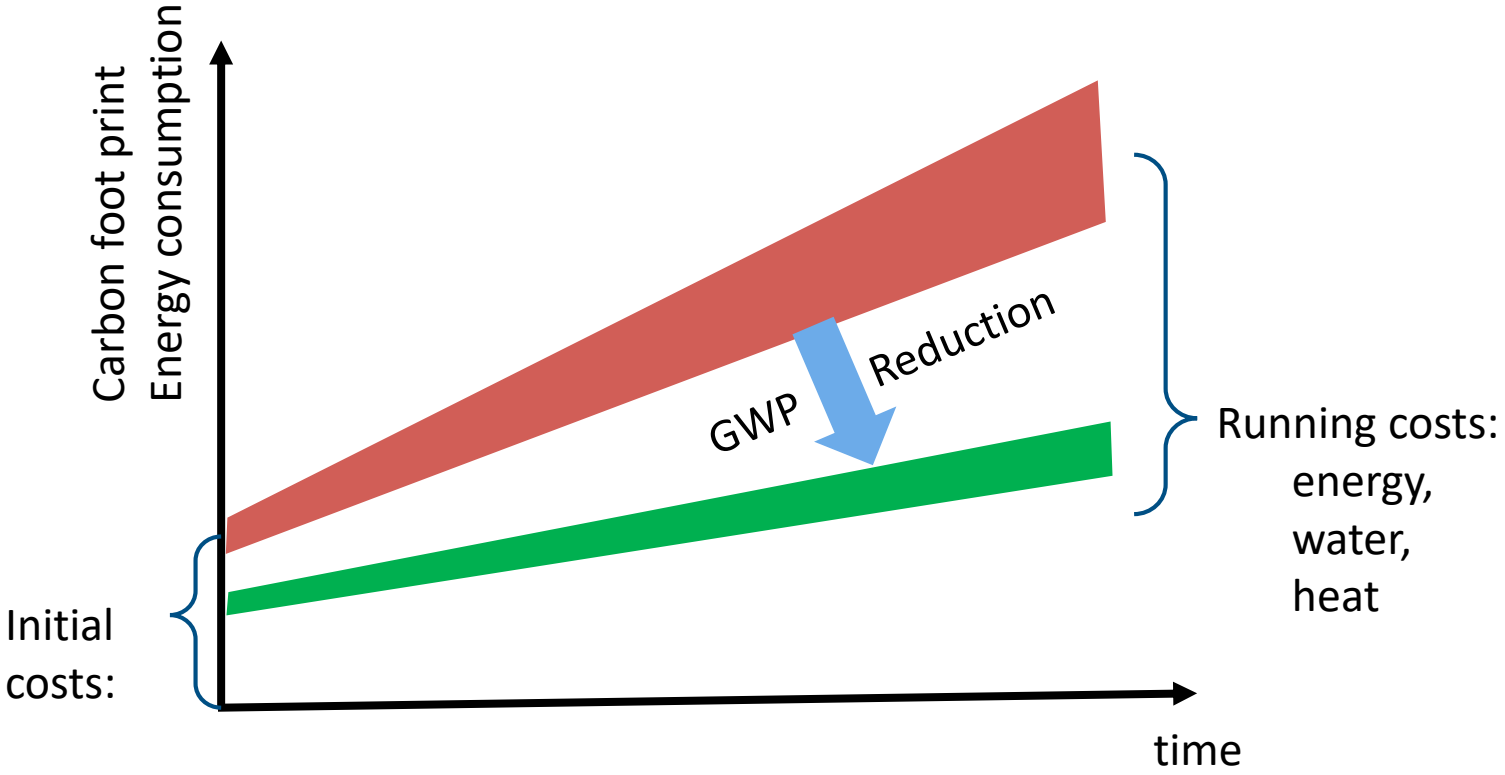
Green field option (BESSYIII / BESSYII):

- **40% larger circumference**
- **48% higher beam energy**
- **66% higher beam current**
- **>100% larger building complex**

Goal for power consumption:

over all power for BESSYIII equal or less than BESSYII !

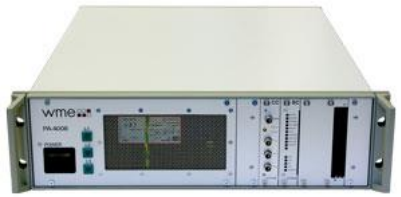
BESSY III (2035)
-> MBA (6BA) lattice (16 arcs)
-> ~340m circumferance
-> hor. emittance <100pmrad
-> energy 2.5GeV
-> up to 500mA beam current



construction
installation
fabrication


https://www.hausjournal.net


Cryoelectra



https://www.wme.de

LCA analyse

OUTLINE:

Accelerator Components
-> RF hardware
-> magnets

Building
-> energy production
-> using waste heat
-> construction

Using BESSYII+ as test bed for these developments

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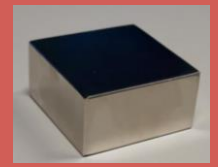
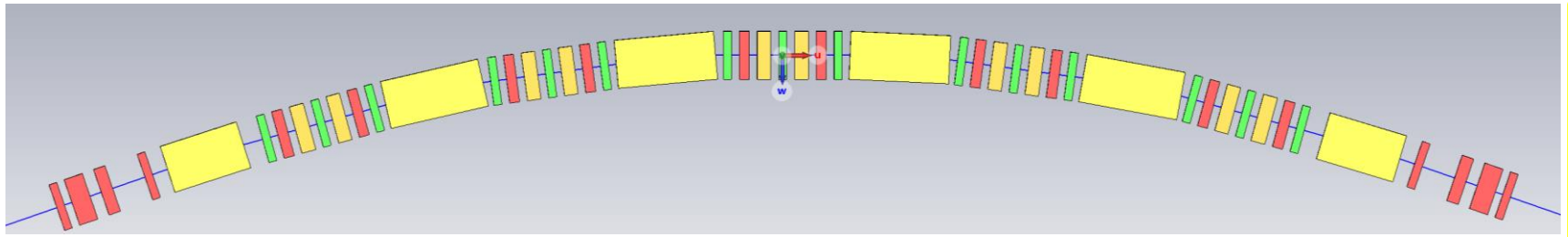
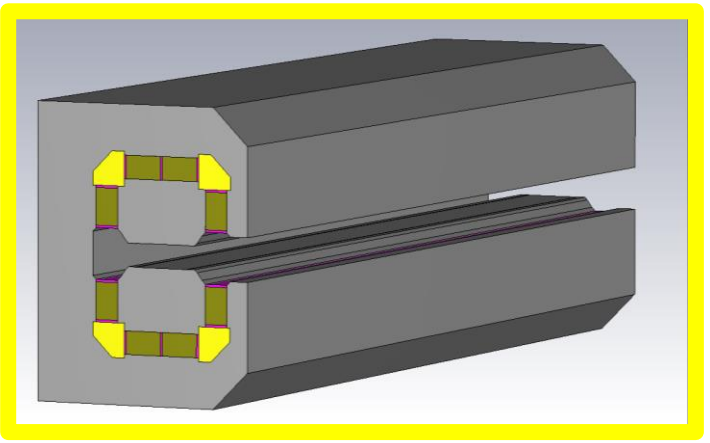
ACCELERATOR COMPONENTS

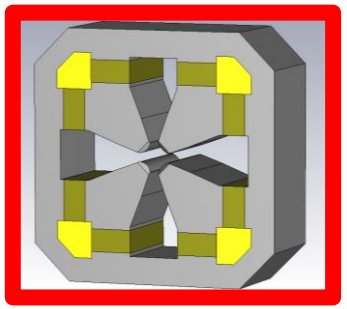


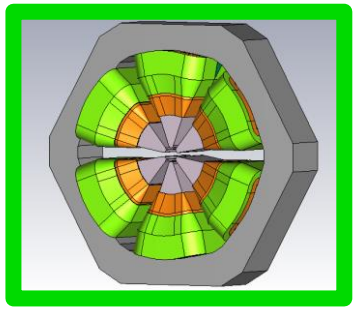
Ongoing projects to reduce running coasts for RF and magnet systems:



Quadrupoles | Homogenous bends | Reverse bends | Sextupoles







	Dipole	Quadrupole	Reverse Bends	Sextupole
Field/gradient	0.6-0.8 T	50-90 T/m	80 T/m + 0.18-0.25 T	<4000 T/m^2
Quality	$0.1 \cdot 10^{-4}$	$\sim 1 \cdot 10^{-4}$	$\sim 1 \cdot 10^{-4}$	tbd
Stability	$< 1 \cdot 10^{-4}$			
Variation	-	<10%	5%	100%
Power consumption (PM / electro)	0 kW / 290 kW	<25 kW / ~600 kW		>100 kW

	BESSY III conventional	BESSYIII PM
96 Dipoles	ca. 290 kW	0 kW
446 Quadrupoles	ca. 600 kW	< 25 kW
NL Multipoles (**240** Sextupoles, **32** Octupoles)	ca. 130kW	
Total	ca. 1000 kW	ca. 150 kW

RF2.0 RESEARCH FACILITY
TOWARDS A MORE ENERGY-EFFICIENT AND SUSTAINABLE PATH

Ongoing projects to reduce running coasts for RF and magnet systems:

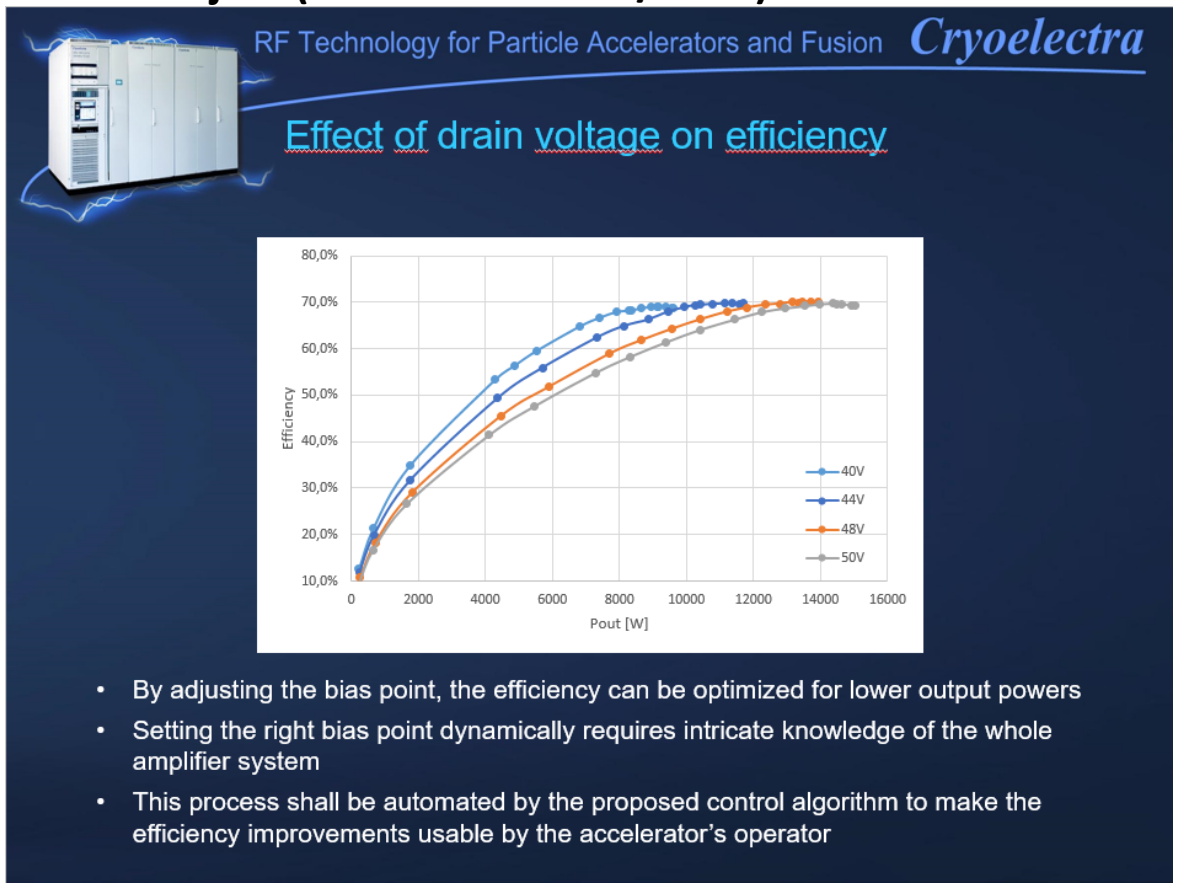
RF-components

500MHz SSA

Cryoelectra

500MHz Cavities at BESSYII

RF 2.0 Project (EU Horizon 2023/2024) WP2.2



Courtesy B. Nordmann (Cryoelectra)

This project has received funding from the European Union's Europe research and innovation program under grant agreement **No 101131850**

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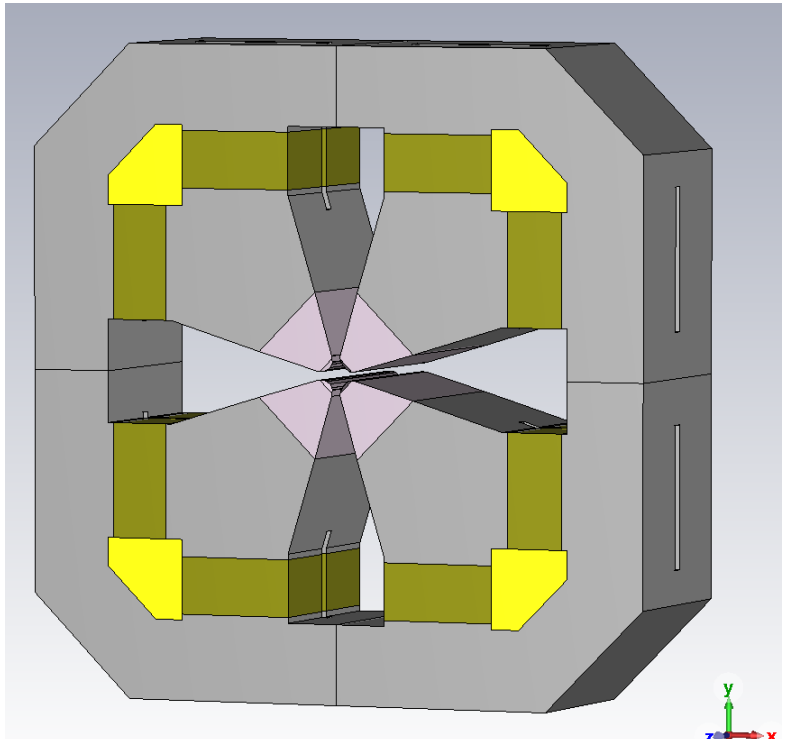
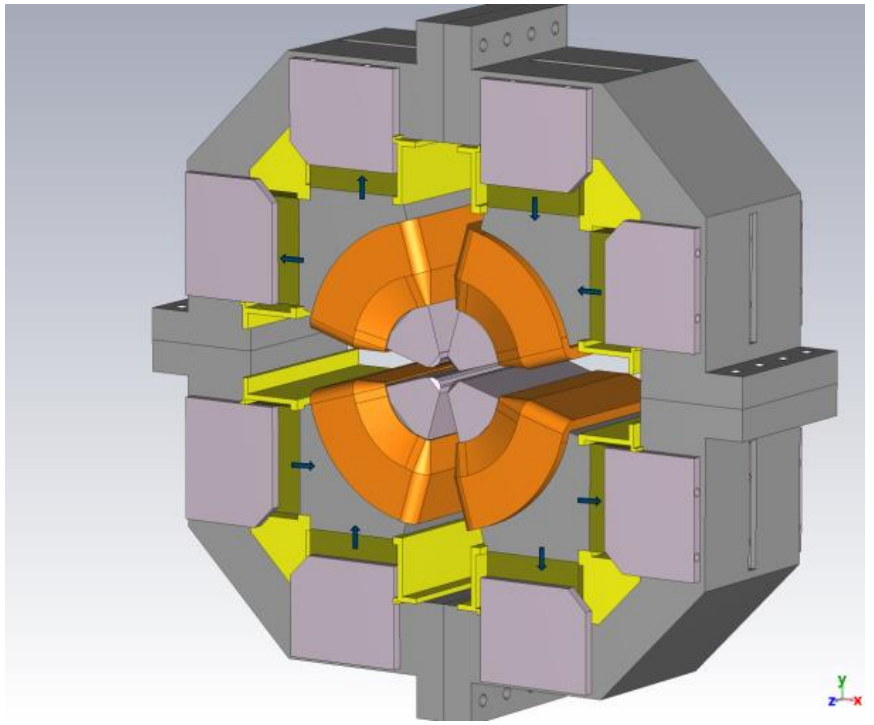


-> PM driven QP magnet with CoFe Pole Shoes (gradient up to 120T/m)
-> Pole Shoe Tip and chamfer are numerical optimized to maximize b2 (quadrupole) and to minimize central and/or integrated b6, b10 and b14

-> up 24 tuning plates (10mm thick CoFe) will be installed in parallel to PM blocks
-> position of plates reduces the max. magnetic flux (short circuit)



-> the plates are mechanical connected
-> position inside yoke can be changed via motors (slow)
-> field strength can be reduced by approx. 40% ($\sim 0.5\%/\mathrm{mm}$)
(or $\pm 20\%$ to operating point)

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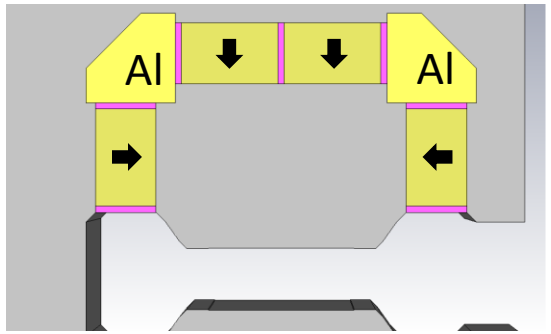
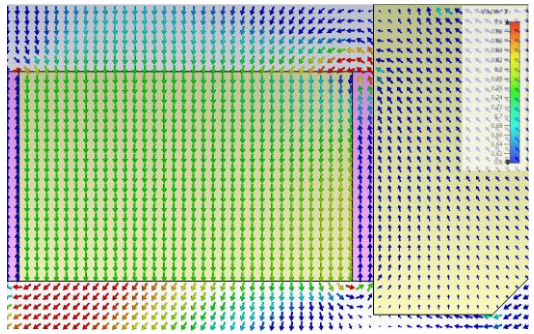
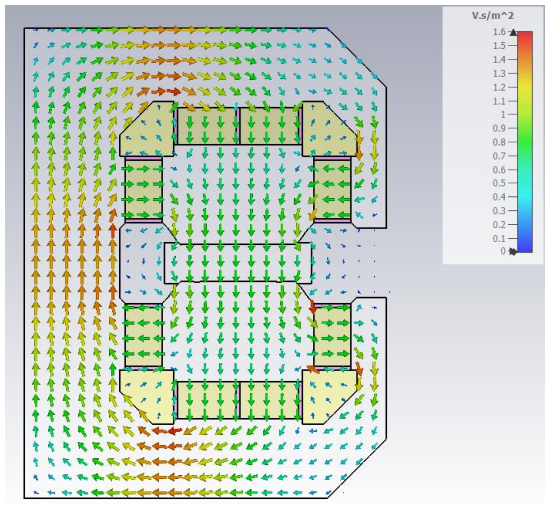
Ongoing projects to reduce running coasts for RF and magnet systems:

Homogeneous PM-Dipole for BESSYIII





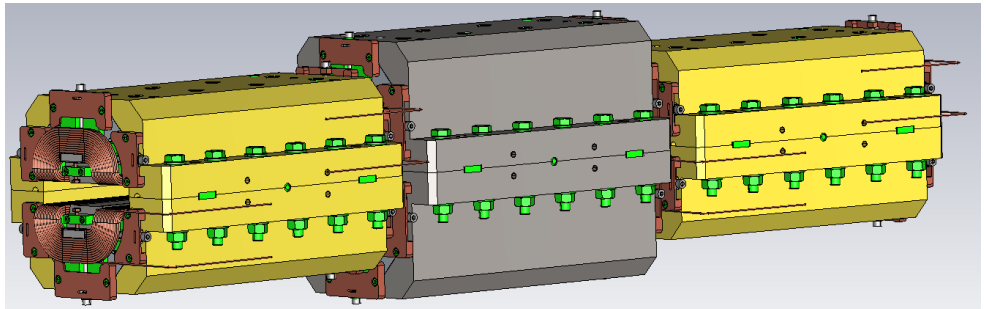


- Increased pole shoe width for straight magnet
- central notch to further flatten the field
  -> homogenous field for the full bended beam

8 PM blocks (40mm x 25mm) in transverse plane
-> 14 thermal shim plates (< 4mm thickness)

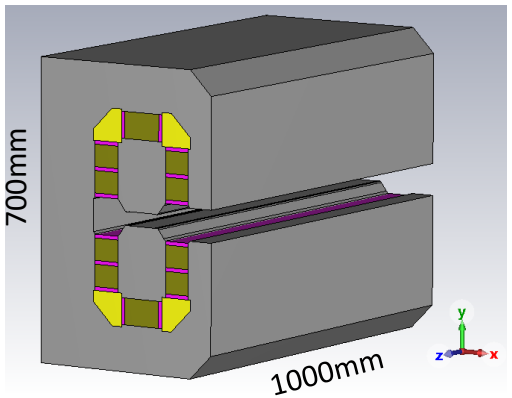
-> idea for two prototypes: **one with new PM blocks and one with recycled PMs**

PM Triplet for BESSYII+ to replace a 20kW dipole in 2025



-> 300mm hom. PM dipole magnets with (0.8T – 1.1T - 0.8T)
-> NdFeB PM with Br=1.3T
-> incl. steerer coils to adjust int. field by 4%

PM bending magnet for BESSYII+ main bending magnets



-> hom. PM bending magnet
-> up to 1.4T (4e-5 error ±20mm)
-> NdFeB PMs with Br=1.42T
-> gap 30mm
-> idea replace two existing electromagnets in BESSYII
-> temperature stabilized: NiFe

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CONSTRUCTION WORK
-> RUNNING COSTS (PV + WASTE HEAT)

Ongoing projects to reduce running coasts: Energy production

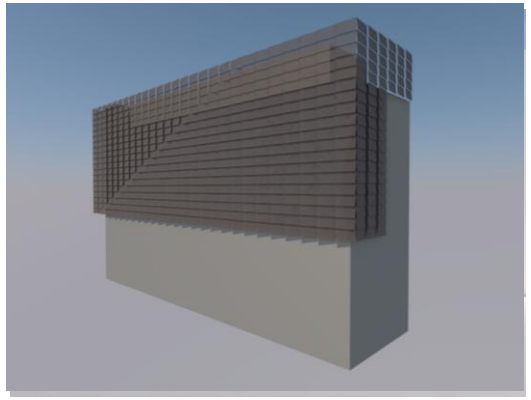
PV-facade study @ TestingHall 2
-> 360 commercial solar modules
-> installed on three sides of the building
-> 28 MWh per year
-> 120 measurements points and sensors

1.2MW
Waste heat

Evaporating cooling system

New Buildings on Campus (2027)

Technikum
(Laboritories and office)



CatLab
(Laboritories)

	Technikum	CatLab
# PV	292	106
Peak power	128.5 kW	64 kW
kWh/a	~84000	~42000

Ongoing projects to reduce running coasts: Energy production

1.2MW
Waste heat

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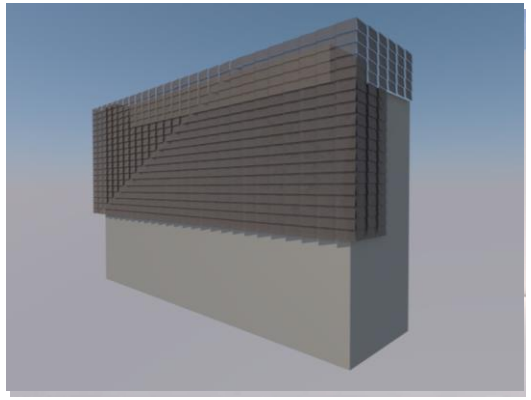
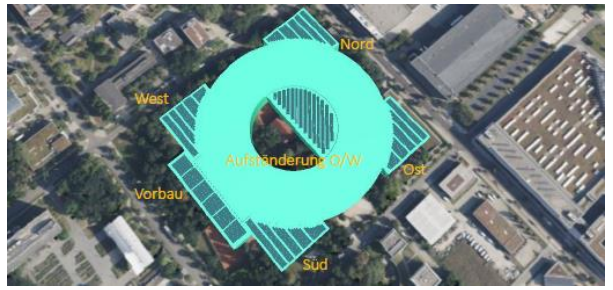
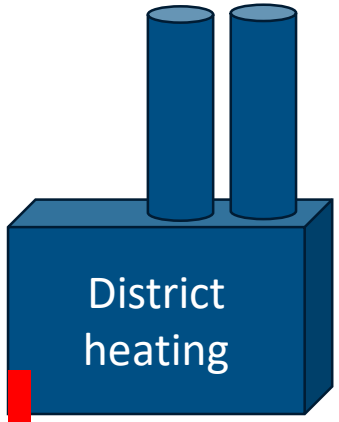


CatLab
(Laboritories)

Option for BESSYIII
Energy-harvesting potential by
PV-skin: **3 GWh/a**



Ongoing projects to reduce running coasts: Energy production



Heat
Recovery

1.2MW
Waste heat

Evaporating cooling system

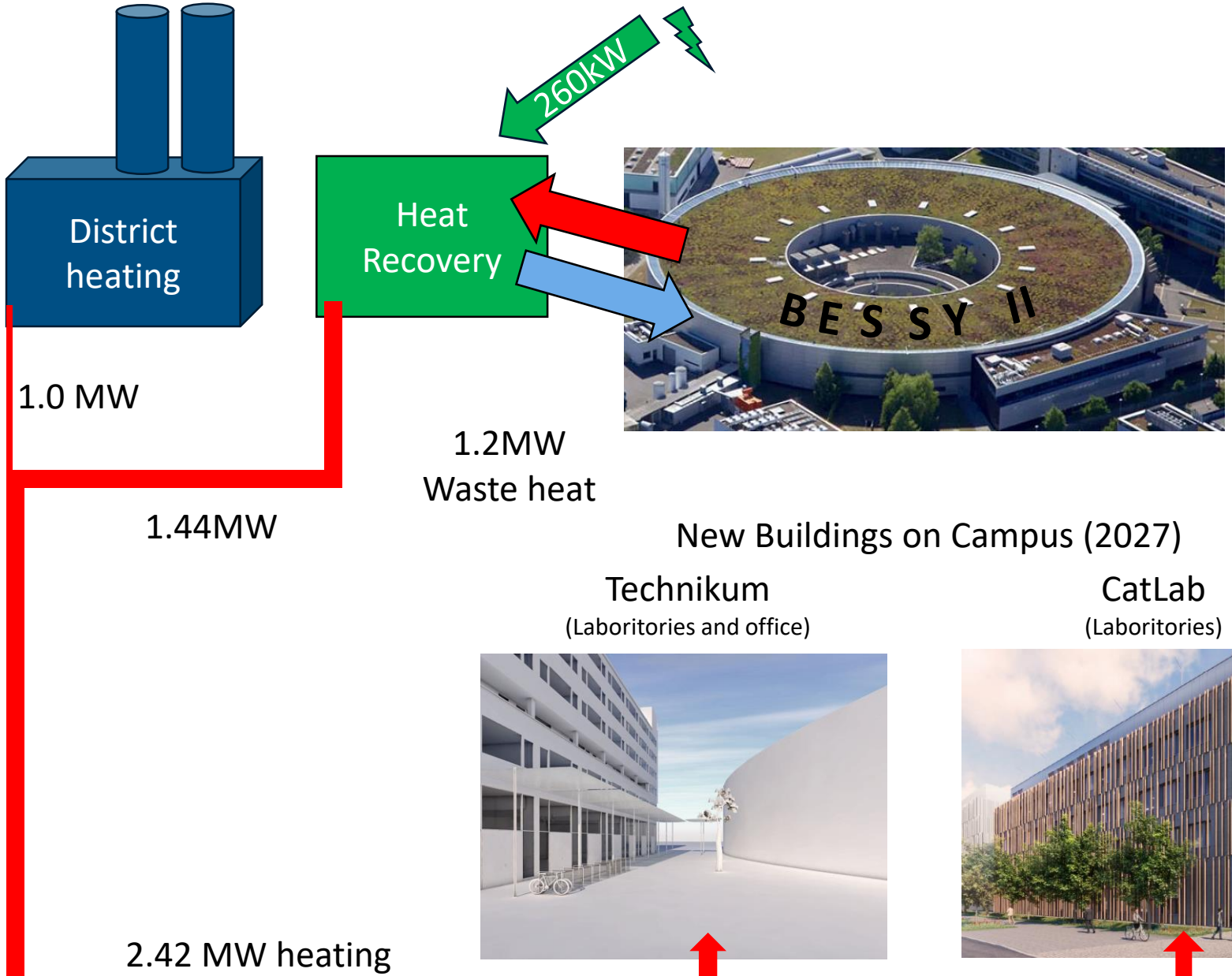
New Buildings on Campus (2027)

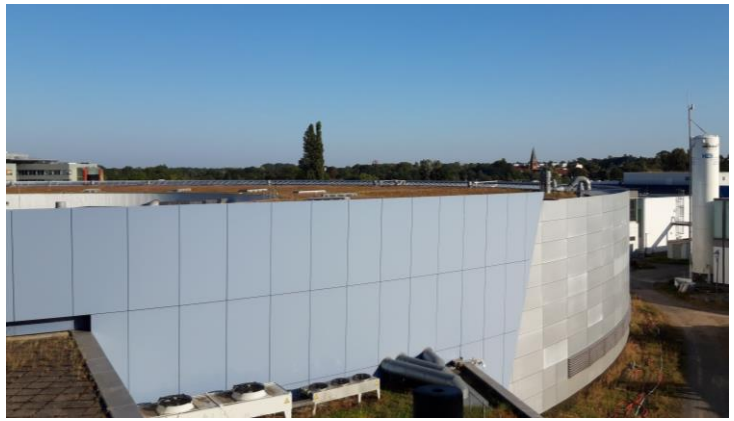
Technikum
(Laboritories and office)

CatLab
(Laboritories)

2.42 MW heating

Ongoing projects to reduce running coasts: Energy production





Option for BESSYIII

- ➔ Implementation of heat recovery direct from the beginning of BESSYIII into the local network
- ➔ Realiziation and scope of such a project has to be discussed with local network provider
- ➔ Just starting

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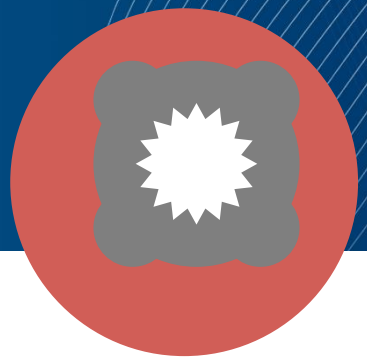
CONSTRUCTION WORK
-> INITIAL COSTS



POSSIBLE ADJUSTMENTS IN THE CONSTRUCTION PHASE

- **material-optimized construction**

  e.g. use of carbon concrete to save concrete, which must have minimum coverings to protect the conventional reinforcing steel from corrosion

- **optimized construction shape**

  optimize shape and cross section of the ground plate for **high stiffness and vibration dampening**, but **less concrete**

Example: Cube in Dresden - the world's first building made of carbon concrete (from: www.bba-online.de/news/cube-neues-bauen-mit-carbonbeton/#slider-

Comparison reinforcing carbon and steel (from https://www.carbocon.de)

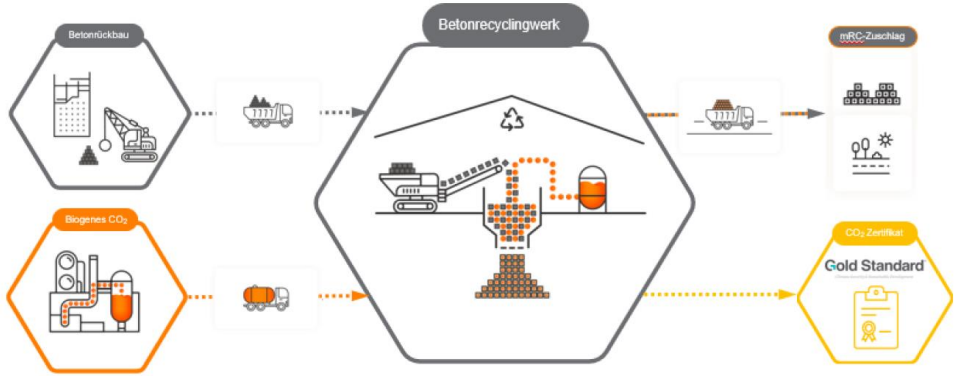
Standard monolitic block

-> ca. 30000m³ concrete

(5% reinforcement)

CO_2 equiv. concrete (t)	ca. 10000
CO_2 equiv. steel (t)	ca. 17500

Options to reduce concrete:



Recycled concret -> 10-18% less CO2

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Standard monolitic block

-> ca. 30000m³ concrete

(5% reinforcement)

CO_2 equiv. concrete (t)	ca. 10000
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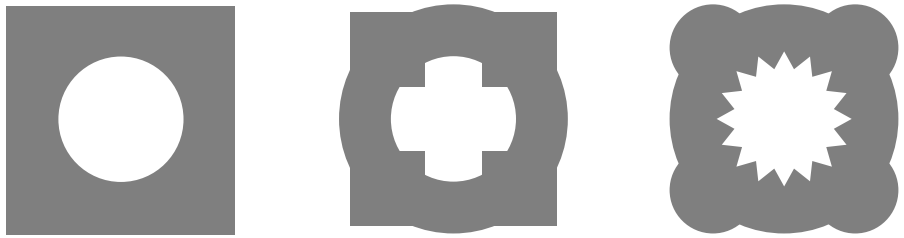
Options to reduce concrete:

-> different cross sections and material distributions:

-> different shapes of the ground plate:

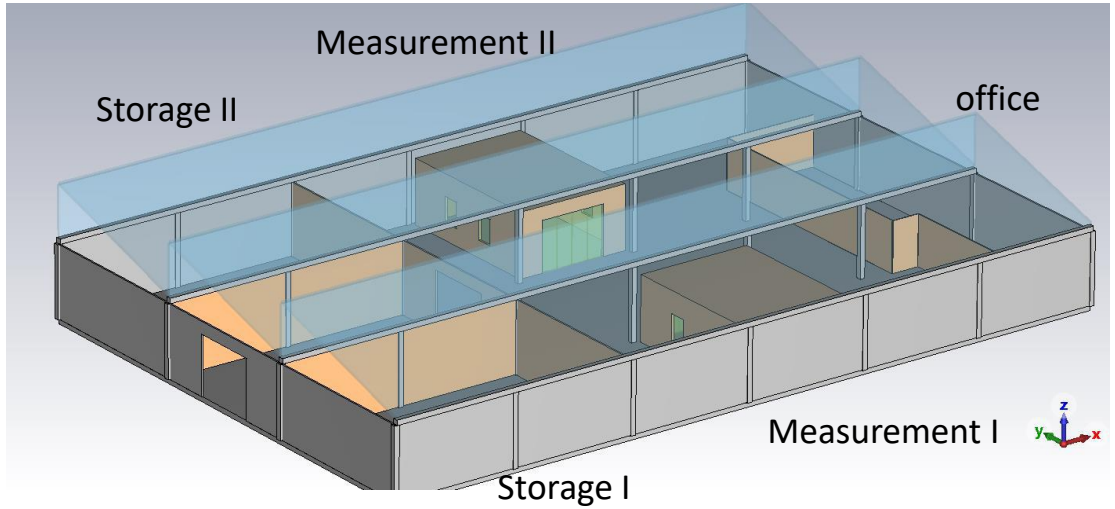


-> Optimization via FEM calculation (static and dynamic parameters) based on measured vibration spectra and assumed load distributions

NEW MAGNET LABORATORY FOR PM AND UNDULATOR DEVELOPMENTS

renting laboratory space instead of rebuild it

-> necessary for a new MagnetLab for PM construction and tests
-> found a 1300 m^2 space for storage/office/construction/tests next to our campus
-> can be used for all ongoing magnet projects in the next 10-15 years
-> idea: modular installations can be deassambled after project time
(we can ends the contract after finishing the big projects)
-> in best case: all magnets for BESSYIII can be assembled and tested there
-> we do not need this space as part of our technical hall for BESSYIII (>4000m^2)
-> costs and carbon footprint can be reduced!



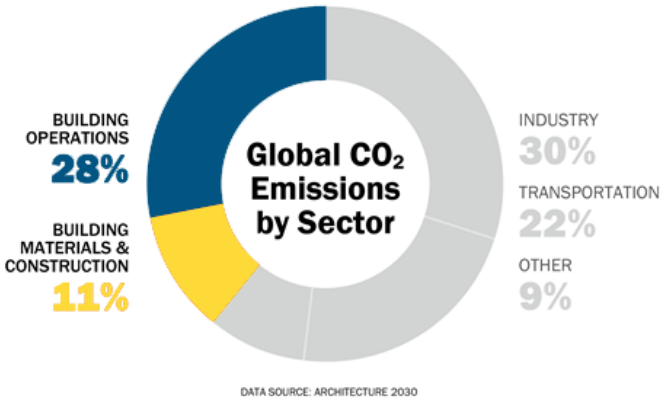
210 m^2 construction area (girder and magnets)
140 m^2 test in thermal stabilized chambers
140 m^2 warm tests
140 m^2 storage for magnets and magnet components
140 m^2 workshop and storage
100 m^2 office/IT/etc.

SUMMARY

-> construction work has most impact for initial GWP
-> optimize material consumption
-> rent instead of own construction

-> decrease running costs
-> install direct energy production
-> Using heat recovery

-> clarify material sources to minimize GWP
-> Recycling?



https://www.architects.org/news/the-new-net-zero

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Thank you!

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