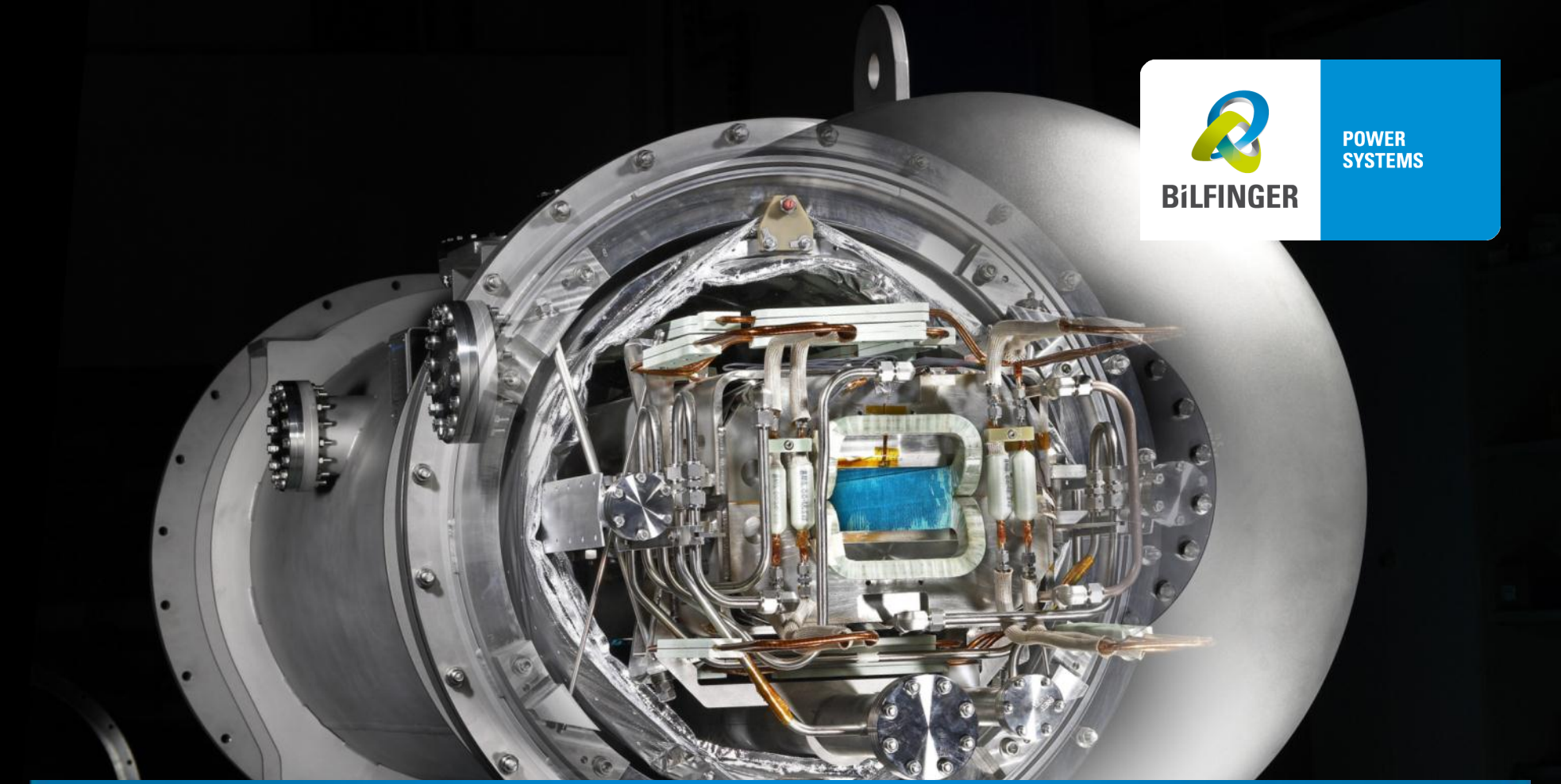


BILFINGER POWER SYSTEMS

Babcock Noell GmbH

Projects and Development Activities at Babcock Noell

Workshop on Superconducting Technologies for the Next Generation of Accelerators 2012

Wolfgang Walter

Outline

- Babcock Noell GmbH
- Superconducting Dipoles
  - LHC Main Dipoles
  - EDIPO
  - SIS 100 Dipoles
- Some Recent Projects
- Recent Developments
  - Cryogen Free Magnets
  - HTS Activities
- Summary

Babcock Noell: Member of Bilfinger SE

Bilfinger SE

Bilfinger Power Systems GmbH

- Energy Technology
- Piping Technology
- Nuclear- & Environmental Technologies
- Machinery- & Apparatus Engineering
- Power Plants

Babcock Noell GmbH

Nuclear Services

Nuclear Technologies

Magnet Technologies

Environmental Technologies

Babcock Noell`s contribution to the LHC

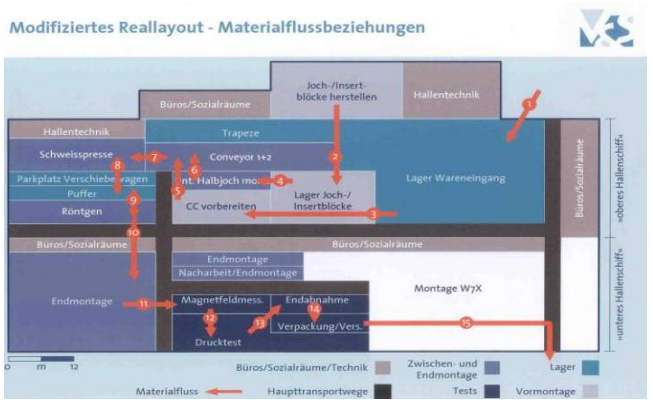
Prototypes

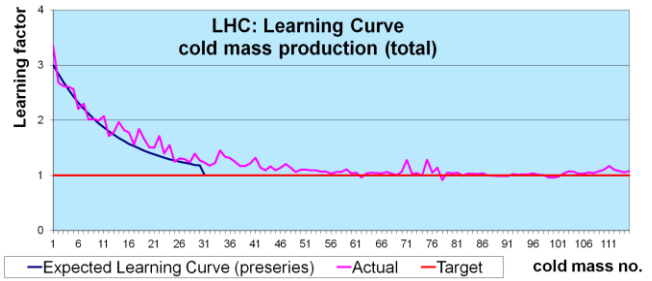
- 1990: 10 m Prototype Cold Masses
- 1995: 10 m All Kapton Collared Coil
- 1997: Tooling Extension 15 m
- 1999: Two 15 m Prototype Collared Coils

Series:

- 1999: 30 Cold Masses
- 2002 - 2006: 386 Cold Masses
  - Overall length 15 m
  - Total weight 30 t
  - Magnetic field 8.33 T
  - Operating current 11.8 kA @1.9 K
  - Rutherford Cable

Up to 4 magnets per week, delivery 7 months ahead of schedule





Cooperation between Industries and Institute: Best Practice Sharing

- A technical exchange between companies in the interest of the project
- Manufacturing the same amount of an identical product by 3 suppliers
- Process started on the initiative of Babcock Noell with support by CERN:
  - Exchange on technical information with respect to the production, tooling and material
  - Discussion on the project status (excluding commercial issues)
  - Mutual support in acquisition of material and tooling
  - Mutual support in case of material shortage or production bottlenecks

Improvements	Benefits of Customer	Benefits of Company
Avoiding of repetitions of mistakes	Higher quality of the final product	Satisfied customer
Optimization of production process	Acceleration of delivery time	Reduced cost due to reduced project duration
Purely technical exchange, alternative solutions from others without discussion on contractual obligations, responsibilities	More uniform products from the various companies	Additional back-up solutions for shortages and bottlenecks
Direct exchange with no intermediate customer	No loss of information or possible misunderstanding	

EDIPO: Manufacturing of high field Nb_3Sn Dipole

Nb_3Sn-Dipole Magnet for ITER Conductor Tests

- Magnet Design: EFDA
- Manufacturing incl. Tooling concept: Babcock Noell
- Customer: EU, (EFDA, F4E) 2006 – 2011

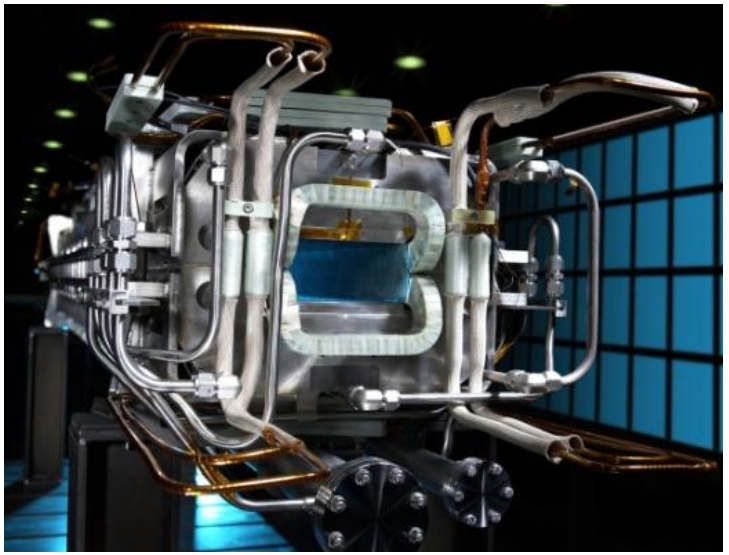
- Magnet Parameters
  - Magnetic Field 12 T
  - Length of cold mass ~ 3 m
  - Total weight 21 t
  - Operating current 17.6 kA @4 K

- Challenges
  - Winding of CICC with steel jacket
  - Heat treatment
  - Insertion of magnet in outer cylinder
  - Coil repair

SIS 100 Dipoles for the FAIR Project

Fast ramped superferric dipoles:

- Fast ramping → 4 T/s
- NbTi, Nuclotron Cable
- Length ~3 m. Magnetic Field 1.9 T
- Customer: GSI

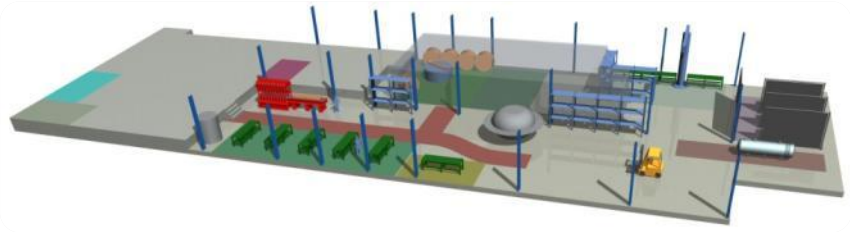


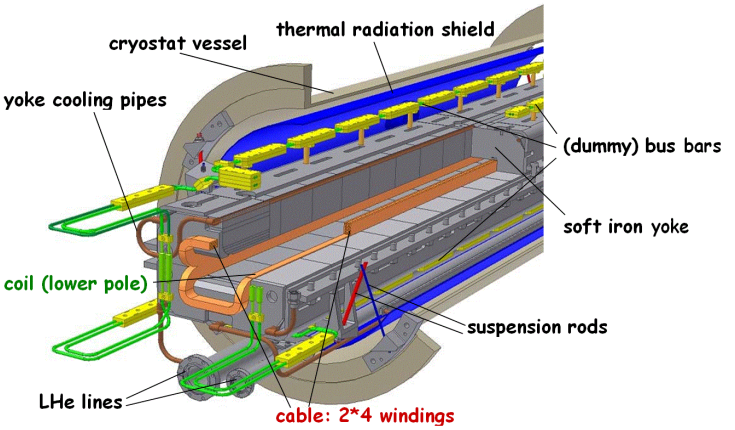
Prototype

- Industrial manufacturing of the SC cable
- Qualification for the industrial series production

Series

113 series magnets including first of series dipole





SIS 100: Development of a Fast Ramping Superconducting Dipole

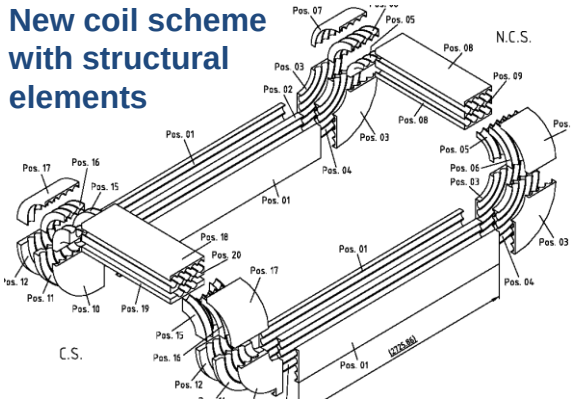
EU-FP6 Development by GSI with partners from institutes and industries:

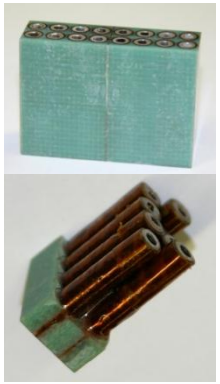
- Strong dynamical forces
- High accuracy and reproducibility

Babcock Noell contribustions to EU-FP6 programm:

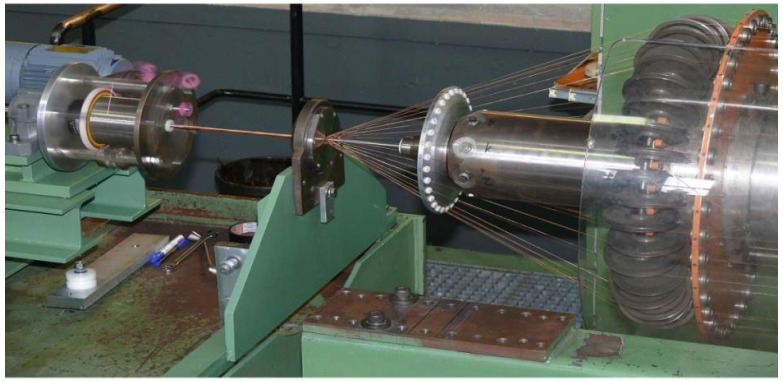
- Design and Layout
- Winding Scheme and Tooling Concept
- Several Test Pieces
- Measurements mech. and thermal properties

New coil scheme with structural elements

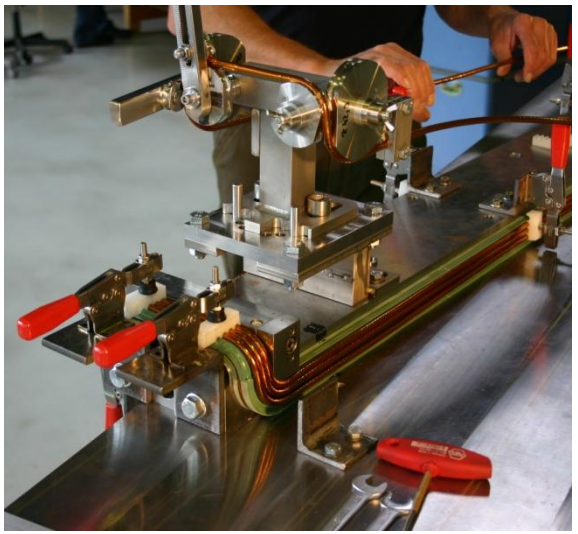




Samples for testing



Cable manufacturing at BNG



Winding

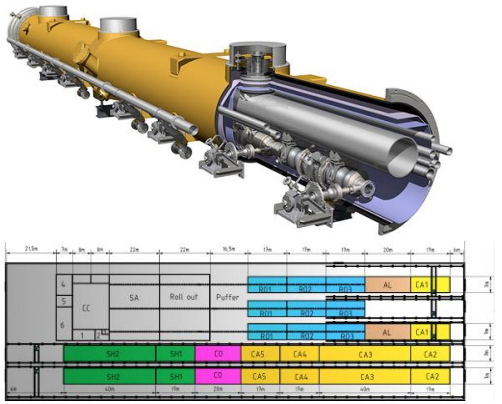
Some Recent Projects

Wendelstein W7-X, IPP
1998 - 2008

PM Undulators for PETRA III, FLASH ,
FLASH II DESY, 2008, 2012 -2013

COLDDIAG, KIT 2009 – 2011

SC Solenoids for Spin-Echo
Spectrometer, FZJ 2006 – 2009



Study on the ILC-Cryomodules
Assembly, CERN 2012

Conduction Cooled Systems

- SC magnets without the additional costs and problems related to LHe handling
- Additional Benefits:
  - Portability
  - Compactness
  - Potential for lower costs (in the long run!)

- **BNG successfully developes Conduction Cooled Systems since 2006**

SC Undulators

- Movable gap
- Precisions within 40µm
- Cryogenic circuit

	SCU15 DEMO	SCU20	SCUW
Conductor	NbTi		
Period length	15 mm	20 mm	18–54 mm
Active length	1.5 m	1.5 m	2 m
Dimension of gap	7 mm	5 to 7 mm	7 mm
Magnetic field on axis	0.7 T	1.18 T	1.09 – 3.2 T
Design beam heat load	4 W		
Numbers of cryocoolers	4		

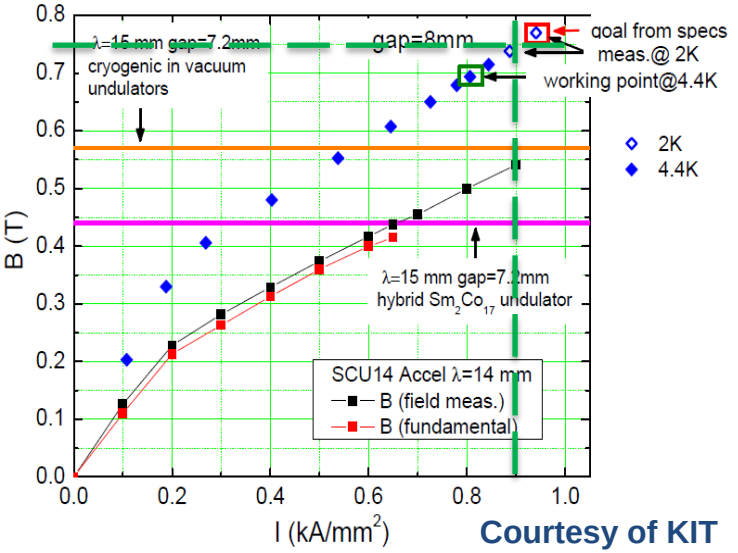
Neutron-Spin-Echo-Spectrometer

- 2 SC solenoid systems installed at Spallation Neutron Source, USA
- Active shielding
- Coil position measurement accurate to 2 µm
- Magnetic field on axis: 1.4 T

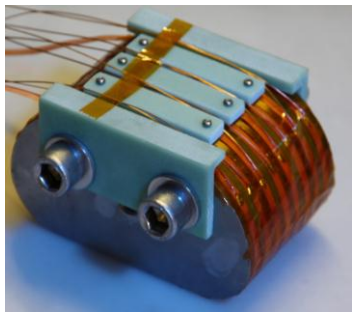
HTS Magnets Development

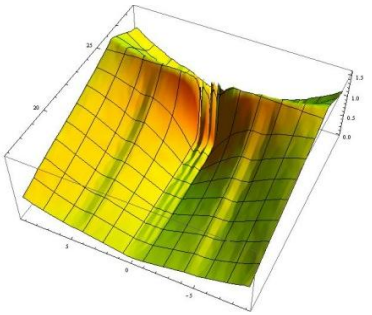
- 2010 **First prototype 2G HTS Undulator** :
  Successfully shows higher performances compared to NbTi are in principle feasible
- 2011 **First tests of double pancakes**
  with development of specific tools for HTS coil design
- 2012 Investigation of **impregnation technology** for HTS coils

- **Infrastructure for LN2 and cryogen-free tests**



Courtesy of KIT





Conclusion

- **Babcock Noell** successfully **develops, designs and manufactures superconducting magnet systems** for more than 15 years
- On projects such as the LHC Main Dipoles or the FAIR SIS100 Dipoles, Babcock Noell **collaborated closely with institutes**
- Collaboration between institutes and industries can be **benefitial for customer and supplier if a suitable collaboration scheme** (win-win situation) is implemented. The experience from best practice sharing has made this evident.
- Babcock Noell is **open to such collaboration** for the future
- For **conduction cooled systems and HTS coils** there are ongoing developments at Babcock Noell
- **There is an exciting future for superconducting magnets ahead.**

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