Superconducting Materials and Magnets Technology at Oxford Instruments

Ziad Melhem

Oxford Instruments NanoScience, UK

Workshop on Superconducting Technologies for the Next Generation of Accelerators
4-5 Dec 2012 - CERN

Diverse End Markets

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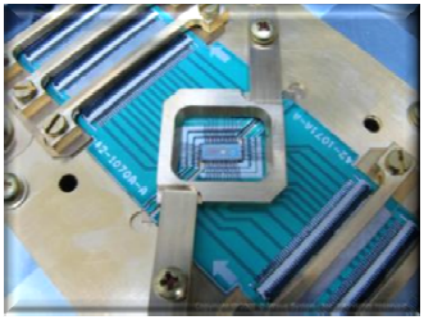
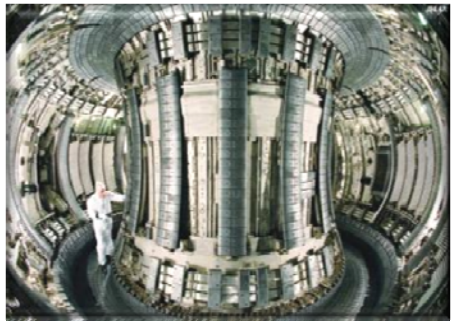
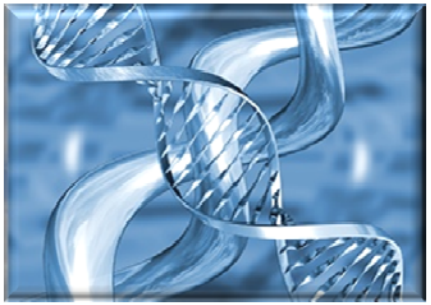
Quantum Computing

Image courtesy of D-Wave Systems Inc



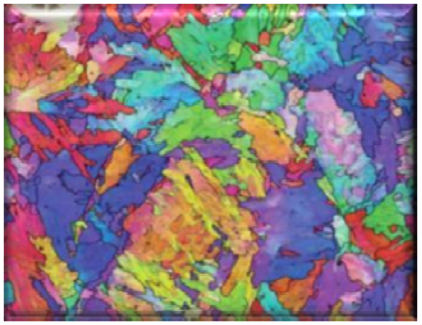


Energy Generation



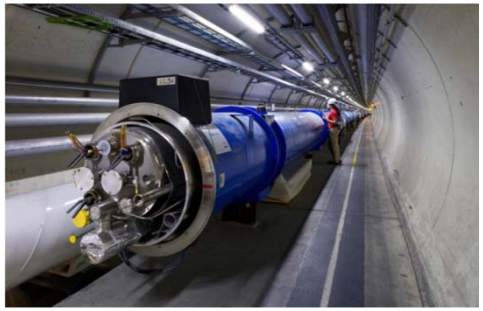
Life Sciences

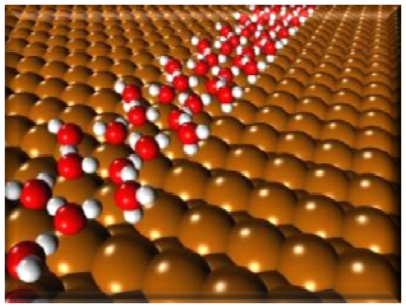
Health Care



Materials Discovery/ Characterisation

Semiconductor Research





HEP/Particle Discoveries

LHC magnet (Courtesy of CERN)

Nanotechnology/ Mesoscience

Manufacturing Sites (~1800 Staff)

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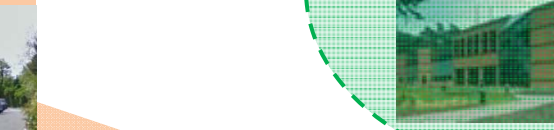
NanoScience
Tubney UK



Bristol UK

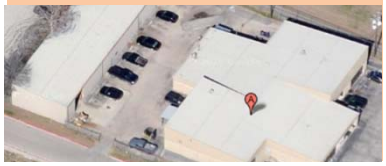
Espoo Finland

OST
Carteret USA

High Wycombe UK

Scotts Valley USA

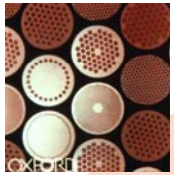
Austin USA



Uedem/Taunusstein
Germany

Shanghai China

Timeline of Innovations!



1960 -1970
Applications

Research Magnets

NMR

Physics

Magnets

1980-

Volume Production

MRI

HTS (1986)

Split Pair

2000 -

New Frontiers

High Field Magnets

Solenoids

NMR

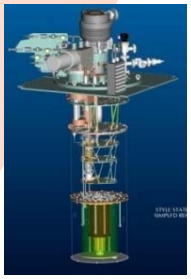
Split Pair

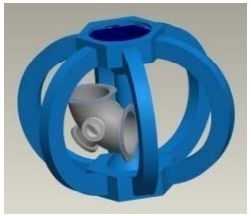
Energy Applications

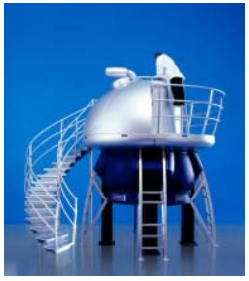
Transport

Large Scale

Special Projects







New generation of Superconducting Magnets

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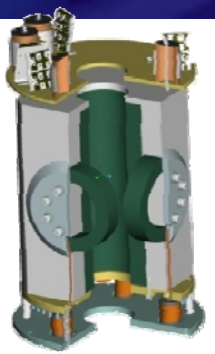
- **New compact HF products**
  - Solenoid magnets up to 20 T and, with HTS insert coils, 22.5 T at 4.2K
  - Split pair magnets
  - Vector rotate magnets
- **Specific properties for applications**
  - High homogeneity, high stability
  - Cancellation, modulation, gradient coils
  - Active shielding
- **Cooling technologies**
  - Liquid helium ('wet')
  - Recondensing
  - Cryofree®
    - 'Stand alone' cryofree magnets
    - Cryofree magnets with shared cooling




Types of internal tin Nb_3Sn wires used for high fields

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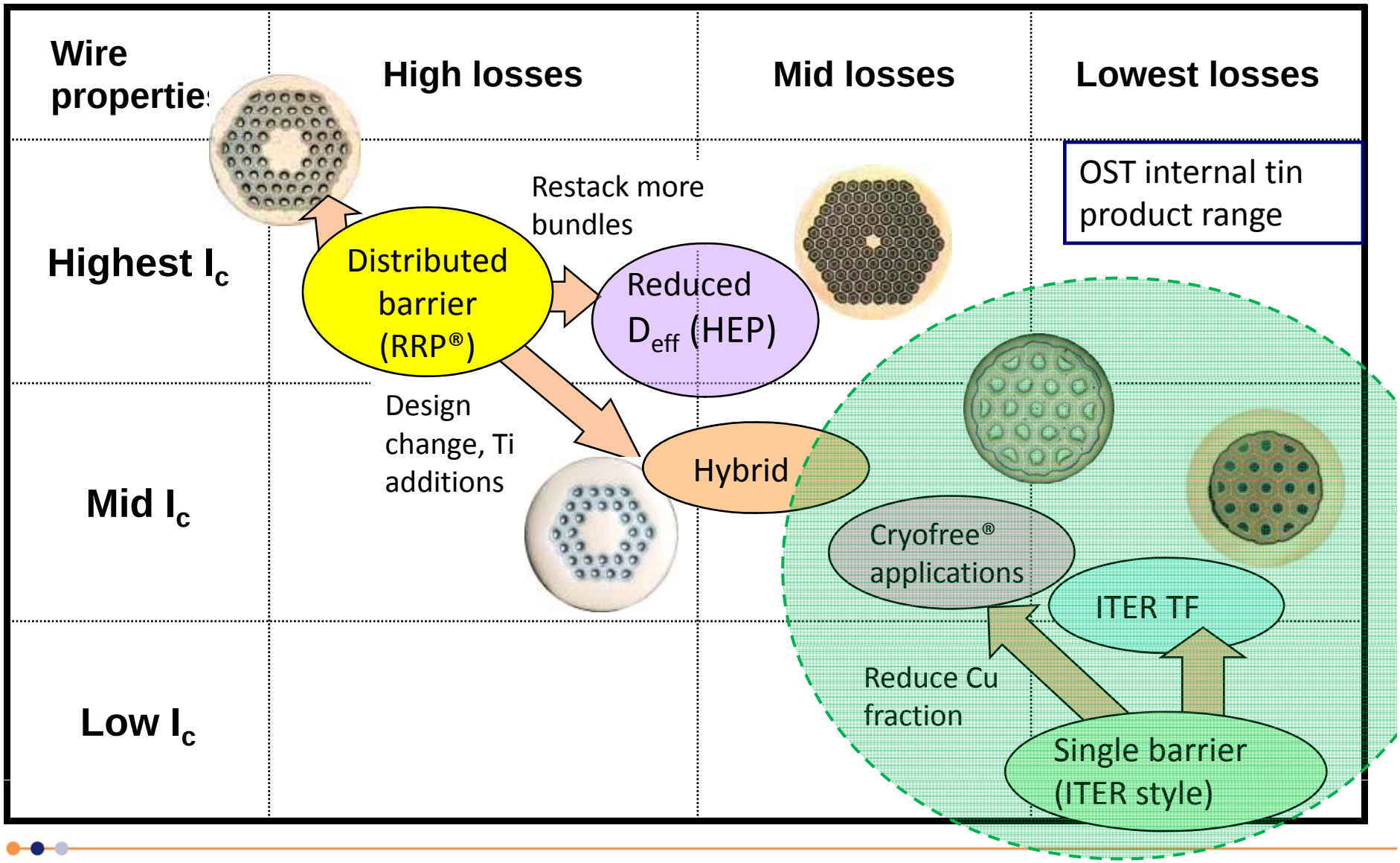

Innovative New wires –
Engineering current density for RRP® wires

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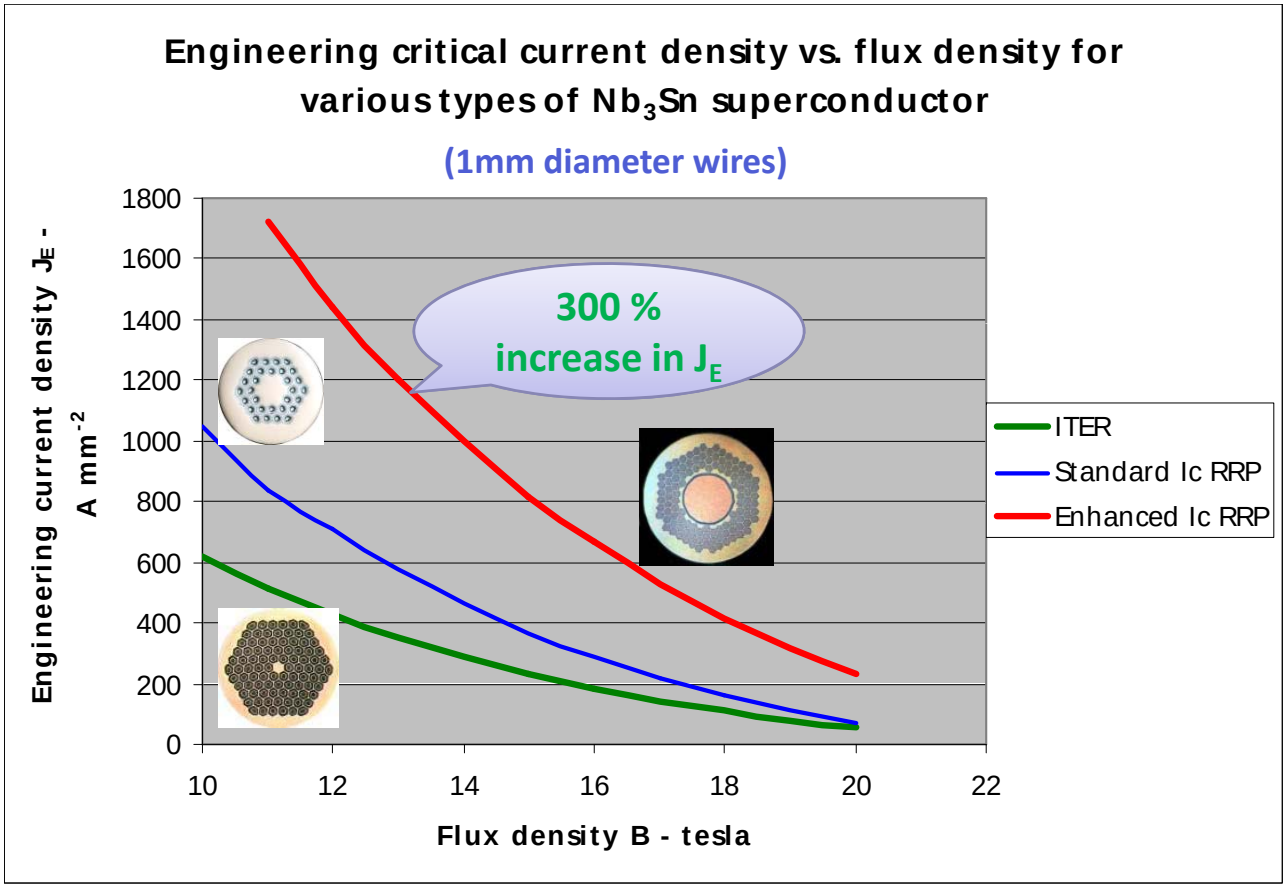

- **'Internal Sn' RRP®**

  Internal Sn wires with **large filaments** enable very high field magnets

- **ITER 'Internal Sn'**

  But for Cryofree magnets, we must reduce the heating from wires when running magnets , hence (**small filaments**)

ITER wires use RRP® technology but with fine filaments for low AC loss heating & thermal stability management

The advantage of ITER style Nb_3Sn vs hi J_c RRP®

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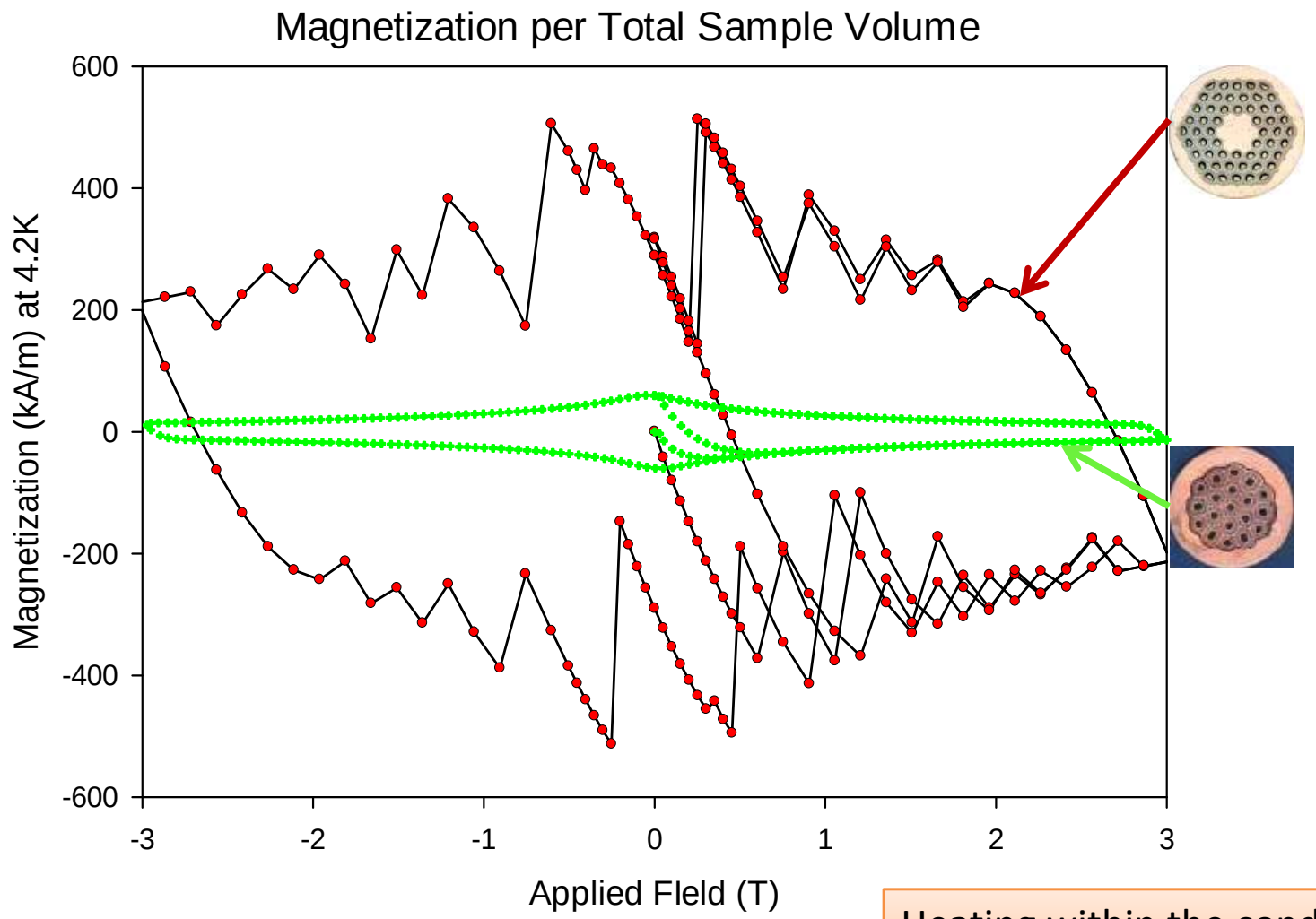

Distributed barrier (RRP®)
-High Jc

-D_{eff} large

-Flux jumping

Single barrier (ITER style)
-Lower Jc

-D_{eff} small

-Minimised flux jumping

Heating within the conductor (the AC losses) are much lower 'ITER style'

Measuring temperature profiles of magnet coils

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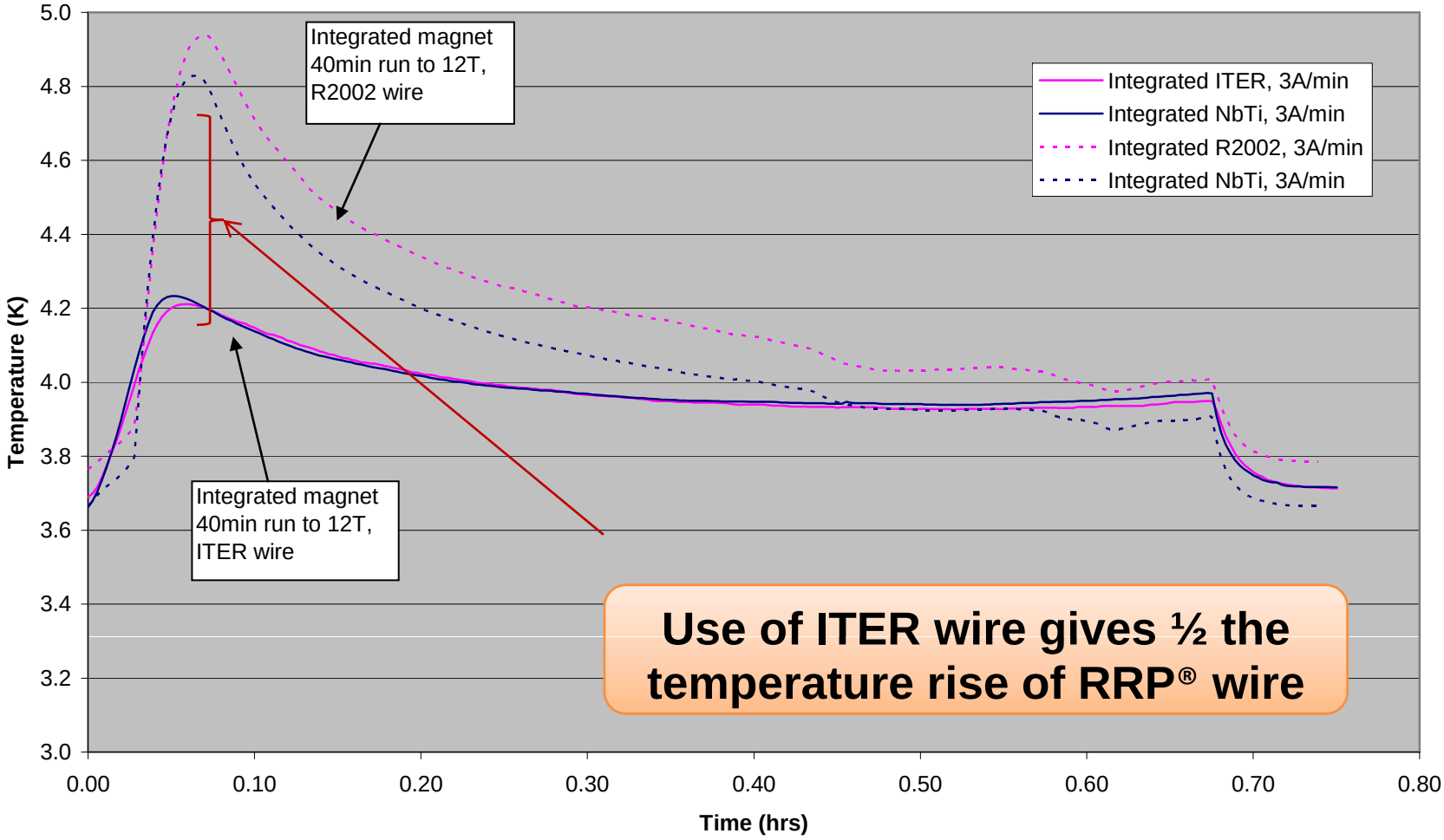
12T magnet run to field with 'ITER style' & RRP ® coils



Innovative Magnet Technology Solutions

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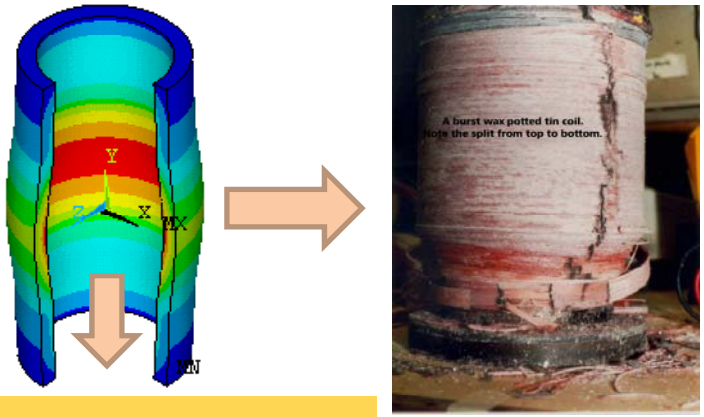
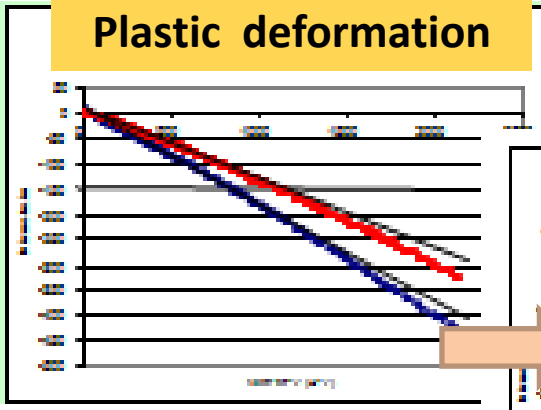
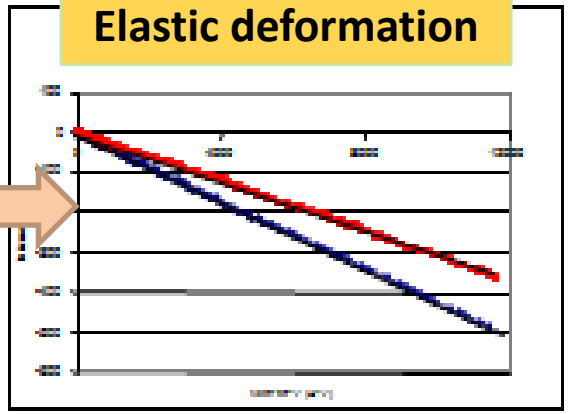
Coil Structure



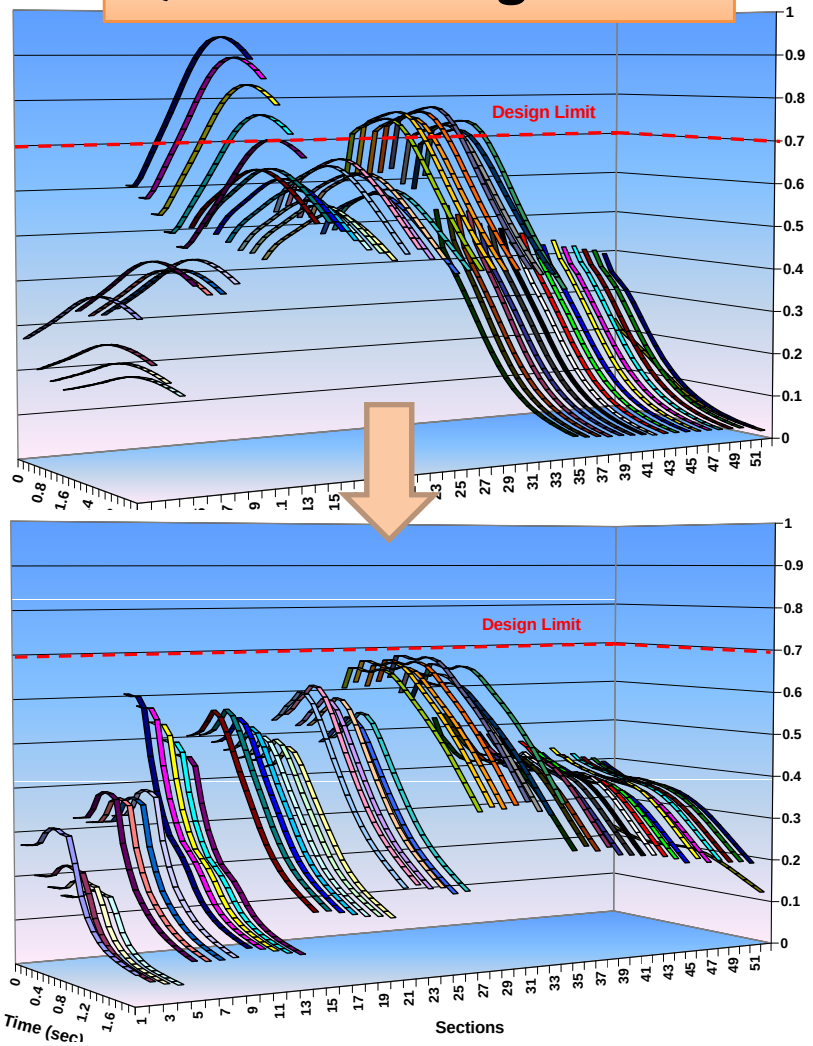
Non-Linear deflection
Plastic deformation



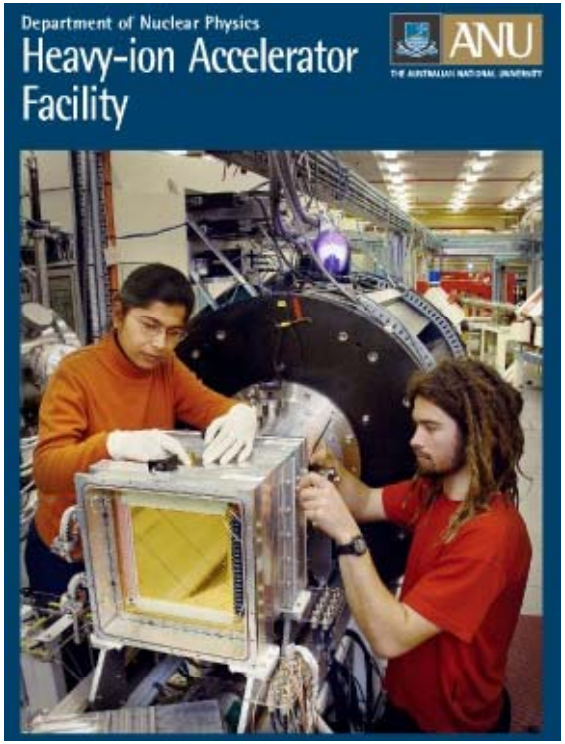
Linear deflection
Elastic deformation

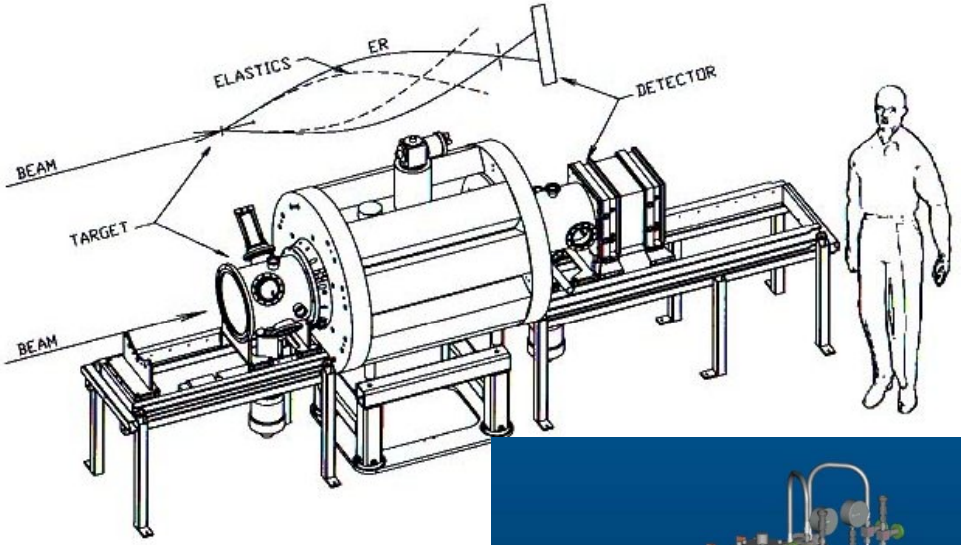


Quench Management



Cryofree Beamline Magnets





SOLITAIRE: SOLenoid for In-beam Transport And Identification of Recoiling Evaporation-residues

8T Cryofree

~210mm w.bore / 720mm long

HTS materials - Bi-2212 Round Wire and Compact High field Magnets (22.5T)

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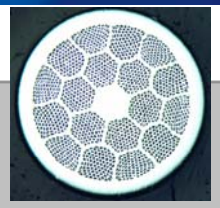
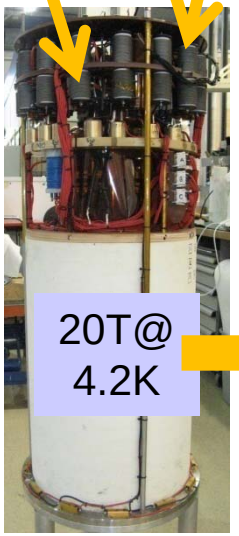


85x 15

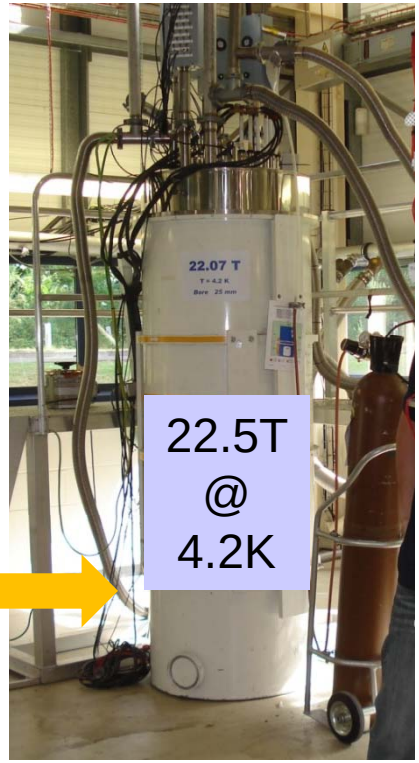
Reported at ASC 2012

Achieved at OI 2010

- Leakage free
- More uniform & weak field dependence
- Longer wires up to 1000m
- More layers up to 14



20T@ 4.2K



22.5T @ 4.2K

Timeline of recondensing beamline magnet development

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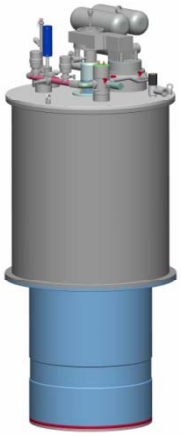
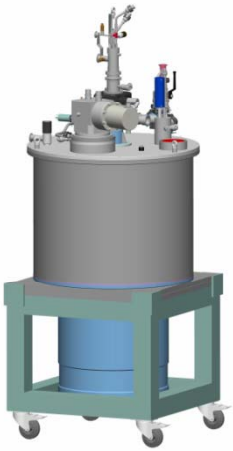
ISIS 14 T



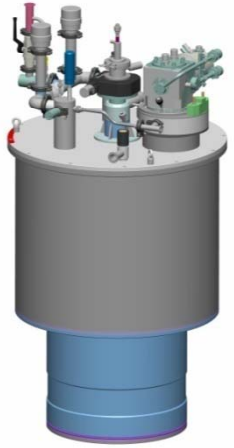
ILL 10 T

HIFR 8 T

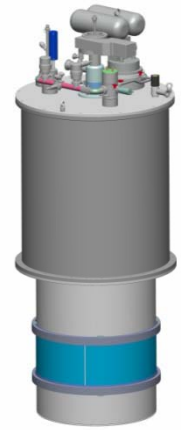


ANSTO 12 T

CARR 7 T

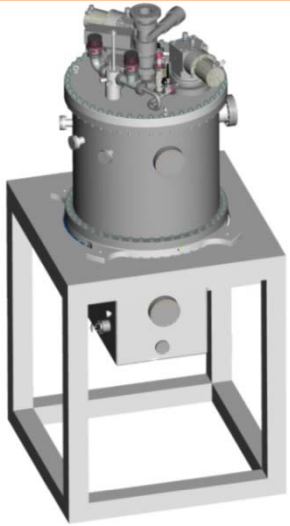


2009 2010 2011 2012

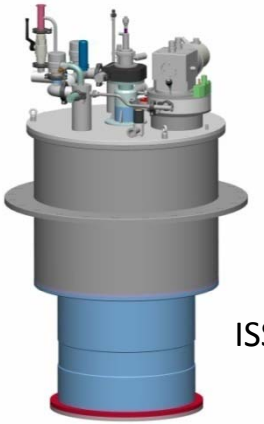


ISIS 9 T

ILL 7 T
wide access



DLS 14 T UHV



ISSP 12/14 T

Cryofree® magnet and 'Integrated System' With Shared Cooling

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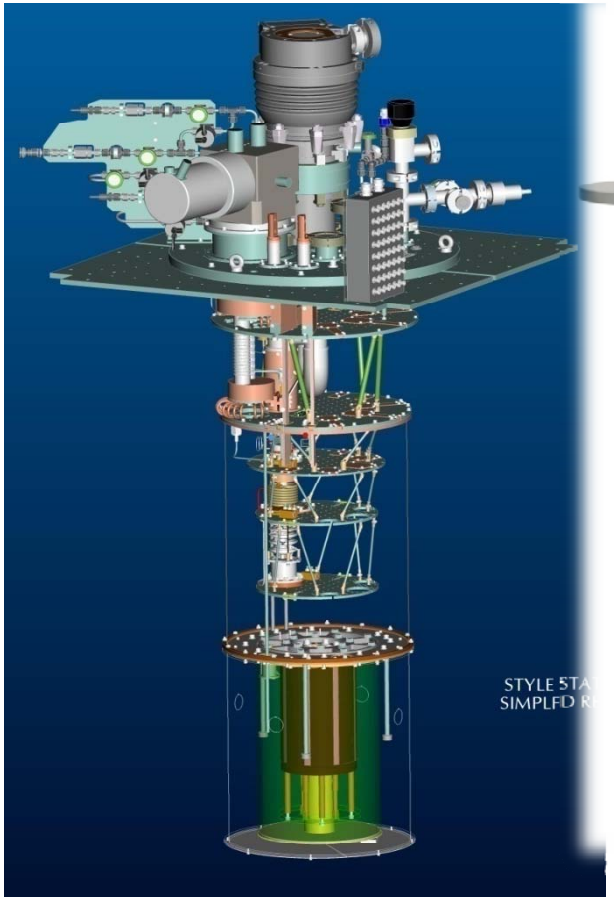
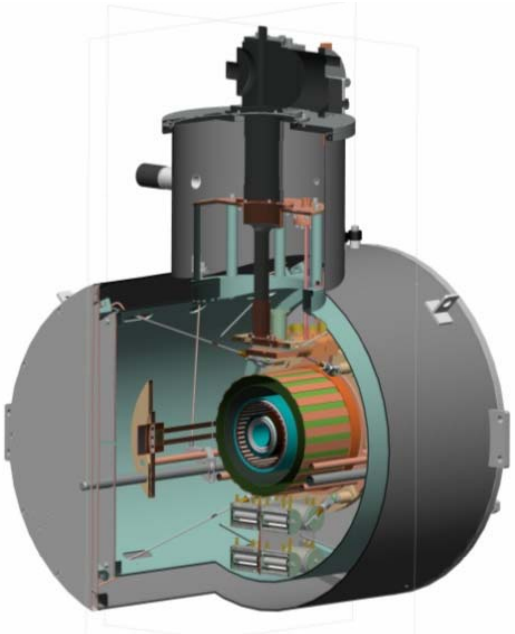
- New 12T magnet for dilution refrigerators >10 installed worldwide
- New 15T design for dilution refrigerators - under development



Sample at 10 mK, using a single 1W pulse tube refrigerator

- 18T Cryofree® magnet RT bore magnet systems
- demonstrated utilising high Jc RRP® conductors



Detector Magnet for the Alpha experiment at CERN -1.5T Fast ramping horizontal System

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Wound main solenoid

Bo(T)	1.5
RT bore (mm)	350
Homogeneity (40mmx130mm) %	0.002
Field decay/hr %	0.0003
He boil off cc/hr	225
He Hold time days	37
Cryostat Dimensions	150cm x 95cm

Completed System

ST25 and HTS Coil Developments Route to HF Tokamaks! Via Small Tokamaks (ST)

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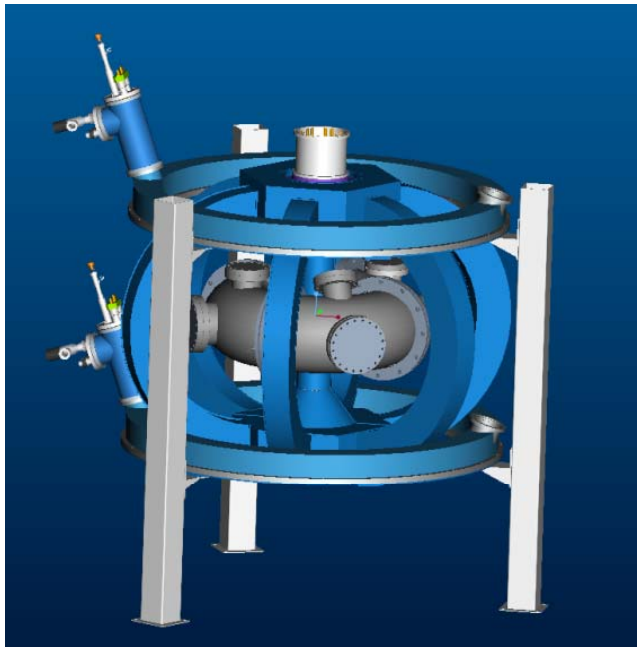
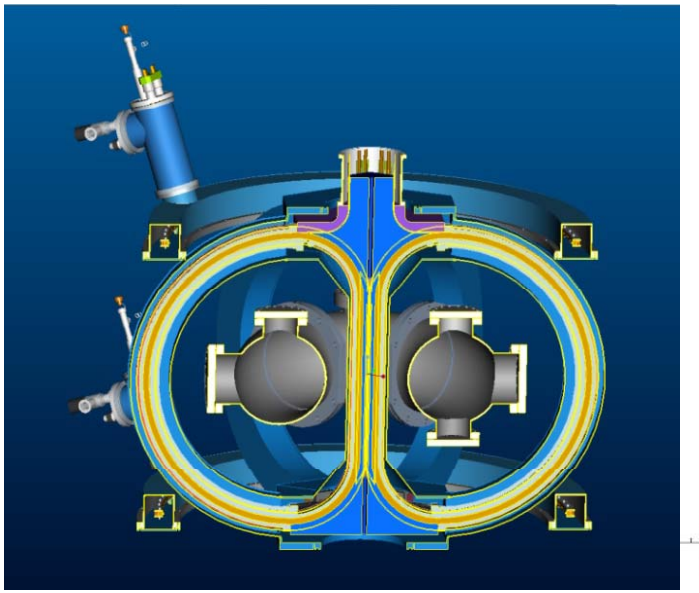
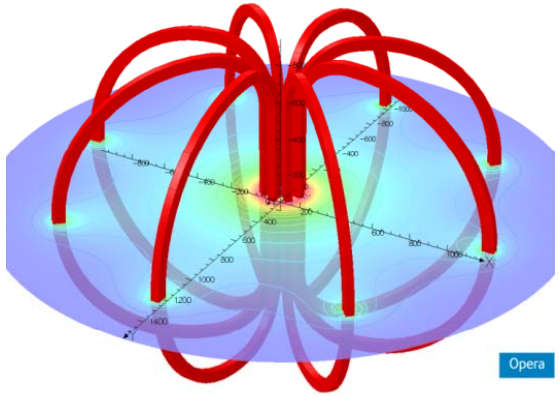
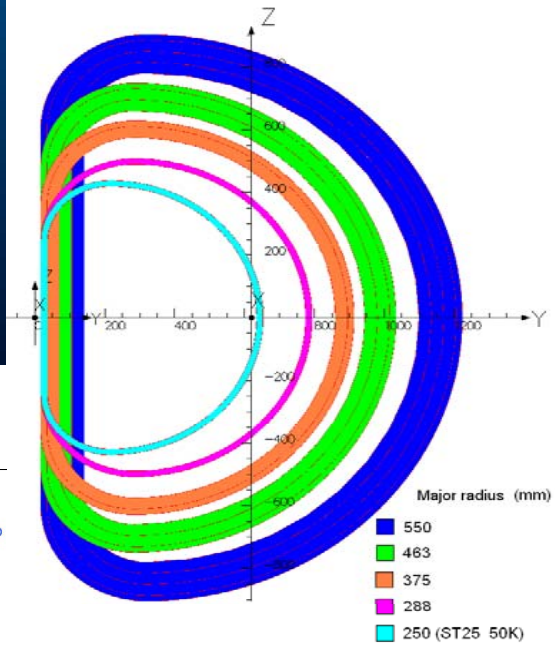


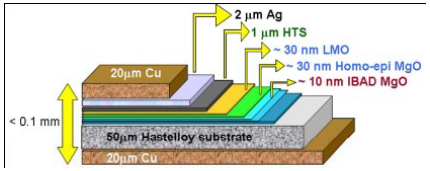




R/a	25/12.5cm
B_t	0.4T
700m HTS	12mm YBCO



Tokamak Solutions



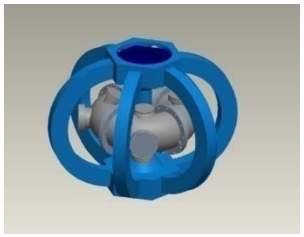
Courtesy of SuperPower Inc

Summary

- A wide portfolio of skills that can positively impact CERN specific requirements
  - Design and manufacture of key components
  - Flexible and tailored approach
  - Consultancy and Programme Management
- Broad range of entry points
  - Magnet systems,
  - cryogenics,
  - Prototyping,
  - System integration







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Thank You