International Accelerator Facility for Beams of Ions and Antiprotons at GSI

A new project in Superconductivity

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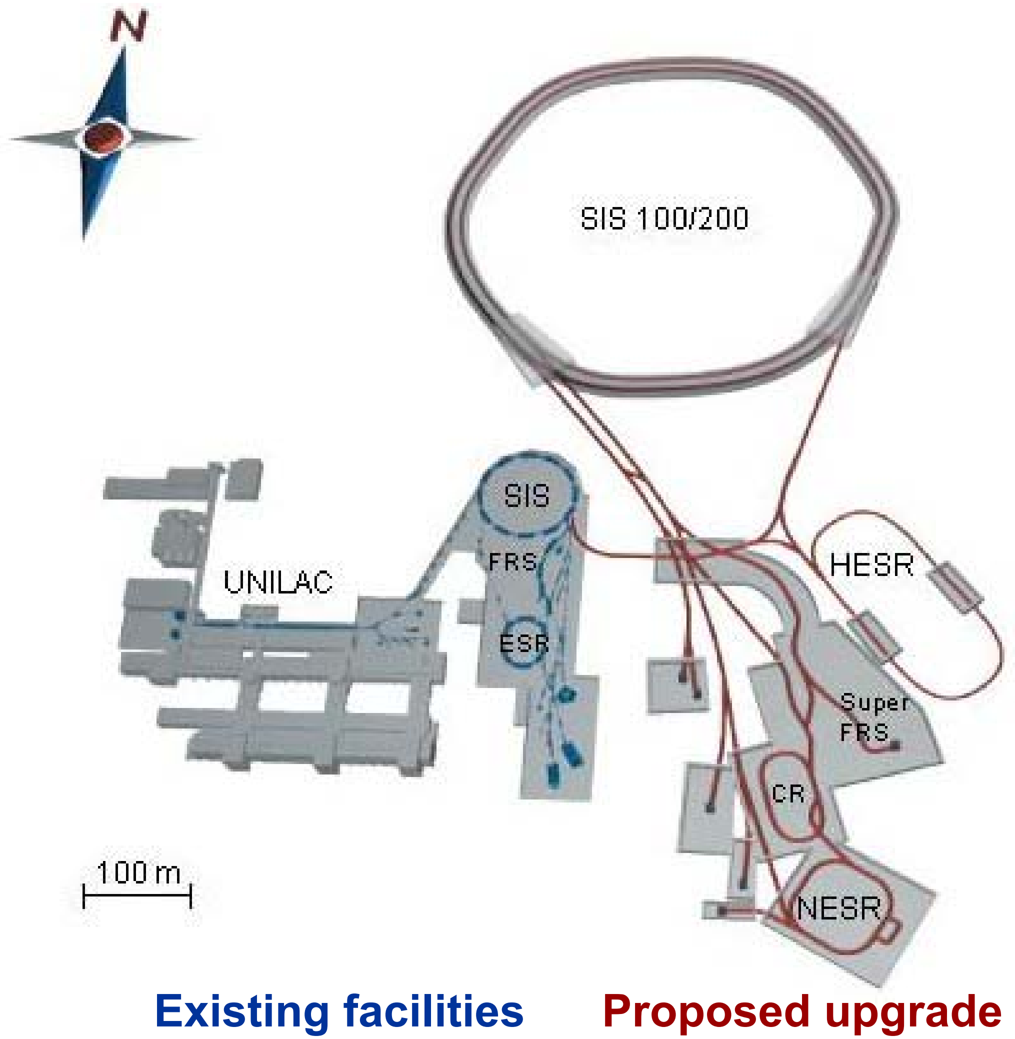
Plan

- **oveview of the project**
- **SIS200 - magnets based on RHIC design – use cored cables for fast ramping**
- **SIS100 - magnets based on Nuclotron design – improve on existing hollow conductor?**

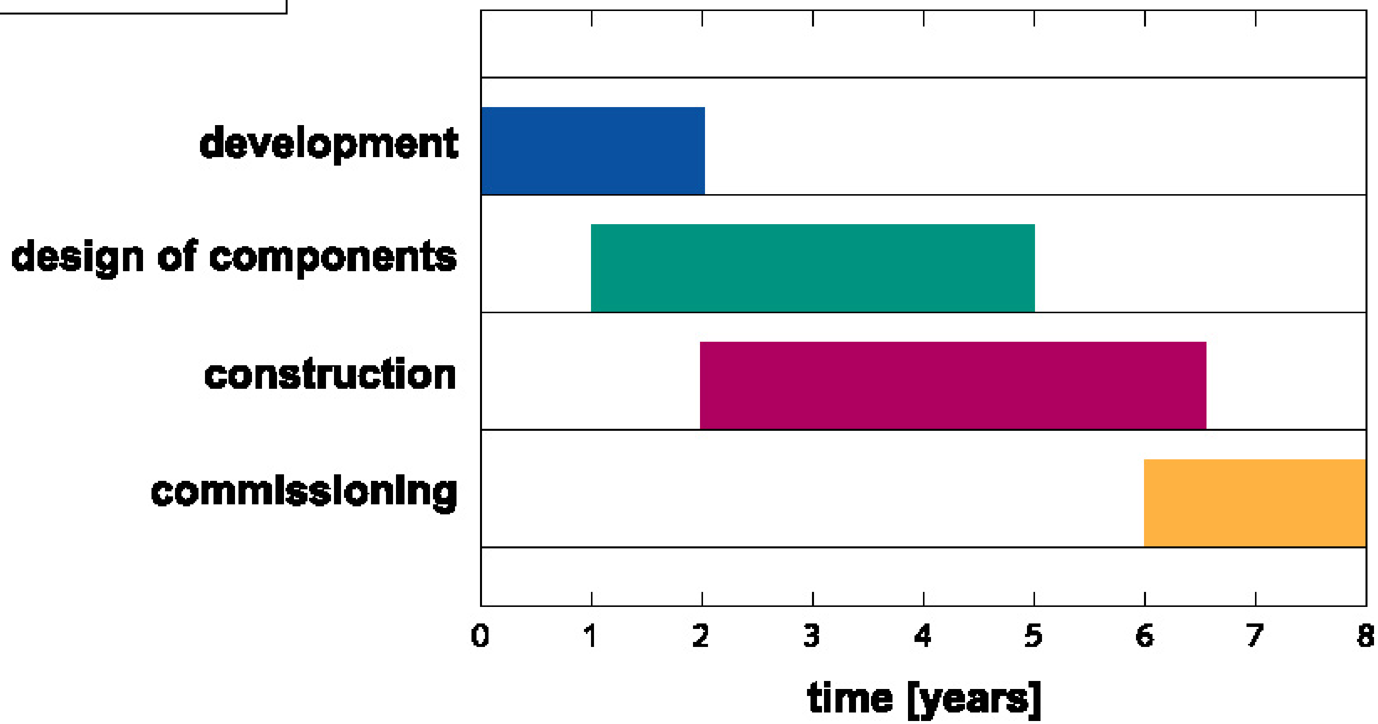
Tasks of the New Facility

- **SIS100 (Synchrotron 100 Tm):**
  - „work horse“ of the whole facility
  - accelerates heavy ions/protons
  - feeds SIS 200 or RIB/Antiproton targets
- **SIS200 (Synchrotron 200 Tm):**
  - accelerates heavy ions to high energies
- **SuperFRS (Fragment Separator):**
  - separates secondary beams
- **CR (Collector Ring):**
  - collects secondary beams
- **NESR (New Experimental Storage Ring):**
  - electron cooling of stored antiprotons
- **HESR (High Energy Storage Ring):**
  - experiments with antiprotons



Costs and Schedule

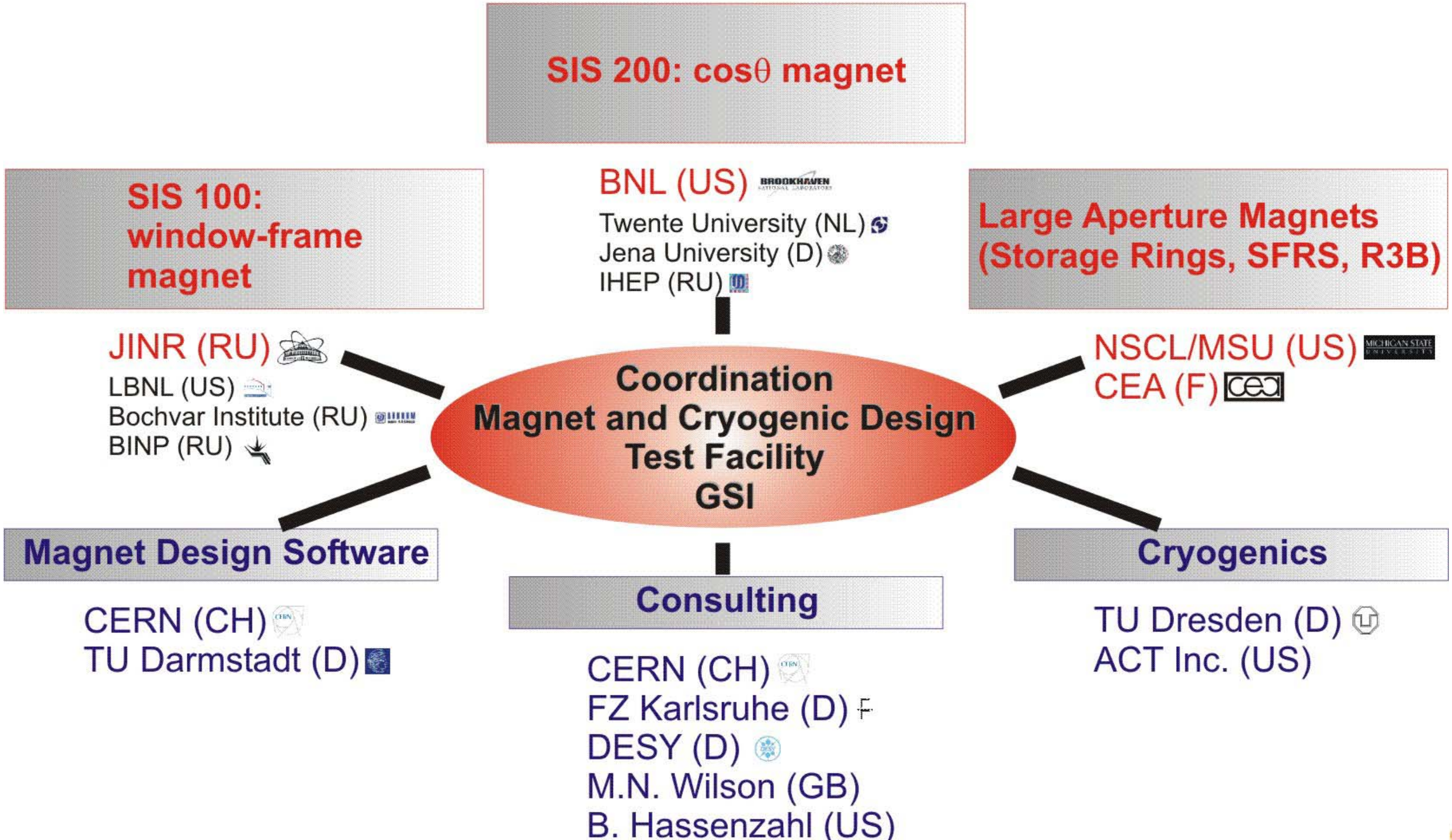
Building and infrastructure:	225 Mio. €
Accelerator:	265 Mio. €
Experiments / detectors:	185 Mio. €
Total:	675 Mio. €



Review by German Science Council

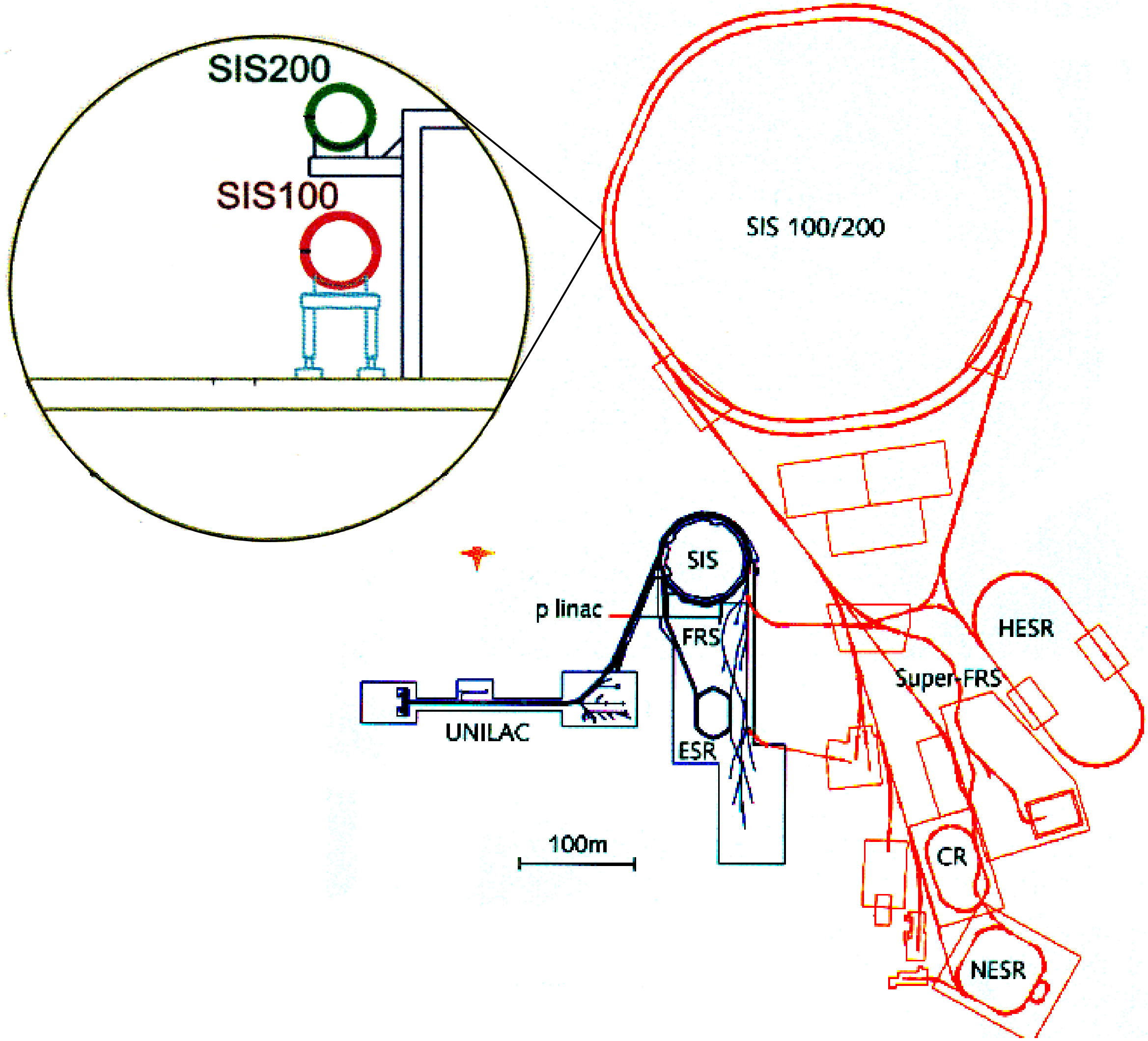
'....can be supported when certain conditions have been fulfilled.....'

Collaboration network

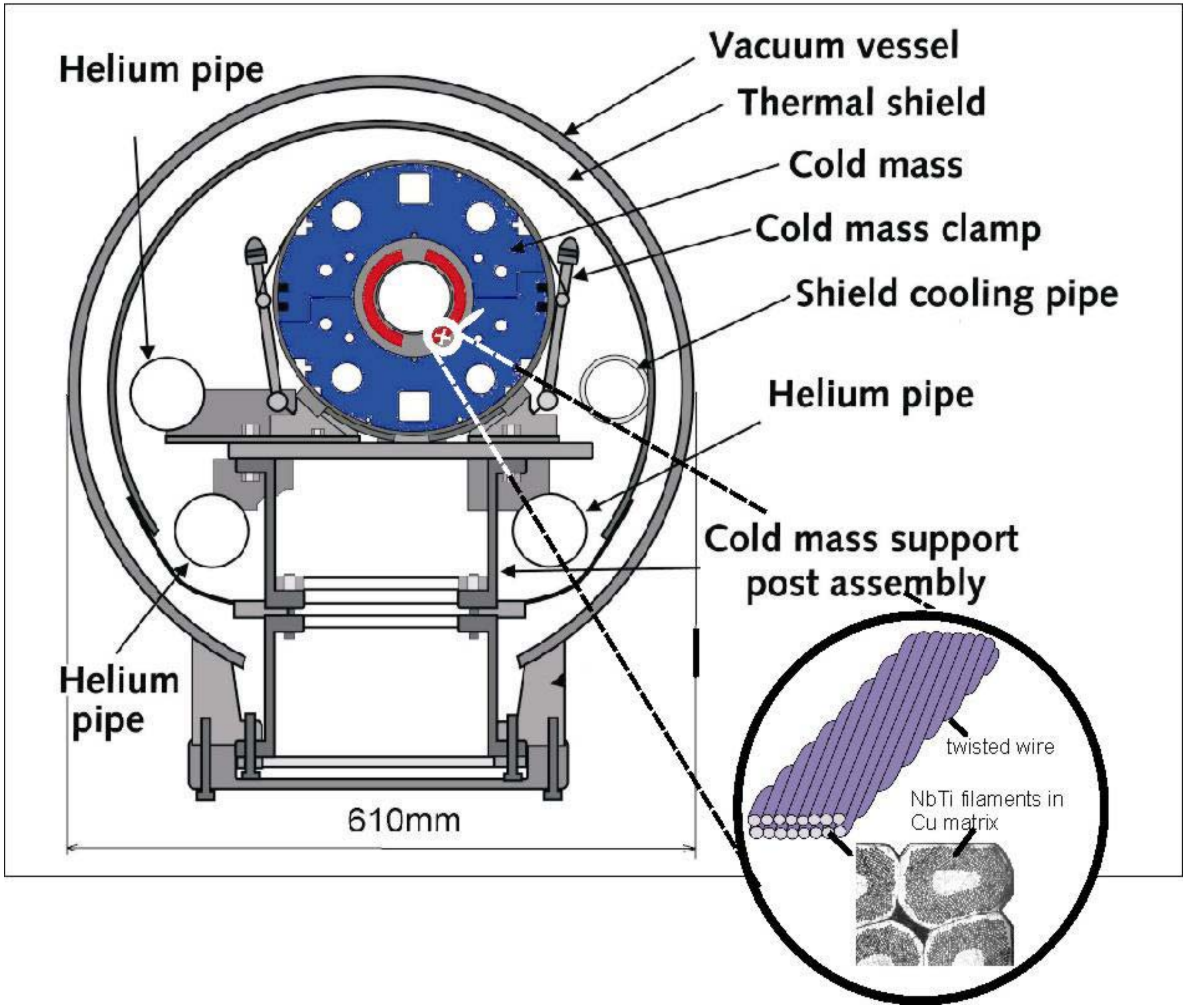


the new acceleration rings

- two rings in same tunnel
- SIS Schwerionen Synchrotron
- SIS 100 Nuclotron magnets
  2T at 4T/s 100 T·m
  circumference = 1080m
- SIS 200 RHIC magnets
  4T at 1T/s (RHIC 0.042T/s)
  200 T·m circ = 1080m
- SIS 300 UNK magnets
  6T at 1T/s
  300 T·m circ = 1080m



RHIC style magnets for SIS 200



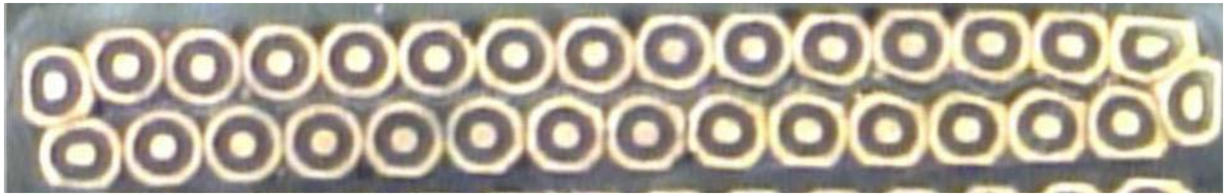
RHIC Dipole

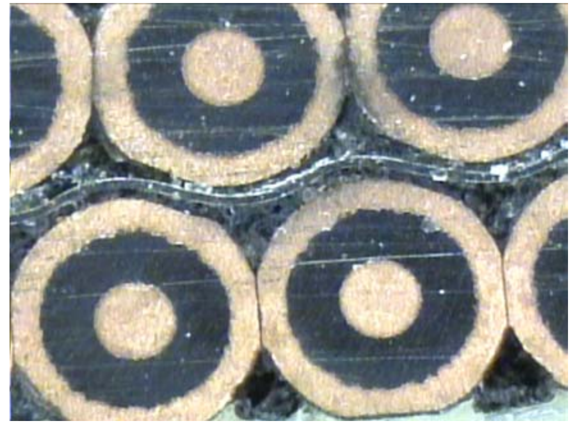
- maximum field: 3.5 T
- ramp rate: 0.042T/s

Goals of R&D: 4 T at 1 T/s

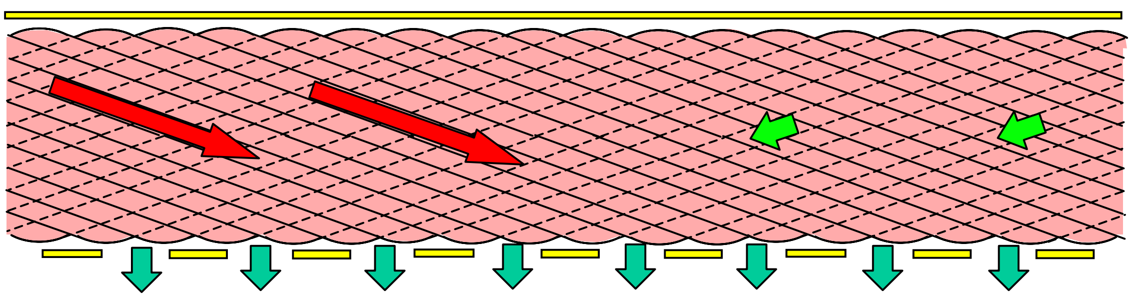
- reduce ac losses
- improve cooling of the Rutherford cable
- reduce field errors caused by the superconductor
- improve mechanical structure

Cored cable for SIS200





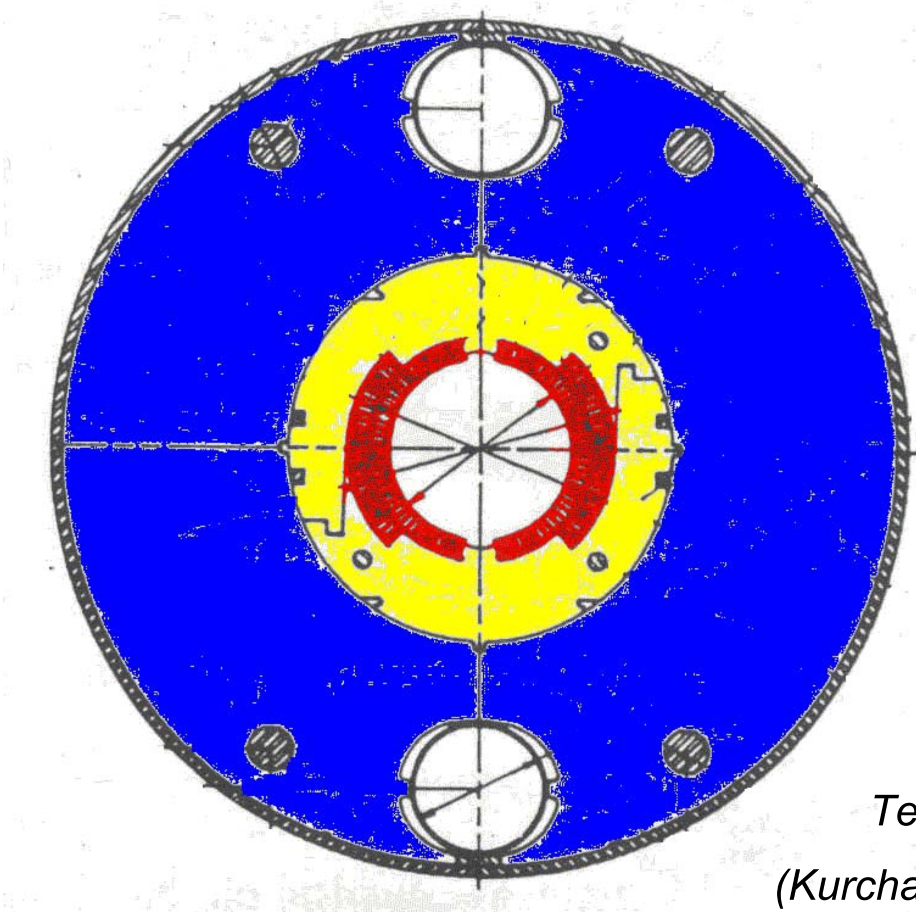
- resistive stainless steel core reduces losses while keeping low (adjacent) interstrand contact resistance
- holes cut in Kapton insulation provide good cooling at the coil inner surface



SIS 300 - Dipole Parameters

UNK Dipole

- 2 layer cosθ design
- 80mm bore
- 5.11 T
- 0.11 T/s



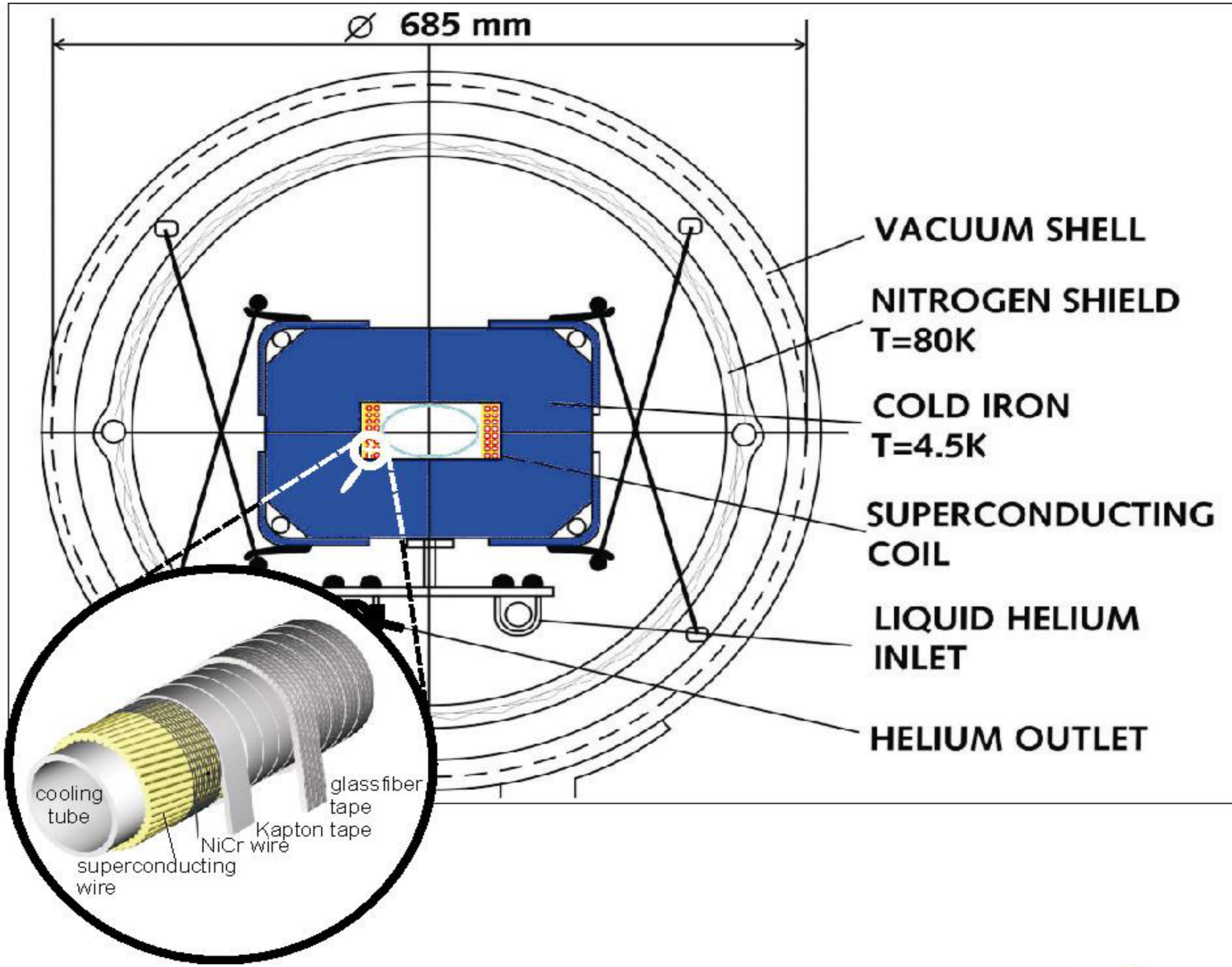
Goal: 6T, 1T/s

Feasibility study by Technopark Kurchatov (Kurchatov Institut Moscow, IHEP, Protvino)

Nuclotron magnets for SIS 100

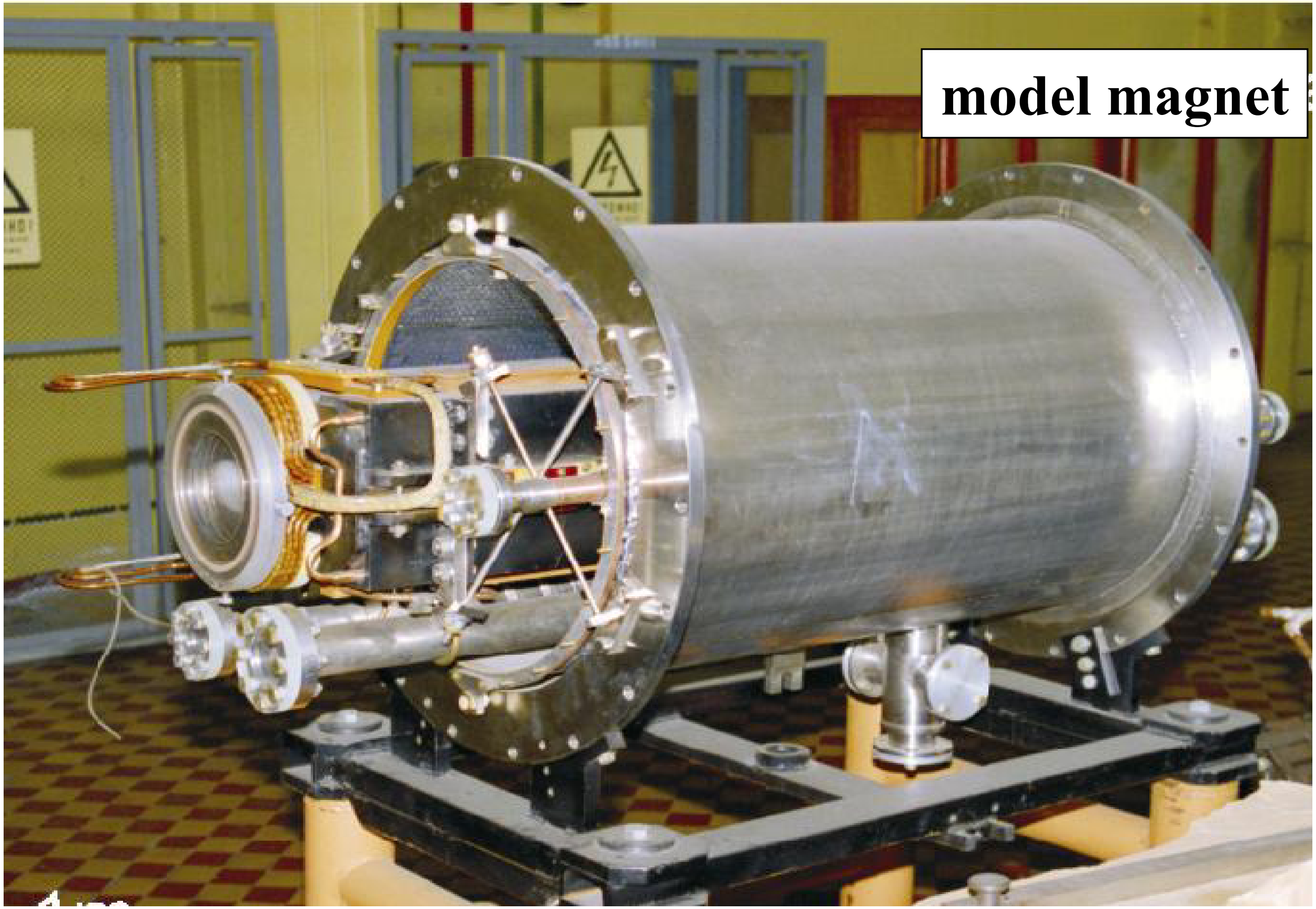
Nuclotron Dipole

- collaboration with JINR (Dubna)
- iron dominated window frame magnet
- maximum field = 2 T
- ramp rate: 4 T/s
- hollow-tube superconducting cable
- two-phase helium cooling



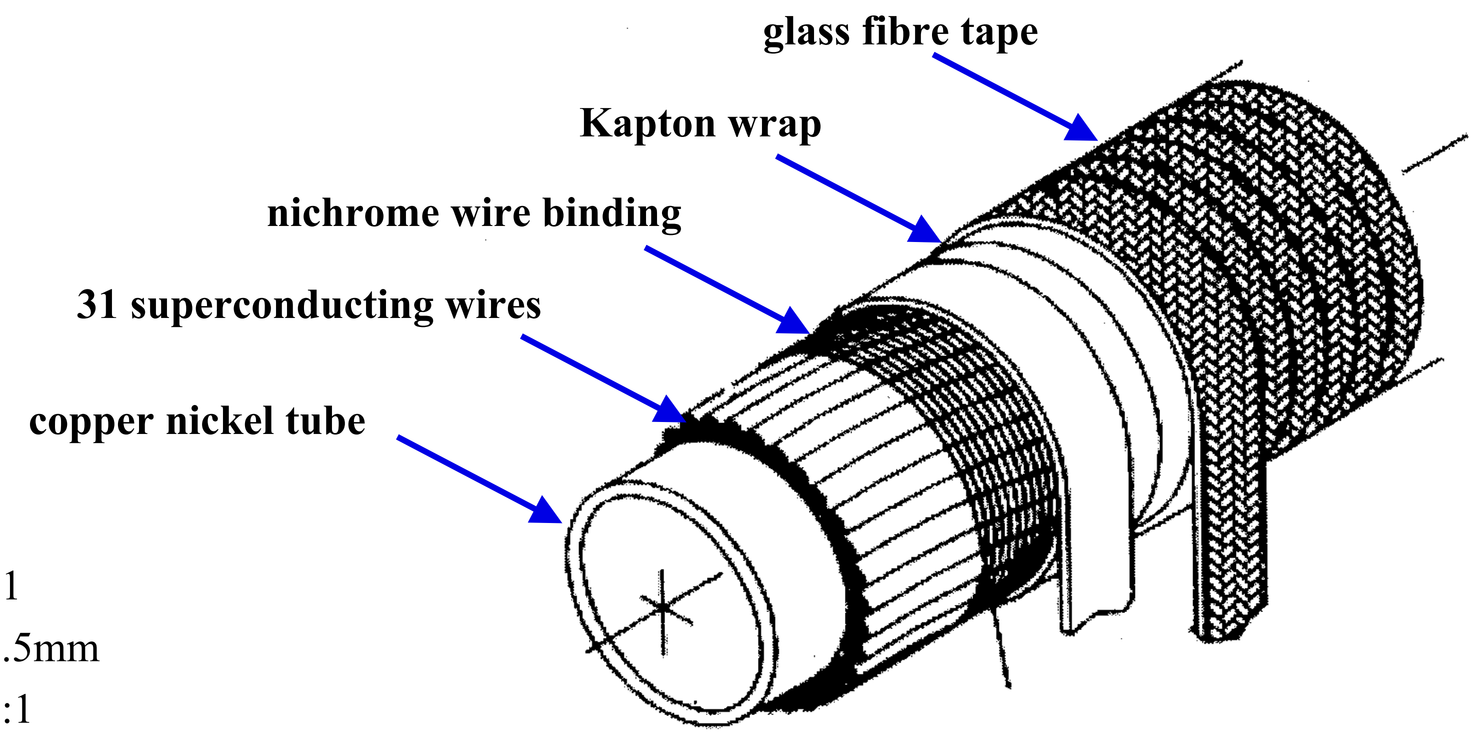
Nuclotron magnets for SIS 100

- **Magnet:**
  - low inductance 0.8 mH/m, i.e.
  - low stored energy
- **Yoke:**
  - 0.5 mm laminations
  - cold iron (4 K),
  - 3 % Silicon, low coercivity
  - alternative: 80 K iron
- **Beam pipe:**
  - thin-walled



model magnet

Nuclotron conductor



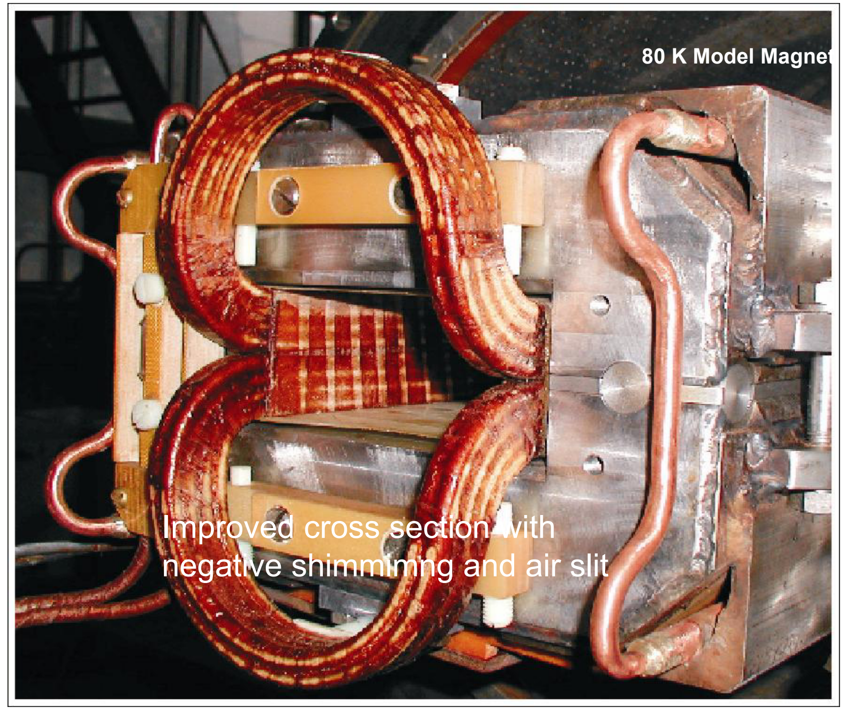
superconducting wires are glued to the copper-nickel tube with epoxy resin

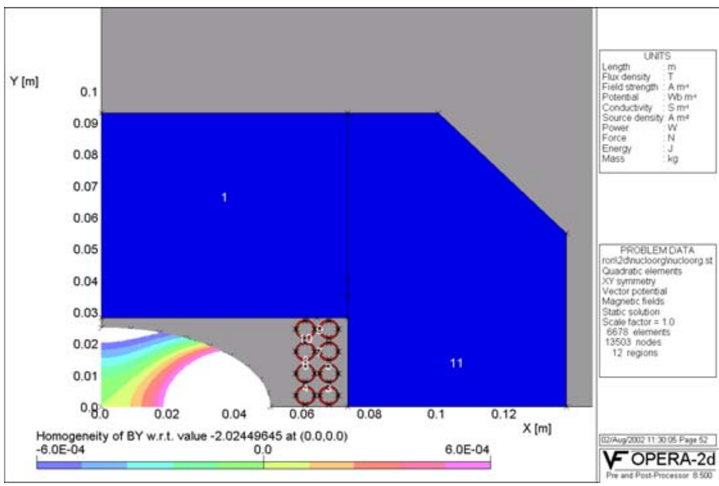
Main parameters

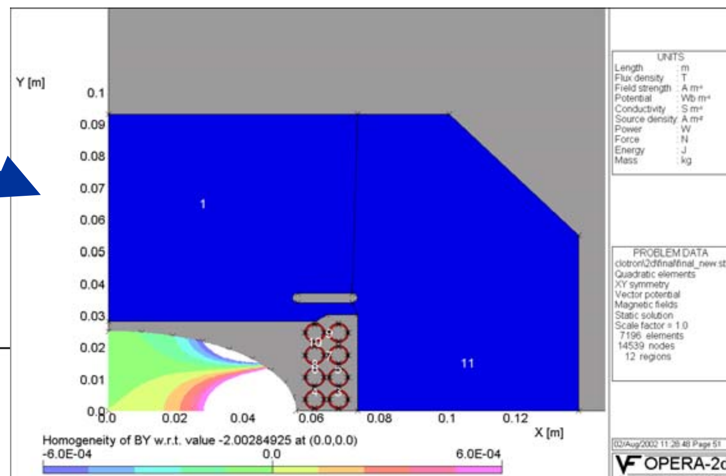
number of wires	= 31
wire diameter	= 0.5mm
Cu:NbTi ratio	= 1:1
number of filaments	= 1045
wire twist pitch	= 4.5mm
cable twist pitch	= 47mm
tube inner diameter	= 4.0mm
tube outer diameter	= 5.0mm

R&D goals for SIS100 magnets

- **Better DC field quality** by modification of the iron geometry.
- **Lower losses at high ramp rates**:
  - reduce iron loss
  - remove all/part of iron loss to 80K
- **Better mechanical performance** ($5 \cdot 10^{8}$ cycles/lifetime)
- **Better reliability** (less training)

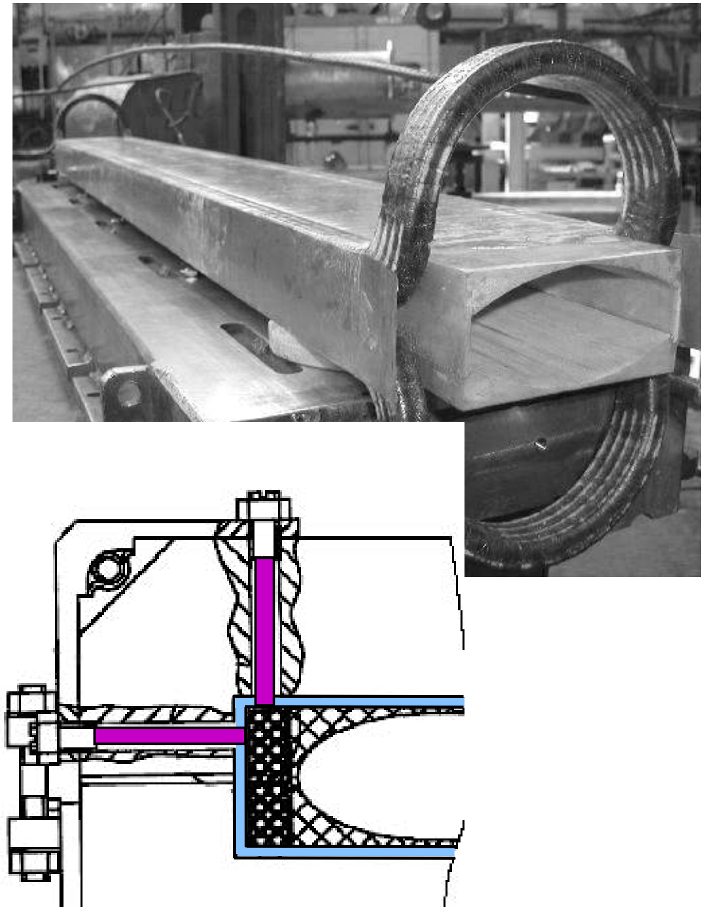






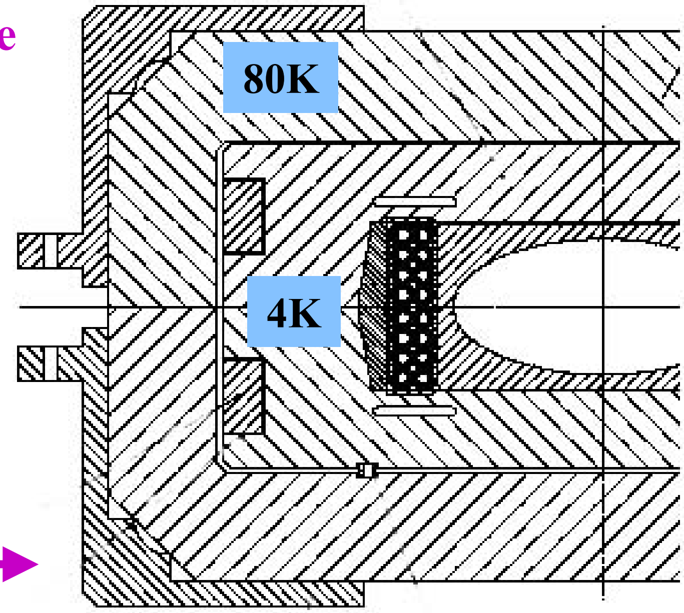
Iron yoke at 80K

Objective: reduced iron losses at 4K



1) Separate coil structure

- magnetic forces supported by glass fibre reinforced epoxy bands at 4K
- problem of structure flexing under load



2) Two part iron yoke

- iron yoke divided into 2 parts - at 4K and 80K
- small 4K collar and wide gap ⇒ low loss
- large 4K collar and narrow gap ⇒ good field quality

Nuclotron-type Dipole – Loss Mechanisms

Losses at 4K Triangular cycle: 1Hz, 2T	Original dipole	4KDP1 Improved yoke	80KDP2 Yoke at 80K
Total (W/m)	44	37	11
Yoke (W/m)	> 27	24	0
Coil (W/m)	12	9	9
Static Loss	5	4	2

Goal: Total 4K loss of 13 W/m

- **Coil (30%):**
  - mainly filament magnetization
  - small coupling
- **Yoke (70%):**
  - magnetization losses
  - eddy currents in ends due to B_z
  - mechanical vibrations ?

Problem: separate coil at 4K shows training

- **improve mechanical structure**
  - **– but need small gaps for magnetic efficiency**
- **improve conductor stability?**

Conclusions

- cored cables are our preferred choice for SIS200/300
  - they give acceptable losses while retaining low inter-strand resistance

- predictions for SIS200:
  - the total loss in the synchrotron is acceptable
  - finer filaments would help - 3.5mm is about optimum with Cu matrix
  - temperature rise is OK provided we use insulation with cooling holes

  BUT - no model test yet
  - ramp rate sensitivity of quench current?

- Nuclotron style magnets are an excellent choice for SIS100
  – the 'workhorse' of the whole facility

  BUT - iron losses are too high
  - separate 4K coil shows training
  - mechanical integrity? - $5{\cdot}10^8$ cycles over facility lifetime

- CICC should give no training and better operational reliability, eg survive particle beam loss

  - over to Luca ⇒ ⇒ ⇒ ⇒ ⇒