Analyse of the operating scheme for SIS100

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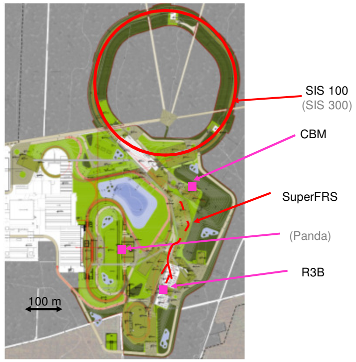
Cryogenic System – Topology



FAIR (**F**acility of **A**ntiproton and **I**on **R**esearch) is a new international accelerator facility for the research with antiprotons and ions. It will be built in cooperation of an international community of countries and scientists. On October, 4th 2010, the international owners founded the FAIR GmbH and the countries' representatives signed a treaty under international law (Convention, Final Act).

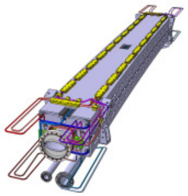
The facility will be financed by a joint international effort of so far ten member states. The Federal Republic of Germany together with the State of Hessen is the majorcontributor to the construction, the current nine international partners - Finland, France, India, Poland, Romania, Russia, Slovenia, Spain and Sweden - bear ca. 30 % of the construction cost.

Construction site in June 14 (by H.Stöcker)

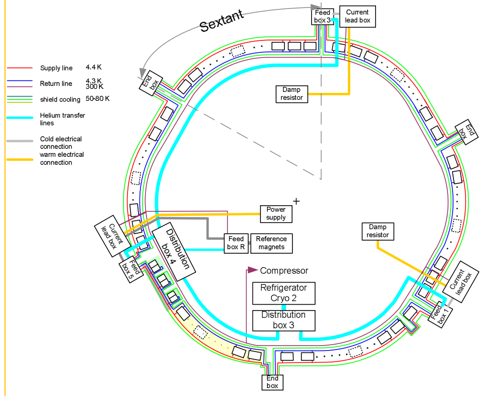
SIS 100

The synchrotron SIS 100 is the primary accelerator in the FAIR project. It is designed for a magnetic rigidity of B_r=100 Tm. SIS100 accelerates high intensity and high energy protons and ion beams.
In SIS 100 fast pulsed, super-ferric synchrotron magnets will be used, which are based on the design of magnets for Nuclotron at JINR Dubna.

3D View of the Curved Single Layer Dipole (CSLD).
Brackets and end plates (in blue) support the laminated yoke (in dark grey). The end coil (indicated in red) is small and close to the vacuum chamber. Bus bars are mounted on top and at the bottom of the magnet (red, blue, light blue and turquoise tubes). The yellow elements keep them in place. The feeding and return helium header is mounted below the magnet. The voltage breakers (in green) are mounted on the end plates for easy accessibility.



Heat Loads



Cryogenic supply of SIS100

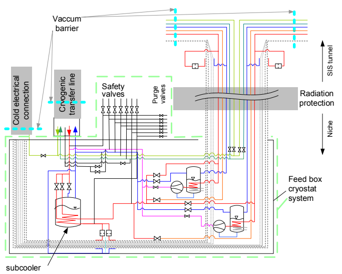
The heat load of the magnets (and their beam chambers) for SIS 100 varies strongly with the different schemes of ramping. The heat loads of the main magnets for two characteristic cycles are given as: More details (2):

(without beam chamber)	Static losses [W]	Dynamic losses [W]	
		proton cycle	triangular cycle
Dipole	2	9	49
Quadrupole Module	3	5	24

The heat loads for SIS100 without safety margin (not for refrigerator design) together are:

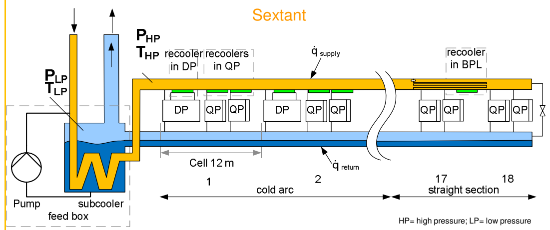
	Static losses [W]	Dynamic losses [W]	
		proton cycle	triangular cycle
Sextant	350	870	2450
SIS 100	2200	5200	14700
Refrigerator	2800	5200	14700

Feed box for 2 sextants(1)



Model

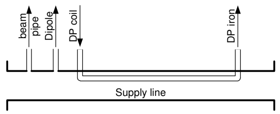
Sextant



p_{LP}= 1.2 ... 1.3 bar $T_{LP}=T_{boiling}(p_{LP})$= 4.4 ... 4.5 K

p_{HP}= 1.5 ... 1.9 bar $T_{HP}=T_{LP}+\Delta T_{sc}$=4.5 ... 4.6 K

Recooler (to compensate the heat in-leak on the supply line)

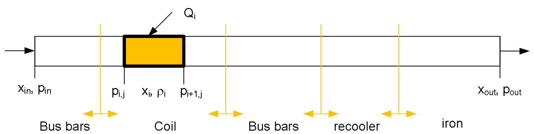


$$\dot{Q}_{recooler} = KA\Delta T$$

$$K = \left(1/\alpha_{subcooled} + \delta_{pipe}/\lambda_{SS} + 1/\alpha_{boiling}\right)^{-1}$$

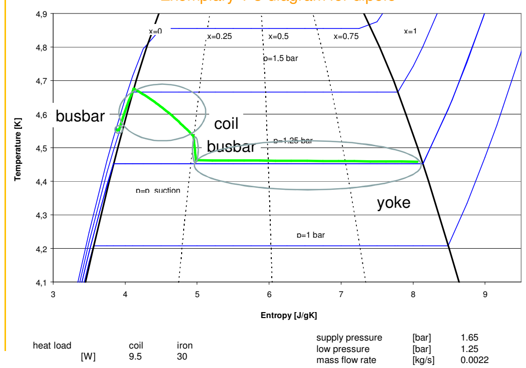
$\alpha_{subcooled} = f(Nu)$ const. Temp; concentric gap $d_h = \frac{4\ cross\ section}{wetted\ surface}$

Finite Volume Methode

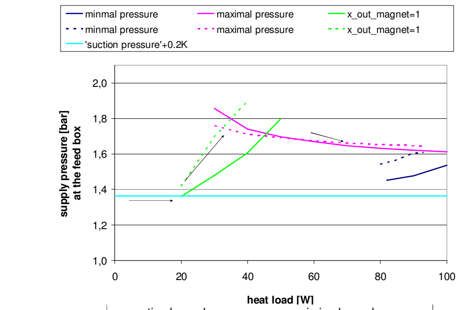


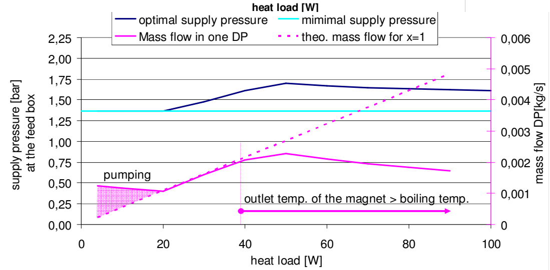
Validation of calculation with the FOS (**F**irst **O**f **S**eries)

Exemplary T-s-diagram for dipole



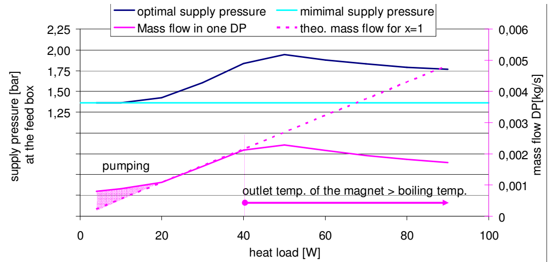
Results





=> For stand-by 110g/s of liquid has to be pumped

Additional restrictor in front of the dipoles



=> For stand-by 63 g/s of liquid has to be pumped

With an additional restrictor in-front of the dipoles ~200W (η_{pump}=0.3) could be saved. The influence onto the stability of the two-phase flow in the return line has to be more investigated.

References

(1) **Cryogenics for the SIS100 Synchrotron at FAIR,** Streicher, B., Kollmus, H., Kauschke, M., Schroeder, C., Eisel, T., Iluk, A., this conference: Thu-Mo Session

(2) **Thermodynamic Properties of the Superconducting Dipole Magnet of the SIS100 Synchrotron**, Bleile, A. this conference: Thu-Af Session

(3) **Cryogenics for FAIR** Kauschke M., Xiang Y., Schroeder C. H., Proceedings of ICEC 24 (2013), 677- 680

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