The Design Study of Superconducting Magnet System for a Advanced ECR Ion Source


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Abstract

The Korea Basic Science Institute is developing a superconducting magnet system for 28 GHz Electron Cyclotron Resonance Ion Source (ECRIS). We are investigating in order to realize compact size, economic operation and generation of high current beam. Although companies and researchers have valuable experience, skill and ability in designing of superconducting magnet for ECRIS, they did not exactly propose a excellent superconducting magnet system for ECRIS because many superconducting magnets were not required. Of course they did if we required many magnets for the various application of ECRIS. In this paper, we have filed reports of former researcher and we have discussed the realization of ECRIS over 50 GHz.

Heat Load & X-ray irradiation

Critical Problems of ECRIS Magnet

- X-ray Irradiation
  - Large Heat Source of Magnet
  - Degradation, Erosion
- Critical Current & Field of Superconducting Wire
  - HTS Wire
  - Nb3Sn 1.5 T Wire
- Hybrid Magnet
  - Reinforcement of Structural Strength for Hexapole Magnet
- Liquid Metal
- Special Structure
- Cooling Method
  - Recirculated Cooling Method
  - Low Temperature
  - Construction Coated Method
  - Simple

Calculation Concept of X-ray Shield

Absorption equation

\[ I = I_0 e^{-\mu \rho x} \]

where:
- \( I \) is the intensity of X-ray after passing through the material
- \( I_0 \) is the intensity of X-ray before passing through the material
- \( \mu \rho \) is the linear attenuation coefficient of the material
- \( x \) is the thickness of the material

Theoretical data with \( W_{\text{corrected}} \)

Reducing factor of \( W_{\text{corrected}} = 4.5 \)
Reducing factor of \( W_{\text{corrected}} = 2.2 \)

Calculating the Thickness of X-ray shielding material for KBSI 28GHz ECRIS

1. When \( R_{\text{out}} = 0.45 \) or 0.5:
   - Beamstrahlung heating rate \( = \) beamstrahlung heating rate of VENUS
   - For evaluation, a 290 GHz at no attenuation

2. When \( R_{\text{out}} < 0.45 \):
   - Beamstrahlung heating rate from VENUS data of Fig. 1 in Leitner et al. (2006)

Theoretical data with Ta

Reducing factor of \( W_{\text{corrected}} = 4.5 \)
Reducing factor of \( W_{\text{corrected}} = 19 \)

Conclusion

- The main heat load of superconducting magnet system for ECRIS source generated by x-ray irradiation.
- The estimation method of s-ray was presented.
- The x-ray heat load for 28GHz ECR Ion source was estimated.
- The heat load of magnet system was calculated and The concept cooling system was designed.
- Also, we were trying the study about rationalized structural system and some basic experiments were performed.