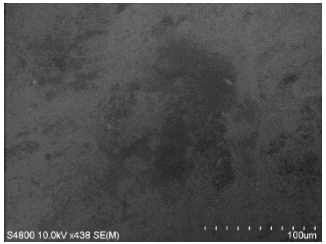
Nb Sample analysis at IHEP

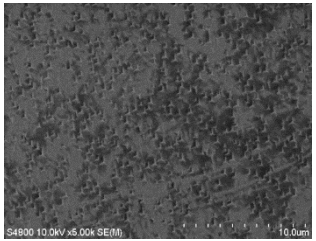
Chao Dong (dongchao@ihep.ac.cn)

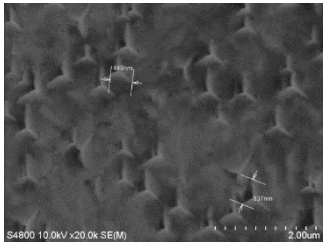
Institute of High Energy Physics, CAS

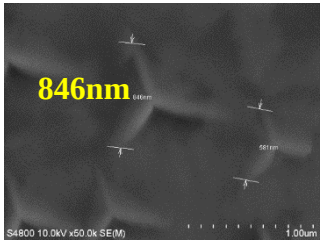
Experiment assignment

- To analyze the concentration of elements in different niobium samples, we use time-of-flight secondary ion mass spectrometry (TOF-SIMS) to measure them.
- After TOF-SIMS measurement, we use scanning electron microscope (SEM) to see the surface image of Nb samples. For the light N-doping sample, and the nitride precipitates is clear as shown below.







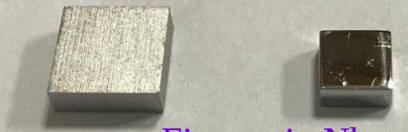


- The resistance versus temperature of fine grain and large grain samples is measured by physical property measurement system (PPMS).
- We use MPMS to measure the DC/AC magnetic performance of Nb/Nb(doped)/SIS samples.

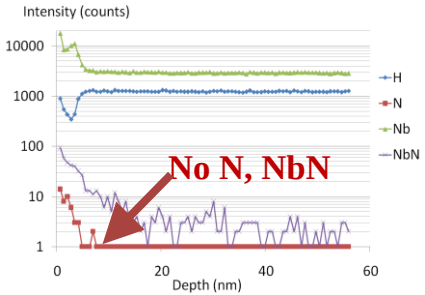
TOF - SIMS Results of N-doping at OTIC

Furnace at Ningxia Orient Tantalum Industry Co., Ltd (OTIC)

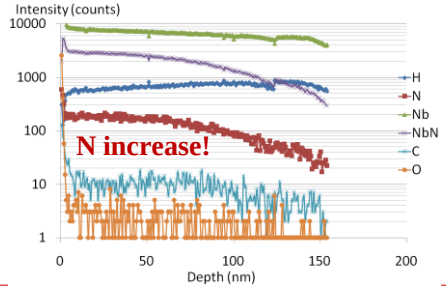
Fine grain Nb sample
with Buffered Chemical
Polishing (BCP)



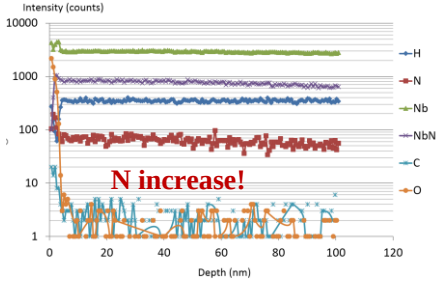
Fine grain Nb sample
with Electropolishing (EP)



Before N-doping



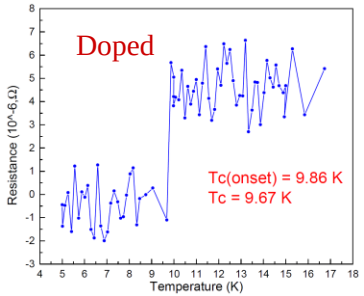
After N-doping
(Light Dope, BCP, without EP)

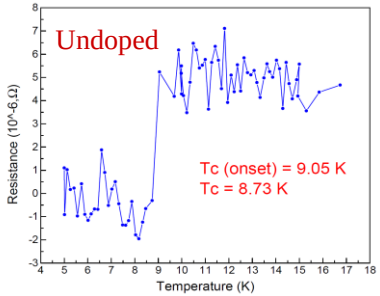


After N-doping
(Light Dope, EP)

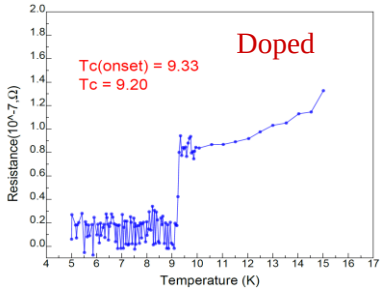
Resistance vs Temperature (RT)

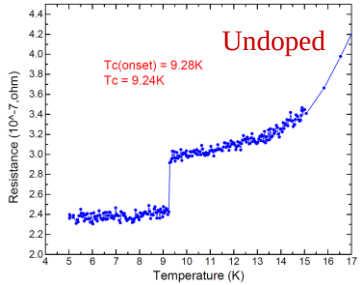
The RT curve is measured from room temperature down to 5K, using a four-point probe method by PPMS.





FG:
9.86K is between Nb (9.2K) and NbN (16.2K), a mixture of Nb and NbN.





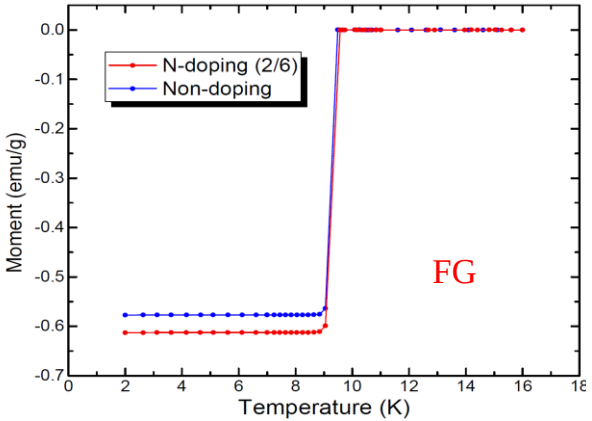
LG: There is no significant change!

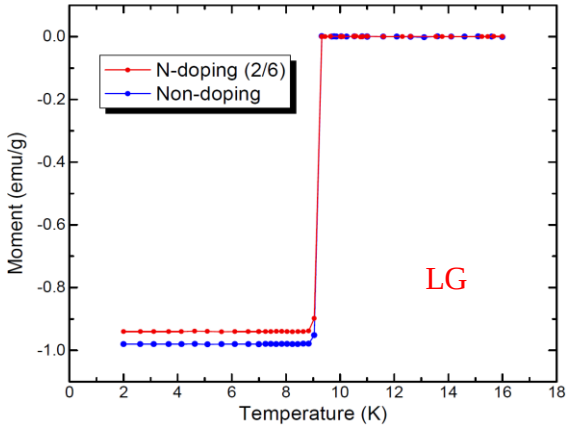
The DC Magnetic Measurement: MT

Magnetic field intensity is 50Oe and it is perpendicular to the surface of sample.
Temperature: from 16K to 2K.

When exposed to a static magnetic field, the superconducting sample will exhibit a negative magnetic moment. The Tc values are similar with RT results, the diamagnetism is different for LG/FG. More inpurities in polycrystal will cause flux pinning, then influence the magnetic moment.

MPMS



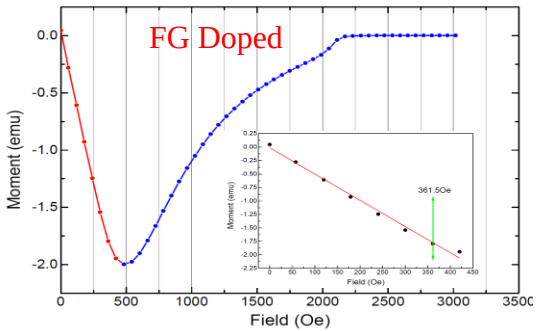


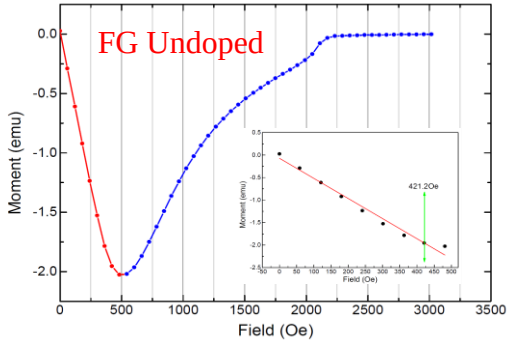
The DC Magnetic Measurement: MH

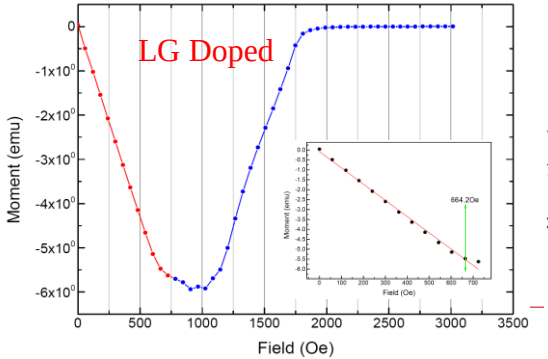
The magnetic moment is measured by increasing magnetic field from 0 to 3000 Oe, and the test temperature is 6K.

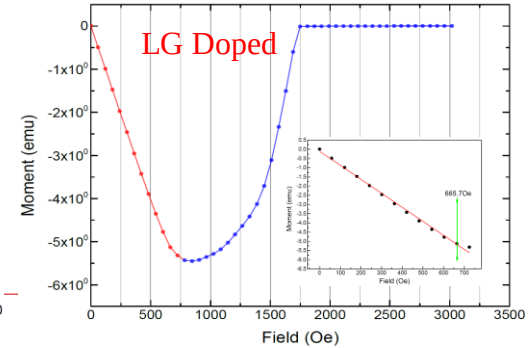
Because the sample is not in ideal geometry, the first point deviated from the linear dependence can not be considered as H_{C1}.

Thus, we define this point the first detected flux entry into the sample as H_{entry}.







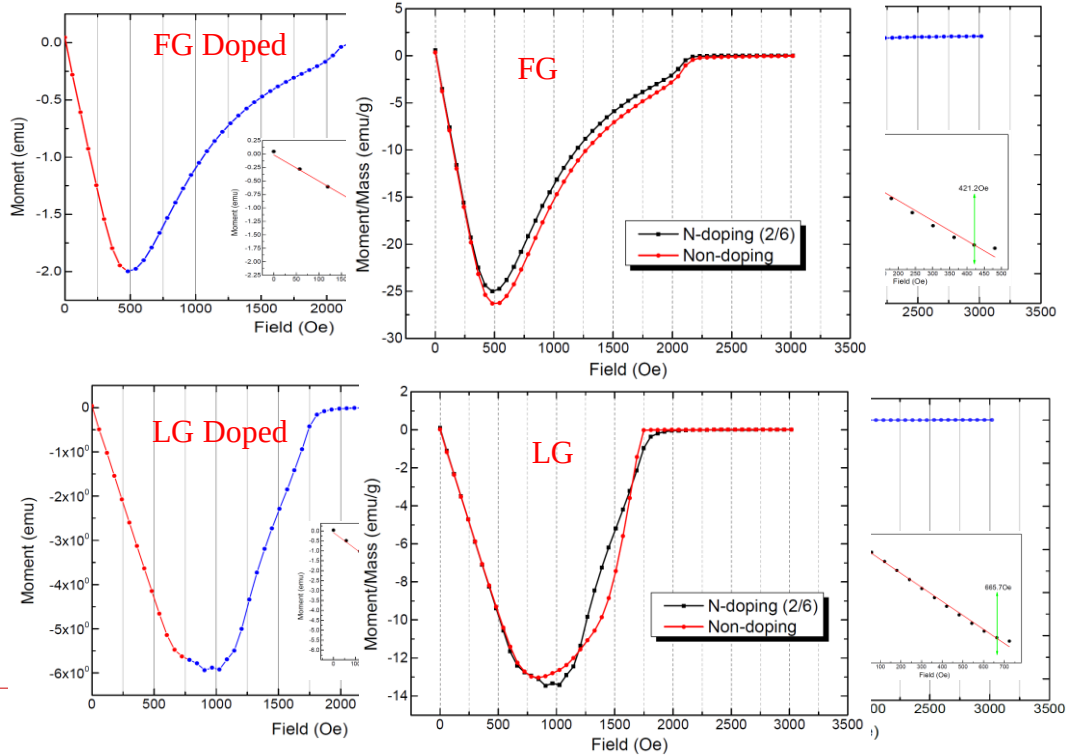


The DC Magnetic Measurement: MH

The magnetic moment is measured by increasing magnetic field from 0 to 3000 Oe, and the test temperature is 6K.

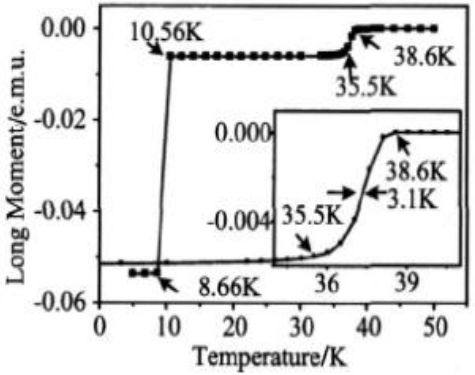
Because the sample is not in ideal geometry, the first point deviated from the linear dependence can not be considered as H_{C1}.

Thus, we define this point the first detected flux entry into the sample as H_{entry}.



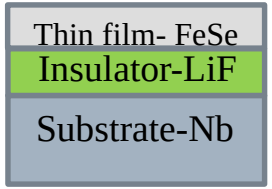
The DC Magnetic Measurement of SS/SIS structure

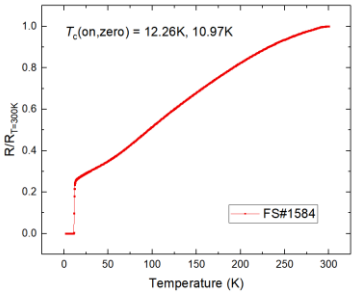
谭腾等. 低温物理学报 31, 179 (2009)



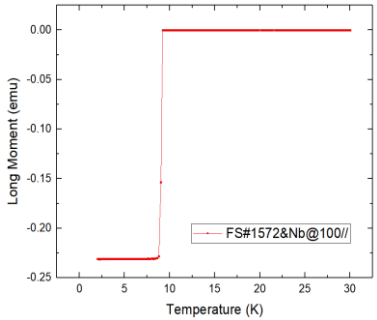
MgB_2/Nb: the MgB_2 thin film turns diamagnetic at about 38.6K, indicating the superconductivity happens at the same temperature. The sharp transition at 10.56K results from the screening effect of Nb substrate.

DC (Yes!)





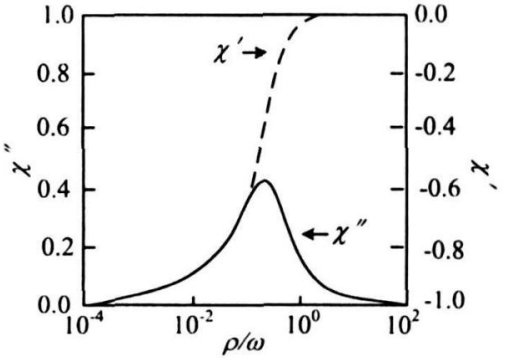
FeSe/LiF:
T_c is about 11 K.
DC (Yes!)



Structure SIS: only one transition related to the Nb is obtained . Therefore, the DC mode seems not appropriate to identify the signal from FeSe film under the background of Nb substrate.

DC (No!)

The AC Magnetic Measurement of SS/SIS structure

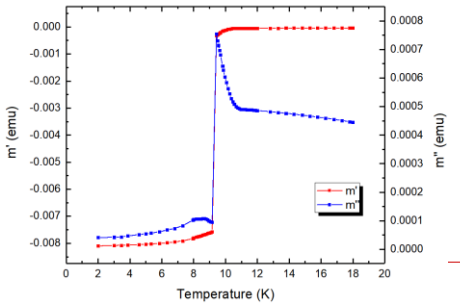


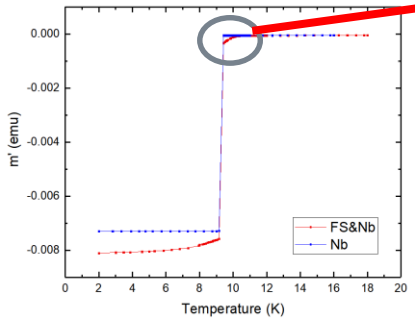
AC susceptibility versus resistivity

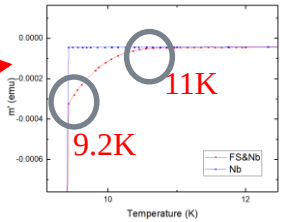
When superconducting sample under the AC magnetic field H, the phase of magnetic induction intensity B will delay due to damping. The AC magnetic susceptibility can be expressed as follows,

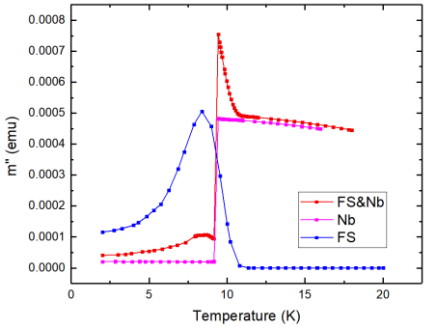
$$\chi = \frac{B}{\mu_0 H} - 1 = \frac{B_m}{\mu_0 H_m} e^{-i\delta} - 1 = \chi' + i\chi''$$

The real part of AC susceptibility has a transition, while the imaginary part shows a peak as the resistivity changes. In contrast with the DC mode, the AC magnetization is more sensitive to the superconducting transition.









DC = 0 Oe,AC = 1 Oe/ 133Hz

Next to do

(1) EP facility is under development, which will be completed in late 2018, and a new furnace will be shipped to IHEP in middle 2018, so our N-doping/infusion technology will be improved.

(2) Research the electromagnetic properties of N-doping/infusion samples taking demagnetization factor into consideration.

(3) Explore the properties of some new structures, such as SS/SIS……

Acknowledgements: KEK, OTIC and PKU.

Thanks for your attention!