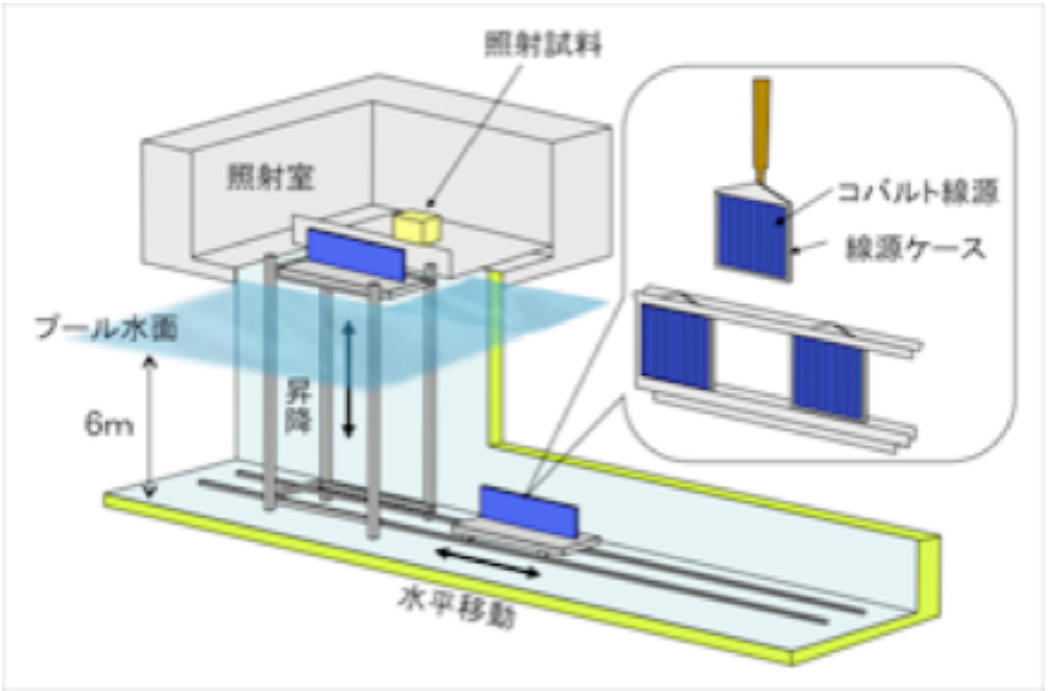
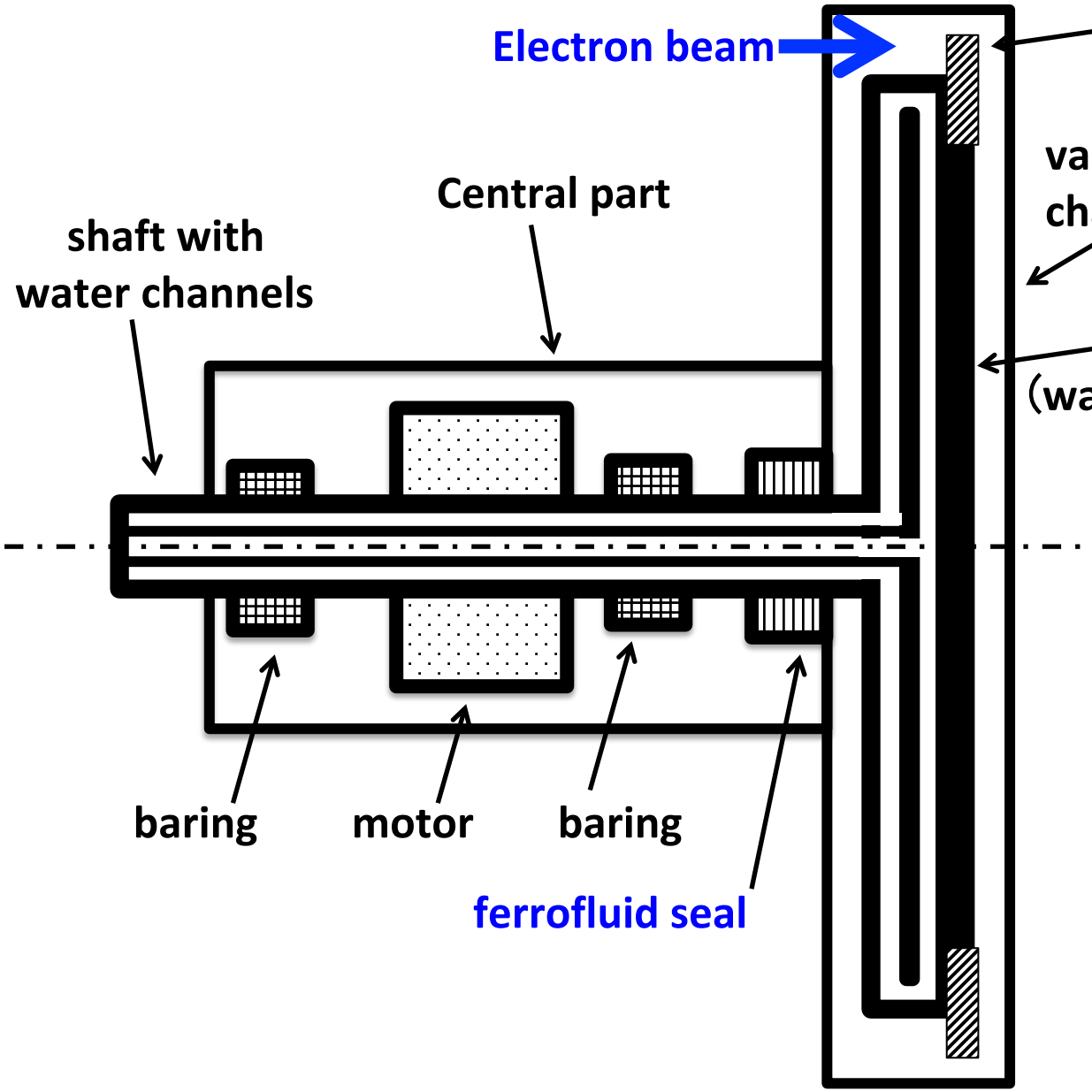
Radiation Tests of ILC e+ production Target and Ferrofuild



31-October-2019
LCWS2019, Sendai, Japan
T. Omori (KEK)

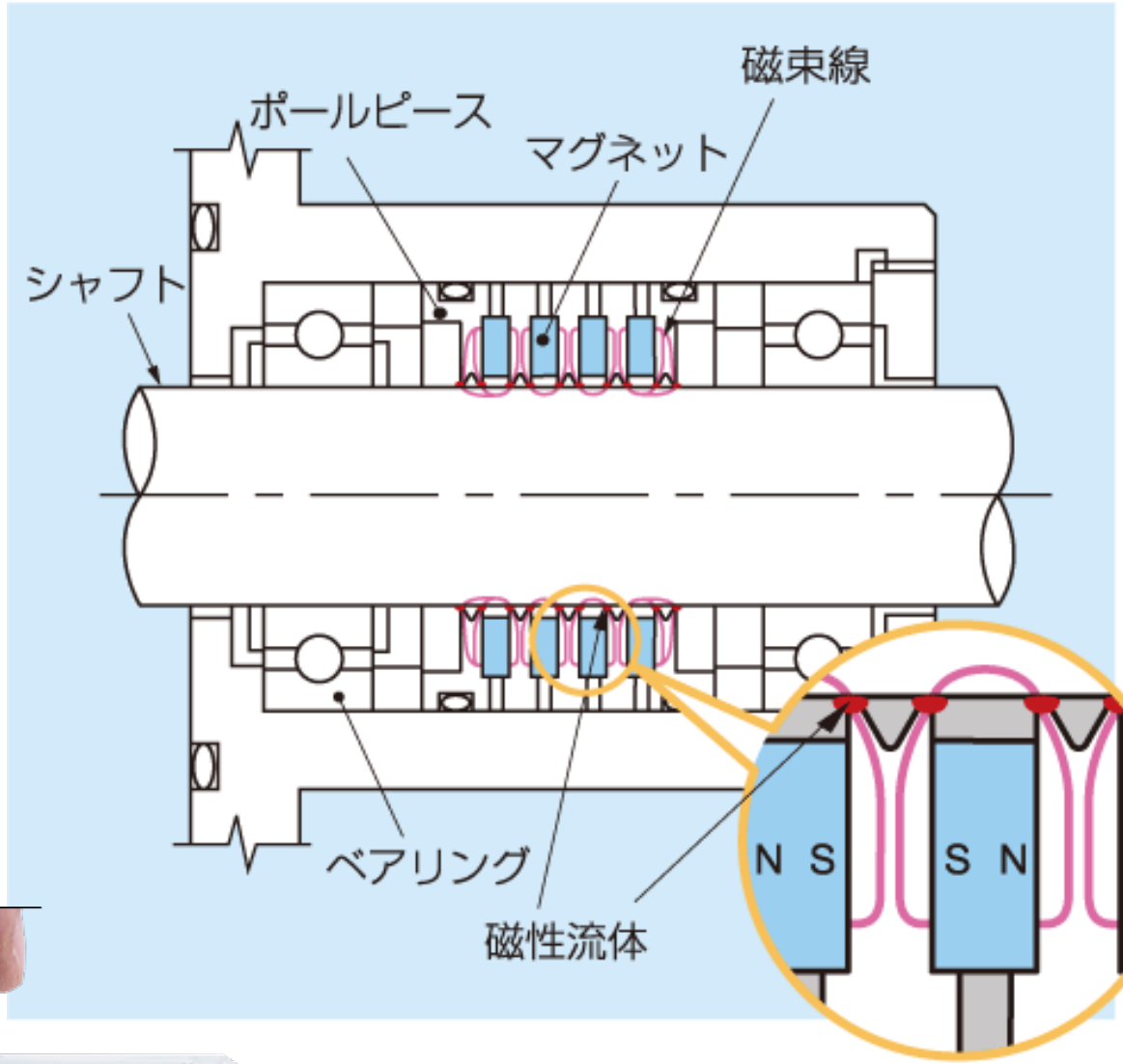
Rotation Target (E-driven)



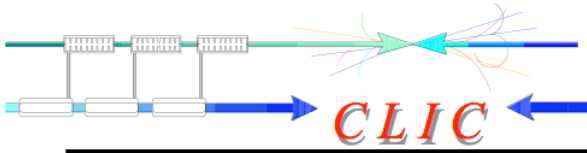
disk
- d= 500 mm
- weight ~ 70 kg

Vacuum
TDR Requirement
10^{-6} Pa

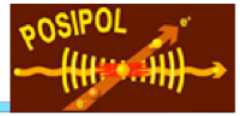
Schematic of ferrofluid seal



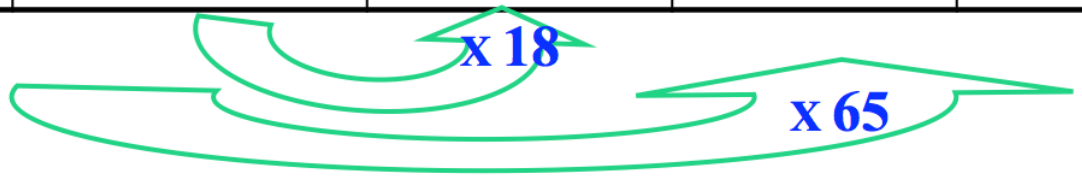
ferrofluid
= base oil + iron powders + surfactant
(oxide iron powders)　(界面活性剤)



Flux of e^+



	SLC	CLIC (3 TeV)	ILC (RDR)	LHeC
Energy	1.19 GeV	2.86 GeV	5 GeV	100 GeV
e^+/ bunch at IP	40 x 10^9	3.72x10^9	20 x 10^9	15x10^9
e^+/ bunch before DR injection	50 x 10^9	7.6x10^9	30 x 10^9	15x10^9
Bunches / macropulse	1	312	2625	20833
Macropulse Repetition Rate	120	50	5	10
e^+ / second	0.06 x 10^{14}	1.1 x 10^{14}	3.9 x 10^{14}	31 x 10^{14}



ILC requires HUGE number of positrons.

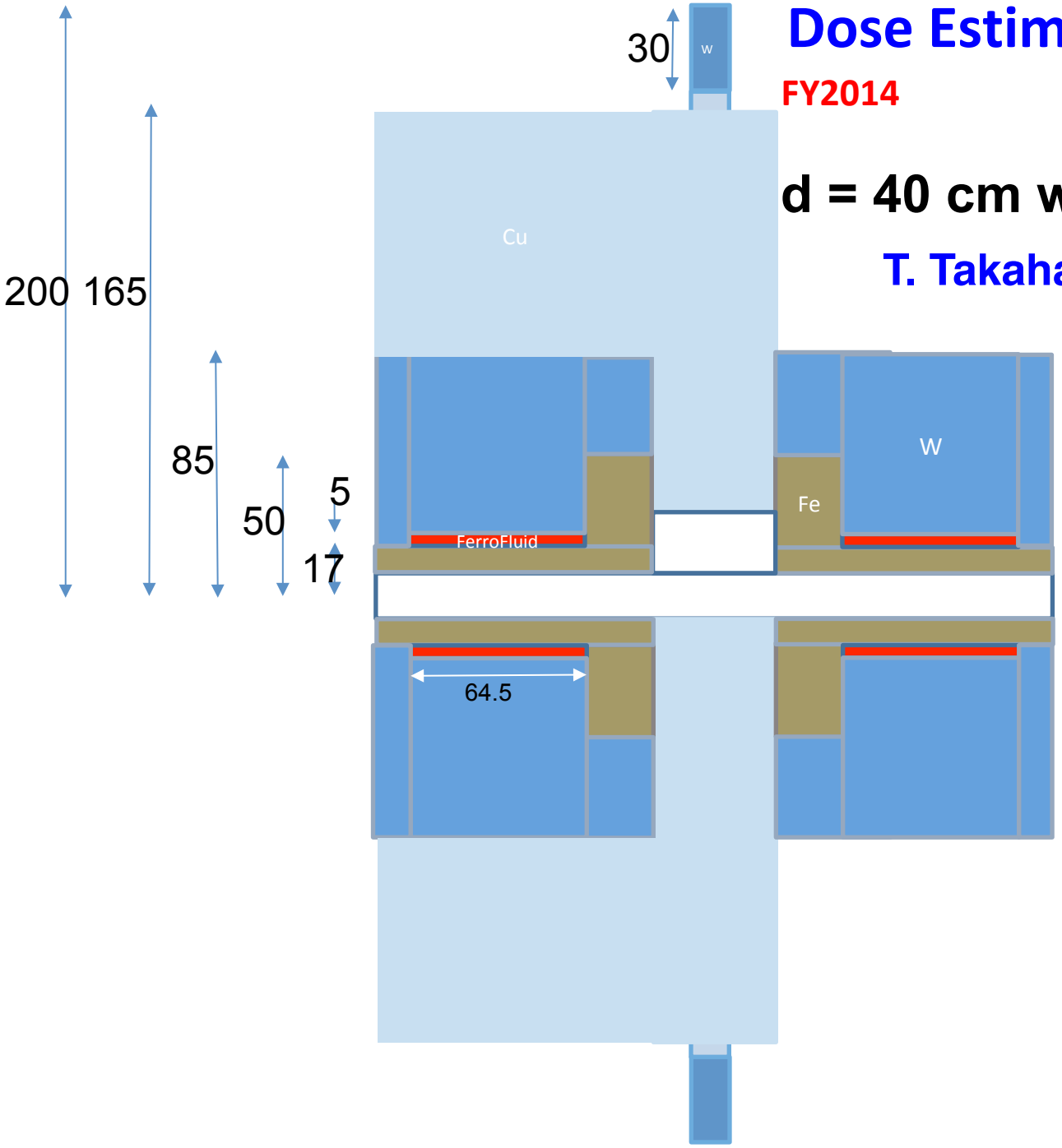
ILC ではとても多い陽電子が必要

Dose Estimation

FY2014

d = 40 cm with radiation shield

T. Takahashi (Hiroshima)

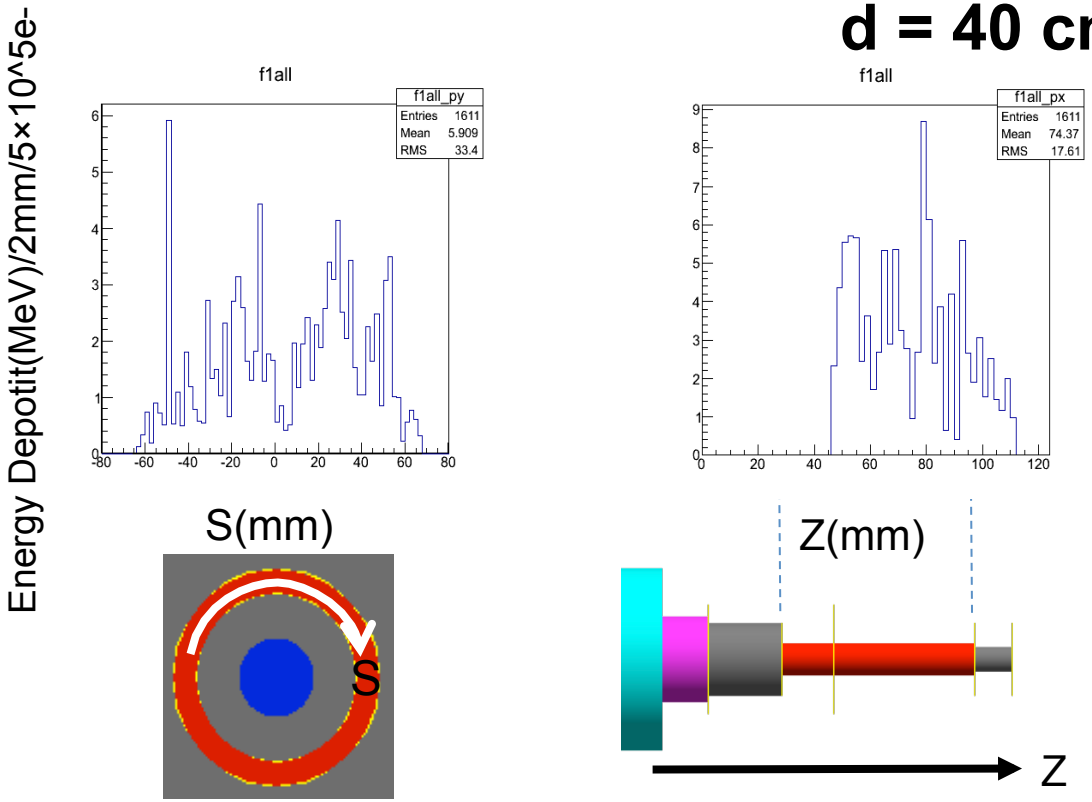


Results

Dose Estimation

FY2014

d = 40 cm with radiation shield



T. Takahashi (Hiroshima)

Peak 1.5MGy/year

(2630bunch 5Hz 2e10/bunch 1 year = 10^7s)

N_b = 2600

Test in 2014

Systematic study of the ferrofluid

We made the test of the ferrofluid up to 4.7 MGy in 2014.

We used irradiated ferrofluid (4.7 MGy) in a small rotation target.

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TEST: Radiation Tolerance

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TEST: Radiation Tolerance

Takasaki Advanced Radiation Research Institute

Takasaki: One of most famous homes of Daruma dolles

TEST: Radiation Tolerance FY2014

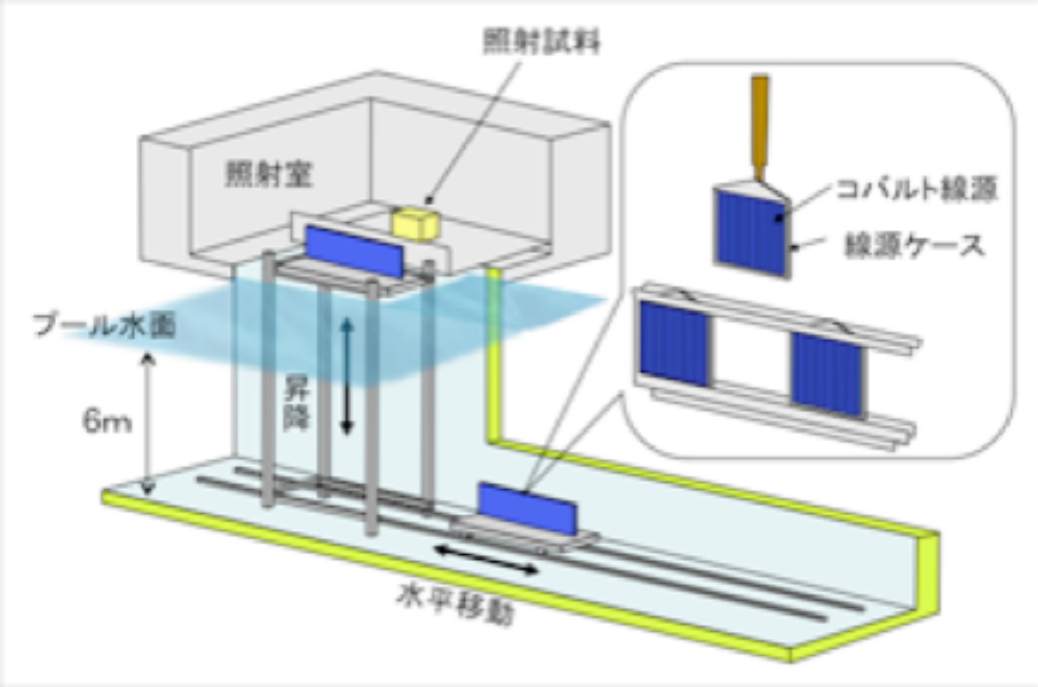
Takasaki Advanced Radiation Research Institute, JAEA

November 2014

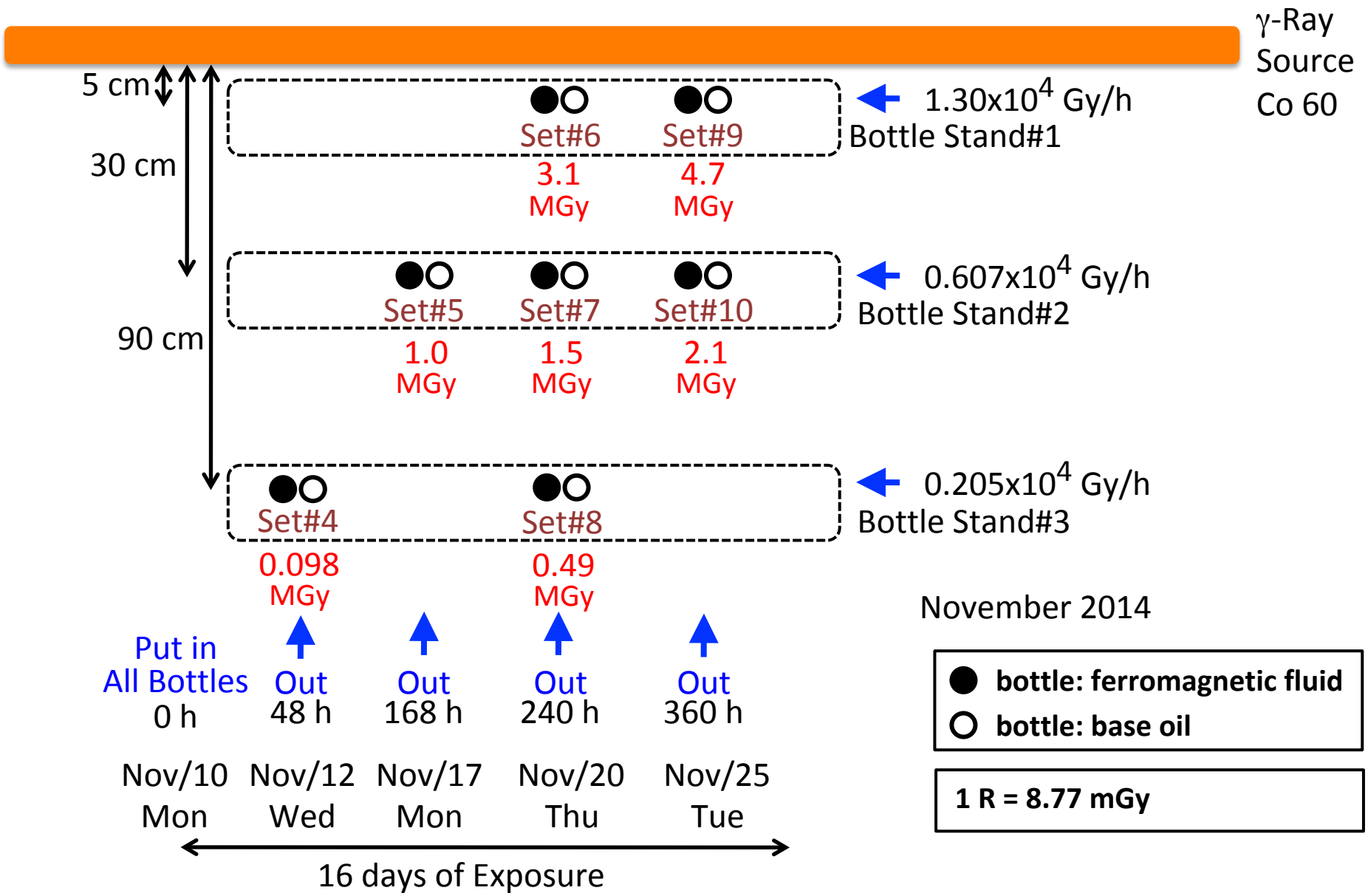
TEST: Radiation Tolerance FY2014

Takasaki Advanced Radiation Research Institute, JAEA

November 2014



TEST: Radiation Tolerance FY2014



TEST: Radiation Tolerance

FY2014

November 2014

Leading With Innovation

粘度の違いは見られるが、外見に異常なし

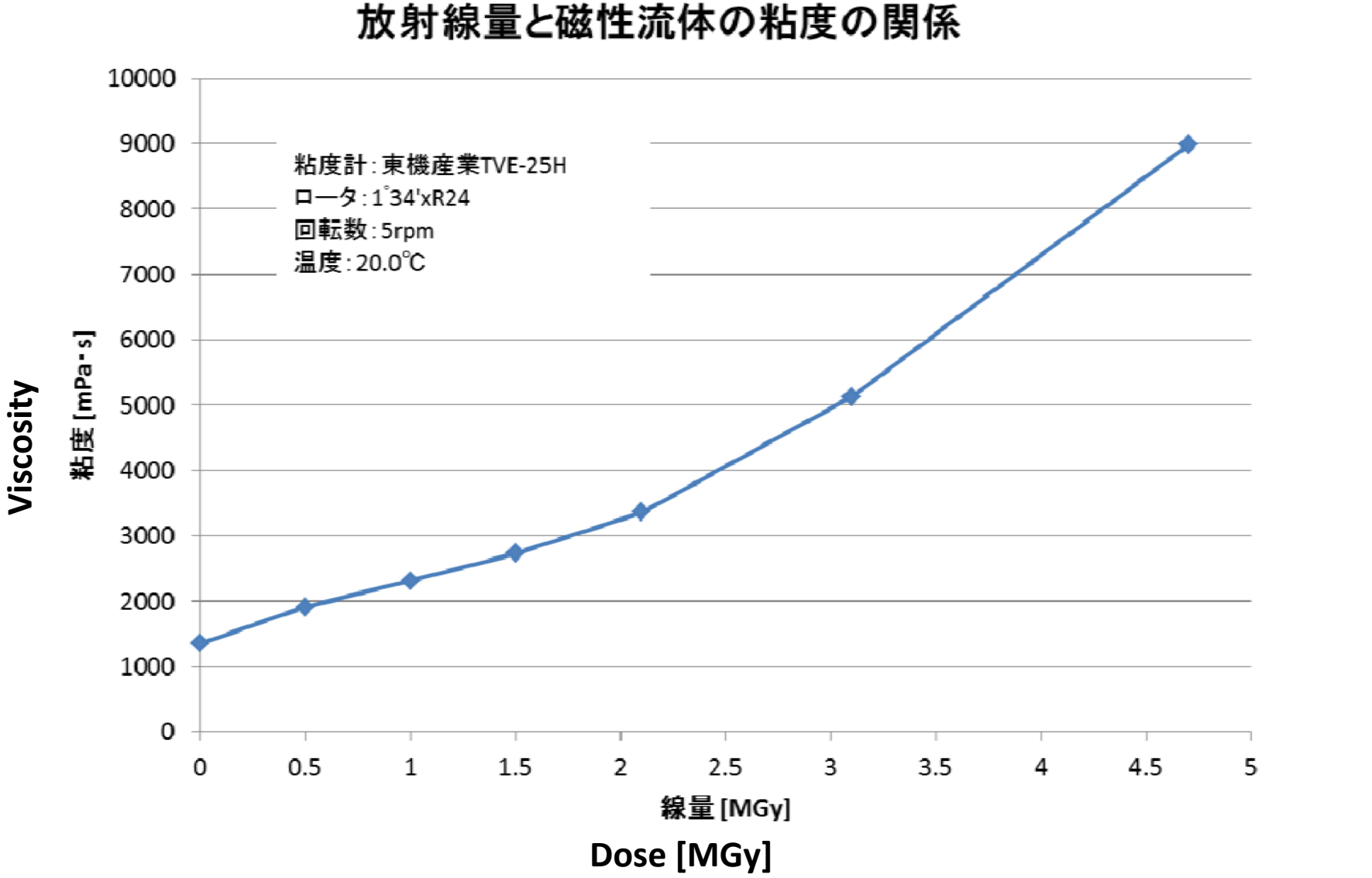
TEST: Radiation Tolerance

November 2014

Systematic study for ferrofluid

FY2014

Viscosity as a function of dose



TEST: Radiation Tolerance

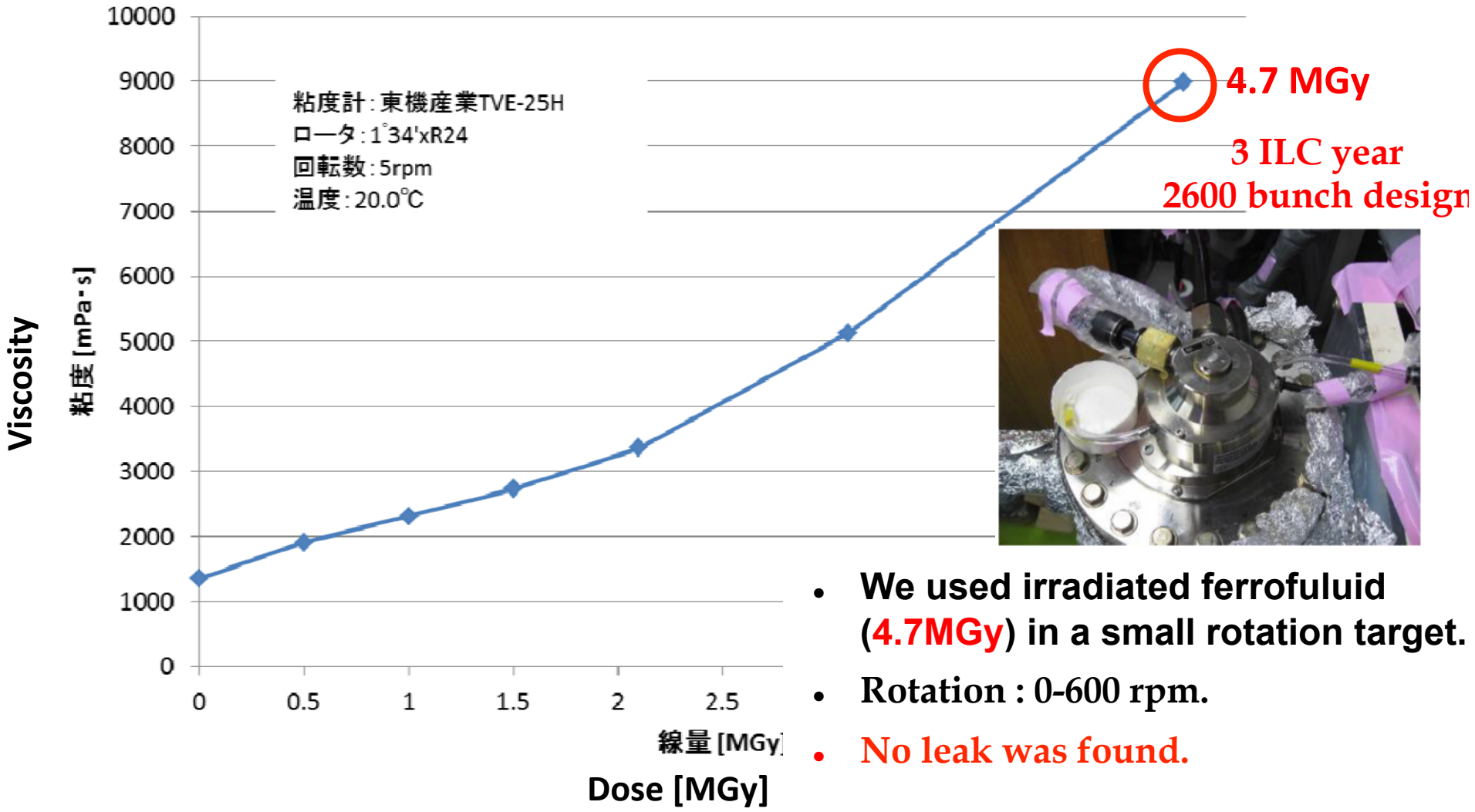
November 2014

Systematic study for ferrofluid

FY2014

Viscosity as a function of dose

放射線量と磁性流体の粘度の関係



- We used irradiated ferrofuluid (4.7MGy) in a small rotation target.
- Rotation : 0-600 rpm.
- No leak was found.

Test in 2015

Irradiation on a small off-the-shelf rotation target.
市販の回転ターゲット全体に照射

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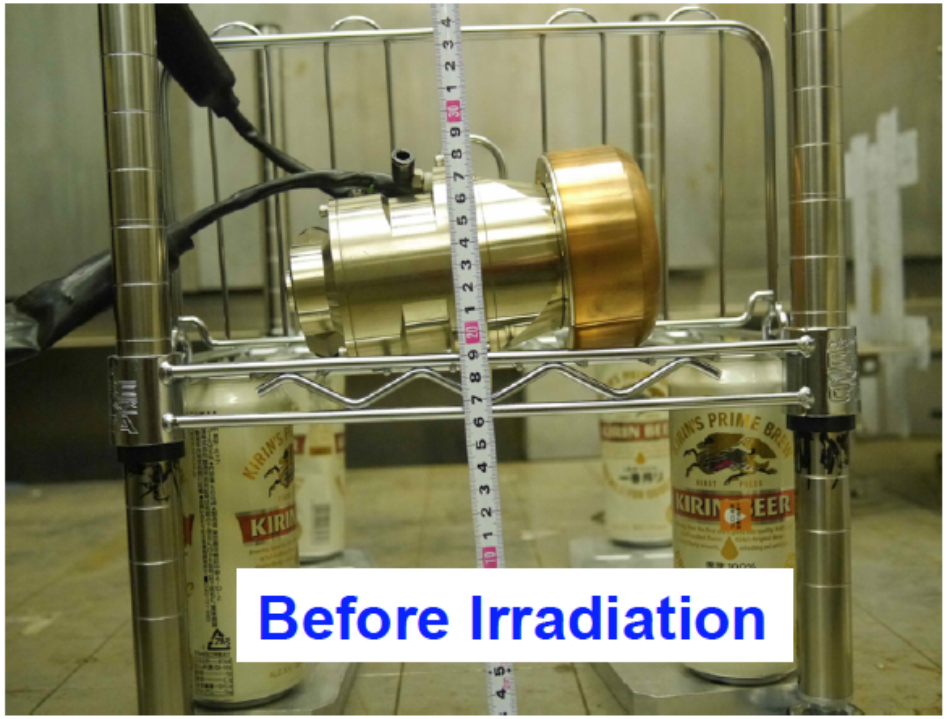
Conventional (E-driven): Target

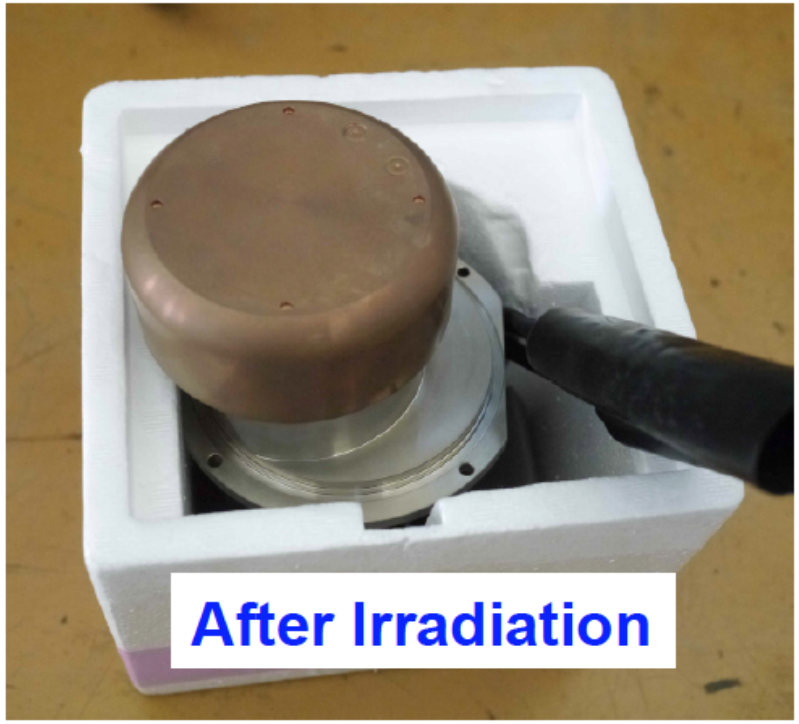
TEST: Radiation Tolerance Mar 2015

Irradiation to the small (d=10 cm) off-the-shelf rotation target

Radiation test of the whole system: motor, bearing, ferrofluid,,,

0.6 M Gy irradiation on the motor.
corresponds 1 ILC year $N_b = 2600$





After irradiation, we made rotation and vacuum test.

We found NO problem

T. Omori

Test in 2018

We made the test of the ferrofluid up to 4.7 MGy. (as same as 2014 test)
磁性流体流体とベースオイルに対して 4.7 MGy までの段階的照射
(2014と同じ)

Study possible change of molecular structure of the base oil and ferofluid by using GPC (Gel Permeation Chromatography).

照射後の磁性流体とベースオイルの分子構造の変化を、GCP (ゲル浸透クロマトグラフィー)などを用いて調べる

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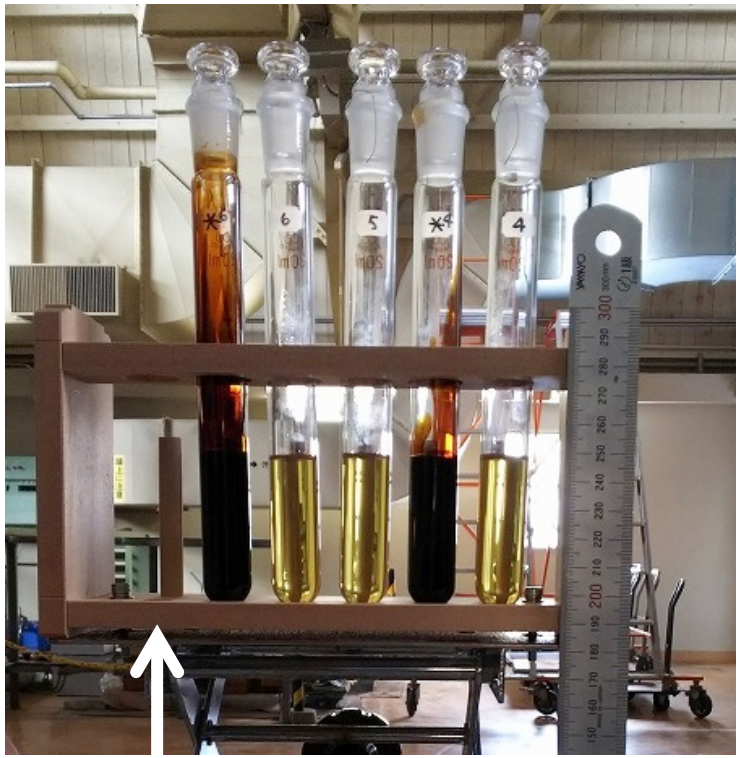
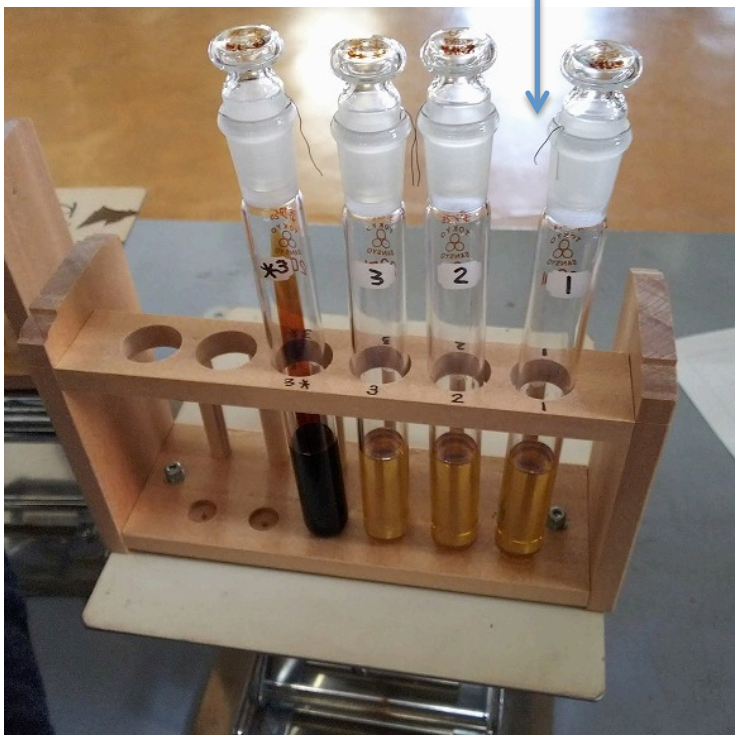
Samples in test tubes

各サンプルをラボジャッキに固定した試験管立てに設置。
ガンマ線照射時に発生するガスが抜けるようにするため、
白金の線をフタに挟んでいる。

a piece of thin wire to make possible gas escaping



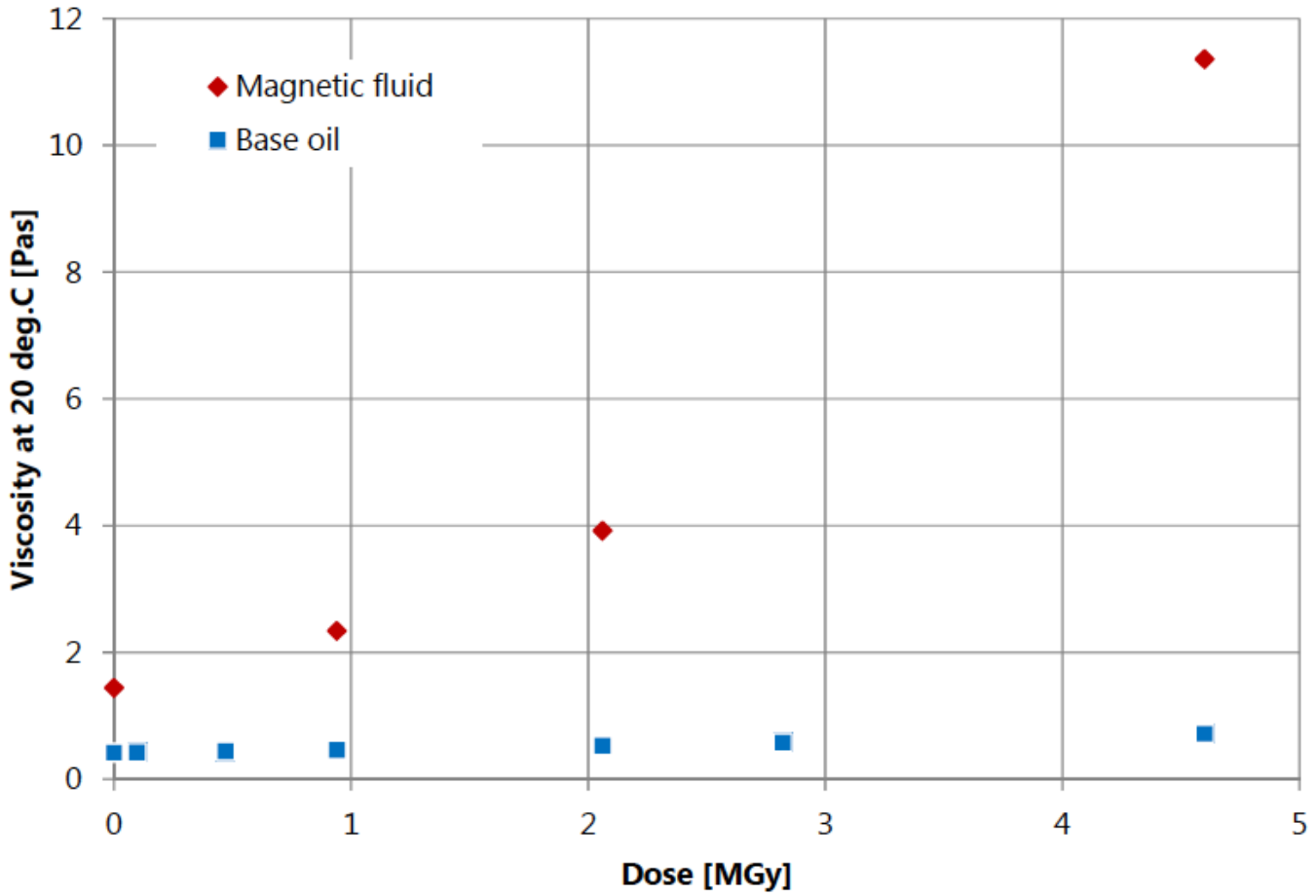


h= 22.5cm

照射線量と磁性流体・ベースオイルの粘度

Viscosity as a function of dose

2018



Rigaku

Results of 2018 Test

1) Viscosity of ferrofluid samples increased significantly by radiation. But almost NO change of viscosity of base oil only sample.

2) GPC results showed that larger macromolecules were produced by cross-link (架橋). Number of larger macromolecules increased as dose increased. But, NO chemical decomposition observed.

3) GPC results showed that majority of base oil molecules (in both base oil only samples and ferrofulid samples) stayed unchanged even after 4.7 MGy of irradiation. We guess this is the reason that ferrofulid is still functioning as vacuum seal after 4.7 MGy of irradiation.

4) No significant difference is observed in molecular weight distributions (分子量分布) of base oil samples and ferrofluid samples. The existence of iron powders does not accelerate cross-link or chemical decomposition.

5) Together (1) and (4) suggest that cross-link (架橋) is not primary cause of viscosity increase.

Test in 2019

We made the test of the ferrofluid up to 4.7 MGy. (as same as 2014 and 2018 tests)
磁性流体とベースオイルに対して 4.7 MGy までの段階的照射(2014, 2018と同じ)

- **Samples were in the vacuum tubes. (The tests so far were "in air")**
- **We corrected produced gas and analysis by gas chromatography (GC).**
- **We observed the surface of iron powders after irradiation by FT-IR (Fourier Transform Infrared Spectroscopy, フーリエ変換赤外分光法).**
- **Study possible change of molecular structure of the base oil and ferofluid by using GPC (Gel Permeation Chromatography). (as same as 2018)**

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a test tube with breakable seal.

Radiation Test of Ferrofluid

2019/Feb.

- Samples were in the vacuum tubes. (The tests so far were "in air")
- We corrected produced gas and analysis by gas chromatography (GC).
- We observed the surface of iron powders after irradiation by FT-IR (Fourier Transform Infrared Spectroscopy, フーリエ変換赤外分光法).
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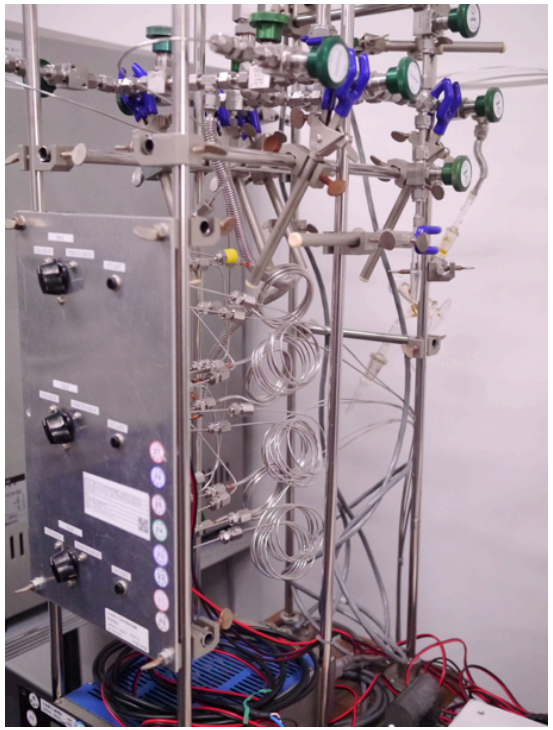

Radiation Test of Ferrofluid

2019/Feb.

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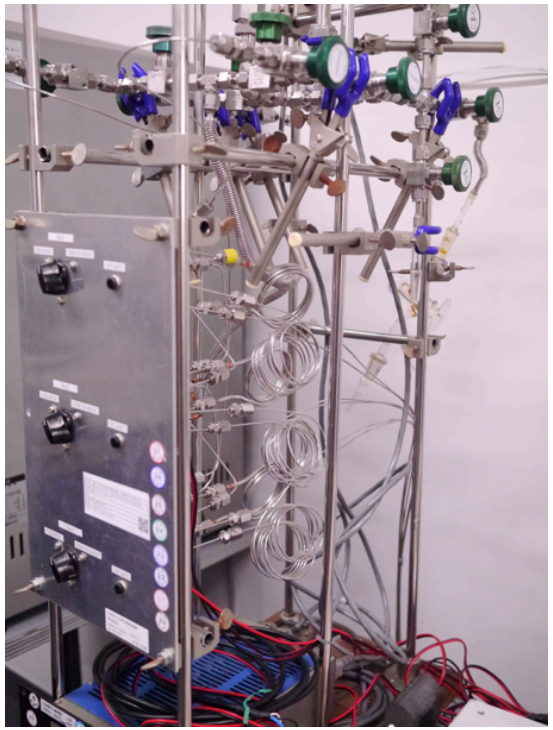
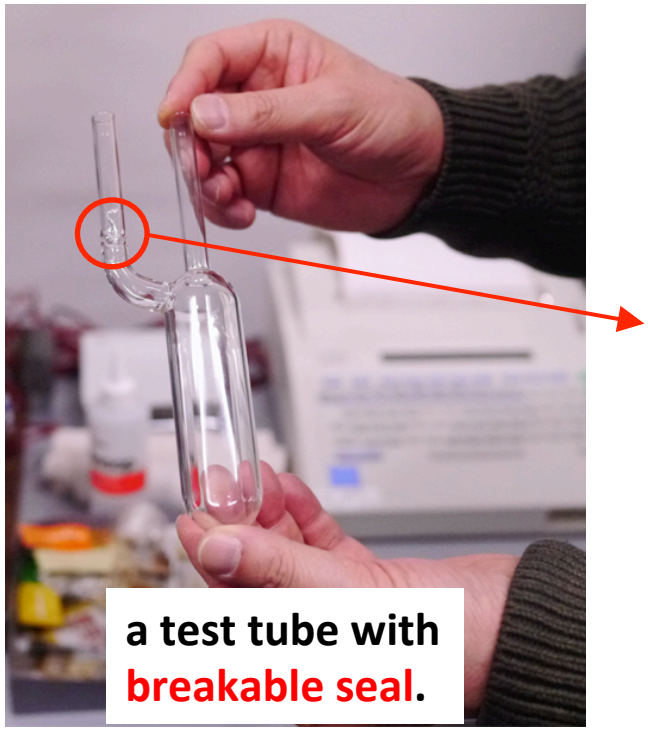


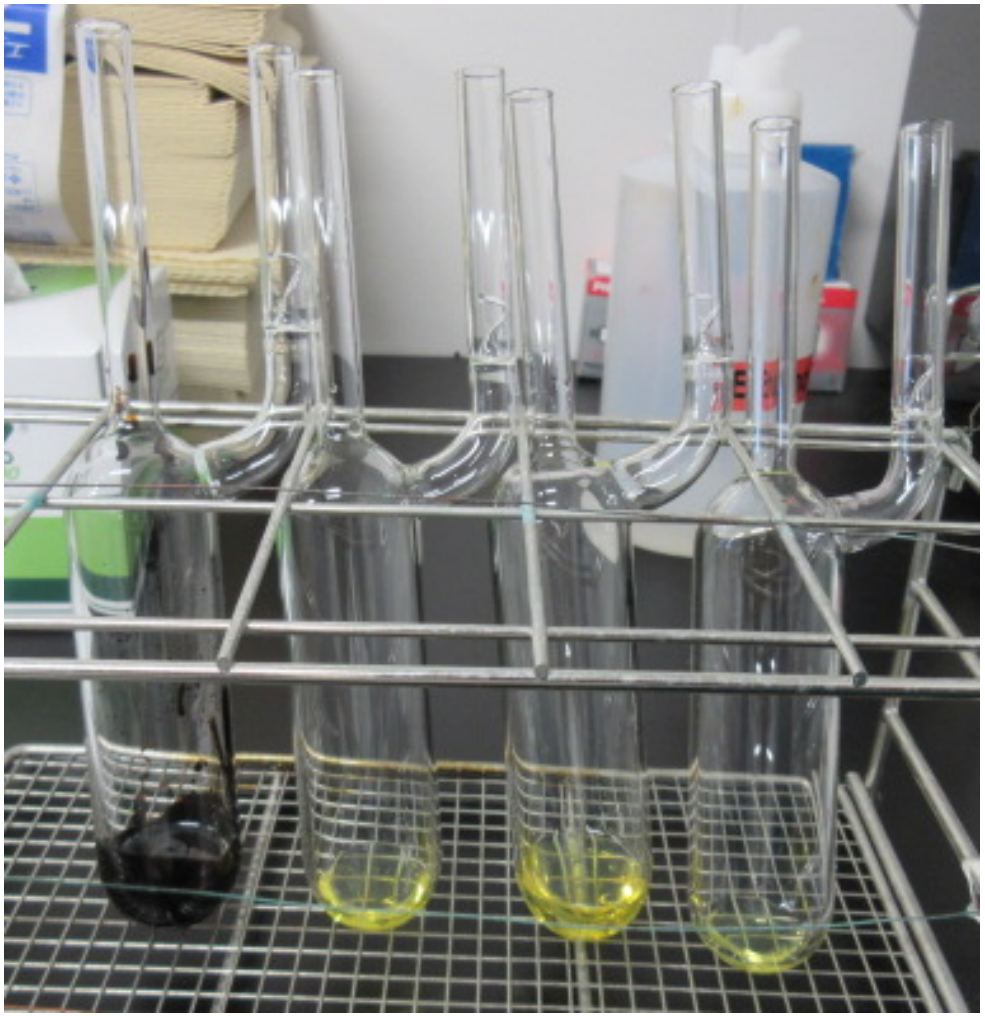


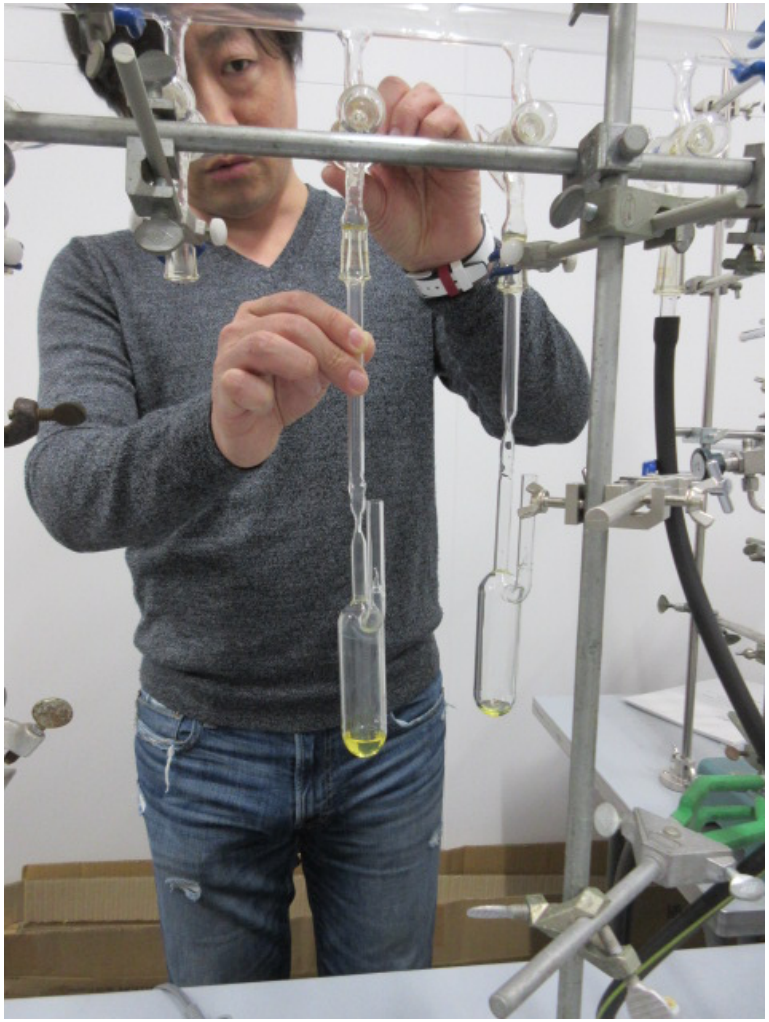
Radiation Test of Ferrofluid

2019/Feb.

Idesaki-san (出崎さん), QST Takasaki

Preparation





Results of 2019 Test

- **Results of GC analysis**
  - Compare to polyethylene, G-value of ferrofluid (and base oil) was significantly small.
  - The result of the GC analysis (= small G-value) was consistent with the result of GPC analysis (= no significant chemical decomposition observed).

- **Results of Viscosity measurement.**
  - The results in 2018/2014 and 2019 were the same.
  - "In air" or "in vacuum" made no difference of viscosity change.

- **Results of GPC analysis.**
  - The results in 2018 and 2019 were the same.
  - "In air" or "in vacuum" made no difference of molecular weight (分子量) change.

Next Steps 1

- **What happen on Surfactant (界面活性剤)?**
  - **We tried to observe surface state of iron powders by FT-IR (Fourier Transform Infrared Spectroscopy). But it was failed. It seemed sensitivity was not high.**
  - **We are planning to apply a new way to observe the surface of the iron powder.**

Next Steps 2

- **Neutron?**
  - **We have started to study effect of neutron. (Miyamoto-san)**