Conventional e^+ Source Rotation Target R/D

T. Omori (KEK)

On behalf of the Truly Conventional Collaboration

ANL, IHEP, Hiroshima U, U of Tokyo, KEK, DESY, U of Hamburg, CERN

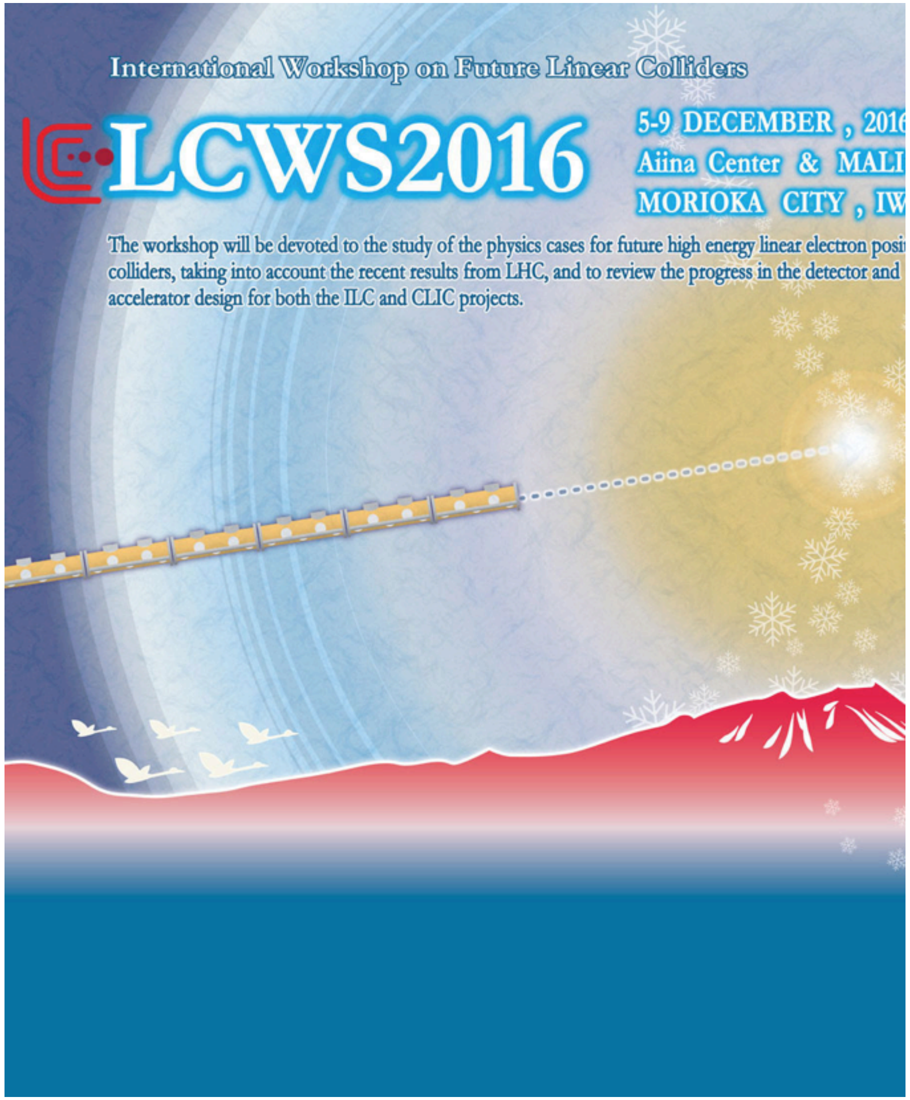
Rotation target design study: ongoing with Rigaku

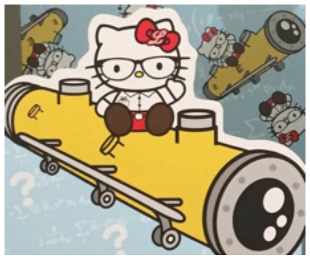
15-September-2016

Posipol 2016, LAL, Orsay, FRANCE

LCWS 2016

5-9 December, Morioka, Iwate, Japan





The T-shut and other Kitty Goods will be sold at LCWS 2016.

Plenary Talk by Lyn EVANS

2nd-June-2016 ECFA LCWS Santander, SPAIN

LINEAR COLLIDER COLLABORATION

Nomura report

Only available in Japanese
Weak points identified are
Positron source.
Beam dump.

Today's Talk

R/D of the Slow Rotation Target of the Conventional e+ Source for ILC

- Overview
- Target R/D (1): Heat and Stress Simulations
- Target R/D (2): Radiation, Vacuum, and Prototype
- Summary

Overview

Conventional e+ Source for ILC

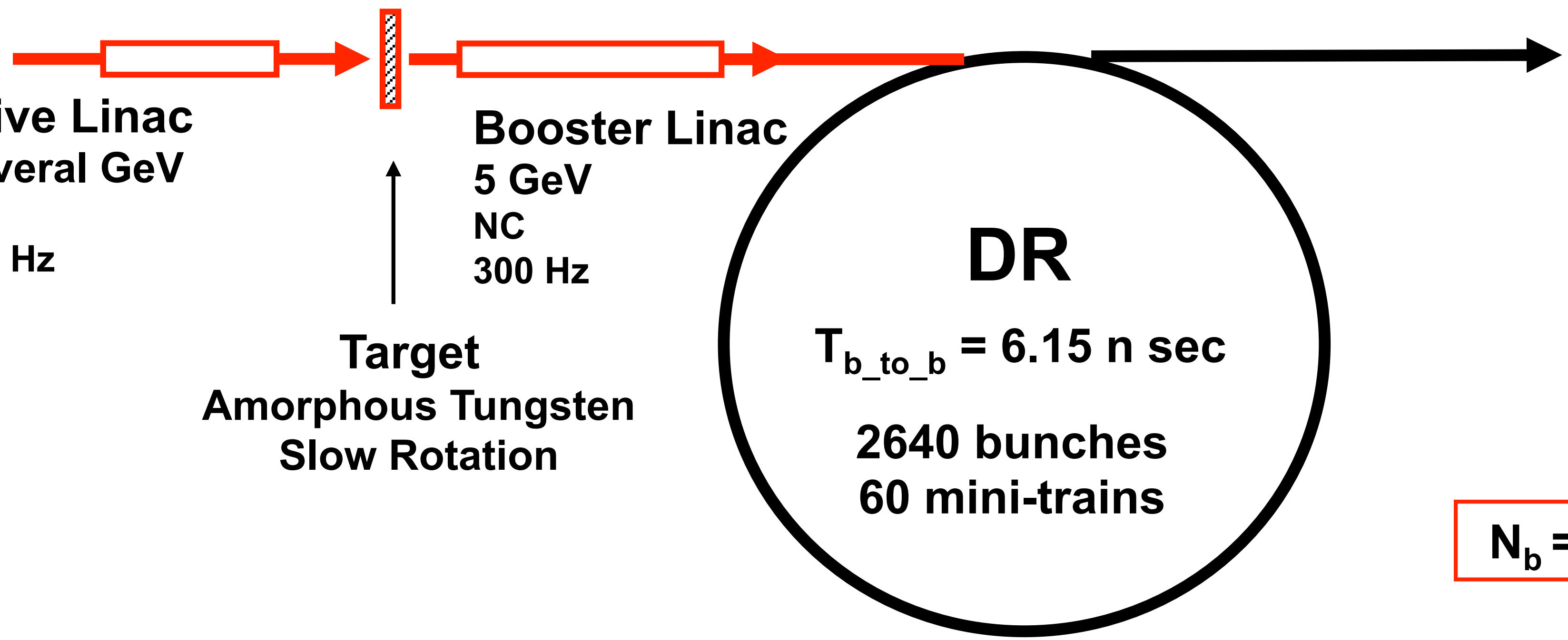
Normal Conducting Drive and Booster Linacs in 300 Hz operation

e+ creation

20 triplets, rep. = 300 Hz
- triplet = 3 mini-trains with gaps
- 44 bunches/mini-train, $T_{b\_to\_b}$ = 6.15 n sec

go to main linac

2640 bunches/train, rep. = 5 Hz
- $T_{b\_to\_b}$ = 369 n sec



N_b = 2600

Time remaining for damping = 137 m sec

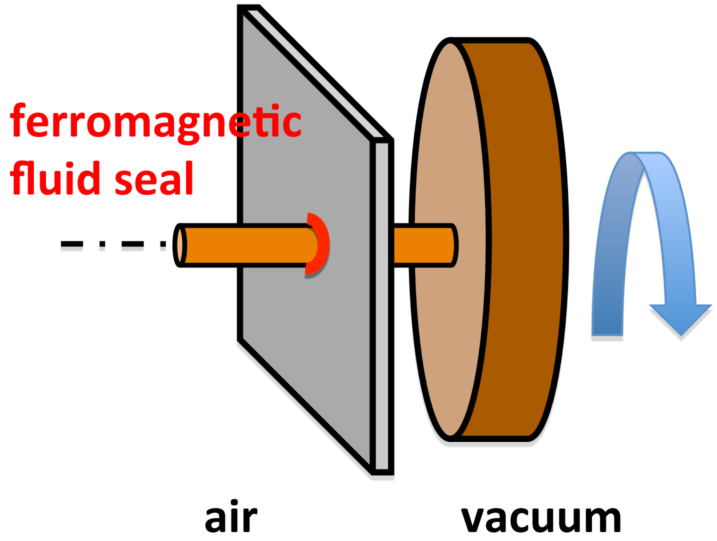
We create 2640 bunches in 63 m sec ⇐ Stretching

NIM A672 (2012) 52—56

Moving Target

- ~5m/sec required (1/20 of undulator scheme)

rotating target with ferromagnetic seal



issues: vacuum, heat, stress

The target R/D (1)

Heat and Stress Simulation

Thermal Analysis:

We did both **CW beam** analysis (for simplicity) and **pulse beam** analysis (more realistic).

We assume **2600 bunches** in all analysis.

- CW beam analysis

  38kW (35kW+3kW(*)) CW

  ↑ beam ↑ FC

* Note
3 kW is not correct
should be 1 kW

- Pulse beam analysis: **step 1**

  114.1 kW(111.1kW+3kW) 63 ms

  0 kW (0kW+0kW) 137 ms

  ↑ beam ↑ FC

- Pulse beam analysis: **step 2**

  20 trains (pulses) in 63 ms

- Common condition

  Cooling water: 30 ℓ /min, T at inlet: 25℃

$N_b = 2600$

Rigaku

Thermal Analysis:

We did both CW beam analysis (for simplicity) and pulse beam analysis (more realistic).

We assume 2600 bunches in all analysis.

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3 kW is not correct should be 1 kW

Reported ALCW 2015, Apr., 2015, Tsukuba and Posipol 2015, Sep., 2015, Daresbury

- Pulse beam analysis: step 2

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$N_b = 2600$

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  Cooling water: 30 ℓ/min, T at inlet: 25℃

Rigaku

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  ↑ beam ↑ FC

- Pulse beam analysis: step 2

  20 trains (pulses) in 63 ms

Reported
LCWS 2015,
Nov., 2015, Whistler

N_b = 2600

- Common condition

  Cooling water: 30 ℓ/min, T at inlet: 25℃

Rigaku

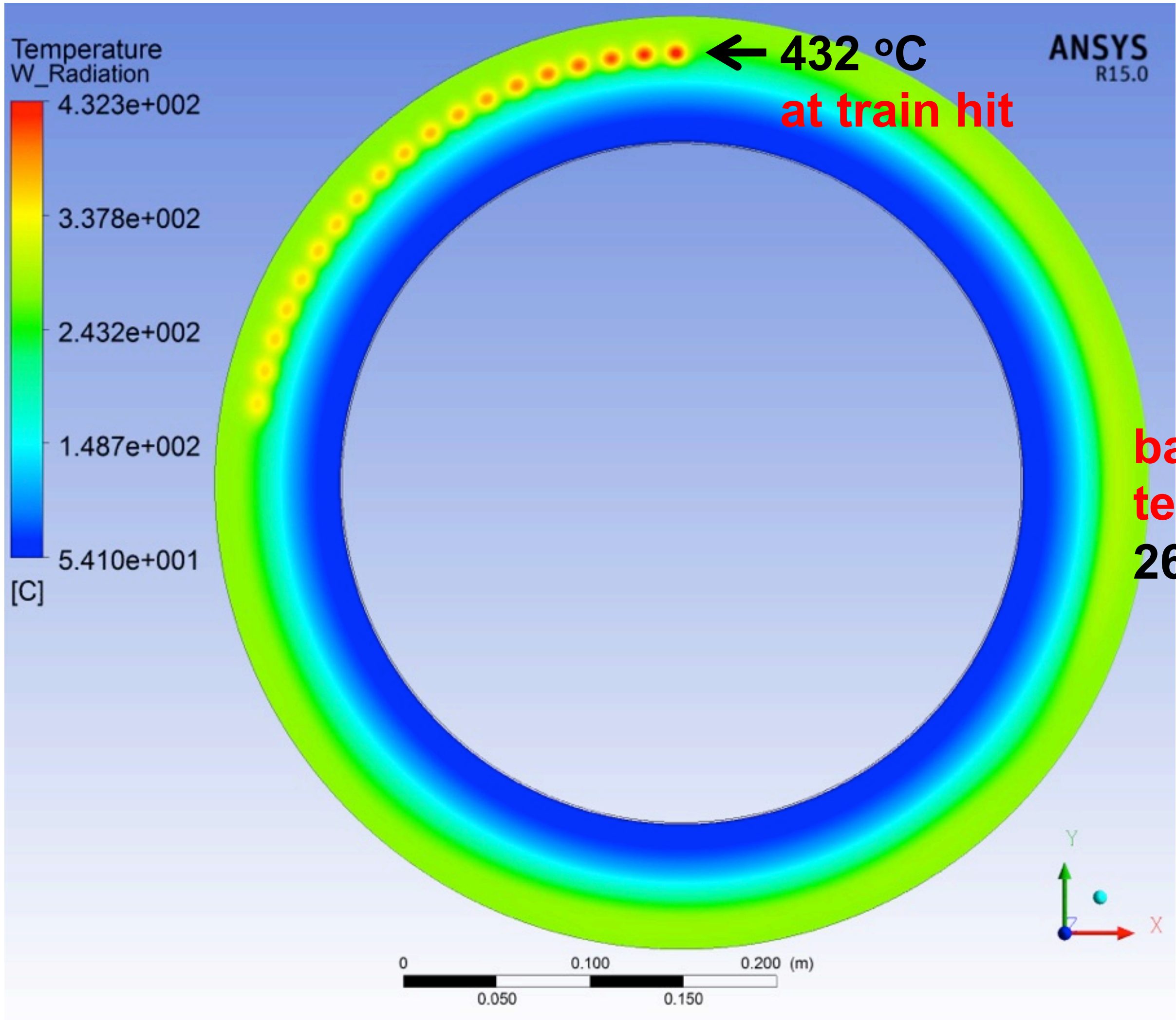
Pulse Beam Analysis step 2:

20 trains in 63 ms

Rotation speed = 220rpm

1 train = 373 kW(**) in 0.99 m sec (*)

train to train separation: 3.3 m sec



← 432 °C at train hit

baseline temperature 262 °C

* Note: 1
One train corresponds 132 bunches, but time structure in a train is ignored.

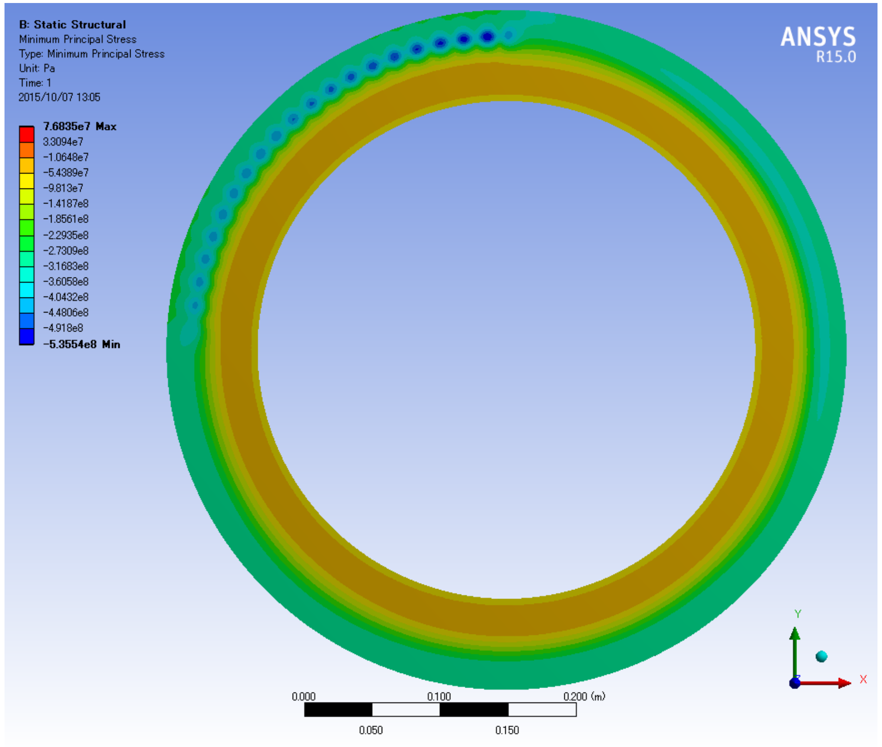
* Note: 2
This is NOT totally correct.
Pulse width of a train is NOT 0.99 m sec. It is 0.99 micro sec.
But difference in the results are small.

** Note: 3
This value is NOT accurate.
This is 5% larger than correct value.

$N_b = 2600$

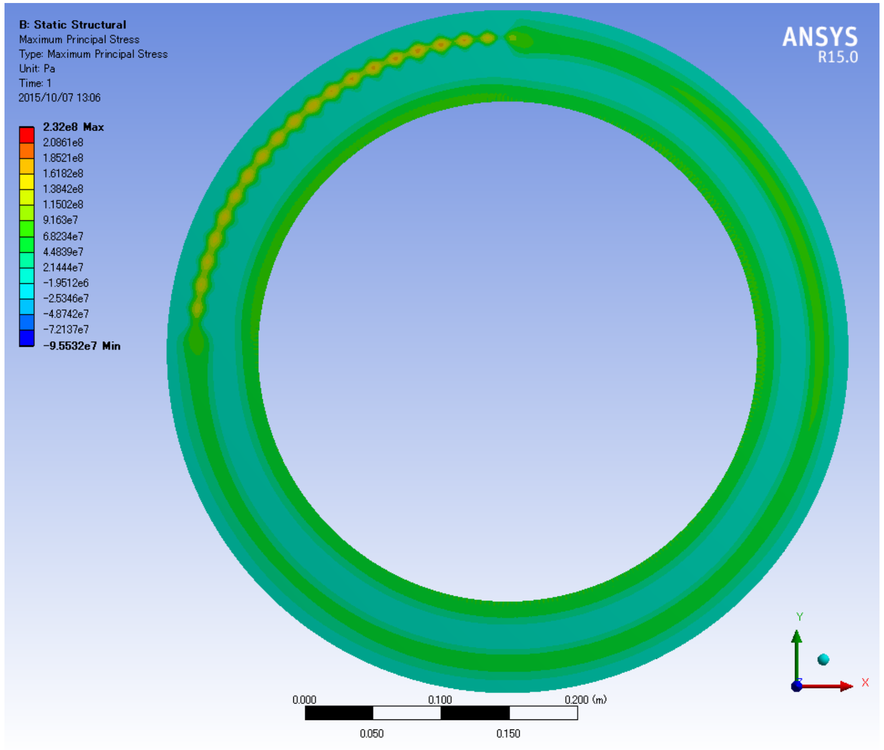
Simulated by Rigaku Nb=2600

Stress: rotation speed 220 rpm, Pulse Beam Analysis, Step 2
20 trains in 63 ms



最小主応力
→ -5.4e+8Pa(圧縮)

Min Principal Stress
(Compression)
→ - 5.4e+8Pa



最大主応力
→ 2.3e+8(引張り)

Max Principal Stress
(Expansion)
→ 2.3e+8Pa

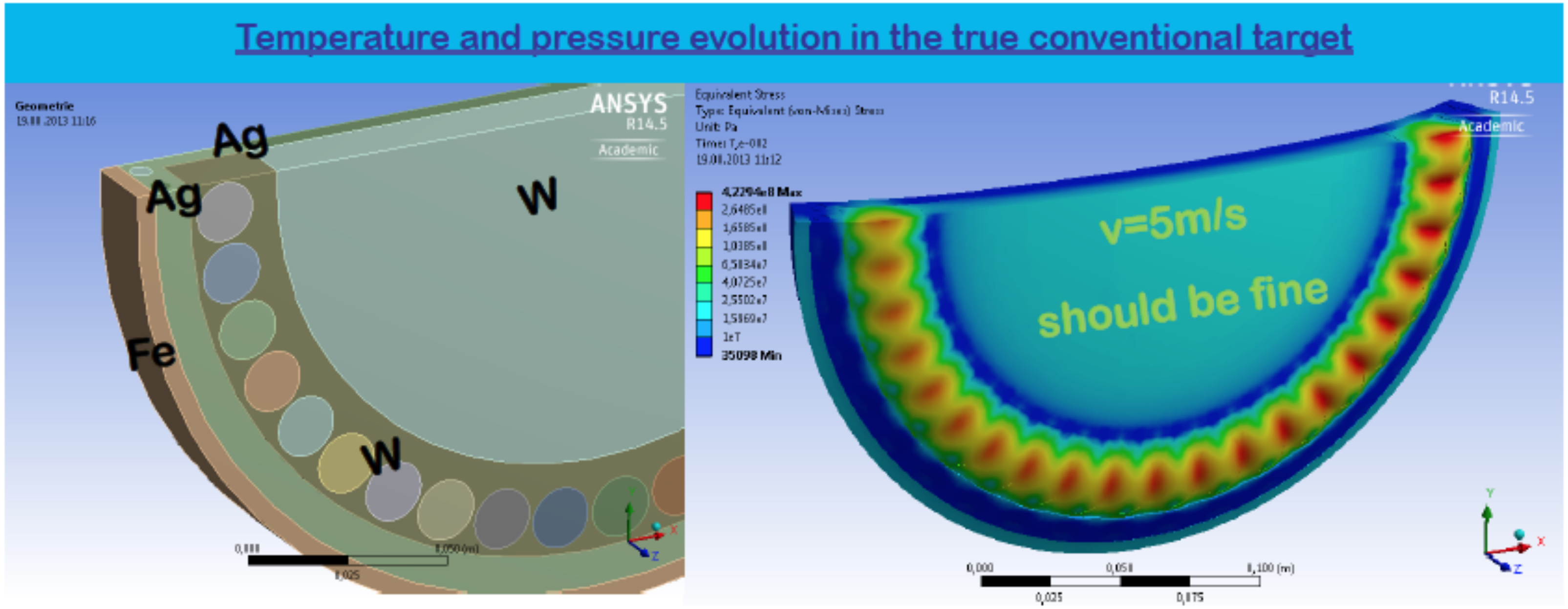
$N_b = 2600$

Simulated by Rigaku

cf. ILC target Analysis by Friedrich-san Posipol 2013, 5th/Sep., at ANL

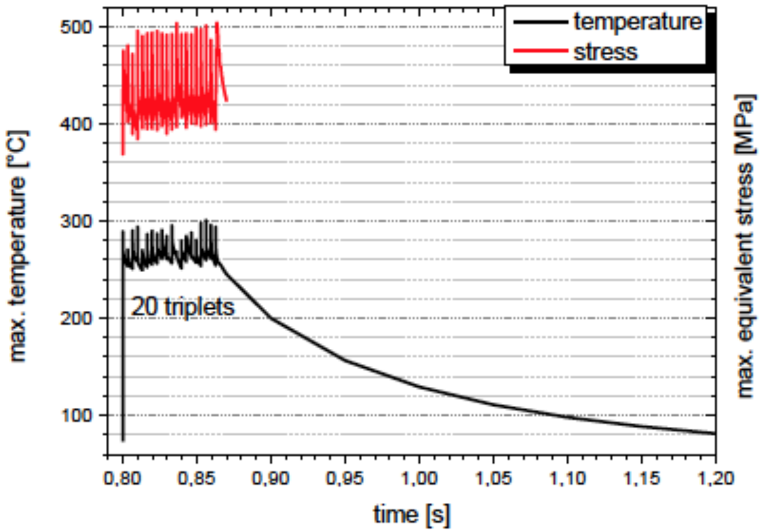
Max Stress 500 MPa (132 bunches hit the same spot)(Von Mises)

Max 300 度C



cooling : 0.2 l/s

wheel ∅ 200mm



Wheel with v = 5 m/s should work!! Beam hits the same place 2.5 times in a sec. like the SLAC target

HELMHOLTZ GEMEINSCHAFT

F.Staufenbiel / POSIPOL13 / 5.9.2013

DESY

Is ILC Target Safe?
with 540 MPa Peak Stress

Is ILC Target Safe?
with 540 MPa Peak Stress

WRe: Yield Strength and Fatigue Limit

Table 1: WRe structural material properties.

Property	**0.0 C**	**500 C**	**1000 C**
Modulus, Pa	4.3e+11	4.0e+11	3.95e+11
Poisson ratio	0.28	0.28	0.28
Thermal Exp. Coef. 1/C	6.7e-6	7.1e-6	7.95e-6
Yield, Pa	1.6e+9	1.3e+9	9.0e+8
fatigue	**640**MPa	**520**MPa	**360**MPa

Freidrich Staufenbie, Posipol 2013, 5th/Sep. at ANL

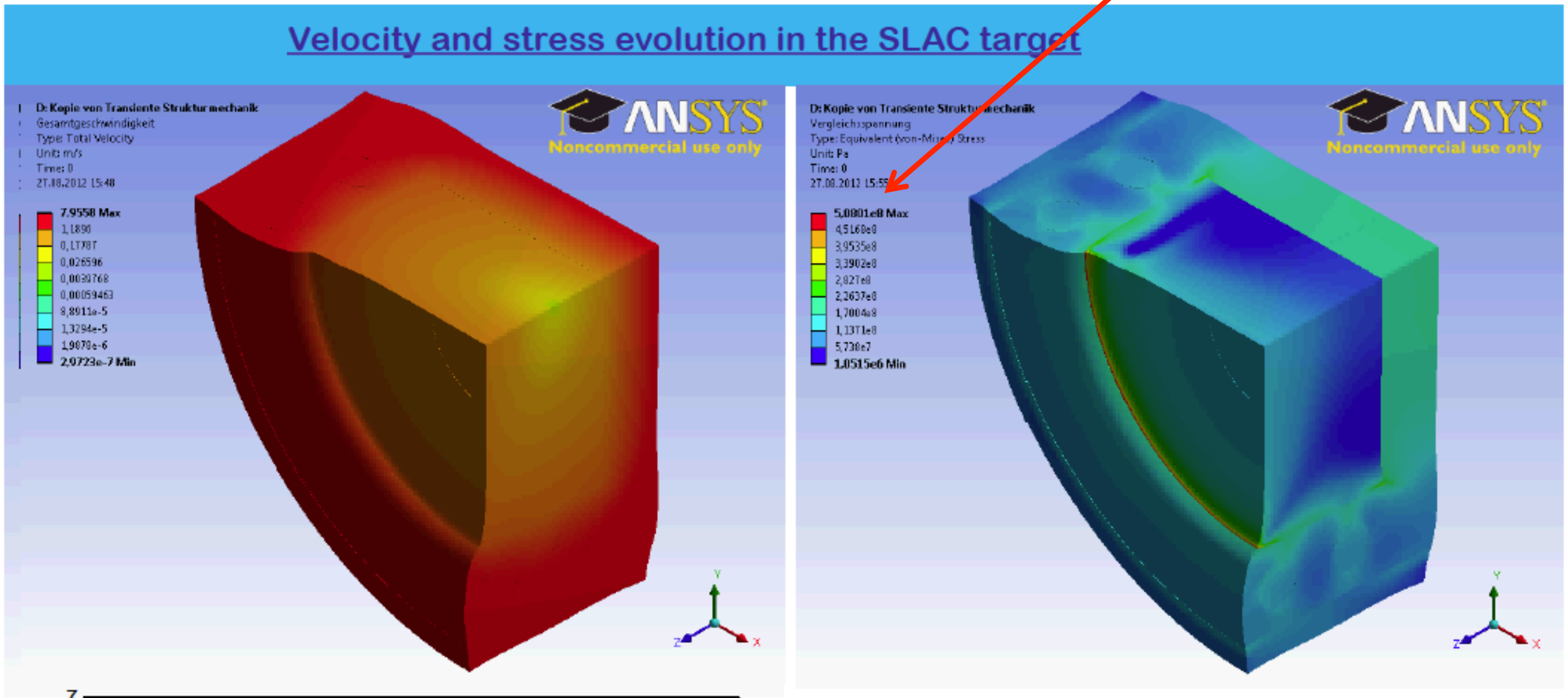
Peak Stress ~ Fatigue Limit

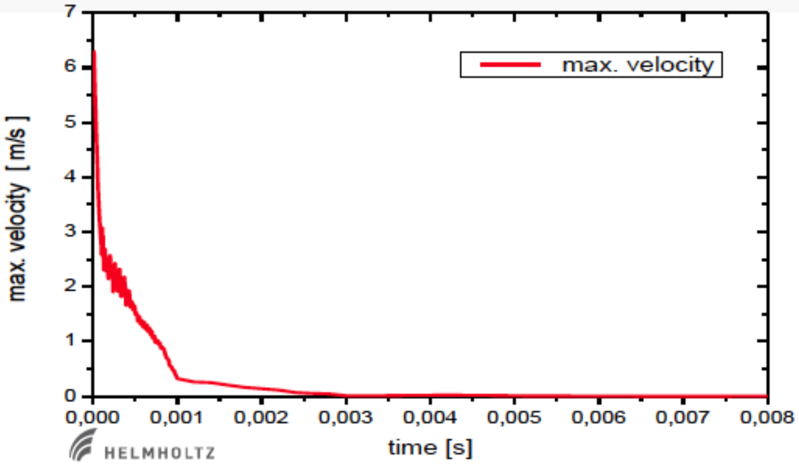
cf. SLC target Analysis by Friedrich-san

Posipol 2013, 5th/Sep., at ANL

Max Stress 508 MPa (single bunch)(Von Mises)

Zoom up if you want see the number.





HELMHOLTZ GEMEINSCHAFT

SLAC

33 GeV e^-
$4*10^{10}$ e^-/pulse (6.4nC)
$\sigma = 0.8$mm
120 Hz ≈ 8 ms

F.Staufenbiel / POSIPOL13 / 5.9.2013

DESY

Is ILC Target Safe?

The greatest achievement so far is the SLC target.

Max stress in the SLC target
508 MPa (analysis by Freidrich-san)
560 MPa (analysis by SLAC, SLAC-PUB-9437)

Max stress in the ILC target
540 MPa (analysis by Rigaku, T. Omori LCWS2015)

SLC target stress and ILC target stress are comparable.

SLC target was destroyed after 3-4 years of operation.
SLC target worked in 3-4 years.

In view point of Max Stress:
ILC target is as safe as SLC target.

Is ILC Target Safe?

Comparison of SLC and ILC

In View Point of Fatigue Effect

PEED	SLC	29 J/g (for 1 bunch)	comparable
	ILC	27 J/g (for 132 bunches)	

cf. Max Stress of SLC and ILC are comparable. ---> consistent

PEED represents effect of all parameters of the beam and the target; beam energy, spot size, target thickness.

Comparison can be made by number of hits per year.

Beam hits run along the circle.
Compare number of hits per unit length.
(Not per unit area, because PEDD already take into account beam spot size.

Circumferences
- SLC: 180mm
- ILC: 1500mm

Is ILC Target Safe?

Comparison of SLC and ILC

In View Point of Fatigue Effect

Number of hit / Year.mm

SLC:

120 Hz x 3600 s/h x 24 h/d x 365 d/y / 180 mm = 2.1 e+7 hits/year.mm

ILC:

2600/132 x 5 Hz x 3600 s/h x 24 h/d x 365 d/y / 1500 mm= 2.1 e+6 hits/year.mm

Def. of hit

SLC: 1 hit = 1 bunch

ILC: 1 hit = 132 bunches

In view point of Number of hit / year.mm;

In the view point of Fatigue;

ILC target (conventional) 10 times ease than SLC target.

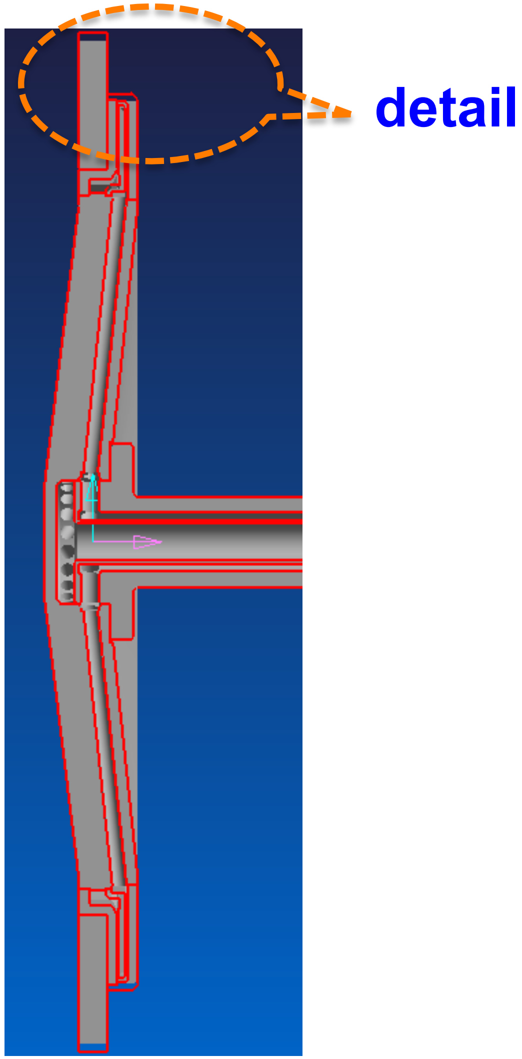
Note: rather rough estimation:

$N_b = 2600$

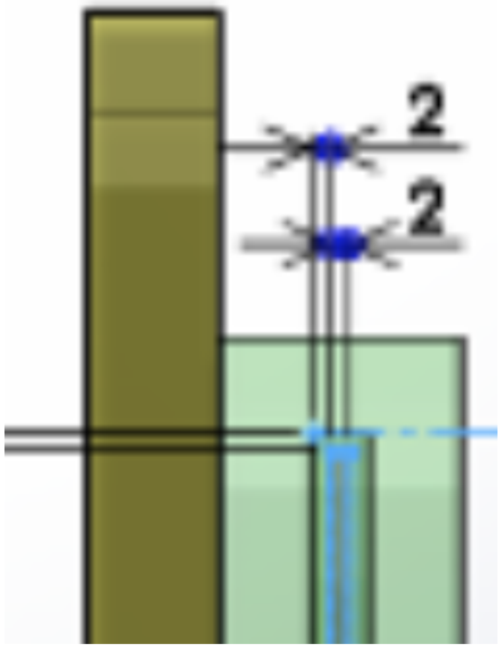
To Get Improved Safety (1)

Trying Better Cooling: water channel design

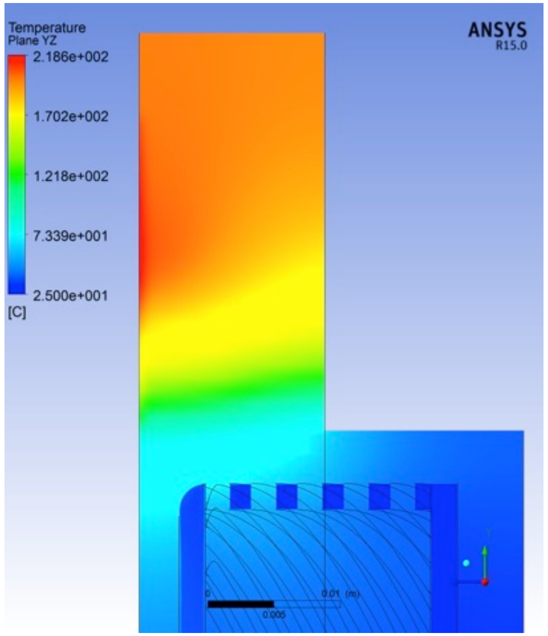
Outline

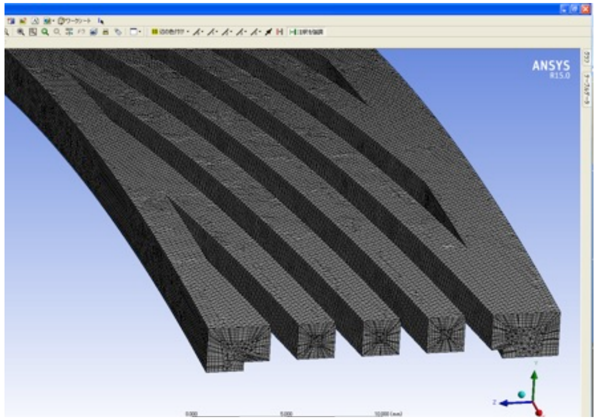


Detail: Old Design (Model 39)



Detail: New Design (Model 50)





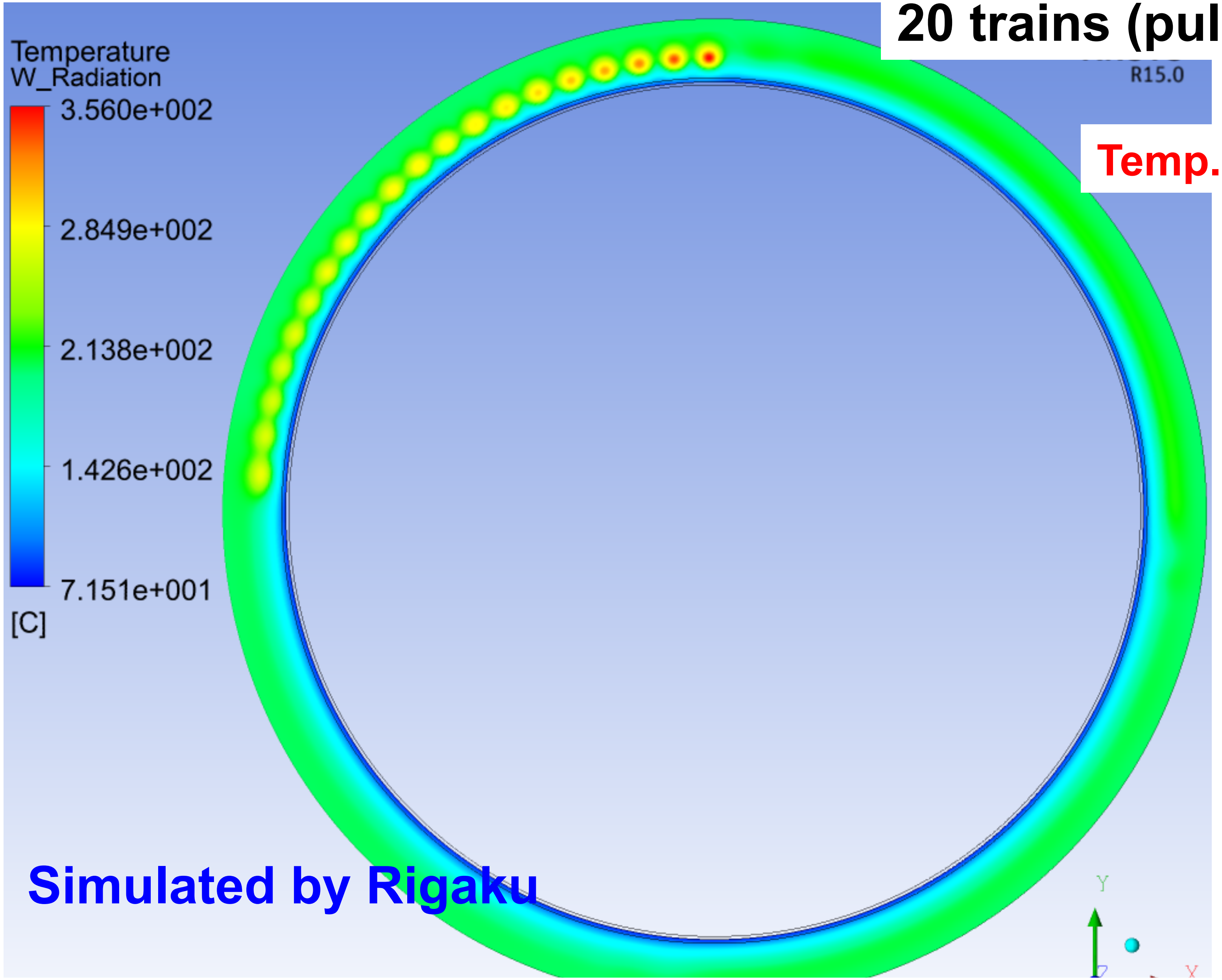
To Get Improved Safety (1)

Trying Better Cooling: water channel design

非定常解析　Pulse#02 225rpm

Pulse beam analysis: step 2

20 trains (pulses) in 63 ms



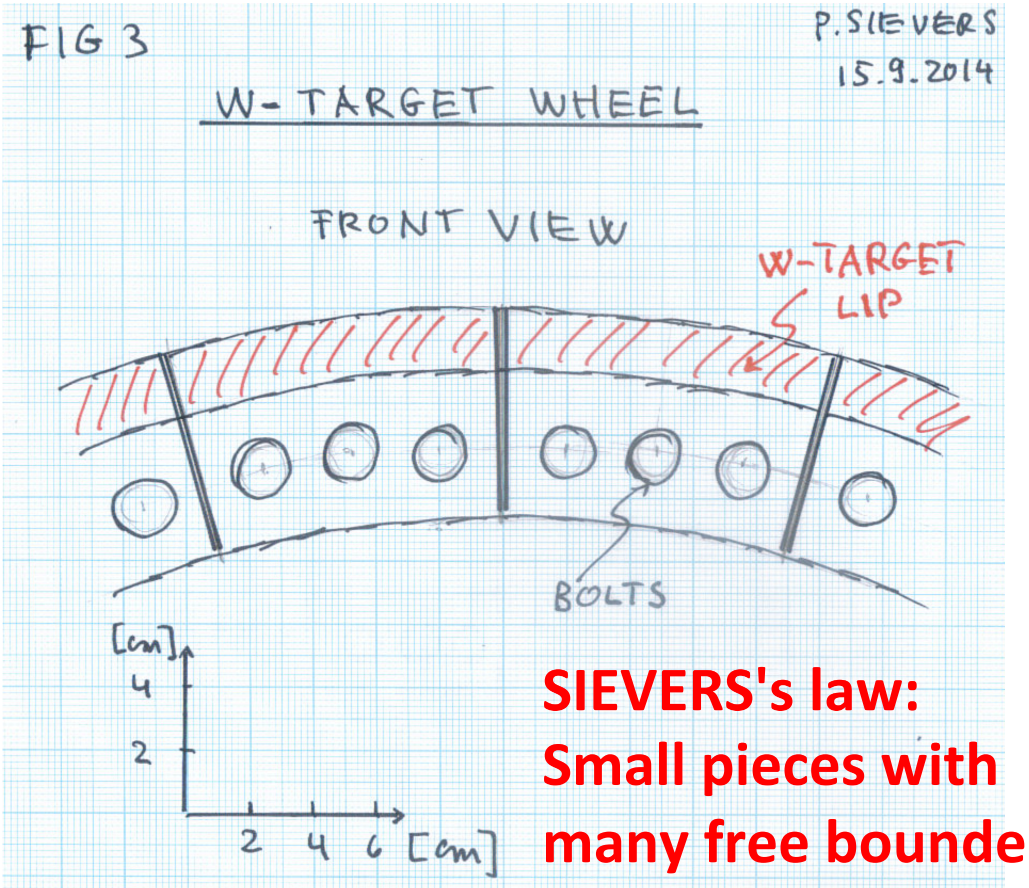
Temp.Max.; 356.0℃

About 100℃ reduction. with new water channel design in the disk. (Model 50)

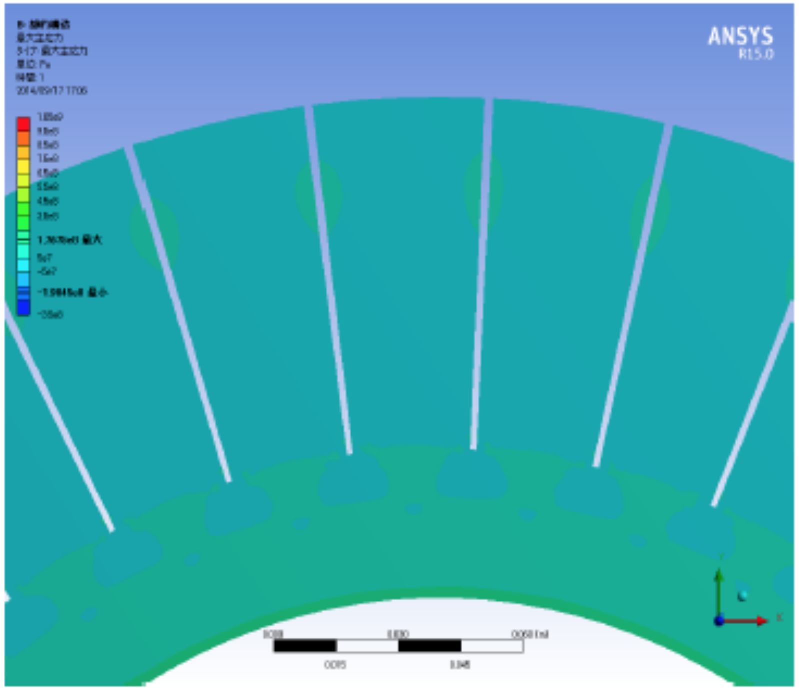
Simulated by Rigaku

To Get Improved Safety

We have another room of improvement



SIEVERS's law:
Small pieces with many free bounderyes make stresses small.



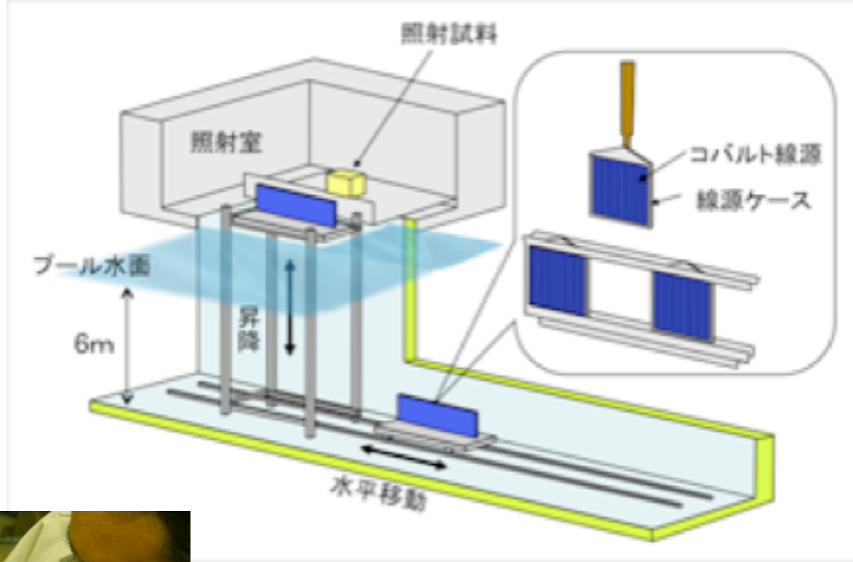
Target outer disk with radial slits

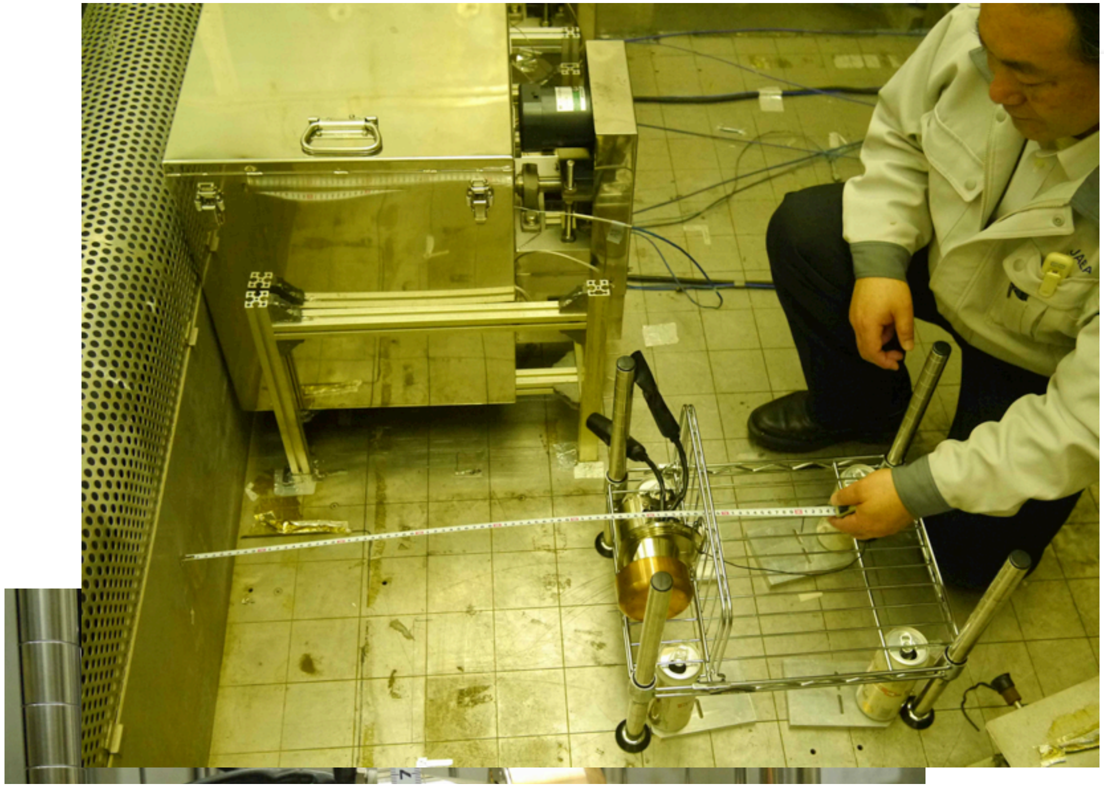
The target R/D (2)

Radiation Issues,
Vacuum Issues,
and
Prototype Target

TEST: Radiation Tolerance Mar 2015

Takasaki Advanced Radiation Research Institute, JAEA





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

Radiation test of the whole system.

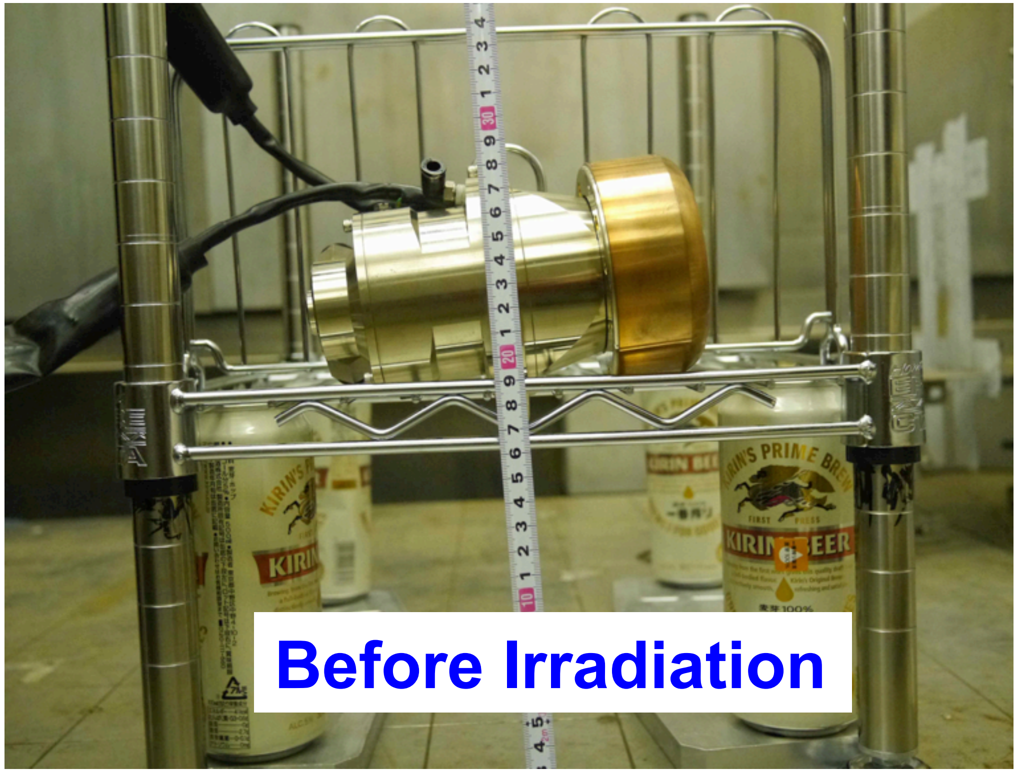
cf. ferrofuid test was already done separately upto 4.7 Mgy (3 ILC years).

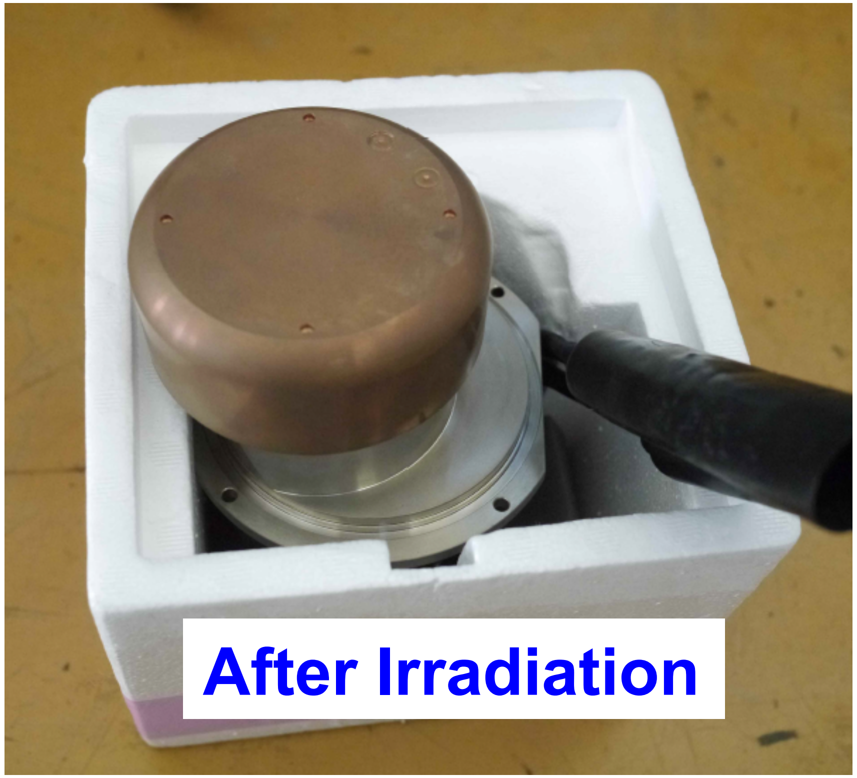
TEST: Radiation Tolerance Mar 2015

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





After irradiation, we made rotation and vacuum test.

We found NO problem

Plan of Prototpe in FY2015-2017

(1) We are making the prototype in three years (FY2015-2017).
(Old Plan: It was two-year plan in FY2015-FY2016)

(2) The prototype is full-size, d=500 mm.

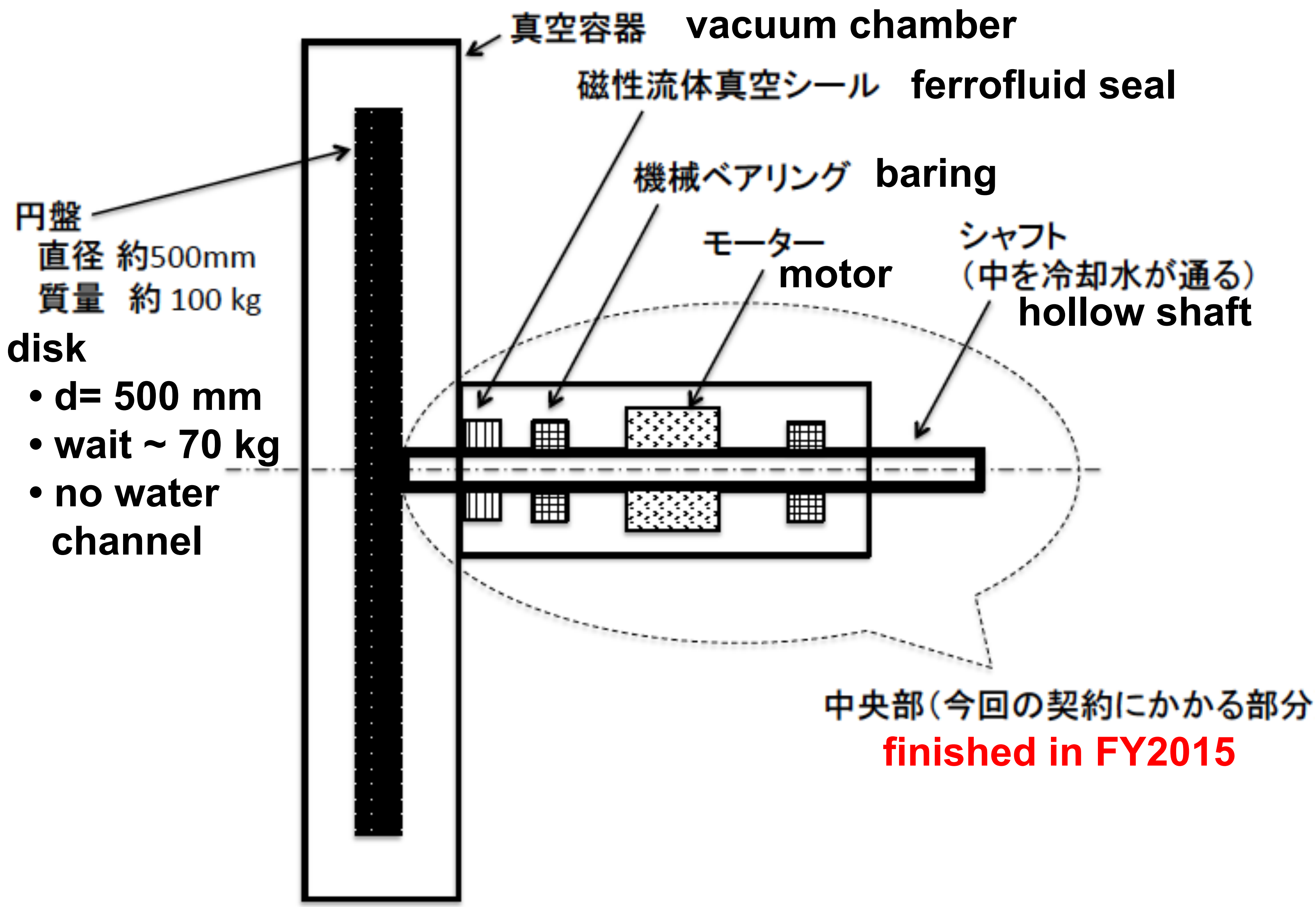
(3) Full-size means that target wheel has the same radius, the same weight, the same moment as those of the real target. The locations of the vacuum seal and bearing in the prototype are as same as those in the real one.

(4) The prototype is not totally as same as the real one.
- The prototype has no water channels in the disk.
- We don’t use W for disk.

(5) We will use irradiated ferromagnetic fluid in the prototype.

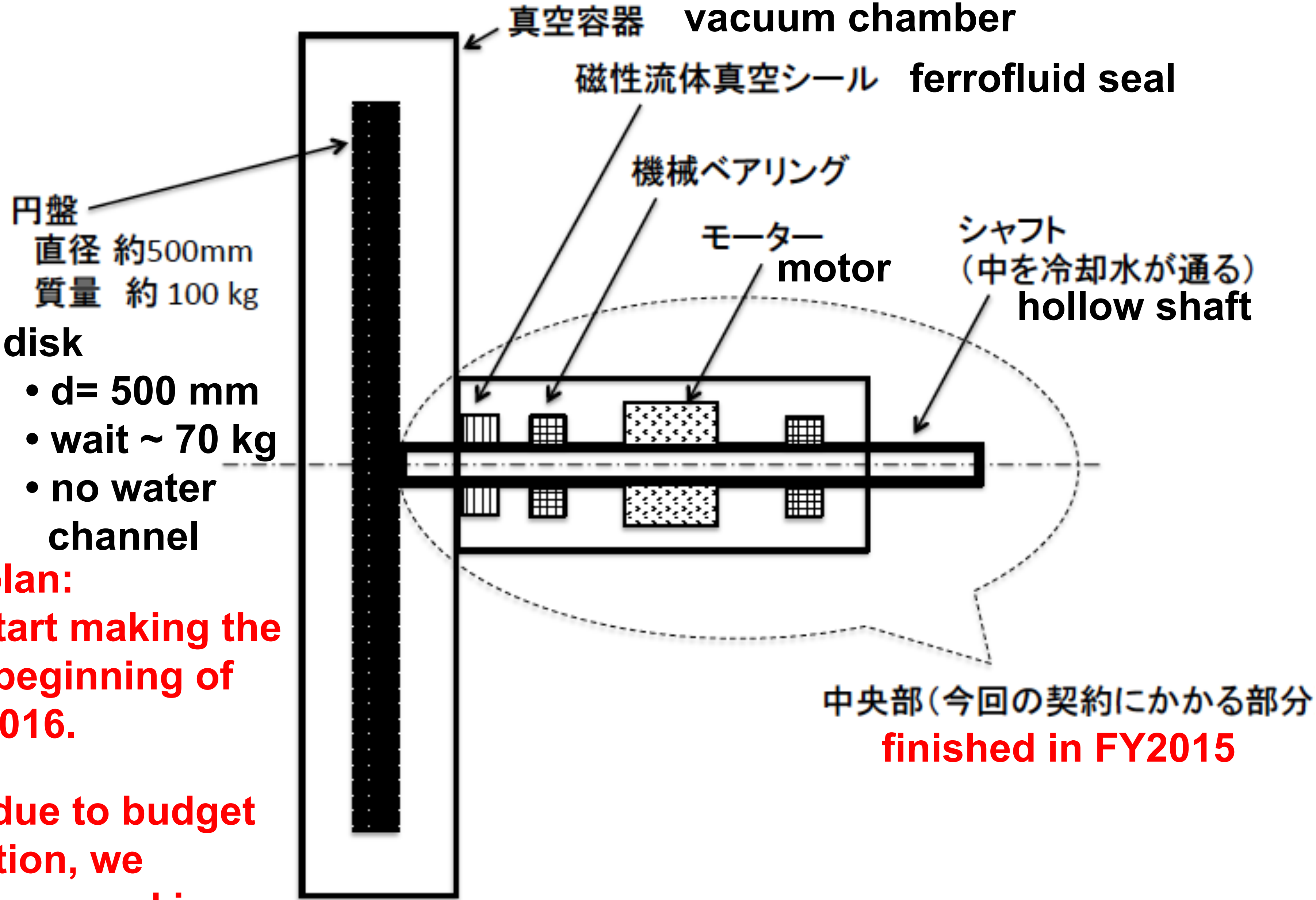
(6) We will make continuous running test (~1 year?) and will prove that vacuum always stay good level.

Prototype: We have made a contract with Rigaku.



回転ターゲットプロトタイプ概略断面図

Prototype: We have made a contract with Rigaku.



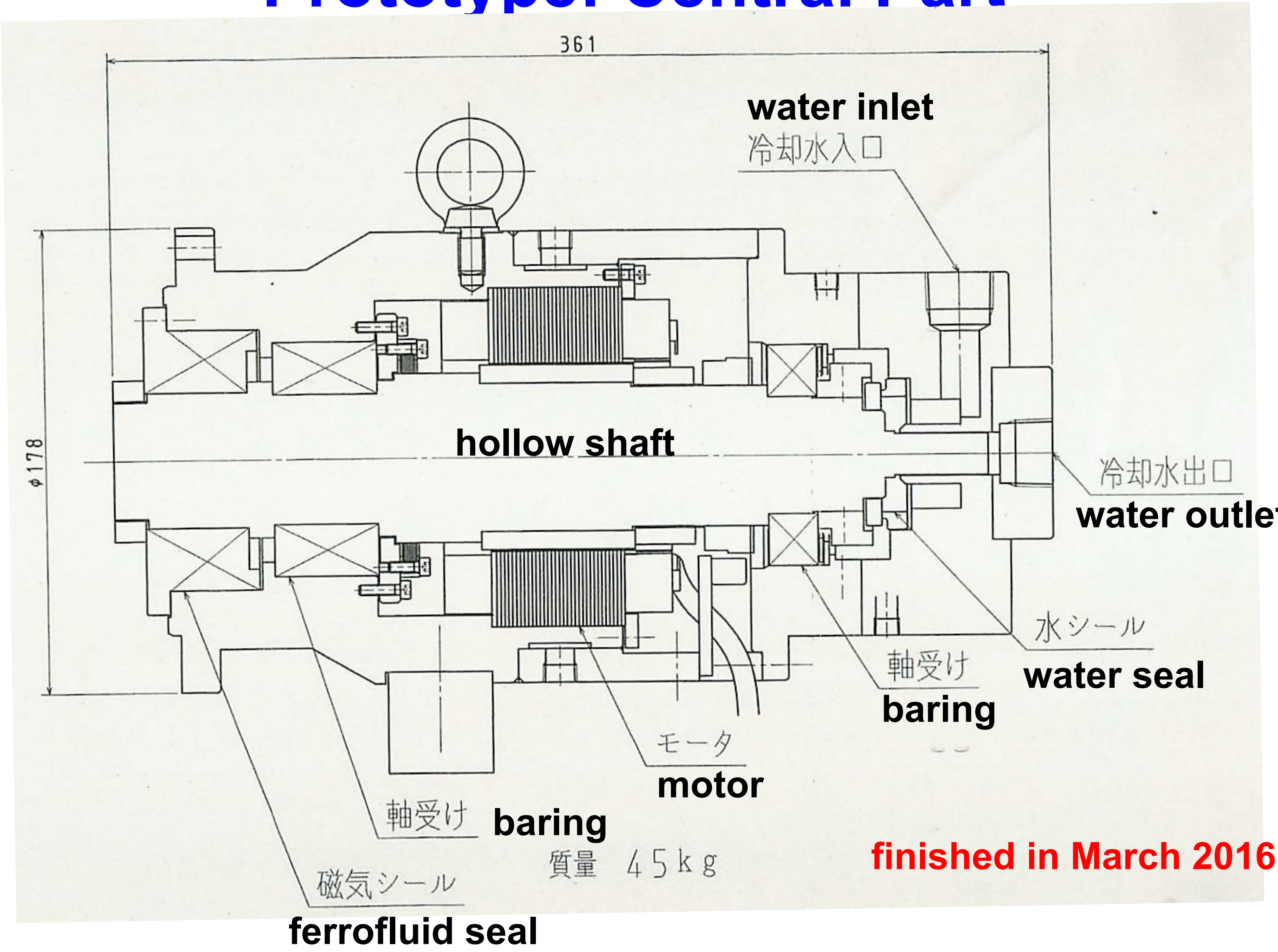
回転ターゲットプロトタイプ概略断面図

disk
- d= 500 mm
- wait ~ 70 kg
- no water channel

Old plan:
We start making the disk beginning of JPY2016.

But, due to budget situation, we postpone making the disk for 1 year.

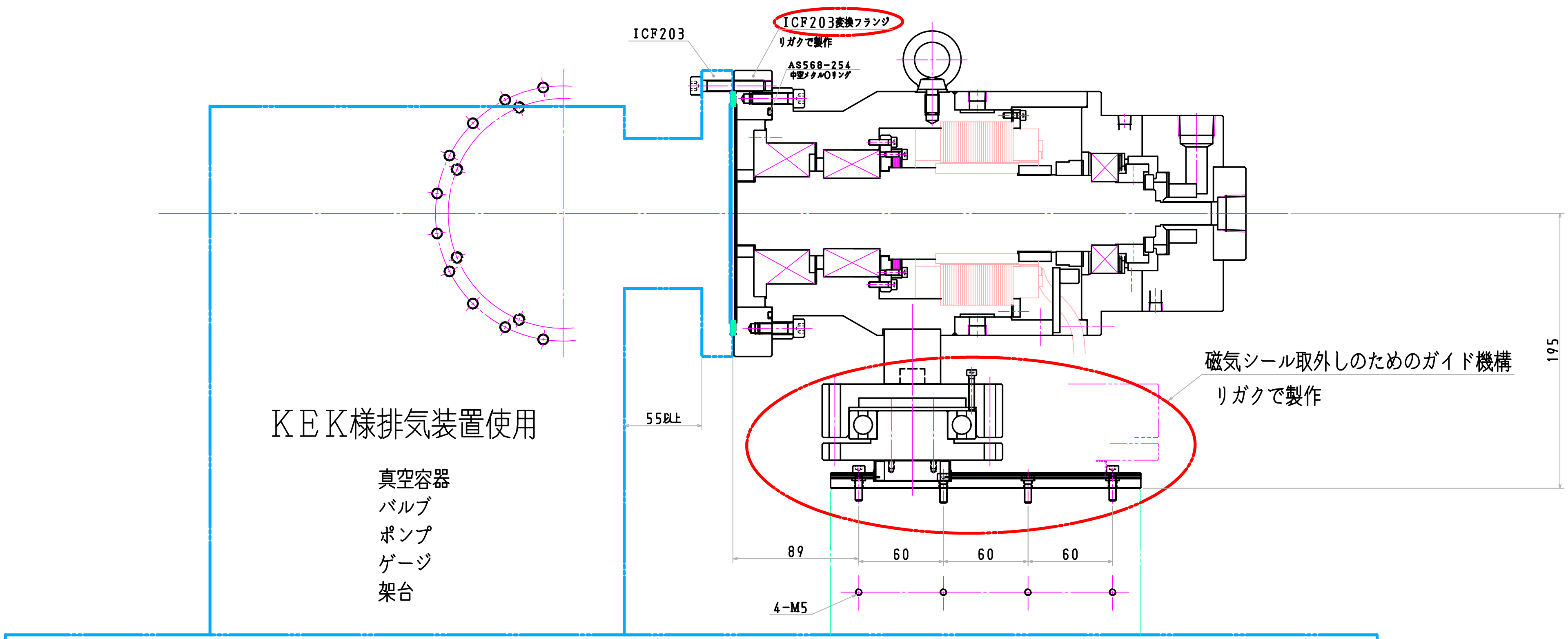
Prototype: Central Part



finished in March 2016

Central Part Prototype Vacuum Test
Plan in 2016 June-November

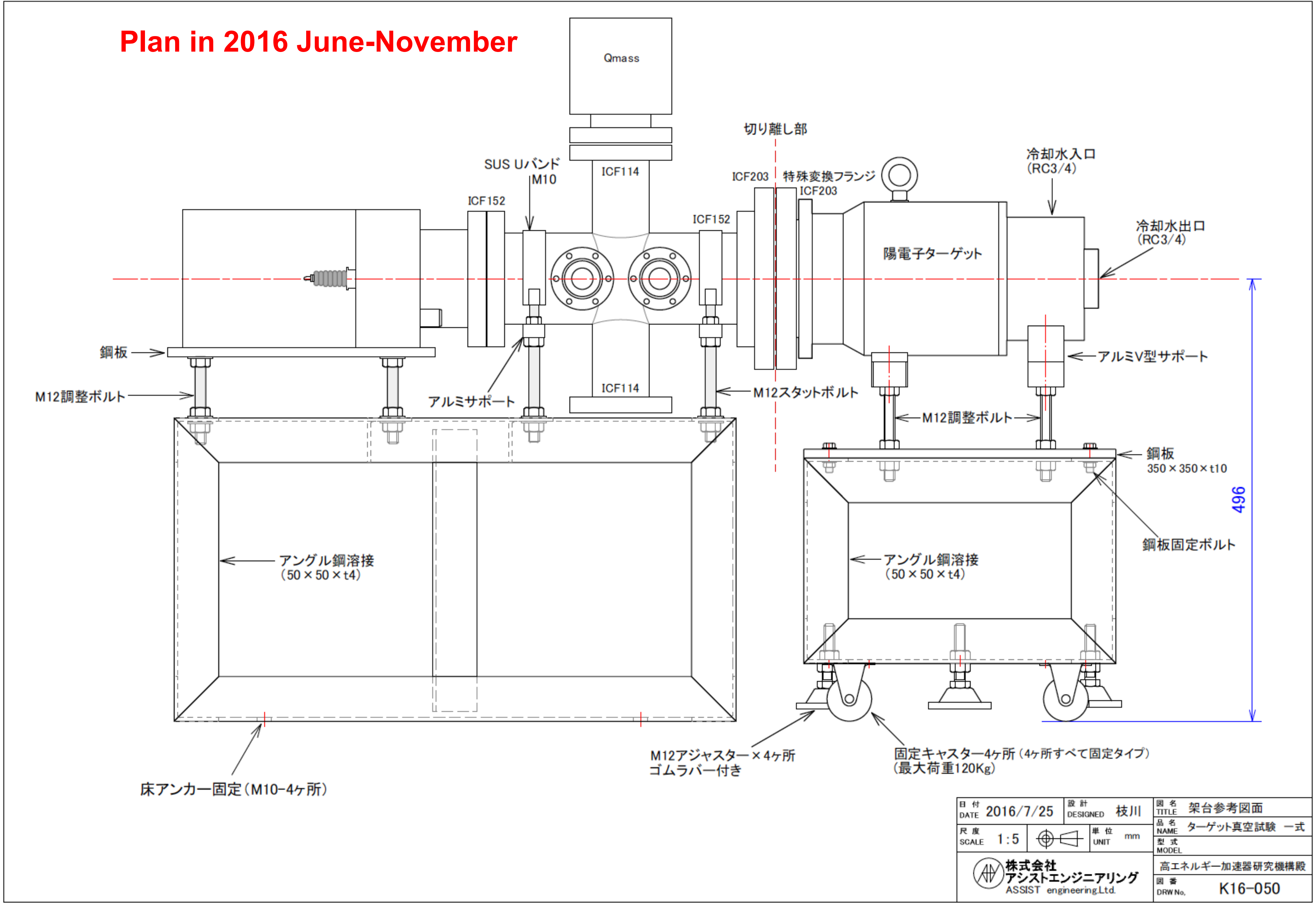
磁気シール実験システム



Vacuum Level
Visual Check of ferrofluid after several month of operation
Residual Gas Analyzer

Central Part Prototype Vacuum Test

Plan in 2016 June-November



Summary

Summary

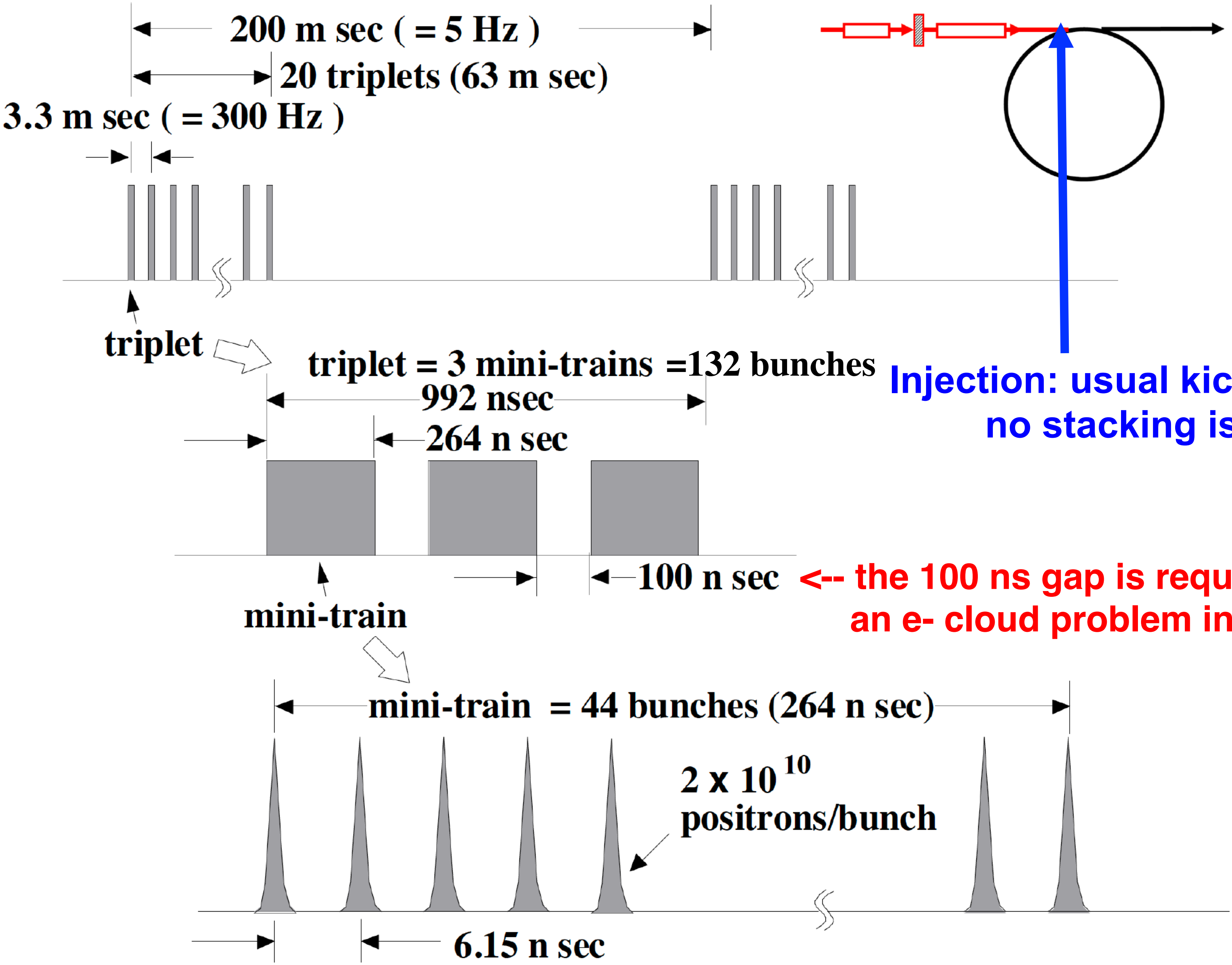
1. Heat and Stress Simulations:
   - Max stress of ILC target and SLC target are comparable.
   - SLC target survived 3-4 years.
   - Comparison of Number of hit / Year.mm

     $N_{ILC} = N_{SLC}/10$
   - We are pursuing better cooling for more safety.
   - Possible stress reduction by divided rim?

2. Vacuum Issue and Prototype Target
   - Irradiation test of the whole system (small off-the-shelf rotation target) was performed. NO problem was found.
   - Central part of the prototype was finished.
   - Disk and large vacuum vessel delay due to budget.
   - Central part vacuum test is planed in November 2016.

Backup

Beam before DR



Injection: usual kicker (~ 1 us)
no stacking is necessary

<-- the 100 ns gap is required to cure an e- cloud problem in e+ DR.

Conventional e+ Source for ILC

Normal Conducting Drive and Booster Linacs in 300 Hz operation

e+ creation

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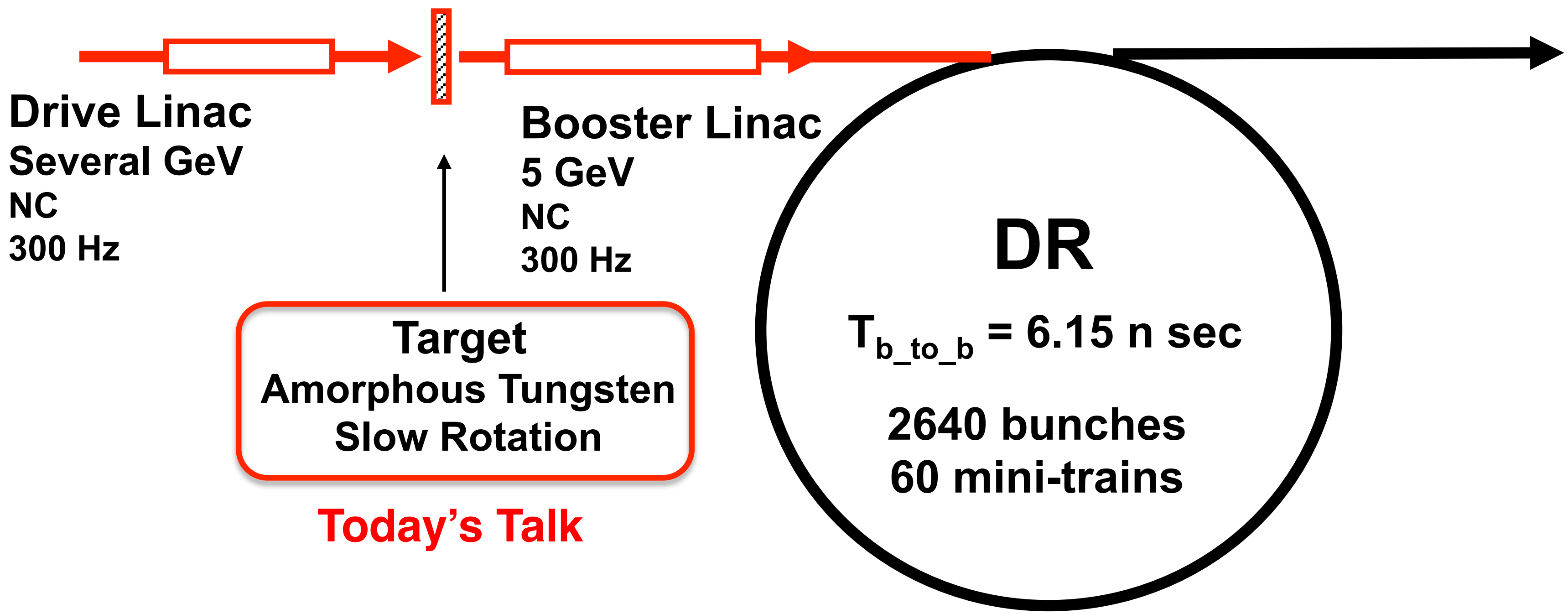


Time remaining for damping = 137 m sec

We create 2640 bunches in 63 m sec ⇦ Stretching

NIM A672 (2012) 52—56

Thermal Analysis: Target Model and Cooling Condition

FY2014-2015

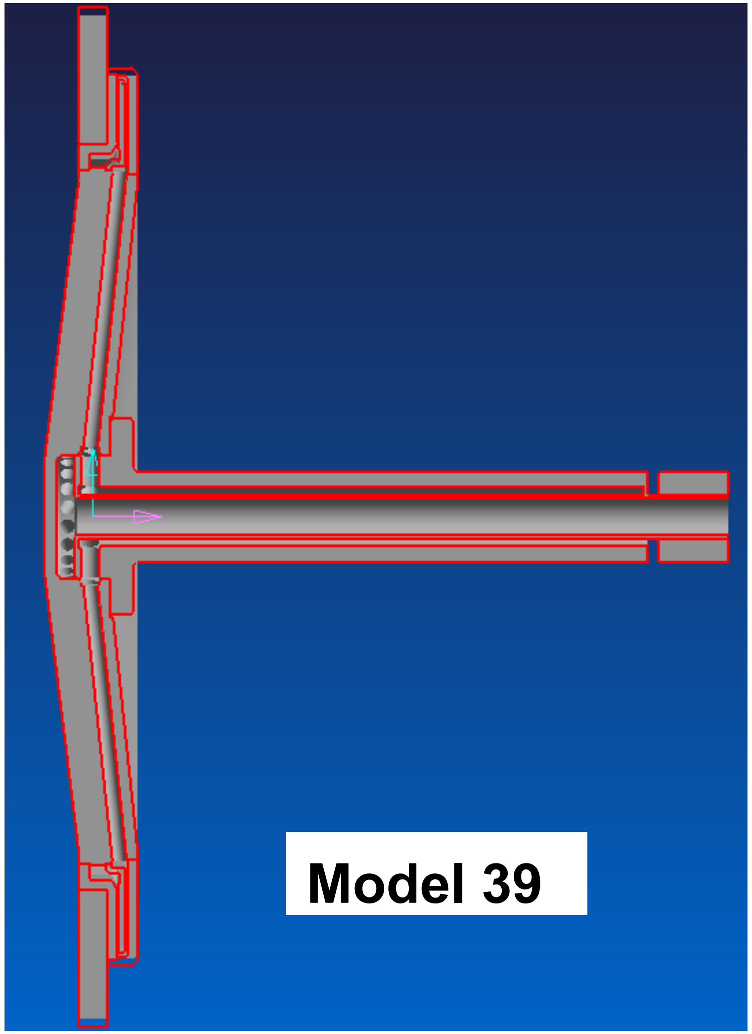
Model : 500 mm diameter rotation target

Rim (φ500-φ366×14t) W + Central Cu Disk (water flow inside)

Rotation: 200 - 600rpm

Water temperature at inlet: 25 °C

Software; ANSYS CFX



Rigaku

Points of the prototype

The loads on the vacuum seal and the bearing are determined by the weight and the moment of the target disk. So we will make full size prototype.

The purpose is vacuum test.
It is not necessary to use W for the disk.
We don't use W for cost saving.

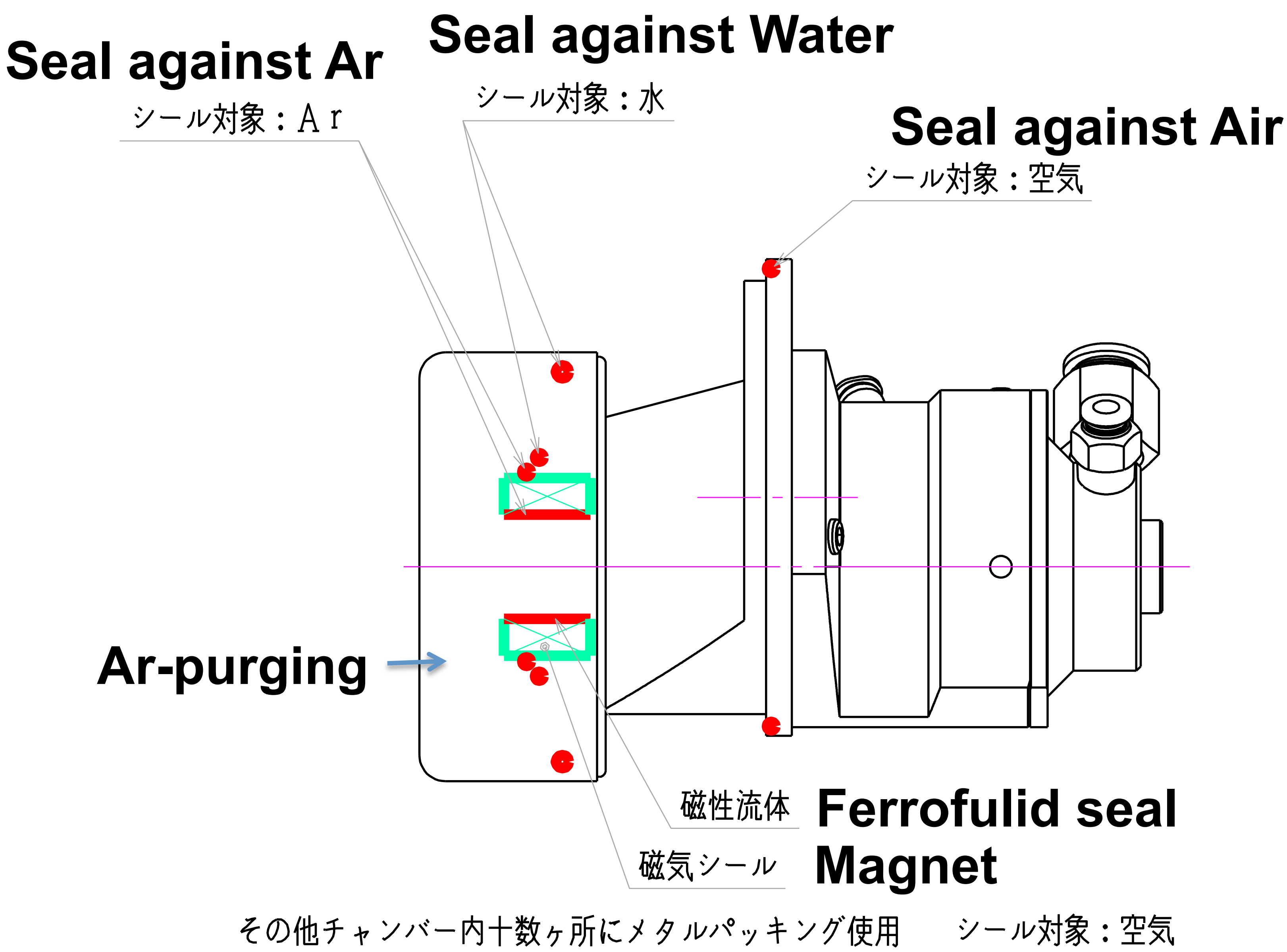
Water channels will be unimplemented. It is cost saving. Target rotation is slow, water circulation is within the past experience of the company. We have no need to demonstrate.

TEST: Radiation Tolerance FY2014
More systematic study for CN oil

November 2014

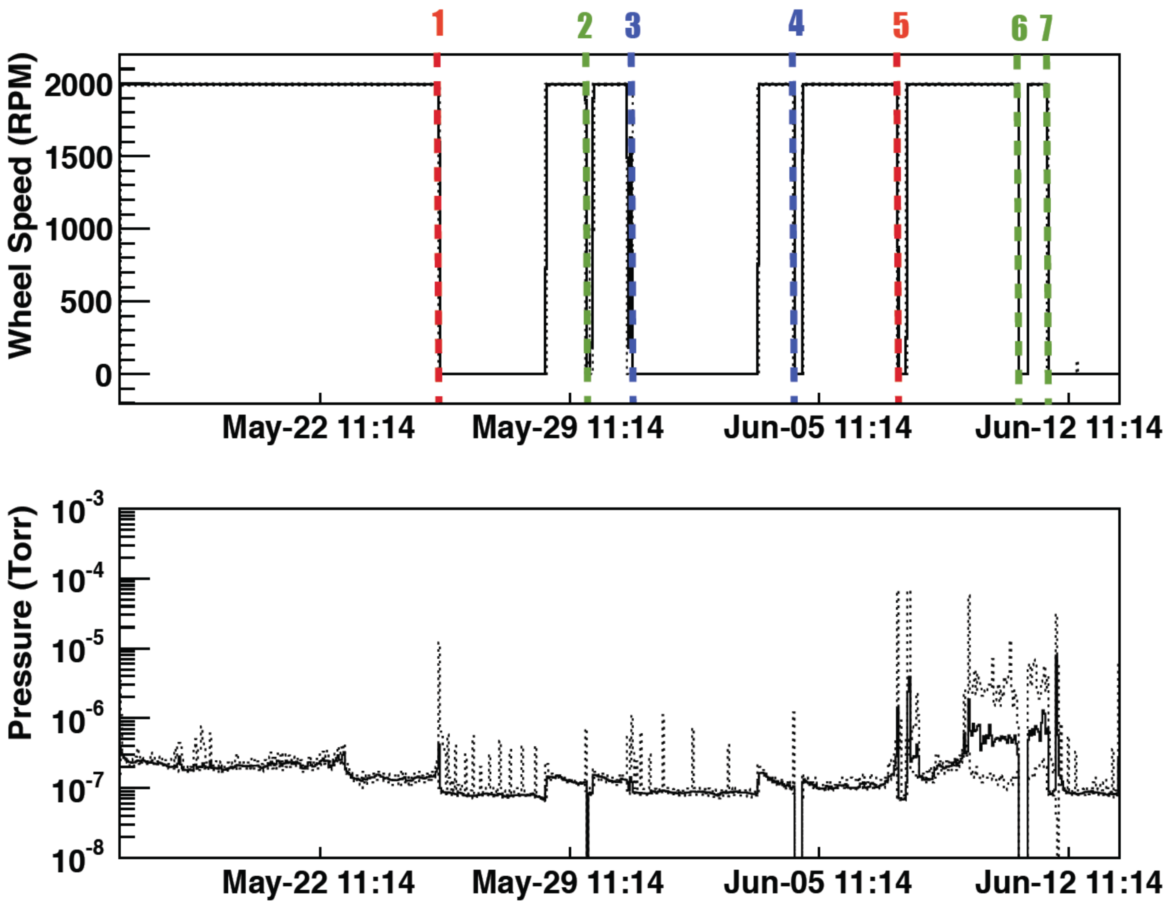
Leading With Innovation

粘度の違いは見られるが、外見に異常なし


Seal against Ar
シール対象：Ａｒ
Seal against Water
シール対象：水
Seal against Air
シール対象：空気
Ar-purging
磁性流体
Ferrofulid seal
磁気シール
Magnet
その他チャンバー内十数ヶ所にメタルパッキング使用　シール対象：空気

undulator source : Vacuum test of rotation seal

FerroTec Seal #1 ran for 1 month (450 hours up)



Pressure Trip

System Trip

Planned Down

1 - Pressure Spike

2 - DAQ software change

3 - Cooling water flow

4 - Vibration Limit

5 - Pressure Spike

6 - Wheel stopped for pressure test

7 - System down for rework

Lessons Learned

- Ferrofluidic seals are not boring, each one has its own individual personality
  - We would prefer them to be anonymously interchangeable and predictable
- They all have outgassing spikes
  - A differential pumping region just after the seal would be a useful modification
- We are pushing them to speeds at which there is significant heat dissipation
  - Off-the-shelf models do not seem to be well designed for this.
  - Improved cooling design is a must for any future system

Rotation target design study: ongoing with Rigaku

FY2014-2015

Points:

Diameter, material, shape, rotation speed, cooling,,,
B-filed on the target disk (Hiroshima),
Flux concentrator (IHEP, BINP)

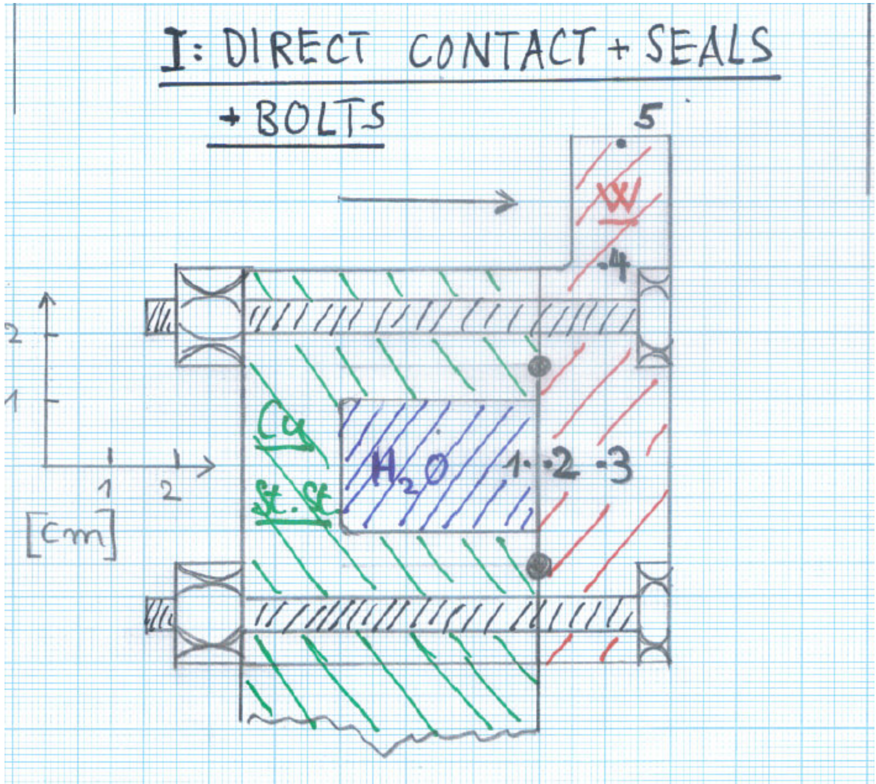
Peter SIEVERS (CERN)

Rotation target design study

FY2014

I Direct Cooling

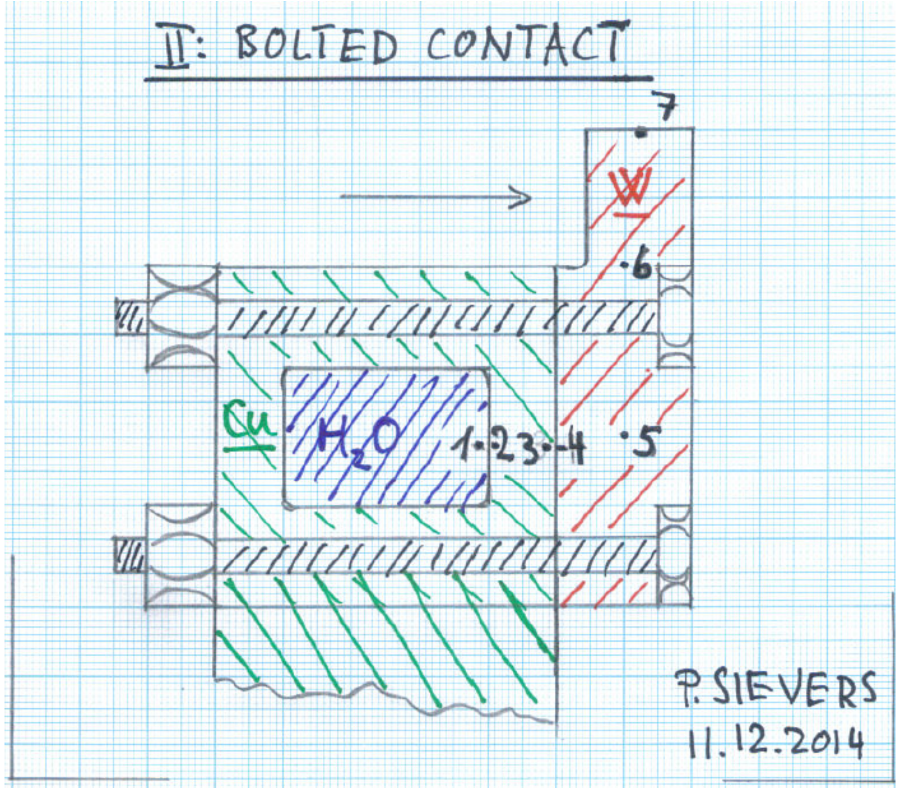
I 直接冷却



W-Cu joint
metal gaskets
remain UHV leak tight?

II Indirect Cooling

II 間接冷却



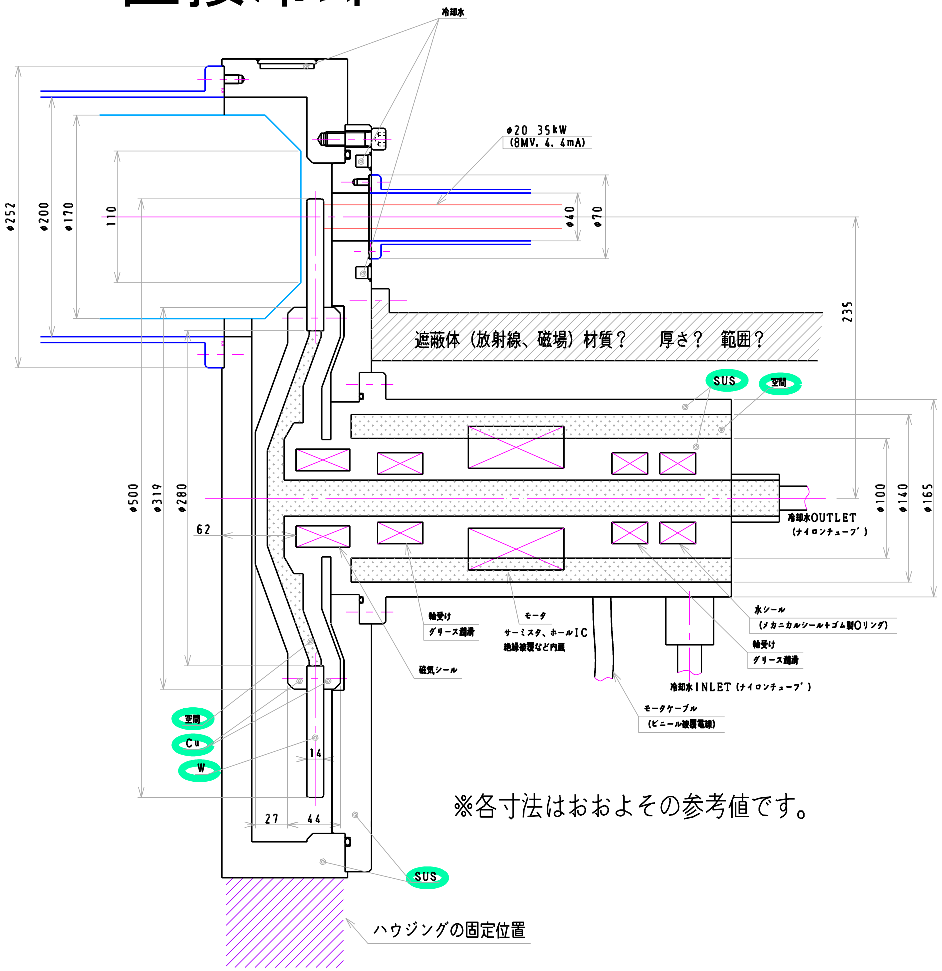
"monolithic welded water circuit entirely of the same material (Cu)"

Rigaku

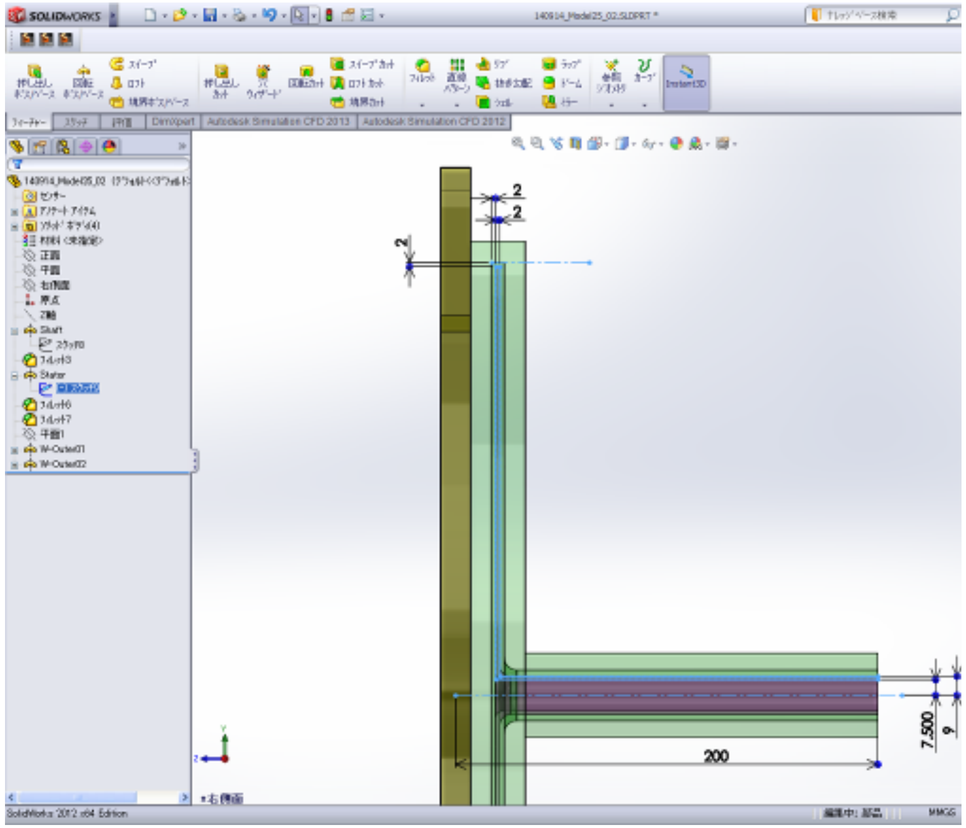
Rotation target design study

FY2014

I Direct Cooling
I 直接冷却

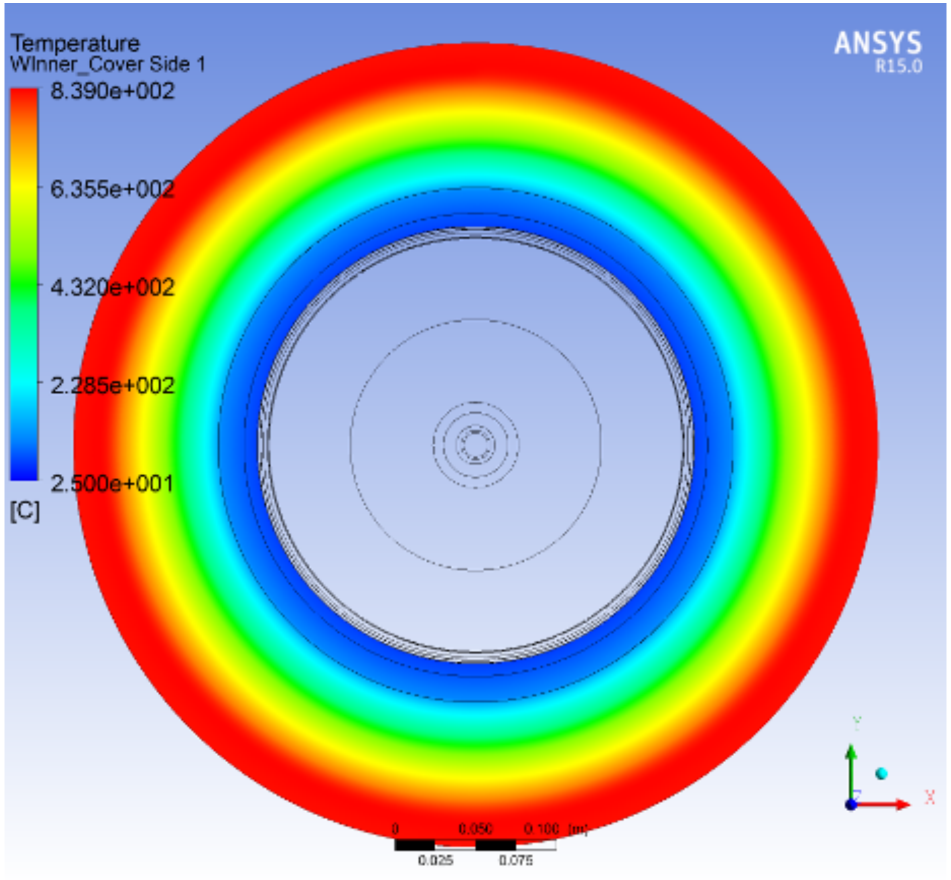


II Indirect Cooling
II 間接冷却



Rigaku FY2014 **Rotation target design study**

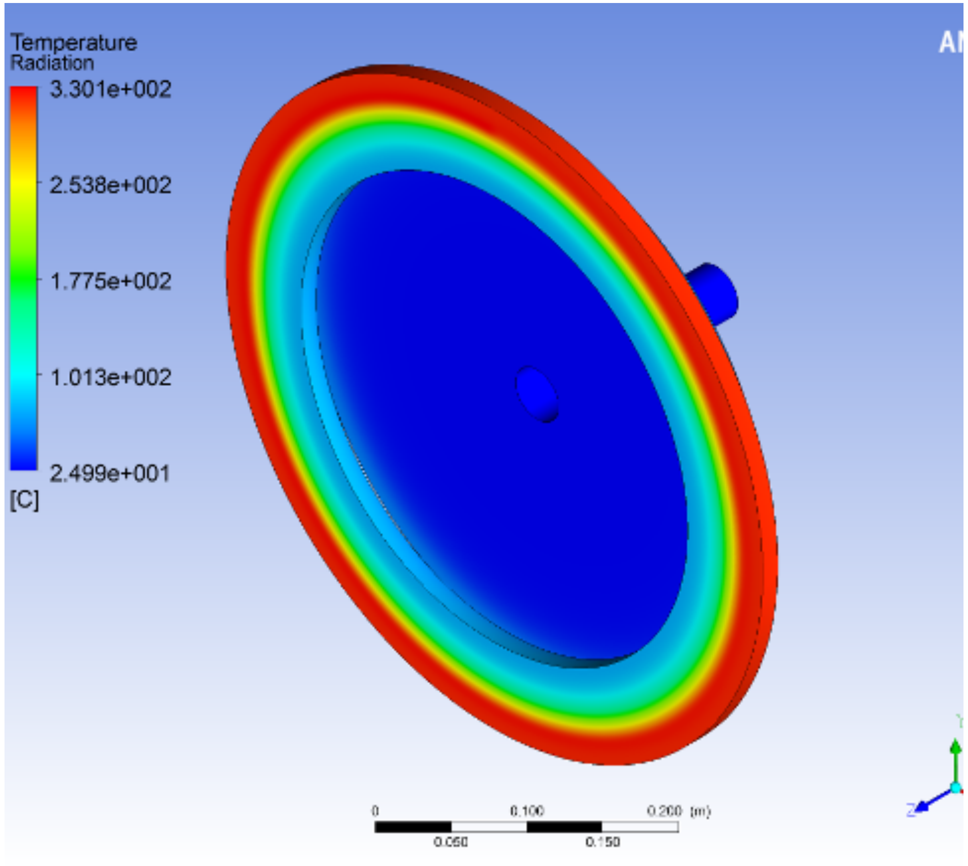
I Direct Cooling



Temperature Distribution

Max. 840℃

II Indirect Cooling



Temperature Distribution

Max. 330℃

600rpm

CW Beam

Conclusion: Indirect cooling is better.

TEST: Radiation Tolerance

FY2013: Conclusion

F-oil

Dissociation/degradation occurred at low dose, 0.27 MGy. No hope.

CN-oil

Viscosity increased, but NO dissociation/ degradation occurred.

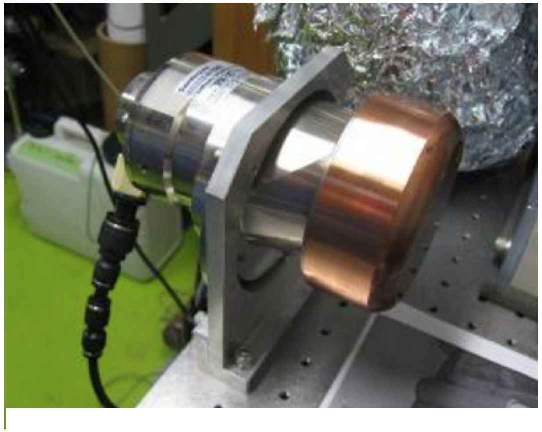
-->

We planed more systematic study.

- **Viscosity change as a function of dose.**
- **Use irradiated fluid in vacuum seal.**

The target R/D in 2013-2014, and the first half of 2015.

TEST: Vacuum Leak Rate FY2013



Small (d=10 cm) off-the-shelf rotation target

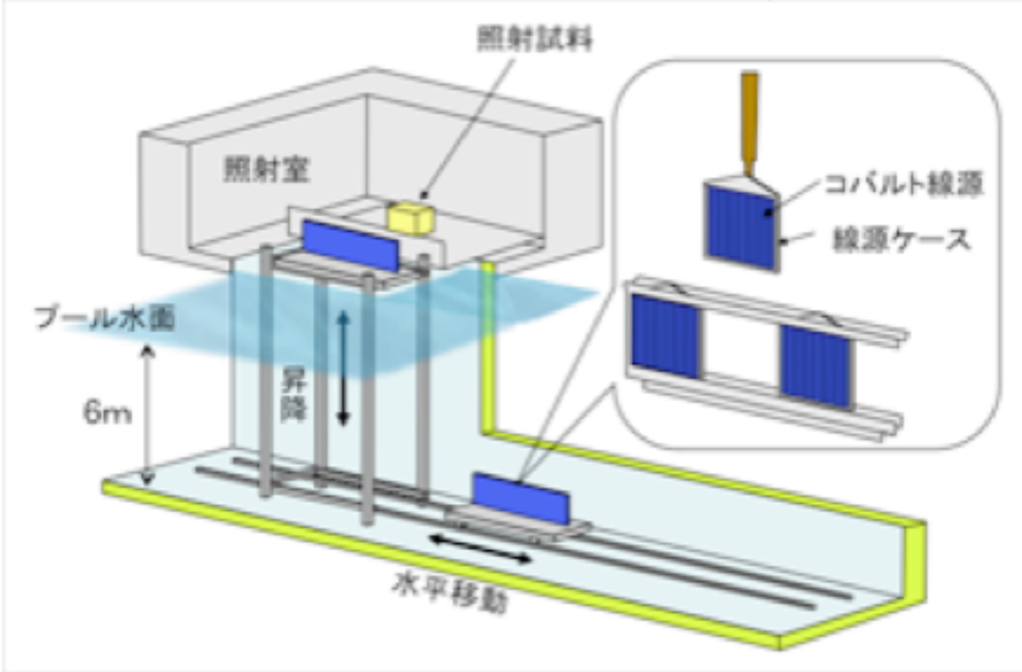
Conclusion: No problem

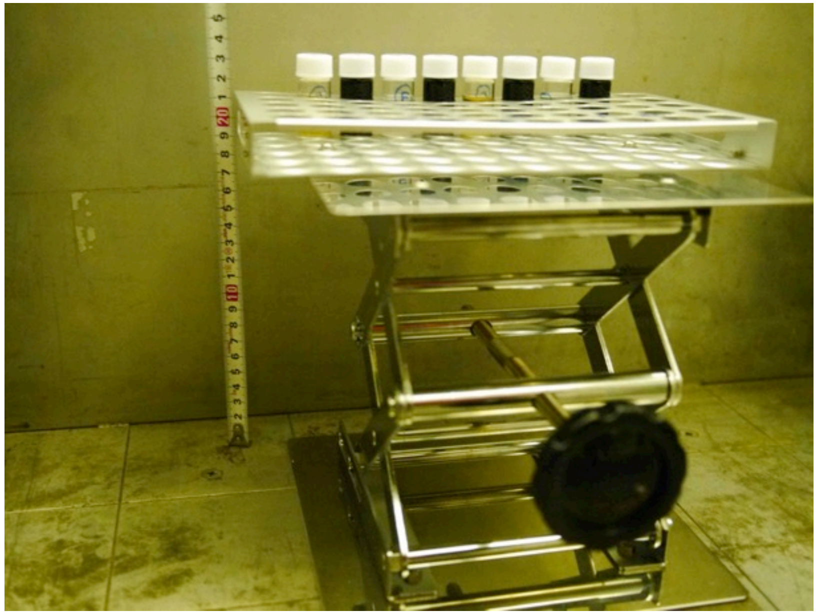
Leak Rate Measurement:
- various speed, various temperature
- no problem (both CN-oil and F-oil)

Lake rate was small enough.
We can get P< 1×10^{-7} Pa, if we put reasonable pumps (several 1000 letters/s) at the upstream of the target.

Radiation Tolerance Test FY2013

Takasaki Advanced Radiation Research Institute, JAEA





Gamma-ray source: Co 60

1.1×10^4 Gy/h

Photo: Dec/2013

2016年2月4までのシミュレーションのまとめ

(a) 132 bunch (= 一塊 = 回転ターゲットから見た時の1パルス)

が1ケ所に当たる部分の peak 温度は466 度C

(b) 466 度C の部分のストレスは 530MPa (圧縮)

(c) この状況は安全か？。

500 度C の時の W-Re の fatigue limit は 520 MPa

（Yield Strength は 1300 MPa)

したがって 466 度C で 530 MPa は Fatigue Limit ギリギリの所。

結論

現状設計では Yield strength に対しては十分余裕があるが、
Fatigue Limit (多数回の繰り返しを考量した値)を考えるとマージンは
ゼロ。

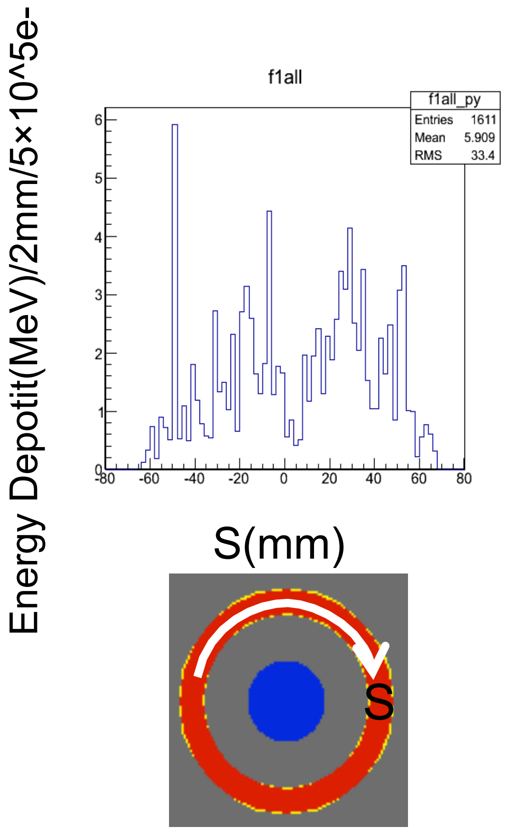
Results

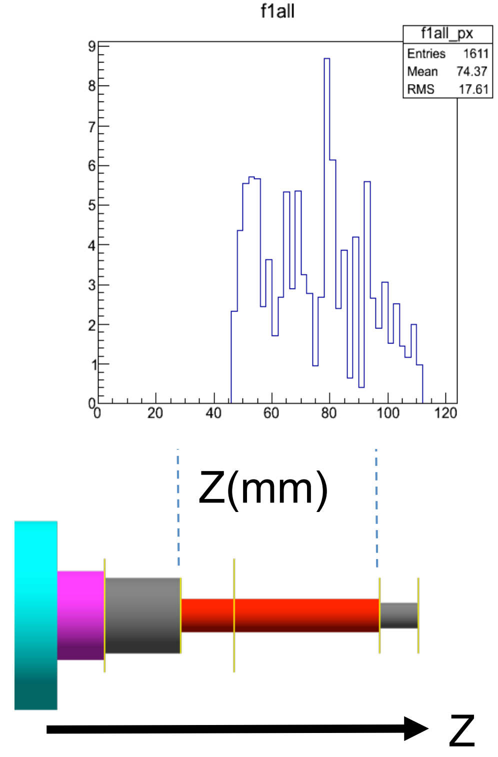
Dose Estimation

FY2014

d = 40 cm with radiation shield

T. Takahashi (Hiroshima)





Peak 1.5MGy/year

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

TEST: Radiation Tolerance FY2014

Takasaki Advanced Radiation Research Institute, JAEA

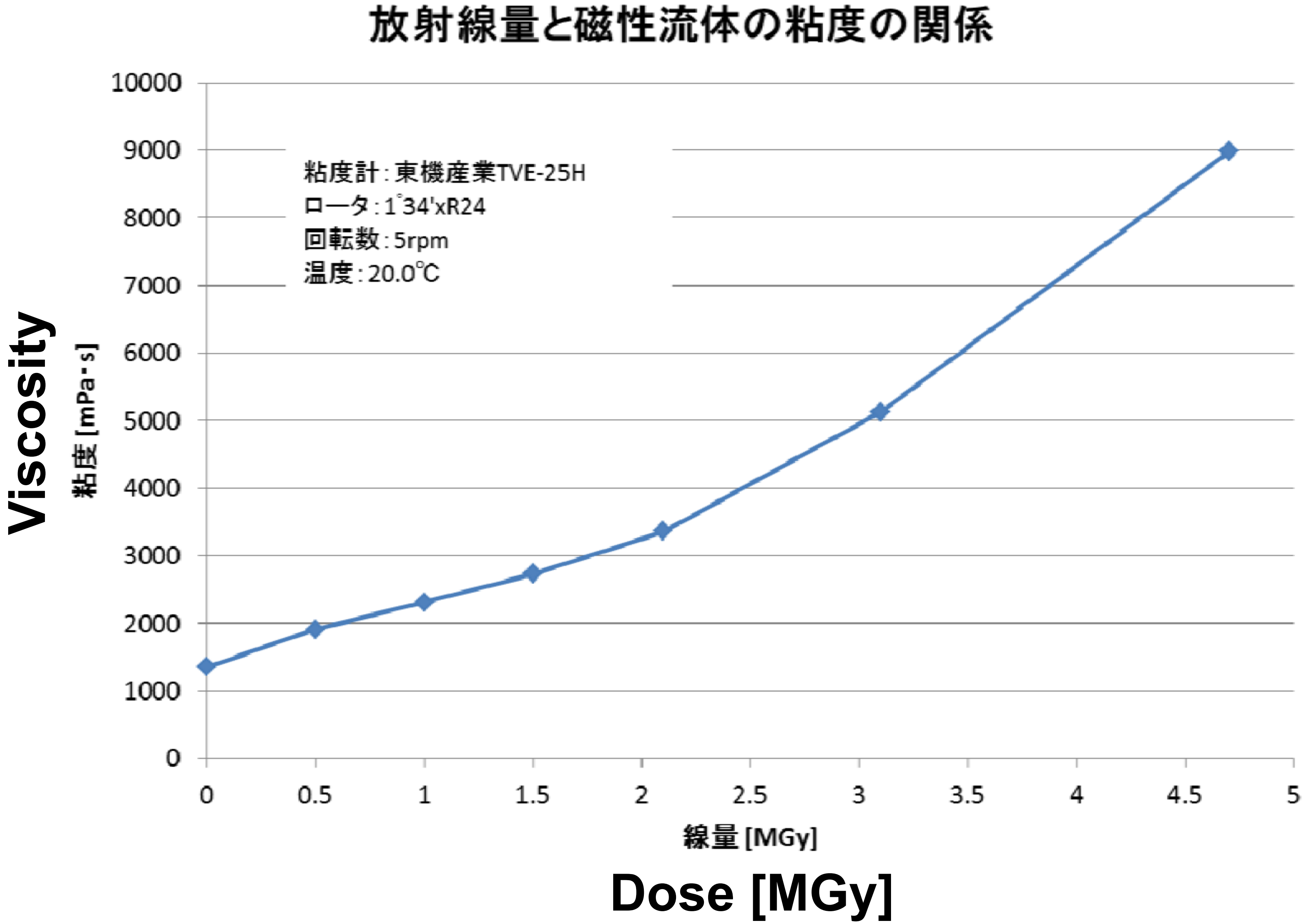
November 2014

10-Nov-2014

TEST: Radiation Tolerance FY2014 November 2014

More systematic study for CN oil

Viscosity as a function of dose

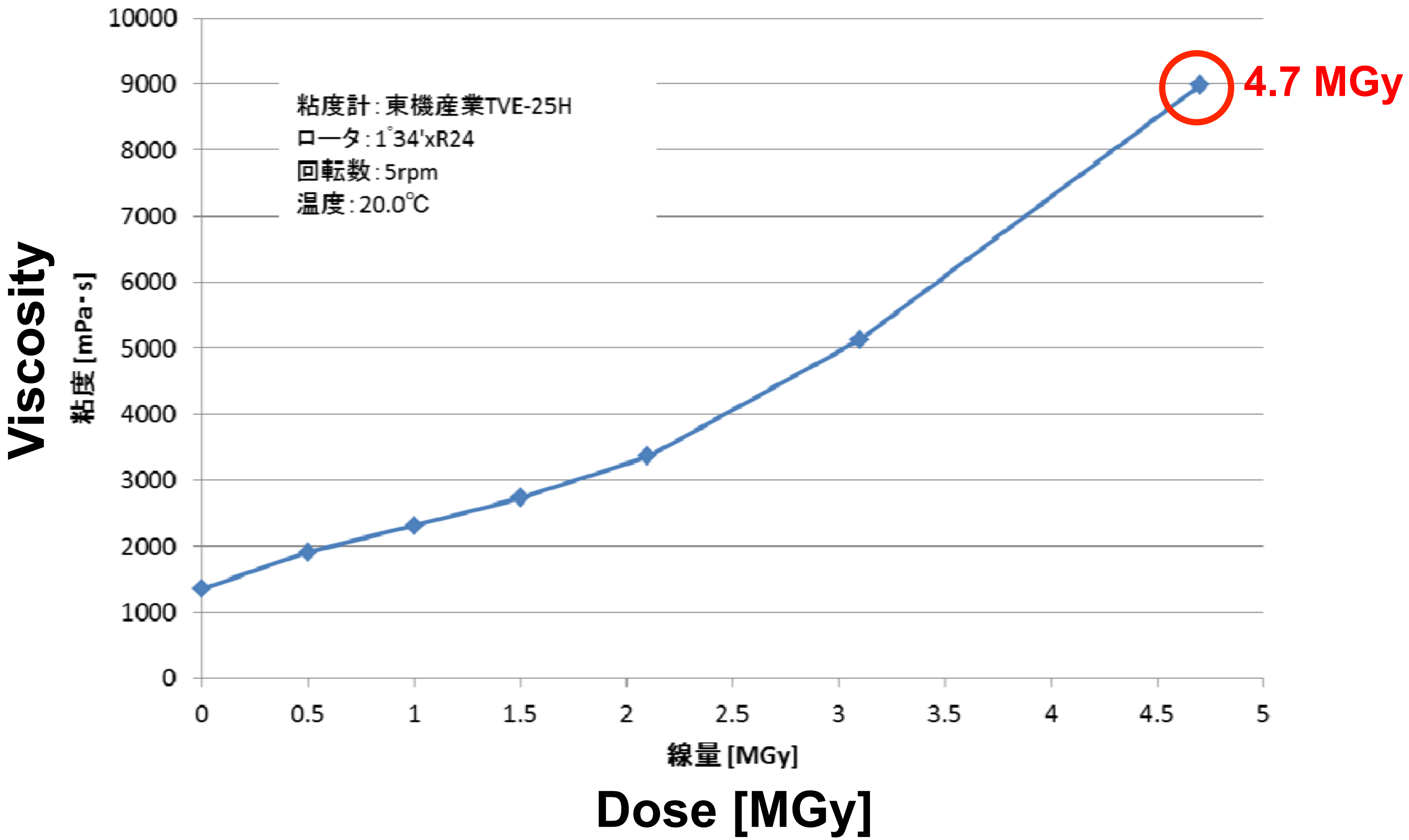


TEST: Radiation Tolerance FY2014 November 2014

More systematic study for CN oil

Viscosity as a function of dose

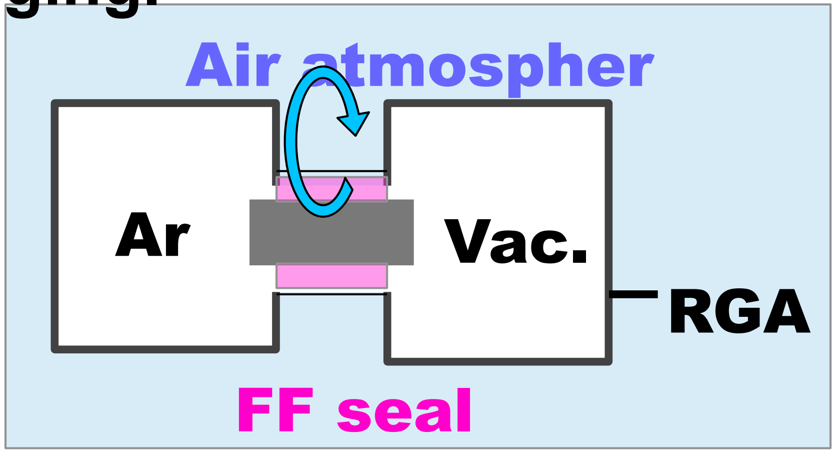
放射線量と磁性流体の粘度の関係



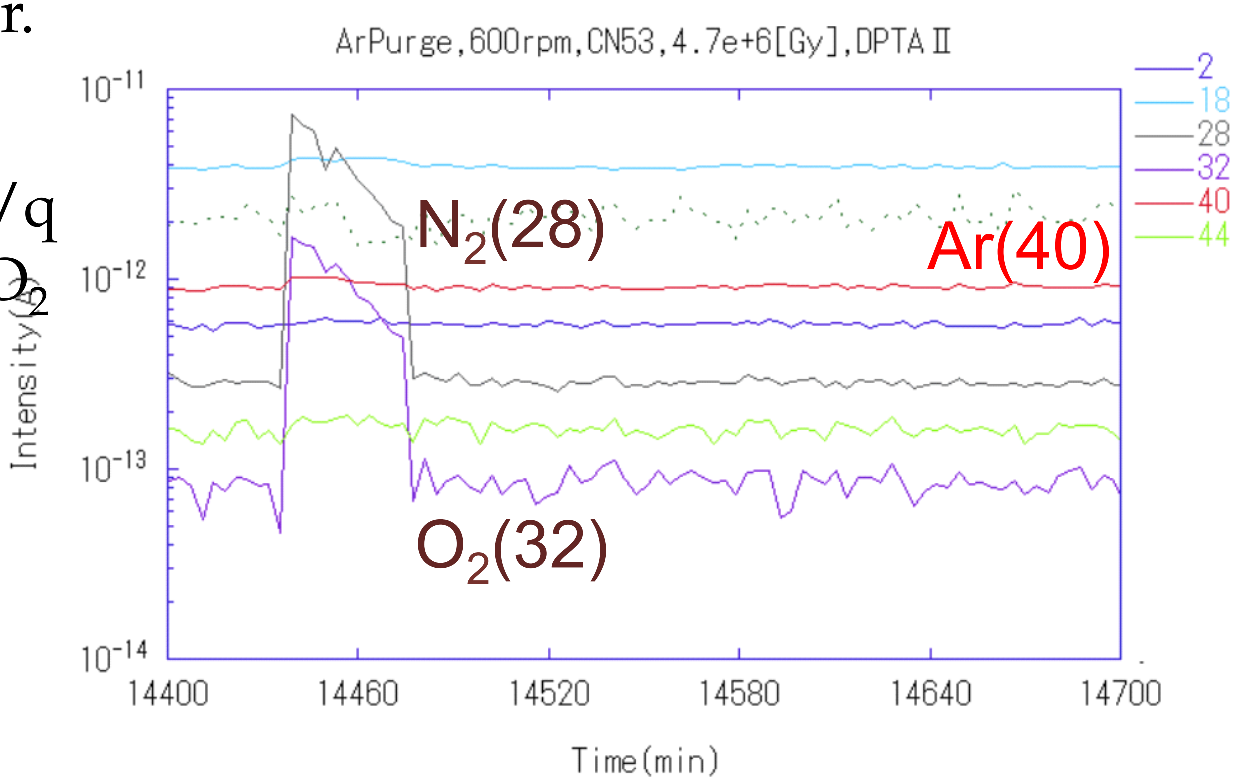
PY2014: Radiation Test:

- **We used irradiated CN-oil (4.7 MGy) in a small rotation target.**
- **Made vacuum test after Ar-purging.**

Ar purge seal test



- The seal dosed 4.7 MGy (3 ILC year) is examined with Ar purged chamber.
- Rotation : 0-600 rpm.
- **No leak was found.** (m/q = 28 and 32 are N_2 and O_2 from air)

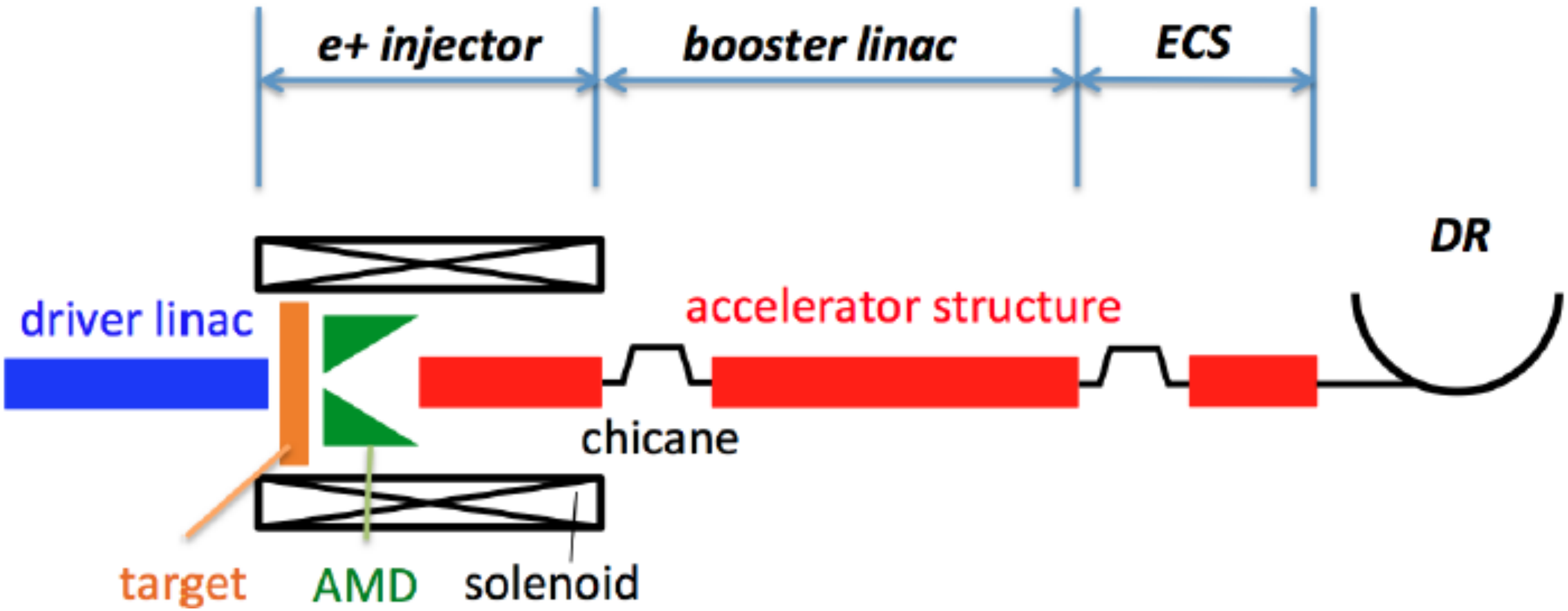


Seimiya & Kuriki
(Hirosima U.)

FY2014 Rotation target design study

AMD is employed is a capture section.
The AMD will be a pulse Flux Concentrator.

Seimiya, Kuriki (Hirosima U.), et al.
Submitted to PTEP



Need to consider the effect of the Flux Concentrator leakage field on the target disk.

FY2014 Rotation target design study

The effect of the FC leakage field on the target.

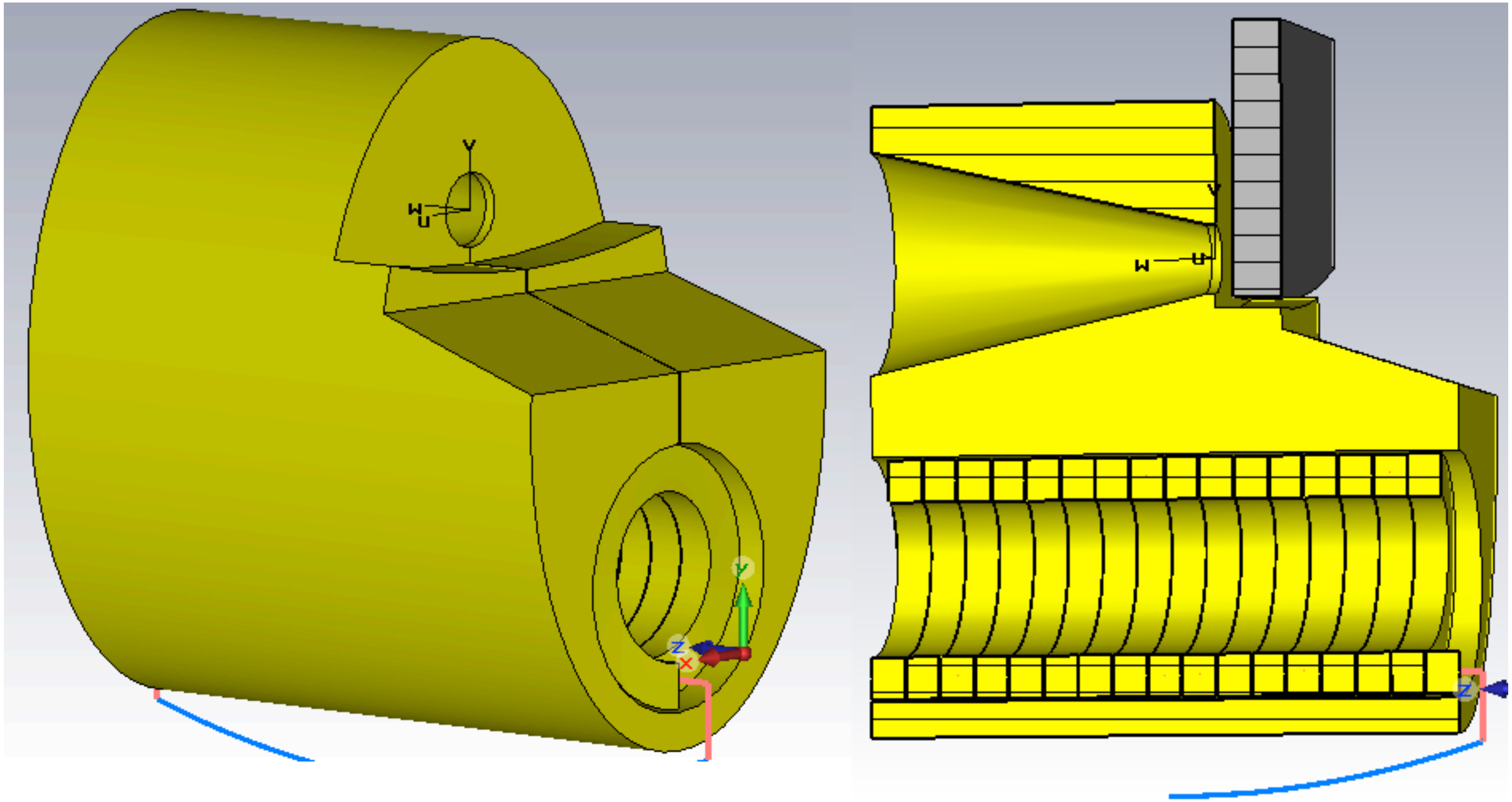
(1) The FC B-field is pulse.
The pulse is fast.
half cycle ~12 micro second (roughly sinusoidal)
Dominant

(2) The target is rotating.
Rotation is slow. ~5 m/s.
Small, Negligible (2)/(1) ~ 1/1000

Pavel Martyshkin (BINP) FY2015 Rotation target design study

Flux Concentrator (FC) leakage field on the target disk.

Cone diameter is 16 mm (Nose FC)



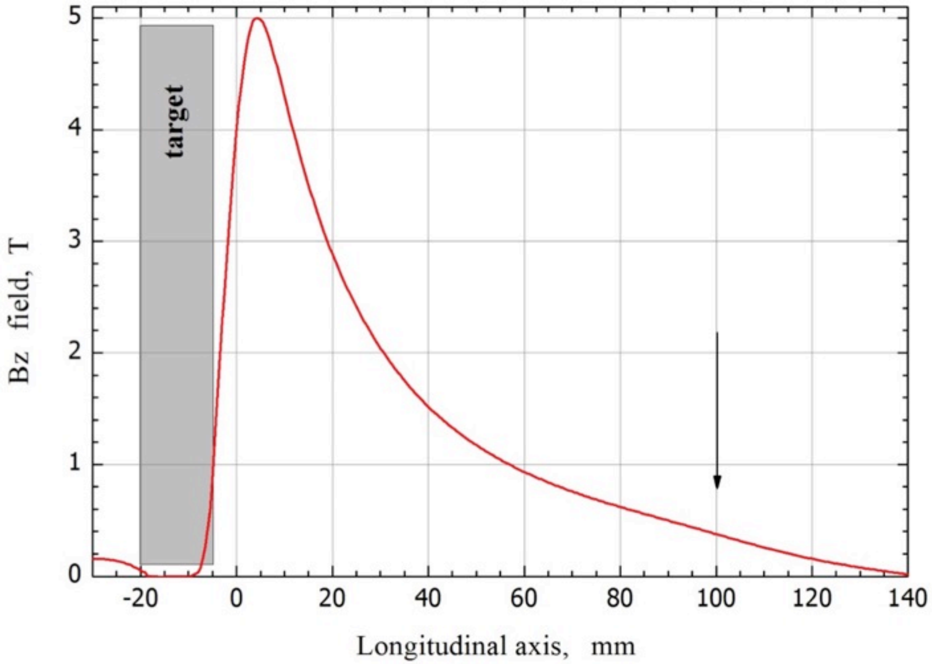
Sun Xianjin (IHEP) also made a study too, based on another design (2014-2015).

Pavel Martyshkin (BINP) **FY2015** **Rotation target design study**

Flux Concentrator (FC) leakage field on the target disk.

Cone diameter is 16 mm (Nose FC)

B = 1 Tesla at Target Disk



	Nose FC type D 16 mm
Peak current	25 kA
Peak field	5 Tesla
Peak transverse field	50-60 mTesla
Current shape	half of sine
Current pulse length	25 µs
Target ohmic loss	≈ 10 J/pulse
FC ohmic loss	≈ 140 J/pulse
Repetition rate 300 pps *	
Target losses *	3.2 kW
FC losses *	**41 kW**

* When we calculate real average, we need to divide the numbers by three.

Sun Xianjin (IHEP) also made a study too, based on another design.

FY2014-2015 **Rotation target design study**

The effect of the FC leakage field on the target.

Heating:

1 kW (3.2 kW in 63 msec). It is 1/30 of the heat by beam.

Conclusion: No problem.

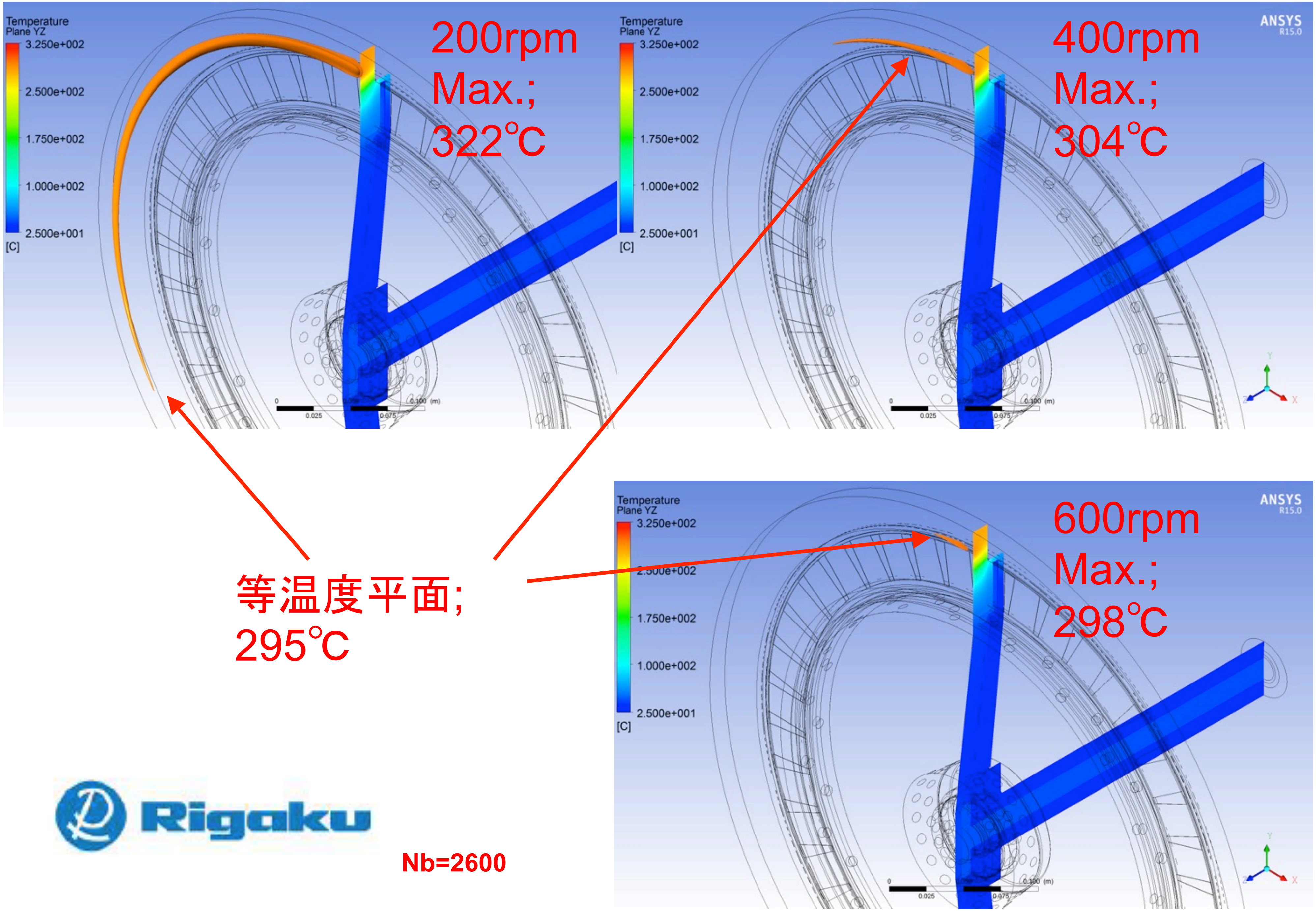
Note:
At LCWS2015 (Tsukuba), Omori reported heating is 190kW. It was rough estimate by hand.
Omori reported that we need cure.
But new conclusion based on detail simulation is NO PROBLEM.

Forces:

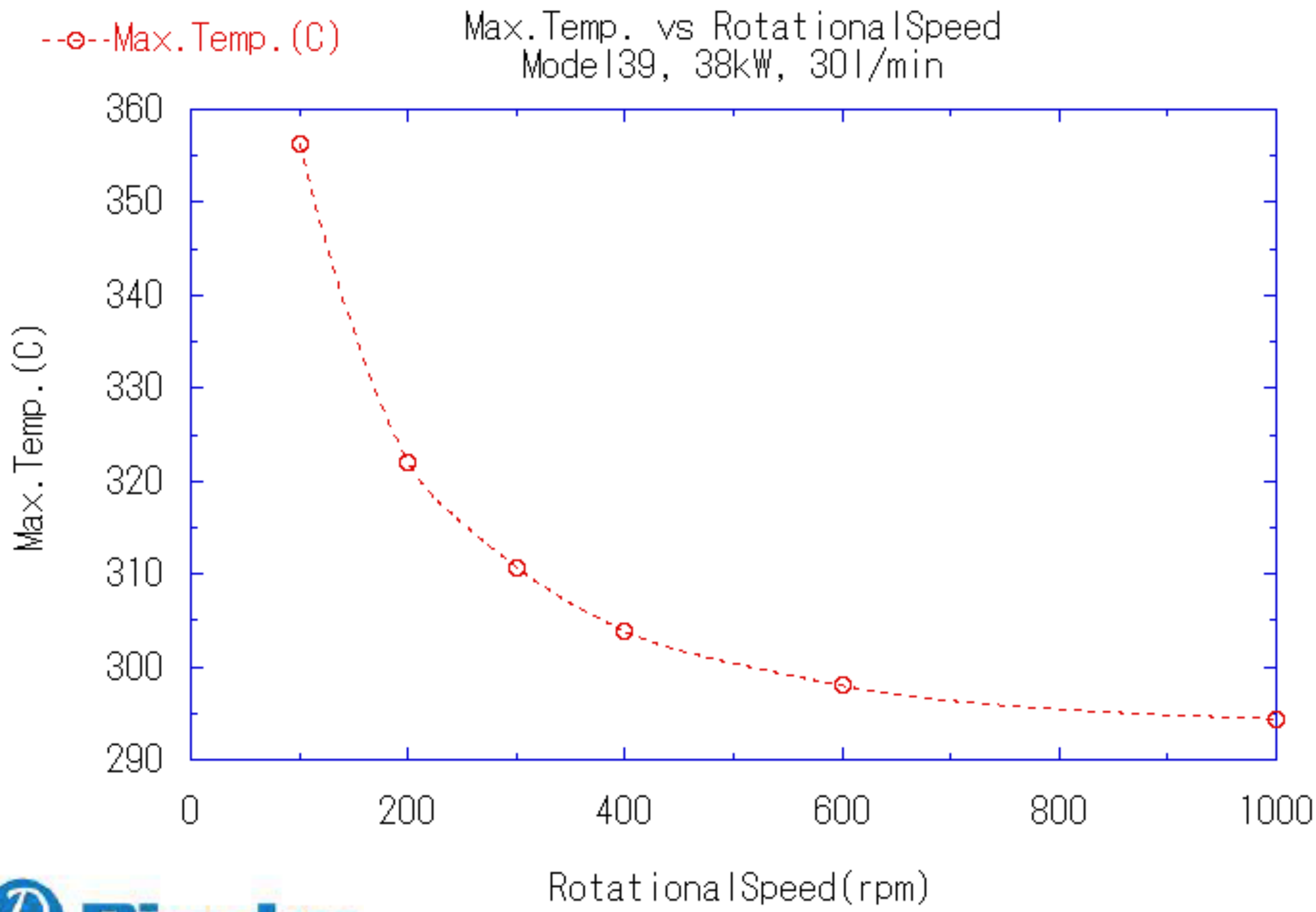
Small in both braking and attractive/repulsive forces.

Conclusion: No problem.

Temperature in various rotation speeds: CW beam analysis



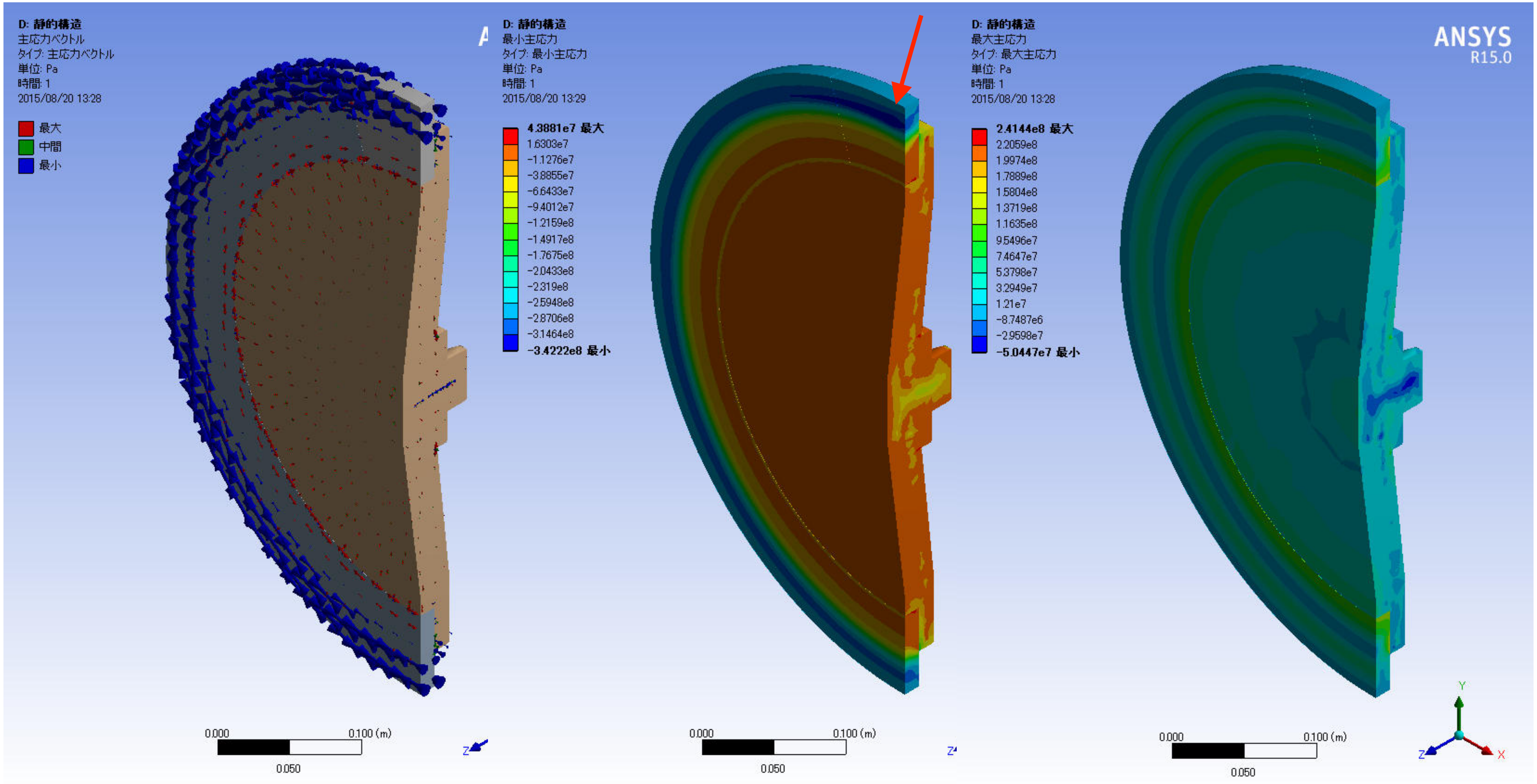
Temperature in various rotation speeds: CW beam analysis



Rigaku

Nb=2600

Stress: rotation speed 200 rpm, CW Beam analysis



Direction (arrows)

Min Principal Stress
(Compression)
→ - 3e+8Pa

Max Principal Stress
(Expansion)
→ 2e+8Pa

Rigaku

Nb=2600

高温部の応力を正確に得る為に非定常解析が必要

Thermal Analysis:

We did both **CW beam** analysis (for simplicity) and **pulse beam** analysis (more realistic).

We assume **2600 bunches** in all analysis.

- CW beam analysis

  38kW (35kW+3kW[(*)]) CW

  ↑ beam ↑ FC

FY2014-2015

* Note
3 kW is not correct
should be 1 kW

- Pulse beam analysis: **step 1**

  114.1 kW(111.1kW+3kW) 63 ms

  0 kW (0kW+0kW) 137 ms

  ↑ beam ↑ FC

FY2015 New
Reported in Posipol 2015

- Pulse beam analysis: **step 2**

  20 trains (pulses) in 63 ms

New^2

- Common condition

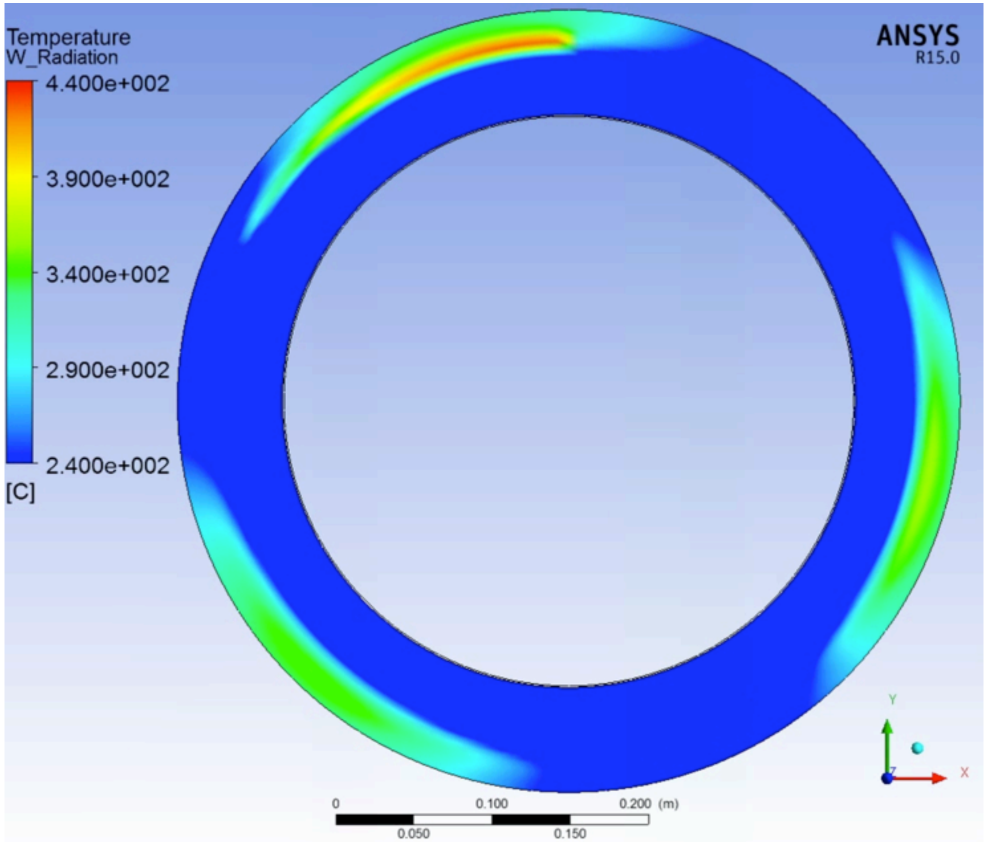
  Cooling water: 30 ℓ/min, T at inlet: 25℃

Rigaku

Pulse beam analysis: Comparison of 200 rpm and 220 rpm

step 1

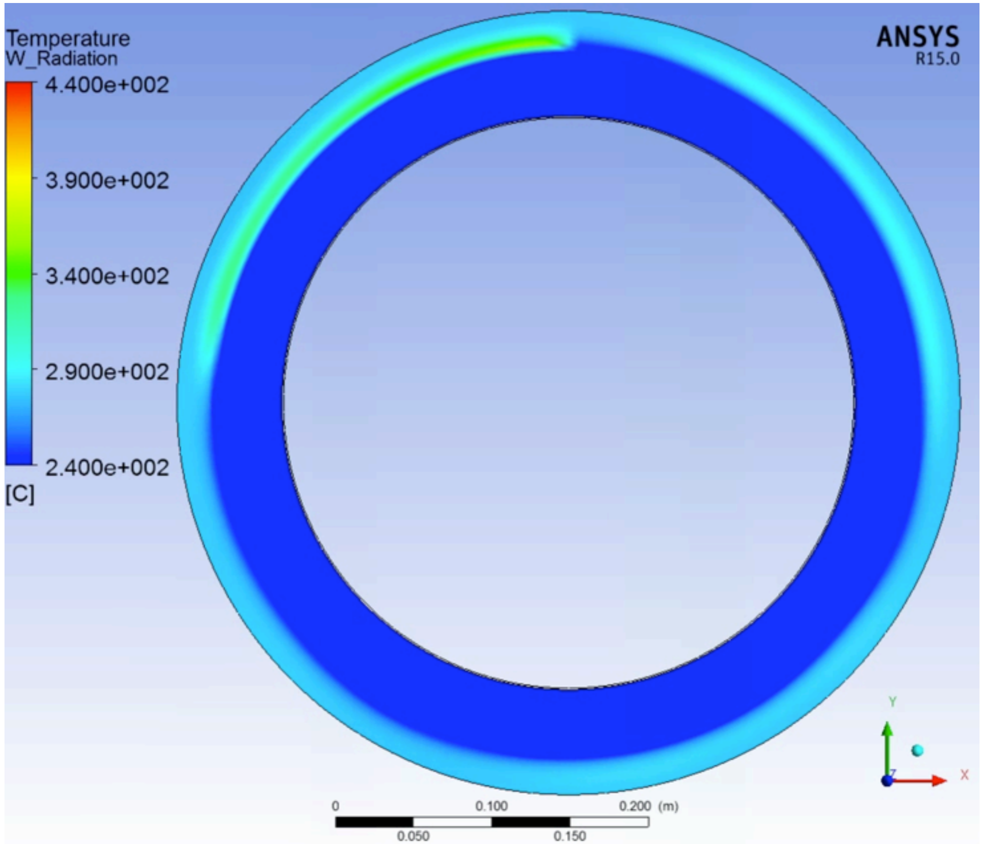
200 rpm



After reaching steady state

Max Temp = 441 °C

220 rpm



After reaching steady state

Max Temp = 373°C

220 rpm is BETTER than 200 rpm.

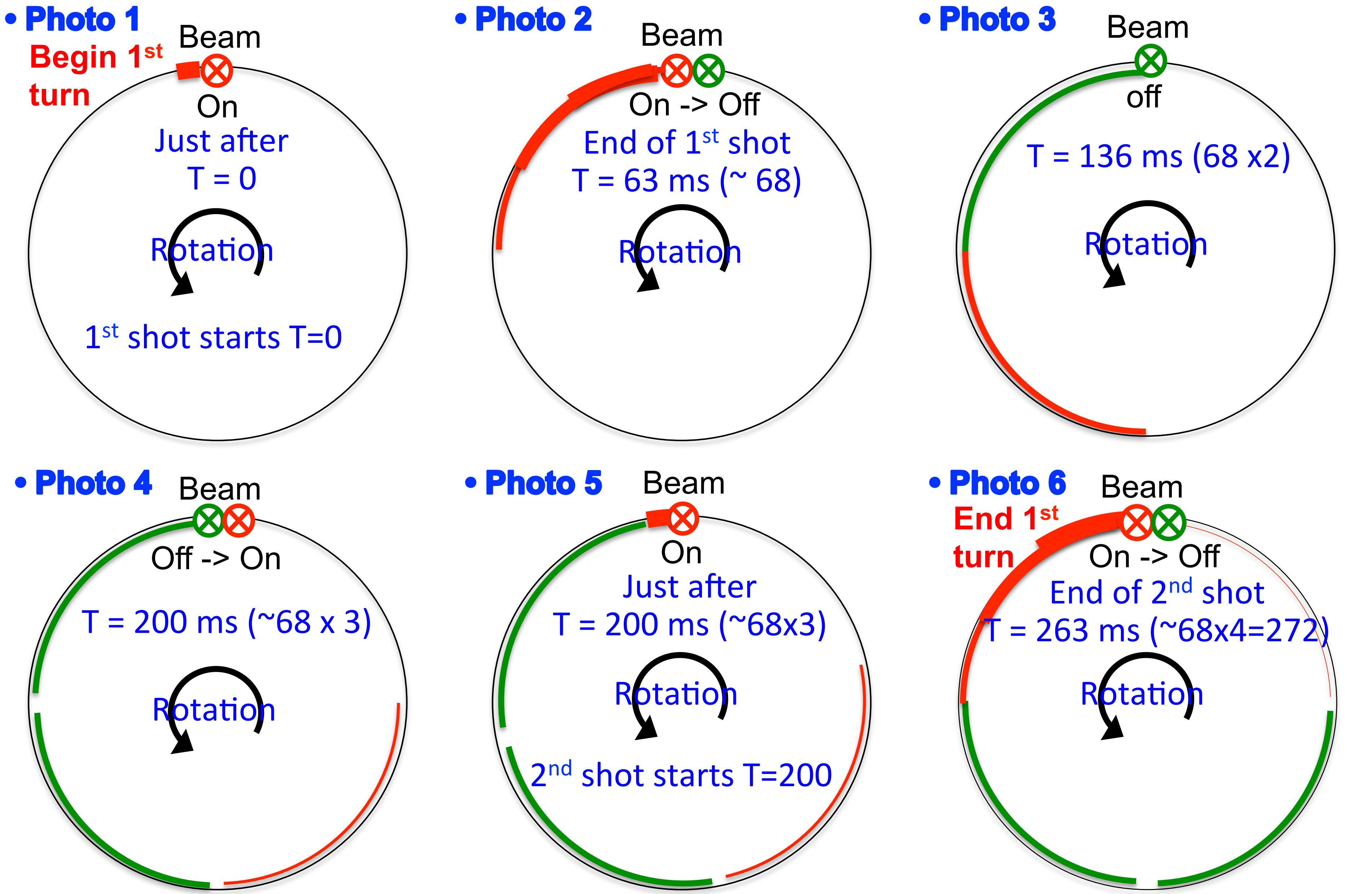
At 220 rpm: Temperature more UNIFORM and LOWER maximum value.

Simulated by Rigaku Nb=2600

At Posipol 2015, Omori presented 200 vs 180.

Rotation = 220 rpm : Photos of 1st turn.

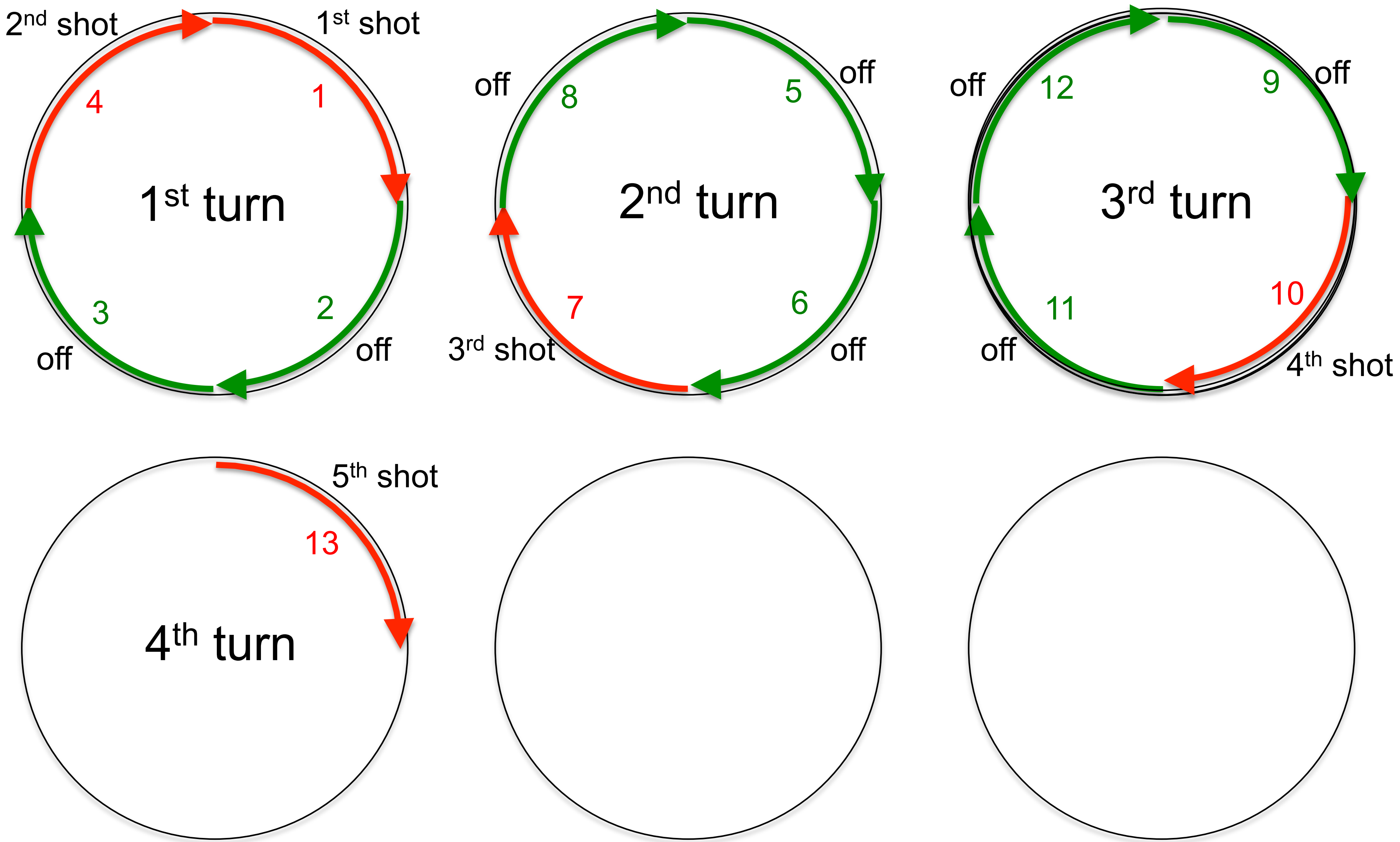
Photos = Lab. Frame Views



One turn takes 272 m sec. 272 m sec / 4 = 68 ms 68 ms ~ 63 ms (duration of beam on)

68 ms x 2 ~ 137 ms (duration of beam off) 68 ms x 3 = 200 ms (one cycle of ILC)

Rotation = 220 rpm **Target Rest Frame Views**



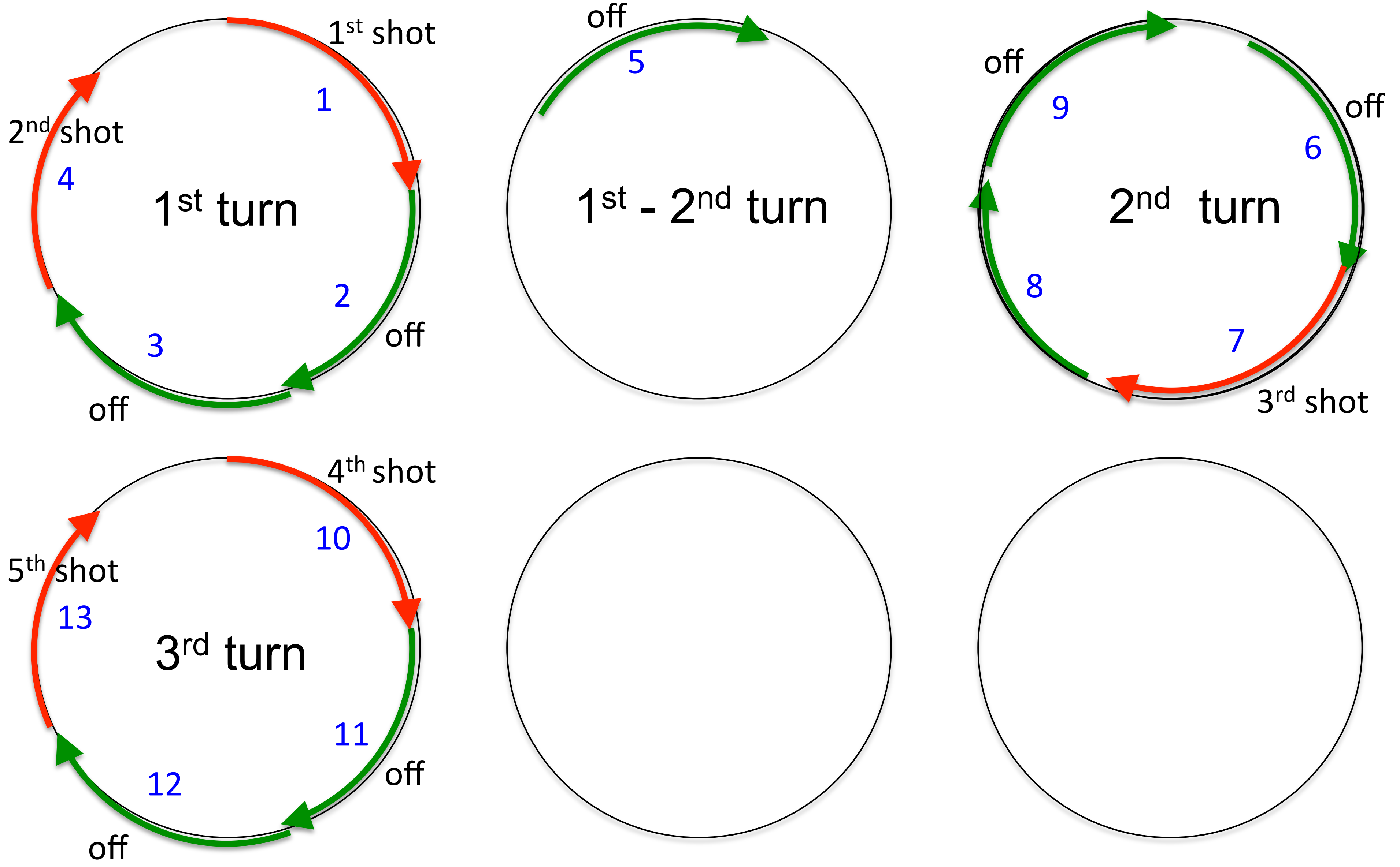
One turn takes about 272 m sec.

Each Red number (1, 4, 7, 10, 13) corresponds 63 m sec.

Each Green number (2,3, 5,6, 8,9, 11,12) corresponds 68.5 m sec.

63ms + 68.5ms + 68.5ms = 200ms

Rotation = 200 rpm **Target Rest Frame Views**



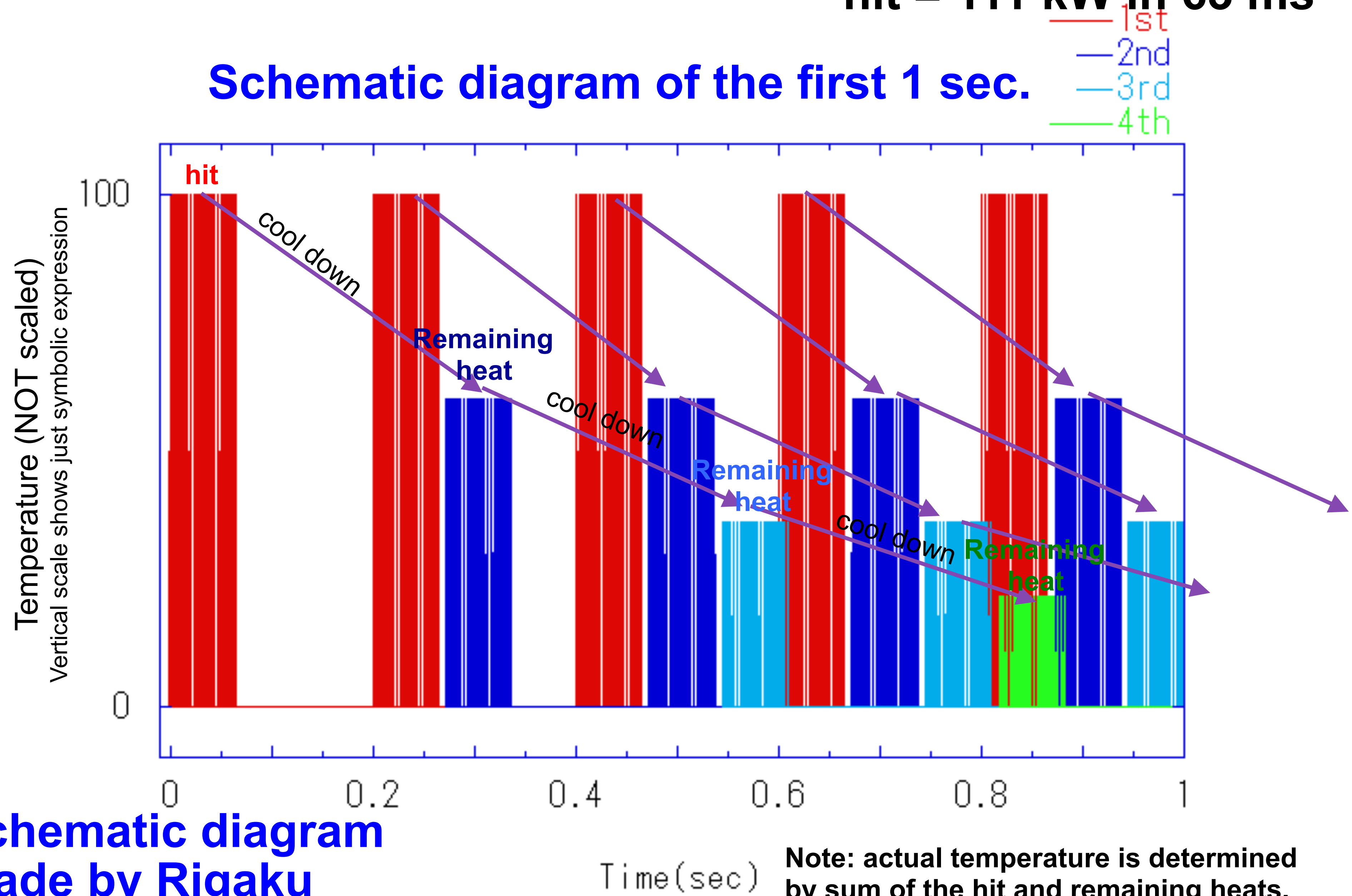
One turn takes about 272 m sec.
Each Red number (1, 4, 7, 10, 13) corresponds 63 m sec.
Each Green number (2,3, 5,6, 8,9, 11,12) corresponds 68.5 m sec.
63ms + 68.5ms + 68.5ms = 200ms

Pulse Beam Diagram

Rotation speed = 220rpm

hit = 111 kW in 63 ms

Schematic diagram of the first 1 sec.



Schematic diagram made by Rigaku

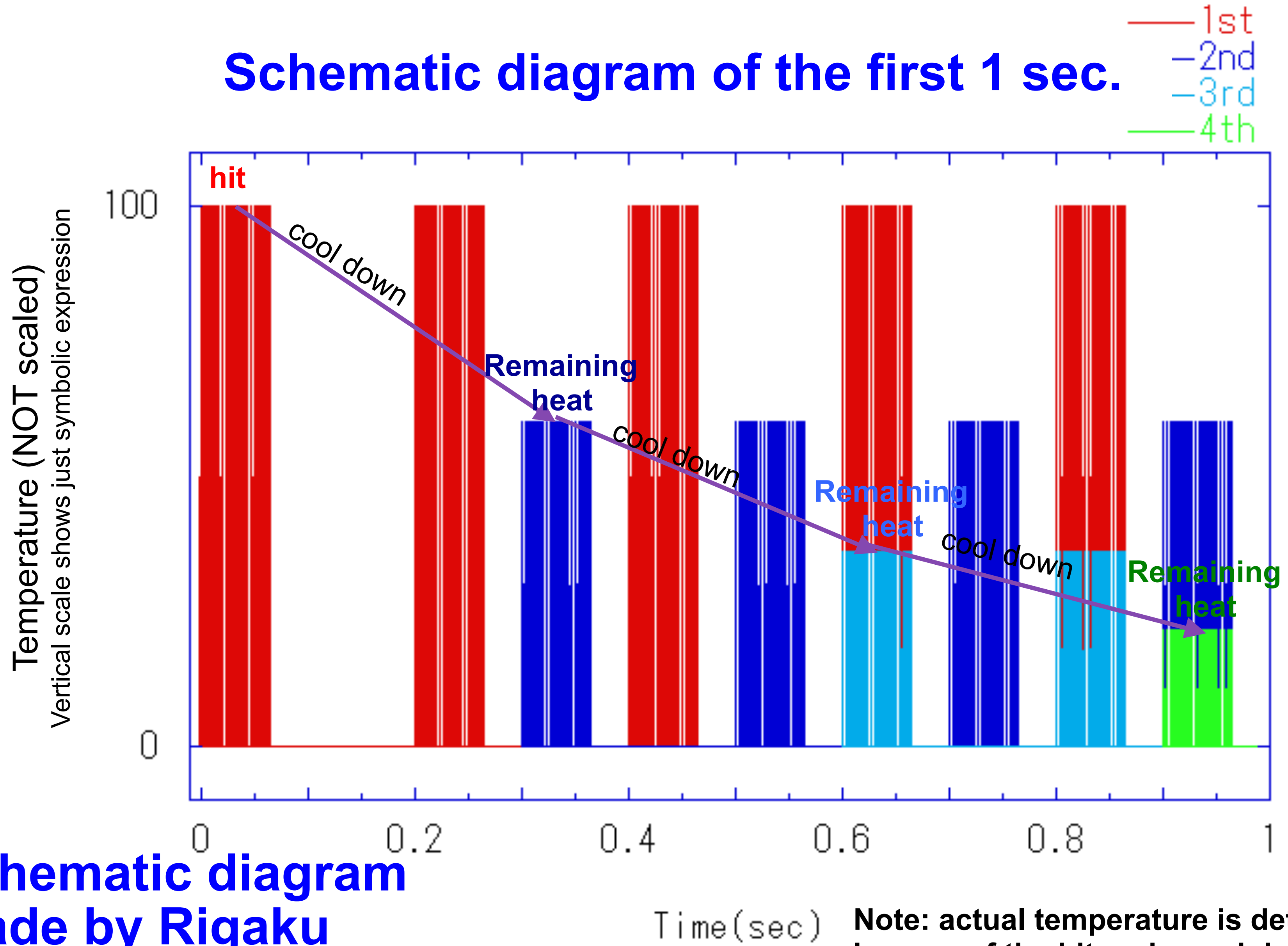
Note: actual temperature is determined by sum of the hit and remaining heats.

Pulse Beam Diagram

Rotation speed = 200rpm

hit = 111 kW in 63 ms

Schematic diagram of the first 1 sec.



Schematic diagram made by Rigaku

Note: actual temperature is determined by sum of the hit and remaining heats.

解釈(これは安全か？)

SLCのターゲットの実績と比べてみる

SLCのターゲットの Max ストレスは約 500 MPa (by Freidrich さん)→ ILC とほぼ同じ

SLAC 自身による解析 (SLAC-PUB-9437) では Max ストレス 560 MPa→ ILC とほぼ同じ

SLCのターゲットは数年の間、壊れずに動いた

解釈（これは安全か？）

SLCのターゲットの実績と比べてみる：続き　年間の hit 数を比べる

シャーワーによるエネルギー密度 (Max) SLCがおよそ 29 J/g（1バンチ），
ILCのパラメーターは 132 バンチが事実上一ヶ所にあたり、その合計で、約27J/g

パルスあたりのエネルギー密度はほぼ同じと考えていい。（この場合 SLC は1バンチが1パルス、ILC は 132 バンチを纏めて1パルスとしている） これは、Max ストレスが SLC と ILC でほぼ同じであることとコンシステント。

この場合は 入射ビームエネルギーや、ビーム半径の因子は、この数値に繰り込まれているので、パルス数での比が妥当な計算。

ビーム半径の因子はすでに織り込まれていることから、単位面積あたりのパルス数ではなく、単位周長あたりのパルス数を比較する

ビームが落ちる周長の比較

SLCでは　180mm
ILCでは　1500mm

の領域（長さ）がビームを受け入れる。

解釈（これは安全か？）

SLCのターゲットの実績と比べてみる:　年間の hit 数を比べる （続き）

パルス数をこれで除したものが、年間あたりの周長あたりのパルス数。

SLC 120 x 3600 x 24 x 365 / 180 = 2.1 e+7 pulse/year.mm
ILC 2600/132 x 5 x 3600 x 24 x 365 / 1500 = 2.1 e+6 pulse/year.mm

（SLC は1バンチが1パルス、ILC は 132 バンチを纏めて1パルスとしている）

年間 hit 数では ILC は SLCとくらべて 10 倍らくと考えられる。

注意:
これはかなり荒っぽい計算

Summary of the R/D in Past 2.5 Years: FY2013-mid.FY2015

FY2013: Leak Rate measurement

We took leak rate data by using a small (d=10cm) rotation target off the shelf.

Conclusion: Leak Rate is small enough.

FY2013-2014: Radiation Test:

We made radiation test of ferrofluid at Takasaki Lab.

Conclusion:

F-oil: No hope.

CN-oil: No problem up to 4.7 MGy (about 3 ILC years).

FY2014-2015: Target Design Study.

We made design study with the company, Rigaku. Study included both mechanical design and thermal stress analysis.

We now have a nearly final mechanical design.

Thermal stress study is ongoing.

Pulse Beam Analysis step 2:

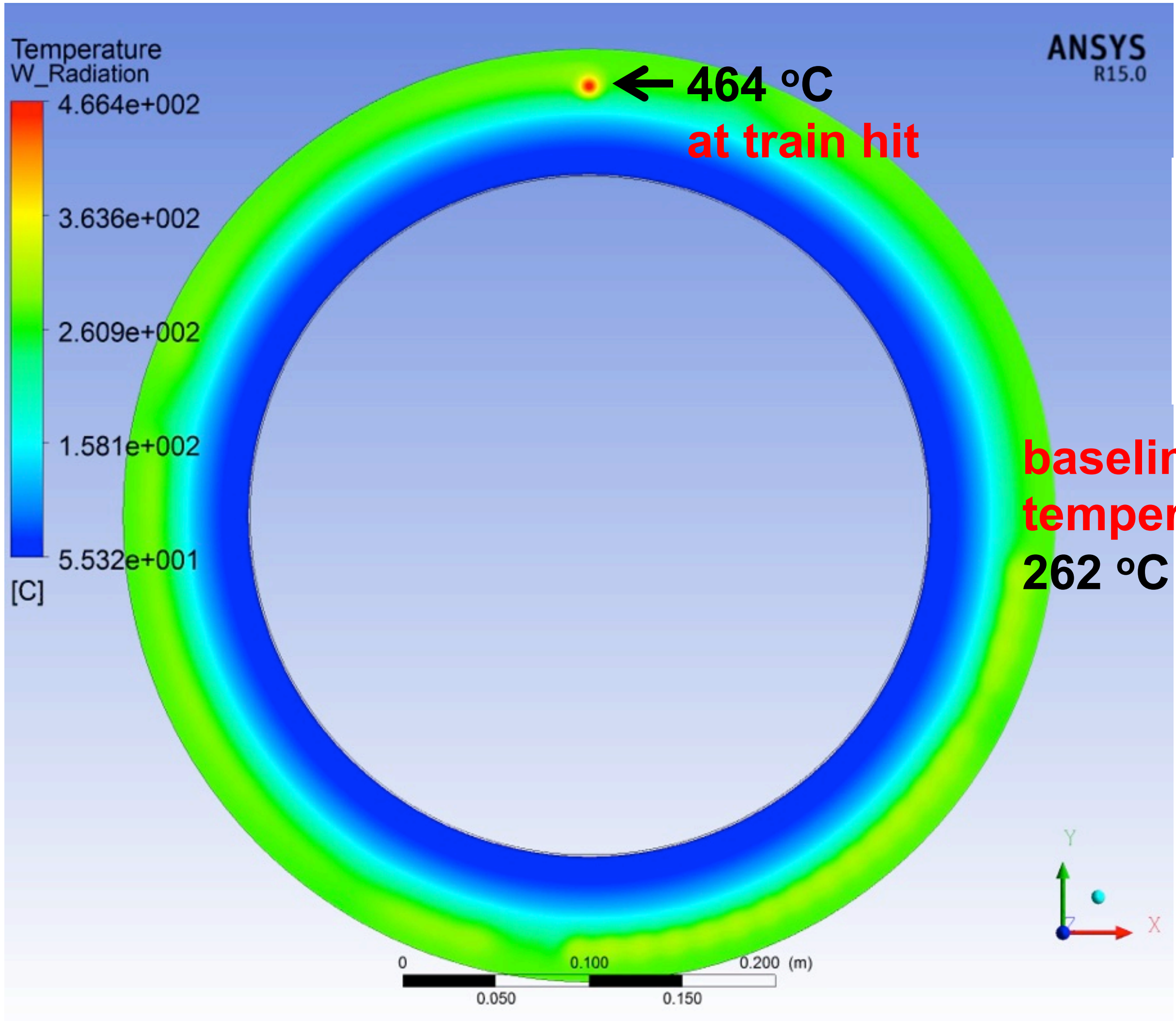
20 trains in 63 ms

1 train simulated

Rotation speed = 220rpm

1 train = 373000 kW(**) in 0.99 micro s (*)

train to train separation: 3.3 m sec



* Note: 1
One train corresponds 132 bunches, but time structure in a train is ignored.

- Note: 2
  Pulse width of a train is NOT 0.99 m sec. It is 0.99 micro sec.
  We made correction
  But difference in the results are small.

Corrected.

** Note: 3
This value is NOT accurate.
This is 5% larger than correct value.

Simulated by Rigaku Nb=2600

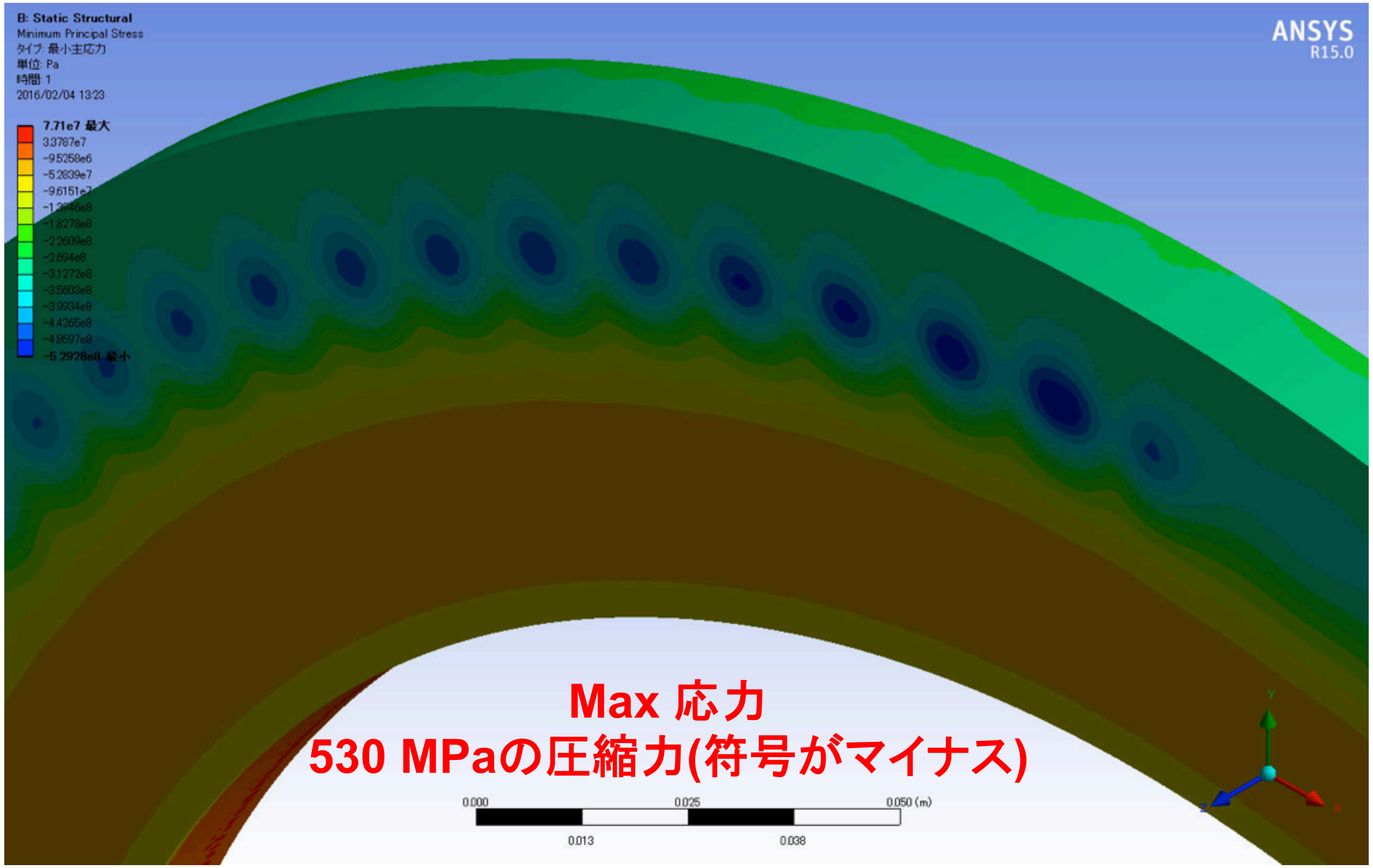
Posipol 2015 以降 (2015年9月7日以降) の解析

(2) まず (1) の方法で十分に長い間シミュレーションし定常状態に達した後、その温度分布を
引き続いて、1 μsの間に 132 バンチがほぼ同一地点に当たるパルスの peak (1μs の間
373 MW(注1)：132 バンチはまとめて一塊=パルスとする)をシミュレーション。

Max 435 度C (@220rpm) 前ページの場所(注3)のストレスを求める。

注3）前ページでは 466 度C となっている。
本当は 466度C であるべきだが、間違った温度分布が使われている。
ただしこのことによる差異は小さい。

山片さんの 2016年2月4日のメール
160204_Model39_3D_最小主応力_拡大.jp

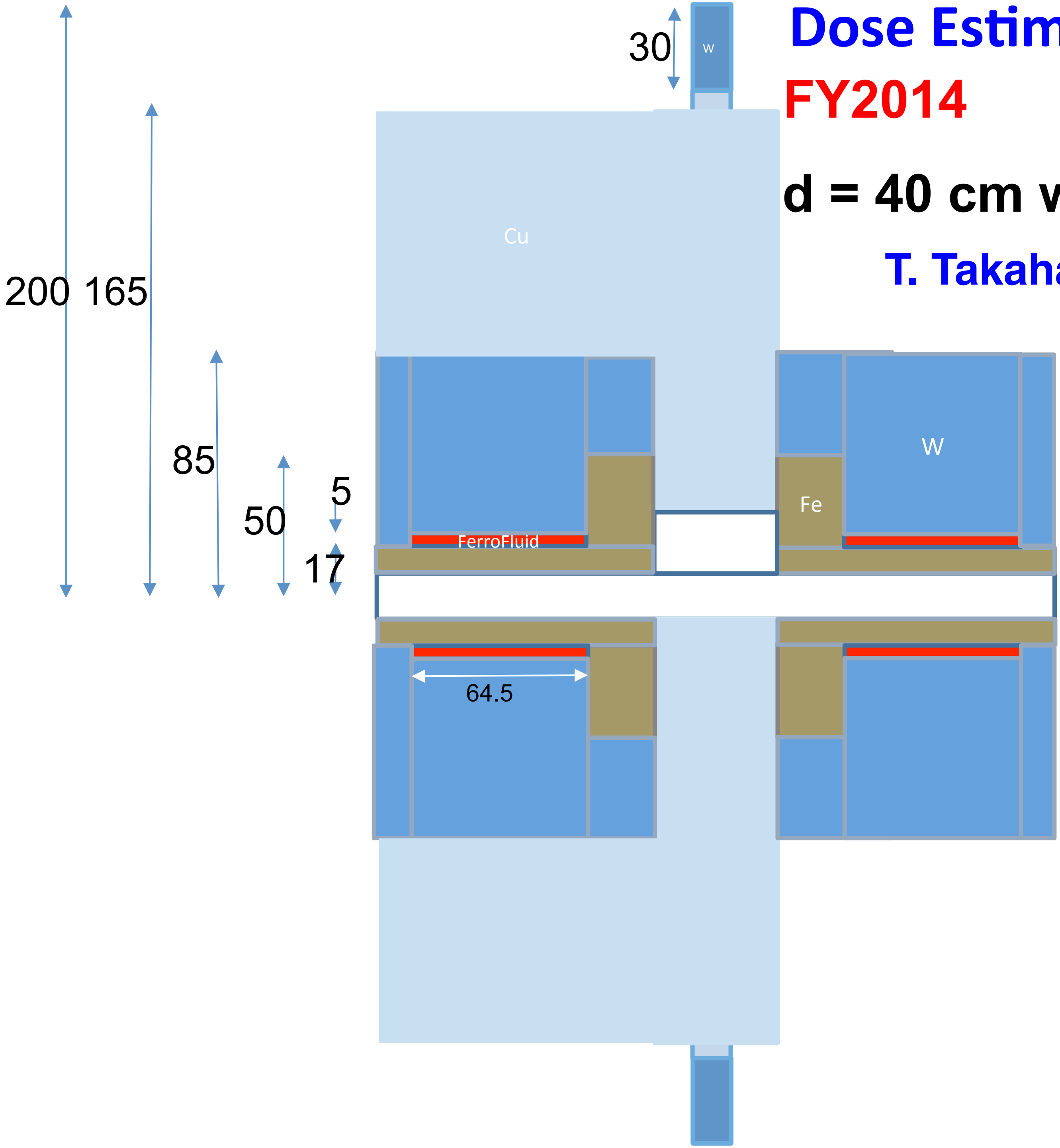


Dose Estimation

FY2014

d = 40 cm with radiation shield

T. Takahashi (Hiroshima)



Conventional e+ 源 (E-Driven) のR/D

ターゲット R/D

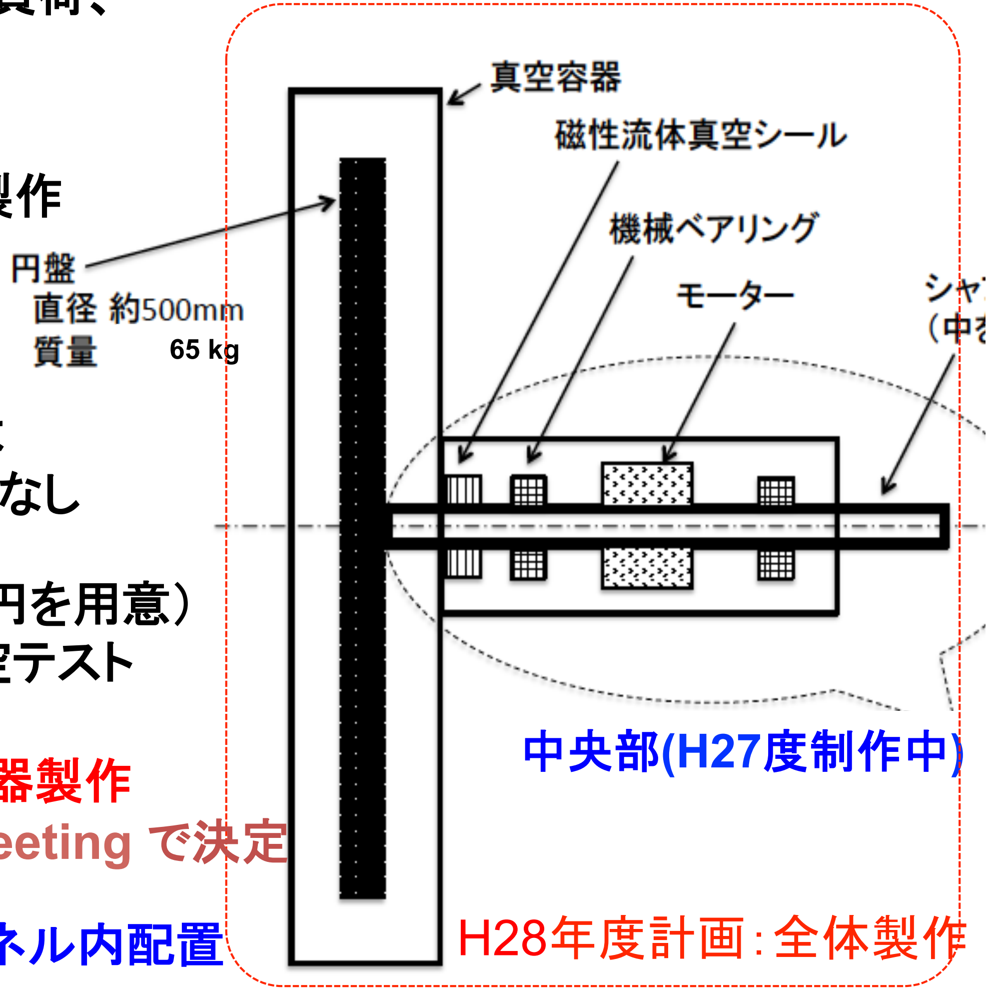
回転ターゲットは、類似のものが X 線発生目的で数多く作られているが、ILC 陽電子源の要求は、重量、大きさ、真空度などで、かなり異なる点がある。シミュレーションだけで十分でない部分もあり ILC がアプルーブされる前に実機大モデルの製作・実証が必要。

0. これまでに磁性流体の耐放射線試験や熱負荷、
   冷却、ストレスを考慮した基本設計を実施

1. 従来の計画（右図）
   実機大モデル（＊）を H27-H28年度 で製作
   H27：中央部製作
   H28：ディスクと真空容器製作
   長期間運転：真空テスト
   （＊）実機大ではあるが、ディスクの材質は
   W ではない、ディスクに冷却チャネルなし

2. 新しい計画（＊） （広島大で 120-200 万円を用意）
   小さな真空容器を作り中央部のみで真空テスト
   基本設計のさらなる練り上げ
   補正予算がもらえればディスクと真空容器製作

＊暫定案、正式には 4/12 に 広大-KEK meeting で決定



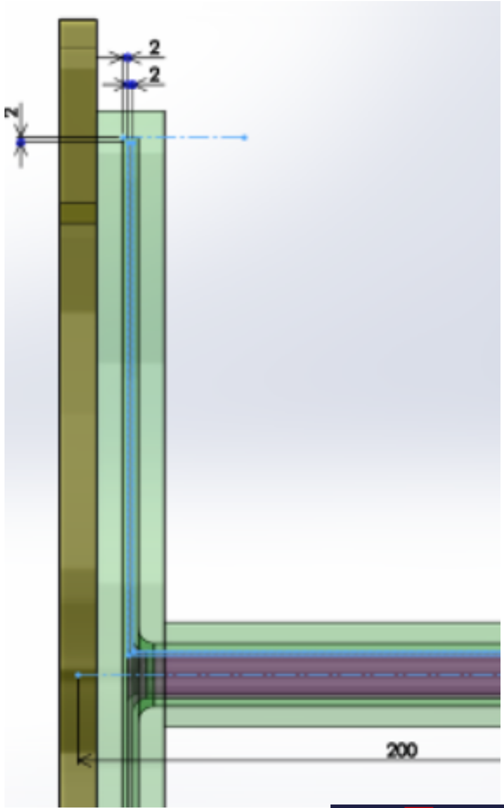
回転ターゲットプロトタイプ概略断面図

Capture 部、5 GeV Booster、シールド、トンネル内配置

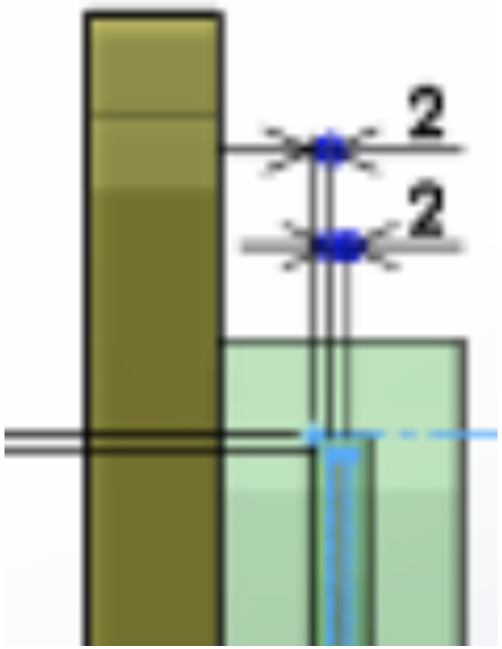
シミュレーション、図上検討を継続

To Get Improved Safety
Trying Better Cooling: water channel design

Outline



Detail: Old Design (Model 39)



Detail: New Design (Model 50)