ILC E-Driven e+ Source Plan

- Positron source is the only area of ILC where real R&D is still remaining **(K. Yokoya POSIPOL 2014)**

T. Omori (KEK), 14-Mar-2017
Positron WG

ILC e+ Sources

- **Baseline: Undulator (Baseline)**
  Drive Beam: e- Main Linac -> undulator -> γ beam
  Create e^+s in 1 m sec
  Fast Rotation Target : 100m/s = 360 km/h

- **Backup: 300 Hz Conventional (Backup)**
  Drive Beam: 3-5 GeV 300 Hz linac
  Create e^+s in 63 m sec
  Slow Rotation Target : 5m/s

Remark

Number of positrons/sec: N_{ILC}(1300 bunch, 5 HZ) = 30 x N_{SLC}

Conventional e+ source
E-driven
(backup)

Conventional e+ Source for ILC

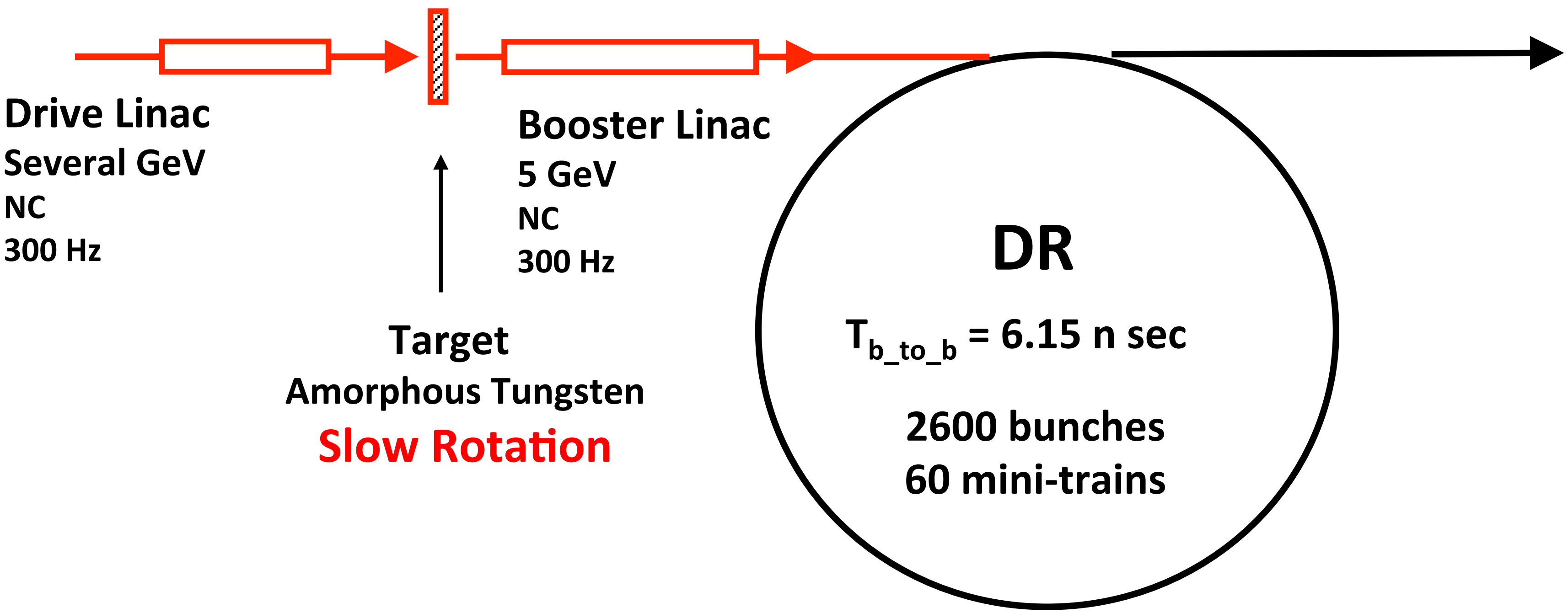
Normal Conducting Drive and Booster Linacs in 300 Hz operation

e+ creation

20 trains, rep. = 300 Hz, 3.3 msec gap btw trains
- 130 bunches , $T_{b\_to\_b}$ = 6.15 n sec
- 2600 = 130 x 20

go to main linac

2600 bunches/train, rep. = 5 Hz
- $T_{b\_to\_b}$ = 500 n sec



Time remaining for damping = 137 m sec

We create 2600 bunches
in 63 m sec
(3.3 x 20)

⇐ Stretching

Issues of Conventional e+ source in 2014-2015

- **S-to E simulation with beam loading**

- **Heat deposit in FC and 1st and 2nd Capture Cavity**

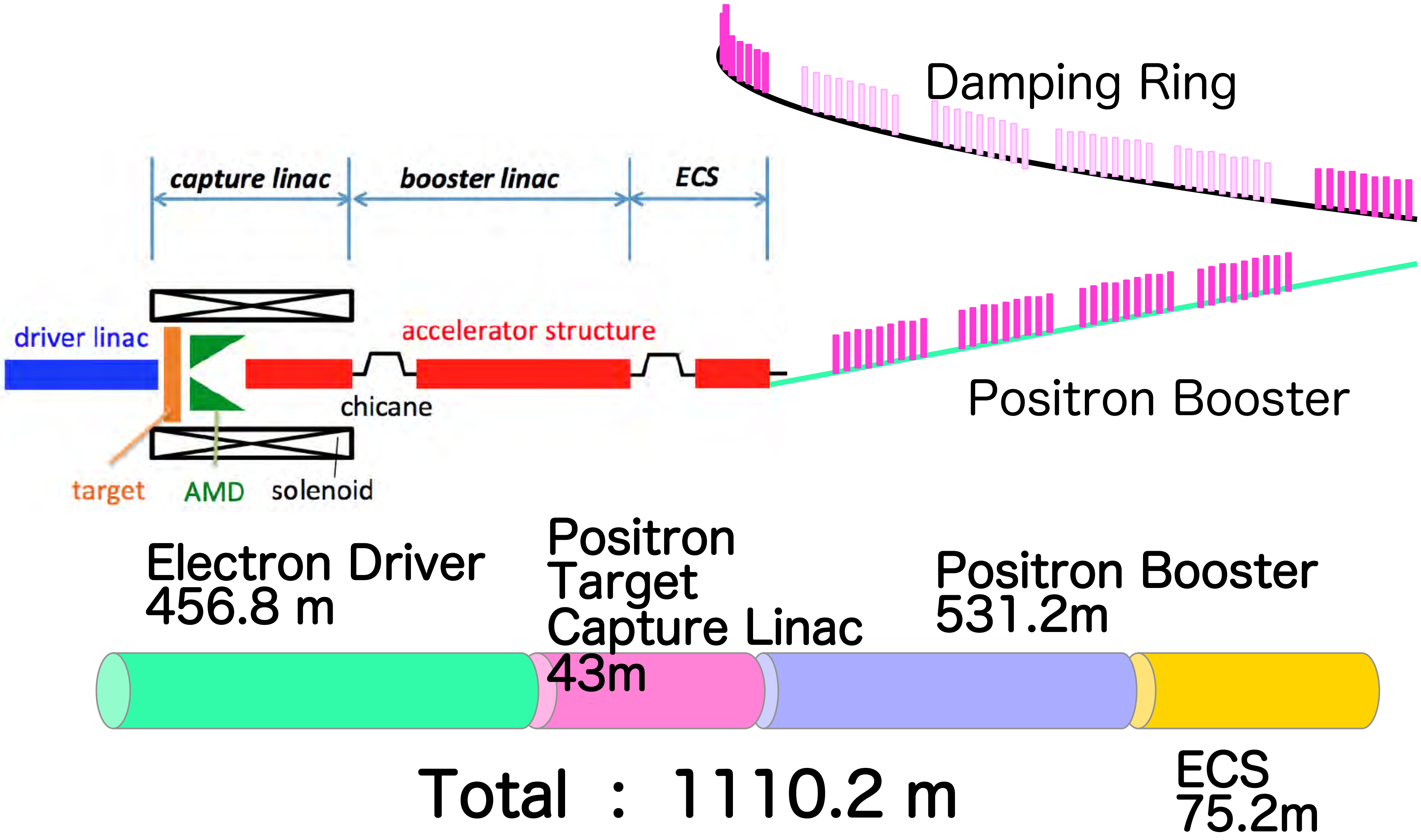
FC	**33 kW**	**(2600-bunch option)**
1st cavity	**67 kW**	**(2600-bunch option)**

- **Target**

  Detailed simulation study of heat, cooling, stress.
  Vacuum (can we keep good vacuum?)
  Radiation damage of ferrofluied

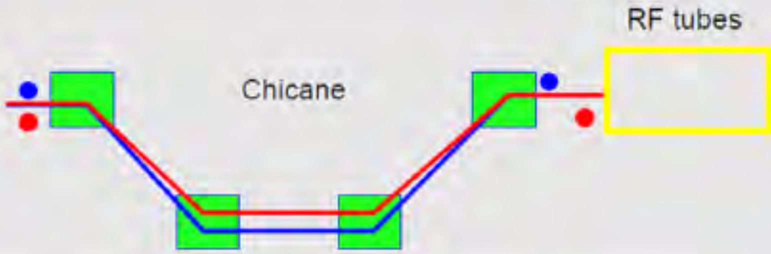
- **FC design**

E-driven ILC Positron Source: Y. Sumitomo



Total ： 1110.2 m

ECS



Energy compression

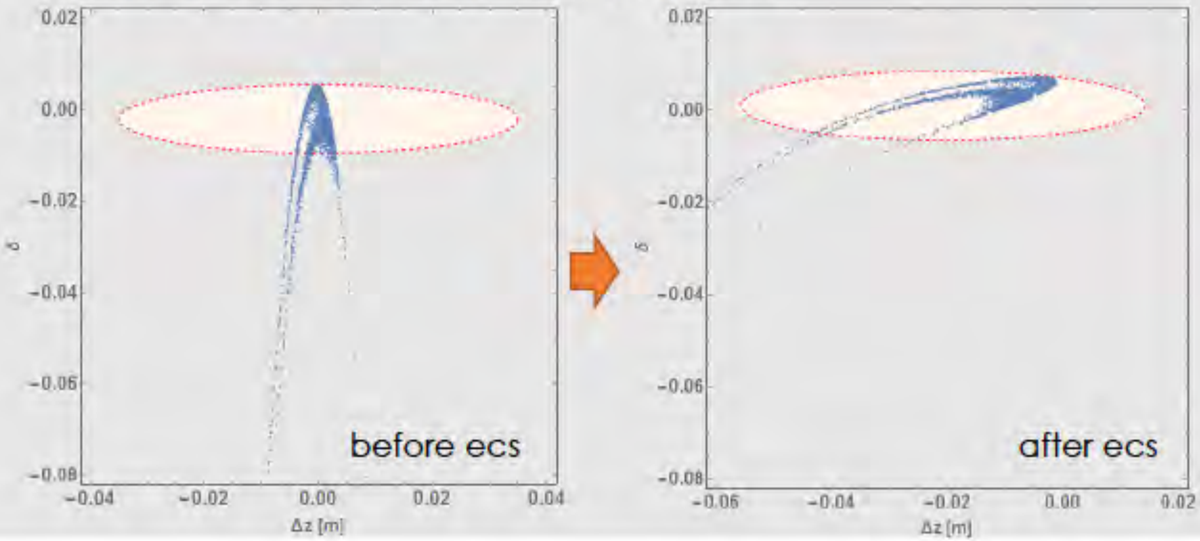
Bunch length change by 3 chicanes + 4 L-band boosters compression

Satisfy DR acceptance:

long. $\left(\frac{\Delta z}{0.035}\right)^2 + \left(\frac{\Delta \delta}{0.0075}\right)^2 < 1$ trans. $\gamma(A_x + A_y) < 0.07$

Scanning chicane & phase (overall)

Y. Sumitomo



Succ. Yield

1.36

1.75

S-to E simulation with beam loading was performed. Result was Good.

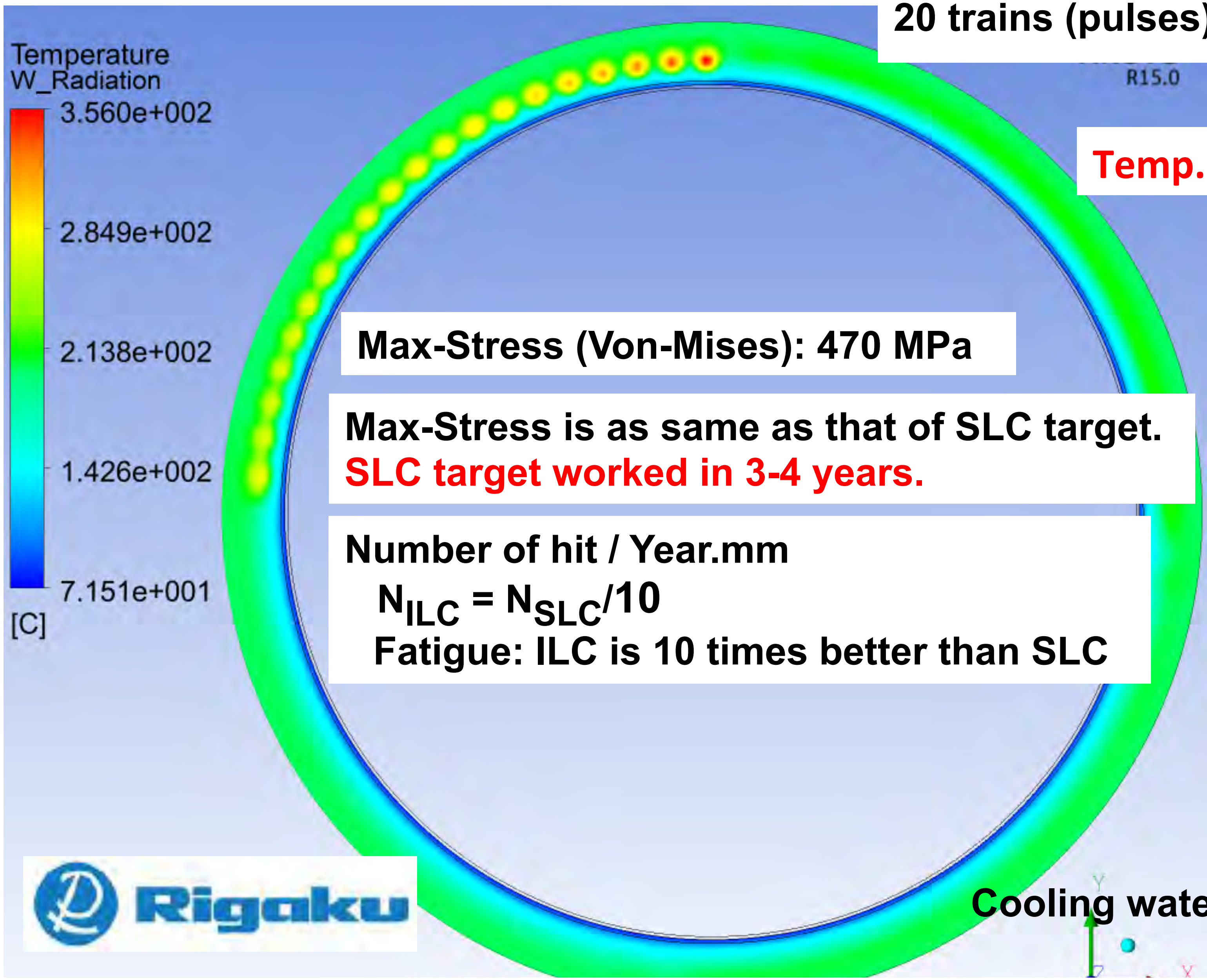
Note: Transit beam loading was also took into account.
Note: Transit beam loading in the ESC was not took into accuont yet.

Simulation : target stress and cooling

Pulse#02 225rpm

Pulse beam analysis: step 2

20 trains (pulses) in 63 ms



Temp.Max.; 356.0℃

Max-Stress (Von-Mises): 470 MPa

Max-Stress is as same as that of SLC target.
SLC target worked in 3-4 years.

Number of hit / Year.mm
$N_{ILC} = N_{SLC}/10$
Fatigue: ILC is 10 times better than SLC

Stress: OK
Cooling: OK

$N_b = 2600$

Cooling water: 60 ℓ/min

TEST: Radiation Tolerance FY2014

Takasaki Advanced Radiation Research Institute, JAEA

November 2014

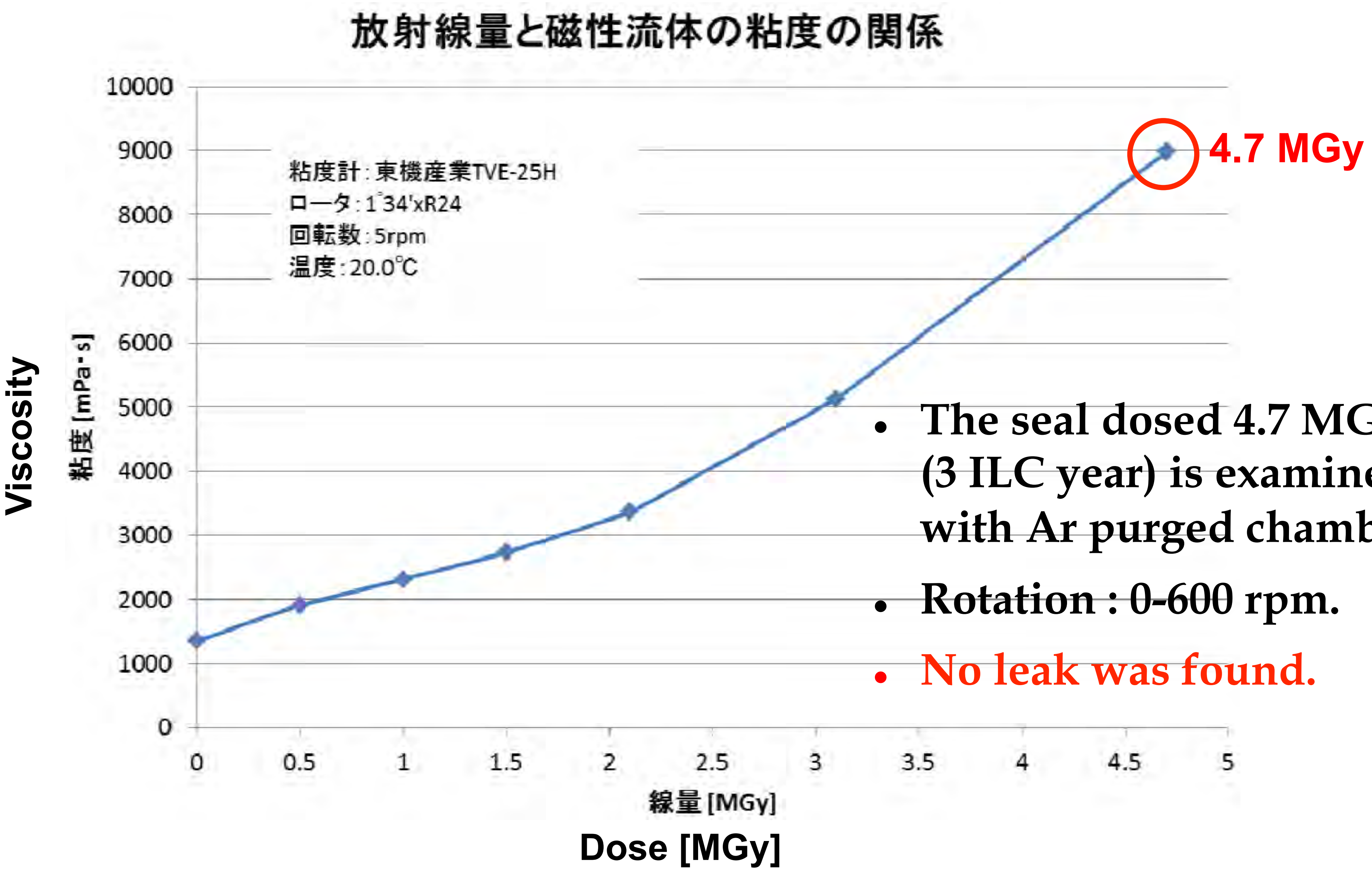
10-Nov-2014

TEST: Radiation Tolerance FY2014

November 2014

More systematic study for CN oil

Viscosity as a function of dose

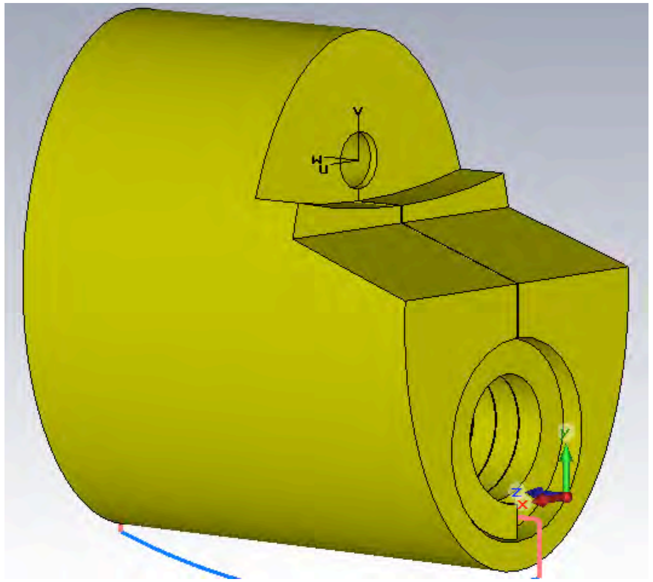


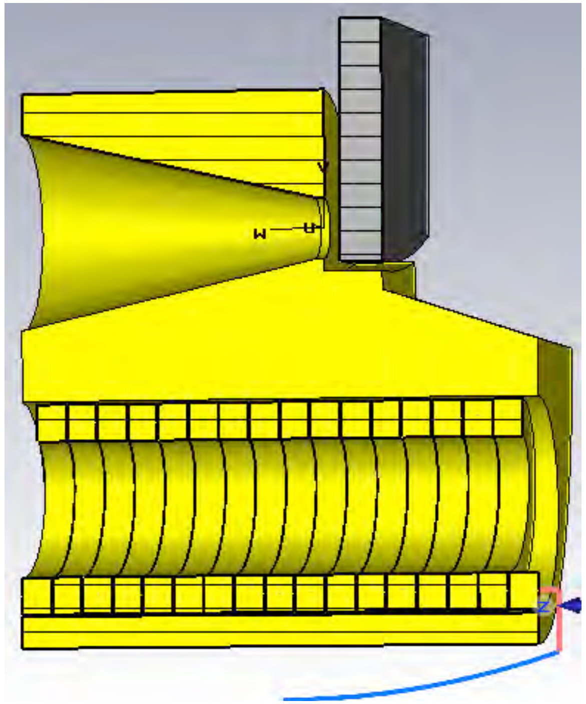
- The seal dosed 4.7 MGy (3 ILC year) is examined with Ar purged chamber.
- Rotation : 0-600 rpm.
- No leak was found.

Flux Concentrator design study

Pavel Martyshkin (BINP)

FY2015

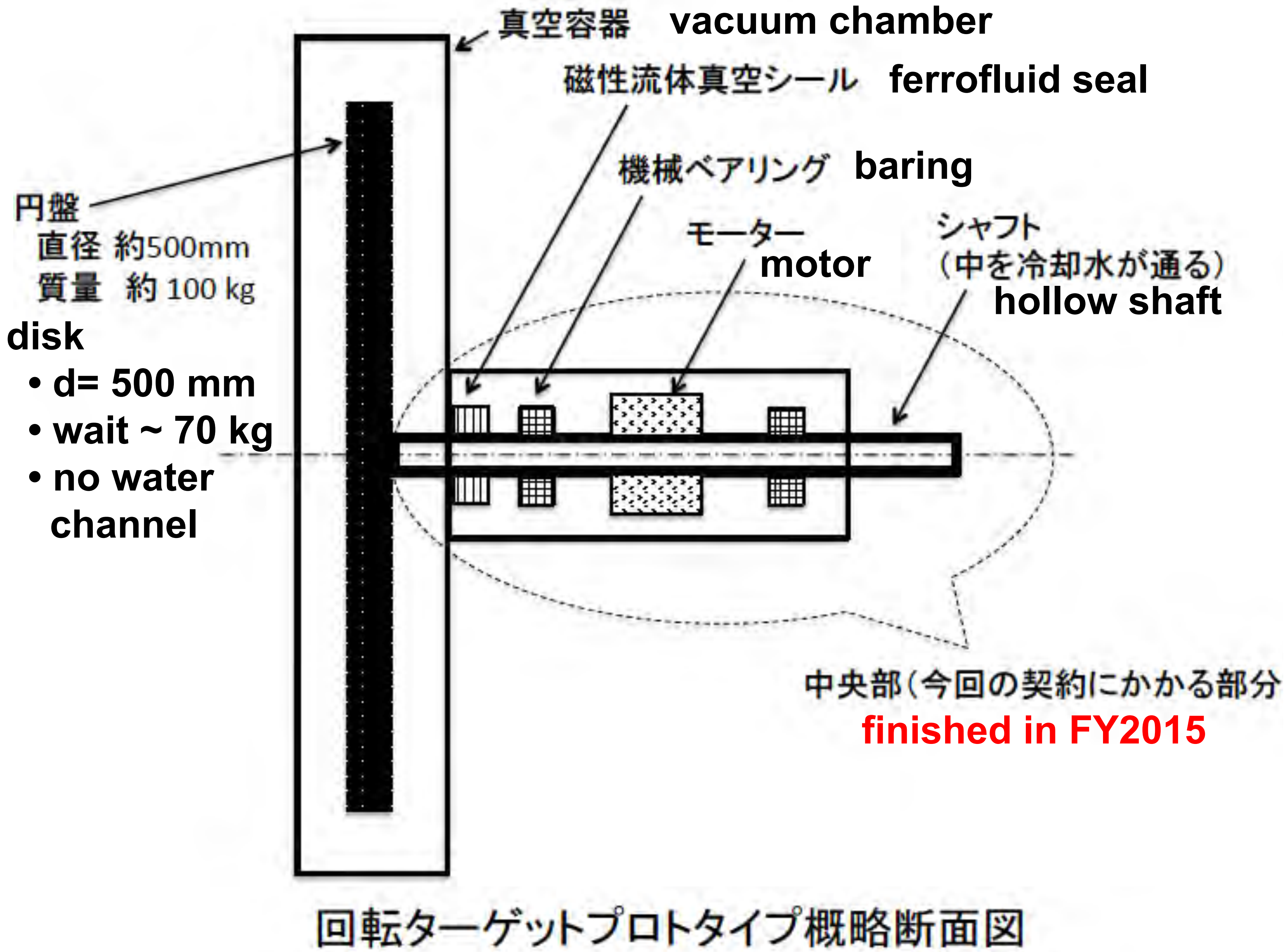




Cone diameter is 16 mm (Nose FC)

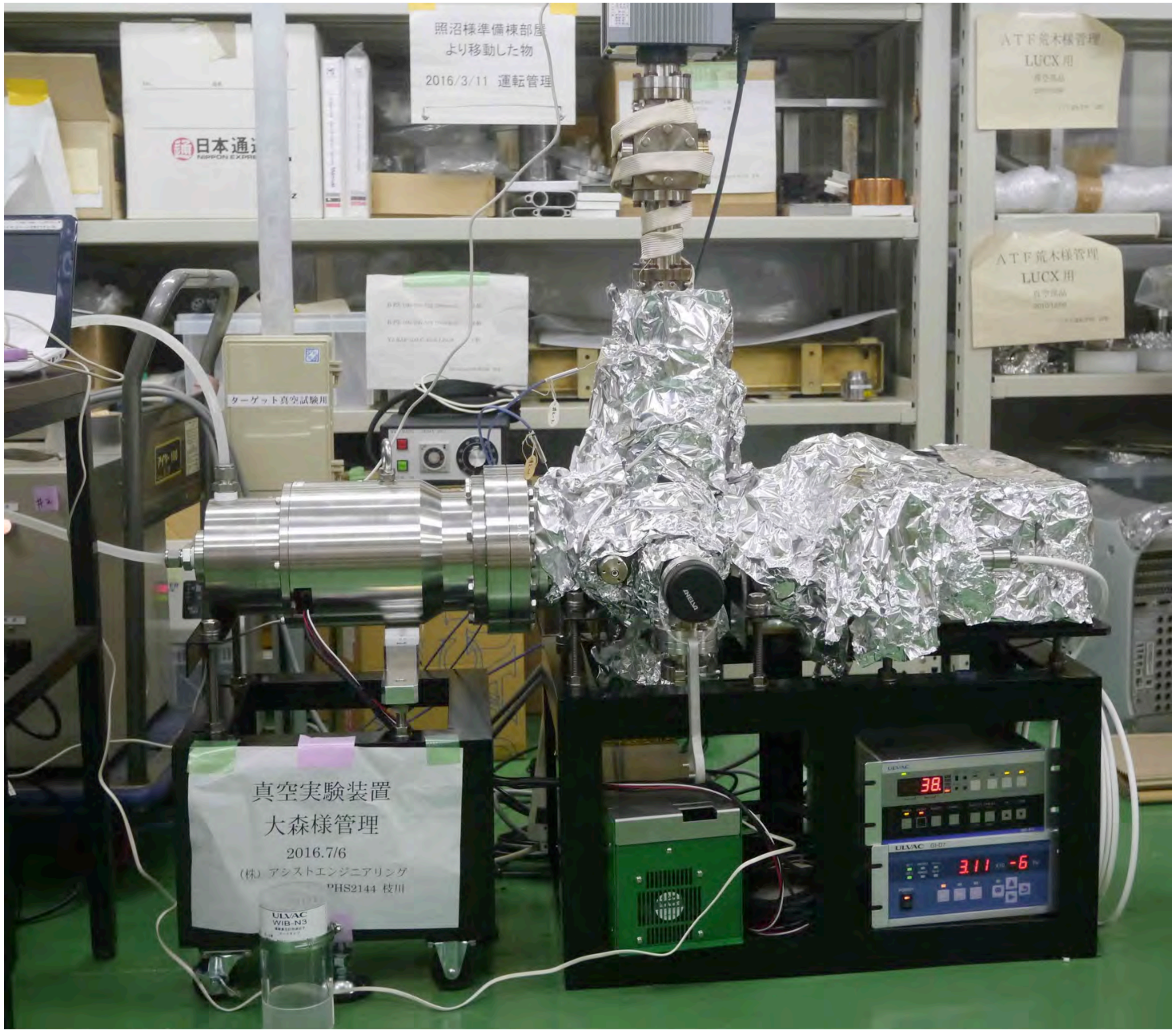
	Nose FC type D 16 mm
Peak current	25 kA
Peak field	5 Tesla
Peak transverse field	50-60 mTesla
Current shape	half of sine
Current pulse length	25 μs
Target ohmic loss	≈ 10 J/pulse
FC ohmic loss	≈ 140 J/pulse
Repetition rate 300 pps *	
Target losses *	3.2 kW
FC losses *	**41 kW**

Prototype of the Rotation Target (Conventional)



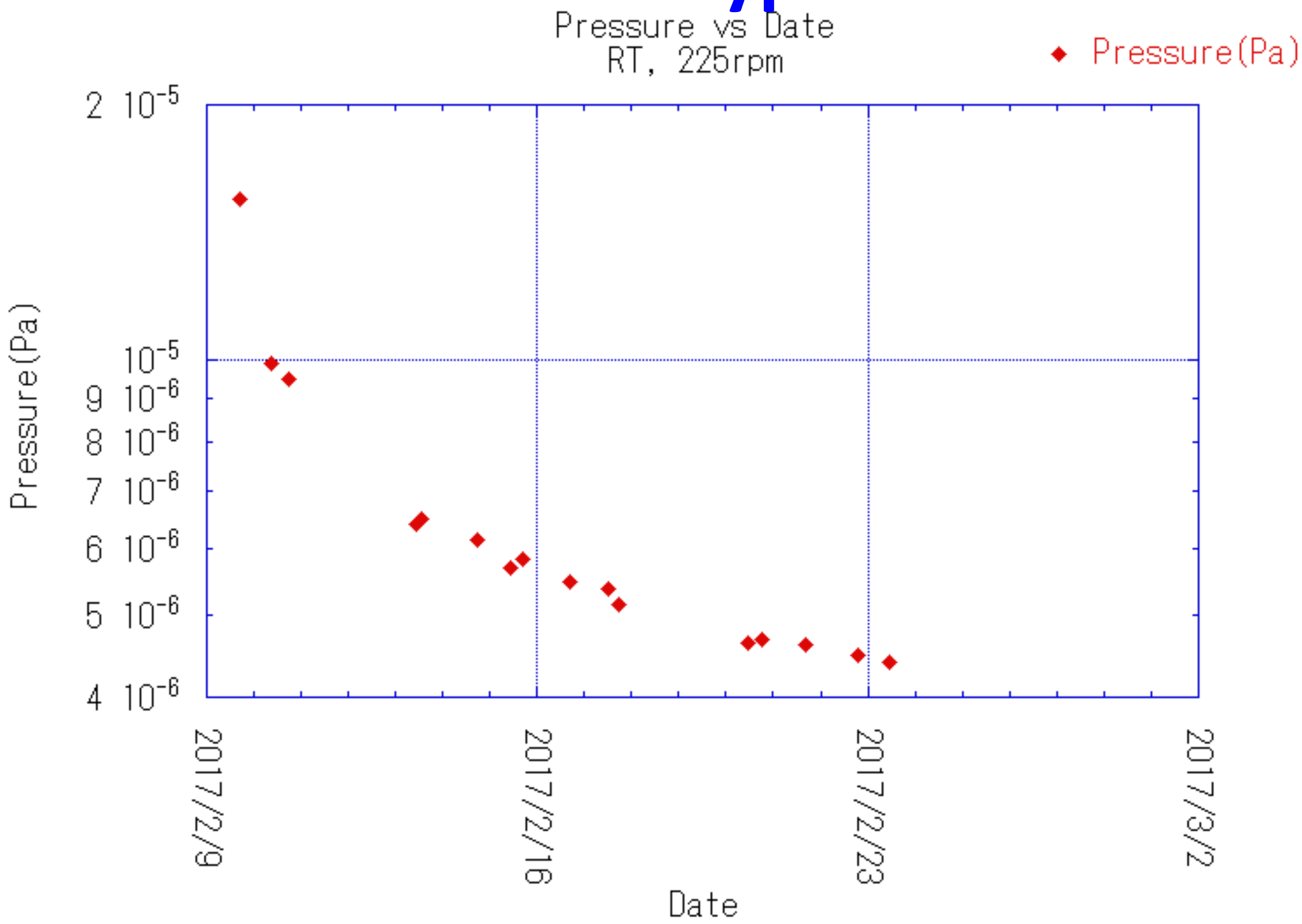
Central Part Prototype Vacuum Test

Feb/2017



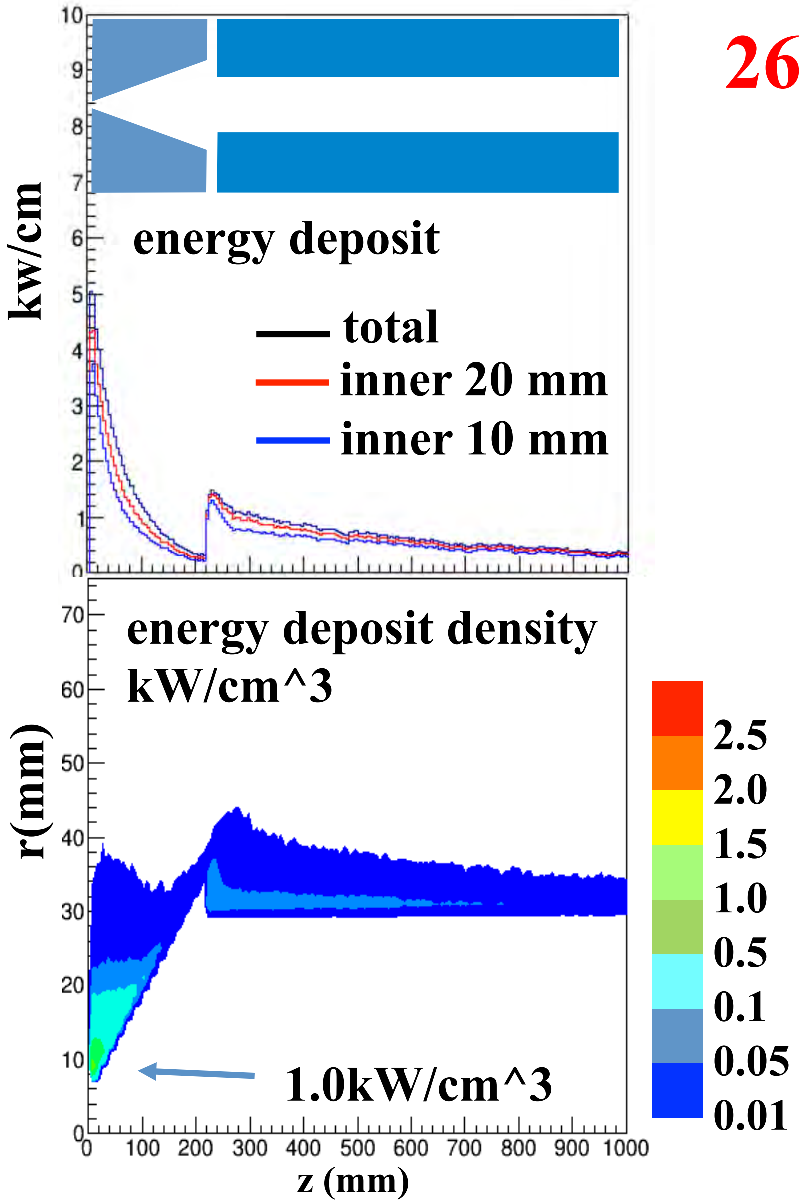
Central Part Prototype: Funded by KEK
Vacuum Test: Funded mostly by Hiroshima Univ.

Central Part Prototype Vacuum Test



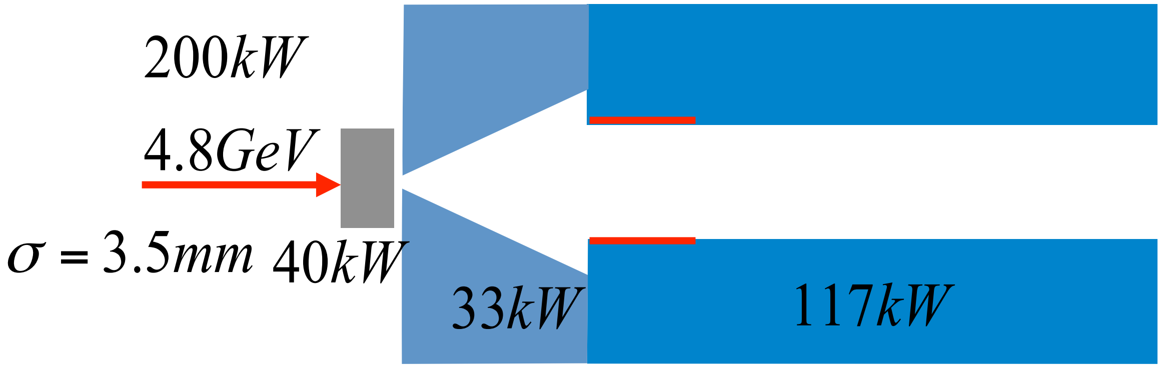
The vacuum test started on February 9th with continuous rotation at 225 rpm (design vale). The vacuum level seems to be reasonable in comparison with the expectation. The vacuum level is as good as the ILC TDR requirement. It seems promising. But the prototype has no disk. We will make further study.

E_e = 4.8GeV, target thickness 16 mm
sigma of e^- beam = 3.5mm



2600 bunch

yield: 1.55e+/e-
PEDD 30J/g



67kW in the 1st Cavity

expansion of the worst point of 1st cavity by beam (in 63 ms)
~ width of resonance in the cavity

It is issue

Re-optimization: dedicated to 1300 bunch operation

#bunch	E electron (GeV)	sig electron (mm)	PEDD target (J/g)	E dep. Target (kW)	E dep. FC (kW)	E dep. 1st Cav (kW)
2600 until now	4.8	3.5	30	40	33	67
1300 just make it half	4.8	3.5	15	20	16	33
1300 (*) dedicated	3	2	26	16	13	16

Common: t_target = 16 mm

- **Just make it half:**
  2600 = 20 x 130 --> 1300 = 20 x 65
- **Dedicated to 1300: (*) preliminary**
  (1)1300 = 20 x 65
  (2) sig_e: small 3.5mm --> 2mm (keep PEDD_target as high as 2600)
  (3) E_e : small 4.8 GeV - -> 3 GeV
  comb. (2) & (3) makes heat on FC and 1st Cav even more.

ΔT in 63 m sec,
cooling is not take into account

1st Cav.(1.27m) : 0.06k (expansion 10^{-6})
worst point of 1st Cav.:1.6k (exp. $2x10^{-5}$)
→ OK

Summary

Summary of Conventional e+ Source

- S-to E simulation with beam loading
  - → Simulation was done. → OK
- Heat deposit in FC and 1st and 2nd Capture Cavity
  - Just make it half Edep (1st Cav) -> 1/2
  - Dedicated to 1300 Edep (1st Cav) -> 1/4 → OK
- Target
  - Detailed simulation study of heat, cooling, stress.
    - →OK (OK even for 2600 bunches)
  - Vacuum (can we keep good vacuum?) → Test ongoing
  - Radiation damage of ferrofluid
    - →It was tested dose corresponded 3 ILC years → OK
- FC design
  - Basic design was done in collaboration with BINP → OK

Next Step

R/D plan

Simulation studies will be continued (NO budget request).
Followings are R/Ds which need budget allocation.

JPY 2017

Conventional e+ source: Target subtotal 1200 x 10^4 Yen (120k USD)

We will make full size prototype and make vacuum test.

* Full size prototype (no water circuit in disk) 1000 x 10^4 Yen(100k USD)
* Ion pump etc 200 x 10^4 Yen(20k USD)

JPY 2018-2019

Conventional e+ source: Target. subtotal 0 Yen

We assume prototype will be completed in 2017. 0 Yen

A prototype with real water circuit and a brazed W-Re ring should be tested in the lab, in vacuum and with a thermal load?
When? 2018-2019?