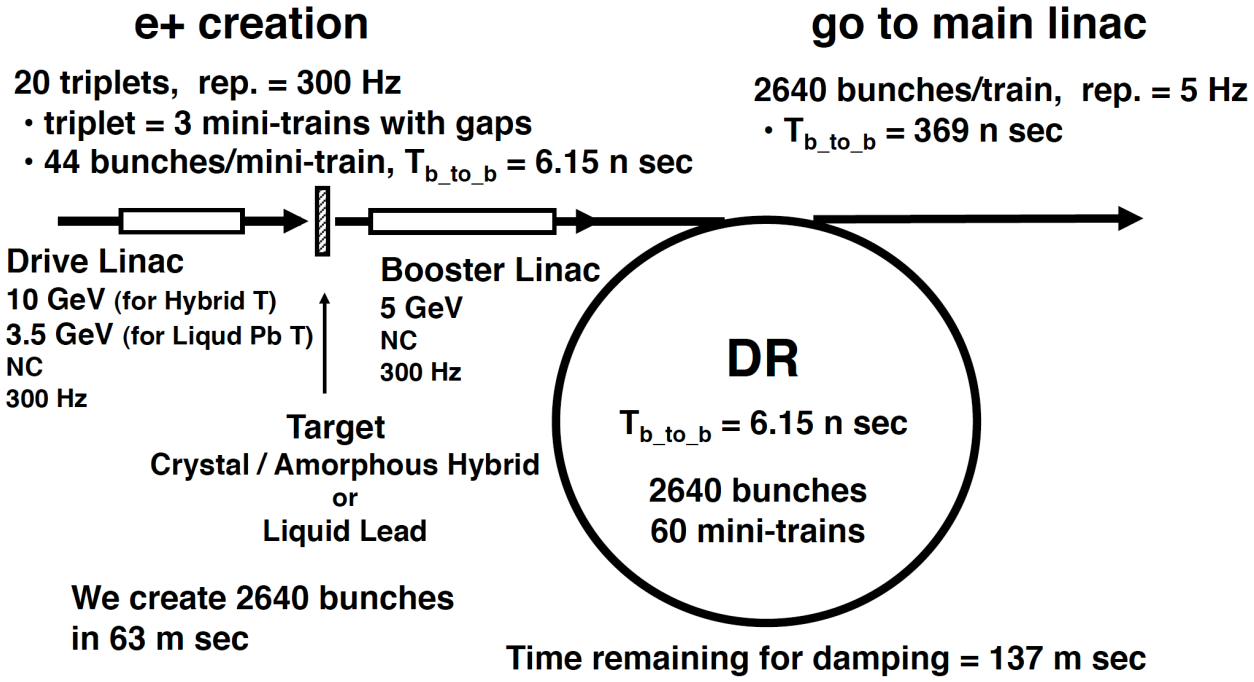
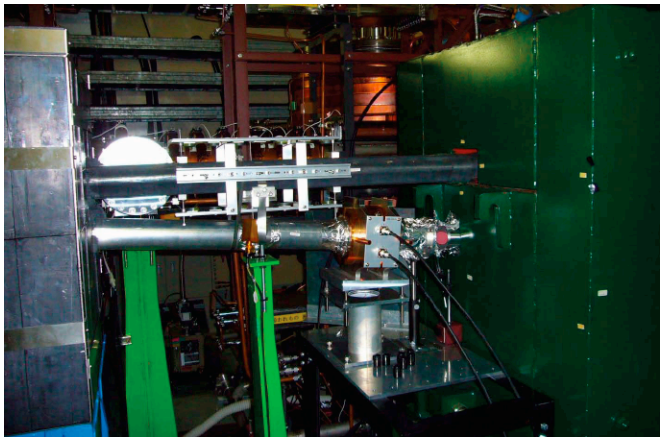
300 Hz e+ Source Update and ongoing R/Ds





T. Omori (KEK)

ALPCG2009 and GDE meeting
1-Oct-2009, UNM, Albuquerque

Many thanks to:

Chehab-san, Dadoun-san, Logachev-san, Bonder-san, Wanming-san, Wei-san, James-san, Ian-san, Susanna-san, Louis-san, Liu-san, Potylitsyn-san, Urakawa-san, Abhay-san, Kuriki-san, Takahashi-san, Suwada-sam, Kamitani-san, Furukawa-san, Umemori-san, Sugimura-san, Kawada-san, Akagi-san, Iida-san

Today's talk

1. 300 Hz e^+ source update
2. e+ target R/Ds
    - Hybrid target study at KEKB liniac
    - Liquid Pb Target System Test at ATF
    - Simulation Study of Liquid Pb Target (update)
    - BN window test of Liquid Pb Target at KEKB ring
3. Summary

300 Hz e^+ source update

300 Hz generation

e+ generation in 63 ms (c.f. UND generate e+ in 1ms)

(a) Liquid Pb target + Flux concentrator
- Drive e- beam: 3.5 GeV, 5.9 nC, 300 Hz, NC Linac
- e+ booster : 5 Gev, 300 Hz, NC Linac

(b) Hybrid Target + Flux concentrator
- Drive e- beam: 10 GeV, 3.2 nC, 300 Hz, NC Linac
- e+ booster : 5 Gev, 300 Hz, NC Linac

- Aiming mature and low risk.
- Need R/D of targets

↑ Parameters meet x1.5 margin.

c.f. parameters with no margin (presented in TILC09)

(a) Liq. Pb target: Drive e- beam: 2.2 GeV, 5.9 nC

(b) Hybrid target: Drive e- beam: 10 GeV, 2.1 nC

How?

- Total Number of bunches: 2640
- Divide into 20 triplets
  (1 Triplet = 3 Mini-Trains)
- Each triplet contains 132 bunches
- 2640 = 20 x 132
- 300 Hz creation of triplets
  triplet to triplet = 3.3 m sec
- Create 20 triplets : 63 m sec

Advanced Conventional e+ Source for ILC

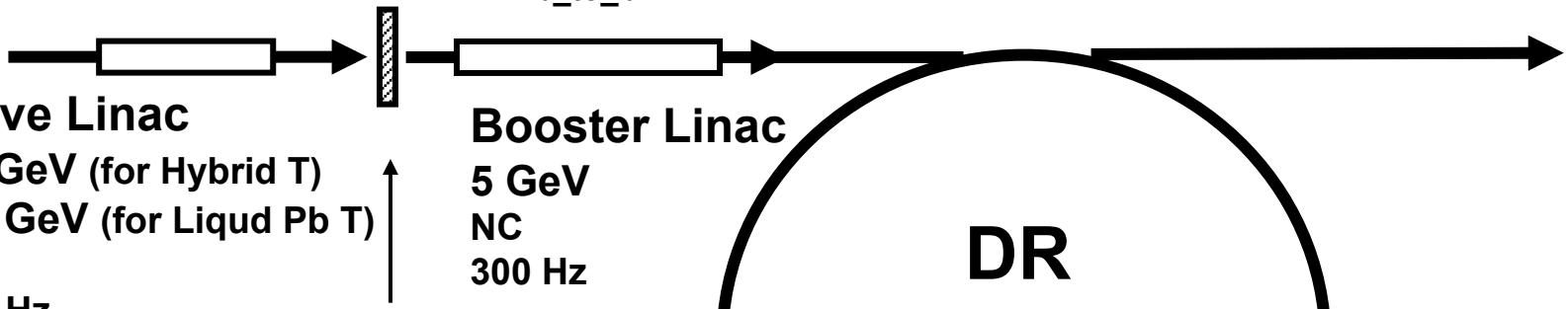
Crystal/Amorphous Hybrid Target or Liquid Lead Target
Normal Conducting Drive and Booster Linacs in 300 Hz operation

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



Drive Linac
10 GeV (for Hybrid T)
3.5 GeV (for Liqud Pb T)
NC
300 Hz

Booster Linac
5 GeV
NC
300 Hz

Target
Crystal / Amorphous Hybrid
or
Liquid Lead

DR
$T_{b\_to\_b}$ = 6.15 n sec
2640 bunches
60 mini-trains

We create 2640 bunches in 63 m sec

Time remaining for damping = 137 m sec

Comparison to Warm Machines

GLC/NLC (warm LC)

Ne+/bunch = 0.7 x 10^{10}

Nbunch/tarin = 200

3 targets (conventional)

150 Hz (6.7 m sec train to train)

x 3

x 1/1.5

ILC (cold LC)

Ne+/bunch = 2 x 10^{10}

Nbunch/tarin = 1320 = 10 x 132

300 Hz generation: similar to warm machines

in view point of target thermal/shock issues (diff = x2)

Need 6 targets ?

1 target --> Hybrid or Liquid-Lead target

Advanced Conventional e+ Source for ILC

Crystal/Amorphous Hybrid Target or Liquid Lead Target
Normal Conducting Drive and Booster Linacs in 300 Hz operation

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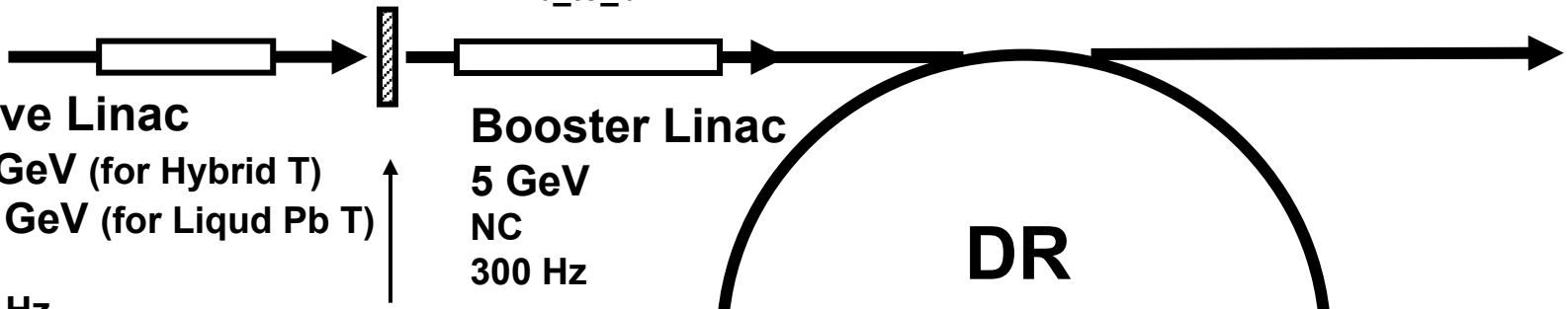

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300 Hz

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5 GeV
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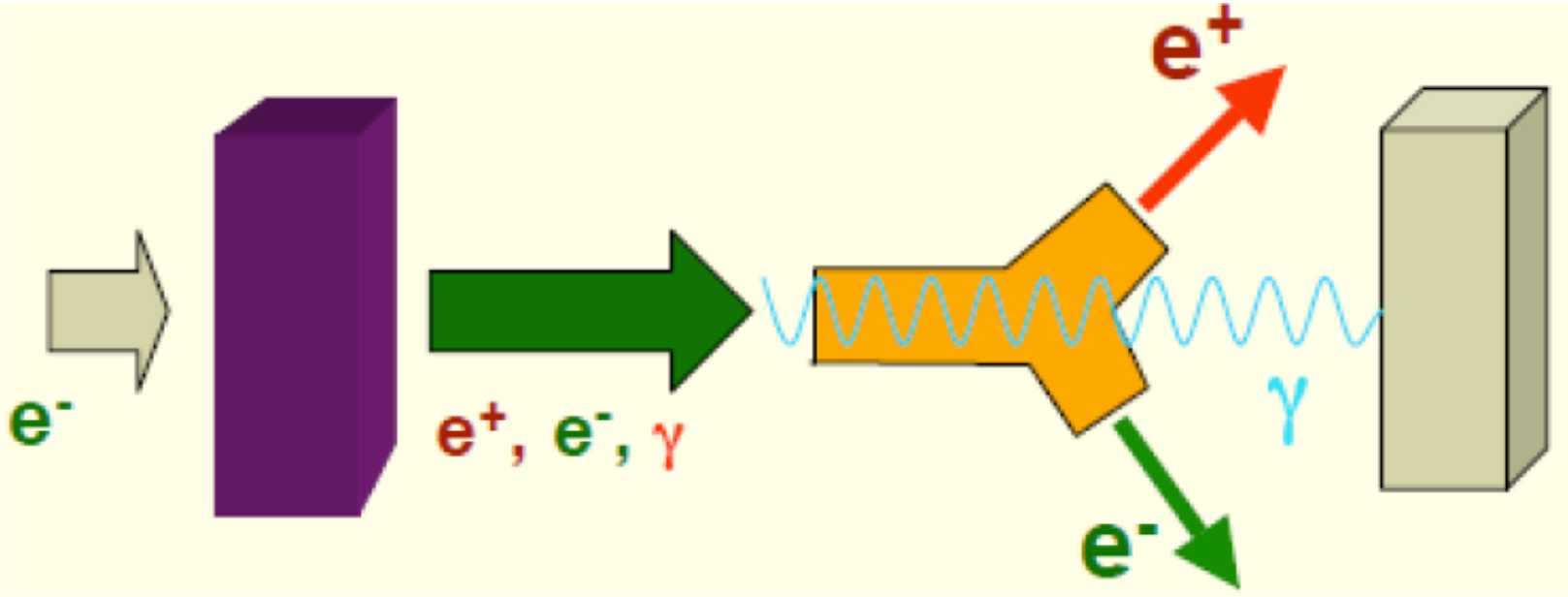
e+ target R/D

Hybrid Target
(Test at KEKB Linac)

Hybrid Target

Chehab-san



"Radiator"
Thin CRYSTAL

"Converter"
Thick AMORPHOUS

Proposal by Chehab et al

E_{beam} = 10 GeV

$t_{crystal}$ = 1 mm

$t_{amorphous}$ = 8 mm

Test at KEKB Linac

E_{beam} = 8 GeV

$t_{crystal}$ = 1 mm

$t_{amorphous}$ = 8 mm

Hibrid Target TEST at KEKB LINAC

JFY2009

1 To Demonstrate

- **positron yield with the hybrid system**
- **heat reduction by hybrid target**

w/ a real beam (angular divergence, alignment) and crystal (mosicity),,,

JFY2010~

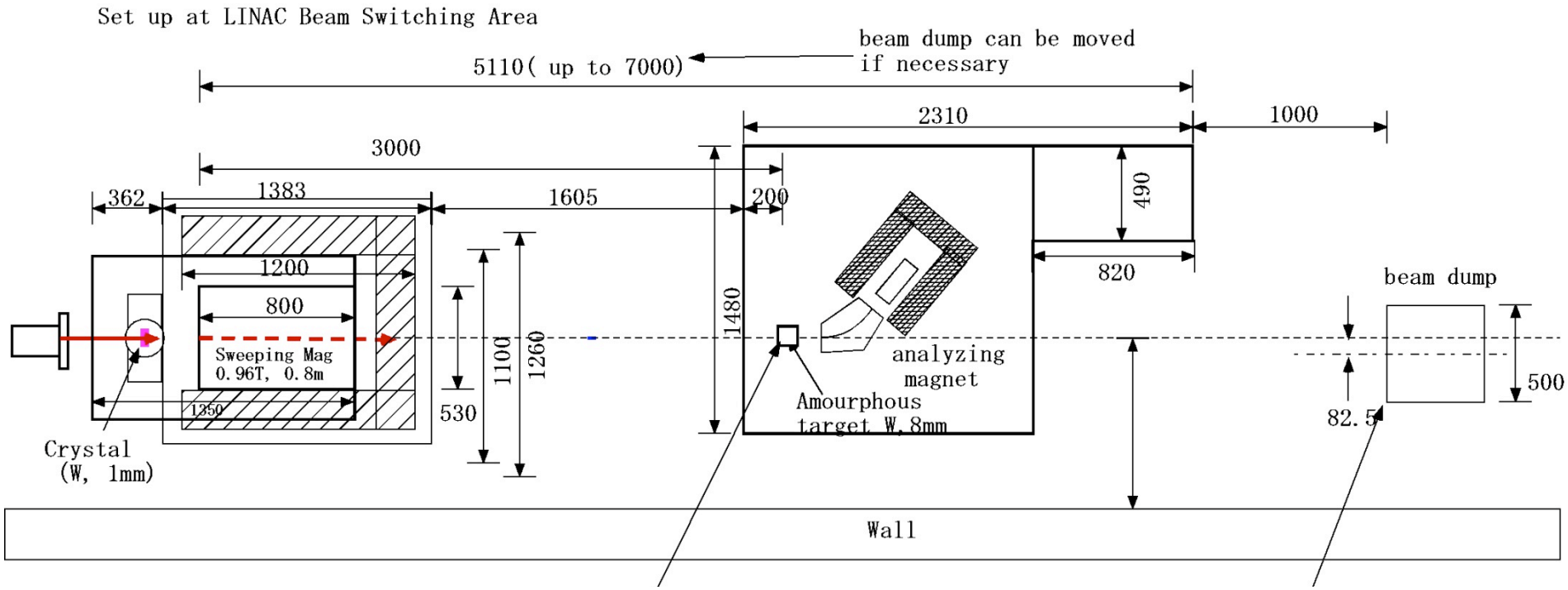
2. Detail investigation toward the positron source

- **momentum distribution,**
- **angular distribution of e+**

Site Set up

Looking up from Down stream

Status



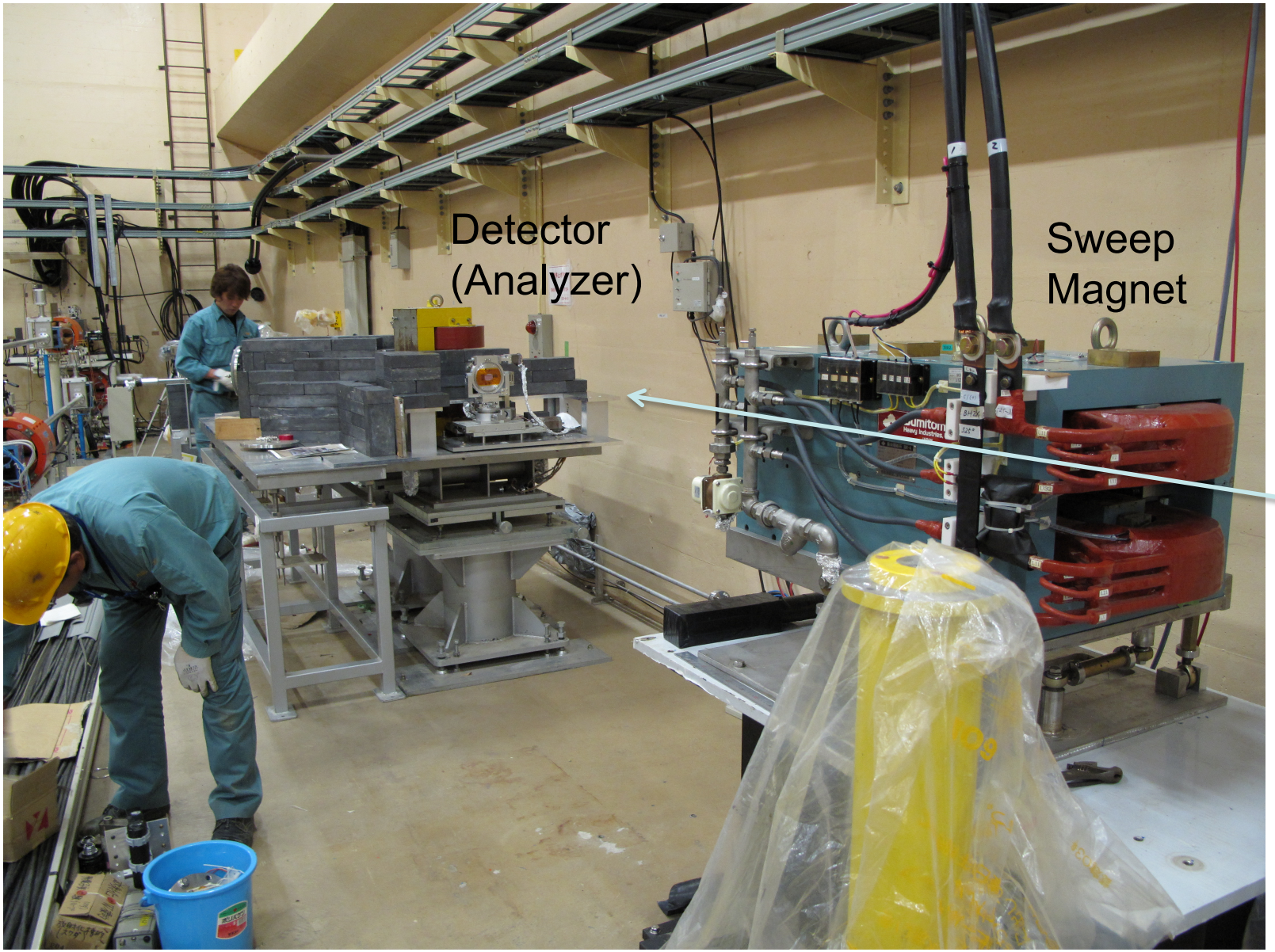
Major Equipments

Sweep Magnet, Detector (Analyzer), Beam dump have installed at the end of KEKB lineac.

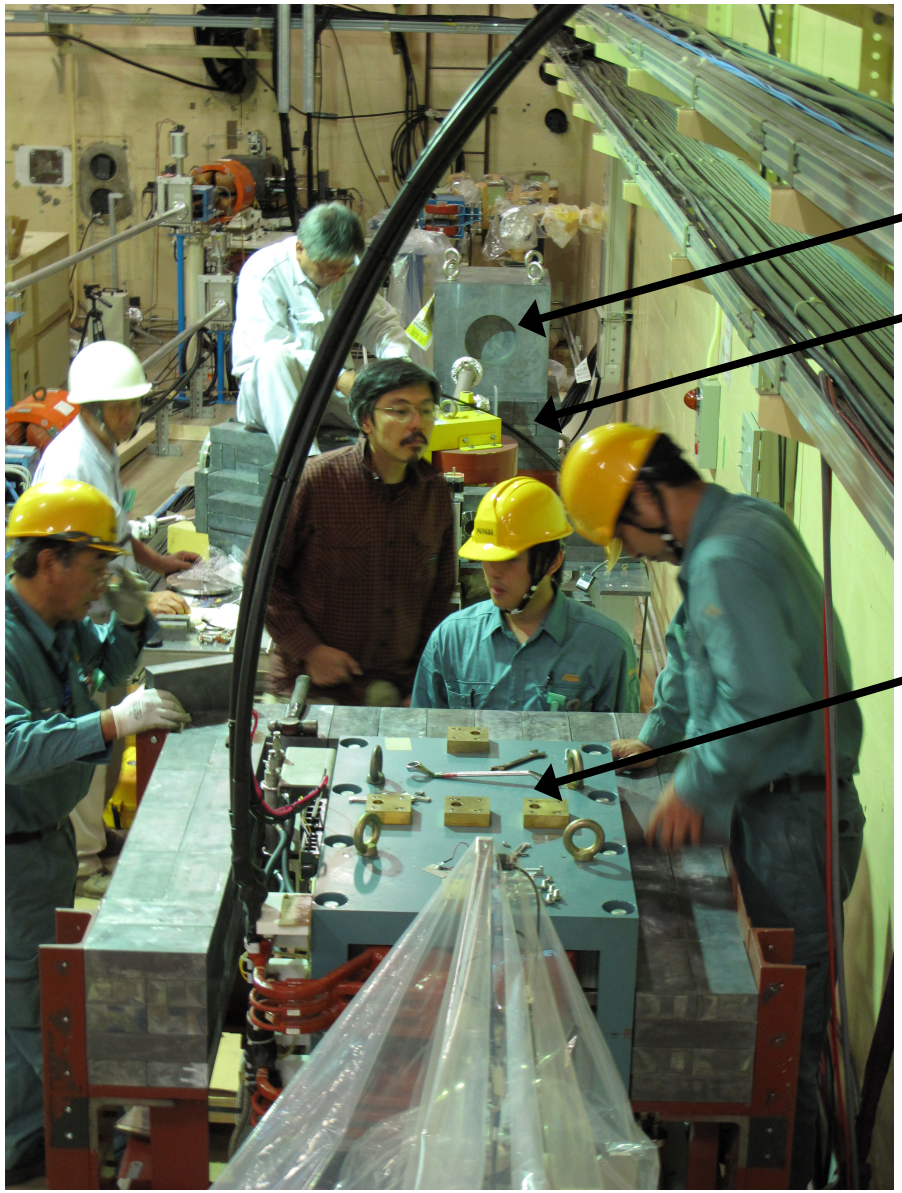
No DAQ, No computer control of the targets were installed yet.

First short experiment was done in the end of September

View of the experimental setup under construction
Summer 2009



Sweep magnet and lead block shields under construction
Summer 2009



Status of the Hybrid Target Test

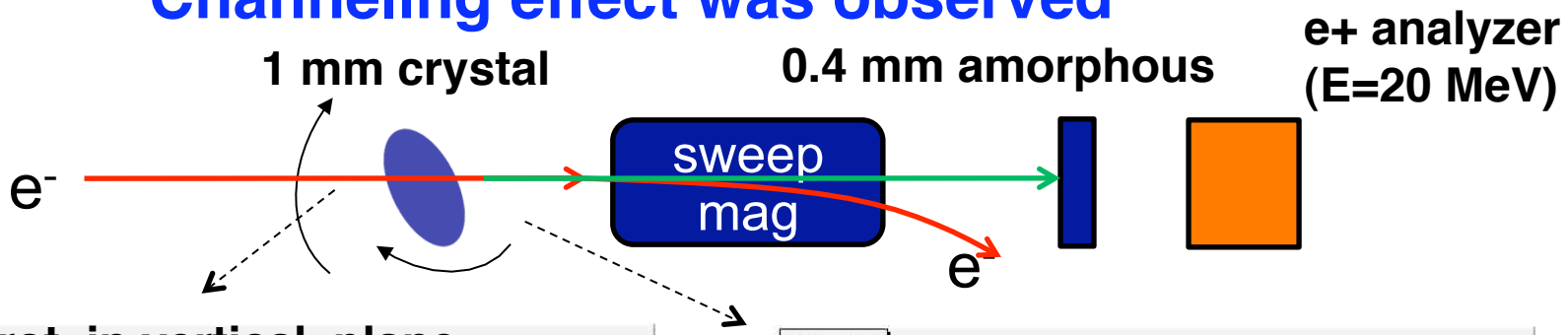
1. Major Equipments have installed at the end of KEKB linac.
   Sweep Magnet, Detector (Analyzer), Beam dump, Targets,
   have installed at the end of KEKB liniac.

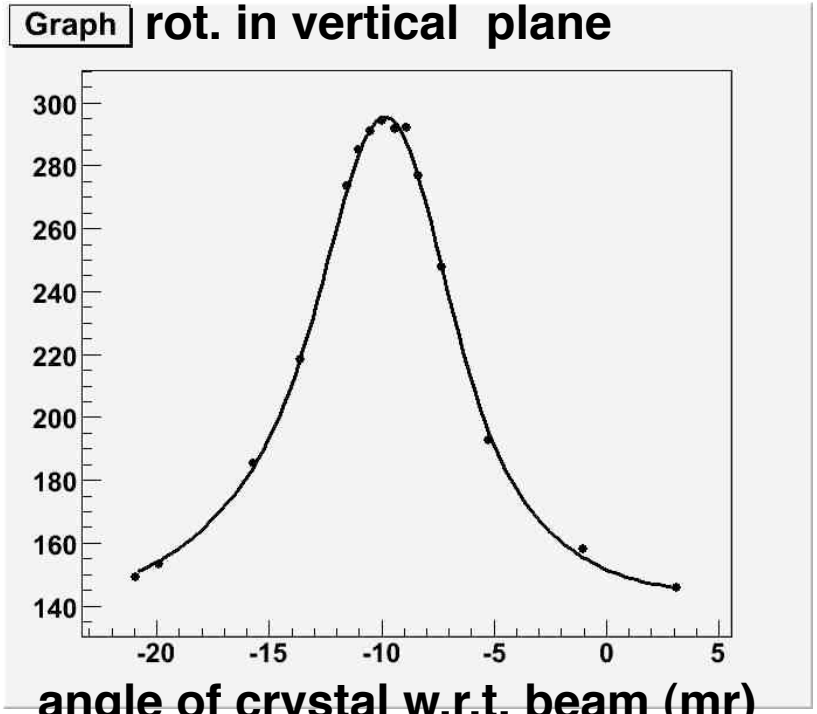
2. No DAQ, No computer control of the targets were installed yet.

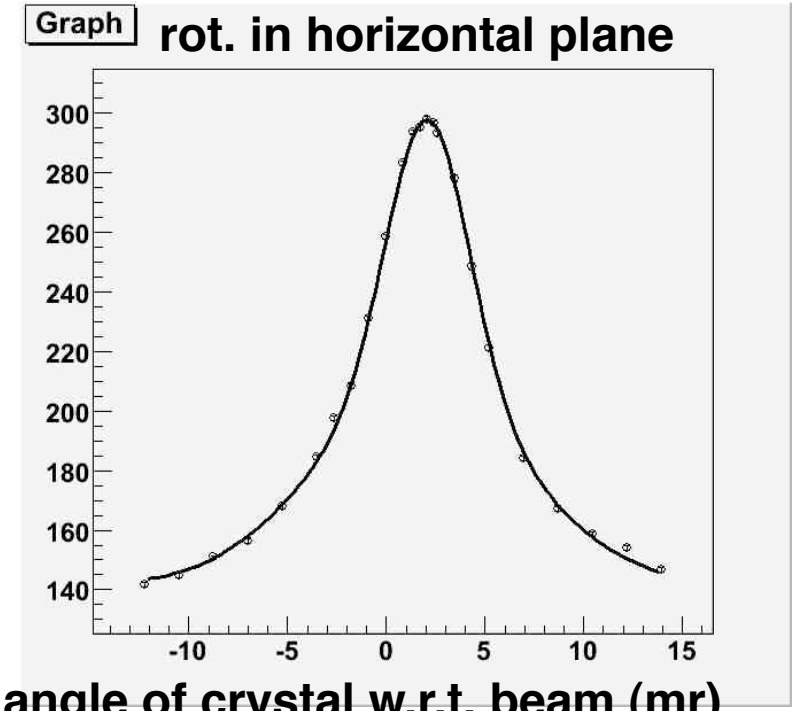
3. Pilot running was done in the end of September.
   Background was measured and it was acceptable level.
   We observed channeling effect of the thin crystal target.

4. The experiment of the hybrid target will be Jan-Mar of 2010.

Channeling effect was observed







curves are fitted with Gaus + Gaus + const

sig1 = 2.271 +- 0.060
sig2 = 4.86+- 0.23
const = 144.4 +- 1.1

sig1 = 2.074 +- 0.036
sig2 = 5.3 2+- 0.19
const = 141.3 +- 1.0

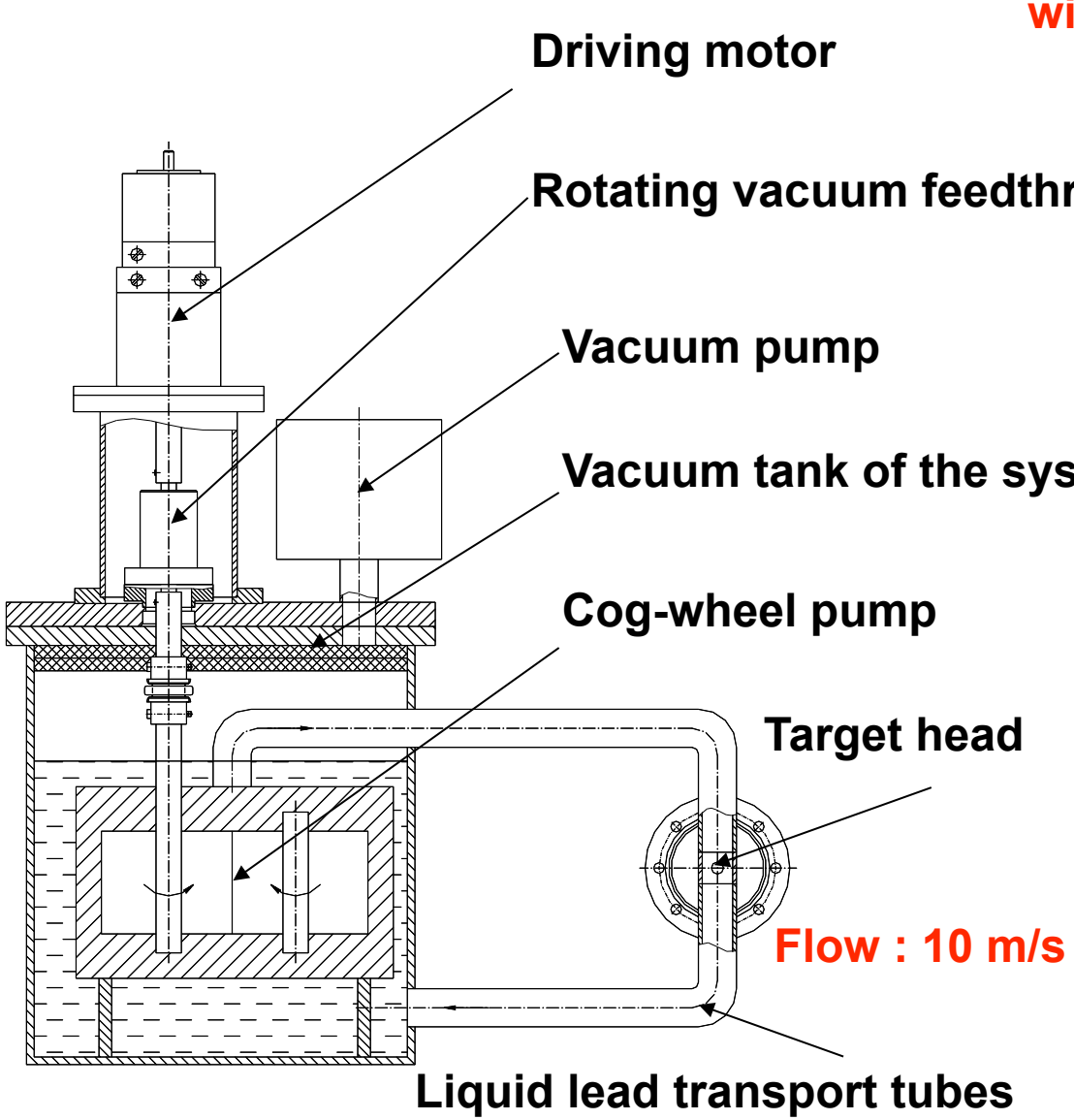
e+ target R/D

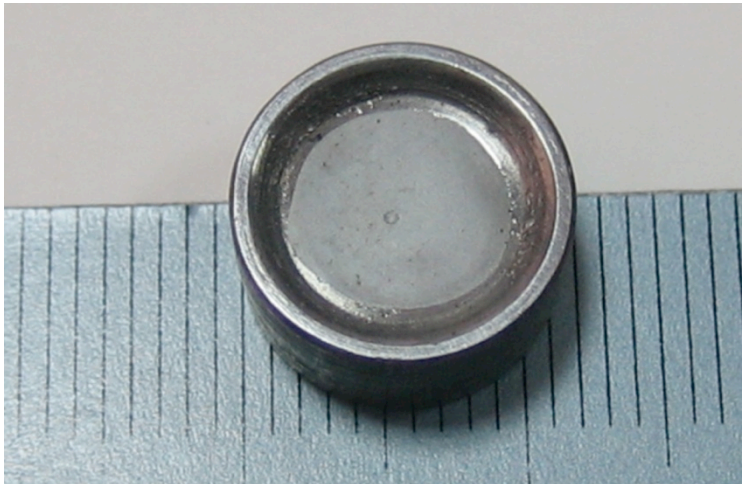
Liquid Pb target (test at ATF linac)

Prototype of Liquid Lead Positron Production Target

Logachev-san et al, BINP

Operation experience 20000 h with NO beam

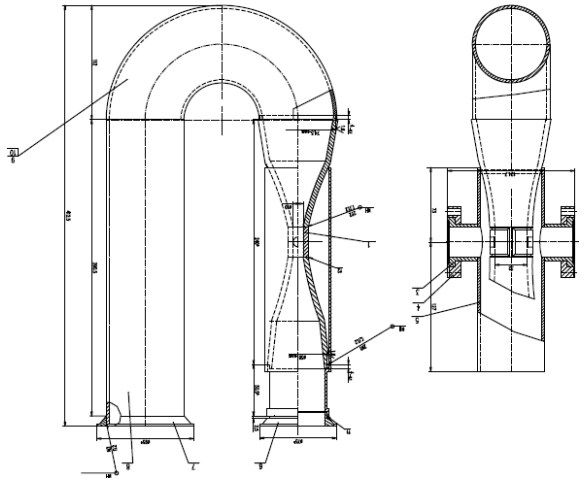




Window thickness 4mm
BN disks for windows
Diameter 12mm

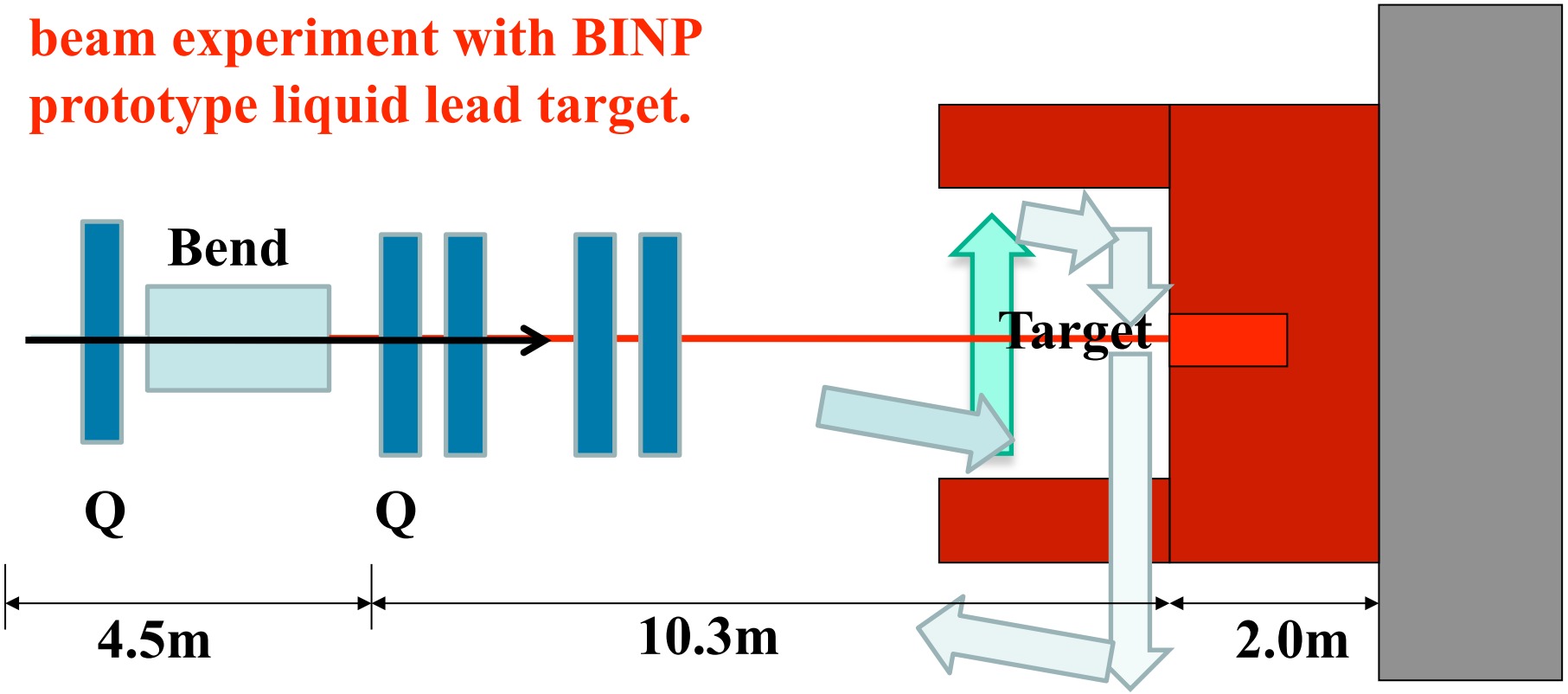
Liquid lead target test

at ATF Linac End



Liquid lead 300℃

We kek decided to do the beam experiment with BINP prototype liquid lead target.



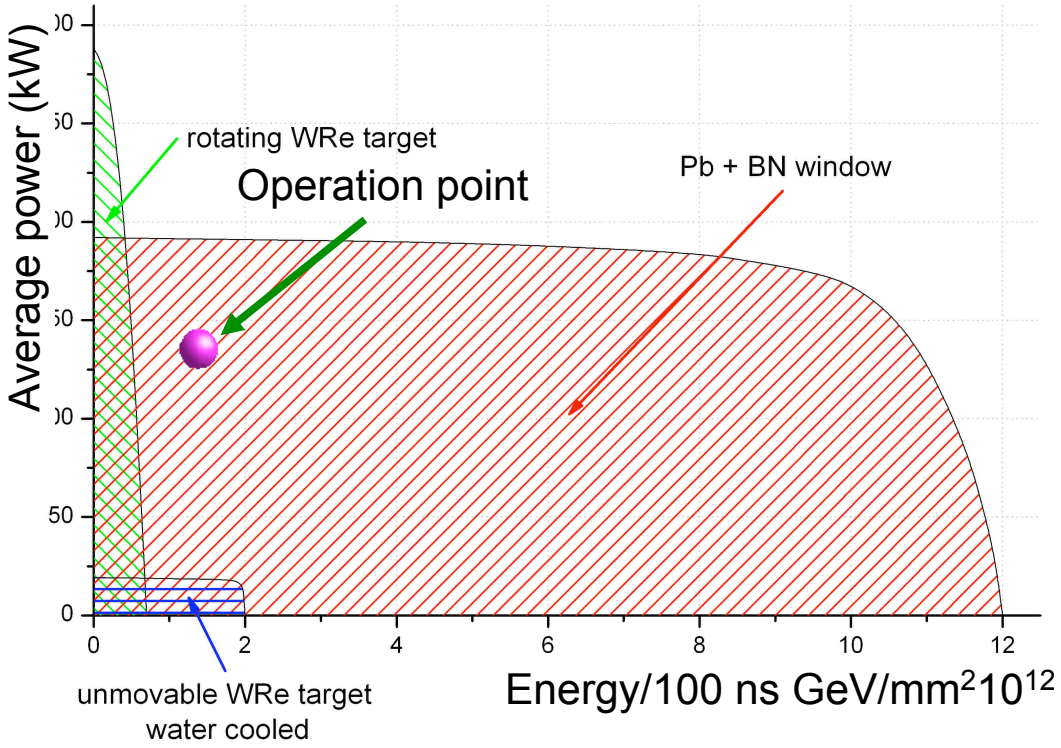
ATF Linac Beam Parameters

β function tuning range : 0.1m to 10m
Bunch structure : 1 to 20 bunches/train
Bunch charge : 0.5 to 2.0 x 10^{10} electrons/bunch
Beam energy : 1.3GeV
Repetition rate : 0.7 to 6.25Hz
Usual normalized emittance : less than 10πmmmrad
Beam size : 0.2 to 2.0mm

Energy density on target
0.006 to 48 x 10^{10} GeV/mm^2
Power deposit on target
0.004 to 300 x 10^{10} GeV/mm^2 s
Acceptable beam rep. rate?

Liquid Pb-Sn Target

- Liquid Pb target + BN window is very strong against high peak power, but less average power.
- Pulsed operation (e.g. 100 bunches with 6.2ns spacing, 0.6μs, 150Hz) moderates thermal effects.
- In the pulse operation, capture efficiency is higher and incident electron can be fewer.



P. Logachov et al. in APAC2007

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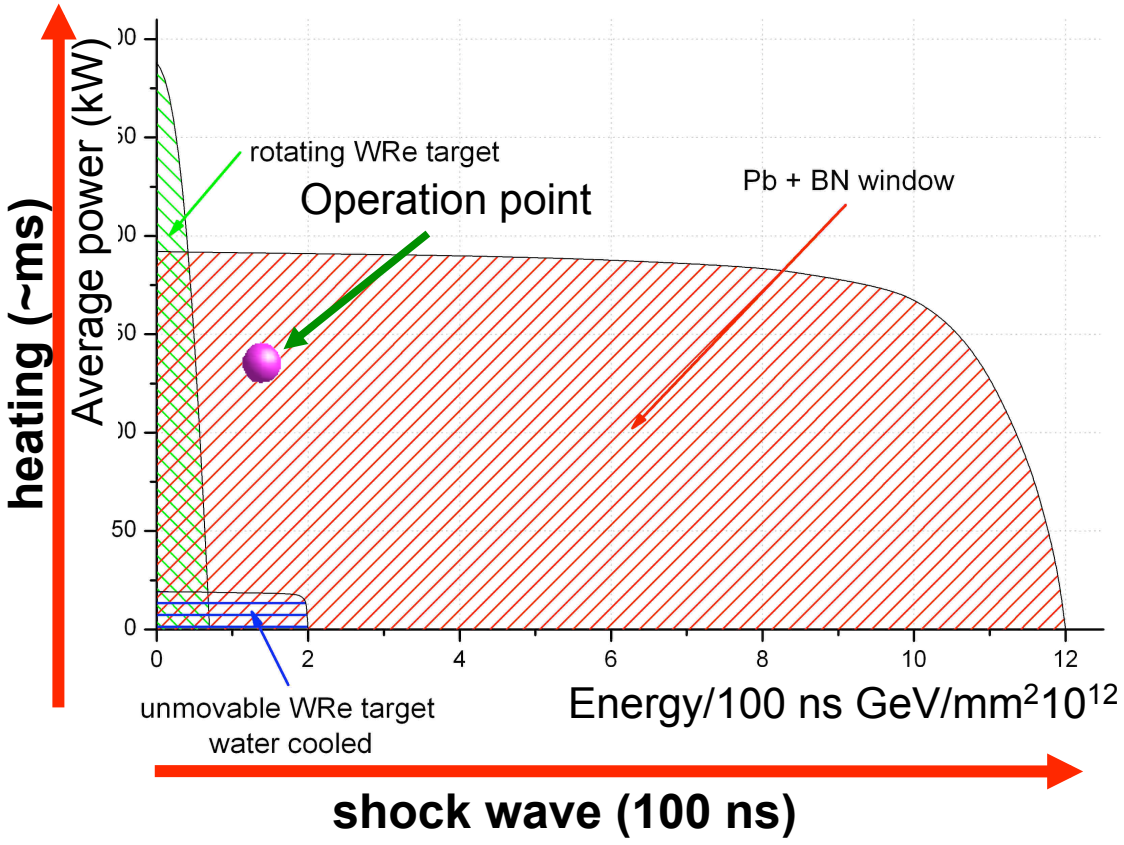

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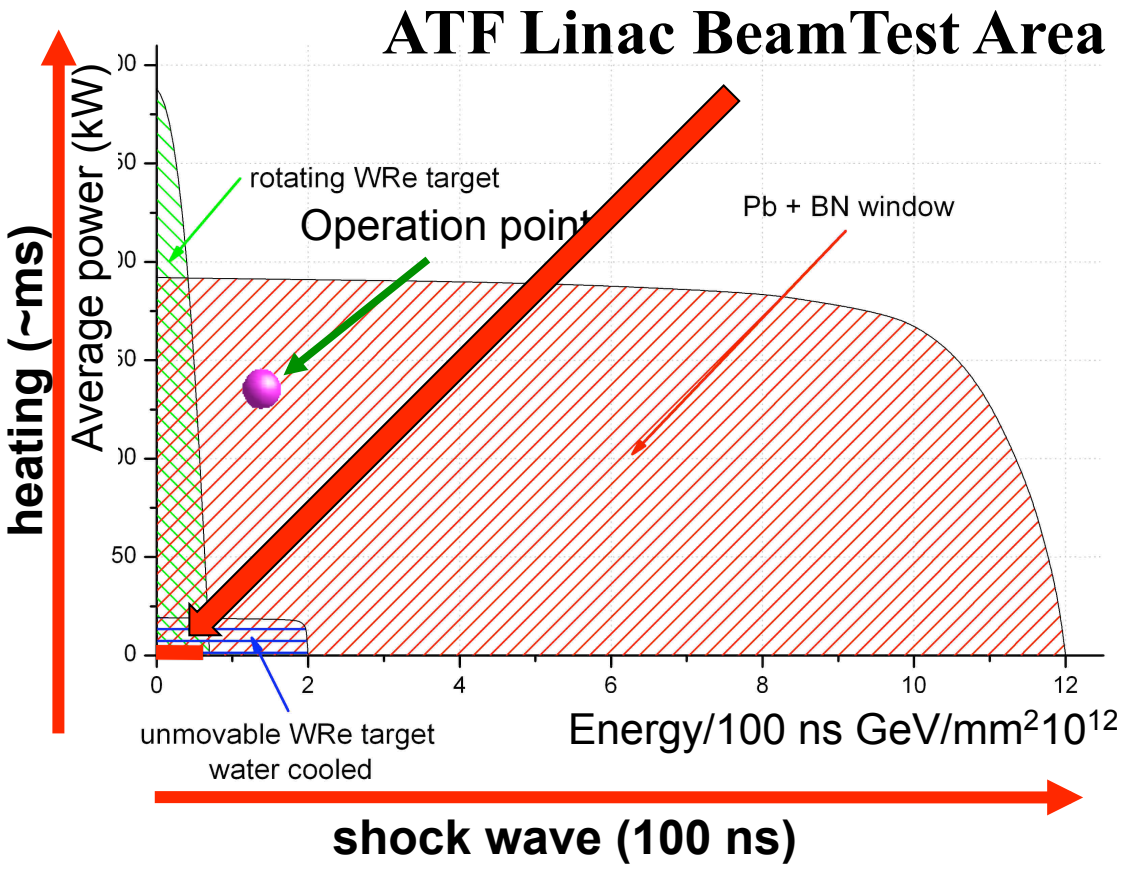


P. Logachov et al. in APAC2007

Liquid Pb target test at ATF

To learn the operation of this liquid target is important for the evaluation of the reliability and the maintainability.

We can get data (heating by beam, for example) and compare with simulation.

Status of the Liquid Pb Target Test at ATF

1. The liquid target system will be delivered from BINP in the end of October (or the beginning of November).

2. **It will be installed in ATF in December or January.**

3. **The schedule of the beam test is not fixed yet.**

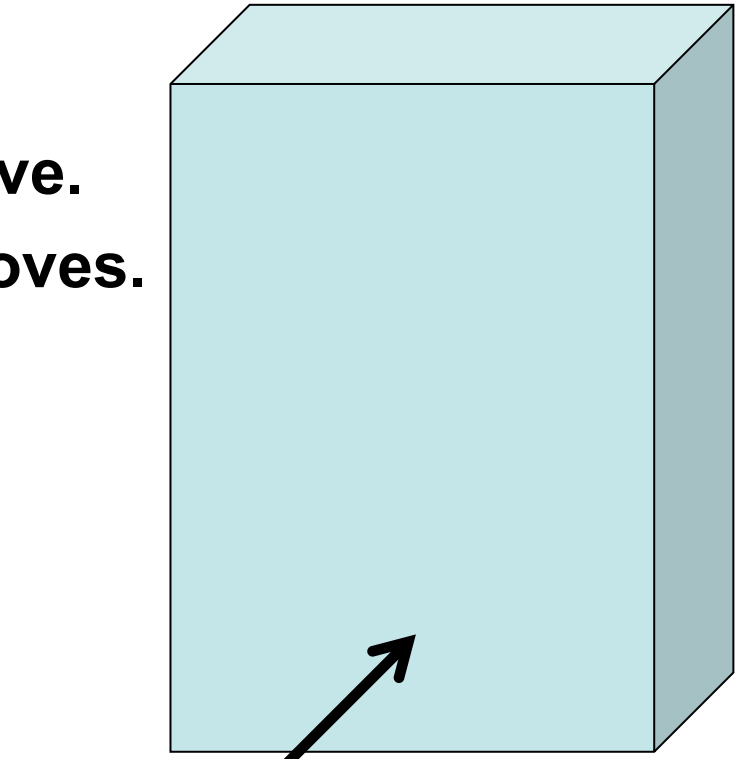
e+ target R/D

Liquid Pb target
(Simulation Study of Heat Issue)

Simulation of heating by beam (Wanming-san)

Model

- **Liquid Lead doesn't move.**
- **Beam injection point moves.**



liquid lead
(no move)

1st triplet

t ~ 18 mm

Temperature at "t = 16 mm" is monitored

Simulation of heating by beam (Wanming-san)

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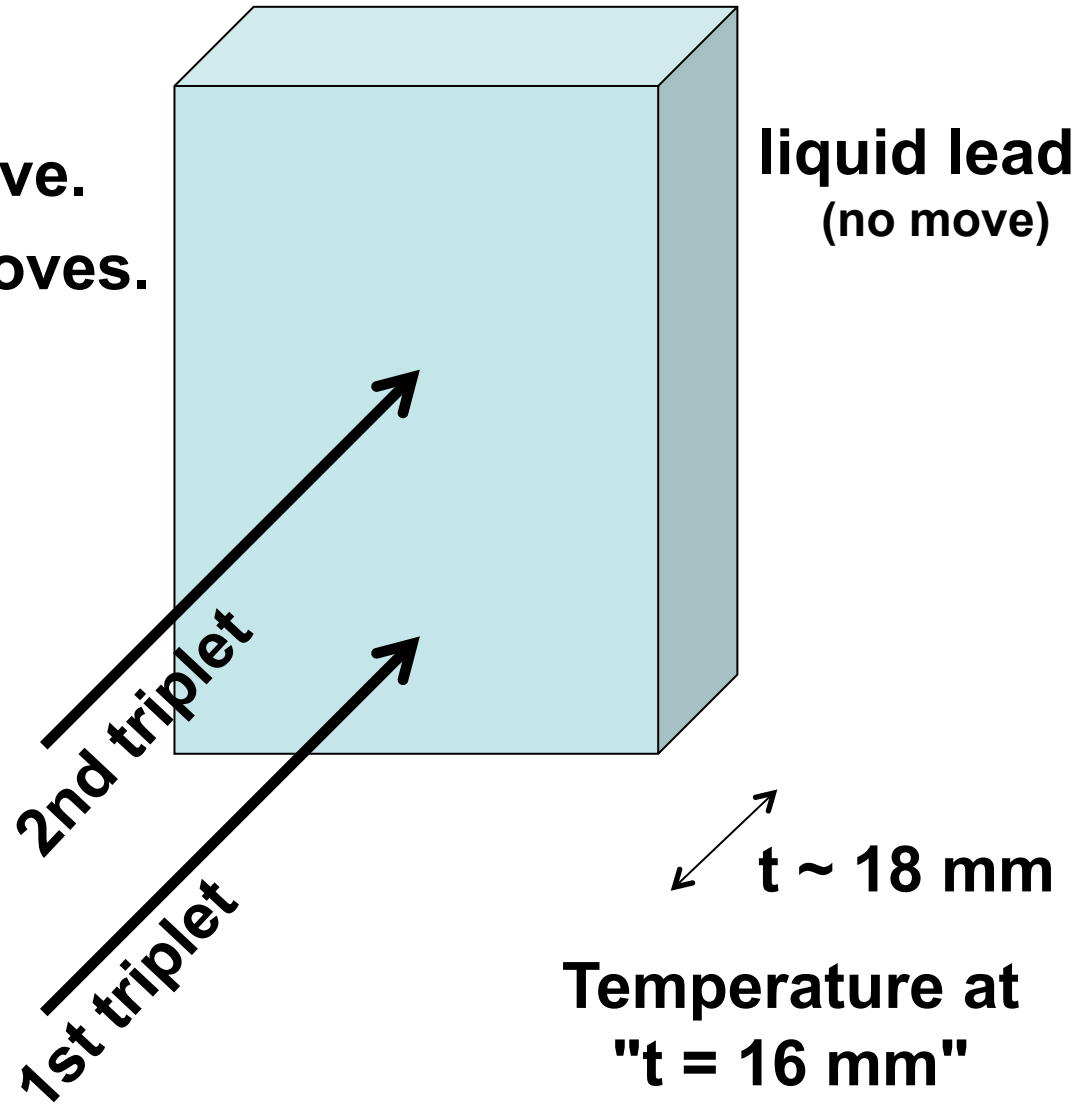

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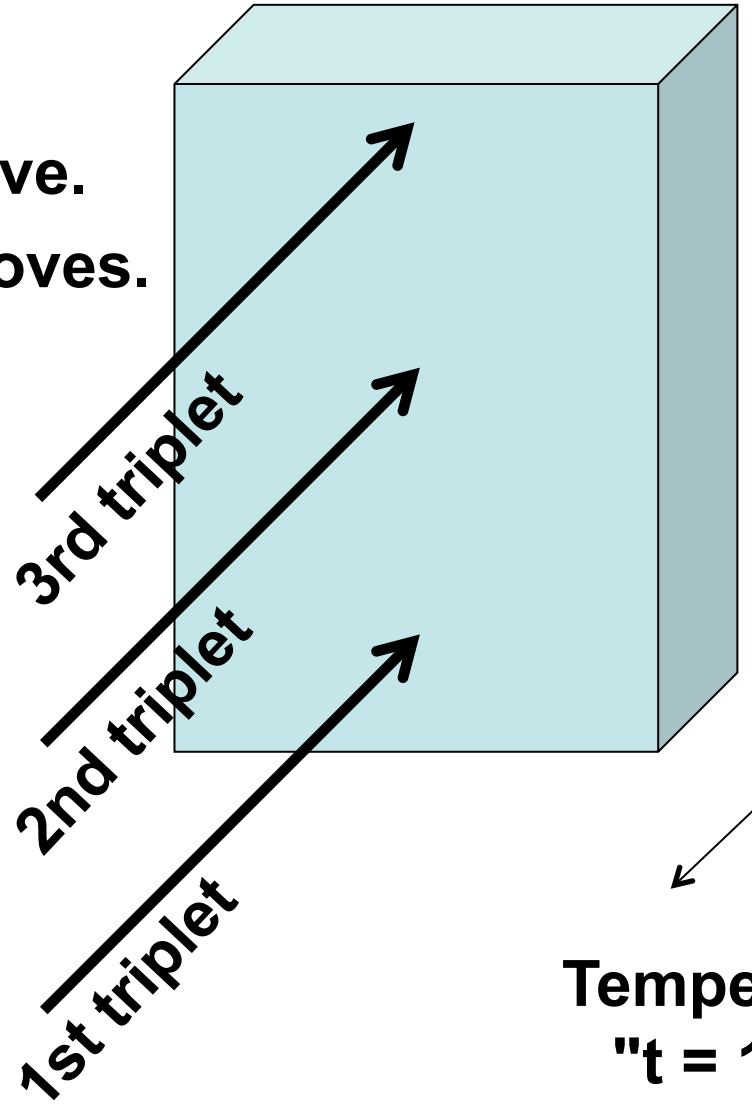
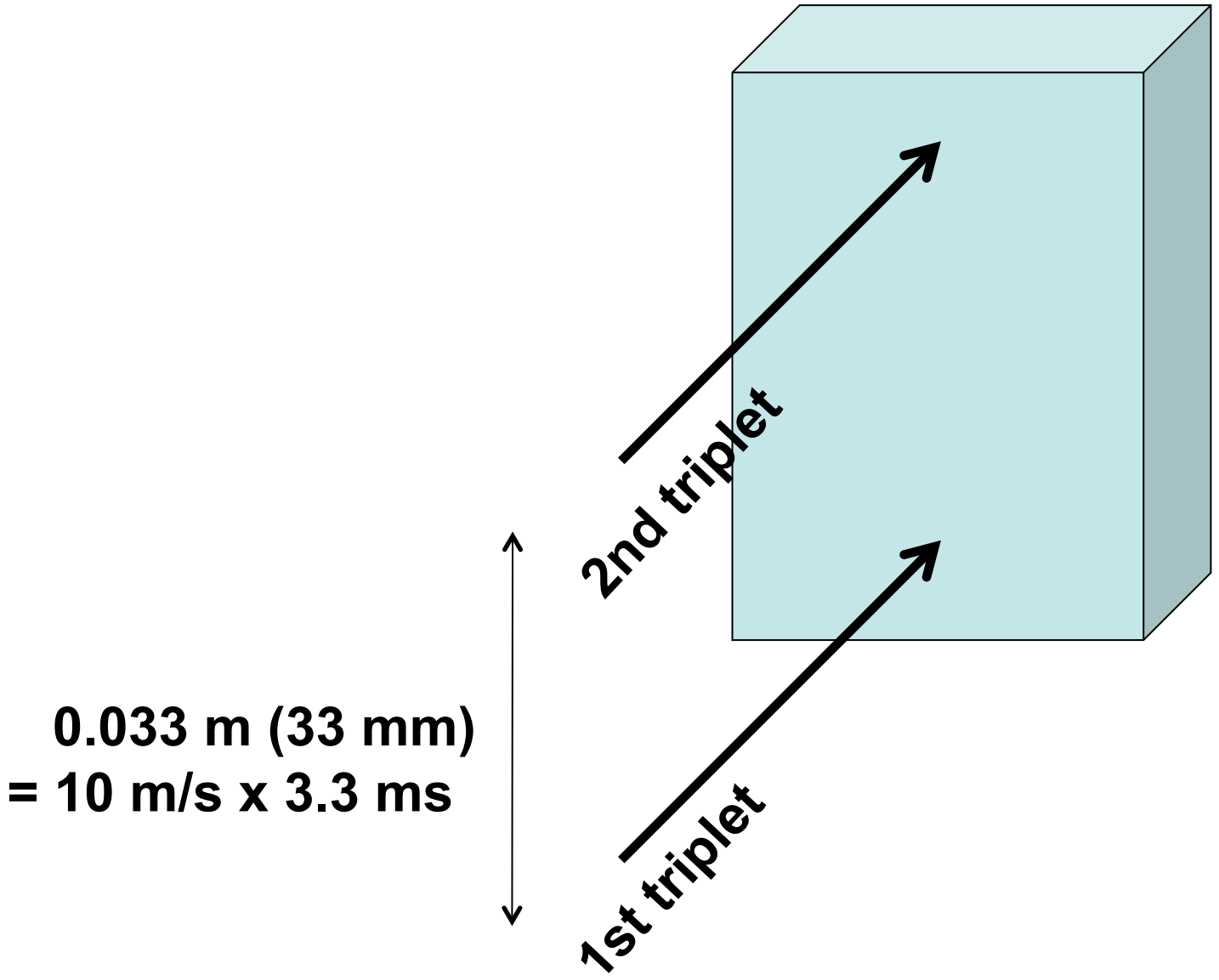


liquid lead
(no move)

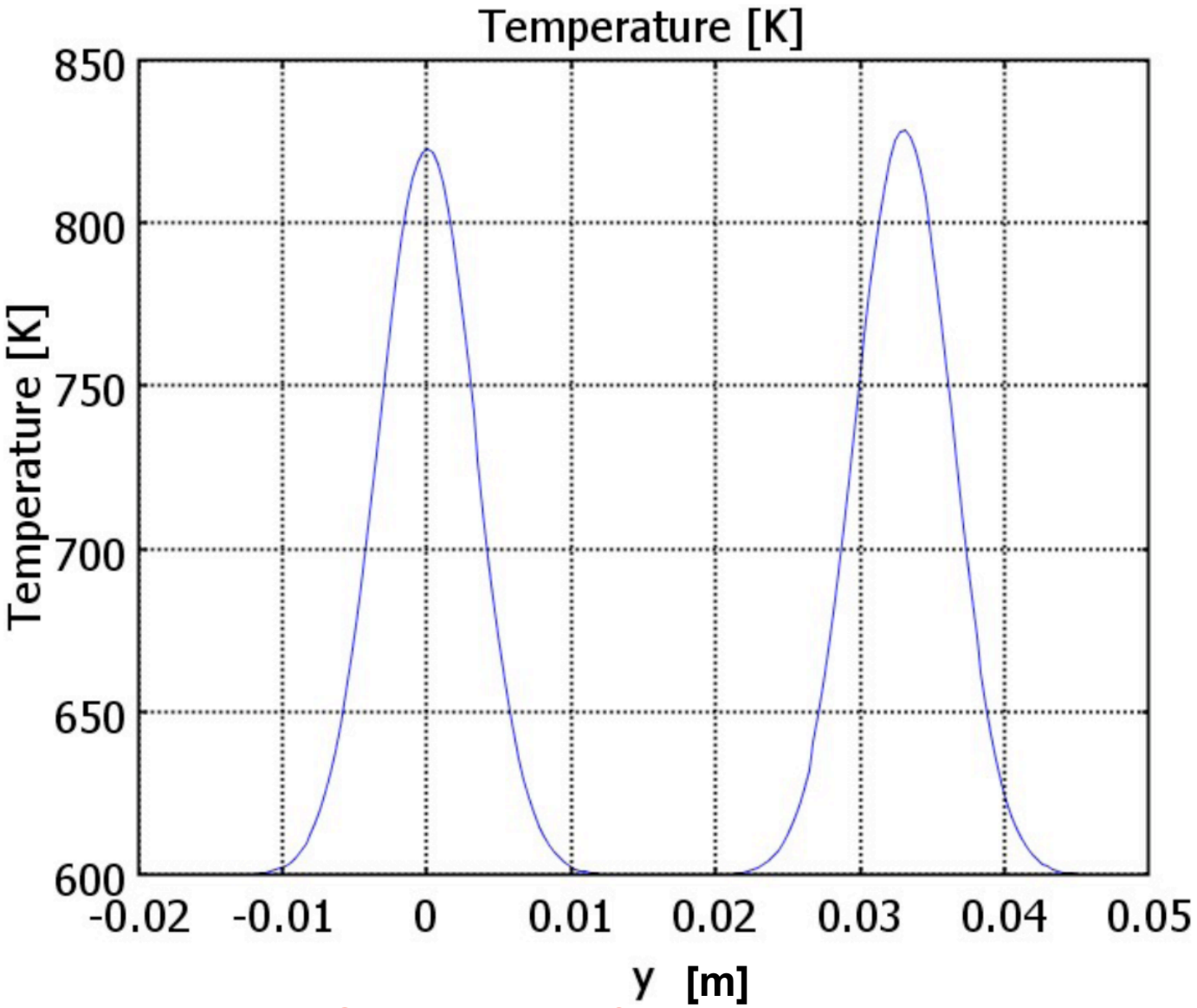
t ~ 18 mm

Temperature at "t = 16 mm" is monitored

10 m/s, after 2 triplets



10 m/s, after 2 triplets

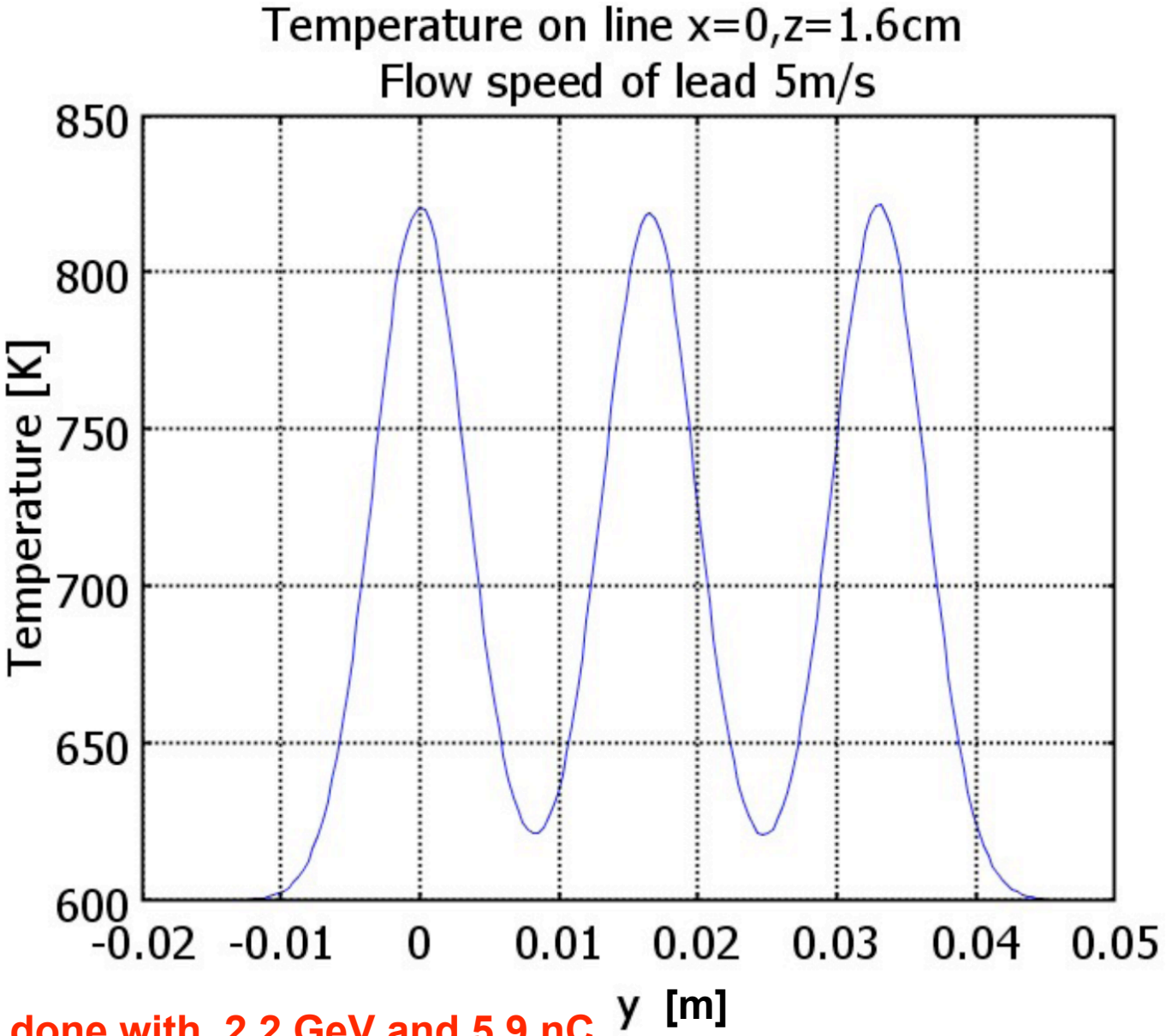


sim. was done with 2.2 GeV and 5.9 nC.

If 2.2 GeV --> 3.5 GeV, delta_T change 220 K --> 350 K

Wanming (ANL)

5 m/s, after 3 triplets

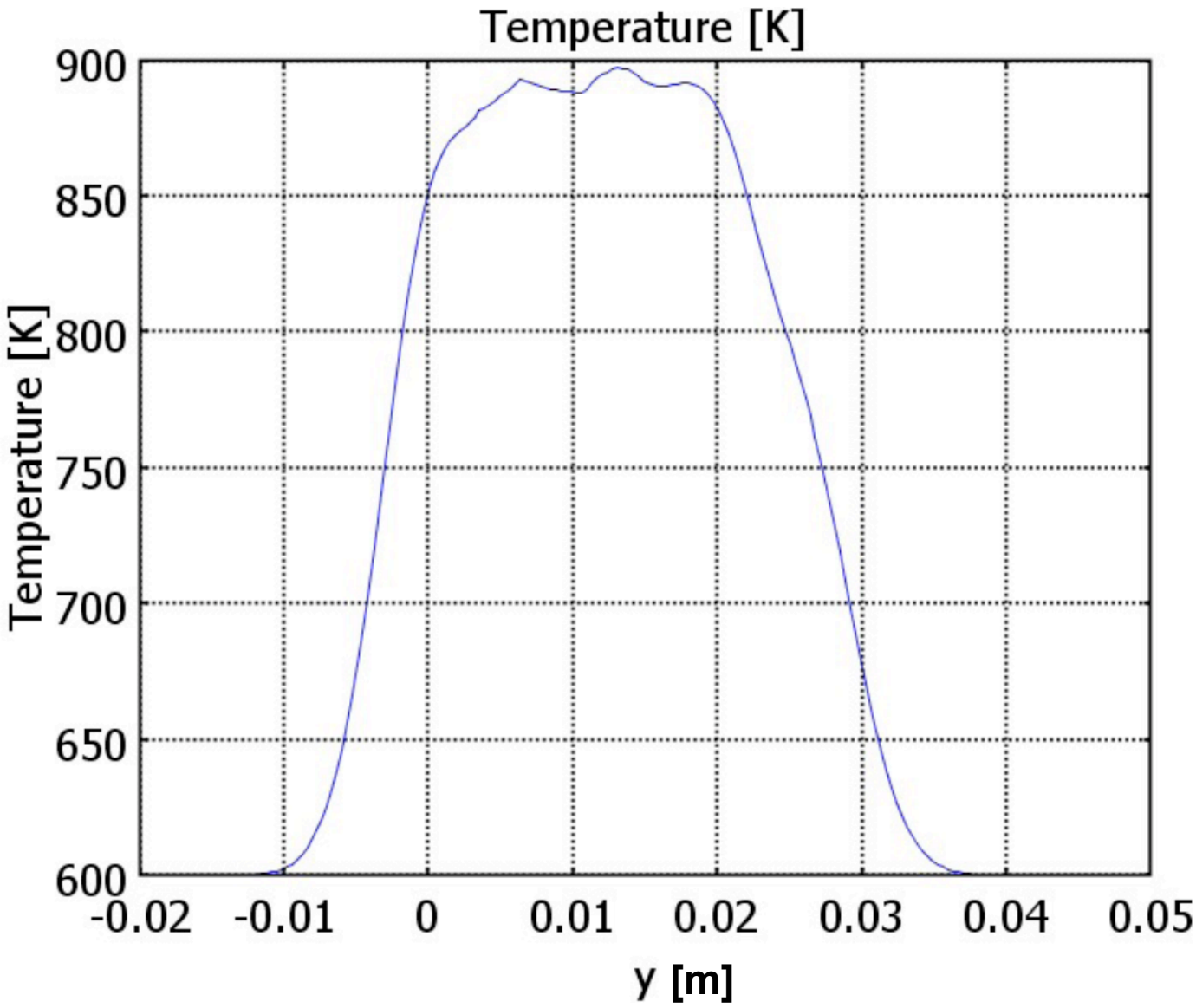


sim. was done with 2.2 GeV and 5.9 nC.

If 2.2 GeV --> 3.5 GeV, delta_T change 220 K --> 350 K

Wanming (ANL)

2 m/s, after 5 triplets



sim. was done with 2.2 GeV and 5.9 nC.

If 2.2 GeV --> 3.5 GeV, delta_T change 290 K --> 460 K

Wanming (ANL)

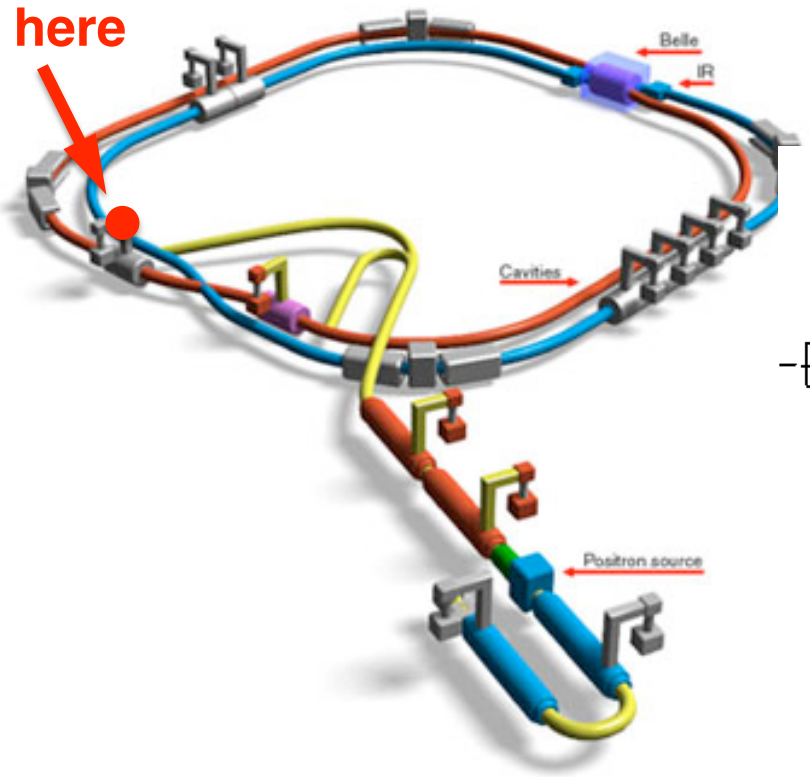
Simulation of heating by beam (Wanming-san)

- No heat problem in 300 Hz generation
- Flow speed can be low.
  10 m/s is not necessary.
  Probably 3 - 4 m/s is OK.
- Temperature is 950 K (= 650 C)
  if flow speed = 3 - 4 m/s.
  Lower than brazing melting temp. (800-900C).

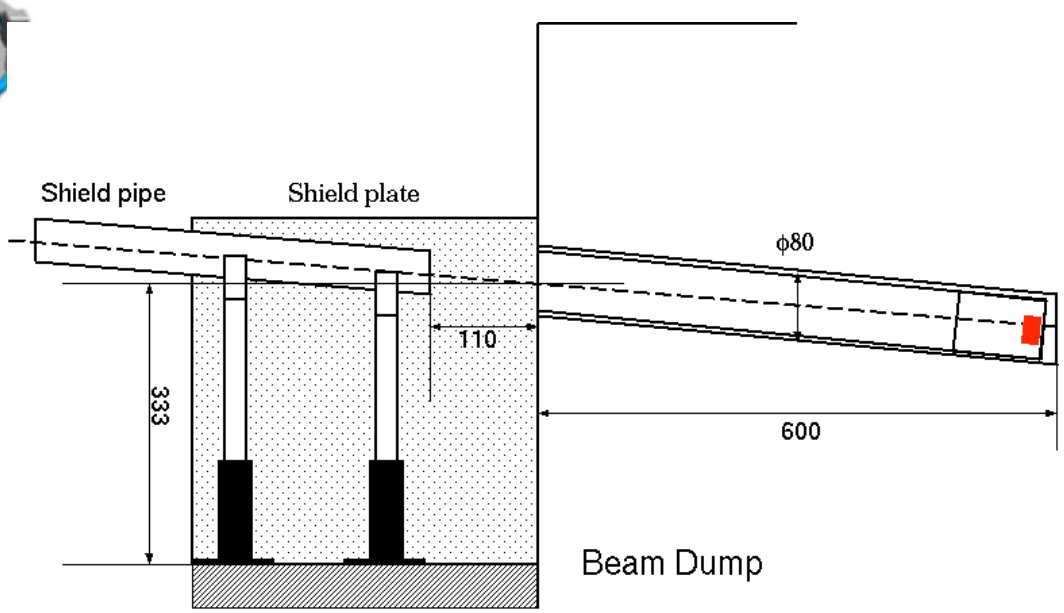
e+ target R/D

Liquid Pb target
BN window test at KEKB ring
for Shock Wave Issue

BN Window (for Liquid Pb target) Test at KEKB Ring



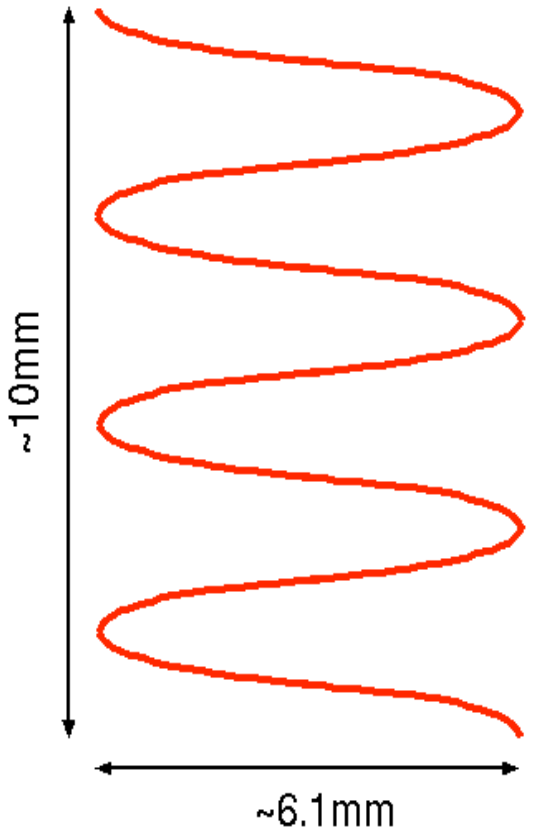
Stored beam and dump



- KEKB-HER: 8GeV, 10nC, 1300 bunches (1300mA)
- The beam is deflected by the abort kicker as shown when it is dumped.
- Because of “Step size” variation, the enrgy density is varied from 1810 to 13700 J/mm2

Beam Condition

- 10nC, ~1300 bunches, 10μs
- Bunch-by-bunch impossible
- Unable to change beam size (~1mm rms?)
- Swept by kicker (protect extraction window)
- Moves 7μ ~ 45μ/bunch on target (0.9mm ~ 6mm over 132 bunches)



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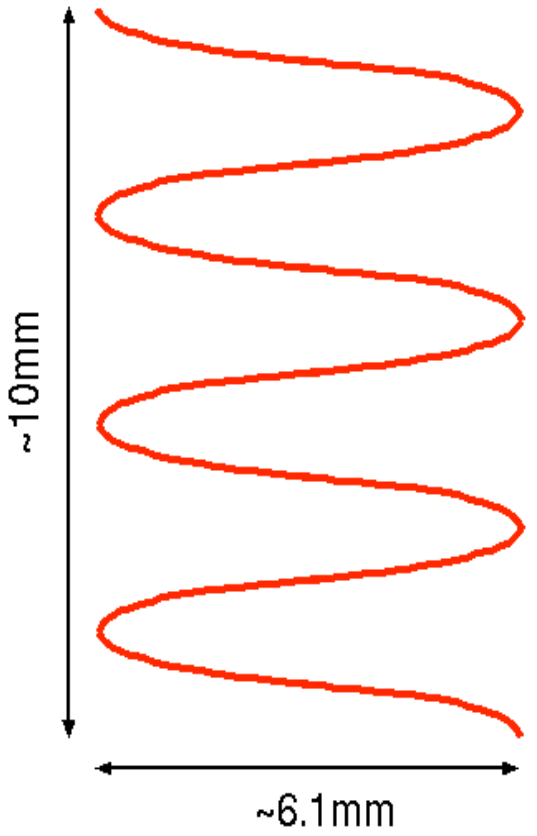

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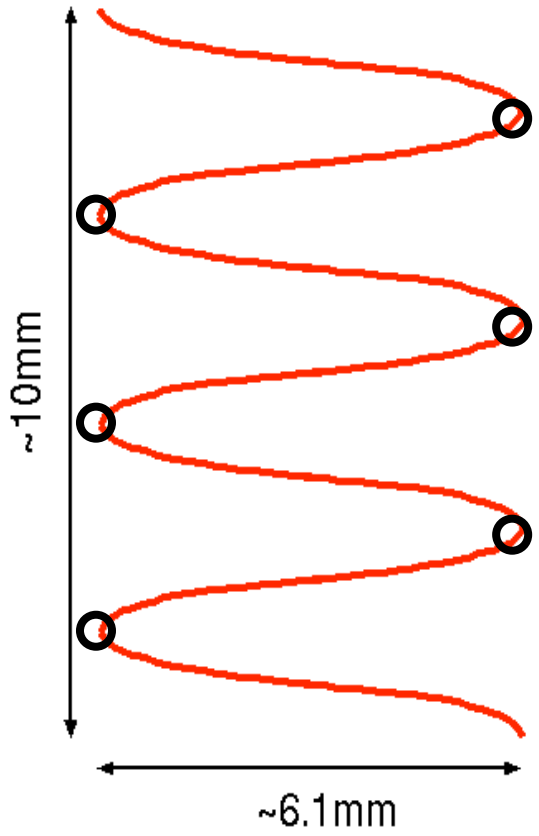
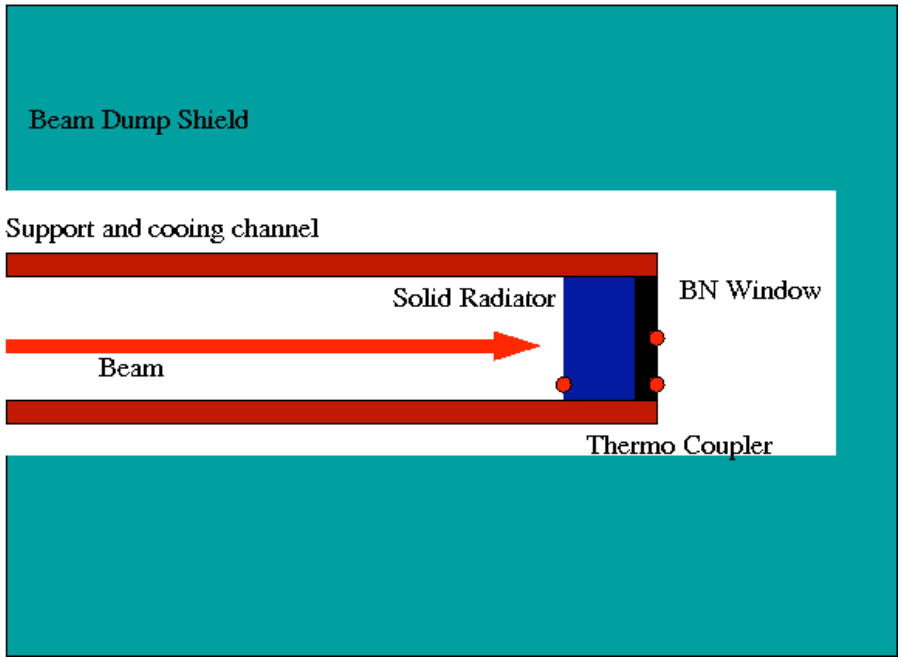


o 132 bunches in ~ 1mm

KEKB Beam Dump setup

- It is a test for isolation window material for liquid Pb target system.
- Space is very limited for KEKB BD.
- Solid Radiator (Solid Pb) is placed before BN plate, as a test material.
- Final investigation for damage is made by optical and laser microscopy.



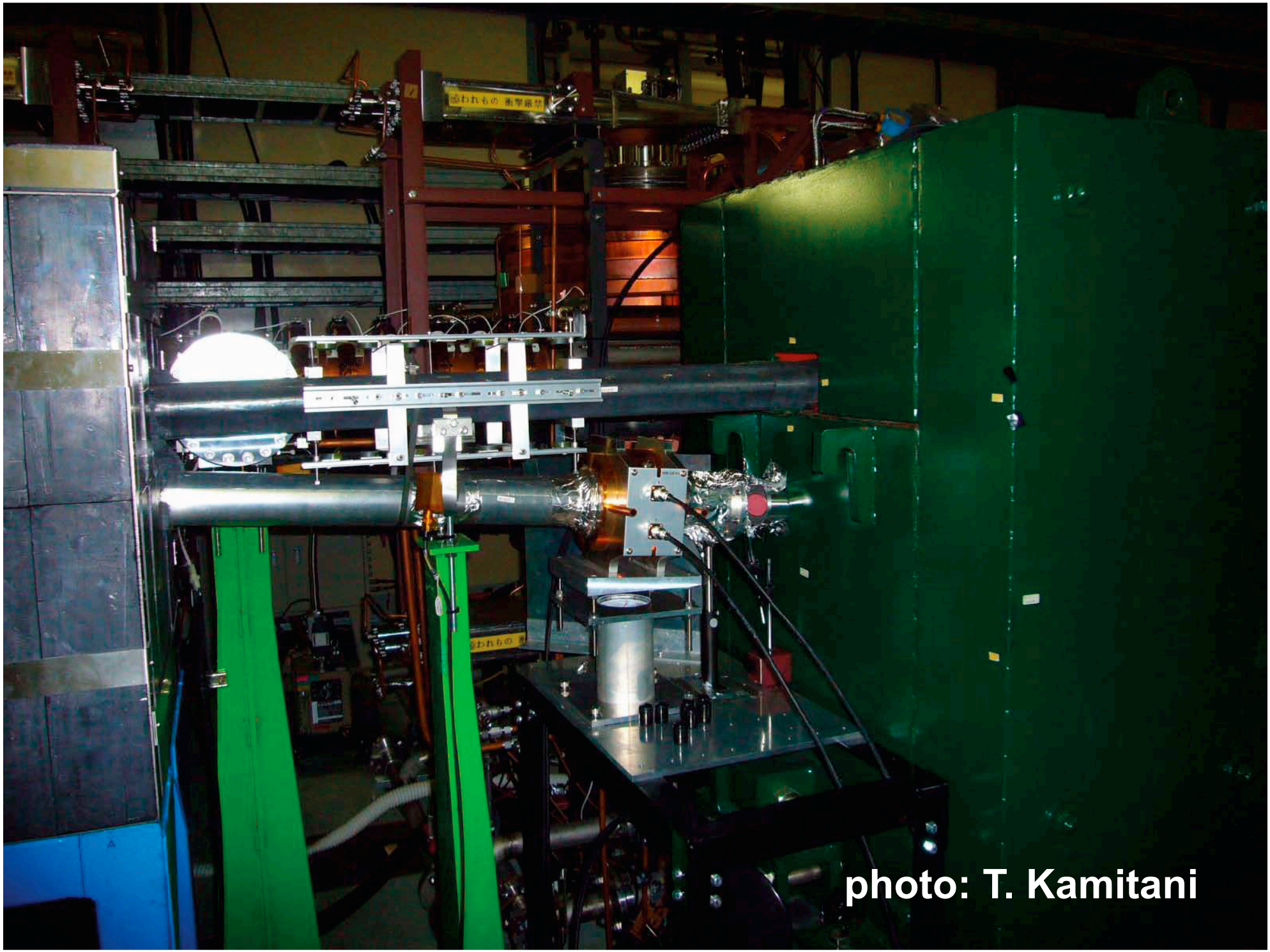
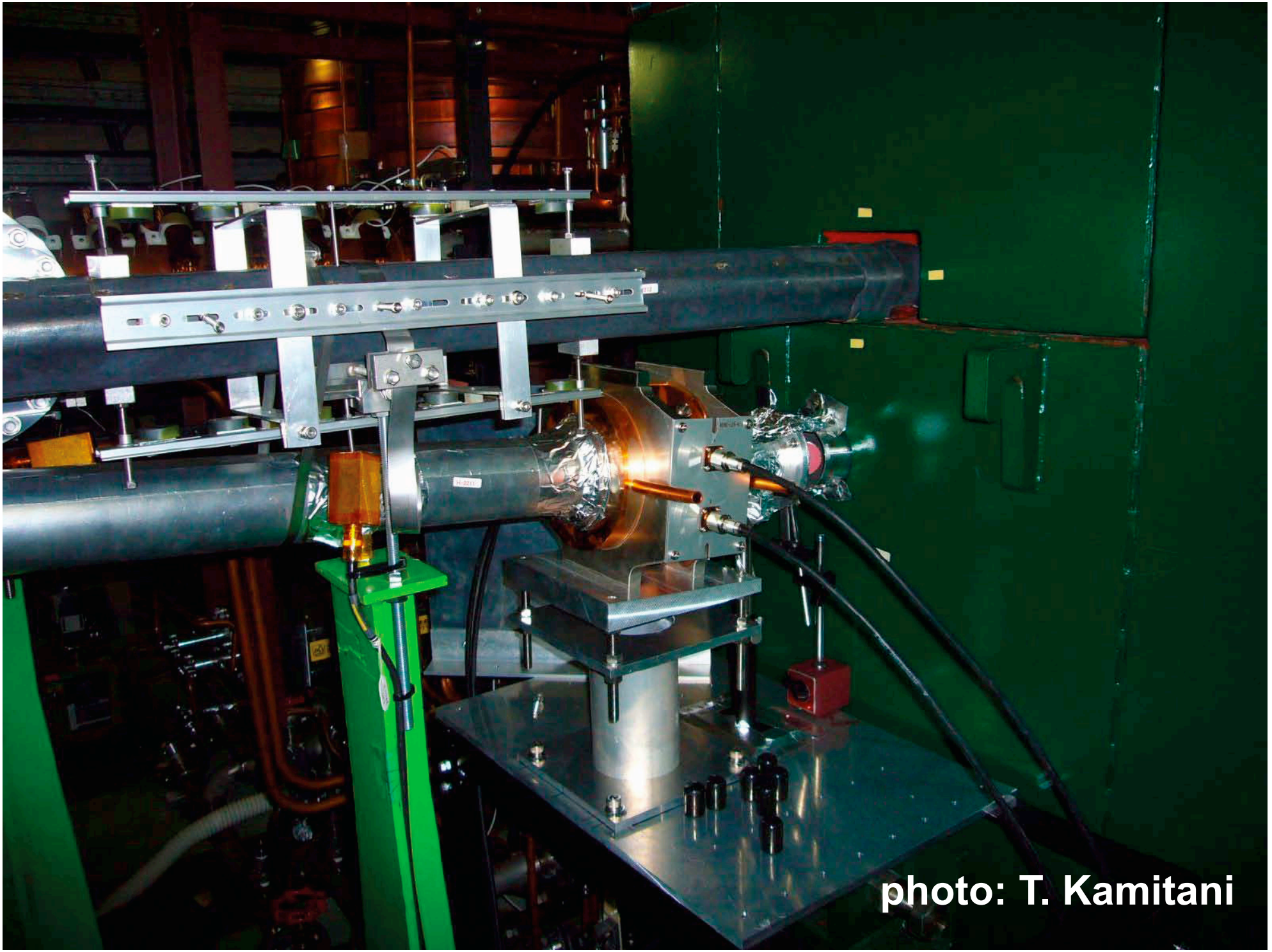


photo: T. Kamitani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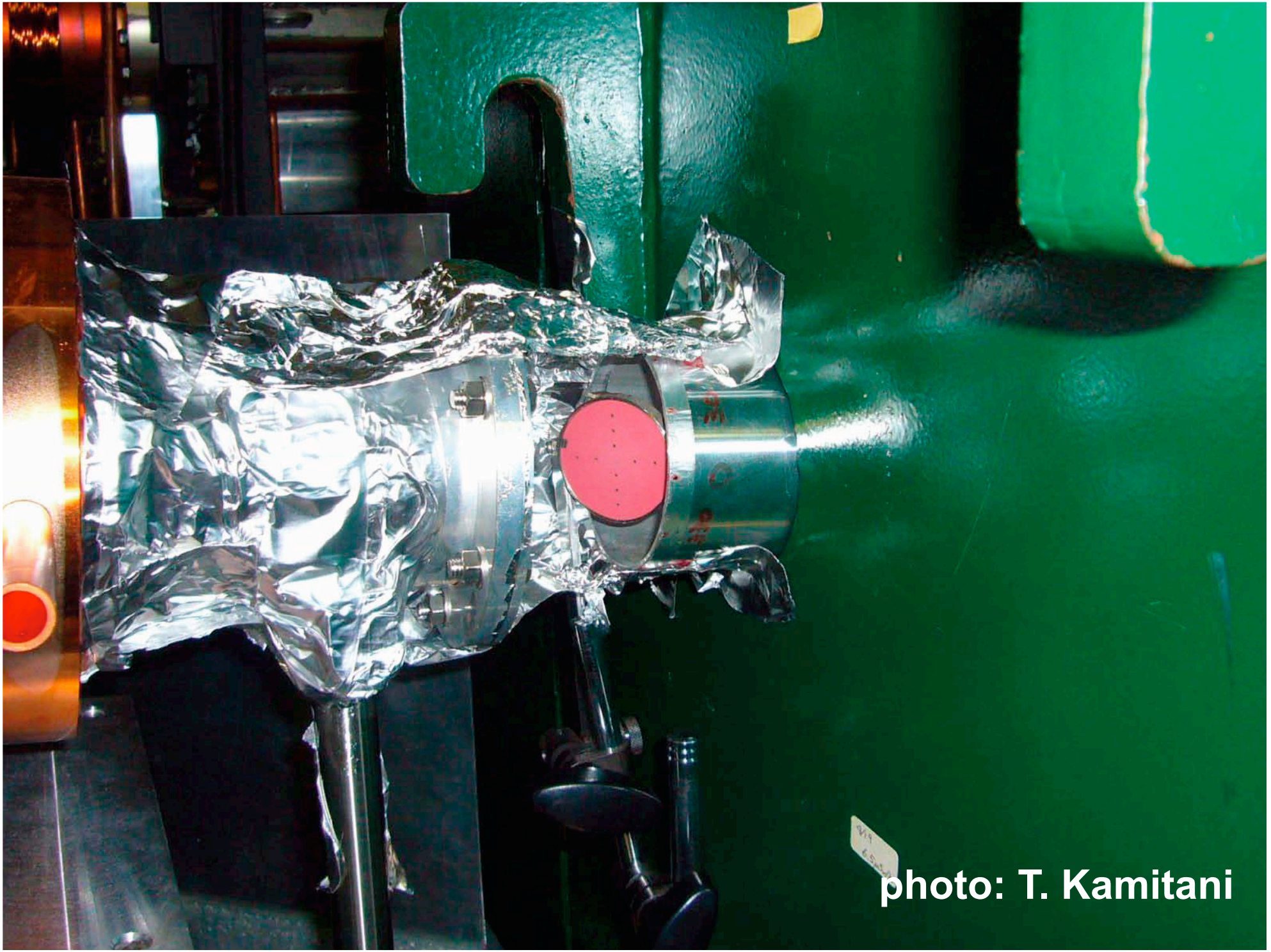
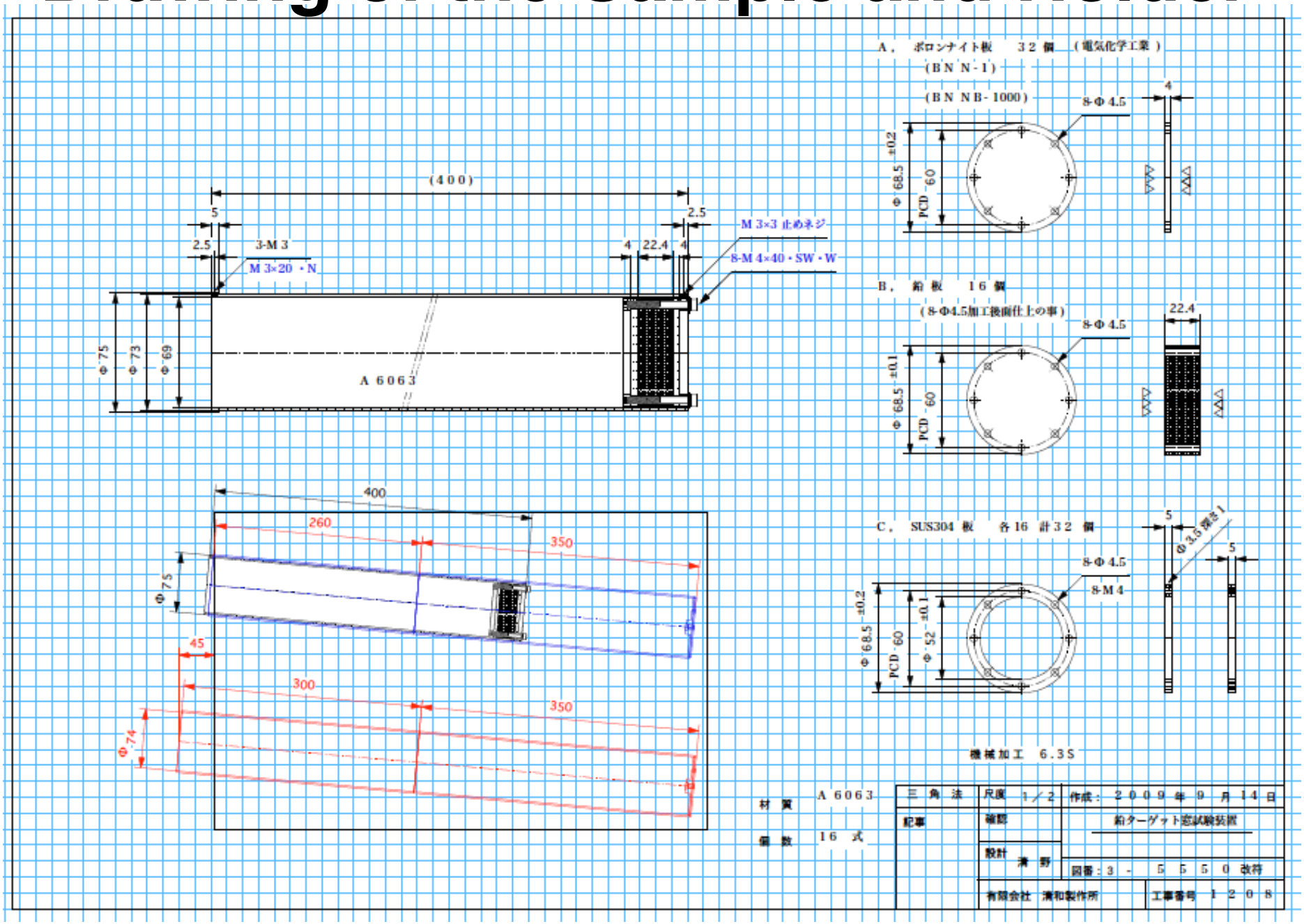


photo: T. Kamitani

Drawing of the Sample and Holder



Status of the BN window test at KEKB ring

1. Preparation is on going.
2. We will use a sandwich of BN-SolidPb-BN as a sample.
3. We started fabrication of samples and sample holders.
4. We will have 4 times of short machine time in Oct-Dec.
5. First test will be on October 22nd.

Summary

Summary

1. 300 Hz parameter are updated:
   Now it has "x1.5 margin". (both Liquid Pb and Hybrid options)

2. Hybrid target study at KEKB liniac:
   Major Equipments have installed at the end of KEKB liniac.
   The results of the pilot running was promising.

3. Liquid Pb Target System Test at ATF:
   Liquid Pb Target System will be installed in ATF in Dec or Jan.

4. Simulation Study of Liquid Pb Target (update):
   The parameter with "x1.5 margin" is OK in the view point of heating.

5. BN window test of Liquid Pb Target at KEKB ring:
   Preparation is ongoing.
   We will have four short beam tests in Oct-Dec.

Backup Slides

A design for the ILC (Chehab et.al)

- **INCIDENT BEAM: 10 GeV**
- **TARGETS:**
  - **CRYSTAL: a 1 mm thick W crystal <111>orientation**
  - **AMORPHOUS: an 8 mm thick amorphous target**
- **CAPTURE SYSTEM: AMD with decreasing field from 6 to 0.5 Tesla on 50 cms Accelerating field is 18 MeV/m, peak [SW]**
- **Accepted yield: 1.5 e+/e- ($\sigma^- = 2.5$ mm)**
- **PEDD/bunch:**
  - **assuming an incident e- bunch of 2. 10^{10} e- $\sigma^- = 2.5$mm**

crystal	amorphous
0.058 J/g/bunch	0.33 J/g/bunch

Amorphous target may survive with 300 Hz design