300 Hz e+ Source for ILC

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

T. Omori (KEK)
Posipol 2009, 24-June-2009, Univ. Lyon

300 Hz generation
300 Hz e- driven non-polarized e+ source

e+ generation in 63 ms   (cf. undulator scheme: 1 ms)

(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.

cf. parameters with no margin

(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
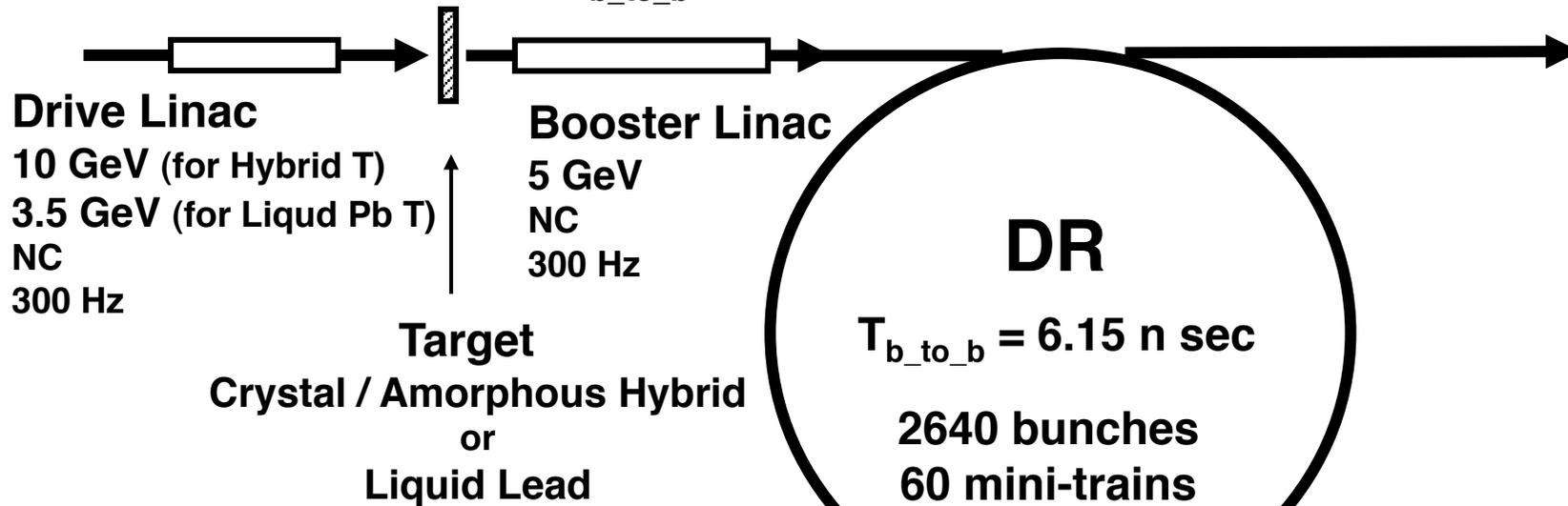## Normal Conducting Drive and Booster Linacs in 300 Hz operation

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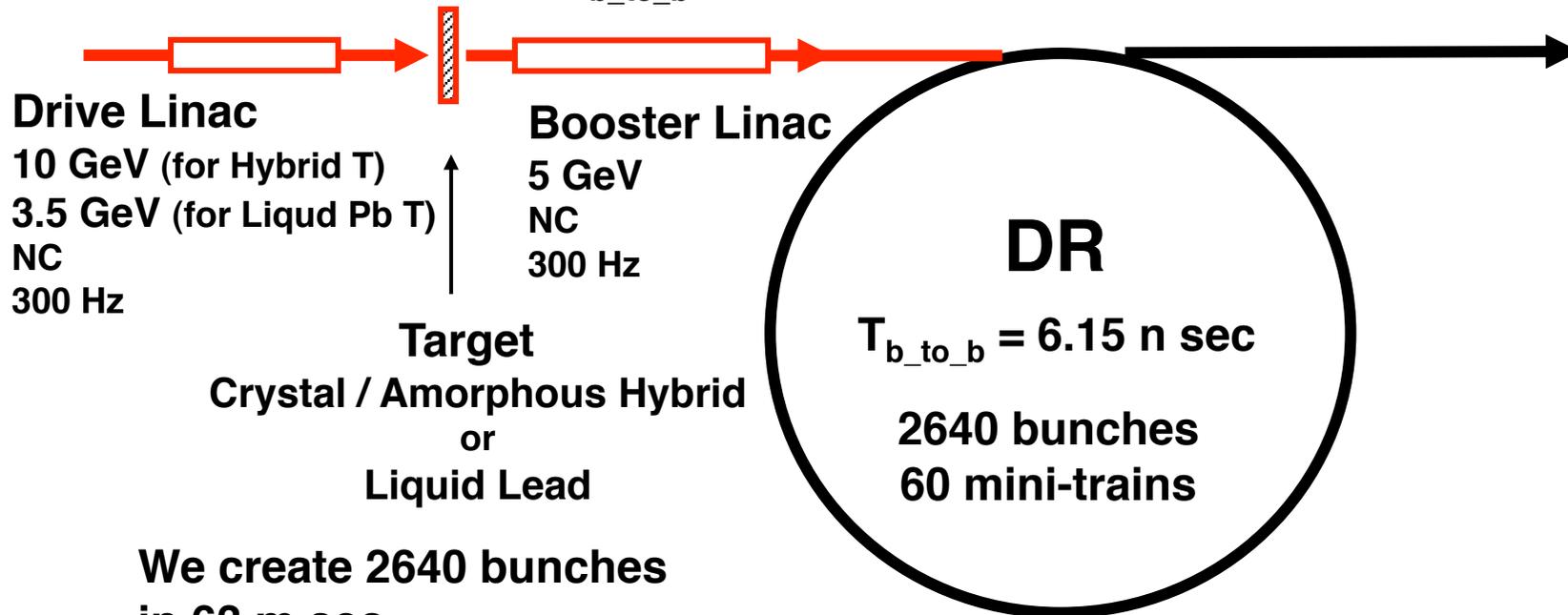## Normal Conducting Drive and Booster Linacs in 300 Hz operation

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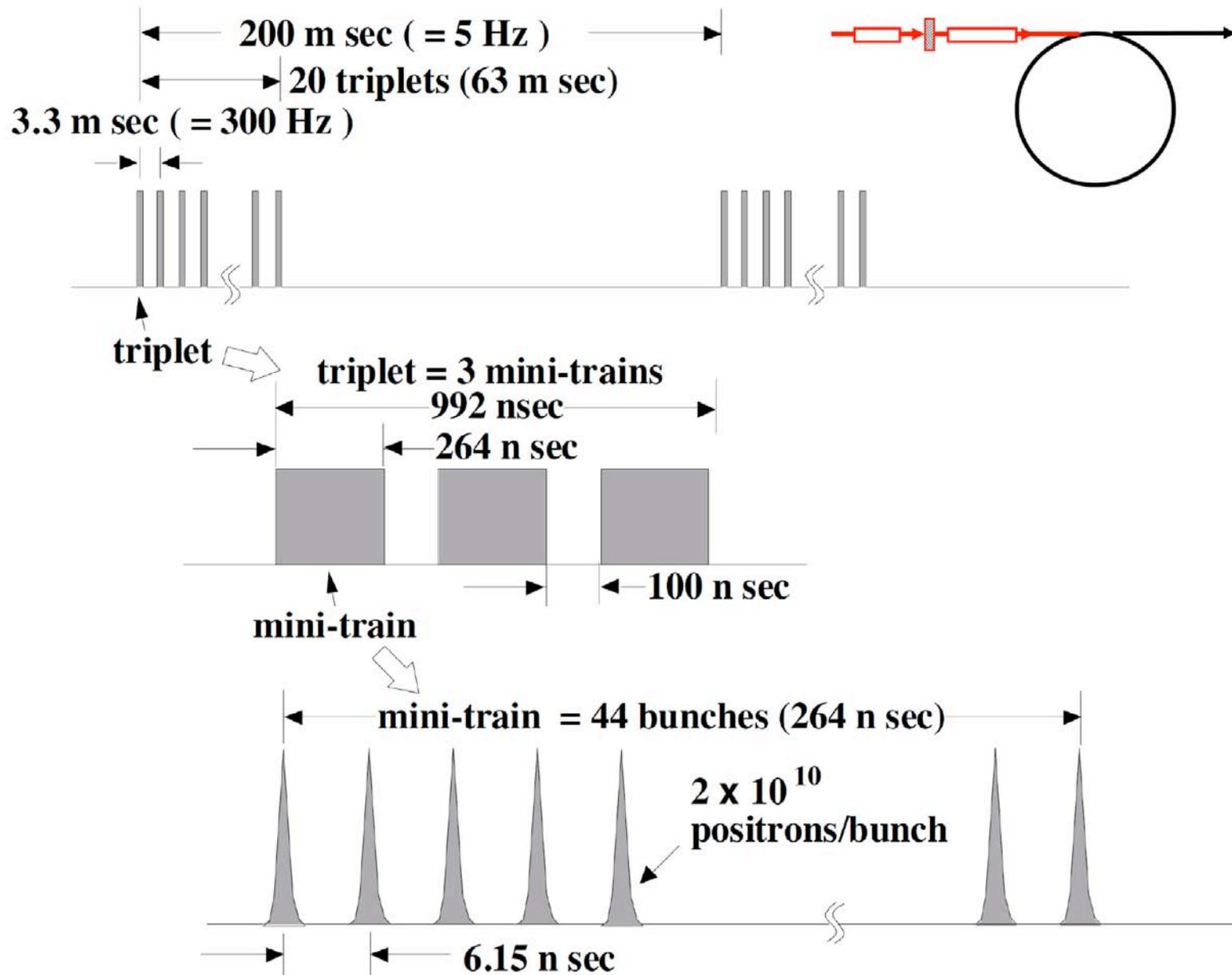
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**We create 2640 bunches
in 63 m sec**

DR

$T_{b\_to\_b}$ = 6.15 n sec

**2640 bunches
60 mini-trains**

Time remaining for damping = 137 m sec

Beam before DR

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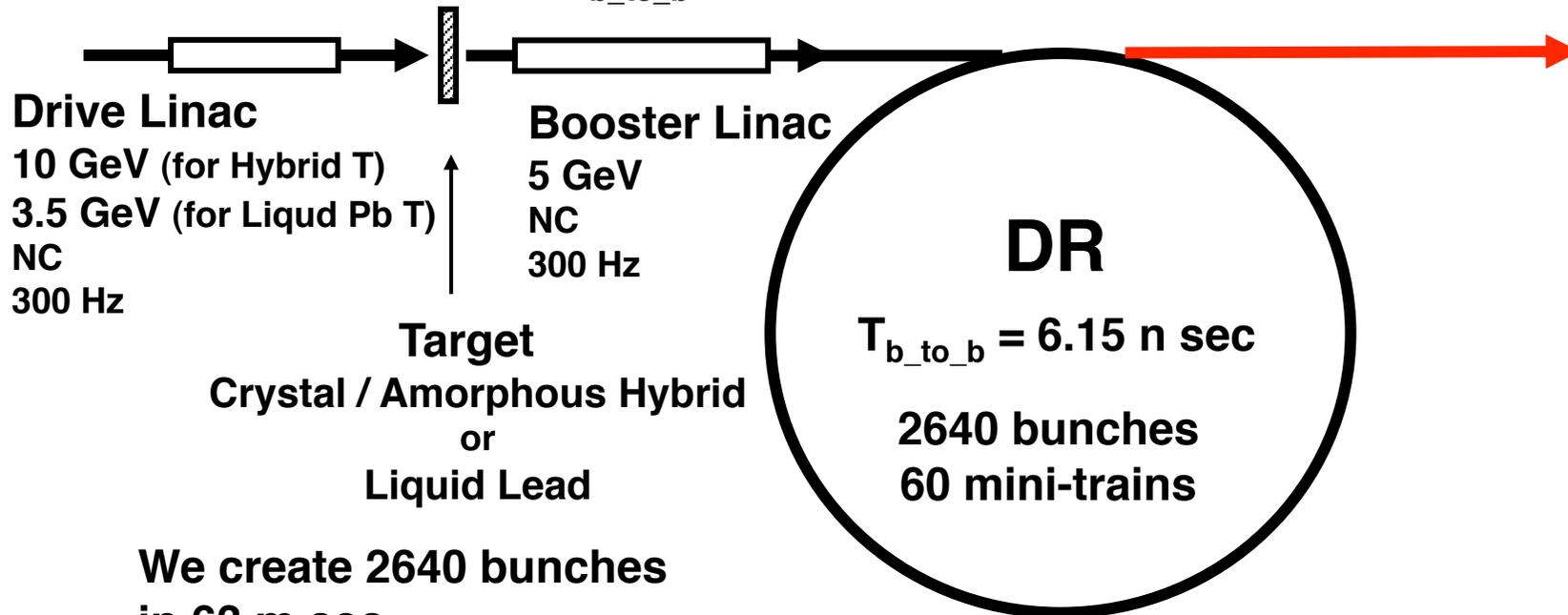## Normal Conducting Drive and Booster Linacs in 300 Hz operation

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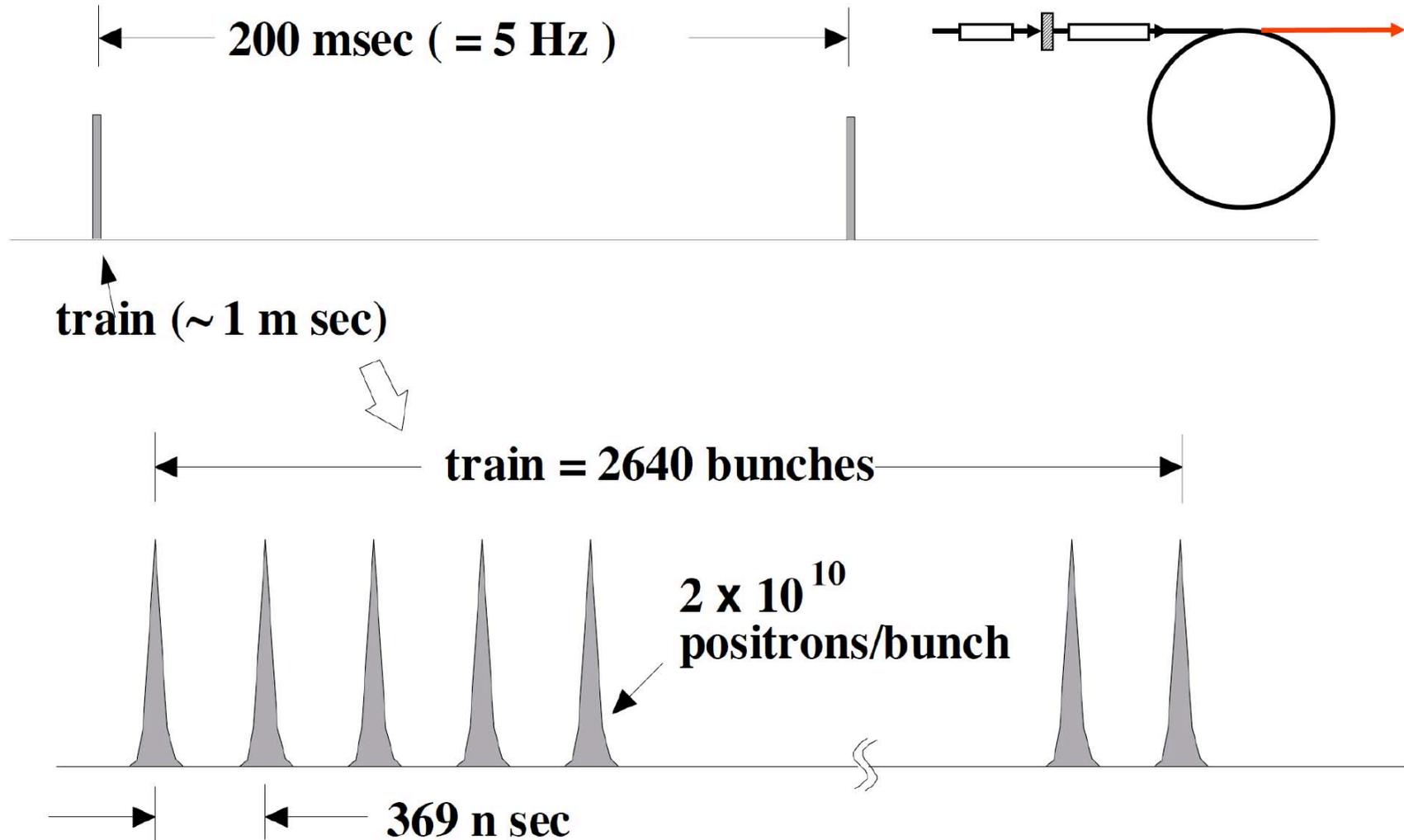
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Beam after DR

Comparison to Warm Machines

GLC/NLC (warm LC)

Ne+/bunch = 0.7×10^{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 = 2×10^{10}

Nbunch/tarin = 2640 = 20 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
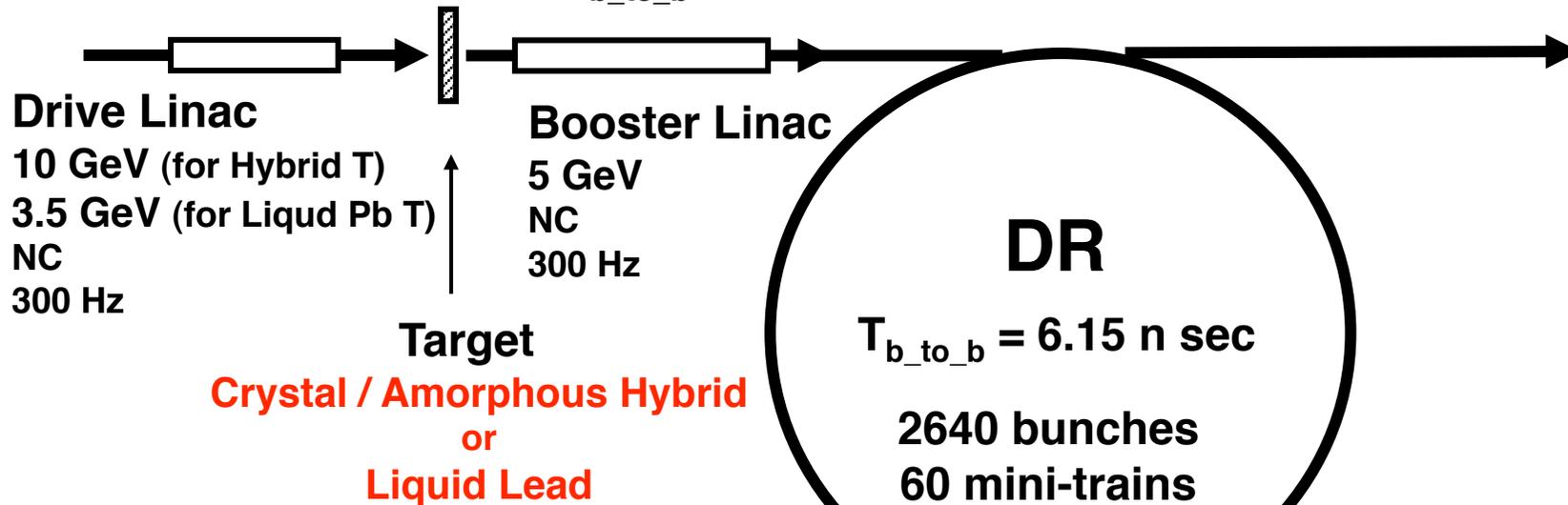## Normal Conducting Drive and Booster Linacs in 300 Hz operation

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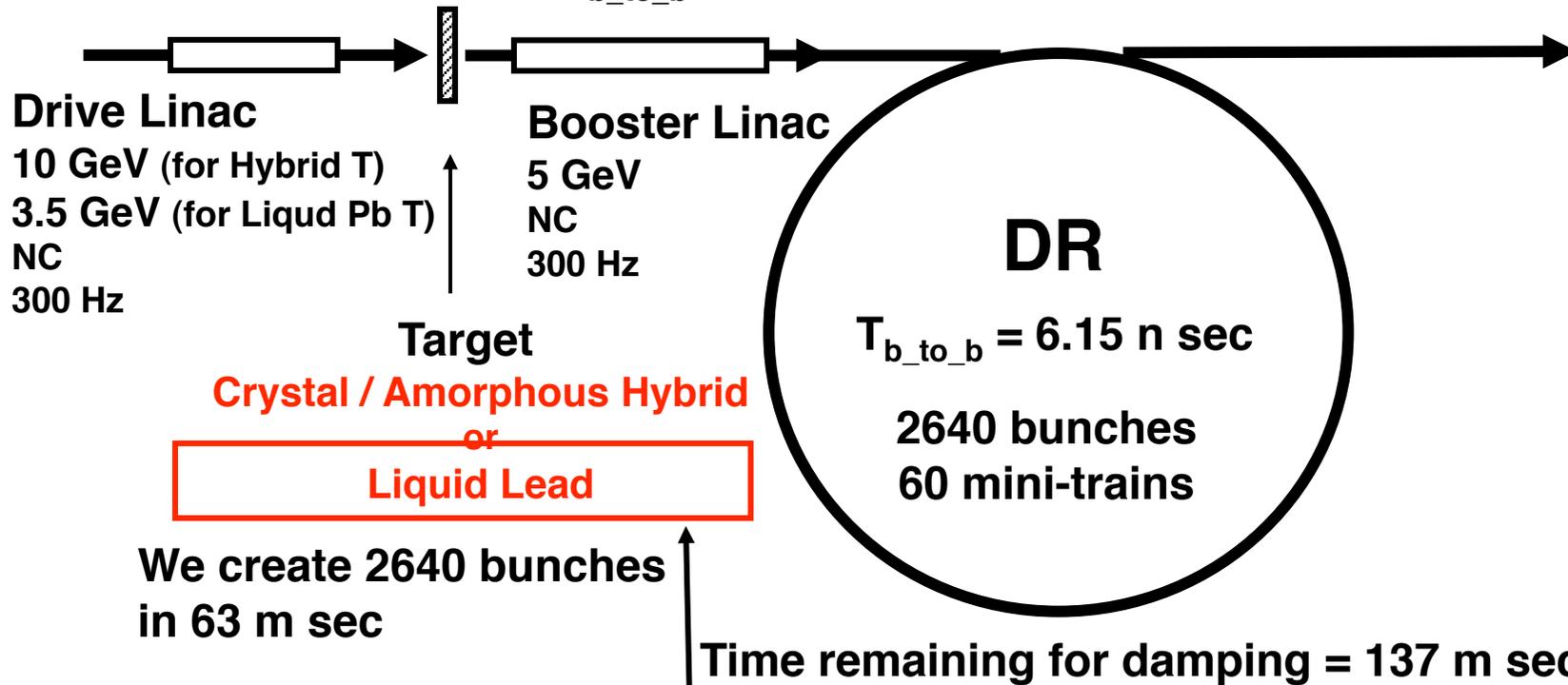## Normal Conducting Drive and Booster Linacs in 300 Hz operation

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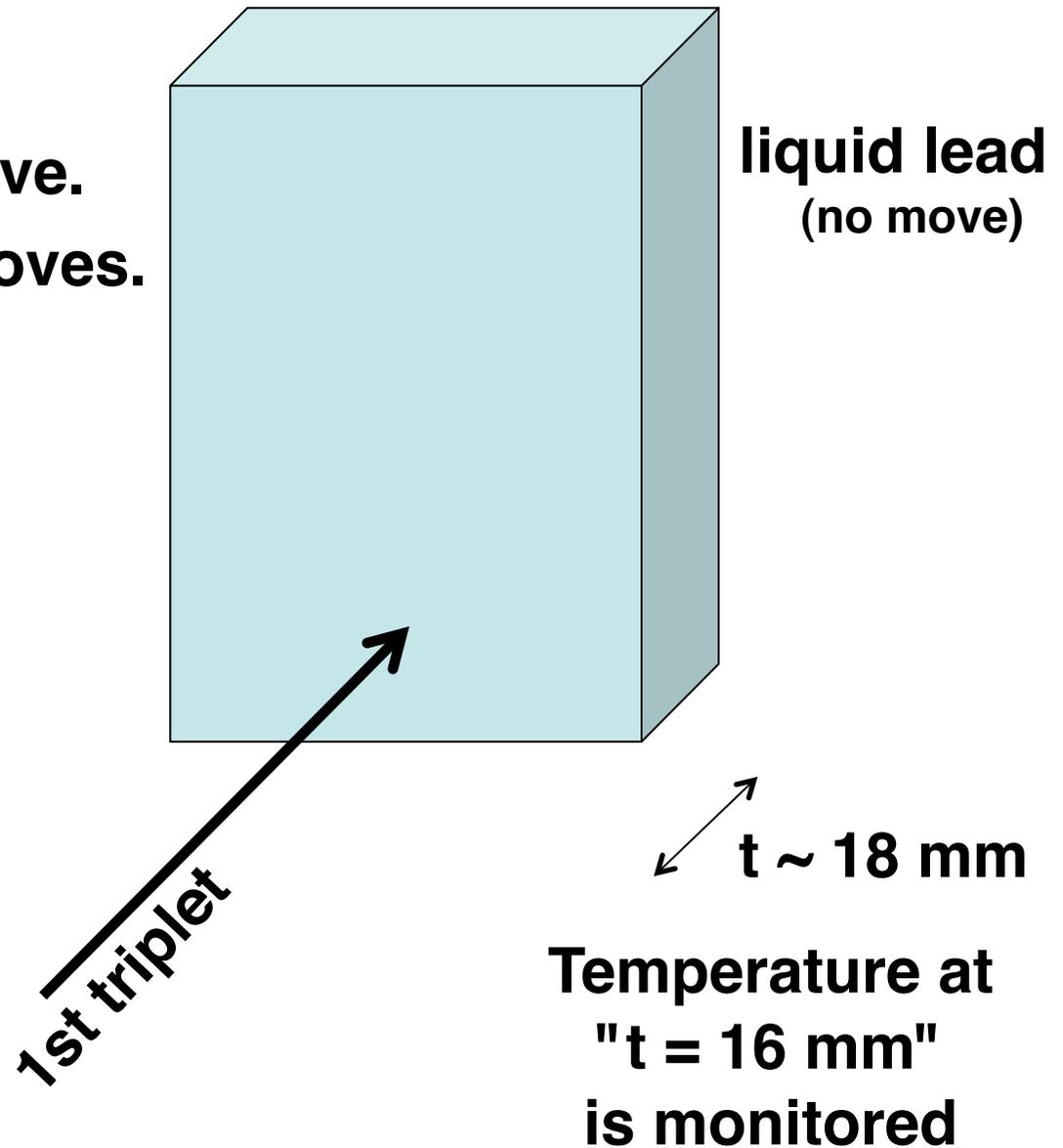
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Simulation of heating by beam (Wanming-san)
Simulation of eddy current (James-san)
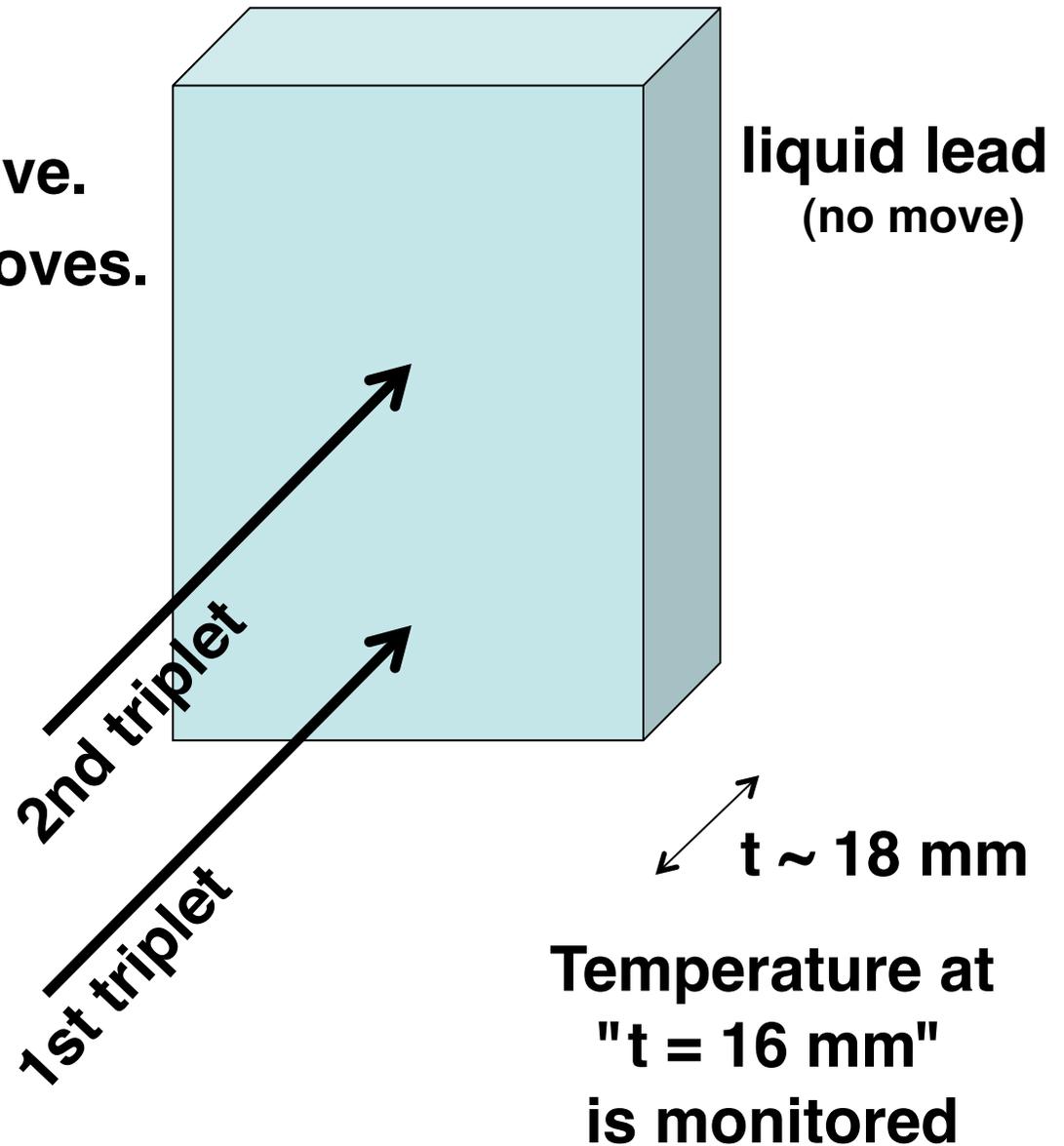
Simulation of heating by beam (Wanming-san)

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)

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

liquid lead
(no move)

2nd triplet

1st triplet

t ~ 18 mm

Temperature at
"t = 16 mm"
is monitored

Simulation of heating by beam (Wanming-san)

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

liquid lead
(no move)

3rd triplet

2nd triplet

1st triplet

t ~ 18 mm

Temperature at
"t = 16 mm"
is monitored

10 m/s, after 2 triplets

2nd triplet

1st triplet
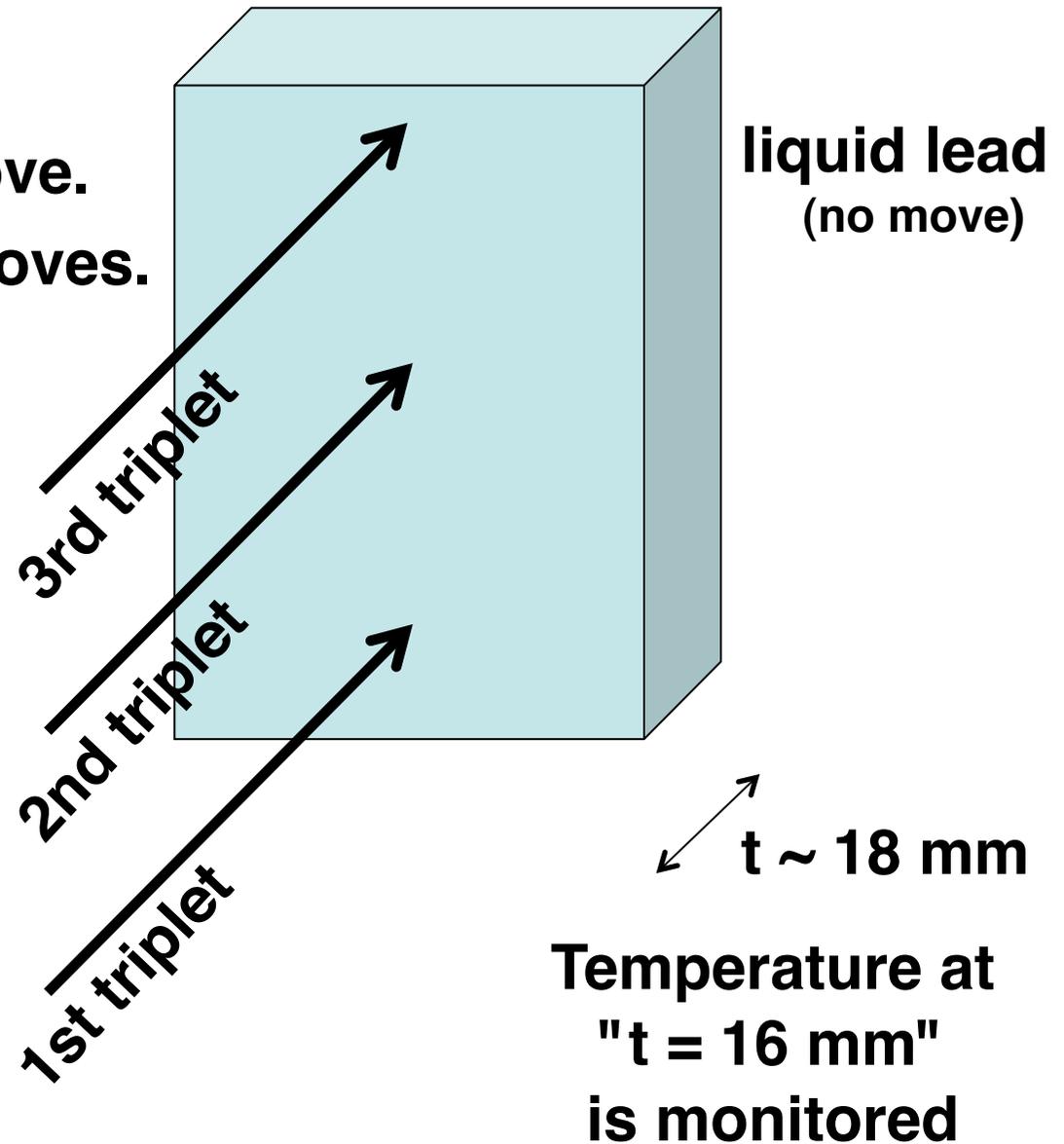
0.033 m (33 mm)
= 10 m/s x 3.3 ms

10 m/s, after 2 triplets

Temperature [K]
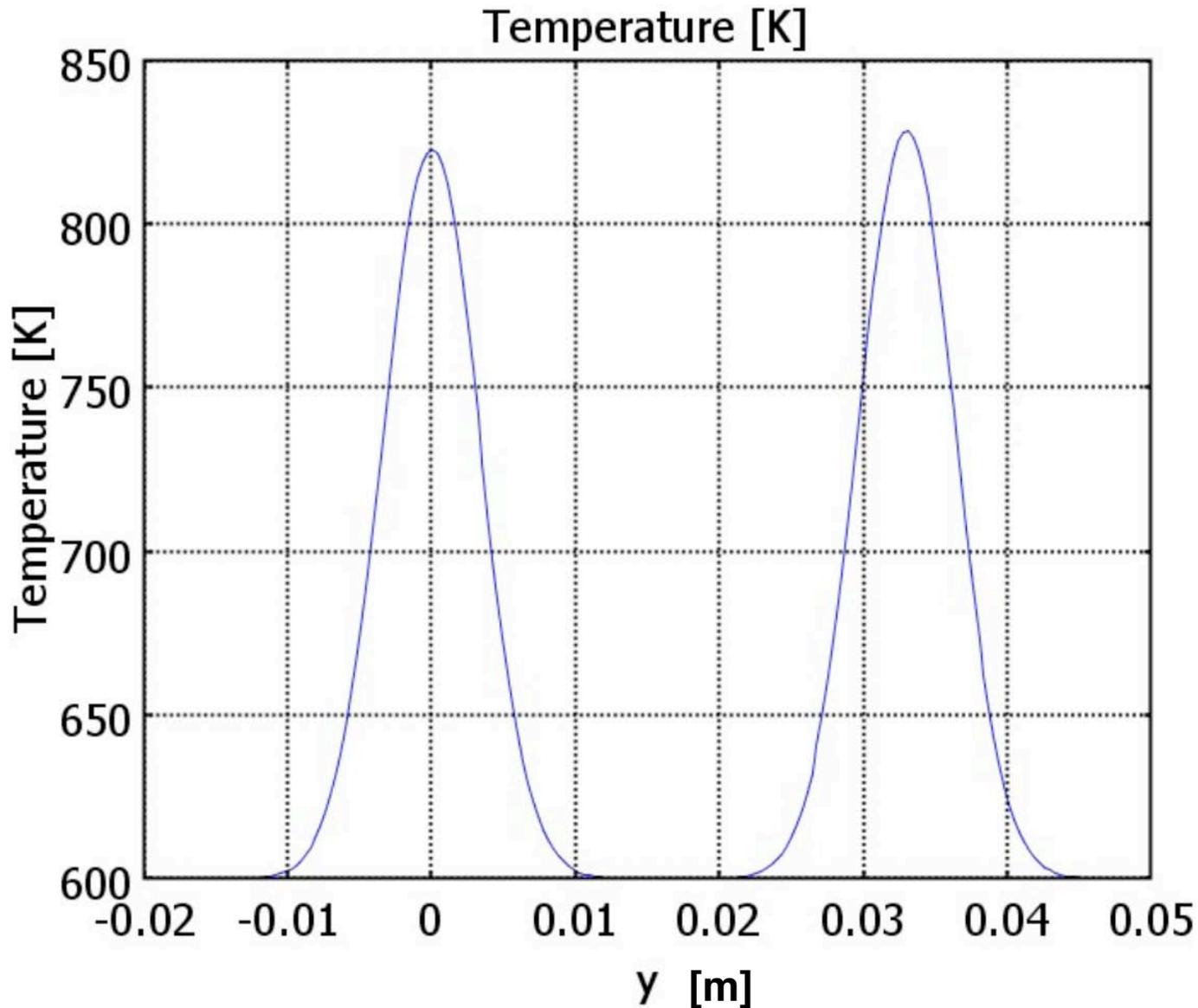
sim. was done with 2.2 GeV and 5.9 nC.
If 2.2 GeV --> 3.5 GeV, delta_T change 220 K --> 350 K

Wanming (ANL)

5 m/s, after 3 triplets
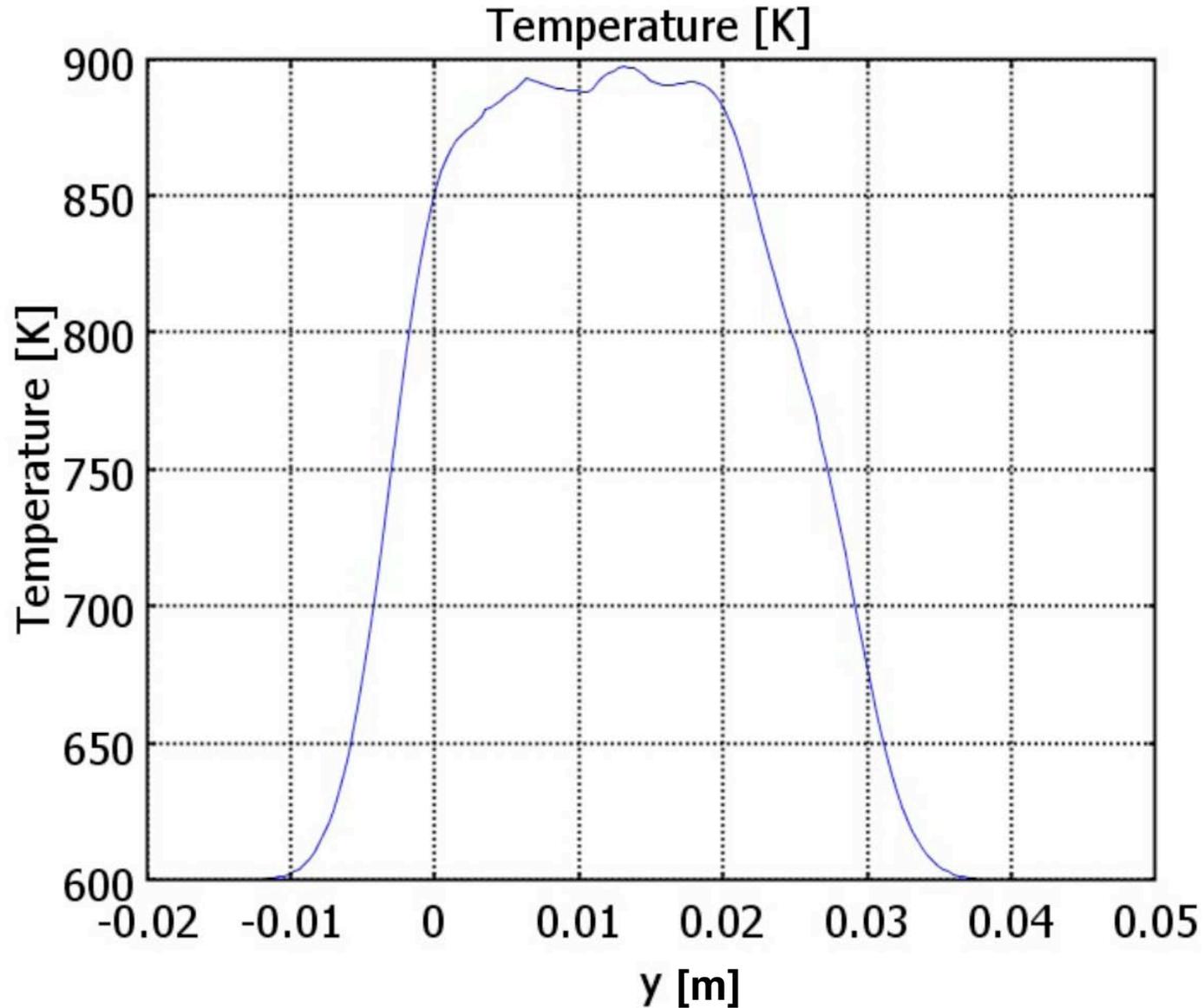
Temperature on line x=0,z=1.6cm
Flow speed of lead 5m/s
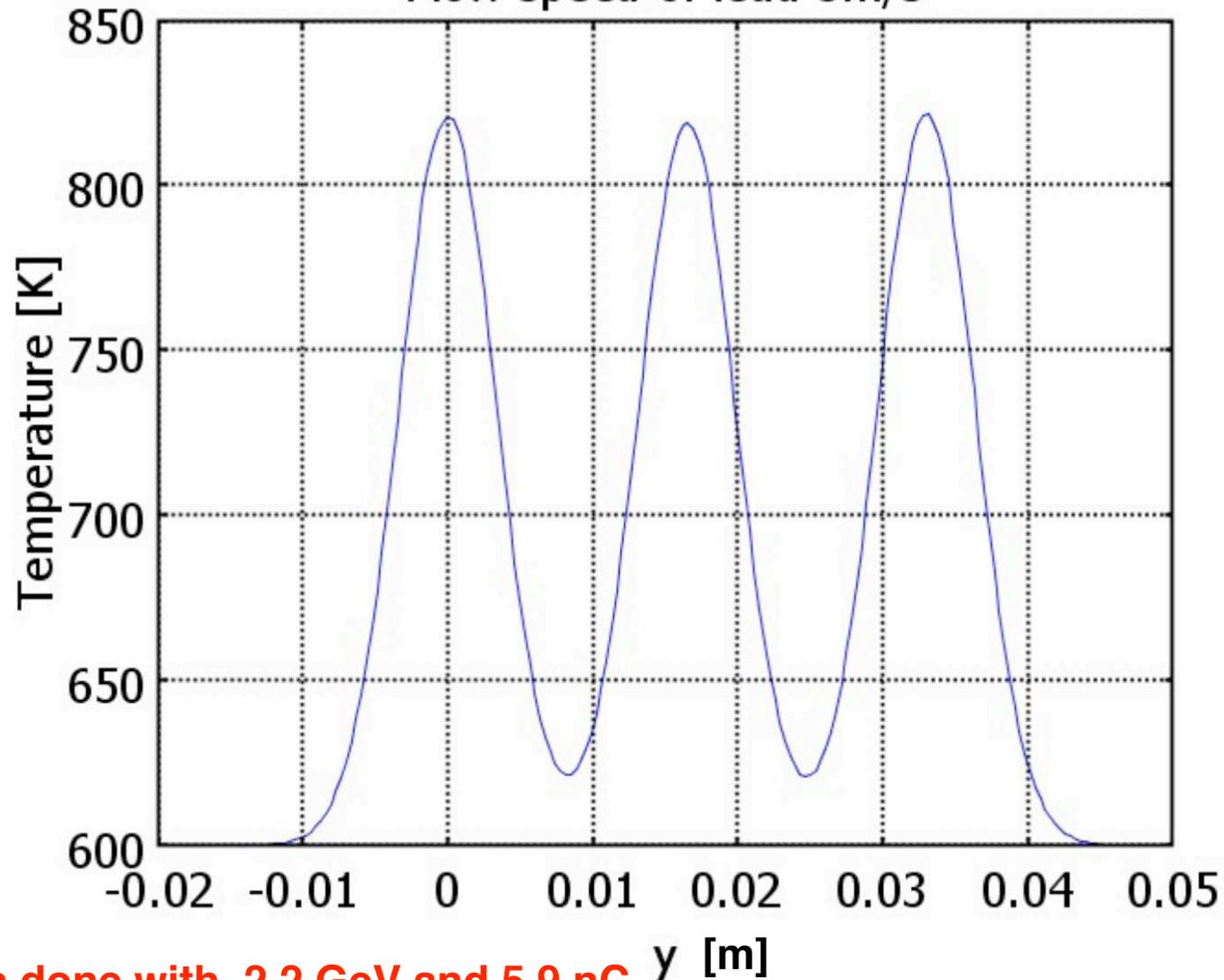
sim. was done with 2.2 GeV and 5.9 nC.
If 2.2 GeV --> 3.5 GeV, delta_T change 220 K --> 350 K

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).

Heating by eddy current (James Rochford)

Model
- a rotating rim (solid)
- mean diameter 0.955m
- angular velocity 99rpm
- rim speed of 4.95 m/s.
- the radial thickness of the rim = 4.5cm
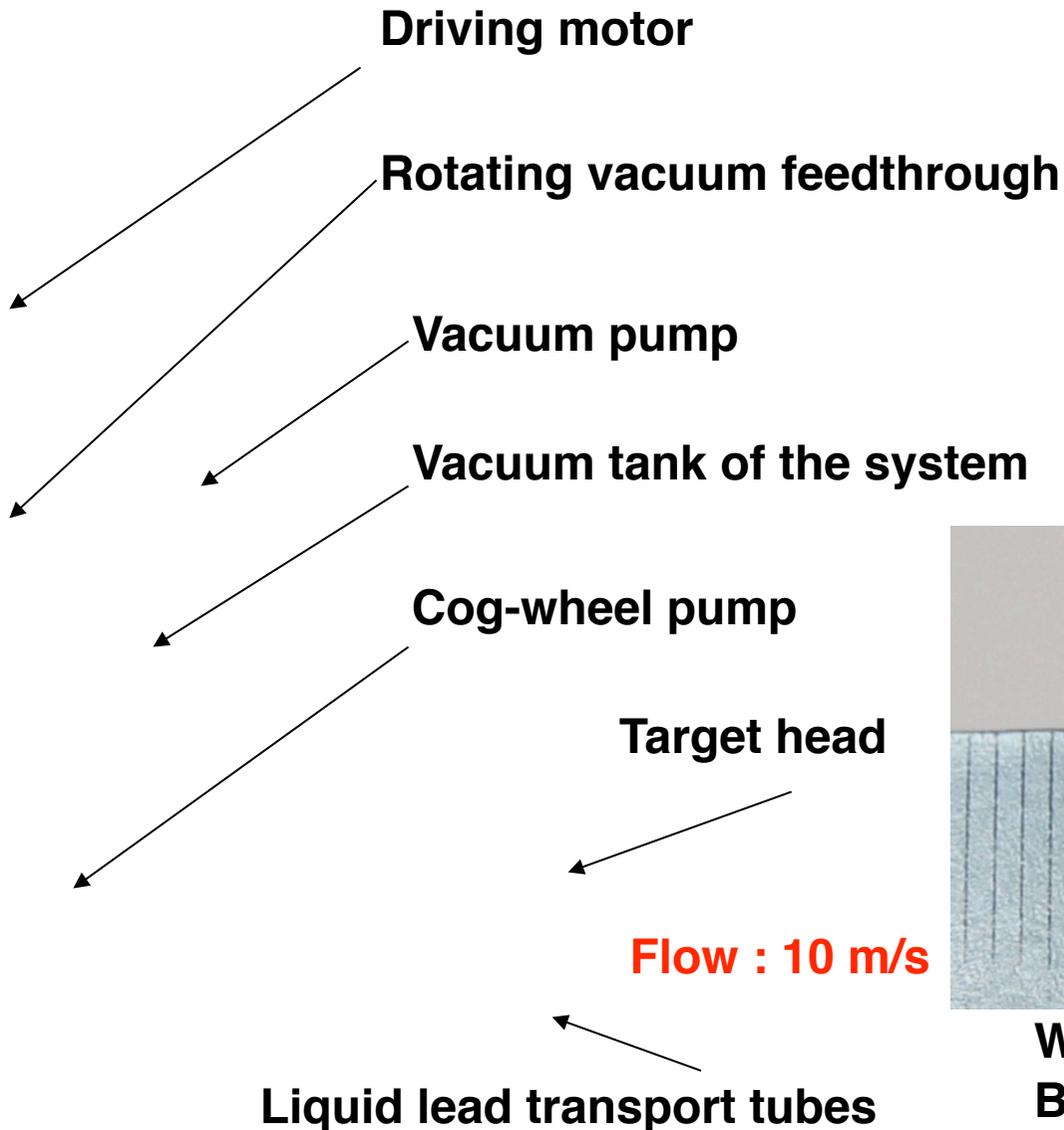- the longitudinal thickness =14mm

Result of simulation
   5 m/s, solid lead, 6 Tesla immerse target
   --> ~ 1 kW

# Prototype of Liquid Lead Positron Production Target

Logachev-san et al, BINP
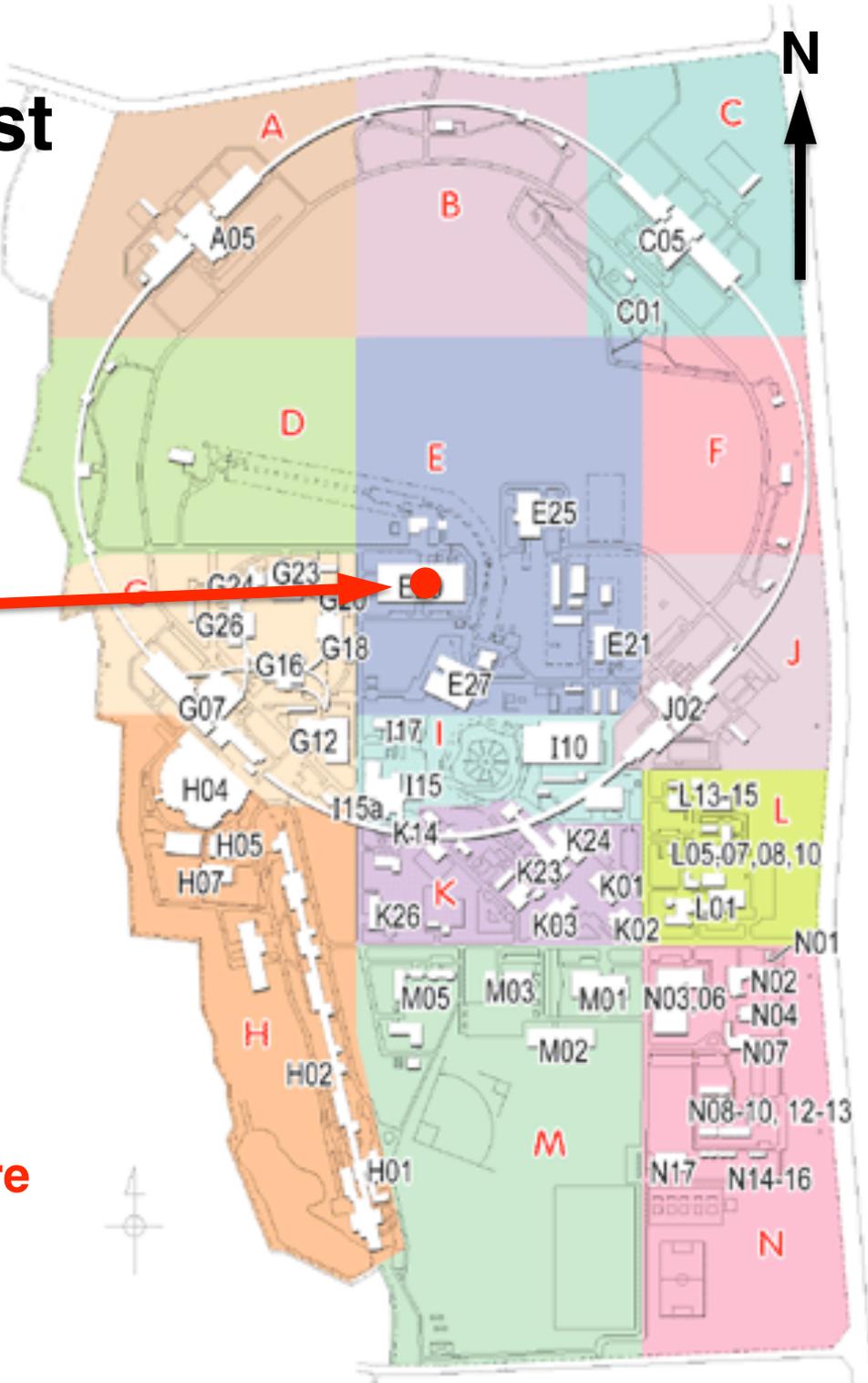
Operation experience 20000 h

Driving motor

Rotating vacuum feedthrough

Vacuum pump

Vacuum tank of the system

Cog-wheel pump

Target head

Flow : 10 m/s

Liquid lead transport tubes

Window thickness 4mm
BN disks for windows
Diameter 12mm

Liquid Lead Target Test
at ATF Linac End

Urakawa-san's talk today
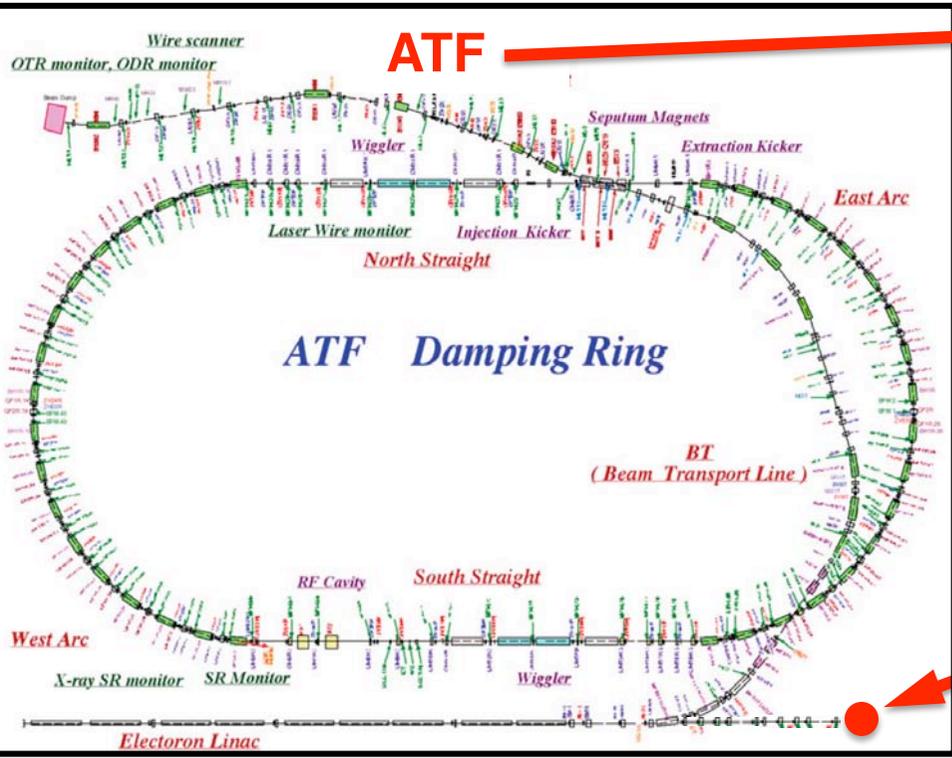
Advanced Conventional e+ Source for ILC

Crystal/Amorphous Hybrid Target or Liquid Lead Target
Normal Conducting Drive and Booster Linacs in 300 Hz operation
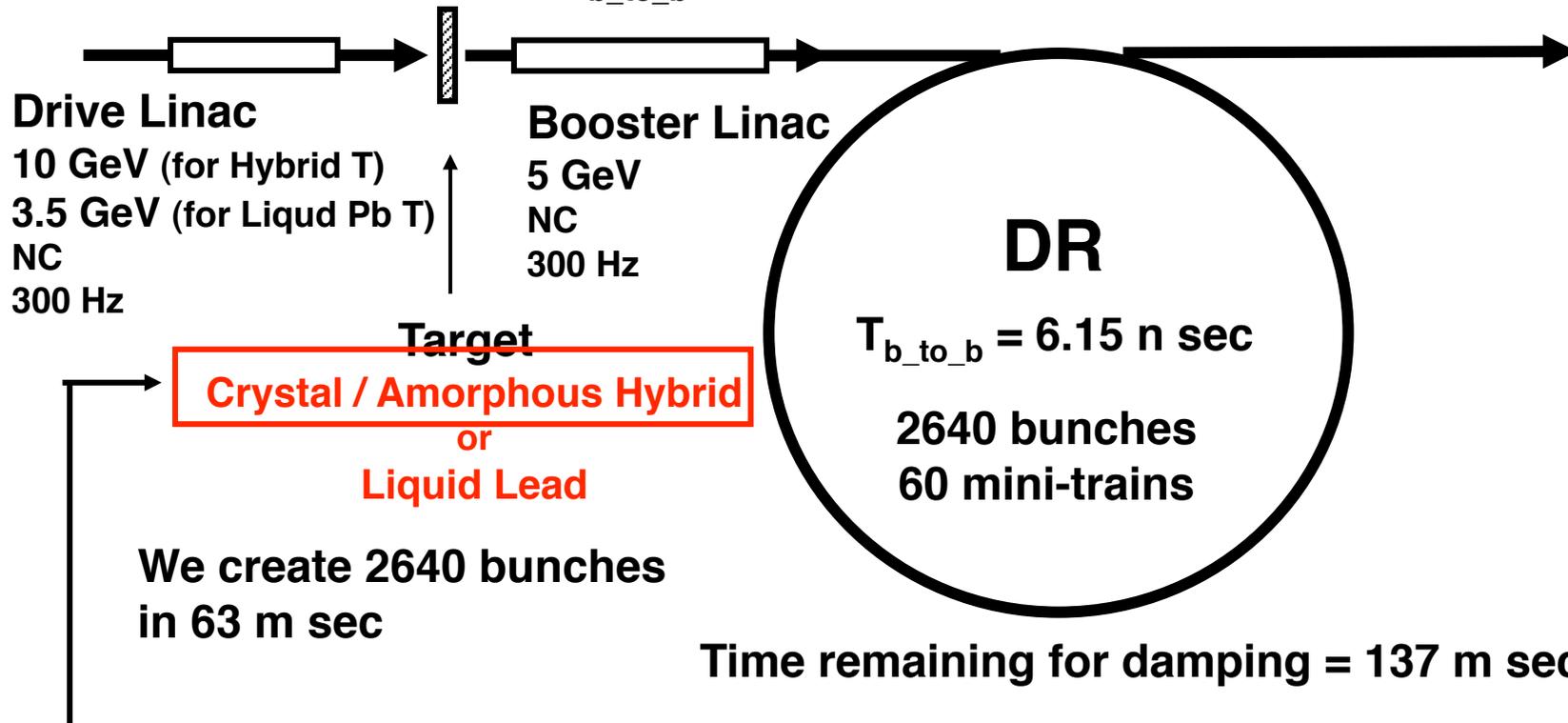
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We create 2640 bunches
in 63 m sec

Time remaining for damping = 137 m sec

PEDD simulation (Chehab-san)

Hybrid Target

Chehab-san
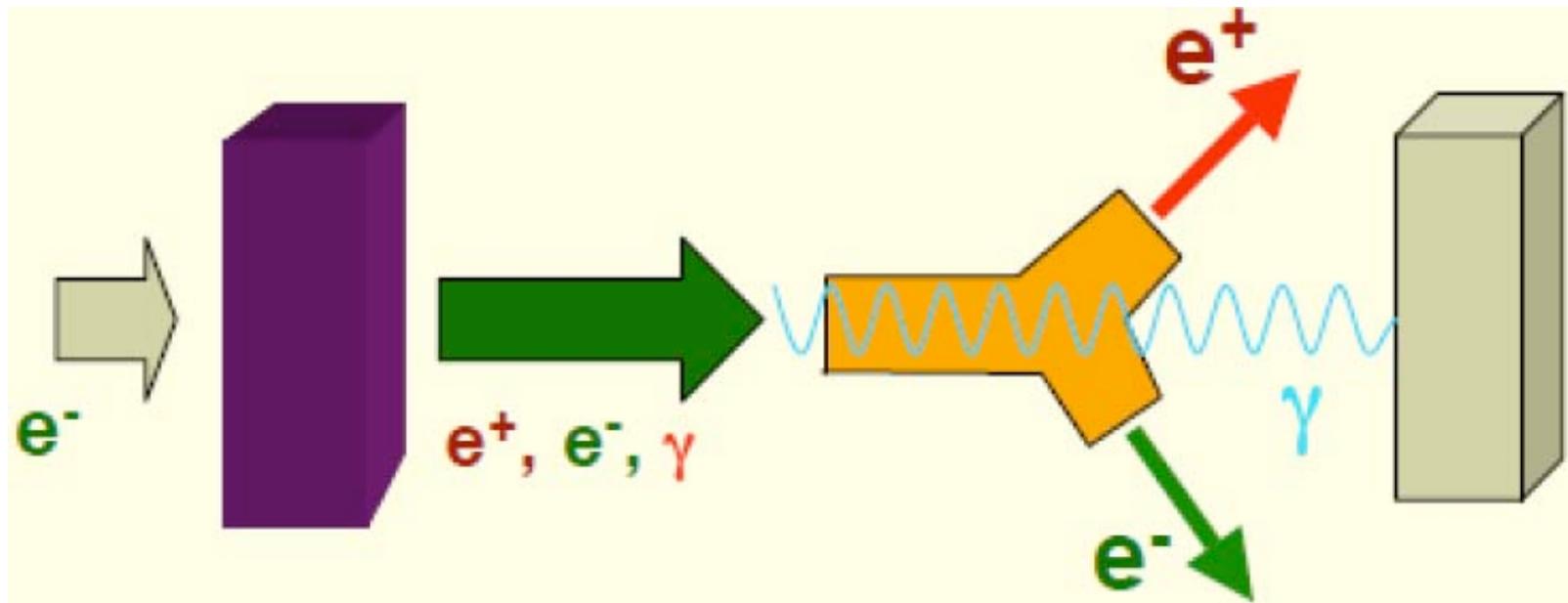
"Radiator"
Thin CRYSTAL

"Converter"
Thick AMORPHOUS

Detailed study ongoing -->   **Dadoun-an's talk today**

Hybrid Target

HYBRID SCHEME FOR ILC & CLIC

simulation of CLIC baseline target

- **RECALL: it might be interesting to remind a comparison made in the case of CLIC between purely amorphous, purely crystal and hybrid targets in the case of an incident beam with $\sigma=1mm$** [CLIC WORKSHOP OCTOBER 2007]

- **COMPARISON WITH PURELY AMORPHOUS AND CRYSTAL TARGETS GIVING THE SAME YIELD (at E- = 5 GeV)**
- **If we consider an amorphous target giving almost the same total positron yield $\eta+$ [~8 e+/e-], the target thickness is: 9 mm**
- **A purely crystal source giving the same total e+ yield is 4 mm thick**
- **Comparison of the 3 kinds of e+ sources for CLIC conditions [3.4×10^{12}e-/pulse]: we compare for same total $\eta+$:**

	Total Dep. En.(%)	PEDD(Gev/cm3/e-)	PEDD (J/g)[pulse]
Purely amorp.	4.5%	7	200
Purely crystal	2.4%	7.2	204
Hybrid	6%	1.5	42

PEDD important

- **We recall that these results correspond to an incident e- beam with $\sigma= 1mm$**
- **We can see the interesting advantage of the hybrid source on the others for the PEDD. If we consider the maximum limit of 35 J/g for W, we are led to multiple targetting: 6 for the to first cases and 1-2 for the third. (see discussion later). Comparisons related to accepted yields instead of total yields lead to analog conclusions.**
- **The intensity in this table is larger (3.4×10^{12}e-) than in the former (2.34×10^{12})**

Hybrid Target

Chehab-san

simulation of CLIC baseline target

	Total Dep. En.(%)	PEDD(Gev/cm3/e-)	PEDD (J/g)[pulse]
Purely amorp.	4.5%	7	200
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Hybrid	6%	1.5	42

**Hybrid Target
reduces PEDD ~ 1/5**

Hybrid Target

simulation of ILC hybrid target

POSITRON SOURCES USING CHANNELING FOR ILC & CLIC

- **INCIDENT BEAM:** an incident electron beam of 10 GeV
- **TARGETS:**
- **CRYSTAL:** a 1 mm thick W crystal <111> orientation
- **AMORPHOUS:** a 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]
- **RESULTS:** accepted yield: 1.8 e+/e- ($\sigma^- = 1$mm)
- 1.5 e+/e- ($\sigma^- = 2.5$ mm)
- **PEDD:** assuming an incident e- bunch of 2. 10^{10} e-

PEDD important

	crystal		amorphous	
	PEDD/e-	PEDD/bunch	PEDD/e-	PEDD/bunch
$\sigma^- = 1$mm	2 GeV/cm3	0.33 J/g/bunch	7.5 GeV/cm3	1.25 J/g/bunch
$\sigma^- = 2.5$mm	0.35 GeV/cm3	0.058 J/g/bunch	2 GeV/cm3	0.33 J/g/bunch

- It is quite clear that the hybrid target cannot sustain the 2820 bunches and that distributed targets system must be considered.

Hybrid Target

Chehab-san

simulation of ILC hybrid target

PEDD: assuming an incident e- bunch of 2. 10^{10} e-

	crystal		amorphous	
	PEDD/e-	PEDD/bunch	PEDD/e-	PEDD/bunch
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Effect of acoustic shock wave: time scale ~ 100 ns

If accumulate 132 bunches (1000 ns) --> 44 J/g (> 35 J/g)

If accumulate 44 bunches (300 ns) --> 14 J/g   (< 35 J/g)

Values are Marginal:
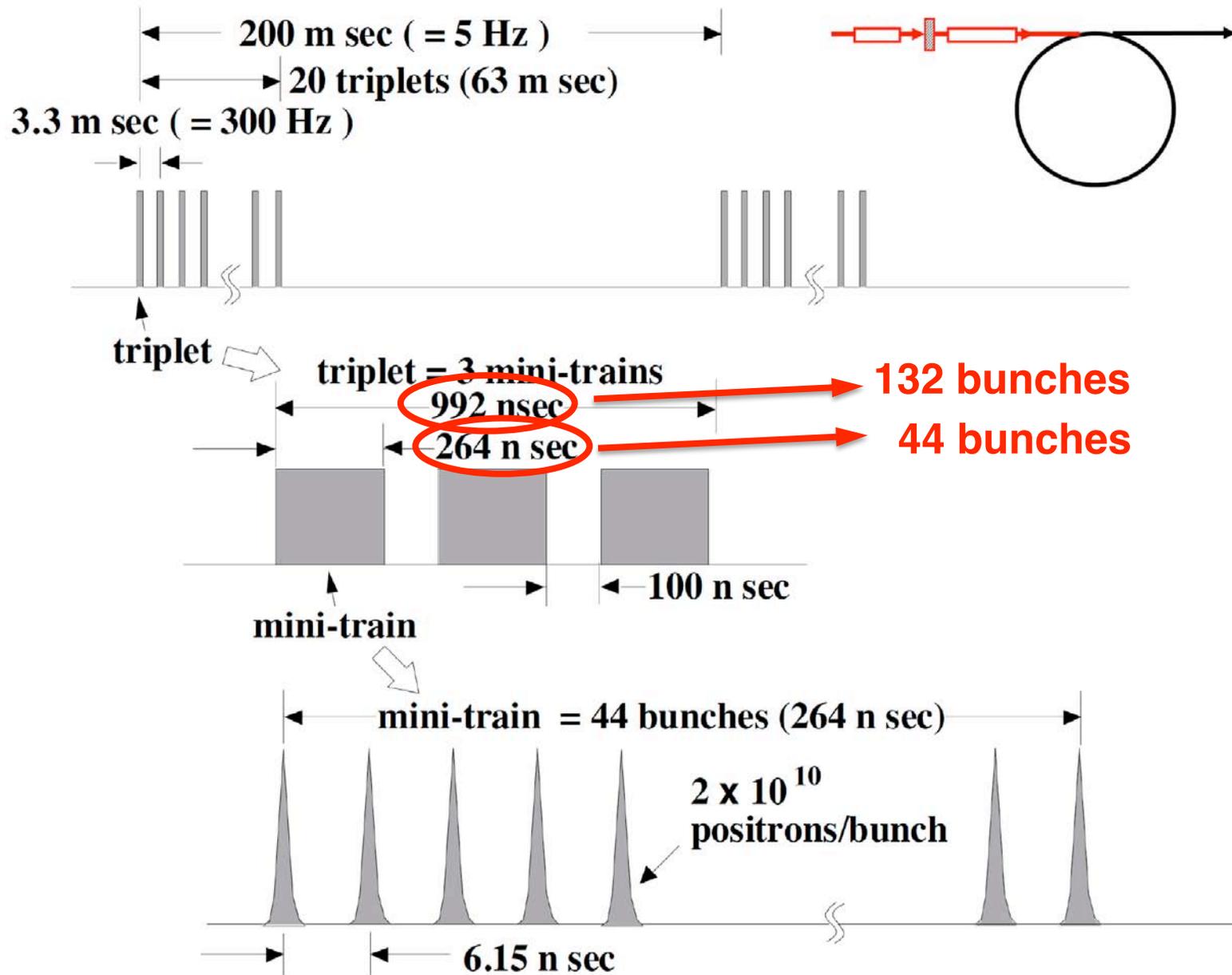   We need concrete values based on experiments.
      • PEDD reduction ~1/5?
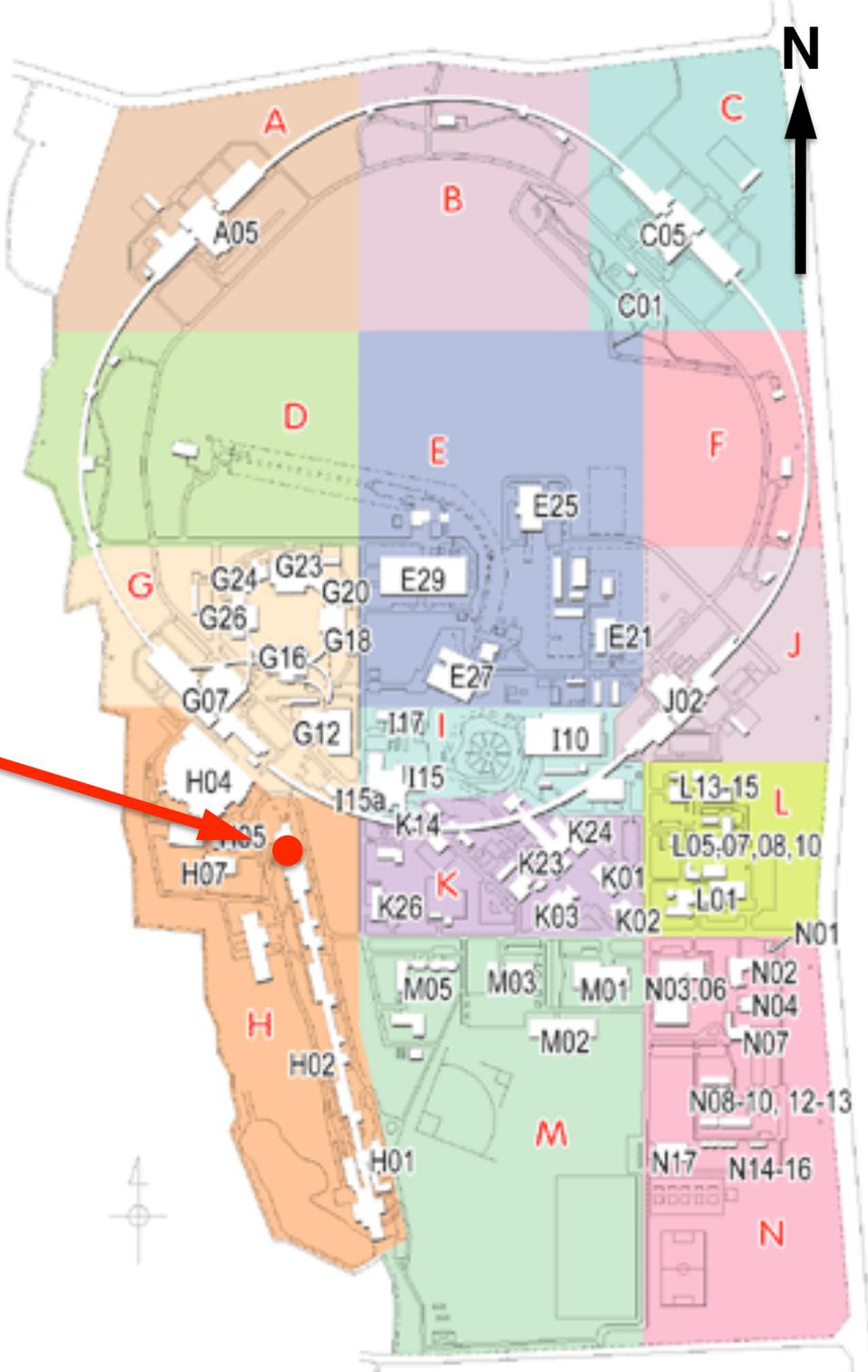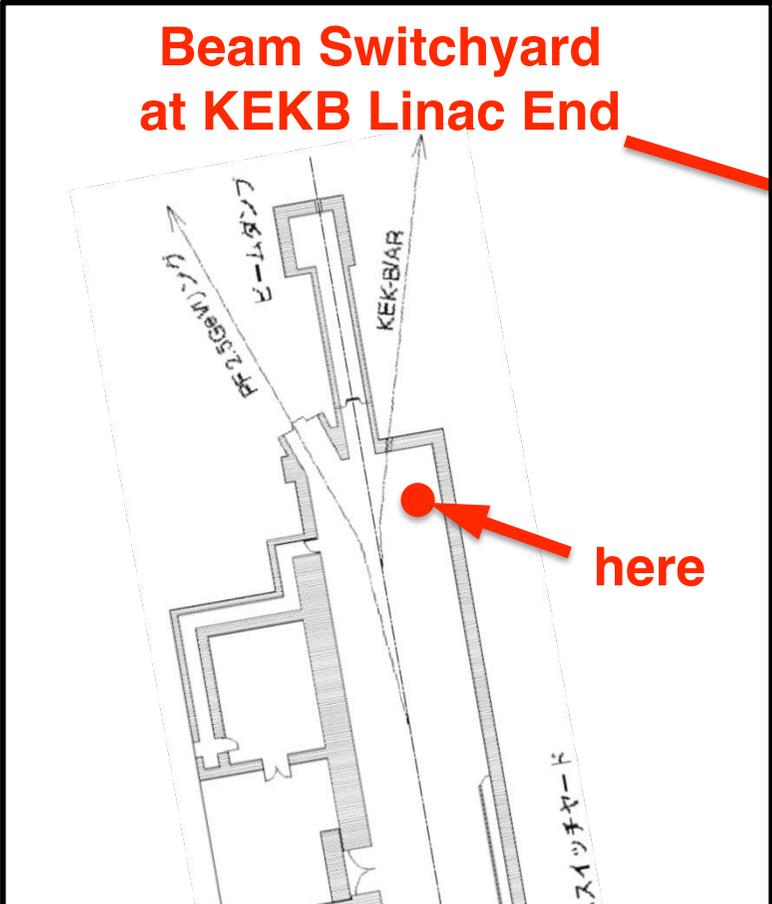   • e+ yield enhancement ~ 6?

Crystal: will be prepared by Tomsk/Dubna
Beam experiment: will be at KEK

# Beam before DR

Hybrid Target Test
at KEKB Linac End

Takahshi-san's talk today

Beam Switchyard
at KEKB Linac End

here

300 Hz e⁺ Generation solves flux Concentrator issue

- 1 micro sec flux concentrator <-- existing technology
    - It was working at SLC.
      6 T, 120 Hz
    - Prototype study is ongoing for SuperKEKB
      10 T, 50 Hz, need long time operation test

      Kamitami-san's talk on 26th

- Baseline design (undulator scheme) assumes 1m sec flux concentrator   ---> jump 1000 times

- 300 Hz generation use 1 micro sec flux concentrator

Beam before DR
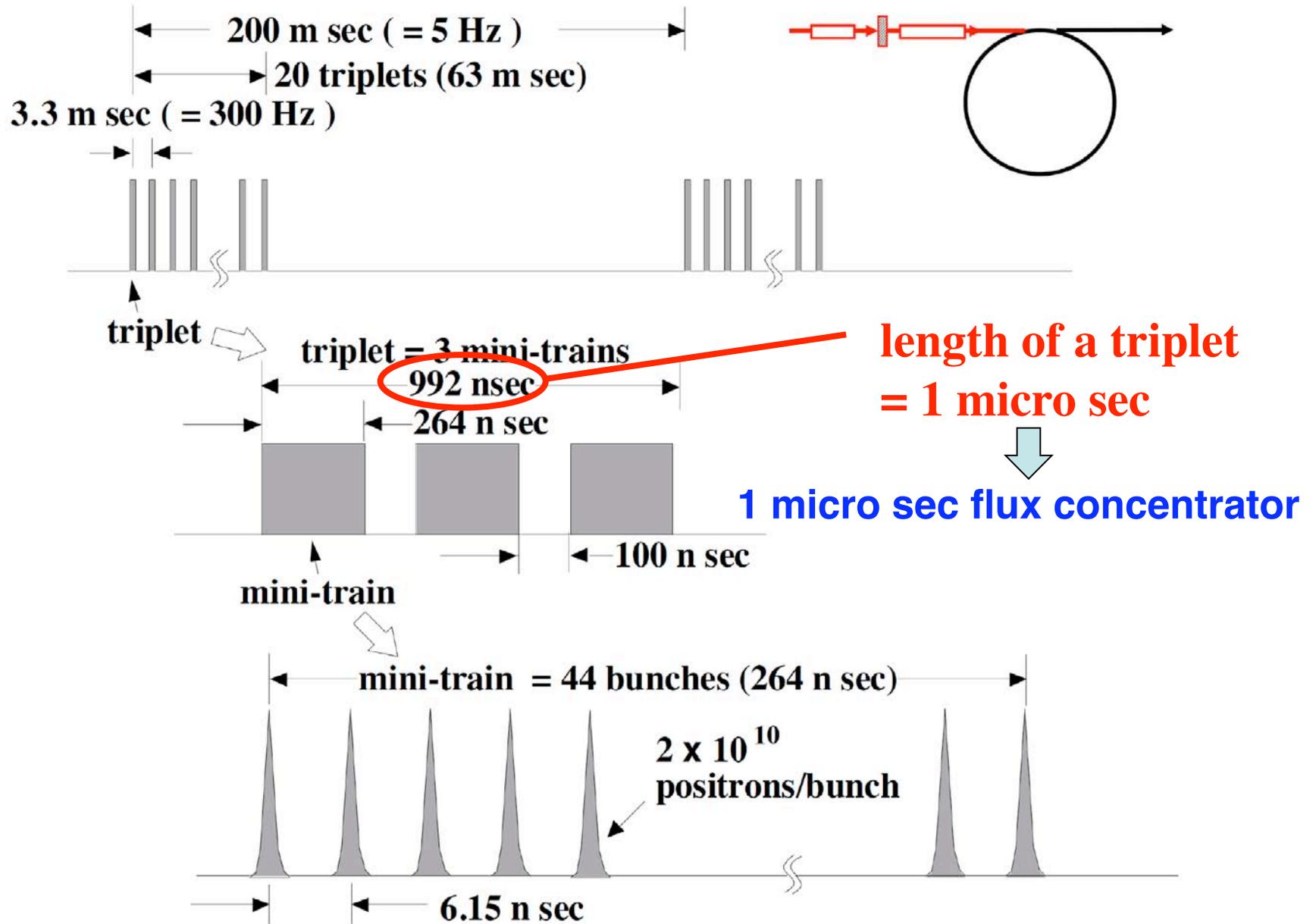
length of a triplet
= 1 micro sec

1 micro sec flux concentrator

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Is this OK?**

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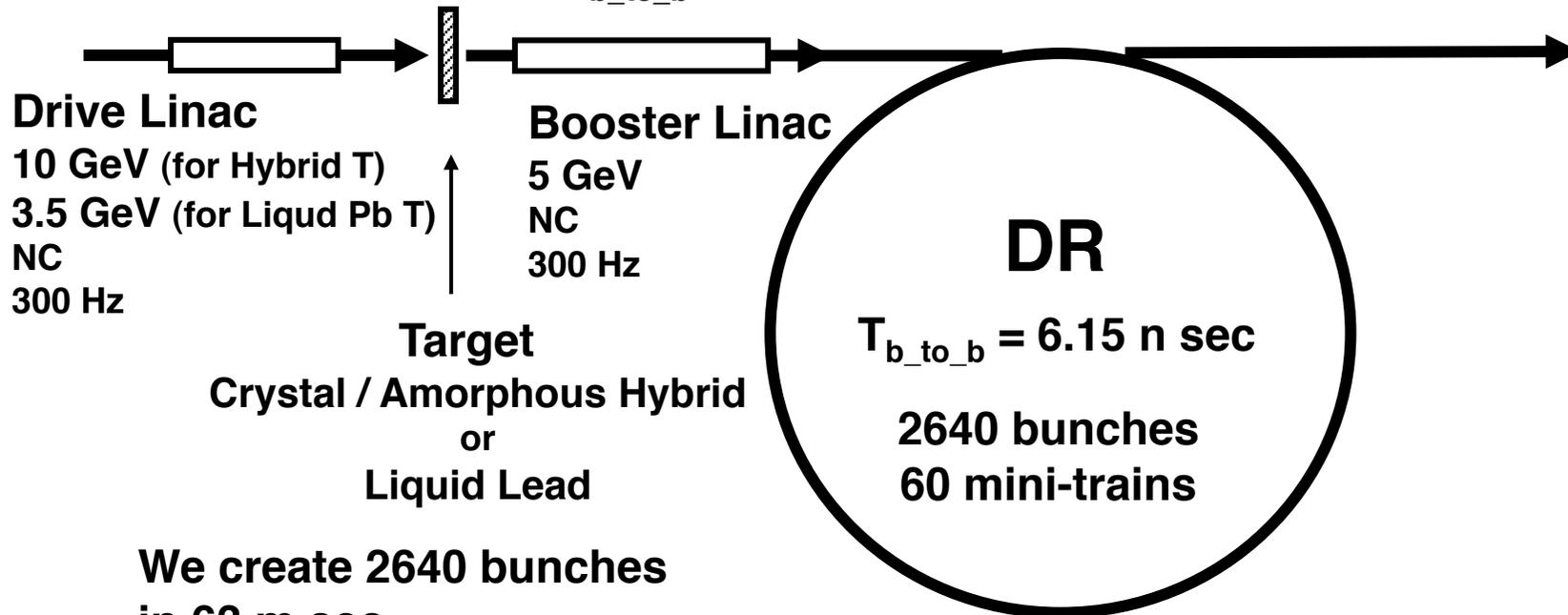## Normal Conducting Drive and Booster Linacs in 300 Hz operation

Time remaining for damping = 137 m sec
Is this OK?

Answer from Susanna-san

> present DCO lattice has a transverse damping time of
> 21 ms, i.e. 140 msec corresponds to 6.7damping times.
> This should be enough to get the extracted vertical
> emittance near enough to the equilibrium emittance.
>
> For the minimum machine the wiggler is reduced and
> it is easier to get a short damping time.

Summary

1. Target survivability is the issue in ILC e+ source (especially conventional source).

2. Ease the survivability issue by 300 Hz gen.
   make e$^+$s in 63 m sec

3. Advanced Targets Technology
   Crystal/Amorphous Hybrid Target
   Liquid Target

4. We can use existing flux concentrator tech.

5. Advanced Targets Tech. + 300 Hz gen.
   maybe the most mature solution