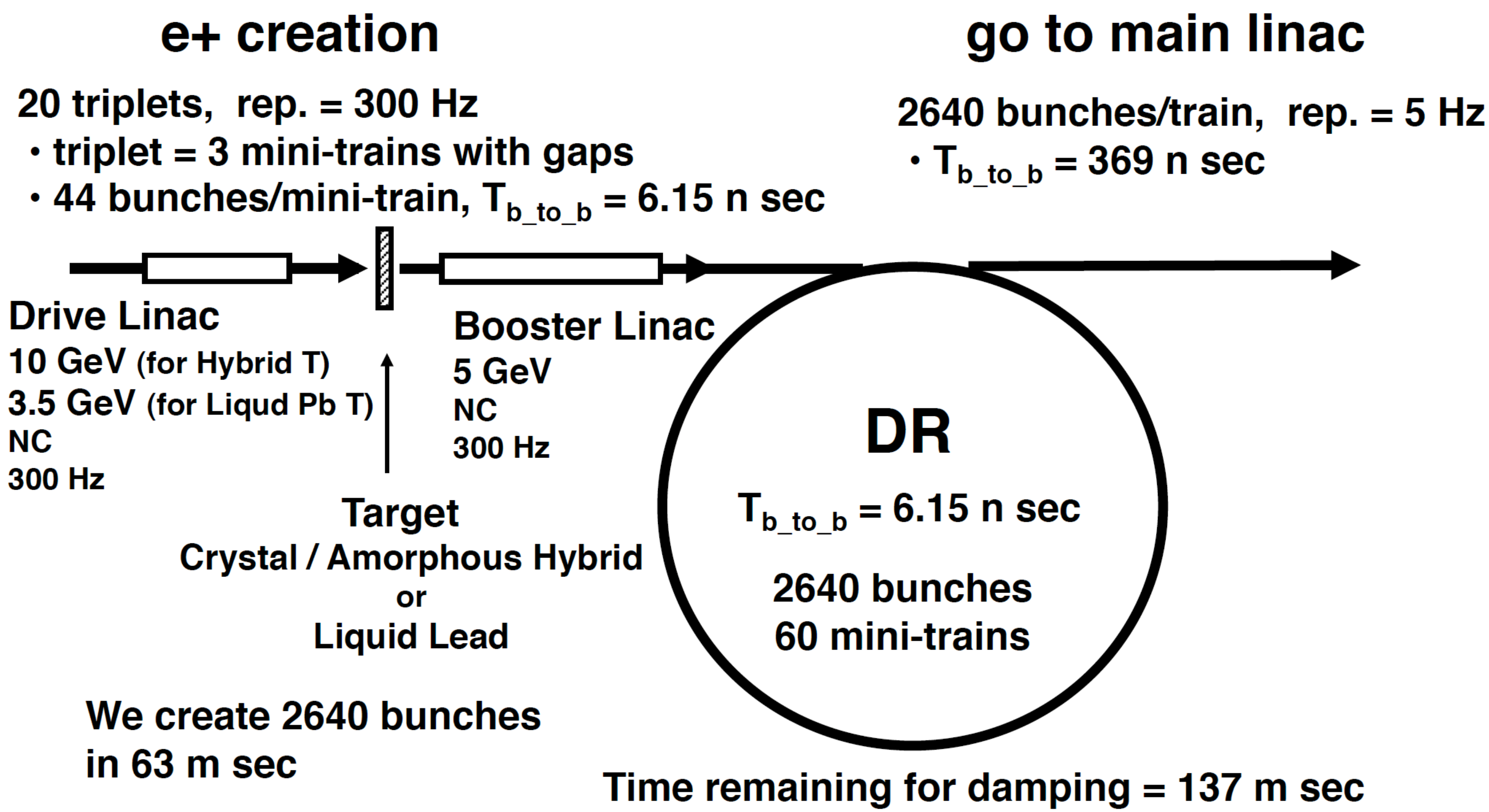
300 Hz e+ Source for ILC



T. Omori (KEK)

Accelerator Design and Integration Meeting

29-April-2008, DESY

Many thanks to Chehab-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

300 Hz generation

e+ generation in 63 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

300 Hz generation

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- 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

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 = 2640 = 10 x 132

300 Hz generation: similar to warm machines

in it's time structure
in view point of target thermal/shock issues

300 Hz generation: takes 63 m sec

3.3 m sec(300 Hz) x (20-1) = 63 m sec

Advanced Conventional e+ Source for ILC

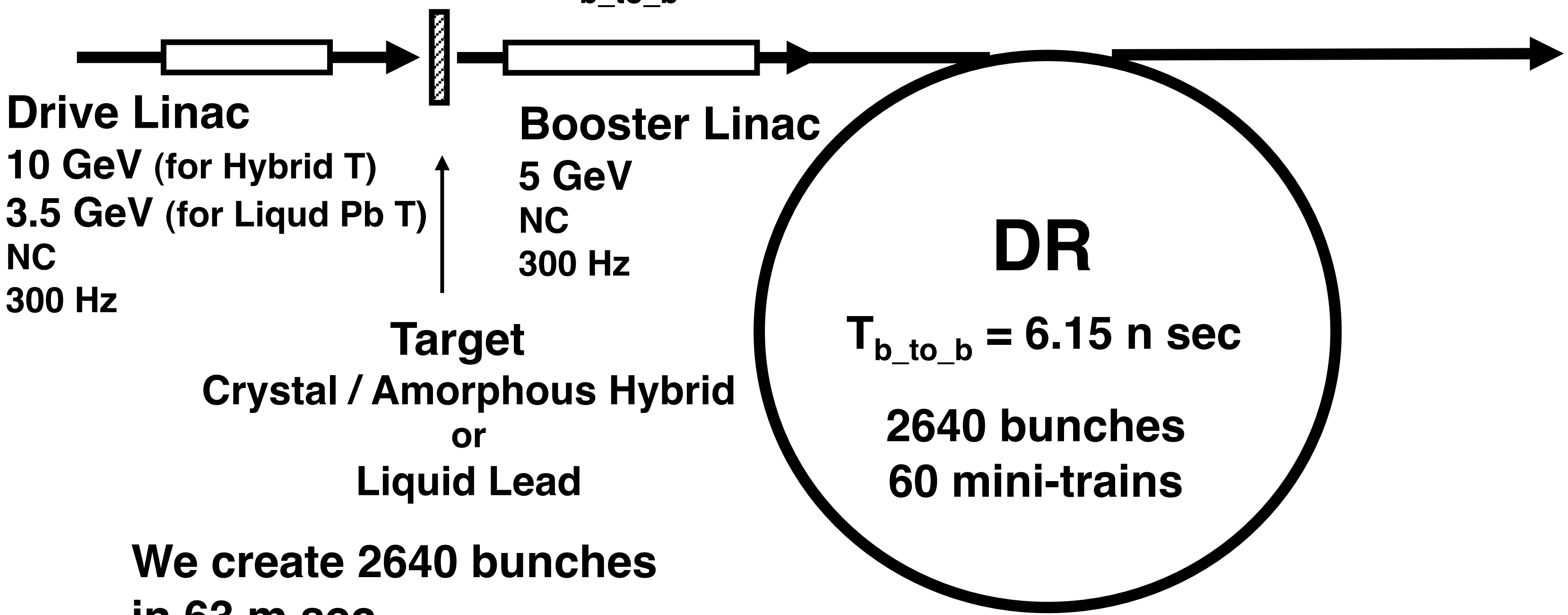
Crystal/Amorphous Hybrid Target or Liquid Lead Target
Normal Conducting Drive and Booster Linacs in 300 Hz operation

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



We create 2640 bunches
in 63 m sec

Time remaining for damping = 137 m sec

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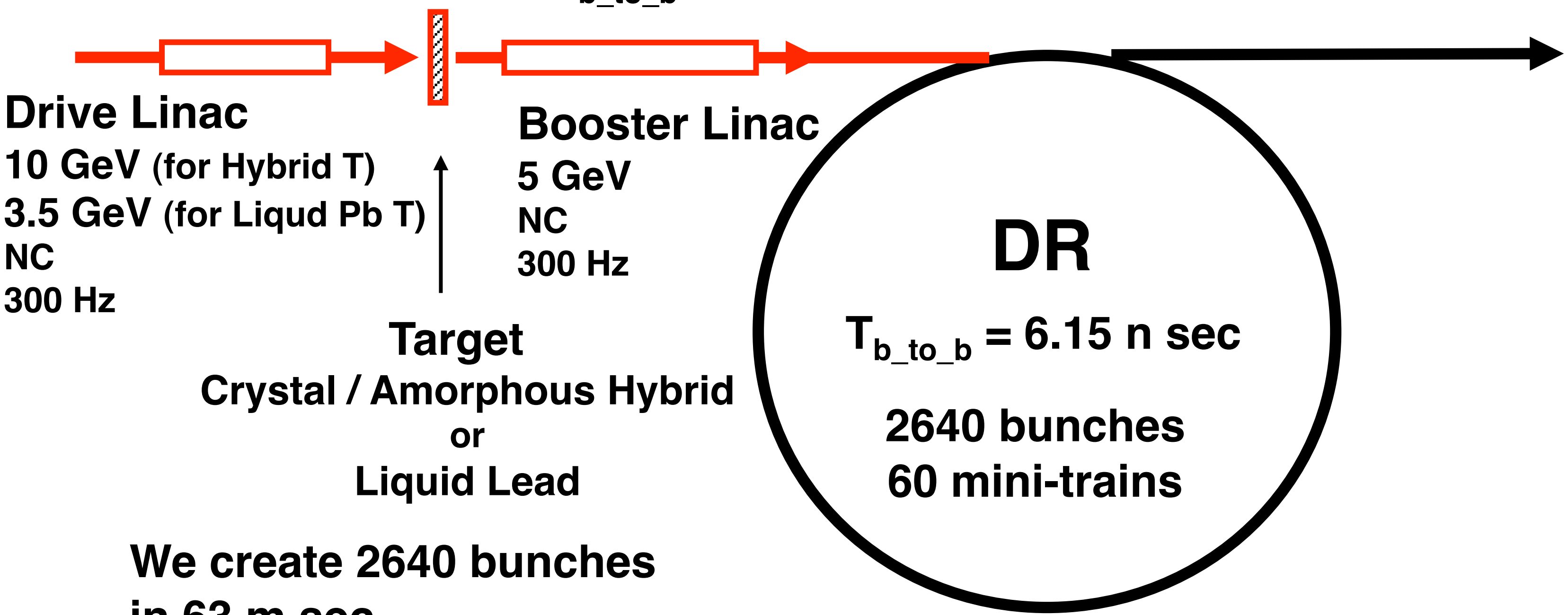

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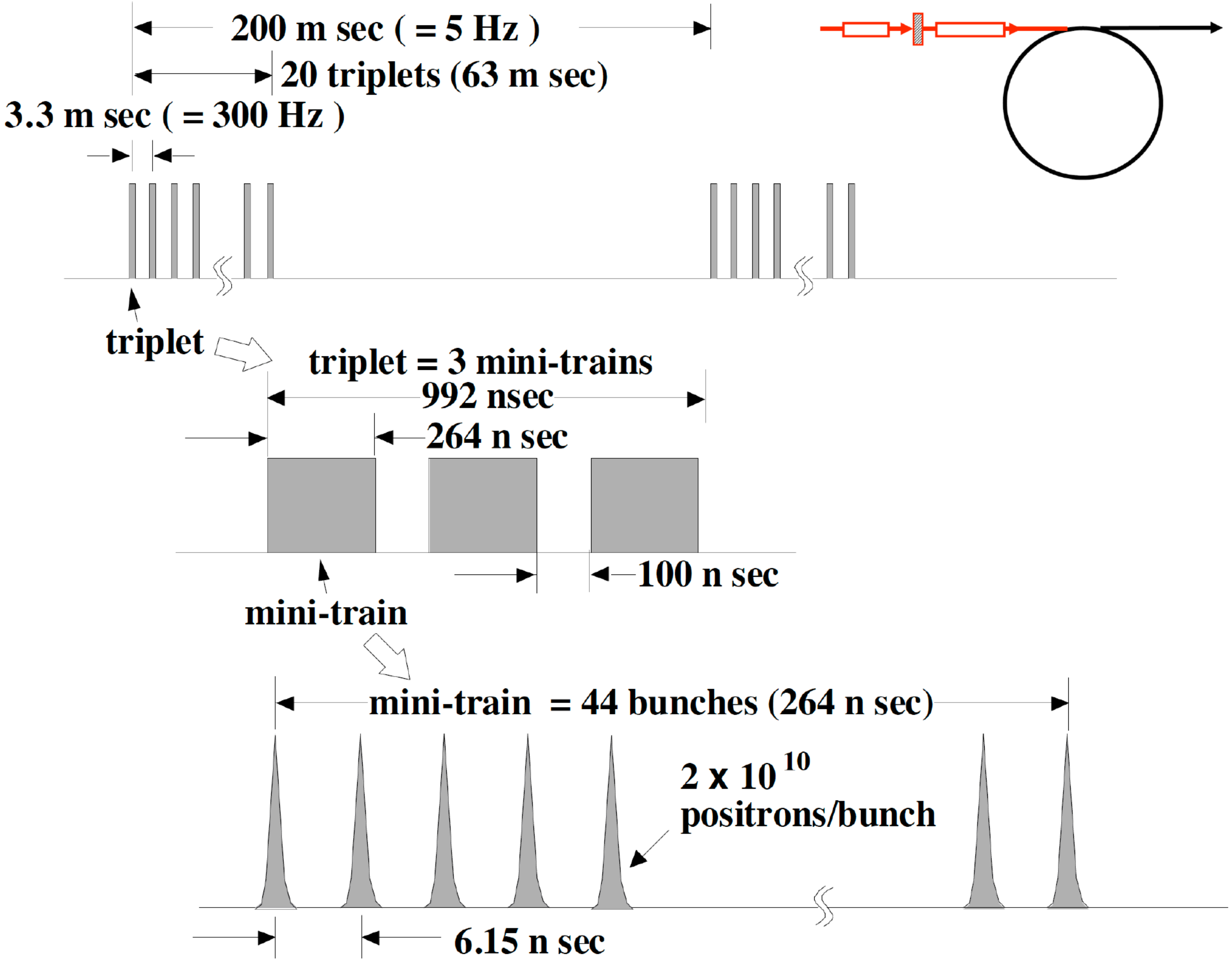
Beam before DR



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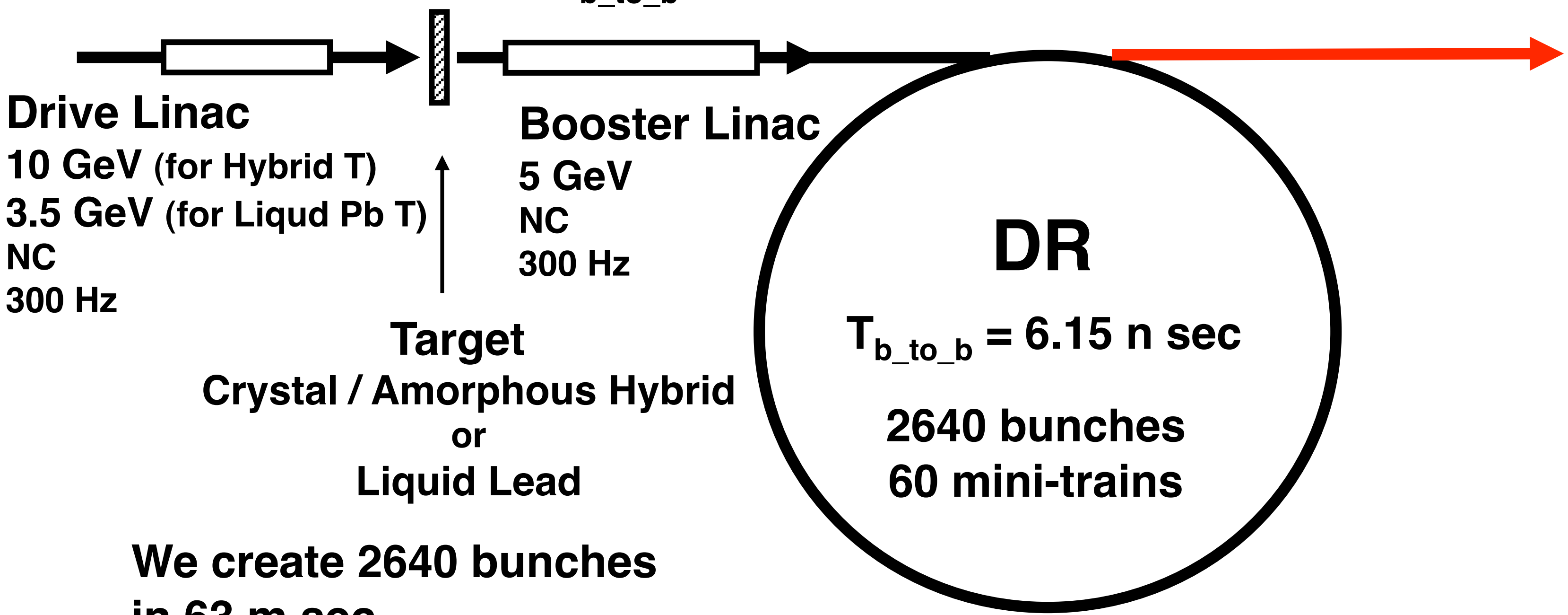

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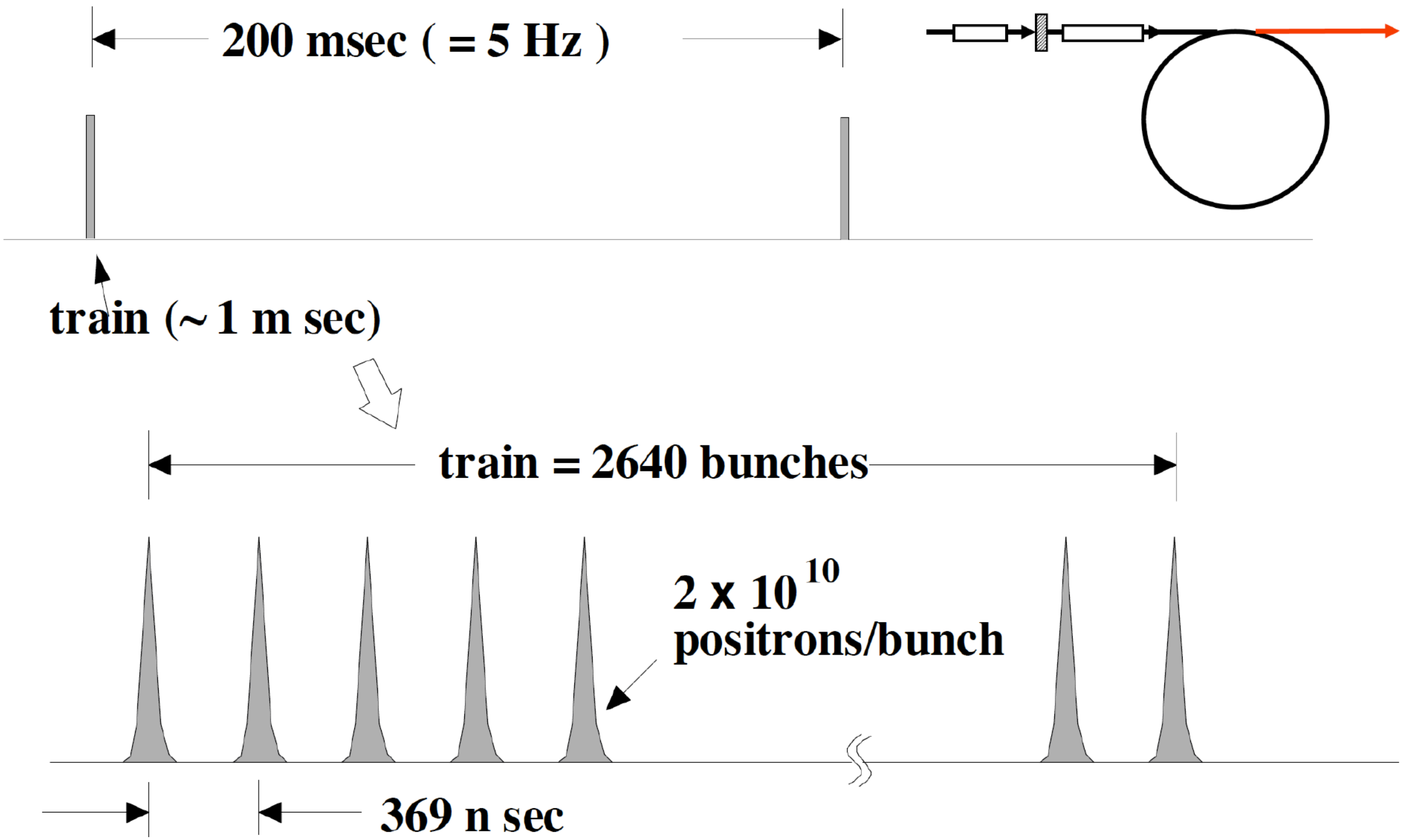

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ILC (cold LC)

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

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Normal Conducting Drive and Booster Linacs in 300 Hz operation

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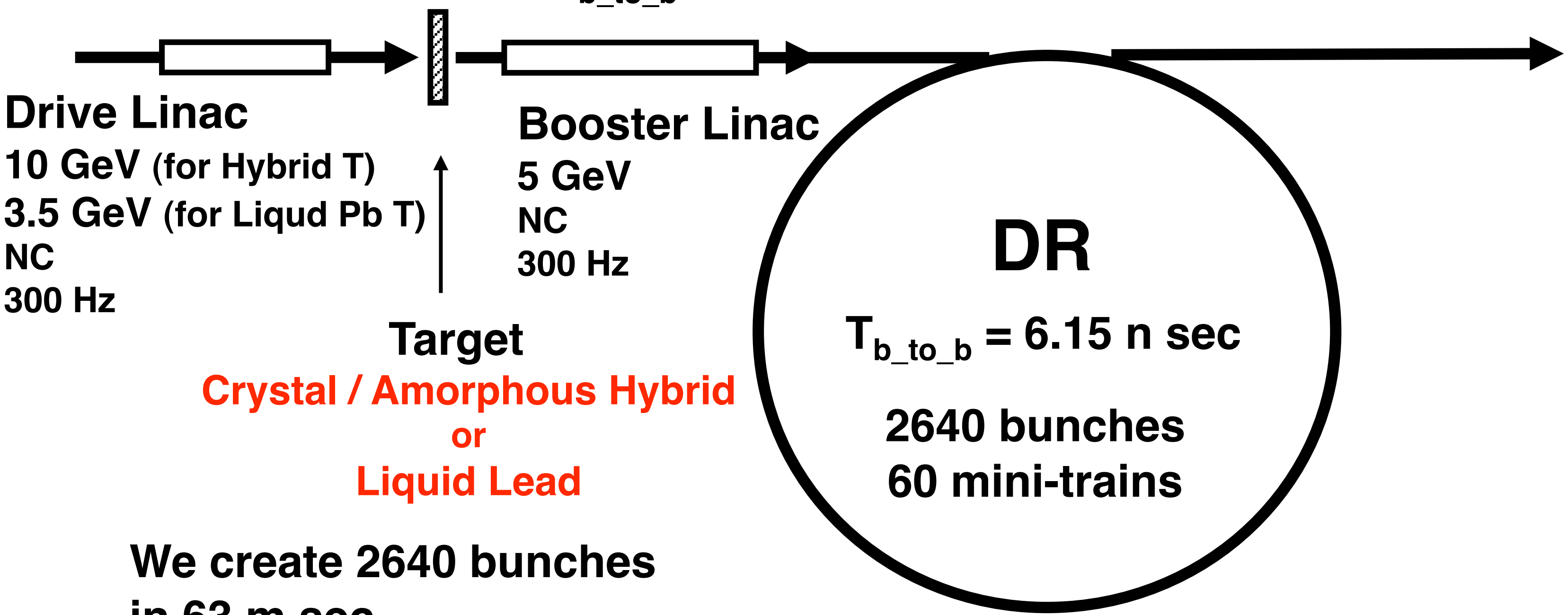

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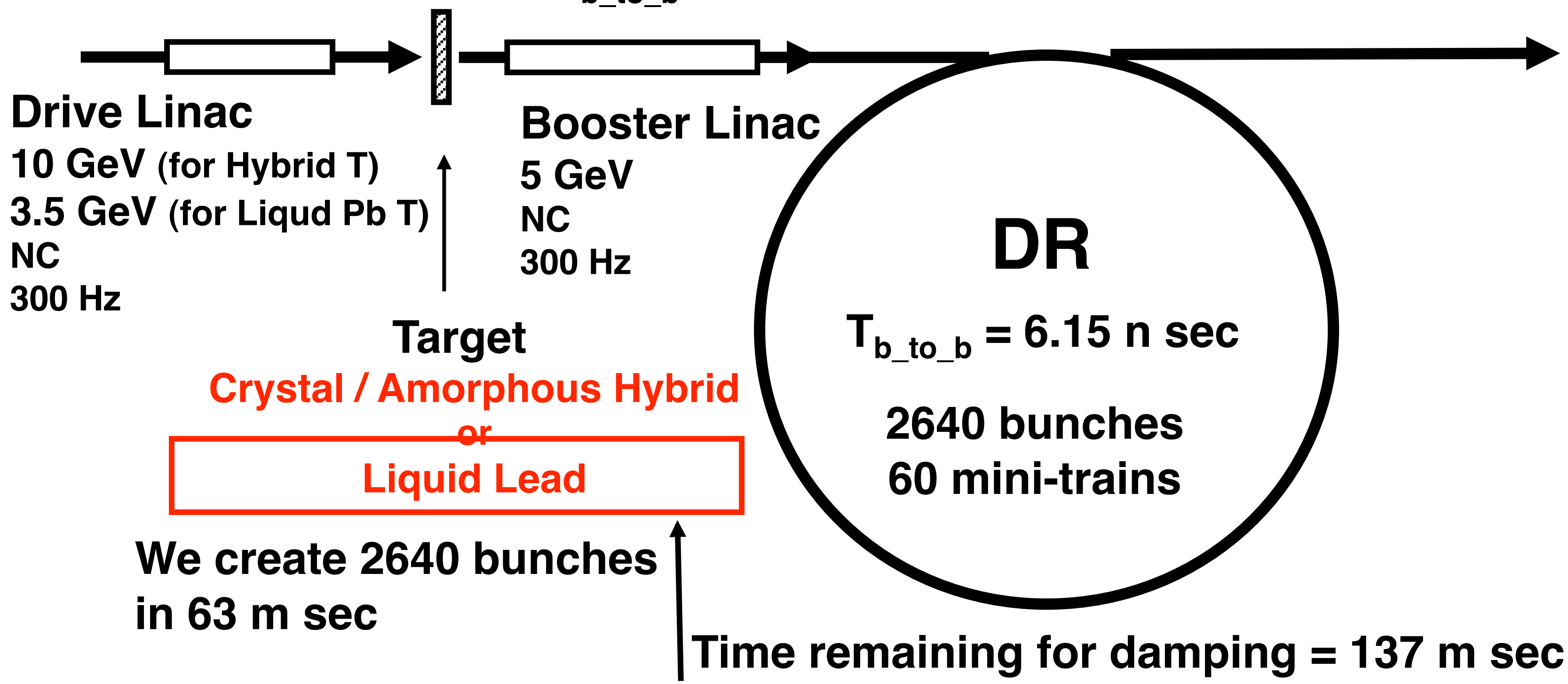
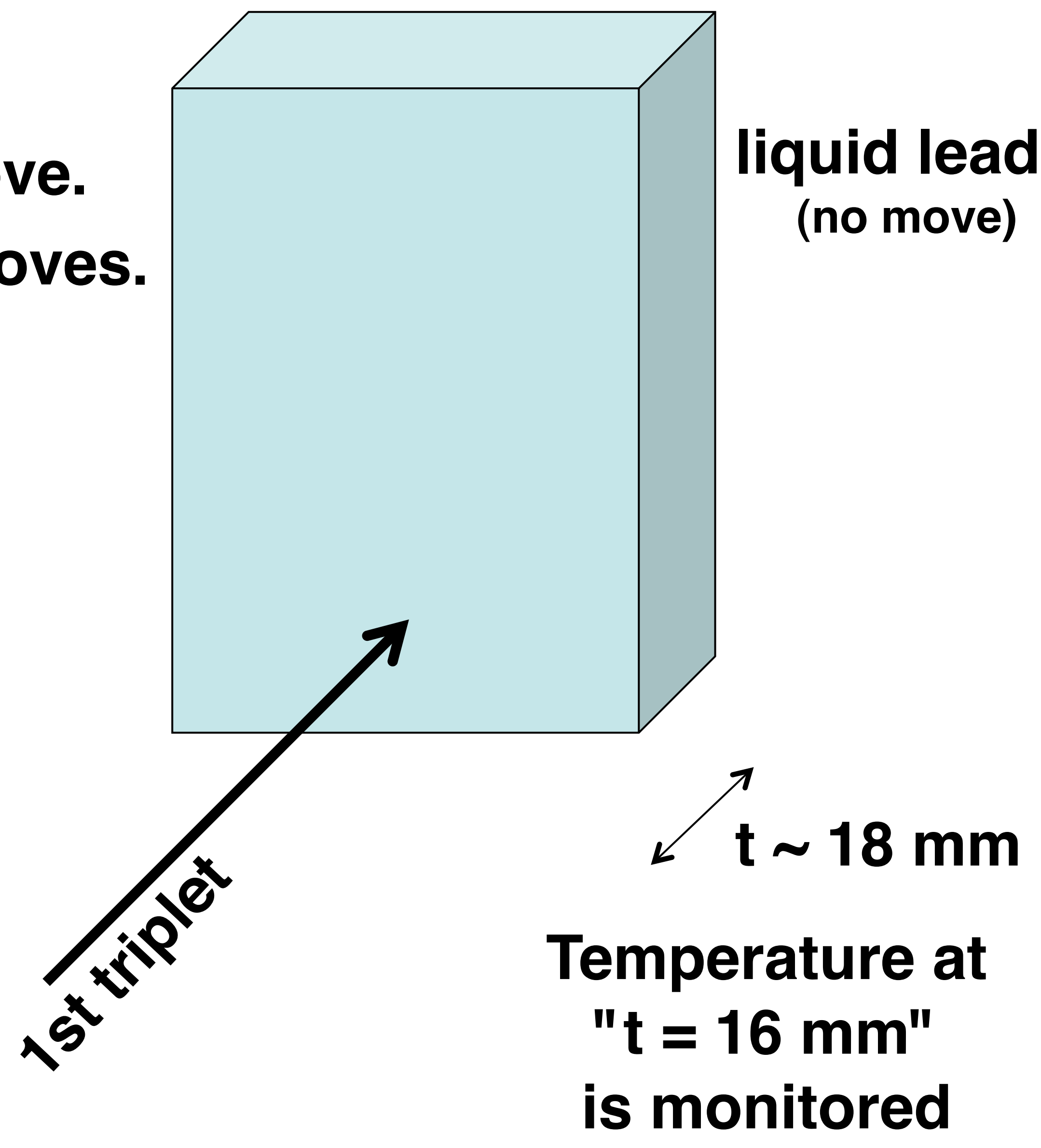


Simulation of heating by beam (Wanming-san)
Simulation of eddy current (James-san)

Simulation of heating by beam (Wanming-san)

Model

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



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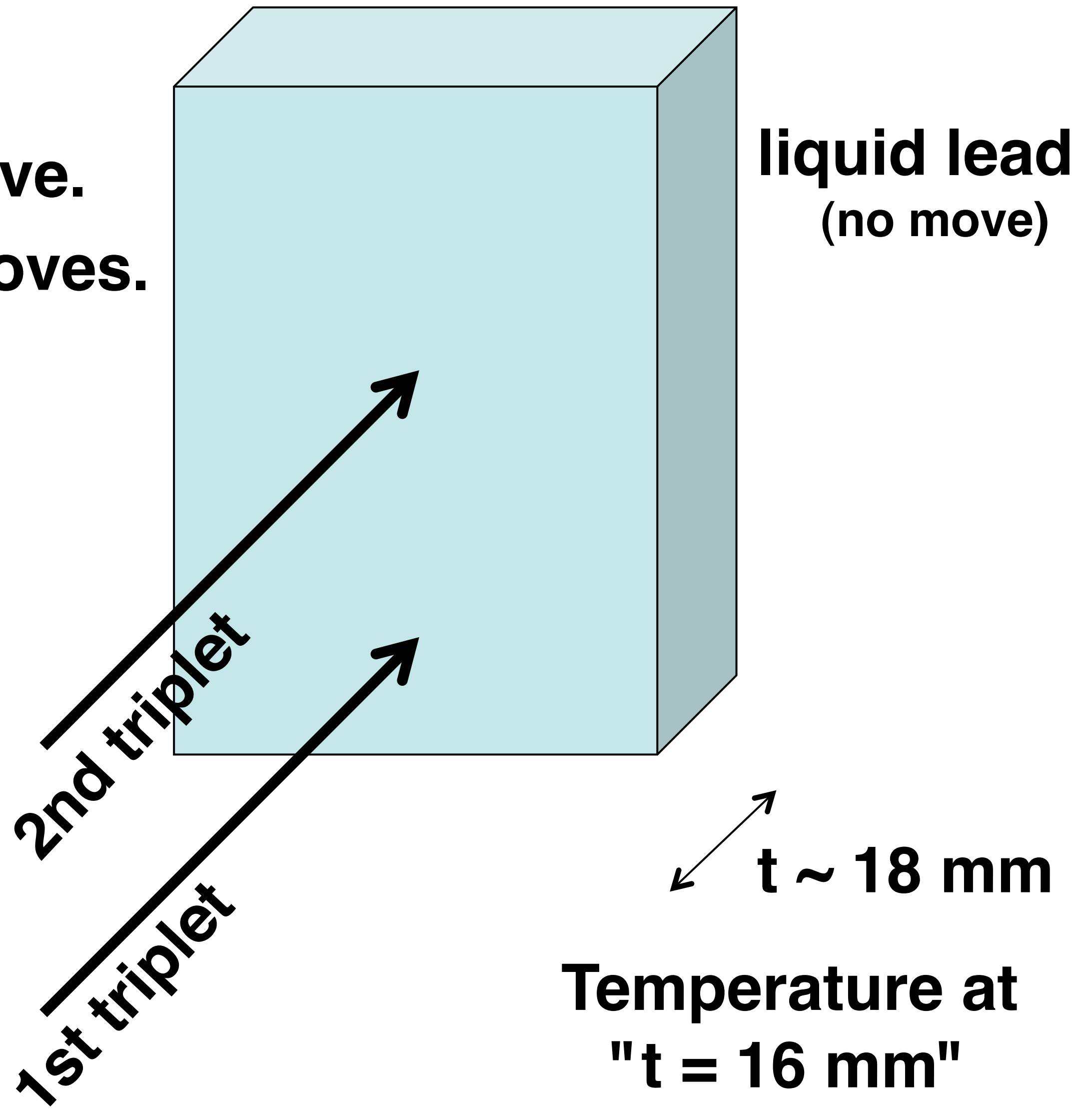

Temperature at "t = 16 mm" is monitored

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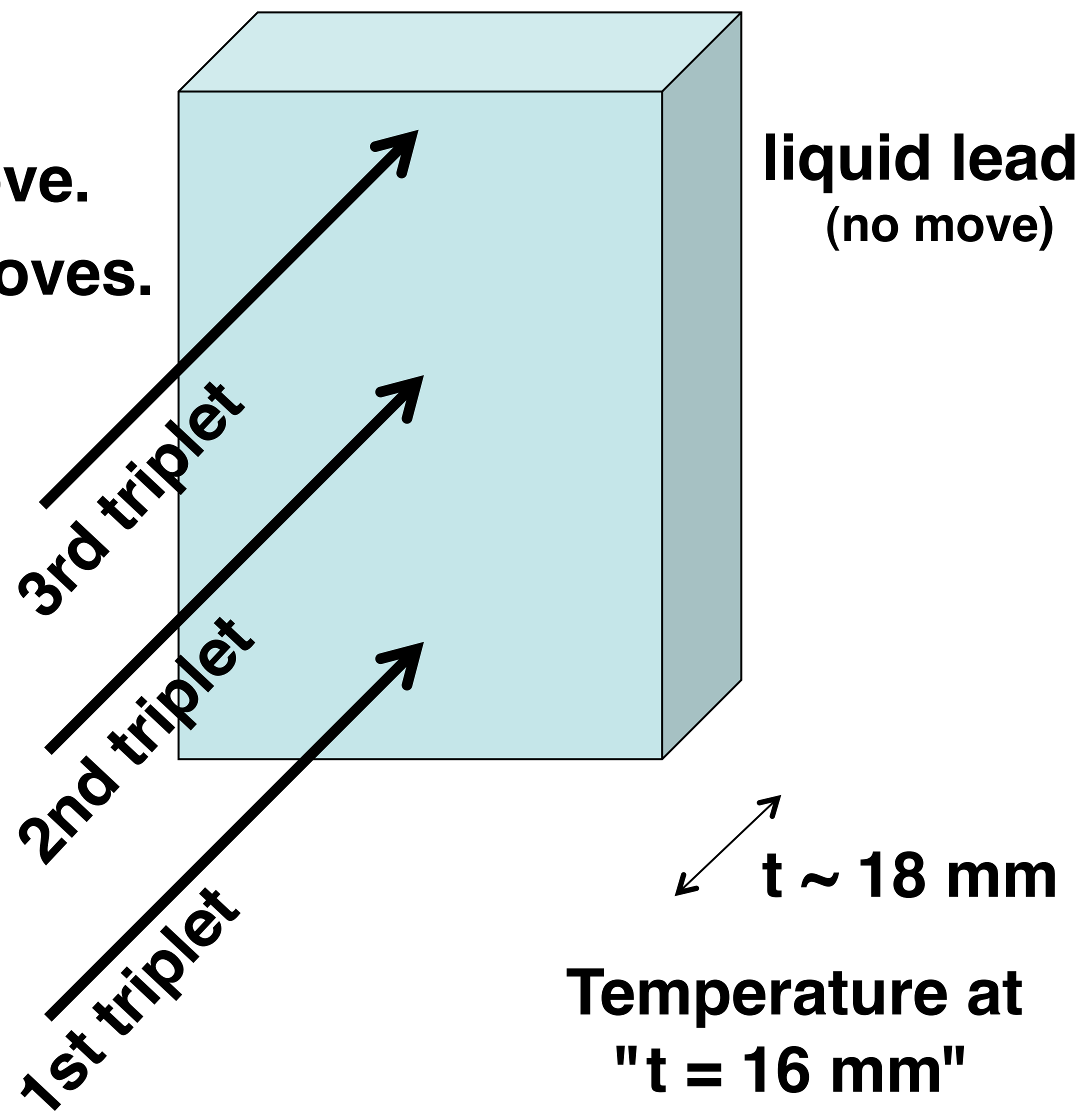

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Simulation of heating by beam (Wanming-san)

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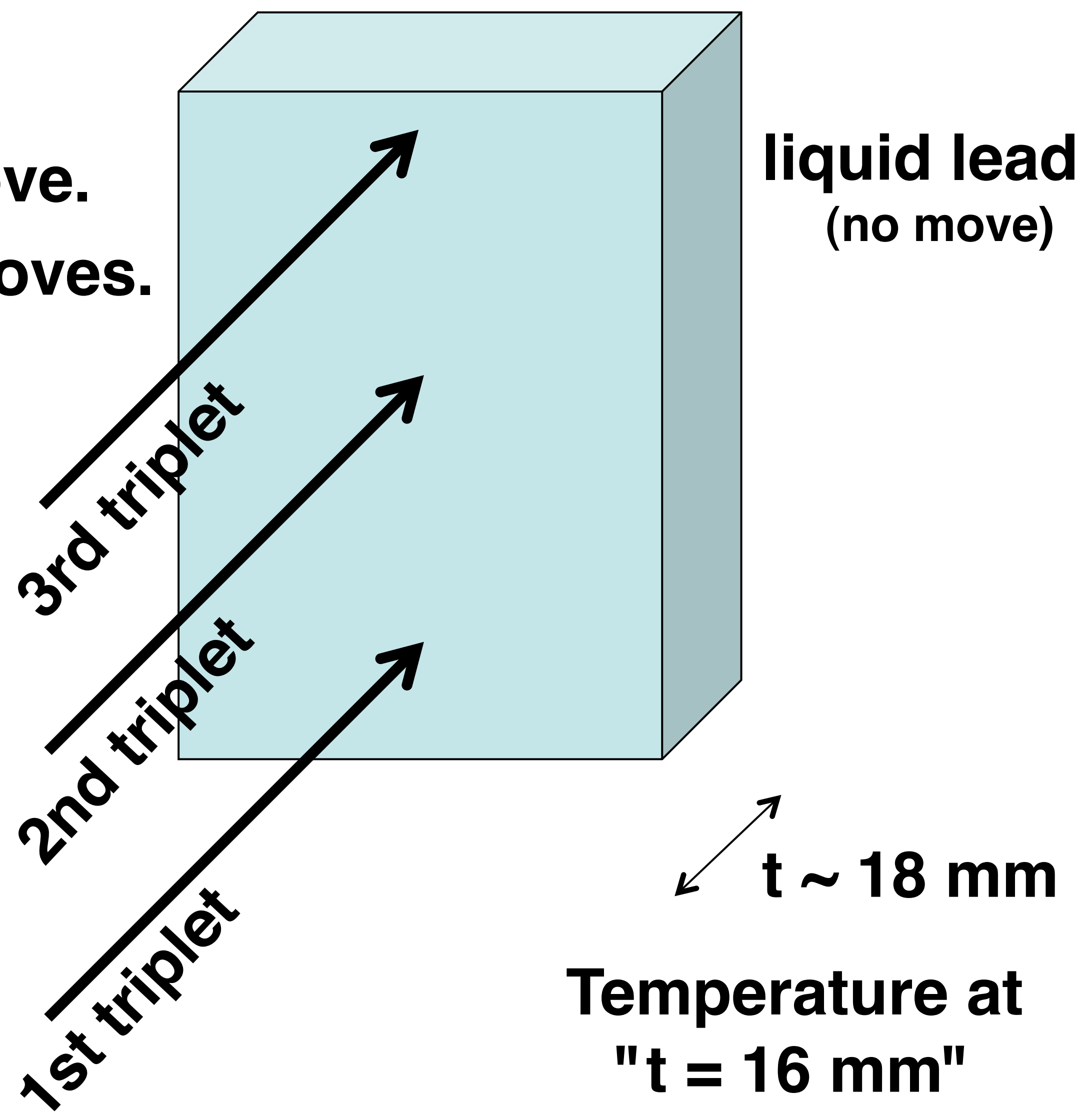
It is not written in this figure, however bunch structure in the triplet (= 3 mini-trains) is reproduced in the simulation.



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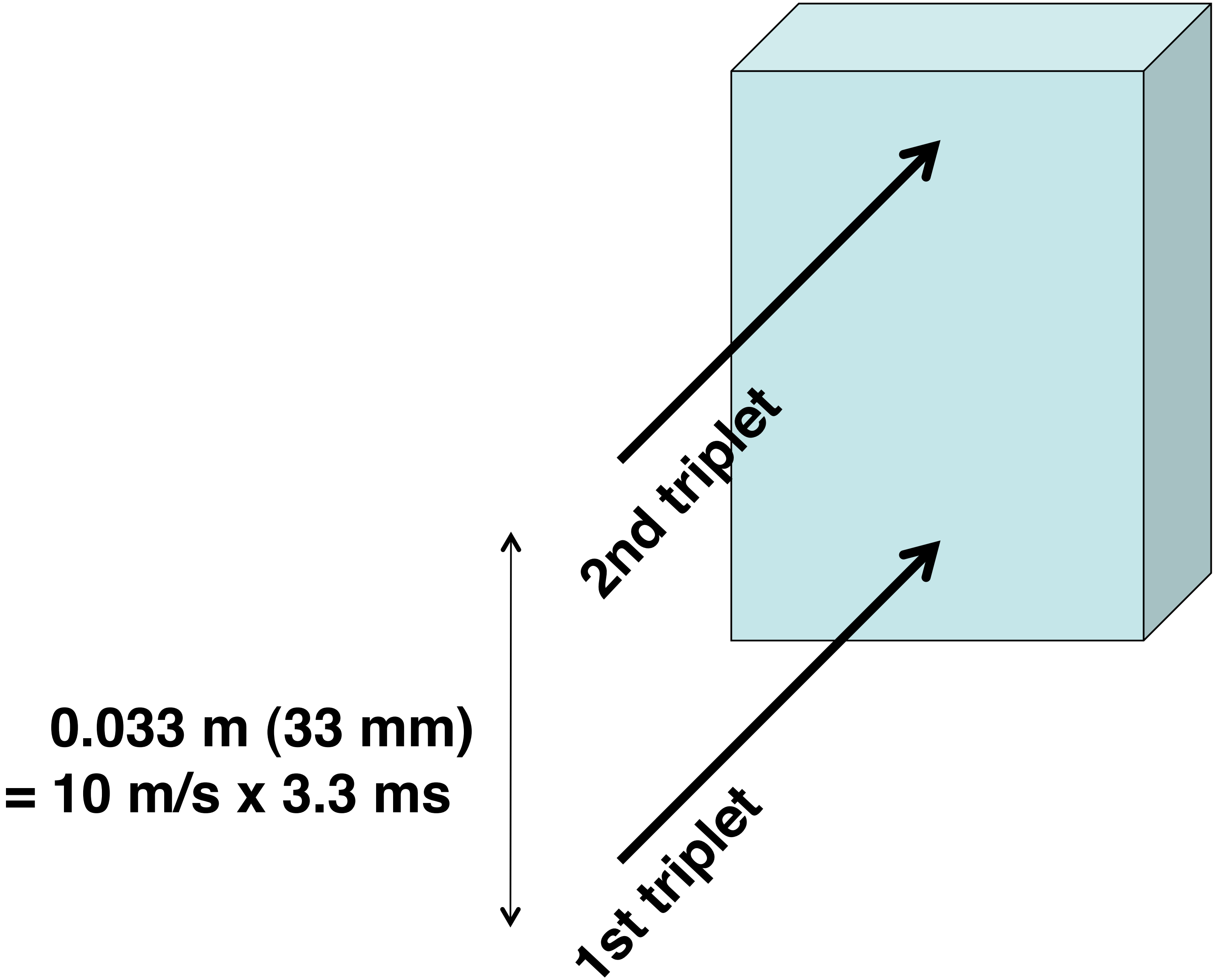
10 m/s, after 2 triplets



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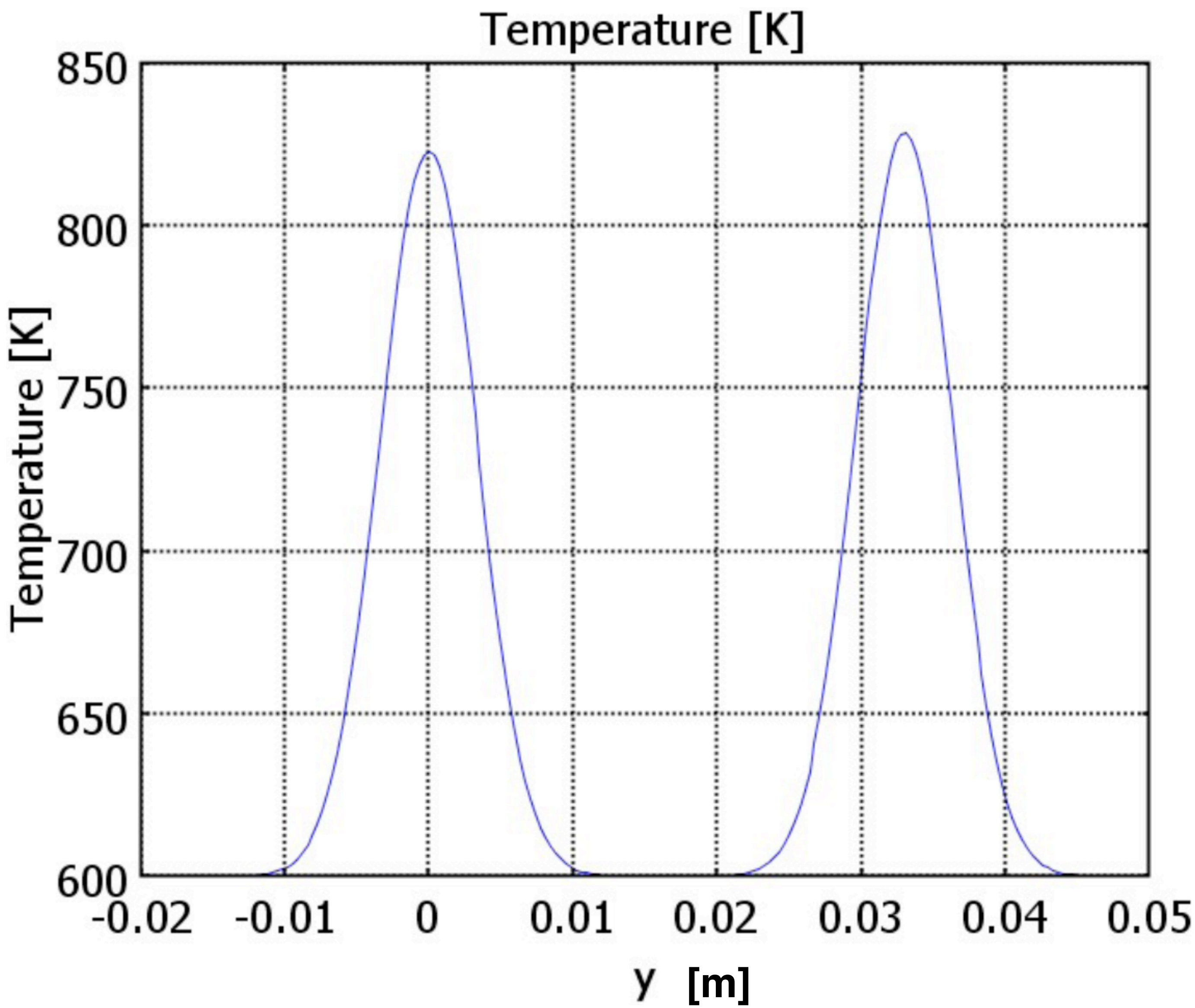
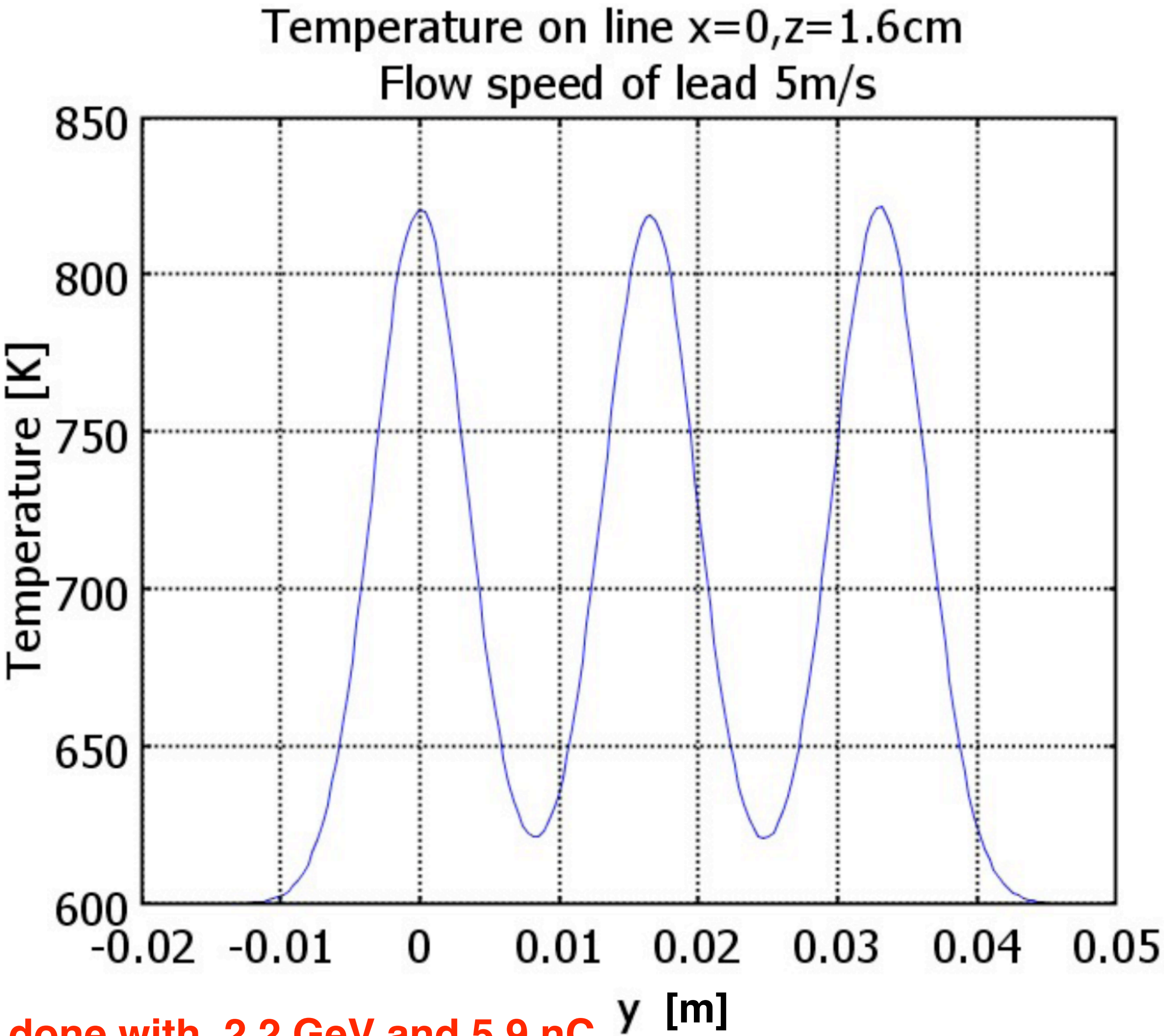


sim. was done with 2.2 GeV and 5.9 nC.

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

Wanming (ANL)

5 m/s, after 3 triplets



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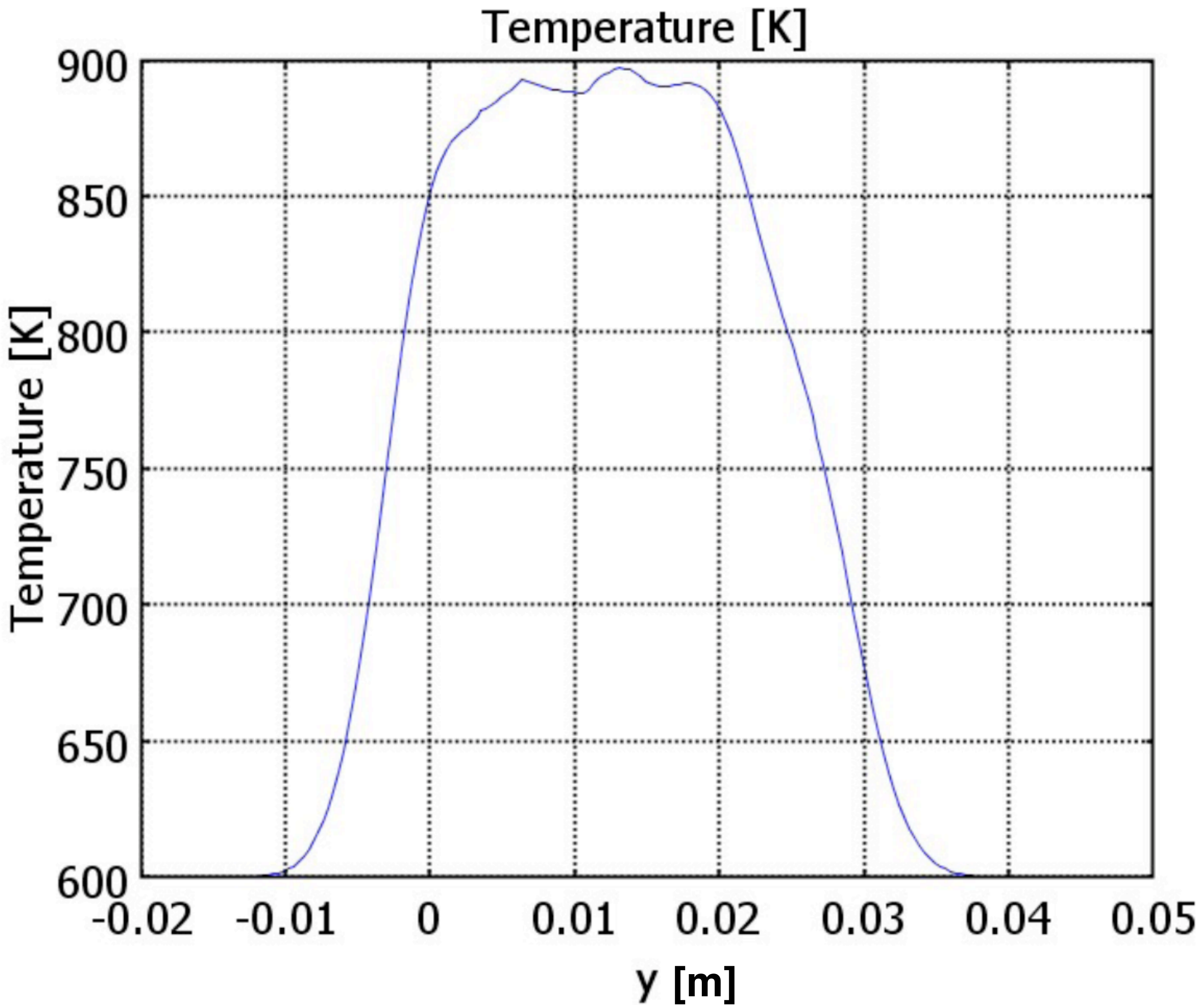
Wanming (ANL)

2 m/s, after 5 triplets

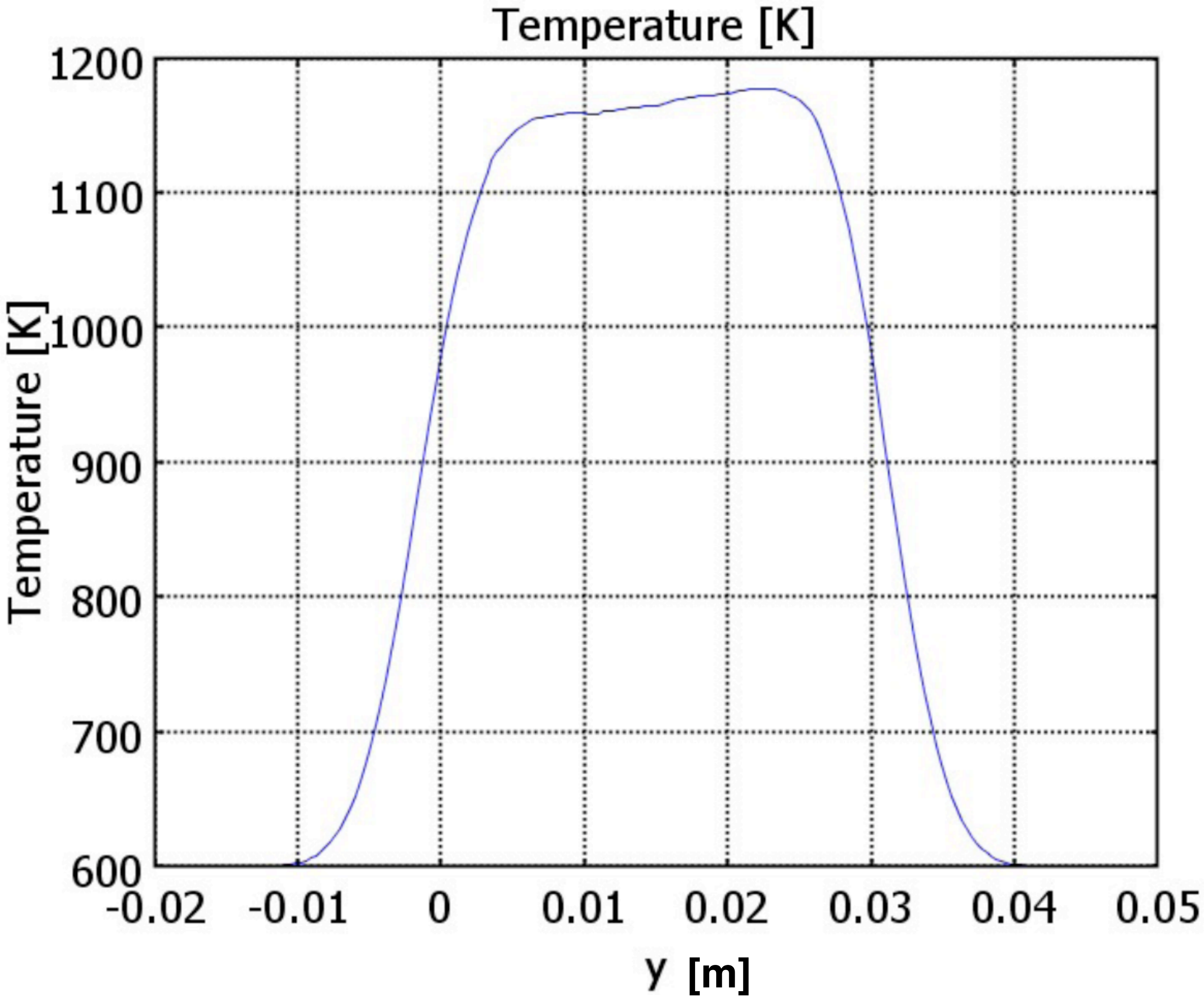


Wanming (ANL)

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

1 m/s, after 10 triplets



Wanming (ANL)

sim. was done with 2.2 GeV and 5.9 nC.
If 2.2 GeV --> 3.5 GeV, delta T change 570 K --> 910 K

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

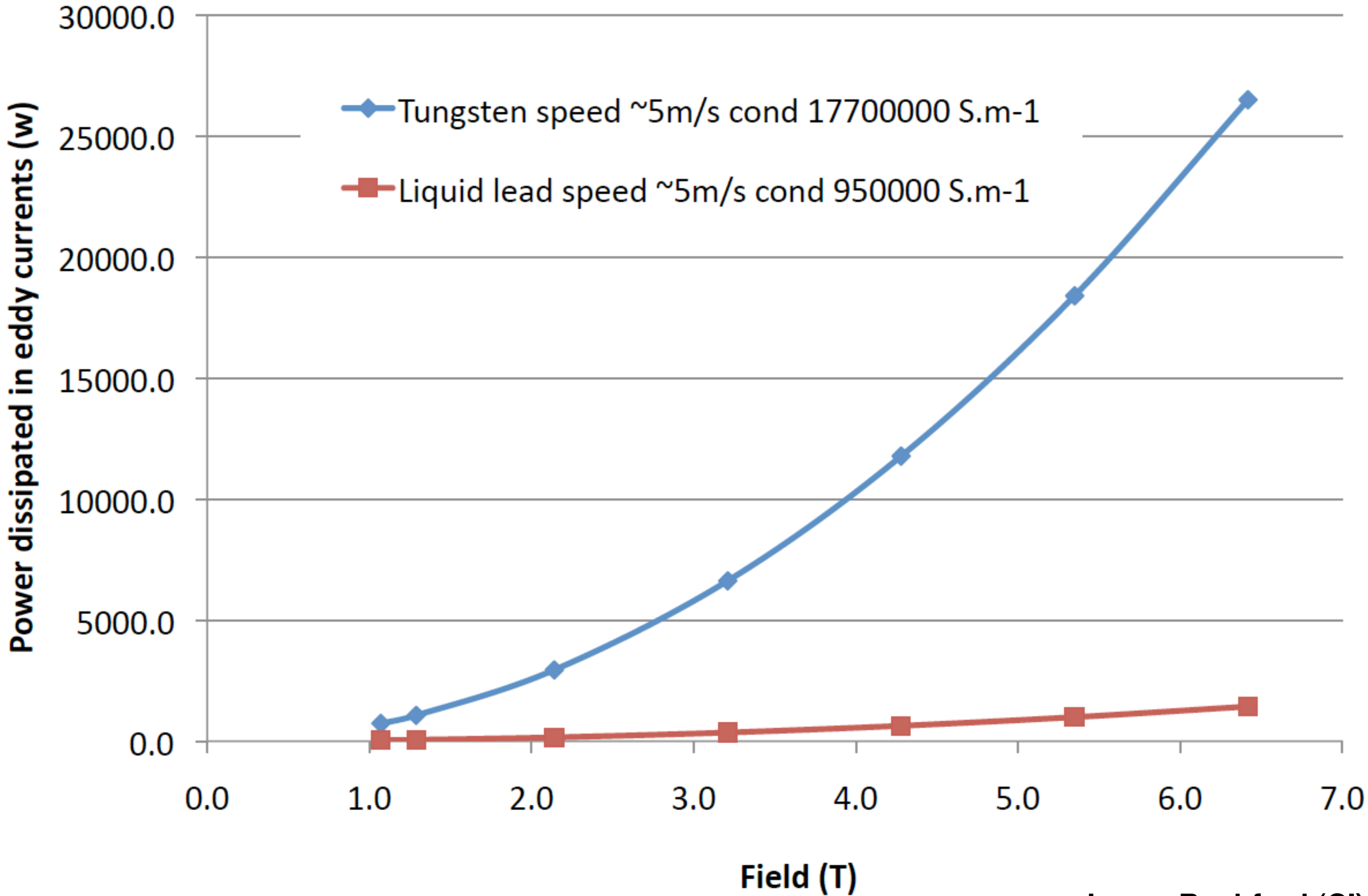
- a rotating rim (solid)
- mean diameter 0.955m
- angular velocity 99rpm
- rim speed of 4.95 m/s.
- the radial thickness of the rim = 4.5cm
- the longitudinal thickness =14mm

Result of simulation

5 m/s, solid lead, 6 Tesla immerse target

--> ~ 1 kW

Heating by eddy current (James Rochford)



James Rochford (CI)

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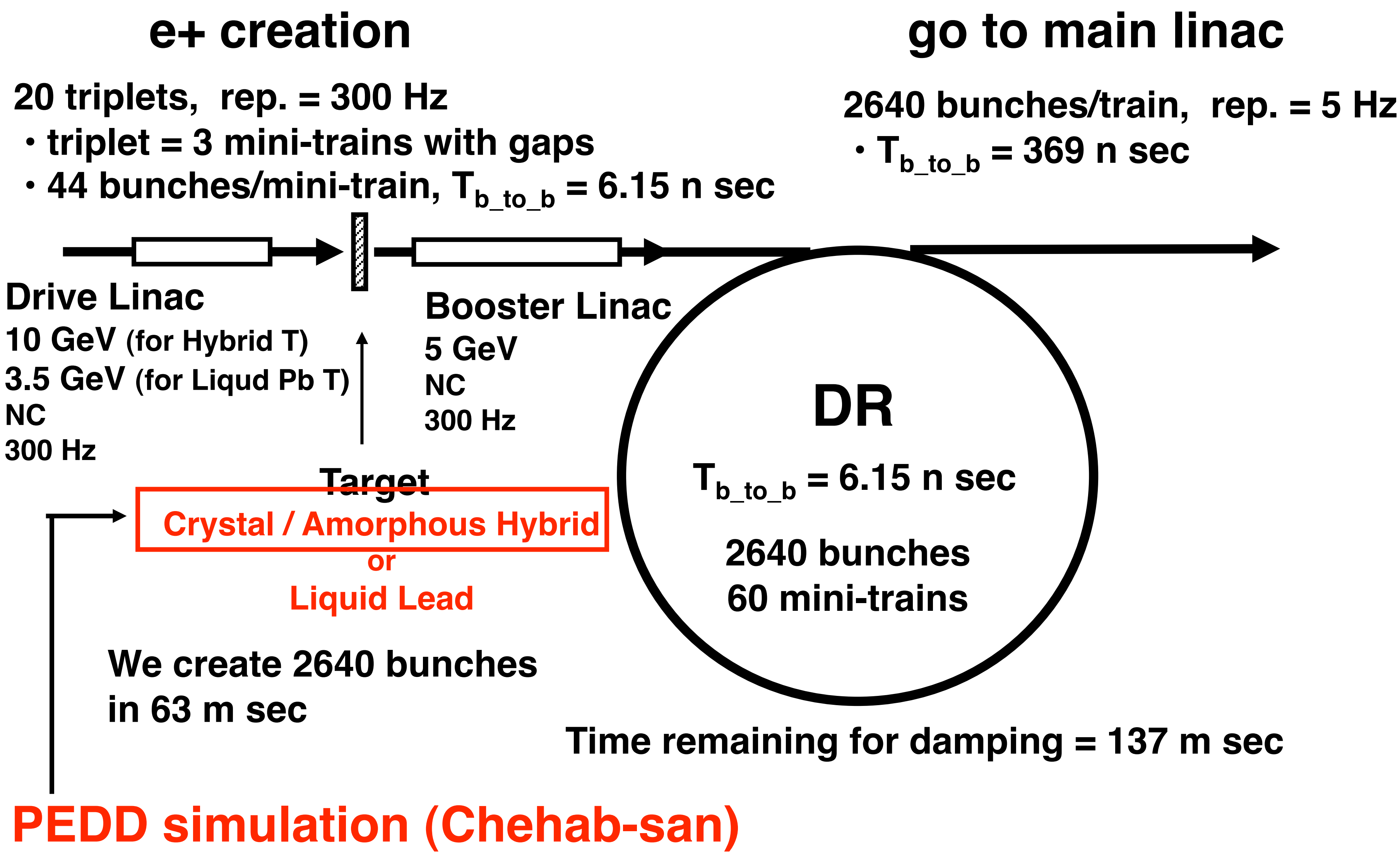
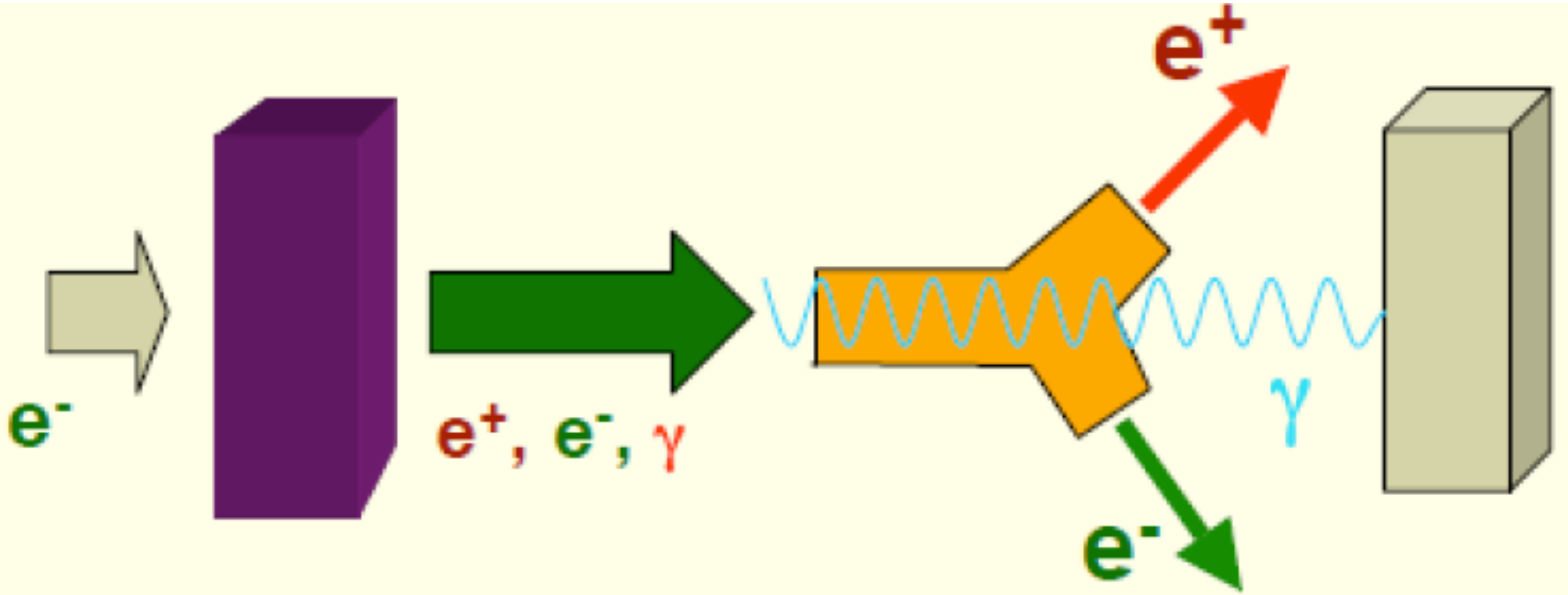


Hybrid Target

Chehab-san



"Radiator"
Thin CRYSTAL

"Converter"
Thick AMORPHOUS

Hybrid Target

Chehab-san

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 σ=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 η_+ [~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 η+ :

	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

  - We recall that these results correspond to an incident e- beam with σ= 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

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Hybrid Target

Chehab-san

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Hybrid Target reduces PEDD ~ 1/5

Hybrid Target

Chehab-san

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- (σ^-=1mm)
- 1.5 e+/e- (σ^-= 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
σ^-=1mm	2 GeV/cm3	0.33 J/g/bunch	7.5 GeV/cm3	1.25 J/g/bunch
σ^-=2.5mm	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

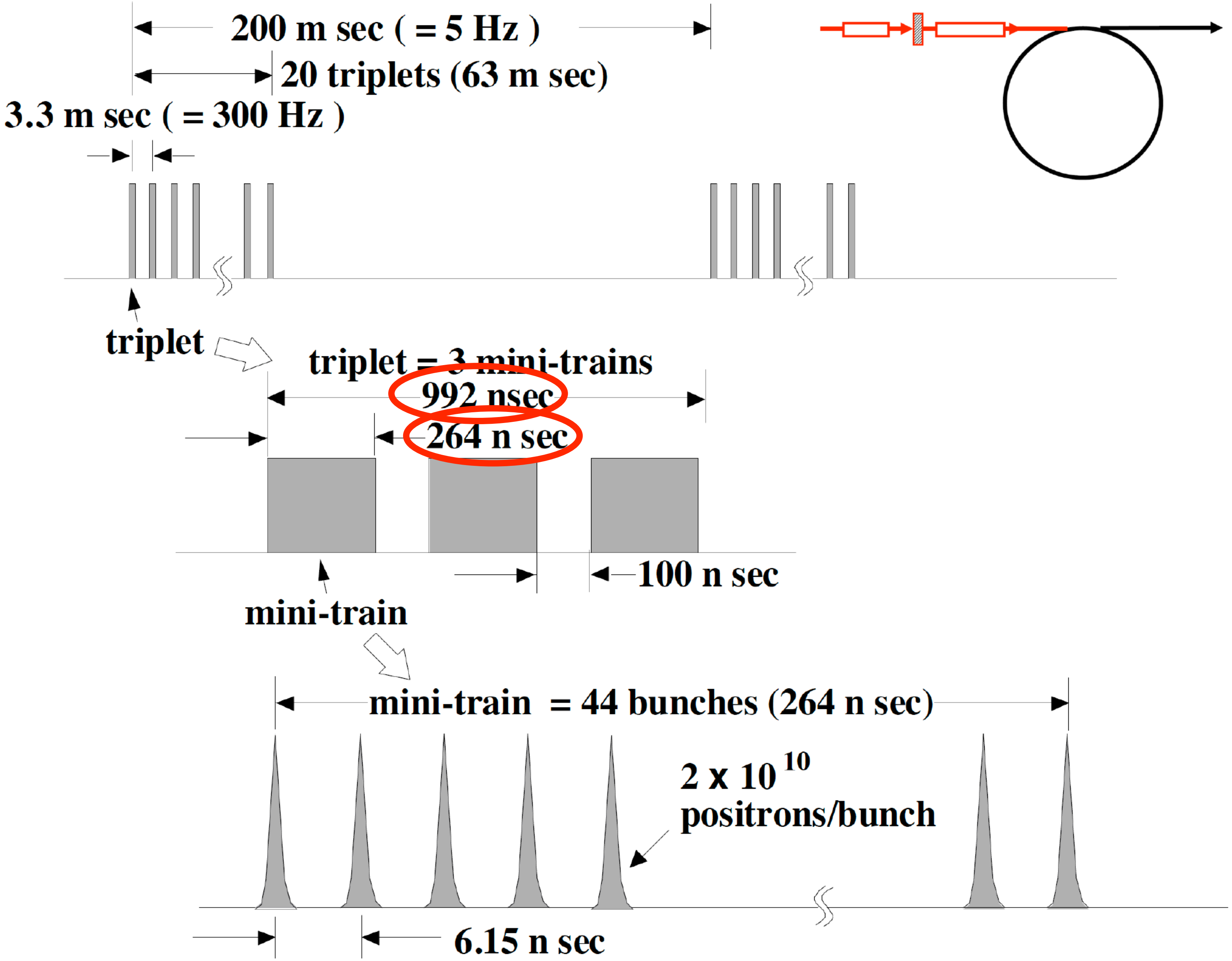
If accumulate 132 bunches (1000 ns) --> 44 J/g (> 35 J/g)

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

Question:

- **Time scale od acoustic shock wave?**
  100 ns?, 300 ns? 1000 ns?
- **What is the "real" limit?**
  Is "35 J/g" reliable?

Beam before DR



300 Hz e^+ Generation solves flux Concentrator issue

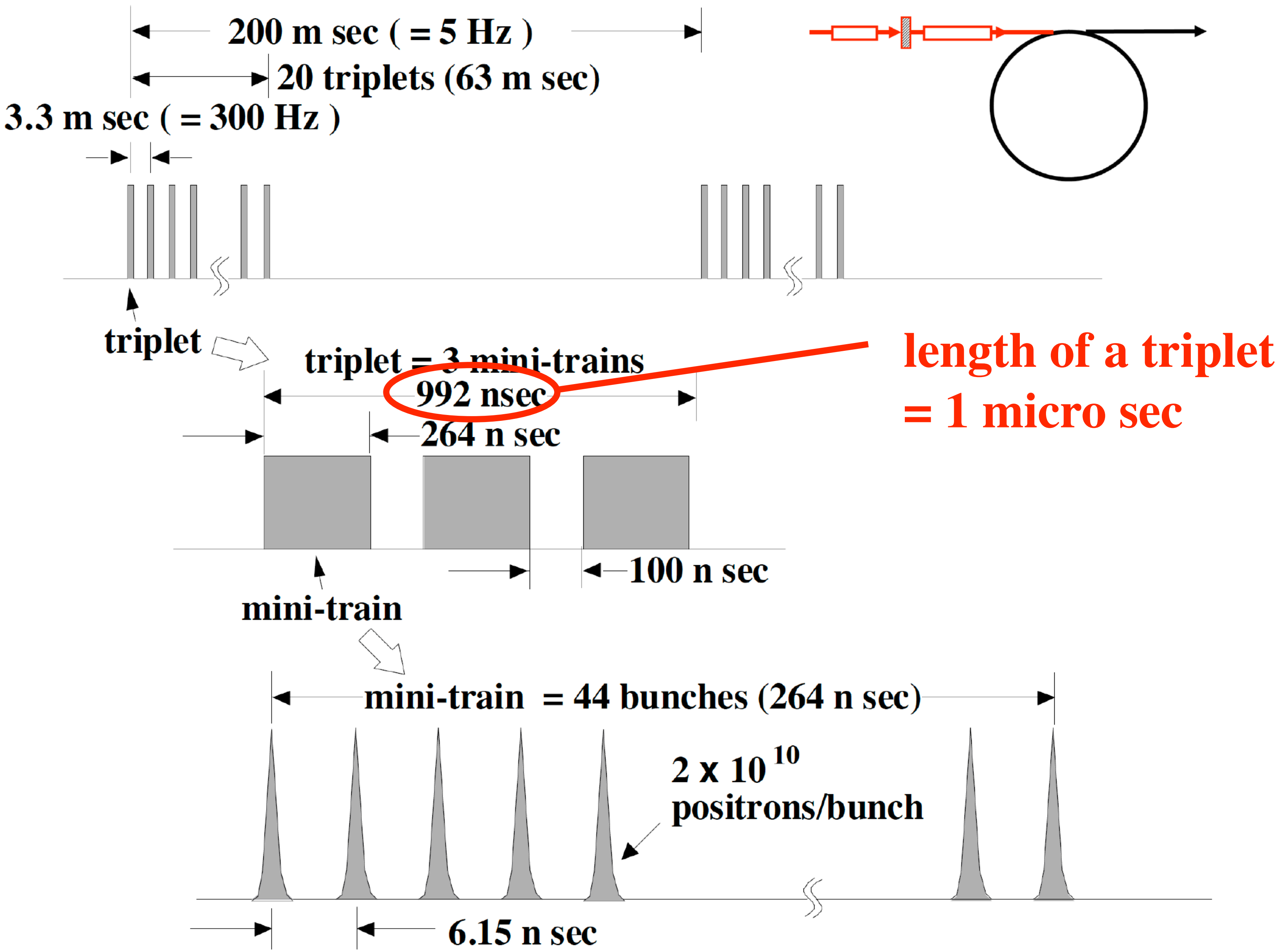
- 1 micro sec flux concentrator <-- existing technology
  - It was working at SLC.
    6 T, 120 Hz
  - Prototype study is ongoing for SuperKEKB
    10 T, 50 Hz, need long time operation test

- Baseline design assumes 1m sec flux concentrator

---> jump 1000 times

- 300 Hz generation use 1 micro sec flux concentrator

Beam before DR



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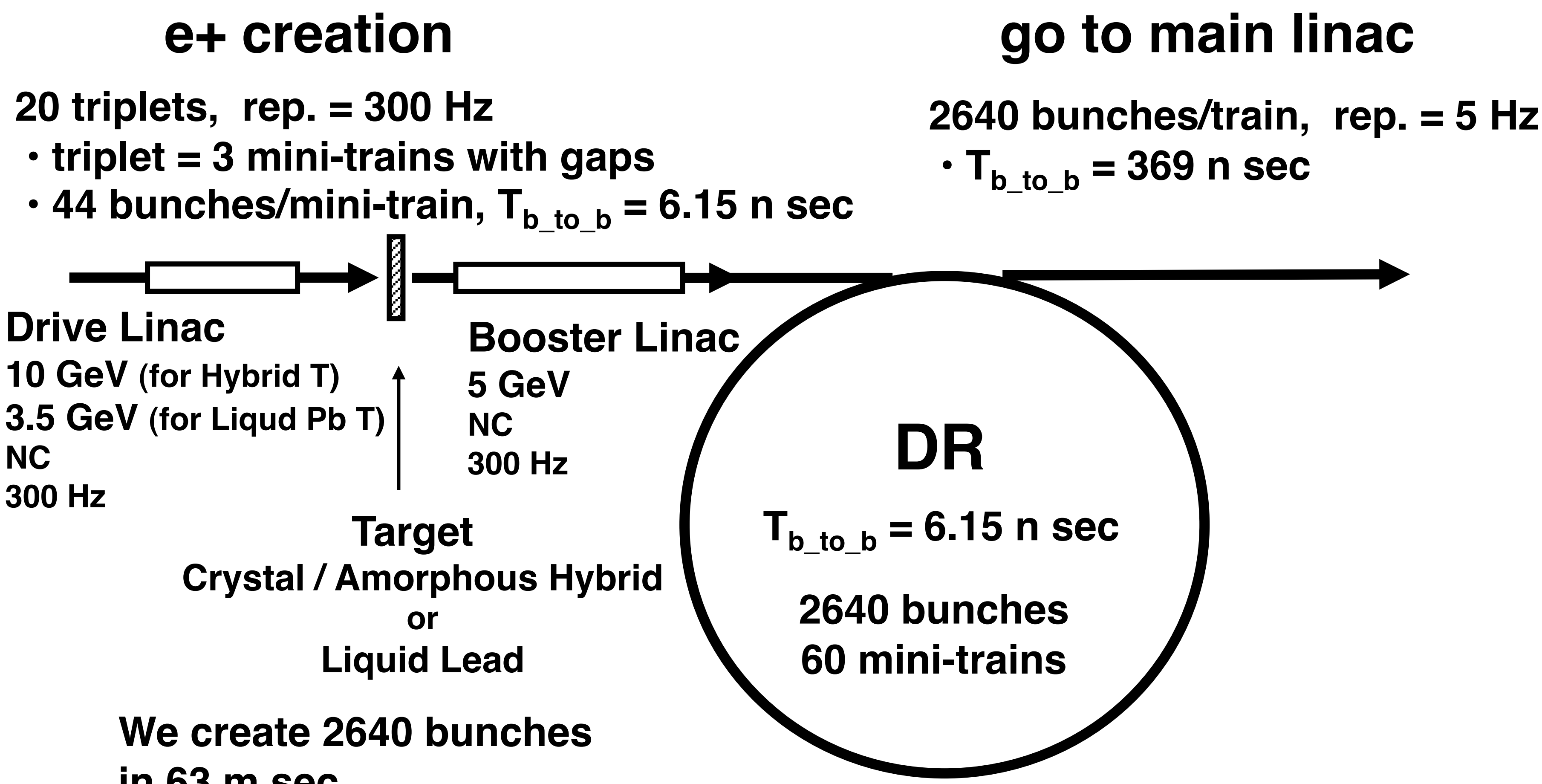

Time remaining for damping = 137 m sec
Is this OK?

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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 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