Overview of 300 Hz Conventional e^+ Source for ILC

T. Omori (KEK)

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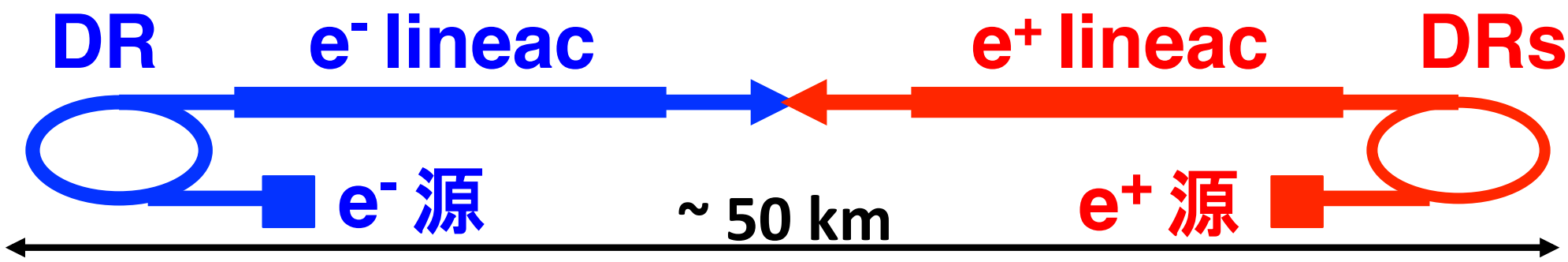
LCWS 2014, Hyatt Regency, Belgrade

Truly Conventional Collaboration

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

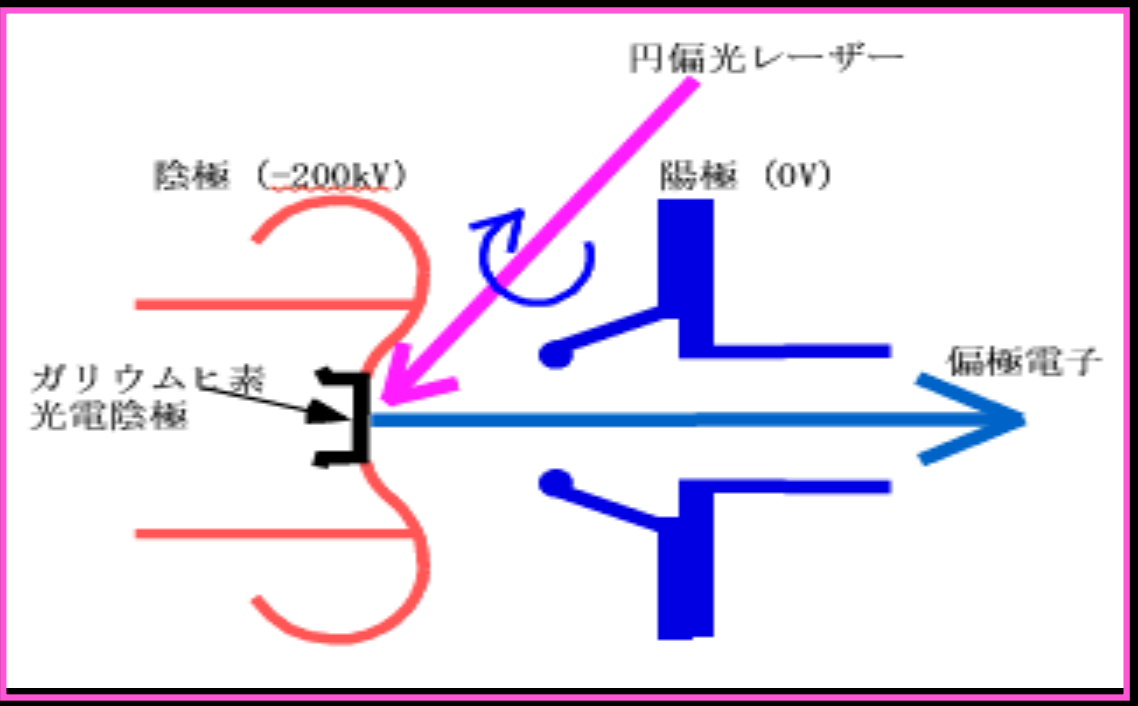
NIM A672 (2012) 52—56

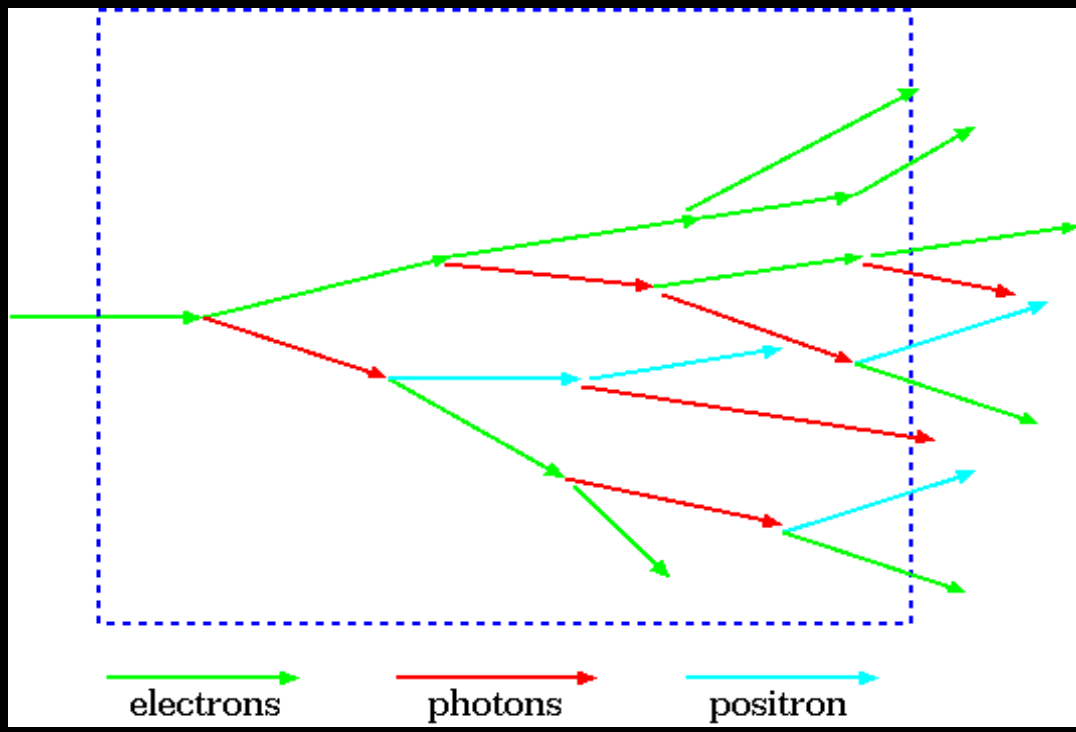
ILC: International Linear Collider



E_{cm} = 500 - 1000 GeV

e- source and e+ source





e- source

We extract electron from a material.

e+ source

There are no positrons in materials.
We have to "create" positrons.

Flux of e^+

	SLC	CLIC (3 TeV)	ILC (RDR)	LHeC
Energy	1.19 GeV	2.86 GeV	5 GeV	100 GeV
e^+/ bunch at IP	40×10^9	3.72×10^9	20×10^9	15×10^9
e^+/ bunch before DR injection	50×10^9	7.6×10^9	30×10^9	15×10^9
Bunches / macropulse	1	312	2625	20833
Macropulse Repetition Rate	120	50	5	10
e^+ / second	0.06×10^{14}	1.1×10^{14}	3.9×10^{14}	31×10^{14}

x 18

x 65

ILC requires HUGE number of positrons.

Target Issues

Heat, Stress, and Vacuum

- **Undulator Scheme (base line)**
  - In order to create e+s, it uses e- beam in the main linac.
  - It creates 2600 bunches of e+s in 1 m sec.
  - Heat load is a serious problem.
  - It requires the challenging rotation target (100 m/s).
    (spreads 2600 bunches in 100 mm length)
  - Difficulty in cooling and vacuum.

- **300 Hz Truly Conventional**
  - It creates 2600 bunches of e+s in 63 m sec. (stretching)
  - We can employ much slower speed target: 3-5 m/s.

300 Hz scheme

e+ generation in 63 m sec (cf. undulator : in 1 m sec)

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 time space = 3.3 m sec
- Create 20 triplets : 63 m sec

→ **Stretching in time**

Conventional e+ Source for ILC

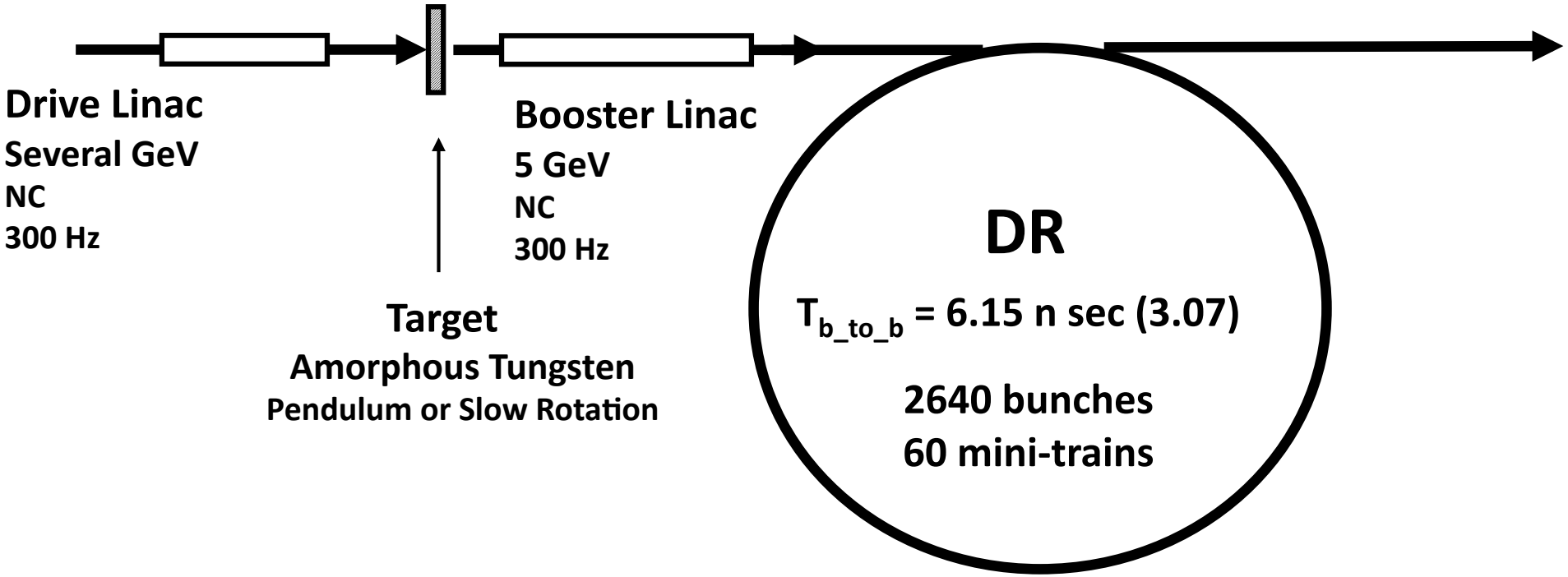
Normal Conducting Drive and Booster Linacs in 300 Hz operation

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



Time remaining for damping = 137 m sec

We create 2640 bunches
in 63 m sec

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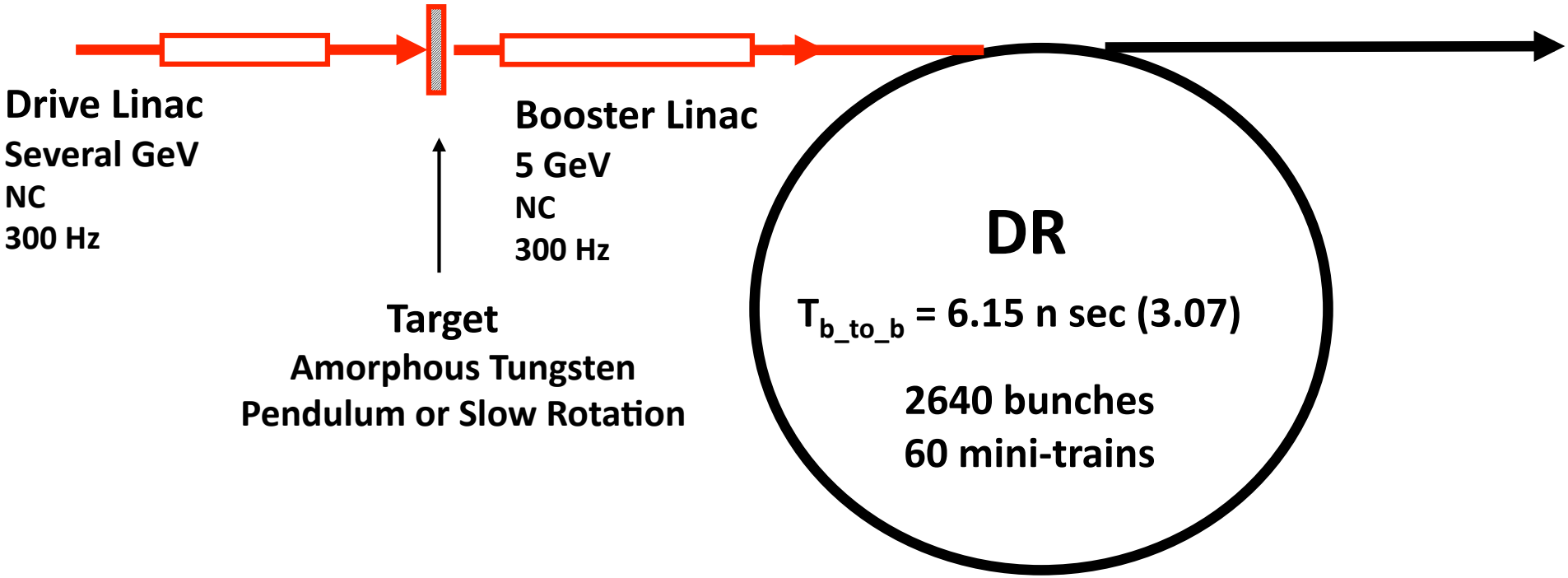
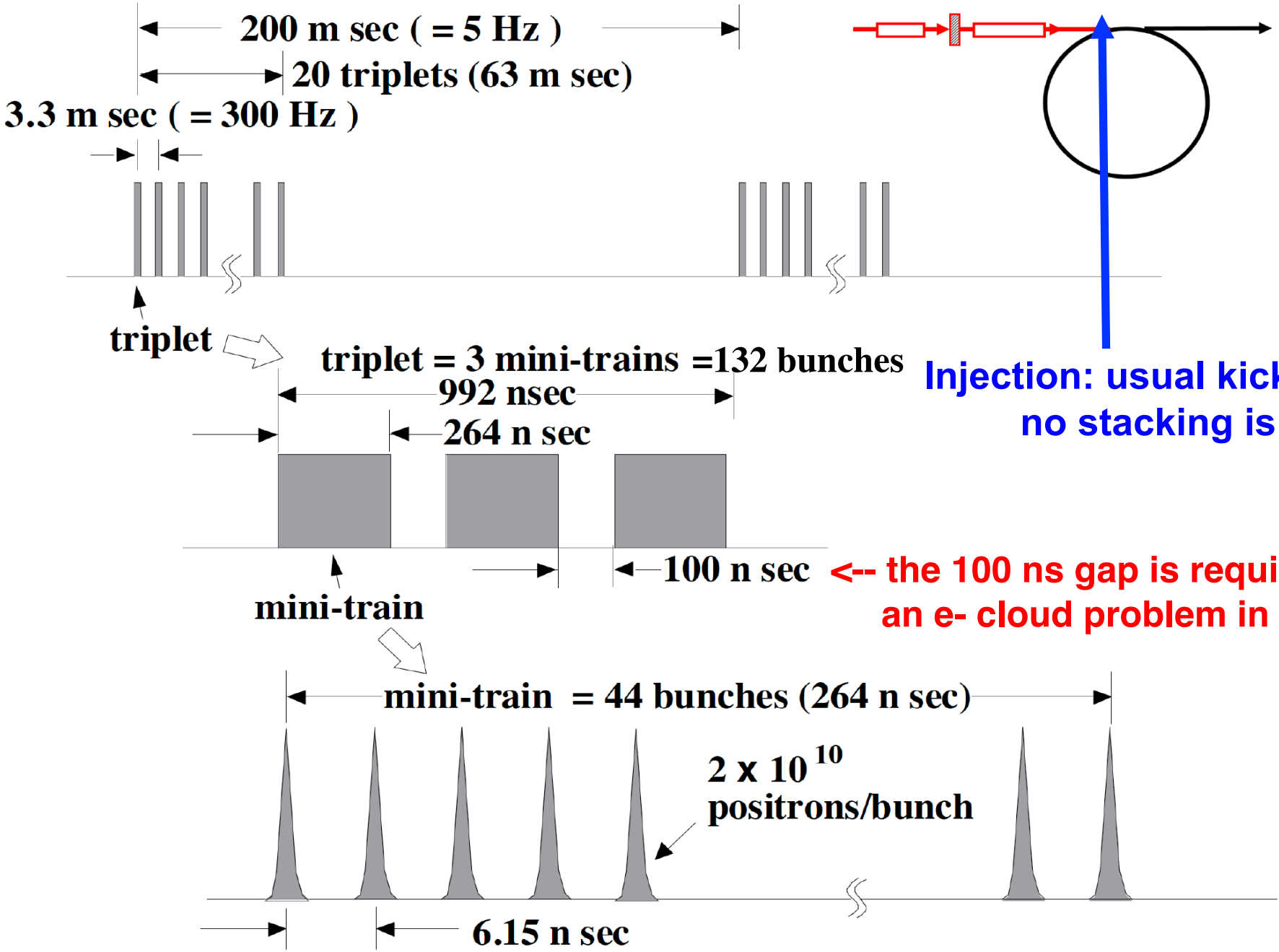


Time remaining for damping = 137 m sec

We create 2640 bunches in 63 m sec ← Stretching

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.

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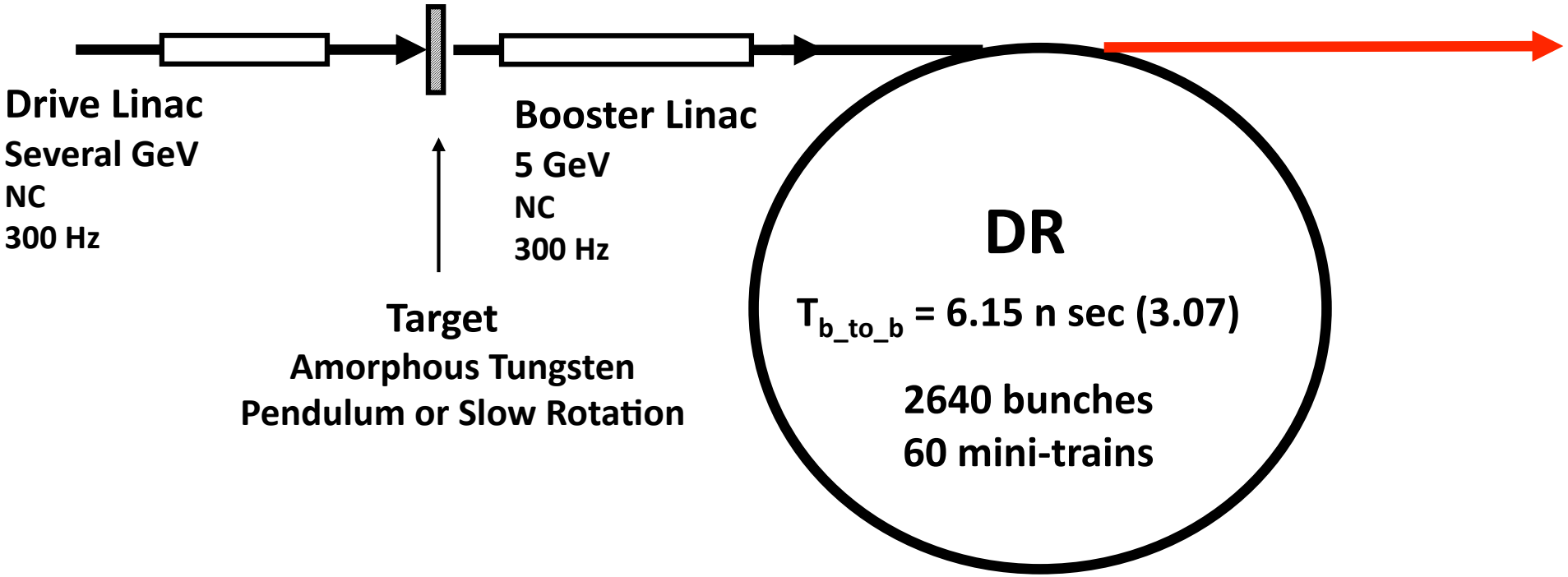

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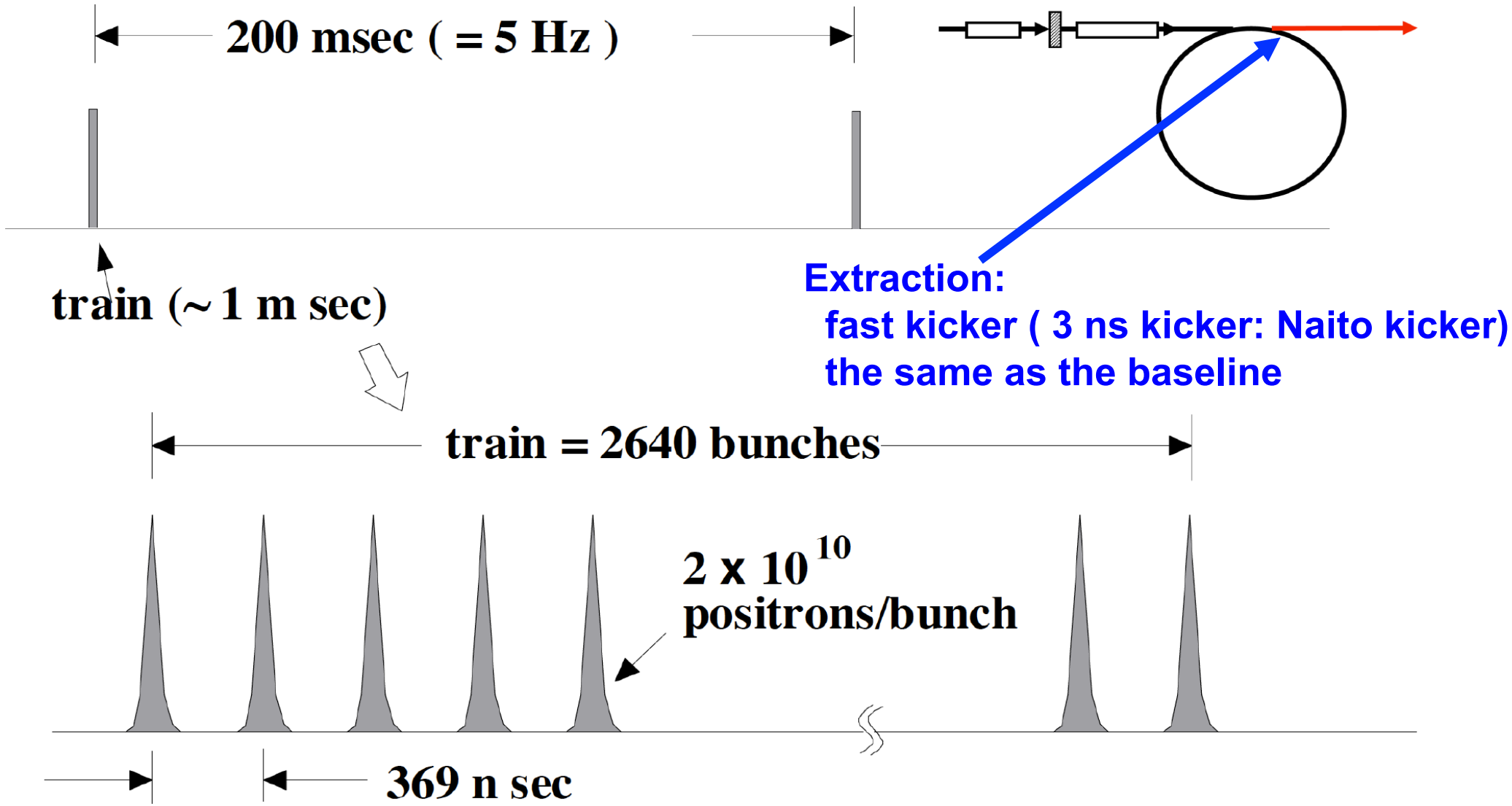
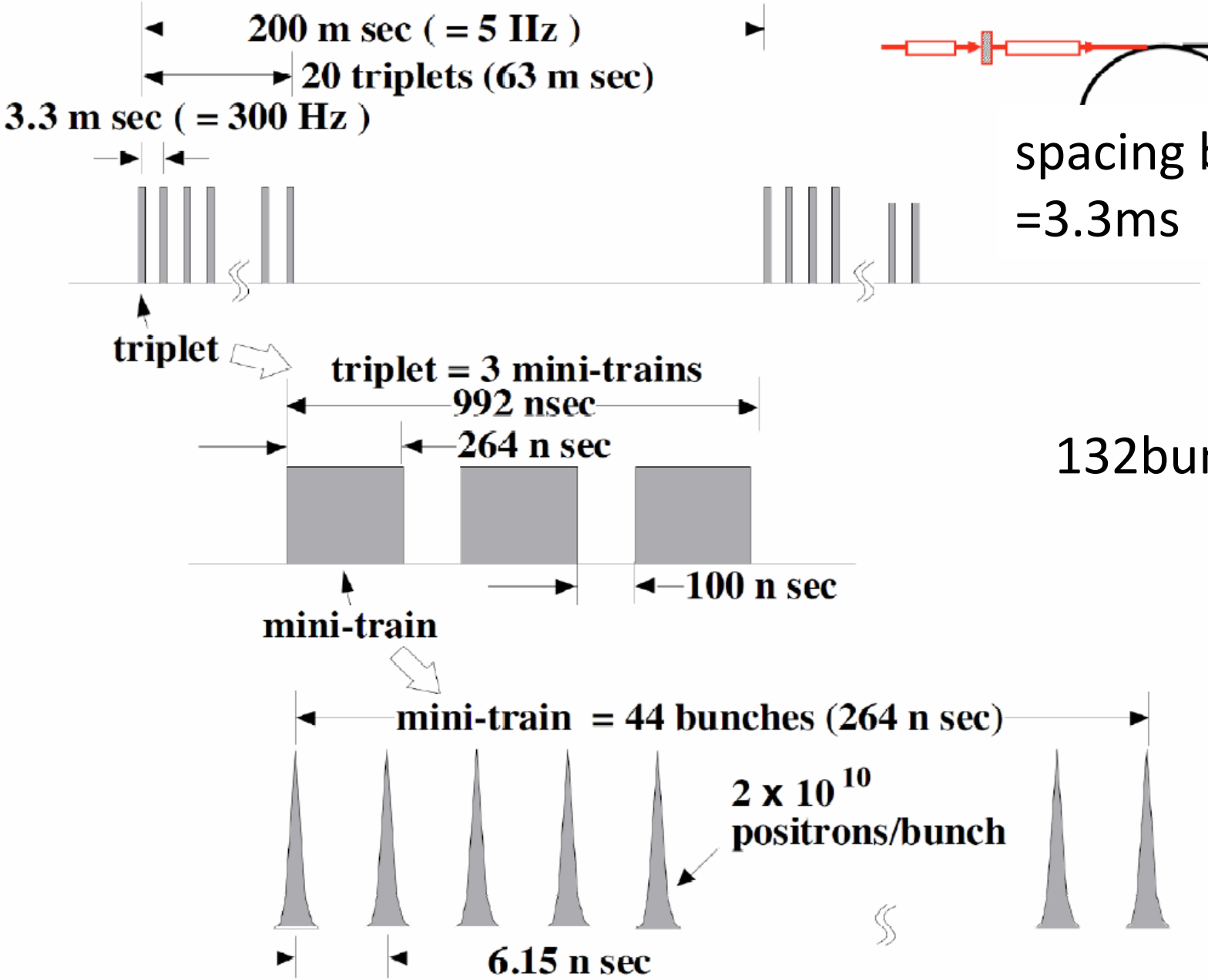
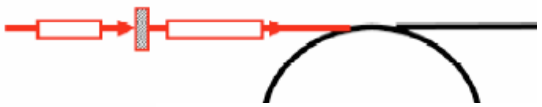


Target and Drive_Beam Optimization

In the case of 300Hz scheme





spacing between triplets =3.3ms

132bunches in 992ns

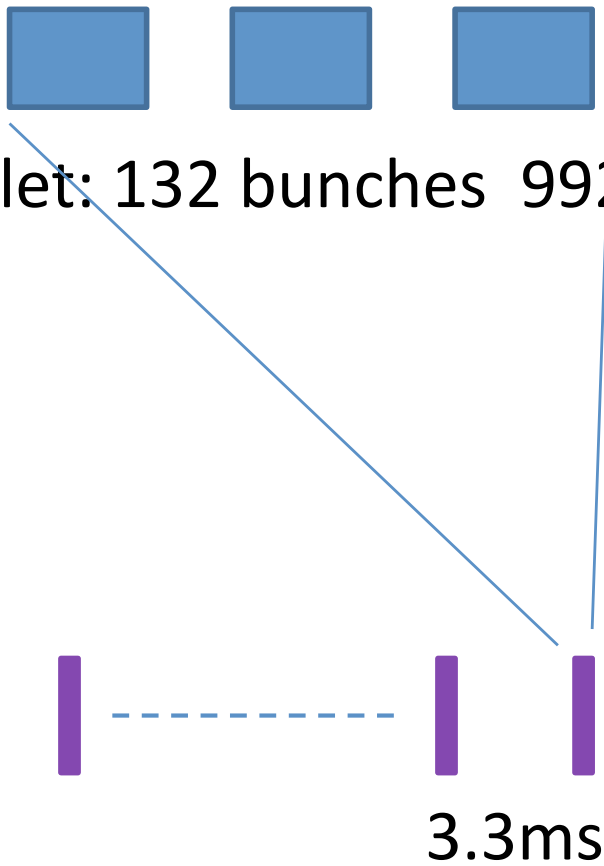
good for a FC

we can use existing FC technology

Assumptions

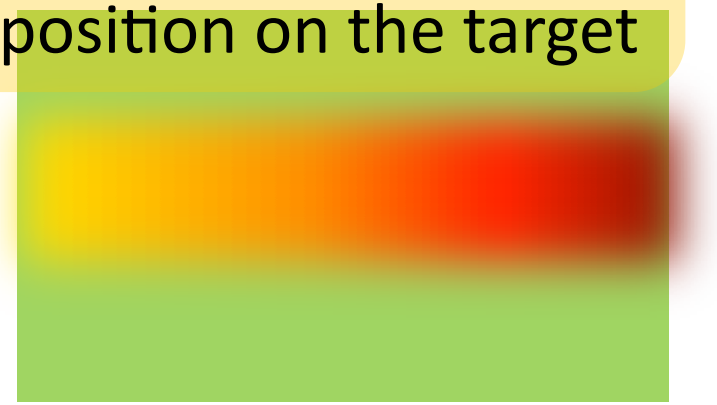
drive electrons

2×10^{10}/bunch



a train: 20 triplet
= 2640 bunches 63ms

132 bunches
make a shock wave
heat same position on the target



each triplet hits
different position on the target

pendulum or slow rotation target

Parameter Plots for 300 Hz scheme

e- directly on to Tungsten

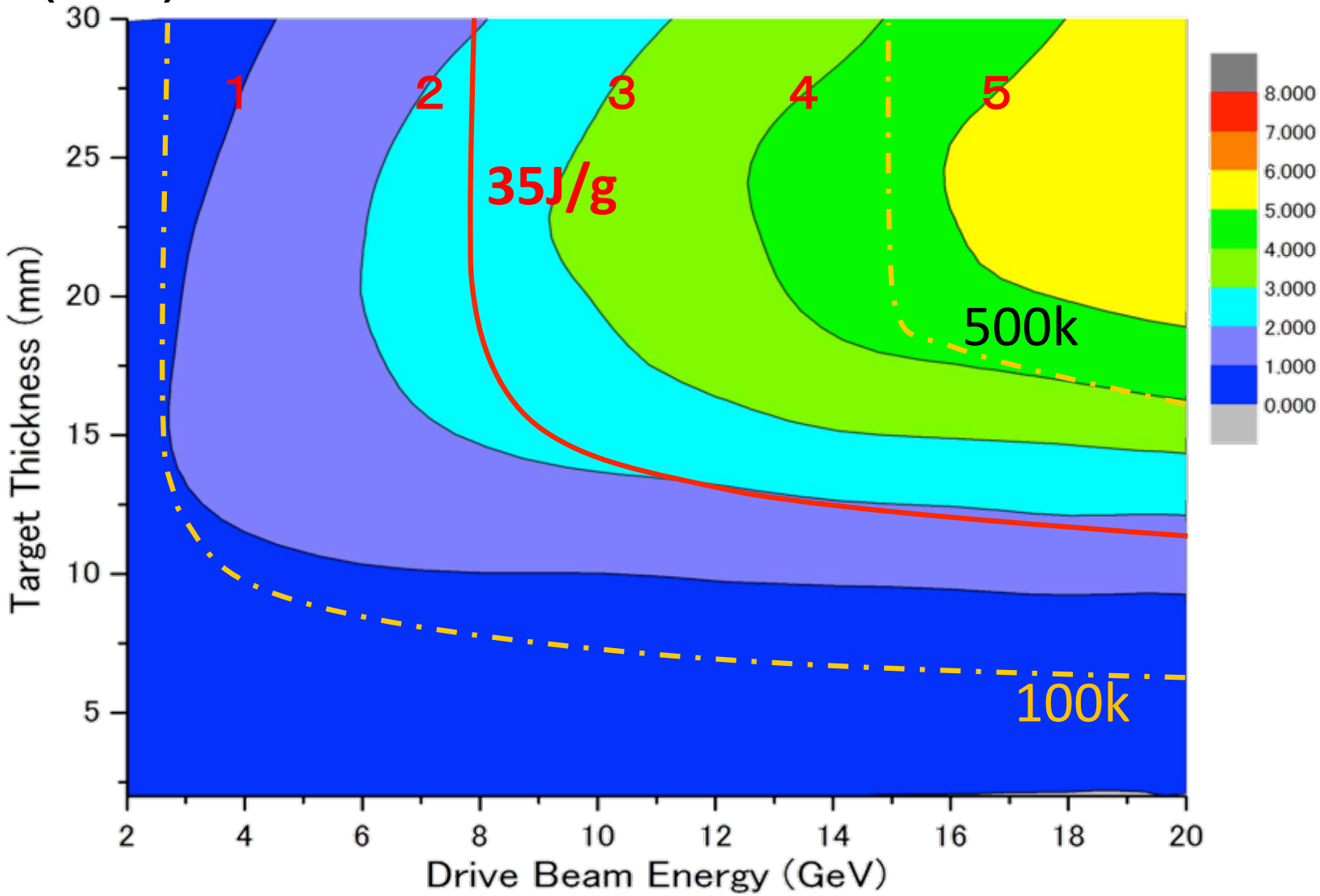
σ=4.0mm

Ne^-(drive) = $2x10^{10}$ /bunch

colored band — accepted e+/e-

PEDD J/g

dT max by a triplet



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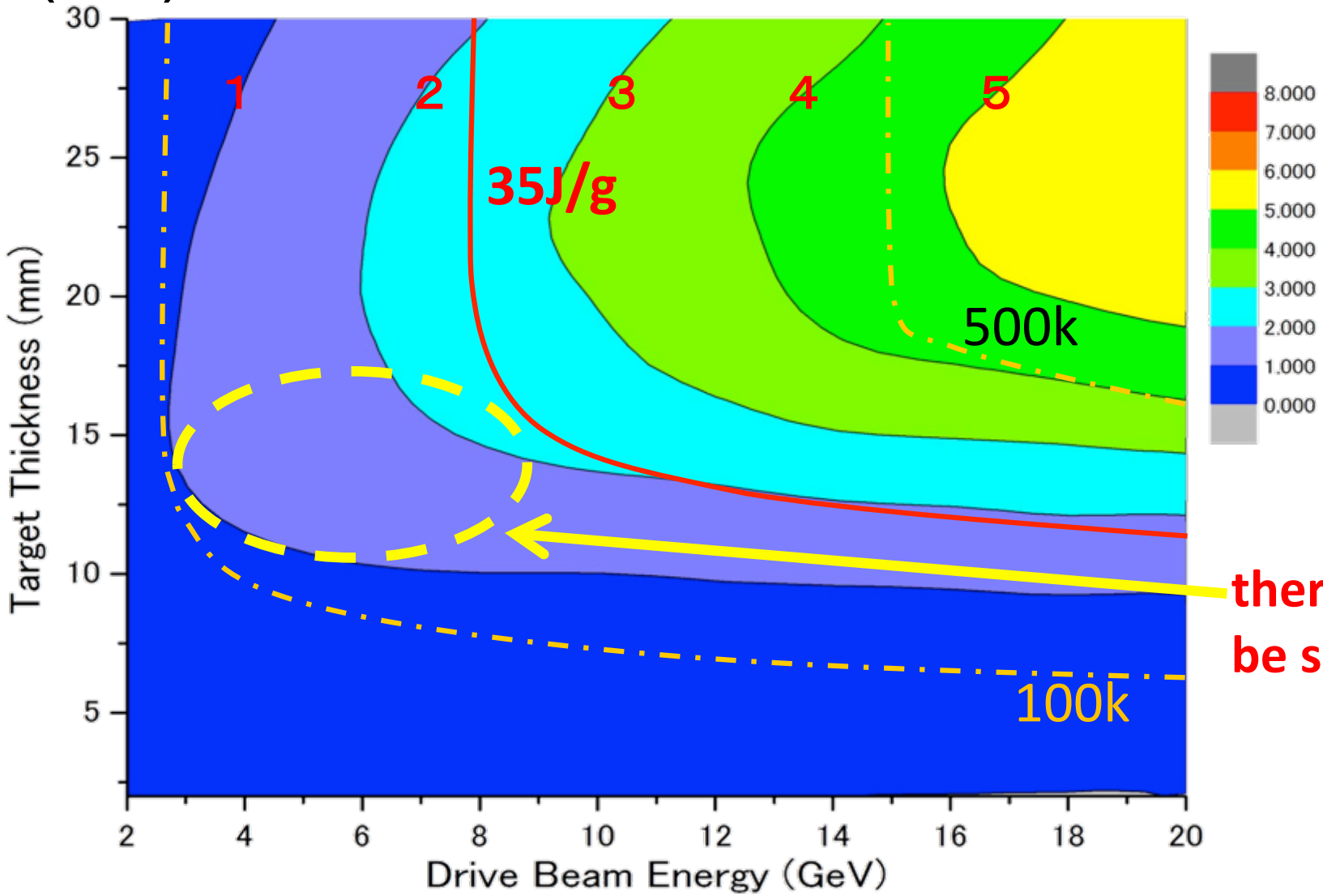
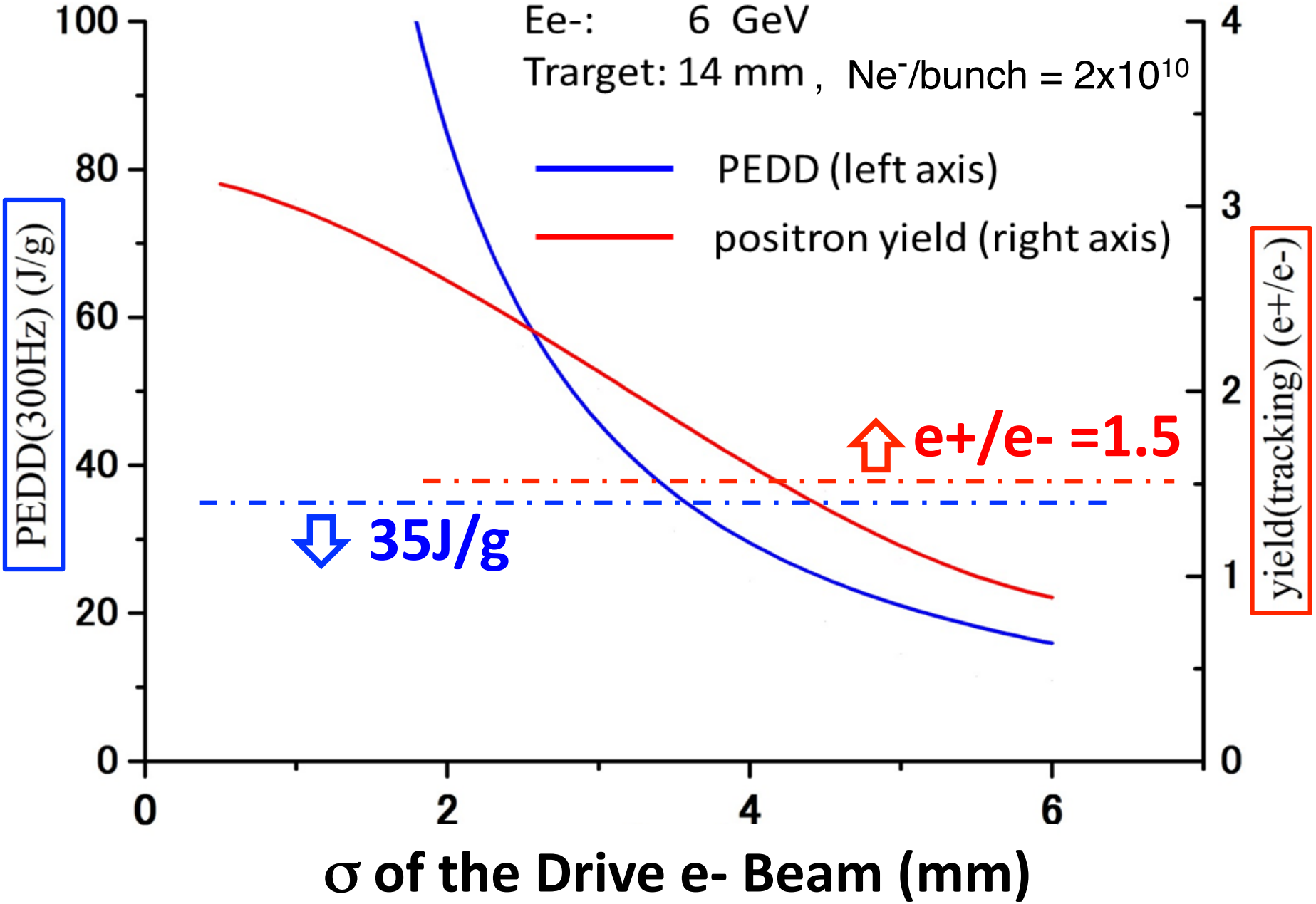
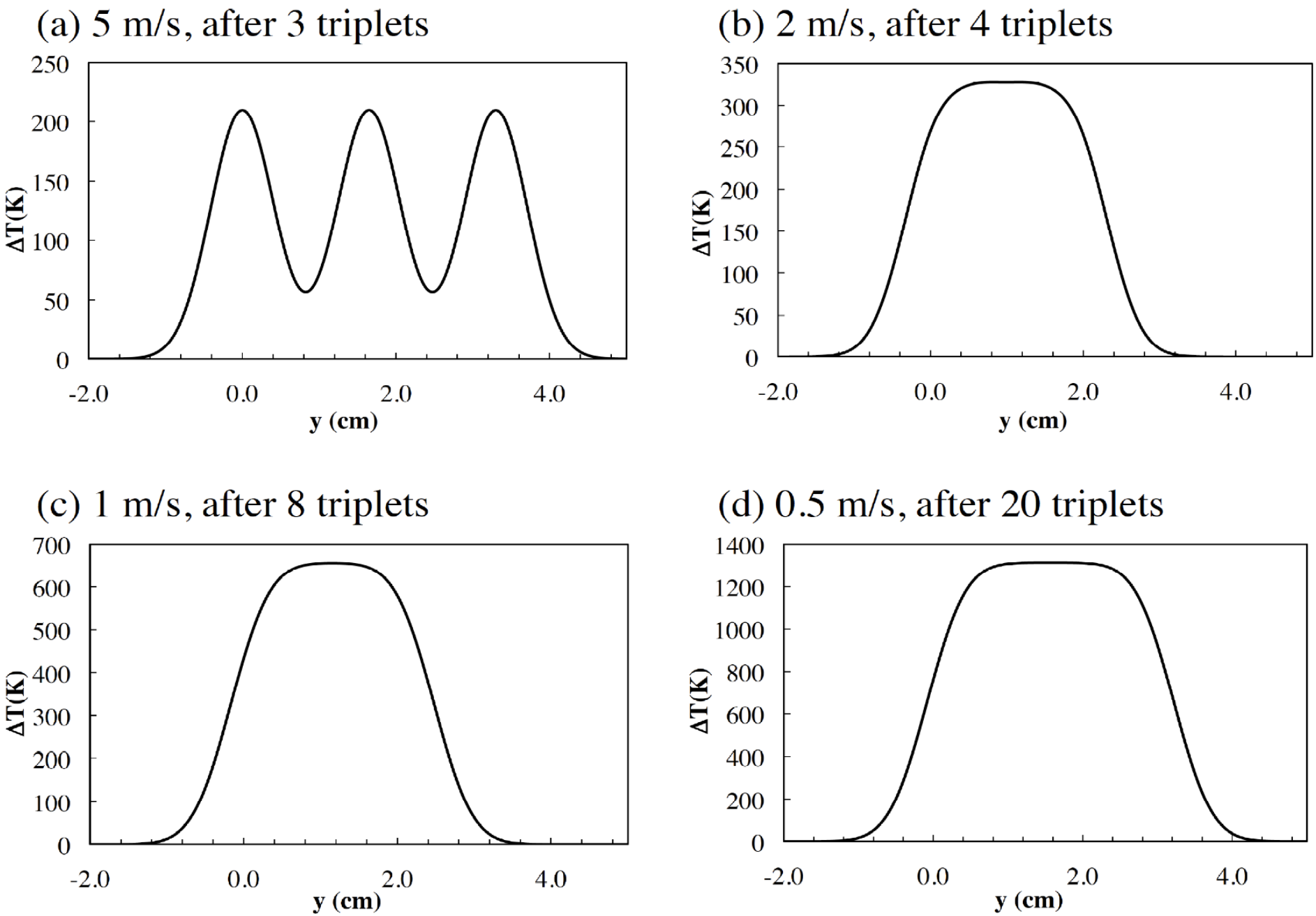


there seems to be solutions

Dependence on Drive beam size



Target Heat Simulation (Wanming)



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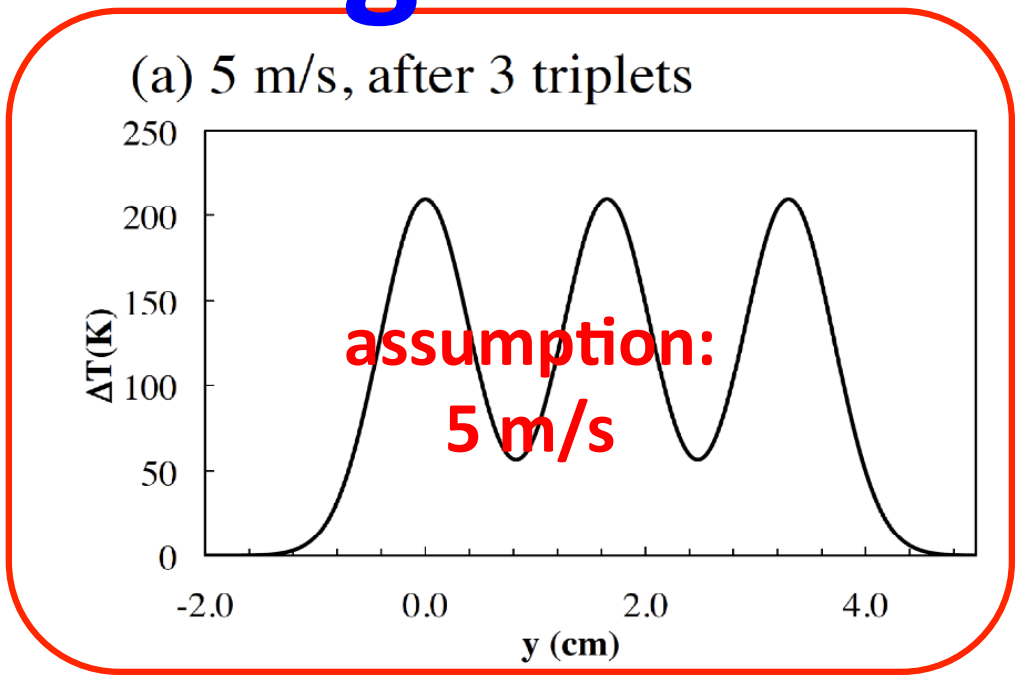

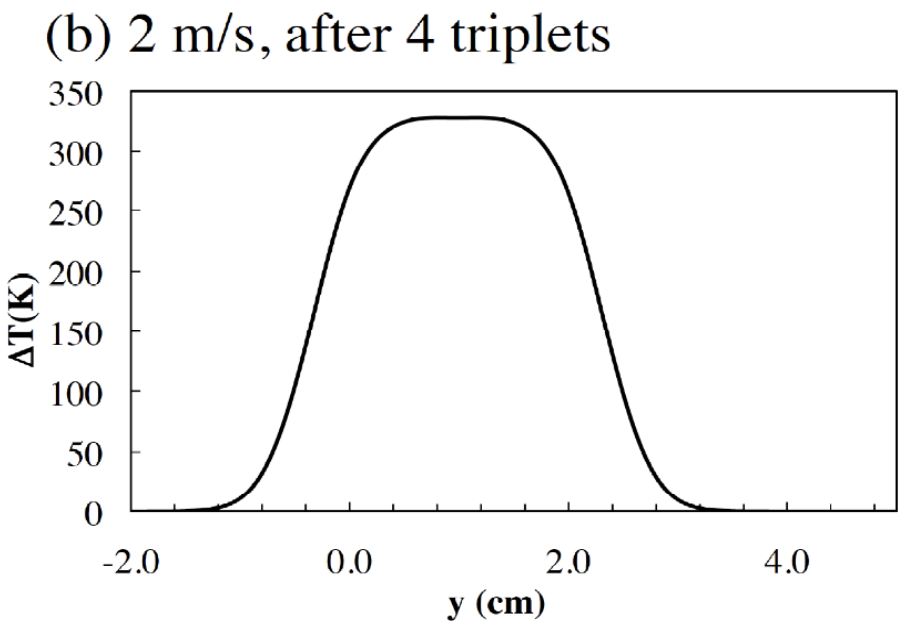

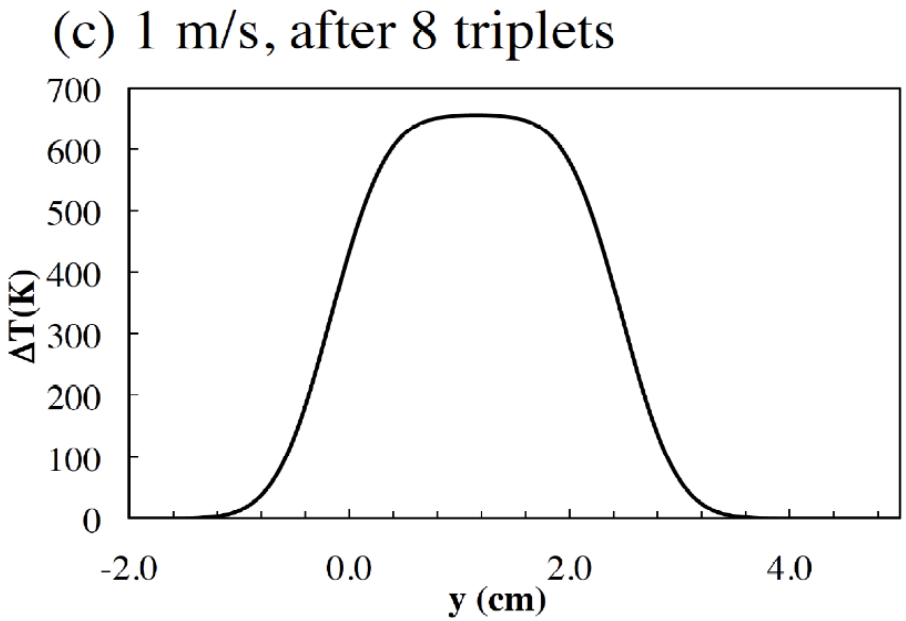

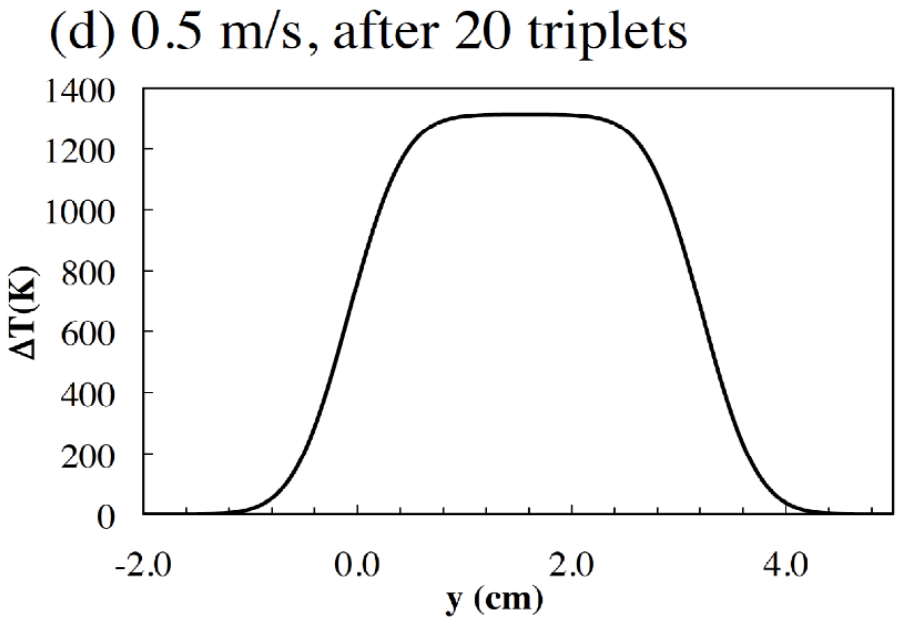

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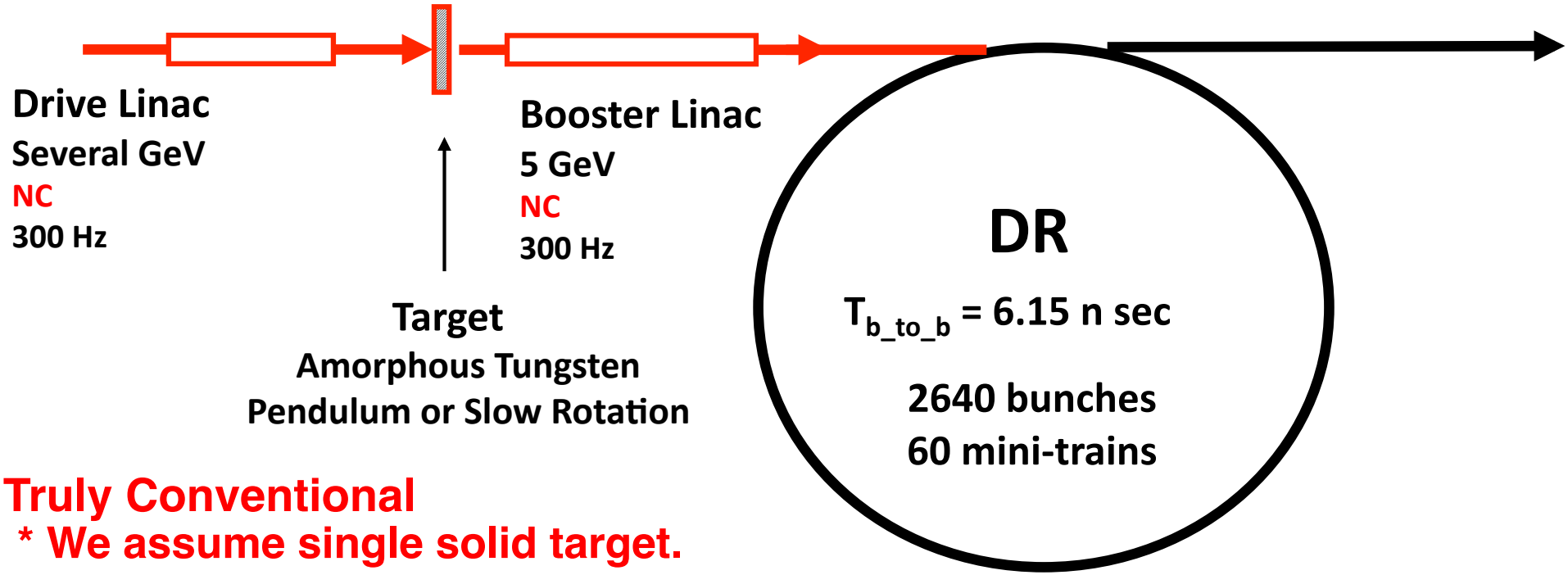


Time remaining for damping = 137 m sec

Truly Conventional

* We assume single solid target.

* NO Liquid Target or NO Hybrid Target are assumed

R/D items

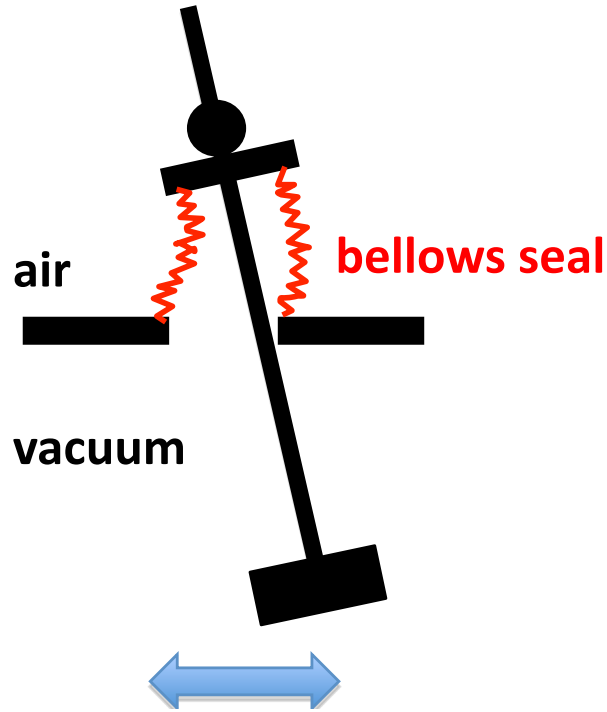
R&D Issues of the Conventional Source

- “conventional” but still needs some more R&D
- High current, high rep rate driver linac
- Moving target
- Flux concentrator
- Capture and Booster linac
- Overall simulation
- How to go with the undulator source (compatibility)

Moving Target

- ~ 3-5m/sec required (1/20 of undulator scheme)
- 2 possible schemes being developed at Hiroshima/KEK

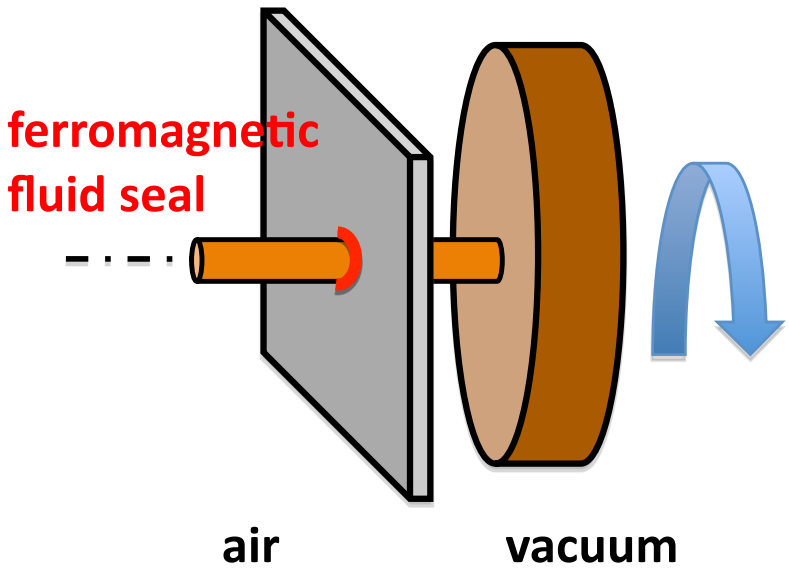
5Hz pendulum with bellows seal



main issues: life of bellows, mechanism

First step prototype fabricated

rotating target with ferromagnetic seal



main issue: vacuum

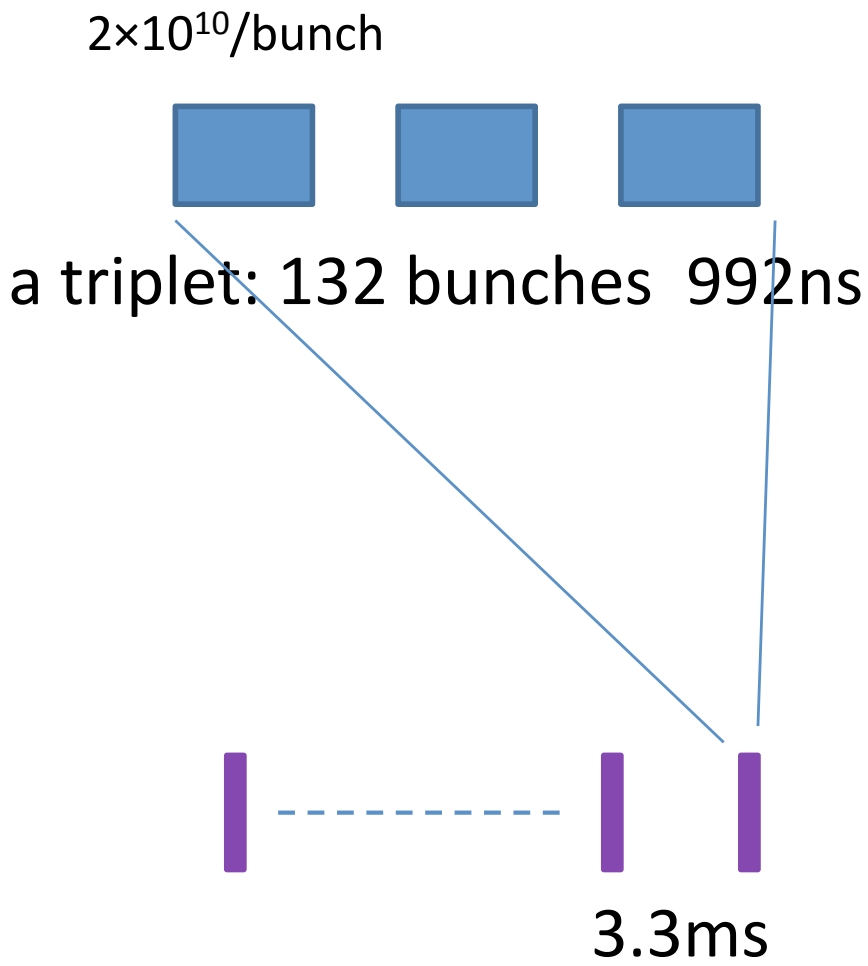
common issue: stress by heat

Flux Concentrator

- Almost existing technology
  - pulse length ~1μsec (cf. ~1msec in undulator scheme)
- SuperKEKB
  - aperture 7 mm (diameter)
- Beam aperture should be a bit larger
  - ~7mm → ~12mm or more

Linacs

- Driver linac (~6GeV)
  - high current
  - high rep rate (300Hz)
- Booster linac (~5GeV)
  - high rep rate
  - accurate loading compensation (due to uneven bunch structure)



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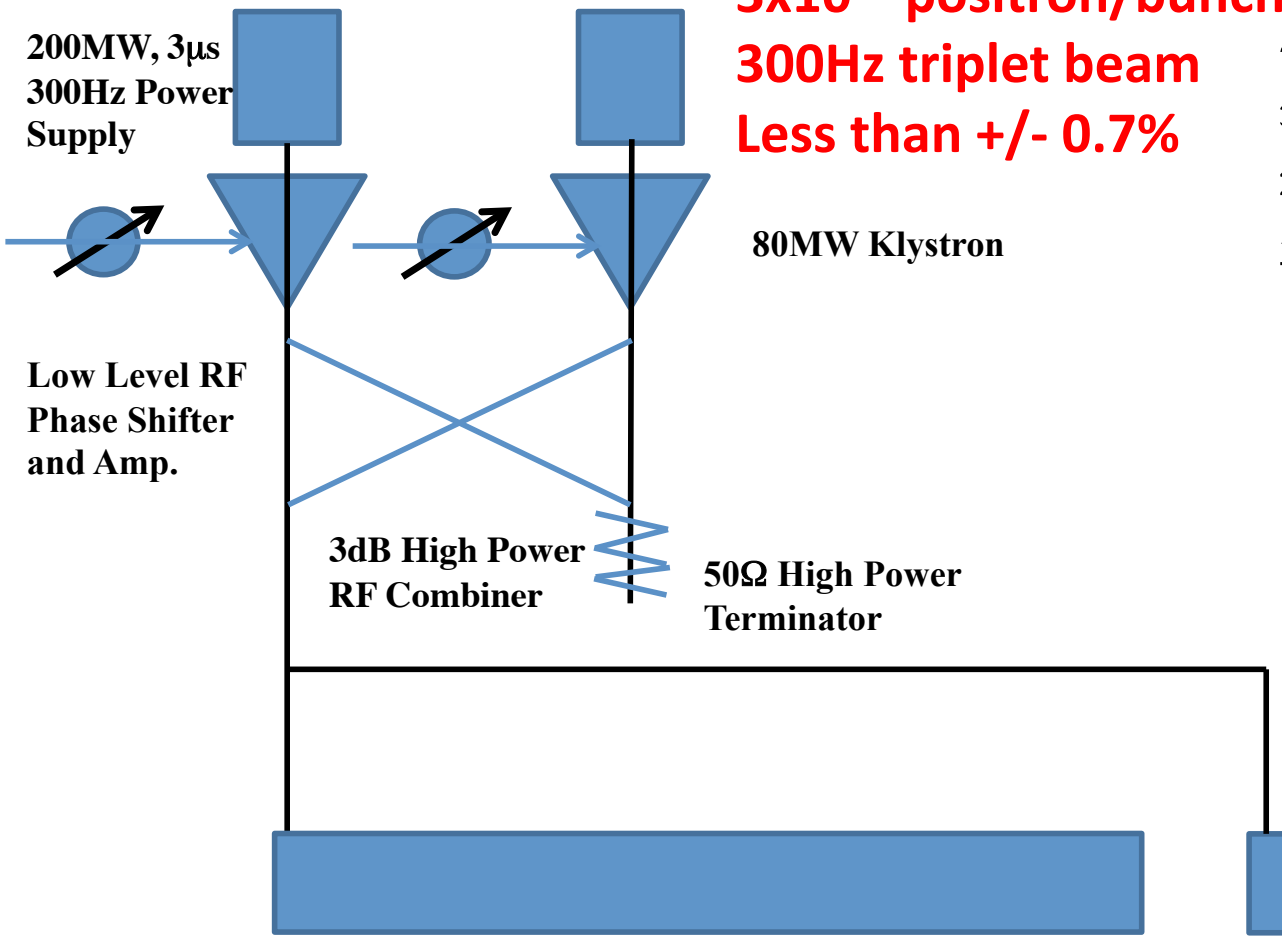
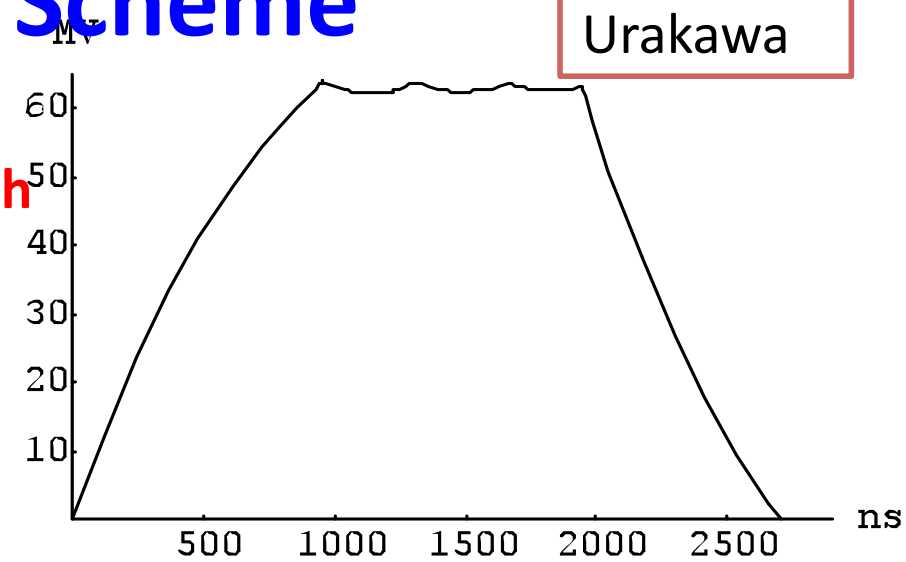
= 2640 bunches 63ms

Loading Compensation Scheme

Urakawa



$3x10^{10}$ positron/bunch
300Hz triplet beam
Less than +/- 0.7%



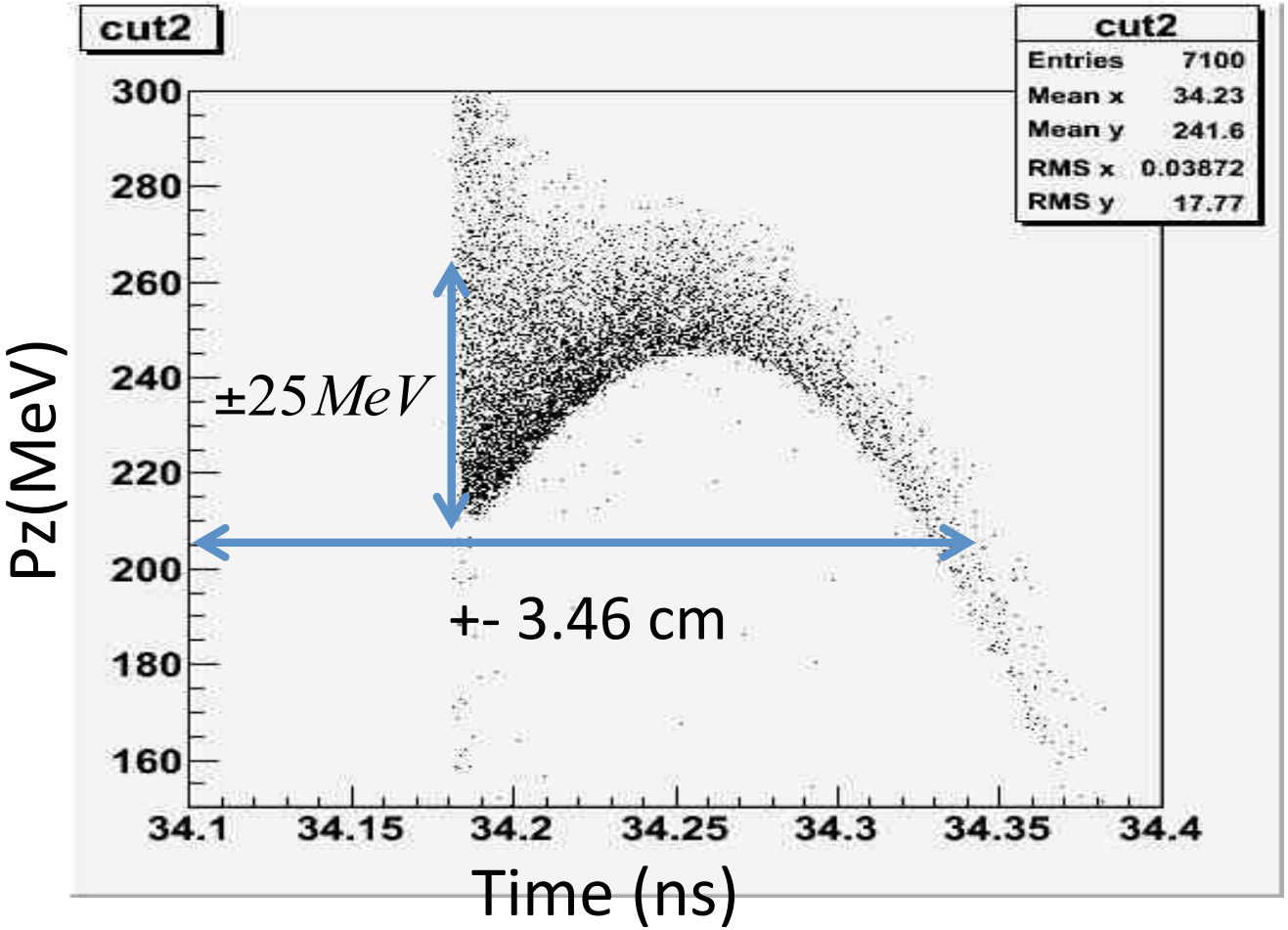
precise control of
the phase shifters needed

Test at ATF linac being planned

Overall Simulation

- DR aperture
  - $\Delta E < +-37.5$MeV
  - $\Delta z < +-34$mm
  - $A_x + A_y < 70\mu m$
- Must include
  - target simulation
  - loading compensation
- Is S-band linac acceptable?

Longitudinal Phase Space



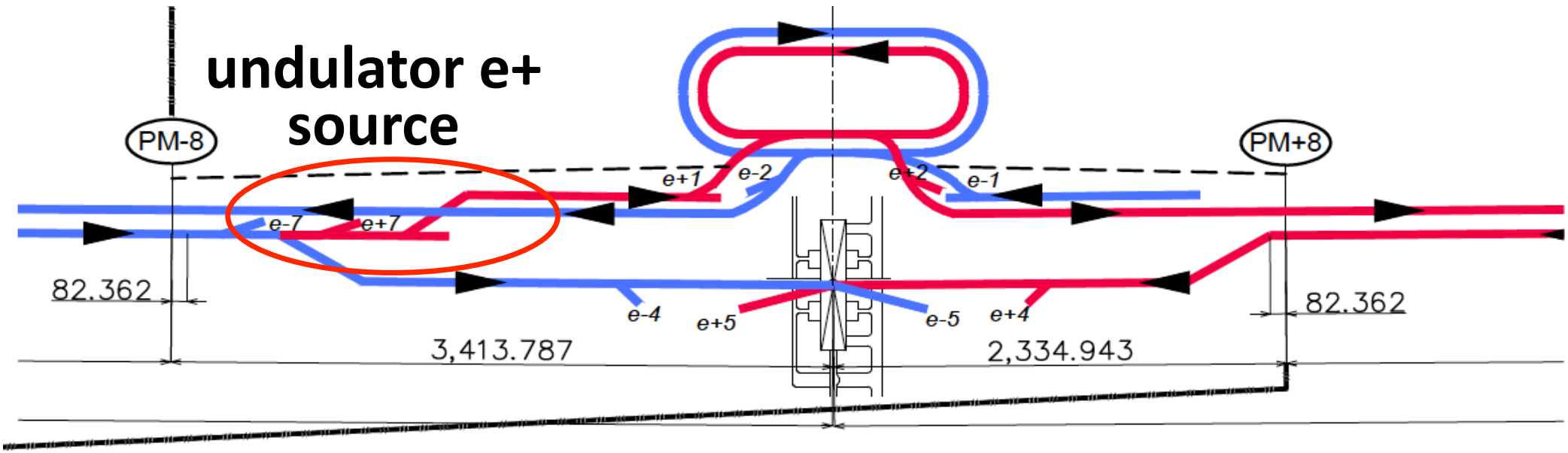
Undulator-Conventional Compatibility

Discussion@LCWS2013(Tokyo)

If we start with "Conventional", we need to keep smooth path to "Undulator".

footprint compatibility (no change of the tunnel)

- "300Hz conventional source" should fit the space for "undulator source"



Summary

Summary

- Conventional e+ source can be a solution for ILC, with 300Hz scheme and optimized beam&target parameters.

- to go forward -> We need R/Ds
  - High current, high rep rate driver linac
  - Moving target
  - Flux concentrator
  - Booster linac
  - Overall simulation
  - Target R/D