The ILC Compton Scheme

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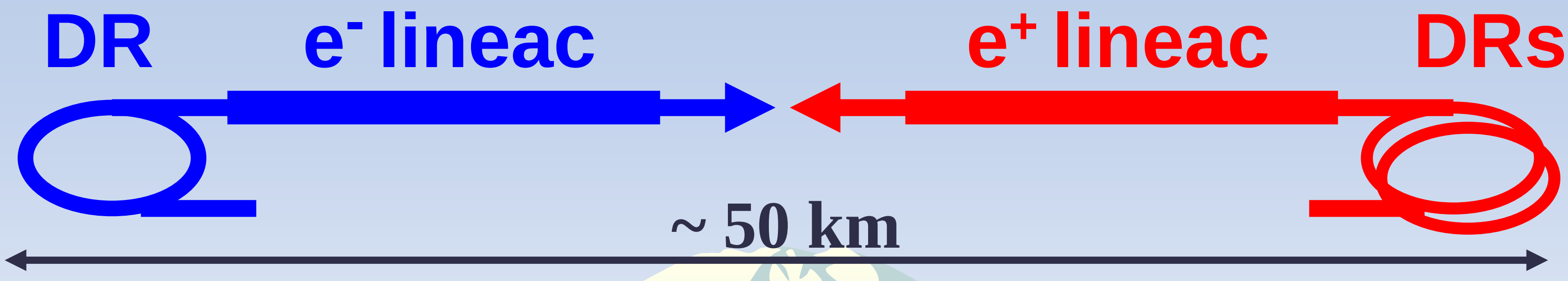
at CERN, KEK

1. The Compton Scheme for ILC polarized positron source after Snowmass WS
2. Modified Points
3. Future
4. Summary

ILC: International Linear Collider



E_{cm} = 500 - 1000 GeV

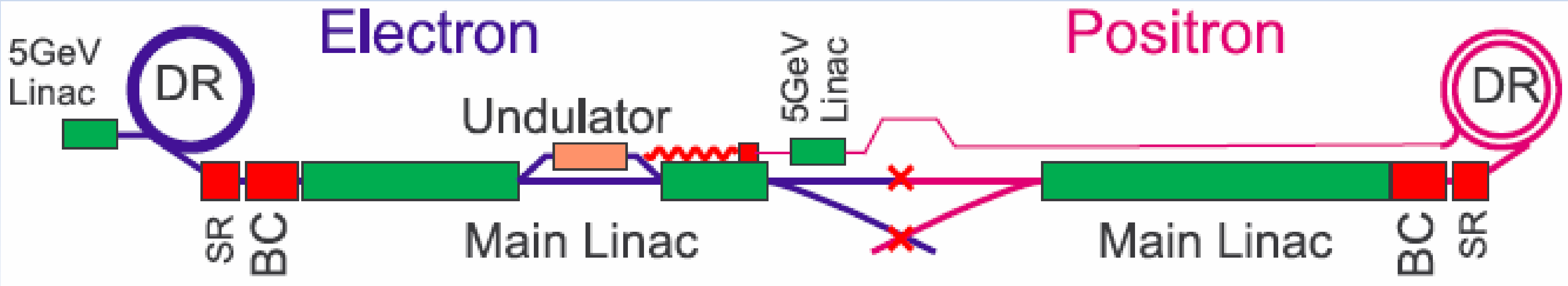
start experiment at ~2015.

Polarized Beams play important role.

- **Suppress back ground.**
- **Increase rate of interaction (if both beam pol.).**
- **Solve Week mixing of final state.**

Base Design Configuration (BCD)

ILC Undulator-base e^+ Source



150 GeV　250 GeV　250 GeV

Experiments

There are many problems which we have to solve. You can image from above Figure. Enjoy problems.

Why Laser Compton ?

i) Positron Polarization.

ii) Independence

Undulator-base e^+ : use e^- main linac

Problem on design, construction, commissioning, maintenance,

Laser-base e^+ : independent

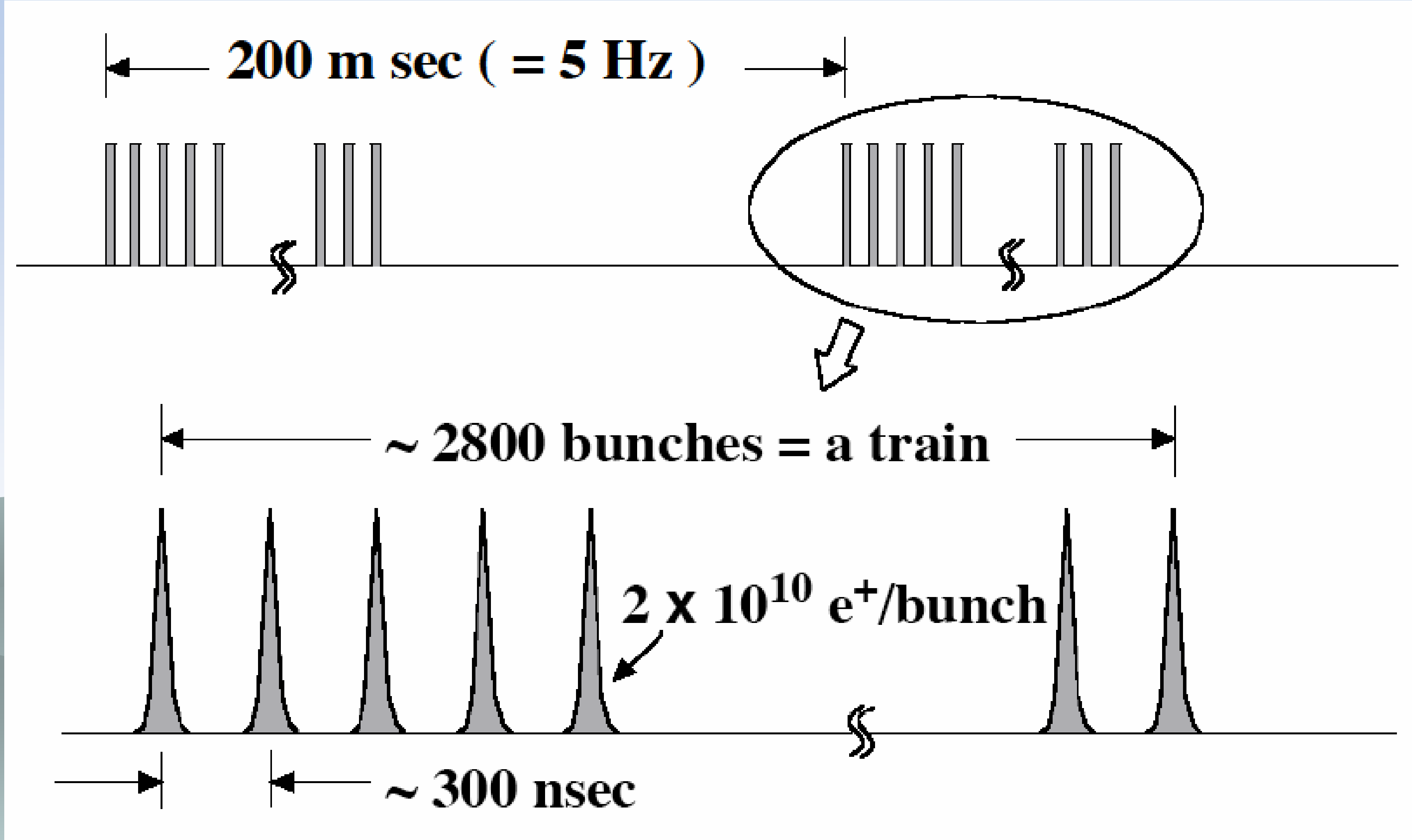
Easier construction, operation, commissioning, maintenance

iii) Low energy operation

Undulator-base e^+ : need deccelation

Laser-base e^+ : no problem

ILC requirements

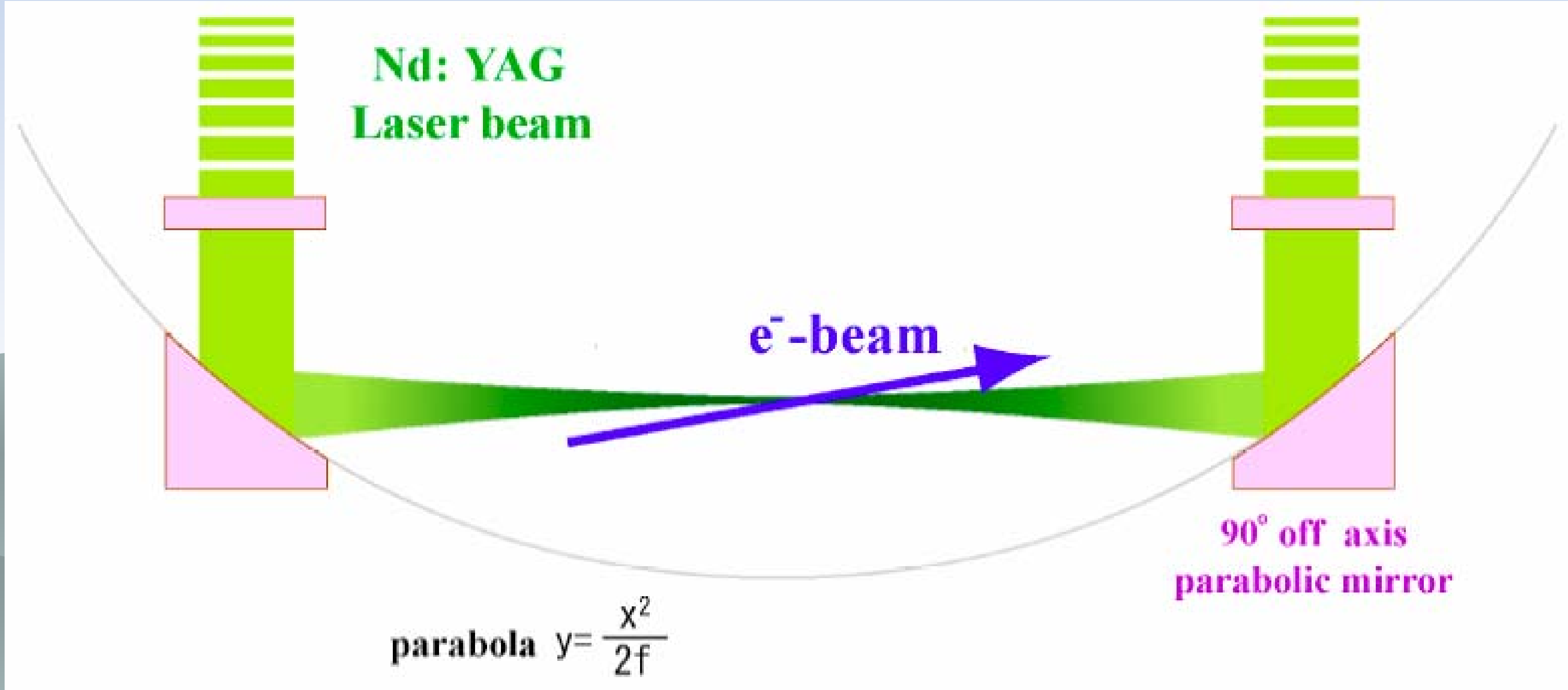


Laser Pulse Stacking Cavity

Input laser (YAGlaser)
- Energy 0.75 mJ/bunch
- 3.077 nsec laser pulse spacing
- train length = 50 μsec

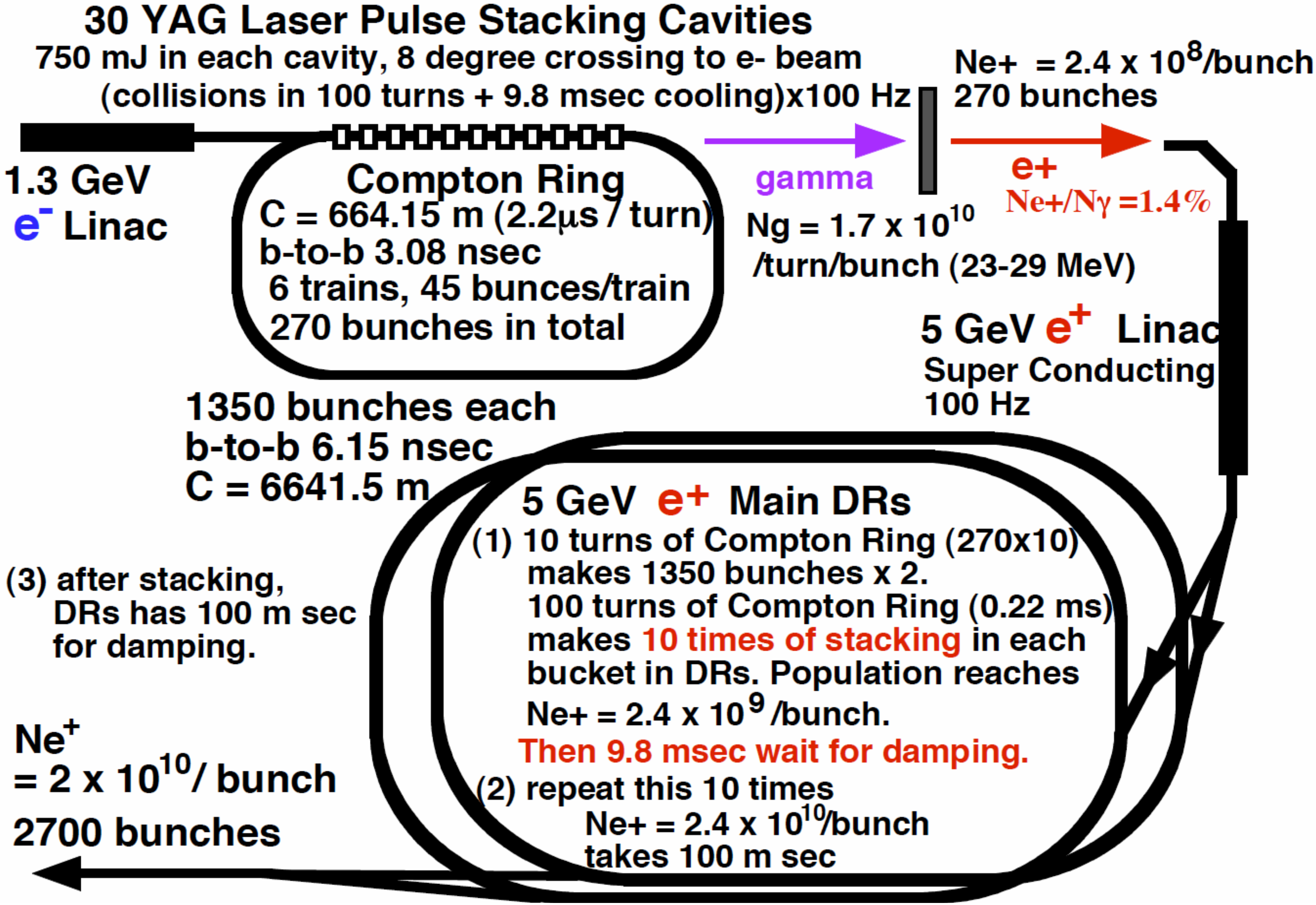
Fabry-perot Resonator

Cavity
Enhancement Factor =1000



Laser pulse in cavity
- 750 mJ/bunch
- single bunch in a cavity

Schematic View of Whole System

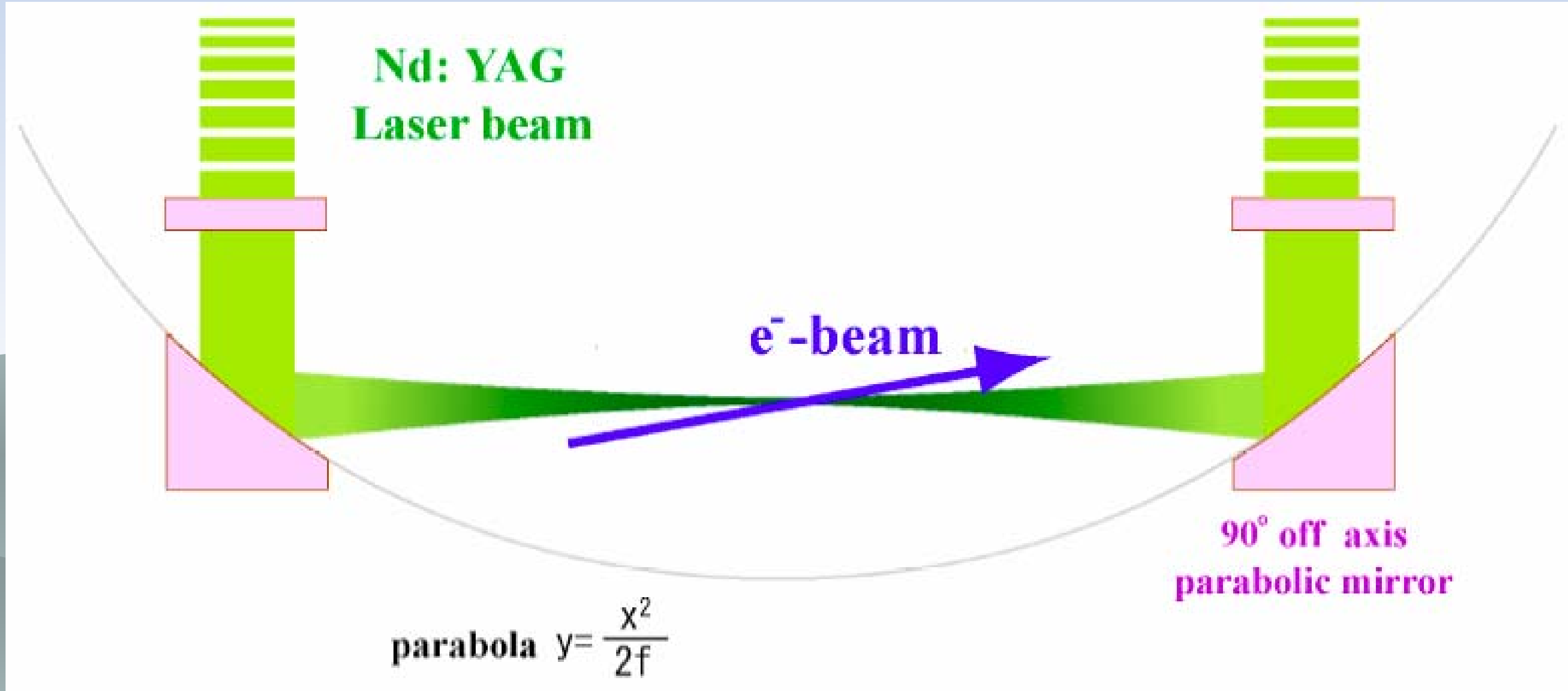


Laser Pulse Stacking Cavity

Fabry-perot Resonator

Input laser (YAGlaser)
Energy 0.75 mJ/bunch
3.077 nsec laser pulse spacing
train length = 50 μsec

Cavity
Enhancement Factor =3000



30 IP will be reduced to 10 IP.

Laser pulse in cavity
2250 mJ/bunch
single bunch in a cavity

We should install longitudinal phase rotation system into straight section for optical cavities in order to reduce electron bunch length from 5mm to 1mm.

Main Modified Points for Compton Ring

We can increase γ yield per collision with about 4 times and the electron bunch length can be increased until about 12mm in the region except for the region of Compton collision.
I propose the charge of Compton ring to reduce from 10nC to 2.5nC with 12mm bunch length. Compton ring is realistic.

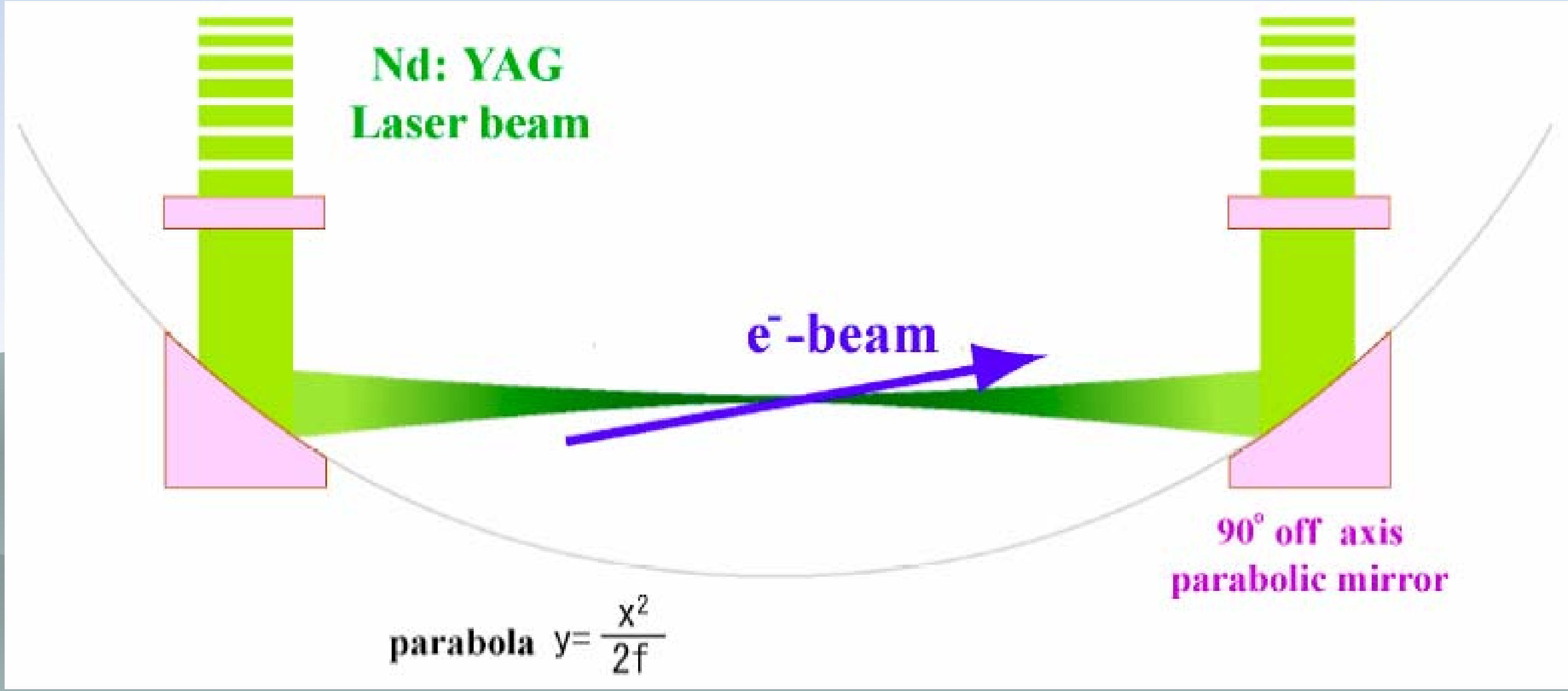
We need the design of the longitudinal phase rotation system which consists of two sets of four magnets chicane and two sets of RF cavity system. I think design of this system will be realized soon.
This is bunch compressor and bunch expander with the factor of 1/12.

Possibility in the Future

Fabry-perot Resonator

Input laser (YAGlaser)
- **Energy 0.75 mJ/bunch**
- **3.077 nsec laser pulse spacing**
- **train length = 50 μsec**

Cavity
Enhancement Factor =30000



10 IP will be reduced to 1 IP. ???

Laser pulse in cavity
- **22500 mJ/pulse**
- **single pulse in a cavity**

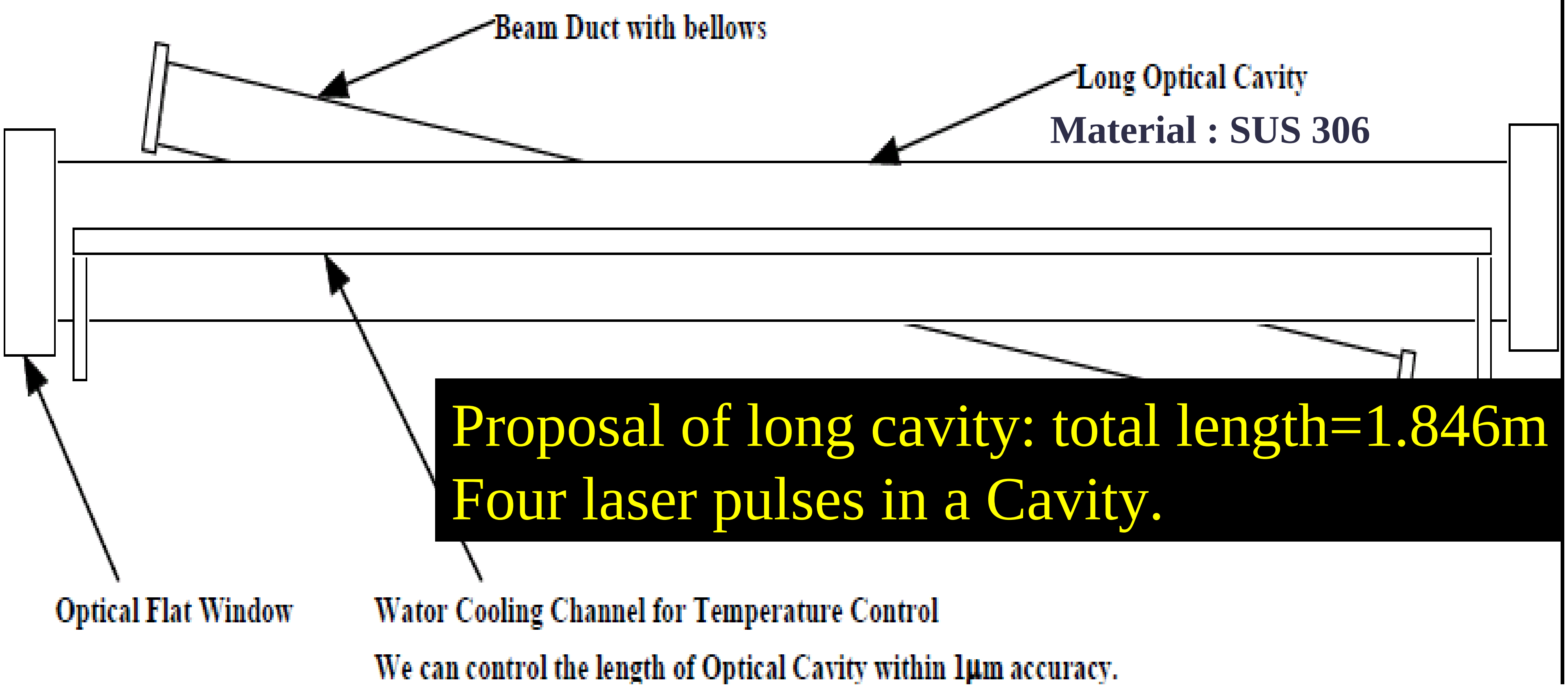
Nonlinear Compton scattering effect is problem.

750mJ/pulse is OK. Maybe, three times power 2.25J/pulse is acceptable.
Please check this effect because we have to reduce the number of IP.
I am sure that 22.5J/pulse is not acceptable.

However, I will reject the increase of laser pulse power option of 2.25J/pulse. See next slide.
5 IP proposal was written in the proceedings of Nano-beam05 by me assuming 3000 enhancement factor. If we reduce waist size at IP, we can reduce the number of IP in Compton ring.

Power density threshold on high reflectance mirror (99.99%) : 10MW/cm^2, Degradation of multi-layer dielectric coatings due to the heating.

Peak power density on mirror (Laser single shot threshold): 10GW/cm^2, Main problem is discharge (or breakdown of hydrocarbons on the mirror surface).



Proposal of long cavity: total length=1.846m

Four laser pulses in a Cavity.

Example

$$z_R = \frac{\pi {w_0}^2}{\lambda}, \quad \text{and}$$

$$w(z) = w_0 \sqrt{1 + \left(\frac{z}{z_R}\right)^2}$$

Rayleigh range

Spot size on the mirror

Waist size 5µm, w_0=10µm, z=92.3cm

w(z) at mirror =29.4mm

750mJ, 357MHz---→ 9.5MW/cm^2

Our design value already reaches the threshold.

Peak power density : 3GW/cm^2 less than the threshold.

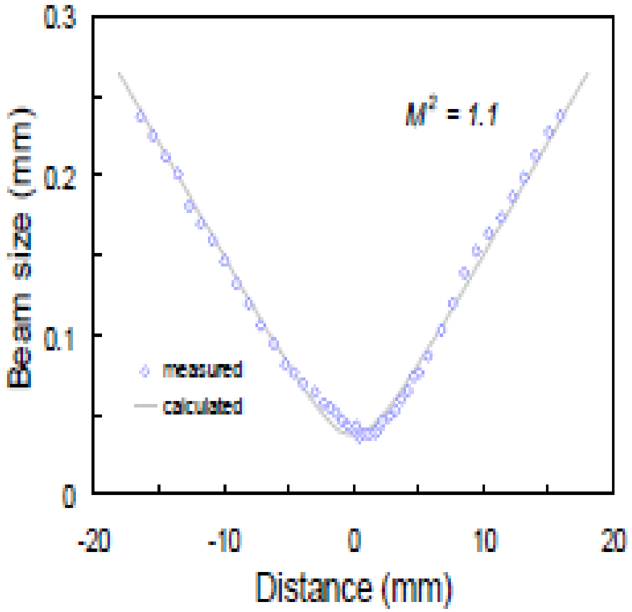
Real Mirror size : Diameter of 17.5cm

If we keep 30 IP in the straight section of the Compton Ring, we can reduce injected laser Power from 750μJ to 25μJ. We have to prepare 30 mode-lock laser oscillators with 325MHz repetition rate and 25μJ output laser pulse power.

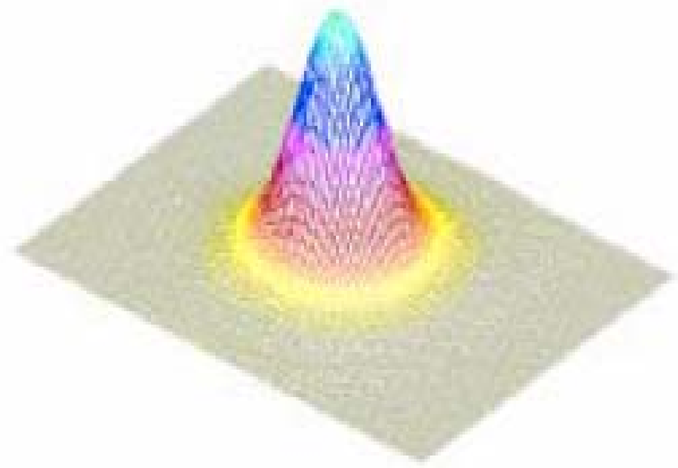
DUETTO - OEM produced by Time-Bandwidth

> 10 W	output power
50 kHz – 4 MHz	repetition rate
up to 200 μJ	per pulse
< 12 ps	pulse width
up to 16 MW	peak power
1064 nm	wavelength
< 1.3	M^2 (TEM_{00})

Quality of Laser Pulse is essential for laser storage into Optical Cavity.

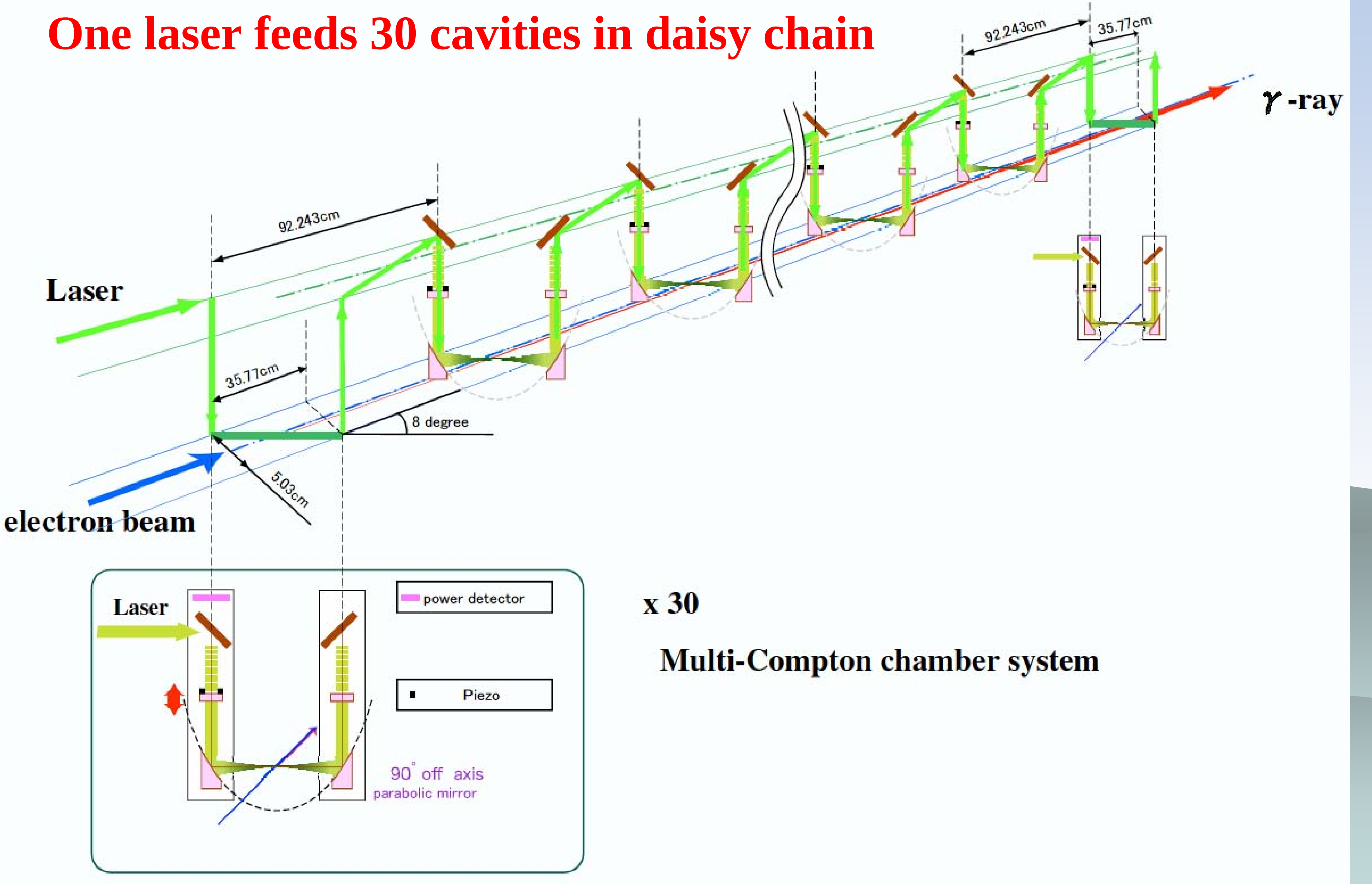


Measured beam size versus propagation distance through a beam focus. The calculated curve shows the dependence for a Gaussian beam with the indicated M^2 value.



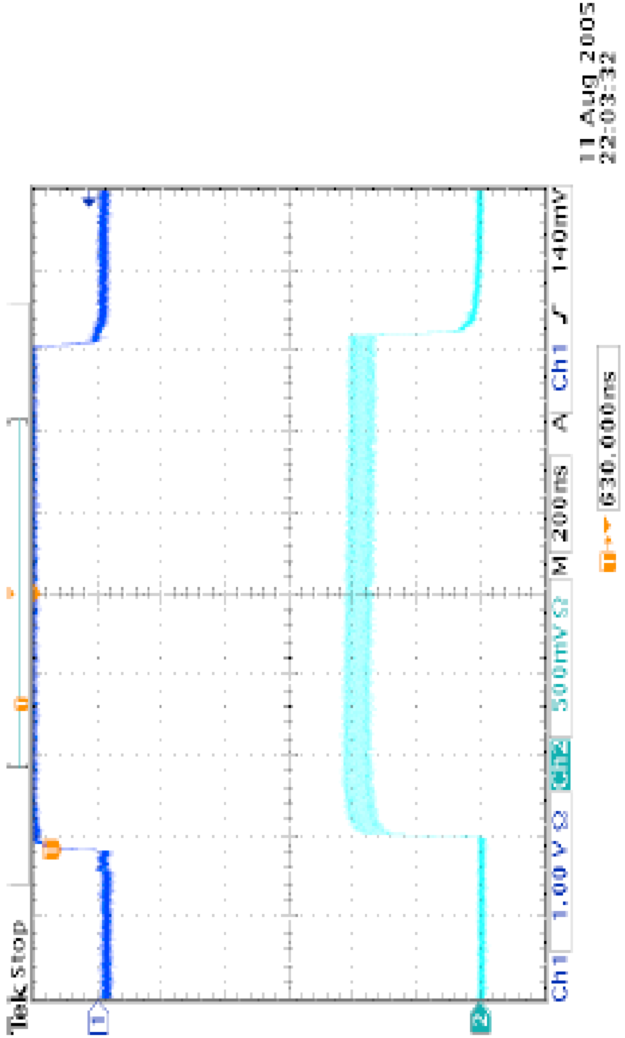
Typical 3D image of the DUETTO - OEM output beam profile, the Gaussian fit coefficient is approximately 0.98 in both X and Y planes

In order to increase the reality, following scheme is changed to 30 independent systems.



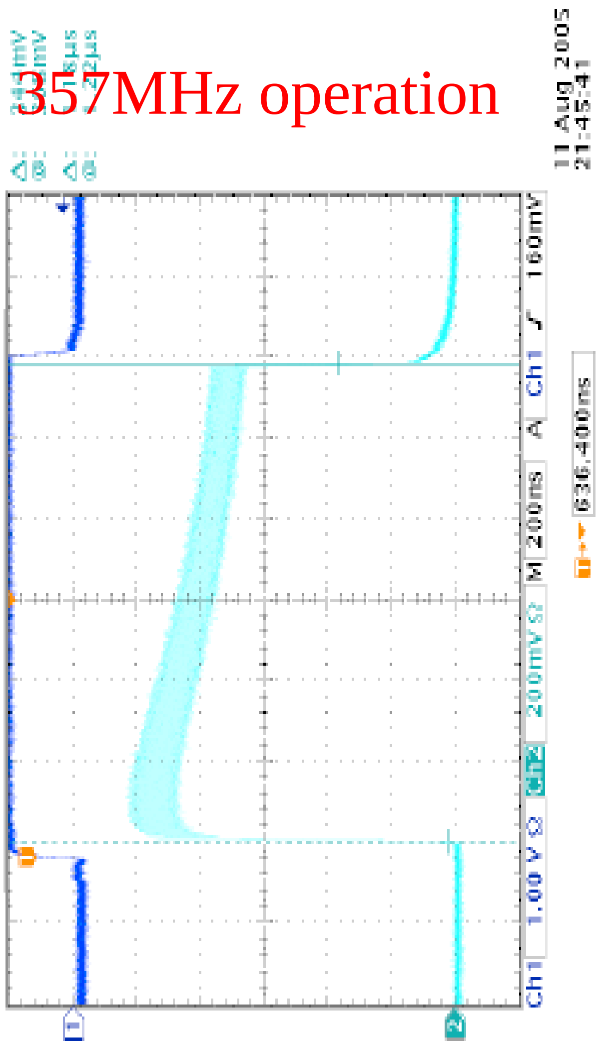
Quick test on 443 pulse train with 12.5Hz operation (1.24μsec). Amplification by two pass 9mmφYAG rod

3.6μJ/pulse

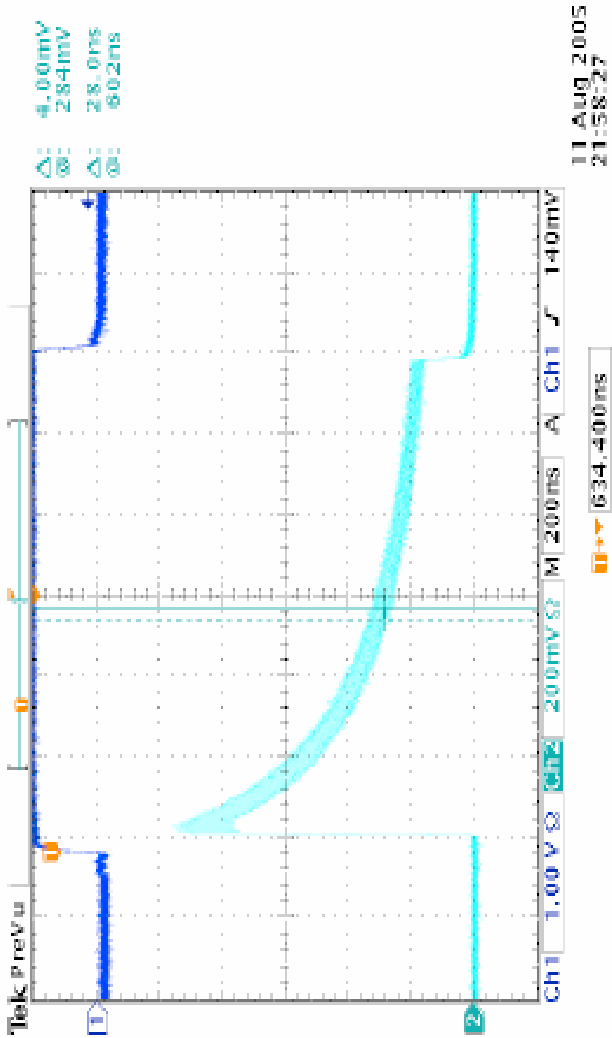


65μJ/pulse

357MHz operation



660μJ/pulse



Summary

1. Introduce the longitudinal phase rotation in the region of 30 IP of Compton Ring.
Design Parameters : Compressor ratio = 1/12, bunch length 12mm, bunch charge 2.5nC

2. Proposal of long cavity: total length=1.846m
Four laser pulses in a Cavity.

3. Temperature precise control within 0.01degree to ease the control of the length of the Optical cavity.

4. We use independent 30 laser optical cavity systems to make more flexible.
The number of the cavity system should be reduced, then we can reduce the cost.

5. Pulsed mode operation of laser system is necessary to recover the electron beam in the Compton ring. We need laser gate which consists of Faraday rotator etc. before the amplifier.

Summary of Summary

Requirement of the Design of Compton Ring is changed to realistic one. We need the complete design.
30 laser systems are independent, so precise tight tuning between cavities is not necessary.
The cost estimation of Compton scheme until
RDR (Reference Design Report) Completion
is necessary with assumption of 30000 enhancement factor.