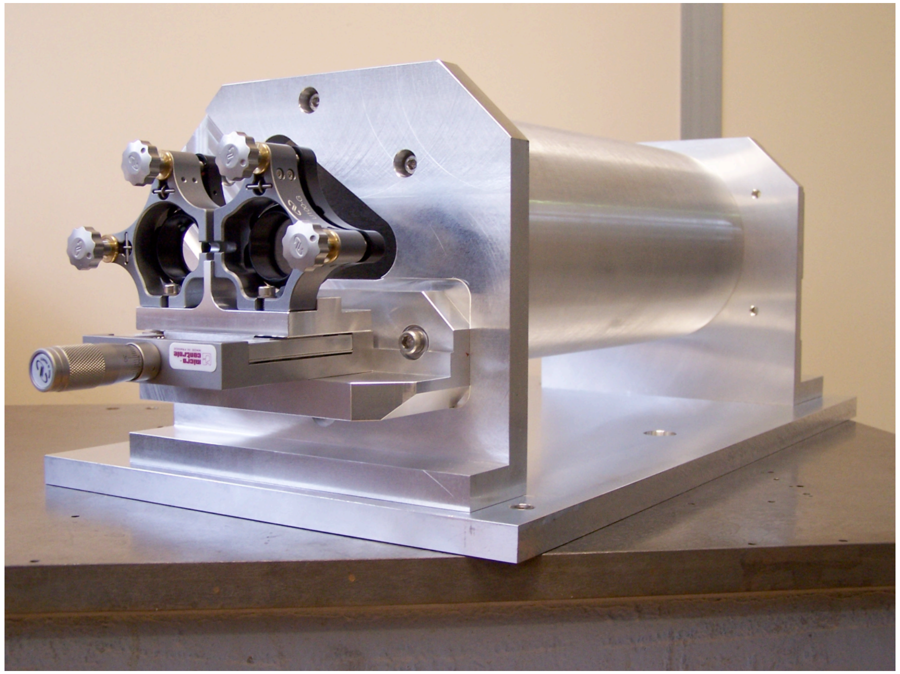
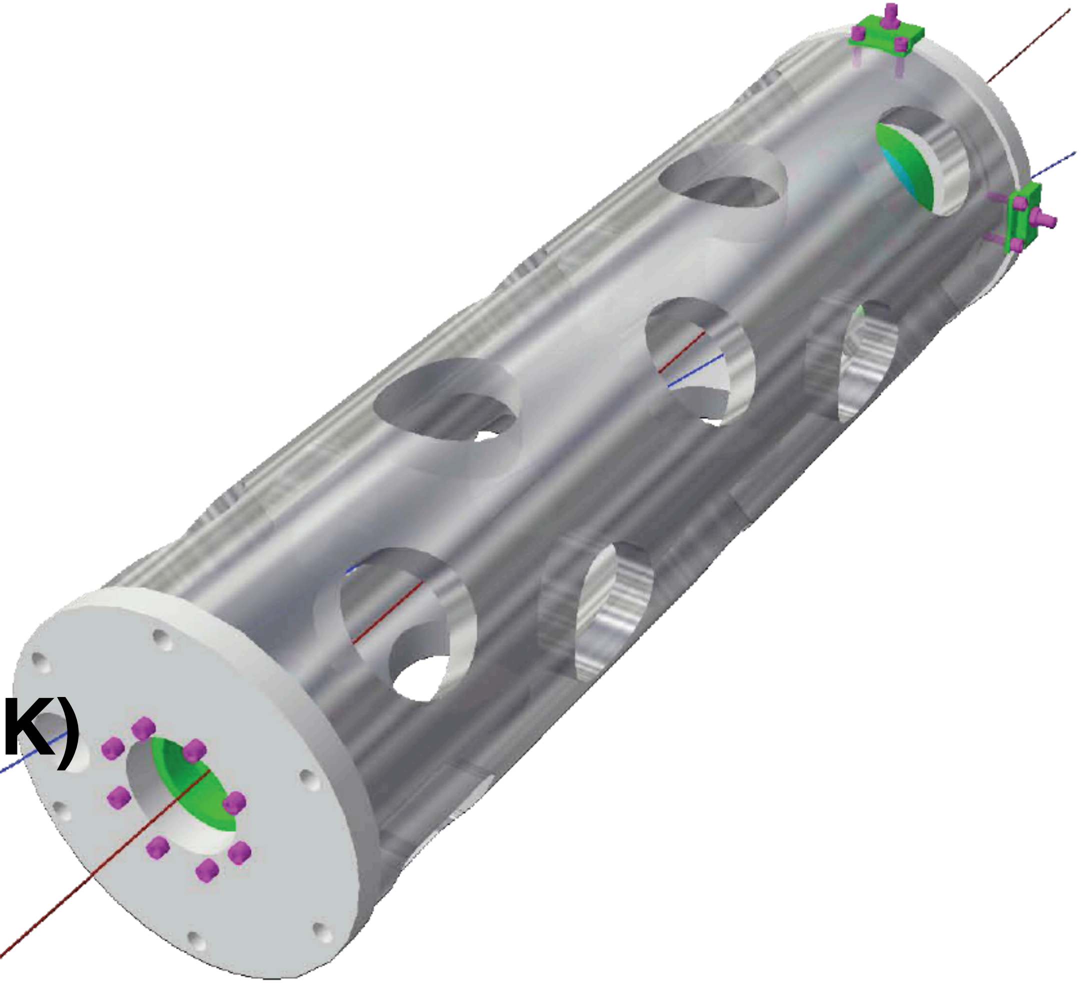
Optical Stacking Cavity for ILC Compton e^+ source





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10/May/2007

FJPPL optical cavity Compton collaboration

France

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Today's Talk

1. Laser Compton e^+ source for ILC.

2. Why Stacking Cavity R/D

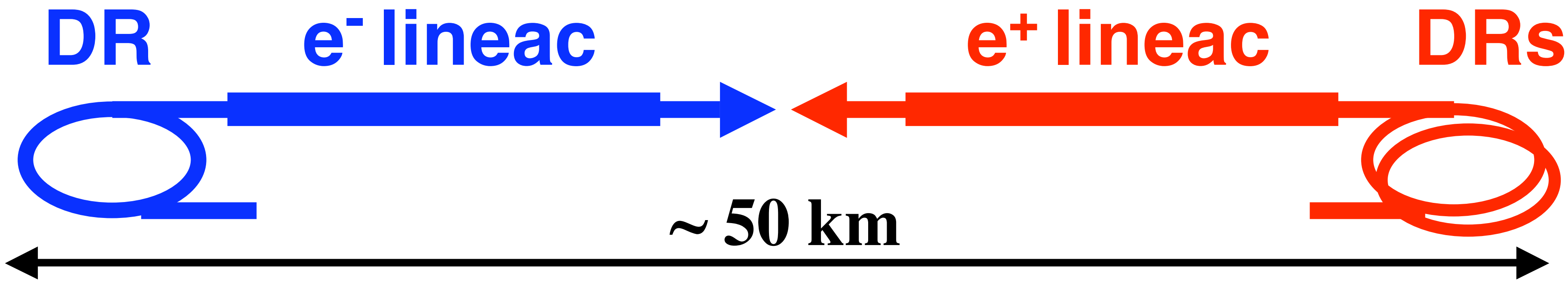
3. R/D in Japan

4. R/D in France

5. World-wide collaboration

6. Summary

ILC: International Linear Collider



E_{cm} = 500 - 1000 GeV

start experiment at ~2020

Polarized Beams play important role

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

ILC positron sources

1) undulator-based e^+ source

base line choice

1st stage: non-polarized source

later: upgrade to polarized source

2) Compton-based e^+ source

advanced alternative

polarized source

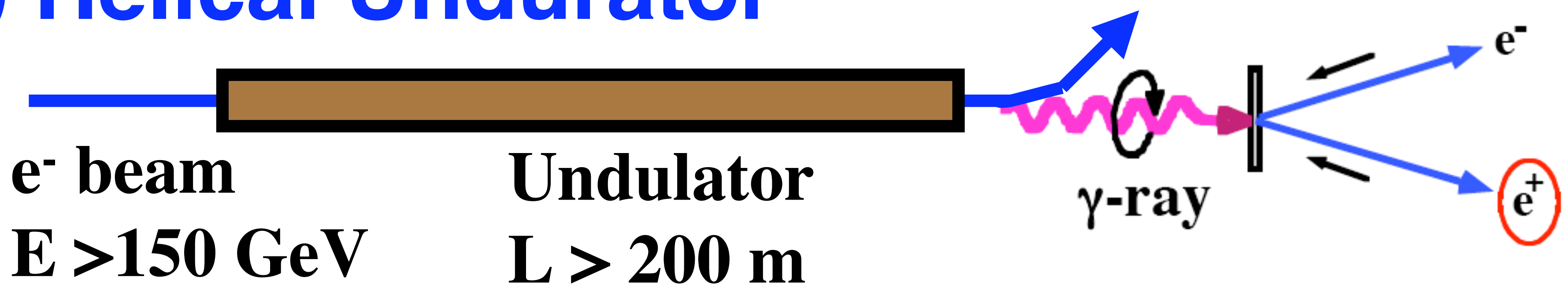
3) Conventional e^+ source

back up

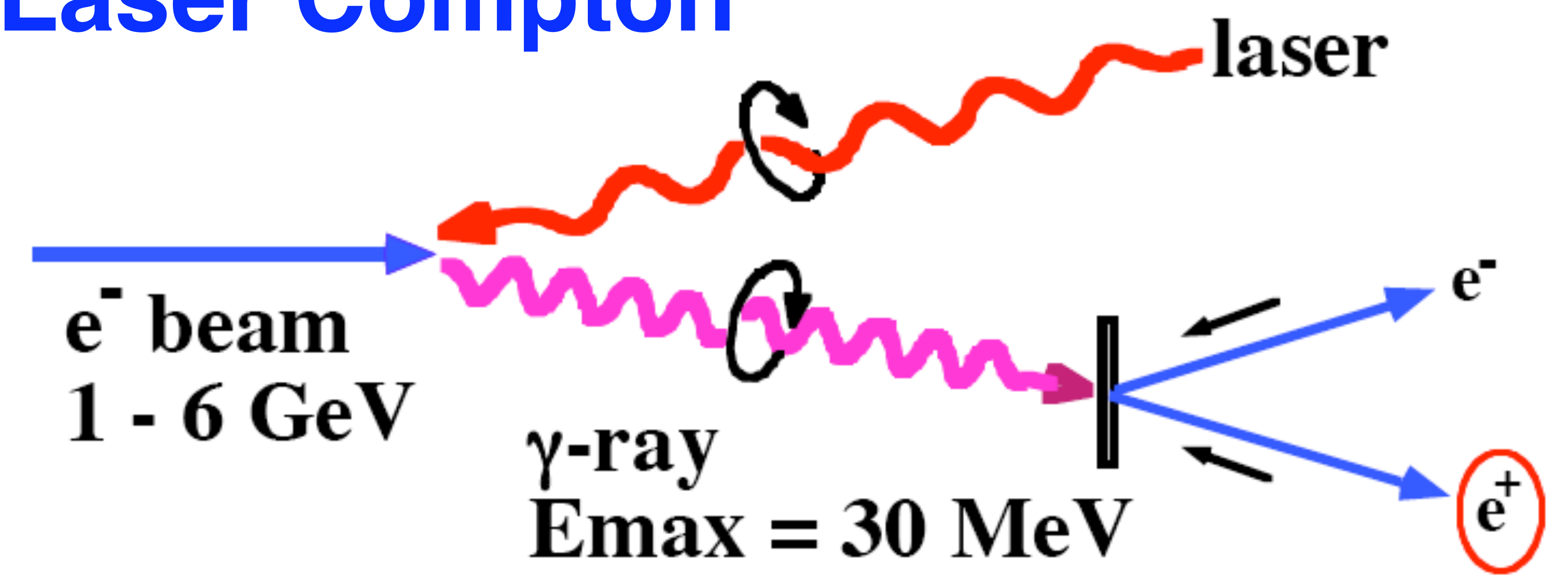
non-polarized source

Two ways to get pol. e^+

(1) Helical Undurator

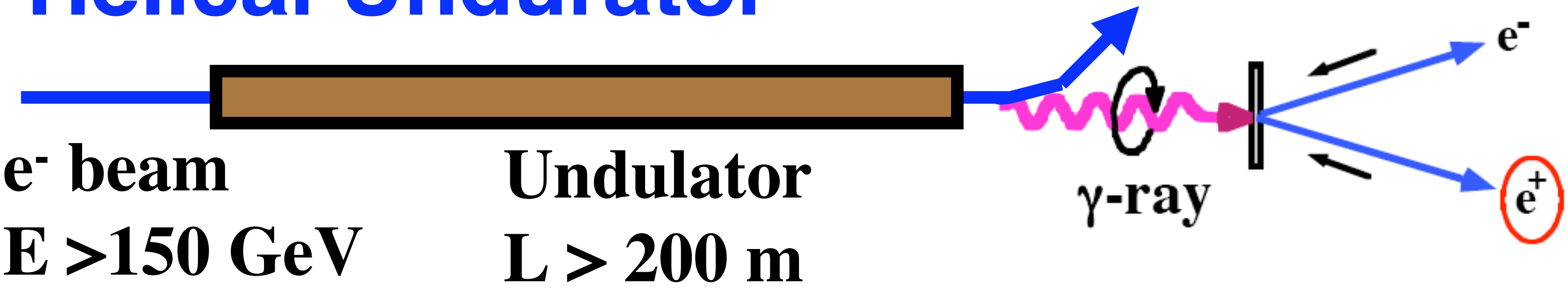


(2) Laser Compton



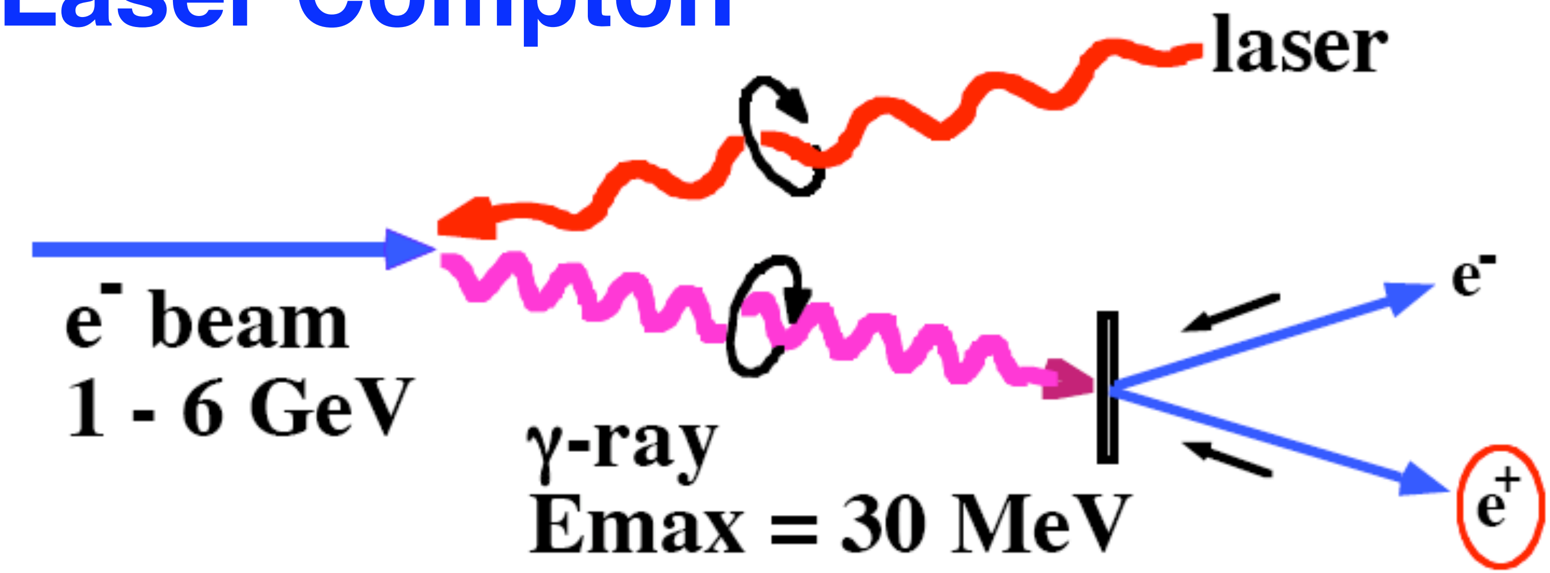
Two ways to get pol. e^+

(1) Helical Undurator



Our Proposal

(2) Laser Compton



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

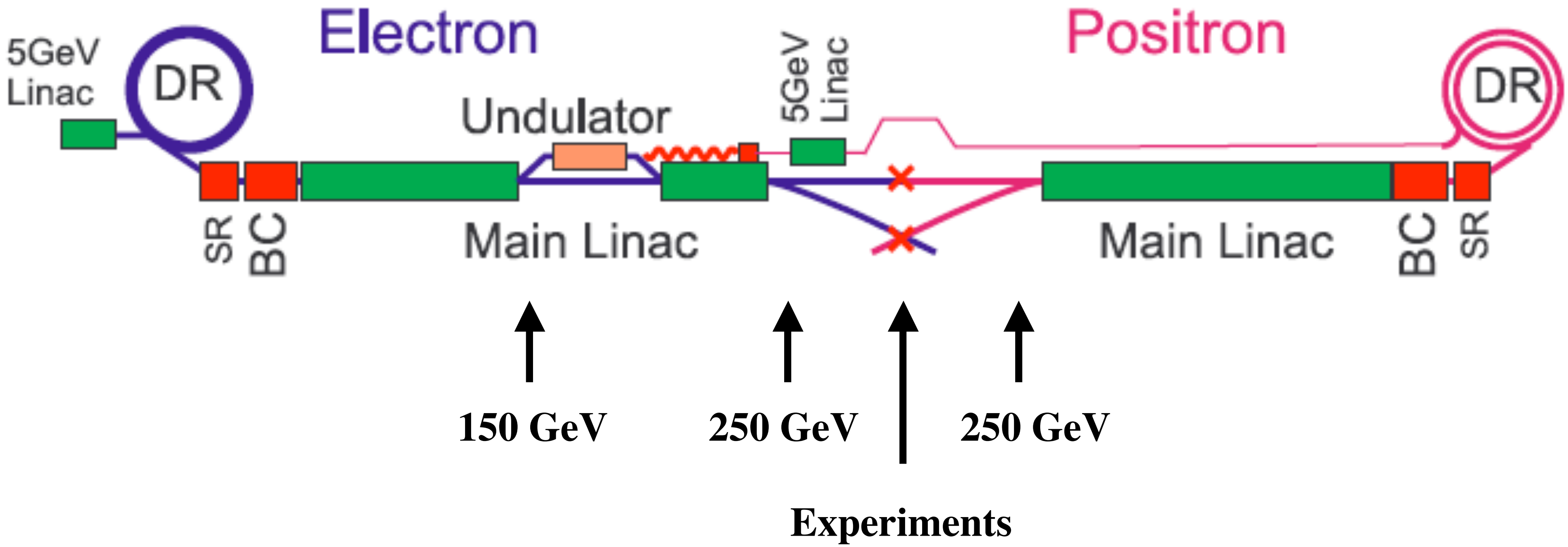
Easier construction, operation, commissioning, maintenance

iii) Low energy operation

Undulator-base e^+ : need deccelation

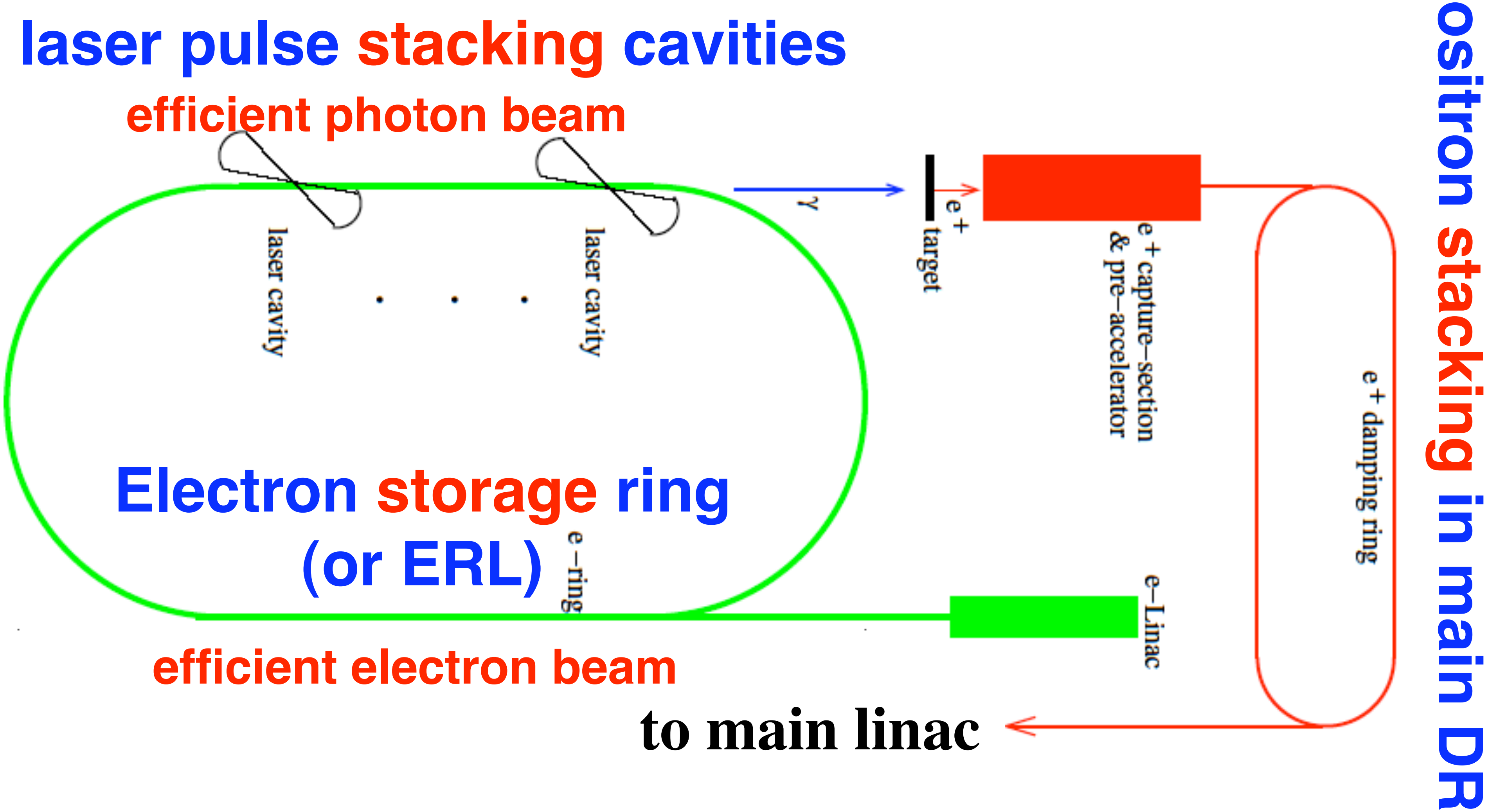
Laser-base e^+ : no problem

ILC Undulator-base e^+ Source

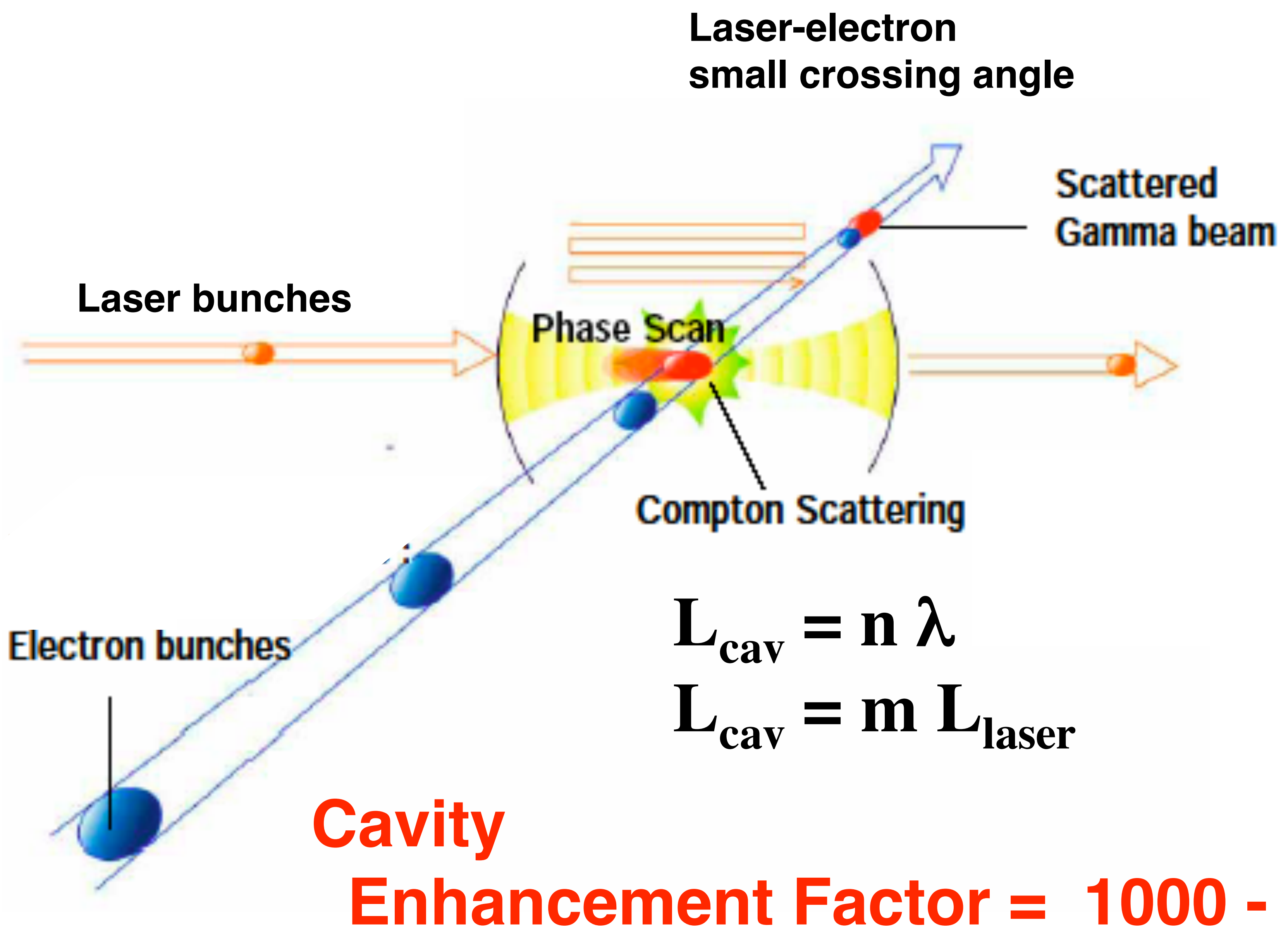


Ring Base Compton (an example)

Re-use Concept



Laser Pulse Stacking Cavity



$$L_{cav} = n\,\lambda$$

$$L_{cav} = m\,L_{laser}$$

Cavity

Enhancement Factor = 1000 - 10^5

Why Stacking Cavity R/D?

a) The most uncertain part of the current design.
b) The efficiency of whole system highly depends on the optical cavity design.
   - laser spot size
   - collision angle
   - enhancement factor

Simulation alone is not effective in desiging cavity.

We need experimental R/D.

R/D in Japan

Moderate Enhancement ~ 1000

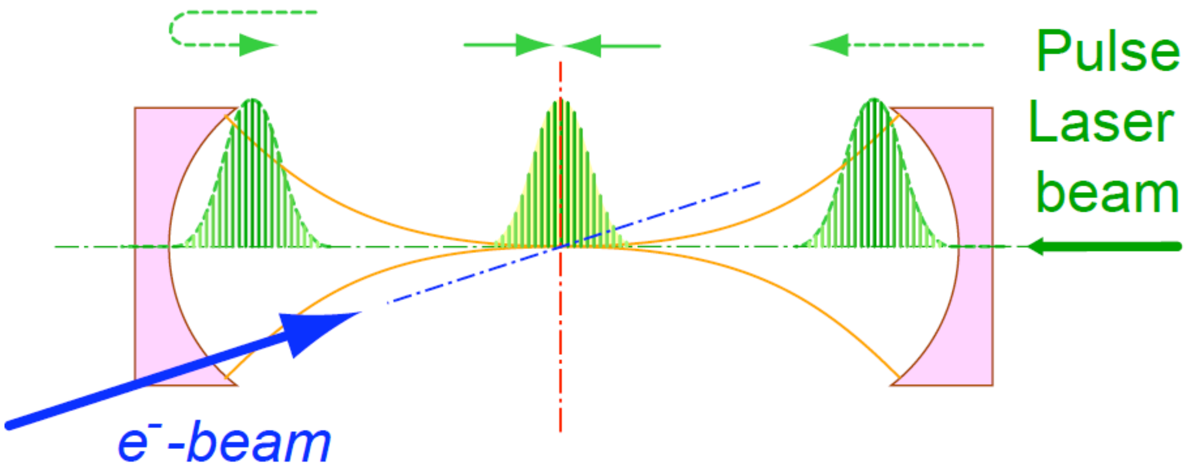
Moderate spot size ~ 30 micron

Simple cavity stucture with two mirrors

Get experinence with e^- beam

Experimental R/D in ATF

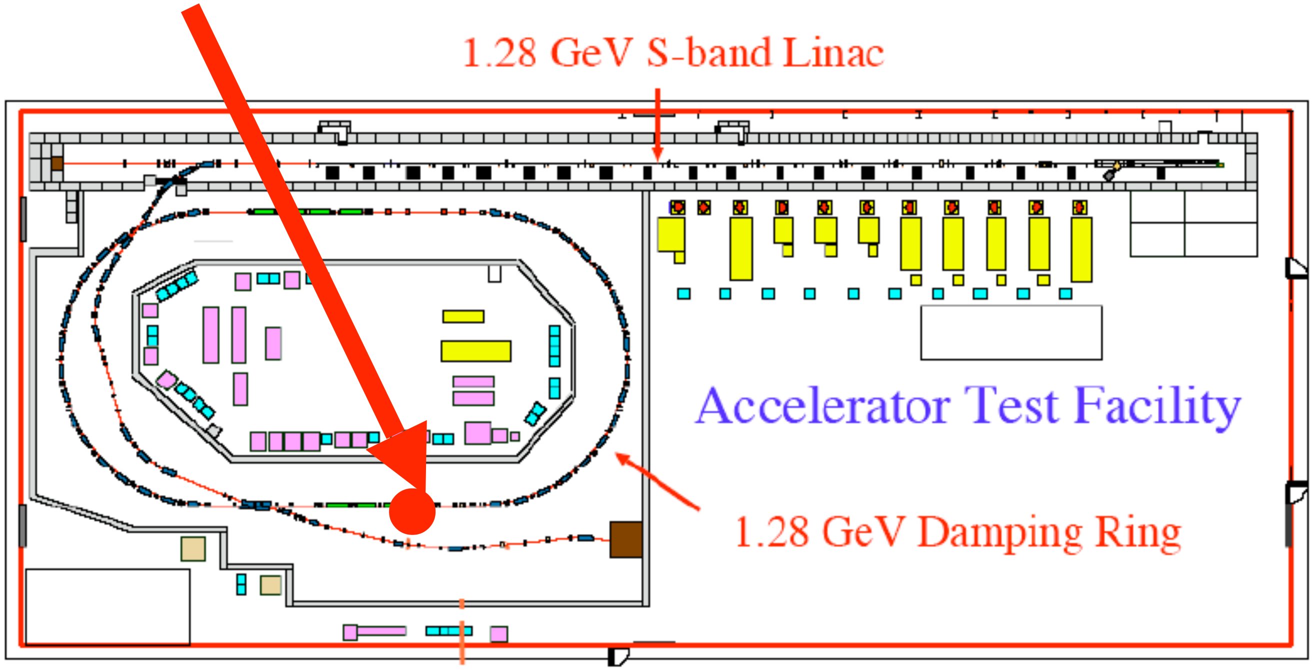
Hiroshima-Waseda-Kyoto-IHEP-KEK



Make a fist prototype 2-mirror cavity

L_{cav} = 420 mm

Put it in ATF ring



Points of R/D

Achieve <u>both</u>

high enhancement & small spot
(less stabile) & (less stabile)

Points for high enhancement factor

remove/suppress vibration

establish feed-back technology

Points for small spot

$2\rho - L_{cav}$ --> +0

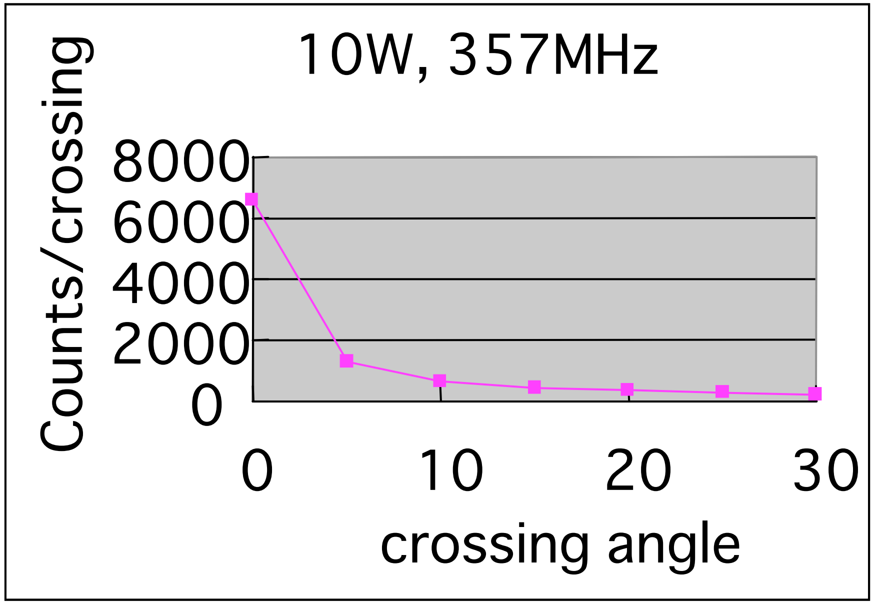
good matching between laser and cavity

all are common in pol. e^+ and laser wire

Points of R/D (continued)

Achieve smaller crossing angle

Number of γ-rays strongly depends on crossing angle



ATF

e^- bunch length = 9 mm (rms)

Ne = $1x10^{10}$/bunch

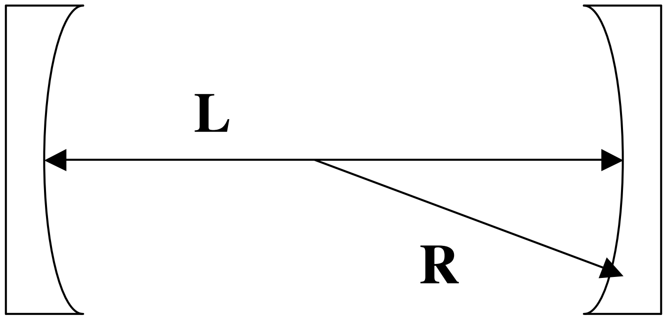
--> Small crossing angle is preferable

--> constraint in chamber design

This in NOT common in pol. e^+ and laser wire

Laser stacking cavity with Two Spherical Mirrors

Choice of R and spot size



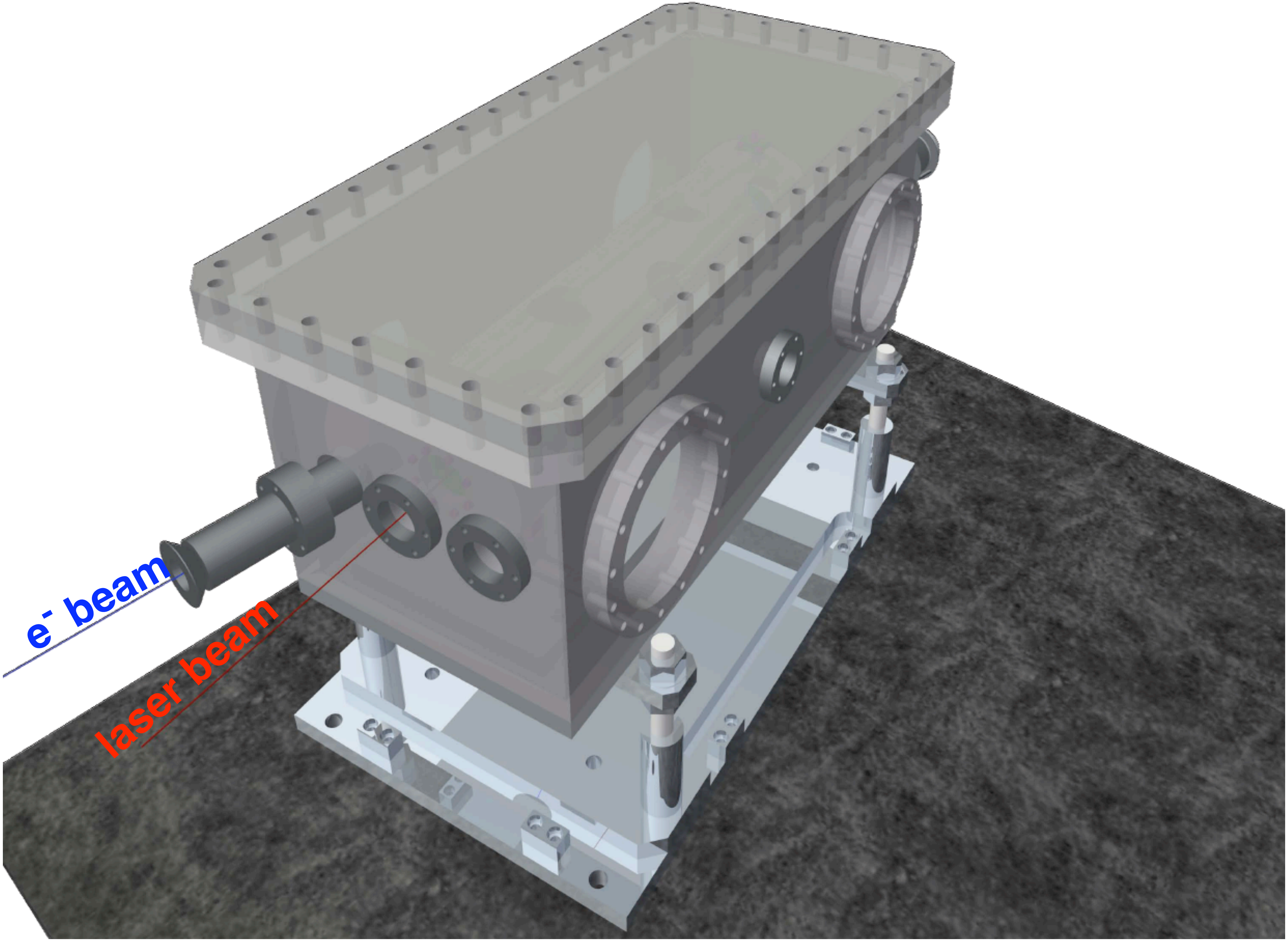
L = 420.00 mm

our choice for 1st prototype →

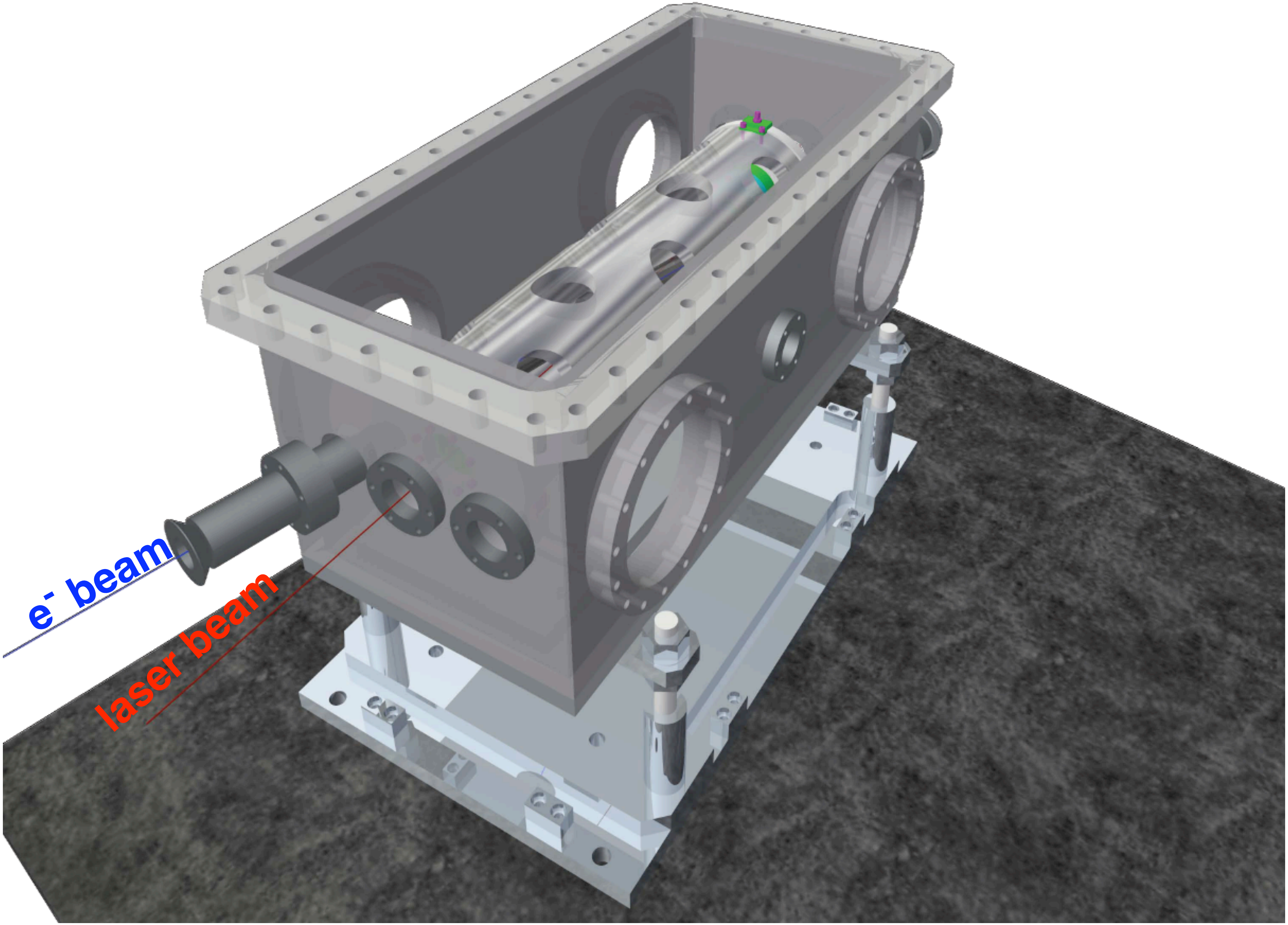
Mirror R (mm)	rms laser spot size (micron)
250	88
211	35
210.5	30
210.1	20
210.01	11
210.001	6

concentric configuration

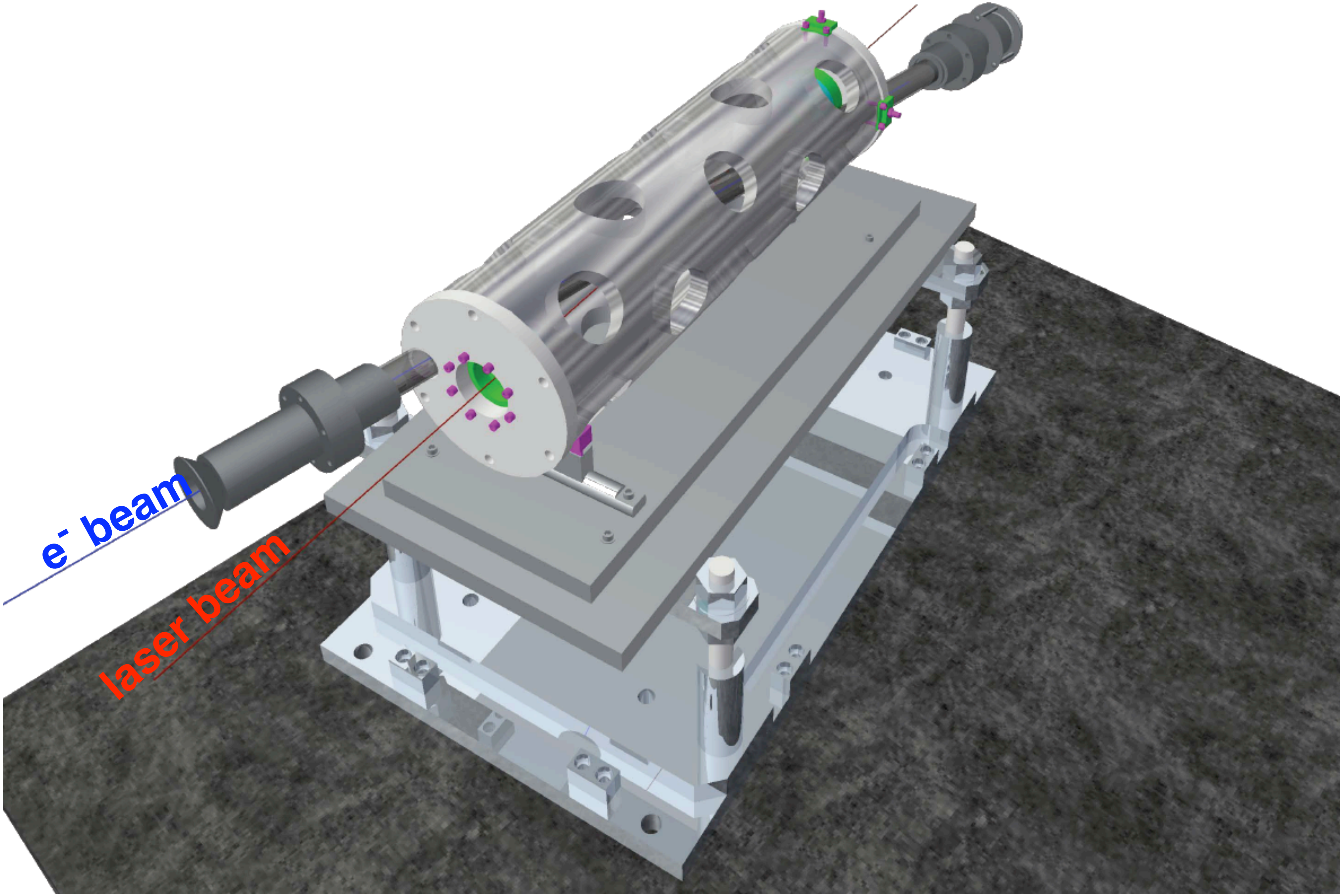
R + R ~ L

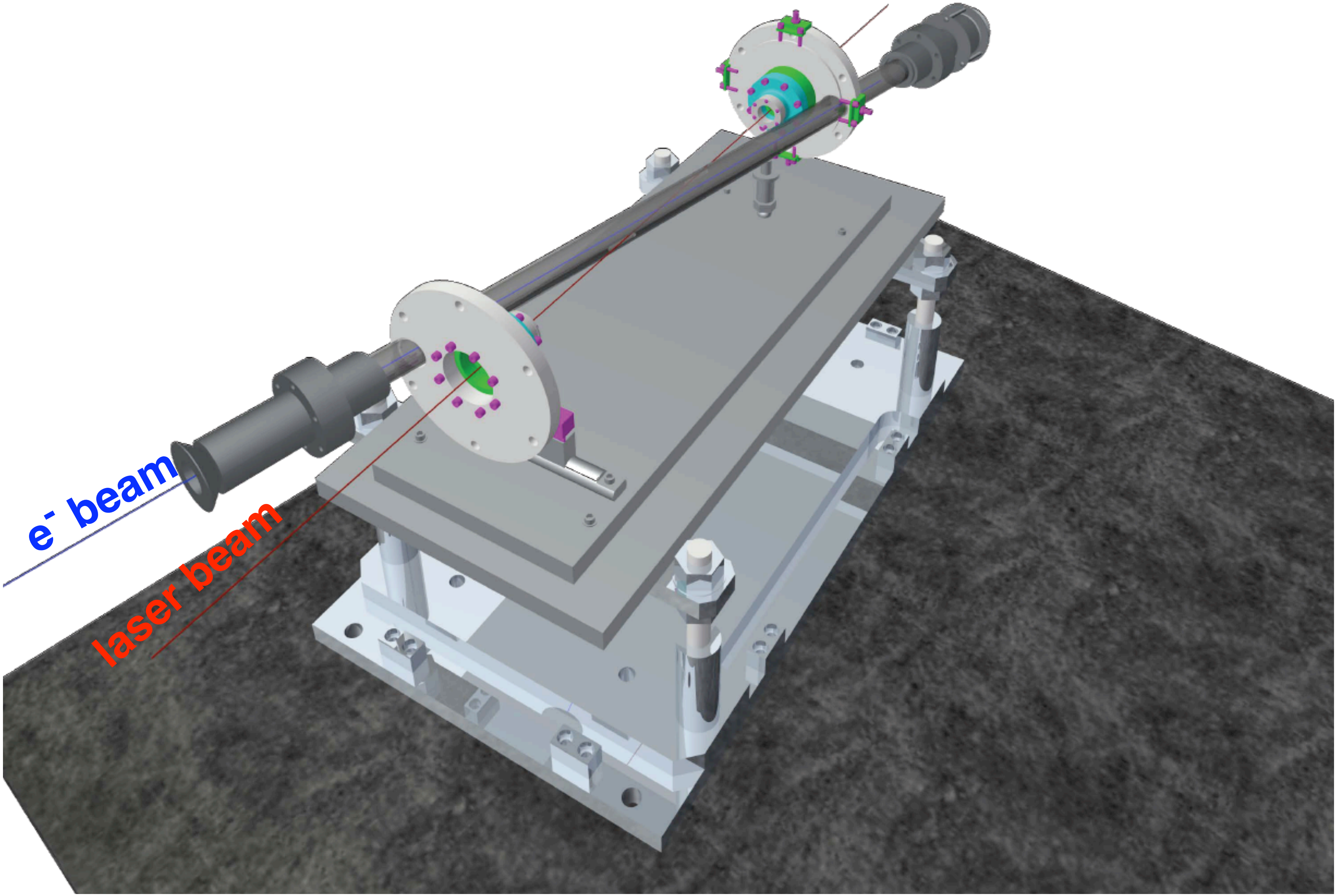


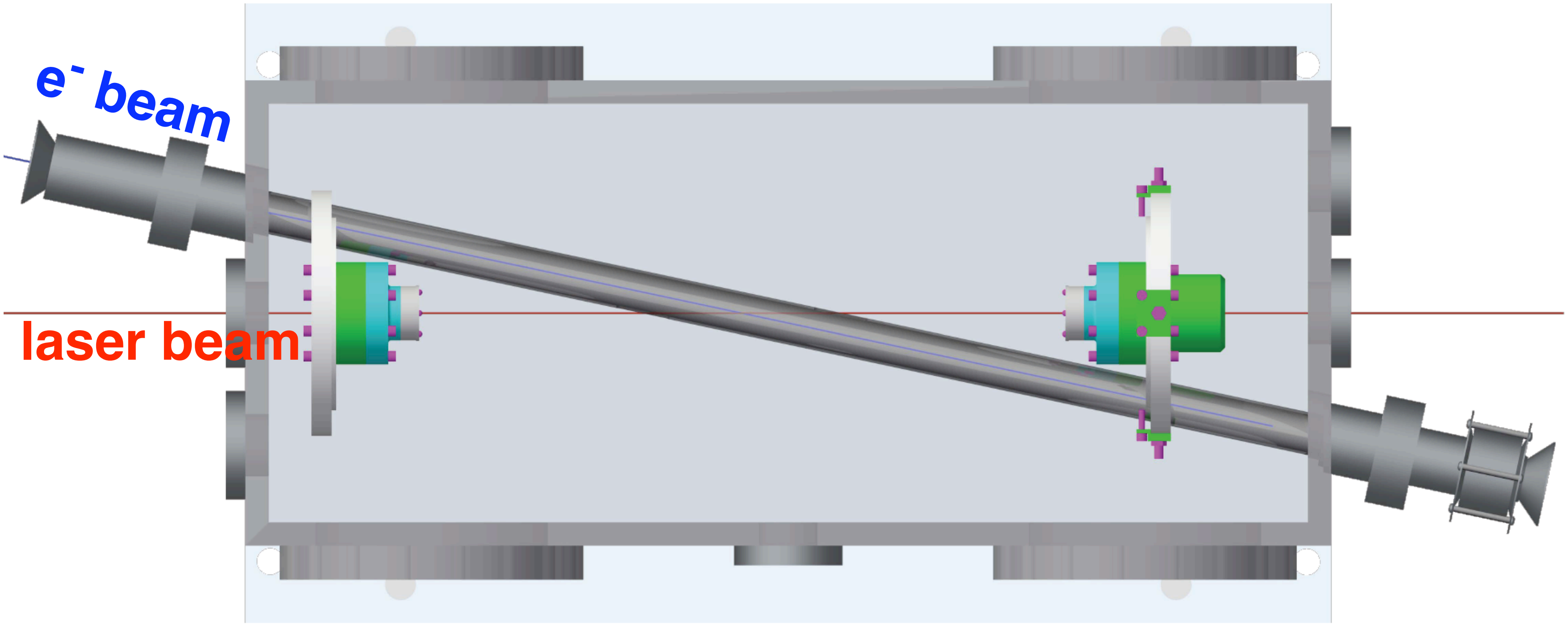
e⁻ beam
laser beam



e- beam
laser beam

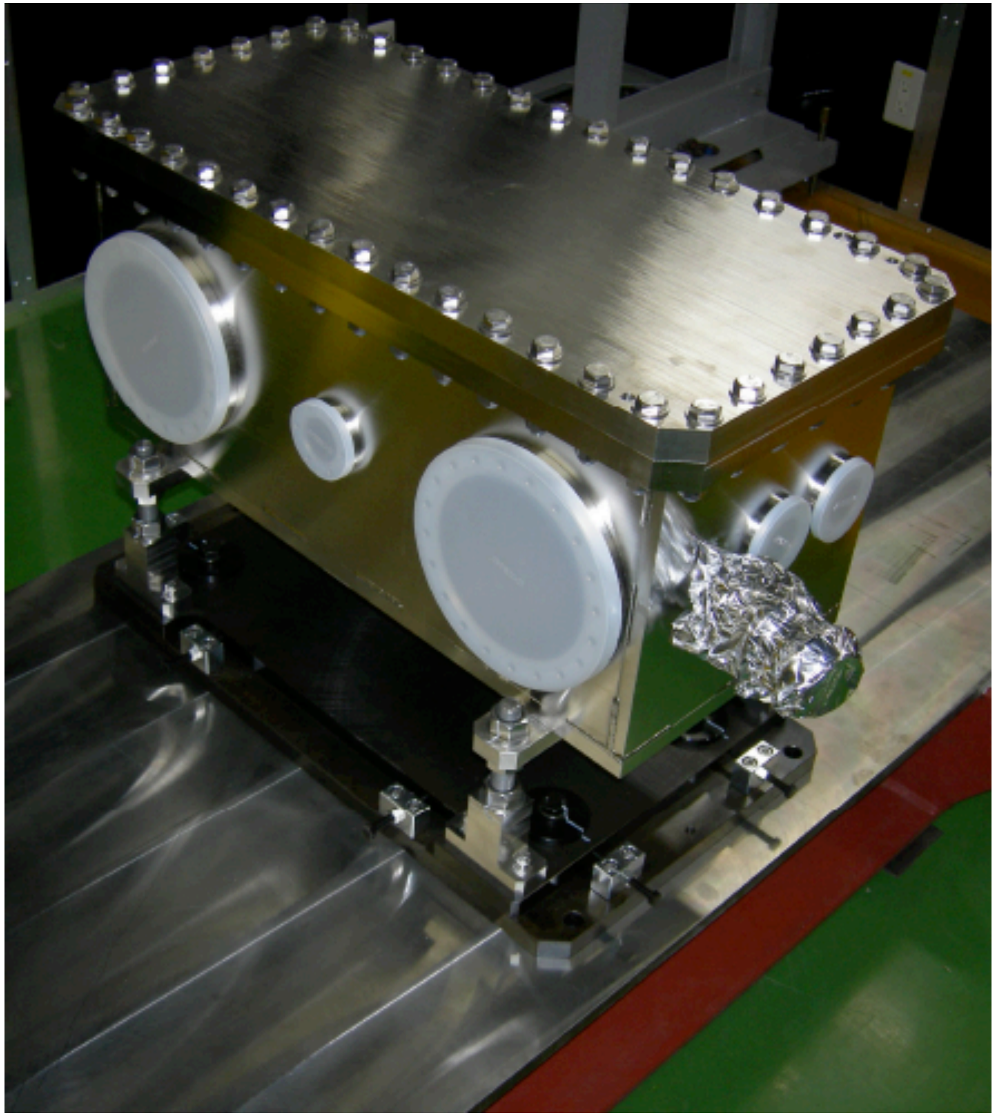

e- beam
laser beam


e- beam
laser beam


e- beam
laser beam

Optical Cavity

Vacuum chamber



Preparation and Schedule

End/2006	Parts of the Optical Cavity delivered
March	Pre-Assemble Optical Cavity done
May	Vacuum chamber delivered
July-Jul	Assemble whole system and make test at outside ATF-DR
Summer	Install prototype cavity into ATF-DR
Oct-Dec	First gamma-ray generation test

Expected Number of γ-rays

Number of γ-rays/bunch

Electron :Ne = 2×10^{10} (single bunch operation)
Laser : 10 W (28 nJ/bunch)
Optical Cavity: Enhancement = 1000

Nγ =1300/bunch X-ing angle = 10 deg
Nγ = 900/bunch X-ing angle = 15 deg

Number of γ-rays/second

Electron :Ne =1×10^{10} (multi-bunch and multi-train operation)
Electron 20 bunches/train, 3 trains/ring
Laser : 10 W (28 nJ/bunch)
Optical Cavity: Enhancement = 1000

Nγ = 8.5×10^{10}/sec X-ing angle = 10 deg
Nγ = 5.7×10^{10}/sec X-ing angle = 15 deg

R/D in France

Very High Enhancement ~ 20000 - 100000

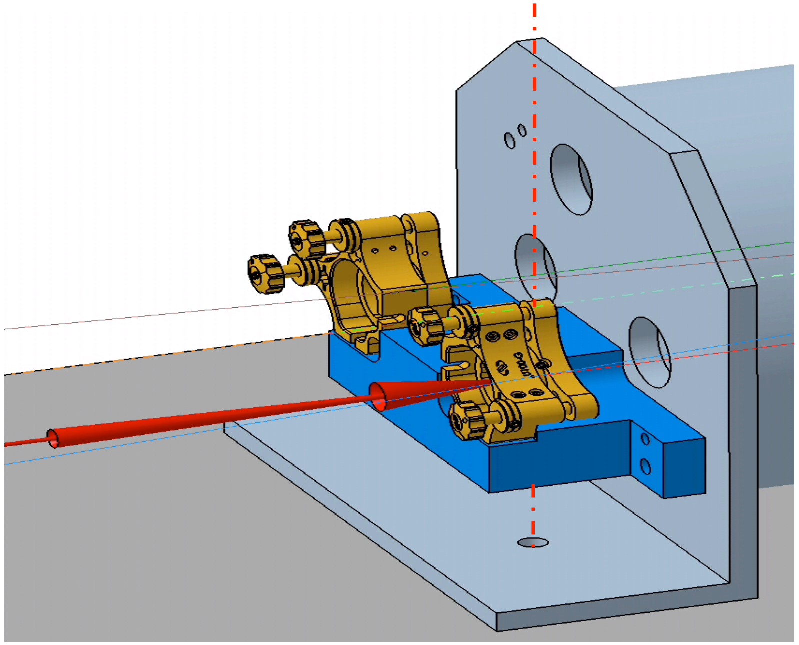
Small spot size ~ 5 micron

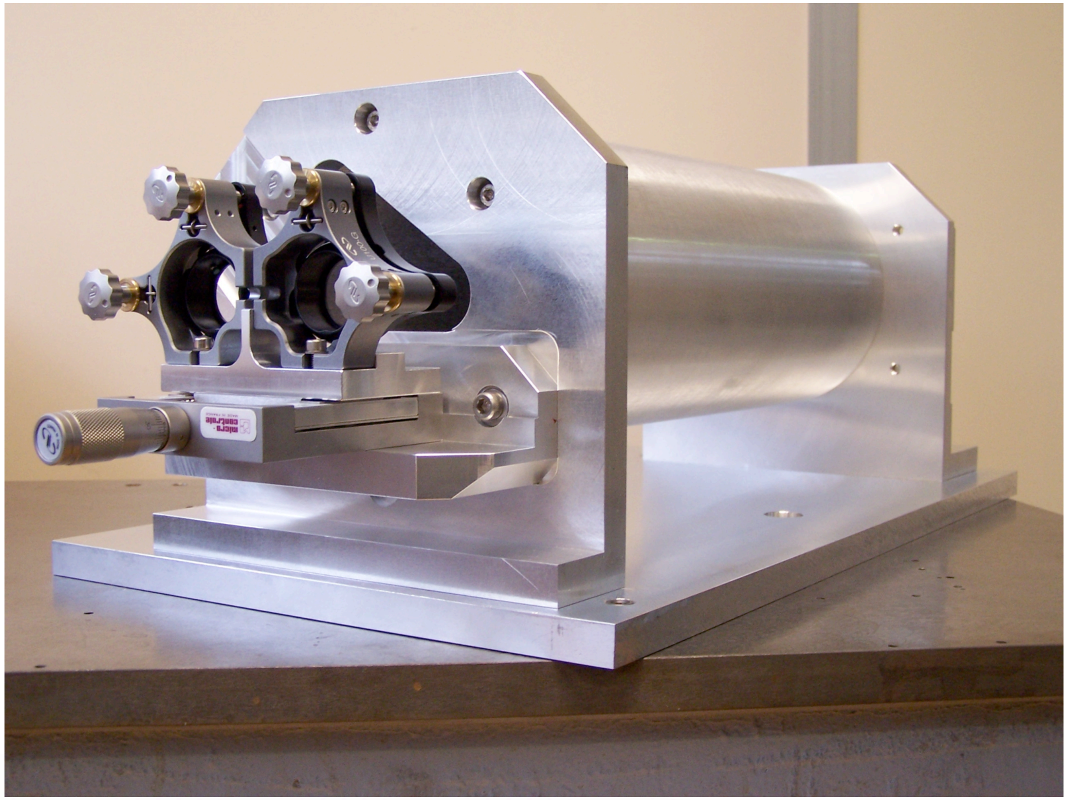
Sofisticated cavity stucture **with 4 mirrors**

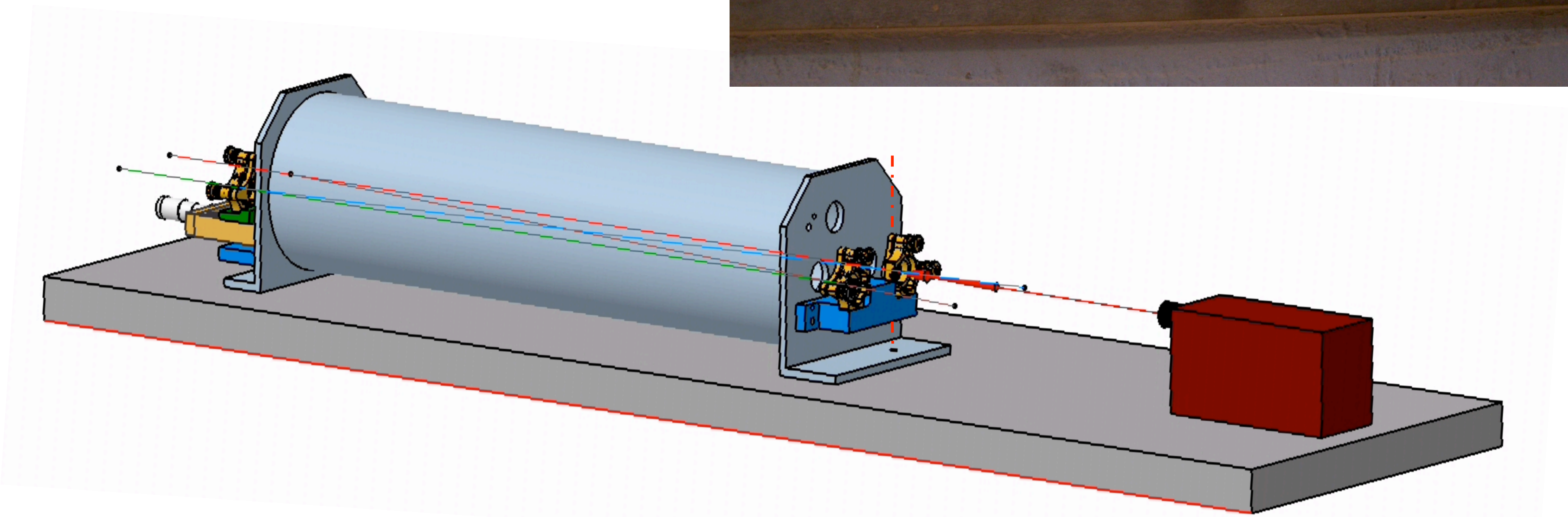
Start with no e^- beam

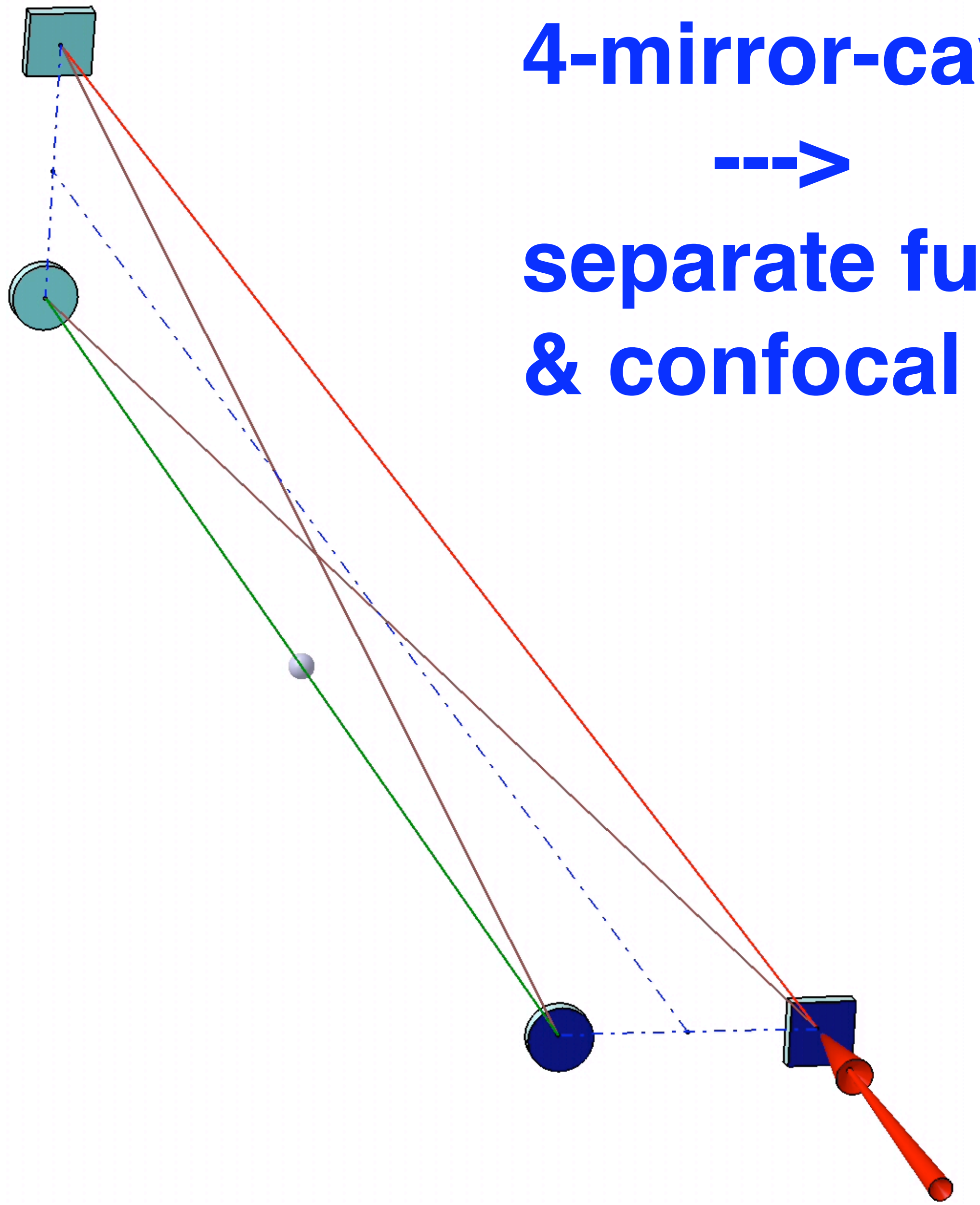
Later we will make a e^- beam compatible cavity

Non planer cavity with 4 mirrors in LAL









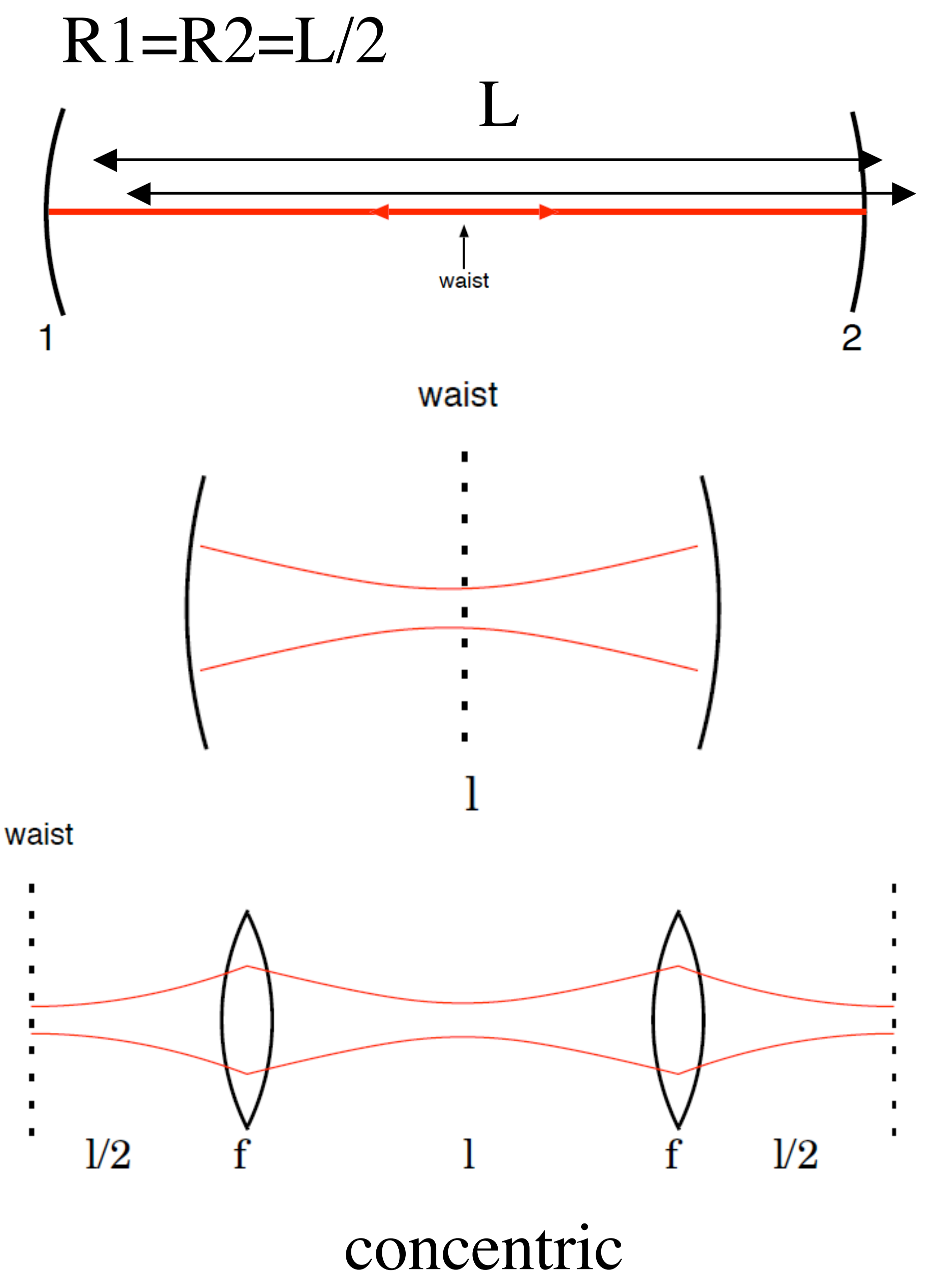
4-mirror-cavity

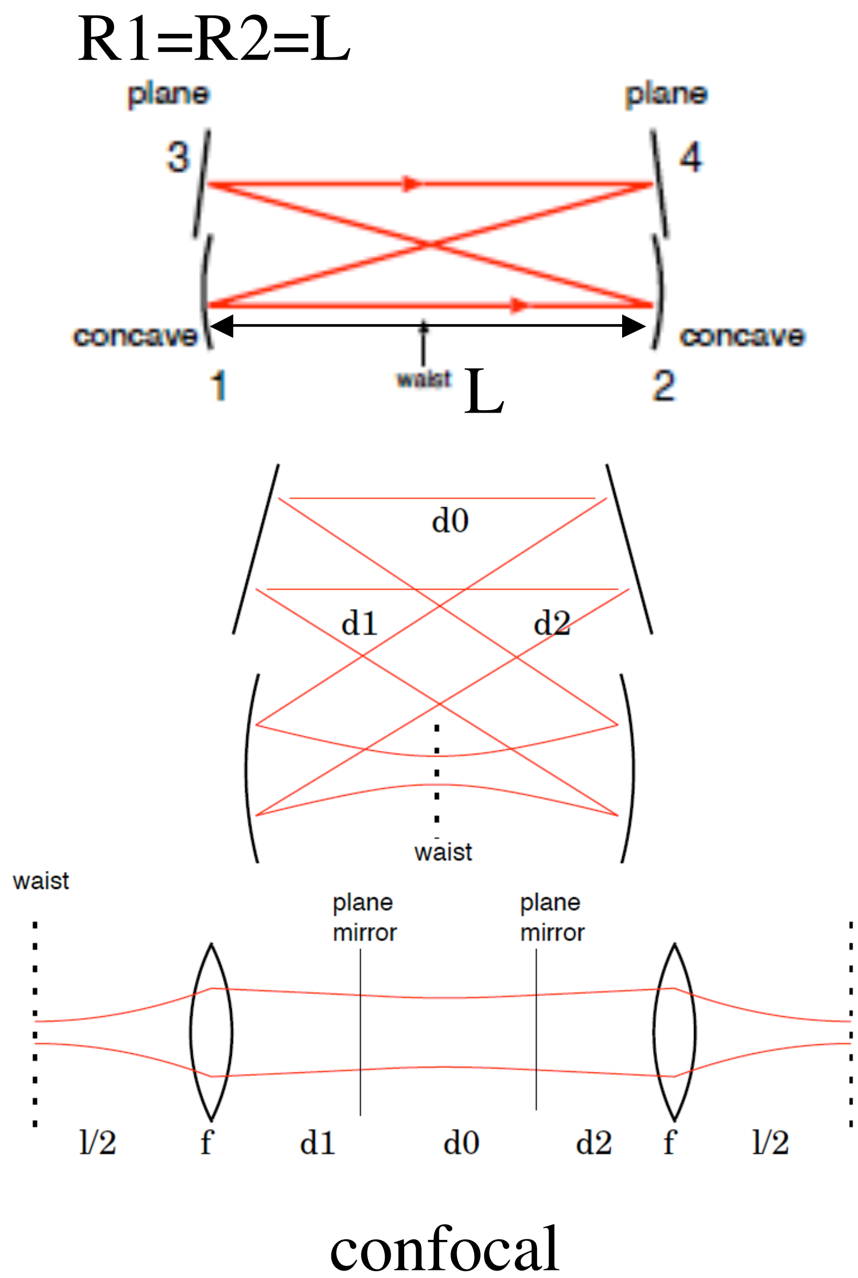
--->

separate functions
& confocal configuration

2-mirror cavity

4-mirror cavity





R/D in France and in Japan are Complementary

R/D in France

Very High Enhancement ~ 20000 - 100000

R/D in Japan

Moderate Enhancement ~ 1000

R/D in France and in Japan are Complementary

R/D in France

Very High Enhancement ~ 20000 - 100000

Small spot size ~ 5 micron

R/D in Japan

Moderate Enhancement ~ 1000

Moderate spot size ~ 30 micron

R/D in France and in Japan are Complementary

R/D in France

Very High Enhancement ~ 20000 - 100000

Small spot size ~ 5 micron

Sofisticated cavity stucture with 4 mirrors

R/D in Japan

Moderate Enhancement ~ 1000

Moderate spot size ~ 30 micron

Simple cavity stucture with two mirrors

R/D in France and in Japan are Complementary

R/D in France

Very High Enhancement ~ 20000 - 100000

Small spot size ~ 5 micron

Sofisticated cavity stucture with 4 mirrors

Digital feedback

R/D in Japan

Moderate Enhancement ~ 1000

Moderate spot size ~ 30 micron

Simple cavity stucture with two mirrors

Analog feedback

R/D in France and in Japan are Complementary

R/D in France

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Digital feedback

Start with no e^- beam

R/D in Japan

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Analog feedback

Get experinence with e^- beam

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Simple cavity stucture with two mirrors

Analog feedback

Get experinence with e^- beam

World-wide Collaboration

PosiPol Collaboration

Collaborating Institutes:

BINP, CERN, DESY, Hiroshima, IHEP, IPN, KEK, Kyoto, LAL, NIRS, NSC-KIPT, SHI, Waseda, BNL, and ANL

Sakae Araki, Yasuo Higashi, Yousuke Honda, Masao Kuriki, Toshiyuki Okugi, Tsunehiko Omori, Takashi Taniguchi, Nobuhiro Terunuma, Junji Urakawa, X. Artru, M. Chevallier, V. Strakhovenko, Eugene Bulyak, Peter Gladkikh, Klaus Meonig, Robert Chehab, Alessandro Variola, Fabian Zomer, Alessandro Vivoli, Richard Cizeron, Frank Zimmermann, Kazuyuki Sakaue, Tachishige Hirose, Masakazu Washio, Noboru Sasao, Hirokazu Yokoyama, Masafumi Fukuda, Koichiro Hirano, Mikio Takano, Tohru Takahashi, Hirotaka Shimizu, Shuhei Miyoshi, Akira Tsunemi, Li XaioPing, Pei Guoxi, Jie Gao, V. Yakinenko, Igo Pogorelsky, Wai Gai, and Wanming Liu

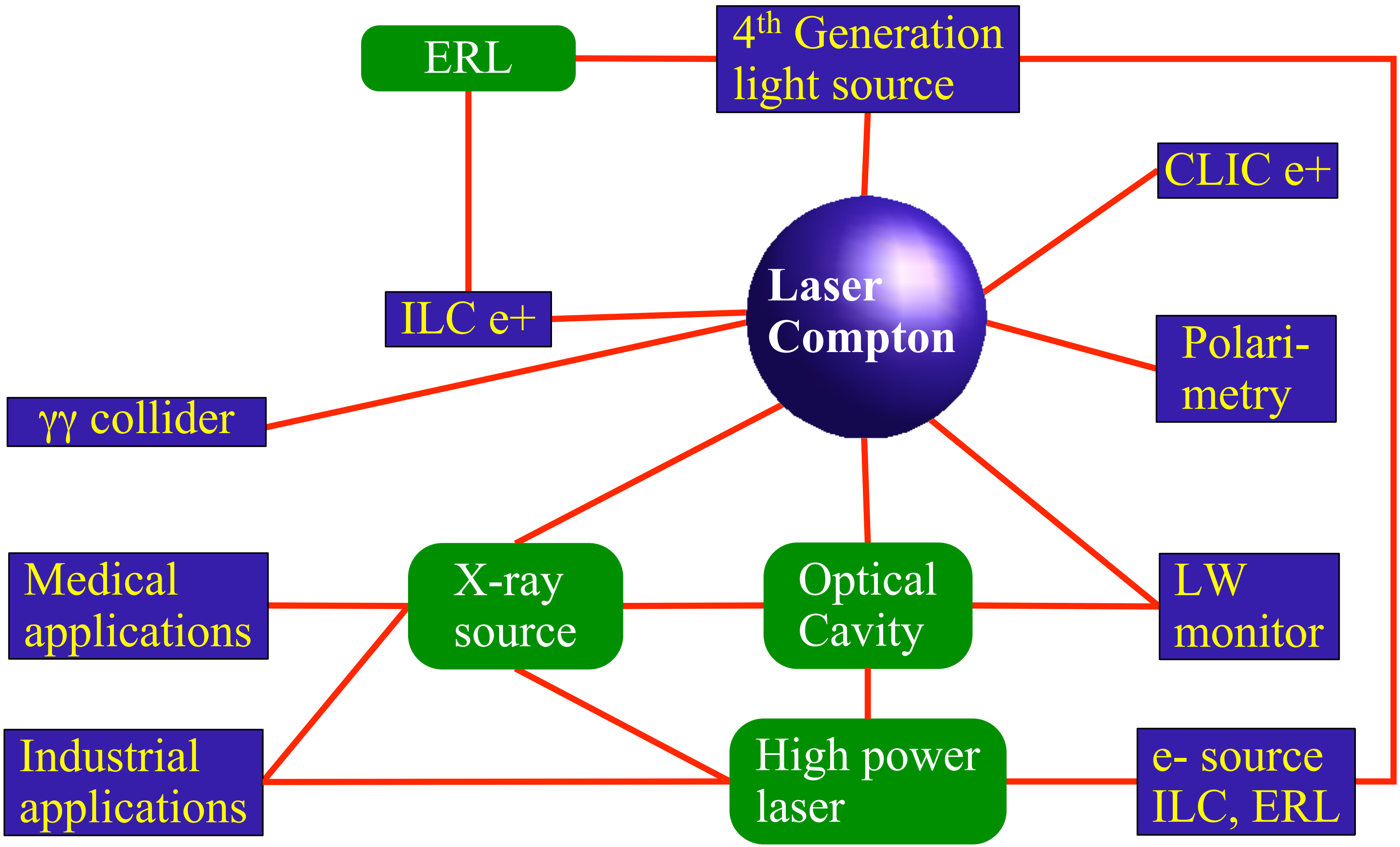
POSIPOL 2006
CERN April 2006

http://posipol2006.web.cern.ch/Posipol2006/

POSIPOL 2007
LAL-Orsay, France
23-25 May

http://events.lal.in2p3.fr/conferences/Posipol07/

World-Wide-Web of Laser Compton



Summary

1. Compton e^+ source is an advanced alternative of ILC e^+ source
2. Laser stacking cavity is a key.
3. In Japan, we are preparing γ-ray generation by installing the stacking cavity in ATF-DR.
4. In France, we are developing a very advanced cavity with 4 mirrors. In future, a 4-mirror cavity will be installed in ATF-DR for γ-ray generation.
5. We have a world-wide collaboration for Compton. Not only for ILC e^+ source. Also for many other applications.

Extra Slides

Cavity History in Japan

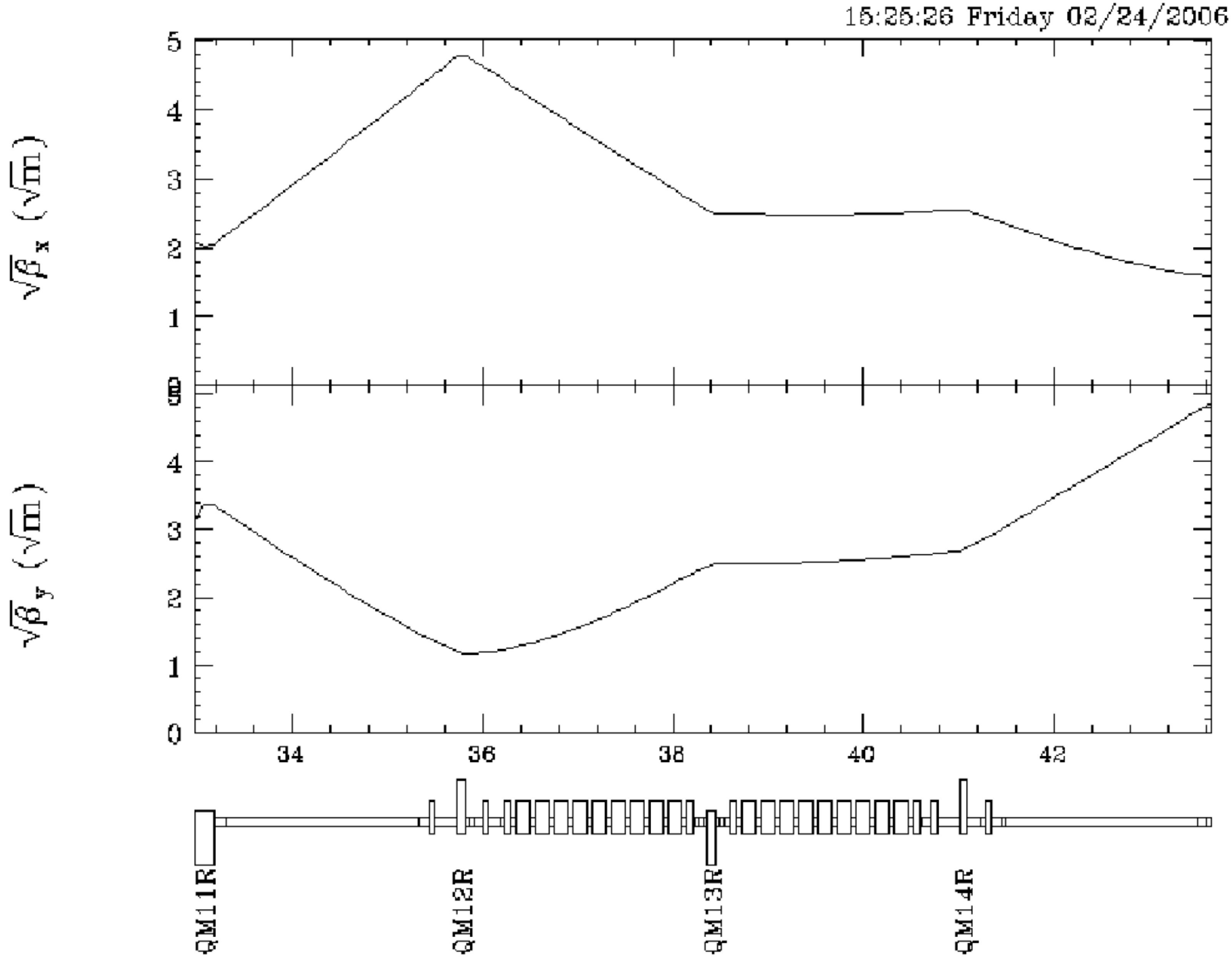
by H. Sato (Posipol 2006)

	What we want ILC YAG case (Snowmass 2005)	Now on Going at KEK-ATF	Achieved in 2004 (Takezawa(Kyoto U) et al) at KEK-ATF
Electron Energy (GeV)	1.3	1.3	1.3
Ne/bunch	6.2E10	2.0E10	1.0E10
Electron repetition rate (MHz)	325	357	357
Hor. Beam size (rms,us)	25	79	79
Ver. Beam size (rms,us)	5	6	6
Bunch length (rms,mm)	5	9	9
Laser type (wavelength)	YAG(1064nm)	YAG(1064nm)	YAG(1064nm)
Laser frequency (MHz)	325	357	357
Laser radius (rms, um)	5	29	125
Laser pulse width (rms,mm)	0.9	0.9	0.9
Laser pulse power /cavity	750μJ x 1000	28nJ(10W) x 1000	1nJ(0.3W) x 65
Number of laser cavities	30	1	1
Crossing angle (degree)	8	12	90

e^- beam optics

DR North Straight Section

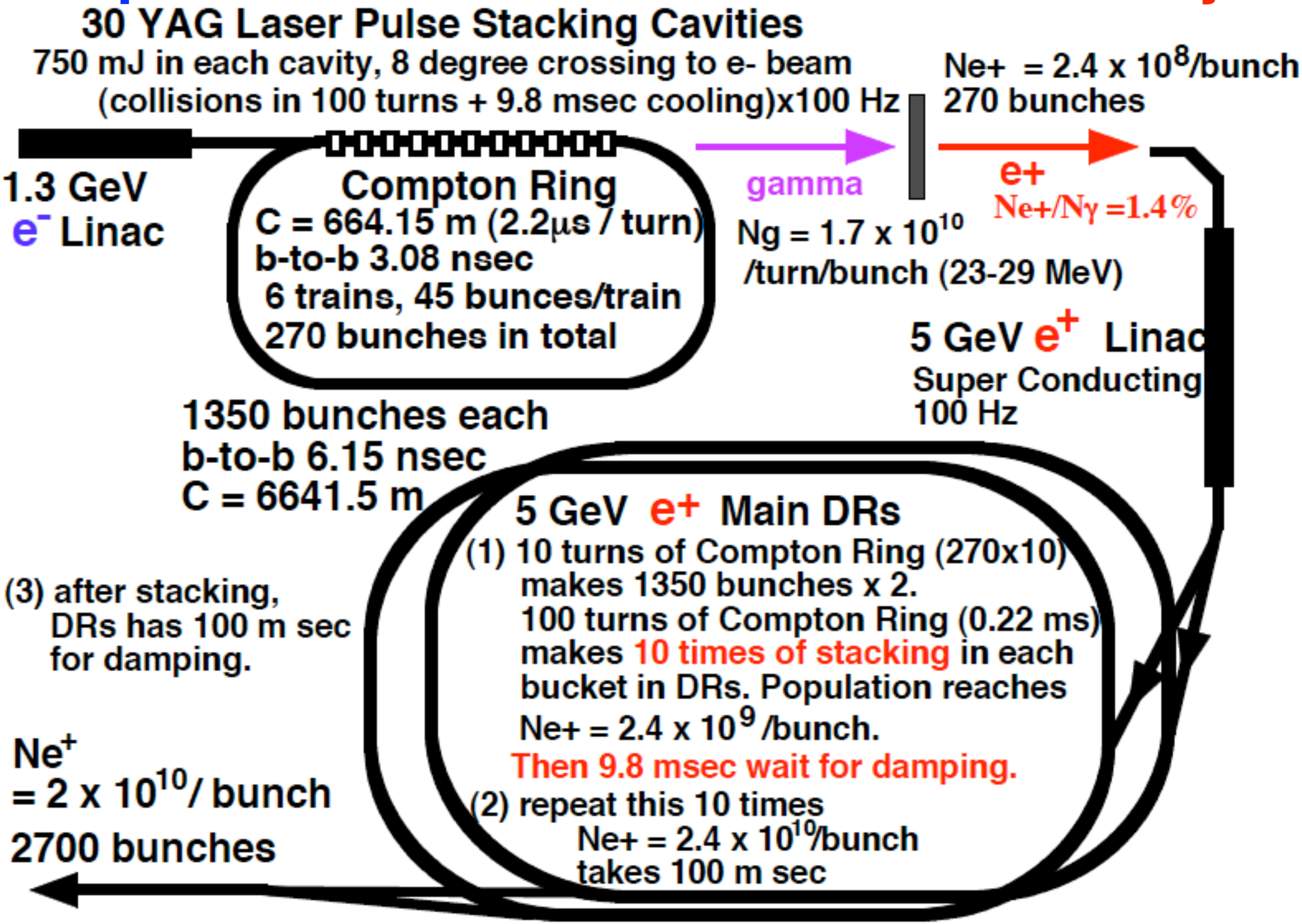
by T. Okugi



e^- beam optics and spot size

```
s = 40 m (=s0)  (between QM13R and QM14R)

    Twiss Parameter
         alpha_x = -0.092 m
         beta_x  =  6.155 m
         eta_x   =  0     m

         alpha_y = -0.232 m
         beta_y  =  6.546 m
         eta_y   =  0     m

    Assume
         eps_x   = 1.0E-09 m
         eps_y   = 0.5E-11 m

    e- beam spot size
         sig_x (s0) = 78 um
         sig_y (s0) =  6 um
           Stay almost constant in S = +- 1 m
```

Compton for "2 x 6 km DR": no simulation yet



Collision Point

Collision point is at between QM13R and QM14R (s = 40 m)