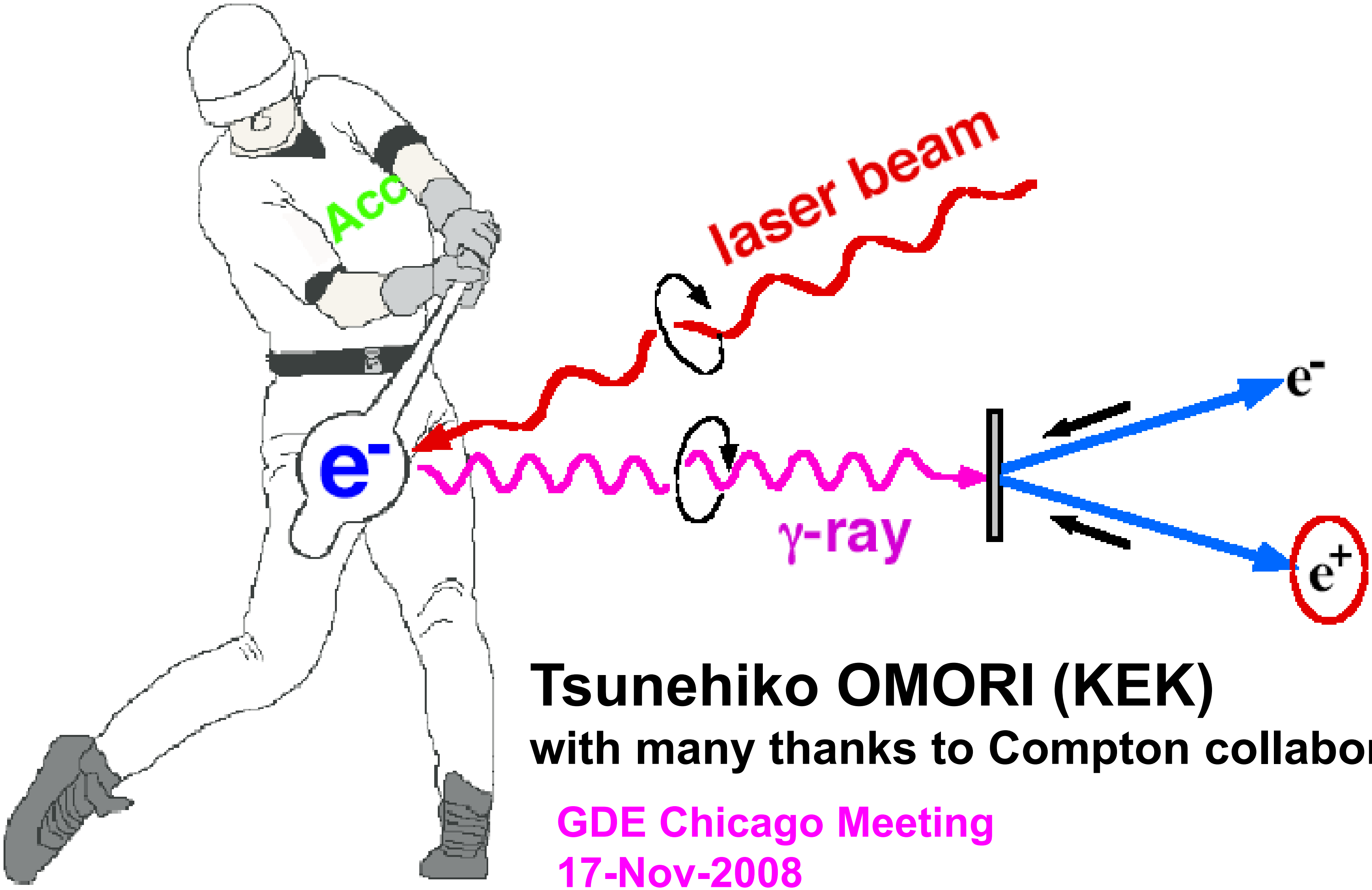
Ring/ERL Compton e^+ Source for ILC



Tsunehiko OMORI (KEK)
with many thanks to Compton collaborators

GDE Chicago Meeting
17-Nov-2008

Why Laser-Compton ?

i) Positron Polarization.

ii) Independence

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

Laser-base e^+ : independent

iii) Polarization flip @ 5Hz (for CLIC @ 50 Hz)

iv) High polarization (potentially <-- 1st harmonic)

v) Low energy operation

Undulator-base e^+ : need deceleration

Laser-base e^+ : no problem

vi) Synergy in wide area of fields/applications

Laser Compton e^+ Source for ILC/CLIC

We have 3 schemes.

1. Ring-Base Laser Compton
   Storage Ring + Laser Stacking Cavity (λ=1μm), and e+ stacking in DR
   S. Araki et al., physics/0509016

My talk today

2. ERL-Base Laser Compton
   ERL + Laser Stacking Cavity (λ=1μm), and e+ stacking in DR

3. Linac-Base Laser Compton
   Linac + non-stacking Laser Cavity (λ=10μm), and No stacking in DR

Vitaly-san at Chicago

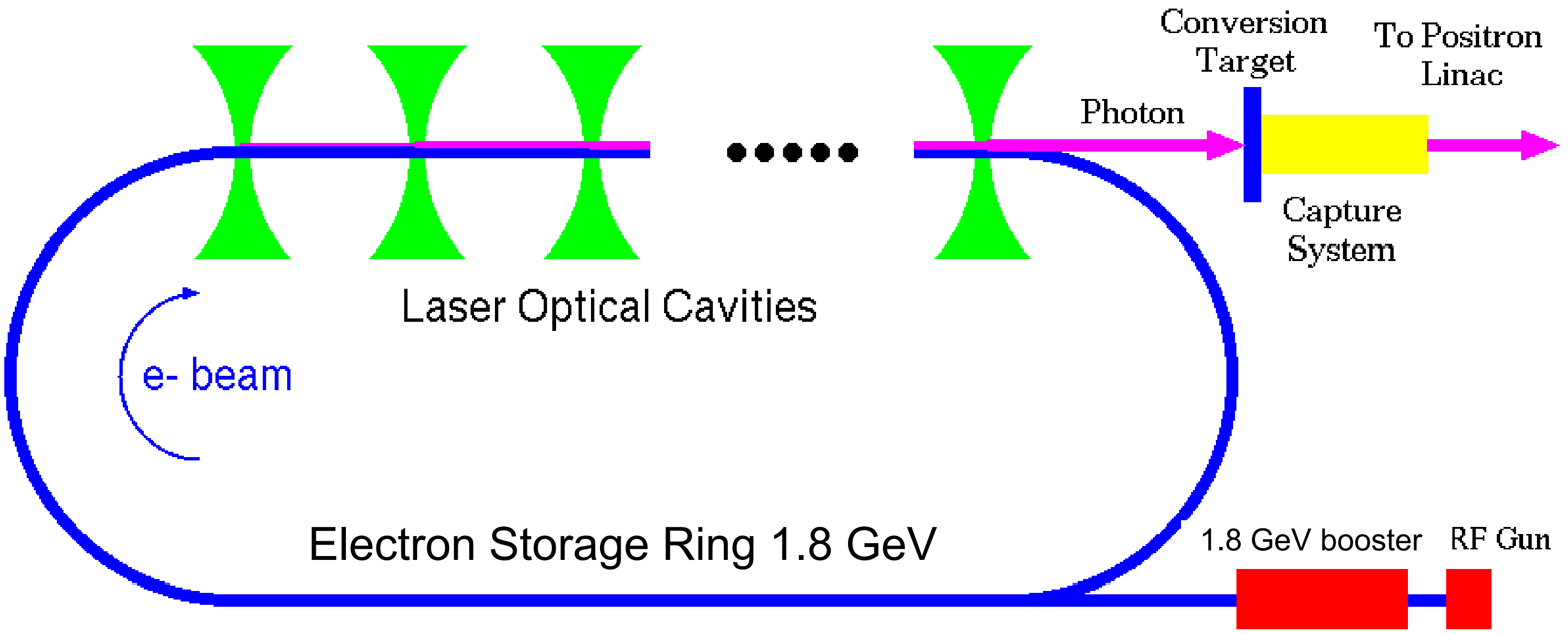
Proposal V. Yakimenko and I. Pogorersky

T. Omori et al., Nucl. Instr. and Meth. in Phys. Res., A500 (2003) pp 232-252

Ring/ERL Scheme
for ILC

Compton Ring Scheme for ILC

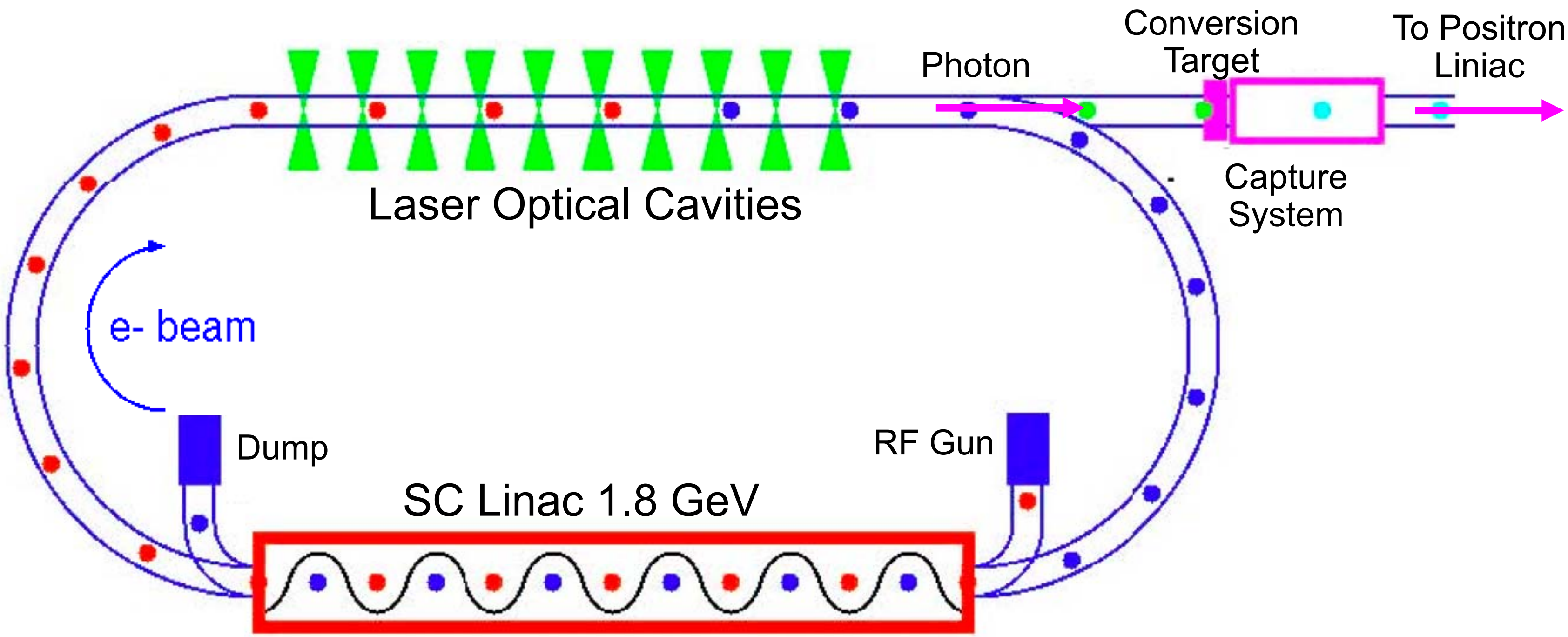
- ►Compton scattering of e- beam stored in storage ring off laser stored in Optical Cavity.
- ►5.3 nC 1.8 GeV electron bunches x 5 of 600mJ stored laser -> 2.3E+10 γ rays -> 2.0E+8 e+.
- ►By stacking 100 bunches on a same bucket in DR, 2.0E+10 e+/bunch is obtained.



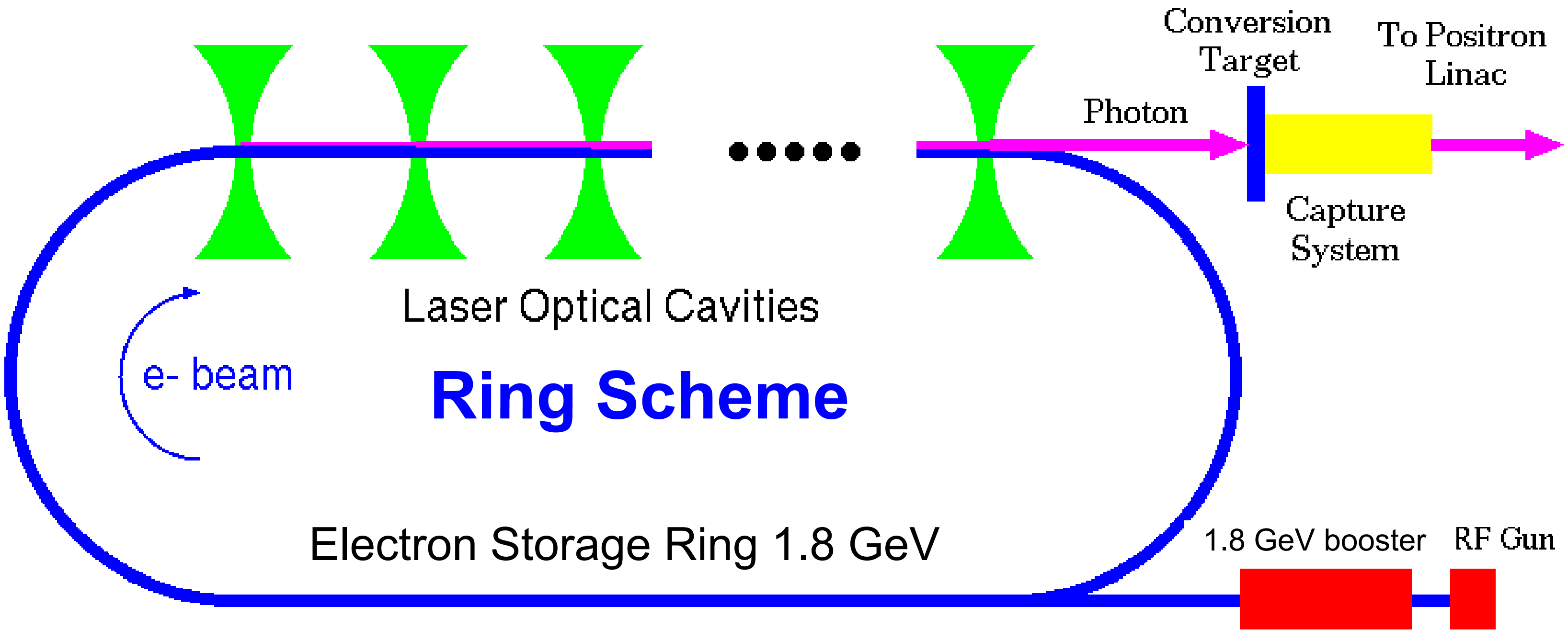
ERL scheme for ILC

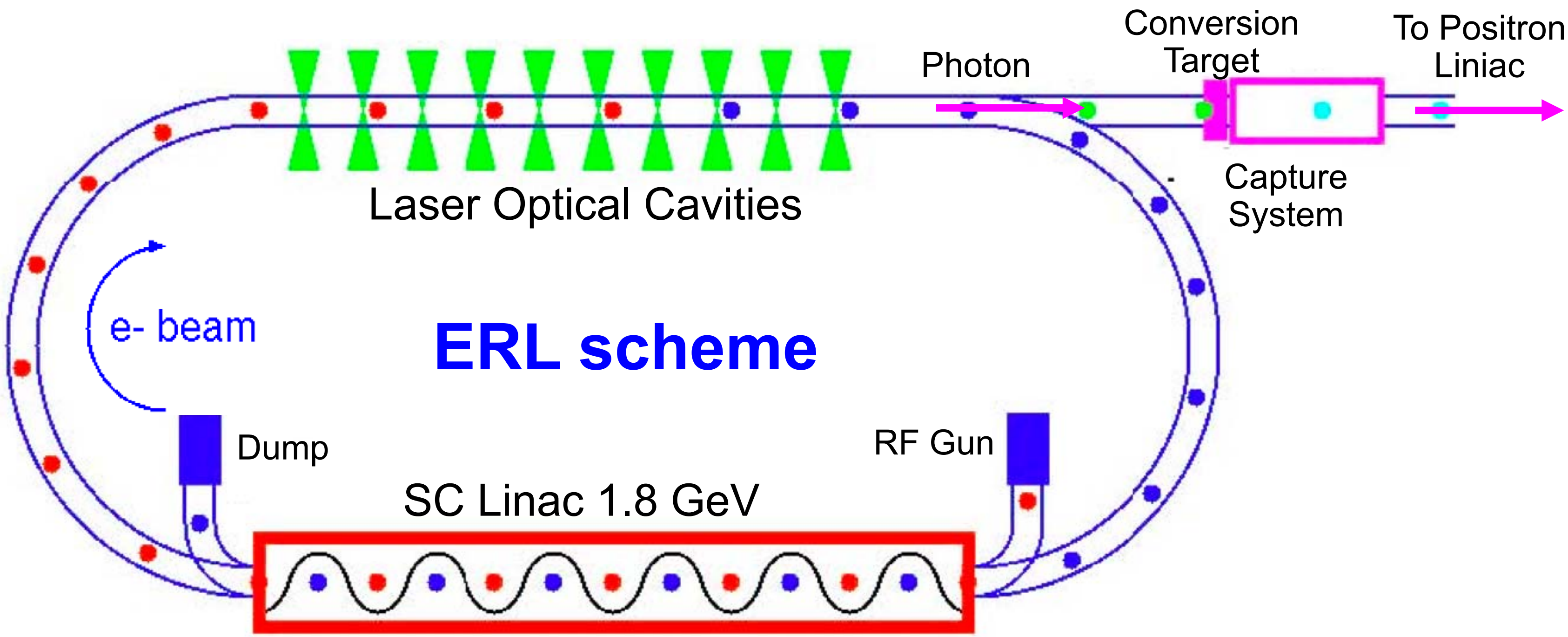
- High yield + high repetition in ERL solution.
  - 0.48 nC 1.8 GeV bunches x 5 of 600 mJ laser, repeated by 54 MHz -> 2.5E+9 γ-rays -> 2E+7 e+.
  - Continuous stacking the e+ bunches on a same bucket in DR during 100ms, the final intensity is 2E+10 e+.

1000 times of stacking in a same bunch



Ring scheme and ERL scheme are SIMILAR





What is the Difference? : Ring and ERL

What is Reused

Ring: Electron Beam

ERL: Energy of the electron beam

What is the Difference? : Ring and ERL

What is Reused

- Ring: Electron Beam
- ERL: Energy of the electron beam

Collision / Operation

- Ring: Burst Collision (need cooling time)
- ERL: as CW as possible

What is the Difference? : Ring and ERL

What is Reused

Ring: Electron Beam

ERL: Energy of the electron beam

Collision / Operation

Ring: Burst Collision (need cooling time)

ERL: as CW as possible

Bunch Length

Ring: Naturally Long (typically 30 psec)

ERL: Short (can be less than 1 p sec)

What is the Difference? : Ring and ERL

What is Reused

Ring: Electron Beam

ERL: Energy of the electron beam

Collision / Operation

Ring: Burst Collision (need cooling time)

ERL: as CW as possible

Bunch Length

Ring: Naturally Long (typically 30 psec)

ERL: Short (can be less than 1 p sec)

Bunch Charge

Ring: Larger

ERL: Smaller

Necessary R/Ds

for Ring / ERL scheme

Ring / ERL scheme R&D List

e+ stacking in DR

simulation studies

talk F. Zimmermann

Compton Ring simulation studies

ERL simulation studies

e+ capture (common in all e+ sources)

Simulation study

Collaboration with KEKB upgrade

e+ production target

Laser

Fiber laser / Mode-lock laser

Laser Stacking Cavity

experimental and

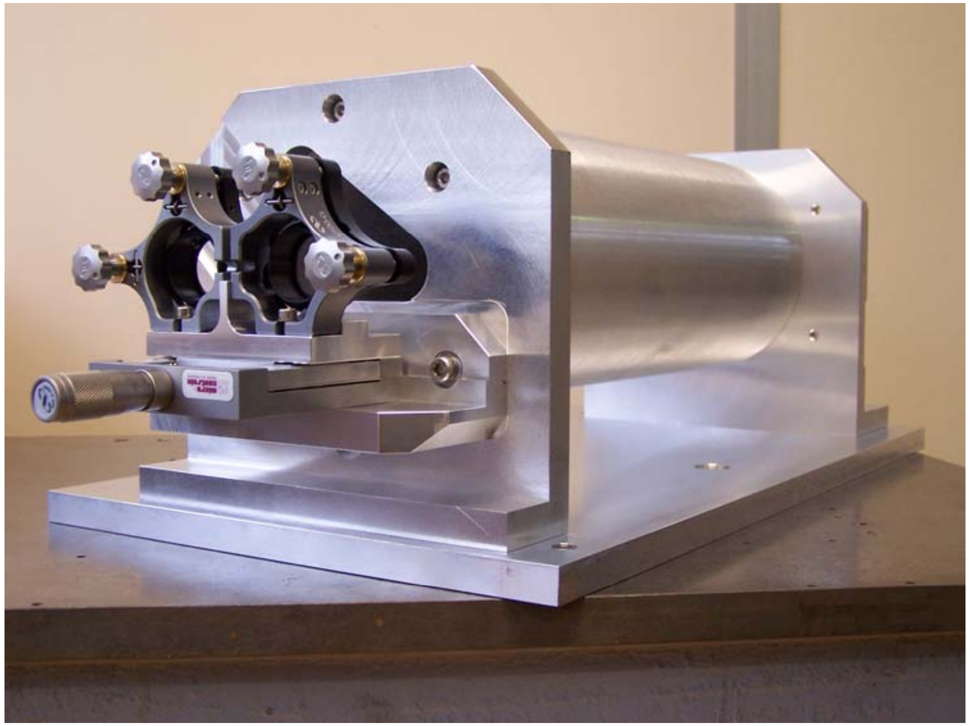
theoretical studies

Prototype Cavities

2-mirror cavity (Hiroshima / Weseda / Kyoto / IHEP / KEK)

moderate enhancement
moderate spot size
simple control

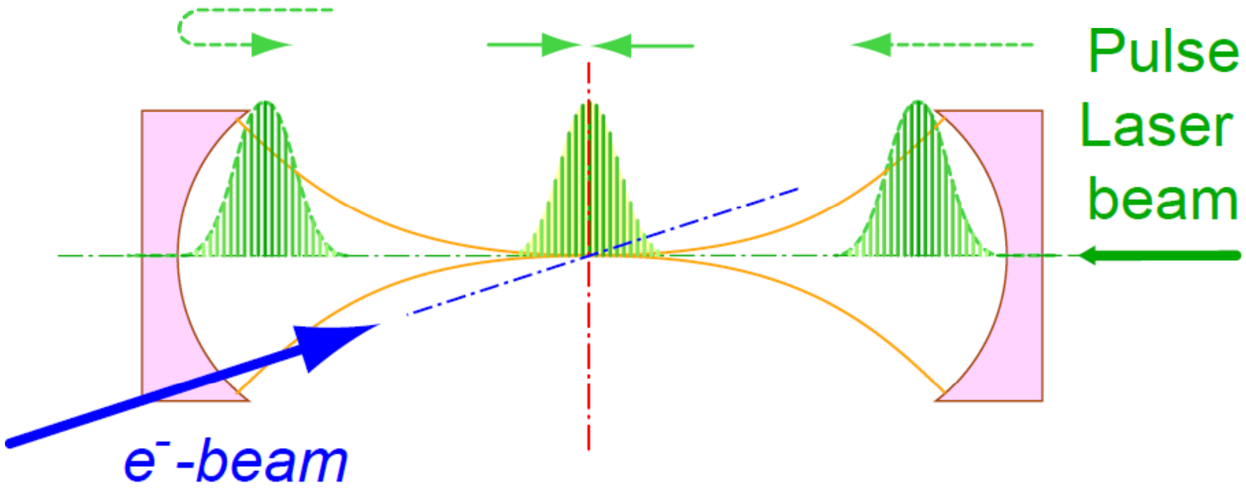
4-mirror cavity (LAL)



high enhancement
small spot size
complicated control

Experimental R/D in ATF

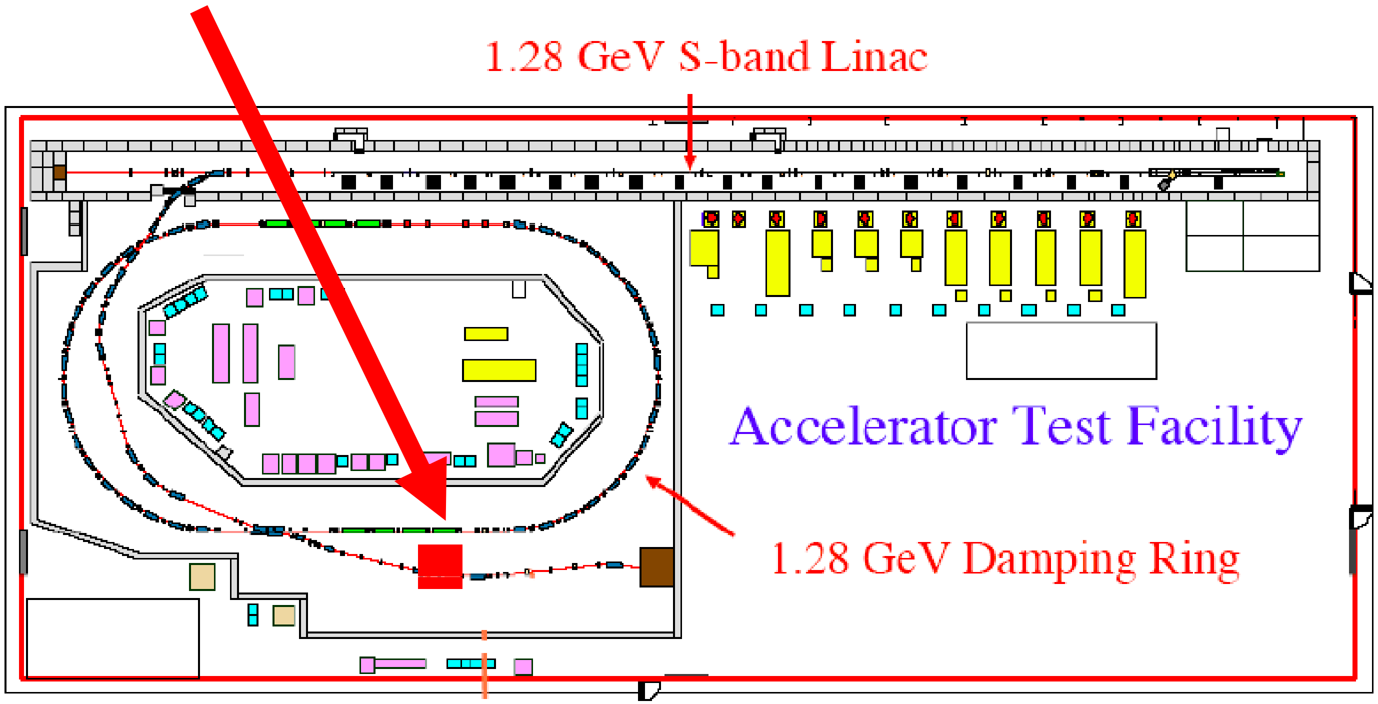
Hiroshima-Waseda-Kyoto-IHEP-KEK



Make a fist prototype 2-mirror cavity

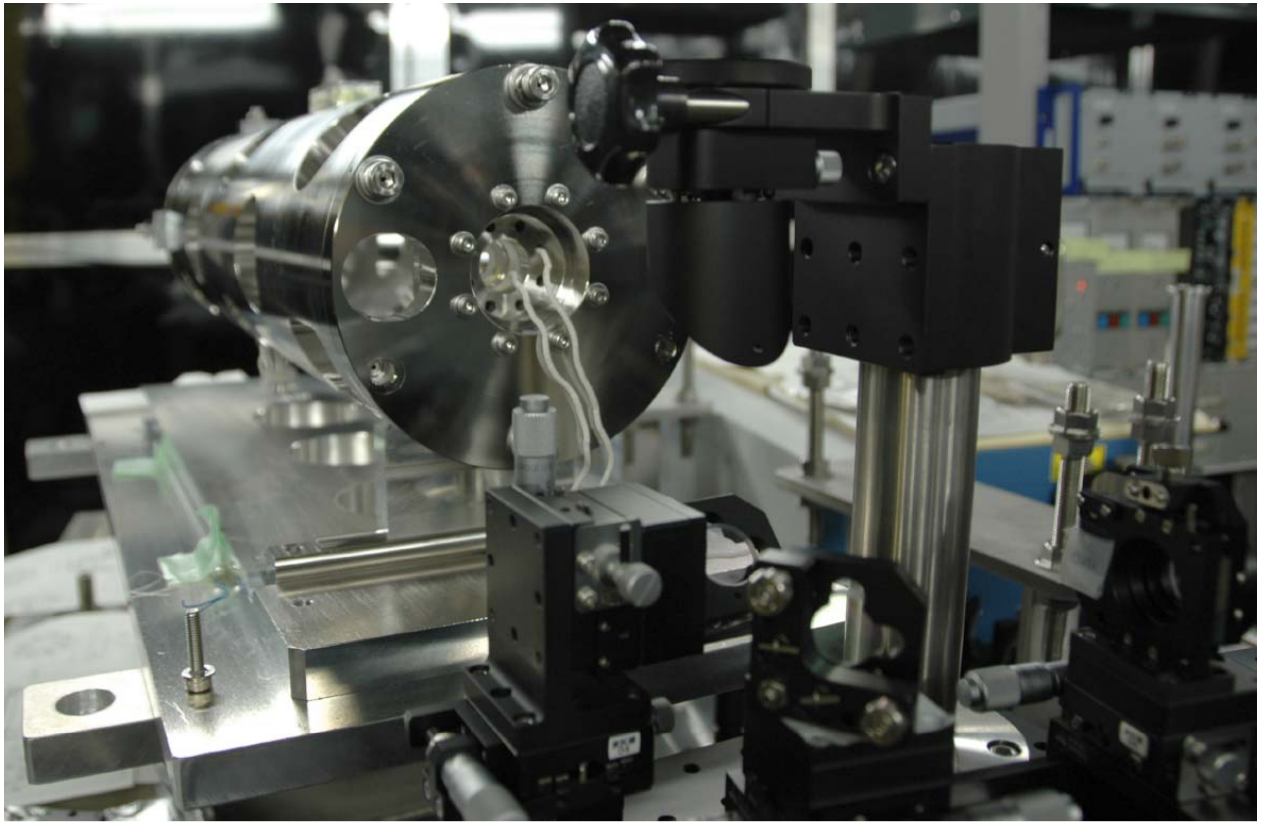
L_{cav} = 420 mm

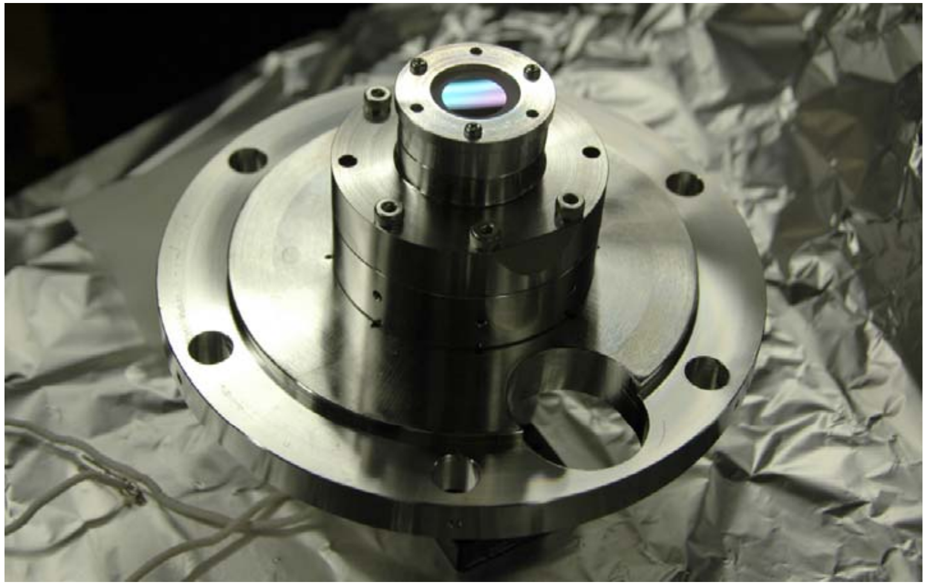
Put it in ATF ring



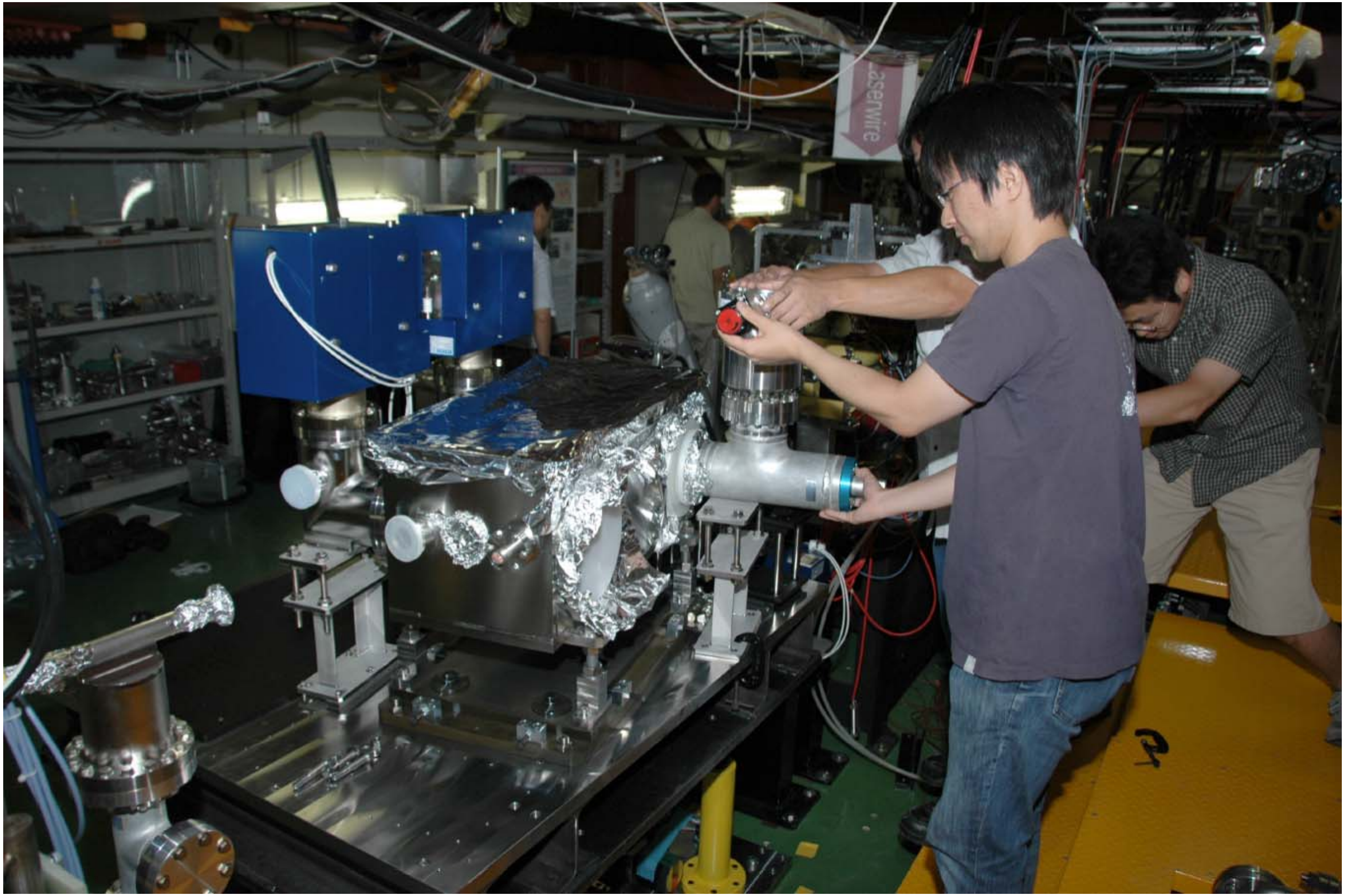
Laser Stacking Optical Cavity in Vacuum Chamber

Summer 2007: Assembling the Optical Cavity



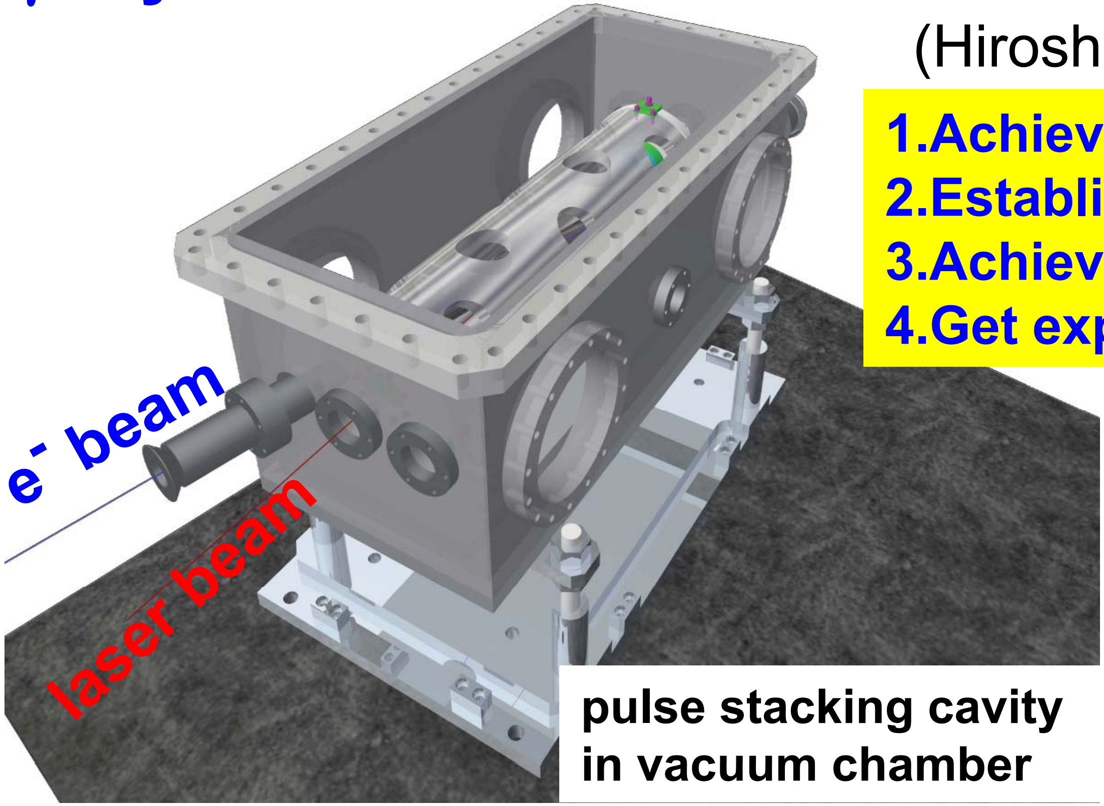


October 2007: Install the 2-mirror cavity into ATF-DR



γ-ray Generation with Laser Pulse Stacking Optical Cavity

(Hiroshima-Waseda-IHEP-KEK)



pulse stacking cavity
in vacuum chamber

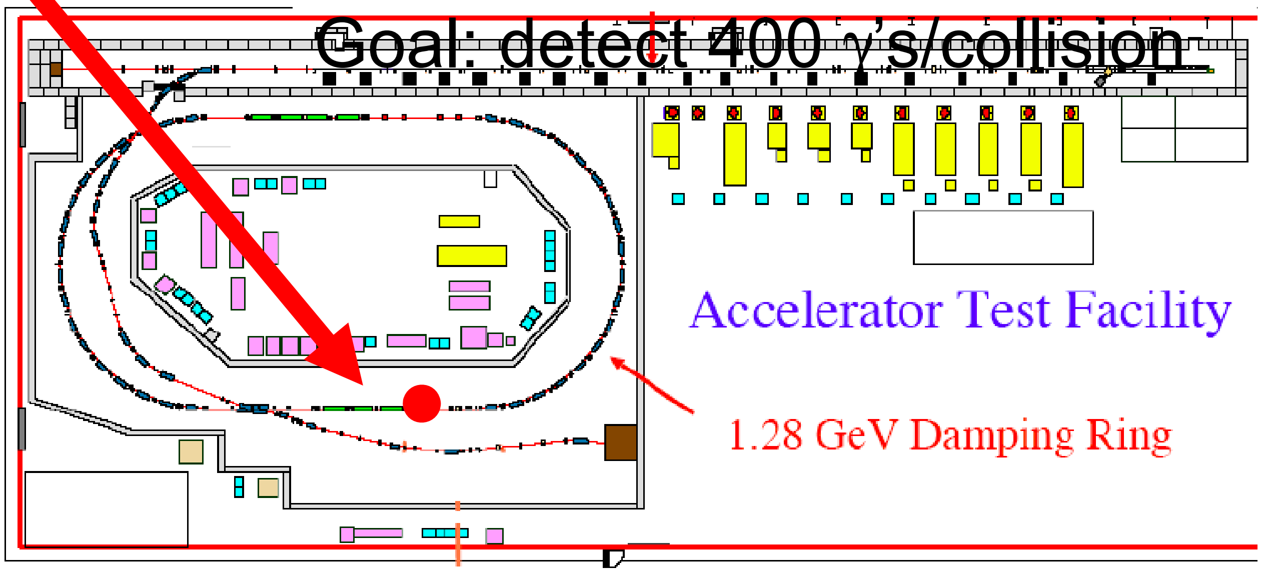
1. **Achieve high enhancement & small spot size**
2. **Establish feedback technology**
3. **Achieve small crossing angle**
4. **Get experience with e^- beam**

We will detect 20 γ's/collision in current configuration.
Test is on going.
No deterioration of e-beam
(so far achieved 3 γ's/collision)
Goal: detect 400 γ's/collision

Stack power estimate

date	Finesse	electron	transmitted power	ncident power	reflected power	input power	λ	stack power	
		1/pulse	W	W	W	W		transmi	by i
8/3/14	200	?		6.2	6	0.2	1.1	-	
8/4/10	218	2.9E+10	0.325	5.3	4.5	0.8	2.5	81	
8/4/15	110	1.5E+10	0.119	5.3	5	0.3	2	30	
8/4/22	486	2.2E+10	1.69	5.3	2.5	2.8	3	423	
	486	2.3E+10	1.64	5.3	2.51	2.79	3	410	
	486	2.6E+10	1.55	5.3	2.55	2.75	3.1	388	

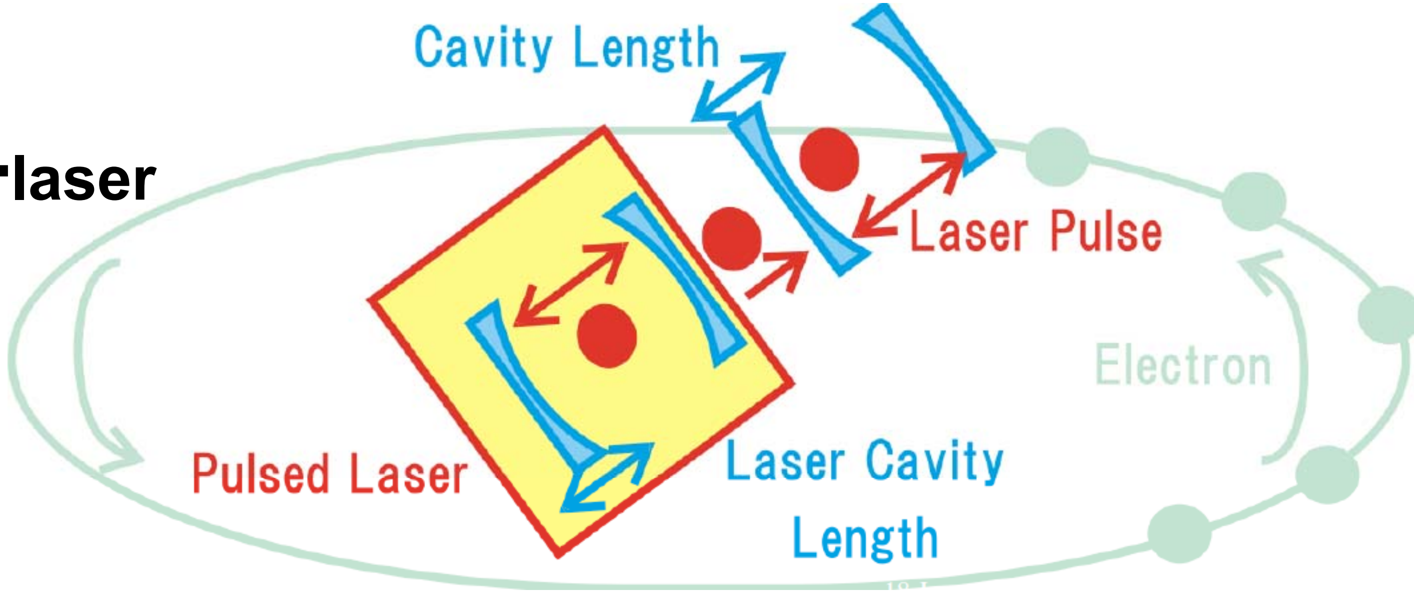
by transmitted power ~ 400W



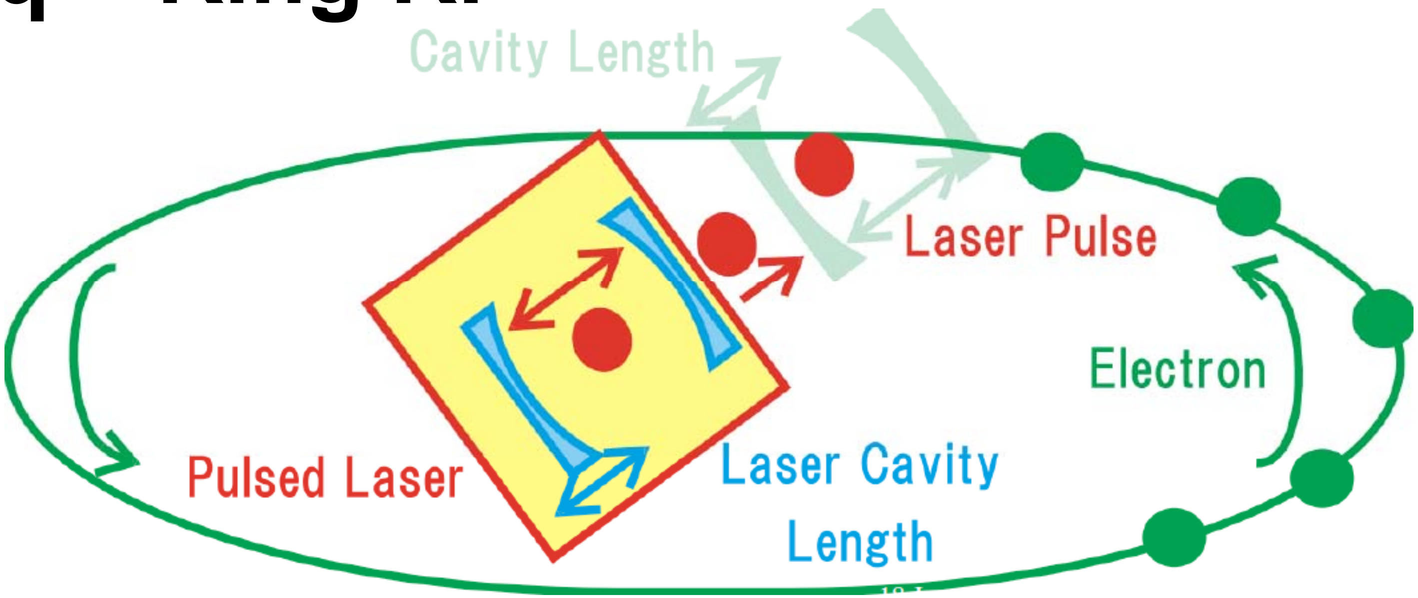
Feedback to Achieve 3 Conditions

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

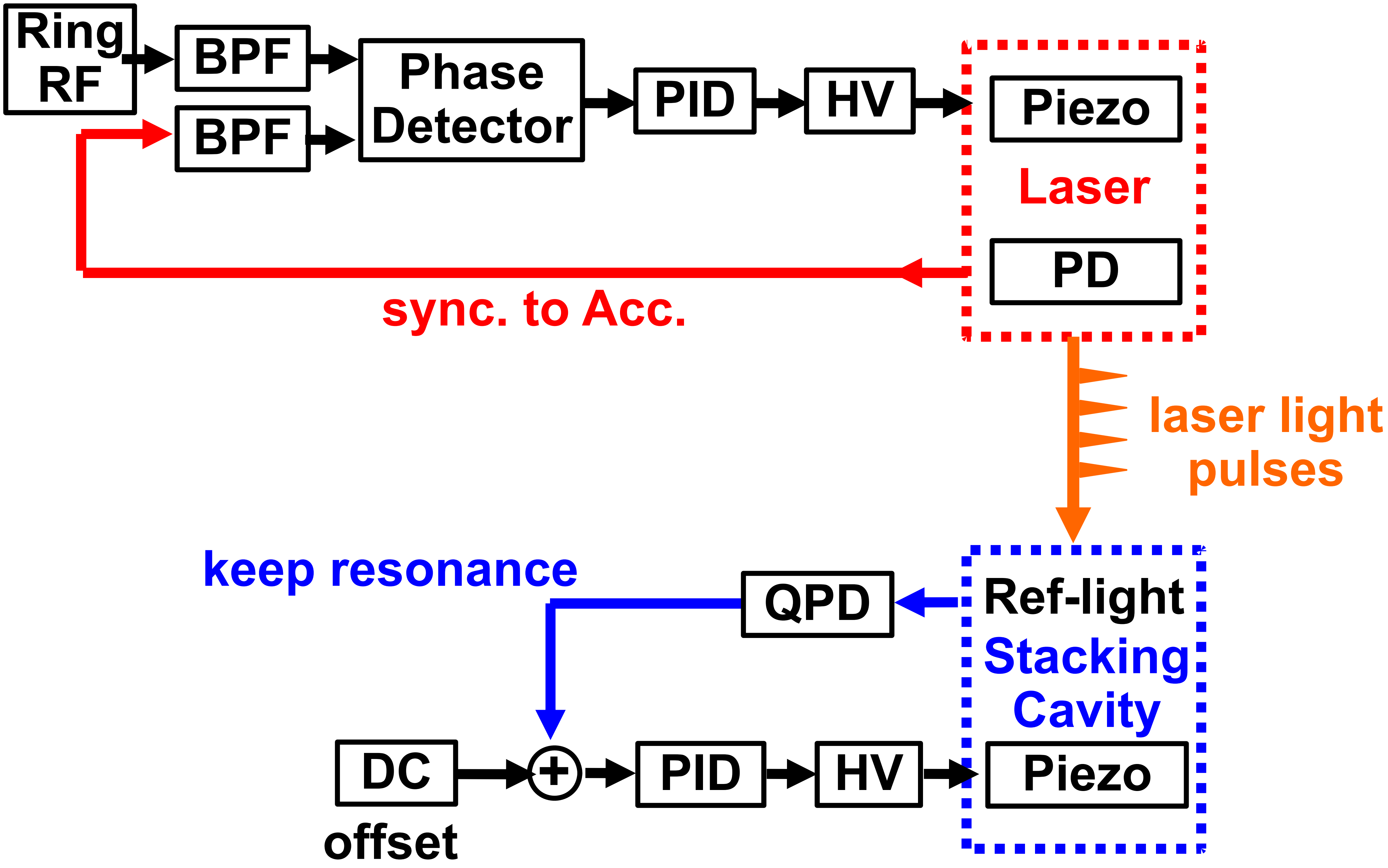
$L_{cav} = m\,L_{laser}$



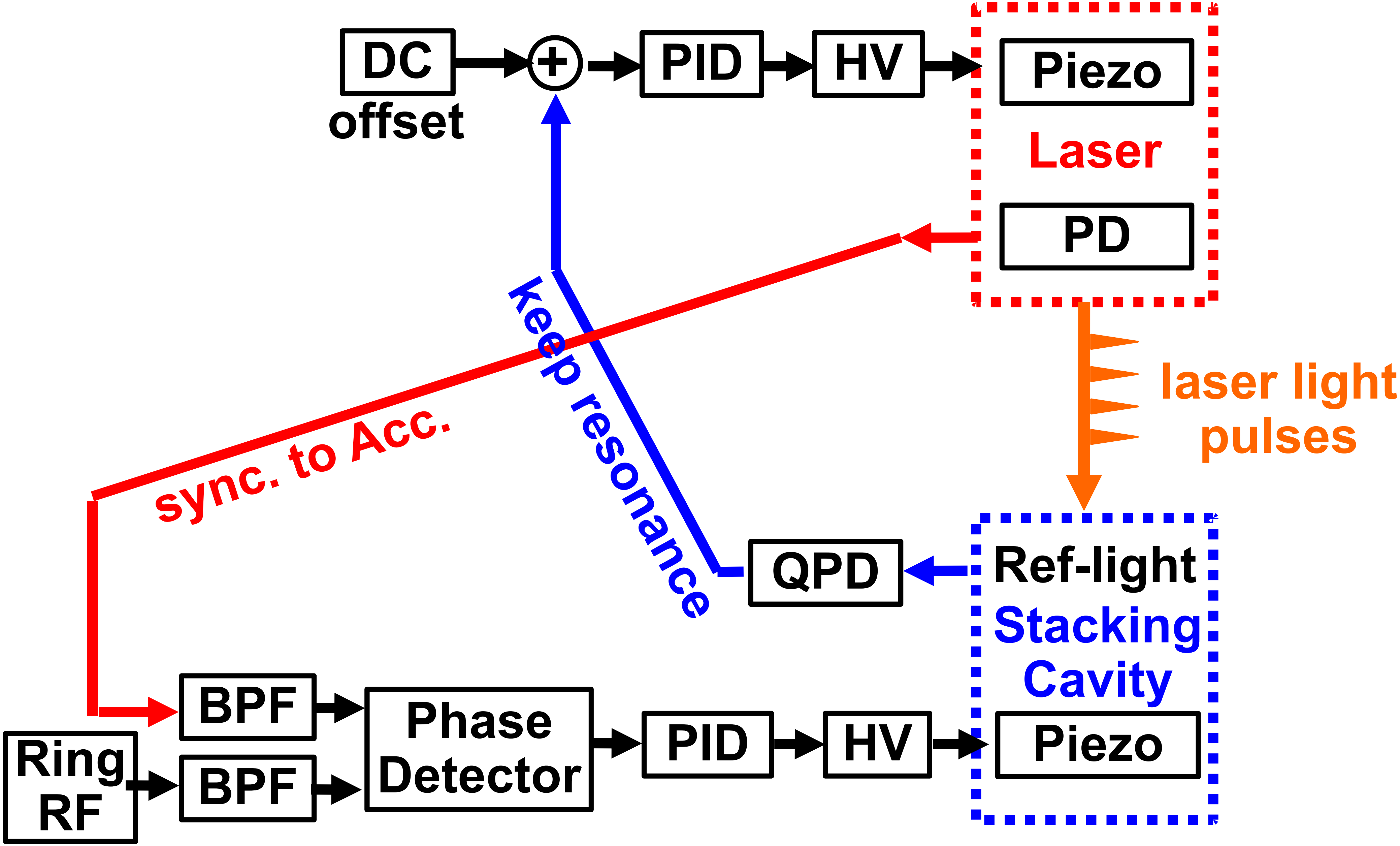
Laser freq = Ring RF



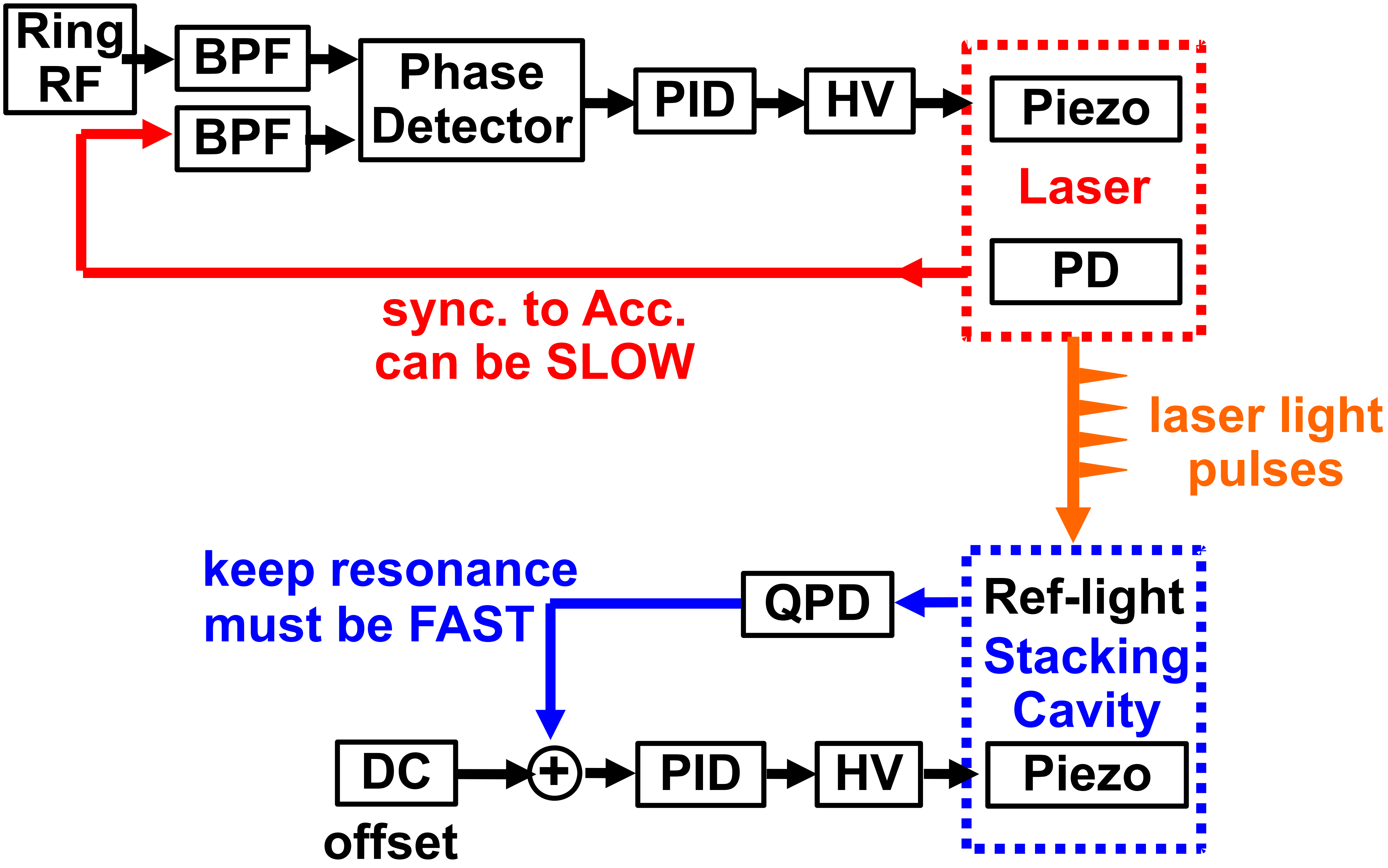
Normal Solution



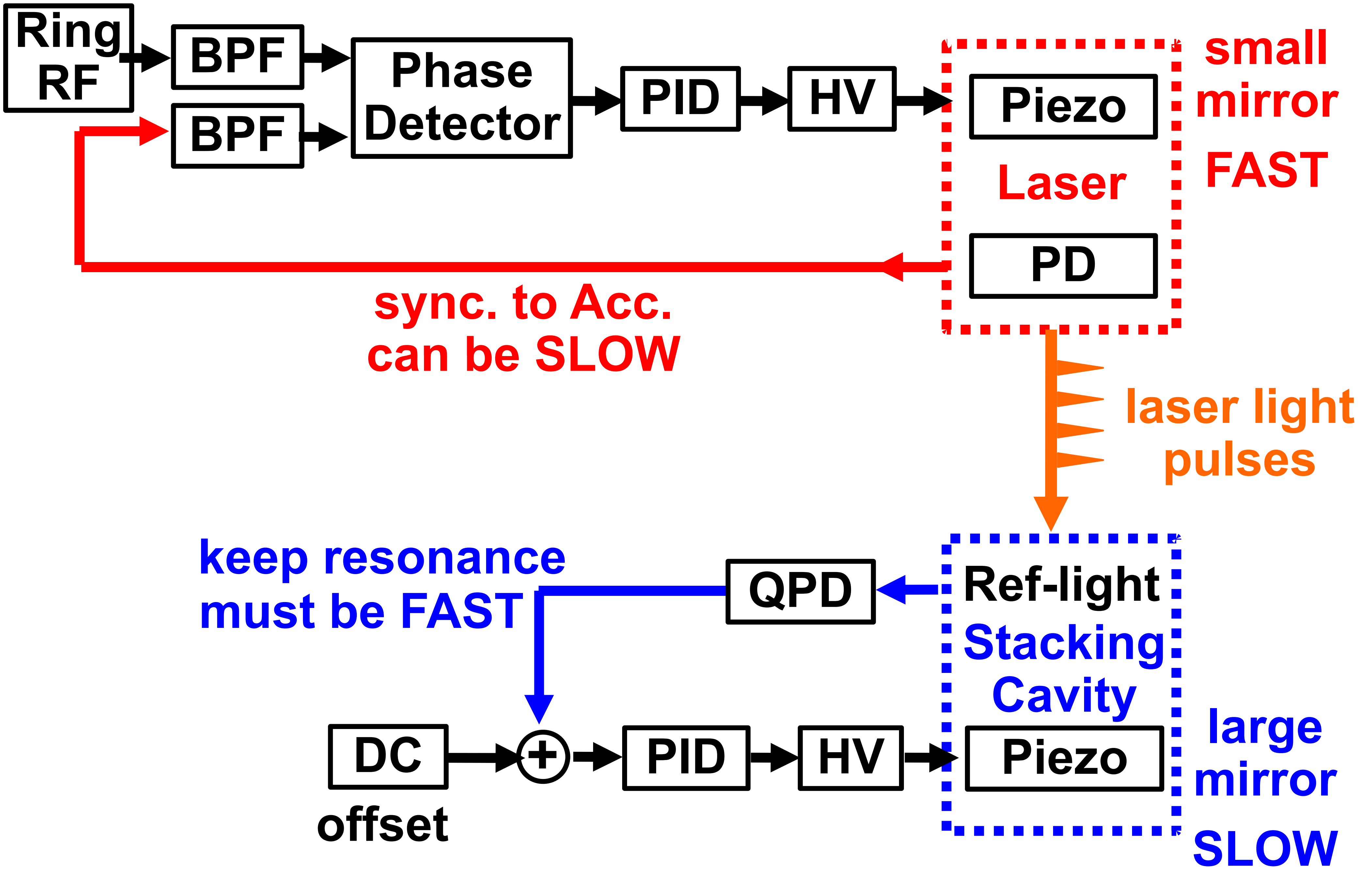
Cross-feedback Solution (Sakaue)



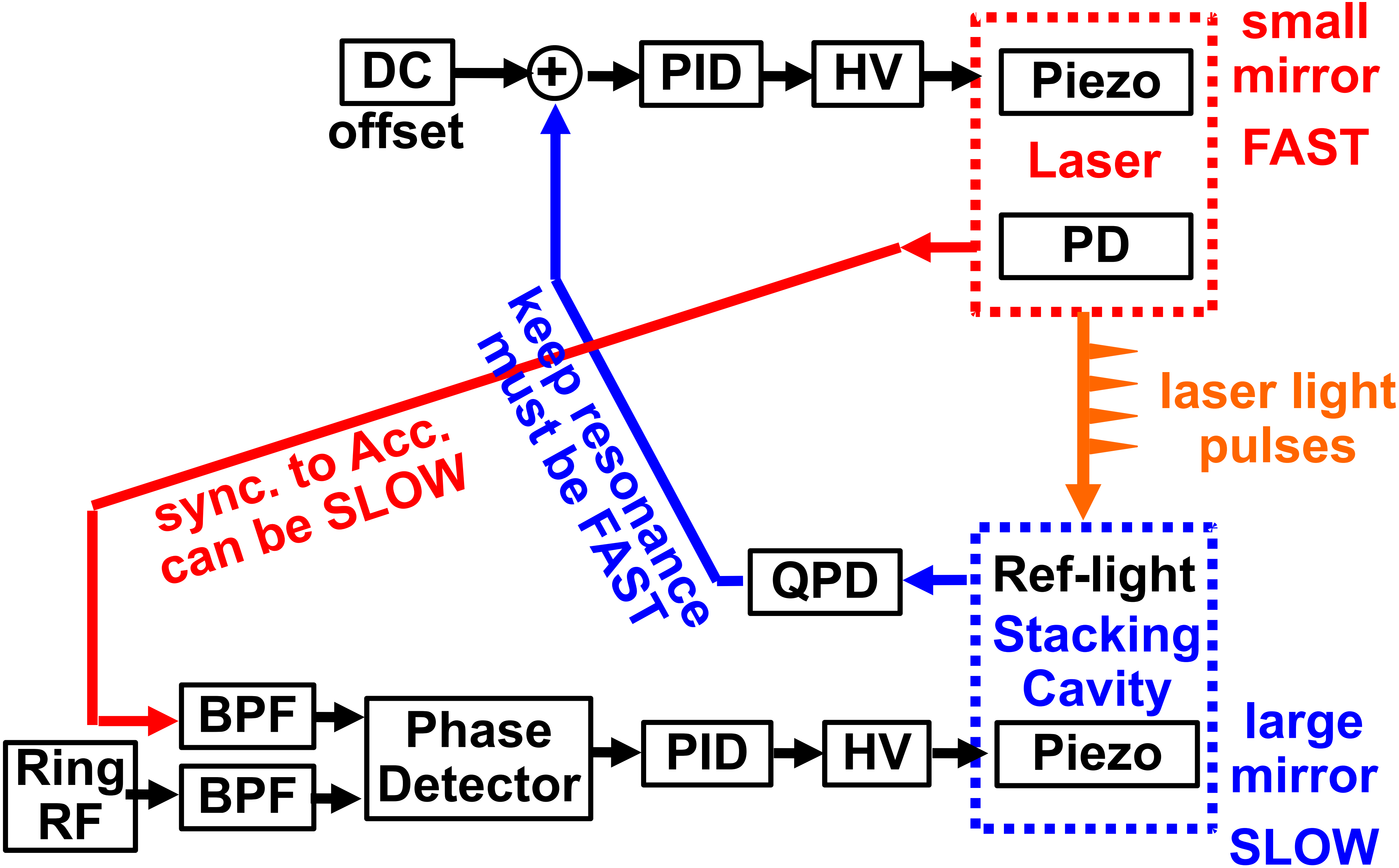
Normal Solution



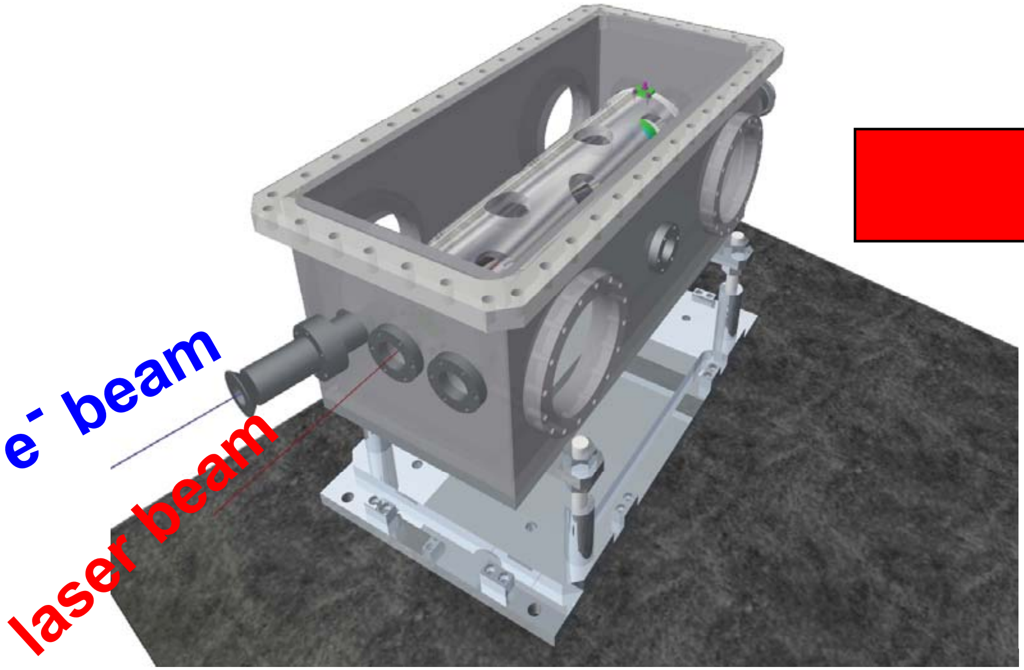
Normal Solution

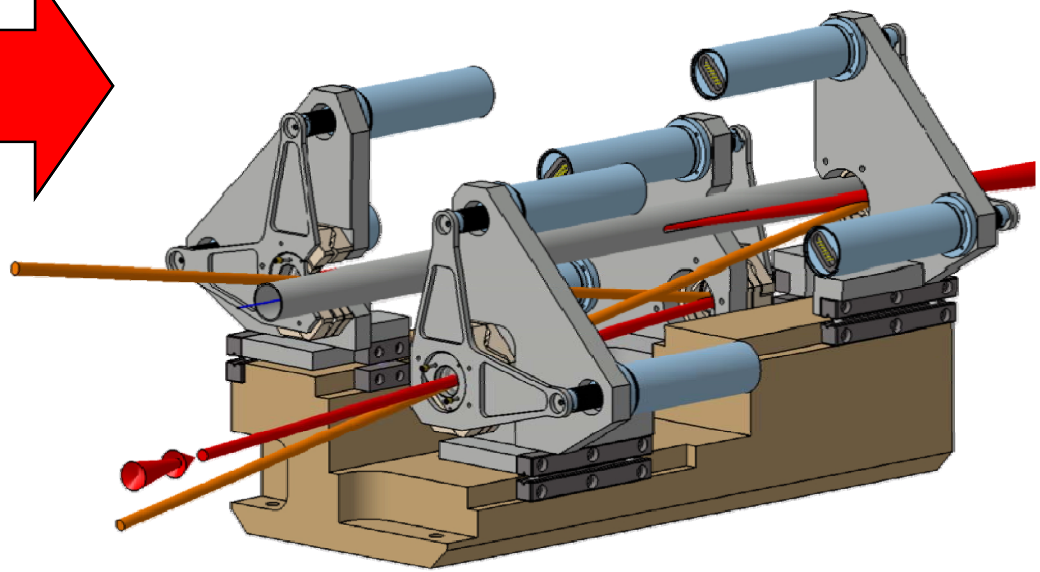


Cross-feedback Solution (Sakaue)



We are moving from 2-mirror-cav to 4-mirror-cav.





R. Cizeron

Spot size = 30 um
Enhance = 1000

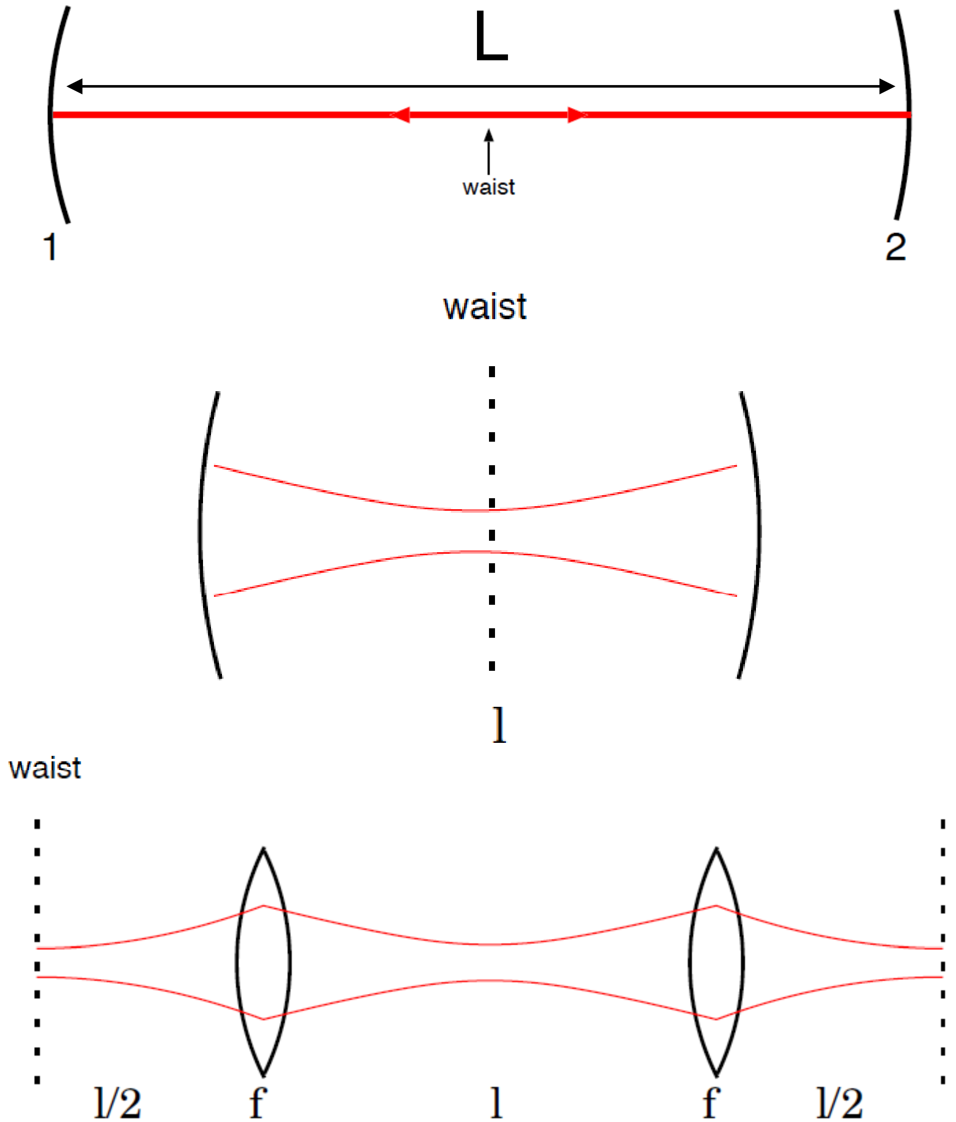
2-mirror cavity

Spot size = 10 um
Enhance = 10000

4-mirror cavity

2-mirror cavity

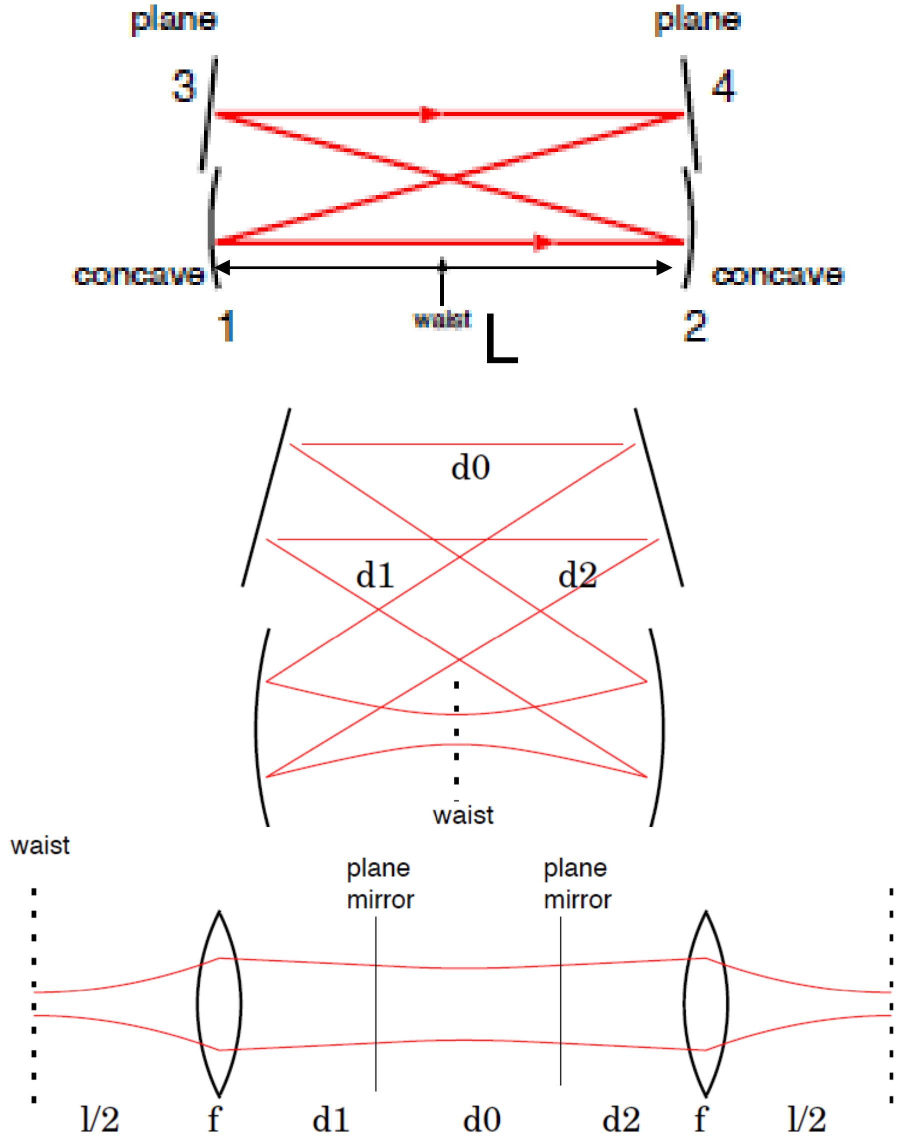
R1=R2=L/2



concentric

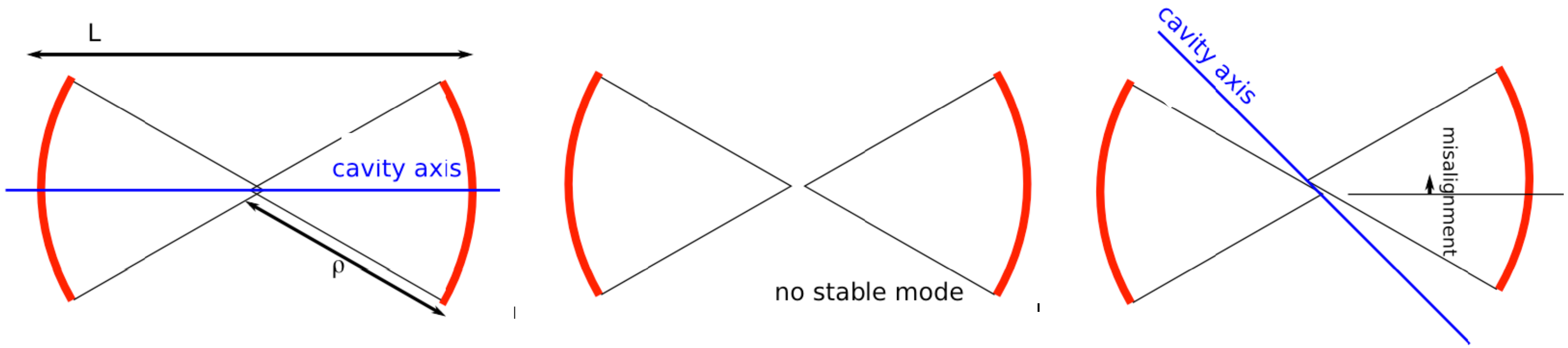
4-mirror cavity

R1=R2=L

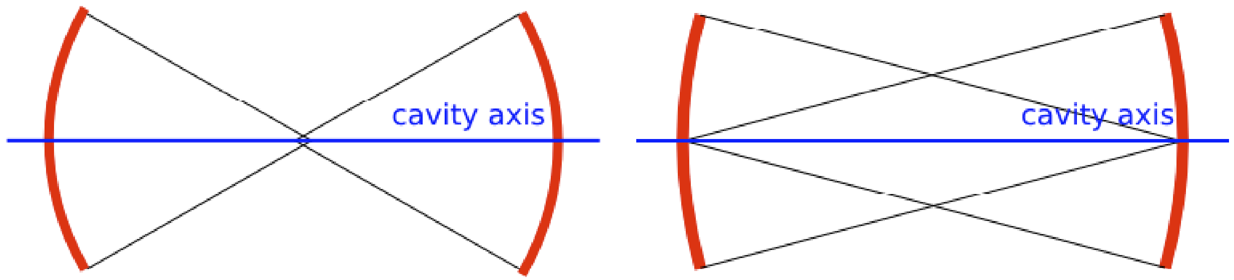


confocal

Tolerance of 2-mirror cavity



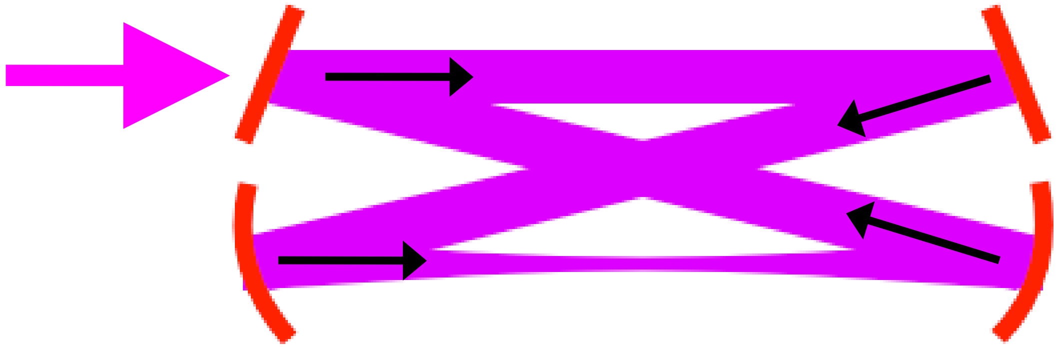
Concentric Configuration and Confocal Configuration



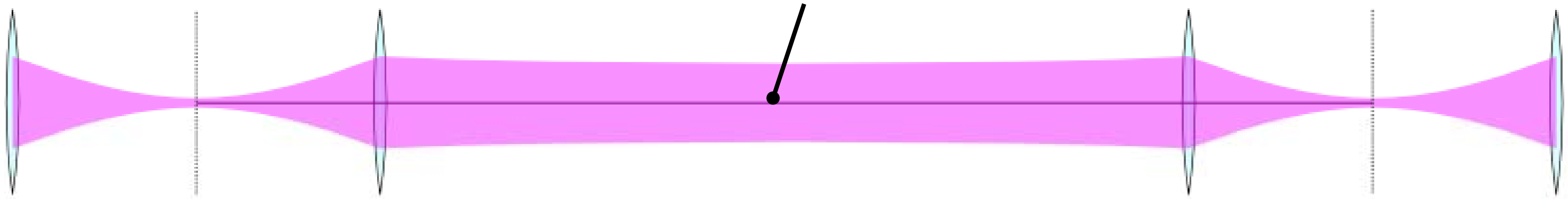
concentric

confocal

4-mirror ring cavity



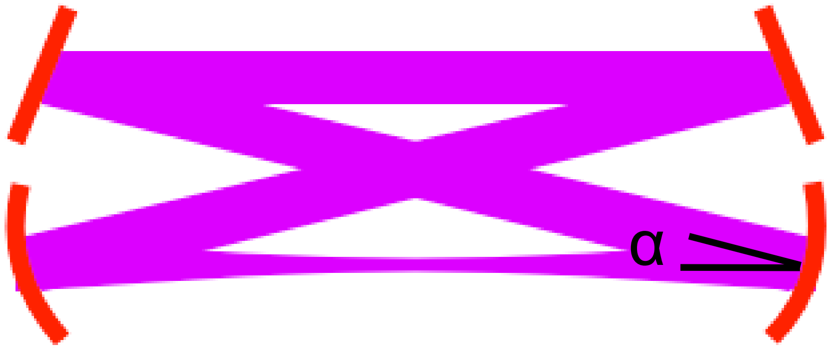
Very Large Focal Point



Equivalent Optics of the 4-mirror Cavity

tolerance : 4-mirror = 100 x 2-mirror

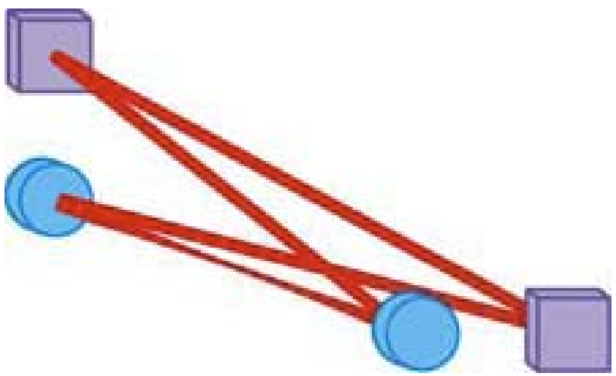
2D configuration

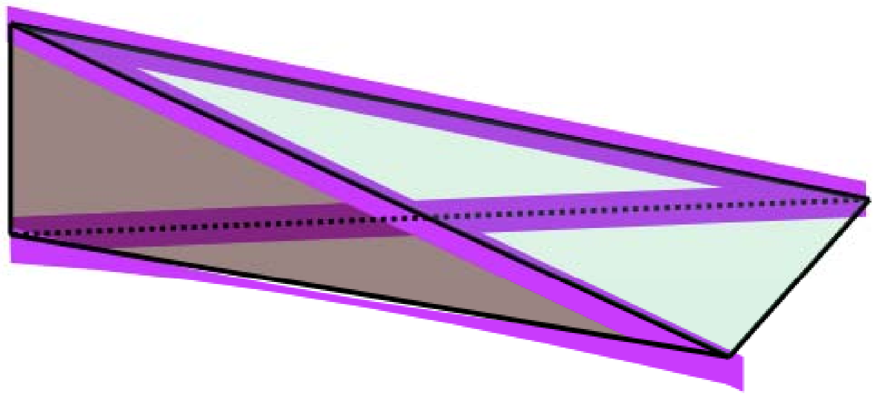


$$f_t = \frac{\rho}{2}\cos(\alpha/2)$$

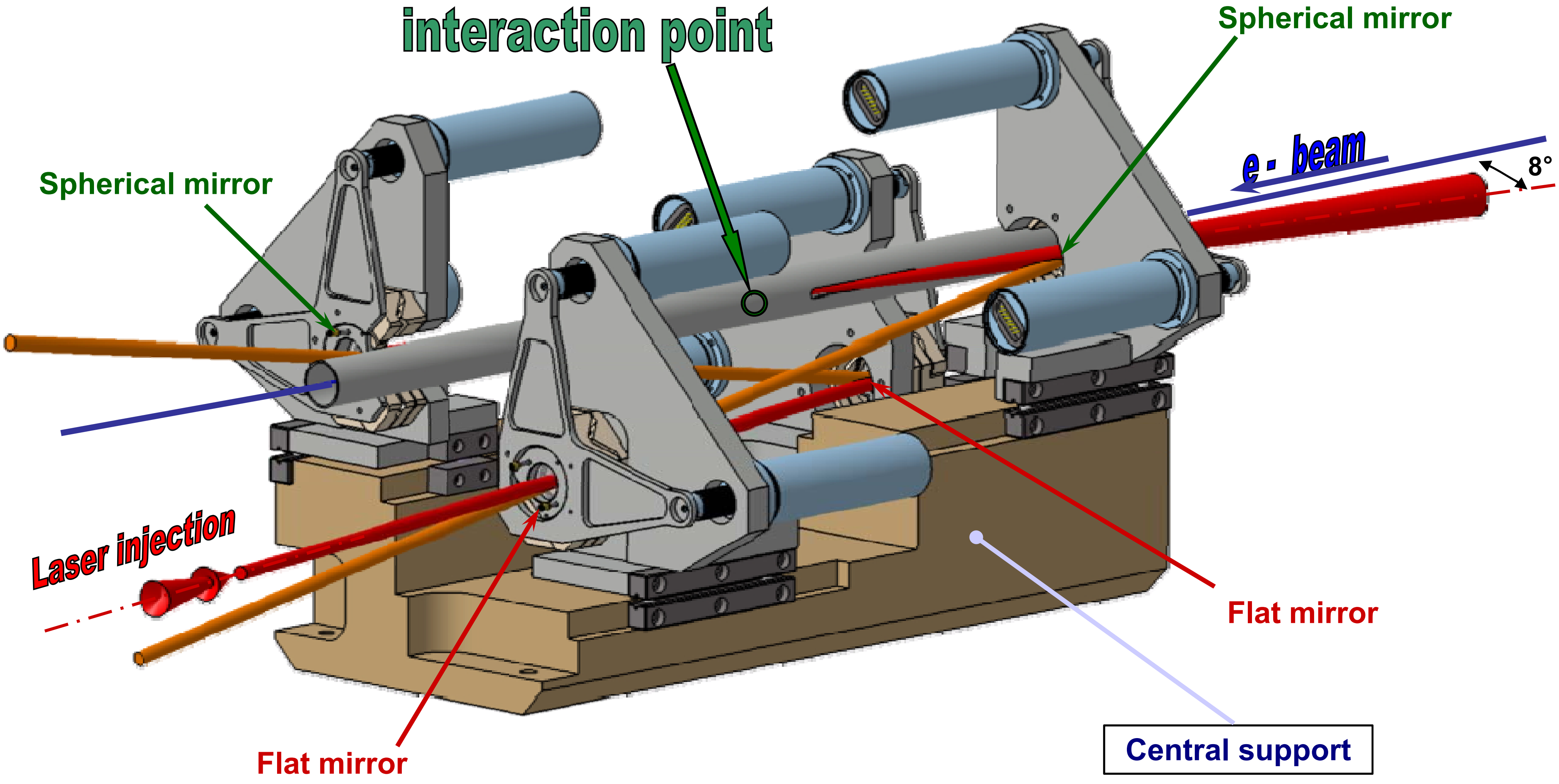
$$f_s = \frac{\rho}{2\cos(\alpha/2)}$$

3D configuration





e^- beam compatible 4-mirror cavity



R. Cizeron
LAL 30/01/2008

World-wide PosiPol Collaboration

Collaborating Institutes:
BINP, CERN, DESY, Hiroshima, IHEP, IPN, KEK, Kyoto, LAL, CELIA/Bordeaux, NIRS, NSC-KIPT, SHI, Waseda, BNL, JAEA and ANL

Sakae Araki, Yasuo Higashi, Yousuke Honda, Masao Kuriki, Toshiyuki Okugi, Tsunehiko Omori, Takashi Taniguchi, Nobuhiro Terunuma, Junji Urakawa, Yoshimasa Kurihara, Kazuyuki Sakaue, Masafumu Fukuda, Takuya Kamitani, X. Artru, M. Chevallier, V. Strakhovenko, Eugene Bulyak, Peter Gladkikh, Klaus Meonig, Robert Chehab, Alessandro Variola, Fabian Zomer, Alessandro Vivoli, Richard Cizeron, Viktor Soskov, Didier Jehanno, M. Jacquet, R. Chiche, Yasmina Federa, Eric Cormier, Louis Rinolfi, Frank Zimmermann, Kazuyuki Sakaue, Tachishige Hirose, Masakazu Washio, Noboru Sasao, Hirokazu Yokoyama, Masafumi Fukuda, Koichiro Hirano, Mikio Takano, Tohru Takahashi, Hirotaka Shimizu, Shuhei Miyoshi, Yasuaki Ushio, Tomoya Akagi, Akira Tsunemi, [illegible]g, Pei [illegible], [illegible], V. [illegible]akinenko, Igo Po[illegible], [illegible] and Wanming Liu

POSIPOL 2006
CERN Geneve
26-27 April
http://posipol2006.web.cern.ch/Posipol2006/

POSIPOL 2008
Hiroshima
16-18 June
http://home.hiroshima-u.ac.jp/posipol/

POSIPOL 2007
LAL Orsay
23-25 May
http://events.lal.in2p3.fr/conferences/Posipol07/

POSIPOL 2008
Near CERN

Summary

Summary 1

1. Laser Compton e+ source is attractive option for ILC/CLIC
   - Independent system
   - high polarization (potential)
   - 5 Hz polarization flip (for CLIC 50 Hz flip)
   - Operability
   - wide applications
2. Three schemes are proposed
   - Ring Laser Compton for ILC
   - ERL Laser Compton for ILC
   - Linac Laser Compton

   My talk Today

3. Ring: We have a design of ring --> But still many questions
   - What is the best way to cure long bunch length?
     - very small momentum compaction?
     - bunch compress/decompress?
     - crab crossing?
   - Do we need experiments (bunch compression, crab,,,,)?
   - Ring Circumference? (Energy spread of e- beam)

Summary 2

4. ERL: Many basic parameters are NOT decided yet
   Repetition Rate of ERL = Repetition Rate of Laser
   charge/bunch
   continuous e+ stacking is possible?

5. We still need many R/Ds ---> Good! We have many funs.
   Recent encouraging results:
   - stacking: stacking efficiency 90 - 95 %
     -> Frank-san's talk
   - 2-mirror cavity: installation done succesfully
     no deterioration was observed in e-beam quality
     we observed gamma-rays (still many problems)
   - 4-mirror cavity: R/D is on going

6. POSIPOL 2009, near CERN