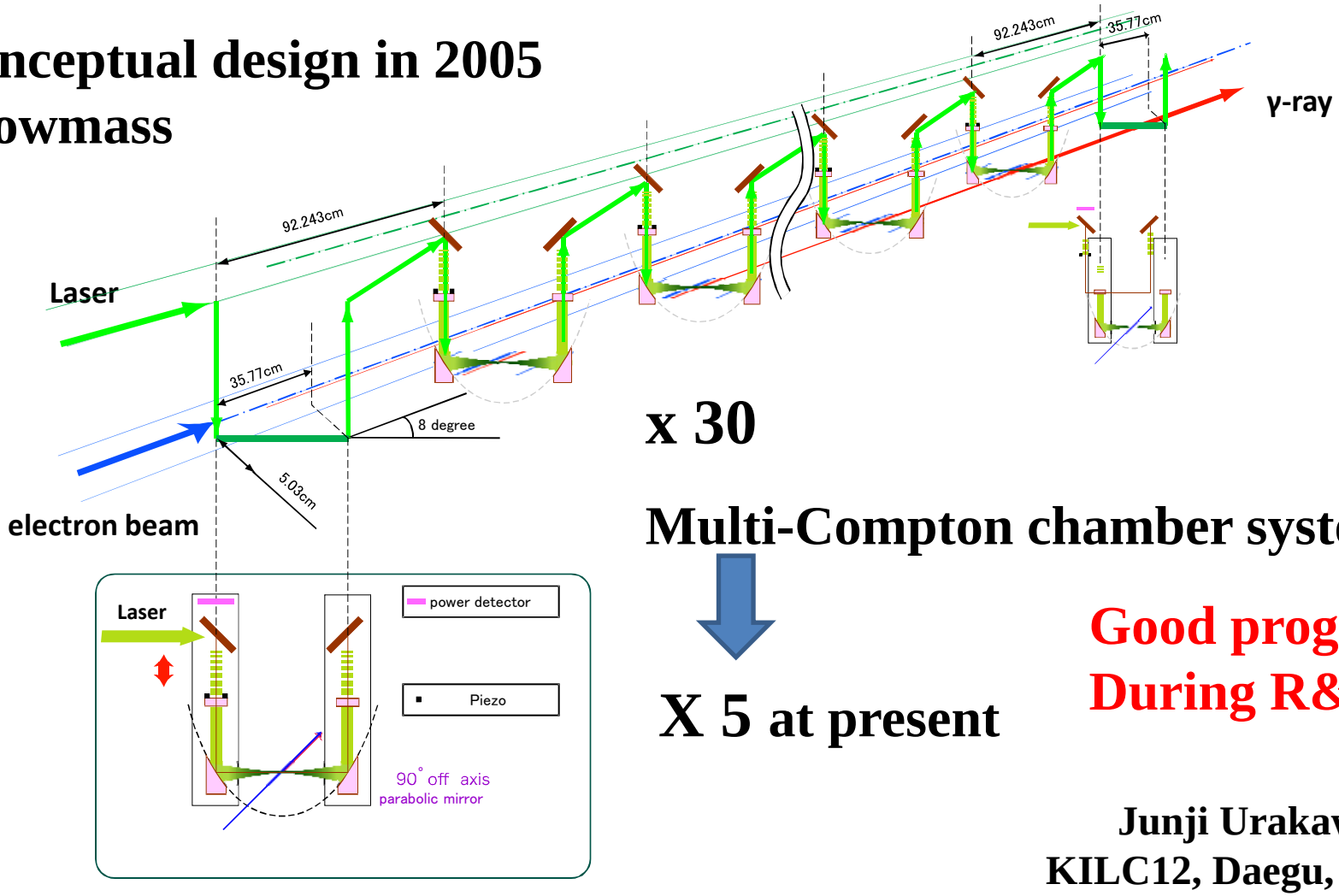
From Conventional to Compton upgrade

Conceptual design in 2005
Snowmass



x 30

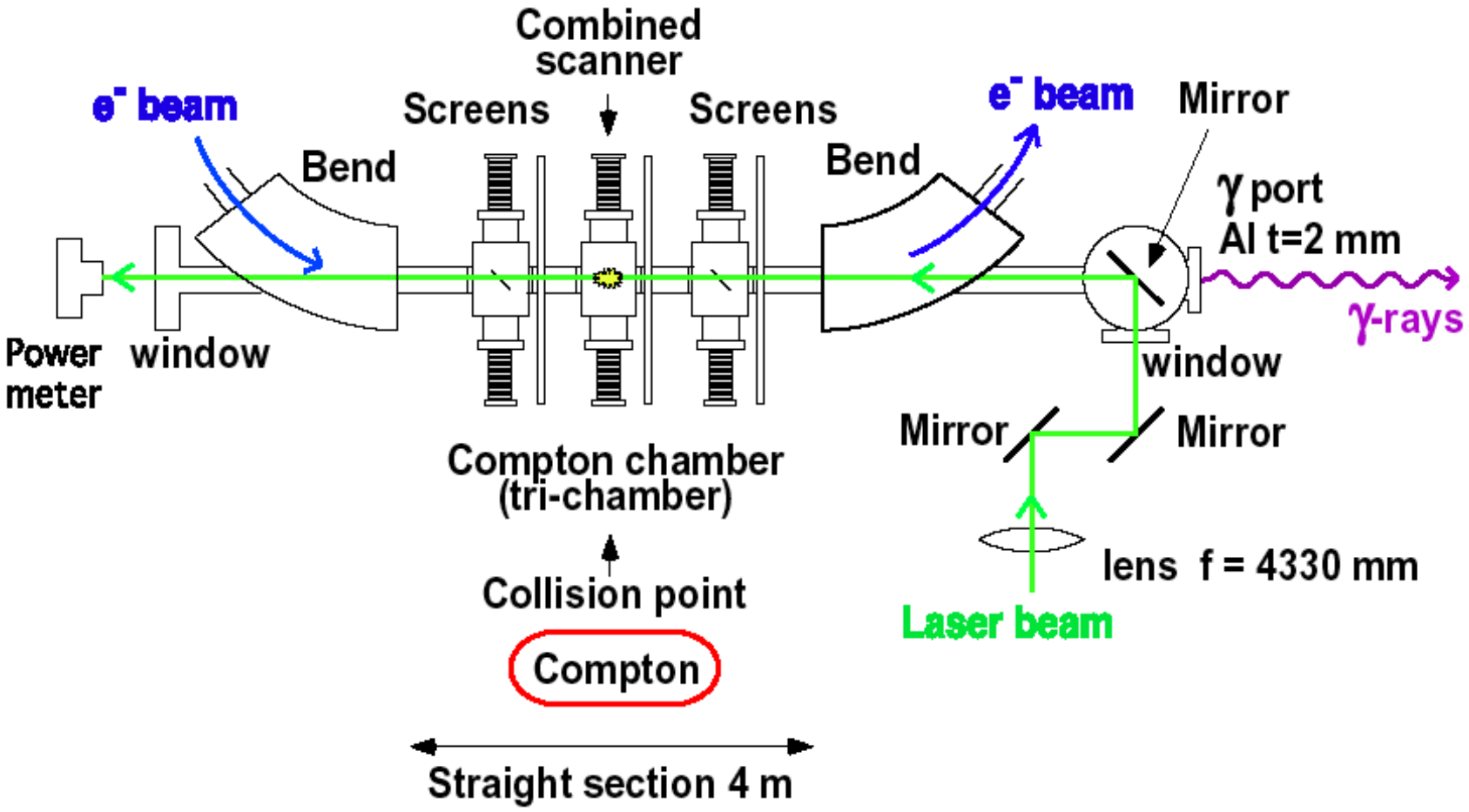
Multi-Compton chamber system

X 5 at present

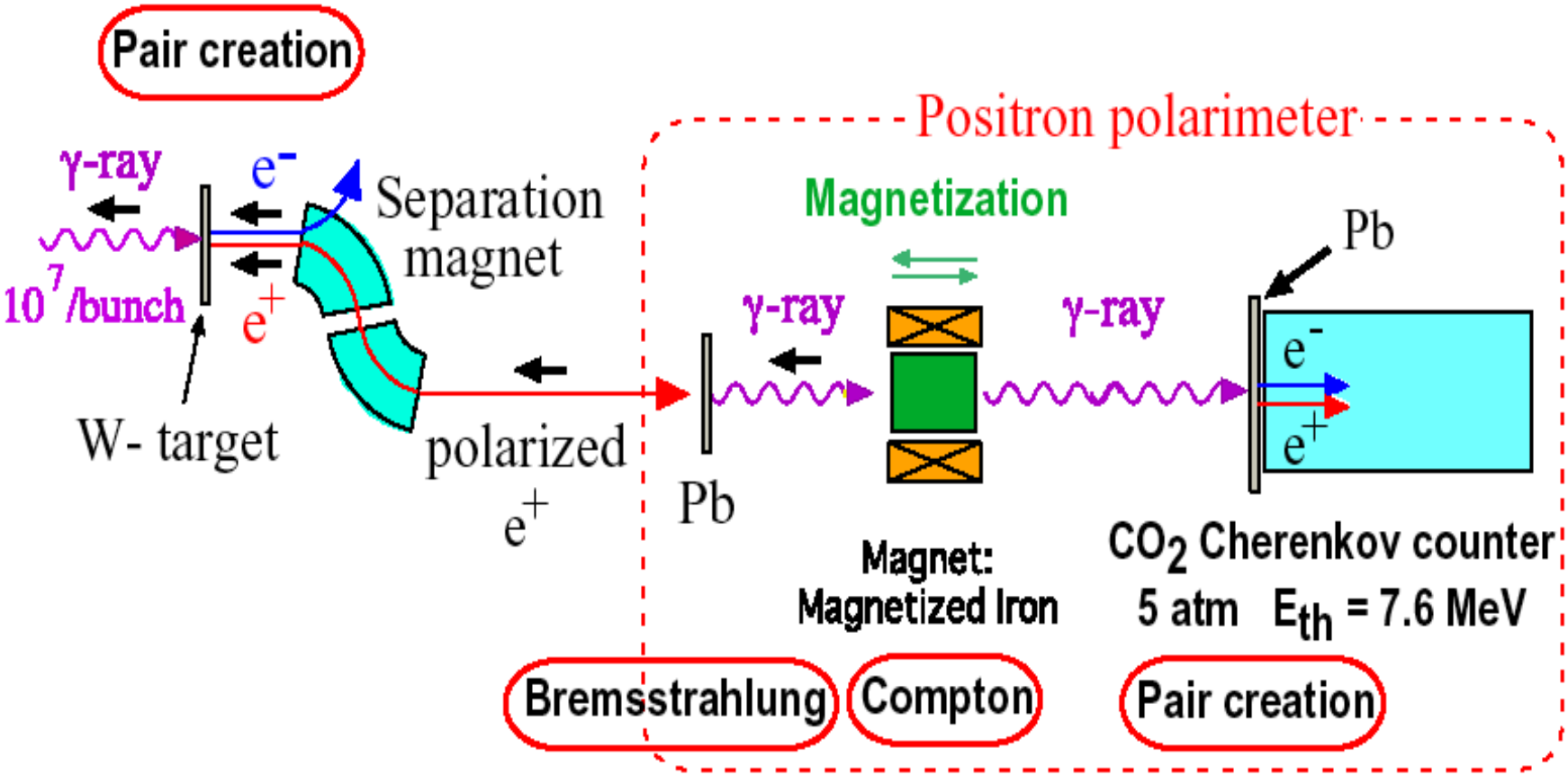
Good progress During R&D

Junji Urakawa
KILC12, Daegu, Korea
GDE Source, 30min.

Compton chamber



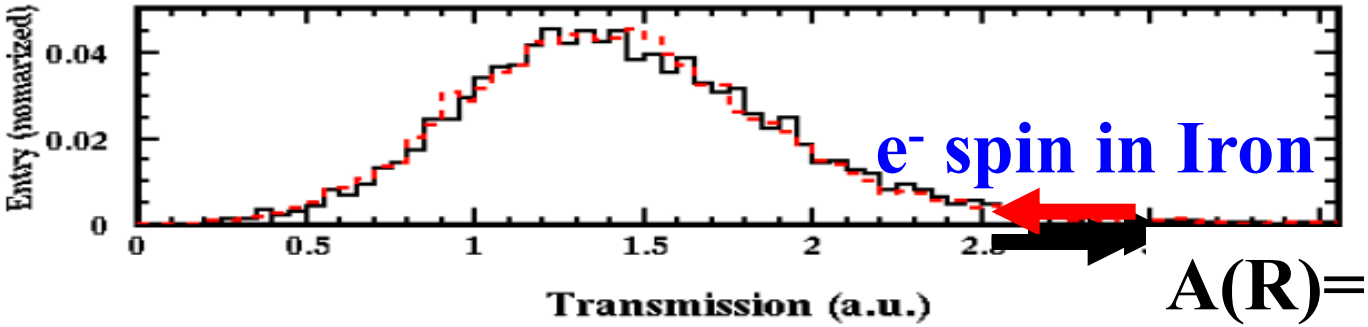
Positron: production, selection, and polarimetry



Experimental Results

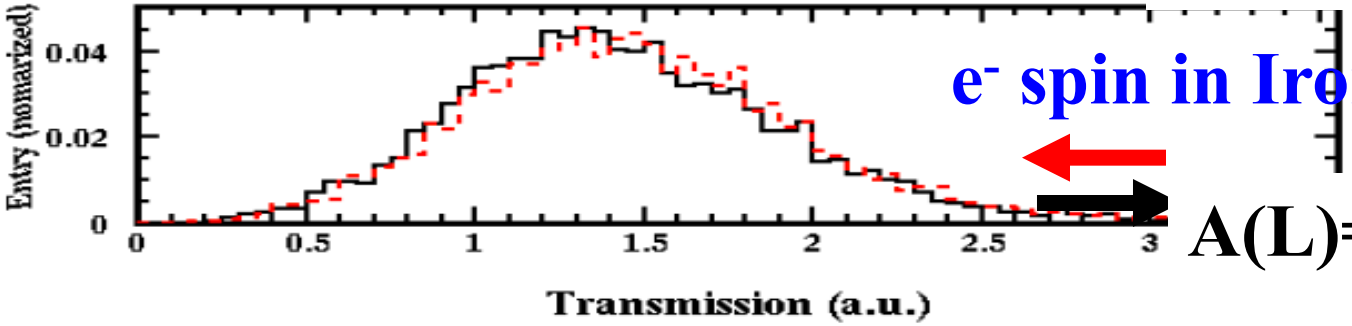
- Polarization of positron beam

72+/-21%, predicted cal. value 77+/-10%



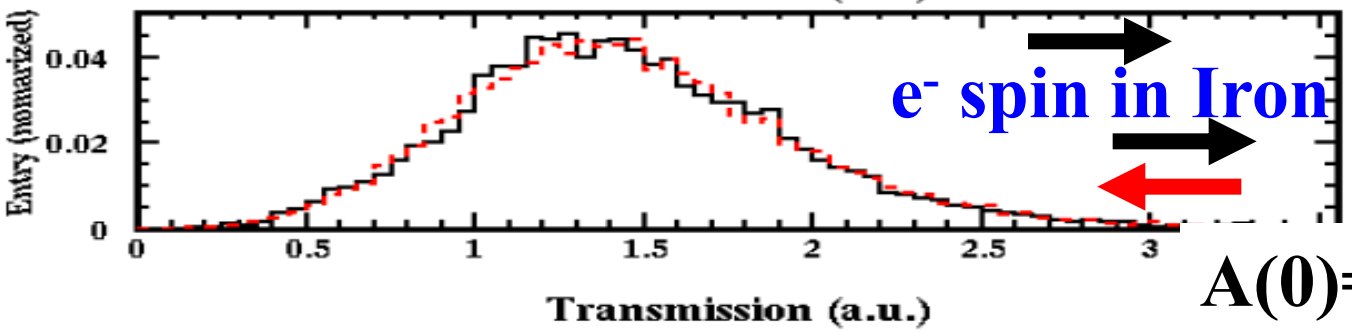
e^+ beam spin

A(R)= +0.60± 0.25%



e^+ beam spin

A(L)= -1.18± 0.27%

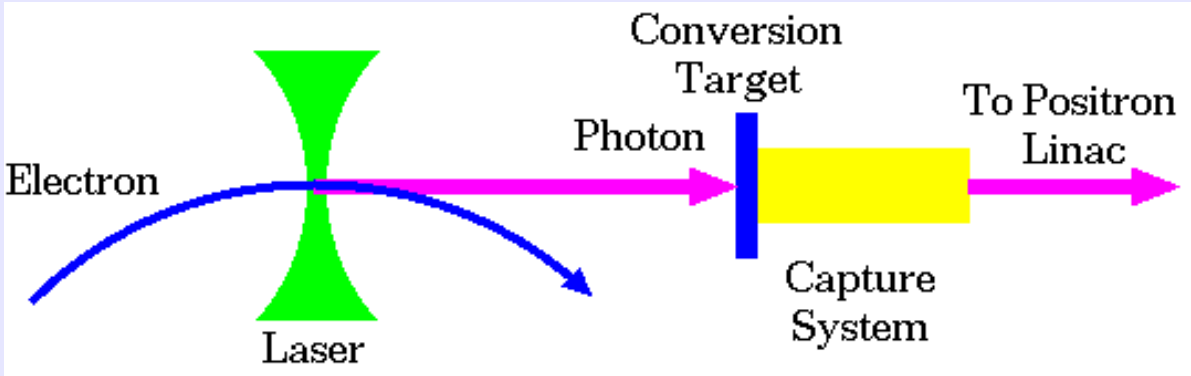


e^+ beam spin non

A(0)= -0.02± 0.25%

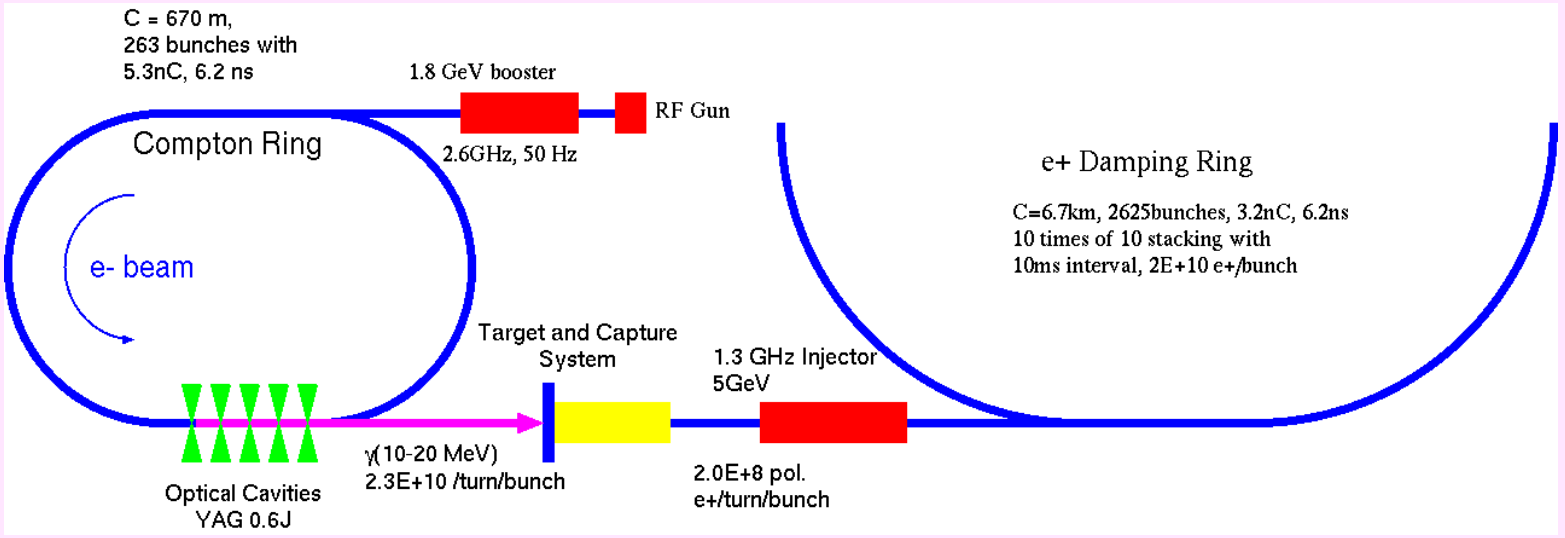
Polarized Positron Soure
Compton Scheme

- An independent system based on the dedicated electron driver is a big advantage.
- Obtaining enough positron, is a technical challenge.
  - High intensity electron beam: Linac, Storage ring, ERL
  - High intensity photon beam: High power laser, optical cavity.
  - Stacking scheme: DR stacking, Pre-DR, etc.



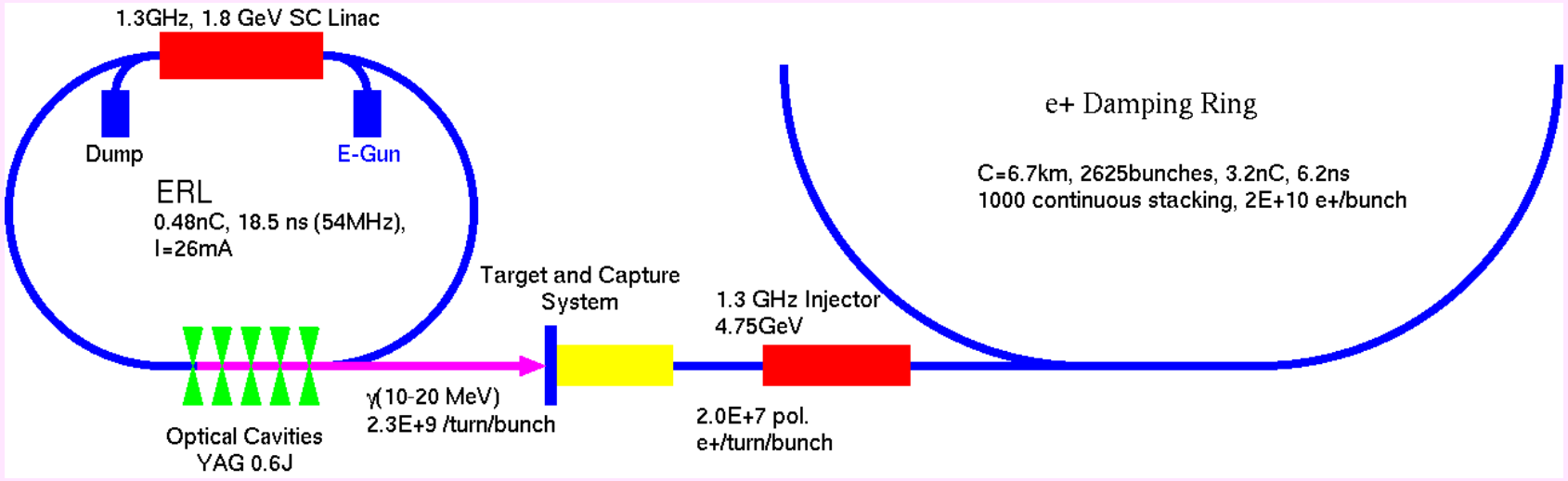
Compton Ring

- A storage ring for electron driver:5.3nC, 6.2ns, 1ps, 1.8GeV, **0.6Jx5CP.**
- Positron Ne+:2.0E+8/bunch is generated.
- 10 bunches are stacked on a same bucket. This process is repeated 10 times with 10ms interval for beam cooling.
- Finally, Ne+:2E+10 is obtained.



ERL

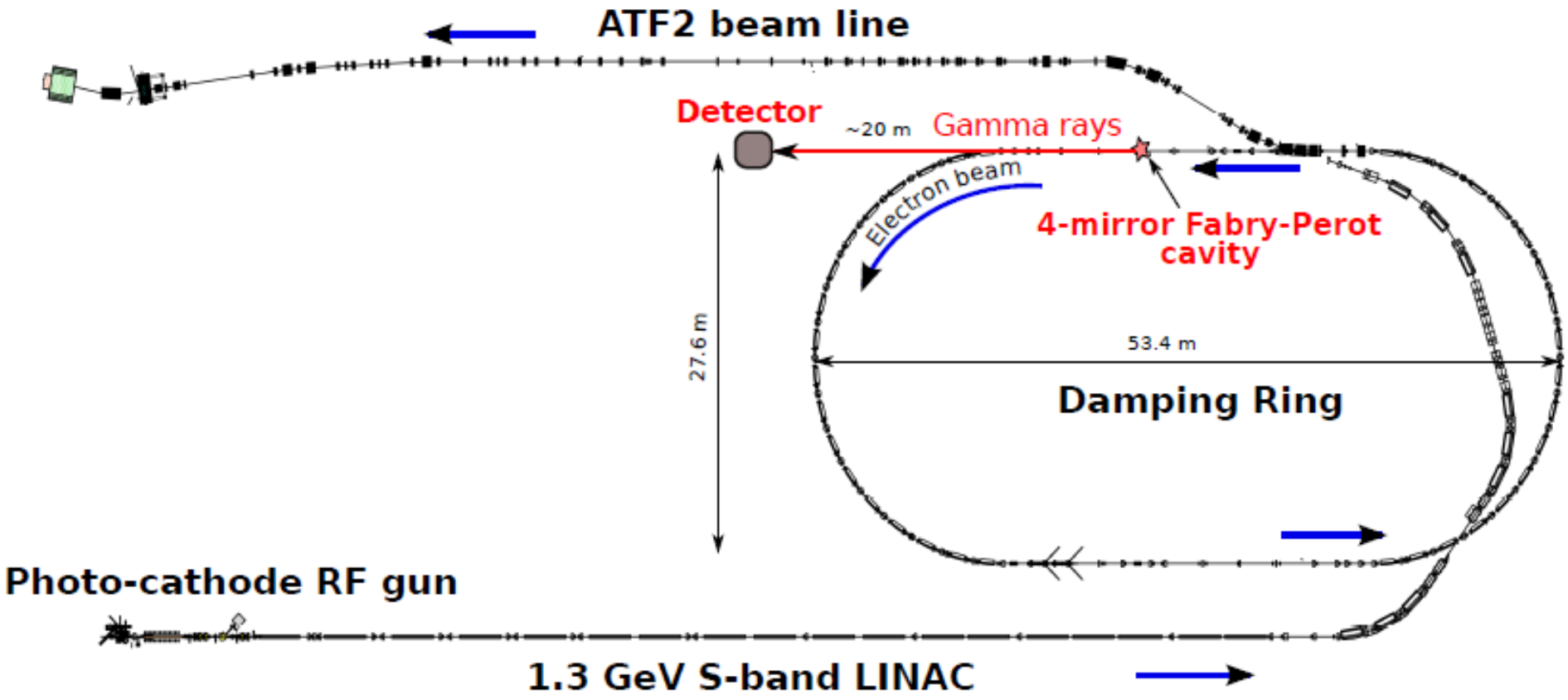
- ERL(Energy Recovery Linac) is employed as the dedicated electron driver.
  - 0.48nC, 18.5ns (54MHz) ~ 26mA, E=1.8GeV
  - N_γ=2.3E+9 by 0.6 Jx5 CP, N_{e+}=2.0E+7/bunch
- By a semi-CW operation (50ms), 1000 times stacking in DR is performed and Ne+=2.0E+10 is obtained.

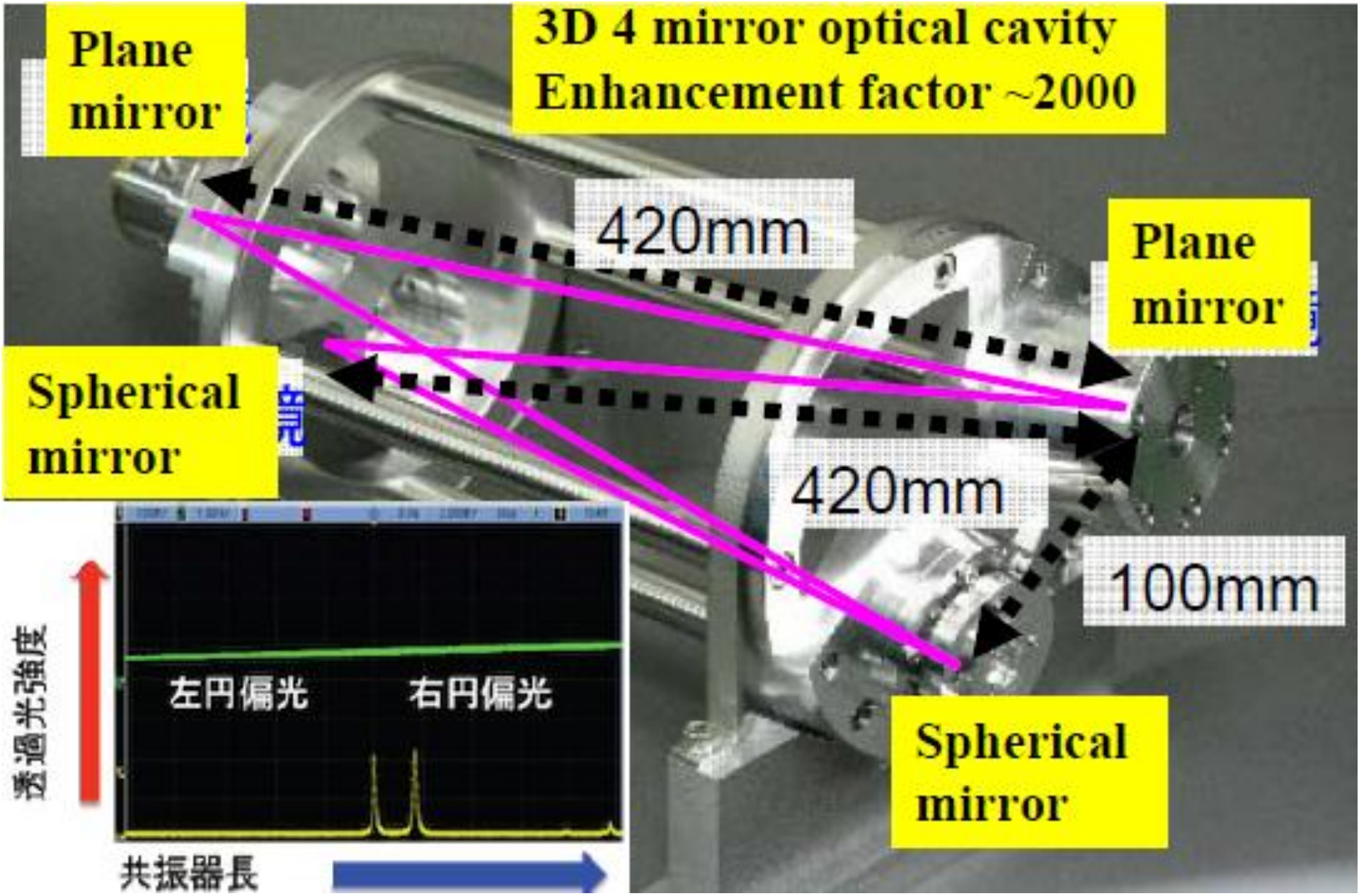


For Linac Compton Scheme, we can reuse 6GeV e-Linac with CO_2 laser cavity system. Also, the 6GeV Linac has to accelerate 10nC bunched beam with 132 bunches/pulse.

Table 1. Design parameters for Ring Compton and ERL Compton.

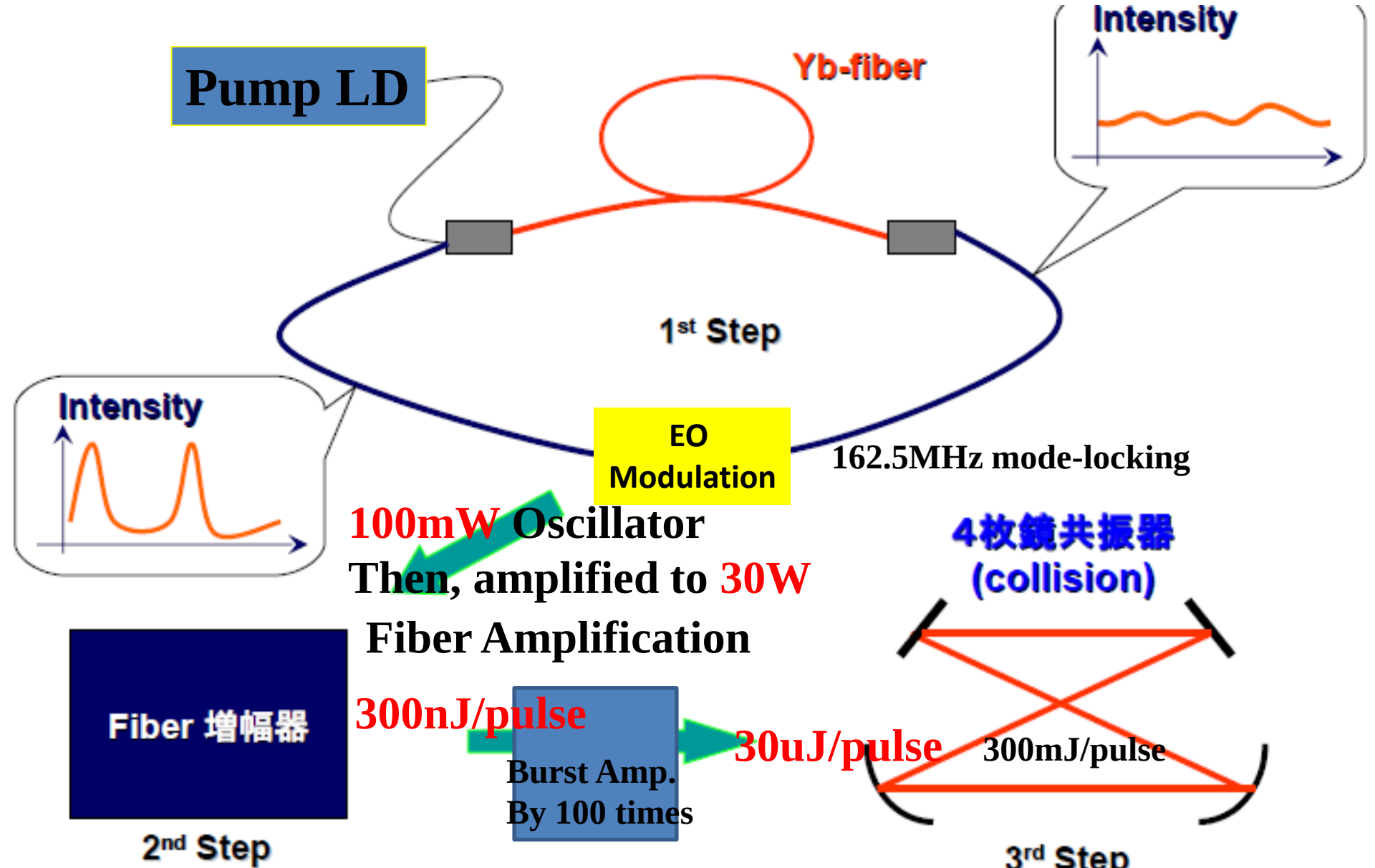
	Ring Compton	ERL Compton
Bunch charge	5.3nC	0.48nC
Energy	1.8GeV	1.8GeV
Bunch spacing	6.15ns	18.5ns
Bunch length at IPs	1ps	1ps
Laser energy at IPs	600mJ-1μm laser	600mJ-1μm laser
Number of IPs	5	5


ATF2 beam line
Detector
~20 m
Gamma rays
Electron beam
4-mirror Fabry-Perot cavity
27.6 m
53.4 m
Damping Ring
Photo-cathode RF gun
1.3 GeV S-band LINAC



Finesse 5800, gain ~2000 was confirmed by generation of gamma-ray last year. Also, laser waist size was less than 15μm.

Laser System Development for Optical Cavity for Q-Beam project and ILC by 2015.



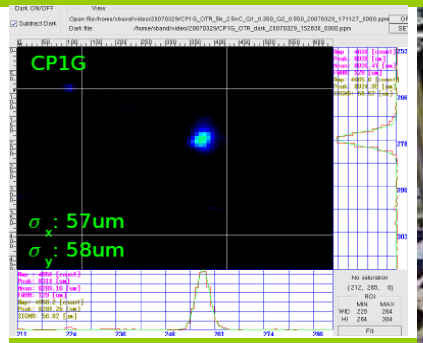
Pulse laser storage in optical cavity and X-ray measurement in 2009.2

X-ray generation with 1000 enhancement by optical cavity

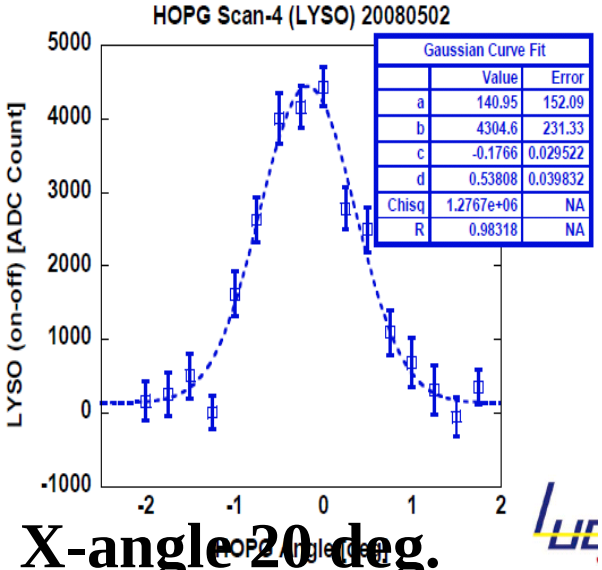
Average power :40kW,
7psec(FWHM),
next step :2MW

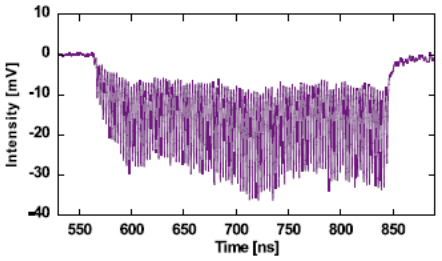
Status : 0.2mJ/pulse,
target : 10mJ/pulse

X-ray measurement
at 20 degree crossing angle



Electron beam
size 60μm in σ





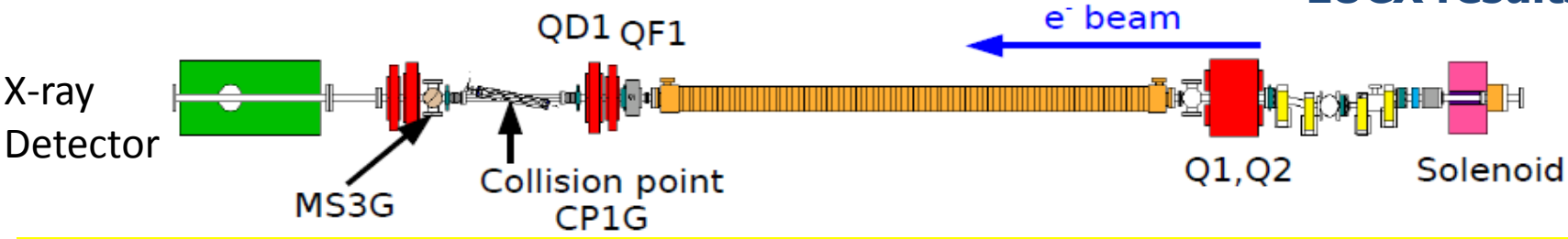
MCP waveform
background subtracted.
Detected X-ray flux
1.2×10^5 Hz/~10%b.w.

X-angle 20 deg.

Beam collision technique

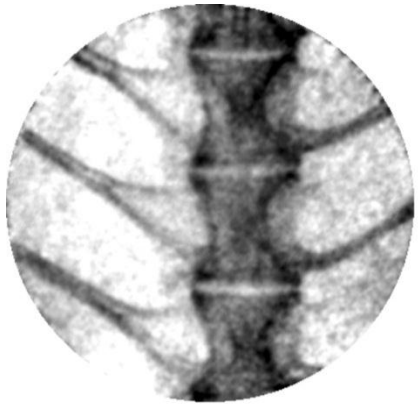
43MeV Multi-bunch beam+ Super-Cavity = 33keV X-ray.

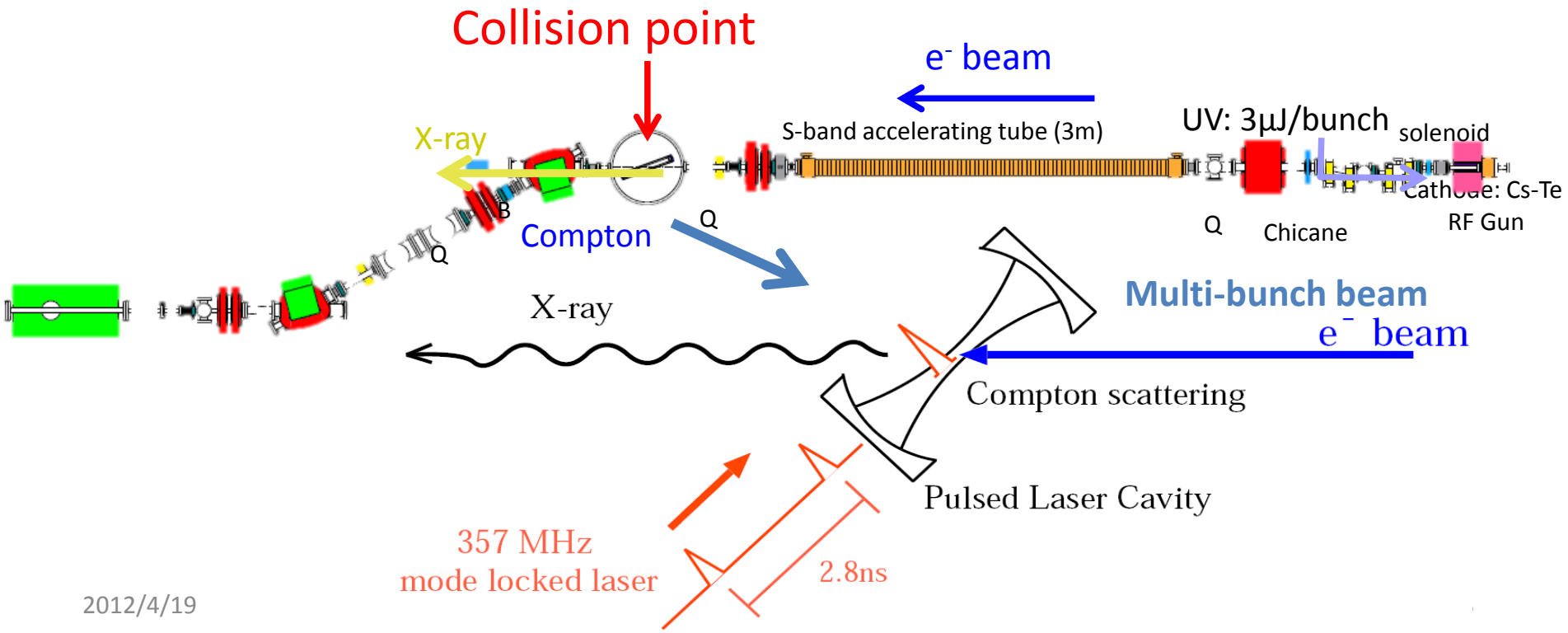
LUCX results



Laser size:30μm in σ, target:electron beam size:10μm in σ, laser waist size:8μm in σ

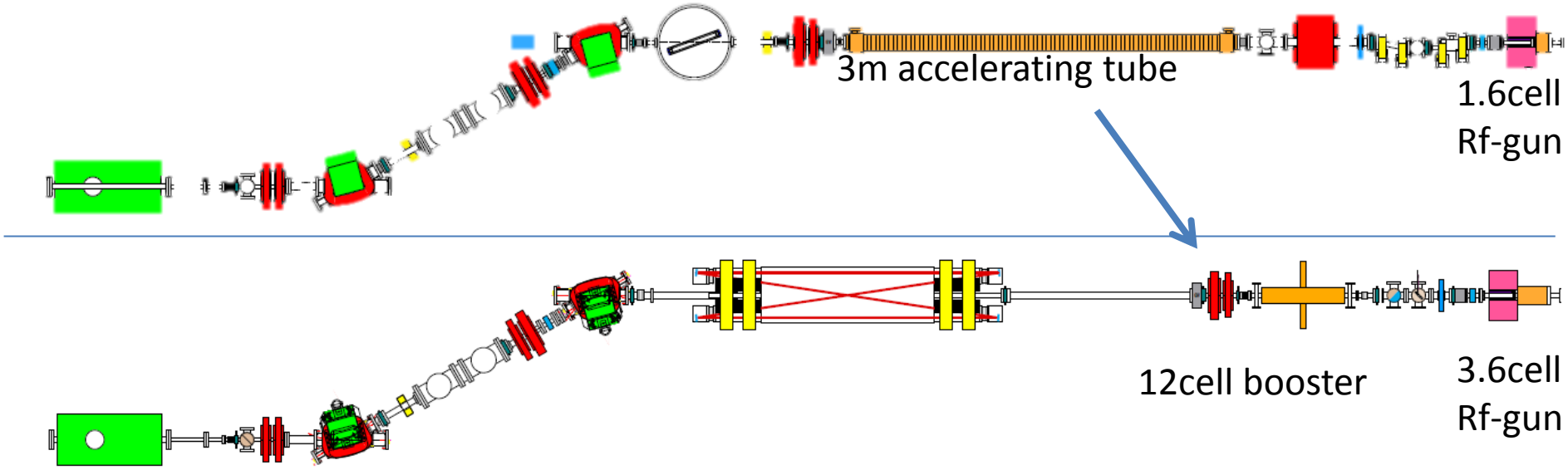
We have developed the X-ray source based on inverse Compton scattering for X-ray Imaging.





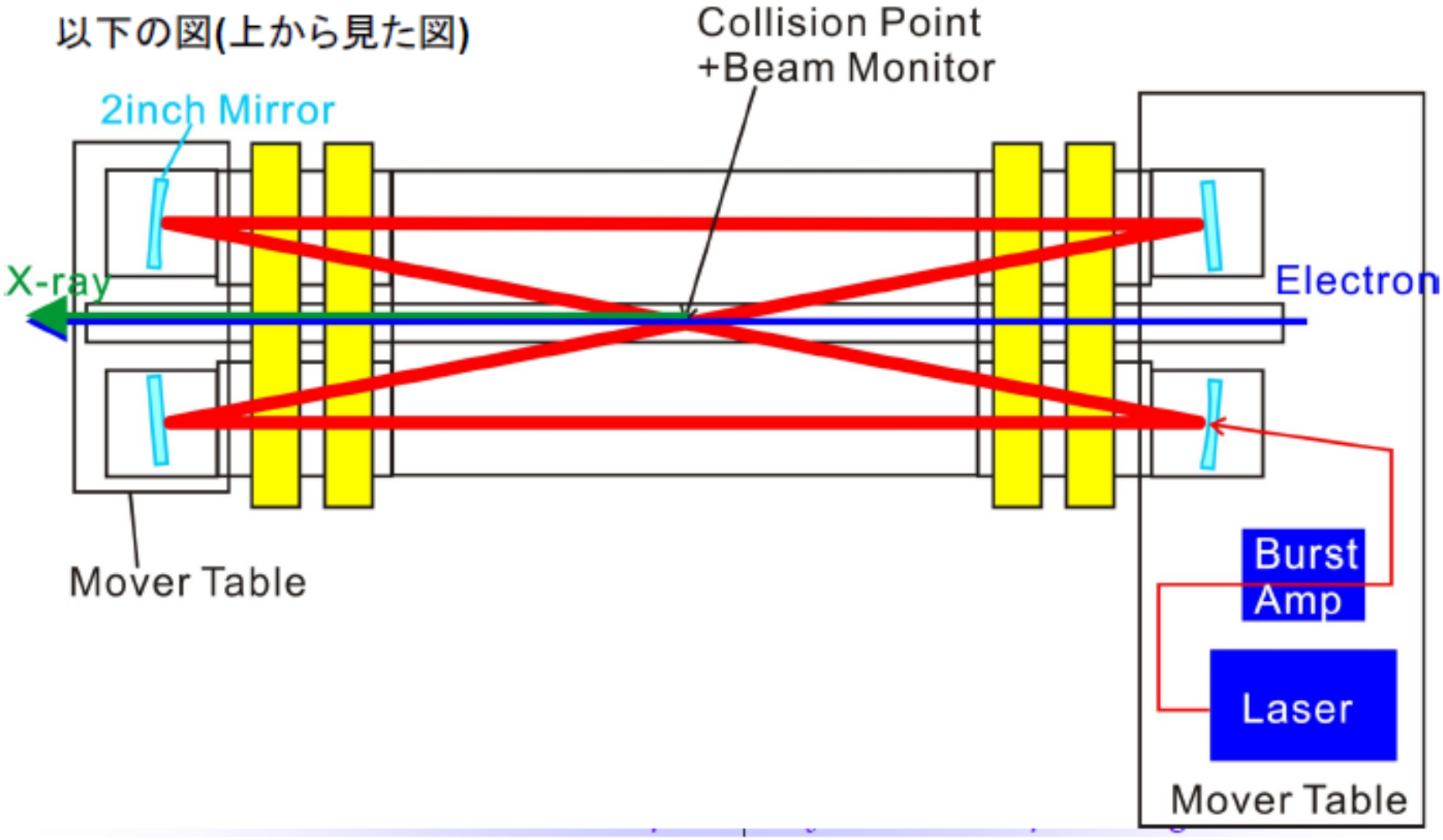
Future plan for LUCX accelerator

- To downsize the accelerator, we have planed to install a 3.6cell rf-gun and a 12cell booster.
  - 3.6cell rf-gun
    - Beam test has been started from Jan 2012.
  - 12cell booster
    - This booster is making now.



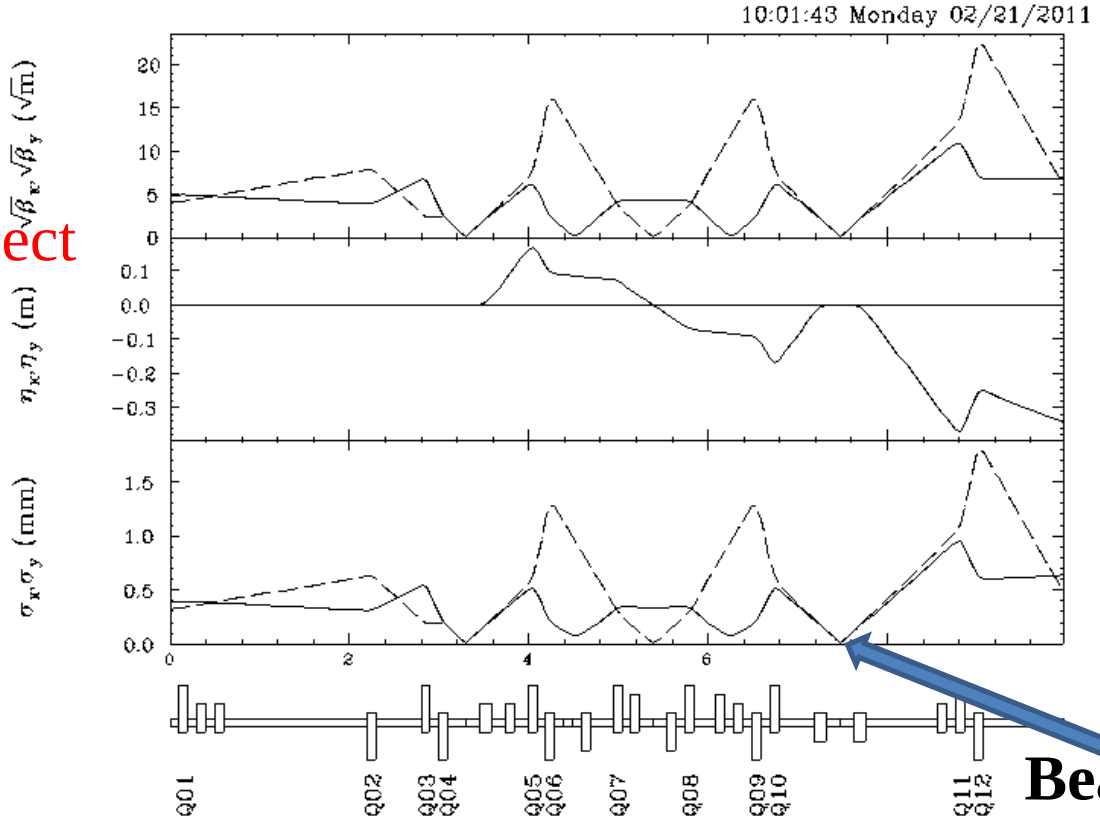
Cavity Design

前述の衝突角度問題＋4枚ミラーCavityという境界条件の下良さそうな設計が以下の図(上から見た図)

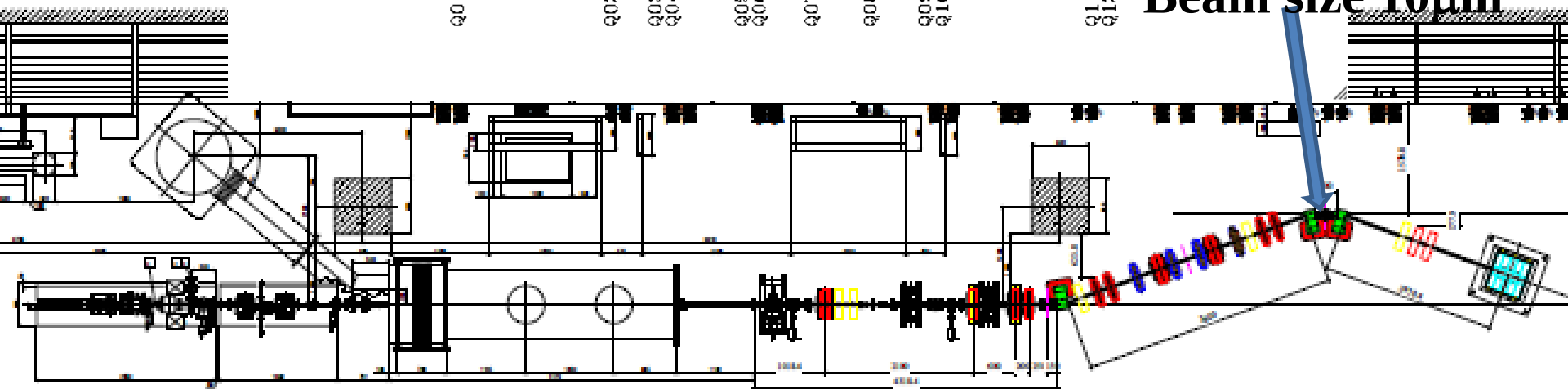


Change to head collision scheme to get another enhancement of 5 and to increase laser pulse duration ~30ps.

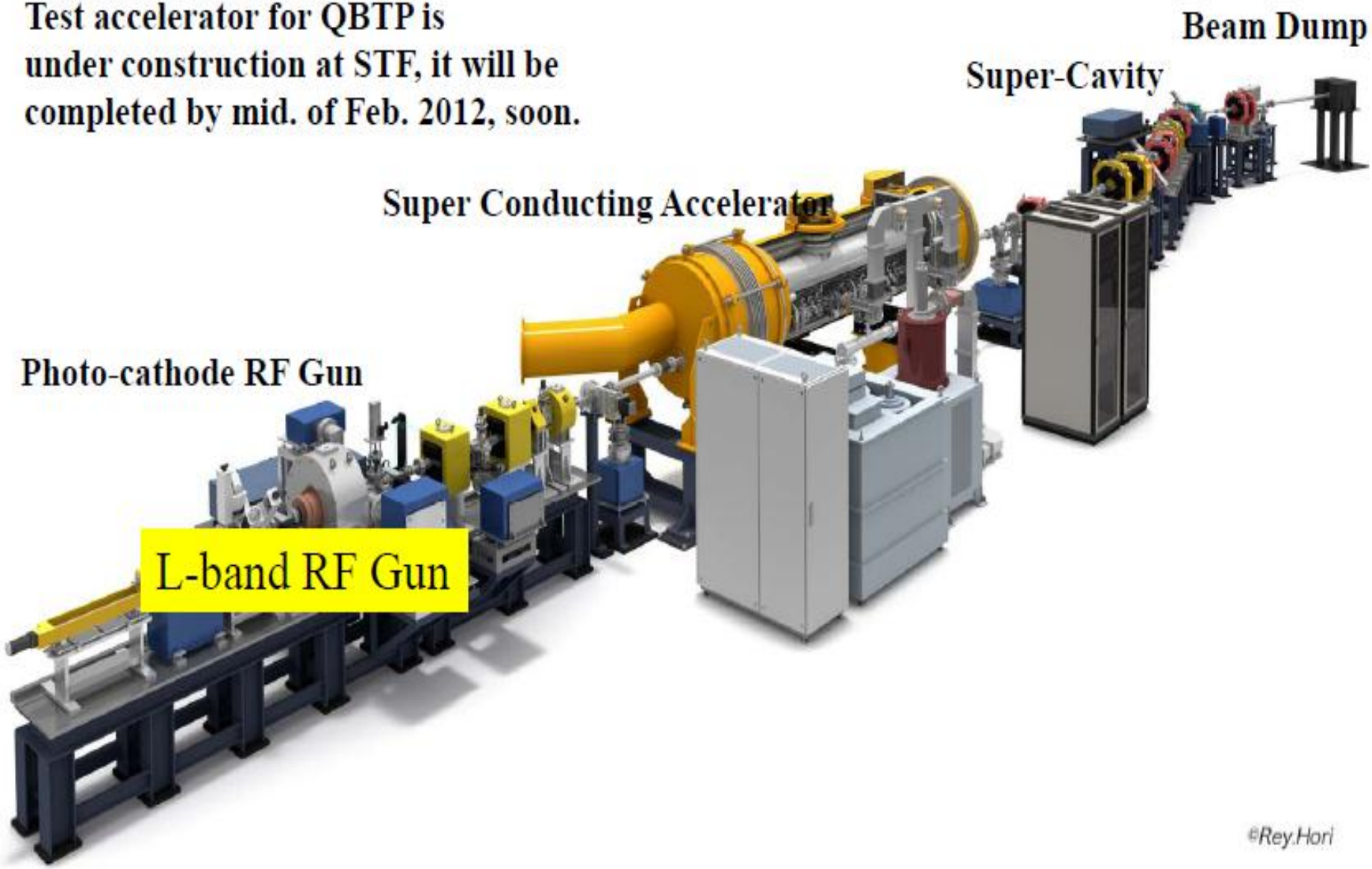
Quantum project at STF



Beam size 10μm



Test accelerator for QBTP is under construction at STF, it will be completed by mid. of Feb. 2012, soon.



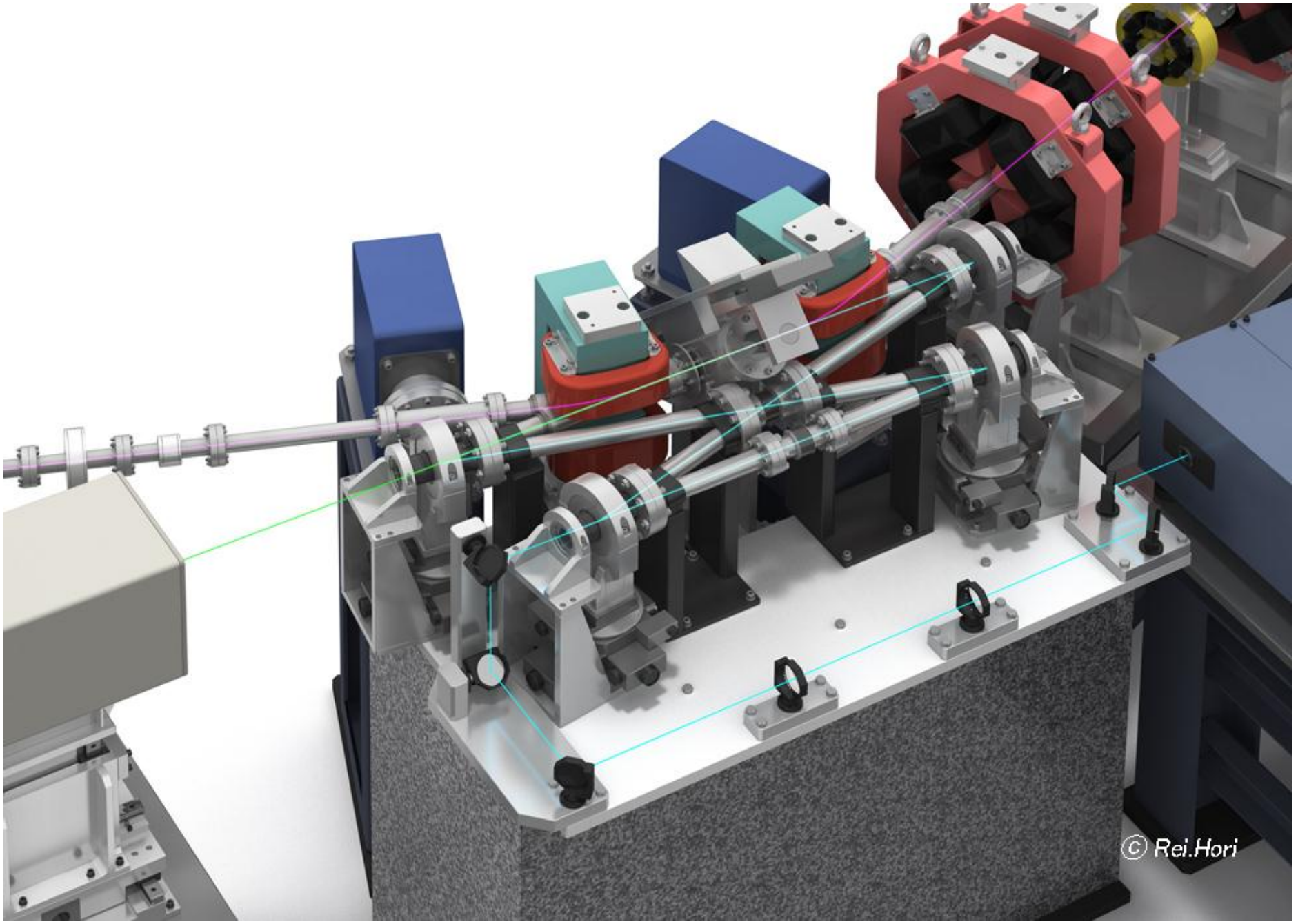

© Rei.Hori

Table 2. Beam parameters for QBTP project and STF injector for ILC

	Operation Parameter for Quantum Beam	Operation Parameter for ILC-STF Phase2
Pulse length	1ms	0.9ms
Repetition rate	5Hz	5Hz
Bunch Spacing	6.15ns (162.5MHz)	369.27ns (2.708MHz)
Number of bunch/pulse	162500	2437
Bunch charge	62pC	3.2nC
Total charge /pulse	10,000nC	7,798nC
Beam current	10mA	8.7mA
Bunch length	12ps(Laser, FWHM)	10ps(Laser, FWHM)
Max. beam energy	50MeV	21.5MeV
Beam power	2.5kW (50MeV beam) Usually 2.0kW (40MeV)	0.8kW (21.5MeV beam)

Q-Beam and cERL

- Quantum-Beam project is a strategic R&D for X-ray source for various applications based on the SC linac.
- 1st step: Pulsed X-ray generation with SC linac; It is carried out at KEK-STF, 2010-2012.
- 2nd step: CW X-ray generation with SC ERL; It will be carried out at cERL-KEK, 2013~2014.

Energy : 25-30 MeV
Micro pulse rep.:162.5MHz,
Current in macro pulse:10mA,
Macro pulse rep: 5Hz

http://kocbeam.kek.jp/project/index.html

Laser Compton R&D

- A proof of principle experiment of the polarized positron generation by the inversed laser Compton has been done already at KEK-ATF.
- Demonstration of the system feasibility is the next milestone.
  - Demonstration of CR scheme : The experiment at ATF.
  - Demonstration of ERL scheme: 2nd phase Q-beam and cERL at KEK.

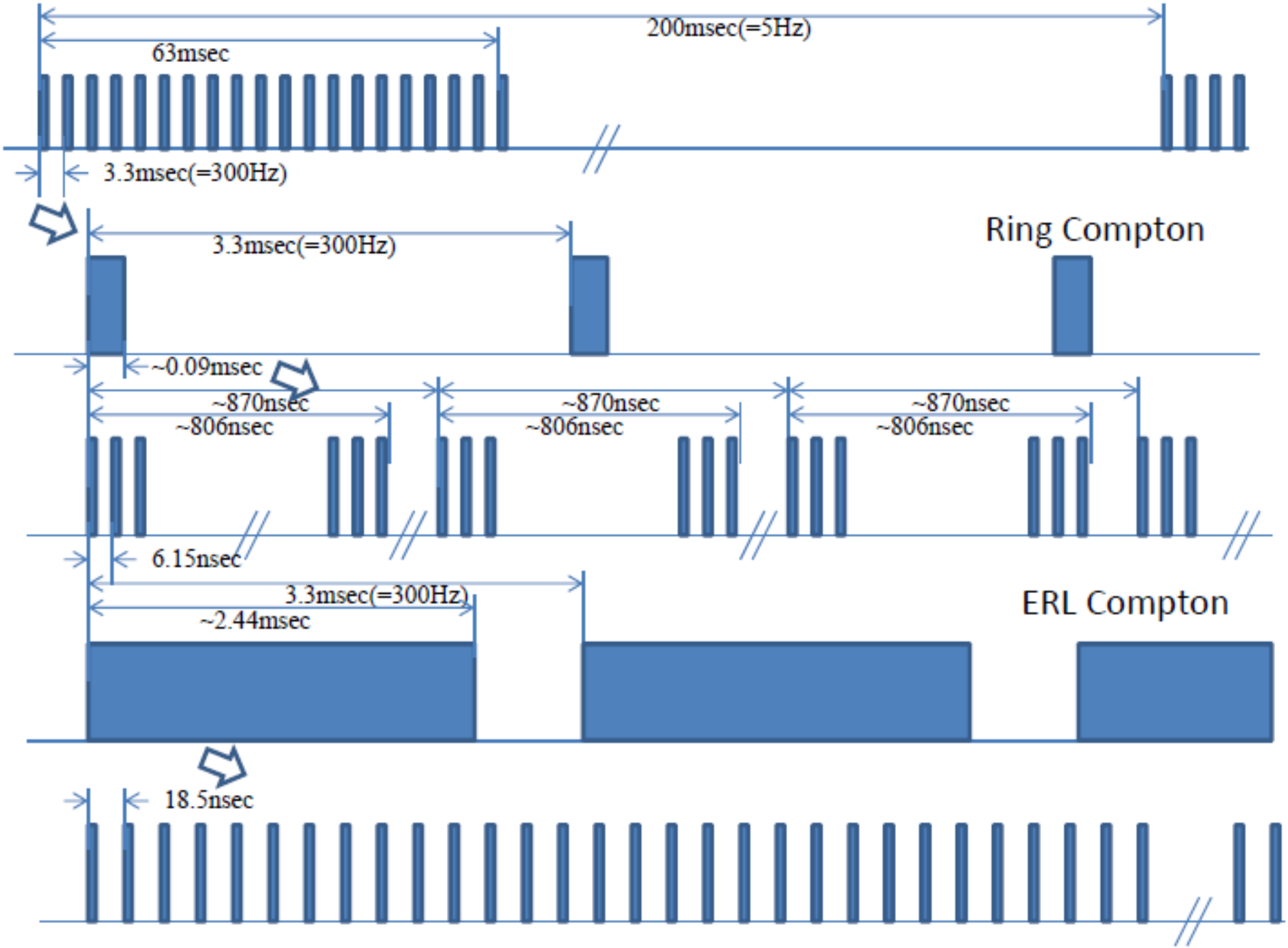
Suggestion for future R&D

1. Should consider multi-laser pulses in a ring cavity which means the development of larger optical cavity for γ-γ collider.
One optical cavity has about 10 laser pulses with 6.15 ns spacing and mirror cooling is necessary.

2. Positron bunch stacking into damping ring should be no beam lose. We have to invent new scheme, maybe asymmetric strong laser cooling. (Consider 1GeV stacking ring.)

3. Strong high reflectivity mirror should be developed for future high field physics and laser beam acceleration.

4. Redesign the scheme with head collision. How many optical cavities will be needed?


200msec(=5Hz)
63msec
3.3msec(=300Hz)
3.3msec(=300Hz)
Ring Compton
~0.09msec
~870nsec
~806nsec
~870nsec
~806nsec
~870nsec
~806nsec
6.15nsec
3.3msec(=300Hz)
~2.44msec
ERL Compton
18.5nsec

We have to assume **1GeV stacking ring (SR) with about 260m circumference**. Then, we can reuse 5GeV heavy beam loading Linac to inject bunch train of $3x10^{10}$ positrons/bunch into the damping ring within 63ms. Regarding Ring Compton since the period of 100 times positron bunch stacking is about 87μs, the cooling period of 3.2ms for Compton ring and SR is enough for stable operation of the ring. 20 times beam extraction from SR means it takes 63ms by 300Hz Linac operation. Of course, **we have to construct 5Hz SC Linac with 63ms pulse duration and 1GeV acceleration.** Regarding ERL Compton since we need 1000 times of the beam stacking, the period of 1000 times positron bunch stacking is about 2.5ms for ERL Compton. **1GeV SC Linac with 63ms pulse duration has 20 trains which consist of 132x1000 bunches train in 2.5ms with train spacing of 0.8ms for the bunch train extraction.** The 0.8ms for SR is enough for the stable operation of the beam extraction operation. Then, we can reuse 300Hz Linac to accelerate and to inject into the damping ring within 63ms. Figure shows the timing structure in the 300Hz booster linac and in the 5Hz superconducting linac for SR regarding Ring and ERL Compton.

1GeV stacking ring with about 260m circumference is necessary for accumulation beam.
Also, 5Hz superconducting Linac with 63ms pulse duration and 1GeV acceleration are needed for 100 times or 1000 times bunch stacking. Thanks ERL cavity technologies.

For Ring Compton scheme;
100 times injection with 132 bunches/pulse into stacking ring.
Then, we can reuse 5GeV 300Hz heavy beam loading Linac from the 1GeV stacking ring to inject 132 bunches/pulse with $3x10^{10}$ electrons/bunch.

For ERL Compton Scheme;
1000 times injection with 132 bunches/pulse into stacking ring.
Then, we can reuse 5GeV 300Hz heavy beam loading Linac from the 1GeV stacking ring to inject 132 bunches/pulse with $3x10^{10}$ electrons/bunch.