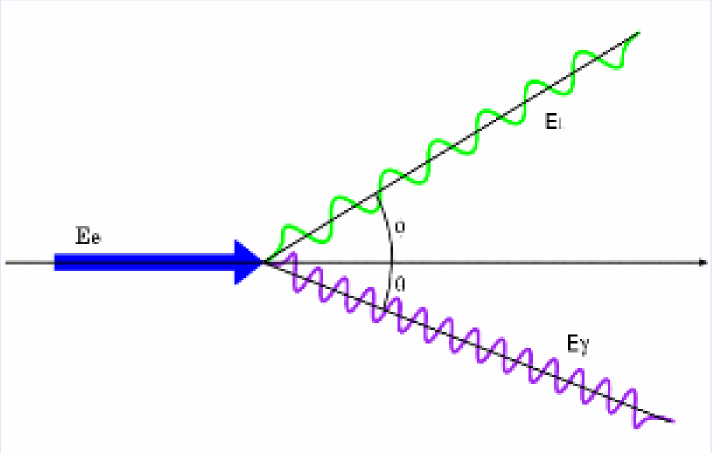
Compton Back-scattering

- Laser acts as a quite short period undulator; high energy gamma (several 10s MeV) is obtained with a few GeV electron beam.
- Positron helicity is easily switched by laser polarization.

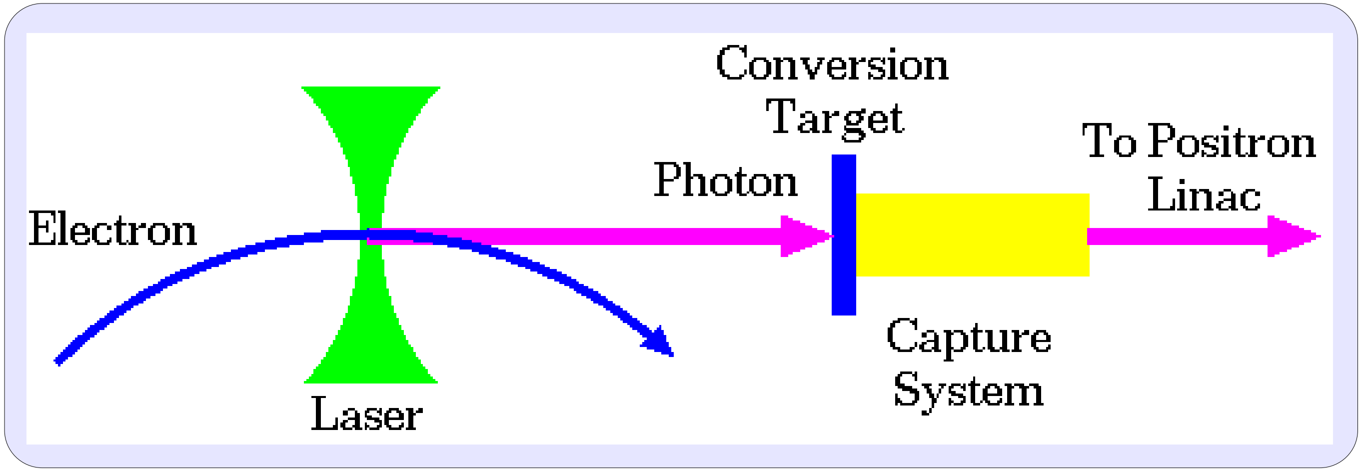
$$E_\gamma \sim \frac{4\gamma^2 mc^2 E_L}{mc^2 + 4\gamma E_L}$$

- E_L : Laser energy 1eV @ 1um.
- Electron beam 1GeV, γ=2000.
- E_γ ~ 16MeV



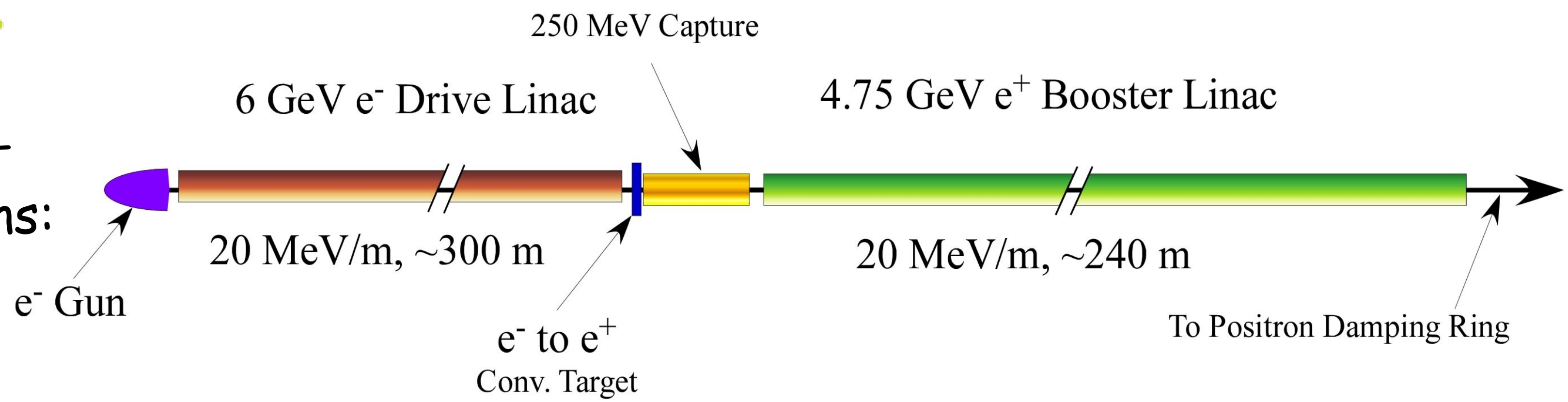
Polarized Positron Soure Compton Scheme

- 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.

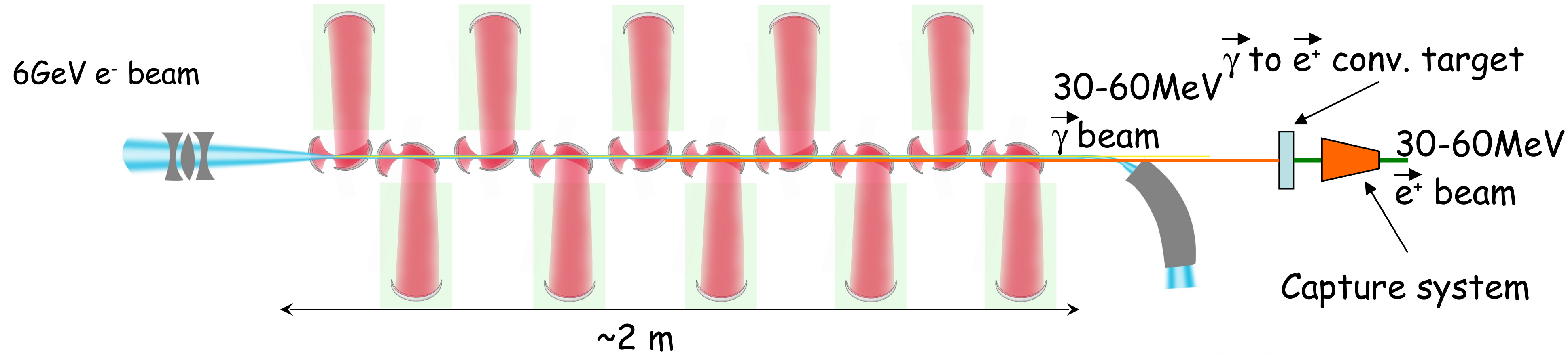


Linac Scheme

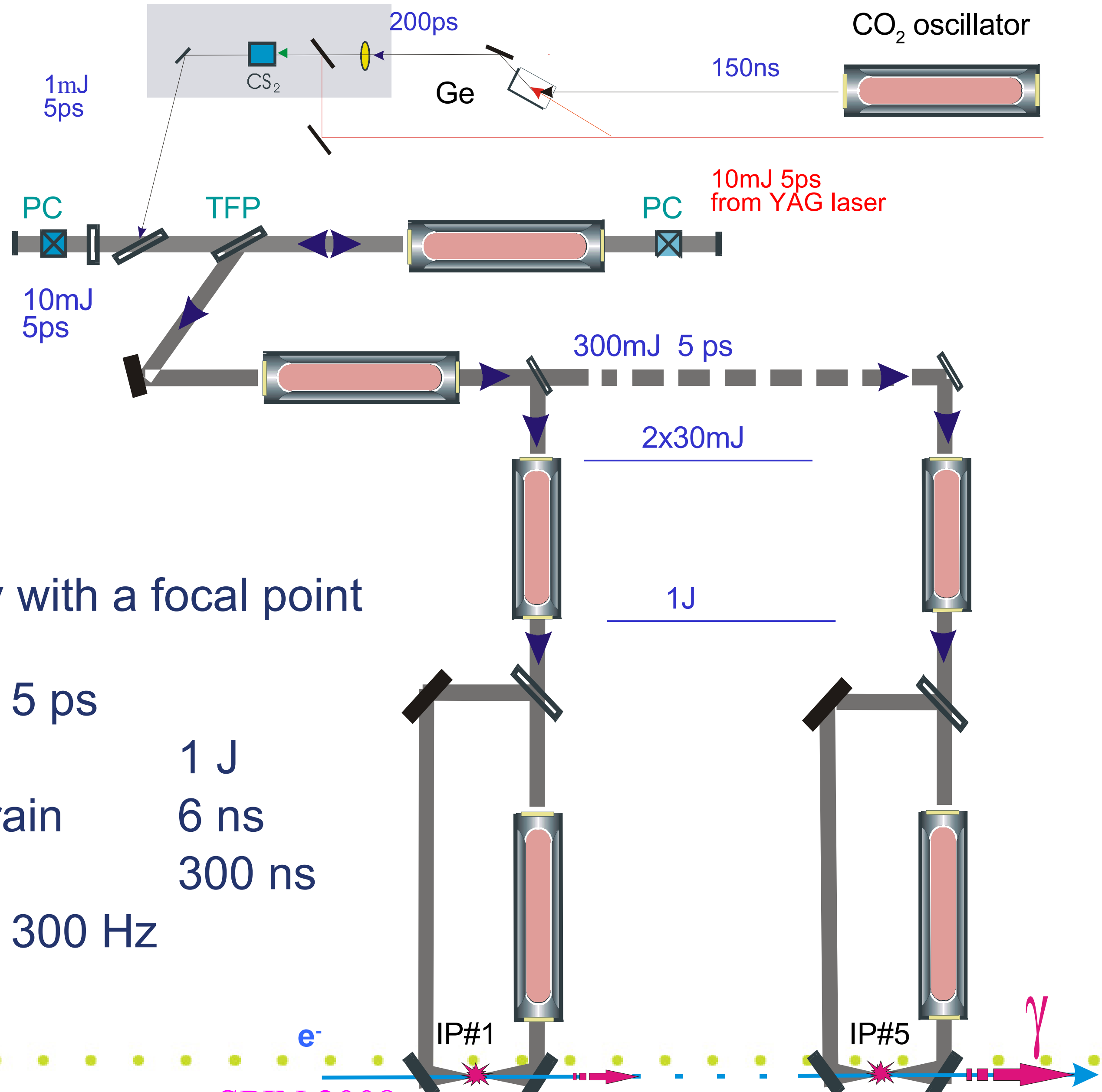
Conventional Non-Polarized Positrons:



- Conventional Positron source (Electron linac driven) is upgraded with a simple modification.
- polarized γ-ray beam is generated in the Compton back scattering inside optical cavity of CO_2 laser beam and ~6 GeV e-beam produced by linac.
- The required intensities of polarized positrons are obtained due to 5 times increase of the e-beam charge (compared to non polarized case) and 10 CO_2 laser system IPs.

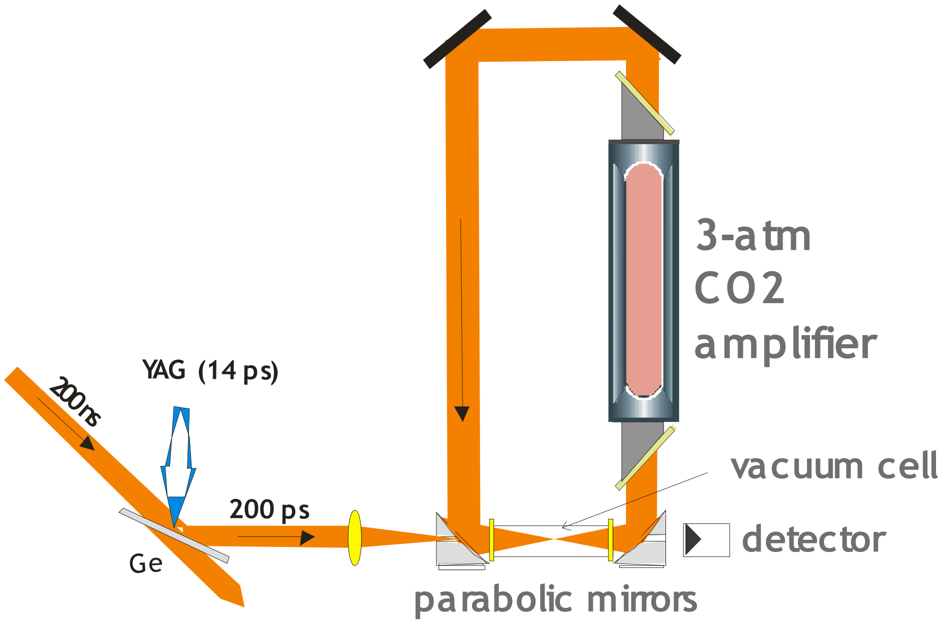


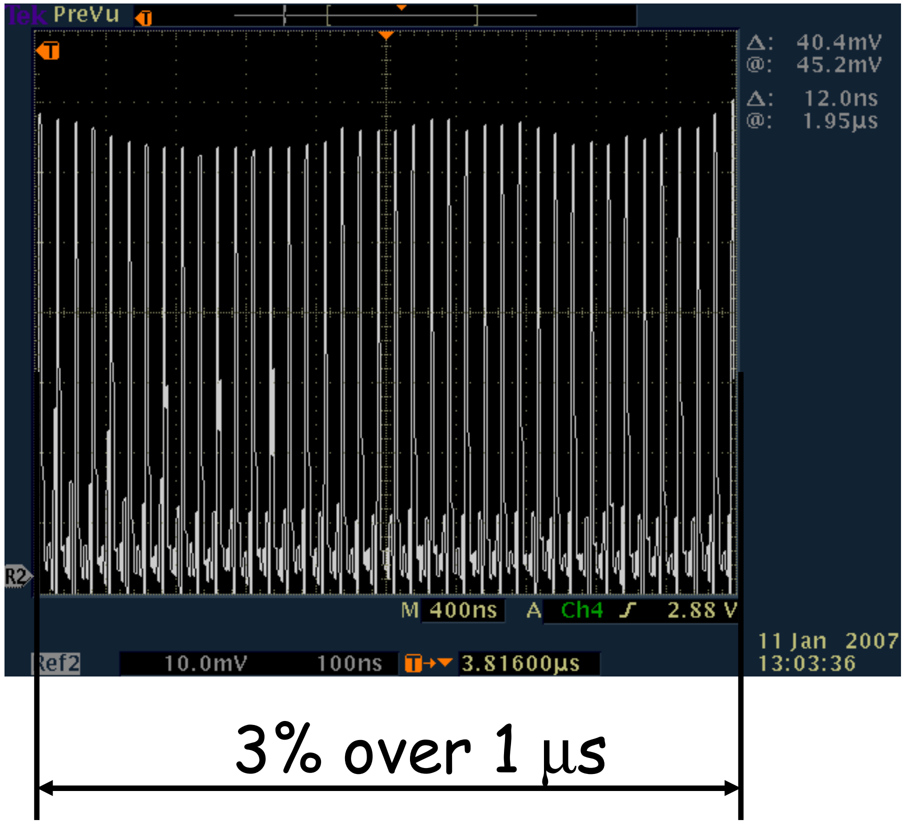
CO_2 laser system



- CO2 laser ring cavity with a focal point as a collision point.
- pulse length 5 ps
- energy per pulse 1 J
- period inside pulse train 6 ns
- total train duration 300 ns
- train repetition rate 300 Hz

Optical cavity: Simplified test setup

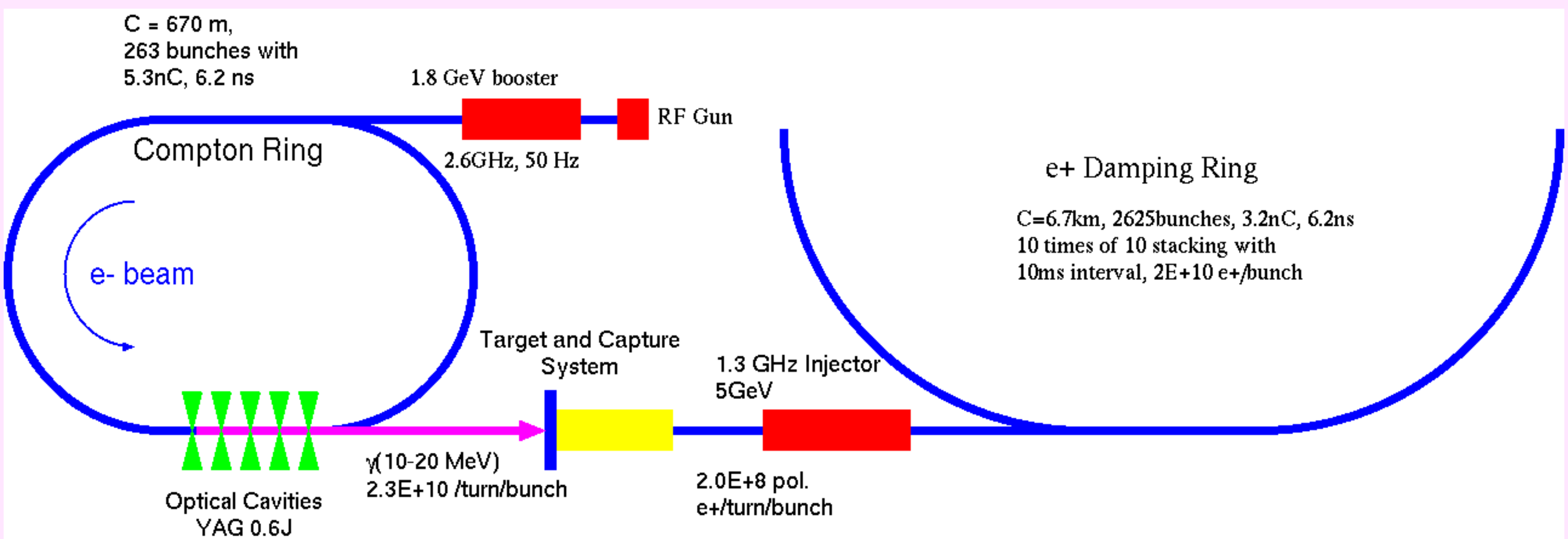




- Very encouraging results obtained with simplified cavity test setup: ~200 ps pulse of the order of 100 mJ circulated for >1 µs.
- Further test would require pulse length monitoring and high pressure or isotope mixture based amplifier (to sustain 5 ps beams).

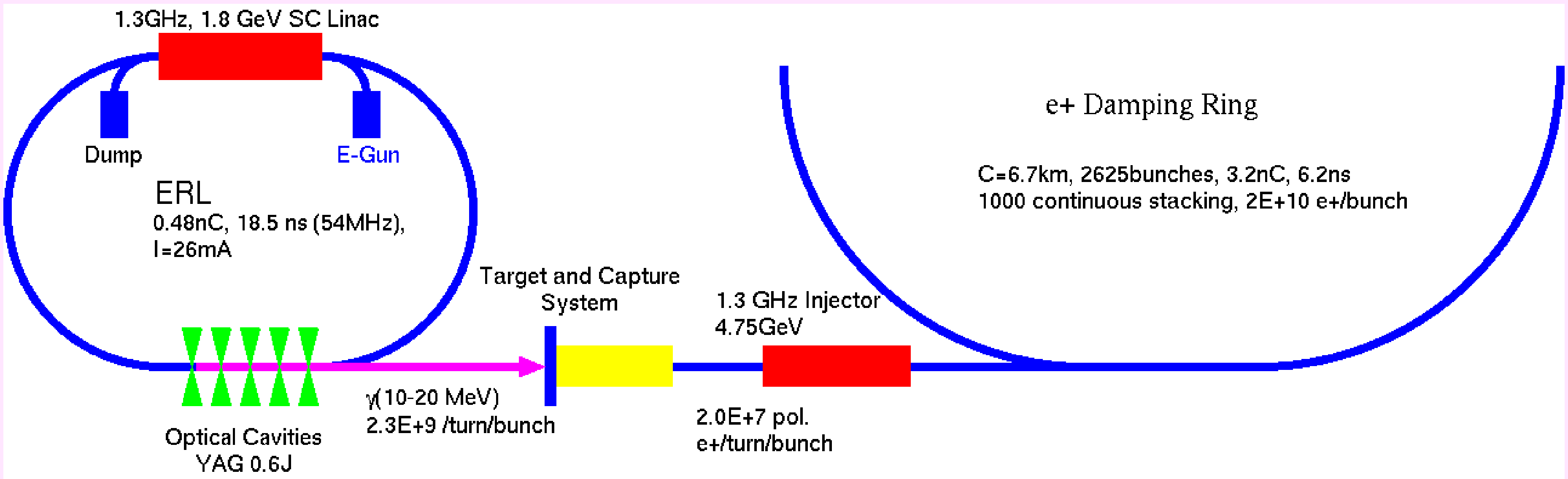
Compton Ring

- 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.



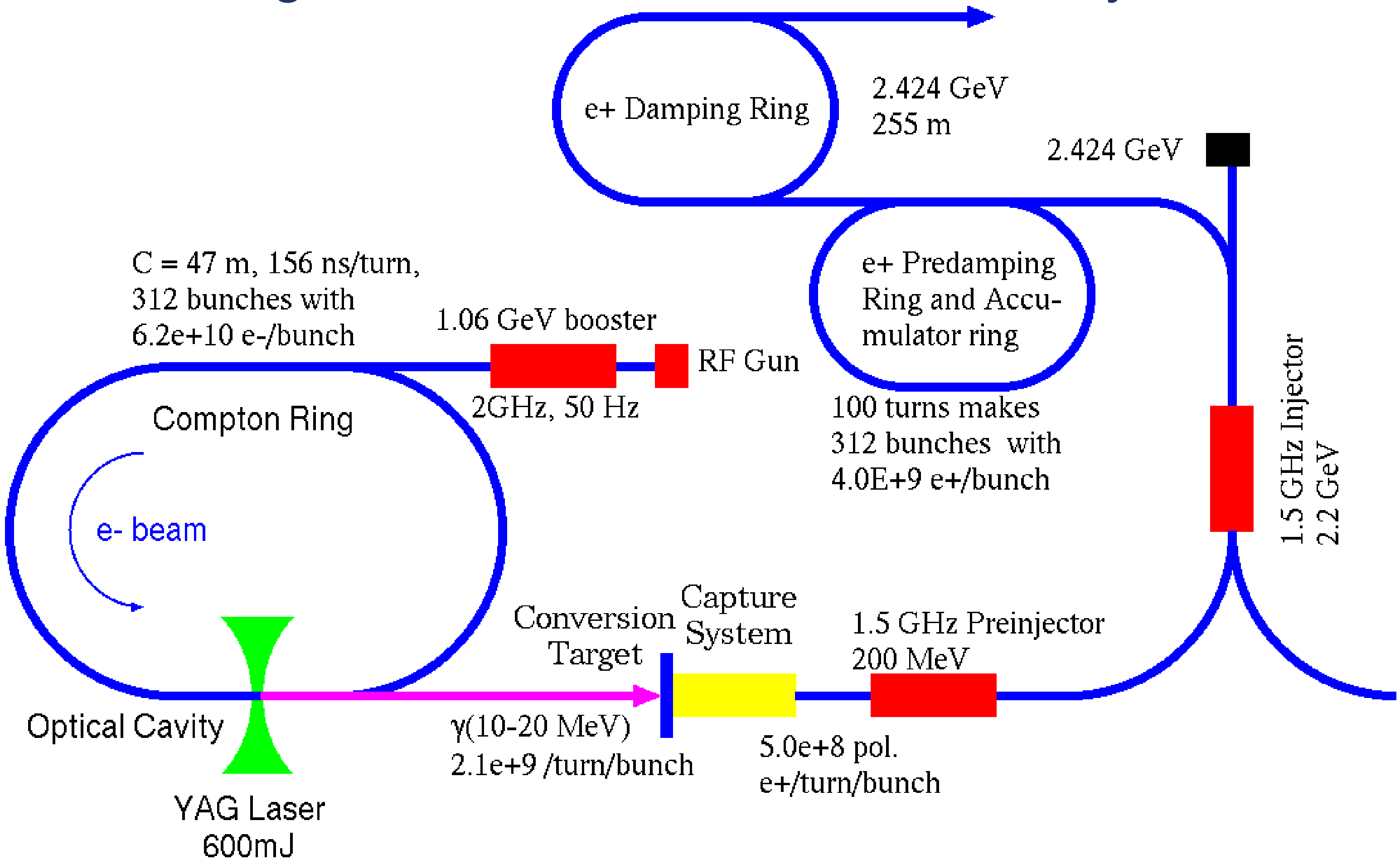
ERL

- 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.



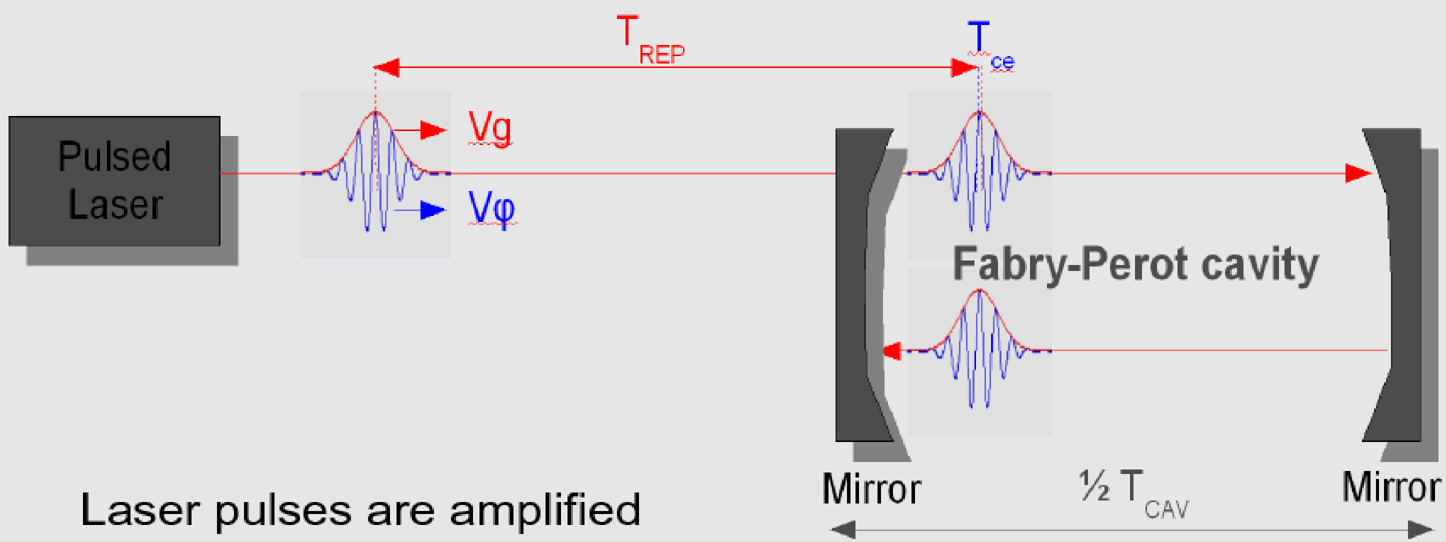
CLIC Compton Scheme

- Storage ring with a single optical cavity.
- 9.8E+6 e+/bunch is generated.
- 450 times stacking in Pre-DR make the full intensity beam.



Pulse Stacking Optical Cavity

- High power mode lock laser is “stored” in an optical cavity.
- Both group velocity and phase velocity should be matched for high enhancement.
- 30000 finess is achieved in September 2008.



Laser pulses are amplified
if laser field overlays with FP cavity field :

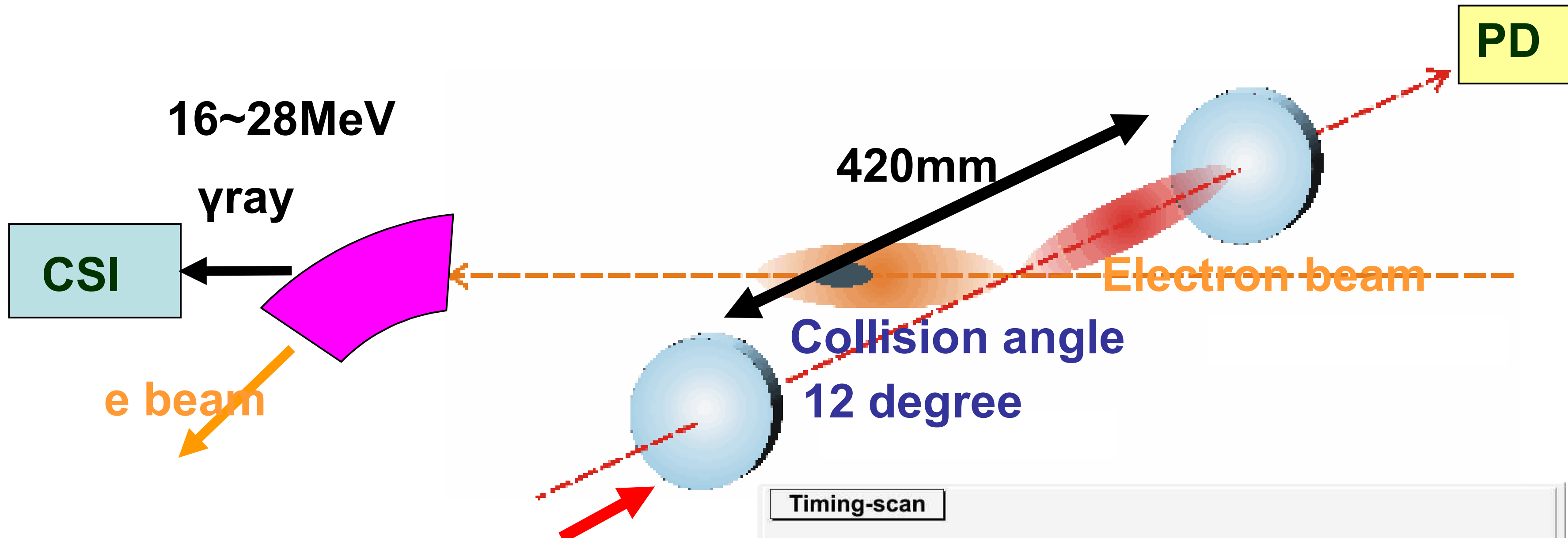
$$Trep \triangleq \frac{Lrep}{Vg} = Tcav \triangleq \frac{Lcav}{Vg} \quad \Rightarrow \quad \boxed{Lrep = Lcav}$$

$$Tce \triangleq Lrep\left(\frac{1}{Vg} - \frac{1}{V\varphi}\right) = k\frac{\lambda}{V\varphi} \quad \Rightarrow \quad \boxed{Vg = \frac{V\varphi}{1 + k\frac{\lambda}{Lrep}}}$$

$$k \in \mathbb{N}$$

Vg	: Group Velocity
Vφ	: Phase Velocity
Lrep	: Laser repetition Length
Lcav	: Fabry-Perot cavity Length

Experiment at KEK-ATF



Mode lock laser

λ:1064nm

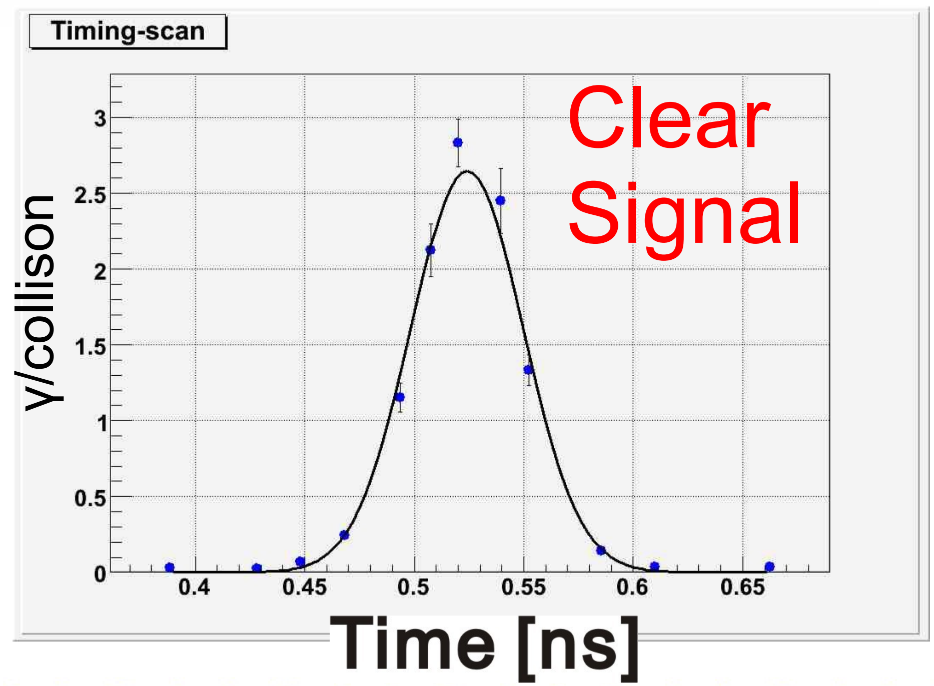
10W=28nJ , 2.8ns spacing

Pulse length : 7ps

Optical Cavity

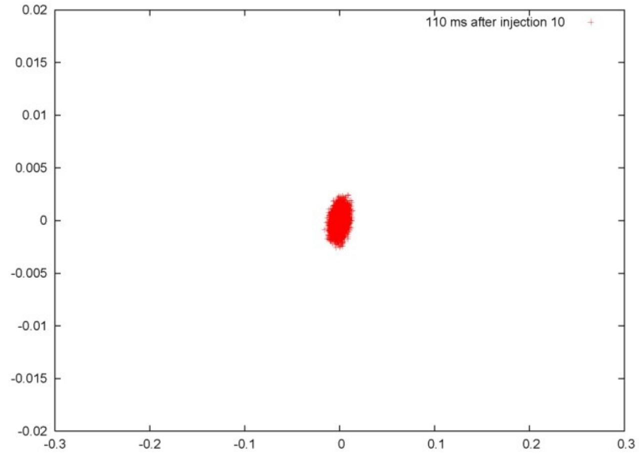
Finess = 780

σ = 30 μm



Stacking Simulation

F. Zimmermann

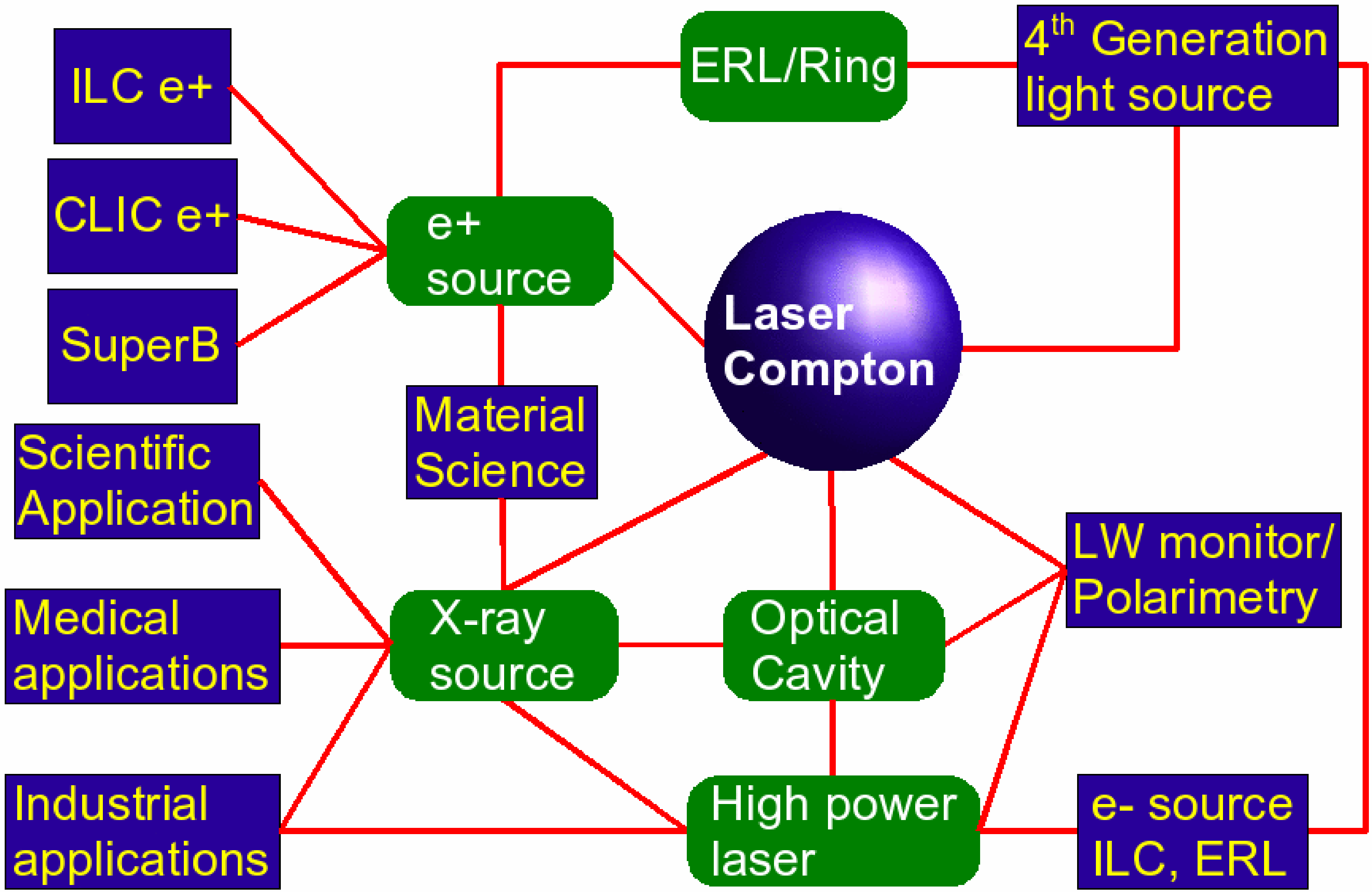


- Except linac scheme, # of positron by a single collision is not sufficient -> need stacking.
- Stacking simulation in DR (multi-turn injection) shows stacking efficiency ~90%.
- The tolerance of the injection loss would be qualified.

PosiPol-Collaboration

- Laser-Compton has a large potential as a future technology.
- Many common efforts can be shared in a context of various applications.
  - X-ray/SR sources for industrial and medical applications,
  - Beam diagnostics with Laser,
  - Polarized Positron Generation for ILC, CLIC, SuperB, ..
- State-of-the-art technologies are quickly evolved with world-wide synergy.
- PosiPol collaboration has been started in 2006.
- The last annual meeting was held at Hiroshima in July 08. The next meeting will be held at near CERN in 2009.

WWW of PosiPol R&Ds



Summary

- Laser Compton can generate high energy gamma with a few GeV dedicated electron driver.
- To obtain an enough positron yield is a technical challenge.
- Aggressive R&D is being carried out for ILC and CLIC polarized positron source based on Laser Compton.
- Annual workshop has been held by PosiPol collaboration, because of a large potential for various applications.