The 12th
Advanced Accelerator Concepts Workshop
Grand Geneva Resort, Lake Geneva, Wisconsin, USA
July 10-15, 2006

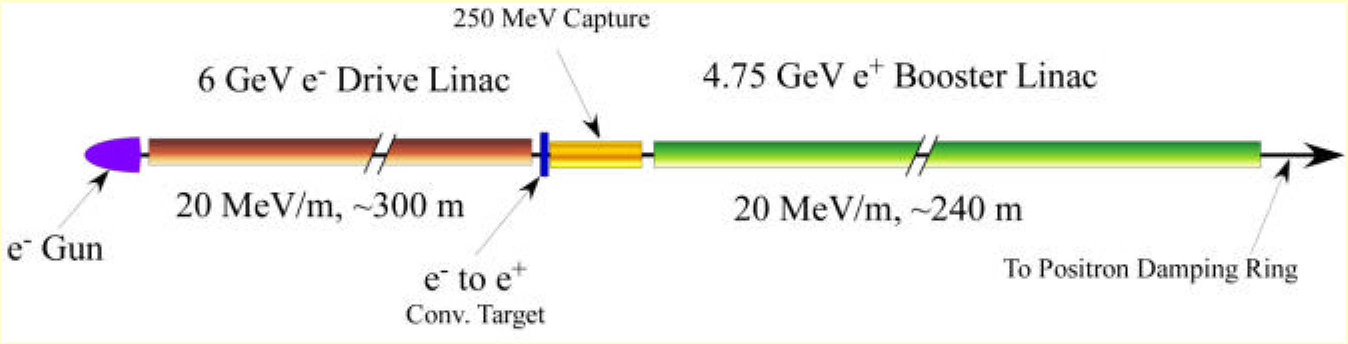
Polarized g-source based on Compton backscattering in a laser cavity

Igor Pogorelsky
Vitaly Yakimenko

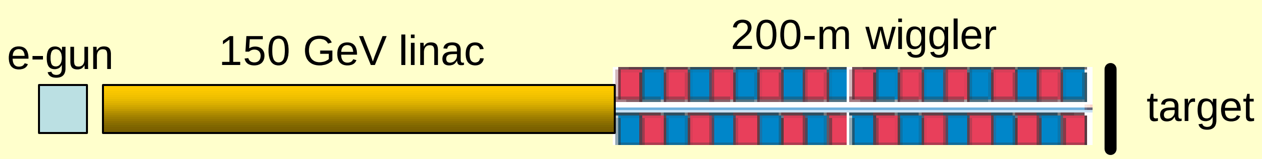
BROOKHAVEN NATIONAL LABORATORY

Current Positrons Source Proposals for ILC

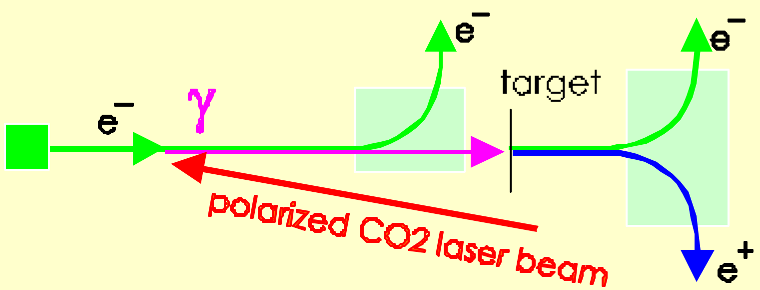
Conventional non-polarized positron source



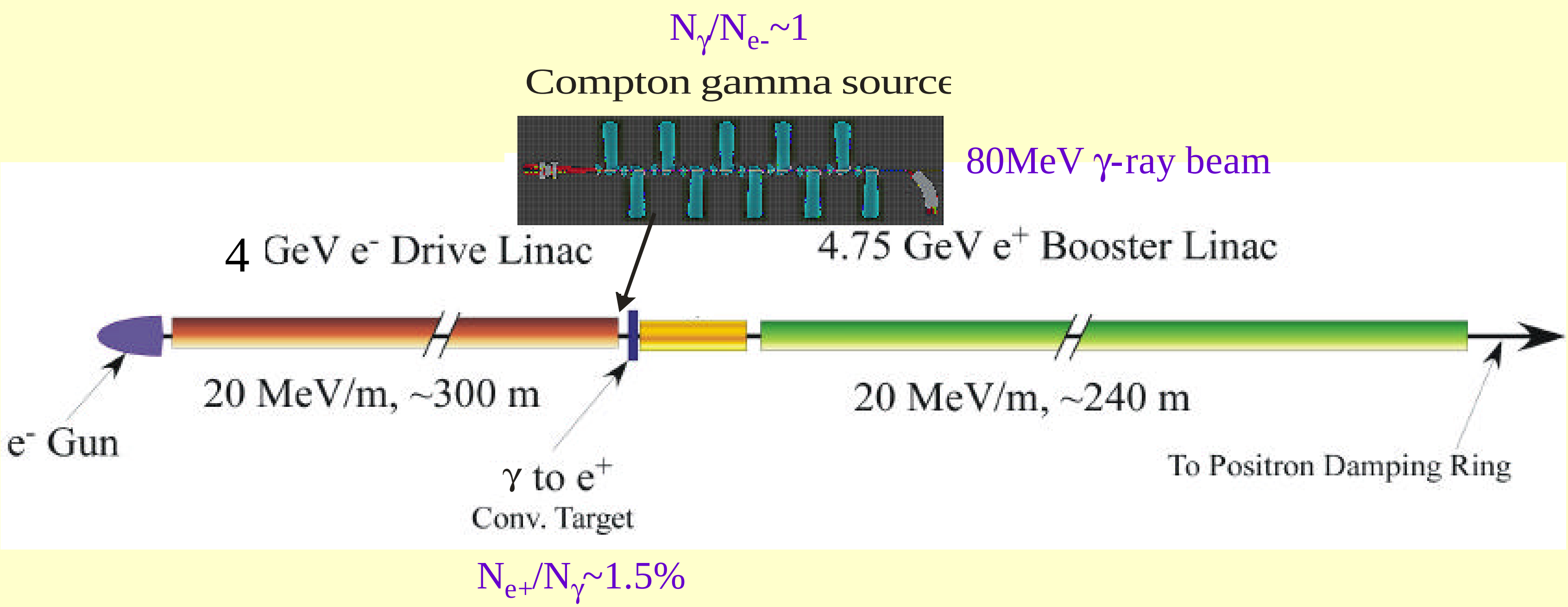
Polarized gamma source by spontaneous wiggler radiation



Polarized gamma source by Compton scattering



Polarized positron source by Compton scattering in a laser cavity



- SLAC type linac is considered for the accelerator and does not require any R&D
- Laser system relies on commercially available lasers but needs R&D for a new mode of operation

CO_2 laser advantages for a Compton source

$$N_x = 6.7 \times 10^{11} \frac{E[J] Q[nC] l[mm]}{w_0^2[mm]}$$

CO_2 laser produces 10 times more photons per joule than solid state laser

- **X-ray wavelength** $l_x \approx l / 4g^2$
- **Divergence** $q \approx 1/g$
- **Bandwidth** $\Delta n_X / n_X = 2\Delta g / g$
- **Brightness** $B = N_x / (2prq)^2 \Delta n_x t_x$

***Choosing 10-mm CO_2 instead of the 1-mm laser requires g increase µ Öl =3.**

however:

***Divergence drops** µ l $^{-1/2}$

***Bandwidth drops** µ l $^{-1/2}$

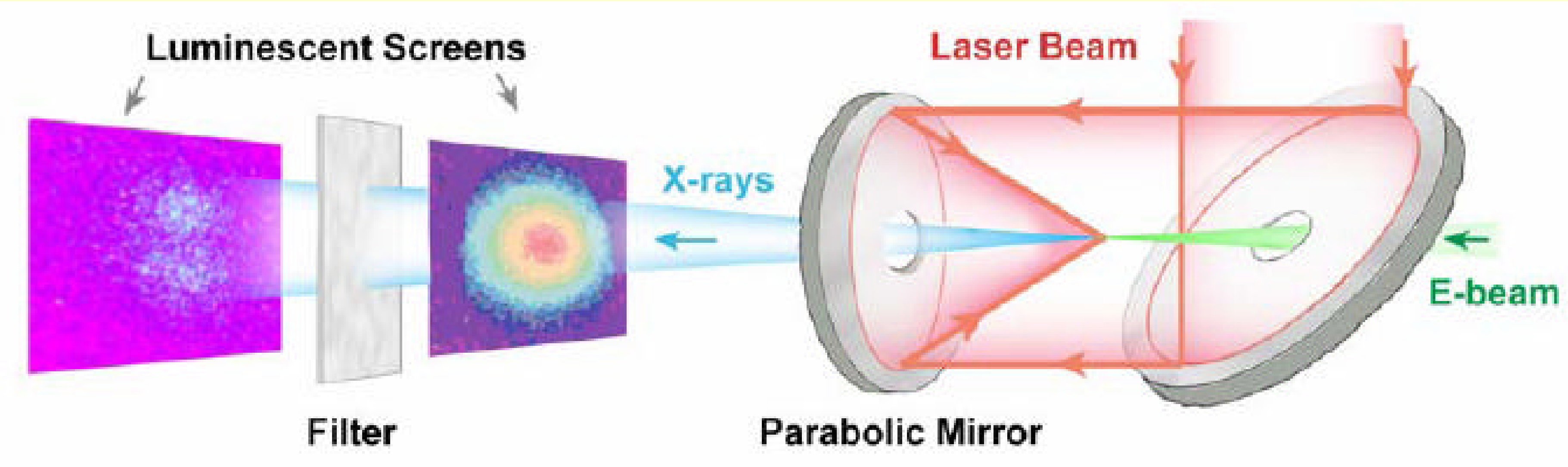
***Spectral Brightness increases** µ l $^{5/2}$ **(~300 times!).**

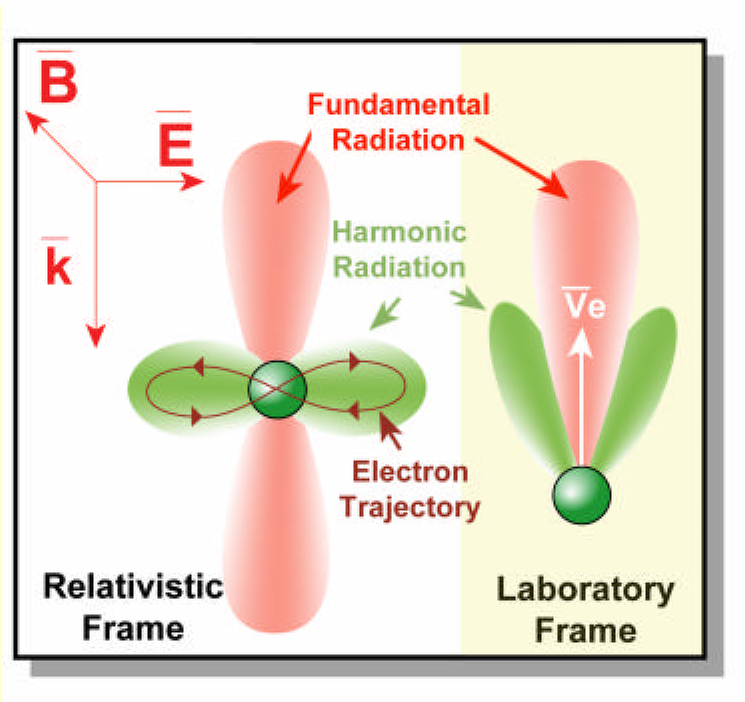
Polarized γ source requirements

Parameter	Symbol	Value	Unit
Pulse repetition rate	f_{rep}	150	*Hz*
Bunches per pulse	N_b	100	
Bunch Spacing	Dt_b	12	*ns*
Laser energy	E_{laser}	1	*J*
Size at focus	s_{laser}	40	*mm*
Laser pulse length	t_{laser}	5	*ps*
Number of γ per electron	$N\gamma / n_e$	1	
e^- per bunch	n_e	6×10^{11}	
Number of lasers	N_{laser}	10	
Number of γ per bunch	$N\gamma \times N_{laser}$	6×10^{12}	

Positron storage ring will be filled in 30 laser shots to accumulate 2820 bunches in the train, and to make 5 Hz train repetition rate as is required by ILC design.
For CLIC, a correct beam structure is produced without accumulation.

Observation of Nonlinear Thomson Scattering





demonstration of

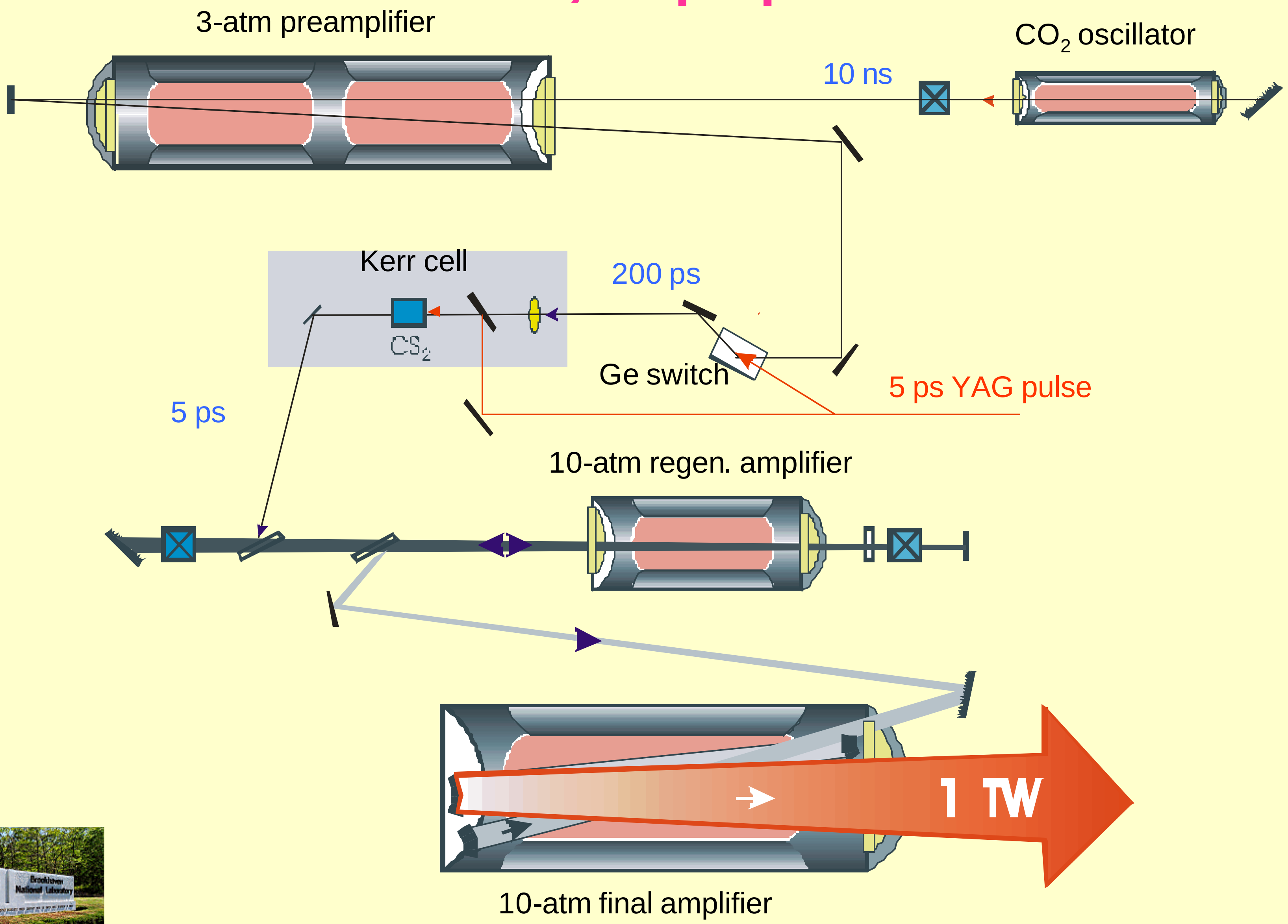
$$N_\gamma / N_{e-} \sim 1$$

Laser parameters:

t = 5 ps, E = 5 J, P = 1 TW, s = 35 μm

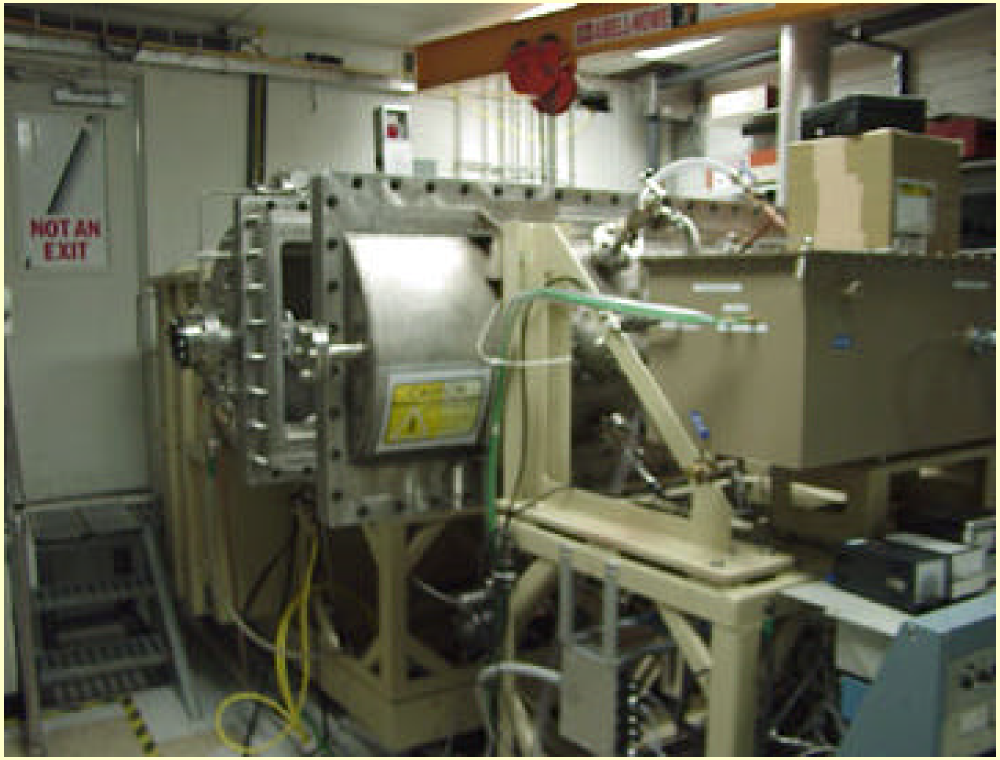
BROOKHAVEN NATIONAL LABORATORY

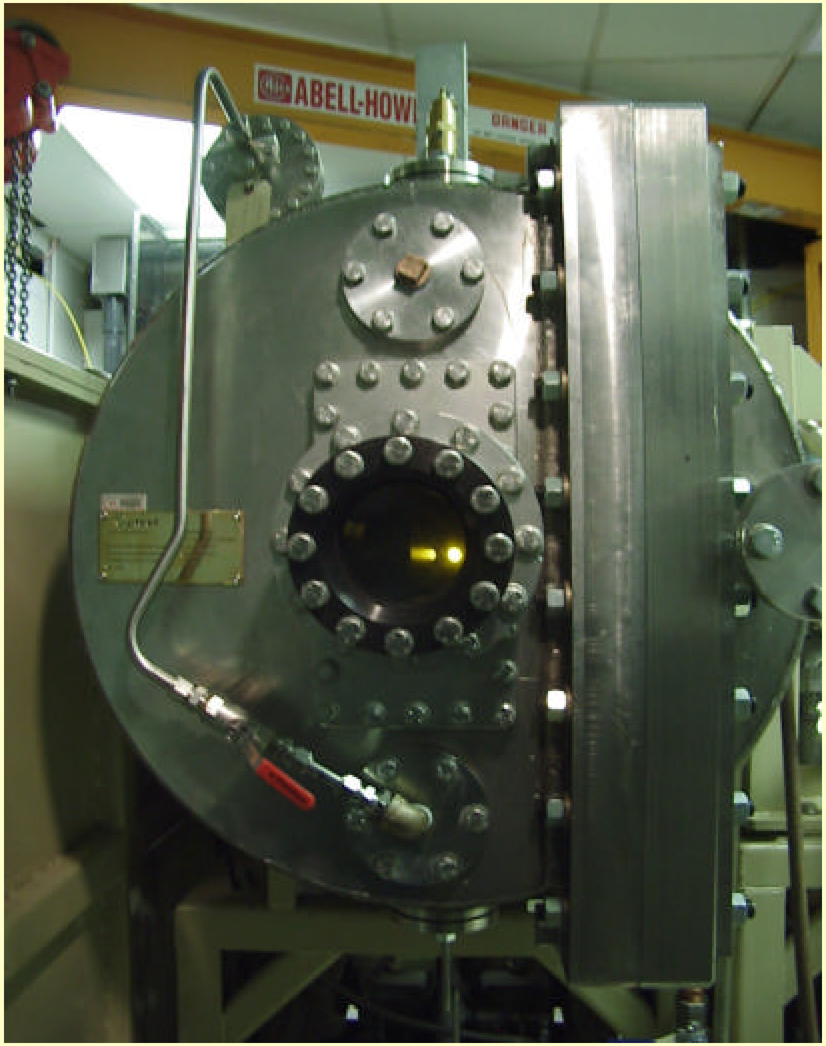
BNL/ATF CO_2 laser system delivers 1 TW, 5 ps pulses



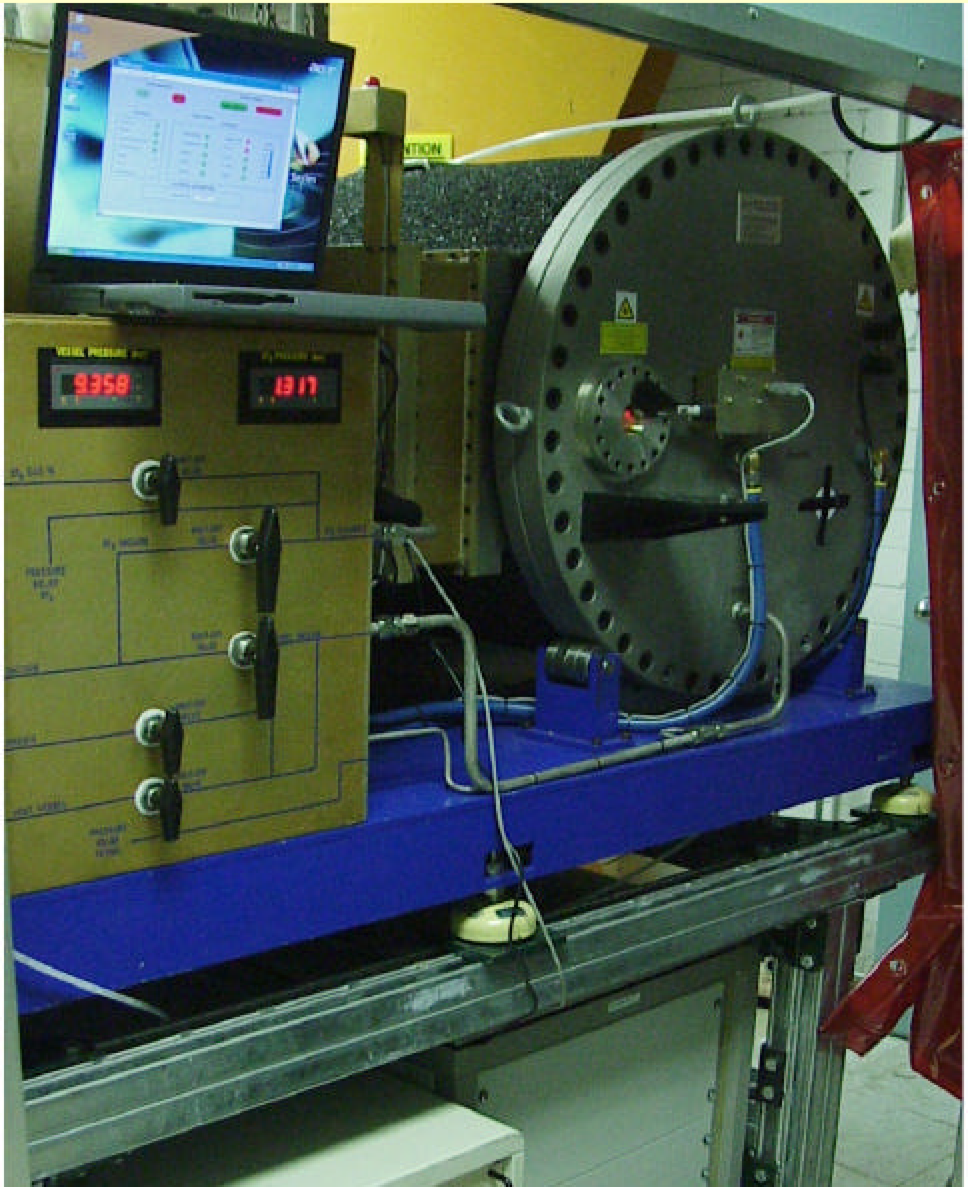
X-ray preionized 10-atm CO_2 Laser PITER-I

Small-Signal Gain	**2.5%/cm**
Active Volume	**10 liter**
Output Energy	**10 J**
Repetition rate	**1 / 20 Hz**



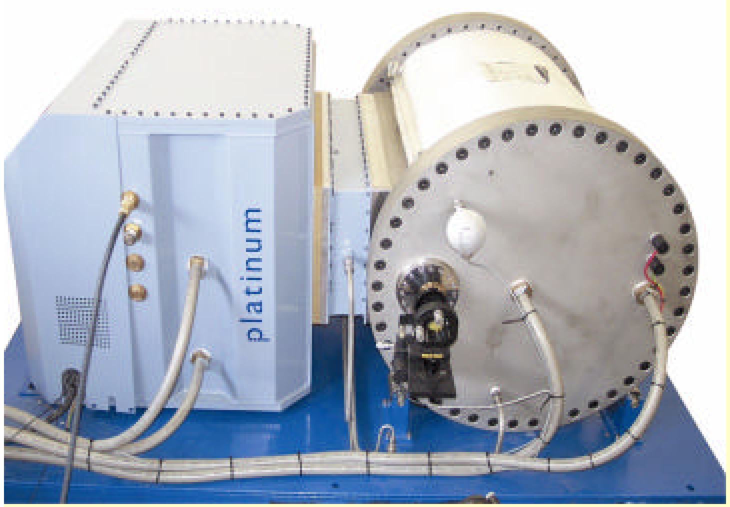


Commercially Available High-Pressure CO_2 Lasers

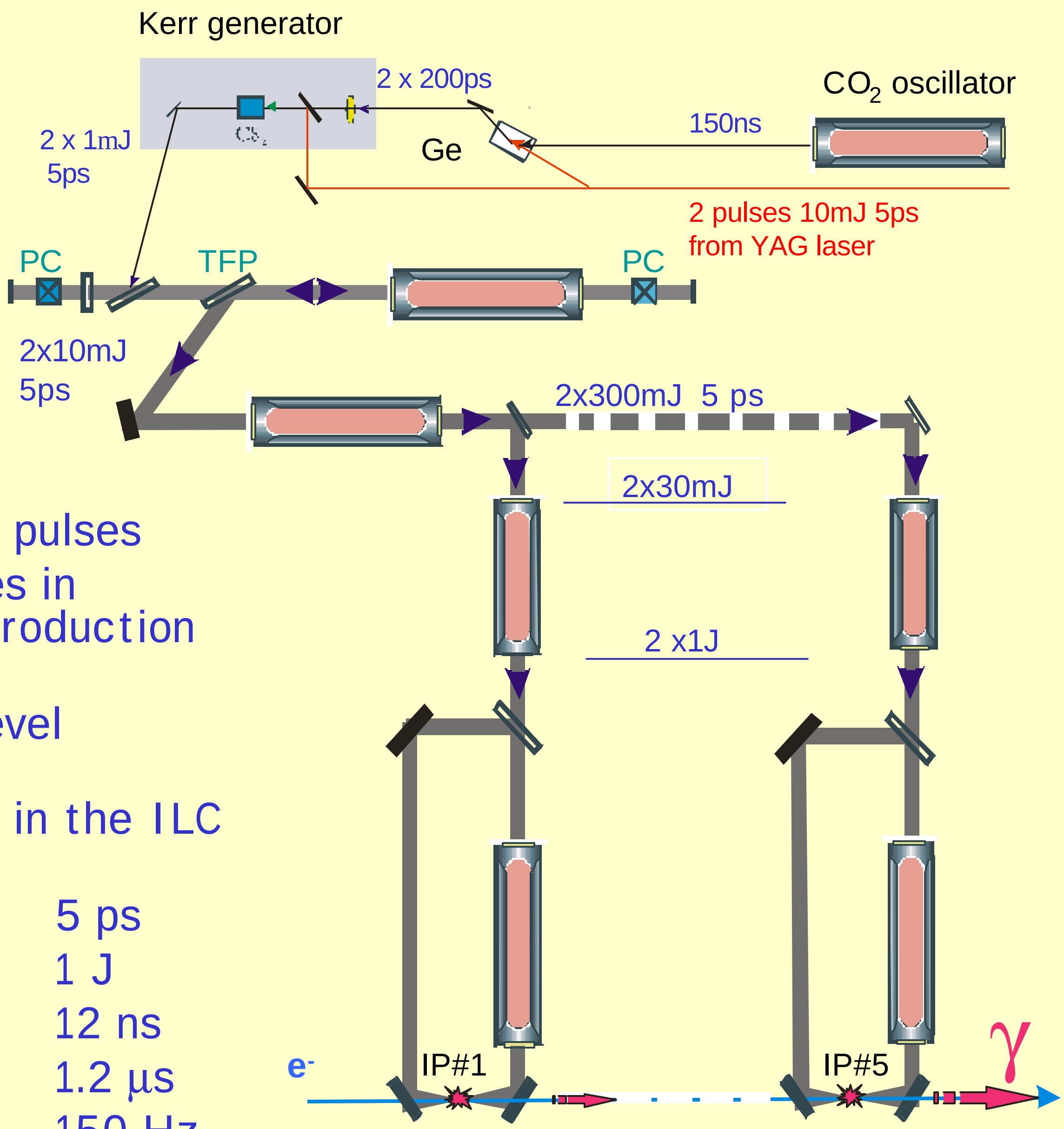


SCIENTIFIC DEVELOPMENT & INTEGRATION (PTY) LTD

Repetition Rate	20 -500 Hz
Pulse Energy	1.5 J
Beam Size	13 x 13 mm^2
Average Power	750 W



CO_2 Laser system for PPS



- production of dual 5-ps seed pulses
- amplification of double pulses in regenerative amplifier and production of a uniform-energy output.
- power amplification to the level 1J/pulse
- intra-cavity pulse circulation in the ILC format:
  - pulse length 5 ps
  - energy per pulse 1 J
  - period inside pulse train 12 ns
  - total train duration 1.2 µs
  - train repetition rate 150 Hz

Conclusions

- CO_2-Laser/e-beam interaction conditions are optimized and a record-high x-ray yield has been achieved.
- Production of one x-ray photon per every electron was demonstrated. Nonlinear scattering is observed.
- Optical slicing of 5 ps CO_2 pulses has been demonstrated and 5 J pulses are used in experiments.
- CO_2 oscillator and amplifier are commercially available lasers from SDI operational at rep. rate up to 500Hz.
- Advanced CO_2 lasers with optical pumping are under study.
- A CO_2 laser system for ILC polarized γ-source based on intra-cavity Compton backscattering is within a reach.