Japan/U.S. cooperation in the field of High Energy Physics

"Study of Compton Scattering of Picosecond Electron and CO_2 Laser Beams to Prototype the Polarized Positron Source for Japan Linear Collider"

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[b] *Waseda University, Japan*
[c] *Tokyo Metropolitan University, Japan*
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Brookhaven National Laboratory
Accelerator Test Facility
ATF

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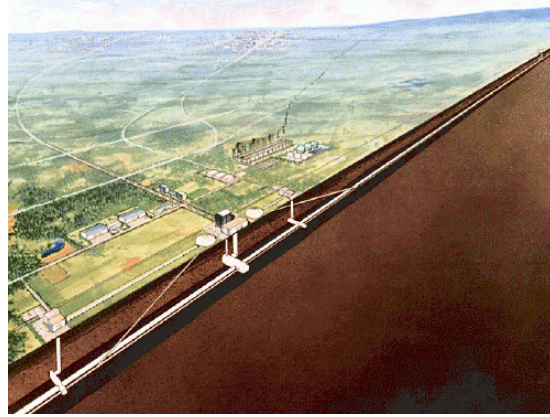
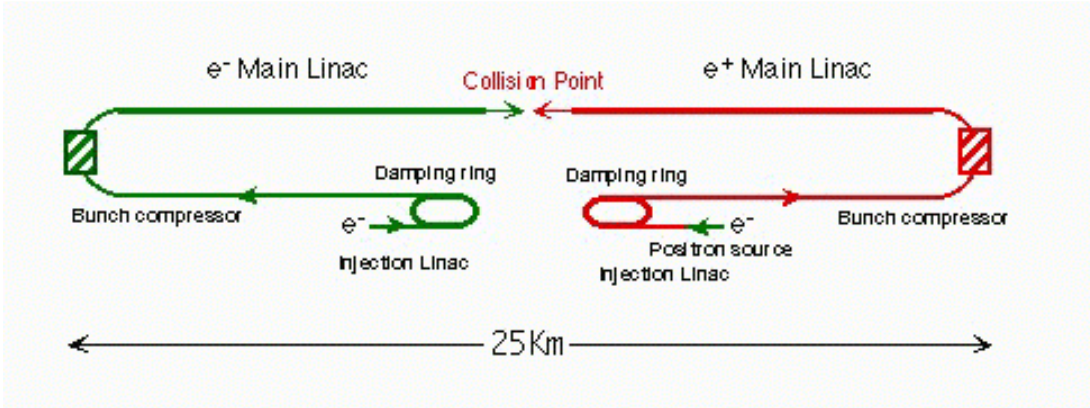
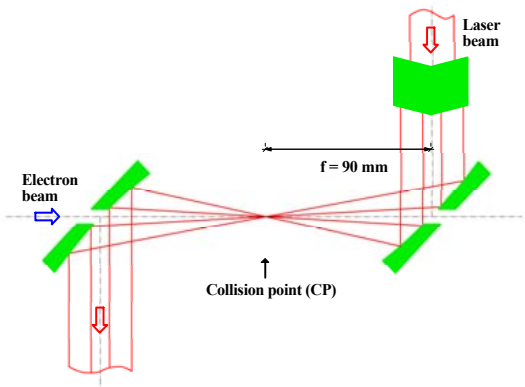
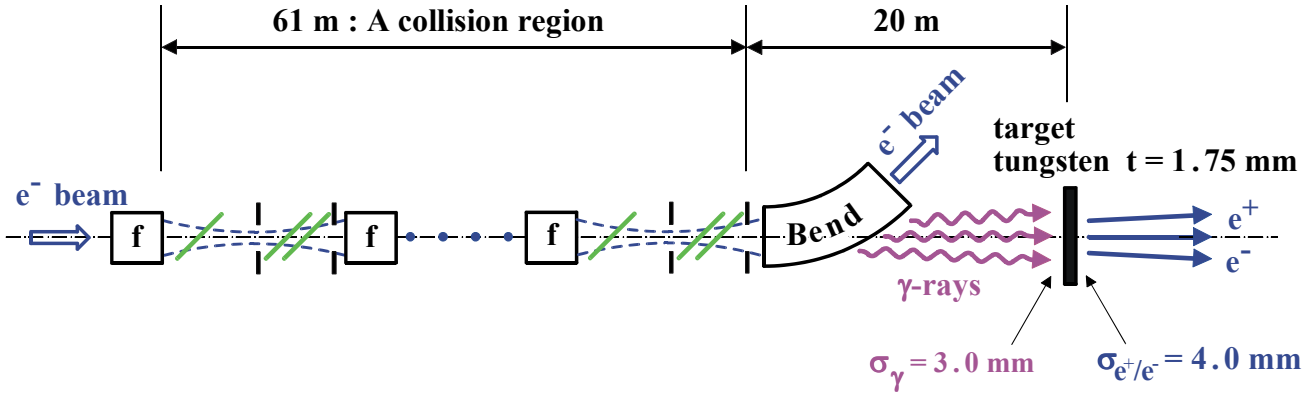
Proposed polarized positron source for Japan Linear Collider





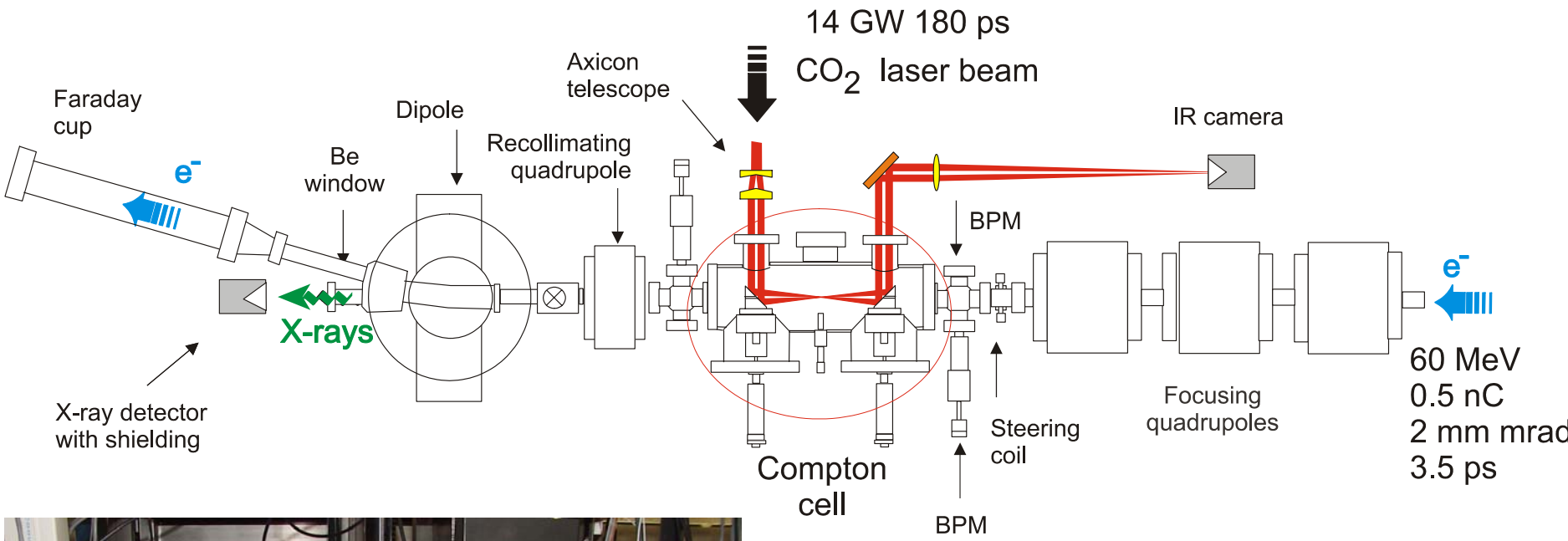


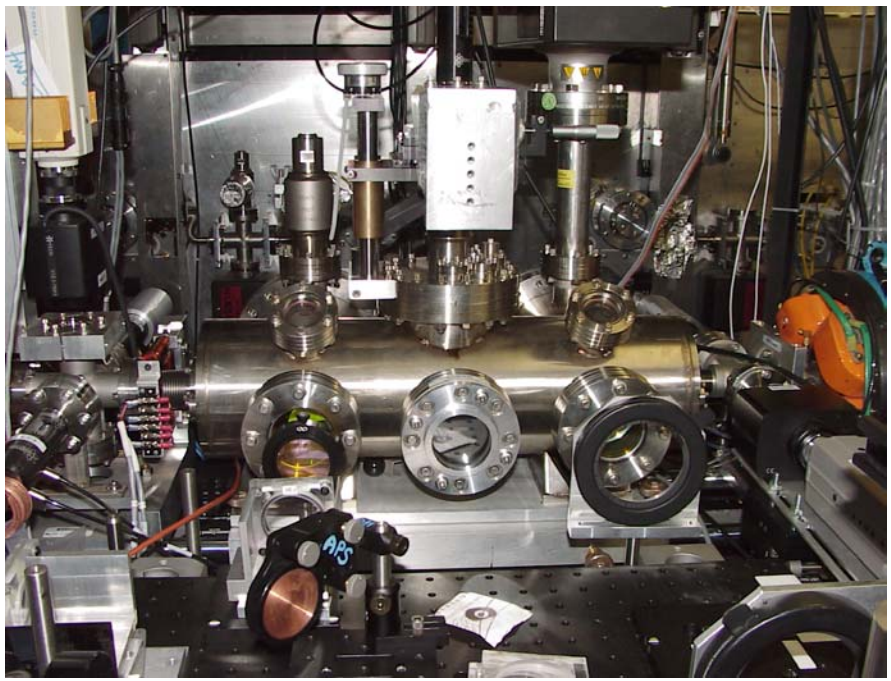


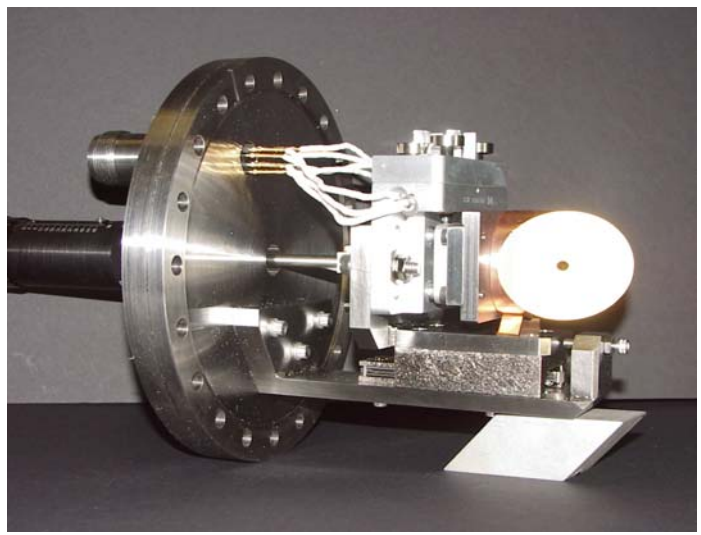
The total number of γ-rays generated in 200 collision points is 8.3×10^{11} photons/bunch.

W target of 1.75 mm thickness generates 6.9×10^{10} polarized positrons/bunch.

ATF Thomson Scattering Experiment AE22

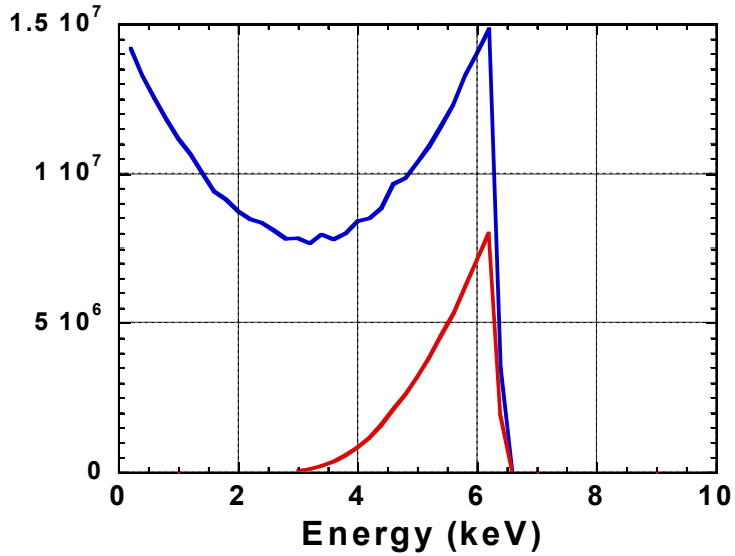


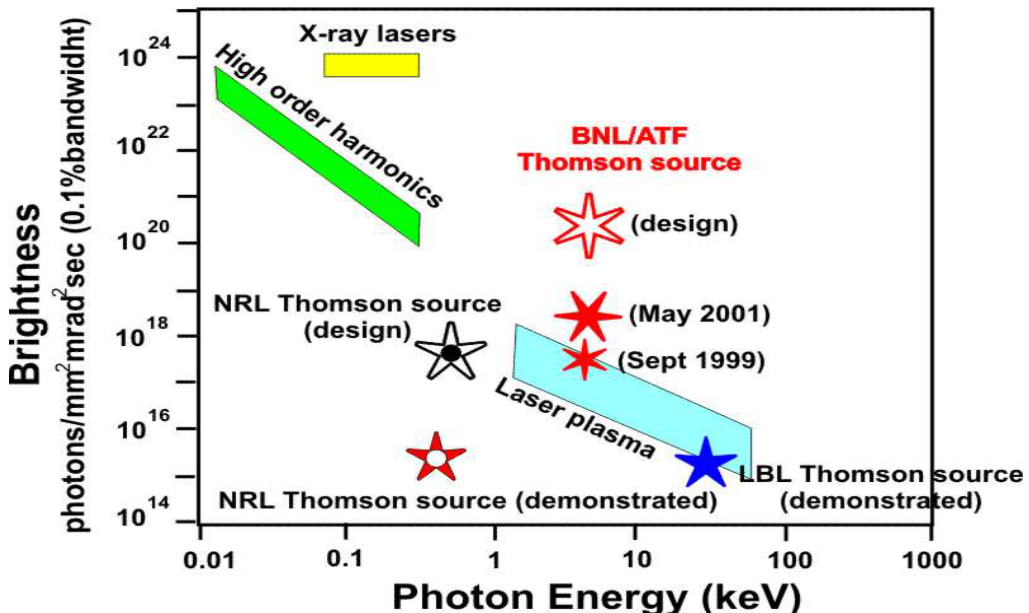




Results from Thomson Scattering Experiment

- Signal on detector is equivalent to 2.5x10^7 photons/pulse.
- Low energy x-rays are blocked by Be window and air.
  15% of total generated photons reach the detector.
- 1.7x10^8 photons/pulse produced at the interaction point.
- Since pulse duration of the x-ray signal is equal to the electron bunch length (3.5 ps), estimated peak x-ray intensity is 5x10^{19} photons/second.





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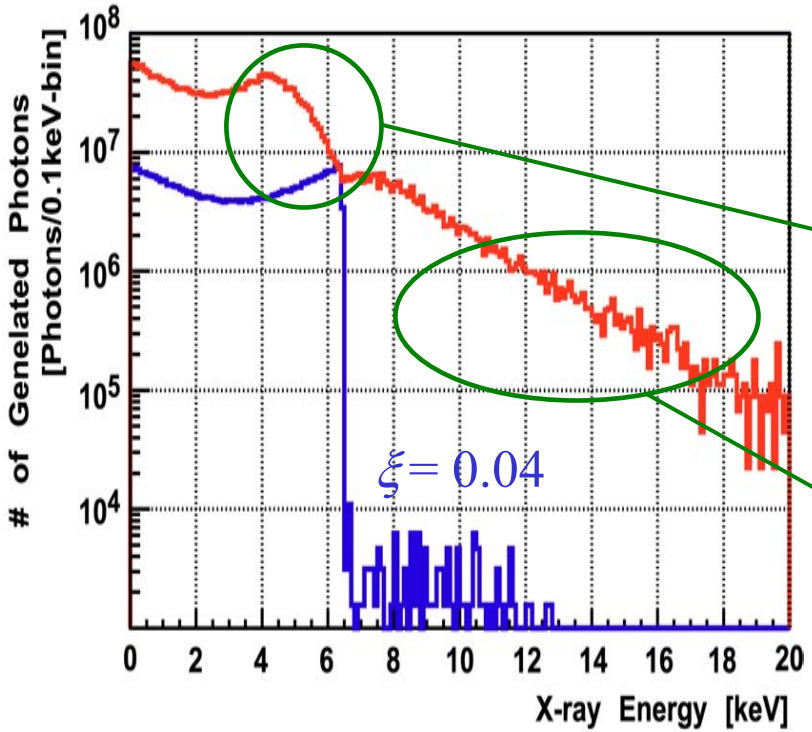
Nonlinear Thomson Scattering

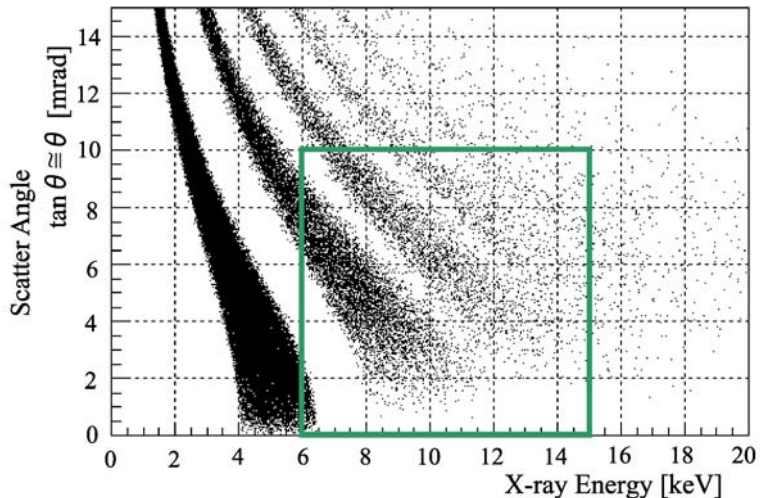
- Ongoing upgrade of the ATF CO_2 laser to the 1 TW level allows detailed study of study of relativistic electron mass shift.



due to relativistic electron mass shift in the laser field

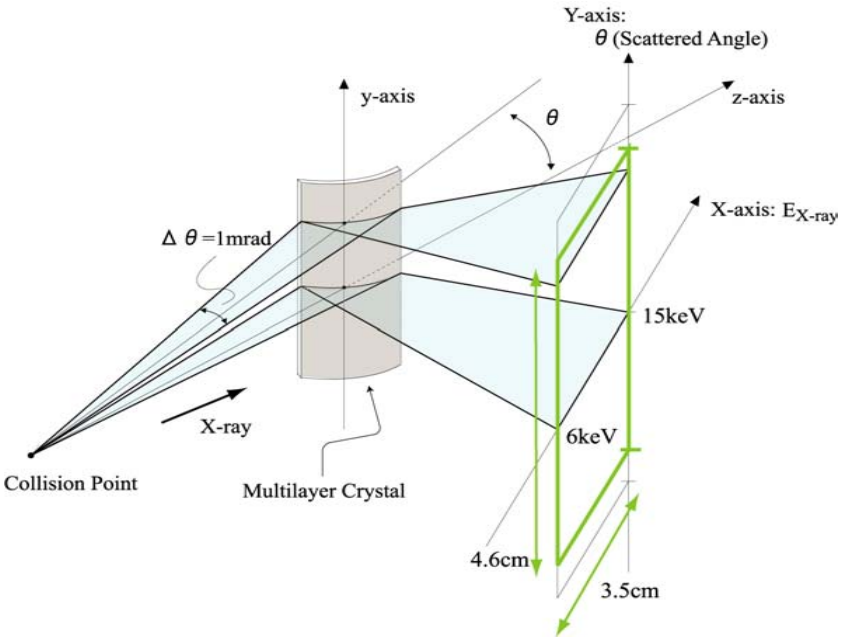
$$\lambda_x = \frac{\lambda\left(1 + a^2/2\right)}{4\gamma^2}$$

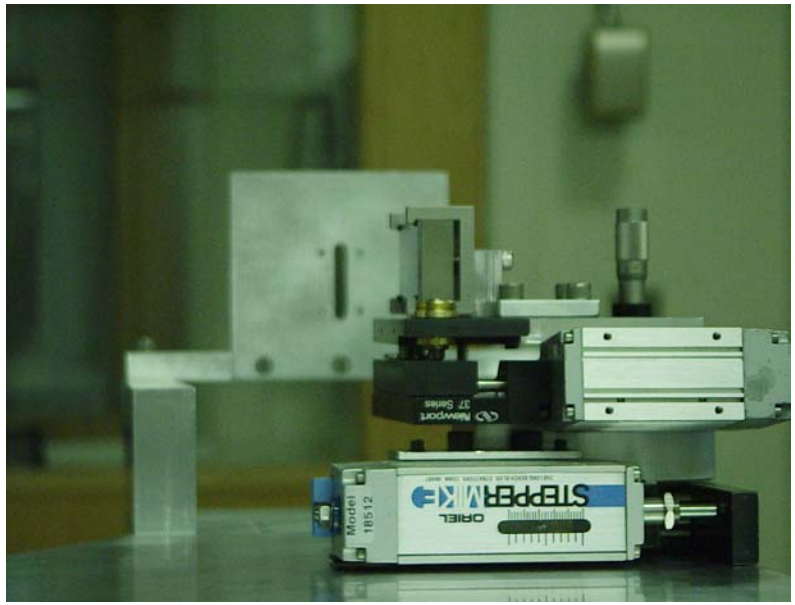
due to harmonics



X-ray Spectrometer

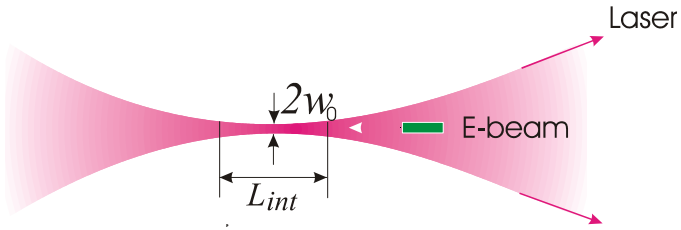
- Single-shot x-ray spectrometer will allow study spectral and angular distributions.





From Free Space …

$$N_x = \frac{E_L Q_b \lambda}{w_0^2}$$

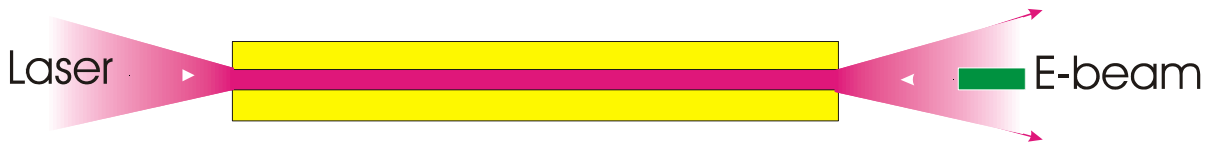


Laser pulse duration shall match the interaction length that is defined by Rayleigh distance in free space.

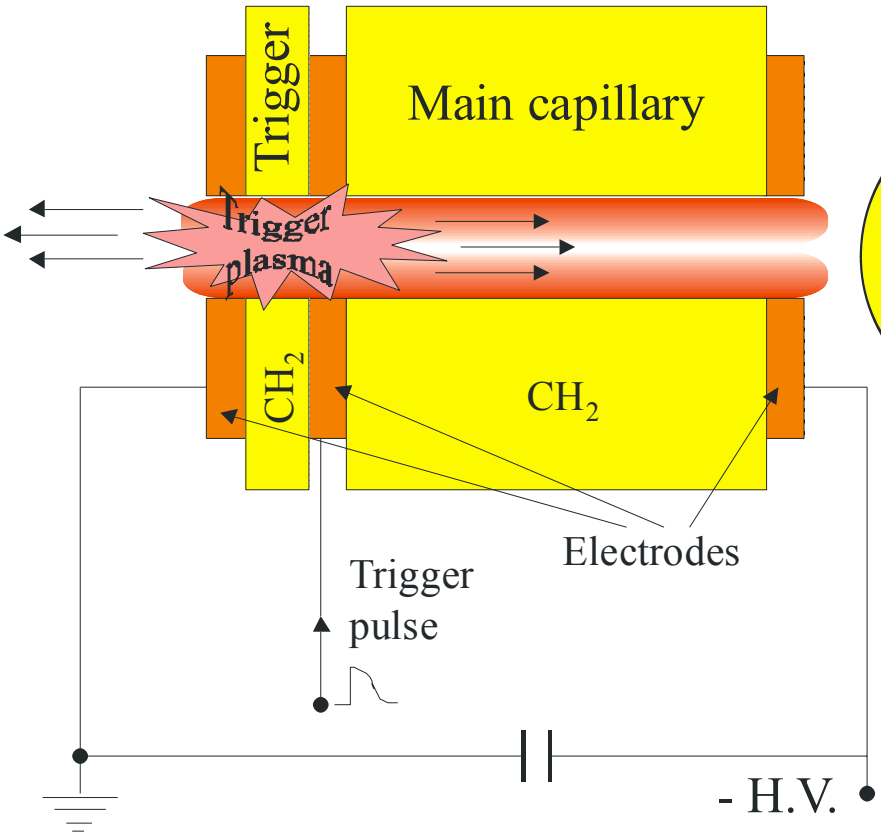
$$L_{\text{int}} = \frac{\pi^2 w_0^2}{\lambda} = \frac{\tau_l c}{2}$$

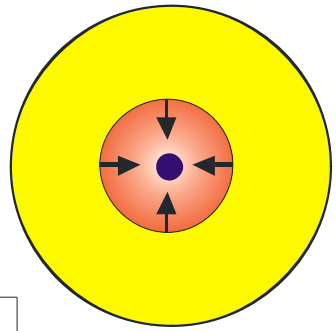
….to Plasma Channel

We brake the laser pulse duration constraint by extending the interaction length in a plasma channel.

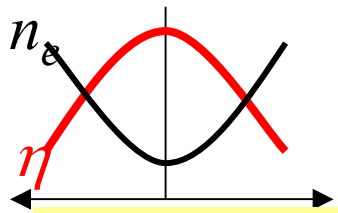


Plasma channel formation in the capillary discharge

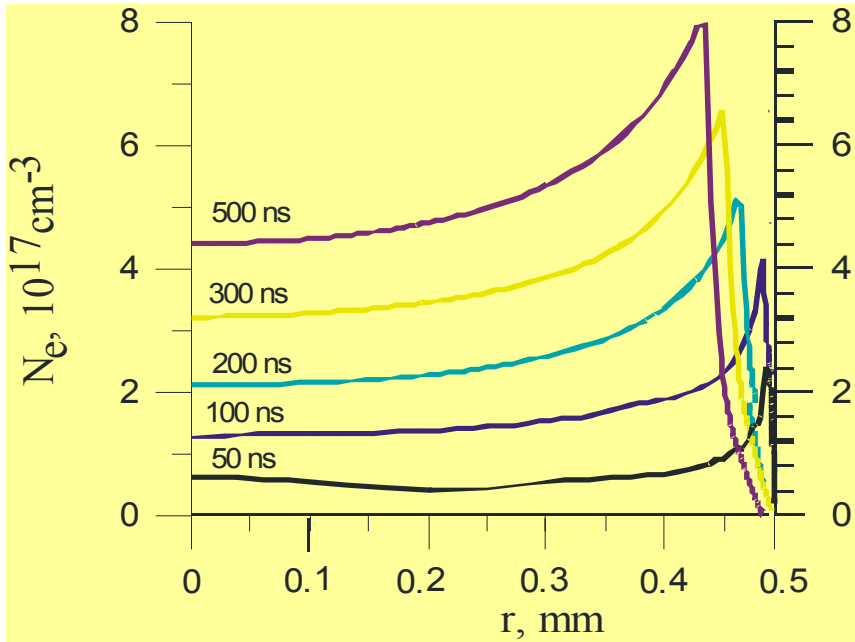




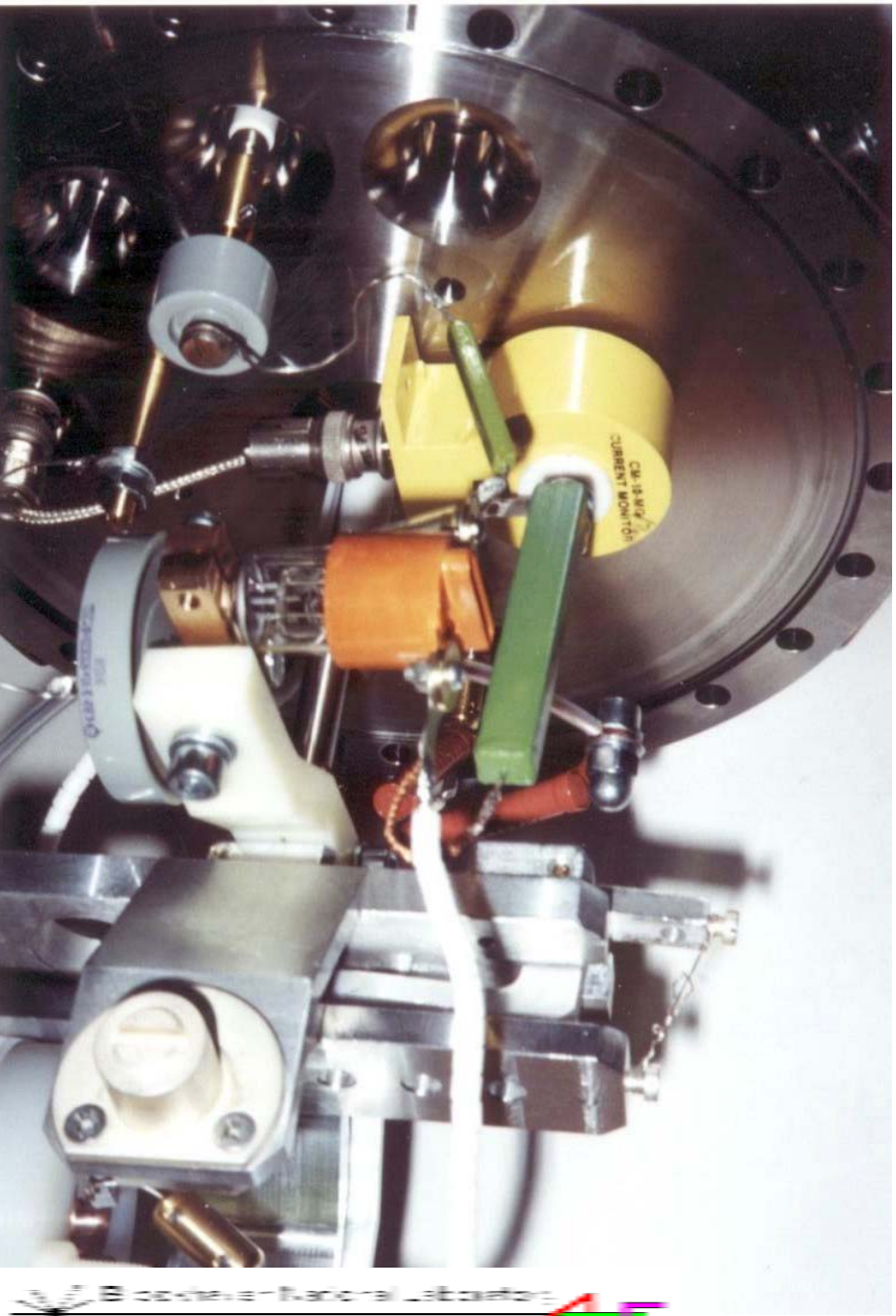
$$\eta = \sqrt{1 - \frac{n_e}{n_{crit}}}$$

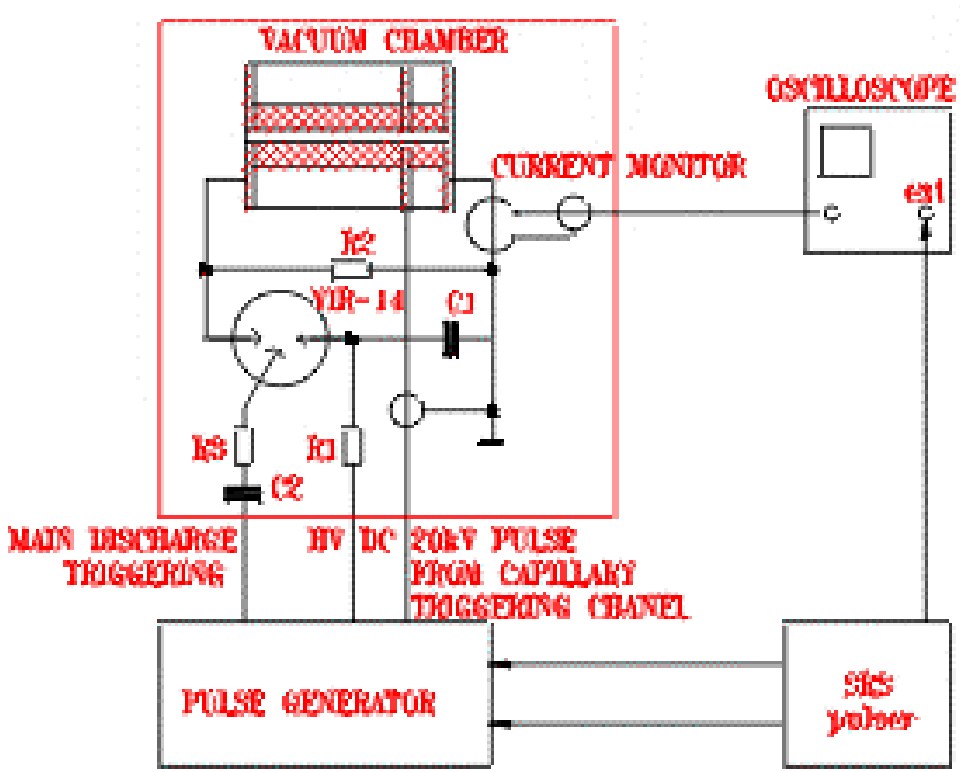


optical guide

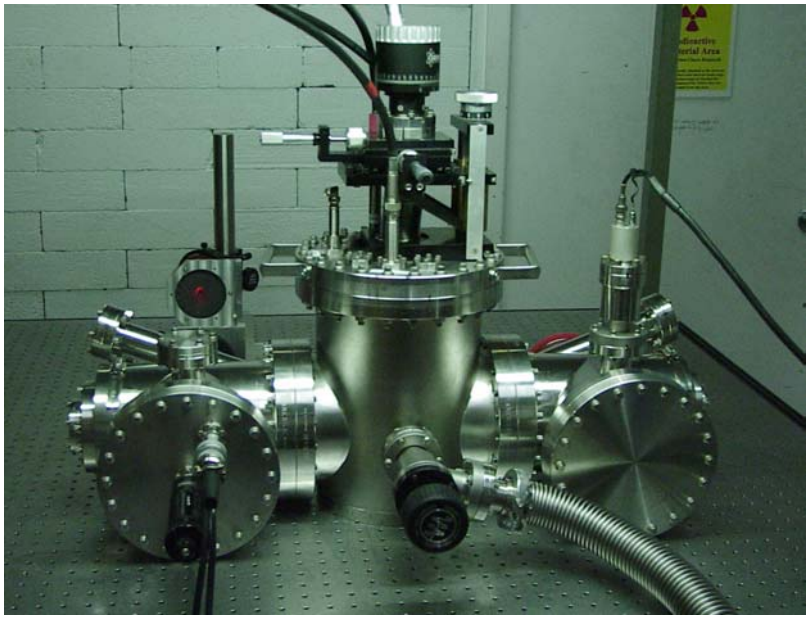


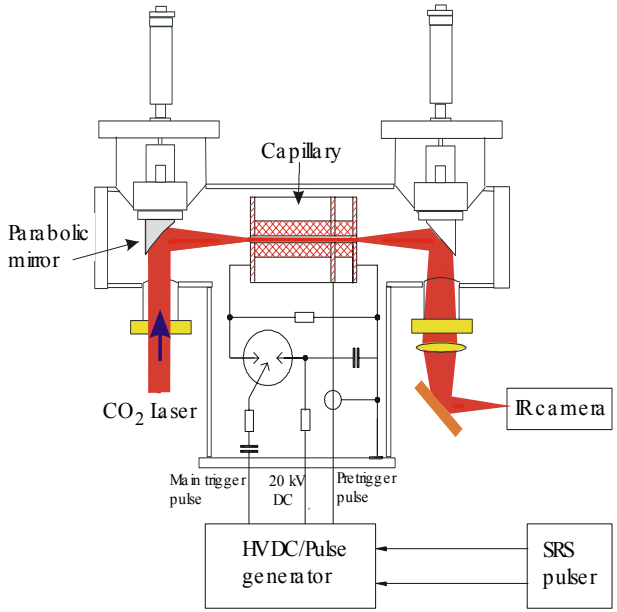
Capillary discharge setup

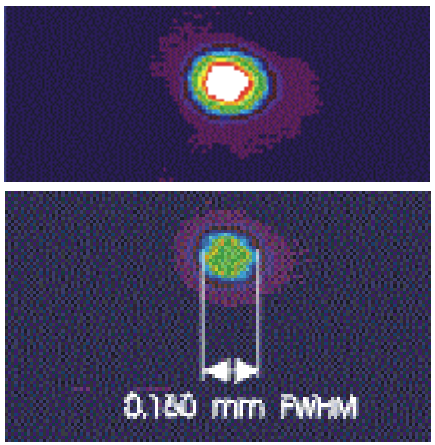




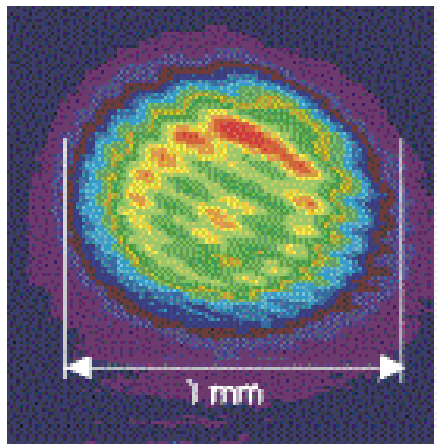
Channeling of CO_2 laser in capillary discharge



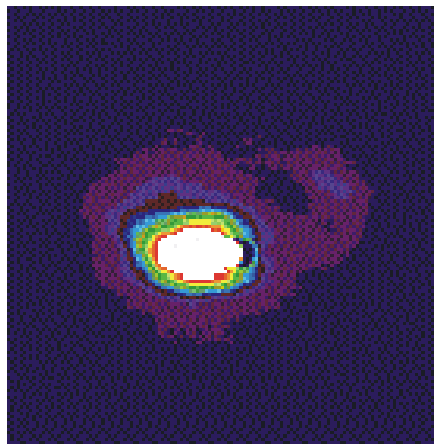




laser beam at the focal point



laser beam 18 mm downstream from the focus in the free space



laser beam at the exit of the 18 mm plasma discharge with the capillary entrance placed at the focal point