LEPS2 Workshop @RCNP, 8 Jan 2007

# High Intensity Beamline and Related Physics at LEPS2

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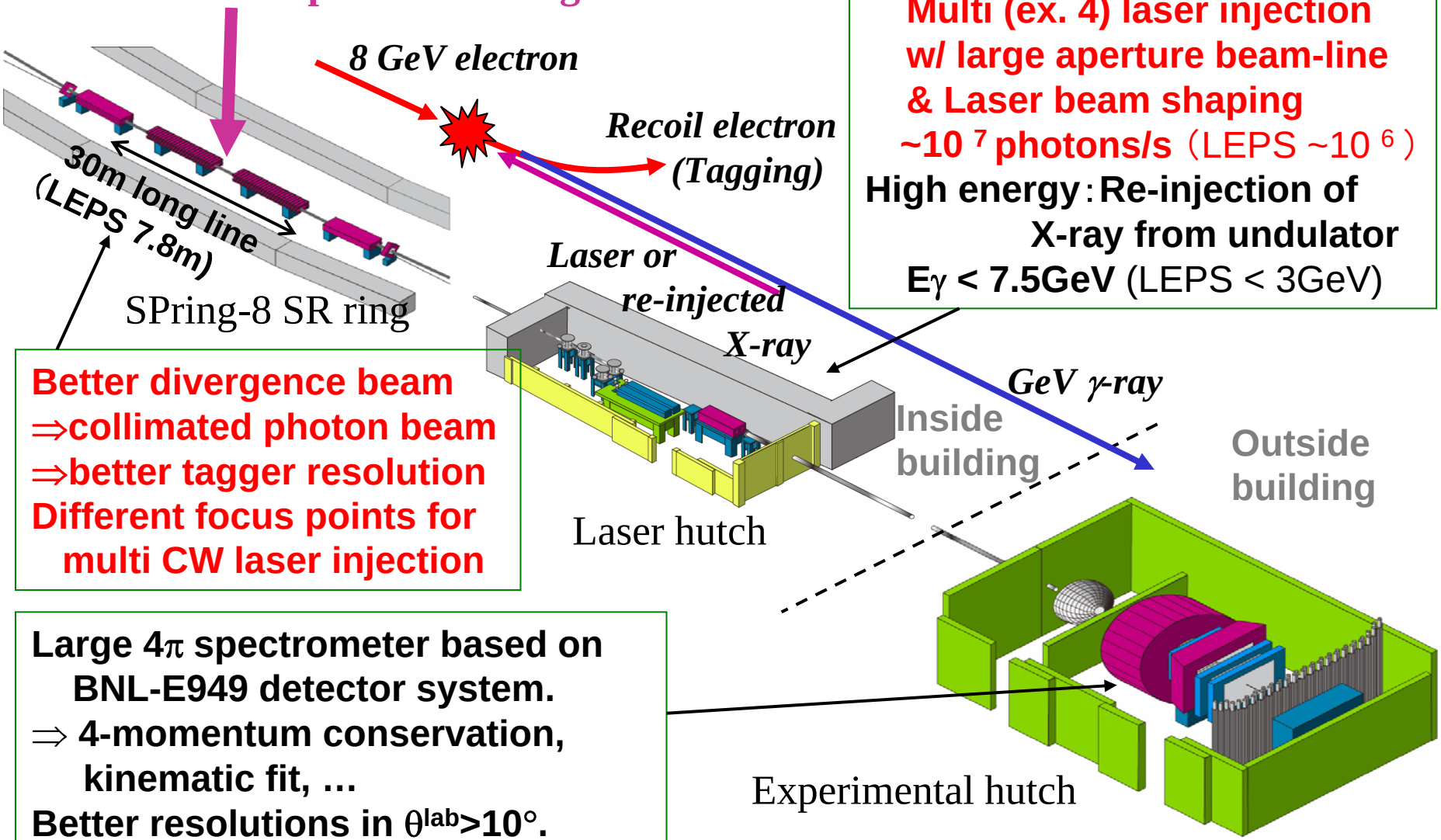
Thanks to Date-san (beamline emittance)
Yorita-san (beamline structure)
Aruga-san (laser beam shaping)

# New Beamline Project at SPring-8

**Backward Compton Scattering**

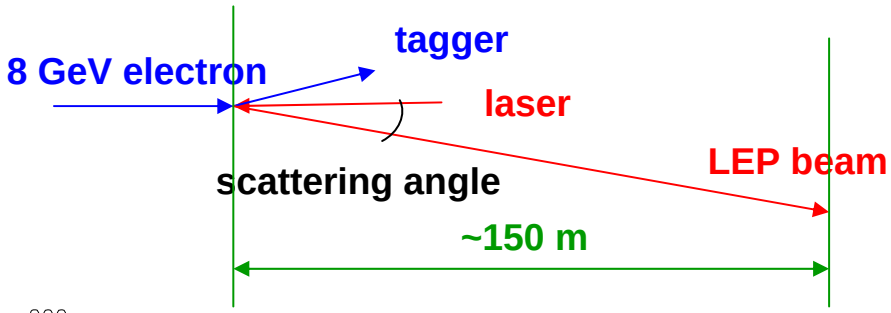


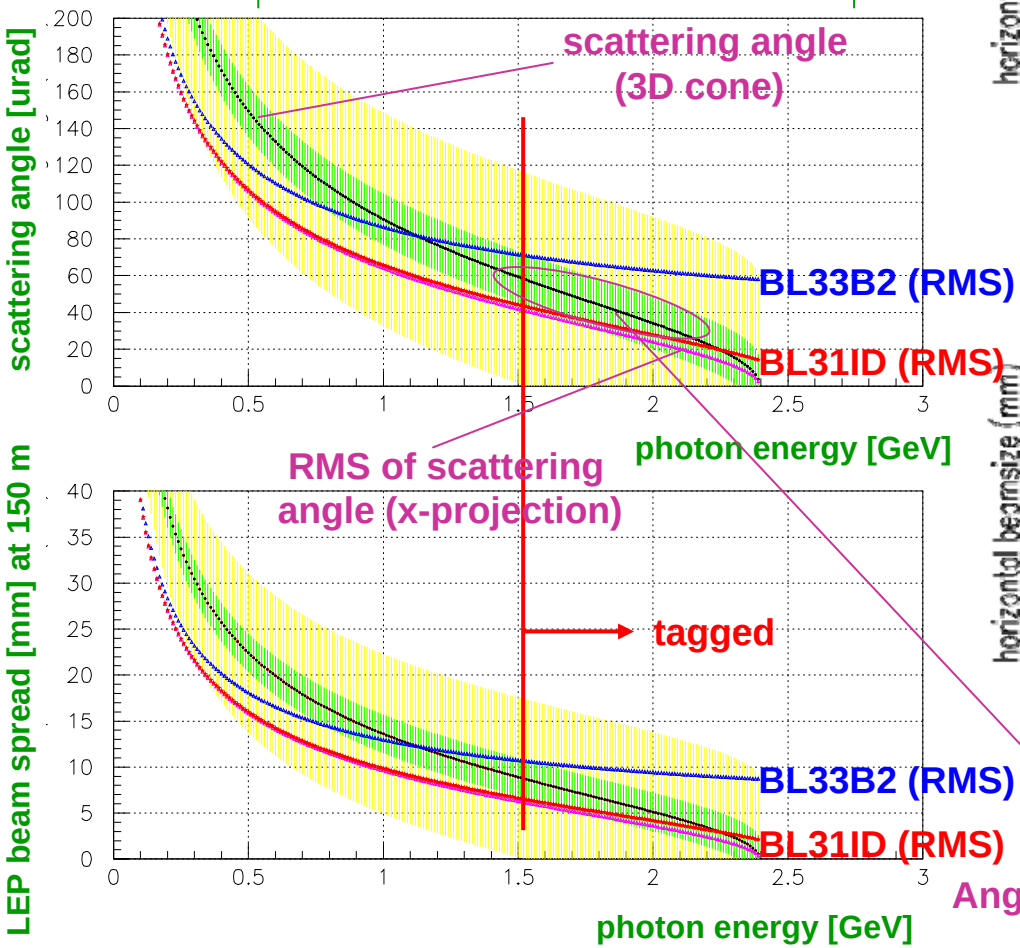

**High intensity:**
**Multi (ex. 4) laser injection w/ large aperture beam-line & Laser beam shaping**
**~$10^7$ photons/s** (LEPS ~$10^6$)
**High energy: Re-injection of X-ray from undulator**
**Eγ < 7.5GeV** (LEPS < 3GeV)

**Better divergence beam**
**⇒collimated photon beam**
**⇒better tagger resolution**
**Different focus points for multi CW laser injection**

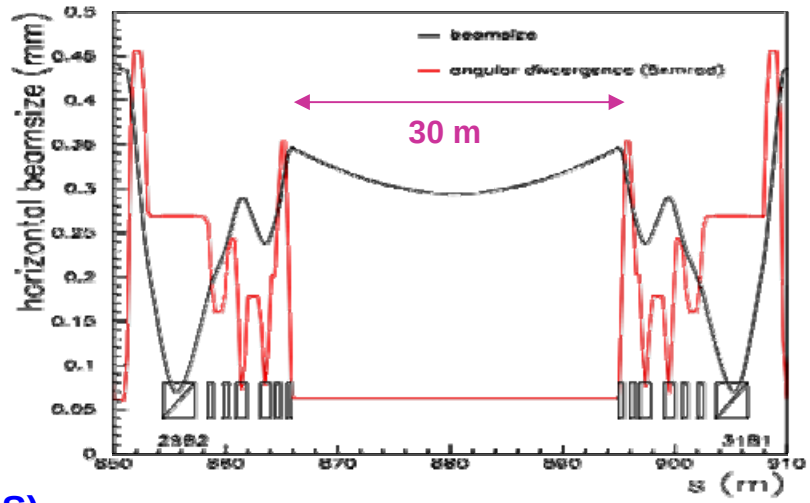
**Large 4π spectrometer based on BNL-E949 detector system.**
**⇒ 4-momentum conservation, kinematic fit, …**
**Better resolutions in $\theta^{lab}$>10°.**
**Simultaneous photon detection.**

# Divergence of LEP beam

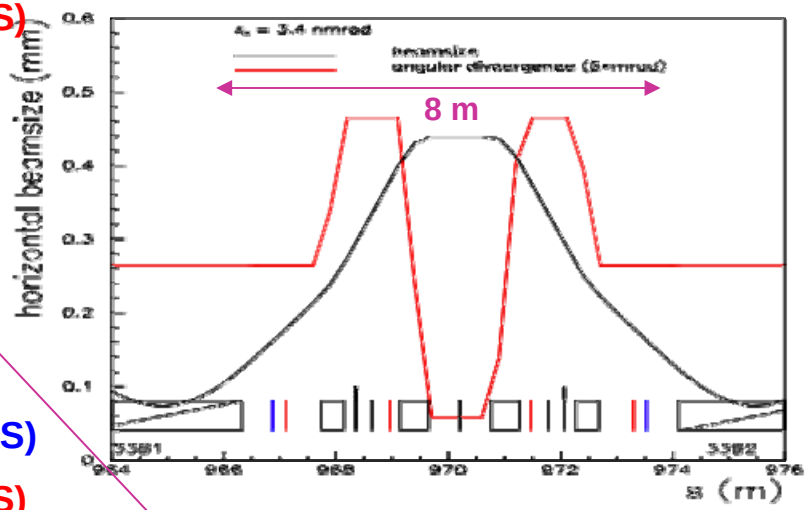



**BL31ID** $<\sigma_{x'}>=14\ \mu rad$



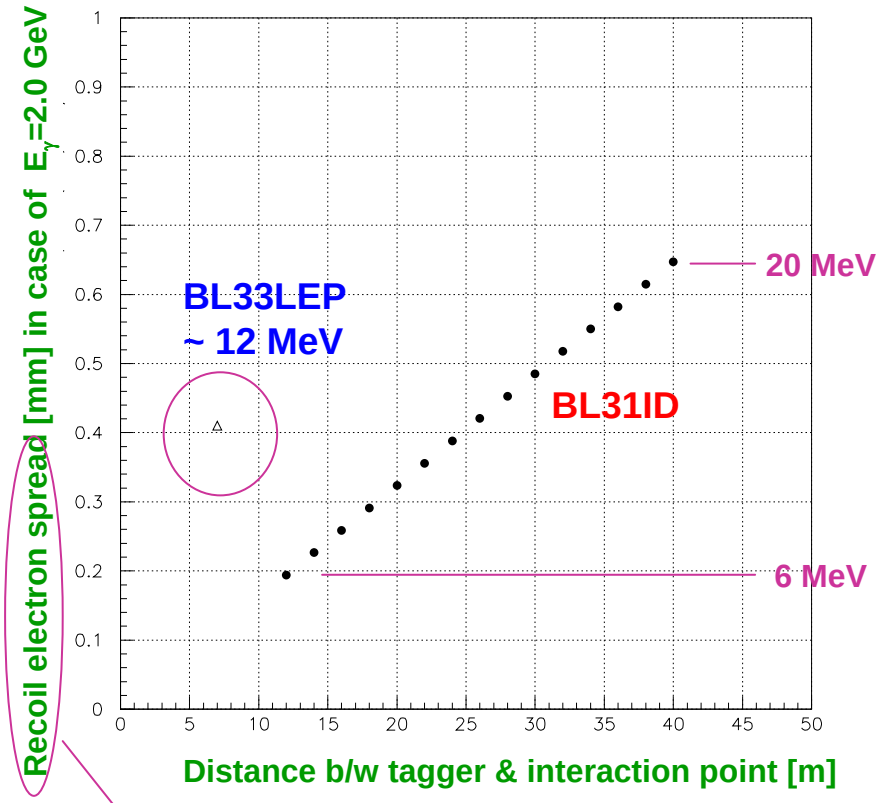

**BL33B2** $<\sigma_{x'}>=58\ \mu rad$




Angle measurement will also give photon energy.

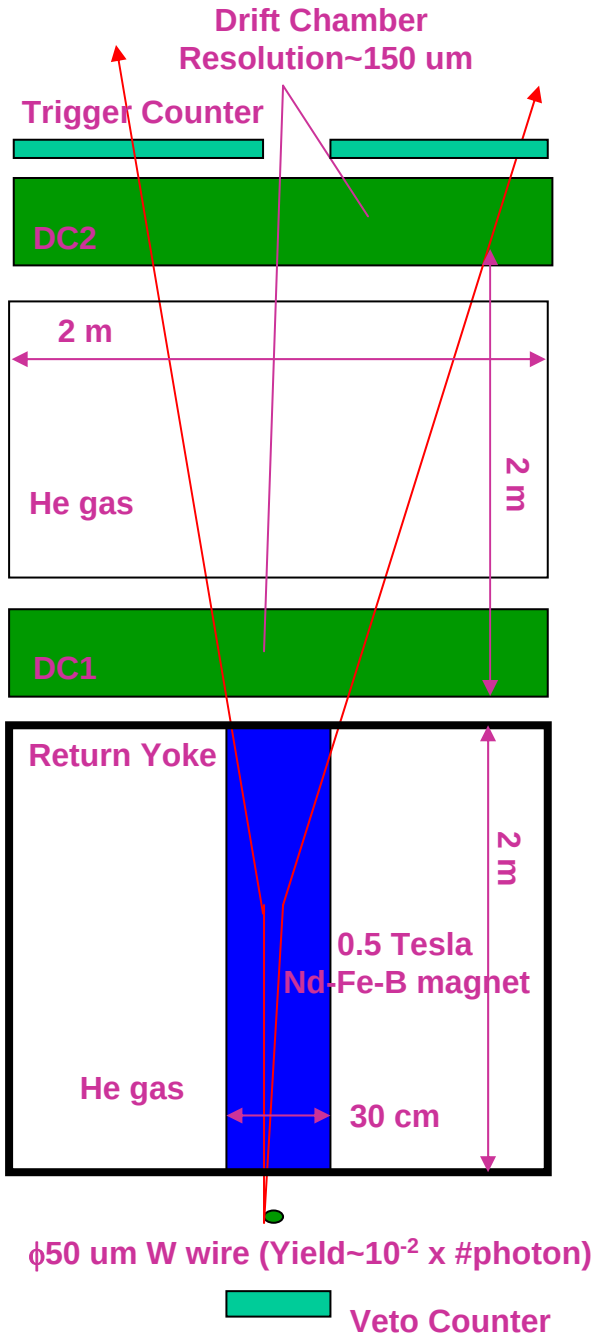
# Tagger Energy Resolution

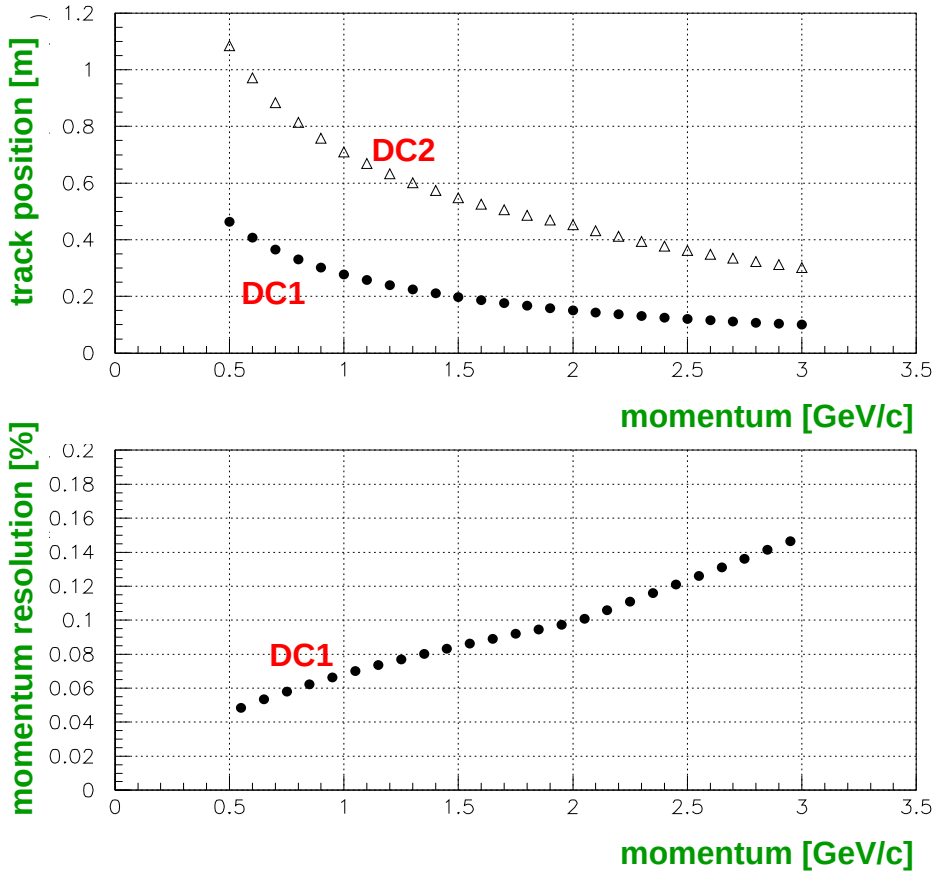
Bending magnet : 30 MeV/mm




- Better resolutions will be available in case of nearer interaction point.
- 100-150 um pitch structure is desired for tagger.
- Electron beam divergence is worse in case of IP<10 m at BL31 due to beamline optics.
  ⇒ Need focus adjustment.
  ⇒ and/or resolution monitor by pair spectrometer
  = momentum analyzer for pair-created $e^+e^-$ with sweep magnet.
  Resolution~$10^{-3}$
  Initial idea from Mecking.

# Pair Spectrometer




Emission angle of electron/positron

$<\theta> \sim m_e c^2/E_\gamma \sim 0.25$ mrad : 500 um / 2 m

$\Rightarrow$ Angle measurement (ex. 0.06 mrad)

Multiple scattering : $\Delta P/P = 0.14$ % w/ He.

Sweep magnet : P=7 GeV $\Rightarrow$ 4.3 cm / 2 m

# Expected Intensity

- 2.4-GeV LEP with Ar laser [351 nm, 6.5 W, CW] : ~800 Kcps

  $\Rightarrow$ Paladin (Solid state & 80 MHz pulsed laser) [355 nm, 8 W]

  - 4-laser injection w/ larger aperture beamline x4
  - Paladin 16 W model may be available in future. (x2)
  - Twice energy density by laser beam shaping in vertical direction x2

  $\Rightarrow$ In total 8-16 times more intensity relative to Ar laser

  (Note: 2 Mcps has been achieved by 2-laser injection at BL33LEP.)

- 3.0-GeV LEP with Deep-UV laser [257 nm, 1-1.5 W, CW] : ~150 Kcps

  - 4-laser injection (4-different focus points) x4
  - laser beam shaping x2
  - vertically long beam shape because of SHG $\rightarrow$ horizontally long shape (like electron beam) by mirrors [additional factor]

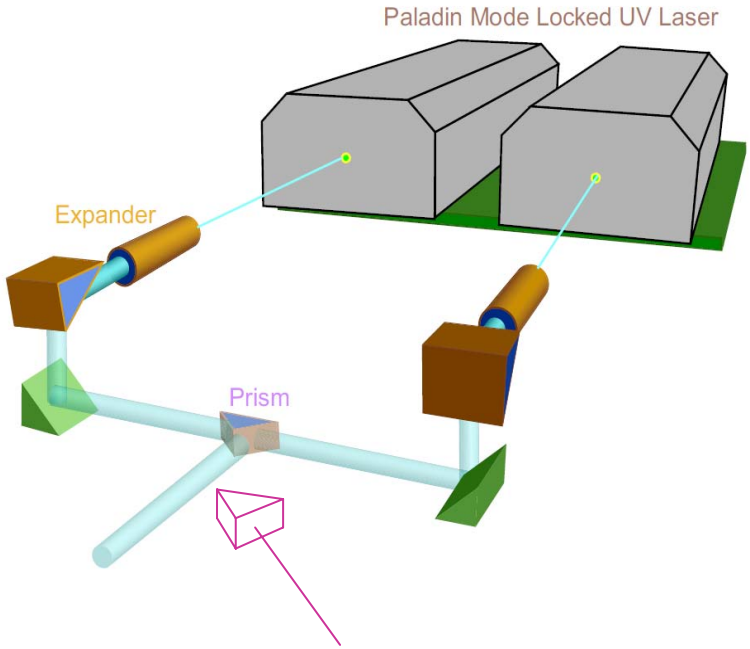
  $\Rightarrow$ In total 8+$\alpha$ times more intensity

# Multi-laser Injection

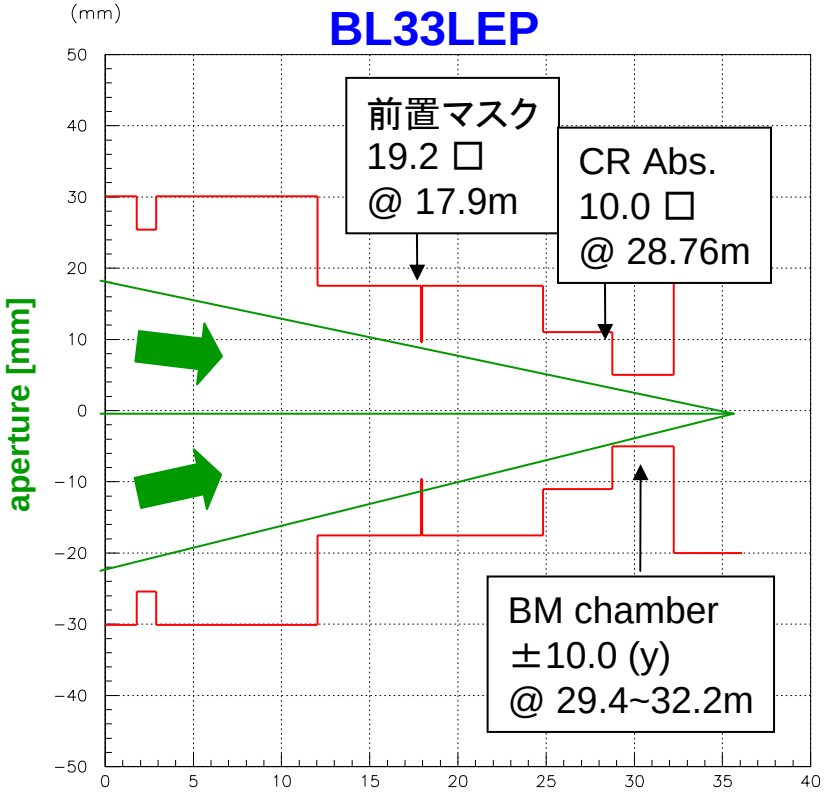
- 80 MHz pulsed laser : (1) quasi-CW (2) no interference
- 2-laser injection has been installed at BL33LEP. ⇒ ~2 Mcps
- Aperture of BL33LEP is narrow. [Only 20 mm / laser is allowed.]

  $1/e^2$ diameter = 1 mm & x28.5 expander : 1.4 σ region

  ⇒ Larger aperture will give more efficient transmission and allow additional laser injections.

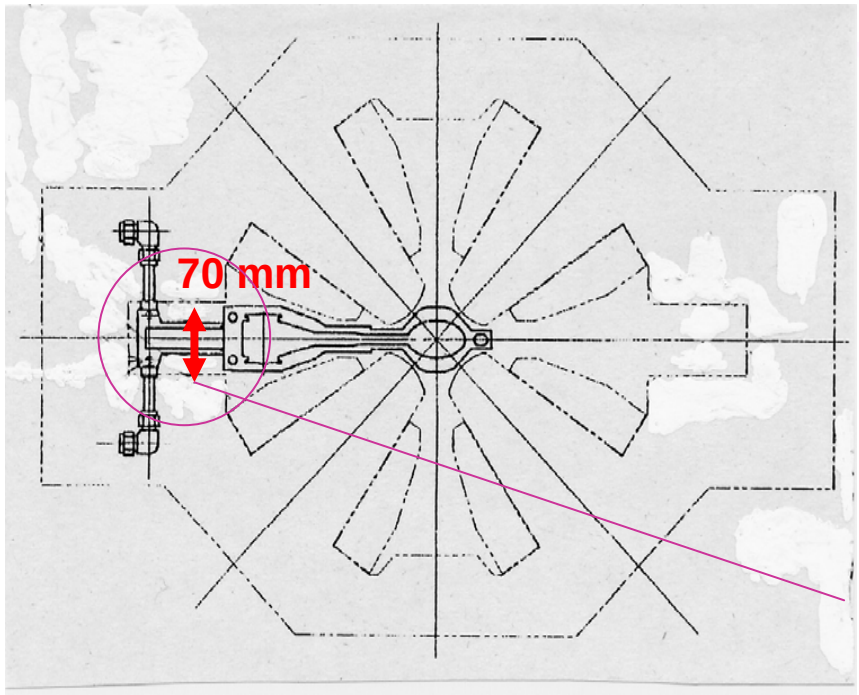



additional prism for 4-laser injection

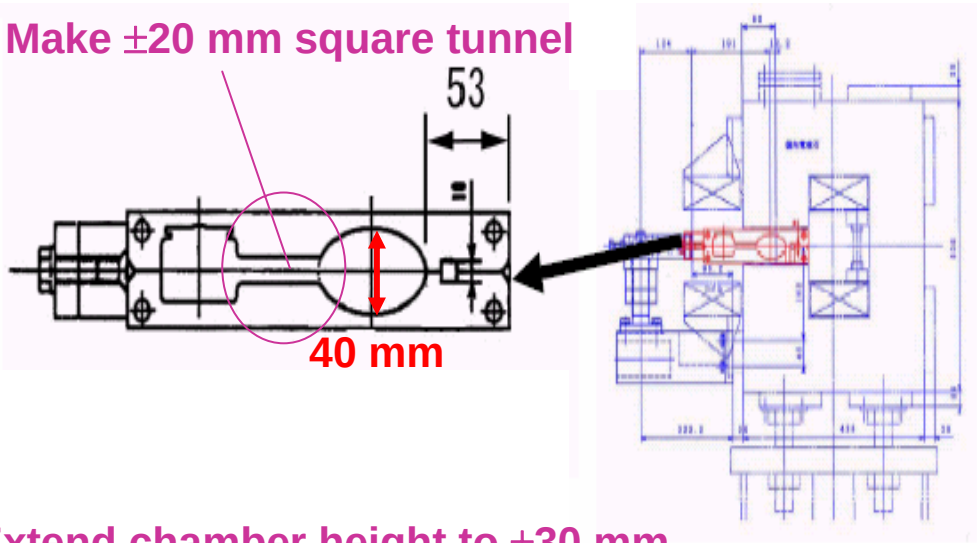


# Modification of Beamline

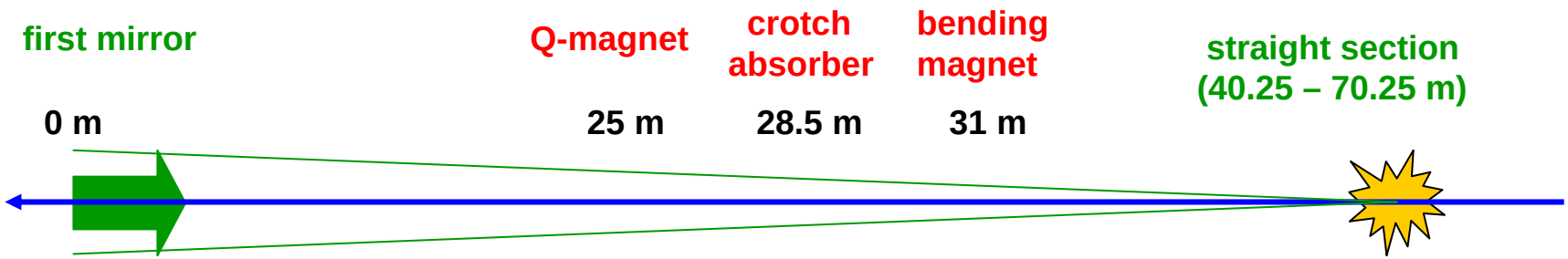
**Q-magnet**




**bending magnet**




**Extend chamber height to ±30 mm.**
**Need to take care of cooling water pipe.**




| H ±80 mm (for beam shaping) | H ±11 mm | H +6 mm | H ±5 mm |
|---|---|---|---|
| At least ±40 mm (beam core) | ⇒ ±30 mm | ⇒ +30 mm | ⇒ ±20 mm (bottle neck) |

**Paladin should focus at nearer position.**

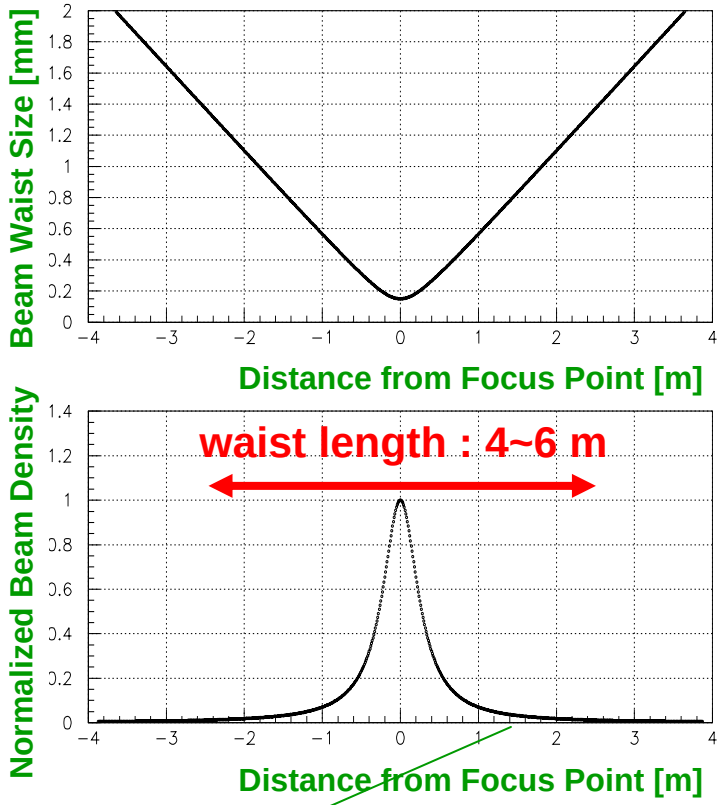
# 30 m-long straight section

Multi-injection of CW laser

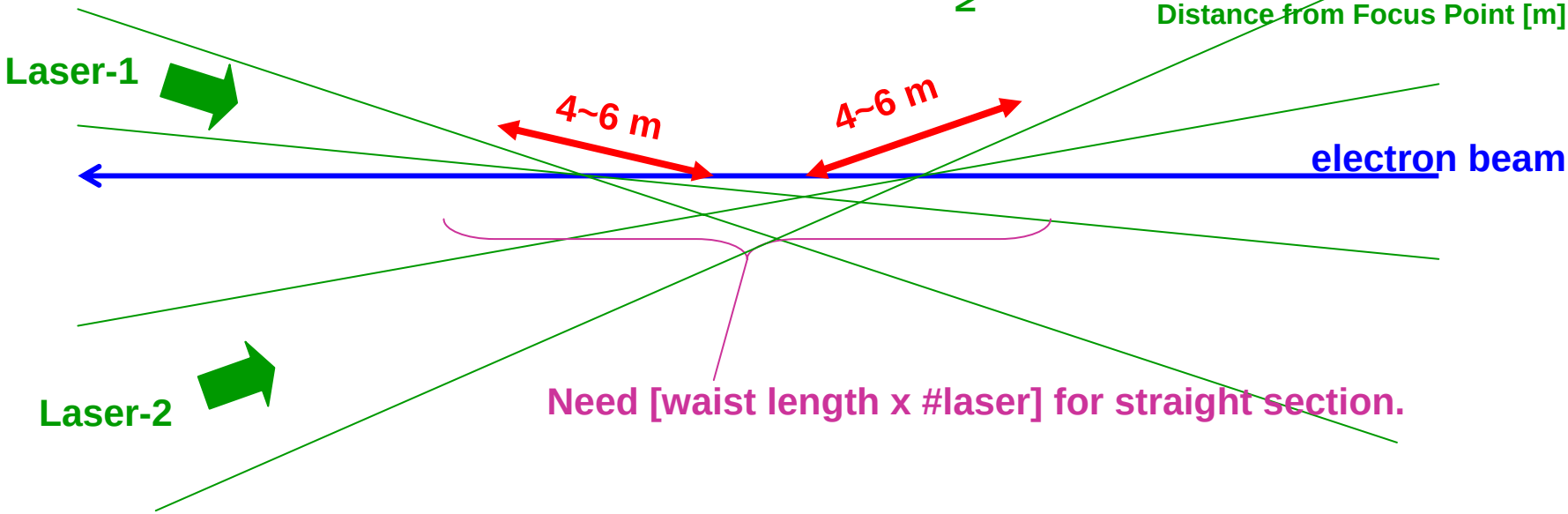
⇒Interference is problematic.

⇓

Need to differ focus points.

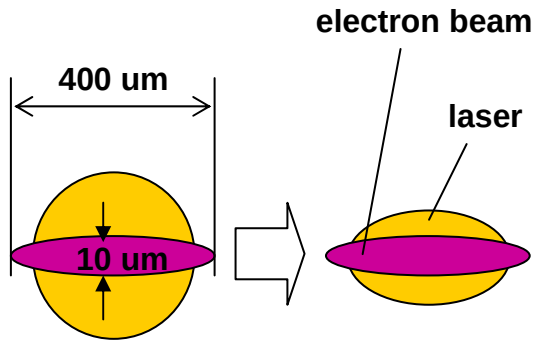


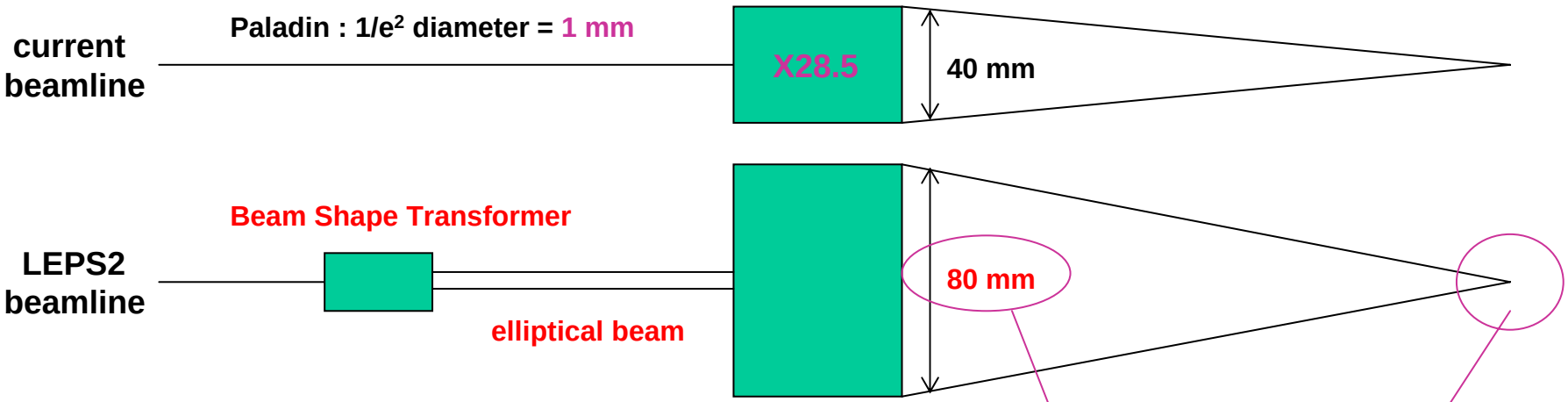

**Deep UV laser (257 nm)**
**$1/e^2$ diameter: 1.4 mm**
**Focused at 36 m by using X28.5 expander**



# Laser Beam shaping

- Electron beam is horizontally wide.
  ⇒ BCS efficiency will be increased by elliptical laser beam.




| | Beam Shape Transformer x : y | Expander magnification |
|---|---|---|
| Option (1) | 1 mm : 2 mm | x28.5 |
| Option (2) | 0.5 mm : 1 mm | x 57 |

Need twice diameter in vertical direction.

Beam spot at focus point:
Horizontal size = electron beam
Vertical size = 1/2 x horizontal size.
⇒ Energy density becomes twice.

- Both methods are technically available, but option (1) will be easier. (ITOCHU Aero-Tech)

# $\Theta^+$ Photoproduction with vector $K^*$ meson

**Nam, Hosaka, and Kim, Phys. Rev. C74, 025204 (2006)**

$\gamma N \rightarrow \bar{K}\Theta^+$ : contact term w/o K* exchange

neutron traget > proton target (CLAS-p)

$\gamma N \rightarrow K\Lambda^*$ : neutron < proton

$\gamma N \rightarrow \bar{K}^*\Theta^+$ ($E_\gamma$ > 2.66 GeV)

- small isospin asymmetry
- spin 3/2 & parity –

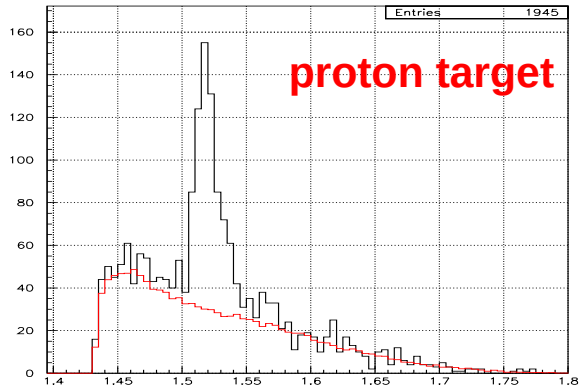
  $\Rightarrow$ 10 times larger cross section
- spin 1/2 & parity +

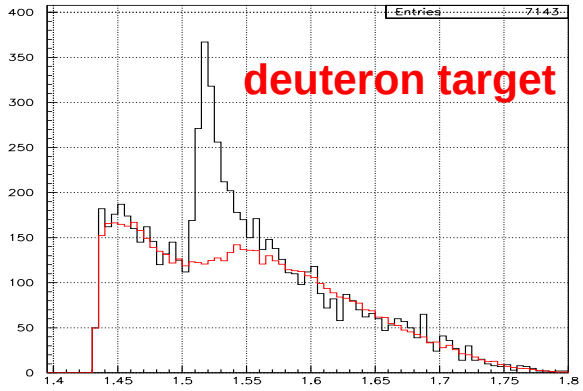
  $\Rightarrow$ beam asymmetry

  proton : reaction plane $\perp$ pol. vector

  neutron:reaction plane // pol. vector

**$\theta^{CM}$(K-p) < 60°**



# Summary

- Better divergence electron beam results in

  collimated photon beam : $\sigma$~5 mm at 150 m

  better tagger resolution : 6-20 MeV depending on focus point.

- Intensity upgrade by 4-laser injection + laser beam shaping

  1.5-2.4 GeV photon : 8-16 Mcps w/ 355 nm pulsed laser

  Nearer focus point for better $E_\gamma$ resolution

  1.5-3.0 GeV photon : $\geq$1.2 Mcps w/ 257 nm CW laser

  Different focus points in 30-m straight section

- High intensity photon beam up to 3.0 GeV

  - Photoproductions of $\Theta^+$ and $\Lambda(1405)$ accompanied by K*

  - Polarized target experiment (relaxation time)

  - Precise measurements of differential cross sections & spin observables for expanded energy regions with large acceptance detector

Today we have a party from 18:15 at 4th floor.
Please join and enjoy the party.

staff 2,000 yen
(Donation is welcome!)
student 1,000 yen
To Sawada-kun.

Thanks.