

Production of a coherent bremsstrahlung photon beam with several tens of GeV at ILC

Norihito Muramatsu

ELPH, Tohoku University

LCWS @Sendai, 29 Oct 2019

Contents

*Proposing the production of **70~80 GeV photon beam with linear polarization**, as **a diversified use of ILC**.*

- ***Motivation & Introduction***
- ***Feasibility & Beam properties at ILC***
- ***Considerations for experimental design***
- ***Physics prospect & Summary***

Motivation

Development of an **unprecedented** photon beam for **hadron photoproduction** using a fixed target.

- Unique feature of a photon beam
 - ❑ It can couple with a **$q\bar{q}$** component in a hadron.
 - ❑ Easily **polarized**. \Rightarrow Usable for spin-related studies.
- ILC energy can produce **heavy hadrons** including charm & bottom quarks.



Past experiments

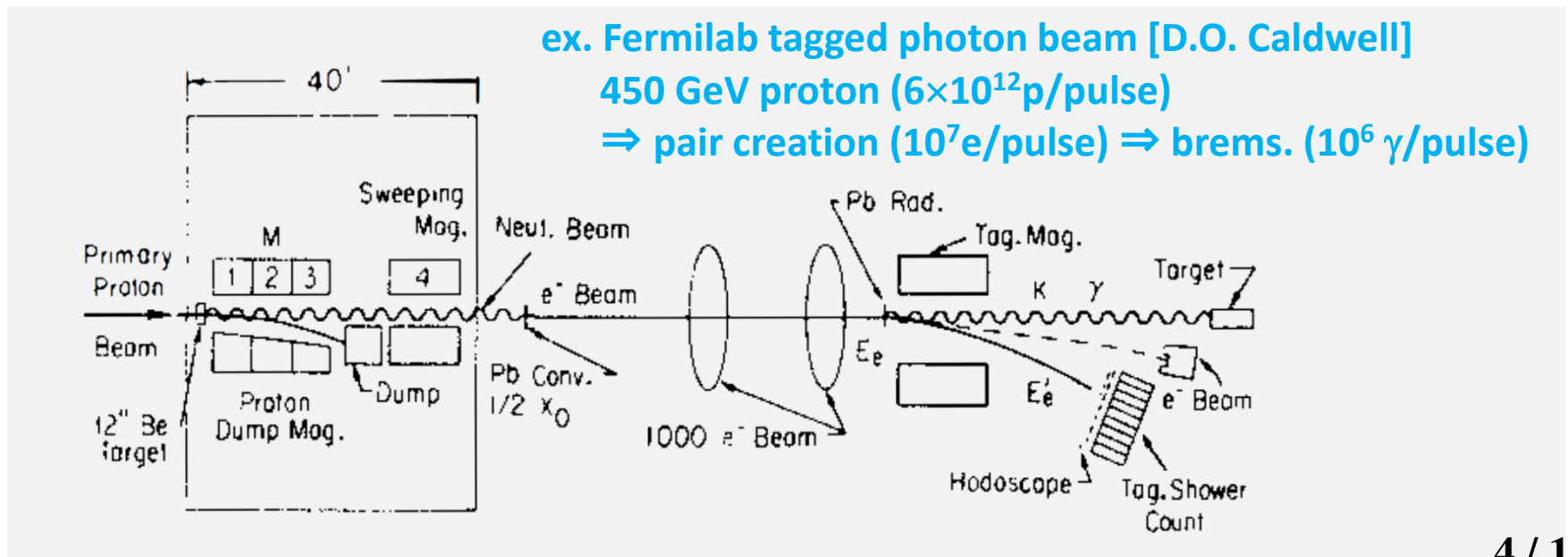
Brems. beam with Pb/W radiator in 1970s-1980s

➤ **CERN SPS** ($25 < E_\gamma < 70$ GeV)

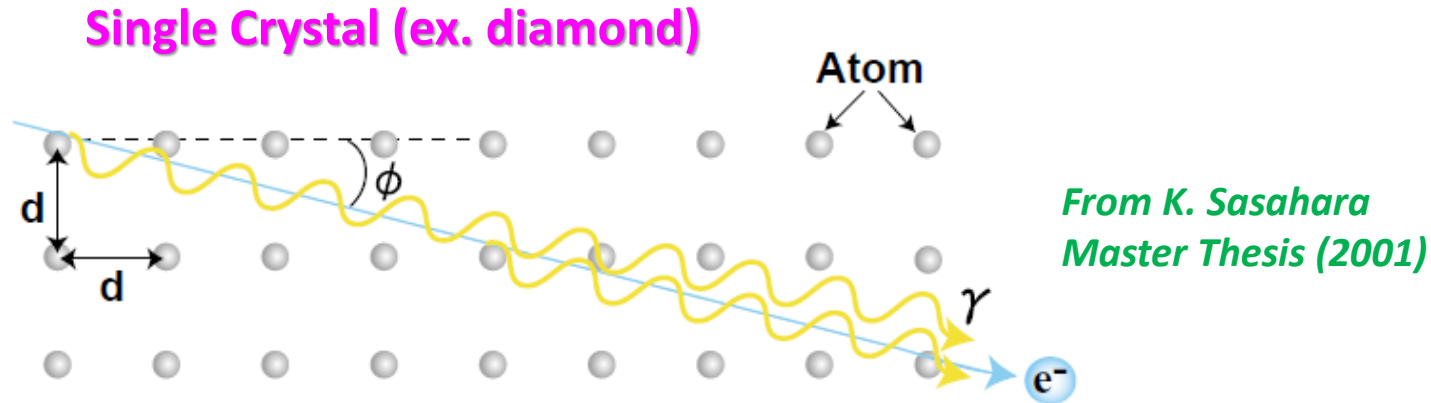
➤ **Fermilab Tevatron** ($18 < E_\gamma < 185$ GeV)

⇒ **Polarization did not attract much attention**

maybe because of a beam divergence problem.



Coherent bremsstrahlung



Interference of γ -rays in **a periodic nuclear EM field**.

- **Monochromatic & Linearly polarized.**
- Now **in practical use** for hadron photoproduction experiments. (MAMI, ELSA, J-Lab, etc.)

Why at ILC?

- The **energy of e^\pm beam** (125 GeV) is attractive.
Coherent brems. \Rightarrow **E_γ range : 20-80% of E_e**
- **High e^\pm current** results in high γ intensity.
- **High quality e^\pm beam** is available.
 - ✓ Characteristic cone angle
 $\theta = 1/\gamma \sim 4 \mu\text{rad}$ > **divergence $\sim 1 \mu\text{rad}$**
 - ✓ Multiple scattering @ radiator (**$t \leq 50 \mu\text{m}$**)
is suppressed to be less than $4 \mu\text{rad}$ with
the high energy e^\pm beam.

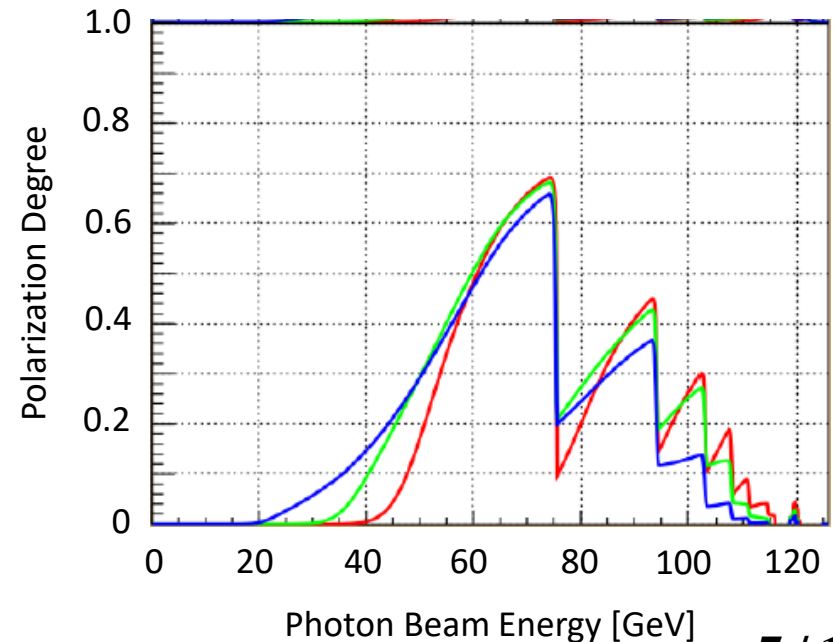
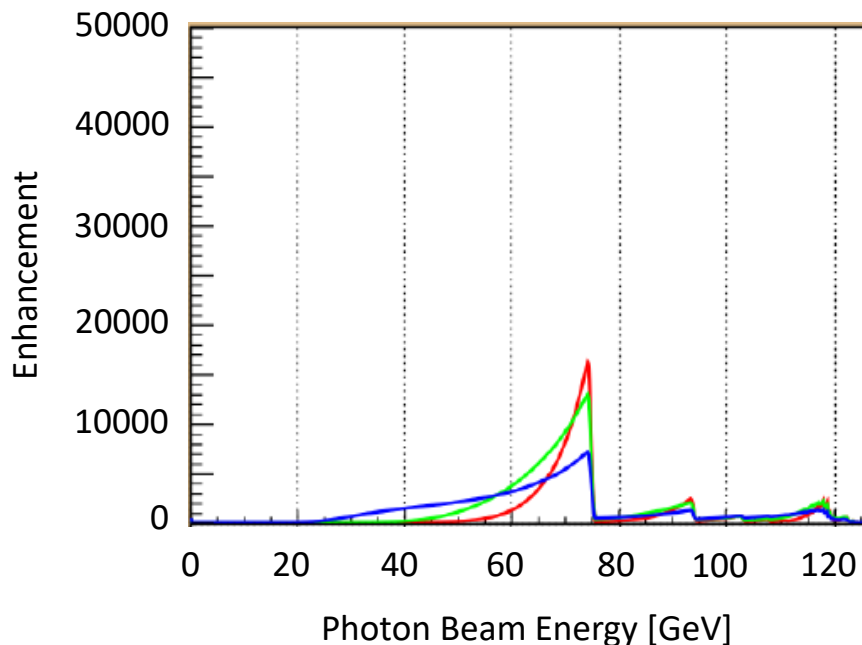
Photon beam properties

Collaboration with **Dr. Ken Livingston (Univ. of Glasgow)**

➤ Peak energy setting by **radiator angle**

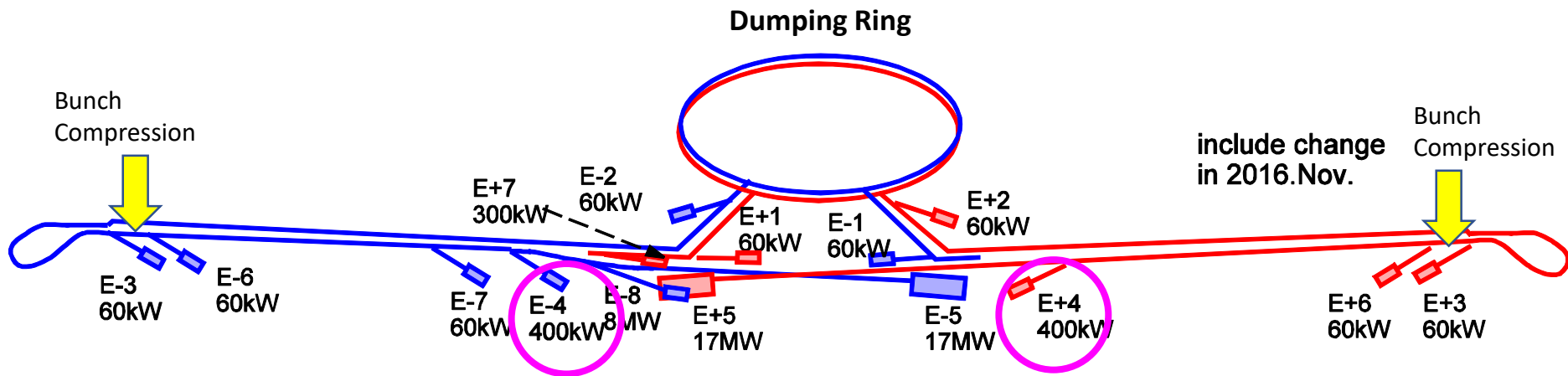
$$\text{ex. } E_{\gamma} = 0.6E_e \text{ (75 GeV)} \Rightarrow P_{\text{lin}}^{\text{max}} \sim 70\%$$

➤ A **collimator** reduces incoherent contribution.



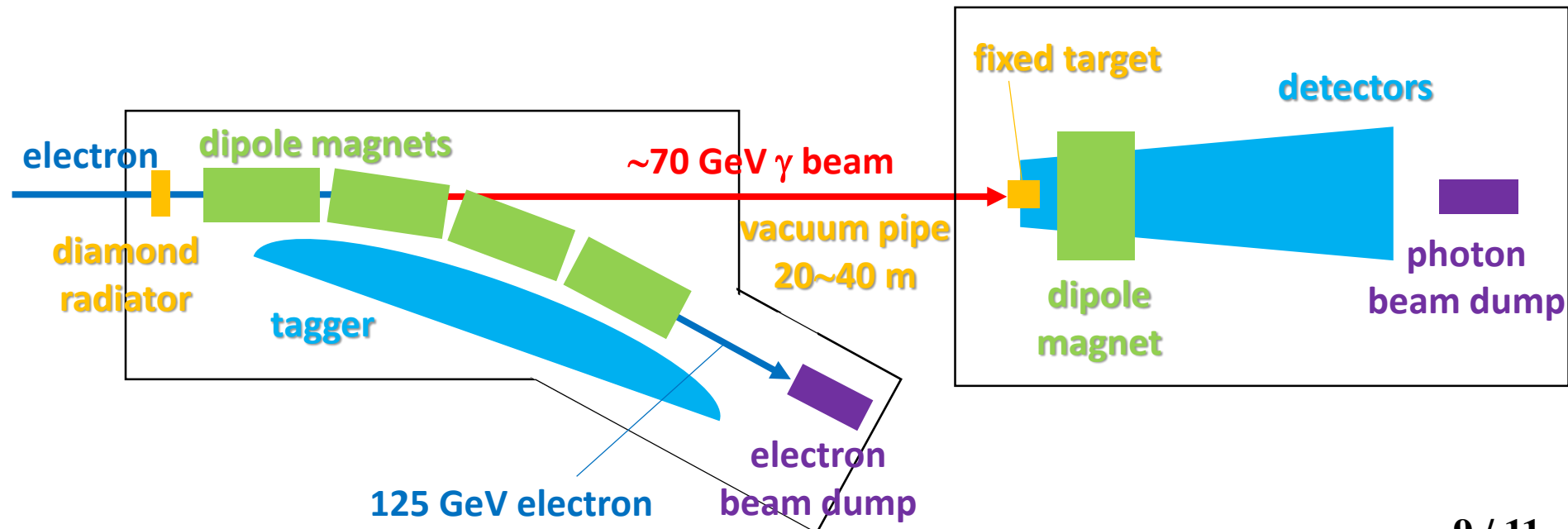
Possible experimental areas at ILC

- Tune-up dump for main linac (125 GeV) : **E-4 / E+4**
- **10% bunch steal** is OK for the **dump power** (400 kW).
 $\Rightarrow 20 \mu\text{A} \times 10\% = 2 \mu\text{A}$ **[enough beam intensity]**
cf. J-Lab (12 GeV) Hall-D : $10^7 \gamma/\text{sec}$ with **200 nA**



Concept of experimental setup

- **Diamond radiator** : $t=20\text{-}50\text{ }\mu\text{m}$ with a Goniometer.
- **Tagger** : Fine-segmented detector for **recoil electrons**.
Event-by-event measurement of E_γ .
- **Spectrometer** w/ a fixed target like **CERN COMPASS exp.**



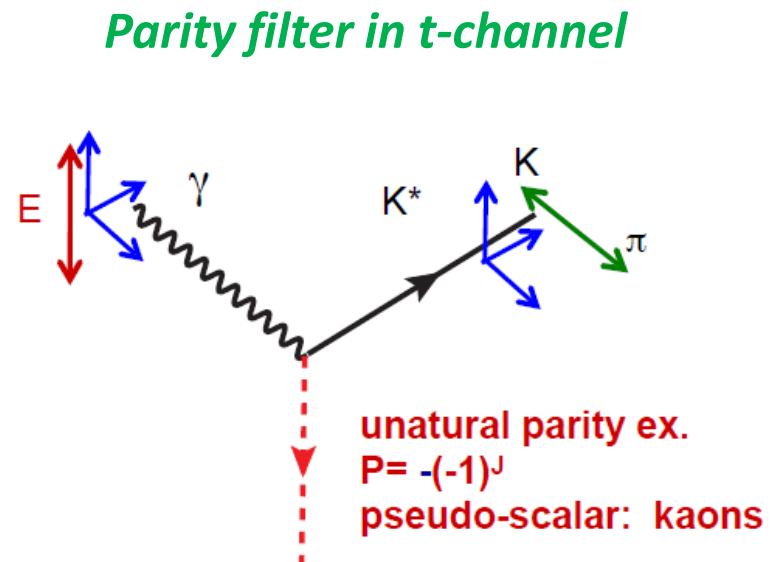
Physics prospect

- **Many exotic hadrons** in charm & bottom sectors.
Complementary to **Bell-II**, **J-PARC**, **LHC-B**, ...
- **Photoproduction cross sections & spin observables** would be sensitive to **hadron structures**.

reaction	E_γ thr.
$\gamma p \rightarrow J/\psi p$	8.21 GeV
$\gamma p \rightarrow \bar{D}^0 \Lambda_c^+$	8.71 GeV
$\gamma p \rightarrow \bar{D}^0 \Sigma_c^+$	9.47 GeV
$\gamma p \rightarrow X(3872) p$	11.9 GeV
$\gamma p \rightarrow Z^+(4430) n$	14.9 GeV
$\gamma p \rightarrow Y(1S) p$	57.2 GeV
$\gamma p \rightarrow B^+ \Lambda_b$	62.8 GeV

JLab
GlueX

New !



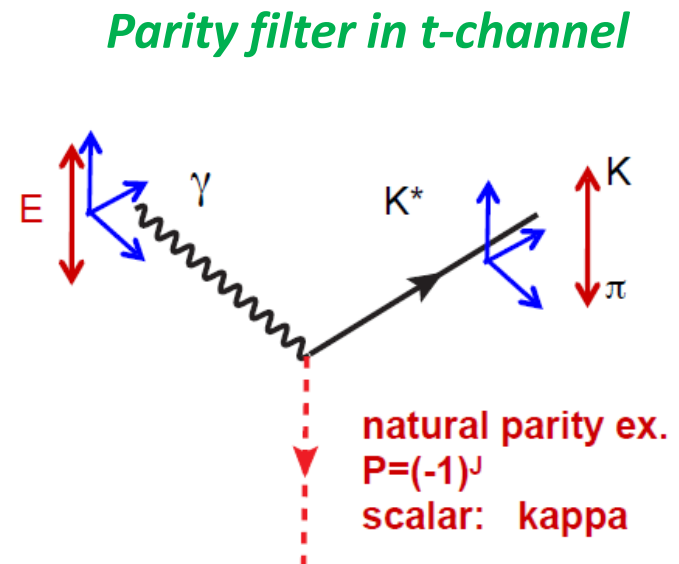
Physics prospect

- **Many exotic hadrons** in charm & bottom sectors.
Complementary to **Bell-II**, **J-PARC**, **LHC-B**, ...
- **Photoproduction cross sections & spin observables** would be sensitive to **hadron structures**.

reaction	E_γ thr.
$\gamma p \rightarrow J/\psi p$	8.21 GeV
$\gamma p \rightarrow \bar{D}^0 \Lambda_c^+$	8.71 GeV
$\gamma p \rightarrow \bar{D}^0 \Sigma_c^+$	9.47 GeV
$\gamma p \rightarrow X(3872) p$	11.9 GeV
$\gamma p \rightarrow Z^+(4430) n$	14.9 GeV
$\gamma p \rightarrow Y(1S) p$	57.2 GeV
$\gamma p \rightarrow B^+ \Lambda_b$	62.8 GeV

JLab
GlueX

New !



Summary

- Proposing a facility to produce **a coherent bremsstrahlung photon beam** at **a beam dump** ($E_{\pm 4}$).
- An **unprecedented** photon beam with $E_{\gamma} \sim 75 \text{ GeV}$ & $P_{\text{lin}}^{\text{max}} \sim 70\%$ can be obtained at ILC.
- **Heavy exotic hadrons** including **charm** or **bottom** quarks can be explored with the extremely high energy & linearly polarized photon beam.