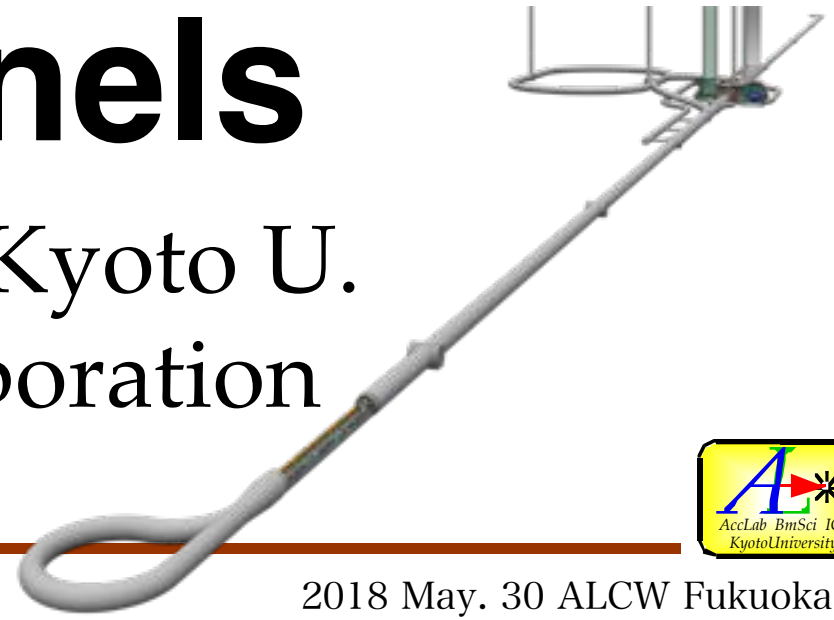
Accelerator Laboratory
Advanced Research Center for Beam Science
Institute for Chemical Research
Kyoto University

Utilization study of ILC beams and impact on ILC tunnels

Y. Iwashita, ICR, Kyoto U.
for divILC collaboration



2018 May. 30 ALCW Fukuoka

Diversified ILC

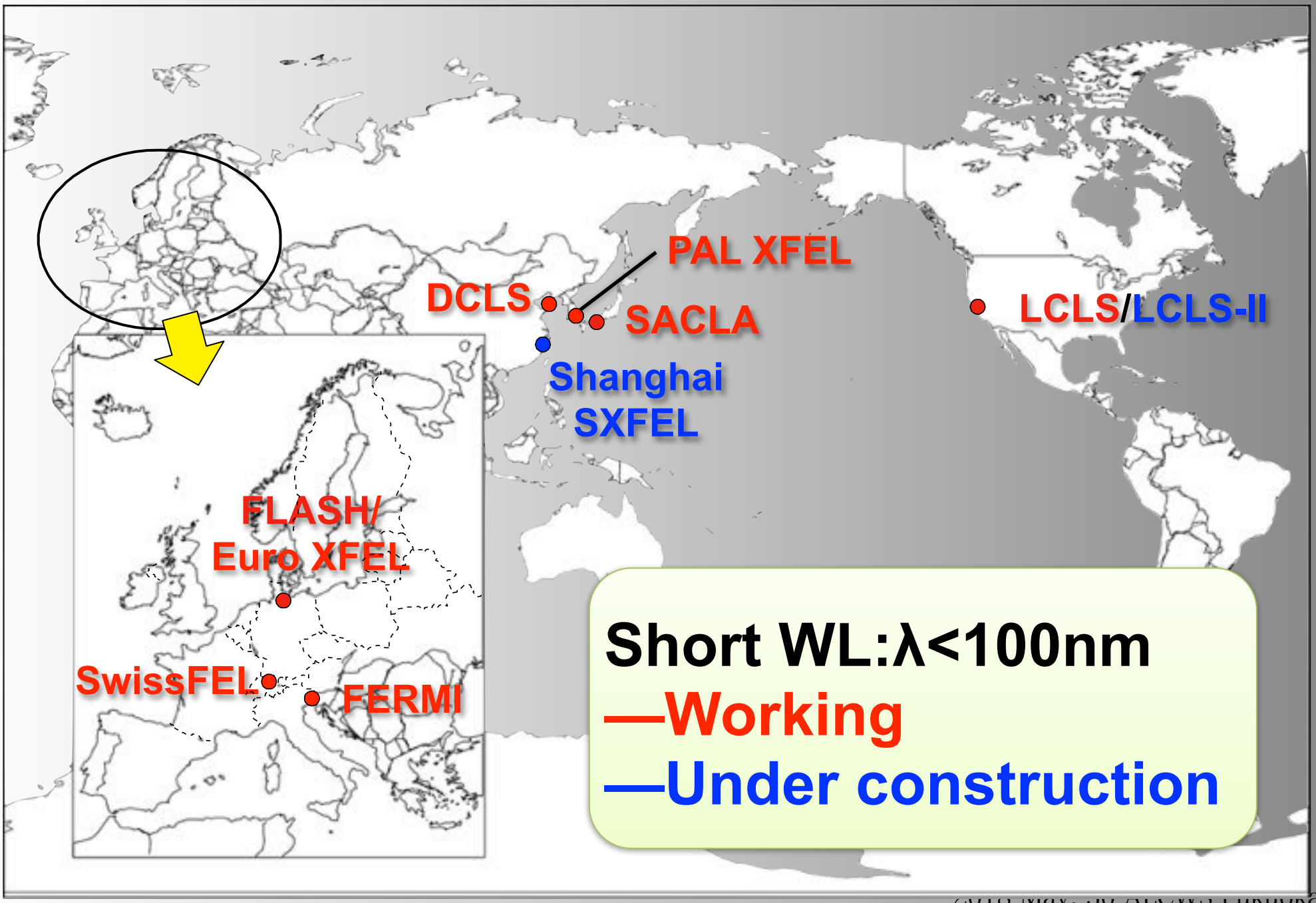
2017 Nov. 29-30 @KEK

also MOPML047, IPAC2018 Vancouver
http://ipac2018.vrws.de/papers/mopml047.pdf

Possibilities

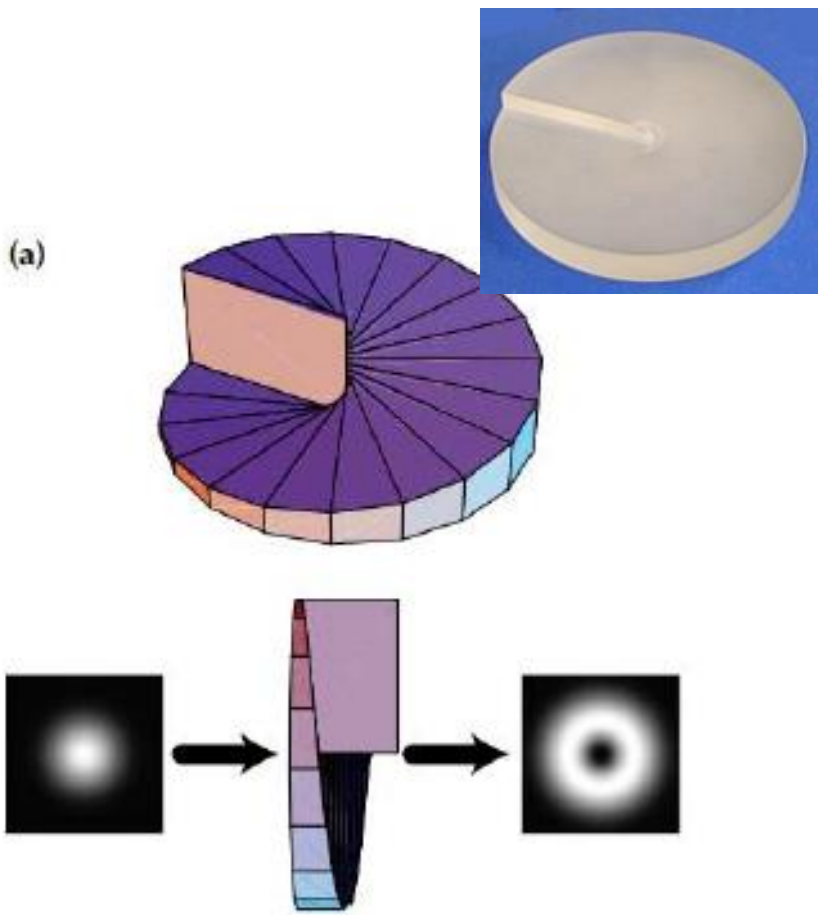
- Short WL X-FEL
- Direct generation of keV neutrons through MeV gamma.
- Muon generation from e+
  –> Muon collider
- Neutrinos from muons @ beam dump(s)
  –> Needs long decay section
- Radiography @ beam dump ?
- RI productions (ex. ^{99}Mo ...)
- LE positrons for material science ...
- ...

World short WL X-ray FEL Facility



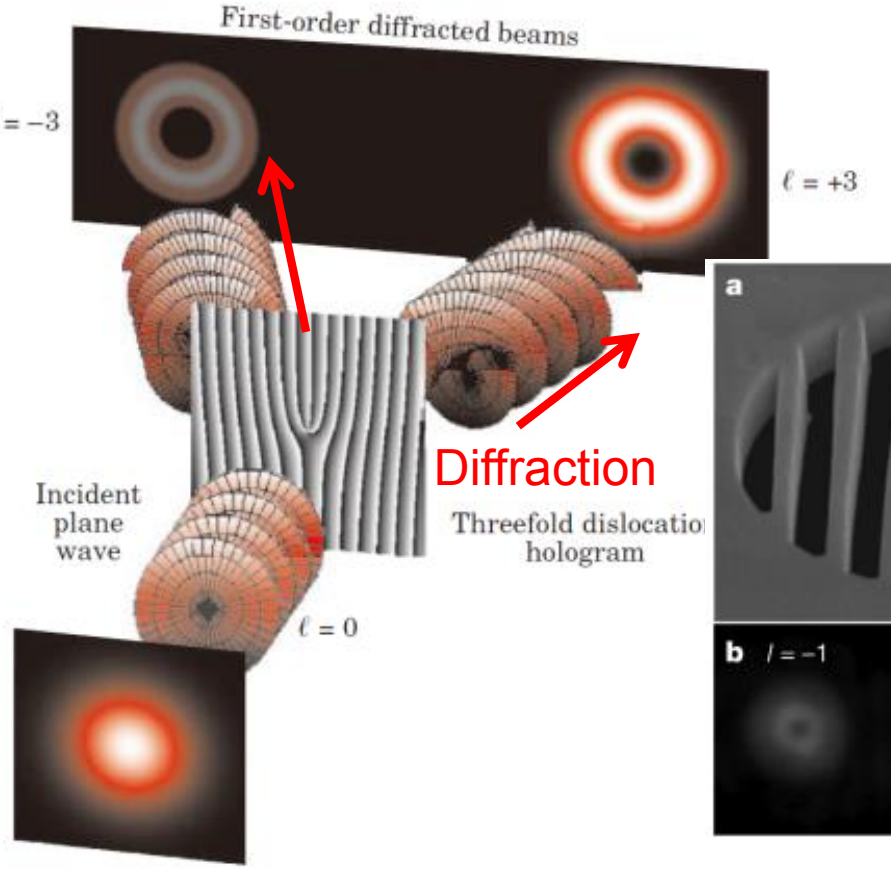
Photons with angular momentum

Spiral phase plate

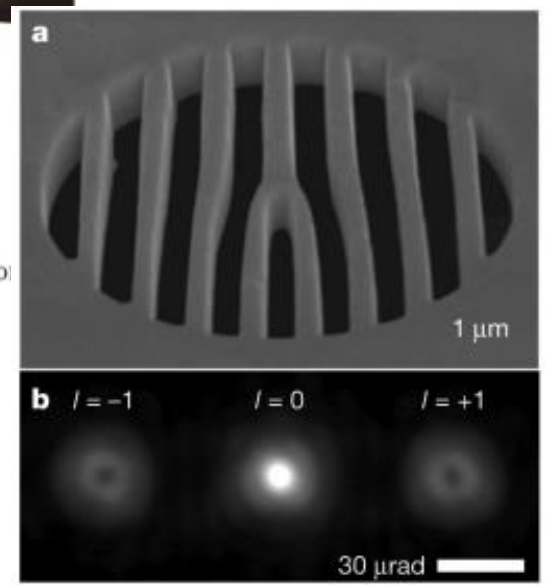


J. Courtial, K. O'Holleran, Eur. Phys. J. Special Topics 145, 35 (2007)

Holographic phase plate



M. Padgett et al., Phys. Today 57 (2004) 35



Phase dislocation aperture

J. Verbeeck, et al. Nature, 467, 301 (2010).

Monochromatic keV Neutrons

AccLab BmSci ICR KyotoUniversity

Possibility of neutron source using photon beam from ILC

by S.Sasaki

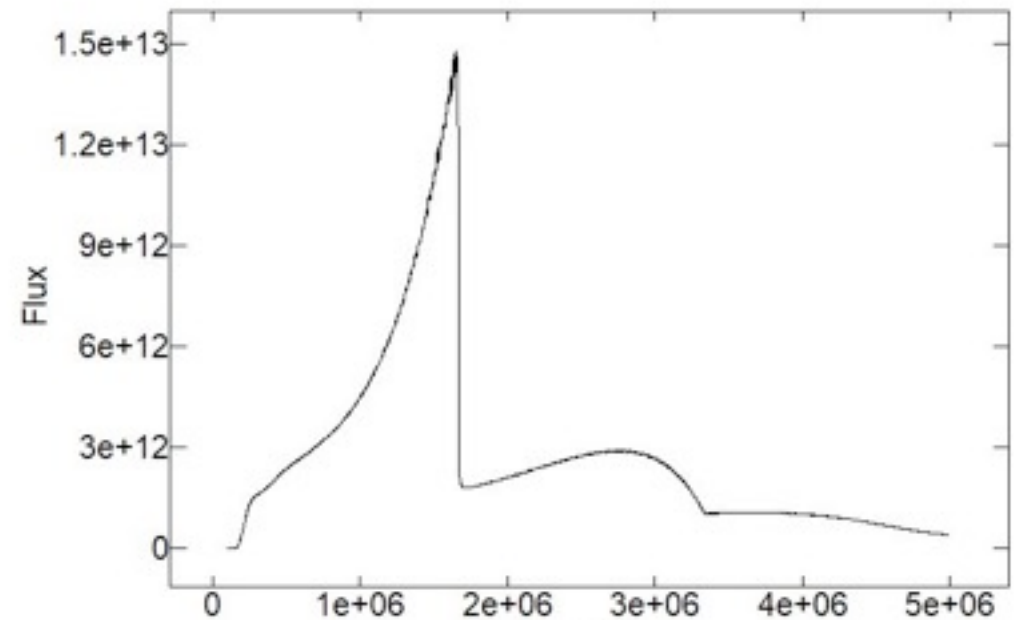
ILC main linac parameters @ E-4

Normalized emittance $\gamma\varepsilon$:	5.0×10^{-6}	m·rad
Total emittance at 125 GeV:	2.0×10^{-11}	m·rad
Beam current:	0.58	mA (10% of main current)

Undulator parameters

Undulator period *l* :	6.5	cm
Undulator strength *K* :	0.61	
Undulator type:	helical	
Active undulator length:	20	m
Field on-axis:	0.1	T

Polarized photon



Partial Flux thru 25 μmϕ aperture
Peak Photon Energy = 1.66 MeV

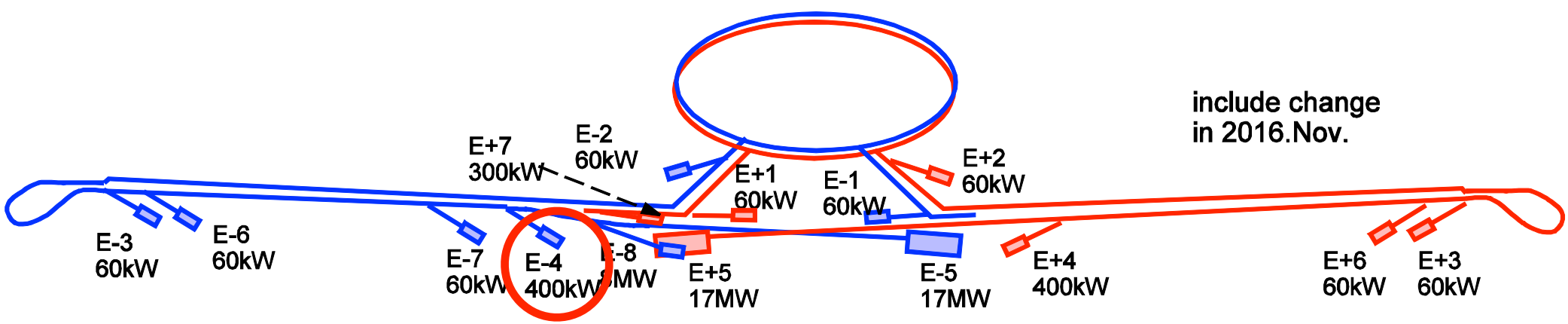


Photo induced neutron source

γ-rays from an undulator (~2 MeV) can be produce monochromatic pulsed neutrons via photodisintegration process as $^{9}Be(\gamma,n)\,^{8}Be$ or D(γ,n)H.

by K.Mishima

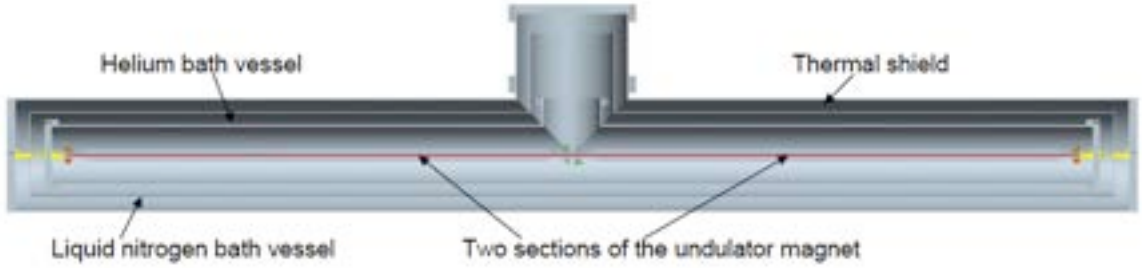
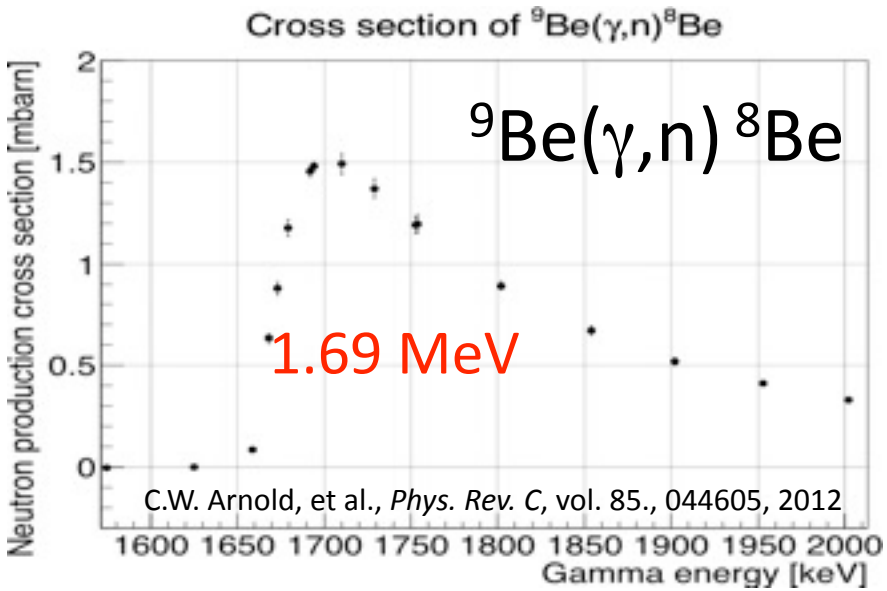


FIGURE 2.3-7. 4-meter undulator cryomodule.

Features of $^{9}Be(\gamma,n)\,^{8}Be$ neutron source

- Required γ-ray energy : 1.69 MeV
- Reaction cross section: 1.5 mbarn
- Neutron energy (spread): 25 keV
  (no moderator — **Better quality**)
- Neutron/γ conversion rate: 0.6%
  (30 cm target)
- Average energy per neutron: 280 MeV/n
  (cf. ~50 MeV/n for spallation)



- No radioactive productions, less background — **Clean!, better solid angle**

Applications

The short pulsed monochromatic keV neutron source is very unique and possibly available for

- keV neutron imaging
- Precise total cross section measurements
- Boron neutron capture therapy (BNCT)

J-PARC neutron facility

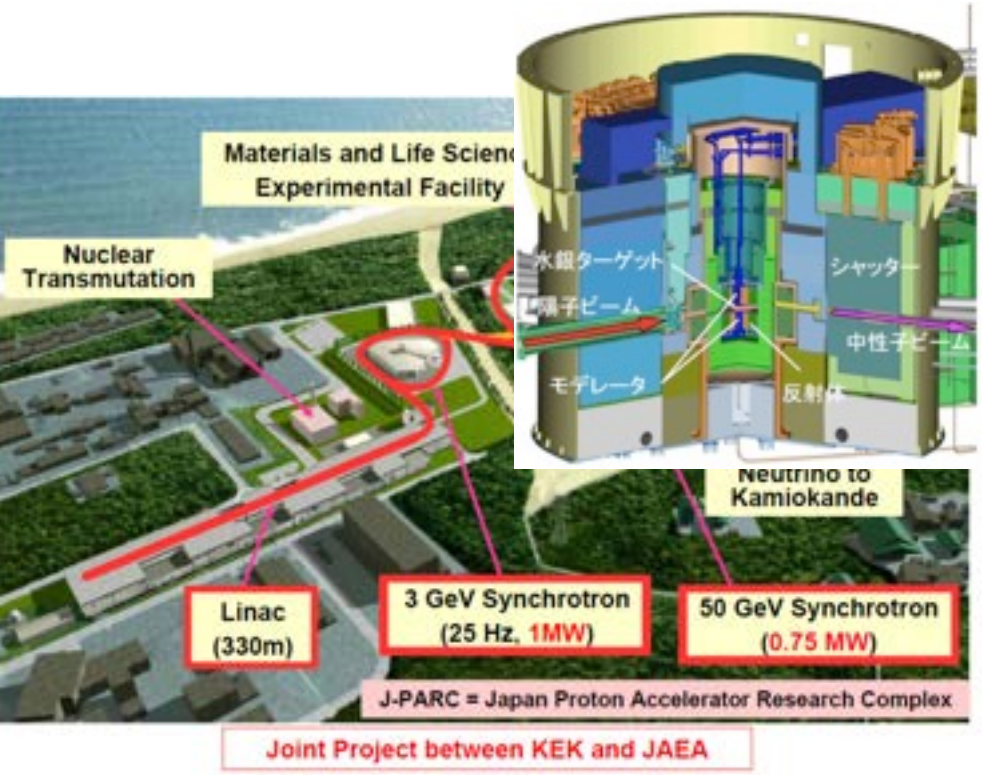
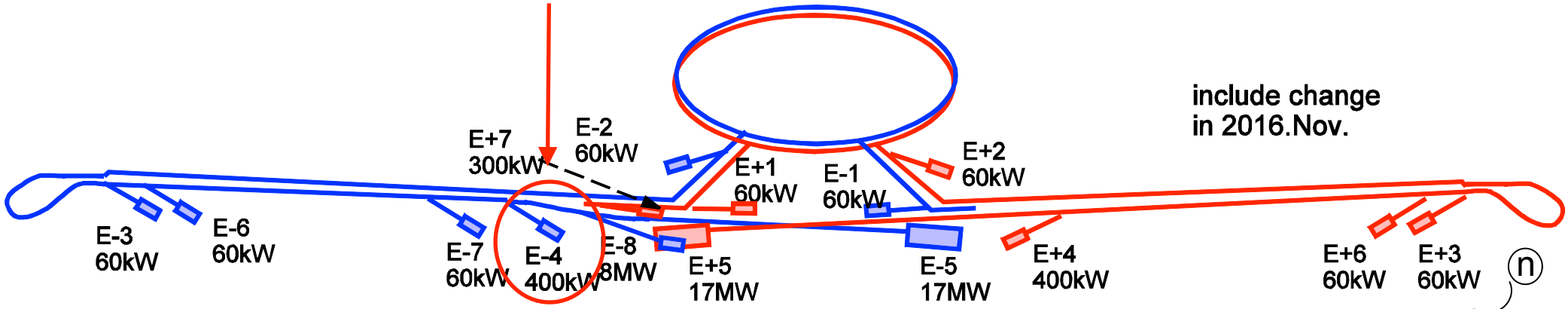
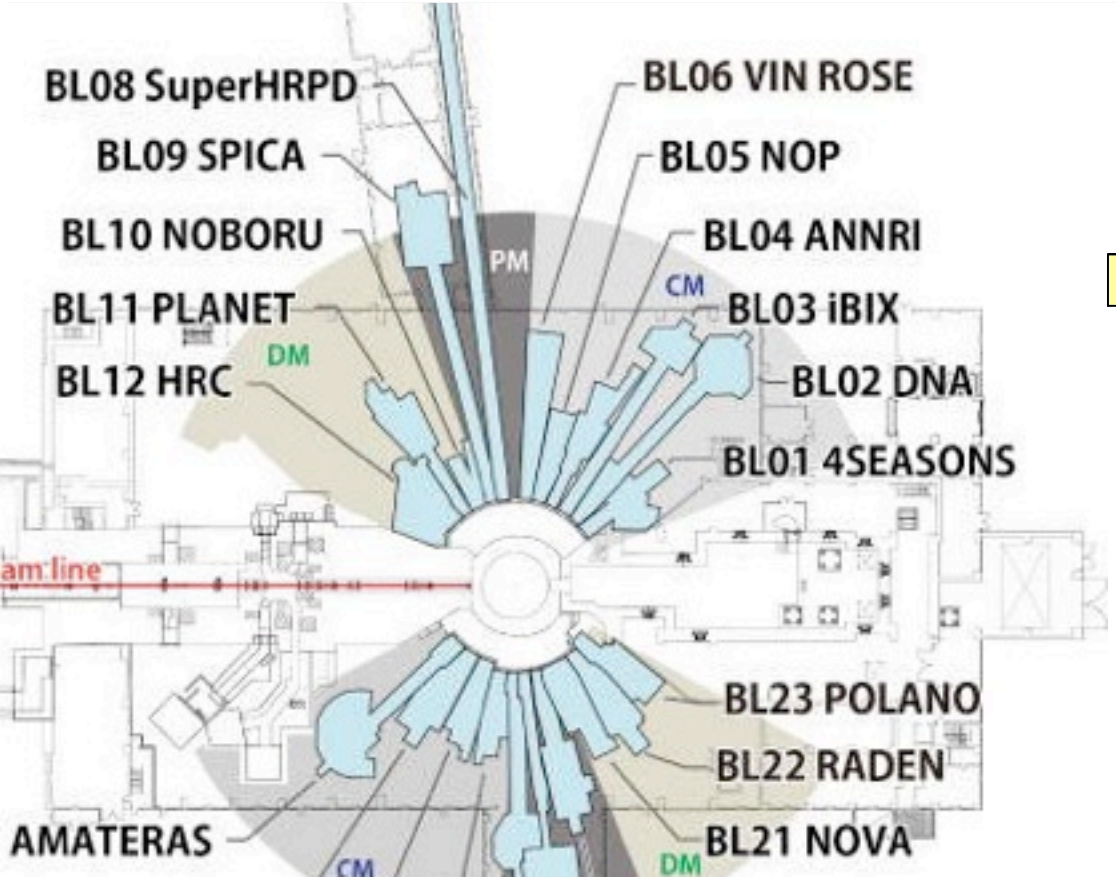
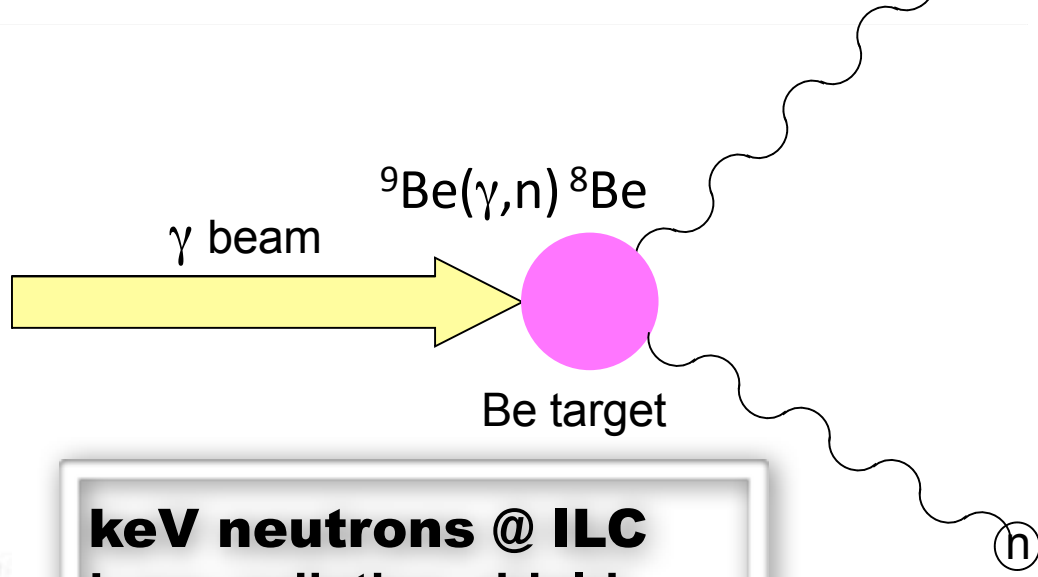


Photo induced neutron source

An undulator for positron production may be used for the neutron production.







keV neutrons @ ILC
Less radiation shield
No radioactives
No moderator
Well defined energy (ToF)
Polarized neutrons

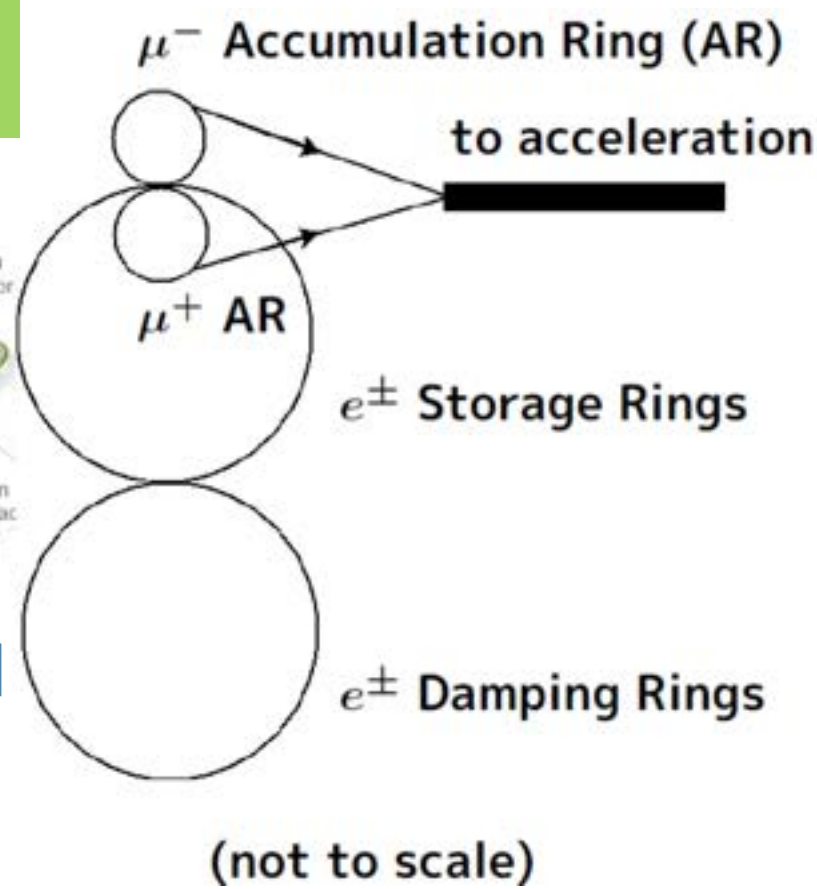
Muon Collider

by K. Shimomura, et al.

ILC→muon collider

Based on M. Antonelli et al.
Novel proposal for a low emittance muon beam using positron beam on target,
Nucl. Instrum. Meth. A, vol. 807, 101, 2016

fig from ILC TDR



Scheme (muon pair production with positron beam and fixed target)

$$e^+e^- \to \mu^+\mu^- \quad (\lesssim 1\ \mu\mathrm{b})$$

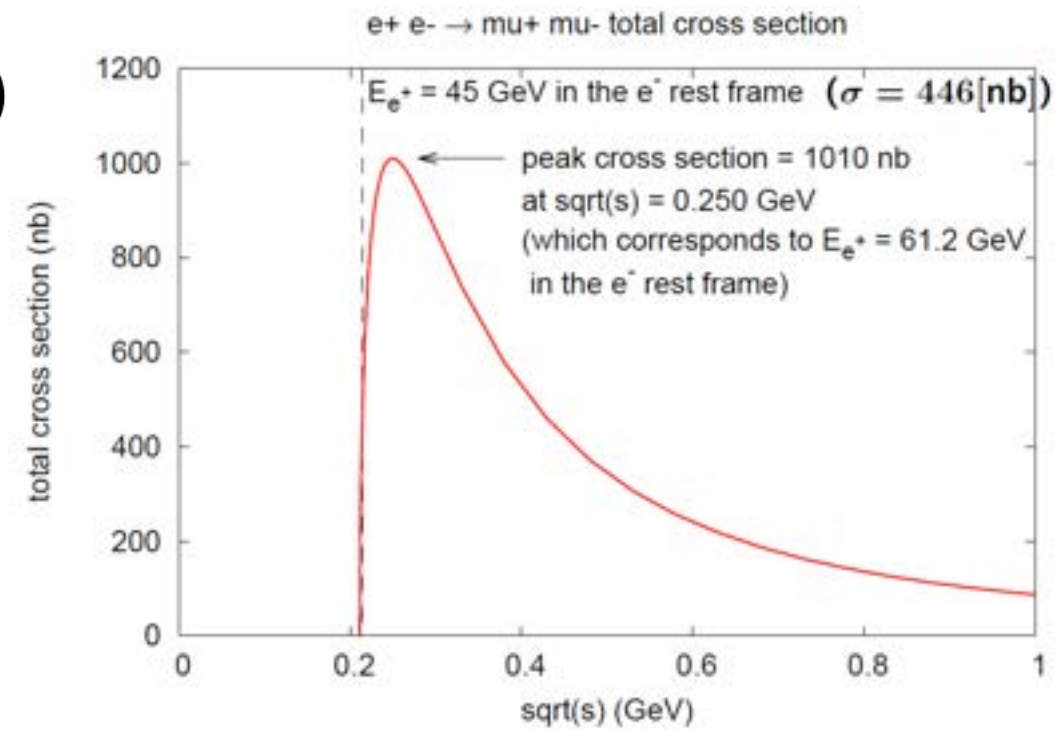
If we set positron energy at 45 GeV and hit thin target like C or Li

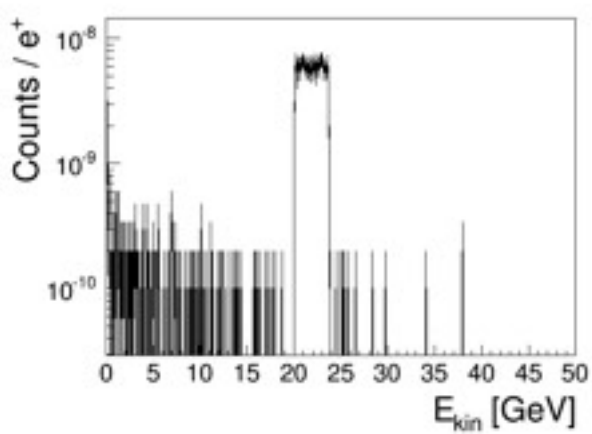
$e^+ + e^- \to \mu^+ + \mu^-$ pair production at 22GeV

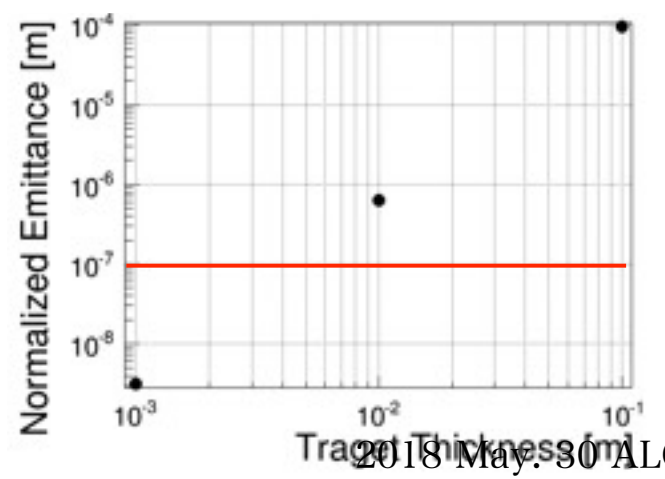
Efficiency $(\mu^+\mu^-) = 2\times10^{-8}$

If we adopted 2mm C target.

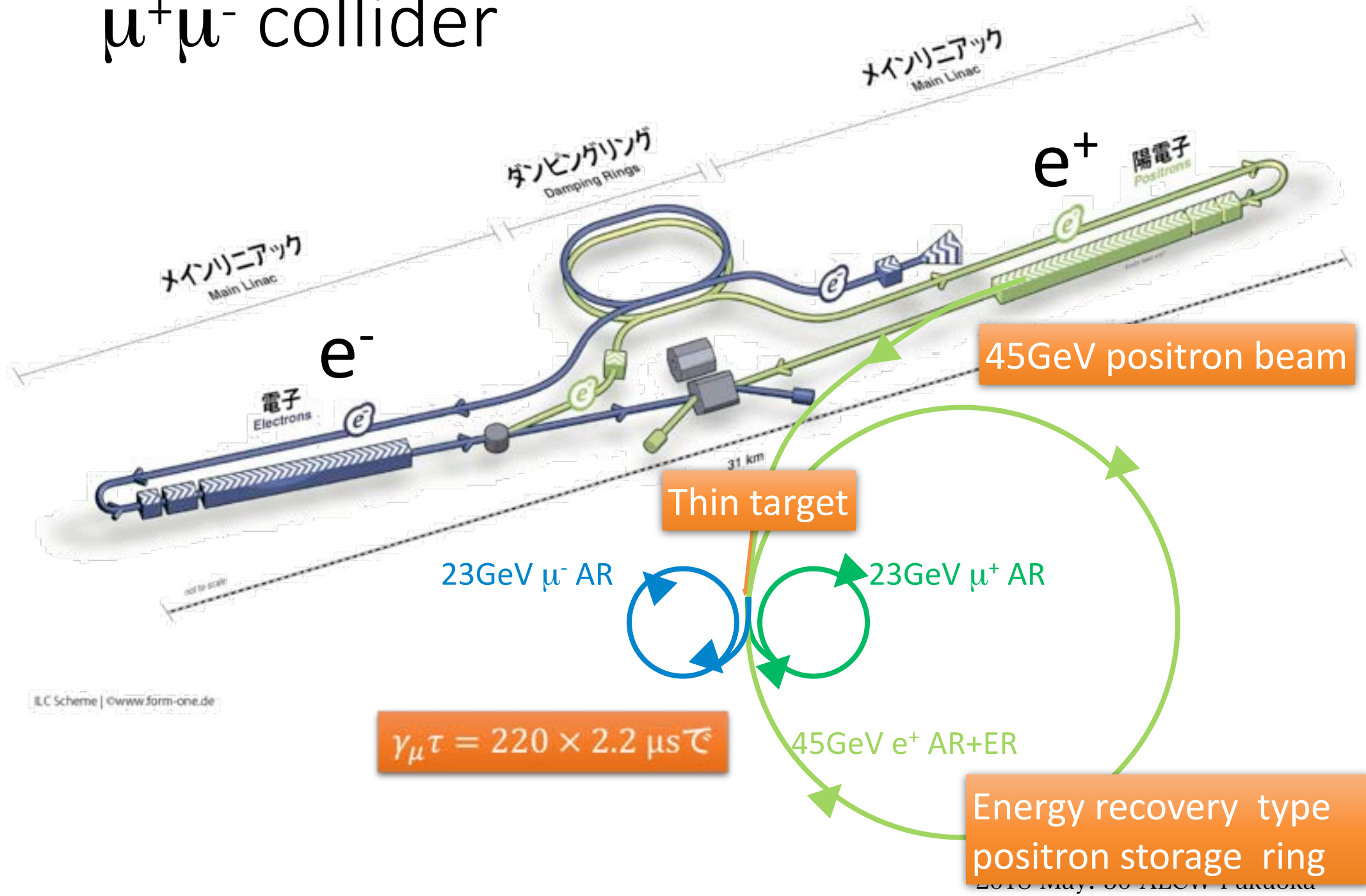
In this case, multiple scattering of positron Beam is negligible.





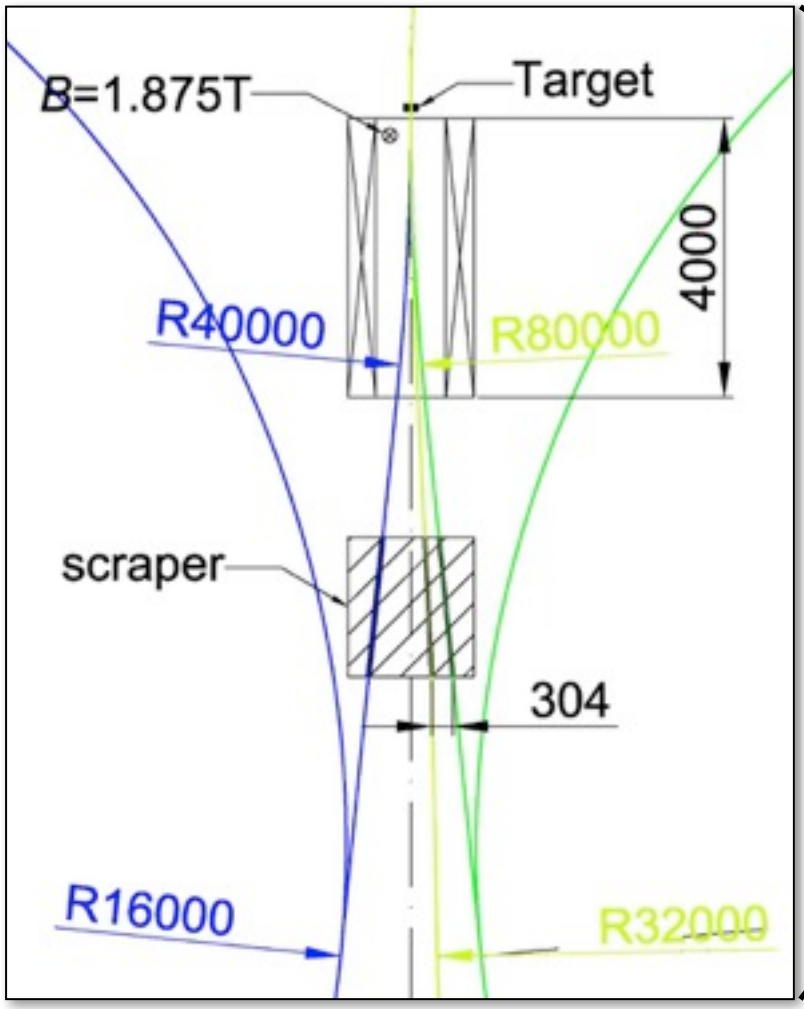


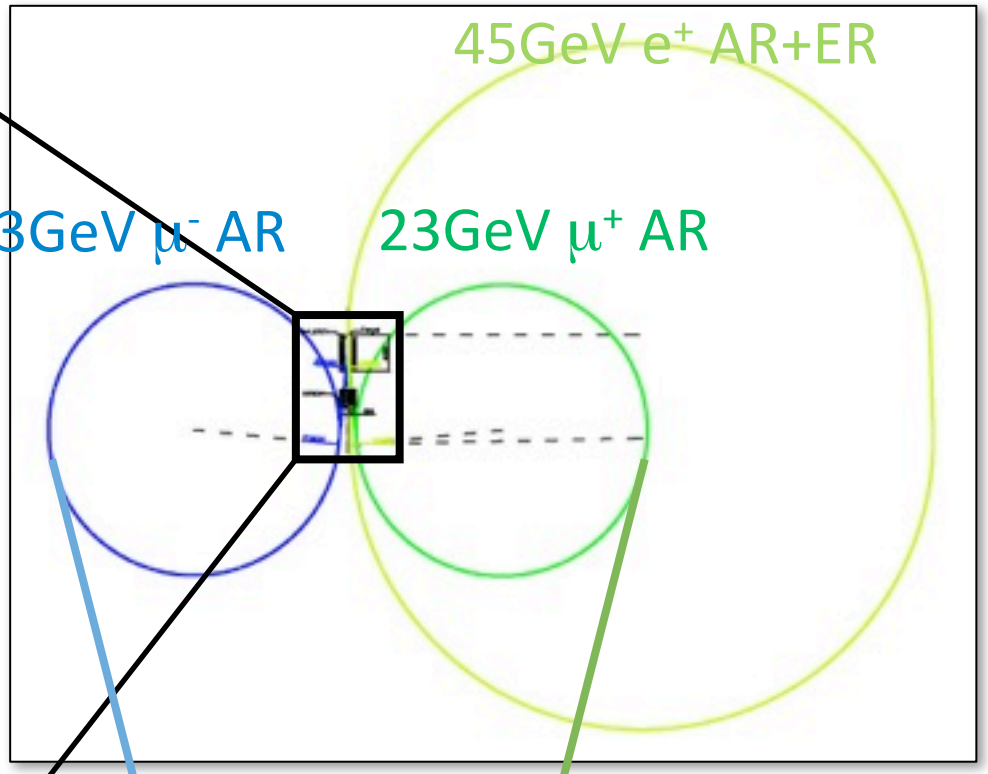
$\mu^+\mu^-$ collider



$\gamma_\mu \tau = 220 \times 2.2\ \mu s$で

Target region





Acceleration and circulate in main ring

Very preliminary luminosity

- ILC 2820 bunchs/train, 4 trains/s, 1 bunch 2×10^{10} e^{+}
- Muon pair for 1 bunch 4×10^{2}
- If we synchronize positron beam bunch and muon circulation, ideally muon bunch grows up to

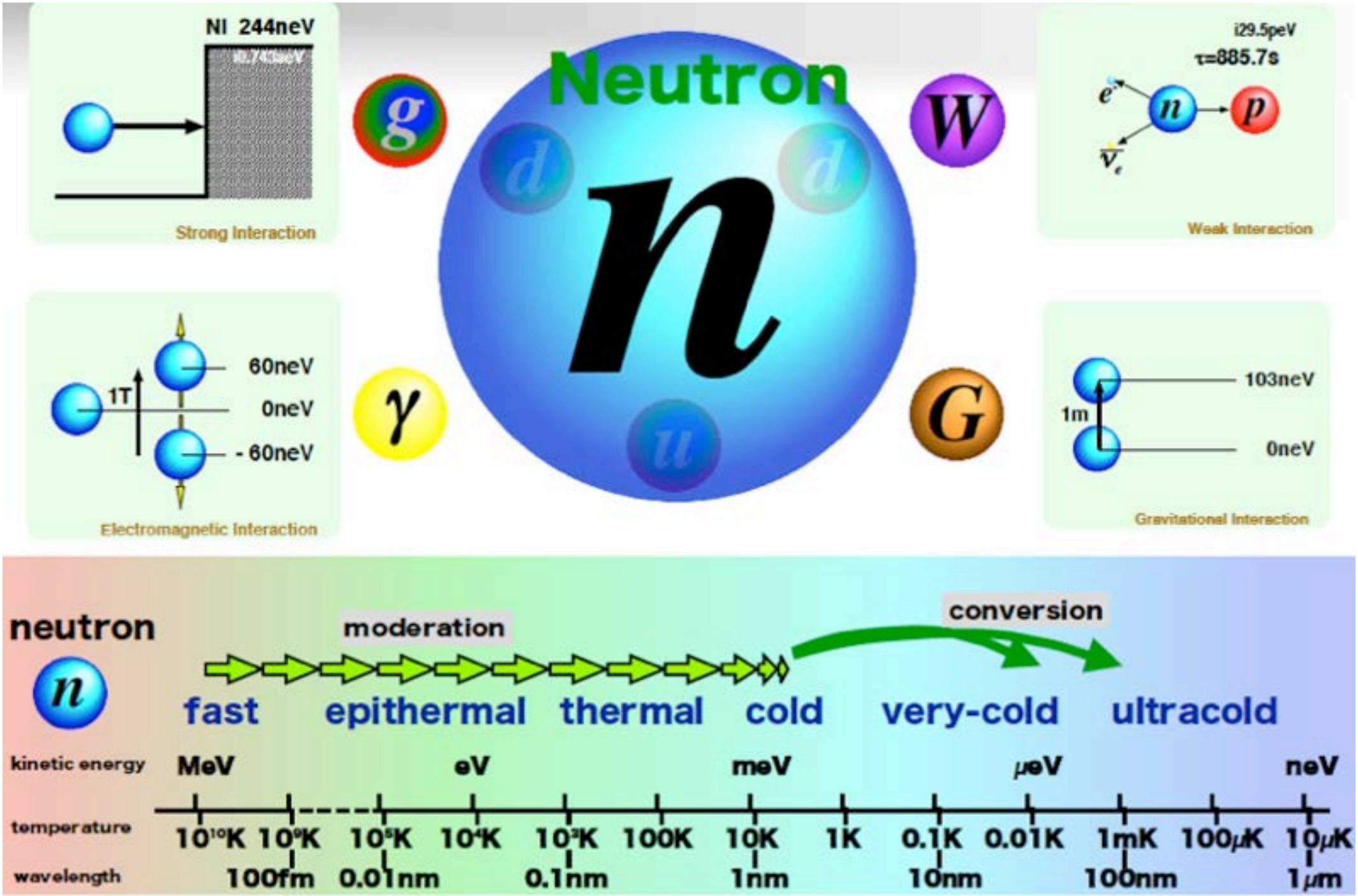
  $2820 \times 4 \times 10^{2}$
- We also assume radius of MC main ring 0.5km
- $\mathcal{L} = \frac{f_{col} N^2}{4\pi\sigma_x\sigma_y} \sim 1 \times 10^{29}\ [\mathrm{cm}^{-2}\mathrm{s}^{-1}]$

  $f_{col} = 4 \times 10^{5}\mathrm{Hz}$、$N = 2820 \times 4 \times 10^{2}$、 $\sigma_x = \sigma_y = 10\ \mathrm{nm}$

Remarks

- We discussed wide possibilities of ILC once it was build.
- Since this kind of big facility will be supported by a town wide community, it should last decades of years as has the success of CERN.
- Many diversified applications of ILC are discussed such as X-FEL, keV neutrons, and a possible muon collider.
- More ideas are welcomed!

Addendum


Ni 244neV
Strong Interaction
Neutron
g
d
d
u
W
γ
G
i29.5peV
τ=885.7s
Weak Interaction
60neV
1T
0neV
- 60neV
Electromagnetic Interaction
103neV
1m
0neV
Gravitational Interaction
neutron
moderation
conversion
fast
epithermal
thermal
cold
very-cold
ultracold
kinetic energy
MeV
eV
meV
μeV
neV
temperature
10¹⁰K 10⁹K 10⁵K 10⁴K 10³K 100K 10K 1K 0.1K 0.01K 1mK 100μK 10μK
wavelength
100fm 0.01nm 0.1nm 1nm 10nm 100nm 1μm

Delbrück Scattering