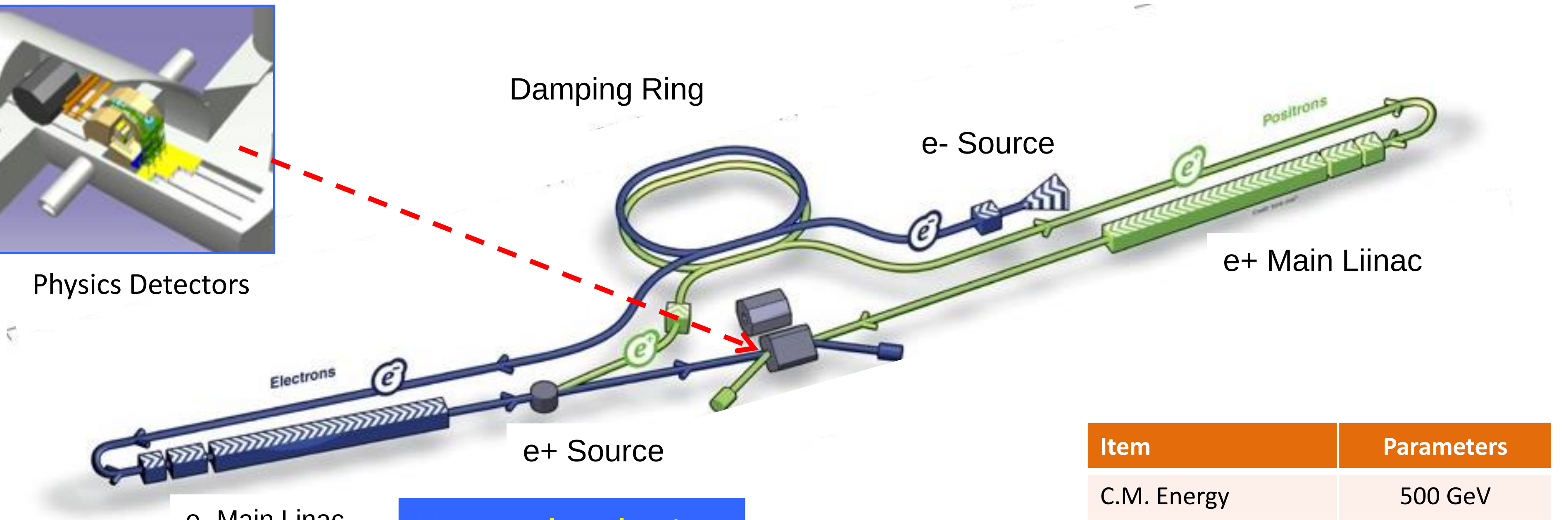
ILC Update

KEK/LCC

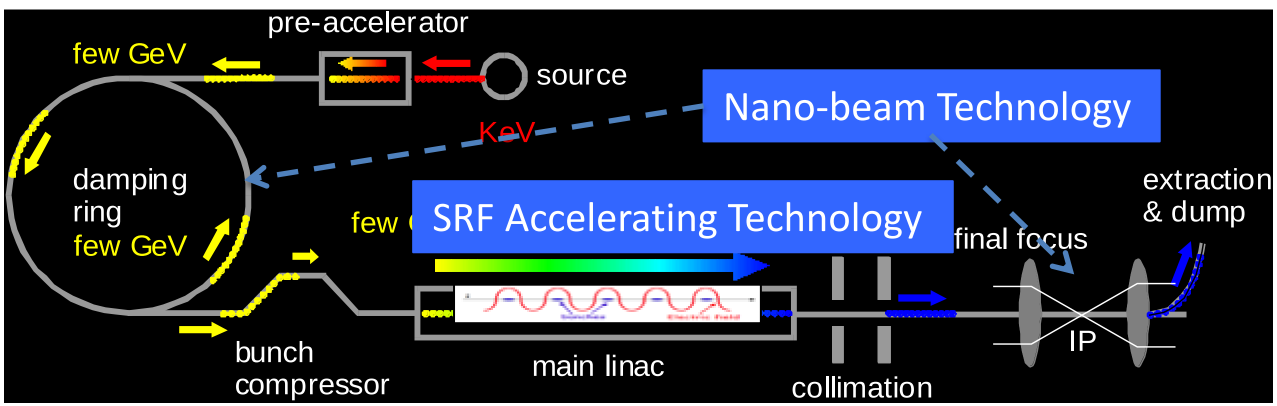
Shin MICHIZONO

- *The ILC*
- *Why ILC?*
- *ILC area systems*
  - *Sources*
  - *Damping ring*
  - *Main linac*
  - *Final focus*
- *Industrialization*
  - *SRF accelerators in the world*
- *Recent status including "cost reduction"*

ILC Acc. Design Overview (in TDR)



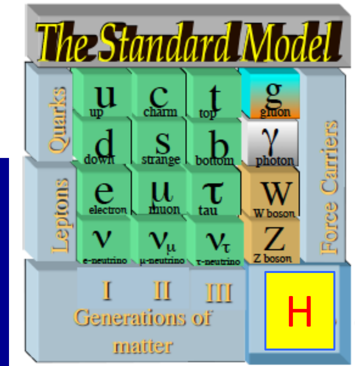
Key Technologies

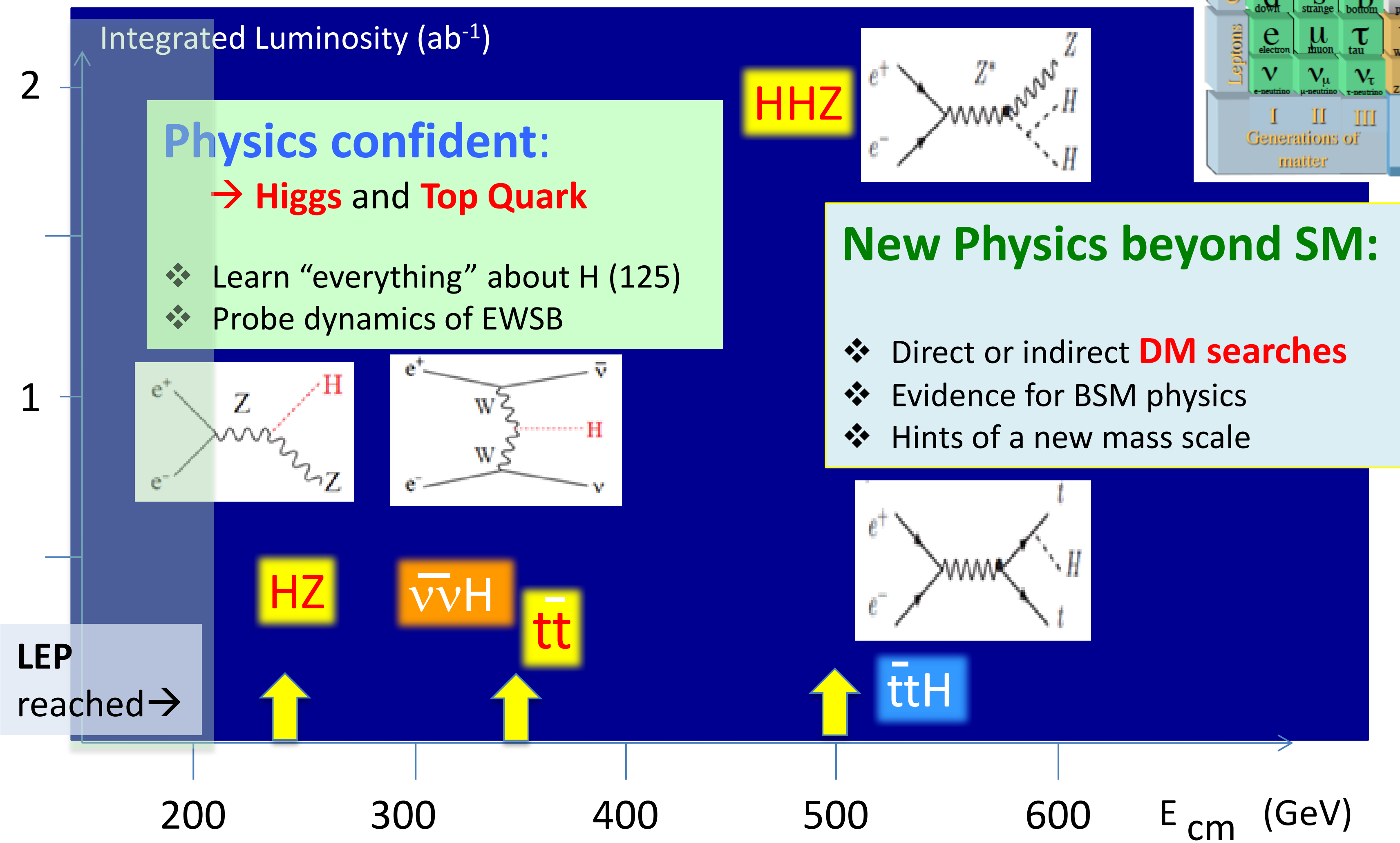


Item	Parameters
C.M. Energy	500 GeV
Length	31 km
Luminosity	1.8 x10^{34} $cm^{-2}s^{-1}$
Repetition	5 Hz
Beam Pulse Period	0.73 ms
Beam Current	5.8 mA (in pulse)
Beam size (y) at FF	**5.9** nm
SRF Cavity G. Q_0	**31.5** MV/m Q_0 = 1x10^{10}

Important Energies in ILC

125 GeV Higgs discovery reinforcing the ILC importance





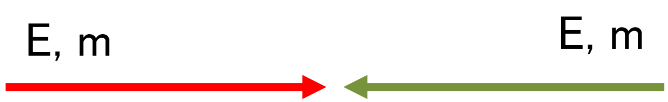
Why collider?

Center of Mass Energy (Ecm) = discovery reach

Fixed Targets

$$E_{CM} = \sqrt{2mE}$$

Colliders



$$E_{CM} = 2E$$

We must collide the beams

,,,,, efficiently,,,,,,

Why linear accelerator?

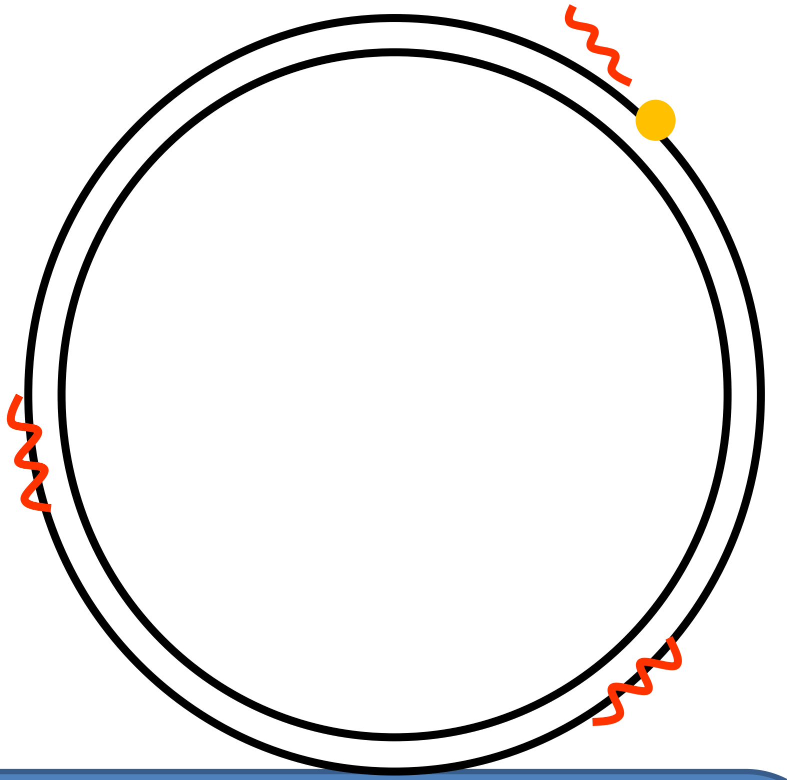
- **Synchrotron radiation**
  - Circulating beam loses energy
  - Energy loss per turn is

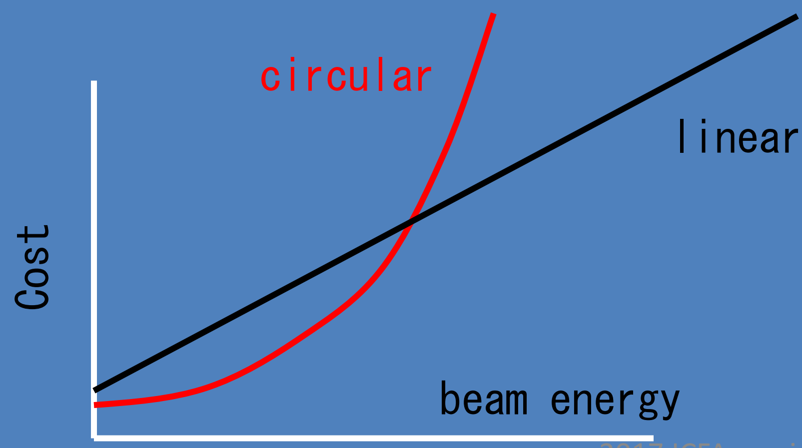
$$\Delta E = \frac{E^4}{m^4 R}$$

  - proportional to 4th power of γ

Example: 210GeV (LEP) -> 250GeV

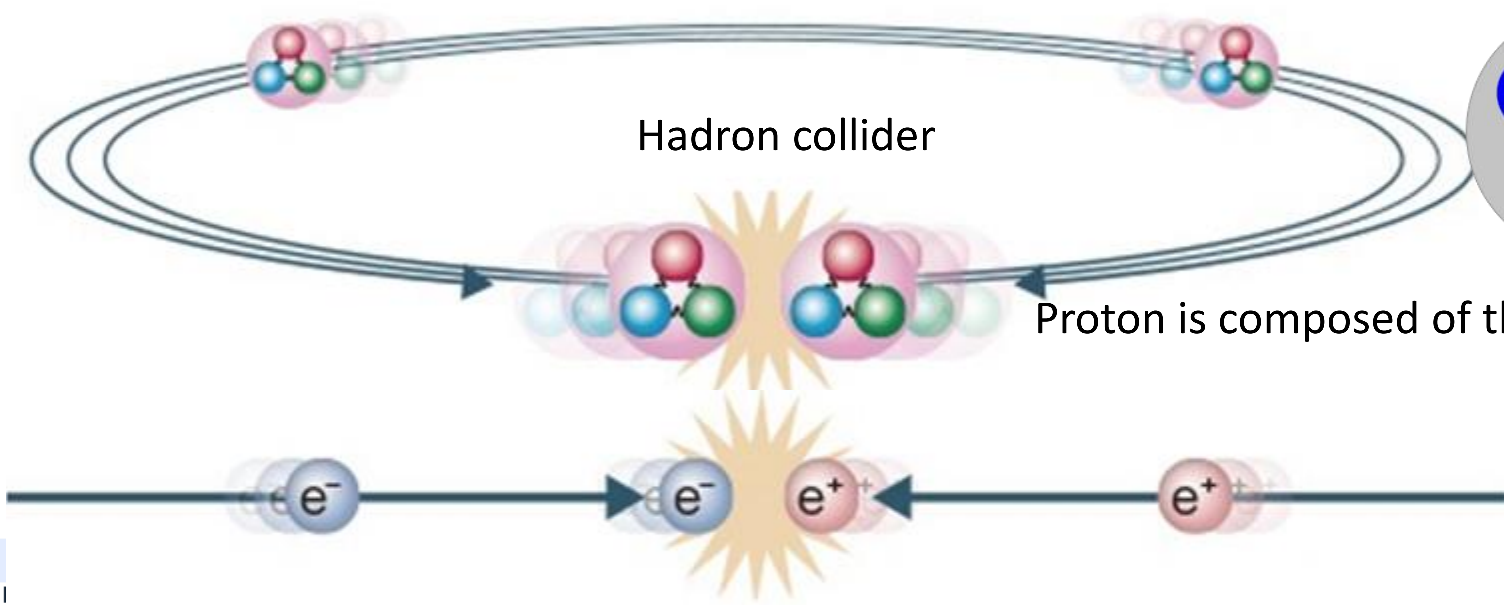
ΔE becomes twice.

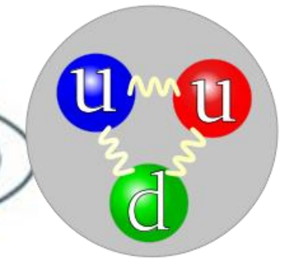




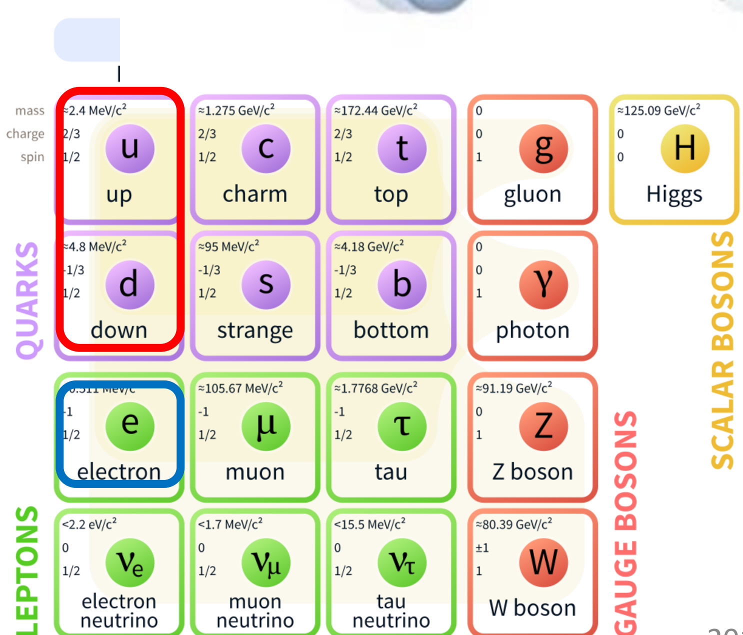
Linear accelerators are cheaper for higher energy

Why electron-positron?





Proton is composed of three quarks.



Lepton collider

Collision analysis of electron/positron (Lepton) is simple.

LCC organization from Dec. 2016

ICFA

Linear Collider Board
Tatsuya Nakada
(Lausanne)

LCC

Linear Collider Collaboration

Directorate
Lyn Evans

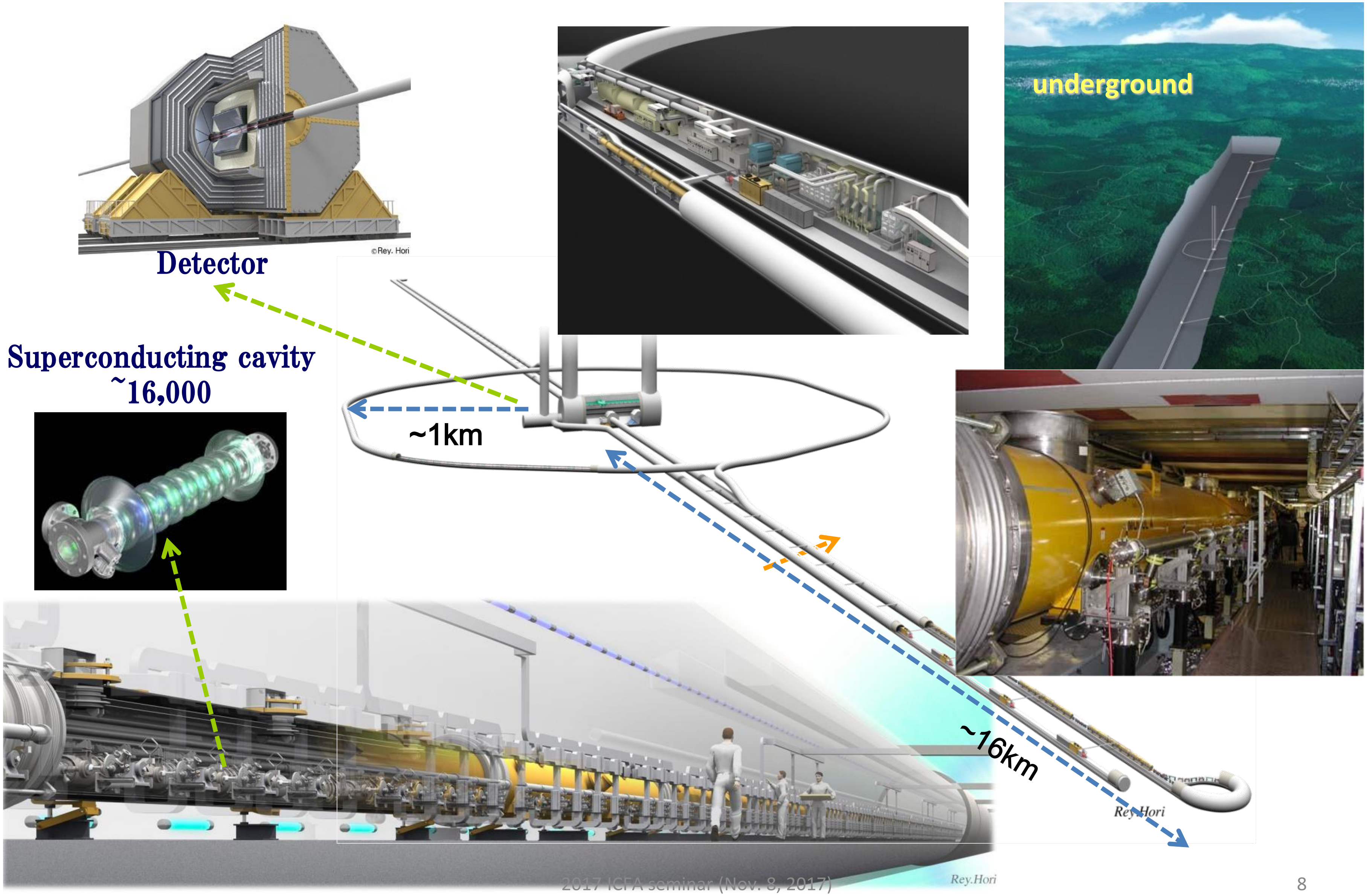
Deputy (Physics)
Hitoshi Murayama

ILC
Shin Michizono

CLIC
Steinar Stapnes

Physics & Detectors
Jim Brau

ILC schematic



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- ***ILC area systems***
  - *Sources*
  - *Damping ring*
  - *Main linac*
  - *Final focus*
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  - *SRF accelerators in the world*
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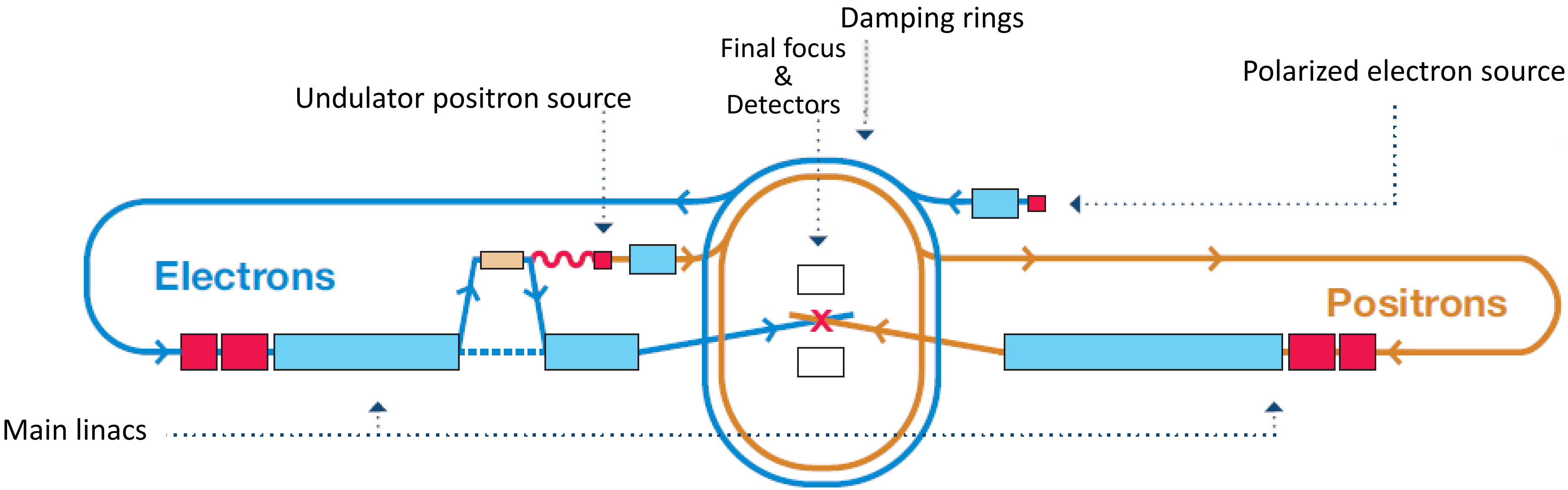
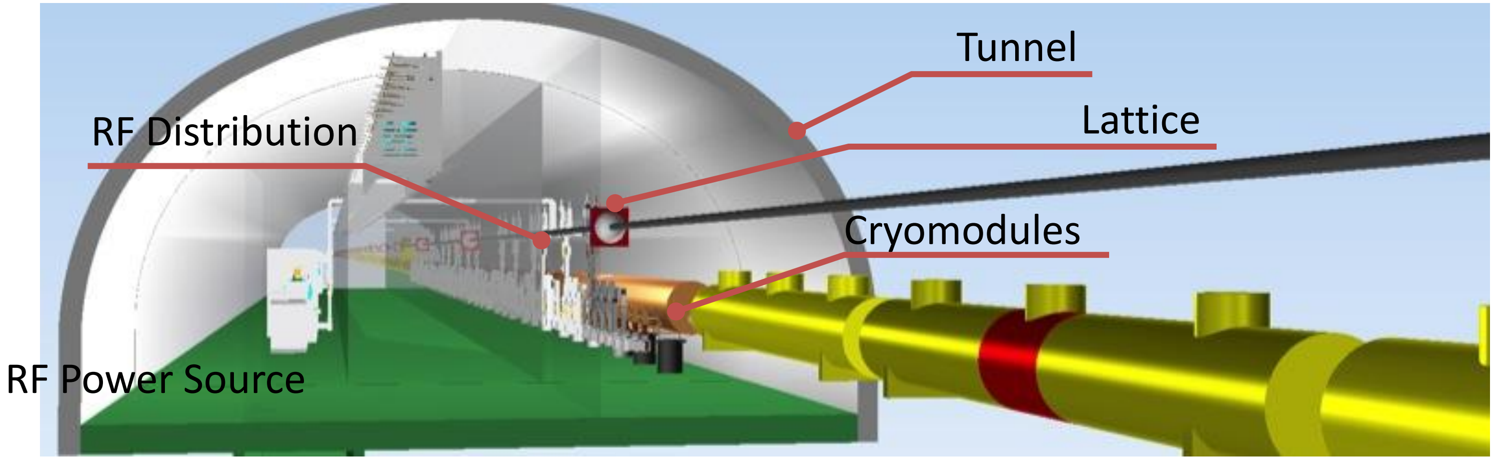
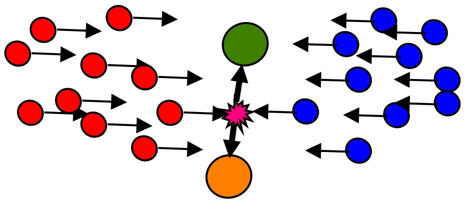
ILC area systems



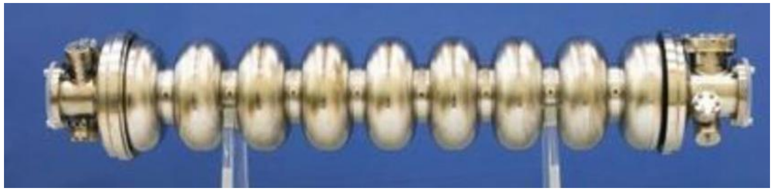


Technology of the ILC

bunch, consisting of ~10^10 e+/e-



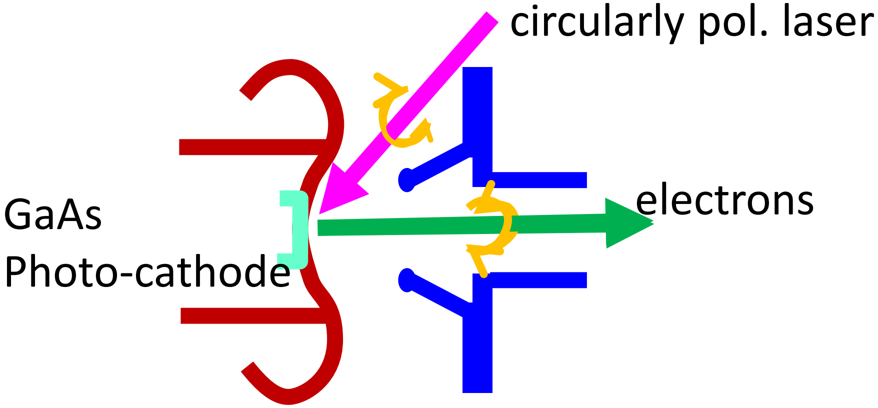
- Creating particles ***Sources***
  - polarized elections/positrons
- High quality beams ***Damping ring***
  - Low emittance beams
    - Small beam spread (small beam size)
    - Small momentum spread (parallel beam)



- Acceleration ***Main linac***
  - superconducting radio frequency (SRF)
- Getting them collided ***Final focus***
  - nano-meter beams

Beam sources -electron/positron-

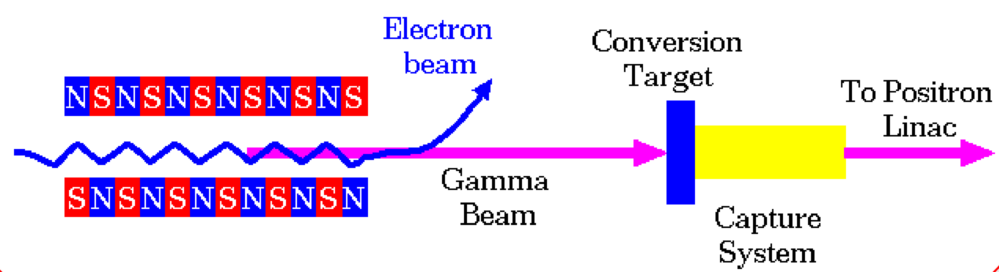
Polarized electron beams

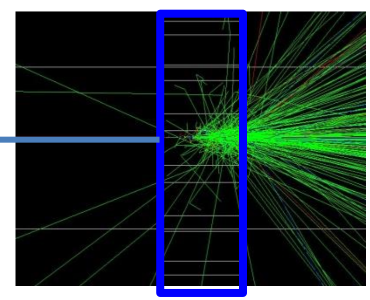


$$P \equiv \frac{N_L - N_R}{N_L + N_R} > 0.8$$

Undulator* positron source

*Undulator is the insertion device (where the static magnetic field alternates) and produces γ ray

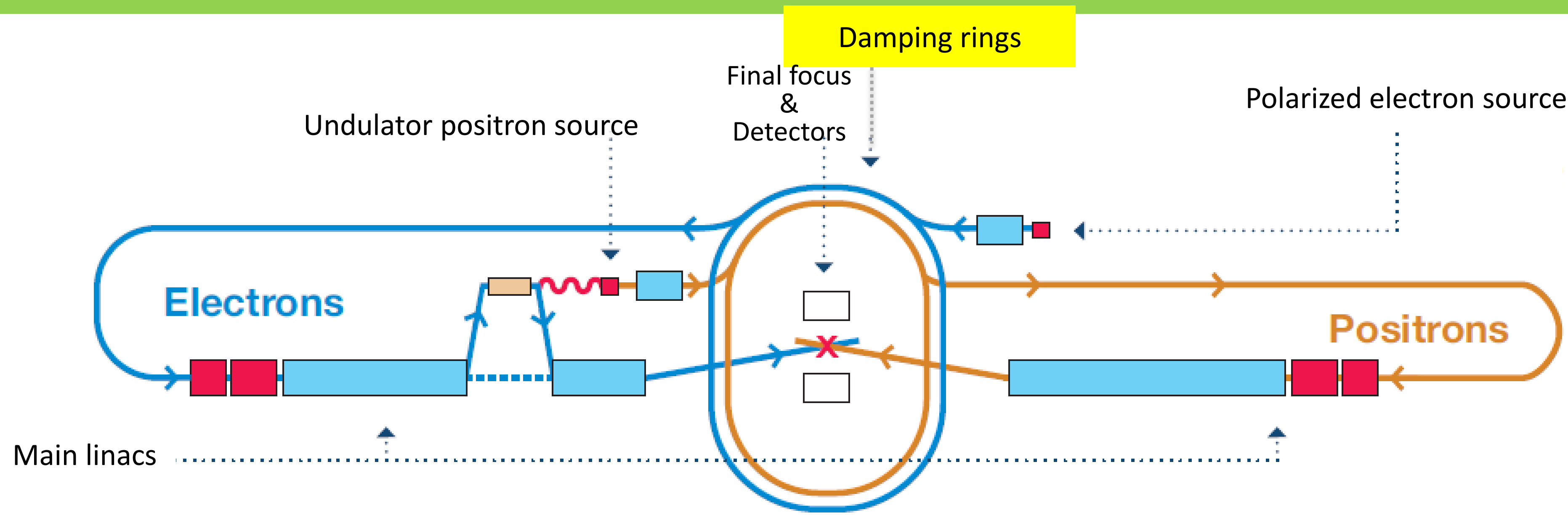


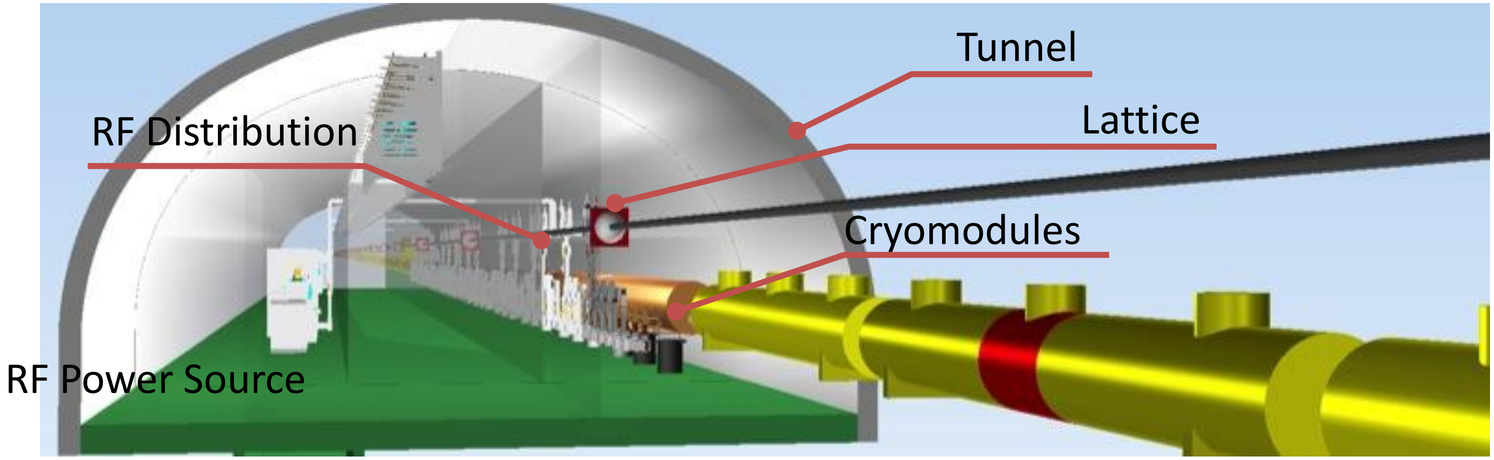


Need to be created via pair (e-/e+) production process

150 GeV e-, 150 m long undulator @ILC

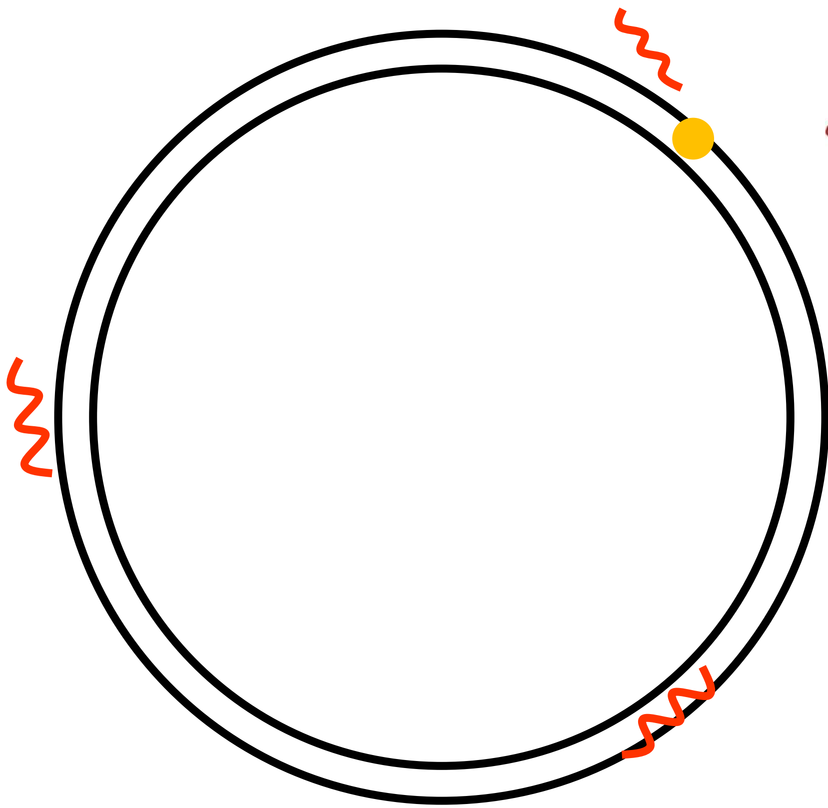
ILC area systems

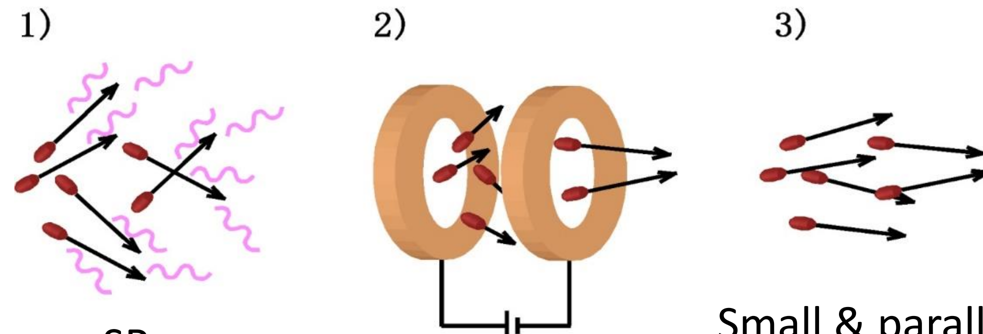




Damping ring

e-/e+ beam will be focused down to a few nm at the IP.
Preparation of the high quality beams to make it possible

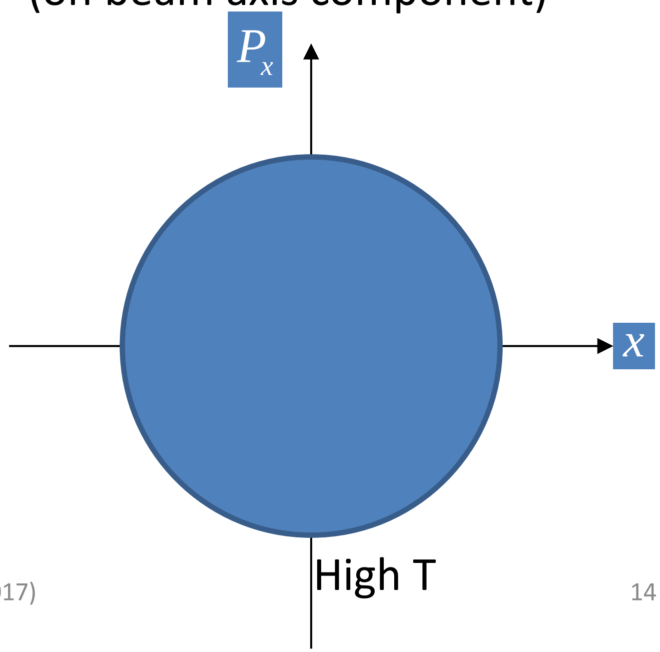




SR

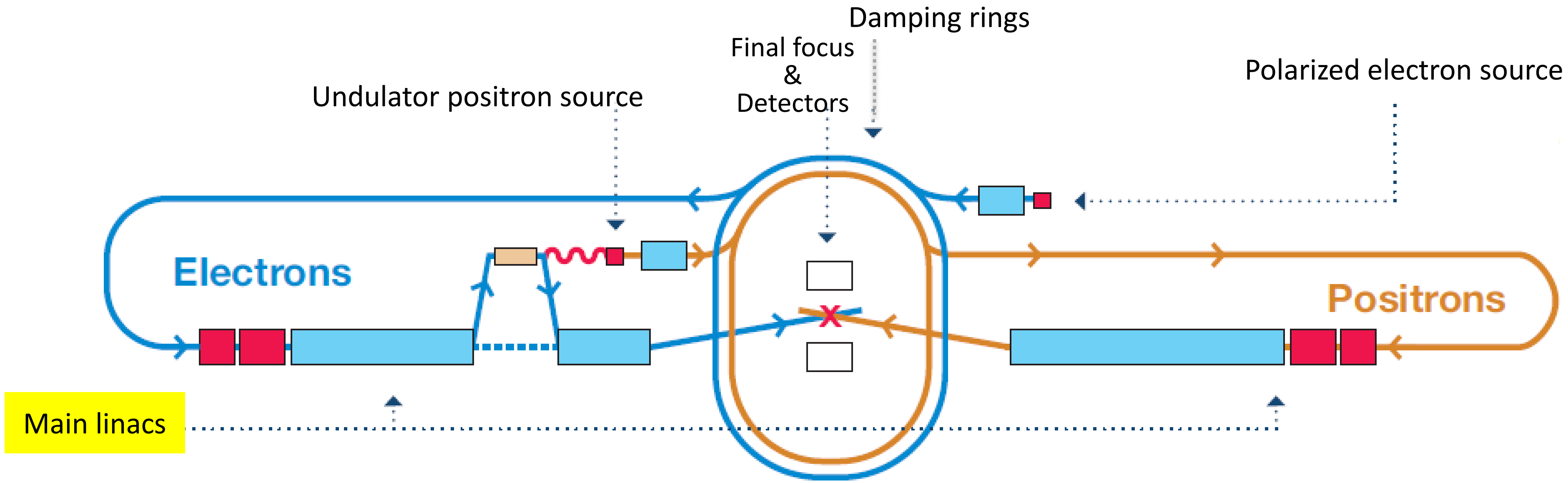
ΔE is compensated
(on beam axis component)

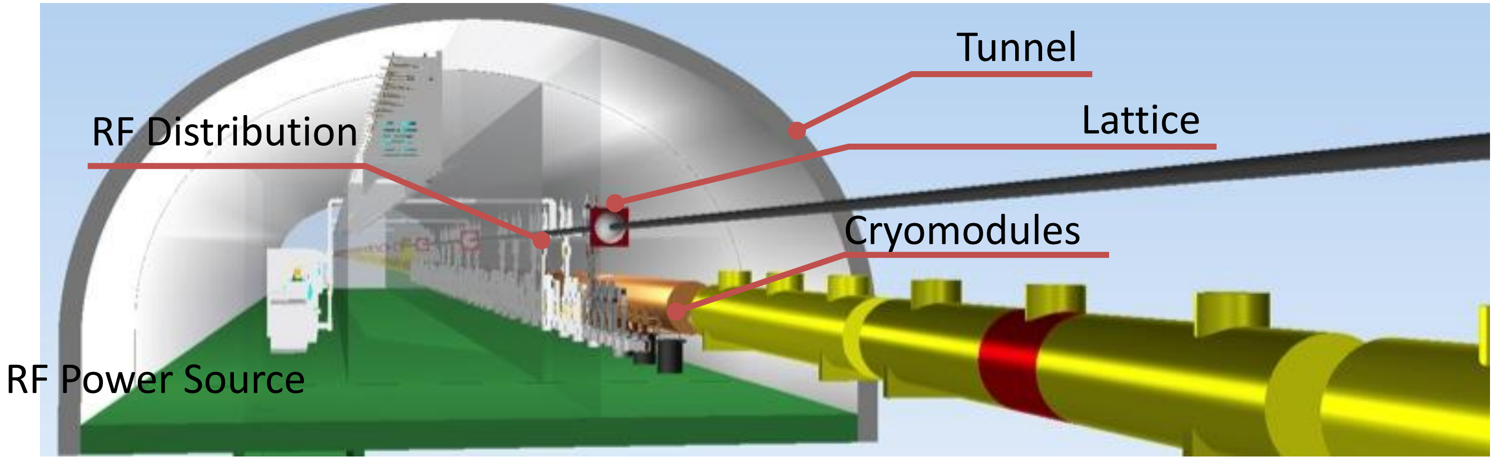
Small & parallel



High T

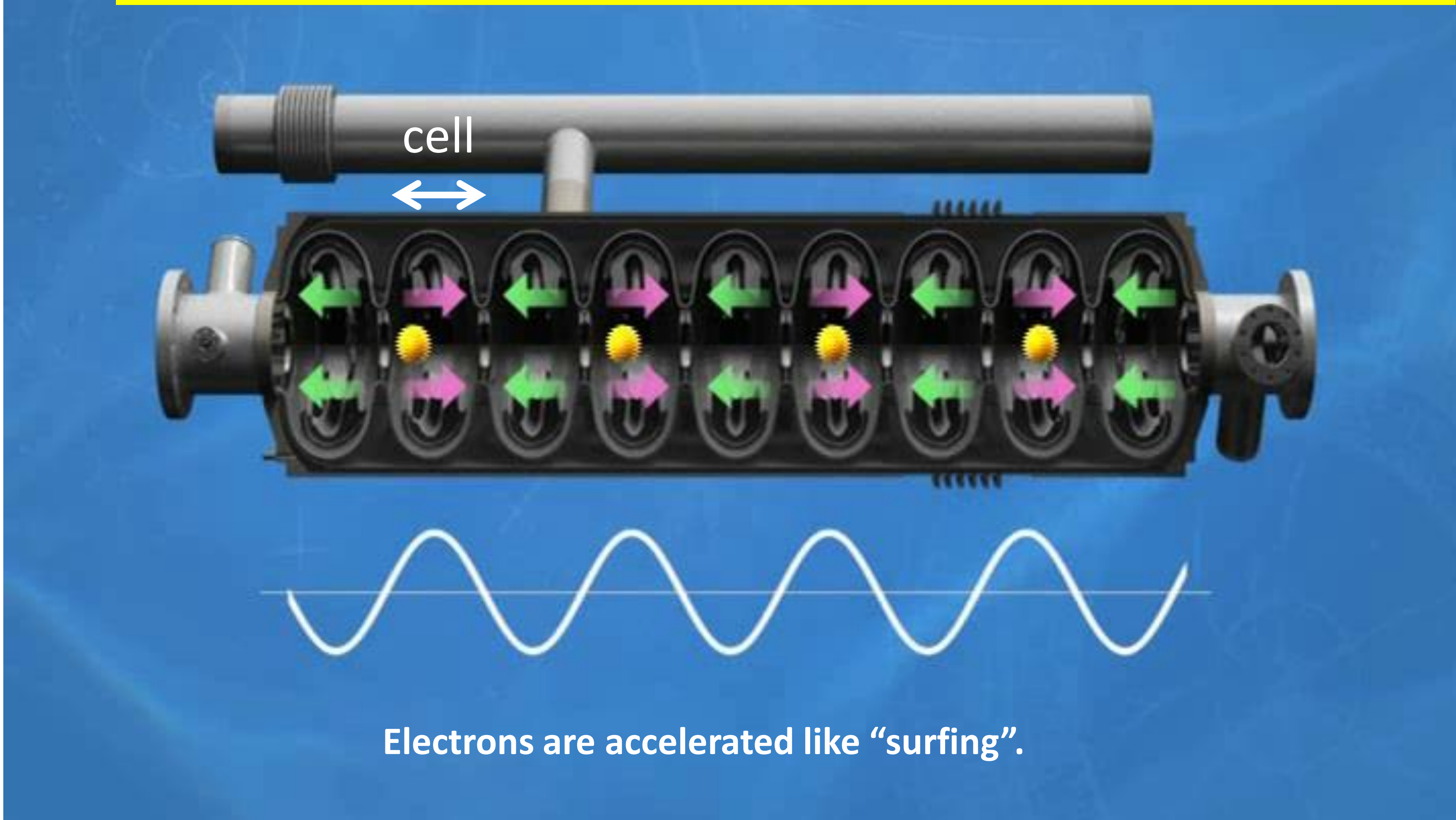
ILC area systems



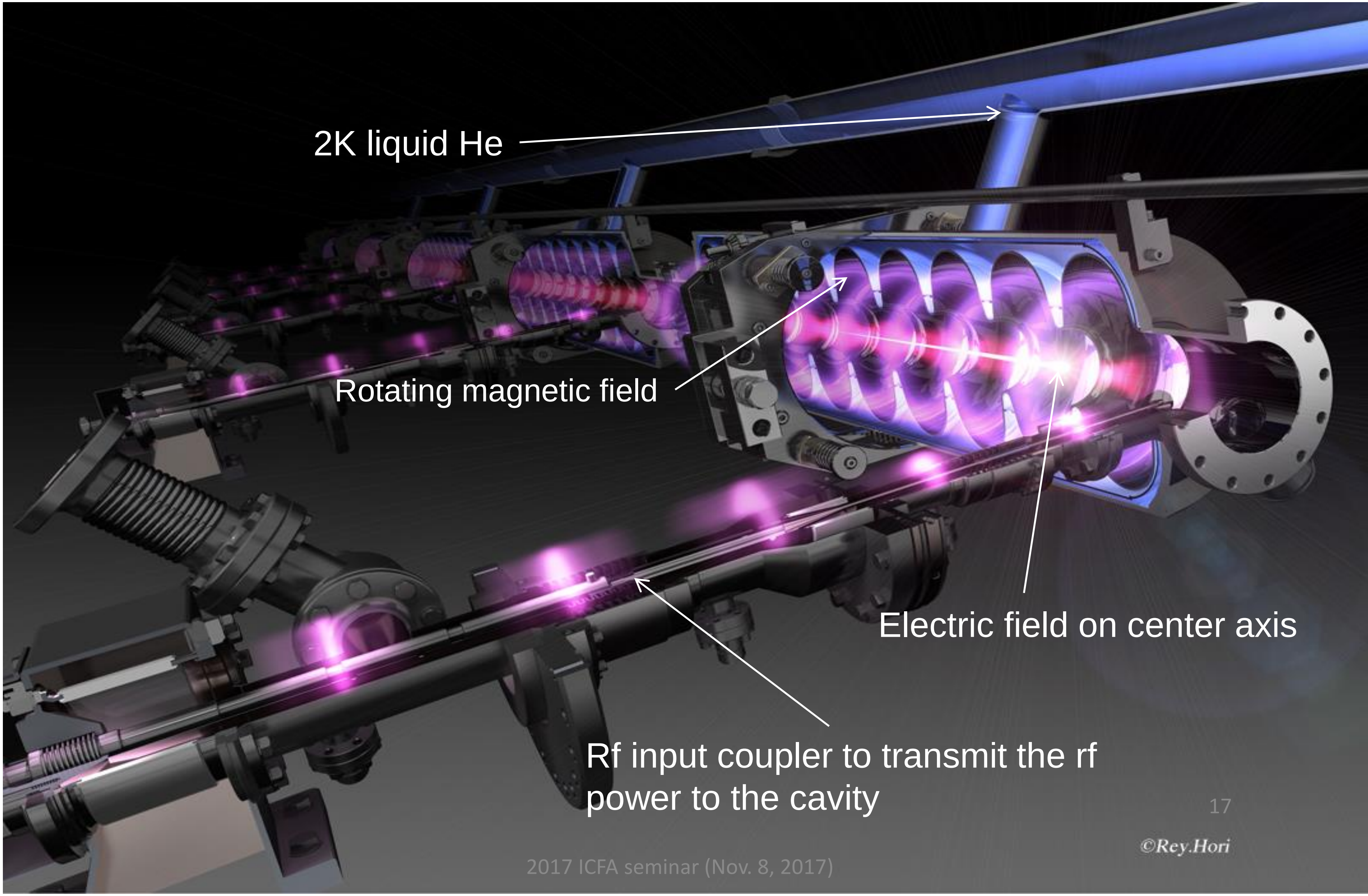


Beam acceleration by radio frequency

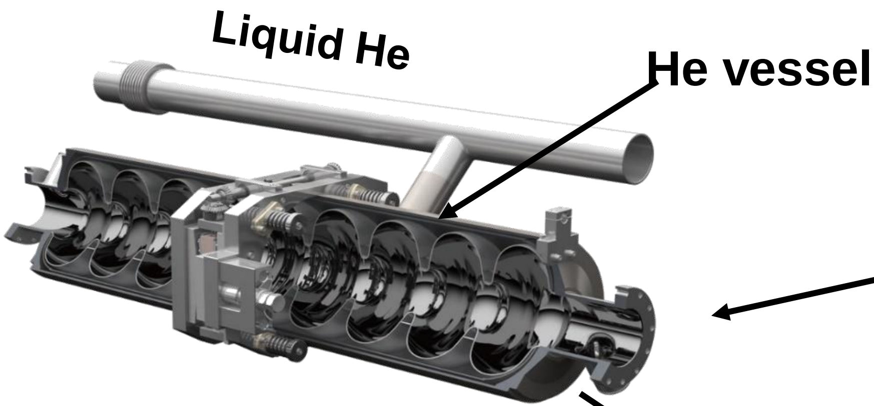
If period of the "radio frequency" is synchronized with the electron movement in the "cell", electrons can be accelerated continuously.



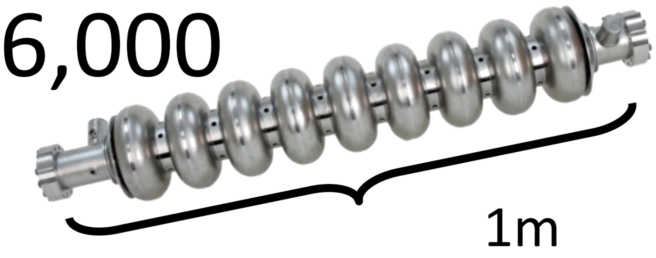
RF field inside the superconducting rf cavity



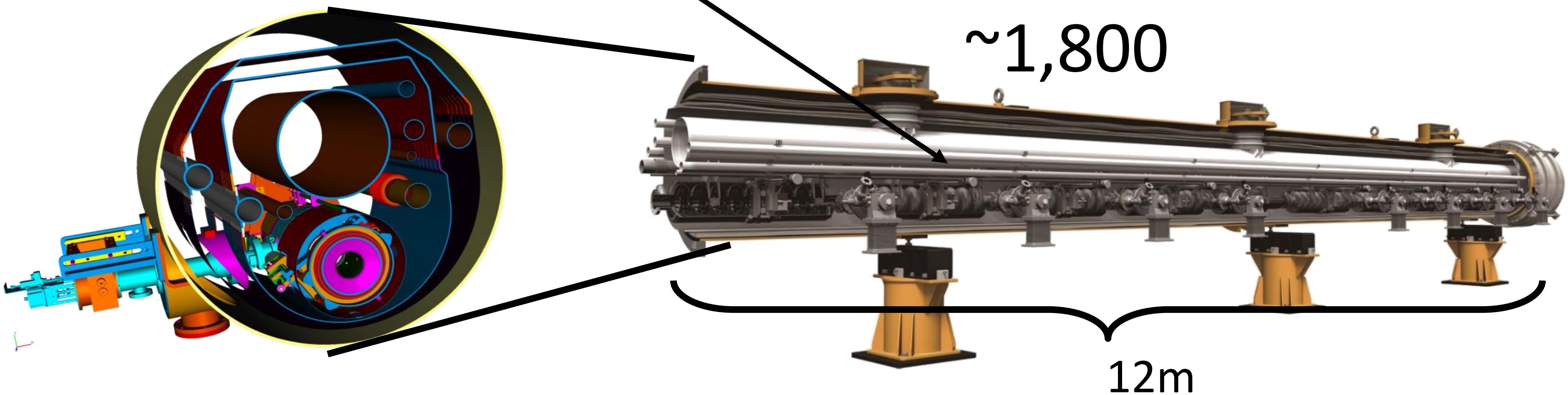
Accelerator Complex



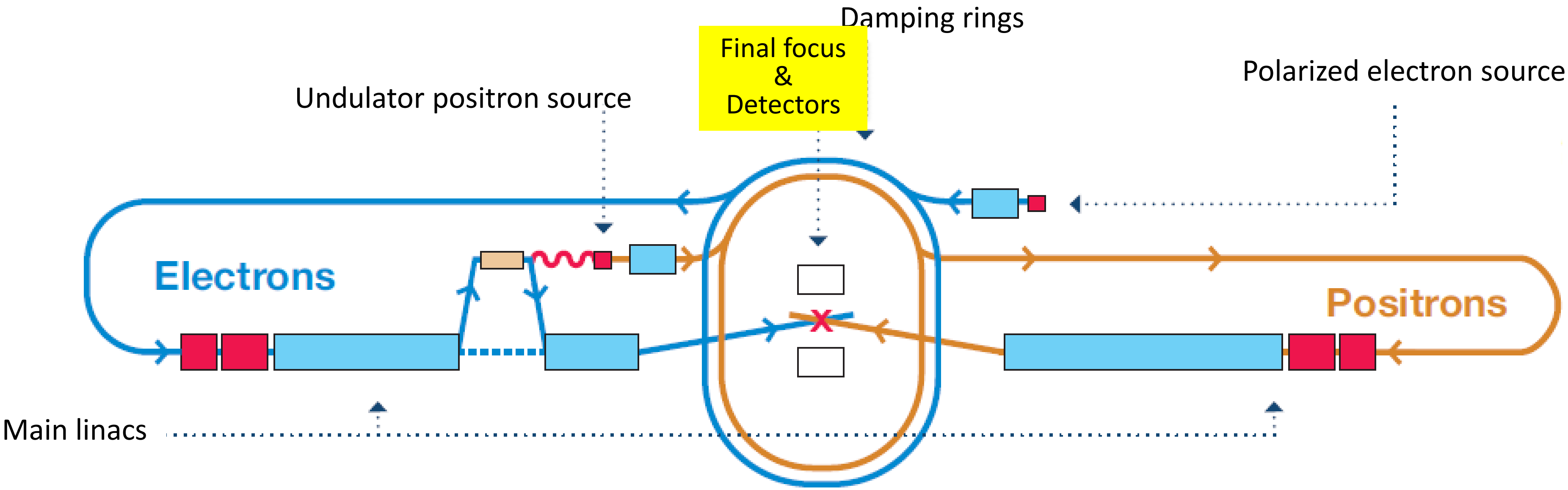
Cavities
~16,000

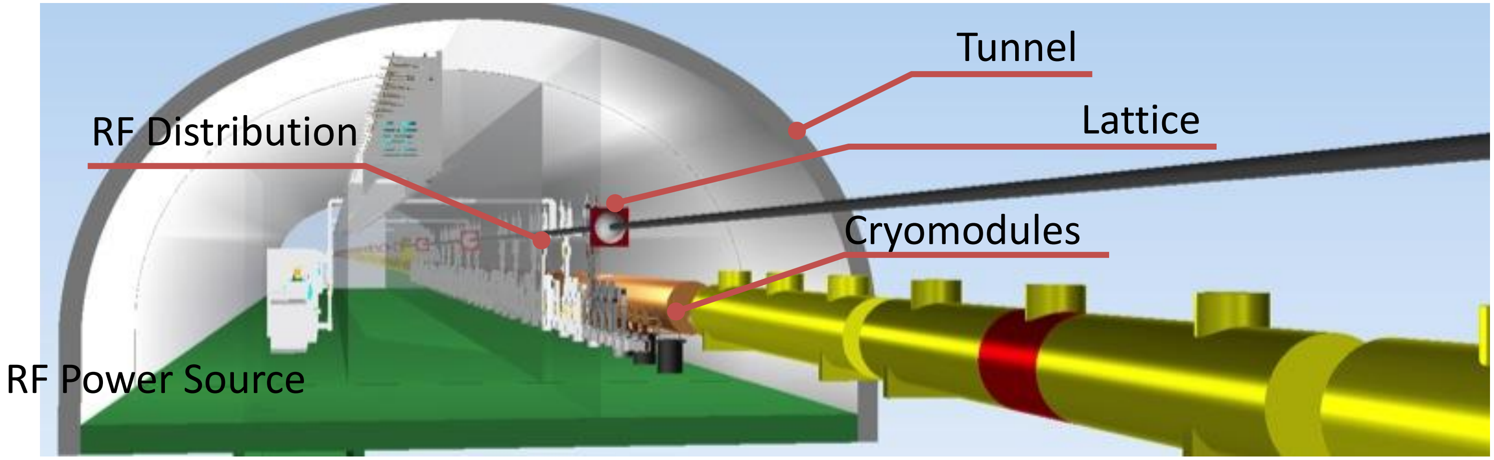


Cryomodules
~1,800

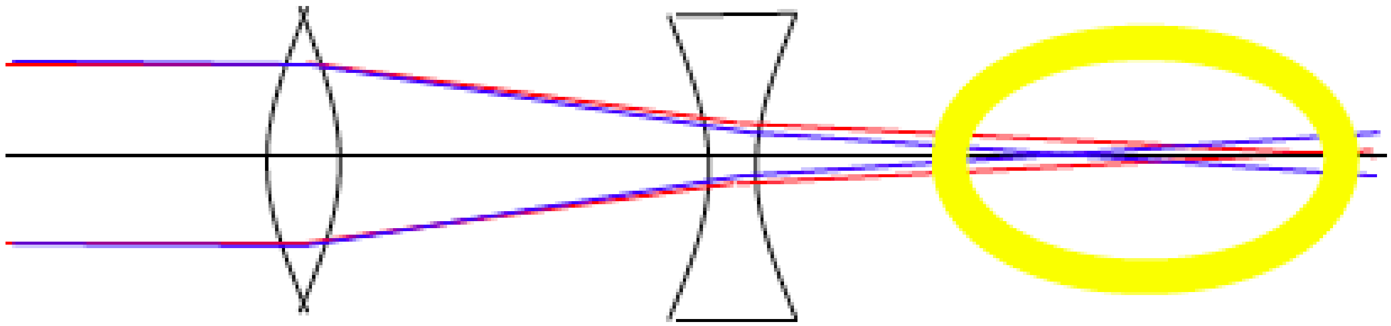


ILC area systems





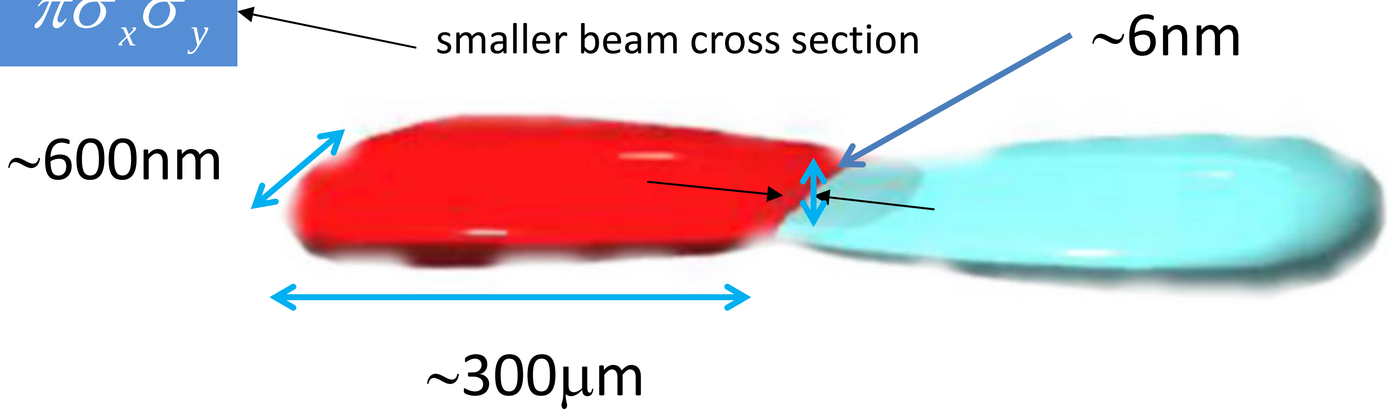
nano beams at interaction point (IP)



$$L \propto \frac{f\,N^2}{\pi \sigma_x \sigma_y}$$

Beam power ~ cost

smaller beam cross section



Final Focus system has been developed at ATF/ATF2 in KEK

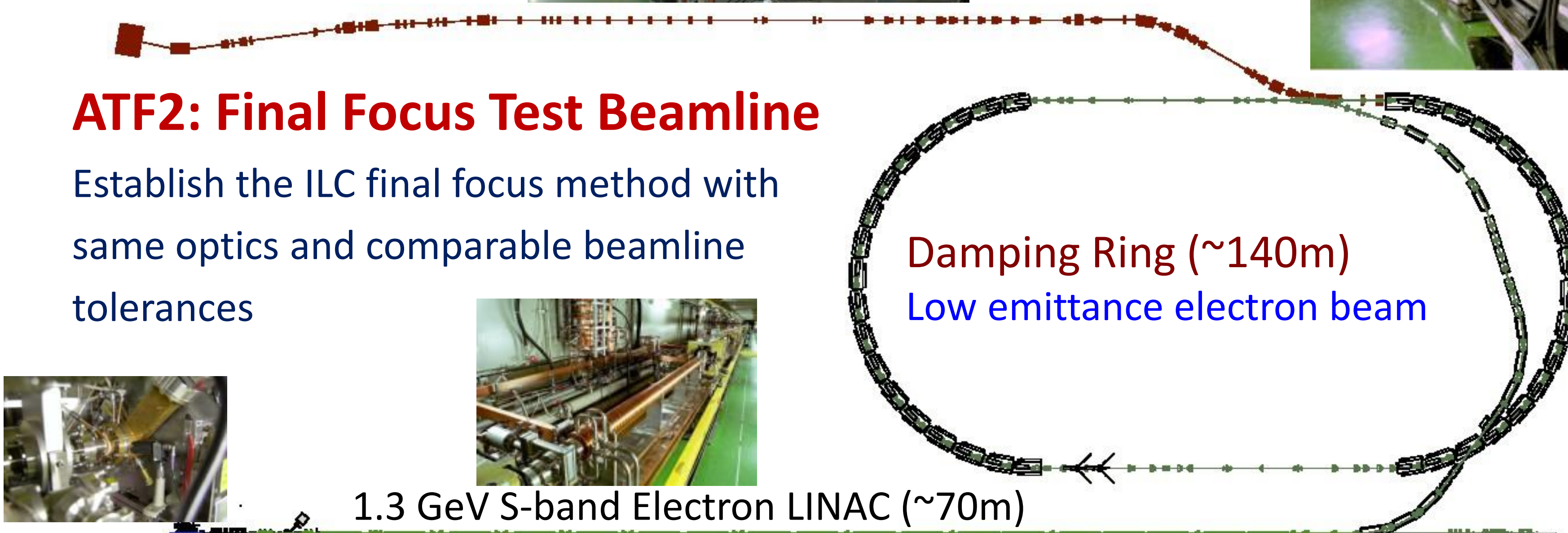
ATF/ATF2: Accelerator Test Facility@KEK

Nanometer beam technologies for ILC has been developed at ATF/ATF2

- Key of the luminosity maintenance
- 6 nm beam at IP (ILC)

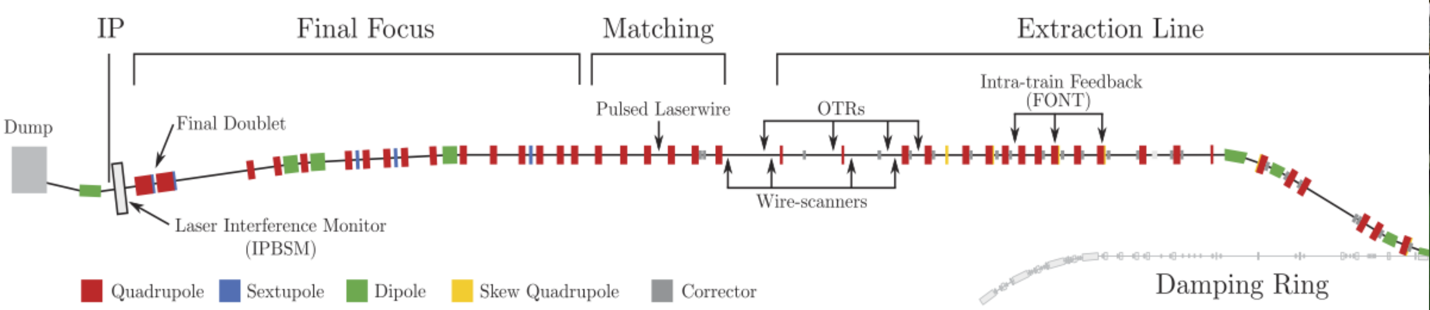
ATF2: Final Focus Test Beamline

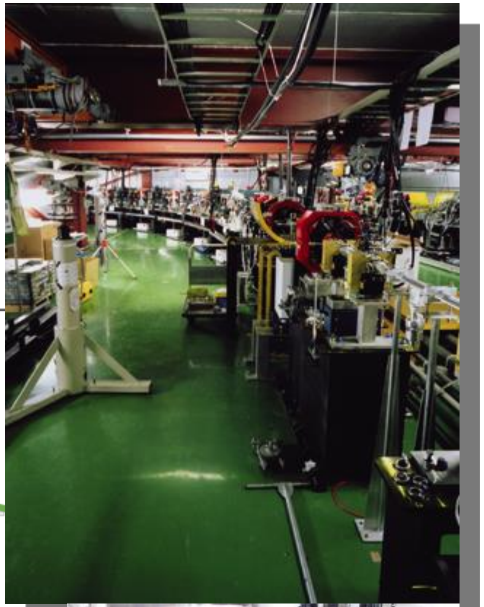
Establish the ILC final focus method with same optics and comparable beamline tolerances

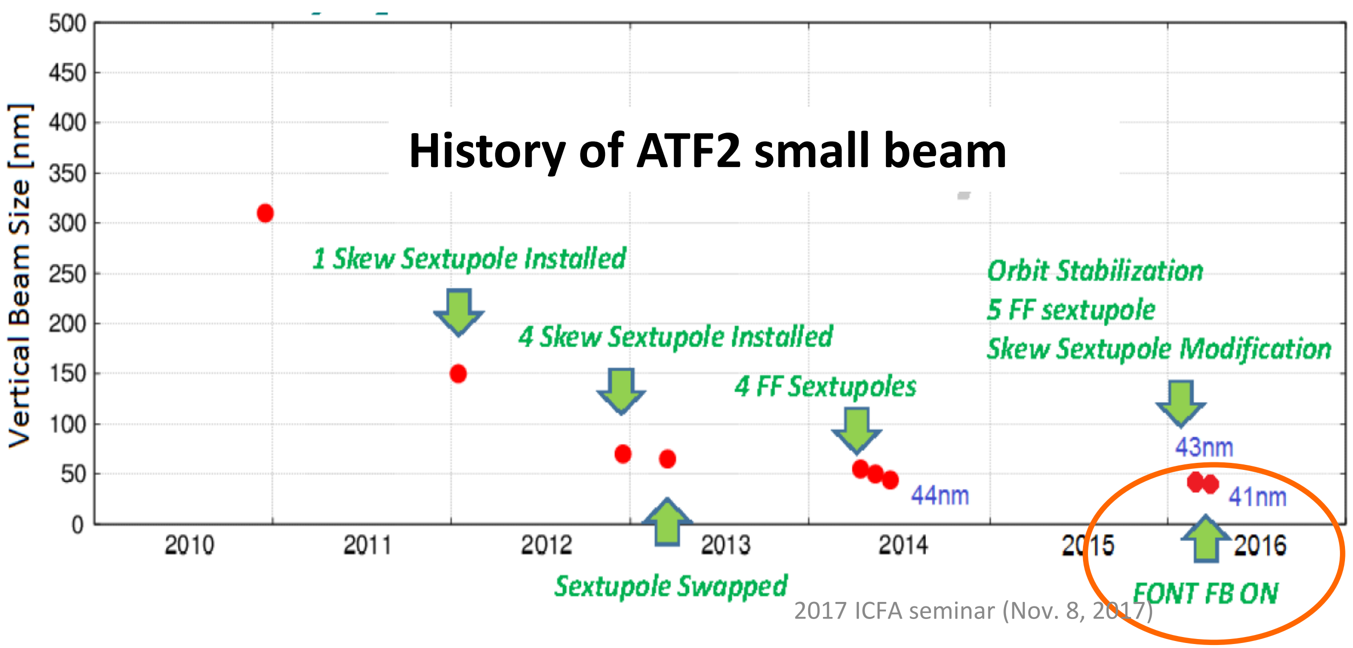


Progress in final focus beam at ATF2

- ATF2 Goal : **37** nm → ILC **6** nm
  - Achieved **41 nm** (2016)







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  - *SRF accelerators in the world*
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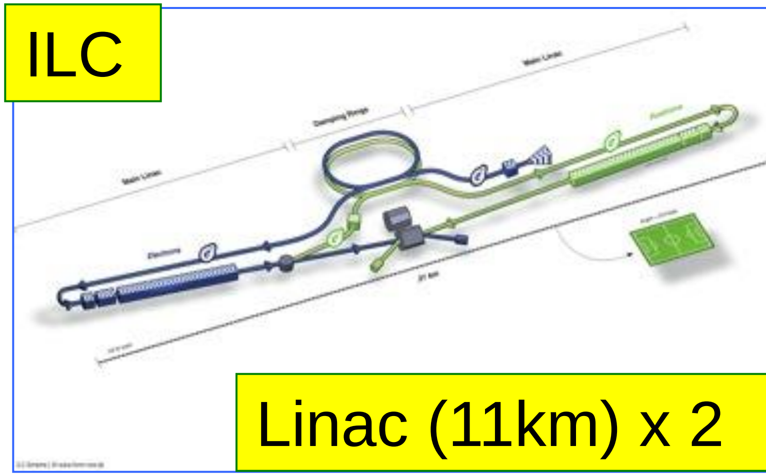
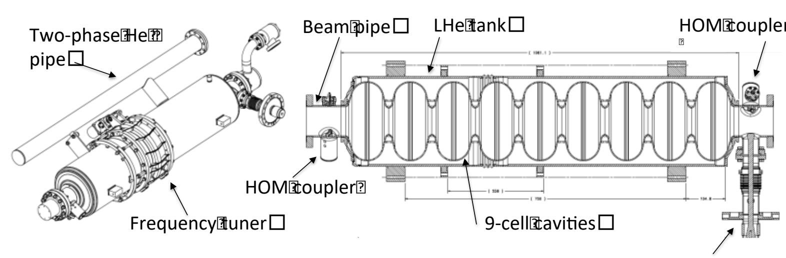
SCRF Industrialization required for ILC

Parameters	Value
C.M. Energy	500 GeV
Peak luminosity	1.5 x10^{34} $cm^{-2}s^{-1}$
Beam Rep. rate	5 Hz
Pulse duration	0.73 ms
Average current	5.8 mA (in pulse)
Av. field gradient	31.5 MV/m +/-20% Q_0 = 1E10
# 9-cell cavity	16,024 (x 1.1)
# cryomodule	1,855
# Klystron	~400

ILC



Linac (11km) x 2



High quality

16024 x 1.1(Yield = 90%)
~ 17600 cavities of mass-production

Major Accelerators Under Construction

2010 ~

Project	Notes	# cavities
CEBAF-JLAB (US)	Upgrade 6.5 GeV => 12 GeV electrons	80
XFEL-Hamburg (EU)	18 GeV electrons – for Xray Free Electron Laser – Pulsed)	840
LCLS-II – SLAC (US)	4 GeV electrons –CW XFEL (Xray Free Electron Laser)	300
SPIRAL-II (France)	30 MeV, 5 mA protons -> Heavy Ion	28
FRIB – MSU 8US)	500 kW, heavy ion beams for nuclear astrophys	340
ESS (Sweden)	1 – 2 GeV, 5 MW Neutron Source ESS - pulsed	150
PIP-II–Fermilab (US)	High Intensity Proton Linac for Neutrino Beams	115
ADS- (China, India)	R&D for accelerator drive system	> 200
Globally Int. Effort		> 2000

SRF accelerators in the world

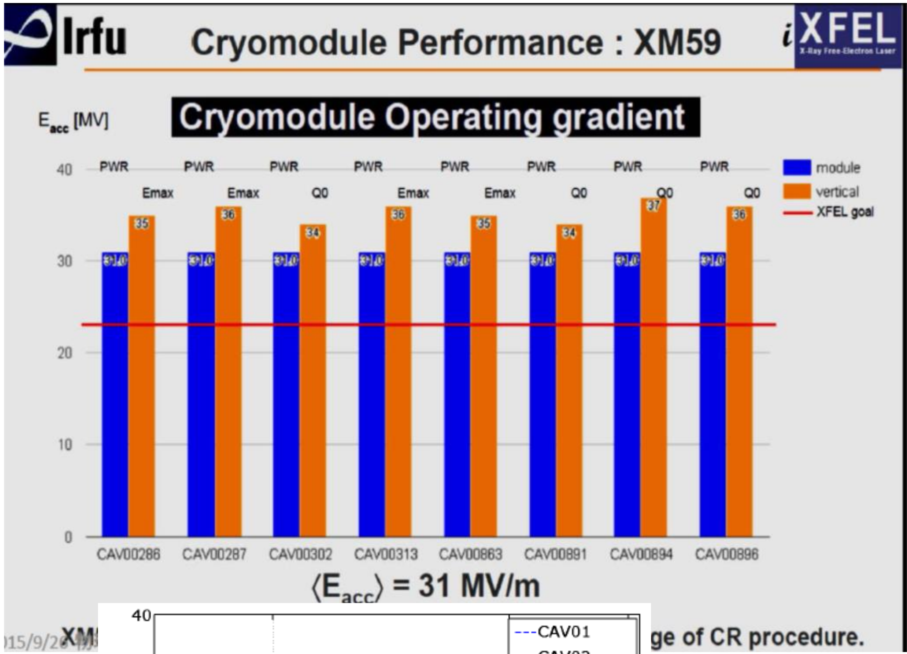
Linear Accelerator

XFEL started commissioning from 2017

Cavity performance

Requirements of cavity gradient
Vertical test (individual test): >35MV/m
Cryomodule test: >31.5MV/m

XFEL example: >35MV/m @vertical test

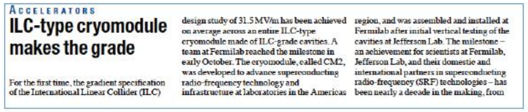


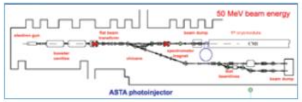
FNAL example: cryomodule test 31.5MV/m

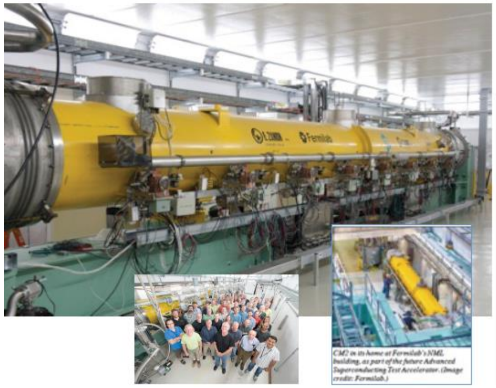
E. Harms, TTC2014

Fermilab : CM2 reached <31.5 MV/m >

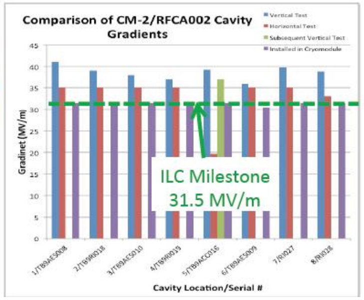
CERN Courier December 2014

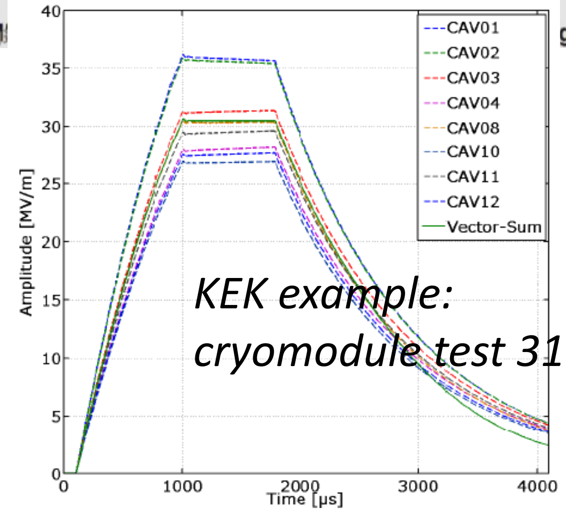






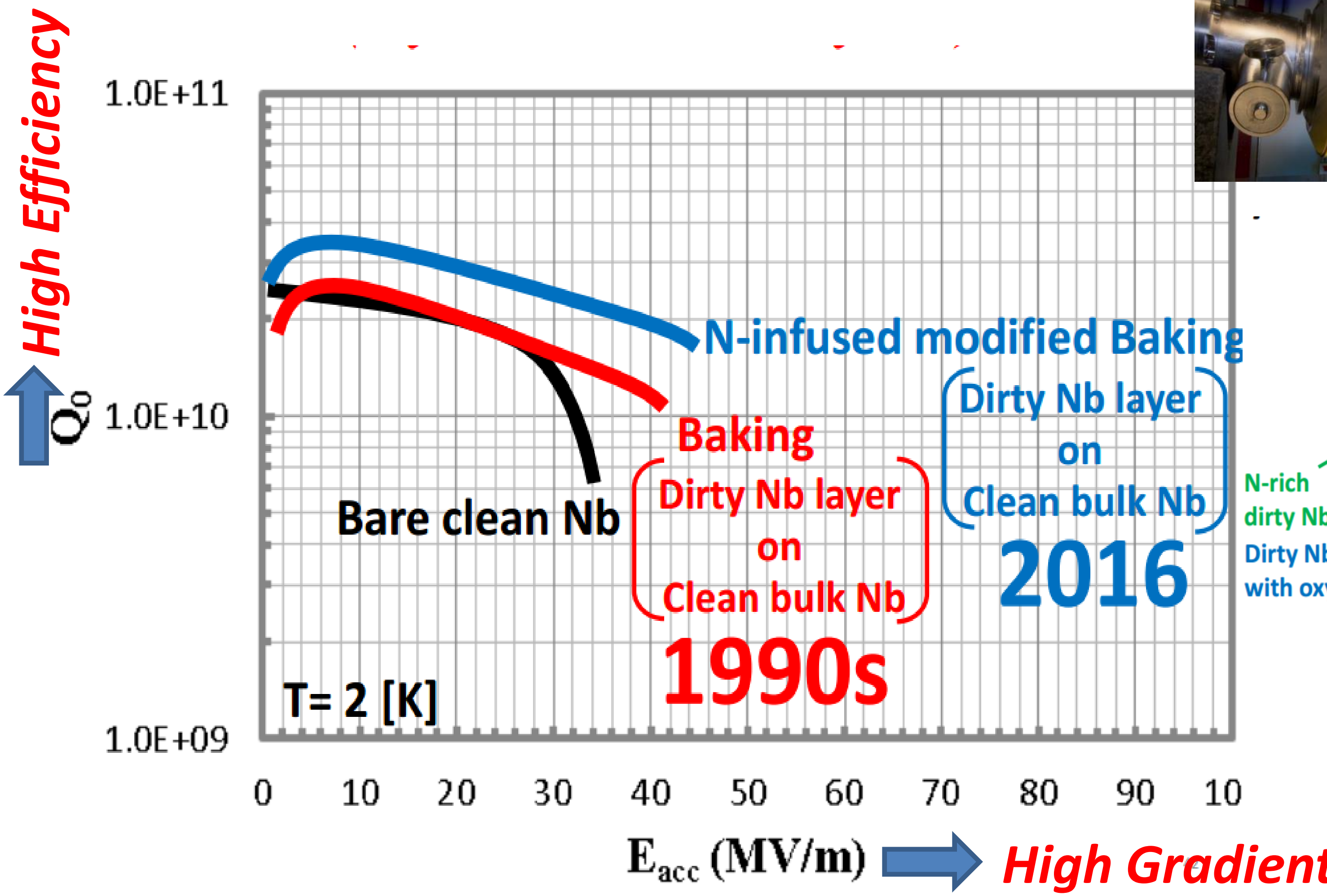
Cryomodule test at Fermilab reached < 31。5 > MV/m, exceeding ILC specification

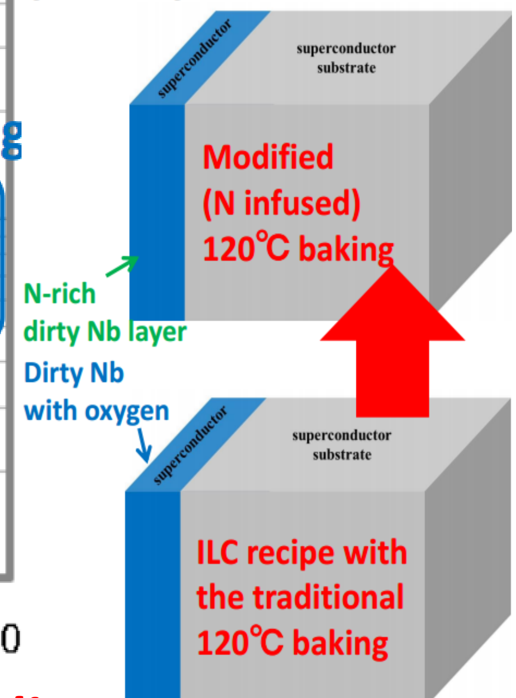




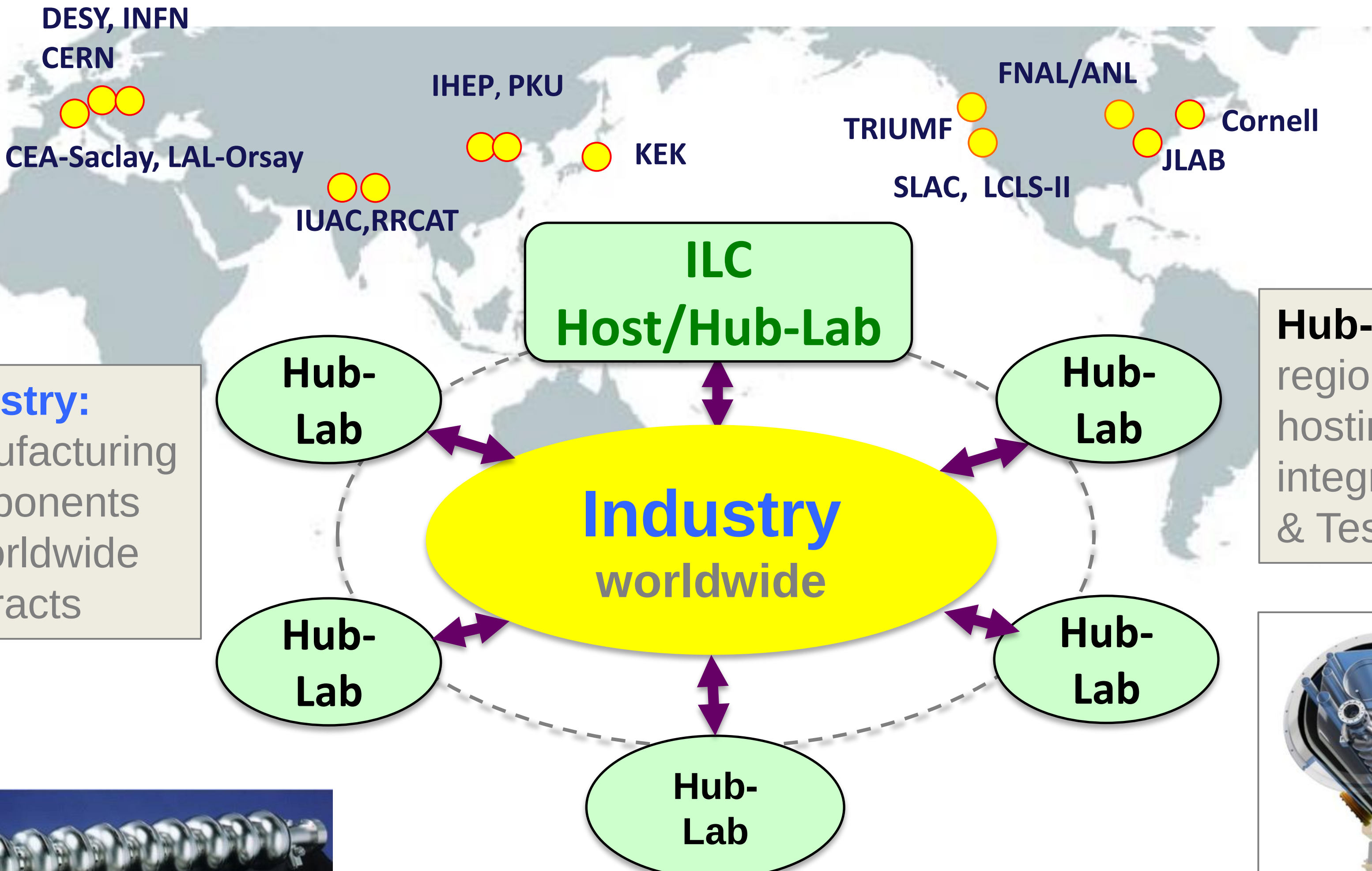
KEK example: cryomodule test 31MV/m

A breakthrough for Higher acc. gradient



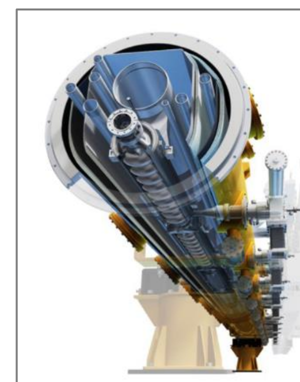


ILC SRF Global Integration Model



Industry: manufacturing components w/worldwide contracts

Hub-lab: regionally hosting integration & Test



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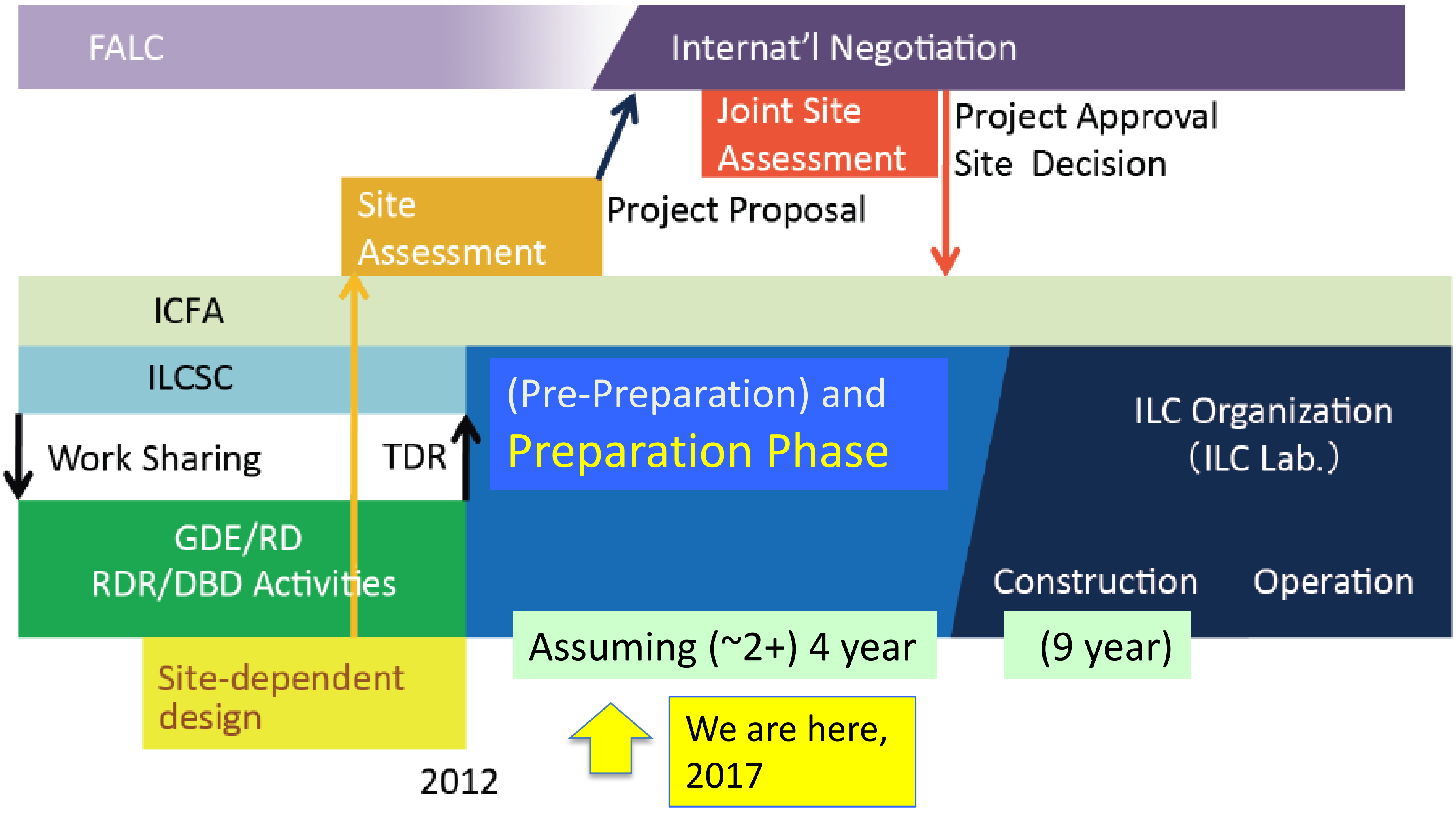
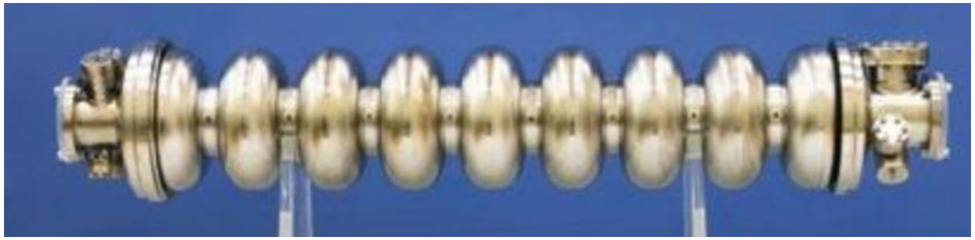
ILC Time Line: Progress and Prospect



US-Japan cost reduction R&D



Cost reduction by technological innovation

Innovation of Nb (superconducting) material process: decrease in material cost

Innovative surface process for high efficiency cavity (N-infusion): decrease in number of cavities

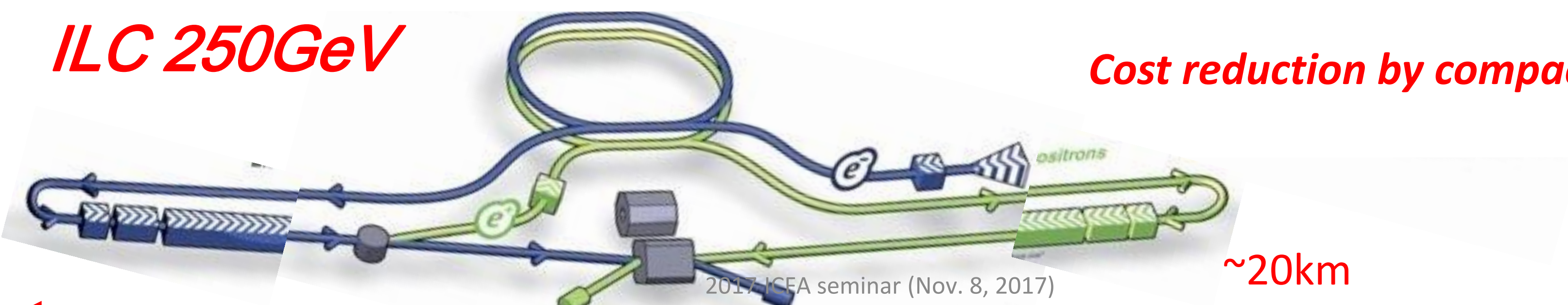
Staging

ILC 500GeV

~31km

ILC 250GeV

Cost reduction by compact ILC



~20km

Thank you for your attention