Accelerator Overview

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7th ACFA Workshop, Taipei, Nov.9.2004

Status
Design Review
Test Facility Plans

A Decision

ICFA chose Superconducting Technology at ICHEP04 Beijing

ITRP Report lists advantages of SC

`http://www.ligo.caltech.edu/~skammer/ITRP/ITRP_Report_Final2.pdf`

`http://www.ligo.caltech.edu/~skammer/ITRP/execsumm_final1.pdf`

- Simpler operation
  - Large cavity aperture ⇒ less sensitive to ground motion
  - Large bunch distance ⇒ inter-bunch feedback
- Lower risk of main linac
- XFEL provides prototype
- Industrialization underway
- Less power consumption

The report also states

- We are recommending a technology, not a design
- We expect the final design to be developed by a team drawn from the combined warm and cold linear collider communities

Next Step

- Formation of international collaboration
  - We needed ITRP because 1 region alone cannot build LC
  - LC never built if warm proponents give up collaboration
- Review of all the design aspects of Superconducting LC
- List up remaining R&D
- Refinements towards industrial design

Depressed?

Honestly yes, for a while, but

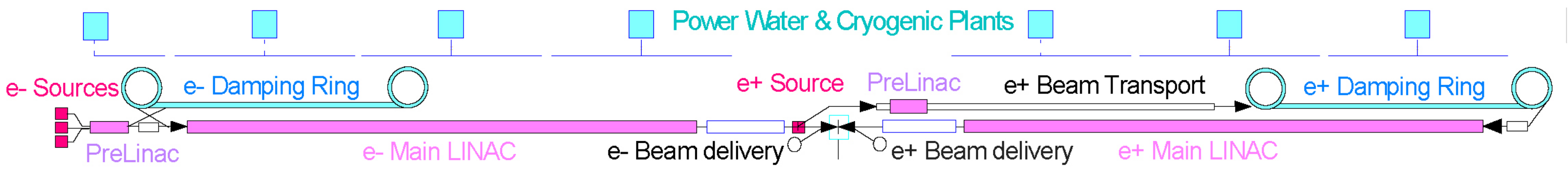
Quickly reforming ourselves

- Forming SCRF group
  - Fortunately we have rich manpower and experience for SCRF (Tristan, KEKB, J-Parc)
  - Planning a test facility
- ATF continues
  - The only ring that can create low emittance beam
  - May even create TESLA format beam
- Strengthening Asian collaboration ($\Rightarrow$ Kurokawa)
- Even more enthusiastic participation of industries

Can TESLA be the baseline?

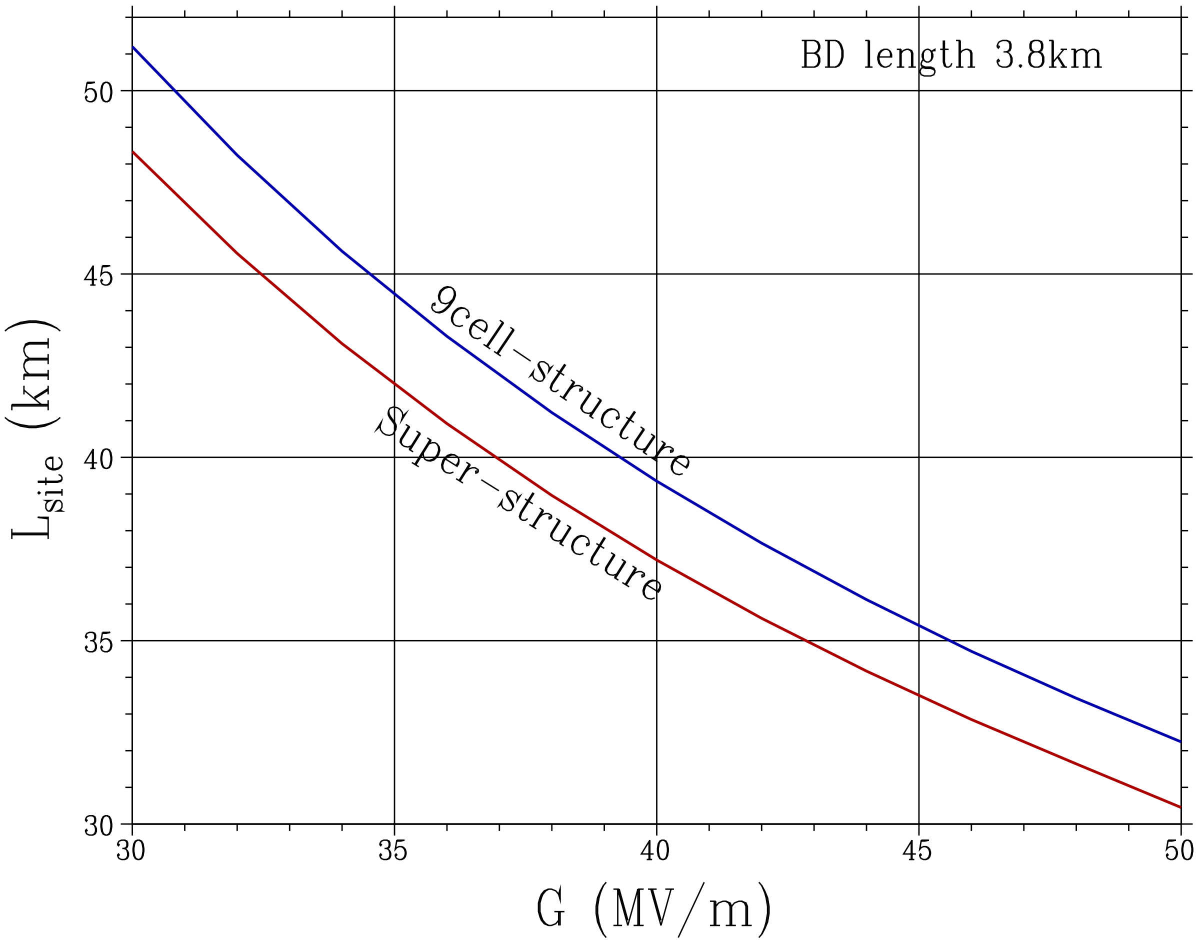
Still many alternatives remain after the SC/NC decision

- Accelerating gradient: 35MV/m or higher ?
- Tunnel: Single or double (or triple) ?
- Damping ring: dogbone or small ?
- Positron production: undulator or conventional ?
- Crossing angle: zero or small or large ?



Gradient

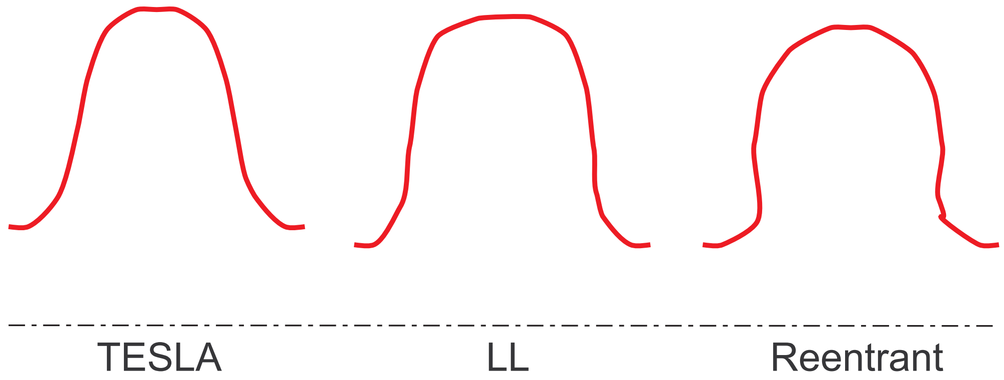
- Must reach 1TeV
- Gradient gives an impact on the site length
- Presumably not an issue for US, but
- Is an issue for Japan and, perhaps, for Germany too.
- A few candidates in Japan $\gtrsim$45km, but prefer higher gradient



Site length vs. Gradient for 1TeV

Higher Gradient Cavities

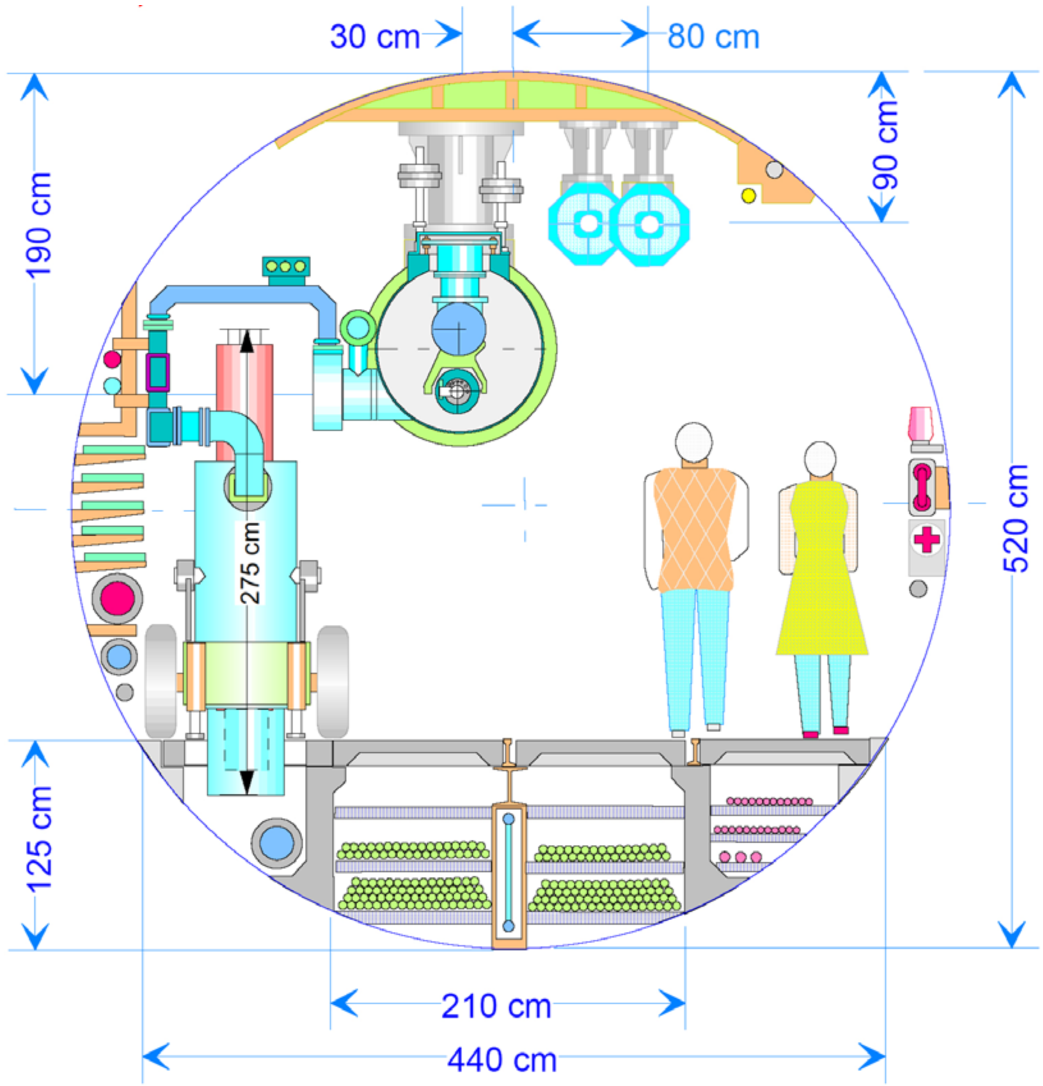
- Today's data seems to indicate the SC breakdown limit already nearly reached.
  Max.surface magnetic field $\approx$ 1750 Oe
- With TESLA cavity
  (Max.surface magnetic field)/(Accelerating electric field)=45.6 Oe/(MV/m)
- Other possible shape
  LL(Low Loss) type designed at JLab : 37.4 Oe/(MV/m)
  or reentrant type
- Can presumably reach
  $\gtrsim$45MV/m
- At KEK
  Single-cell test : Dec.2004
  9(8)-cell test: Sep.2005



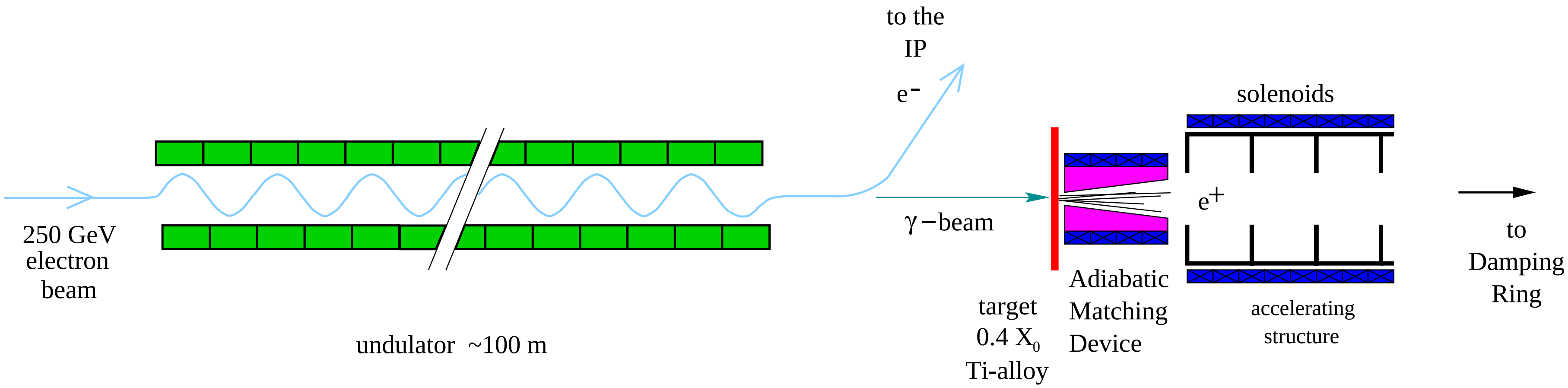
Not to be accuarate

1/2 Tunnels?

- TESLA design adopts single tunnel, accomodating
  - Klystron
  - Linac cryomodule
  - 2 Damping Ring lines
- TESLA says
  - Save cost ~300MEuro
  - Double tunnel has ground motion problem
- But many problems of operation
- Not a big impact on overall design



Positron Production



Pros

- Polarized positron
- Single target

  Cf: X-band e^+ source requires 3 targets
- Better emittance of created e^+ beam

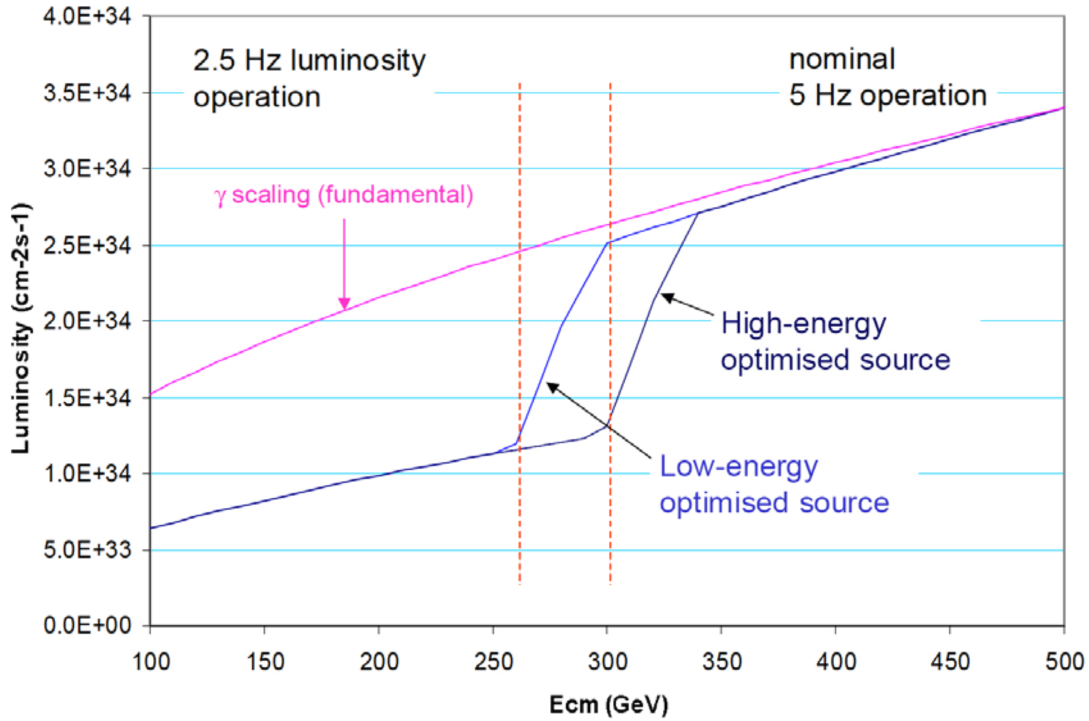
Cons

- Complex commiss./operation (e^+/e^- operation coupled)
- Low energy operation
- IP energy spread of e^- beam $0.05\% \Rightarrow 0.15\%$

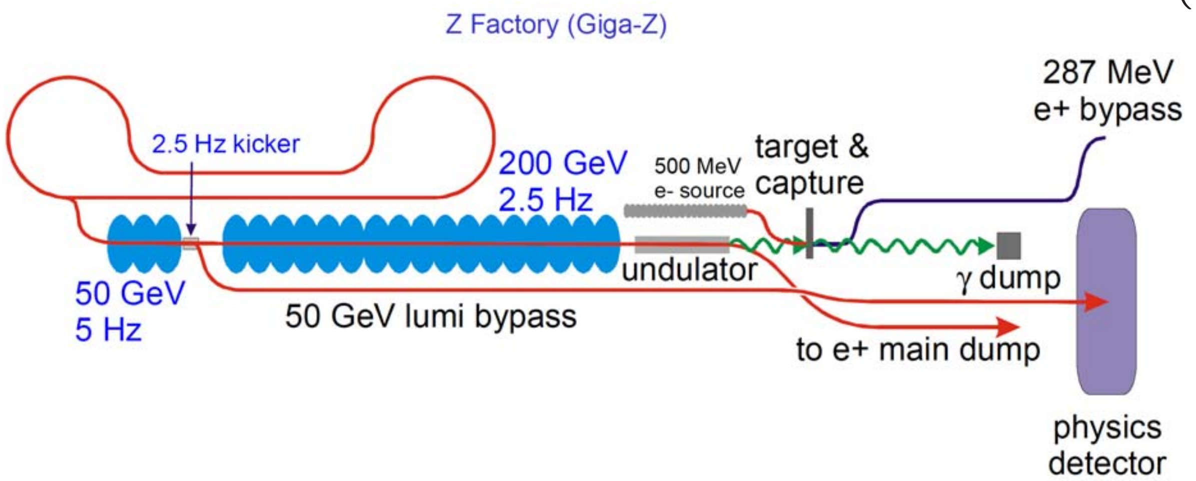
Low-Energy TESLA

According to TESLA estimation

- $N(e^+)_{produced}/N_{needed}$=2 at E_{CM}=500GeV
- $\approx$ 1 at 340GeV
- $\approx$ 1/2 at 300GeV
- Use every other pulse for e^+ generation for <300GeV Luminosity $\Rightarrow$ half
- Special configuration for Giga-Z



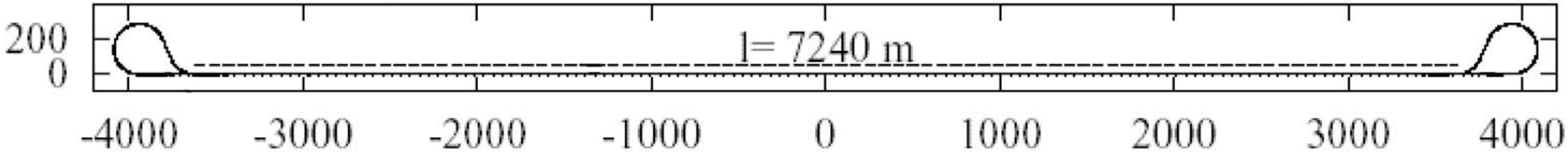
(From a poster in ITRP at DESY)



Conventional Positron Production

- Hit electrom beam on target rather than photon.
- Can decouple e^+/e^- beams
- Thick target (several rad length) $\Rightarrow$ more energy deposit
- TESLA rejected the conventional method since the design start, because of the large pulse charge (40 times X-band)
- But, later turned out 1ms pulse is long enough to prevent stress accumulation.
- US estimation says comparable to X-band
- Target damage test possible at KEKB
  - Ring total charge $\sim 10\mu$C, close to TESLA pulse charge
  - Extraction in 10μs by existing abort system
    (Extraction in 1ms requires advanced kickers)
- No polarized positron

Damping Ring



Problems of the Dogbone design

(a) Commissioning/operation

- DR commissioning only after linac completion
- No DR tuning during linac repair

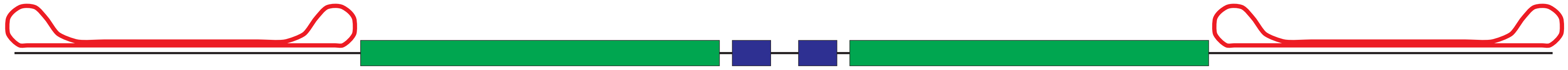
(b) Stray field from linac can disturb beam extraction from DR. $O(\mu$Tesla) matters.

(c) The long straight sections

- Space-charge force (Coulomb force within a bunch)
- Long wiggler section needed $\Rightarrow$beam stability range

(d) Fast kicker ($\lesssim$20ns) needed for injection/extraction

- (a)+(b) (coming from sharing tunnel) can be partially solved by



  in the 500GeV stage (But not in 1TeV stage)

- Space-charge problem is solved by 'coupling bump' in theoretical/computer level

- Kicker under development at DESY (data as of Apr.2004)

	spec.	measured	
Rise time (10%-90%)	8ns	4.9ns	
Micro pulse rep rate	3MHz	2MHz	
Macro pulse rep rate	5Hz	5Hz	
Amplitude stability	0.05%	1.2%	(0.2% with 30 kickers)
Residual kick	0.5%	2.75%	

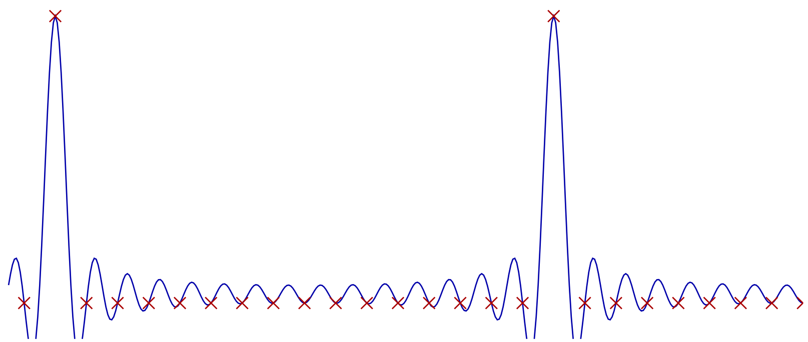
Alternative Design of DR   Is a smaller ring possible?

- Compress more the bunch interval
- Main motivation is to avoid interference with linac
- but not the cost issue

Numerous ideas on injection/extraction

- Stripline kicker
- Fourier kicker

$$\sum_{k=0}^{N-1} e^{i(\omega_0 + k\Delta\omega)t}$$



Difficulties of Small DR

- Even more ambitious kickers required
- Collective instabilities harder (higher beam current)

Also, note:

- We are going to adopt 35MV/m as baseline
- TESLA 35MV/m (800GeV) requires 4886 bunches (11.5ns in DR), not 2820 bunches (20ns)
- Even more bunches preferred at higher gradient
  (in order not to loose power efficiency)

Crossing Angle

- Basically no big difference from warm design
- except for items related to the bunch distance
  - No bunch-to-bunch interference
  - IP fast feedback easier
- Three different designs

Original TESLA	zero crossing angle
GLC	small angle (7mrad)
	$\rightarrow$ bunch-to-bunch interference
NLC	large angle (20mrad)

- 2nd IP: e^+e^- and γ-γ compatible?
- Linac orientation is another issue

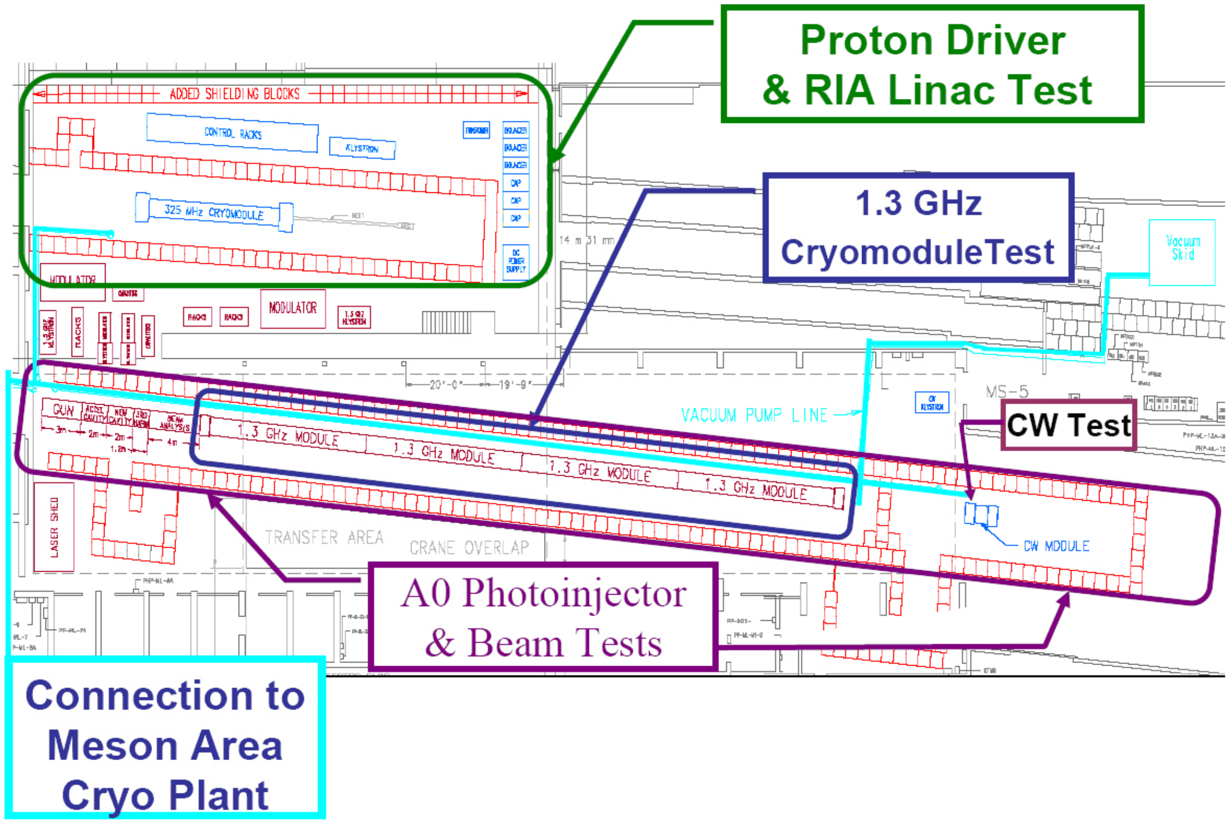
Test Facilities

blue:existing, red:near future

- US
  - SMTF at FNAL
- Europe
  - TTF at DESY
  - Euro X-FEL at DESY
- Japan
  - STF at KEK
  - ATF at KEK

SMTF Superconducting Module & Test Facility

FNAL Meson Area SM&TF Layout Concept



Collaboration of

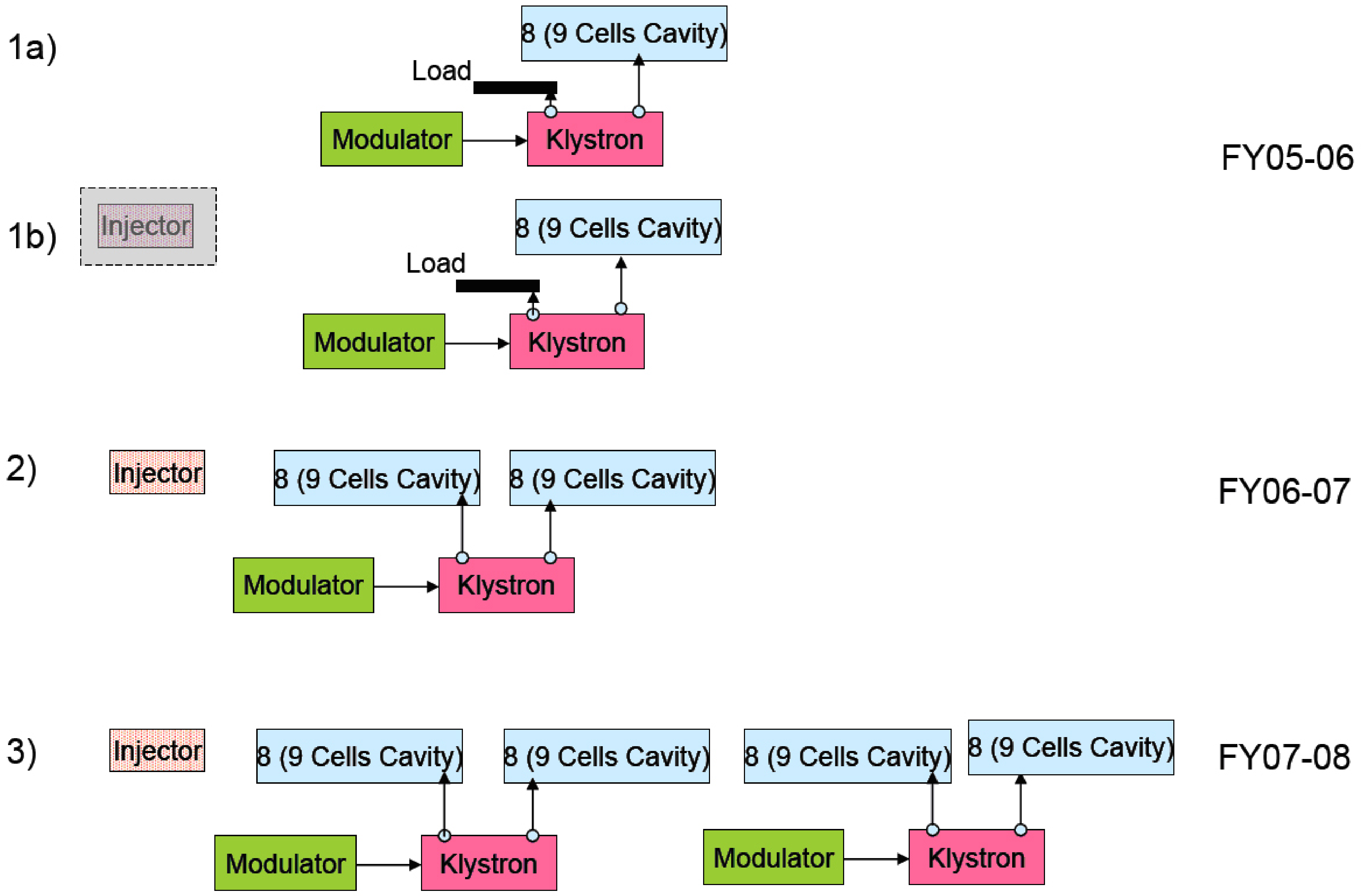
- FNAL, ANL, BNL, JLab, LBL, SNS, SLAC...
- DESY, INFN, KEK

SMTF Program

FNAL Meson Experimental Area: Not an LC-dedicated facility

- ILC R&D
  - cryomodule fabrication
  - module test with upgraded A0 injector
  - establish 35MV/m
- CW test area (for light source)
  - RF, cryogenics, controls
  - 20MV/m CW
- Proton Driver and RIA (Rare Isotope Accelerator) R&D
  - $v < c$, 325MHz

1.3 GHz Cryomodule Test Facility

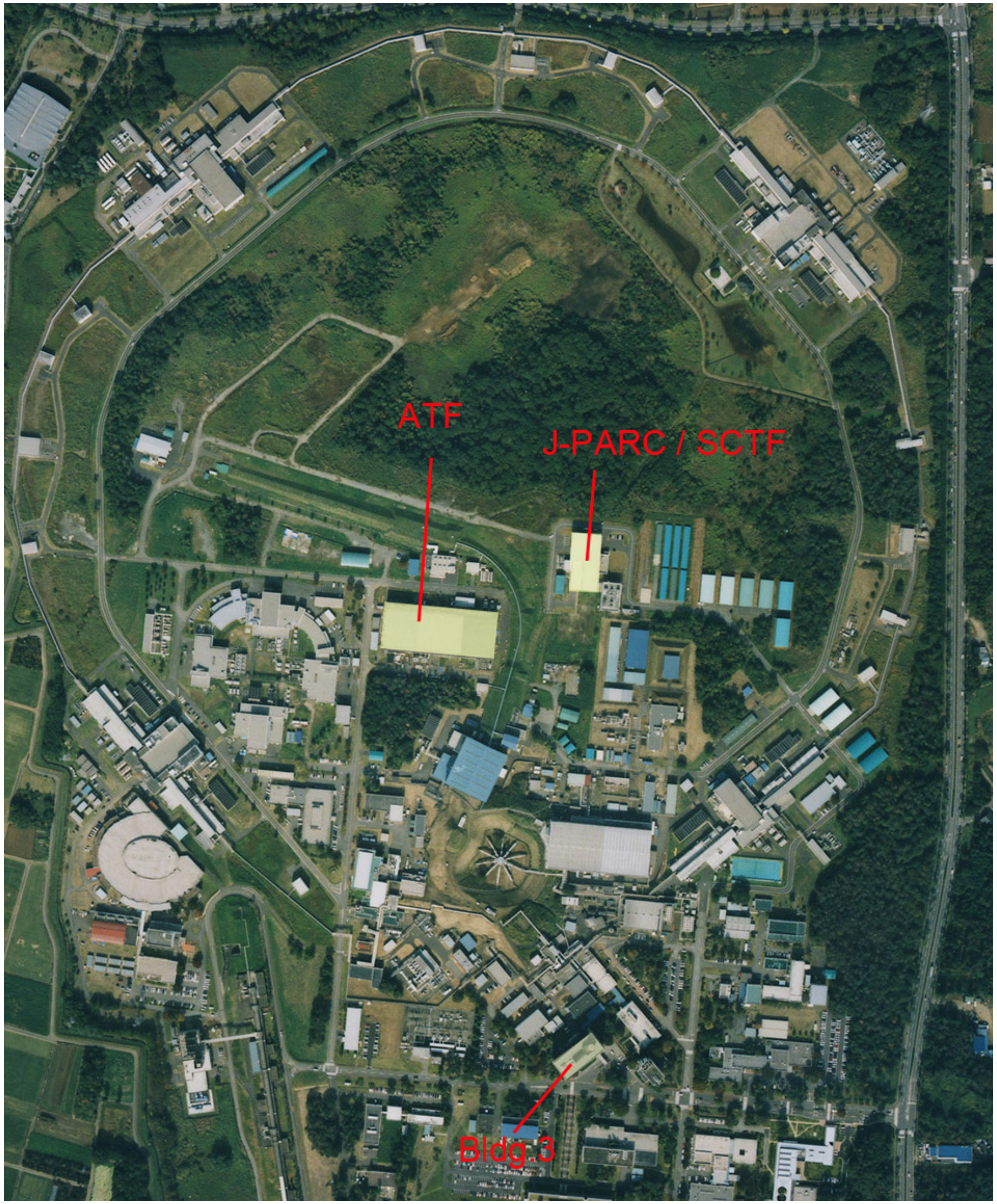


STF

Superconducting RF Test Facility

- An ideal space available at KEK near ATF
- Length: 93m tunnel
- Has been in use for J-Parc linac R&D

  To be evacuated by summer 2005
- Move existing refrigerator from AR East bldg
- Second-hand power system available for the first step



Here comes Hayano's SCTF_tunnel_plan4.pdf

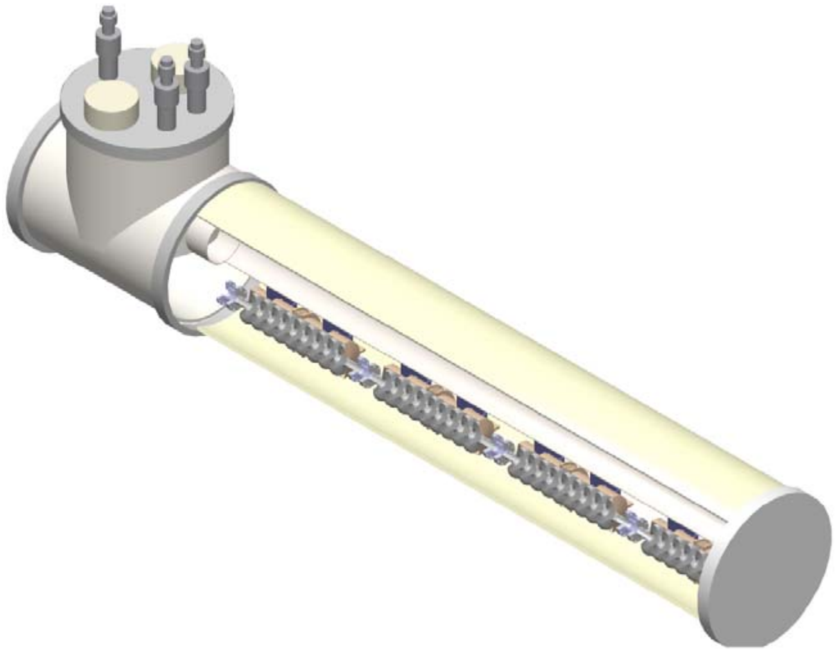
Here comes Hayano's SCTF_detail_plan4.pdf

Present View ⇐ Ground floor

⇓ Underground

What can be done at STF?

- 35MV/m Baseline Development
  - Establish 35MV/m
  - complete TESLA unit
    - ⋆ 3 sets of 17meter cryomodule
    - ⋆ fed by 1 klystron+1 modulator
- Higher Gradient (∼45MV/m) Test
  - Challenge for higher gradient
  - 1 cryomodule with 2 or 4 cavities
  - long module if R&D fast enough

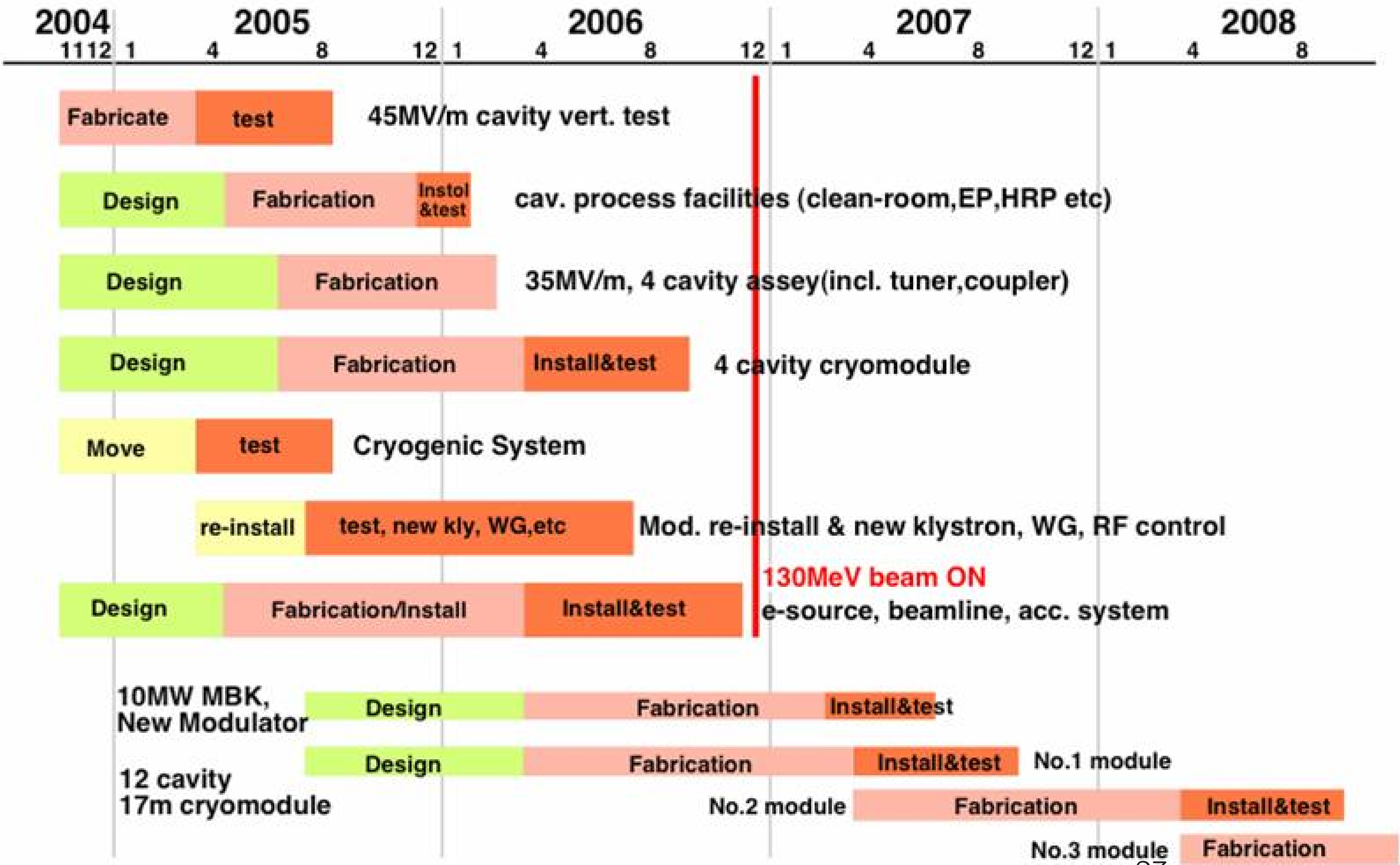


High Grad capture section

Here comes Hayano's STF_blockdiagram.pdf

STF long-term Plan

H. Hayano 11032004

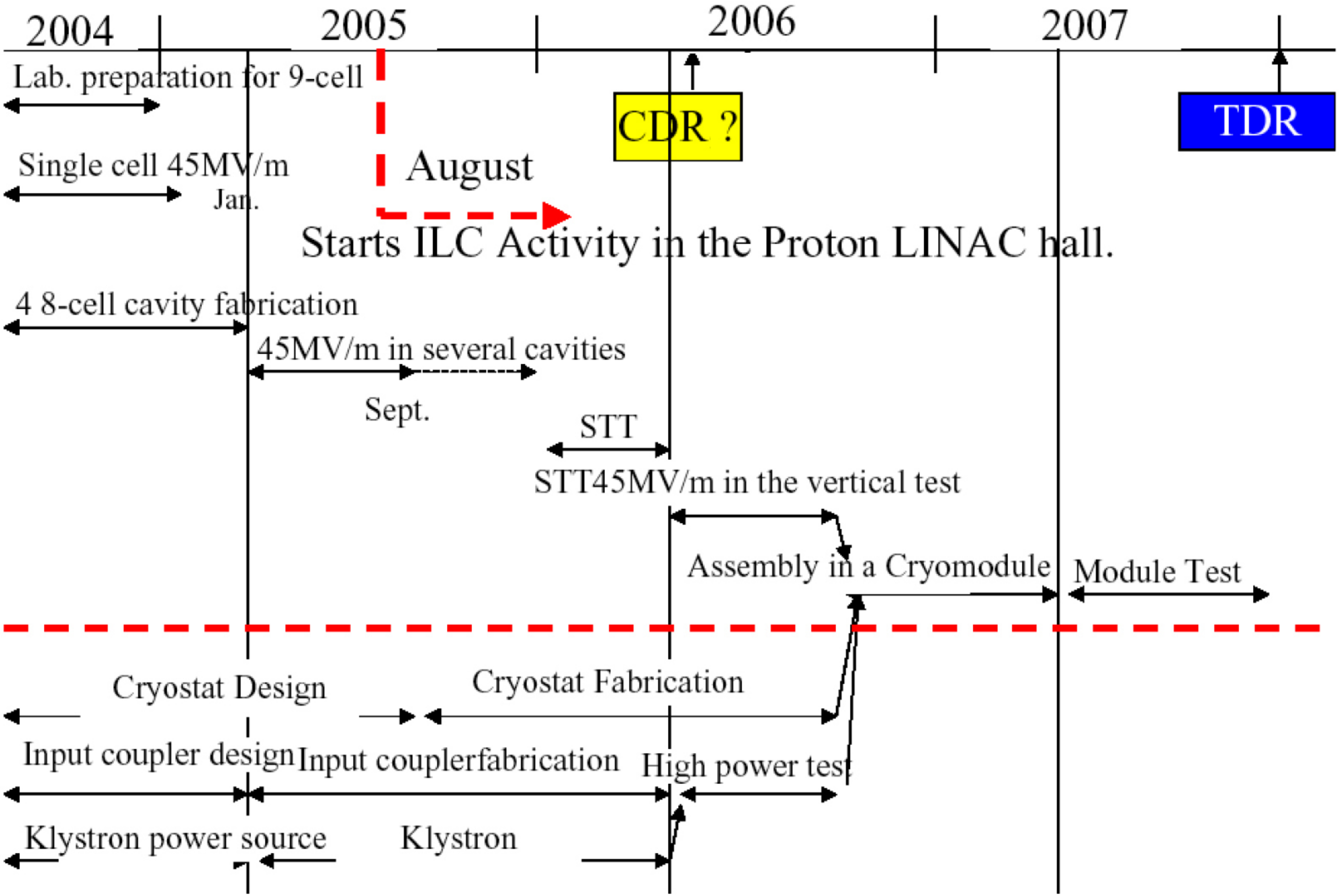


Higher Gradient Cavity R&D at KEK

Pressing Nb plate

Half cells

Ater trimming

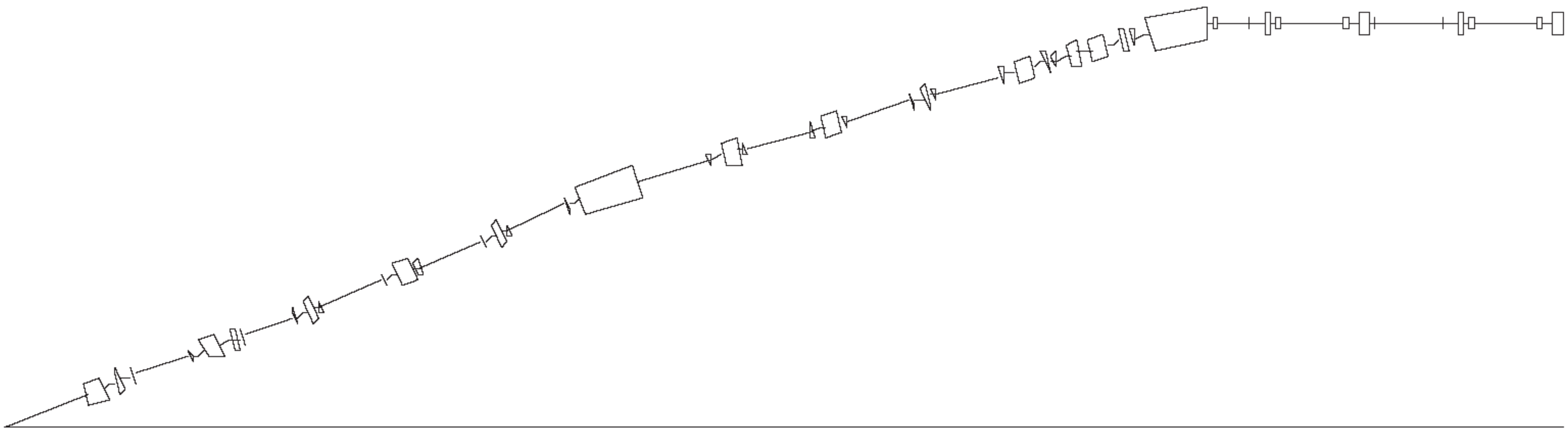

2004
2005
2006
2007
Lab. preparation for 9-cell
CDR ?
TDR
Single cell 45MV/m
Jan.
August
Starts ILC Activity in the Proton LINAC hall.
4 8-cell cavity fabrication
45MV/m in several cavities
Sept.
STT
STT45MV/m in the vertical test
Assembly in a Cryomodule
Module Test
Cryostat Design
Cryostat Fabrication
Input coupler design
Input couplerfabrication
High power test
Klystron power source
Klystron

ATF

- The only machine that can reach TESLA emittance
- Cannot simulate TESLA DR in some aspects
  - dogbone (space-charge, stray field, etc)
  - positron
- Beam dynamics items that can be studied to some extent
  - ion instability (revisit soon)
  - wiggler effects (starts this month)
- Development of fast kickers
  - important item for next fyscal year

Possible Extension of ATF ?

- FFTB at SLAC succeeded in getting ~60nm beam
- But there are still many issues on Final Focus
- We can get ~36nm beam by extending ATF extraction line.
- Energy spread comparable to ILC FFS, but
  Beam energy 200× lower ⇒ Geometric emittance 200× larger



Here comes Tauchi's ffir.test.layout.pdf

GDI

- Central GDI (Global Design Initiative) to be formed in Feb.2005
  - Location and director search
  - Location candidates:

FNAL	SLAC	LBL	BNL	Cornell U
TRIUMF	DESY	CCLRC	KEK	

- 3 Regional GDIs (North America, Europe, Asia) soon
  - Asian GDI at KEK

Most Optimistic Schedule

- CDR (Conceptual Design Report) by 2005 or early 2006
- TDR (Technical Design Report) by end of 2007
- Site selection
- Ground breaking in 2009
- Commissioning in 2014

First ILC Workshop Nov.13-15 at KEK

http://lcdev.kek.jp/ILCWS/

Participants

Asia	79
(Japan)	(62)
Europe	46
North America	62
ILCSC	14
else	5
Total	206

Working Groups

WG1	Overall design, facility
WG2	RF system
WG3	Injectors
WG4	Beam Delivery
WG5	Cavity