Status of R&D on Linear Collider

4th meeting of CERN-KEK committee
March 29, KEK

T. Higo (Accelerator, KEK)

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- Basic idea behind KEK X-band R&D
- History of X-band R&D
- Production of test structures
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- Expansion of test facility
- Basic studies related to breakdown
- Expansion of our collaboration

CERN situation

- Multi-TeV machine after LHC
- Feasibility study is needed to judge
- Key judgment of energy around 2012
- Optimization of parameters reached 12GHz in late 2006, presented at APAC in India
- Tight collaboration for normal-conducting high-gradient approach among CERN, SLAC and KEK

Present target area of KEK for collaboration on CLIC

- Key technologies for CLIC accelerator
  - High gradient acceleration
    - Present focus in collaboration
    - Most benefit to both sides
  - RF generation from drive beam
  - Low emittance
  - ……

History of X-band structure developments at KEK

- Early 1990 by KEK
  - Established fabrication technology→1.3m DS
- Late 1990 with SLAC
  - Realized discharge problem
- By 2004 ITRP with SLAC
  - Proved 50MV/m in 60cm HDDS with HOM suppression
- 2007 and later among CERN/SLAC/KEK
  - CLIC oriented R&D at X-band toward twice gradient
  - Collaboration among three laboratories

Reasoning of X-band collaboration

- KEK
  - High-frequency technology for higher energy as one of the missions of high energy accelerator laboratory
  - Study ground for physical mechanism governing and preventing high gradient acceleration, discharge
- CERN
  - Demand of high power facility at 12GHz to prove high gradient
  - There are only two places now to efficiently run, SLAC and KEK, at very close frequency, 11.4GHz
  - Expand the collaboration to support the technology

Formal history of collaboration

- 2006: Dec. at APAC in India, X-band choice
- 2007: Started structure collaboration meeting
  - Jun. 1st Collab. mtng at CERN
- 2008: Addendum in CERN/KEK MoU, ICA-JP-0103
  - May 2nd collab. Mtng at KEK
  - Addendum 2 in MoU, ICA-JP-0103
    - Collaboration of High Gradient Accelerator Technology Centered at Fabrication and Tests of X-band Accelerating Structures
  - Supported accelerating structure fabrication and test
  - Dec. 3rd Collab. mtng at UK
- 2009: Pursue under collaboration research contract
  - Established collaboration research contract to support KEK activities
- 2010: Continue and expand collaboration
  - Mar. Collab. mtng in China
  - May 4th Collab. mtng at CERN

Actual history of collaboration

Red: main financial support from CERN

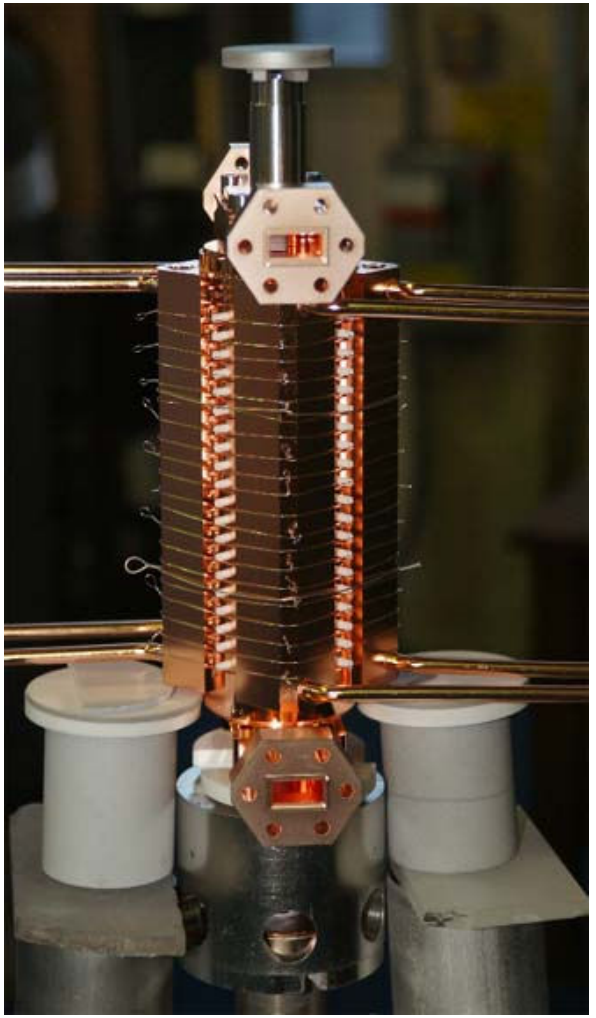
- 2007: Started structure collaboration meeting in June
  - Structure fabrication started discussion
  - Moved test facility to the present area
- 2008: Addendum in CERN/KEK MoU, ICA-JP-0103 in Aug.
  - Structure fabrication (QuadX1, T18X2, TD18X2)
  - Establishment of high power facility, Nextef
- 2009: Pursue under collaboration research contract
  - Structure fabrication (C10X2, CD10X2, T24X2, TD24X2)
  - Structure test (T18X1, QuadX1, TD18X1)
  - Started preparation of extension of Nextef by pulse compression
- 2010: Continue and expand collaboration
  - Structure fabrication (under discussion)
  - Structure test (cont. TD18, followed by T24, TD24, ……)
  - Establishment of high power facility for basic studies

Preparation of accelerator structures based on GLC/NLC technologies

- Technology established for GLC/NLC
  - KEK precision machining followed by SLAC assembly
  - This is the best starting point for higher gradient.
  - Extensive study is ongoing among CERN, SLAC and KEK
- Nominal test flow
  - Precision machining
  - Chemical polish
  - Diffusion bonding and brazing
  - Baking in vacuum at 650C
  - High gradient test at KEK and SLAC

Fabrication of damped structures

KEK fabricated all parts.



SLAC made assembly.

Vacuum Baking of T18_vg2.4_DISC

650°C

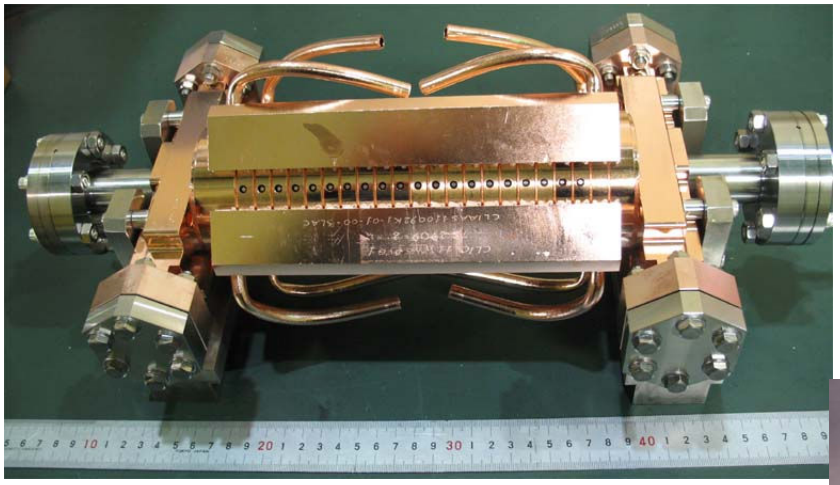
10 days

at SLAC

From Sami, Mar. 1

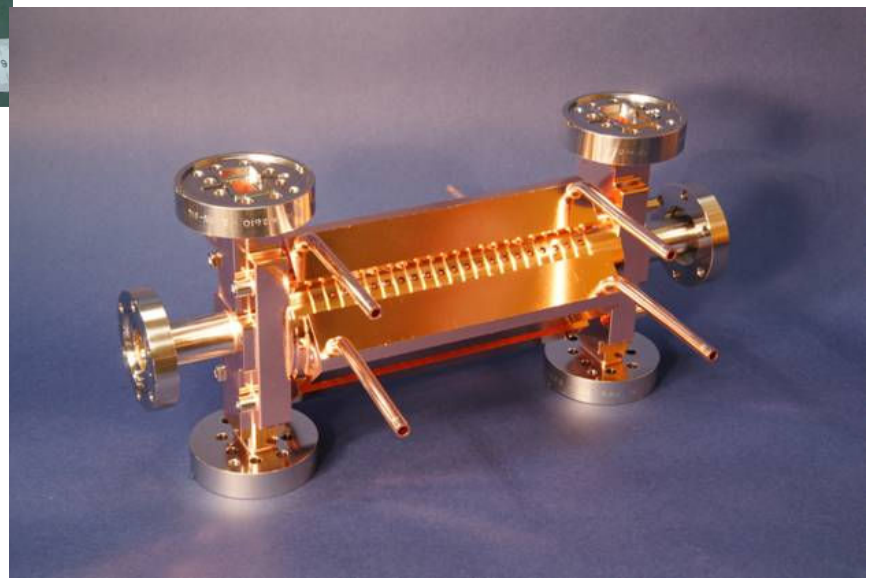
TD18 first pair #2(KEK) & #3(SLAC)

Design = CLIC-C

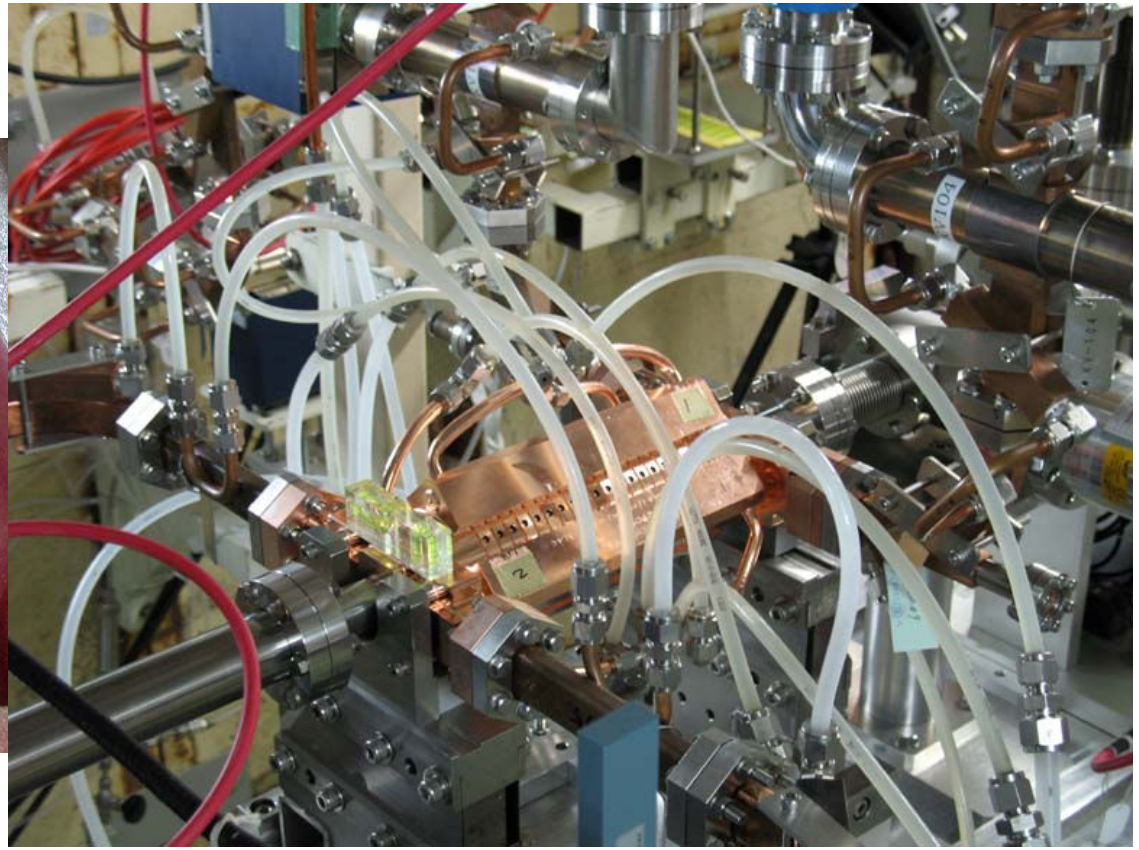


#2 being tested at KEK Nextef

#3 being tested at SLAC NLCTA



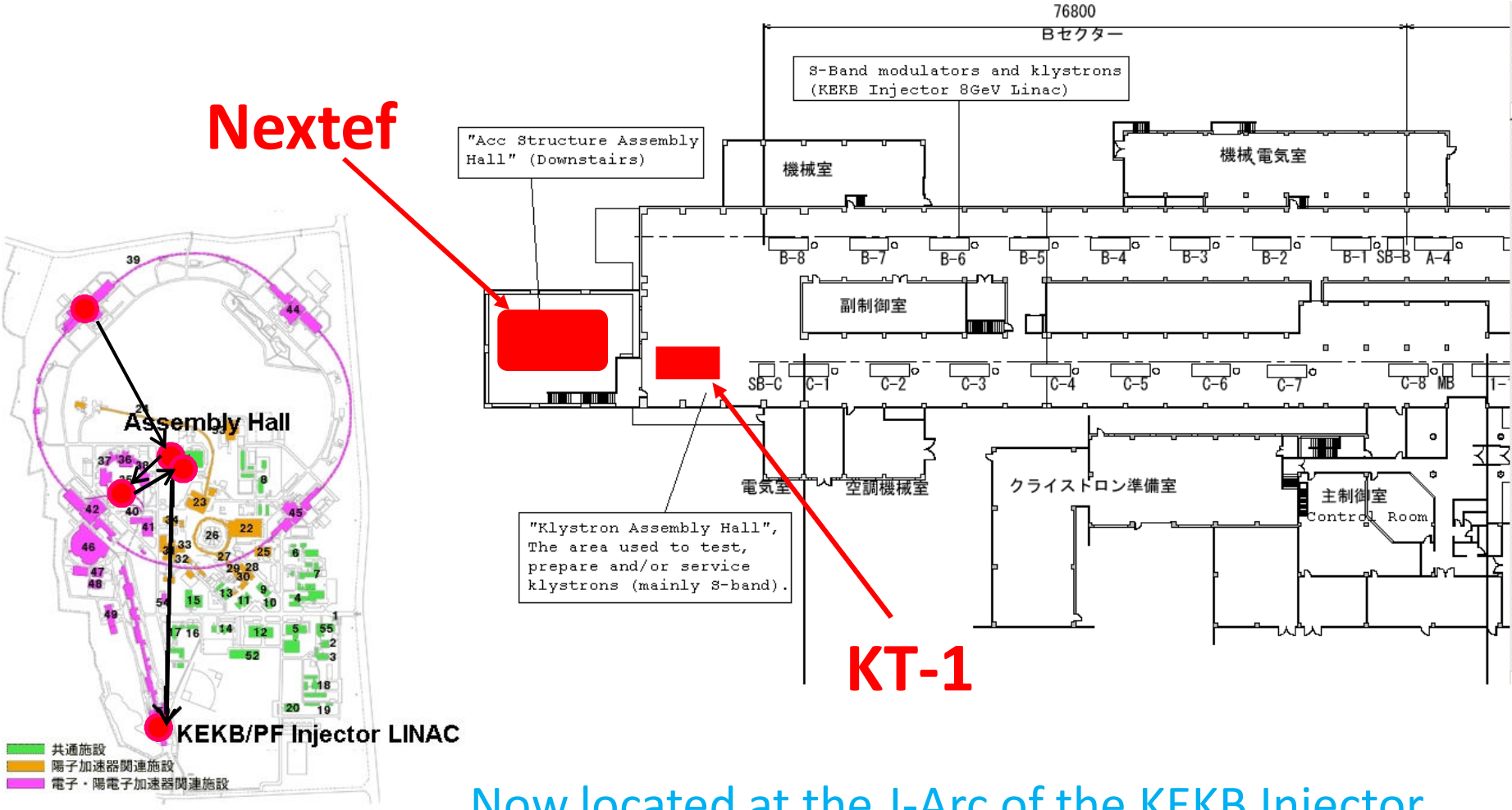
Sent from SLAC and installed at Nextef



Requirement to high gradient test

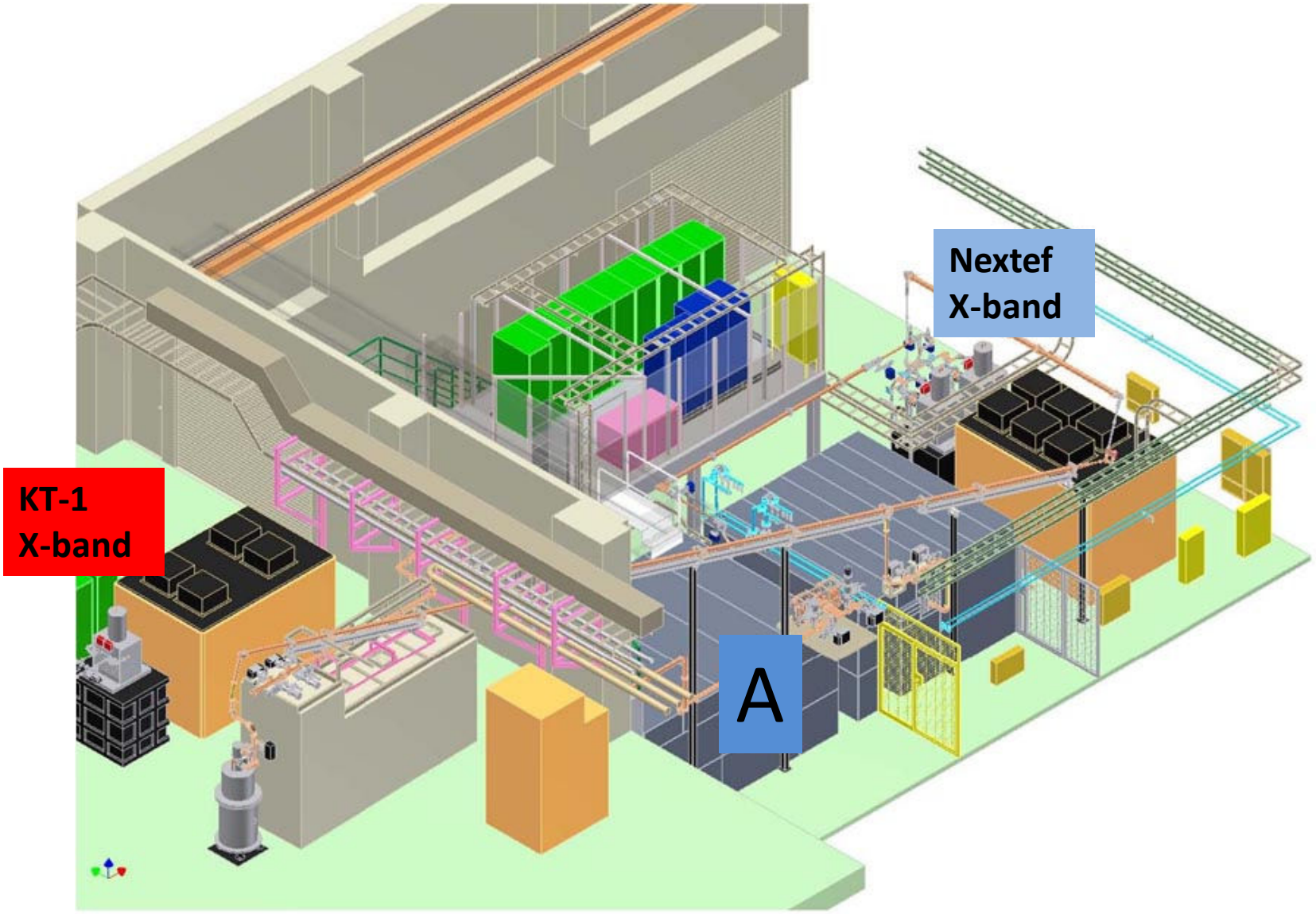
- Evaluate at more than one laboratory
  - Independent evaluations
  - Equivalent to "S0" idea for ILC
  - Aiming at obtaining statistical info and reproducible technology with scientifically proven mechanism
  - Start at SLAC and KEK then include CERN test stand
- Requirement for facility
  - Long-term operation with 100MW or more
- Actual facilities
  - SLAC NLCTA with pulse compression
  - KEK Nextef with two klystrons
  - CERN 12GHz test stand (in this year)

Test facilities of KEK

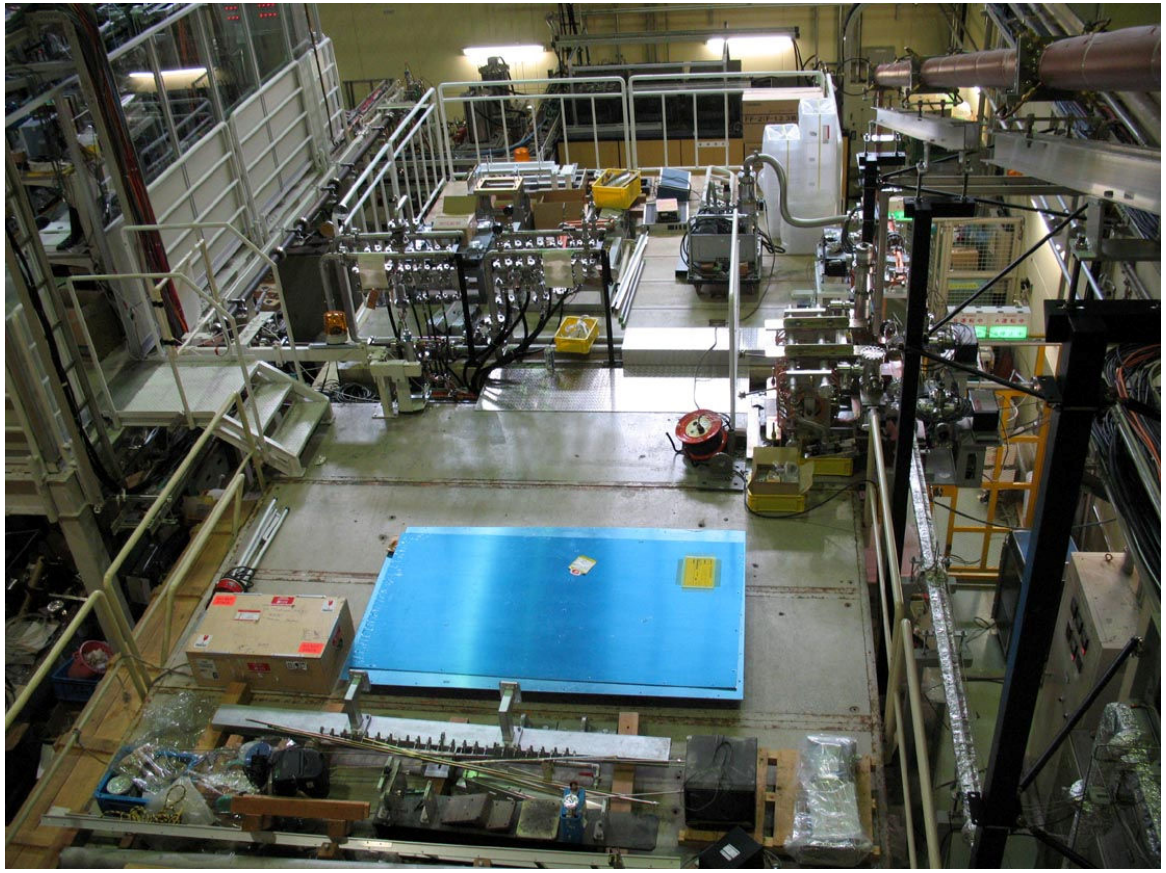


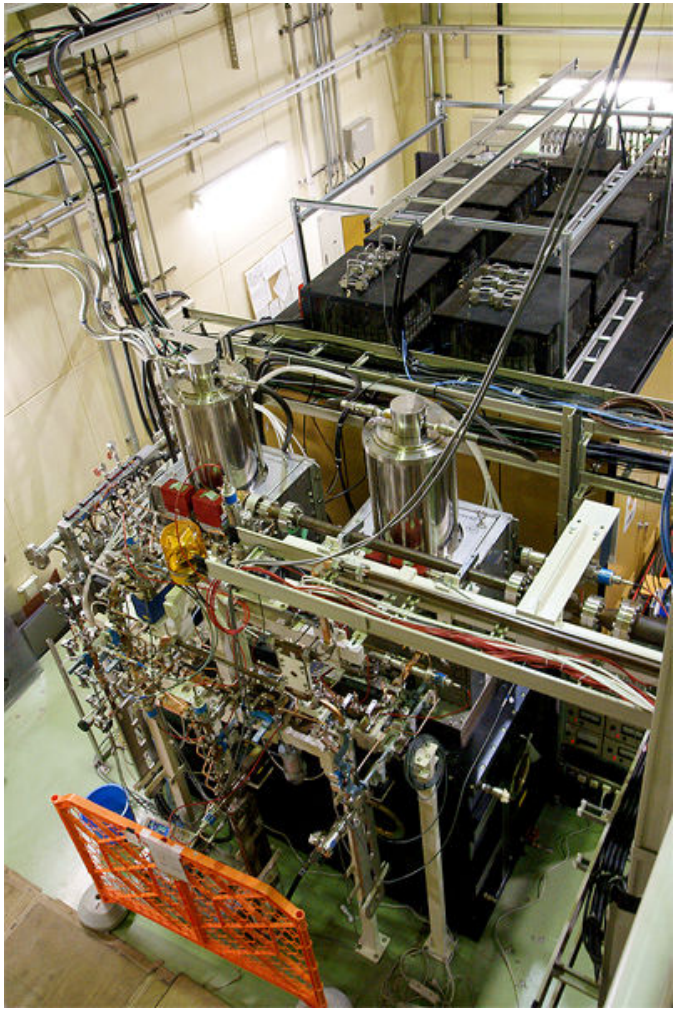
Now located at the J-Arc of the KEKB Injector

KEK: Nextef Configuration

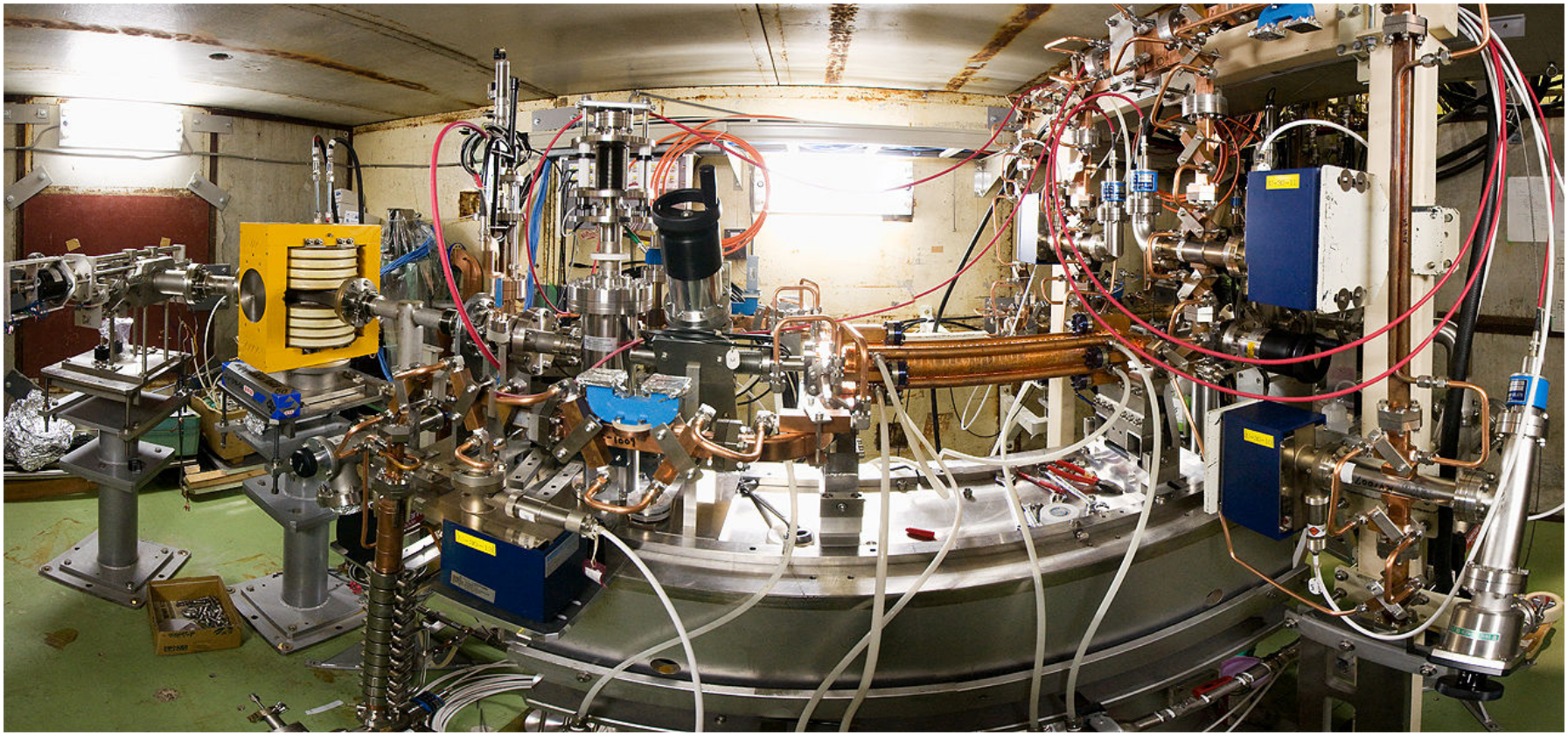


Nextef operation since 2007





Nextef inside shield room

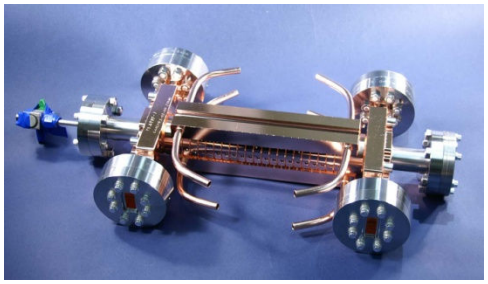


High gradient test of three CLIC-C prototype structures

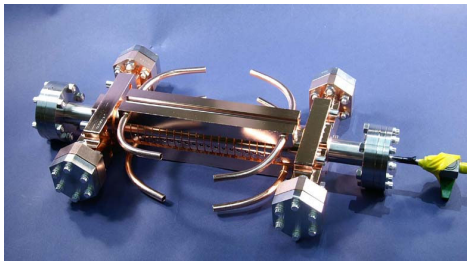
- Disk-based un-damped
  - T18_Disk Oct. 2008~June 2009
  - 4000hr, 9 months
- Quad-based heavily damped
  - TD18_Quad_#5 Sep. 2009~Nov. 2009
  - 1000hr, 3 months
- Disk-based heavily damped
  - TD18_Disk_#2 Dec. 2009~
  - 1200hr, 4 month+

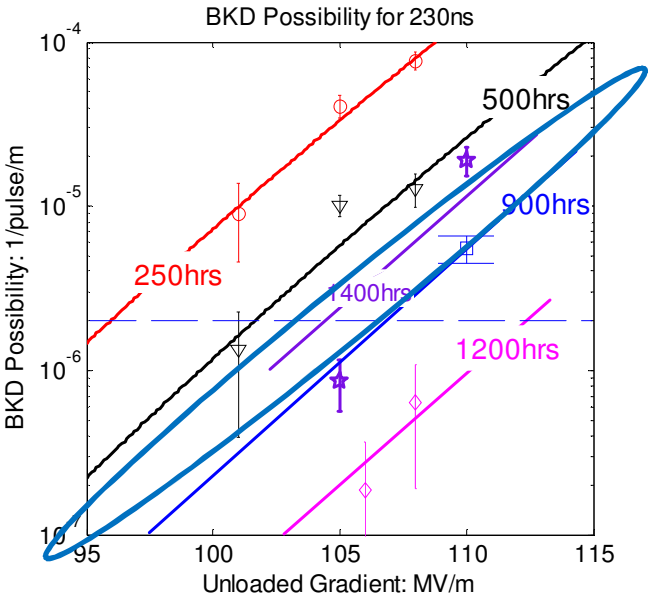
Proof of 100MV/m with a pair of un-damped 18cell prototype structures

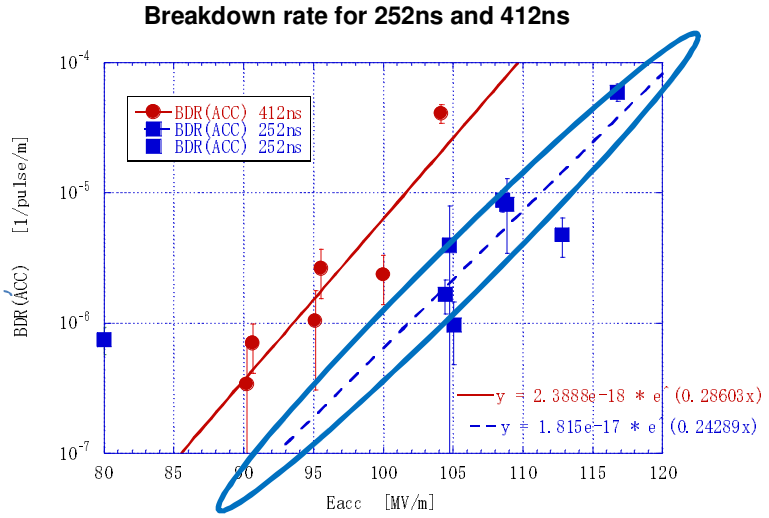
#1 test at SLAC



#2 test at KEK





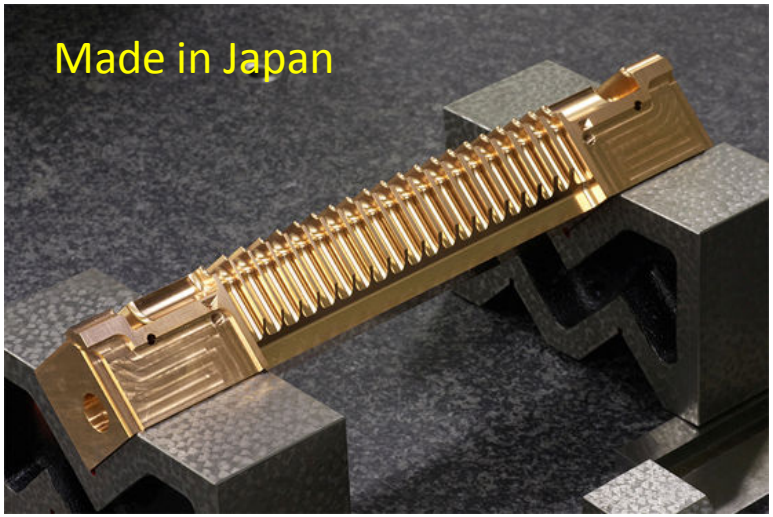


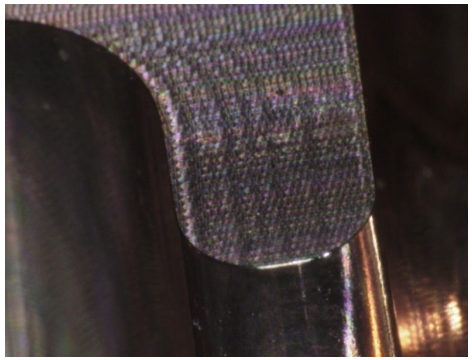
C. Adolphsen, US-HG@ANL, 2009

Roughly the same breakdown rates were observed for a pair of structures.
Will pursue the same comparison again for the second pair.

Quad fabrication and test

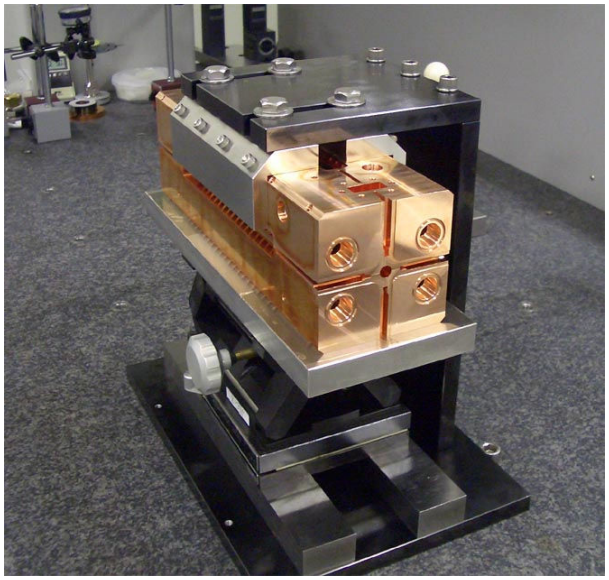
Must be cheap mass production but high gradient is not yet proved.



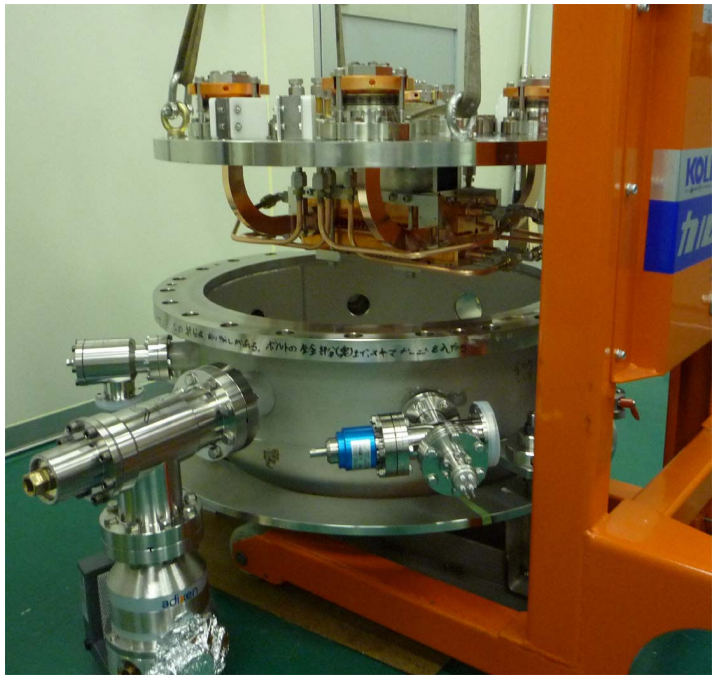


With 50 micron rounding

Fine assembly

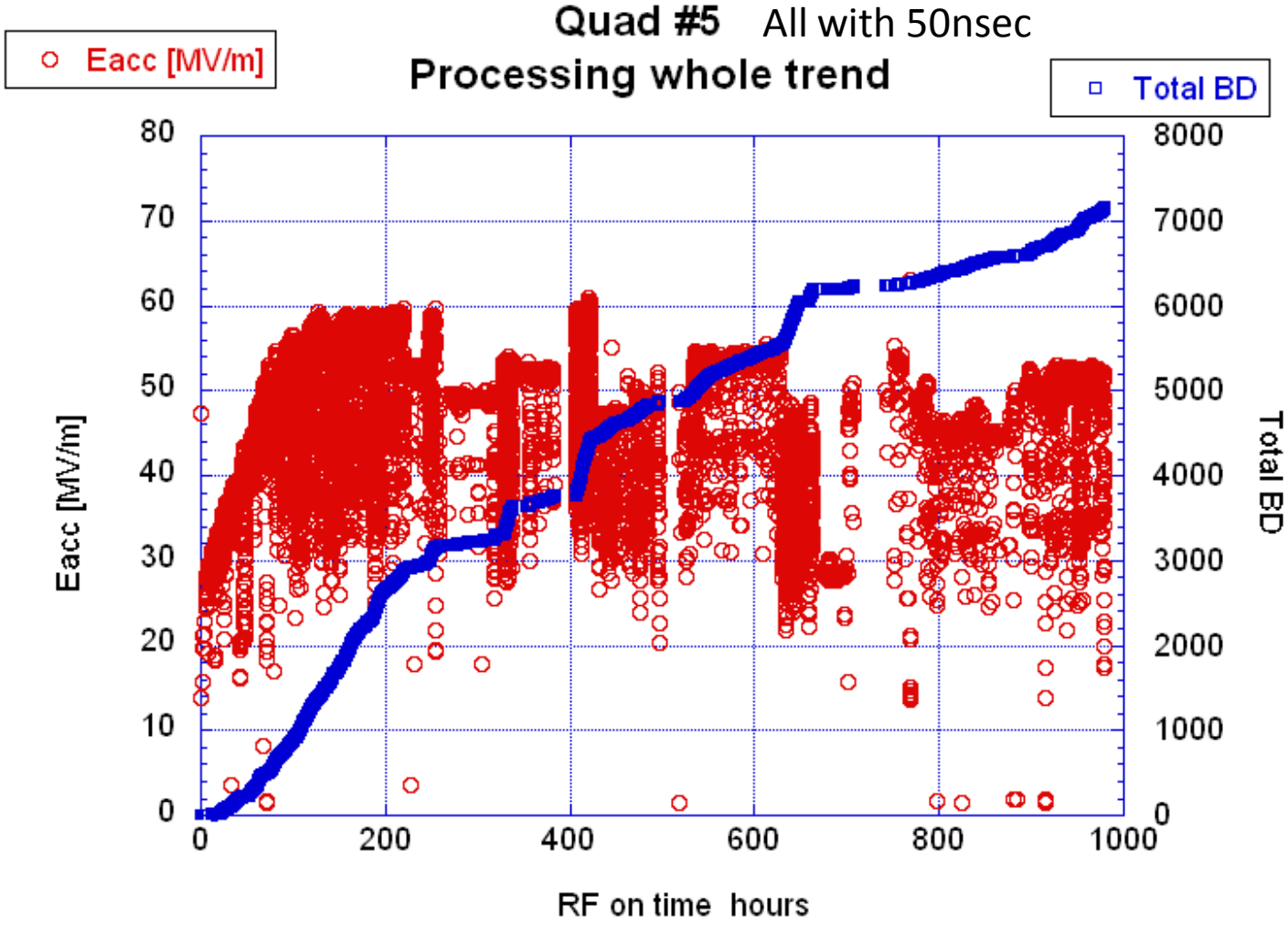


High gradient test in chamber



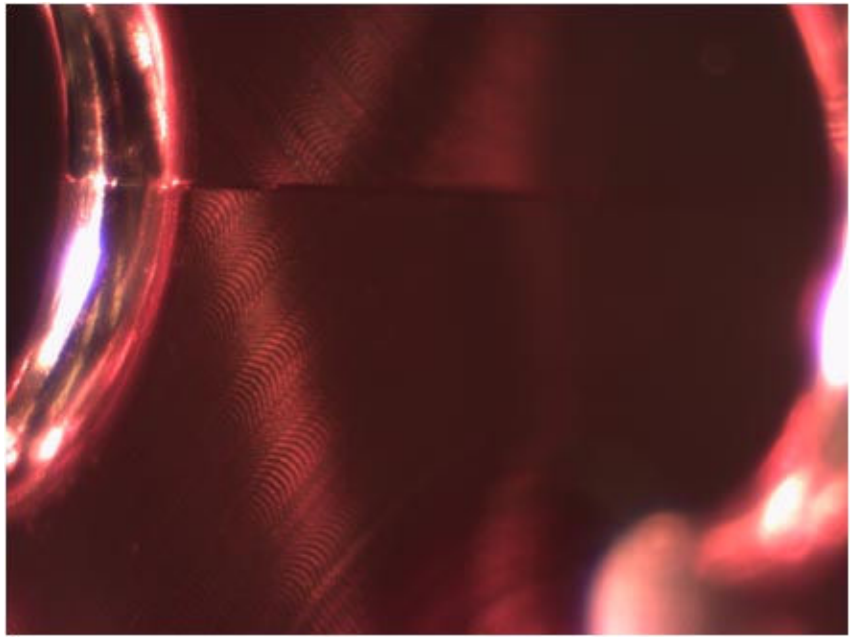
Gradient limited at 50~60MV/m

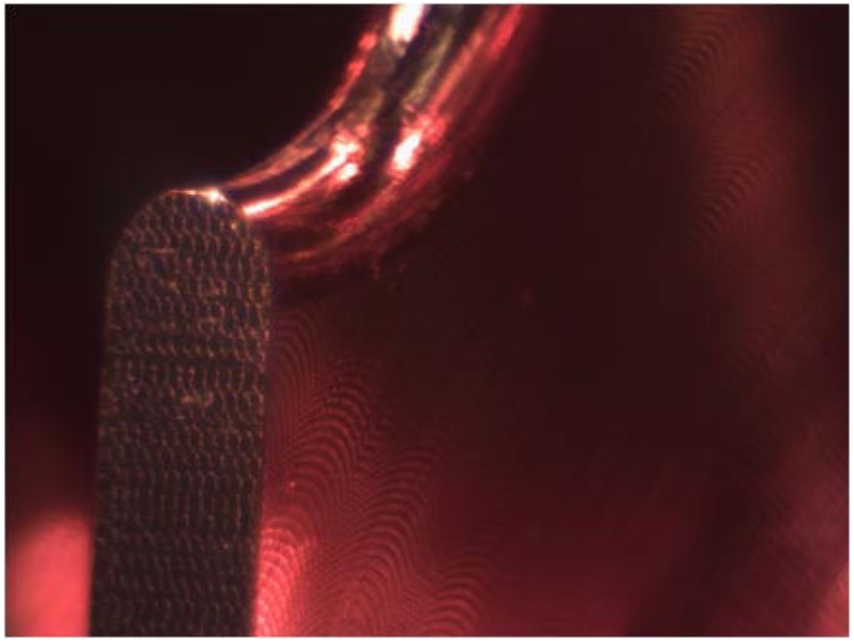
Difficult to reach 100MV/m!!



Optical inspection after test

No.18 Q2-2 to match Q1-1



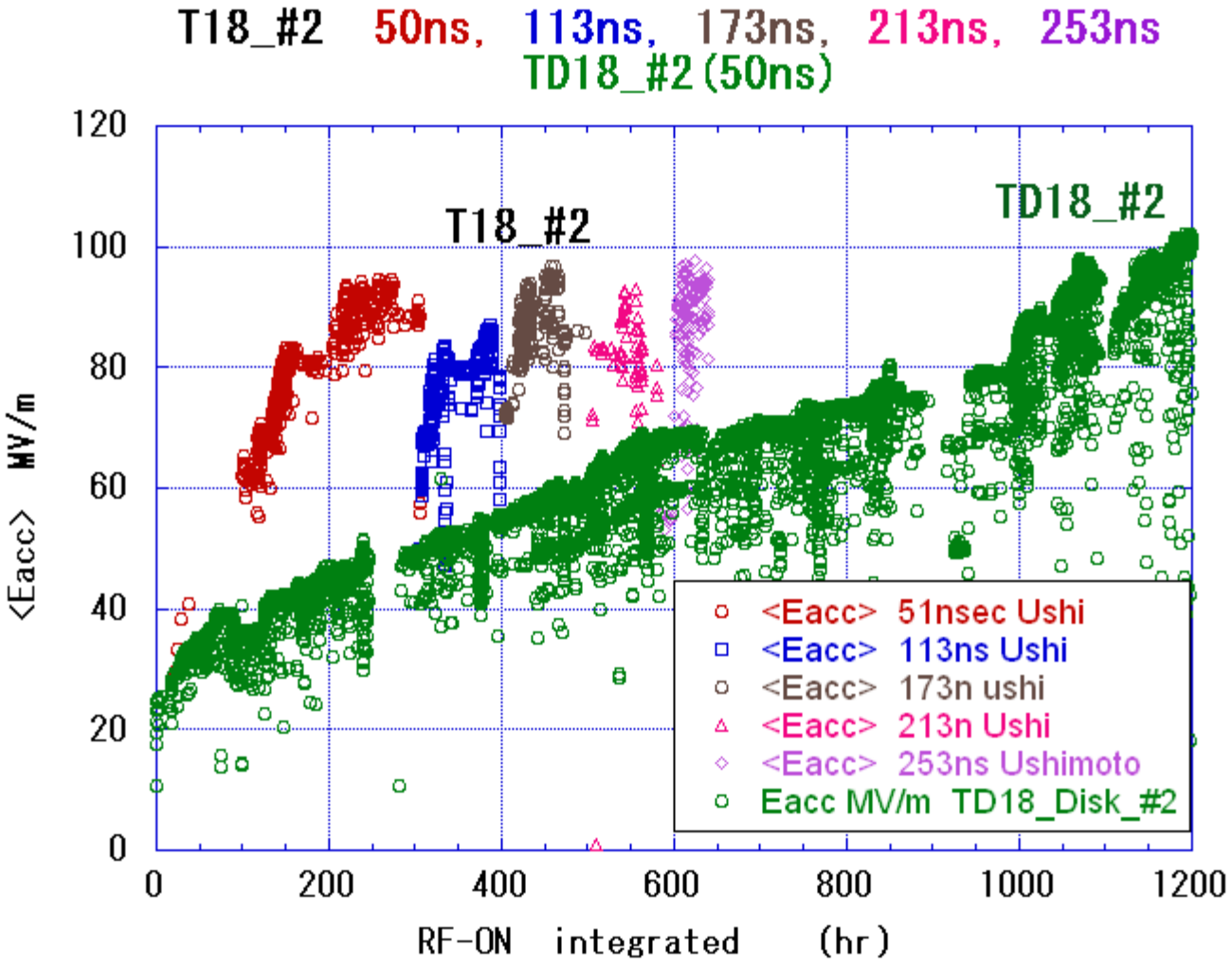


No clear understanding of poor performance!
We will send it to CERN for SEM inspection.
We continue the study of this idea with CERN.

TD18_Disk_#2

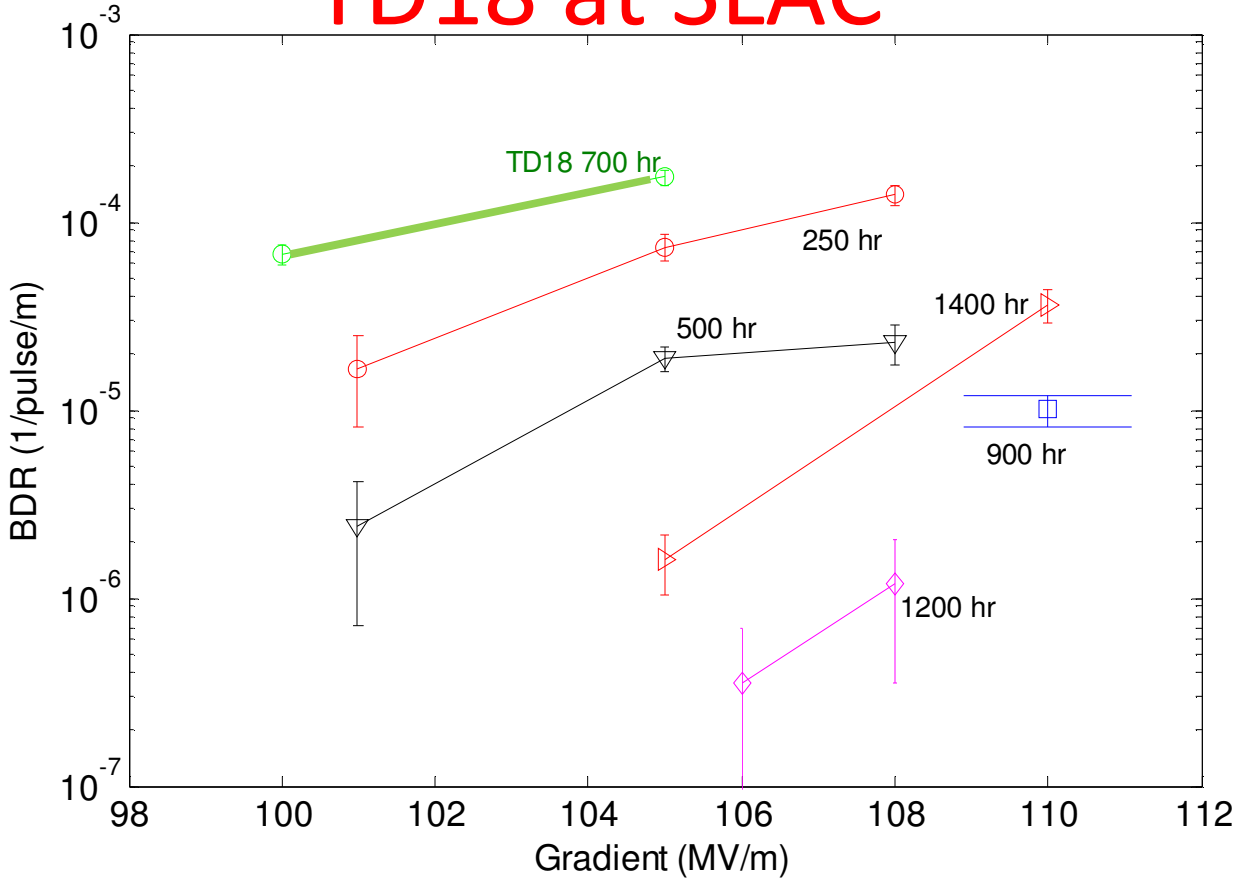
- Aim: Prove heavily damped structure
  - Electric gradient: possibility to realize 100MV/m
- Design geometry
  - Heavy damping slots with wide opening
  - Big increase of gradient toward downstream
  - Big pulse heating temperature rise at the damping port opening
  - No longitudinal cut but disk-based as T18 structures
- Fabrication in practice
  - Milling surface in many places
  - Fabrication flow the same as T18

Slow processing on TD18 at KEK



Fast processing but high BDR on TD18 at SLAC

Faya wang
100311



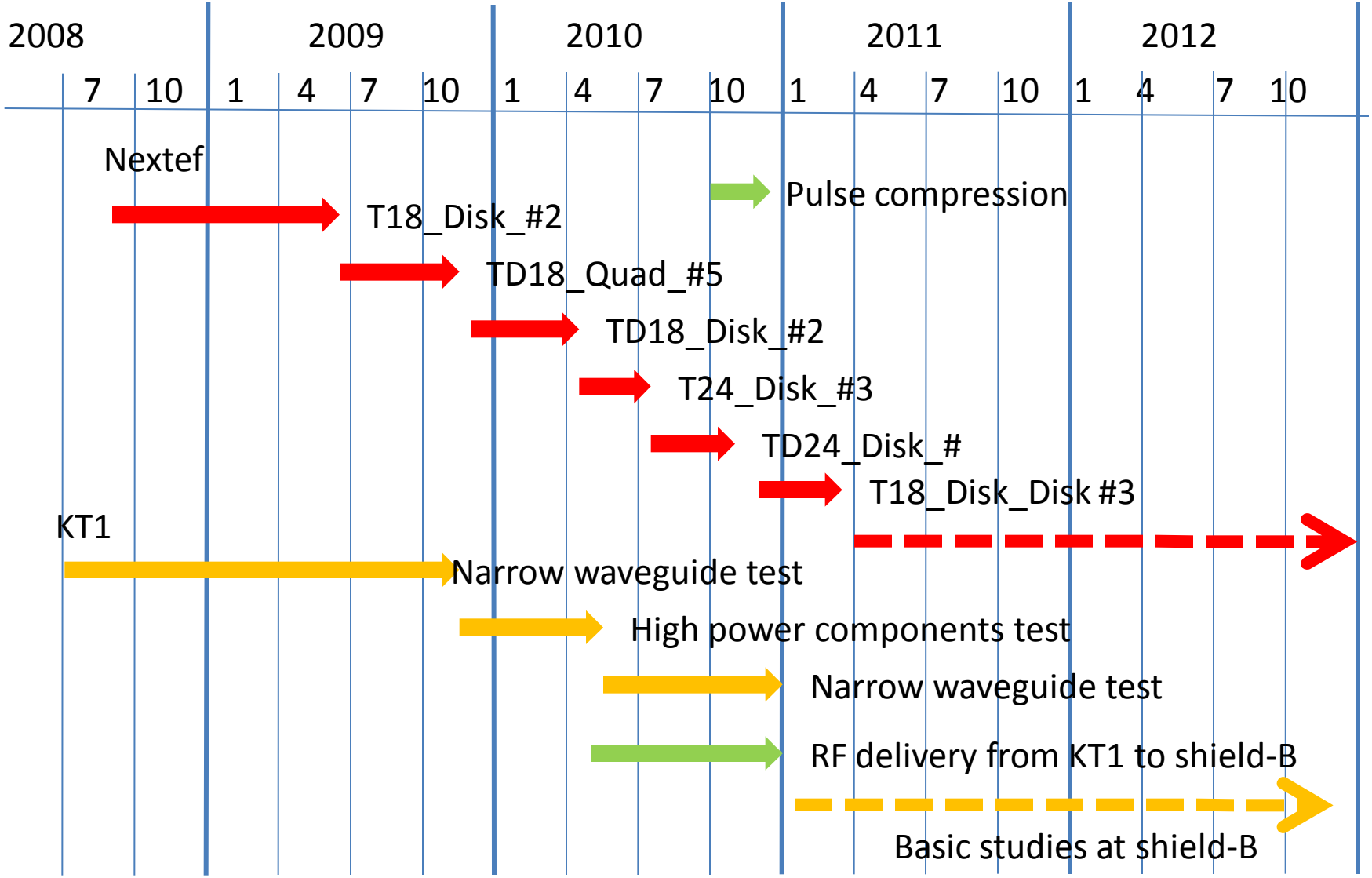
Pulse width 230ns

Green line for TD18

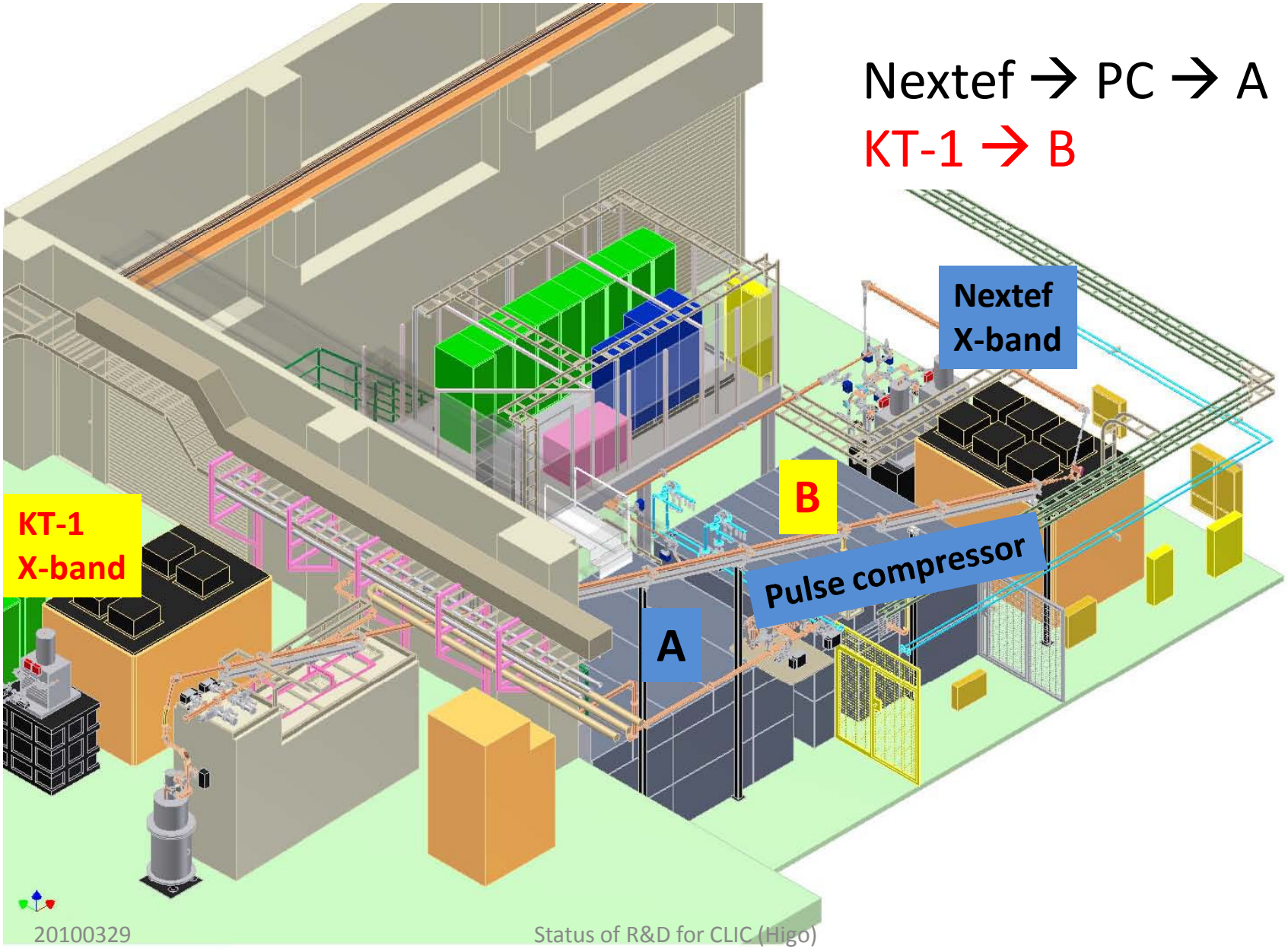
Others for T18

But higher breakdown rate than T18 (un-damped).
Should continue to study the mechanism.
Should study TD24 with lower magnetic field.

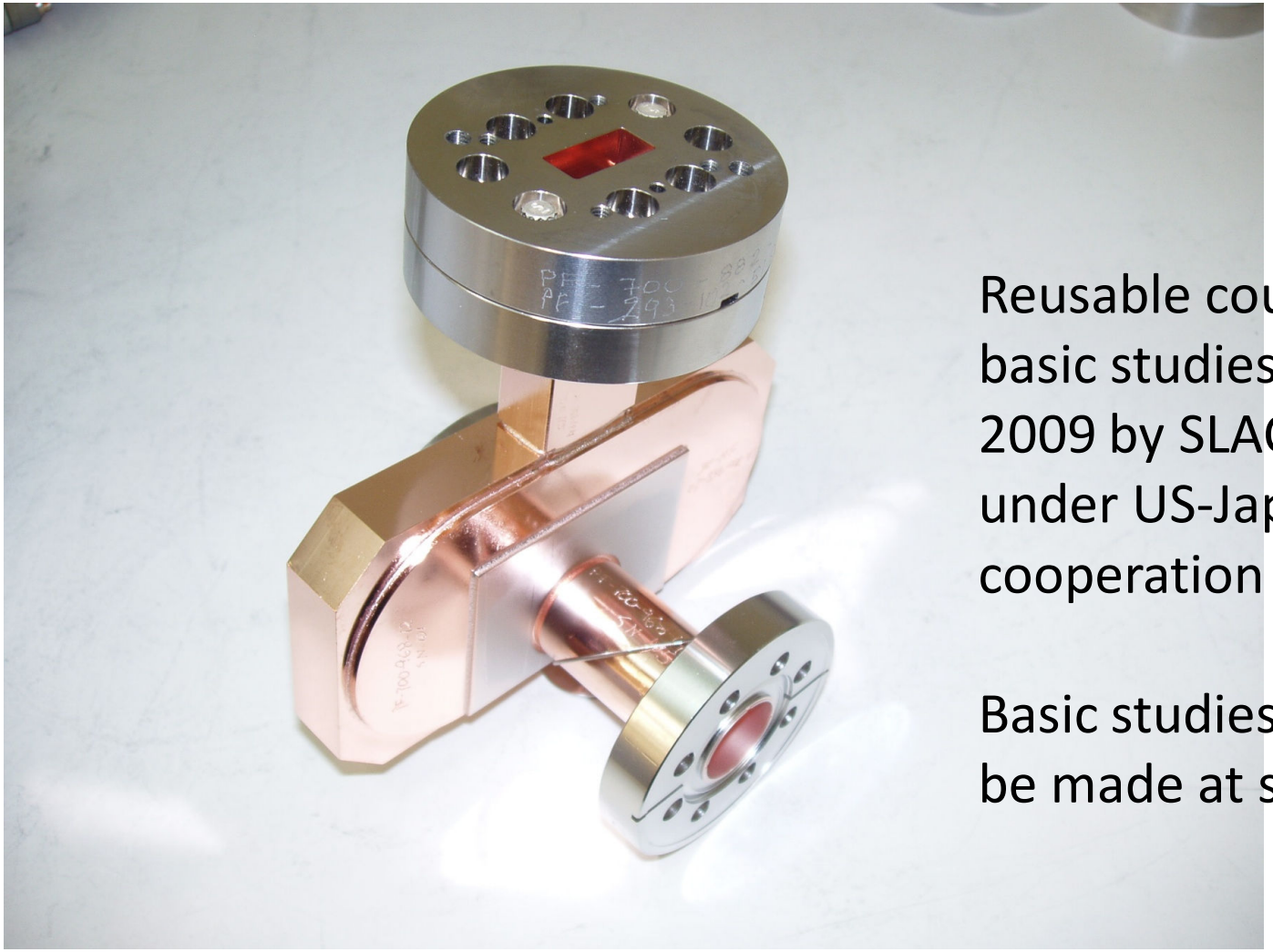
Nextef for prototype structure tests
KT1 for basic studies



Nextef expansion plan



Mode Launcher for basic studies

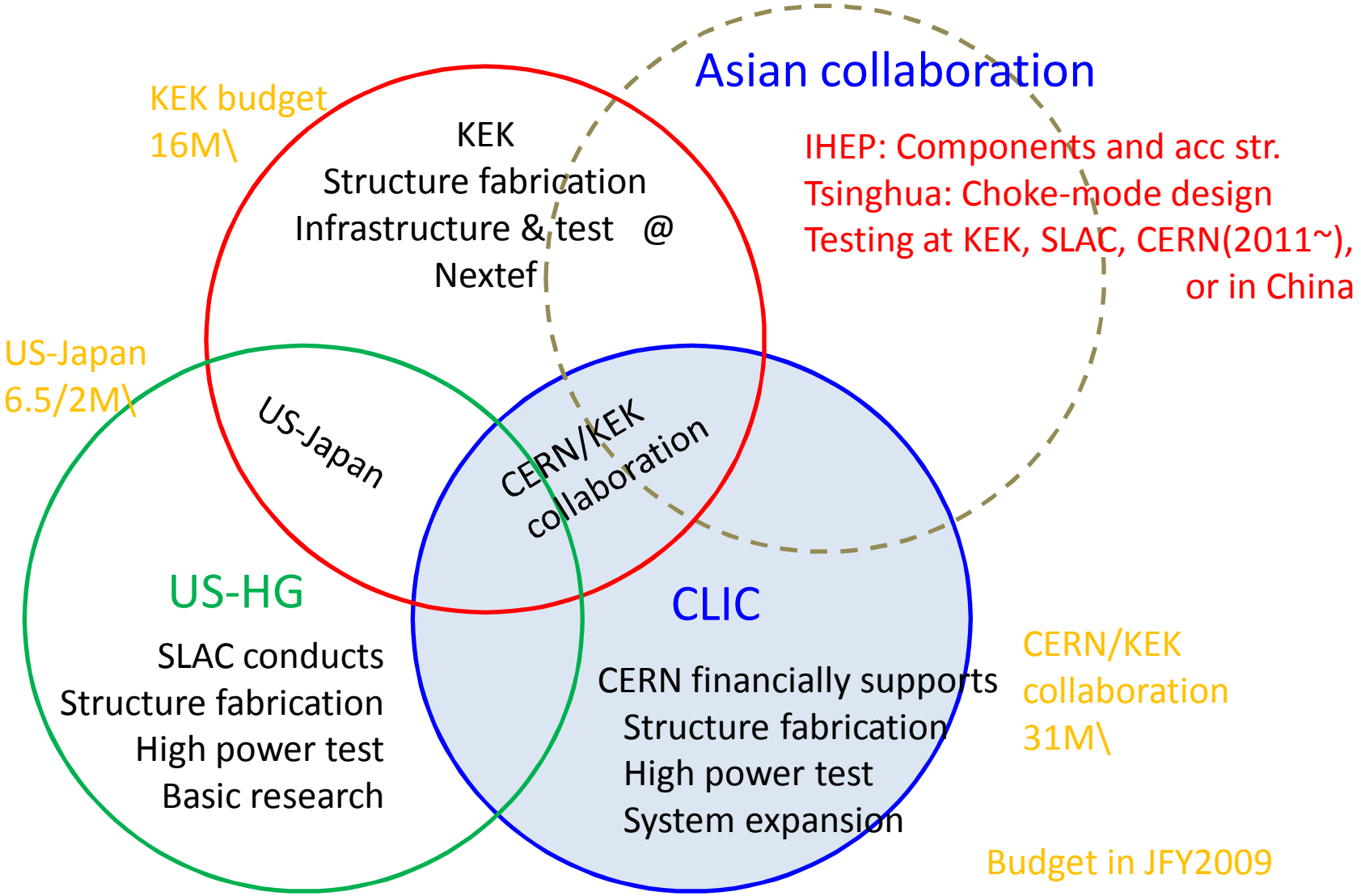


Reusable coupler for basic studies made in 2009 by SLAC for KEK under US-Japan cooperation program.

Basic studies are to be made at shield-B.

From Sami, Mar. 1

X-band collaboration



Conclusion

- Collaboration between CERN and KEK is very critical for the feasibility proof of CLIC 100MV/m
- Nextef is strengthening its high power production by introducing pulse compressor to stably run high gradient test for CLIC prototypes
- New test area is being established to conduct basic studies to obtain a firm scientific understanding needed for CLIC
- Collaboration is being expanded into an Asian laboratories with KEK as a foot stone
- Financial support from CERN is very critical for the present KEK X-band activities