Accelerator Summary #2: SRF, NCRF, Sustainability and Applications, and Conventional Facilities

Emma Snively, SLAC National Accelerator Laboratory

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SLAC NATIONAL ACCELERATOR LABORATORY

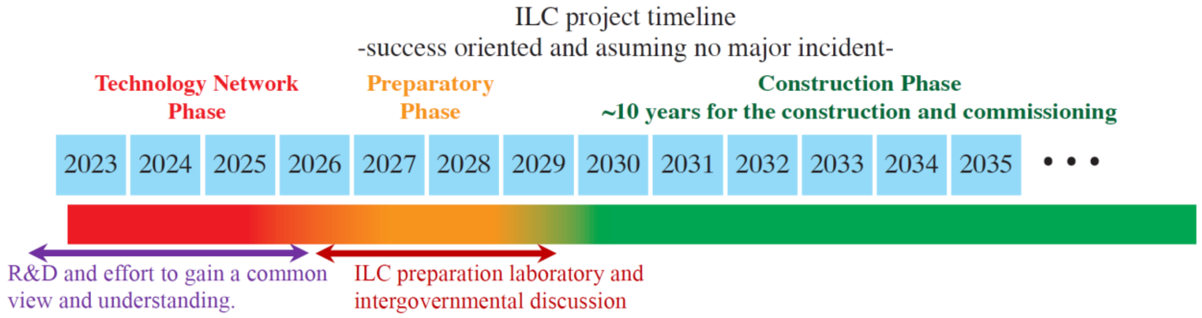
SRF TG summary

Mattia Checchin (SLAC), Kirk Yamamoto (KEK) and
Sergey Belomestnykh (Fermilab)

ILC

- ILC is entering an ILC Technology Network (ITN) phase, which will include three major components: SRF, Sources and Nanobeams
- SRF: WP-prime 1, Cavity industrial production readiness; WP-prime 2, Cryomodule design, Global transfer and Performance assurance; WP-prime 3: Crab cavity development
- The 5-year plan in Japan will address the SRF Work Packages. The particular important issues are: Fixing the global cavity design; 2 change requests (tuner and SC magnet current leads box); Some ancillaries to be developed and produced
- KEK has a plan to upgrade SRF infrastructure
- Medium grain Nb material has mechanical properties similar to the fine grain Nb but will be cheaper. Studies of medium grain Nb are in progress
- SRF cavities and cryomodules must satisfy the High Pressure Gas Safety Regulations (HPGR) in Japan. Cavity and cryomodule designs should be fixed and analyzed before an approval can be obtained
- SRF crab cavities are essential for achieving the design luminosity. 2 new designs were down-selected for prototyping: an RF Dipole cavity (ODU/JLAB) and QMiR cavity (FNAL). After the prototypes are tested, one of the designs will be selected for the complete crab cavity system development

S. Michizono (KEK) “ILC Technology Network (ITN)” - Plenary
K. Yamamoto (KEK) “SRF 5-year plan in Japan for ILC”
A. Yamamoto (KEK/CERN) “New Nb material for cost saving”
K. Umemori (KEK) “Current status of high pressure gas regulation for SRF cavity fabrication in Ja
S. De Silva (ODU) “1.3 GHz RF-Dipole crabbing cavity system for International Linear Collider”
R. Laxdal (TRIUMF) “ILC crab cavity developments” – Accelerator plenary

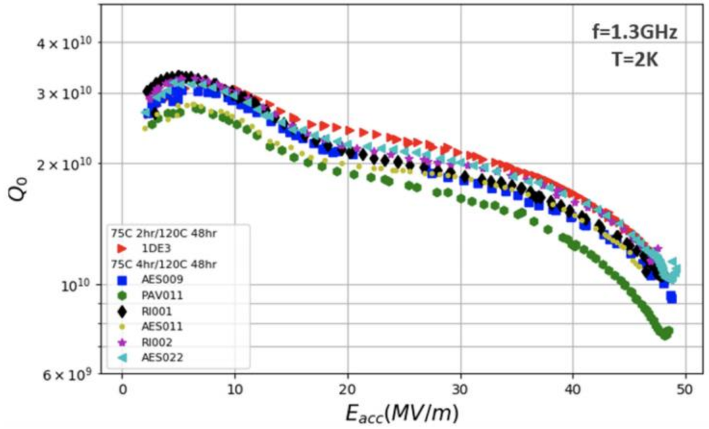


SRF R&D

- There have been substantial advances in high gradient / high Q technologies since ILC TDR. R&D results can be applied to ILC and other recent SRF linear collider proposals, some in the ILC-250 and some in the future upgrades
- KEK and CEA Saclay teams continue developing vertical electropolishing (EP), which is likely safer and easier to implement than horizontal EP. The recent results were presented.
- New cavity treatment recipe (cold EP + 2-step low temperature baking) demonstrated higher gradient and Q factor both on single-cell SRF cavities and 9-cell ILC/TESLA cavities with some cavities reaching accelerating gradients of almost 50 MV/m. A High Gradient Cryomodule (HGC) collaboration is working on demonstrating an average accelerating gradient of > 38 MV/m in an ILC-type cryomodule at Fermilab.
- Other surface treatments (e.g., medium temperature baking) are studied for CW accelerators
- Multilayer SRF cavities are being investigated at CEA Saclay with initial promising results. More R&D efforts are needed in this area

SRF cavity installed in vertical EP system at KEK

High gradient cavity test results



S. Belomestnykh (FNAL) "Overview of [SRF] accelerator technology development relevant to ILC and other future lepton linear collider options" - Plenary

T. Goto (KEK) "Development of vertical electropolishing (VEP) for surface treatment of 9-cell Nb cavities at KEK"

F. Eozenou (CEA Saclay) "SRF activities at CEA Saclay"

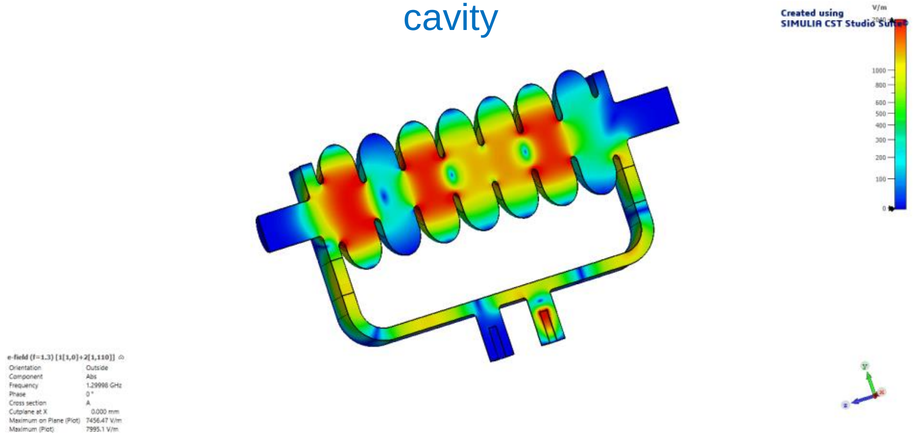
S. Belomestnykh (FNAL) "High Gradient Cryomodule (HGC)"

D. Bafia (FNAL) "Surface engineering research for high Q and high gradient CW accelerators"

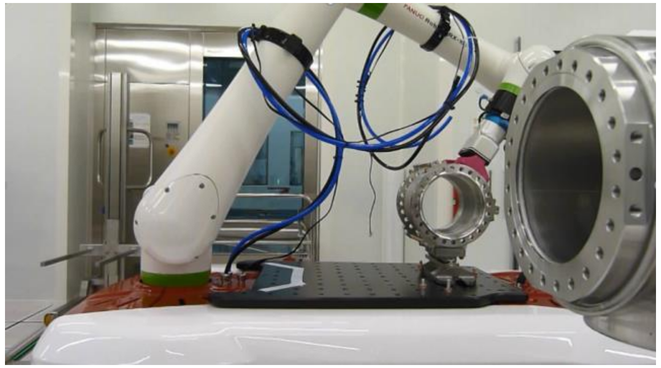
SRF R&D

- Maintaining a particulate-free SRF cavity surface is imperative to avoid field emission (FE). CEA Saclay is developing robotic tools and procedures to assist humans in the clean room. Such methods should help mitigating FE.
- If SRF cavities are affected by FE and/or multipacting in a cryomodule, in-situ methods could be used for mitigation. One of such methods is plasma processing, which was successfully demonstrated on a verification LCLS-II-HE cryomodule at Fermilab. Further R&D is in progress to apply this technique to ILC-type cryomodules
- Developing reliable and inexpensive diagnostic is important to support the SRF cavity development. New sensors include X-ray detectors and magnetic sensors (CEA Saclay)
- Traveling wave (TW) SRF structures have a potential to deliver high gradient (up to ~ 70 MV/m) and higher cryogenic efficiency. A proof-of-principle 3-cell cavity is being prepared for testing at Fermilab

Simulation of traveling wave SRF cavity



Robotic assembly of ESS SRF cavity bellows (under development)



F. Eozenou (CEA Saclay) “SRF activities at CEA Saclay”
V. Yakovlev (FNAL) “Traveling wave SRF cavity status and R&D plan”
B. Giaccone (FNAL) “Progress with plasma processing and plans”

LCLS-II / HE results and lessons learned

LCLS-II SRF linac was successfully cooled down three times and demonstrated expected performance

While this is a CW linac operating at medium accelerating gradients, the experience is very useful for ILC

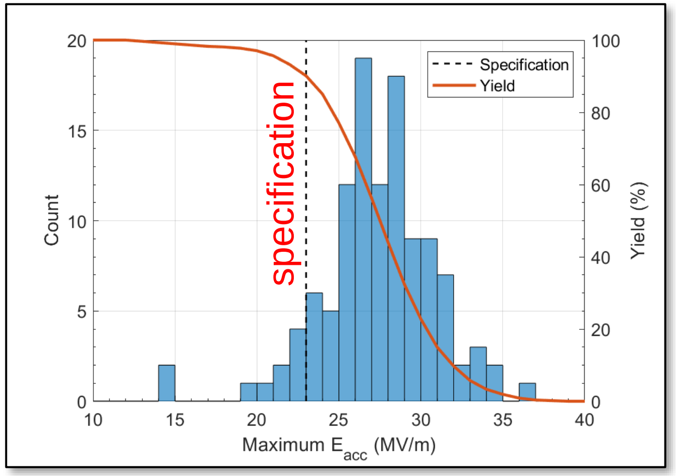
There are several important lessons learned from LCLS-II. A particularly important is to have very good QA/QC processes through strict oversight and statistical analysis

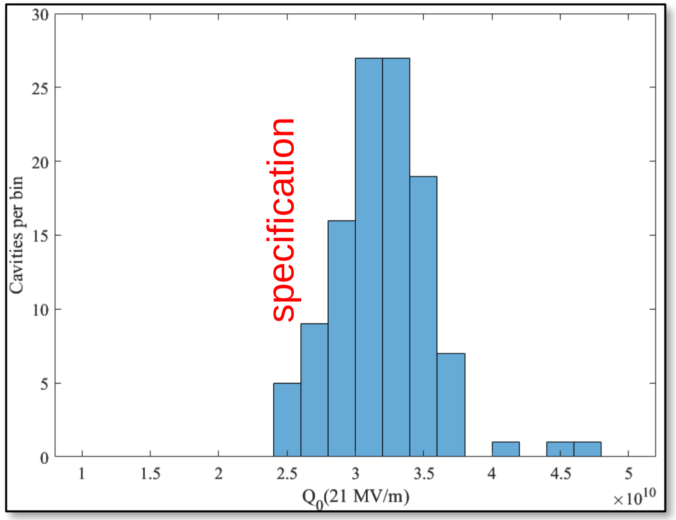
What questions can LCLS-II answer for ILC?

1. Gradient
   - Can we build cavities that achieve gradients required for ILC? **We're getting there**
   - If we achieve those high gradients in vertical test, can they be preserved in the installed linac? **YES**
2. Q0
   - Can we build cavities that achieve high Q0? **YES**
   - Can we achieve the required cool downs to maintain high Q0 in the linac? **YES**

Lessons learned from LCLS-II production and LCLS-II-HE R&D led to significant improvement in gradient performance while maintaining high Q_0

LCLS-II cavity production statistics to date

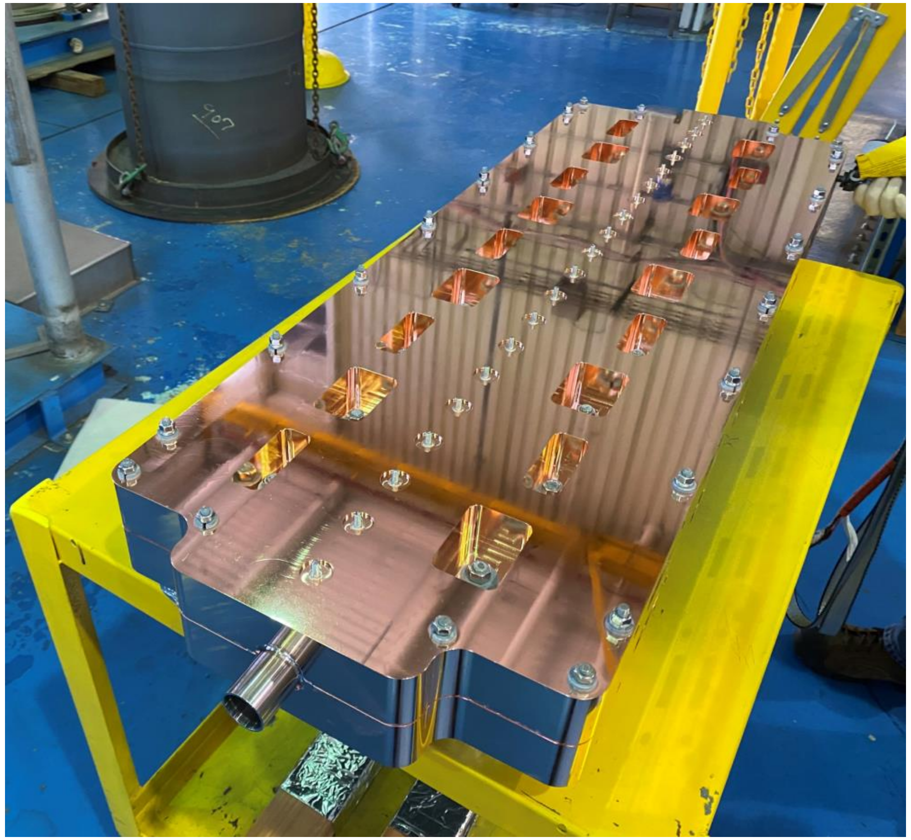




J. Maniscalco (SLAC) "LCLS-II-HE cavity and cryomodule testing"

D. Gonnella (SLAC) "Leveraging experience from production, commissioning, & early operations of LCLS-II and HE for ILC" – Accelerator plenary

NCRF TG summary



Evgenya Simakov (LANL), Mohamed Othman (SLAC),
Tetsuo Abe (KEK)

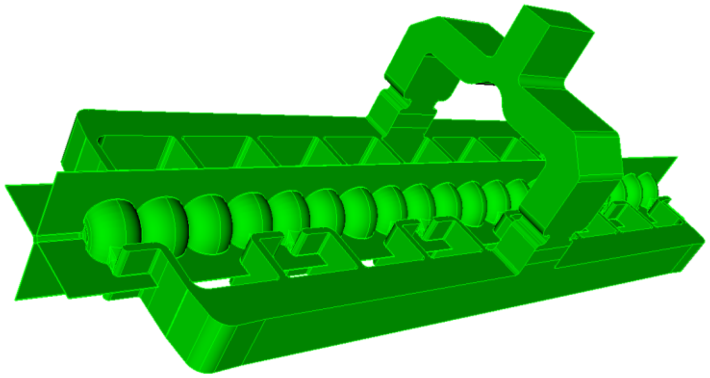
C3 Developments

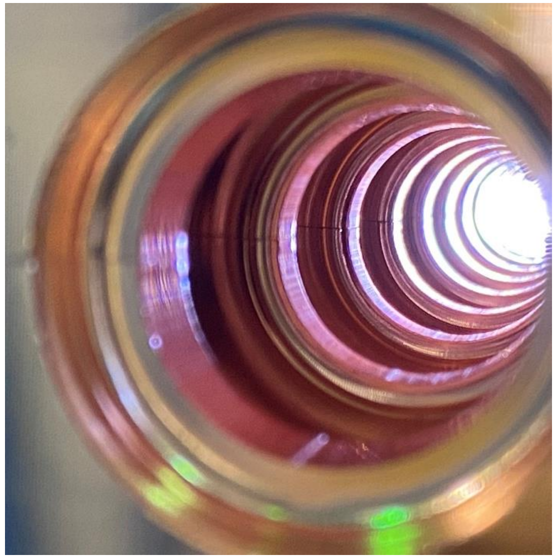
- C3 demonstration plan is being solidified
  - RF and cryomodule technology and beam dynamics investigation for the C3 main LINAC will need to continue
- Distributed coupling structures for C3 are currently being investigated at SLAC to include wakefield damping and large apertures for high beam charge
- Technologies for LLRF RF systems needed for C3 modulators are essential to improve electrical efficiency

F. Wang (SLAC) "C[3] Demonstration Plan and Applications"

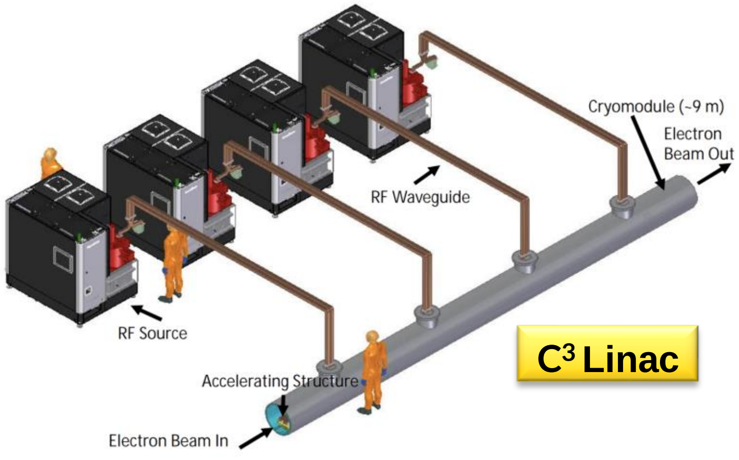
A. Dhar (SLAC) "Distributed Coupling Linac for Efficient Acceleration of High Charge Electron Bunches"

A. Krasnykh (SLAC) "RF sources and power distribution for the C3-demo and beyond"

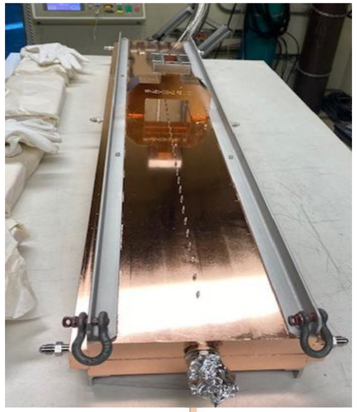


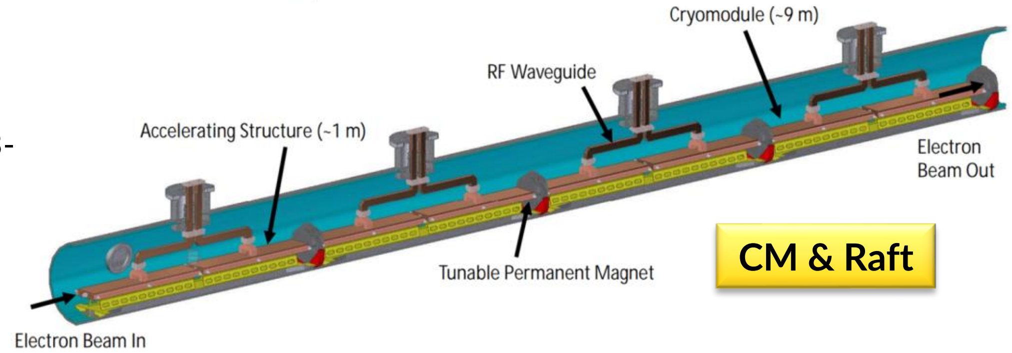


RF Structure

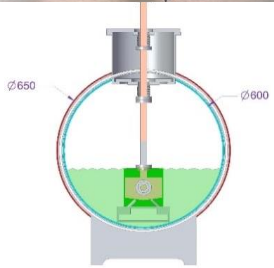


C^3 Linac





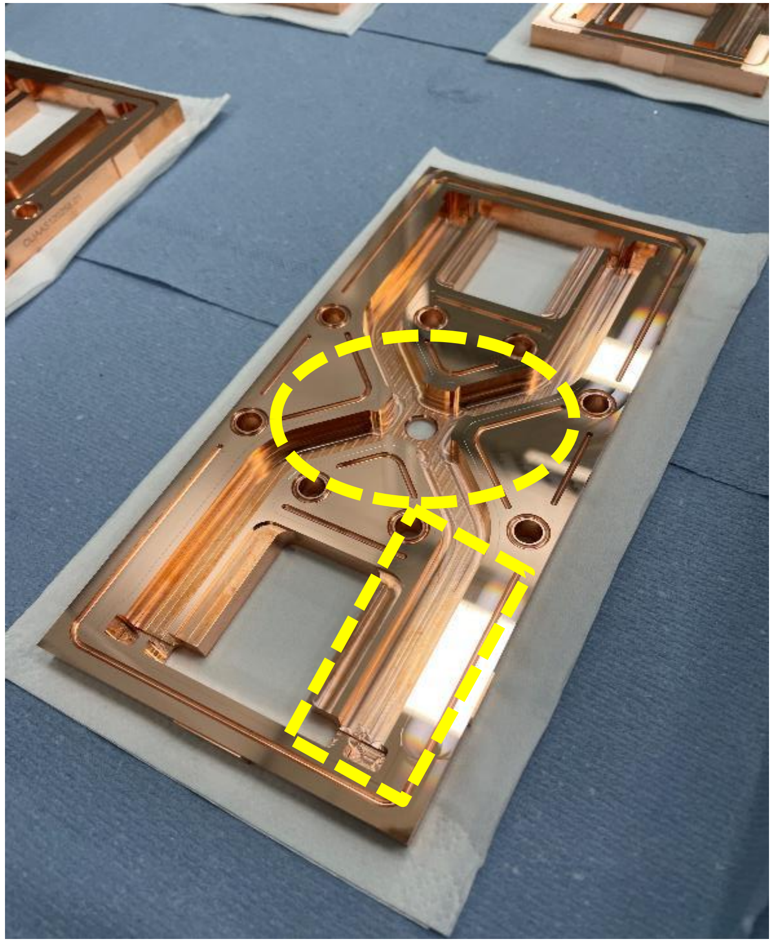
CM & Raft



CERN Highlights

- CERN commissioning high gradient structures is on-going with successful two simultaneous structure testing from the same RF source
- CERN advanced manufacturing techniques result in surfaces and braze joints with high quality

CERN structures



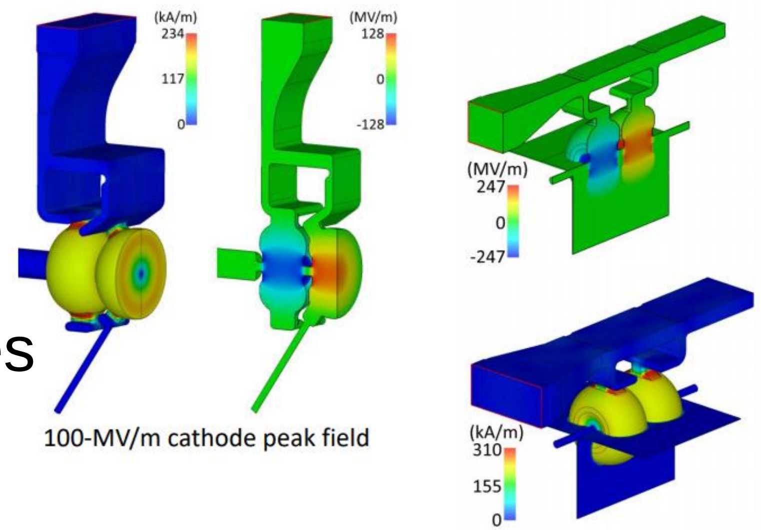
The new design integrates the RF area, cooling circuits, HOM loads and part of the vacuum system in one part

M. Boronat (CERN) “CERN’s High Gradient X-Band Test Stands: Status and Update”
P. Morales Sanchez (CERN) “CERN Xband Acc. structure update”
E. Ericson (CERN) “Wakefield Damping in a Distributed Coupling Accelerating Structure for CLIC”

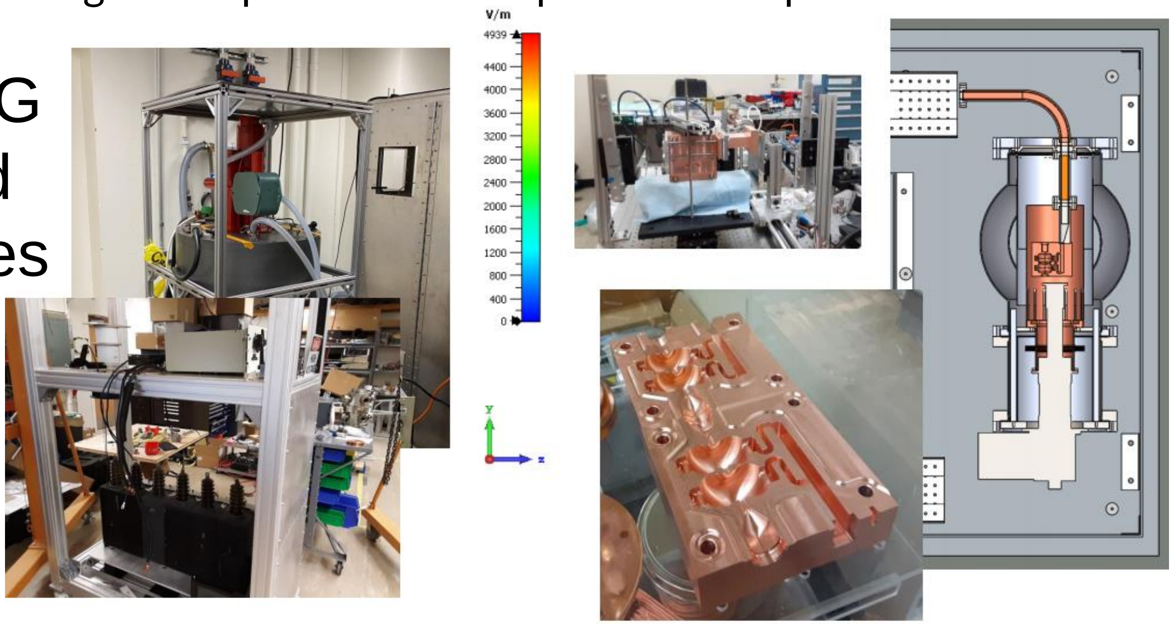
NCRF R&D

- LANL is developing multiple high gradient C-Band structures.
    - Technology innovation in wakefield damping and high brightness photoinjectors (Haoran Xu talks)
- UCLA CYBORG beamline is being constructed with first successful power from C-Band klystron with plans to power cryogenic C-Band structure
- Dielectric disc accelerator structures are still being investigated in Euclid and ANL with potential for low breakdowns
- A modeling tool for radiation dosage in accelerator facility is being developed at SLAC as part of US-Japan collaboration.

LANL Structures



CYBORG C-Band Structures



C. Di Giulio (INFN) “TEX (TEst stand for X-band) at LNF”
V. Dolgashev (SLAC) “High Efficiency Traveling Wave Linac”
H. Xu (LANL) “Two-cell high-gradient C-band RF accelerator cavity for high power HOM absorber testing”, “A design of the C-band RF photoinjector cavity for testing photocathodes under extreme fields”
B. Shirley (SLAC) “Development of a Compact Periodic Permanent Magnet Focused C-Band Klystron”
G. Lawler (UCLA) “Application of CrYogenic Brightness-Optimized Radiofrequency Gun (CYBGORG) for Future Collider Studies”
C. Jing (ANL/Euclid Techlabs) “Development of Dielectric Disk Accelerators”
L. Ge (SLAC) “An Integrated Simulation Tool for Dark Current Radiation Effects using ACE3P and Geant4”

LCWS2023
INTERNATIONAL WORKSHOP ON LINEAR COLLIDERS

Industry, Sustainability, and Applications: TG summary

Session Conveners:
Nuria Catalán Lasheras (CERN)
Valery Dolgashev (SLAC, USA)
Juan Fuster (IFIC-Valencia, Spain)
Jie Gao (IHEP Beijing, China)
Benno List (DESY, Germany)
Sam Posen (FNAL, USA)
Takayuki Saeki (KEK, Japan)
Emma Snively (SLAC, USA)
Steinar Stapnes (CERN)
Tohru Takahashi (Univ. Hiroshima, Japan)
Maxim Titov (Irfu, CEA Saclay, France)
Marc Winter (IJCLab, France)
Masakazu Yoshioka (Iwate University, Japan)

SLAC

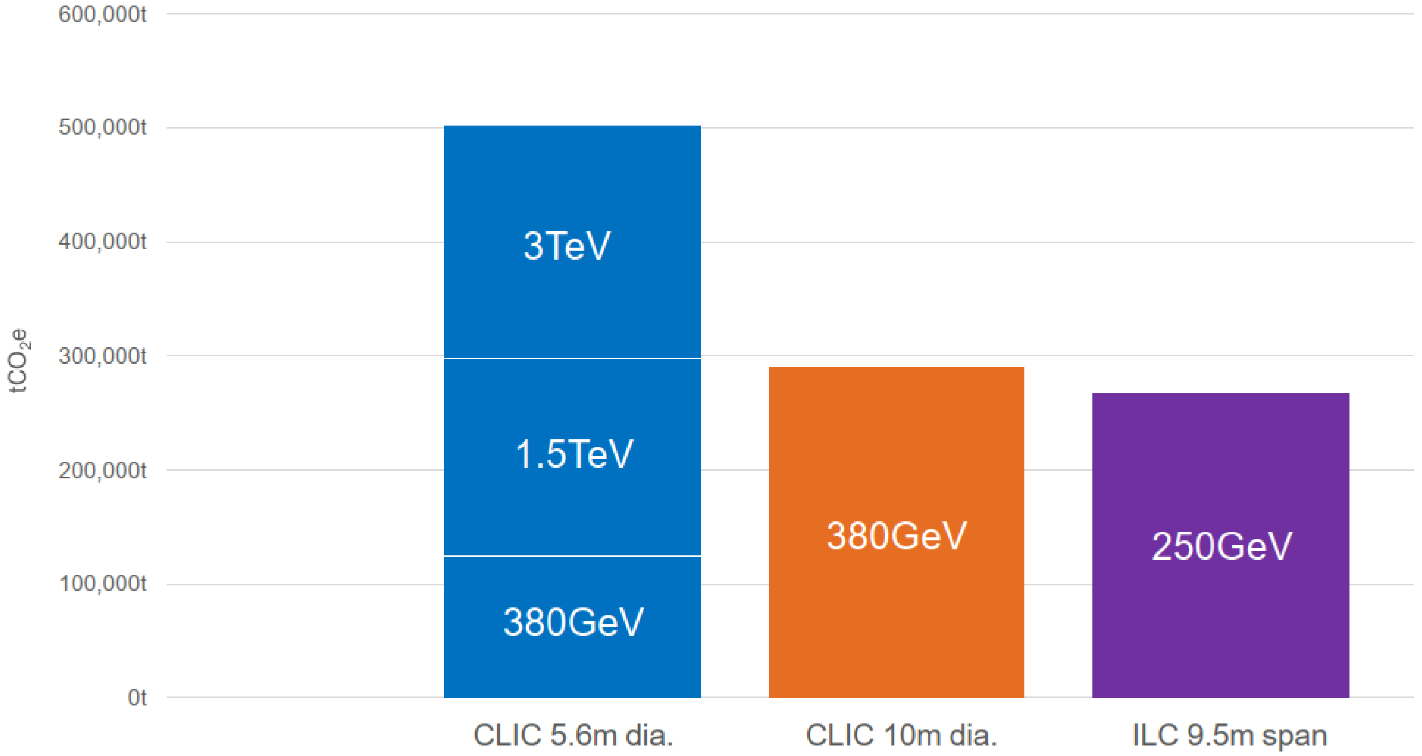
ARUP

A1-A5 Results

Global Warming Potential, GWP (tCO_2e)

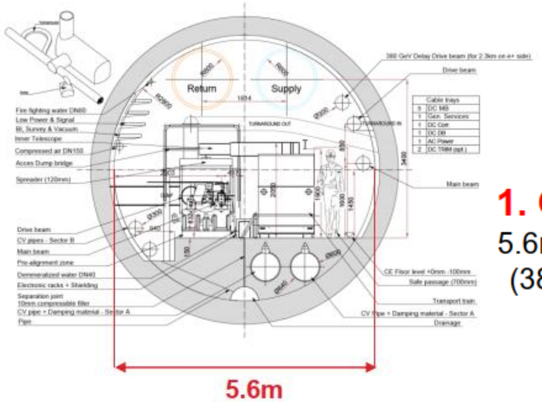
"Linear Collider Carbon Assessments: A Life Cycle Assessment of the CLIC and ILC Linear Collider Feasibility Studies"

Suzanne Evans

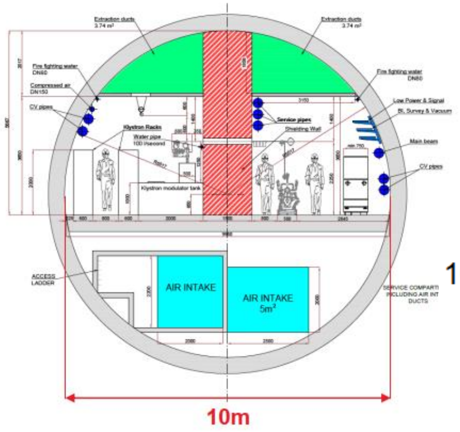


Materials
- **A1** Raw material supply
- **A2** Transport
- **A3** Manufacture

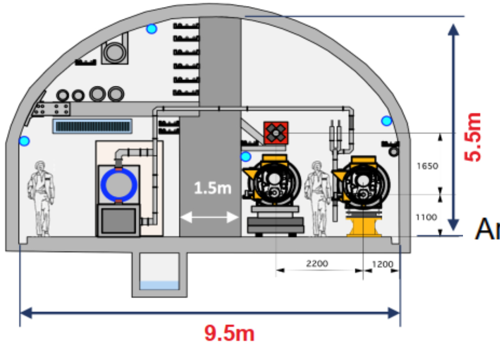
Transport & construction activities
- **A4** Transport to works site
- **A5** Construction process



1. CLIC Drive Beam
5.6m internal dia. Geneva. (380GeV, 1.5TeV, 3TeV)



2. CLIC Klystron
10m internal dia. Geneva. (380GeV)



3. ILC
Arched 9.5m span. Japan. (250GeV)

Components and Subsystems

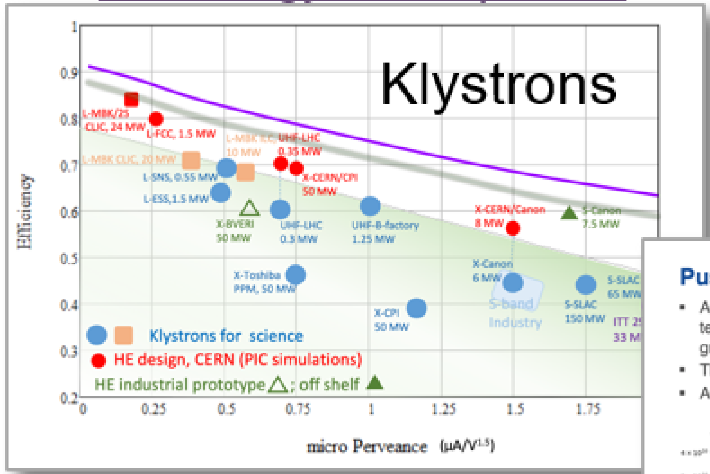
Better performance through better technology at same or lower cost

Difficult: lower operating cost through higher invest – needs trade off studies (LCA)

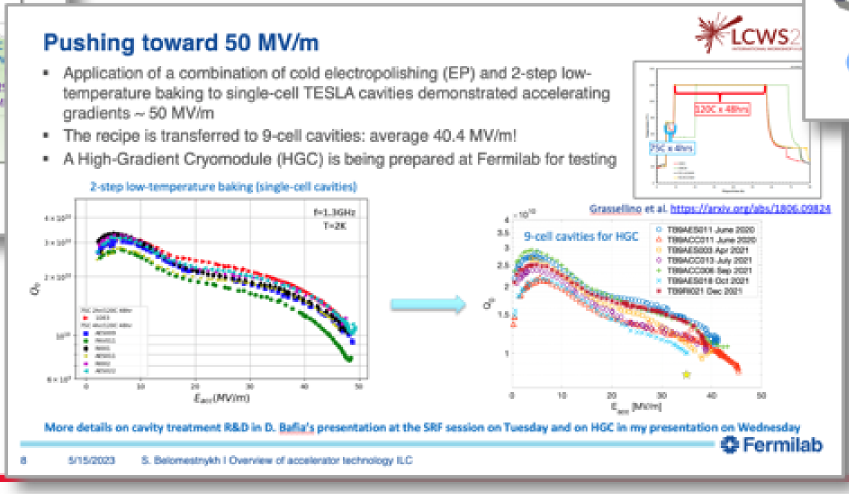
Igor Syratchev: *High efficiency klystrons at CERN*; **Zysheng Zhou**: *IHEP high efficiency klystrons* – *Today*

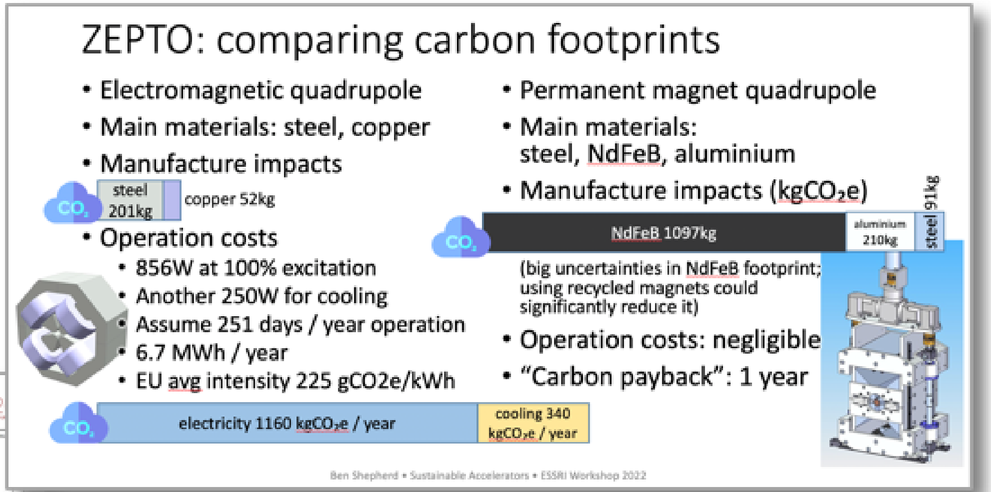
Sergey Belomestnykh: *Overview of accelerator technology development* - *Monday*

Ben Shepherd: *Permanent magnet technology* - *Today*

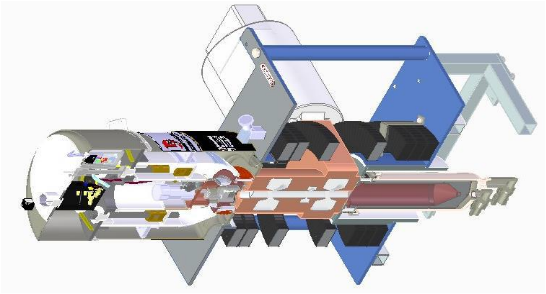


Cavities

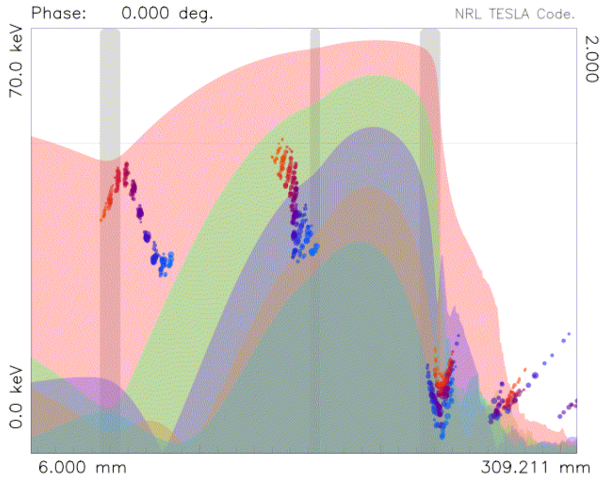


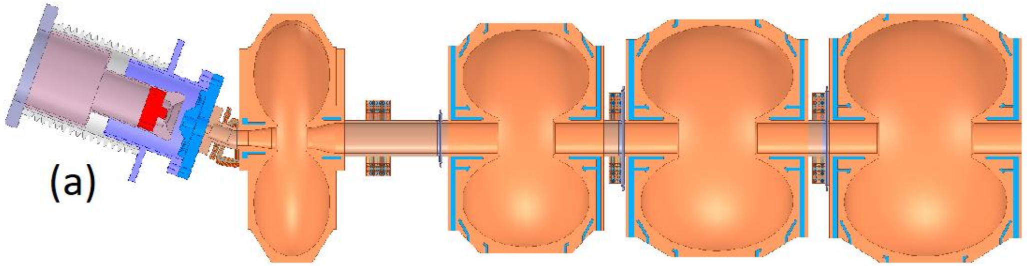


Applications

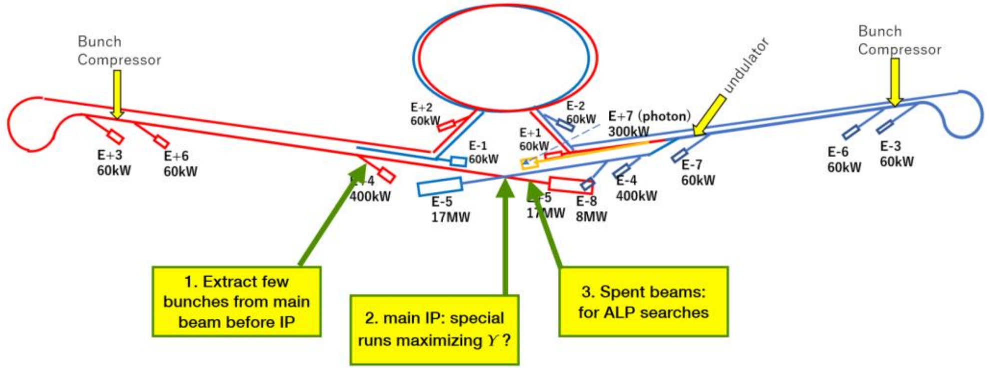


M. Othman (SLAC) “Progress of High-Efficiency L-Band IOT Design for Accelerator Applications at SLAC”



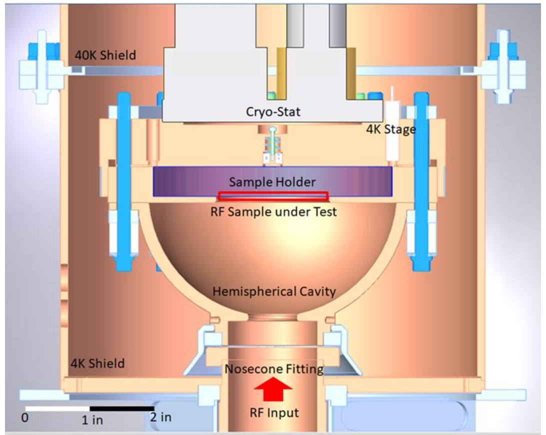


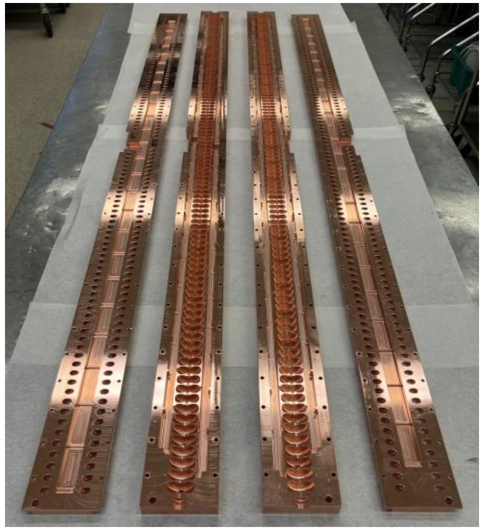
M. Shumail (SLAC) “High Efficiency, 1 MW, 1 MeV Accelerator for Environmental Applications”



J. List (DESY) “Strong-field QED Experiments for & at Linear Colliders”

M. Schneider (SLAC) “High Temperature Superconducting RF cavity”





E. Snively (SLAC) “Applications of High Gradient Accelerator Research for Novel Medical Accelerator Technology”

Conventional Facilities:
TG summary

Liam Bromiley
Latest Plans for FCC Civil Engineering and Site Investigations

Tomoyuki Sanuki
Site-specific Studies for the ILC in Tohoku

Claudio Di Giulio
The Frascati Beam Test Facility

Martin Breidenbach
Cryogenic Design for C3 Main Linacs

Harry van der Graaf
Rasnik as alignment system for linac submodules

Tetsuo ABE
Safety Measures Taken in High-Gradient Accelerating-Structure Test Facility at KEK

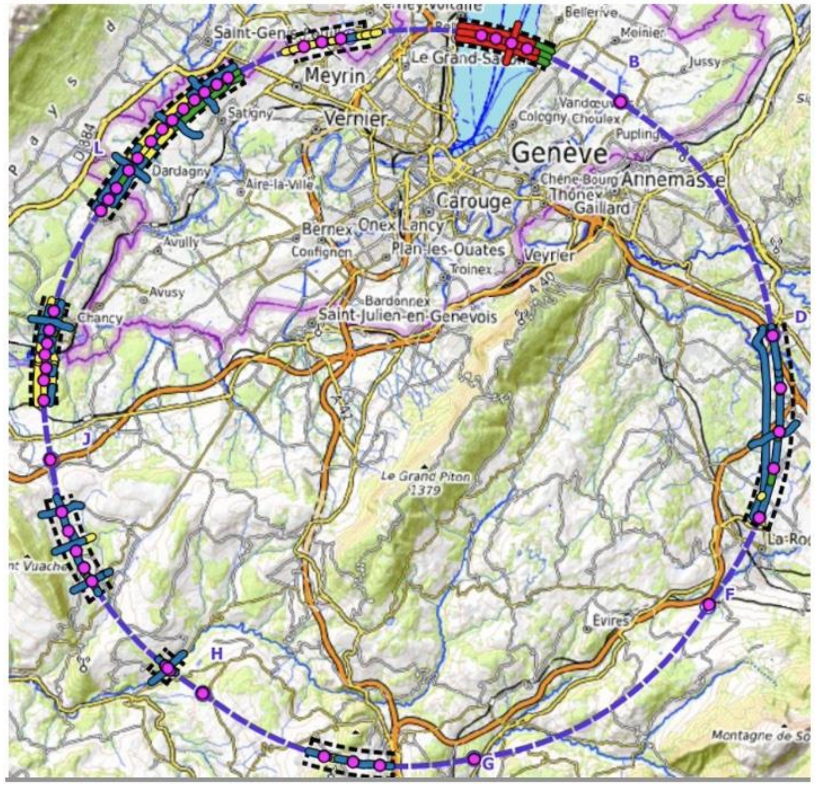
Session Conveners:
John Osborne (CERN)
Nobuhiro Terunuma (KEK)
Tomoyuki Sanuki (Tohoku U.)

Wednesday; Conventional Facility Session (6 talks)

Civil Engineering Reports (2 talks)

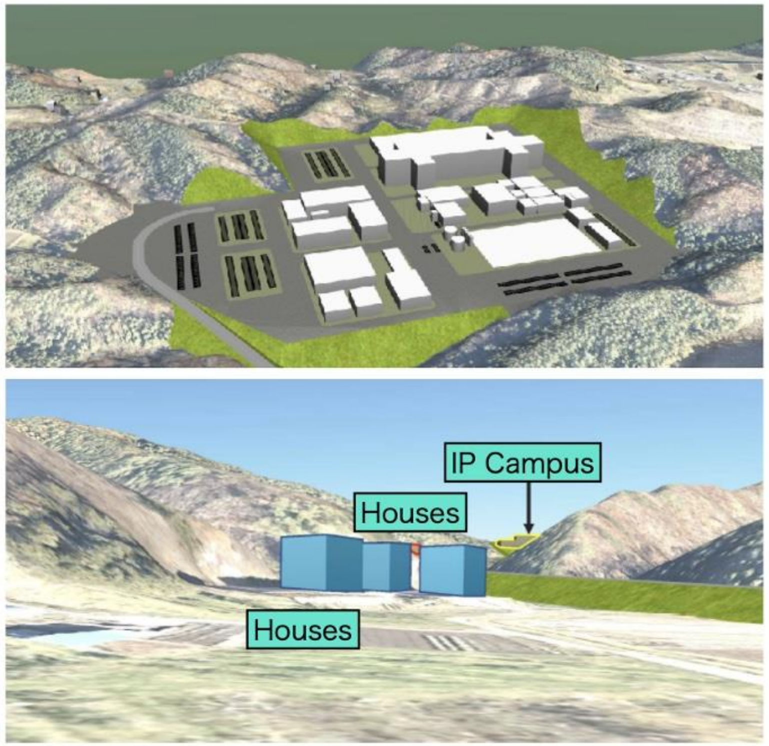
Liam Bromiley

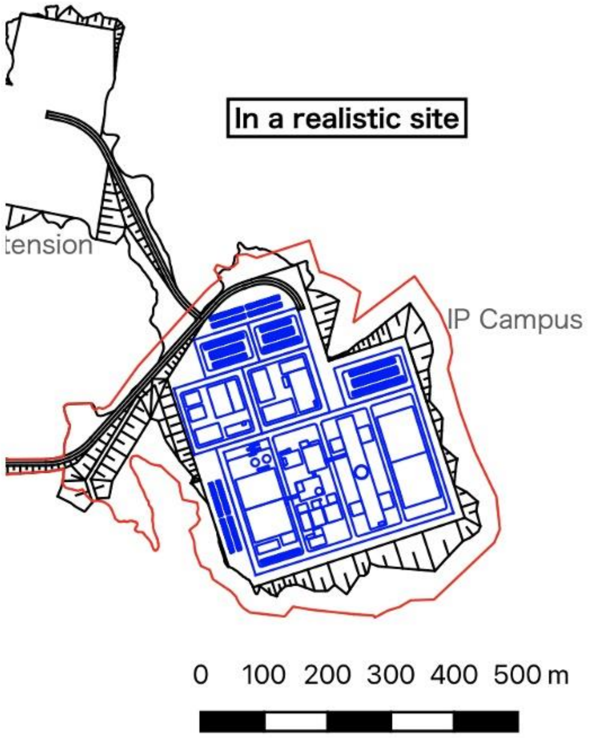
Latest Plans for FCC Civil Engineering and Site Investigations



Tomoyuki Sanuki

Site-specific Studies for the ILC in Tohoku





Wednesday; Conventional Facility Session (6 Talks)

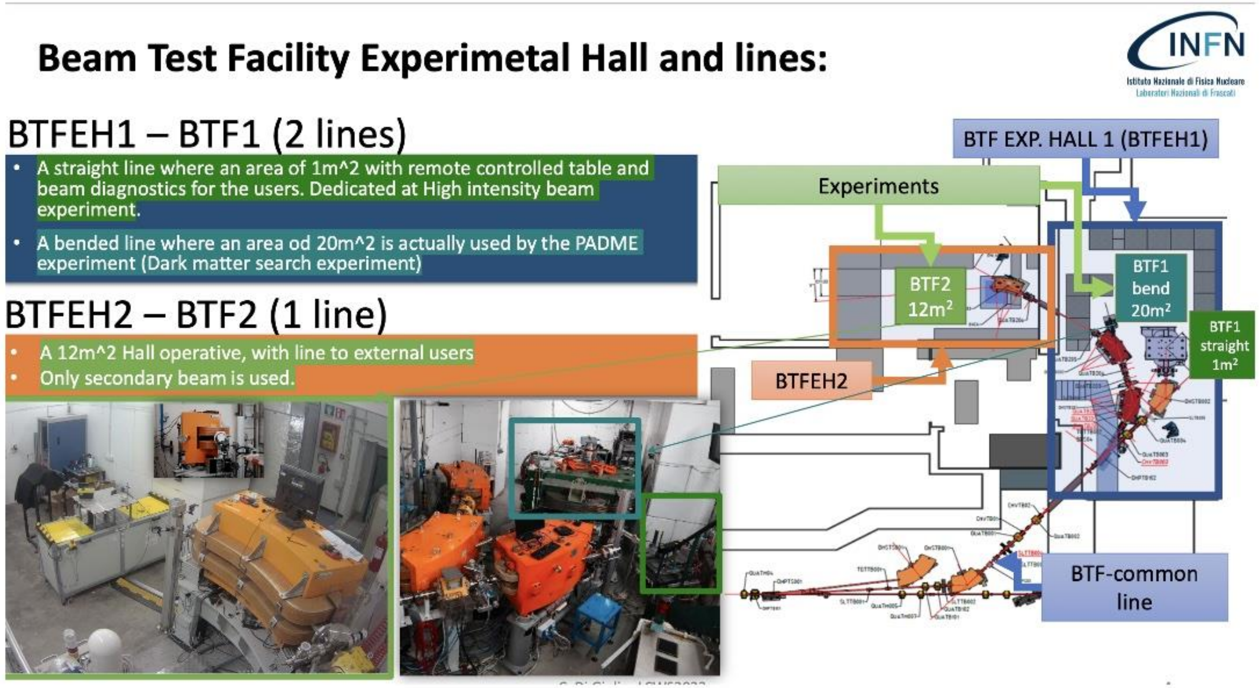
Test Facilities (2 talks)

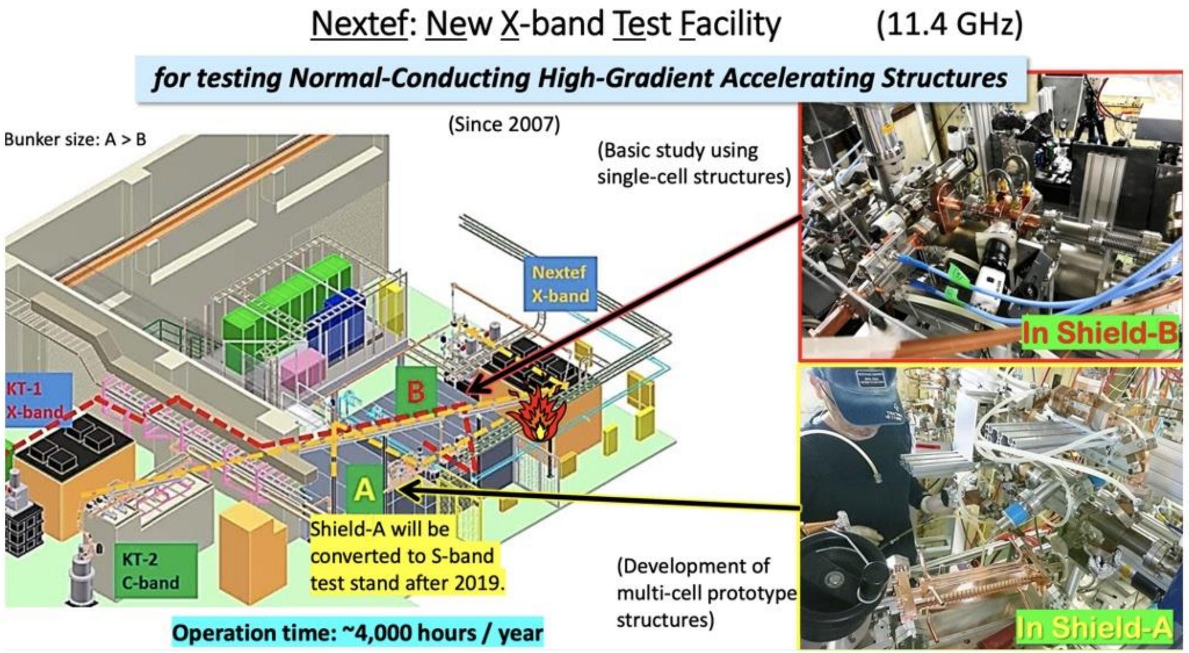
Claudio Di Giulio

The Frascati Beam Test Facility

Tetsuo ABE

Safety Measures Taken in High-Gradient Accelerating-Structure Test Facility at KEK





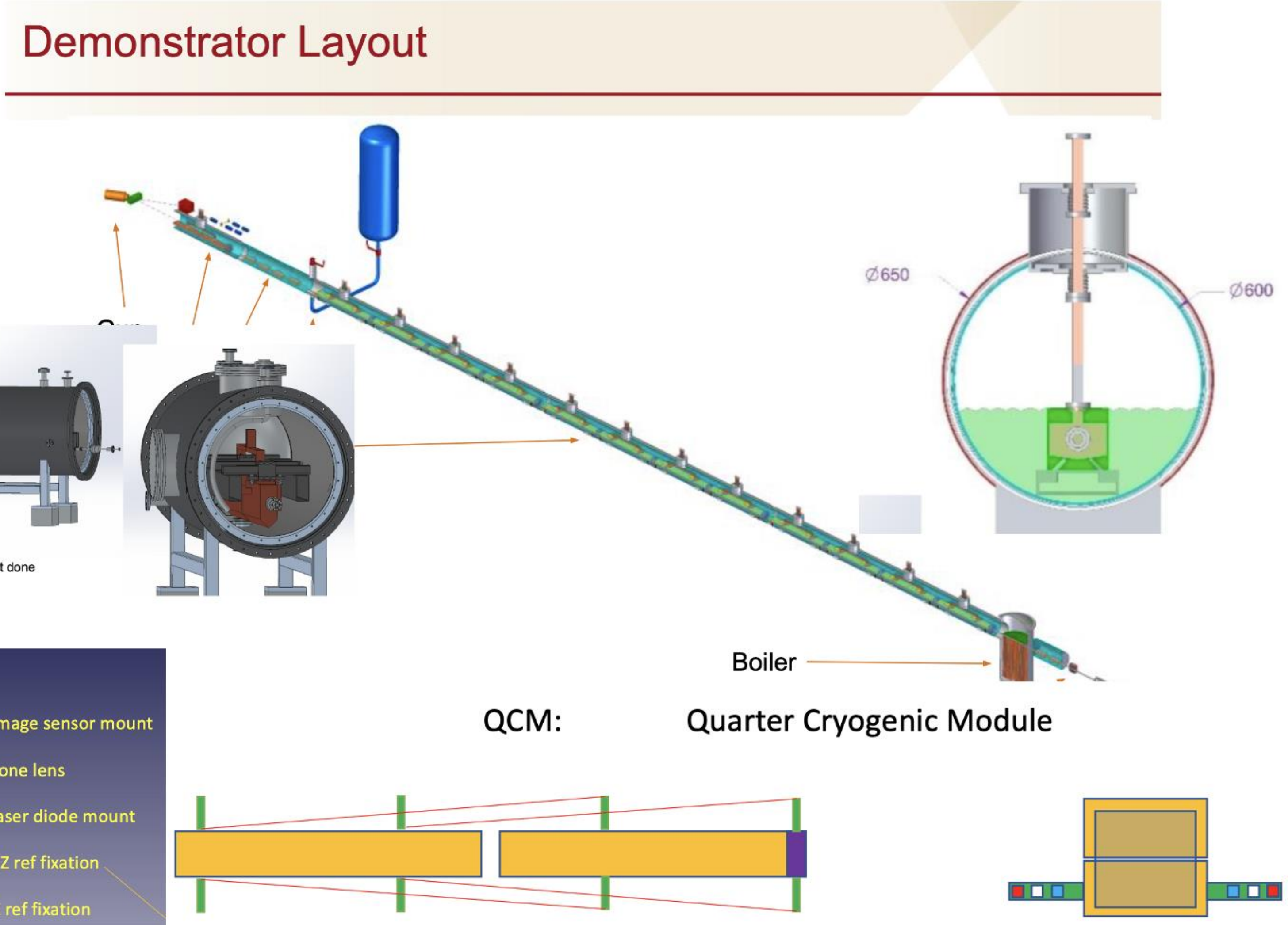
SLAC

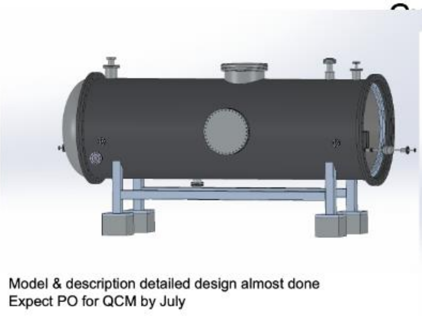
Wednesday; Conventional Facility Session (6 Talks)

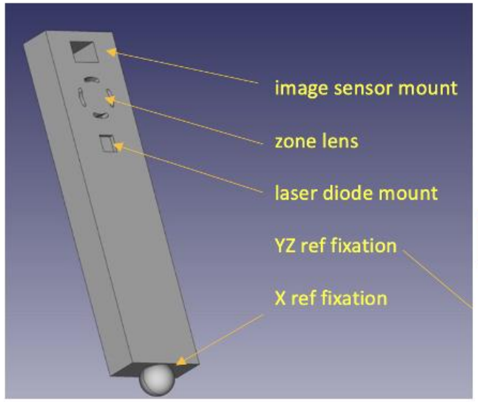
C3 Cryomodule (2 talks)

Martin Breidenbach
Cryogenic Design for C3 Main Linacs

Harry van der Graaf
Rasnik as alignment system for linac submodules







SLAC

Thank you!