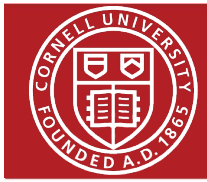


Cornell Laboratory for
Accelerator-based Sciences and
Education (CLASSE)

CESRTA Collaboration

M. Billing

September 11, 2012

152 Collaborators: Program Contributors

N. Omcikus[1], K.C. Harkay[2], R. Dowd[3], W. Guo[4], S.Y. Zhang[4], R.L. Holtzapple[5], L. Fabrizio[5], M. Randazzo[5], D. Asner[6], M. Cunningham[6], D. Carmody[7], J. Chu[7], F. Antoniou[8], S. Calatroni[8], F. Caspers[8], M. Gasior[8], R. Jones[8], Y. Papaphilippou[8], J. Pfingstner[8], G. Rumolo[8], H. Schmickler[8], M. Taborelli[8], D. Gonnella[9], J. Jones[10], A. Wolski[10], D. Teytelman[11], J.P. Alexander[12], J. Barley[12], L. Bartnick[12], M.G. Billing[12], K.R. Butler[12], J.R. Calvey[12], S.S. Chapman[12], G.W. Codner[12], M. Comfort[12], C.C. Conolly[12], J.V. Conway[12], J.A. Crittenden[12], C.A. Dennett[12], J.A. Dobbins[12], G.F. Dugan[12], N. Eggert[12], M. Ehrlichman[12], E. Fontes[12], M.J. Forster[12], R.E. Gallagher[12], S.W. Gray[12], S. Greenwald[12], D.L. Hartill[12], W. Hartung[12], Y. He[12], R. Helms[12], L. Hirshman[12], W.H. Hopkins[12], N. Kaminsky[12], J. Kandaswamy[12], J-S. Kim[12], D.L. Kreinick[12], B. Kreis[12], J. Lanzoni[12], Z. Leong[12], Y. Li[12], H. Liu[12], X. Liu[12], J.A. Livezey[12], A. Lyndaker[12], J. Makita[12], M. McDonald[12], V. Medjidzade[12], R.E. Meller[12], T.P. Moore[12], T.I. O'Connell[12], M.A. Palmer[12], S.B. Peck[12], D.P. Peterson[12], G.A. Ramirez[12], M.C. Rendina[12], P. Revesz[12], D.H. Rice[12], N.T. Rider[12], D.L. Rubin[12], D.C. Sagan[12], S. Santos[12], J. Savino[12], R.M. Schwartz[12], R. Seeley[12], J. Sexton[12], J. Shanks[12], J.P. Sikora[12], E.N. Smith[12], K.W. Smolenski[12], K.G. Sonnad[12], M. Stedinger[12], C.R. Strohman[12], A.B. Temnykh[12], M. Tigner[12], J.T. Urban[12], S. Vishniakou[12], S. Wang[12], W. Whitney[12], T. Wilksen[12], H.A. Williams[12], Y. Yariv[12], M.C. Ross[13], C.Y. Tan[13], R. Zwaska[13], B. Carlson[14], K. Hammond[15], M. Lawson[16], C. Cude[17], T. Demma[18], J. Flanagan[19], H. Fukuma[19], T. Ishibashi[19], P. Jain[19], K. Kanazawa[19], S. Kato[19], K. Kubo[19], K. Ohmi[19], K. Oide[19], H. Sakai[19], K. Shibata[19], Y. Suetsugu[19], H. Tajima[19], M. Tobiyama[19], J. Urakawa[19], R.J. Macek[20], J. Byrd[21], C.M. Celata[21], J.N. Corlett[21], S. De Santis[21], M.A. Furman[21], A. Jackson[21], R. Kraft[21], D.V. Munson[21], G. Penn[21], D.W. Plate[21], A. Rawlins[21], M. Venturini[21], M. Zisman[21], E.L. Wilkinson[22], H. Jin[23], L. Boon[24], A.F. Garfinkel[24], D. Kharakh[25], J. Ng[25], M.T.F. Pivi[25], L. Wang[25], R.P. Badman[26], S. Veitzer[27], L. Schachter[28], P. Kehayias[29], and L. Hales[30]

(Author list from CESRTA Phase 1 Report)

30 Collaborating Institutions

1 American River College, Sacramento, CA 95841

2 Argonne National Laboratory, Argonne, IL 60439

3 Australian Synchrotron, Clayton, 3168, Australia.

4 Brookhaven National Laboratory, Upton, NY 11973

5 Physics Department, California Polytechnic State University, San Luis Obispo, CA 93407

6 Department of Physics, Carleton University, Ottawa, Ontario, K1S 5B6, Canada.

7 Department of Physics, Carnegie Mellon University, Pittsburgh, PA, 15389

8 CERN, CH-1211 Geneve 23, Switzerland.

9 Department of Physics, Clarkson University, Potsdam, NY 13699

10 Cockroft Institute, Warrington, Cheshire, U.K.

11 Dimtel, Inc., San Jose, CA 95124, U.S.A.

12 Cornell Laboratory for Accelerator-based Sciences and Education, Cornell University, Ithaca, NY, 14850

13 Fermi National Accelerator Laboratory, Batavia, IL 60510

14 Physics Department, Grove City College, Grove City, PA 16127,

15 Department of Physics, Harvard University, Cambridge, MA 02138, U.S.A.

16 Department of Physics, Harvey Mudd College, Claremont, CA 91711

17 Department of Physics, Indiana University, Bloomington, IN 47405

18 Istituto nazionale di Fisica Nucleare - Laboratori Nazionali di Frascati, 00044 Frascati, Italy.

19 High Energy Accelerator Research Organization (KEK), Tsukuba, Ibaraki 305-0801, Japan.

20 Los Alamos National Laboratory, Los Alamos, NM 87544

21 Lawrence Berkeley National Laboratory, Berkeley, CA 94270

22 Department of Physics, Loyola University, Chicago, IL, 60626, U.S.A.

23 Department of Physics, Postech, Pohang, Gyeongbuk 790-784, R.O.K.

24 Department of Physics, Purdue University, West Lafayette, IN 47907

25 SLAC National Accelerator Laboratory, Menlo Park, CA 90425

26 Department of Physics, Syracuse University, Syracuse, NY 13244

27 Tech-X Corporation, Boulder, CO, 80303

28 Department of Electrical Engineering, Technion-IIT, Haifa, 32000, Israel.

29 Department of Physics and Astronomy, Tufts University, Medford, MA 02155, U.S.A.

30 Department of Physics and Astronomy, University of Utah, Salt Lake City, UT 84112

Type of Collaborative Activity

Collaborators	Institution	Participation
K. Harkay	ANL	Collaborative research and personnel exchange: electron cloud measurements and simulations with a particular focus on validation of the primary photoelectron models.
R. Dowd	Australian Synchrotron	Collaborative research: low emittance tuning.
W. Guo, S.Y. Zhang	BNL	Collaborative research: low emittance optics design.
R. Holtzapple	CalPoly	Collaborative research, in-kind contributions, and personnel exchanges: instrumentation and beam dynamics measurements.
D. Asner*	Carleton U.	Collaborative research: secondary electron yield measurements.
F. Antoniou, S. Calatroni, F. Caspers, M. Gasior, R. Jones, Y. Papaphilippou, J. Pfingster, G. Rumolo, H. Schmickler, M. Taborelli	CERN	Collaborative research, in-kind contributions and personnel exchanges: electron cloud measurements and simulations, beam instrumentation, microwave transmission techniques, machine stability, and beam dynamics studies.
J. Jones, A. Wolski	Cockroft Institute	Collaborative research and personnel exchanges: low emittance tuning.
M.C. Ross, C-Y. Tan, R. Zwaska	FNAL	Collaborative research and personnel exchanges: electron cloud measurements and secondary electron yield measurements.
Theo Demma	INFN-LNF (Frascati, IT)	Collaborative research and personnel exchanges: electron cloud measurements and simulations.
K. Kanazawa, K. Kubo, K. Ohmi, K. Oide, J. Flannagan, H. Sakai, Y. Suetsugu, K. Shibata, H. Tajima, M. Tobiyama,J. Urakawa	KEK (Japan)	Collaborative research, financial support, in-kind support and personnel exchanges: electron cloud measurements and simulations, feedback system, low emittance instrumentation (eg, high resolution x-ray beam size monitor).
J. Byrd, C. Celata, J. Corlett, S. De Santis, M. Furman, A. Jackson, R. Kraft, D. Munson, G. Penn, D. Plate, A. Rawlins, M. Venturini, M. Zisman	LBNL	Collaborative research, in-kind support and personnel exchanges: electron cloud measurements and simulations, wiggler chambers for electron cloud suppression, microwave transmission techniques for characterizing plasmas.
A. Garfinkel	Purdue U.	Collaborative research and personnel exchanges: electron cloud simulations with a particular focus on validation of the primary photoelectron models.
D. Kharakh, J. Ng., M. Pivi, L. Wang	SLAC	Collaborative research, in-kind support and personnel exchanges: electron cloud measurements and simulations, dipole and wiggler chambers for electron cloud suppression, secondary electron yield measurements.
L. Schächter	Technion-Haifa (Israel)	Collaborative research and personnel exchanges: electron cloud measurements and analysis.

Student Participation

Student	Institution	Participation
Graduate Students		
Joseph Calvey	Cornell	Electron cloud measurements & simulations
Nicholas Eggert	Cornell	xBSM development
Michael Ehrlichman	Cornell	Intrabeam and Touschek scattering
Richard Helms	Cornell	Accelerator design
Walter Hopkins	Cornell	xBSM development
Benjamin Kreis	Cornell	xBSM development
James Shanks	Cornell	Low emittance tuning
Jeremy Urban	Cornell	Accelerator design
Yanay Yariv	Cornell	Low emittance tuning
Laura Boon	Purdue	Electron cloud simulations
Puneet Jain	KEK	Electron cloud simulations
Undergraduate Students		
Kaitlin Butler	Cornell	Electron cloud simulations
Noah Kaminsky	Cornell	Electron cloud simulations
Jin-Sung Kim	Cornell	Secondary electron yield measurements
Zhidong Leong	Cornell	Electron cloud simulations
Hongwan Liu	Cornell	xBSM development
Jesse Livezey	Cornell	Electron cloud measurements & simulations
Junki Makita	Cornell	Electron cloud measurements & simulations
Michael McDonald	Cornell	xBSM development
Gabriel Ramirez	Cornell	Electron cloud measurements & simulations
Steven Santos	Cornell	Electron cloud measurements & simulations
Robert Schwartz	Cornell	Electron cloud measurements & simulations
Siarhei Vishniakou	Cornell	Software support
William Whitney	Cornell	Electron cloud measurements
Heather Williams	Cornell	Beam dynamics studies
Leah Fabrizzio	CalPoly	Instrumentation development
Matthew Randazzo	CalPoly	Instrumentation/beam dynamics studies

REU Student Participation

Student	Institution	Project
Research Experience for Undergraduates		
Johan Bonilla	Stanford University	Beam dynamics simulation
Daniel Carmody	Carnegie Mellon	Electron cloud simulations
Chris Cude	Indiana University	Electron cloud measurements
Danielle Dugans	Gordon College	Microwave measurements of electron cloud
Emily Hemingway	S. Olaf's College	Electron cloud measurments
Pauli Kehayias	Tufts	Beam dynamics simulation
Matthew Lawson	Harvey Mudd College	Low emittance tuning
Benjamin Carlson	Grove City College	Microwave measurements of electron cloud
Daniel Gonnella	Clarkson	Intrabeam and Touschek scattering
Eric Wilkinson	Loyola	Electron cloud simulations
Laurel Hales	University of Utah	Low emittance tuning
Kenneth Hammond	Harvard University	Microwave measurements of electron cloud
Neboysa Omcikus	American River College	Electron cloud simulations
Zoey Warecki	Towson University	Low emittance simulation
Kiel Williams	Guilford College	Electron cloud measurements

Contemporary Tools for Collaboration

- Meetings required Web-based communications to encourage participation
- Collaboration Web-site:
  - Contains meeting notes for Technical & Research areas
  - Schedules: CESR's & Machine Studies shifts
  - ILC DR Group design & planning pages
- Web-based Logbook –available to collaborators
- Remote Experimental Operations of CESR
- Long-term Archives for CESRTA Data
  - Database constructed for results of measurements
  - Accessible to all collaborators

Organization of Collaboration

- Routine Meetings
- Special ad hoc Design Efforts:
  - Production of Wiggler Vacuum Chambers
  - Production of Clearing Electrode
  - Design of new RFAs
- Participation in Planning for ILC DR
  - Optics design
  - Wiggler design
  - Magnet & PS design
  - Vacuum Chamber design
  - EC modeling

CESRTA Publications & Contributions

- Total of 99 papers & reports to date
  - by subject:
    - 68 Electron Cloud
    - 17 Low Emittance and Intra-beam Scattering
    - 14 CESRTA Project, Instrumentation, Other
  - by classification:
    - 84 Conference or Workshop Papers
    - 9 REU Student Reports
    - 5 Journal Articles
    - 1 Other (ICFA Beam Dynamics Newsletter)
- Contributors for ILC Design
  - DR design:
    - Optics
    - Magnets/PSs
    - Vacuum Chamber & Mitigation
    - Electron Cloud Modelling
    - Archives for Entire Design effort

Participation in Conferences & Workshops

- Conferences
  - PAC09
  - IPAC10
  - IPAC11
  - PAC11
  - IPAC12
  - IBIC12
- Workshops
  - ECLOUD 10
    - Incl. ILC DR Satellite Meeting
  - IWLC 2010
  - LC 2010
  - LCWS10
  - BIW10
  - ECLOUD 11
  - LCWS11
  - LER 2011
  - ECLOUD 12
  - BIW12

CesrTA Phase I Report

- Report exceeds 400 pages
  - Nine chapters
    - Introduction
    - The CESR Conversion
    - Low Emittance Tuning
    - Description of the Electron Cloud Model
    - Electron Cloud Growth and Mitigation
    - Electron Cloud Induced Beam Dynamics
    - Status of Our Understanding of the Electron Cloud Model
    - Recommendations for the ILC Positron Damping Ring
    - Conclusions and Future Plans

- Final draft undergoing revisions now

A Few Examples of Collaborative Efforts

- Hardware development
  - Design/production of RFAs - APS, Los Alamos, SLAC, CU
  - Clearing electrode - KEK, SLAC, Berkeley, CU
  - Vacuum chamber coatings - CERN, SLAC, Berkeley, CU
  - Grooved chamber - KEK, SLAC, Berkeley, CU
  - L3 Chicane chambers – SLAC, CU
  - Beam size instrumentation – CERN, KEK, Cal Poly, CU
- Experimental collaboration (capable of remote access)
  - EC Tune shifts of trains – Cal Poly, CU
  - EC Instabilities – KEK, Cal Poly, CU
  - LET – CERN, Berkeley, CU
- Software development
  - CMAD, ECLOUD, POSINST, Synrad3D, BMAD
- Data archive (& collaboration web-site)

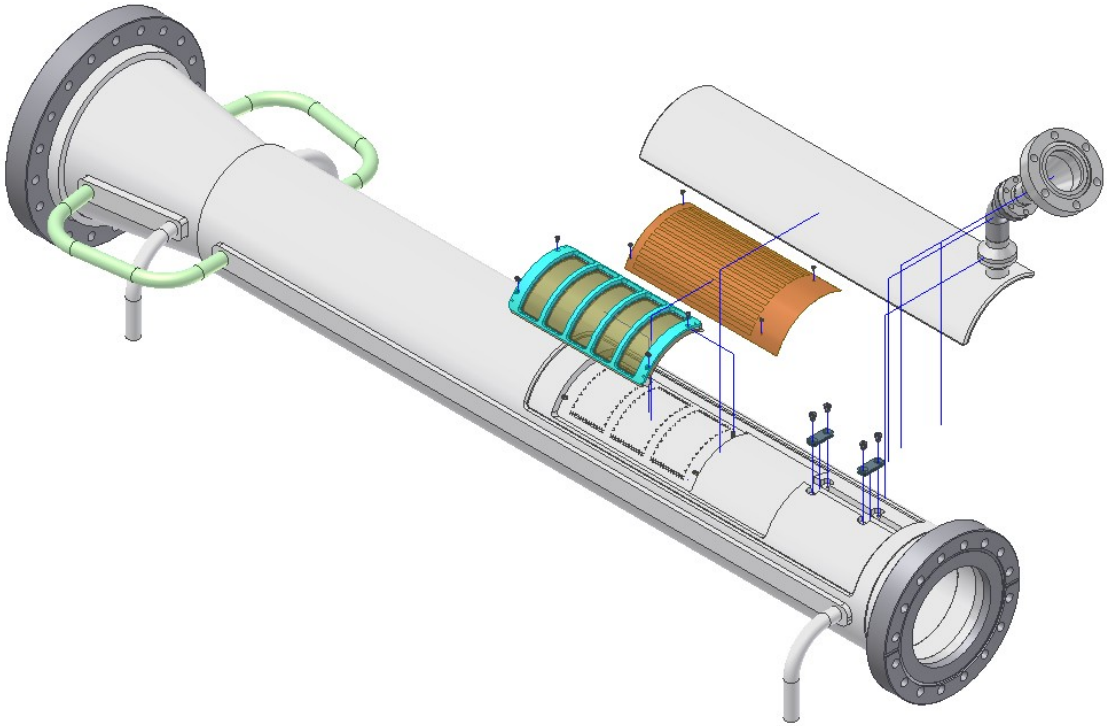
The next section illustrates examples using slides from concurrent meetings

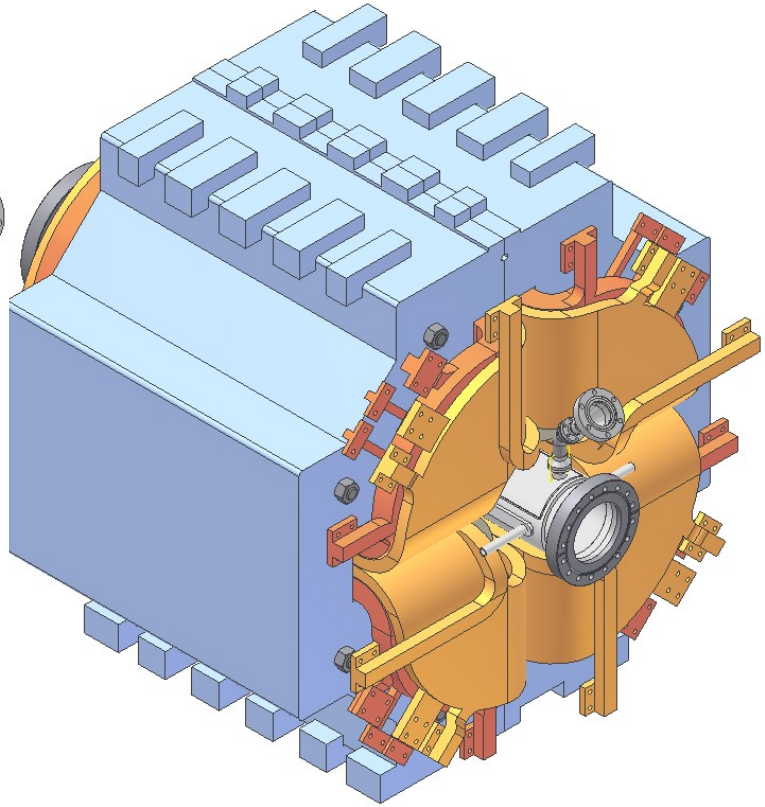
Design/Production of RFAs: Quadrupole Chamber

APS, Los Alamos, SLAC, CU

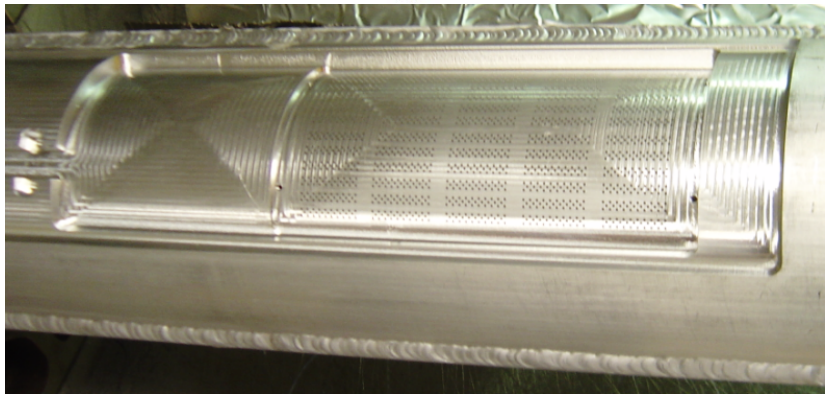
- Collaborative design using Web-Ex

Q48E RFA Chamber – TiN Coated

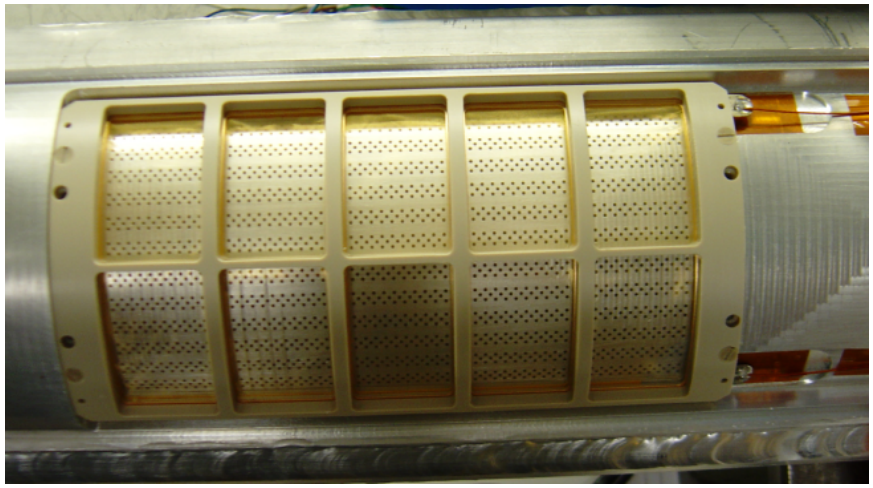


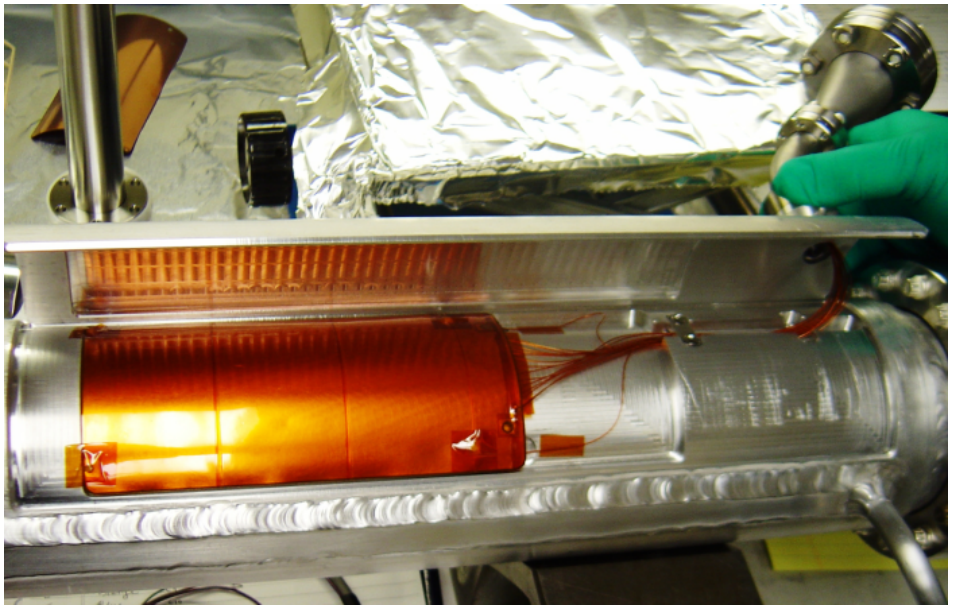


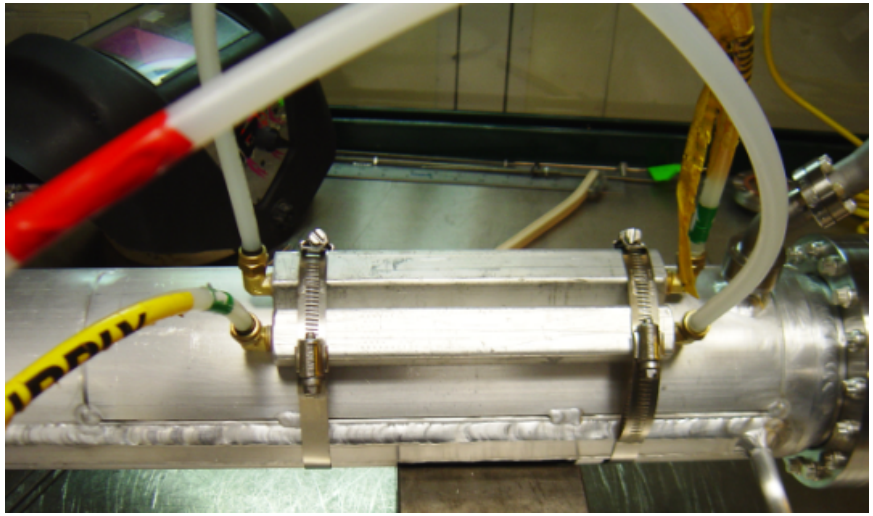
- *Aluminum beampipe fabricated and welded*
- *TiN coating in January 2010*
- *RFA Assembly in Jan/Feb 2010*

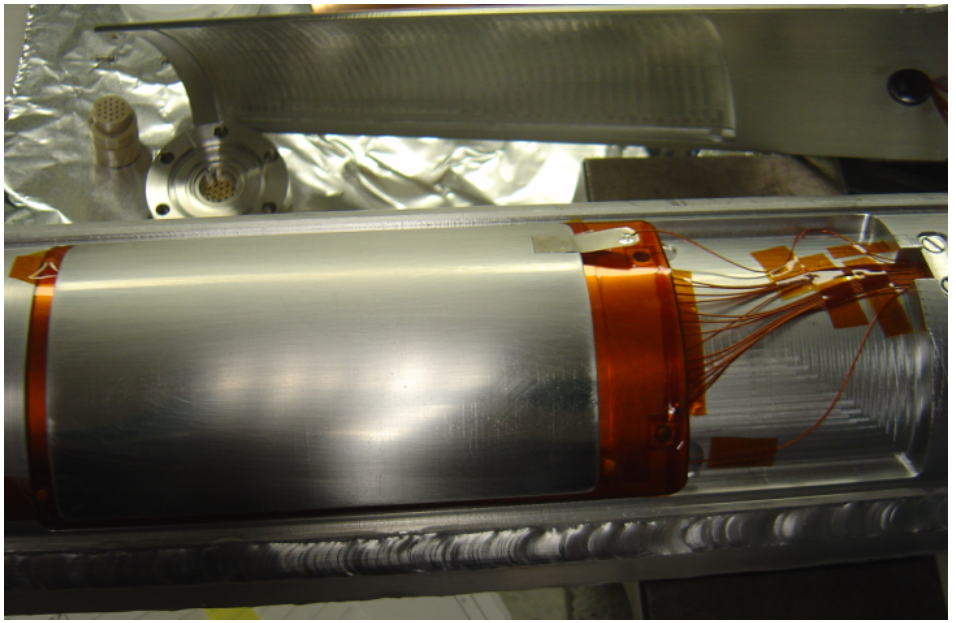


Q48W Quad RFA Chamber









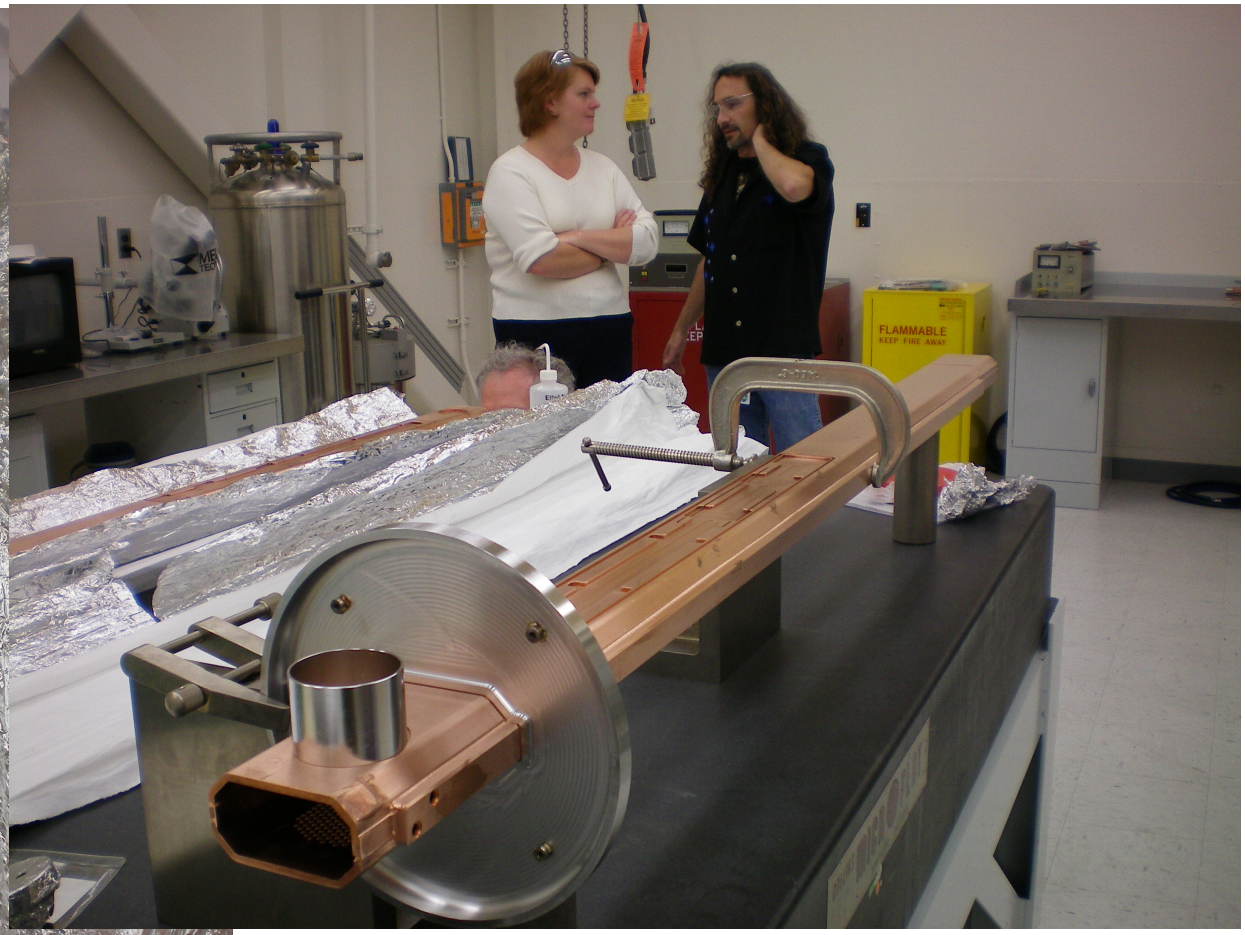
- Single retarding grid

Design/Production of RFAs: Wiggler

APS, Los Alamos, LBNL, SLAC, CU

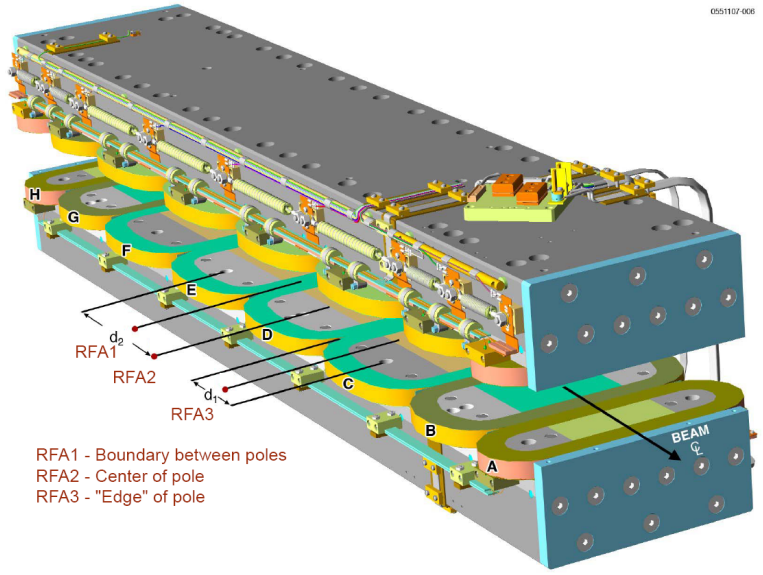
- Sophisticated design effort using Web-Ex
- Material from SLAC
- Integrated design & machining tools
- Machining at LBNL

Wiggler Chambers at LBNL

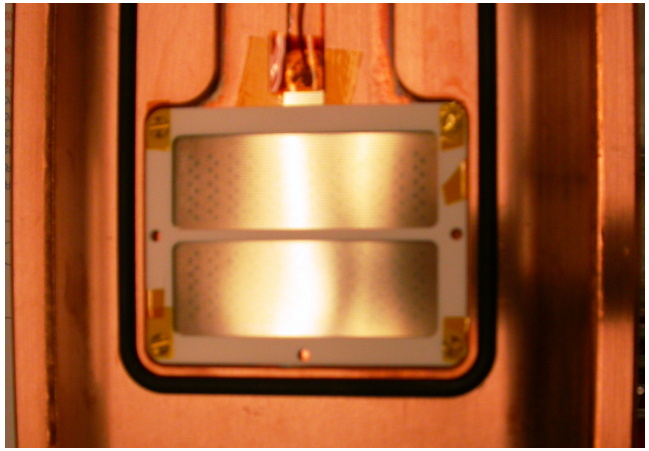


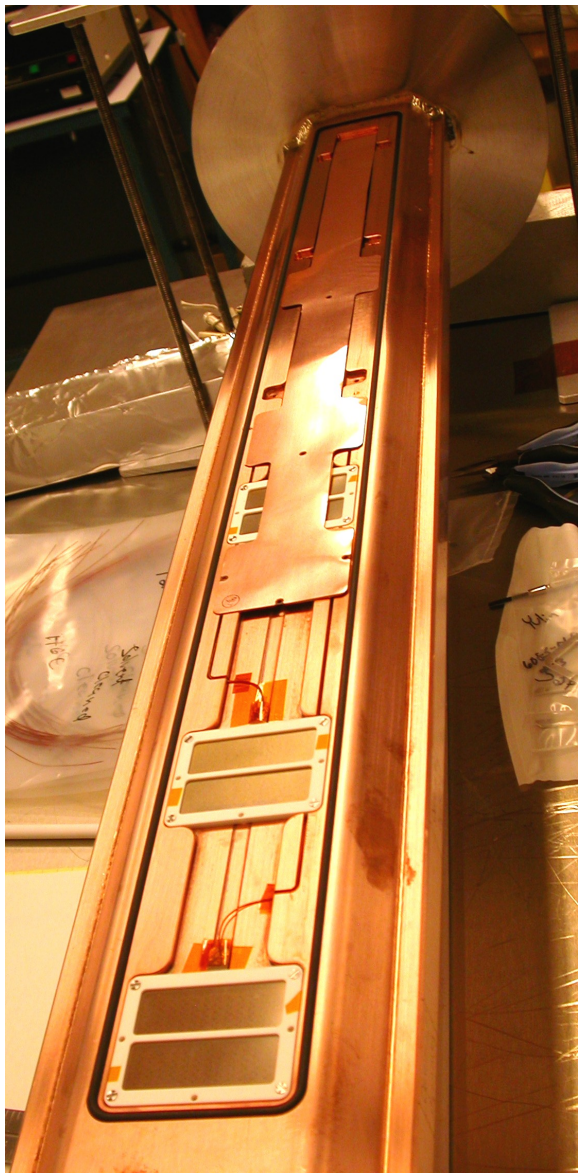
Dawn Munson, Rick Kraft and wiggler chambers 1 & 2

SCW RFA Beampipe

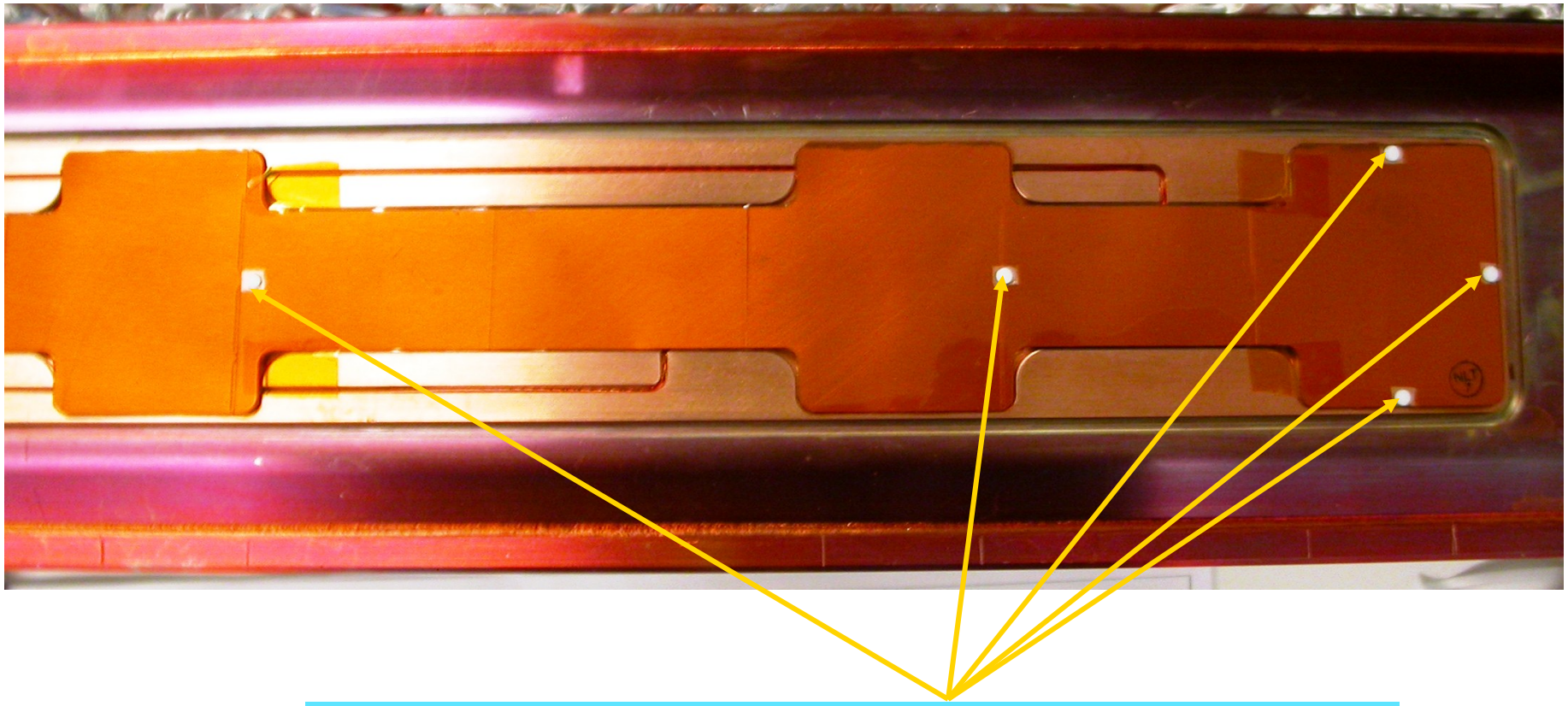


Assemble Grids



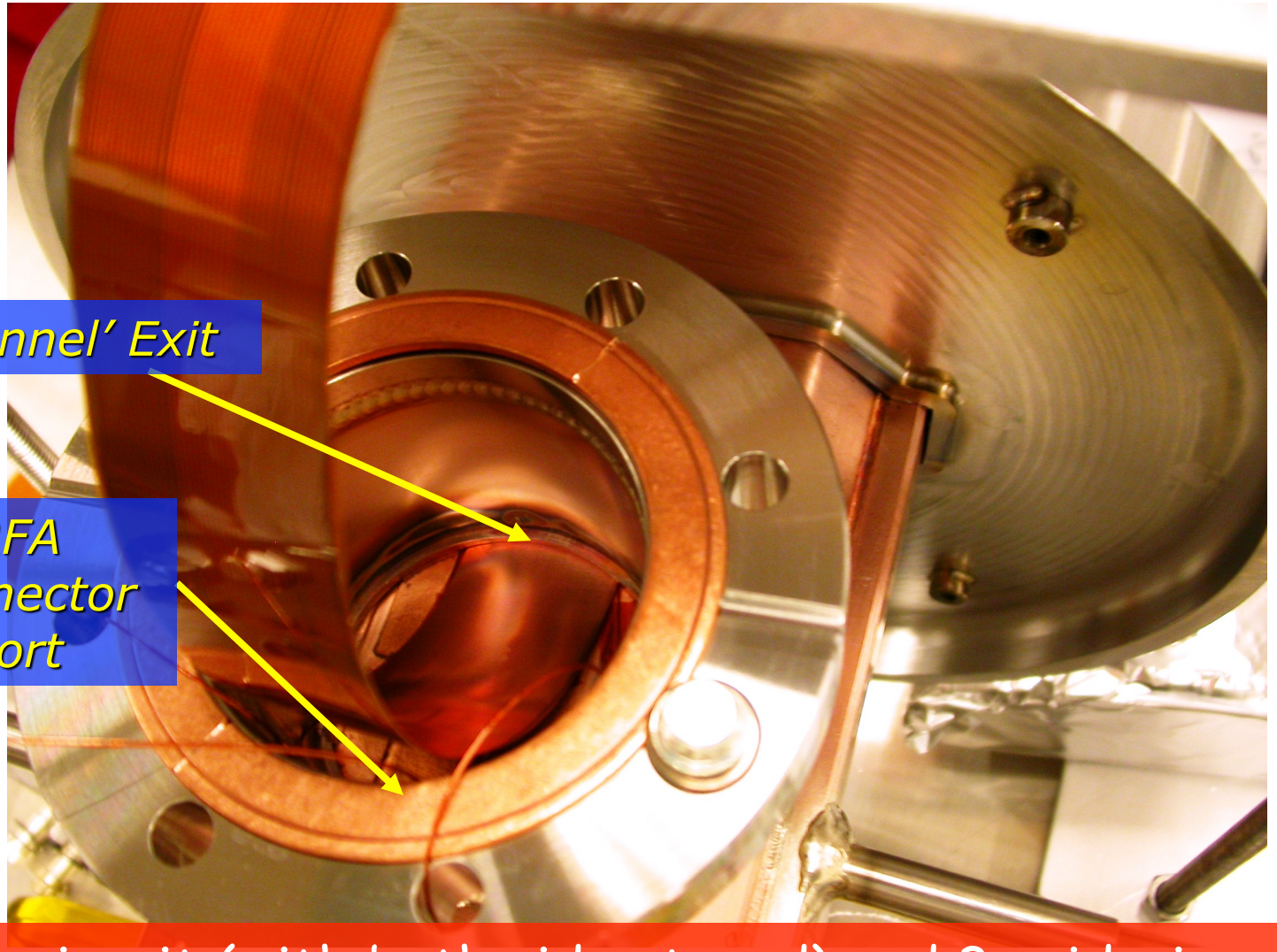


Flex-Circuit Pinned Down



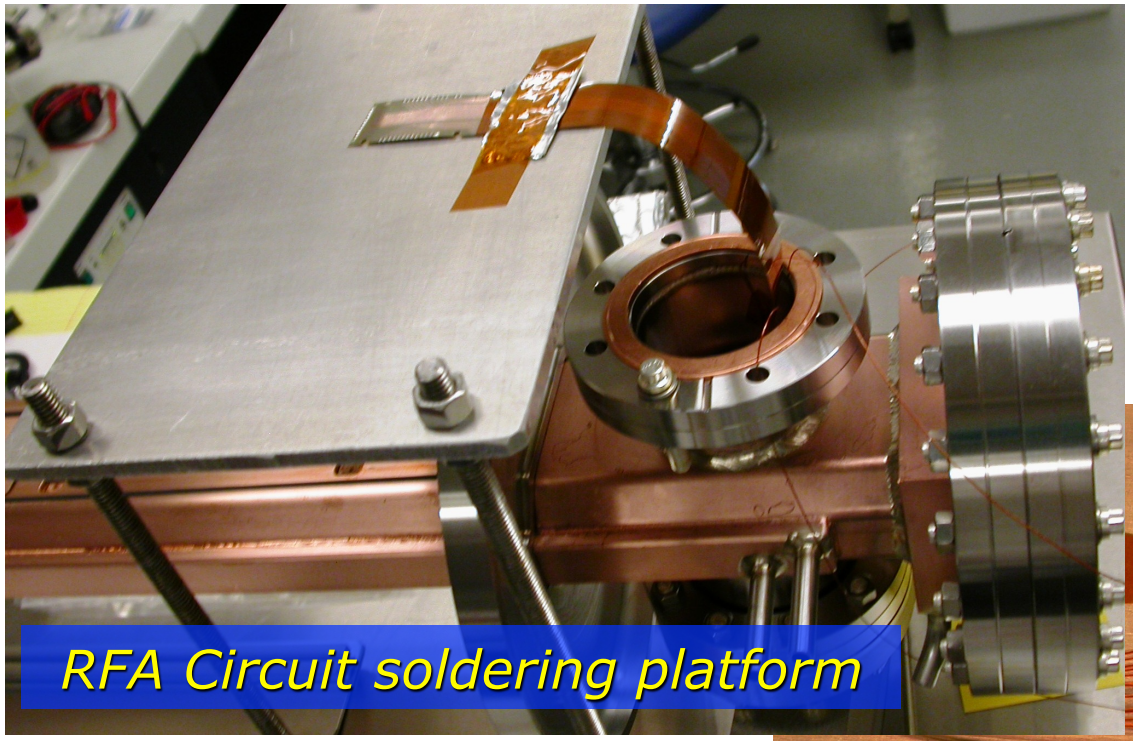
Ceramic head pins to position the flex circuit collectors w.r.t to hole patterns

Coming out of the 'Tunnel'

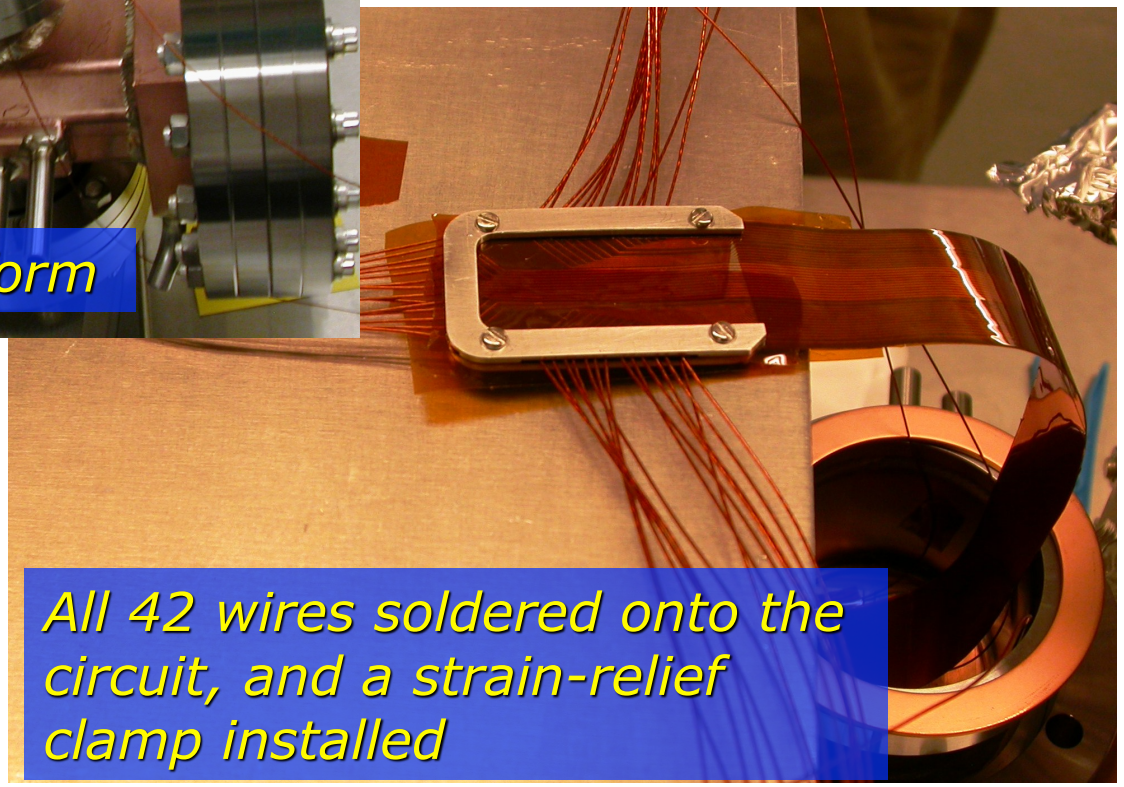


Flex circuit (with both sides taped) and 3 grid wires fed through the 'tunnel' duc-under into the connector port.

Soldering wires



RFA Circuit soldering platform

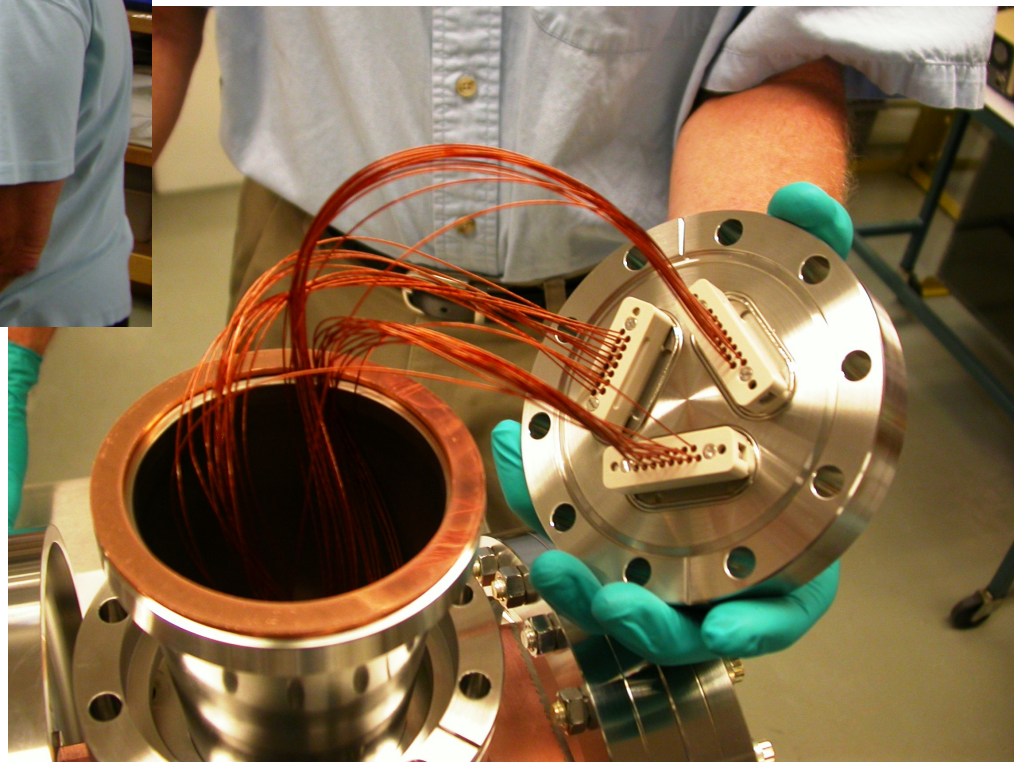


All 42 wires soldered onto the circuit, and a strain-relief clamp installed

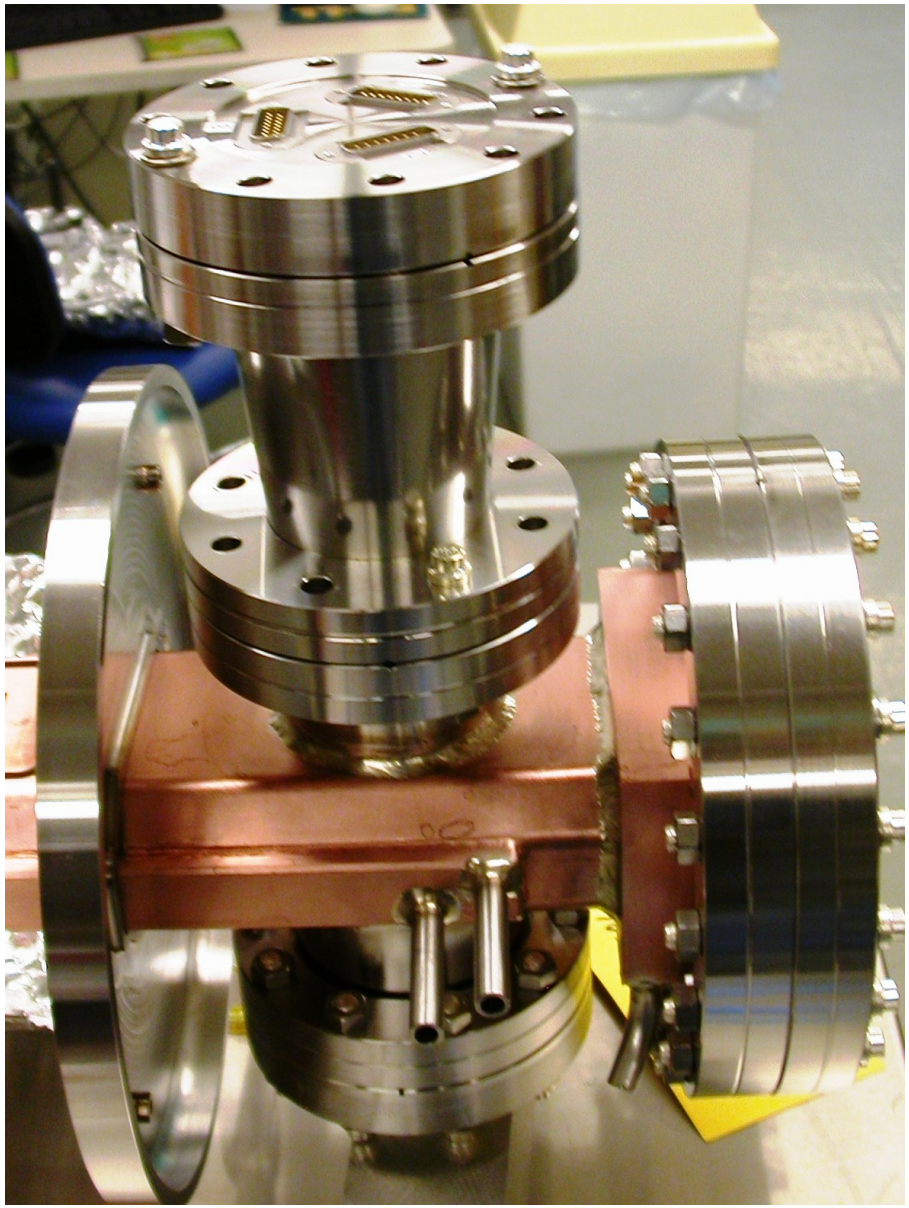
Small amount of UHV solder flux (Accu-Glass) had to be used. The flux residue was rinsed off

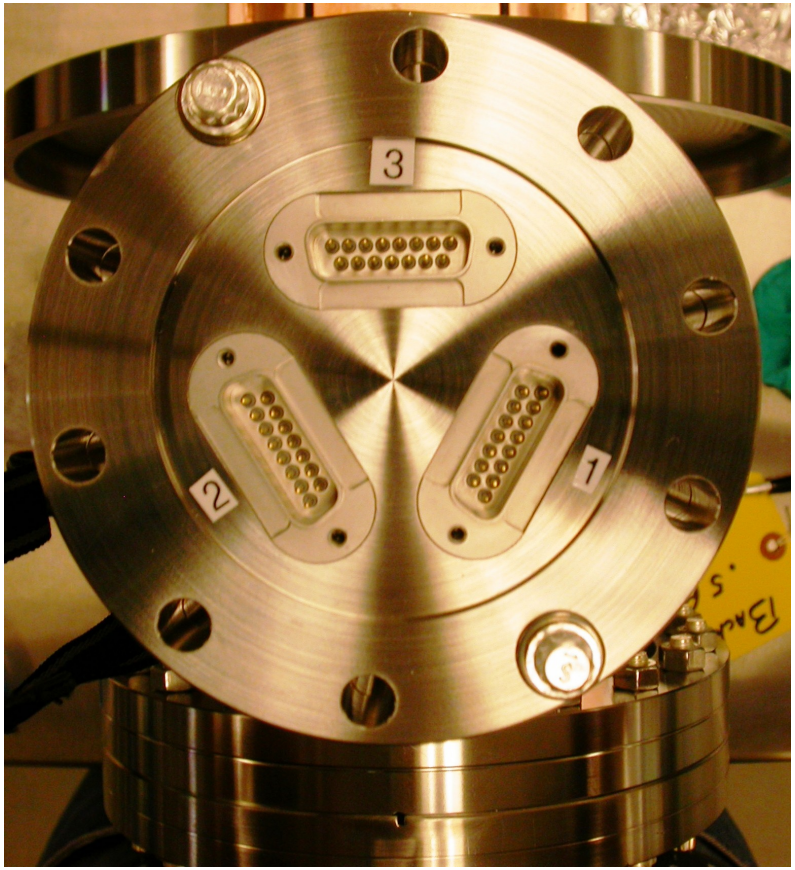
Wiring Checkout and Connected

Checked all 45 connections from pins to pads, many times



Ready for EB-Weld





A final air-side pin-to-circuit wiring check out was done before tightening the two flange joints

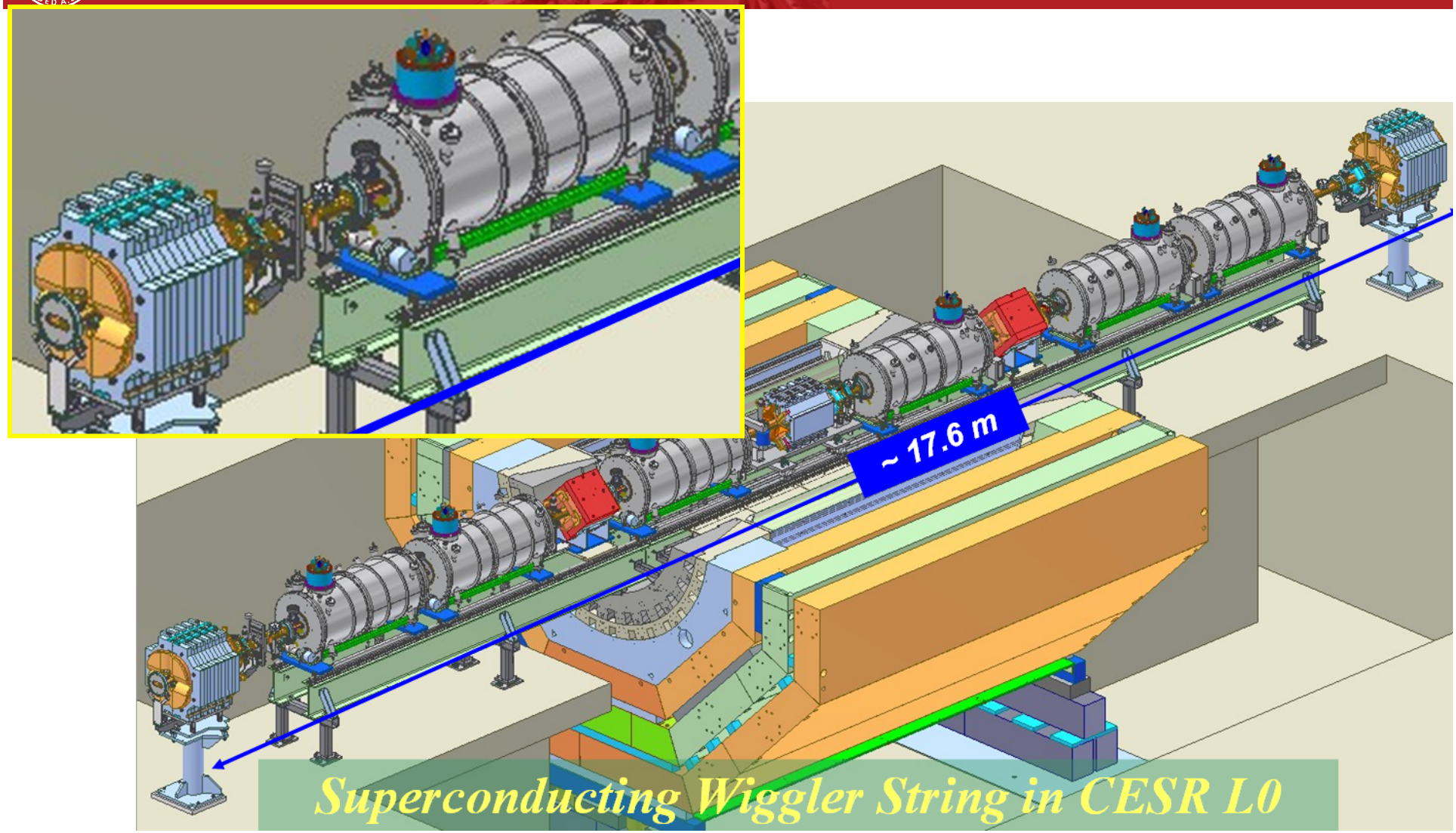
Final Wiring Check and Leak Check

Clearing Electrode

KEK, SLAC, LBNL, CU

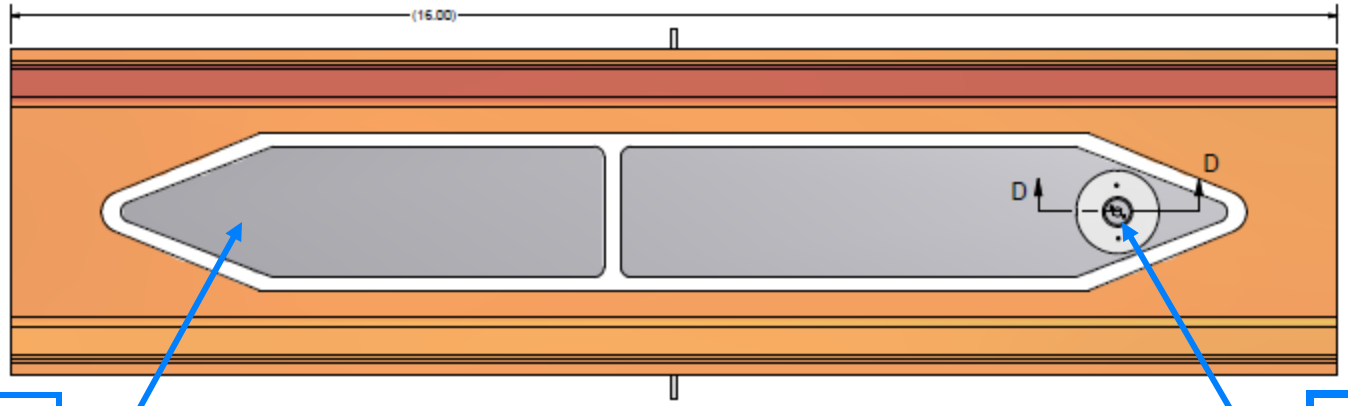
- Collaborative design using Web-Ex
- Material from SLAC
- Integrated design & machining tools
- Machining at LBNL
- Ceramic & Electrode deposition at KEK

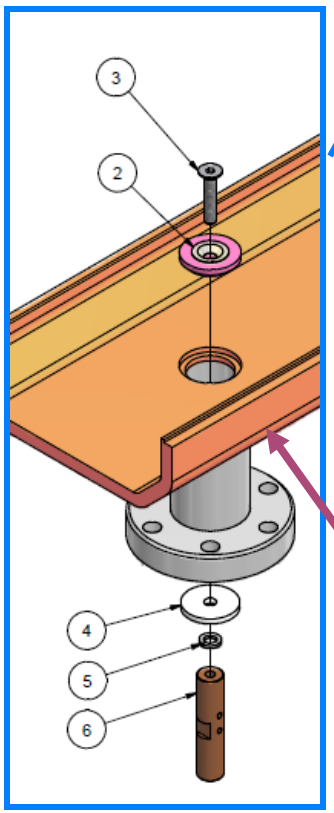
L0 Vacuum Modifications



- Install a RFA wiggler with clearing electrode
- Enhance vacuum pumping at Q2W

EC Clearing Electrode Tests

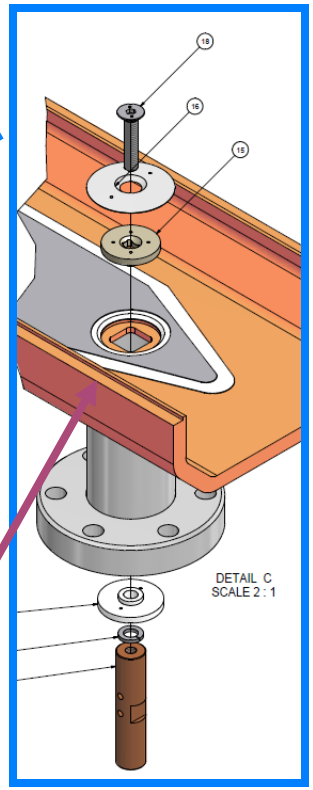




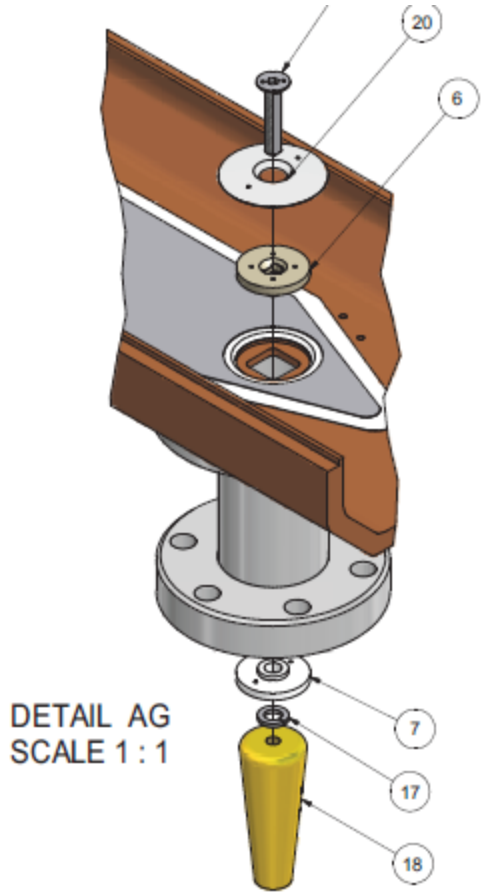
- *Two welding tests went successfully at LBNL. One assembly will be at Cornell for further measurement (capacitance, TDR, etc.)*
- *Cornell-style will be used for final chamber*

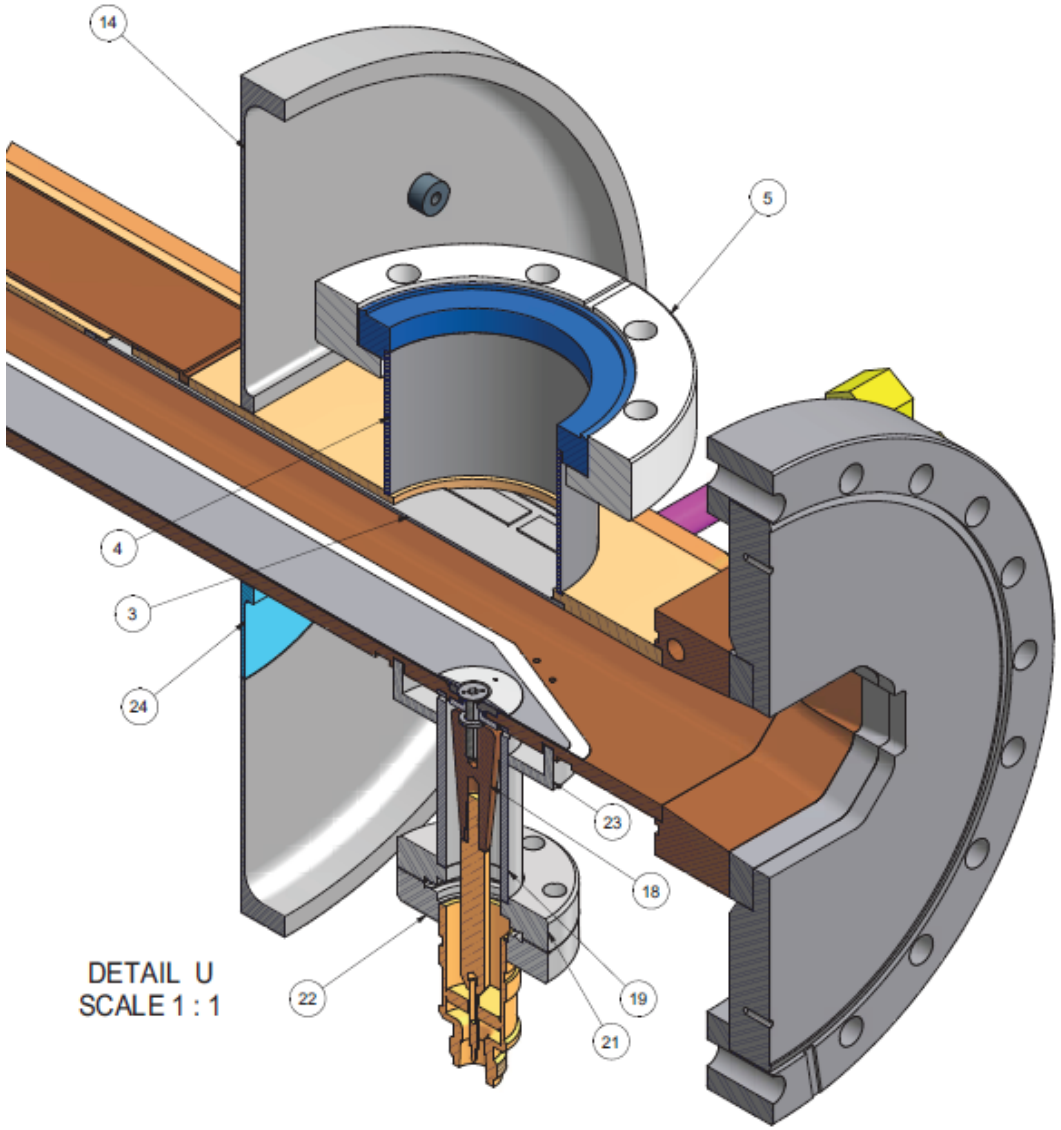
KEK-Style Connection

Cornell-Style Connection



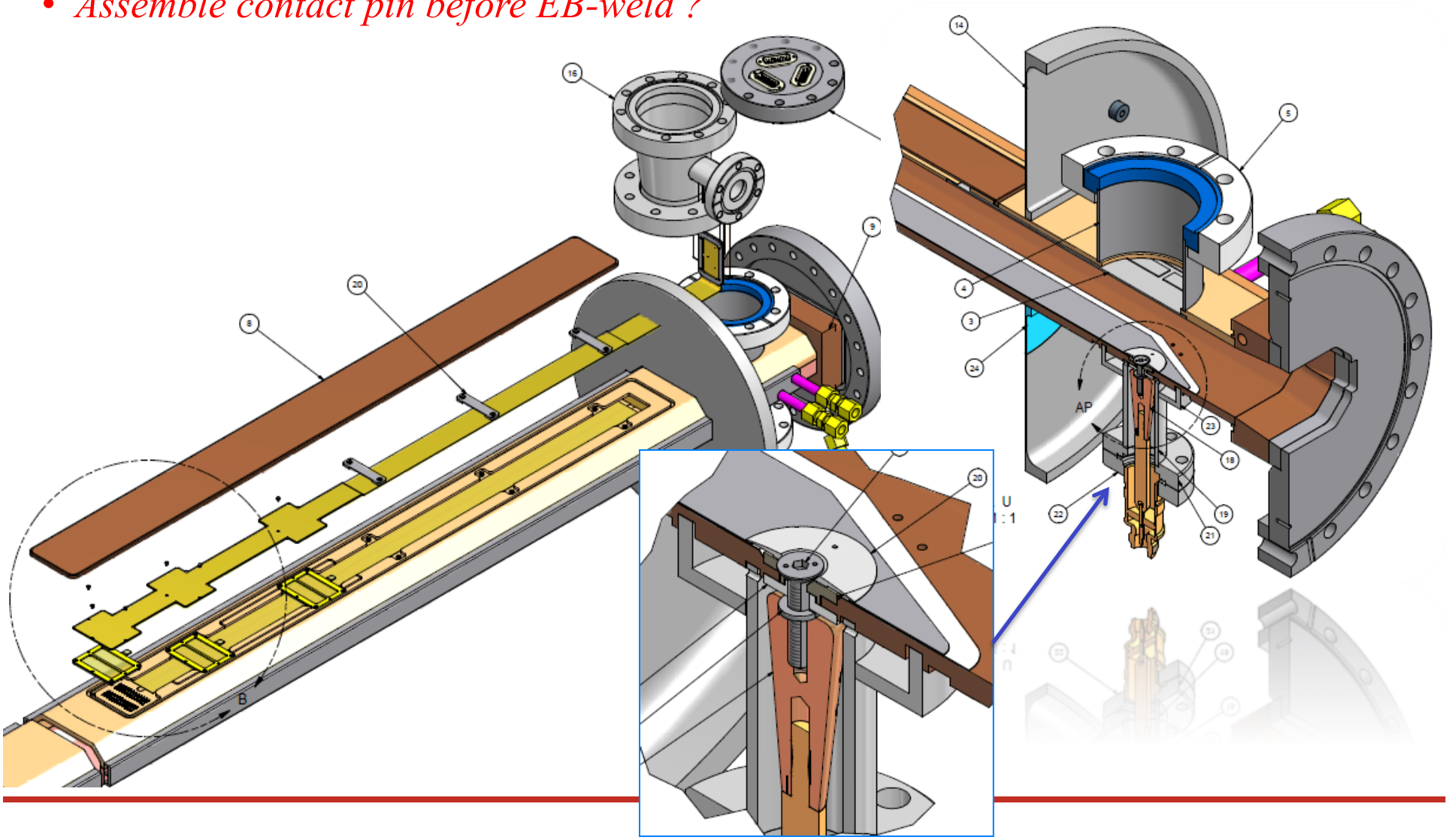
Wiggler chamber with EC Electrode





RFA SCW Chamber w/ Electrode

- *Still need to decide what is the best and practical way of isolating the flexible circuit – Kapton with or without adhesive*
- *Assemble contact pin before EB-weld ?*



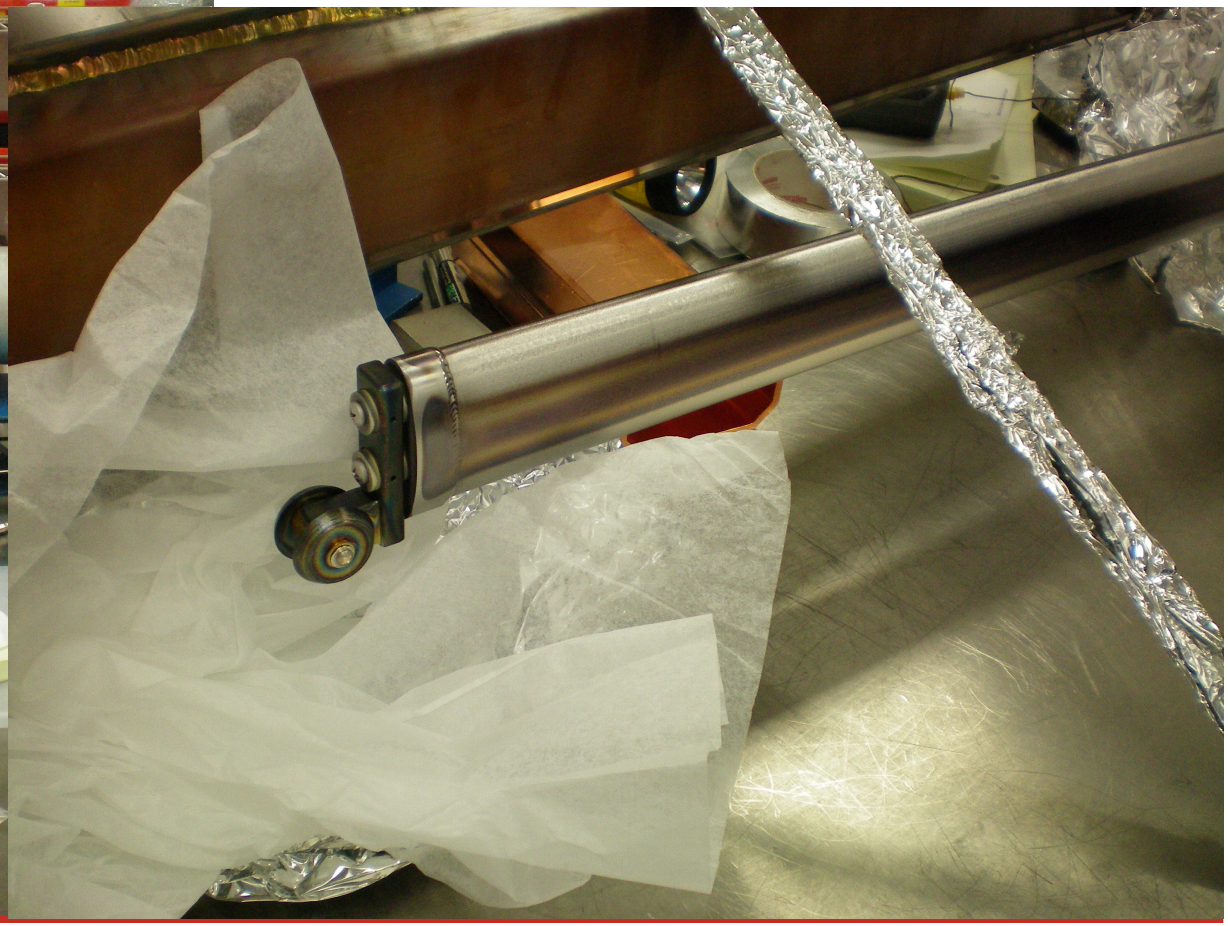
Chamber Coatings: Titanium-Nitride, NEG, Diamond-like Carbon

KEK, SAES, CERN, SLAC, CU

- TiN coating from SLAC
- NEG coating from SAES
- Diamond-like Carbon coating from KEK
- Amorphous Carbon coating from CERN

TiN Coating at SLAC

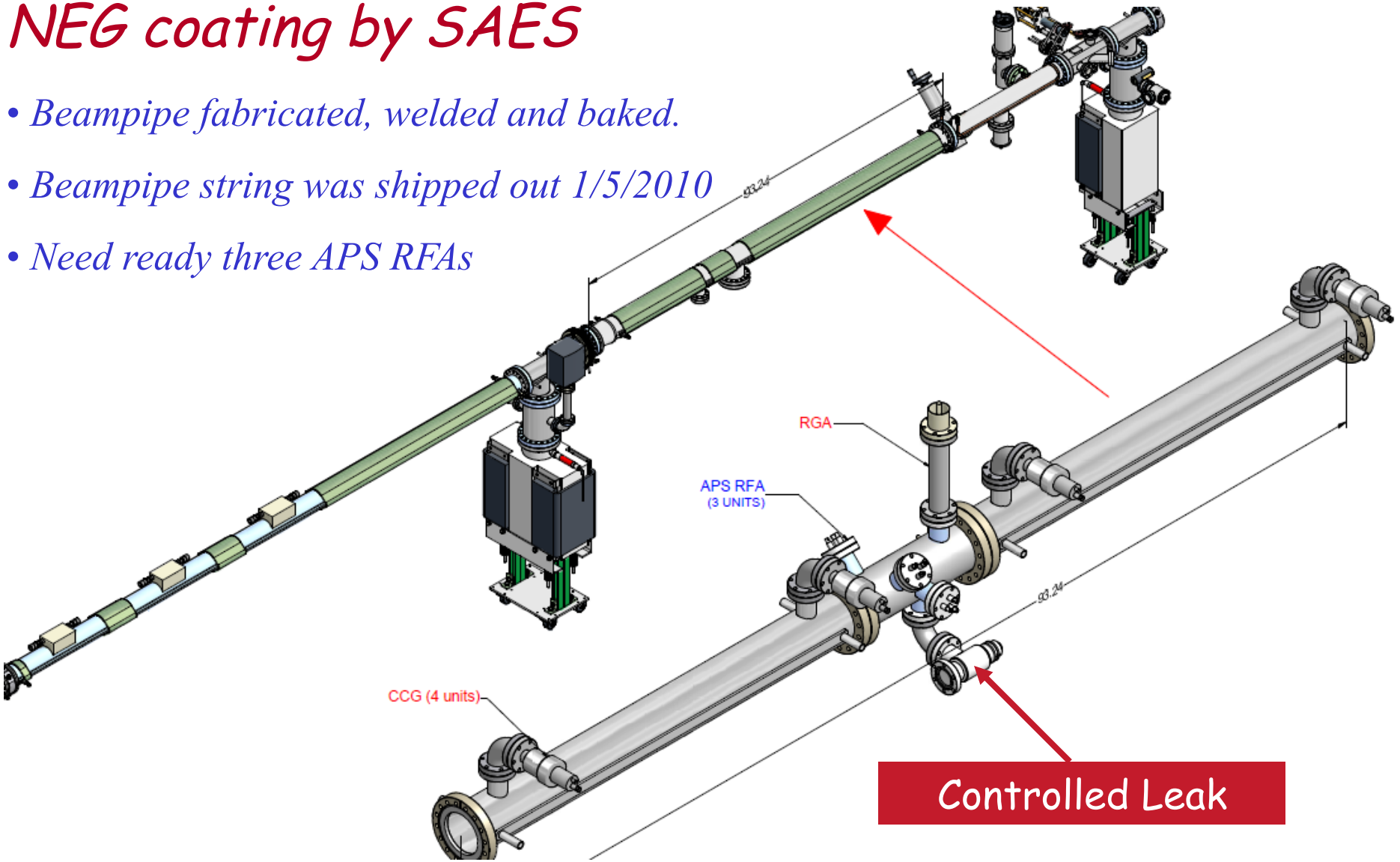
Dan Wright, Chamber #1 (14BE), and the Ti Electrode



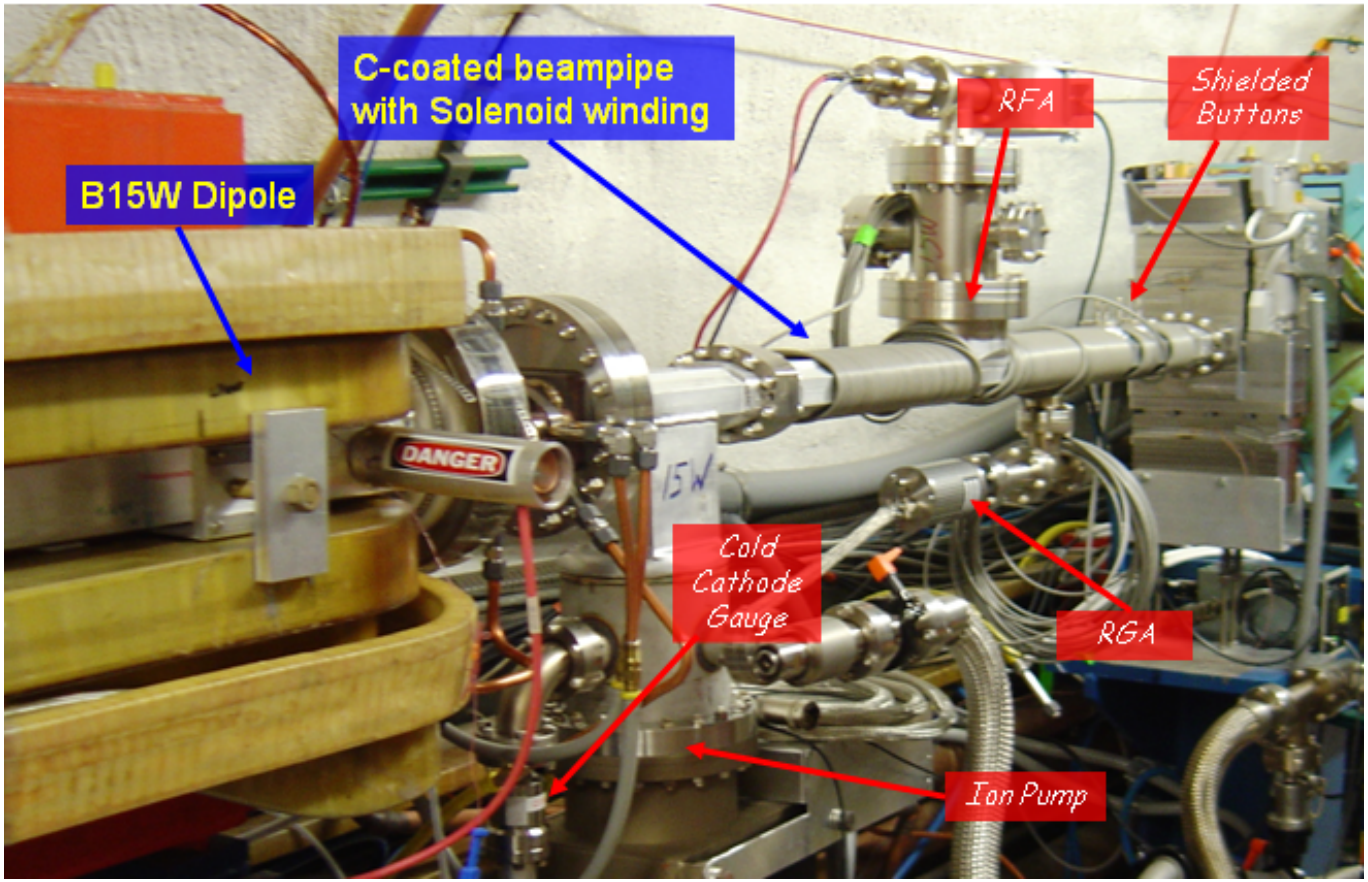
NEG Coated Beampipes @ L3

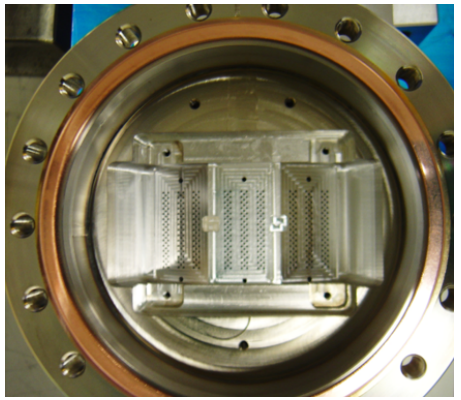
NEG coating by SAES

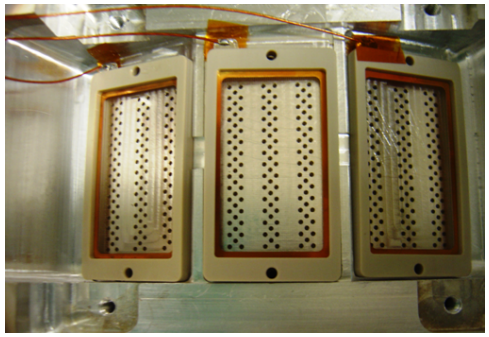
- *Beampipe fabricated, welded and baked.*
- *Beampipe string was shipped out 1/5/2010*
- *Need ready three APS RFAs*

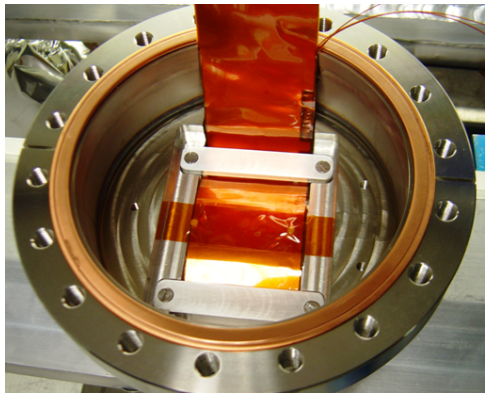


Diamond-Like Carbon RFA Chamber









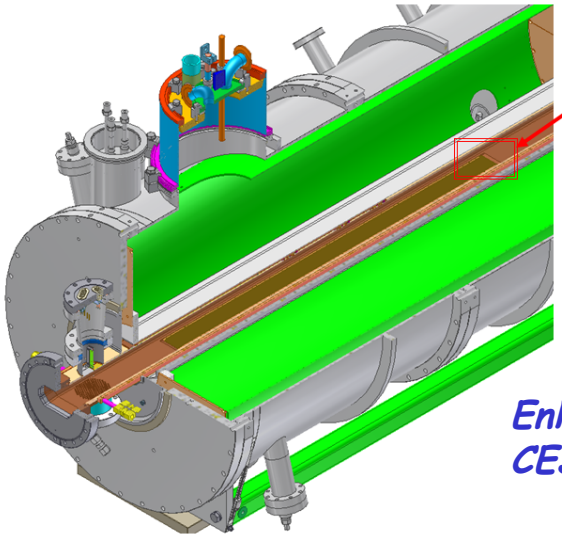
- *Q15W chamber coated with DLC coating (by CERN)*
- *Q15E RFA chamber is a reference chamber, with bare aluminum extrusion*
- *Both chambers with dipole-style RFAs, but with reversed wiring (in error, needing new special cables)*

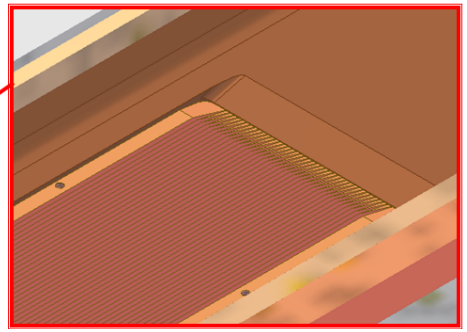
Grooved Wiggler Beam Pipe with RFA

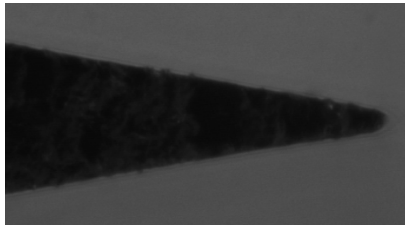
KEK, SLAC, LBNL, CU

- Collaborative design using Web-Ex
- Material from SLAC
- Integrated design & machining tools
- Machining at LBNL
- Groove machining at KEK

Grooved RFA SCW Beampipe

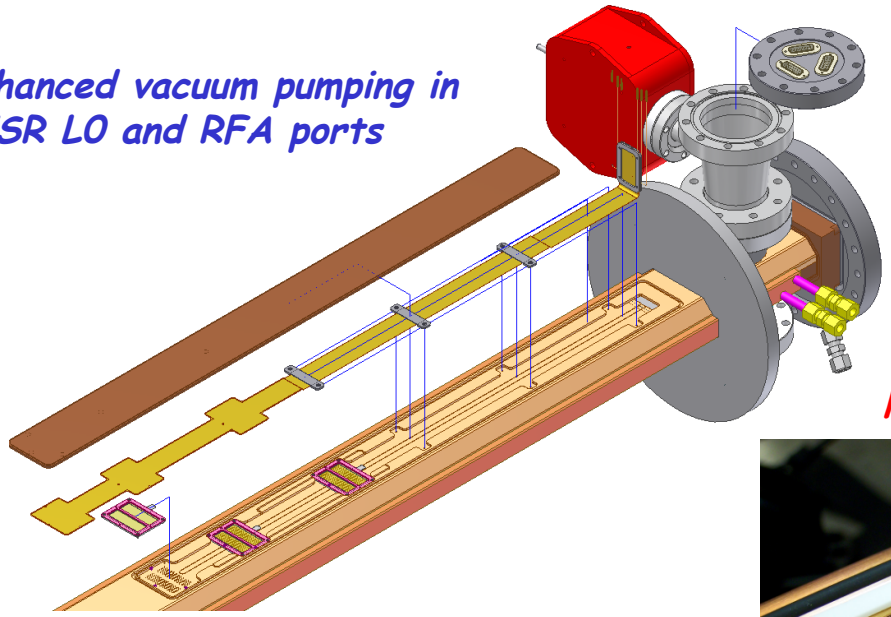


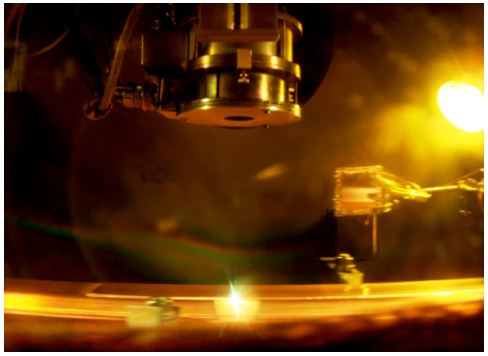




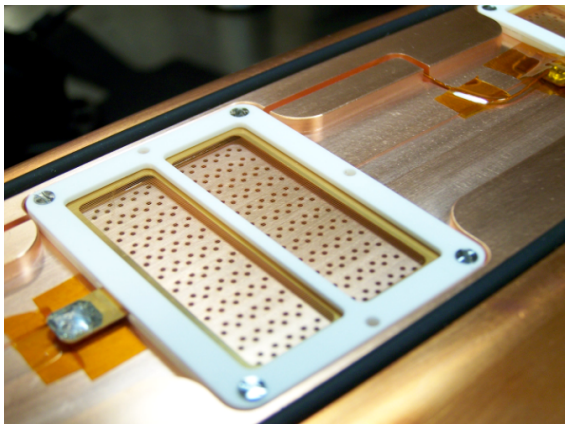
Groove tips/valley radius < 0.002" !!

Enhanced vacuum pumping in CESR LO and RFA ports



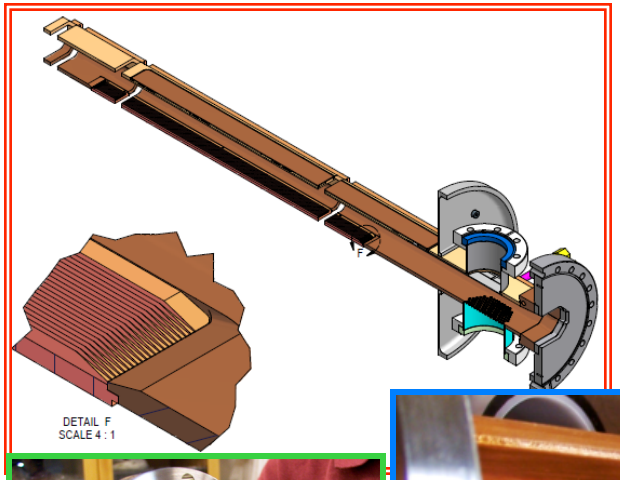


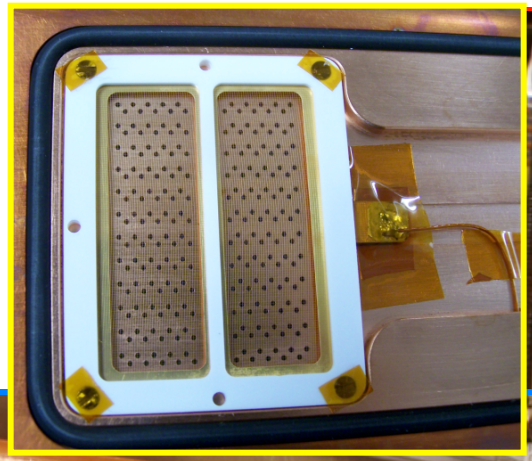
High-T Cu-mesh grids

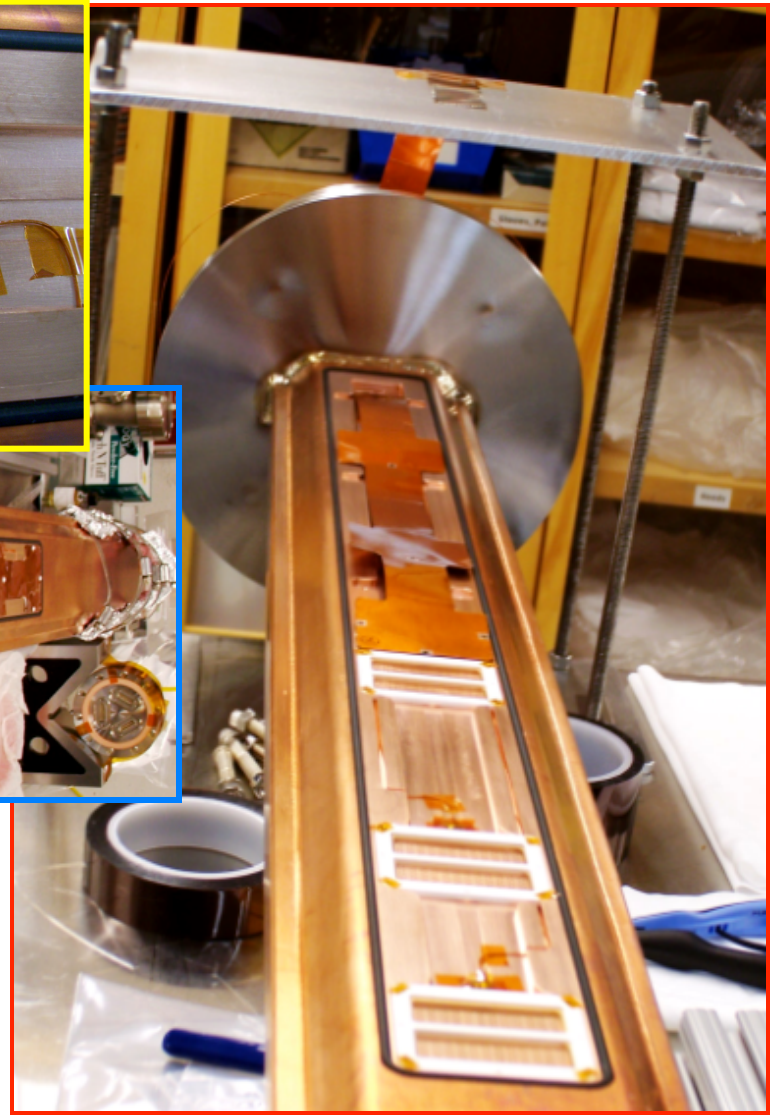


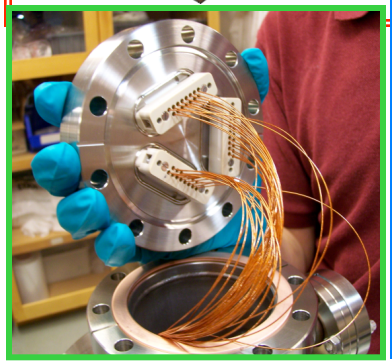
- Finished RFA assembly and RFA cover EBW
- In the final stage of assembly, scheduled for 7/20 installation

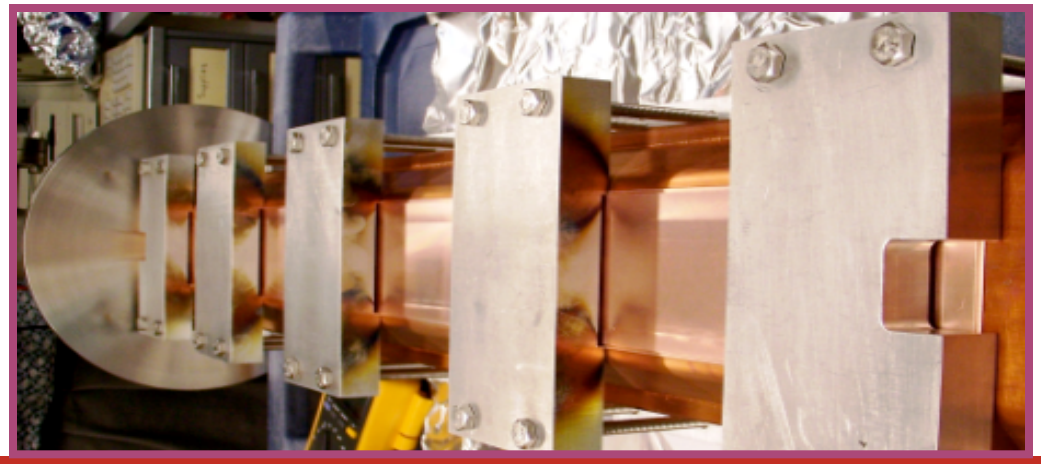
RFA Assembly for Grooved Wiggler Beam Pipe









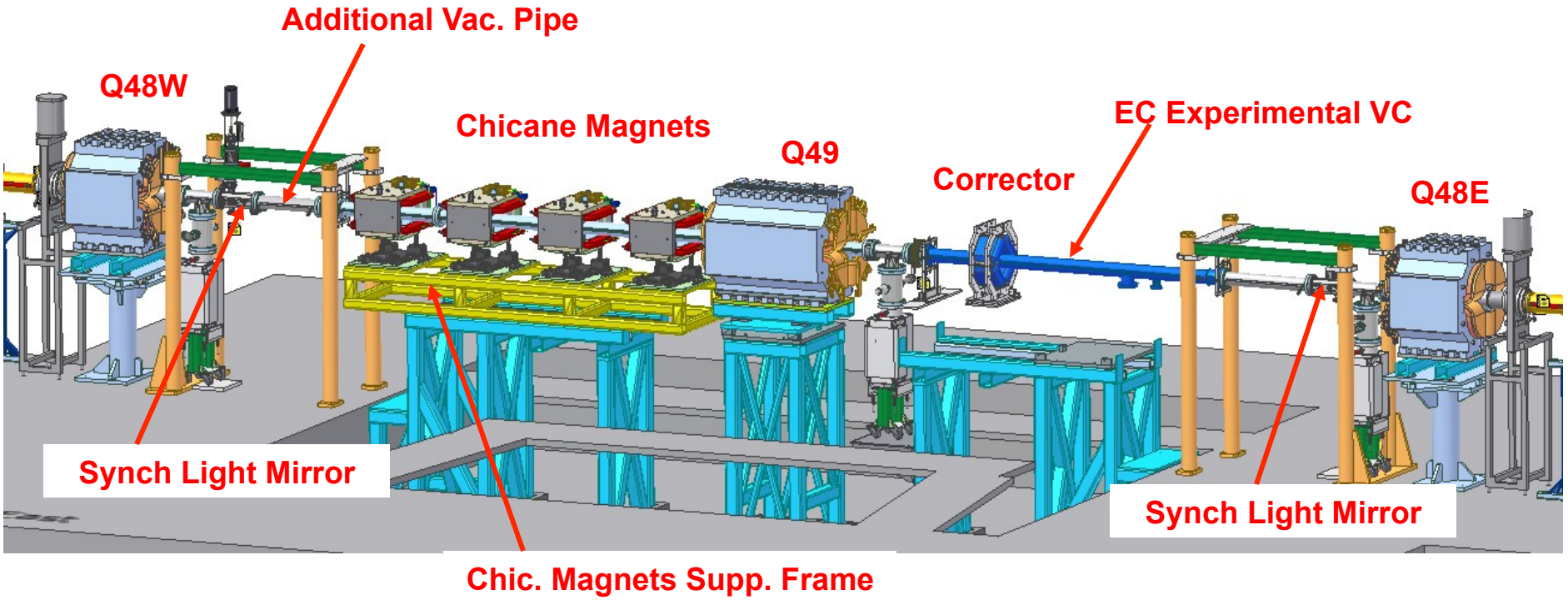


L3 Chicane Magnet Studies

SLAC, LBNL, CU

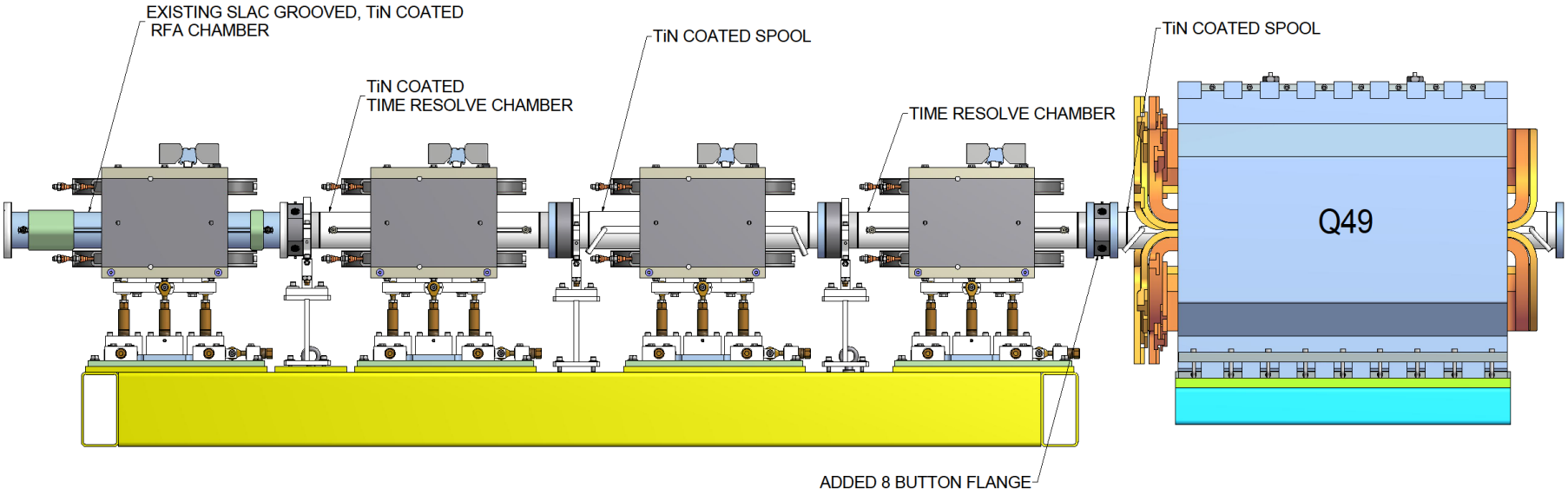
- Planning via Web-Ex
- Magnets & PSs from SLAC
- TE-Wave measurements – LBNL, CU

CESR-TA: L3 Modification Meeting 11/20/08

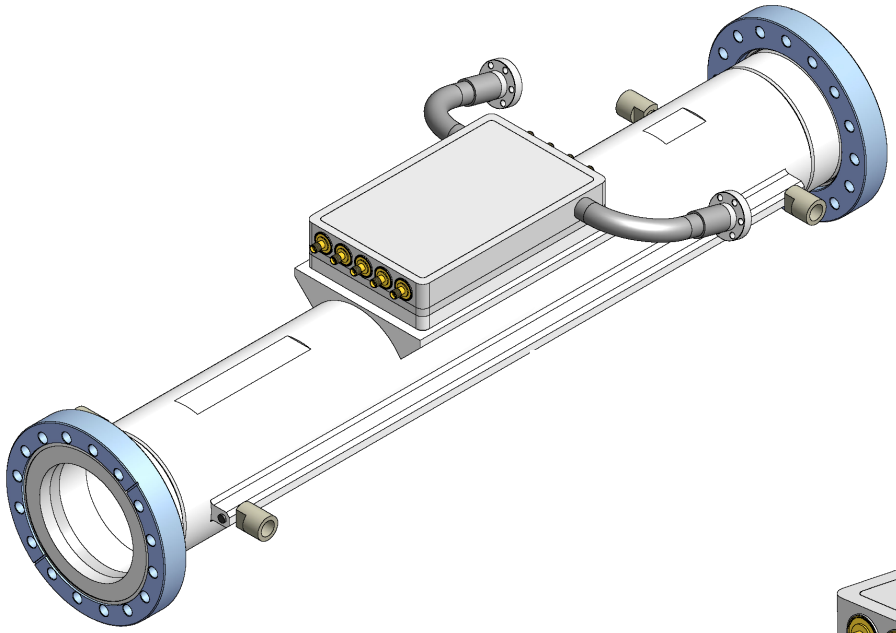


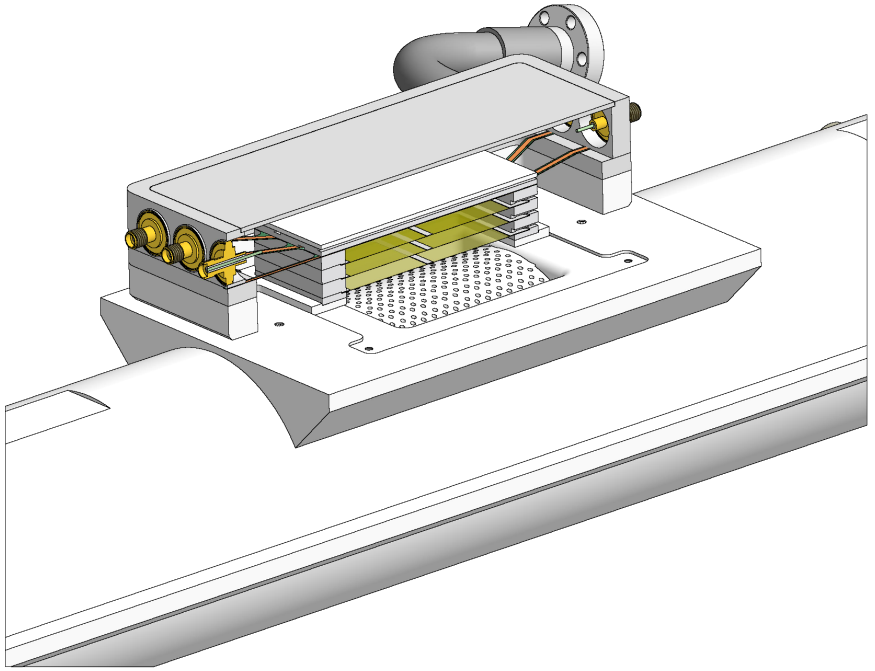
L3 Region Iso View

Close Up of SLAC Chicane



Time Resolve Dipole Chamber



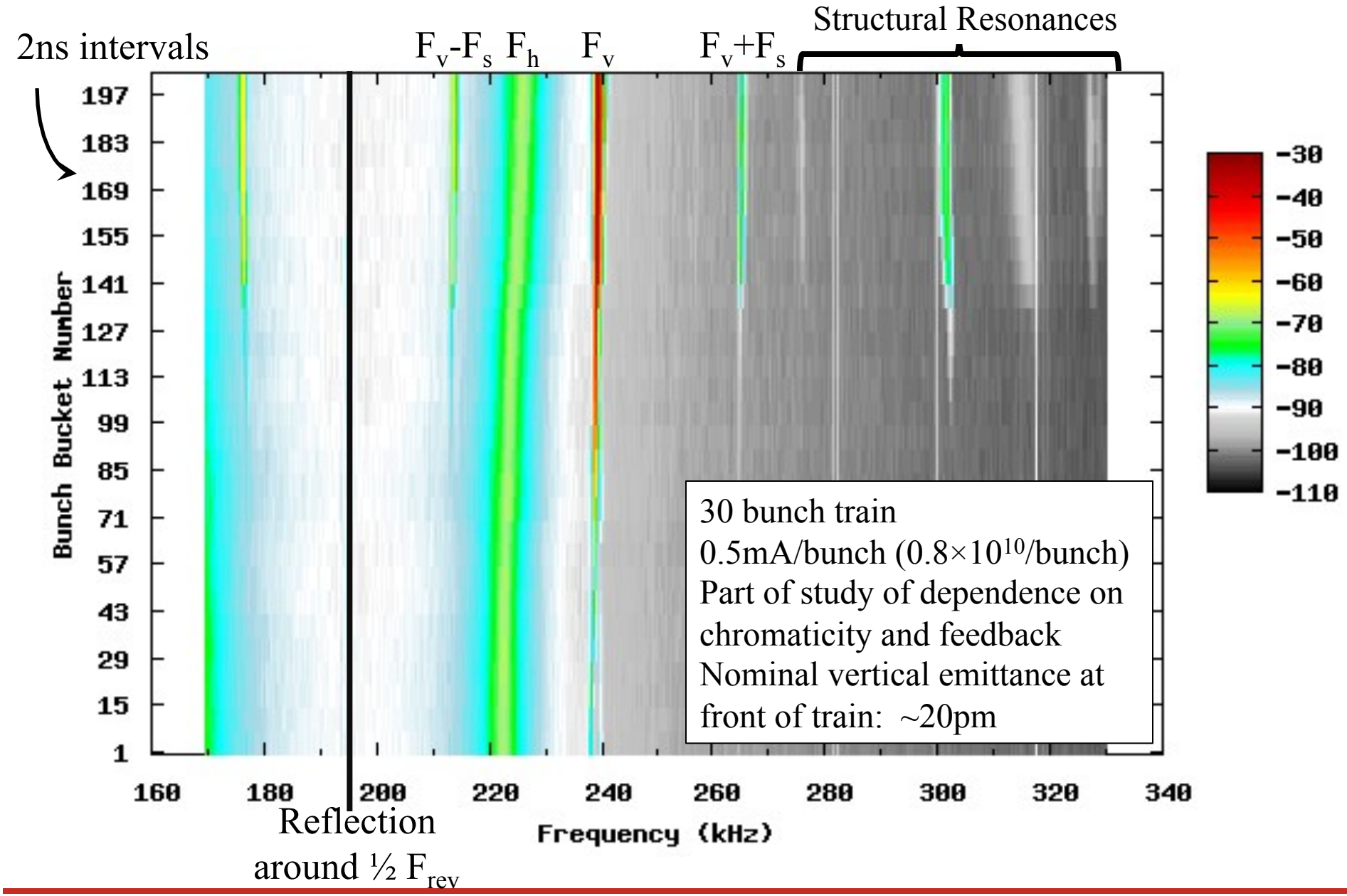


Electron Cloud Instability Measurements

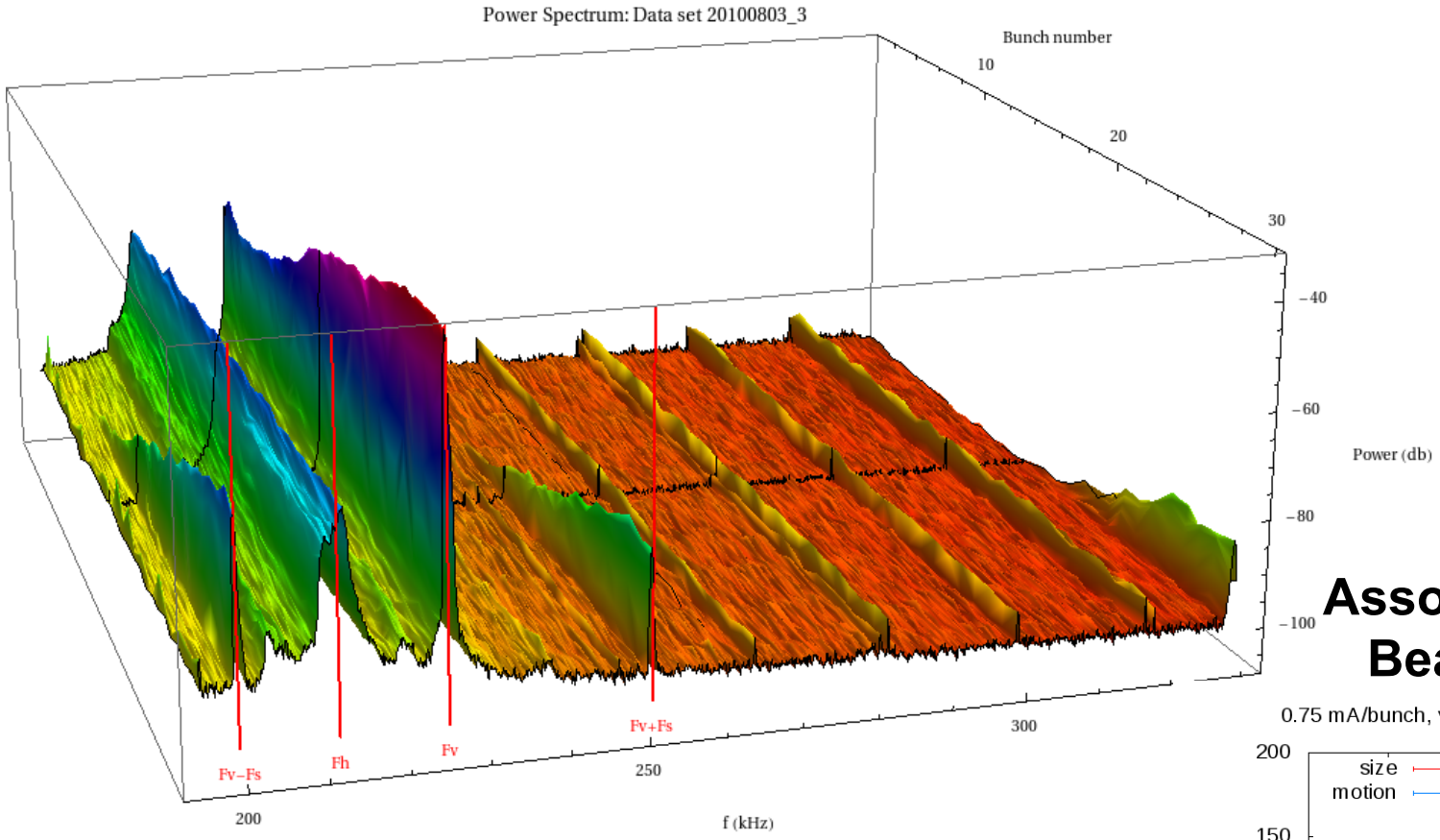
Cal Poly, KEK, CU

- Instrumentation – CU
- Local (CU) & Remote (KEK) **Online Data Acquisition**
- Local (CU) & Remote (KEK, Cal Poly) **Offline Analysis**
- Remotely available Data Archival at CU

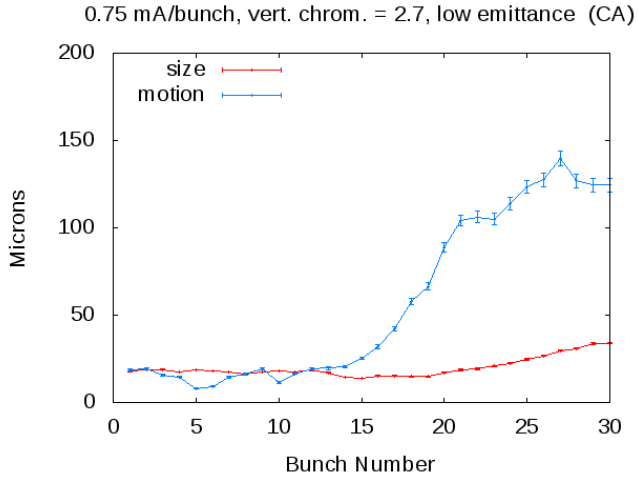
An Example


2ns intervals
F_v-F_s F_h F_v F_v+F_s
Structural Resonances
Bunch Bucket Number
197
183
169
155
141
127
113
99
85
71
57
43
29
15
1
160
180
200
220
240
260
280
300
320
340
Frequency (kHz)
-30
-40
-50
-60
-70
-80
-90
-100
-110
30 bunch train
0.5mA/bunch (0.8×10^{10}/bunch)
Part of study of dependence on chromaticity and feedback
Nominal vertical emittance at front of train: ~20pm
Reflection around ½ F_{rev}

Bunch-by-bunch Power Spectrum & Beam Size



Associated Vertical Beam Size Data



Vertical beam size data acquired simultaneously by J. Flanagan (KEK) remotely

Future-Directed Collaborative Activities

- Hardware development
  - ODR/XDR Detector – CERN, Royal Hollaway (London), CU
- Experimental
  - Lower Emittance Tuning – CERN, CU
  - Intra-Beam Scattering – CERN, CU
- Improvements in Modeling & Simulation

Optical Diffraction Radiation Detector

CERN, Royal Hollaway (London), CU

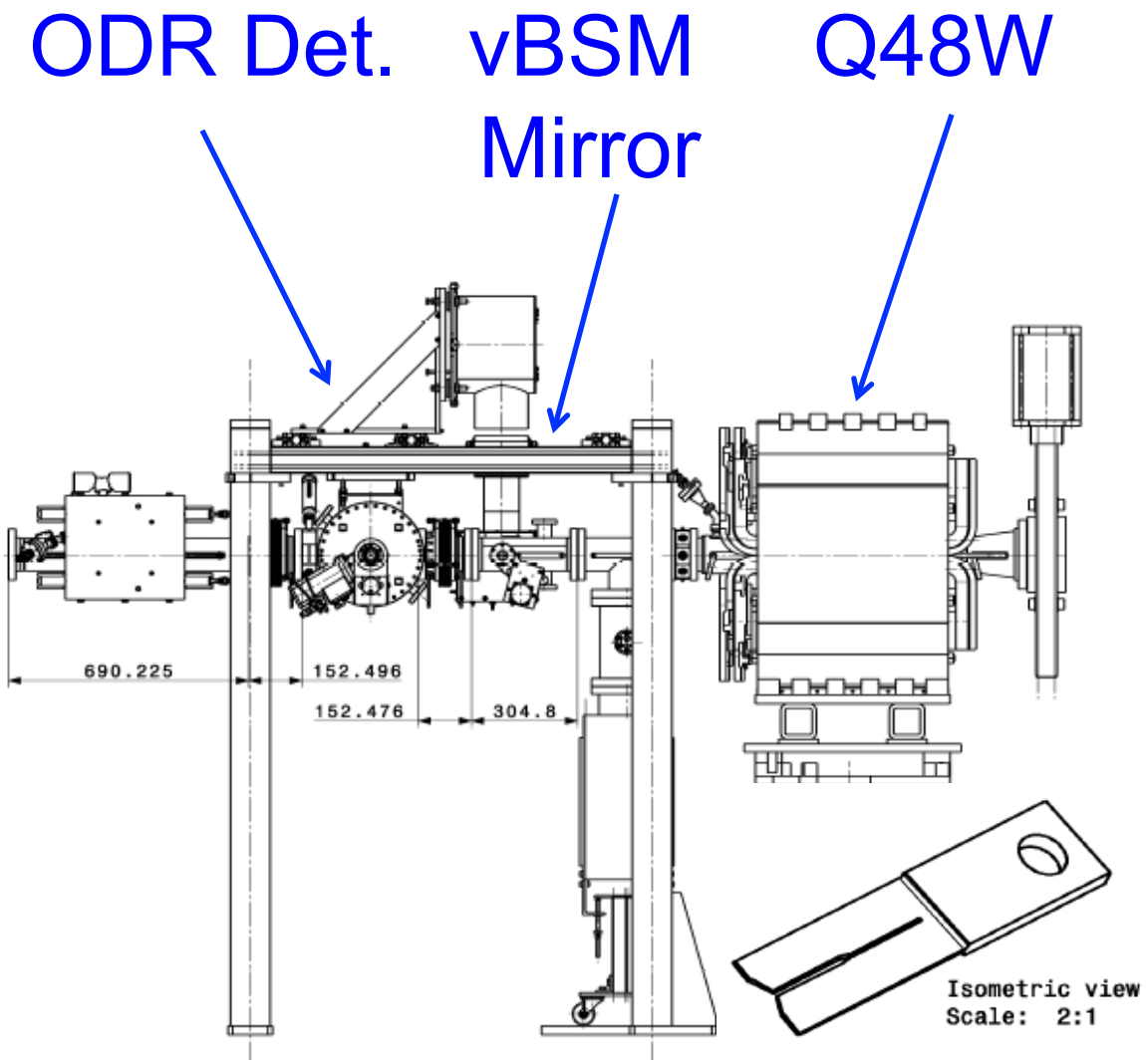
- Experimental Design via Web-Ex
- Vacuum Chamber Design & Construction – RH, CERN
- Vacuum System Integration – CERN, CU
- Instrumentation – CERN, CU

ODR Vacuum Chamber Layout

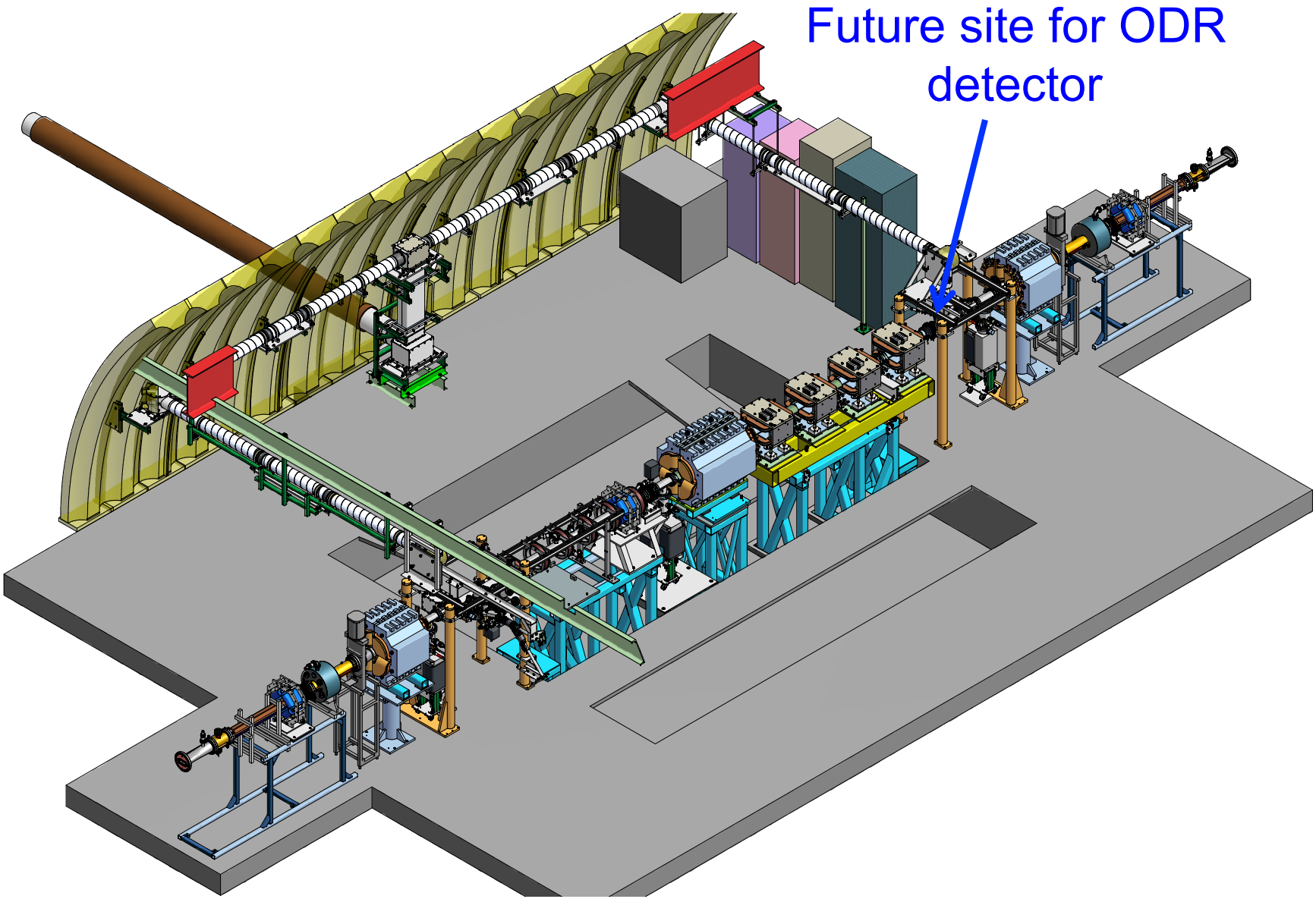
e- ODR Detector Components

- Internal movable-removable round beam pipe – slides to the radial inside of CESR
- Moveable fork having two different slit widths, tilted at 30° to the horizontal plane, e.g. 1 mm & 0.4 mm - arm projects slits inward from radial outside
- **Bunch injected, then slit is moved around the beam**
- Observation port pointing east at 45° to H-plane
- Laser alignment making use of a) an inline port, b) a movable mirror, which illuminates the front face of ODR
- BPMs and sliding joints on both sides of detector chamber
- Downstream radiation monitors

L3 Looking Southward

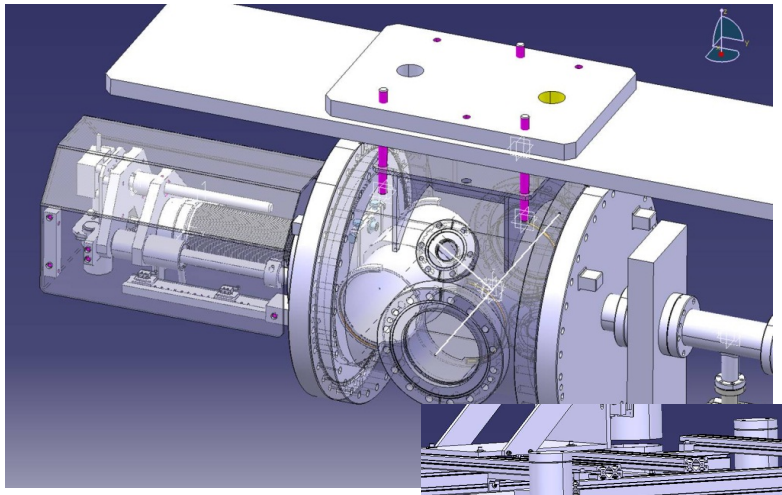


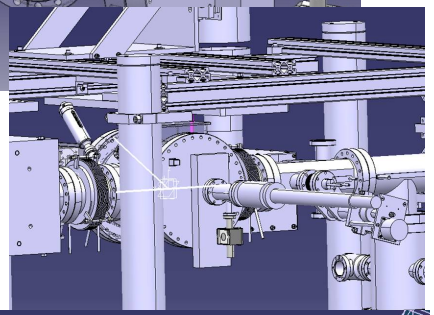
Present L3 Layout



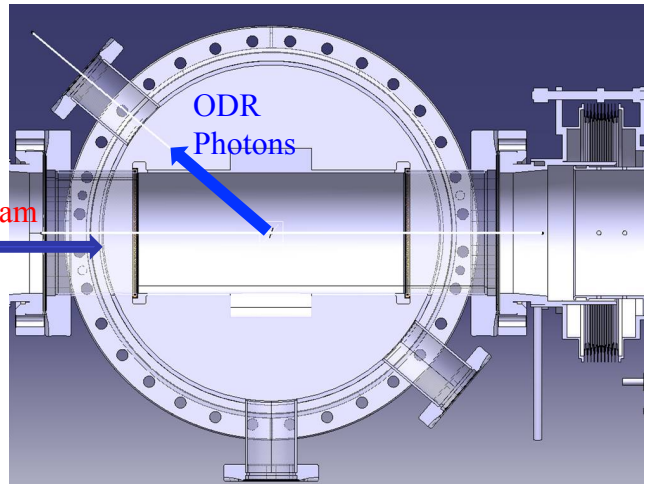
ODR Chamber in L3

Observing Optical Diffraction Radiation angular distribution to measure Beam size

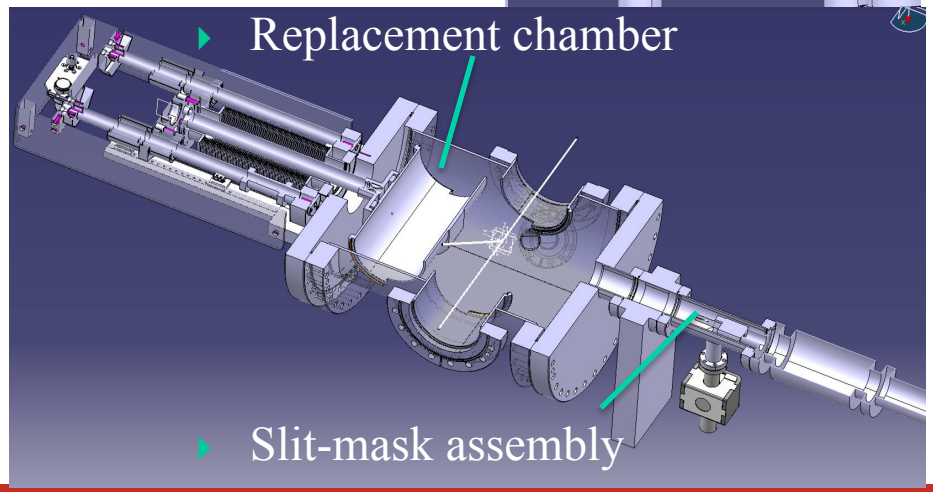


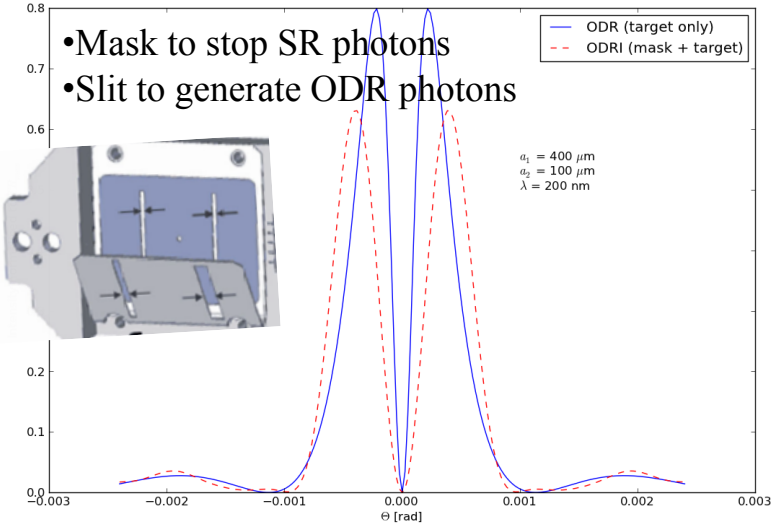


Integration of Chamber in the L3 straight section



Simulation of the optical distribution





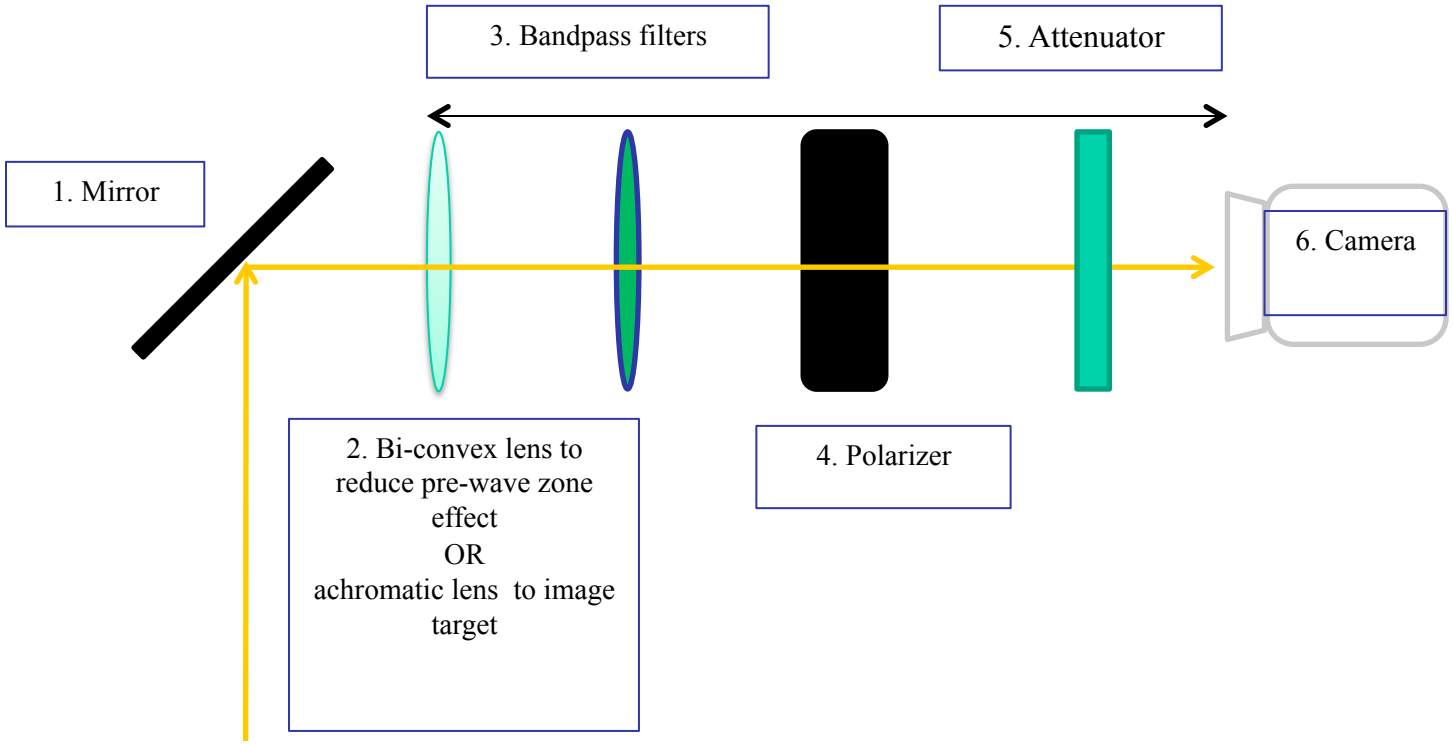
Status of the Design of Optical System

Optical system schematic

1. Images the target
2. Obtains DR angular distribution
3. Considering either a) 200 nm (UV) or b) 400 nm (visible) detection

Visible camera:
To be decided, there are a few options.
ICCD.
e.g. http://www.proxivision.de/products/proxikit.html

UV camera:
Hamamatsu C8484-16C
http://sales.hamamatsu.com/assets/pdf/parts_C/e_c848416c.pdf



Conclusions from Experiences with CESRTA

- This is a collaboration of many individuals and many institutions contributing to a variety of research efforts at CESRTA.
- All collaborators have access to all materials and meetings.
- The collaboration functions well:
  - Components have been cooperatively designed, built and operated.
  - Research and data acquisition and analysis have been jointly undertaken.
  - Simulation and modeling have benefitted from unified efforts.

In Conclusion

Finally, we strongly welcome anyone or institution, who may wish to collaborate in common research.