EUCARD Contributions and Funding

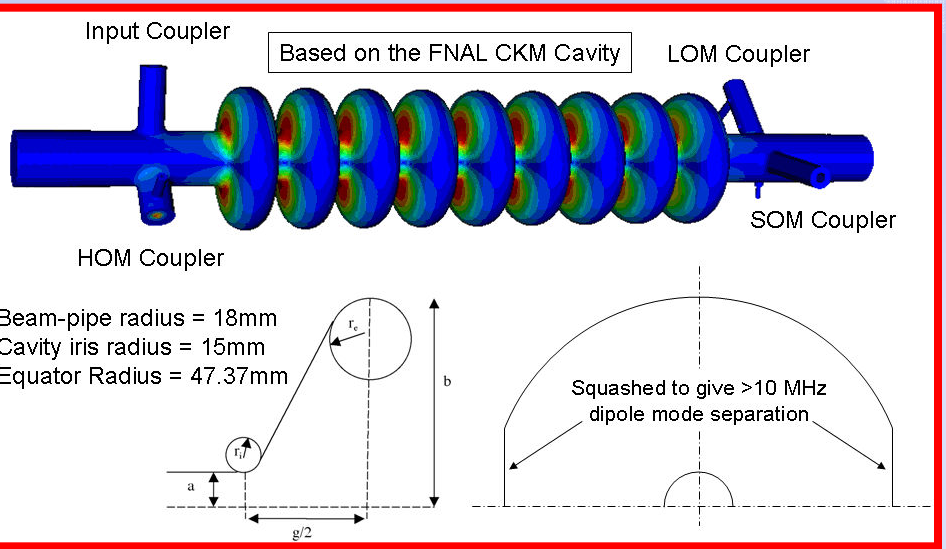
Peter McIntosh (STFC)

LHC-CC09, CERN, 16th – 18th September, 2009

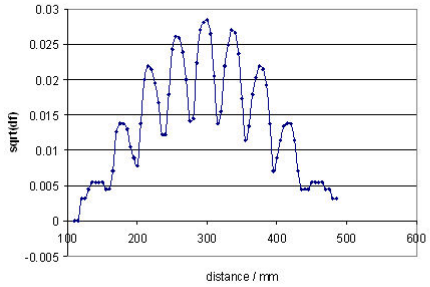
Outline

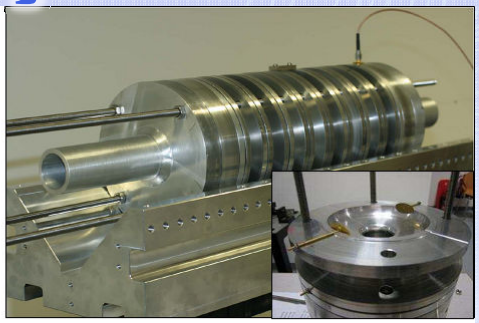
- CC Design Capability in the UK
- EUCARD FP7 LHC-CC Workpackage
- Funding and Deliverables
- UK LHC-CC Qualification Infrastructure
- EUCARD LHC-CC R&D Integration
- Summary

ILC-CC R&D - Cavity

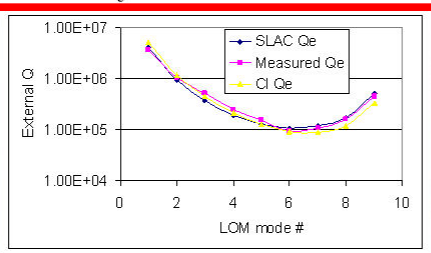


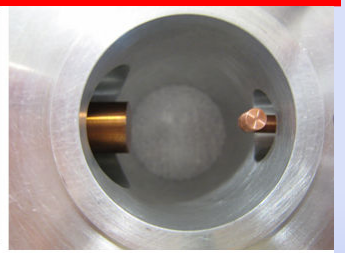
- Model fabricated at DL and used to evaluate:
  - Mode frequencies
  - Cavity coupling
  - HOM, LOM and SOM Qe and R/Q



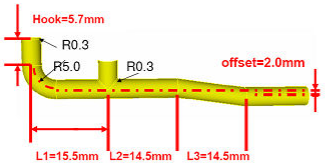


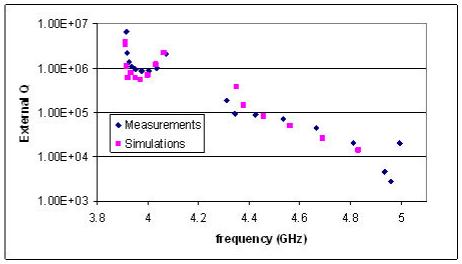
- Modular design allows evaluation of:
  - Up to 13 cells.
  - Including all mode couplers.

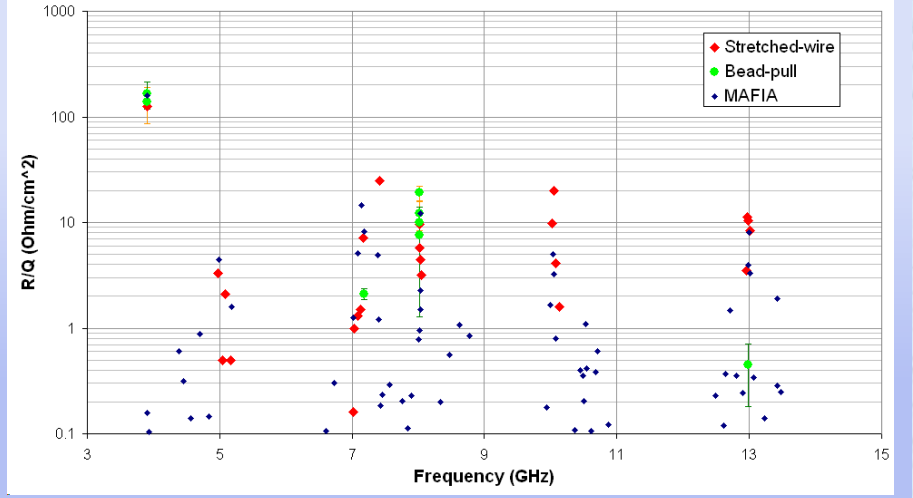




The LOM coupler was found to give good agreement with both MWS and Omega3P simulations.

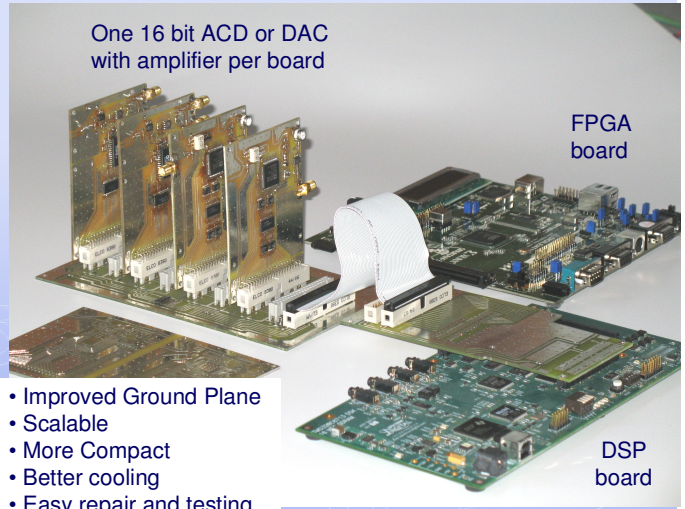




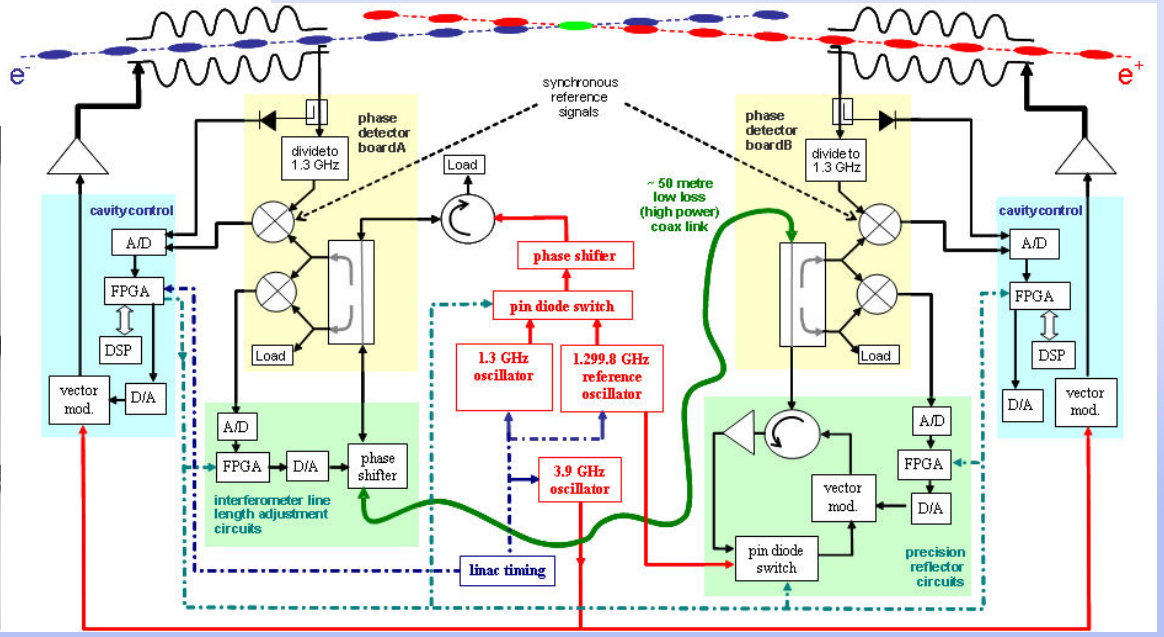


ILC-CC R&D - LLRF

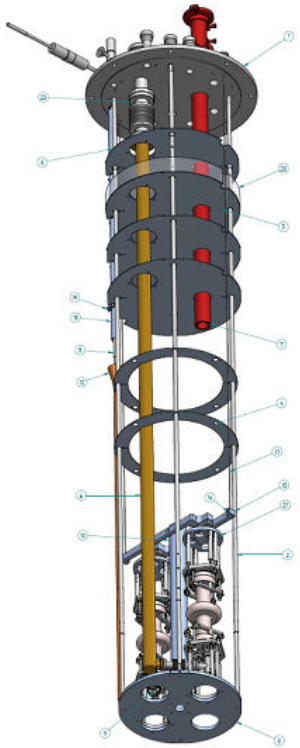
- Bunch-RF phase error in a crab cavity causes unwanted centre-of-mass kick.
- Providing both crab cavities are phase balanced, can compensate these COM kicks.
- ILC crab cavity zero crossings need synchronisation to 94 fs for the 2 % luminosity loss budget.
- Stability required 0.095° phase and 0.33% amplitude
- Main linac timing requirement is nominally 0.1° at 1.3 GHz or ~ 200 fs and hence cannot be relied upon directly to provide timing signals for the crab cavities:
  - ⇒ **~30% luminosity loss.**



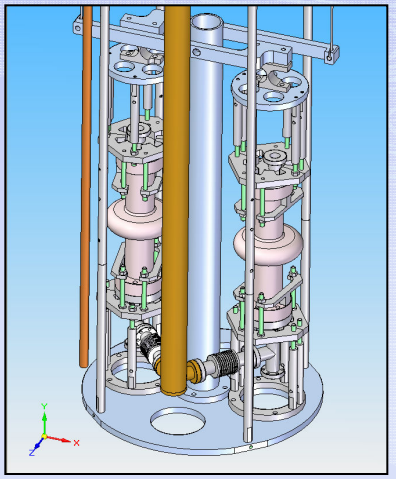
- Improved Ground Plane
- Scalable
- More Compact
- Better cooling
- Easy repair and testing



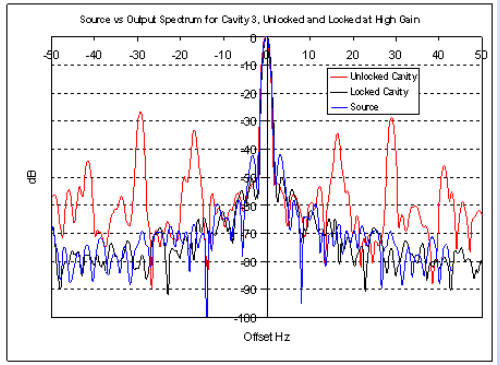
ILC-CC - Validation

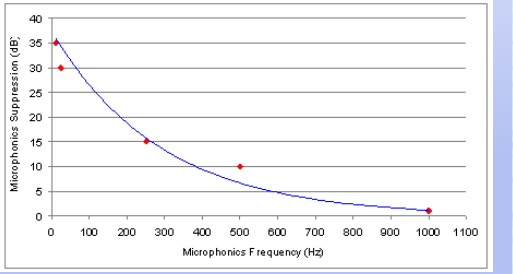


Cavities limited in gradient to 1 MV/m (~40kV/cell)



- Independent phase lock achieved for both cavities:
  - Unlocked ⇒ 10° r.m.s.
  - Locked ⇒ 0.135° r.m.s.
- Performance limited by:
  - Source noise (dominant)
  - ADC noise
  - Measurement noise
  - Cavity frequency drift
  - Microphonics
- Improvements being made.





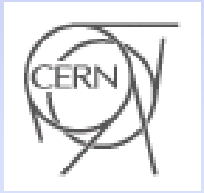
EUCARD LHC-CC Activity

- Targets the fundamental synergies for the design of crab cavity systems; not only in terms of the RF structure design and wakefield suppression, but also in the RF system control and full system integration and validation.
- Crab cavity and LLRF systems developed for ILC, being verified right now.
- Proposal (WP 10.3) combines both LHC and CLIC CC R&D.
- For LHC:
  - Local system preferred (Phase II):
    - Transverse beam separation restrictions,
    - Frequency limited to 400 - 600 MHz.
  - Emittance growth is a major concern:
    - ~0.010° phase tolerance required @ 400 MHz with 300 μrad crossing.

EUCARD SRF-WP10 can be found at: https://espace.cern.ch/SRF/default.aspx

EUCARD LHC-CC Team

- CERN (Switzerland)
  - CERN Coordinator (F Zimmermann)
  - Fellow
    - 18 man months
- **CERN Total 18 m.m.**
- Fellow appointment Nov. 09



- ULAN-CI (UK)
  - RA-Cavity (C Lingwood)
    - 8 man months
  - RA-LLRF (I Tahir)
    - 6 man months
  - Academic-Cavity (G Burt)
    - 2 man months
  - Academic-LLRF (A Dexter)
    - 2 man months
- **ULAN-CI Total 18 m.m.**
- All in post already

- ASTeC, STFC (UK)
  - WP Coordinator (P McIntosh)
    - 4 man months
  - RF Engineer (P Goudket)
    - 10 man months
  - Mech Designer (Undefined)
    - 4 man months
- **STFC Total 18 m.m.**
- All in post already

- **Additional effort:**
- ULAN-CI:
  - CI-Student (B Hall, 36 m.m.)
  - CI-RA (C Lingwood, 10 m.m.)

- **Flexibility to shift some EUCARD staffing funds to capital.**

Team Resource Roles

- CERN Fellow:
  - Links, steering and information exchange with UK, US-LARP and KEK.
  - CC integration in LHC:
    - Find space for global CC.
    - Integrate cryostat into LHC infrastructure.
    - Determine auxiliary infrastructure required:
      - RF, cryo, waveguide, QRL, controls etc.
    - Develop plan for CERN LHC-CC test stand.
- CI-ULAN RA-Cavity:
  - LHC-CC and coupler development.
- CI-ULAN RA-LLRF:
  - LHC-CC LLRF system architecture development.
- CI-ULAN Student:
  - LHC-CC and coupler development.
- ASTeC RF-Eng:
  - LHC-CC and coupler prototype testing.
- Mech-Des:
  - LHC-CC and coupler fabrication.

LHC-CC EUCARD Funding

- STFC, CI-LAN and CERN collaboration
- Total staffing: 1.5 FTE/yr (over 3 years)
- Total LHC-CC proposal cost: 670k€
- Total capital, consumables: 72k€
- Total EUCARD LHC-CC contribution: 203k€

- Objectives:
  - As part of the global LHC-CC collaboration:
    - Develop cavity and coupler designs
    - Identify suitable LLRF system design and architecture
    - Verify integrated system performance (possibility)

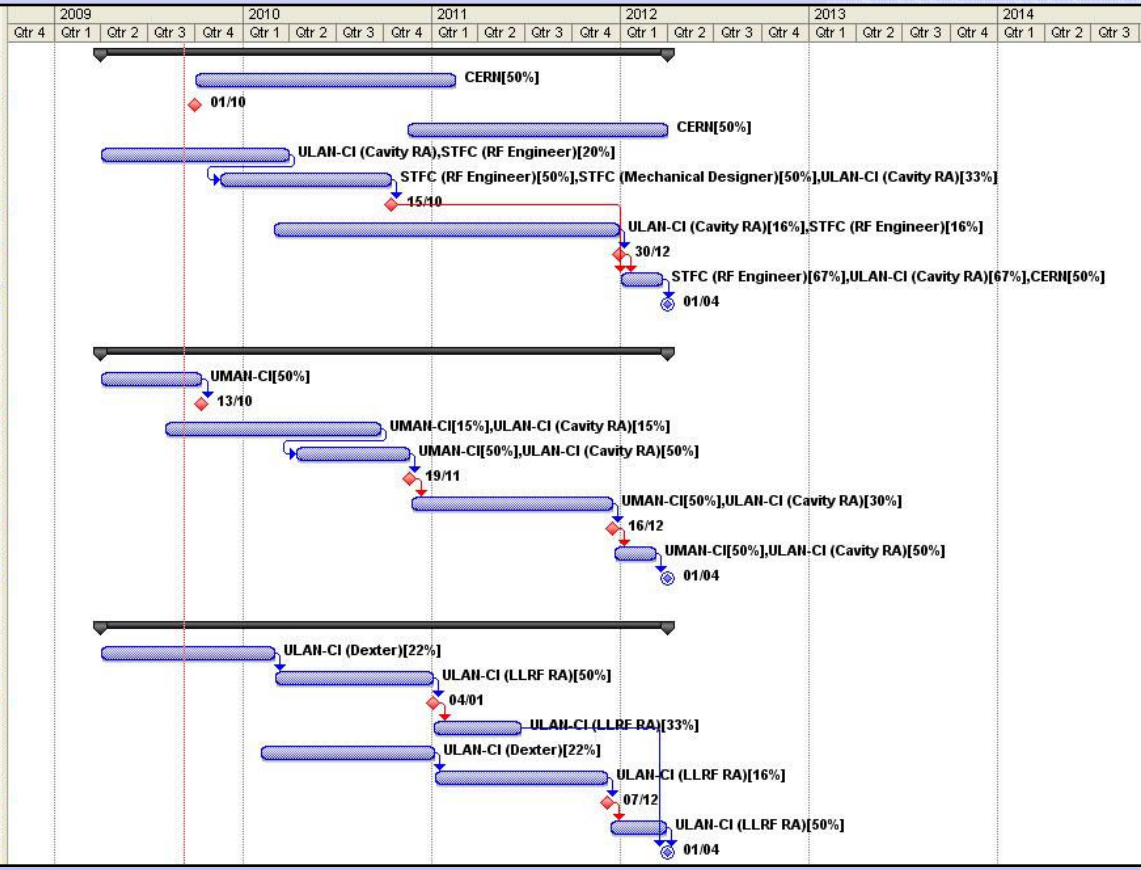
Milestones and Deliverables

Output[1]	Description	Nature[2]	Delivery month[3]
M1	**LHC crab cavity specifications completed**	**R**	**M12**
M2	**LHC model crab cavity completed**	**P**	**M24**
M3	**LHC coupler development finished**	**P/R**	**M33**
M4	CLIC crab cavity specifications completed	R	M12
M5	CLIC model crab cavity completed	P	M24
M6	CLIC coupler development finished	P/R	M33
M7	**Development of LHC LLRF system**	**P**	**M21**
M8	Development of CLIC LLRF system	P	M30
D1	**LHC crab cavity final report**	**R**	**M36**
D2	CLIC crab cavity final report	R	M36
D3	**LHC and CLIC LLRF final reports**	**R**	**M36**

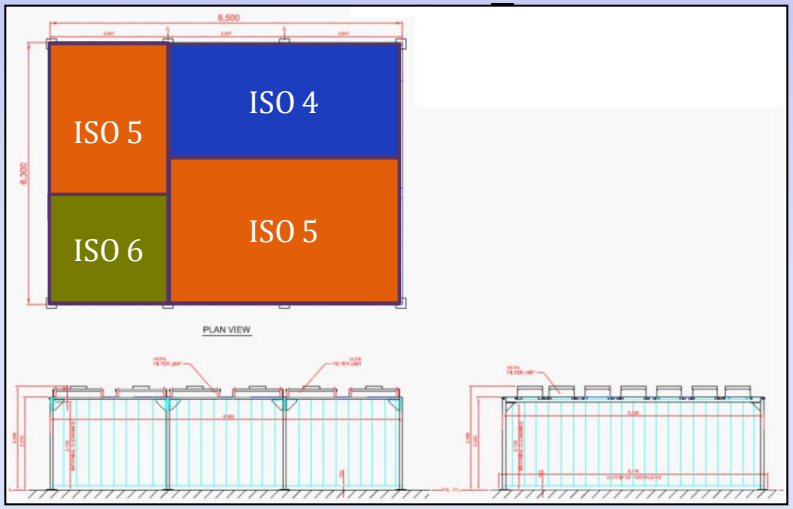
[1] M = Milestone, D = Deliverable
[2] Nature: R=Report, P=Prototype, D=Demonstrator, O=Other
[3] Counted from the starting date

Project Status

Task Name	Duration	Start	Finish
WP 10.3.1 LHC-CC Development	**783 days**	**Wed 01/04/09**	**Sun 01/04/12**
LHC-CC Coordination: Links, steering, info exchange	18 mons	Thu 01/10/09	Wed 16/02/11
M1: LHC-CC Specifications Completed	**0 days**	**Thu 01/10/09**	**Thu 01/10/09**
LHC-CC Integration: Location, cryostat, test stand etc	18 mons	Mon 15/11/10	Sun 01/04/12
Establish LHC-CC Design	13 mons	Wed 01/04/09	Tue 30/03/10
Manufactute/testing of LHC-CC Prototype	12 mons	Mon 16/11/09	Fri 15/10/10
M2: LHC-CC Prototype Model Tested	**0 days**	**Fri 15/10/10**	**Fri 15/10/10**
LHC-CC Coupler Designs	24 mons	Mon 01/03/10	Fri 30/12/11
M3: LHC-CC Coupler Development Completed	**0 days**	**Fri 30/12/11**	**Fri 30/12/11**
Complete LHC-CC Design Report	3 mons	Mon 02/01/12	Fri 23/03/12
Deliverable 1: LHC-CC Design, Prototyping and Validation	**0 days**	**Sun 01/04/12**	**Sun 01/04/12**
WP 10.3.2 CLIC-CC Development	**783 days**	**Wed 01/04/09**	**Sun 01/04/12**
Study CC effects on CLIC beam dynamics	7 mons	Wed 01/04/09	Tue 13/10/09
M4: CLIC-CC Specifications Completed	**0 days**	**Tue 13/10/09**	**Tue 13/10/09**
Establish CLIC-CC Design	15 mons	Mon 03/08/09	Fri 24/09/10
CLIC-CC Coupler Designs	8 mons	Mon 12/04/10	Fri 19/11/10
M5: CLIC-CC Coupler Development Completed	**0 days**	**Fri 19/11/10**	**Fri 19/11/10**
Manufacture/testing of CLIC-CC NC Prototype	14 mons	Mon 22/11/10	Fri 16/12/11
M6: CLIC-CC Prototype Tested	**0 days**	**Fri 16/12/11**	**Fri 16/12/11**
Complete CLIC-CC Design Report	3 mons	Mon 19/12/11	Fri 09/03/12
Deliverable 2: CLIC-CC Design, Prototyping and Validation	**0 days**	**Sun 01/04/12**	**Sun 01/04/12**
WP 10.3.3 LHC-CC and CLIC-CC LLRF Development	**783 days**	**Wed 01/04/09**	**Sun 01/04/12**
Establish LHC-CC phase control model and validate	12 mons	Wed 01/04/09	Tue 02/03/10
Develop LHC-CC LLRF system design and validate	11 mons	Wed 03/03/10	Tue 04/01/11
M7: Development of LHC-CC LLRF Completed	**0 days**	**Tue 04/01/11**	**Tue 04/01/11**
Complete LHC-CC LLRF Design Report	6 mons	Wed 05/01/11	Tue 21/06/11
Establish CLIC-CC phase control model and validate	12 mons	Thu 04/02/10	Wed 05/01/11
Develop CLIC-CC LLRF system design and validate	12 mons	Thu 06/01/11	Wed 07/12/11
M8: Development of CLIC-CC LLRF Completed	**0 days**	**Wed 07/12/11**	**Wed 07/12/11**
Complete CLIC-CC LLRF Design Report	4 mons	Mon 12/12/11	Fri 30/03/12
Deliverable 3: LHC-CC & CLIC-CC LLRF Design and Validation	**0 days**	**Sun 01/04/12**	**Sun 01/04/12**



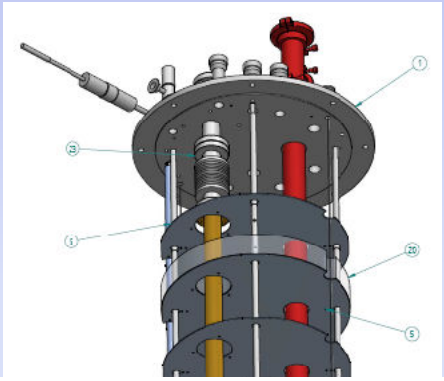
ISO 4/5/6 Cleanrooms @ CI



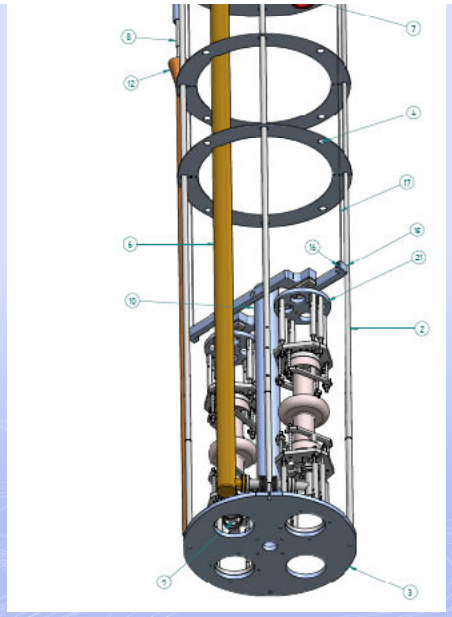
- **ISO 4 (Class 10)**
  - **(5.7 m x 2.8 m) = 16 m^2**
- **ISO 5 (Class 100)**
  - **(8.5 m x 3.5 m) = 30 m^2**
- **ISO 6 (Class 1000)**
  - **(2.8 m x 2.8 m) = 8 m^2**

- **Validated March 2007**

SRF Vertical Test Facility @ CI



ILC 3.9GHz Crab Cavity Insert



- **Cryostat (2.9m x 0.85m)**
- **3 layers of magnetic shields**
- **2K pumping capability**
- **Dewar fed**

High Pressure Rinse Facility @ CI

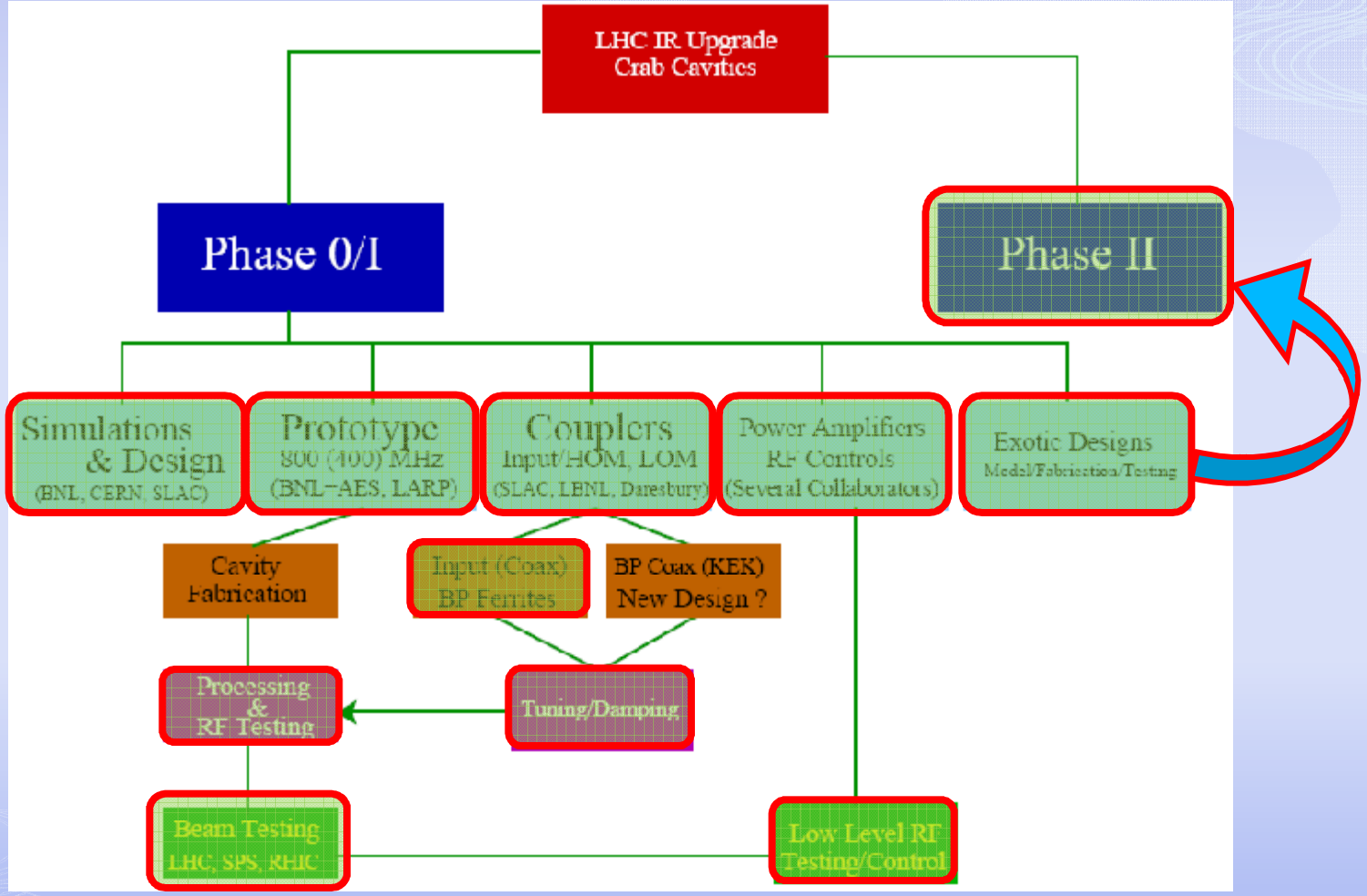
- FNAL designed.
- Cavity moves vertically over rinse nozzles.
- Rinse nozzles rotate inside cavity.
- Uses commercial Bosch Rexroth Linear Actuators.
- Capabilities:
  - 1350psi HP water supply.
  - Rinse nozzle wand 2RPM max.
  - Linear rail 60 inches/min max.
  - Motions are slow, no pinch points.
  - Fully automated.
- Under fabrication:
  - ETA Oct 09.

BCP Etching Capability @ CI

- BCP fume cupboard
- Single-cell etching
- Manual handling

- Ultra pure water system
- >18 MΩ/cm conductivity
- TOC monitor included

LHC-CC R&D Plan



From LHC-CC08 BNL, 25-26 Feb 2008

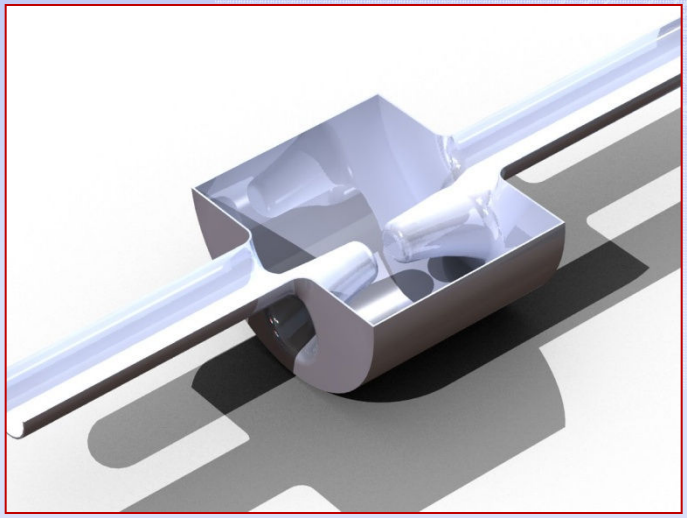
EUCARD FP7 Contribution

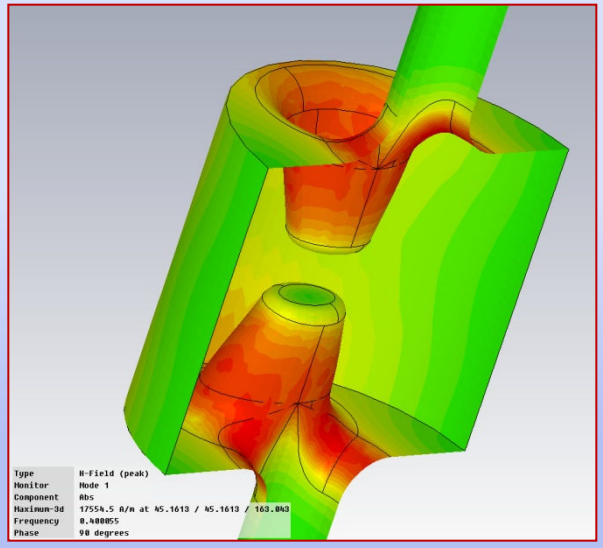
Phase II – LHC-CC R&D

- Low surface field solution sought:
  - 0.1 m beam-pipe diam.
  - 0.4 m body diam.
- Preliminary design @ 3 MV/m achieves:

  E_{max} = 40 MV/m

  B_{max} = 53 mT
- Further parameterisation possible.
- Collaboration with Jlab and Tech-X initiated.





Summary

- UK have led ILC-CC development through to system validation.
- Design synergies are clear for LHC-CC.
- SRF infrastructure at CI available for LHC-CC component and/or system verification.
- EUCARD LHC-CC design priorities identified, which require meshing with global collaboration effort.
- Cavity down-selection process will define UK resource focus.