WG2 Meeting
WP3: Crab Cavity System Preparations for Pre-Lab

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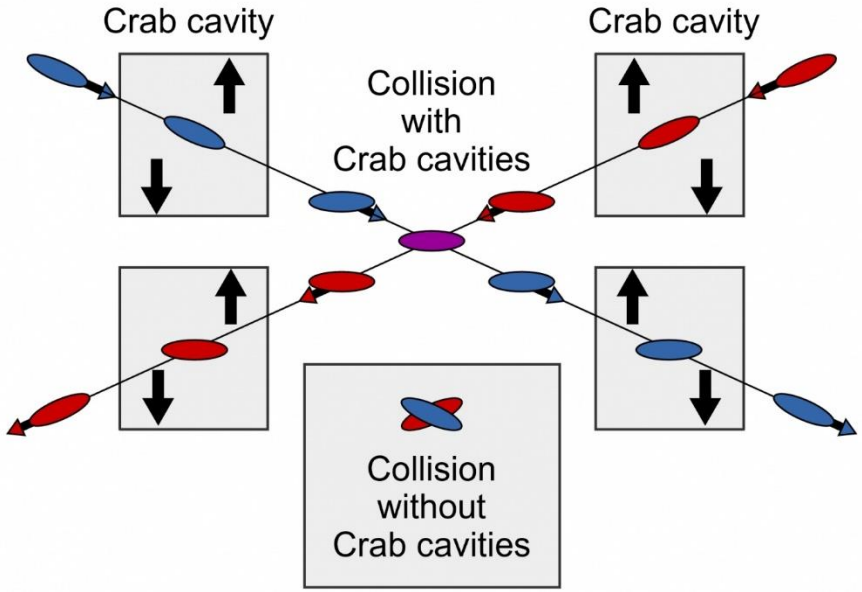
8th June 2021



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Summary of CC Preparations to Date

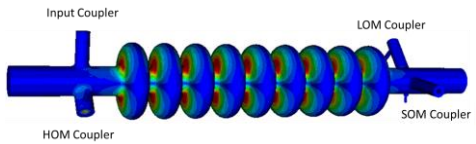
- Workshop for Crab Cavity – 18th Feb 2021
  - Reviewed the ILC CC status, original TDR CC solution along with a variety of additional CC technology options.
- WP-3: Summary of Crab Cavity Workshop - Presented at LCWS2021 (16th Mar 2021)
- 1st WP3 Crab Cavity Preparation Meeting – 24th March 2021
  - Reviewed Pre-Lab CC scope and recommendations from International review.
  - Identified provisional set of parameters to facilitate CC system developments.
  - Updated Pre-Lab scope, TPD description and resources Annex defined for WP3.
- 2nd WP3 Crab Cavity Preparation Meeting – 27th April 2021
  - Reviewed modified Pre-Lab CC scope and resources.
  - Further reviewed CC specification parameters to be developed.
  - Initiated assessment of collaborative CC development plans, prior to Pre-Lab phase.
- 3rd WP3 Crab Cavity Preparation Meeting – 25th May 2021
  - Invited BDS team to review CC specifications – further assessments proposed.
  - Review and agree provisional plan for CC designs and review timescales.
- 4th WP3 Crab Cavity Preparation Meeting – Planned early July 2021:
  - Plan to fix CC design specifications and formally initiate collaborator developments.
  - Agree CC development milestones and review processes for 2021.

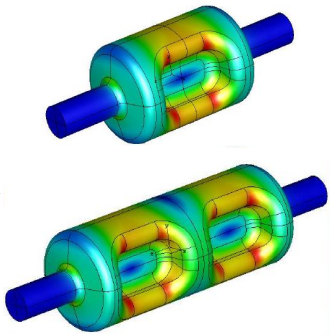
CC Workshop Summary

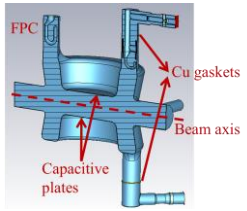
- Workshop for Crab Cavity – 18th Feb 2021
- During which we reviewed the ILC CC status, from TDR solution along with a variety of additional CC technology options:

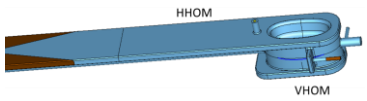
	Elliptical (TDR)	RFD (1/2-cell)*	DQW (LHC/EIC)*	WOW (EIC)*	QMiR*
Frequency (GHz)	3.9	1.3	1.3	1.3	2.6
Vt (MV) – per cell	0.3	1	1.2	1.3	0.7
Ep (MV/m)	17	39/40	41/51	50	54
Bp (mT)	73	79/77	80/80	80	75
	ULAN	ODU/JLab	BNL	BNL/SLAC	FNAL/ANL

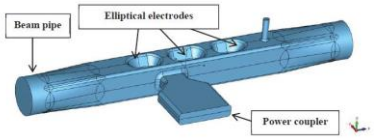
*Not optimised for ILC











TPD Update for WP3

- Technical Planning Document (TPD) and its resourcing Annex updated – many thanks for all WP3 collaborator input:
  - https://agenda.linearcollider.org/event/9179/
- Key changes from original Pre-Lab scope of work include:
  - Early stage development agreed for cavity EM design optimisation.
  - Two cavity technology down-selection processes incorporated:
    - First: Select 2 most optimum integrated cavity designs (cavity, couplers, tuner) to move into prototyping stage a validation.
    - Second: Perform final cavity technology selection to be used as basis for integrated cryomodule design.
  - Perform 2-cavity synchronisation test using the 2 prototype cavities demonstrated at a suitable lab partner location.
  - Crab cavity Pre-Lab scope will result in a final engineering design of a 2-cavity cryomodule solution, ready for prototyping beyond the Pre-Lab phase.

Modified CC Scope for Pre-Lab (2022 – 2026)

	Work package	Items	Quantity
WP-3	Crab Cavity (CC) for BDS #CC production : 2 + SRF validation # CC-CM design :	Decision of installation location with cryogenics/RF location accelerator tunnel	–
		Confirm the complete CC system specifications	–
		Development of CC cavity/coupler/tuner integrated design (ahead of Preliminary CC technology Down-selection)	TBC
		Preliminary CC technology down-selection (2 cavity options)	–
		CC Model-work and Prototype production and high-power validation of CC cavity/coupler/tuner integrated system for two primary candidates (ahead of Final CC technology Down-selection)	Model x 2 (cavity, couplers, tuner) Proto x 2 (cavity, couplers, tuner)
		Perform harmonized operation of the two prototype cavities in a vertical test to verify ILC synchronisation performance (cryo insert development and commercial optical RF synchronization system).	1
		Final CC technology down-selection	–
		Preliminary Crab CM design – confirming dressed cavity integration and compliance with beam-line specification	1
		Final CM engineering design prior to production	1
		Infrastructure for CC development and test (with each regional responsibility.)	–

CC Specifications – In Progress

Parameter	Recent Spec (After TDR)		10Hz Upgrade[1,2]	1 TeV CoM Spec [2]		
Beam Energy (GeV) e-	125			500		
Crossing Angle (mrad)	14					
Installation site (m from IP)	14					
RF Repetition Rate (Hz)	5		10	4		
number of bunches	1312		2625	2450		
Bunch Train Length (ms)	727		961	897		
Bunch Spacing (ns)	554		366			
Beam current (mA)	5.8		8.75	7.6		
Operating Temp (K)	2 ?					
Cryomodule installation length (m)	3.8					
Horizontal beam-pipe separation (m)	0.197					
Cavity Frequency (GHz)	3.9	2.6	1.3	3.9	2.6	1.3
Total Kick Voltage (MV)	0.615	0.923	1.845	2.5	3.7	7.4
Amplitude regulation/cavity (% rms)	3.5 (for 2% luminosity drop)					
Relative RF Phase Jitter (deg rms)	0.069					
Timing Jitter (fs rms)	49 (for 2% luminosity drop)					
Missing Parameters						
Beam-cavity jitter (fs rms)						
Longitudinal impedance threshold (Ohm)						
Trasverse impedance threshold (Ohm/m)						
Cavity alignment tolerance (x, y) (mm)						
Cavity field rotation tolerance/cavity (mrad rms)	5.2 (for 2% luminosity drop)					
Beam tilt tolerance (H and V) (mrad rms and urad rms)	0.35, 7.4 (for 2% luminosity drop)					
Minimum beam aperture size (mm)	20 (same as FD magnets)					
Qext						
Cavity bandwidth (Hz)						
Input power (kW)						
Cavity dynamic load (W)						
Cryomodule static load (W)						
Cavity aperture (H and V) (mm)						
Beam size at CC location (X, Y,Z) (mm,um,um)	0.97, 66, 300					
Microphonic effects, cryogenics?						
Active positioning expected, tolerance (X,Y) - 2mm indicated?						
Multipole effects for CC (May take some time if not already available)						

TBD

Likely to be cavity specific

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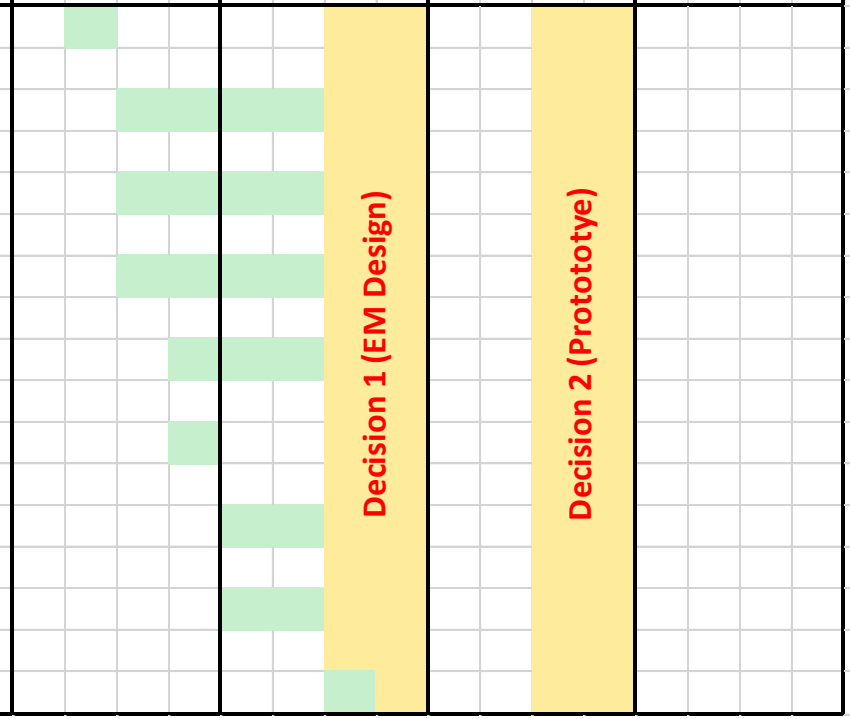
WP3 CC Planning

Activity	R&D Plan	Tmescale	When?
		2021 (Q1 Q2 Q3 Q4) / 2022 (Yr 1) (Q1 Q2 Q3 Q4) / 2023 (Yr 2) (Q1 Q2 Q3 Q4) / 2024 (Yr 3) (Q1 Q2 Q3 Q4)	
Set CC specifications	**T0 + 3m**		**24-Jun-21**
Bare cavity EM design parameters			
Hom damped cavity parameters			
HOM coupler development			
Mechanical design			
Workshop review of various design options (cavity, HOMs, couplers)	**T0 + 9m**		**07-Dec-21**
Multipacting assessment			
Tuning solution and pressure analysis			
Decision 1 - cavity shape, HOMs, couplers, multipacting, tuning, pressure stability, fabrication	**T0 + 18m**		**24-Sep-22**



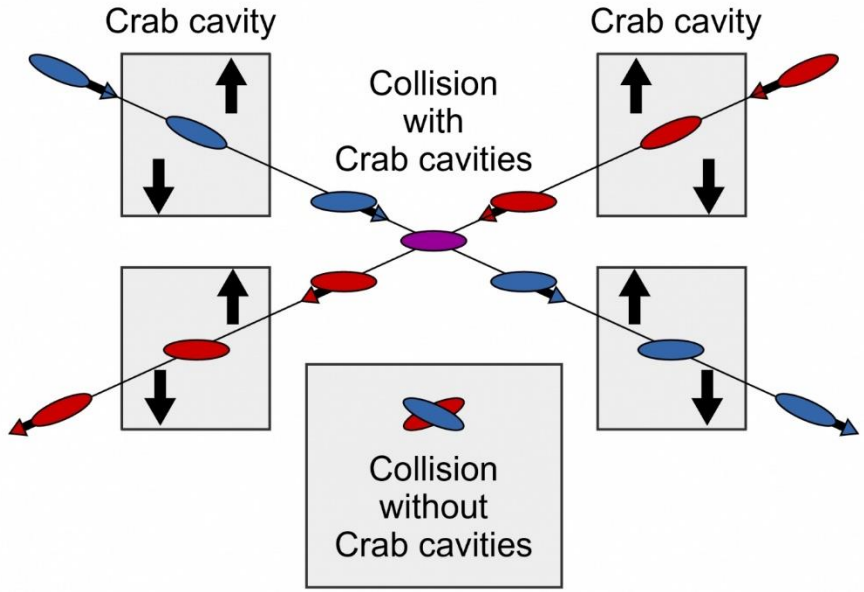
Note:

T0 set as 24/3/21 at 1st WP3 collaborative meeting

CC design progress review workshop proposed for 7/12/21

First Pre-Lab CC technology down-selection decision during late 2022.

MANY THANKS



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