WG2: Joint Meeting with BDS

WP3: Crab Cavity Specifications

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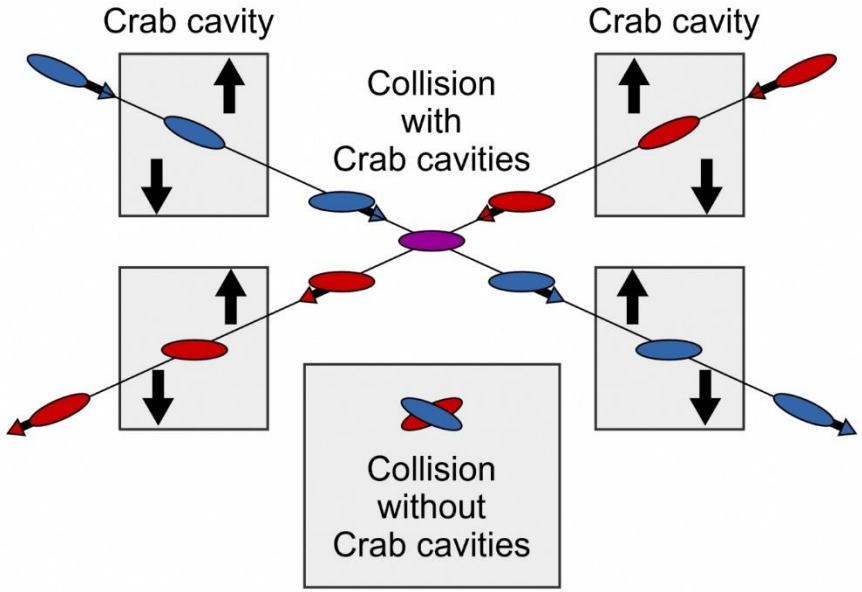

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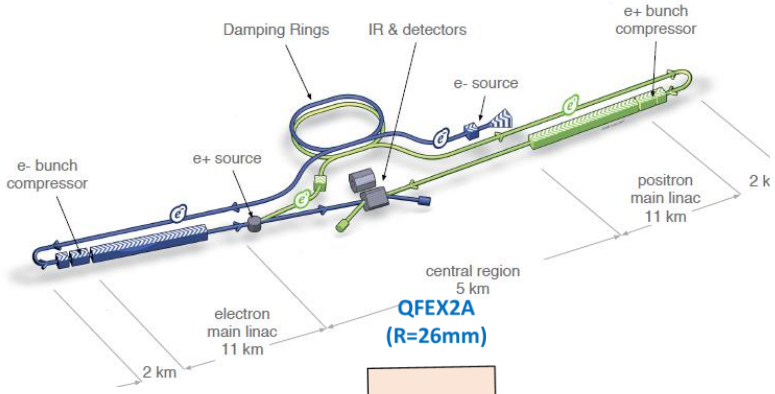
ILC Crab Cavity (CC) Requirements

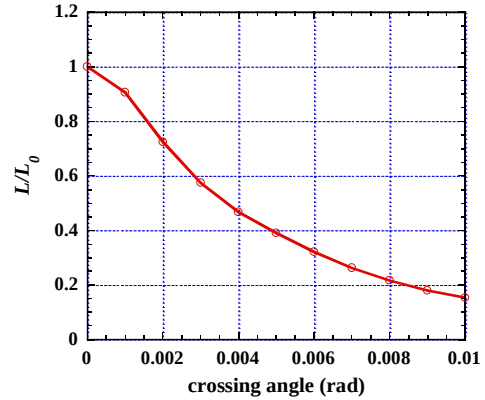
CC system is indispensable for ILC!

Luminosity reduced by >80% without CCs!

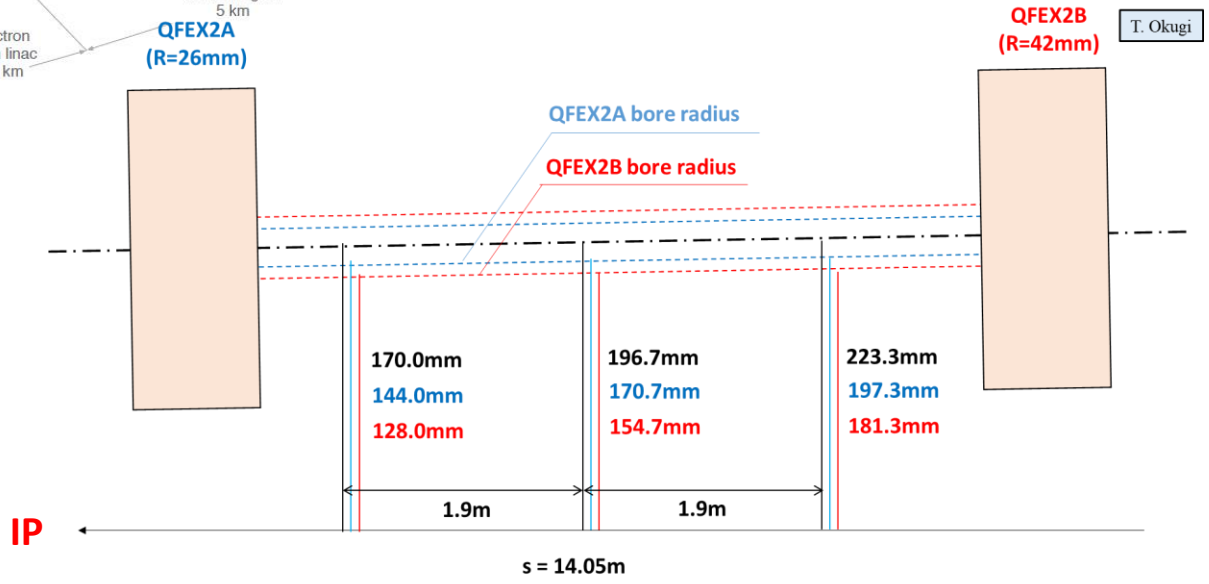
- No development progress since TDR (2013).
- Further development required as CC considered **not-matured technology** (Nomura Research Institute, Ltd):
  - **During the technical preparation period (Pre-Lab), prototype CM should be constructed and tested.**



ILC RDR parameter, by CAIN simulation



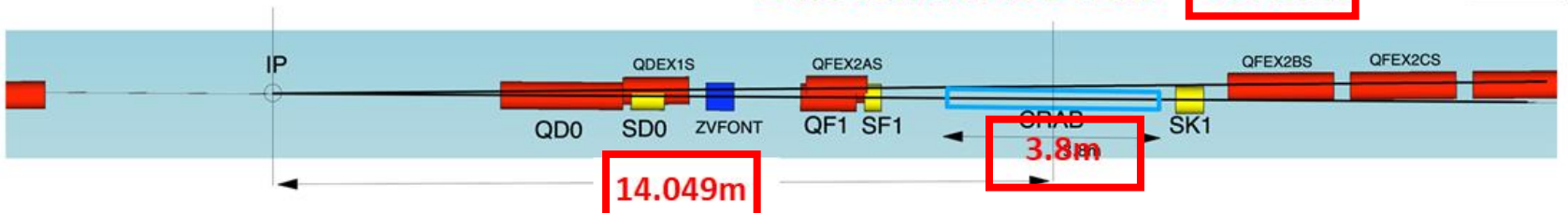
T. Okugi



H. Hayano

Two beamline separation

14.049m x 0.014rad = 197mm



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ILC CC Specifications (v11)

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)	0.1967 (centre) ±0.0266 (each end of installation length)		

Interface apertures?

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
Max Ep (MV/m)			45			45
Max Bp (mT)			80			80
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)					
Max Detuning (Hz)						

Scaling with frequency?

Longitudinal impedance threshold (Ohm)	
Trasverse impedance threshold (MOhm/m) (X,Y)	48.8, 61.7 (from TDR)
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 CC beam-pipe aperture size (mm)	20 (same as FD magnets)
Minimum Exraction beam-pipe aperture size (mm)	20
Beam size at CC location (X, Y,Z) (mm,um,um)	0.97, 66, 300
Beta function at CC location (X, Y) (m,m)	23200, 15400
CC System operation	assume CW-mode operation

Cavity wakefields (GdfidL sims)?

Collimation studies?

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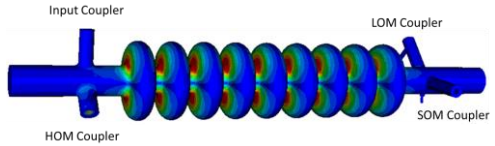
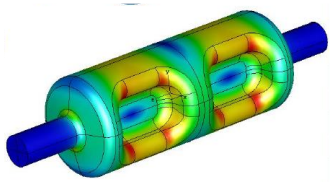
WP3 Crab Cavity Developments

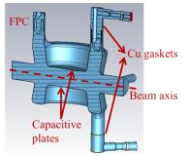
Options study (currently underway):



Elliptical/Racetrack

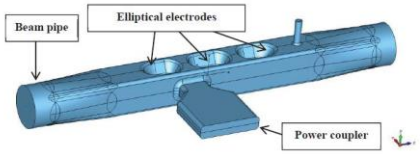


RFD



DQW

WOW



QMiR

- Cavity down-selection #1 (**Sept 22**):
  - EM design optimisation for cavity, couplers (input and HOM) and tuner.
  - Select 2 primary options to take forward to prototype stage.
- Cavity down-selection #2 (**Mar 24**):
  - Choose most optimum single CC technology solution from prototype tests.
- Propose to use both prototype CC's in VTS for synchronisation studies.
- Use final chosen design as basis for 2-cavity CM integration design and prototype
  - Targeted basis for **ILC Pre-Lab phase**.

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WP3 Planning for Pre-Lab

Activity	R&D Plan	Tmescale																When?
		2021				2022 (Yr 1)				2023 (Yr 2)				2024 (Yr 3)				
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	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																		
1st Workshop review of various design options (cavity, HOMs, couplers) ✓	**T0 + 9m**																	**07-Dec-21**
Multipacting assessment																		
Tuning solution and pressure analysis																		
2nd Workshop review of various design options (cavity, HOMs, couplers, multipacting, tuning)	**T0 + 15m**																	**21-Jun-22**
Decision 1 - cavity shape, HOMs, couplers, multipacting, tuning, pressure stability, fabrication (2 cavities chosen)	**T0 + 18m**																	**27-Sep-22**
Decision 2 - Prototype cavity manufacture and ancillaries (couplers (FPC and HOMs) and tuner) and high power test (1 cavity chosen)	**T0 + 36m**																	**Mar-24**

Decision 1 (EM Design)

Decision 2 (Prototoye)

WP3 Planning and Pre-Lab Phasing

	Milestone	Activity	When?	Duration (Months)?
	MS-0	Set CC design specification	T0 + 3m	3
	MS-1	Cavity EM design optimisation	T0 + 18m	12
	MS-2	Coupler EM design optimisation (i.e. LOM, SOM and HOM)	T0 + 18m	12
Pre-Lab Phase	MS-3	Dressed cavity mechanical design with tuner (concept)	T0 + 18m	6
	MS-4	Prelim cavity down-selection process (2off) - Agreed	T0 + 18m	Decision 1
	MS-5	Input coupler design and prototype validation	T0 + 36m	24
	MS-6	High power validation of prototype cavity?	T0 + 36m	18
	MS-7	Integrated 'dressed' cavity optimisation	T0 + 36m	3
	MS-8	Final Cavity down-selection (choose final solution)? Include input coupler Agreed	T0 + 36m	Decision 2
	MS-9	Preliminary Crab CM design - confirm integration with beam-line specification	T0 + 48m	24
	MS-10	Final CM engineering design prior to production	T0 + 54m	6
	MS-11	CM assembly design	T0 + 54m	6
	MS-12	CM assembly tooling development	T0 + 54m	6
	MS-13	Design of CC pCM transport cage and shock damper	T0 + 60m	6
	MS-14	CC production, including cavities w/He tank + mag. shield for CM, high-pressure gas regulation, EP/HT/Clean work, including VT	T0 + 72m	18
	MS-15	Coupler production including preparation/RF processing readiness (excluding klystron, baking furnace, clean room)	T0 + 72m	12
	MS-16	CM production including High-pressure-gas formality, vacuum vessel, cold-mass (cavity-string, coupler/tuner, SCM, etc.)	T0 + 72m	18
	MS-17	Manufacture of CC pCM transport cage and shock damper system	T0 + 72m	12
	MS-18	Prototype CM (pCM) assembly	T0 + 78m	12
	MS-19	Acceptance verification of integrated CM	T0 + 79m	1
	MS-20	High power test of prototype CM	T0 + 83m	3
	MS-21	RF synchronisation of integrated 2-cavity CM cavities	T0 + 86m	3
	MS-22	Transportation validation (ship trans-atlantic and retest)	T0 + 91m	6

WP3 Specification Discussions Today

BDS specific actions from WP3 Design Review Workshop from 8/12: https://agenda.linearcollider.org/event/9515/

- BDS team requested to perform a 10σ simulation, as this is expected to be more representative of beamline effects and likely to need a larger aperture, but how much larger? **Action: T Okugi**
- It was noted that the beam-size at the CC location will vary with energy and so parameters should be provided for 1TeV. **Action: T Okugi**
- Important that the WP3 team have a clear specification for the interfacing beam-line components, which need to be confirmed. **Action: A Yamamoto**
- How much do need to detune CC if it is to be parked, suggestion of >1000 x BW proposed, seems too high. Can BDS team provide some indication of scaling for linac vs circular machine. **Action: T Okugi**

MANY THANKS

Questions?

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