Crab Cavity Design Options

Double Quarter Wave (DQW)

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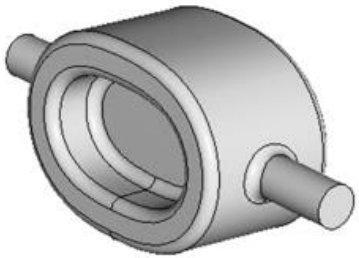
DQW Design Evolution

HL-LHC

- 400 MHz
- Vertical kick
- With waist
- Elliptical profile



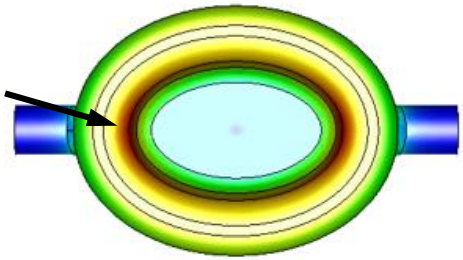
EIC

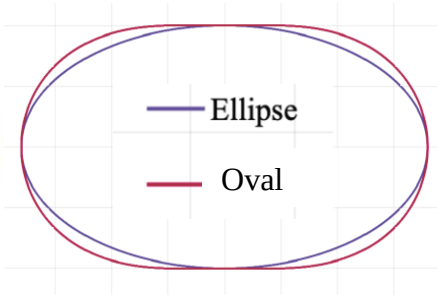
- 200, 400 MHz
- Horizontal kick
- Flat walls
- “Cassini” oval profile

… No clearance issues, ease fab, reduce cost →

…Further reduce peak fields →

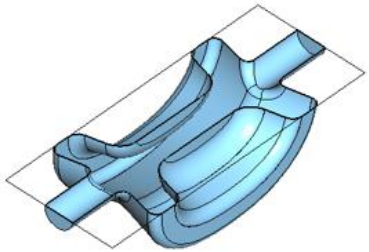
Max. peak surface H





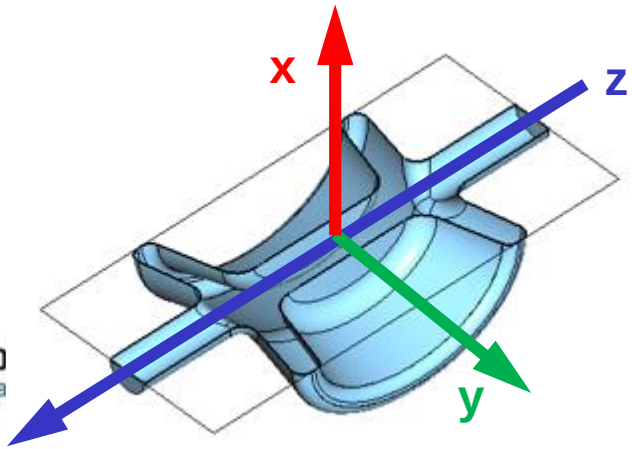
ILC = HL-LHC + EIC

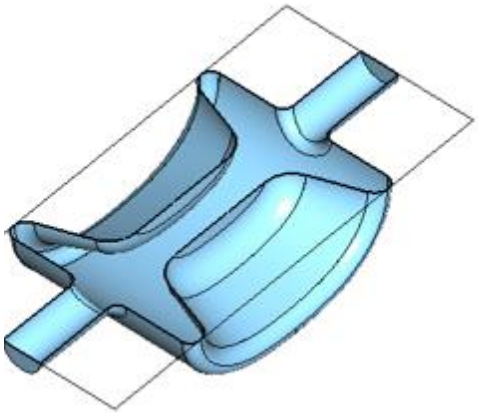
- With waist, “Cassini” oval profile



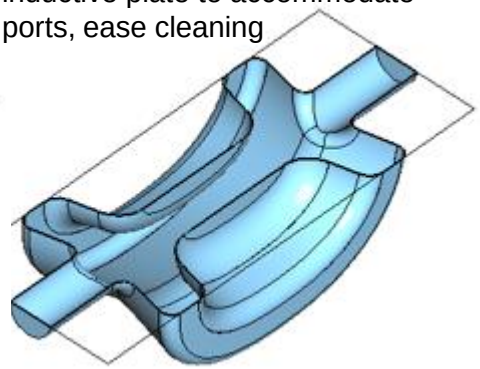
Comparison between cavity models

	LHC-type DQW (B05)	EIC-type DQW (A42)	LHC+EIC-type (C02)
Aperture, capacitive plate distance (mm)	20	20	20
Profile	Elliptical, with waist	Oval, straight walls	Oval, with waist
Dimensions: L x W x H (mm)	95 x 100 x 88	115 x 98 x 82	117 x 76 x 97
Circuit Rt/Q (Ohm)	309	333	311
Geometric factor (Ohm)	80	82	97
Epk (MV/m) at 1.86 MV	50	56	55 ←
Bpk (mT) at 1.86 MV	99	81	84 ←
First HOM (GHz)	1.74 (z)	1.98 (z)	2.18 (z) ←



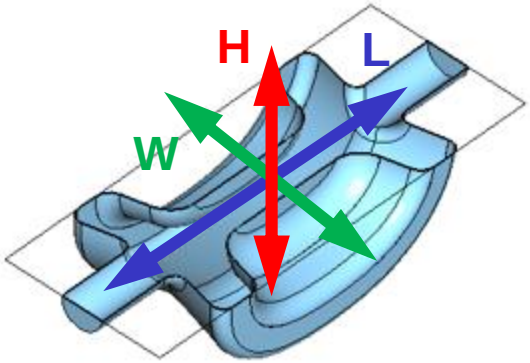


Added advantages: broad inductive plate to accommodate ports, ease cleaning



ILC 1.3 GHz: DQW aperture study

	LHC+EIC-type	LHC+EIC-type
Aperture, capacitive plate distance (mm)	30*	20
Profile	Oval, with waist	Oval, with waist
Dimensions: L x W x H (mm)	126 x 91 x 106	117 x 76 x 97
Circuit Rt/Q (Ohm)	153	311
Geometric factor (Ohm)	104	97
Epk (MV/m) at 1.86 MV	63	55
Bpk (mT) at 1.86 MV	109	84
First HOM (GHz)	1.84 (z)	2.18 (z)



* Peak fields may be further reduced with refined optimization

- Depending on beam scenario and adopted maximum peak fields and minimum aperture, one or two cavities needed to provide required crabbing kick with low peak fields.
  [Vt = 1.86 MV (for 125 GeV, with 1 cavity for 20 mm aperture or 2 for 30 mm) or 1.5 MV (for 500 GeV, with 5 cavities)]

- Next step : -- reiterate cavity optimization once aperture value is agreed upon

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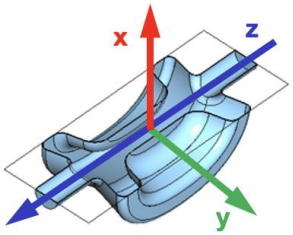
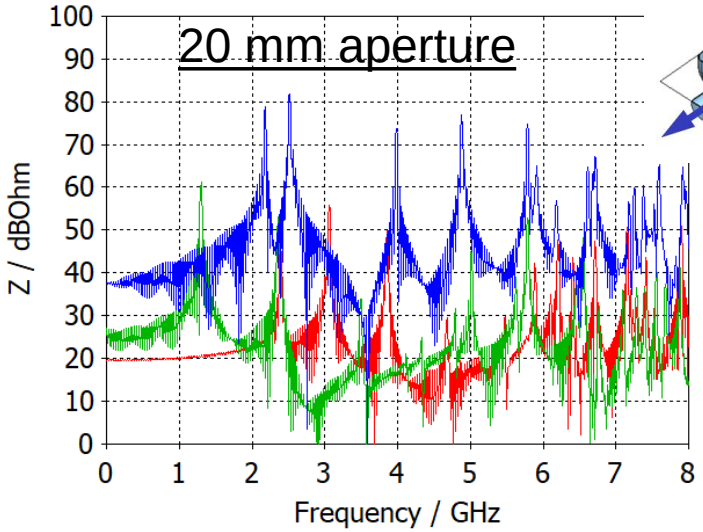
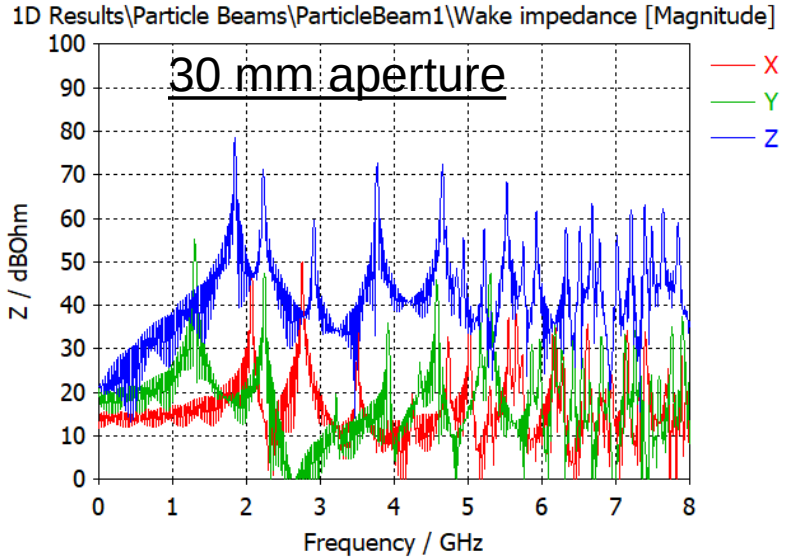
Mode spectrum w/o HOM Couplers

LHC+EIC-type DQW

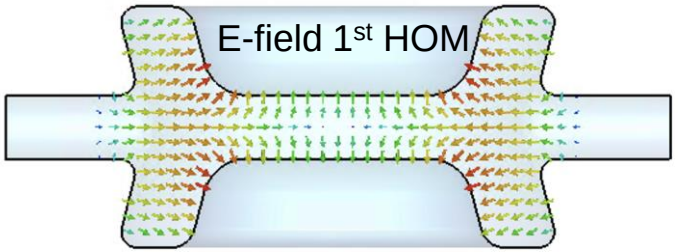




HOM Freq (GHz)	Type
2.18	Long. (z)
2.35	Horiz. (y)
2.39	Vertical (x)



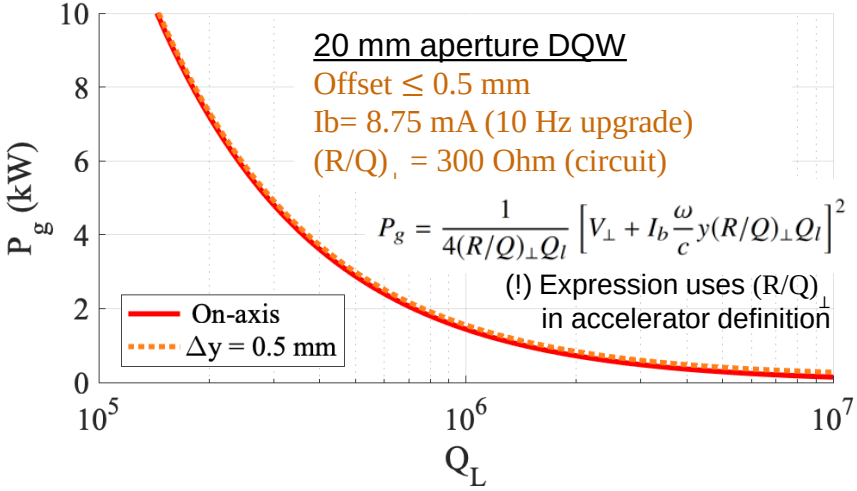
HOM Freq (GHz)	Type
1.84	Long. (z)



Couplers

INPUT POWER COUPLER

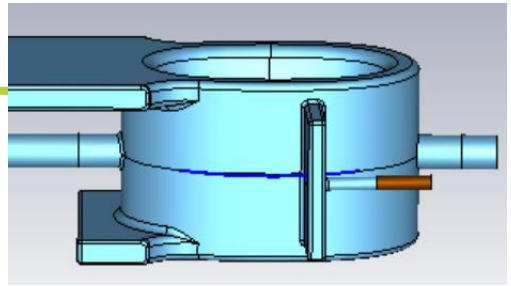
- Selecting a **loaded Q ~ 10^6** leads to **input power below 2 kW** with cavity **bandwidth of 1.3 kHz**.



HOM COUPLER

- Depending on the impedance requirements, either **coaxial or waveguide or a combination** can be used to damp the HOMs.
- Due to **high frequency of the 1st HOM**, a waveguide or a waveguide stub coupled to an antenna can be an efficient and simple solution.

  [Rectangular WG with a ~ 83 mm has $f_{c,TE10}$ = 1.8 GHz.]

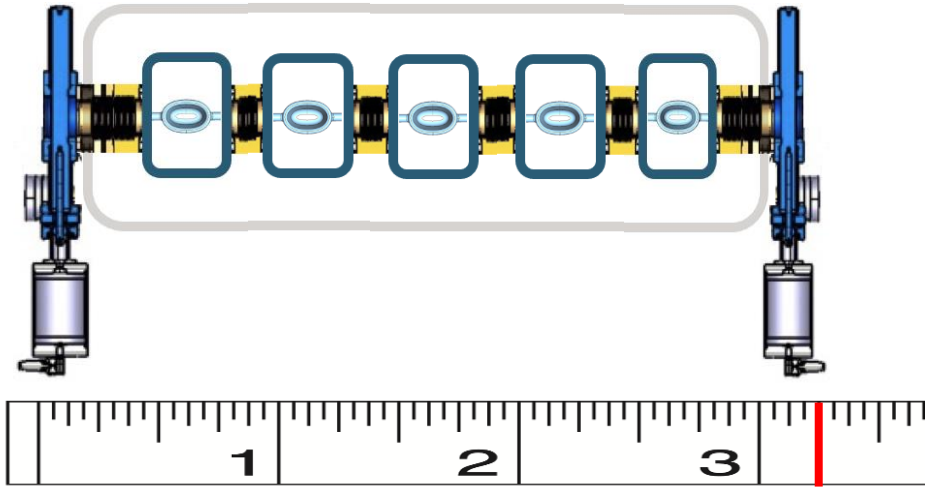


- Next steps: -- HOM coupler integration, FPC

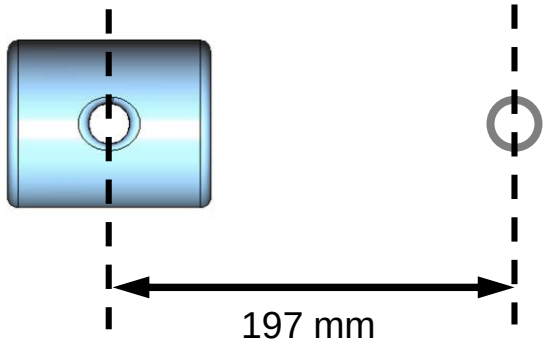
Integration: cryomodule, 2nd beam pipe

- For 1 TeV CoM beam scenario, **5 DQW cavities** are sufficient to **provide a 7.4 MV crabbing kick at 1.3 GHz**.
- Length available of **3.25 m enough for crab cavities and other necessary components** (cold-warm transitions, gate valves, etc.).
- Sufficient **clearance to 2nd beam pipe for coupler integration**.

Side view, 5 DQW in cryomodule



Front view, distance to 2nd beam pipe



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Summary and Overview

- The **DQW** cavity is a **compact solution for the ILC crabbing system**. Two **single-cell cavities** provide **1.86 MV with safe max. peak fields**.
- Tuner and coupler integration can be borrowed from HL-LHC and EIC.
- Cavity **compactness opens the possibility of manufacturing the cavity out of ingot**, which in turn makes the port fabrication much easier and enables the implementation of port interfaces with smooth surfaces for peak field reduction. (The HOM coupler for the HL-LHC DQW was made from ingot and demonstrated good performance.)
- Fabrication and **testing of a prototype** will help the decision on how many cavities are needed to provide the required crabbing kick for ILC.
- Work **to be done**: coupler integration, multipacting, mechanical analysis.

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