

# ILC Damping Ring RF System

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# Main Topics

## ■ *Choice of the D.R. RF Frequency .....*

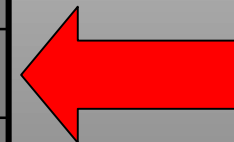
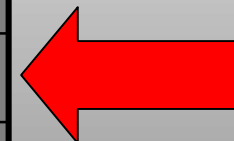
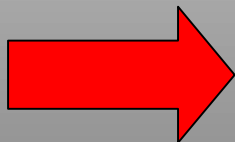
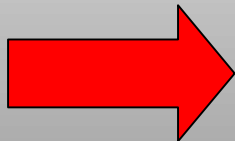
*To make easier design and implementation of the synchronization and timing systems of the whole ILC, the DR RF frequency will be 650 MHz, that is half the Linac frequency.*

## ■ *Choice of the RF technology.....*

*To provide the RF voltage (24 MV per ring) required to get short bunches and necessary beam lifetime, the superconductive technology (SRF) must be used to reduce the RF active length.*

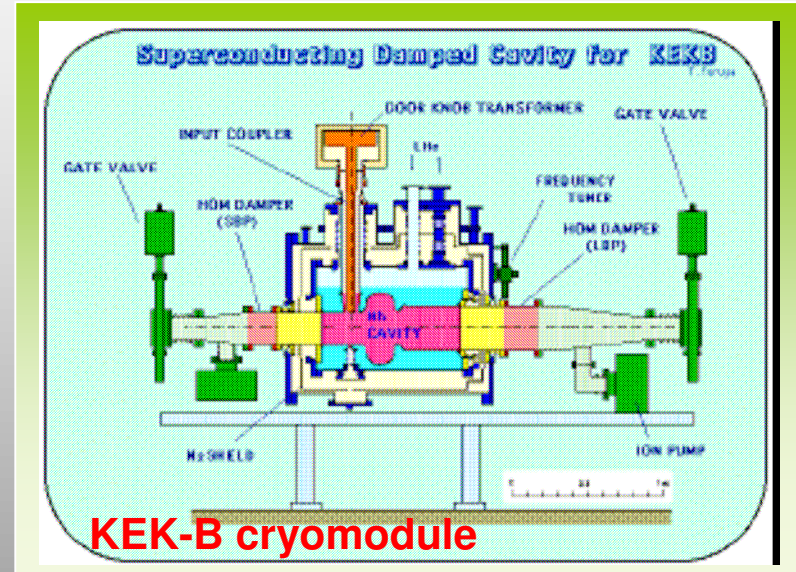
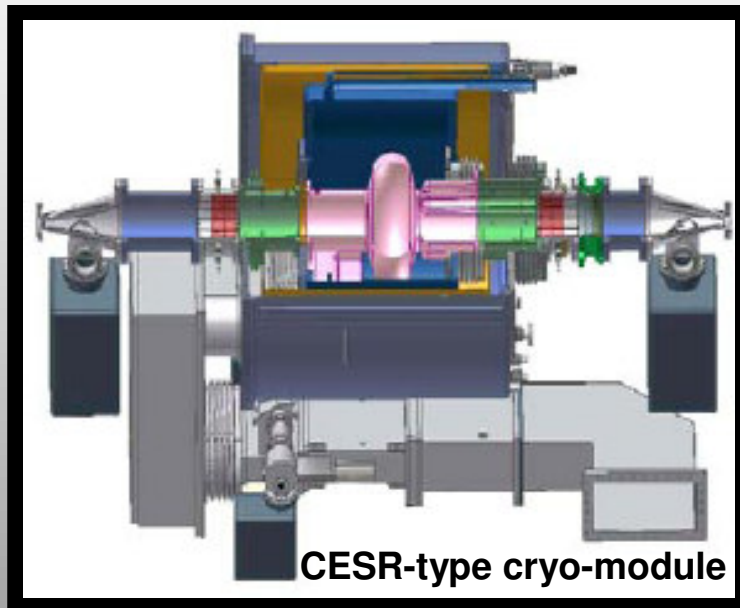
■ *Main D.R. parameters .....*

Energy (GeV)	5
Number of bunches per train	2767
Number of particle per bunches	$2 \times 10^{10}$
Energy loss per turn (MeV)	8.7
Average beam current (A)	0.40
<b>Beam power (MW)</b>	<b>3.5</b>
Bunch current (mA)	0.14
<b>Total RF Voltage (MV)</b>	<b>24</b>
Ring circumference (km)	6.695



## ■ SRF Cavities operating @ 500 MHz

are widely and successfully utilized in various storage rings (CESR, Diamond, KEKB, SRRRC, CLI, Soleil, SLS, .....



- They are “single Nb-cell” housed in cylindrical cryo-modules and immersed in 4.5K liquid He.
- The cavities are in practice “single-mode” resonators thanks to highly effective HOM dampers wrapped-around the cavity ends beam pipe.
- Those SRF cavities are being routinely operated at  $5 \div 7$  MV/m.

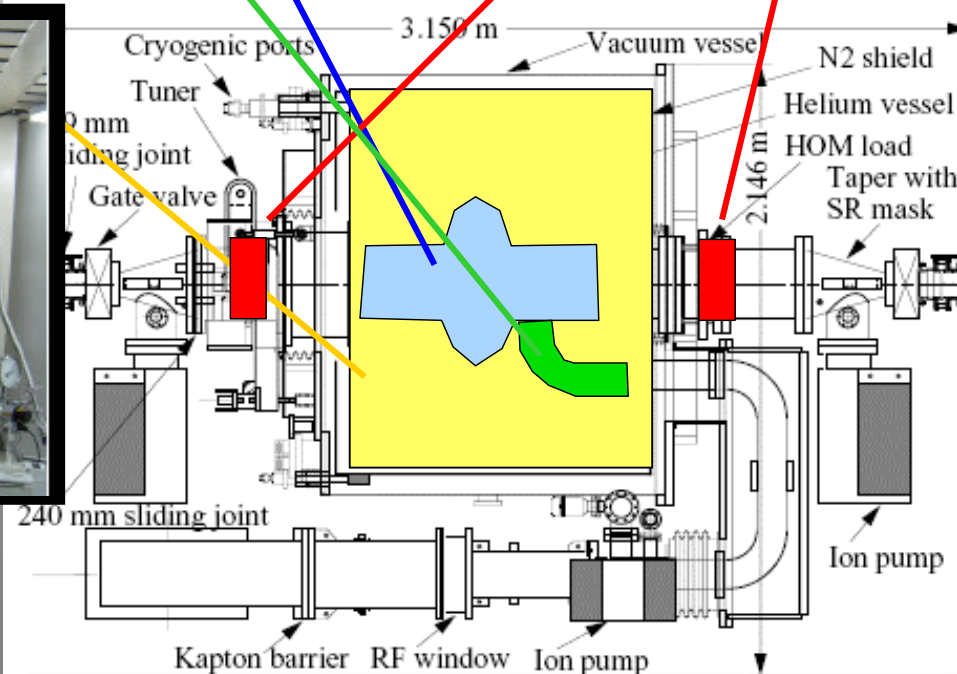
- *The development of 650 MHz SRF cavities, derived from existing 500 MHz units, requires to be somewhat re-designed .*

*The main modifications are :*

- ★ *Cavity profile scaling to 650 MHz*
- ★ *New HOM characterization and new re-sized HOM dampers*
- ★ *New design of the power coupler*
- ★ *Cryostat revision (... possible operation @ 2 K ?)*

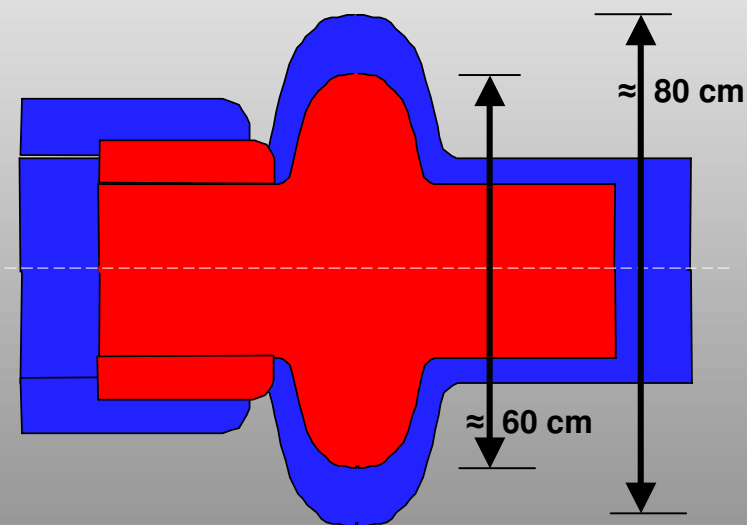


SRRF 500 MHz cryo-module



■ The specifications of a new 650 MHz sc cavity, may be estimated by scaling dimensions and parameters of the 500 MHz sc cell.

Frequency	500 MHz	650 MHz
Active cavity length	0.30 m	0.23 m
R/Q (CESR cell)	89 $\Omega$	89 $\Omega$
Operating temperature	4.5 K	4.5 K
Stand-by losses	$\leq 30$ W *	$\approx 30$ W
Accelerating gradient	$> 8$ MV/m *	$\approx 7.5$ MV/m
Qo [ $\times 10^9$ ]	$> 0.7$ *	$\approx 0.6$



(\*) S. Belomestnykh, PAC2005, pp.4233-4235.

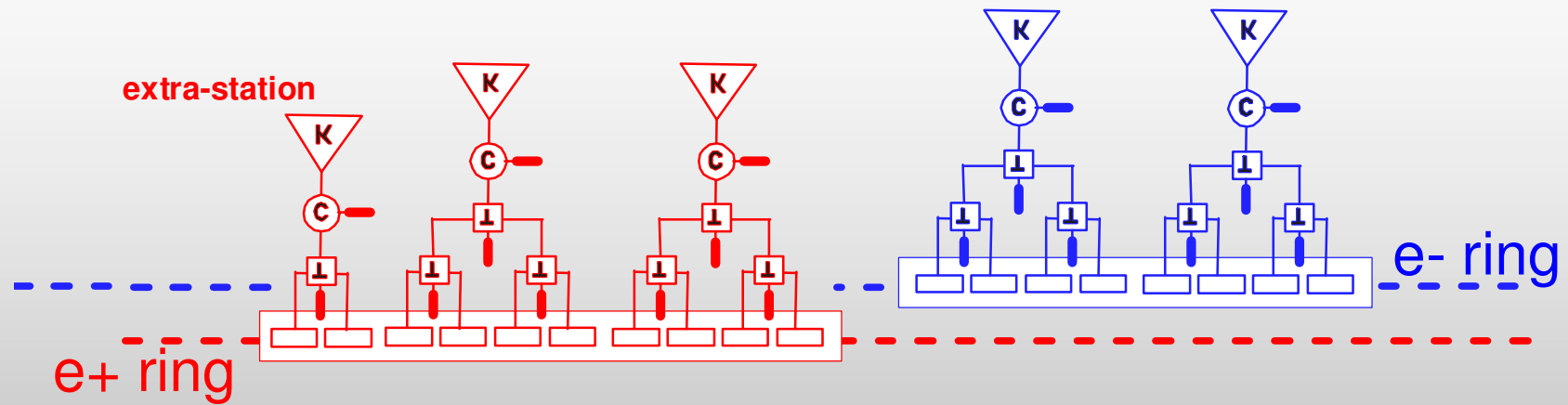
■ *With the parameters assumed in the previous slide, the following RF system is proposed for both rings:*

Number of cryo-modules per ring	18	14 *
Accelerating gradient [MV/m]	5.8	7.5 *
Accelerating voltage [MV]	1.33	1.72 *
$Q_0$ ( $\times 10^9$ ) at operating voltage	0.7	0.6 *
Cryo-RF-losses per cavity [W]	28.5	50 *
Total cryo-losses per ring [W] **	1053	1120 *
Beam power per cavity [kW]	195	250 *
Number of klystrons per ring	5	4 *
Klystron RF power [kW]	780	1000 *

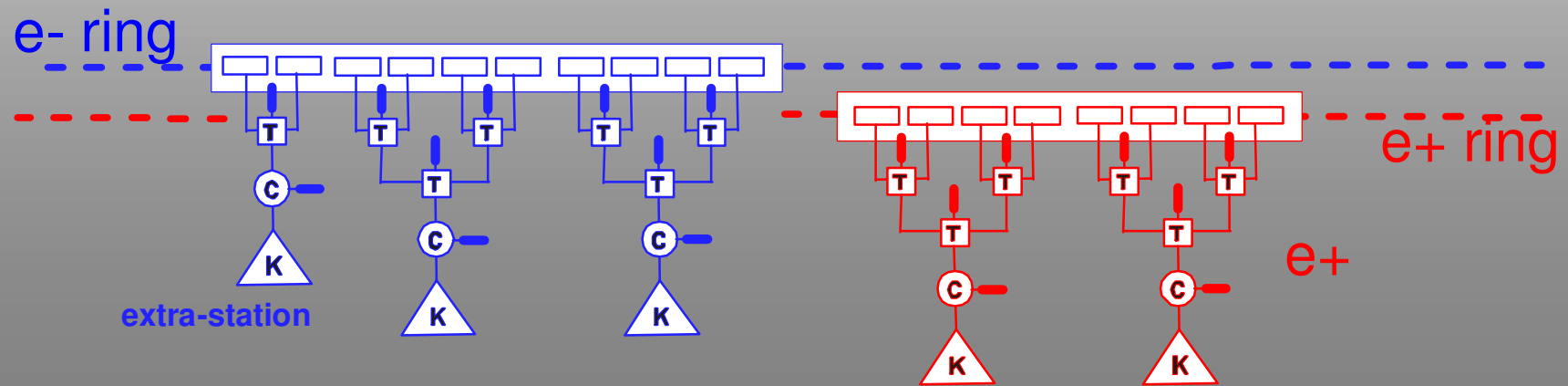
(\*) One RF station OFF-DUTY

(\*\*) Includes stand-by losses

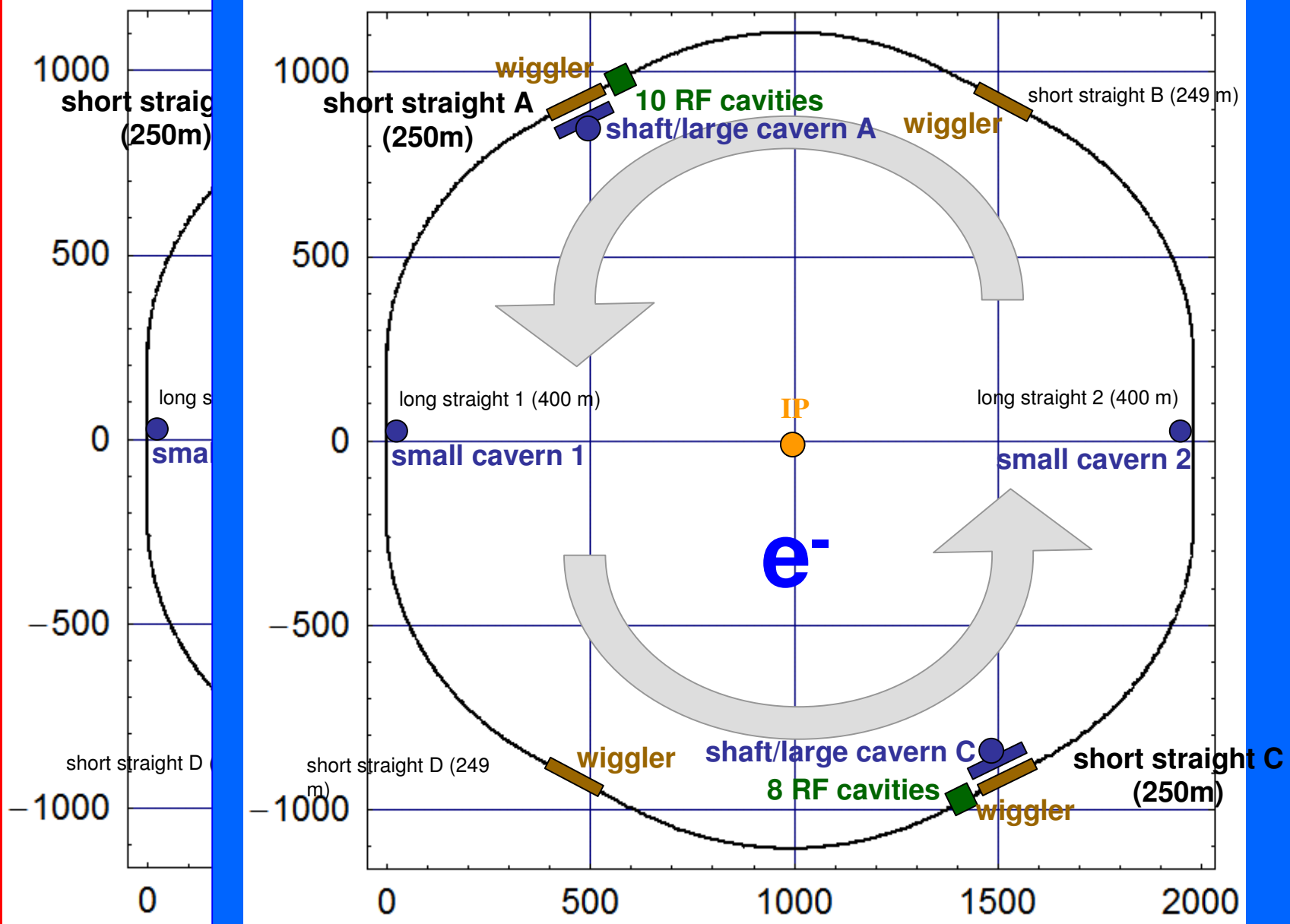
# System Layout



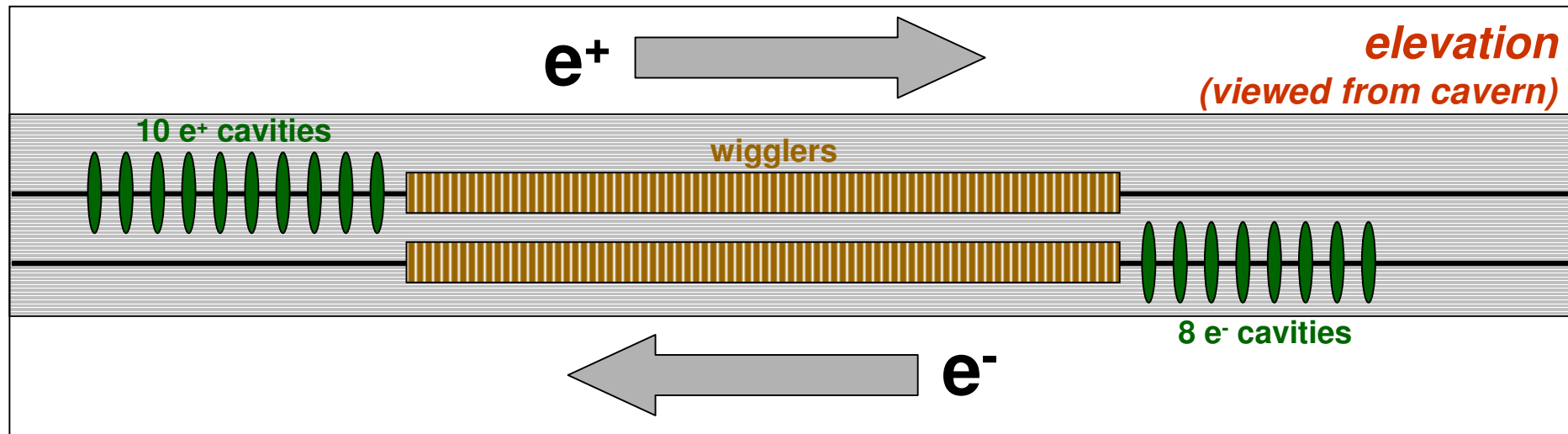
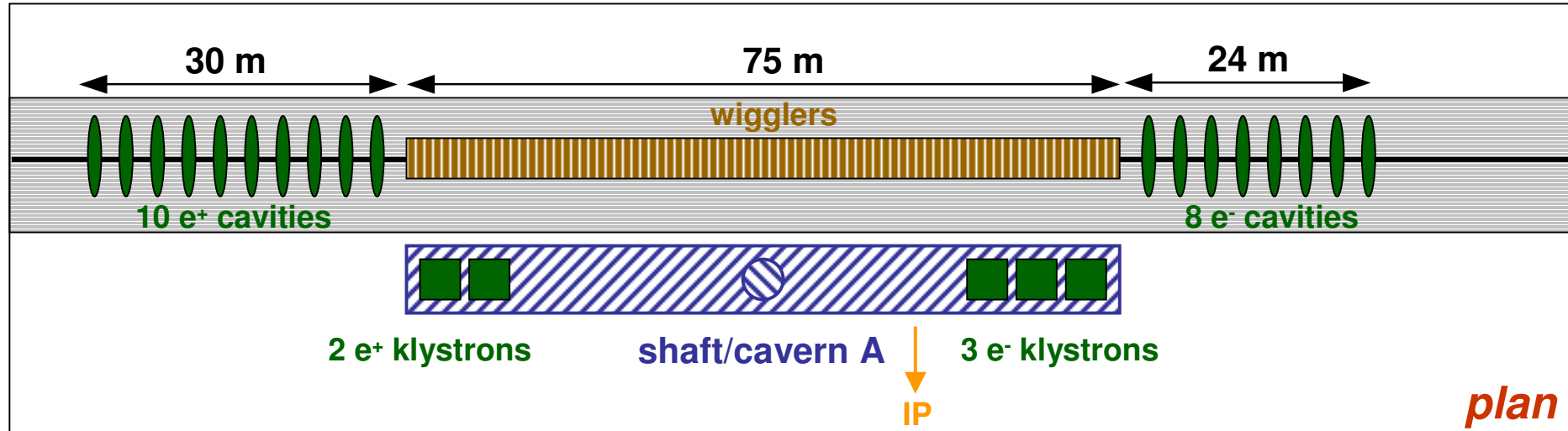
RF STATIONS  
IN OPPOSITE RING STRAIGHTS







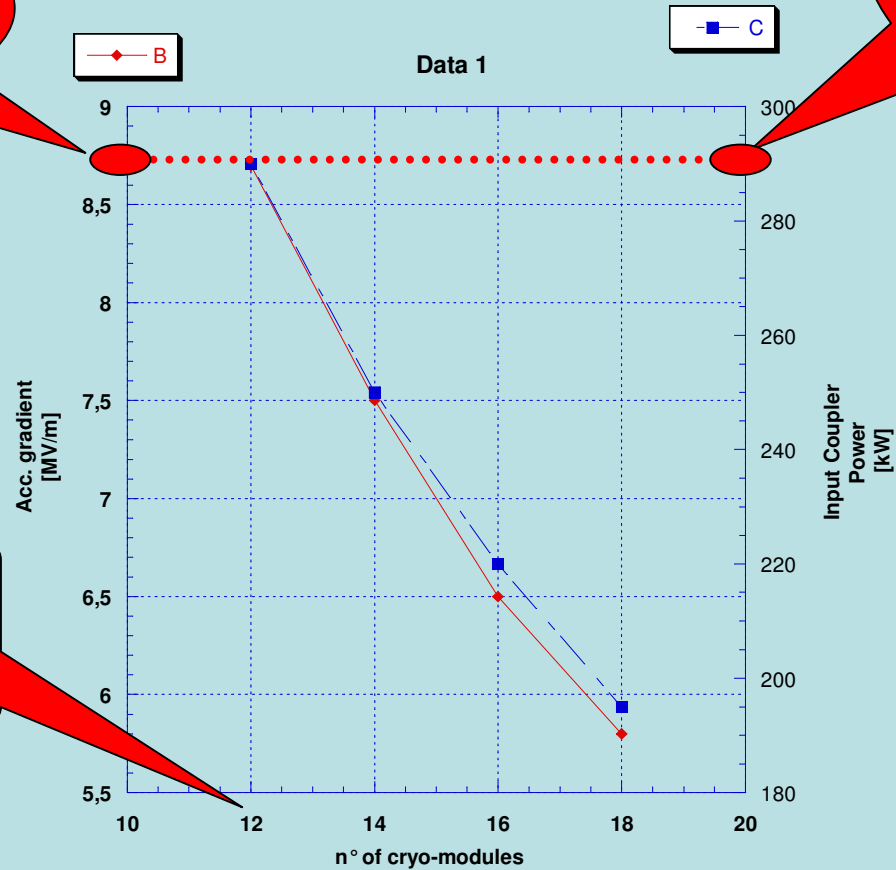
# Schematic Layout of Short Straight C



.... about the additional RF Station

High gradient without extra station

High Input Coupler RF Power without extra station



3 Stations ON  
1 Station OFF  
No extra station

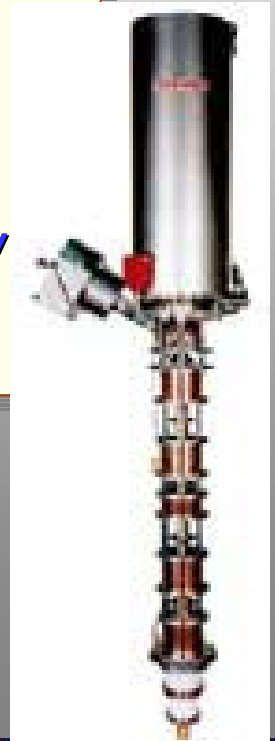
## RF POWER SOURCE

- **KLYSTRON 1 MW – cw - 650 MHz**
- *RF sources having frequency and output power close to those needed for the ILC DR are .....*

**THALES 2178 - 500 MHz – 800 kW CW**



**TOSHIBA E3732 - 508.6 MHz - 1.8 MW CW**



**Thales is available to upgrade the TH2178. Toshiba should agree to modify the E3732 too.**

■ ... other RF components ...

■ Waveguides ...rectangular WR1500

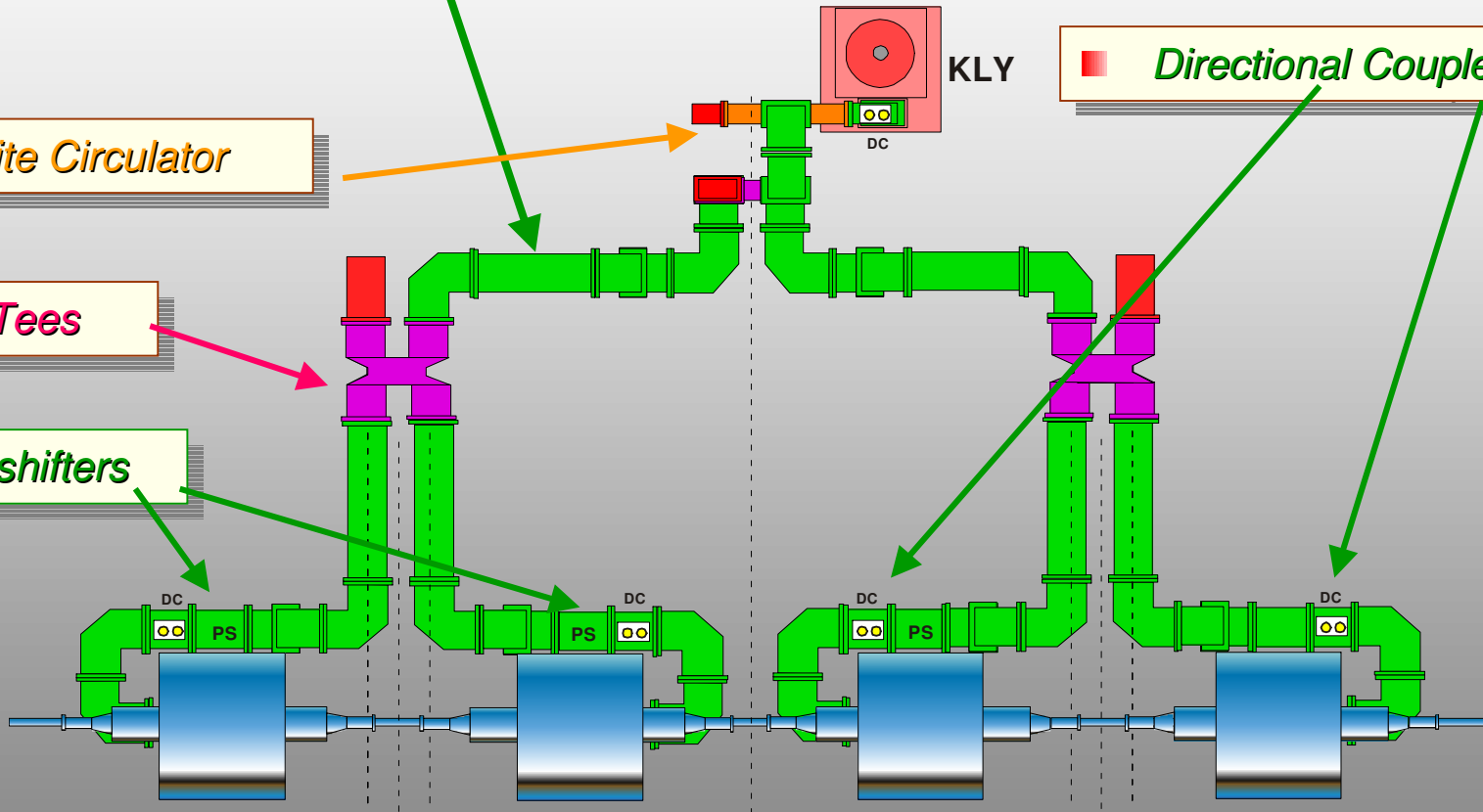
■ SCHEMATIC LAYOUT

■ Ferrite Circulator

■ Directional Couplers

■ Magic Tees

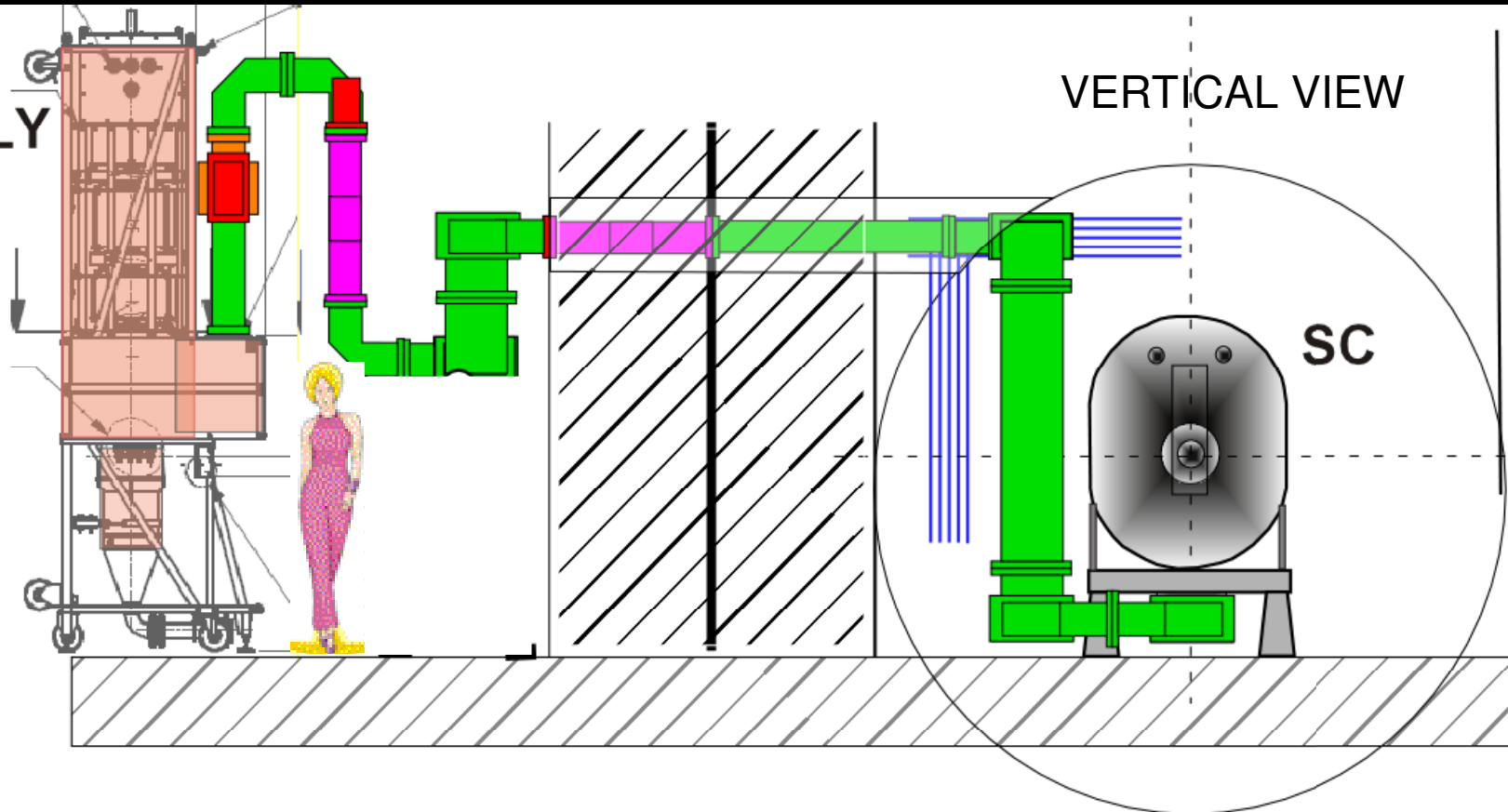
■ Phase shifters



KLY

VERTICAL VIEW

SC

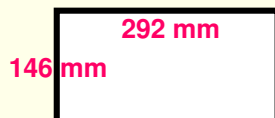
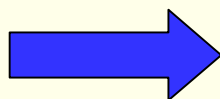


## Waveguides

Standard **WR1150** or **WR1500** rectangular Aluminium waveguides

Typical Specifications									
Size EIA WR	Size IEC R( )	Recom- mended Frequency Range (GHz)	Cut-off for TE <sub>10</sub> Mode (GHz)	Attenuation* Max/Min***	Peak Power In Megawatts* Max/Min***	Material Alloy	Dimensions		
							Inside Width Height Inches (mm)	Outside Width Height Inches (mm)	Wall Thickness Inches (mm)
1150	8	.64-.96	0.513	.113	87.1	Al	11.500 (292.10)	11.750 (298.45)	0.125 (3.18)
				.076	61.5		5.750 (146.05)	6.000 (152.40)	
1500	6	.49-.75	0.393	.076	148	Al	15.000 (381.00)	15.250 (387.35)	0.125 (3.18)
				.051	104		7.500 (190.50)	7.750 (196.85)	

**WR1150**



Att.  $\approx$  0.05 dB per 20 meters  
(negligible)

preferable, because ...  
more compact, lighter  
and cheaper.

**WR1500**



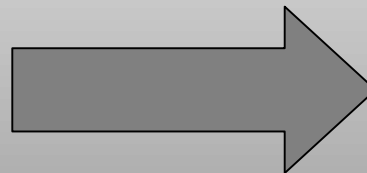
Att.  $\approx$  0.034 dB per 20 meters  
(negligible)

- ... these accessories are standard devices, widely used at 500 MHz and designing at 650 MHz does not require special R&D

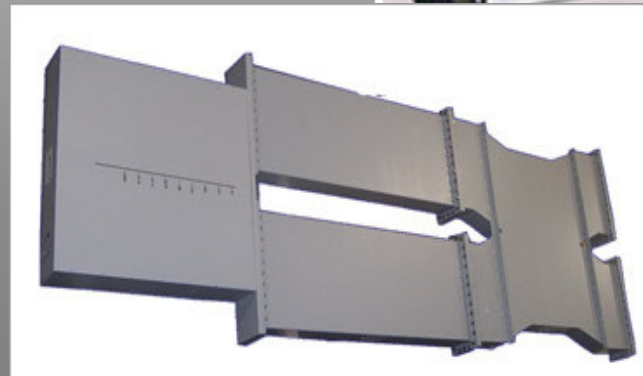
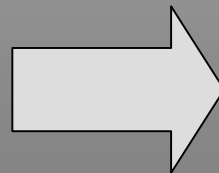
■ *Directional Couplers*



■ *Magic Tees or Hybrids*



■ *Phase shifters*





## ■ Ferrite Circulator

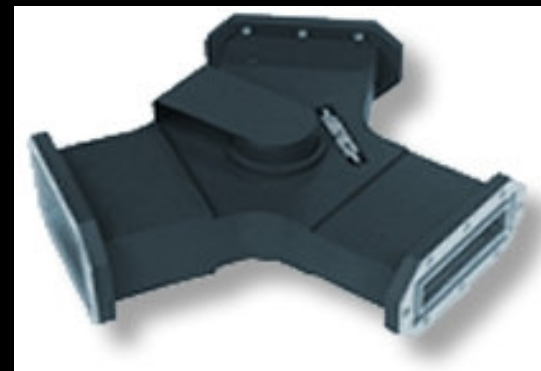
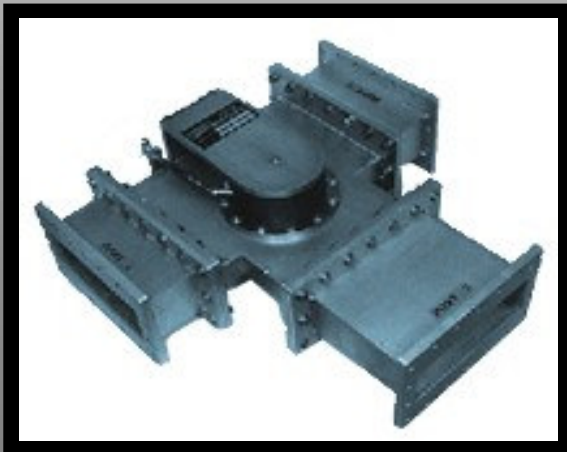
*It's a non-reciprocal device used to protect high power sources against the power reflected back by standing-wave (SW) resonators or any unmatched load.*

■ *The ILC-DR cavities will be SW structures and the klystron protection is therefore mandatory.*

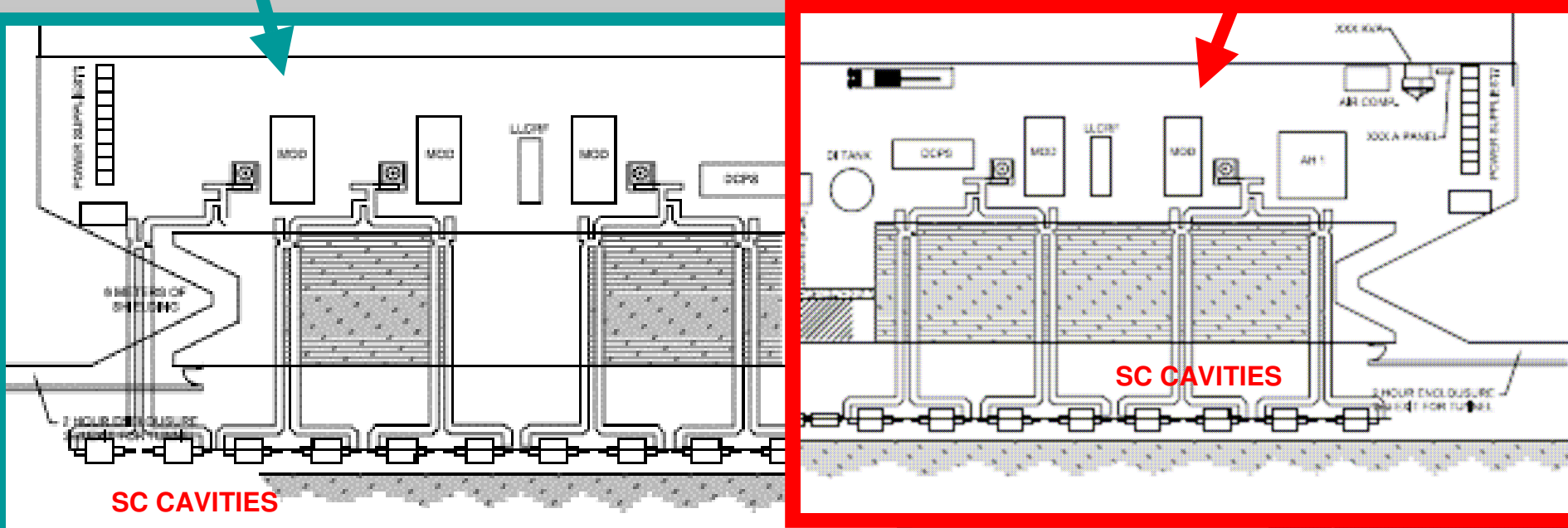
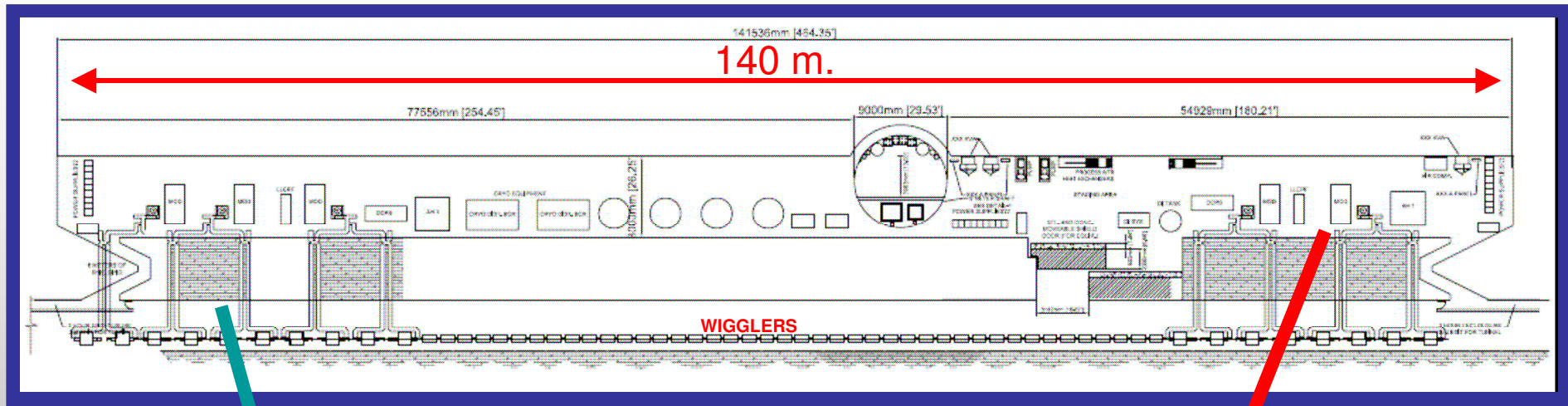
■ *The ILC-DR RF system needs 10 circulators the cost of which is < 2 % of the total RF system cost*

■ *European and US companies already manufacture high CW power 500 MHz circulators. The development of 650 MHz devices would not be a problem.*

Examples  
of 3-port 500 MHz Ferrite Circulators  
produced by the industry



# DRAFT D.R. ALCOVE ...



## ■ LIST OF RF SYSTEM R&D ACTIVITIES

- *Design of the 650 MHz RF cavities:  
dimensions and HOM frequencies*
- *Develop conceptual and engineering design for the cryo-modules*
- *Design of a new power coupler*
- *Design of a new HOM damping system*

*...or ...*

- *Contracting the full Cryo-module to private companies*  
*(ACCEL .... supplied 500 MHz cryo-modules to Cornell, CLS, Diamond ...)*  
*(Mitsubishi .... supplied 508 MHz cryo-modules to KEKB ...)*

*.... and ....*

- *High power test at ... Cornell, or KEK or .....*

## ■ SUMMARY

- *The RF system of the ILC -DR is made up of equipment and devices of well proven technology at an adjacent frequency.*
- *The cost estimate for the RDR has been based on existing 500 MHz system.*
- *For the EDR available resources are not sufficient for engineering design of the 650 MHz system but we are confident that scaling cryo-modules and klystrons to 650 MHz shouldn't be a problem.*