

# The Beauty of an ERL for LHeC

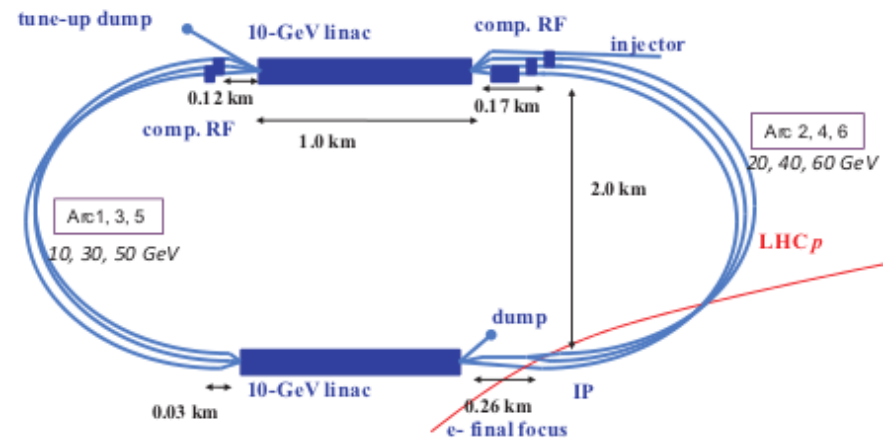
## ...and the interest to collaborate

Erk Jensen, Ed. Ciapala  
(with lots of material provided by Rama Calaga,  
Joachim Tückmantel and many others)

ASTeC/Cockcroft visit, 5 Sept 2012

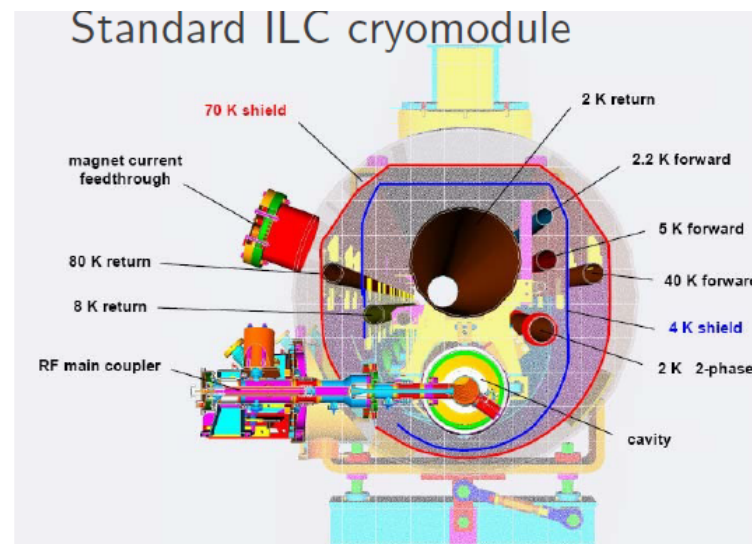
# The Beauty of the ERL

- e-beam power at IP: 384 MW (!)
- Total power consumption: 80 MW!
- “Efficiency” of 480%

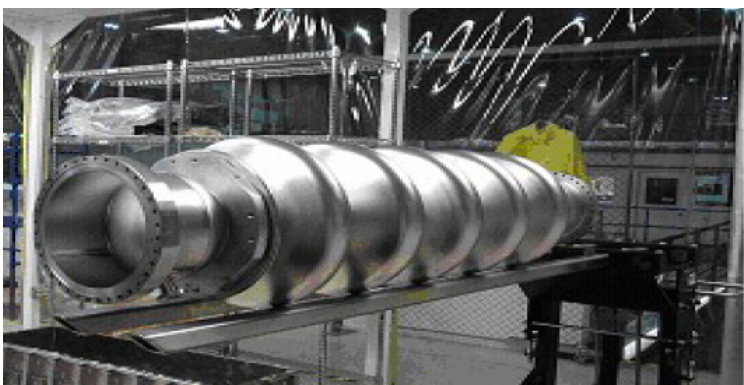


# LHeC ERL $f$ Options Condition: $n * 120.237$ MHz

1.322 GHz ( $n=11$ )

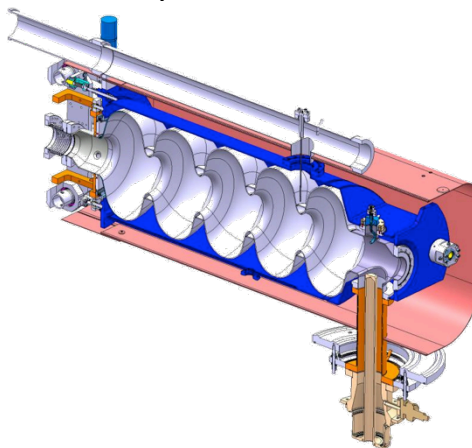


721 MHz ( $n=6$ )

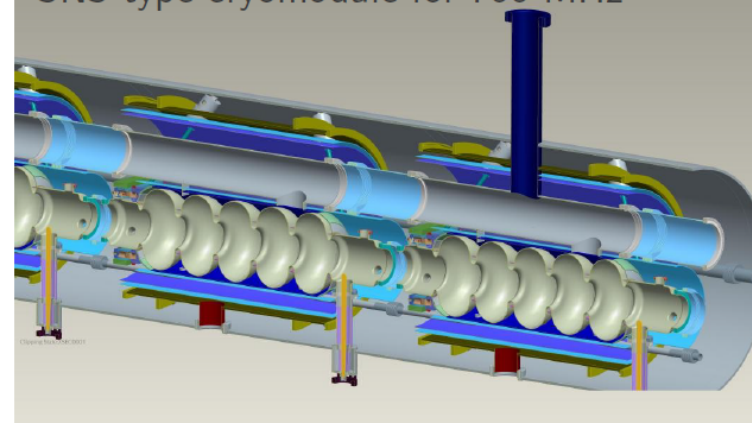


BNL 704 MHz cavity (20 MV/m with high  $Q_0$  demonstrated)

SPL cryomodule 704 MHz



SNS type cryomodule for 700 MHz



# Which frequency?

## Advantages 700 MHz

- Synergy SPL, ESS, JLAB, eRHIC
- Smaller BCS resistance
- Less trapped modes
- Smaller HOM power
- Beam stability
- Smaller cryo power
- Power couplers easier
- IOT and SSPA available/easier

## Advantages 1300 MHz

- Synergy ILC, X-FEL
- Cavity smaller
- Larger  $R/Q$
- Smaller RF power (assuming same  $Q_{\text{ext}}$ )
- Less Nb material needed

Personal preference: 700 MHz (stability threshold at higher beam current)!

# Low Energy ERL's/Test Facilities

IHEP ERL-TF	HZB BERLinPro	BINP	Peking FEL	BNL ERL-TF	KEK cERL	Daresbury ALICE	JAERI	CERN ERL-TF
35 MeV	100 MeV	11-40 MeV	30 MeV	20 MeV	245 MeV	10 MeV	17 MeV	300 MeV
1.3 GHz 9 cell	1.3 GHz	180 MHz	1.3 GHz 9-cell	704 MHz 5-cell	1.3 GHz 9-cell	1.3 GHz 9-cell	500 MHz	721 MHz 2x4x5 cell
10 mA	100 mA	30 mA	50 mA	50-500 mA	10-100 mA	13 $\mu$ A	5-40 mA	2-6 mA
60 pC	10-77 pC	0.9-2.2 nC	60 pC	0.5-5 nC	77 pC	80 pC	400 pC	500 pC
1 pass	1-2 pass	4 passes	1 pass	1 pass	2 passes	1 pass	1 pass	2 passes
under construction	planned / construction	operating		under construction	under construction	operating	operating	first ideas

# Interesting, challenging R&D

- ERL: (almost) no beam loading in steady state, so potentially small RF power.
- R&D for highest possible  $Q_0$ !
  - Technology? Thin film? Ingot?
- R&D: How large  $Q_{ext}$  do you dare?
- R&D: How to get to steady state?
- influence of bunch amplitude jitter, phase jitter?
- Compensation of SR radiation loss ...
- failure modes
- ...
- ...

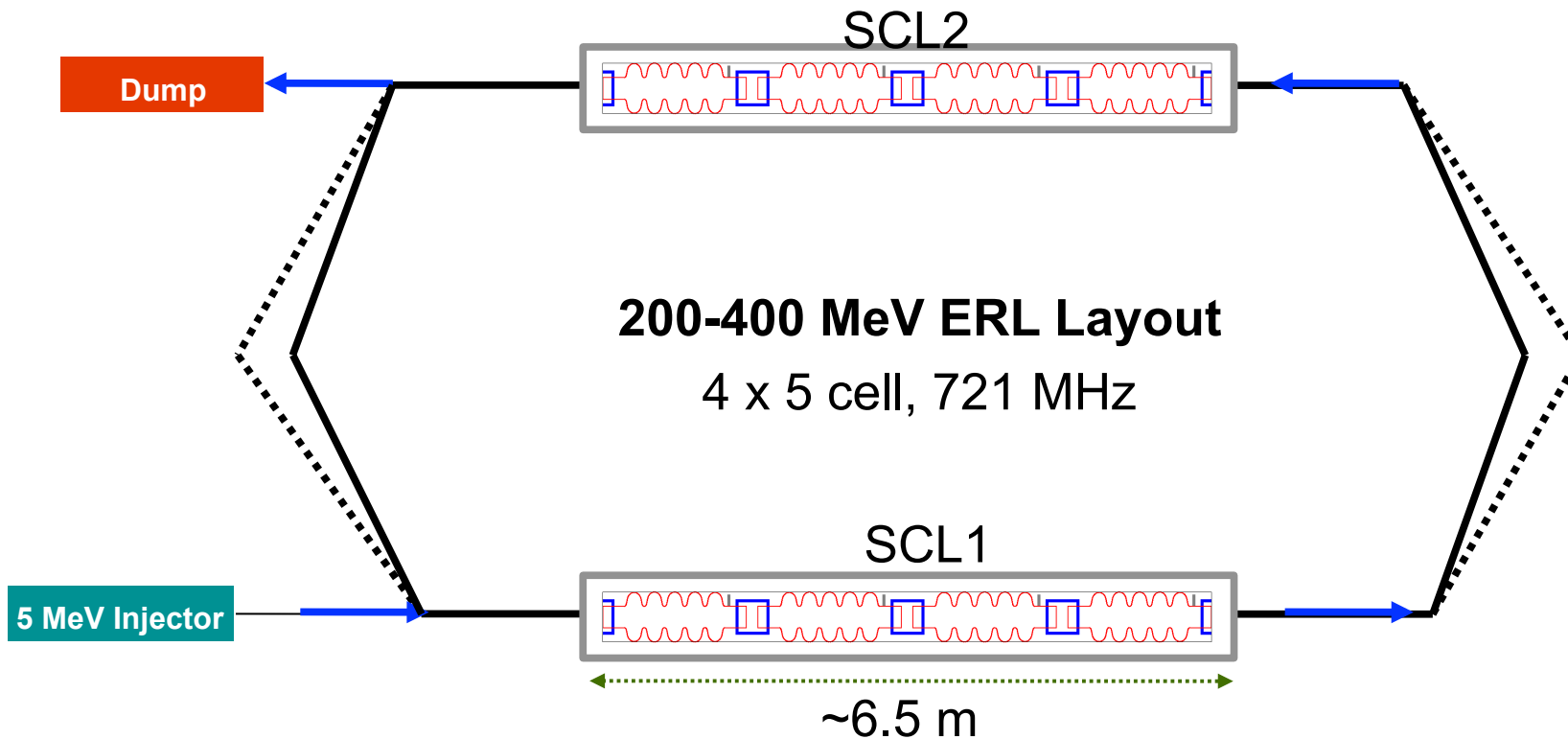
# An ERL Test facility @ CERN...

**... could help answer some of these questions!**

**But also:**

- Physics motivation:
  - ERL demonstration, FEL,  $\gamma$ -ray source, e-cooling demo!
  - Ultra-short electron bunches
- One of the 1<sup>st</sup> low-frequency, multi-pass SC-ERL
  - synergy with SPL/ESS and BNL activities
- High energies (200 ... 400 MeV) & CW
- Multi-cavity cryomodule layout – validation and gymnastics
- Two-Linac layout (similar to LHeC)
- MW class power coupler tests in non-ER mode
- Complete HOM characterization and instability studies!
- Cryogenics & instrumentation test bed
  
- **... for CERN RF Group to re-establish practical expertise in SC-RF, train new people and get ready for the future.**

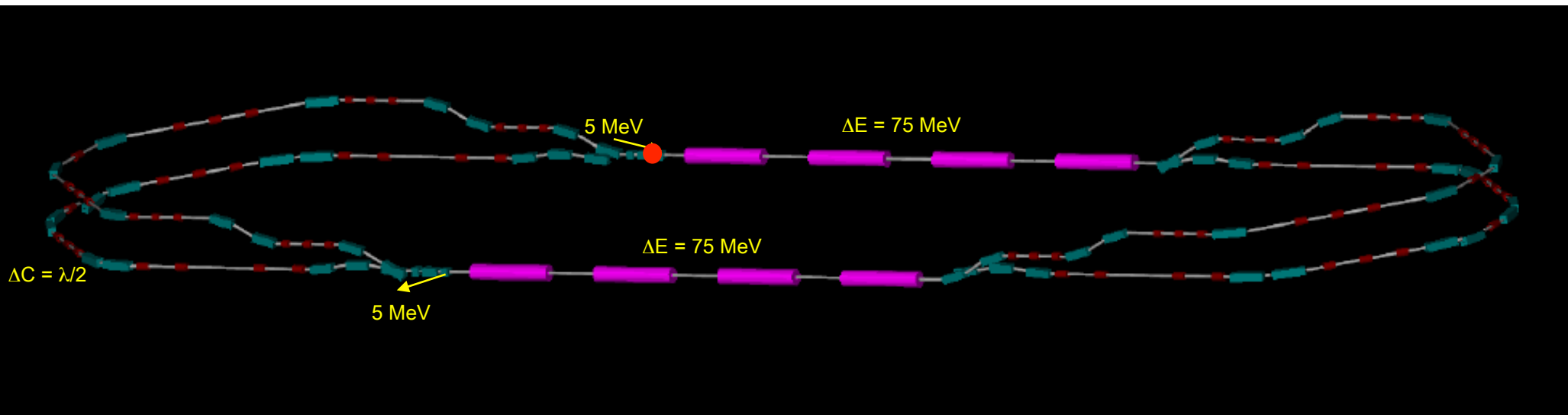
# ERL-TF @ CERN



	units	1-CM	2-CM
Energy	[MeV]	75 ... 100	200 ... 400
Frequency	[MHz]	721.4	721.4
Charge	[pC]	~500	~500
Rep rate		CW	CW

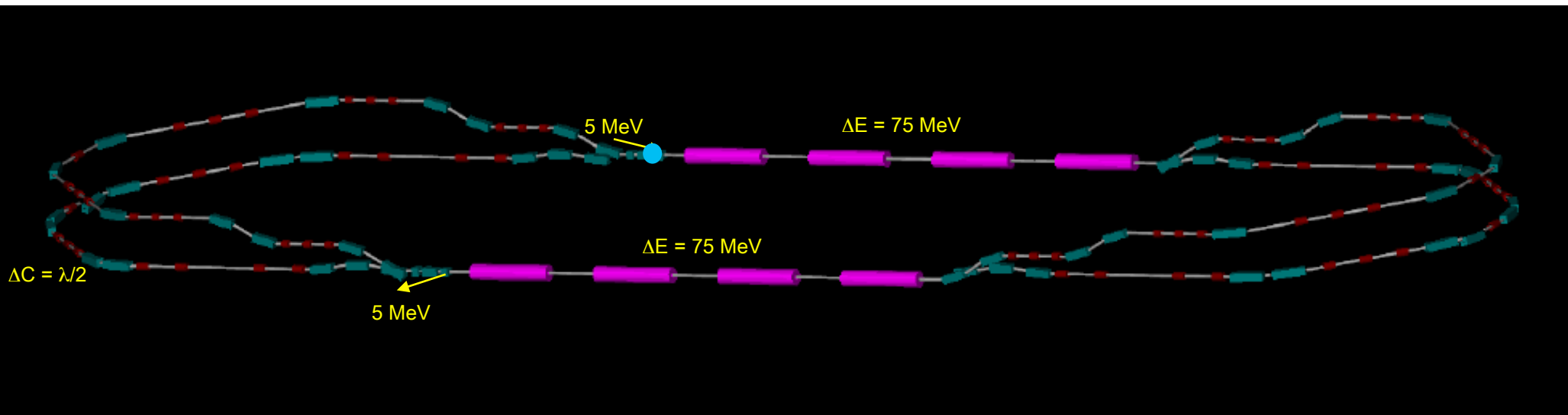


# ERL-TF (300 MeV) – Layout



Two passes 'up' + Two passes 'down'

# ERL-TF (300 MeV) – Layout



Two passes 'up' + Two passes 'down'