CERN ERL Test Facility

Erk Jensen for the LHeC team and the CERN RF group

LHeC Workshop (20-21 January 2014)

20-January-2014

MOTIVATION: ERL BASED E⁻ LINAC FOR LHEC

LHeC CDR published: arxiv.org/abs/1206.2913

Goal: Collide LHC proton beam with e^- or e^+ for DIS.

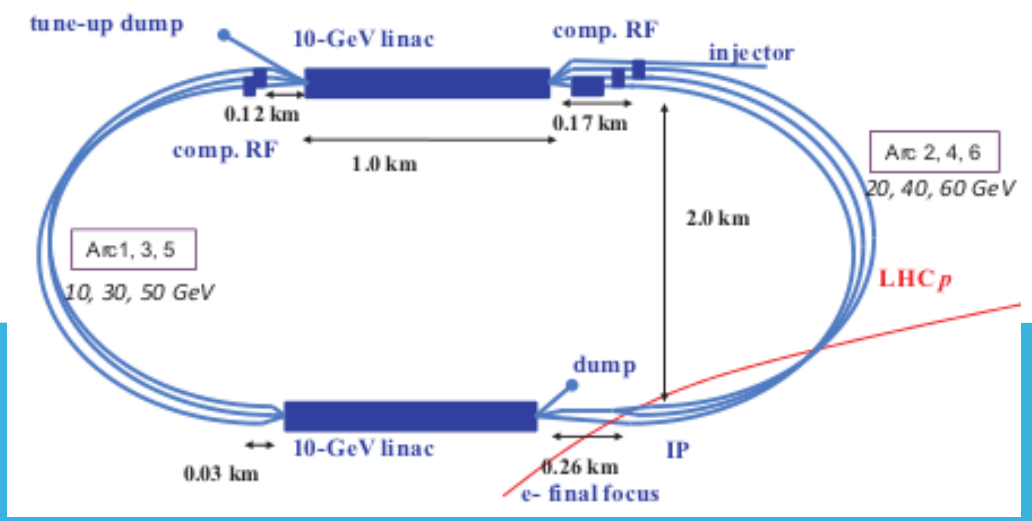
Power consumption ≤ 100 MW!

60 GeV ERL with two 10 GeV Linacs

Frequency choice:

$f = 801.58$ MHz

Same as SPS and LHC harmonic systems!



SOME REFERENCES

This is a relatively recent proposal at an early stage; here some references documenting the birth of the idea:

Chamonix, 9 Feb 2012: “SC Cavities R&D for LHeC and HE-LHC”
https://indico.cern.ch/materialDisplay.py?contribId=67&materialId=slides&confId=164089

15 June 2012, LHeC Workshop Chavannes: “ERL & Frequency Choice”
http://indico.cern.ch/materialDisplay.py?contribId=51&materialId=slides&confId=183282

22 Jan 2013, Meeting at Daresbury
https://eventbooking.stfc.ac.uk/news-events/lhec-meeting?agenda=1

12 March 2013, LHeC meeting: “Choice of RF Frequency”
http://indico.cern.ch/materialDisplay.py?contribId=0&materialId=slides&confId=240837

09 Sept 2013, ERL-2013 Novosibirsk: “A proposed ERL Test facility at CERN”
http://ssrc.inp.nsk.su/Conf/ERL2013/Presentations/WG604_talk.pdf

GOALS OF A CERN ERL TEST FACILITY

Study behaviour of a high energy multi-pass multiple cavity ERL for LHeC

- Optics, beam dynamics, RF power, couplers, synchronization & delay issues …
- HOMs & HOM couplers, cryogenics, instrumentation, controls, LLRF …
- Cryogenics and instrumentation test bed

Injector studies DC gun (JLAB, KEK ?) or SRF gun (FZ Rossendorf ?, BNL ?)

Study real SCRF cavities with beam (not interfering with HEP)

Study reliability issues, operational issues!

Could it be foreseen as the injector to LHeC ERL ?

Beam facility for controlled SC magnet quench tests!

Beam facility for HEP detector R&D

Possible a low-energy physics facility

Demonstrator and study facility for e-cooling (parameters?)

FEL?, γ-ray source? …

STRONG INTEREST BY ELI-NP

ELI-NP is the M€ 293 pillar for nuclear physics of the European Extreme Light Infrastructure presently under construction at Magurele, near Bucharest, Romania.

It is a major laser facility, including a 700 MeV electron linac for production of intense, energy-tuneable, quasi-monochromatic, polarized gamma-ray beams, i.e., a femtometer light source with as narrow band width as technically feasible.

http://www.eli-np.ro/

Interest formulated by Norbert Pietralla, IKP Darmstadt

With a ERL TF @ CERN, one could produce significantly (orders of magnitude) larger gamma-flux in very narrow bandwidth (CW operation)

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FEL?, γ-ray source? …

A real, practical, non-trivial facility not interfering with LHC to train new staff!

Fostering collaboration (UMainz, JLAB, BNL, Cornell, ASTeC, DESY, IHEP …)!

Ref.: https://cds.cern.ch/record/1519112 & https://cds.cern.ch/record/1595213

WHERE DO WE STAND TODAY?

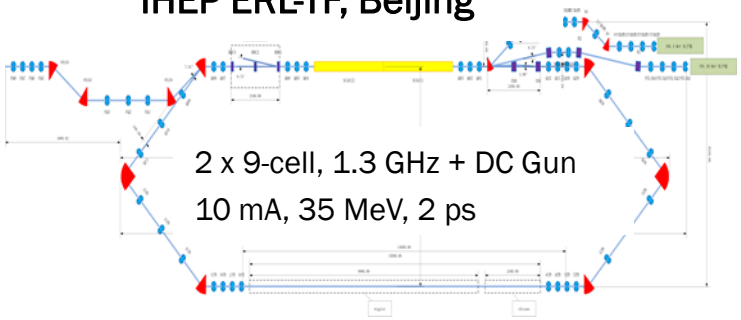
We have received the mandate by CERN management to perform a conceptual design study of an ERL-TF at CERN. This design study includes fabrication and tests of prototype cryostats and cavities (high Q_0; time line: Design → end 2014, CM's → end 2016).

Design work has started (ref.: other talks in this session), allocation of resources not yet finalized, but 3 fellows at CERN.

We have agreed collaboration with Mainz (Aulenbacher). A Framework Collaboration Agreement is being finalized. Less formal collaboration with ASTeC, The Cockcroft Institute, BNL and JLAB exist.

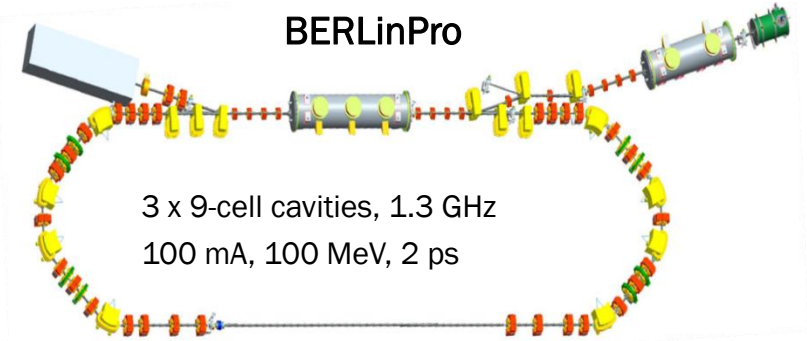
SIMILAR, BUT DIFFERENT: SOME LOW ENERGY ERL'S/TEST FACILITIES

IHEP ERL-TF, Beijing



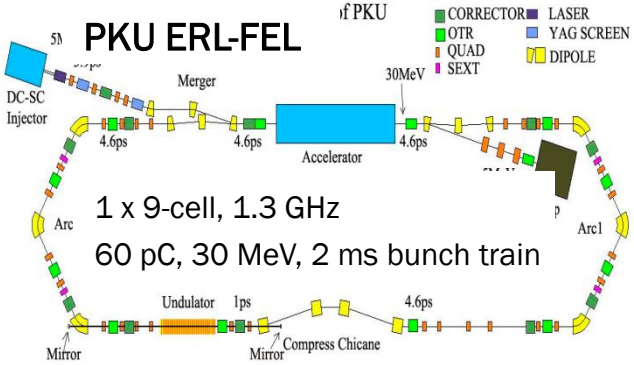
2 x 9-cell, 1.3 GHz + DC Gun
10 mA, 35 MeV, 2 ps

BERLinPro



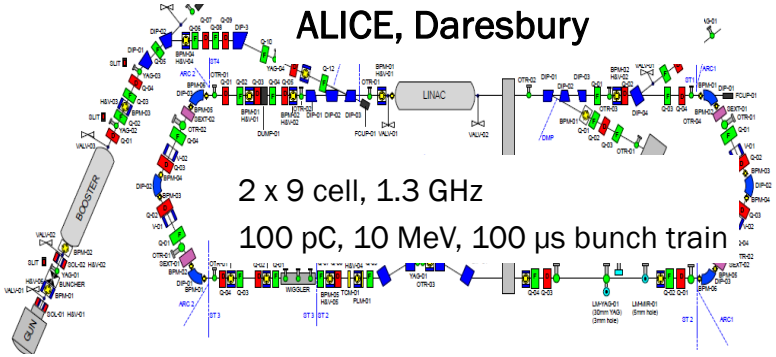
3 x 9-cell cavities, 1.3 GHz
100 mA, 100 MeV, 2 ps

PKU ERL-FEL



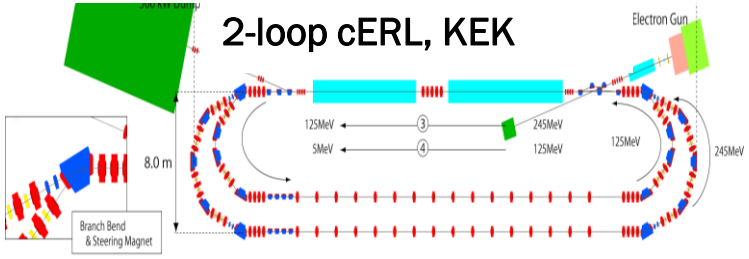
1 x 9-cell, 1.3 GHz
60 pC, 30 MeV, 2 ms bunch train

ALICE, Daresbury



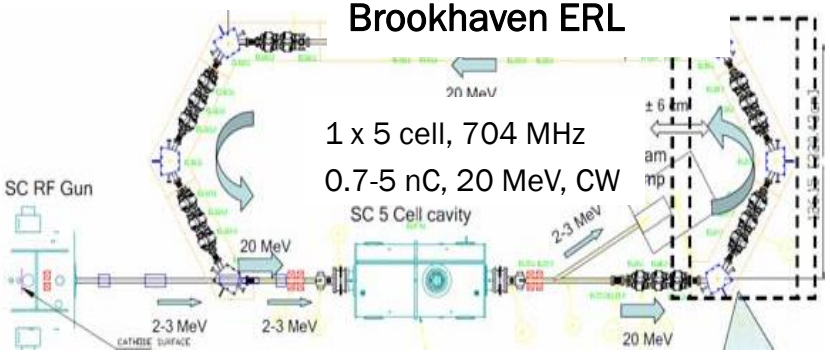
2 x 9 cell, 1.3 GHz
100 pC, 10 MeV, 100 μs bunch train

2-loop cERL, KEK



9 cell, 1.3 GHz cavities, 4 modules
77 pC, 245 MeV, 1-3 ps

Brookhaven ERL

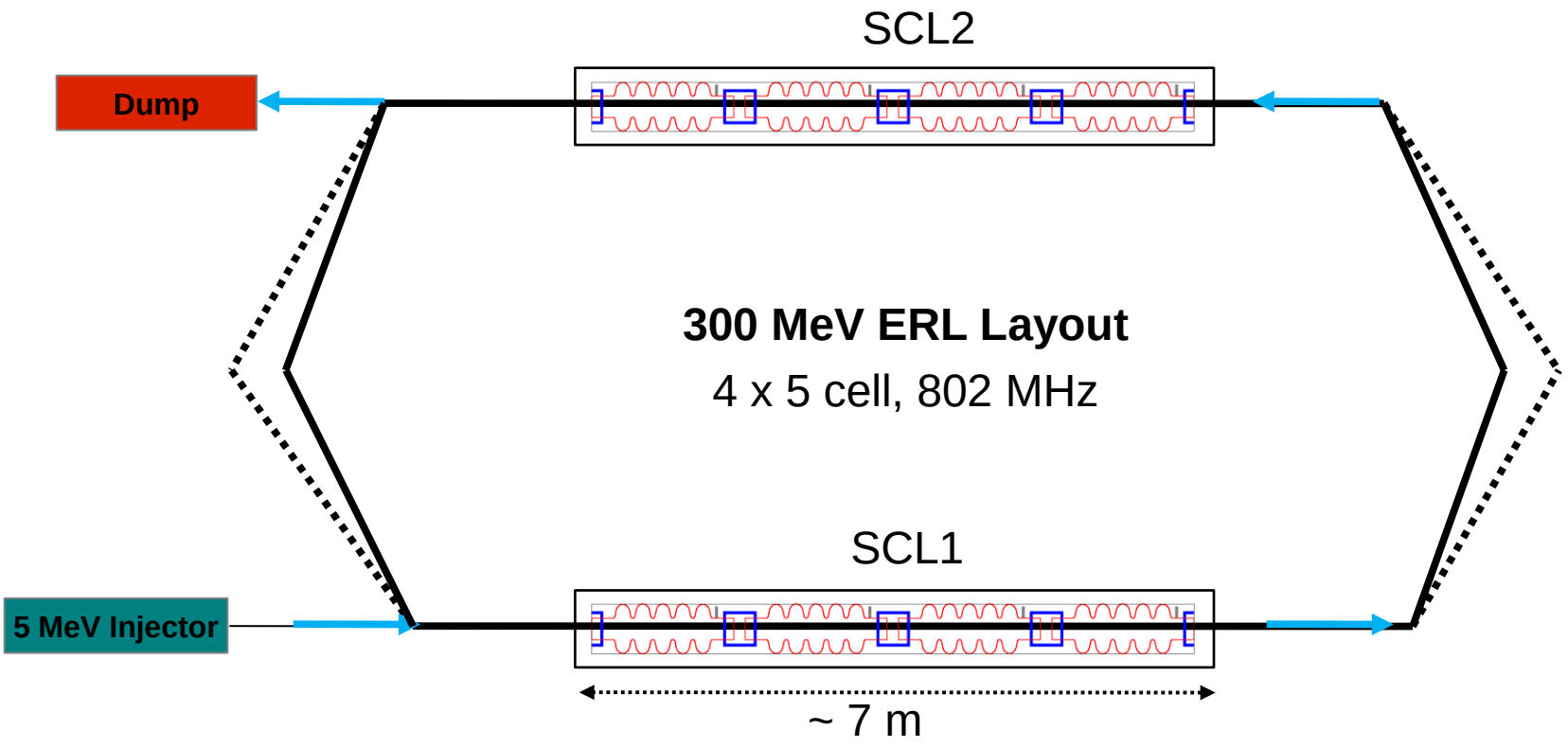


1 x 5 cell, 704 MHz
0.7-5 nC, 20 MeV, CW

PRELIMINARY PARAMETERS OF CERN ERL-TF

Parameter	Value
Injection energy	$5\ MeV$
# of passes	$2\ (3)$
Energy gain per pass	$2 \cdot 75\ MeV\ (2 \cdot 150\ MeV\ )$
Max energy	$300\ MeV\ (450\ MeV\ \ldots 900\ MeV)$
Operation frequency	$801.58\ MHz$
RF power/CM	$< 50\ kW$
# cells/cavity · cavities/CM · CMs	$5\ \cdot\ 4\ \cdot 2\ (4)$
Bunch charge	$2 \cdot 10^9\ e = 320\ pC$
Beam current	$4 \cdot \frac{320\ pC}{25\ ns} \approx 50\ mA\ (100\ mA)$
Duty factor	CW

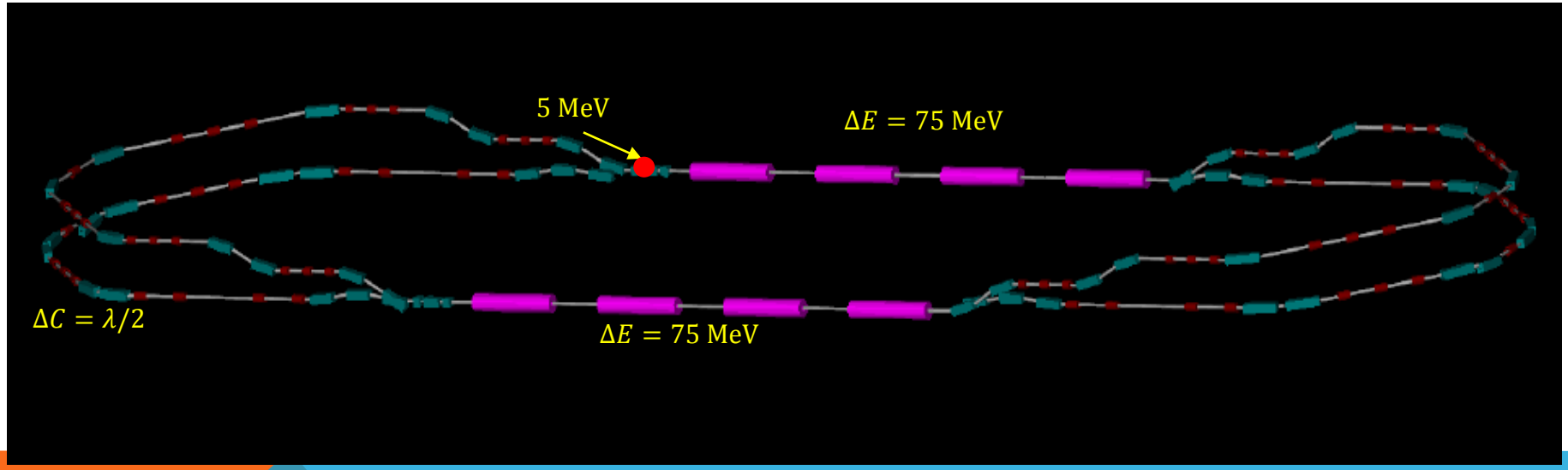
A POSSIBLE LAYOUT



ERL-TF 300 MEV – INITIAL LAYOUT

Alex Bogacz (JLAB)

2 passes up:



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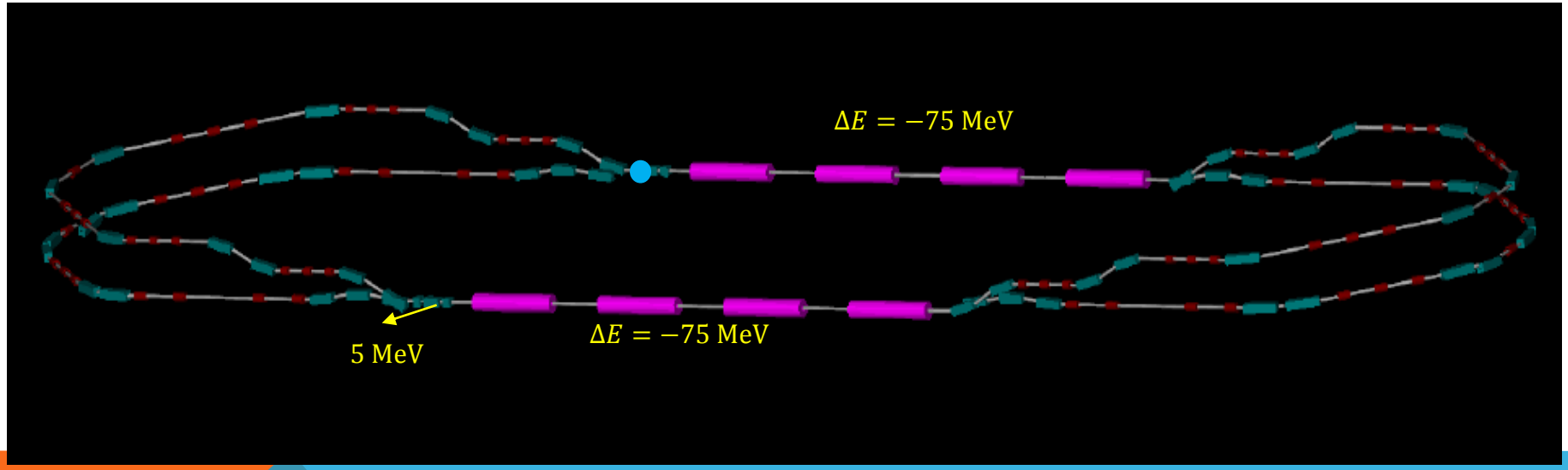
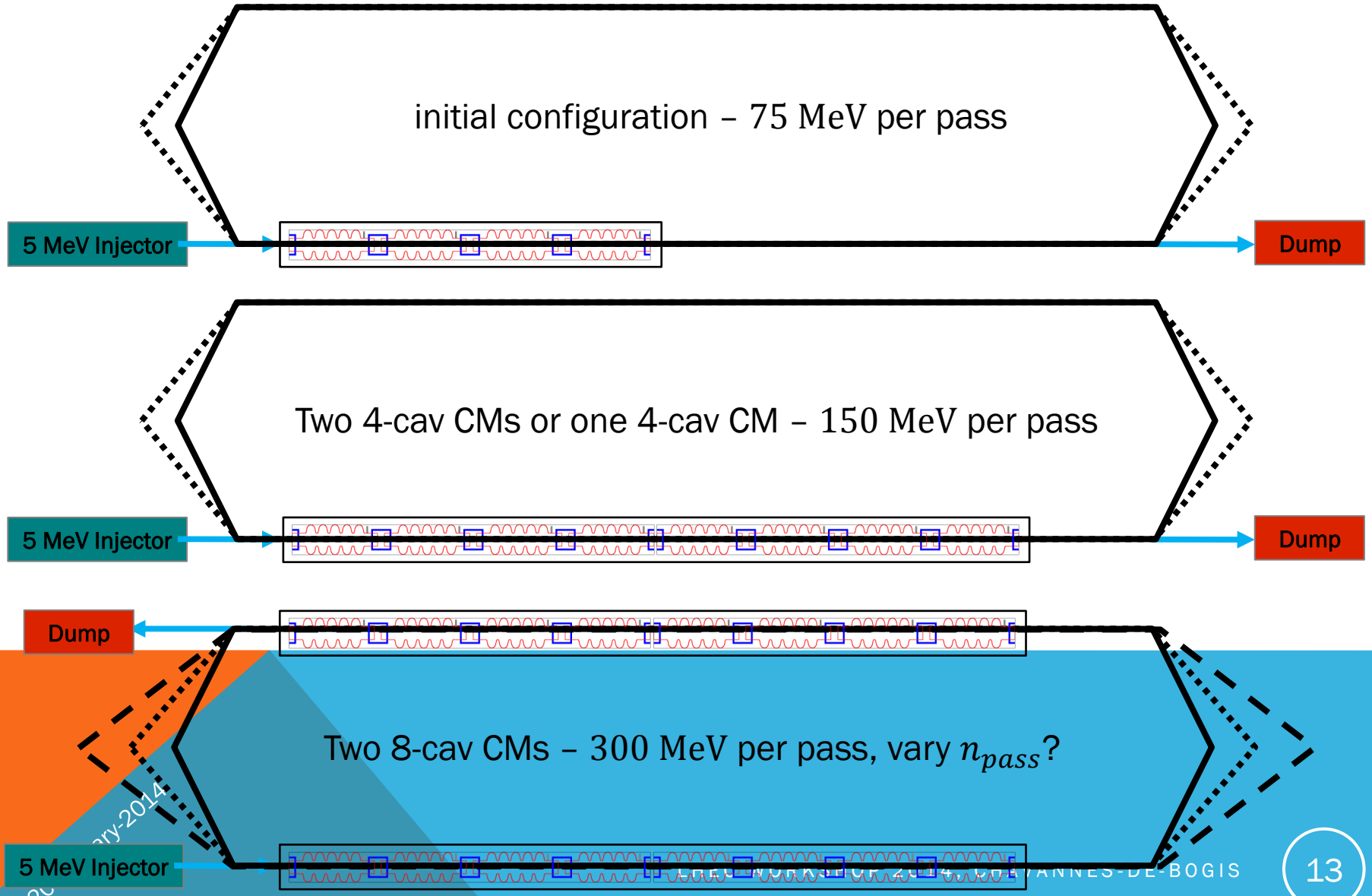


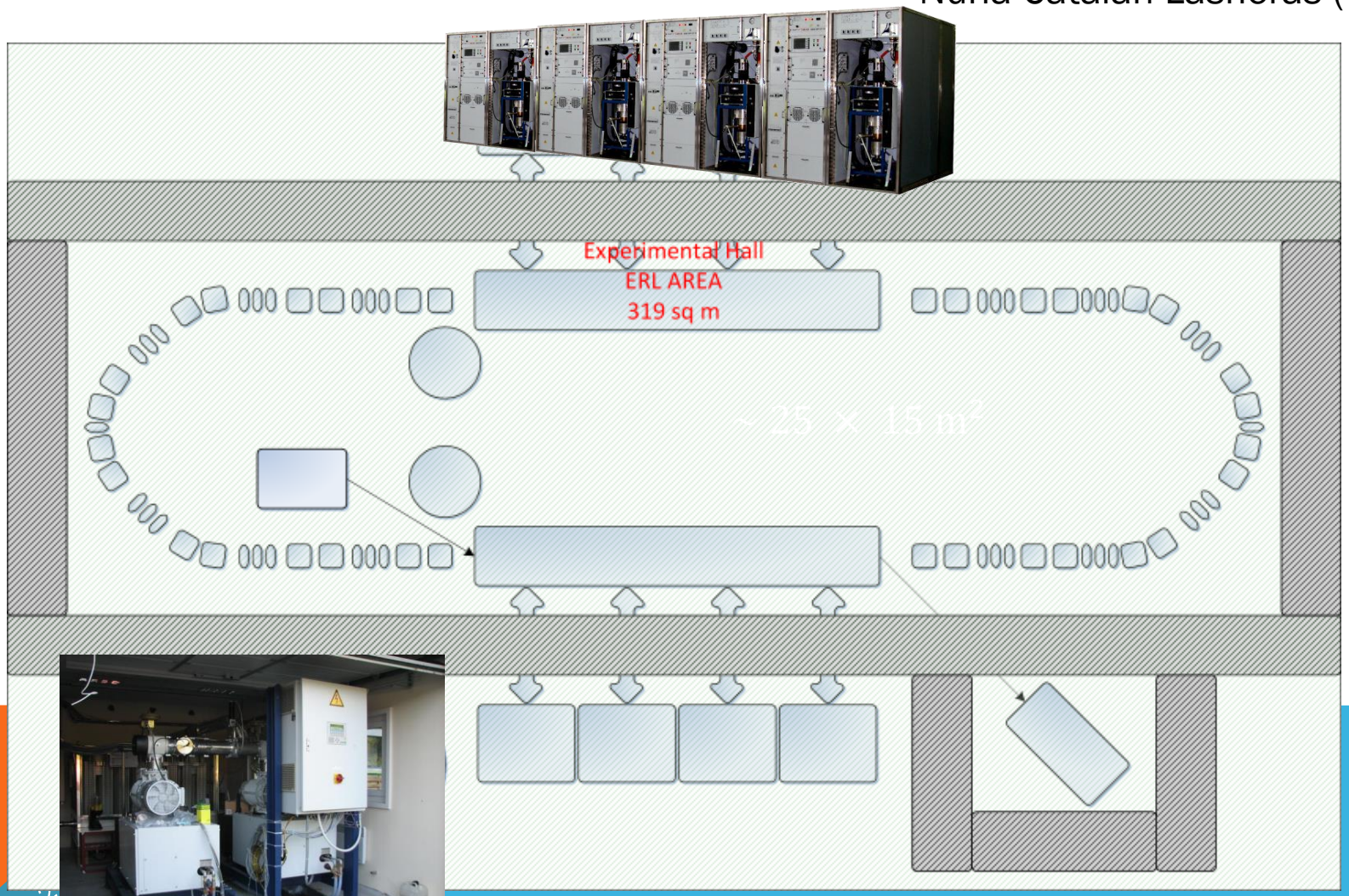
VARIATIONS – BUILT-IN FLEXIBILITY

Alessandra Valloni (CERN)



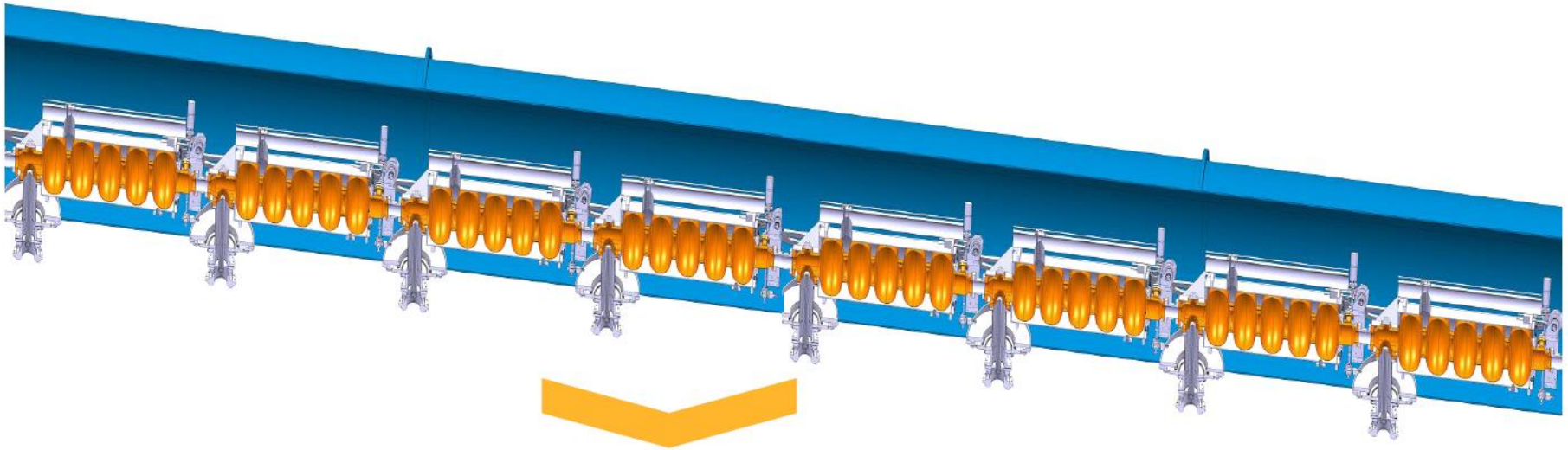
LOOKING AT EXPERIMENTAL HALLS @ CERN

Nuria Catalan Lasheras (CERN)



801.59 MHZ 8-CAVITY CM?

Alessandra Valloni (CERN)

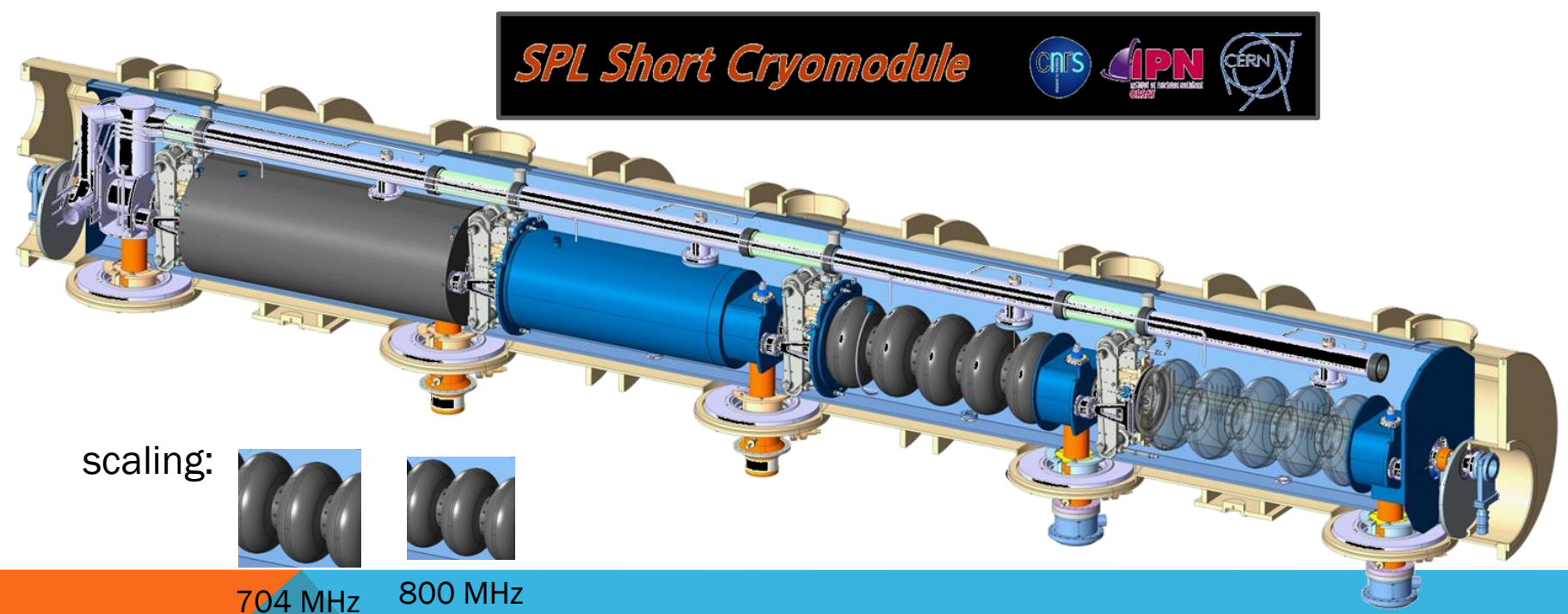


ONE CRYOMODULE: 8 RF CAVITIES

Parameter	Value
Input energy	5 MeV
ΔE	149.7 MeV
Energy after 1st pass	154.7 MeV
Energy after 2nd pass	304 MeV
Total length CM	12.6 m

RELEVANT ONGOING WORK AT CERN: SPL (704 MHZ) CM

Vittorio Parma (CERN)



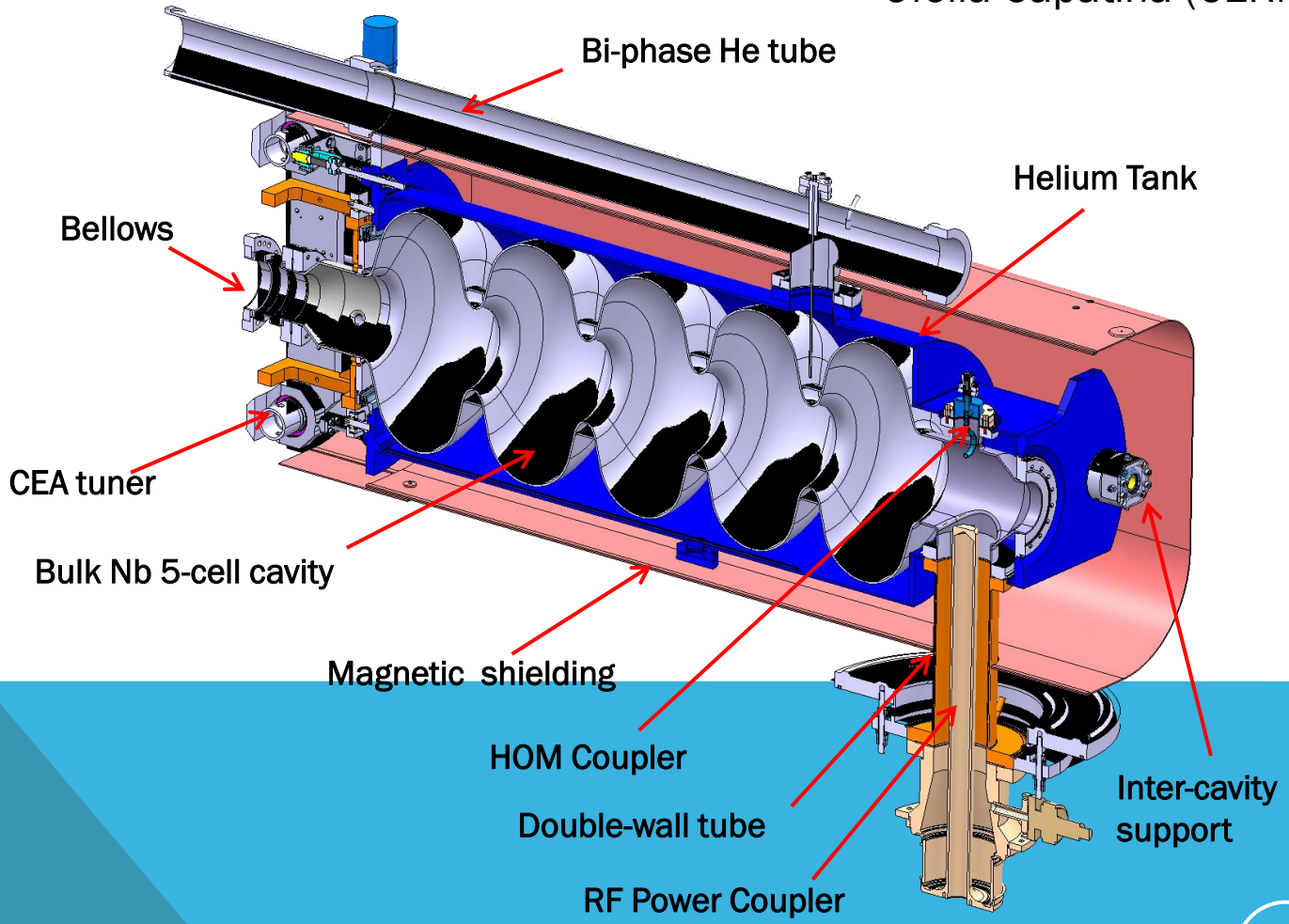
scaling:

704 MHz

800 MHz

SPL CM DESIGN

Ofelia Capatina (CERN)



SPL CAVITIES

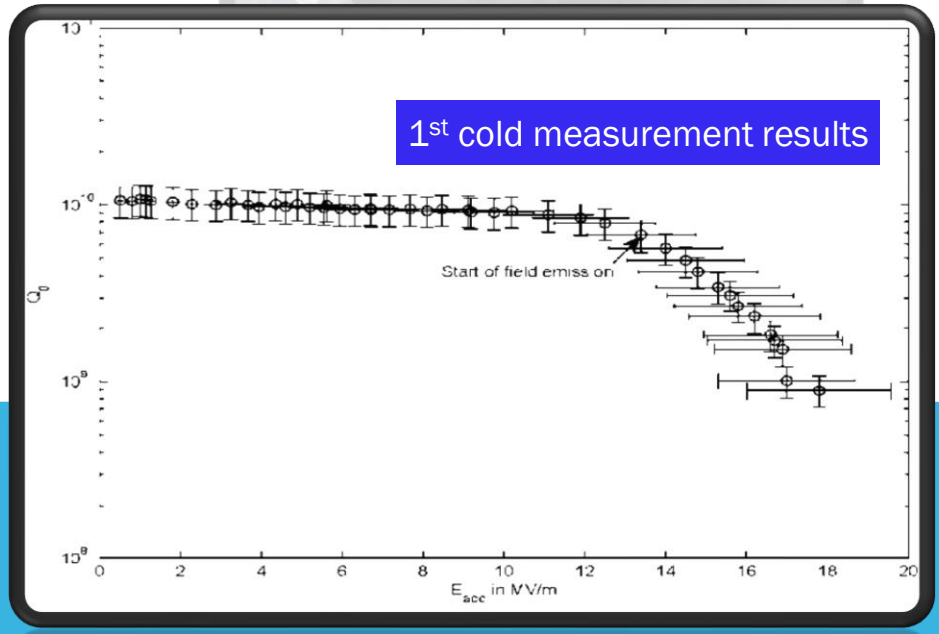
1st industrially produced cavity received Aug/12 from RI.

Treated, rinsed & tested at CERN, 1st results encouraging (very preliminary).

First of five 5-cell cavities in production,

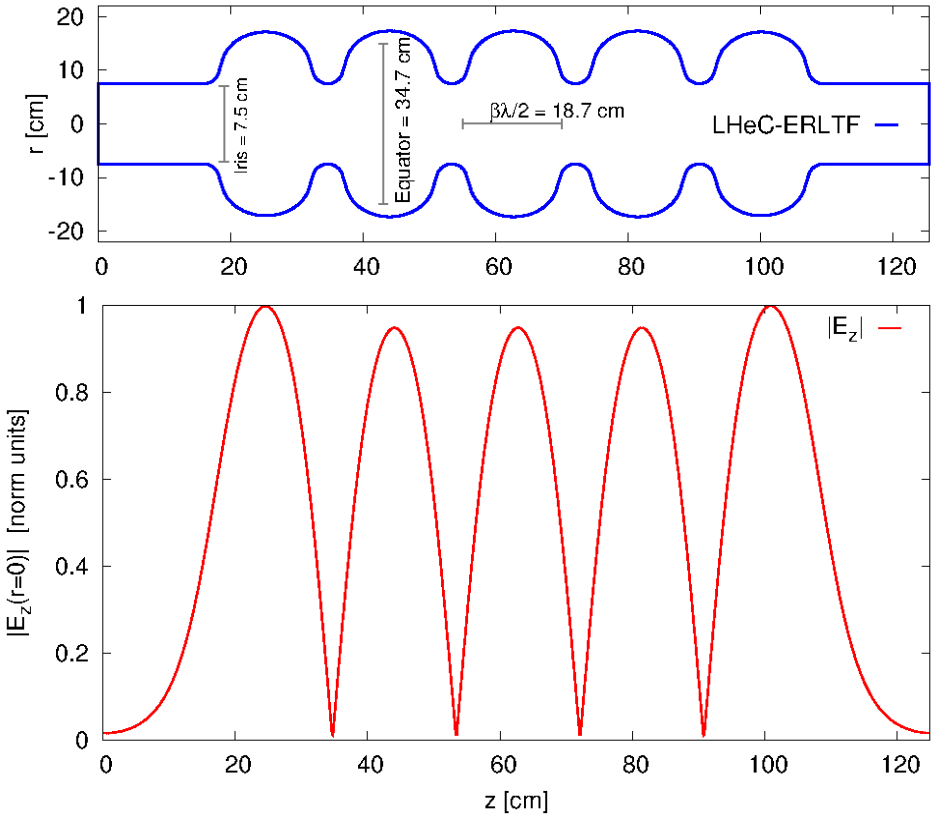
SM18 upgrade advancing well

Clean room assembly ongoing



1ST STEP TOWARDS A DEDICATED 802 MHZ DESIGN

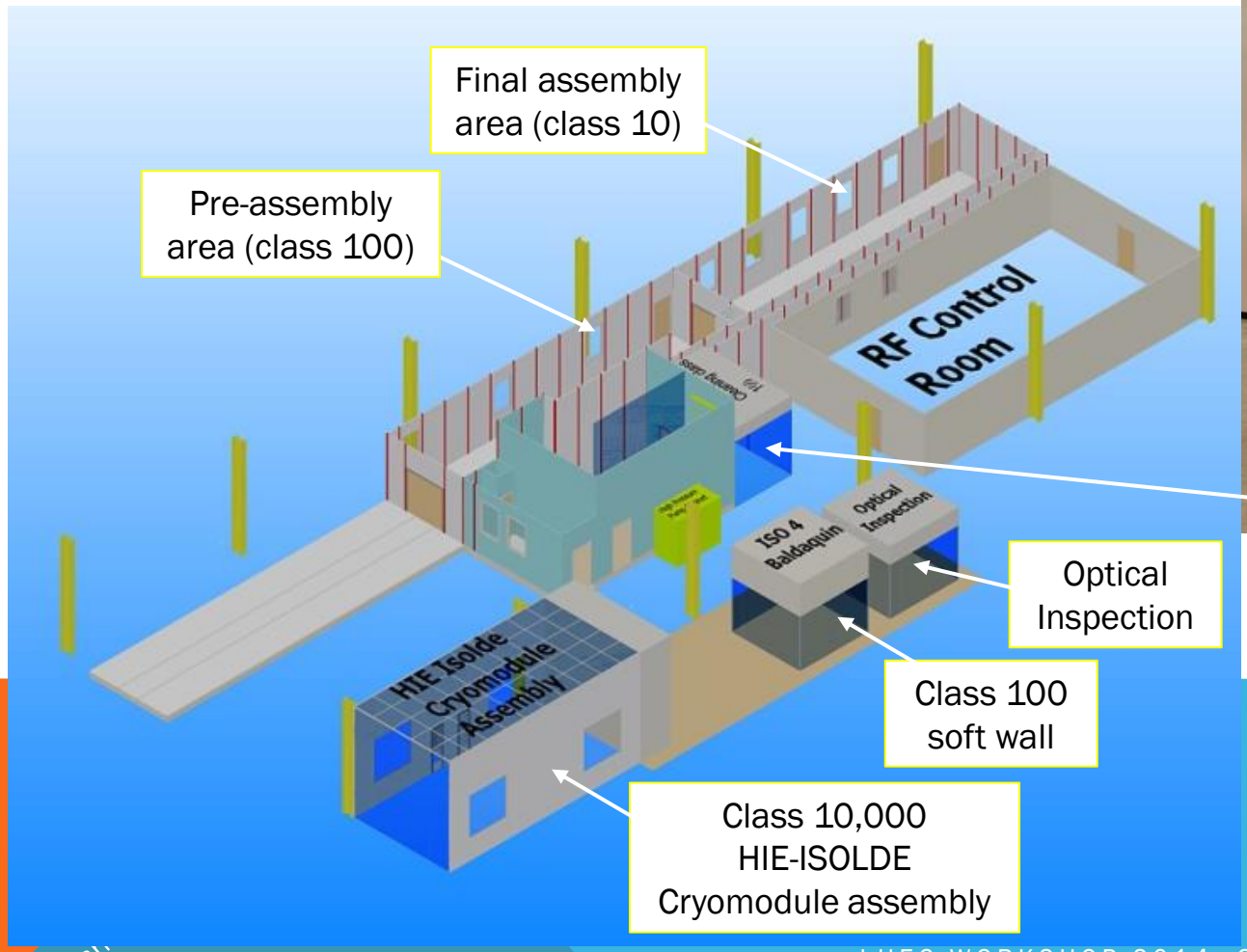
f	801.58 MHz
W_{stored}	131 J
E_{acc}	18 MV/m
$G\ (Q_0/R_{surf})$	276 Ω
E_{pk}	41 MV/m
B_{pk}	86 mT
R/Q	462 Ω
P_{diss}@2 K	< 28 W
P_{HOM}@40 mA	200 W



Rama Calaga (CERN)

SM18 CLEANROOM UPGRADE

Karl Schirm, Janic Chambrillon (CERN)



HPR Cabinet (BNL-SPEC)

SM18 UPGRADE

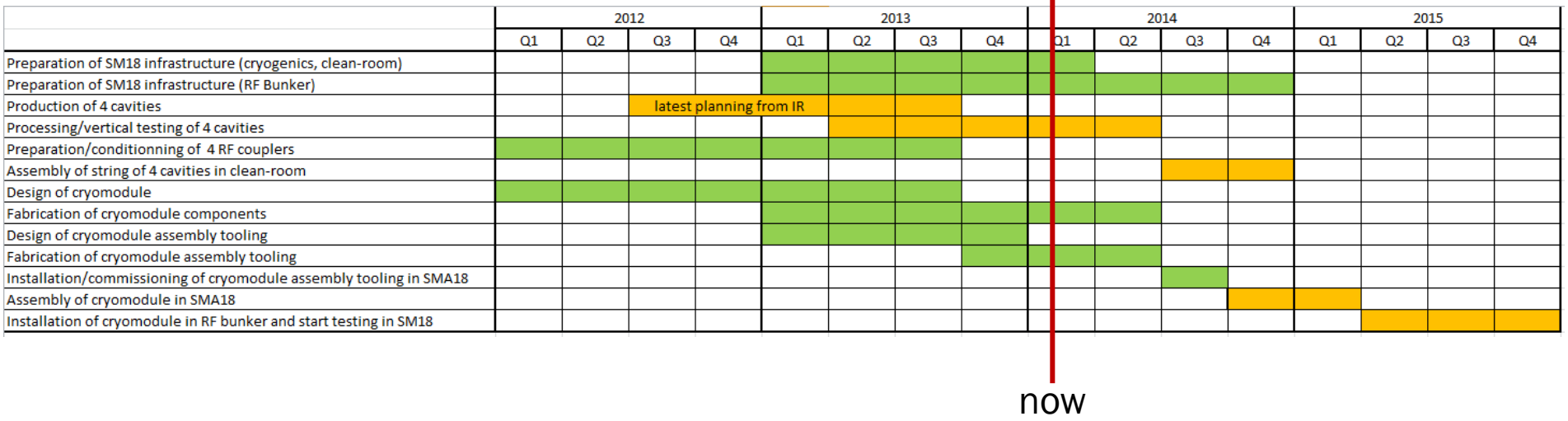
Karl Schirm, Janic Chambrillon (CERN)

New HP Rinsing Cabinet

Commissioning: 02.2014

SPL TIME-LINE (VERSION IV/13)

Karl Schirm (CERN)



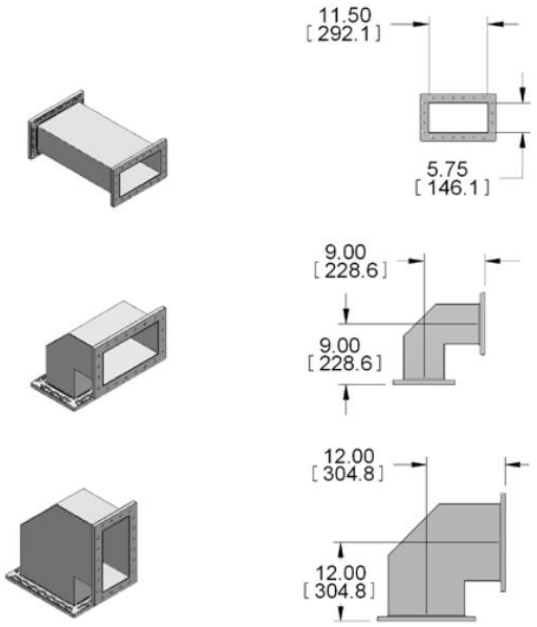
SPS 801 MHZ SYSTEM RENOVATION

Eric Montesinos (CERN)

CERN is upgrading the old SPS 801 MHz system (“Landau” cavities)

New CERN 801 MHz, 60 kW CW IOT TX
8 units received & tested, 1 more to come

Thales trolley with IOT,
60 kW CW @ 801 MHz,
BW-1dB > 6 MHz



Standard WR1150 waveguide components

CONCLUSIONS

ERLs – a fascinating concept, modern and energy efficient! CERN cannot ignore!

As a 1st step to embark on ERL's, we propose an ambitious yet feasible ERL TF @ CERN.

This facility is complementary to & synergetic with other proposals – it would complement our facilities to build, assemble and test SC RF cavities and CMs.

A Design Study of the ERL-TF has started – collaboration agreements with JLAB and JG|U are in preparation.

We invite other interested potential partners to participate!

Thank you very much