PERLE summary session:

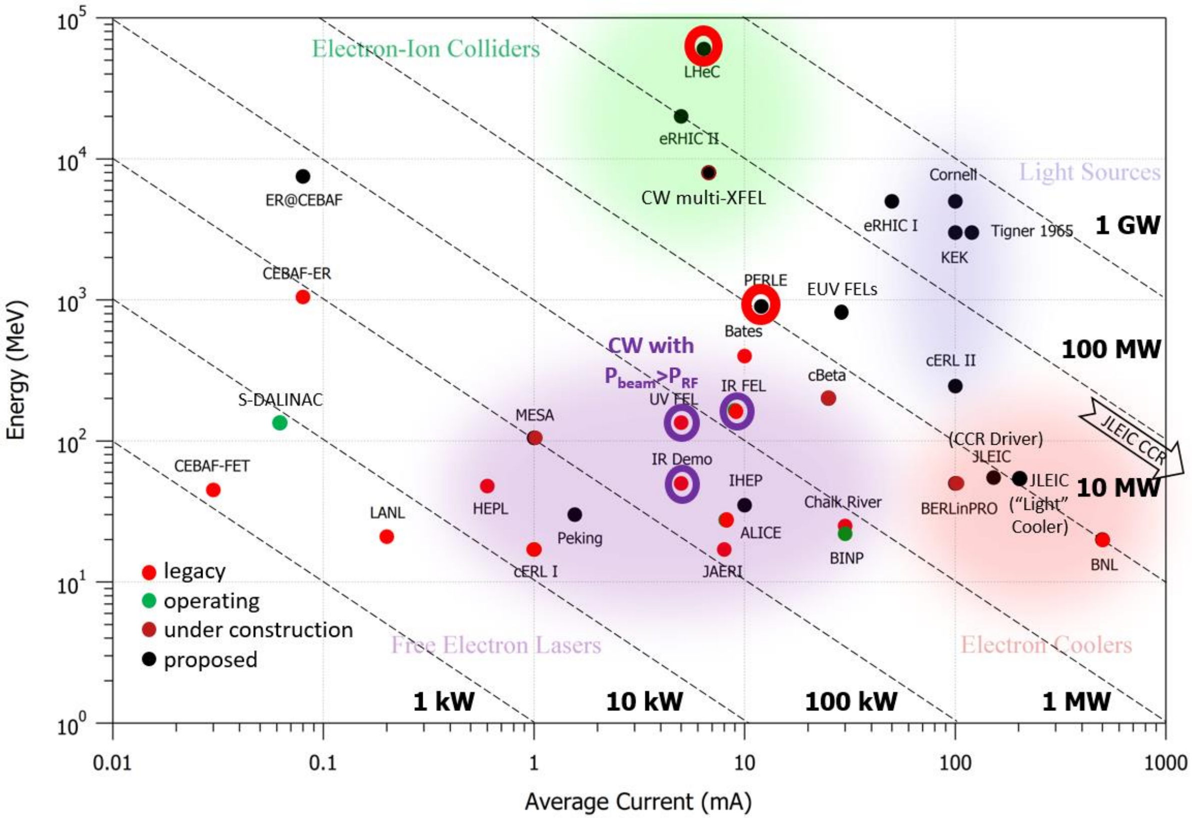
Walid Kaabi-LAL/CNRS

PERLE

Why PERLE as an ERL demonstaror?

By Peter Williams

ERL Landscape: Current State of the Art



➔Currently Only 1 operating SRF ERL!!!

➔Current only demonstrated 1MW beam power in single ERL turn

➔Only 3 ERLs had demonstration of operation with $P_{beam} > P_{RF}$!!!

PERLE ➔ multi-turn; high current ERL with $P_{beam} > P_{RF}$

➔ need for coordinated simulation studies

Possibility of operation of the ALICE gun upgrade with average current of 20 mA

- Design and physical parameters of the ALICE gun upgrade allows for operation with Sb and GaAs based photocathodes and delivery average current of 20 mA with required bunch charge and emittance
- Current status of the gun
  - Original ALICE gun and its power supply have been decommissioned, disassembled and placed into temporary storage
  - ALICE laser system is decommissioned
  - Some components of the upgrade option are manufactured and in stock
  - GaAs photocathode infrastructure commissioned and is ready for operation at initial stage
- For gun operation at initial stage with reduced average current is necessary:
  - Physical optimisation and design of the electrode system for operation with 500 pC bunches
  - Mechanical design and procurement of the electrode system and photocathode exchange mechanism including revision of photocathode cooling possibility
  - Manufacturing of missing gun upgrade components
  - Design of the photocathode transport system for alkali photocathodes
  - Design of the laser system for operation with unpolarised beam
  - Revision of the existing focusing solenoids and gun-to-booster components on the basis of beam dynamics simulation
- High level managerial decision is required to go ahead with delivery of the PERLE injector

Design of the PERLE injector

By Benjamin Hounsell

- The PERLE injector comprises of a 350 kV DC photoemission electron gun based on a modified ALICE upgrade gun, two focusing solenoid and a 802 MHz normal conducting buncher between them, booster linac consisting of 5 individually fed and controllable 802 MHz single cell cavities followed by a merger.
- A multi-objective genetic algorithm optimisation has been performed from the gun up to the exit of the booster.
- At the moment realistic RF designs of the buncher cavity and booster cryomodule are not available. The current simulation has a scaled approximation for the buncher and estimates of positions of booster cavities within the cryomodule.
- Further refinements of the optimisation are needed to improve the phase spaces and bunch distributions and reduce the uncorrelated energy spread.
- A detailed study of possible merger options will be performed.

Parameters after the booster but prior to the merger		
Parameters	Goal	Achieved
Injection energy	7 MeV	6.99 MeV
Bunch charge	500 pC	500 pC
Transverse emittance	< 6 π mm mrad	5.6 π mm mrad
Max RMS beam size		5.7 mm
Longitudinal emittance		64.7 π keV mm
RMS bunch length	3 mm	2.7 mm
RMS energy spread		25.7 keV
Uncorrelated energy spread	10 keV	

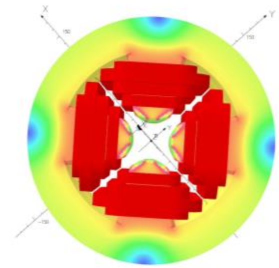
PERLE MAGNET STATUS

By Cynthia Vallerand

Arc region : Simulation results with OPERA3D fulfill requirements for quadrupoles and long arc bending magnet.

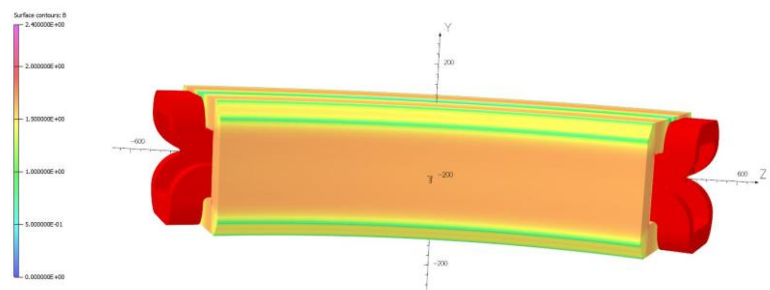
⇒ **Quadrupole** : Design done

- Diameter = 250 mm
- Gap = 40 mm
- Gradient = 32.55 T/m > 30 T/m
- By (z=0) @ 20mm = 0.583 T
- Gradient homogeneity = $7\ 10^{-5}$ @ 20 mm < 5.10^{-4}



⇒ **Long radius bending magnet** : Design done

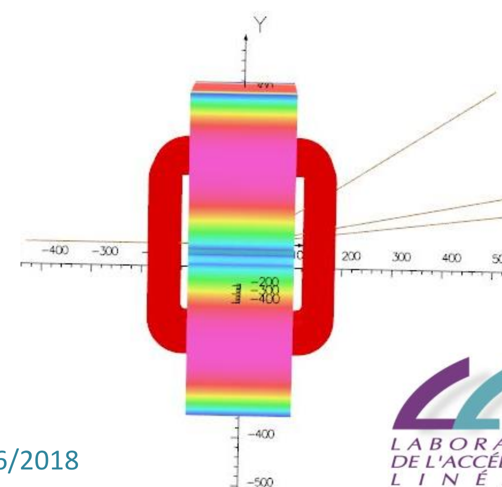
- Same structure for 3 higher energies
- H-magnet design with bedstead coils
- Radius of curvature = 1192 mm
- Deviation angle = 45°
- $j = 5.5\ A/mm^2$
- Max magnetic field homogeneity @ 20 mm = $1.4\ 10^{-4} < 5\ 10^{-4}$



Spreader/Combiner region :

⇒ **Splitter** : Feasibility done

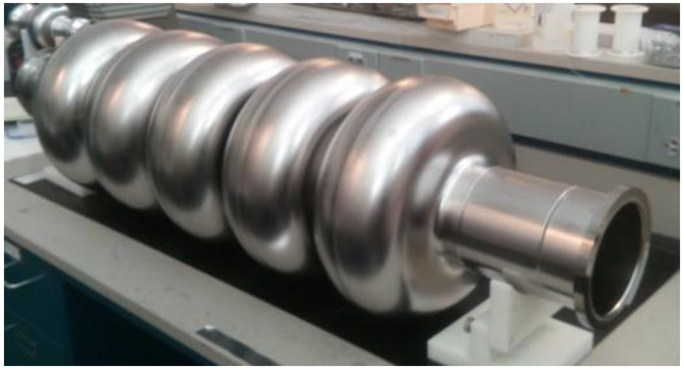
- Deviation angle = 41° for 80MeV and y = 35 cm @ z = 40 cm
- Deviation angle = 14° for 230 MeV and y = 20.4 cm @ z = 80 cm
- Deviation angle = 9° for 380 MeV and y = 7.6 cm @ z = 50 cm

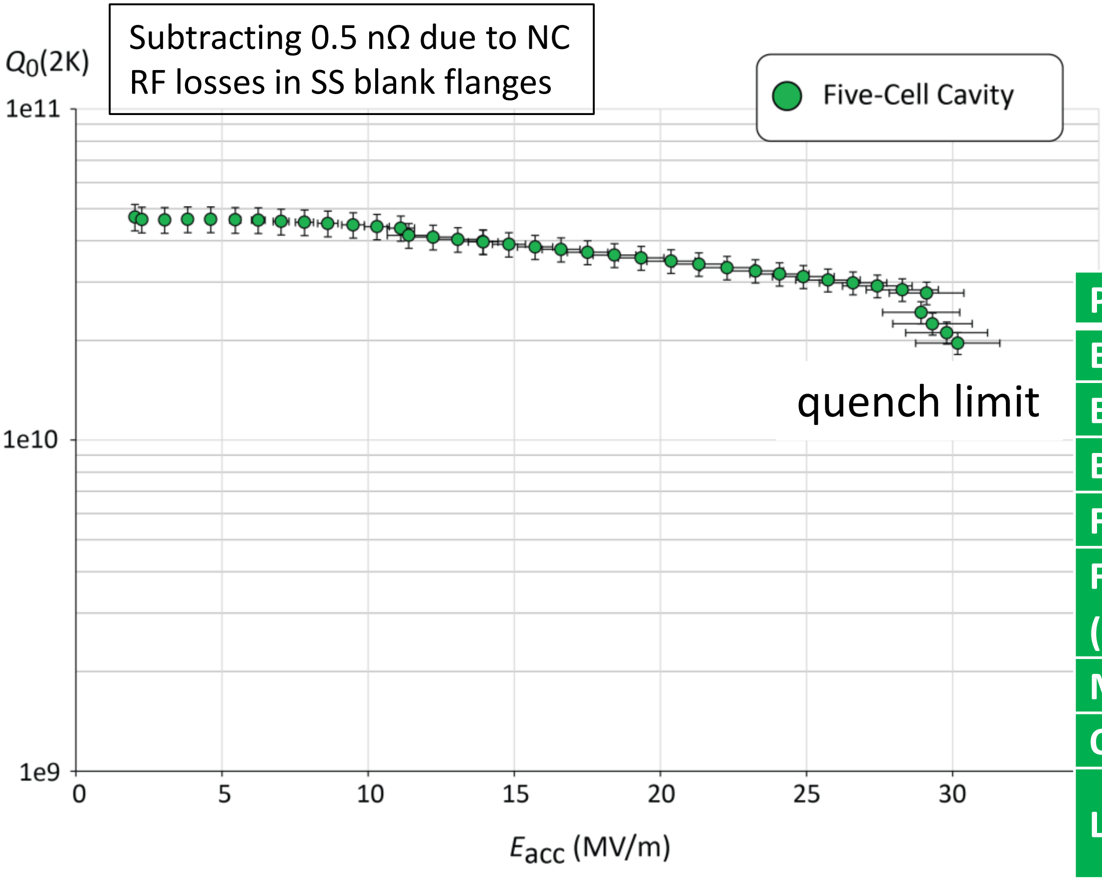


Recent Results on a Multi-Cell 802 MHz bulk Nb Cavity

By Alex Bogacz

Frank Marhauser/JLAB





Tabulated Results

Parameter	Unit	*CRN5*
E_{acc} at quench	MV/m	30.1
E_{pk} at quench	MV/m	68.1
B_{pk} at quench	mT	126.3
FE onset field	MV/m	~25
FE-induced radiation (max.)	mR/hr.	0.06
Max. Q_0-value	/1e10	4.72
Q_0-value at 25 MV/m	/1e10	3.12
Lorentz Force Detuning	$Hz/(MV/m)^2$	-1.5

Development and Study of HOM coupler for the SRF ERL

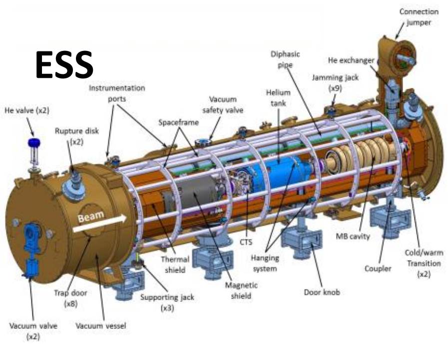
By Shahmam Gorgi Zadeh

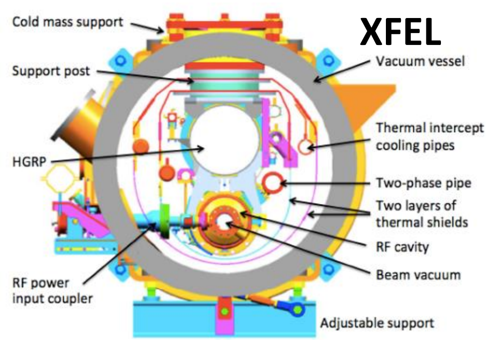
- An optimization method was used to optimize the mid-cells for minimal losses with constraints on the different figures of merit of an elliptical cavity.
- The end-cell was designed to maintain field-flatness in the cavity and also to allow sufficient HOM damping without significantly changing E_{pk}/E_{acc} and B_{pk}/E_{acc} of the cavity.
- The HOM power of PERLE operation is in the order of ten Watt.
- Waveguide couplers were compared with coaxial HOM couplers. Multiple waveguides is an overkill and not practical. However, a single waveguide for high frequency modes with targeted coaxial dampers for low frequency HOMs looks very promising as we approach higher current with high HOM power .
- A catalogue containing the mode spectrum of the 4-cavity module is created that can serve as reference for beam dynamic analysis.

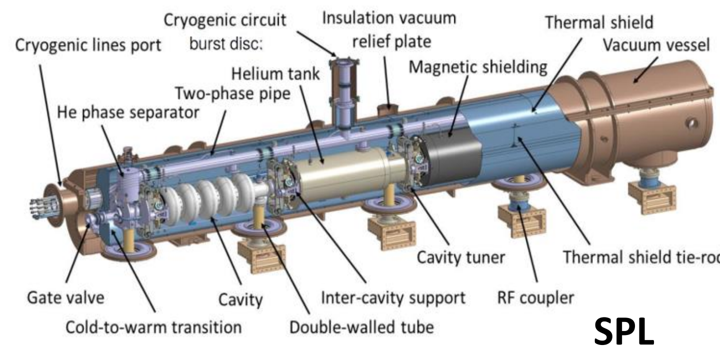
LHeC / Perle Cryomodules Challenges

By Sebastien Bousson

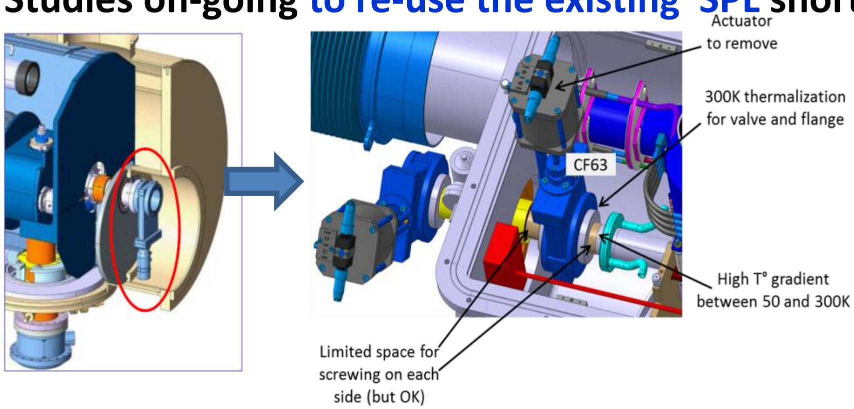
- **LHeC CDR: 2x60 cryomodules, 2x480 cavities (with Q_0 2.5 10^{10}) operated CW at 2 K** *(dynamic load dominated)* **=> 80 kW of cryogenic power @ 4.5 K is required (½ of the LHC cryogenic power !!!)**
  LHeC cryogenics is a large part of construction and operation costs !
- **Main concern for the cryomodule: to maintain as much as possible the cavity quality factor achieved in vertical cryostat** (tiny margin due to ambitious Q_0 spec.) **=> cryostat design should be driven by magnetic shielding and magnetic hygiene capabilities.**
- **3 cryostat topologies could be envisaged:**







Studies on-going to re-use the existing SPL short cryomodule to be the PERLE prototype:



- Vacuum vessel could be reused without refurbishing (thanks to similar geometries of SPL and PERLE cavities)
- Thermal and magnetic shields designed but not yet purchased. They can be modified.
- Major difficulty: interference between CTS and HOM dampers: the reuse of the cryomodule will depend on the number and the type of the HOM dampers

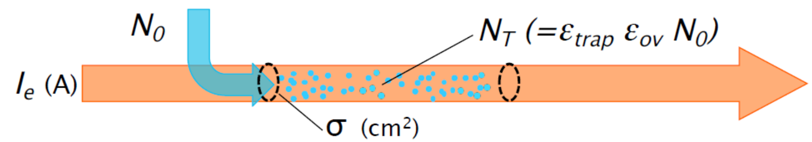
A "two stages" solution found to use an all metal valve

SCRIT (Self-Confining Radioactive Ion Target)@PERLE (@Orsay) ?

By David Verney

Chancé et al (CEA Saclay) ETIC project within GANIL-2025 (2015)
calculations within ERL hypothesis :
I_e=200 mA N_A=10^6 trapped ions: $\mathcal{L} \simeq 10^{29}$ should be achieved
based on
[A.N. Antonov et al., Nucl. Instr. and Meth. A **637** 60 (2011)] ELISE project GSI

Achievable luminosity



$$L \sim \frac{I_e/e \quad N_T}{\sigma} \ /(\text{cm}^2\text{s})$$

PERLE@Orsay : 20 mA $\rightarrow \mathcal{L} \simeq 10^{28}$ is *probably* achievable for a **10^6** trapped RI population **on the principle**

but the dynamical e-beam-RI coupling should be investigated : first time with a ERL time structure
e-beam instabilities ? impact on ERL operation ?

Production pps