WG3: Superconducting RF and RF Control

M. Dykes, J. Knobloch and M. Liepe

WG3: Superconducting RF and RF Control

- … to identify critical SRF related items for the construction of ERLs, evaluate the readiness of the related science and technology, and to lay out an R&D path for solving remaining open issues.

Charge

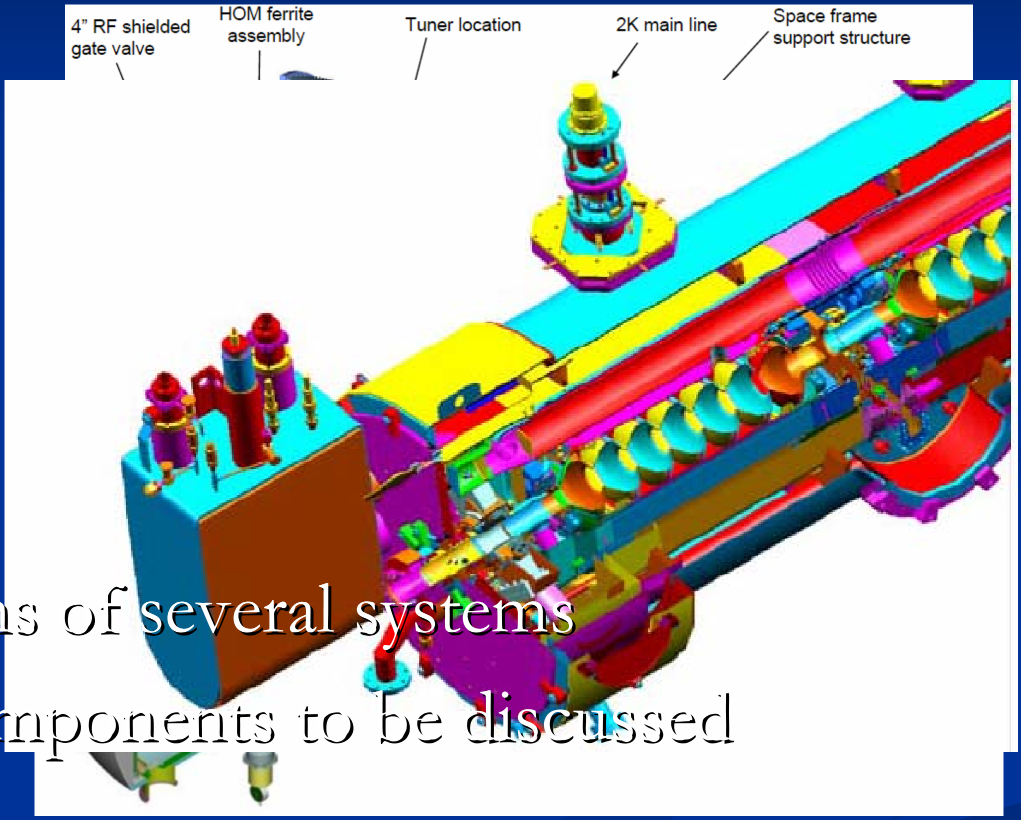
- Review parameter space covered by ERLs, concentrate on the „tough ones“ C. Beard, DL
- What are the SRF-related ERL-specific challenges?
- What solutions have already been developed?
- Which components still need more R&D work?
- Organize R&D effort, develop a roadmap to coordinate studies and identify collaborative possibilities

Thematic Areas

- Main Linac Module Development
  - Cavity
  - HOM coupler
  - Tuner
  - Power Coupler
  - …
- Injection Linac Issues
- RF System
  - Transmitter
  - RF Distribution
  - RF Control
  - …
- CW Cryogenics
- Transfer of Technology to Industry

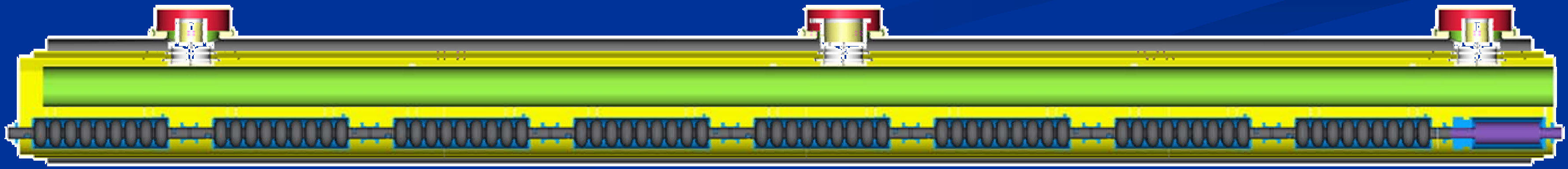
Module Designs

- Many types of SRF modules available as baseline design for ERLs
  - CEBAF upgrade
  - ELBE
  - BNL
  - TESLA
  - …



- Overview presentations of several systems
- Identify the critical components to be discussed

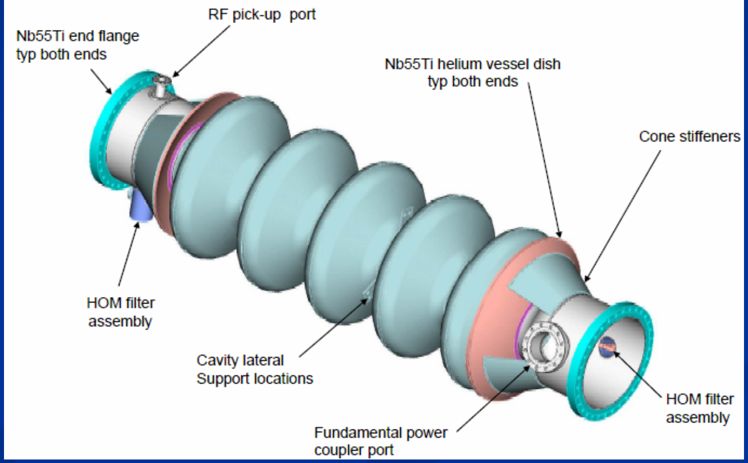
W. Funk, T. Grimm, R. Calaga, J. Teichner, J. Knobloch



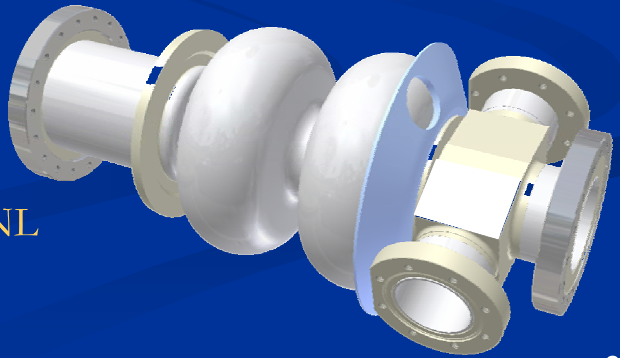
Cavity Design for ERLs

- Which parameters should one consider?
  - Frequency
  - Shape
  - Number of cells
  - R/Q
  - Beam-tube diameter
- What drives these parameters?
- Which are the most critical?
- Overview of designs, suitability

RHIC electron cooler, 704 MHz



Cornell ERL Injection Linac, 1.3 GHz

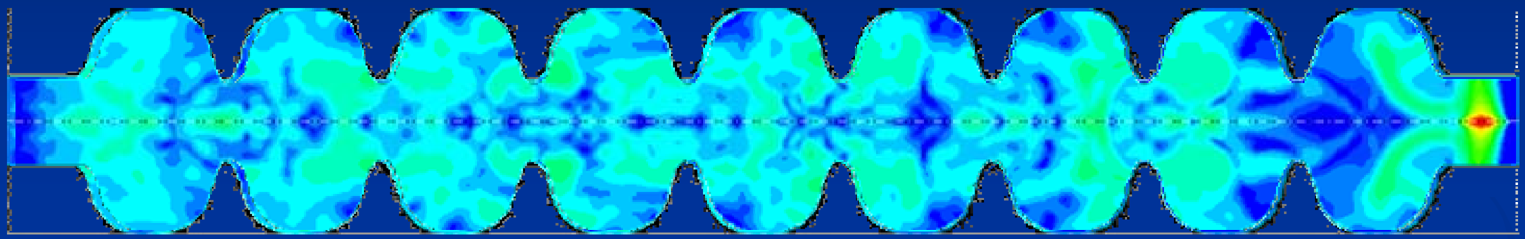


R. Calaga, BNL

Cornell ERL main linac, 1.3 GHz

HOMs

M. Dolus, DESY



- 100 mA x 2, 77 pC, 0.6 mm bunch
- P_{total}= 160 W
- Also must consider BBU limit and effect on emittance!

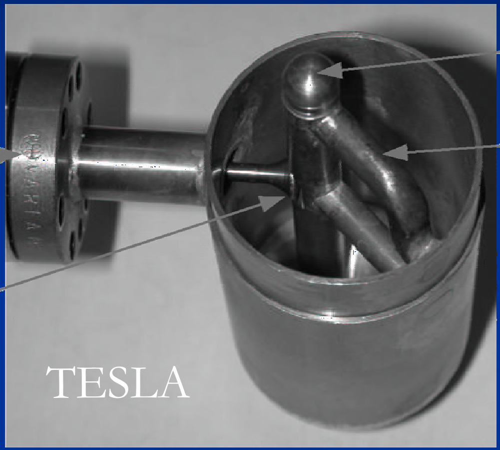
HOMs

- How accurately can we predict?
  - HOM Power
  - Cavity spectrum
  - Trapped modes
  - HOM extraction efficiency
  - BBU limit
  - …

HOMs

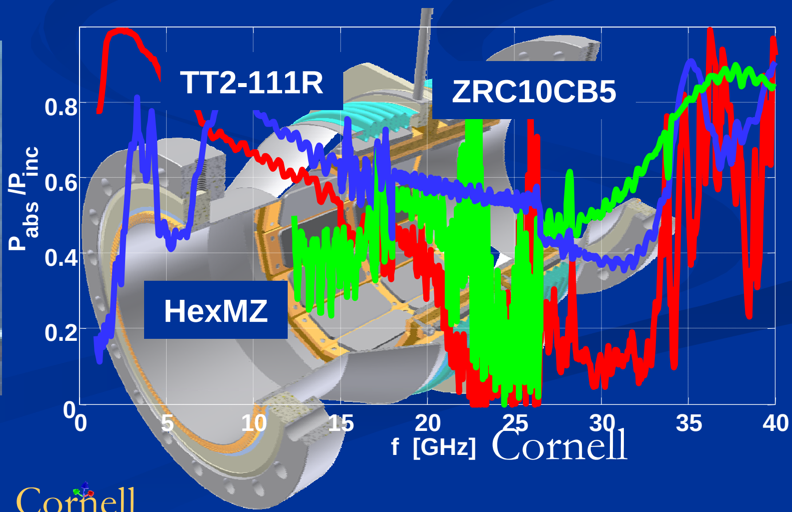
B. Rimmer, JLAB

- Types of HOM couplers
  - Loop coupler
  - Waveguide coupler
  - Ferrite load
  - Radial transmission line



Kensei Umemori, JAERI

CEBAF



V. Shemelin, Cornell

Cavity Preparation/*Q* Factor

- For CW operation, *Q* factor is critical
- Overview of cavity production techniques
  - BCP, EP
  - High-pressure rinsing
  - RF/He processing
  - Bakeout
  - Niobium quality
  - …

P. Kneisel, JLAB

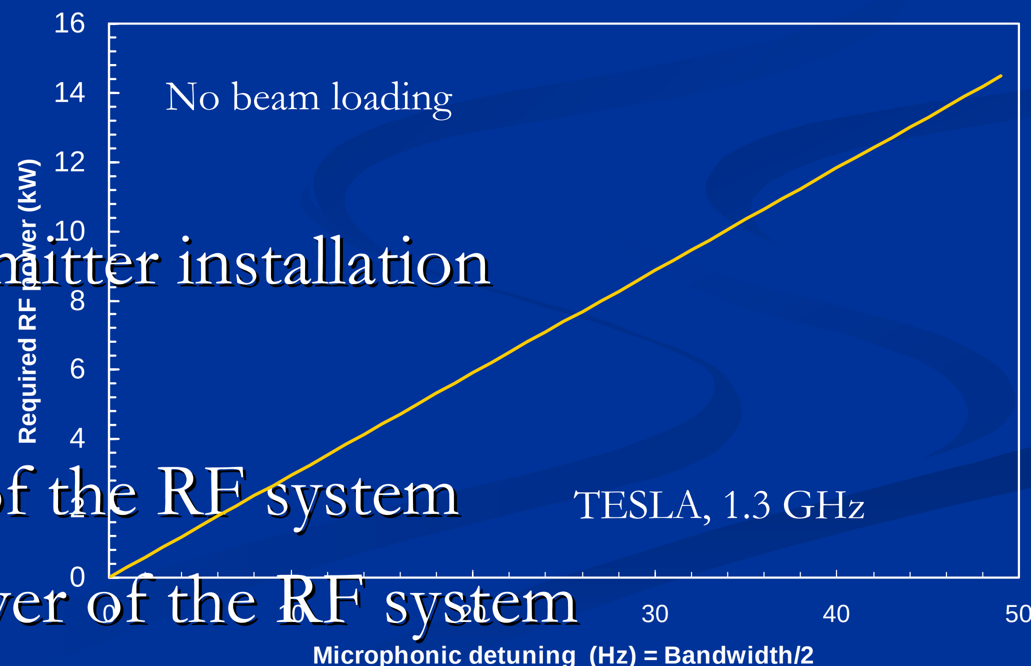
- What else impacts the quality (magnetic shielding, bath temperature, bakeout …)
- Recipe for cavity production *for CW applications*
- What *Q* factors can we expect *in a module*? How long is this maintained? What recovery options are there?

Microphonics

- By definition, ERL cavities are narrow band-width

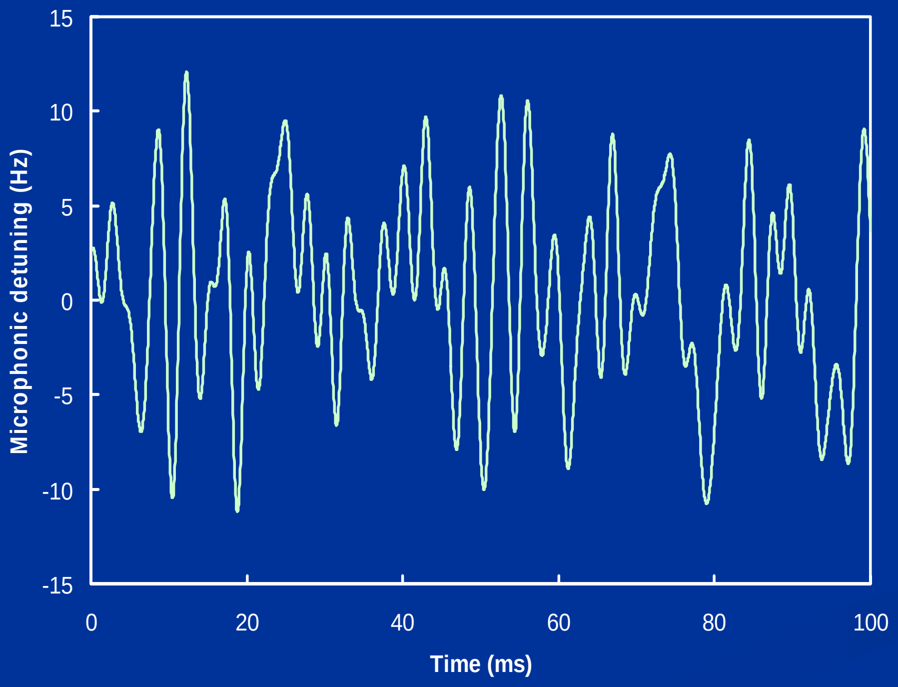
→ Microphonic detuning dominates the power budget

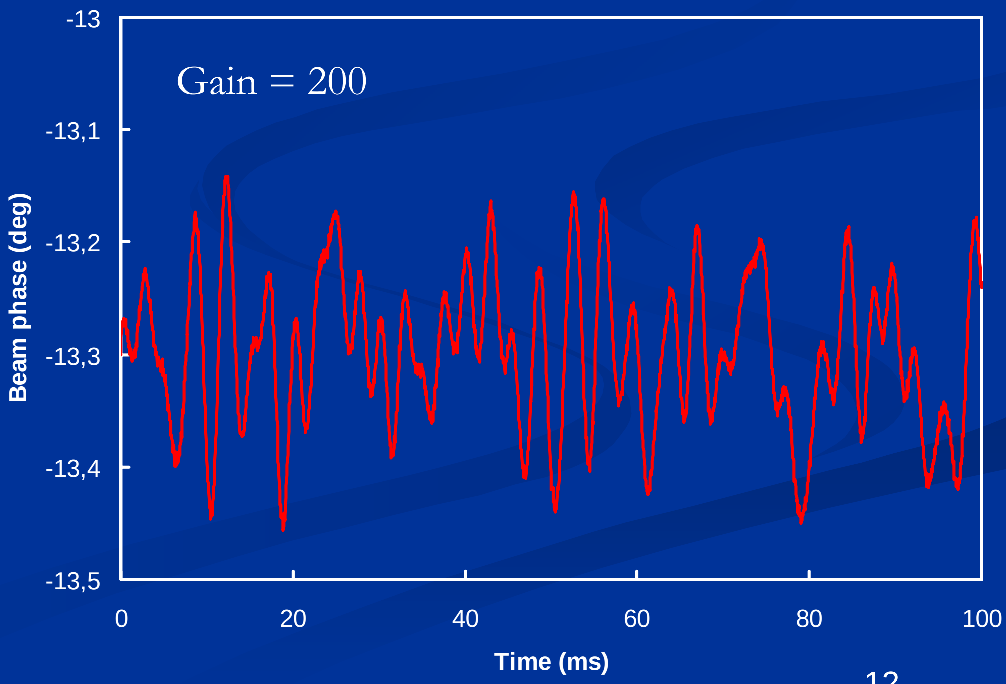
- Peak RF power
  - → Cost of RF Transmitter installation
- Average power
  - → Thermal aspects of the RF system
  - → AC operating power of the RF system



Microphonics

- Microphonic detuning impacts RF control

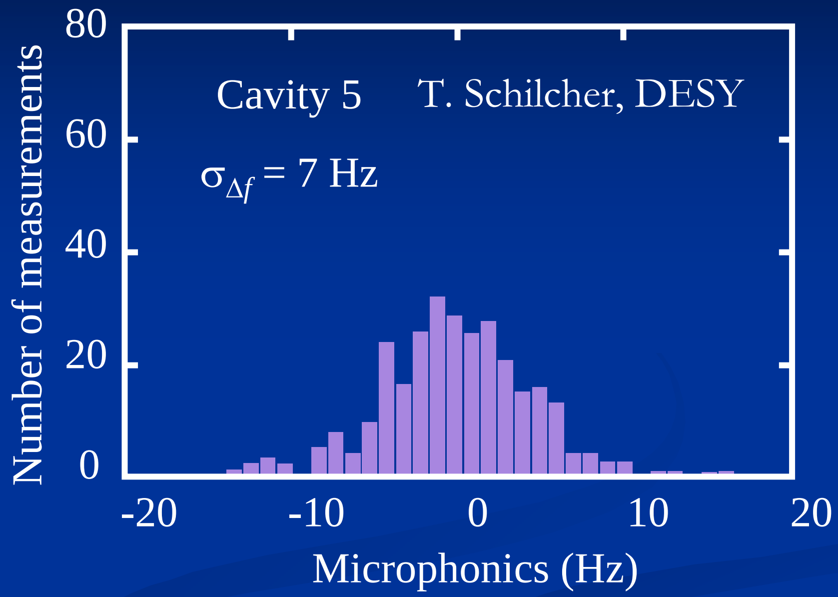


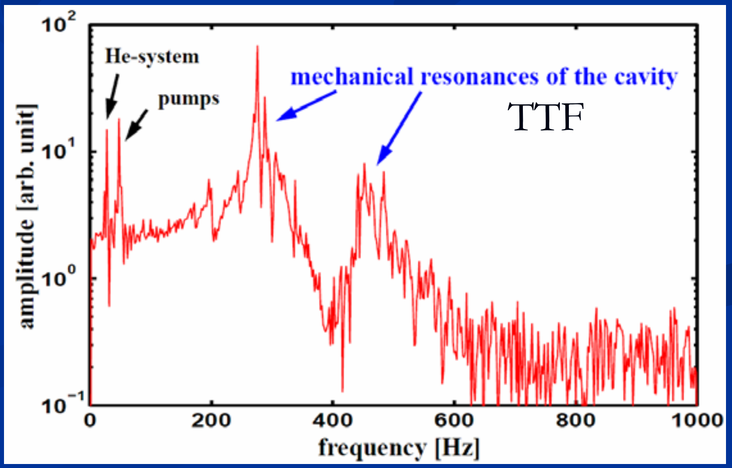


Microphonics

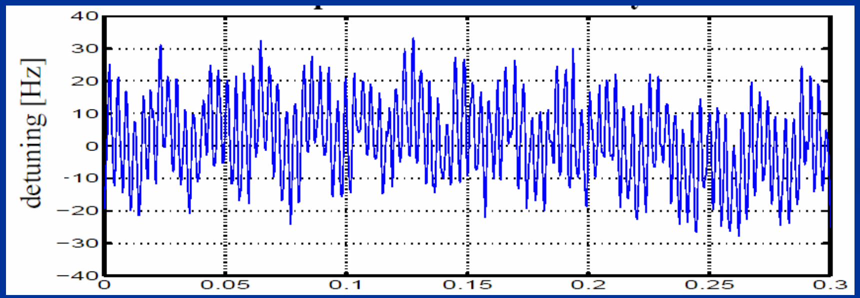
M. Liepe, Cornell

- How much microphonics?
- How much can we afford?
  - Installed RF Power
  - Trip Rate
  - …
- Spectrum?
  - Identify sources
  - Damping schemes



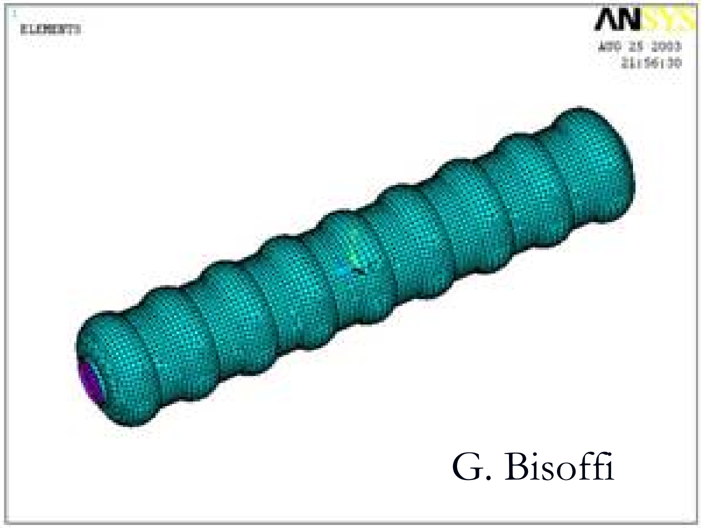


M. Liepe, Cornell



Damping Microphonics

- Passive means of damping microphonic detuning



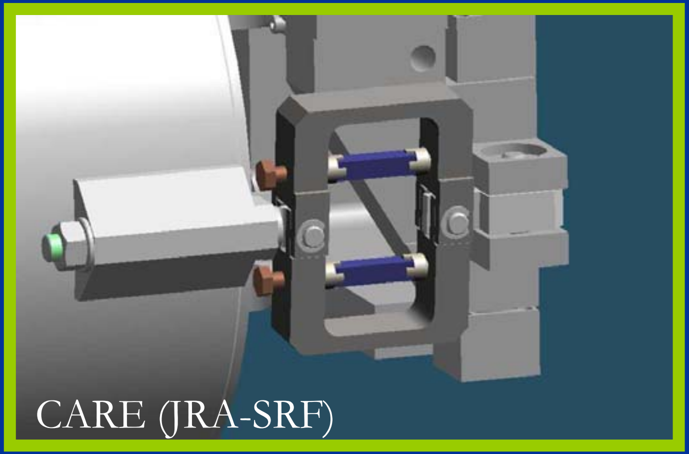
G. Bisoffi

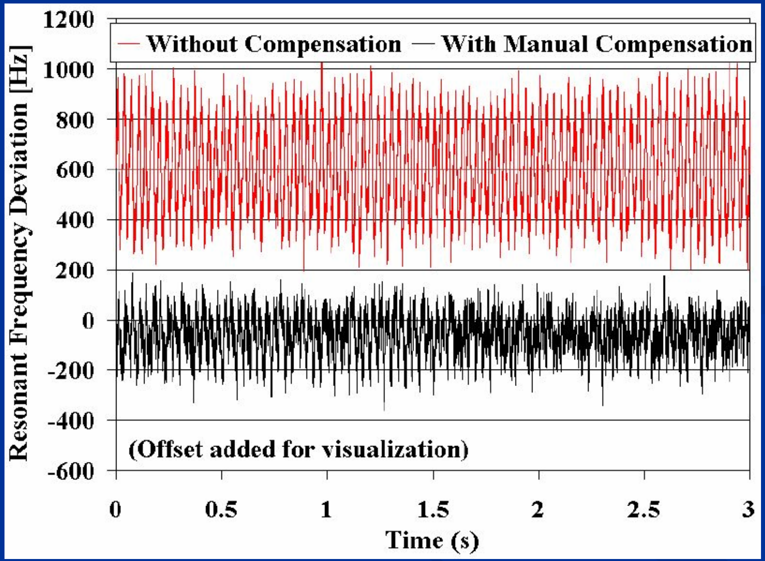
Mechanical mode no.	With present ring (Ø110) - Hz	With additional ring (Ø180) - Hz
1	33.6	122.9
2	85.7	222.1
3	125.1	425.6
4	152	695.7
5	222.5	830.3
6	248.1	- not given -

Compensating Microphonics

- Active means of reducing microphonics T. Grimm, MSU

Piezo compensation

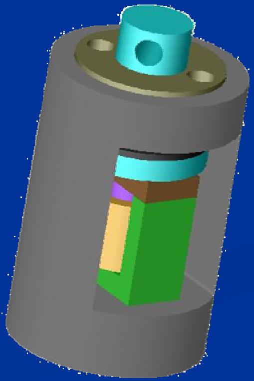




R. Carcagno et. al, Fermilab

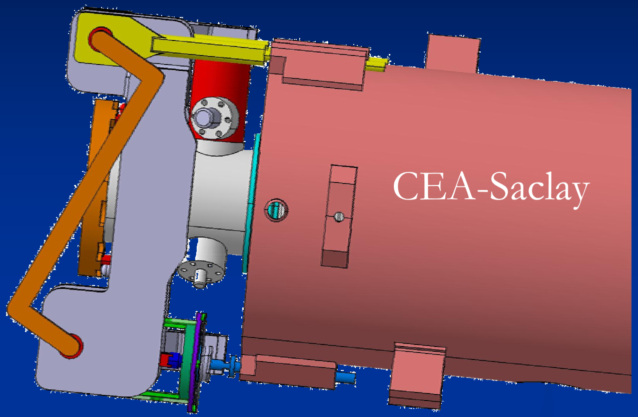
Magnetostrictive Tuner

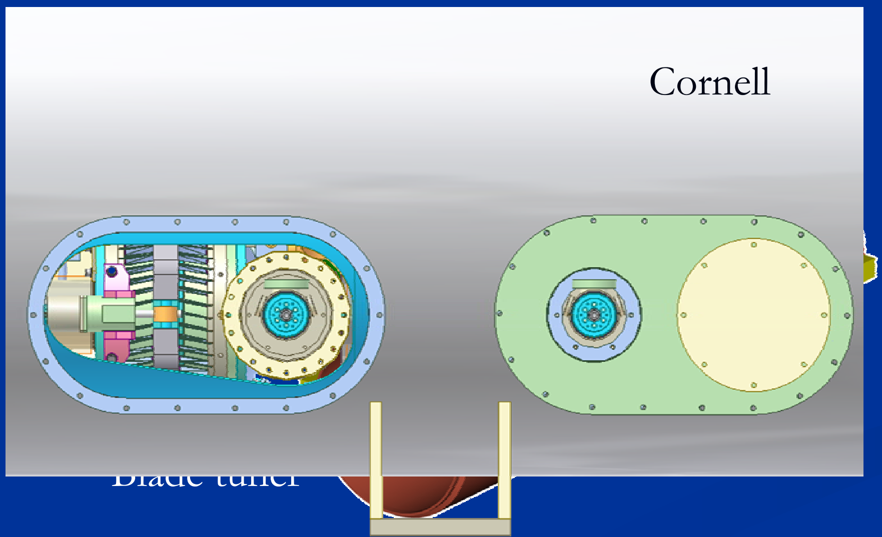
CARE (JRA-SRF)



Tuner Systems

- Overview of existing systems, properties   E. Daley, JLAB
- Design requirements, mechanical design, resolutions, spectrum
- Reliability issues



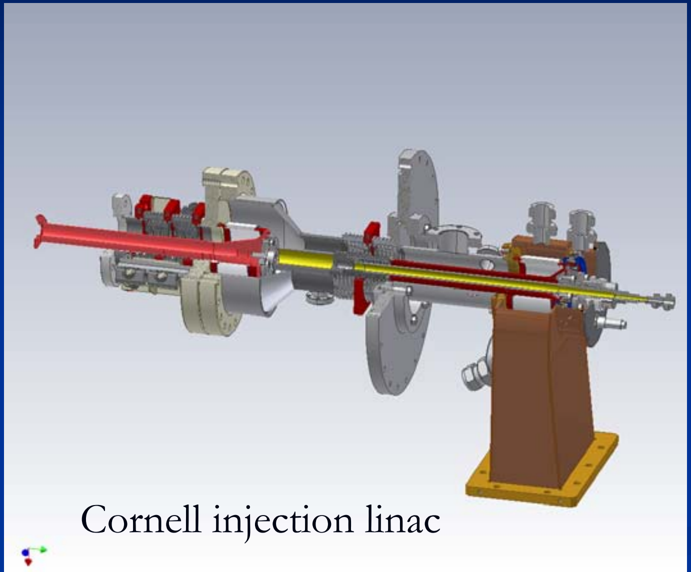


RF Control

- Requirements
  - 10^{-4}, 0.01 deg?
- What drives the requirements
  - Recovery efficiency
  - Bunch jitter and synchronization
- Noise sources
- Overview of options for RF control, simulations, hardware performance — S. Simrock, DESY
- Hardware design (digital, analog, I/Q, A/Phi, sampling frequency, filters etc)
- Feedforward
- Limit on cavity bandwidth, Q_L — M. Liepe, Cornell

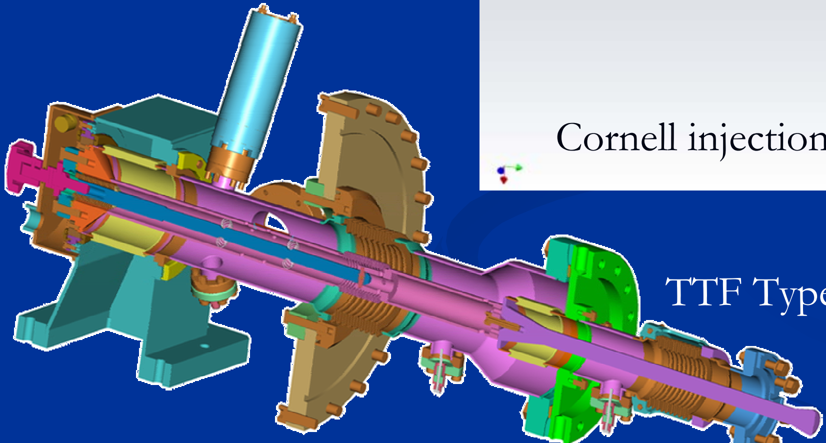
Power Couplers

- Requirements
  - SW ave power, peak power
  - coupler kicks
  - cryogenic losses …
- Overview of existing systems that can serve as baseline designs
  - Coax
  - Waveguide, …
- Layout
  - Adjustibility
  - Windows
  - Multipacting



Cornell injection linac

R. Campisi, SNS



TTF Type-III

Mircea Stirbet, JLAB

CEBAF

RF Sources

1.3 GHz CPI IOT

- Overview of requirements
  - CW operation
  - Pulsed operation
  - Efficiency
  - Reliability
- Overview of existing systems (klystron, IOT SS-amplifier …) Mike Dykes, DL & Masaru Sawamura, JAERI

RF Distribution

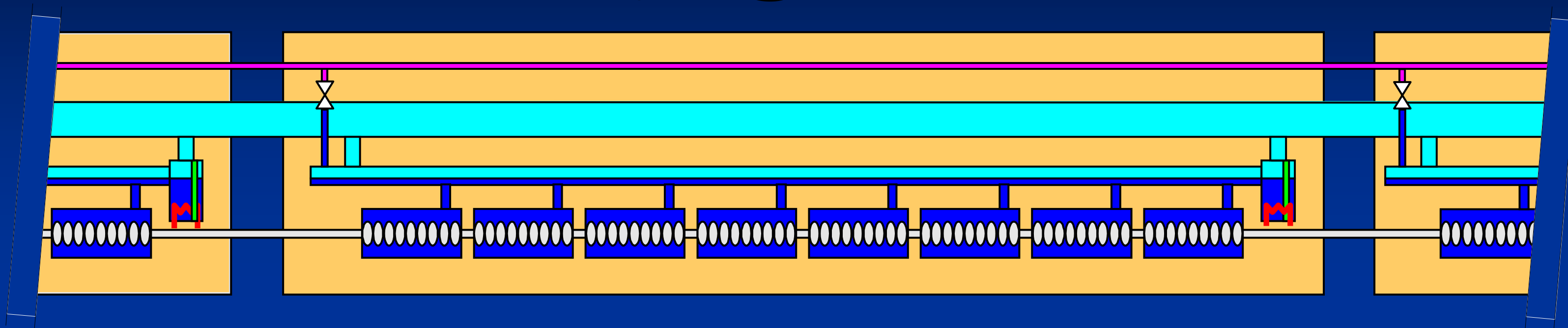
- One transmitter per cavity?
  - Expensive
  - Flexible
  - Reliable
- One transmitter for several cavities?
  - Vector sum operation
  - Active modulators in the transmission lines

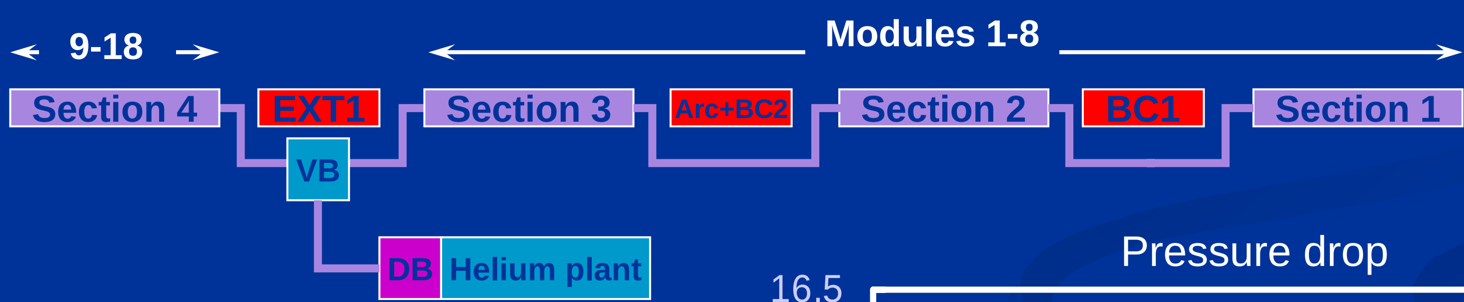
Cryogenics

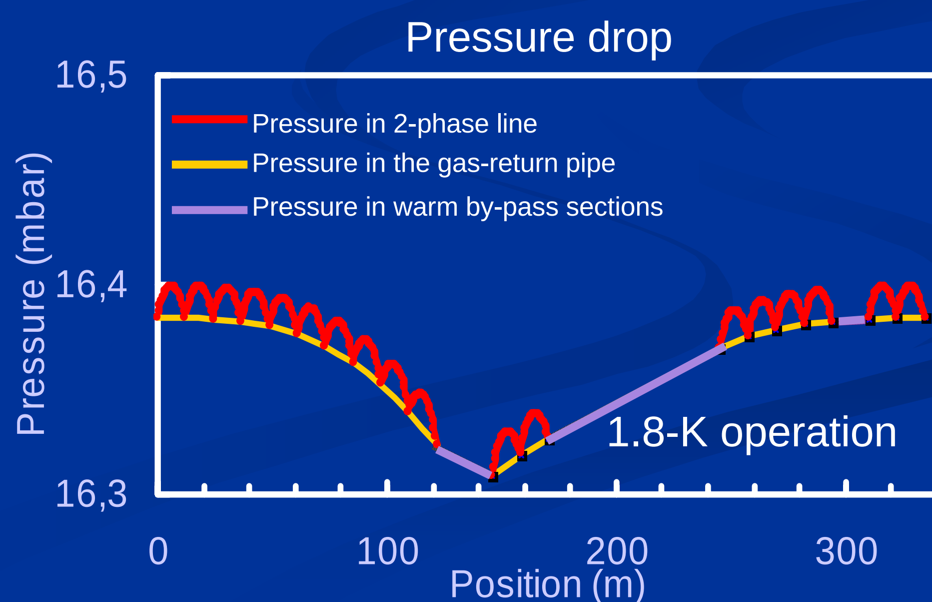
- Requirements/loads
  - Per cavity/module/linac
  - Stability
- Optimization of cryogenics/layout B. Petersen, DESY
- Module design/linac layout for ERLs from a cryogenic point of view

Eisuke Minehara, JAERI & J. Knobloch, BESSY

Cryogenics




9-18
Modules 1-8
Section 4
EXT1
Section 3
Arc+BC2
Section 2
BC1
Section 1
VB
DB
Helium plant


Pressure drop
Pressure in 2-phase line
Pressure in the gas-return pipe
Pressure in warm by-pass sections
1.8-K operation
16,5
16,4
16,3
Pressure (mbar)
0
100
200
300
Position (m)

Transfer of Technology

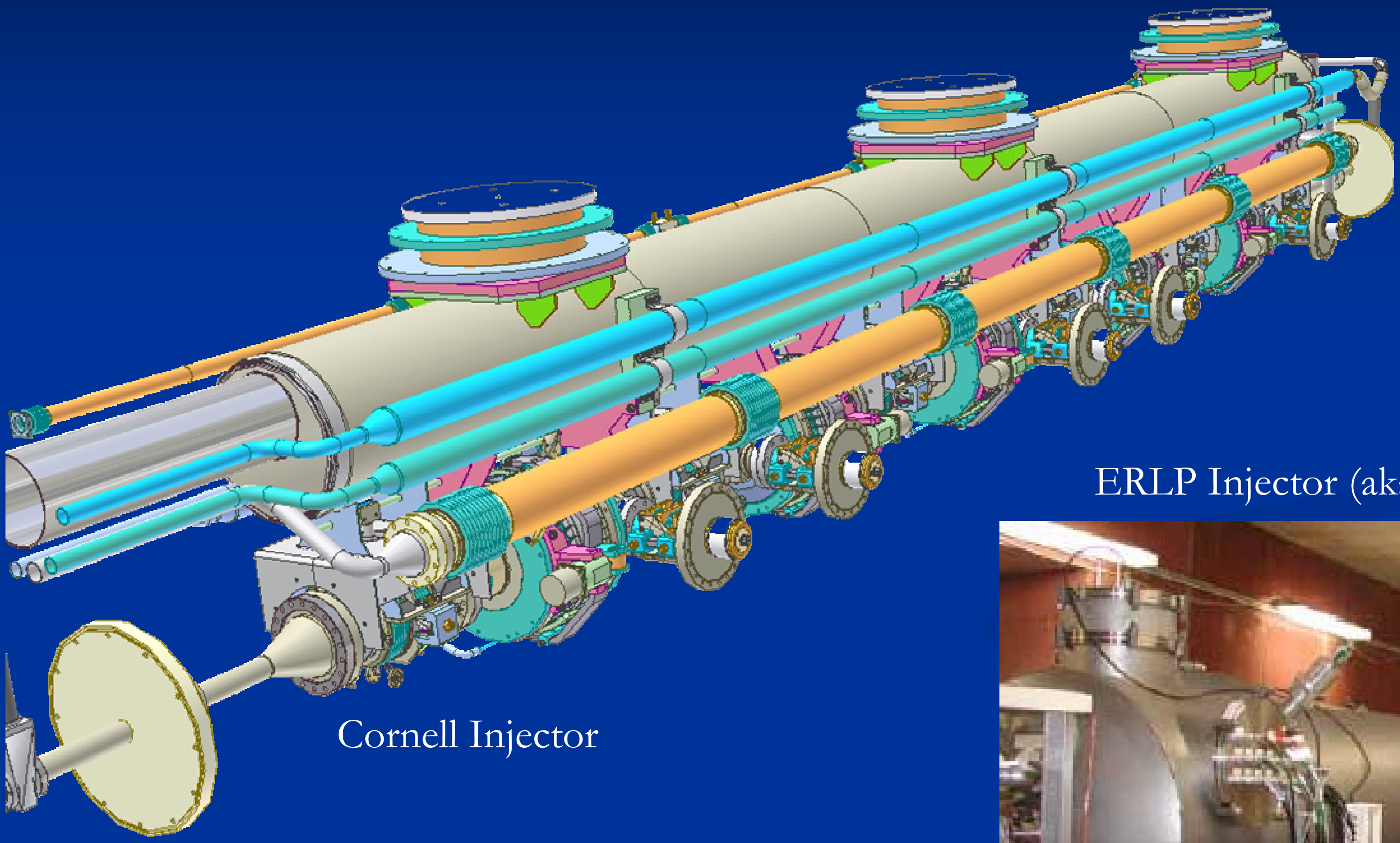
- Overview of industrial capabilities — H.P. Vogel, ACCEL
  - Present
  - Near-term plans
- Model for industrial production, quality assurance
- Optimization of module design from point of view of:
  - Production/Assembly
  - Alignment
  - Transport
  - Cost
  - …

Injector Modules

- Requirements and differences to main linac modules
  - Beam loading
  - Emittance dilution
  - Reliability and required redundance
  - …
- Revisit subsystems from point of view of injector modules
- Overview of current designs

S. Belomestnykh, Cornell

Injector Modules



Cornell Injector

ERLP Injector (aka ELBE Module)