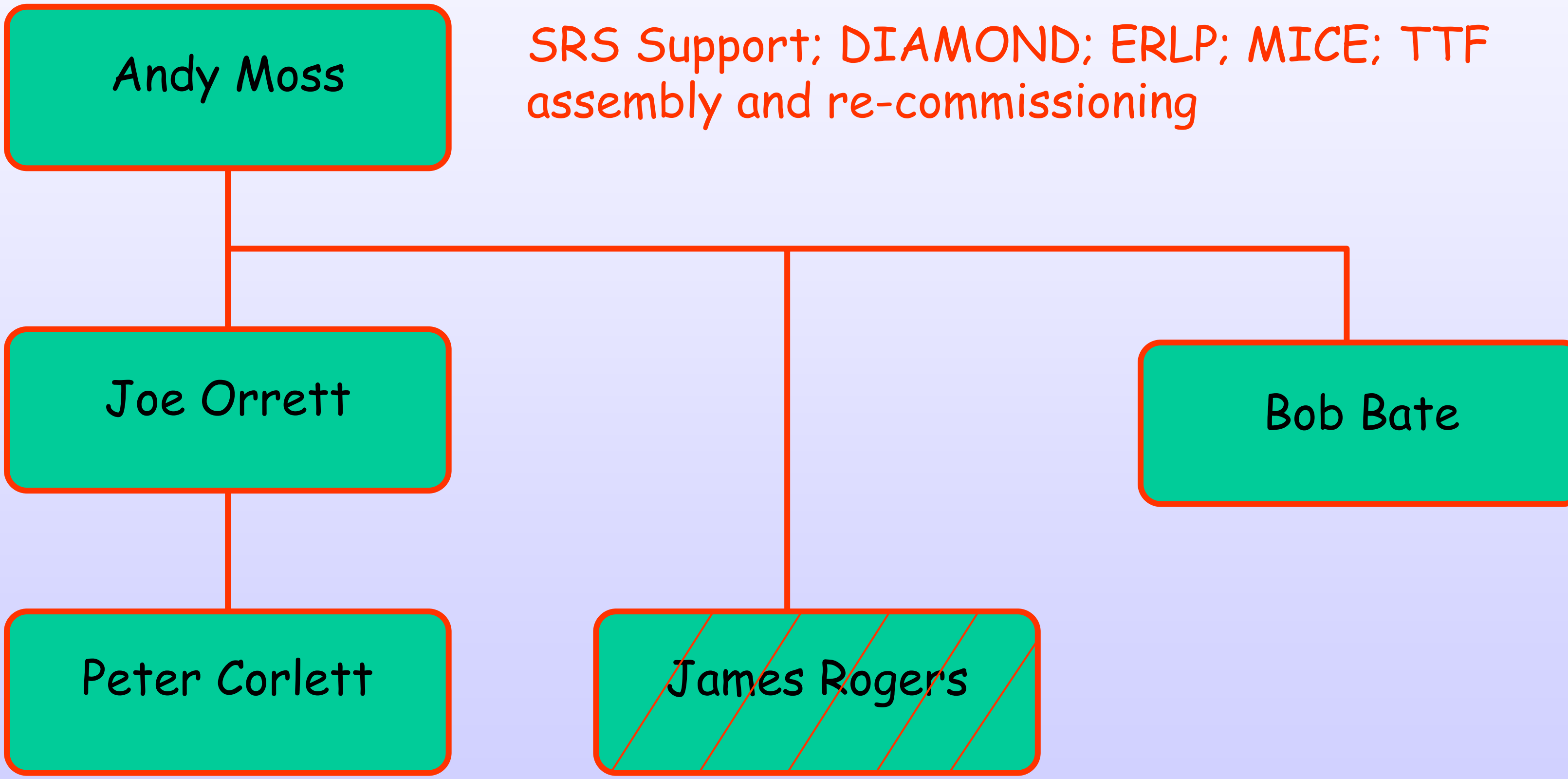
ERLP Status

Mike Dykes

Content

- ASTeC RF & Diagnostics Group
- Work of the Group
- 4GLS
- ERLP
  - Photo-injector
  - Accelerating Modules
- Summary

High Power RF Engineering



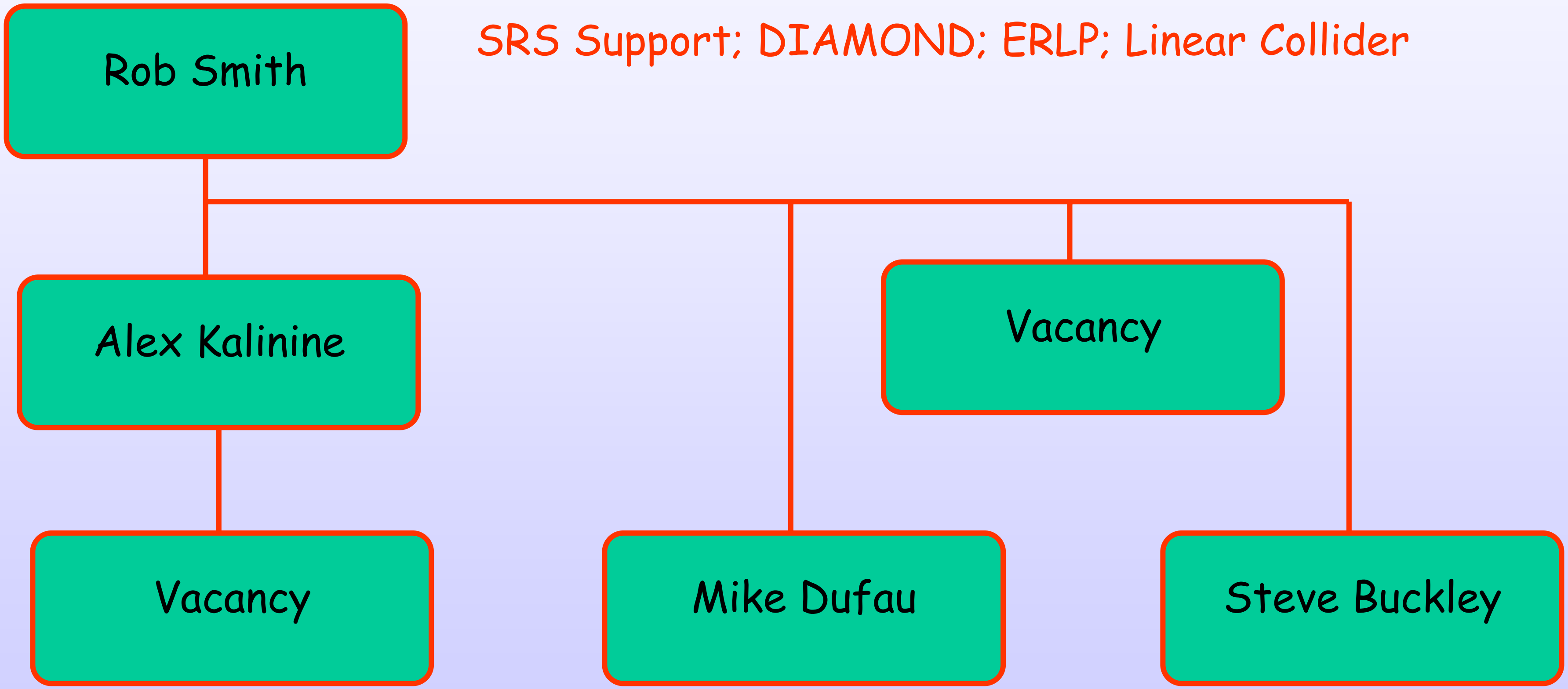
High Power Amplifiers
Transmission lines

Medium Power
Monitoring

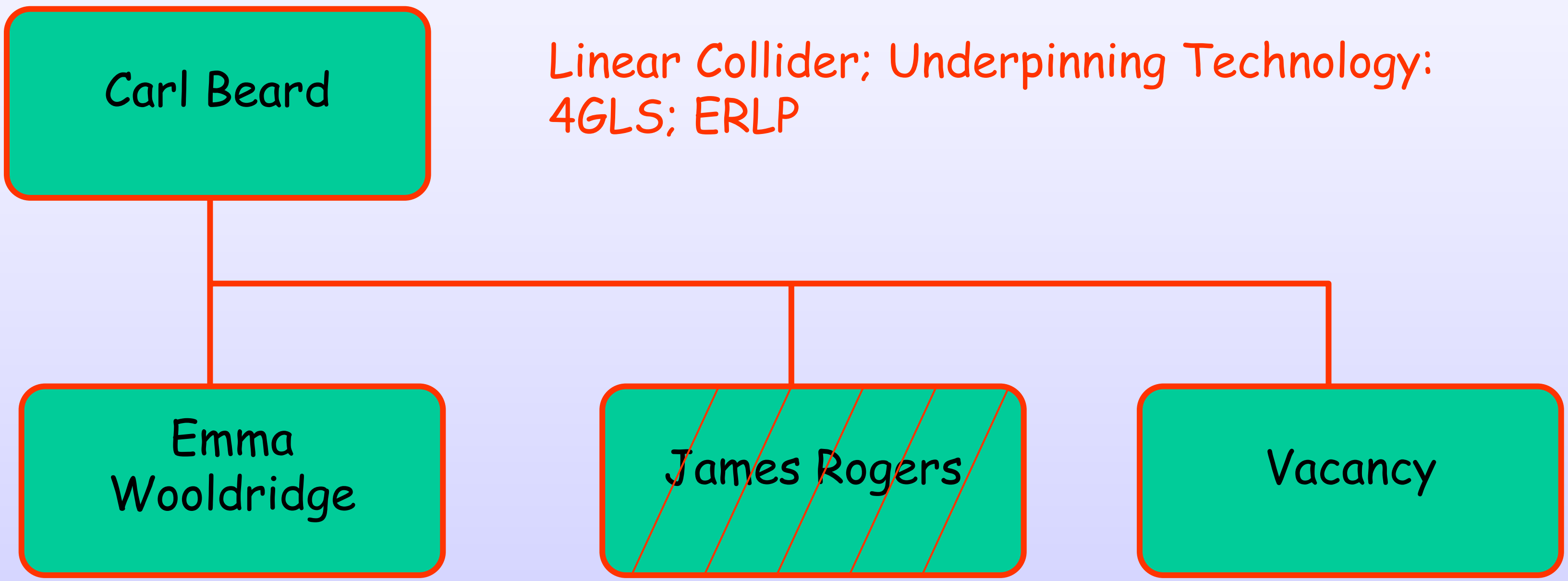
Cryogenics
Cryo-module assembly

Low Power RF & Diagnostics

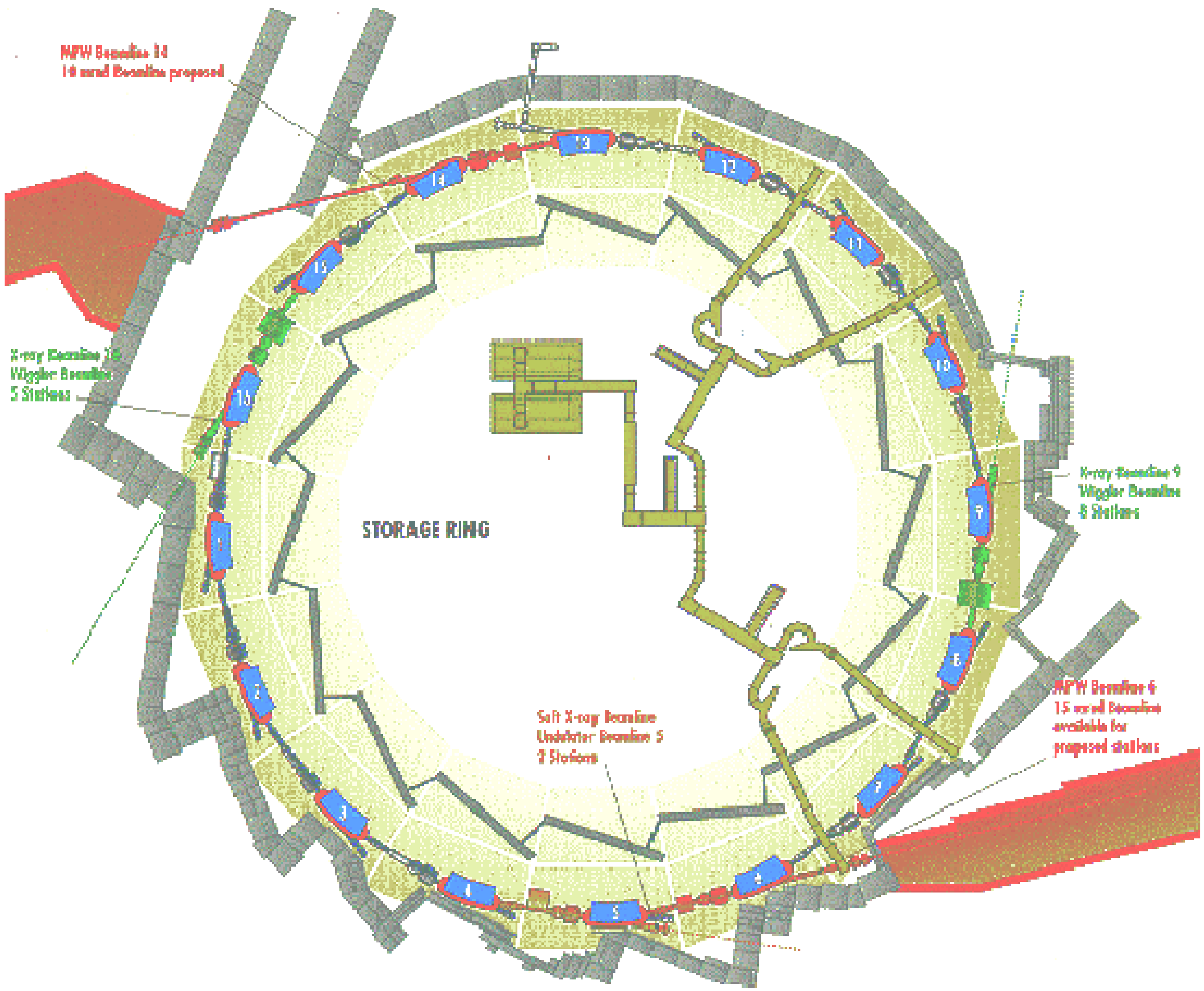
SRS Support; DIAMOND; ERLP; Linear Collider



Structure Design



SRS Support

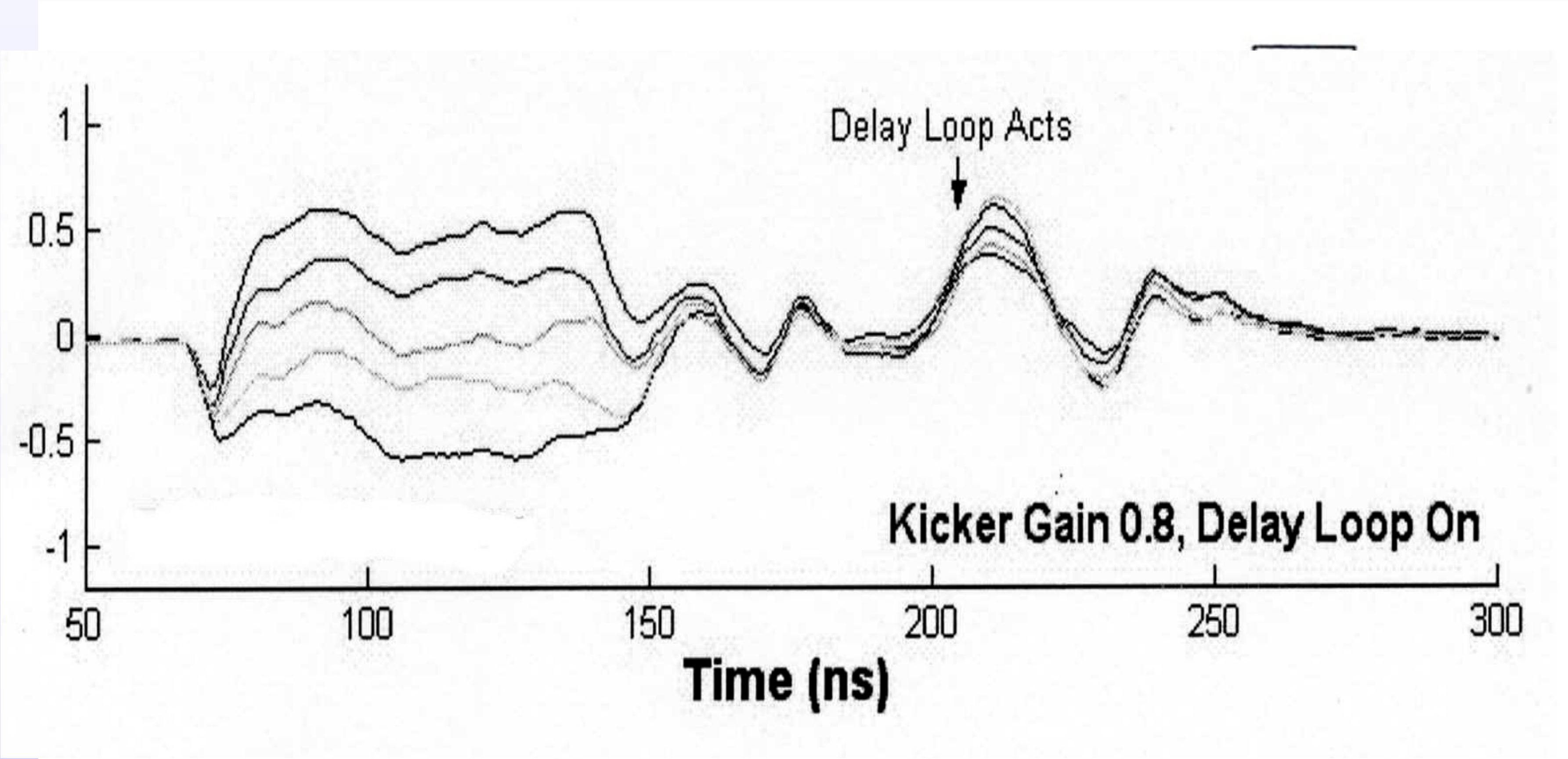

MPW Beamline 14
X-ray Beamline 16
Wiggler Beamline
5 Stations
STORAGE RING
X-ray Beamline 9
Wiggler Beamline
8 Stations
MPW Beamline 6
available for
proposed stations
Soft X-ray Beamline
Undulator Beamline 5

Diamond Support

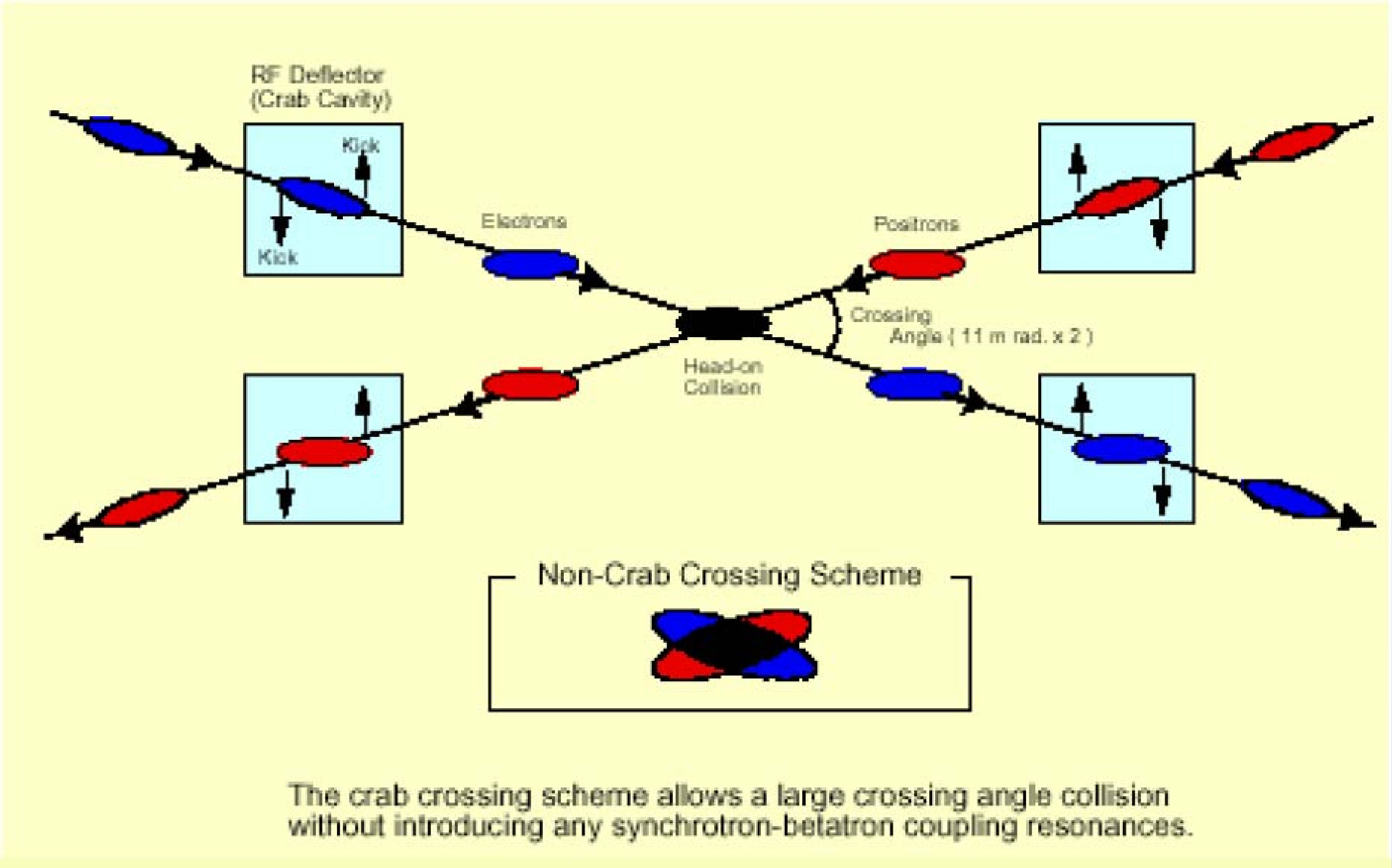
2004/05

Design and Procurement of Linac; booster RF; storage ring RF and diagnostics

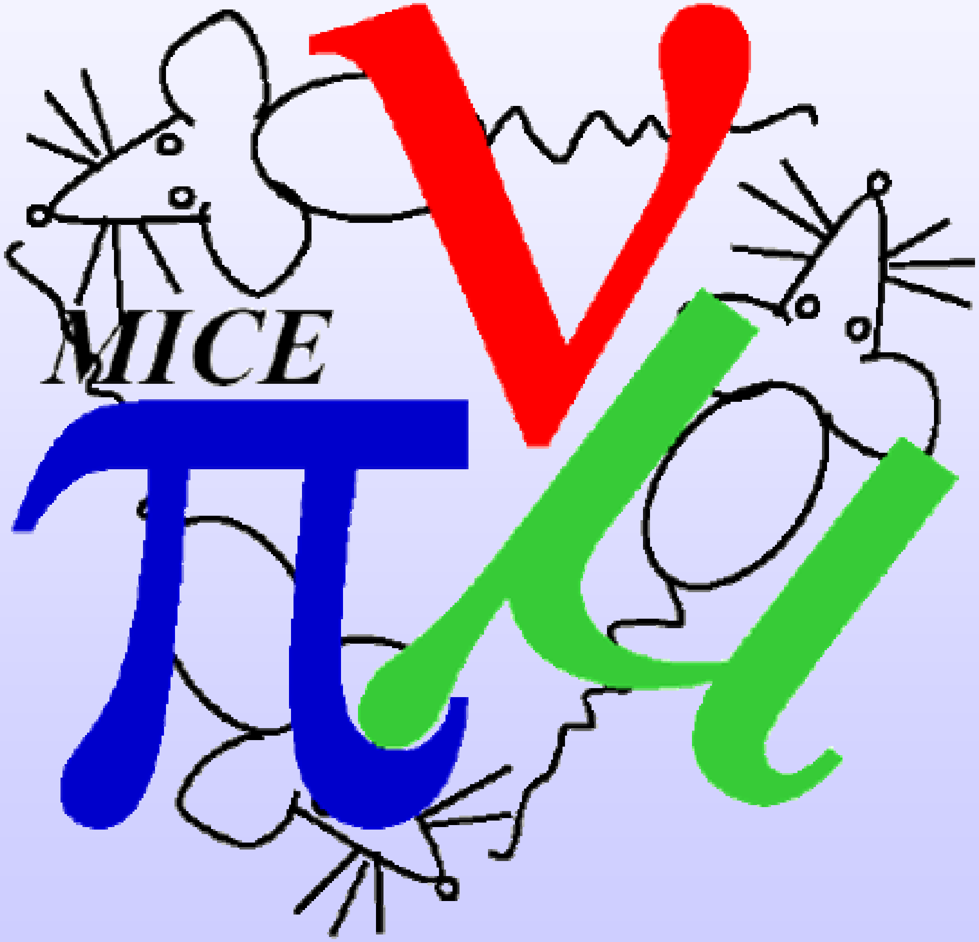
Linear Collider -FONT



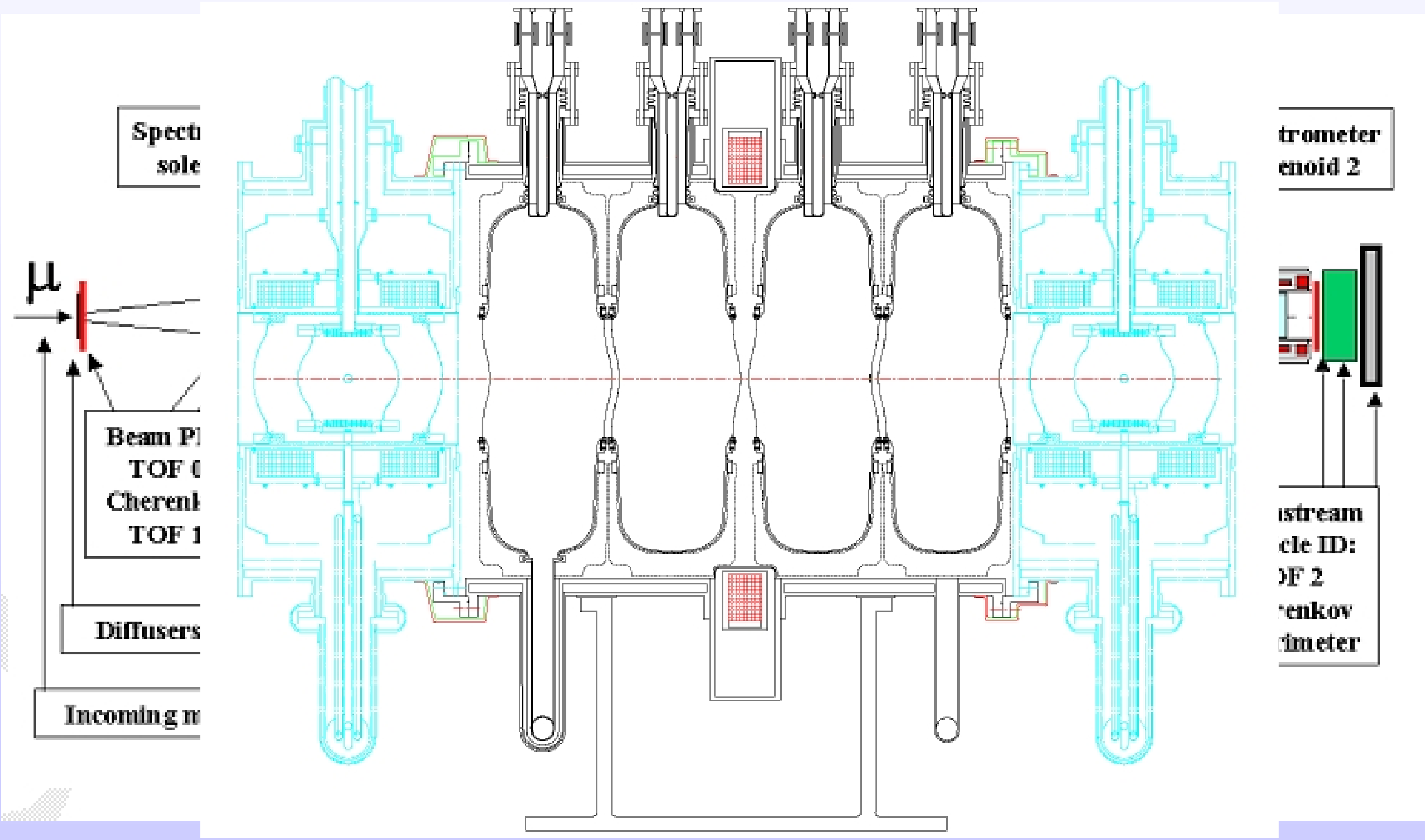
Linear Collider – 'Crab' cavity



Muon Ionisation Cooling Experiment



MICE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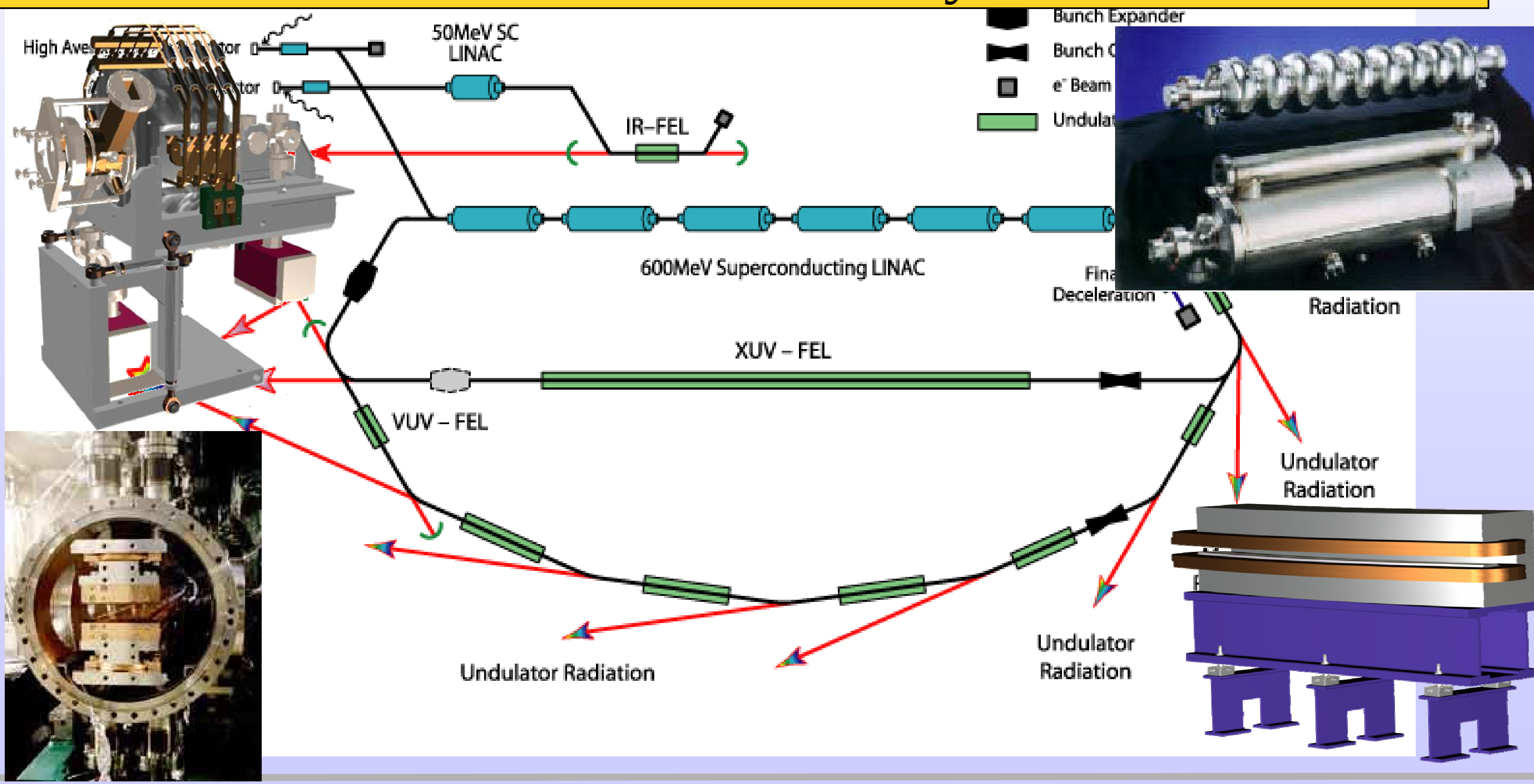
4GLS combines, for the first time, superconducting ERL, SR and FEL technology in a fully integrated multi-source facility



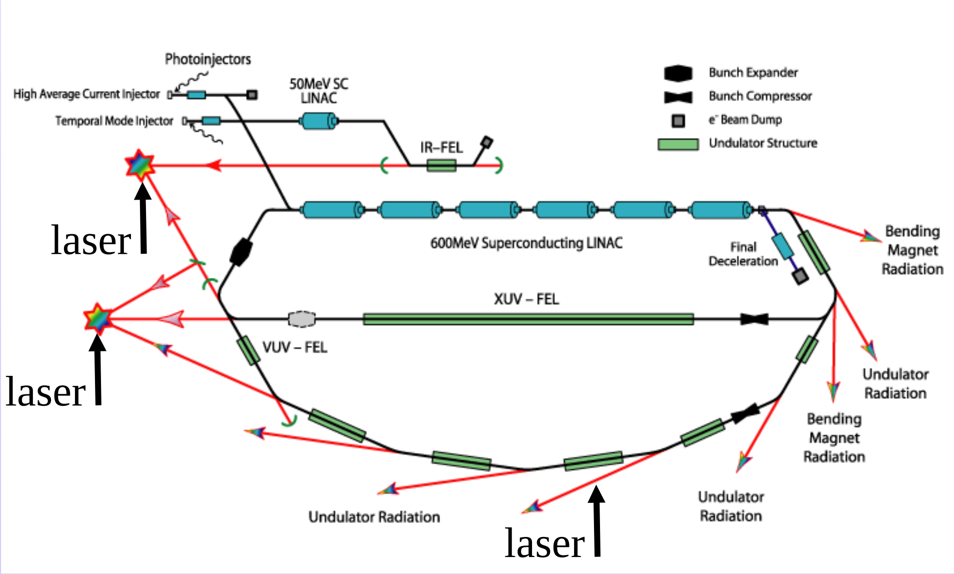
The benefits...

- short pulses - femtosecond (10^{-15}s) regime
- control of pulse structure - pulse tailoring
- larger peak currents
- effectively infinite beam lifetimes
- coherence
- symmetrical beam and small emittance

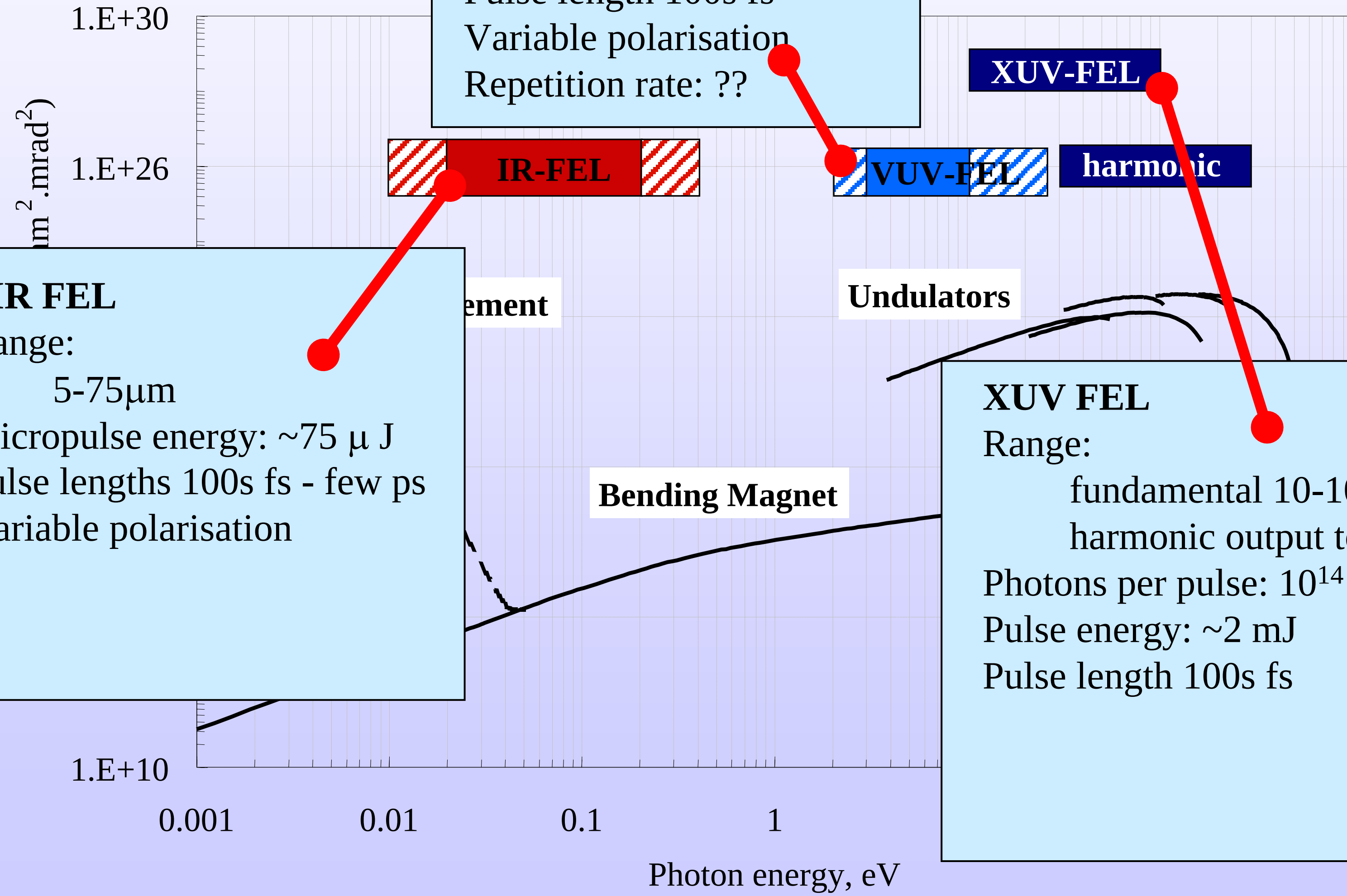
and, of course, the ERL approach combined with high brightness injectors are ideal for free electron lasers, FELs.

A suite of light sources...

- **spontaneous emission sources**
  undulators and bending magnets
- **stimulated emission sources**
  free electron lasers
- **combinations of sources**
  internal or with conventional lasers



VUV FEL
Range:
3-10 eV??
Photons per pulse: 10^{13}
Pulse energy: ~15 μJ
Pulse length 100s fs
Variable polarisation
Repetition rate: ??



FIR FEL
Range:
5-75μm
Micropulse energy: ~75 μ J
Pulse lengths 100s fs - few ps
Variable polarisation

XUV FEL
Range:
fundamental 10-100 eV??
harmonic output to 300eV
Photons per pulse: 10^{14}
Pulse energy: ~2 mJ
Pulse length 100s fs

In summary, 4GLS offers...

4GLS will deliver very short, very bright pulses of coherent light that are tuneable over a wide range and have variable polarisation.

fs - timescale of bond making and disruption

More than a million times brighter than the peak brightness of a 3rd generation storage ring

Research, Development and Design

Four years of funding (currently £14.7M) for the research, development and design work needed to address the key challenges of the 4GLS facility.

- establish and operate 4GLS ERL prototype facility
- undertake 4GLS design studies
- collaborate where other international efforts are directed at addressing problems of common interest

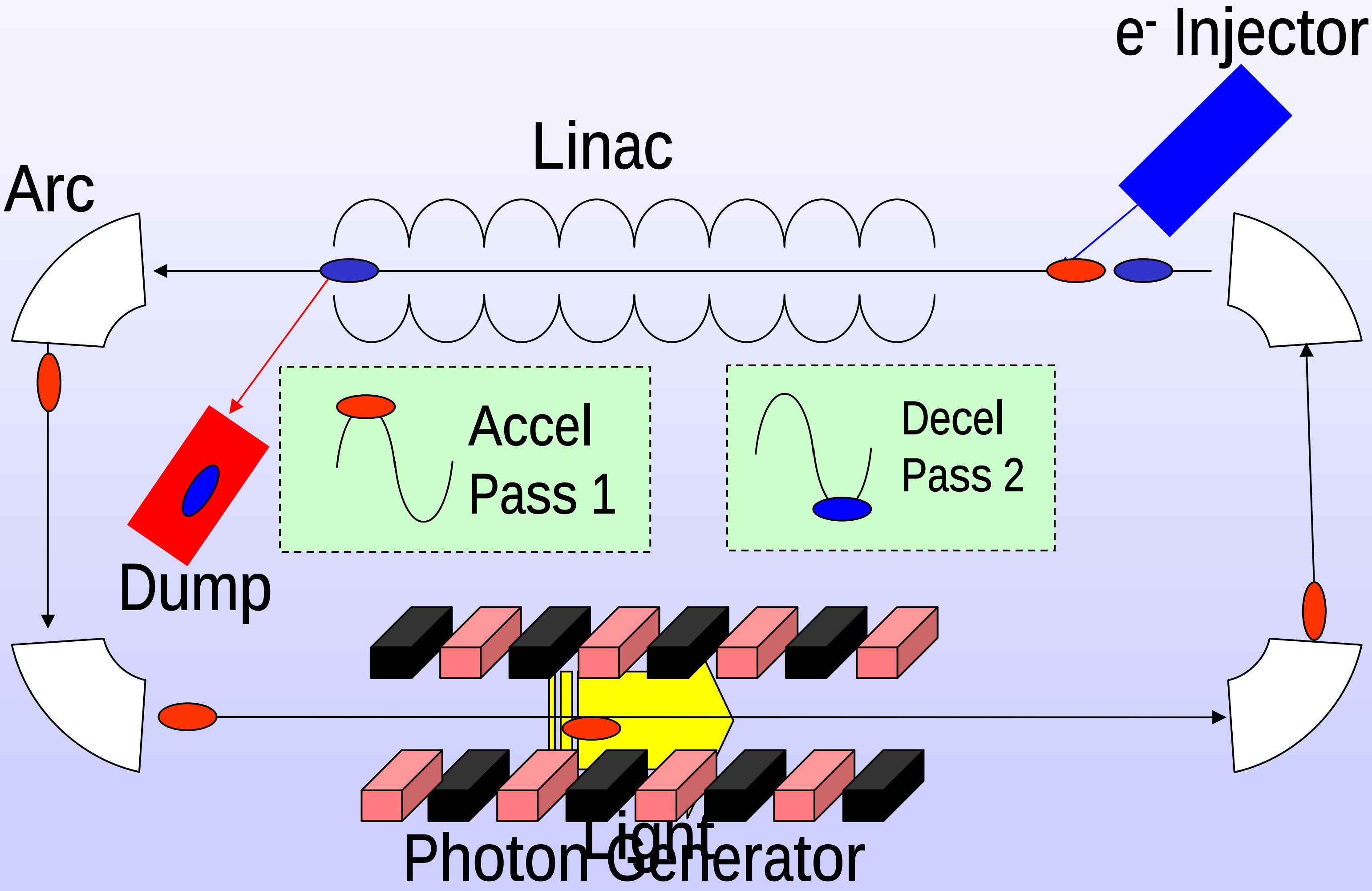
4GLS ERL Prototype

Aims: To enable the development of core skills and to gain 'hands on' experience to meet the 4GLS challenge.

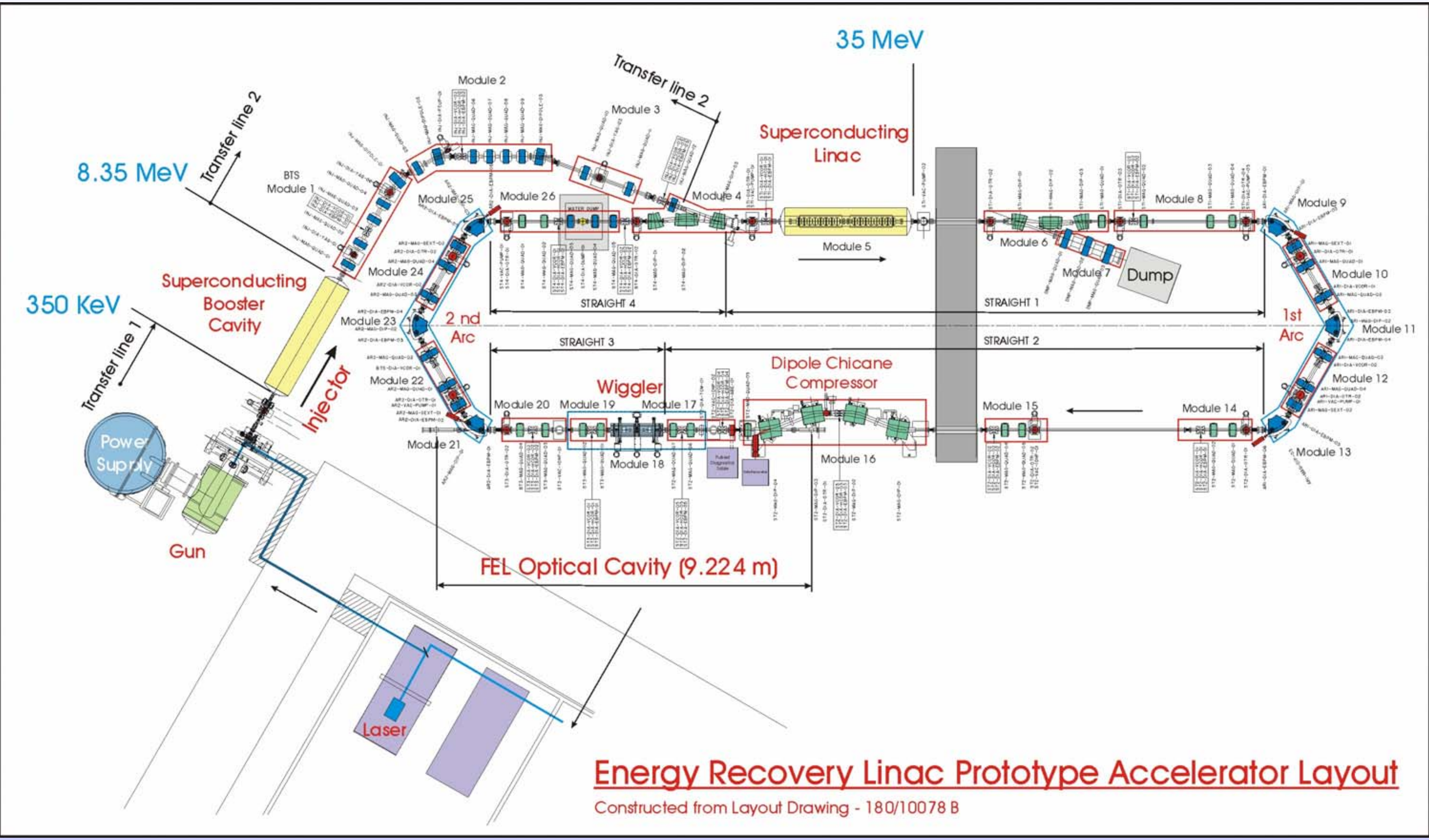
- high brightness photoinjectors
- superconducting linac technology
- FEL and spontaneous source operation together
- electron beam dynamics issues
- synchronisation challenges

The work will be cross departmental and will involve ASTeC, SRD, CLF, ED, ID and HEIs.

Generic 1.5 Turn ERL



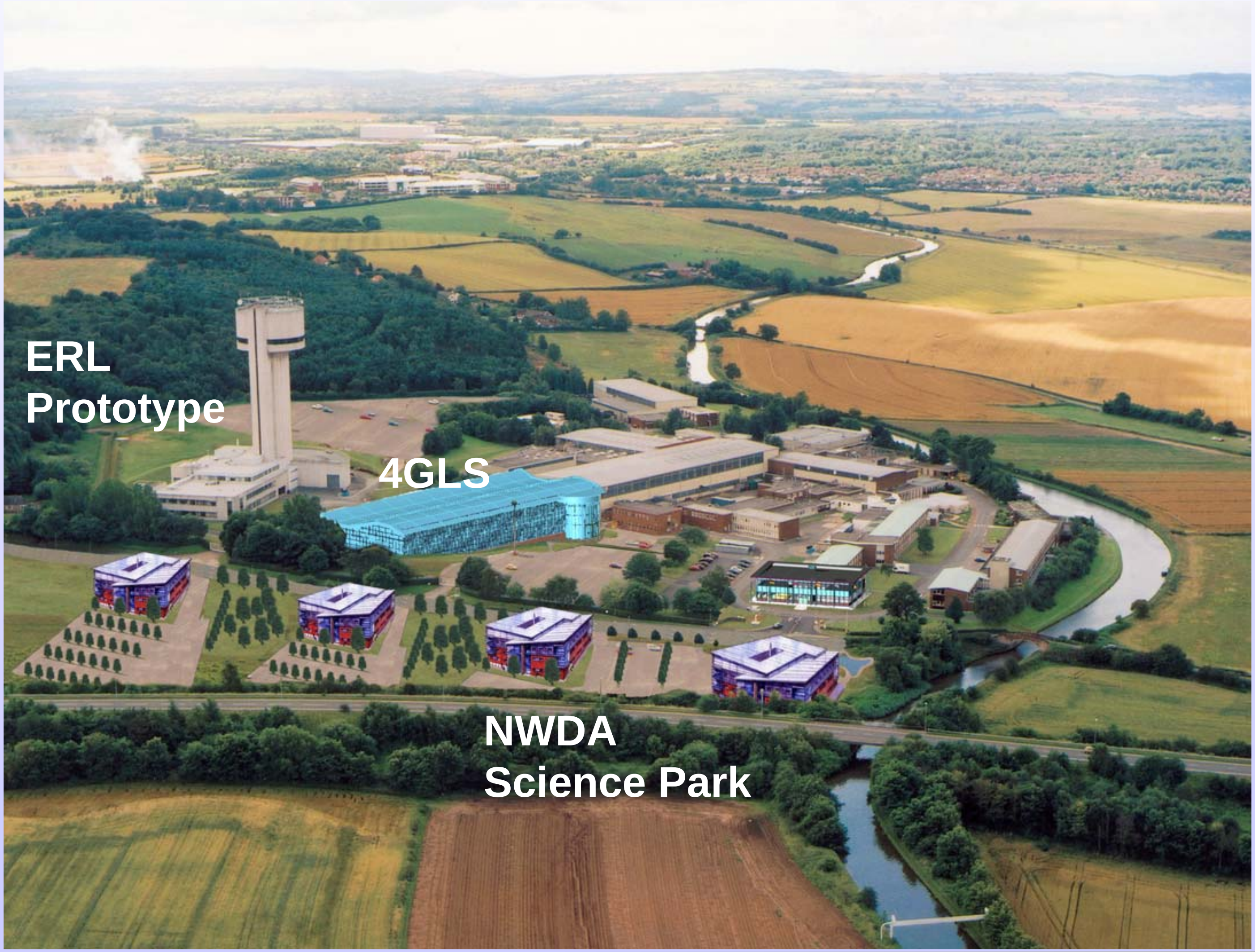
ERLP



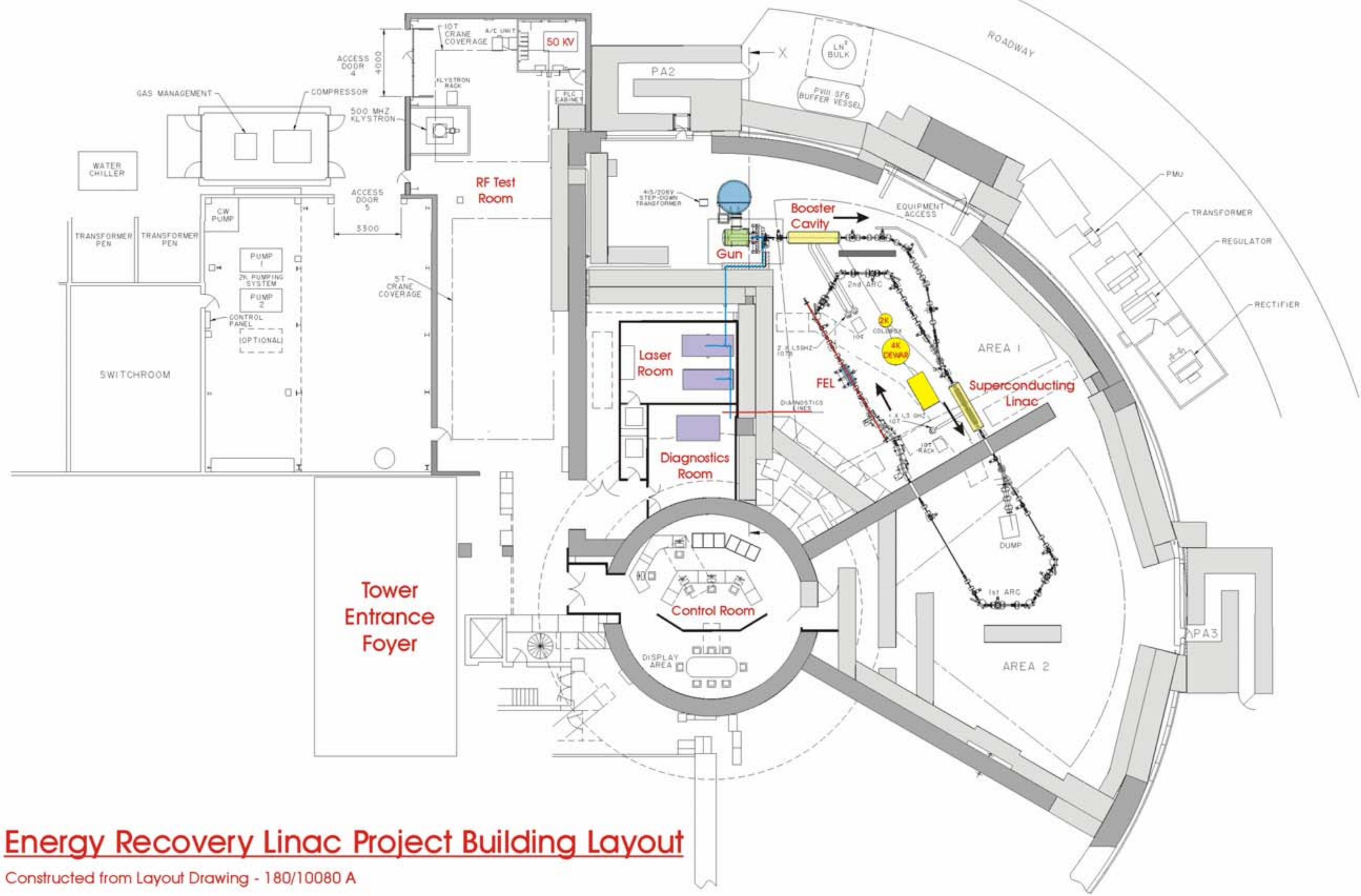
35 MeV
8.35 MeV
350 KeV
Transfer line 2
Transfer line 1
Transfer line 2
Module 2
Module 3
BTS Module 1
Superconducting Linac
Module 25
Module 26
Module 4
Module 5
Module 6
Module 7
Module 8
Module 9
Module 10
Module 11
Module 12
Module 13
Module 14
Module 15
Module 16
Module 17
Module 18
Module 19
Module 20
Module 21
Module 22
Module 23
Module 24
Dump
STRAIGHT 4
STRAIGHT 1
STRAIGHT 3
STRAIGHT 2
2 nd Arc
1st Arc
Superconducting Booster Cavity
Injector
Dipole Chicane Compressor
Wiggler
Power Supply
Gun
FEL Optical Cavity (9.224 m)
Laser
Energy Recovery Linac Prototype Accelerator Layout
Constructed from Layout Drawing - 180/10078 B

Parameters

Parameter	Set up Mode	Short Pulse	Long Pulse	CW
Gun Energy (keV)		350		
Booster Energy (MeV)		8.35		
Final Energy (MeV)		35		
Max. Bunch Charge (pC)		80		
Bunch Repetition Rate (MHz)		81.25		
Bunches per Train	1	1625	8125	
Train Length (μs)	0.0123	20	100	
Train Repetition Rate (Hz)	20	5	20	
Average Current (μA)	0.0016	0.65	13	6500
Beam Power at 8.35 MeV (W)	0.0134	5.43	108.55	54275
Beam Power at 35 MeV (W)	0.056	22.75	455	227500


ERL
Prototype
4GLS
NWDA
Science Park

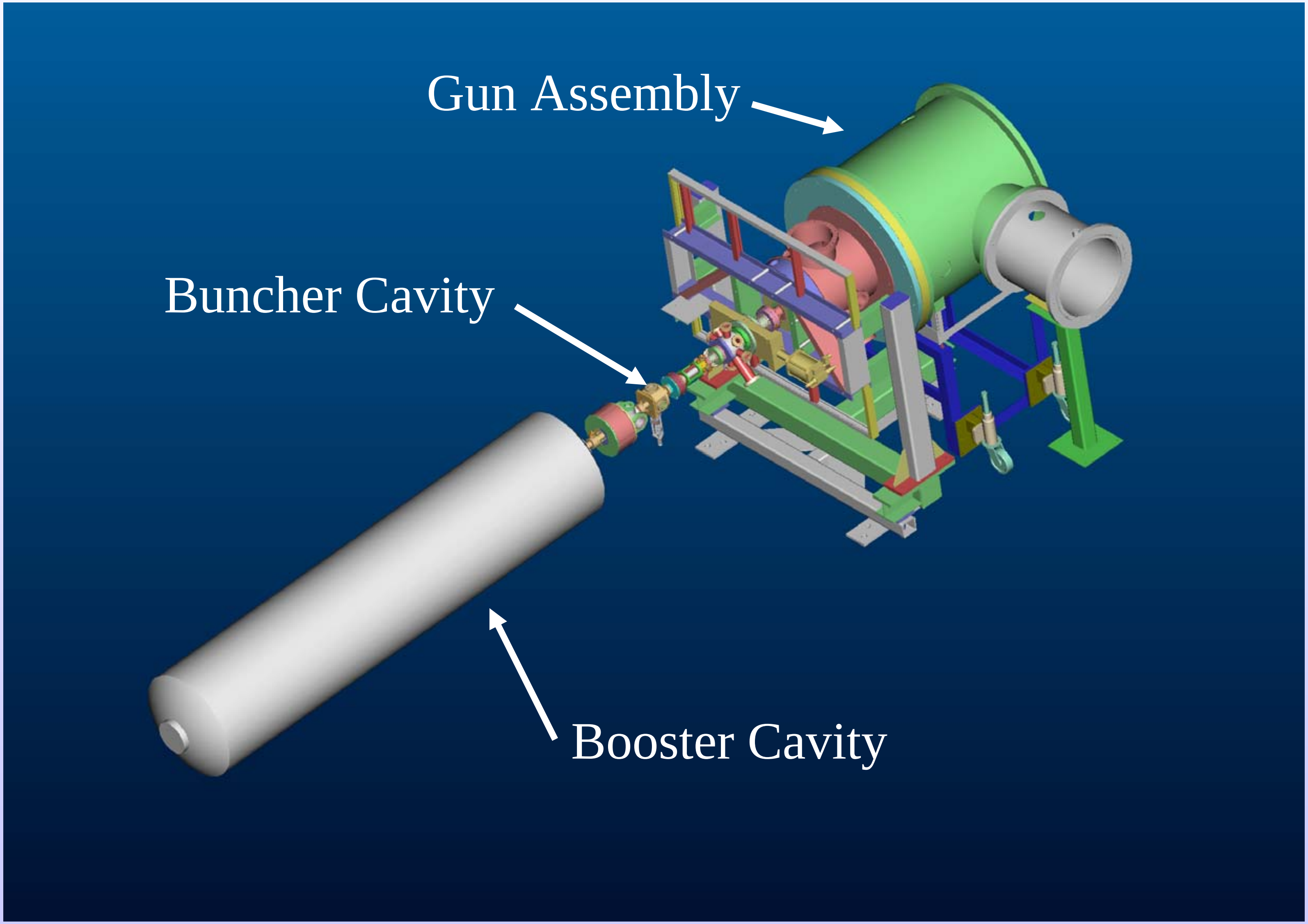
ERLP



Energy Recovery Linac Project Building Layout

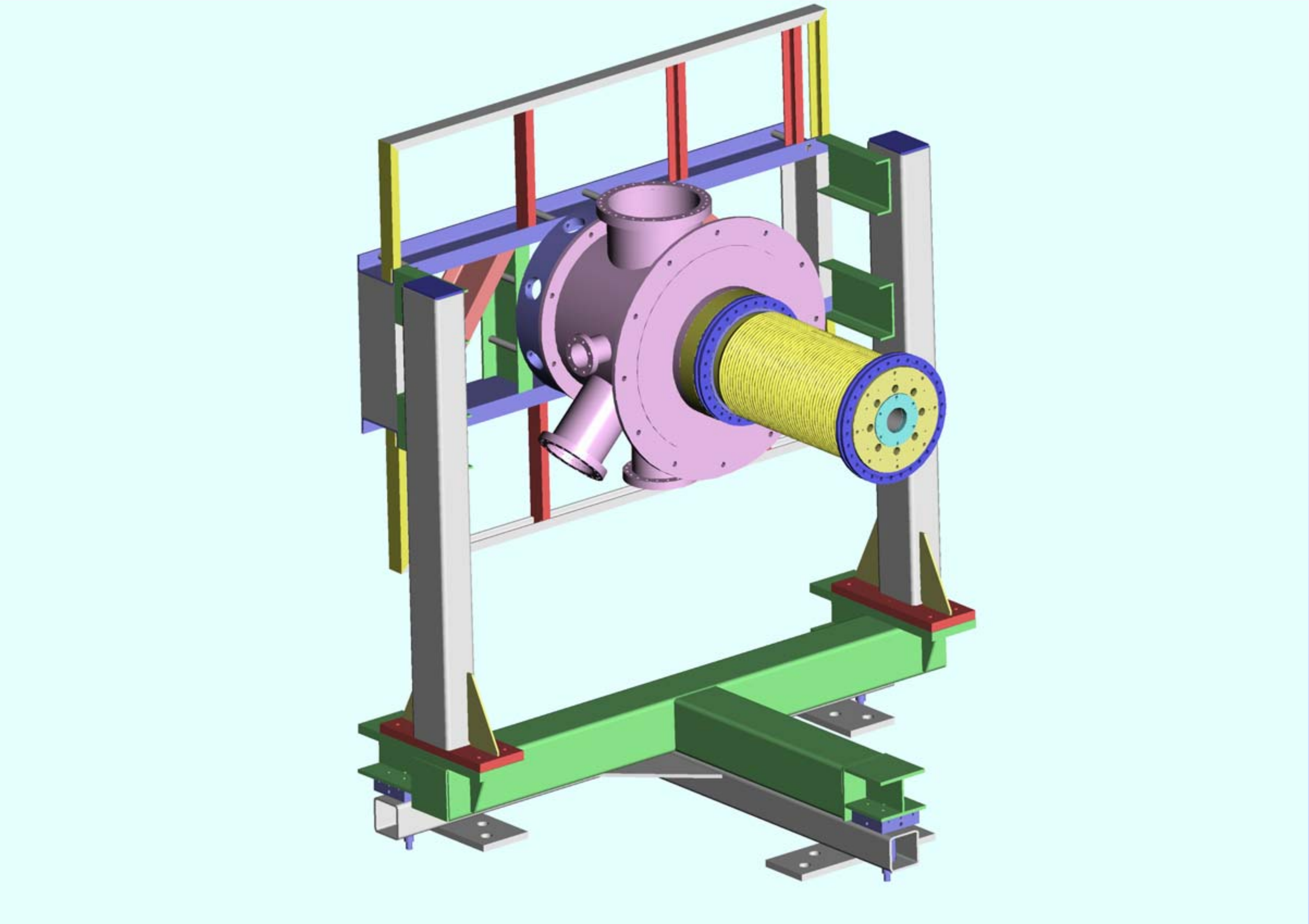
Constructed from Layout Drawing - 180/10080 A

Injector Layout



Gun

Gun



Gun

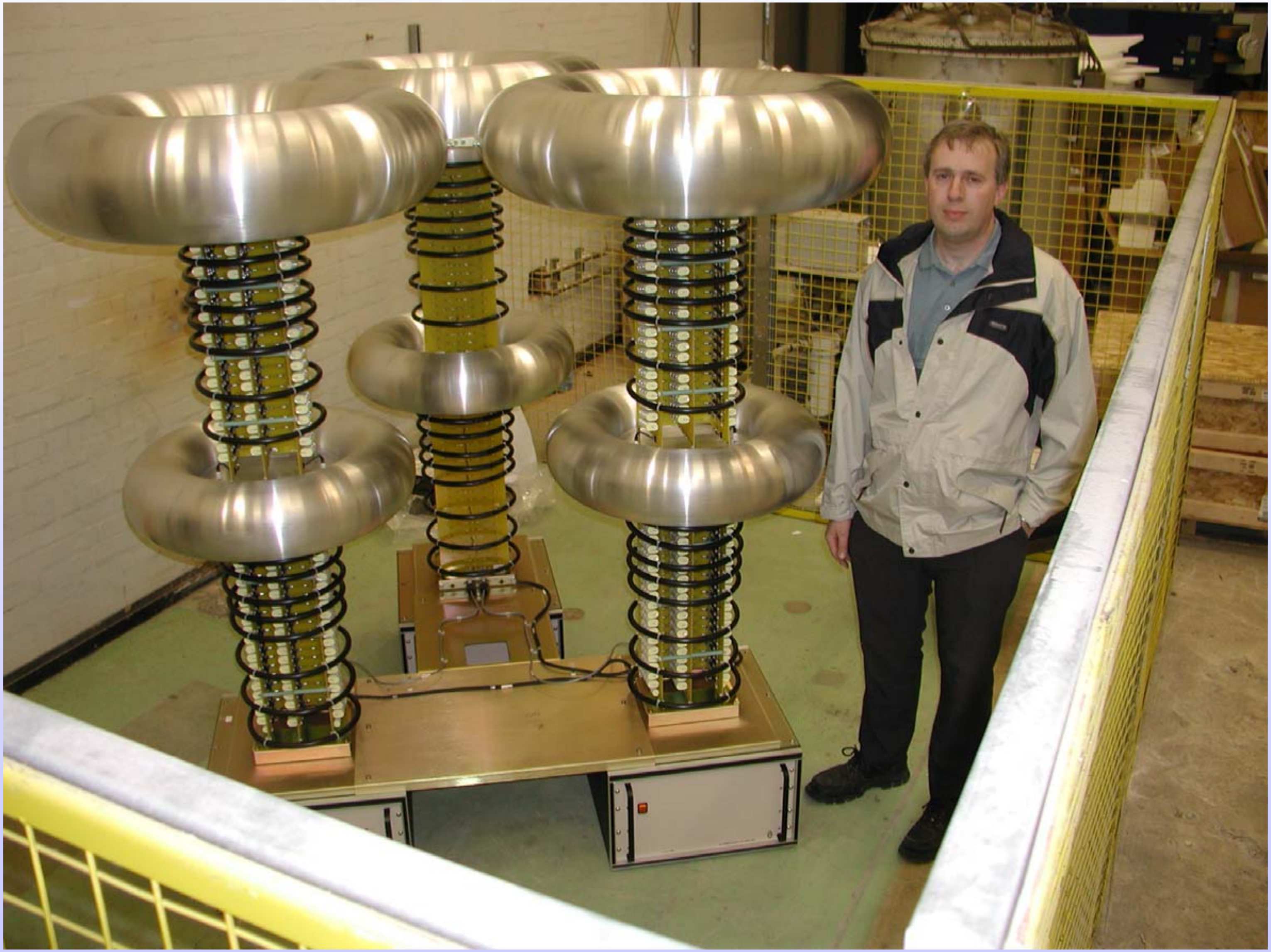
Gun Power Supply

- Glassman PK500N008GD5

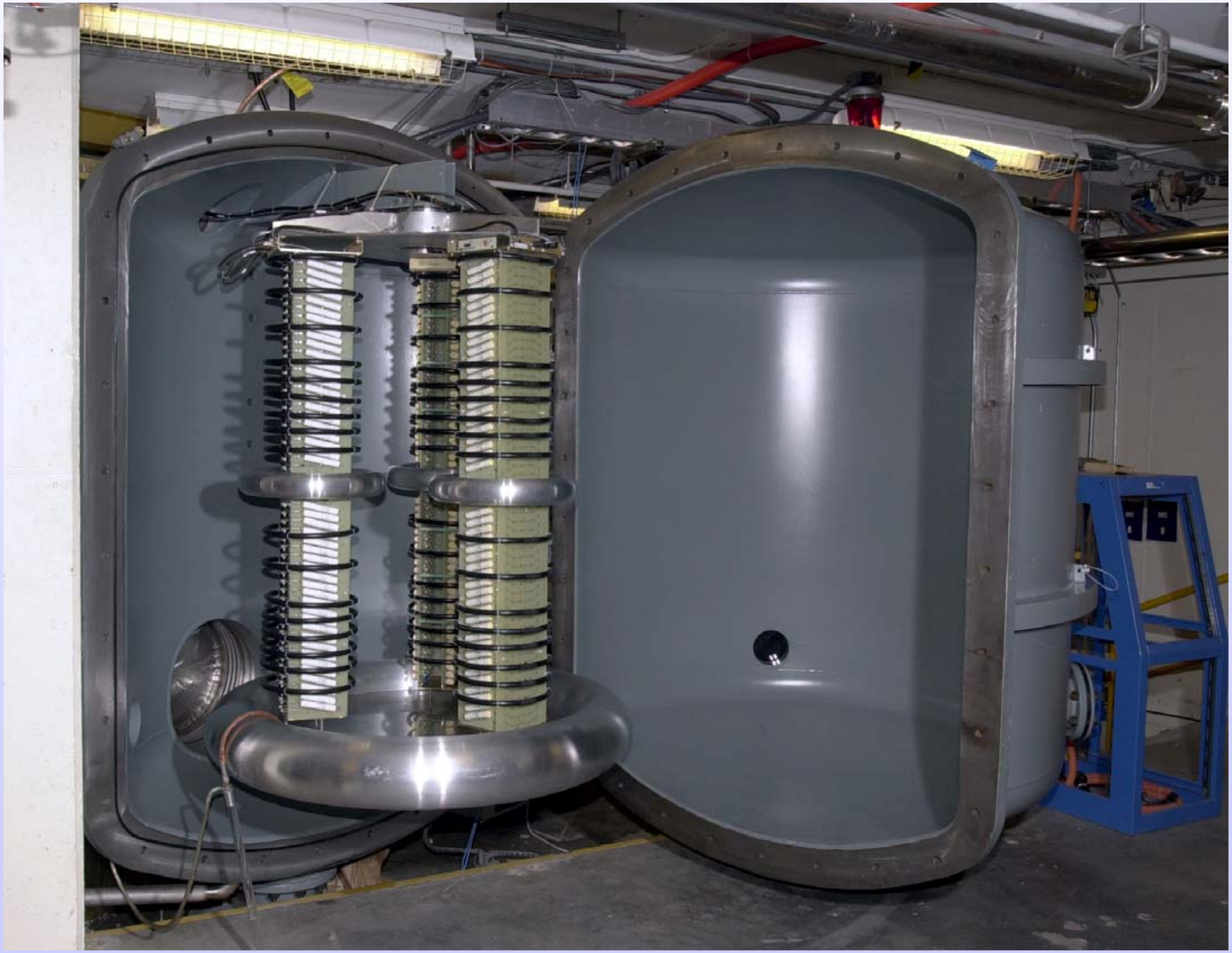
- Voltage -500 kV
- Current 8 mA
- Cockcroft-Walton based multiplier

- Delivered December 2003

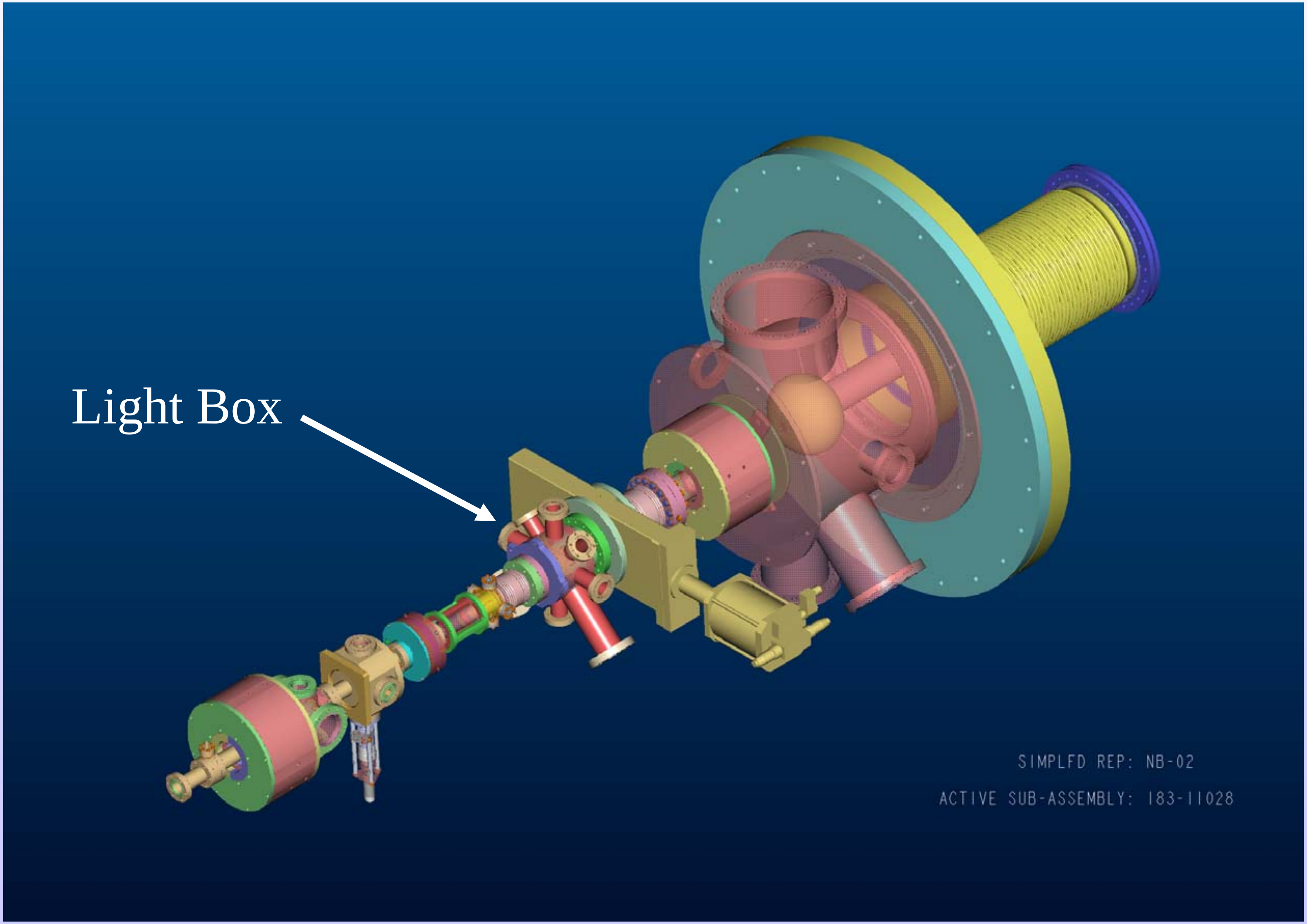
Gun Power Supply



SF_6 Tank



Vacuum



Laser

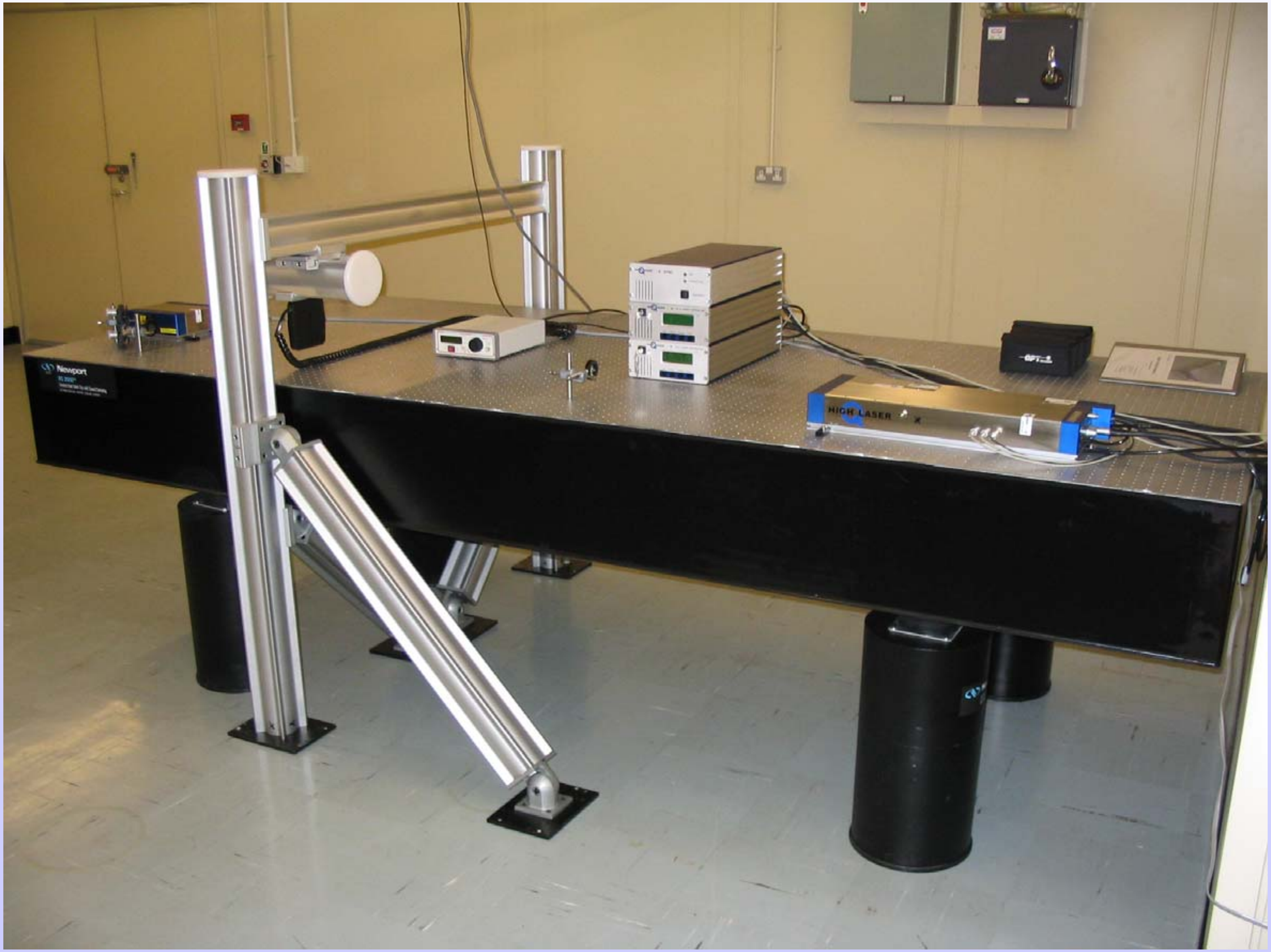
- Basic laser delivered and set up at CLF, but far from complete
- Still need system to provide macro pulses

• Power	10 W in Infrared
	5 W in Green
• Pulse width	6 – 7 ps in Green
• Repetition Rate	81.25 MHz (CW)
• Jitter	<0.5 ps
• Beam Quality M2	<1.2

Laser

- Wavelength: 1.05μm, multiplied to 0.53μm/0.26μm (NdY:VO_4)
- Pulse energy: 80nJ on target
- Pulse duration: 10ps FWHM
- Pulse repetition rate: 81 MHz
- Macropulse duration: 20 ms
- Duty cycle: 0.2%
- Timing jitter: <1ps
- Spatial profile: circular (top hat) on photocathode

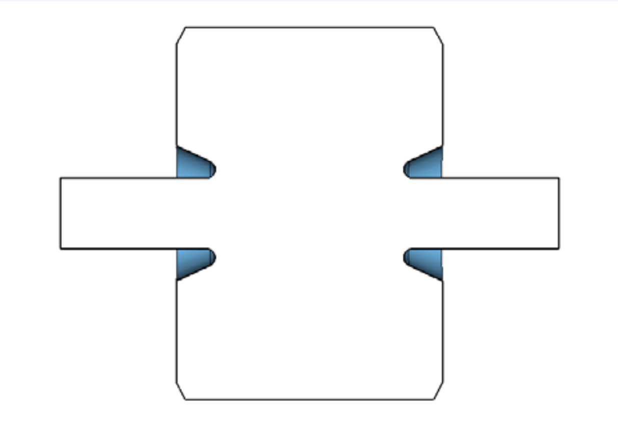
Laser



Buncher Cavity Requirements

- Single Cell
- 1.3 GHz
- Longitudinal bunch compression
- No Acceleration
- Zero-phase crossing angle

Design Options

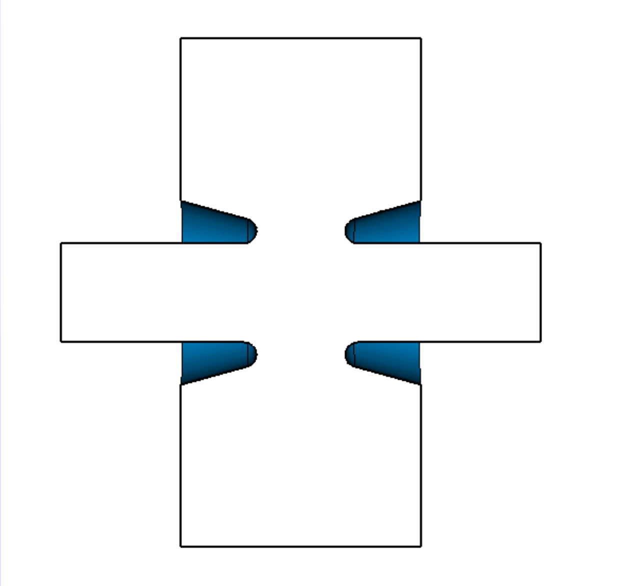


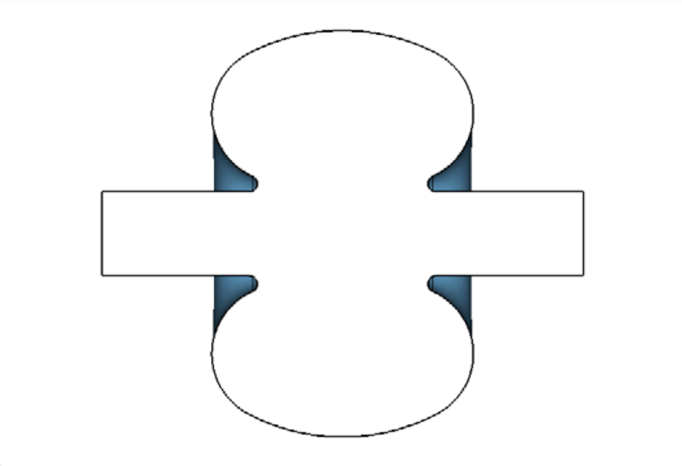
EU Cavity

A scaled version of the 500 MHz HOM Damped cavity.

ELBE Design

Copy of the buncher used at ELBE.

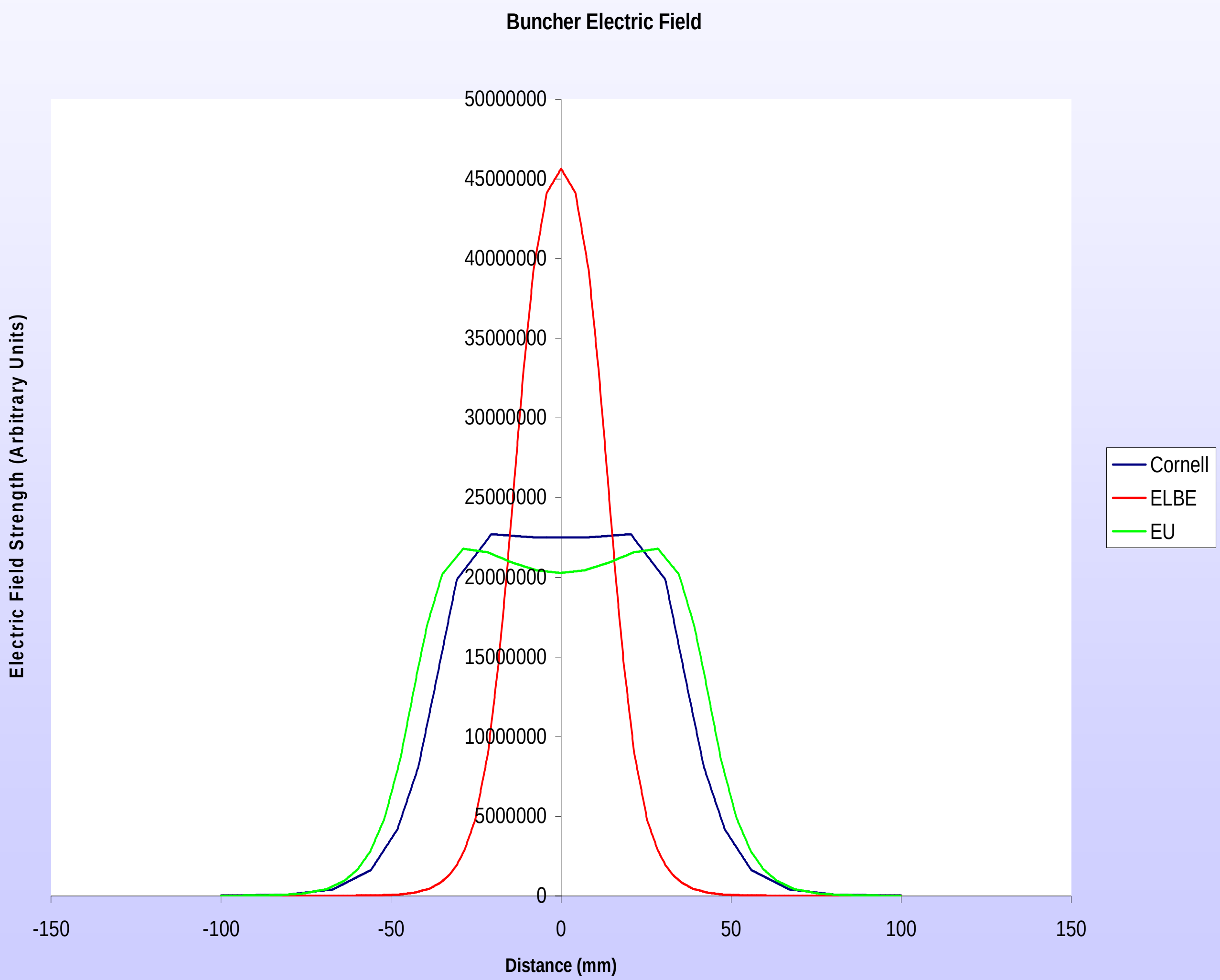




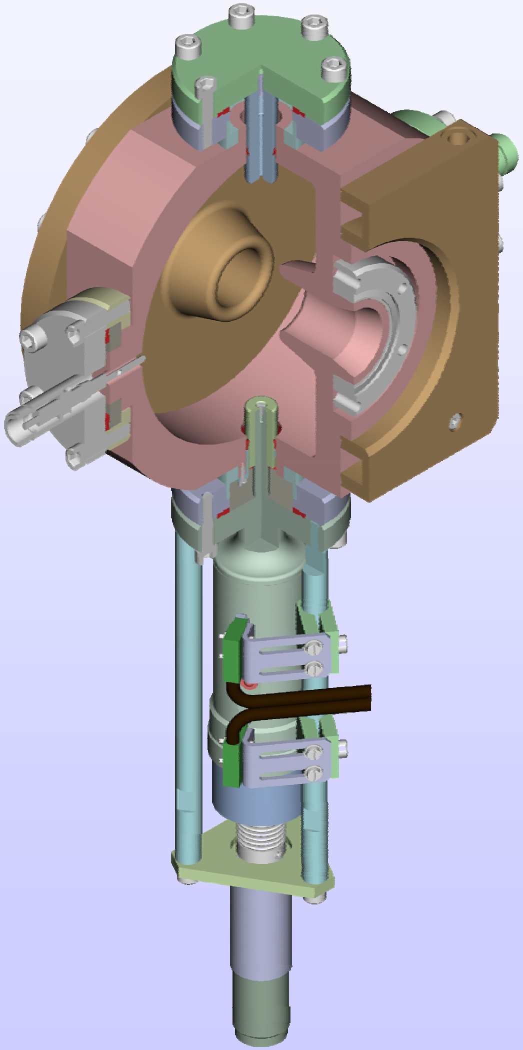
Cornell Design

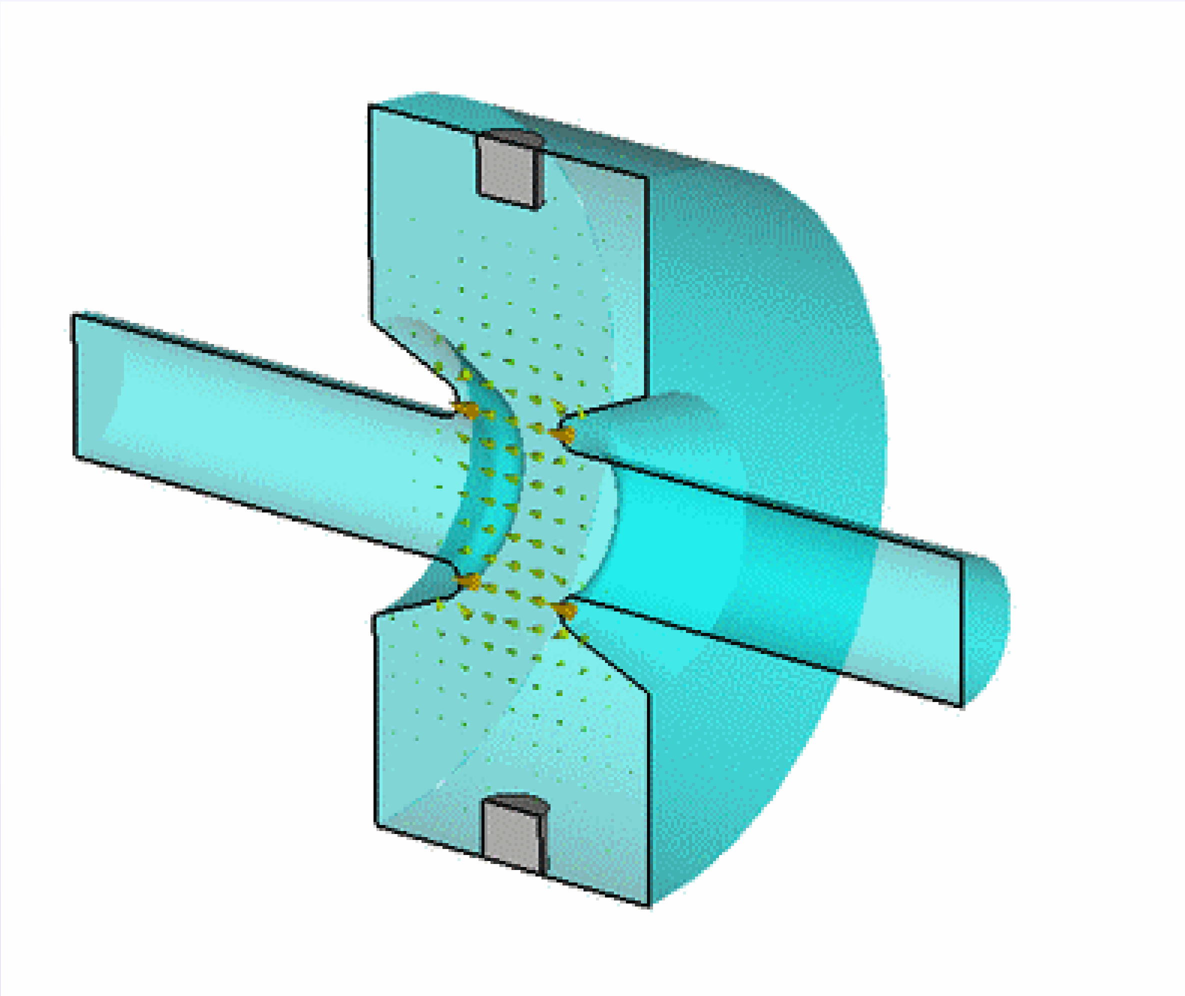
Based on a scaled version of the PEPII cavity.

Field Profile

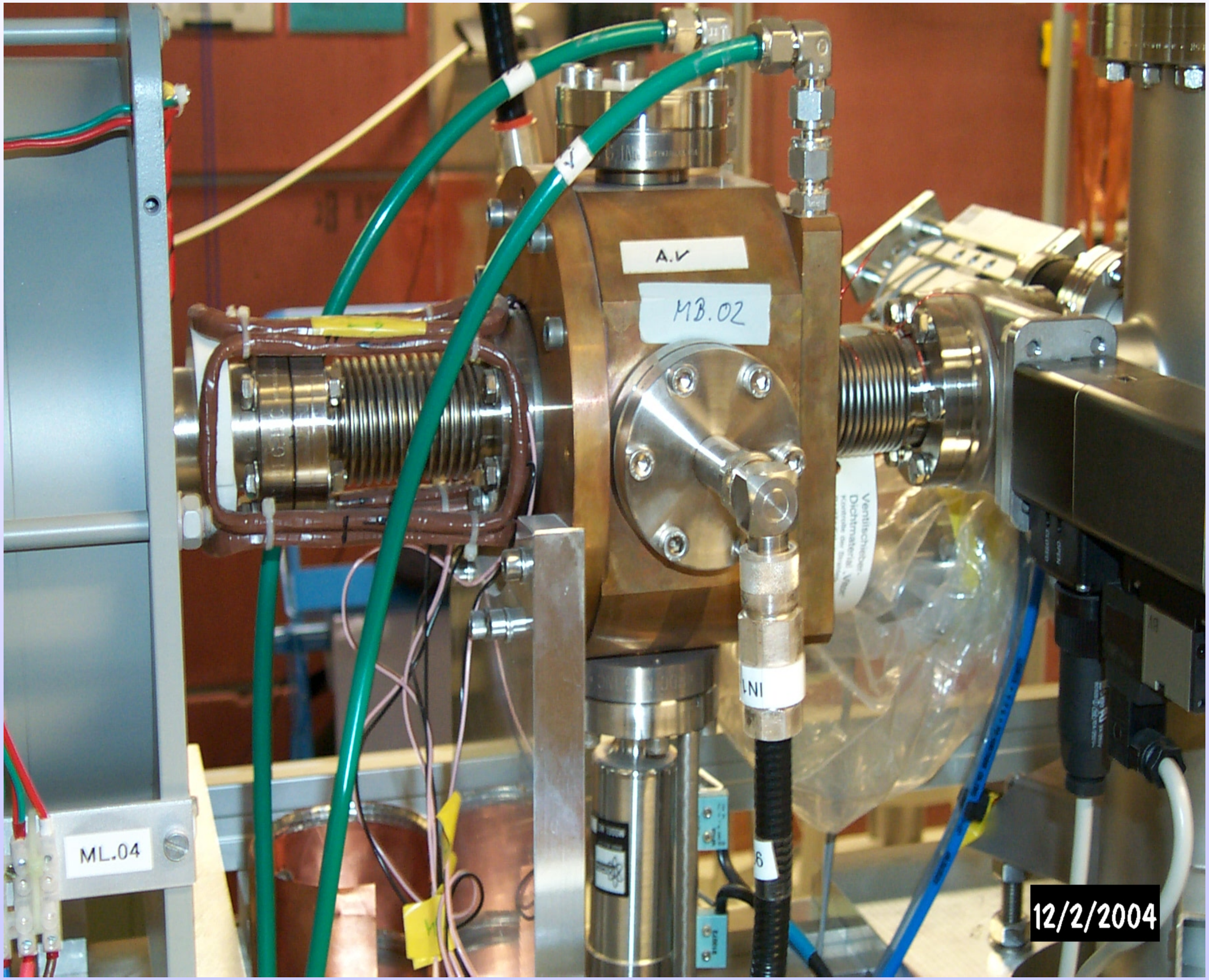


ELBE

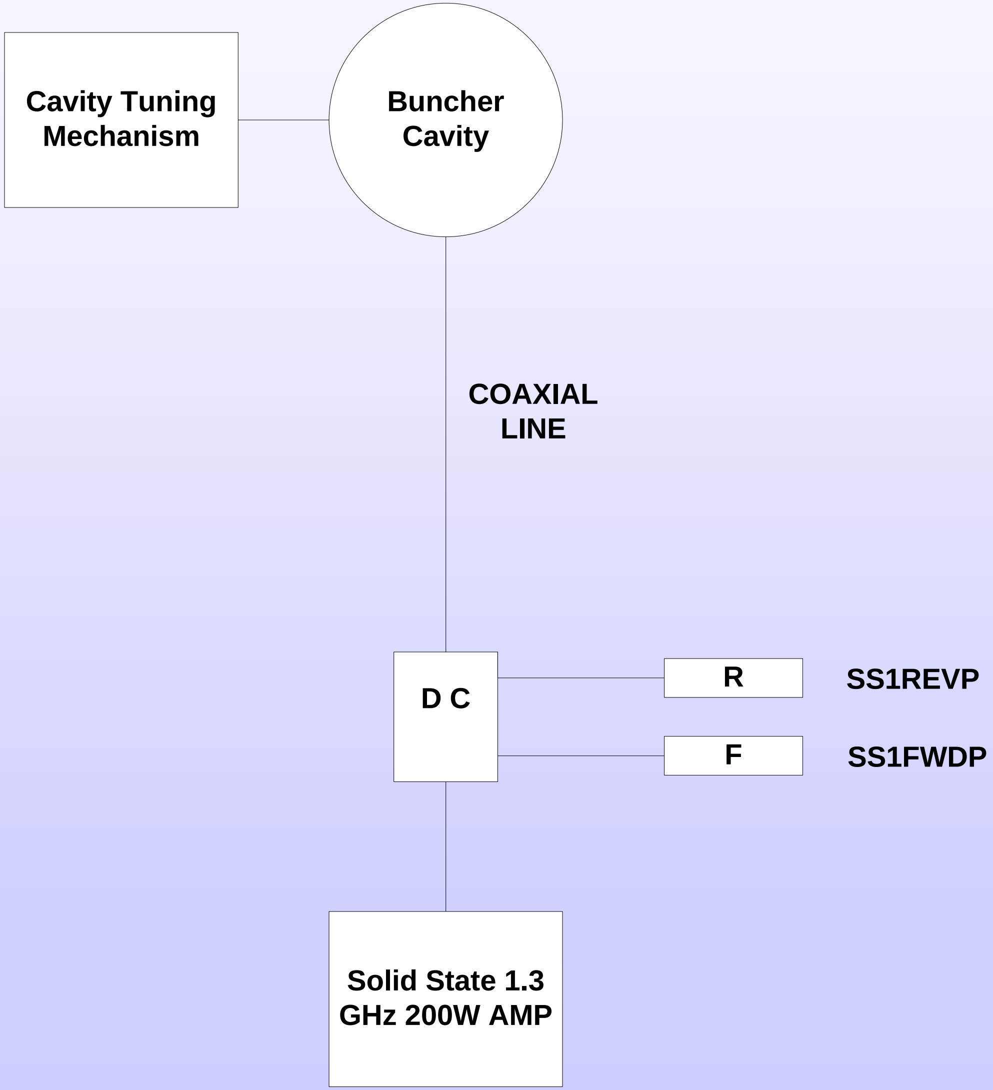




Installed at ELBE



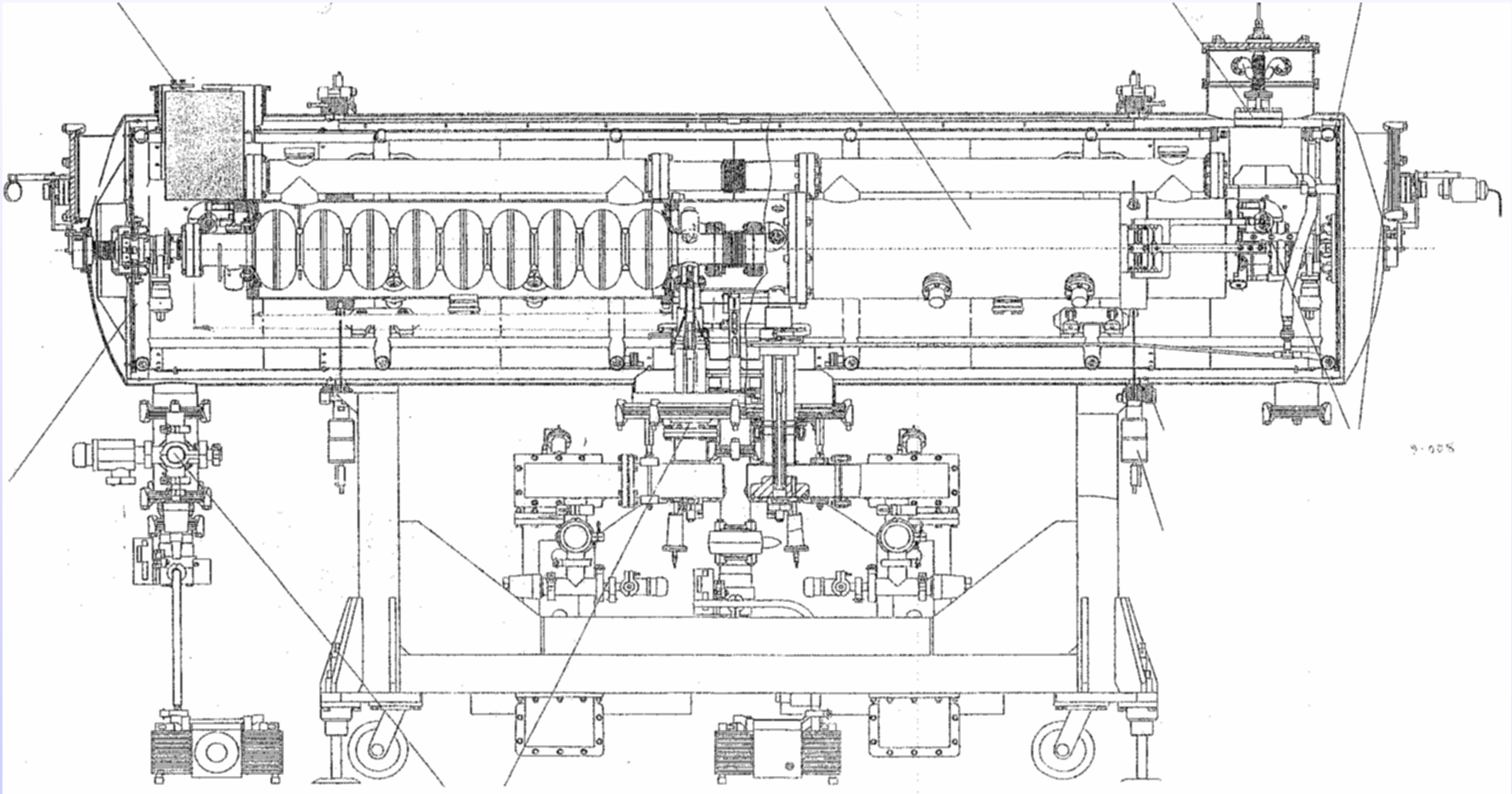
Buncher RF Power System



Booster Cavity

- Order placed 23rd March – Accel
- Rossendorf Module – two TESLA cavities
- Energy Gain 8 MeV
- Independent control of Q_{ext}
- Independent control of cavity phase

Booster Cavity

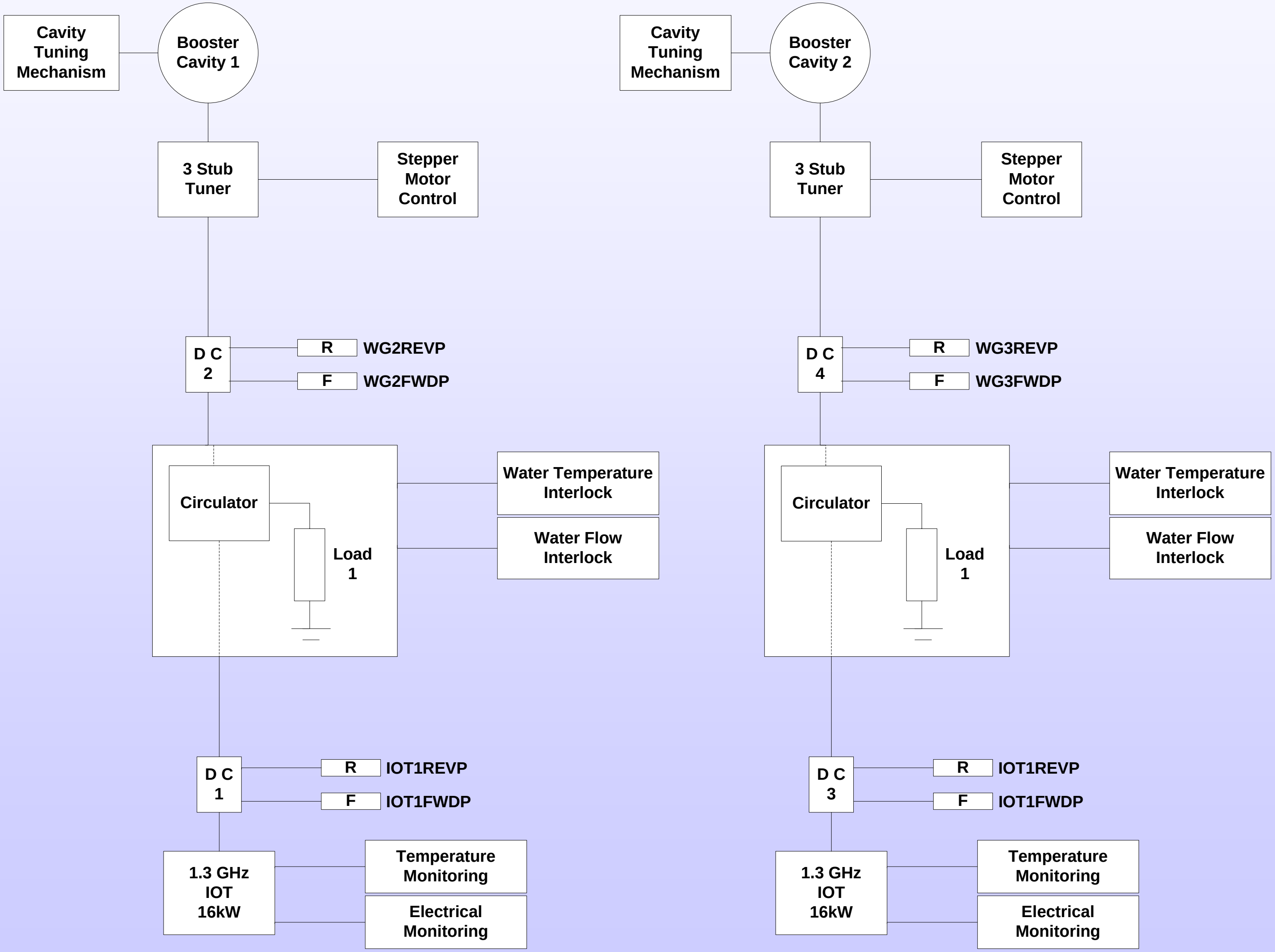


ELBE Type Cryostat with dual Tesla Linac Sections

Booster Cavity

TESLA Cavity

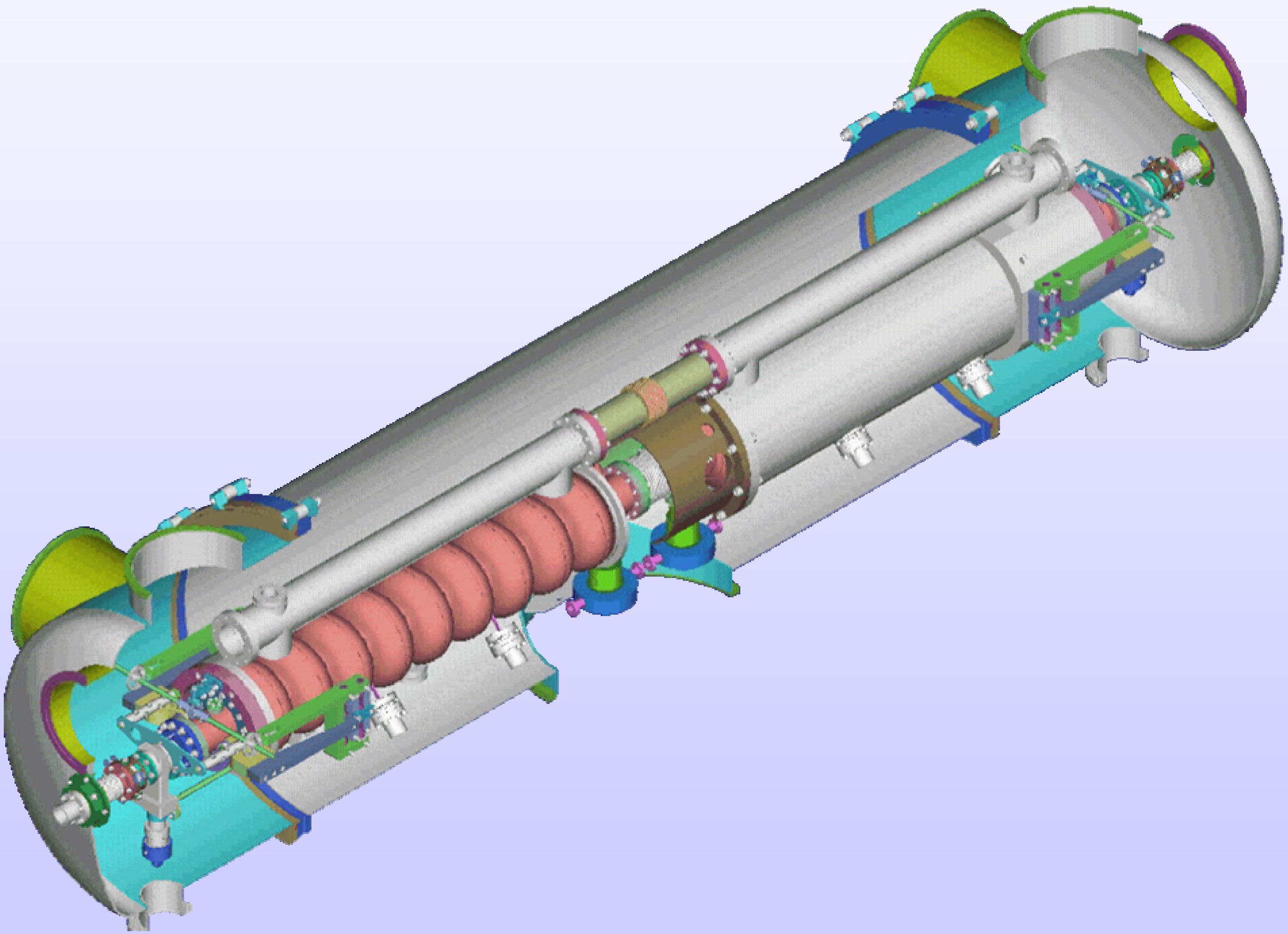
Booster RF Power System



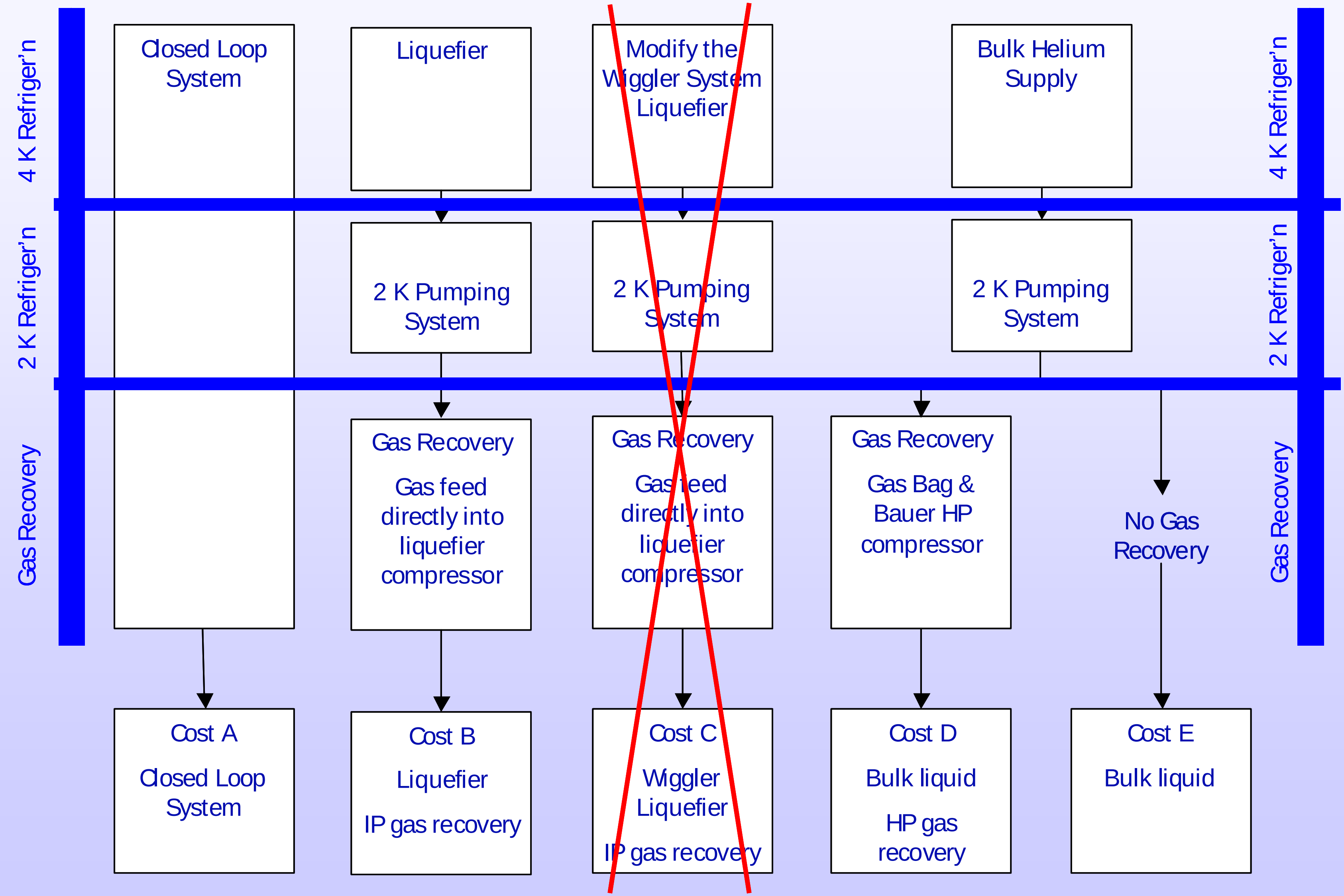
Linac Module

- Order placed 23rd March – Accel
- Rossendorf Module – two TESLA cavities
- Energy Gain 26.65 MeV
- Independent control of Q_{ext}
- Independent control of cavity phase

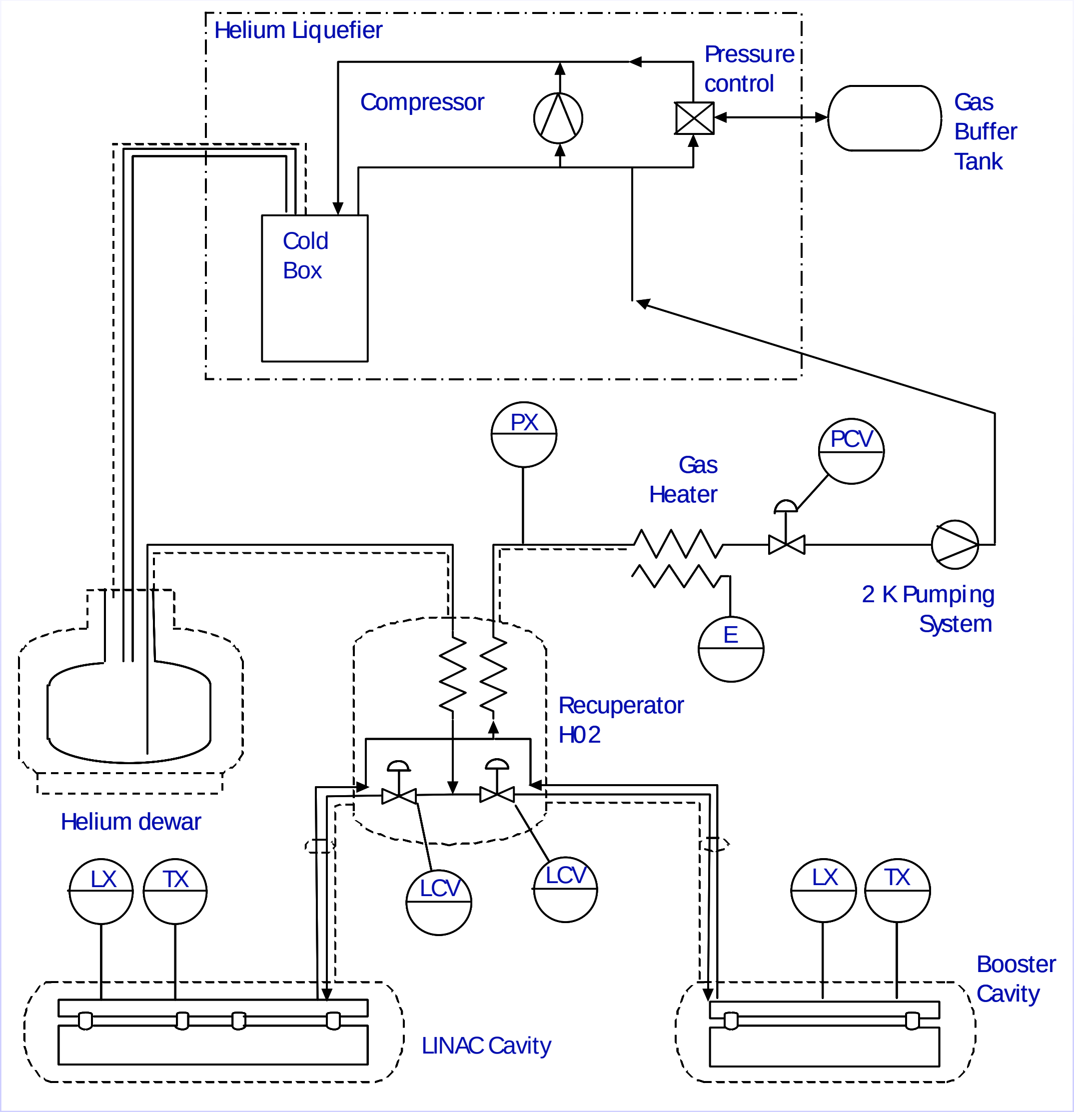
Linac Module



Cryogenics


4 K Refriger'n
2 K Refriger'n
Gas Recovery
Closed Loop System
Liquefier
Modify the Wiggler System Liquefier
Bulk Helium Supply
2 K Pumping System
2 K Pumping System
2 K Pumping System
Gas Recovery
Gas feed directly into liquefier compressor
Gas Recovery
Gas feed directly into liquefier compressor
Gas Recovery
Gas Bag & Bauer HP compressor
No Gas Recovery
Cost A
Closed Loop System
Cost B
Liquefier
IP gas recovery
Cost C
Wiggler Liquefier
IP gas recovery
Cost D
Bulk liquid
HP gas recovery
Cost E
Bulk liquid
4 K Refriger'n
2 K Refriger'n
Gas Recovery

Cryogenics



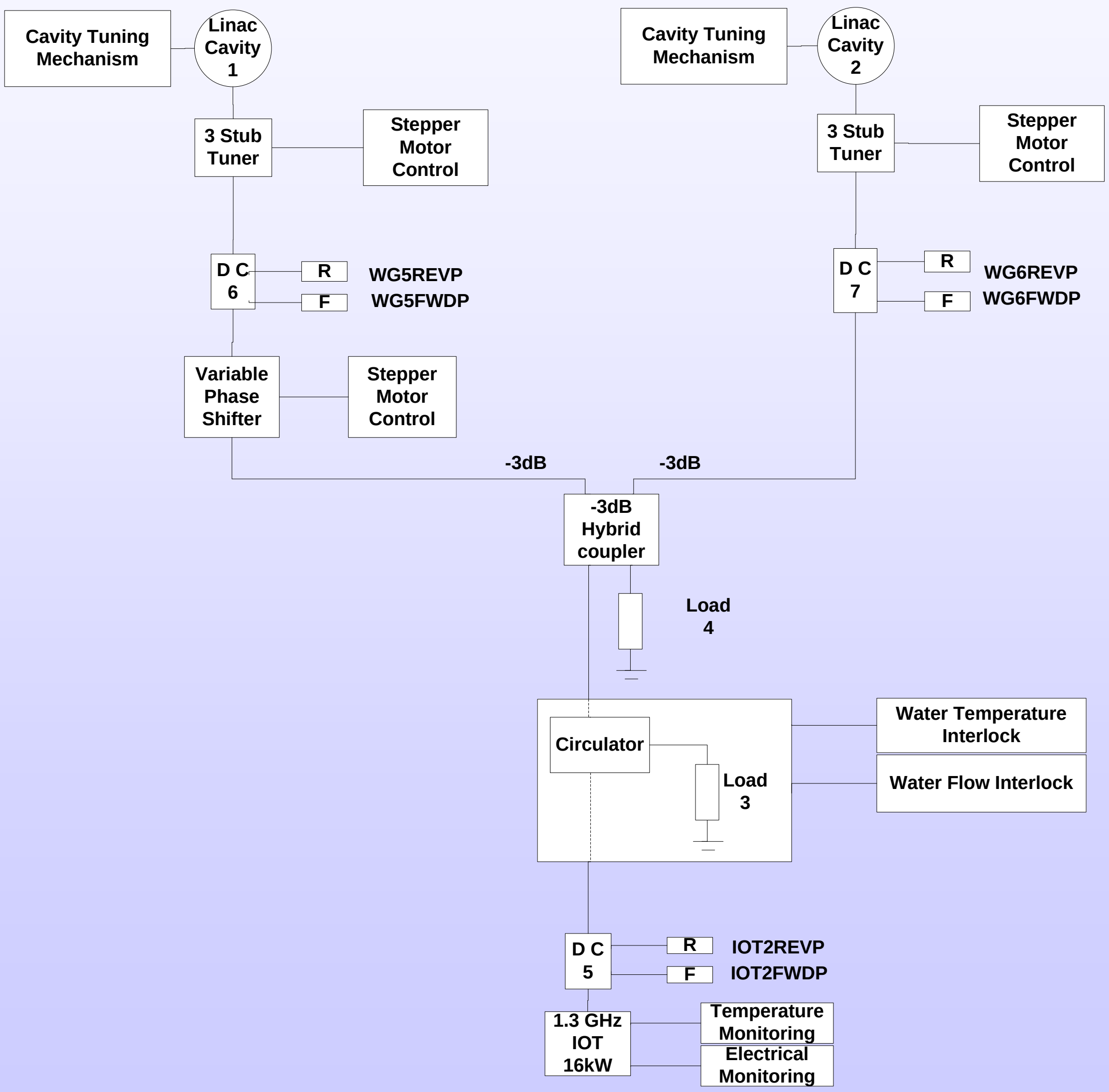
EQUIPMENT LIST

1. Liquefier
2. Gas buffer tanks
3. Recuperator H02 & control valves LCV
4. Gas Heater plus control
5. Pump system
6. Pressure control system (PCV, PX & controller)
7. Dewar pressure regulation (not shown)
8. Liquid helium dewar
9. Transfer lines
10. Pumping lines
11. Control System

Revised Specification

	Static Duty	Dynamic Duty	Total Duty	Time Averaged	
TOTAL SYSTEM					
Cavities	45.1	161.3	206.4		litres / hour
Main transfer lines	24.4		24.4		litres / hour
Other equipment	12.8		12.8		litres / hour
Total consumption	82.3	161.3	243.6	109	litres / hour
	1650		974	2620	litres / day

Linac RF Power System



DC Power Supply

IOT 116LS

e2v IOT

- 1st prototype power tested 21/06/04
- Design power 16kW
- Design frequency 1.3/1.5GHz
- Conservative gun design
- Input cavity with large adjustment
- Output cavity with adjustable tuner
- Result Power 20kW; 50% efficiency

Programme

• Laser installed	Nov 04
• Gun assembled	Feb 05
• Cryogenics installed	Jul 05
• Booster cavity delivered	Oct 05
• Linac cavity delivered	Dec 05
• 1st beam	Apr 06

Further Information

Collaborations:

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e.a.seddon@dl.ac.uk

http://www.4gls.ac.uk