Summary of Working Group 2 (Tuesday)

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(1) Project overviews
   - (a) JLAB
   - (b) Cornell
   - (c) Daresbury
   - (d) KEK / JAEA

(2) Are there optimal schemes to minimize bunch length and energy spread?

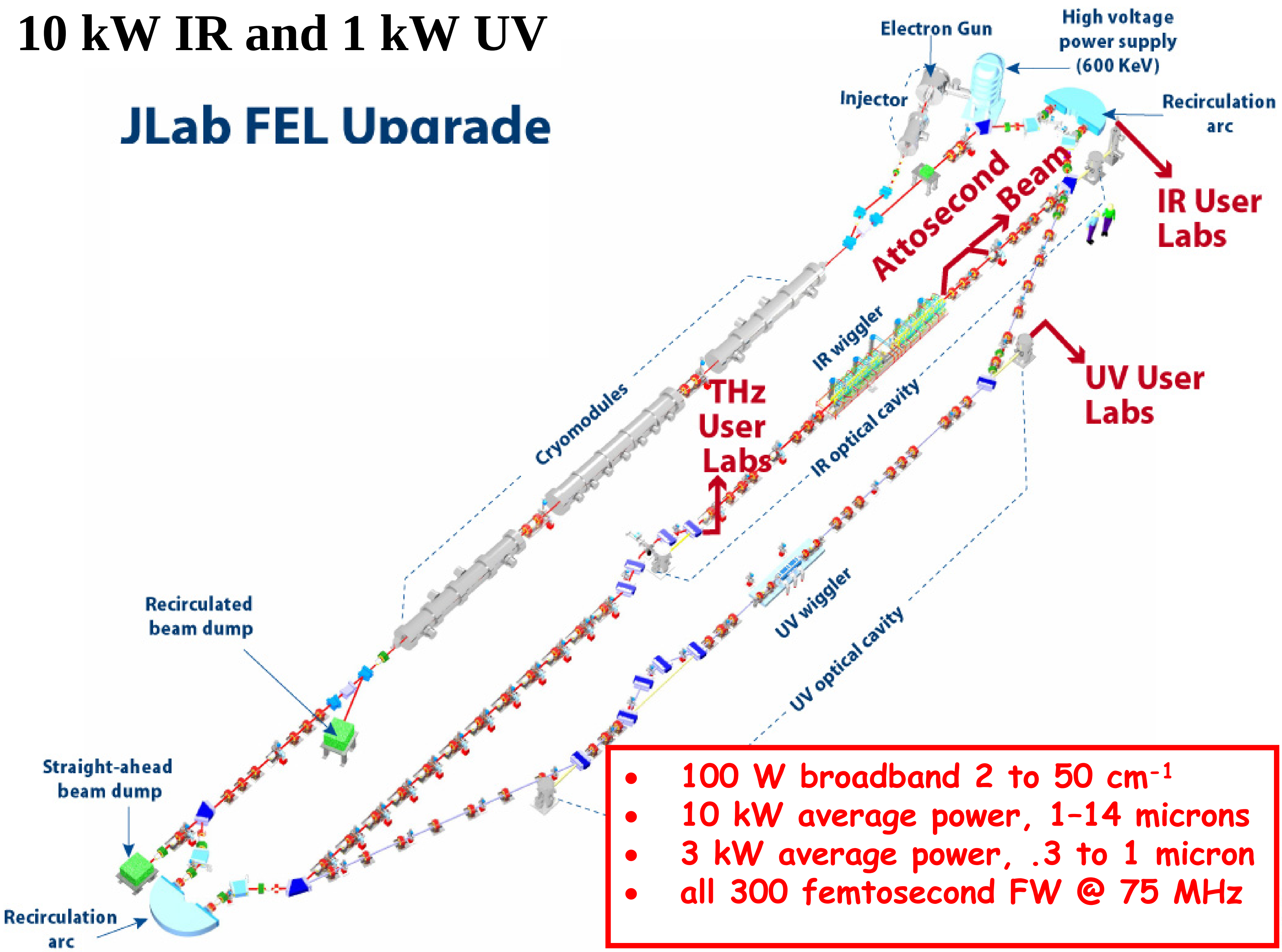
(3) What is the optimal injector-to-linac merger design for ERLs?

(4) What should start to end simulations include?

(5) What are beam abort strategies and beam loss tolerances?

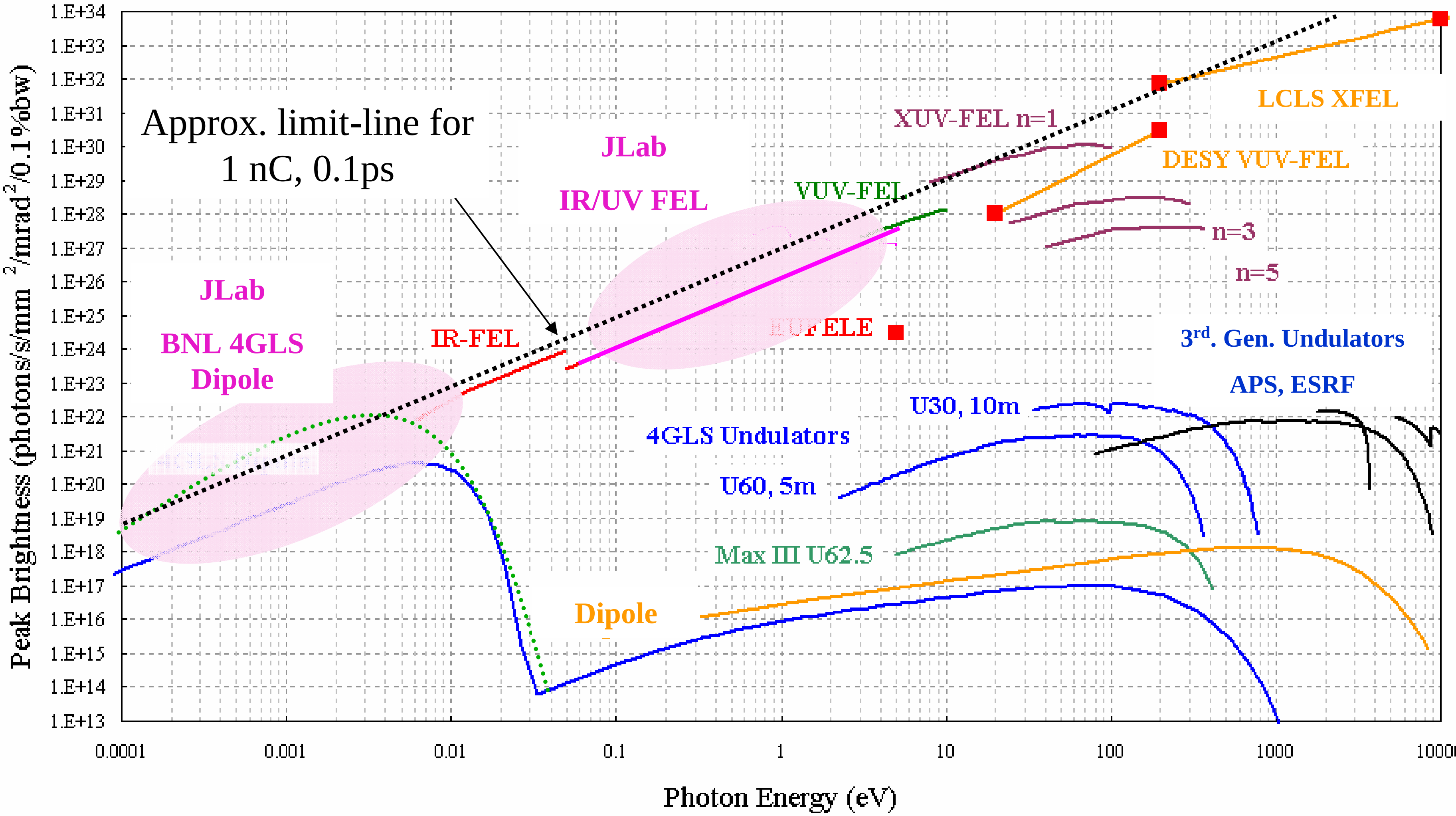
(6) What are diagnostic needs specific to x-ray ERLs?

10 kW IR and 1 kW UV



- 100 W broadband 2 to 50 cm^{-1}
- 10 kW average power, 1–14 microns
- 3 kW average power, .3 to 1 micron
- all 300 femtosecond FW @ 75 MHz

Light Source Landscape



All data is approximate for illustrative purposes

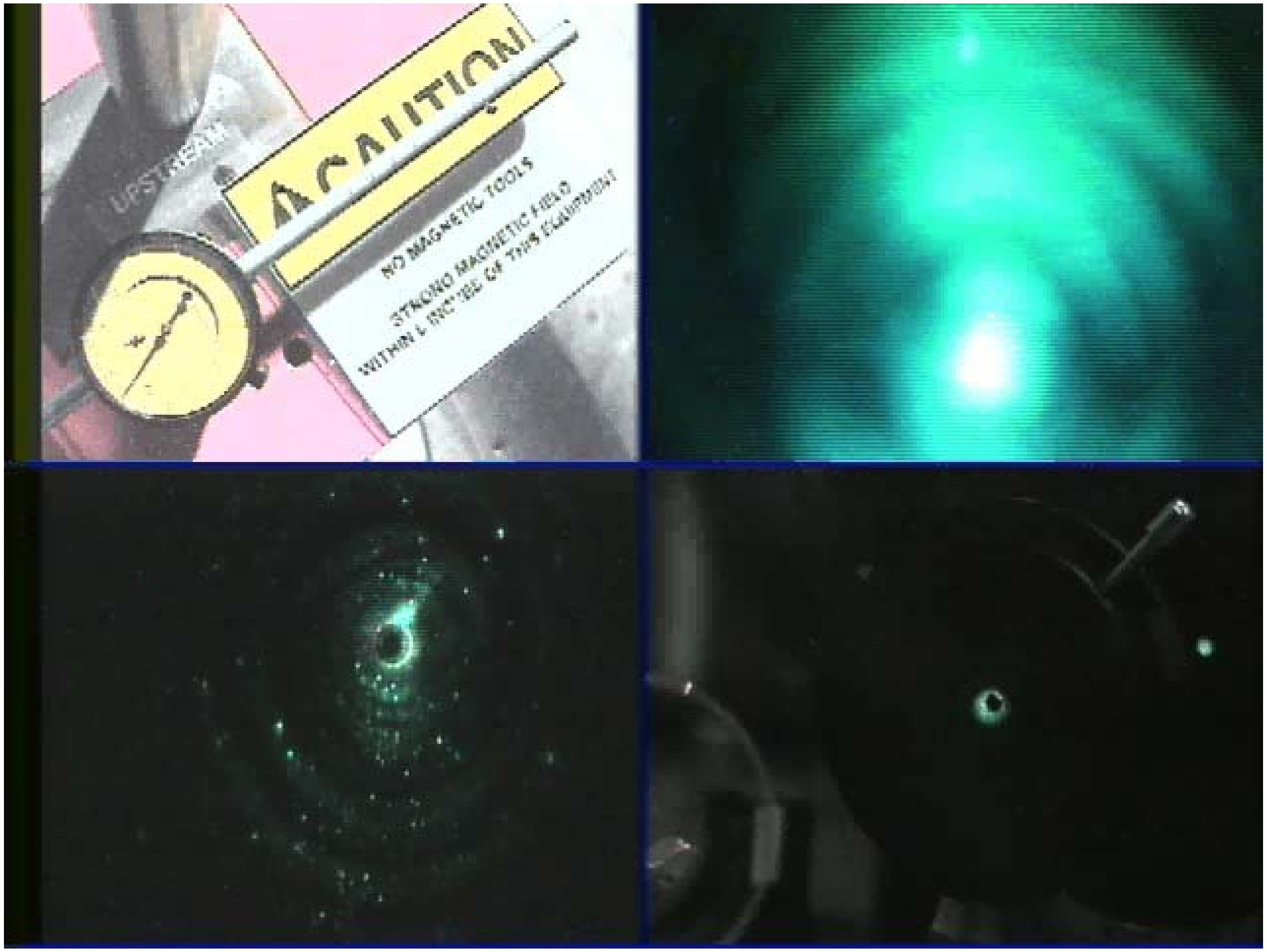
Wendy Flavell Manchester University UK

Harmonic Radiation while lasing

Tuning movie

Wiggler gap

High Reflector



Hole Outcoupler

Beam in control room

ERL Layout

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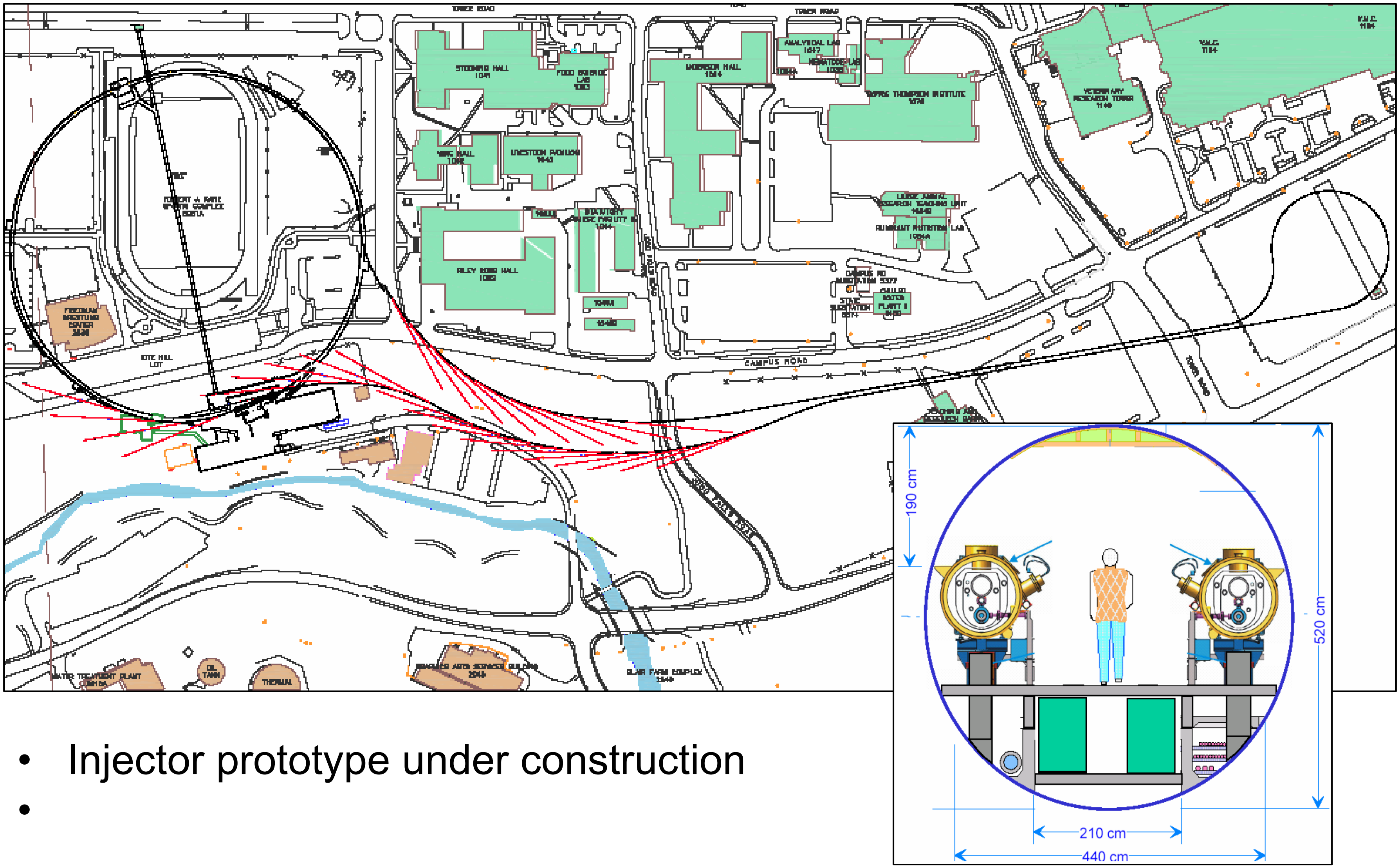
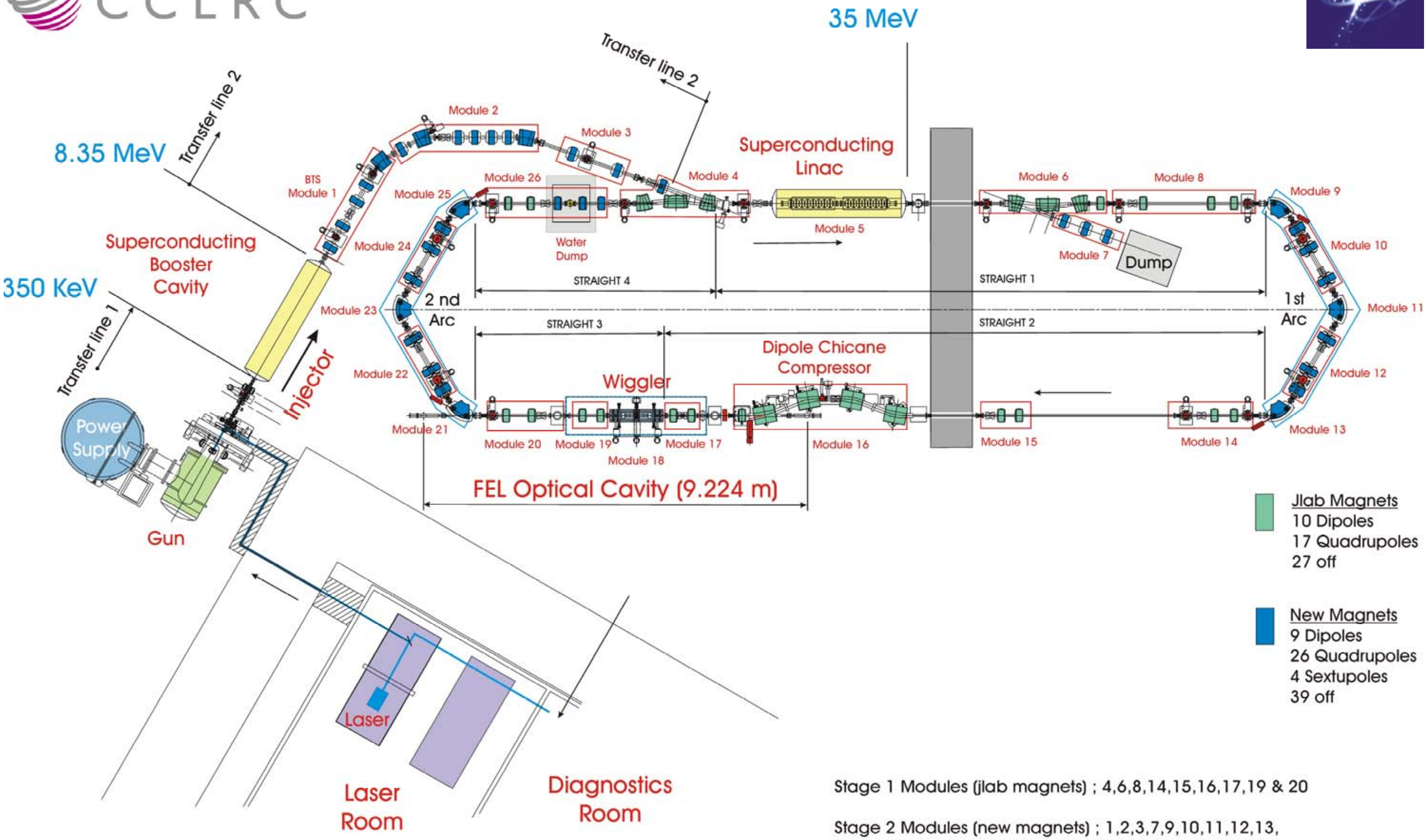


- Injector prototype under construction
-

Constructed from Layout Drawing - 1

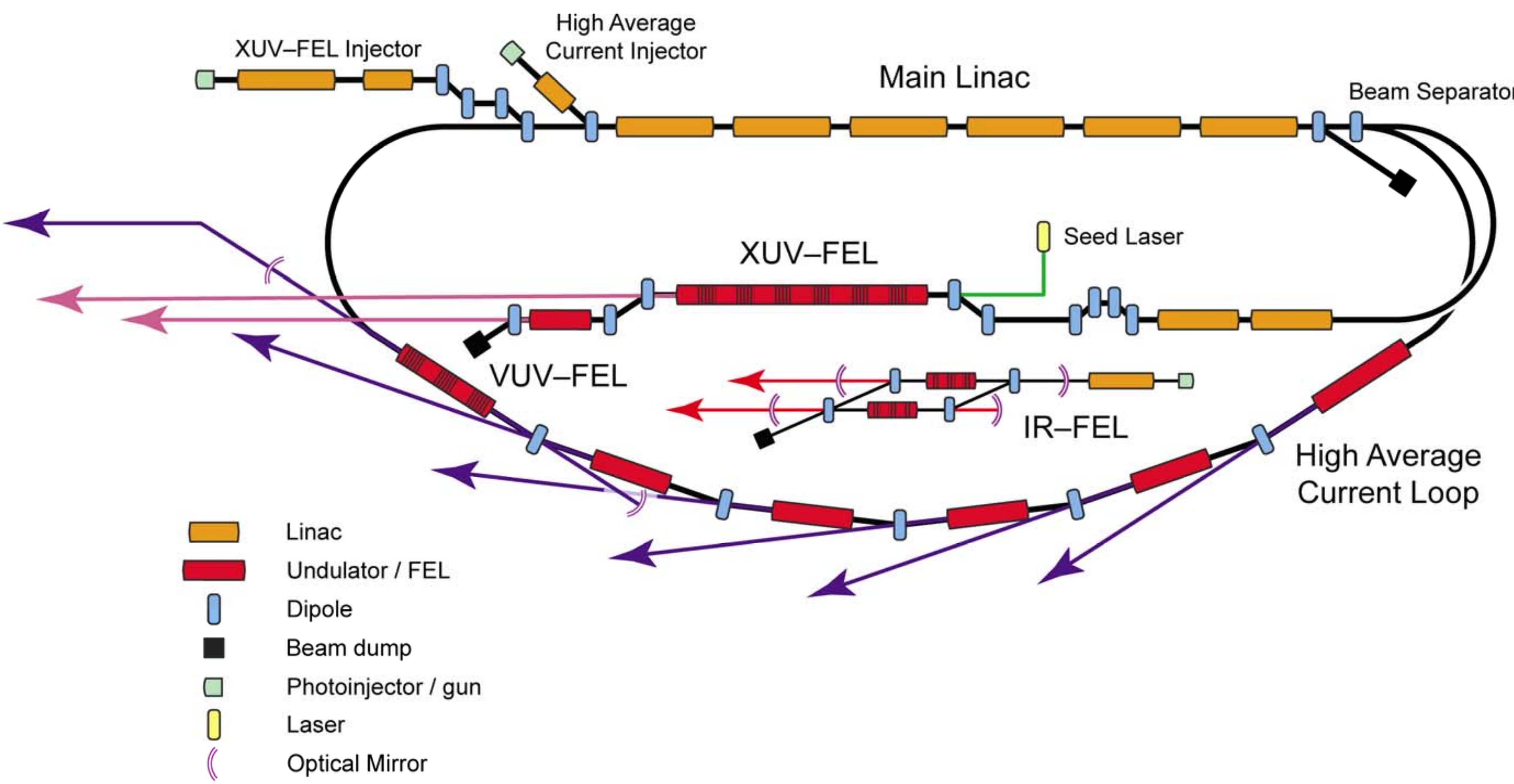


Stage 1 Modules (jlab magnets) ; 4,6,8,14,15,16,17,19 & 20

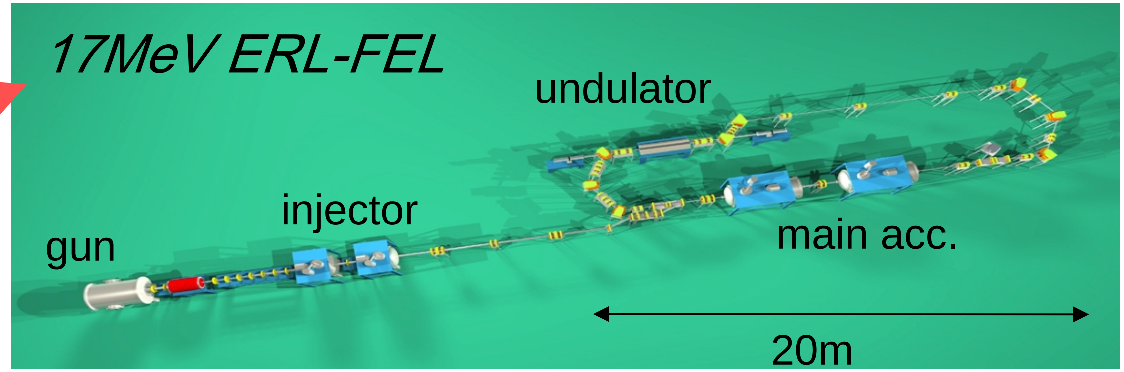
Stage 2 Modules (new magnets) ; 1,2,3,7,9,10,11,12,13, 21,22,23, 24, 25 & 26

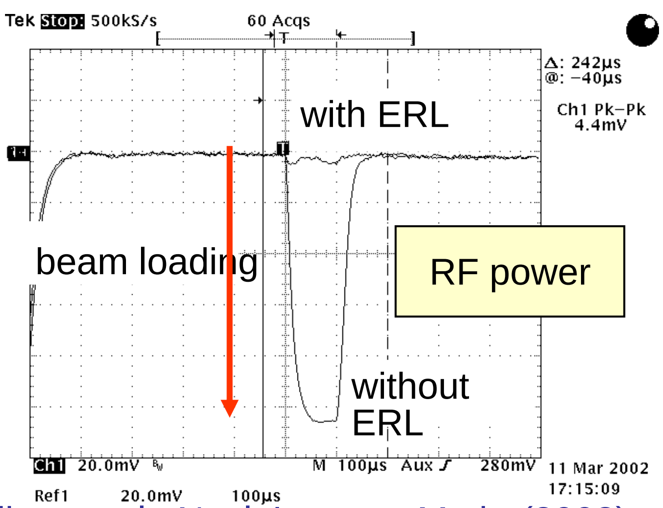
Stage 3 Module (Wiggler) ; 18

Conceptual Layout of 4GLS

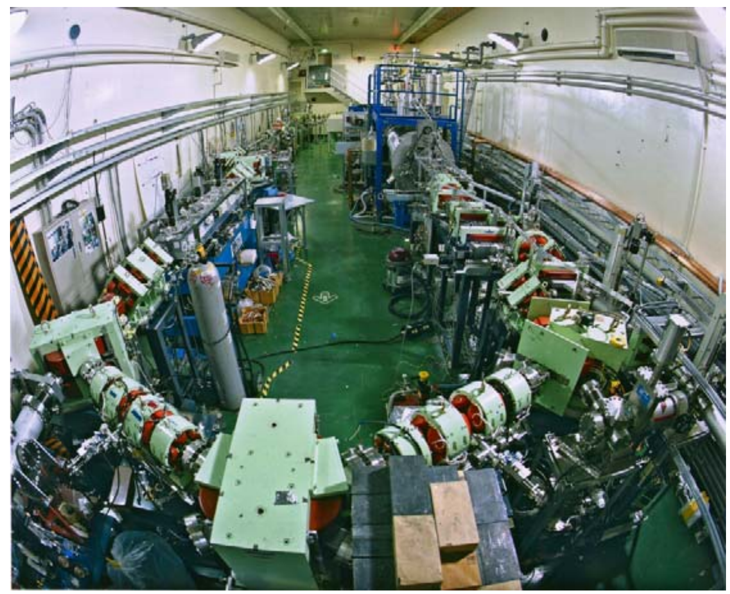


17MeV ERL at JAEA



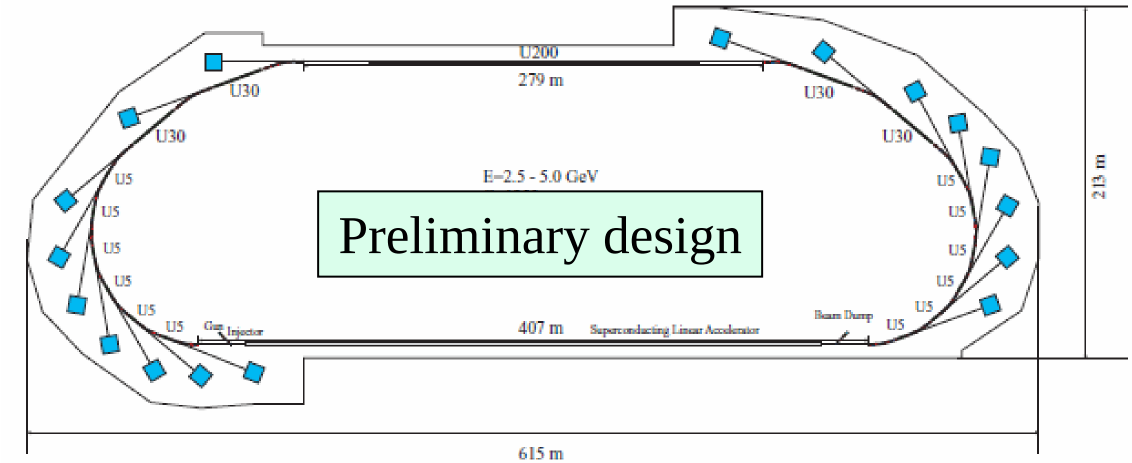


R. Hajima et al., Nucl. Instrum. Meth. (2003)



Design, Construction and Operation of the ERL (1999-2006)

Target specifications of ERL



Beam energy	5 GeV
Average current	100 mA
Normalized emittance	0.1 – 1 mm·mrad
Average brilliance (@ 0.1 nm) from ID's	10^{21} – 10^{23} ph/s/0.1%/mm^2/mrad^2
Average flux	> 10^{16} ph/s/0.1%
Spectral range	30 eV – 30 keV
Minimum bunch length	< 100 fs
Number of ID's	20 - 30

Questions to Keep In Mind

- Method of Compression
  - Single Stage (JLab, ERLP)
  - Stepped/2-Stage (FLASH, XFEL, LCLS etc.)
  - Progressive/Modular (4GLS)
  - Large Dispersion/Split Linac Approach (Cornell)
  - Velocity Bunching (JAERI)
- Sextupoles or 3rd-Harmonic for Linearisation?
  - Higher-Order Terms
- Problems in Particular Machines
  - Combined Beams (4GLS)
  - Topology (Cornell)

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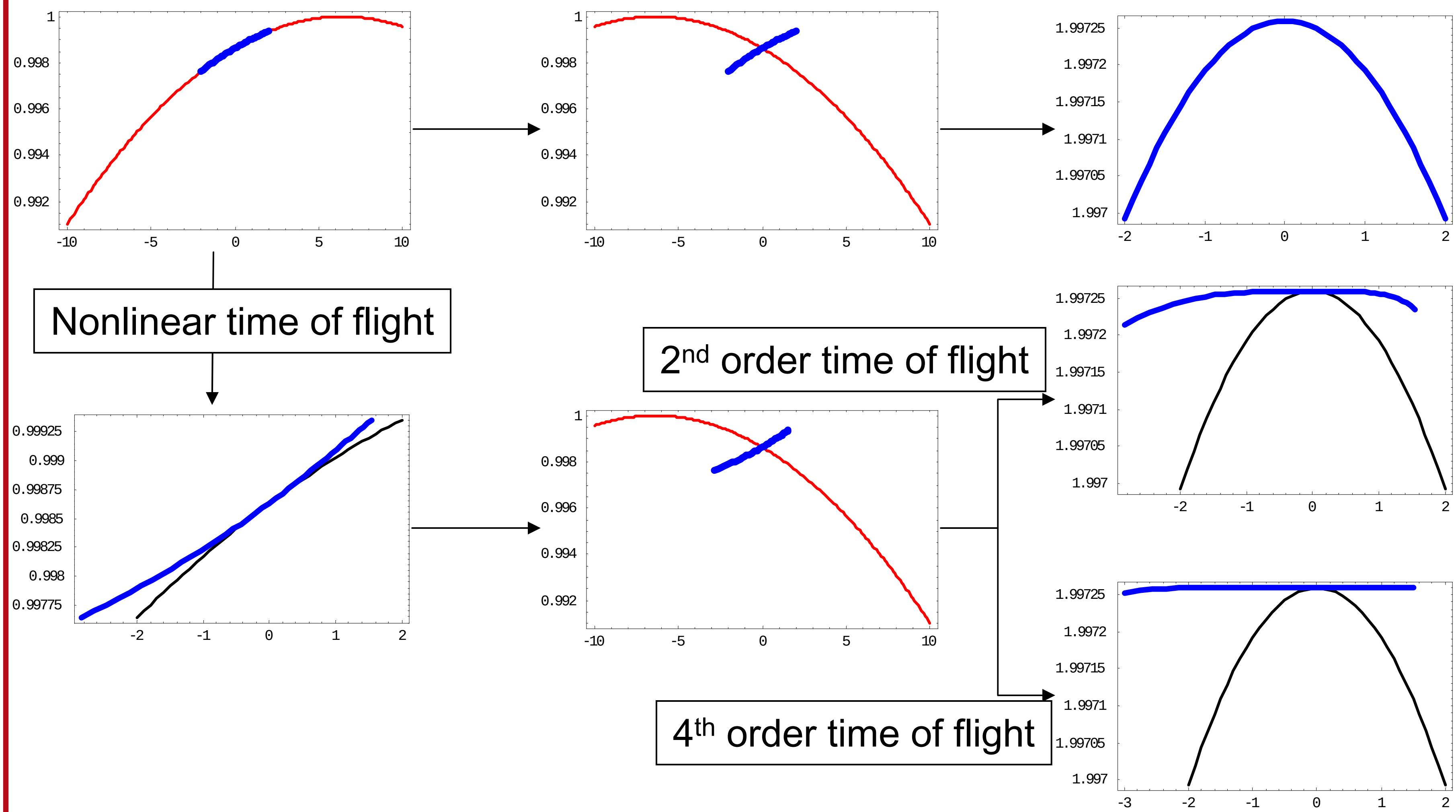
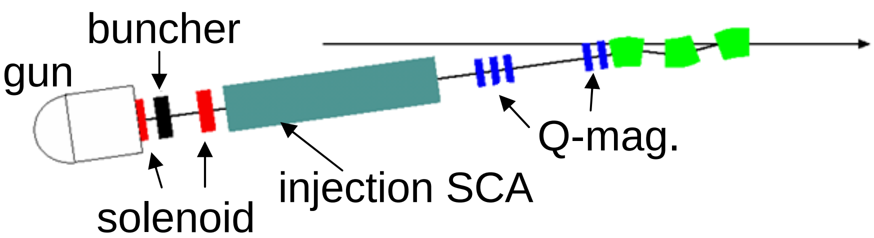
Split Linac Bunch Flattening



Emittance dilution in an ERL injector and merger



short-term goals

high-flux = 77pC, 1mm-mrad
high-coh =7.7pC, 0.1mm-mrad
ultrafast = 1nC, 5-10mm-mrad

emittance growth source	location	how to deal with
transverse space charge	whole the path	emittance compensation by solenoid and Q magnets with avoiding “over bunching”
longitudinal space charge	inside the merger	envelope matching to bunch slice displacement induced by LSCF
time-dependent RF	buncher, 1st SCA	controlling σ_r, σ_z by solenoid, buncher

We cannot eliminate all the emittance dilution simultaneously.
However, numerical simulations give a reasonable design for the emittance requirement.

helpful design tips so far we have:

+ changing position and strength of focusing magnets = minimum “ε_{TSCF} + ε_{RF}”,
+ a weak focusing merger shows better emittance compensation.

2step staircase (JAERI type) is not suitable for small emittance due to strong focusing

What should Start to End Simulations for Light Source ERLs be sure to include?

• energy spread and emittance are very crucial for FEL operation and have to be carefully observed therefore

• most relevant (single bunch) effects with the potential to deteriorate bunch quality: space charge and CSR fields, cavity wakes, resistive wall and geometric wakes

• simulation codes for each of these effects are available but no code that includes all

• for Start-to-End simulations output-input conversion has to be done: best and most easily the 6D macro particle phase space is used

•with parametrizations: correlations between phase space dimensions may not be neglected

What are realistic beam abort strategies and beam loss tolerances for light source ERLs?

Standard beam trip detection and abort seems to be acceptable for ERLs. The energy in the beam appears to be not significantly different from 3rd generation light sources. Just don't put too much energy in sensitive points.

Beam loss tolerances and the causes of halo are less well characterized and various labs are presently taking different approaches. Work on minimizing sources of such halo and developing methodologies for dealing with it is desirable.

Halo sources

- Beam induced (not usually significant)
- Field emission from gun and srf cavities
- Scattered light in photoinjector (both temporal and transverse halo)

Loss impacts:

- Wiggler life
- Vacuum and vacuum failures
- Background radiation
- Radiation on X-ray beamline
- ….

Injector Diagnostics < 10 MeV

- Initial measurement of gun performance should be done in *test stand* where additional diagnostics can be used
- Shielded Beam Viewers
  - <10MeV these should be phosphor coated
    - YAG or ceramic OK but these bloom more than the thin coat of phosphor
- Multiple BPMs, Shorted striplines for larger signal than button and low impedance
- Multislit or pepper pot for H/V emittance
- Beam Current Monitor (BCM)
  - Knowing charge is crucial to setup
  - Transformer or cavity, advantage with cavity is one can use log-amp on output and this makes tuning the drive laser E/O cells easy, and it is only ~$5k
- Streak camera for longitudinal measurements

Linac Diagnostics

- All devices should be *shielded* to minimize beamline shunt impedance
  - Including bellows and ion pump drops
- BPMs, both single pass and multi-pass
- OTR beam viewers
  - In linac where there are two beams they should have 5mm holes to pass accelerating beam
- Interferometer for bunch length
  - Source can be from THz and/or OTR
- Transverse kicker cavity for longitudinal measurements
  - Needed where bunches are beyond streak camera resolution
- Synchrotron light ports at every bend
- Halo monitors
  - These can be phosphor coated beam viewers with or without holes or forks