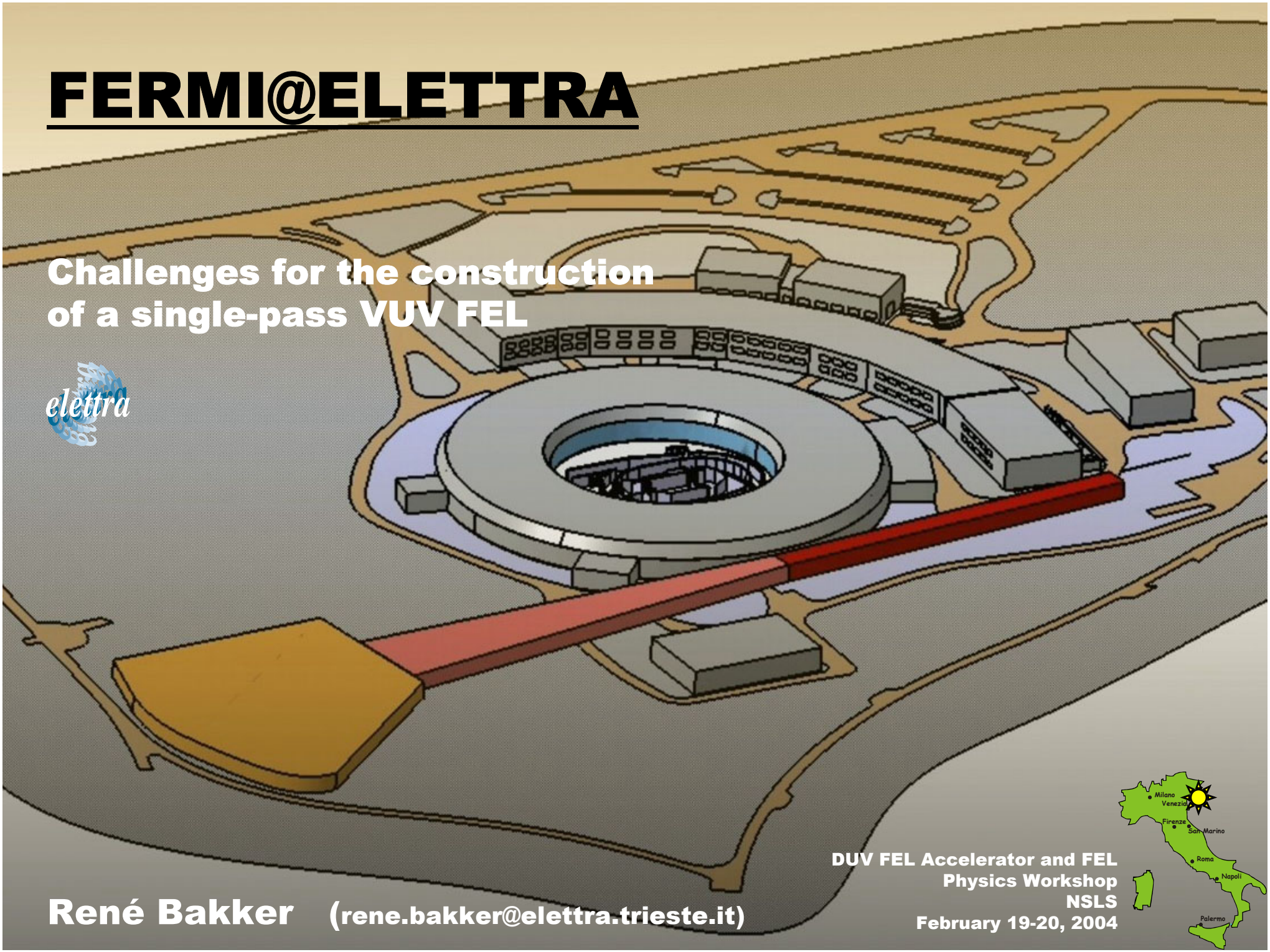
FERMI@ELETTRA

Challenges for the construction of a single-pass VUV FEL



René Bakker (rene.bakker@elettra.trieste.it)

DUV FEL Accelerator and FEL Physics Workshop
NSLS
February 19-20, 2004

Outline

1. Project target

2. Short overview of the planned machine

3. Challenges for the project
   - technological
   - planning

FERMI@ELETTRA

Key features:

- Development of a user-facility.
- Based on existing 1-GeV S-band linac infrastructure.
- Project budget: ~ 75 M€ (~ 95 M$) (machine & beamlines)

Specifications:

- Spectral range (2 undulator lines):
  1. 100 – 40 nm → (12 – 30 eV): FEL-1
  2. ← 40 – 10 nm (30 –124 eV): FEL-2
- Flexible polarization.
- Seeded operation (SASE as optional).
- Short pulses (sub-ps → < 100 fs RMS).
- 50 Hz repetition rate, 1 micro-pulse per macro-pulse.

Planning

Present status:

- Request for funding granted
- Linac serves as injector for ELETTRA (22 h/day)

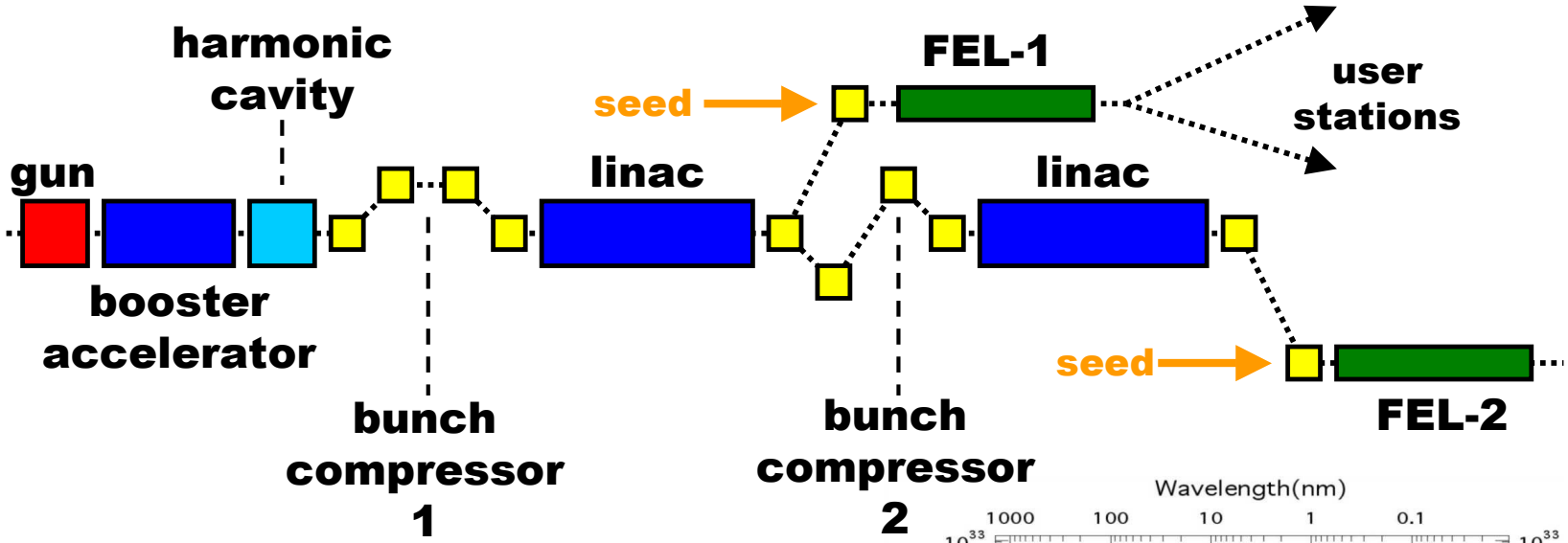
2004 – 2006:

- Linac serves as injector for ELETTRA (22 h/day)
- Construction of a new full-energy injector (booster) for ELETTRA
- Commencement of FEL construction

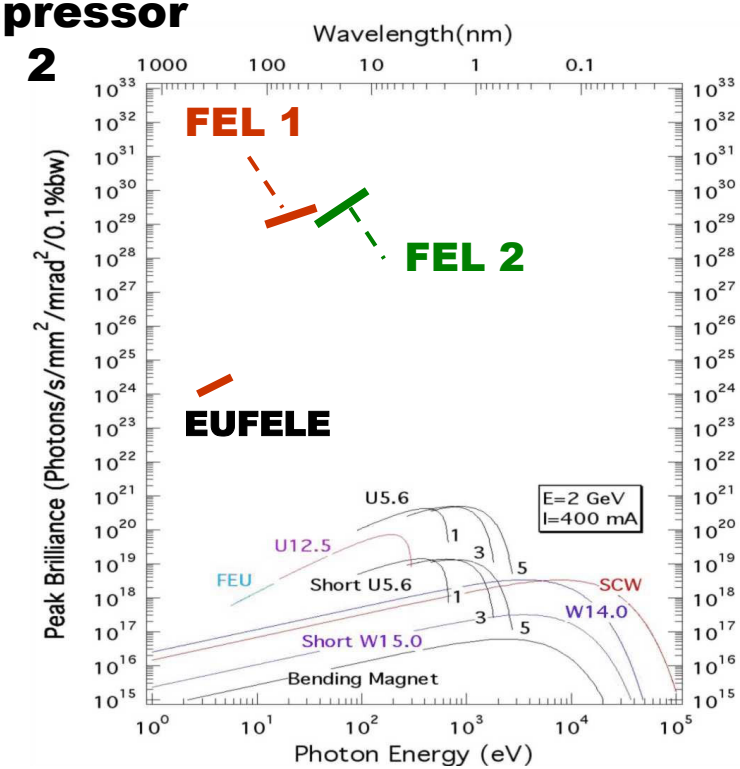
2007 .....

- Implementation and use of the linac FEL user-facility

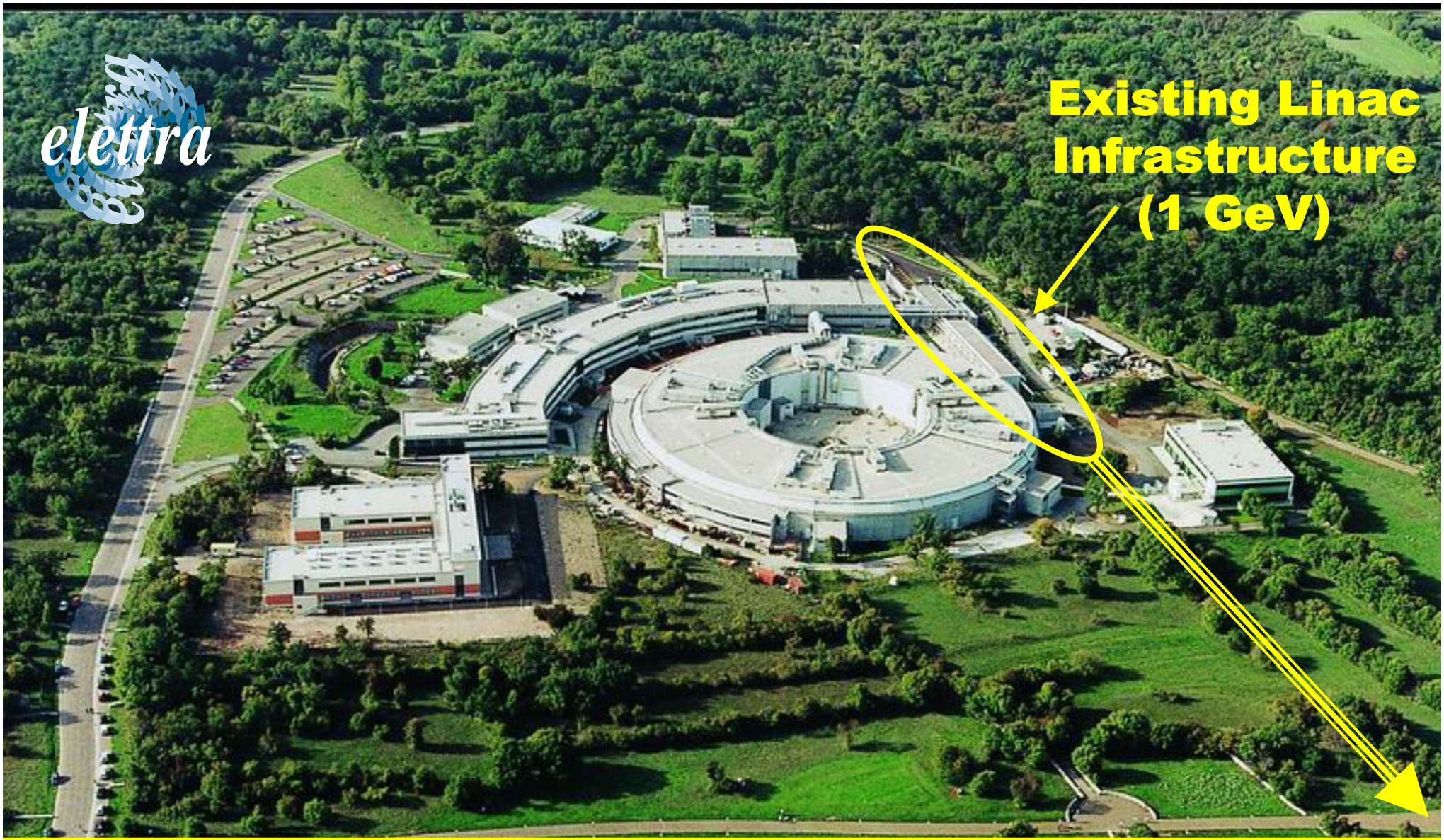
Schematics

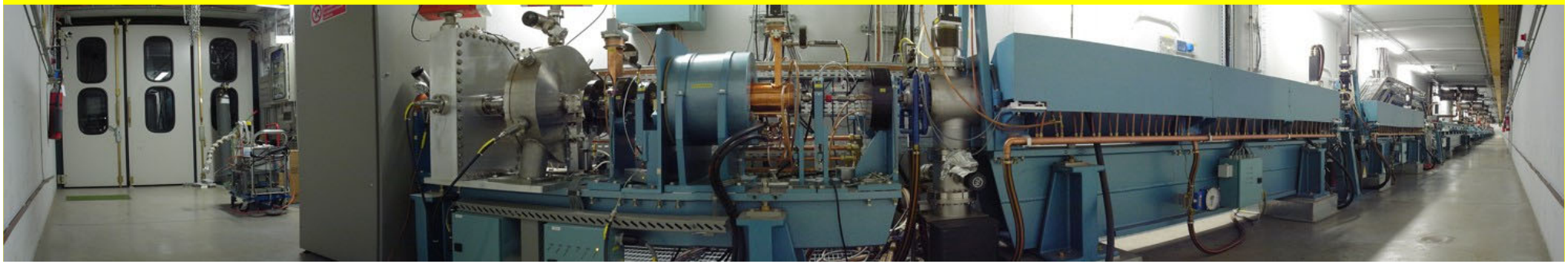


	FEL-1		FEL-2		
Wavelength Target	100	40	40	10	nm
	10	31	25	124	eV
Electron Beam Energy	0.70		0.55	1.00	GeV
Bunch Charge	1.0		1.0		nC
Peak Current	0.8		2.5		kA
Bunch Duration (rms)	500		160		fs
Energy Spread (rms)	0.5		1.0		MeV
Normalized Emittance	2.0		1.5		$\times 10^{-6}$ m
Undulator Period	52		36.6		mm



René Bakker


elettra
Existing Linac
Infrastructure
(1 GeV)



Tasks Ahead

1. **Linac improvements and modifications**

   Getting the electron beam to FEL specifications (peak & stability), diagnostics, ...

2. **Civil engineering**

3. **FEL design**

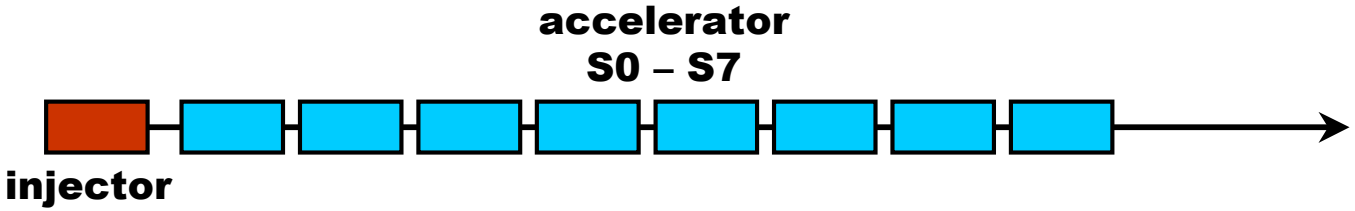
   Undulator lines, seeding schemes, diagnostics, control, ...

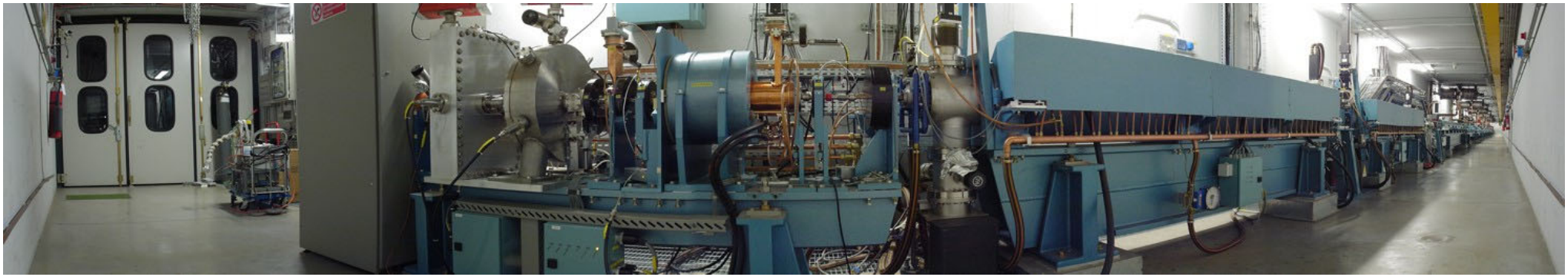
4. **Experimental stations**

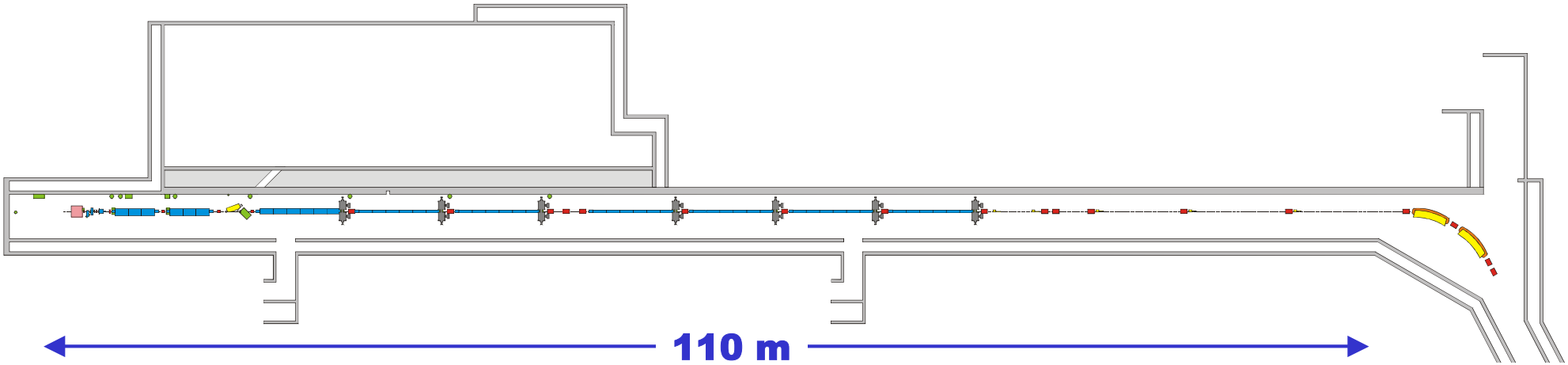
   Beamlines, diagnostics, synchronization, ...

1. Linac Modifications

Present linac configuration

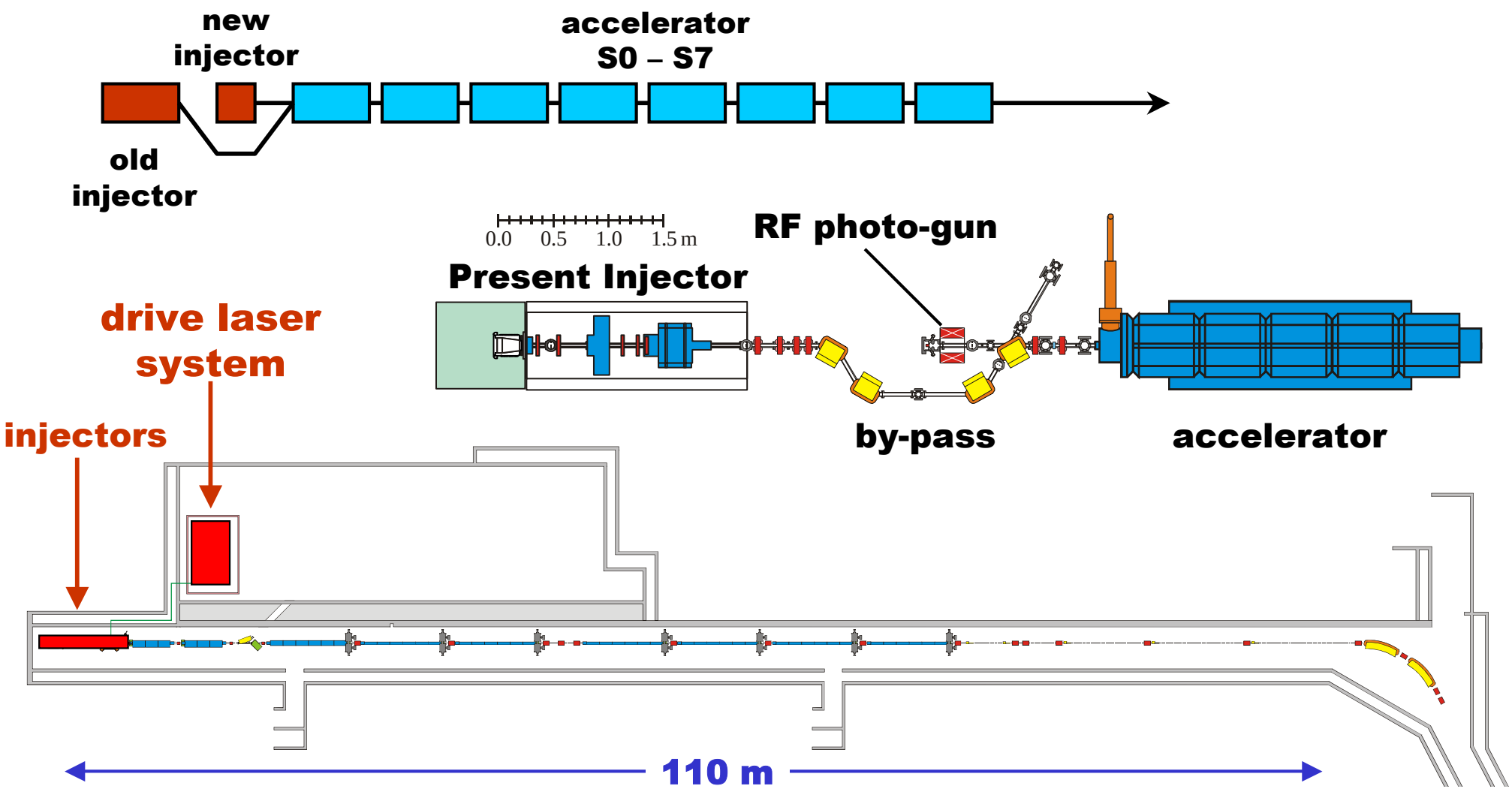






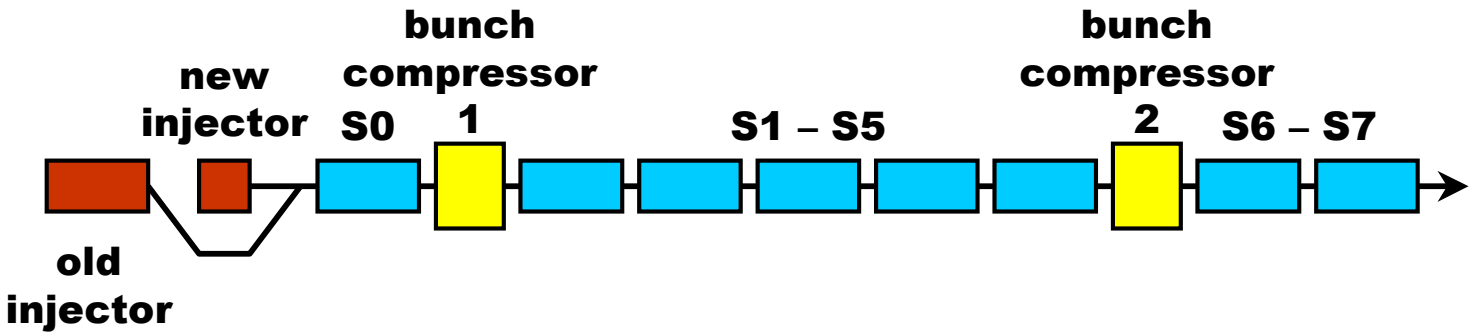
1. Linac Modifications

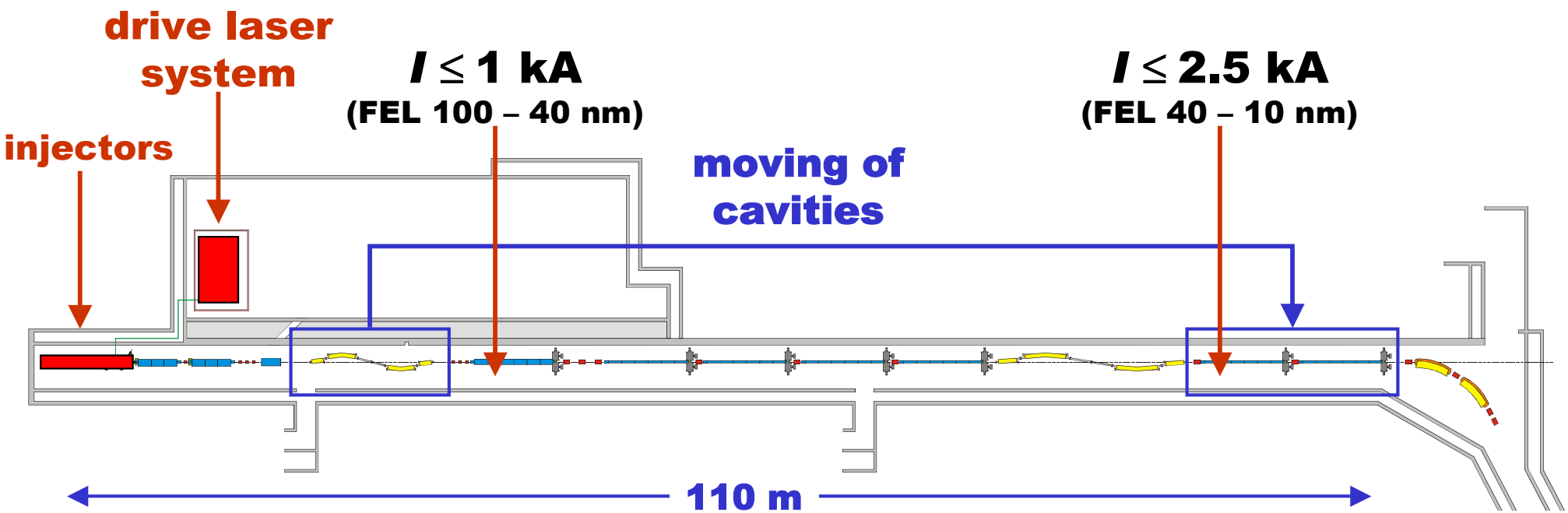
Insertion of a new low-emittance RF photo-cathode



1. Linac Modifications

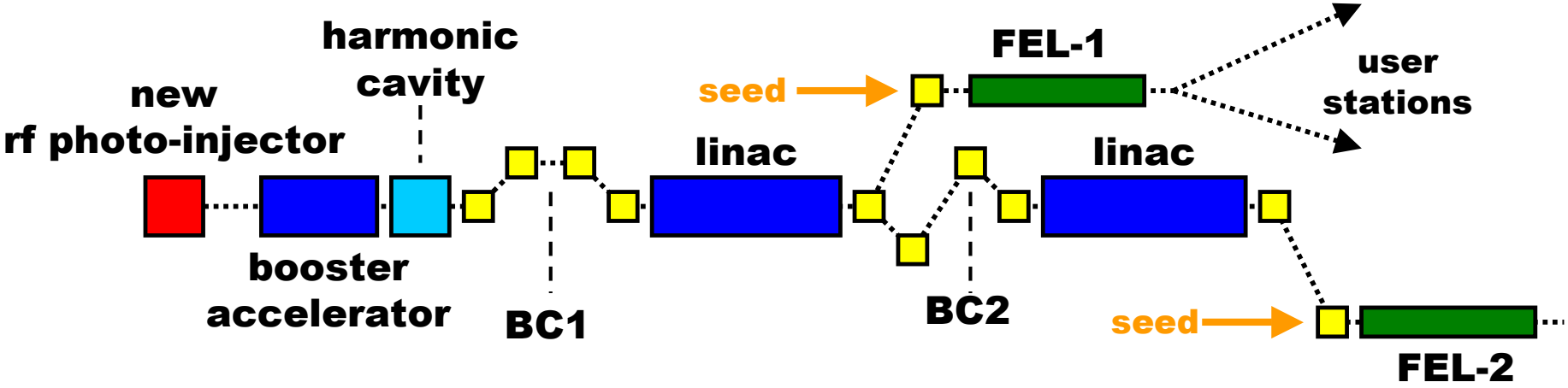
Increase of the peak current



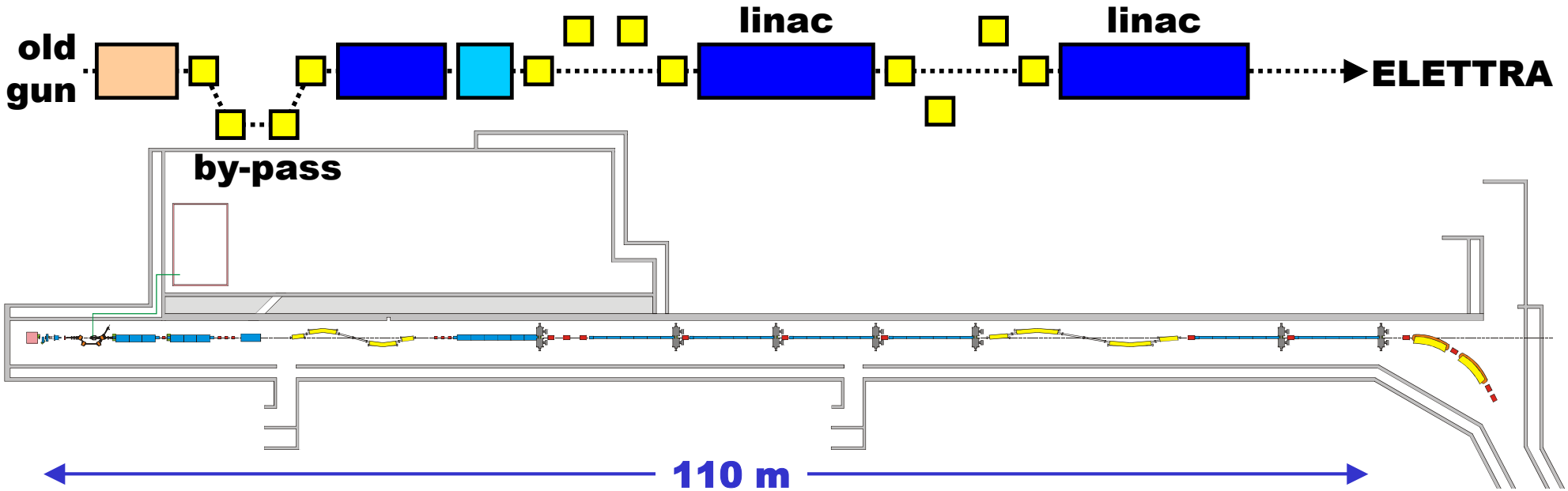


1. FEL and Injection

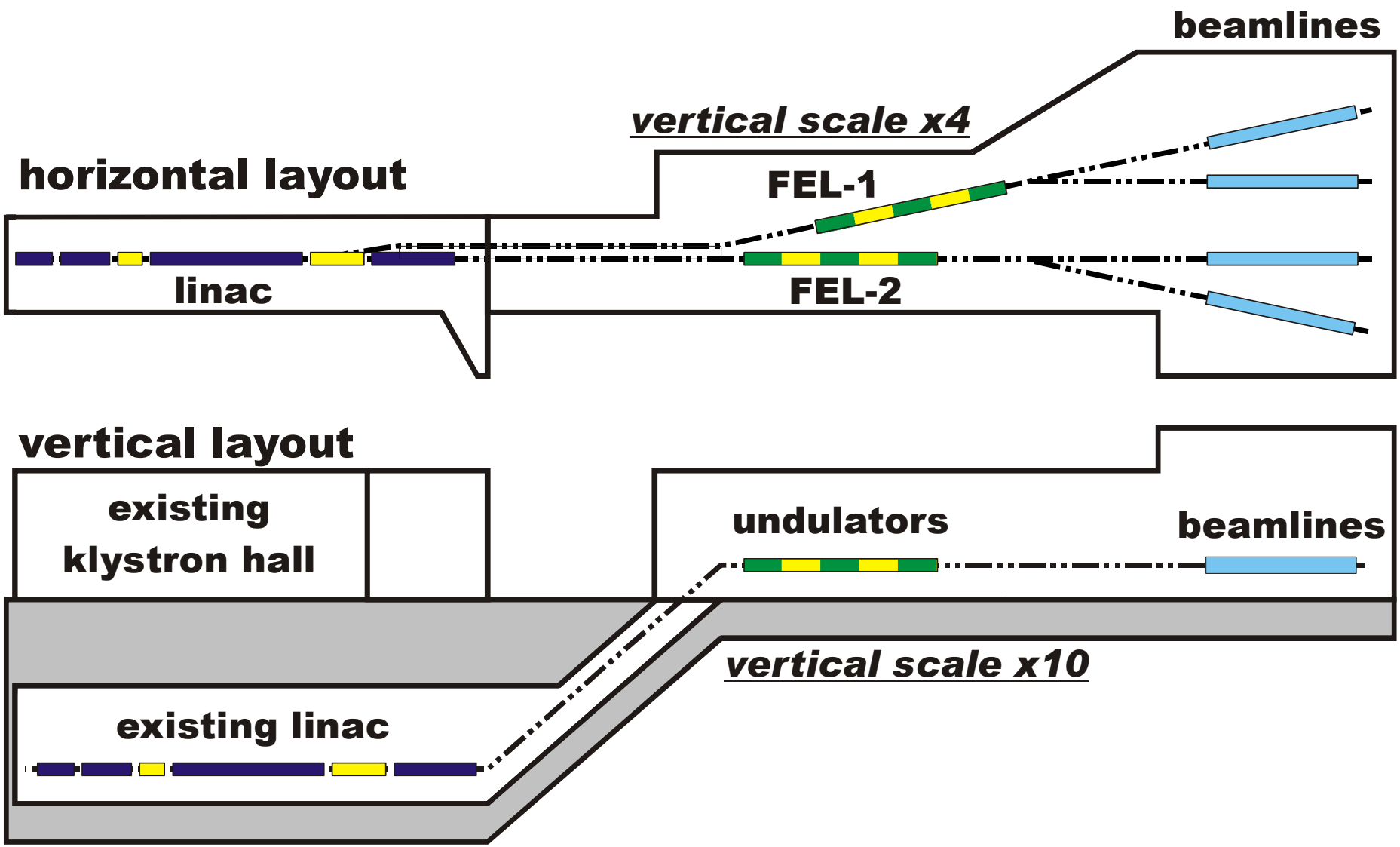
FEL mode:



Storage-ring injection mode:



2. Civil Engineering



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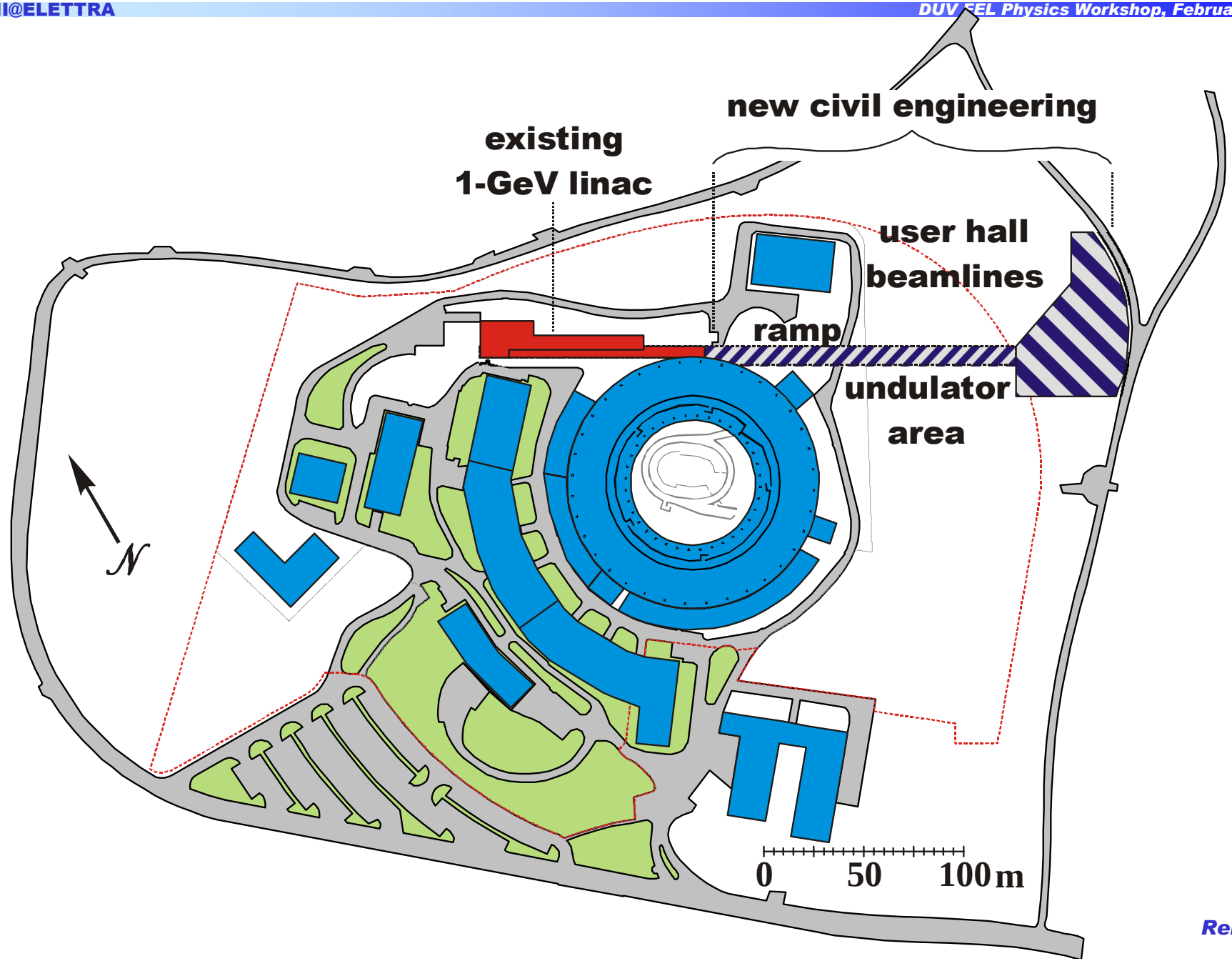
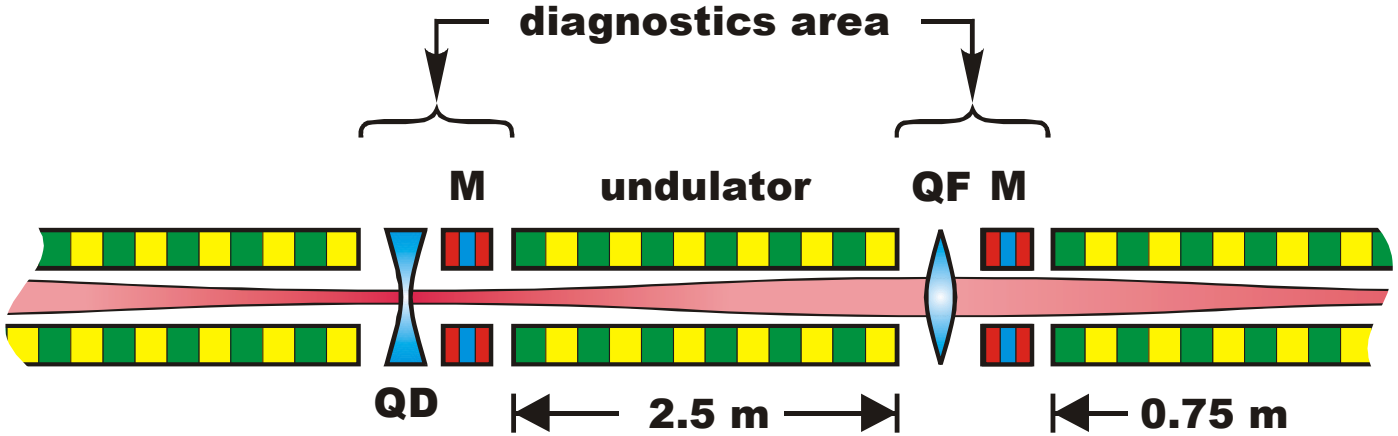


3. FEL Concept

Segmented undulator sections

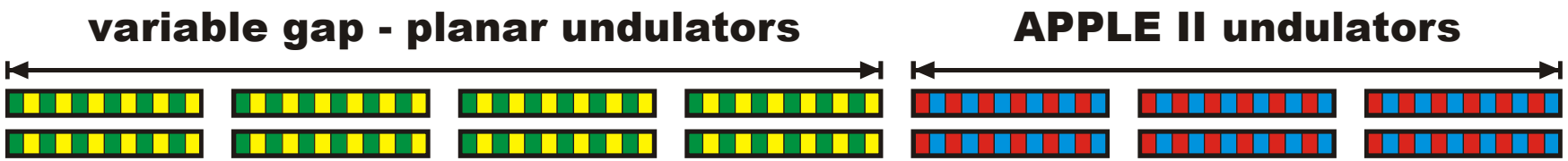


Period:

- FEL-1 λ_u = 52.0 mm
- FEL-2 λ_u = 36.6 mm

Type:

- Planar undulators for bunching-process
- APPLE II as radiators (control of polarization)



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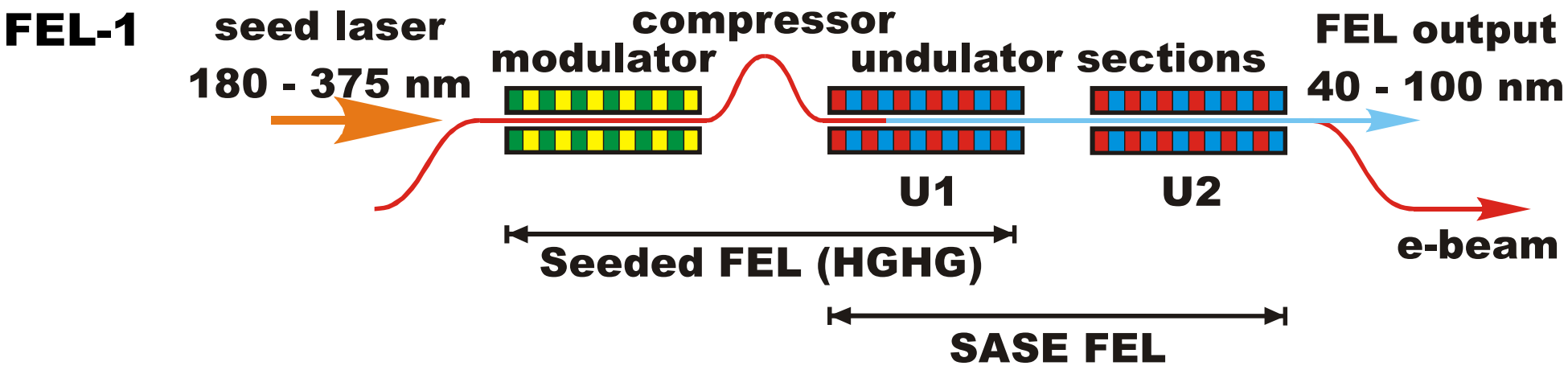
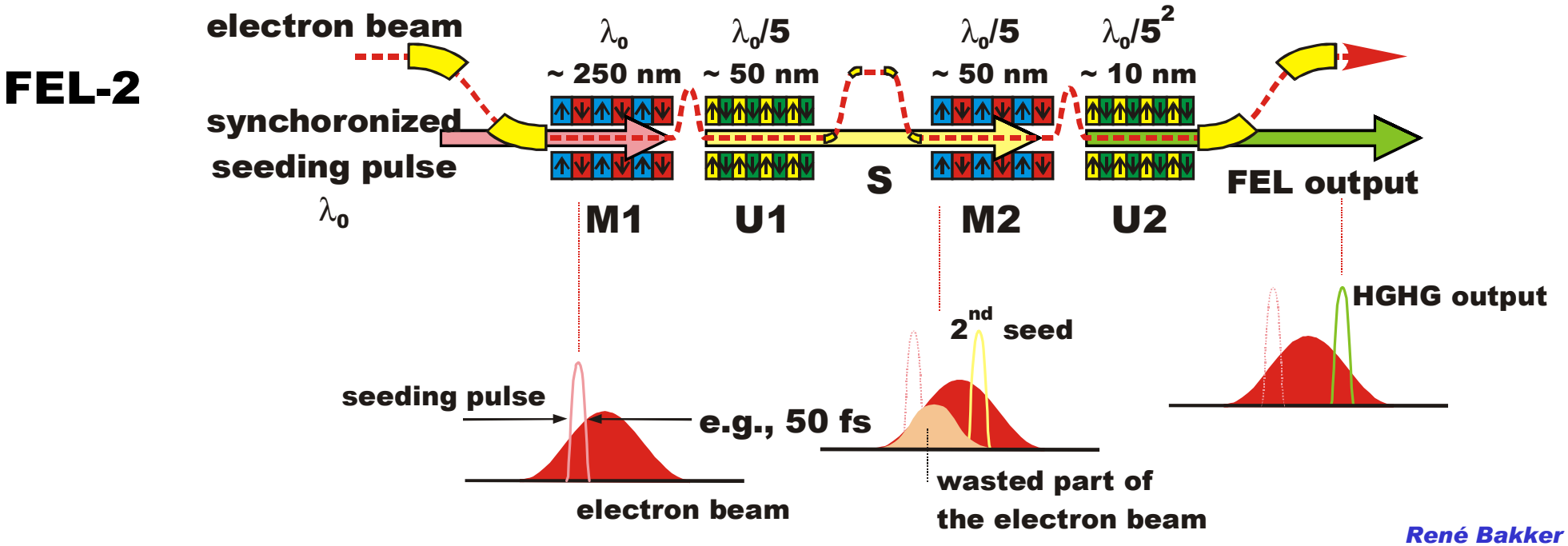
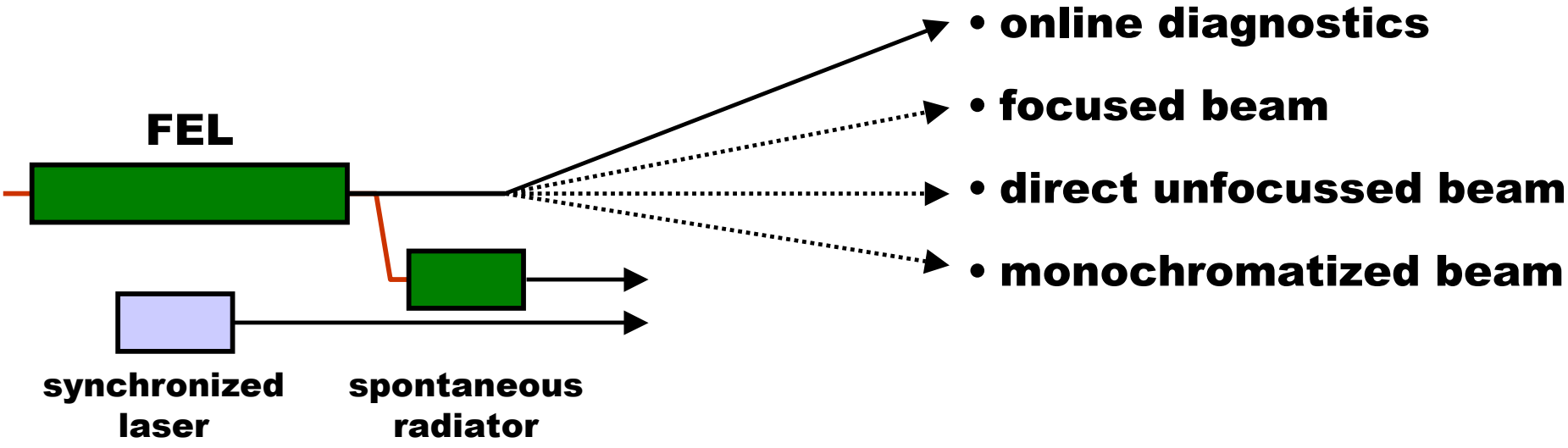




4. Experimental Stations



The Pathway

- Construction of a high-brightness electron source
- Modifications to the linac
  - bunch compressors
  - stability
  - diagnostics
- Civil engineering to bring the electron beam to the surface → undulator and user hall
- "Relaxed" e-beam parameters
  - E = 0.7 – 1 GeV (1.2 available)
  - I < 1 kA (initially)
  - $\varepsilon = 2\pi$ mm mrad (initially)

100 nm – 40 nm FEL

- SASE
- SEEDED

↓

Both modes available to users

↓

Use experience to finalize the design of a 10 nm FEL

Challenges

1. **Linac modifications while guaranteeing injection for the ELETTRA storage ring.**

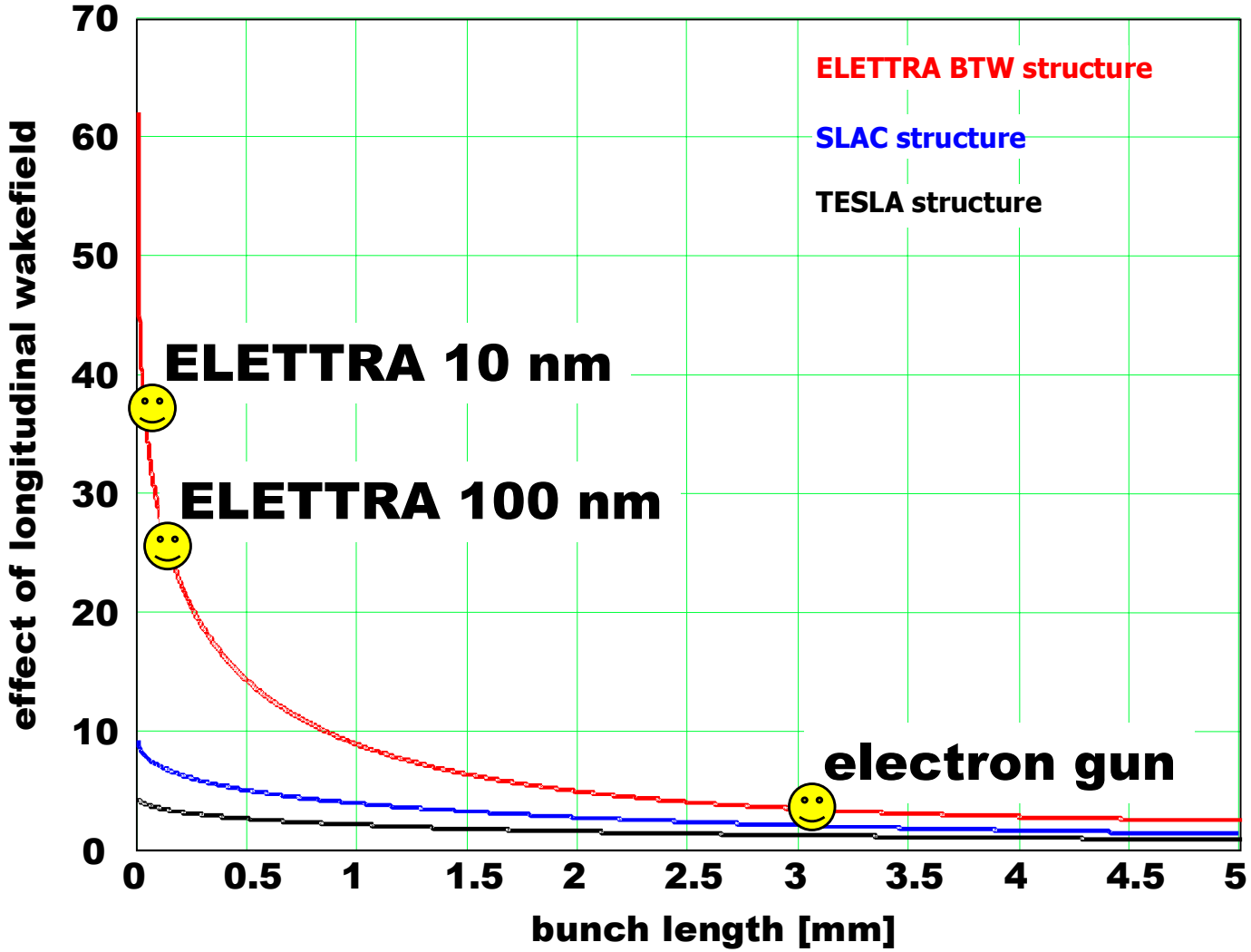
2. **Reaching the electron beam specifications:**
   - **stability**
   - **peak current**
   - **emittance (FEL-2)**
   - **energy spread (FEL-1)**

   } **wakefields!**

3. **Diagnostics & feedback:**
   - **electron beam: jitter, online diagnose, slice parameters, profile, feedback, ...**
   - **photon beam diagnose: spontaneous, high-power, online, ...**

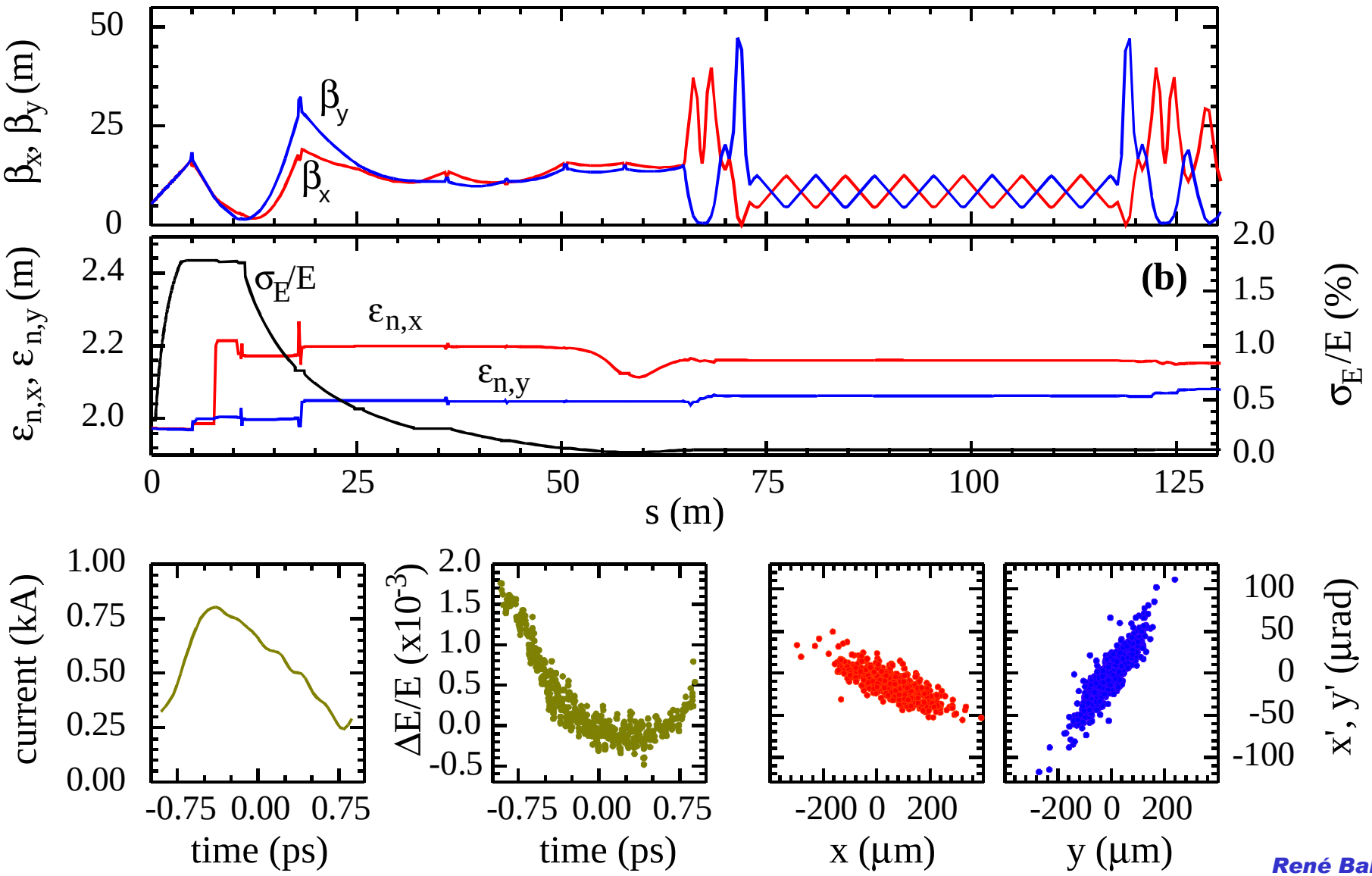
Wakefields

Influence of longitudinal wakefields



S2E simulations

FEL: 100 nm, E = 1 GeV



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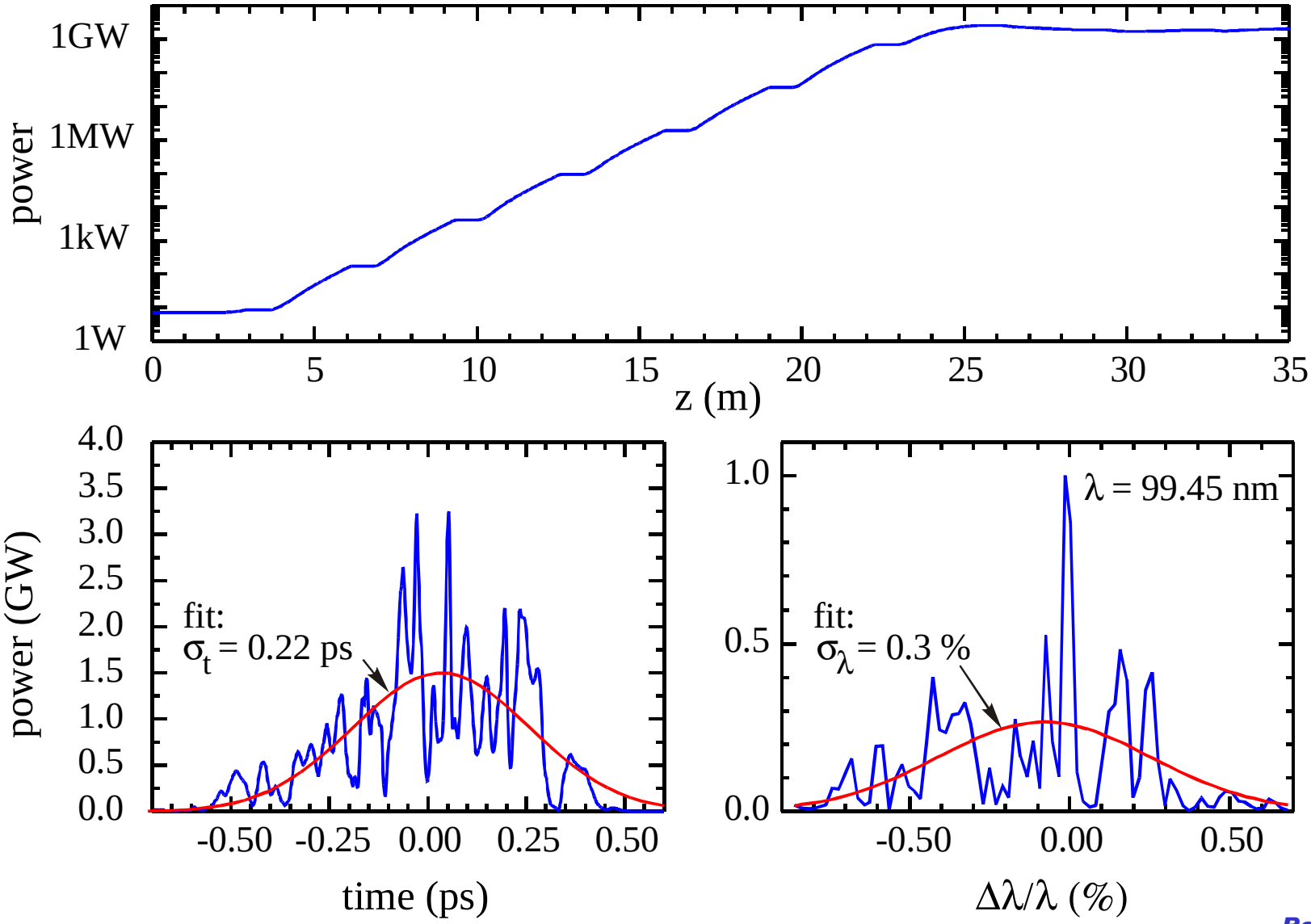

Challenges

4. Synchronization

- **Definition of a fs reference clock (laser)**

5. The FEL concept: SASE or seeding

- **SASE is spiky (at least for short wavelengths)**
- **Seeded & HGHG demonstrated:**
  - **wavelength tunability?**
  - **stability?**
  - **multi-stage concept?**

} **more calculations and experiments required**

The Way Out

- **We have a concept**

- **We like to collaborate to:**
  - **Verify and/or implement parts of the concept**
  - **Improve on the concept**