Status of PAL-XFEL & Injector Development

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Pohang Accelerator Laboratory

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  - Layout
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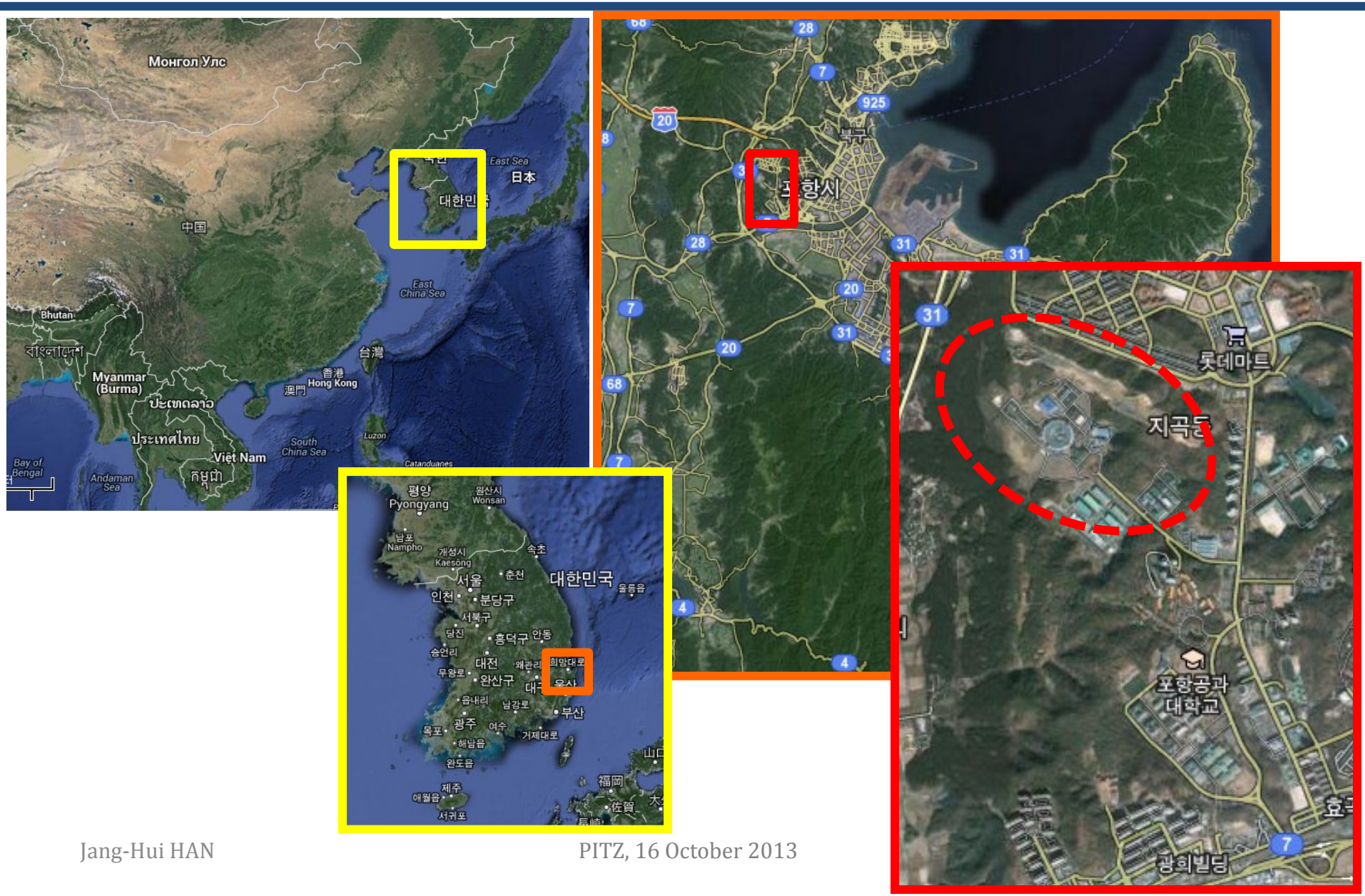
- PAL-XFEL Injector

Location of Pohang Accelerator Laboratory



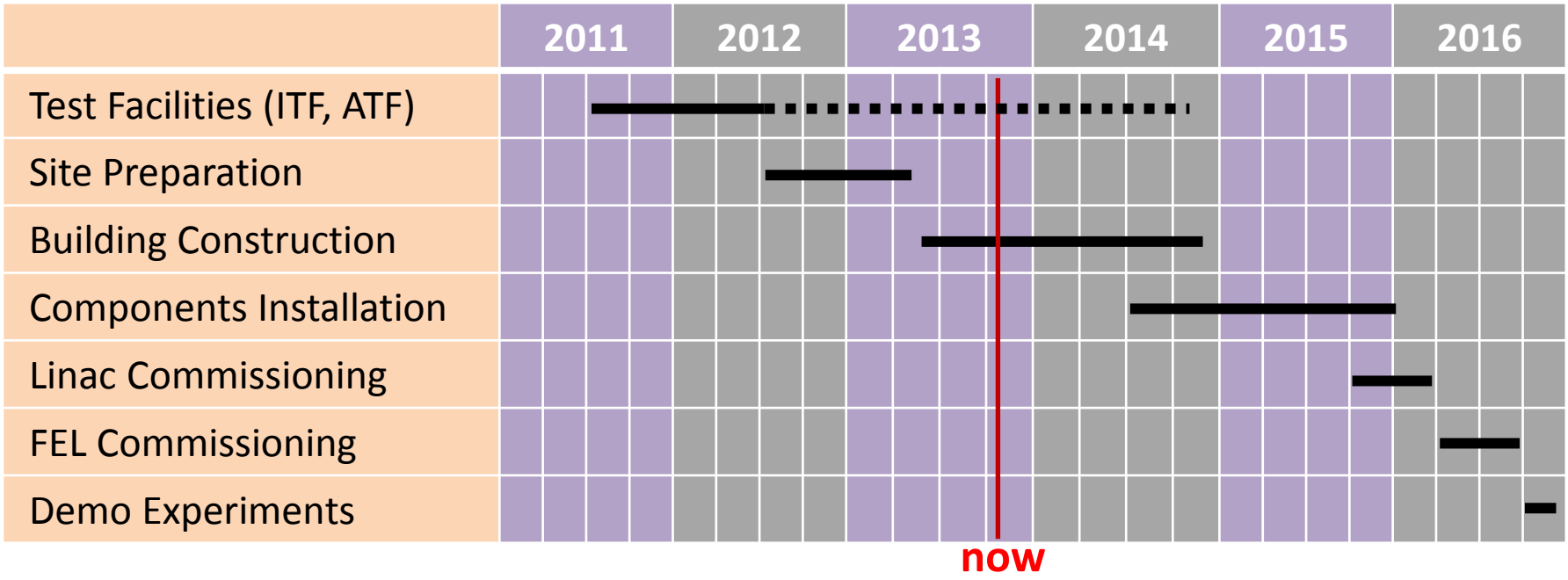
PAL-XFEL Project

- The project started in 2011 aiming at construction by 2014
- Building construction ongoing
- Commissioning to start in 2015

View of the Construction Site

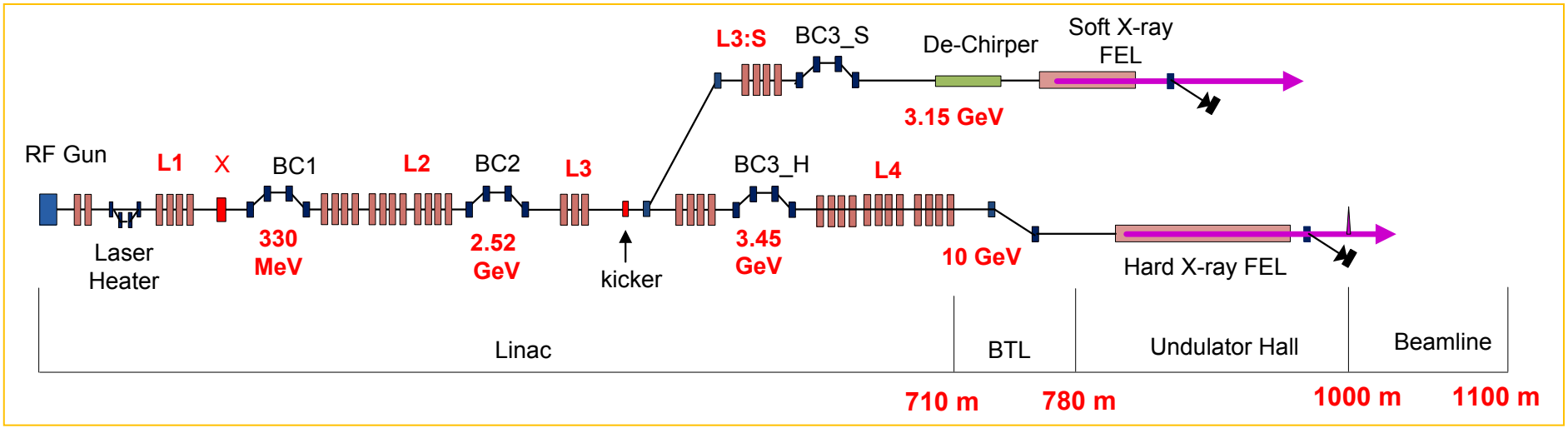
Aerial view on 28th August 2013

Schedule


2011
2012
2013
2014
2015
2016
Test Facilities (ITF, ATF)
Site Preparation
Building Construction
Components Installation
Linac Commissioning
FEL Commissioning
Demo Experiments
now

Linear Accelerator & Undulator

- 10 GeV S-band normal conducting linac
- 1 hard & 1 soft X-ray undulator beamlines
  (space for two more hard and one more soft lines reserved)
- 60 Hz repetition rate with single or two micro bunches



Accelerating Structure

- Potential providers: Mitsubishi Heavy Industries, IHEP, RI …
- PAL developing structures with a domestic company
- High power test of prototypes ongoing at ATF

Operation frequency	2856.00MHz (30℃, in vacuum)
Accelerator type	Constant-Gradient, Traveling-Wave
Operation mode	2π/3
Attenuation constant	0.57 neper
Shunt impedance	≧53MΩ/m
Filling time	~0.83μs
Q	>13000
Phase error	Σθi<±2.5deg
Operation temperature	30℃±0.1℃
Overall length	3.120 (acceleration length 2.91475) m

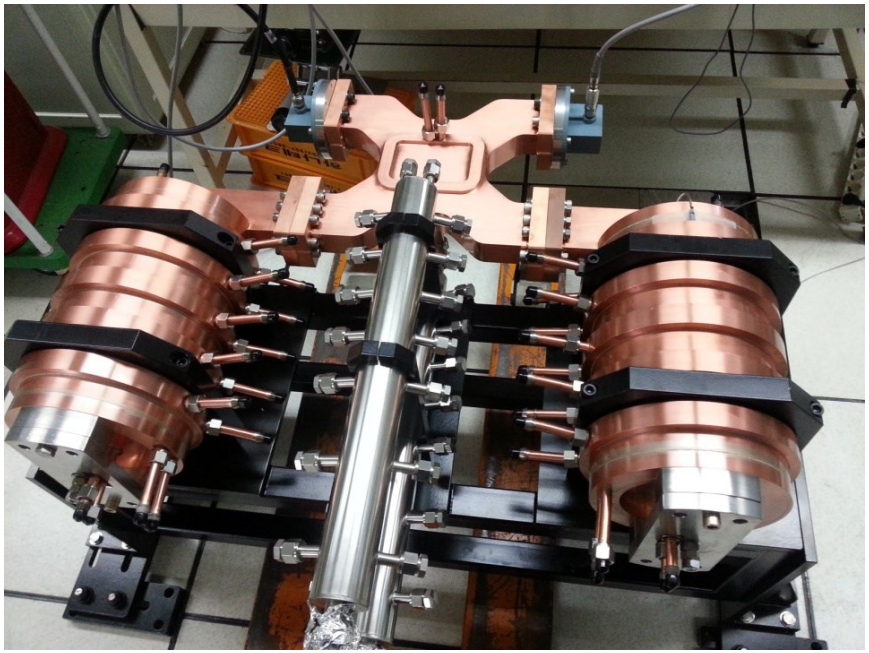
High power test at ATF

Accelerator & Modulator Test Facility

High power RF source for accelerator components

Modulator test stand

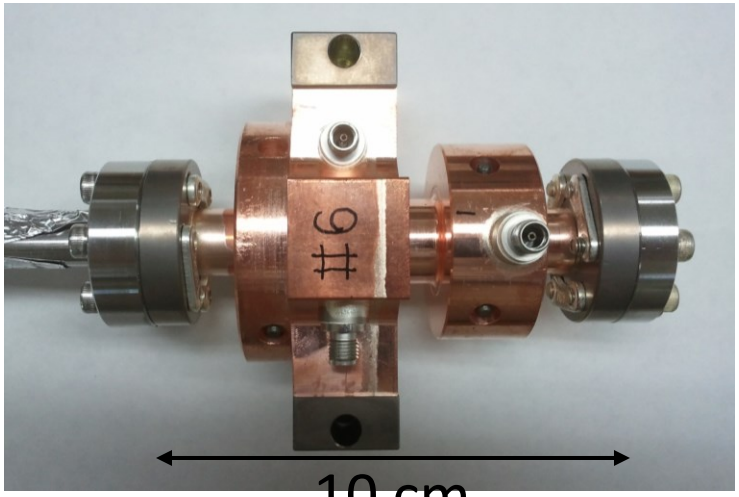
RF Components Production & Test



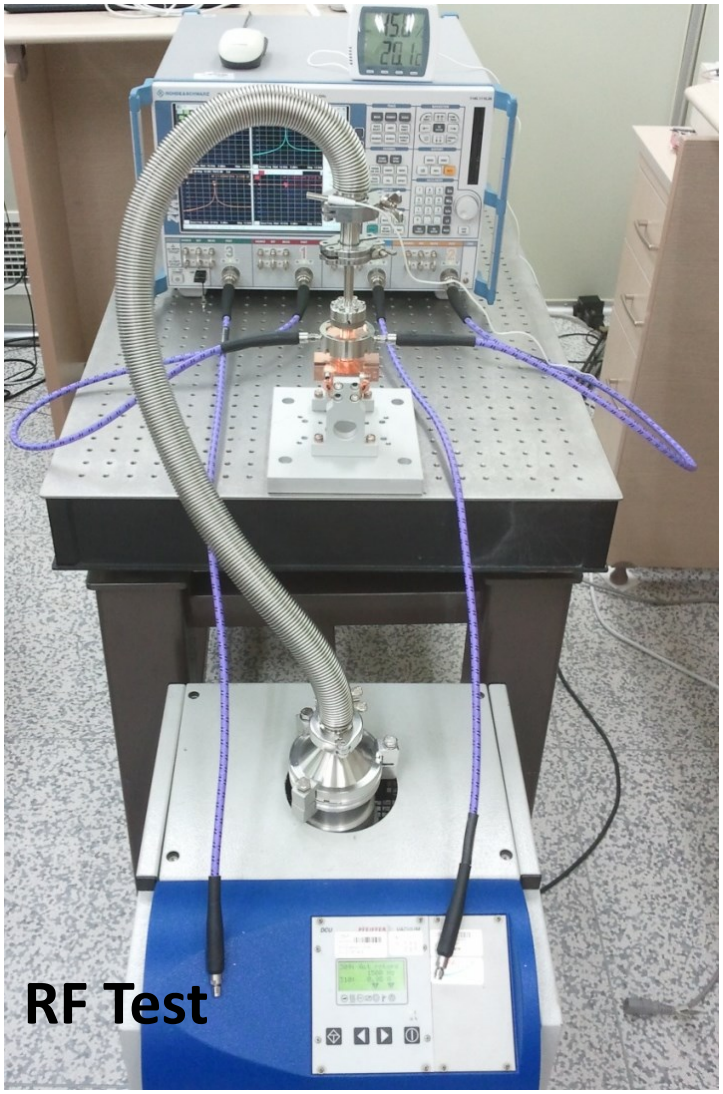
Energy Doubler (SLED)

Test of SLED

Cavity BPM: sub-μm e-beam Position Monitor

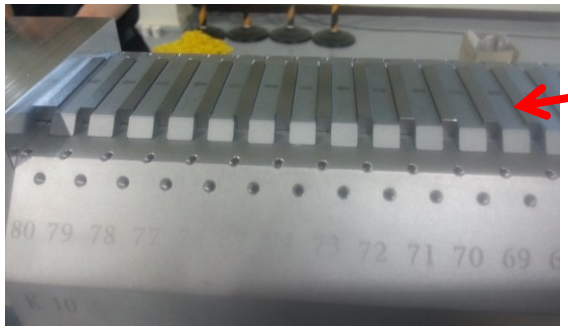


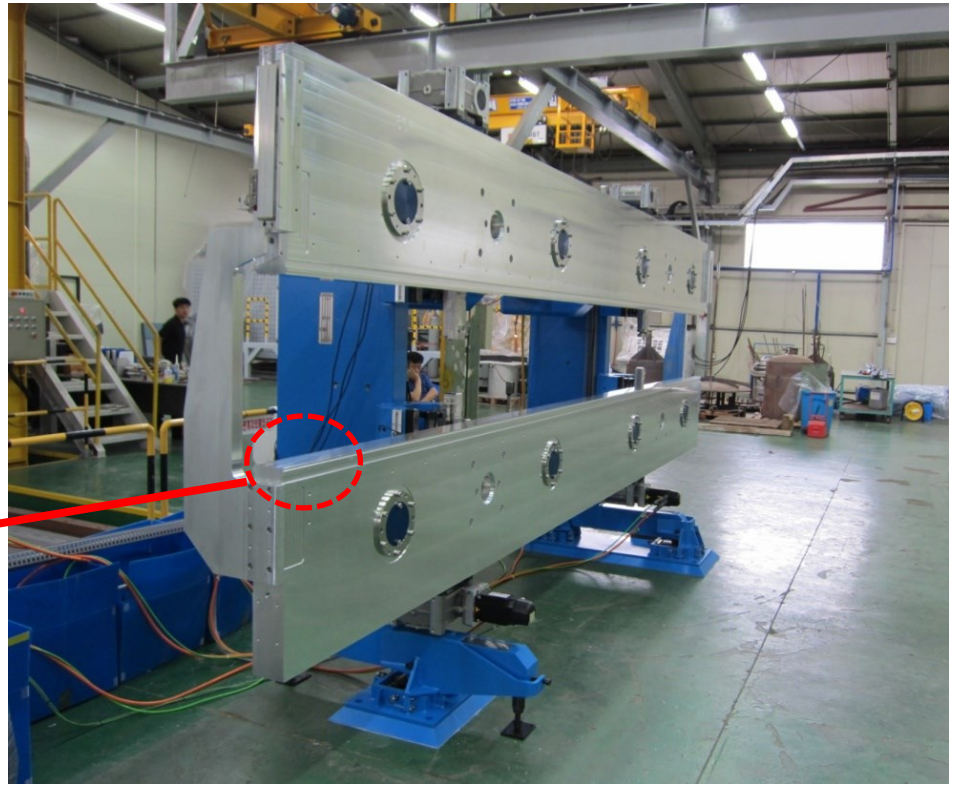
Holder for beam test at LCLS in October 2013



RF Test

Undulator Prototype



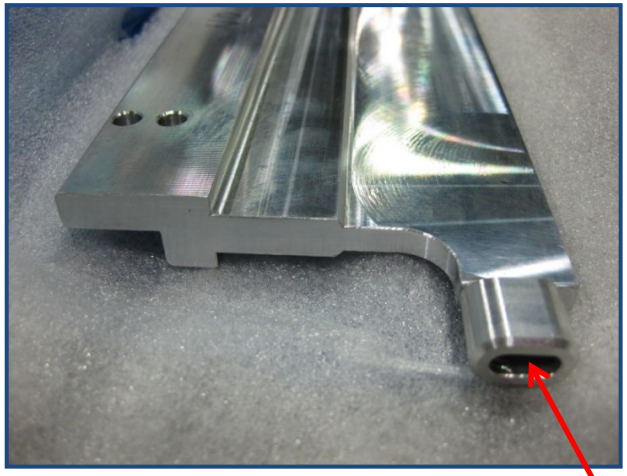


Hard X-ray undalator

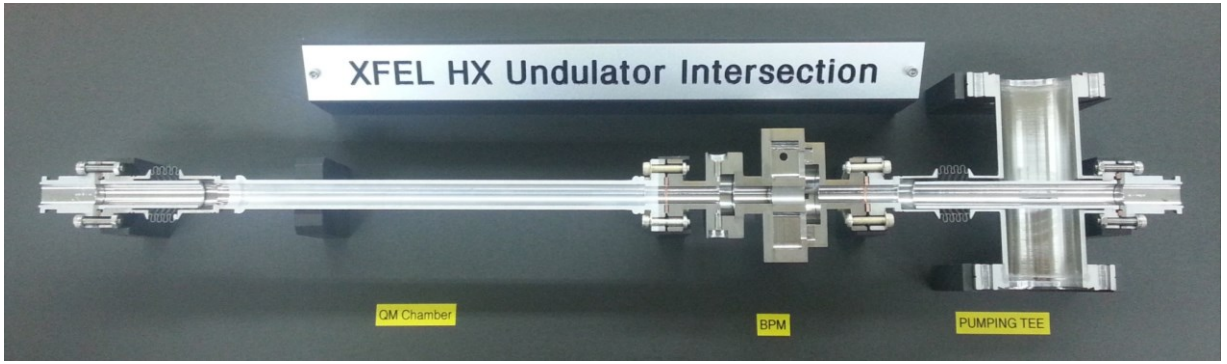
- 5 m long planar
- Variable gap
- 18 undulators to be installed at HX line initially

Prototype of ID chamber and Intersection

Length=6m

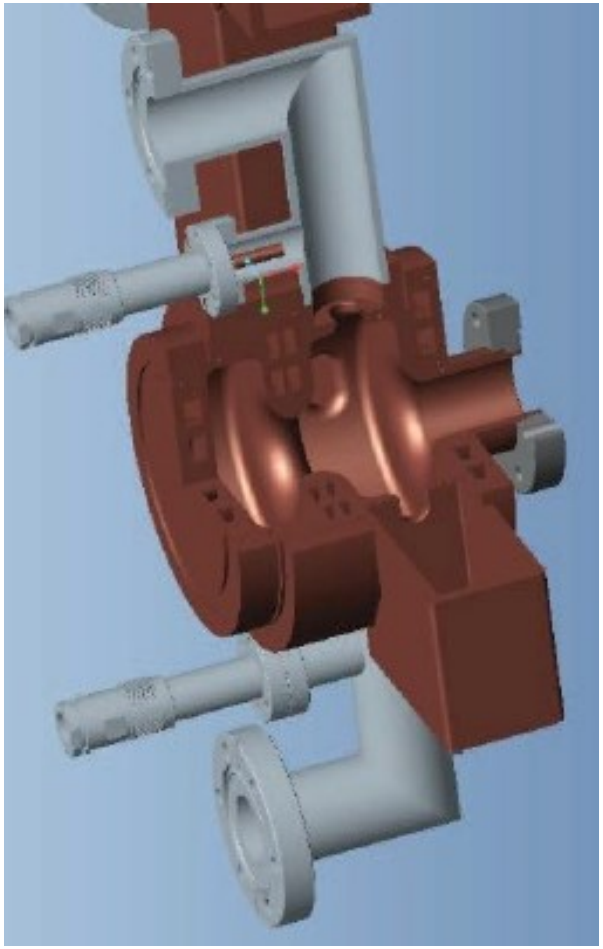


Inner gap=6.8mm

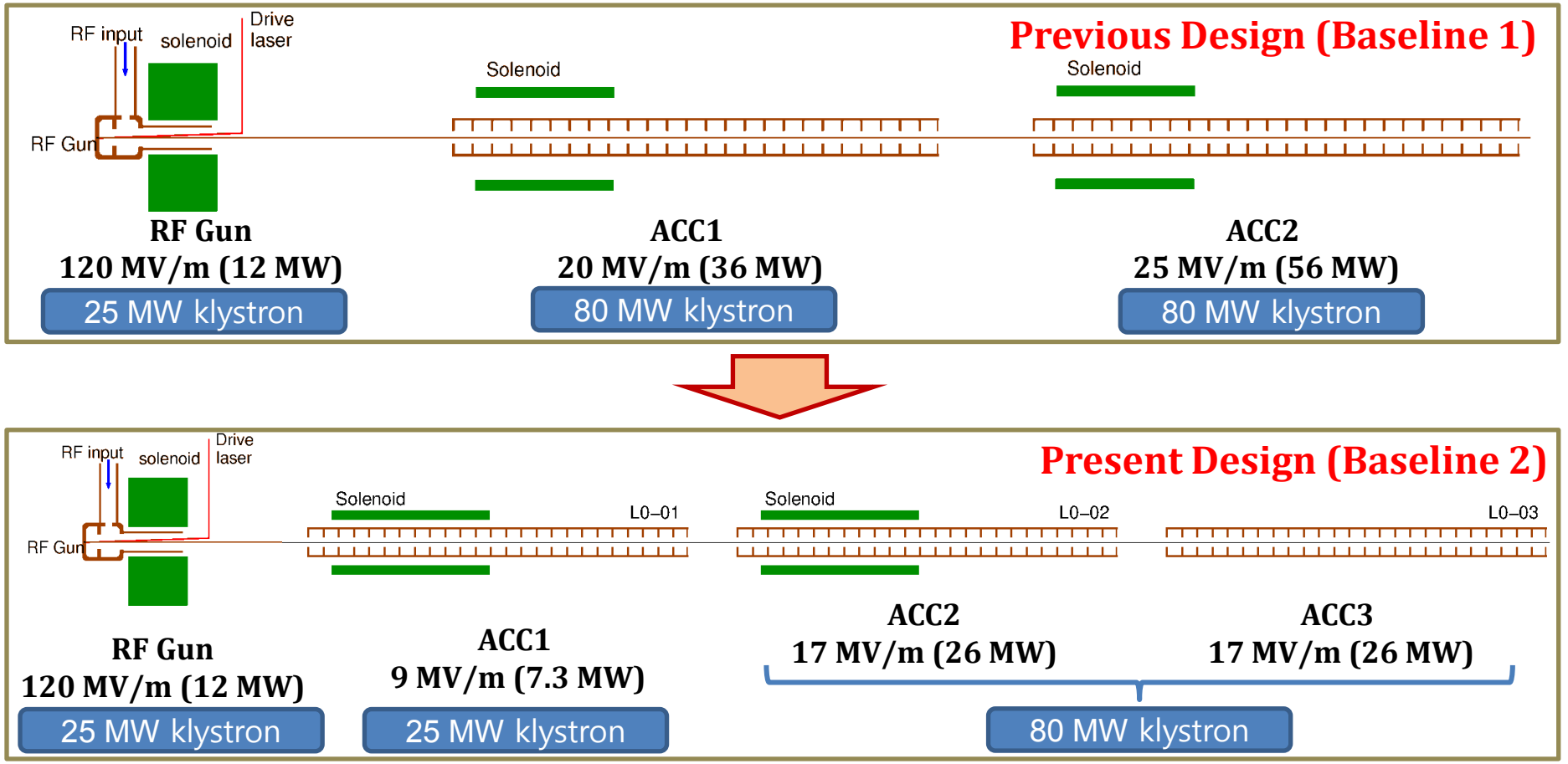


PAL-XFEL Gun 1

- Developed by PAL & POSTECH since 2005
- Design based on BNL S-band gun
- 1.61 cell & side coupling with 2 RF and 2 pumping holes
- Beam commissioning ongoing at ITF



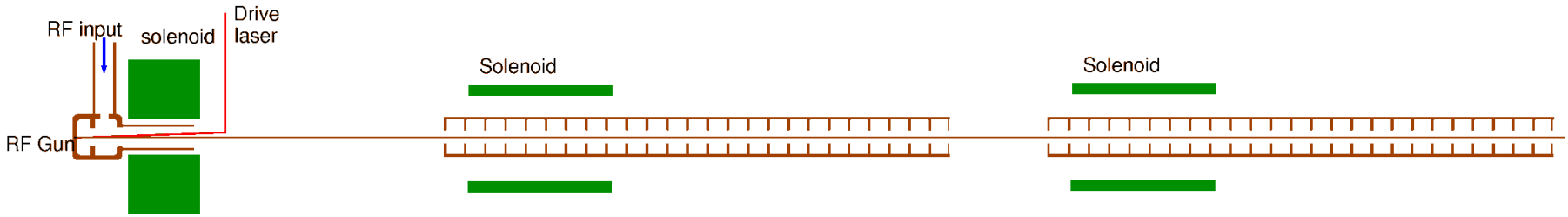
PAL-XFEL Injector – Based on Gun1



- **Injector length: 9 m → 12.3 m**
- **RF station: 1 × 25 MW, 2 × 80 MW → 2 × 25 MW, 1 × 80 MW**

Baseline 1

- **Gun1**
- **Gun solenoid** at 205 mm from cathode (no magnetic field compensation solenoid)
- **2 accelerating sections with 2 focusing solenoids**
- 120 MV/m max field at cathode, 5.7 MeV beam energy at gun exit
- **20 MV/m gradients at 1st accelerating tubes, 25 MV/m at 2nd tube → 139 MeV beam energy at injector end**
- 1st accelerating section starts at 2.2 m from the cathode (longer e-beam focal length due to the smaller laser beam at cathode)
- No quadrupoles for keeping the beam transverse shape to be circular through the injector



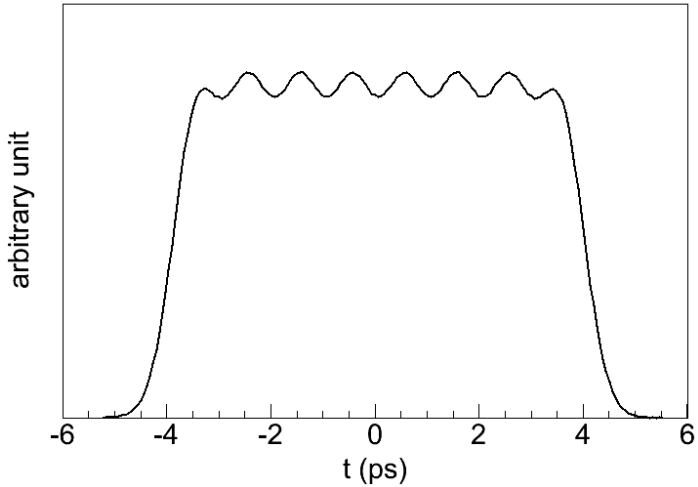
Beam Parameters of Baseline 1 Injector

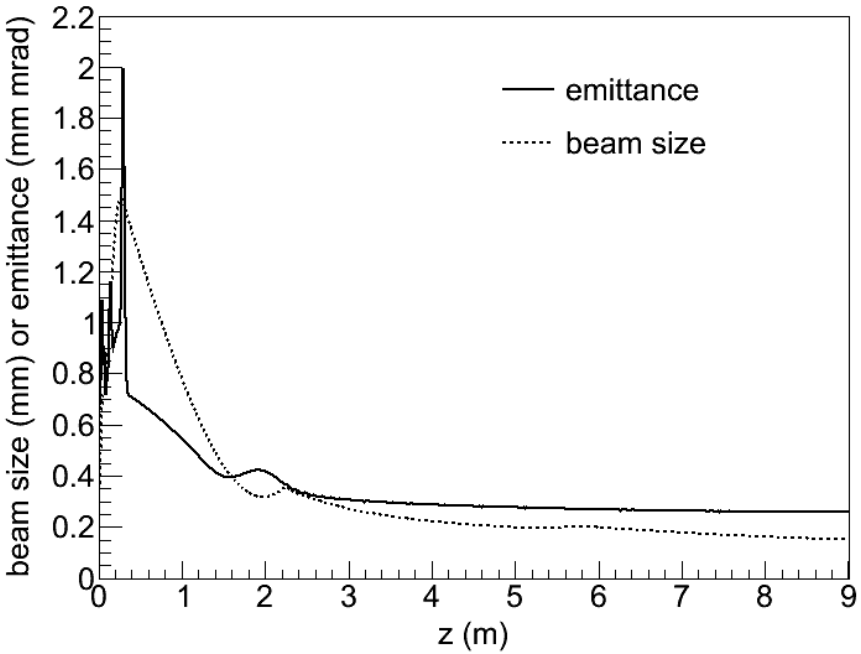
Cathode laser

Longitudinal shape:

- 8 short Gaussian pulses stacked
- 8 ps fwhm

Transversely uniform

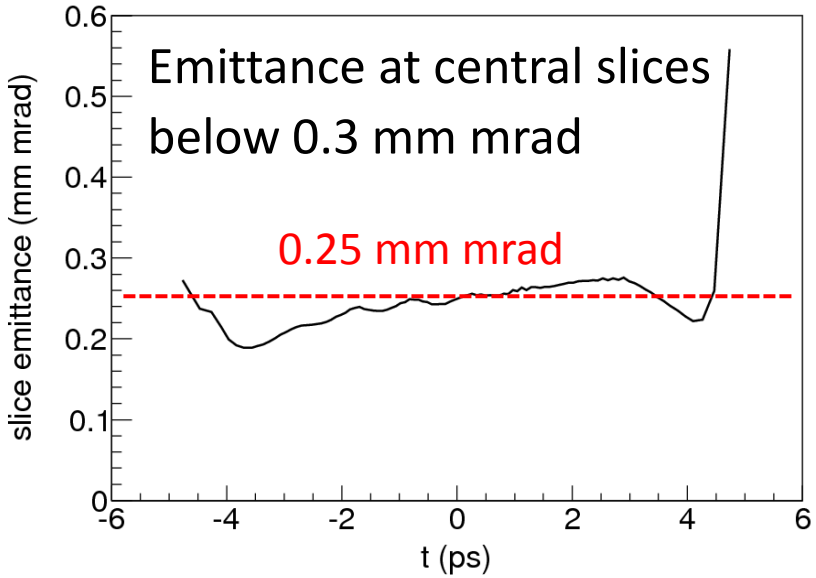




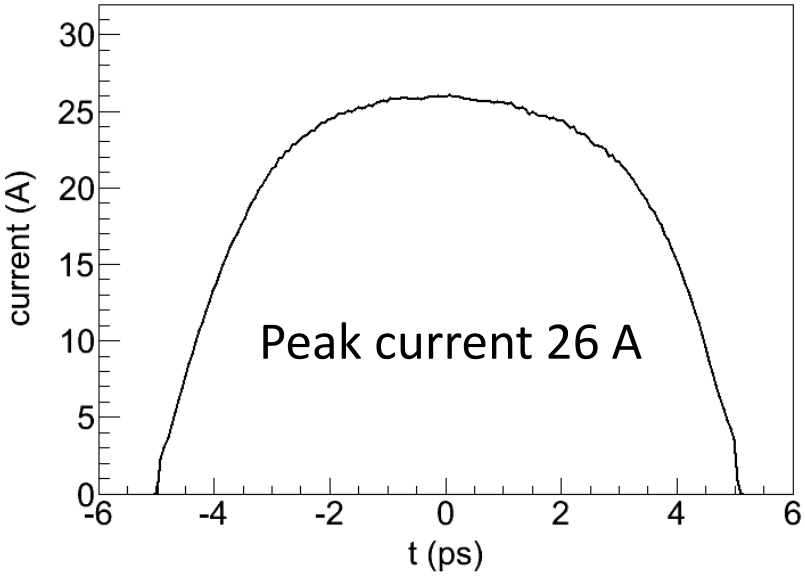
200 pC beam simulation at injector end

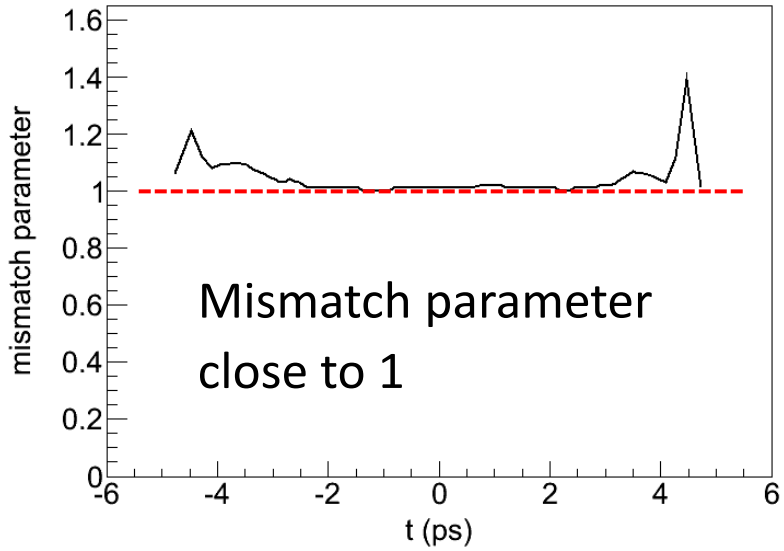
→ 0.26 mm mrad transverse projected emittance

Beam Parameters of Baseline 1 Injector

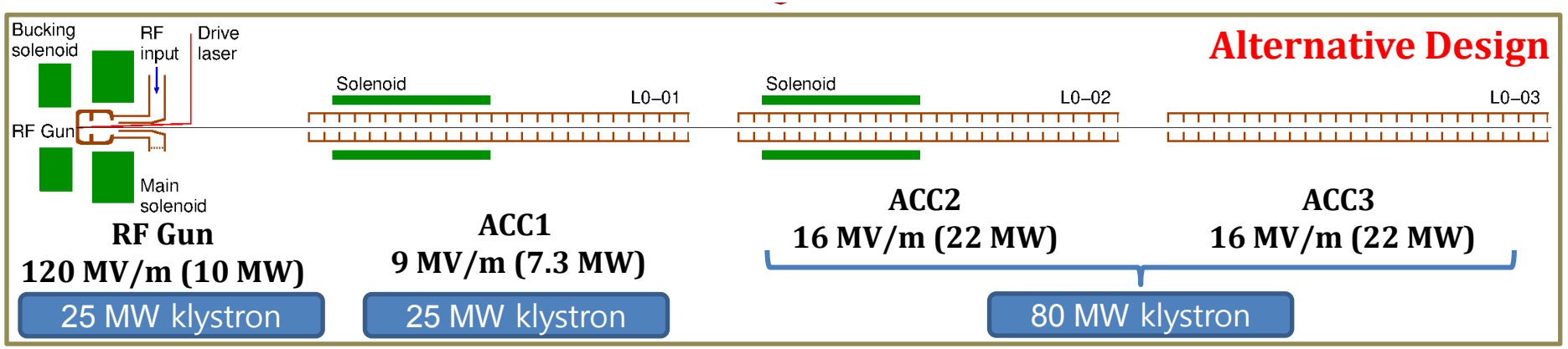


200 pC





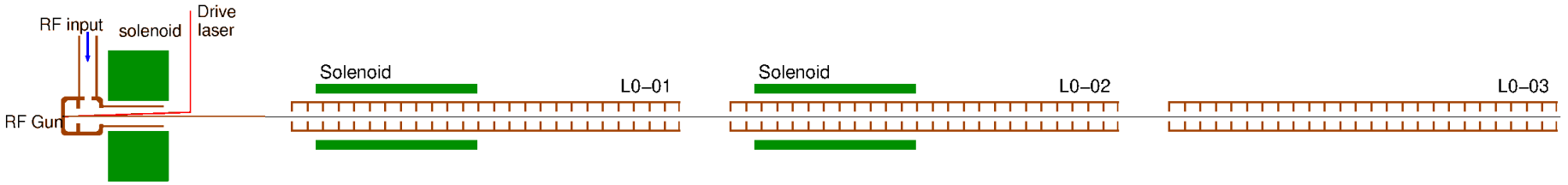
PAL-XFEL Injector – Based on Gun2



- **RF gun change**
- **RF station: 1 × 25 MW, 2 × 80 MW → 2 × 25 MW, 1 × 80 MW**

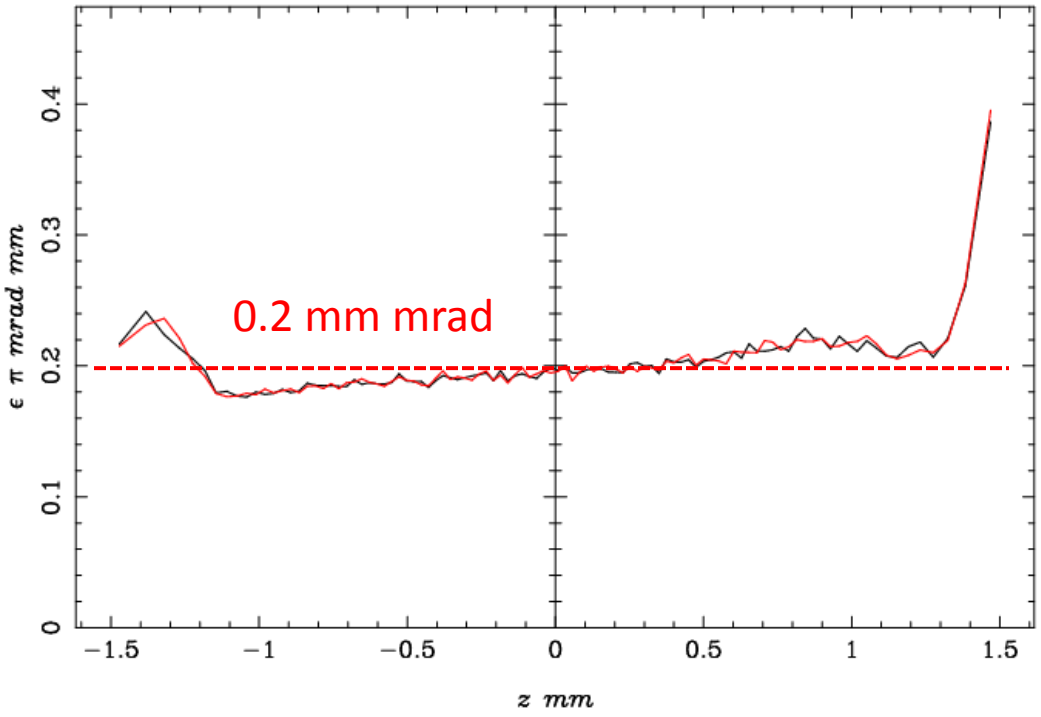
Baseline 2 Injector (updated Spring 2013)

- **Gun1**
- **Gun solenoid** at 205 mm from cathode (no magnetic field compensation solenoid)
- **3 accelerating sections with 2 focusing solenoids**
- 120 MV/m max field at cathode, 5.7 MeV beam energy at gun exit
- **9 MV/m gradients at 1st accelerating tubes, 17 MV/m at 2nd and 3rd tubes → 132 MeV beam energy at injector end**
- 1st accelerating section starts at 2.2 m from the cathode (longer e-beam focal length due to the smaller laser beam at cathode)
- No quadrupoles for keeping the beam transverse shape to be circular through the injector

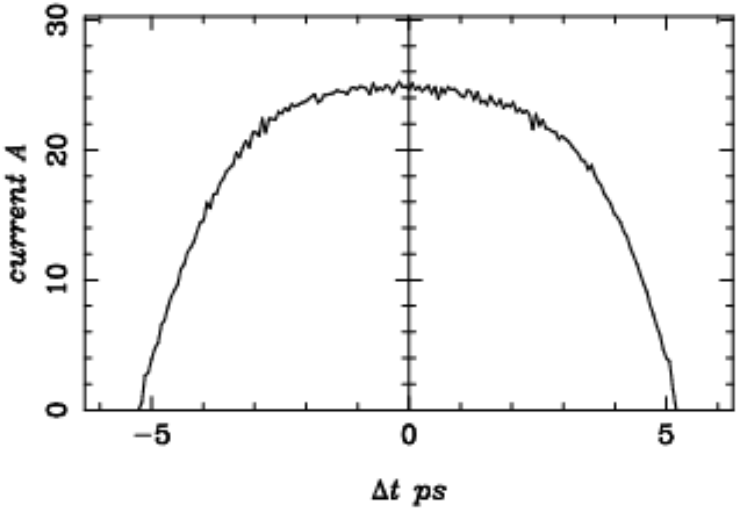


Beam Parameters of Baseline 2 Injector

Emittance at central slices ~ 0.2 mm mrad

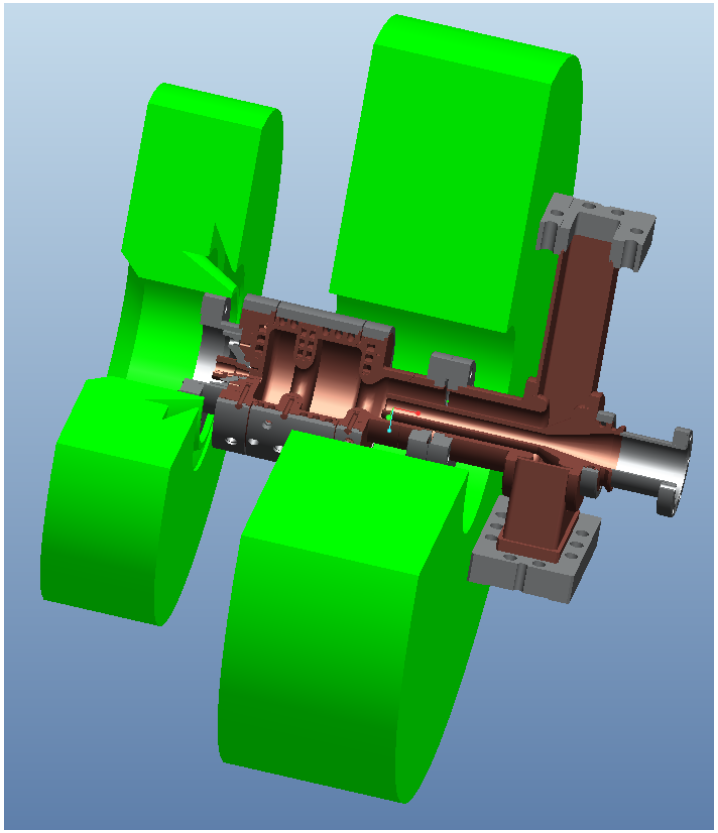


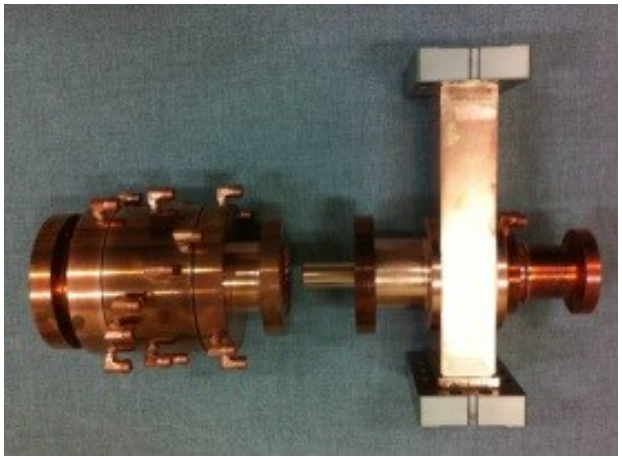
Peak current 25 A



PAL-XFEL Gun2

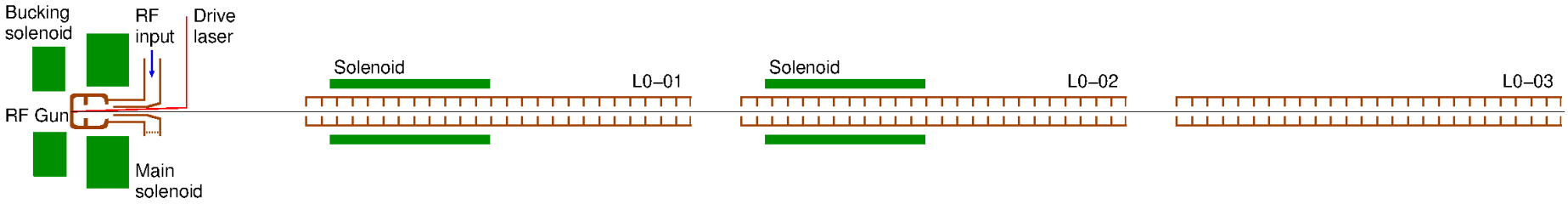
- Developed by PAL since 2012
- Design based on Diamond S-band gun which is based on PITZ L-band gun
- 1.54 cell & coaxial coupling
- Cold test ready
- Beam commissioning planned in 2014





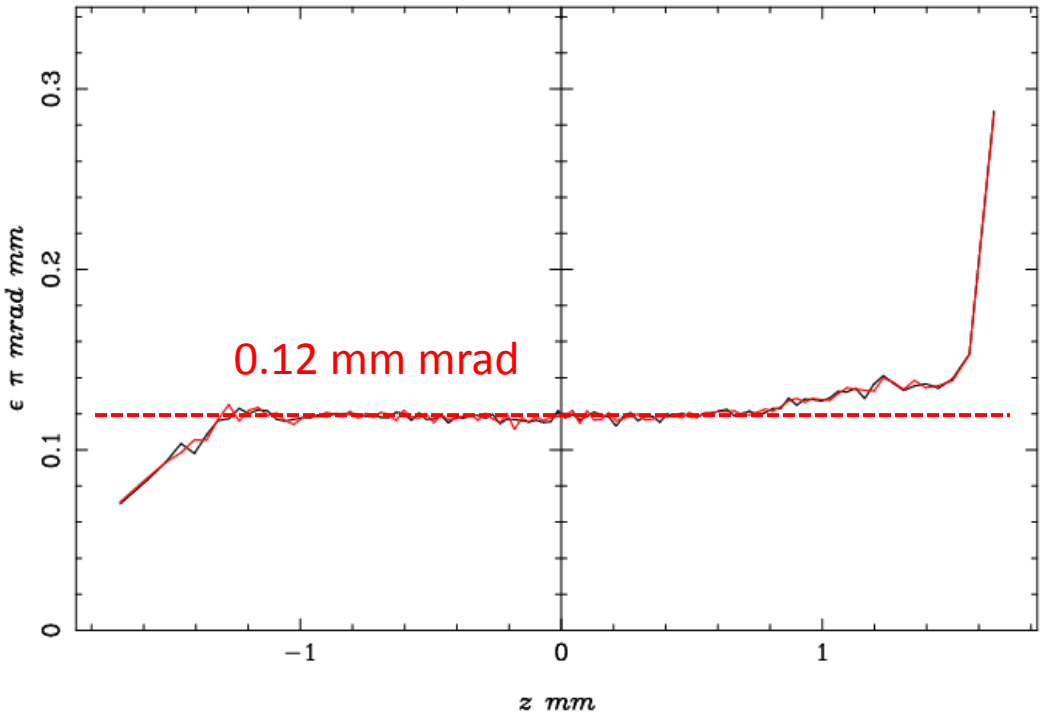
Alternative Injector (for lower Emittance)

- **Gun2**
- **Gun solenoid** at 105 mm from cathode with a bucking solenoid
- **3 accelerating sections with 2 focusing solenoids**
- 120 MV/m max field at cathode, 5.3 MeV beam energy at gun exit
- **9 MV/m gradients at 1st accelerating tubes, 16 MV/m at 2nd and 3rd tubes → 125 MeV beam energy at injector end**
- 1st accelerating section starts at 1.7 m from the cathode
- No quadrupoles for keeping the beam transverse shape to be circular through the injector

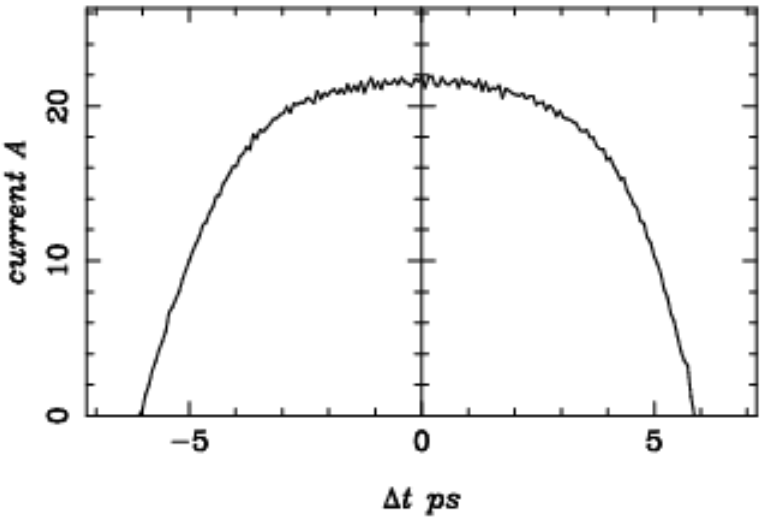


Beam Parameters of Alternative Injector

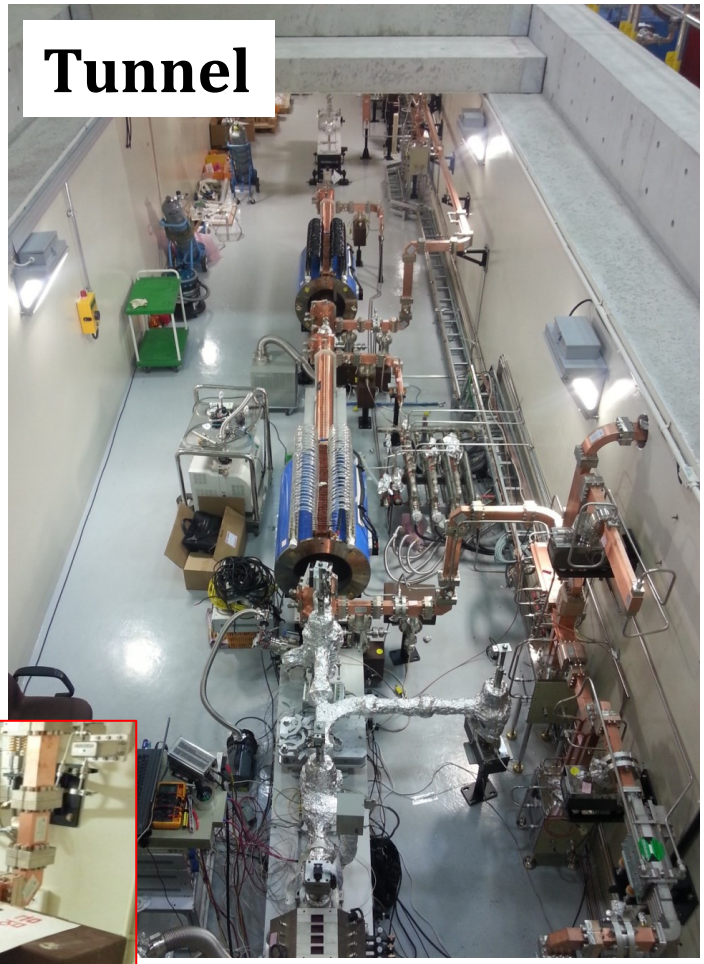
Emittance at central slices ~ 0.12 mm mrad

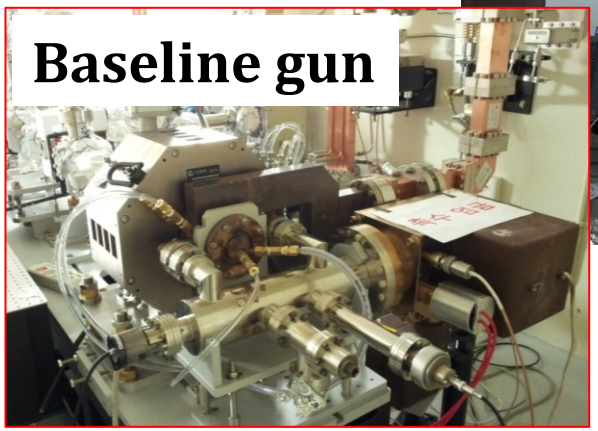


Peak current 22 A

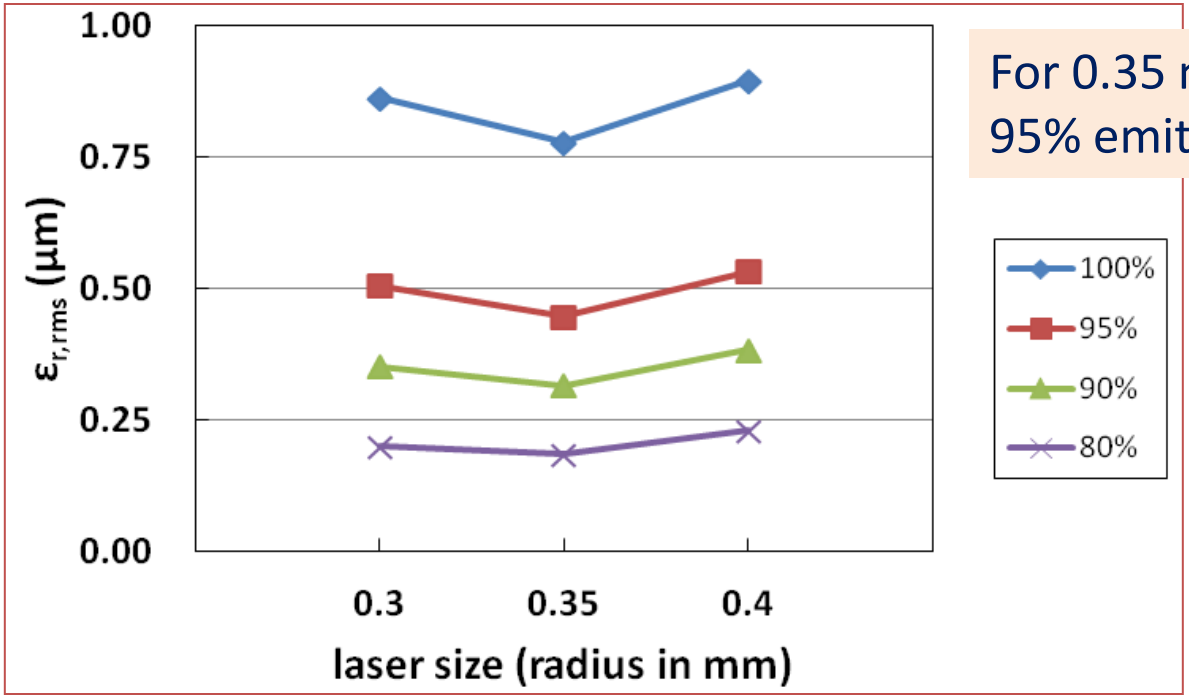


Injector Test Facility (ITF)



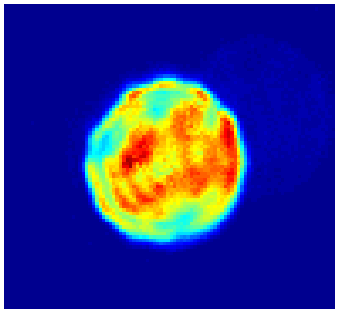


First Results from ITF



For 0.35 mm laser size (full radius)
95% emittance: 0.41 / 0.48 µm in X / Y

Laser beam profile



parameter	Value
Beam energy	135 MeV
charge	200 pC
Gun phase (laser injection)	35 degs
Accelerating column phase	on-crest (both)

Thanks