Turkish FEL Projects and Proposals

- **Turkish Accelerator and Radiation in Ankara (TARLA) Project**
- **SASE FEL Proposal based on X-band accelerating structure**

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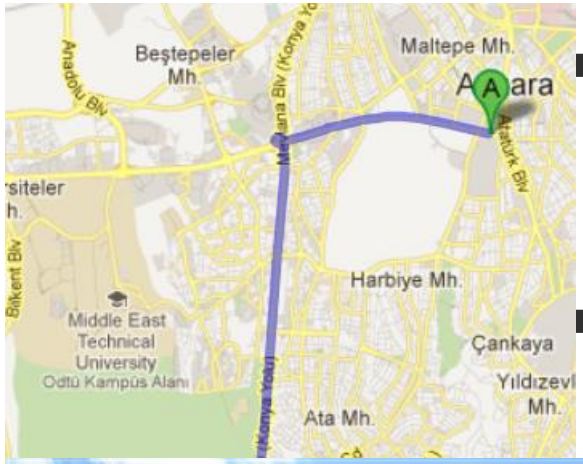
TARLA facility at Institute of Accelerator Technologies of Ankara University

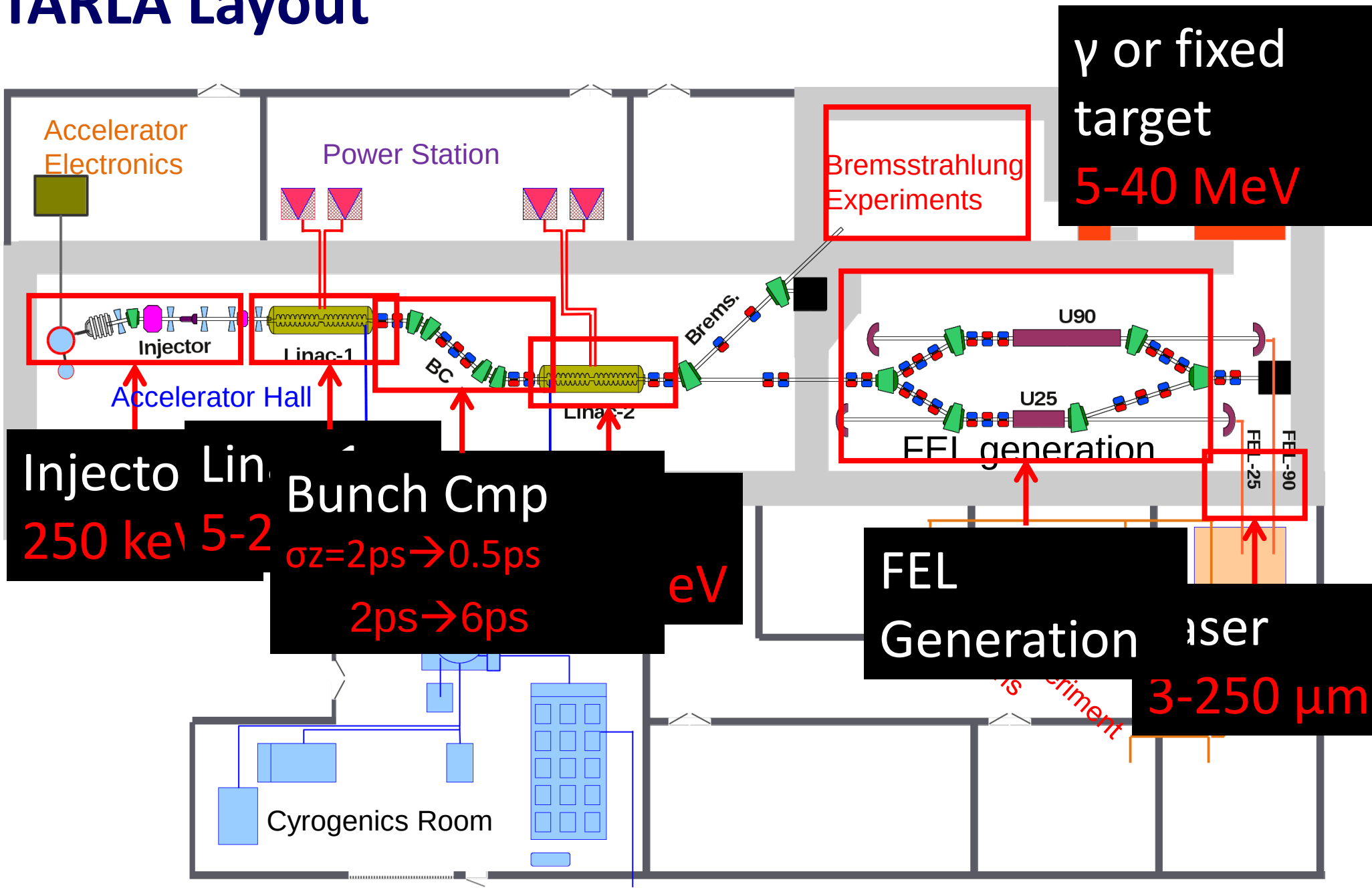


- The institute which is only 2 years old is the first institute established as research in the fields of accelerators and related topics in Turkey
- TARLA project which is essentially one of the sub-project of national project Turkish Accelerator s been coordinated by Ankara 2006.
- elongs to Institute of Accelerator Ankara University (located in s supported by Ministery of

Main goals of TARLA

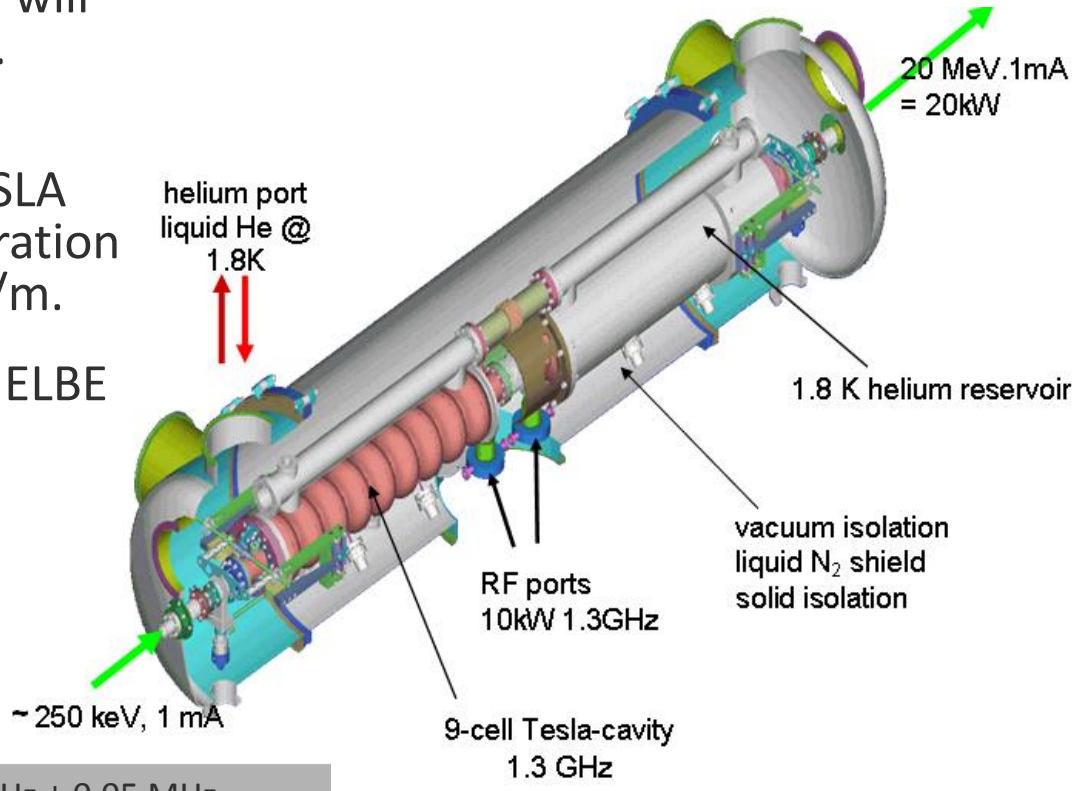
- TARLA basically proposed to generate Free Electron Laser between 3-250 μm using 15-40 MeV electron beam
- In order to have wide research area, the electron beam is requested to be continuous wave with high current as well as pulsed with low current
- We plan to use high average current normal conducting injector which operates CW mode and Superconducting accelerators which are fed by solid states power amplifiers.
- To obtain FEL 3-250 micron range using two different optical resonators with 2.5 and 9 cm period length undulators has been proposed..
- Additionally a Bremsstrahlung station is also proposed for nuclear structure and gamma radiation studies.

TARLA Layout



Main accelerator: SRF Module (ELBE Module)

- Super conducting RF accelerating modules will be manufactured by Research instruments.. (Contract in 2012 Oct., Delivery 2015 Jan.)
- This module is compact and houses two TESLA cavities and is designed for continuous operation at accelerating fields in the range of 15 MV/m.
- The cryostat design has been developed by ELBE team (HZDR) and is used under a license agreement.



Cavity frequency at 2K	1300.0 MHz ± 0.05 MHz
Tuning range	±120 kHz
External Q of input couplers	(1.2 ±0.2) x 10^7
External Q of HOM couplers	> 5x10^{11}
Stand by losses of cryostat	< 15W
Total accelerating voltage of the module	> 20 MV
Dynamic losses at 20 MV cw operation	< 60W
Total cryogenic losses at 20 MV cw operation	< 75W
Power coupler performance (standing wave)	≥ 8 kW

Power source → Bruker Solid States Amplifiers

LLRF → JLab digital LLRF

Main Parameters of TARLA

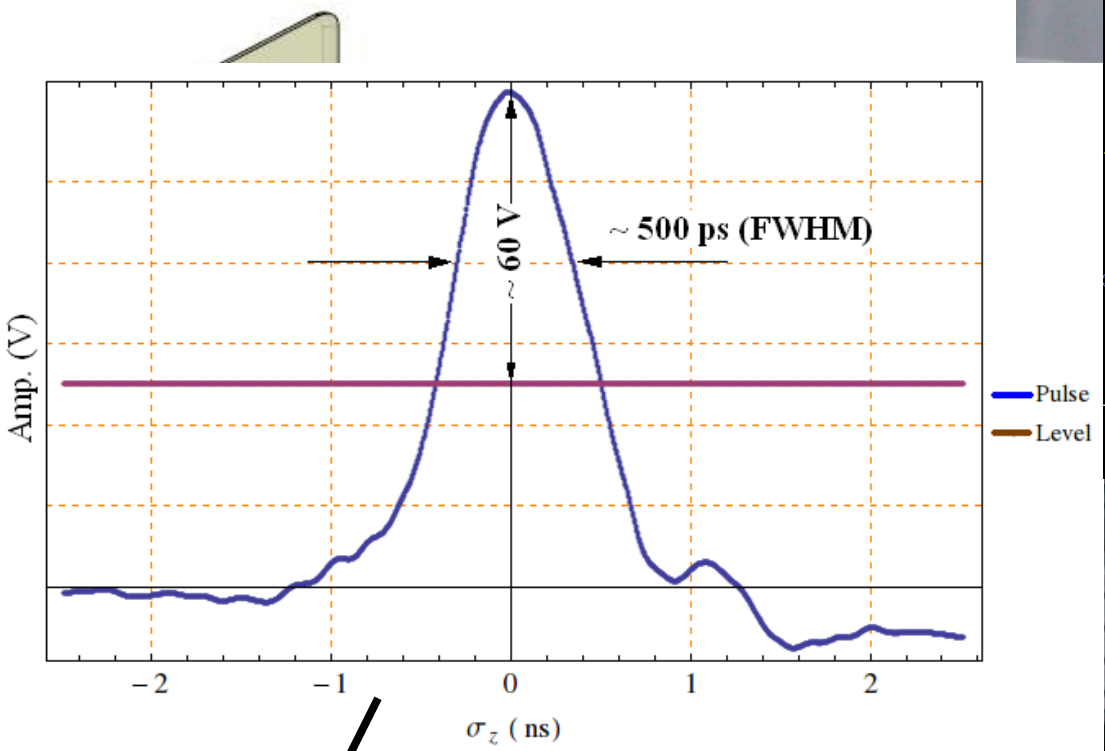
Electron beam Parameters

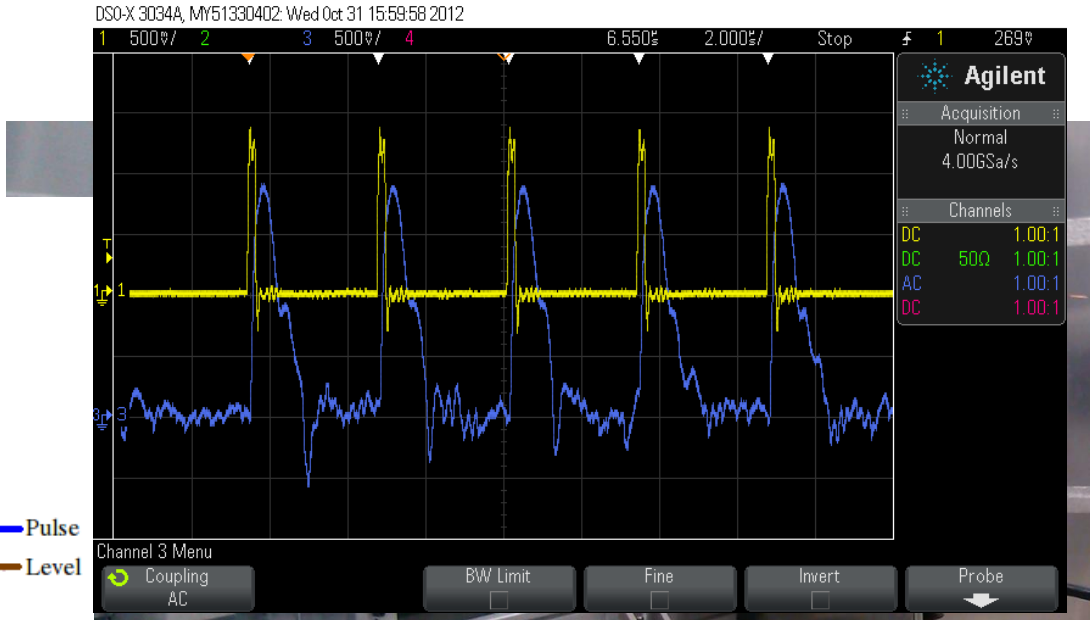
Parameter	Base	Upgrade	Unit
Beam energy	15-38.5	15-38.5	MeV
Max average beam current	1	1.5	mA
Micro pulse repetition frequency	13	13-26	MHz
Micro pulse length	0.5-6	0.5-6	ps
Transversal emittance	< 12	<13	mm.mrad
Longitudinal emittance	< 50	< 50	keV.ps
Macro pulse length	CW / 40-100	CW / 40-100	µs
Macro pulse repetition frequency	CW / 1-100	CW / 1-100	Hz

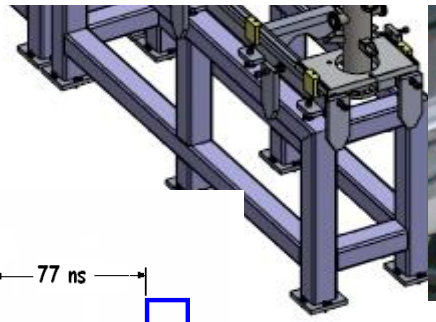
Laser Parameters

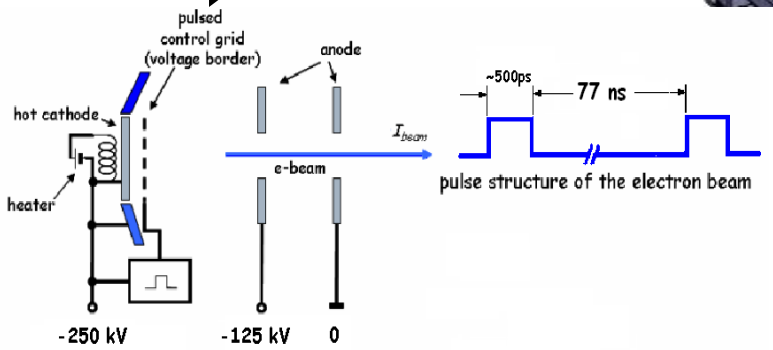
Parameter	U25	U90	Unit
Wavelength	3-18	17-250	µm
Micropulse repetition	13	13	Mhz
Max. Peak Power	0.1 – 5	0.01-2	MW*
Pulse length	0.5-6	0.5-6	ps *
Average Power	1-100	1-50	W*
Max. Pulse energy	0.1-3	0.1-3	µJ*

Gun Commissioning









Time table of TARLA

- Completing the injector test → mid 2014
- Installation of He plant → 2014-2015
- Installation of first cyromodule → 2015
- Installation of second cyromodule → mid 2015
- Beam at 40 MeV → end of 2015
- Fixed target experiments → 2015 - …
- Installation of lasing section → 2015-2016
- FEL for users → 2017

SASE FEL Proposal of TAC

SASE-FEL based on 1 GeV linac proposal was the second FEL project of TAC.

It has been preliminary studied based on SC linac similar to FLASH.

- The new idea is using X-Band linac for TAC SASE FEL project proposed by CERN CLIC team by end of 2012

Oportunities

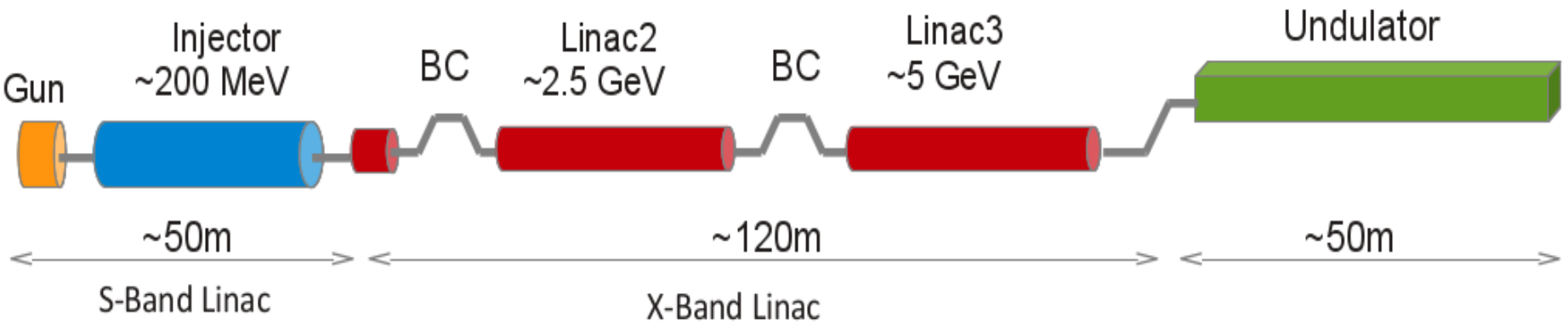
- Turjey will have oportunity o transfer new technology to Turkish acclerator comminity and industry, and will have SASE FEL with huge support of CERN
  - Knowhow, infrastructure, development

- CERN will have the opportunity to demonstrate the performance of the CLIC accelerating structures in a realistic operational environment as a user facility.

X-band Based SASE FEL Proposal

- Meeting on X-band Linac based FEL facility 17-18 January 2013, Ankara, Turkey

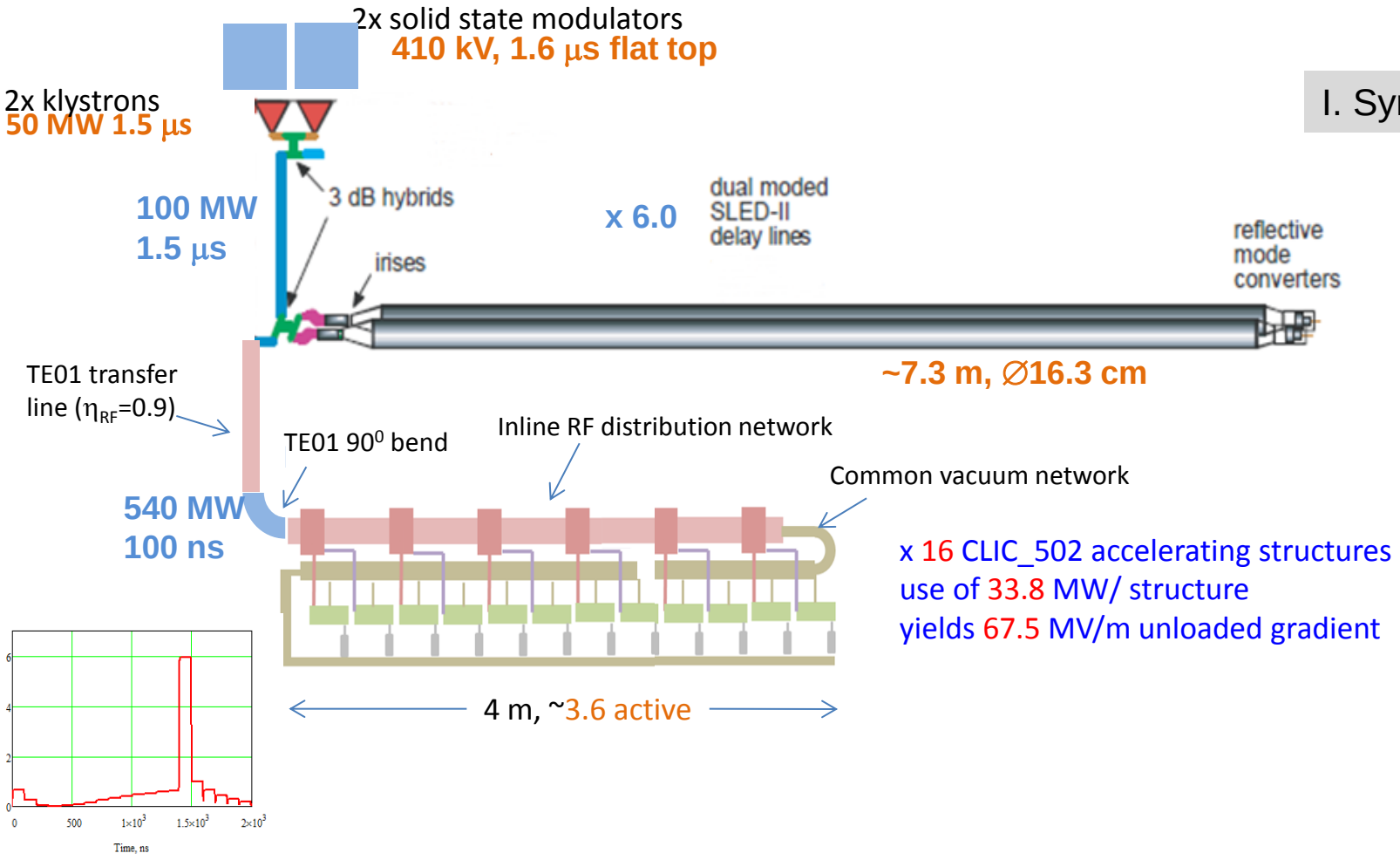
Layout of proposed SASE FEL



- 200 MeV injector based on S band linac
- 2 stage of main accelerating section based on X-band up to 5-6 GeV
- Lasing section: several undulators or single undulator

X-band accelerating module (RF Unit)

Electron linac RF unit layout based on the existing Rf sources (klystron and modulator)



This unit should provide ~248 MeV acceleration beam loading.
For 5 GeV 20 RF units are needed.

Power compression options

- Repetetition rate — < 100 Hz — > 100 Hz
  - Klaystron power — 50 MW — 6 MW
  - Number of klaystrons — 40 — 320

- Number of bunches — single — multi
  - Combination scheme — CC — SLED II

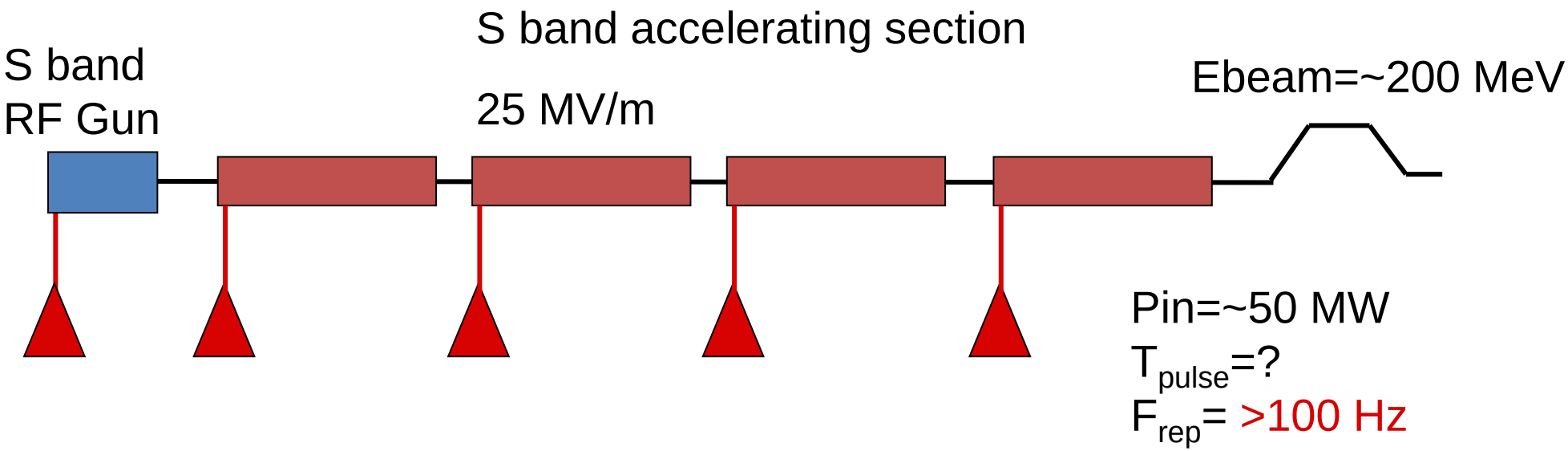
Requested Pulse Pattern	
Single bunch	47 %
multi-bunch with different bunch spacing	53 %
Requested FEL pulse duration	
< 50 fs fwhh	28 % (*)
50 -100 fs	54 %
not critical, but high intensity	18 % (**)

(*) 72 % multi-bunch (**) mostly multi-bunch

Josef Feldhaus
European XFEL / HASYLAB Users' Meeting
DESY, January 26, 2012

The user comminitee will define these options

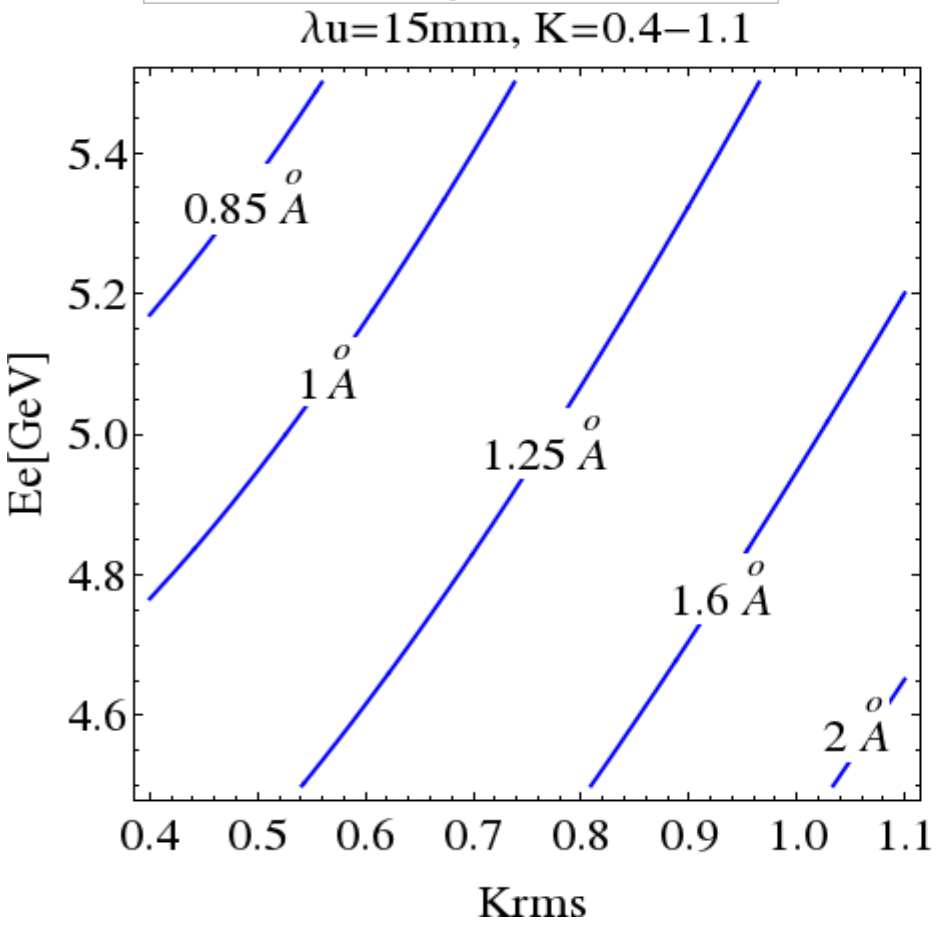
Injector

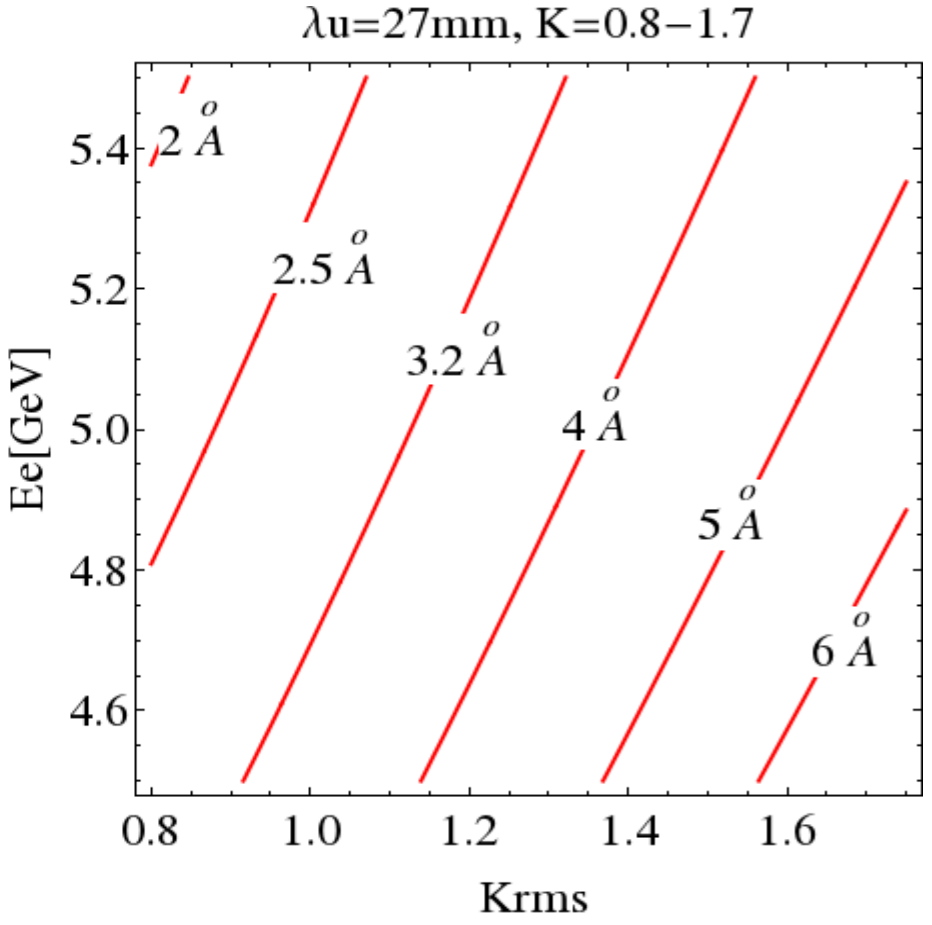


- It can be similar to SwissFEL injector
- For high repetition rate (>100 Hz) option we will have same problem for the klystrons in the injector…
  - Is there high repetition rate klystrons which can drive S band structures?
  - Or we have to make combination for the Low power High reprate klystrons?
  - For single bunch option shall we also use power compression?

Scanned wavelength

$$\lambda_{FEL} = \frac{\lambda_{und}}{2\gamma^2}\left(1 + K_u^2\right)$$

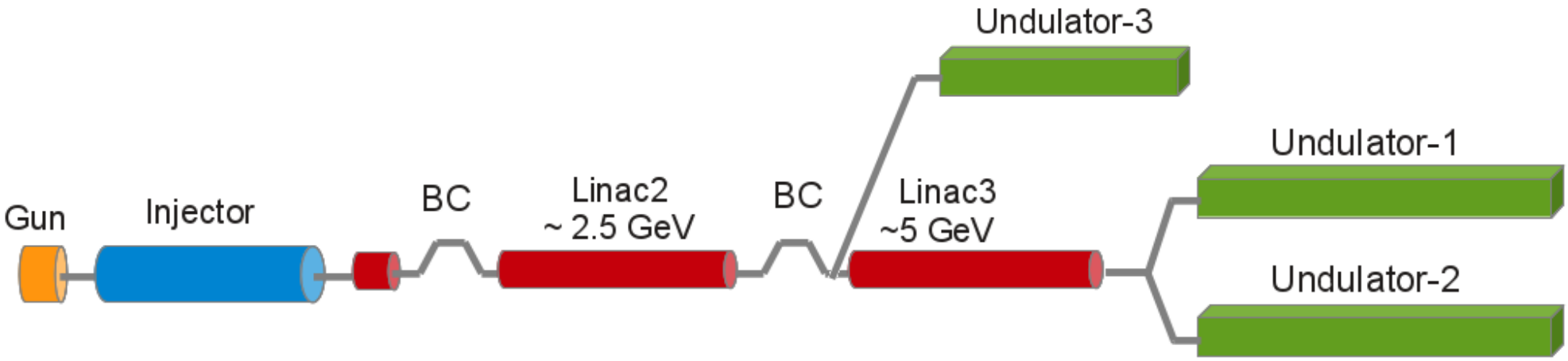




- In order to scan large FEL wavelength ranges tunable energy 4.5 GeV – 5.5 GeV would not be enough

Lasing section

- Lasing section should be multiple undulator line



- Reducing the gradient or energy will cause longer bunch length
  - Slippage effect $\Delta z \approx N_u \lambda_{FEL}$
- Shortest bunch length is required by shortest FEL wavelength

Time table for XFEL

- The preparation phase, including
  - the Conceptual Design Report (1 Year)
  - the Technical Design Report (~3-4 Years)
    - the development of the RF gun and
    - a klystron and 12 GHz test stand;
- the construction of the injector (~2 years)
- The construction of the X-band acceleration section to 2.5 GeV (~2 years)
- the construction of the final stage of X-band acceleration to 5 GeV. (~2 years)
- installation of undulator section(s) (~2 years)

Conclusion

- Turkey wants to fulfill the needs of accelerator and accelerator based technology inside country and its region within next 20 years..
- Therefore three different light source project/proposal within TAC scope is (going to be) supported step by step..
  - Oscillator FEL (TARLA) under construction
  - Synchrotron Radiation based on 3 GeV ring (TDR phase)
  - SASE FEL project based on 5 GeV linac (CDR phase)

- The support of CERN will be a big step towards our goals
- We have a chanche to build SASE XFEL relatively cheaper by using x-band structures..