

AREAL –Status and Plans

B.Grigoryan

Contents

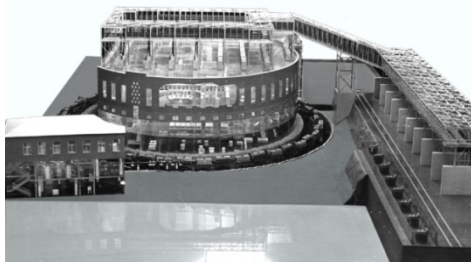
- AREAL accelerator
 - Schematic overview
 - Laser System (AREAL, AVESTA)
 - Experiments (Running, Planned)
 - Facility experimental possibilities
- Laboratories (DELTA, Vacuum, Magnets, Workshop)
- Experimental possibilities at CANDLE

Introduction.

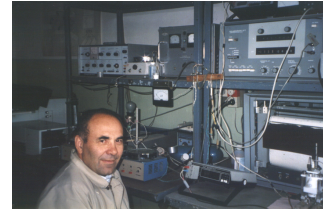
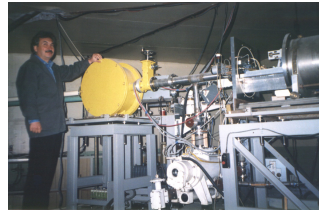
6 GeV synchrotron (1967)



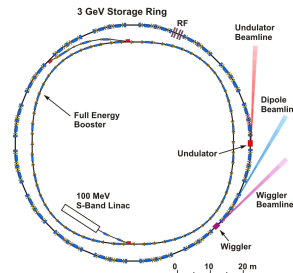
A.I. Alikhanian



3 Synch Rad Beamlines (1973)



3 GeV CANDLE Light Source



Energy	3 GeV
Current	350 mA
Circumference	216 m
Emittance	8.4 nm

The strong user community will emerge as the facility is readied.

Review Panel

Introduction.



→ 2011
“Exit” Scenario

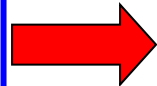
AREAL – Advanced Research Electron Accelerator Laboratory

- Small facility + Limited investment
- State-of-the art facility
- Scientific & Technology asset
- Long Term Highlights
- Multiple applications



Ultrafast Science
and Technology

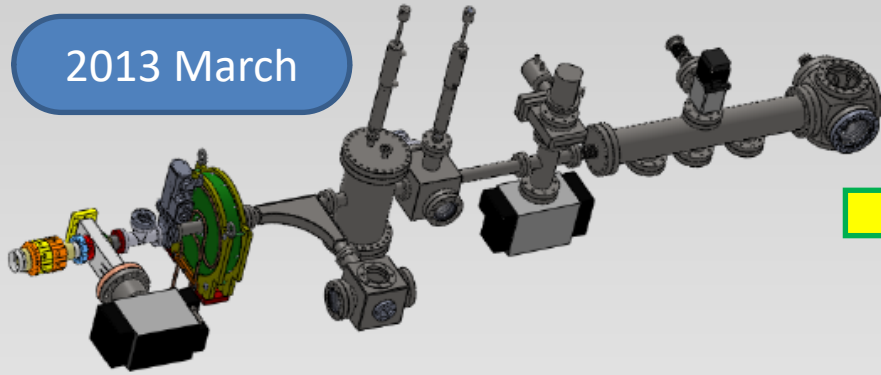
→ Ultrashort e^- bunches – sub ps
Small phase space $< 1 \mu\text{m}$



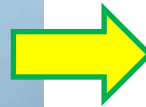
Free Electron Laser

Introduction.

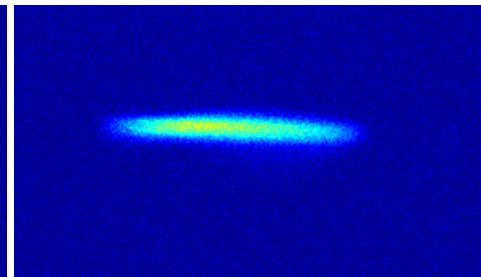
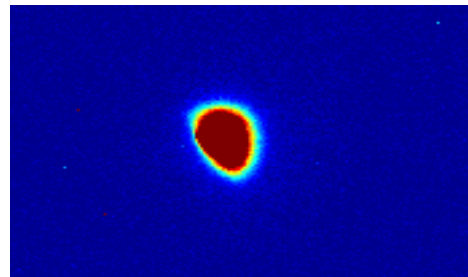
2013 March



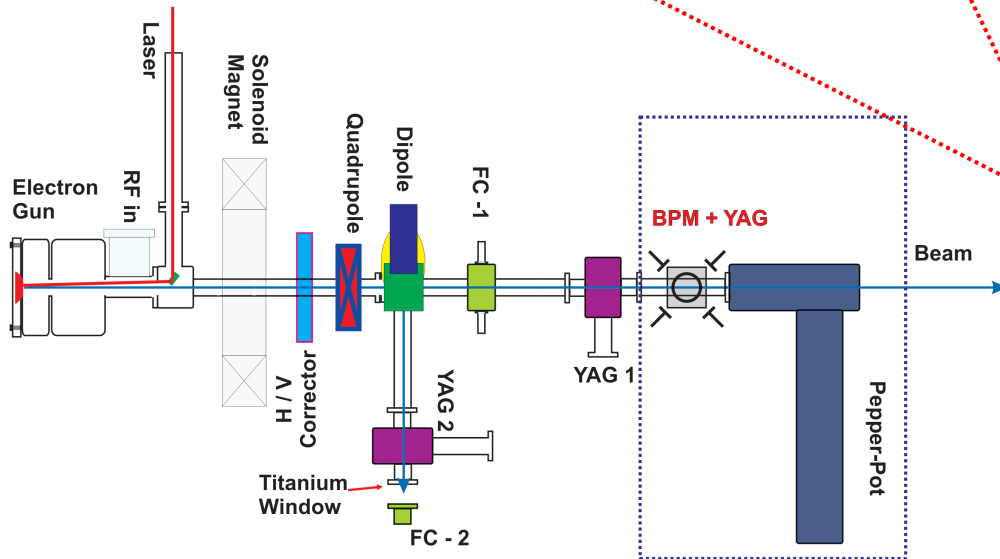
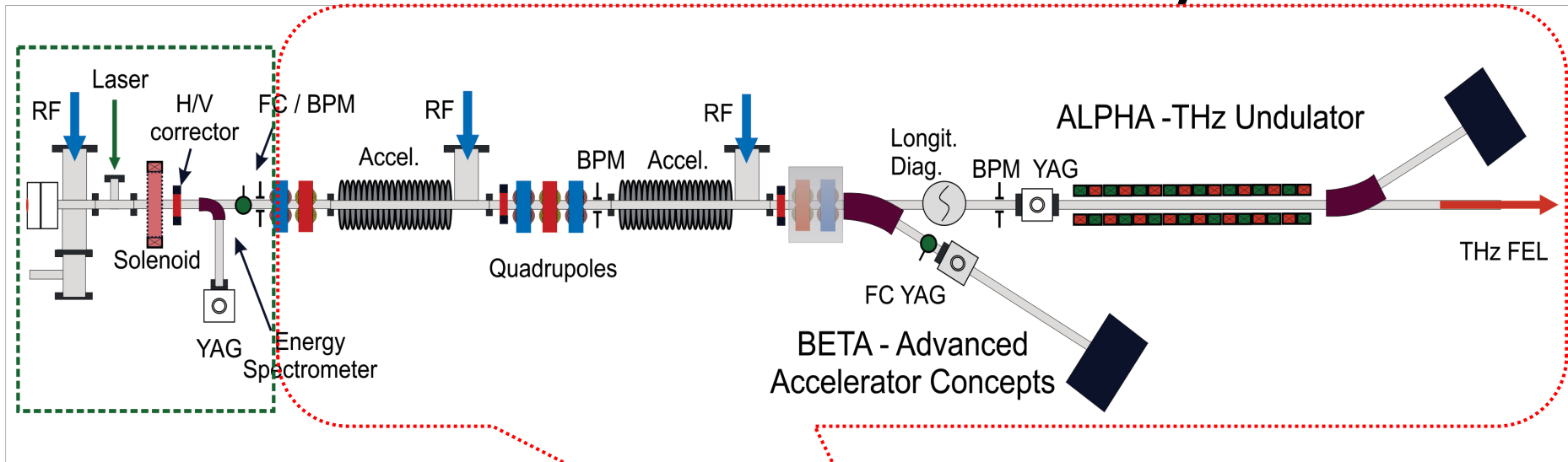
2013 October



17:32 20 Dec 2013
First Beam – 36 pC charge

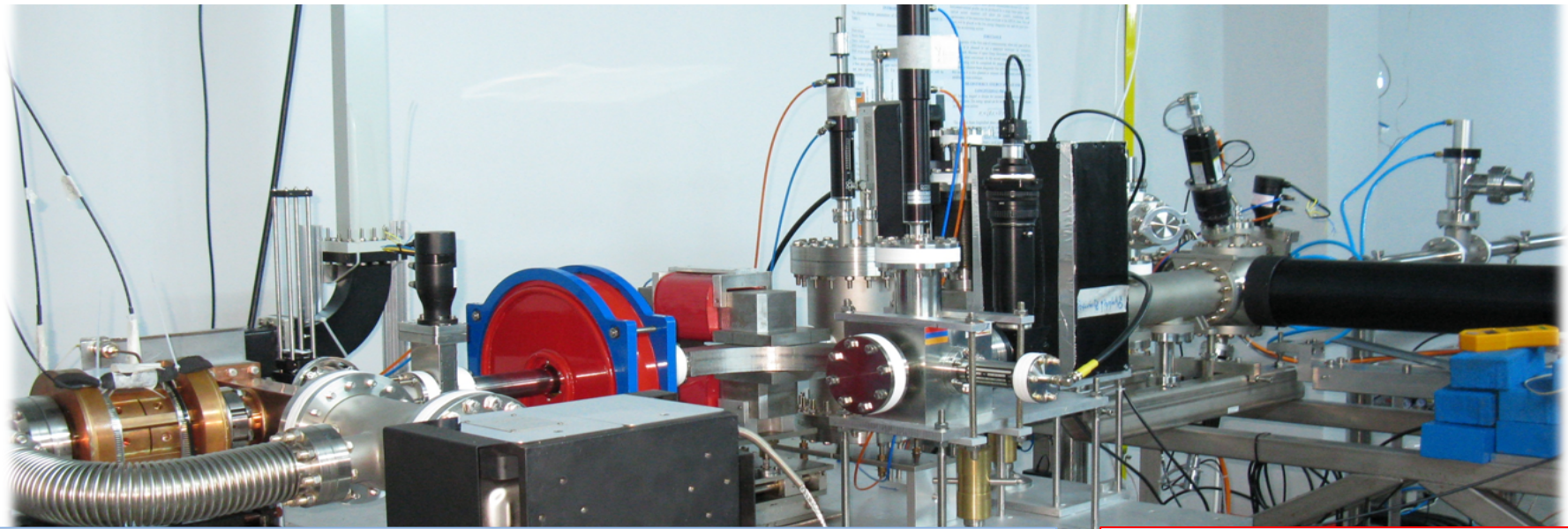


AREAL- Advanced Research Electron Accelerator Laboratory



AREAL -50 Upgrade Program

- 20,50 MeV electrons
- FEL Radiation
 - Wavelength 2- 6.7 μm
 - Frequency 45 -125 THz
 - Pulse energy 60-100 μJ



AREAL General Parameters:

Charge	10 - 850* pC (150-250 pC nominal)
Repetition rate	1- 50 ** Hz
Transv. beamsize (x/y)	2/3 (@ straight) 20 / 8 mm (@ dipole)
Norm. Transv. emitt. (x/y)	≤ 1 mm-mrad
Energy	≤ 5.0 MeV
Energy spread (at dipole)	< 0.5%
Experiment duration	1 - 744*** hours

Fields of Potential Interest:

Solid State Physics

Biology

Molecular Physics

Optics

Material Science

Food Processing

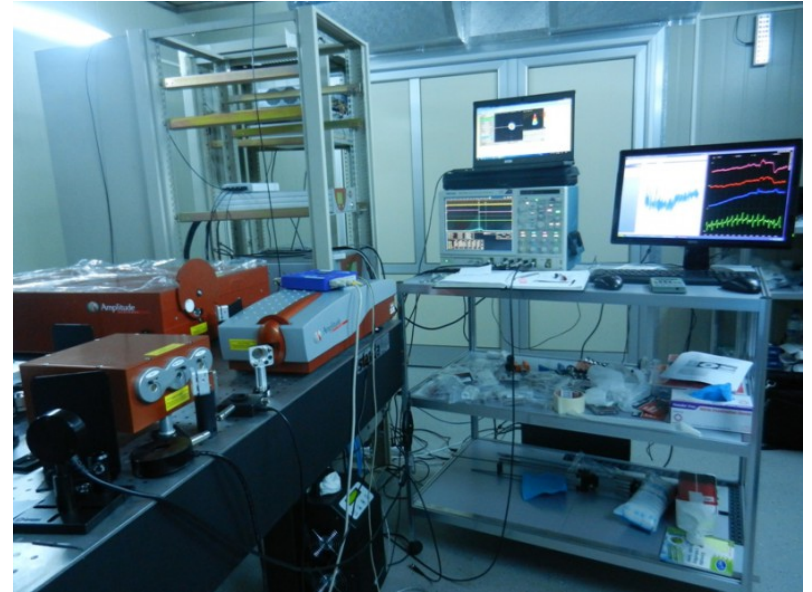
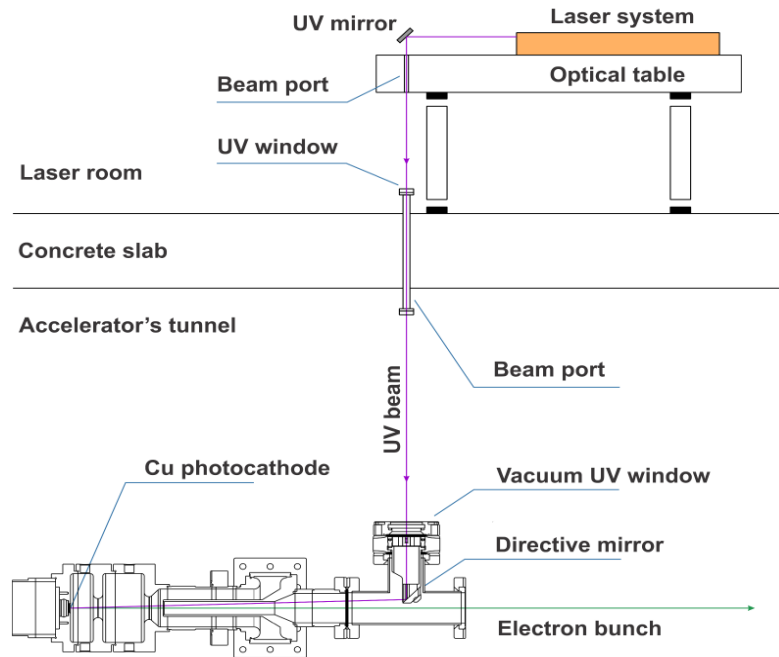
Chemistry

Oncology

Medical Equipment Sterilization

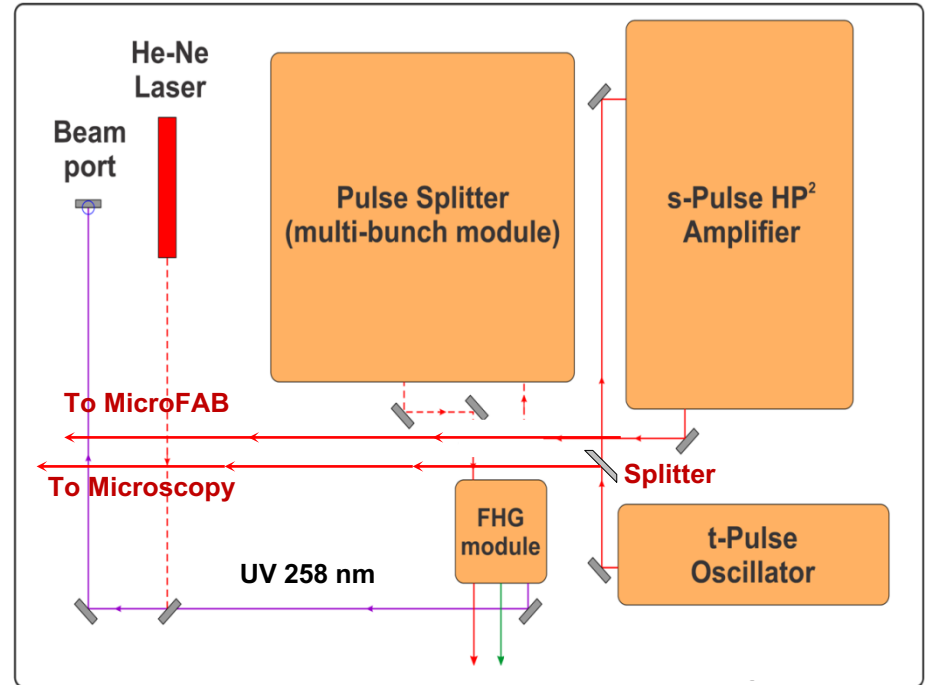
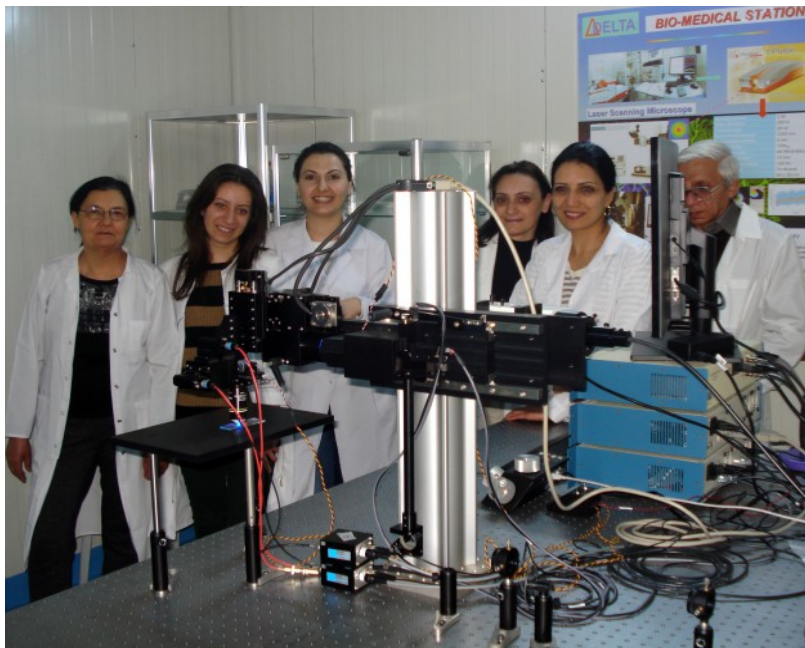
- * High charge regime for dedicated experiments (achieved November 2015)
- ** Tests were performed up to 47 Hz with nominal charge of 150 pC. (end 2015)
- *** 31 days of uninterrupted operation in May-June 2014, September-October 2018.

AREAL Laser System



Parameters of UV laser pulse	
Central Wavelength	258 nm
Pulse energy	up to 450 μ J
Rep. Rate	up to 100 kHz
Pulse length FWHM	0.45-9 ps
Energy Stability 18 h	< 0.9 %
Pulse-to-pulse jitter	< 0.5ps

AREAL Laser System



Parameters	
Central Wavelength (Osc, Ampl./ HG)	1030 nm /1030 nm/ 258 nm
Pulse energy (Osc. / Ampl.)	20 nJ / up to 450 μ J
Rep. Rate (Osc. / Ampl.)	49.96 MHz / up to 100 kHz
Beam Quality M ² (Osc. / Ampl.)	< 1.1 / < 1.2
Pulse length FWHM (Osc. / Ampl.)	237 fs / 0.4-9 ps
Energy Stability 18 h (Osc./ Ampl.)	<0.9 % / < 1.0%

Ongoing Activities. Laser Based

DELTA Laboratory

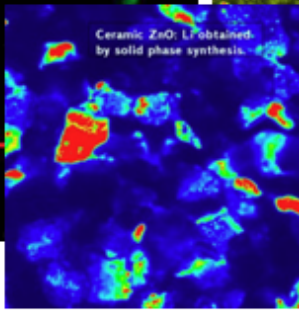
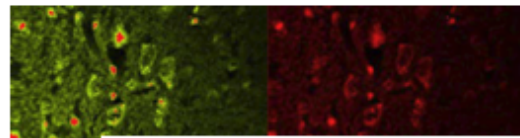
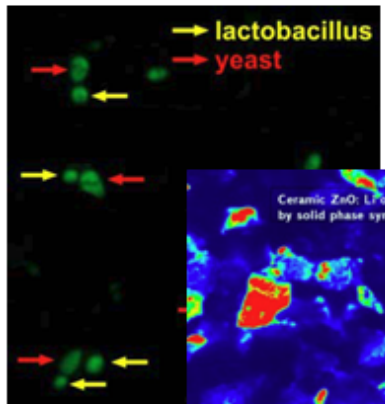
Two-photon Microscopy Station

Microfabrication Station

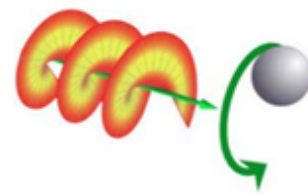
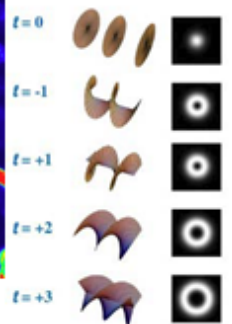


- Bio-medicine
- Material science
- Environmental science

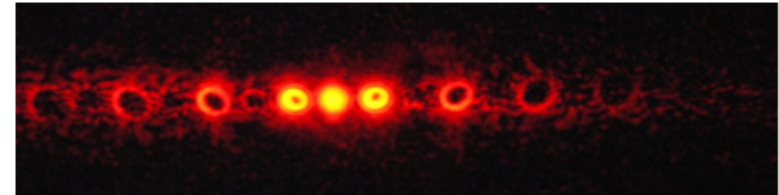
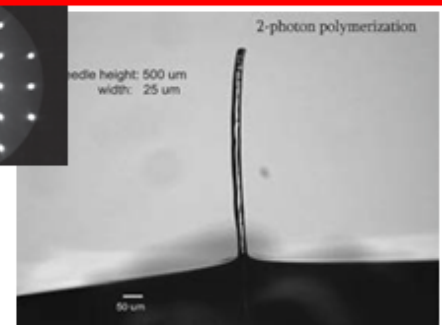
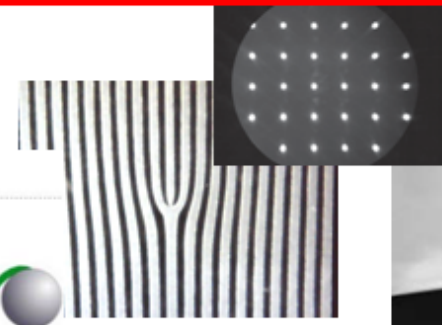
- Photonics, microelectronics, MEMS
- Polymers, semiconductors, ceramics
- Micro- and nano-structuring,



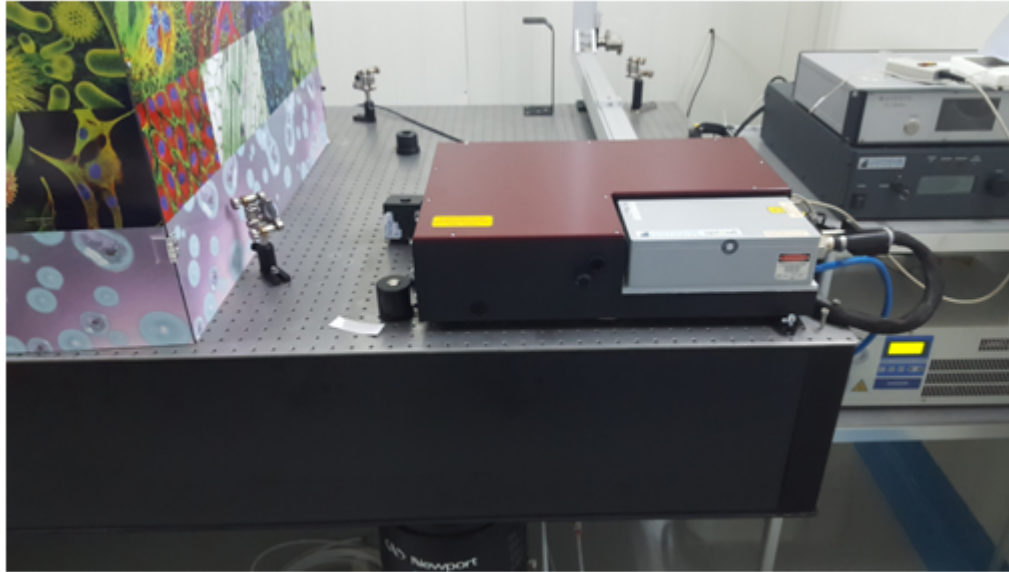
Helically phased beams



- › Azimuthal phase dependence $\exp(i\ell\phi)$
- › Optical vortex
- › Carry OAM of $\ell\hbar$ per photon

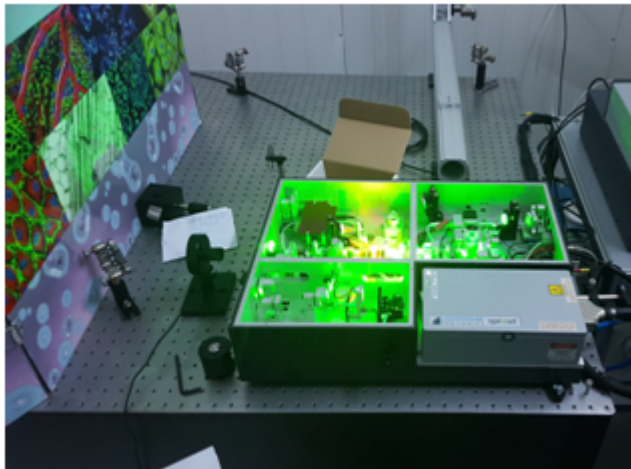


AVESTA Ti:Saph Laser System



Ongoing:

- The transport line to uFAB station
- Additional diagnostics
- Set-Up for two – lasers experiments



Parameters	AVESTA laser pulse	
Wavelength	tunable	750 – 900 nm
Average power @ 800nm		~ 1 W
Rep. Rate		~ 81 MHz (1/37 of S-band)
Pulse length FWHM		50 fs

2015-2019 – Exper. program

Genetics

Proposals –24
Institutions –14
Scientists – 68

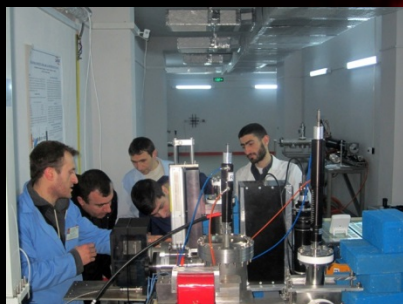
Molecular Physics



Biology



Micro- electronics



New materials



Solid State Physics

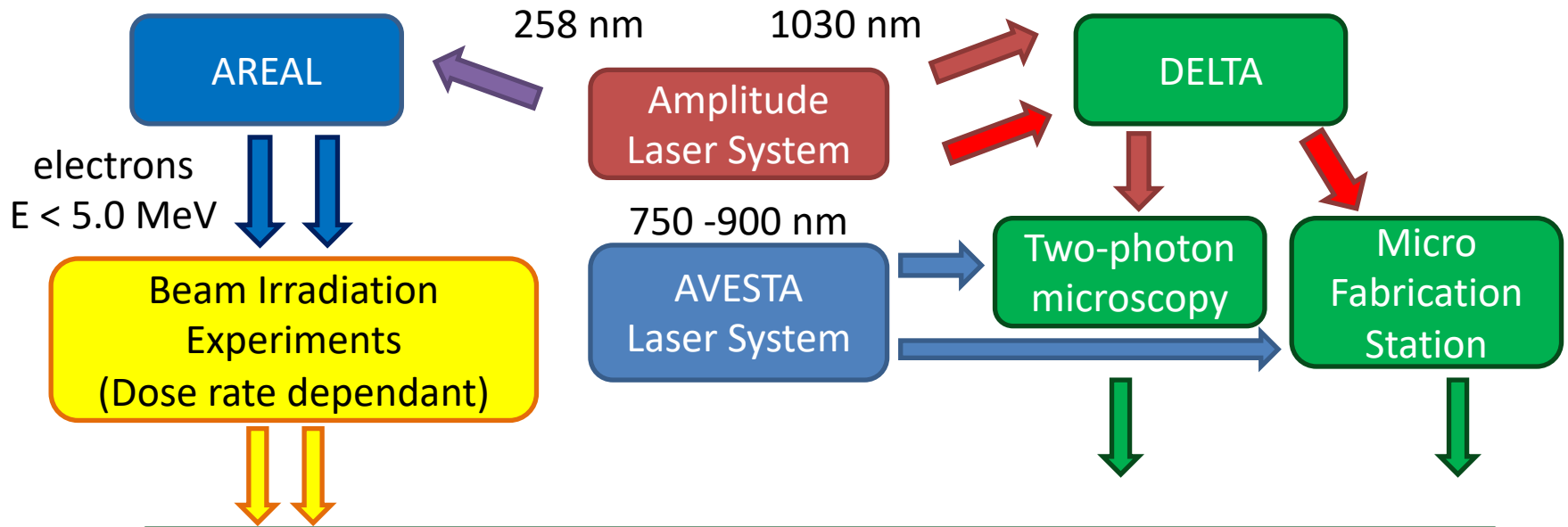


Oncology

Micro-Fabrication



Ongoing Experiments at AREAL



- | | |
|-----------------------------------------------------------|-----------------|
| • Solid State Physics (YerPhi) | - AREAL |
| • Food processing (Agrarian State Univ.) | - AREAL / DELTA |
| • Biology (Genetics chair, Yerevan State Univ) | - AREAL / DELTA |
| • Biology (Institute of Molecular Biology, NAS, Armenia) | - AREAL / DELTA |
| • Biology (Institute of Radiation Biophysics NAS, Russia) | - AREAL |
| • Microelectronics (State Polytechnical Univ.) | - AREAL |
| • Molecular Physics (Yerevan State Univ.) | - AREAL / DELTA |
| • Biophysics (YerPhi) | - AREAL / DELTA |

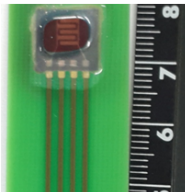
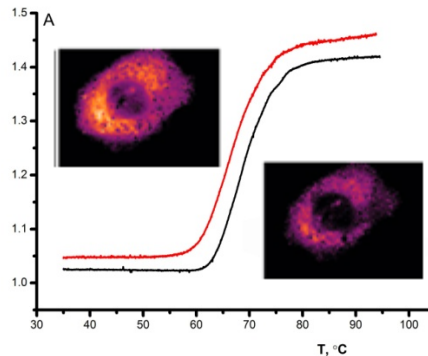
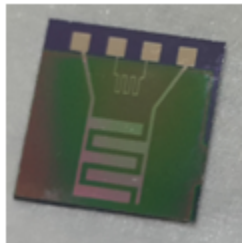
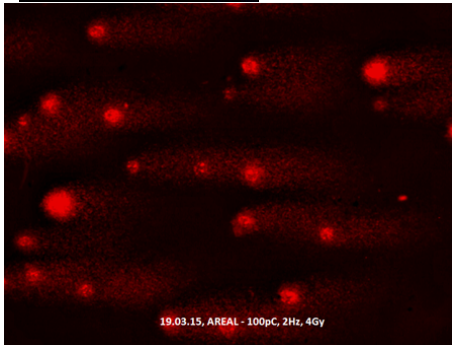
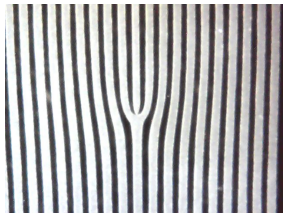
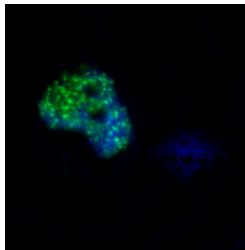
Experimental Stations

Ongoing Experiments 2015-2019:

1. YerPhI (Semiconductors)
2. YSU (Genetics)
3. NAS RA (Molecular physics)
4. NPUA (Microelectronics)
5. CANDLE (EM fields)
6. NAS RF (Radiation Biophysics)

Upcoming Experiments. Starting 2020:

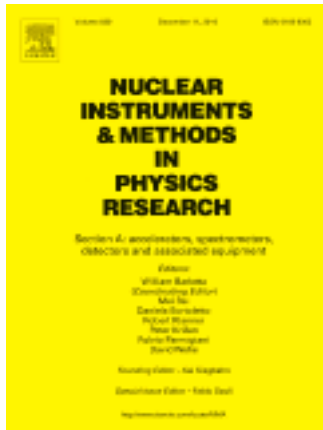
1. YerPhI (Semiconductors)
2. YSU (Genetics)
3. NAS RA (Molecular physics)
4. State Agrarian Univ. (Food Processing)
5. CANDLE (Single Mode Resonator)
6. NAS RF (Radiation Biophysics)



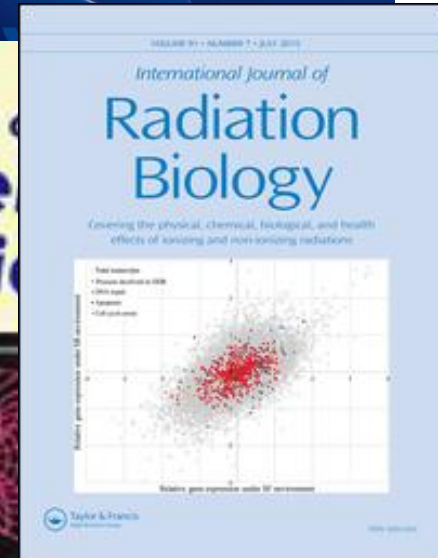
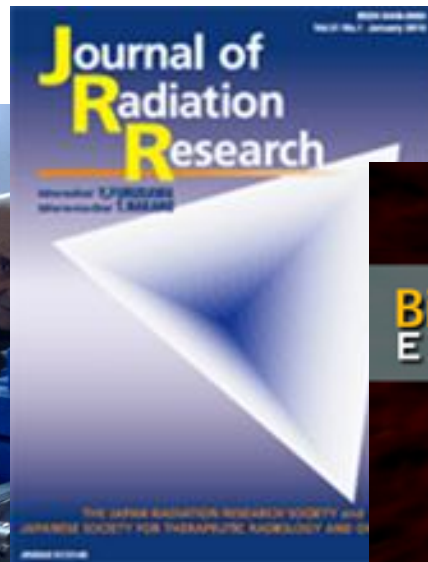
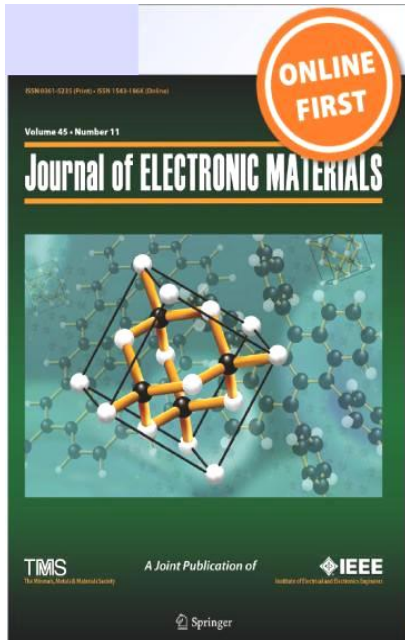
Operating Parameters:

Charge	30 - 50 pC
Repetition rate	2- 25 Hz
Transv. size (x/y)	20 / 8 mm
Energy	2.8 - 4.7 MeV
Av. exper. duration	1 - 8 hours

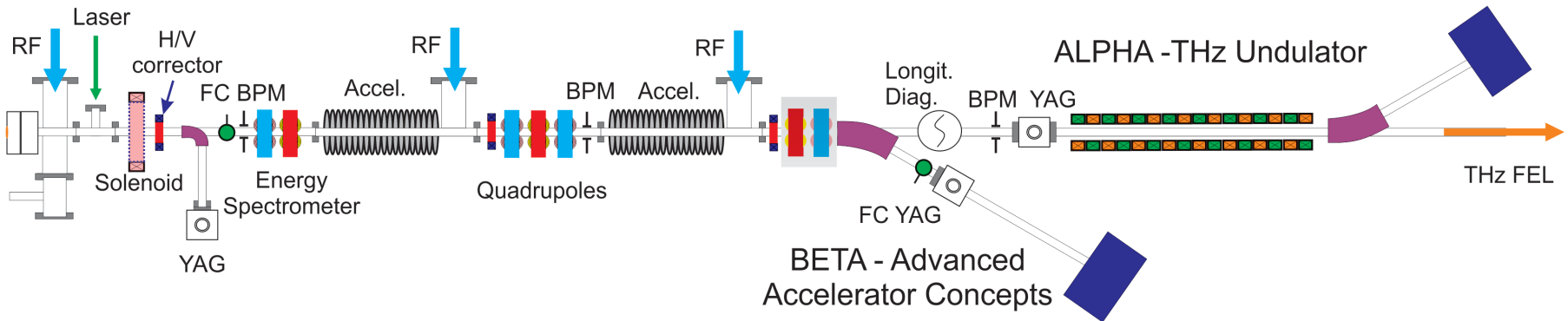
Publications



PHYSICAL REVIEW ACCELERATORS AND BEAMS

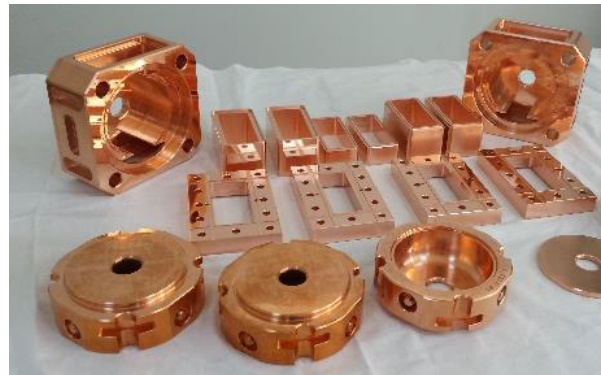
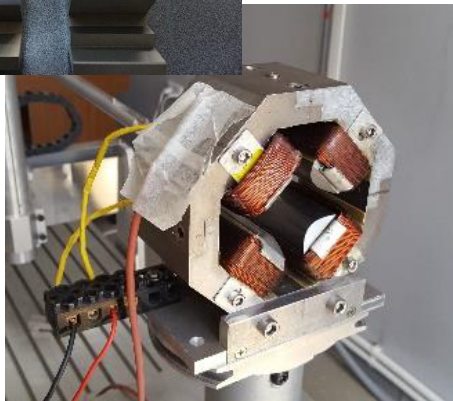
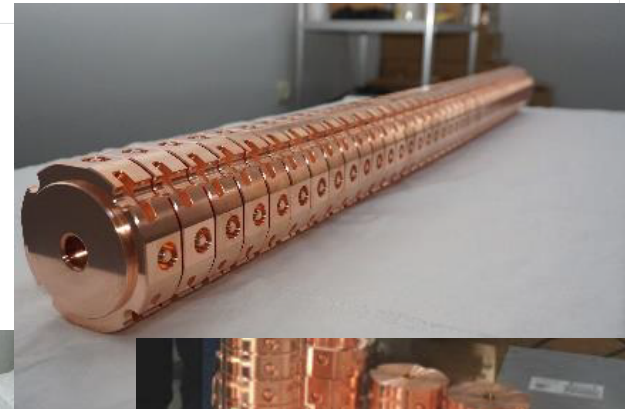


Upgrade Program.

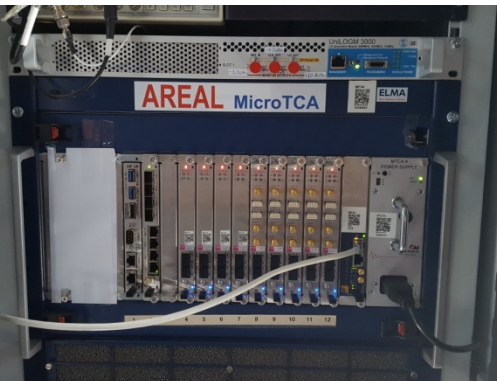
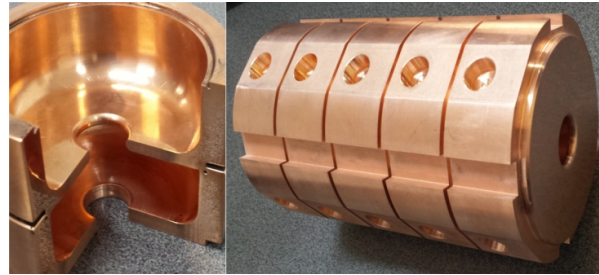


V. M. Tsakanov, G. A. Amatuni, Z. G. Amirkhanyan, et al.,
“AREAL Test Facility for Advanced Accelerator and Radiation Source Concepts”,
Nuclear Instruments and Methods in Physics Research A, 284-290, 2016.

**Start with a development
of new equipment (Design & Fabrication)**

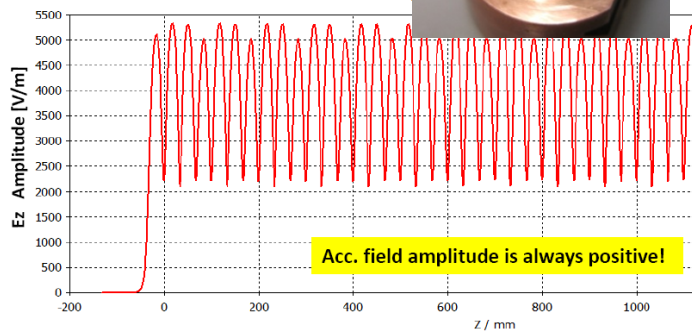
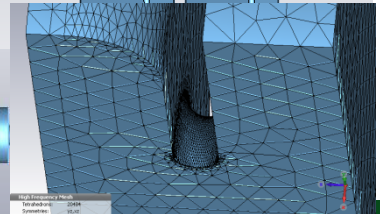
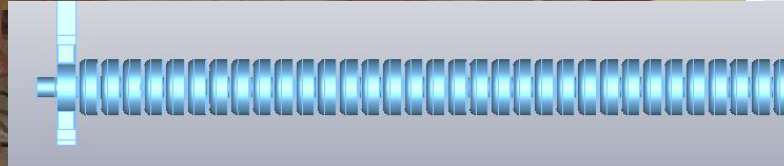
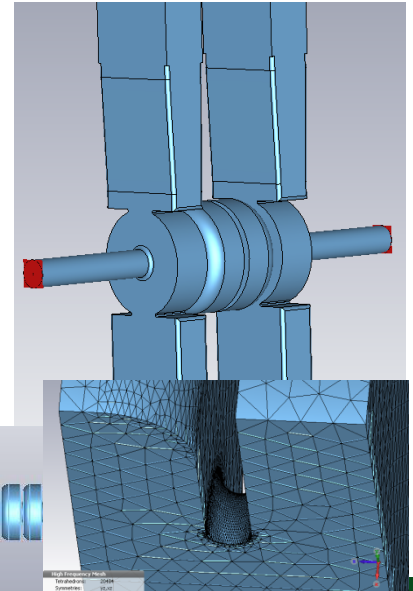
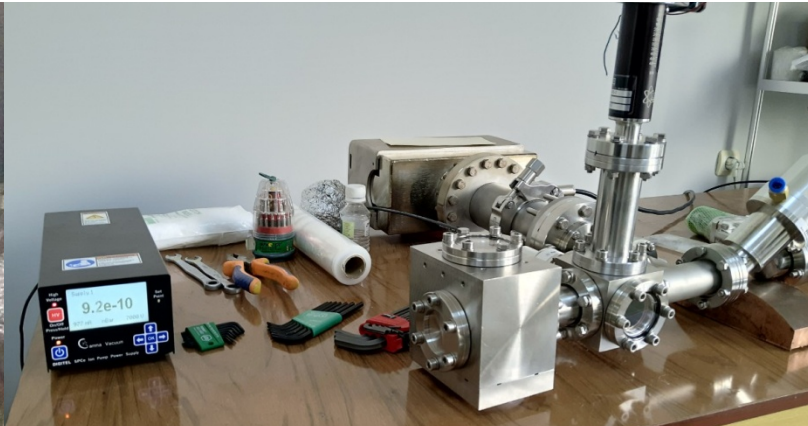


Machine Upgrade. Equipment



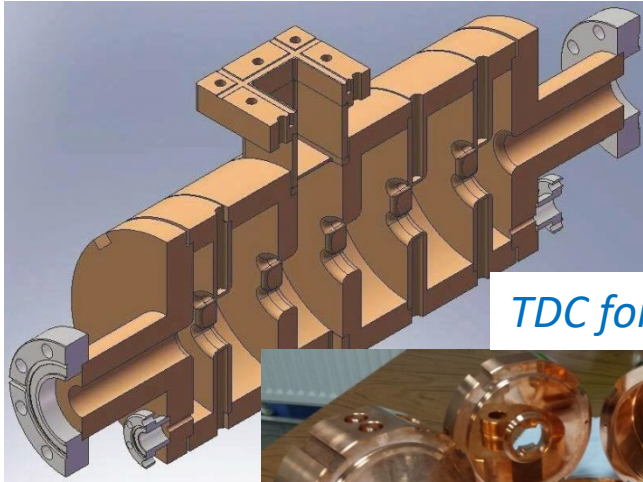
CANDLE - DESY - PSI

Ongoing Activities. Equipment Development

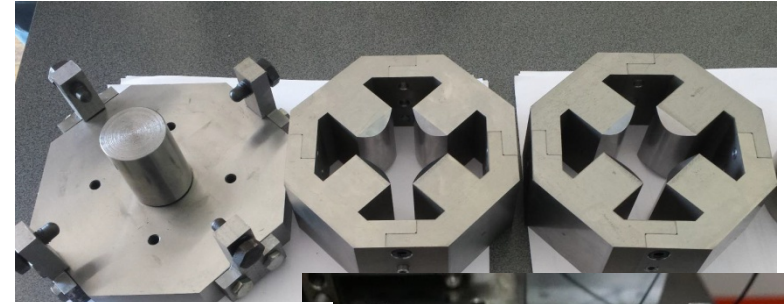


- *For AREAL*
 - *Dipole, corrector, solenoid, quadrupole*
 - *Optical stations, movers, supports, alignment tools*
 - *1.46 m long TW accelerating sections*
- *Joint with DESY*
 - *TDC for REGAE*
 - *Quadrupole magnets*
 - *Universal beam diagnostic system*
- *Many other equipment*

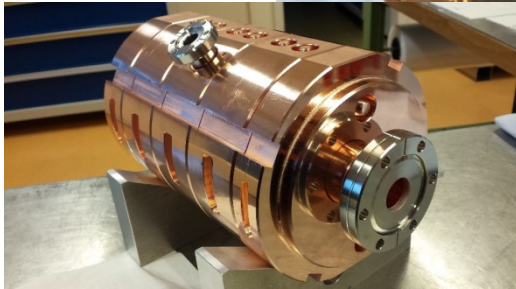
Ongoing Activities. Fabrication and Production



TDC for REGAE (DESY)



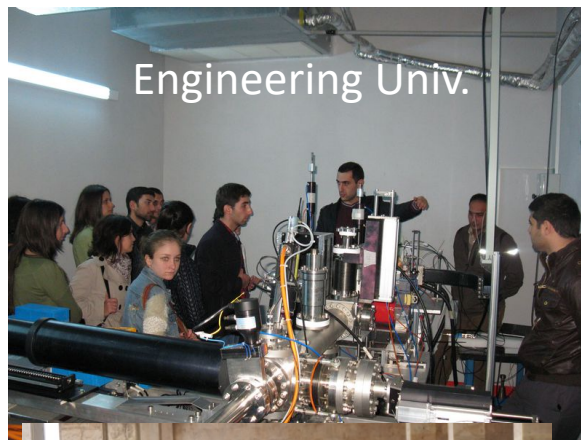
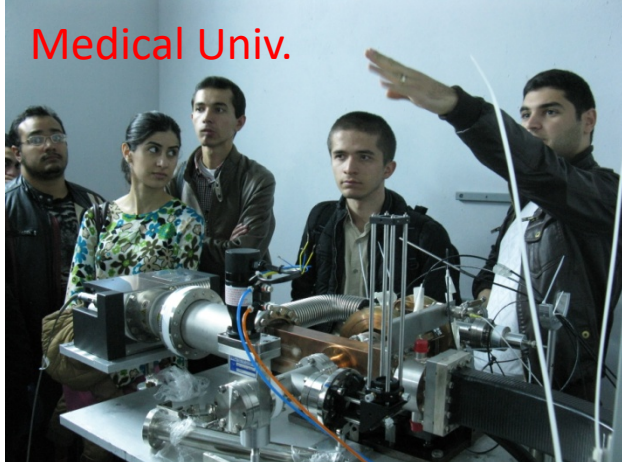
Magnets for AREAL



*Many Other Types
of New Equipment*



Educational Activities





2019 German-Armenian



Practical Course on Accelerator Physics



29 September – 05 October, 2019

- | |
|----------------------------------------------------------------------|
| ➤ <i>Electron Beam Parameter Measurements</i> |
| ➤ <i>Generation and Acceleration of ultra-short electron bunches</i> |
| ➤ <i>Femtosecond lasers for linear electron accelerators</i> |
| ➤ <i>Vibrating wire monitors and beam profile measurements</i> |
| ➤ <i>Radiofrequency techniques in accelerators</i> |
| ➤ <i>Vacuum technology in accelerators</i> |
| ➤ <i>Accelerator magnets and magnetic field measurements</i> |
| ➤ <i>Beam – matter interactions and radiation dose measurements</i> |



2019 German-Armenian Practical Course on Accelerator Physics





Armenia



Germany



Italy



Netherlands

HORIZON2020

ADRENALIN

Accelerator Driven Research for

Ultrafast Beams and Applications

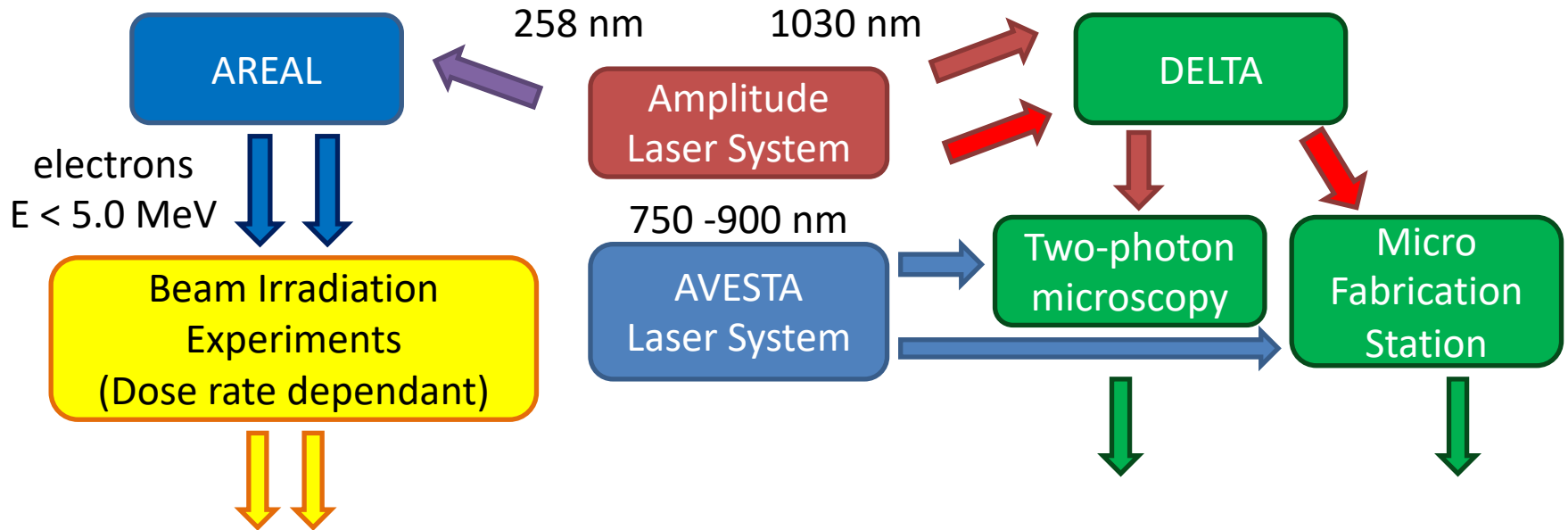
European Neighborhood Advancement in

Sustainable S&T development through cooperation

Launching Interdisciplinary Network

WIDENNING of International User community

Experimental Possibilities at CANDLE



RF Measurements, (R&S joint educ. center) , Timing and Synchronization LAB.

Radiation Biology LAB

New Advanced Materials LAB

Magnetic Measurements LAB

Vacuum Technology, Brazing, Welding LAB

Scientific Engineering Workshop

Scanning Electron Microscope

Electron Beam $E = 20, 50$ MeV

FEL $\lambda = 2.5 -30 \mu\text{m}$
pulse energy 60-100 mJ

0.35 THz Radiation & acceleration (BETA)

Thank you and Welcome to Armenia

