The Henryk Niewodniczański
Institute of Nuclear Physics
Polish Academy of Sciences

TIARA
and
IFJ PAN

Mid-term meeting of the TIARA-PL group

Kraków, 27th September 2012

Prof. Marek Jeżabek

Director General

- General information
- Accelerator activities at IFJ
  - Accelerator infrastructure
  - Projects
  - Scientific and technical staff
- IFJ PAN and accelerator projects
  - Large scale projects
  - Small scale projects
  - Future accelerator projects
- TIARA and IFJ PAN

Outline

- 444 personnel
- Prof. 37, Assoc. Prof. 36, Ph.D. 128
- PhD studies – 77 students
- Interdisciplinary PhD studies (by AGH University of Science and Technology) – 6 students from the Institute
- 6 divisions: 27 departments
- centres of excellence
- centres of advanced technology
- 4 accredited laboratories
- Equipment and Scientific Infrastructure Construction Division

General information

Main Research Fields

Particle physics and astrophysics

Nuclear and strong interactions physics

Condensed matter physics

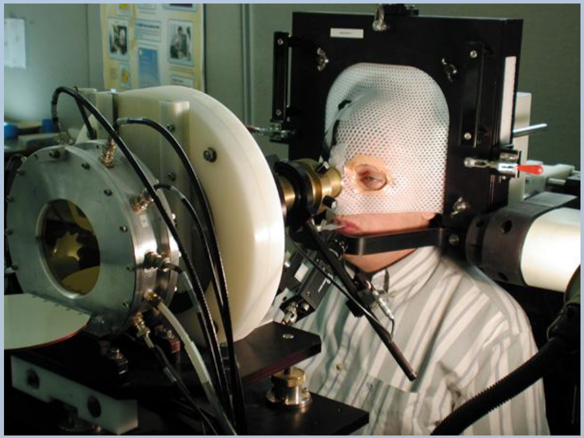
Interdisciplinary and applied research

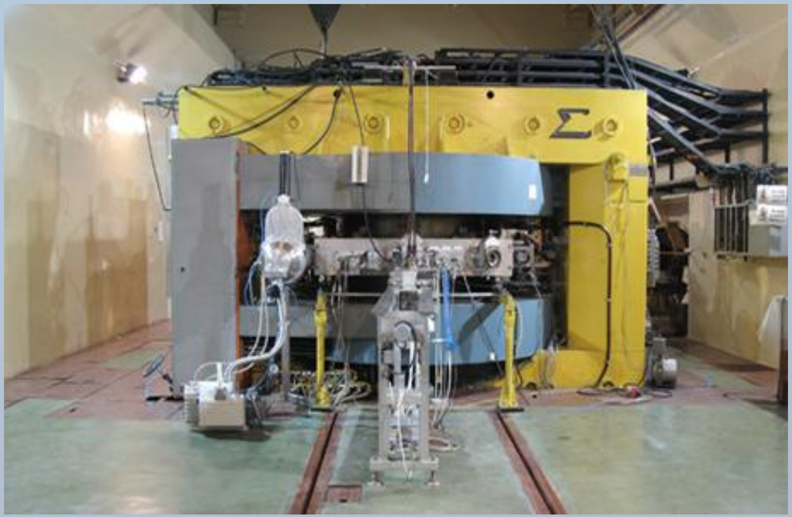
Theoretical physics

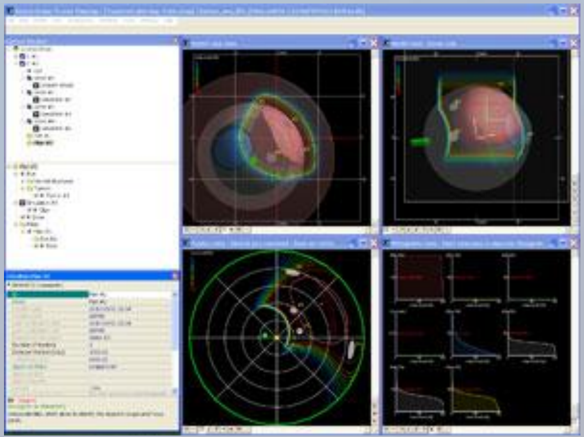
- **cyclotron AIC-144**
  - proton beam energy: 60 MeV
  - Proton Radiotherapy of Eye Melanoma
- **cyclotron Proteus C-235**
  - National Centre for Hadron Radiotherapy
  - under construction (2013)
- **neutron generator**
  - 14 MeV
- **VdG high stability**
  - 2.5 MeV

Proton Radiotherapy of Eye Melanoma

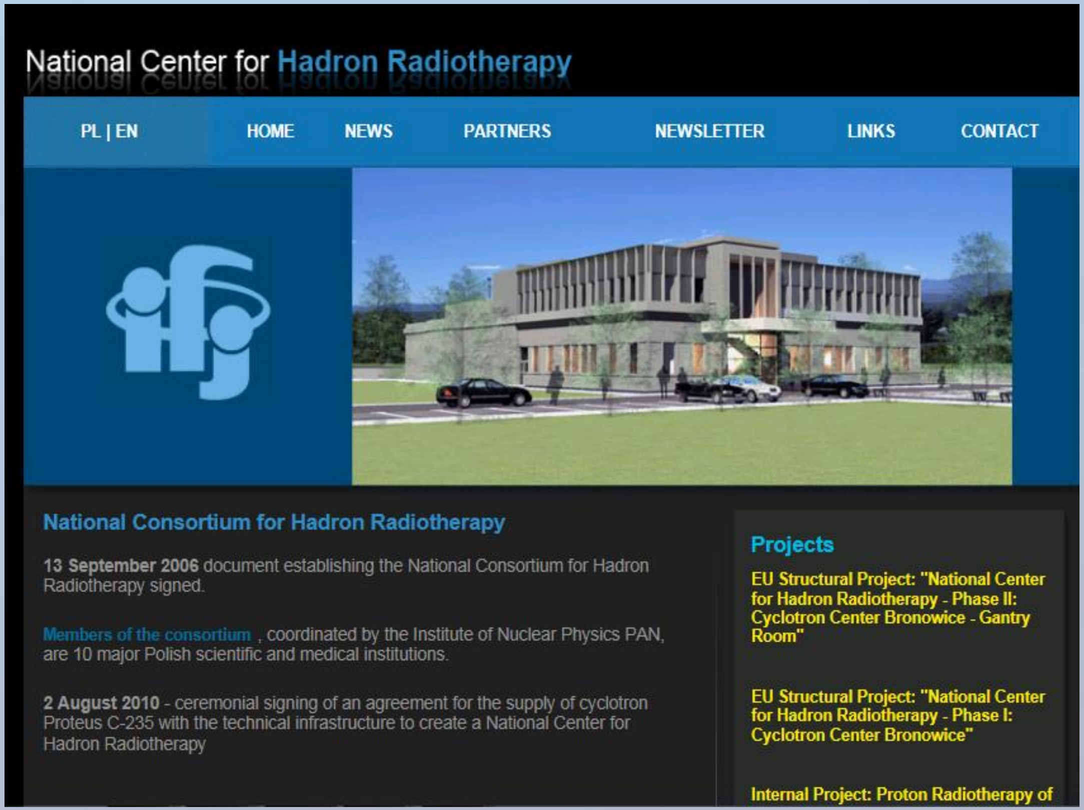
- cyclotron AIC-144,
- proton beam 60 MeV







cyclotron Proteus C-235



Weight	220 t
External yoke diameter	4,34 m
Średnica nabiegunników	2,1 m
Magnetic structure	4 spiral magnetic sectors
Maximal magnetic field	3,1 T
Maximal current in main coil	800 A
frequency	106 MHz
Voltage	50 - 100 kV
Extraction system	4 harmonic coil in the centre, passive magnetic field corrector, electroctatic deflector
Extraction factor	70%
Beam current at 235 MeV	1 - 300 nA
Ion source	Internal, PIG type
Power consumption (of full system)	1,3 MW

Fundamental Physics Research Program at the Bronowice Cyclotron Centre

See: http://experimentsccb.ifj.edu.pl/

Details will be given by prof. A. Maj (tomorrow, this conference)

CCB physics program

- dynamics of a few-nucleon systems and physics of nuclear clusters
- measurements of collective, high-energy excitations in nuclei (e.g., giant nuclear resonances)
- high resolution gamma-ray spectroscopy of nuclei produced in the process of proton-induced fission and spallation,
- tests of elements of the modern detection systems (SPIRAL2, FAIR),
- development of the new treatment planning systems for hadron radiotherapy,
- new methods for dosimetry and diagnostics of the proton beam

Accelerator activities at IFJ

Projects: Scientific

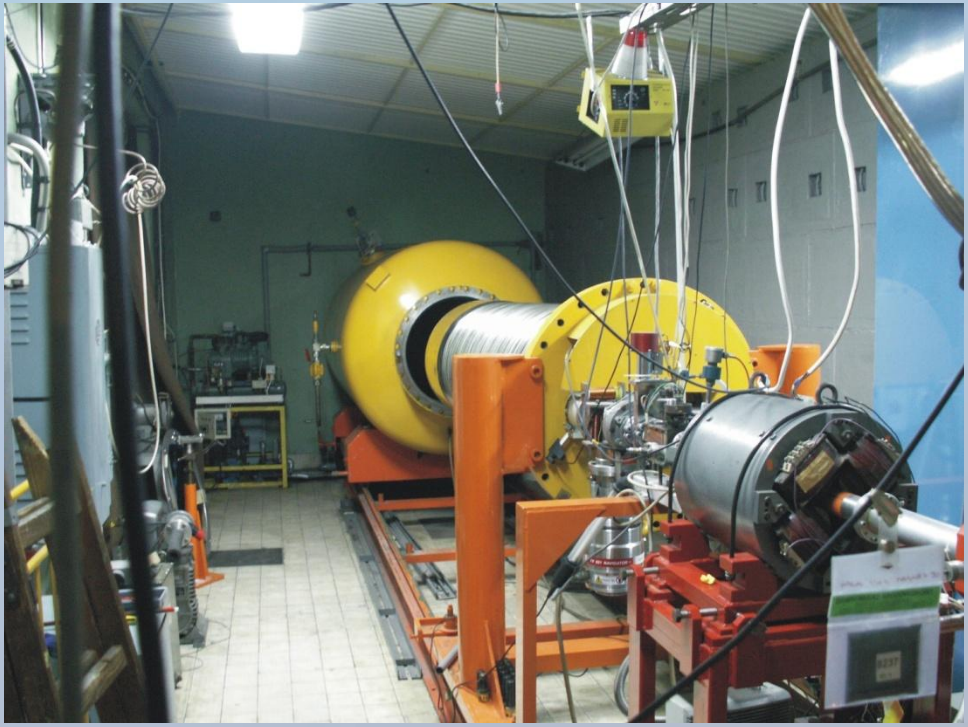
Fast neutron generator 14 MeV IGN-14

Research on the neutron transport physics

- determination of the neutron parameters of geological media
- investigation of the thermal neutron scattering in hydrogeonous media (hydrogen bound in molecules)
- dependence of the thermal neutron parameters of materials on temperature
- test properties of diamond detectors, (spectrometric measurements of the α particles.

Continuous regime:	neutron yield:	$5x10^8$ n/s	
	ion current:	~50 µA (do 100 µA)	
Pulsed regime:	Neutron burst:	duration:	25 to 1000 µs (step 1)
		repetition:	0.3 to 100 ms (step 0.1)
		neutron yield during the pulse:	$5x10^9$ n/s
Target:	T/Ti,	max. activity 170 GBq	
H.F. ion source:		50 MHz	
Pulsed extraction voltage:		variable up to 4 kV	
Accelerating voltage:		max. 125 kV + 50 kV	
Two measuring lines:		^{3}He detectors	
Monitors:		BF_3 detector in paraffin, Scintillation fast neutron probe	
Thermostatic chamber for samples:		(0 - 70) ^{0}C	

Van de Graaff Accelerator



Model	High Voltage Engineering, type KN-3000
Energy range:	2.5 MeV for protons and He^+ ions, 5 MeV for α particles
Stability:	0.3%
Beam current:	2 - 100 μA (protons and He^+)
Beam diameter:	1mm (FWHM)

Accelerator is equipped in three beam lines, dedicated to nuclear analytical methods like PIXE/PIGE and RBS/channeling.

Applications:
- Environmental studies
- bio-medical research
- material engineering.

- **Finished projects**
  - T2K, J-PARC Tokai, Krakow/J-PARC, 2007 – 2009
  - **LHC, CERN Geneva / Krakow, 2005 – 2012**
  - ATLAS, CERN Geneva, 2004 – 2009, 2010-2012

- **Ongoing projects:**
  - **European XFEL, DESY Hamburg, 2009 – 2015**
  - Cherenkov Telescope Array (CTA), 2008 – 2013
  - Wendelstein 7 – X, IPP Greifswald, 2007 – 2013

- **Future projects**
  - **LHC shutdown, CERN Geneva, 2013 – 2014**

LHC – ELQA, 2005 – 2009, 2011 - 2012

Engineering & prototyping

Design and construction of movable **measuring equipment and accessories**

The main task of the IFJ PAN groups was to verify the electrical circuits of all superconducting magnets in the LHC machine during installation phase and hardware commissioning phase. The complexity of electrical circuits and huge distances in the tunnel required building of movable measuring equipment. 46 mobile units of 6 types were built. All the measuring units were computer controlled by means of the dedicated software application (LabView) and connected to Oracle data base.

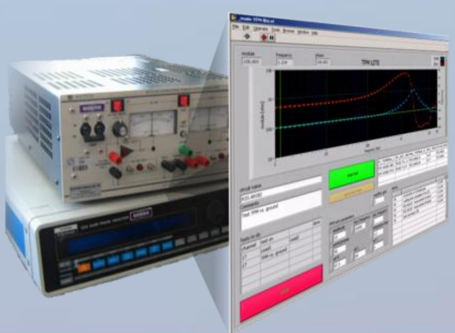
Currently an upgrade of the measuring equipment is performed at IFJ PAN.

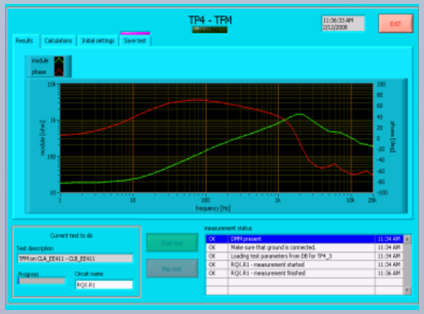
LHC – ELQA, 2005 – 2009, 2011 - 2012

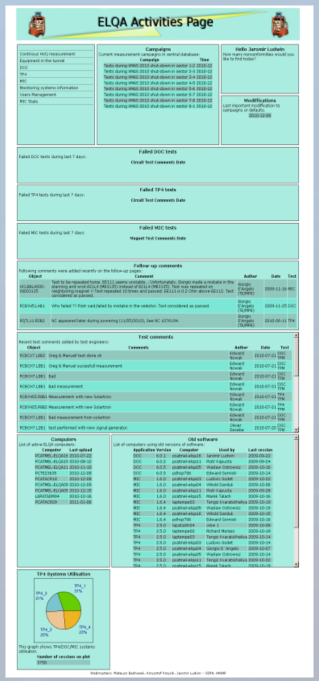
Programming & web applications

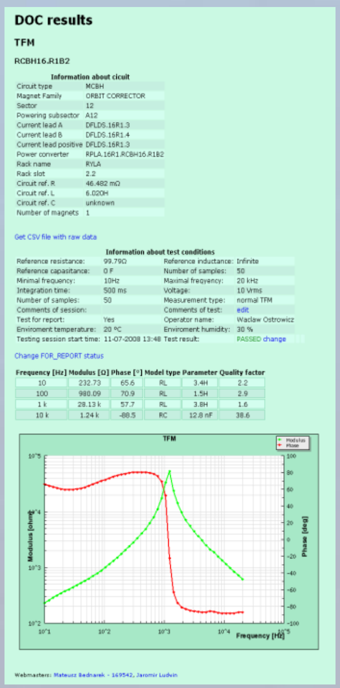
Programming of the Electrical Quality Assurance equipment creating **web applications**

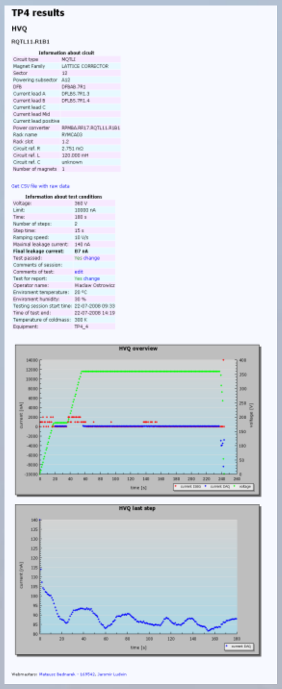
The ELQA measuring units were controlled by computers with dedicated LabView software (left). Data gathered during measurements were accessible via web applications (centre, right). Oracle database was used as central point of the software system. An upgrade of the software is currently performed at IFJ PAN.











LHC – ELQA, 2005 – 2009

Quality Assurance

Electrical Quality Assurance **of** **electrical circuits** of LHC superconducting magnets

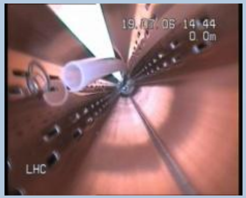
LHC assembly phase:
- 2500 electrical tests of 8 types
- tests performed on different configuration of the superconducting magnets
- 20 to 76 circuits or lines in terms of continuity, resistance and HV qualification
- 12000 tests to check nearly 1600 superconducting circuits at warm and cold

The measurement results were the base for CERN groups developing a new Quench Protection System.

LHC – ELQA, 2005 – 2009

Quality Assurance

Quality Assurance of **interconnections of the LHC magnets**



Metallic chip (left) and plastic shaving found and removed during reflectometry and endoscopic (right) inspections of the beam lines

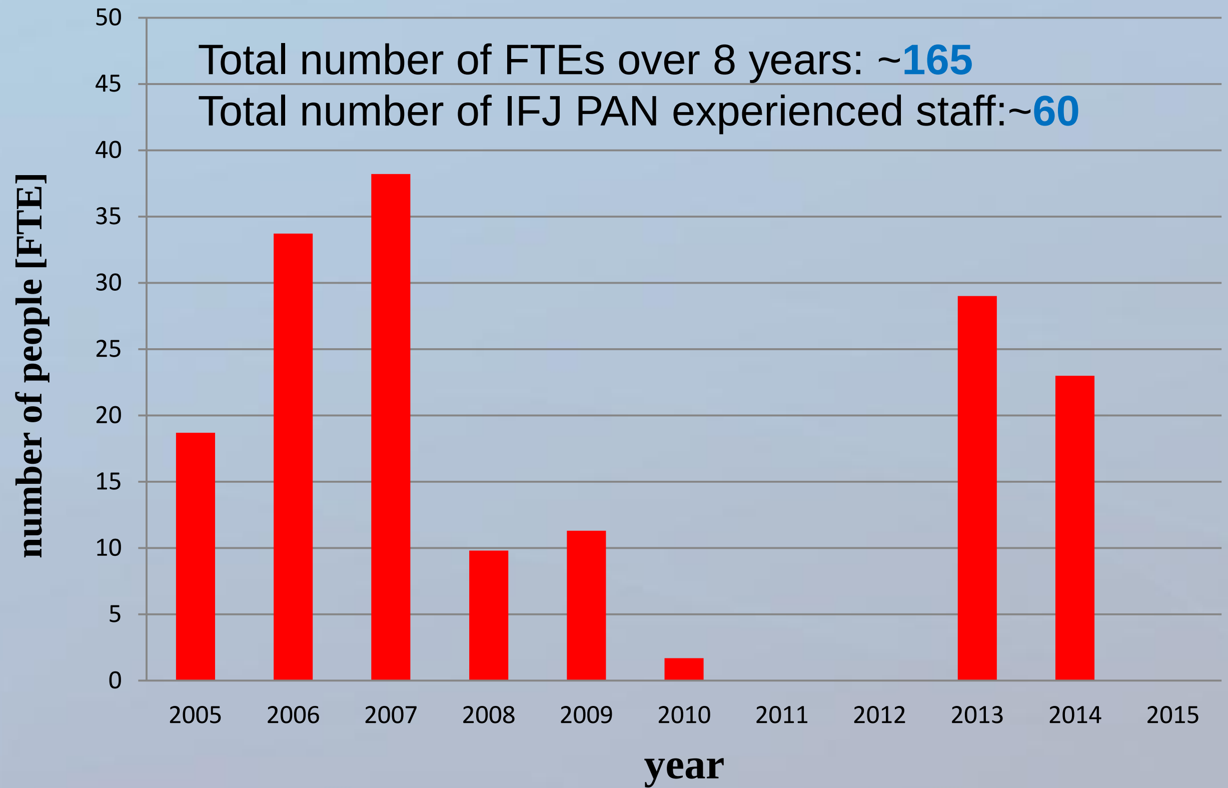
- Pre-inspection of each single magnet on surface and in the tunnel (visual inspection of all magnet components and checking of beam lines by means of microwave reflectometry and endoscopy methods)
- Visual inspection of interconnections after orbital and ultra-sonic welding
- Microwave reflectometry measurements of the beam lines in series of connected magnets
- Final visual inspection just before the closure of each interconnection

Non-conforming weld (left) and compensation bellow (right)

A plug-in module (PIM) damaged during a cool-down/warm-up thermal cycle of the magnets

In collaboration with CERN staff, the team worked out a method for the localization of damaged PIMs, that is two times more precise than that employed before.
The method could be used without opening the interconnections between magnets.

IFJ PAN - LHC
(2005 - 2014)



IFJ PAN in-kind contribution to XFEL construction
(2009 - 2015)

European XFEL

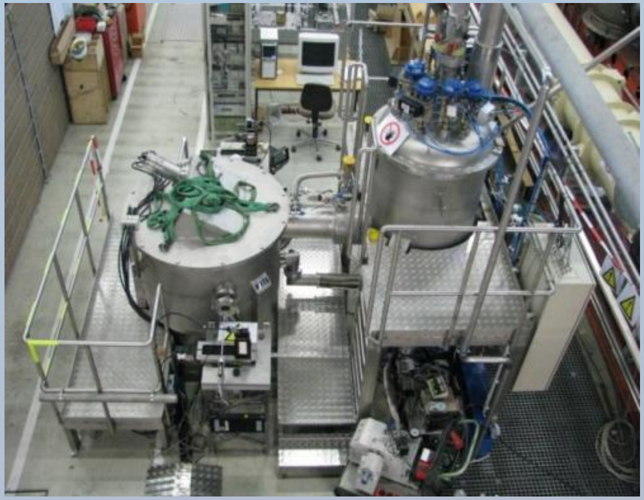
1) Performance of acceptance tests of ***cavities*** for a series of 840 units on DESY infrastructure and delivering the corresponding test reports

2) Performance of acceptance tests of ***cryomodules*** for a series of 103 units on DESY infrastructure and delivering the corresponding test reports

3) Performance of acceptance tests of ***cold magnets*** for a series of 103 units on DESY infrastructure and delivering the corresponding tests reports – common effort with DESY

IFJ PAN – XFEL preparatory phase
(2009 – 2012)

- design of the electronics for cold magnets test stands measurement and database preparation
- preparation of software or/and hardware for the test-stands
- elaboration of the test procedures and work instructions
- training of personnel and verification of procedures on the existing testing facility



Setup for tests of magnets (left), quadrupol inside the cryostat vessel (right)

IFJ PAN – XFEL preparatory phase
(2009 – 2012)

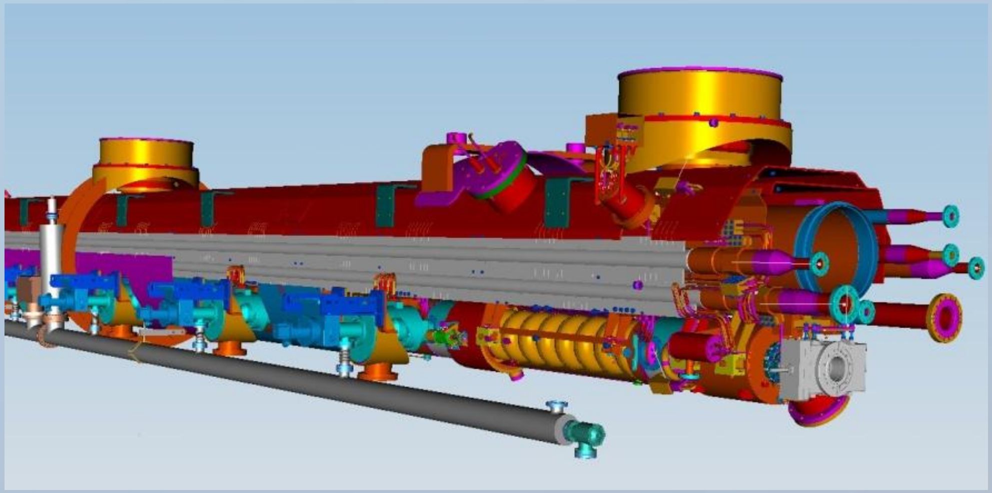
European XFEL

Tests of RF cavities at warm

Installation of RF cavities in the vertical cryostat

IFJ PAN – XFEL preparatory phase
(2009 – 2012)

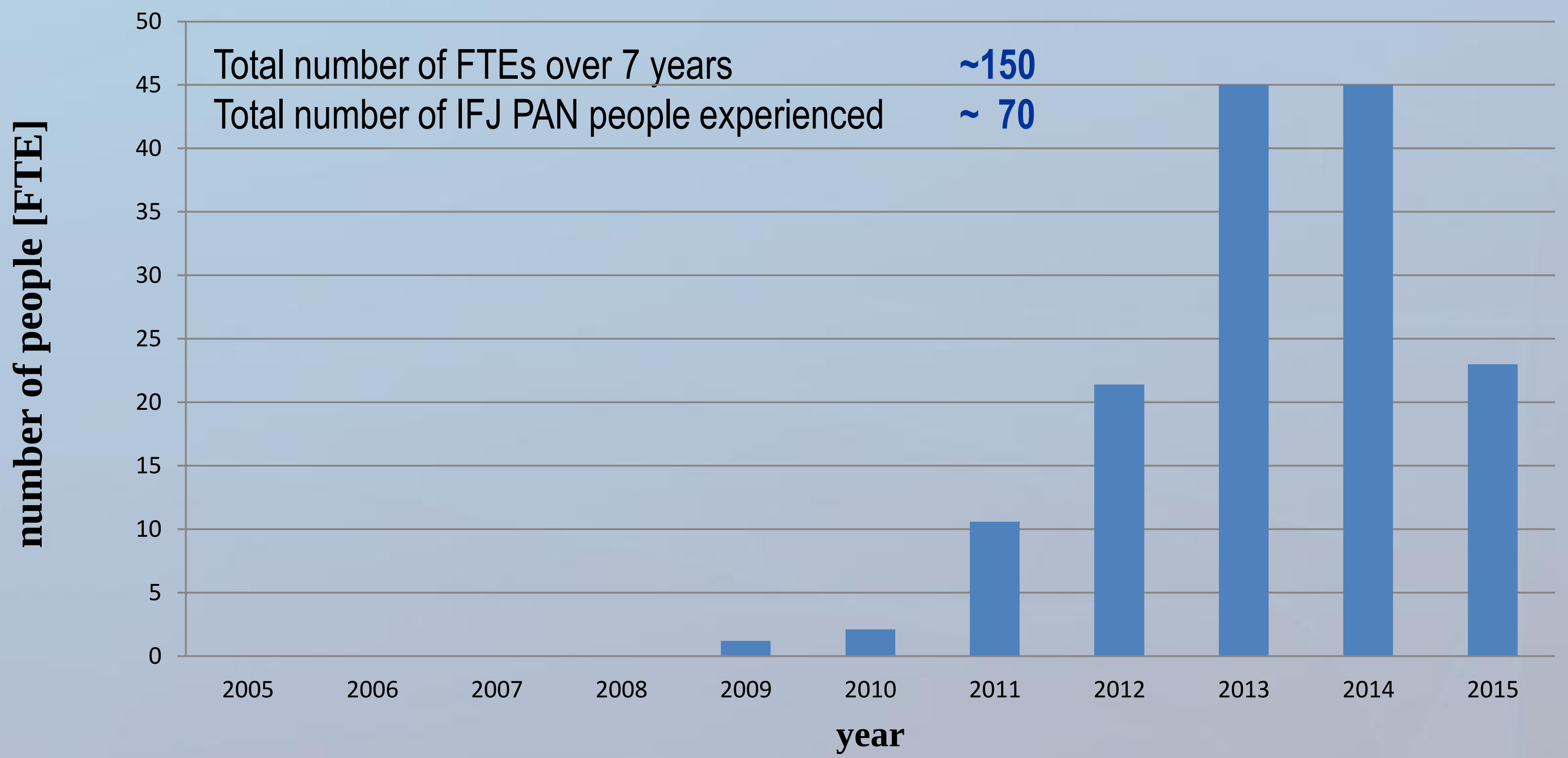
European XFEL



Longitudinal cross-sections of cryo-module

Transportation of the prototype cryomodule to the test stand

IFJ PAN in-kind contribution to XFEL construction
(2009 - 2015)



Prospective contribution IFJ PAN to ESS

1) Magnets
   - Superconducting quadrupole magnets tests (~100 magnets) - DAI
   - Normal conducting quadrupole magnets tests (25 magnets in HEBT) - DAI
   - Thermal study of superconducting magnets (Quench limits, heat transfer, magnet thermal optimization) - DAI/FA
2) Accelerating structures
   - RF cavities tests (~220 RF cavities) - DAI
   - RF modules tests (48 modules) - DAI
3) Beam diagnostics
   - Beam parameters measurements - DAI/FA
   - Accelerator protection system - DAI/FA
4) Beam dynamics - DAI/FA

DAI - **Division of Scientific Equipment and Infrastructure Construction ;** FA – Accelerator Physics Section

Possible future activities: SuperB

- Beam dynamics - DAI/FA
- Superconducting IR magnets - DAI/FA
- Normal conducting magnet testing - DAI
- Contribute to magnets design - DAI/FA
- Beam diagnostic - DAI/FA
- Polarimetry - DAI/FA
- RF cavities testing - DAI

DAI - **Division of Scientific Equipment and Infrastructure Construction ;** FA – Accelerator Physics Section

Projects:

- Proton Radiotherapy of Eye Melanoma,
  design and manufacture of components for the set-up,
  2009 – 2012
- Belle 2 – design and manufacture of SVD mock-up,
  2011 – 2012
- PRESPEC Collaboration, design and manufacture
  of mechanics for the finger detector,
  2011 – 2012

- Present
  - Infrastructure
    - Existing infrastructure
    - Dosimetry
    - Electronics
    - Mechanical projects
  - Staff
    - Team of skilled engineers and technicians
    - Local accelerators staff

- Future
  - Accelerator Physics Group
    - Beam dynamics
    - Beam diagnostics
    - Magnets
    - RF systems
    - New concepts (example: HTS superconductors)
  - Education

TIARA and IFJ PAN

- IFJ groups contribute to major world experiments in particle physics, astrophysics and nuclear physics.
- New 250 MeV cyclotron (planned start 2013) will be used for experimental activities (nuclear physics, radiobiology) and radiotherapy of eye melanoma. Gantry will allow for treating pediatric patients.
- Biomedical research based on local infrastructure:
  eye protontherapy, VdG single proton irradiations, MRI, artificial heart
- Priorities for safely use of nuclear energy and for fusion projects (ITER, Greifswald)
- Income from accredited labs and export of engineers and technicians

Summary and Conclusions

BACKUP SLIDES

- Institutions in Poland (Cracow only):
  1. ACK CYFRONET,
  2. AGH-UST,
  3. CUT,
  4. IFJ PAN.

  The above entities formed the national SuperB consortium (16. May 2011)

- Participants:
  - 7.1 staff,
  - 2.5 PhD students,
  - 1 support

Courtesy M. Witek

- Main hardware contribution:
  - contribution to the Instrumental Flux Return (IFR) detector
    - ✓ current R&D work on SiPMs, electronics, mechanical construction and software;
    - ✓ application for funds after TDR– autumn 2012).
  - Substantial participation in the accelerator construction (2015).
  - Participation in the overall computing system.
- Main responsibilities:
  - Co-responsibility for the IFR detector,
  - Co-resposibility for the computing system,
  - Physics studies: CP and T violation in B meson and tau lepton decays
- Financing:
  - Application to NCN (Dec. 2012),
  - Very limited resources at home institutions,
  - One individual „diamond” grant.

Courtesy M. Witek

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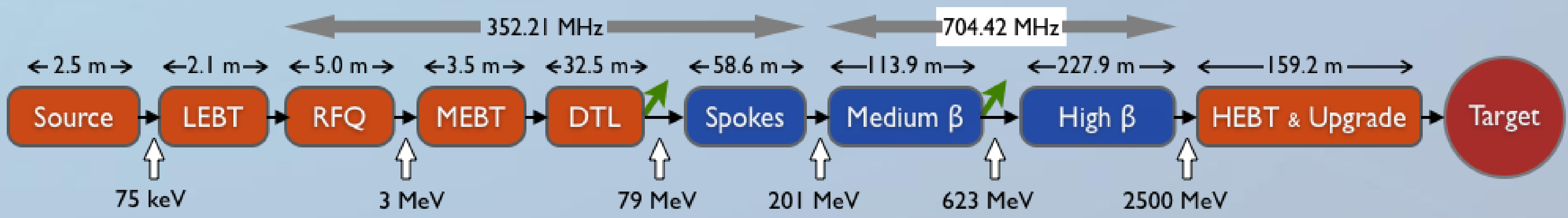

- Electron Cyclotron Resonance source (ECR
- Low Energy Beam Transport (LEBT)
- Radio-Frequency Quadrupole (RFQ)
- Medium Energy Beam Transport (MEBT)
- Drift-Tube Linac (DTL)
- spoke resonator cavities (Spokes)
- elliptical cavities (Medium β)
- elliptical cavities (High β)
- High Energy Beam Transport (HEBT)

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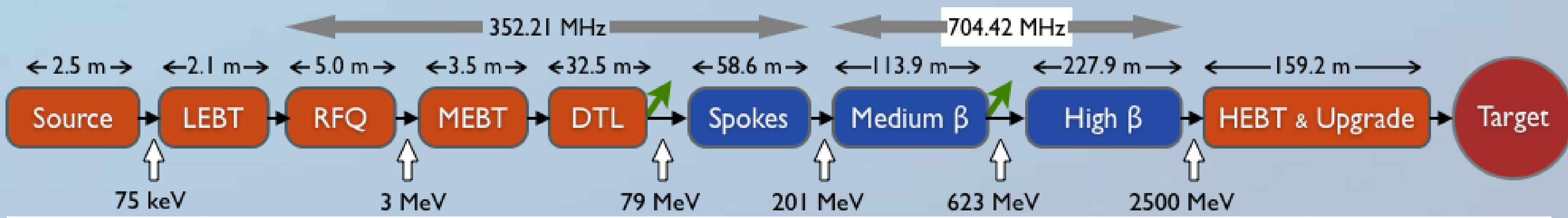

	Length (m)	Input Energy (MeV)	Frequency (MHz)	Geometric β	# of Sections	Temperatura (K)
LEBT	2.05	0.075	-	-	-	300
RFQ	4.95	0.075	352.21	-	1	300
MEBT	3.53	3	352.21	-	-	300
DTL	32.58	3	352.21	-	1	300
Spoke	58.46	79	352.21	0.50	18 (2 cavities)	2
Medium β	113.84	201	704.42	0.70	16 (4 cavities)	2
High β	227.86	623	704.42	0.92	14 (8 cavities)	2
HEBT	158.66	2500	-	-	-	-

Reference: Conceptual Design Report (Feb. 2012)

The cavity geometrical beta can be defined by the cell length of $\beta_g \lambda/2$, where λ is the RF free space wavelength.