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Overview of IFJ PAN contribution to scientific infrastructures supporting research in applied superconductivity

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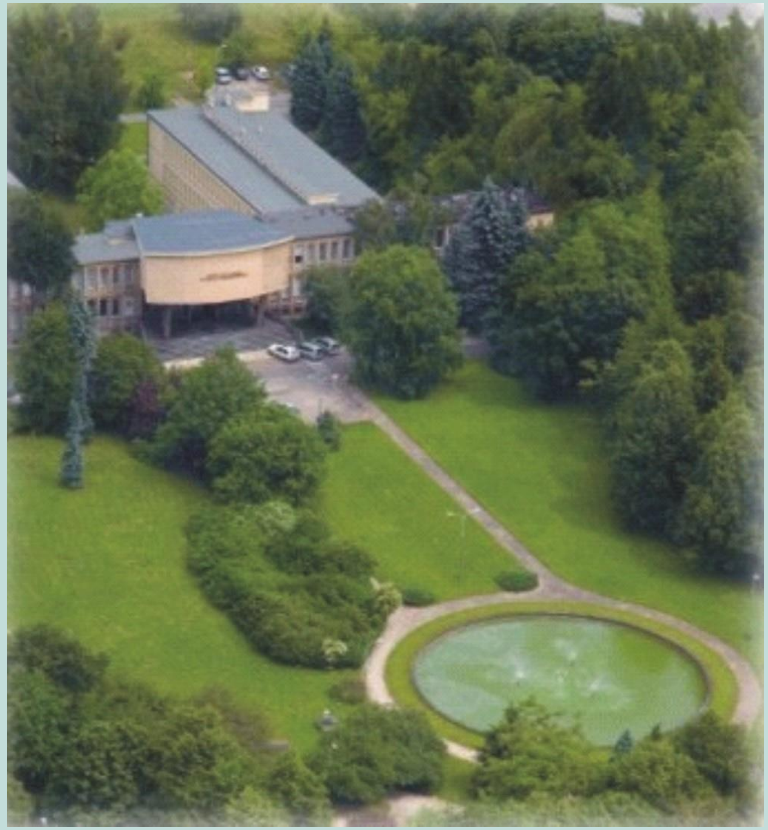
Outline

- **IFJ PAN and selected projects**
  - **European XFEL**
  - **LHC consolidation and upgrade**
  - **Wendelstein 7X**
- **Scientific equipment construction**
- **Summary**



General information

Expertise:

→ **XFEL** (construction)

→ **LHC** (construction, consolidation, upgrade)

→ **W7-X** (construction)

→ **AIC-144** (construction, medical applications)

→ **Proteus C235** (medical applications, research)

Staff:

→ **Scientists: 5**

→ **Engineers: 34**

→ **Technicians: 65**

Scientific activities:

→ **International:**
- **LHC upgrade**

→ **Local (at IFJ PAN) :**
- **CCB research program**
- **AIC-144 (medical applications)**

Local infrastructure:

→ **cyclotron Proteus C-235**

→ **cyclotron AIC-144 (60 MeV)**

→ **Fast neutron generator (14 MeV)**

→ **Van der Graaf generator (2.5 MeV)**

General information: Projects

Running projects:

- **XFEL, DESY, Hamburg, 2009 – 2015**
- **LHC, CERN, Geneva, 2013 – 2014**
- **ITER, Cadarache, 2010-2015**
- **Cherenkov Telescope Array (CTA), 2008 – 2013**

Completed projects

- **LHC, CERN Geneva, 2005 – 2012**
- Wendelstein 7 – X, IPP Greifswald, 2007 – 2012
- ATLAS, CERN Geneva, 2004 - 2012
- T2K, J-PARC Tokai, Krakow/J-PARC, 2007 – 2009

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

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

XFEL RF cavities tests

XFEL quadrupole magnets tests

XFEL cryomodules tests

Acceptance tests of the accelerator components

The IFJ PAN work at DESY:

- preparatory phase (2009-2012)
- series tests (2013-2015).

Preparatory phase**:**

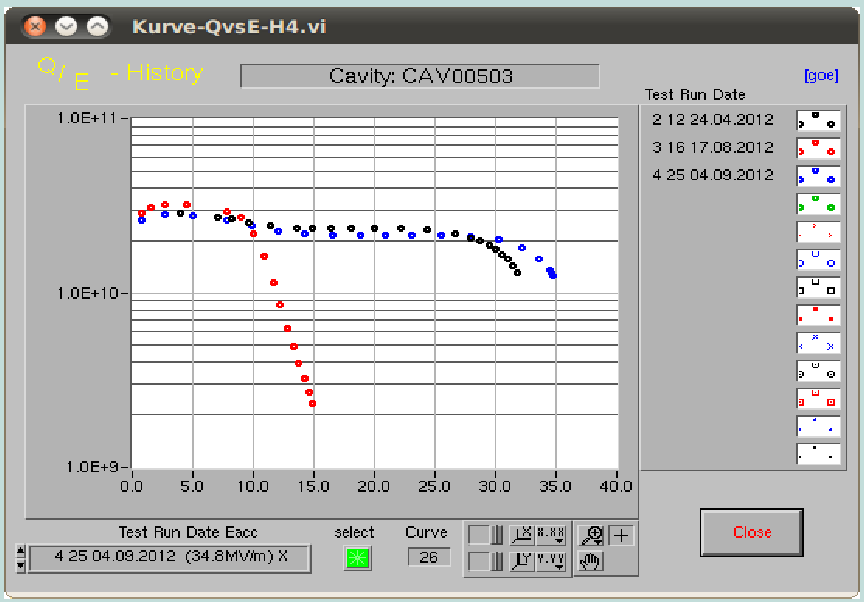
- elaborate scopes of the tests,
- development of measurement software
- design/create data bases for acceptance tests of magnets, cavities and cryomodules;
- prepare test procedures and verify them on existing test-stands
- Perform-tests of prototype and pre-series components
  (15 cold magnets, 60 cavities and 3 cryomodules)
- prepare required documents
  (Quality Plan, Risk Assessment, Working Instructions,
  Inspection/Testing /Non-conformities forms, …)

Tests of RF cavities

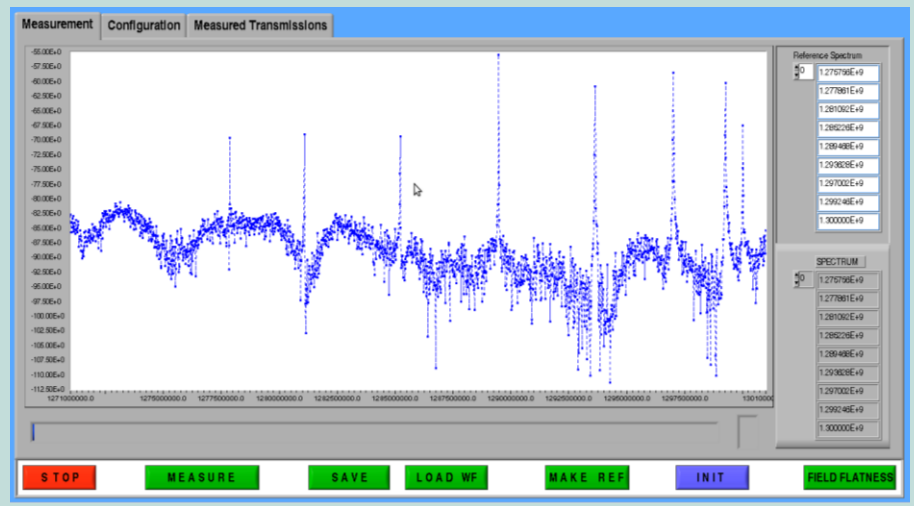
prototype and pre-series cavities – tested

production cavities – testing

Insertion of the cavity into the vertical cryostat



Results of RF cavity measurement



Measurement of the cavity fundamental mode spectra

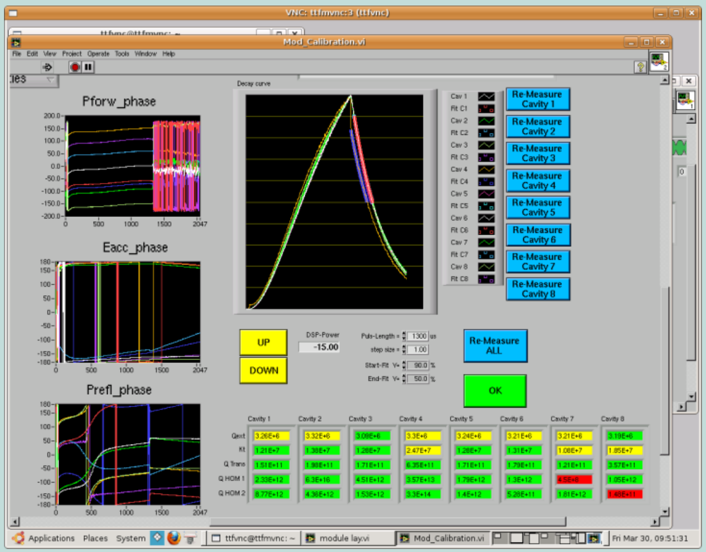
Tests of accelerator cryomodules

3 prototype cryomodules – tested

3 pre-series cryomodules - tested

100 series cryomodules – testing

Prototype module on existing test bench



Calibration coefficient and check quality factors
of the couplers during cryomodule RF test

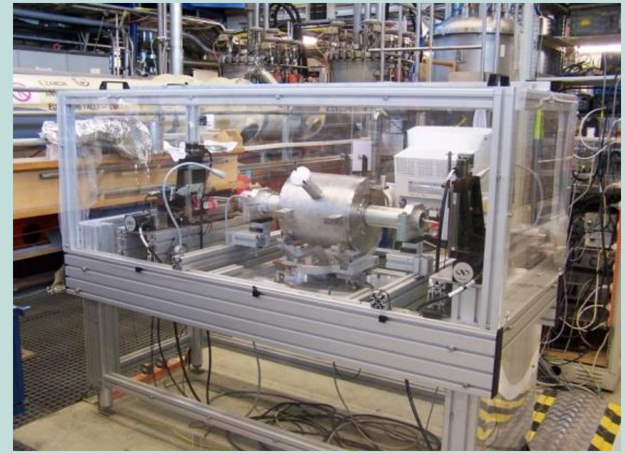
Leak test of vacuum pipes

Tests of superconducting magnets

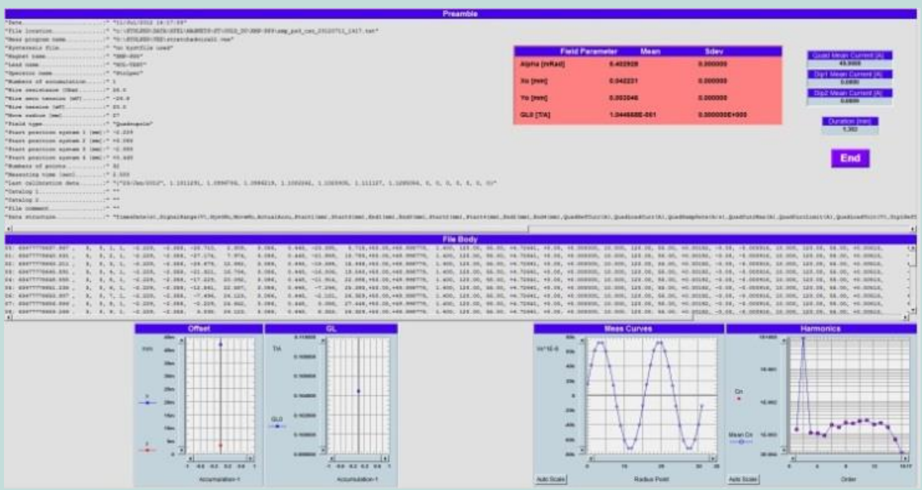
15 prototype and pre-series magnets – tested

10 production magnets – tested

90 production magnets – testing



XFEL quadrupole magnet test at warm

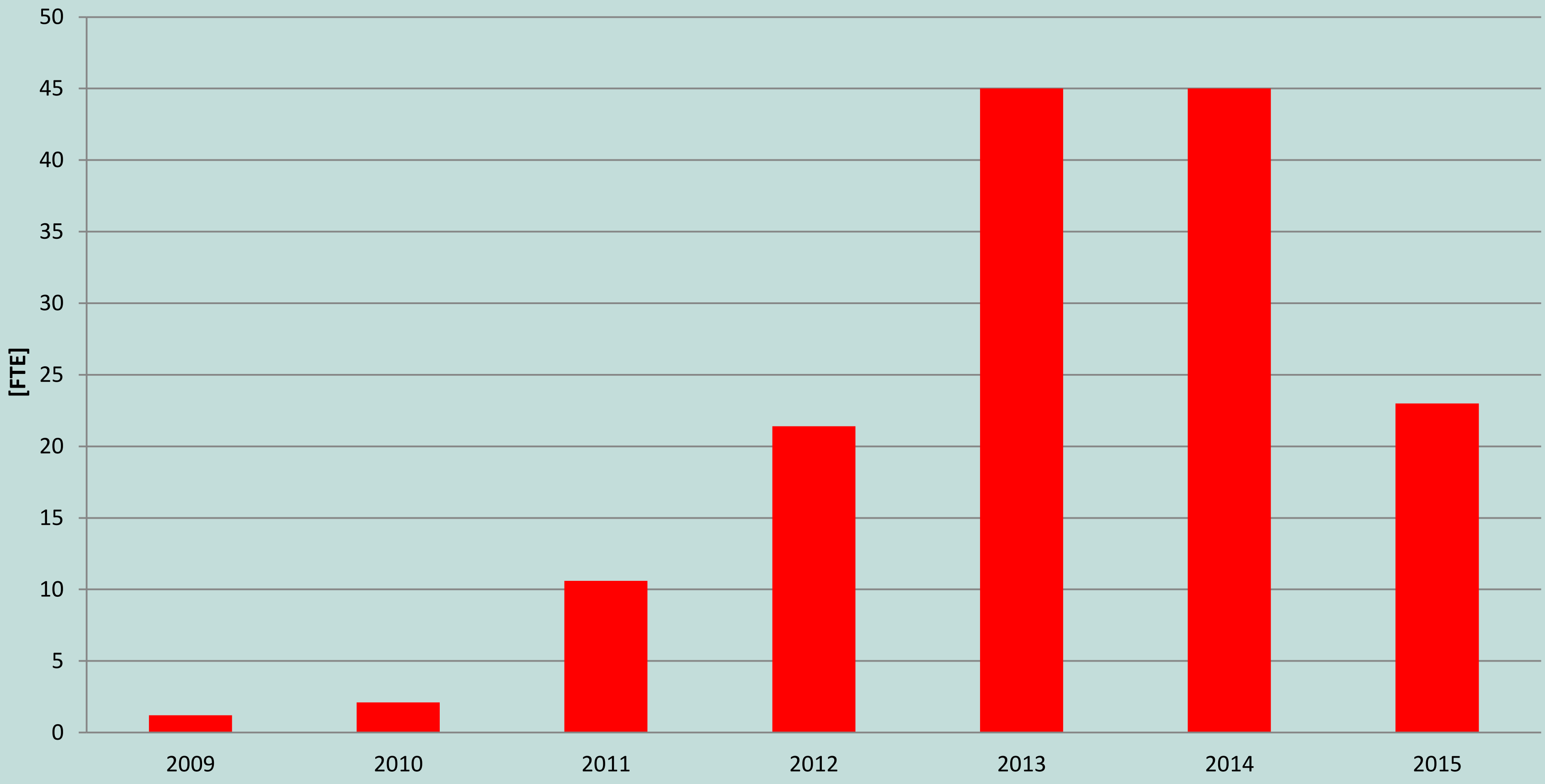


XFEL quadrupole test at cold

XFEL quadrupole inside the cryostat vessel

IFJ PAN effort to XFEL construction

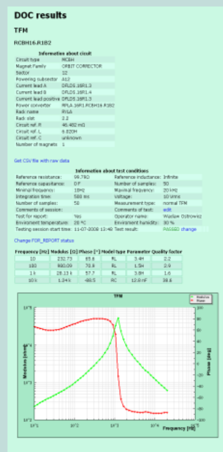
Total number of FTE's over 7 years	~150
Total number of trained IFJ PAN staff	~ 60



IFJ PAN contribution to LHC construction
(2005-2014)

1) design & construction of measuring/testing devices
2) preparation of necessary software and data bases
3) manufacturing of superconducting N-lines
4) development of measuring/testing methods
5) organization, performance & documentation of electrical measurements /tests
6) organization, performance & documentation of interconnection inspection

Mobil test stations in LHC tunnel



User interface

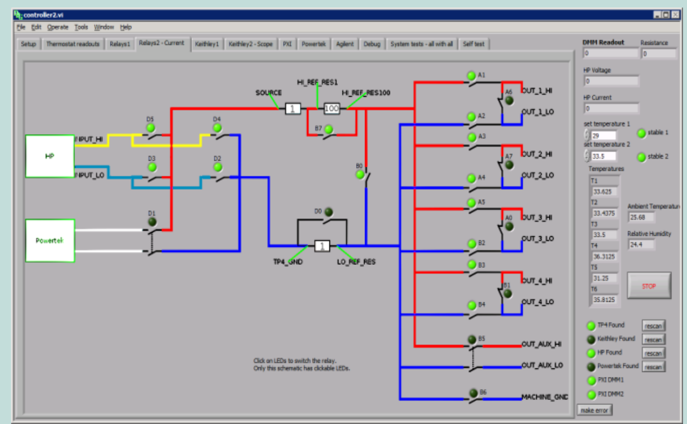
Damaged PIM (*Plug-In Module)*

Electrical measurements and tests

2005 – 2010 Thousands of electrical measurements/tests performed in terms of continuity, resistance and HV qualification of superconducting circuits in warm and cold states.

The team, as the first, performed measurements of very low resistance of main bus bar connections at cold (without necessity of opening interconnections between magnets). The measurement results were essential for CERN groups developing a new Quench Protection System.

***2011 – 2012* Upgrade of the measuring/testing devices**
***2013 – 2014* Campaign of measurements/tests has started**



Measurements in the LHC tunnel (2005-2010)

Upgraded hardware and software (2011-2012)

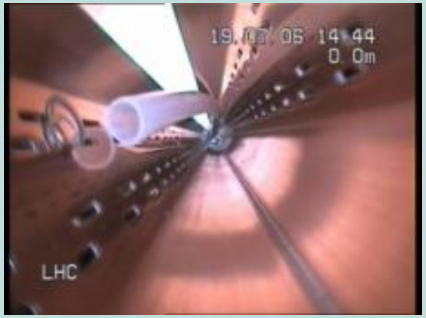
Inspection of interconnections

Scope of inspection:

- **Pre-inspection** of a single magnet
  (visual inspection of all magnet components, checking of beam lines by means of endoscopy and **microwave reflectometry** 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

In collaboration with CERN staff, the team developed a method for the localization of damaged PIMs

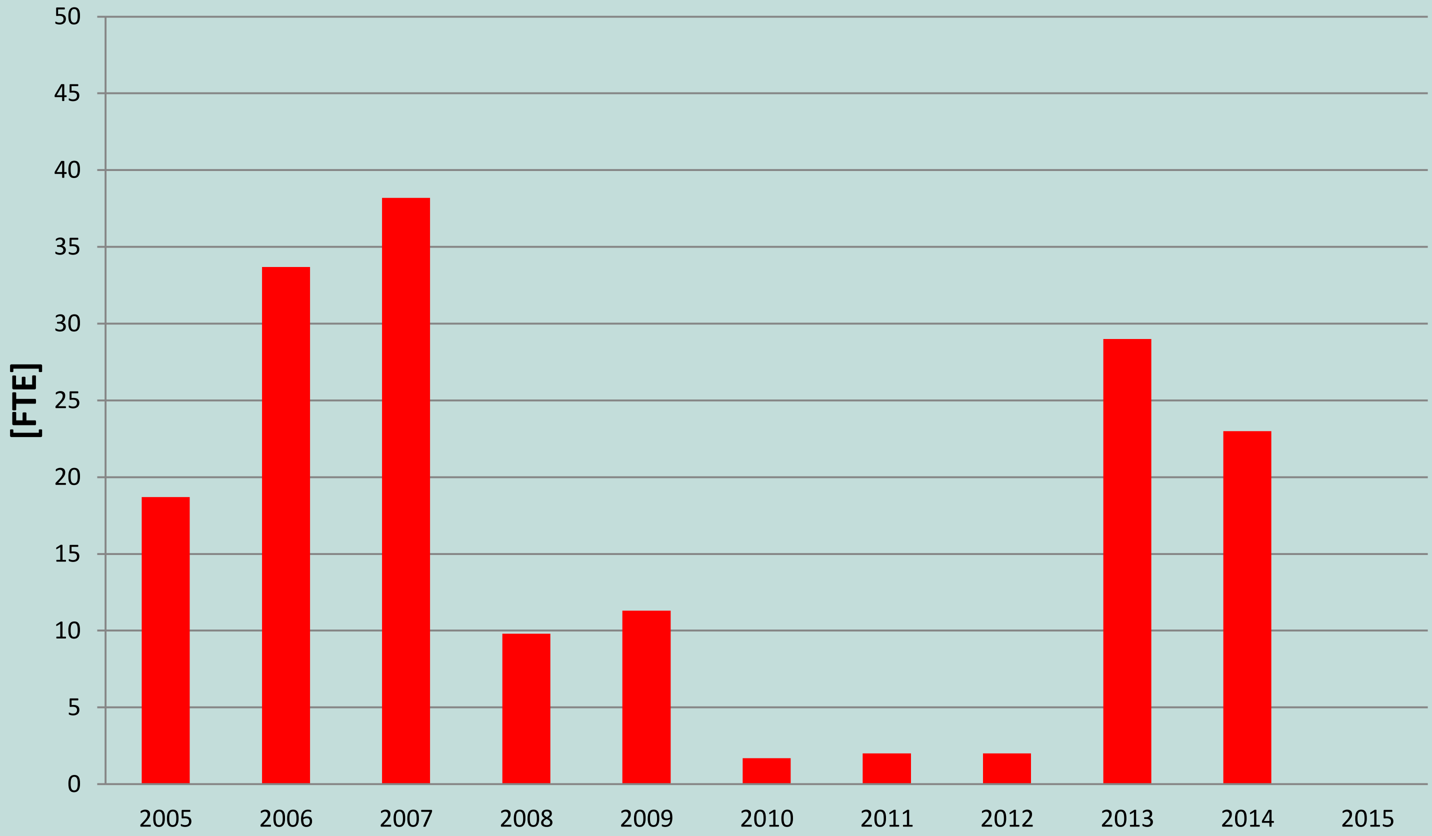
- **method is two times more precise than that employed before.**
- **method could be used without opening the interconnections between magnets.**



IFJ PAN effort to LHC

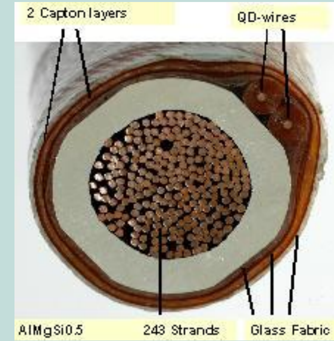
Total number of FTEs over 8 years: ~160

Total number of trained IFJ PAN staff: ~50

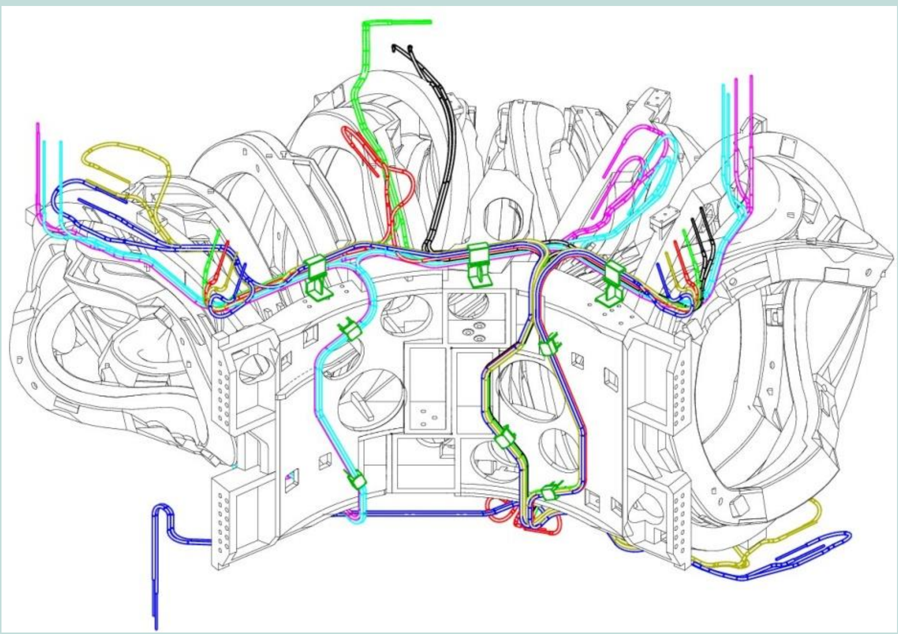


IFJ PAN contribution to W7-X construction
(2007 – 2012)

- IFJ PAN was responsible for the assembly of the bus bar system powering 70 superconducting coils on five modules of the stellarator.
- The bus bars are made of the NbTi superconductors in an aluminium jacket.
- There are 24 bus bars on each module.



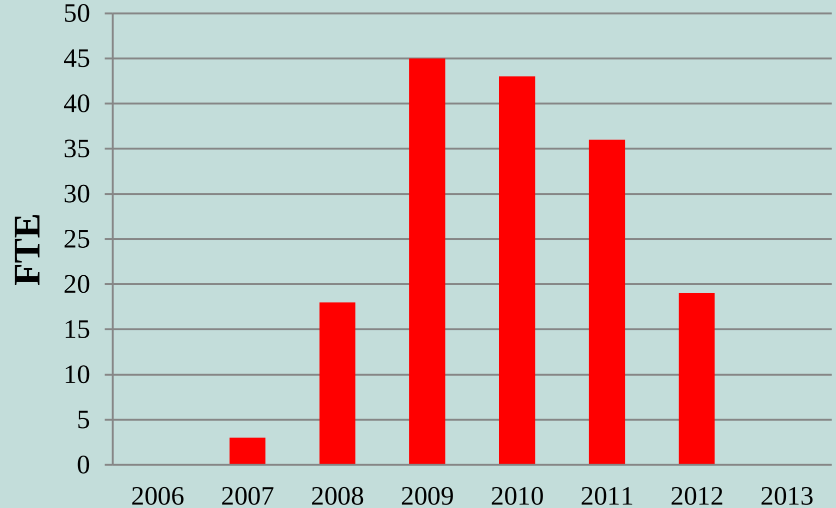
Bus bar cross section



Example of bus bars routing on one module

Total number of FTE over 6 years > 160

Total number of trained IFJ PAN staff > 50



Mechanical and electrical connection of the superconductors

Electrical connection of 81 triplets

Connected triplets squizzed with clamps
and covered by stainless steel caps

Electrical insulation of joints (wet wrapping)

Electrical insulation of the assembled joints (divided into three steps)

All joints (184) passed successfully tightness and HV tests

Installation of 24 bus bars on the module
and final shaping of the bus bar ends

Module Separation Plane
set of six joints painted and clamped

1. **Design and prototyping of Davis – Cotton (D-C) telescope structures**
2. **Design and prototyping of composite mirrors.**

Ad. 1

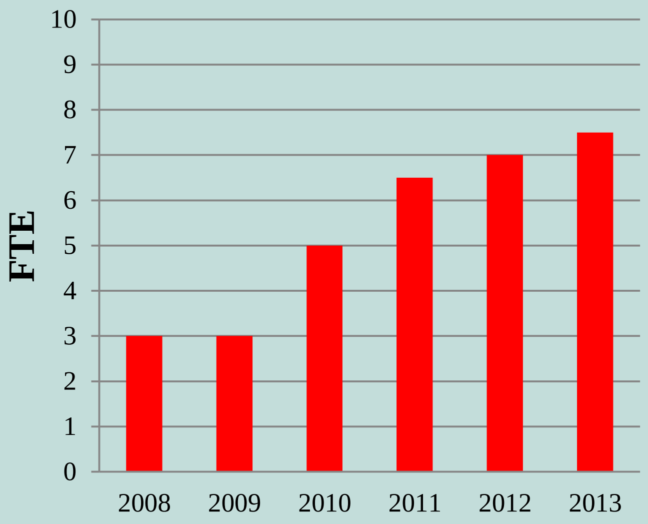
IFJ PAN provided a complete design of three Small Size Telescope (SST) structures of various mirror dish diameters (6m, 7.6m, 4m)

Ad. 2

Starting from circular mirror samples of 0.2m and 0.4m diameters IFJ PAN built full size prototypes of hexagonal mirrors for SST (0.78m flat-to-flat, curvature radius 23m) and MST (1.20m flat-to-flat, curvature radius 32m)

Total number of FTE over 6 years > 30

Total number of trained IFJ PAN staff > 10

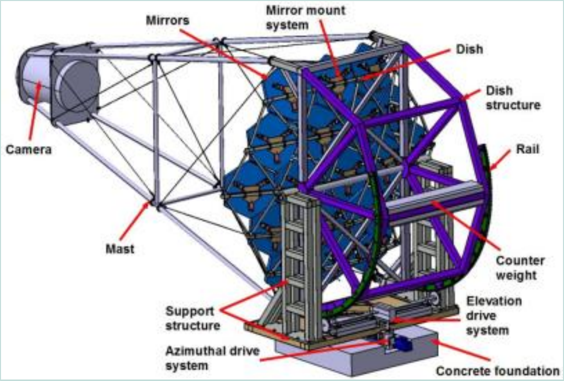


D-C Small Size Telescope structures

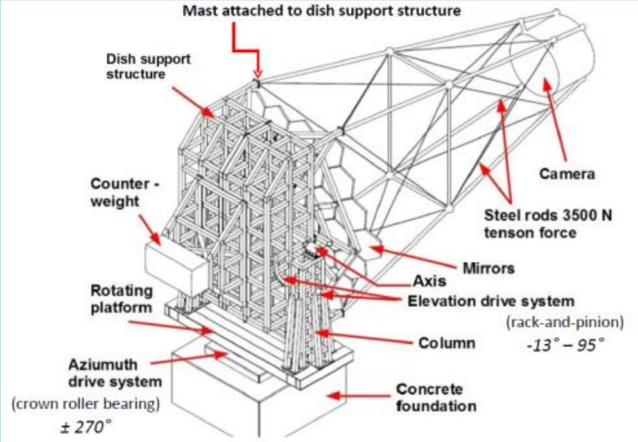
The design process included:

- structural optimization,
- strain-stress analysis under static and dynamic loads,
- modal analysis,
- cost estimate.

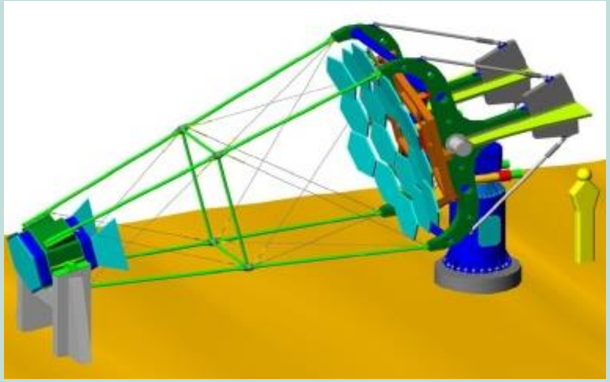
Various types of drive systems of the elevation and azimuth axes were considered.



6 m dish diameter



7.6m dish diameter



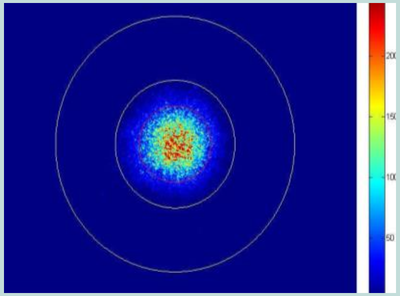
4m dish diameter

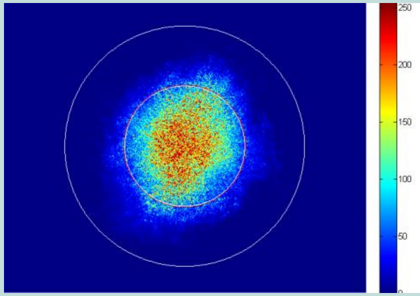
The D-C SST structure with the mirror dish diameter of 4.0 m will be manufactured in the Polish industry in 2013. Following, it will be tested at IFJ PAN in 2014.

Composite mirror prototypes

Two prototypes of the open structure mirrors were built for the D-C SST (7.6 m mirror dish diameter). The hexagonal mirrors has size 0.78 m (flat-to-flat), the curvature radius 23 m and weights 16.6 kg. R&D included also performance of ANSYS® simulations.

The prototypes were tested by CTA laboratories. Due to the test results IFJ PAN was recommended to build nine prototype mirrors for D-C Medium Size Telescope (MST). The size of the MST mirrors is 1.2 m (flat-to-flat) and the curvature radius 32 m.





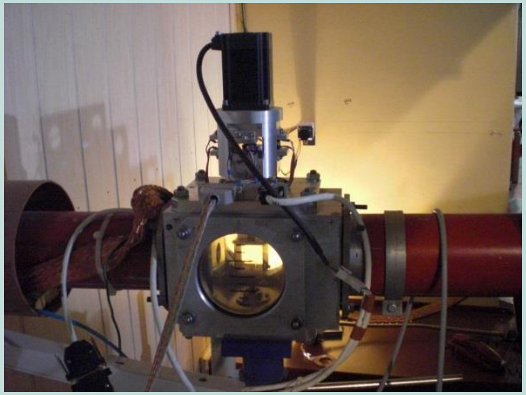
SST **p**rototype mirror (0.78 m, 23 m)

PSF (D80) = 10.5 mm

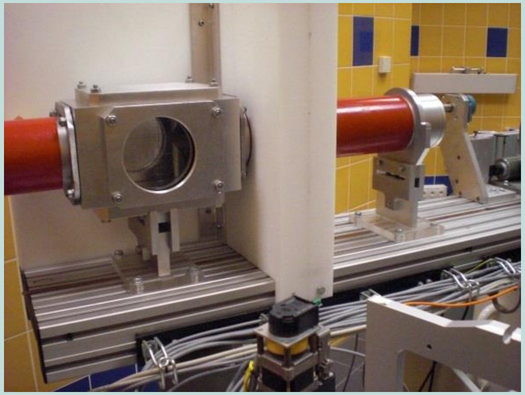
MST **p**rototype mirror (1.20 m, 32 m)

PSF (D80) = 17.4mm

Components of eye melanoma setup



Device for immediate proton beam cut-off, so called shutter



Supports for the end of beam line

Adjustable supports for x-ray lamps

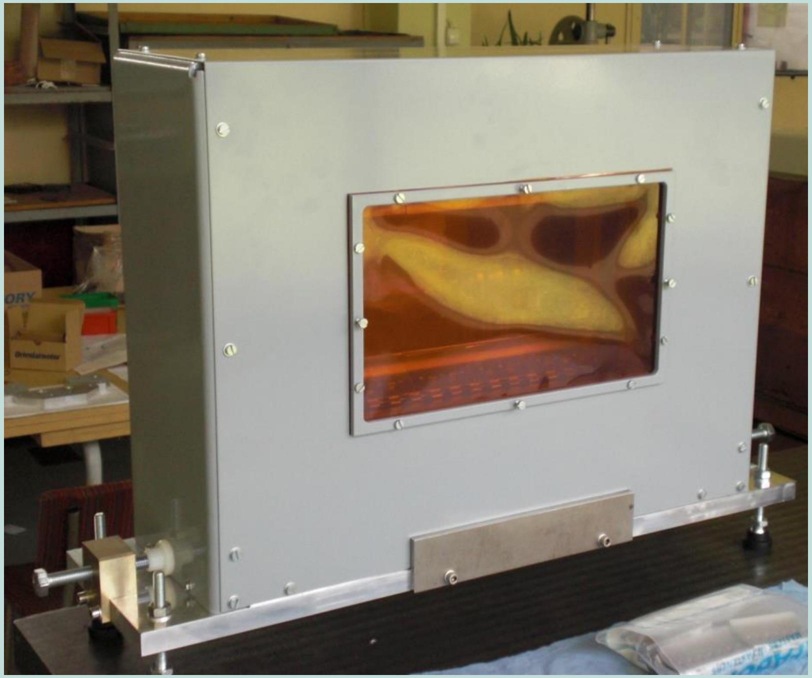
range discriminators and beam collimators

Holders for digital x-ray recorders

Scientific equipment construction

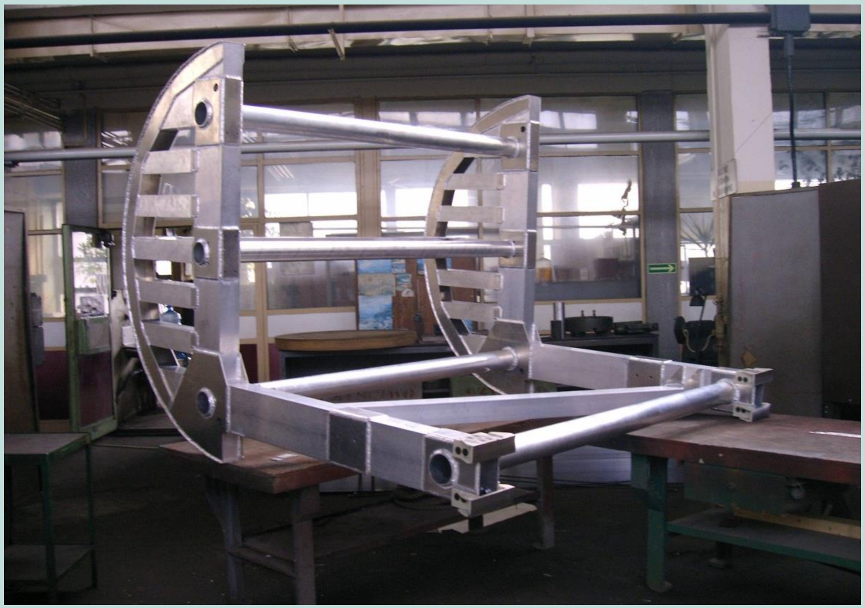
Finger detector at GSI Darmstadt

Mechanics for one detector – completed in 2012



Mechanics for 30 sets of polychromators – completed in 2011

Aluminium frame to install Muon Chambers – completed in 2006



The frame at IFJ PAN

The frame used during installation in the ATLAS cavern

Conclusions

- IFJ PAN groups contribute to major world experiments in particle physics, astrophysics and nuclear physics.
- IFJ PAN contributes to XFEL and LHC
- IFJ PAN is involved in fusion projects (W7X, ITER)
- We are ready to do next steps:

  → R&D program in applied superconductivity
  → Cryogenic test infrastructure