Dosimetry for cancer radiotherapy

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The Aims of Radiotherapy

- The general aim of radiotherapy is to deliver the required dose to the treated volume, with minimum exposure of healthy tissues.
- Modern irradiation techniques lead to high dose gradients which cannot be easily measured with presently used dosimetry techniques.
- New methods of two- and three-dimensional dosimetry are needed.

The problem is to assess and confirm the dose delivered to the patient.
Proton radiotherapy at IFJ PAN

Facility for therapy of eye melanoma

- Consortium of the National Centre of Hadron Radiotherapy, NCRH
- The first 9 ocular melanoma patients have been treated at IFJ PAN in 2011

The Bronowice Cyclotron Centre (CCB) at IFJ PAN

The Goal: development of infrastructure for clinical ion radiotherapy and for biomedical research at IFJ PAN

Part 1
- Proteus C-235 cyclotron
- complex of buildings
- funds ~27 ME
- Completed by Dec 2012

Part 2
- proton gantry
- medical building
- funds ~ 18ME
- Completed by June 2014
Proton radiotherapy in Kraków

Juny 2011

Dec 2014
Methods used in clinical dosimetry

1-dimensional

- TL pellet
- diamond
- OSL
- ionisation chamber
- semiconductor diode

2-dimensional

- films
  - fotochromic
  - thermoluminescent foils
- strip and pixel semiconductor detectors
- matrix of ionisation chambers

3-dimensional

- Fricke gel
- 3-D scintillators
Thermoluminescence is an emission of light by certain materials during their heating after previous irradiation.

Amount of light $\propto$ absorbed dose
Dosimetry for cancer radiotherapy

Two types of foils:
- LiF : Mg, Cu, P
- CaSO_4 : Dy

Water resistance and flexibility
- Up to 20 x 20 cm^2 area
- Reusability
- Resolution below 0.1 mm^2
- Linearity of dose response: 0.05 - 20 Gy
Dosimetry system – procedures

Aim: preparation of measurement procedures

- Testing of new foils
- Preparation for use
- Irradiation
- Heating
- Collection of emitted light
- Data analysis

Diagram:
- Camera
- Detector
- Heater
- Light
The objectives of my research

To further develop and test in clinical conditions the 2-D thermoluminescence system developed at IFJ PAN

- Improve the heating and image acquisition of the reader
- Improve the spatial resolution of the system
- Improve the measurable dose range
- Investigate the basic properties of the 2-D TL system
- Develop new software for image correction and processing
- Prepare operating procedures
- Verify operation of improved system
- Test system in ion radiotherapy beams in foreign therapy centers
- Prepare system for scanning beam QA at IFJ PAN
The 2-D TL Dosimetry system developed at IFJ PAN

Aim: refinement of reader system

Clinical Reader:
- detector size 200 x 200 cm²
- resolution 1024 x 1024 px
- easy and safe to use

Laboratory Reader:
- detector size 50 x 50 cm²
- resolution 640 x 480 px
- fully adjustable
Dosimetry system – software

Aim: to develop software for image processing and analysis

After correction with Individual Reference Factor Image we obtain better uniformity of detector sensitivity.
Results – dose response uniformity

Aim: improve homogeneity of foils and readouts

Better uniformity of heating and use of different corrections improves the accuracy of dose response.

Homogeneity of dose response after previous irradiation in uniform field (histogram)
Results – repeatability of readouts

Aim: to obtain better repeatability

Improvement of the image acquisition system and procedures significantly improves the repeatability between readouts
Collaboration with foreign partners

Aim: tests of the 2-D TL dosimetry system in proton and carbon beams at foreign partners' facilities

Prof. Oliver Jäkel, leader of Research Group Heavy Ion Therapy,

Prof. Martin Jermann, in the Paul Scherrer Institute, Switzerland
Summary

• Improvement of Clinical TL Reader is in progress (about 60% of work completed)

• Development of dedicated software (FlatView) for image processing is almost completed (80% - test stage)

• First measurements conducted with laboratory TL reader have been made – first results obtained (20%)

• Tests in proton and carbon fields are to be conducted in 2012 (1% - first tests with proton beam at IFJ)

• 2-D TL procedures are under development (40% completed)
Thank you for your attention