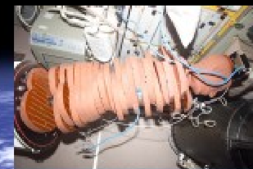
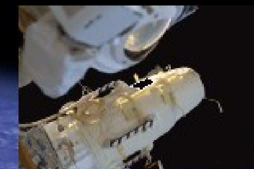




HAMLET: Ground Based Verification of the MATROSHKA Facility: Results from the experiments at HIMAC and GSI

Pawel Bilski for the HAMLET consortium

IFJ, Krakow, Poland

Ground Based Research

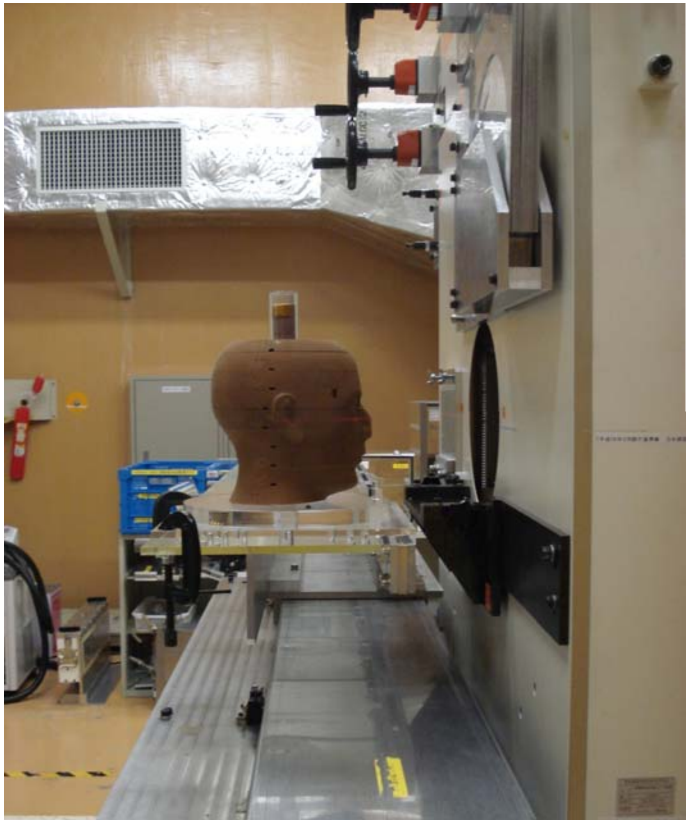
Goals:

- To characterize and to intercompare various detectors' systems with the high-energy ion beams

- To produce datasets (dose distributions within a phantom head), as tools for benchmarking radiation transport codes

Ground Based Research

Heavy Ion Medical Accelerator, HIMAC, Chiba, Japan



HIMAC research project 20P-240

- May 2008
- February 2009
- February 2010
- June 2010

Future:

- February 2011

HAMLET Ground Based Research

Ion	Energy (MeV/n)	Day
Carbon	400	8 May 2008
Helium	150	9 May 2008
Iron	500	10 May 2008

Ion	Energy (MeV/n)	Day
Helium	150	13 February 2009
Iron	500	18 February 2009

Ion	Energy (MeV/n)	Day
Silicon	490	10 February 2010
Carbon	400	11 February 2010

Ion	Energy (MeV/n)	Day
Iron	500	10 June 2010

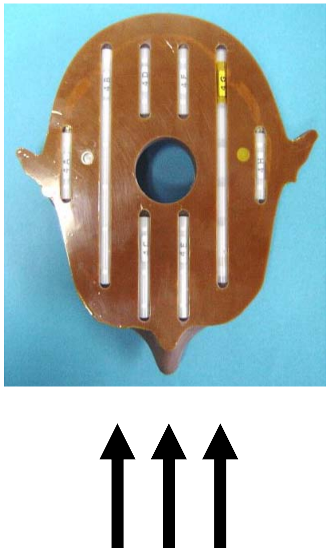
Types of exposures:

- without phantom (efficiency studies)

- phantom head with detectors

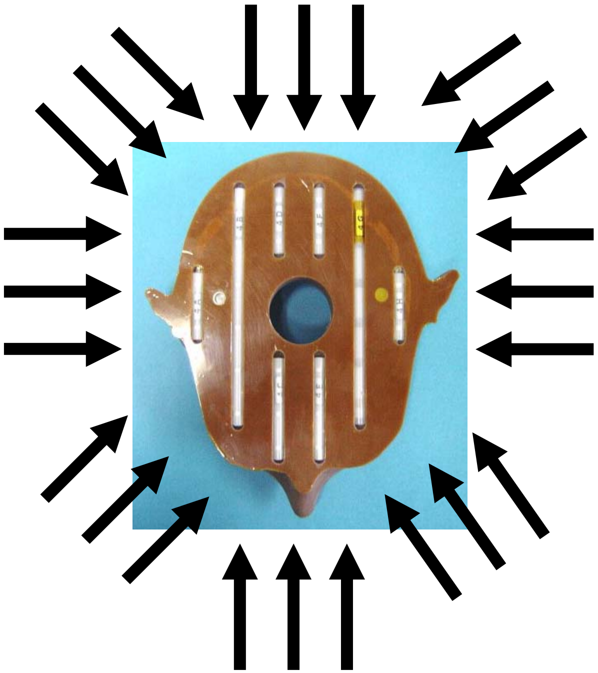
Phantom head exposures:

a) monodirectional

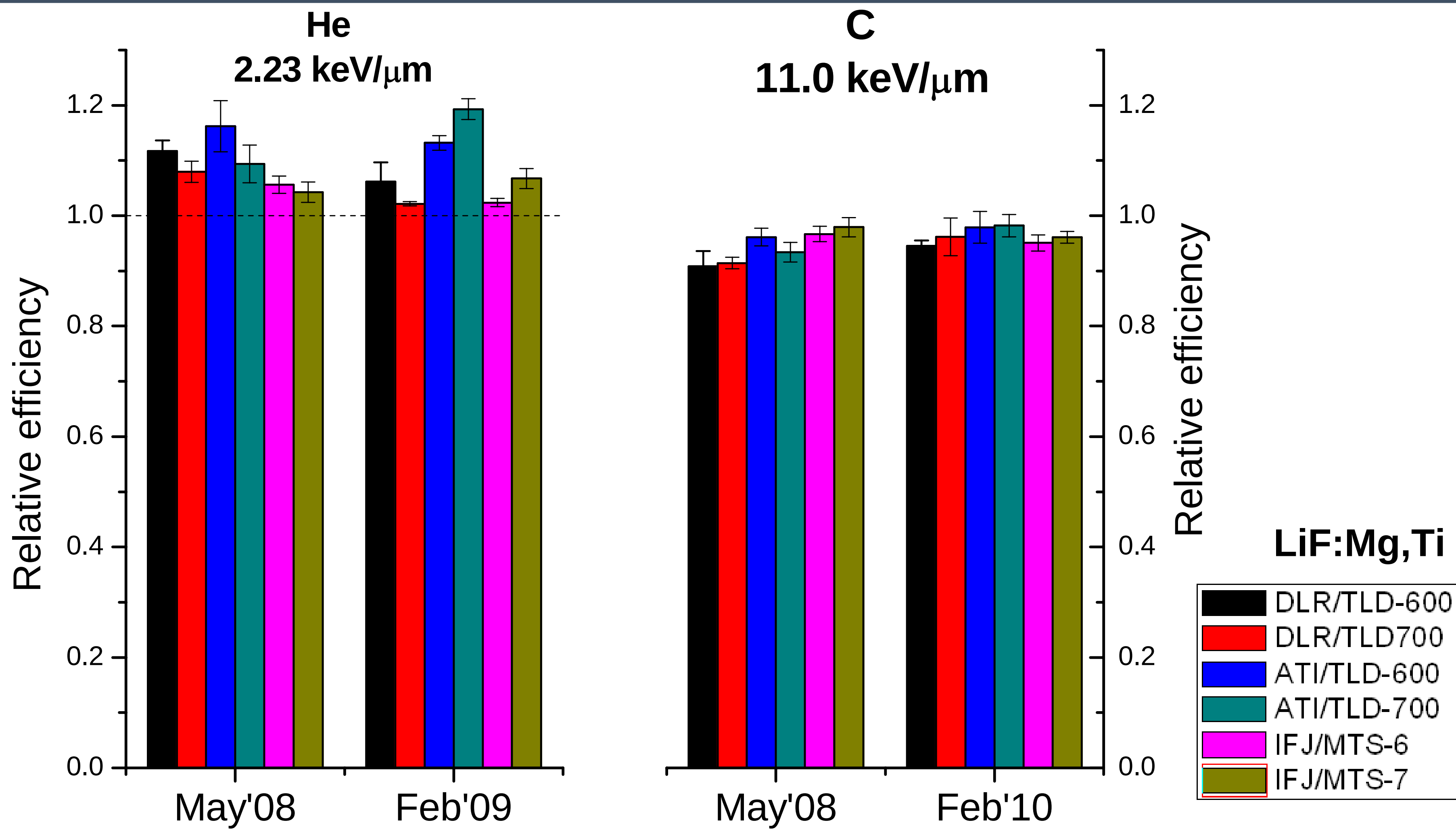


b) 'omnidirectional'

head rotation 45° or 60° or 30°

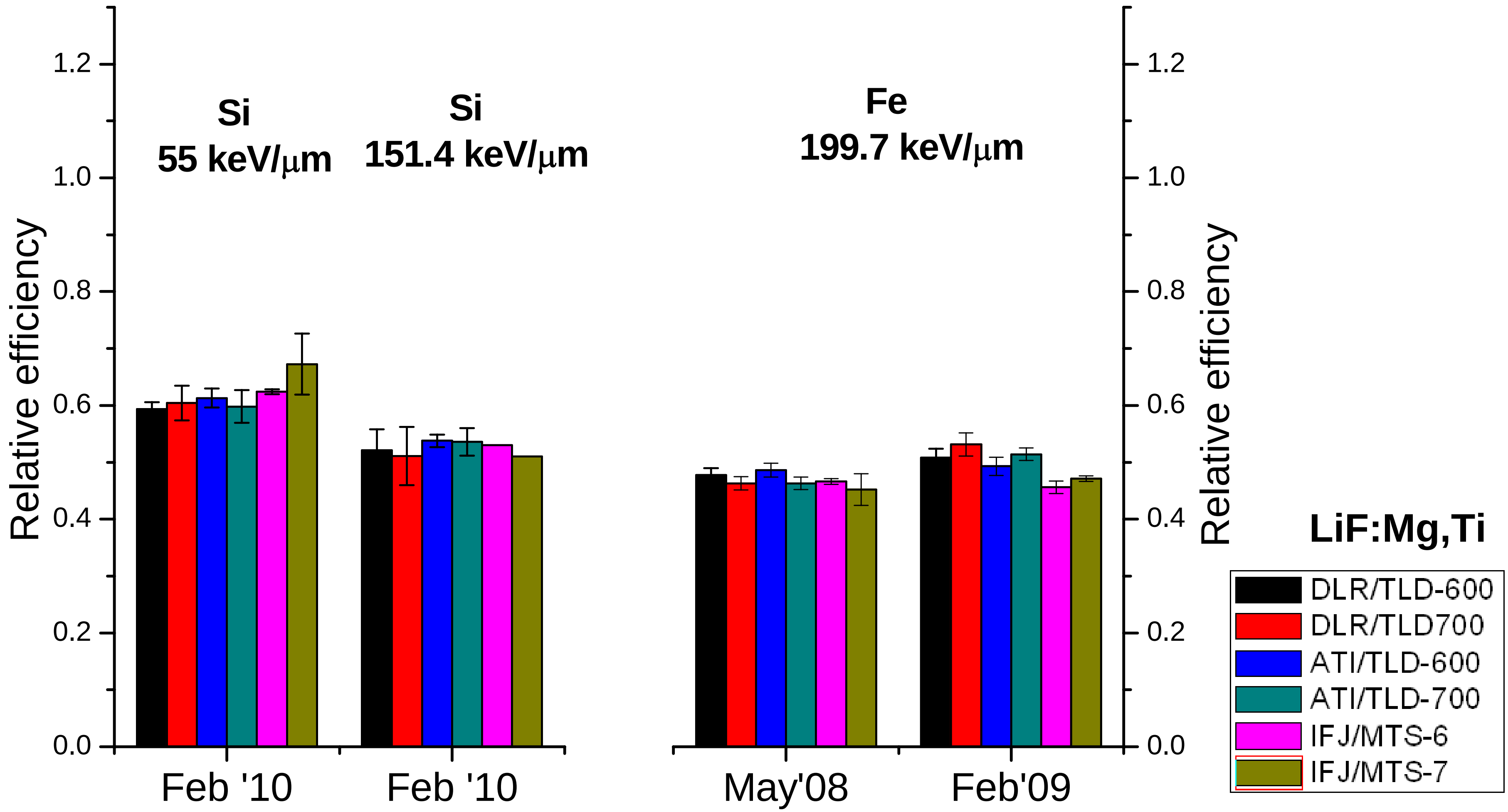


HIMAC – efficiency comparison

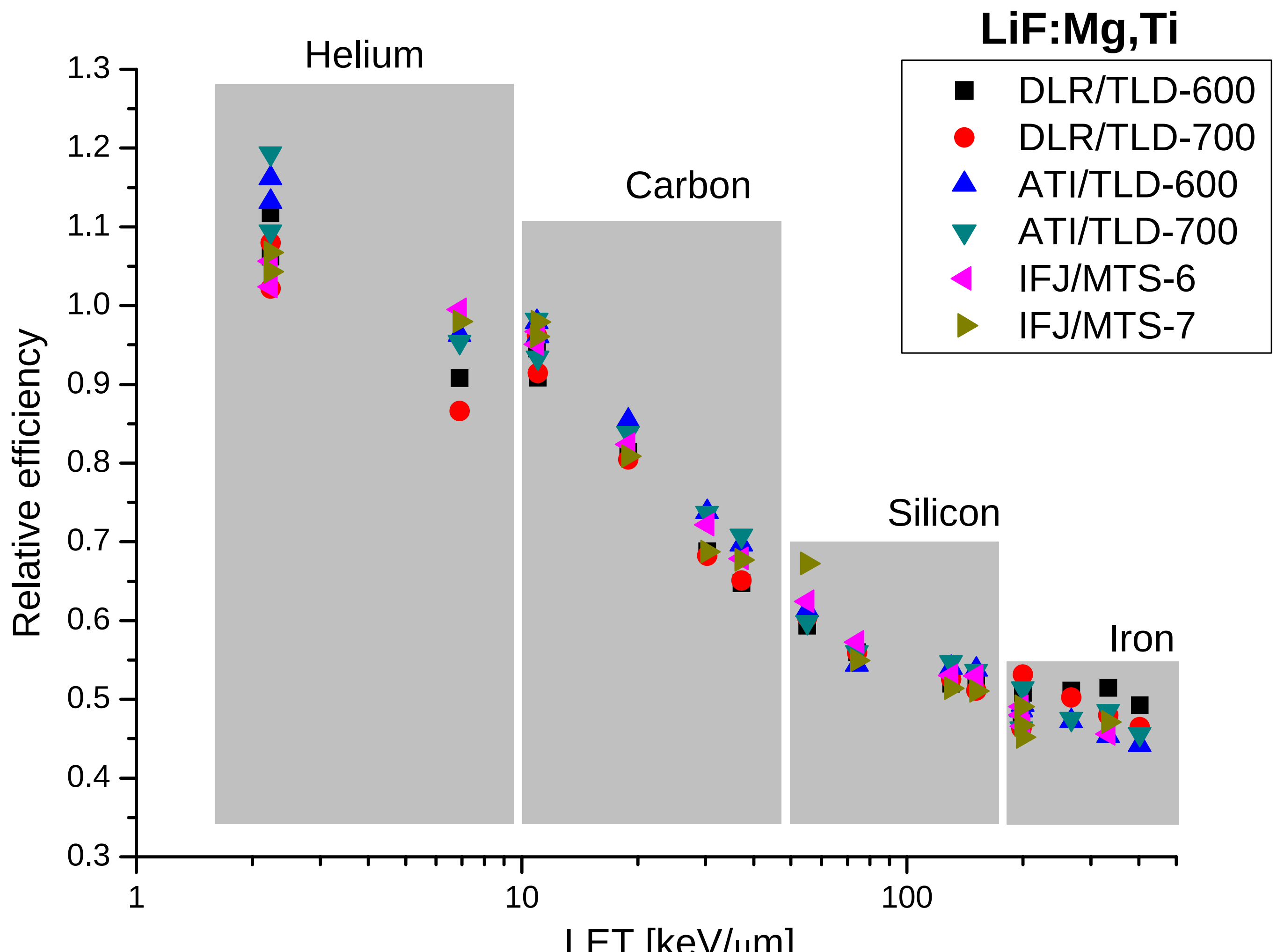


DLR ATOMINSTITUT CAU AEKI

HIMAC – efficiency comparison

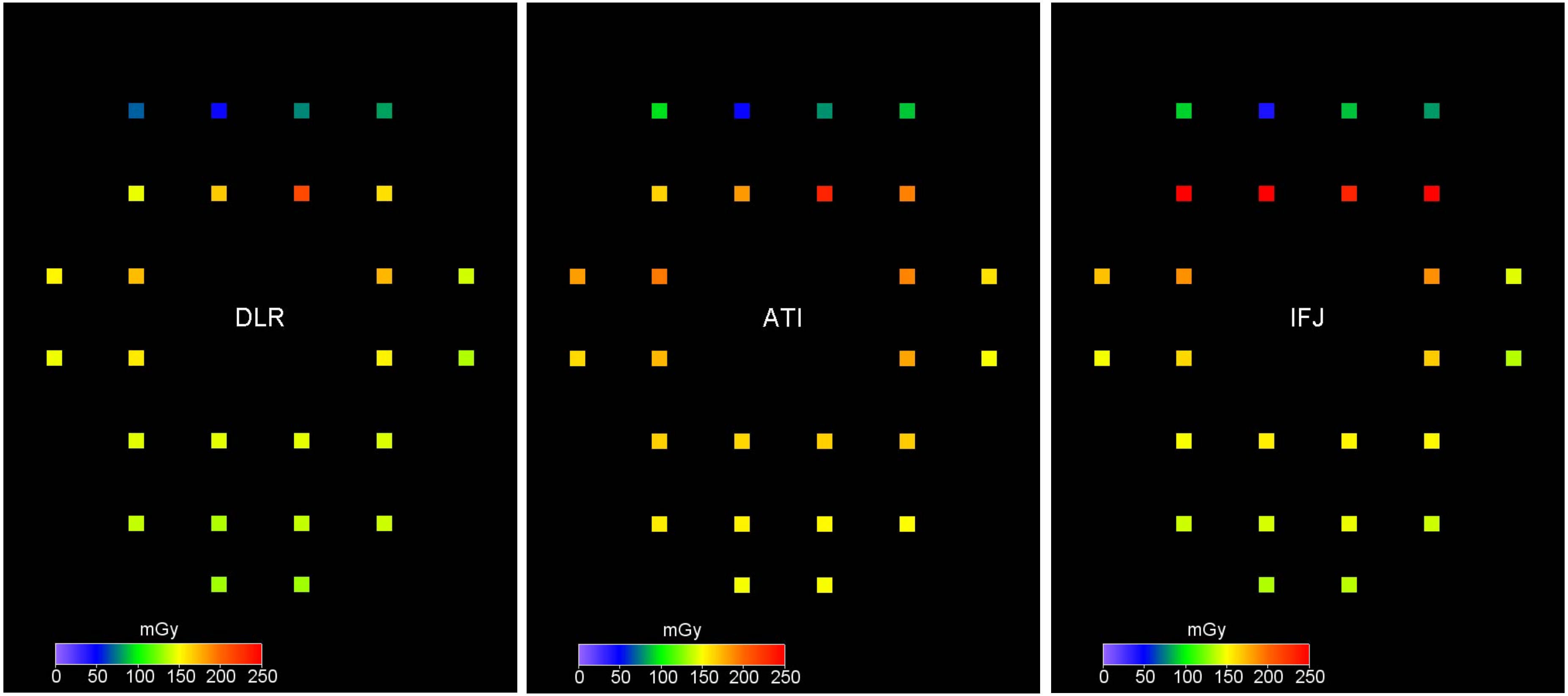


HIMAC – efficiency comparison



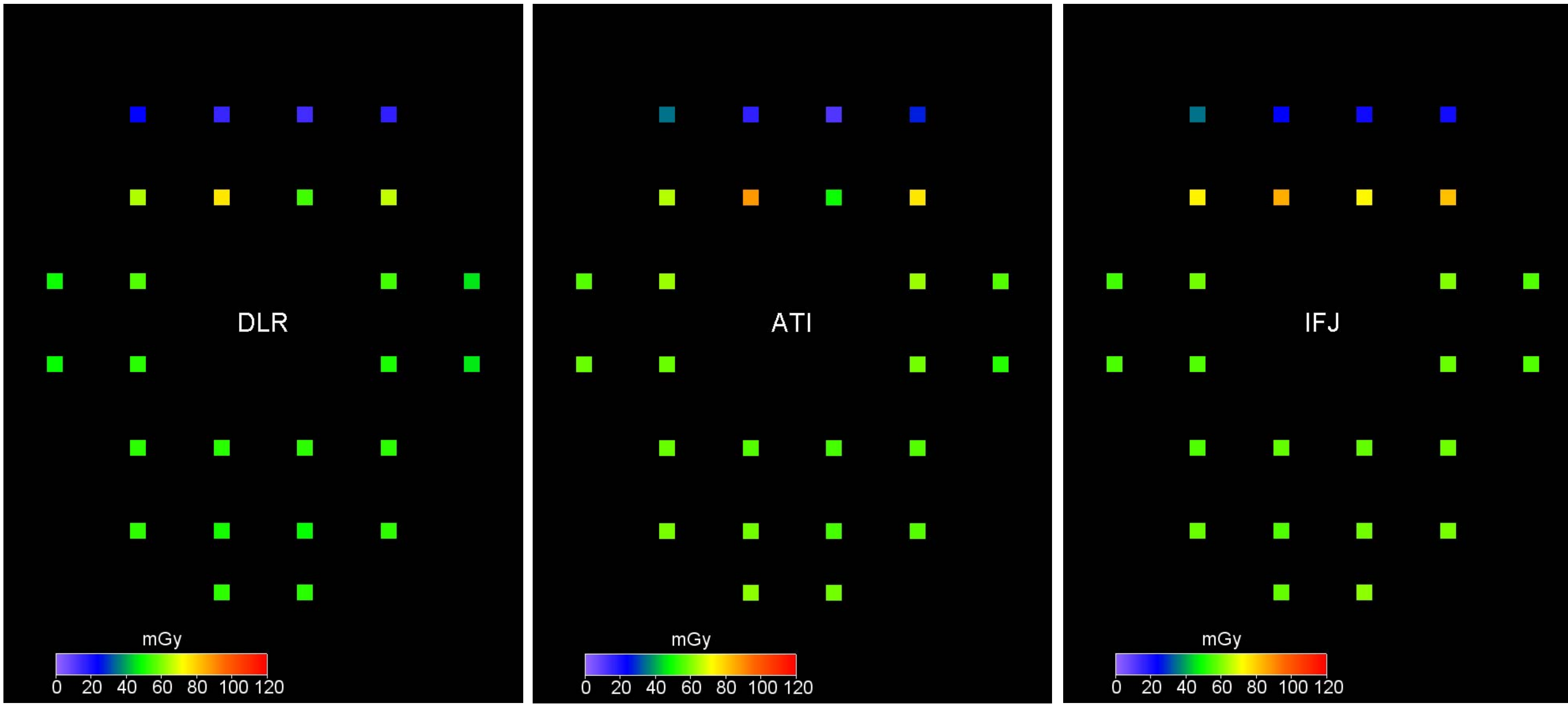
HIMAC – tubes in phantom head

He 2.23 keV/µm, May 2008



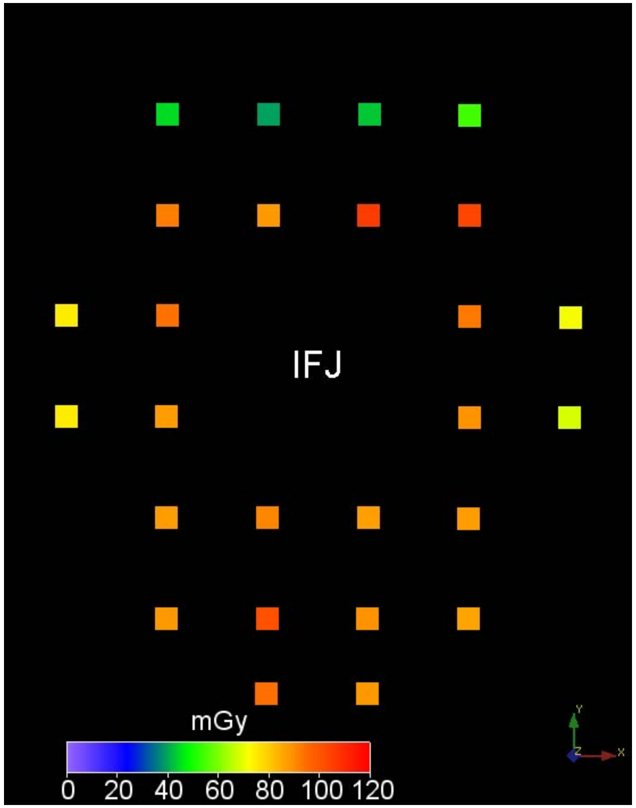
HIMAC – tubes in phantom head

Si 55 keV/µm, Feb 2010

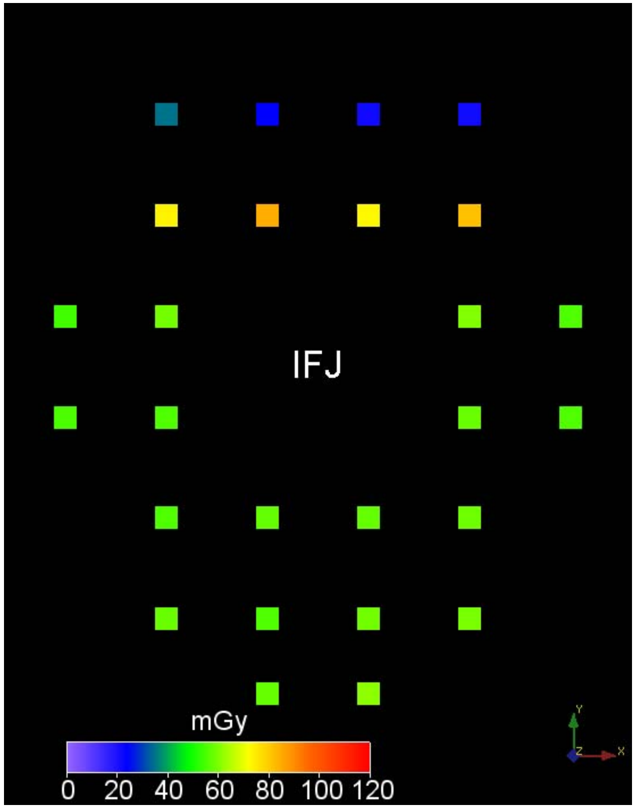


HIMAC – tubes in phantom head

Carbon 21 keV/µm



Silicon 55 keV/µm

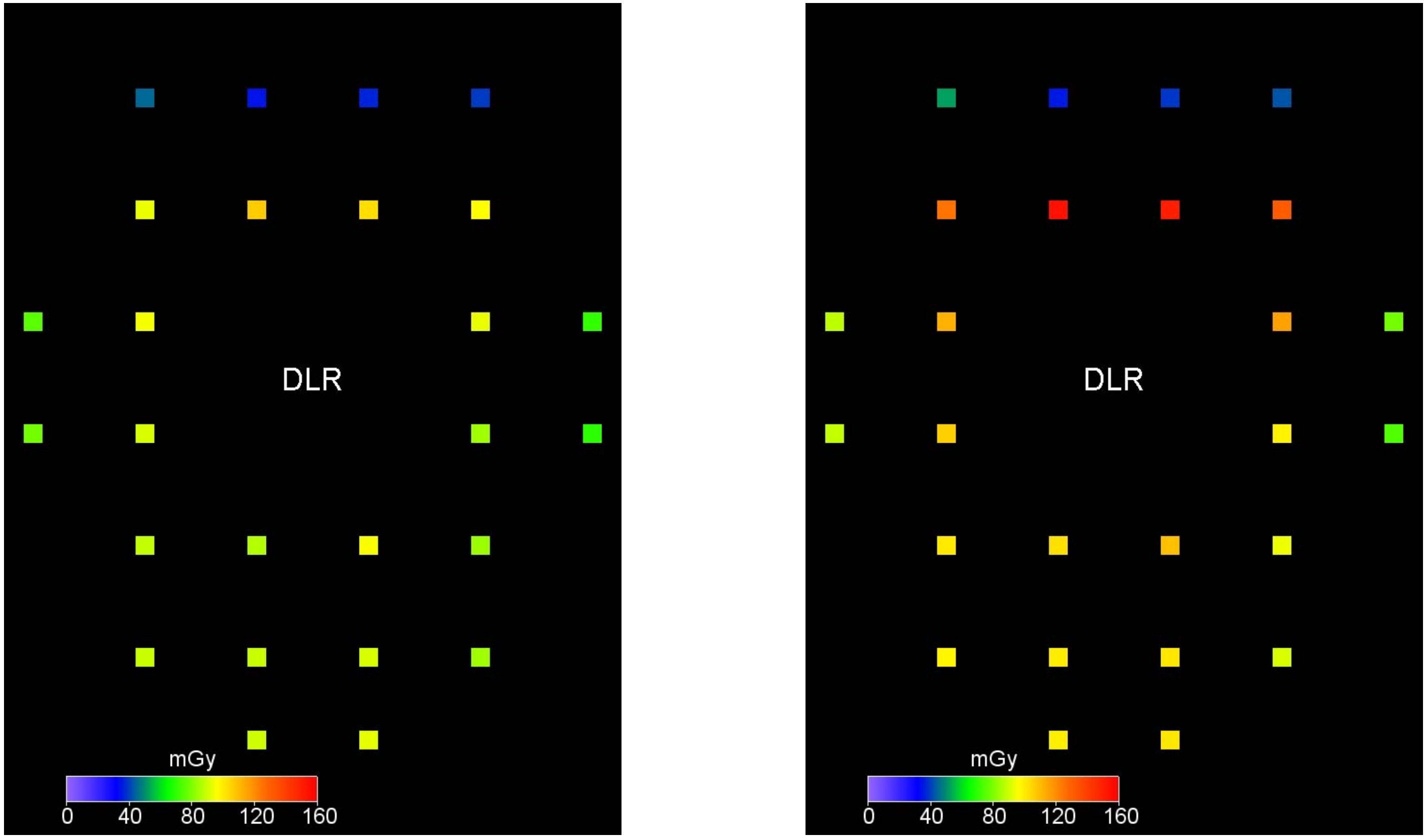


both beams has the same range in water

DLR
ATOMINSTITUT
CAU
AEKI
Health Protection Agency

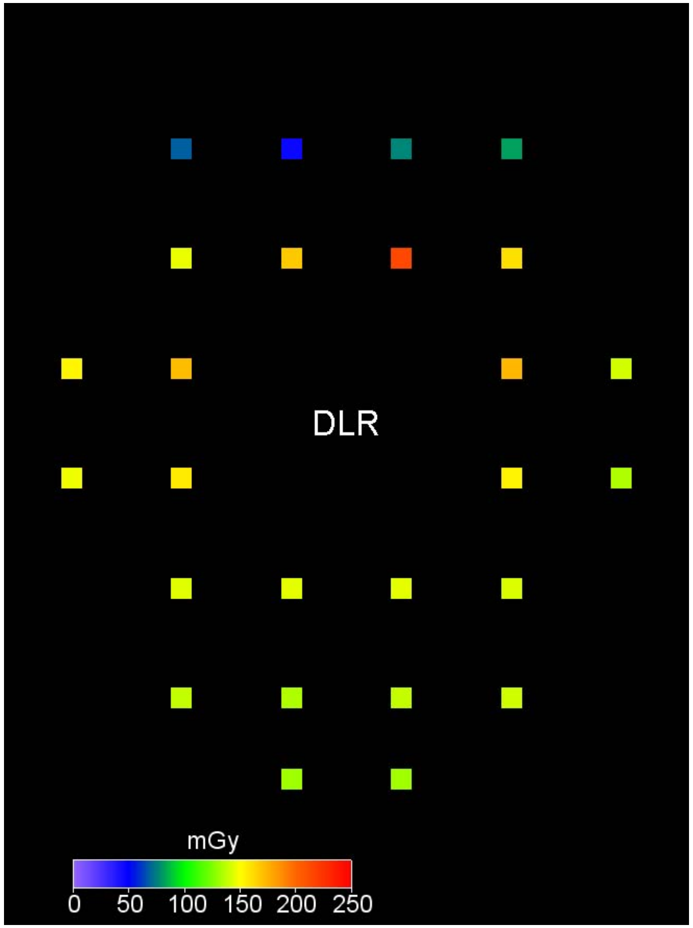
HIMAC – tubes in phantom head

C 12.6 keV/µm, Feb 2010

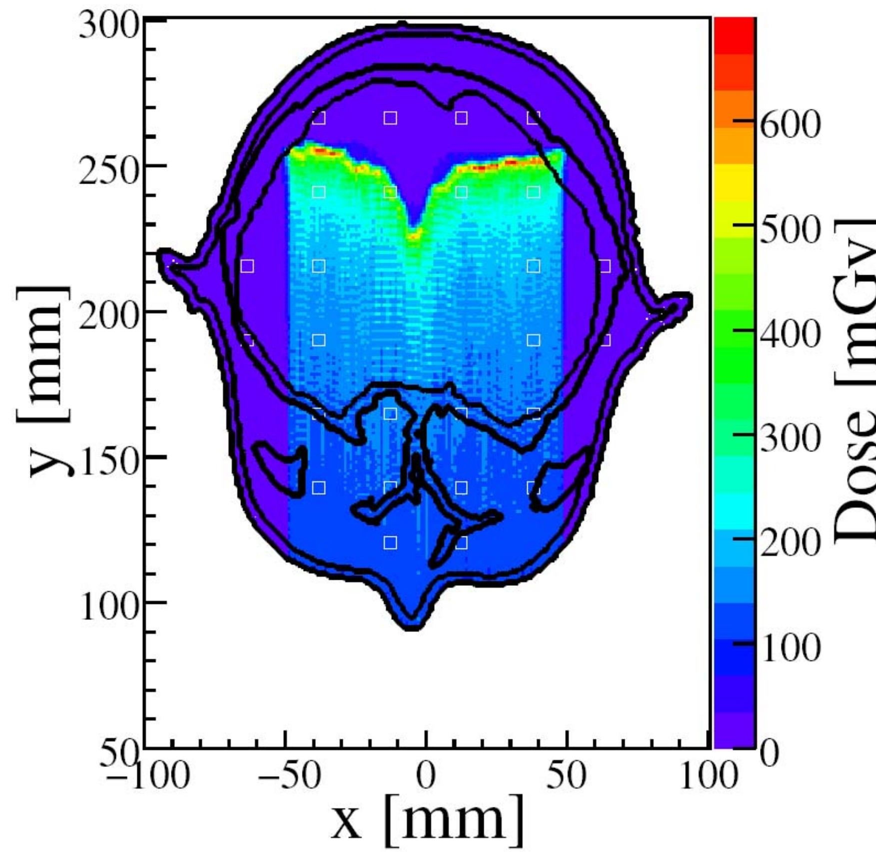


uncorrected data   HTR-based efficiency correction

HIMAC Simulations

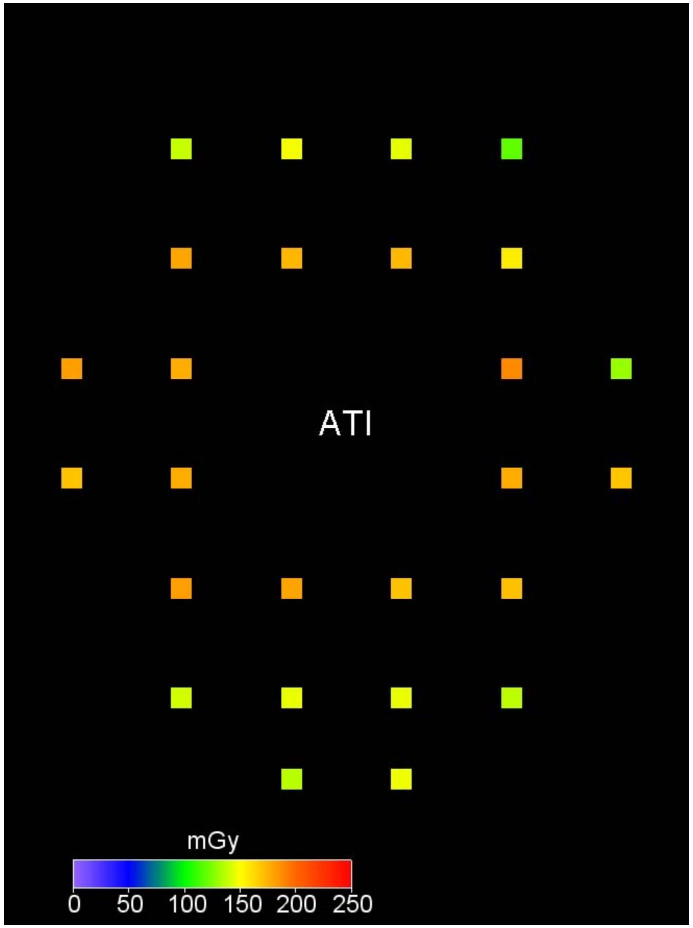


He - monodirectional

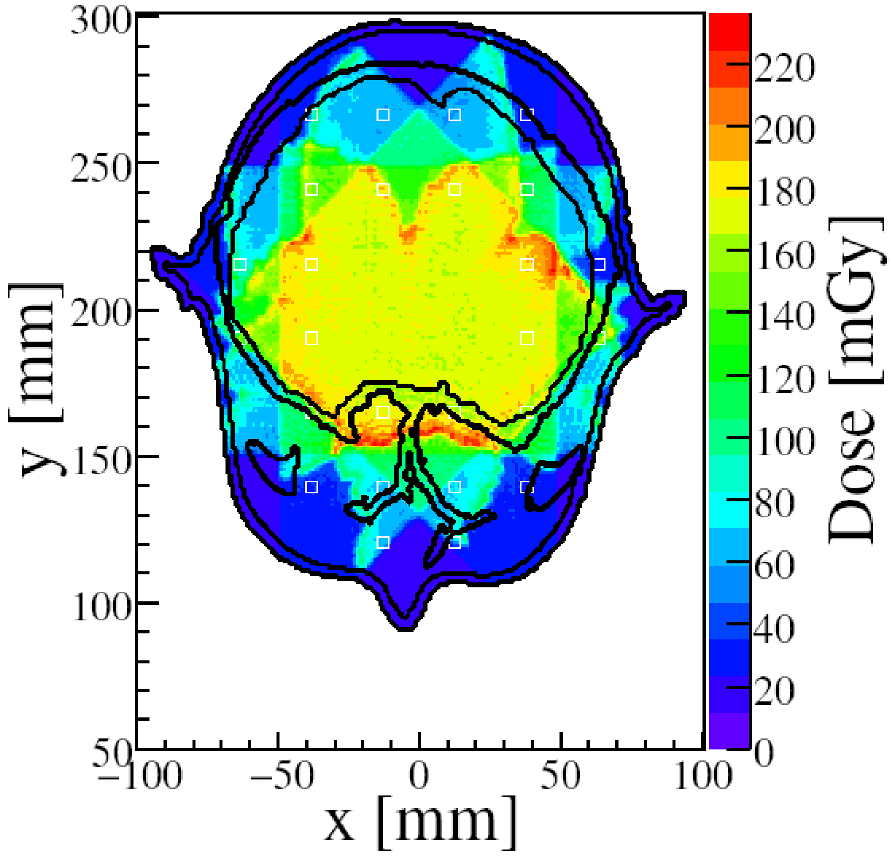


GEANT4 simulation

HIMAC Simulations

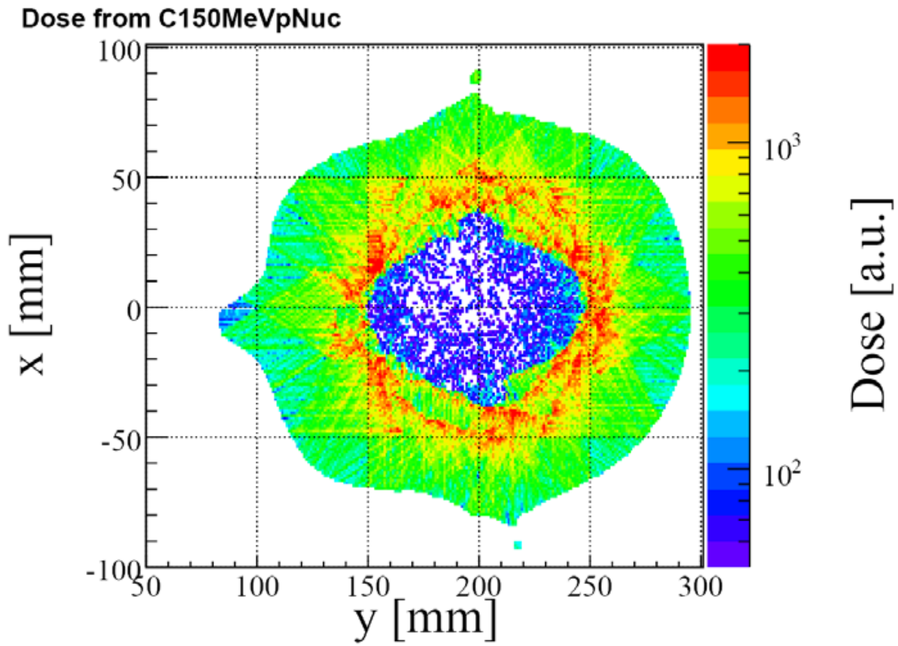


He omnidirectional (45º)

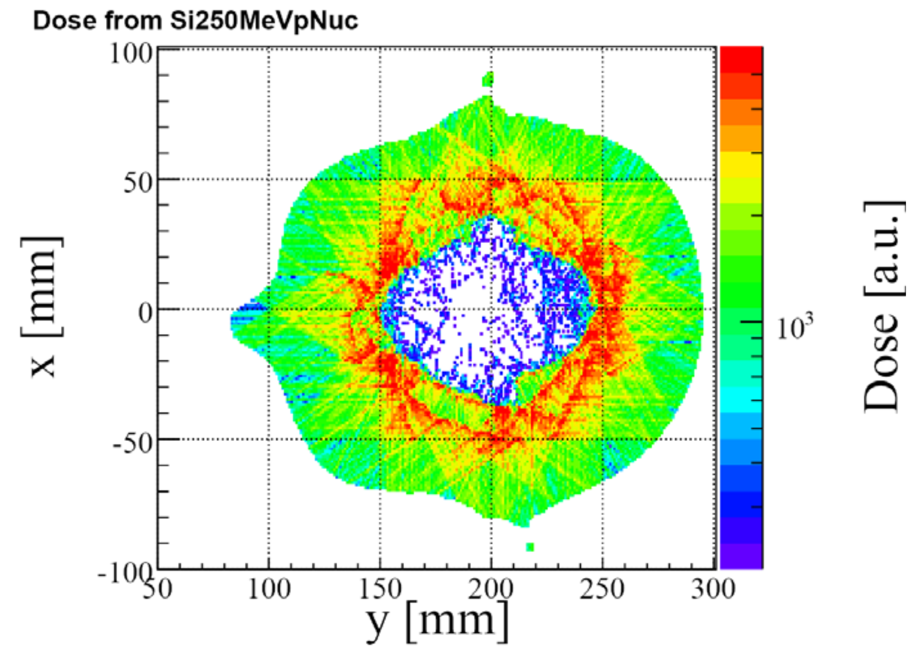


GEANT4 simulation

HIMAC Simulations



omnidirectional Carbon

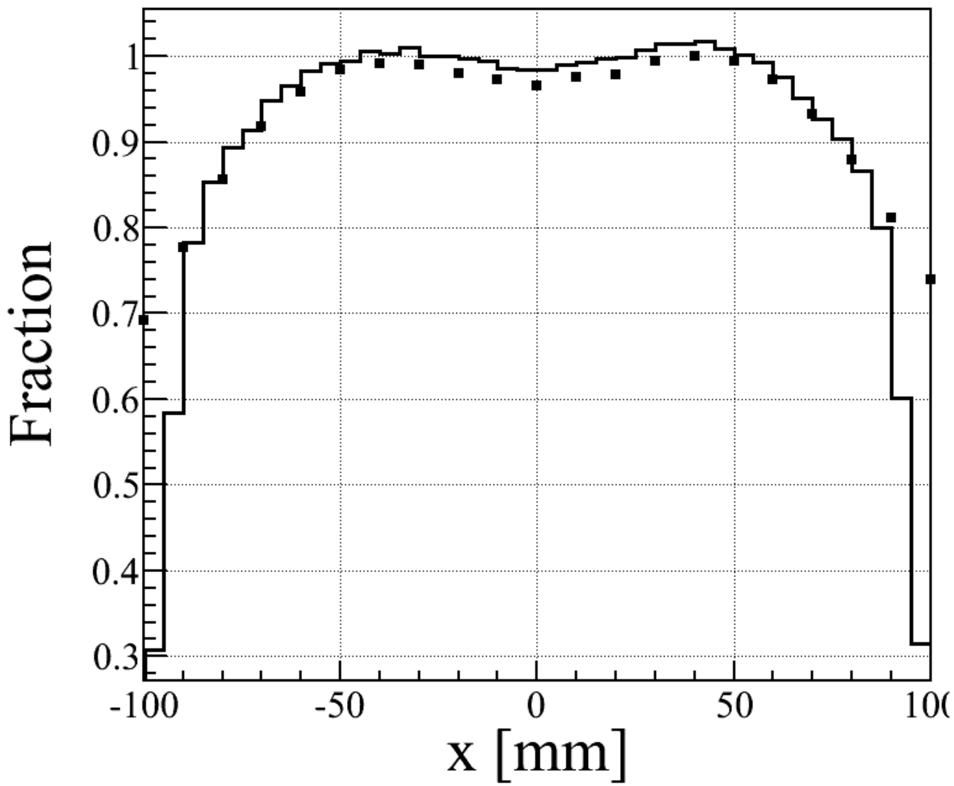


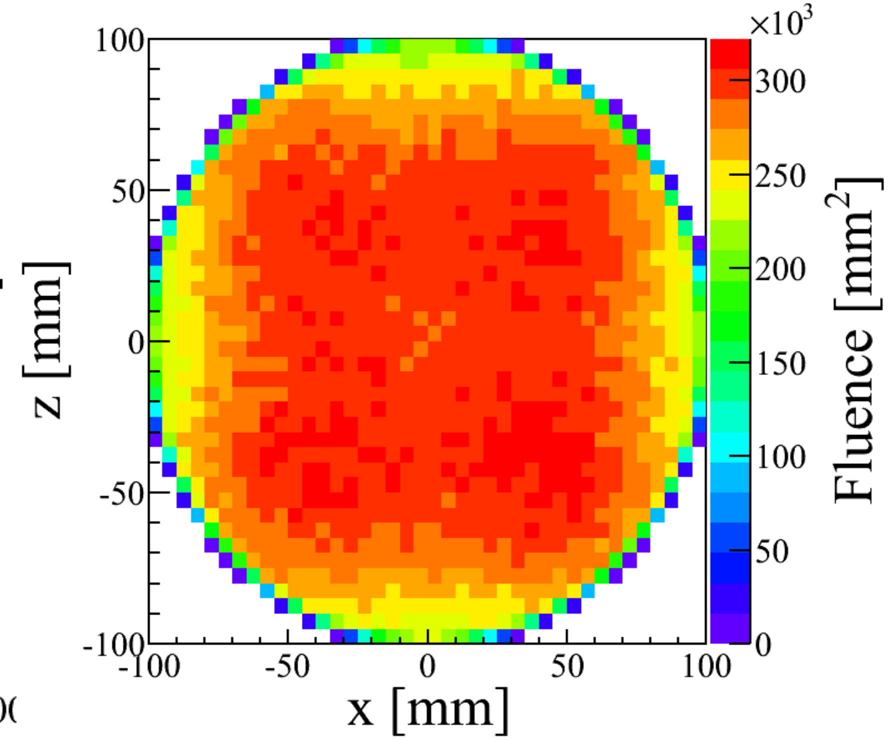
omnidirectional Silicon

HIMAC - Simulations

Beamprofile

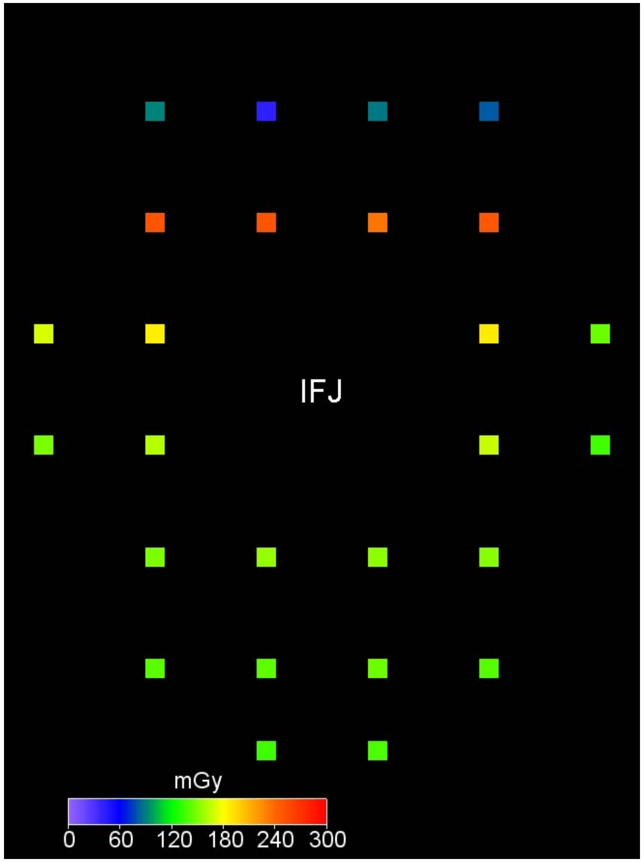
Acknowledgments to HIMAC, NIRS for providing the beamprofiles



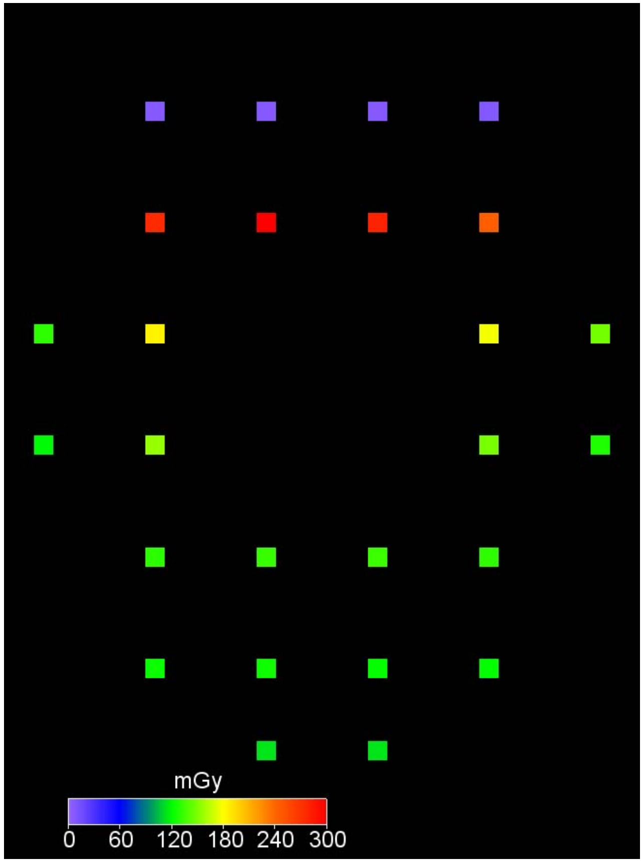


HIMAC – Simulations

using the real beamprofile



experiment

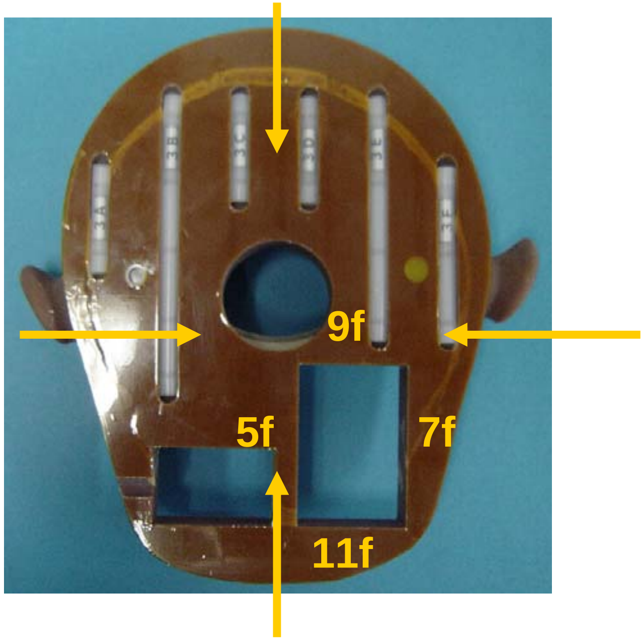


simulation

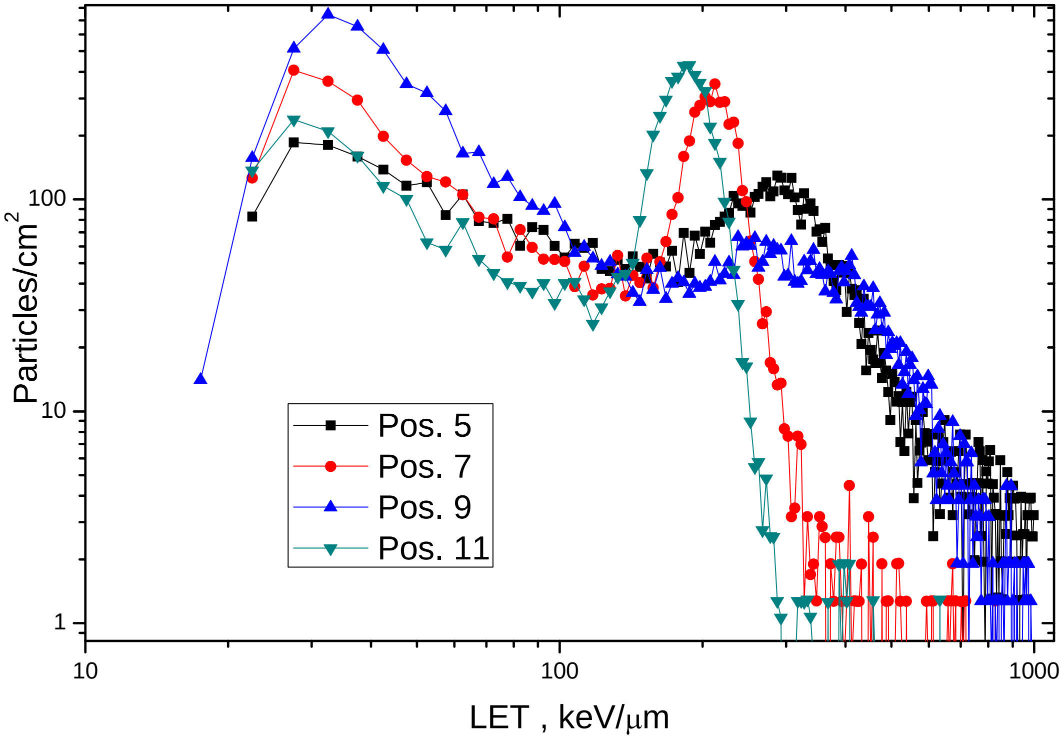
He 2.23 keV/µm
May 2008

Track Detectors

HIMAC May 2008



Multidirectional and multi-ion exposure: He, C, Fe

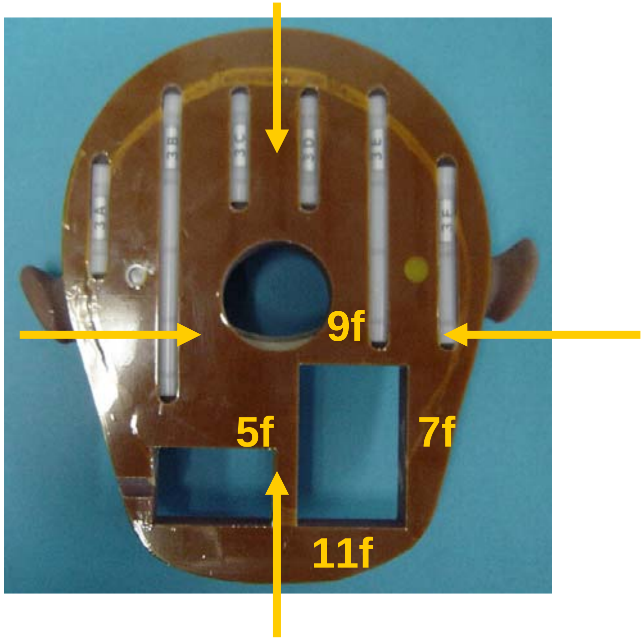


Low LET particles (<100 keV/μm) are slowed down carbon ions while the higher ones (> 300 keV/μm) were induced by He ions via target fragmentation procedure. The distinct peaks can be related to the Fe ions.

AERI Budapest data

Track Detectors

HIMAC May 2008



Multidirectional and multi-ion exposure: He, C, Fe

Position	D mGy	H mSv	Q
5f	5.77 ± 0.41	95.7 ± 4.9	16.6 ± 0.5
7f	3.36 ± 0.17	67.2 ± 1.9	20.0 ± 0.6
9f	4.99 ± 0.44	79.5 ± 4.5	16.0 ± 0.7
11f	3.12 ± 0.18	67.0 ± 2.0	21.5 ± 0.7

Dose values obtained by PADC stacks at different positions inside the head phantom as shown in the figure.

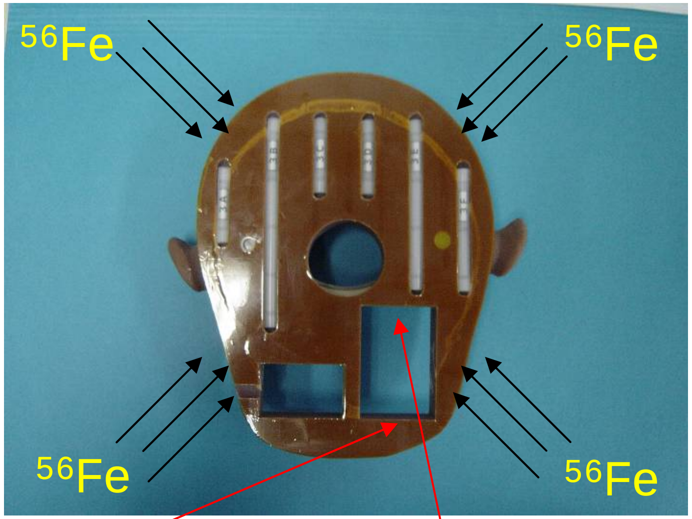
LET > 15 keV/µm

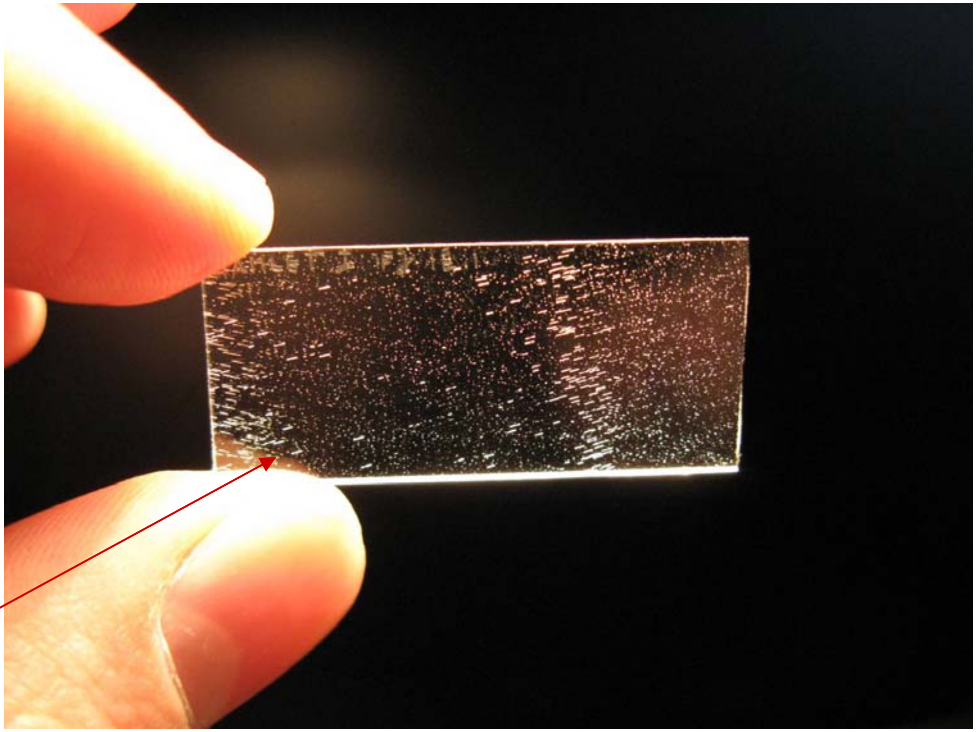
The higher Q at position 7f and 11f is due to the dominant effect of Fe ions.

AERI Budapest data

Track Detectors

HIMAC Feb 2009





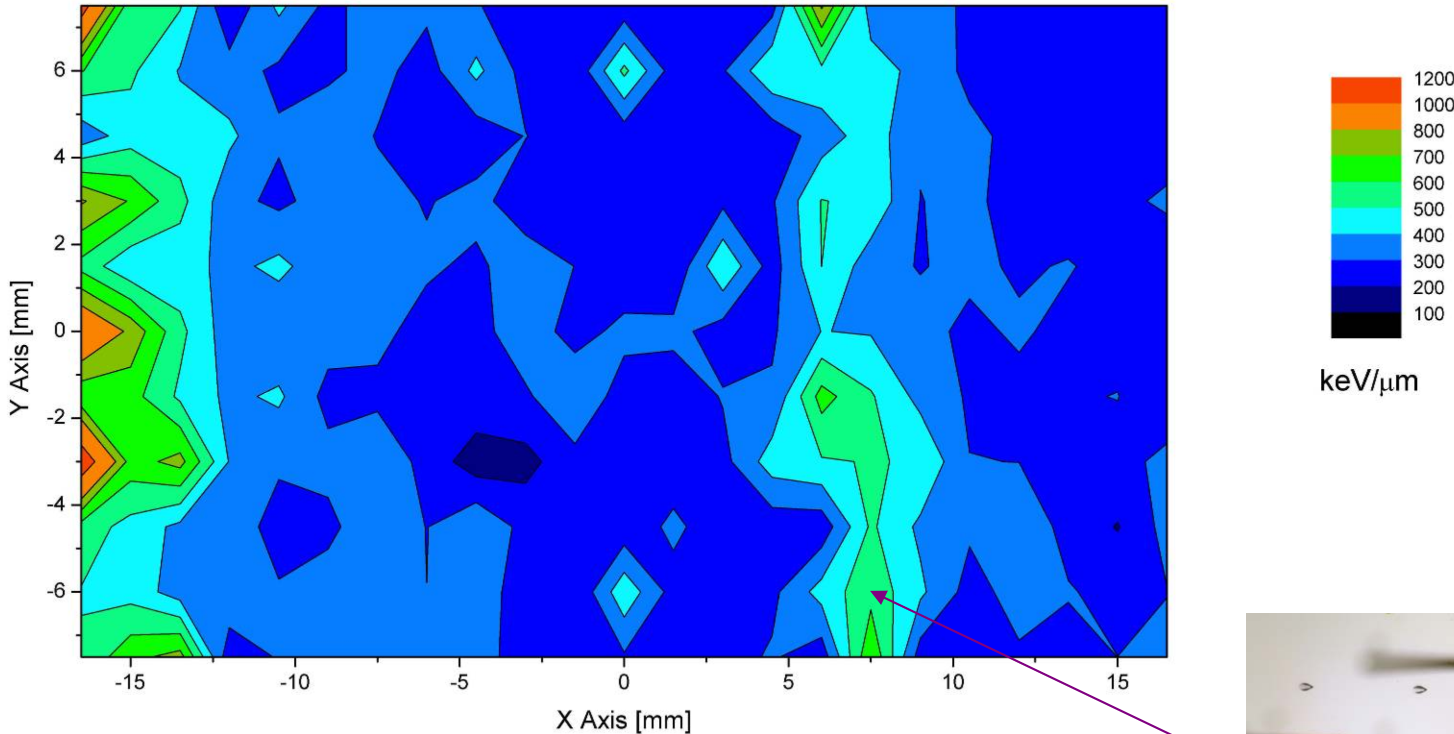
Detector 1:

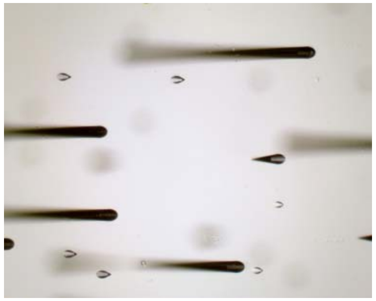
Detector 2:

IFJ Krakow data

Track Detectors

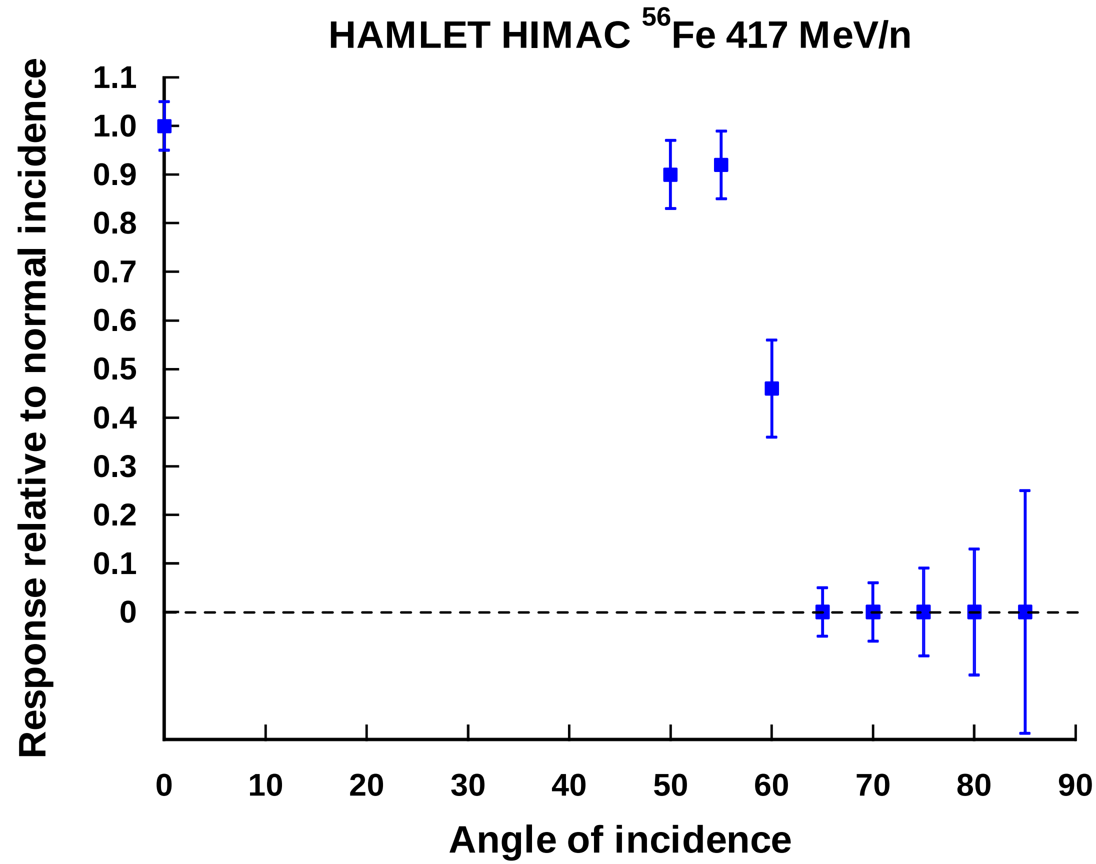
Average LET_{H2O} distribution





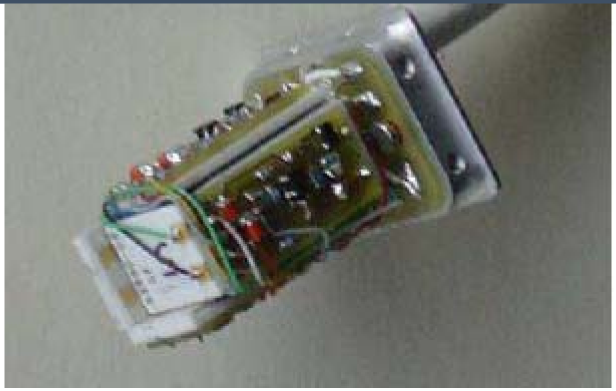
IFJ Krakow data

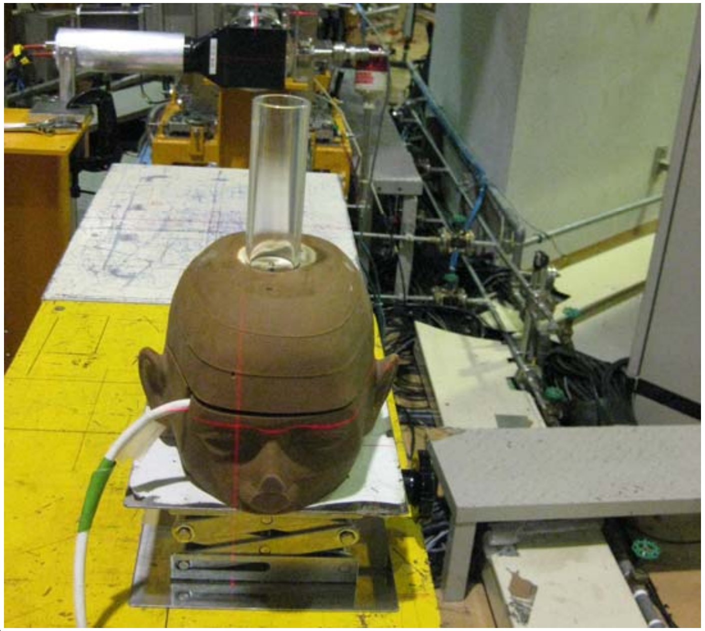
Angular characteristics

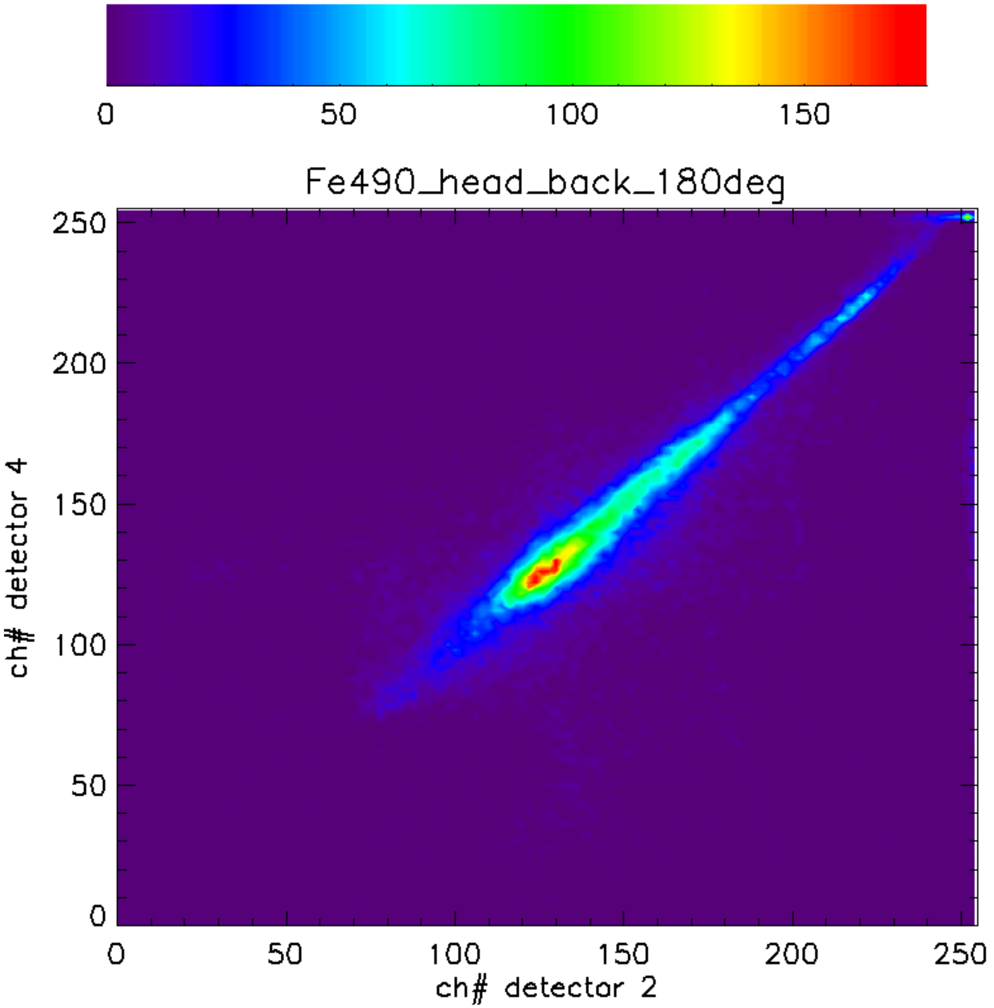


HPA data

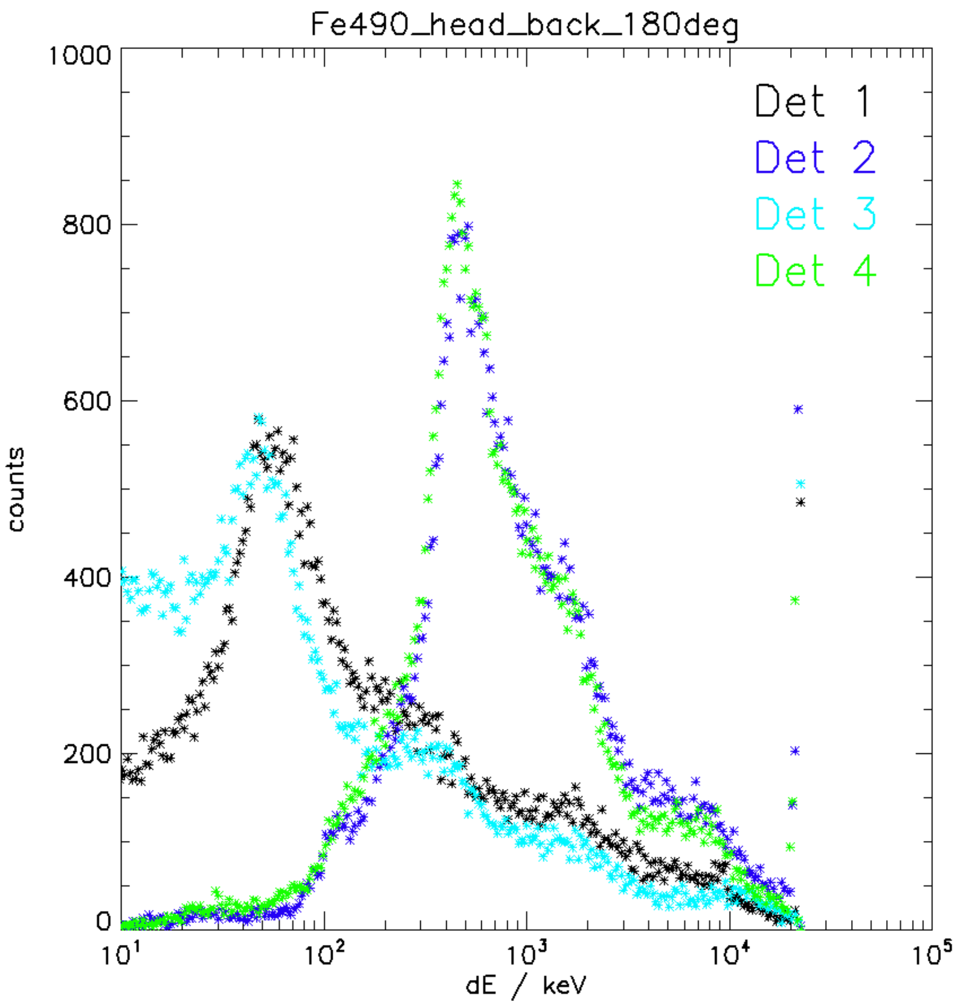
SSD detectors







SSD detectors



- Fe ions 490 MeV/nuc hitting the back of MTR phantom head

- Detector 2 and 4 were perpendicular to beam (direct hits in the silicon diodes + light from BC-430)

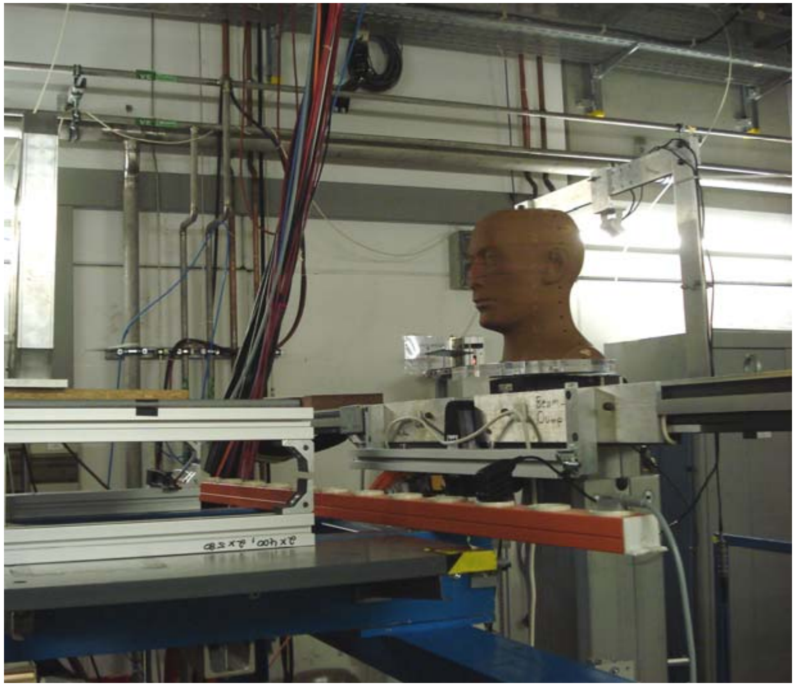
- Detector 1 and 3 were parallel to beam (only light from BC-430)

- All detectors show iron fragments

Gesellschaft für Schwerionenforschung, GSI, Darmstadt, Germany

ESA-IBER research project AO-08-IBER-12

- August 2009, Iron 1 GeV/u
- April 2010, Nickel 1 GeV/u



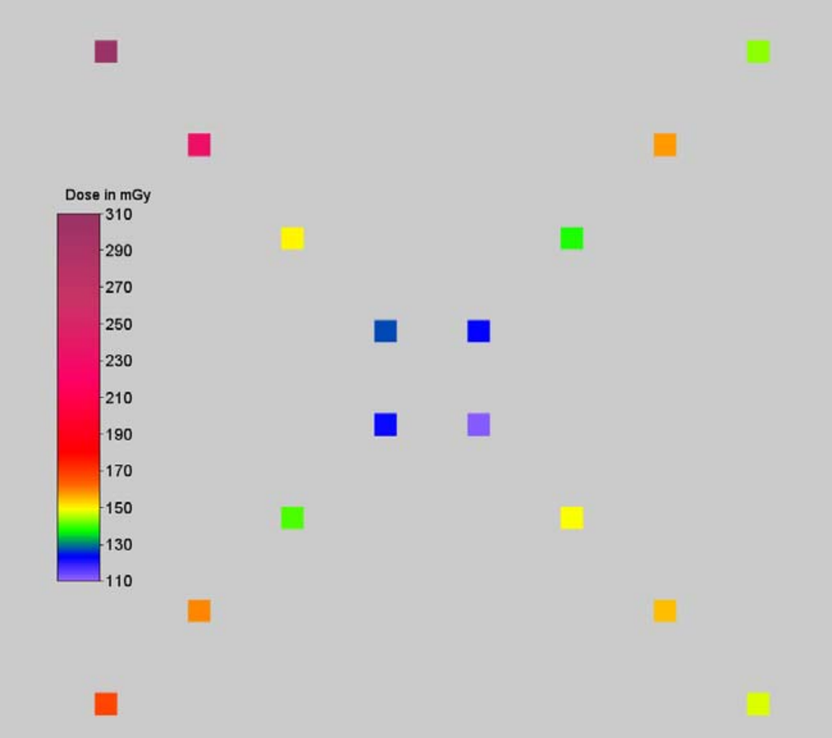
Problems:

- ➢ large deviations of results - between detectors
- ➢ large deviations of results - between irradiations
- ➢ efficiency results much too high comparing to previous experiments

April 2010

Ni 1GeV/nuc

10x10 cm field

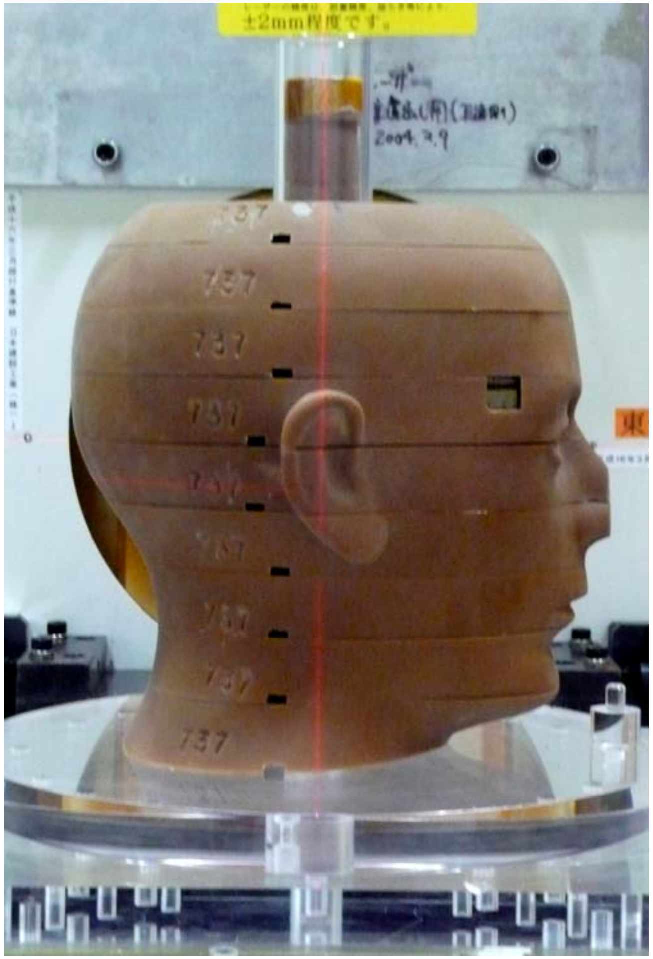


Result of the spot-scanning technique?

SUMMARY

- 6 irradiation campaigns at HIMAC and GSI (one more to come)
- 5 ion species used (He, C, Si, Fe, Ni)
- About 20 phantom head experiments
- About 40 calibration/intercomparison exposures

→ ***still a lot of data to be analyzed***



Thank you very much for your attention