EUROPEAN SYNCHROTRON RADIATION FACILITY

INSTALLATION EUROPEENNE DE RAYONNEMENT SYNCHROTRON

ESRF

Experiment Report Form

The double page inside this form is to be filled in by all users or groups of users who have had access to beam time for measurements at the ESRF.

Once completed, the report should be submitted electronically to the User Office using the **Electronic Report Submission Application:**

http://193.49.43.2:8080/smis/servlet/UserUtils?start

Reports supporting requests for additional beam time

Reports can now be submitted independently of new proposals – it is necessary simply to indicate the number of the report(s) supporting a new proposal on the proposal form.

The Review Committees reserve the right to reject new proposals from groups who have not reported on the use of beam time allocated previously.

Reports on experiments relating to long term projects

Proposers awarded beam time for a long term project are required to submit an interim report at the end of each year, irrespective of the number of shifts of beam time they have used.

Published papers

All users must give proper credit to ESRF staff members and proper mention to ESRF facilities which were essential for the results described in any ensuing publication. Further, they are obliged to send to the Joint ESRF/ ILL library the complete reference and the abstract of all papers appearing in print, and resulting from the use of the ESRF.

Should you wish to make more general comments on the experiment, please note them on the User Evaluation Form, and send both the Report and the Evaluation Form to the User Office.

Deadlines for submission of Experimental Reports

- 1st March for experiments carried out up until June of the previous year;
- 1st September for experiments carried out up until January of the same year.

Instructions for preparing your Report

- fill in a separate form for each project or series of measurements.
- type your report, in English.
- include the reference number of the proposal to which the report refers.
- make sure that the text, tables and figures fit into the space available.
- if your work is published or is in press, you may prefer to paste in the abstract, and add full reference details. If the abstract is in a language other than English, please include an English translation.

ESRF	**Experiment title:** *Di-chromatic angiography and fluorescence imaging, a new non-invasive diagnostic method and first application for dynamic measurements of cardiac function*	**Experiment number**:
Beamline:	**Date of experiment**: from: Nov. 2004 to: June 2005	**Date of report**: Sept. 2nd 2005
Shifts:	**Local contact(s)**: Dr. Herwig Requardt	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

B. Bertrand, J.F. Le Bas, CHU, Grenoble,
A. Bravin*, S. Fiedler*, Ch. Nemoz,
H. Ellaume, F. Esteve*, Unite IRM, Grenoble
M. Böhm, K. Walenta*, University Hospital, Homburg, Saar, Germany
R. Erbel, S. Möhlenkamp*, University Hospital, Essen, Germany
O. Kalthoff*, J. Mielebacher*, FH-Heilbronn, Germany
C. Venanzi*, Univ. Trieste, Italy
A.H. Walenta*, K. Nurdan*, A. Ching, M. Moisa, M. Costin, I. Balescu

Report prepared by A.H. Walenta, University of Siegen

Report:

In the second phase of the long term project progress has been achieved in the three main topics of the proposal which will be discussed separately.
In total 4 animals of 35 kg have been foreseen of which one developed serious irregularities and could not be used for measurements. The other 3 pigs were prepared with catheters and sensors and a test program has been carried out as summarized in table I.

Table I

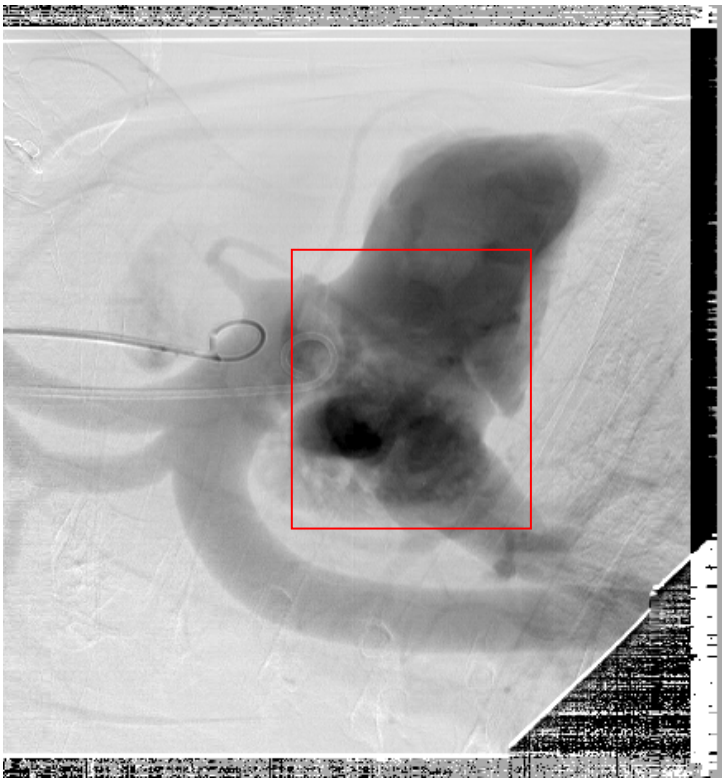
animal	scans	images	contrast m.	measurement	remarks
pig 1	5 IV	10 ..20	Magnevist	variable bolus,	study timing and contrast
	8 IA	16	Magnevist	variation of medication: atropine, nitroglycerine, dobutrex	study position of arteries, flow of bolus, perfusion
pig 2	-				
pig 3	3 IV interleafed with 4 IA	16	Gadobutrol	steady state	study of higher contrast
pig 4	9 IA interleaved with 3 IV	16	Gadobutrol Magnevist	steady state	study of image contrast

a. Development of a technique to achieve higher sensitivity with the non-invasive coronary angiography.

Calculations of the contrast obtained under ideal conditions using dichromatic subtraction imaging, show that for a typical human setting (25 cm of tissue, 2 cm bone) a depth resolution of 1.2 mm can be achieved for a skin dosis of 100 mSv (two exposures). This resolution only deteriorates very slowly behind a filled left ventricle. Therefore it is expected that a stenosis in all major vessels should detectable. On the other hand there are two major obstacles to overcome:

- the partially filled ventricle may exhibit some structure in the absorption picture which could be confused with the arteries
- the improves resolution of Gd requires a much higher relative intensity resolution which could be limited by beam instabilities .

In order to test the possible range of this concept, animal tests (pigs, 35 kg) have been imaged using intravenous injection of Gadobutrol and Magnevist. The beam instabilities have been corrected to a precision of about 0.5 10^{-3} using a newly developed position sensitive beam monitor including the software. The naked eye distinguishes already most structures (fig.1a) and the development of an algorithm for separating blood vessels from the irregular shaped background is able to locate the major vessels (Fig. 1b).



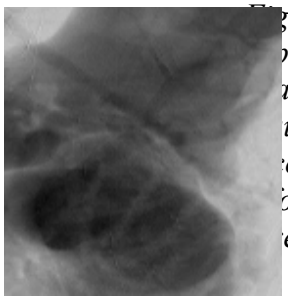


Fig. 1 (left) ROI showing superposed vessels over heart ventricle; (right) results of vessel reconstruction; no width information is shown (20 pixels clipped).

b. Imaging based on the detection of fluorescence radiation from the contrast medium.

This covers the measurement of the fluorescence radiation and the Compton background as well as the test of a new position sensitive detector with a multiwire read out. The challenge of such a measurement consists in the directional capture and imaging of fluorescence photons in a strong background of Compton scattered photons. The requirements can be summarized as follows:

- position resolution of 0.2 mm or better
- energy resolution of
- multi channel high rate read out of amplitude and position
- efficient detection of 42 keV x-rays

A number of measurements for optimizing the capture of the fluorescence radiation have been carried out. Fig 2 shows the position sensitive multi wire proportional chamber of the type Induction Drift Chamber (Xe –filled). In this type of chamber spectroscopic measurements and high position resolution are possible at the same time.

Fig. 3a shows the captured amplitude spectrum from a gadolinium containing sample and fig 3b shows the spectrum for the gadolinium containing sample in a water container adding Compton scattered background. The fluorescence peak still can be extracted. The position resolution has been measured to be smaller than $\Delta x = 200$ μm (up to now limited by beam collimation).

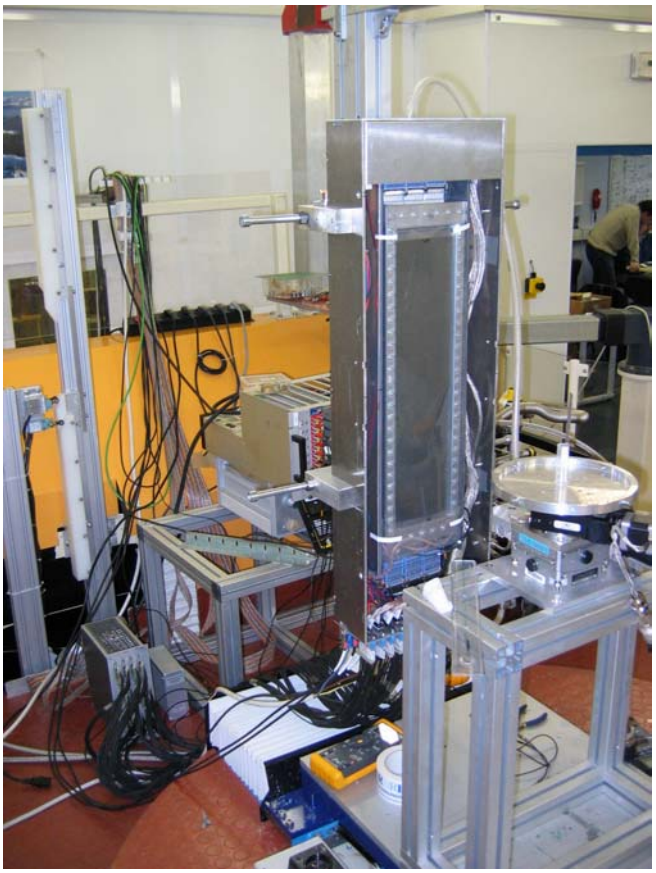


Fig. 2. X-ray area detector

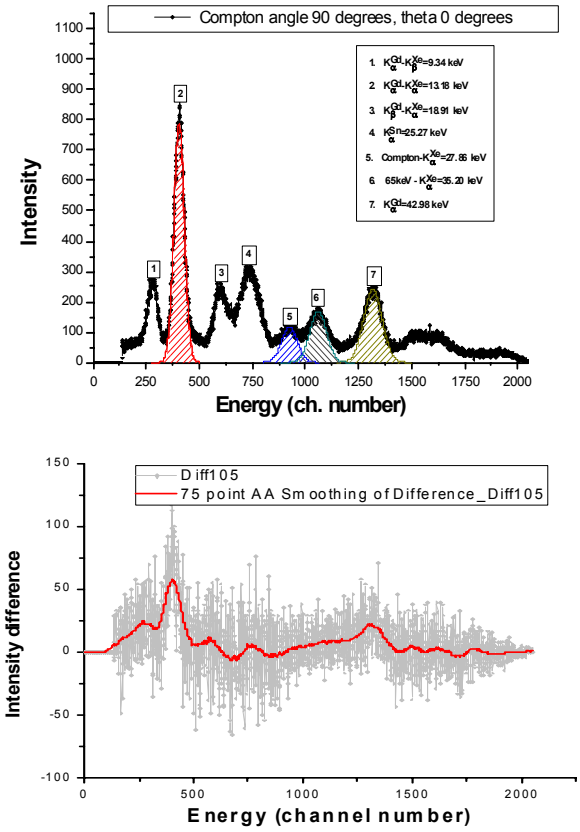


Fig. 3. Recorded spectrum. a) small Gd sample, b) with water scatterer

c. Investigate the underlying mechanism of perfusion and develop quantitative models.

Measurements with animals using different sequences for subtraction angiography (selective and minimal invasive) were successfully performed to demonstrate the feasibility of dynamic recording and yielded first results on model independent micro-circulation parameters. Fig. 4 shows images with the selective injection of contrast medium into the coronary arteries at different moments, one at the beginning when the conrast medium just appears in the myocard (a), and the other one at the end when the contrast medium flows back through the venes (b). The quality of the images is such that in a cross esectional imaging time sequences could be recorded with a time sclice resolution of 2 ms. The data are evaluated at the moment in order to compare them to the current flow models of cardiac circulation.

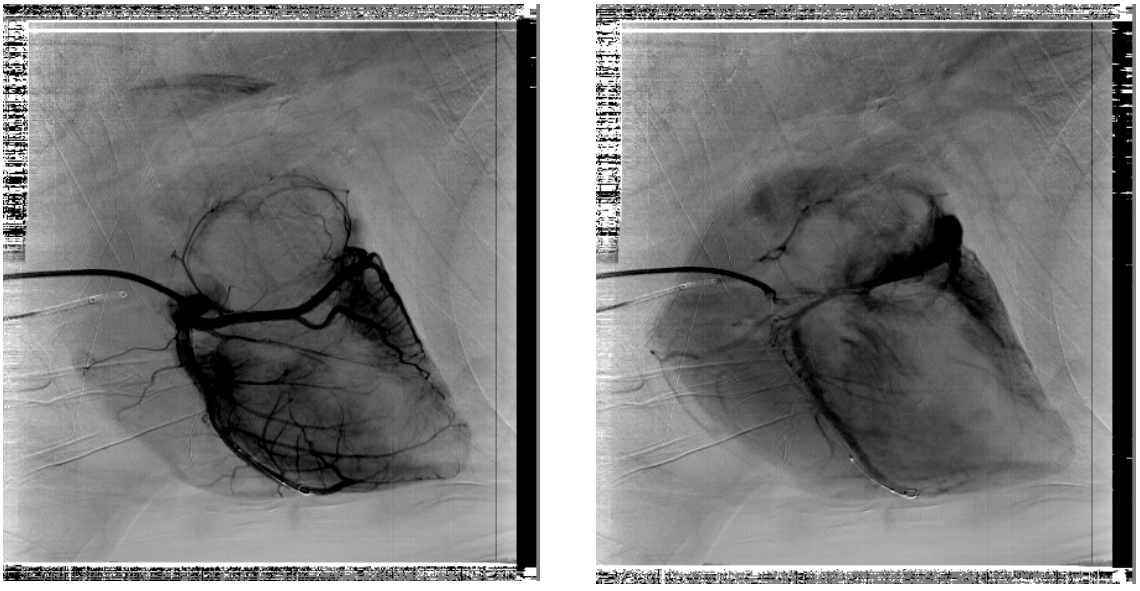


Fig. 4. Selective injection. a) phase of arterial inflow b) venous backflow