## TECHNICAL INFORMATION

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<td><strong>Total grant:</strong></td>
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<td><strong>Start date:</strong></td>
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<td><strong>Duration:</strong></td>
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<tr>
<td><strong>Co-ordinator:</strong></td>
<td>Prof. Dr. Dr. h.c. Manfred Thumm Forschungszentrum Karlsruhe, IHM Phone: +49 7247 82 2440, E-mail: <a href="mailto:manfred.thumm@ihm.fzk.de">manfred.thumm@ihm.fzk.de</a></td>
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<td><strong>Team information:</strong></td>
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<tr>
<td><strong>Team : FZK (Co-Ordinator)</strong></td>
<td>Prof. Manfred Thumm Forschungszentrum Karlsruhe, Institut fuer Hochleistungsimpuls- und Mikrowellentechnik, Karlsruhe, Germany, <a href="mailto:manfred.thumm@ihm.fzk.de">manfred.thumm@ihm.fzk.de</a></td>
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<tr>
<td><strong>Team : SPbSPU</strong></td>
<td>Prof. Gennadi Sominski St. Petersburg State Polytechnical University, Physical Electronics Department High-Current Electronics and Microwaves Laboratory, St. Petersburg, Russia, <a href="mailto:sominski@rphf.spbstu.ru">sominski@rphf.spbstu.ru</a></td>
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<td><strong>Team : IAP</strong></td>
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<tr>
<td><strong>Team : HUT</strong></td>
<td>PhD Olgierd Dumbrajs Helsinki University of Technology, Department of Technical Physics and Mathematics Laboratory of Advanced Energy Systems, Espoo, Finland, <a href="mailto:dumbrajs@csc.fi">dumbrajs@csc.fi</a></td>
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<td><strong>Team : PhTI</strong></td>
<td>Dr. Klara Poduschnikova A.F. Ioffe Physico-Technical Institute RAS, High Temperature Plasma Physics Laboratory, St. Petersburg, Russia, <a href="mailto:S.Fefelov@mail.ioffe.ru">S.Fefelov@mail.ioffe.ru</a></td>
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**Second periodic report due:** 28 February 2006  
**Submission date of this report:** 28 February 2006
1 RESEARCH

1.1. Introduction
Gyrotrons produce CW and long-pulsed mm-wave radiation with unmatched power level and, therefore, are extensively applied for plasma fusion electron cyclotron resonance heating and current drive and for materials processing. Recent improvements in gyrotron design and fabrication technologies resulted in substantial progress in the output parameters of such devices. But up to now the efficiency of these tubes typically does not exceed 40-50%, and needs to be further enhanced. The usual obstacle phenomenon for such an enhancement is a low-frequency oscillatory process (LFO) developing in the helical electron beam (HEB). In gyrotrons HEBs are used as the active medium for DC to RF energy conversion. These LFOs are caused by electron trapping between the cathode and the gyrotron resonator, were the beam is compressed by the increasing magnetic field. The contribution of LFOs to the electron energy spread provokes a reduction of the gyrotron efficiency. Another possible cause for energy spread growth and efficiency decrease can be associated with a spatial non-uniformity of the HEB, originating, for instance, from non-uniformity of cathode emission. These two factors are usually considered to have the strongest negative influence on the beam quality. Even presently, the available quantitative data on their effect are absolutely insufficient. So, acceptable methods for suppression or neutralization of such features have to be developed.

The present project includes studies of mechanisms of the influence of non-uniformity and LFOs of an annular electron beam on its quality and investigation of the ways of gyrotron efficiency enhancement through suppression of parasitic oscillations and reduction of the negative effect of beam non-uniformity. These principle objectives will be achieved as the result of theoretical and experimental investigations of the influence of these two factors on electron beam energy spread and on overall gyrotron efficiency.

Methods for the reduction of the negative effects from these parasitic phenomena will be developed. This work is expected to yield new scientifically valuable data on HEB space charge behavior and information on the ways for efficiency enhancement in high-power gyrotrons.

1.2. Research Objectives
The objectives of the proposed research project are:
- investigation of the influence of the configuration of the gyrotron helical electron beam (HEB) formation system on the excitation of space-charge low-frequency oscillations (LFO);
- determination of the influence of HEB azimuthal non-uniformity on the electron energy distribution and on LFO development in the beam;
- investigation of the influence of electron energy spread in HEB and of LFO on gyrotron efficiency;
- development of LFO suppression methods;
- estimation of HEB energy spread reduction and of gyrotron efficiency enhancement possibilities resulting from LFO suppression;
- investigation of the possibility for gyrotron efficiency enhancement by reducing the detrimental effect related to azimuthal electron beam non-uniformity;
- design and manufacturing of a gyrotron for operation at pitch-factor values higher than 1.5 and study of gyrotron efficiency enhancement prospects in operation of such devices in the absence of LFO.

In accordance with the Work Programme, the following Tasks (out of 12) were completely covered in the second period (out of 3)

Task 5: Output and LFO characteristics in high-power gyrotron with improved HEB formation system.

Task coordinator: Dr. Vladimir Zapevalov, IAP
Collaborator: Prof. Gennadi Sominski, SPbSPU
Task 6: Output and HEB characteristics of the medium-power gyrotron with improved formation system.

Task Coordinator: Prof. Gennadi Sominski, SPbSPU
Collaborators: Dr. Klara Podushnikova, PhTI
Dr. Vladimir Zapevalov, IAP

Task 7: Specifications for SPbSPU gyrotron modification needed for operation at pitch-factor values > 1.5.

Task Coordinator: Prof. Gennadi Sominski, SPbSPU
Collaborators: Prof. Manfred Thumm, FZK
Dr. Olgierd Dumbrajs, HUT
Dr. Vladimir Zapevalov, IAP

Task 8: Parasitic LFO in the modified coaxial cavity gyrotron.

Task Coordinator: Prof. Manfred Thumm; FZK
Collaborator: Dr. Olgierd Dumbrajs, HUT
Prof. Gennadi Sominski, SPbSPU
Dr. Vladimir Zapevalov, IAP

For the future we do not see any deviations from the Work Programme.

1.2 Scientific Results

Task 5: Output and LFO characteristics of the high-power gyrotron with improved HEB formation system.

Task coordinator: Dr. Vladimir Zapevalov: IAP

Objectives:
Measurement of output parameters and LFO characteristics in high-power (~ 1 MW) gyrotron of IAP with improved HEB formation system.

On this stage of work the IAP gyrotron modified in subtask 3.1 is used and the main activity was directed on the experimental study of the output and of space-charge low-frequency oscillations (LFO) characteristics of the high-power gyrotron with improved helical electron beam (HEB) formation system. The main goal of the subtask 3.1 was the finding of HEB formation conditions which impede (or even eliminate) the excitation of high magnitude LFOs and result in gyrotron efficiency enhancement. As a result of the activities 3.1 and 3.2 recommendations for modification of magnetron-injection guns in HEB formation systems aiming at minimization of dangerous LFOs and gyrotron efficiency enhancement were given. Designs of improved HEB formation systems for gyrotrons at IAP and SPbSPU were elaborated. Both the gyrotrons available at IAP and SPbSPU were equipped with improved versions of HEB formation systems.

For creating of powerful and high efficiency gyrotrons formation of high quality helical electron beams (HEB) with required parameters is one of the main problems. For example, in a 1 MW output power gyrotron with operating voltage U ≈ 80 kV and efficiency ≈ 35% or more, an electron beam with a current I ≈ 40 A and a pitch-factor α≈1.25 or higher (α= v⊥ / v , v⊥, v - oscillatory and longitudinal velocity in operating region) is required. All the powerful gyrotrons use the magnetron injection guns (diode and triode versions), which form a boundary or quasi-laminar helical beam. The configuration of the HEB formation system has fundamental influence on the excitation of low-frequency oscillations (LFOs) of the space charge in the region between the magnetron-injection electron gun and the magnetic mirror in front of the cavity (HEB formation and transportation subsystems). Possibilities for evaluation of the gyrotron efficiency reduction effect due to LFOs were under investigation in previous subtask.
In result of numerical simulation for operating modes of 1 MW IAP gyrotron, the shapes of gun electrodes were
optimized and the dependence of velocity spread $\delta v_{\perp}(I)$ and ratio of oscillatory energy to the total one- $t_{\perp}(I)$ on
the beam current was obtained. For this purposes numerical simulations of HEB characteristics based on the
advanced EPOS-V code were used taking into account the initial velocity distribution at the cathode. To increase
the precision of numerical simulations the existing EPOS code was enhanced for trajectory analysis on the
complete beam formation length. Such adaptation of the code also gives us the possibility to investigate numerically some influence of the eigen space charge voltage depression on HEB parameters.

The modernization of the high-power (~1 MW) gyrotron at IAP and the experimental set-up was produced. This
modernization includes improvement of the HEB formation system electrode configuration, introduction of an
additional coil in the gyrotron gun region for a fine adjustment of the magnetic field distribution at the
magnetron-injection gun section and some upgrading of the HEB diagnostic system.

For experimental study of HEB properties the method of retarding field was used. The measurements were
carried out for guns with accelerating voltage $U =80$ kV and average cathode radius $R_c=41.5$mm with high-
temperature lanthanum-hexaborid (LaB6) emitter in a scale down regime on an automated installation, as at
presence of influence electrons, locked in adiabatic trap between the cathode and magnetic mirror, and at
exception such electrons. The received dependencies $\delta v_{\perp}$ and $t_{\perp}$ are compared with results of numerical
simulation and good correlation was observed. Evolution of the electron distribution functions $f(v_{\perp})$ as the
beam current grows has been traced also. We try to make the tails of electron distribution functions $f(v_{\perp})$
smaller and so diminish the amount of electrons reflected from the magnetic mirror and provoke LFO
instabilities.

The experimental short-pulse 1 MW IAP gyrotron had been redesigned and all necessary parts were
manufactured. Short-pulse experiments were prepared and performed with pulse durations 0.05-0.1 ms on the
automation set-up and dependencies of gyrotron parameters on the beam current, accelerating voltage and
magnetic field were analyzed. Observations demonstrate that for an optimised HEB formation system in
comparison with the original one of starting conditions, LFO instabilities are moved to larger beam current and the
region of stable tube operation becomes broader. LFO instabilities lead to grows of velocity and energy spread in
the helical electron beam transmitted to the gyrotron cavity. As it is well known increasing HEB velocity spread
and especially energy spread provoke gyrotron efficiency reduction.

Results of measurements of the output power and efficiency depending on the electron beam current for the
experimental 1 MW gyrotron were received and compared with calculated data. Calculation and
experimental data are in a rather good agreement. The output power level 1 MW was achieved at the operating
mode in the design regime with an efficiency exceeding 40% with optimized (improved) HEB formation
system. For previous HEB formation system a typical efficiency value was 30-35% for poor and high quality
emitter respectively. Results of experiments demonstrate the importance of the emitter property for
achievement of a high efficiency of gyrotron and reproducibility of experimental data. So the technology for
reliable fabrication and test of the high quality emitters for gyrotron gun have to be developed. The maximum
output power near 1.3 MW was achieved at the operating mode with improved HEB formation system.

So advantages of the improved gyrotron system in comparison with the ordinary original system are clear from
experimental results.

**Task 6: Output and HEB characteristics of the medium-power gyrotron with improved formation system.**
Task coordinator: Prof. Gennadi Sominski, SPbSPU

**Objectives :**
Measurement of output parameters and LFO characteristics and electron energy distributions in the medium-
power (~ 70 kW) gyrotron at SPbSPU with improved formation system.

In gyrotrons, the excitation of parasitic low-frequency oscillations (LFOs) is caused by the reflection of electrons
from the magnetic mirror in the beam compression region. At a fixed pitch-factor value, the reduction of electron
reflection can be resulted from the modification of the electron velocity distribution function by decreasing the
amount of electrons with largest transverse velocity.
According to the calculations performed by the IAP team, the required modification of the distribution function can be achieved as a result of increase of cathode inclination angle to the axis in the region immediately adjacent to the emitting strip from the outer side (larger radii and further from the resonator). It was expected that such improvement of cathode geometry will result in the suppression of parasitic LFOs. The influence of the electric field distribution in the gun region on LFOs was studied experimentally with a medium-power 4-mm gyrotron at SPbSPU. The measurements were made with the standard and improved geometries of the cathode system. In the first case, the inclination angle to the axis was equal to 35° all along the conical part of the cathode. In the improved cathode system, this angle was increased up to 50° for the region above the emitter strip.

The cathode systems of both geometries were equipped with the emitters differing in emission non-uniformity. This gave us the additional experimental data on the influence of cathode emission uniformity on HEB characteristics and gyrotron output parameters. The measurements were performed with three LaB$_6$ cathodes and two impregnated W-Ba cathodes. The relative spreads of emission current density $\delta_j$ determined as root-mean-square values were in the range from 13% to 75% for these cathodes. The comparison of the data from different cathodes shows that the decrease of emission uniformity causes a reduction of gyrotron output power and efficiency as well as a decrease of threshold pitch-factor $\alpha_{\text{thr}}$ corresponding to LFOs appearance. Measured values of $\delta_{\text{thr}}$ were used for estimation of the velocity spread resulting from cathode emission non-uniformity.

In the case of the standard cathode system, the maximum values of gyrotron efficiency (32%) and threshold pitch-factor (1.31) were achieved for the LaB$_6$ emitter with emission non-uniformity $\delta_j = 20\%$. Further increase of emission uniformity did not influence either the gyrotron efficiency or the threshold pitch-factor.

It was observed that the replacement of the standard cathode system by the improved one was accompanied by a significant decrease of the LFOs amplitude and an increase of the pitch-factor $\alpha_{\text{thr}}$. In the case of the LaB$_6$ emitter with $\delta_j = 30\%$ installed in the improved cathode system, the parasitic LFOs appeared at $\alpha_{\text{thr}} \approx 1.4$. The values of the gyrotron efficiency measured in the improved cathode system were 2 – 3 % smaller than those in the standard cathode system with an emitter having the same emission uniformity. At that, this minor reduction of gyrotron efficiency was able to be compensated by the varying of magnetic field in the cathode region. Thus, the data obtained confirm experimentally the expediency of the improved cathode system for LFOs suppression.

For further decrease of LFOs amplitude and for the broadening of the zone of stable gyrotron operation toward high pitch-factor regimes, we studied the possibility of the combined effect of two methods for suppressing parasitic oscillations: (1) by modifying the cathode geometry and (2) by varying the magnetic field distribution in the beam compression region. Numerical simulation with the PIC code GyroTrap gave us an optimized magnetic field distribution for which the development of space-charge instability in the gyrotron trap was impeded. Realization of this optimized distribution in the gyrotron with the improved cathode system allowed to increase the threshold pitch-factor of LFOs appearance up to $\approx 1.6$.

Thus, the optimization of electric and magnetic field distributions in the beam formation region led to achieve stable gyrotron operation in the absence of parasitic LFOs at pitch-factor values higher than 1.5 even for a cathode with no highest emission uniformity ($\delta_j = 30\%$).

The members of the PhTI team were involved in the discussion of the experimental results and also in the design and manufacturing of the appliances which were needed for successful fulfillment of the investigations at SPbSPU. At this stage of the project, the following works were done by the PhTI team:

1. A new digital device was designed for automated operation of the power supply for the gyrotron pulse magnetic system. This device allows to measure magnetic field magnitude with high accuracy and to control charging of the capacitor battery in dependence on temperature variation of solenoid parameters during gyrotron operation. This device will be put into gyrotron experiments in the first quarter of 2006.

2. A vacuum chamber with an evacuation system was designed and manufactured. This chamber is planned to be used as a part of a high vacuum stand for measurement of azimuthal non-uniformities of temperature and emission current density of gyrotron cathodes differing in their configuration, dimension and coating.

An advanced cathode system of the SpbSPU gyrotron was designed jointly with the IAP team.

**Task 7: Specifications for SPbSPU gyrotron modification needed for operation at pitch-factor values $>$ 1.5.**

Task coordinator: Prof. Gennadi Sominski, SPbSPU

The new experimental and theoretical data, which were obtained by the SPbSPU team under the Task 6, give an evidence of possible effective operation of the gyrotron at high pitch-factor ($> 1.5$) in the conditions of suppressed parasitic LFOs. The high Q-factor microwave cavity of the gyrotron will have to be replaced in order
to provide gyrotron operation at high pitch-factor values. A new modified microwave cavity for the operation of the SPbSPU gyrotron at a pitch-factor of 1.6 has been designed by the IAP team in collaboration with the SPbSPU, FZK and HUT teams.

The increase of the pitch-factor from 1.28 (for the previous version of the cavity) to 1.6 allows to increase the beam energy related to the transverse motion of electrons and, therefore, to enhance the gyrotron efficiency that is the key objective of the investigations under this project.

**Task 8: Parasitic LFO in the modified coaxial cavity gyrotron.**

*Task coordinator: Prof. Manfred Thumm, FZK*

**Objectives:**
Investigation of parasitic LFO in the modified coaxial cavity gyrotron and study of the mechanism responsible for the occurrence of those LFO.

When starting the operation of the 170 GHz coaxial-cavity gyrotron strong parasitic low frequency (LF) oscillations have been observed at beam currents $I_b \geq 10$ A and accelerating voltages $U_a > \sim 35$ kV. The amplitude of these oscillations could become very large making a reliable gyrotron operation nearly impossible. With increasing value of $U_a$ first the most intensive LF oscillation at about 260 MHz occurred followed by an LF oscillation at $\sim 328$ MHz from $U_a \sim 55$ kV on. In the intermediate range a mixing frequency has been observed at $\sim 68$ MHz. The appearance of those LF oscillations was unexpected, in particular because they did not appear in the previous 165 GHz coaxial-cavity gyrotron in which the geometrical dimensions (relevant for the wavelength of the LF frequencies) are practically the same. In addition, the external assembly including the cabling has not been modified either. Intensive discussions on various possible reasons for these LFOs were done with the collaborators at HUT, SPbSPU and IAP.

Finally the LF oscillations have been suppressed by installing around the insert in the bottom part of the gyrotron a grounded metal cylinder lined inside with absorbing material ("ECCOSORB").

In numerical simulations with the 3-dimensional "CST Microwave Studio" code, the LF oscillating characteristic of the gyrotron arrangement has been investigated. As input for the code the geometry of the gyrotron including the warm bore of the superconducting magnet has been modeled in great detail. The results of the numerical modeling have shown resonances at frequencies in good agreement with the experimentally observed LF oscillations. The field of the LF oscillations as obtained from the calculations is concentrated around the coaxial insert and in the region between the cathode and anode.

Based on the results the mechanism of excitation of the LF oscillations is considered to be as follows: the electric LF field near the cathode is modulating the velocity ratio $\alpha$, the axial velocity $\beta_z$ and the transit time $t_{tr}$ of the electron beam. This velocity modulation results in a bunching of the beam. In an interaction of the bunched beam with an axial component of the LF field around an aperture on the cathode side of the cavity, energy is transferred from the electron beam to the LF oscillation. The axial component of the LF field is enhanced due to some radial steps in the geometry of the insert. An experimental prove of this hypothesis is under preparation.

**LIST OF COMMON PUBLICATIONS**

**Articles in International Journals**


Articles in Conference Proceedings


Samsonov, D.B.: Experimental study of the influence of cathode emission inhomogeneity on helical electron beam characteristics and output parameters of a 4-mm gyrotron, M. Sc. thesis, SPbSPU, St.-Petersburg, 2005, 68 p [in Russian].

Jin, J.B.: Advanced trippled wall mode converter for a coaxial cavity gyrotron, PhD thesis, South West Jiaotong University, Chengdu, China, 2006, 98 p [in English].

#### Ref. No 03-51-3861

**1.3. Impact and Applications**

Gyrotron oscillators are mainly used as high power millimeter wave sources for electron cyclotron resonance heating (ECRH), electron cyclotron current drive (ECCD), stability control and diagnostics of magnetically confined plasmas for generation of energy by controlled thermonuclear fusion. Operation at the 1st and the 2nd harmonic of the EC frequency enables gyrotrons to act as medium power step-tunable mm- and sub-mm wave sources in the frequency range from 38 GHz (fundamental) to 889 GHz (2nd harmonic) for plasma diagnostics, EC plasma discharges for generation of multi-charged ions, high-frequency broadband electron paramagnetic resonance (EPR) spectroscopy and medical applications. Gyrotrons have also been successfully used in materials processing. Future applications which await the development of novel high-power gyro-amplifiers include high
resolution radar ranging and imaging in atmospheric and planetary science as well as deep-space and specialized satellite communications and RF drivers for next-generation high-gradient linear accelerators (supercolliders).

After successful achievement of the project objectives, the following results will have most significant potential for application:

- effective methods of suppression of parasitic low-frequency space-charge oscillations in gyrotrons;
- calculation techniques for evaluation of influence of non-uniform electric and magnetic fields on HEB characteristics;
- improvement of experimental techniques for diagnostics of spatial, energy and oscillatory characteristics in HEB.

Methods of gyrotron efficiency enhancement based on the actions (measures) listed above will reduce their costs and thus the costs of above mentioned applications.

During the project period, most important results of the studies are applied to gyrotron R&D and design practice in FZK, IAP / GYCOM Ltd (Russia) and THALES ED (Europe). For dissemination of this information, most interesting of the project results are being published in refereed journals and reported at representative international scientific conferences. Intellectual property rights for some of original methods and design solutions will possibly be protected with patents.

The received experience was used to optimize an electron gun for design of 17.5 GHz and 28 GHz GYCOM/IAP gyrotrons with output power 0.5-1 MW, for development and improvement of double/multi-frequency 1 MW GYCOM/IAP gyrotron (collaboration with FZK, Karlsruhe) for ASDEX-Upgrade tokamak (IPP, Garching) and elaboration of a 300 GHz/4 kW/CW GYCOM/IAP gyrotron for Research Center for Development or Far Infrared Region, University of Fukui, (Fukui, Japan). The 300 GHz/4 kW/CW gyrotron will be used with a 12T LiHe-free superconducting magnet.

2 PROJECT MANAGEMENT

2.1 Meetings and Visits

The management of the project has been undertaken by Prof. M. Thumm & Dr. B. Piosczyk liaising with the group leaders Dr. O. Dumbrajs (Helsinki Univ. of Technology), Prof. G. Sominski (SPbSPU), Dr. V. Zapevalov (IAP/RAS) and Dr. K. Poduschnikova (PhTI), and their deputies. Electronic e-mail communication between the five groups listed has been used to discuss policy matters, assess progress and achievements, ensure the programme is adequately executed and to co-ordinate the activities.

The five team leaders are managing the human resources of their respective groups, help to identify areas where bi-lateral visits are needed, assist in collaborations and exchange visits and organise the activities of the postgraduate researchers. Organizational meetings were held during 2005 and early 2006 at the following Conferences:

(1) 6th International Vacuum Electronics Conference IVEC 2005, April 20 – 22, 2005 Noordwijk, The Netherlands
Discussion of Tasks 5, 6 and 8
Participants: FZK: Prof. Thumm, Dr. Dammertz, MSc Jin, Dipl.-Ing. Rzesnicki, Dr. Yang
IAP: Prof. Litvak, Dr. Zapevalov, Dr. Denisov

(2) 7th Workshop on High Energy Density and High Power RF, June 13-17, 2005, Kalamata, Greece
Discussion of Tasks 6, 7 and 8
Participants: FZK: Prof. Thumm
SPbSPU: Prof. Sominski
(3) 6th International Workshop on Strong microwaves in plasmas, July 24 – August 1, 2005, Nizhny Novgorod – St. Petersburg, Russia
Discussion of Tasks 5, 6, 7 and 8
Participants: FZK: Prof. Thumm, Dr. Piosczyk, SPbSPU: Prof. Sominski, Dr. Louksha (also representing PhTI)
IAP: Dr. Zapevalov, Dr. Kufin, Mr. Zavolsky
HUT: Dr. Dumbrajs
After this Conference, Prof. Thumm and Dr. Piosczyk stayed for 2 days at SPbSPU.

(4) 13th Winter School on Microwaves Electronics and Radiophysics, January 31 - February 5, 2006, Saratov Russia
Discussion of Tasks 5, 6 and 7
Participants: SPbSPU: Prof. Sominski,
HUT: Dr. Dumbrajs
IAP: Dr. Zapevalov, Prof. Manuilov,

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2.2 Collaboration
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2.3 Time Schedule
Up to now, the time schedule has been fully in accordance with the Work Programme and we do not see any deviations from the Work Programme for the future.
2.4 Problems Encountered

Up to now no problems have been encountered.

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2.5 Actions Required

At present, no action from INTAS is required.

3 FINANCIAL INFORMATION – PROPER EXPENDITURE OF THE PROJECT – DEVIATION FROM THE FINANCIAL PLANNING

3.1 Finances

The contributing members of the 5 teams were exactly the research scientists listed in the Co-operation Agreement.

However, since Dr. V.K. Lygin died on 27 Jan 2005, Dr. V.N. Manuilov replaced his position in the IAP-Team (see Payment Requests for 2005).

The individual grants to participants from the NIS teams and the expended funds for labour costs, equipment, consumables, travel subsistence and overhead of all 5 teams were also in accordance with the Co-operation Agreement.

The only major deviation from the breakdown of costs was for PhTI, because the team of Dr. Pudushnikova used only 500 EUR (as a part of the planned sum of 860 EUR, see Finances Report of first period) during the second period of the project. The saved amount of 360 EUR of the PhTI travel budget will be used in the travel budget of PhTI in the third period.

The travel budget was expended in the following way:

FZK: Prof. Thumm and Dr. Piosczyk, Karlsruhe – Nizhny Novgorod – St. Petersburg, Russia, July 24 – August 3, 2005

SPbSPu: Prof. Sominski, St. Petersburg – Kalamata, Greece, June 13-17, 2005 and Saratov, Russia, January 31 – February 5, 2006.

Prof. Sominski and Dr. Louksha, St. Petersburg – Nizhniy Novgorod, Russia, July 31 – August 1, 2005.

IAP: Dr. Zapevalov, Nizhny Novgorod – Noordwijk, The Netherlands, 20 - 22 April 2005
Dr. Zapevalov, Nizhny Novgorod – Saint Petersburg, Russia, July 25 – August 1, 2005
Dr. Zapevalov, Dr. Manuilov, Nizhny Novgorod – Saratov, January 29 – February 6

HUT: Dr. Dumbrajs, Helsinki – Saratov, Russia, January 29 – February 6

PhTI: Dr. Podushnikova, St. Petersburg – Nizhny Novgorod (IAP RAS), Russia, January 15-22, 2006.
## Contractor Summary Cost Statement

<table>
<thead>
<tr>
<th>Contractor</th>
<th>Labour/Individual Grants</th>
<th>Overheads</th>
<th>Travel and Subsistence</th>
<th>Equipment</th>
<th>Consumables</th>
<th>Other Costs</th>
<th>TOTAL (Euro)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FZK</td>
<td>6,183</td>
<td>650</td>
<td>1,681</td>
<td>-</td>
<td>456</td>
<td>-</td>
<td>8,970</td>
</tr>
<tr>
<td>SPbSPU</td>
<td>13,130</td>
<td>820</td>
<td>1,000</td>
<td>750</td>
<td>700</td>
<td>-</td>
<td>16,400</td>
</tr>
<tr>
<td>IAP</td>
<td>12,780</td>
<td>819</td>
<td>1,200</td>
<td>1,000</td>
<td>800</td>
<td>-</td>
<td>16,599</td>
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<tr>
<td>HUT</td>
<td>3,120</td>
<td>300</td>
<td>1,000</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>4,510</td>
</tr>
<tr>
<td>PhTI</td>
<td>7,040</td>
<td>410</td>
<td>500</td>
<td>-</td>
<td>800</td>
<td>-</td>
<td>8,750</td>
</tr>
<tr>
<td>TOTAL</td>
<td>42,253</td>
<td>2,999</td>
<td>5,471</td>
<td>1,750</td>
<td>2,756</td>
<td>-</td>
<td>55,229</td>
</tr>
</tbody>
</table>

1) Costs for liquid helium of the superconducting gyrotron magnet at FZK.
2) Equipment including PC and Scope.
3) Consumables include spare parts for computer repair and upgrade, materials, spare parts, liquid nitrogen and tools.
4) Equipment includes computer hard and software, mechanical and electrical tools.

### 3.2 Other funding

This project did not receive substantial funding from other sources than INTAS.

#### Coordinator’s Certificate

I hereby certify that the above costs to my best knowledge are true and honest, have been incurred and fall within the definition of allowable costs as specified in Articles 11, 12 and 13 of the General Conditions to the Cooperation Agreement and were necessary for the execution of the project. The above Summary Cost Statement has been compiled based on each of the Contractor’s Cost Statements submitted to me which are available for audit.

Name of the Co-ordinator: Prof. Manfred Thumm

Date and original signature of the Co-ordinator: 28. February 2006