Early [2] the HD-gas was generated in the reaction of metal hydrides $LiAlH_4$ with heavy water:

$$LiAlH_4 + 4D_2O \rightarrow LiAl(OD)_4 + 4HD$$

The $LiAlH_4$ was suspended in an hydrous tetrahydrofuran and at about 0°C, D_2O was slowly added and HD evolved. One of the problem of this method was sensitivity to any admixtures of Li which also involved in reaction $Li+2D_2O \rightarrow 2Li(OD) + D_2$ with generation of D_2-admixture. Another problem was a high level of impurities in HD-sample – near 200 ppm. In our method instead of using heavy water we used reaction of normal water with deuterated hydrides: $LiD + H_2O \rightarrow LiOH + HD$. In this case the any amount of metallic Li or LiH will give only H_2 as background that will not influence on the determination of the $\lambda_{dd\mu}$-formation rate on HD-molecules: $LiH + H_2O \rightarrow LiOH + H_2$. The technological layout of HD-gas production is presented on Fig.1. The HD-gas after purification in LN_2-traps are stored in vessels (6–8) and then go to a special compression system with cooling by liquid helium. We reached the following parameters of HD-mixture: HD(94,1%) + D_2(1,3%) + H_2(4,6%) (Fig.2). The chromatography analysis has indicated a very small level of impurities: $N_2 = 0,5$ ppm, $O_2 = 5 \cdot 10^{-2}$ ppm, $H_2O = 1,5$ ppm. The long time testing of the stability of HD-gas in the IC showed that during one month the level of D_2 background increased no more than on 0,6%. Thus, our new setup will permit to us investigate $dd\mu$-catalysis on almost pure HD-molecules [3].

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PERSPECTIVES OF THE RADIOPHOTOLUMINESCENT (RPL) METHOD APPLICATION TO CLINICAL MEDICINE

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In this report we present the technique to measure the depth dose fields, based on the RPL-method. The principle of the RPL process lies in the fact that, there are some materials (silver- activated metaphosphat glasses for instance), in which stable luminescent centers or dose centers (DC) are produced under irradiation. DCs are complicated configurations with Ag_2^+ and Ag_3^{2+} as the basis. The readout information is realized by UV light activation of DCs (the wavelength range is 300 – 350 nm) and by registration of the luminescent photon (life time of the exitated state is about 3–4 μs, maximum of the emitting spectrum at the 650 nm). The RPL-method allows the multiple dose readout without any dose information missing. The dose information can be rubbed off only after annealing RPL glasses at the

temperature 350 - 380 C°. Another feature of the RPL-method is connected with the very low fading (less than 1% per a year).

The existence of the background centers (BC) in the RPL glasses defines the lower sensitivity limit of the RPL-method. The BC nature is not very clear, but it is known that the number of the BCs is independent on the dose but only on the purity of the glass. The progress in UV lasers techniques and in lownoise photomultipliers, working in a single electron regime, allowed to decrease the lower limit of measured doses and to make the RPL method more effective. In 1988-1990 independently and practically simultaneously the two devices were created. They are FGD-10 (Japan, TOSHIBA) and KID RPL-2 (Russia, PNPI) to guarantee the lower level of measurements from 0.003-0.010 sGr. The KID RPL-2 was used with glasses, destined to individual gamma-irradiation dosimetry, developed in GOI, St.Petersburg, Russia. The principles of the KID RPL-2 device are presented below. The nitric laser ALM-2 (power about 0.5 mvt, frequency : 100-200 1/s and pulse's width : 10 ns) is used as the source of the UV light. The size of the spot of the laser's flash is no more then 1.5–2 mm. The part of intensity of the laser's pulse due to a plane-parallel quartz plate, placed under 45 degrees to laser beam, is deflected to the monitor PM, working in a linear regime. The amplitude of the signal from the monitor PM is proportional to the intensity of the laser pulse (Nm) and simultaneously the monitor signal is used as the start for the measurement of DC and BC. The photons of luminescence are detected by the counting PM, working in the single electron regime. Measurements are carried out in two time gates: counting (CG) and background (BG) gates. The widths of them are $\Delta t_c = 1$ μs and $\Delta t_b = 10$ μs correspondingly , the delays from laser's flash time are $t_c = 0.5$ μs and $t_b = 40$ μs. Since the precise knowledge of the background from BC is essential only near the threshold dose, so for doses less then 10R the followed method is used to separate the real dose from the background. The count in BG ($Nb1$) concerns only to the luminescence of BC and the count in CG (Nc) is the sum of BC's ($Nb2$) and DC's (Nd) luminescence $Nc = Nd + Nb2$. Since the form of the background spectrum is constant for the given tipe of the glass , then there is a possibility to recount the background from BG to CG and to select the real dose. If $Nb2/Nb1 = const = Kb$, then the dose is determined as

$$D = Kd \cdot (Nc - Kb \cdot Nb1)/Nm$$

where Kd and Kb are determed from calibrating on glasses, with the known background and irradiated by the known dose. To avoid overloading and to provide a possibility of dose measurements in the wide range without rebuilding the device, measurements are carried out not in one but in several counting gates. Delays and widths of gates choose from the requirement of equality of background's count in every count gate.

In principle, from the reason of statistic accuracy and possible overloading, the KID RPL-2 can measure the doses in limits from 10^{-4} R to 10^6 R. In the reality the range of measurements lies in limits from $3 \cdot 10^{-3}$ R to 10^4 R. The lower limit is determined by the number of BC in RPL glasses and the upper limit is determined by the radiation resistance of the glass (it turns yellow). The device has the mikro- processor, which allows to guaranty autonomic dose measurements during the time less then 10 s, the KID RPL-2 has output to PC.

KID RPL-2 was tested on glasses, destined for the individual dosimetry of gamma-irradiation. For this purposes were used the glasses 12 mm $\times$ 12 mm. The laser's beam was fixed in the center of the plane 12 mm $\times$ 12 mm.

To measure the depth dose fields, used for irradiation of the head pathologic centers during the biaxial rotation on the medical proton beam of PNPI's 1 GeV synhrocyclotron, the special RPL glass was prepared. It was 80 × 50×1 mm in size and was installed on a two-dimensional moving system (error of coordinate determination is 0.2 mm). The laser's beam was collimated to the size x= 1 mm, y= 1 mm.

To calibrate the system, the RPL glass was irradiated by the doses 100Gr, 10Gr, 2Gr at the medical beam of PNPI's synhrocyclotron (diameter of the beam 6mm).The measurements showed the right ratio between brought doses (error 10%) and gave the diameter of the beam 6 mm.

To test of the gomogenity of glass properties, the RPL plate was irradiated with the dose equal to 100R of a gomogenical gamma field. The gomogenity of the measured dose throughout the surface of the glass keeps constant within 6% error.

The irradiation of the glass in the standart head phantom at the PNPI's system of the proton stereotacsic therapy was the final test. Measurements of the dose field were made at 200 points on the RPL plate with the 2 mm step, the measurement's time at every point was about 1 min. The measured depth dose field is presented on Fig. Measured widths at the half of the distribution height was x=6 mm and y=11 mm. The form of the dose distribution obtained by the RPL-method coincides to the measurements done by the thermoluminescent technique.

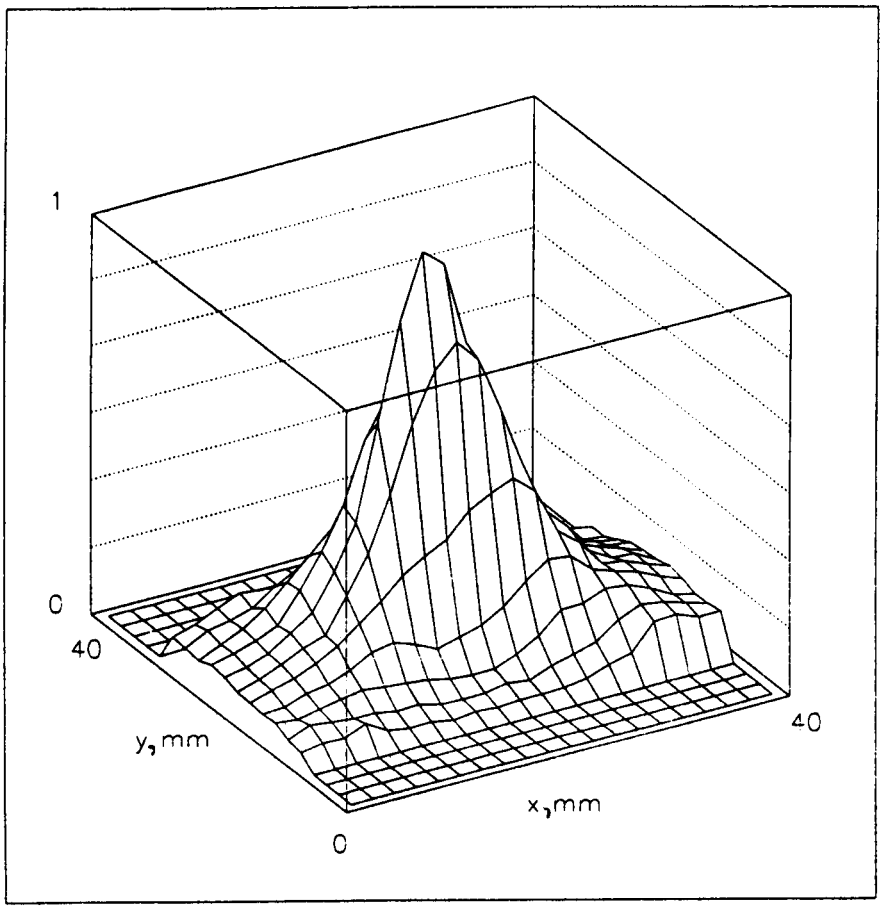

Fig. The depth dose field, measured by the RPL-metode

Results of our measurements appear encouraging and we'll continue our experiments in this field.

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THE STEREOTACTIC PROTON THERAPY AT THE 1 GeV PNPI SINCHROCYCLOTRON

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During 1994-1995 the stereotactic ptoton therapy was continued. Data on the treatment are given in Tables 1–3.

Table 1

Experience of stereotactic proton therapy at the synchrocyclotron of PNPI in 1994-1995

	Hypophysectomy		
Total number of patients	Normal pituitary	Pituitary adenomas	Arterio-venous malformations
107(39)	17	27	63(39)

In brackets the number of repeated treatments are given.

Table 2

Experience of normal pituitary

Total number of patients	Cancer of the breast	Ophthalmo-pathy	Diabetic angio-retionopathy	Concer of prostatic
17	4	–	–	13