DEVELOPMENT OF MINIATURE “BARC $^{125}$I OCU-PROSTA SEEDS” FOR THE TREATMENT OF EYE AND PROSTATE CANCERS

Radiopharmaceuticals Division
A. Shanta
Radiological Physics & Advisory Division
B.G. Avhad
Isotope Applications Division
and
G.L. Goswami
Laser Processing & Advanced Welding Section

Introduction

Interstitial brachytherapy using $^{125}$I sources for the treatment of eye and prostate cancer is fast emerging as a radiation therapy modality. Radioisotopes emitting low energy ionizing radiations are preferred to treat these types of cancers. On account of the suitable radiation characteristics such as low energy X-rays and γ rays, and a long half-life of around sixty days, $^{125}$I is the most common choice among the other available radioisotopes for this modality of treatment.

The Radiopharmaceuticals Division upon the request of Sankara Nethralaya, Chennai, one of the leading eye hospitals of our country, took up the development of...
the radiation sources for ophthalmic plaque therapy. Using the sources developed by the Radiopharmaceuticals Division, Sankara Nethralaya has started the treatment of retinoblastoma (a type of eye cancer mostly found in infants) and other types of choroidal and ocular melanomas. This article gives an account of the development of the sources which involved very high challenges with respect to source preparation, development of the capsules, laser welding the sources to meet the stringent safety parameters and qualification of the sources for human application, etc. Several Divisions of BARC (Laser Processing and Advanced Welding Section, Centre for Design and Manufacture, Isotope Applications Division, Radiometallurgy Division, Radiological Physics and Advisory Division) as well as external agencies like Atomic Energy Regulatory Board and Hindustan Machine Tools Ltd., Bangalore, contributed in this development.

Historical Perspective

It is well known that tumor tissues as well as normal tissues both respond to irradiation from a radiation source, and when the tissues are exposed to ionizing radiation the cells are killed. Hence, a significant decay of the cancerous cells can be achieved in case of malignant diseases by exposing them to radiation. However, it is of utmost importance that the tumoricidal effect (i.e. the killing of cancerous cells) obtained from a radiation source should not be at the expense of normal tissues. Generally, teletherapy (external beam therapy) and brachytherapy (wherein the source lies in the close proximity of tumor) are adapted as the modes of radiotherapy for treating the malignant tumors. In this perspective, brachytherapy has a distinct advantage over external beam therapy. External beam therapy mostly uses the ionizing sources of high energy and intensity such as those of $^{60}$Co, $^{192}$Ir, etc. and only deep-seated tumors can be treated more effectively without causing much damage to healthy tissues, whereas, in case of brachytherapy, the ionizing source could be of low energy and low intensity as the source lies very close to the tumor site and the required radiation dose could be easily delivered to the effected lesion without any undue exposure to the nearby healthy tissues. In fact, one of the oldest modalities used in the treatment of prostate cancer was brachytherapy using a naturally occurring radionuclide $^{226}$Ra, but owing to the side effects it caused on other organs, it was not much popular and subsequently it was totally discontinued. The technological advancement in the production and isolation of low energy radionuclides such as $^{103}$Pd, $^{125}$I, $^{106}$Ru, etc., the preparation of miniature sources using these radionuclides and the development of easy techniques for implanting these sources (seeds) using ultrasonography, together with advances in dosimetric studies using latest software, led to the commercial exploitation of these sources in the low dose rate (LDR) brachytherapy of malignant tumors.

Radiotherapeutic Management of Eye and Prostate Cancer

Retinoblastoma is a cancerous growth that occurs in the eye of infants. It can be present as white reflex at the pupil of the eye and if ignored, can cause protrusion of the eye ball (Fig. 1) and spread of tumor to other organs like brain etc., which could be fatal to the life of the child.

Fig.1 An eye ball with retinoblastoma
Like most of the other cancers, the exact reason in this case also is not known but usually attributed to hereditary factors. Retinoblastoma mainly occurs in one eye of the child but occurrence in both the eyes is not unusual.

The second most common cancer in men is prostate cancer. Radiotherapy is an alternative to radical surgery of the prostate (prostectomy) and has been advocated as a less invasive and more tolerant treatment of prostate cancer. However, external beam therapy has tremendous side effects and other complications arising from radiation to surrounding organs. One way to achieve maximum radiation focusing on the prostate is by interstitial radiotherapy (brachytherapy). Though brachytherapy treatment of prostate cancer began in 1911, it was rediscovered later after the availability of radioactive sources (seeds) using the radioisotopes such as $^{125}$I, $^{103}$Pd, $^{106}$Ru, etc. which have favourable radiation characteristics in terms of half life, energy and dose distribution. In addition to these, the availability of better imaging techniques such as transrectal ultrasound, fluoroscopy, high quality CT scan, etc. have now made permanent prostate implants much more popular in the western countries on an outpatient basis. The low energy radiation miniature source (seeds) with much lower activity (0.5 –1.0 mCi) than that used for ocular or eye cancer (2- 5 mCi) are used for permanent prostate implants. Although prostate cancer occurs quite frequently in Indian male population, radioactive seed implantation is not carried out in India due to various reasons, one of which is the non-availability of the radioactive seeds in India. The BARC $^{125}$I Ocu-Prosta Seeds could be used for prostate implantation.

**Diagnosis and treatment of Retinoblastoma**

An ophthalmologist, with the help of ultrasound of the eye and in conjunction with CT scan of the brain, can effectively make a diagnosis of retinoblastoma. In general, most of the cancers are treated either by removing the affected part before it spreads to other parts of the body or by other modes such as radiotherapy and chemotherapy. Usually, the treatment of retinoblastoma is based on combination of all these modes. Surgical removal is considered as an option if the cancer is well advanced. Very small tumors may also be dealt with laser or cryosurgery. Radiation therapy combined with chemotherapy is considered an option to save the eye left with some vision. It has been observed that retinoblastoma is radiosensitive and most often when the external beam radiation treatment is used, the radiotreated tumors usually regress leaving a scarred tissue. In addition to this, the external beam radiation has long-term side effects such as cataracts. The brachytherapy with low energy sources kept in the close proximity of tumors is more safe and effective method to deal with such type of cancers.

**Radiation Plaque Therapy**

Plaque is actually a metallic disc (Fig. 2) containing radioactive sources that were developed in the thirties to irradiate retinoblastoma and now this modality has come a long way. Today plaques are custom built for each patient. Generally, two surgical operations are carried out for this kind of treatment, one to insert the plaque and the other to remove it after a period of three to four days depending on the radiation dose required (40-60Gy) at the tumor.
Complete remission of the tumor could be achieved by treating the tumor using low energy radio-nuclide “plaque” brachytherapy.

The low energy miniature sources containing $^{106}$Ru, $^{125}$I or $^{103}$Pd are enclosed inside a laser welded titanium capsule and glued with cyanocrylate polymer into a custom built gold plaque. The plaque is placed in proper position and radiation dose is delivered to the affected lesion over a precalculated duration, which could be a few days.

**Choice of Radionuclides for Plaque therapy for Ocular cancer**

Radionuclides used in the plaque radiotherapy for retinoblastoma are $^{125}$I, $^{103}$Pd and $^{106}$Ru. The radiation characteristics of these three isotopes are given in Table 1. Iodine and palladium radionuclides may provide equal cell killing. However, the longer half-life of $^{125}$I is an advantage over $^{103}$Pd. The uranium fission produced $^{106}$Ru is not very commonly used, although it is convenient for the user in terms of logistics due to long half life (~1y). But the Bremsstrahlung radiation produced from its daughter $^{106}$Rh due to high-energy betas ($\beta_{\text{Max}}$ - 3.5 MeV) are not desirable for the intended use. The high energy (10-50 MeV) cyclotron produced $^{103}$Pd is not yet available in India and the logistics and cost considerations of this isotope do not permit its use at present. The reactor production of this isotope is not feasible due to low percentage abundance (~1%) and low neutron absorption cross-section of $^{102}$Pd. On the other hand, $^{125}$I with its relatively longer half-life and suitable gamma energy coupled with ease of production is a cost effective isotope and can be easily produced by $(n,\gamma)$ reaction of natural $^{124}$Xe gas in a special set up provided in the reactors CIRUS and DHRUVA at BARC. The production and processing procedures for $^{125}$I have been already optimised and regular production of this isotope is going to be commenced soon at the Radiopharmaceuticals Division.

**Source Requirements**

The basic source core for the brachytherapy application demands that the source should have very high specific activity and the source should be incorporated in a solid and non-leachable matrix. The source has to be encapsulated in a capsule made up of non-reactive metal. The outer dimension of the titanium encapsulated source for ocular and prostate radiotherapy is 4.5mm (l) x 0.8mm (OD) with wall thickness of 0.05 mm (Fig. 3). The specifications of these sources are well defined and stipulated by ISO. The sources are encapsulated in tiny titanium capsules by laser welding. There are many techniques and many matrices used for the adsorption of radio-iodine like electrochemical deposition, adsorption on organic materials, coating on to tungsten surface, adsorption on palladium wire, coating on silver and ceramic beads, coating on ion exchange resins, etc. The know-how of most of the coating procedures are trade secrets and are usually covered by patent rights (IPR).

<table>
<thead>
<tr>
<th>Isotope</th>
<th>$T_{1/2}$</th>
<th>Mode of Decay</th>
<th>Emissions</th>
<th>Internal Conversion</th>
<th>Energy (KeV)</th>
<th>Range (KeV)</th>
<th>Production methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{125}$I</td>
<td>60d</td>
<td>EC (100%)</td>
<td>$\gamma$ - rays (~7%)&lt;br&gt;Te X-rays (~138%)</td>
<td>~ 93%</td>
<td>35.5</td>
<td>27</td>
<td>Reactor</td>
</tr>
<tr>
<td>$^{106}$Ru</td>
<td>~1y</td>
<td>Beta</td>
<td>$\beta_{\text{Max}}$</td>
<td>-</td>
<td>39.4</td>
<td>-</td>
<td>Fission</td>
</tr>
<tr>
<td>$^{103}$Pd</td>
<td>17d</td>
<td>EC (100%)</td>
<td>X-rays</td>
<td>~10%</td>
<td>25</td>
<td>20-25</td>
<td>Cyclotron</td>
</tr>
</tbody>
</table>

Table 1: Radiation characteristics of radionuclides used for ocular/prostate cancers
Work carried out at the Radiopharmaceuticals Division, BARC

Preparation of $^{125}$I miniature sources

The development of miniature sources suitable for eye plaque application started in the late nineties in the erstwhile Isotope Division. A novel method of adsorption of radiiodine ($^{125}$I) on palladium coated silver wire of guaranteed purity having dimension 3.0 mm in length and 0.5 mm ($\phi$) was developed and optimized. The experimental conditions like amount of radioactivity, carrier concentration, reaction time, reaction temperature, reaction volume, pH of the reaction mixture, etc. were systematically optimized. By this method, more than 80% of the initial radioactivity could be firmly deposited on the source core and 3 - 4 mCi of radiiodine could be irreversibly adsorbed on the palladium coated silver wires, which have to be encapsulated in ISO specified titanium capsules [1]. The sources with extremely good reproducibility and consistency w.r.t. activity content and other quality parameters could be produced.

Quality control of the unencapsulated (bare) source

Radioactivity content was measured preliminarily by dose - activity relationship at a fixed geometry using a radiation survey meter. Accurate assaying of the activity on the sources was carried out after encapsulation using an ion chamber calibrated with standard Amersham-6711 $^{125}$I seed.

Leachability

Non-leachability of the activity from the source was ascertained by placing the sources individually in distilled water at room temperature for 48h. The released radioactivity in the water was measured in a NaI (TI) well type scintillation counter. The sources exhibited leachability well below the prescribed AERB limit (i.e.< 0.01% of total activity).

Determination of uniformity of adsorbed $^{125}$I activity on the source core

A specially designed gadget was used for estimating the uniformity of adsorption. Using this gadget, one could autoradiograph the radiation
emerging from eight directions from a single palladium coated silver wire source, which was placed at the center of the gadget, as shown in (Fig. 4). Optical density (OD) measurements were carried out on the developed radiographic film. The variation in OD values at different positions was generally found to be within ±5%.

Fabrication of titanium capsules

Development of the ISO specified miniature titanium capsules was initiated in the Centre for Design and Manufacture (CDM), BARC. The fabrication of these capsules was subsequently entrusted to the Precision Machinery Division of Hindustan Machine Tools, Bangalore. HMT, Bangalore, has done a yeomen service in developing these capsules and maintaining a steady supply. The capsules were evaluated for quality and dimensions by the Center for Design and Manufacture, BARC.

Sealing of $^{125}$I sources in titanium capsules

Iodine is a highly volatile element and the encapsulation of sources containing radiiodine with the help of conventional TIG welding, etc. might lead to loss of radioactivity during encapsulation. Moreover, the sources were to be sealed in a capsule made up of low density and body compatible titanium metal. Due to oxidising nature of titanium, its welding techniques have undergone several modifications in the recent times, the latest being the laser welding. As compared to plasma arc welding, which some manufacturers used in the eighties, laser welding also provides superior precision and low HAZ resulting in more consistency without any appreciable loss of radioactivity.

Laser welding of titanium capsules (initial trials)

Initially, the laser welding was carried out at Laser Processing and Advanced Welding Section. Subsequently, a new 50 W, Nd:YAG laser system was procured exclusively for this work and the welding head was installed in a well-ventilated fume-hood in a radioactive laboratory at Radiopharmaceuticals Division at BARC (Fig. 5). The sources were inserted titanium capsules manually with the help of specially designed gadgets (Fig.6).
leak proof welds. The welded samples were evaluated for leak test and metallography. The leak test was carried out in different ways. The samples were kept in hot water and appearance of air bubbles was observed. Later, the samples were kept in helium chamber at 6-atmosphere pressure for 22 hrs. Subsequently, the samples were tested in an UL-200 (Lebold make) unit and found to be leak free. The actual values of leak rate are given in Table 2.

The metallography test of inactive welded capsules was carried out by optical metallography and Scanning Electron Microscopy (Fig. 7). The penetration depth in the samples was found to be ~ 2-3 times the wall thickness of the capsules.

**Table 2 : Leak rate of titanium capsules**

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Vacuum (Torr)</th>
<th>Leak Rate (std. cc/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>7.3x10^-3</td>
<td>0.5x10^-9</td>
</tr>
<tr>
<td>2.</td>
<td>9.2x10^-3</td>
<td>0.7x10^-9</td>
</tr>
<tr>
<td>3.</td>
<td>1.2x10^-3</td>
<td>0.8x10^-9</td>
</tr>
<tr>
<td>4.</td>
<td>9.0x10^-3</td>
<td>0.7x10^-9</td>
</tr>
<tr>
<td>5.</td>
<td>1.2x10^-3</td>
<td>1.1x10^-9</td>
</tr>
<tr>
<td>6.</td>
<td>9.7x10^-3</td>
<td>1.1x10^-9</td>
</tr>
</tbody>
</table>

Welding of $^{125}$I encapsulated sources.

The radioactive sources were inserted into the titanium capsule. The capsule was manually loaded on to the machine and held vertically. A laser beam was focused to the weld joint horizontally by an optical fiber based delivery system. All laser parameters along with rotation of the capsule including inert gas supply were controlled by a PC. The system was operated remotely. (Manual operation is also possible, if needed). A camera with separate optical lenses based arrangement was provided to view the welding region. The welding of titanium capsules containing radioactive BARC $^{125}$I OcProsta seeds was carried out and quality evaluation was done for regular production [3]. The welded sources were cleaned to remove surface contamination (if present) and tested for leak as prescribed by AERB [2]. The air activity was constantly monitored during the process of welding. Some of the laser-welded capsules are shown in (Fig. 8).
Quality assurance of the sealed sources (seeds)

The miniature sources after encapsulation need to be quality assessed for their final use. Accurate measurement of activity, surface contamination, uniformity of activity in the laser welded encapsulated sources, leak tightness, etc. as prescribed by AERB, were all part of the quality assessment of the sources [4]. The welded sources were decontaminated and accurate measurements of activity of individual sources (seeds) were carried out by using two different types of well ionization chambers. Both the ionization chambers were calibrated using Oco-seed model - 6711 at two different accredited dosimetry calibration laboratories, University of Wisconsin, USA, and K&S Associates, USA. The air kerma strength/activity measured on the seeds prepared using both types of chamber agreed within ± 5%. The uniformity of activity and leakage tests were also carried out.

The dosimetry of low energy photon emitting tiny brachytherapy sources containing radioisotope like $^{125}$I is sensitive to source geometry, encapsulation internal structure, etc. Therefore, it is the ultimate responsibility of the medical physicists to validate the clinical dosimetry and other safety parameters. The dosimetric studies of sources were carried out at Radiological Physics and Advisory Division (RP&AD) of BARC, which revealed that the source design produced by Radiopharmaceuticals Division (RPhD) is similar to commercial source 6711 Oncoseed of Amersham International. In phantom dose, values calculated at a few depths by Monte Carlo simulation were also found to be in good agreement with the dosimetry data of type 6711 seed. The RP& AD, BARC, therefore, recommended that the published dosimetry data of similar sources could be used for clinical dosimetry of $^{125}$I sources developed at RPhD, BARC.

Laser Encapsulation of Sources

The encapsulation of tiny $^{125}$I radioactive sources in titanium capsules needed a systematic evaluation and optimisation of laser parameters like laser energy, pulse width, frequency, time of encapsulation, etc. The Nd:YAG laser installed inside the fume-hood of a lab in Radiopharmaceuticals Division is first of its kind in India. The encapsulation of medical radiation sources with the help of laser could be successfully done by taking the laser beam inside the radioactive area with the use of fiber optic cable. The welded samples showed high integrity and superior metallurgical quality. This is one of the finest application of laser in the service of mankind.

Dosimetry of BARC $^{125}$I Ocu-Prosta Seed

The new model of $^{125}$I seed designed and developed by Radiopharmaceuticals Division of BARC, is similar in construction to the Model-6711 seed, produced by Medi-Physics Inc. of Nicomed Amersham, which is considered as the reference standard for similar model seeds. The standardization of the new model seed was done using two different types of well-ionization chambers, both calibrated for model-6711 seed. The mean value of the air kerma strength ($\pm$2%), measured using the two types of chambers, was used for establishing the dosimetry parameters of the new model seed. The dosimetric parameters of sources were determined by measurements using LiF TLD micro-rods and by Monte Carlo (MC) calculations. The measured dose rate constant, dose rate at 1cm along the perpendicular bisector of the long axis of the source, agrees with MC calculated values within 2%. The mean of the measured and MC calculated dose rate constant ($\leq 0.96$) was recommended for the clinical dosimetry of BARC $^{125}$I Ocu-Prosta seed. This value agrees with the dose rate constant reported for model-6711 seed, within 1%.
Packing and despatch

Due to small dimensions of these radioactive sources and to keep a proper inventory, the sources are individually packed in suitably labeled screw capped brass containers. These containers are packed in glass vials tightly capped with aluminum cap and the vials are finally kept inside half-inch thick lead shipping containers. The packed sources are despatched to the user through BRIT.

Clinical Application of the Miniature Sources

Only specialised medical oncologists trained for the purpose may carry out ocular and prostate implantation with radiation sources. The "BARC 125I Ocu-Prosta seeds" can be used for the treatment of retinoblastoma and other ocular melanomas. Once a patient is found suitable for brachytherapy (not all patients of retinoblastoma are suitable for this therapy), the tumor dimensions are measured based on clinical examination by ultrasonography or in certain cases by CT/MRI. These parameters are fed into dosimetry programme. The programme is designed to calculate the size of the plaque, radiation dose to be delivered, activity/number of seeds to be used, seed arrangement in the plaque and time duration of the treatment. 125I sources are placed from end to end around inner side of an eye plaque. The eye plaques are made from gold alloy (92% Au and 8% Cu) or pure gold. The metal of plaque attenuates photons by ~99.9% and thus protects external surface of the eye from radiation and directs the energy towards the tumor. Plaques are made with semicircular edge cutouts to allow treatment of tumors lying close to the optical disc. Suture holes of 0.4 mm in diameter are drilled around plaque peripheries. They are usually made in pairs so that non-radioactive plaques can also be used for suture positioning. The radioactive seeds are positioned securely with the help of sterile cyanoacrylate adhesive. The plaque is sutured and left for requisite time to give the required radiation dose. The sources are carefully removed from the plaque after use and inventoried to be stored back. The decayed sources are to be returned to BARC / BRIT.

Clinical Trial with BARC 125I Ocu-Prosta seed

The first clinical trial for the brachytherapy of retinoblastoma (a type of eye cancer found in infants) using BARC 125I Ocu-Prosta seeds was performed at Sankara Nethralaya, Chennai. The AERB approved laser encapsulated 125I radiation sources used in this treatment were prepared in Radiopharmaceuticals Division. The sources were supplied to Sankara Nethralaya, Chennai, through BRIT, for the treatment of a four-year old child suffering from retinoblastoma. Deploying 125I radiation sources in ocular brachytherapy was treatment for the first time in India.

Clinical History of the Patient

A four-year old child was under treatment in Sankara Nethralaya for the last two years. This child had a bilateral tumor in both the eyes. He had vision in both the eyes and this factor could help the ophthalmologists to go ahead with chemoreduction of tumors. After the chemoreduction, the tumors were treated with laser therapy. This treatment could help to eliminate the tumor of one eye and the other eye could not be treated well. The tumor left in the second eye was subsequently treated with external beam therapy using a photon beam obtained from LINAC. This treatment helped the tumor to show some sign of improvement but at a later stage it again started growing with even much faster rate. Since the tumor was growing faster, it could spread up to brain and other parts as well and also there was a threat to the life of the child. The doctors at this stage were left with an option of either removing the eye as a whole or to go for a brachytherapy treatment by placing the low energy radiation sources in the close proximity with the tumor. After taking consent with the parents of the child and getting the clearance from ethical committee of Sankara Nethralaya, they decided to treat this tumor with 125I radiation sources and requested RPhD, BARC, for supply of sources on priority basis.

(Contd...)
Treatment Planning

One fresh batch of $^{125}$I brachytherapy sources was processed, sources were laser encapsulated and their quality w.r.t. leakage, surface contamination, etc. was evaluated. A total of 23 sources were supplied to Sankara Nethralaya through BRIT. The treatment using these sources, having a total activity of ~ 36 mCi, was planned to be done on September 11 2003, and the fabrication of plaque (an eye shaped metallic holder made up of gold on which the sources are mounted) was planned to be done on September 10, 2003. Considering the size of tumor, the magnitude of radiation dose to be delivered was decided to be ~45Gy in a total duration of 88 hours. The removal of the plaque was decided to be done on September 15, 2003.

Fabrication of Plaque

The plaque was fabricated on September 10, 2003 by adhering 23 radiation sources on 18 K gold holder with cyanoacrylate glue. Over the adhered sources another layer of glue was applied to ensure the firmness of the sources with the metallic plaque. The plaque was sterilised with 2% lysoformin solution by leaving it overnight in the sterilising solution. The plaque was subsequently washed and the wash solution was tested for any release of activity. There was no detectable release of radioactivity noticed in this operation. The whole operation was performed in a separate room near the operation theatre well equipped with adequate provision of radiation shielding.

Treatment

The treatment using the sterilised plaque was started at 3:45 p.m. on September 11, 2003. The child was given general anesthesia and the sclera of the eye was opened. The tumor was marked with surgical marker and the radioactive plaque was implanted at about 4:15 p.m. After placing the plaque in position, the sclera was again stitched and the eye was closed with a 2mm lead sheathed plastic cup kept over the eye to bring the radiation level around the patient to almost background level. The bandages used in surgery were checked for the presence of any radioactivity and were found to be free from contamination. The plaque was removed on September 15, 2003 following a similar surgical procedure. The radiation field around the patient was monitored regularly throughout the treatment and found to be near background. Other than the regular doctors of Sankara Nethralaya, the treatment was performed in the presence of a consulting oncologist, a consulting physicist and supporting medical personnel. Dr. A.N. Nandakumar, Head, RSD, AERB, also visited on September 12, 2003, and went through all the records. Subsequently, Dr. N. Ramamoorthy, Associate Director, Isotope Group, BARC, and Dr (Ms) Meera Venkatesh, Head, RPCS, RPhD, BARC, also visited Sankara Nethralaya on September 13, 2003. After the treatment, all the 23 radiation sources were recovered from the plaque by treating the plaque with acetone for about 30 minutes.

The other relevant details related to the treatment are mentioned below:

Size of the Plaque : ~ 22 mm (φ) x 12.5 mm R (radius of curvature) x 1.5mm thick
Material of Plaque : 18 K Gold
Size of the tumor : ~ 15 mm (φ) x ~6 mm depth.
Total radioactivity used : ~ 36 mCi.
No. of sources used : 23 Nos. (~ 1.56 mCi each on 11/09/03).
Total radiation dose delivered : ~ 45Gy at the apex of tumor.
Duration of treatment : 88 hrs.
Radiation level around the patient after treatment : Background level.

Result

The sources supplied by RPhD, BARC, could be successfully used for the first brachytherapy of retinoblastoma in India using $^{125}$I radiation sources. There was no increase in the radiation field in and around the body of the child after removal of sources.

In order to evaluate the efficacy of this treatment, the child has been asked to report to Sankara Nethralaya after 3-4 weeks, duration and subsequently after a regular interval of every two weeks. The approximate time to come to know the results regarding the effectiveness of the above treatment is likely to be about three months.
Conclusion

The $^{125}$I sources developed at BARC have opened a new therapeutic window for the treatment of ocular and prostate cancer patients in India. The sources are being prepared regularly and the clinical trials are on the way. The first clinical trial using these sources was successfully performed at Sankara Nethralaya, Chennai, on September 11, 2003 (See clinical study report in box).

References

2. "Testing and classification of sealed radioactive sources - AERB SS-3-1990".

BARC MANUFACTURES 6.65m SPECTROMETER

Centre for Design and Manufacture and Spectroscopy Division of BARC. have designed and developed a 6.65metre long Off-Plane Eagle Mount Spectrometer for high resolution V.U.V. Beamline. This will be the third instrument of its kind in the world.

Grating end of spectrometer