3 b - RADIATION ONCOLOGY

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Executive summary

Aims of the XIth Plan of the NCCP

- Address the existent socio-demographic disparities in cancer control
- Improve strategies for prevention, early detection, and treatment of cancer
- Strengthen and enhance infrastructure for cancer control (capacity building)
- Reduce waiting times for cancer diagnosis and therapy
- Reduce morbidity and mortality from cancer and its therapy

Cancer in India

Current scenario (2000-05)

- 800,000 new cases; 2,500,000 prevalent cases; 550,000 cancer deaths in a year (GLOBOCAN 2000 & 2002, IARC)
- Relatively young cancer population as per the existent age pyramid (NCRP)
- Tobacco-related cancers-an important concern (40% in men & 25% in women) (Cancer ATLAS; Tobacco Control in India-2004)
- Cervix is still the leading cancer in women across the country (ICMR; NCRP)
- Breast cancer has overtaken cervix in urban metropolitan registries (NCRP)
- Only 337 teletherapy units in the entire country presently (RP&AD, BARC)
- 2/3rds of cancer patients need radiation therapy (RT) i.e. 500,000 patients / year (NCCP)
- Only 1/3rd of these estimated patients actually receive RT due to major shortfall in number of therapy units and urban-centric distribution of centres

Projections for future (2015-2020)

- Doubling of the cancer incidence in next 15 years (WHO)
- Ageing population with consequent increase in cancer incidence & prevalence (WHO; ICMR; NCRP)
- Huge shortage of RT infrastructure (equipment and human resource) to meet recommended norms (IAEA; WHO)

Table I: Cancer Control - Facilities in Radiation Oncology (December 2005)

State	Population	Tele-cent/ milln	Tele Cen	Tele-dens/ million	Tele unit	Co60	LA	Cs-137	LDR	HDR	MIC	Int BRT	BRTCent
India	**1027000000**	**0.21**	**207**	**0.33**	**337**	**260**	**69**	**8**	**37**	**73**	**76**	**28**	**134**
NE-Arunachal	1091117	0	0	0.00	0	0	0	0	0	0	0	0	0
NE-Sikkim	540493	0	0	0.00	0	0	0	0	0	0	0	0	0
NE-Nagaland	1988636	0	0	0.00	0	0	0	0	0	0	0	0	0
Uttaranchal	8479562	0	0	0.00	0	0	0	0	0	0	0	0	0
Andman	356265	0	0	0.00	0	0	0	0	0	0	0	0	0
Dadra-Haveli	220451	0	0	0.00	0	0	0	0	0	0	0	0	0
DamanDiu	158059	0	0	0.00	0	0	0	0	0	0	0	0	0
Lakshadweep	60595	0	0	0.00	0	0	0	0	0	0	0	0	0
Bihar	82878796	**0.03**	3	0.04	4	4	0	0	1	1	0	0	2
Jharkhand	26909428	**0.07**	2	0.07	2	2	0	0	1	0	0	0	1
Uttar Pradesh	166052859	**0.08**	14	0.13	22	20	2	0	5	5	3	0	6
Chhatisgarh	20795956	**0.14**	3	0.19	4	4	0	0	0	1	0	0	1
Harayana	21082989	**0.09**	2	0.19	4	4	0	0	0	1	1	0	1
NE-Assam	26638407	**0.11**	3	0.19	5	4	1	0	1	1	0	0	1
Rajasthan	56473122	**0.12**	7	0.19	11	10	1	0	1	3	2	1	5
Orissa	36706920	**0.13**	5	0.22	8	7	1	0	1	1	1	0	3
Madhya Pr	60385118	**0.15**	9	0.23	14	13	1	0	2	4	1	1	6
North East	39035582	0.21	8	0.23	9	8	1	0	2	1	0	0	2
NE-Tripura	3191168	0.62	2	0.31	1	1	0	0	0	0	0	0	0
West Bengal	80221171	**0.14**	11	0.31	25	15	5	5	1	3	3	1	4
Himanchal Pr	6077248	**0.16**	1	0.33	2	2	0	0	1	0	1	0	1
Andhra Pr	75727541	0.33	25	0.34	26	21	5	0	2	9	12	5	19
Gujarat	50596992	**0.15**	8	0.34	17	10	6	1	1	2	2	2	3
Punjab	24289296	0.29	7	0.37	9	6	3	0	1	3	1	1	5
NE-Manipur	2388634	0.41	1	0.41	1	1	0	0	1	0	0	0	1
NE-Meghalay	2306069	0.43	1	0.43	1	1	0	0	0	0	0	0	0
Maharashtra	96752247	0.28	27	0.44	43	34	9	0	7	12	14	2	24
Karnataka	52733958	0.28	15	0.59	31	26	4	1	1	4	10	6	12
Jammu Kash	10069917	0.29	3	0.60	6	5	1	0	1	0	0	0	1
Tamil Nadu	62110839	0.45	28	0.63	39	27	12	0	5	6	16	5	20
Kerala	31838619	0.35	11	0.72	23	17	5	1	2	5	4	1	6
NE-Mizoram	891058	1.12	1	1.12	1	1	0	0	0	0	0	0	0
Goa	1343998	1.48	2	1.48	2	2	0	0	0	0	1	0	1
Delhi	13782976	1.01	14	1.95	27	17	10	0	2	6	2	2	7
Pondicherry	973829	1.02	1	3.08	3	2	1	0	0	1	1	0	1
Chandigarh	900914	2.22	2	6.66	6	4	2	0	1	2	0	1	1

Source: Radiological Physics & Advisory Division, BARC

Fig. I: Growth of RT infrastructure in India over the years

1962-1986 — 76 Telecobalt units (> 20 years old)

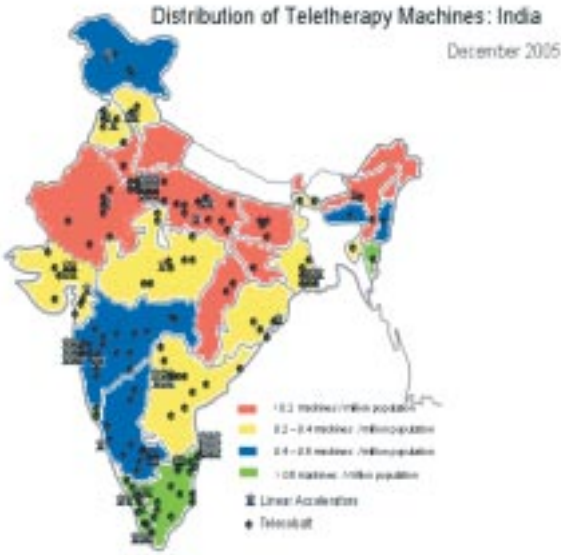
1987-1991 — 35 Telecobalt units (> 15 years old)

Pre 1991 LA — 12 units (>15 years old)

76/260 Telecobalt units outdated and old: Need to be decommissioned

12/69 LA units outdated and old: Need to be decommissioned

Fig. II: Tele-density Map of India as of December 2005



Measurable components in Radiation Oncology

- ***Equipment:*** Teletherapy, Brachytherapy, Simulator, Treatment Planning System (TPS), Mould Room Tools, and Physics Accessories (Dosimeters, Chambers, Survey Meters, Phantoms)
- ***Personnel:*** Radiation Oncologist, Medical Physicist, Dosimetrist, RT Technologist
- ***Logistics:*** Quality Assurance (QA) and inter-disciplinary co-operation

Table II: Radiation Oncology Infrastructure in India (Gap between supply & demand)

Parameter	*Current Existing*	*Ideal Scenario* (international norms)*	*XIth Plan- Practical Recommendation*	*Shortfall*
Equipment				
Tele-density	0.33 per million population	2 per million population	0.5 per million population	**0.17 per million**
Tele-units	337 (includes 76 units >20 years old)	2000	500	**163 + 76 (old units for replacements)**
Brachytherapy	186 (0.19 per million)	330 (0.33 per million population)	250 (0.25 per million population)	**64**
Simulator	41	1 per RT centre	1 per sec/tertiary centre	**59**
3-D TPS	48	1 per RT centre	1 per sec/tertiary centre	**52**
Personnel				
Radiation Oncologist	700 (1 per 715 patients annually)	2000 (1 per 250 patients annually)	1000 (1 per 500 patients annually	**300**
Medical Physicist	500 (1 per 1000 patients annually)	1250 (1 per 400 patients annually)	1000 (1 per 500 patients annually)	**500**
Dosimetrist	Nil	500 (1 per 1000 patients annually)	1 per RT centre	**250**
RT Technologist	700 (2 per MV unit)	8000 (4 per MV units)	1500 (3 per MV unit)	**800**

****Ideal scenario (ACR guidelines)***

8 working hours per day; 25-30 patients per day per teletherapy unit

Average: 5 weeks of external RT treatment (radical & palliative); 50 working weeks/ year

250-300 patients per teletherapy unit per year; 500,000 patients need RT every year

Proposed 3-tier network -Radiation Oncology

- **Primary Referral Centre (Taluka / District Hospital)**

Should provide routine RT services for 80% of standard common cases

- ❖ No. of districts in the country: 600
- ❖ No. of centres needed if RT resources shared between 4 adjacent districts: 150
- ❖ No. or RT centres currently existing at the Taluka/District Hospital level: 100

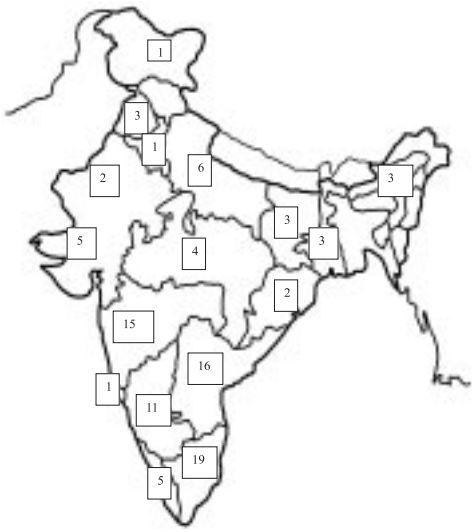
50 additional primary referral RT centres need to be established

25 existing centres need to be equipped with brachytherapy facilities

Mimimum RT requirements for primary referral centre

- ➢ Teletherapy
  - 1 Telecobalt unit with beam modifiers
- ➢ Brachytherapy
  - 1 Manual low-dose rate / remote high-dose rate brachytherapy unit
- ➢ Planning/Verification (Physics accessories for minimum Quality Assurance)
  - Secondary Standard Dosimeter
  - Gamma Zone monitor
  - Survey Meter (Ion chamber based)
- ➢ Optional
  - Treatment Planning System

Fig. III: State wise distribution of primary referral centres



- **Secondary Referral Centre (Oncology Wing of a Medical College)**

Should provide service and education/training

- ❖ No. of Govt. Medical Colleges in the country: 120 out of total 242
- ❖ No. of Govt. Medical Colleges with any RT facility (mostly primitive): 40
- ❖ No of Teaching Institutes with MCI recognized PG seats in RT: 28
- ❖ Immediate aim: Secondary referral RT centre - every 2nd Govt. Medical College

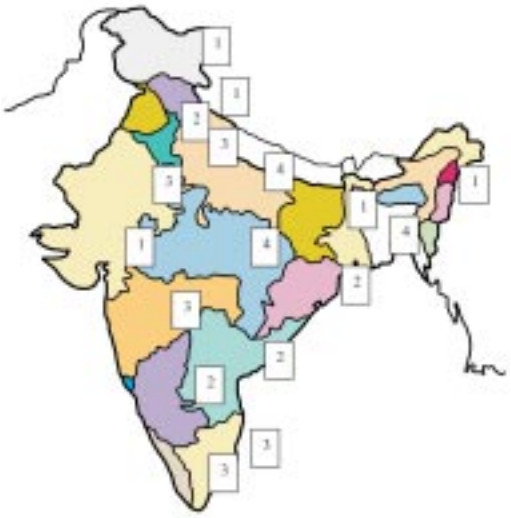
20 additional Medical Colleges need to be equipped as secondary referral RT centres

25 existing Medical College RT departments need to be upgraded

Minimum RT requirements for a secondary referral centre

- ➢ Teletherapy
  - 2 Telecobalt units or 1 Telecobalt with beam modifiers + 1 low energy LA with/without electrons
  - Mould room facility
- ➢ Brachytherapy
  - 1 High-dose rate brachytherapy system
- ➢ Planning
  - Simulator or CT Simulator with Virtual Simulation facility
  - Treatment Planning System
- ➢ Verification (Physics accessories for comprehensive QA)
  - Secondary Standard Dosimeter
  - Gamma Zone monitor
  - Survey Meter (Ion chamber based)
  - Radiation Frequency Analyzer
- ➢ Optional
  - Dual Energy LA with electrons with multi-leaf collimators (MLCs)
  - TPS with Inverse Planning module

Fig. IV: Government Medical Colleges with RT facilities



- **Tertiary Referral Centre (National Centre & Regional Cancer Centres)**

Should provide service, education & research (comprehensive cancer care)

- **No. of states in the country currently: 28**
- **No. of RCCs existing currently in the country: 25**
- **Each state should have at minimum one RCC**

Fig.V: RCC Map of India

Minimum RT requirements for an RCC

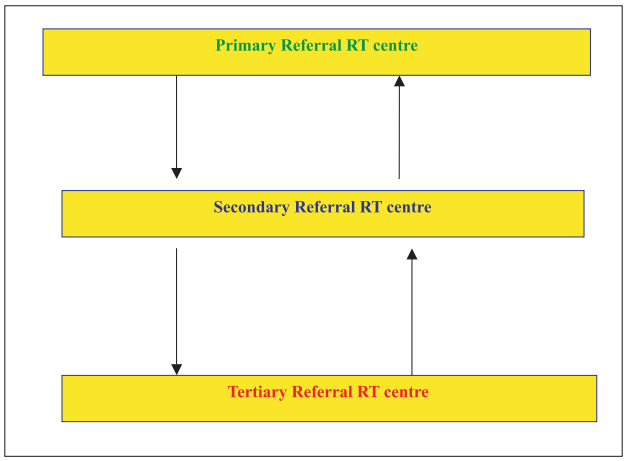
- Teletherapy
  - 2 Telecobalt units or 1 Telecobalt with beam modofoers + 1 low energy LA with/without electrons
  - 1 Dual energy LA with electrons & multileaf collimators (MLCs)
  - Mould room facility
- Brachytherapy
  - 1 High-dose rate brachytherapy system
- Planning
  - Conventional Simulator or CT-Simulator with Virtual Simulation
  - 3-D TPS with Inverse planning module with networking
- Verification
  - Electronic portal imaging device on LA
  - Extensive physics accessories for comprehensive QA
    - Secondary Standard Dosimeter
    - Gamma Zone monitor
    - Survey Meter (Ion chamber based)
    - Radiation Field Analyzer (RFA)
    - Film based dosimetry and Intensity map check facility
- Optional
  - TPS with image fusion algorithms
  - Automated compensator cutting & milling unit
  - Stereotactic Radiotherapy/Radiosurgery System
  - PET scanner with networking to TPS
  - Image Guided Radiation Therapy (IGRT)
  - Dose Guided Radiation Therapy (DGRT)
  - Helical Tomotherapy

NETWORKING via TELE-MEDICINE

Elements in Tele-medicine Network for Radiation Oncology

- ***Tele-consultation (expert opinion)***
- ***Training of manpower (virtual classroom)***
- ***Treatment planning (planning, evaluation & verification)***

Fig. VI: Tele-network hierarchy for Radiation Oncology



Activities in Radiation Oncology

- Huge discrepancy between demand and supply, cannot be met in next 5-year plan
- Identify key areas which need to be strengthened in a realistic mode
- Reduce the existent socio-demographic disparity in RT infrastructure
- Accelerate indigenization of technology in all areas
- Promote sharing of resources across adjacent centres
- Implement proposed 3-tier structure with objectively measurable goals
- Networking including DICOM RT connectivity via Tele-medicine between the three tiers

Role & responsibility of government

The Ministry of Health should act as the nodal agency for co-ordinating the various activities and components of this program viz.

- Manpower development
- Deployment of equipment
- Indigenization of technology

This committee shall be more than happy to provide the technical expertise for the proposed programs. Since indigenization of Telecobalt and Linear Accelerators is going to be a key component of this program, without which it may not fulfill some of its aims, an officer of the level of Joint Secretary must participate on various monitoring committees of indigenization so that the technology can be incorporated in the program at appropriate stages. The government must support deployment of at least 30 units of Bhabhatron (indigenous telecobalt) with a minimum of 5-year comprehensive maintenance and service over the next 5 years in order to enable indigenous technology sustain itself and complete with multi-national companies.

Fig. VII: Proposed planned expansion of Radiotherapy equipment in XIth Plan (NCCP)

- **Telecobalt : LA=2:1**
- **Indigenous: Imported=1:2**

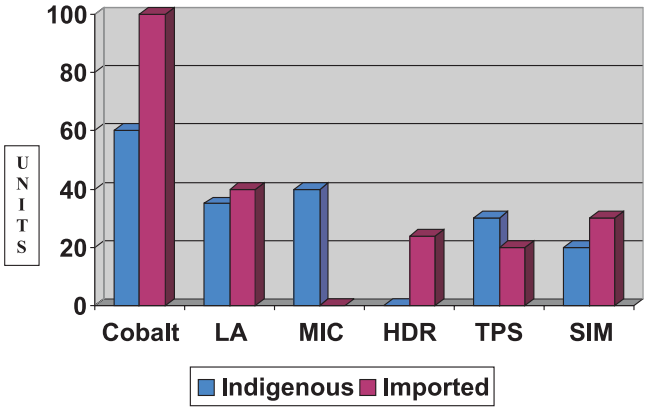
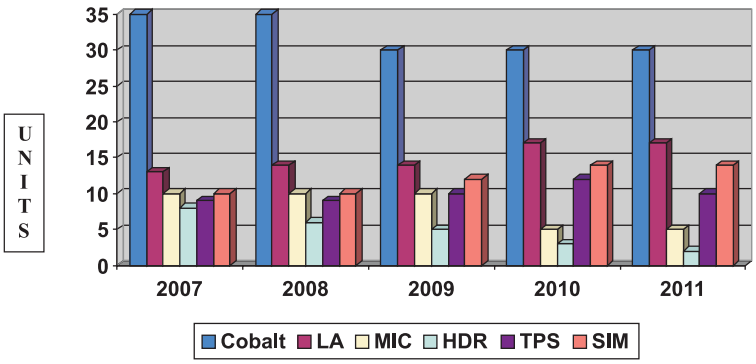


Fig. VIII: Proposed Year-wise installation of RT equipment in XIth Plan (NCCP)



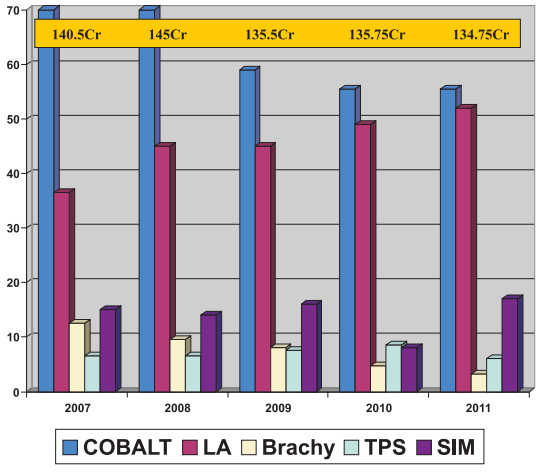
Budgetary Proposal

Table III: Budget Estimate for proposed RT installation (XIth Plan-NCCP)

Equipment	Approx Cost/ unit (in Cr)	1st yr No of units (cost in Cr)	2nd yr No of units (cost in Cr0	3rd year No of units (cost in Cr)	4th year No of units (cost in Cr)	5th year No of units (cost in Cr)	TOTAL (5 yrs) NO OF UNITS (cost in Cr)
Telecobalt							
Indi Cobalt	1.5	10 (15)	10 (15)	10 (15)	15 (22.5)	15 (22.5)	**60 (90)**
Impo Cobalt	2.2	25 (55)	25 (55)	20 (44)	15 (33)	15 (33)	**100 (220)**
LA							
Indi low LA	2.5	3 (7.5)	4 (10)	6 (15)	8 (20)	9 (22.5)	**30(75)**
Indi dual LA	3.5	0	0	0	2 (7)	3 (10.5)	**5 (17.5)**
Impo low LA	3.0	3 (9.0)	5 (15)	5 (15)	4 (12)	3 (9)	**20 (60)**
Impo dual LA	5.0	4 (20)	4 (20)	3 (15)	2 (10)	2 (10)	**15 (75)**
Brachy							
Manual ICA	0.05	10 (0.5)	10 (0.5)	10 (0.5)	5 (0.25)	5 (0.25)	**40 (2)**
HDR brachy	1.5	8 (12)	6 (9)	5 (7.5)	3 (4.5)	2 (3)	**24 (36)**
TPS							
Indigenous	0.5	5 (2.5)	5 (2.5)	5 (2.5)	7 (3.5)	8 (4)	**30 (15)**
Imported	1.0	4 (4)	4 (4)	5 (5)	5 (5)	2 (2)	**20 (20)**
Simulator							
Indigenous	1.0	0	2 (2)	4 (4)	6 (6)	8 (8)	**20 (20)**
Imported	1.5	10 (15)	8 (12)	8 (12)	8 (12)	6 (9)	**40 (60)**
TOTAL (in Cr)		**(140.5)**	**(145)**	**(135.5)**	**(135.75)**	**(134.75)**	**(690.5)**

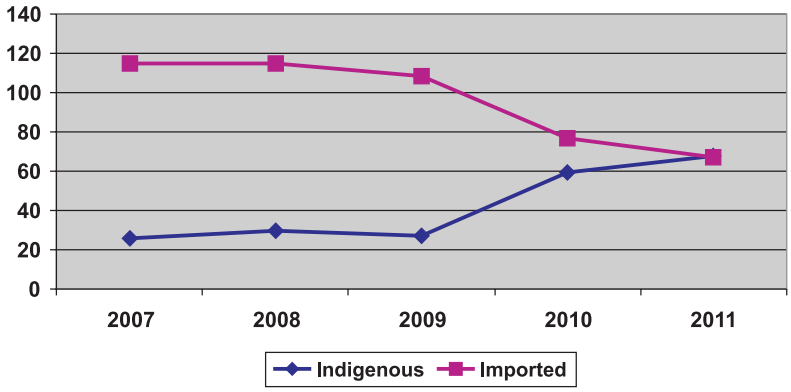
Indi = Indigenous; Impo = Imported
low LA= low energy Linac; dual LA= dual energy Linac
Cr= Crores

Fig. IX: Year-wise Budget Estimate in INR (Crores)



TOTAL 5-YR BUDGET : Rupees690.5 Crores
(XIth Plan - RT equipment

Fig. X(A&B): Year wise proposed increase in Indigenization (Figures in Crores)



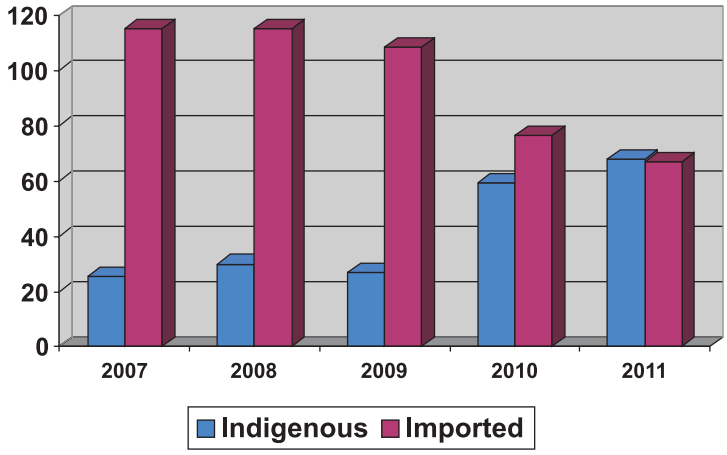


Table IV: MCI Recognised Institutions for MD Radiotherapy

State	Name and Address of Medical College / Medical Institution	Manage-ment	Year of start	Annual Intake (Seats)	Staus of MCI Recognition
Andhra Pradesh	Nizam's Institute of Medical Sciences			1	Permitted u/s 10(A)
Andhra Pradesh	Osmania Medical College	Govt.	1946	3	Recognized
Delhi	Maulana Azad Medical College & GB Pant Hospital	Govt.	1858		Recognized
Delhi	All India Institute of Medical Sciences	Govt.	1956	2	Recognized
Gujarat	B J Medical College, Ahmedabad	Govt.	1946	-	Recognized Oct.1984
Haryana	Pt. B D Sharma Postgraduate Institute of Medical Sciences	Govt.	1960	2	Recognized after Nov'91
Himachal Pradesh	Indira Gandhi Medical College	Govt.	1966	2	Permitted u/s 10 (A)
Jammu & Kashmir	Sher-I-Kashmir Instt. Of Medical Sciences,Srinagar	Trust	1988	4	Recognized
Karnataka	Kasturba Medical College, Manipal	Trust	1953	2	Recognized
Karnataka	Bangalore Medical College	Govt.	1955	1	Recognized
Karnataka	Kidwai Memorial Institute of Oncology			1	Recognized
Kerala	Medical College, Thiruvananthapuram	Govt.	1951		Recognized after 1978
Madhya Pradesh	M G M Medical College	Govt.	1948	2	Recognized after Apr'76
Maharashtra	Tata Memorial Hospital			5	Recognized
Orissa	SCB Medical College	Govt.	1944	4	Recognized
Punjab	Christian Medical College	Trust	1953	-	Recognized after Jan-2000
Punjab	Postgraduate Institute of Medical Education & Research			4	Recognized
Rajasthan	Sardar Patel Medical College	Govt.	1959	-	Recognized after 1982
Rajasthan	SMS Medical College	Govt.	1947	-	Recognized after 1982
Tamil Nadu	Cancer Institute, College of Oncological Sciences			1	Recognized
Tamil Nadu	Chennai Medical College	Govt.	1835	4	Recognized
Tamil Nadu	Christian Medical College, Vellore	Trust	1942	3	Recognized
Uttar Pradesh	Institute of Medical Sciences, BHU	Univ.	1960	1	Recognized
Uttar Pradesh	GSVM Medial College	Govt.	1955	2	Recognized after Jul'97
Uttar Pradesh	King George Medical College	Govt.	1911	2	Recognized after 1986
Uttar Pradesh	Sanjay Gandhi Postgraduate Institute of Medical Sciences			2	Recognized after Dec'94
West Bengal	Medical College, Kolkata	Govt.	1838	4	Permitted u/s 10(A)
West Bengal	University College of Medicine				Recognized after 1973
INDIA				**52**	

Source: Medical Council of India

Given the current shortfall of Radiation Oncologists, the existing number of Post-Graduate seats in Radiotherapy (around 50 on an average annually) is woefully inadequate to address this inequality. Since the discipline is also evolving rapidly, there is a constant need to keep abreast with current and upcoming technology in Radiation Oncology. It is thus recommended to:

- Increase number of centres offering MD-Radiotherapy (secondary & tertiary level)
- Increase the number of MD-Radiotherapy seats in existing tertiary referral centres
- Stop running MD-Radiotherapy courses in centres not fully equipped

Table V: Medical Physics - Education in India over the years

Post MSc. Dip. in Radiological Physics		*TOTAL*
1963 – 2002	**2003- 2005**	**1963-2005**
610	**71**	**681**
@ Average 15.64 per year	**@ Average 23.67 per year**	**681 @ 16.21 Per year**
M.Sc. Medical Physics		***TOTAL***
1983- 2003	**2004- 2005**	**1983-2005**
320	**54**	**374**
@ Average 16 per year	**@ Average 27 per year**	**374/42 @ 17 per year**

There are 5 training centres for medical physics including four universities for medical physics and one for post M.Sc Dip.RP course in the country currently. Only 500 (47.39 %) Medical Physicists are actively working in Clinical Radiotherapy in the year 2005, out of a total of 1055 Medical Physics / Radiological Physics post graduates trained over the last 42 years, whereas PhDs among them are only 40. The rest 555 (52.61) out of 1055 are working in diverse sectors - Research Institutes, Industry, Universities, Radiation Safety in Industrial / Agricultural Institutes in India, and many have migrated for greener pastures abroad. Given the existing shortfall, the following measures are recommended:

- Increase post MSc Dip. In Radiological Physics seats
- Mandatory 6-month internship for DRP students in tertiary referral centres
- Introduce and promote PhD courses at tertiary referral centres

Table VI: Training courses for RT Technologists

Degree / Post B.Sc diploma	Eligibility	Course duration	Average annual seats (Institute)
B.Sc.Medical Tech. (RT)	10 + 2	3 yrs	10 / yr (KMIO, Bangalore)
B.Sc. Medical Tech. (RT)	10 + 2	3yrs	5 / yr (PGIMER, Chandigarh)
B.Sc. Radiotherapy	10 + 2	3 yrs	10 / yr (KMC Manipal)
Post B.Sc. Diploma in Radiotherapy	B.Sc. (Sc) B.Sc. (Sc)	2yrs2yrs	15 / yr (TMC Mumbai)5 / yr (Apollo, Chennai)
B.Sc.Medical Radiological Tech (RD/RT) Gandhi Univ. Kottayam, Kerala)	10 + 2	4 yrs	6 / yr (School of Medical Education- Mahatma
B. Sc. Medical Radiological tech(RD/RT)	10 + 2	4 yrs	6 / yr (School of Med. Sciences, Calicut Univ. Calicut, Kerala)
B.Sc.Med. Tech Radiology (RD/RT)	10 + 2	3yrs	5 / yr (PGIMER, Chandigarh)
Diploma in Radiological Tech. (RT)	10 + 2	2 yrs	5 / yr (CMAI, CMC Vellore)
Dip. in Rad.Tech (RT)	10 + 2	2 yrs	5 / yr (CMAI, CMC Ludhiana)
Dip. in Rad.Tech (RT)	10 + 2	2 yrs	5 / yr (CMAI Amla Cancer Inst. & Res. Centre, Trichur, Kerala)
Dip. in Rad. Tech. (RT)	10 + 2	2 yrs	5 / yr (CMAI Padhar Cancer Hospital, Betul)

Courtesy: Dr P S Negi

According to the register of Association of Radiotherapy Technologists of India there are 700 RT Technologists working in India currently. To address the shortfall it is recommended:

- Increase the number of seats in exclusive training courses for RT technologists
- Introduce training courses for Dosimetrists
- Mandatory 3 month internship for all RT technologists and dosimetrists in a clinical radiotherapy department at either a secondary or tertiary level centre

Radiotherapy Package:

- Bunker Design & Floor Plan (Appendix I)
- Telecobalt Technical Specifications (Appendix II)
- Low energy LA Specifications (Appendix III)
- Dual Energy with Electron capability LA Specifications (Appendix IV)
- Mould Room requirements (Appendix V)

- Simulator (with or without CT option) Specifications (Appendix VI)
- 3-D TPS (with or without Inverse Planning Module) Specifications (Appendix VII)
- HDR Brachytherapy Specifications (Appendix VIII)
- Dosimetry & QA Requirement Specifications (Appendix IX)

Major Goals to be achieved in the XIth Plan

Thus the proposed plan for next 5-year plan should include the following

- Ensure existence of 1 primary referral centre in 4 adjacent districts
- Ensure existence of 1 secondary referral centre in every 2nd Govt. Medical College
- Ensure existence of 1 tertiary referral centre in each state
- Support indigenous technology (At least 30 Indigenous cobalt-Bhabhatron-next 5 years)
- Link up all RT centres via Tele-medicine with DICOM-RT connectivity
- Create necessary infrastructure for proper training of manpower (in next 5-years):

  Radiation Oncologists

  Medical Physicists

  Dosimetrists

  RT Technologists
- Training program for all RT professionals

  Short term: Seminars, Workshops, CMEs

  Long term: Fellowships, Courses
- Adopt uniform, transparent, creditable and accountable QA system
- Improve radiation protection and radioactive waste disposal program
- Create public awareness about cancer and role of RT in cancer control
- Mid-term appraisal and 5-year evaluation of the program implementation

Appendix I: Typical layout of an Ideal Radiation Oncology Department

Appendix II: Telecobalt: Technical Specifications

Parameters	Specifications
Source	Co60 radioisotope 2 cm diameter Pneumatic movement mechanism
Source head	Maximum capacity 250 RMM Shielding: uranium and lead encased in a welded steel structure
Collimator	Two pairs of motorized uranium jaws Field size: Max. 35×35 cm2 and Min.5×5 cm2 at SAD=80cm Rotation: ± 90º around its central axis Field size indicator : Digital display
Gantry	Source head and its counterweight are mounted on it Can be rotated about a horizontal axis by ±180º
Source to isocenter distance	80 cm
Floor to isocenter distance	128 cm
SSD indicator	Optically projected over the field (Range: 60 – 100 cm)
Patient couch	Vertical limit : 67 to 167 cm from floor Longitudinal : 100 cm, Lateral : ± 18 cm, Rotation : ± 95º
Control console	Computerized (partially or fully) Digital display indicating exposed time and set time Source position indicator ON/OFF switch Patient and treatment database Treatment data interlock Interlocks for wedge, shielding tray, tissue compensator Gantry, collimator and couch motions Emergencies stop switch
Control hand panel	Gantry, collimator and couch motions Room lights and lasers Emergencies stop switch
Accessories	Standard Wedges15,30,45 for different field sizes Standard Blocks (rectangle, triangle, kidney, pencil eye block) Breast cone (half-beam block) Compensator set
Standards	IEC 60601-2-11

Appendix III: Low Energy Linac Technical Specifications

Parameters	Specifications
Photon Energy	4 or 6 MV for
RF Source	Klystron / Magnetron
Wave-guide Type	Standing wave / Traveling wave
Electron Gun	Sealed / Demountable
Treatment Modes	Normal - TSD / TADRotation - CW / CCW
Dose-Rate	Photons: Normal: 100 - 600 cGy / Min Photons: Special low dose rate: £ 100 cGy/ Min
Field Size	Maximum - 40 x 40 cm^2 Minimum - 3 x 3 cm^2 or less Penumbra should be <10mm for 10x10 cm^2 field at 10 cm depth
Beam Flatness	± 3 % For photons field sizes 10 x 10 cm and above (central 80% zone of the field) ± 5 % For lower field sizes and ± 5 % for electrons
Beam Symmetry	< 3 % for all the field sizes (Photons & Electrons)
Gantry	Rotation ±180° (360° total) Read out - Digital and / or Mechanical Control - Hand pendent and control-console Target - Axis Distance. - 100 cm ODI Range- 80 cm to 130 cm Gantry rotation Isocenter: £ 2 mm dia. sphere No beam stopper
Collimator	Rotation - ± 95° Readout accuracy ± 0.5° Collimator rotation isocenter £ 2mm dia. sphere Control - Hand pendent and control- console Isocenter to collimator base distance Independent jaws movement (at least one jaw, preferably both jaws)
Portal Imaging (EPID) : optional	Type of detectors Retractable arm
Treatment Couch	Movements: Versatile extended range

Appendix IV: Dual Energy Linac Technical Specifications

Parameters	Specifications
Photon Energy	6,10,15 or 18 MV for Dual energy Linac
Electron Energies	5-6 Energies selectable from 3 to 20 MeV
RF Source	Klystron / Magnetron
Wave-guide Type	Standing wave / Traveling wave
Electron Gun	Sealed / Demountable
Treatment Modes	Normal - TSD / TAD Rotation - CW / CCW Arc - CW / CCW
Dose-Rate	Photons: Normal: 100 - 600 cGy / Min Photons: Special low dose rate: £ 100 cGy/ Min Electrons: Normal: 100-500 cGy /Min Electrons: Special high dose rate: ³ 800 cGy / Min
Electron Arc	Optional
Field Size	Maximum - 40 x 40 cm^2 Minimum - 3 x 3 cm^2 or less Penumbra should be <10mm for 10x10 cm^2 field at 10 cm depth
Electron Cones	- Electron Cone Applicator System with mould kit for individualized shielding blocks - Touch plate safety interlock
Beam Flatness	± 3 % For photons field sizes 10 x 10 cm and above (central 80% zone of the field) ± 5 % For lower field sizes and ± 5 % for electrons
Beam Symmetry	< 3 % for all the field sizes (Photons & Electrons)
Gantry	Rotation ±180° (360° total) Read out - Digital and / or Mechanical Control - Hand pendent and control-console Target - Axis Distance. - 100 cm ODI Range- 80 cm to 130 cm

Parameters	Specifications
	Gantry rotation Isocenter: £ 2 mm dia. sphere No beam stopper
Collimator	Rotation - ± 95° Readout accuracy ± 0.5° Collimator rotation isocenter £ 2mm dia. sphere Control - Hand pendent and control- console Isocenter to collimator base distance Dynamic / virtual Wedge Both Jaws independent movement
Multileaf collimator (MLC)	Number of leaves Leaf width at Isocenter £ 10mm Accuracy of the leaf movements Over center travel Maximum field length DivergenceOther details
Portal Imaging (EPID)	Type of detectors (preferable amorphous Silicon) Retractable arm MLC Dosimetry Other details
Treatment Couch	Movements: Versatile extended range

Appendix V: Mould Room requirements

3-D Styrofoam / Block & Compensator Cutter	Computer controlled Based on CT pixel data Milling of Styrofoam Milling of alloy directly for compensator Possibility of producing IMRT calculated beam modifiers Connectivity to treatment planning system/CT scanner
Water bath	With thermostat
Heat gun	With temperature range for thermoplastic cutting
Kavo hanging motor with hand piece & accessories	For Thermoplastic modification
Ostalloy	100 Kg (Bismath-50%, Lead-25%, Cadmium-13%, Tin-12%)
Alloy melting pot	With thermostat
Block tray cart/ Block tray cabinet	Storage / transfer of blocks
Drill press with drill bit set	Should have tap dispenser
Lathe Machine	For cutting Perspex sheets, designed applicators and fabricating new gadgets
Immobilization devices	Including neck rests, Base plates for Plaster of Paris & Orfit moulds for various sites, Head rest set, Breast boards, Vacuum cushion sets.
Positioning Lasers	One sagittal and two cross lasers

Appendix VI: Simulator with / without CT option

Parameters	Specifications
Gantry	A minimum rotation ±180 with accuracy of ± 1 degree. Gantry rotation isocenter accuracy: < 2mm spherical diameter without accessories Digital and Mechanical readout Control - Hand Pendant (local) and Control console (Remote) with variable speed Readouts at local & remote locations. Readouts accuracy: ± 1^0 / resolution: 0.1^0 Collision avoidance system: logic and mechanical. Auto setup facility
Focus to Axis Distance (FAD)	A minimum of 80-140 cm Local as well as Remote control with the accuracy of ± 2mm. Digital readouts at local and remote locations. Readouts accuracy: ± 2mm / resolution: 1mm. Auto setup facility.
Collimator	Rotation of ±180 degrees with local and remote control. Collimator rotation isocenter: £ 2mm spherical diameter Local as well as Remote control facility. Digital & mechanical readouts at local and remote locations. Readouts accuracy: ± 0.2^0 / resolution: ± 0.1^0 Reticules for 80 cm and 100 cm FAD. Should be capable of taking over 10KG load of Block trays etc. Auto setup facility MLC Shape Projection if available.
Control Console	Microprocessor based Display type of X- and Y-delineator readouts Gantry and Collimator angle readouts Field Size readouts. Table Top Position readouts (vertical, longitudinal, and lateral) Specify number of Monitors & computer - Hardware in Control Console area. Connectivity to network system
Optical Distance Indicator (ODI)	Range of 75 -140 cm. Accuracy to be ± 2mm for 80 cm to 120 cm

Parameters	Specifications
Couch	Versatile extended range movements Electrical and mechanical control Local and Remote control Digital & mechanical readouts at local Digital readouts at remote location Accuracy of couch movement: ± 2mm / ±1^0 Maximum focus to tabletop distance ~180cm Auto setup for all couch movements Carbon Fiber Table top, composition, attenuation, size and deflection Transmission of Tabletop: ~1mm Al equivalent or more
Safety Features	Collision Avoidance system for couch and Imaging System. Emergency switches at the hand pendant, couch and remote control console
Field Size	*Delineator wires* 3 cm x 3 cm to 40 cm x 40 cm at 100cm FAD Digital readouts Symmetric & Asymmetric movements with cross over. Local and Remote control. Readouts Accuracy: ± 1 mm at FAD 100cm. Resolution: 1 mm.
	X-Ray shutter 3 cm x 3 cm to 45 cm x 45 cm at 100cm FAD with accuracy of ± 1mm. Symmetric & Asymmetric movements with cross over. Local and Remote control. Tracking Mode Pairing Mode
Isocenter	Isocenter tolerance should be within the spherical diameter of 2 mm. Minimum Floor to Iso-center distance should be less than 130 cm.
X-Ray Generator	Radiographic rating-300 mA at 125 kV; Radiographic mA control: 50 - 500 mA

Parameters	Specifications
	Radiographic mAs range: 1 to 500 mAs; Radiographic kVp control - 40 to 125 kV Anatomical programming; Automatic exposure control kV, mA, mAs controls with independent selector Fluoroscopic ratings- 20 mA at 125 kV; Fluoroscopic kV_p control - 40 kV_p to 125 kV Fluoroscopy mA range- 1 to 20 mA in 1 mA steps Automatic brightness control; Zooming facility; Pulsed Mode if available
X-Ray Tube	Ratings of the X-ray tube to be specified. Focal spot size: small £ 0.6mm: Large £ 1mm Target angle ~ $16^{0.}$ High speed Rotating Anode type Anode heat storage capacity Anode heat dissipation capacity Details of target material and tube housing Tube Housing Heat Storage Capacity and It's Cooling rate
Digital Fluoroscopic Imaging System	*Image Intensifier* Lateral movement range. Longitudinal movement range. Vertical movement range. Resolution lp / mmHigh Resolution image storage with built-in frame averaging and image reversal. Auto -Centering facility. Image Area Size 30cm X 30cm dia. or higher CCD Camera with digital imaging chain High resolution flat monitor size 20" or more Any other advanced Imaging System
Film Cassette Holder	Stationary or rotating type Should hold Grids Anti-collision guard Cassette holder to hold Cassette of standard sizes from 8"X10" to 14"X 17
Software Features	*Auto Setups* Acquisition & storage of fluoroscopic Images in digital form. Auto correction for end skewness (provision for calibration) Facility to merge images taken from different parts. Quad & Dual Image Merge.

Parameters	Specifications
	MLC overlay on Fluoroscopy Image. Patient image-database management facility. Networking to Treatment planning system. Any additional Features
Accessories	Front Pointer Interface Mount to be provided for the accessories like shadow Block Tray etc. Laser System: 2 cross & 1 Line lasers Arm Rest
Up-gradation feature	AccessoriesHardware; Software
OPTIONAL	
CT Option	Image quality ~2 mm spatial resolution and ~1% density resolution Scan circle for particular aperture Aperture sizeAcquisition time ~1 min/slice Reconstruction time ~1to 2.5 min. Video Monitor (High resolution)
Hardware Feature	Collimator Attachment (details) Detectors Attachment (details) CPU & Architecture Hard disk storage capacity Image memory size Graphic overlay
Software Feature	Pan / Zoom facility Multiple image display Image Annotation facility Readout of CT numbers Window & labeling facility Distance measuring facility Manual image sequencing facility Image storage Image storage media and its capacity (size) Storage media for archiving Export capability: DICOM-RT/ Ethernet with TCP/IP Hardcopy device: single & multiformat film/ paper Any other information
Film Processor	Manual or Automatic

Appendix VII: External Beam Radiation Therapy: Treatment Planning System

Hardware

- Processor: 1.7GHz or higher
- Hard disk Memory (quote highest available)
- RAM (quote highest available)
- Interface to CT, MRI and PET image transfer
- Interface to Local area networking- Dosimetric beam data interface
- Flat High graphical resolution 18"/ 14" monitor.
- CD ROM drive
- DAT drive or ZIP drive for back up
- Optical MOD drive.
- High resolution film scanner to transfer CT/ MRI images
- Digitizer
- 600 dpi laser jet printer and plotter.
- Keyboard and Mouse (as required)
- Connectivity to Record & Verifying System

Software

- 3 Dimensional Voxel based planning software using measured beam data and Pencil beam / Monte Carlo beam models for all photons and electron energies in therapeutic range
- Correction for in-homogeneity and body obliquities
- Coplanar and Non coplanar Photon electron fields
- Combined beam plans of different energies and different modalities.
- Irregular, asymmetrical fields
- Photon and electron rotational and arc therapies.
- MLC, wedges, Blocks and compensators
- IMRT: inverse planning for dynamic and static dose delivery methods
.- SRS and SRT
- Dynamic arc therapy.
- Electronic Compensators
- Dynamic / Virtual / Motorized wedges
- Plan evaluation by dose volume histograms,
- 3D image reconstruction using CT images
- Multi planar image reconstruction
- Beams Eye View
- CT/ MRI/ PET image registration and image fusion.

Appendix VIII: Remote Afterloading HDR Brachytherapy Specifications

Treatment Unit	A high dose rate Brachytherapy unit capable of intracavitary, interstitial, intraluminal, intraoperative and surface mould radiation therapy. Unit should be on wheels for easy mobility Motorized head movement for various heights Check cable that ensures the treatment path is clear and free from obstruction Separate stepper motors to control the check cable and source cable Built- in radiation detector1 8-24 treatment channels Source retractable mechanism in the event of emergency or power failure. Battery backup for emergency Source container, Transport container, Emergency container Patient couch / trolley with necessary accessories for treatment
Control Console	Stand alone and independent PC based control unit with colour monitor, keyboard, mouse, printer Network facility to treatment planning system Access to authorized user with password protection Automatic decay correction Storage of multiple standard configuration Keeping track of patient's fractionated treatment Treatment length: 12-50 cm with a step size of 2-10 mm step size Dwell position display and Dwell time display Source maximum extension length 1500 mm Display of indexer length, activity and dose In built protection to prevent treatment without proper connection and proper indexer locking Online extensive display of status code with an indication of the action required Built in log book Back up of patient data to an external storage device
Radiation source	Single Ir-192 source of activity about 10 Ci Active length 3.5 mm to 10 mm, Active diameter 0.3 mm to 0.6 mm

	Capsule length and Capsule diameter Treatment path curvature<1.5 cm Accuracy of positioning of source +/- 1 mm Supply of sources over 3 – 5 years
Applicators	Cervix applicators, Uterine applicators, Oesophagus applicator, Bronchus applicator Nasopharynx applicator, Tongue applicators, Bile duct applicator Breast implant template set, Prostate implant template set, Perineal implant template set Implant needles: steel needles & trochar, Nylone tubes (plain & loop) flexible
TPS for HDR brachytherapy	Treatment planning system 3-D TPS capable of carrying out the planning of HDR stepping source for all sites DVH algorithm and Optimization algorithm Transfer of treatment planning data to control console Input devices: Digitizer/ Film scanner/ DICOM-RT interface Facility for combining external RT and brachytherapy
Quality Assurance Tools	Source position check device Source calibration jig Auto radiograph kit
Essential Spares	List of spare parts Manuals & Isodose charts

Appendix IX: Dosimetry & QA requirements

Chambers	Following chambers for X & ³ rays (in the energy range of 30 keV – 50MV), electrons and brachytherapy 0.6 cc Farmer type ion chamber (PMMA) with Aluminum electrode, with build up cap for cobalt energy, water proof 0.125 – 0.015 cc thimble detector water proof 0.4 - 0.055 cc Parallel plate chamber 200 cc well type chamber
Electrometers	Electrometer reader compatible with all the chambers above Polarizing Voltage: 400V (max) in steps of 50V Useful to Co-60, Accelerators, LDR and HDR measurements Sensitivity up to 200 Na Range: 0.01 pC to 999.999 nC Meter linearity: $\leq \pm$ 0.5% Digital display Option to select type of measurement (charge; current; radiological) Dose/Dose Rate mode Auto switching of range Signal input connector- M-type, BNC with banana plug, TNC Connection cable-20 m
Check Source	Source with calibration certificate
Phantoms IMRT/3D QA PhantomSolid tissue equivalent Water phantom	Accommodative of Ion chambers, TLD chips, MOSFET, Diodes, Ready Pack Films and radio chromatic films Absolute dose verification Correction verification of TPS 3D volumetric/Depth Dose verification 30cm x 30cm x 5cm Cavities to hold various ion chambers 1mm to 5mm , 10 mm thick sheets of same type each 30 x 30 x 30 cm^3 Multiple airtight chamber holders arranged in a linear array for absolute dose rate measurements and relative depth dose measurements Chamber holder that can be moved (thumb-wheel assembly) continuously through vertical and horizontal direction

Survey Meters	Energy: b, x, g Ion chamber type detector Dose/Dose Rate mode Range: Upto 5R/hr Auto switching of ranges Audio Digital Display
Zone Monitors	Energy: b, x, g Range: upto 100mR/hr Analog meter/Digital meter Audio Re-chargeable battery back-up
QA Tools	Beam flatness symmetry check device Isocentre check tool Any other
Radiation Field Analyser (RFA)	Water phantom
Scanning Volume	48x48x48 to 60x60x50 CC
Scanning speed	0.5-5 cm/sec
Mode of scanning	Continuos & Steps
Position Reproducibility	Min 0.1 MM
Position accuracy	+/- 0.5 MM
Electrometer	
Type	Dual Channel
Range	10 E -6 A to 10 E -14 A: Full scale range
Resolution	1 x 10 E -14 A
Polarizing Voltage	+/- 500 V - Steps of 1 or 5 V
Time Constant	20-50 ms Both channels
Calibration	Absolute calibrated
Modes	Dose and Dose Rate
Leakage	< 1 x 10 E –15 A
Mains Voltage	220 V/50 Hz

Water Reservoir	(Lift Table & Water Tank)
Tank water capacity	200-300 Liters
Pump mechanism	Drain and Filling Two way
Lift table operation	Electrical
Lift table motion (vertical)	70-120 cm
Leveling Mechanism	Accurate (inbuilt if any) Spirit level
Detectors	All calibrated. Absolute option.
Thimble ionization chambers	Signal & reference 0.1-0.13 CC (n=2)
Thimble ionization chambers	Stereotactic 0.01- 0.04 CC (n=1)
Diode detectors	Signal & reference Active area 2 mm (n=2)
	Electron 2 mm (n=1)
	Stereotactic Active area 0.3-0.6 mm (n=1)
Parallel Plate	Electron Active area 0.05-0.15 CC (n=1)
Inner electrode	Graphite/PMMA
Diode Detector Array	24-25 Detectors Spatial resolution 5 mm & Dose rate resolution (2-30 Gy/Min) (n=1 set)
Cables	10 Meters (n=2)
Connectors	TNC (n=2)
Build up caps	Perspex and Brass (both separately) For all photon energies ranging from Co60-18MV
Air Scanner	1 D Gantry Mounted Compatible to all chambers Holders for all chambers (n=1)
TMR/TPR Measurement Set	Probes, sensor, cables, Electrometers etc.Compatible to water reservoir and Phantom (n=1)
Reproducibility & resolution	0.1 MM
Position linearity	+/- 0.1 MM

Filling & drawing speed	3-5 cm/min Smooth function
Hardware	Pentium P4. CPU 600 MHz
	20 GB HD, 64 MB RAM ,Internal Modem
	CD ROM, 1.44 MB Floppy
	Backup & Restore Facility
	Monitor Color, 14-21", VGA, Graphics card
	Film scanner Vidar-16
	Printer/Plotter Laser-jet: A3 & A4 paper size
Software	DOS/Windows 95 or higher
	Windows based beam data acquisition & analysis software which support many peripheral measuring devices.
	Interface to data transfer to Treatment Planning Systems
	Protocols for analysis of beam data

This is to state that the following members of the Radiation Oncology sub-committee are in full agreement with the contents of this draft proposal for strengthening and augmenting the infrastructure of Radiation Oncology during the XIth Five year plan of NCCP (2007-2011)

Chairman

Dr (Mrs) K A Dinshaw ..... 20 Jan 06

Members

Dr G K Rath 31-1-06

Mr M Singh .....

Dr N K Mehta ..... 1st Feb 06

Dr P S Negi 31/1/06

Dr R Sarin 31/1/06

Dr S C Sharma 1/2/06

Dr S K Srivastava .....

Dr T Gupta 25/1/2006