HIGH DOSE RATE SOURCES AND DELIVERY SYSTEMS

Rupak K. Das, Ph.D.

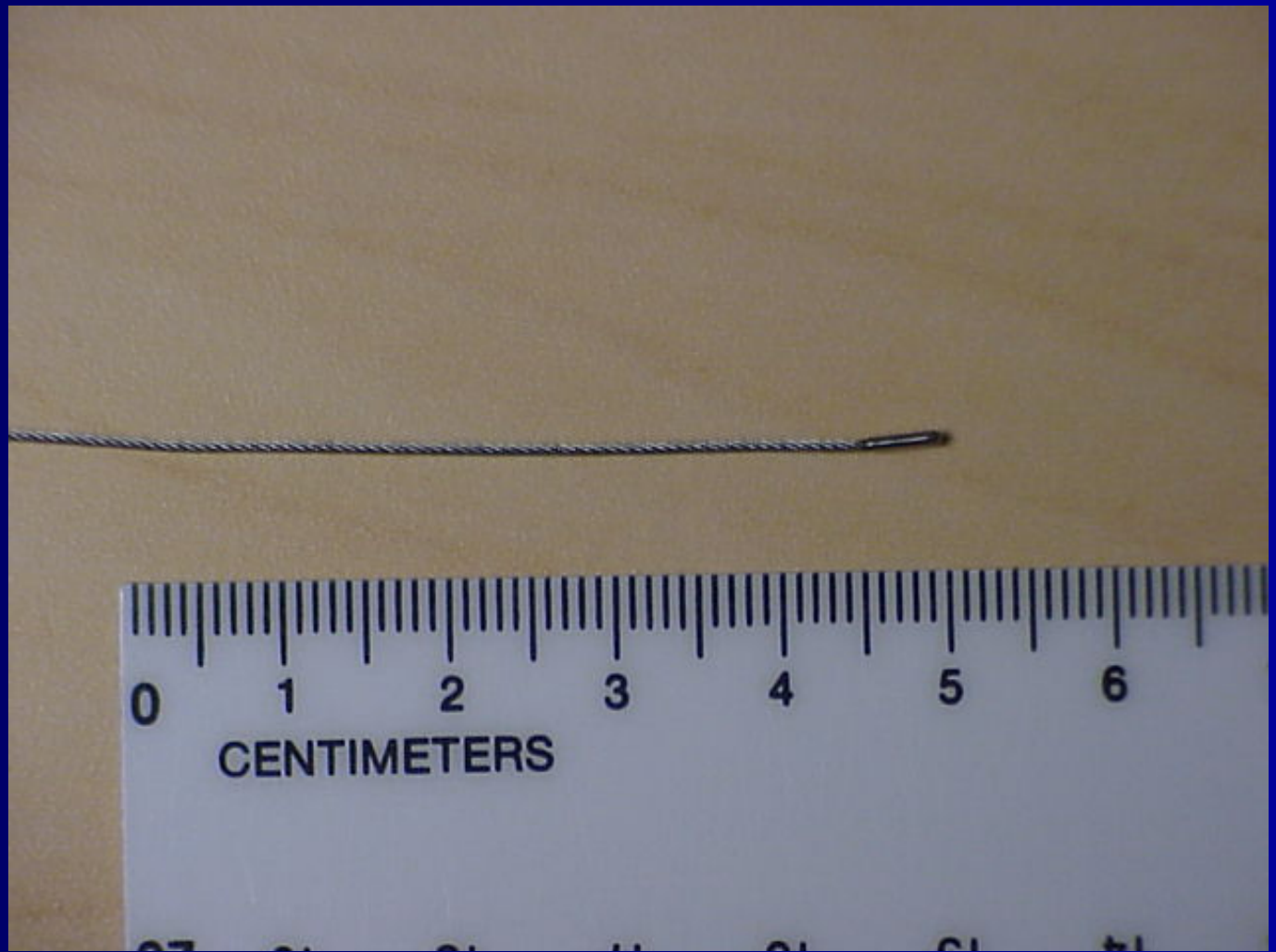
AAPM/ABS School of Brachytherapy Physics

July 19, 2005

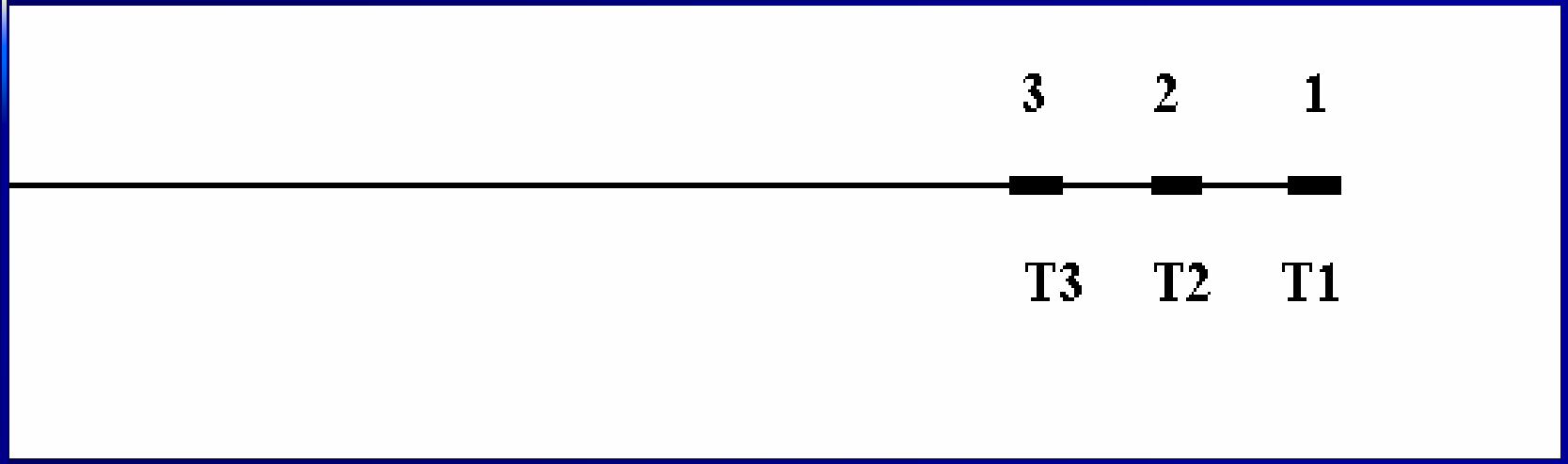
Dose Rate

- Low : Continuous, 2 Gy/h at 1 cm.
- Medium: Continuous, 2Gy - 12Gy/h at 1 cm.
- High: Discrete (weekly), 12Gy - 42Gy/h at 1 cm.
- Pulsed: Discrete (hourly), simulates LDR.

HDR source with cable



Single Stepping Source



1, 2, 3 - Dwell positions

T1, T2, T3 - Dwell times

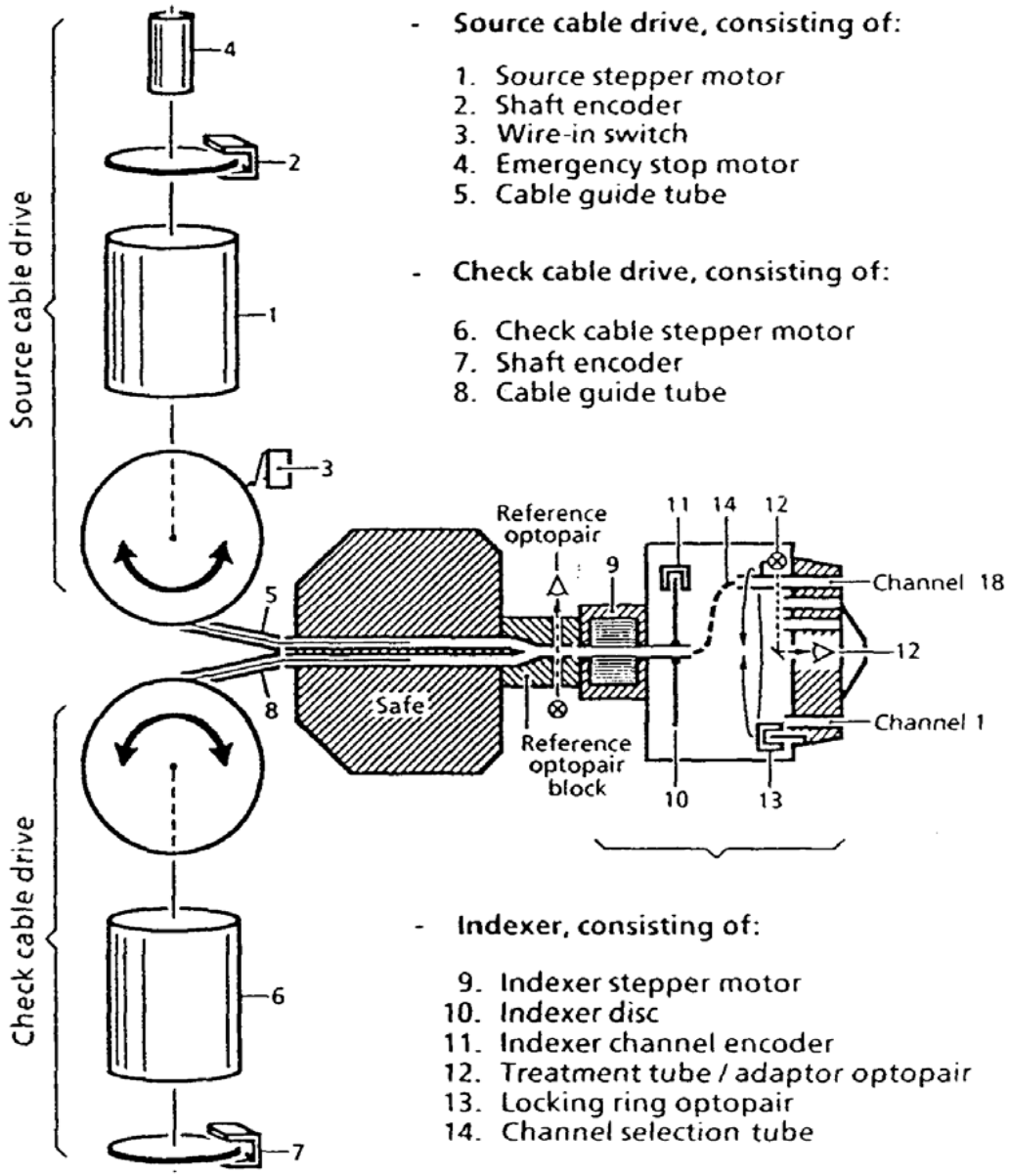
HDR RALs

Specific features of 3 HDR RALs.

	MicroSelectron V_2	GammaMed+	VariSource 200/200t
Vendor	Nucletron	Varian	Varian
Sources	10Ci of ^{192}Ir	10Ci of ^{192}Ir	10Ci of ^{192}Ir
Source Dimension	3.5mm L, 1.1mm OD	4.52mm L, 0.9mm OD	5mm L, 0.59mm OD
Source Cycle	25,000 transfer	5,000 transfer	5,000 transfer
Channels	18	2,3 or 24	20
Source Extension	1500mm	1300mm	1500mm
Channel Length	Variable	Fixed	Variable
Source Movement	Stepping forward	Stepping backward	Stepping backward
Step sizes	2.5, 5 or 10mm	1-10mm, 1mm steps	2-99mm, 1mm steps
Dwells/channel	48	60	20

Components of HDR RALs

- Shielded Safe
- Radioactive Source
- Source Drive Mechanism
- Indexer
- Transfer Tubes
- Treatment Control Station
- Treatment Control Panel



- **Source cable drive, consisting of:**

1. Source stepper motor
2. Shaft encoder
3. Wire-in switch
4. Emergency stop motor
5. Cable guide tube

- **Check cable drive, consisting of:**

6. Check cable stepper motor
7. Shaft encoder
8. Cable guide tube

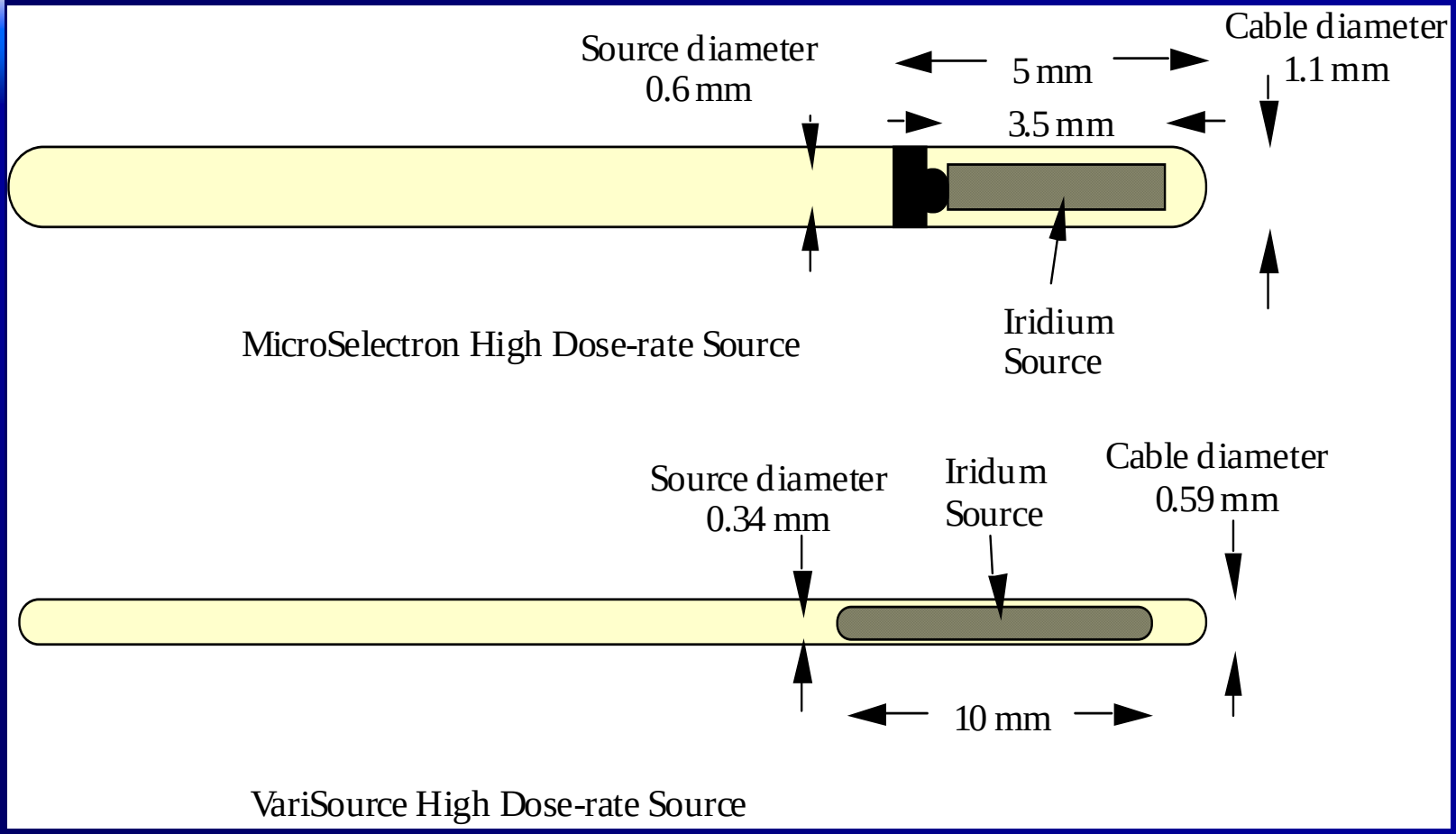
- **Indexer, consisting of:**

9. Indexer stepper motor
10. Indexer disc
11. Indexer channel encoder
12. Treatment tube / adaptor optopair
13. Locking ring optopair
14. Channel selection tube

Shielded Safe

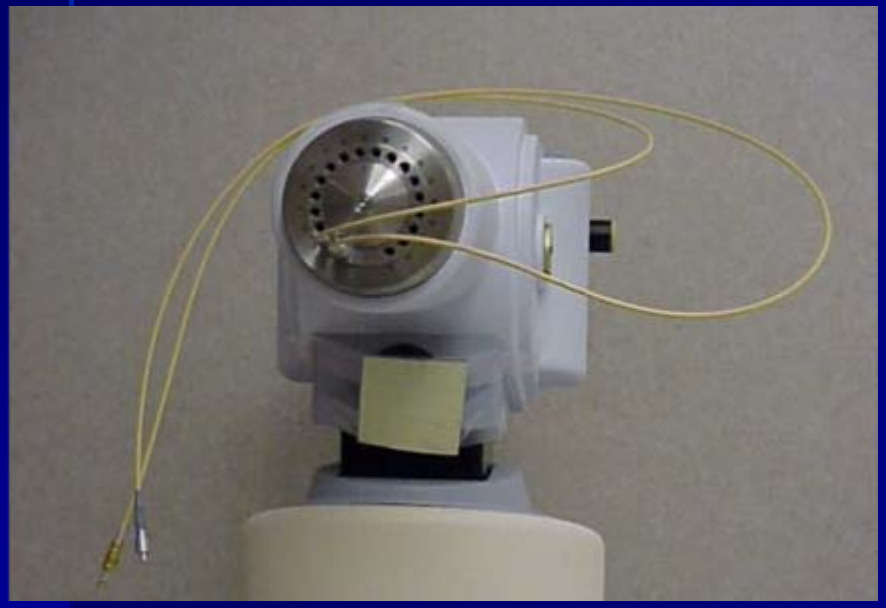
- ^{192}Ir source of 5 - 10 Ci provides a dose rate of 7Gy/min at 1cm from the source.
- Shielding needed to reduce the air kerma rate to 1-4μGy/h.
- Tungsten or depleted uranium provides the shielding.

HDR source


Source diameter
0.6 mm
5 mm
Cable diameter
1.1 mm
3.5 mm
Iridium
Source
MicroSelectron High Dose-rate Source
Source diameter
0.34 mm
Iridum
Source
Cable diameter
0.59 mm
10 mm
VariSource High Dose-rate Source

Indexer

Transfer Tube



Treatment Control Station

Treatment Control Panel

Safety Features

- Emergency Switches
- Emergency Crank
- Door Interlock
- Audio/Visual System
- Radiation Monitor/Treatment On Indicator
- Emergency Service Instruments
- Back-up Battery

Emergency Crank


MANUAL RETRACT
YUASA
6V,10Ah

Typical situation	Distane [m]	Dose equivalent rates [Sv/h]	Time to receive 10 Sv (Likely injury)		Time to receive 0.05 Sv (Annual body limit)	
In Patient	0.01	460 Actually more like 4.6R/mCi h * 0.966 rem/R=4.44 =>444 Sv/h	1.35	min	0.007 0.4	minutes seconds
Handling with Kelly Clamps, to hands	0.1	4.44	2.3	hours	0.67 (10	minutes minutes for hand limit)
Handling with Kelly Clamps, to body	0.3	0.5	20	hours	0.10	hour
Standing near	1	0.044	9.5	days	1.1	hours
Standing far	2	0.012	34.7	days	4.5	hours

Shielding

- For a 10Ci source exposure rate is 45mSv/h at 1 meter.
- Limits
  - Public (annual): 1mSv
  - Occupational (annual): 50mSv
  - Dose rate (unrestricted): 0.02mSv/h
- ALARA - 10% of Limits
- Shielding
  - 40 to 50cm concrete (5' from the source)

Quality Assurance

- Verification of Dose Variables
  - Source Strength, Time.
- Verification of Position Control
  - Location, Coincidence, Consistence
- Verification of Proper Operation of Safety Features
  - Interlocks, Detectors, Emergency, Interrupt.

Costs

- Remote Afterloader + Treatment Plan + some applicator with transfer tubes
  - $0.5 - 1.0M
- Shielding + Emergency Systems
  - $0.5 - 0.75M

Advantages

- Safety
- Optimization
- Stability
- Dose reduction to normal tissue
- Applicator size
- Out-Patient Treatment

Disadvantages

- Investment ($1M - $2M)
- Complexity
- Compressed Time Frame
- Radiobiology