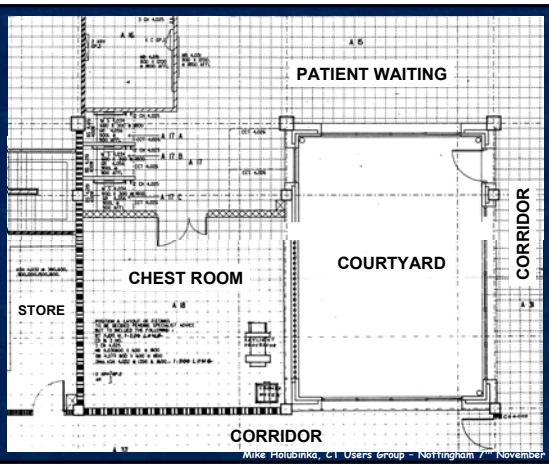
Taking it on the chest…. when planning assumptions change

Mike Holubinka
Radiological Sciences Group
Portsmouth Hospitals Medical Physics Service

- Conversion of chest room to CT suite
- Original design & alterations
- Assessment of environmental protection
- Assessment of environmental doses
- Legal requirements under IRR 1999



Original design specifications – whole department

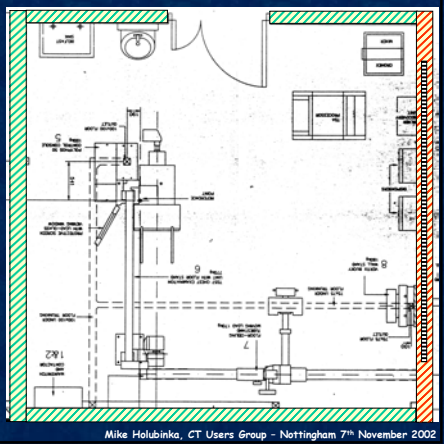
Internal walls	190mm dense concrete 2000 kg/m^3
	PbE ~2mm (? Energy)
External walls	190mm aerated concrete 850 kg/m^3
	PbE ~0.8mm (? Energy)
	100mm red brick 1850 kg/m3
	PbE ~0.7mm (? Energy)
Windows	Pilkington X-ray glass 5-7mm
(above 2.1m)	PbE ~1.5mm 100-150 kV

Design specifications

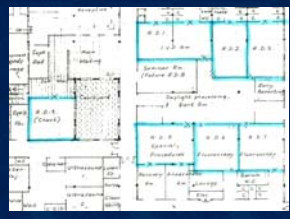
PbE ~2mm

PbE ~1.5mm

PbE 1.5mm



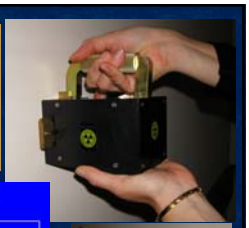
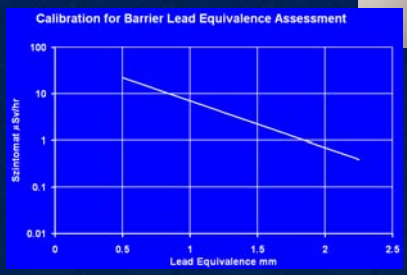
Commissioning of Radiodiagnostic Block 1990



37 GBq 241-Am (special form)

J.M. Hewitt NRPB
A self-contained method for assessing the lead equivalence of protective barriers in diagnostic X-ray departments
Journal of the Society of Radiation Protection Vol 2 1982



Survey findings from RD block commissioning 1990




Useful for:

Sampling PbE of structures

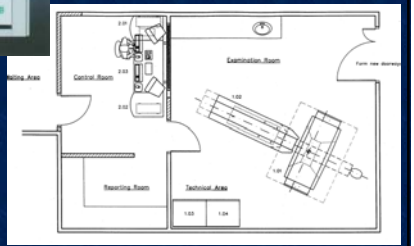
Assessing spot PbE

Verifying PbE post repair

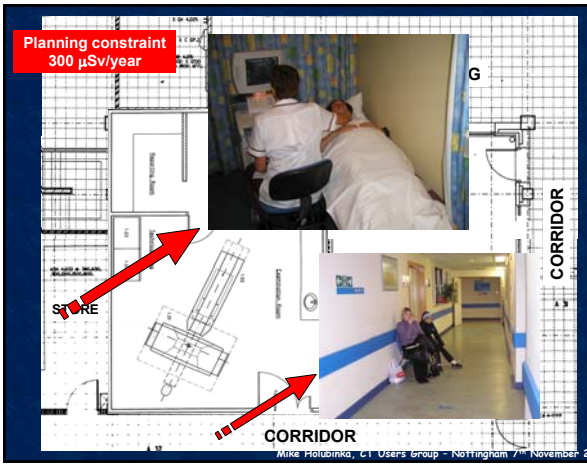
Internal walls >2mm PbE (241-Am energy)

– March 2001 –

Siemens Plus 4 Volume Zoom (Sensation 4)
Combined Diagnostic & Oncology



? Shielding requirements

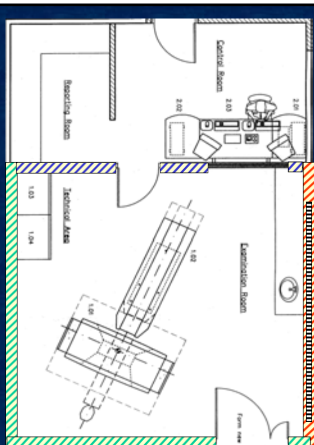


Existing & adequate ?

- PbE ~2mm
- PbE ~1.5mm
- PbE 1.5mm

New construction

- ? PbE

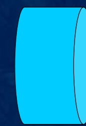


	1,50m	1,00m	0,50m	0,00m	0,50m	1,00m	1,50m
1,50m	0,0121	0,0326	0,042	0,0450	0,0405	0,0315	0,0086
1,00m	0,0036	0,0175	0,0792	0,0958	0,0750	0,0241	0,0034
0,50m	0,0016	0,0020	0,1889	0,3316	0,1931	0,0020	0,0016
0,00m	0,0016						0,0015
0,50m	0,0045	0,0271	0,2045	0,3943	0,1951	0,0238	0,0038
1,00m	0,0302	0,0491	0,0766	0,1051	0,0743	0,0476	0,0277
1,50m	0,0226	0,0300	0,0367	0,0442	0,0364	0,0291	0,0215
2,00m	0,0160	0,0191	0,0212	0,0225	0,0209	0,0185	0,0155
2,50m	0,0120	0,0129	0,0135	0,0134	0,0132	0,0126	0,0111
3,00m	0,0084	0,0092	0,0094	0,0092	0,094	0,0090	0,0085

Siemens Plus 4 Volume Zoom / Sensation 4

Doses in air µGy/mAs

(gantry centre height)



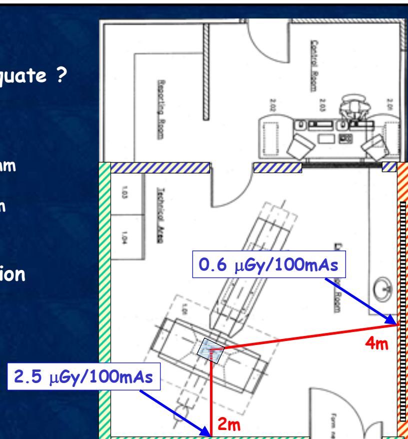
32 cm PMMA phantom
16 cm length
140 kV
20 mm slice

Existing & adequate ?

- PbE ~2mm
- PbE ~1.5mm
- PbE 1.5mm

New construction

- ? PbE



PART 2

PROTOCOLS

1. **Head**
   1A. Routine Head Scan
   1B. Spiral Brain Scan – 2 Blocks
   1C. Spiral Brain Scan – Single Block
2. **Brain Angio**
3. **Orbits**
   3A. Orbits (Soft Tissue)
   3B. Orbits (Bone)
4. **Sinuses**
   4A. Landmark
5. **Petrous Temporal Bones**
6. **Neck**
   6A. Neck (General)
   6B. Neck High Resolution
7. **Chest - Routine**
   7A. High Resolution Thorax (HiRes SEQ)
   7B. Chest – Asbestos Protocol (Alones)
   7C. [illegible]
8. **Pulmonary Emboli**
9. **Thorax Cancer Staging (Chest & Liver)**
10. **Contrast Thorax, Abdomen & Pelvis**
11. **Abdomen/Pelvis – (General Survey)**
12. **Liver/Pancreas**
13. **Lymphoma/Seminoma Studies**
14. **Aortic Aneurysm Study**
    14A. Renal Angio
15. **Dental Scan**
16. **Hips**
    16A. FW Hips and Knees
    16B. Trauma Pelvis
17. **Spine**
    17A. Cervical Spine
    17B. Thoraco Lumbar Spine
    17C. Lumbar Spine for Discs
    17D. Pars Defect
18. **Extremity**
    18A. Shoulder/Shoulder Arthrogram
    18B. Elbow/Wrist
    18C. Knee
    18D. Calcaneum
19. **Multi Trauma**
20. **Biopsy/Drain**
21. **Radiotherapy Planning**
    21A. Head
    21B. Chest
    21C. Planning

Workload assumptions !

SOMATOM Volume Zoom Application Guide

	AbdFast
kV	120
mAs	155
Slice collimation	4 x 5 mm
Slice width	7 mm
Feed/Rot.	25 mm
Rot. time	0.5 s
Kernel	B30f
Increment	5 mm
Direction	cr-ca

	Native	Arterial phase	Venous phase
kV	120	120	120
mAs	155	145	155
Slice collimation	4 x 2.5 mm	4 x 1 mm	4 x 2.5 mm
Slice width	5 mm	1.25 mm / 5 mm	5 mm
Feed/Rot.	12.5 mm	5 mm	12.5 mm
Rot. time	0.5 s	0.5 s	0.5 s
Kernel	B30f	B30f / B30f	B30f
Increment	5 mm	1 mm / 5 mm	5 mm
Direction	cr-ca	cr-ca	ca-cr

Routine protocols Software version A20

Oncology patients 5-10 each a.m. (Chest/Abd/Pelvis)

Diagnostic patients 10-15 each p.m. (mixed)

Assume 20 patients/day, All Abdomens at 140 kV !

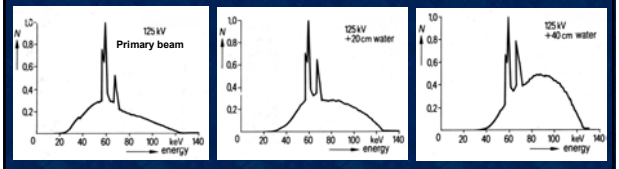
Worst case calculation of shielding requirements

Area	Corridor	Corridor
Dose at barrier (µGy/100mAs)	2.5	2.5
Effective mAs	120	120
Scanned length (mm)	250	250
Rotations	25	25
mAs per Abdomen	3000	3000
Patients per day	20	40
mAs per day	60000	120000
mAs per year	3000000	6000000
Occupancy	0.5	0.5
Dose at barrier/year (µGy)	37500	75000
Planning constraint (µSv/yr)	300	300
~~Transmission~~	~~0.008~~	~~0.004~~
Lead thickness (mm)	1.3	1.5
Concrete thickness (mm)	95	100
Wall thickness (>2mm PbE)	190 mm (dense)	

Assumed 10 mm increment for 20 mm scatter data

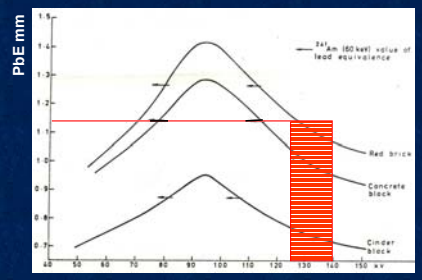
Spectral considerations

Siemens Somatom DR series



Increase in effective energy

Disparity between PbE (241-Am) *vs* PbE X-rays



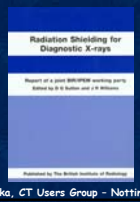
J.M. Hewitt
Journal of the Society of Radiation Protection Vol 2 1982

References:

An analysis of the assumptions and their significance in the determination of required shielding of CT installations
Michael D Harpen
Medical Physics 25 (2) February 1998

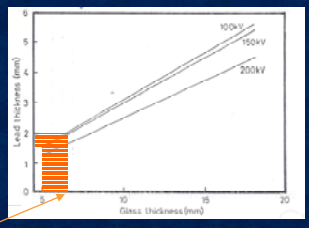
Secondary Shielding barriers for diagnostic X-ray facilities: Scatter and leakage revisited
Douglas J Simpkin & Robert L Dixon
Health Physics Vol 74 (3) 1998

Radiation shielding for Diagnostic X-rays
Report of a joint BIR/IPEM working Party
Edited by D.G. Sutton & J R Williams
BIR 2000



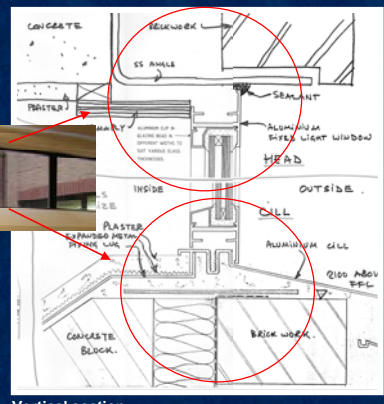
PILKINGTON

TECHNICAL INFORMATION NOTE
X RADIATION SHIELDING GLASS ITWB 46



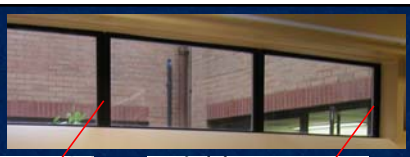
Nominal Thicknesses (mm)	Minimum Lead Equivalent For Stated Source 100 kV	110 kV	150 kV	200 kV	Approx. Weight kg. per 1000cm²
3.5 = 3	1	1	1	85	7.0
3 = 8.2	1.5	1.5	1.5	1.25	2.8
6 = 7.5	1.8	1.8	1.8	1.5	3.2
7 = 8.5	2.1	2.1	2.1	1.75	3.7
8.5 = 10	2.4	2.4	2.5	2.1	4.4
10 = 12	3.0	3.0	3.0	2.5	5.3
12.5 = 14.5	3.8	3.8	3.7	3.1	6.5
16 = 18	4.9	4.7	4.6	4.0	7.7

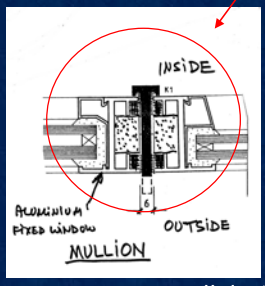
Heads & Cills ?

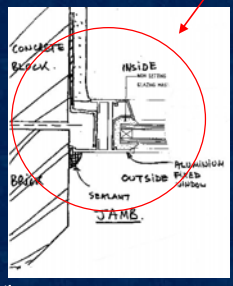


Vertical section

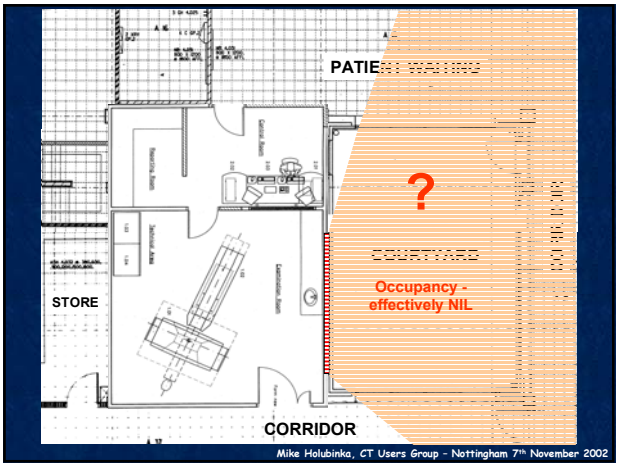
Mullions & Jambs ?





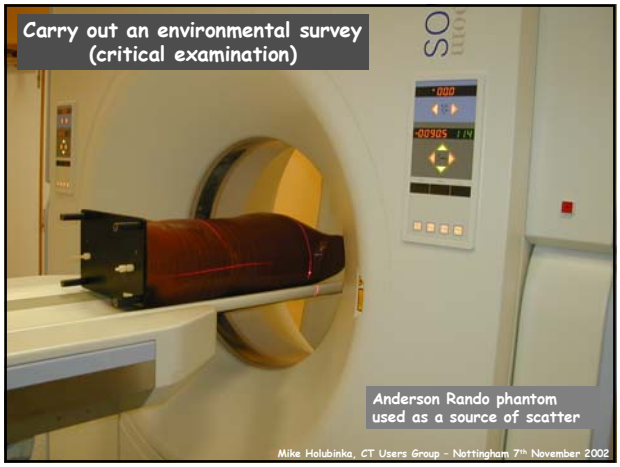


Horizontal section



Siemens Plus 4 Volume Zoom commissioned March 2001

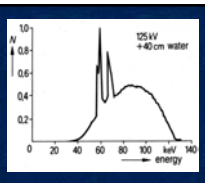
Carry out an environmental survey (critical examination)

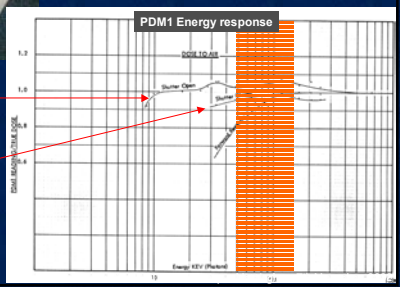


Anderson Rando phantom used as a source of scatter

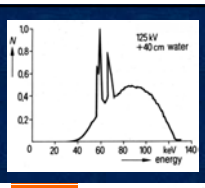
Measurement of ambient dose rates

Time constant ~1 to 10 sec

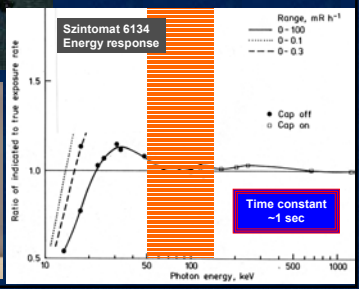




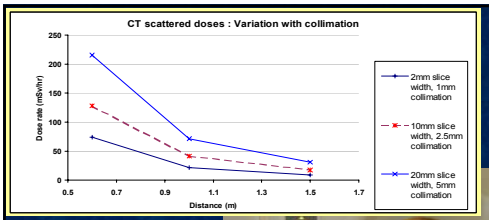
Measurement of ambient dose rates



Szintomat 6134
Energy response

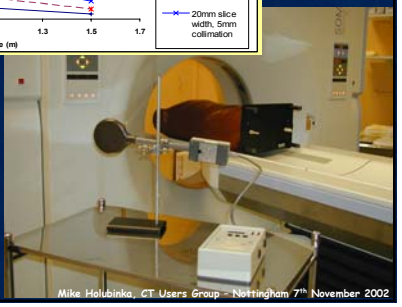


Time constant ~1 sec



Radcal 180cc
Integrated dose 10 µSv-10Sv
Energy response 30 keV-10MeV

Ct scans 140 kV
500 mAs, 1.5 sec
X-ray collimation 2, 10 & 20 mm

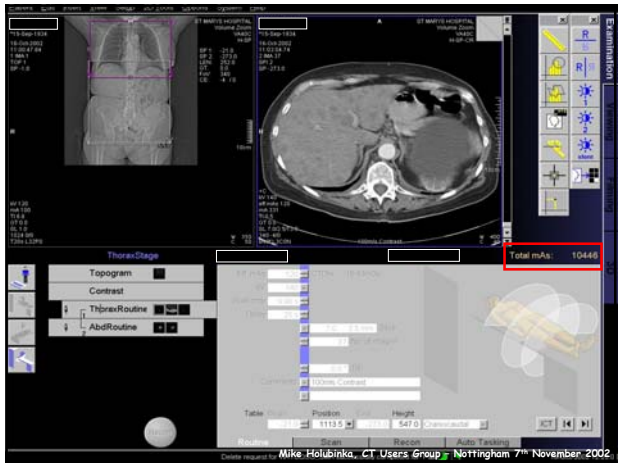


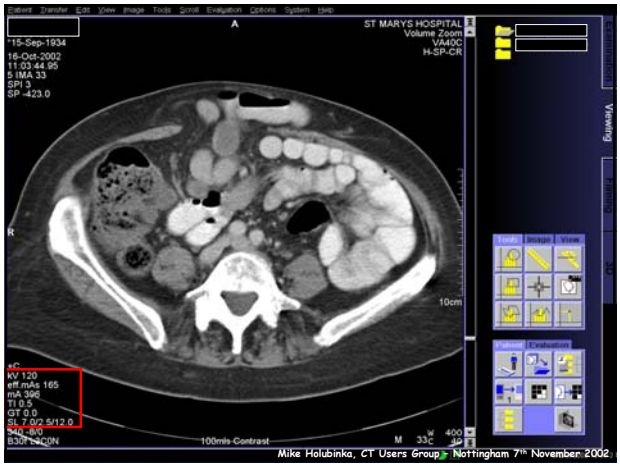
Measurement of ambient dose for 'worst case procedure'

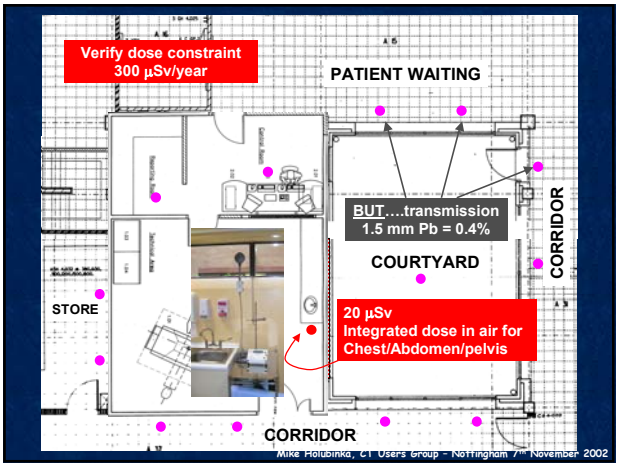
10) CONTRAST THORAX, ABDOMEN & PELVIS

Thorax – Thorax Staging

Scan 2 areas	-	1) Chest - apices to bases. 2) Abdo/Pelvis- domes diaphragm to lower border of symphysis pubis (i.e. slight overlap at lung bases).
kV	-	140
mAs	-	120
SLICE THICKNESS/COLLIMATION	-	3mm/2.5mm
FEED/ROTATION	-	13.8mm
ROTATION TIME	-	0.5 seconds
KERNEL	-	Chest - Medium Sharp Liver - Medium
RECON (Slice thickness/Increment)	-	Chest 1) 3mm/1.5mm to view - Virtuoso 2) 10mm/10mm to film (400/40) 3) 10mm/10mm (lung window) Abdomen/Pelvis 1) 3mm/1.5mm to view – Virtuoso 2) 10mm/10mm to film (400/40)
FILMING	-	20 format, 10mm axial slices
CONTRAST	-	100ml Omnipaque 300, at 3ml per second.

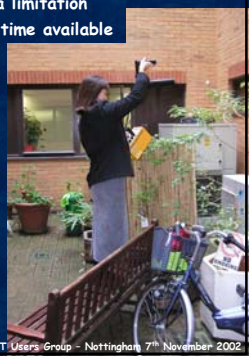


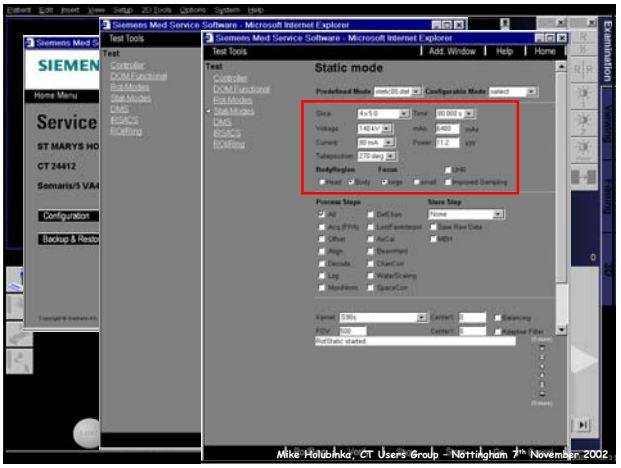




Measurement of ambient dose rates

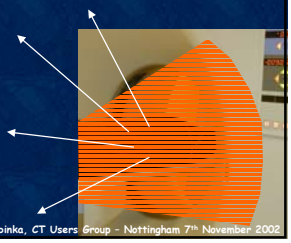
- Stable radiation field
- Instrument response not a limitation
- Survey whole area in the time available

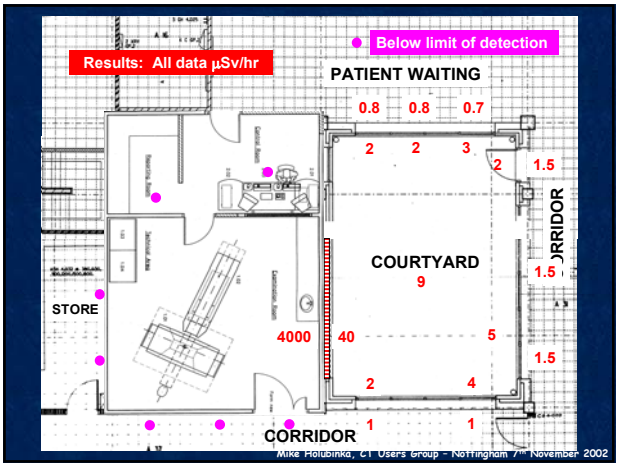


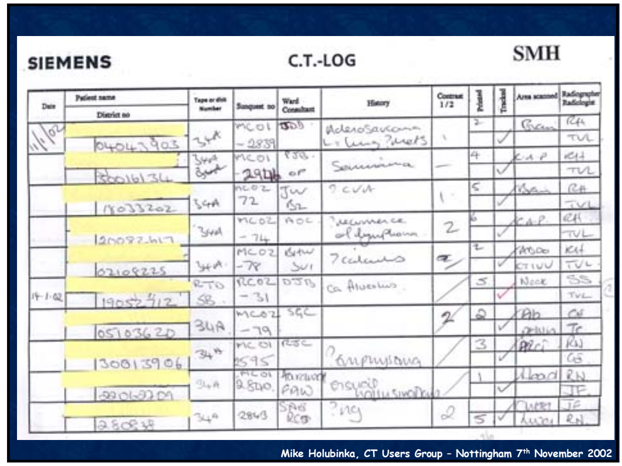


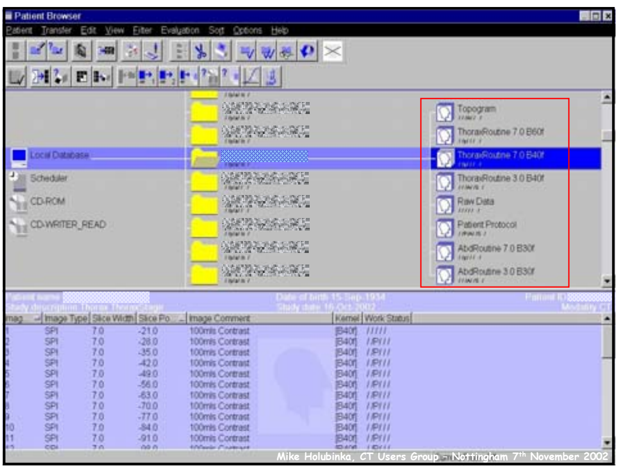
Measurement of ambient dose rates

- Static geometry provides constant radiation field intensity
- Identify maximum rate within an area
- High internal reference dose rate
- Clinical beam quality
- Instrument temporal response eliminated

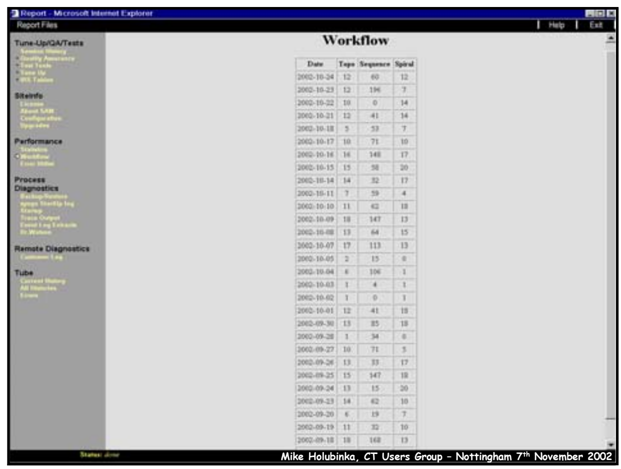




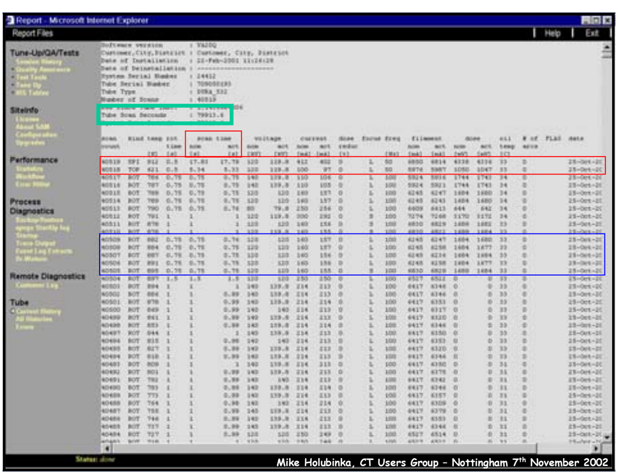


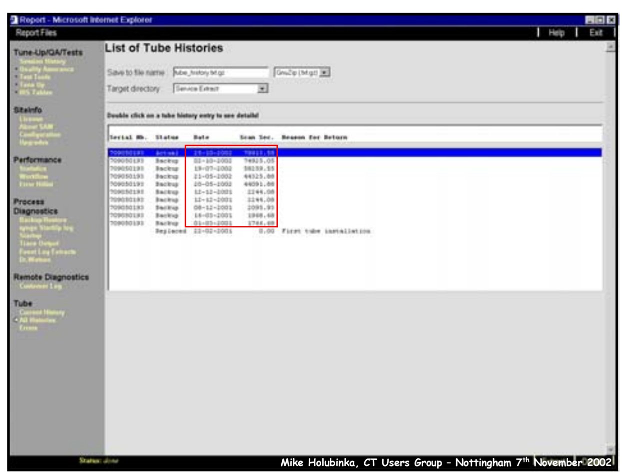


Patient Browser
Patient Transfer Edit View Filter Evaluation Sort Options Help
Local Database
Scheduler
CD-ROM
CD-WRITER_READ
Topogram
ThoraxRoutine 7.0 B60f
ThoraxRoutine 7.0 B40f
ThoraxRoutine 3.0 B40f
Raw Data
Patient Protocol
AbdRoutine 7.0 B30f
AbdRoutine 3.0 B30f
Mike Holubinka, CT Users Group - Nottingham 7th November 2002



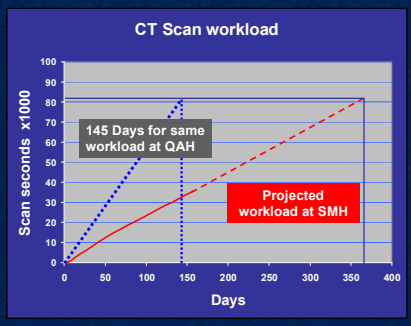
Date	Topo	Sequence	Spiral
2002-10-24	12	60	12
2002-10-23	12	196	7
2002-10-22	10	0	14
2002-10-21	12	41	14
2002-10-18	5	53	7
2002-10-17	10	71	10
2002-10-16	16	148	17
2002-10-15	15	58	20
2002-10-14	14	32	17
2002-10-11	7	59	4
2002-10-10	11	62	18
2002-10-09	18	147	13
2002-10-08	13	64	15
2002-10-07	17	113	13
2002-10-05	2	15	0
2002-10-04	6	106	1
2002-10-03	1	4	1
2002-10-02	1	0	1
2002-10-01	12	41	18
2002-09-30	13	85	18
2002-09-28	1	34	0
2002-09-27	10	71	5
2002-09-26	13	33	17
2002-09-25	15	147	18
2002-09-24	13	15	20
2002-09-23	14	62	10
2002-09-20	6	19	7
2002-09-19	11	32	10
2002-09-18	18	168	13





Report - Microsoft Internet Explorer
Report Files
Help
Exit
List of Tube Histories
Save to file name
Target directory
Double click on a tube history entry to see details!
Serial No.
Status
Date
Scan Sec.
Reason for Return
Tune-Up/QA/Tests
SiteInfo
Performance
Process Diagnostics
Remote Diagnostics
Tube
Mike Holubinka, CT Users Group - Nottingham 7th November 2002

Derivation of annual mAs



Projected scan sec = 82,000

Assumed mA = 400

Annual mAs = 32,800,000 (83,000,000 for QAH workload)

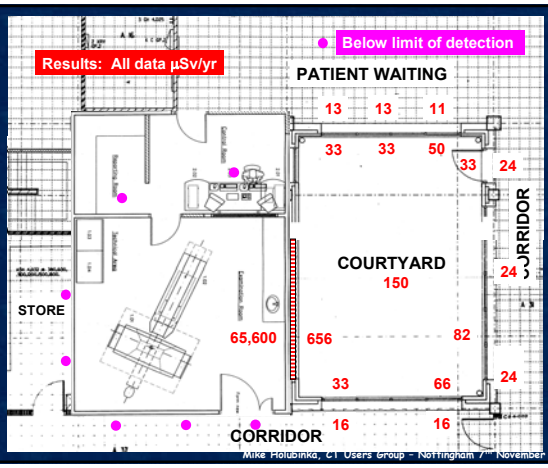
Derivation of Casemix Dose$_{(window)}$

$$\text{Casemix Dose}_{(window)} = \frac{\text{Chst/Abd/Pelv Dose}_{(window)} \times \text{Annual mAs}}{\text{Chst/Abd/Pelv mAs}}$$

$$= \frac{20 \times 32{,}800{,}000}{10{,}000}$$

$$= 65{,}600 \ \mu Sv$$

$$= 66 \ mSv$$



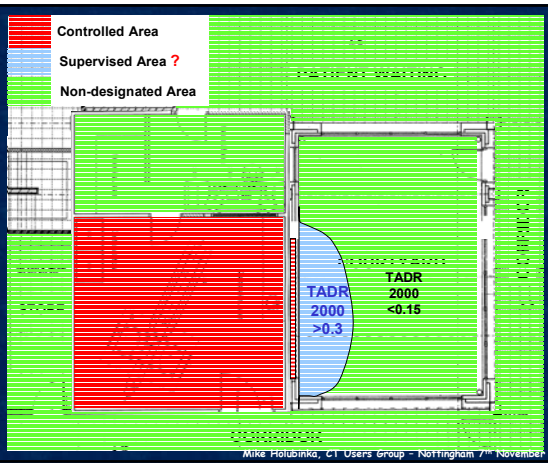
Designation of areas - Public

All dose rates µSv/hr

IDR Instantaneous Dose Rate averaged over 1 minute

TADR Time Averaged Dose Rate averaged 8 hrs (worst case assumptions)

TADR2000 TADR averaged over 2000 hrs (taking workload & occupancy into account)



- ✓ Conversion of chest room to CT suite
- ✓ Original design & alterations
- ✓ Assessment of environmental protection
- ✓ Assessment of environmental doses
- ✓ Legal requirements under IRR 1999

THE END