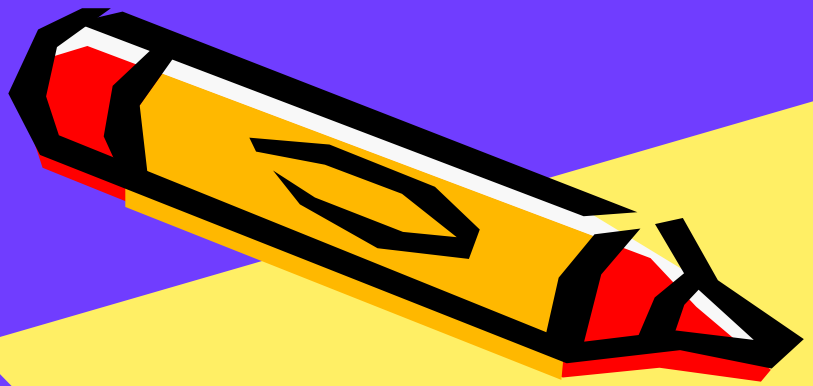


Progress Report from the HDR Brachytherapy Working Party

Margaret Bidmead

- HDR Ir-192 calibration service provided by NPL since May 2004
- Primary standard irradiated with a Nucletron "classic" HDR IR-192 source
- Farmer thimble chambers and associated jigs
- Well chambers

- Working Party set up with representation from NPL/RT SIG/IPEM/BIR
- To provide a consistent implementation method to radiotherapy departments using a
- Code of Practice

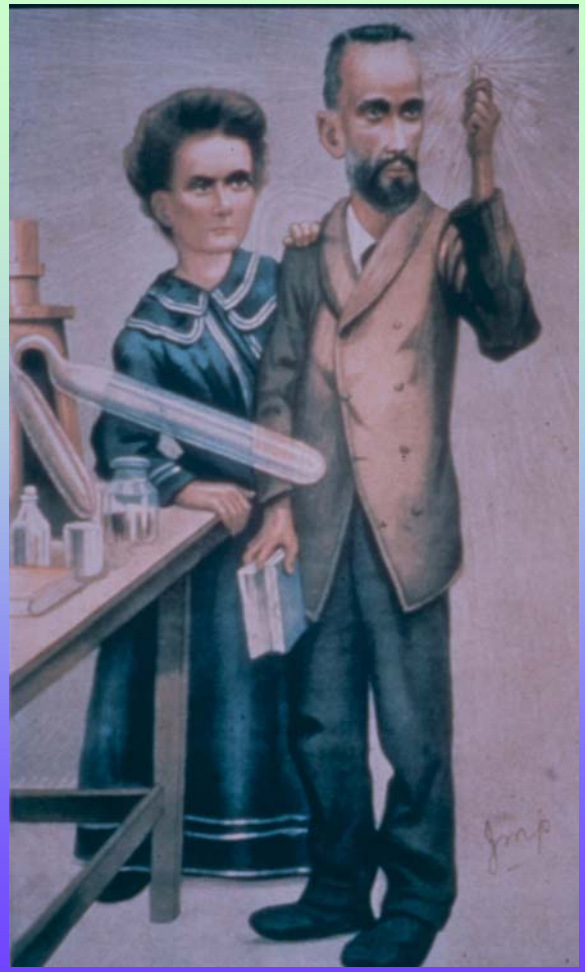
- Edwin AIRD (Mount Vernon)
- Margaret BIDMEAD (Royal Marsden) Chair
- Chris LEE (Clatterbridge)
- Steve LOCKS (Newcastle General)
- Rebecca NUTBROWN (NPL)
- Thorsten SANDER (NPL)

- (Tony FLYNN (Cookridge))

REMIT

- Produce a Code of Practice for the dosimetry of an HDR Ir-192 source using an Ir-192 NPL-calibrated ionisation chamber
- Ensure the NPL standard can be disseminated in a consistent way to UK RT departments
- Consideration given to instrumentation and geometry to be used

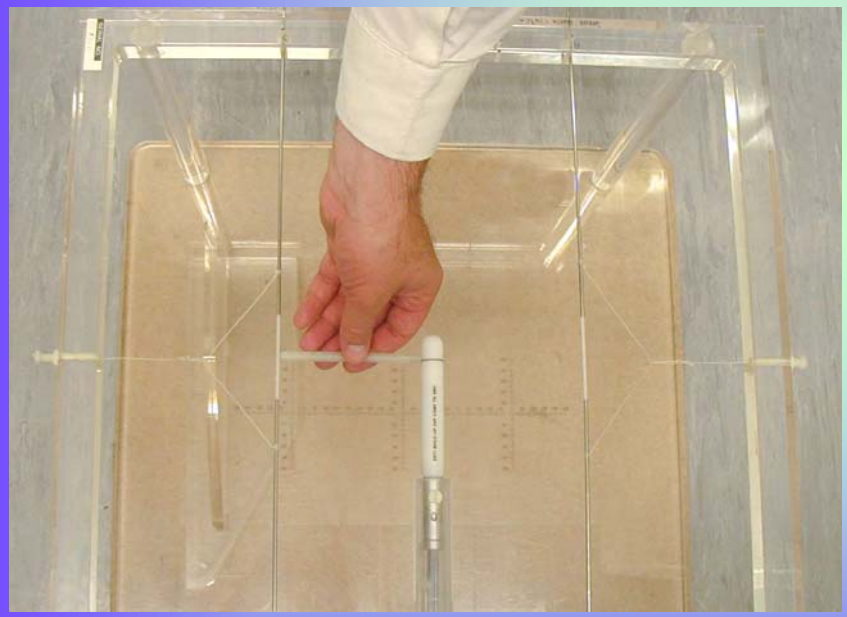
How do we do it now?

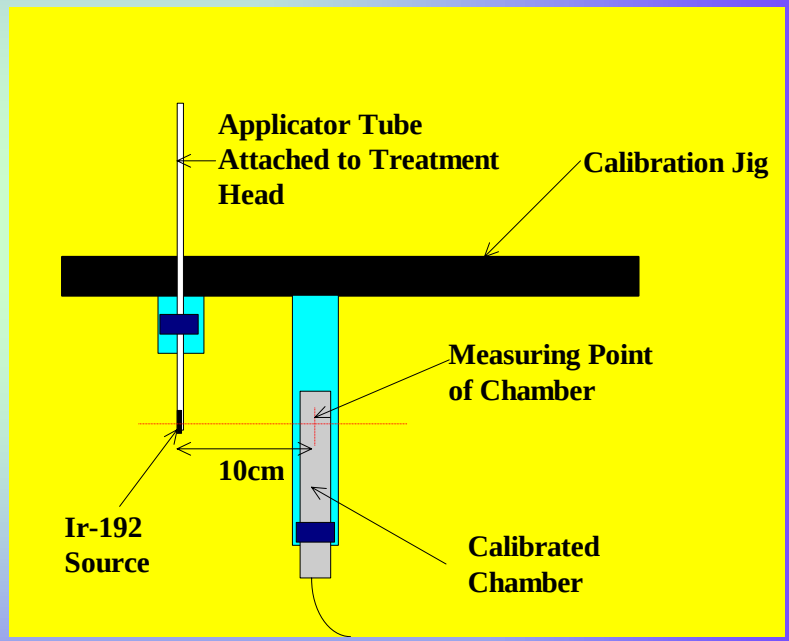


Background

- Original/current recommendations published in a joint BIR/IPSM report in Dec 1992
- Used to enable the measurement of RAKR of an HDR Ir-192 source
- RAKR traceable to NPL via the heavily filtered 280kV x-ray quality factor
- Measurements carried out using a 0.6cc Farmer type chamber in a relatively scatter free jig
- BU cap used to exclude Auger electrons produced in source

- 3-4 readings 5 minutes each with source in 2 catheters either side of the chamber





- Check for correct source positioning prior to measurement

Primary calibration (Method A):

RAKR initially calculated from the following

$$RAKR\ (cGyh^{-1}) = Rdg \times F_c \times F_{ic} \times F_{tp} \times F_s \times F_g \times F_e \times F_{is} \times 3600/t$$

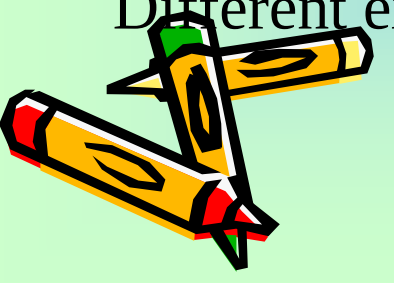
- Allow at least 20mins for temperature equilibration

2nd check (Method B)

Calculate a time to deliver a dose of 0.3Gy using measured RAKR

Time set in treatment console

Different experienced physicist and different equipment



2. Calculation Of Equivalent Activity

$$A_e = \frac{RAKR}{\Gamma}$$

where: -

A_e is the equivalent activity (GBq)

RAKR is the reference air kerma rate ($Gy\,h^{-1}$ @ $1m$)

Γ is the specific air kerma rate constant ($110 \mu Gy\,m^2\,h^{-1}\,GBq^{-1}$)

(equivalent exposure rate constant 0.466 $R\,m^2\,h^{-1}\,Ci^{-1}$)

Problems/Dislikes with existing system

- Time consuming measurement method
- Introduction of uncertainties
- Calculation of activity is prone to error

Problems/Dislikes with existing system

- 2° std calibration factor not specific to radiation source
- Chamber dose gradient effect
- Auger electron exclusion method

TABLE XVII. TYPE AND FREQUENCY FOR ACCIDENTS REPORTED IN BRACHYTHERAPY TREATMENTS

Accident caused by	Number of cases
Dose calculation error	6
Error in quantities and units	2
Incorrect source strength	7
Equipment failure	4
Other	13
Total	32

Survey results from NPL/Working party

Compiled by Steve Locks

Number and type of treatment unit:

Hospitals with HDR in UK and Ireland	30
Nucletron Classic	14
Nucletron V2	11
Gammamed plus	2
Varisource	2
Beibig	?
Flexitron /Isodose control	1

Several Nucletron V3's around now

Brachytherapy equipment used in the UK 2004

Site	Number of Centres	HDR	Remote afterloading LDR	Iridium	Iodine Seeds
Gynaecological	40	19	25	3	
Bronchus	10	10			
Head and Neck	10	2	1	7	
Prostate	16	2			15
Breast	5	3		2	

Calibration equipment (details from 20 centres):

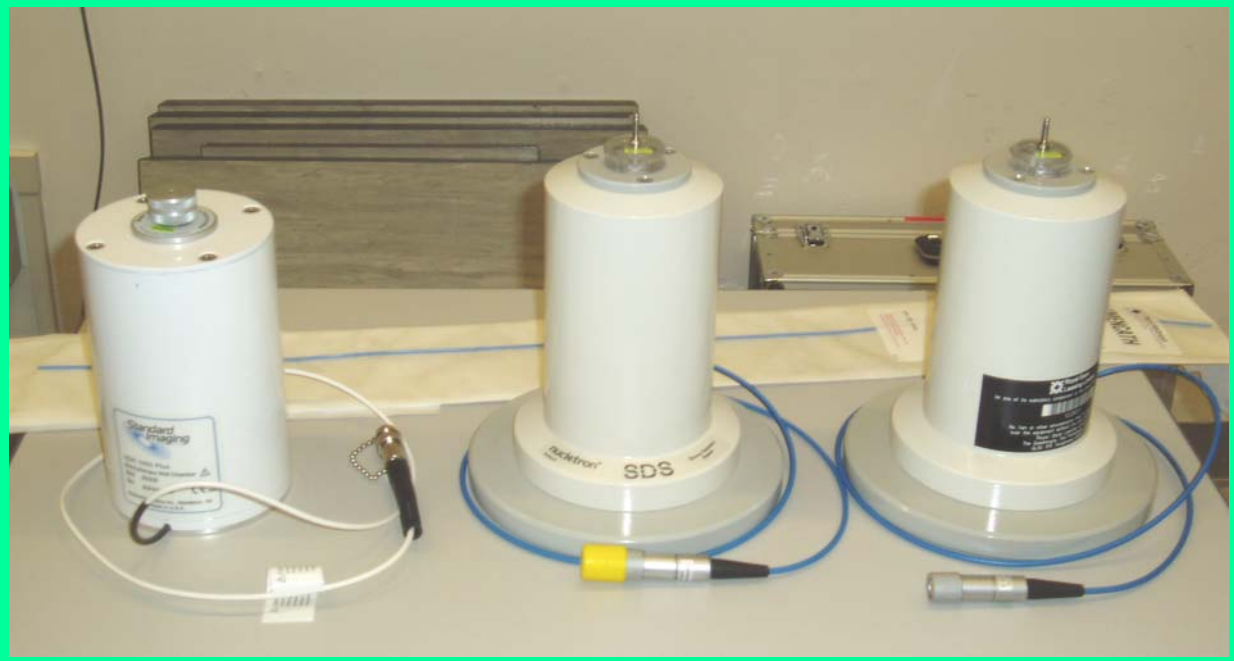
Number of centres with Well chambers	10
Standard Imaging 1000+	5
Nucletron SDS	3
PTW Freiburg 077091	1
PTW 33004	1

Other chamber possibilities:

PTW Sourcecheck

IVB1000

Types of Well Chamber: Standard Imaging HDR 1000+, Nucletron, PTW



Calibration equipment contd..

Jigs for Farmer measurement:

Nucletron jig	12
In House jig	5
Gammamed original	1
Varian in-air jig	1
Varian track stand	1

Same?

All centres use Farmer as 1° calibration

Some use well chamber for stability checks

Calibrations at NPL

Farmer Chamber

- More time consuming
  ➡ More expensive!
- Jigs to be transported
- More correction factors required, more error possibility
- Low ionisation current
- Greater positional uncertainty

•Uncertainties 1.8%

Well Chamber

- Quicker and simpler
- Easy to transport
- High ionisation current
- However most centres only have one

•Uncertainties 1.3%

Recommend Well Chamber calibration

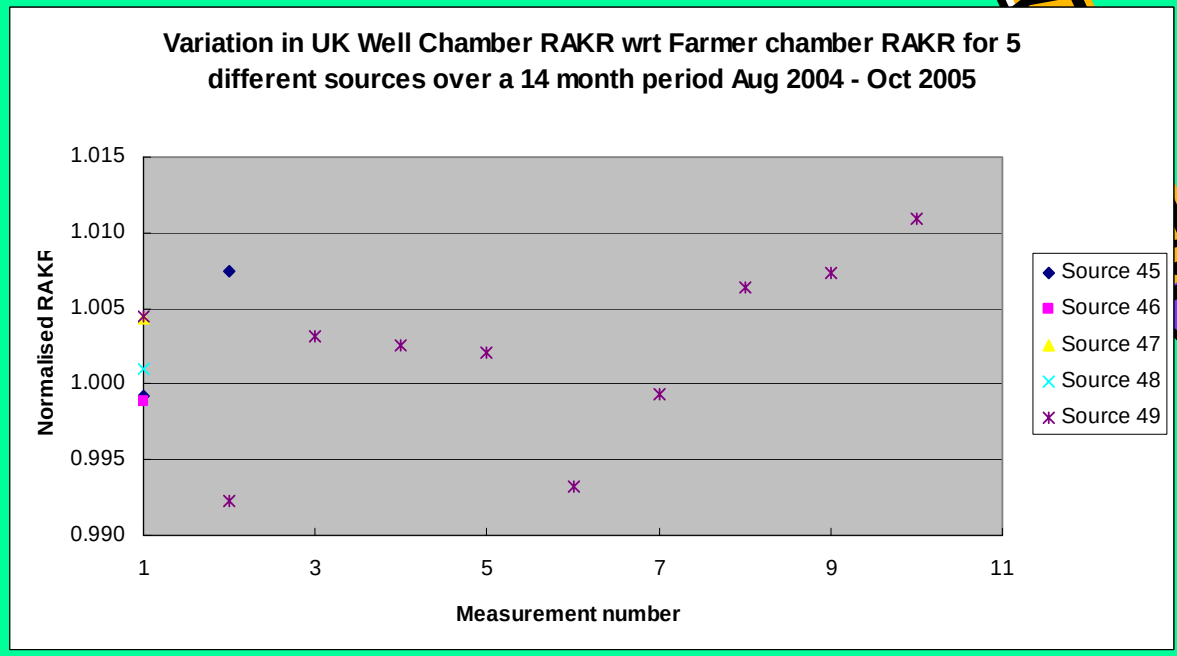
Issues with well chambers

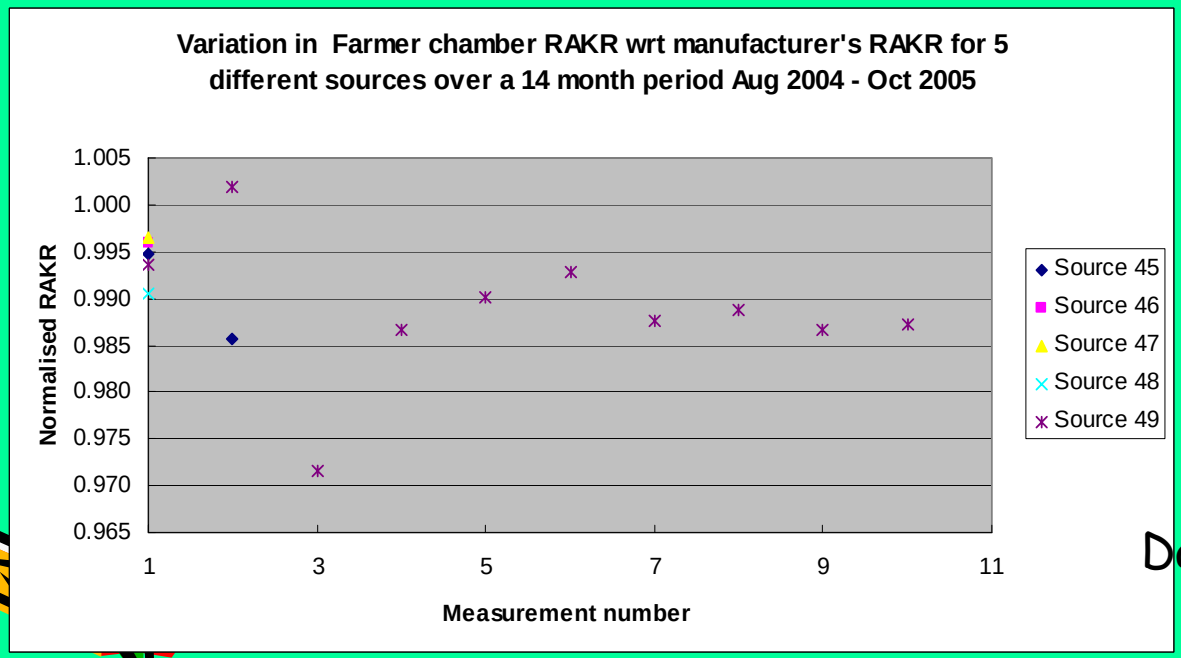
- Effect of source type used for standard calibration
- Method of constancy check
- Saturation effects of well chambers at high currents
- Sweet spot of chamber
- Second, independent check of source calibration

Stability measurements

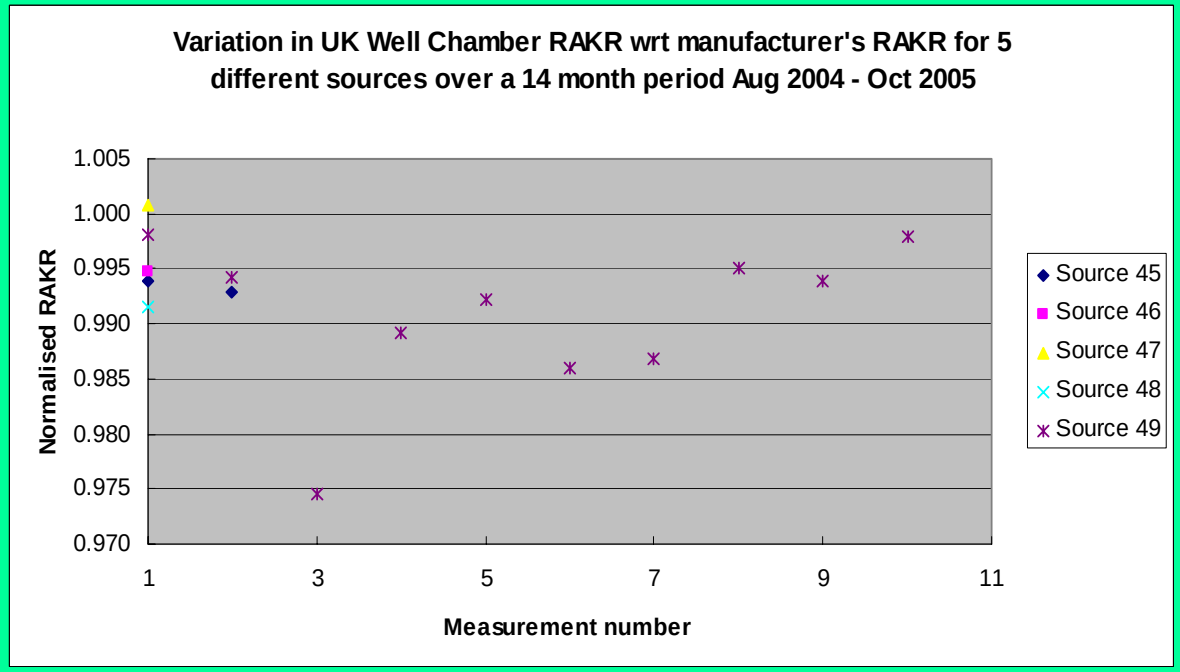
- Measured 5 sources
- Calibration using new factor as well as existing Farmer method
- Measurement corrected back to a reference date and time
- Repeatability measurements carried out on some sources
- Comparisons made between RAKRs

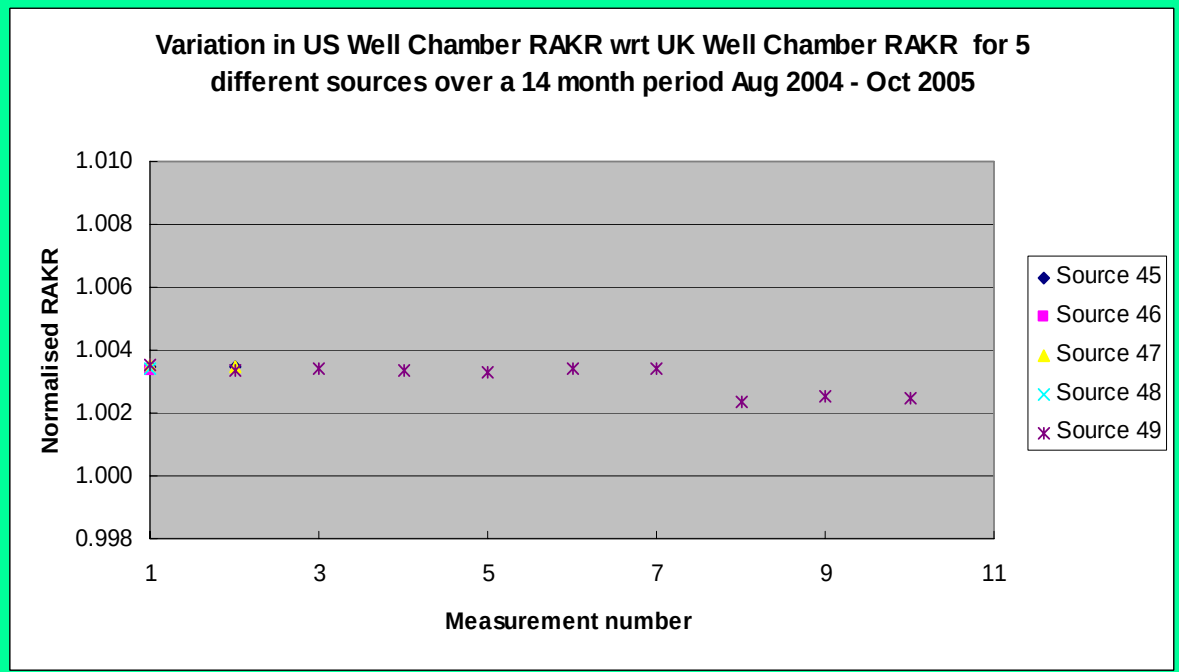
RAKR Stability analysis

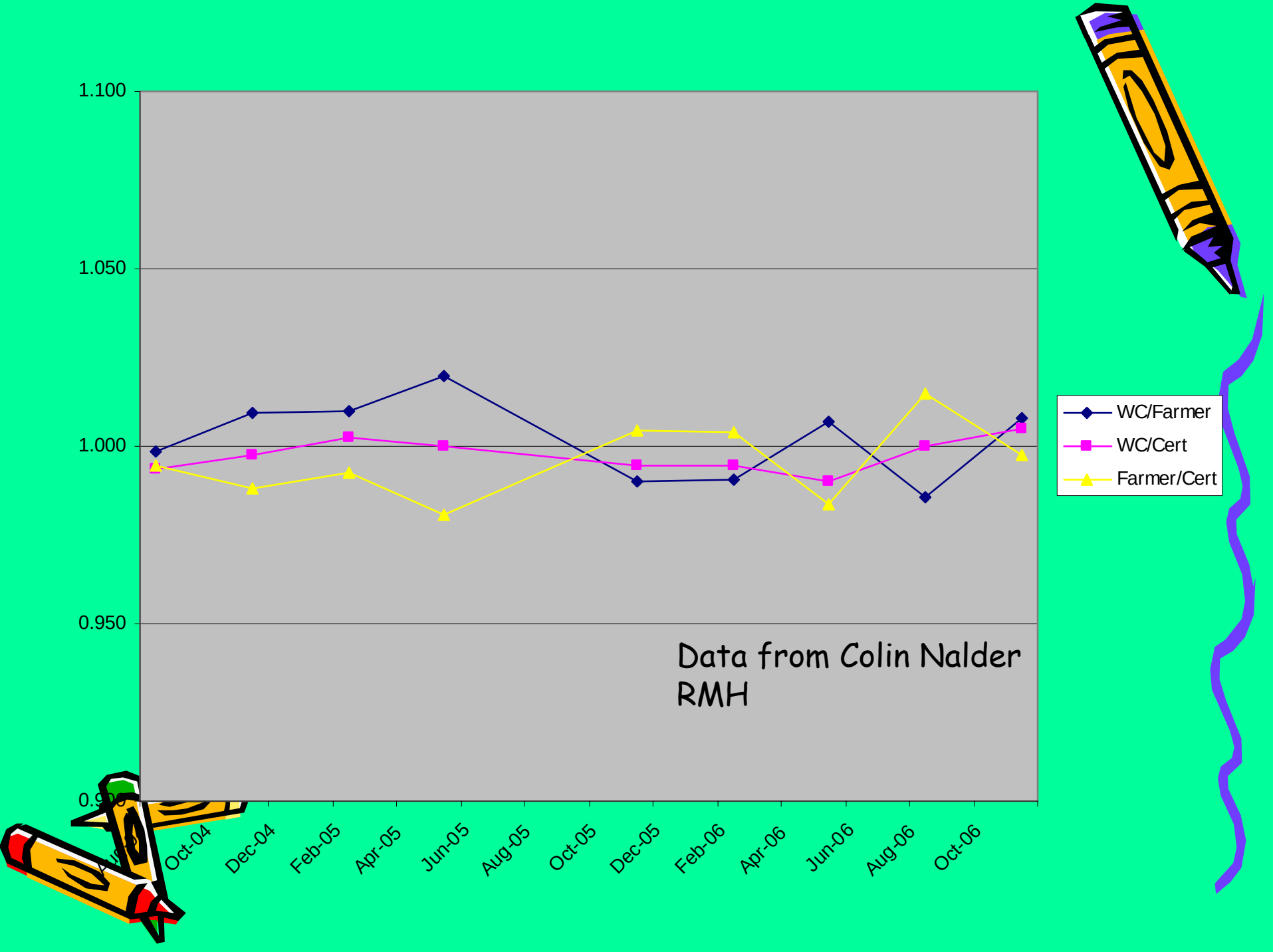




Data collected by Chris Lee


Variation in UK Well Chamber RAKR wrt manufacturer's RAKR for 5 different sources over a 14 month period Aug 2004 - Oct 2005
Normalised RAKR
1.005
1.000
0.995
0.990
0.985
0.980
0.975
0.970
1
3
5
7
9
11
Measurement number
Source 45
Source 46
Source 47
Source 48
Source 49


Variation in US Well Chamber RAKR wrt UK Well Chamber RAKR for 5 different sources over a 14 month period Aug 2004 - Oct 2005
Normalised RAKR
1.010
1.008
1.006
1.004
1.002
1.000
0.998
1
3
5
7
9
11
Measurement number
Source 45
Source 46
Source 47
Source 48
Source 49


1.100
1.050
1.000
0.950
Oct-04
Dec-04
Feb-05
Apr-05
Jun-05
Aug-05
Oct-05
Dec-05
Feb-06
Apr-06
Jun-06
Aug-06
Oct-06
WC/Farmer
WC/Cert
Farmer/Cert
Data from Colin Nalder
RMH

Work in progress

Correction factor for different source construction

Simpler to do for a Farmer calibration than well chamber

Use MC simulation for both source types

Calculate, from MC, calibration coefficients for NPL source and hospital source:

$$N_{K,2(Farmer)} \quad , \quad N_{K,1(Farmer)}$$

Correction to NPL calibration coefficient will be ratio:

$$N_{K,1(Farmer)} \cdot \frac{N_{K,2(Farmer)}}{N_{K,1(Farmer)}}$$

Correction factors contd...

Could use similar MC simulation for well chambers

BUT

Need accurate information from manufacturers perhaps at first look at the Classic and the most different source:

Rebecca Nutbrown working on this

Correction factors contd...

Alternatively carry out a series of measurements at hospitals to determine the well chamber correction factor for the different source i.e

- Obtain RAKR for the different source using Farmer set up and method described on previous slide

$$I_{2,Farmer} \cdot N_{K,2(Farmer)} = RAKR_2$$

- use RAKR to calculate a correction factor to correct the NPL well chamber calibration coefficient

$$correction = \frac{RAKR_2}{I_{2,well} \cdot N_{K,1(well)}} = \frac{N_{K,2(well)}}{N_{K,1(well)}}$$

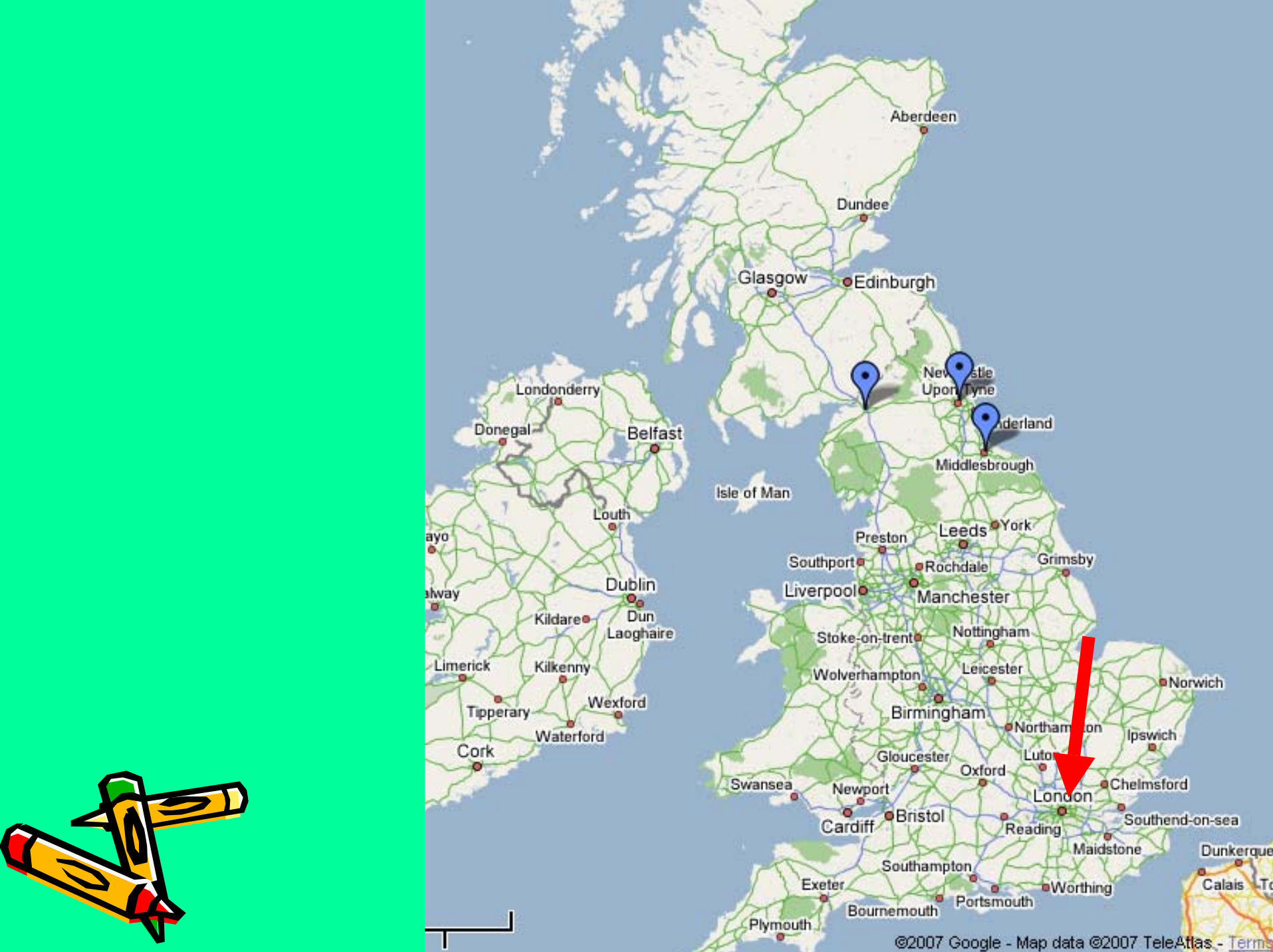
Different sources

- Steve Locks and Thorsten Sander to tour the North East!

Newcastle: Nucletron V2

Middlesbrough: Varisource 2000

Carlisle: Gammamed 12i


Aberdeen
Dundee
Glasgow
Edinburgh
Londonderry
Donegal
Belfast
Isle of Man
Louth
Dublin
Kildare
Dun Laoghaire
Limerick
Kilkenny
Tipperary
Wexford
Waterford
Cork
Middlesbrough
Leeds
York
Preston
Southport
Rochdale
Grimsby
Liverpool
Manchester
Stoke-on-trent
Nottingham
Wolverhampton
Leicester
Norwich
Birmingham
Ipswich
Gloucester
Oxford
Swansea
Newport
Cardiff
Bristol
London
Chelmsford
Reading
Southend-on-sea
Maidstone
Southampton
Exeter
Worthing
Portsmouth
Bournemouth
Plymouth
Calais
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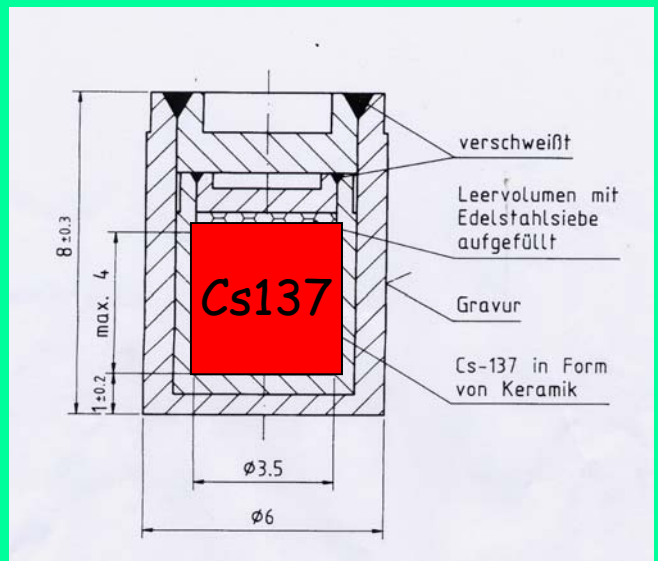
Constancy checks of well-chambers

- Cs 137 source, available but custom made jig for well chamber required.
- Investigations ongoing at RMH and CCO
- Activity and associated current to be selected

HTSL



Currents from HDR sources

The BS EN 60731:1997 standard sets a "maximum input current"
for a secondary standard dosemeter at 5 nanoamp

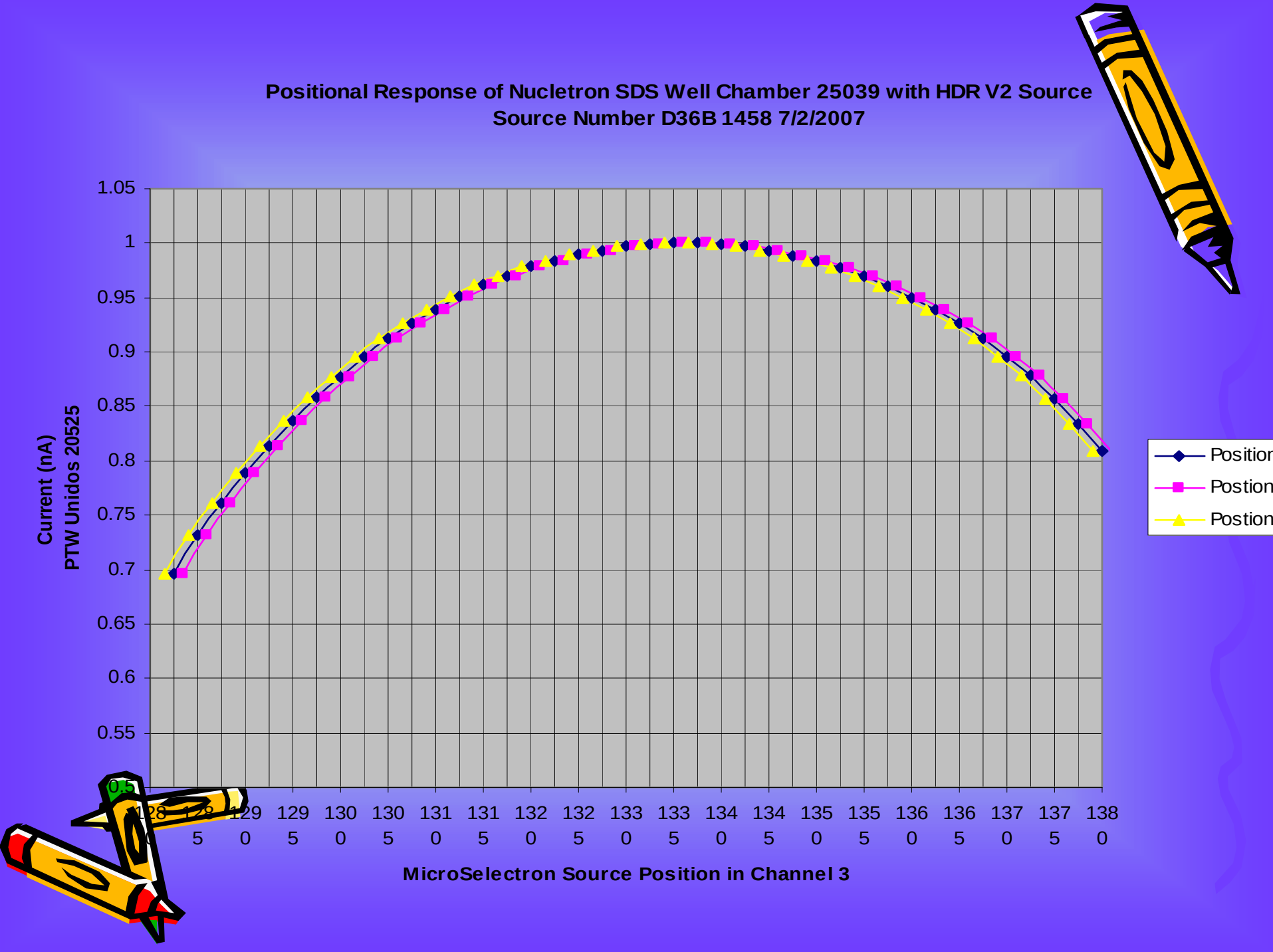
currents of 10-30nA per Ci
therefore possibly 500nA from a very hot HDR source

Electrometer manufacturer: PTW allow currents upto 1 micro-amp

Sweet Spot of chamber

- Each centre must find its own sweet spot for a particular transfer tube
- NPL will also test for sweet spot location

- "Peak" is broad (15-20mm) so any positional error (<+-1mm) in source is OK


Positional Response of Nucletron SDS Well Chamber 25039 with HDR V2 Source
Source Number D36B 1458 7/2/2007
Current (nA)
PTW Unidos 20525
1.05
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0.6
0.55
0.5
128 5
129 0
129 5
130 0
130 5
131 0
131 5
132 0
132 5
133 0
133 5
134 0
134 5
135 0
135 5
136 0
136 5
137 0
137 5
138 0
MicroSelectron Source Position in Channel 3
Position
Postion
Postion

Ion Recombination

- Recommend Attix two voltage method for determination of recombination factor within the COP for users to determine their own factor, using the two-voltage method

F H Attix, AAPM radiotherapy dosimetry protocol, Med. Phys. 11, 714 (1984)).

Second "independent" check

- Is the AKR from the source certificate a second check?

- Yes in Austria, the Netherlands and Norway! (unless the measurement is >5% different from the certificate)

- Recommended monthly calibration check
- 3 yearly calibration at NPL of chamber and electrometer
- Final code of practice to be published in PMB by end 2008

Is it worth it????

New areas of Brachytherapy, 2004 (RCR report):

25 LDR centres have to decide PDR or HDR

8 new centres hope to implement HDR prostate brachytherapy. (3 centres already doing it)

9 centres are interested in commencing lung/oesophageal HDR brachytherapy (4 centres already doing significant numbers)

5 centres are considering HDR breast brachytherapy.(3 centres already doing it)