

QA/QC in the Digital Radiography Environment (part 1)

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3 Rivers Technical Conference
18-19 August 2009

WHY THIS TOPIC?

- 1. Received a call from an engineer wanting to know how to measure the dose rate on his LINAC, and he believes that the energy is changing but does not know how to measure it. Is there a QA/QC process that I know of and what instrumentation is needed.
- 2. Journal of the American College of Radiology , July 2009.
"The existing practice of quality assurance in medical imaging is problematic because of the subjective manner in which it is performed, the lack of community and industry-wide QA standards, a paucity of supporting technology, and an overall lack of accountability. QA is usually performed by the same tech who performed the image acquisition."

WHY THIS TOPIC?

- **3. The Society for Imaging Informatics in Medicine, July 2009.**
"Ask the experts: Monitor characteristics, and general monitor questions."
- **4. "Artifacts Found During Quality Assurance Testing of Computed Radiography and Digital Radiography Detectors" SIIM vol.22, number4, pp 383-393, 2009**
- **5. "Medical Grade vs. Off-the-Shelf Color Displays: Influence on Observer Performance and Visual Search" SIIM vol.22, number 4 pp 363-369, 2009**

DISCLAIMER

REMEMBER,

- VERY LITTLE
- MATH!!!

$$BR(t \rightarrow Wb) = \frac{\Gamma(t \rightarrow Wb)}{\Gamma(t \rightarrow Wg)}$$

$$= \frac{|V_{tb}|^2}{|V_{td}|^2 + |V_{ts}|^2 + |V_{tb}|^2}$$

$$\approx \frac{(0.9745)^2}{(0.0094)^2 + (0.040)^2 + (0.9745)^2}$$

$$= 99.82\%$$

but F.C.N.C...

$t \rightarrow Zc$
 $t \rightarrow Zu$

$t \rightarrow Yc$
 $t \rightarrow Yu$

$$U_{CKM} = \begin{pmatrix} c_{12}c_{13} & & \dots \\ -s_{12}c_{23} - c_{12}s_{23}s_{13}e^{i\delta} & & \dots \\ s_{12}s_{23} - c_{12}c_{23}s_{13}e^{i\delta} & & \dots \end{pmatrix}$$

OBJECTIVES

- Define QA/QC
- Define the DR Environment
- High energy machines
- Equipment
- Tests and one sample
- Questions

WHAT IS QA/QC?

- **QUALITY ASSURANCE (QA):**

All plans and systematic actions necessary to provide adequate confidence that a structure, system, or component will perform satisfactorily in service .
(International Organization for Standardization-ISO 1995)

- **QUALITY CONTROL:**

The regulatory process through which the actual quality performance is measured, compared with existing standards and finally the actions necessary to keep or regain confidence with the standard .
(International Organization for Standardization- ISO 1995)

The normal radiation safety checks are not part of the quality control.

WHAT IS CQI?

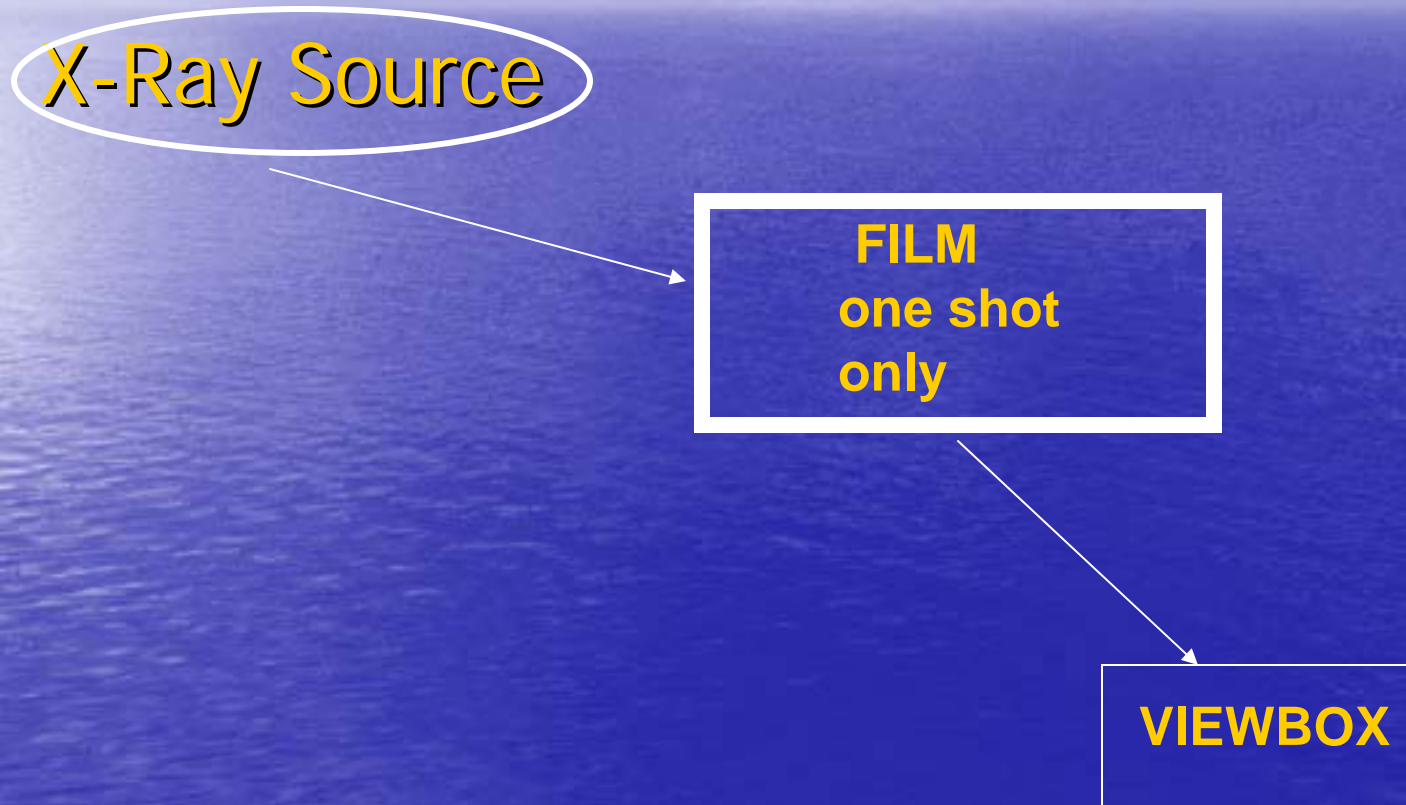
- **CONTINUOUS QUALITY IMPROVEMENT:**

Documentation of the results of the quality assurance program.

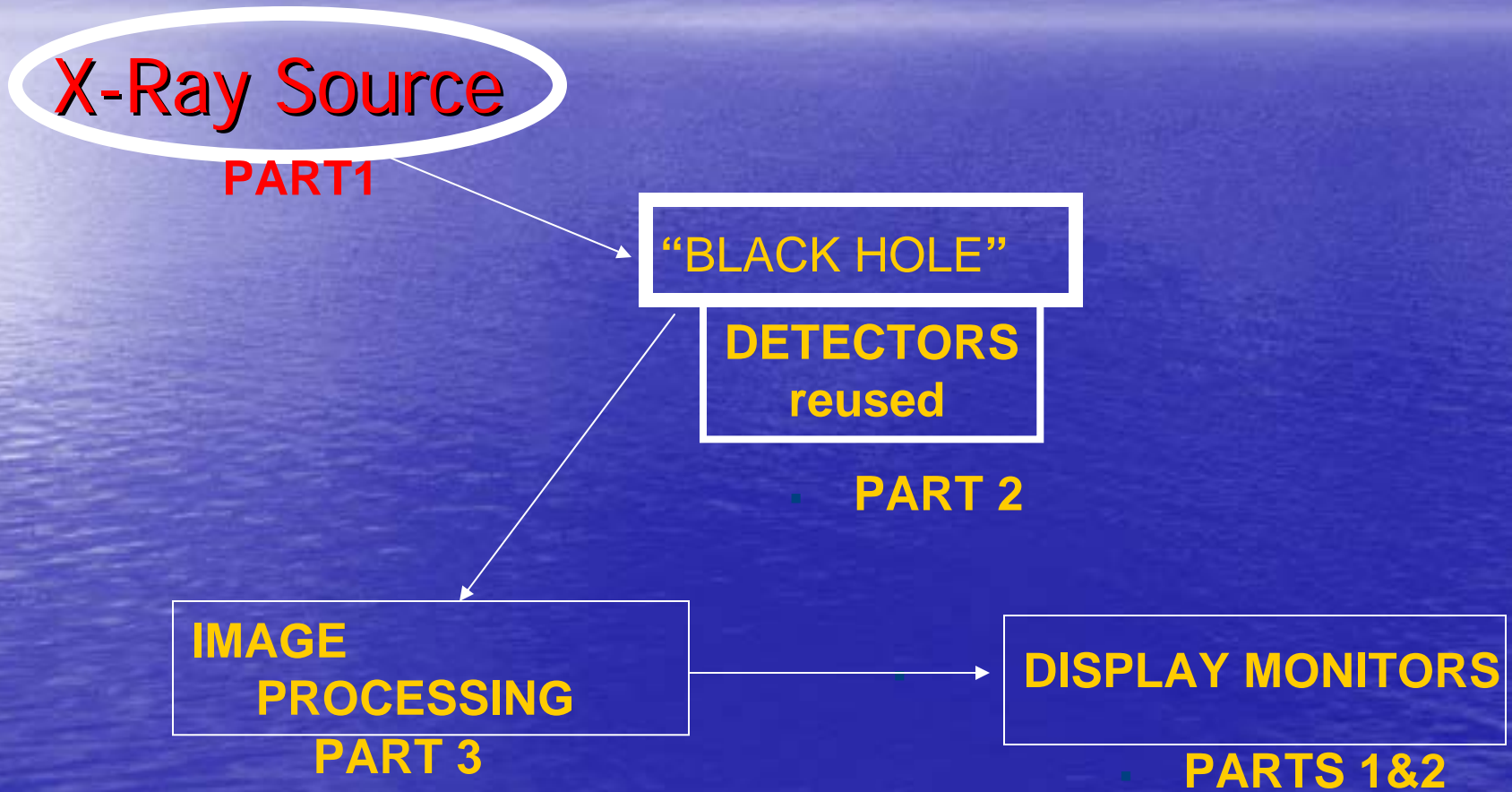
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Actions taken whenever the results are outside of the stated tolerance.

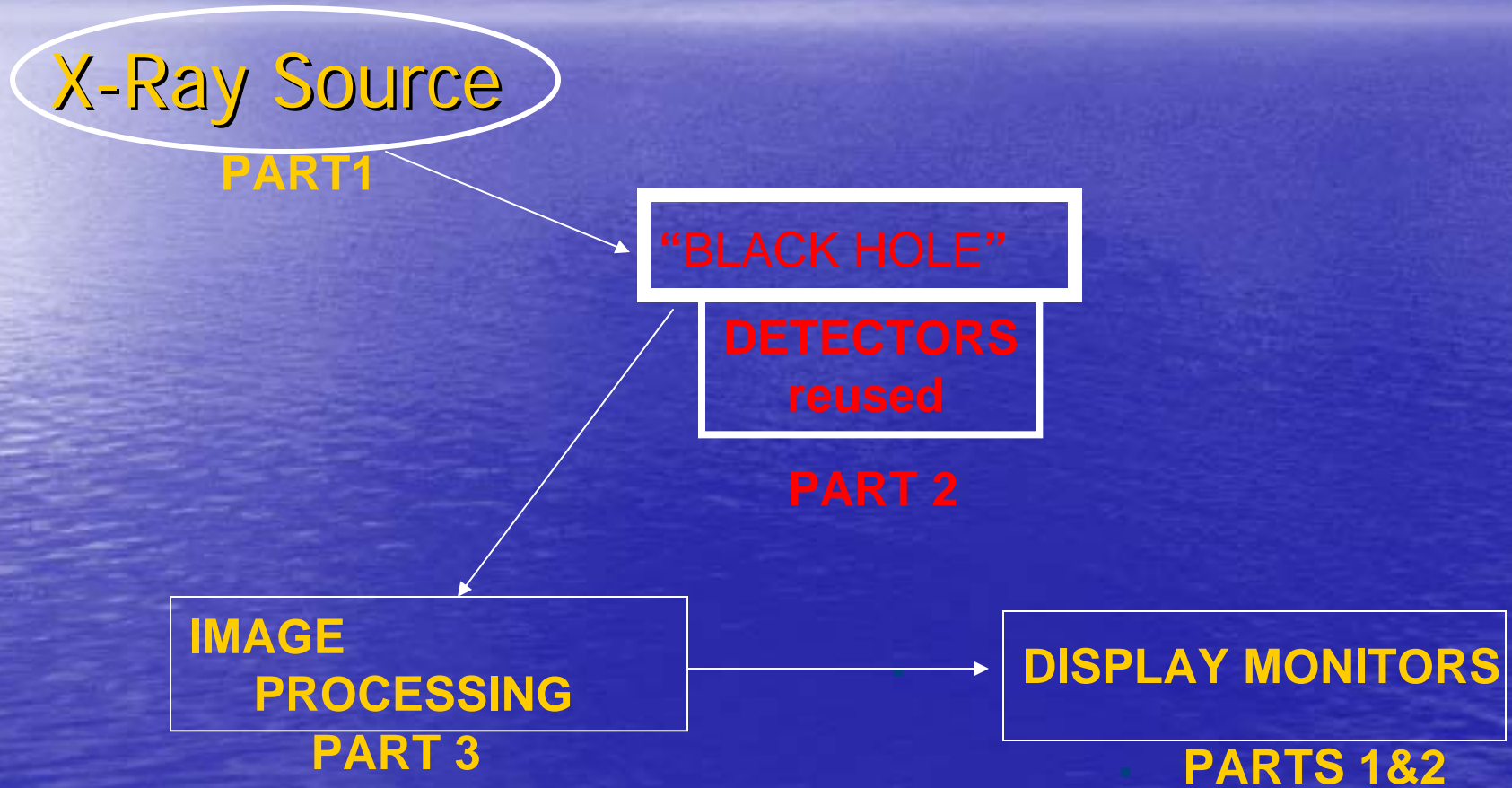
OLD IMAGING ENVIRONMENT



IMAGING ENVIRONMENT



IMAGING ENVIRONMENT



BLACK HOLE -DETECTORS

- **TYPES:**

CR

DR

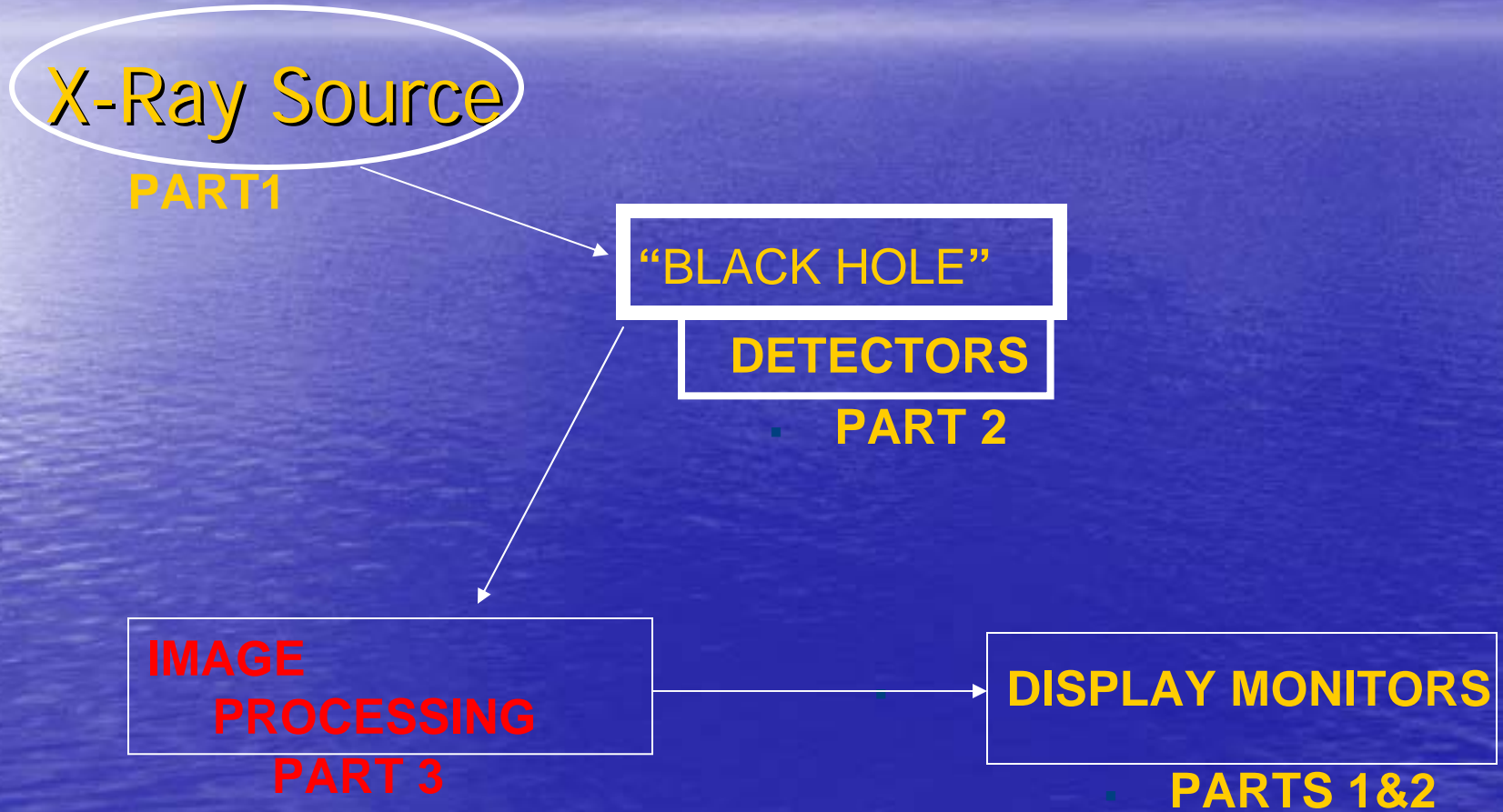
**DIRECT
INDIRECT**

CCD

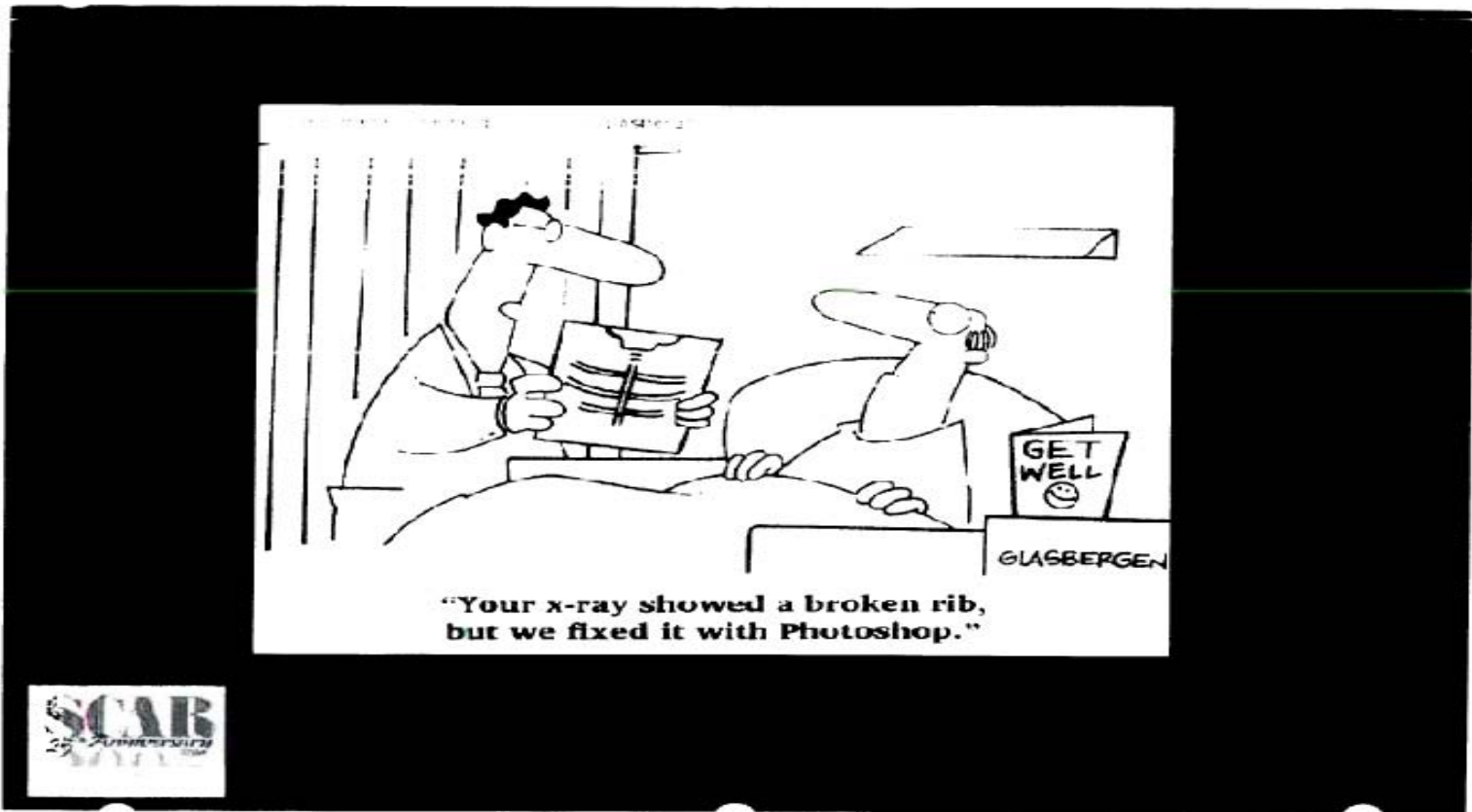
CMOS

DIGITIZED X-RAY FILM

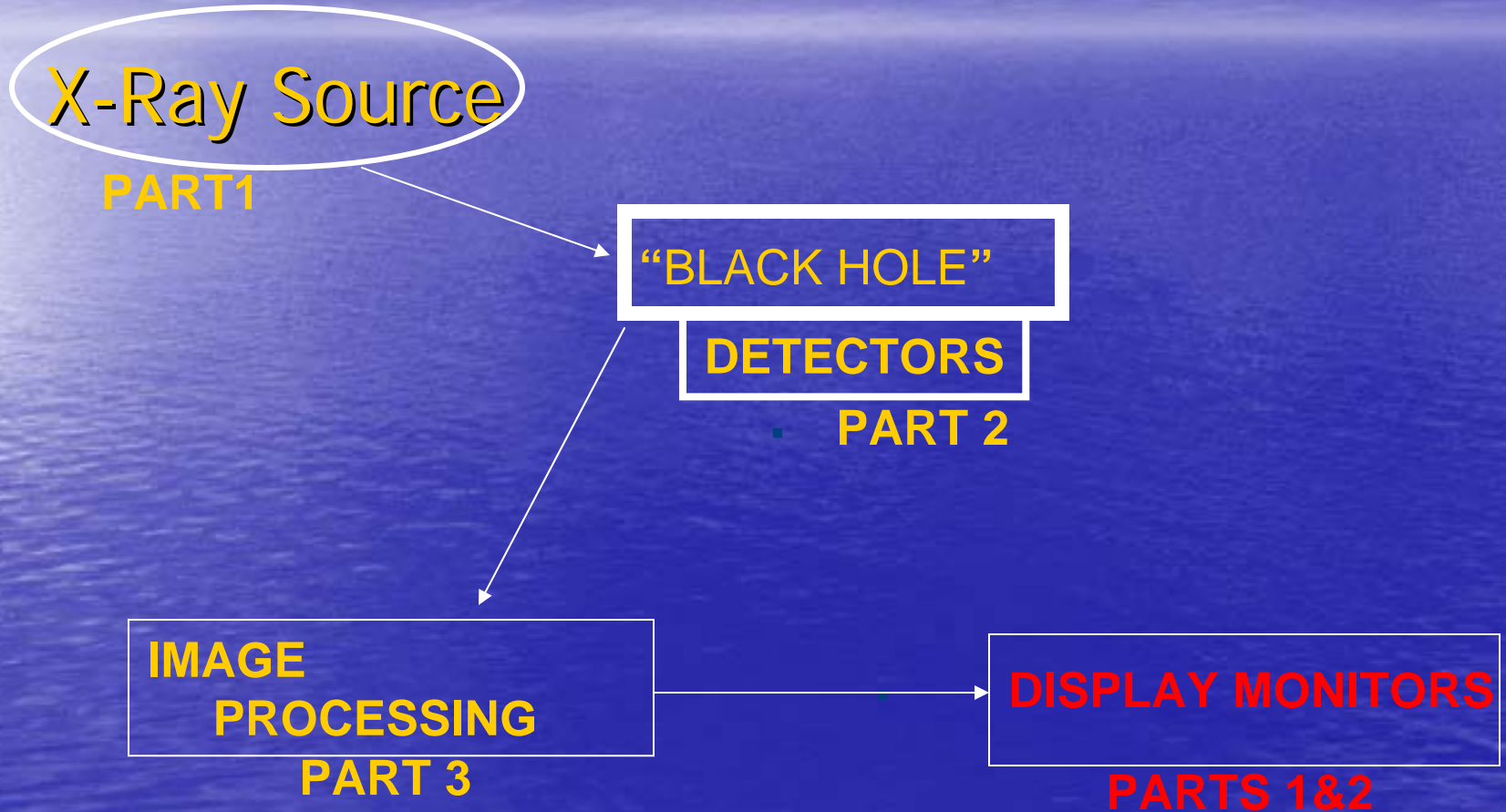
IMAGING ENVIRONMENT



WHY A SECTION ON IMAGE PROCESSING?



IMAGING ENVIRONMENT



REQUIREMENTS of a QUALITY SYSTEM

Clear definition of responsibilities

Documented procedures

Accurate record keeping

Control of system failures

Internal audit procedures

Training needs

WHY ARE WE DOING THE LINAC?

STARTING POINT FOR THE IMAGING PROCESS

LAST CHANCE TO INSURE THAT YOU HAVE THE BEST POSSIBLE PHYSICS PARAMETERS FROM THE LINAC INTERACTING WITH THE PART BEFORE ENTERING THE VIRTUAL WORLD.

WHY ARE WE DOING THE LINAC?

Dose rate of the LINAC can be between 250-15,000 rad/min@ 1 meter.

Major contribution of dose is to the object, only 1 -3% exits the object.

Panel is reused thereby receiving a dose

Energy response of the detector is different from film (changing spectrum)

Need to monitor x-ray uniformity and flatness to insure image quality

WHO PERFORMS THE TESTS?

(Each subset may have different personnel)

**WHO PERFORMS THE TESTS ON
THE HIGH ENERGY MACHINES?**

ASNT LEVEL I or LEVEL II (RADIOGRAPHER)



ASNT LEVEL III (RADIOGRAPHER)



RADIOLOGICAL PHYSICIST



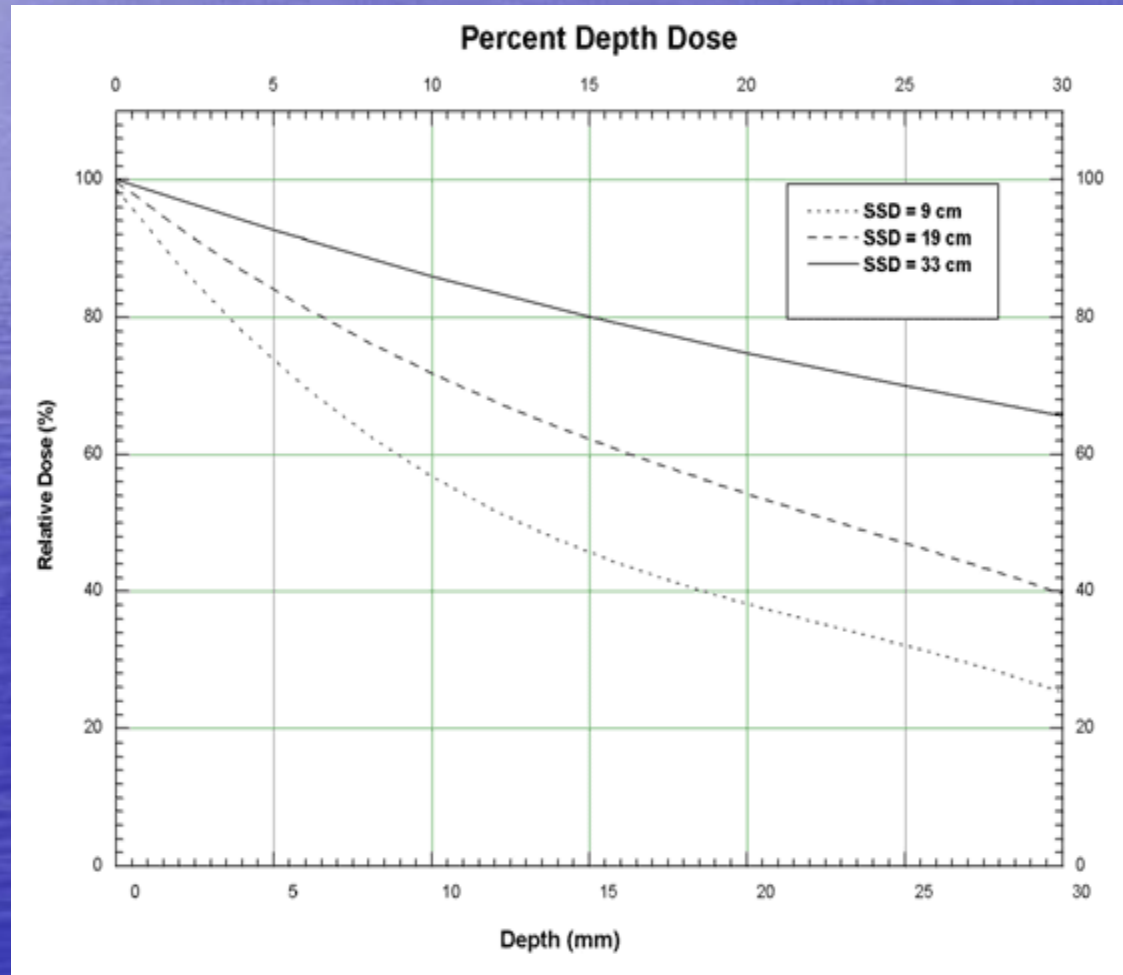
- Where is the water phantom?

- Here comes Dr. Berry, QUICK, hide the water phantom!!

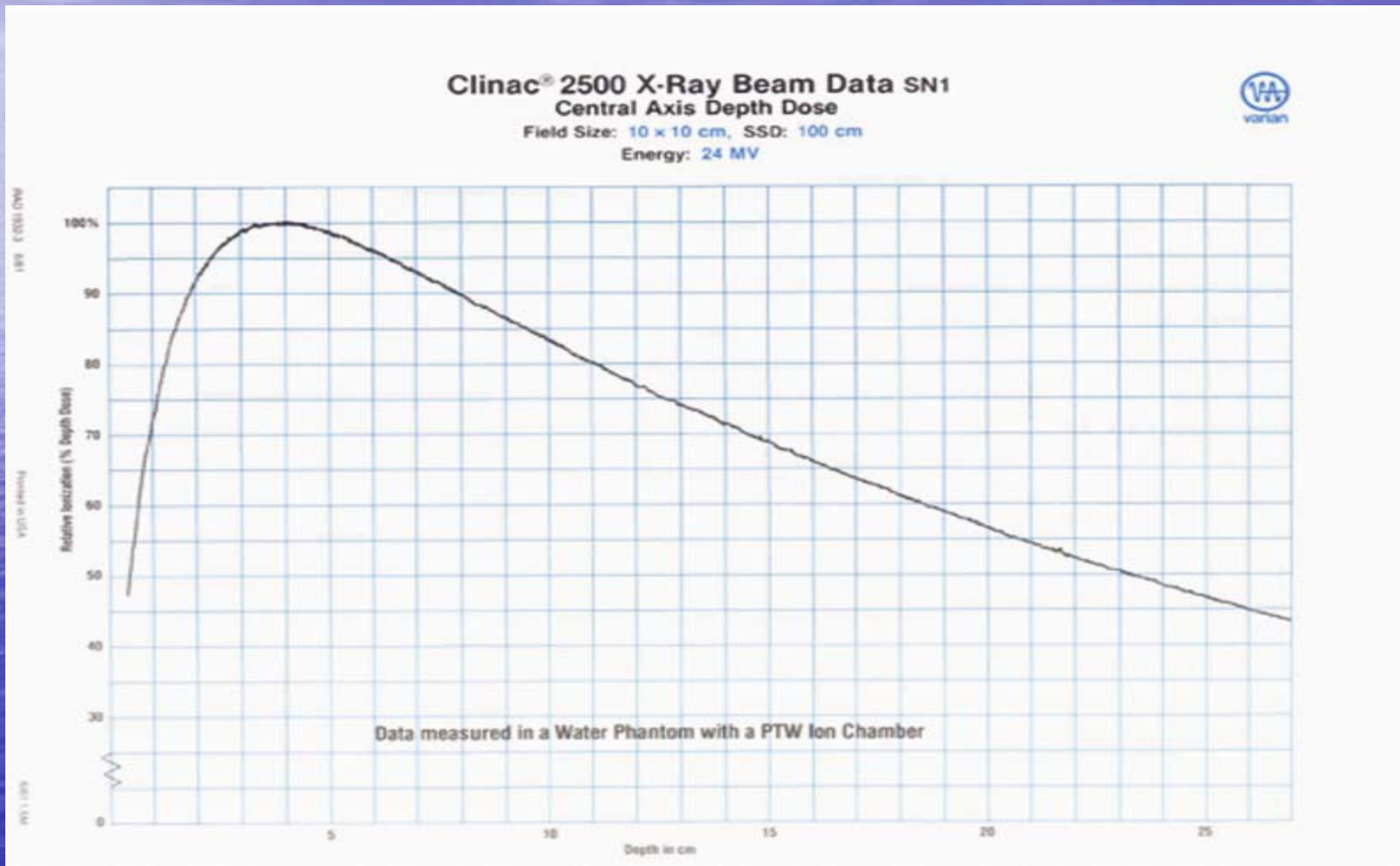
HIGH ENERGY X-RAY SOURCES

BRIEF TUTORIAL ON LINEAR ACCELERATORS, MICROTROTRON and BETATRON

DIFFERENCE BETWEEN A LOW ENERGY AND HIGH ENERGY SOURCE



DIFFERENCE BETWEEN A LOW ENERGY AND HIGH ENERGY SOURCE



LINEAR ACCELERATOR

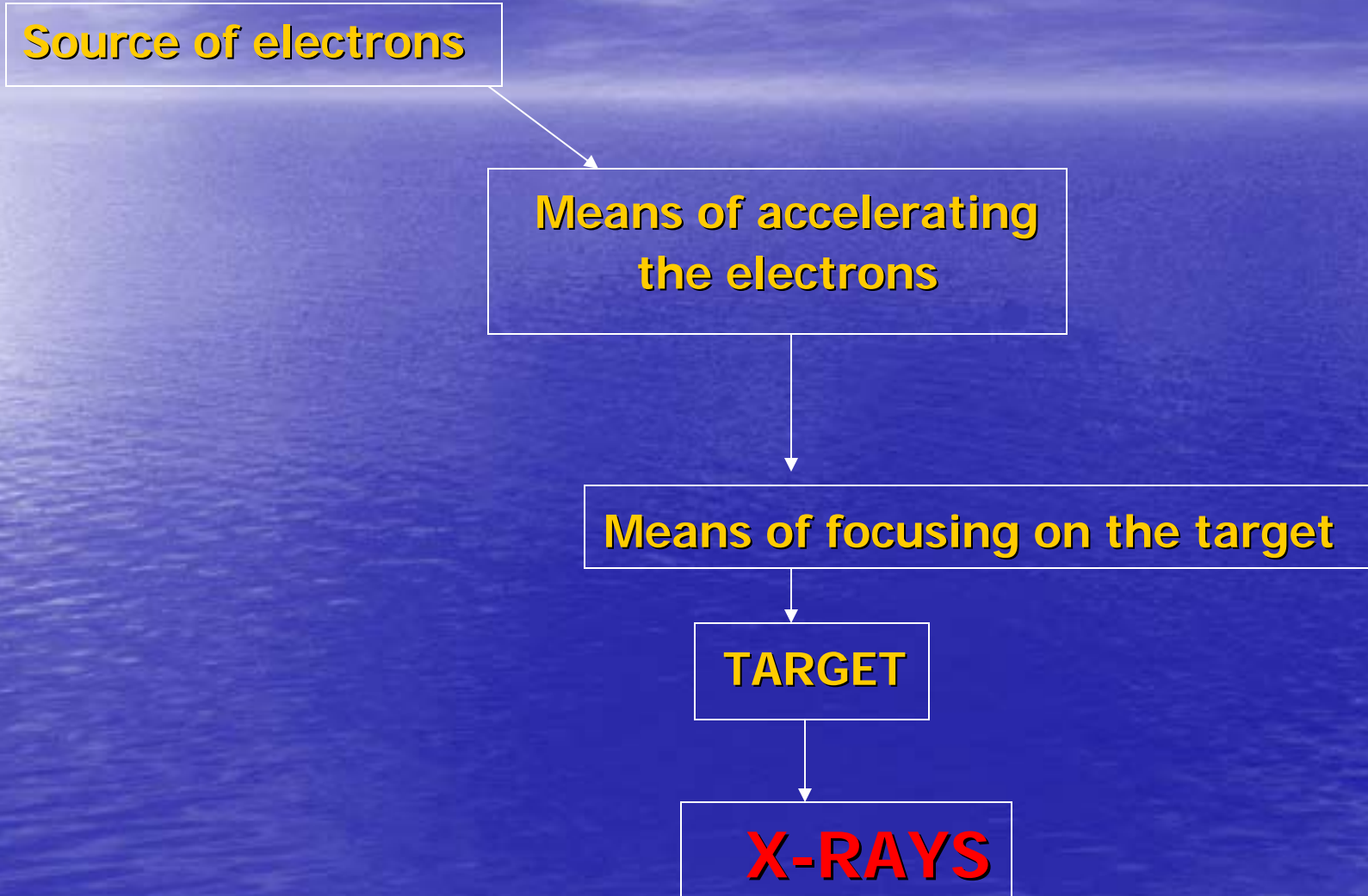
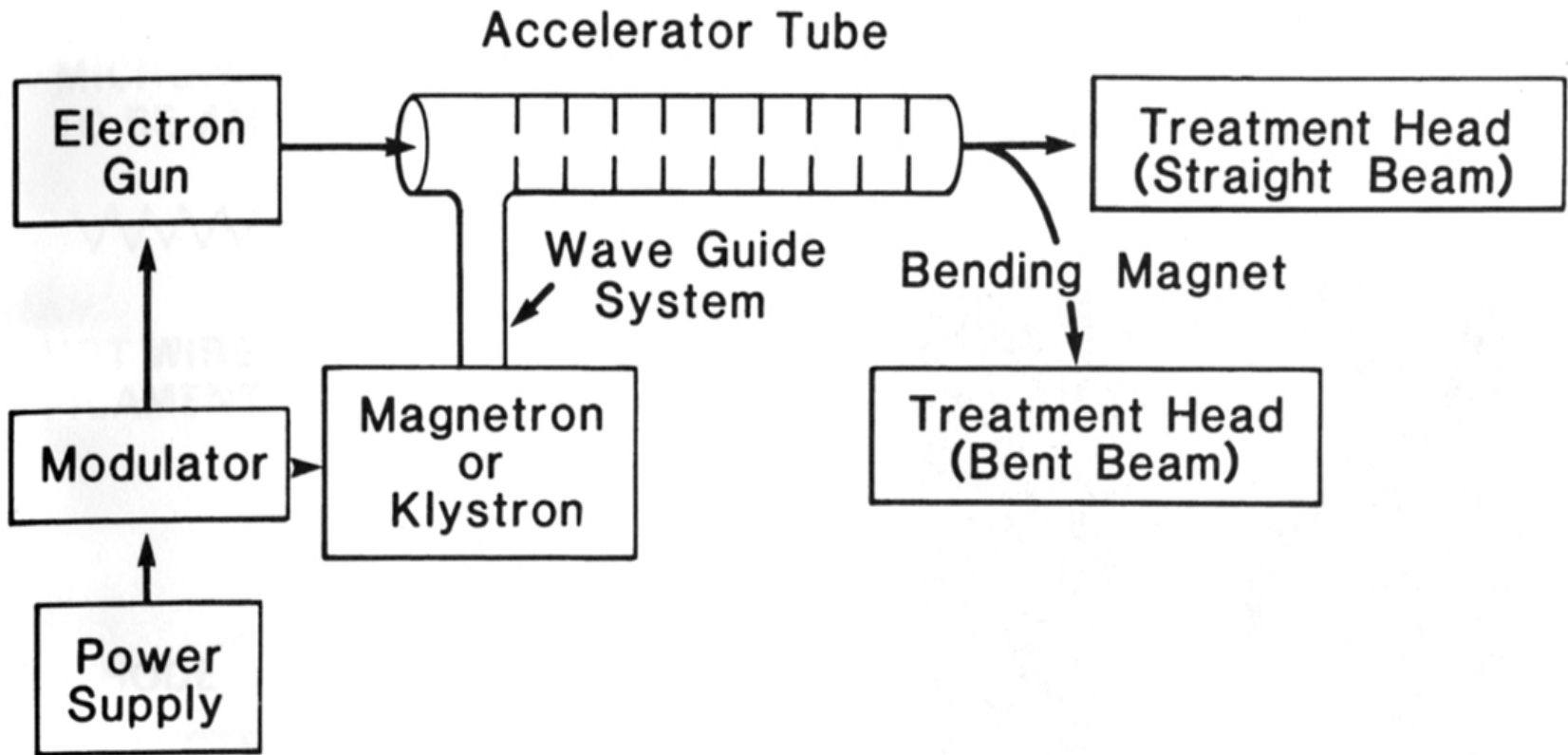


Diagram of Linear Accelerator



LINEAR ACCELERATOR



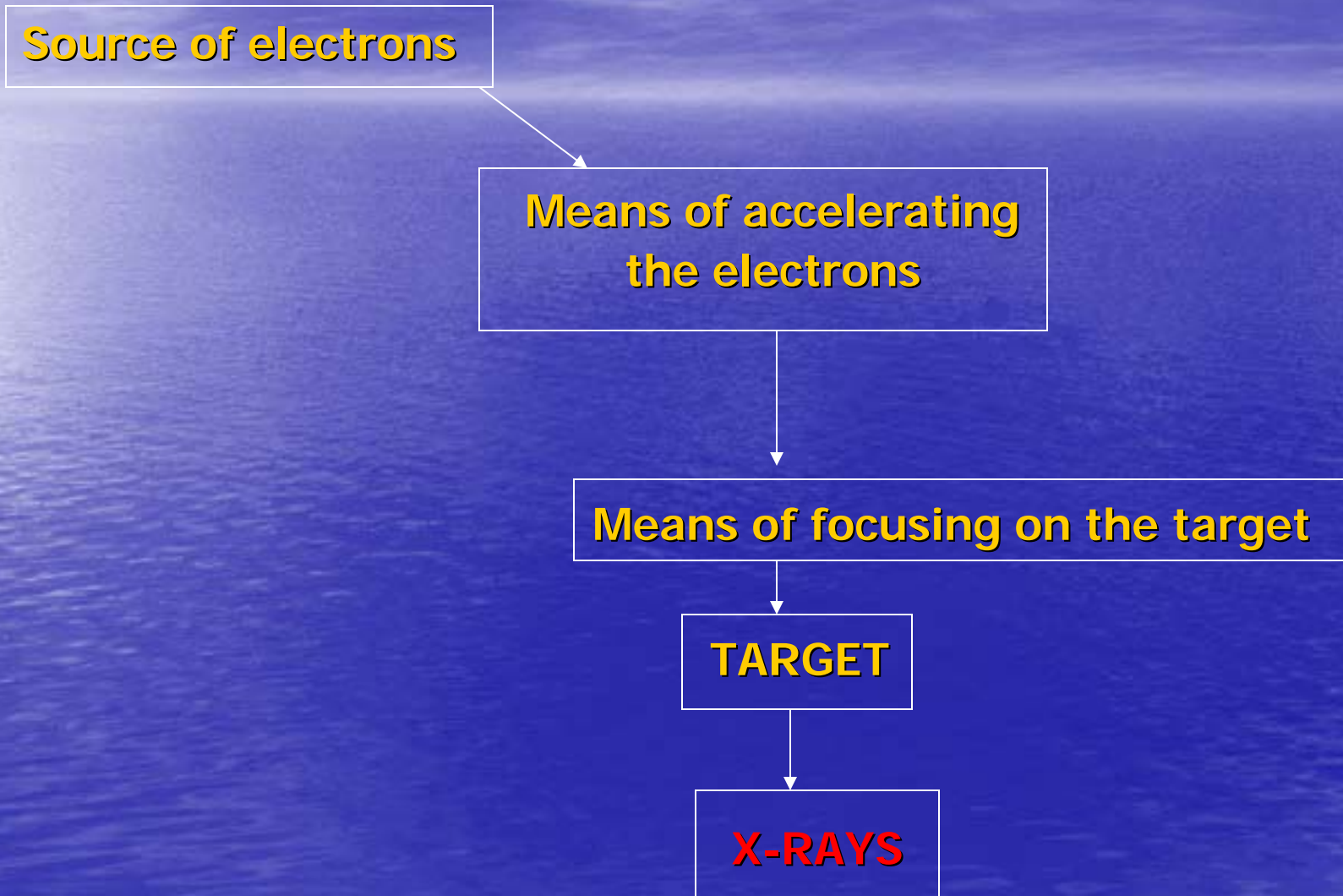
▪ Courtesy of Varian Medical System

LINEAR ACCELERATOR

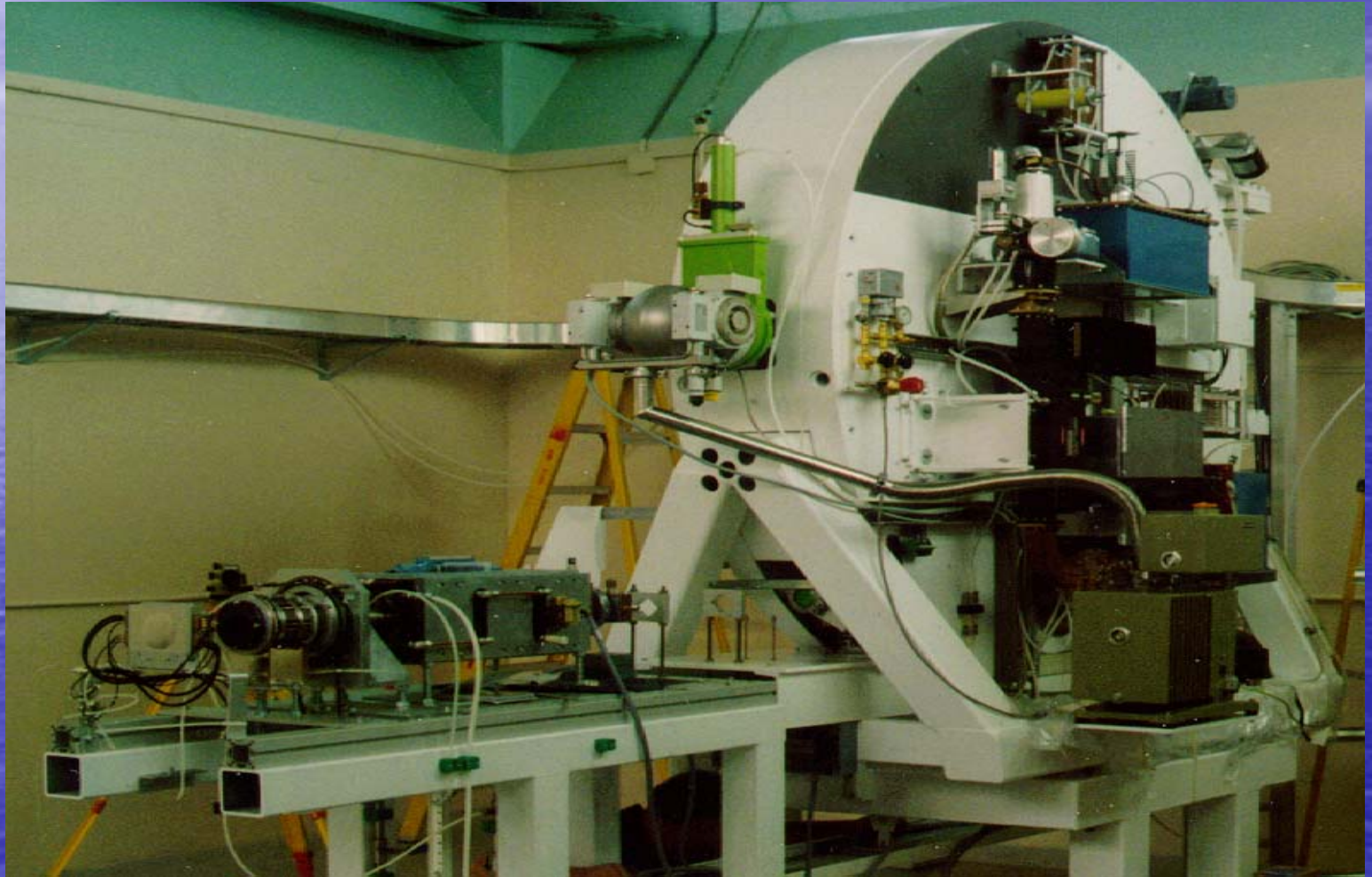


Courtesy of Varian Medical System

MICROTRON



MICROTRON

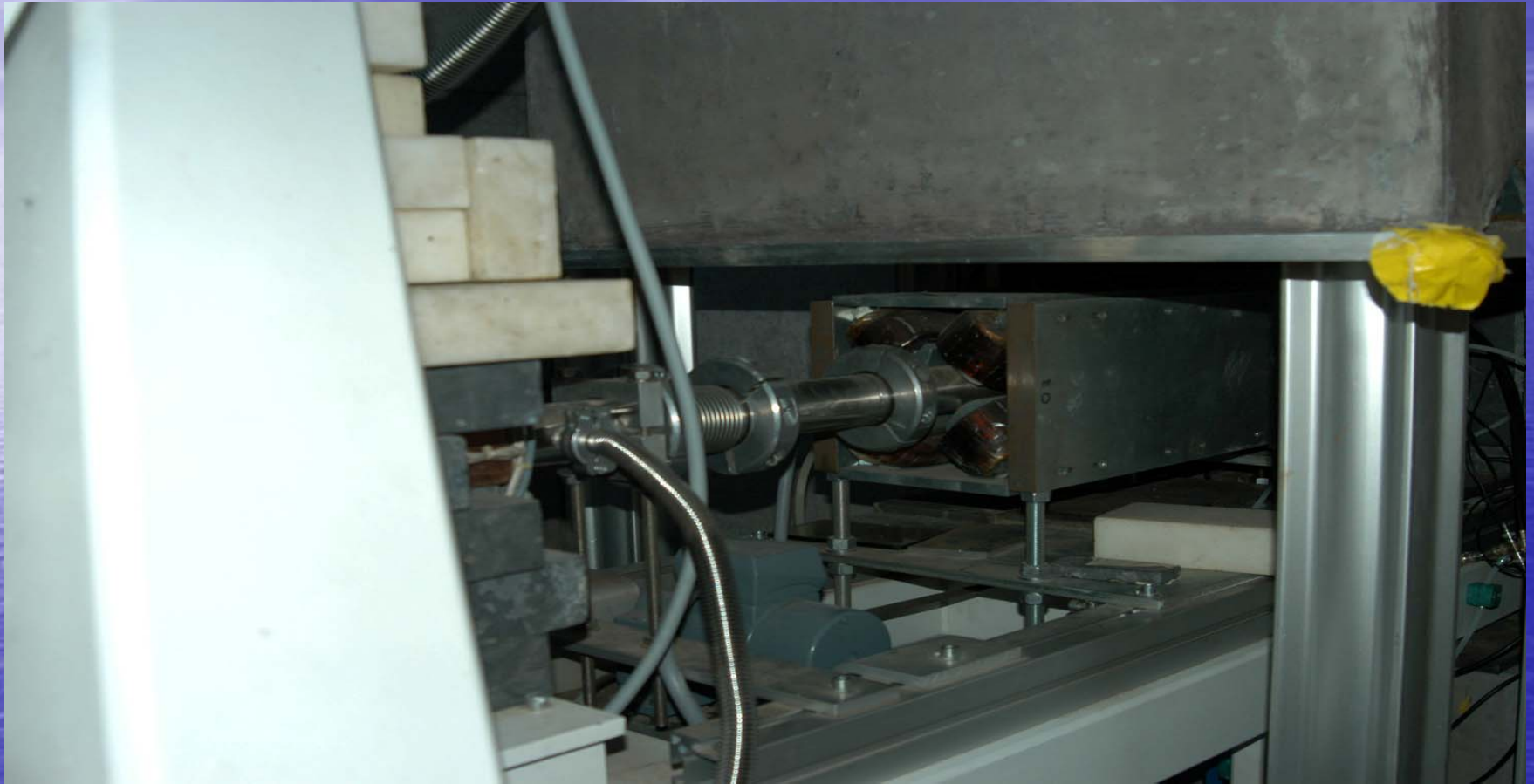


MICROTRON



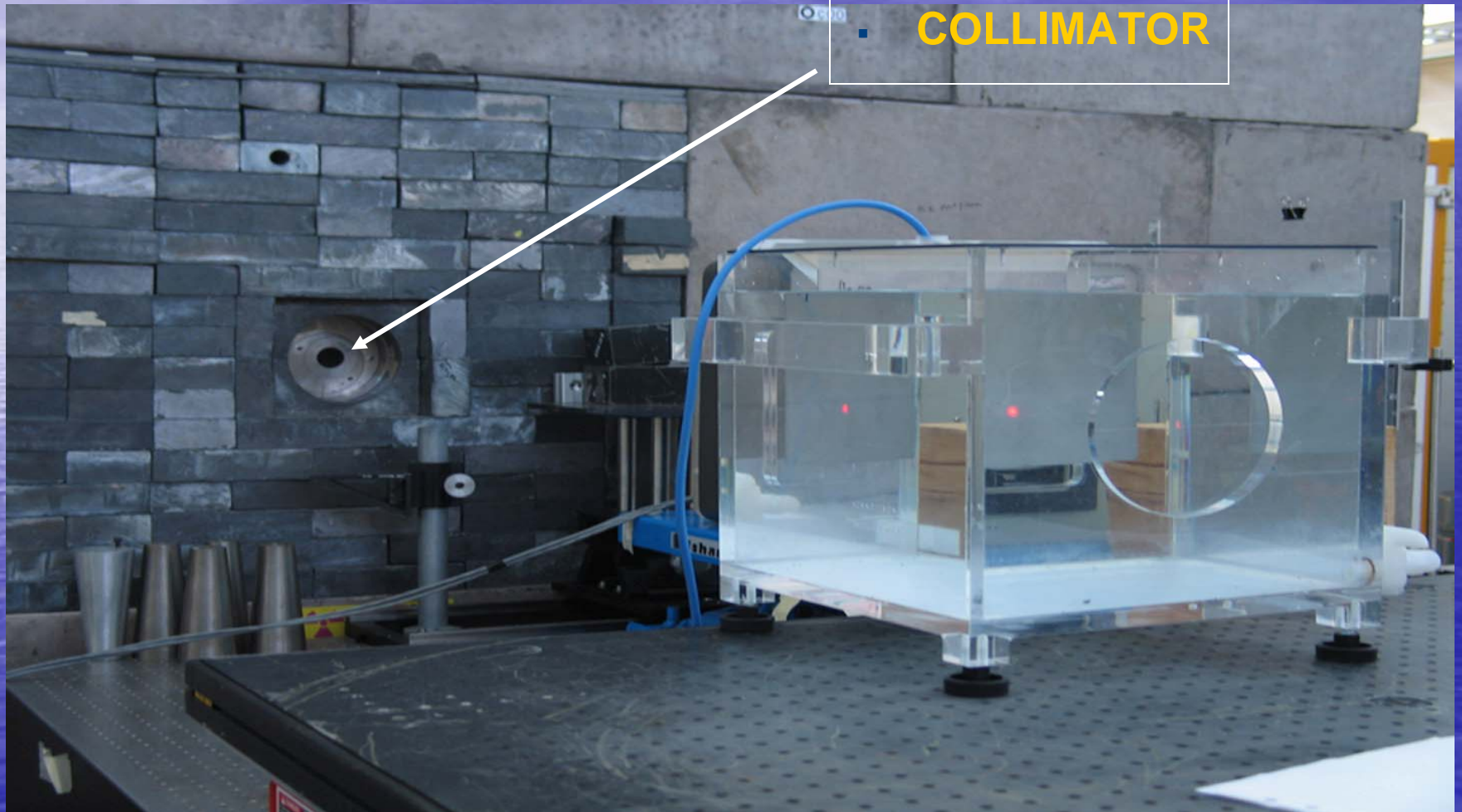
- View from target towards electron exiting position

MICROTRON



- **View from magnet looking towards the target**

MICROTRON



- Front view of the microtron

BETATRON

[click to go back](#)



TESTS TO BE PERFORMED

ACCEPTANCE: Baseline

Manufacturer and customer perform the tests jointly

QUALITY CONTROL (specific frequency)

Performed by the User

Testing Interval: semi-annual unless a major component has to be replaced or a software updating.

Diagnosis of change in performance before radiologically apparent

Verification of corrective action

ACCEPTANCE TESTS

- **RADIATION OUTPUT** (dose calibrated at a specific distance and collimator setting or cone size)
- **Beam flatness and symmetry**
- **Machine ion chamber linearity**
- **X-ray beam spectrum**
- **Beam stability**
- **Focal spot size**
- **Beam energy verification**

QC tests

- **NOTE: These are our recommendations.**
- Radiation output
- Ion chamber uniformity
- Flatness and symmetry
- Energy check

QC tests

Why these tests:

1. In the digital environment we will need to know the dose to the digital panel so that degradation and a “dead panel” statistics can be gathered.

At what approximate dose did your panel die?

2. Some components in an object are radiosensitive so that the dose has to be tracked.

3. To perform calculations, we have to know that what is read out is really what was given.

4. A stable and uniform beam is preferred to doing “software” manipulations.

5. A method of monitoring the internal components.

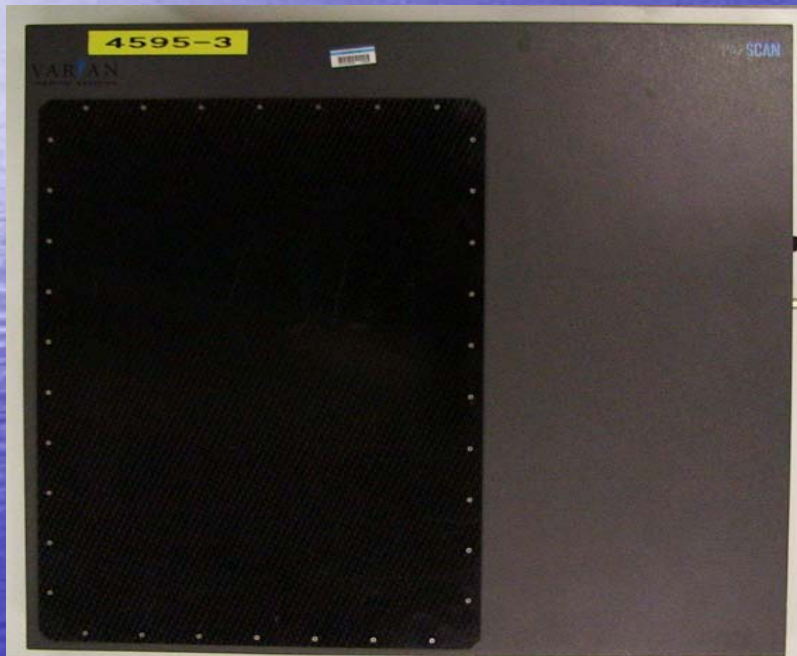
EQUIPMENT FOR THE LINEAR ACCELERATOR TESTS

EQUIPMENT -CR



- Can be used for flatness/symmetry measurement

High Energy Panel



- Can be used for flatness/symmetry measurement

EQUIPMENT (TLDs and Ion Chambers)



- Ion chamber with various build-up caps

EQUIPMENT (ELECTROMETER)



- **ELECTROMETER** used with the various
Ion chambers and build-up caps
Used for any quantitative measurement

EQUIPMENT (ION CHAMBER w/ Electrometer)



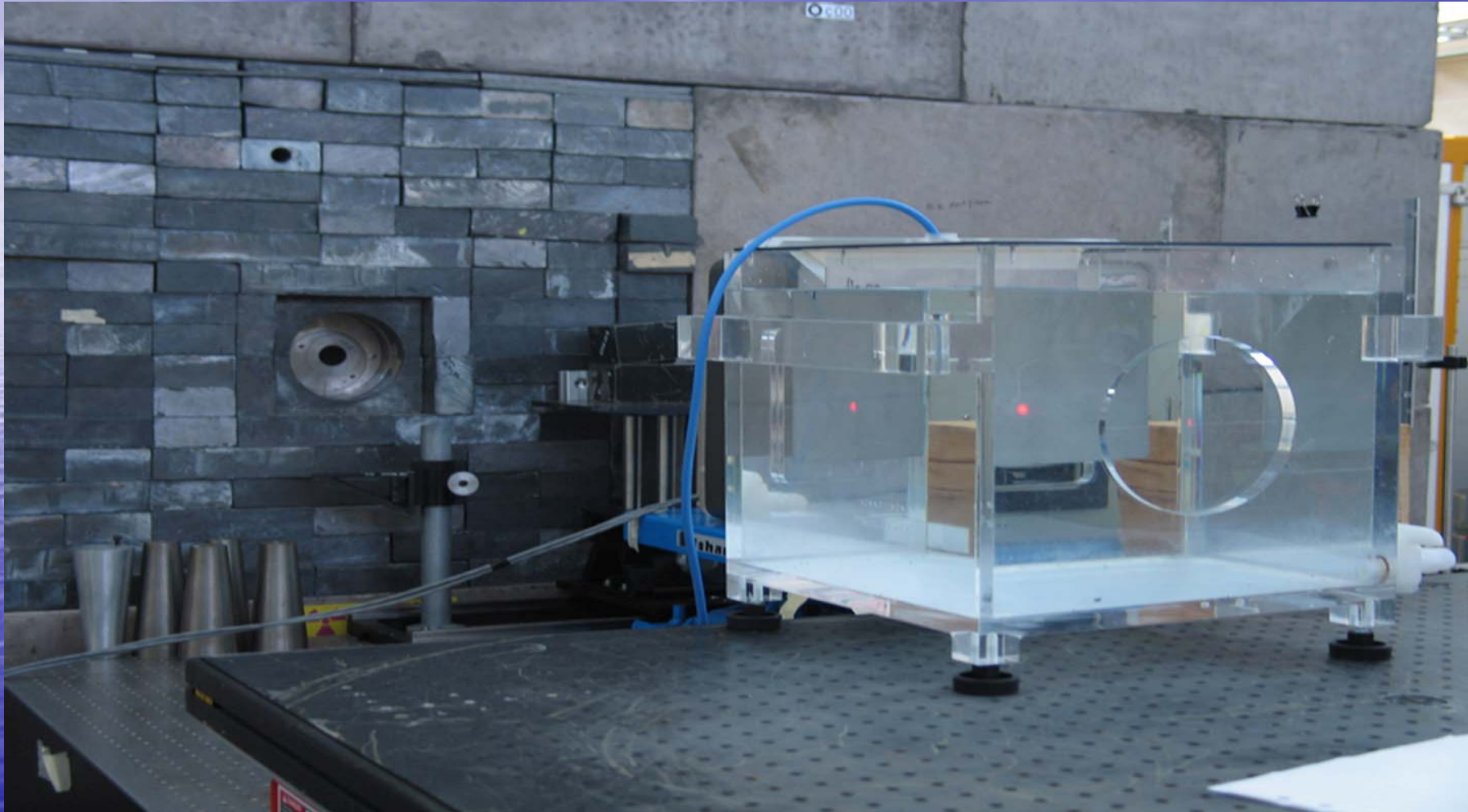
- **RADCAL 9015**
can be used for output checks

EQUIPMENT (IC PROFILER)



- The Profiler can be used for flatness/symmetry measurements

EQUIPMENT (WATER PHANTOM)



EXAMPLE: OUTPUT CHECK

- **EQUIPMENT:** ion chamber with appropriate build-up cap, and electrometer, barometer, thermometer
- **Procedure:**
 1. choose collimator setting to define output (10cm X 10 cm, 2 degree cone etc.)
 2. Set the source to detector distance (100 cm to the front of the build-up cap)
 3. Record the pressure and temperature
 4. Attach the ion chamber to the electrometer and allow it to warm-up.
 5. Once it is warmed-up zero the electrometer.
 6. Either set an appropriate time (1 minute) or number of rads (200 rads)
 7. Turn on the radiation and obtain three readings.

OUTPUT CHECK

8. Average the three readings and record the time.
9. If the electrometer reads (nC), take the average reading multiply it by the calibration factor (for both the ion chamber and electrometer), and the temperature-pressure correction factor and divide it by the time.
10. This will give rads/min or rads/sec depending on the units for time.

OUTPUT CHECK (SAMPLE FORM)

Temp ___ C + 273 = _____K (a)

Pressure = _____mmHg (b) H (t-p) = (a/295)*
(760/b) (c)

Instrumentation Used

Chamber _____ SN _____ N= _____

Electrometer _____ SN _____ Bias Voltage

Field size (Cone) = _____cm x _____cm

Source Surface Distance _____ cm

Time (min):
AVERAGE (d)

Electrometer (nC) AVERAGE (e)

NOTE: N is the ion chamber and electrometer calibration factor

OUTPUT CHECK (SAMPLE FORM)

$$\text{OUTPUT rad/min) = (e/d) * (c) * N}$$

REMEMBER: This is only for the field size calibrated

DISPLAY QA/QC

DISPLAY



DISPLAY QA/QC

The American Association of Physicists in Medicine (AAPM) has done a lot of research in this area.

TASK GROUPS HAVE BEEN CHARTERED TO PROVIDE GUIDELINES

The American College of Radiology is updating the guidelines

The Society for Imaging Informatics in Medicine continues to publish articles ask "Ask the Expert" section.

DISPLAY QA/QC

<http://deckard.duhs.duke.edu/~samei/tq18.htm> (This has the procedures and images that are needed)

P. Berry, K. Vansyoc, D. Summa , The Future Radiography Department, Materials Evaluation, vol. 65, number 11, pp1099-1101, Nov 2007, section on the "reading room" and monitors.

e-mail me (pberry@lanl.gov) for power point presentation from Argentina conference and additional articles on the subject.

MONITOR ISSUES: QUESTIONS ASKED

- CRT vs. LCD **LCD**
- How many Mpx **5**
- What about the contrast ratio? **250+**
- How many bits 8,10, or 16? **9-10**
- Monochrome LCD or color LCD? **Color**
- Consumer grade or medical grade display **Medical**
- What about PDAs? **Do NOT Use**
- What about ambient conditions **Modest**
- Do displays need testing? **Yes**

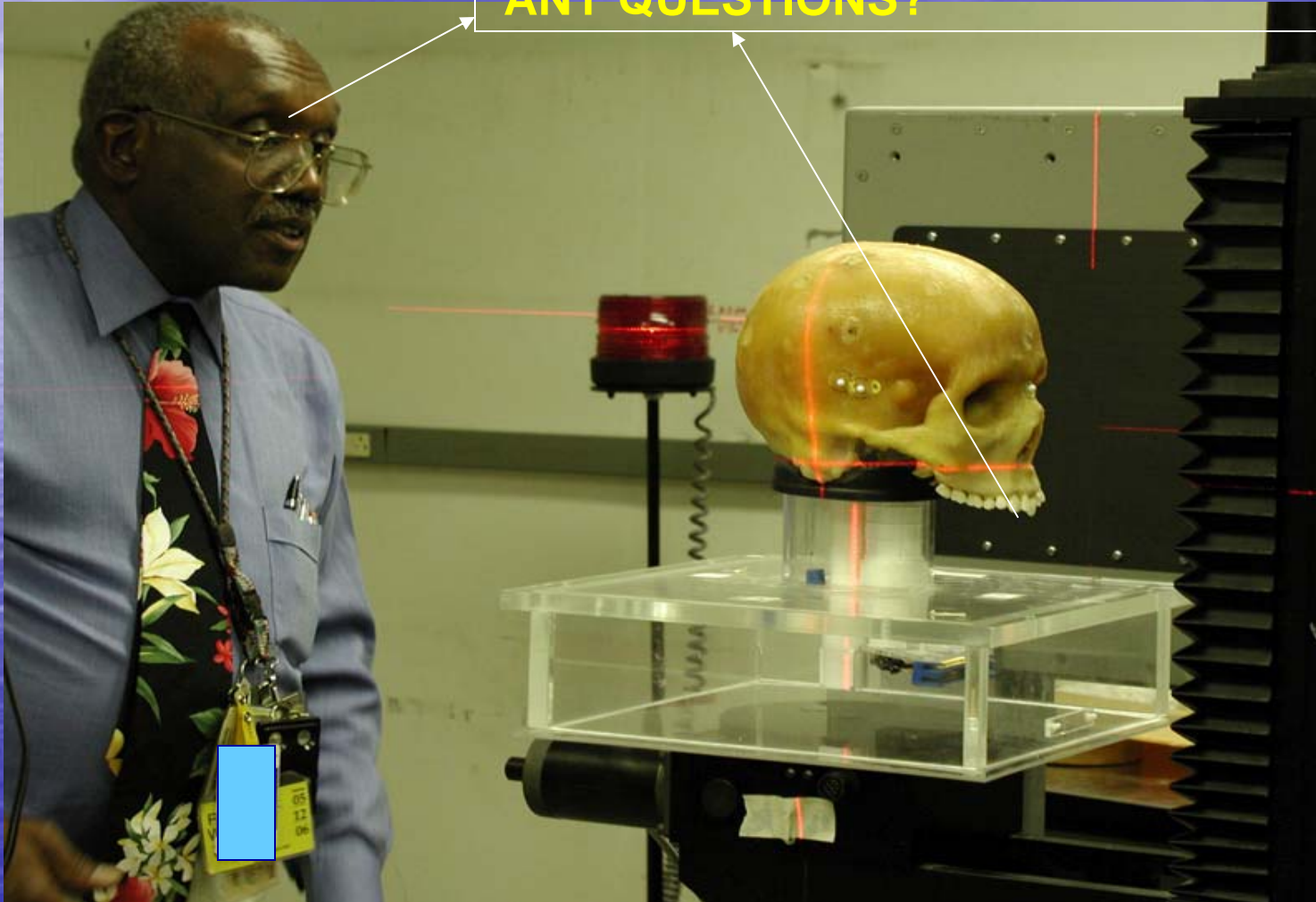
Courtesy of E. Samei

GREAT NEWS

RSNA 2009 will showcase : READING ROOM OF THE FUTURE

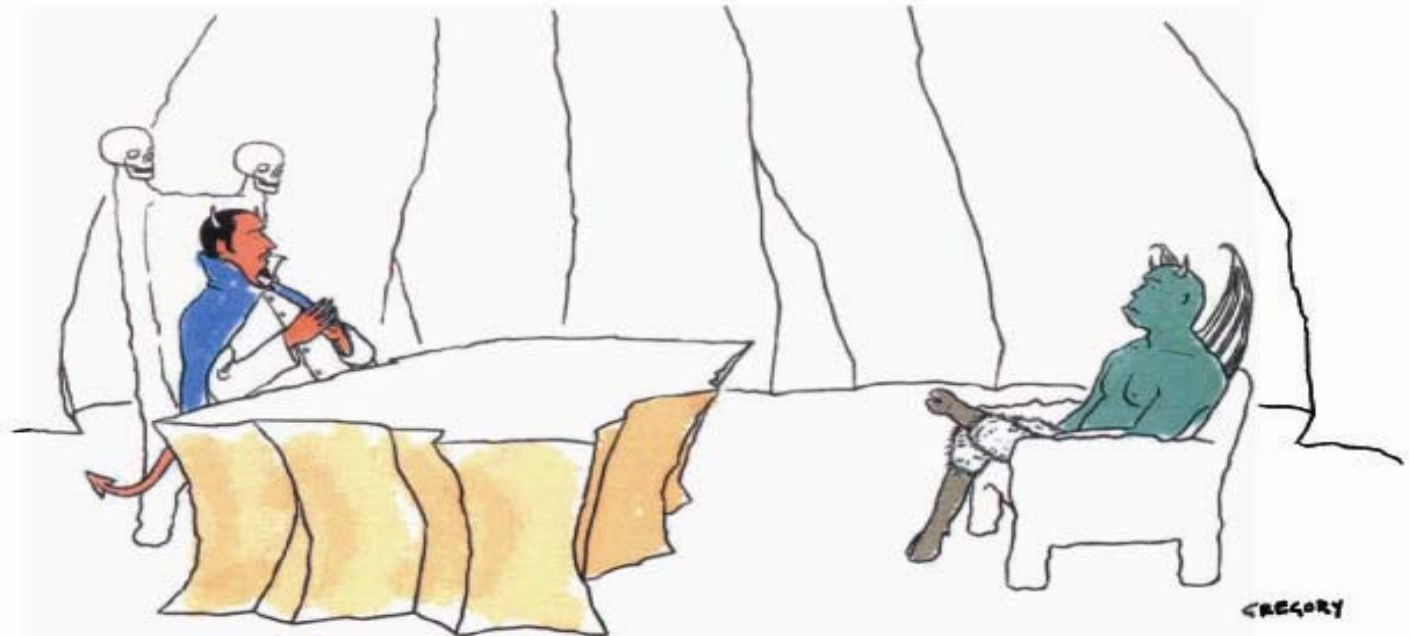
NOT A PRODUCT PROMOTION BUT WILL SHOWCASE PRODUCTS THAT INTEGRATE QUANTITATIVE ANALYSIS INTO THE IMAGE INTERPRETATION PROCESS.

Well, that's all that there is for QA/QC
part 1.
ANY QUESTIONS?



THE END

Questions?



"I need someone well versed in the art of torture—do you know PowerPoint?"