

NM Q.A.

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2019/9/7

-
- ◎ 在現代醫學系統中**臨床檢查&檢驗系統**扮演相當重要的角色，因此對於**本身品質**的責任更重要。
 - ◎ 目前一般都使用品質保證計畫(Quality Assurance ;QA) Program 的觀念來對**相關測試**做**整合與規劃的工作**，而在此計畫下包括實際對相關測試所得數據統計處理的品質控制 (Quality Control :QC)部分。

QC

- ◎ 品質管制 Quality Control (Q.C.)
- ◎ 執行穩定 Performance Stability :
- ◎ { Acceptance testing :Specification 、 function 、 safety.
- ◎ { Routine performance monitoring
- ◎ { Error correction
- ◎
- ◎

-
- ◎總而言之，品保的目標可視為一個全面的管理計畫，用於制訂完整且周全的設備管理、品質測試、資料收集並進行結果分析，其最終的目的為確保並促進病患的權益。

Why To Do

- ◎ 1：合理化(Justification):確保暴露成本遠小於所得利益的價值。
- ◎ 2：最適化(Optimization):增加在相同暴露成本之下所得到的利益、減低暴露的成本並得到合理的價值。(ALARA、TSD....)
- ◎ 3：限制化(Limitation)

QC



設備品管
?

Outline

- Purpose
- NEMA
- Planar images
- SPECT



Purpose (目的)

偵測 gamma camera system 的改變

- ◎ 遵循 **NEMA** 所訂的測試方法、**確保檢查的一致性**。
- ◎ 提供最好的服務設備與對病人最好的照顧。
- ◎ 提供 **最好的影像品質**，並將病人的 **輻射劑量降至最低**。
- ◎ 減少危險與金錢的浪費、及不正確的診斷。

NEMA

(National Electrical Manufacturers Association 美國電子設備製造廠商協會)

- ◎ Acceptance testing (接收測示)
- ◎ Routine performance evaluations (例行性能評估)
- ◎ Error correction tests (錯誤校正測試)

NEMA

- National Electrical Manufacturers Association (1926)
- <http://www.nema.org/>
- NEMA is the trade association of choice for the **electrical manufacturing industry**. Founded in 1926 and headquartered near Washington, D.C., its approximately **450 member** companies manufacture products used in the generation, transmission and distribution, control, and end-use of electricity.

GAMMA CAMERAS

- 2.1 Intrinsic Spatial Resolution
- 2.2 Intrinsic Energy Resolution
- 2.3 Intrinsic Flood Field Uniformity
- 2.4 System Spatial Resolution Without Scatter
- 2.5 System Alignment
- 2.6 Spect Reconstructed Spatial Resolution Without Scatter
- 2.7 Wholebody System Spatial Resolution Without Scatter



單光子閃爍偵檢儀

Single Photon Emission Computer Tomograph

PLANAR

&

SPECT

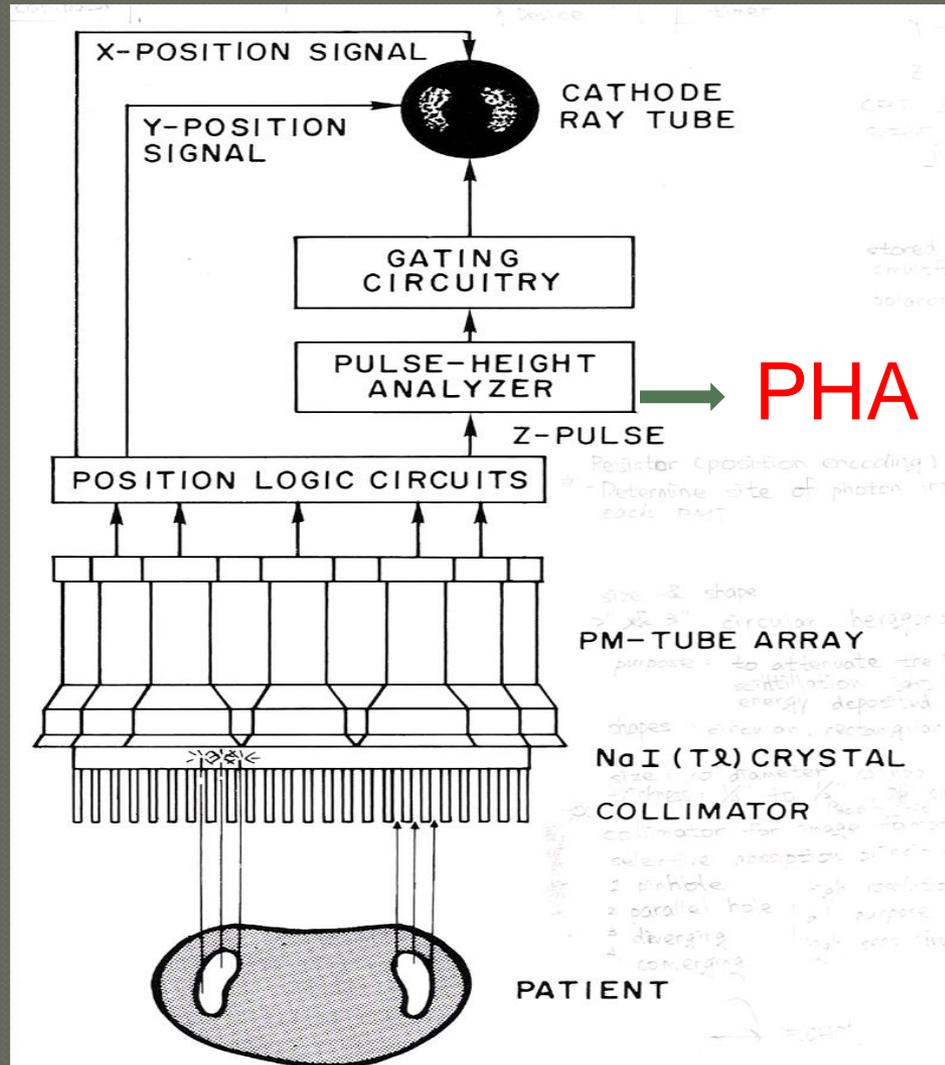
GAMMA CAMERAS

● 安格攝影機基本組件包括：

- 準直儀(collimator)
- 晶體(crystal)
- 光電倍增管(Photomultiplier tube，簡稱PMT)
- 閃爍定位電路(scintillation localization circuitry)
- 修正電路(correction circuitry)
- 能量分析電路(energy analysis circuitry)
- 計數電路(counting circuitry)
- 成像裝置(image display device)
- 影像記錄裝置(image recording device)

Detector

NaI閃爍偵檢器



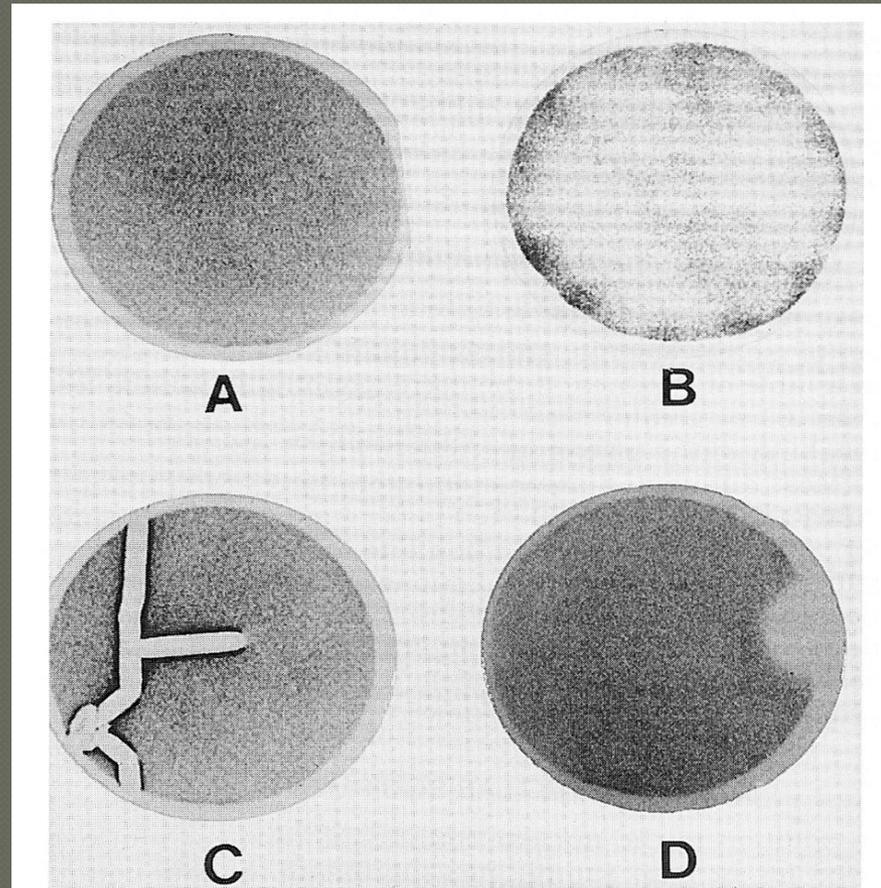
NaI閃爍偵檢器

- ◎ 分辨時間短及偵測效率高
- ◎ 閃爍體吸收能量後，會激發出電子
- ◎ 電子放出可見光
- ◎ 在**NaI**晶體內加入**Tl**，可增加可見光的產率

影響閃爍偵檢效率的主要原因

- ◎ 使用有缺損的準直儀或選用不當之準直儀
- ◎ NaI晶體受潮，或受外力大力撞擊、溫度劇烈變化，使NaI晶體破裂
- ◎ 光電倍增管電路平衡系統故障、功能喪失，或光傳送效率降低
- ◎ 脈衝高度分析器選取不當之光子能峰

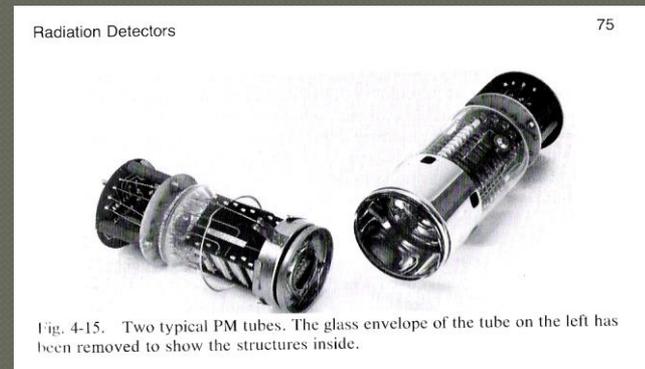
平面造影系統的品質管制 (*QC of Planar Imaging System*)



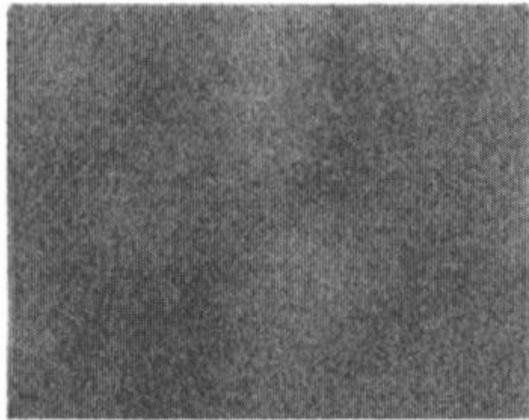
Flood images from a scintillation camera demonstrating (A) acceptable uniformity, (B) shift in high voltage, (C) broken crystal, and (D) nonfunctioning photomultiplier tube. (Reproduced by permission from Sandler MP, Patton JA, Partain CL, eds. *Thyroid and parathyroid imaging*. East Norwalk, CT: Appleton-Century-Crofts, 1986:83.)

光電倍增管 (PM Tube)

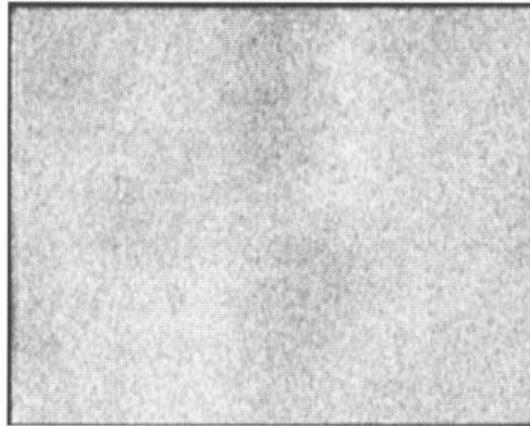
- ◎ 光電倍增管主要是將閃爍脈衝所輸出微弱的光轉變成電子訊號，並大量的增加光電子的數目
- ◎ 晶體通常以矽化脂 (silicone grease) 與光電倍增管連接，以防止由於反射而損失光子



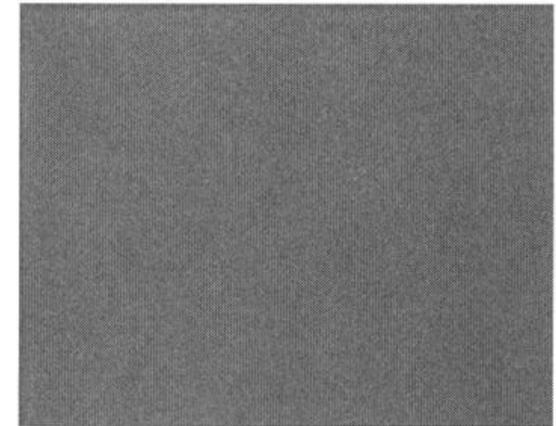
平面造影系統的品質管制 (*QC of Planar Imaging System*)



flood field



correction
matrix



corrected
flood field

Uniformity correction matrix.

Imaging

Planar (平面)

- Photopeak
- **Uniformity Floods** (均勻度測試)
 - ☀ Daily Visual Inspection for Marked Nonuniformity
 - ☀ Correction of Nonuniformity (非均勻度校正)
- **Spatial Resolution** (空間解析)
- **Linearity** (線性)

平面造影系統的品質管制

(QC of Planar Imaging System)

Recommended Types and Frequencies of Quality Control Tests for an Anger Camera

Frequency	Test
Daily	<ol style="list-style-type: none">1. Adjust size and sharpness of dots on CRTs.2. Clean lens, rollers, etc., on cameras.3. Inspect collimators, cables and other components for signs of mechanical damage.4. Obtain flood-field uniformity image5. Calculate system sensitivity.
Weekly	<ol style="list-style-type: none">1. Obtain resolution-phantom image.2. Obtain linearity-phantom image.3. Test performance of accessory devices (multiformat cameras, whole-body scanning tables, computer systems and interfaces, etc.).
Semiannual	<ol style="list-style-type: none">1. Evaluate energy resolution.2. Evaluate counting-rate capability.3. Evaluate multiple-window energy registration.

Planar

Uniformity Floods

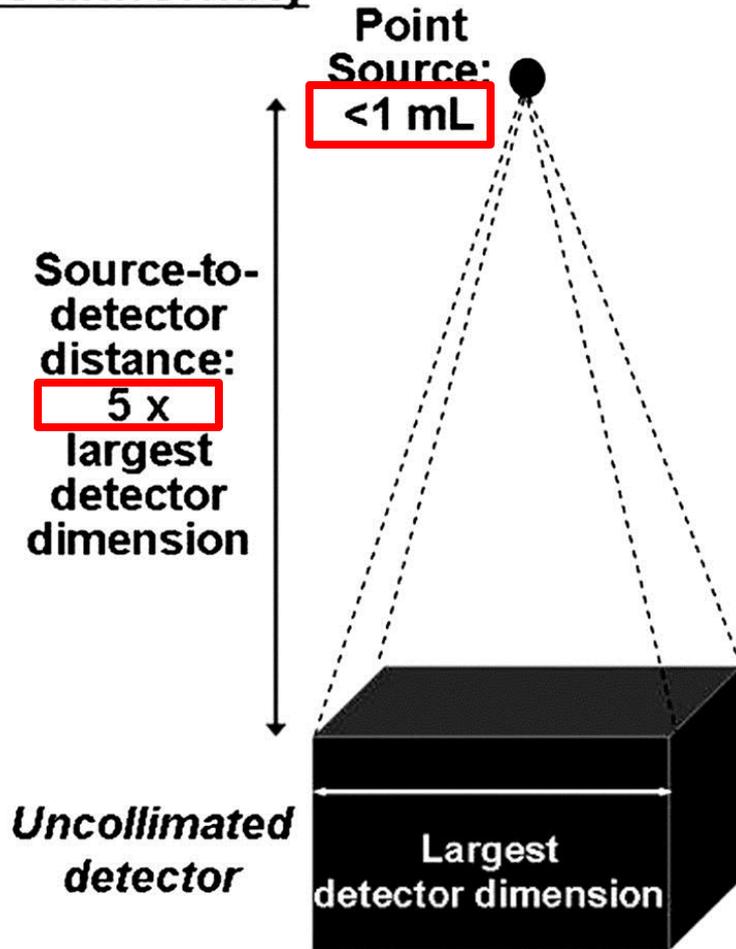
- Imperfections (瑕疵) :
collimators 、 variations in crystal
response 、 differences among PM tubes 、
fluctuations in the electrical circuitry ◦
- Extrinsic Uniformity (with collimator)
Solid plastic disk ex. ^{57}Co
Fluid-filled sheet source container ex. TC

Planar

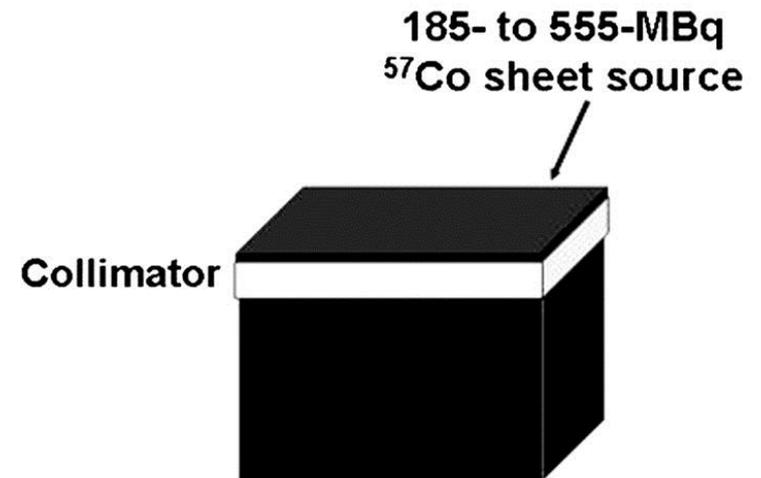
Uniformity Floods

- **Intrinsic Uniformity (without collimator)**
 - Solid plastic disk ^{57}Co
 - Fluid-filled sheet source container $^{99\text{m}}\text{Tc}$
 - Point source $^{99\text{m}}\text{Tc}$**
- 1-3 million-count image

Intrinsic uniformity



Extrinsic uniformity



平面造影系統的品質管制 (QC of Planar Imaging System)



Extrinsic

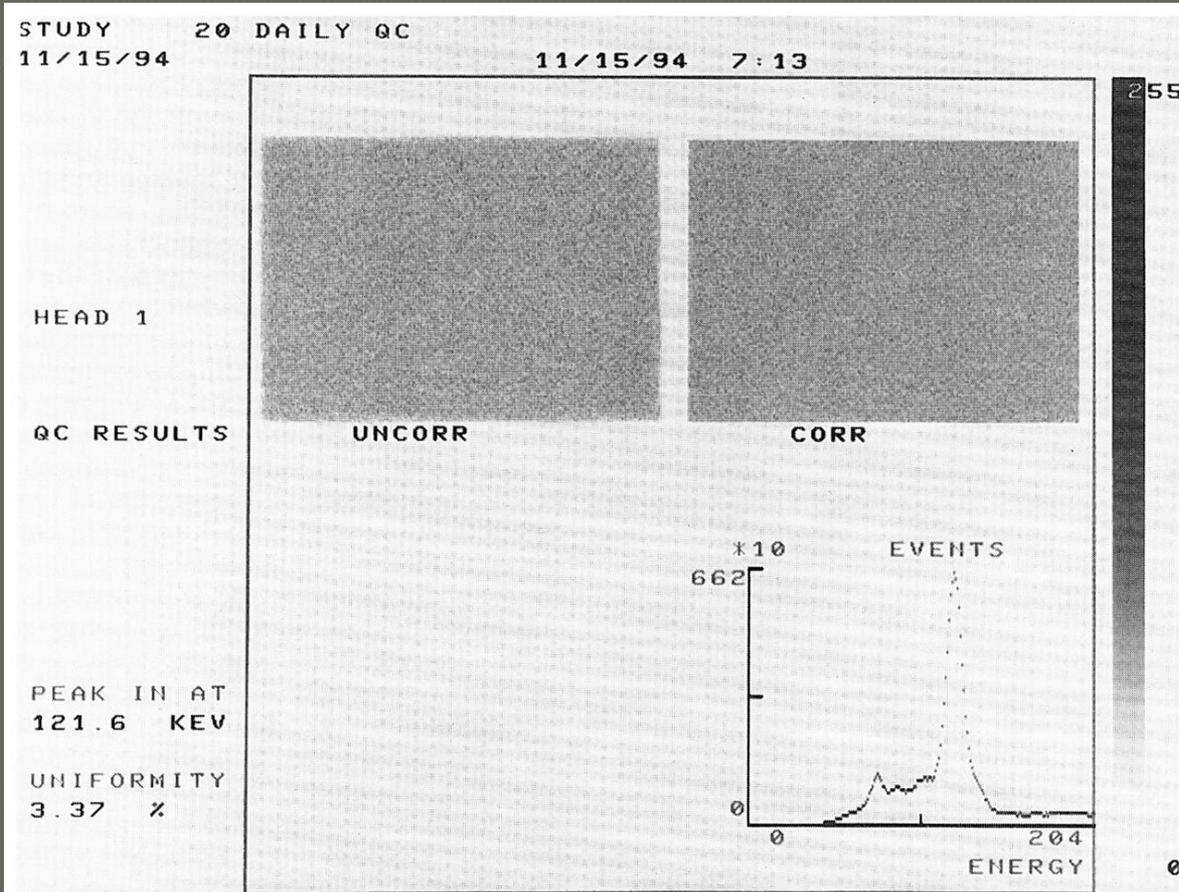
VariCam



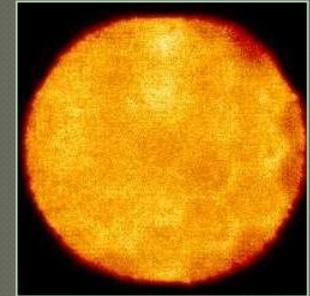
MPR



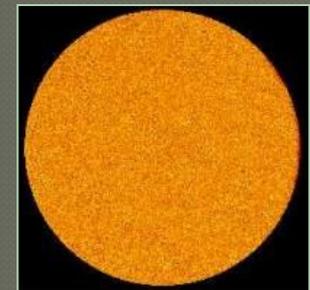
平面造影系統的品質管制 (QC of Planar Imaging System)



Quality control report from a digital scintillation camera showing an energy spectrum from ^{57}Co , the position of the photopeak, a flood from the collimated camera obtained with a plane source of ^{57}Co before and after uniformity correction, and the results of a calculation of integral uniformity.



校正前

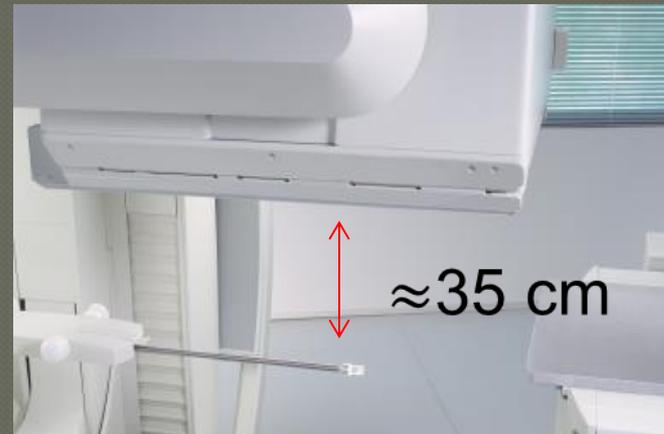


校正後

照野內計數的最大偏差： $\text{Integral uniformity} = (\text{max}-\text{min})/(\text{max}+\text{min}) \times 100\% (\leq 5\%)$

Intrinsic

Point Source



5UFOV \approx 270CM

Uniformity

Calibration QC

ID: siemens

Series Name: Daily Intrinsic Flood

Series Date: 7/17/2008

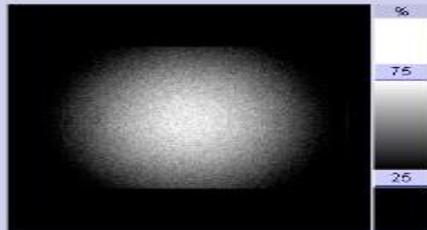
Series Time: 8:01:36 AM

Study 1

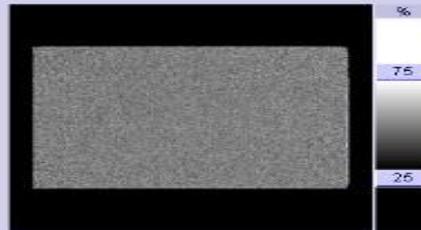
1. IMA Intrinsic Verification

Patient: Calibration QC

Detector 1



Acquired Flood



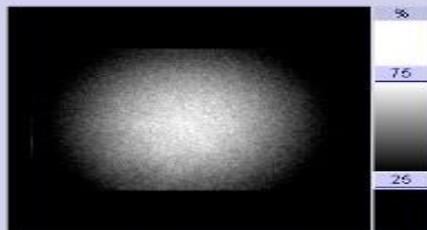
Curvature Corrected Flood

Study: Daily Intrinsic Flood QC Study

Series: Daily Intrinsic Flood

Uniformity	Central FOV	Useful FOV
	Integral: 1.64 %	2.04 %
Differential: 1.30 %	1.30 %	

Detector 2



Acquired Flood



Curvature Corrected Flood

Study: Daily Intrinsic Flood QC Study

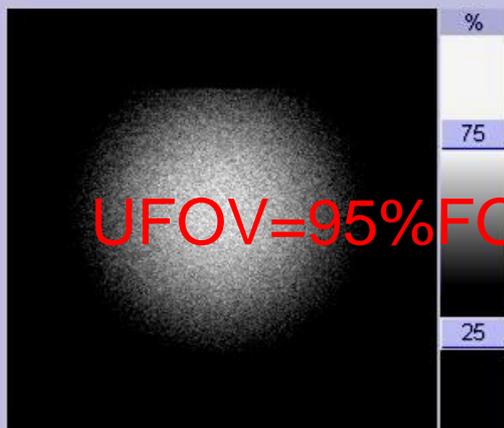
Series: Daily Intrinsic Flood

Uniformity	Central FOV	Useful FOV
	Integral: 2.73 %	2.85 %
Differential: 1.77 %	1.97 %	

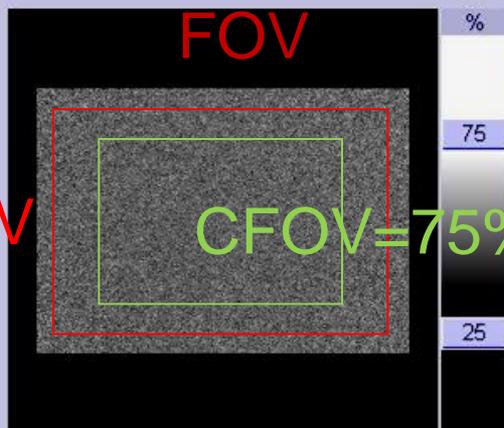
Comment: Daily Intrinsic Flood Display

Daily QC - Intrinsic Uniformity

Detector 1



Acquired Flood



Curvature Corrected Flood

UFOV=95%FOV

CFOV=75%UFOV

Study: Intrinsic Calibration QC Study
Series: Daily QC<20090423><TC99>

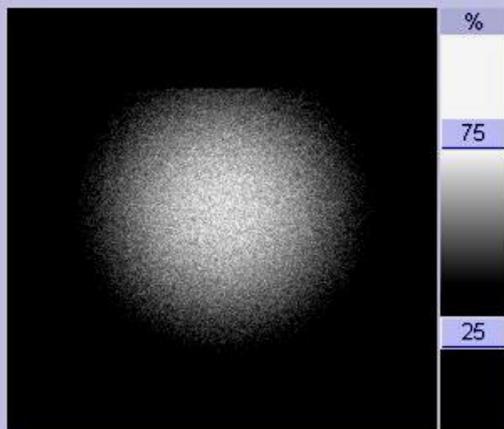
Uniformity

Central FOV Useful FOV

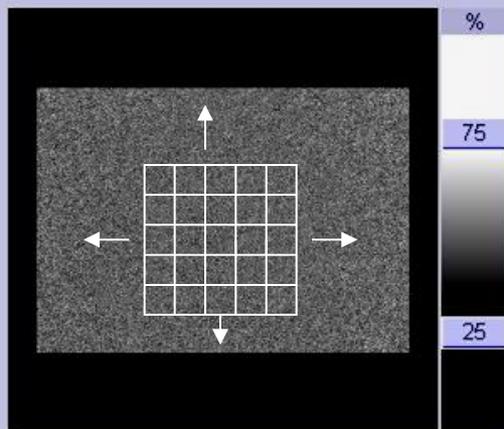
Integral: 1.53 % 1.70 %

$IU = (Max - Min) / (Max + Min) * 100$
Max is the Maximum and Min is the Minimum pixel value in a pixels.

Detector 2



Acquired Flood



Curvature Corrected Flood

Study: Intrinsic Calibration QC Study
Series: Daily QC<20090423><TC99>

Uniformity

Central FOV Useful FOV

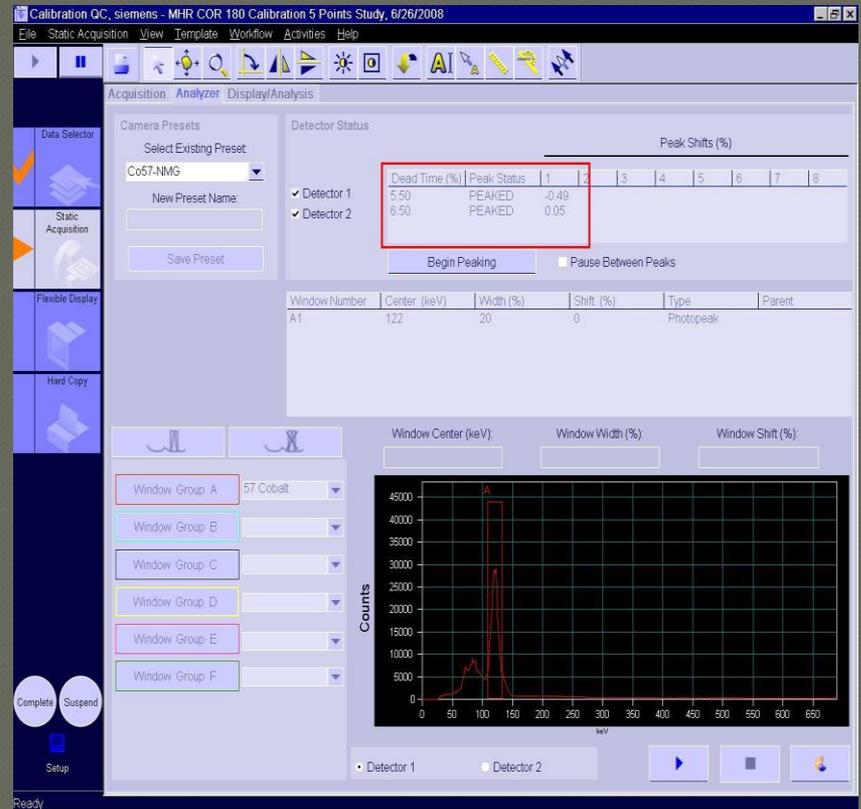
Differential: 1.22 % 1.60 %

$DU = (Hi - Low) / (Hi + Low) * 100$
Hi is the highest and Low is the lowest pixel value in a row of 5 pixels.

Peaking

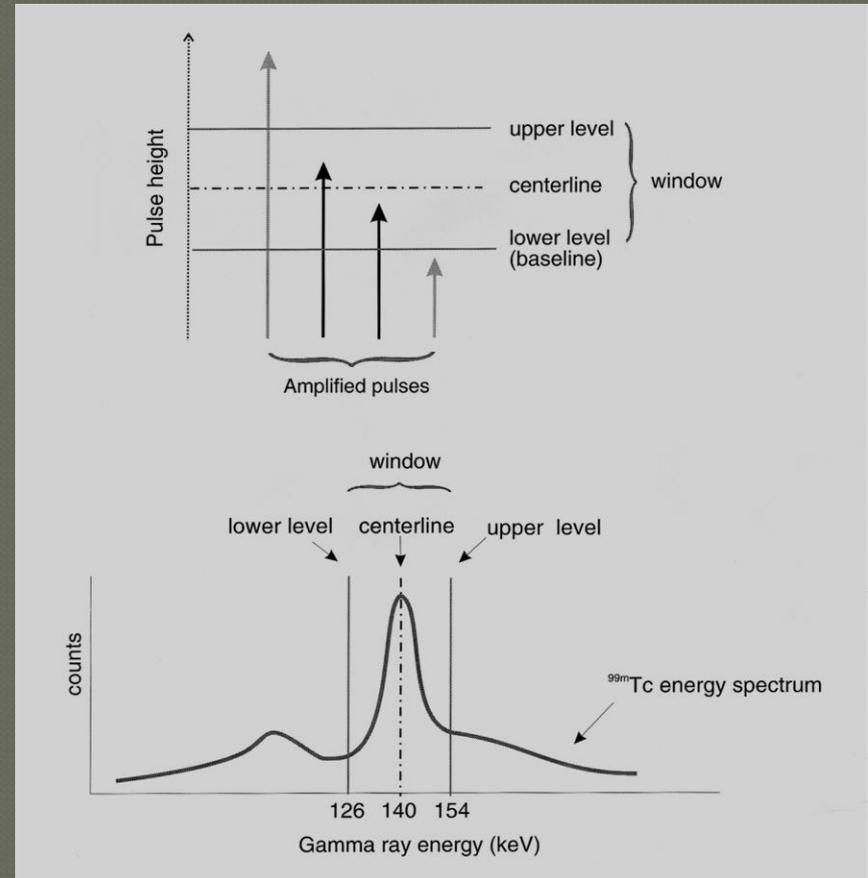
● Tuning procedures :

- 調整個別的 PM tube gains，以使得不同區域之閃爍晶體所產生的 photopeak 其較大或較小部分能夠被包含在 PHA window 內，如此可調整偵測效率以補償影像的非均勻性。



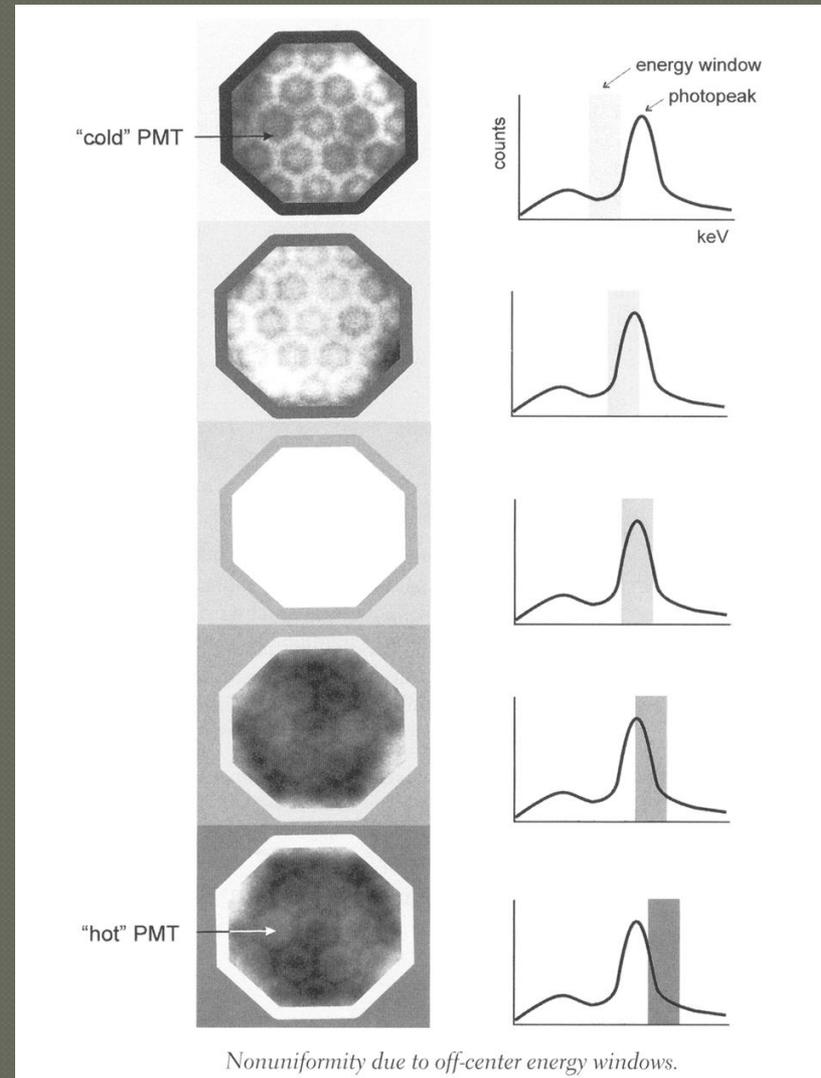
Planar (Photopeak)

- Pulse-Height-Analyzer
- Window of photon energies
- Methods
- Narrow window –
- increases resolution but
- decreases sensitivity

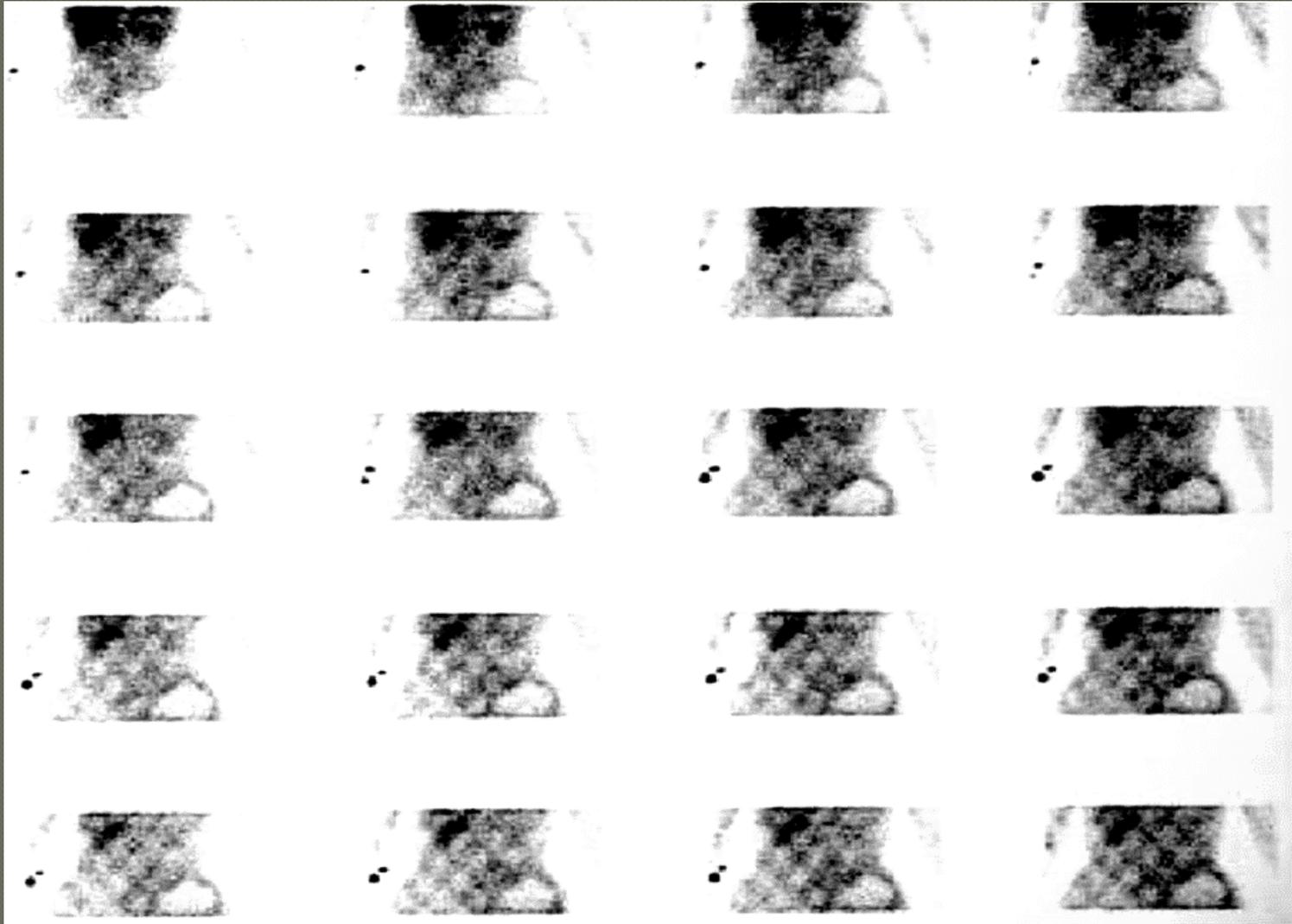


平面造影系統的品質管制 (*QC of Planar Imaging System*)

- Drift of the **energy windows** away from the peak will lead to significant artifacts in images. In some of the older cameras, off-center windows will yield relatively **“hot”** or **“cold”** photomultiplier defects on the daily uniformity floods.



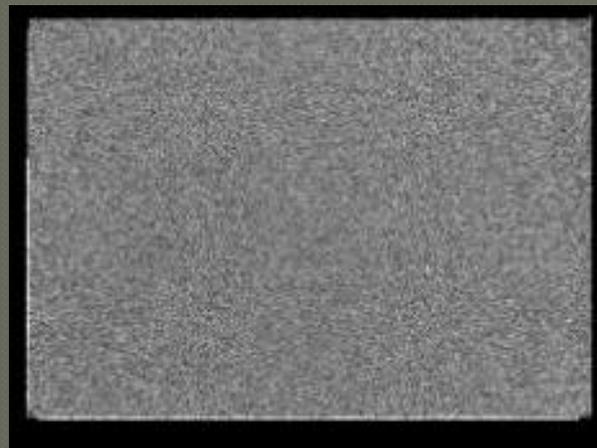
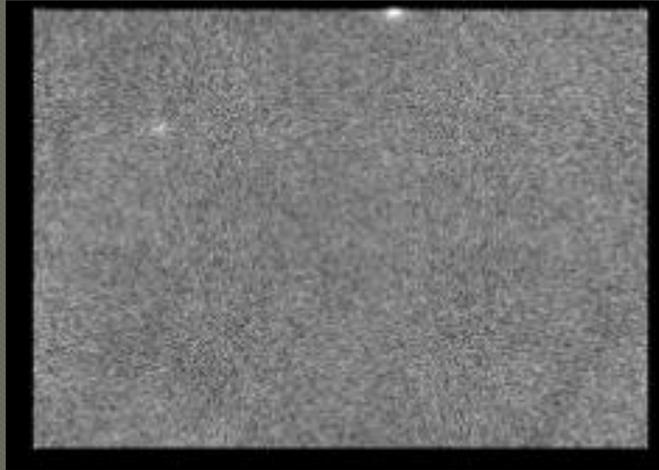
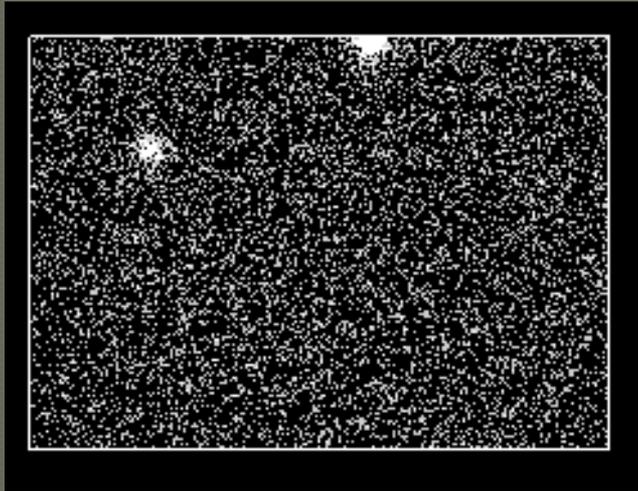
Unstable energy window setting



PM Tube error



Contamination

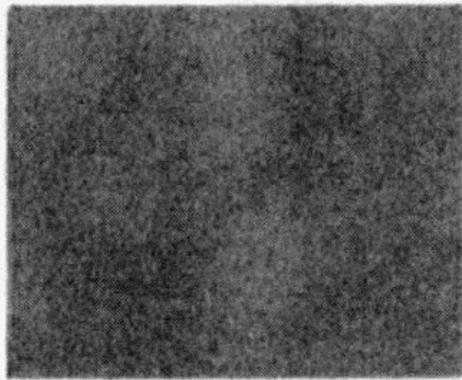


Integral:	3.38 %	3.50 %
Differential:	2.30 %	2.63 %



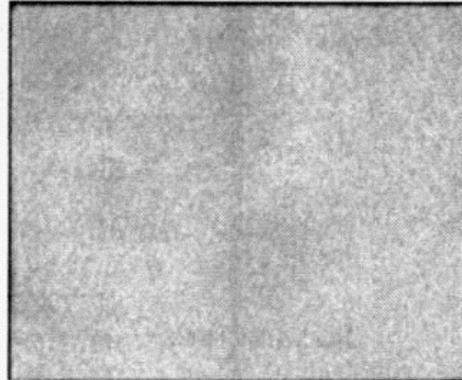
Integral:	1.69 %	2.00 %
Differential:	1.11 %	1.27 %

Uniformity Correction Matrix



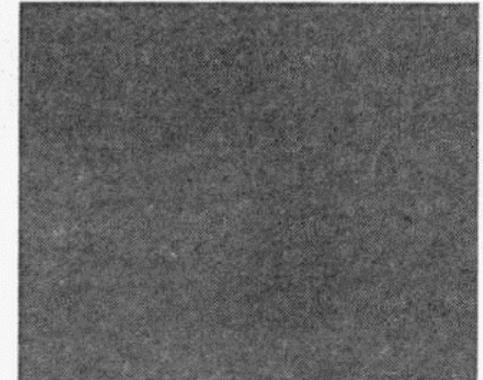
flood field

+



correction
matrix

=

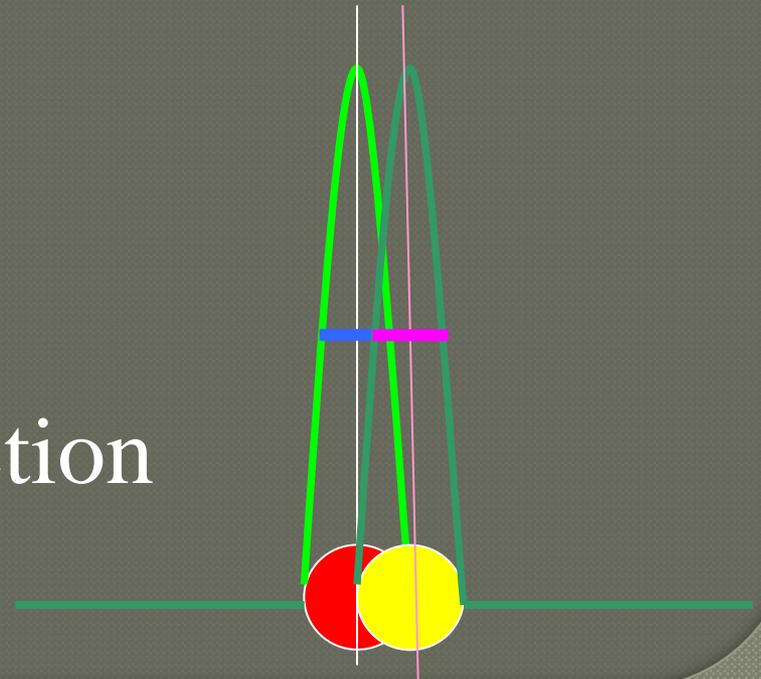


corrected
flood field

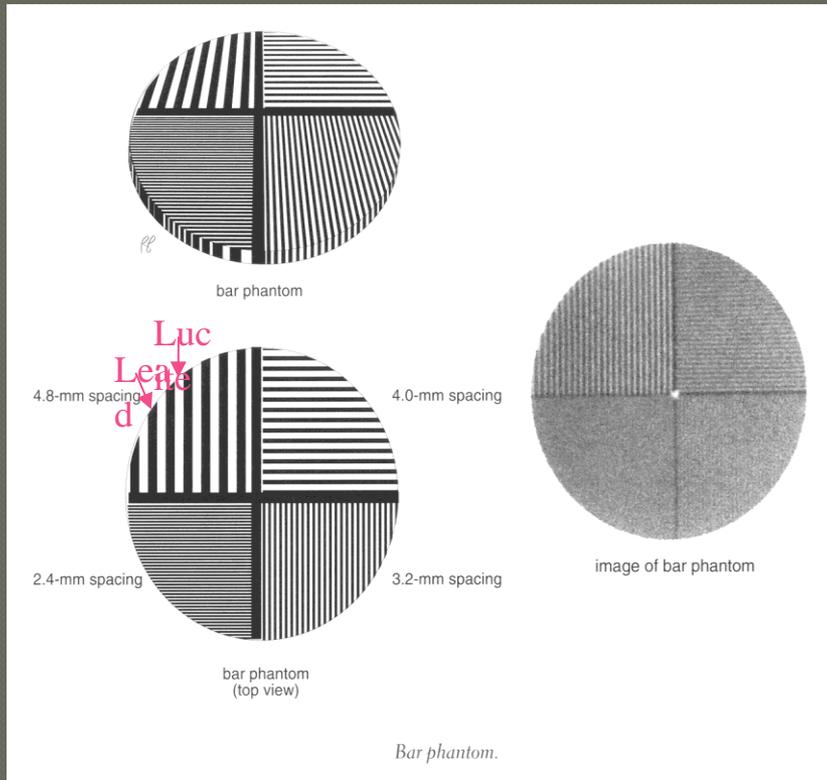
Planar

Spatial Resolution

- Phantom – **Bar phantom**
- Flood source
- Distance
- Weekly
- Line or point spread function



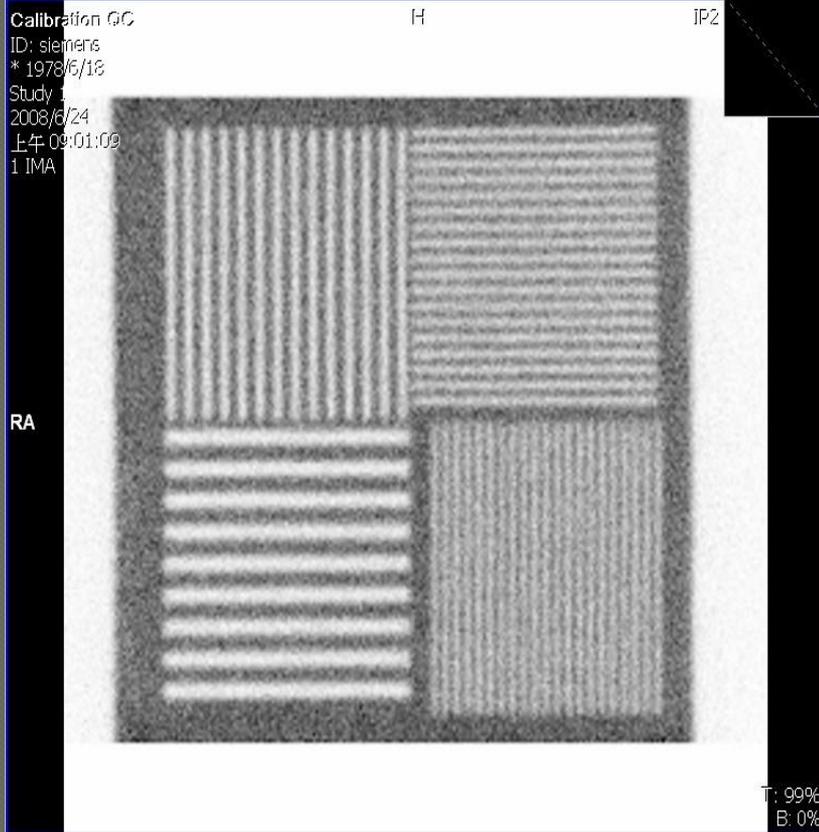
平面造影系統品質管制 (QC of Planar Imaging System)



- The resolution of the imaging system is evaluated visually by imaging a bar phantom

The intervals illustrated in figure above are hypothetical but representative of a standard configuration.

System Spatial Resolution with and without Scatter



Calibration QC
ID: siemens
Spatial Resolution Test 6/24/2008
Study 1
Spatial Resolution Test 6/24/2008

Dept. Nuclear Medicine, Veterans General Hospital, Tai-Chung
Calibration QC siemens

0% 76 0 0 0

Head 1 (Head Out) 2002K Duration: 103sec: 256x256
Pic1: 8mm 57-Cobalt

Head 1 (Head 90) 2002K Duration: 103sec: 256x256
Pic1: 8mm 57-Cobalt

Head 1 (Head out, Phantom Rot 50) 2002K
Duration: 103sec: 256x256 Pic1: 8mm 57-Cobalt

All Images

Spatial Resolution Test 6/24/2008

0% 75 0 0 0

Head 2 (Head out) 2011K Duration: 103sec: 256x256
Pic1: 8mm 57-Cobalt

Head 2 (Head 90) 2011K Duration: 103sec: 256x256
Pic1: 8mm 57-Cobalt

Head 2 (Head out Phantom Rot 68) 2011K
Duration: 103sec: 256x256 Pic1: 8mm 57-Cobalt

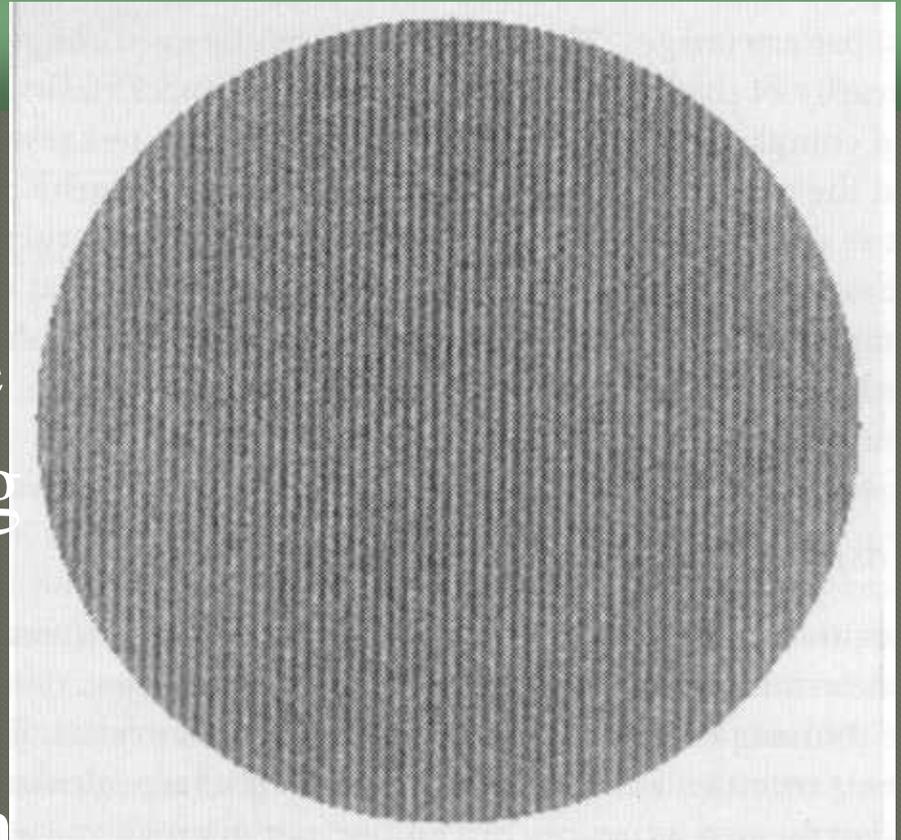
All Images

Comment: Static Display

Planar

Linearity

- Linearity of the gamma camera image is tested by examining the image of the **bar phantom**
- Straight and unbroken



Imaging

SPECT

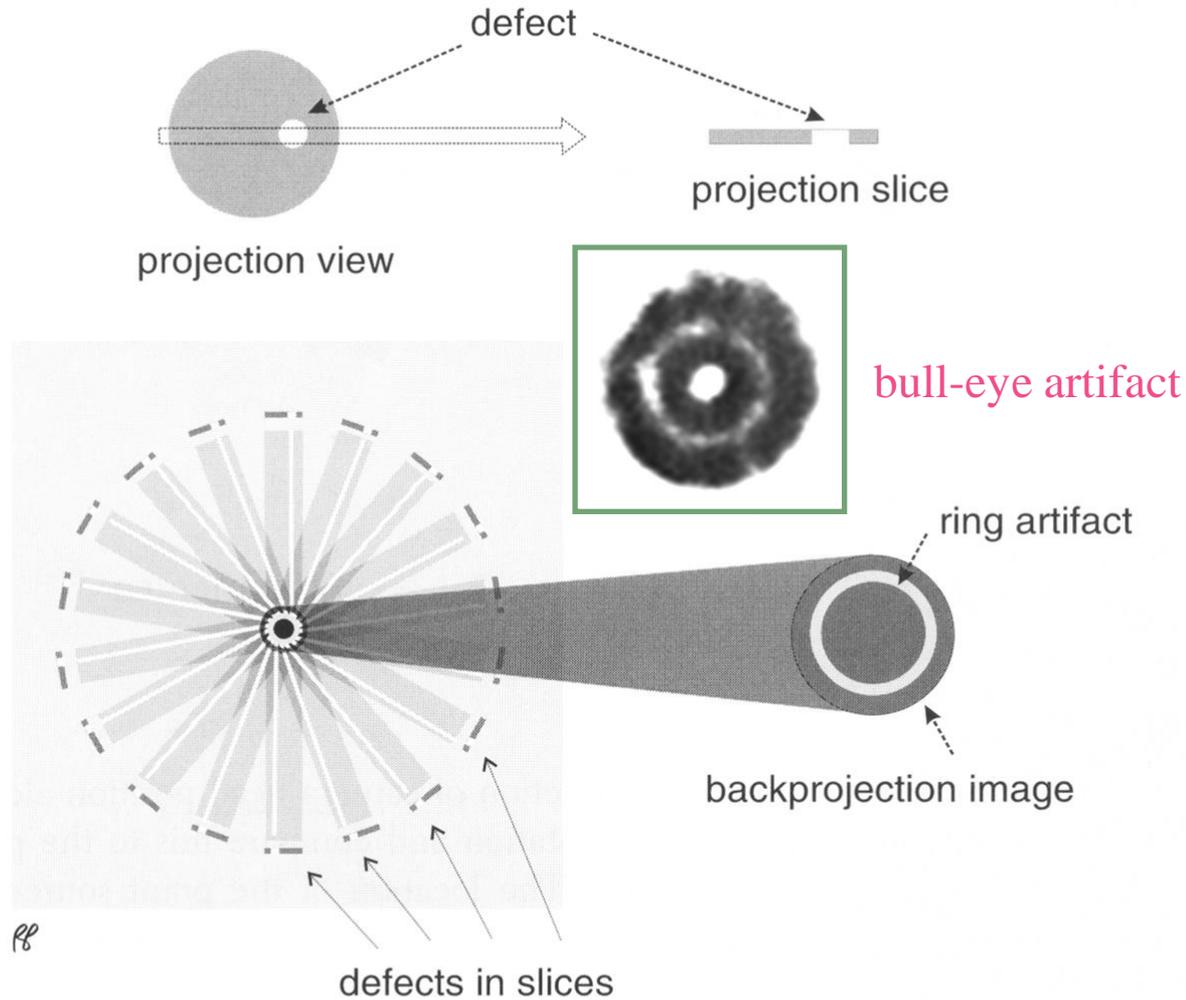
- Uniformity
- Center of Rotation
Measurement of **COR**
- Resolution Using a **Phantom**
- **Images reconstruction algorithm**

SPECT

Uniformity

- SPECT images are degraded by small degrees of **nonuniformity** in the flood field that do not adversely affect **planar images**.
- During backprojection, relatively minor defects will become **quite prominent** and sometimes appear as **ring artifacts** in the reconstructed transaxial slices.

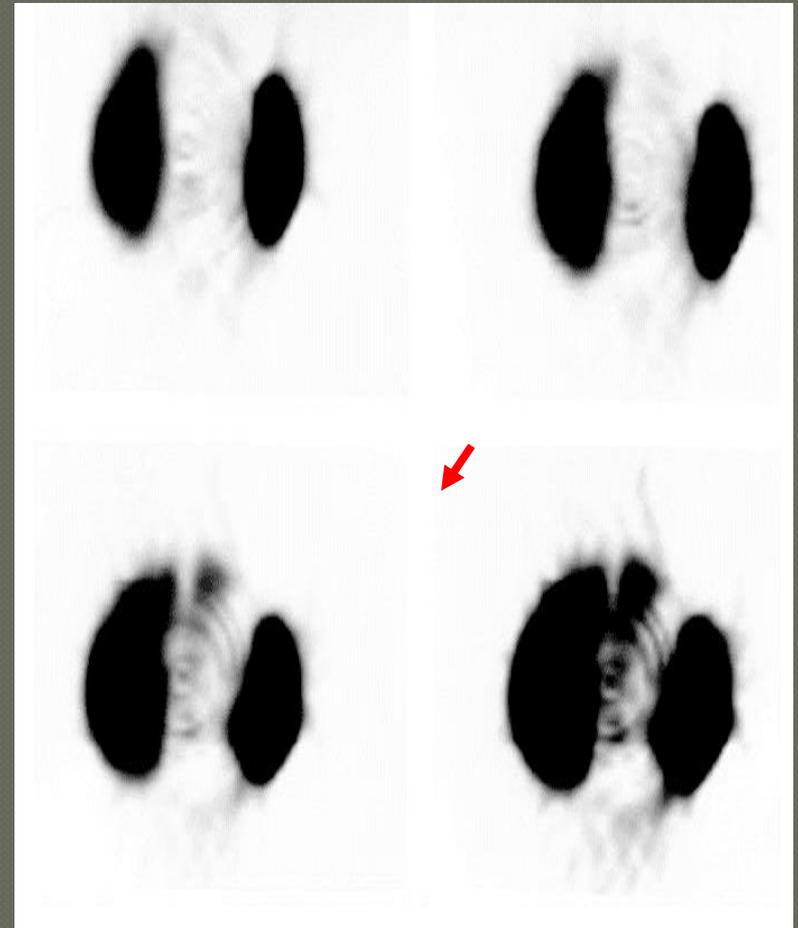
單光子射出電腦斷層掃描系統的品质管制 (QC of SPECT System)



Ring artifact created during backprojection of an area of nonuniformity.

Bullseye Ring Artifact- nonuniformity

- SPECT image through 20-cm diameter ^{99m}Tc -filled cylinder phantom resulting from gross γ -camera nonuniformity Severe ring, or bull's-eye, artifact in transverse



SPECT

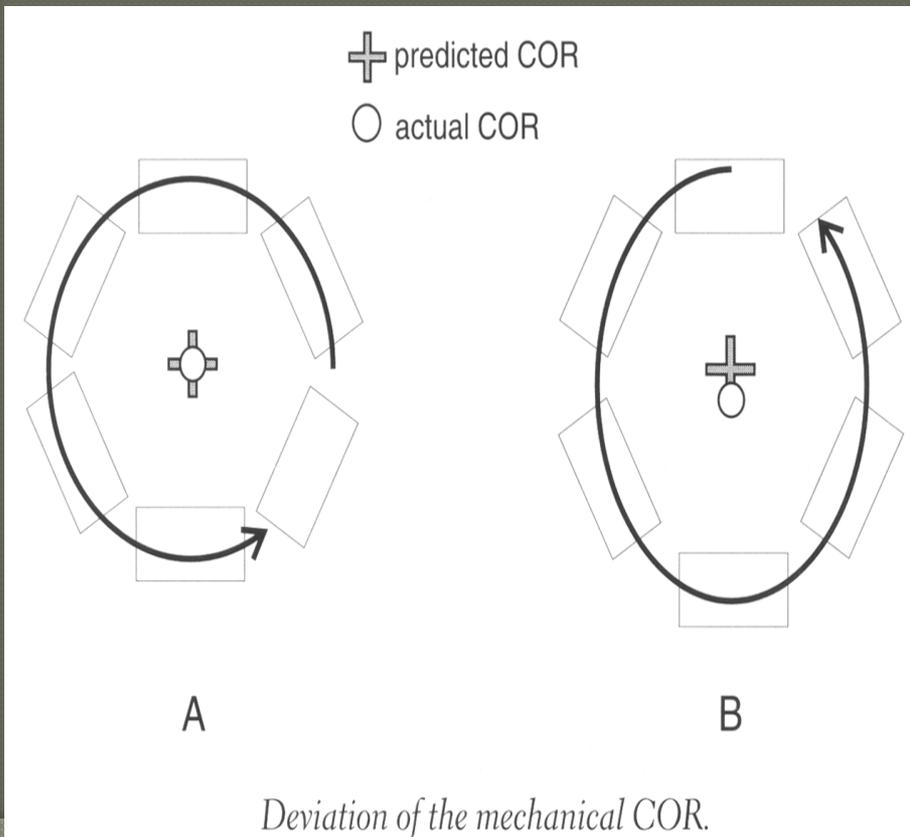
Center of Rotation (COR)

- It is assumed that the camera heads will **rotate in a near perfect circle** (or ellipse) and that heads will remain almost **precisely aligned in their opposing position.**
- It is also assumed that the **predicted** or “**electronic**” center of the path of rotation will match the “**mechanical**” or **actual center** of the camera head rotation.

單光子射出電腦斷層掃描系統品質管制 (QC of SPECT System)

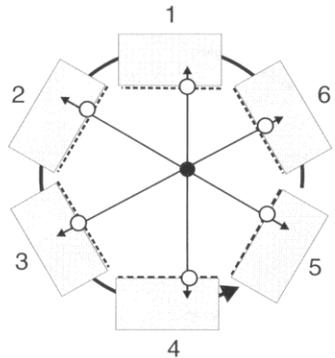
Center of Rotation :

- ❖ The most common cause of true shift of the COR is electronic malfunction.
- ❖ Mechanical problems, such as the use of a **collimator that is too heavy** for the gantry, are less common.

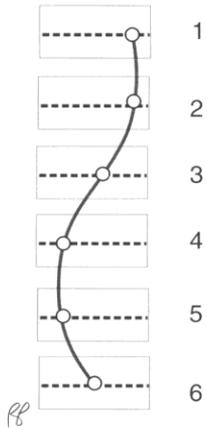
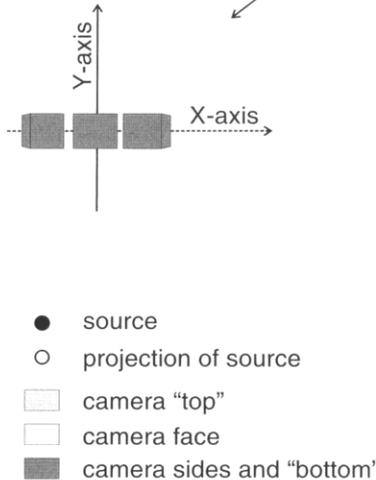
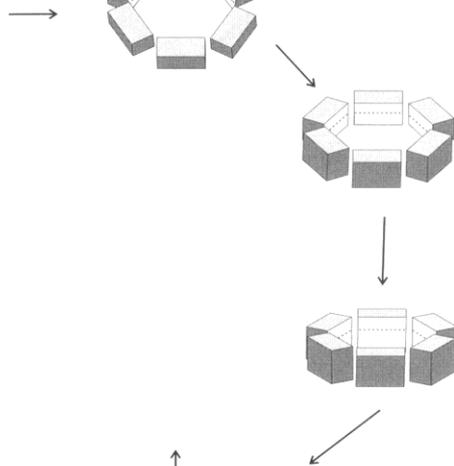


The test for a stable COR consists of placing a **point source** of **Tc-99m** slightly off center on the patient bed. Projection views are obtained over a 360° arc.

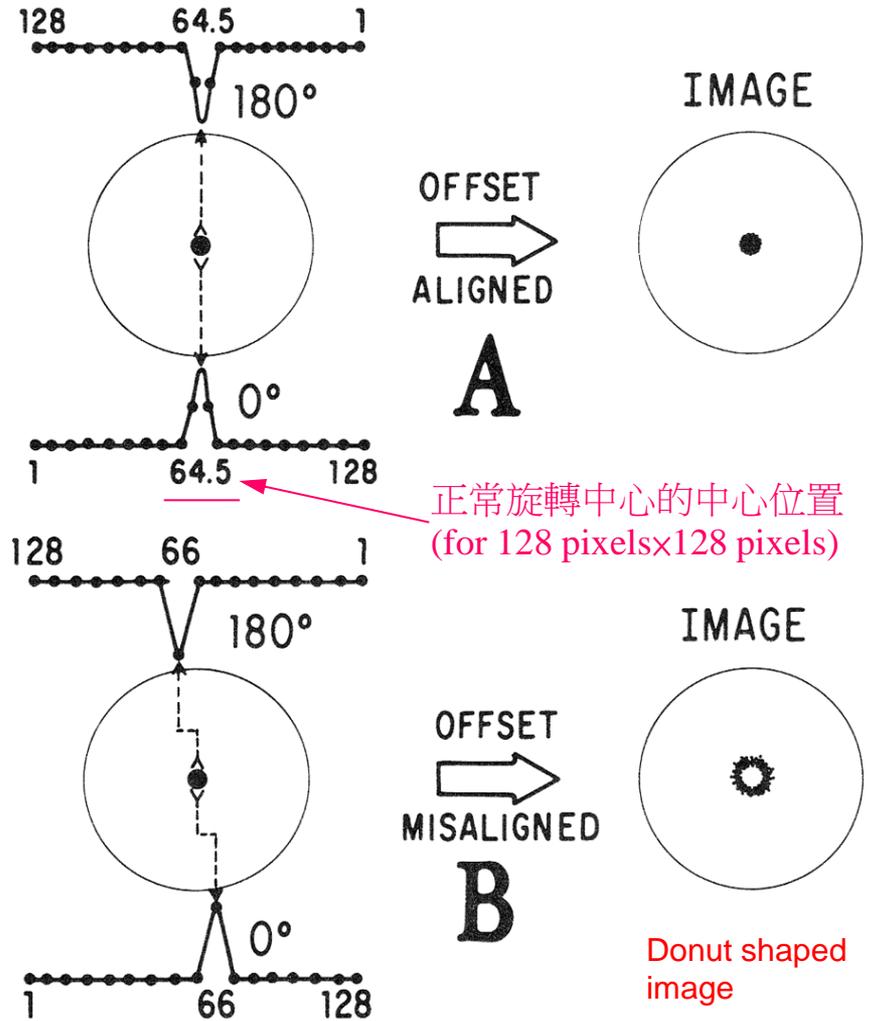
單光子射出電腦斷層掃描系統品質管制 (QC of SPECT System)



camera positions 1-6



COR curves in the x direction.

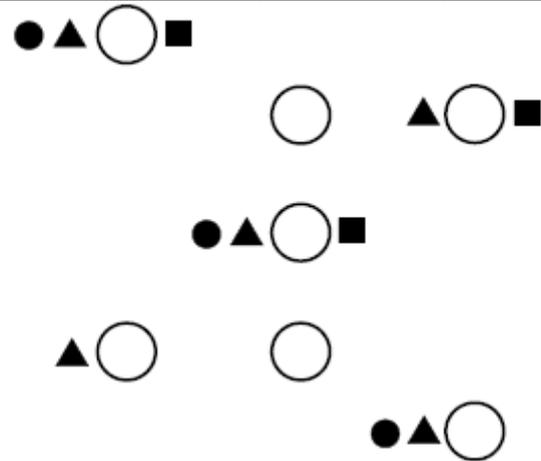


Effect of misalignment of the mechanical axis-of-rotation with the reconstruction axis-of-rotation. Very small misalignment errors result in loss of spatial resolution. For larger errors, images of point sources have a "ring"-type appearance.

不同準直儀的MHR與NCO測試

Collimator	Source No.	180 MHR	NCO	90 MHR	76 MHR
LEAP	5	Y	Y	Y if NCO SPECT	Y if NCO SPECT
HiRes	5	Y	Y	Y if NCO SPECT	Y if NCO SPECT
Med	3	Y	Y if NCO SPECT	-	-
HiEn	3	Y	Y if NCO SPECT	-	-
EHE	3	Y	-	-	-
FB	5	Y	-	-	-
Pin Hole	-	-	-	-	-

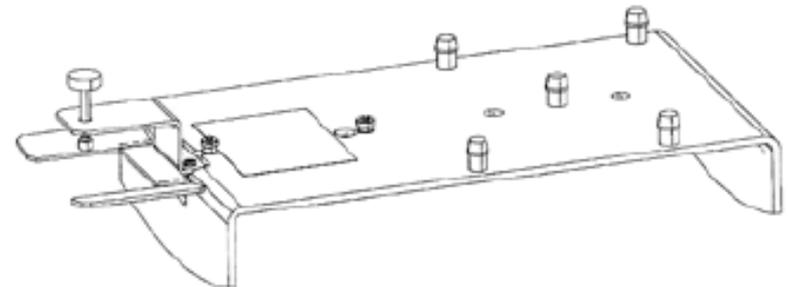
MHR/COR and NCO



Source Location

- Extra High Energy Collimator
- ▲ UHR, HRES, LEAP & Fanbeam Collimator
- All Others

Fig. 12: MHR Phantom Source Placement



MHR/COR

Calibration QC

ID: siemens
 * 1978/5/18
 Study 1
 2008/6/26
 上午 09:21:48
 1 IMA 240 FPM 1

H



IP2

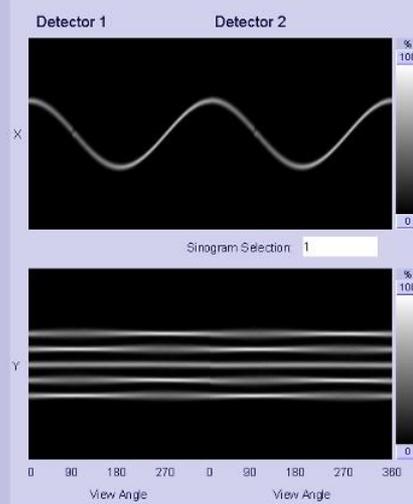
Calibration QC

ID: siemens
 Description: MHR180<LEAP><<20080626>>
 Start Time: 9:21:48 AM
 Series Date: 6/26/2008
 Study 1

1 IMA

Head Alignment Calibration

Patient: Calibration QC
 Study: MHR COR 180 Calibration 5 Points Study
 Series: MHR180<LEAP><<20080626>>



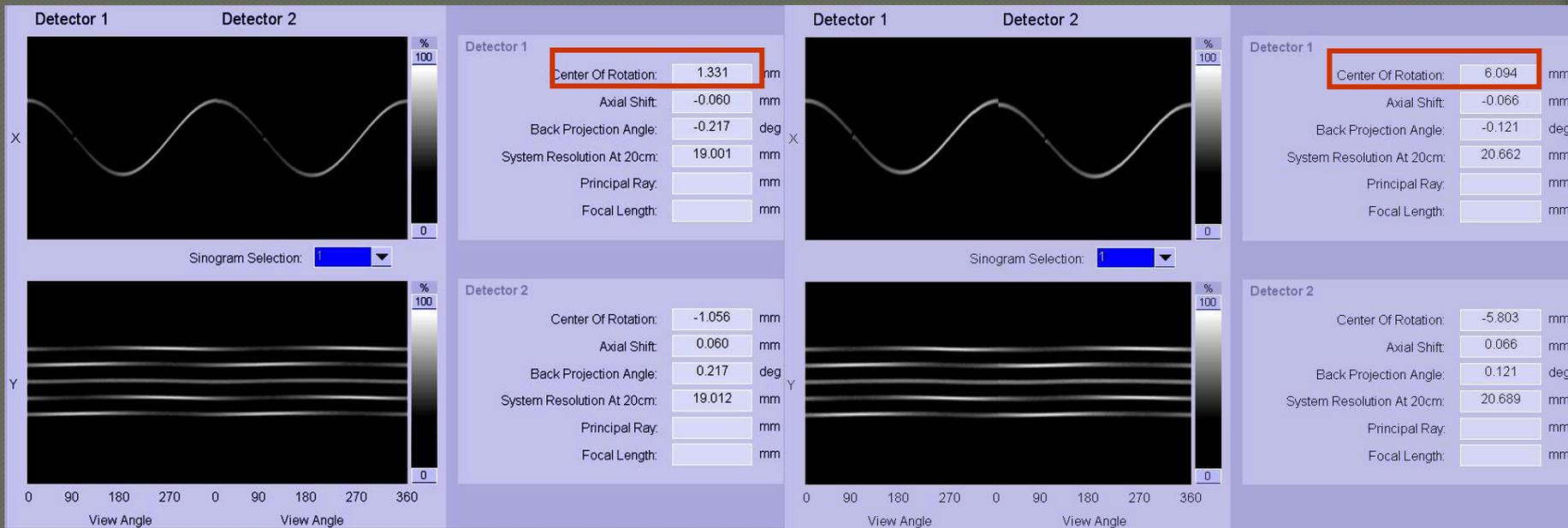
Detector 1	
Center Of Rotation:	-1.150 mm
Axial Shift:	0.544 mm
Back Projection Angle:	45.048 deg
System Resolution At 20cm:	17.072 mm
Principal Ray:	mm
Focal Length:	mm

Detector 2	
Center Of Rotation:	0.550 mm
Axial Shift:	-0.544 mm
Back Projection Angle:	-45.048 deg
System Resolution At 20cm:	17.276 mm
Principal Ray:	mm
Focal Length:	mm

T: 100%
 B: 0%

Comment: Head Alignment Display

Center of Rotation



GE VARI-CAM COR (H-MODE)



GE VARI-CAM COR (L-MODE)



Donut shaped image

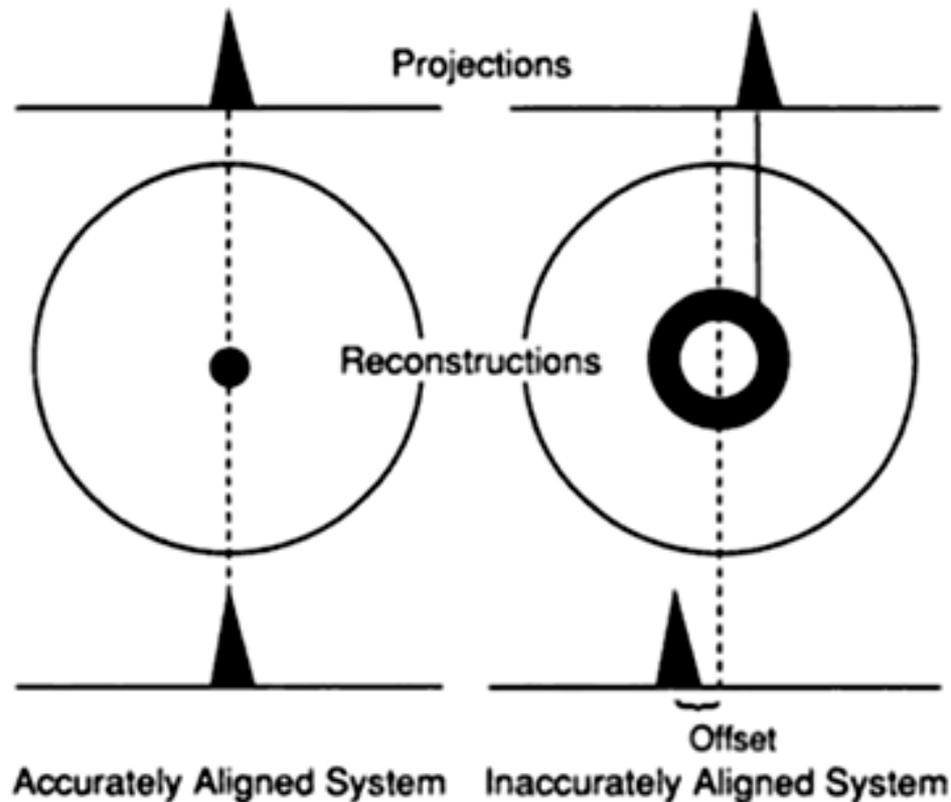


FIG. 12.11. An illustration of the effect of a misaligned center of rotation. A "donut" shaped image appears from inaccurately aligned center of rotation. (From Todd

Doughnut artifacts - COR misalignment



Correct COR



2 Pixel COR
Error
Small
misalignment
blurring



6 Pixel COR
Error
Large
misalignment
tiny doughnut

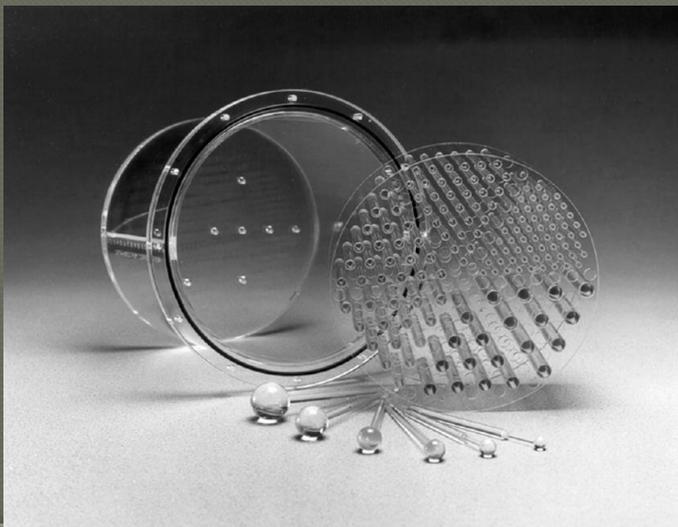
SPECT

Resolution using a Phantom

- SPECT phantoms - **cylindrical lucite containers** - different sized **rods, cylinders spheres**
The container - filled with water containing a small amount of radioactivity (^{99m}Tc)
- **Monthly** and the images assessed for degradation in resolution
- **Uniformity**

單光子射出電腦斷層掃描系統的品质管制 (*QC of SPECT System*)

Jaszczak Phantom

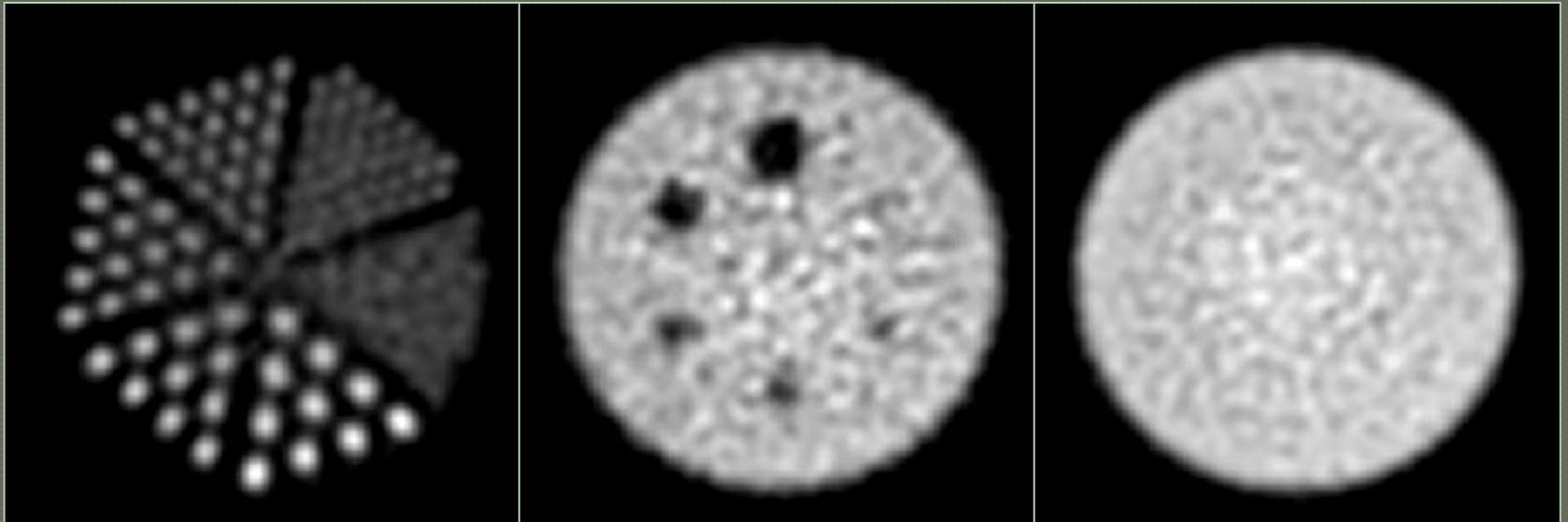


Main Applications :

- For use with SPECT and PET systems
- System performance evaluation (collimator, artifacts, calibration, reconstruction parameters)
- Acceptance testing
- Routine quality, assurance and control
- Evaluation of center-of-rotation error
- Evaluation of non-uniformity artifact
- Evaluation of changes of radius-of-rotation on spatial resolution
- Evaluation of reconstruction filters on spatial resolution
- Evaluation of attenuation and scatter compensation
- Research

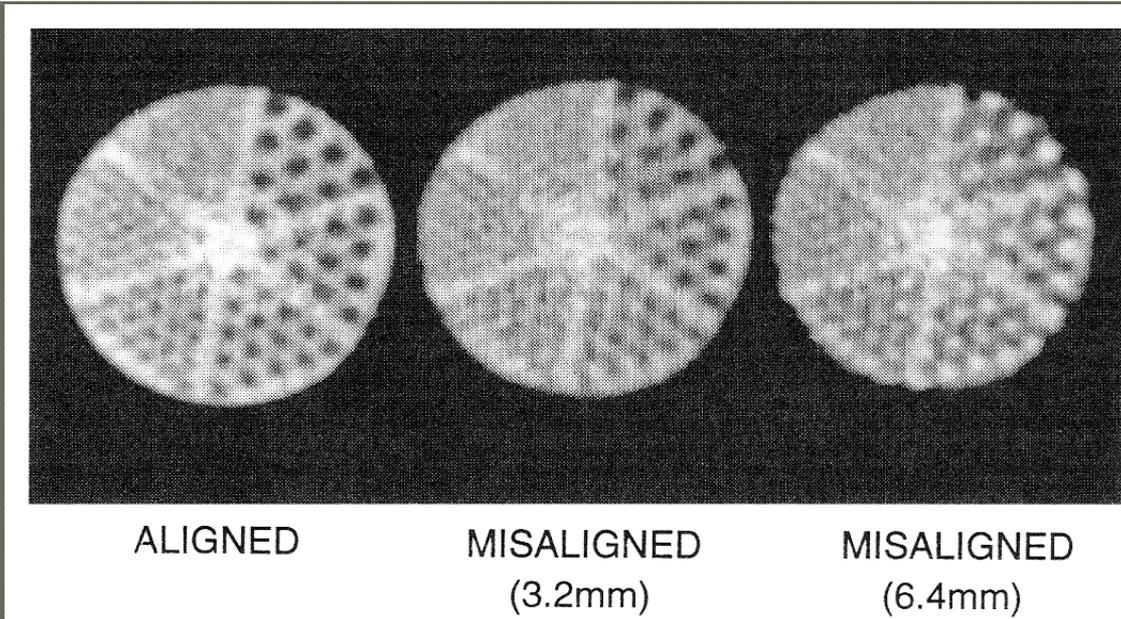
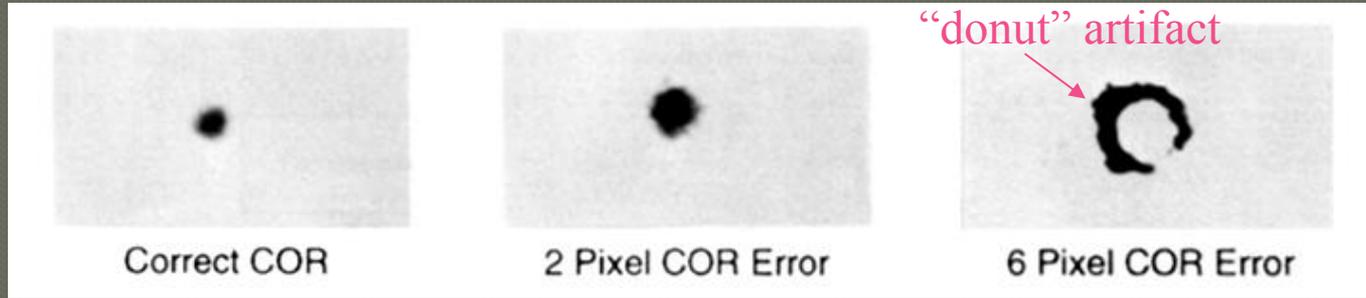
SPECT

Resolution using a Phantom



Jaszczak Phantom

單光子射出電腦斷層掃描系統的品质管制 (QC of SPECT System)



Effect of center-of-rotation errors on SPECT images of a cold rod phantom. With large errors, the appearance of the rods is distorted. Even with small misalignment, image quality is degraded.

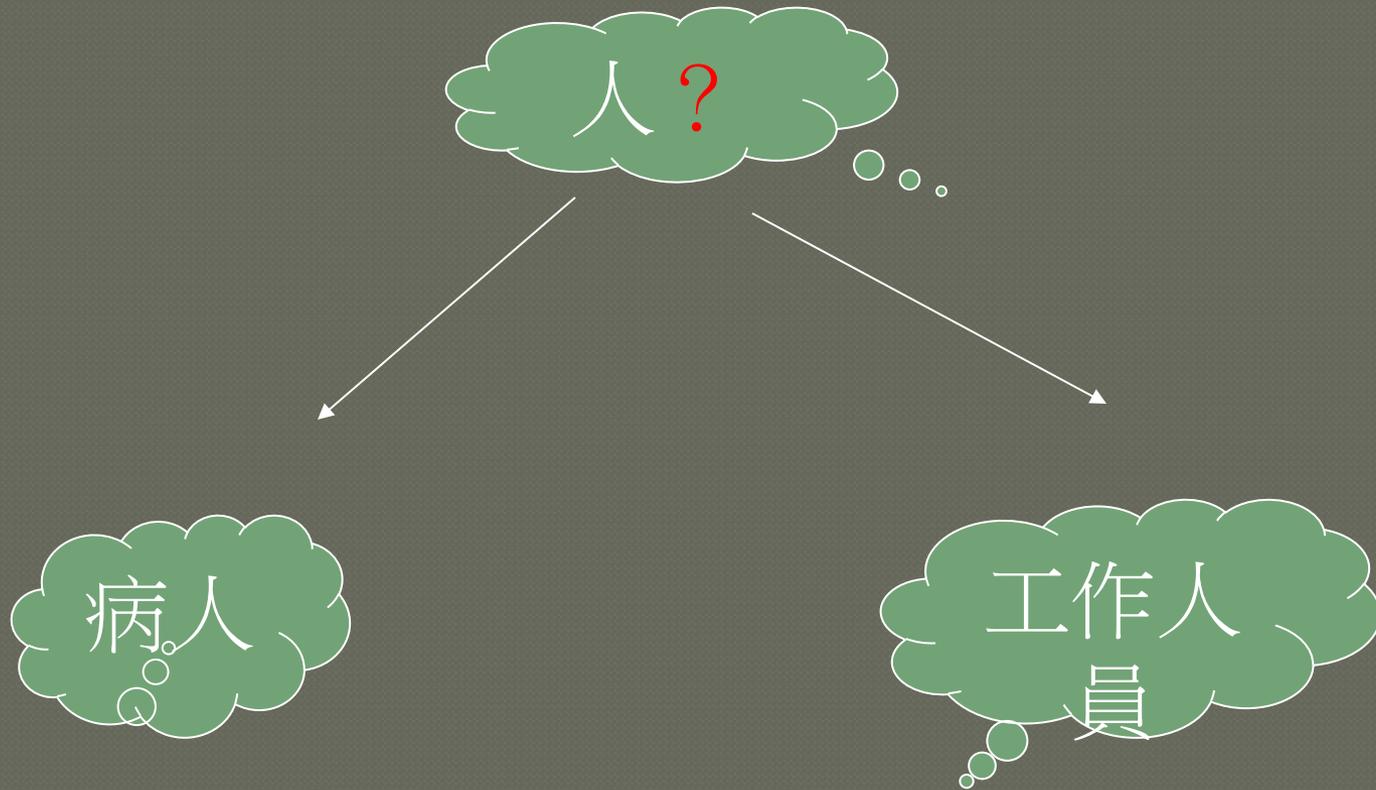
COR 偏離 0.5 個像素以上會造成影像品質變差



QA IN NM

- ◎ 設備品質測試、環境監測。
- ◎ (藥物管控→製藥室)
- ◎ 檢查申請單、病人確認 (一叫、二問、三核對)
- ◎ 檢查流程 (檢查項目、部位、藥物...等核對)
- ◎ 機器設定 (參數的設定)
- ◎ 輔助器的使用
- ◎ 影像處理 (軟體、參數....的使用)
- ◎ 影像上傳 (PACS)

QA IN NM



影像上傳之病人資料

- ◎ HIS 所給病歷資料與PACS 工作站資料是否符合（資料同步化）。
- ◎ 病人資料、檢查項目、影像是否正確。

結語

- ◎ 人員素質、作業流程、設備管控、藥物管控、新知引進、異常分析、持續改進。
- ◎ **Plan**計畫 → **Do**執行 → **Check**檢視 → **Act**修正
- ◎ 軟體方面：作業流程的瞭解與規劃 → 作業流程確實執行與記錄 → 分析與檢討。
- ◎ 硬體部分：品管週期規劃 → 合理閥值擬定 → 品管測試執行與記錄 → 分析與檢討。

◎針對品管結果的調整→二次PDCA
的開始。

◎要持之以恆

感謝

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感謝你的聆聽、並請不吝指教