PHILIPS

Ingenuity TF PET/CT

×Pand[5] quantification support

Personalized scans for **personalized care**

Choices in patient care

Today's patients are living longer. Obesity is on the rise. There's a whole new world of fast-changing technologies and services, enabling early, confident diagnosis that can lead to effective treatment and restore healthy living. At the same time, treatments are growing in complexity and introduced to clinical routines more quickly. Patients have always been at the heart of care. As their needs change, are you adapting the ways in which you deliver that care?

It may feel as though you need to compromise on virtually every front. By prioritizing throughput, for instance, you might limit your possibilities for personalized scans or scanning a broad patient population. And while low-dose protocols are attractive, low expectations of image quality and quantitative information are not.

Why should you have to choose?

Not ready for **a trade-off**?

Then you're ready for the Ingenuity TF PET/CT. It enhances diagnostic confidence by giving you the tools to perform superb exams, work quickly and efficiently, and provide the quantitative information that helps the care team manage the disease. Be prepared for tomorrow's challenges today with support for a variety of clinical specialties and workflows.

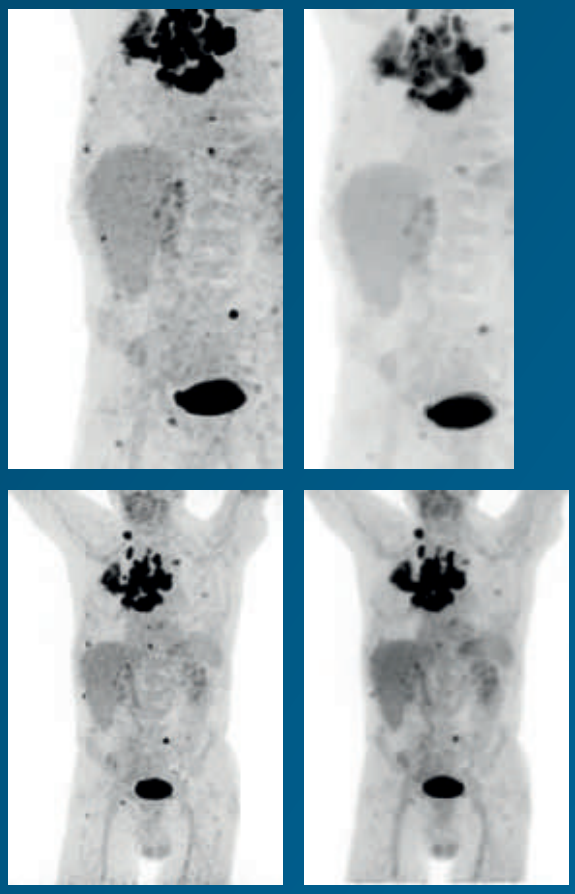
"We liked what we saw with Philips. I didn't even need to ask about key issues such as dose management. They took the lead in discussing those challenges with us. So in the end, the decision for Philips was clear. And I'd make the same decision today."

Dr. Peter Bach
Diagnostic radiology specialist and Chief Physician of Radiology, Hemer Lungenklinik, Germany

Clinical excellence **excellent**

To know what matters, you need to see what matters. Take advantage of rich clinical insight and enhanced lesion detectability with Time-of-Flight (TOF) technology.

Enhanced image contrast
TOF offers an up to 30% increase in image contrast compared to non-TOF images. It uses all 3D line of responses and listmode TOF for true 3D performance.



Patient information
Male patient with metastatic non-small cell lung cancer undergoing FDG PET/CT for initial staging
Height: 1.75 m
Weight: 73 kg

Case information
PET 6.75 mCi (250 MBq) [^{18}F]-FDG
75 sec/bed
CT 100 kV, 52 average mAs
iDose^4 Level 3, 1.8 CTDIvol, 170 DLP

Images courtesy of Salzburg University Hospital, Austria

“Being able to see lymph nodes in the mediastinum with a good amount of contrast resolution has helped my ability to stage. I really think the benefit is my confidence in what I’m saying.”

Dr. Peter F. Faulhaber, MD
Professor of Radiology, University Hospitals, Seidman Cancer Center, Cleveland, USA

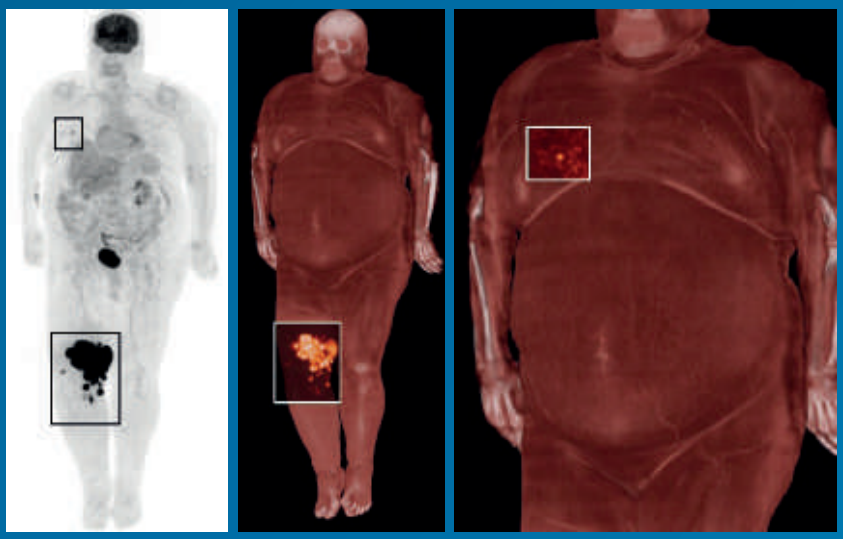
begins with **image quality**

Consistently high image quality
TOF has been demonstrated to improve sensitivity by up to five times in larger patients compared to non-TOF systems.

Patient information
Overweight female patient with soft-tissue sarcoma in the right thigh region and previously unknown dexter breast cancer
Height: 1.75 m
Weight: 150 kg

Case information
PET 9.97 mCi (369 MBq) [^{18}F]- FDG
75 sec/bed
CT 120 kV, 46 average mAs
iDose^4 Level 3, 3 CTDIvol, 390 DLP

Images courtesy of Salzburg University Hospital, Austria



> “I have had diagnostic-quality images in an average-sized patient even three and a half hours after a standard 8 mCi injection of [^{18}F]-FDG. This would not have been possible in my pre-TOF days.”

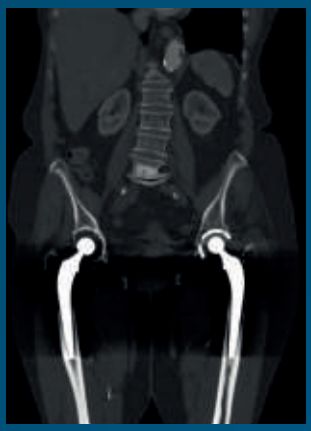
Dr. Pushan Bharadwaj
Consultant in nuclear medicine and head of PET/CT, Apollo Gleneagles Hospital, Calcutta, India

The way to **confidence** is clear

Get a comprehensive view right away. Built-in protocols help produce exceptional images, boosting your confidence and helping you make clinically relevant decisions.

Reduced artifacts
iDose^4 improves image quality through artifact prevention and increased spatial resolution. O-MAR reduces artifacts caused by large orthopedic implants. Together they produce high image quality with reduced artifacts.

Images courtesy of Clinique du Diaconat Roosevelt, Mulhouse, France



iDose^4 and O-MAR OFF

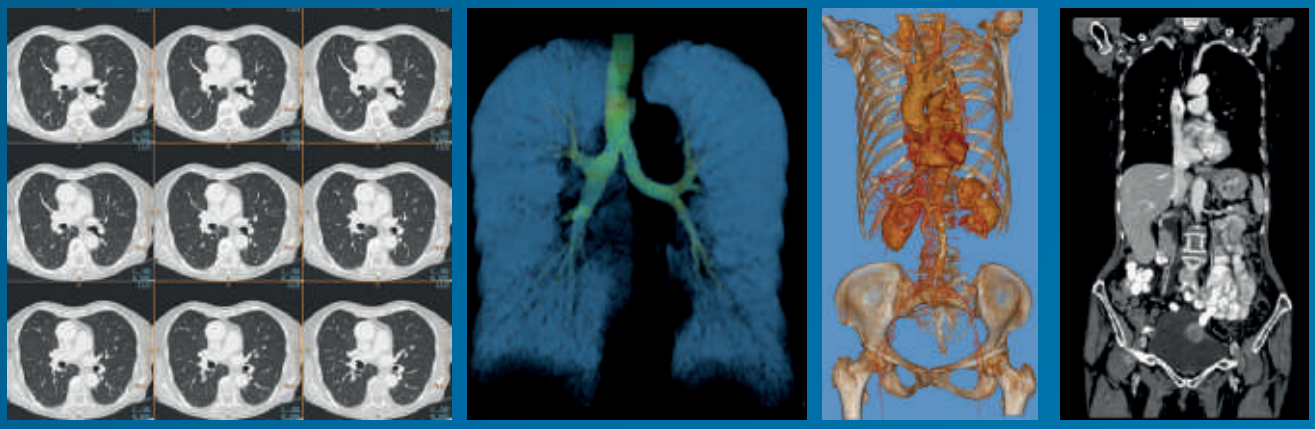
iDose^4 and O-MAR ON

“Our team is delighted with O-MAR. It reduces artifacts without any additional burden on our workflow, and we can preview the results right in the operating room.”

Prof. Dr. Maria Santiago Ribeiro
Head of Nuclear Medicine, Hôpital Bretonneau, Centre Hospitalier Régional Universitaire de Tours, France

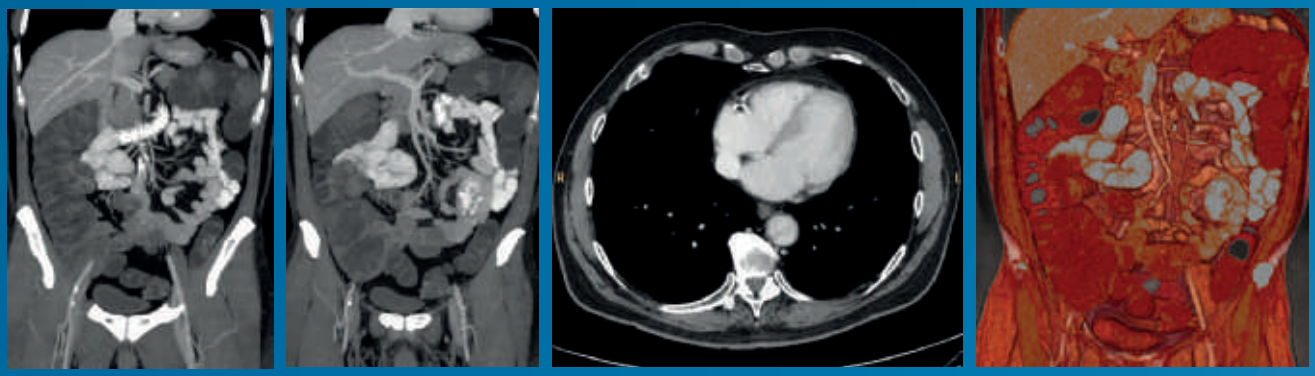
> “We have a rotation time designed to be fast, and that is absolutely key in cardiac imaging in moving organs. Through iDose^4, we have every opportunity to improve image quality.”

Dr. Oliver Klass, MD
Radiologist, cardiac surgeon, and Head of Cardiac Radiology and Cardiac Surgery, MediaPark Klinik, Cologne, Germany



Case information
120kVp, 109 mAs
iDose^4 Level 3, 6.8 CTDIvol, 416 DLP
57.7 cm, 15.8 sec
6.2 mSv (k=0.015)*

Images courtesy of Porte Verte Hospital, Versailles, France



Case information
120kVp, 187 mAs
iDose^4 Level 3, 11.58 CTDIvol, 544.8 DLP
43.2 cm, 12 sec
8.16 mSv (k=0.015)*

Images courtesy of Porte Verte Hospital, Versailles, France

×Pand^5 the power of quantitative imaging

Referring physicians are counting on your expertise and images to create the best possible treatment plans. With enhanced quantification tools at your fingertips, you can expand your diagnostic confidence to care teams. The Ingenuity TF PET/CT leverages multiple technologies, collectively known as **×Pand^5**, that act together to enhance image quality and support quantification.

×Pand^5 quantification tools:

- **×Clean** with Monte-Carlo-based single-scatter simulation (MC-SSS) correction
- **×Sharp** for image reconstructions with resolution recovery
- **×Count** for improved performance at high count rates
- **×Calibrate** to help quantification capabilities remain stable and reproducible
- **×Fine** with 2 mm voxel clinical reconstruction protocols

With **×Pand^5**, your high-quality images allow you to examine changes over time. This capability is an essential part of measuring and monitoring disease progression and therapy response. It also provides insight that can help you make well-informed decisions about the appropriate therapy.

Why does quantification matter?

Although qualitative assessment of images remains an important part of clinical practice, there is increasingly a demand from clinicians for quantitative information from PET scans. The most widely used measure is the semi-quantitative standardized uptake value (SUV), reflecting the relative tissue uptake of the injected radiolabeled tracer (typically [^{18}F]-fluorodeoxyglucose, FDG). While SUVs are typically normalized to body weight, they can also be normalized to body surface area or to lean body mass.

Tumor staging
In practice, the use of SUVs in conjunction with visual assessment can allow clinicians to stage tumors with increased sensitivity and confidence. There is growing acceptance within the molecular imaging community for this approach. Clinicians can see the enhanced metabolism in active tumors and the resulting accumulation of FDG at lesion sites to detect tumors easily and rapidly. The primary tumor, and any local or distant metastases, can be detected in a single examination. The Ingenuity TF PET/CT includes protocols to visualize small lesions. This empowers you to detect tumors quickly and make informed decisions on biopsies.

Monitoring therapy response
A fast start to treatment begins with a fast diagnosis. To monitor therapy response, care teams can turn to subsequent SUV changes as a an alternative. Radio- and chemotherapy alters the functional and biochemical processes of a body's tissues. The PET modality is able to detect these changes in metabolic activity - often before anatomical changes have occurred and become evident using MR imaging or CT.[1] With PET, you're equipped to deliver truly individualized therapy. Assess changes in SUVs over time to quickly determine whether the patient is responding appropriately to treatment and if any changes in therapy are needed.

[1] Zhu A, Lee D, Shim H. Metabolic PET Imaging in Cancer Detection and Therapy Response. Semin Oncol. 2011 February; 38(1): 55–69.

Increasing confidence
The fundamental reproducibility of SUVs enables you to make comparisons over time in the same patient. It also increases confidence in your PET data intended for clinical trials and research, including multi-center studies.

Estimating tracer parameters
A less frequently used quantitative PET methodology involves the full kinetic modeling of tracers in order to measure physiological parameters. In these situations, accurate measurement of the radiopharmaceutical distribution over time is of paramount importance to facilitate correct estimation of the kinetic parameters of the tracer.

×Clean

Focus on what's important with consistent image quality across different patient habitus. See what you need to see, artifact-free, on small or large patients.

Scatter correction is integral to overall image quality and quantitative accuracy in PET. Scattered photons may account for more than 30% of total detected coincidence counts. **×Clean**, a hybrid scatter correction method for reconstructing the PET image, helps the Ingenuity TF PET/CT deliver improved image quality by working to reduce artifacts.

Why is a different approach necessary? The Single Scatter Simulation (SSS) method is widely used for estimating scatter contribution in PET image reconstruction. SSS is typically paired with tail-fitting to scale the modeled scatter contribution and match it to the measured data. Yet tail-fitting has known limitations including the occurrence of photopenic artifacts. This is often the case in large patients (when the available tail part is missing or very small) and patient motion (when the available tail part is very noisy as a result of motion between the PET and CT scans).

×Clean is a more robust method of scatter correction than using SSS with tail-fitting. Instead of relying on patient boundary information, **×Clean** uses SSS to approximate the shape of scatter contribution, and scales the SSS result by a scaling factor determined by a low-count Monte Carlo simulation (a more computationally extensive form of modeling). With rising numbers of longitudinal studies and obese patients, exceptional image quality and consistency are important as ever. In this environment, nuclear medicine professionals can increase their diagnostic confidence based on images generated with **×Clean**.

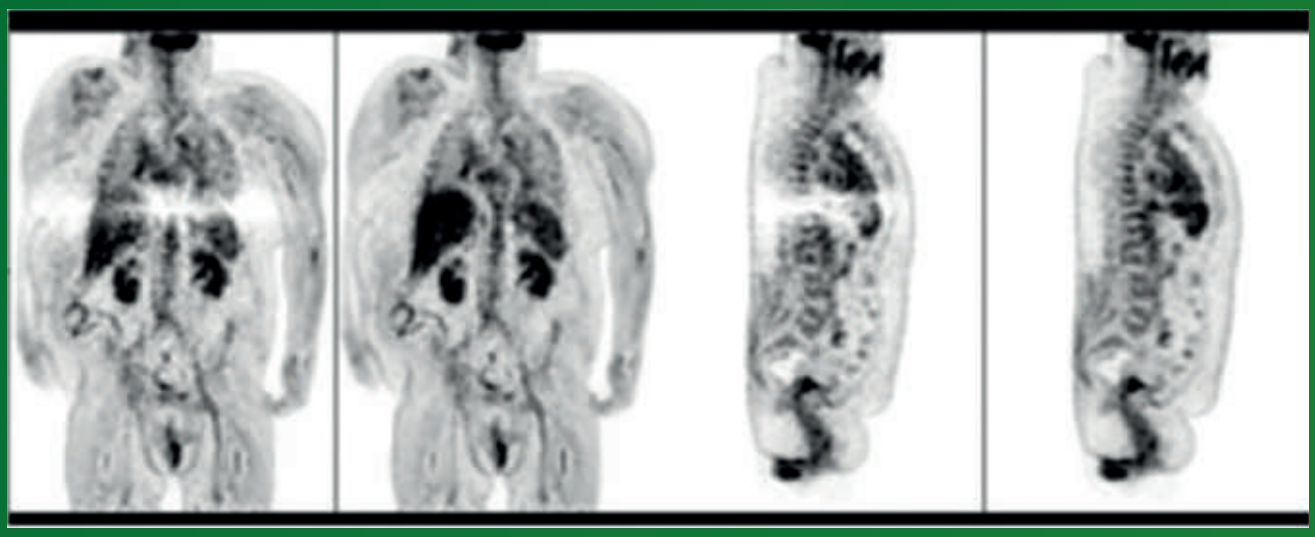


Figure 1: TOF reconstruction using SSS with tail-fitting (left image in each pair) and **×Clean** (right image in each pair). The scatter correction artifacts seen with SSS and tail-fitting are not present in the **×Clean** reconstructions.

Image courtesy of the University of Pennsylvania School of Medicine, Philadelphia, USA

×Sharp

See true activity distribution – especially with small objects. Images acquired with the **×Sharp** on the Ingenuity TF PET/CT show lesions and organ boundaries with high contrast thanks to resolution recovery.

Resolution compensation in reconstructed Ingenuity TF PET/CT images is achieved by **×Sharp**, which models and corrects for the effects of the scanner's point spread function (PSF). This is based on the computationally efficient, iterative, Richardson-Lucy maximum-likelihood algorithm to correct for partial volume effects in PET images.

The PSF was determined during development by imaging point-sources at multiple locations in all three dimensions within the scanner. Applying resolution recovery to take into account the system's inherent variability in resolution across this 3D space allows users to produce an image that more closely reflects the actual object scanned.

A whole-body patient test study suggests how **×Sharp** can enhance the visualization of small lesions. The application of **×Sharp** led to an increase in the lesion SUV_{max} compared with no **×Sharp**. The lesions in the patients were in the 12-20 mm range.

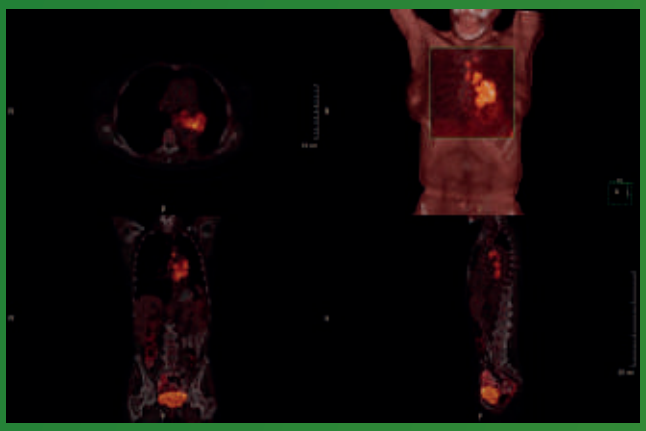


Figure 2: Images reconstructed with **×Fine** for this lung cancer patient demonstrate enhanced lesion detectability.

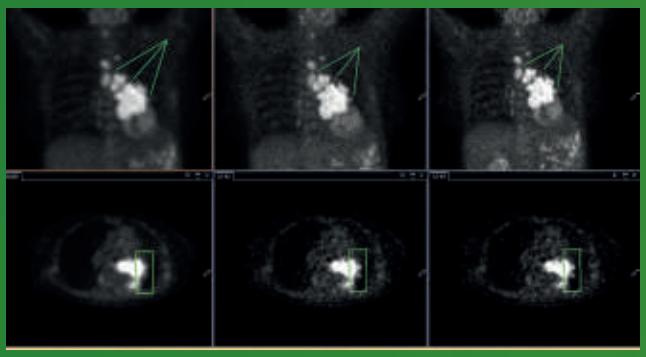


Figure 3: **×Fine** and **×Sharp** further contribute to image quality, seen here in enhanced resolution. **×Fine** reconstruction (center) and **×Fine** with **×Sharp** reconstruction (far right)

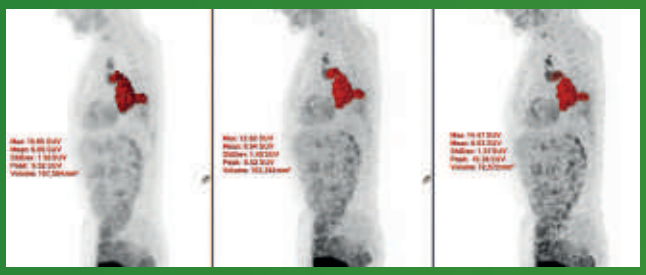


Figure 4: Measurements show the clinical benefit of **×Fine** as well as **×Fine** with **×Sharp**.

All images on this page are courtesy of University Hospital Salzburg, Austria

×Fine

Turn information into insight when you can see the fine details. **×Fine**, a 2 mm whole-body clinical reconstruction protocol, offers superb spatial resolution, so you can draw regions of interest around small structures with increased confidence. The smaller voxels reduce partial volume effects, resulting in enhanced quantification accuracy and lesion detectability.

Smaller image voxels can have a significant impact on clinical decisions. In a recent paper[2], specialists reported a case study of a 68-year-old woman with lung cancer, being investigated for possible metastases in the adrenal gland. On the image reconstructed using 4 mm voxels, there was no enlargement of the gland on CT, and there was a slightly increased FDG uptake. This led the clinicians to consider the gland to be benign. On a retrospective image reconstruction using 2 mm voxels, there was a higher SUV_{max} and a higher contrast (despite increased noise). The gland appeared suspicious and more likely to be metastatic. A follow-up PET/CT scan two months later revealed an even higher SUV_{max} and an enlarged right adrenal gland.

[2] Koopman D, van Dalen J, Jager P. Improved detection of a metastatic adrenal gland using FDG-PET with small voxels. Tijdschrift vood Nucleaire Geneeskunde. 2014; 36(3): 1279

Image courtesy of Salzburg University Hospital, Austria

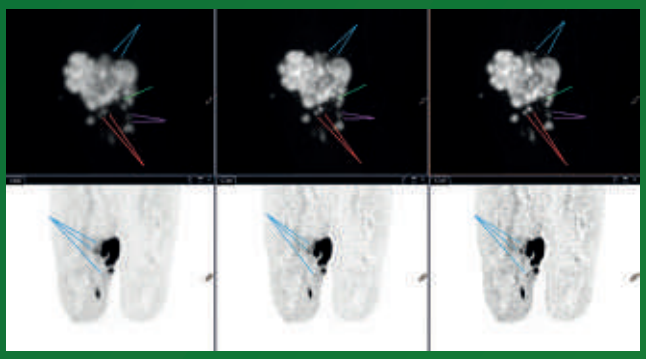


Figure 4: These whole-body scans were reconstructed from the same data using a 4 mm voxel size (left), **×Fine** (center), and **×Fine** plus **×Sharp** (right). The improved detail can be seen with **×Fine** plus **×Sharp**.

> “All our nuclear medicine physicians now favor small voxel reconstructions and even wait with releasing final reports until they have reviewed the ×Fine reconstructed images. The main advantage is excellent detectability of small lesions. Although difficult to quantify, the lesion delineation increases the confidence of reading. Also, we have the strong impression that small lesions are now detectable.”

Prof. Dr. Piet Jager, MD, PhD
Nuclear medicine specialist, Isala Hospital, Zwolle, the Netherlands

×Calibrate

Rely on your quantification capabilities remaining stable and reproducible across a comprehensive range of studies. **×Calibrate** on the Ingenuity TF PET/CT includes accurate PET/CT alignment, robust detector normalizations with universal geometric corrections, automatic synchronization of system clocks to reduce quantification errors and an efficient daily quality control procedure to optimize system performance. All factory clinical protocols use listmode-based TOF reconstructions with an improved listmode-based SUV calibration procedure to facilitate consistent quantification accuracy.

Conduct multi-center research
The improved stability resulting from **×Count** also makes it easier for researchers like you to comply with international criteria for the consistent use of scanners in multicenter trials, such as the EARL (European Association for Nuclear Medicine Research Ltd.) criteria.

To facilitate the use of the Ingenuity TF PET/CT in multi-center clinical trials, this system comes with an EARL-specific whole body reconstruction protocol to help you meet EARL accreditation criteria. You can modify this protocol as necessary and even change the levels of filtering and smoothing to comply with EARL accreditation guidelines.

RESEARCH 4 LIFE©

an EANM initiative

×Count

Take advantage of quantification even on investigations that involve, short-lived tracers. The Ingenuity TF PET/CT uses high-throughput acquisition hardware that expands its count-rate capabilities, with improved linearity at high count-rates. Thanks to **×Count**, the system is stable across count rates (low to high), so you can perform dynamic imaging with a wide range of tracers including (^{82}Rb) Rubidium chloride.

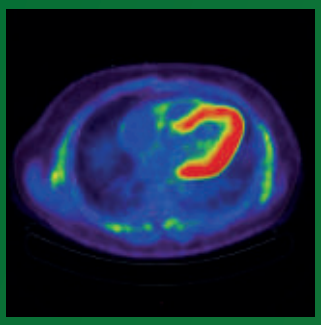
The stability across count-rates was demonstrated in a recently published performance evaluation of the Ingenuity TF PET/CT scanner. Researchers measured timing and energy resolution, dead time, and the linearity of the image activity concentration over a wide range of count rate conditions.

The Ingenuity TF PET/CT measured a NEMA NU 2 peak true count rate of 365 kcps at 35 kBq/mL, demonstrating the higher count throughput compared to the predecessor system. The NEMA NU 2 noise-equivalent count rate (NECR) curve had a broader peak, with the range of activity at which the NECR was above 90% of its peak value spanning 368 MBq (from 241 to 609 MBq), compared with 163 MBq (from 275 to 438 MBq) with the older system. This demonstrates the capability of the Ingenuity TF PET/CT to scan effectively over a wide range of injected activity, which is particularly important for superb PET dynamic imaging.

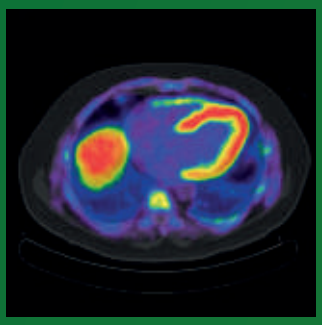
In addition, the phantom studies of the system using (^{82}Rb) Rubidium chloride showed consistent linearity from low activity up to a singles rate of about 65 Mcps. Overall, the study concluded that "the system performance is suitable for application in high-count-rate PET applications".[3] This includes, gated as well as conventional static perfusion imaging.

The TOF technology available on the Ingenuity TF PET/CT provides improved signal-to-noise ratio in the reconstructed images in addition to better count rate performance and better randoms rejection over non-TOF PET. Including the benefits of TOF PET, the Ingenuity TF PET/CT provides effective NECR curves such as the one shown in Figure 3 with effective peak-NECR values (typical) of 320 kcps or more. Note that at clinical FDG concentrations of 5.3 kBq/mL (corresponding to a 370 MBq injection to a 70 kg patient), the effective NECR is greater than 170 kcps, providing significant improvements in the signal-to-noise ratio of reconstructed PET images at these clinical count rates.

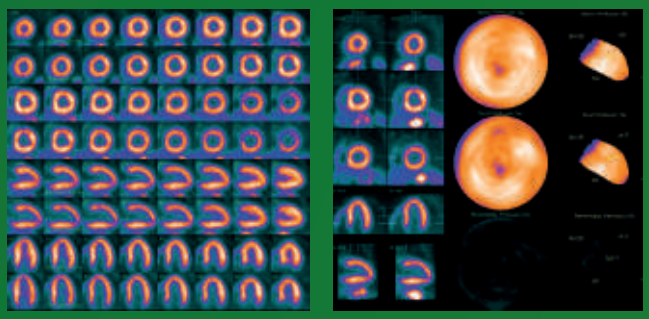
[3] Kolthammer J., et. al. Performance evaluation of the Ingenuity TF PET/CT scanner with a focus on high count-rate conditions. Physics in Medicine and Biology. 2014;59:3843-59



Using [^{18}F]-FDG



Using (^{13}N) Ammonia



Myocardial perfusion scan using (^{82}Rb)Rubidium chloride

Image courtesy of the University Hospital Cleveland, USA

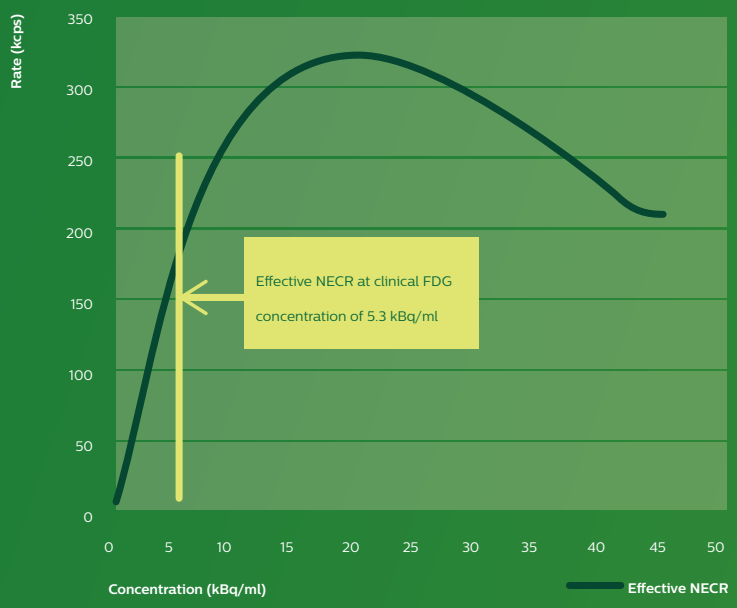


Figure 3: Effective NECR for the Ingenuity TF PET/CT

Efficient for you, **easy on patients**

"Table time" can be difficult for patients. Can you reduce the burden? Rely on short scan times to deliver the high-quality images you need to make confident decisions quickly.

> "We're delighted that acquisition times are down to 75 seconds per bed. These time savings have a genuine impact on our clinical work. We see results fast – so we can act on them quickly."
>
> **Prof. Dr. Christian Pirich**
> Head of Nuclear Medicine and Endocrinology, University Hospital Salzburg, Austria

Get high-quality data, fast

Investigate the entire body and a region of interest in one scan.

Within
5
minutes

TOF technology
With its 495ps timing resolution, the Ingenuity TF PET/CT is designed to acquire data for typical procedures within five minutes.

Speed
up **slow**
down

Variable speed
Vary the frames by acquisition time with the Total Body ExamCard, focusing on a particular area while quickly scanning other regions that contain less clinical information.

See outstanding images quickly

Fast images accelerate your analysis as well as collaboration with referring physicians.

As fast as
30
seconds

PET reconstruction
Philips TOF technology offers accurate list mode capabilities to reconstruct a PET image as fast as 30 seconds per bed. During reconstruction, the system manages count normalization, so that the intensity of the frames remains relatively the same.

60
seconds
or less

CT reconstruction
Using iDose[4] on the Ingenuity TF PET/CT, images show an up to 57% improvement in spatial resolution. And 72% of the most common clinical protocols are reconstructed in under one minute.

Up to
24%
faster[4]

iPatient
Drive confidence and consistency through personalized patient-centric workflows. The iPatient platform for patient-centered imaging can reduce time-to-results by 24% and clicks per exam by 66%.[4]

[4] Buchan, K. (Philips Healthcare), Dharaiya E. (Philips Healthcare), Ardley N. (Monash Health, Australia) "Impact of workflow tools in reducing total exam and user interaction time - 4 phase liver computed tomography exams." Paper presented at ASMMIRT 2012, Sydney, Australia.

The patient at the **cen**

To truly focus on each patient, you need to have the ability to personalize your control. The Ingenuity TF PET/CT offers a variety of patient-specific methods and tools to facilitate optimal[5] management of both image quality and radiation dose.

Tailor the dose

Plan the dose for the patient
With ExamCards, you can use specific protocols to adjust your CT dose. They support personalized CT exams by considering a variety of factors to assess the dose.

Explore new possibilities for PET doses
With up to five times higher sensitivity than non-TOF scanners, you may be able to reduce radiopharmaceutical dosing in some or all of your studies.

Manage the CT dose
Noise reduction through iDose^4 allows you to get more effective power[6] out of your system. The result: high image quality at low dose.

Manage the image quality

Work flexibly, image consistently
Operators scan patients at different times, and with different settings. iPatient makes it easy to create consistent, exceptional images that support your diagnostic confidence. Everyone works with a cockpit view showing the complete workflow and clinical information for the injection for every exam.

Adapt to the indication
Manage image quality and dose from just one platform. You define the image characteristics and adjust the dose modulation and iDose^4 reconstruction settings. iPatient optimizes the collimation, pitch, and rotation time automatically.

Is low dose paramount? Deliver it without sacrificing image quality. In other cases, where image quality would typically be of higher priority than a low dose using iDose^4, iDose^4 significantly improves spatial resolution at a low dose.

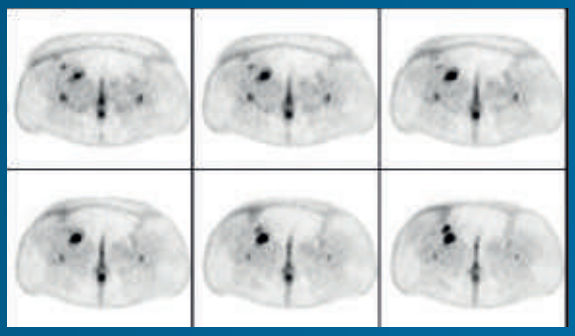
[5] "Optimal" refers to the use of strategies and techniques that facilitate the management and control of both image quality and dose.
[6] Effective power is calculated by using full generator power and using iDose^4 at the same time.

ter of your image

Patient information
35-year-old female
Height: 1.63 m
Weight: 156 kg

Case information
PET 11.1 mCi (410.7 MBq) [^{18}F]-FDG
150 sec/bed
CT 120 kVp, 140 mAs
iDose^4, 6.6 CTDIvol

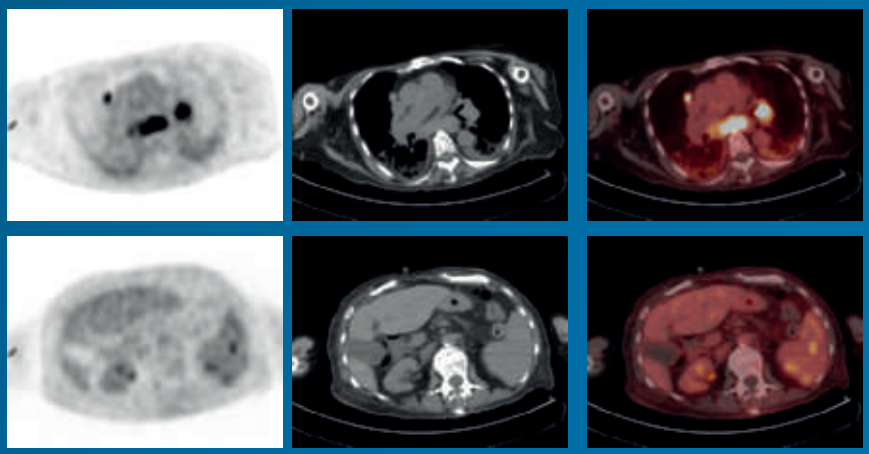
Images courtesy of Loyola Medicine, Illinois, USA



Patient information
78-year-old female
Height: 1.62 m
Weight: 51 kg

Case information
PET 12.9 mCi (477.3 MBq) [^{18}F]-FDG
90 sec/bed
CT 120 kV, 71 mAs
4.6 CTDIvol

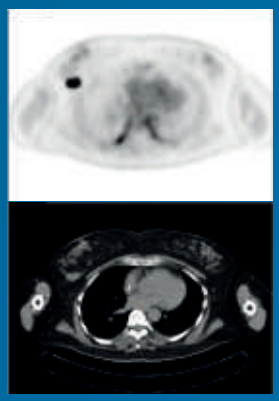
Images courtesy of University Hospital Cleveland, USA



Patient information
58-year-old female
Height: 1.80 m
Weight: 104 kg

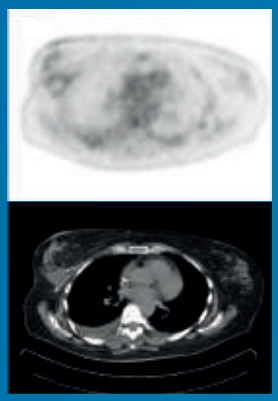
Study 1 case information
PET 12.4 mCi (458.8 MBq) [^{18}F]-FDG
58 min uptake time
135 sec/bed
CT 120 kVp, 100 mAs
iDose^4, 6.6 CTDI vol

Images courtesy of Loyola Medicine, Illinois, USA



Patient information
58-year-old female
Height: 1.80 m
Weight: 93 kg

Study 2 case information
PET 12.2 mCi (451.4 MBq) [^{18}F]-FDG
61 min uptake time
90 sec/bed
CT 120 kVp, 80 mAs
iDose^4, 3.2 CTDI vol



Go beyond the routine

Expand your capabilities beyond [^{18}F]-FDG
Invest in one system – and the opportunity to perform a wide range of scans, whether they're for your own studies or to accommodate more requests.[7] The Ingenuity TF PET/CT now supports an extensive list of isotopes and radiopharmaceuticals. Perform cardiac imaging, including perfusion studies, for example, and conduct neurological studies.

[7] You can add one "customized" isotope to your Ingenuity TF PET/CT.

For details on the isotopes and radiopharmaceuticals supported in your country, please contact your local representative.

"This system helps us work with a variety of tracers in a cost-effective way. A lot of my brain studies use [^{18}F]-FDG, but other radiopharmaceuticals can shed light on different neurological conditions."

Prof. Dr. Maria Santiago Ribeiro
Head of Nuclear Medicine, Hôpital Bretonneau, Centre Hospitalier Régional Universitaire de Tours, France

Quantitative monitoring
For serial studies, clinicians can take advantage of quantitative tools and applications now available in PET/CT to aide in interpretation. The Ingenuity TF PET/CT features several enhancements in this area, collectively known as **×Pand**[5].

Adaptive therapy
Lesion detectability based on PET/CT can provide valuable clinical information about how well therapy is working. This can help you adapt the therapy before it's complete.

PET biology
The information useful to radiation therapy planning (RT) can differ from what is useful for cancer staging. Radiopharmaceuticals and imaging protocols can be optimized for RT planning.

Expand your services beyond PET for oncology staging

PET/CT continues to gain ground in therapy evaluation and follow-up. Stay on the cutting edge and shape the future of care with a system designed to work across the oncology care cycle.

Quantitative monitoring

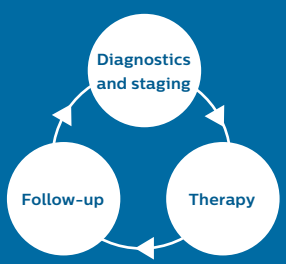
NM / Radiologist
Patient with primary lung lesion

Medical oncologist or radiation oncologist
Metastatic spinal lesion found during PET/CT exam

Patient

Medical oncologist

NM / Radiologist



Adaptive therapy

PET biology

Radiation oncologist

Medical oncologist

A track record that works **for you**

The Philips PET/CT journey
When you choose to work with Philips, you're choosing a partner committed to continuous innovation in PET/CT.

1991	
1996	AcQsim workstation
2000	Pinnacle RTP
2002	3D acquisition for PET
2003	Panorama RT
2006	GEMINI PET/CT
2008	TOF for PET
2009	GEMINI TF Big Bore PET/CT
2010	3rd generation TOF for PET
2012	Astonish TF
2013	Ingenuity TF PET/CT Vereos PET/CT

"Philips is an innovative company because they develop rapidly new PET/CT systems with a short history in that research area. And for that reason I believe they have the mission and competence to achieve and integrate new developments. This can be seen in the new scanner types as well."

Prof. Dr. Christian Pirich
Head of Nuclear Medicine and Endocrinology, University Hospital Salzburg, Austria

Does your PET/CT imaging support outstanding patient care? Or does it limit your choices?

Your world is a new world. And Philips is helping healthcare organizations like yours navigate a way through it – without having to trade off. The time is now to begin preparing your PET/CT capabilities for success.

Visit www.philips.com/ingenuitytfpetct or contact your local Philips representative to learn how this innovative system can help.

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