The brilliance of optical imaging.

Highlights

- High sensitivity optical imaging through camera with eXcelon® coating
- 2D bioluminescence & fluorescence imaging
- 3D tomography
- Low-dose, fast microCT scanning*
- High throughput capacity of up to 10 mice**
- High resolution, fast imaging
- Easy co-registration with other modalities
- Spectral Unmixing algorithm for autofluorescence removal or easy separation and quantification of multiplexed fluorescent signals
- Broadly adopted Living Image® software featuring intuitive, wizard-driven acquisition and analysis

The **IVIS® Spectrum 2 and IVIS SpectrumCT 2** imaging systems expands upon the versatility of the, best-in-class predecessor platform enabling high sensitivity 2D and 3D bioluminescence and fluorescence imaging.

Through the use of an innovative CCD camera with patented eXcelon® coating, the IVIS Spectrum 2 platform delivers the high sensitivity you demand to facilitate non-invasive longitudinal monitoring of disease progression, cell trafficking, drug safety and toxicology, treatment efficacy, and biological processes in the context of the living animal.

This advanced imaging platform combines 2D optical and full tomographic imaging with high-throughput capabilities enabling simultaneous imaging of up to 10 mice. Throughput is also increased through the IVIS Posing Station and Smart Trays to streamline imaging workflow.

The IVIS Spectrum 2 platform is available as either an optical only system or optical with integrated CT bringing anatomical context to your functional studies. The IVIS SpectrumCT 2 incorporates all the features of the IVIS Spectrum 2 but includes a CT module with horizontal gantry and flat panel detector enabling high performance, fast, low-dose CT image acquisition.

IVIS® Spectrum 2
and IVIS SpectrumCT 2

State of the art camera for high-performance, high-sensitivity imaging

Using a CCD camera with patented eXcelon® coating for *in vivo* imaging, the IVIS Spectrum 2 and IVIS SpectrumCT 2 offers high sensitivity optical imaging for advancing your research even further.

The eXcelon® coating technology results in increased sensitivity for both bioluminescence and fluorescence reporters across a broader wavelength range than the standard thinned back-illuminated CCDs. The coating technology also provides lower levels of dark current while maintaining high quantum efficiency at lower wavelengths providing:

- Improved signal-to-noise ratio for fluorescent and bioluminescent signals (figure 2)
- Increased bandwidth to encompass a wider range of NIR fluorescent probes (figure 3)

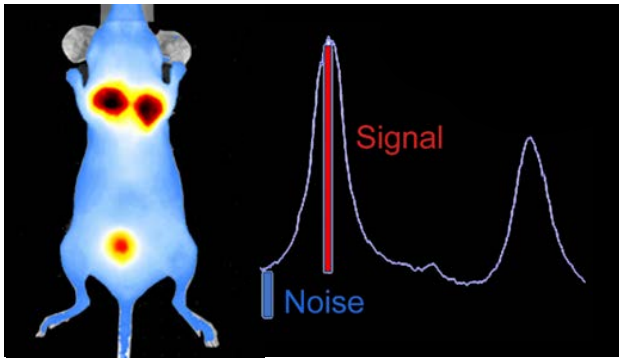


Figure 2: Improved signal to noise ratio. Inset-CCD camera

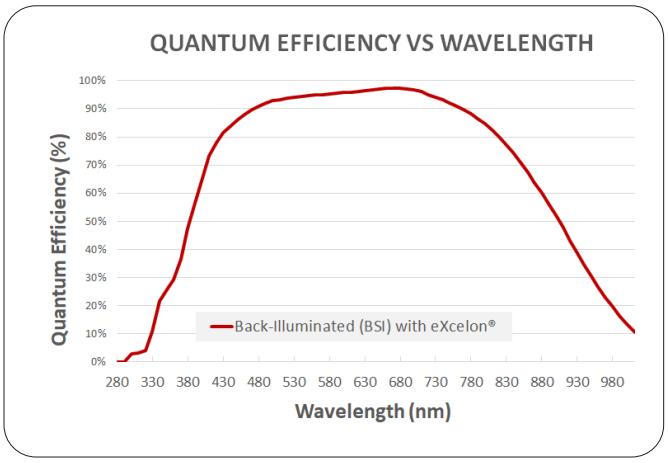


Figure 3: Quantum efficiency graph showing >95% QE across a broad spectrum of wavelengths

Figure 1: Inside the IVIS Spectrum 2 platform

Camera highlights

- Patented eXcelon® coating
- Back-illuminated, thermoelectrically cooled (-90°C) CCD High quantum efficiency (peak >95%) across a wide wavelength range (figure 3)

Imaging chamber

- Light tight imaging chamber
- Integrated gas anesthesia
- Integrated fluorescence
- 10 excitation filters
- Heated stage to maintain optimum body temperature
- Motor controlled stage, filter wheel, lens position, and f-stop
- LED lamps for photographic images
- Electromagnetic door latch
- Scanning laser for mouse alignment and surface topography

CCD camera

- Back-illuminated, thermoelectrically cooled (-90°C) CCD camera with patented eXcelon® coating
- 2048 x 2048 imaging pixels with 13.5 micon pixel size
- Low read noise
- 16-bit digitizer delivers broad dynamic range

Lens

- 6-inch diameter optics, f/1– f/8
- Optical FOV 3.9 - 22.5 cm
- High resolution – down to 20 microns
- Filter wheel with 18 emission filters covering a broad range of wavelengths

Flexible field of view (FOV)

From simultaneous imaging of 10 mice down to a single cell, the IVIS Spectrum 2 platform gives you the flexibility, sensitivity, throughput, and resolution required to quantitate functional developments in your subject

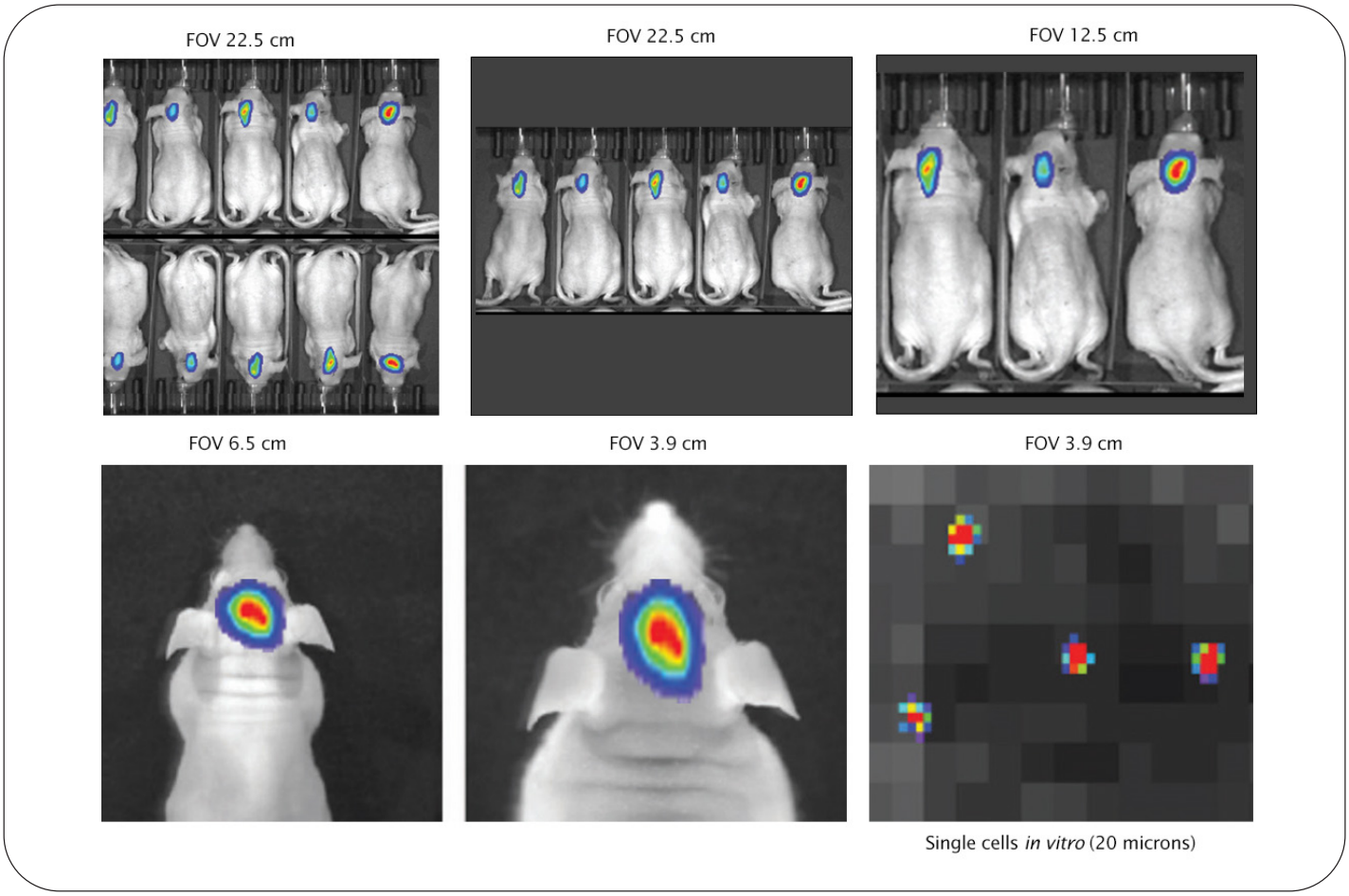


Figure 4: Example of FOV range on the IVIS Spectrum 2 platform

2D bioluminescence and fluorescence imaging

Employing 2D (planar) optical imaging strategies for bioluminescence and fluorescence reporters in the context of the living animal is a powerful tool for research and drug development due to its ease of use and sensitivity. Bioluminescence imaging has been of particular importance in monitoring tumor progression, using luciferase-expressing tumor lines, whereas near infrared (NIR) fluorescent probes provide an array of biology-specific tools for accessing biological processes.

Best in class bioluminescence

Bioluminescence imaging is considered the 'go-to' optical modality due to the ease of use, low cost, and speed.

The IVIS Spectrum 2 platform makes bioluminescence imaging even better with thermoelectrically cooled CCD camera (-90°C) with patented eXcelon® coating for *in vivo* imaging. The camera and wide range emission filter wheel enables high sensitivity bioluminescence light detection of multiple bioluminescent reporters including, firefly, Renilla and bacterial luciferase.

The high sensitivity camera with coating enables detection of single cells (figure 4) for early detection and monitoring of micro-metastasis or tracking disease progression longitudinally and non-invasively *in vivo* (figure 5).

Fluorescence imaging with greater quantum efficiency across a wider spectral range

Whereas bioluminescence imaging is a valuable tool for tracking disease and its progression, fluorescence imaging can provide insight to better understand complex biology and disease states prior to overt physiological changes.

Fluorescence imaging requires an external source for fluorophore excitation, with each fluorophore having its own unique excitation and emission profile. The IVIS Spectrum 2 platform is equipped with a wide range of high spectral resolution filter sets including 10 narrow band pass filters for excitation of multiple fluorophores and 18 narrow band pass emission filters for multispectral signal detection (figure 6). With this range of filters, coupled with the innovative CCD camera with eXcelon® coating, the IVIS Spectrum 2 platform can image and quantify all commonly used fluorophores (proteins, dyes, and conjugates) at **greater efficiency across a wider spectral range.**

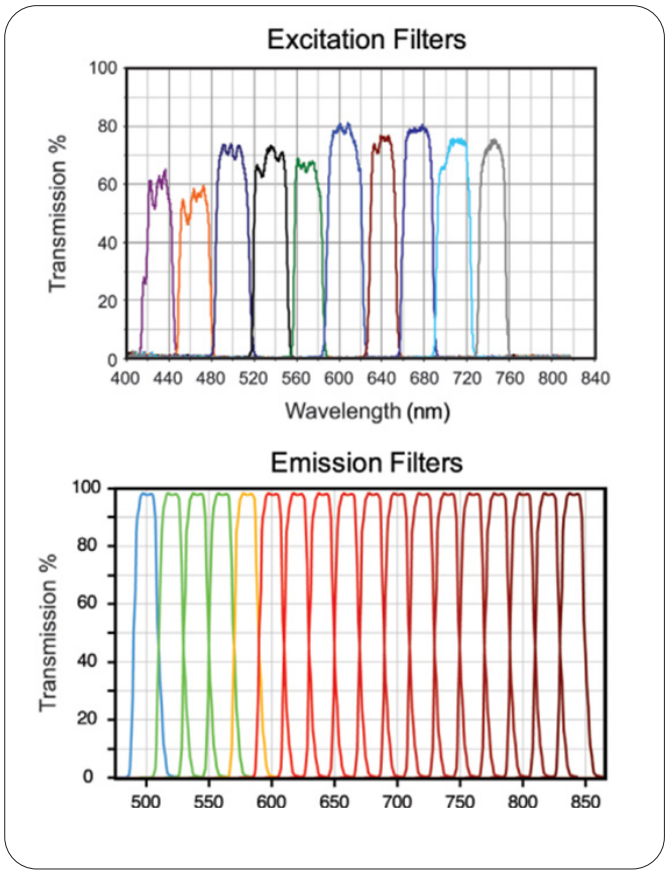


Figure 6: Narrow band pass excitation and emission filters

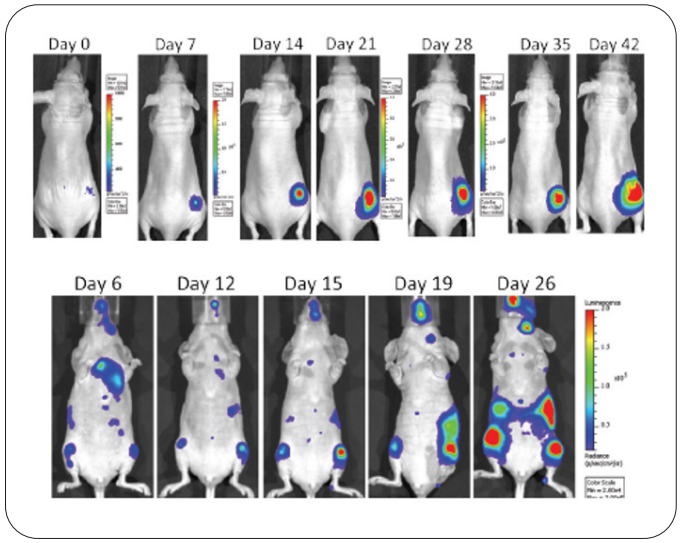


Figure 5: Detection of five IVISbrite 4T1-luc2 tumor cells injected subcutaneously in nude mice (top) and longitudinal monitoring metastasis post intracardiac injection of IVISbrite MDA MA-231-luc2 tumor cells (bottom)

IVIS Spectrum 2 and IVIS SpectrumCT 2: Standard Emission and Excitation Filter Sets

Excitation Filter Ranges (nm)	Emission Filter Ranges (nm)	Common Dyes / Agents / Reporters
415-445	510-530	IVISense™ targeted, vascular, and activatable probes
450-480	530-550	IVISense dyes
485-515	550-570	IVISense self-quenching dyes
520-550	570-590	IVISense cell labeling dyes
555-585	590-610	Alexa Fluor® 600-750
590-620	610-630	Cy5-Cy7.5
625-655	630-650	DsRed, Doxorubicin**
660-690	650-670	mCherry**
695-725	670-690	tdTomato**
730-760	690-710	GFP*
	710-730	FITC*
	730-750	ICG
	750-770	
	770-790	
	790-810	
	810-830	
	830-850	

* Best used with in vitro, ex vivo and surface imaging techniques | ** Enhanced quantification with Spectral Unmixing

Fluorescence imaging: Epi-Illumination vs. trans-illumination

As with the previous IVIS Spectrum series, the IVIS Spectrum 2 platform is capable of imaging fluorophores in either epi-illumination or trans-illumination modes (figures 7 and 8).

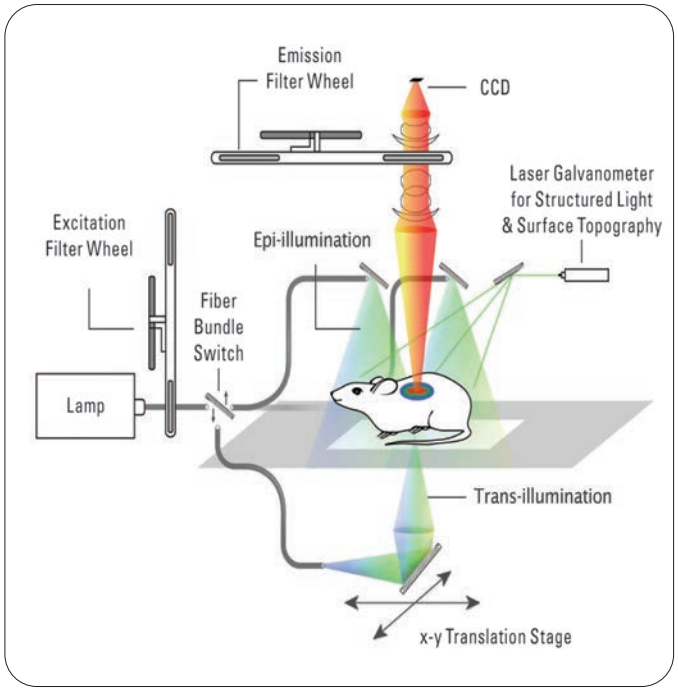


Figure 7: Schematic of the inside of the imaging chamber

Emitted light from the excitation filter wheel feeds through a fiber optic bundle to illuminate the specimen from the top (epi-illumination) ideal for high throughput imaging.

The subject can also be imaged below the stage (trans-illumination) through an automated bundle switch, at precise x, y-locations enabling more sensitive detection and accurate quantification of deep fluorescent sources. Trans-illumination also reduces the effects of autofluorescence.

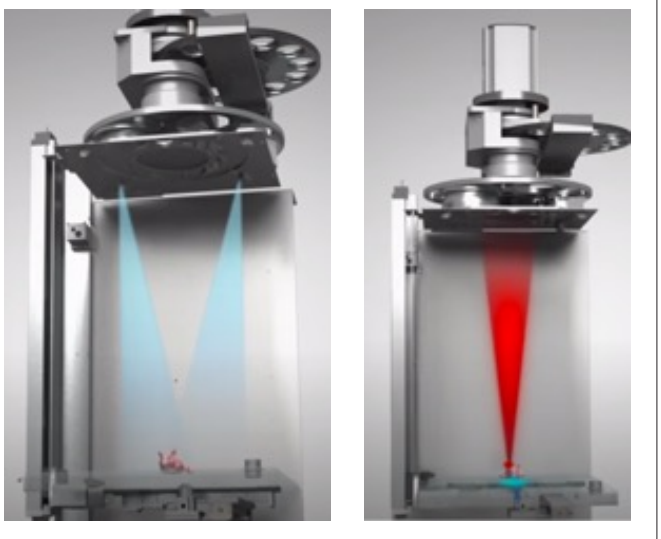


Figure 8: (Left) Imaging from above the specimen (epi-illumination) and (right) from below the specimen (trans-illumination).

Advanced 3D optical tomography

As the pioneer in 3D optical tomography, we continue to make 3D optical tomography a reality in your everyday workflow. The ability to visualize, analyze, and quantify source signal from a disease state in anatomical context brings your *in vivo* imaging studies to a new level. The camera with eXcelon® coating enables high sensitivity imaging of deep bioluminescent and fluorescent sources.

Through the use of diffuse light imaging tomography (DLIT) (figure 9) which uses the data obtained from a filtered 2D bioluminescent sequence in combination with surface topography to represent the signal source in 3D space, you can determine depth and calculate the absolute intensity of the source.

Fluorescence imaging tomography (FLIT) utilizes data obtained from a 2D transillumination sequence also in combination with surface topography to reconstruct fluorescent source in 3D space (figure 10). With FLIT, you can determine depth and calculate absolute intensity of sources.

Take the next step in 3D tomography with Living Image® software which analyzes 3D sources in an anatomical context with the mouse atlas. The 3D software tools also enables the quantification of cell numbers or dye concentration in cells as well as making co-registration with other imaging modalities possible.

Advantages of 3D optical tomography

- Visualize optical sources at depth and in anatomical context
- Ability to detect deeper fluorescent sources
- Determine geometry and quantify bioluminescent and fluorescent sources in 3D space providing true intensity at depth
- Convert quantified light to fluorophore concentration or cell numbers
- View sagittal, coronal and trans-axial sections through a 3D image
- View optical sources from multiple perspectives by converting static 3D views into an animated movie of a rotating subject

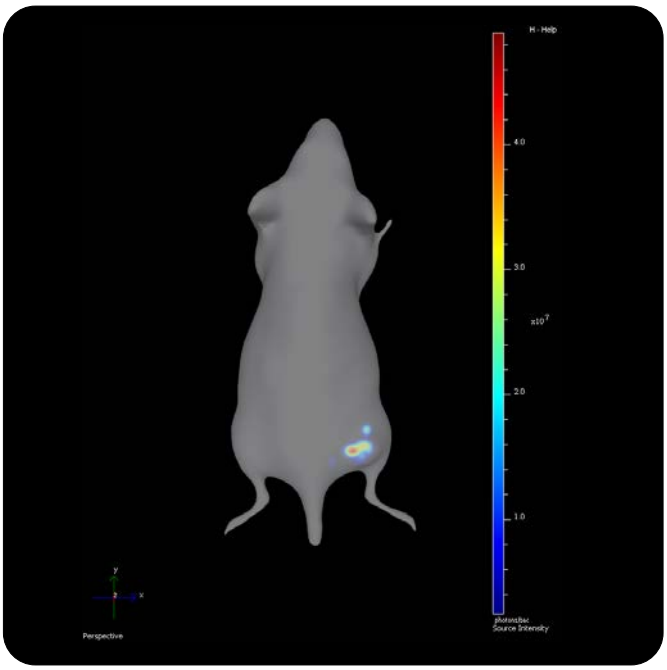


Figure 9: Bioluminescence tomography (DLIT)

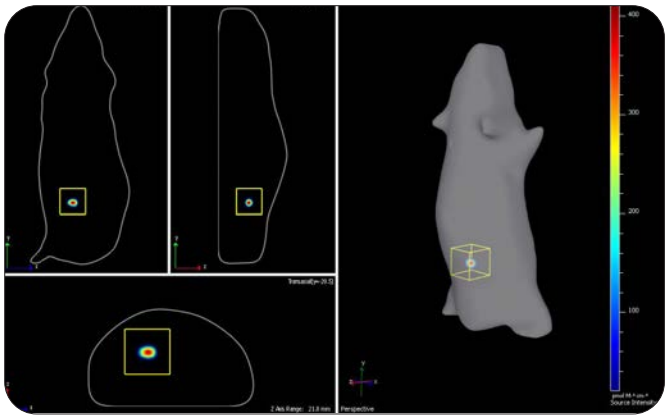


Figure 10: Fluorescence tomography (FLIT). Left panel clockwise: coronal, sagittal, and tra=ns-axial views

The IVIS SpectrumCT 2 - integrating optical and computed tomography into a single system

For ultimate ease and flexibility, the IVIS SpectrumCT 2 system incorporates all the features of the IVIS Spectrum 2 with the addition of integrated, low-dose computed tomography (CT), bringing together functional and anatomical imaging into single system (figure 11).

The horizontal gantry motion and the flat panel detector provides high performance low-dose microCT imaging with automated optical integration. The stable revolving animal platform table rotates 360° to acquire full 3D data (figure 12). Multiple animals can be scanned simultaneously while maintaining an average dose per scan of approximately 13mGy, with a scanning and reconstruction time of less than a minute. Optical and microCT modalities can also operate independently.

Topographic data is essential for the accuracy of 3D tomographic reconstructions, and the IVIS SpectrumCT 2's unique surface mapping allows for true topographic surface mapping of the animal (figure 13B). In addition, the intuitive workflow and imaging wizard features in Living Image software facilitate procedures for 3D tomography and 2D screening modes in bioluminescence, fluorescence and Cerenkov luminescence.

Figure 11: Optical with CT imaging to evaluate folate clearance though the kidneys using IVISense™ Folate Receptor fluorescent probe

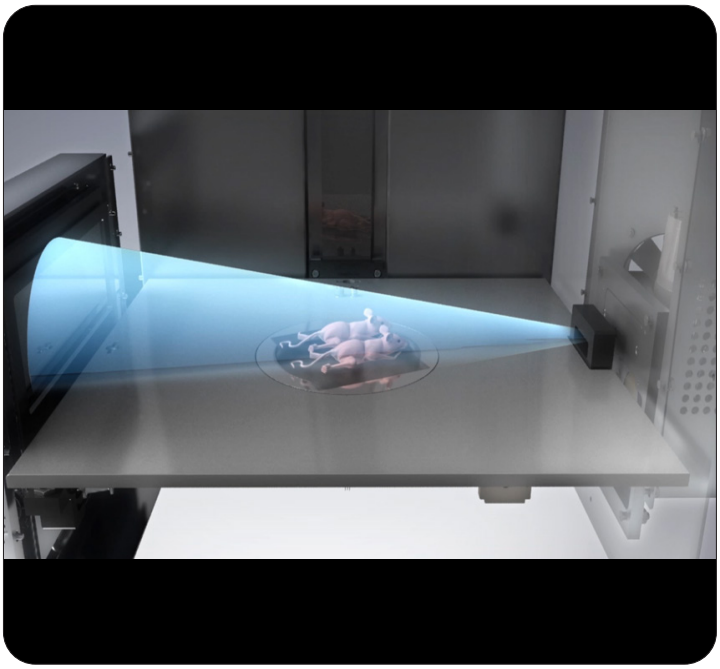


Figure 12: IVIS SpectrumCT 2 – x-ray source, flat panel detector, and 360° revolving animal platform supports simultaneous imaging of up to 2 mice

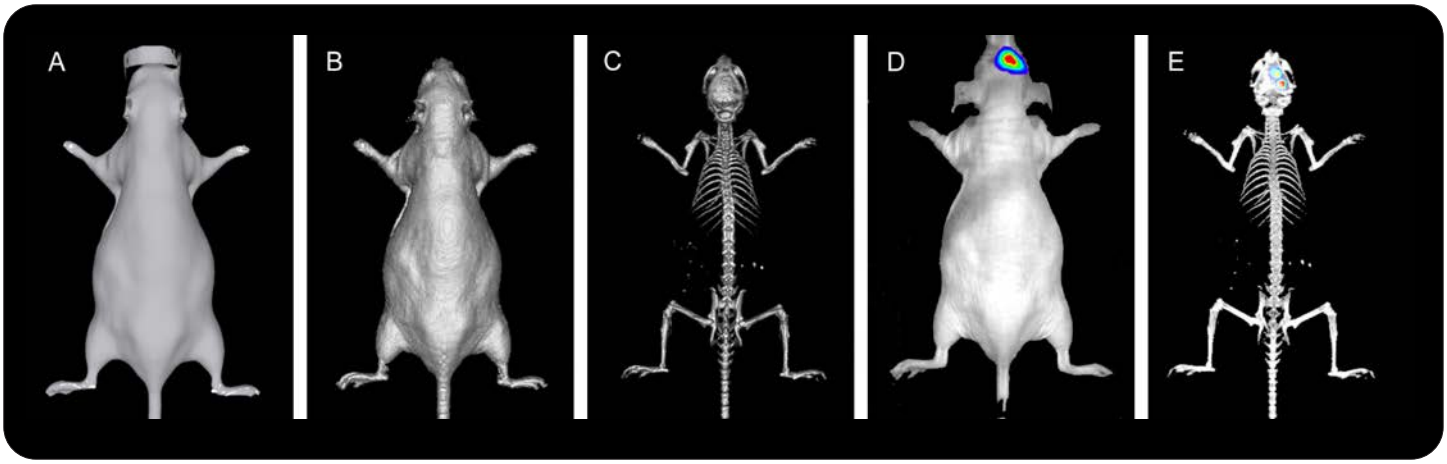


Figure 13: Intracranial implantation of IVISbrite™ U87MG Red F-luc tumor cell line in nu/nu male mice. (A) Surface topography mapping; (B) micro computed tomography (microCT); (C) microCT – segmentation; (D) Optical scan; (E) optical tomographic reconstruction and co-registration

Living image® analysis software – bringing your IVIS images to life

Simplify even the most complex image acquisition and analysis of bioluminescent and fluorescent sources using our broadly adopted Living Image software that sets the industry standard for ease of use and flexibility.

Designed for users of all skill levels, Living Image software includes wizard-based guidance for advanced imaging protocols, spectral unmixing algorithms, expanded fluorescent agent database, and a simplified tool palette (figure 14).

With Living Image software, you can seamlessly capture, visualize, and analyze imaging data to facilitate your drug development and biology research. Highlights include:

- Comprehensive set of tools for 2D and 3D data analysis
- One click 3D reconstructions
- Easily obtain and separate simultaneous fluorescent readouts or remove unwanted autofluorescence background with spectral unmixing
- Co-register optical images with other modalities (e.g., CT, MRI, PET)
- Auto settings for easy image acquisition
- Batch processing analysis tools
- Creation of animated movies and publication ready figures
- Included with IVIS system purchase

Autofluorescence removal and multispectral imaging with advanced spectral unmixing algorithms

Through our advanced patented 'Compute Pure Spectrum' (CPS) spectral unmixing algorithms in the Living Image software, in conjunction with a broad range of high-resolution filters sets, you can easily separate and remove unwanted fluorescence, increasing the signal-to-noise ratio enhancing sensitivity and detection of a wide range of fluorescent sources (figure 15).

Additionally, with fluorescence imaging, the presence of multiple spectrally overlapping fluorophores in the subject can present challenges for interpreting imaging results. With the Living Image patented CPS spectral unmixing tool you can easily identify, separate, isolate, visualize and quantify multiplexed fluorescent signals (figure 16).

Living Image software is designed to simplify advanced and complex biological models by intuitively guiding the user through experiential setup and analysis. The imaging wizard with probe library helps design imaging settings and selection of the right filter pair for fluorescence studies.

Figure 14: Living Image *in vivo* imaging analysis software

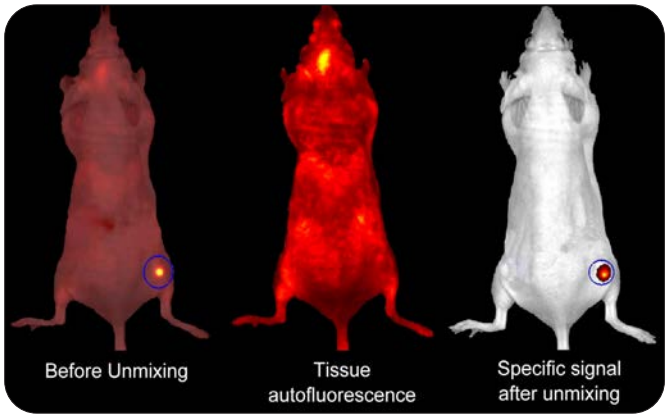


Figure 15: Removal of tissue autofluorescence

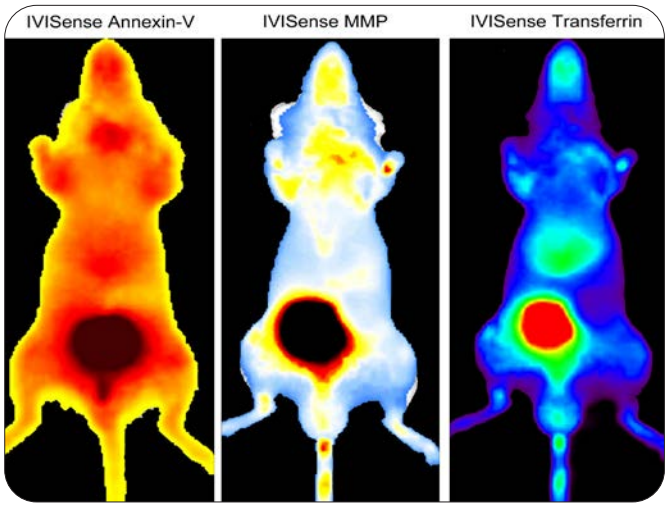


Figure 16: Multiplex imaging of 3 biological events in the same drug induced liver injury mouse model. Fluorescent probes were used to evaluate cell death (IVISense™ Annexin-V), inflammation (IVISense MMP), and metabolic activity (IVISense Transferrin Receptor)

Easily co-register 3D optical tomography with other imaging modalities

The IVIS Spectrum 2 is the most advanced *in vivo* imaging system available on the market today – not only can it quantitate and localize 3D fluorescent and bioluminescent sources *in vivo*, but you can easily import and co-register images from other modalities in DICOM format such as, CT, MRI, PET, SPECT, or ultrasound giving anatomical context to your study.

No need to confine or morph your subject, co-registration is accomplished using a mouse imaging shuttle (figure 17) that keeps the subject anesthetized and in the same position when imaging from one modality to another. Fiducial markers 'tells' Living Image software how to align the two scans enabling automatic co-registration in just a couple of clicks.

Get the most out of your preclinical models by integrating diverse imaging modalities in a single longitudinal study (figure 18).

Figure 14: Living Image *in vivo* imaging analysis software

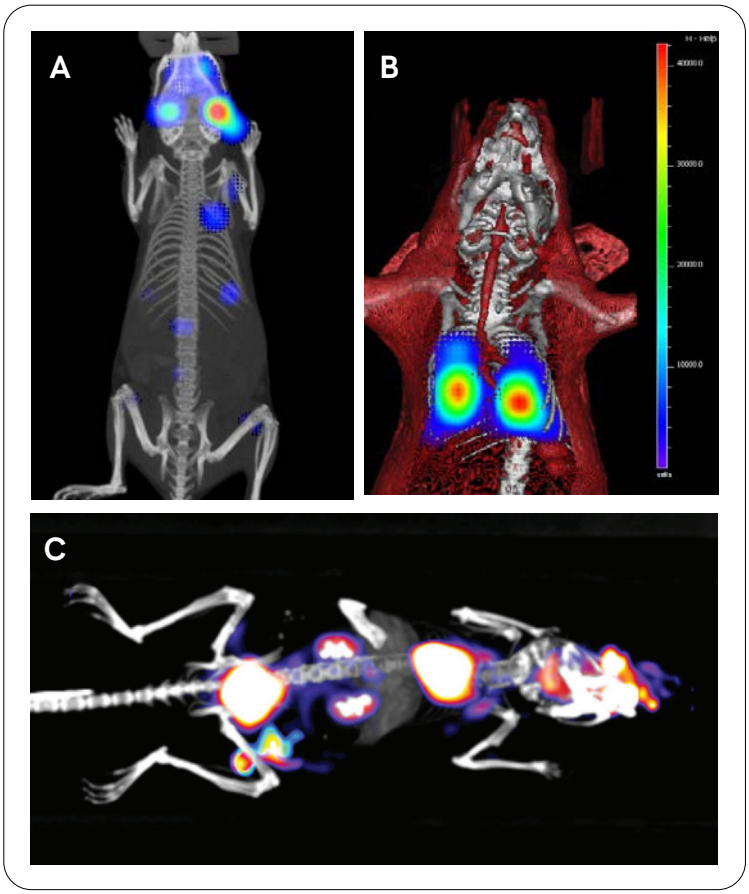


Figure 18: (A) Bioluminescence imaging of IVISbrite™ tumor cell line metastasis co-registered with the Quantum GX2 microCT system. (B) Bioluminescence tomography of mouse lung tumor model co-registered with the Quantum GX2 microCT. (C) Co-registration of PET, microCT, and optical imaging of IVISbrite™ 4T1 tumor cells implanted subcutaneously in the right flank

Increase your throughput

With the IVIS Spectrum 2 imaging platform you get more data faster without sacrificing sensitivity.

The platform incorporates a CCD camera providing a high-throughput 22.5 mm FOV for simultaneous bioluminescence or fluorescence imaging of 5 mice or up to 10 mice with the optional manifold (figure 19).

Figure 19: Imaging 10 mice using optional manifold kit

Streamline Imaging Workflow

Minimize downtime and maximize efficiency with accessories designed to simplify setup, increase throughput, and accelerate data acquisition.

The IVIS Spectrum 2 platform with unique animal management handling accessories (figure 20) is designed for easier animal manipulation on the benchtop increasing and streamlining imaging workflow.

IVIS posing/docking station

The Posing Station is the conduit for connection of the Smart Tray (sold separately) to the RAS-4 anesthesia unit (sold separately) on the benchtop, allowing proper posing and queuing of animals before placing them in the IVIS system.

The posing station base is designed with a warming tray to keep the animals at a comfortable physiological temperature during anesthesia delivery. Use in conjunction with multiple Smart Trays to decrease downtime incurred while animals are being imaged.

Smart trays

Set Up and queue your subjects on the benchtop with smart trays.

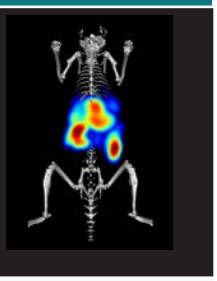
The robust design makes the Smart Trays easily transferable from the benchtop Posing Station to the IVIS Spectrum 2 or IVIS SpectrumCT 2 systems with quick connect anesthesia functionality.

Figure 20: IVIS Posing Station (top) and Smart Trays (bottom)

The IVIS Spectrum 2 platform specifications

General specifications	
Heated Chamber	Yes
Gas Anesthesia Ports	Yes
Injector Ports	Yes
System Dimensions	65 cm x 77 cm x 211 cm (W x D x H)
Imaging Chamber Interior Size	51 x 51 x 66 cm (D x W x H)
Imaging System Space Requirement	203 x 163 x 214 cm (W x D x H)
Power Requirements	20 Amps for 120 VAC Or 10 Amps for 230 VAC
Stage Temperature	20-40 °C
Weight	275 kg (600 lbs) IVIS Spectrum 2 | 334 kg (735 lbs) for IVIS SpectrumCT 2
Optical specifications	
Camera Sensor	Thermoelectrically cooled, back-illuminated CCD camera with patented eXcelon® coating
CCD Size	2.76 x 2.76 cm
CCD Operating Temperature	-90 °C
Imaging Pixels	2048 x 2048
Quantum Efficiency	> 95% from 550 to 720 nm
Pixel Size	13.5 microns
Min. Field of View (FOV)	3.9 x 3.9 cm
Max. Field of View (FOV)	22.5 x 22.5
Min. Image Pixel Resolution	20 microns
Lens f/1 – f/8	1.5x, 2.5x, 5x, 8.8x
Read Noise	< 3 electrons for bin=1,2,4; < 5 electrons for bin=8,16
Dark Current (Typical)	< 100 electrons/s/cm2
Excitation Fluorescence Filters	10
Emission Fluorescence Filters	18
Transillumination Stage	Yes
Computed tomography (IVIS SpectrumCT 2 only)	
Maximum Energy	Maximum Energy of 50 kV with 1 mA
Focal Spot	50 µm
X-ray Detector	CMOS
Detector Size	3072 x 864 pixels
Detector ADC Bit Depth	14 bits
Detector Operating Temp. Range	10-40 °C
microCT Field of View	120 x 120 x 30 mm (L x W x H) to 20 x 20 x 20 mm (L x W x H)
Voxel Size	40 µm – 300 µm
Standard Scan Time	3.6 to 72 seconds
Standard Reconstruction Time	40 to 150 seconds
Standard Scan Dose	minimum of ~13 mGy
Limiting Resolution (3% MTF)	150 µm
Safety Requirements	Less than 1 µSeviert/hour max exposure at 5 cm from anywhere outside cabinet, FDA and TUV approved
Computer and software	
Computer (minimum specifications)	Quad Core 3.6GHz Turbo HT, 32 GB, 2666MHz DDR4, RDIMM, 4GB NVIDIA T400 with 384 CUDA Cores, 4 TB Hard Drive, 24" Flat Screen Monitor
Living Image Software	Included with IVIS purchase

In vivo imaging solutions

OPTICAL			MICRO-CT	ULTRASOUND	REAGENTS
					
IVIS® Lumina Series III ▪ 2D optical imaging ▪ Imaging up to 5 mice using optional expansion lens ▪ Optional integrated x-ray	**IVIS® Lumina 5 Series** ▪ 2D optical imaging ▪ Imaging of up to 10 mice using optional manifold ▪ Optional integrated high-resolution x-ray ▪ Optional Smart accessories to streamline imaging workflow ▪ MVI-2 for automated 360 degree imaging	**IVIS® Spectrum 2 Series** ▪ 2D and 3D optical imaging ▪ Imaging of up to 10 mice using optional manifold ▪ Fully automated, one-click co-registration with IVIS SpectrumCT ▪ Seamlessly co-register 3D optical and hi-res, gated microCT data ▪ Two powerful modes of fluorescence excitation—epi-fluorescence and transillumination	**Quantum GX3** ▪ High-resolution, low-dose microCT ▪ Cardiac and respiratory gating	**Vega®** ▪ Automated, hands-free ▪ High-throughput 3 mice imaging ▪ Scan times in < 1 minute ▪ Whole body field of view ▪ Multiple 3D imaging modes ▪ Elastography (tissue stiffness) ▪ B-mode (soft tissue imaging) ▪ 4D B-mode/M-mode (cardiac imaging) ▪ Acoustic angiography (microvessel networks)	**IVISbrite™** ▪ Bioluminescent substrates, cells, and lentiviral particles **IVISense™** ▪ Fluorescent probes, labels, and dyes **VesselVue®** ▪ Microbubble contrast agents for vascular ultrasound imaging

For more information, please visit our website at www.revvity.com

Revvity, Inc.
940 Winter Street
Waltham, MA 02451 USA

(800) 762-4000
www.revvity.com

For a complete listing of our global offices, visit www.revvity.com