Dental RVG Sensors: From CMOS Technology to Photon Counting

State of the Art, Technological Evolution, and Perspectives for the Practitioner in 2025-2026

Nearly absent from the French dental press, the debate on new-generation intraoral radiographic sensors is nevertheless at the heart of a major technological shift. Between the maturity of CMOS+CsI technology—dominant in the global market—and the emergence of photon counting applied to the intraoral format, practitioners today have an unprecedented range of choices at very differentiated performance and price levels. This dossier provides a comprehensive overview.

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1. Brief History: From Film to CMOS

Digital dental radiography has undergone three successive technological generations.

The first, introduced in 1987 by Trophy Radiology with the RVG (RadioVisiography) system, relied on a **CCD (Charge-Coupled Device)** sensor—technology borrowed from astronomy and digital photography. While CCD produced excellent image quality, it had major drawbacks: high power consumption, heat generation, mechanical fragility, and above all a prohibitive unit cost that limited adoption to the best-equipped practices.

The second generation—**CMOS (Complementary Metal-Oxide Semiconductor)** —gradually established itself from the 2010s onward. More energy-efficient, more robust, and less expensive to manufacture due to synergies with the consumer semiconductor industry, CMOS democratized access to digital sensors. Combined with a **CsI (cesium iodide) scintillator** that converts X-rays into visible light before the chip transforms them into an electrical signal, the CMOS+CsI pair today constitutes the dominant global standard—represented by virtually all sensors on the market, from premium European brands to Chinese alternatives.

The third generation, still emerging, is **Photon Counting Detector (PCD)** technology. It eliminates the X-ray → light conversion step by using a semiconductor that directly captures each individual X-ray photon. In general medical imaging (CT scanners), this technology has been commercially available since 2021 from Siemens Healthineers (NAEOTOM Alpha) and is the subject of advanced clinical research at Canon Medical and GE HealthCare. Its adaptation to the intraoral dental format represents the current technological frontier of the sector.

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2. CMOS+CsI Technology: How It Works, What Performance to Expect

In a standard CMOS sensor, the optical path is as follows: X-rays pass through the patient and strike the CsI scintillator—a layer of cesium iodide crystals deposited in oriented columns (like microscopic optical fibers). These crystals convert X-ray photons into visible light photons, which are then captured by the underlying CMOS matrix and converted into an electrical signal. This signal is amplified, digitized (analog-to-digital conversion), and transmitted to the acquisition software via USB.

Key Technical Parameters

Spatial Resolution (lp/mm): Expressed in line pairs per millimeter, this is the sensor's ability to distinguish two adjacent structures. *Theoretical* resolution (calculated from pixel size) never matches *measured* resolution—only the latter has diagnostic value. A sensor claiming 25 lp/mm theoretical with a GOS (gadolinium oxysulfide) scintillator will only achieve 12-14 lp/mm measured, versus 18-20 lp/mm for a quality CsI of equivalent specification. Always demand the measured value.

AD Conversion Depth (bits): Determines the number of available gray levels. A 12-bit sensor offers 4,096 levels (2^{12}), versus 65,536 levels for a 16-bit sensor (2^{16}). This difference is not cosmetic: clinically, it translates into better discrimination of structures with similar densities—notably for early detection of incipient interproximal caries or fine assessment of bone density in periodontics. Premium sensors and serious mid-range Chinese alternatives offer 16 bits; entry-level sensors with GOS scintillators are often limited to 12 bits.

IP Protection Rating: IP68 guarantees continuous immersion waterproofing—an essential standard for disinfection by soaking. IPX7, often confused with IP68 in commercial literature, **expressly prohibits immersion** according to manufacturers' IFUs. Verify this before any purchase; your practice's disinfection protocol depends directly on it.

FOP (Fiber Optic Plate): A panel of optical fibers interposed between the scintillator and the CMOS chip, serving two functions: reducing lateral diffusion of light produced by the scintillator (improving actual spatial resolution) and filtering residual X-rays not converted by the scintillator (protecting the chip and extending sensor lifespan). Absent from the thinnest sensors (4.5 mm), present in thicker architectures (6 mm) such as the Handy HDR series.

Comparative Table—Principal Sensors on the Market 2025-2026

Parameter	iRay Pluto S2	Handy HDR-500C (CsI)	Handy HDR-500A (GOS)	XpectVision XVD2530	Carestream RVG 5200
Technology	APS CMOS	APS CMOS	APS CMOS	Photon Counting	APS CMOS

Parameter	iRay Pluto S2	Handy HDR-500C (CsI)	Handy HDR-500A (GOS)	XpectVision XVD2530	Carestream RVG 5200
Scintillator	Direct-deposition CsI	CsI:Ti	GOS	None (direct Si)	Scintillator + FOP
True Resolution	14-20 lp/mm	18-20 lp/mm	12-14 lp/mm	12-14 lp/mm	16 lp/mm
AD Conversion	16-bit	12-bit	12-bit	16-bit	12-bit
Thickness	4.5 mm	6 mm	6 mm	5 mm	6.9-7.3 mm
IP Protection	IP68	IP68	IP68	IP67	Fully waterproof
Warranty	1-2 years	1 year	1 year	5 years	2 years
Indicative Price (USD)	~$1,400	~$1,100-1,300	~$1,000-1,200	~$1,800-3,200	~$4,100

Note: Prices are indicative, sourced from international B2B market data (May-July 2025).

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3. GOS vs CsI: A Difference Underestimated by Prescribers

The distinction between GOS (gadolinium oxysulfide) and CsI (cesium iodide) scintillators is one of the most frequently overlooked points in commercial comparisons—yet one of the most determinative for clinical image quality.

GOS is a powder scintillator: crystals are randomly dispersed in a binder. When an X-ray photon strikes it, the emitted light diffuses laterally in all directions before reaching the CMOS matrix. This lateral diffusion is the primary cause of image blur—it mechanically limits actual spatial resolution to 12-14 lp/mm, regardless of the CMOS matrix's pixel count.

CsI, by contrast, is deposited in crystalline columns oriented perpendicular to the sensor surface—like a set of microscopic optical fibers. The emitted light is guided along these columns toward the CMOS chip with minimal lateral diffusion. The result: true resolution of 18-20 lp/mm, enabling visualization of fine structures such as accessory canals, early coronal fissures, and details of inter-radicular lesions. CsI also offers better quantum efficiency (more X-ray photons converted into usable signal), translating into lower exposure dose for equivalent image quality.

⚠ Purchasing Vigilance Point

Many product datasheets claim "27 lp/mm resolution" without specifying whether this is theoretical or measured, nor the scintillator type. A datasheet indicating "27 lp/mm theoretical / 12-14 lp/mm measured" with a GOS scintillator is an entry-level sensor despite the appearance of high performance. Systematically demand: (1) scintillator type, (2) measured true resolution, (3) AD bit depth.

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4. Photon Counting: Technological Disruption or Gradual Evolution?

Photon counting represents a paradigm shift from the CMOS+scintillator architecture. Instead of converting X-rays into light and then into an electrical signal (a two-step process with information loss at each stage), the photon-counting detector uses a semiconductor that **directly captures each individual X-ray photon and measures its energy**. Each photon generates an electrical charge directly in the detector material—without an intermediate light conversion step.

The theoretical advantages are significant: zero electronic noise (no dark current), expanded dynamic range, superior contrast resolution enabling differentiation of very close-density structures, and potential for spectral imaging (material discrimination by photon energy) opening unprecedented diagnostic perspectives—visualization of calcifications, tissue/restoration differentiation, reduction of metallic artifacts.

A crucial counter-intuitive point: photon counting does not necessarily surpass CMOS+CsI in *spatial resolution*. The XpectVision XVD2530 (the only commercially available photon-counting dental sensor to date) displays a measured spatial resolution of 12-14 lp/mm—inferior to the 20 lp/mm of a good CMOS+CsI sensor. This paradox is explained by miniaturization constraints: at 5 mm thickness, the silicon chip used by XpectVision generates slightly less fine pixels than optimized CsI. Photon counting's superiority manifests in *contrast resolution* (distinguishing structures of similar densities)—a different but complementary clinical advantage to spatial resolution.

Clinical validation: A 2025 study published in *Dentomaxillofacial Radiology* (March 2025, Vol. 54, Issue 3) compared a novel photon-counting sensor with 2 CBCT protocols and 2 CMOS sensors for detecting gaps between gutta-percha cones and root canal walls. The photon-counting sensor demonstrated superior sensitivity and accuracy (88.47%, 81.57%), significantly higher than CBCT protocols (50.70%-56.33%, 45.87%-53.17%).

Commercial maturity: Siemens Healthineers commercialized its first photon-counting CT scanner in 2021 (NAEOTOM Alpha, CdTe, >1 million patients scanned); Canon Medical is in advanced clinical research with its CZT system (4 global installations in 2024); GE HealthCare submitted an FDA application in late 2025 for its Photonova Spectra. None of these giants have a commercial intraoral dental product—miniaturizing photon counting to the 5 mm format remains a challenge that only China's XpectVision (Shenzhen, 400+ patents) has solved to date.

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5. The RVG Sensor Market in France: Structure and Players

The French RVG sensor market remains dominated by three or four historical players whose products are distributed via well-established specialized dealer networks. Owandy Radiology (French group, production site in Croissy-Beaubourg), Acteon/Sopro (French group, Mérignac), Carestream Dental, Dentsply Sirona/Dürr Dental, and Planmeca constitute the premium segment (€3,500-6,000 per sensor). These products offer the advantages of irreproachable CE/MDR documentation, a structured national after-sales network, and proven software integration.

Below this, a mid-range segment is progressively structuring around Korean players (Genoray, Ray Co) and importers of Chinese sensors (iRay Technology/Pluto, Shanghai Handy/HDR series). This segment, positioned between €1,200-2,500, often offers technical performance comparable to the premium segment on fundamental criteria (resolution, bit depth, waterproofing), but with variable regulatory documentation and locally-constructed after-sales infrastructure.

Critical regulatory point for the purchasing practitioner: Under European MDR 2017/745, an RVG sensor is a Class IIa minimum medical device (diagnostic imaging device using ionizing radiation). Any sensor placed on the French market must have valid CE marking under MDR (not the former MDD 93/42 directive), an EU Declaration of Conformity, an identified European Authorized Representative with EUDAMED SRN number, and Instructions for Use in French. These obligations apply to the manufacturer and importer—the purchasing practitioner is entitled to demand them before any acquisition.

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6. AI and RVG Sensors: Toward the Integrated Diagnostic Platform

The most structuring underlying trend in the market is not technological in the hardware sense—it is software-based. The integration of artificial intelligence modules into radiographic acquisition chains is shifting added value from the sensor itself (a mere detector) toward diagnostic assistance software.

In the United States, **Pearl AI** and **Videa Health** solutions are already integrated into the workflows of several thousand practices—they automatically detect caries, periapical lesions, periodontal bone loss, and salivary calculi on standard radiographs acquired by any TWAIN-compatible sensor. Dentsply Sirona has formal partnerships with both players. XpectVision announced AI functionality integration into its software platform in 2025.

For the French practitioner, this evolution has an immediate practical implication: the **TWAIN compatibility** of the chosen sensor becomes a strategic selection criterion, as it is the standard protocol enabling these third-party AI modules to connect to any imaging software. A sensor without TWAIN (certain wireless versions of Chinese sensors) closes the door to these future integrations.

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7. Practical Guide: Choosing Your RVG Sensor in 2025-2026

In summary, here are the key questions to ask before any purchase:

1. Which scintillator?

CsI preferred (true resolution 18-20 lp/mm). GOS is acceptable for occasional use, insufficient for a high-volume practice requiring high diagnostic precision.

2. Which AD depth?

16-bit is the recommended standard. Reject 12-bit sensors for primary practice use.

3. Which thickness?

4.5 mm (e.g., iRay Pluto) vs. 6 mm (e.g., Handy HDR, Carestream). Thickness directly impacts patient comfort—a non-negligible factor for patients with a strong gag reflex.

4. IP68 or IPX7?

Verify the IFU: IPX7 prohibits immersion. If your disinfection protocol includes soaking, demand IP68 confirmed in the IFU, not just in the commercial catalog.

5. TWAIN guaranteed?

Essential for integration with existing software (Dexis, Carestream, OpenDental, Logosw, etc.) and current and future third-party AI modules.

6. Regulatory documentation?

Demand: CE/MDR certificate number, European Authorized Representative identity (EUDAMED SRN), IFU in French. These documents are not optional—they condition legal liability in the event of an incident.

7. After-sales service and warranty?

The standard market warranty period is 1-2 years. A locally-based after-sales service in France with a quantified commitment (loaner sensor, exchange lead time) often justifies the price differential over an alternative without local support.

Conclusion: A Maturing Technology, A Disruption Underway

The dental RVG sensor market is at a pivotal moment. CMOS+CsI technology is mature, high-performance, and available at highly competitive prices thanks to the rise of Asian manufacturers (China, Korea). Practitioners today can access performance close to the best premium brands for an investment two to three times lower—provided they select products with solid regulatory documentation and localized after-sales service.

Dental photon counting is only in its early stages: XpectVision represents a genuine and documented innovation (400+ patents, presence at IDS 2026 Cologne), but with current spatial resolution inferior to optimized CMOS+CsI and a still-premium price. The major global players (Siemens, Canon, GE) are not yet on this intraoral segment—the miniaturization barrier remains significant.

For the practitioner renewing equipment in 2025-2026, the best clinical/economic ratio remains a 16-bit CMOS+CsI sensor, IP68, TWAIN-compatible, with a minimum 2-year warranty and localized after-sales service. Dental photon counting merits active monitoring over 3-5 years—it will likely be the standard of the next decade.

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