# Developing a Novel X-Ray Source and a 6th Generation Ultra-Fast and General-Purpose CT

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# Abstract

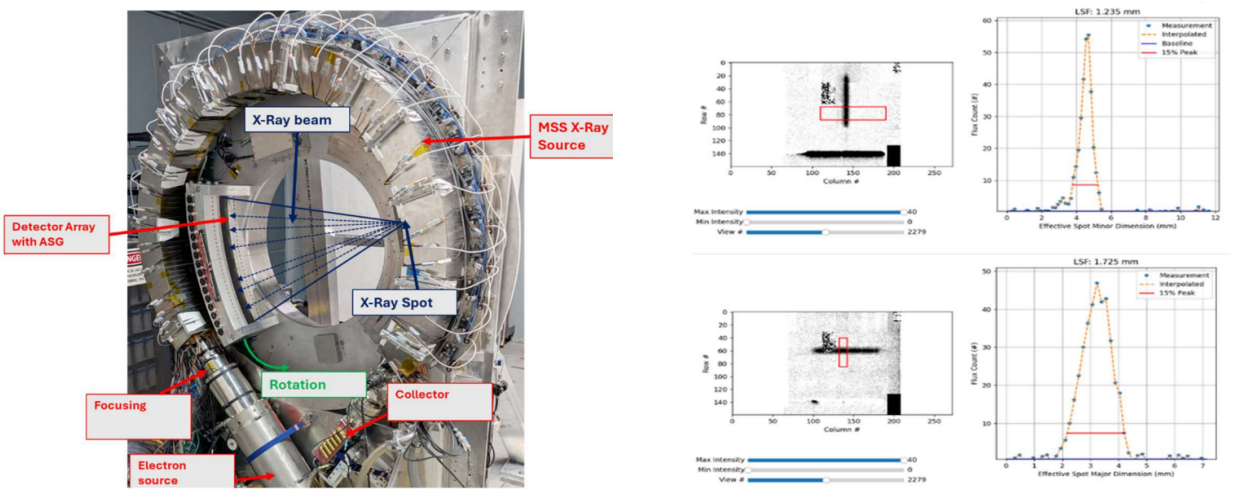
**Purpose:** To develop and evaluate a novel X-Ray source technology, referred to as the Magnetically-Scanning Stationary (MSS) X-Ray source, and a CT platform, referred to as the 6th generation (6th-gen) CT, that combines the MSS X-Ray source and a rotating detector array. A 6th-gen CT avoids the need to rotate heavy X-Ray source(s) and high-voltage power supply, thus promising a much faster rotation speed.

**Methods and Materials:** Several iterations of the MSS X-Ray source and the 6th-gen CT prototype have been developed. The X-Ray focal spot movement is synchronized with the detector rotation using encoderbased scan trigger electronics. The performance of the MSS X-Ray source and the 6th-gen CT were evaluated using hardware prototypes.

**Results:** The MSS X-Ray source has achieved: 1) Ultra-fast scan down to 30 ms of image temporal resolution, far exceeding the 125-250 ms range achieved by today's high-end CT; 2) Sufficient X-Ray flux (up to over 1000 mA) that is required for general-purpose diagnostic CT; 3) An X-Ray focal spot size down to 1x0.6 mm. Currently, the 6th-gen CT prototype has achieved 260 RPM rotation speed measured by a home-position trigger, and the X-Ray focal spot motion is synchronized with the detector rotation as evident by the sinogram data collected.

Table 1: 6th generation CT and MSS X-Ray source performance characteristics.

| **Parameter** | **Achieved** | **Targeted Range** |
|---|---|---|
| Rotation Speed (RPM) | 260 | 480 - 960 |
| Scan Speed (ms) | Up to 30 | 250 - 30 |
| Flux (mA) | Up to 1000 | 10 - 1000+ |
| Focal Spot Size (mm) | Up to $1\times0.6$ | Up to Sub |
| Bore Size (mm) | 689.32 | 800 |
| FOV (mm) | 423.87 | 500 |
| Emission Power (kW) | Up to 140 | |
| Weight/Size/Power | Mobile Friendly | |
| Cost | Competitive | |




(a) (b)

Figure 1: (a) Latest 6th generation CT prototype integrated with MSS X-Ray source; (b) X-Ray spot size measurement using EIC-60336 procedure modified for a constantly moving spot.

**Conclusion:** The MSS X-Ray source has demonstrated the capability to match the X-Ray power performance of leading CTs on the market. The focal spot size of 1 mm has been demonstrated, with a sub-millimeter focal spot is being developed in the next prototype. The current 6th-gen CT prototype has demonstrated a rotational speed of 260 RPM, which is slightly faster than that of the leading CTs. A 480 RPM rotation speed is being developed in the next prototype. A 960 RPM (i.e., an image temporal resolution of 30-40 ms range) is potentially achievable, which constitutes 4x the speed of today's CT, a speed that can be achieved because the current physical constraint of mechanical rotation of the CT tube has been eliminated in the 6th-gen CT.

**Clinical Relevance/Application:** The MSS X-Ray source and the 6th-gen CT will transform the entire field of CT. It is a flexible system that is compatible with all other state-of-the-art technology innovations, such as photon-counting detectors, Spectral CT, dose-reduction techniques, more detector rows, AI, as well as software-based technologies. The 6th-gen CT will transform many CT applications, from general-purpose CT to cardiac CT. Since the 6th-gen CT will be lighter and more compact than conventional CT, it will also open up special applications such as emergency room (ER) / operating room (OR) CT, mobile CT, and miniaturized vehicle-based CT. Due to its stationary source design, it is expected to be more economical compared with high-end CT systems, such as dual-source/dual-detector CT.

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