# 2021「中技社科技獎學金」

## 2021 CTCI Foundation Science and Technology Scholarship

## 境外生研究獎學金

## Research Scholarship for International Graduate Students

# Development of Nyquist-exceeding Mesoscopic Multiphoton and Harmonic Generation Optical Microscopy

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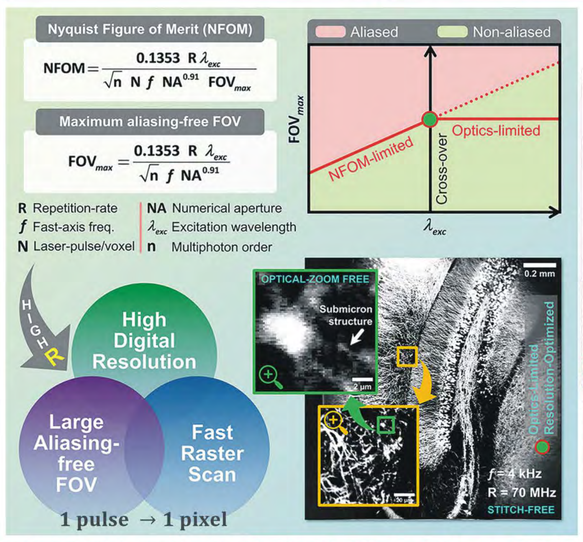
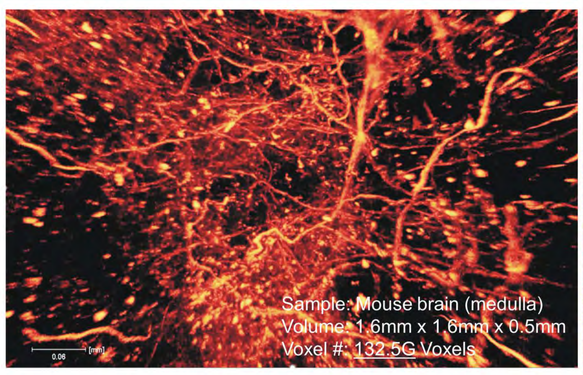
### Abstract

The Nyquist Shannon criterion has never been realized in a laser scanning mesoscopic Multiphoton Microscope (MPM). We introduce a Nyquist figure of merit to characterize an MPM's resolution retrieving ability. A mesoscopic MPM is custom built with indigenously developed electro-opto-mechanical designs together with a custom software package. We enable subminute multicolor GigaPixel imaging of a centimeter-scale tissue with a submicron digital resolution with a record capability of laser-scanning a 34 mm² area with $10^9$ pixels within <31 seconds.

### Research results

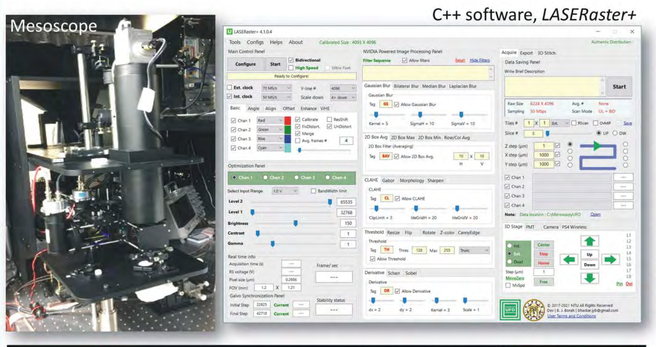
## Fast Large-FOV Aliasing-free MPM Imaging

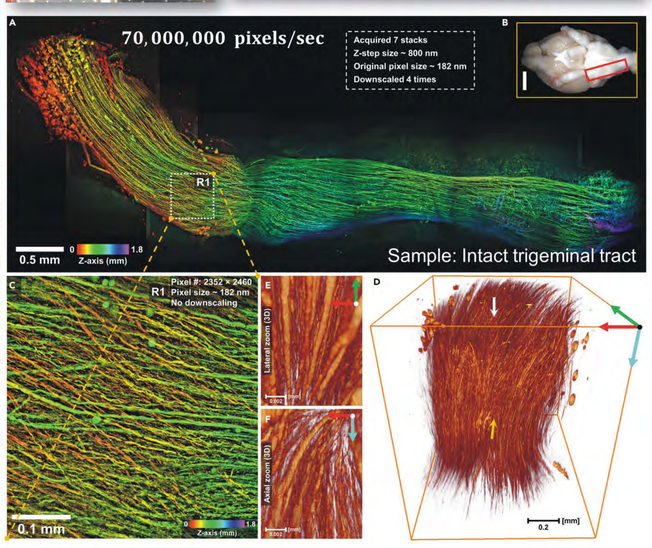



iScience, 24, 103041, 2021 Publication

C++ software, *LASERaster+*

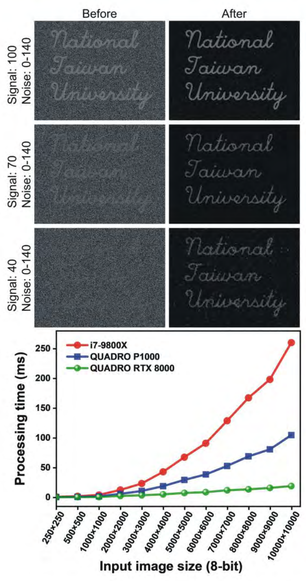


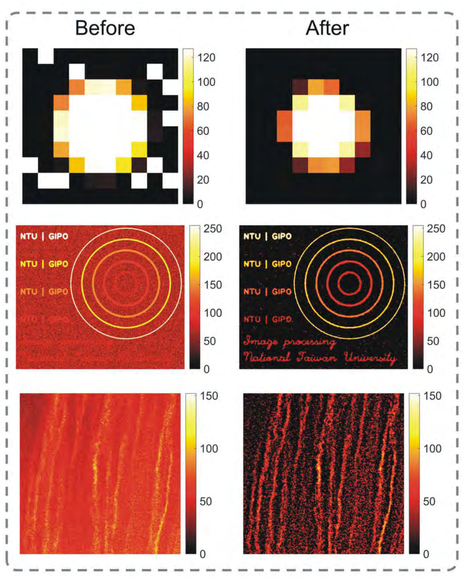




### Comparison with state-of-the-arts

| Systems | NA | Axial resolution (μm) | FOV (mm × mm) | X-axis Pixels | Optical resolution (μm) | Digital resolution (μm) | FOV/ resolution | Effective pixel rate (M/s) |
|---|---|---|---|---|---|---|---|---|
| Tsai, 2015 | 0.28 | 14 | 8×10 | 2000 | 1.0 | 8.0 | 8000 | <1 |
| Bumstead, 2018 | 0.22 | 28 | 5×5 | 1000 | 1.7 | 9.9 | 2912 | <1 |
| Balu, 2016 | 1.05 | 3 | 0.8×0.8 | 1600 | 0.5 | 1.0 | 1600 | 13 |
| Stirman, 2016 | 0.43 | 12 | 3.5 | 2048 | 1.2 | 3.4 | 2917 | 16 |
| Terada, 2018 | 0.6 | 10 | 1.2×3.5 | 512 | 1.3 | 4.7 | 952 | 8 |
| **Our Tech.** | **0.95** | **<2** | **1.6×1.6** | **8800** | **0.4** | **0.4** | **>3800** | **70** |

## Sub-millisecond High-frequency Background-Noise Suppression




IEEE Access, 9, 68746-68757, 2021 Publication

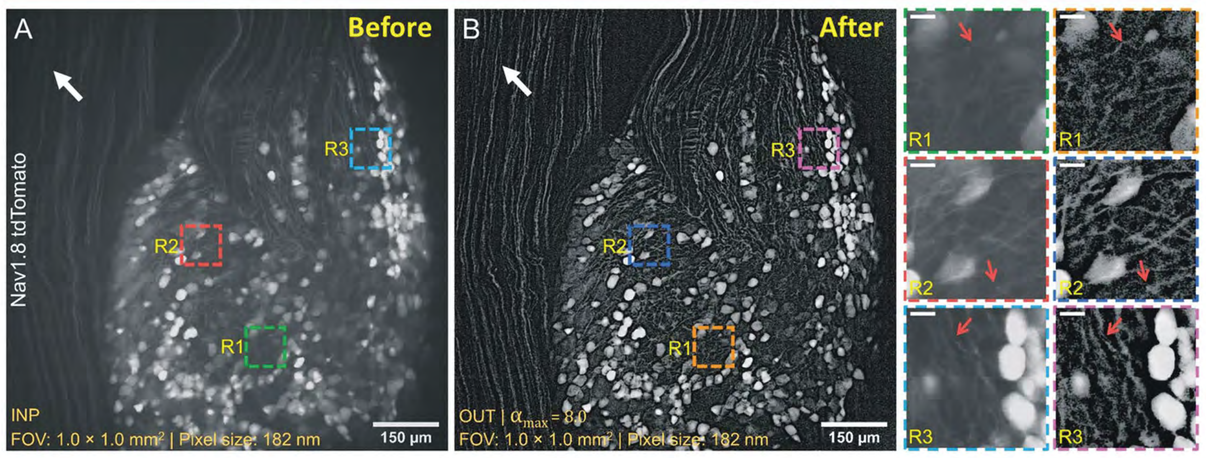
### Ultra-Fast Noise Rejection

<300 μs for 1000×1000-pixels

### Wide Range Applicability

- ✓ Instruments involving real-world data acquisition
- ✓ Multi-modality microscopy
- ✓ Ultrasound, CT/X-ray imaging
- ✓ Astronomical imaging
- ✓ Sophisticated sensor data processing in medical/defense equipment or vehicles

## *Virtually-adaptive* illumination in Optical Neuronal Imaging

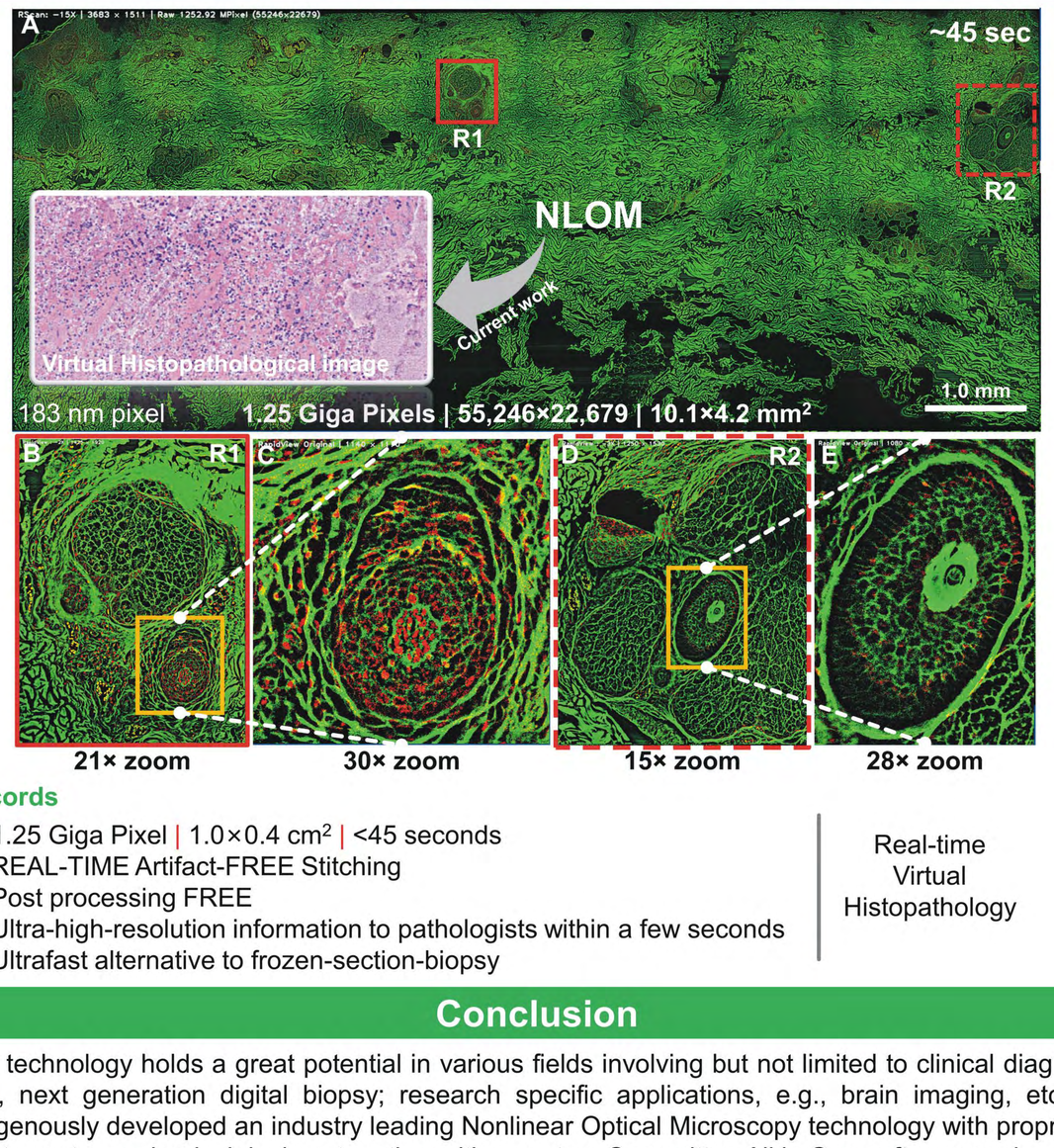



- ✓ Limited dynamic range makes it difficult to visualize weak-intensity nerve fibers and bright somas all together
- ✓ Our method drastically improves Visibility of ULTRAFINE nerve fibers
- ✓ *Bio-imaging Applications:* Brain imaging, Neuronal-mapping, Cell/Fiber segmenting

iScience Under review

<3 ms for 1000×1000 16-bit pixels

## Ultrafast Histopathology with Sub-Minute Giga-Pixel Imaging




### Records

- ✓ 1.25 Giga Pixel | 1.0×0.4 cm² | <45 seconds
- ✓ REAL-TIME Artifact-FREE Stitching
- ✓ Post processing FREE
- ✓ Ultra-high-resolution information to pathologists within a few seconds
- ✓ Ultrafast alternative to frozen-section-biopsy

Real-time Virtual Histopathology

## Conclusion

Our technology holds a great potential in various fields involving but not limited to clinical diagnosis, e.g., next generation digital biopsy; research specific applications, e.g., brain imaging, etc. We indigenously developed an industry leading Nonlinear Optical Microscopy technology with proprietary electro-opto-mechanical designs together with a custom C++ written All in One software package.

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