



Freeform Gratings for Ultra-Compact Spectrograph Designs

CEOI Technologies in a Nutshell – 28/06/2017

C. Bourgenot, A. Calcines-Rosario, R. M. Sharples

Centre for Advanced Instrumentation, Durham University

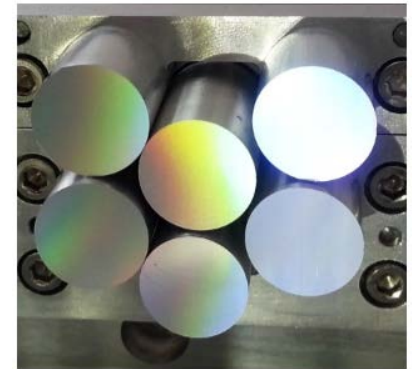
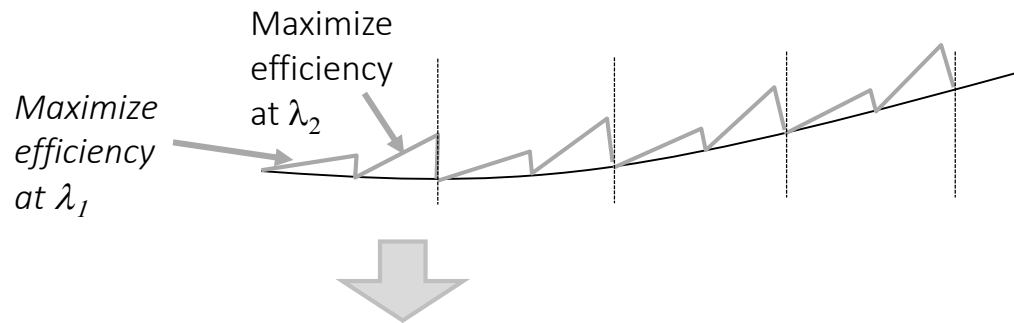


main objectives

- investigate the potential of ultraprecision diamond machining techniques to produce efficient diffraction gratings on aspheric or freeform metal surfaces with full control of the blaze micro-structure.

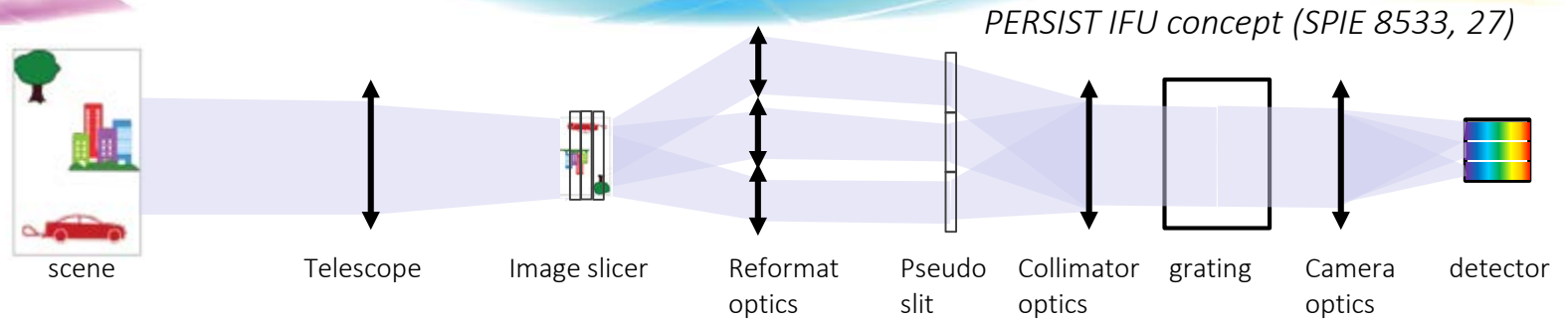


- ✓ cost-effective : Fast machining, simple setup
- ✓ more compact : Freeform generation of highly curved surfaces
- ✓ more flexible : Full control of the blaze profile, material, possibility of making multiblaze structures or variably spaced groove



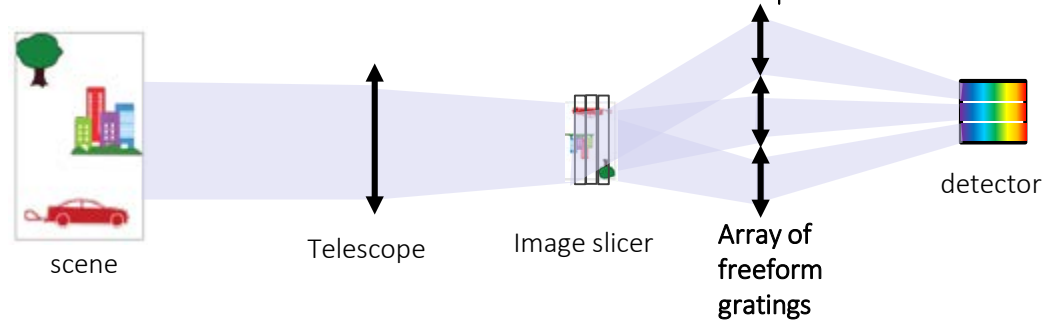
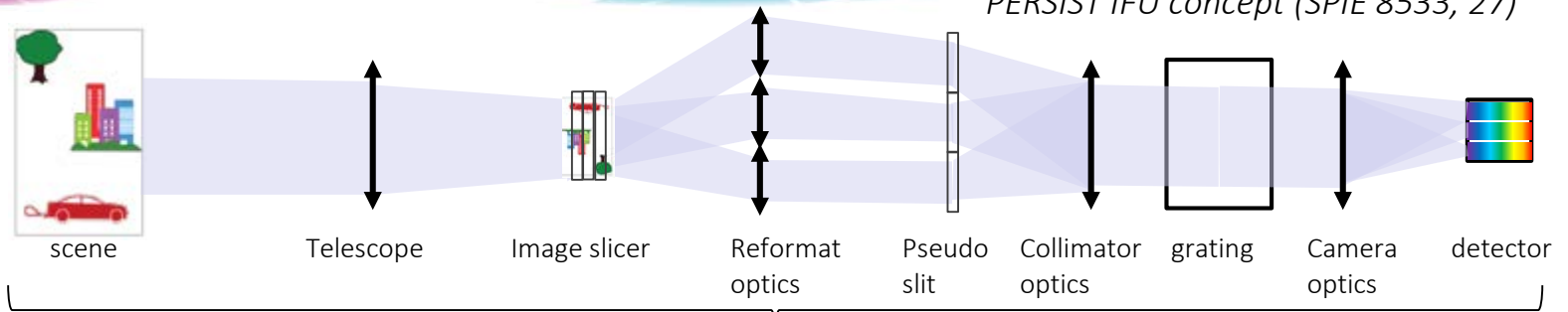
- Design a new type of Integral Field Spectrometer, based on image slicer and array of freeform gratings.

Concept



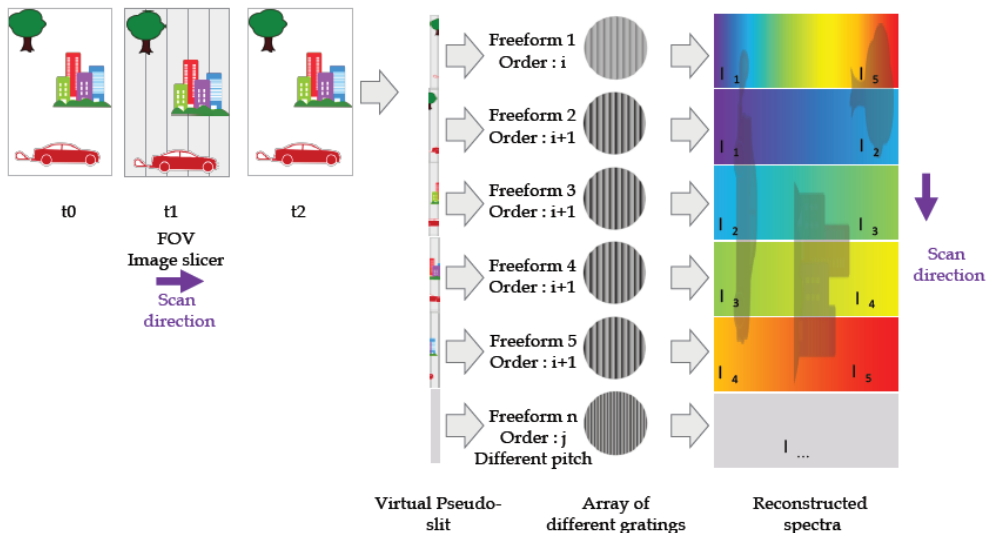
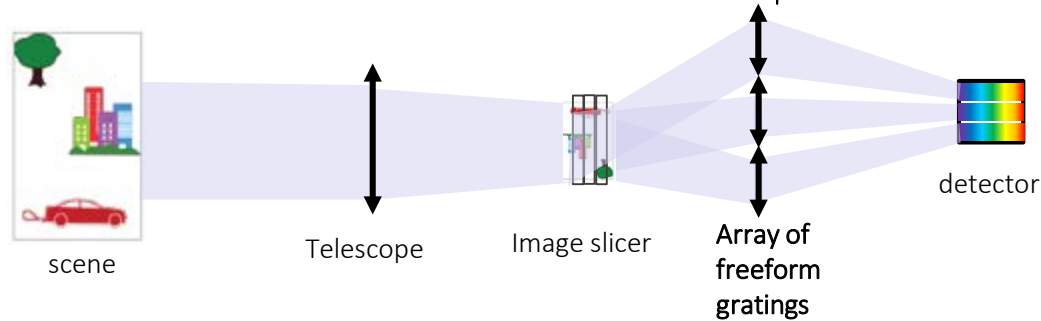
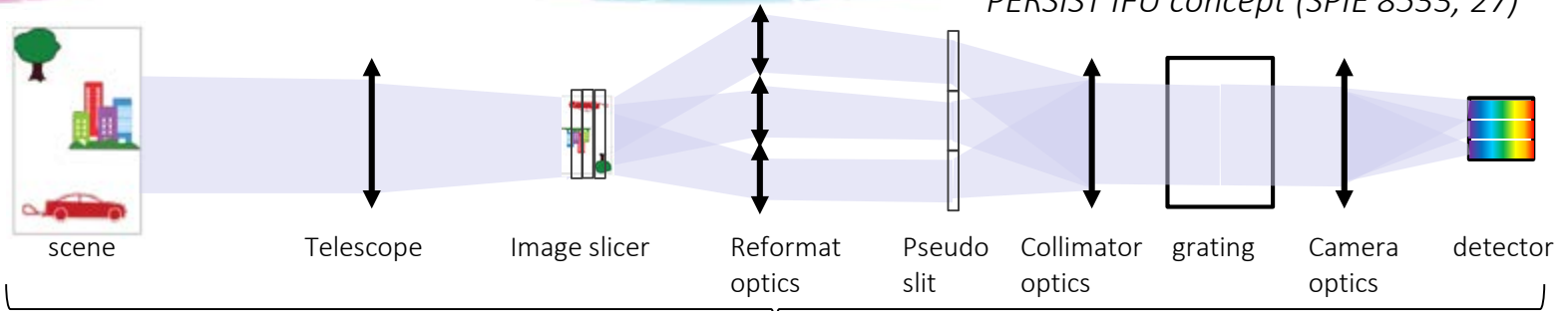
Concept

PERSIST IFU concept (SPIE 8533, 27)



Concept

PERSIST IFU concept (SPIE 8533, 27)



- Pushbroom design
- Different groove spacing
- Different order
- Different blaze angle

target mission/application(s)

- Application ideally in the Near IR (0.75–1.4 μm), SWIR (1.4–3 μm), potentially in the MWIR(3–8 μm) to LWIR(8–15 μm).
- Applications areas are any which require multiple wavelength regions and/or spectral resolutions e.g. probing atmospheric greenhouse gases (PERSIST/GHOST/OCO)
- identifications of many types of surface materials, such as rocks and minerals, soils, snow, plant and phytoplankton functional types and species (HyspIRI)
- Applications where Holographic/ion etched freeform gratings (HORIBA) are limited in surface curvature (sag).

technical work

- experimentally investigate different alternatives for:
 - materials (Aluminium versus Aluminium + Nickel)
 - grating parameters (period, off axis, blaze angle, form etc...)
 - machining parameters (tooling, feedrate, etc...)and to assess their impact on spatial and spectral resolution as well as on efficiency.
- Design and machine 4 gratings :
 - 1 in RSA6061 optimized at 633nm with constantly spaced grooves.
 - 1 in RSA 443 with electroless nickel plating and the same grating definition
 - 1 grating with a dual-angle blazed structure (in the best performing material) optimized at 633nm and at another wavelength to be defined, with constant groove spacing.
 - 1 grating (in the best material) optimized at 633nm, with variably spaced grooves.
- Metrology and test of the 4 gratings in a dedicated setup.
 - Measurement of roughness, resolution (spectral and spatial), efficiency, reflected wavefront (surface form), and PSF on the 4 gratings, stray light analysis
- Design of a preliminary optical concept for a multi-channel compact imaging spectrograph optimized for the science requirement of OCO.