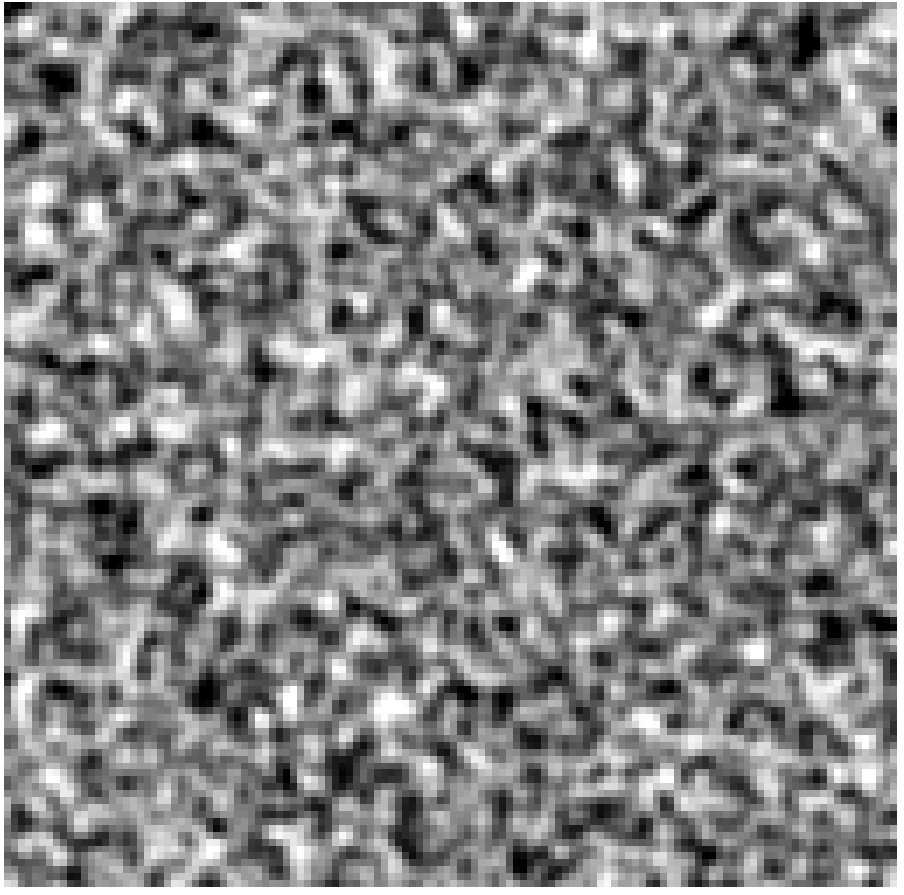
Andrew Kingston
Daniele Pelliccia
Filomena Salvemini
Ulf Garbe
Yin Cheng
Glenn Myers
Joseph Bevitt
David Ceddia
Margie Olbinado
Imants Svalbe
David Paganin
Alexander Rack
Timur Gureyev
Valentina Cantelli
Mario Scheel
Alex Kozlov
Harry Quiney

Ghost imaging using x rays and neutrons

Speckles



Ceddia & Paganin, Phys. Rev. A. **97**, 062119 (2018).
Gureyev, Paganin, Kozlov, Nesterets, Quiney, Phys. Rev. A **97**, 053819 (2018).

“Building signals out of noise”

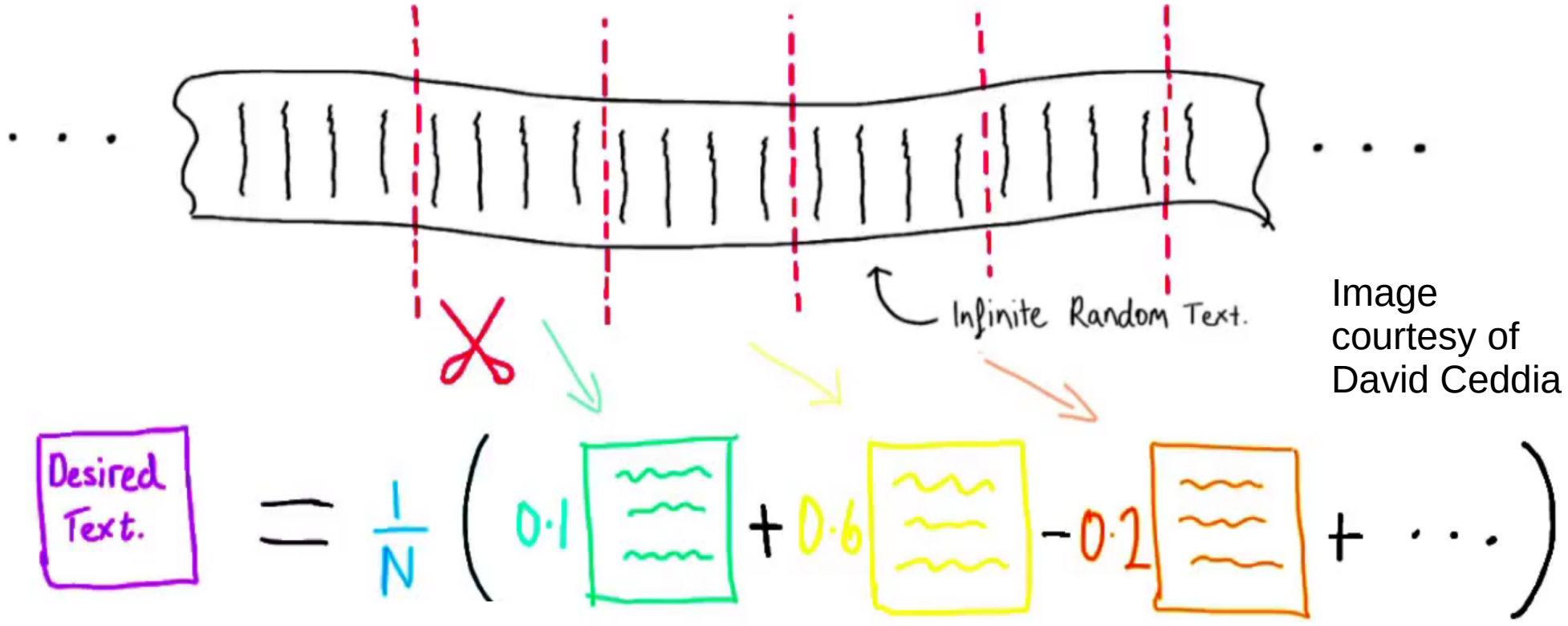
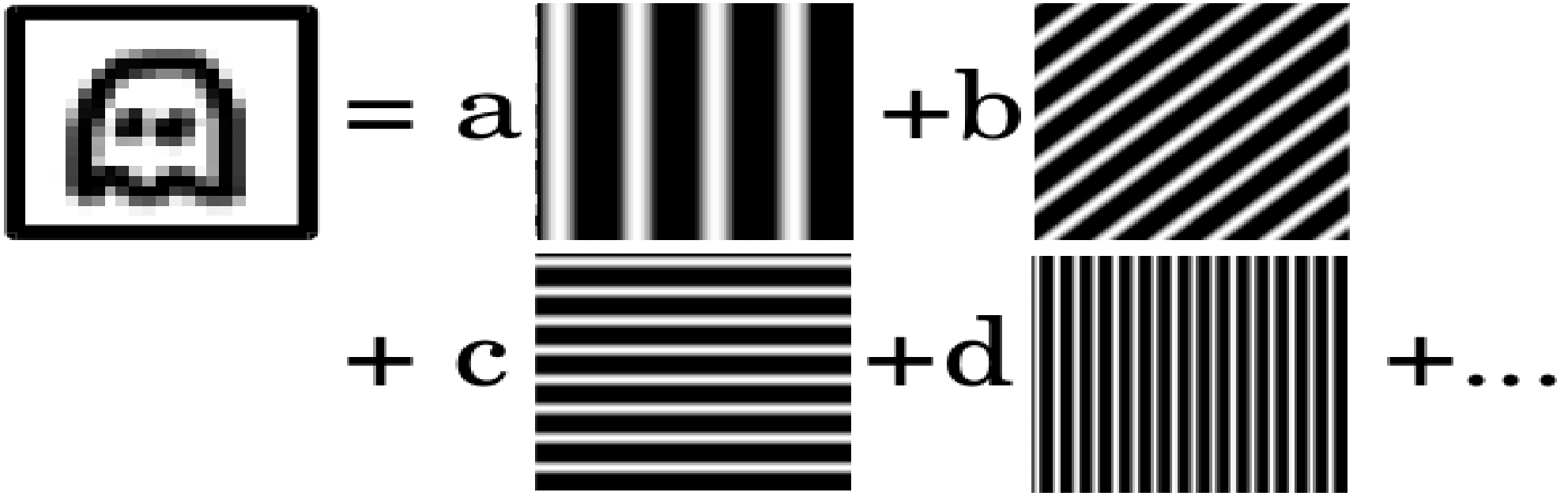
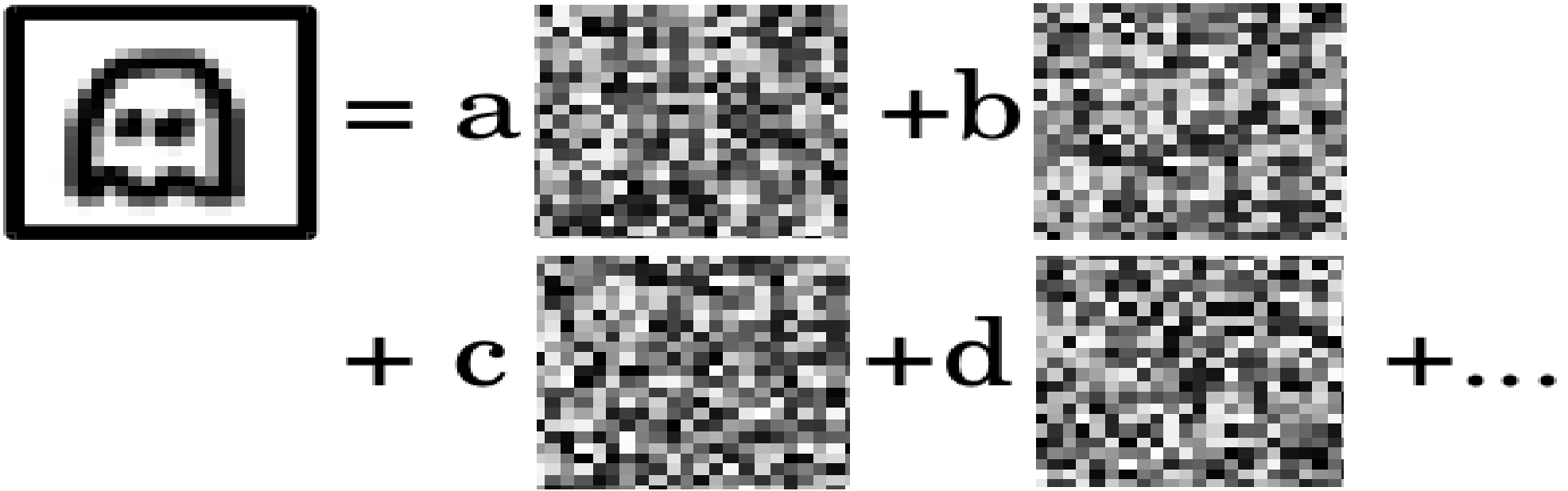


Image courtesy of David Ceddia

Ceddia & Paganin, Phys. Rev. A. **97**, 062119 (2018).
Gureyev, Paganin, Kozlov, Nesterets, Quiney, Phys. Rev. A **97**, 053819 (2018).

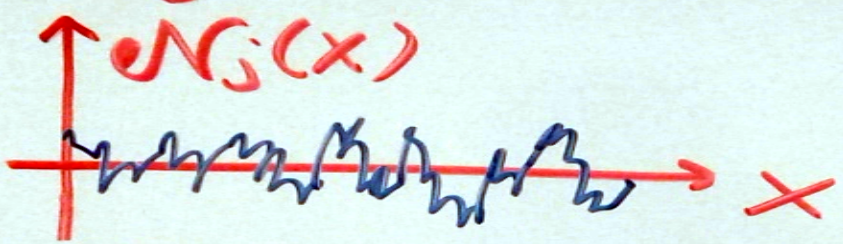

= a
+b
+ c
+d
+...

“Building signals out of noise”



Pelliccia, Olbinado, Rack, Kingston, Myers & Paganin, IUCrJ **5**, 428 (2018)
Ceddia & Paganin, Phys. Rev. A. **97** 062119 (2018)

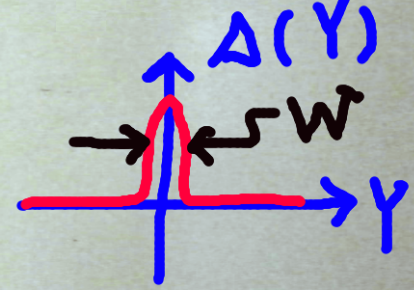
$\{\epsilon N_j(x)\}$ $j = 1, \ldots, m$



$$\epsilon N_j(x) \equiv I_j(x) - \bar{I}$$

$$\frac{1}{m}\sum_{j=1}^{m} \epsilon N_j(x)\,\epsilon N_j(x') = \Delta(x - x')$$

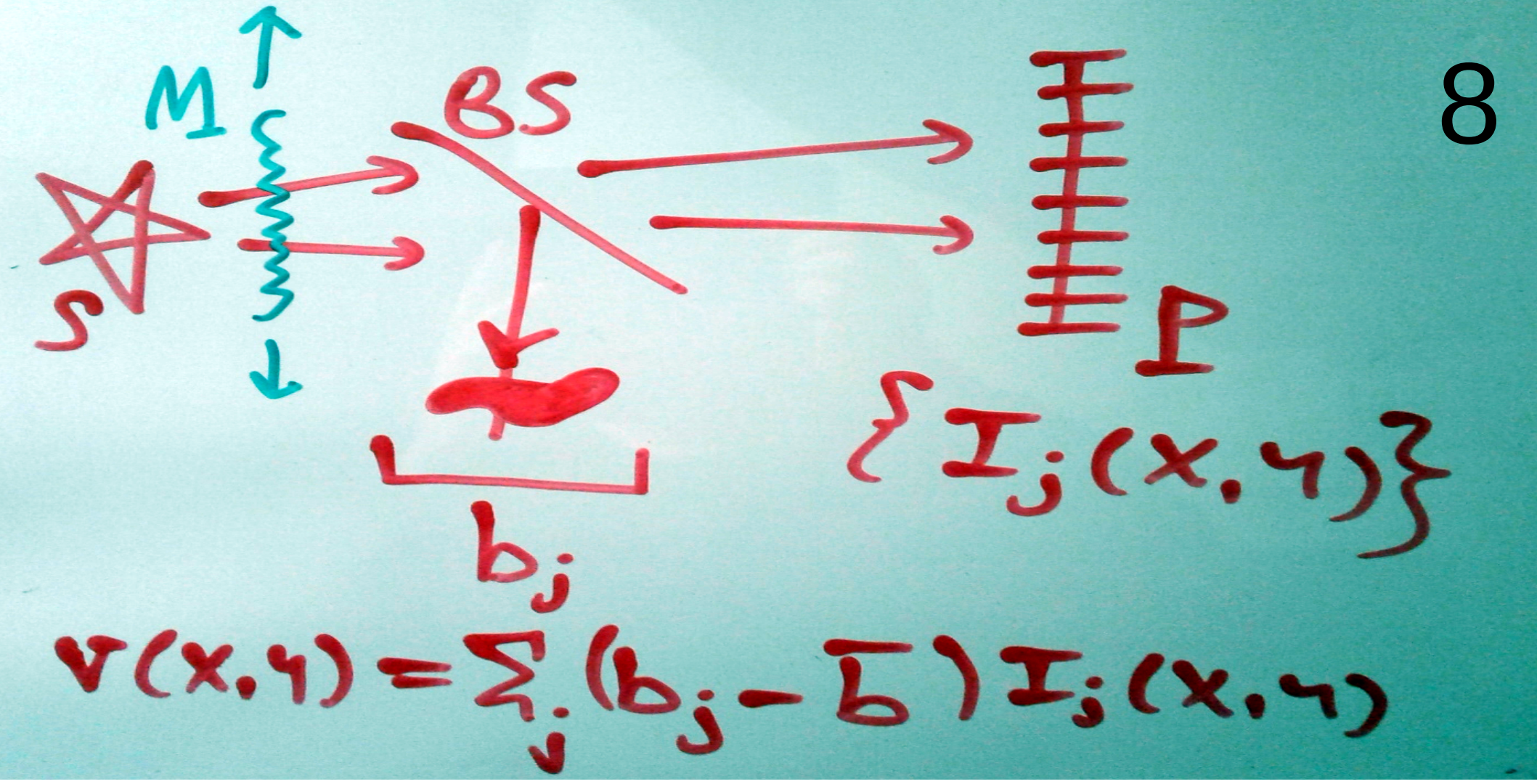
cf. $\delta(x)$



$$\frac{1}{m}\sum_{j=1}^{m} \epsilon N_j(x) \int \epsilon N_j(x')\, V(x')\, dx' = \int \Delta(x - x')\, V(x')\, dx'$$

$$\langle \epsilon N_j(x), V(x) \rangle \equiv V_j$$

$$\frac{1}{m}\sum_{j=1}^{m} \epsilon N_j(x)\, V_j = V(x) \otimes \Delta(x)$$



Bromberg, Katz and Silberberg, Phys. Rev. A, **79**, 053840 (2009).

Fourier-Transform Ghost Imaging with Hard X Rays

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(Received 13 May 2016; published 7 September 2016)

Experimental X-Ray Ghost Imaging

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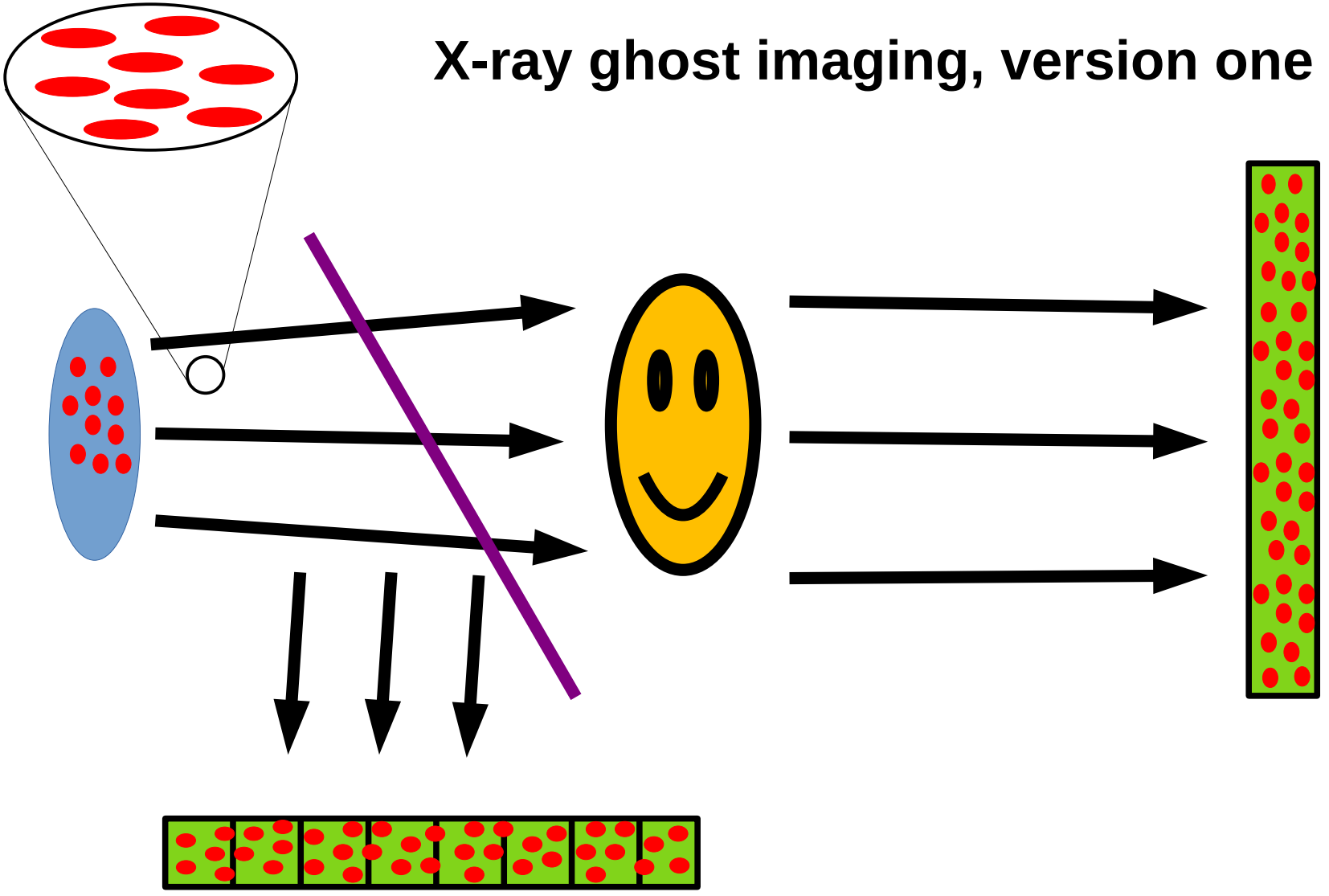
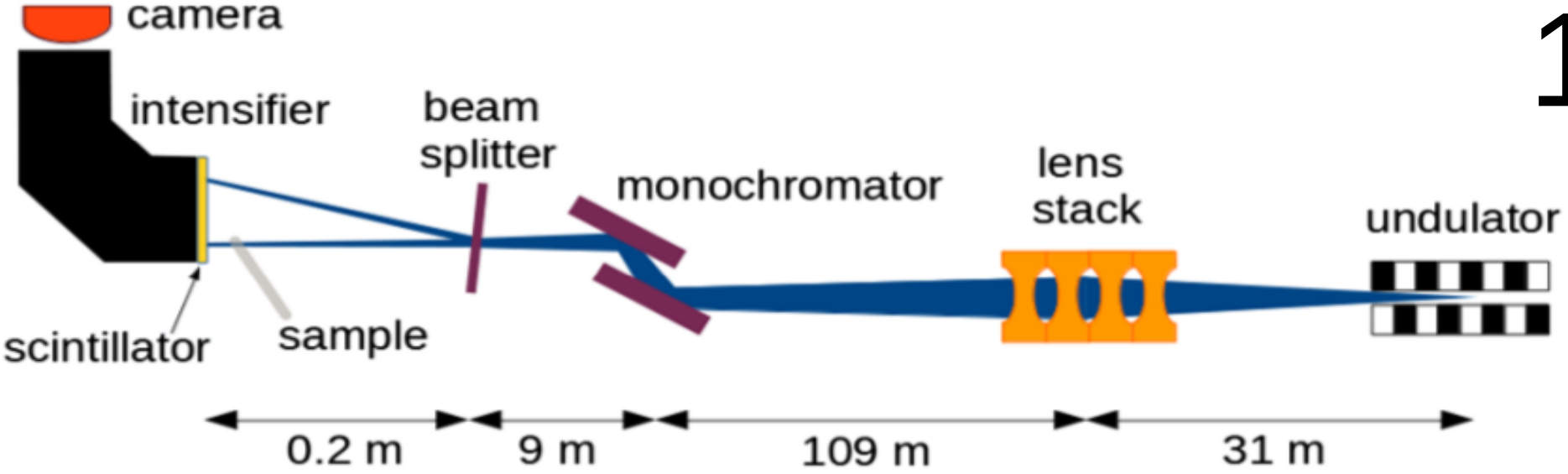
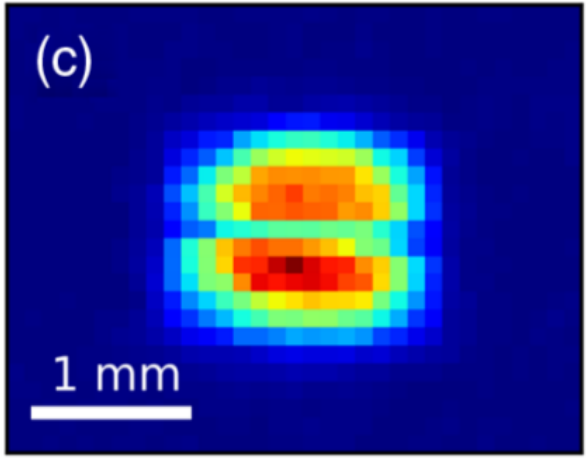
(Received 16 May 2016; published 7 September 2016)

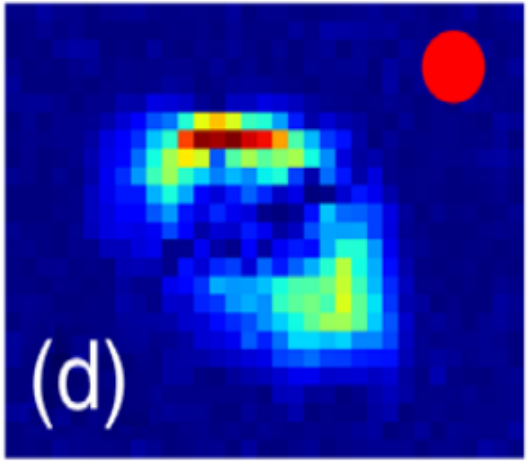
X-ray ghost imaging, version one of two



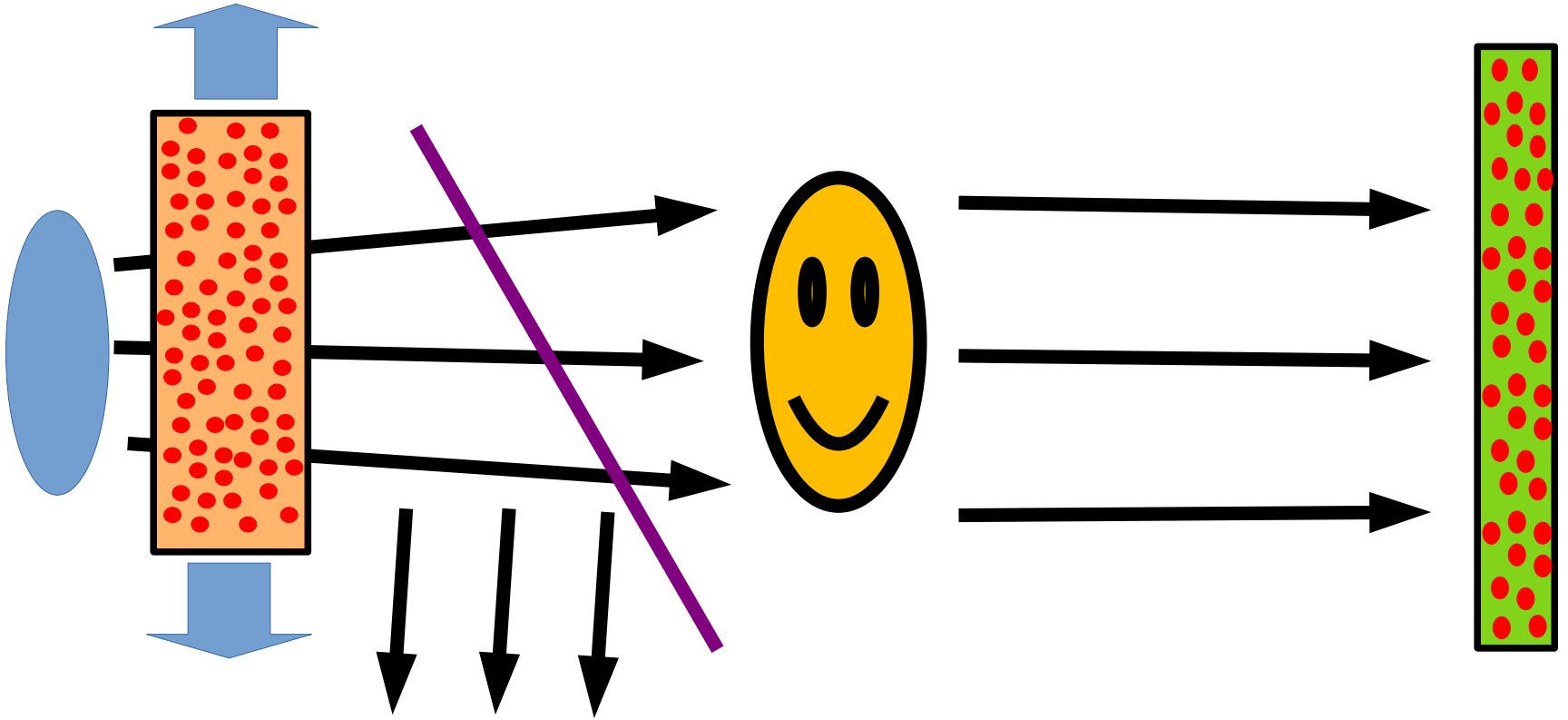


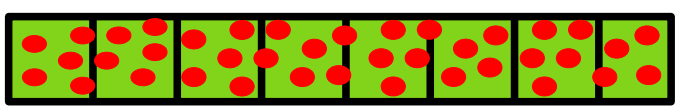


Pelliccia, Rack, Scheel, Cantelli & Paganin, Phys. Rev. Lett. **117**, 113902 (2016).



X-ray ghost imaging, version two of two



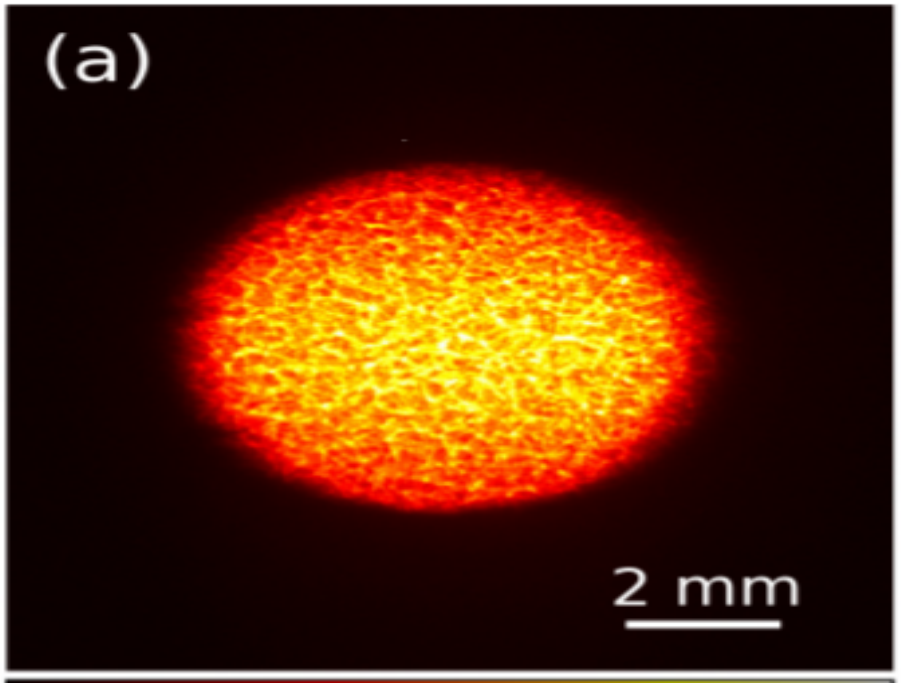


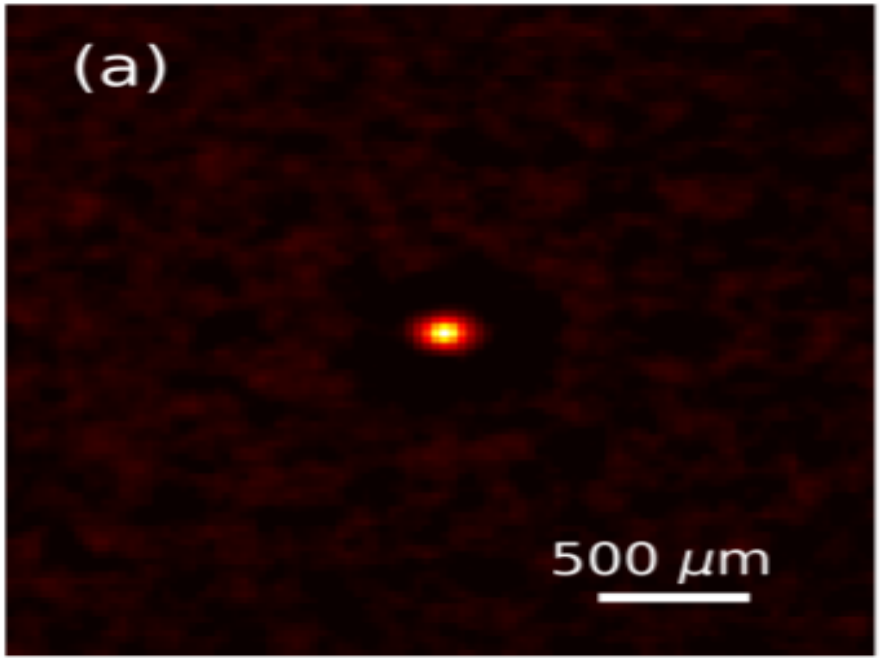
Pelliccia *et al.*, IUCrJ **5**, 428 (2018)
Zhang *et al.*, Optica **5**, 374-377 (2018)

$$\mathrm{PSF}(x-x',y-y') = \frac{1}{m}\sum_{j=1}^{m}[I_j(x',y') - \bar{I}][I_j(x,y) - \bar{I}].$$

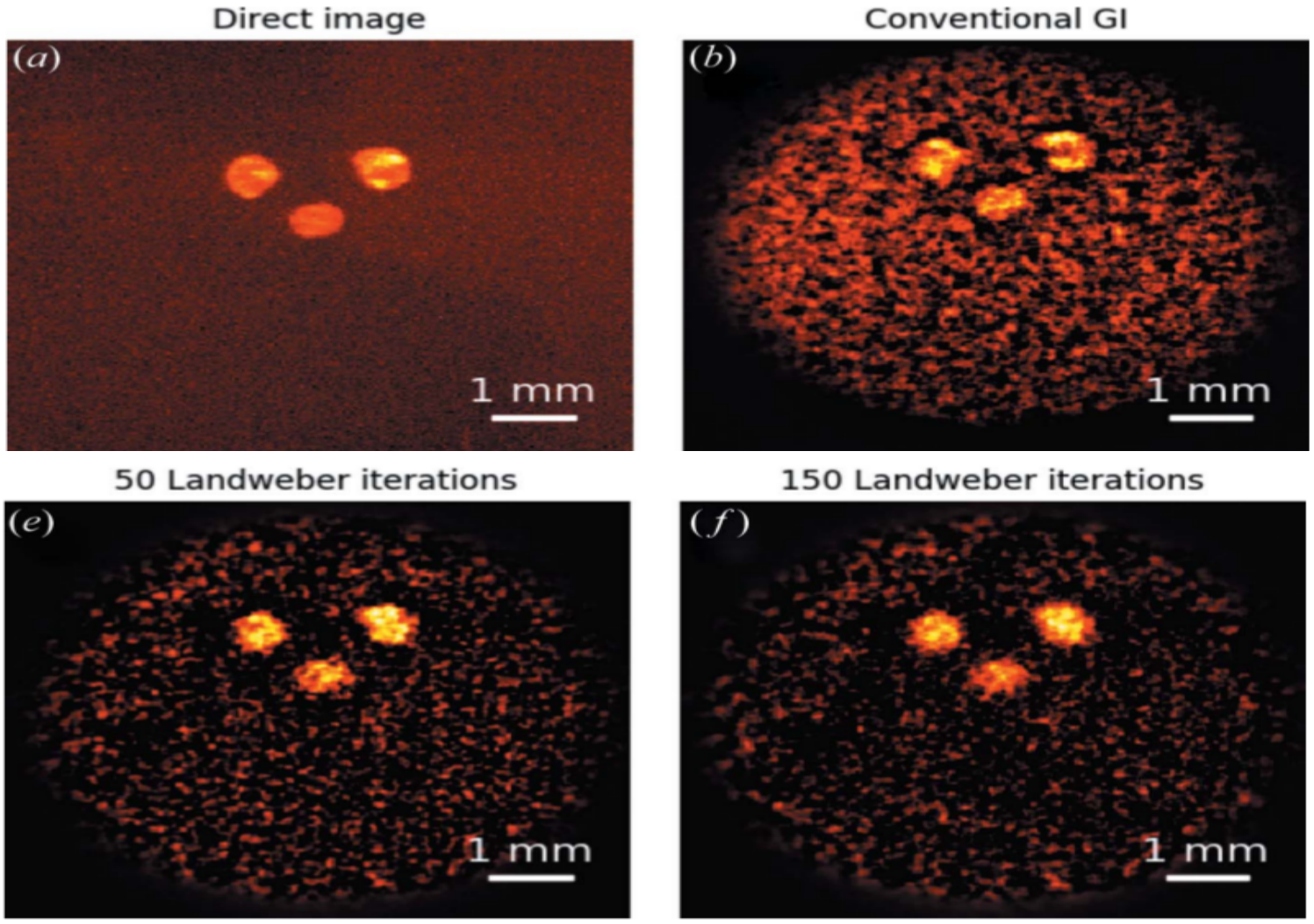
$$v(x,y) * \mathrm{PSF}(x,y) = \frac{1}{m}\sum_{j=1}^{m}(b_j - \bar{b})I_j(x,y)$$

cf. Bromberg *et al.*, Phys. Rev. A, 79, 053840 (2009).

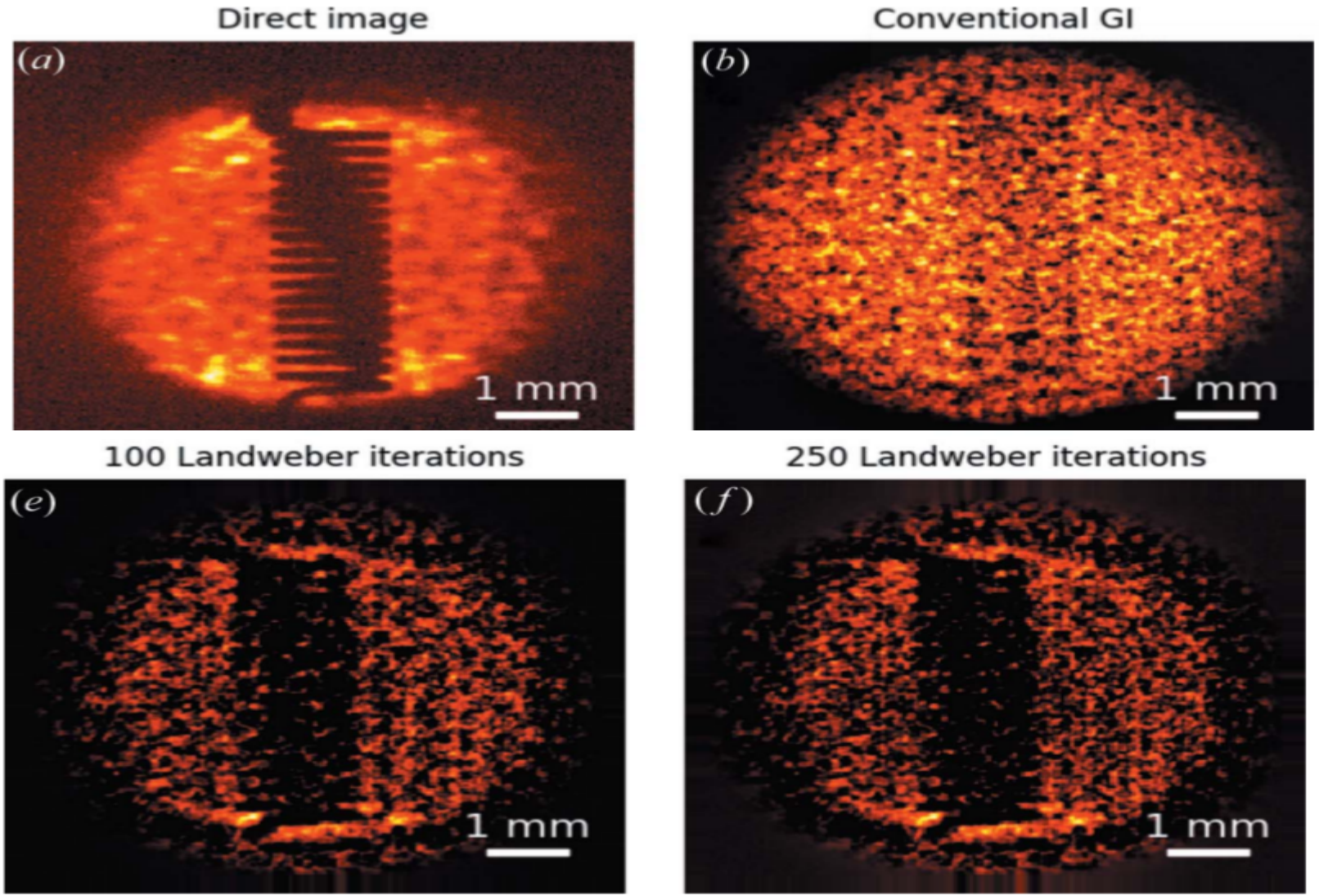




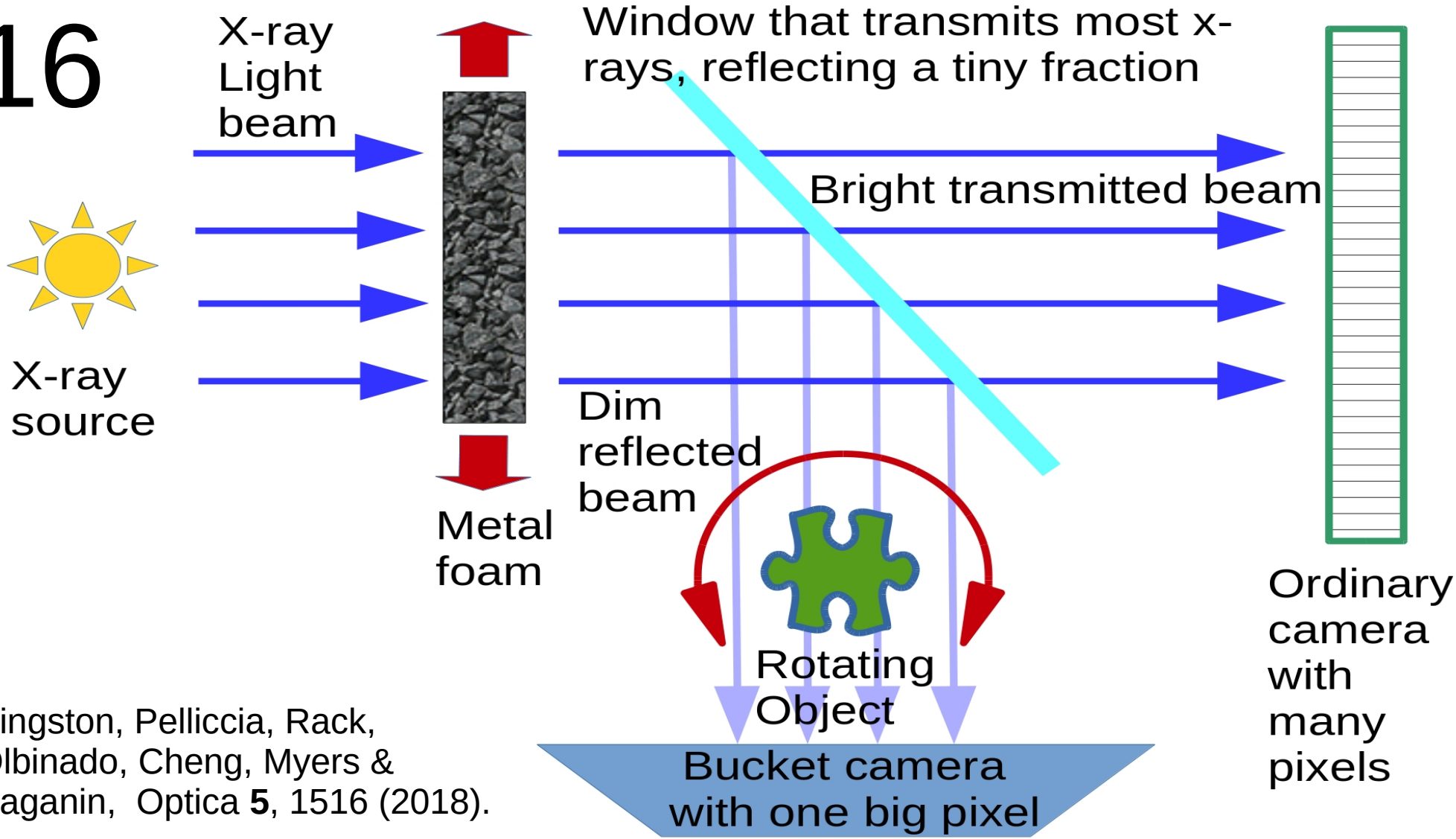
Pelliccia, Olbinado, Rack, Kingston, Myers & Paganin, IUCrJ **5**, 428 (2018).



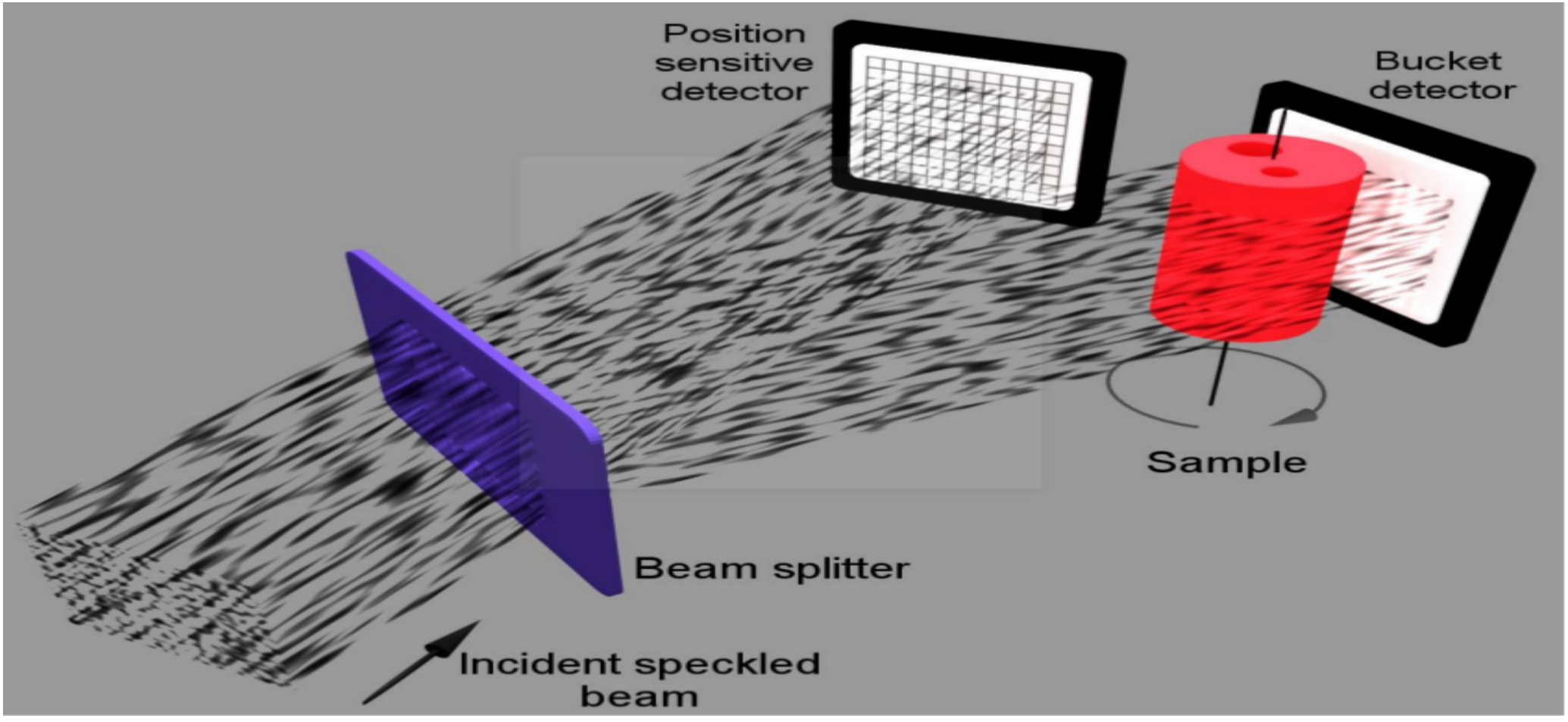
Pelliccia, Olbinado, Rack, Kingston, Myers & Paganin, IUCrJ **5**, 428 (2018).



Pelliccia, Olbinado, Rack, Kingston, Myers & Paganin, IUCrJ **5**, 428 (2018).

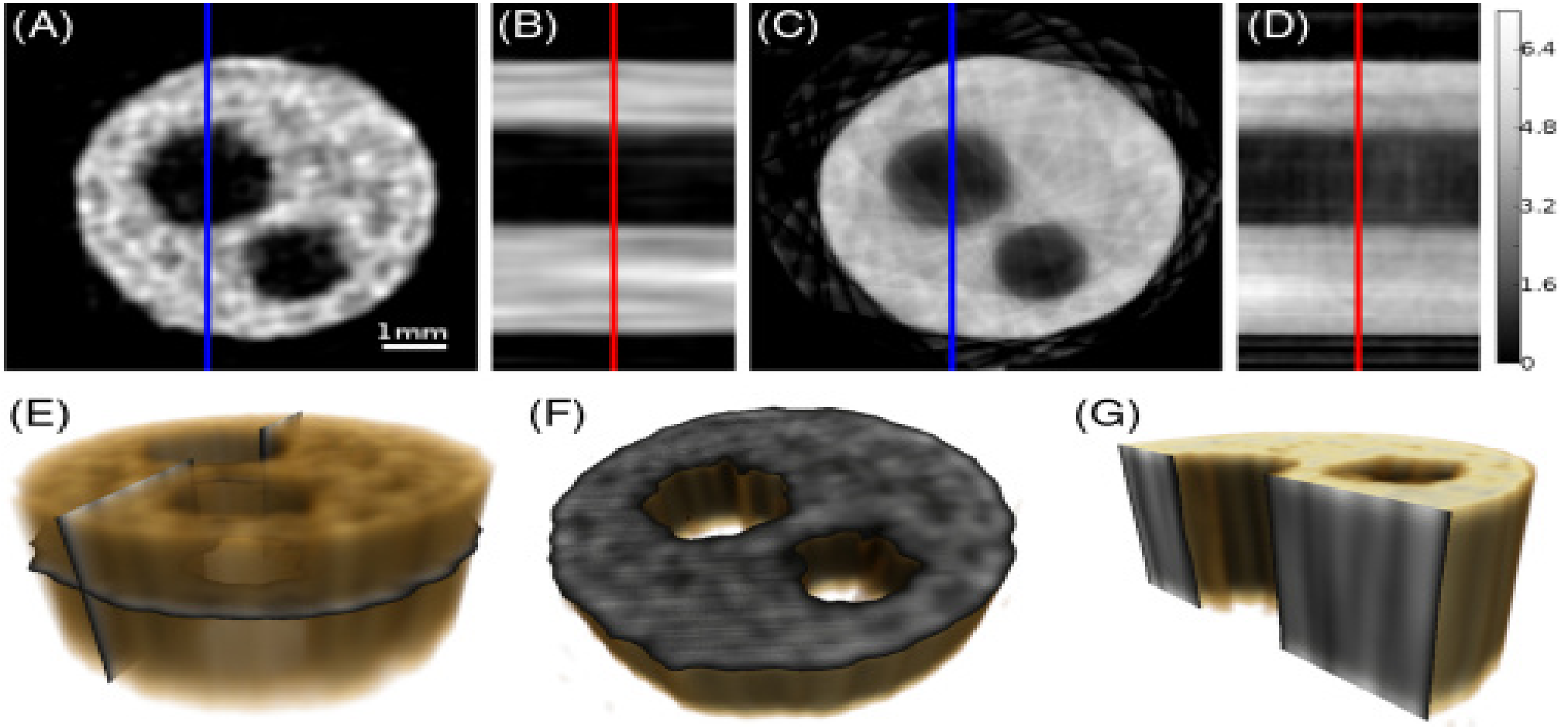


Kingston, Pelliccia, Rack, Olbinado, Cheng, Myers & Paganin, Optica **5**, 1516 (2018).



Kingston, Myers, Pelliccia, Svalbe & Paganin, IEEE Trans. Comp. Imaging **5**, 136 (2019).

Kingston, Pelliccia, Rack, Olbinado, Cheng, Myers, Paganin, Optica **5**, 1516 (2018).



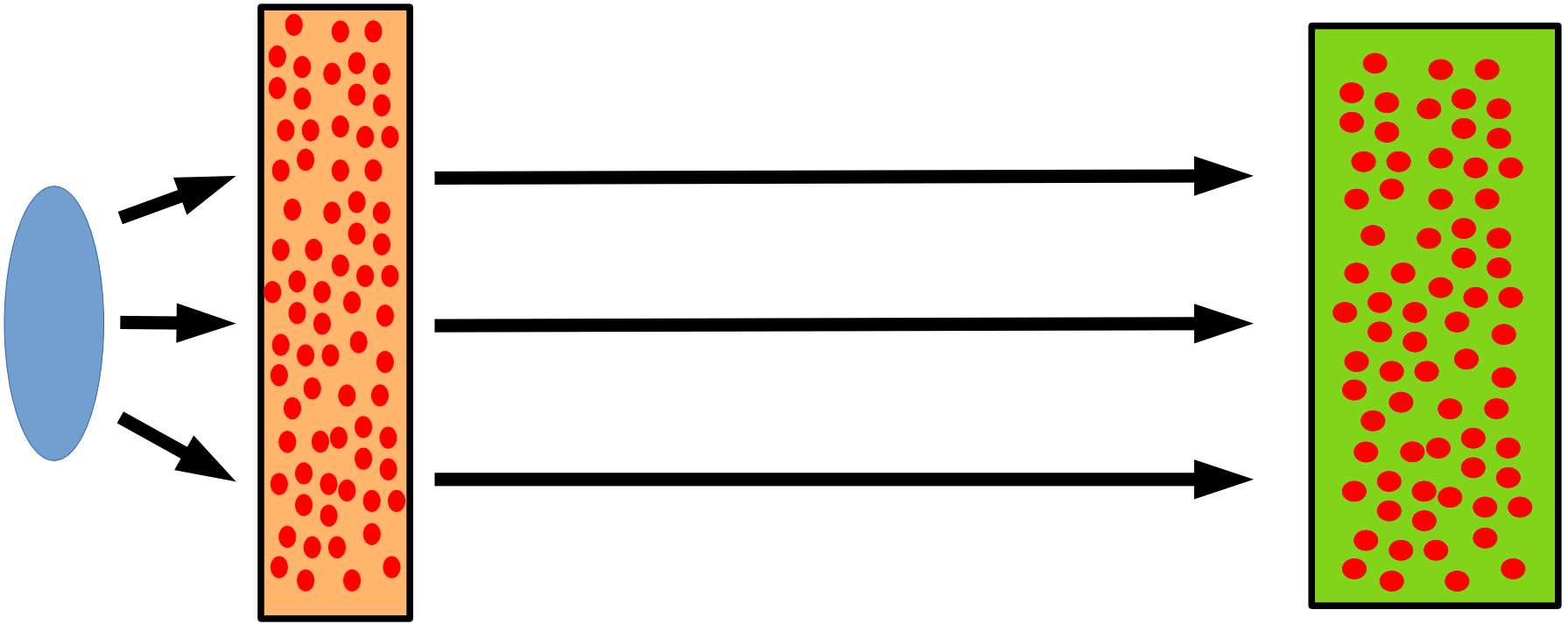
Kingston, Pelliccia, Rack, Olbinado, Cheng, Myers & Paganin, Optica **5**, 1516 (2018).

“Bucket detectors are bad because...”

“Bucket detectors are good because...”

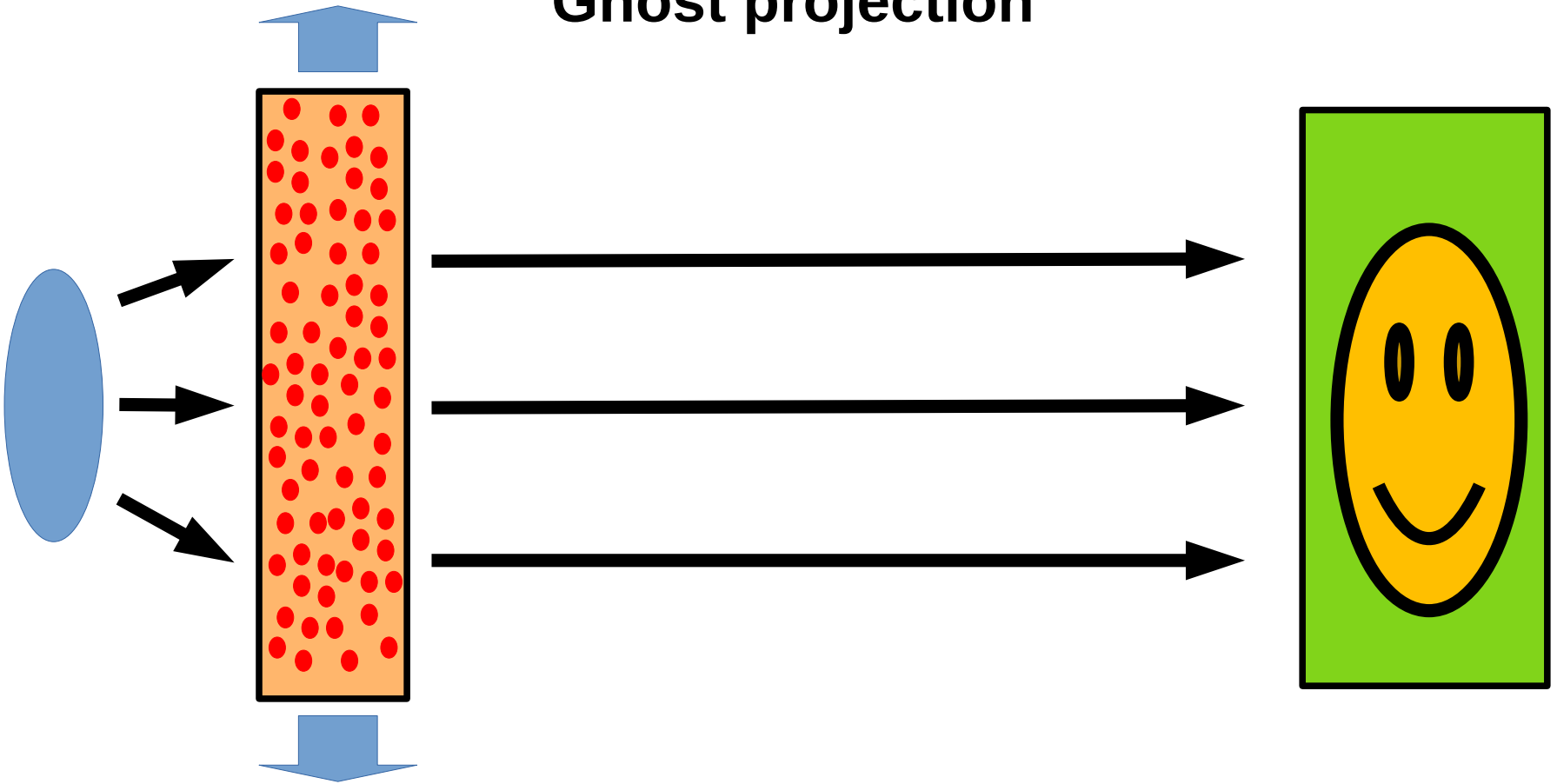
Hybrid virtual-actual optics … computer as an intrinsic part of imaging system … tomographers doing this for long time ... replace hardware with software … computing power cheap, throw away more and more hardware … including the position-sensitive detector .. spectroscopy … fluorescence.

Ghost projection

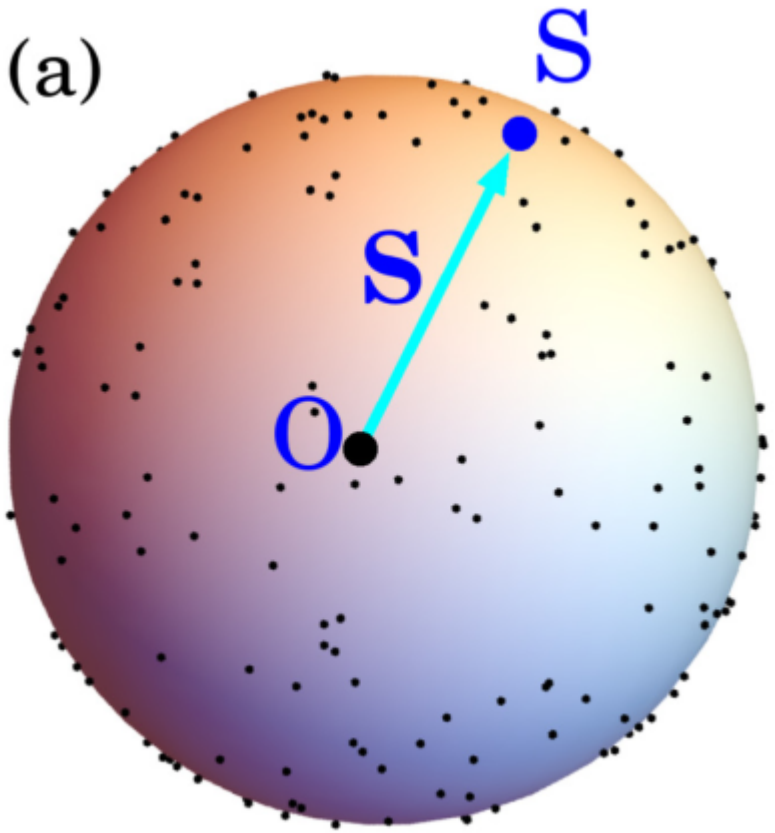


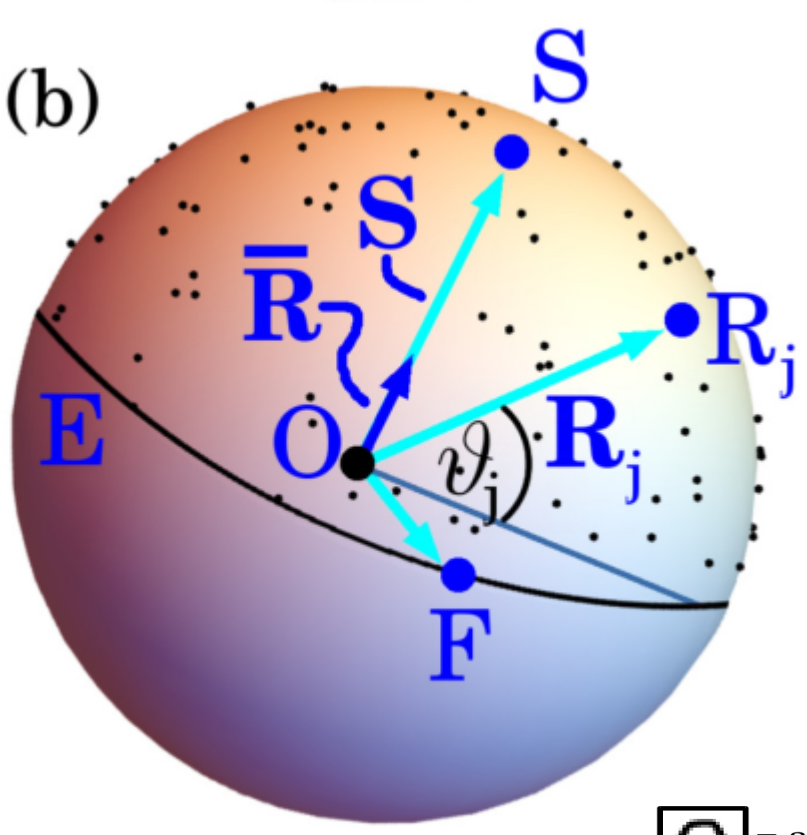
Paganin, Physical Review A **100**, 063823 (2019)
Ceddia & Paganin, Physical Review A **105**, 013512 (2022)
Ceddia, Kingston, Pelliccia, Rack & Paganin, arXiv:2202.10572 (2022)

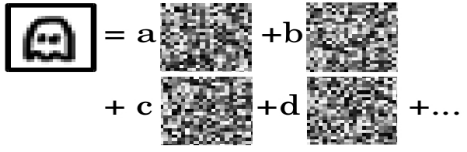
Ghost projection



Paganin, Physical Review A **100**, 063823 (2019)
Ceddia & Paganin, Physical Review A **105**, 013512 (2022)
Ceddia, Kingston, Pelliccia, Rack & Paganin, arXiv:2202.10572 (2022)

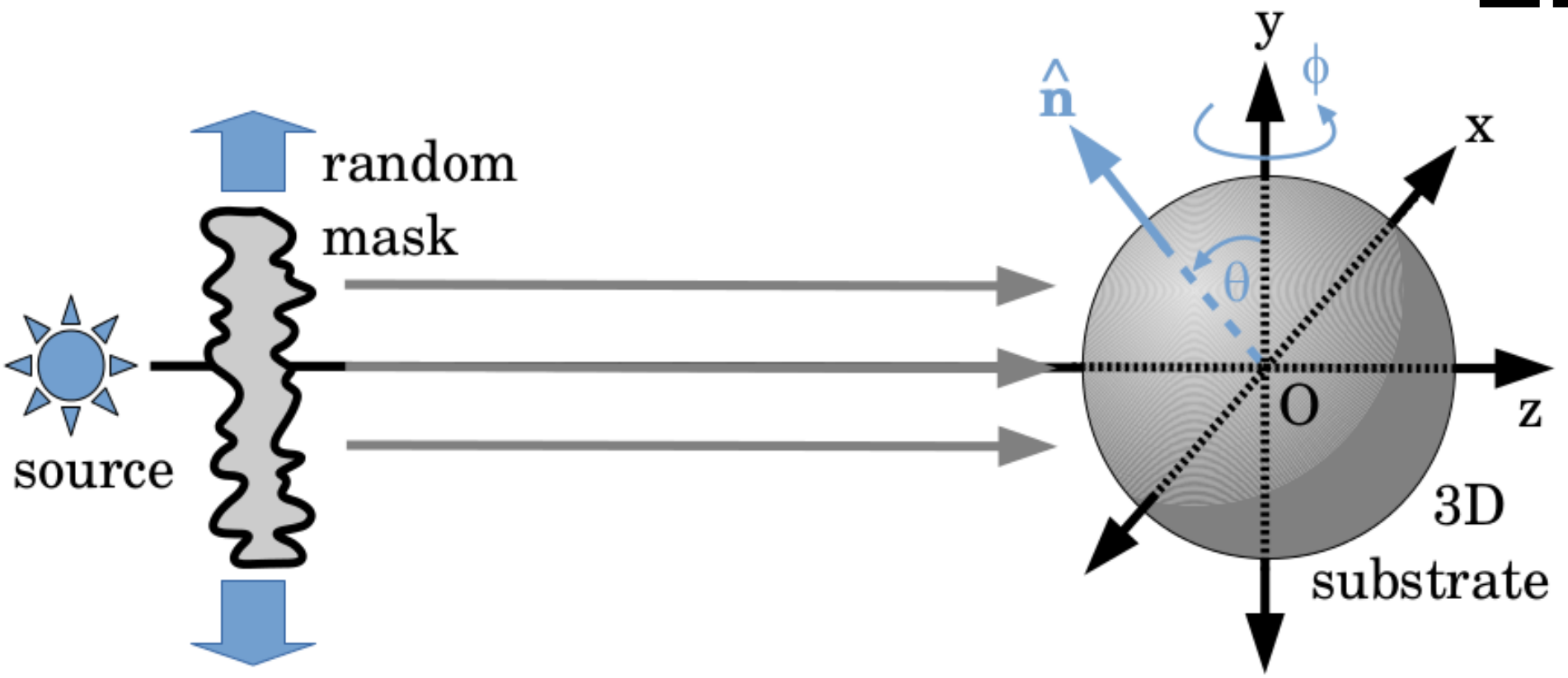




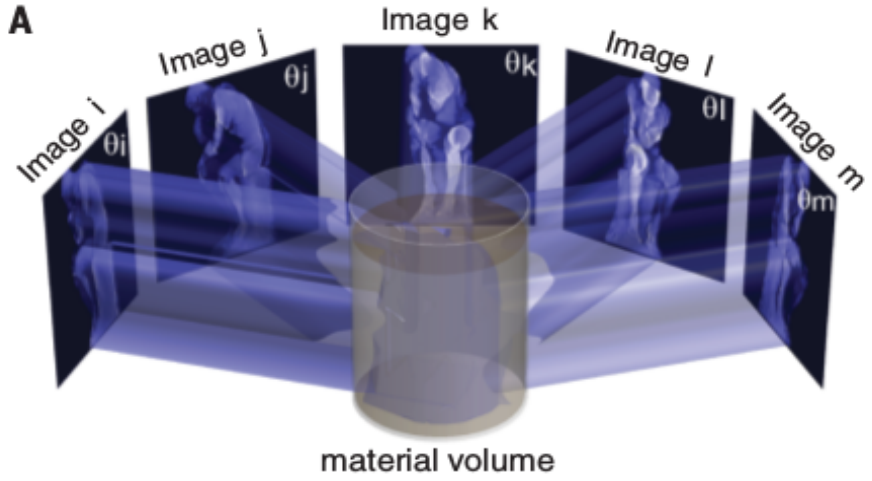


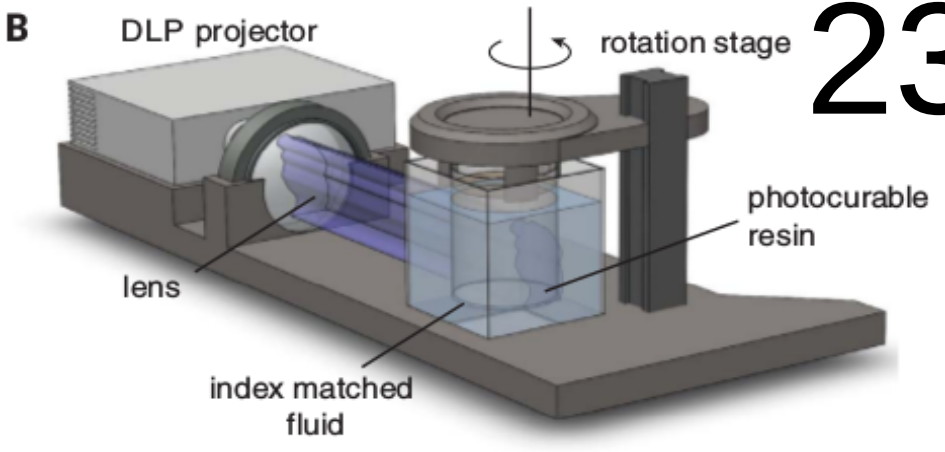
D. M. Paganin, "Writing arbitrary distributions of radiant exposure by scanning a single illuminated spatially-random screen", Phys. Rev. A 100, 063823 (2019).

GHOST TOMOGRAPHY IN REVERSE



D. M. Paganin, “Writing arbitrary distributions of radiant exposure by scanning a single illuminated spatially-random screen”, Phys. Rev. A 100, 063823 (2019).





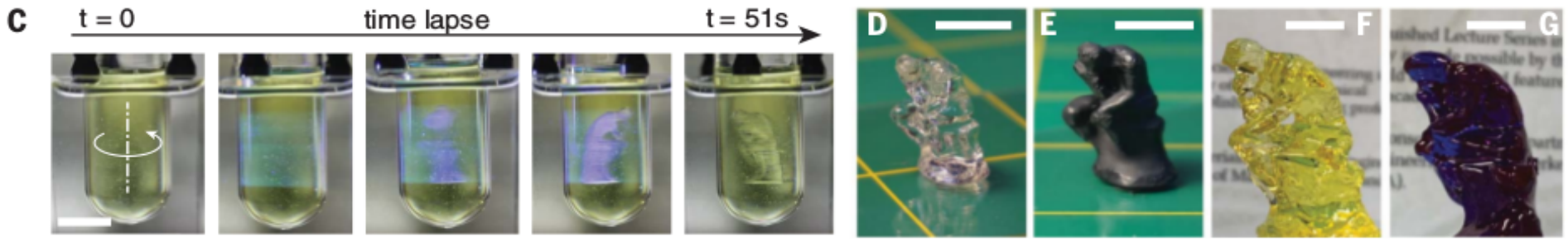
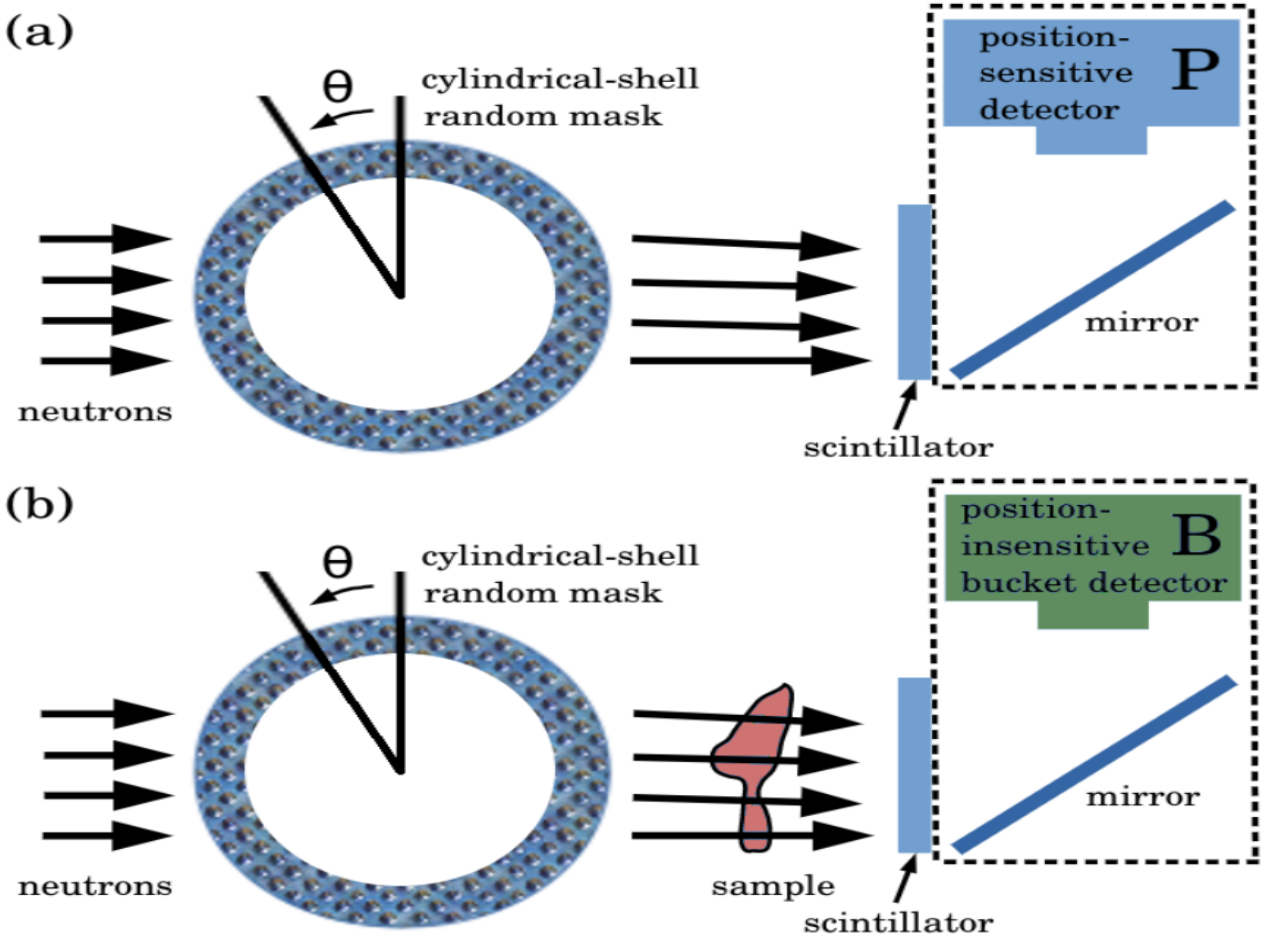
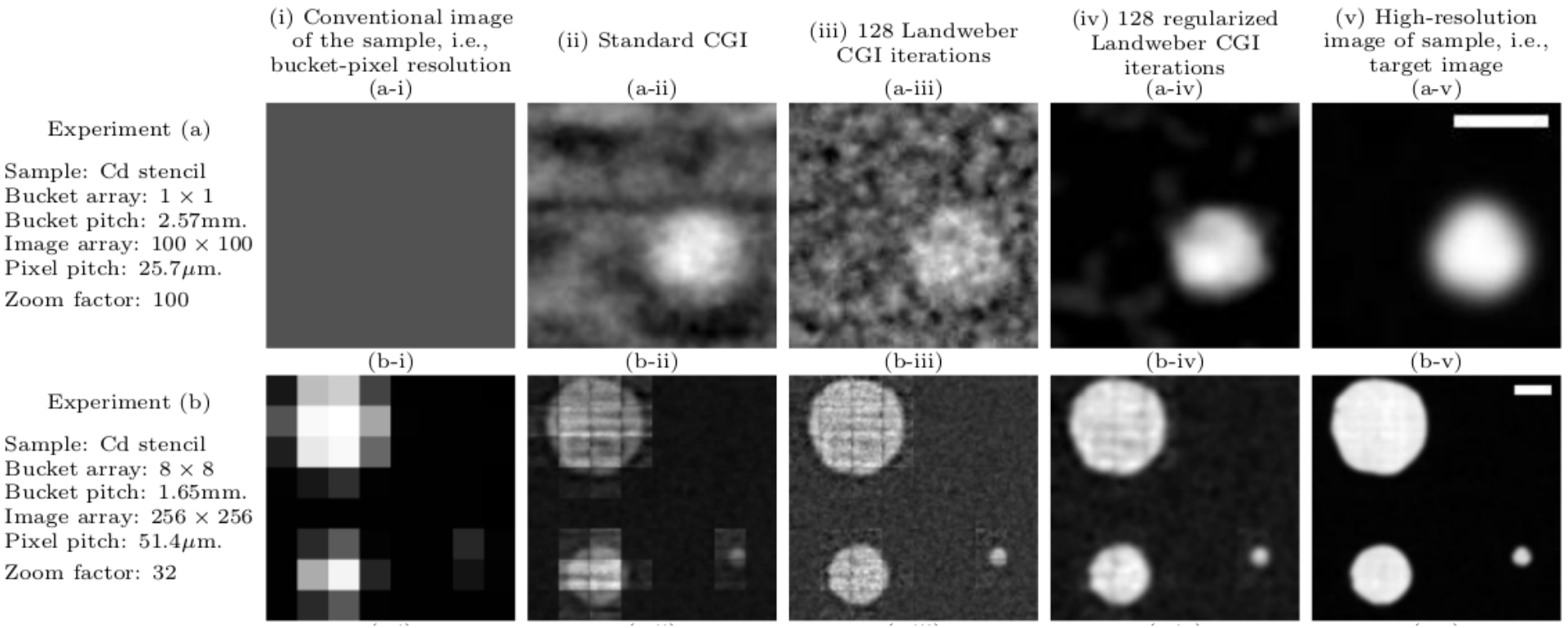


Fig. 1. CAL volumetric fabrication. (**A**) Underlying concept: Patterned illumination from many directions delivers a computed 3D exposure dose to a photoresponsive material. (**B**) Schematic of the CAL system used in this work. DLP projector, digital light processor–based projector. (**C**) Sequential view of the build volume during a CAL print. A 3D geometry is formed in the material in less than 1 min. (**D**) The 3D part shown in (C) after rinsing away uncured material. (**E**) The part from (D), painted for clarity. (**F**) A larger (40-mm-tall) version of the same geometry. (**G**) Opaque version of the geometry in (F), using crystal violet dye in the resin. Scale bars: 10 mm.

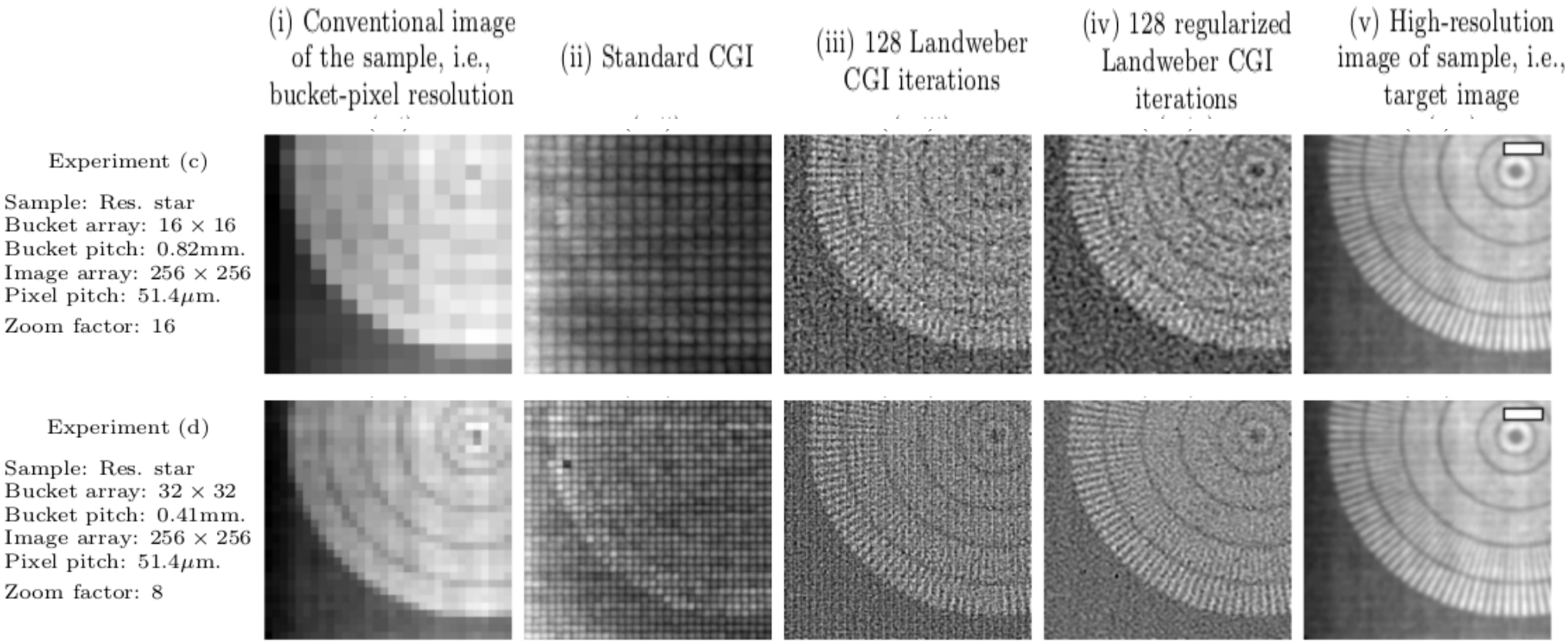
Kelly, Bhattacharya, Heidari, Shusteff, Spadaccini & Taylor, Science **363**, 375 (2019).



Kingston, Myers, Pelliccia, Salvemini, Bevitt, Garbe & Paganin, Physical Review A **101**, 053844 (2020)



Kingston, Myers, Pelliccia, Salvemini, Bevitt, Garbe & Paganin, Physical Review A **101**, 053844 (2020)



Kingston, Myers, Pelliccia, Salvemini, Bevitt, Garbe & Paganin, Physical Review A **101**, 053844 (2020)