Radio-Astronomical Imaging with WSClean and Image-Domain Gridding

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Outline

- Radio-astronomical imaging
- Image-Domain Gridding:
  - IDG algorithm+performance
  - IDG in WSClean
  - IDG for EoR
  - IDG for direction-dependent calibration
- Summary

Radio astronomy

Radio telescope (e.g. LOFAR)

Sky image

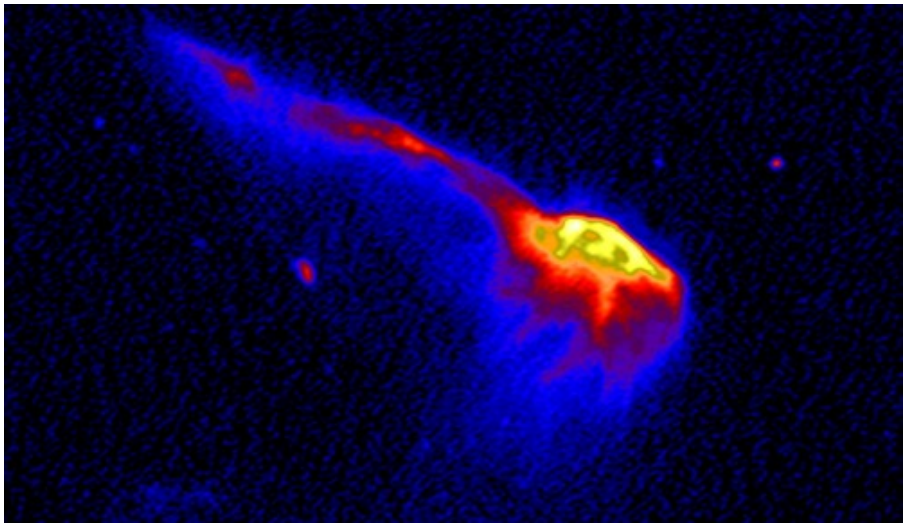

Image credits: van Weeren, R. J. et al.

- visibilities $\overset{gridding}{\rightarrow}$ grid $\overset{FFT}{\rightarrow}$ image

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Radio-astronomical imaging

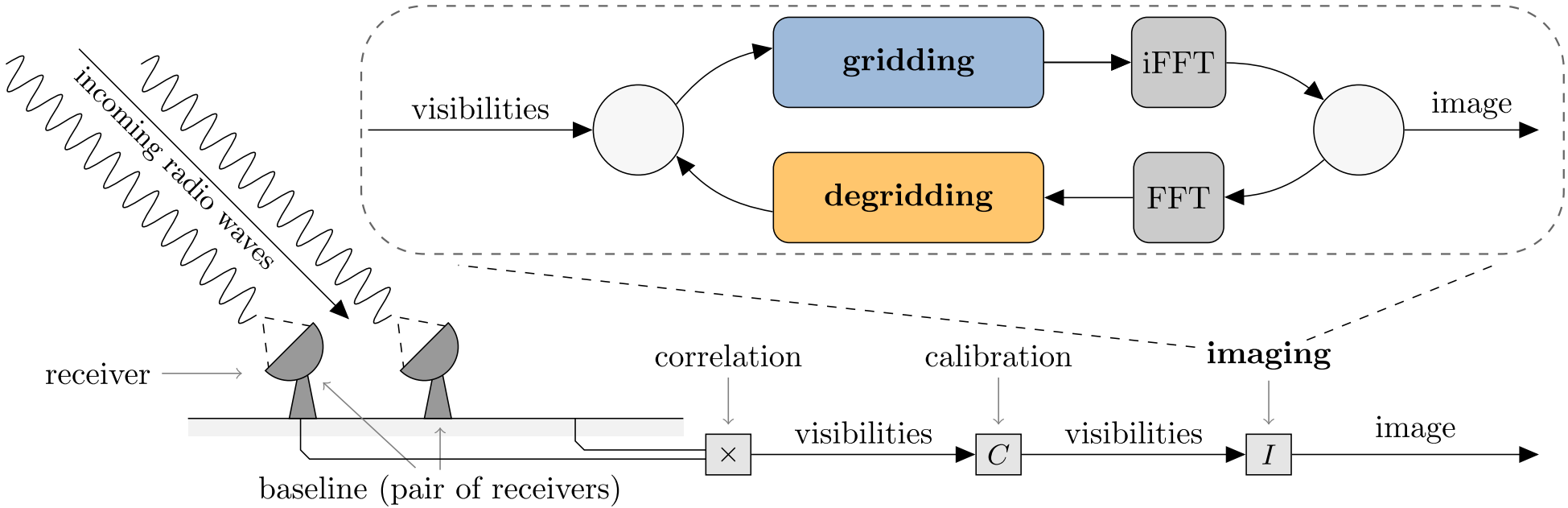

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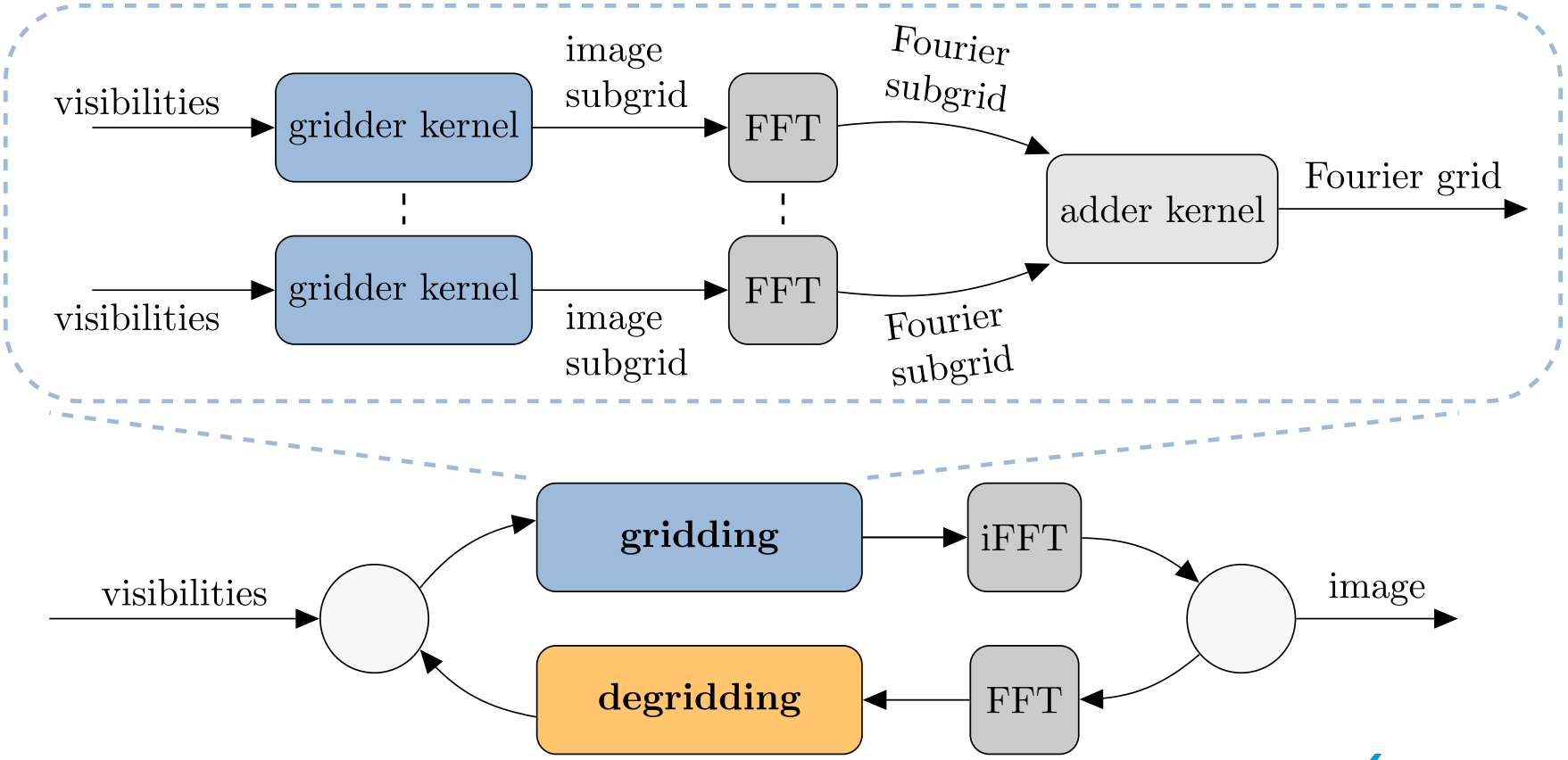
Image-Domain Gridding (IDG)



Reference: “Radio-Astronomical Imaging: FPGAs vs GPUs, B. Veenboer et al., Euro-Par 2019”

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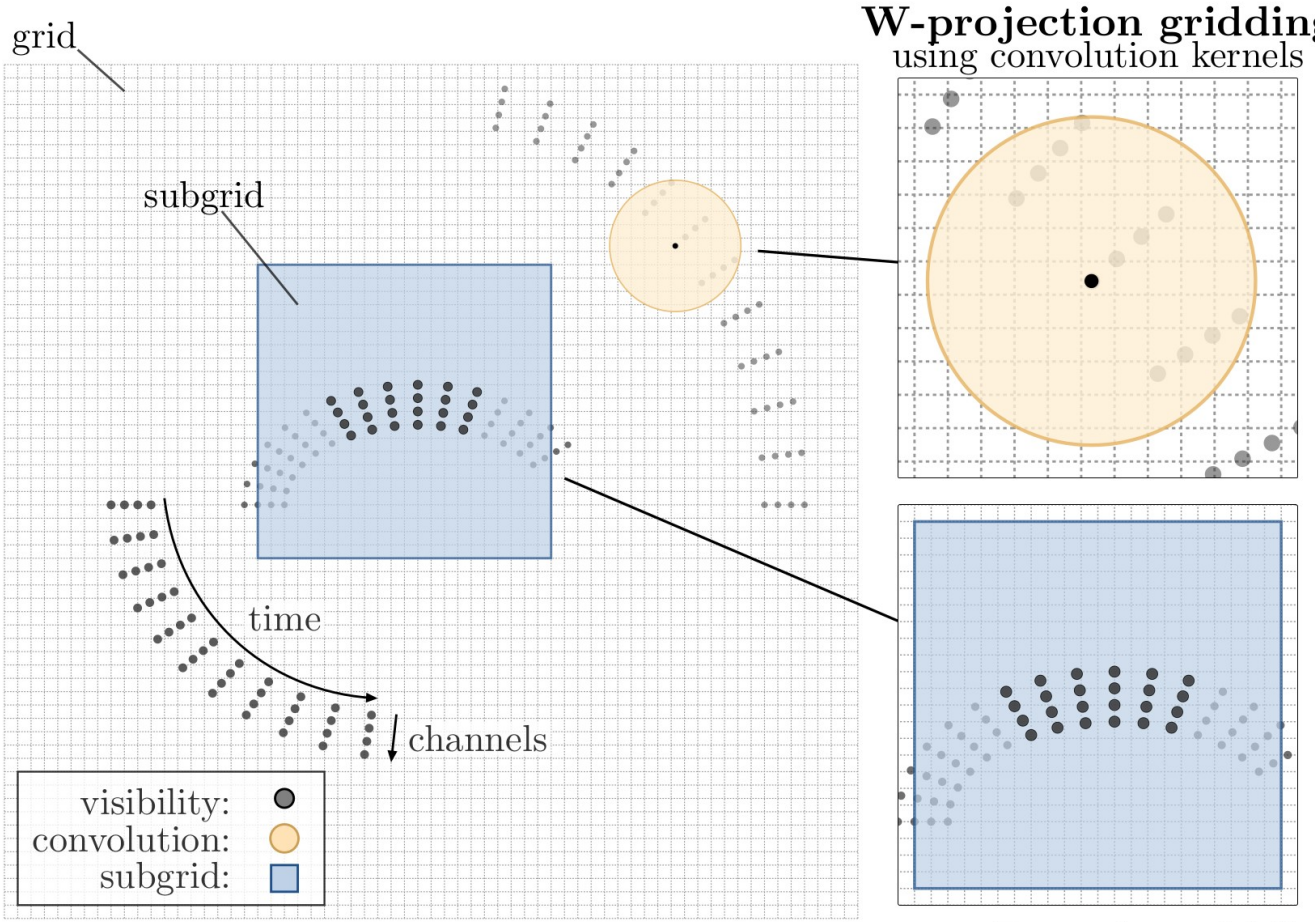
Image-Domain Gridding (IDG)



W-projection gridding
using convolution kernels

Image-Domain gridding
using subgrids

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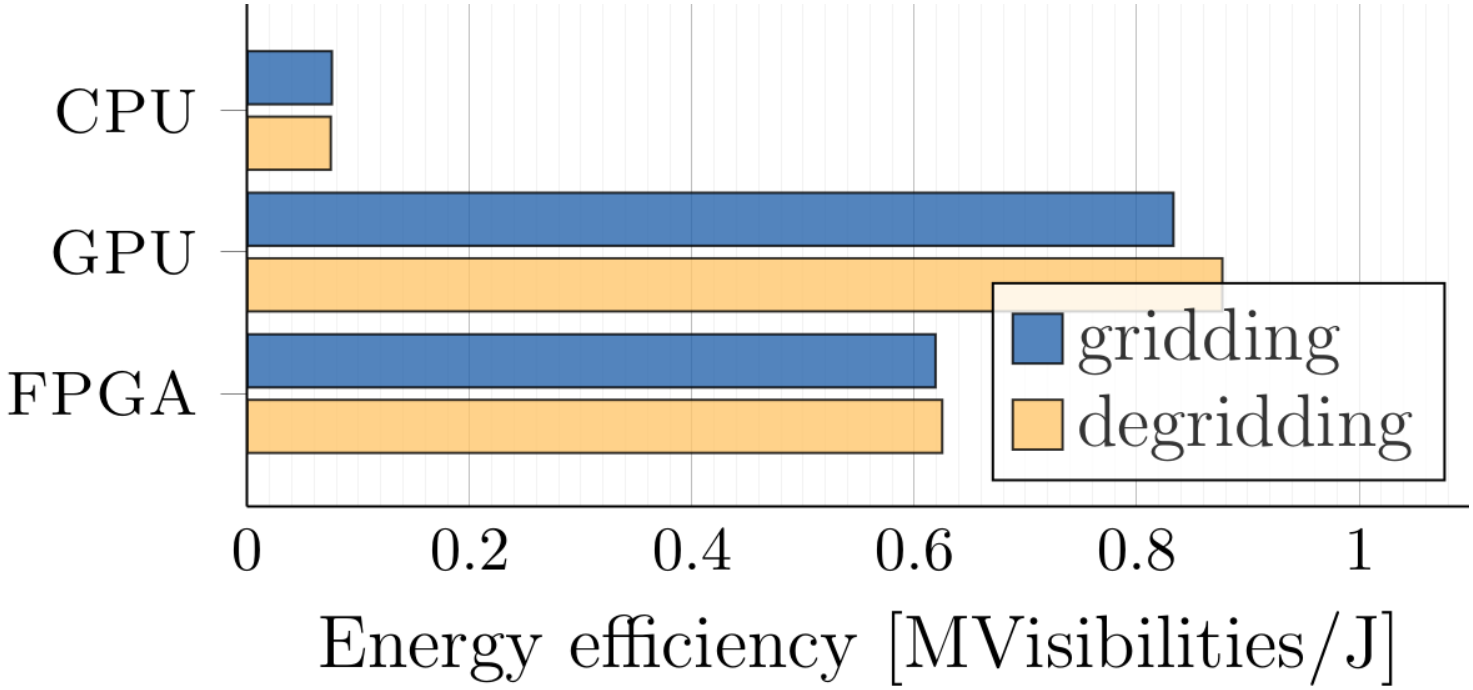
Energy-efficiency comparison

- Compare an Intel Haswell **CPU**, NVIDIA Maxwell **GPU**, and Intel Arria **FPGA**



- **energy-efficiency**: number of visibilities processed per Joule (Mvisibilities/J)

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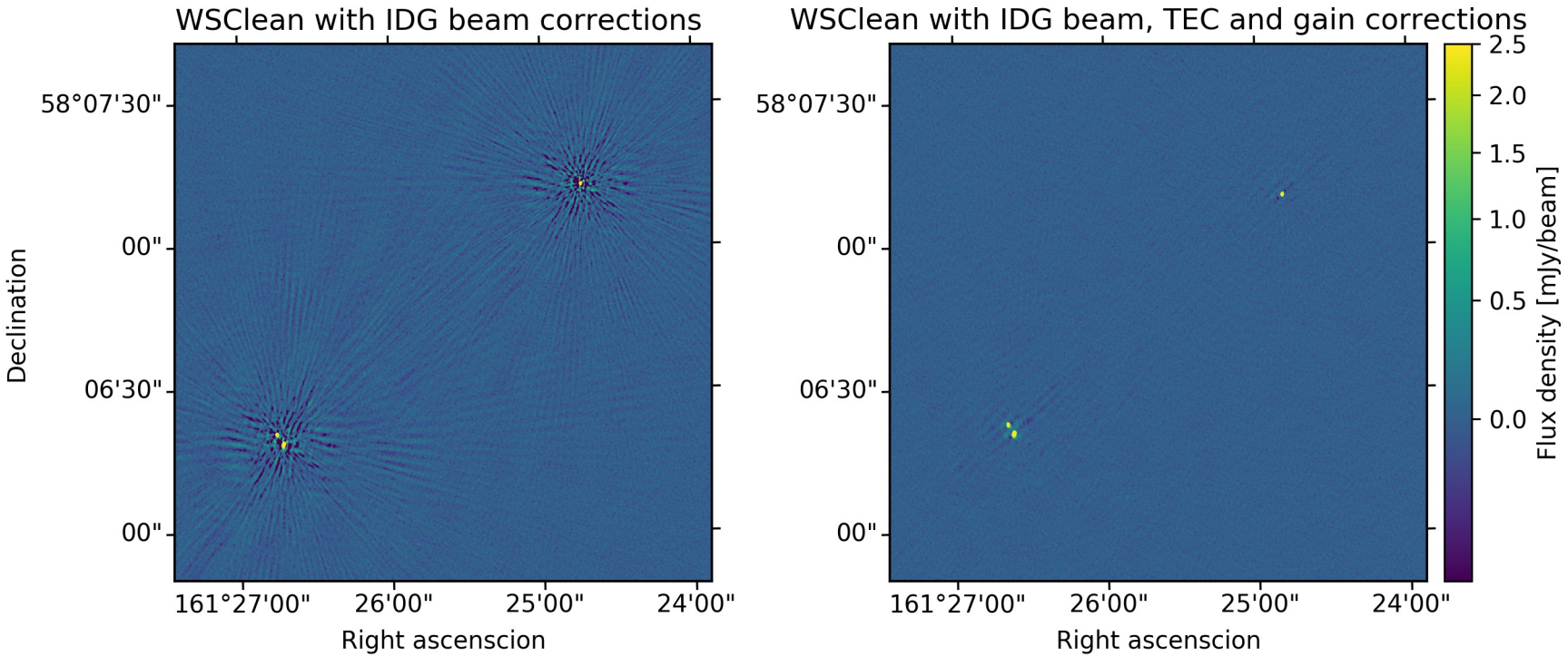
WSClean integration



- Enable IDG with these flags:

```
-use-idg
-idg-mode [cpu/gpu/hybrid]
-grid-with-beam
```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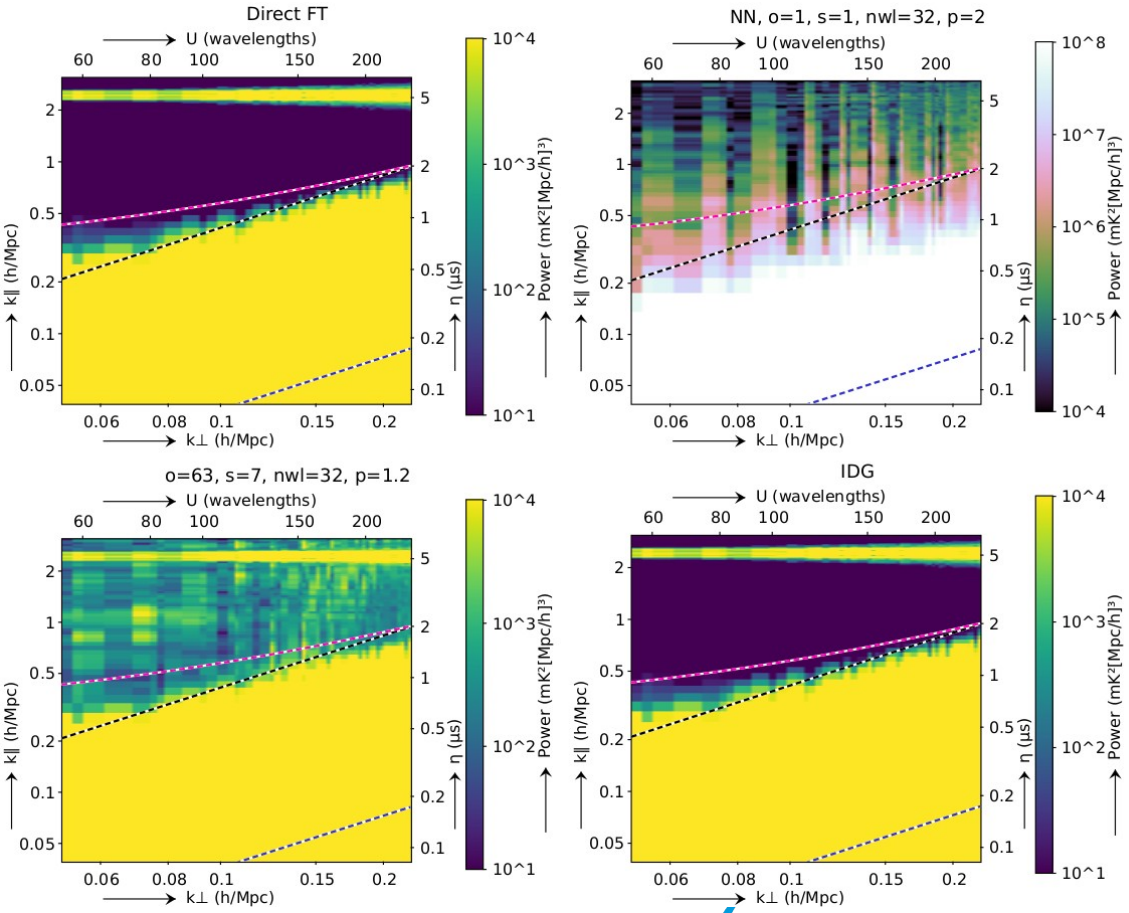
IDG for epoch of reionisation (EoR) research

- **High accuracy needed**
- W-projection:
  - requires kernel oversampling
- Facetting:
  - spatial discontinuities
- W-stacking + parameter tuning:
  - sufficiently accurate
  - expensive
- IDG is overall the most suitable:
  - highly accurate, fast



Reference: “Precision requirements for interferometric gridding in the analysis of a 21 cm power spectrum, A. R. Offringa et al., A&A 2019”

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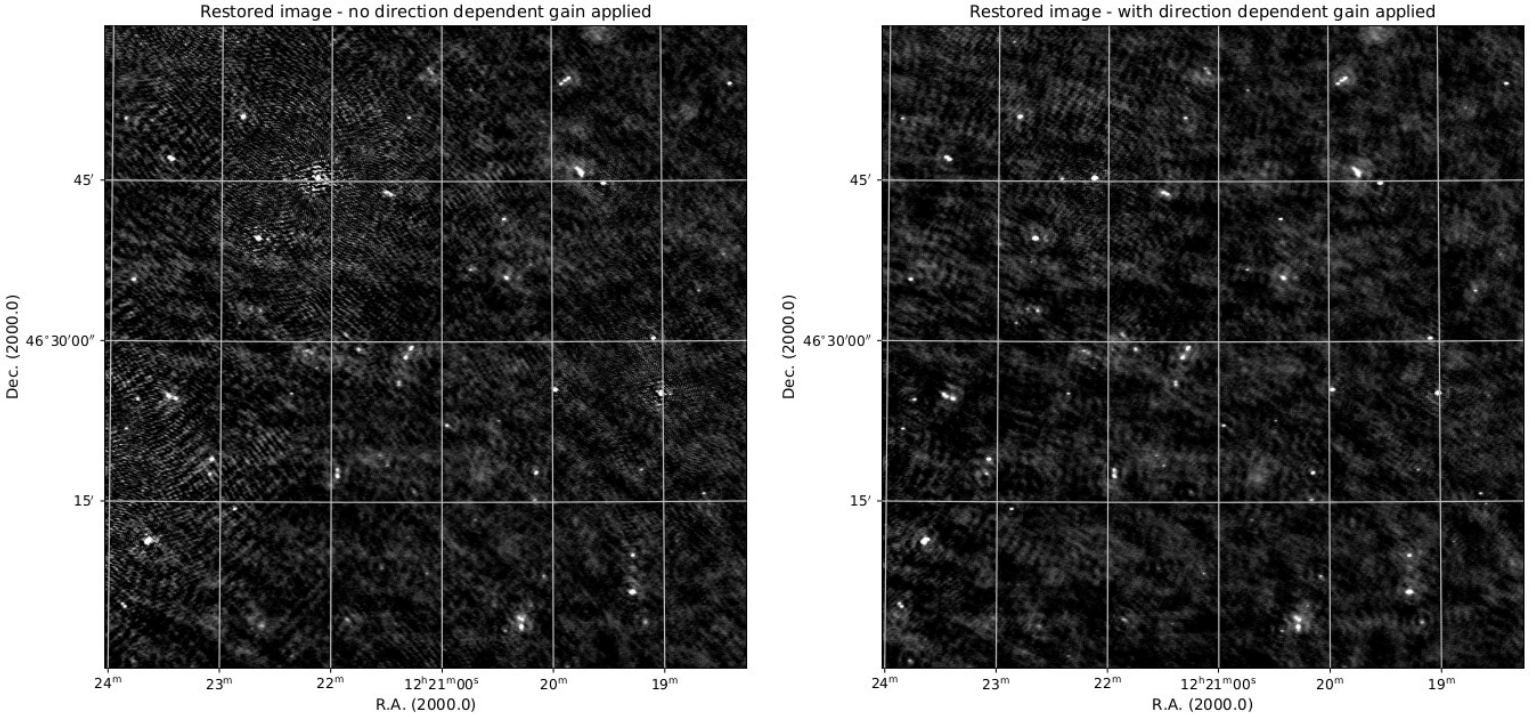
IDG for direction-dependent calibration

- ‘idg-cal’ reduces error artifacts (patterns around sources)



Reference: “Estimating continuous direction-dependent gain screens from radio interferometric visibilities and a large skymodel, S van der Tol et al. ADASS 2019”

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Summary

- WSClean + IDG
  - Combination of state of the art in deconvolution and imaging
  - GPU accelerated imager
  - Correction for polarized direction-dependent effects
  - Unprecedented imaging capabilities for current and future radio telescopes

- Available at:
  - https://sourceforge.net/projects/wsclean
  - https://git.astron.nl/RD/idg

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