Optics measurements in storage rings: simultaneous 3-dimensional beam excitation and novel harmonic analysis

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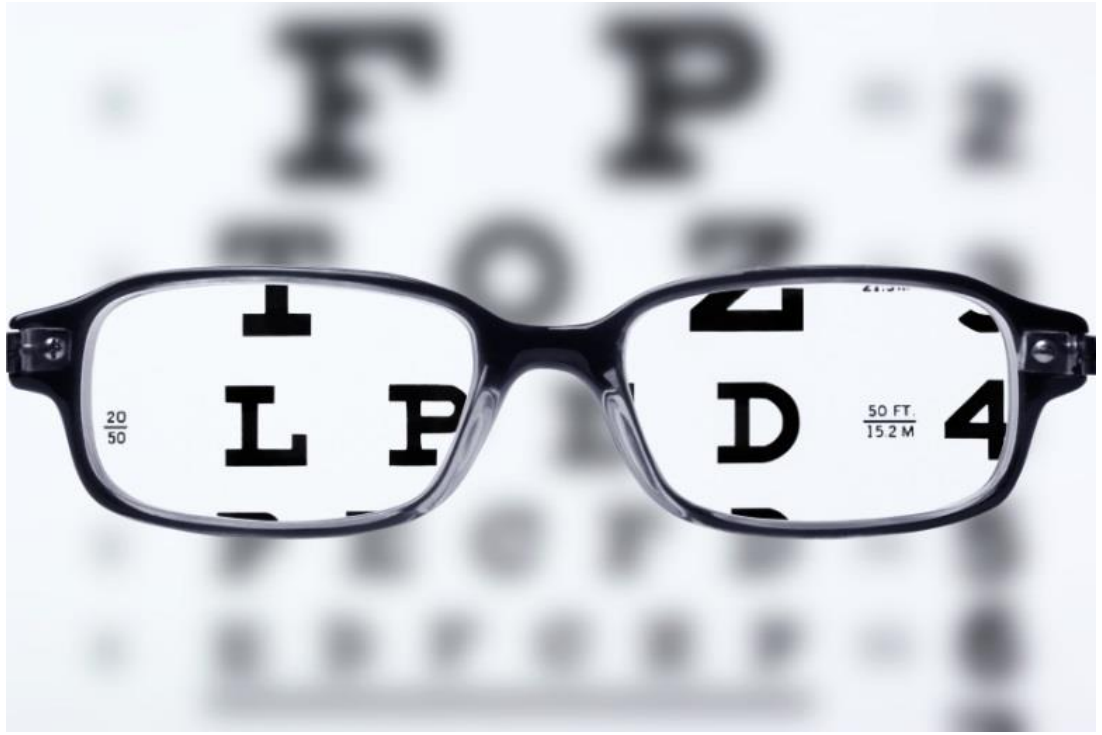
Overview

- Beam optics and its measurement
- Faster 3D excitation not harming the beam quality
- Normalised dispersion
- Harmonic analysis of “compressed” data

Beam optics

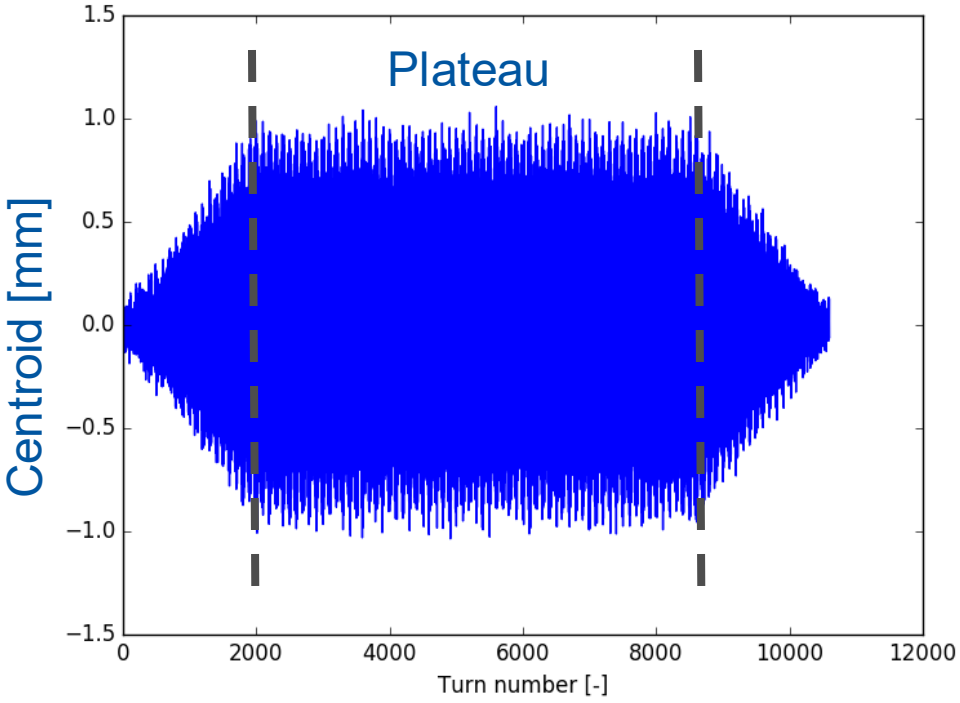
- Very important to prevent:
  - Deterioration of performance
  - Severe machine damage (hadron beams)
- Excellent beam optics control is a must



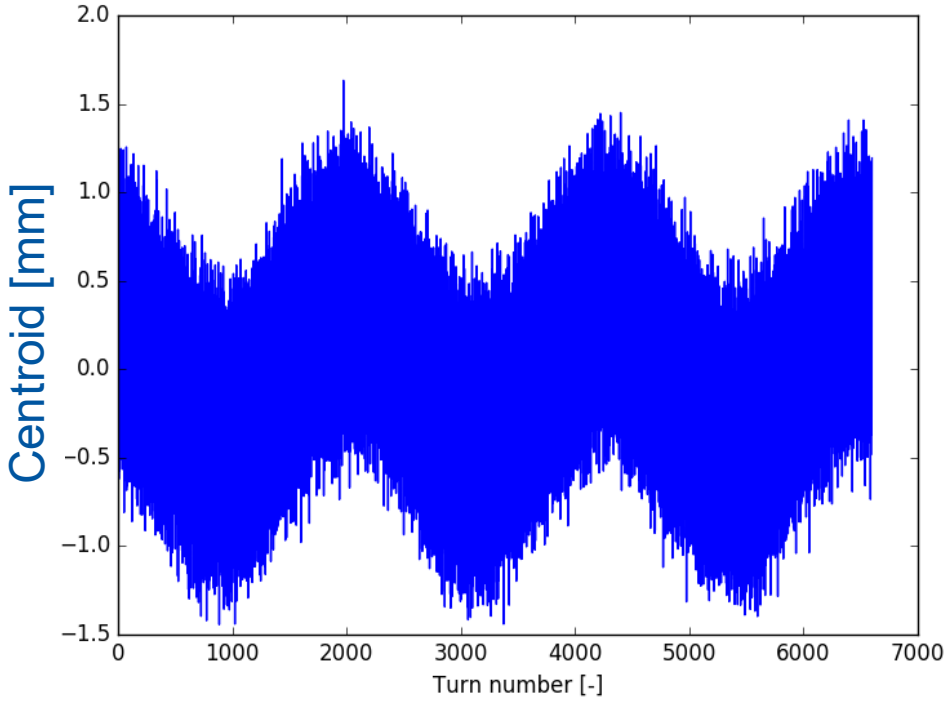
Optics measurements in rings

- Excite the beam transversely -> coherent betatron motion
- Observe beam orbit over thousands of turns
- Repeat at different beam energies $\Delta E/E \approx 10^{-4}$ to 10^{-3}
- Physics quantities from harmonic analysis
  - Transverse optics
  - Transverse-longitudinal coupling

Energy changing in a single excitation



RF-frequency modulation

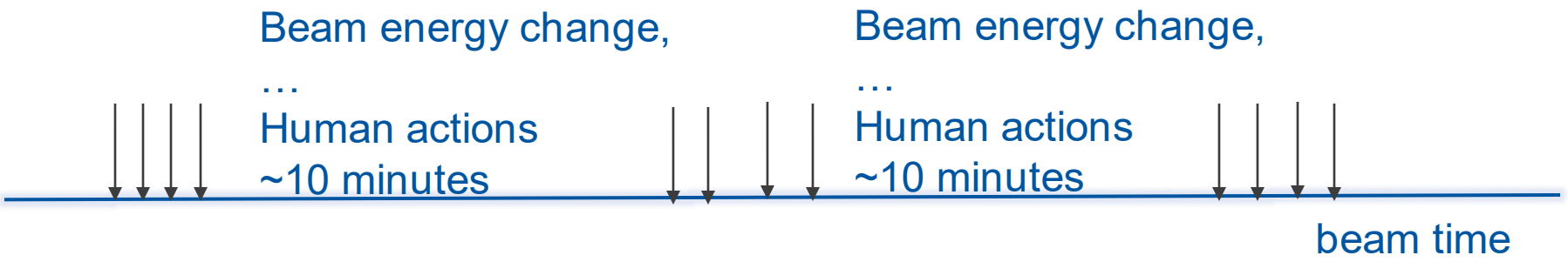


AC-Dipole driven beam oscillations

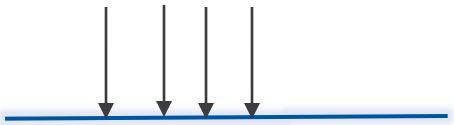
AC-Dipole driven beam oscillation with beam energy variation

Measurement time line

- Transverse excitation only



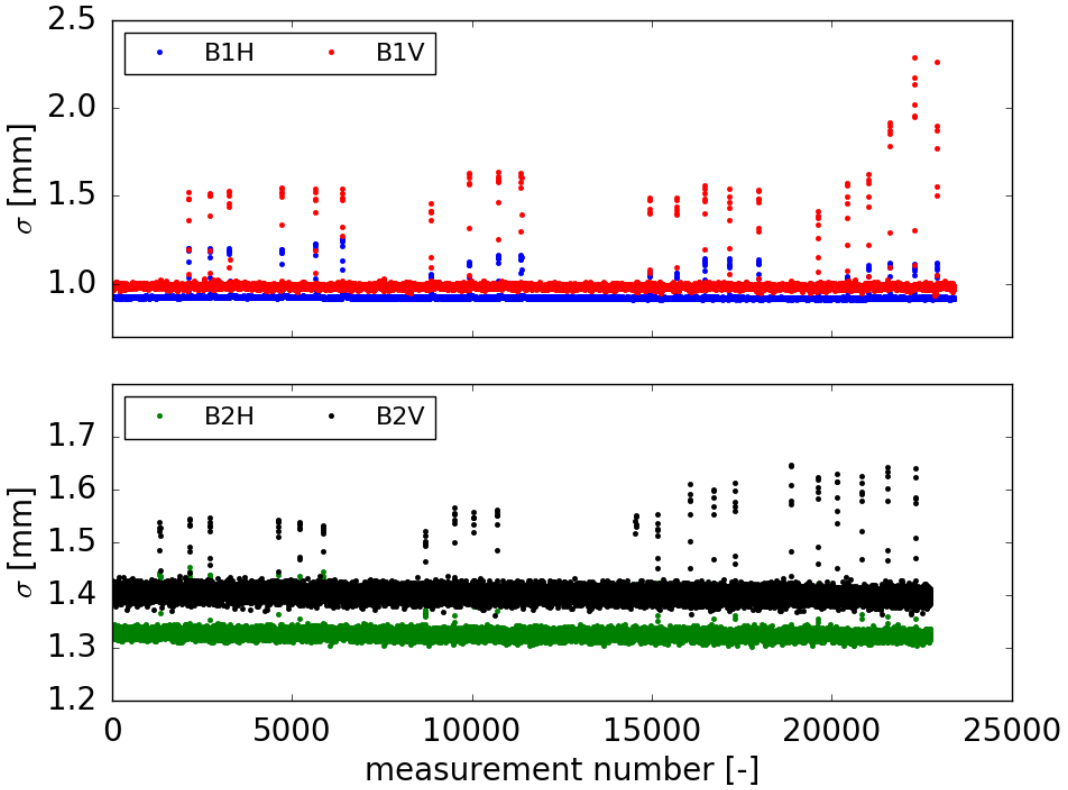
- 3D excitation



saved beam time

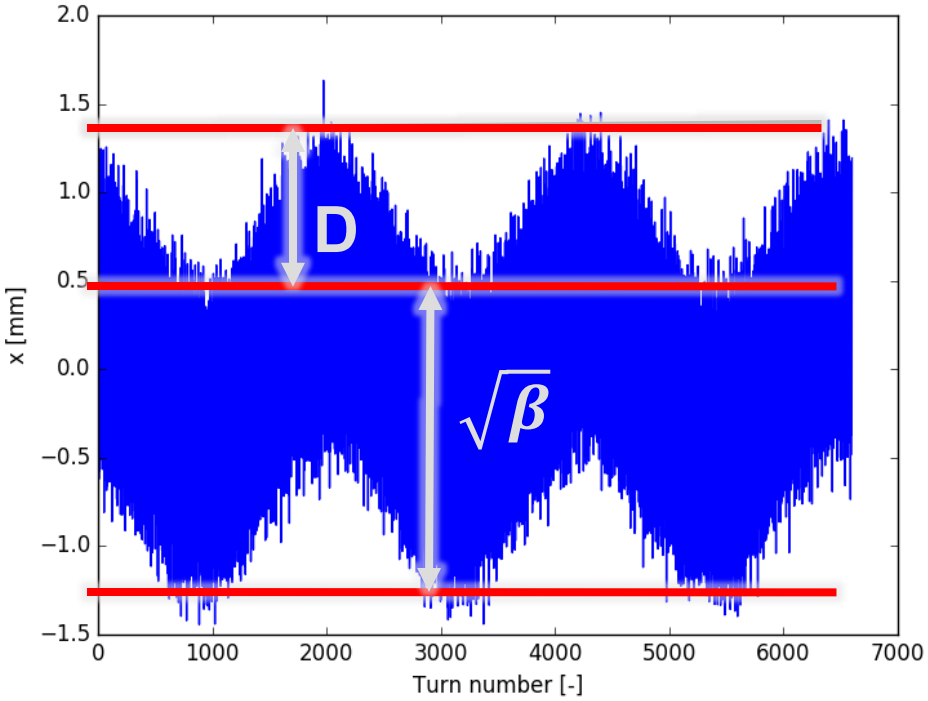
Harmless excitation

- Beam size measured during the 3D optics measurement
- Beam blow up would show as steps
- Trends are flat - > no beam blow up
- Beam useful after the measurement

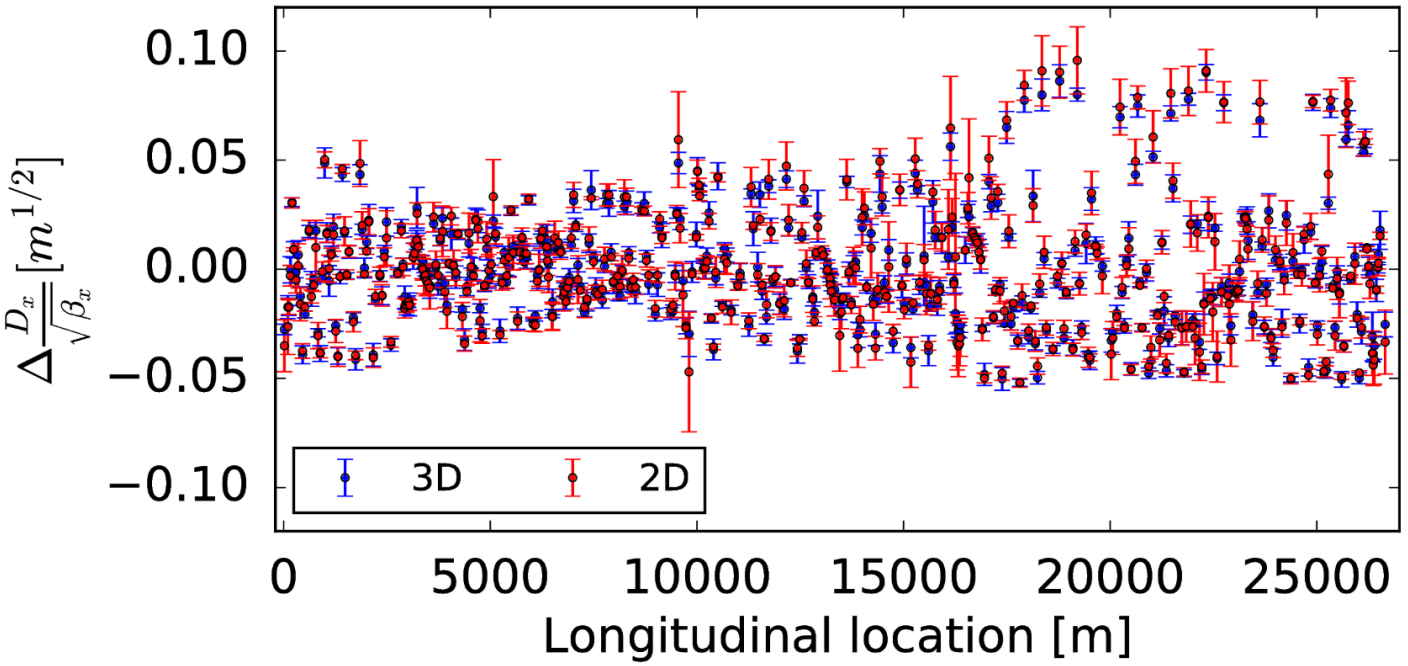


Normalised dispersion

- Correlation between beam energy and transverse orbit
- Normalised by $\sqrt{\beta} \propto$ beam size
- Independent of monitor calibration
- Use the model for global scaling

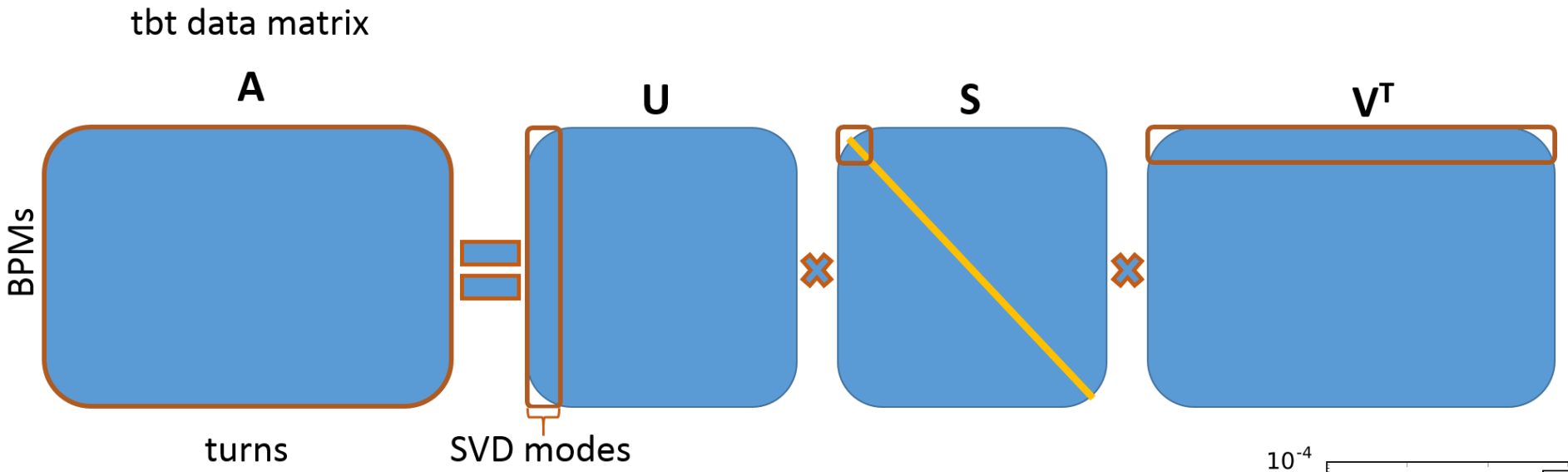


Normalised dispersion – LHC 3D vs 2D



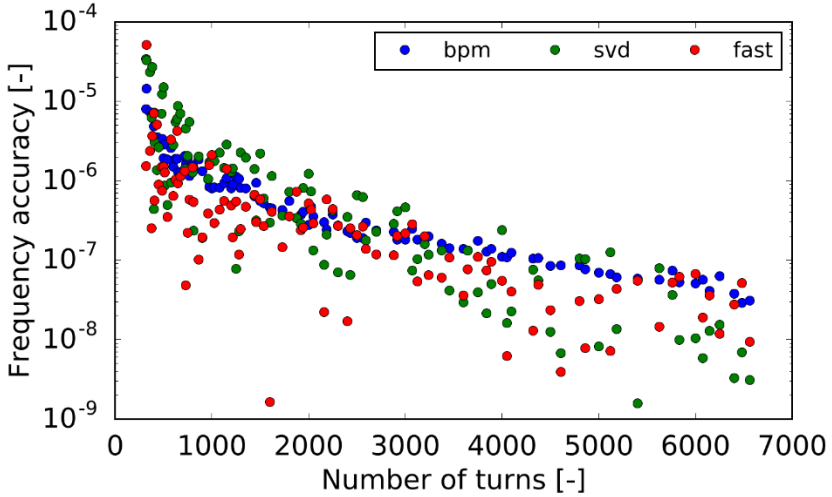
- 3D is more precise
- Using less excitation and shorter beam time

Harmonic analysis of decomposed data

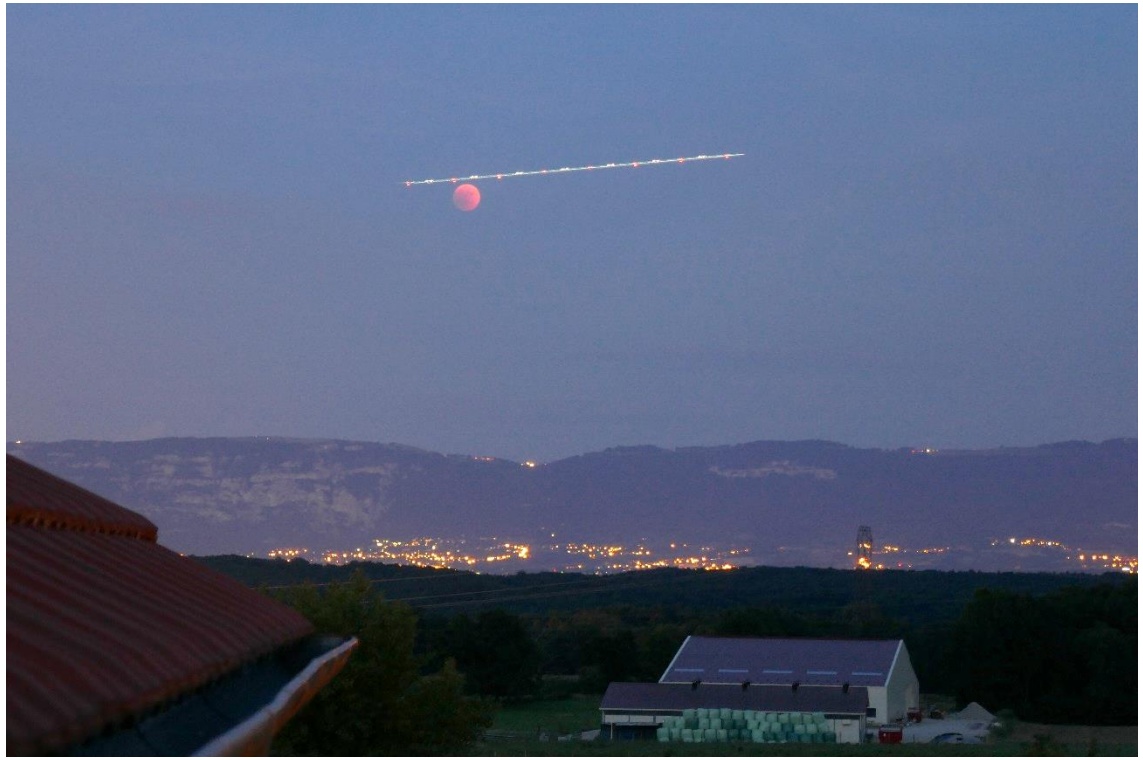


IPAC'18, THPAF045

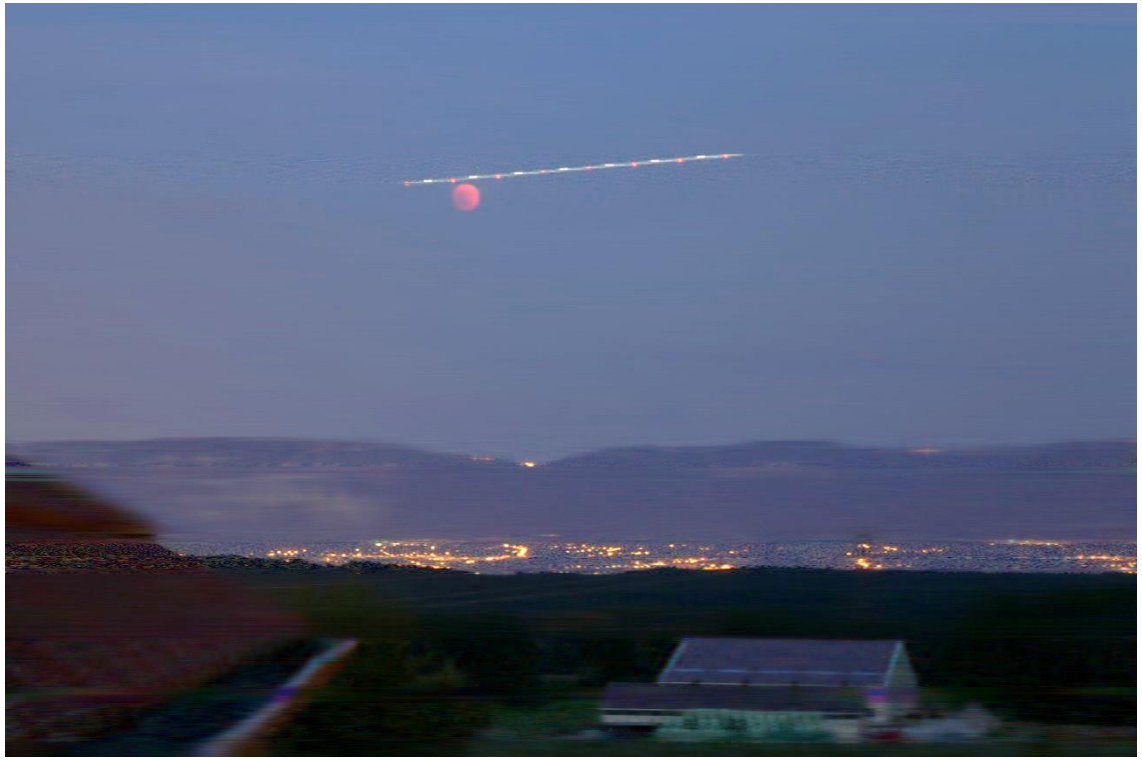
- Noise cleaning + harmonic analysis
- Data is "compressed" -> much faster
- Usually more accurate



Visualised harmonic analysis



Original



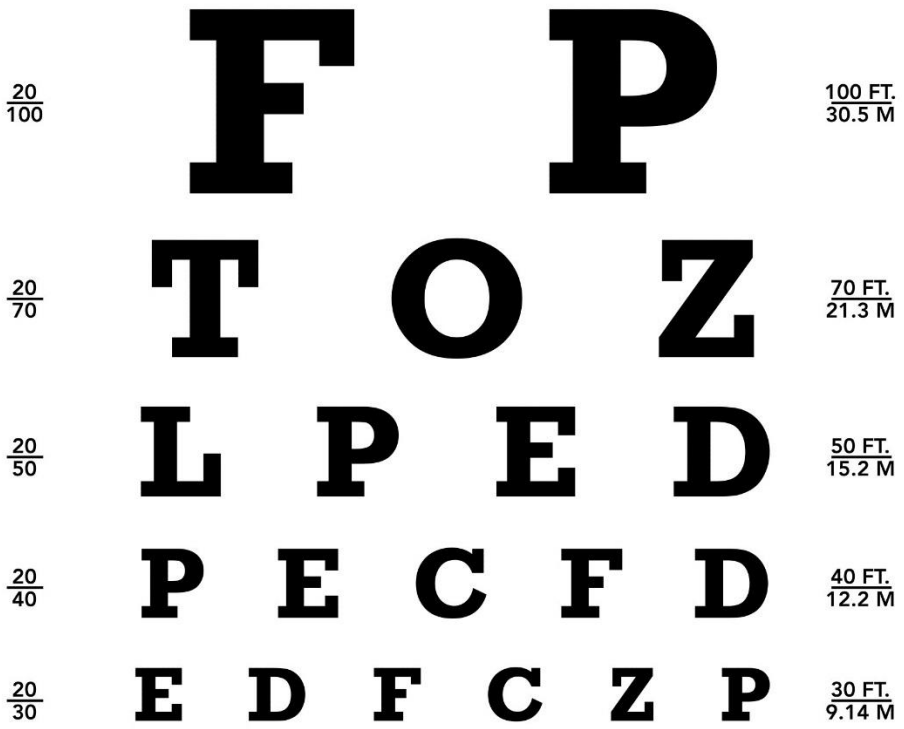
Recomposed

Conclusions & Outlook

- Faster non-destructive optics measurements demonstrated
  - More precise normalised dispersion
- Novel harmonic analysis of decomposed data in operation
- Still progressing on beam dynamics and harmonic analysis

Thank you for your attention

Any questions?



More details in paper TUOB02