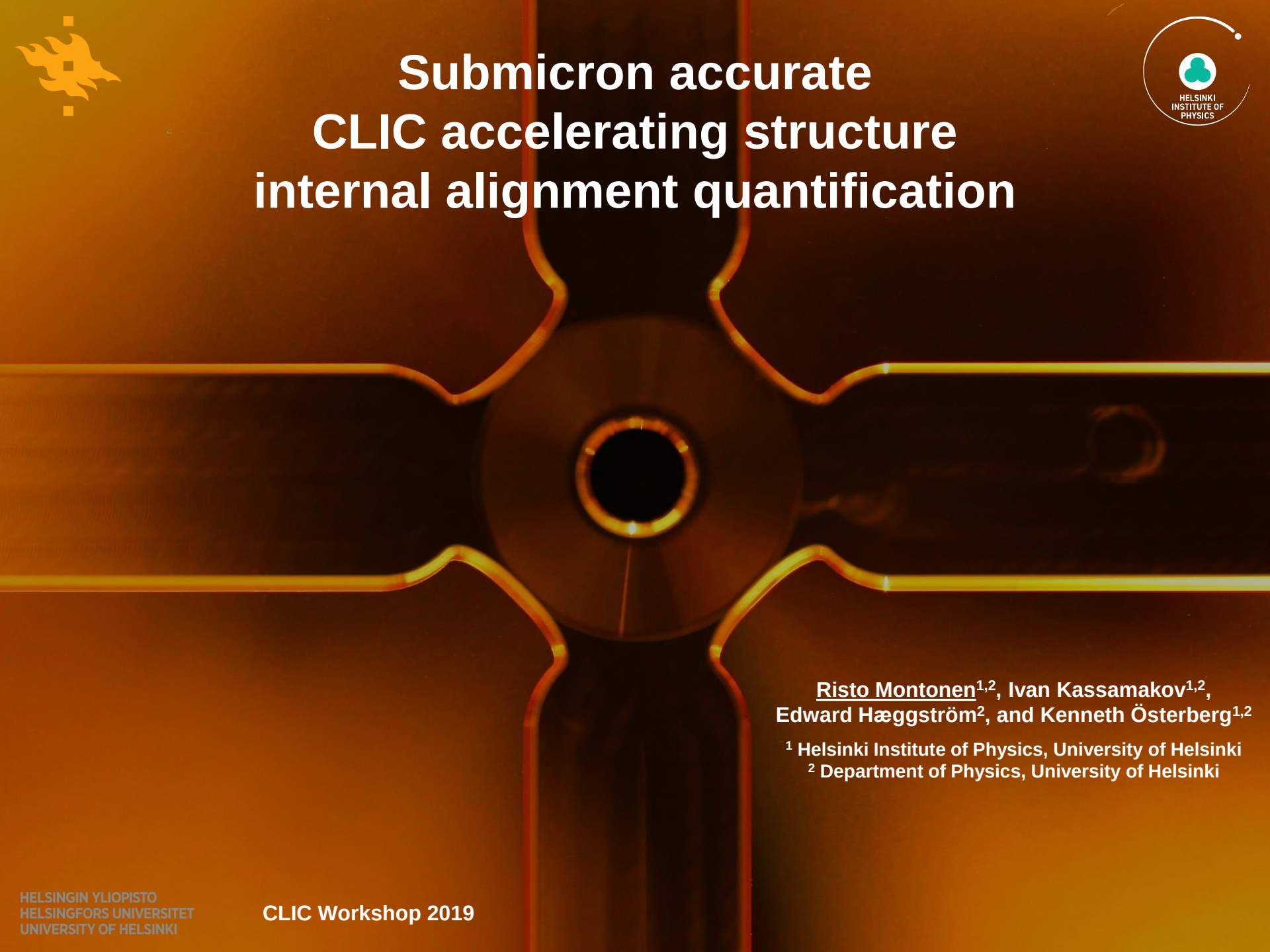
Submicron accurate CLIC accelerating structure internal alignment quantification

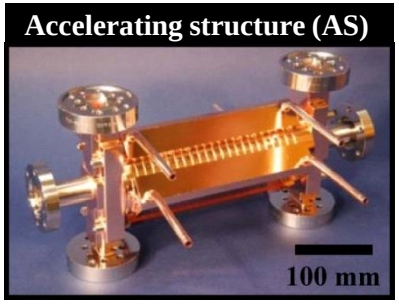


Risto Montonen[1,2], Ivan Kassamakov[1,2], Edward Hæggström[2], and Kenneth Österberg[1,2]

[1] Helsinki Institute of Physics, University of Helsinki
[2] Department of Physics, University of Helsinki

CLIC Workshop 2019

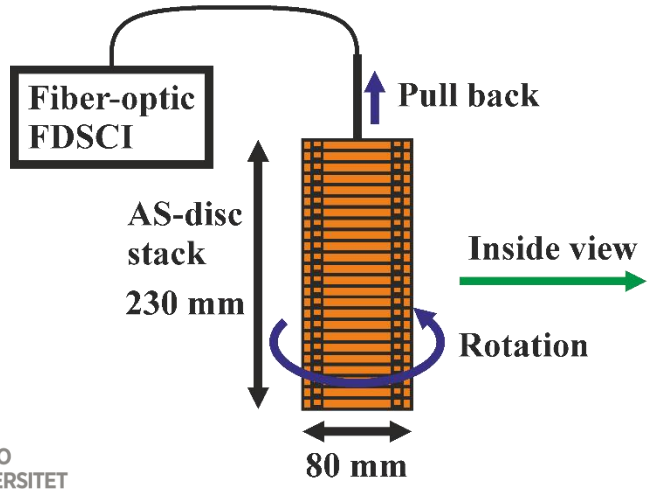
Submicron accuracy across 10 mm range required

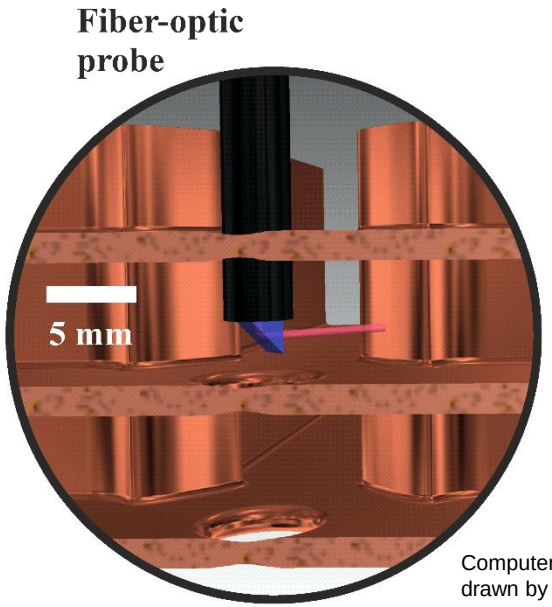


Wang *et al.*, in *The 1st International Particle Accelerator Conference*, Kyoto, Japan, JACoW, THPEA064 (2010).

	Type 1	Type 2	Type 3	Type 4
Shape error	Disc stack alignment	AS-cavity diameter	Iris shape	Disc tilt
Tolerance	5 µm	1 µm	2 µm	140 µrad

✓ Fiber-optic Fourier domain short coherence interferometer (FDSCI)

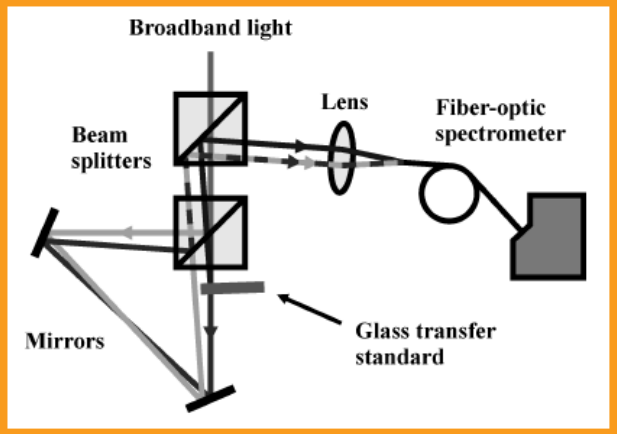




Computer-aided design of the AS-discs drawn by Anastasiya Solodko

Dissertation defended

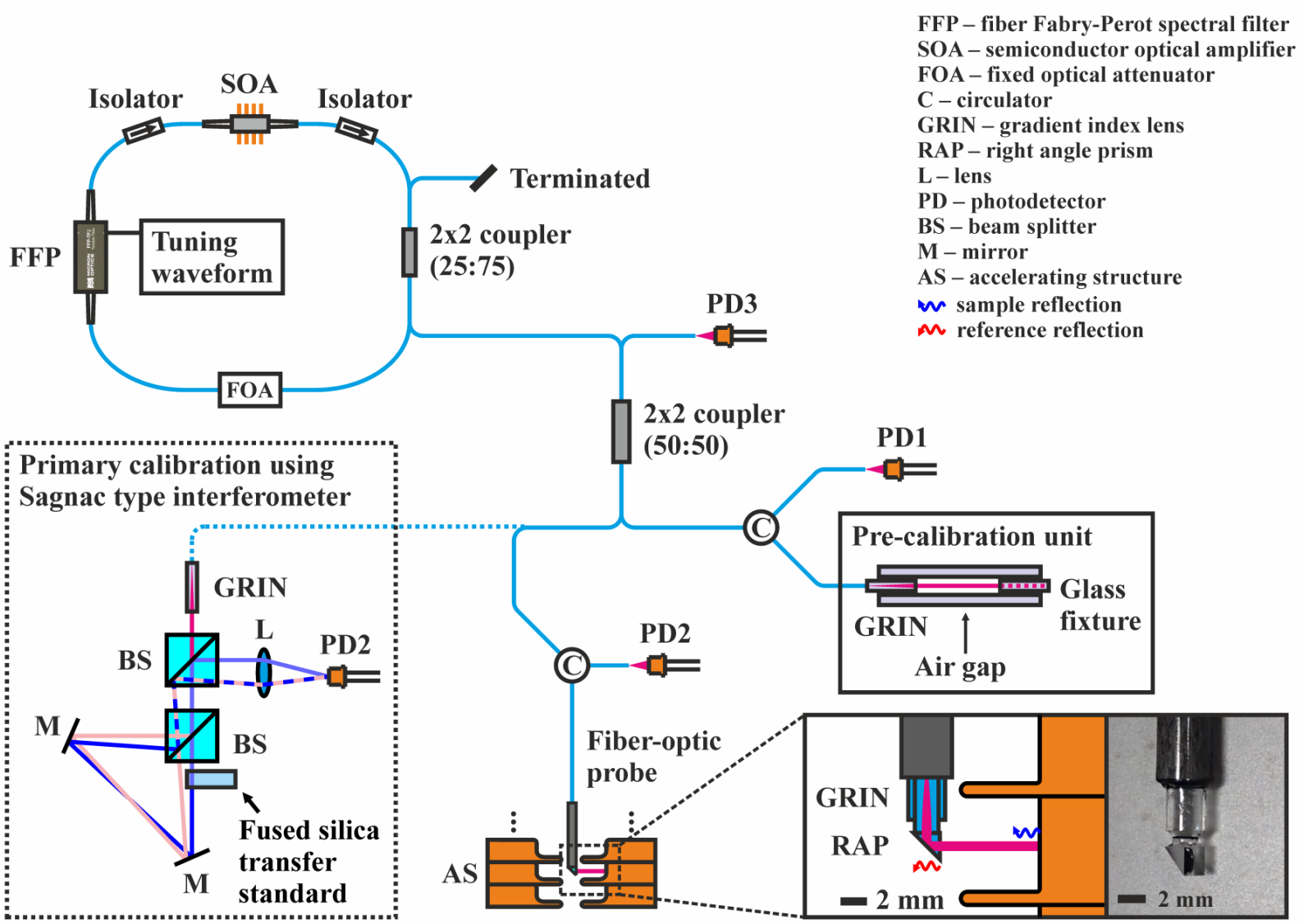
Report Series in Physics
HU-P-D259



LENGTH CALIBRATION OF FOURIER DOMAIN INTERFEROMETER FOR PARTICLE ACCELERATOR QUALITY ASSURANCE

Risto Montonen

Fiber-optic Fourier domain short coherence interferometer



Research aims

1. **Portable fiber-optic FDSCI**
   - Swept laser source, fiber-optics, detectors, and fiber-optic probe

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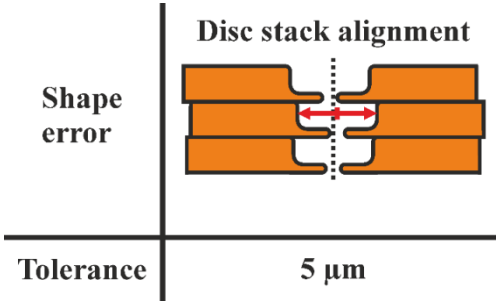
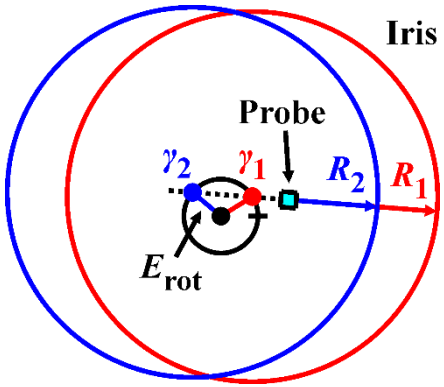
2. **AS scanning system**
   - AS rotation, fiber-optic probe pullback

Option 1	Option 2
Custom made scanning with rotation and translation stages	Portable fiber-optic FDSCI integrated into a form measuring machine

Measurement strategy: Disc stack alignment



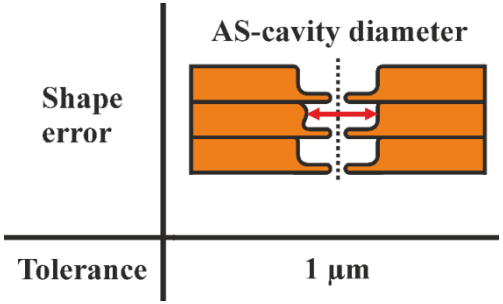


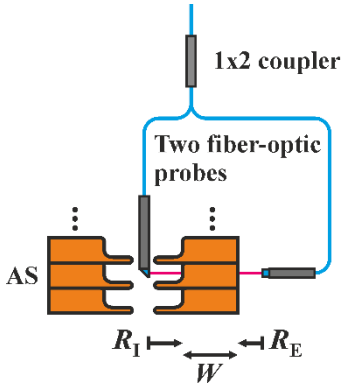
$$E_{\mathrm{rot}} = \frac{R_1 - R_2}{2\sin\left(\frac{\gamma_2 - \gamma_1}{2}\right)}$$

- Eccentricity of each iris plotted in cylindrical coordinate system (Z, γ_1,E_{rot})
- Alignment analyzed as maximum deviation from the centerline
- Dominant sources of uncertainty: FDSCI repeatability, sample orientation, and radial error motion of the rotation table

$U \approx \pm 1$ µm

Measurement strategy: AS-cavity diameter

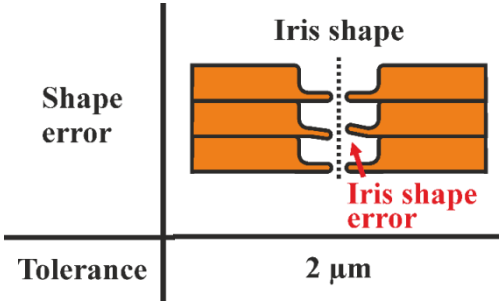




- Reduced distortion by eccentricity zeroing and probe repositioning
- Fiber-Sagnac configuration to measure AS-wall thickness
- Internal shape referenced to outer surface with CMM inspection
- Dominant sources of uncertainty: FDSCI repeatability and calibration, sample orientation, and CMM probing error

$U > \pm 1$ µm

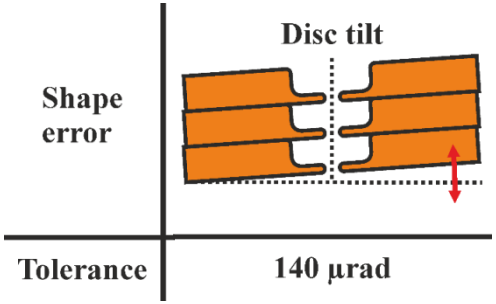
Measurement strategy: Iris shape



- Heavily rounded form of irises not detectable with FDSCI length data
- Iris shapes analyzed by determining zenith positions in confocal manner
- Dominant sources of uncertainty: back reflection intensity variations, pullback repeatability, and axial error motion of the rotation table

$U < \pm 1$ µm

Measurement strategy: Disc tilt



- Systematic tilt of discs (bookshelfing) analyzed as orientation of irises with respect to the centerline of the disc stack
  - Planar fit
- Dominant source of uncertainty: axial error motion of the rotation table

$U \approx \pm 0.1$ µm

Conclusions

- Length calibration of Fourier domain interferometers and systematic and random uncertainty propagation in disc stack alignment measurements shown in the dissertation
- Portable fiber-optic Fourier domain short coherence interferometer under assembly
- Accelerating structure internal alignment and shape measurement addresses strict requirements for the rotation table

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