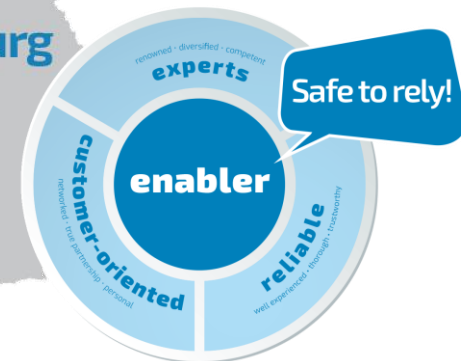
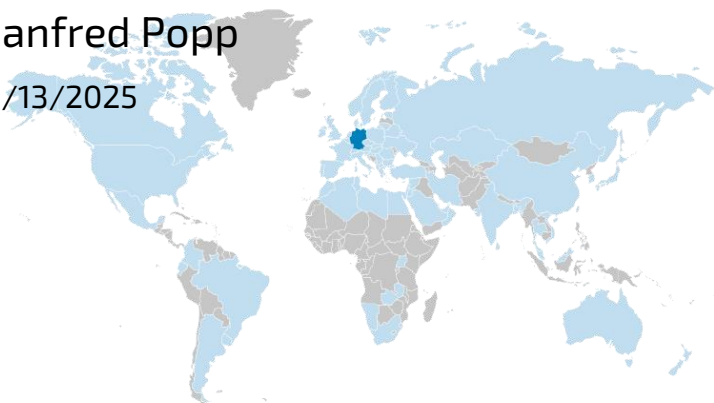


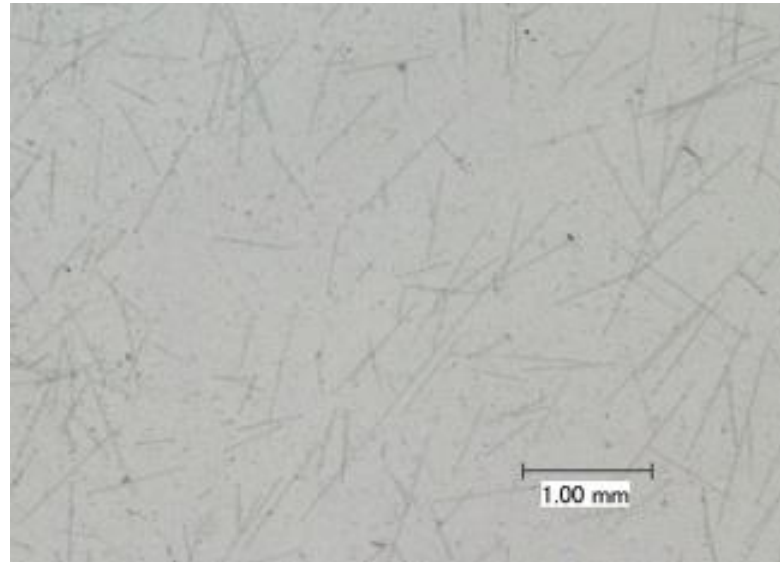
Fiber length analysis with FiVer V2

Manfred Popp

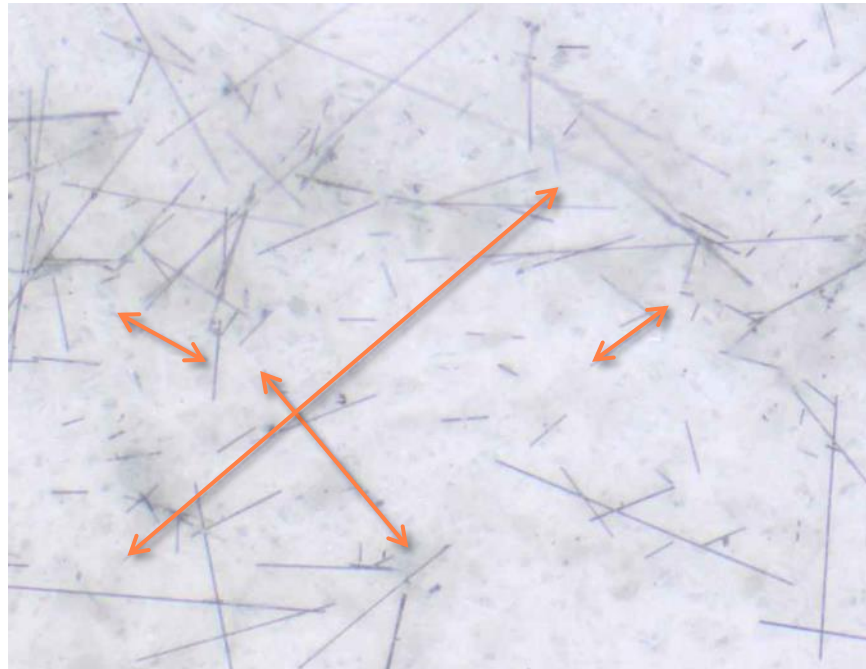
05/13/2025



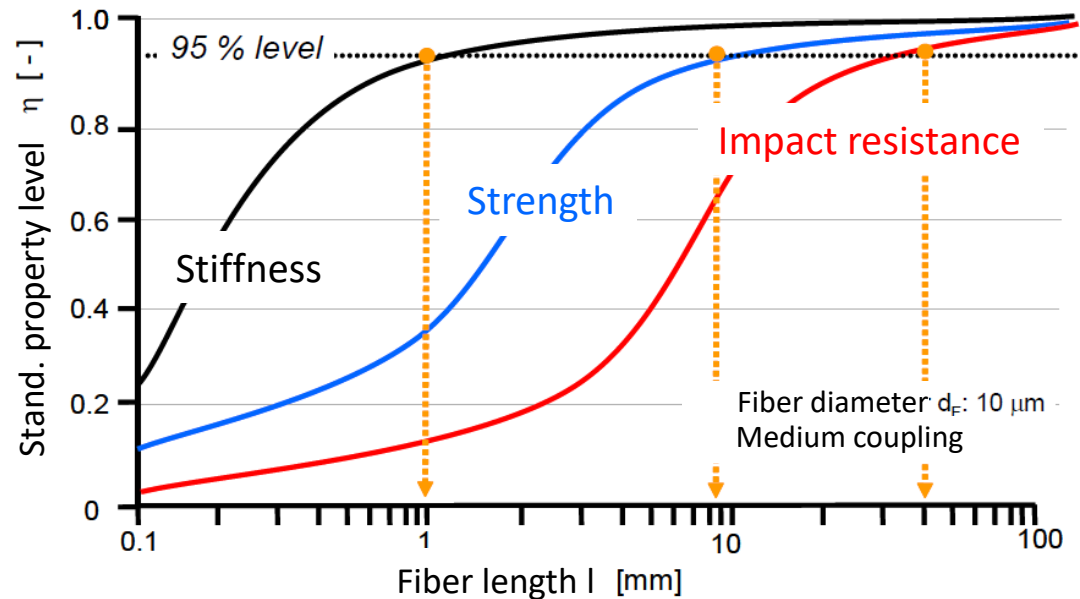
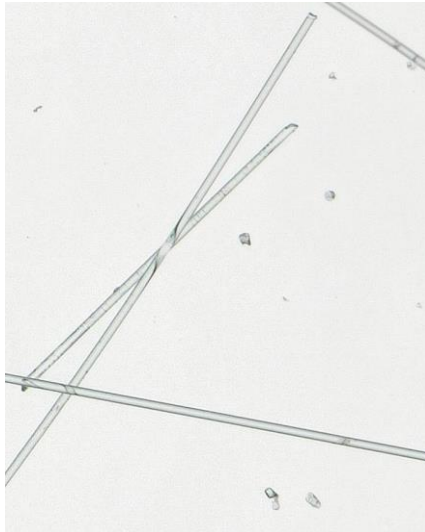
- The most important existing standard for measuring the length distribution of reinforcing fibers is ISO 22314 "Plastics - Glass-fibre-Reinforced products - Determination of fibre length" from 2006.
- It refers specifically to glass fibers with a length of up to 1 mm, in special cases up to 5 mm. A limiting element here is the image capture via a microscope, as the image section is too small to see longer fibres completely at sufficient magnification.



- The actual measurement of the fiber length is done by manually clicking on the end points in a suitable software. In order to keep the effort reasonable, only approx. 300 fibres are evaluated. Only whole fiber segments are explicitly recorded ("Measure manually the length of all the **complete** fibres..."), **not short fragments**.



- However, these short fragments are the remains of fibers that have been damaged in the manufacturing process. In the component, they therefore no longer contribute to improving the mechanical properties. A significant proportion of the weight of the fibers added by the raw material manufacturer is therefore lost for the reinforcing effect, which has been ignored up to now.



Since 2009, long fiber processing has been a research focus at the SKZ (glass and carbon in technical thermoplastics)

- Major FaNuPot project on the KraussMaffei IMC with other industrial partners
- Development of fiber direct compounding (FDC) with Arburg



- It was clear that many hundreds of fiber length analyses would be required as part of these projects
- The known systems, some of which were already in use at the SKZ, could not cope with longer and crossed fibers or required manual support
- For this reason, a separate programme, FiVer, was developed in 2011, the first commercial version of which was released in 2012
- With the Swiss company IST AG, Dr Schmid, we now also have a sales partner since the end of 2012, which is mainly active internationally



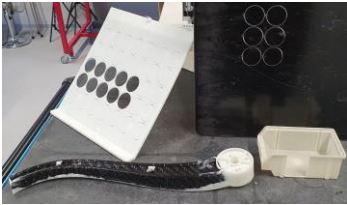
- In the period from 2021 to 2024, two industrial projects were carried out at the SKZ with well-known participants from the fields of material production/compounding, machine technology and processing
- The aim was to standardize fiber length analysis to such an extent that the results from different laboratories would be comparable
- For this purpose, all steps were analyzed with regard to their influencing variables and recommendations for action were developed
- These were also implemented in version 2 of FiVer, which was developed in parallel



Steps of a fiber length analysis



Ashing



Sampling



Preparation

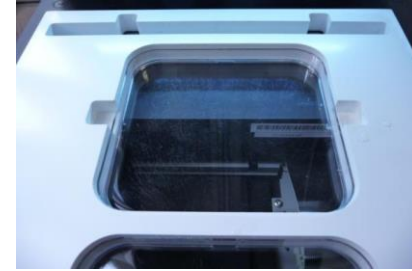
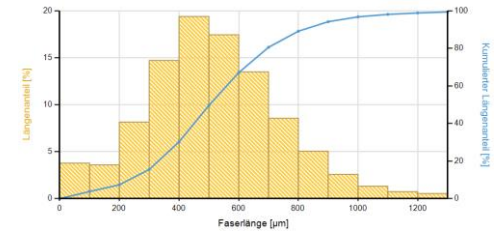


Image acquisition



Evaluation

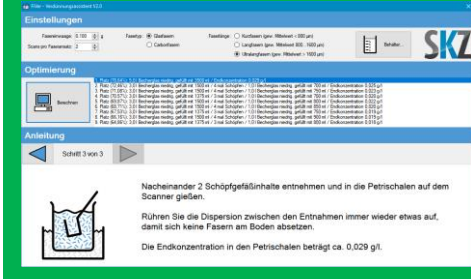
Recommendations and instruction videos



Sampling

Ashing

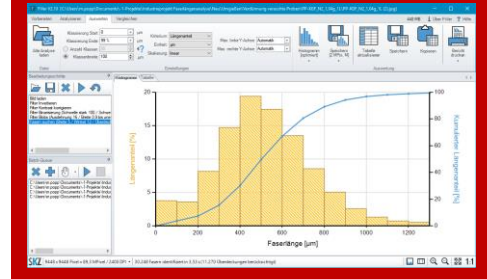
Dilution assistant



Preparation

Image
acquisition

FiVer



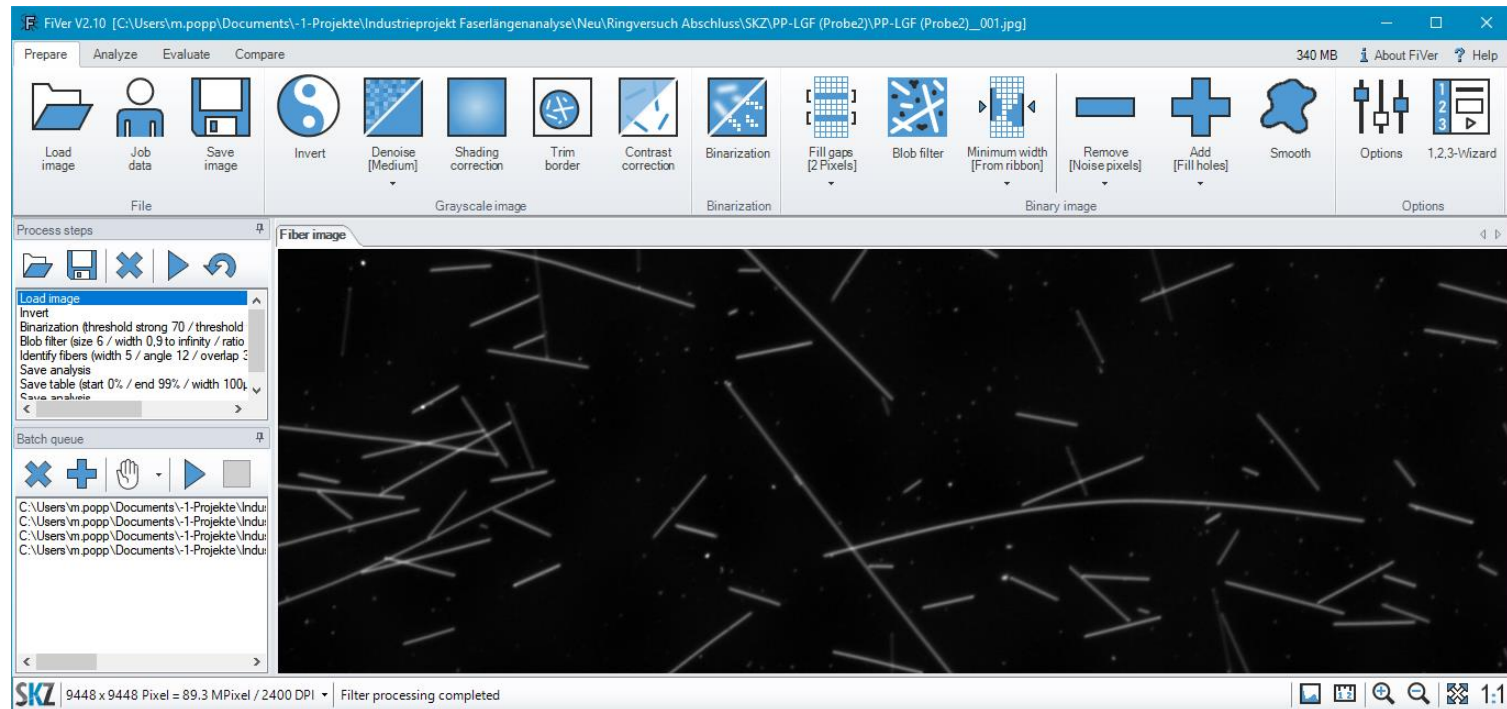
Evaluation

Basic specs

- Runs with Windows 8, 64 bit or higher
- German and English user interface
- Uses multi-core processors for maximum speed
- Maximum scan size **1 gigapixel** (approx. DIN A4 at 3200 DPI)
- Up to 65,000 fibers per image
- Summarised evaluation of several images up to **400,000** fibers in total
- Tabular and graphical comparison between max. **30** evaluations

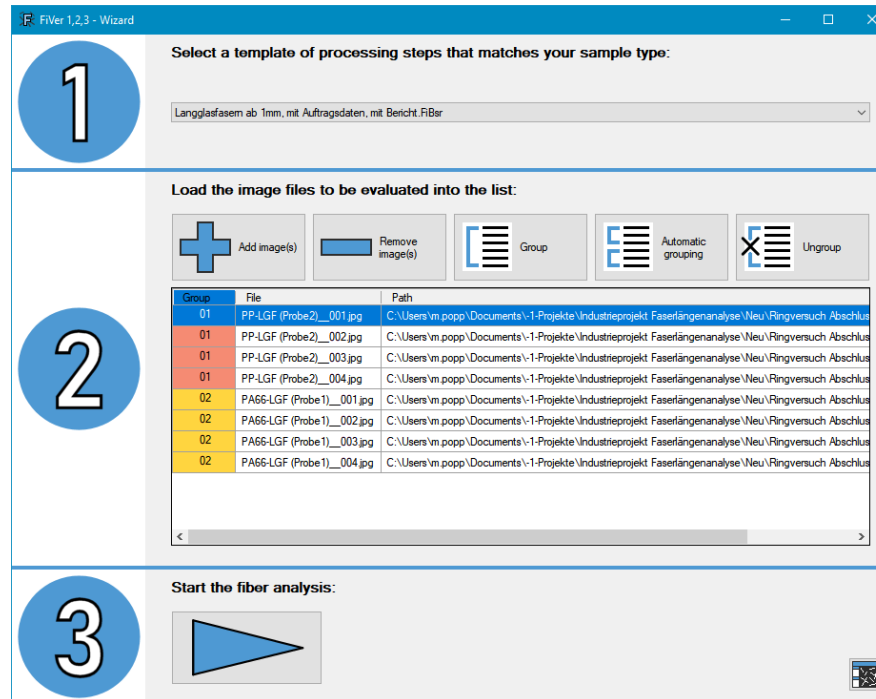
Complete interface

- Wide range of options for adjusting the evaluation process and the presentation of the results



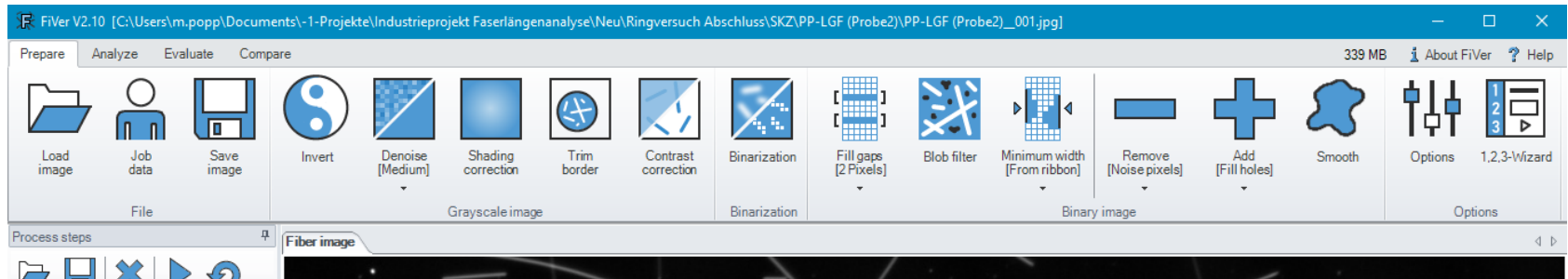
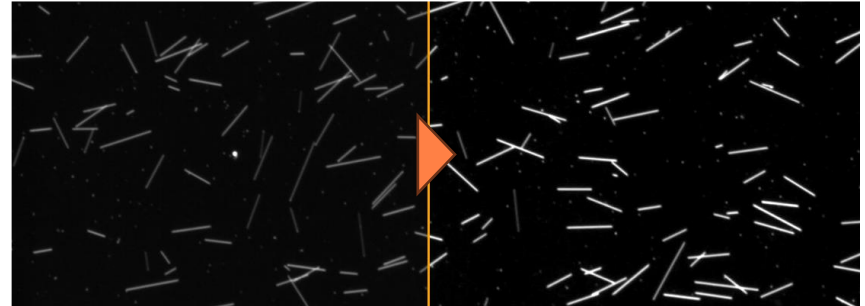
1,2,3 wizard

- Fastest way from image to report in three steps
- For standard analyses with a predefined workflow



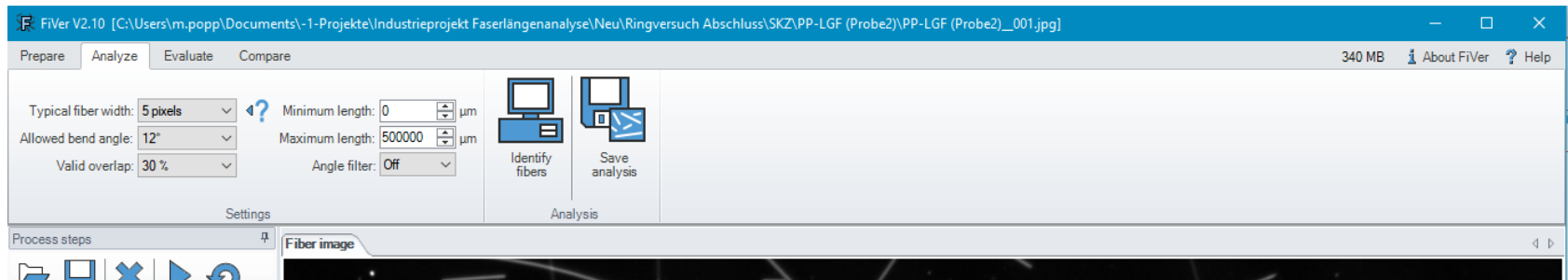
1. Prepare

- Compensation of the differences in brightness due to the serial scattering of the scanners
- Crop unwanted image areas
- Removal of dust particles and foreign objects from the image
- ...



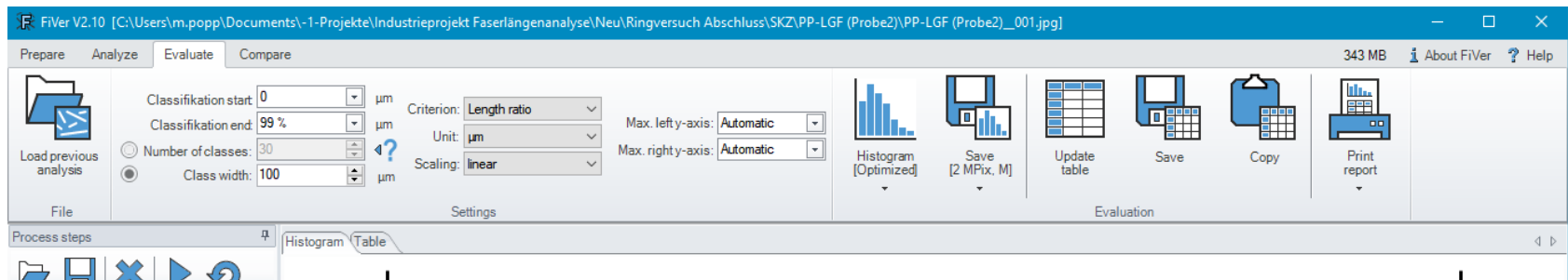
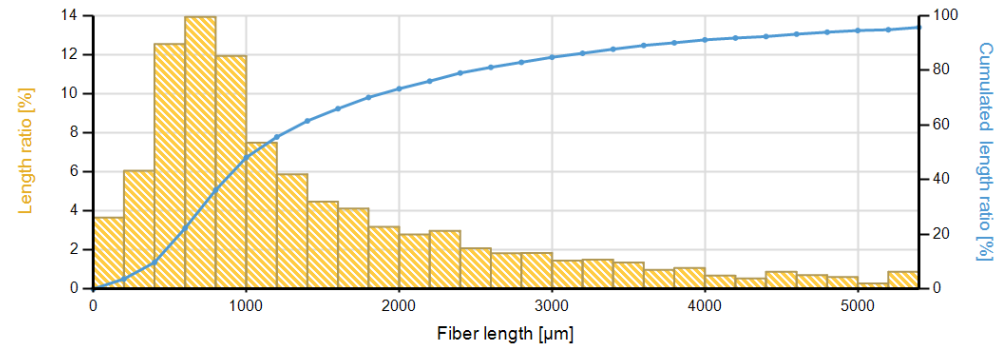
2. Analyze

- Identification of the individual fibers in the scan



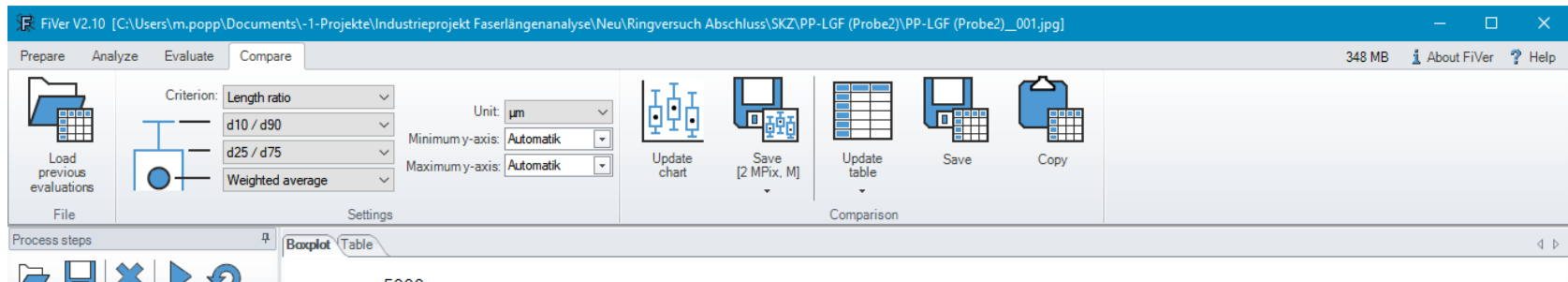
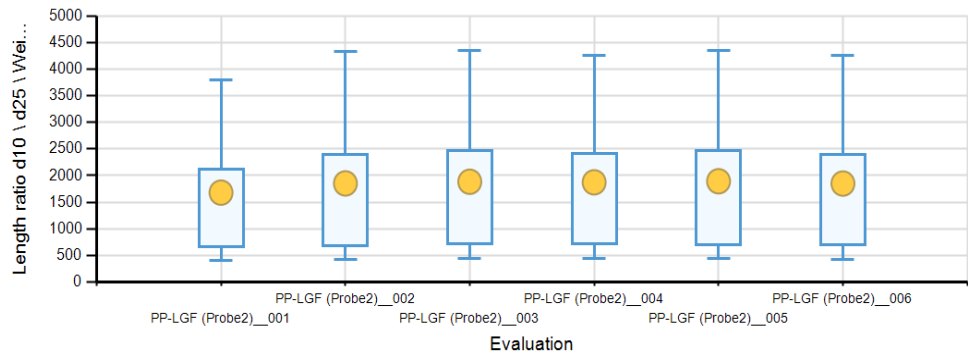
3. Evaluate

- Calculation of the statistical characteristic values
- Display of the length distribution as a histogram and table
- Printout of a report
- ...

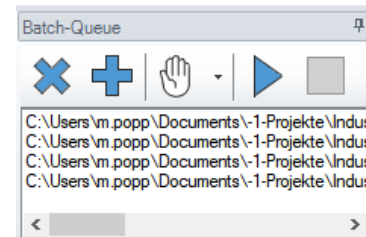
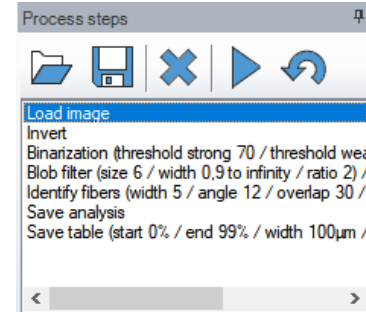
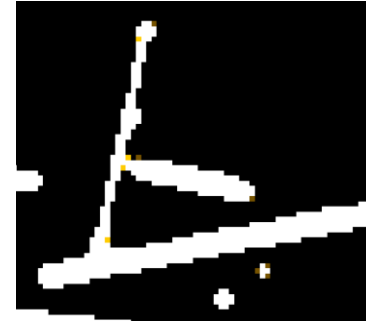


4. Compare

- Comparison of the characteristic values of several evaluations as a box plot



- Interactivity
 - Immediate live display of the effect of changing the settings for some filters
 - Pixels added or deleted by a filter are highlighted in colour
- Transparency
 - The program remembers all the performed evaluation steps and displays them as a list
 - This list is saved together with the evaluation results
 - If desired, it also appears in the report
 - The steps can all be undone incrementally (unlimited undo)
- Automation
 - Own simplified user interface for standardized mass evaluations
 - Batch mode in the complete user interface for processing multiple images with the same settings
 - Steps such as saving a graphic or exporting a table are also included in the list. The file names are generated automatically without the need for user intervention
 - If an appropriately configured PDF printer is used, this also applies to the output of the report



- Export of all tables as readable text
 - Individual fibers found
 - Class assignments of the histogram
 - Comparison of several evaluations
- Export of all graphics in high resolution
 - Histogram
 - Boxplot
 - Adjustable font size and resolution
- Printout of a report with selectable content
 - Job data
 - Image detail
 - Histogram
 - Statistics
 - Quantiles
 - Class table
 - List of processing steps

```

18 =====
19 Explanation of the columns:
20 Column 1 | Lower class limit [µm]
21 Column 2 | Upper class limit [µm]
22 Column 3 | Number of fibers
23 Column 4 | Relative frequency [%]
24 Column 5 | Cumulated relative frequency [%]
25 Column 6 | Length ratio [%]
26 Column 7 | Cumulated length ratio [%]
27 =====
28 < 0      0      0      000      000      000      000
29 0      200    3,395    3088    3088    366    366
30 200    400    1,439    1309    4397    605    971
31 400    600    1,811    1647    6045    1254    2224
32 600    800    1,448    1317    7362    1303    3617

```

