

BACKGROUND

CRYSTAL ARTHRITIS (GOUT AND CPPD) IS THE MOST COMMON CAUSE OF INFLAMMATORY ARTHRITIS.

- Over 12 million US individuals with gout
- Up to 10 million US individuals with CPPD
- Increasing morbidity and healthcare utilization

COMPENSATED POLARIZING LIGHT MICROSCOPY (CPLM) IS DIAGNOSTIC GOLD STANDARD BUT HAS LIMITATIONS.

- Labor intensive & user-dependent
- Sensitive to technician experience & crystal concentration in synovial fluid
- Harder to see smaller and less birefringent CPP crystals, compared to MSU

RESULTS

326 unique crystal objects from the 67 FOV were identified for the analytic set:

229 CPP, 87 MSU, and 10 suspect crystals (uncertain identity)

The 10 suspect crystals of uncertain identity all came from the negative control FOVs

FOV	CPPD	MSU	Unknown	TOTAL
	29	31	7 (Negative FOV)	67
CRYSTAL SUSPECTS	226	87	10	326
CRYSTAL CONFIRMED	180	77	-	259

Table 1: Suspected and confirmed crystals from 67 FOV using both SCPLM and CPLM

Raters identified higher number of crystals with higher detection rate and sensitivity using SCPLM over CPLM for both CPP and MSU crystals.

CPP crystals	Image	AUC	Sensitivity	Specificity	Detection Rate
	CPLM fused	0.61 (0.55, 0.67)	0.35 (0.30, 0.41)	0.83 (0.67, 0.94)	0.31 (0.26, 0.36)
	SCPLM fused	0.71 (0.63, 0.79)	0.62 (0.56, 0.68)	0.75 (0.58, 0.88)	0.55 (0.5, 0.61)

MSU crystals	Image	AUC	Sensitivity	Specificity	Detection Rate
	All	All	All	All	All
	CPLM fused	0.77 (0.72, 0.82)	0.56 (0.47, 0.64)	0.94 (0.70, 1.00)	0.50 (0.42, 0.58)
	SCPLM fused	0.86 (0.76, 0.95)	0.91 (0.84, 0.95)	0.69 (0.41, 0.89)	0.81 (0.74, 0.87)

Table 2: Comparing AUC, sensitivity, specificity and detection rate for both MSU and CPP crystals using either method

BACKGROUND

SCPLM: A NOVEL ENGINEERING METHOD FOR IDENTIFYING CRYSTALS IN SYNOVIAL FLUID

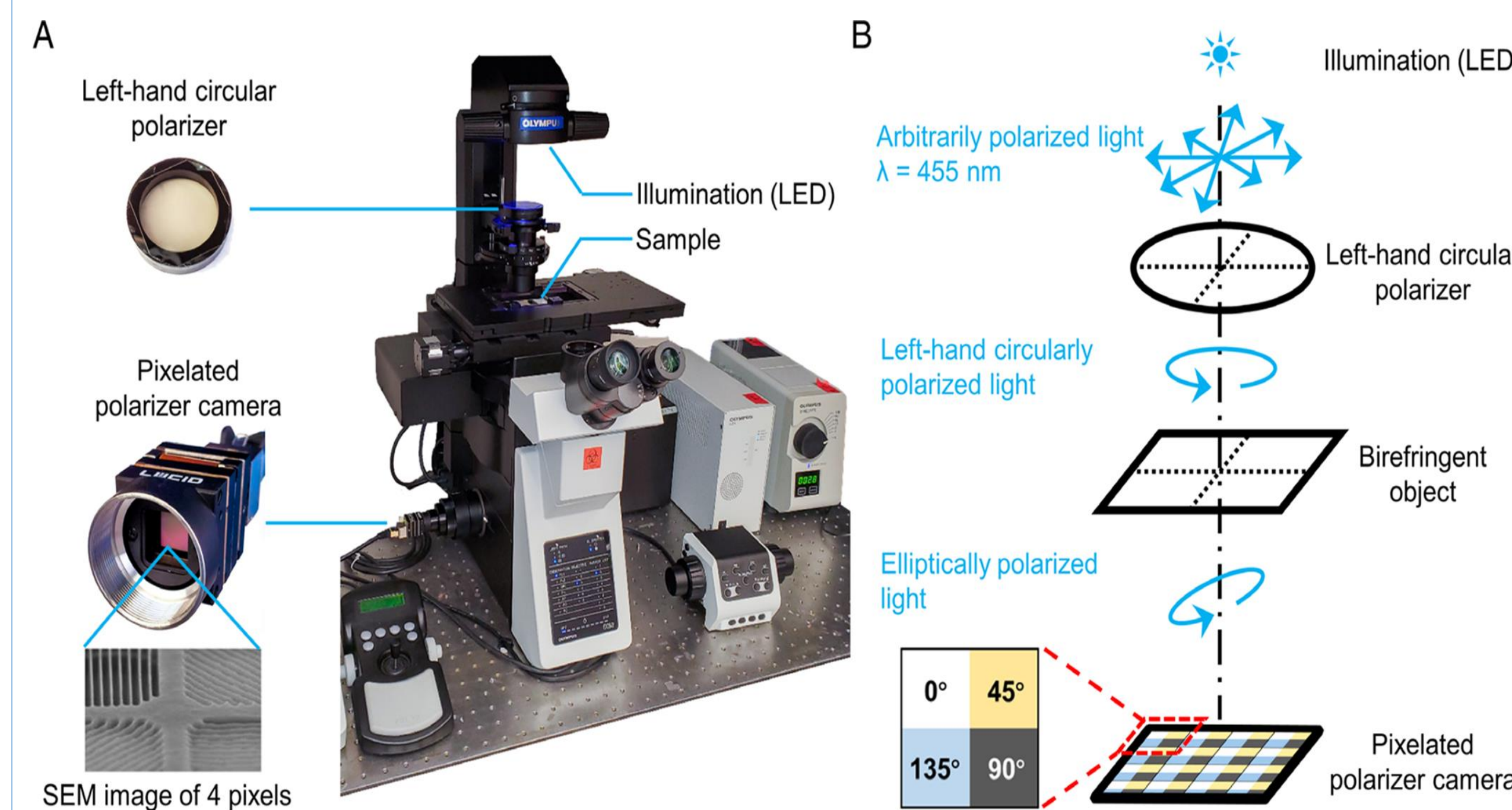


FIGURE 1: A. Single-shot computational polarized light microscopy (SCPLM) setup. B. Schematic diagram of SCPLM setup

CMOS sensor: each pixel has a directional polarizing filter with four axes of polarization (0°, 90°, 45°, 135°).

Combines images from multiple focal depths into a single bright-field fused image.

RESULTS

For majority of FOVs, SCPLM was preferred method for detecting and identifying crystals

	R1		R2	
	Detection	ID	Detection	ID
>3 (Favors SCPLM)	62	60	60	59
3 (Neutral)	5	5	7	8
<3 (Favor CPLM)	0	2	0	0

R1 detected	R1 ID	R2 Detected	R2 ID
4.7	4.8	4.7	4.8

Table 3: Comparing rater preference for crystal detection and identification.

CONCLUSIONS

Greater detection and higher certainty of crystals were observed for SCPLM images over standard CPLM images, particularly notable for CPP crystals.

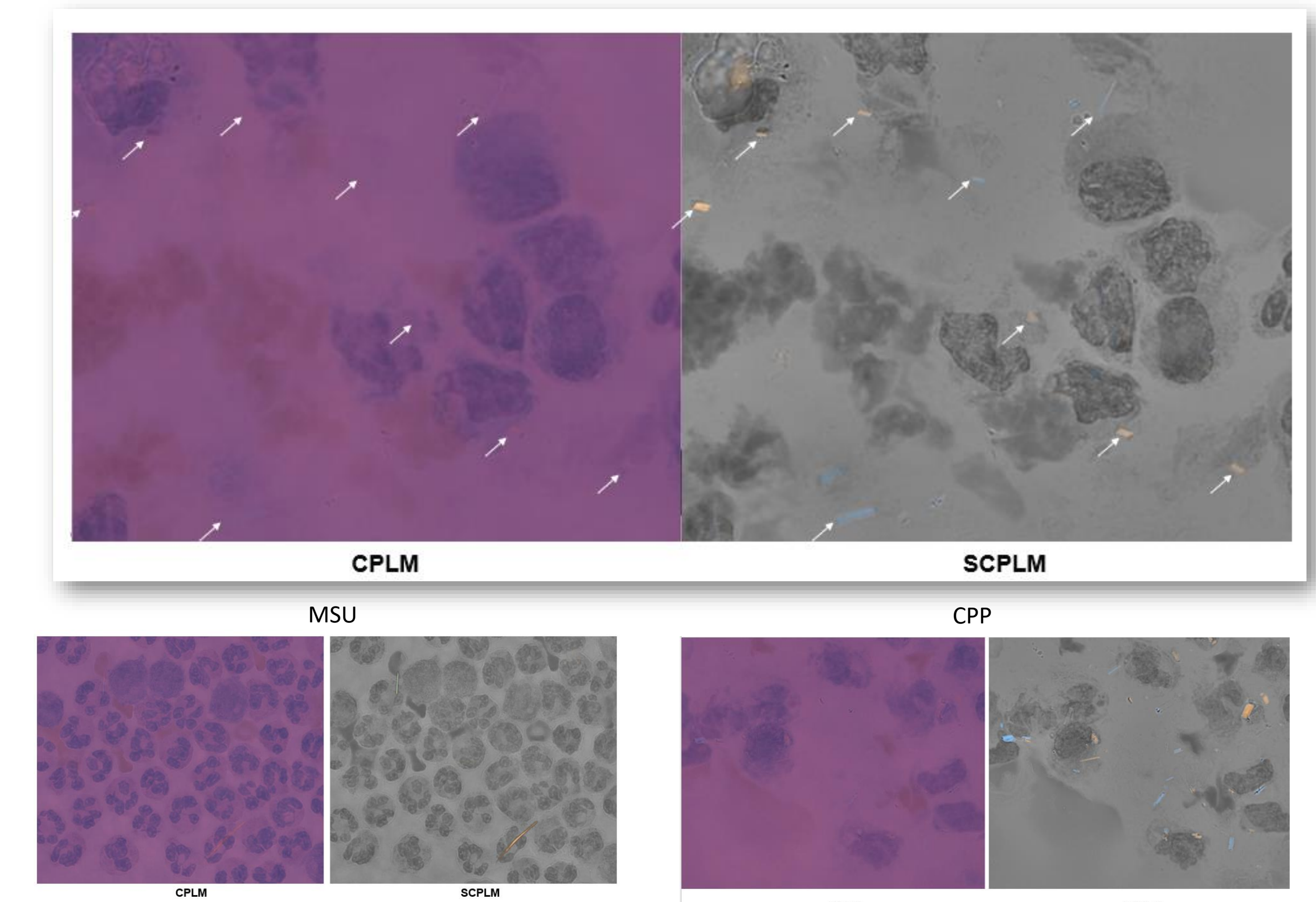
Future work: optimization of CPP and MSU crystal identification using automated scanning platform

METHODS

- In random order, 2 raters presented CPLM (2 paired images with analyzer at 90° angles) AND a single bright-field fused SCPLM image
- For each crystal detected, Raters scored their certainty (from 1-5) and type of crystal (MSU, CPP, other)
- Crystal suspects were selected for the analytic data set if:
 - Both raters scored a crystal with level 3 or higher for certainty (by either method)
 - For any crystal with 4 or higher score by only 1 rater, the PI served as tie-breaker.
- Agreement was determined using AUC, Sensitivity, Specificity, Detection. Raters' global preference (1-5) was scored comparing presented side-by-side FOV (CPLM vs SCPLM)

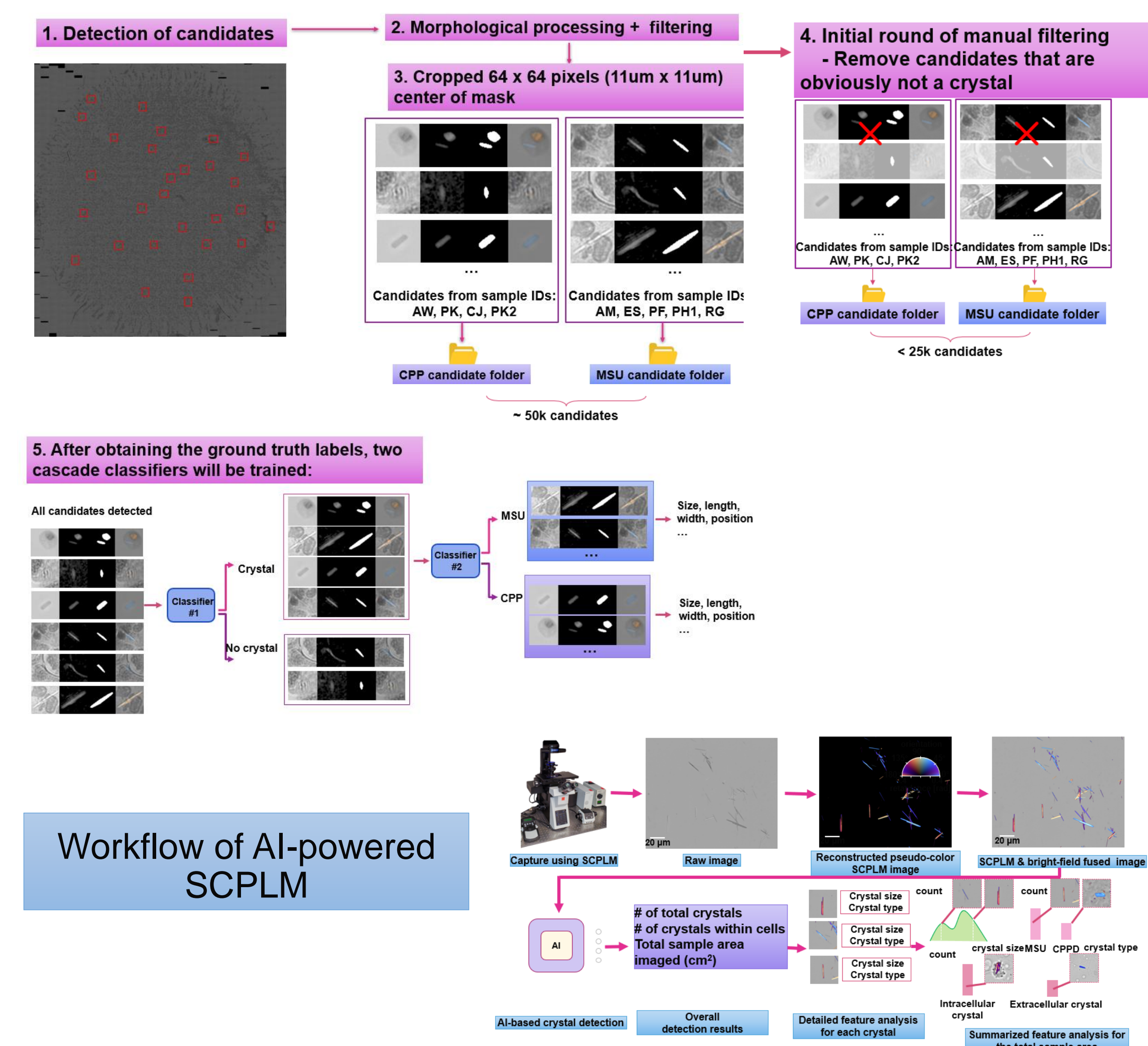
67 FOV images: 29 CPPD, 31 gout, and 7 negative controls

FIGURE 2: Side-by-side comparisons of CPLM vs SCPLM FOV



FUTURE WORK:

AUTOMATED CRYSTAL DETECTION/IDENTIFICATION REPORTS



Workflow of AI-powered SCPLM

REFERENCES

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- Zell M, Zhang D, FitzGerald J. Diagnostic advances in synovial fluid analysis and radiographic identification for crystalline arthritis. Curr Opin Rheumatol. 2019 Mar;31(2):134-143.