# DICOM-compatible compression of WSI and diagnostic evaluation

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Overview Digital Pathology (DP)
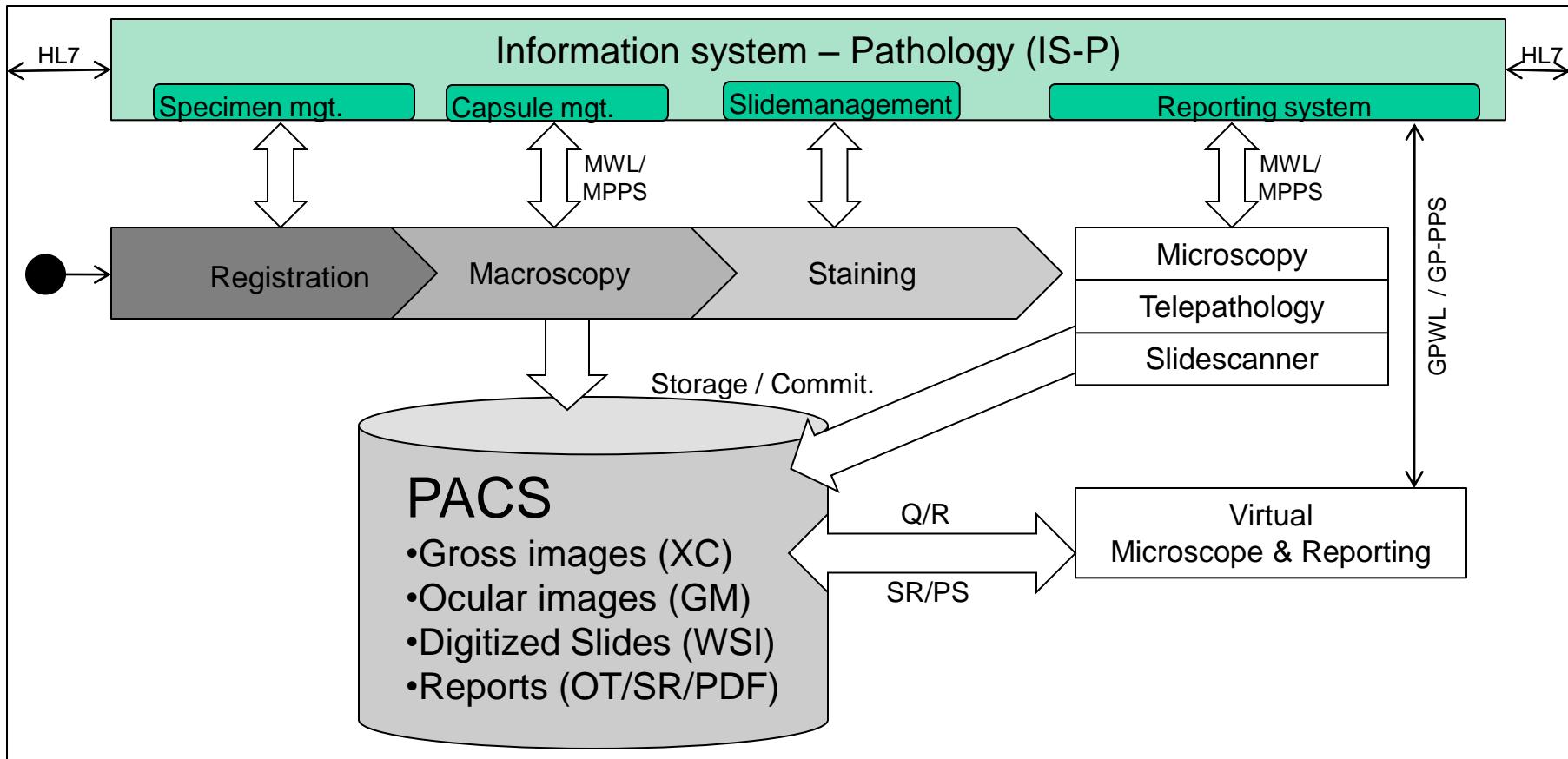
1. Future save integration in clinical infrastructure through DICOM
2. Organization of documents within a scalable information model (IM)
3. Query and retrieve out of this IM → Image distribution

Modality Worklist (MWL) – Specimen Identification

	SPCode	Modalität	Station	AE	Befunder	Behälter	Beschriftung	Präparat	Acc.No.	Ort
1		XC	Grosser Zuschnitt	Zuschnitt-A	Dr. Kalinski	Transportbehälter	H4487/03	H4487/03-3	ACC12348	
2	Multiangel 16 Gradteile	XC	AV Zentrum	FotoAcq-A	Dr. Kalinski	Glasbehälter	I12/97	H12/97-1	ACC12349	
3		GM	Mikroskop-B	WSIACQ-B	Dr. Kalinski	Objektträger Glas	H378/04	H378/04-1C4	ACC12347	
4	WSI Schichtdicke ein Mü	SM	Hamamatsu-A	WSIACQ-A	Dr. Kalinski	Objektträger Glas	H238/09	H14532/09-2A3	ACC12345	
5	WSI Schichtdicke ein Mü	SM	Hamamatsu-A	WSIACQ-A	Dr. Kalinski	Objektträger Glas	H238/09	H14532/09-1B1	ACC12346	

```
    E   0512 (8) Container Identifier (LO:1) H4487/03
 +  E   0513 (104) Issuer of the Container Identifier Sequence (SQ:1) unassigned
 +  E   0518 (74) Container Type Code Sequence (SQ:1) unassigned
    E   051A (18) Container Description (LO:1) Transportbehälter
 -  E   0560 (312) Specimen Description Sequence (SQ:1) unassigned
       P  LoadFromStream
       -  G  Group 0040
          +  E   0000 (4) Group Length (UL:1) 292
             E   0551 (10) Specimen Identifier (LO:1) H4487/03-3
             E   0554 (24) Specimen UID (UI:1) 1.11365836.1300.1004.1.3
          +  E   0562 (104) Issuer of the Specimen Identifier Sequence (SQ:1) unassigned
          +  E   059A (68) Specimen Type Code Sequence (SQ:1) unassigned
             E   0600 (6) Specimen Short Description (LO:1) Leber
             E   0602 (8) Specimen Detailed Description (UT:1) proximal
             E   0610 (0) Specimen Preparation Sequence (SQ:1) unassigned
    E   1001 (8) RP-Id (SH:1) RP12348
    E   1003 (0) RP-Priority (SH:1) unassigned
```

- Specimen information and workflow communication according to DICOM requires extensions from Supplement 122.

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Macroscopic Images (Clinic)
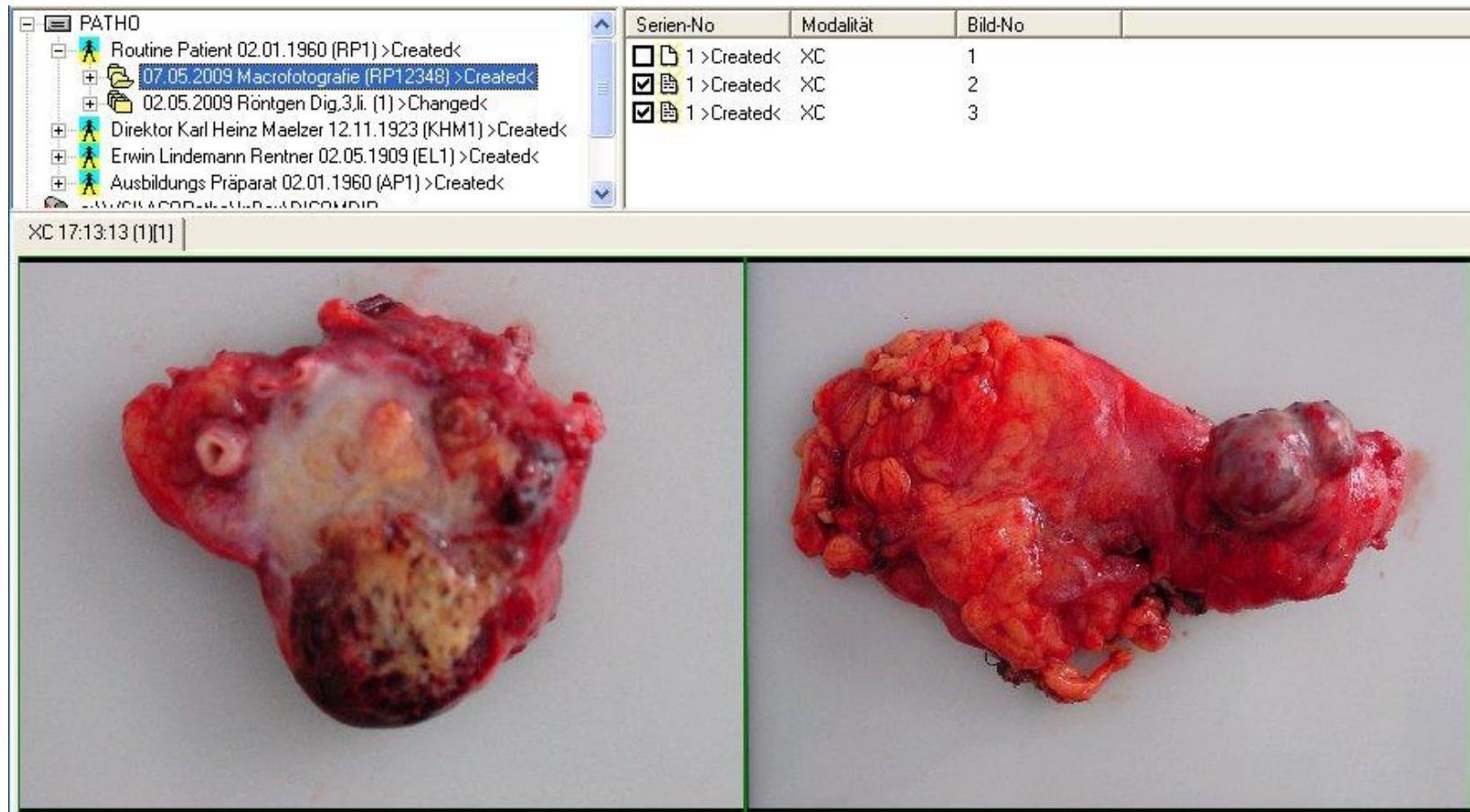
- DICOM Class Visible Light Photographic is sufficient
- Specimen ids required → Supplement 122

Macroscopic Images (Teaching & Learning)
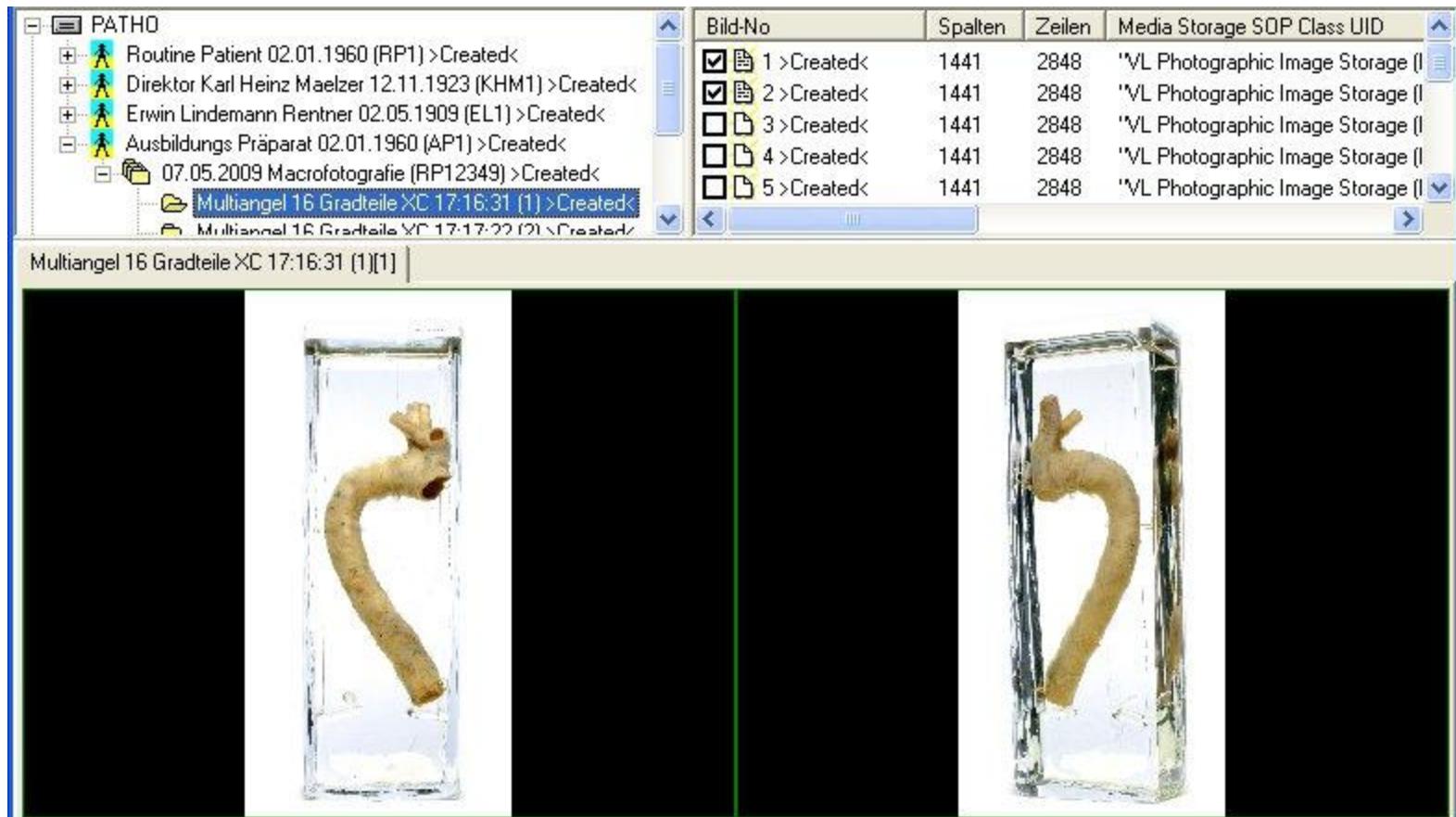
- DICOM Class Visible Light Photographic is not sufficient.
- Multi frame module needed

Microscopic Ocular Images
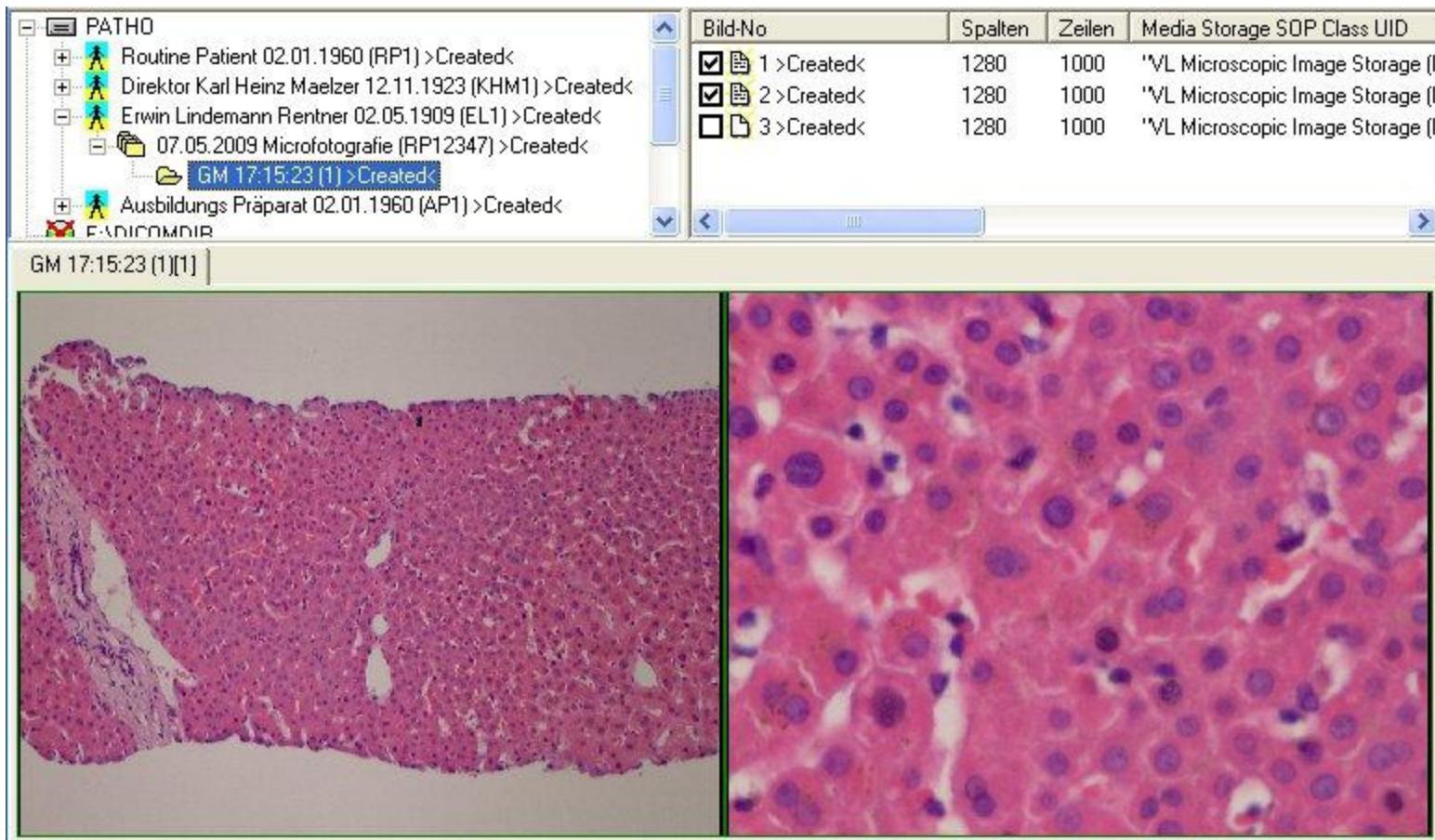
- DICOM Class Visible Light Microscopic is sufficient
- Single images in series

Whole Slide Images (WSI)
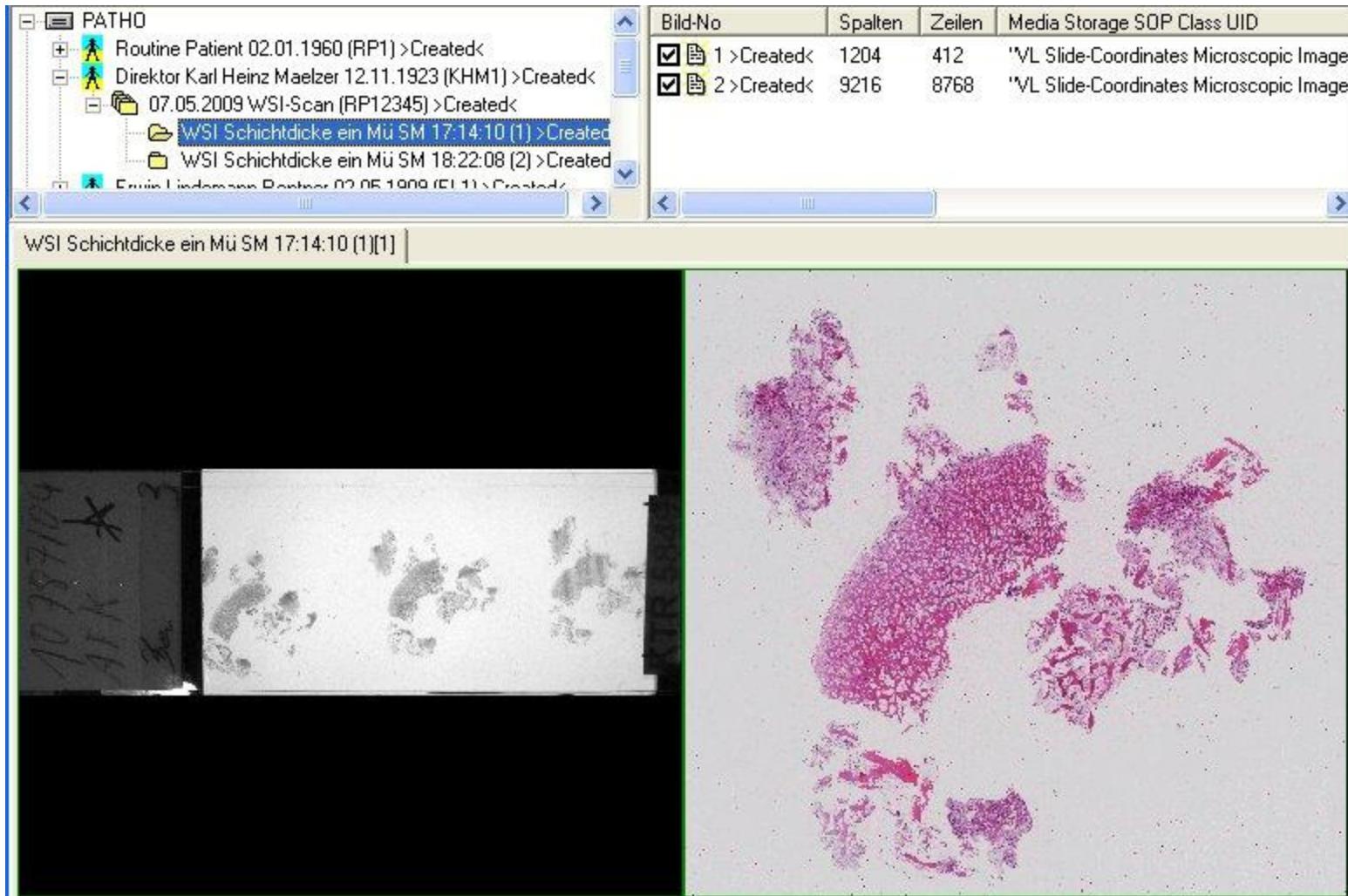
Whole Slide Images (WSI)
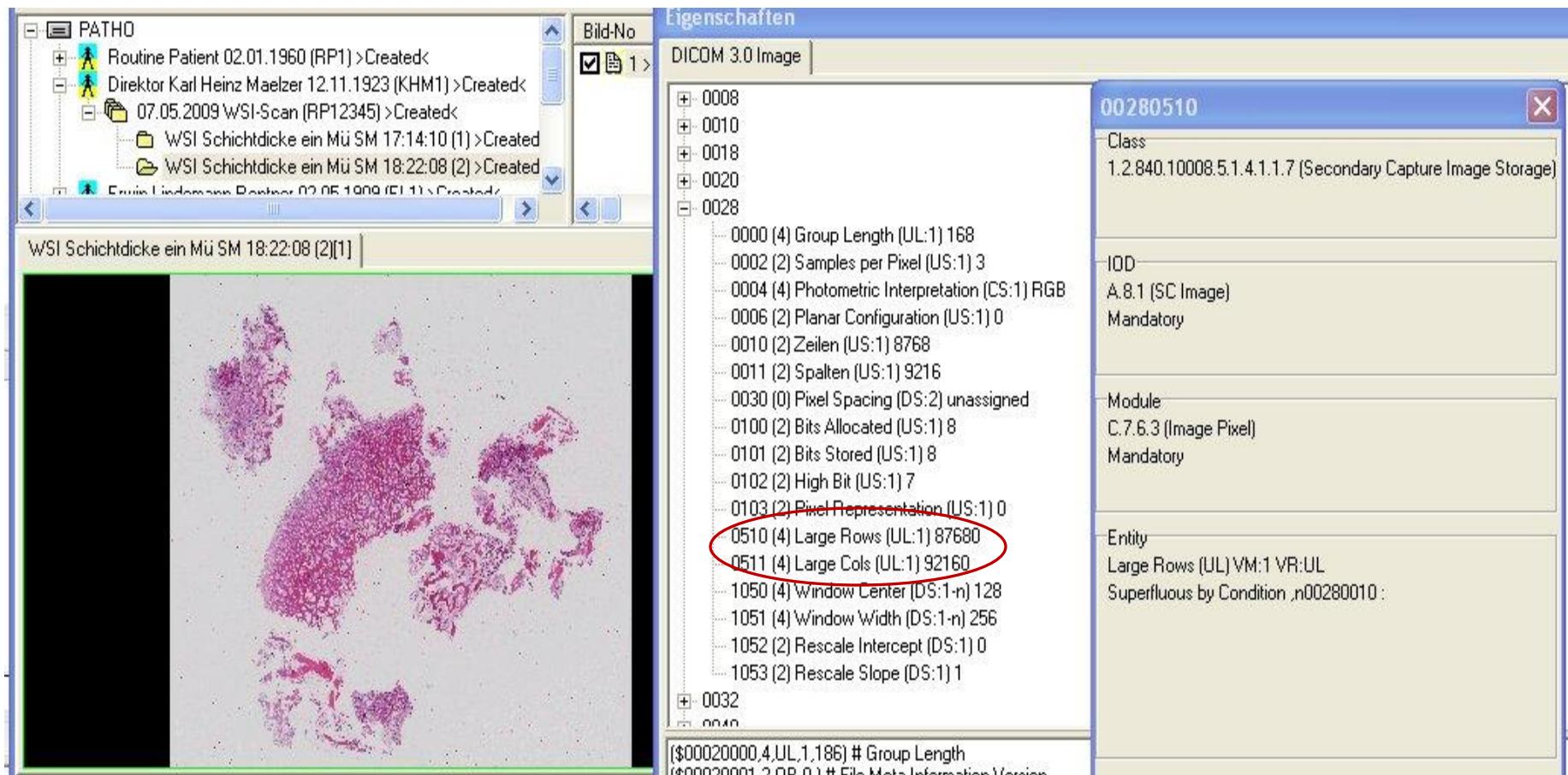
- DICOM Class Visible Light Slide Coordinates is not sufficient
- Multi frame module and Large-Dimension-Tags needed

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Radiologic Image Distribution - DICOM (store and forward)
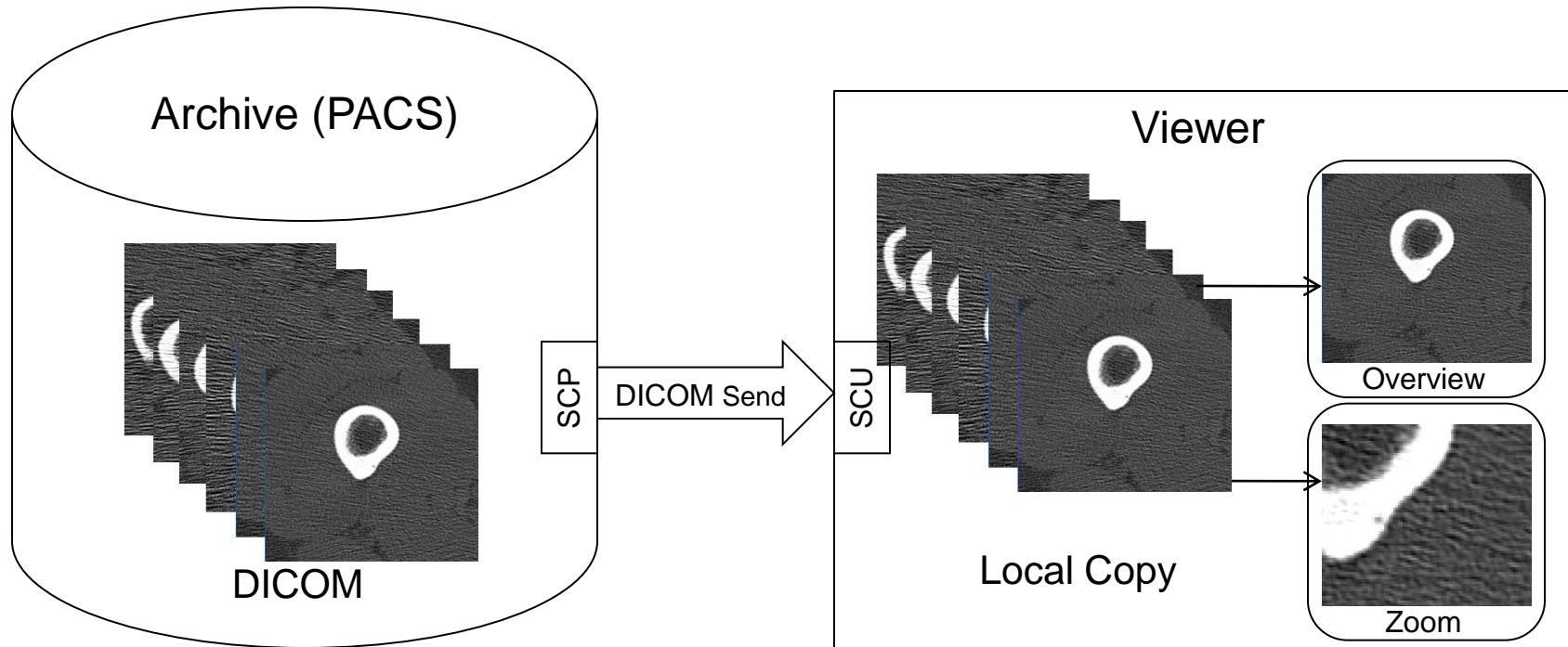
- Display after complete transport only
- → Store and forward is not sufficient for very large WSI images
- → Integration of JPIP in DICOM solves this problem by streaming

Image Distribution „Fractioning" (e.g. silverZoom , Zoomify)
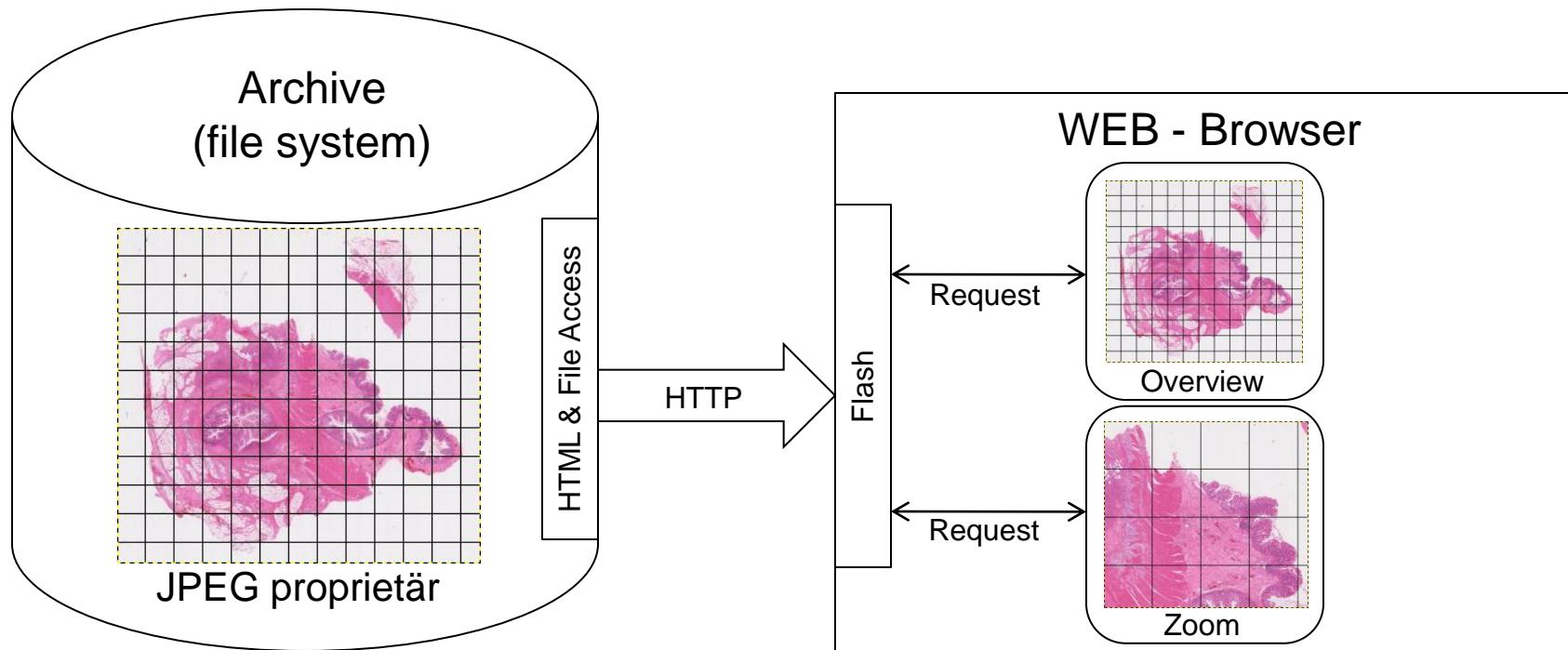
- Image fractioning results in higher resource loads
- Problems possible by active parts in browser (e.g. Flash)
- Non-standard format und protocol, no integration in DICOM
→ Not sufficient for future save archiving huge amount of data

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Image Distribution - JPEG2000 / JPIP (AJAX)
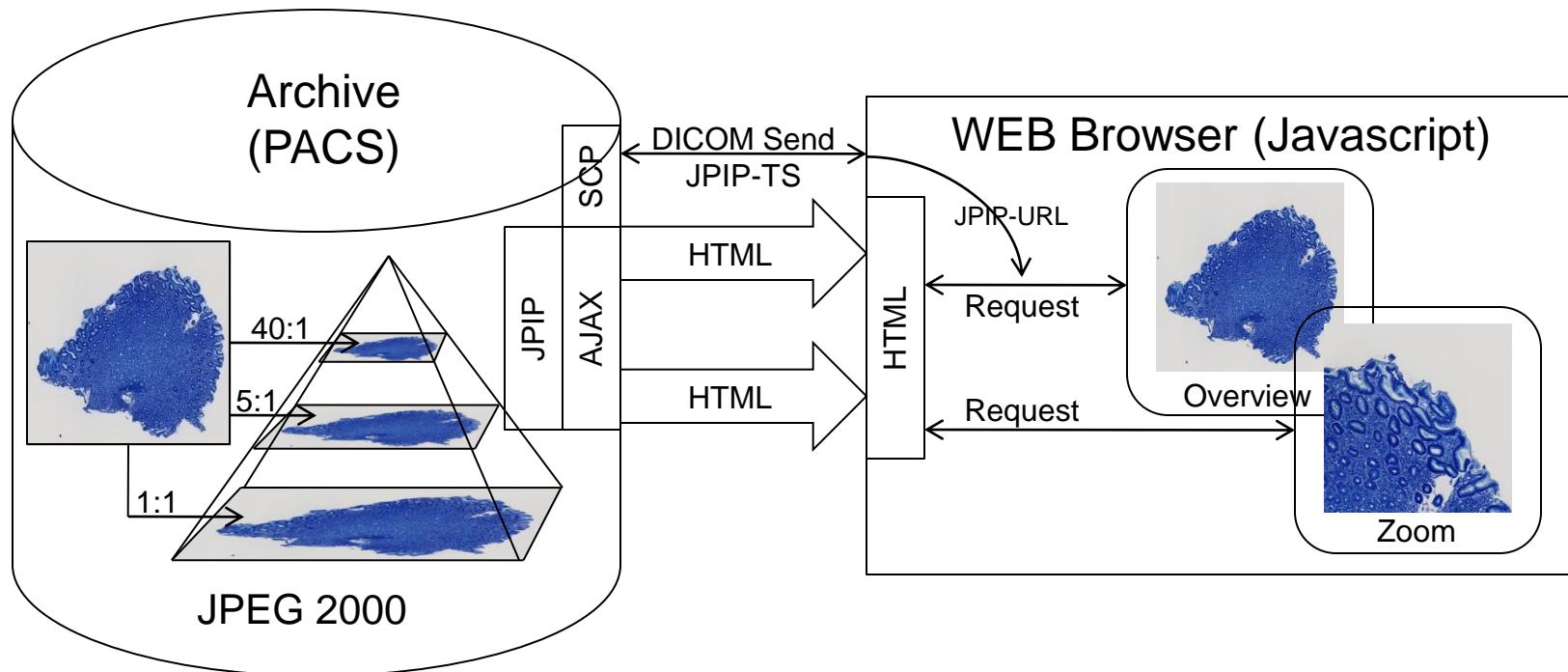
- Image calculation on demand on server.
- Access to JPEG2000 images through JPIP or directly.
- Parallel usage for intra- and internet possible, one format only.
→ Sufficient for intranet and internet but elaboration on server.

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Technical Requirements Image Compression

	JPEG2000	JPEG
Integration in DICOM	yes	yes
Image quality (over all lossy)	1	3
Efficiency	3	1
→ Effort for coding and decoding		
Data organization und flexibility	1	5
→ Growing amounts, all sizes and kinds of images		
Autonomy	2	4
→ Future save		
Scalable with use case	1	4
→ Supports image distribution with progressive requests		
Only one Algorithm (lossy and lossless)	1	5
→ Format supports all criteria	yes	no

Current WSI Approaches

„Large Dimensions"

Scanner

vendordependent

DICOM

* CP-896

PACS

DCM

JPEG2000

JPIP / HTML

Supplement 145

Scanner

Distribution

vendordependent

proprietär

Propr. HTML

DICOM

PACS

DCM
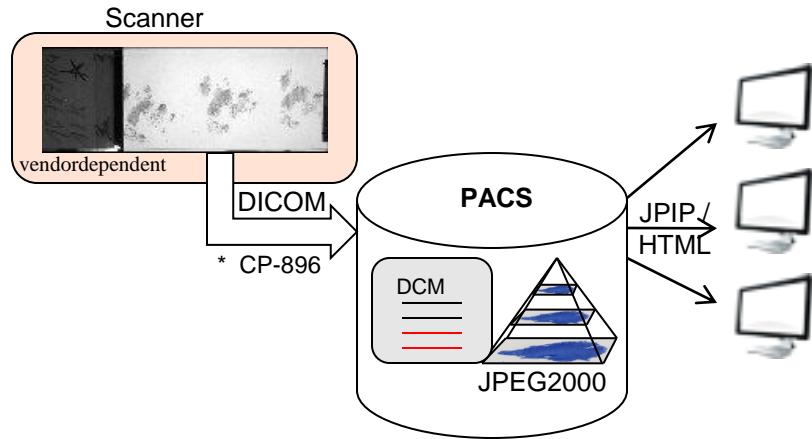
- New tags for large dimensions or extended negotiation (*)
- DICOM Header & JPEG2000
- Image distribution out of archive
- Vendor independent
- Synergies with other image classes
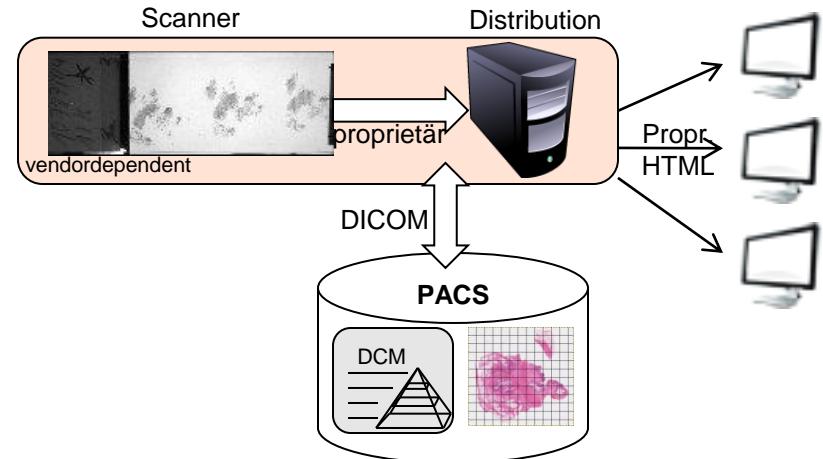
- Fractions instead of huge images
- DICOM Header contains progressive information
- Extra distribution needed
- Dependency on propr. distribution
- No synergy effects

Summary so far …

- ## DICOM is usable for Digital Pathology
  - → Supplement 122 functional
  - → Worklist and MPPS are sufficient
  - → Existing image classes with multi frame applicable
  - → JPEG2000 integration for lossy encoding and streaming

- ## JPEG2000
  - → Image distribution for all image types and transports with JPIP / AJAX
  - → Efficiency depends on optimization

- ## DICOM WSI
  - → Supplement 145 introduces image fractioning
  - → Large dimensions anticipated, even optional
  - → Usability of old archives for WSI image distribution doubtful

- ## Diagnostic Evaluation
  - → Lossy compression up to 75:1 applicable to biopsy images
  - → Other image contents to be evaluated

Can we trust virtual microscopy in diagnostic pathology?
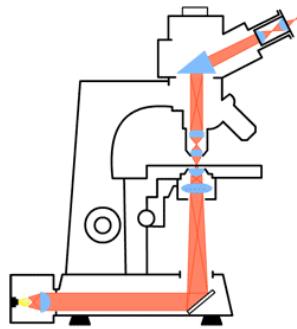
Essential functions of
   conventional microscopes:

- Magnification

- Focusing

- Polarizing

Scanner conditions (as provided):

- Uncompressed raw data

- Resolution (0,23 µm/pixel)

- Multiplane images

→ Comparative investigations on the diagnostic accuracy using conventional
   microscopy or virtual microscopy with different qualities

Can we trust virtual microscopy in diagnostic pathology?
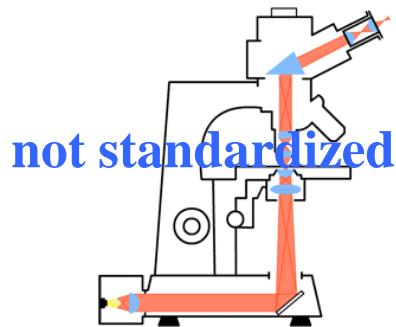
not standardized


standardized

Essential functions of
    conventional microscopes:

- Magnification
- Focusing
- Polarizing

Scanner conditions (as provided):

- Uncompressed raw data
- Resolution (0,23 μm/pixel)
- Multiplane images

→ Comparative investigations on the diagnostic accuracy using conventional
    microscopy or virtual microscopy with different qualities

To begin with... Helicobacter gastritis.
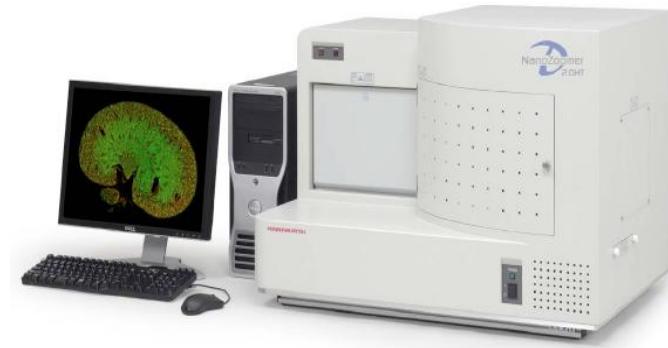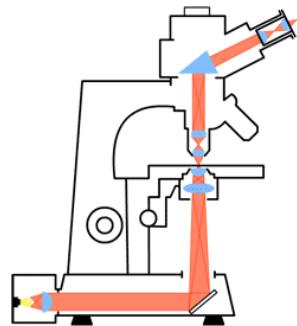
Updated Sydney-classification:

- Comparable grading of Helicobacter gastritis:
    - very coarse criteria:
        - intestinal metaplasia (Grades 0,1,2,3)
        - atrophy (Grades 0,1,2,3) [not applicable in our studies]
    - coarse criteria:
        - chronic inflammation (Grades 0,1,2,3)
        - activity of inflammation (Grades 0,1,2,3)
    - fine criteria:
        - Helicobacter colonization (Grades 0,1,2,3)
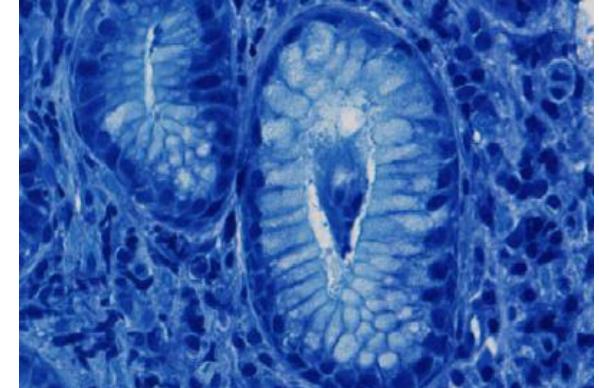
Do we need focusing for the correct diagnosis?

Am J Clin Pathol 2008;130:259-264
**Virtual 3D Microscopy Using Multiplane Whole Slide Images in Diagnostic Pathology**

Thomas Kalinski, MD,[1] Ralf Zwönitzer,[2] Saadettin Sel, MD,[1] Matthias Evert, MD,[1,3] Thomas Guenther, MD,[1] Harald Hofmann,[4] Johannes Bernarding, MD,[2] and Albert Roessner, MD[1]

Comparative Study No.1:

- 144 gastric biospies with/without Helicobacter gastritis

- 3 consultant pathologists:
    - conventional microscopy versus:
    - 1. virtual 2D microscopy (single focus plane)
    - 2. virtual 3D microscopy (5 focus planes)
    - 3. virtual 3D mircoscopy (9 focus planes)

- Standard format: JPEG2000; Compression: 20:1
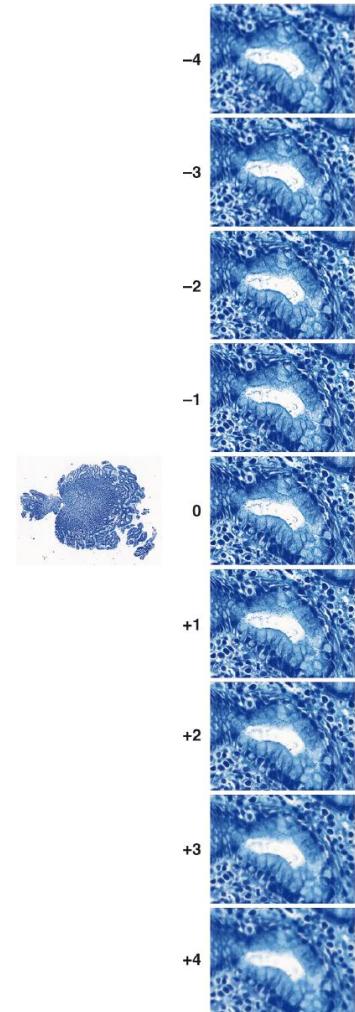
Results:

→ Virtual 3D microscopy with 9 focus planes is required for the correct diagnosis of ‚fine‘ criteria such as Helicobacter colonization
[specificity/sensitivity: ≥0.95; kappa: 0.9]

→ Virtual 2D microscopy is sufficient for ‚coarse‘ criteria

# Compression in virtual 3D microscopy -- where is the limit?

Lossy compression in diagnostic virtual 3-dimensional microscopy—where is the limit?

Thomas Kalinski MD[a],*, Ralf Zwönitzer[b], Florian Grabellus MD[c], Sien-Yi Sheu MD[c], Saadettin Sel MD[a], Harald Hofmann[d], Johannes Bernarding MD[b], Albert Roessner MD[a]

Comparative Study No.2:

- 46 gastric biospies with/without Helicobacter gastritis
- 3 consultant pathologists:
    - conventional microscopy versus:
    - 1. virtual 3D microscopy (9 focus planes); Compression 20:1 (no visible artifacts)
    - 2. virtual 3D microscopy (9 focus planes); Compression 40:1
    - 3. virtual 3D microscopy (9 focus planes); Compression 50:1   (little artifacts)
    - 4. virtual 3D microscopy (9 focus planes); Compression 75:1
    - 5. virtual 3D microscopy (9 focus planes); Compression 200:1 (clearly visible artifacts)
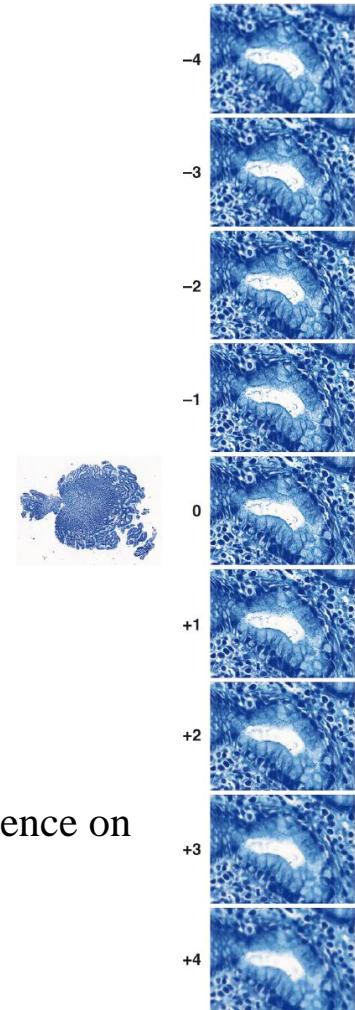
Results:

→ Even high compression rates with clearly visible artifacts have little influence on the diagnostic accuracy in Helicobacter gastritis!

Can we really do without uncompressed virtual slide?

Comparative Study No.3:

- 46 gastric biospies with/without Helicobacter gastritis

- 3 consultant pathologists:
    - conventional microscopy versus:
    - 1. virtual 3D microscopy (9 focus planes); Compression 1:1 (no compression)
    - 2. virtual 3D microscopy (9 focus planes); Compression 5:1
    - 3. virtual 3D microscopy (9 focus planes); Compression 10:1
   - 4. virtual 3D microscopy (9 focus planes); Compression 20:1
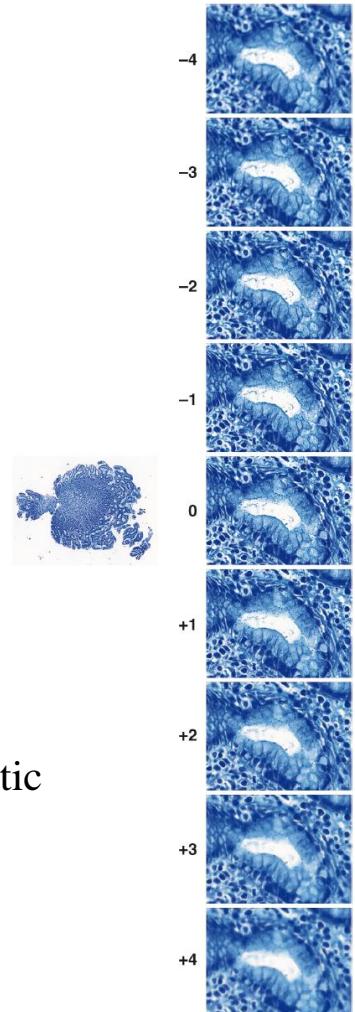
Results:

→ Uncompressed or nearly uncompressed slides do not enhance the diagnostic accuracy!

What are the remaining questions?

Next comparative studies on lossy compression:

- Where is the limit in diagnostic virtual (2D/3D) microscopy regarding diverse diagnoses?
- → Where is the limit in *image analysis*?

→ Towards a definition of the minimum image quality required in diagnostic virtual microscopy.
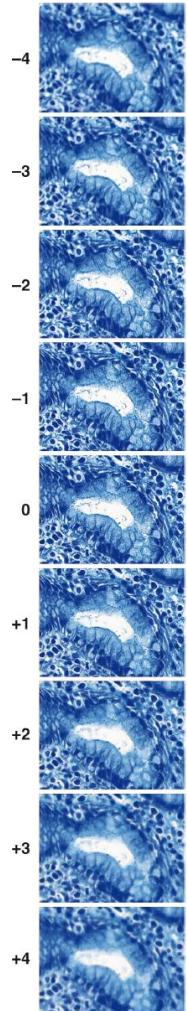
Thank you very much
for your attention.