

# Virtual Microscopy in Routine Pathology

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## What do we need?

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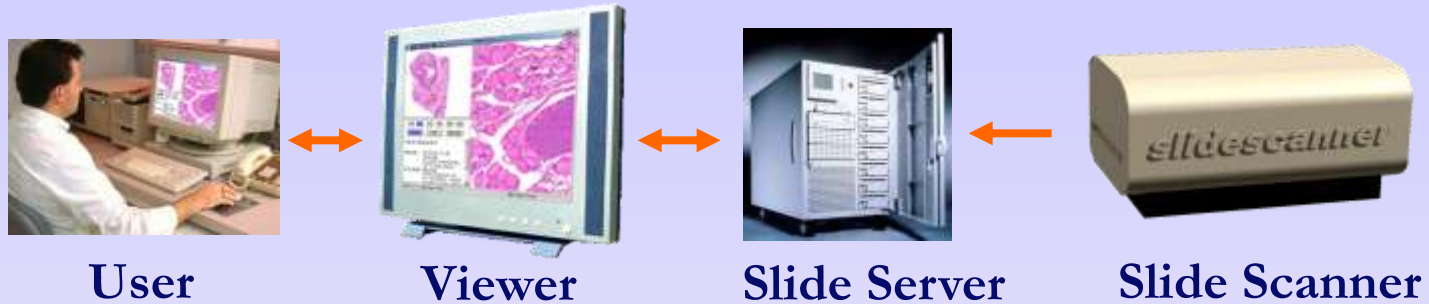
# Talk at a Glance

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- Advantages of VM
- Problems with introduction in routine pathology
- Solutions
  - Speed
  - Handling
  - PLIS Integration
  - Imaging
- Conclusions



# Advantages of Virtual Microscopy



- No glass archive, no glass transportation
- Microscopic diagnostic anytime anywhere
- Parallel viewing of different stainings, positions
- Viewing and handling parallel at different locations
- Image analysis just in time
- Annotations are simple to handled



# Pathologist Look on Virtual Microscopy

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- No necessity to use VM now
- Image quality is better in conventional microscopes
- Introduction of VM must have positive financial effects
- Navigation of WSI is not efficient and slow
- Storage is needed and expansive
- Added value is not visible
- Legal problems – allowed for routine use?



# Storage requirement, Scanning time

- 1 day, 400 cases, 10 slides per case 4 TB
- 1 month 88 TB
- 1 year 1056 TB
- Charité radiology department /month 1,8 TB
  
- 3000 biopsies (1,5 cm<sup>2</sup>) 4500 minutes
- 1000 surgical slides (4 cm<sup>2</sup>) 6000 minutes
- Total time for scanning (Hmamatsu) 10500 minutes  
175 hours

7 Scanner work 24 hours

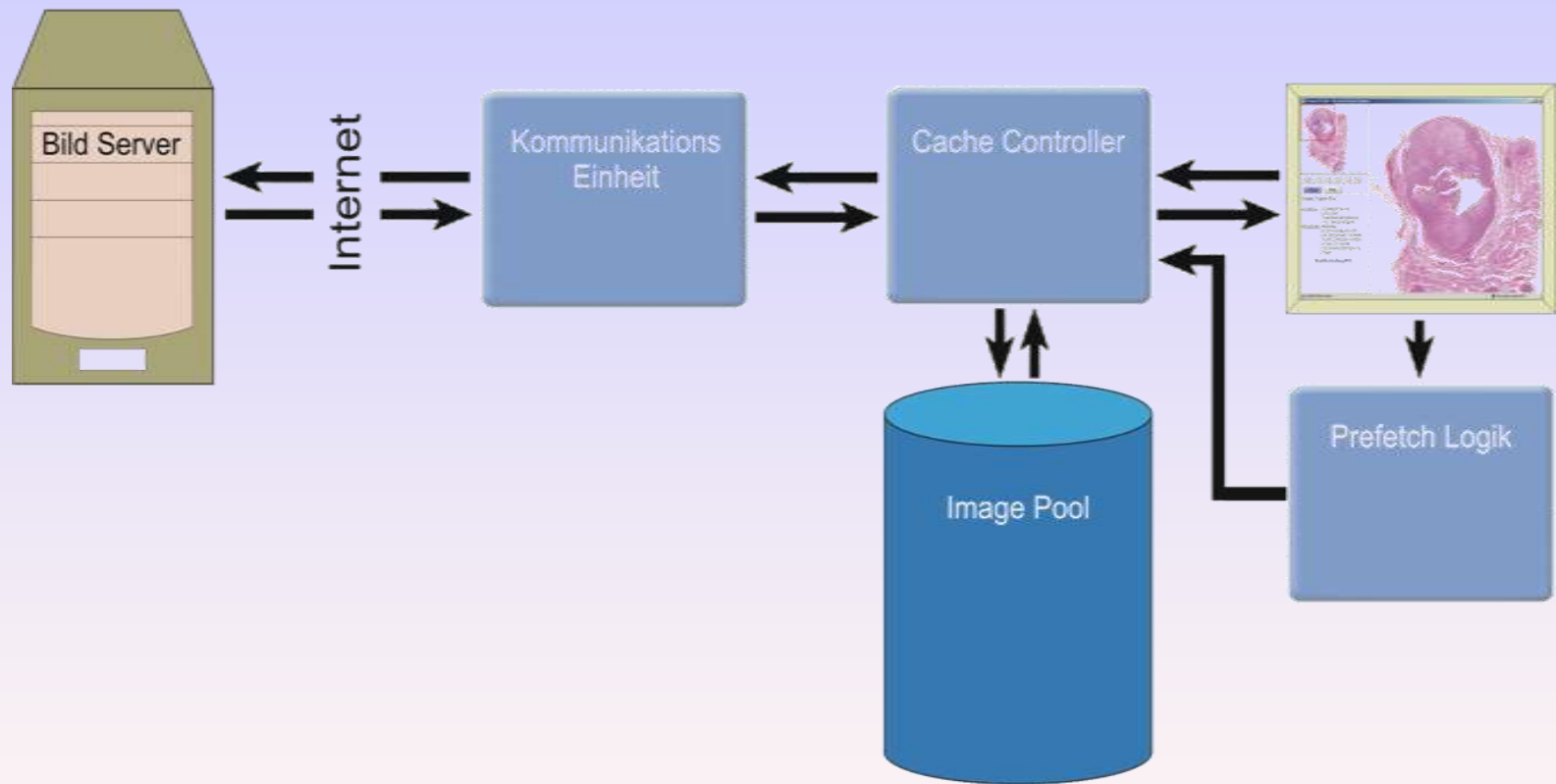


# **SPEED up using Diagnostic Path**

- **Pathologists analyse between 2 and 30 ‰ of a WSI for diagnostic purposes**
- **For second opinion in breast cancer between 2 and 9 ‰ of the WSI area have been measured**  
(measured on T.Konsult of the Berufsverband Deutscher Pathologen e.V)
- **The diagnostic paths depend on the material, the kind of diagnostic (first, second opinion) and the complexity of the diagnostic problem**

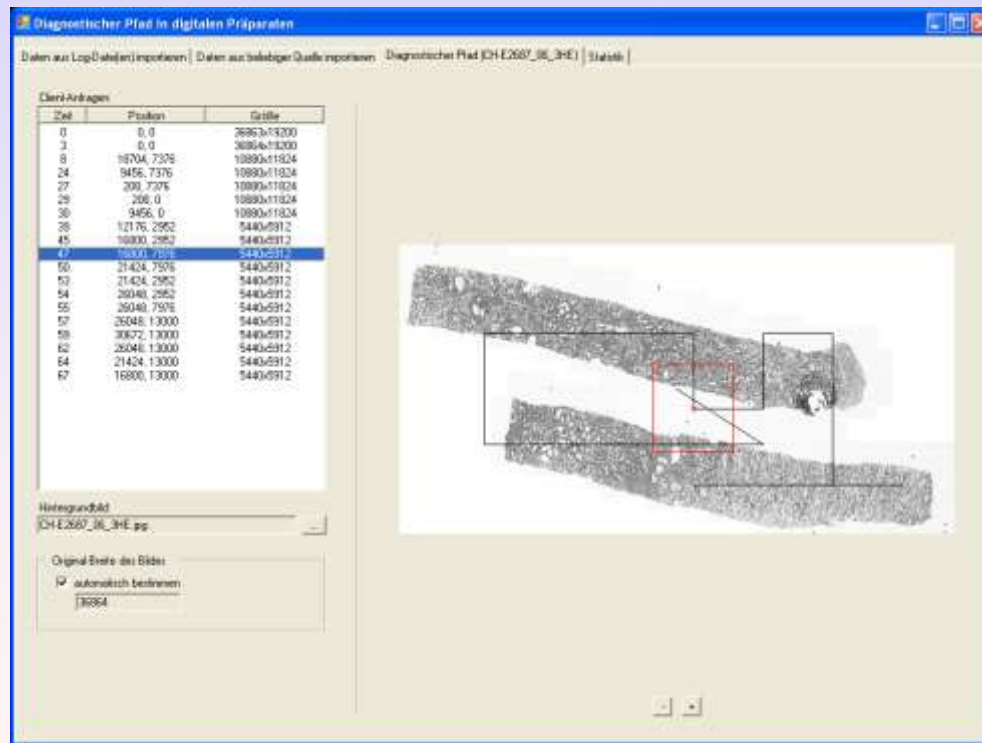


# Caching and Prefetching



# Prefetching

Optimal pre-fetching corresponds to pathologists way through the WSI

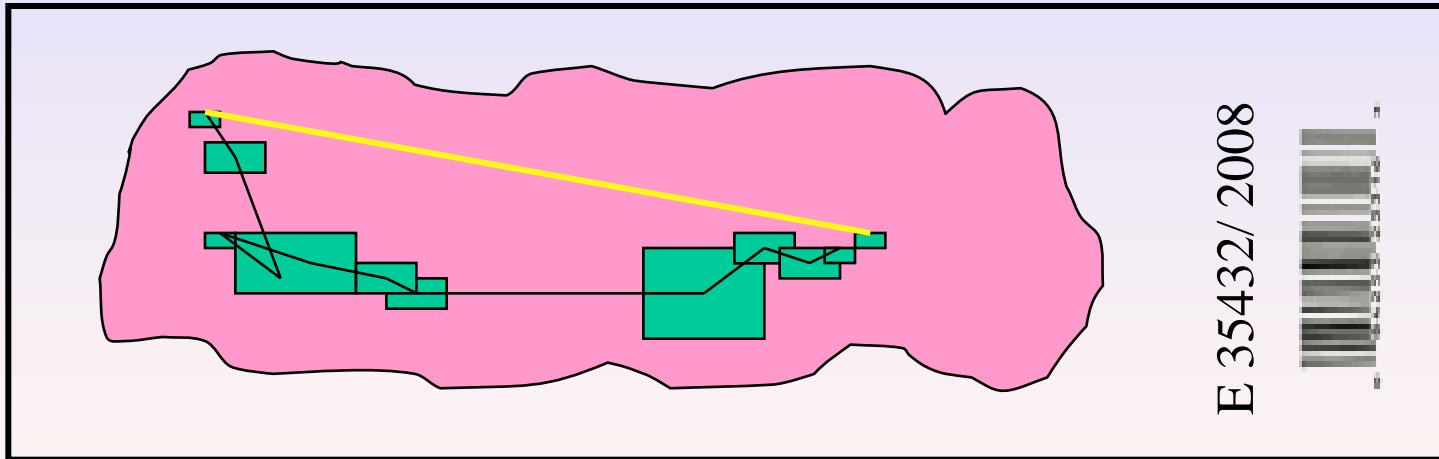




# Linearity

Euclidean distance  
between the starting and  
the end point divided by  
the length of the way  
between these points

Linearity lies between  
0 – fuzzy  
1 – all points in one line



# Material

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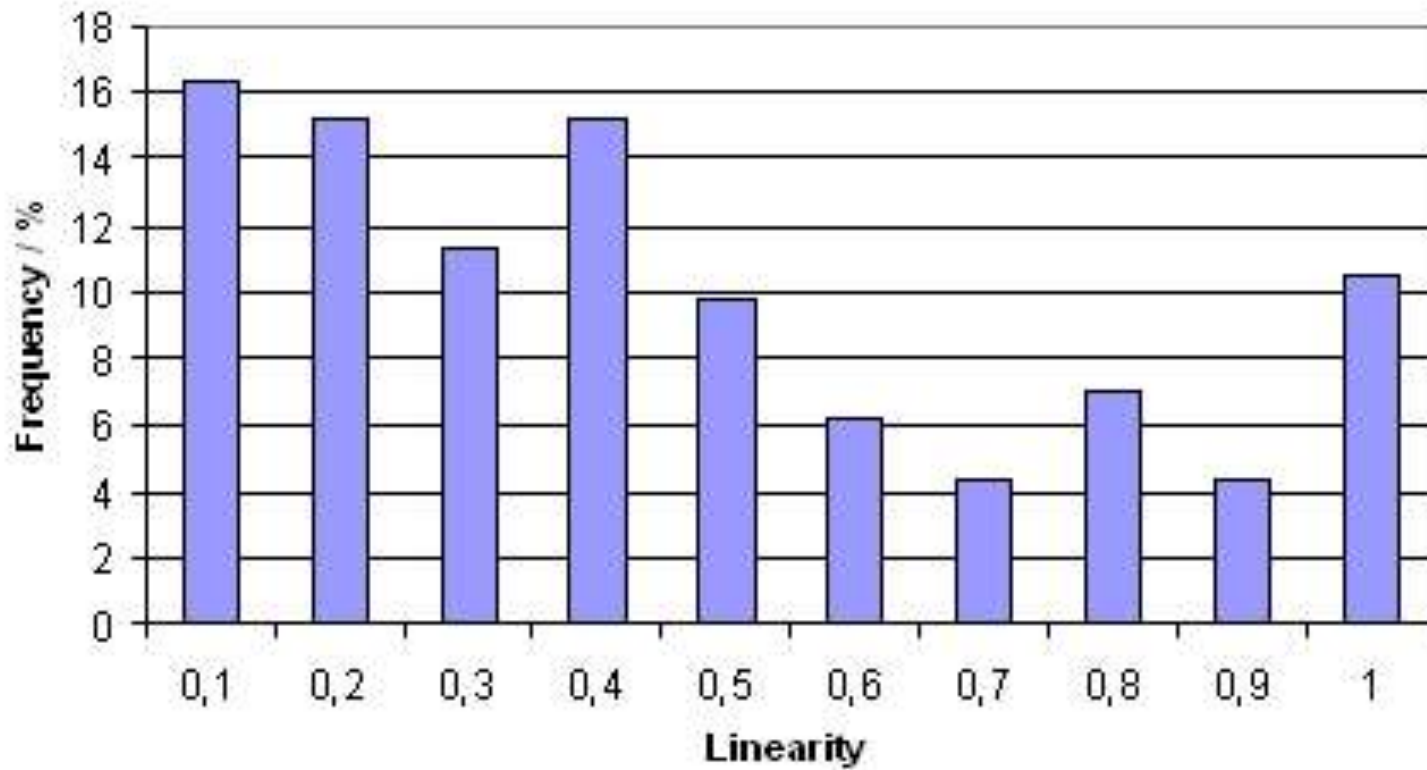
In total 257 diagnostic paths from 131 WSI have been extracted and analysed.

Glass slides were scanned with three scanners (Olympus .Slide, Zeiss Mirax, Hamamatsu Nanozoomer).

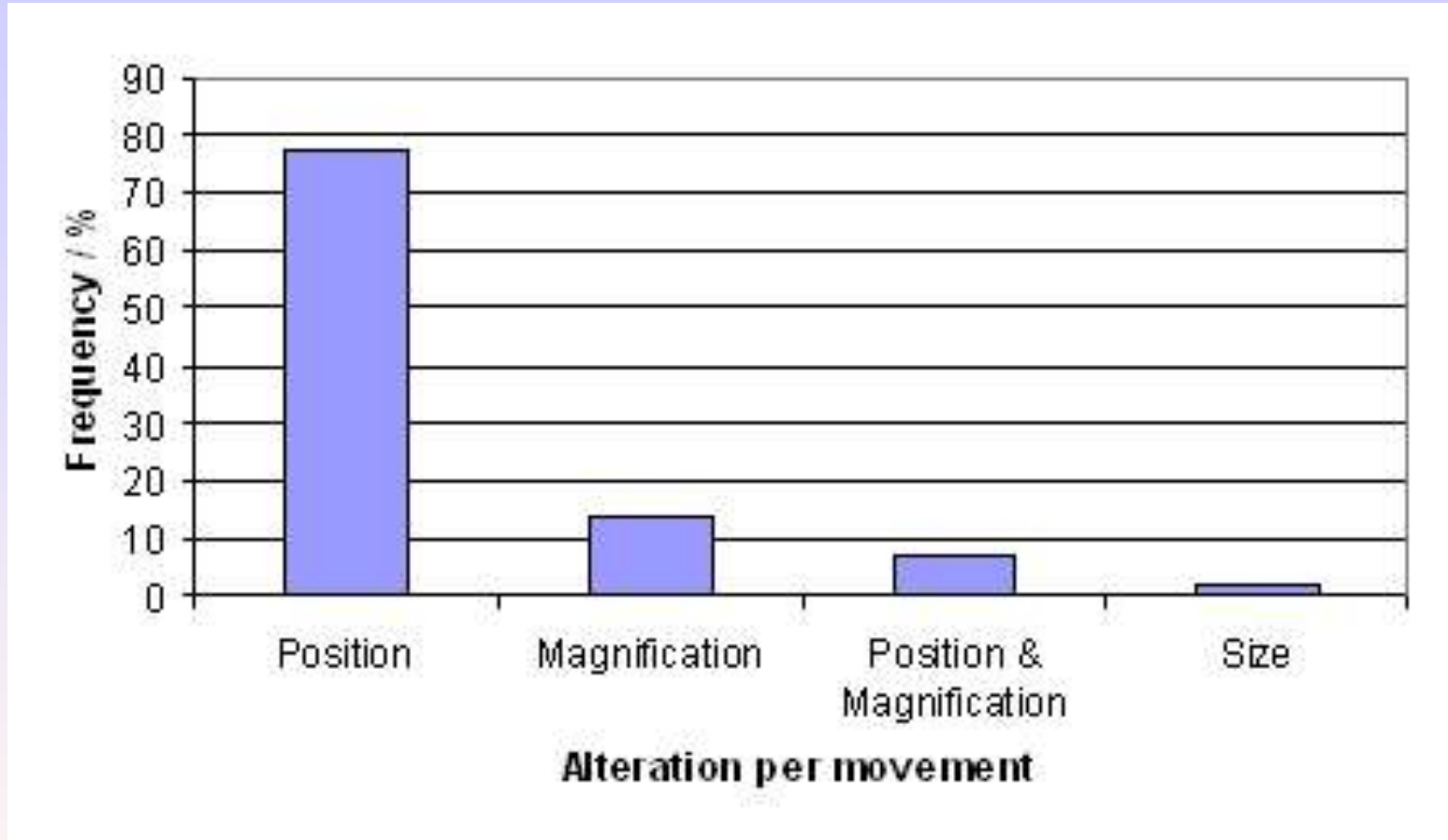
On average a diagnostic path consists of 16 image requests and takes 189 seconds between first and last image request.



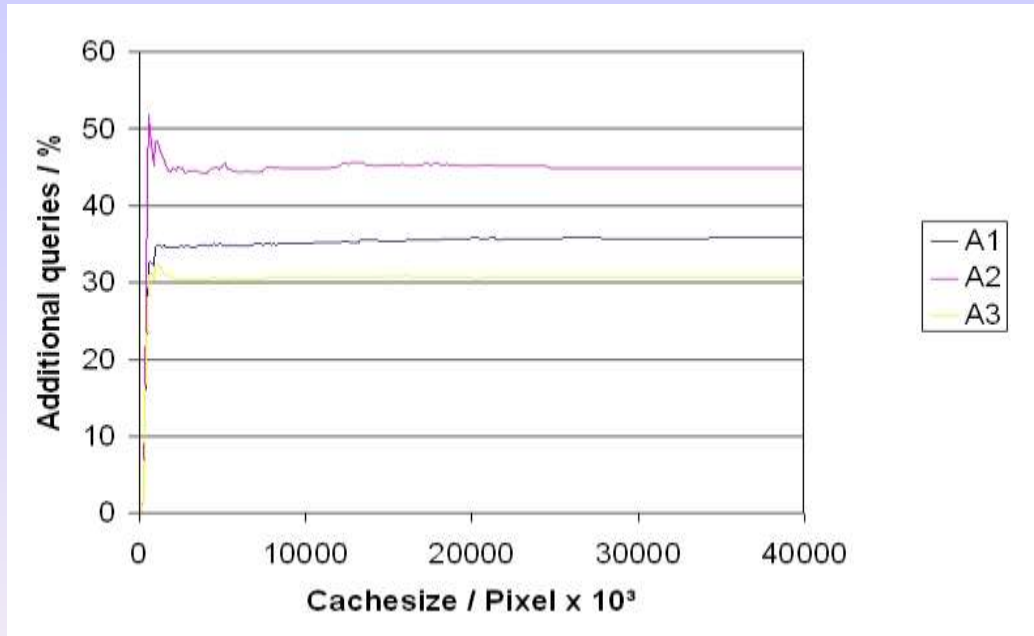
# Frequency of Linearity



# Frequency of Alterations per Movement



# Additional Queries for Algorithms A1, A2, A3



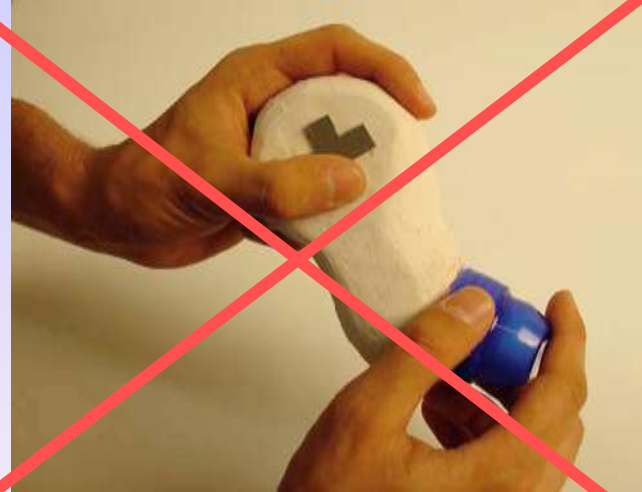
**Optimal algorithm for second opinion in breast cancer is A3.**

**Up to two three times faster.**

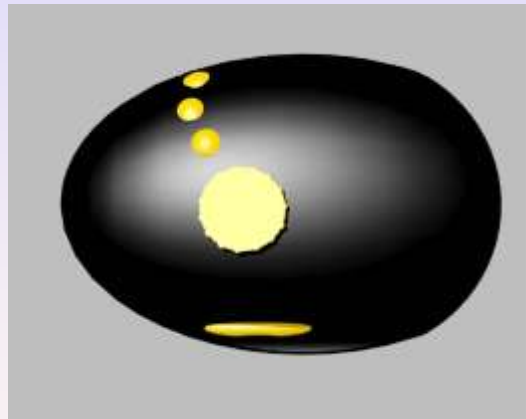


# HANDLING Optimize Man Machine Interface

- Simple
- Intuitive
- Fast
- One hand tool
- Does not tire pathologists
- Usable for left and right hand



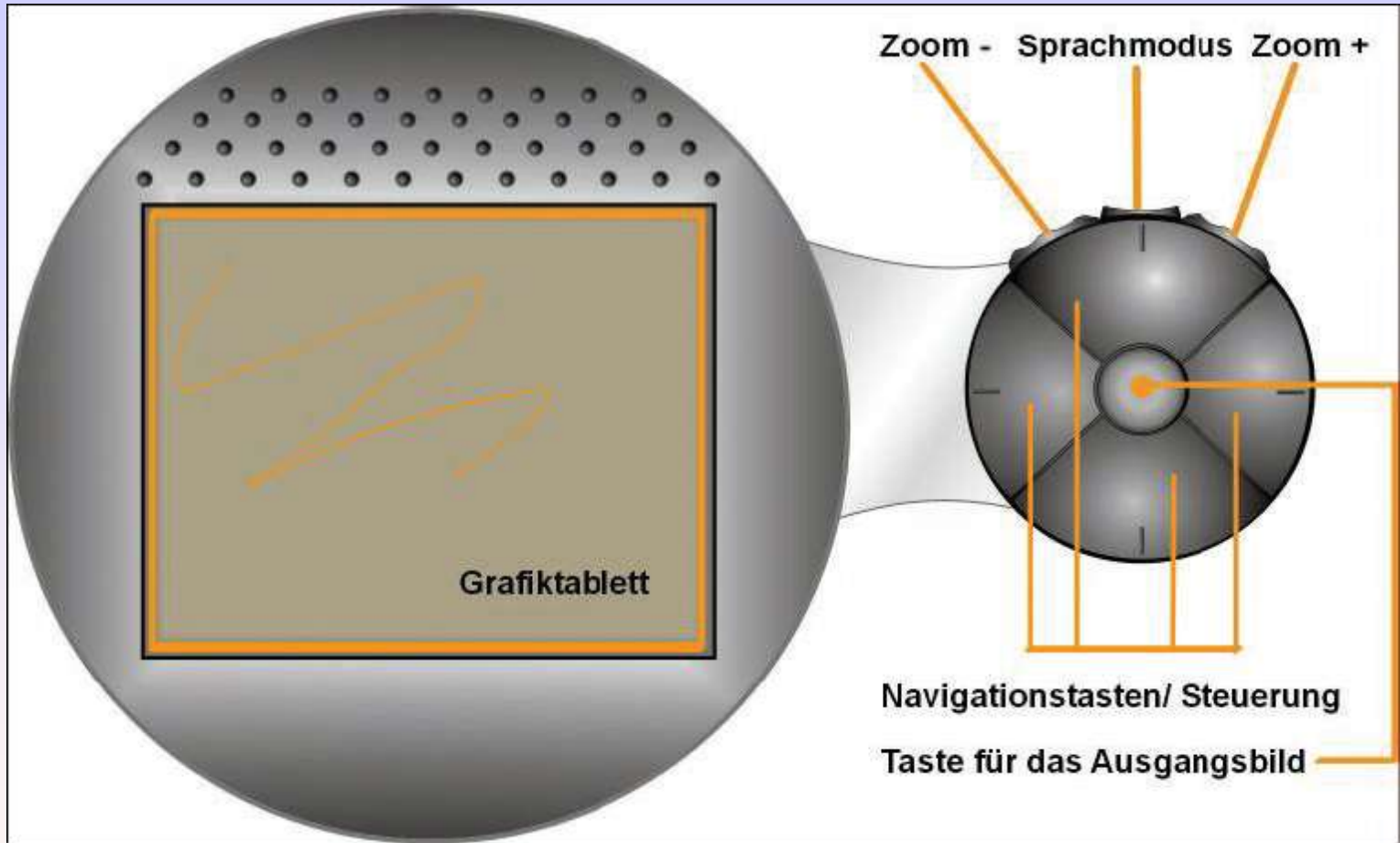
# VM Navigation



**Results of design studies by students, Uni Magdeburg**



# VM Navigation





# VM Commercial Navigation Tools

**Space Navigator**



**Space Pilot**



**Space Explorer**





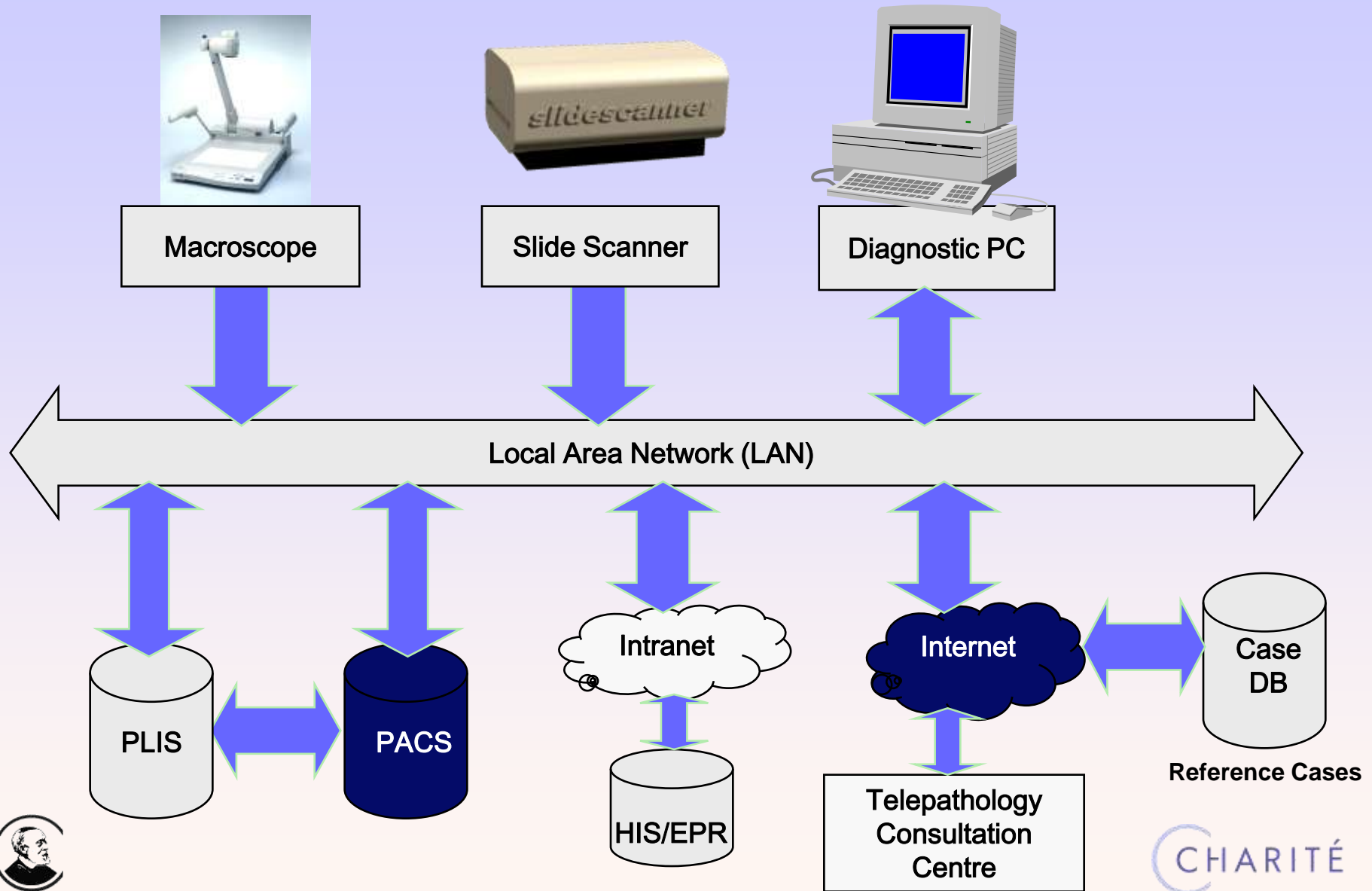
# EFFICIENCY – Integration to PIS

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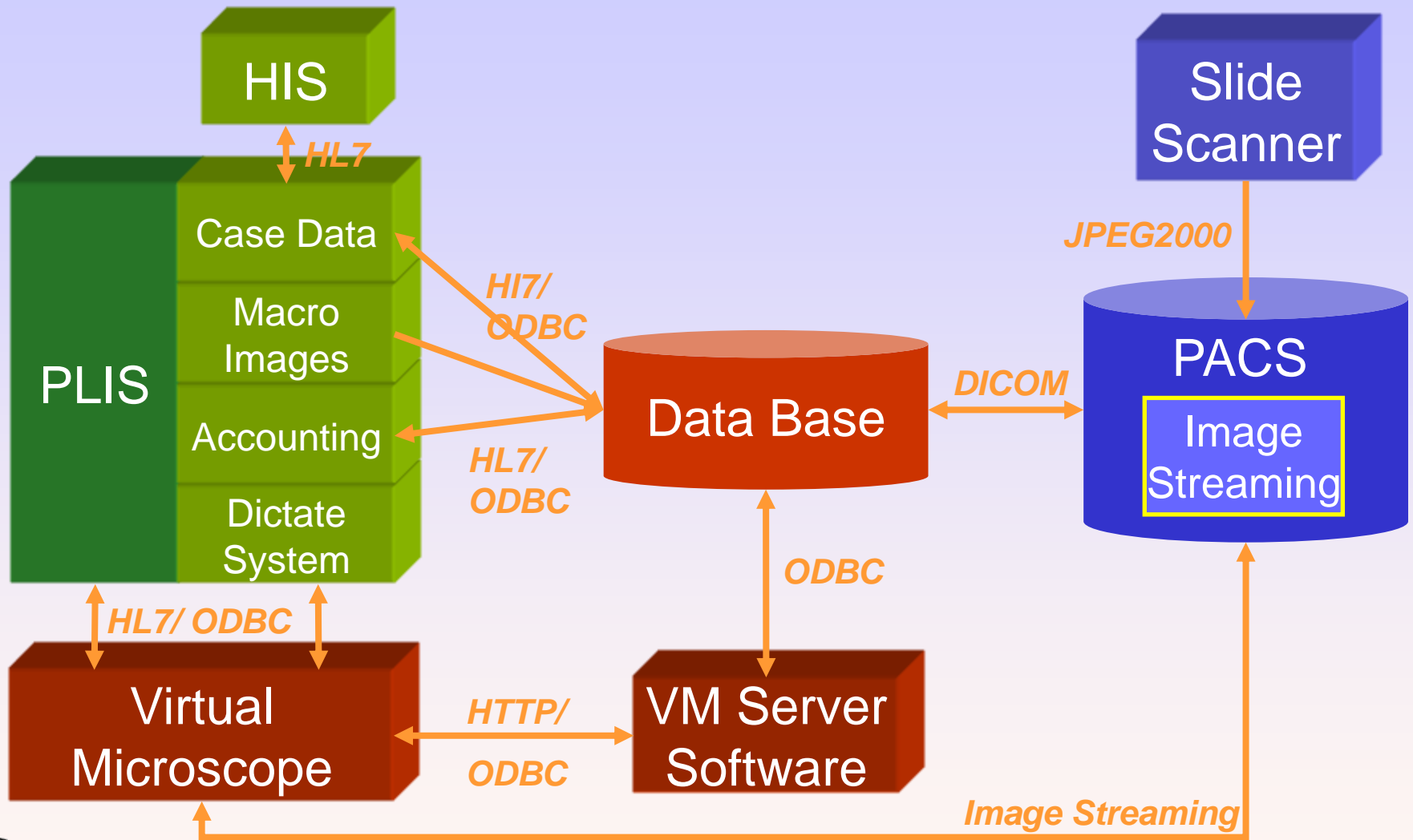
- Simple
- Intuitive
- Faster than conventional work
- Imaging integrated
- Case and slide have own IDs



# Pathology Network



# Integration into Pathology Information System



# Routine Pathology – Design Study

**Administration**

- Eingang
- Ausgang
- Bestellung

**Patientenakte**

- Persönlich
- Material

Dokumentation

Mikroskopie

Fall Beenden

Zugriff Sperren

Logout

Eingang    Ausgang    Ablage    Bestellung    Abrechnung    TelePatho    Papierkorb    Archiv    Index    Hilfe

**Worklist**

Status	Betreff 1	E-Nummer	Datum	Absender	Organ	Nachname	Vorname	Geburtsdag
normal	Gemeinsame Diagnostik	E-238473-24	10.01.2005	Prof. Kent	Mamma	Müller	Klaus	13.01.1934
schnell !	Neuzugang	E-238473-25	10.01.2005	Labor 1	Mamma	Schmidt	Maria	17.03.1967

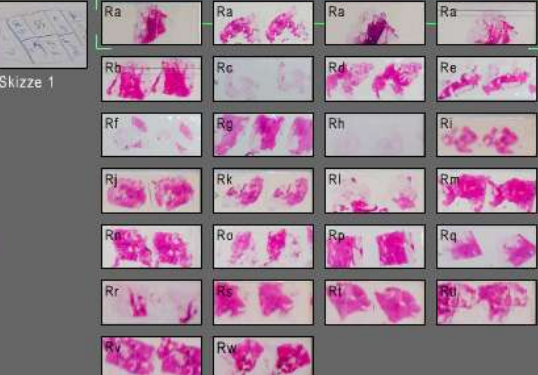
Worklist: 14 Fälle offen! Eingang: 1 neuer Fall

**Schmidt, M...**

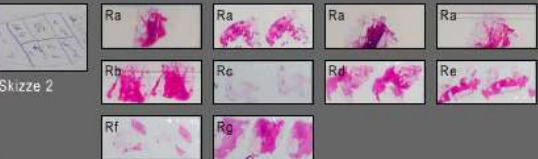
Persönlich    Laufzettel    Makroskopie    Vorbefund    Befund    **Material**    Annotationen    Notizen    TumorCode

Eingangsnummer	E-238473-25
Eingangsdatum	10.01.2005 - SGGX 1:14 PM
Name	Schmidt, Maria
Geschlecht	Weiblich
Geburtsdatum	30.11.1964
I. Nr.	0071005784
Anschrift	Kösliner Str. 5 13357 Berlin
Krankenkasse	AOK, privatversichert
Vers.Nr.	20030111964-B-00
Fall	Mamma
Entnahme	09.01.2005 MARS
Lokalisierung	Mamma re. SS
Telefon 1	030 564972
Telefon 2	030 564972
Behand. Arzt	Prof. Dr. Rhein
Krankenhaus	Charité Wedding

Skizze 1



Skizze 2



Material	Annotationen	Notizen	TumorCode
	Ra	Ra	Ra
	Rb	Rc	Rd
	Rf	Rg	Rh
	Rj	Rk	RI
	Rl	Rm	Rn
	Ro	Rp	Rq
	Rr	Rs	Rt
	Rv	Rw	
	Ra	Ra	Ra
	Rb	Rc	Rd
	Rf	Rg	

Makroskopisches Diktat liegt vor!

**Medical Workstation - All Information in One View**



# Routine Pathology – Support in Diagnostic (PAS)

The screenshot displays a software interface for a pathology department. The window title is 'Arztarbeitsplatz - H/2008/000001 (\*00.00.0000) (schreibgeschützt)'. The interface is divided into several panes:

- Untersuchung (Examination):** Shows details for '01.01.0001'.
  - Eingangsnr.: H/2008/000001
  - Einsender: H. Lobeck(Lobeck) / - (Kli...)
  - Makro-Mikro: Makro: - Mikro: -
  - Kommentar: (empty)
  - Eingangsd.: 13.05.2008
  - Diagnoses.: (empty)
  - Patienten I...: 766d7361-6d70-6c65-696...
  - Mandant: Standard-Mandant
- Patient:** Shows personal data.
  - Nachname: (empty)
  - Vorname: (empty)
  - Geschlecht: unbekannt
  - Geburtsd.: 00.00.0000
  - Info (cave): 766d7361-6d70-6c65-6...
- Einsender (Referring Physician):** (empty)
- Untersuchungsverlauf (8 Elemente) - Strg + L:** A list of examination numbers from H/2008/000001 to H/2008/000012.
- Voruntersuchungen (1 Element) - Strg + L:** A table with the following data:

Eingangsnummer	Einsender	Materialarten	Eingangsdatum	Diagnosetext
H/2008/000001	H. Lobeck		13.05.2008 14:11:20	

The main text area contains the following clinical and microscopic findings:

**Materialarten:**  
[Hauptbefund](#)

**Klinische Angaben:** 81-jähriger Patientin, langsam wachsender Tumor im Dorsalbereich des Handgelenks rechts, strecksehnenseitig.

**Makroskopie:** 150x45x40 mm großes grauweißes derbes Gewebstück mit faserartiger Schnittfläche und graugelblichen, unregelmäßigen Herden, von Fettgewebe umgeben.

**Mikroskopisch:** Repräsentativer Anteil des Tumors.

The taskbar at the bottom shows 'Dokumente - Auftrag: H/2008/000001', 'Voruntersuchungen (1 Element) - Strg + L', and 'Auftragsprotokoll - Liste (20 Elemente)'. The current layout is 'Standard'.



# **BETTER than in conventional microscopy : Imaging**

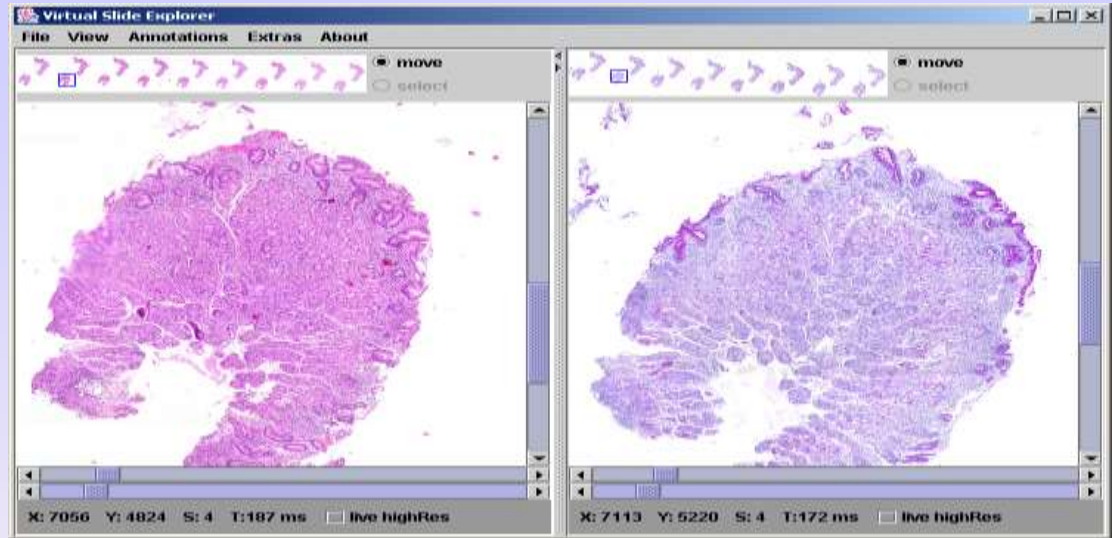
- **Mesurement**
- **Biopsy stacks**
- **Parallel viewing of different stainings**
- **Ploidy analysis**
- **Case search and comparison**
- **.....**



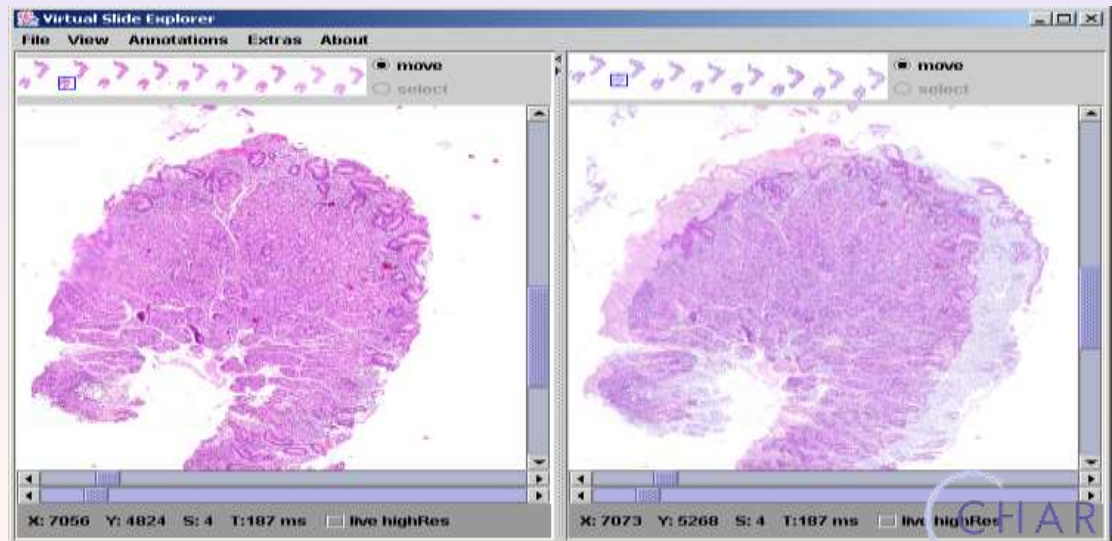


# Routine Pathology – Support in Diagnostic

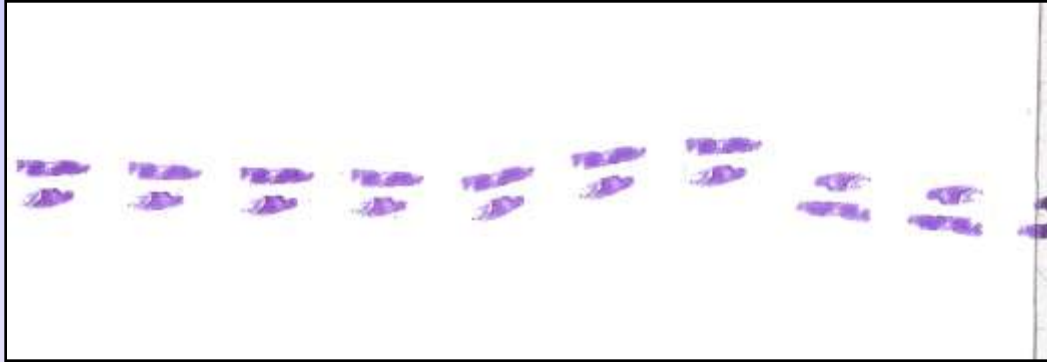
**Simultaneous Viewing  
of Different Stains and  
Slices**



**Semi-Transparent  
Overlay of Different  
Stains and Slices**



# Typical Biopsy Stack



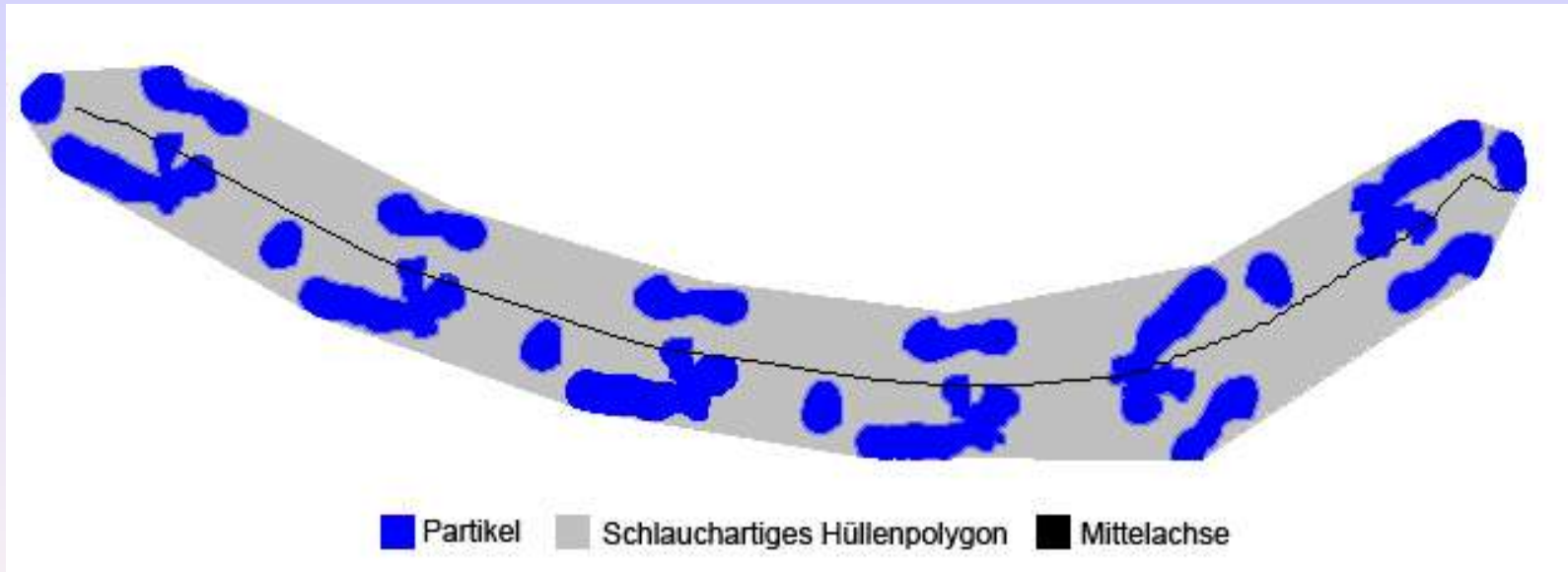
Rotation of biopsies



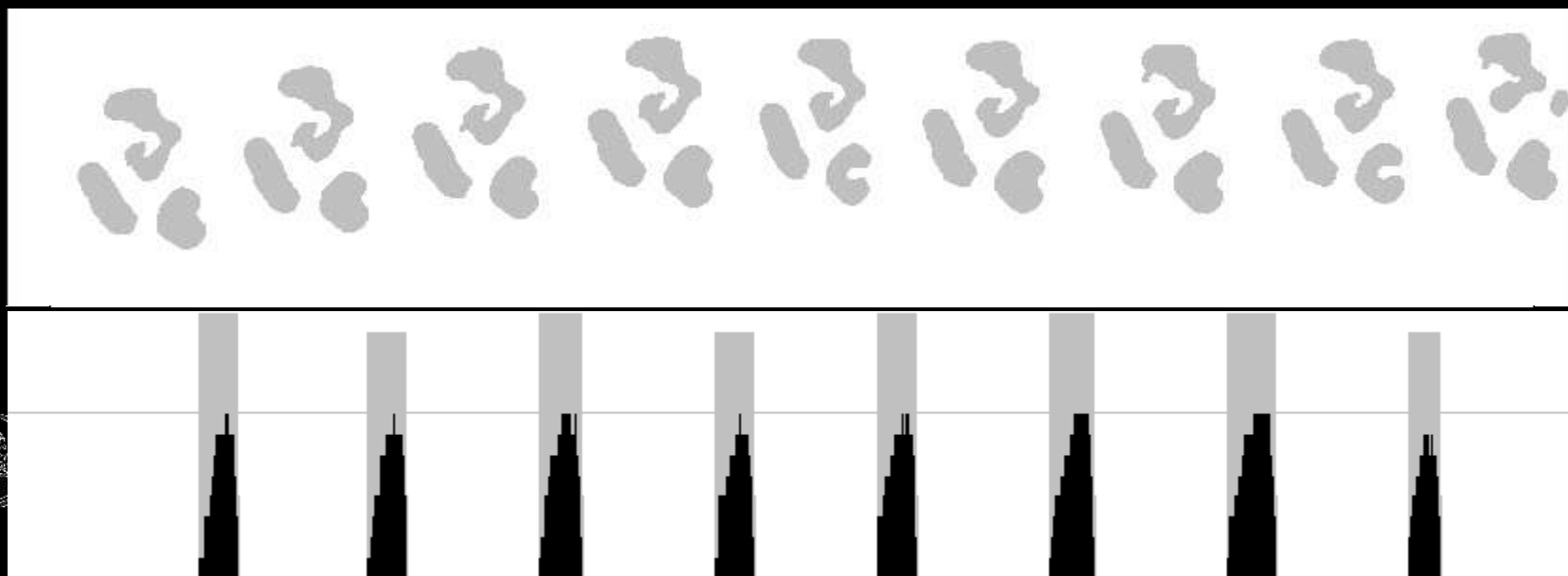
Variation of particle number in neighbouring planes



# Determination of Rotation



# Full-automatic analysis of serial histological sections in context of estimating similar tissue artifacts on neighboured sections



- Annotations
- Gespeicherte Positionen



# Steps for imaging in routine

- Scanning
- Analysis of the total WSI
- Viewing in dependence of image analysis results (open at highest density of mitoses)
- Measurements in ROI (preprocessed)
  - (- count number of mitoses within marked area
  - determine percentage of marked cells, ....)
- Case search and comparison



# Way of Introduction in Germany

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- **VM in education**
- **VM in second opinion and decentral departments**
- **VM as tool for interdisciplinary tumour centres**
- **VM for routine marker quantification**
- **VM for smaller departments (e.g. Neuropathology)**
- **VM for whole university institutes**



# Conclusions

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- **VM has a large potential in the near future**
- **Introduction will take years**
- **Process will run similar to digital radiology**
- **Largest advantages now for universities**
- **DRGs, certification of tumour centres, will promote process**





# Thank you!

