AI in cancer diagnostics: Application and validation

AI for Good Global Summit

Geneva, 29. 5. 2019

Frederick Klauschen

Charité and Berlin Institute of Health

Histopathology: Diagnose diseases, guide therapy decisions

Diseases

Autoimmune
Cancer
Degenerative
Infectious

Diagnostics

GP/ Specialists

Radiology

Biopsy/ Surgery

Pathology

Therapy

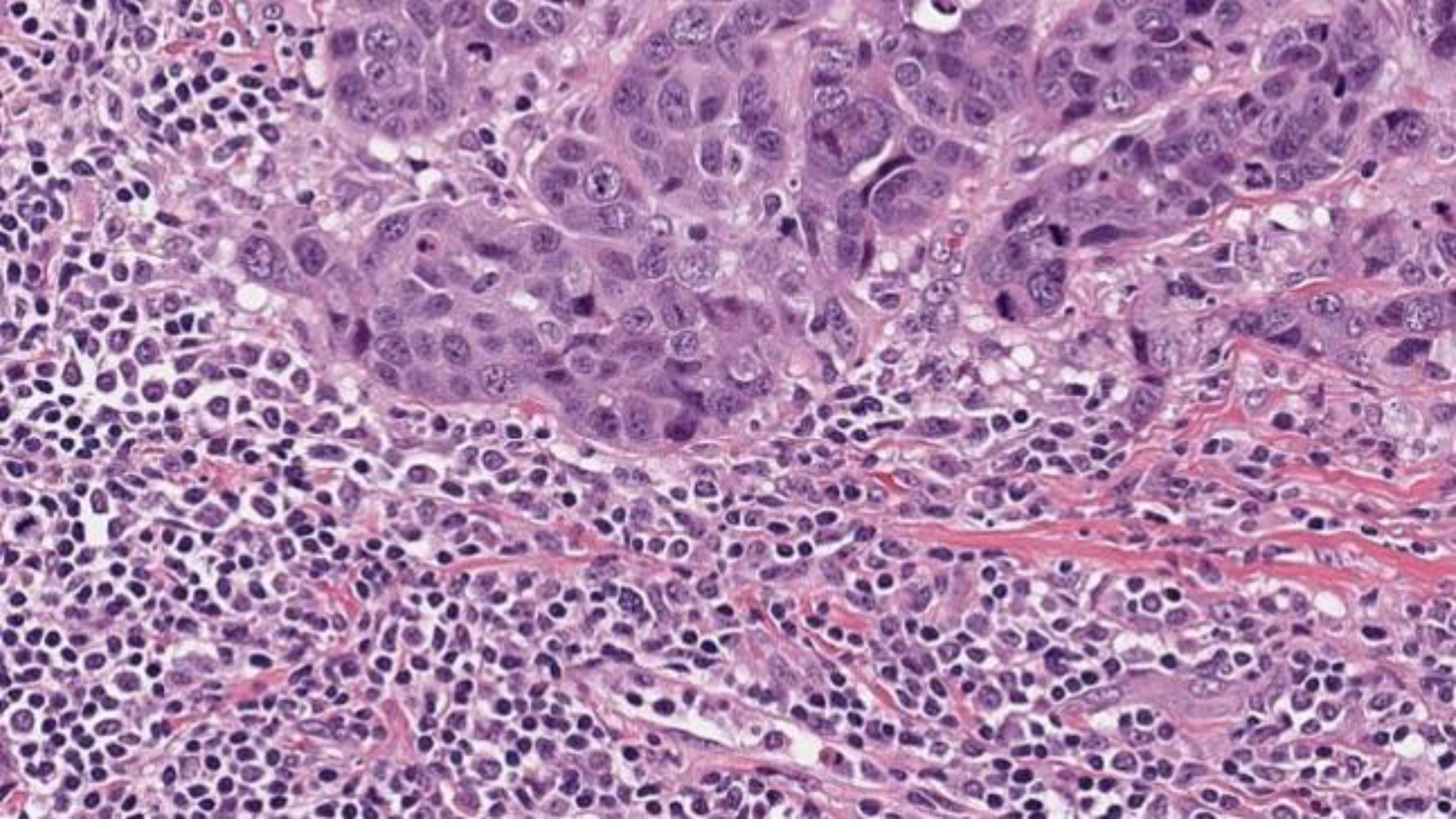
Intervention

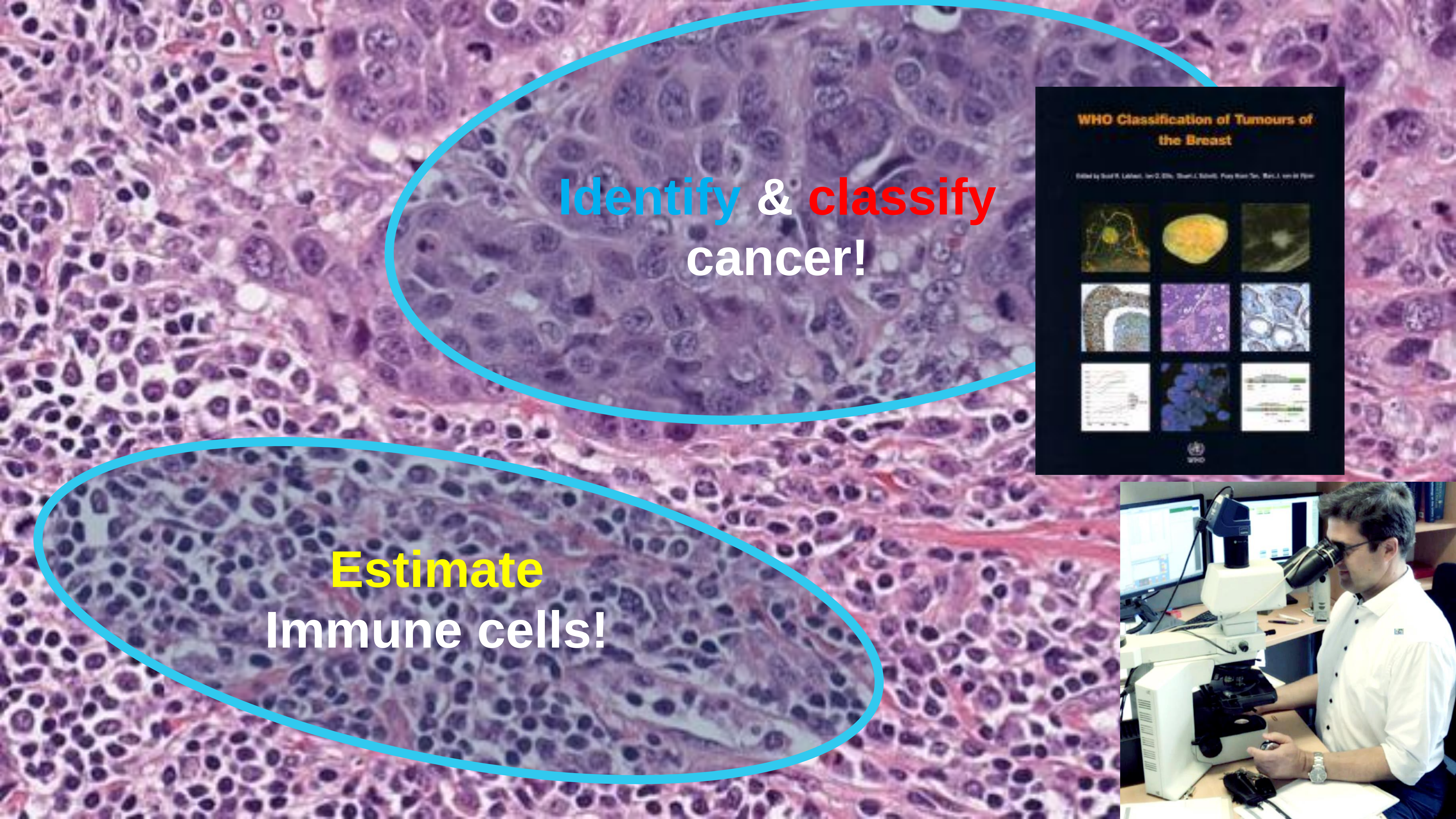
350 Mio. diagnostic cases worldwide per year!

Histological slide

Microscopic diagnostics

Manual evaluation




Identify & classify
cancer!
WHO Classification of Tumours of the Breast
Estimate
Immune cells!

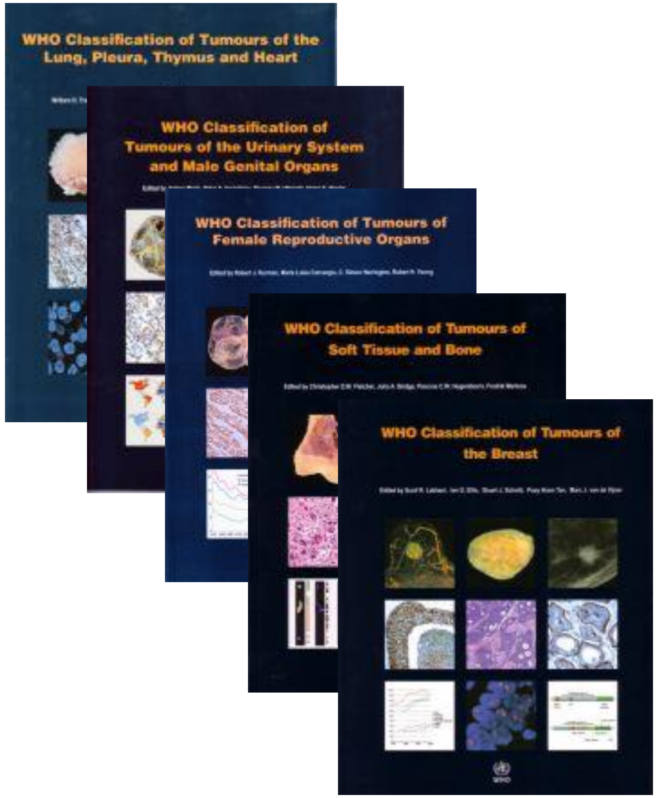
Re-classification of tumors based on molecular profiling

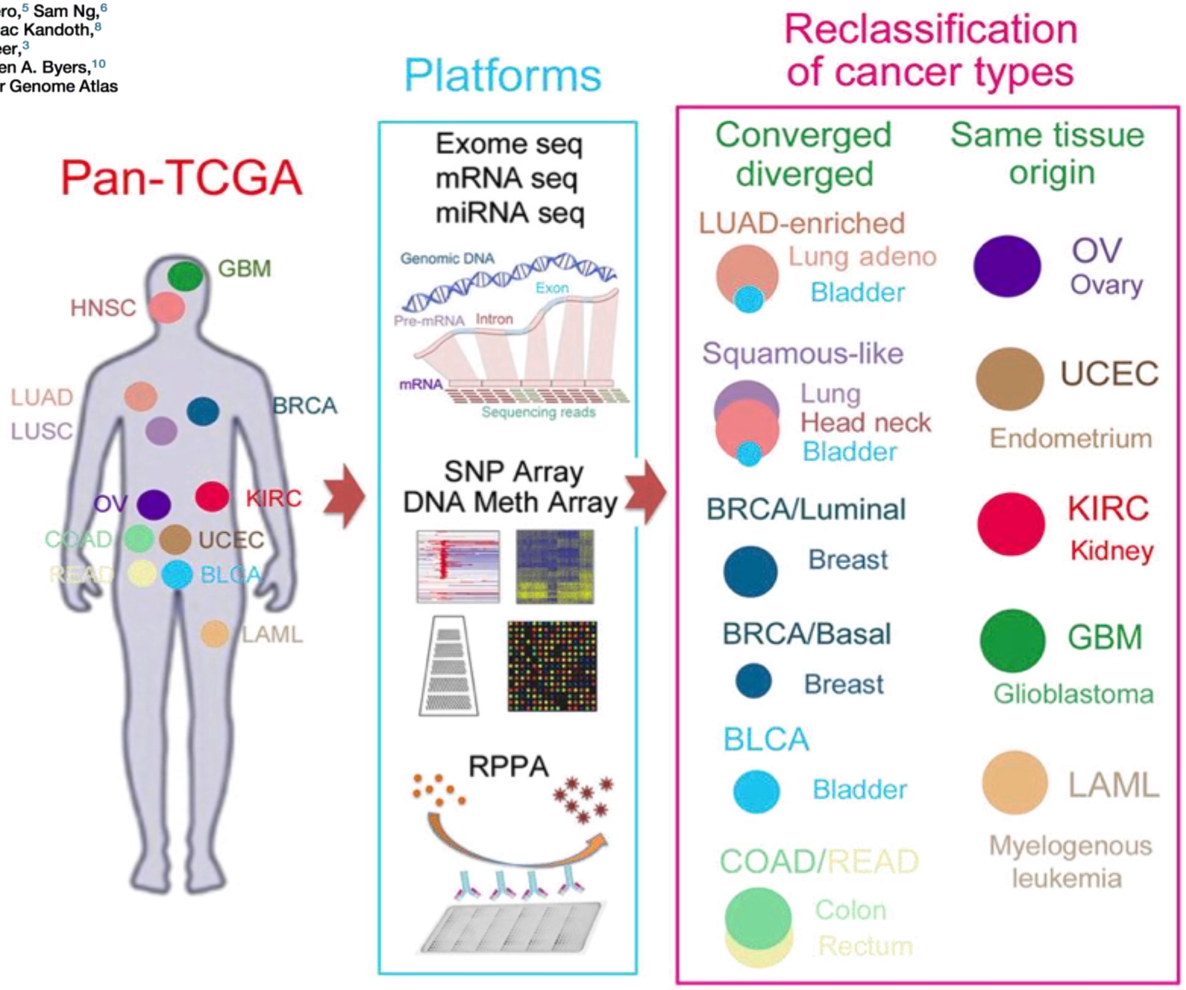
Multiplatform Analysis of 12 Cancer Types Reveals Molecular Classification within and across Tissues of Origin

Cell

Katherine A. Hoadley,[1,20] Christina Yau,[2,20] Denise M. Wolf,[3,20] Andrew D. Cherniack,[4,20] David Tamborero,[5] Sam Ng,[6] Max D.M. Leiserson,[7] Beifang Niu,[8] Michael D. McLellan,[8] Vladislav Uzunangelov,[6] Jiashan Zhang,[9] Cyriac Kandoth,[8] Rehan Akbani,[10] Hui Shen,[11,22] Larsson Omberg,[12] Andy Chu,[13] Adam A. Margolin,[12,21] Laura J. van't Veer,[3] Nuria Lopez-Bigas,[5,14] Peter W. Laird,[11,22] Benjamin J. Raphael,[7] Li Ding,[8] A. Gordon Robertson,[13] Lauren A. Byers,[10] Gordon B. Mills,[10] John N. Weinstein,[10] Carter Van Waes,[18] Zhong Chen,[19] Eric A. Collisson,[15] The Cancer Genome Atlas Research Network, Christopher C. Benz,[2,*] Charles M. Perou,[1,16,17,*] and Joshua M. Stuart[6,*]

Cell 2014 158, 929-944.
Cell 2018.





Molecular Cancer Re-Classification

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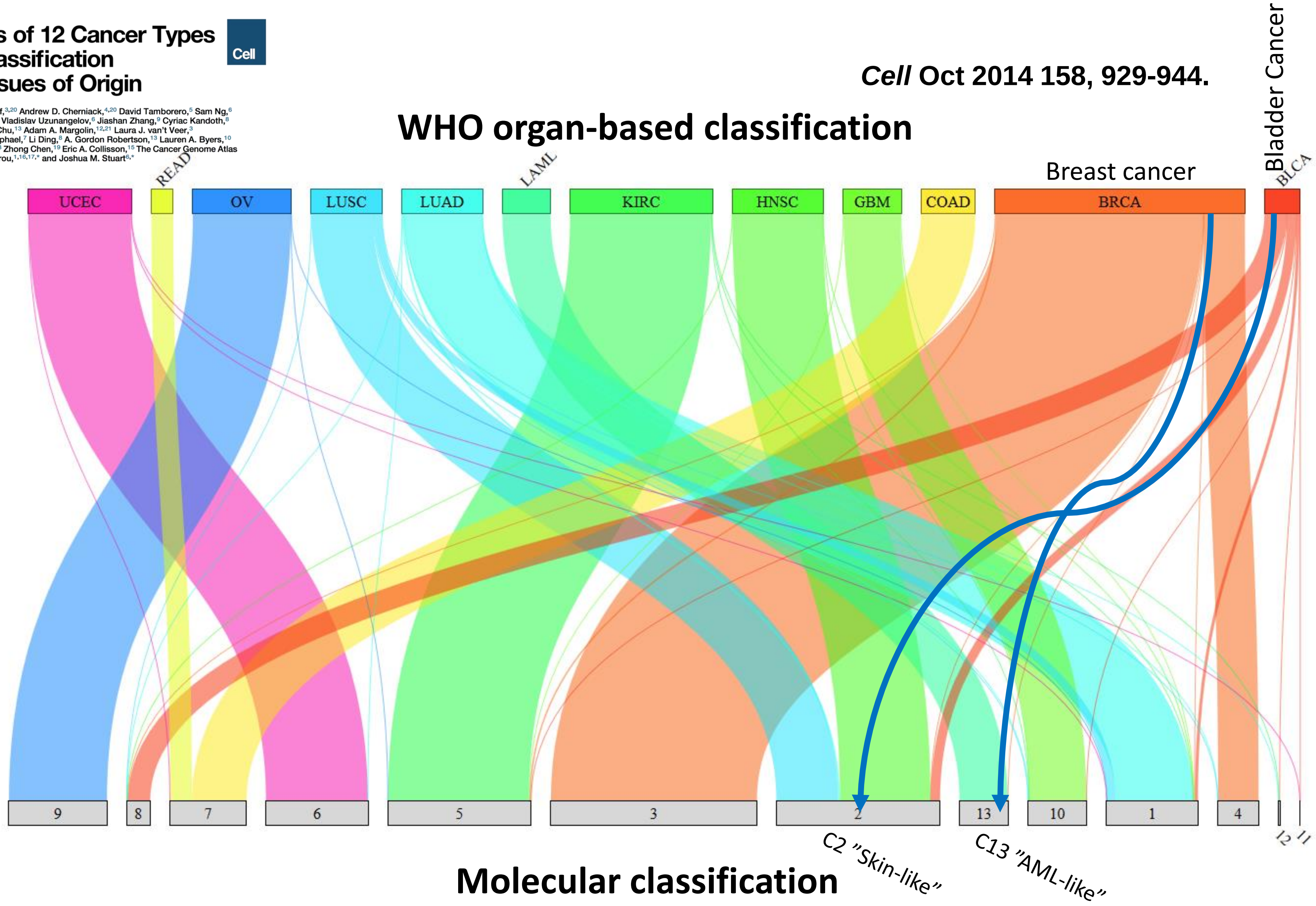
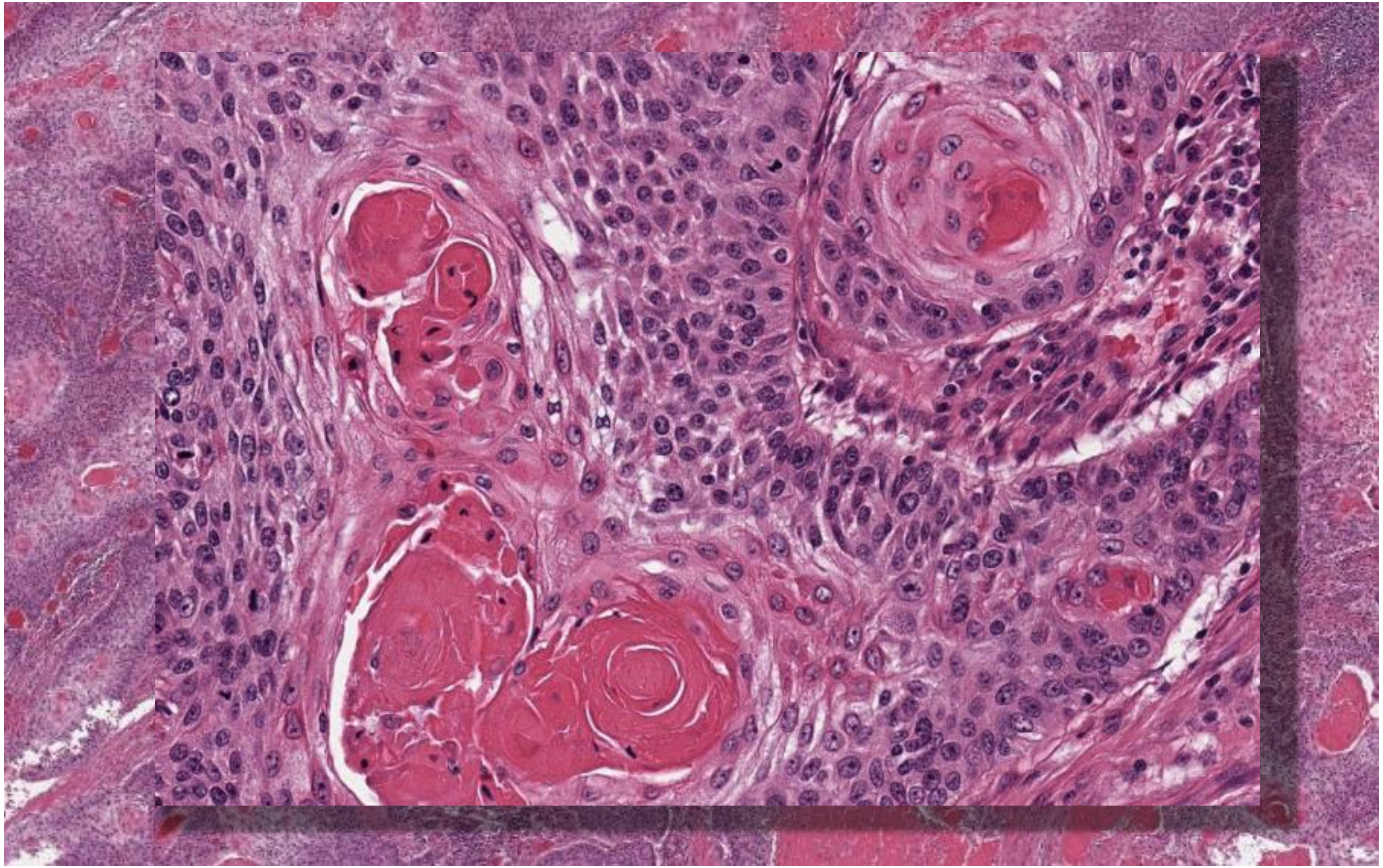
WHO organ-based classification

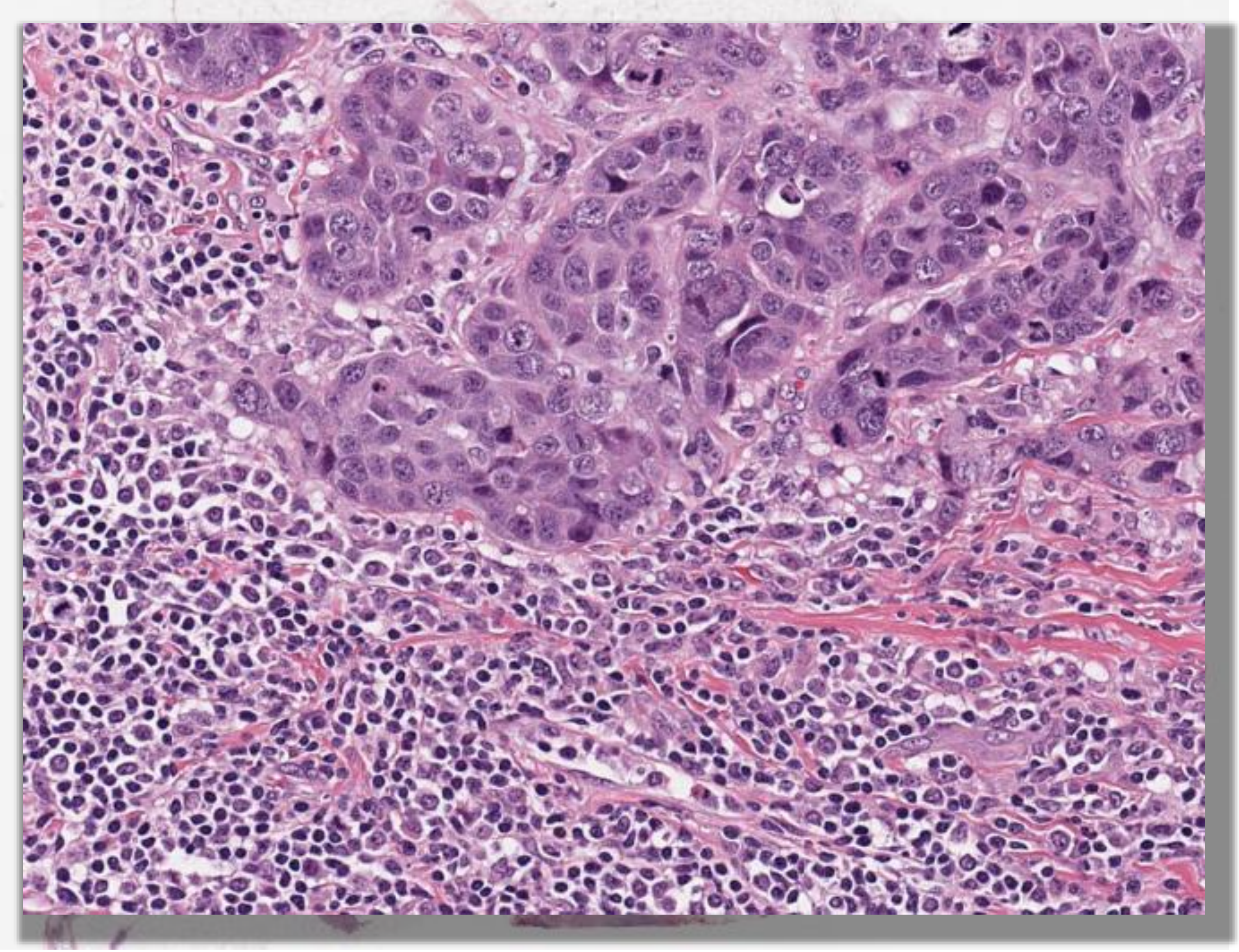


Molecular classification

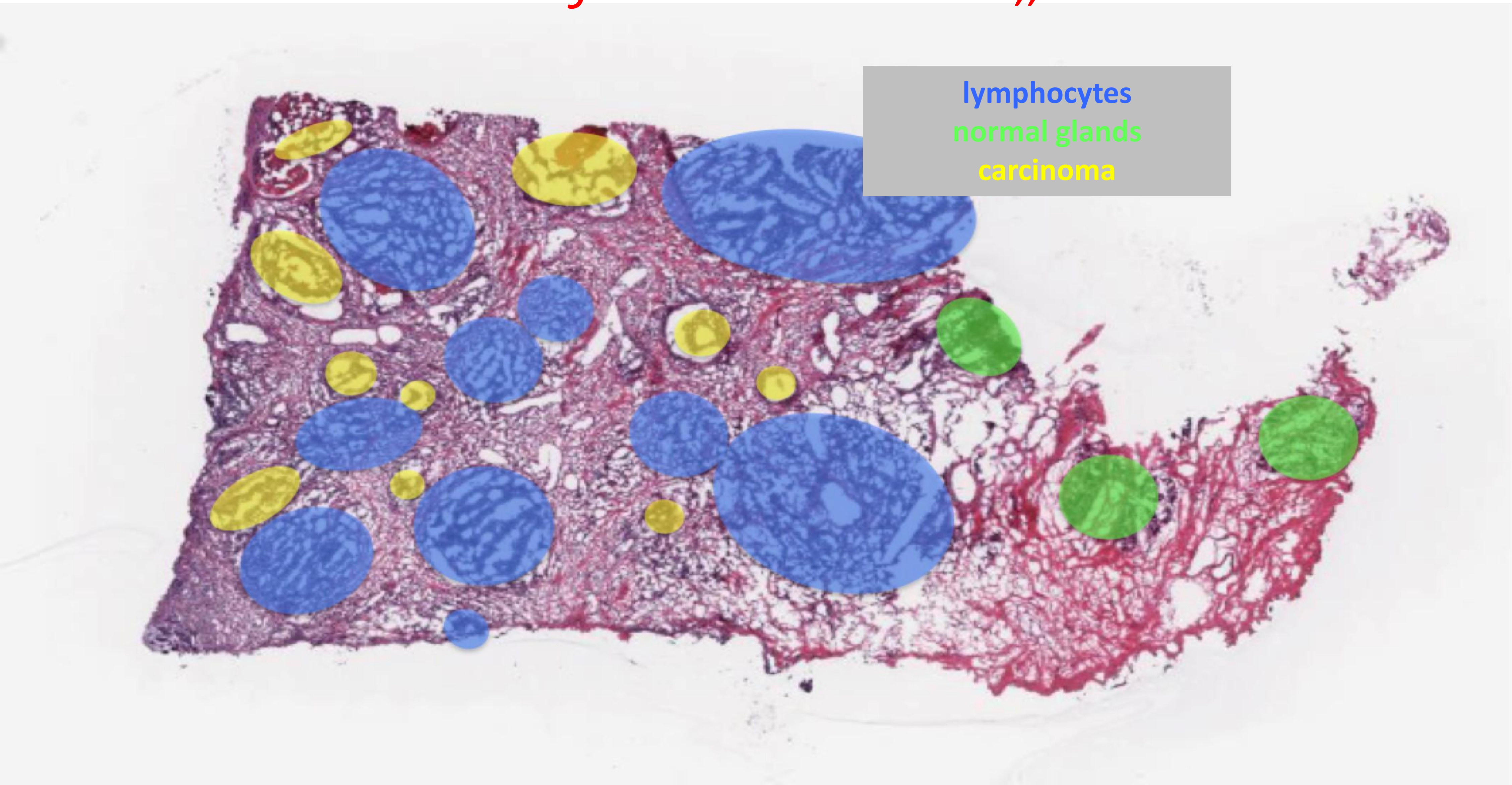
Bladder Ca *re-classified as* C2 „Skin-like“



Breast Ca *re-classified as* C13 – „Leukemia-like“



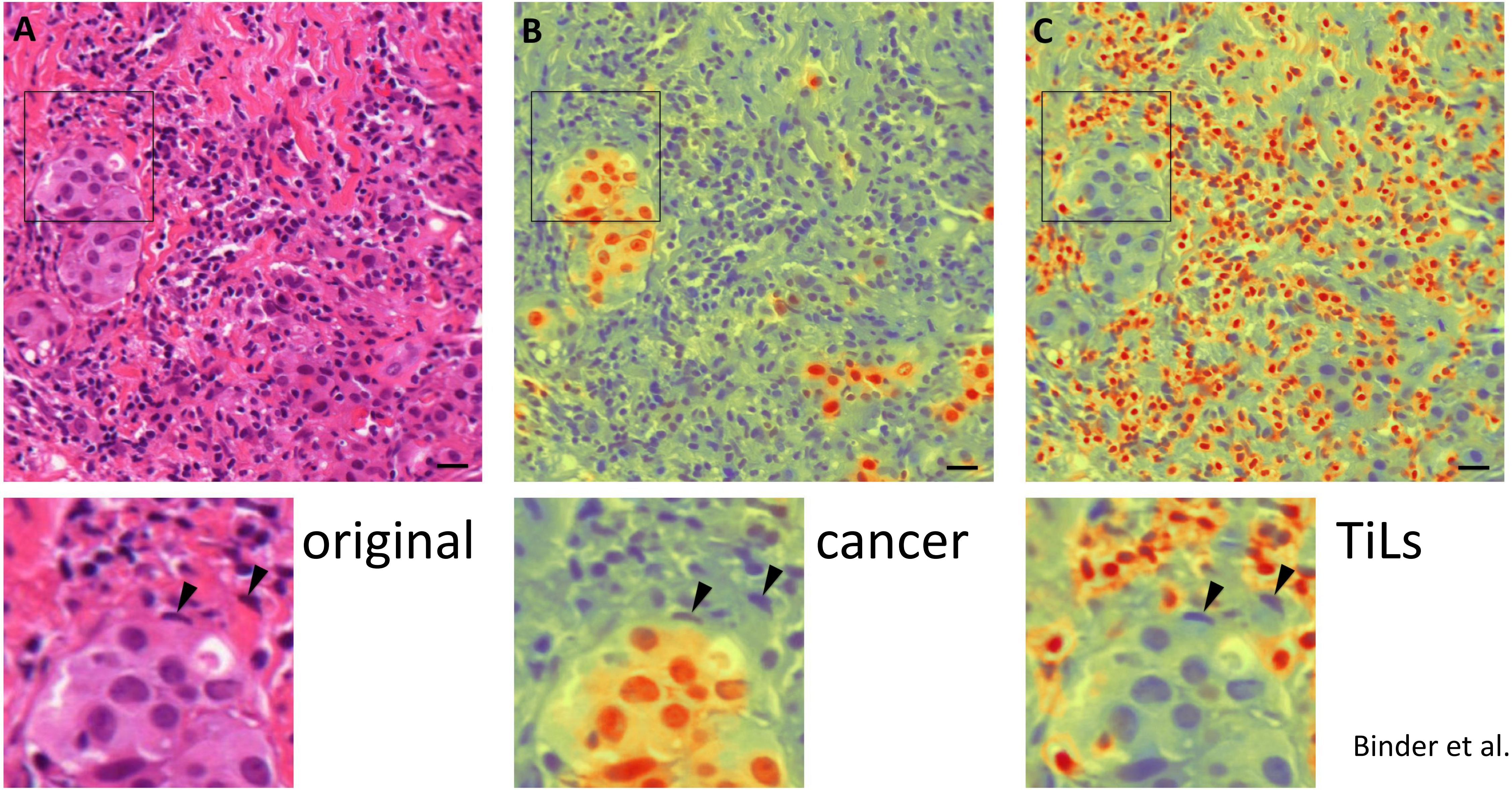
Breast Ca *re-classified as* C13 – „Leukemia-like“



Incorrect classification because of

- incomplete training data
- imprecise evaluation of histopathology!

AI-assisted histopathology



Binder et al.

Artificial Intelligence in Diagnostics:

PATIENTS IN DANGER?

Need for validation and benchmarking of AI in medicine!

ITU/WHO Focus Group AI for Health Topic Group Histopathology

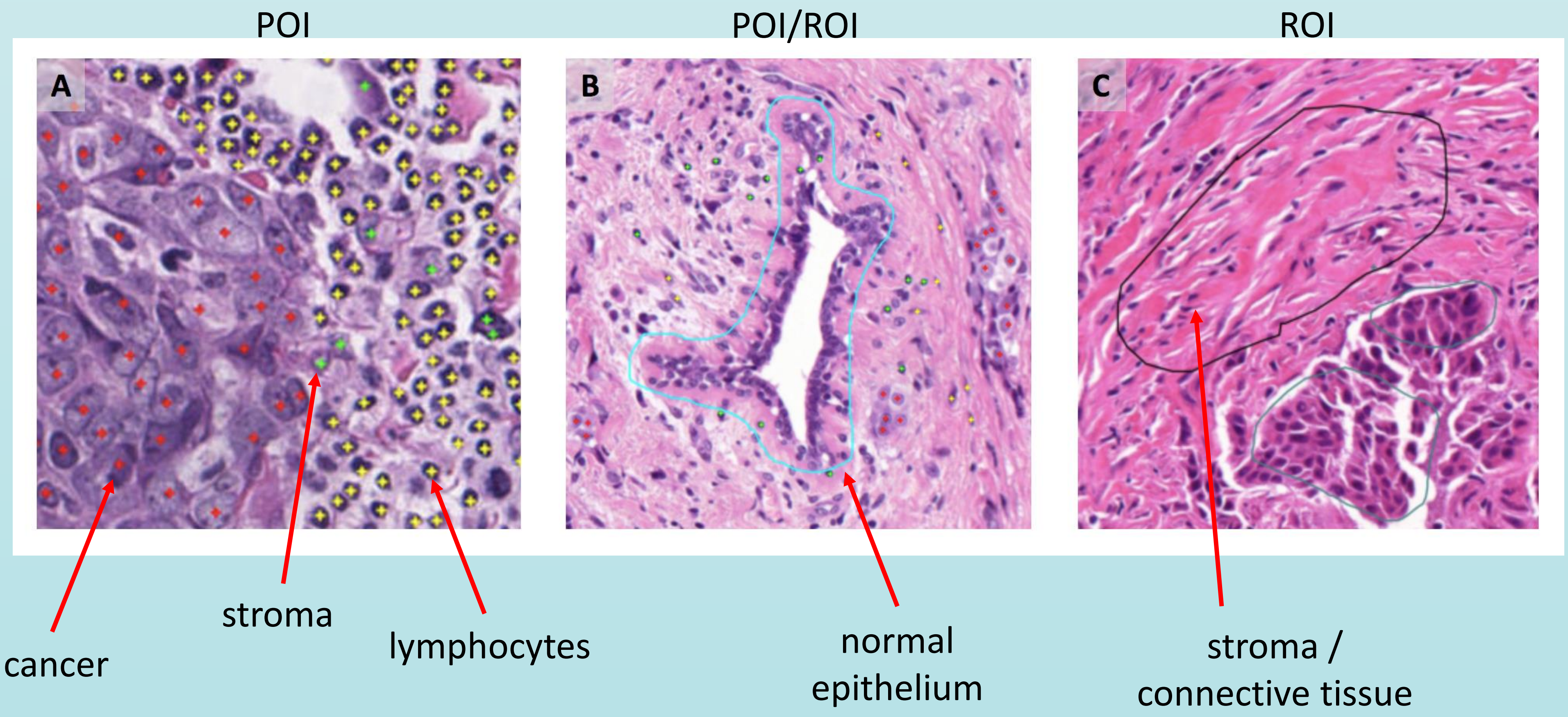
- Topic group dedicated to benchmarking AI approaches in histopathology
- First use case: Detection of breast cancer cells and tumor-infiltrating lymphocytes
- Define what should be annotated and how
- Define criteria for benchmarking
- Provide server infrastructure to perform benchmarking

Annotation of the histopathology images

Specifications:

- Digitized histological slides in standard staining
- Comprehensive tissue component annotations:
  - **cancer tissue**
    - multiple subtypes
      - focus on NST (no-special-type) and invasive-lobular breast cancer
  - **normal tissue**
    - normal breast gland and duct epithelium
    - connective tissue (fibers, cells)
    - fatty tissue, bone tissue, nerves
    - blood and lymphatic vessels
  - **immune system**
    - Lymphocytes, plasma cells
    - Granulocytes, monocytes/macrophages
  - **necrotic tissue**
  - **artifacts**
  - **Background**
- Positive and negative annotations

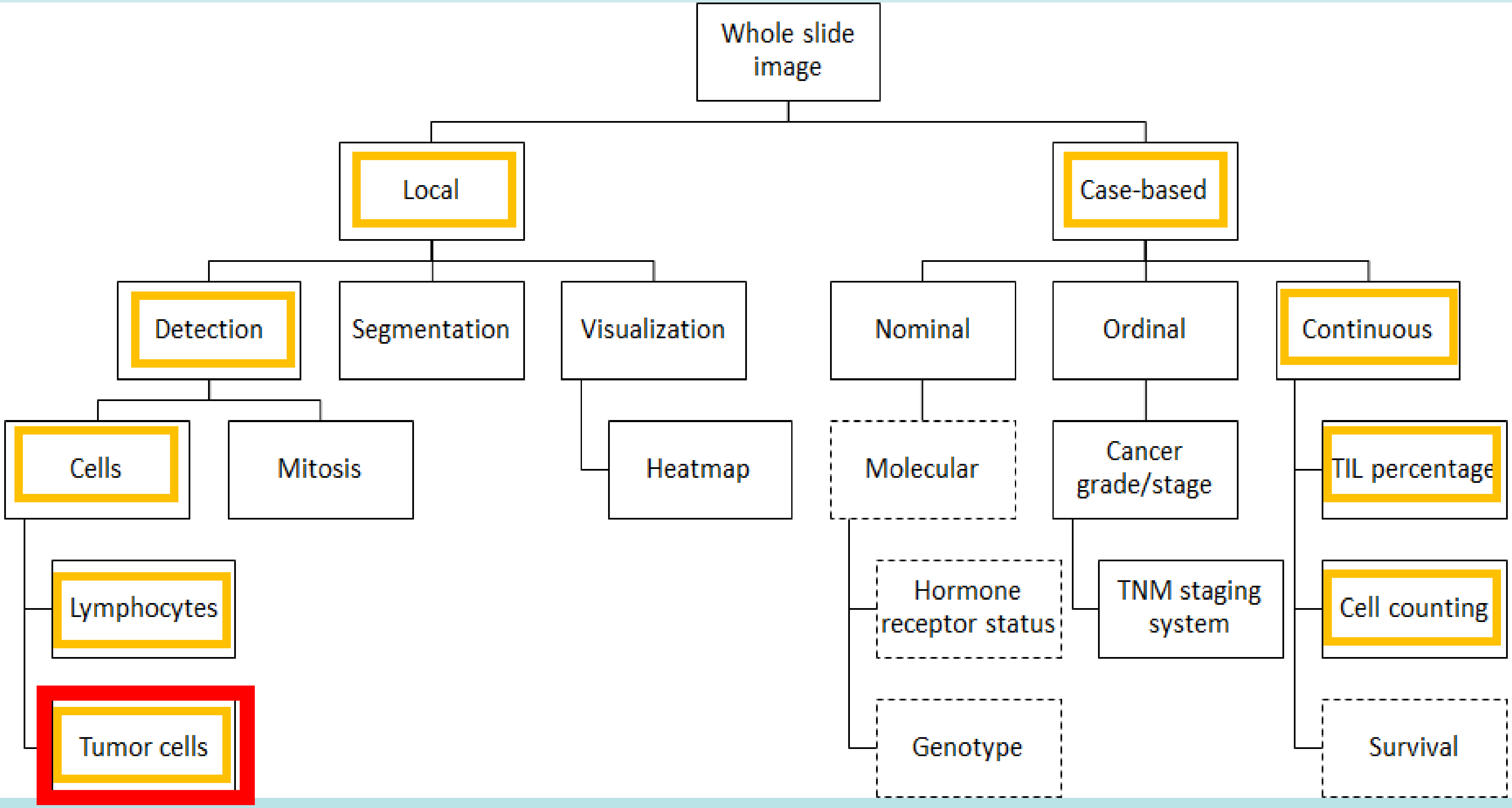
Annotation of the histopathology images

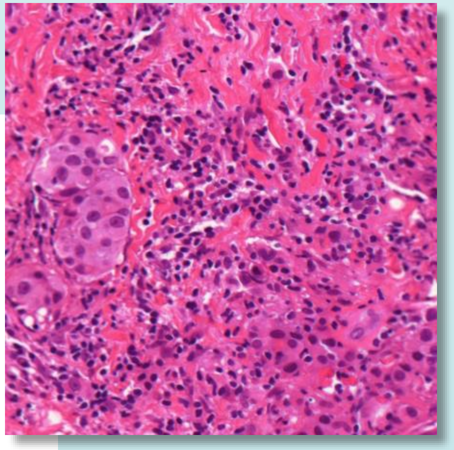


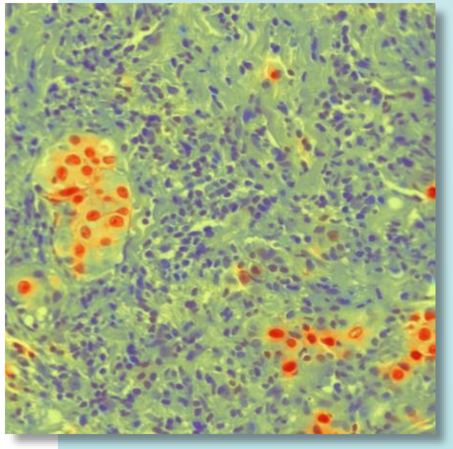
Provision of test and benchmarking images

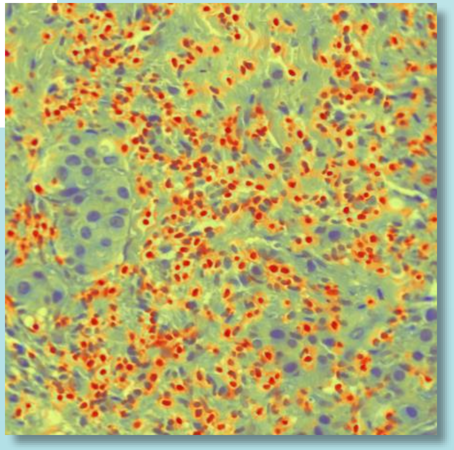
- image data 3000x3000 at 400x
- consensus annotations by two pathologists
- 4 exemplary images made available with test annotations to provide overview of data
- 86 annotated images not public, available only for benchmarking on WHO/ITU servers with
- 258k annotations

3 Benchmarking



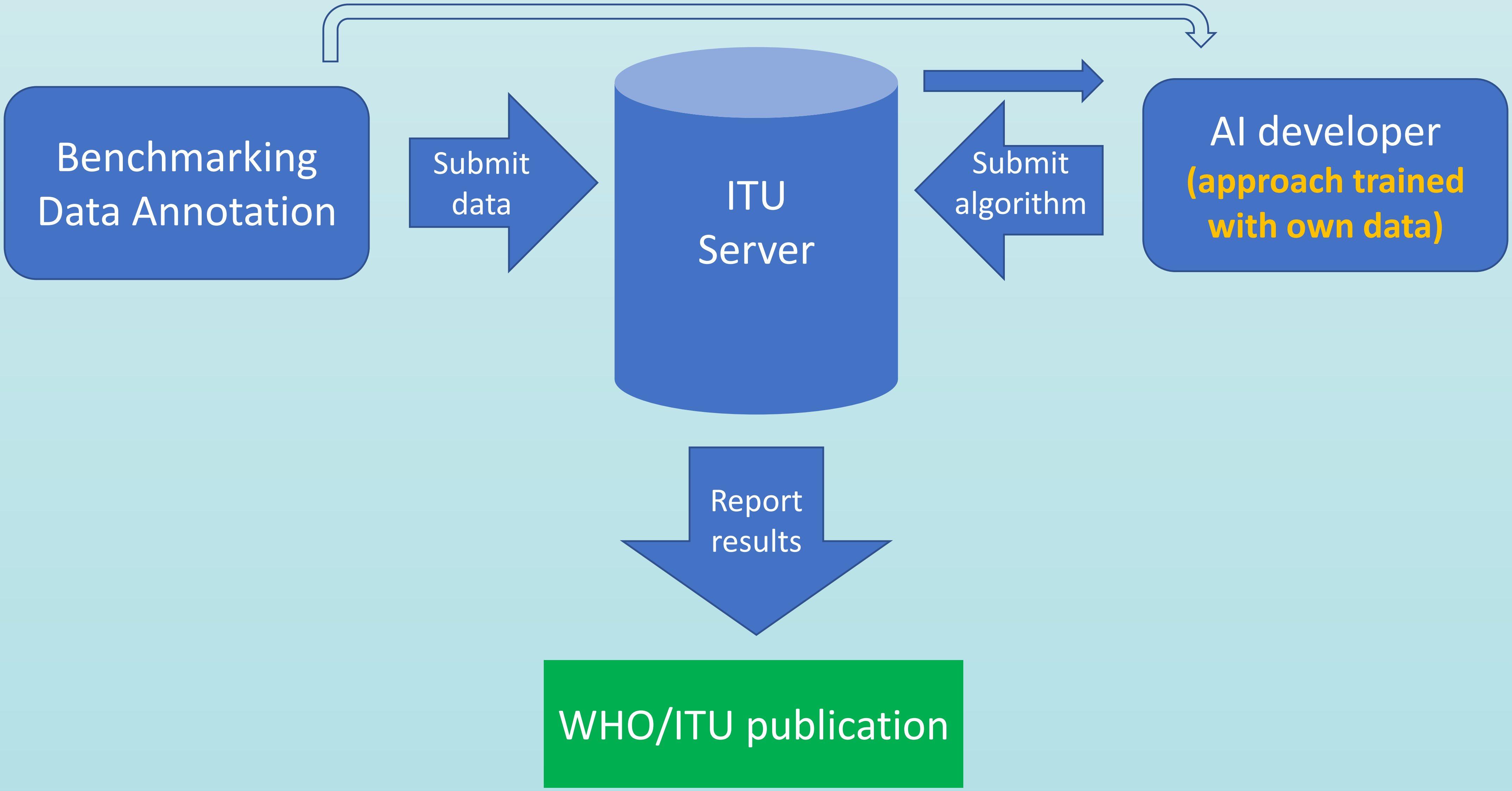




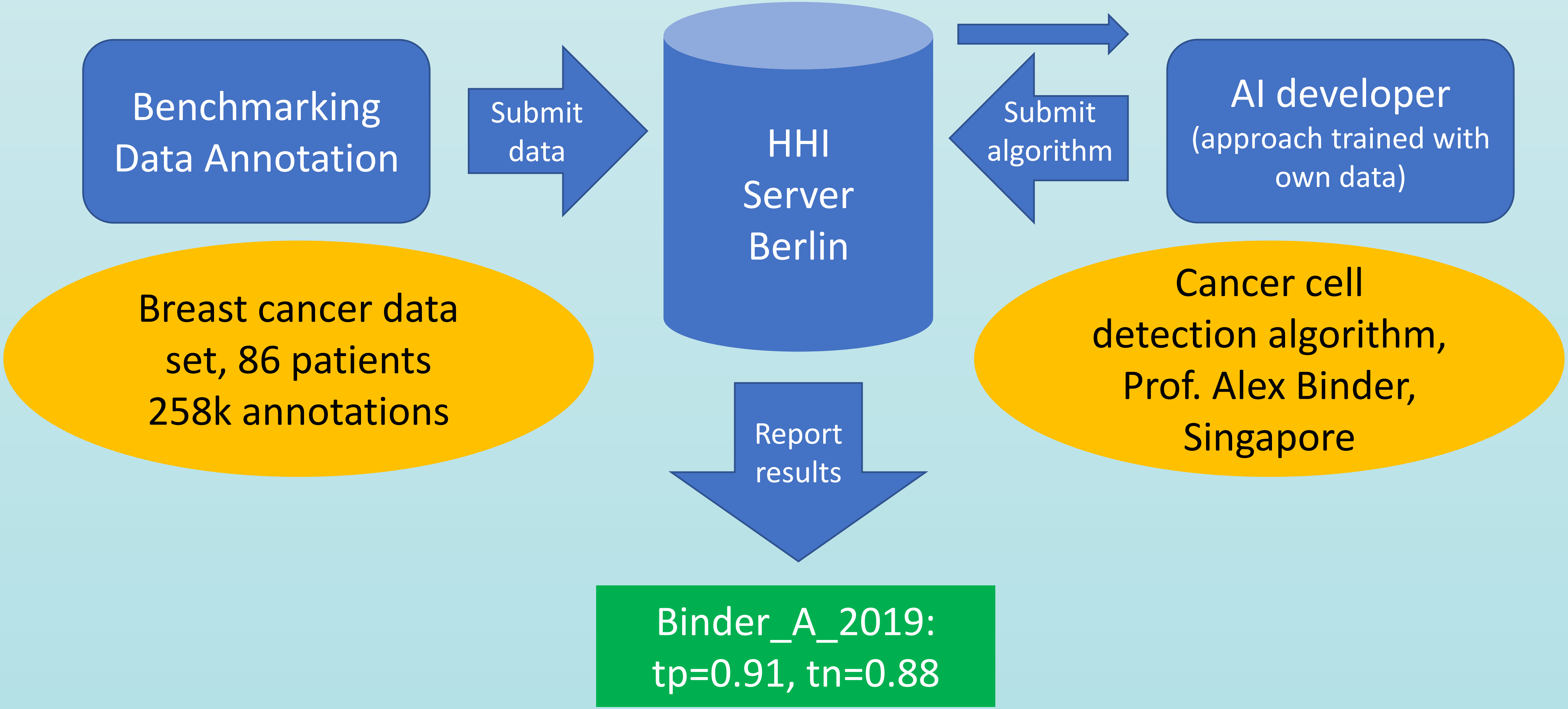


true positive, true negative, precision

Benchmarking pipeline



Benchmarking breast cancer cell detection



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