# WHEN DATA MET TOOL

## Make Something New!

**민 현 석**

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## 오늘 제가 말씀드릴 내용…

WHEN

**DATA**

**(TOMOCUBE HOLOTOMOGRAPHY)**

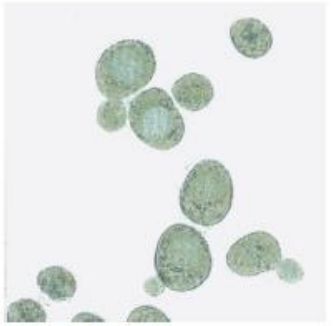
MET

**TOOL (AI)**

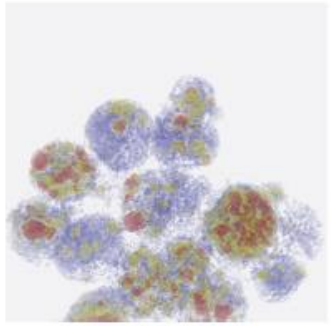
# WHAT TOMOCUBE SEE ?

Tomocube HT-2

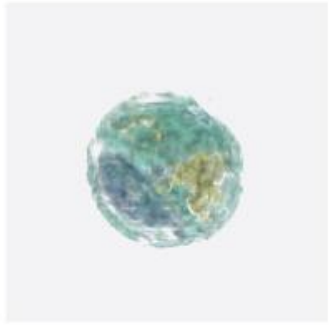
Cyanobacteria



Baker's yeast



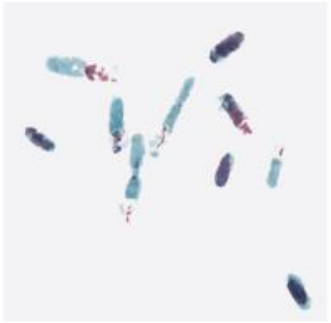
Polychaeta eggs



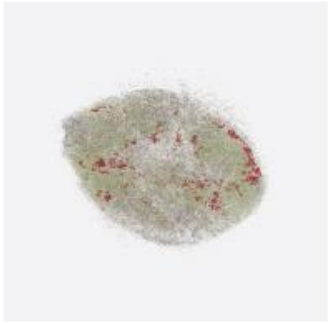
Chlorella

Diatom

Fission yeast



Bacteria (*E.coli*)



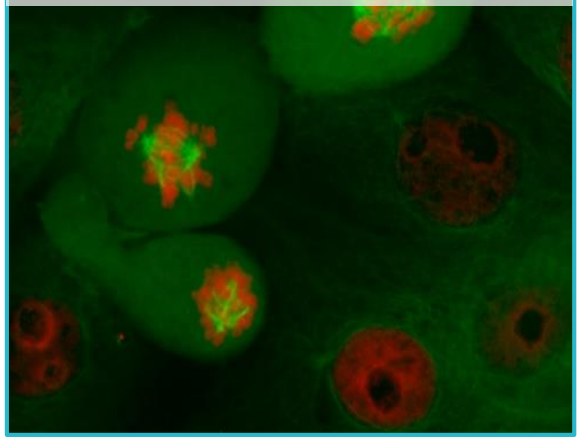
Ostreopsis

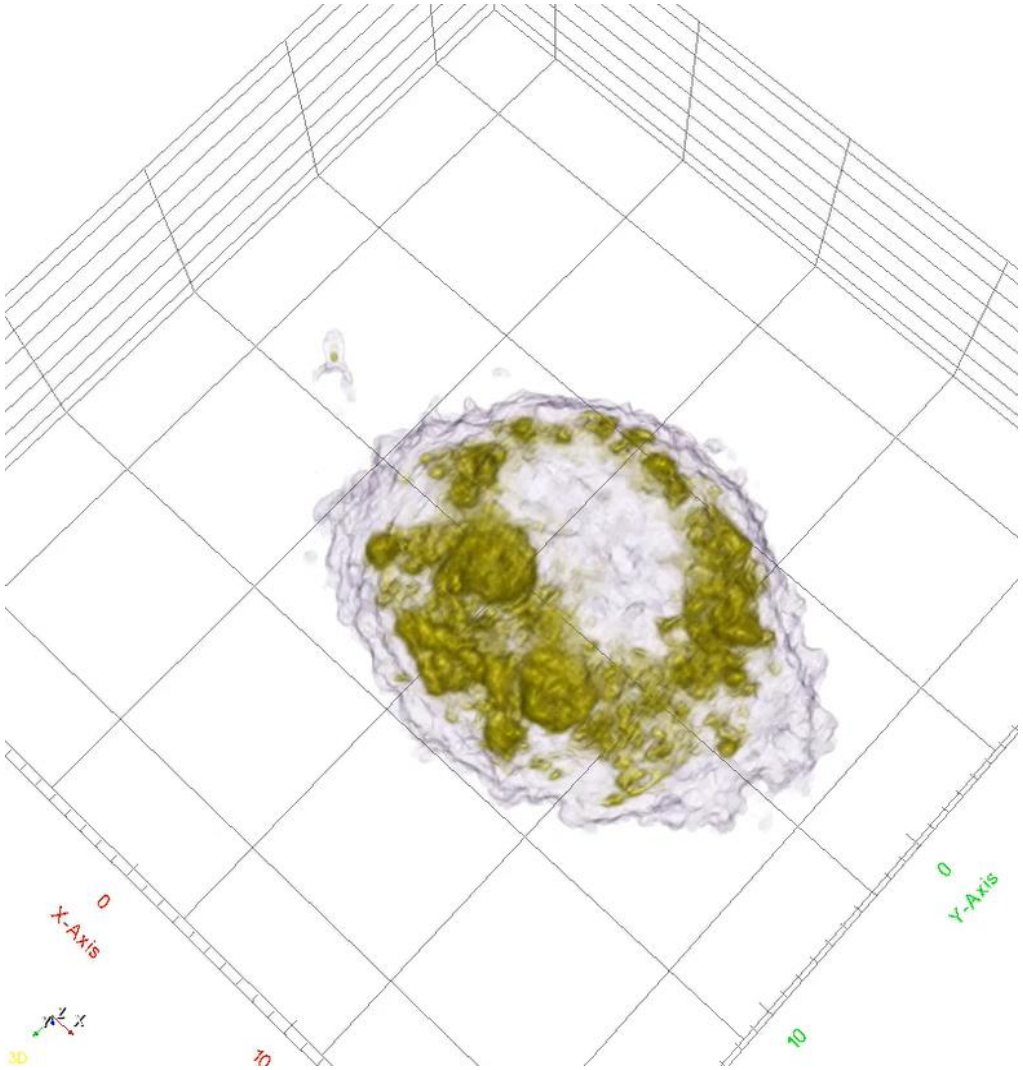
# WHAT TOMOCUBE SEE ?

Bright-field microscopy
(17th century)

Phase contrast
(Nobel Prize, 1953)

Fluorescence
(Nobel Prize, 2008)



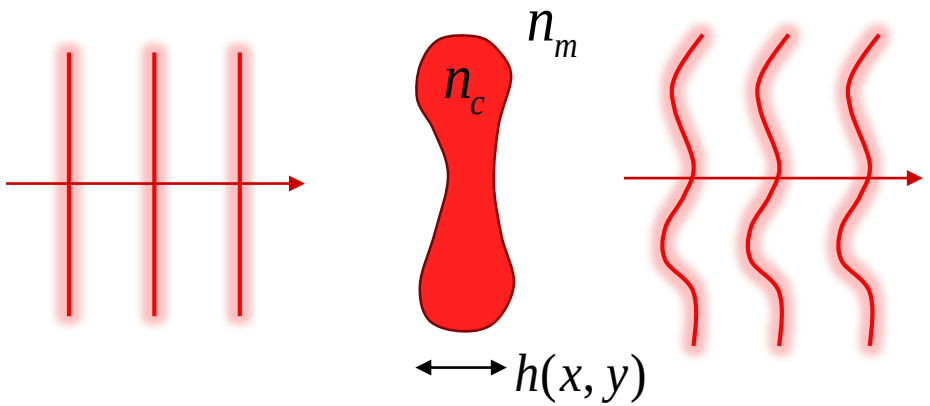



HoloTomography (HT)
(Tomocube, 2016)

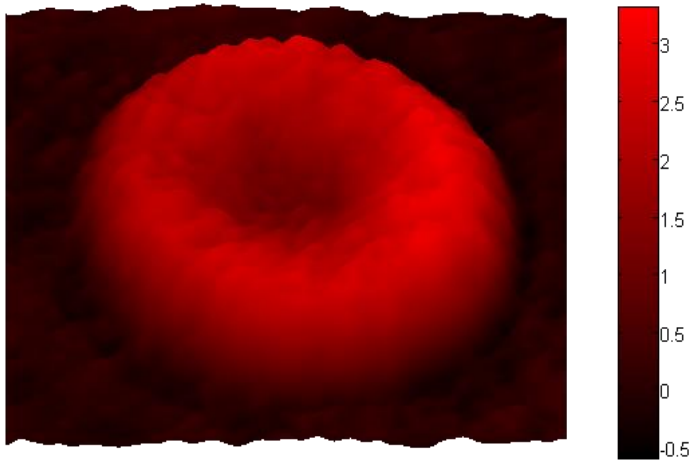
# WHAT TOMOCUBE SEE ?

## Holographic imaging

- Refractive index : intrinsic optical contrast

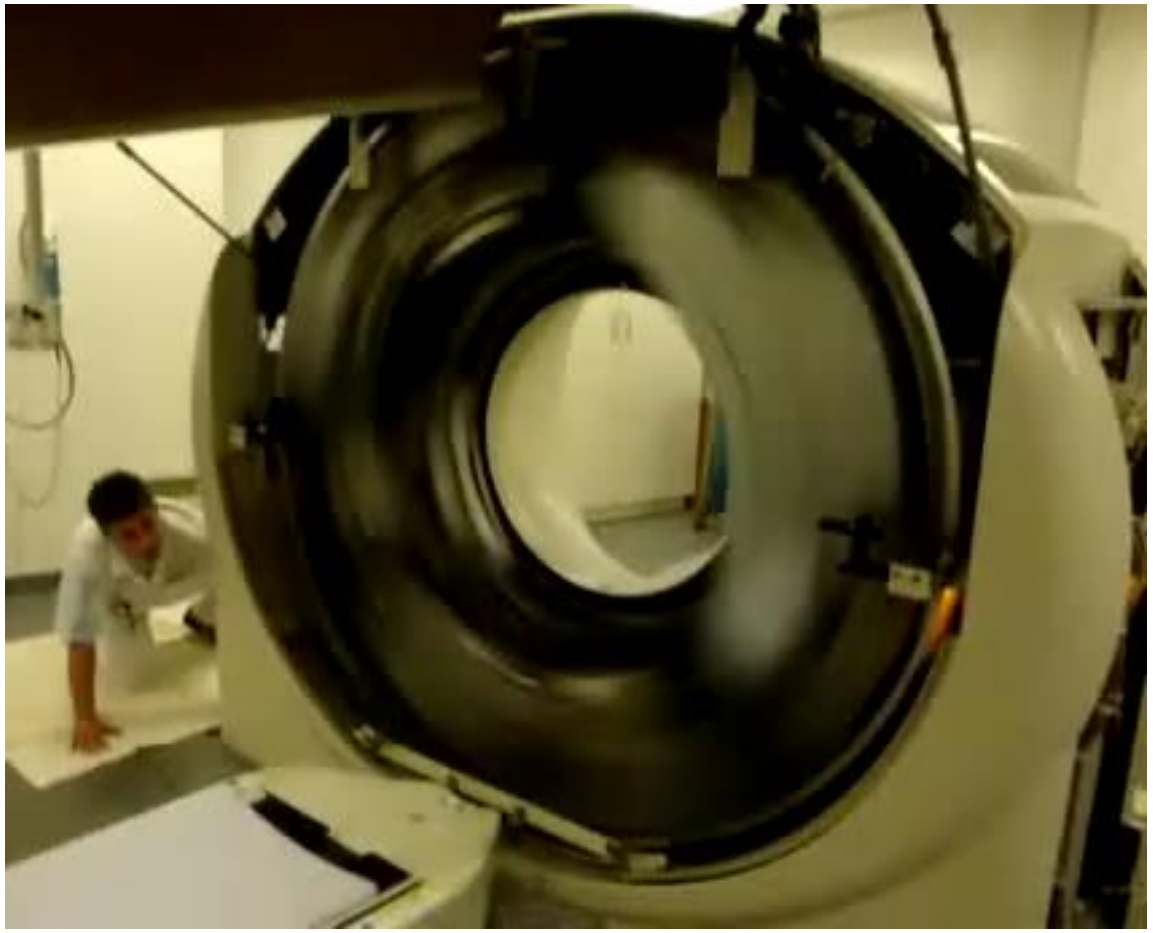


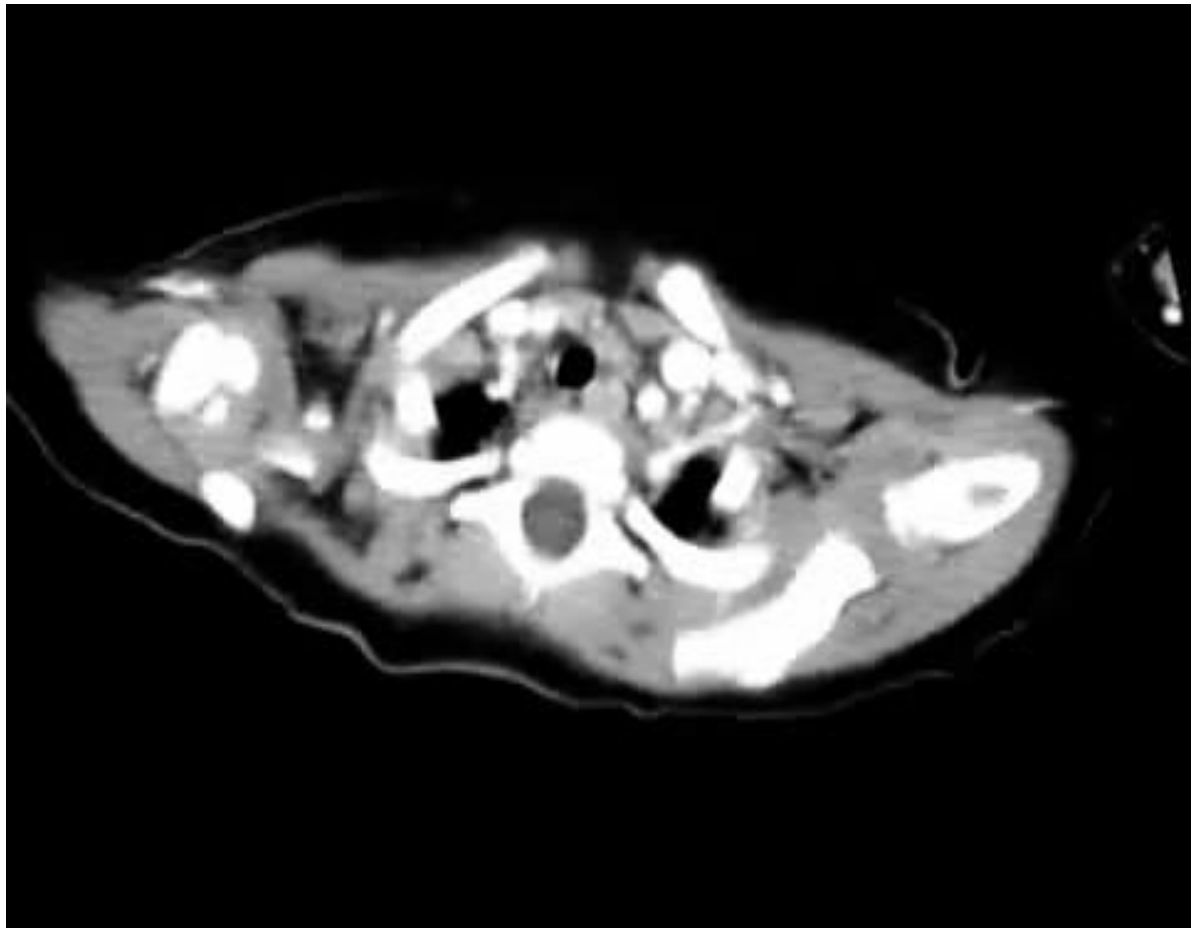

- label-free quantitative bioimaging



# WHAT TOMOCUBE SEE ?

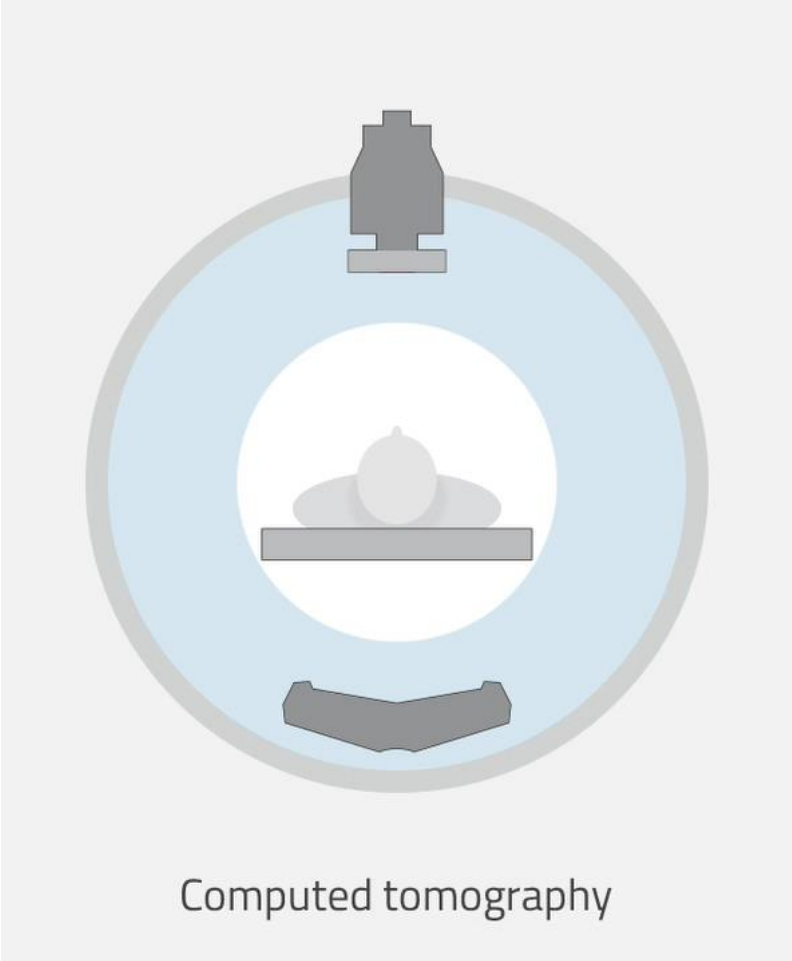
## CT of Cell?



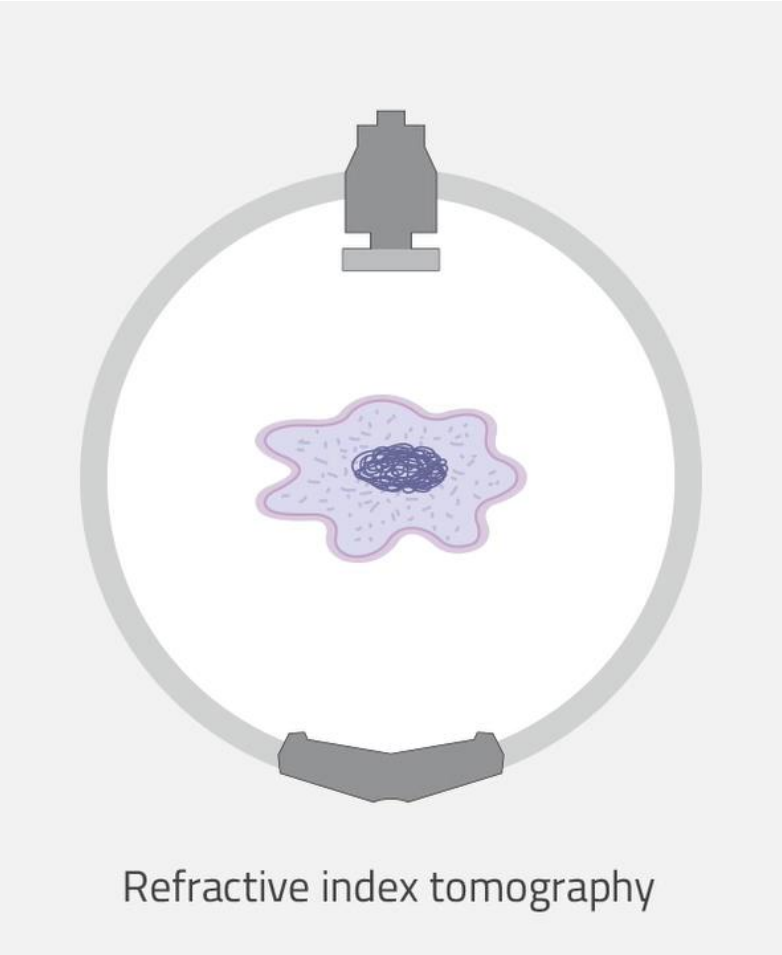


# WHAT TOMOCUBE SEE ?

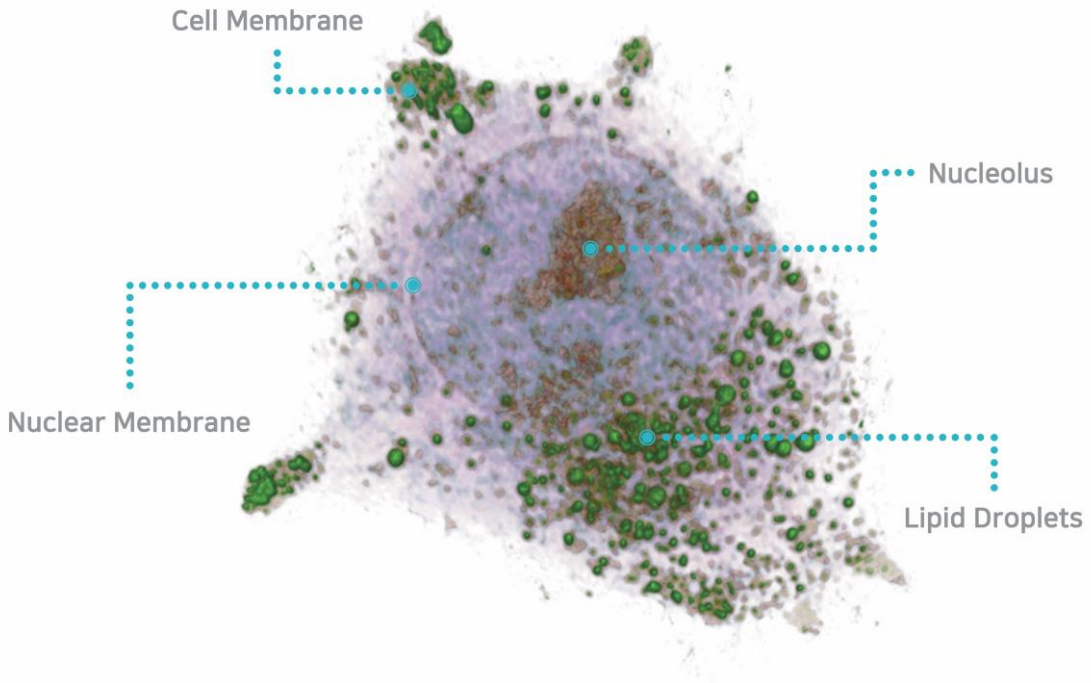
01 X-ray CT (computed tomography)



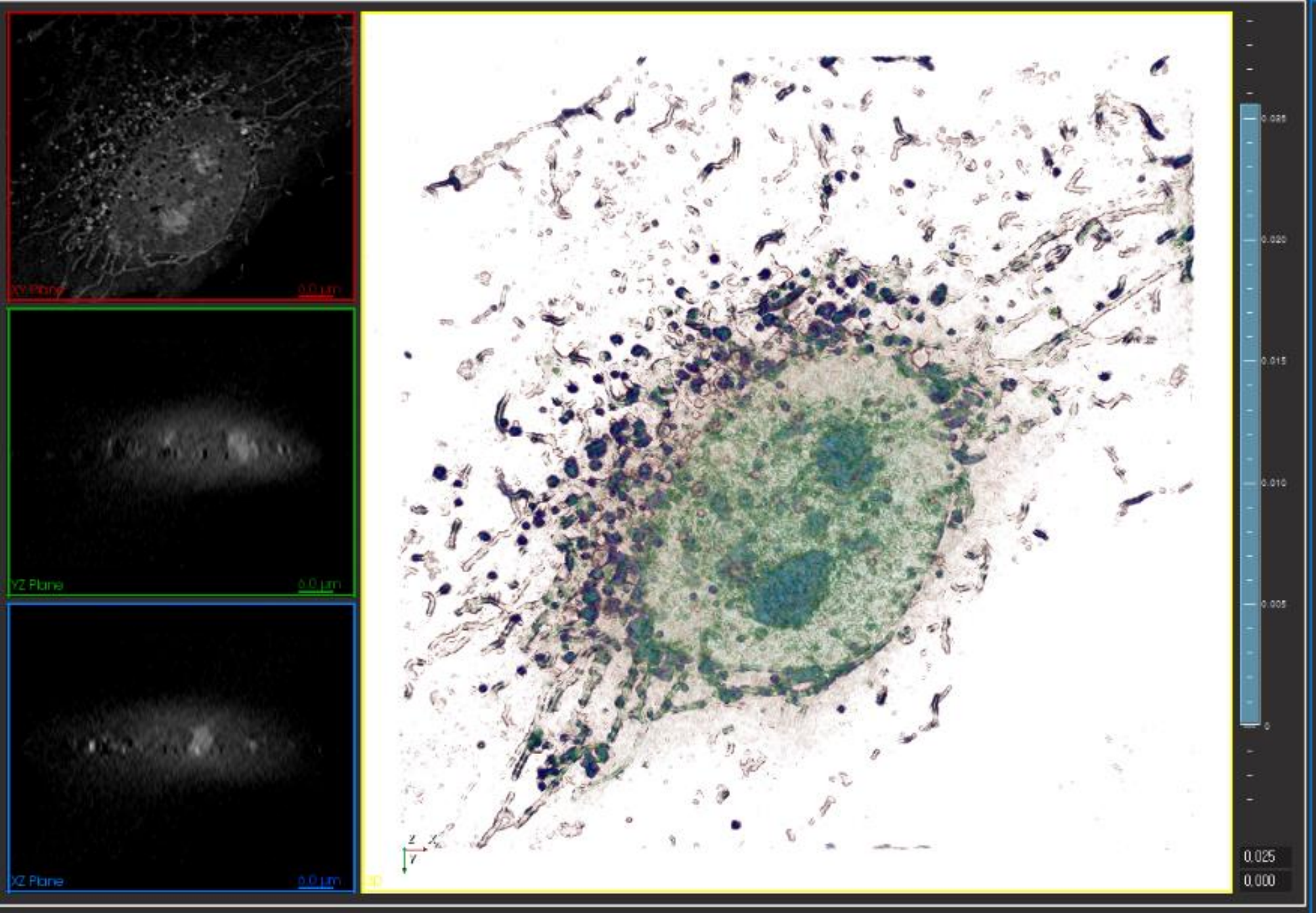

02 Laser HT (holotomography)



# WHAT TOMOCUBE SEE ?




Hepatocyte




Presets

Choose a TF preset

Current: F:/.../...41434,392,BEAS2B-029.xml

Save As | Load | Save

RI | FL

1.3322 / 0.0000

1.3322 1.3705

2D Overlay

RI Range 1.3402 ~ 1.3439

Grad Range 57.9050 ~ 142.415

Opacity 5

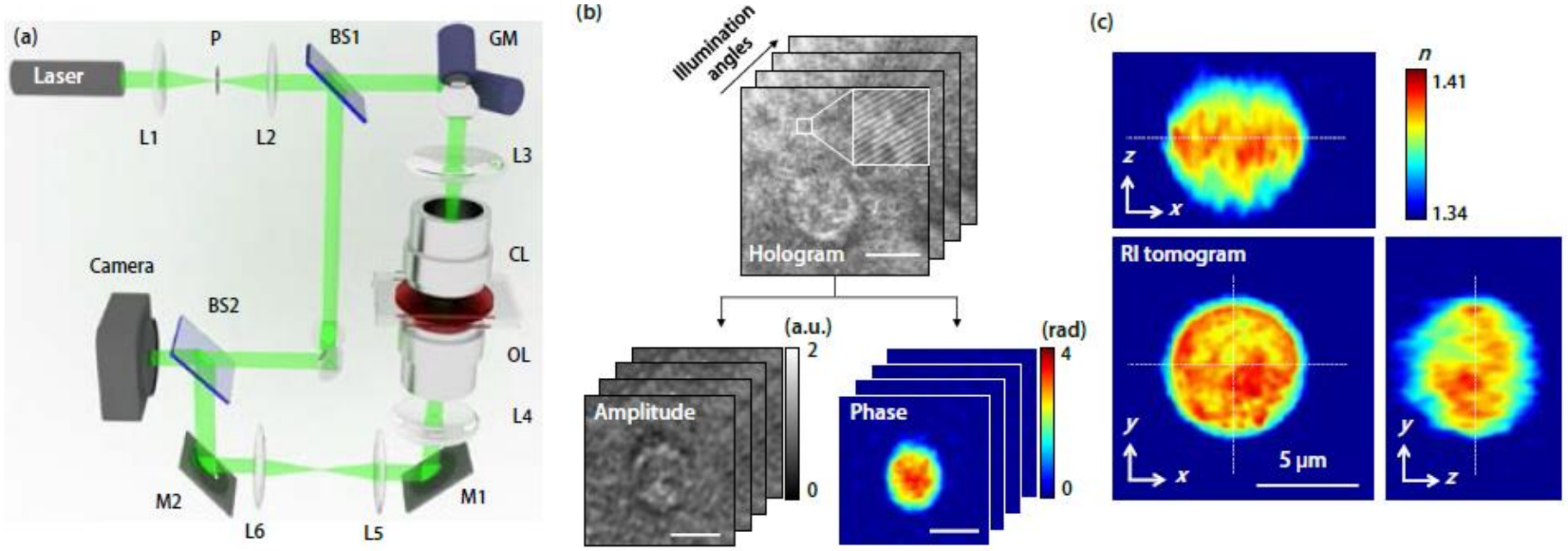
Softness 0

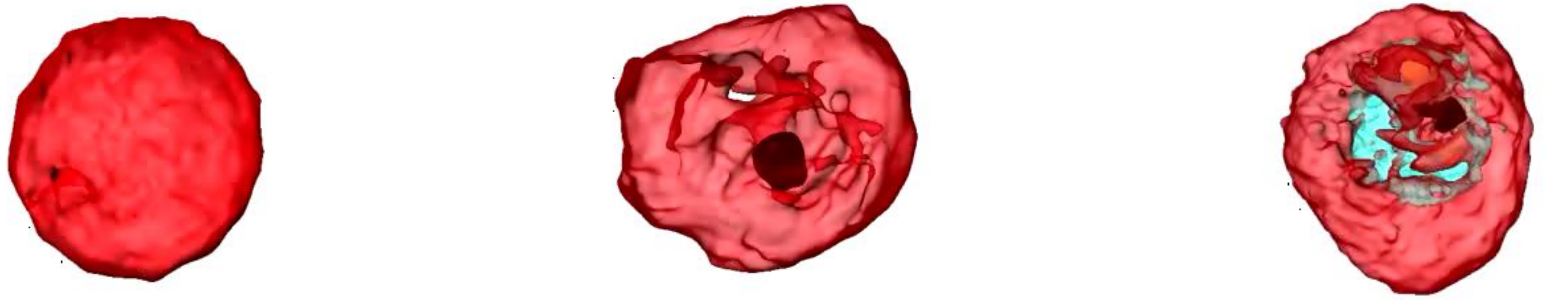
| | V | No. | MinRI | MaxRI | |
|---|---|---|---|---|---|
| 2 | v | 0 | 1.341 | 1.362 | default |
| 3 | v | 0 | 1.348 | 1.356 | default |
| 4 | v | 0 | 1.342 | 1.347 | default |
| 5 | v | 0 | 1.344 | 1.348 | default |
| 6 | v | 0 | 1.340 | 1.344 | default |

Clear | Copy | Save

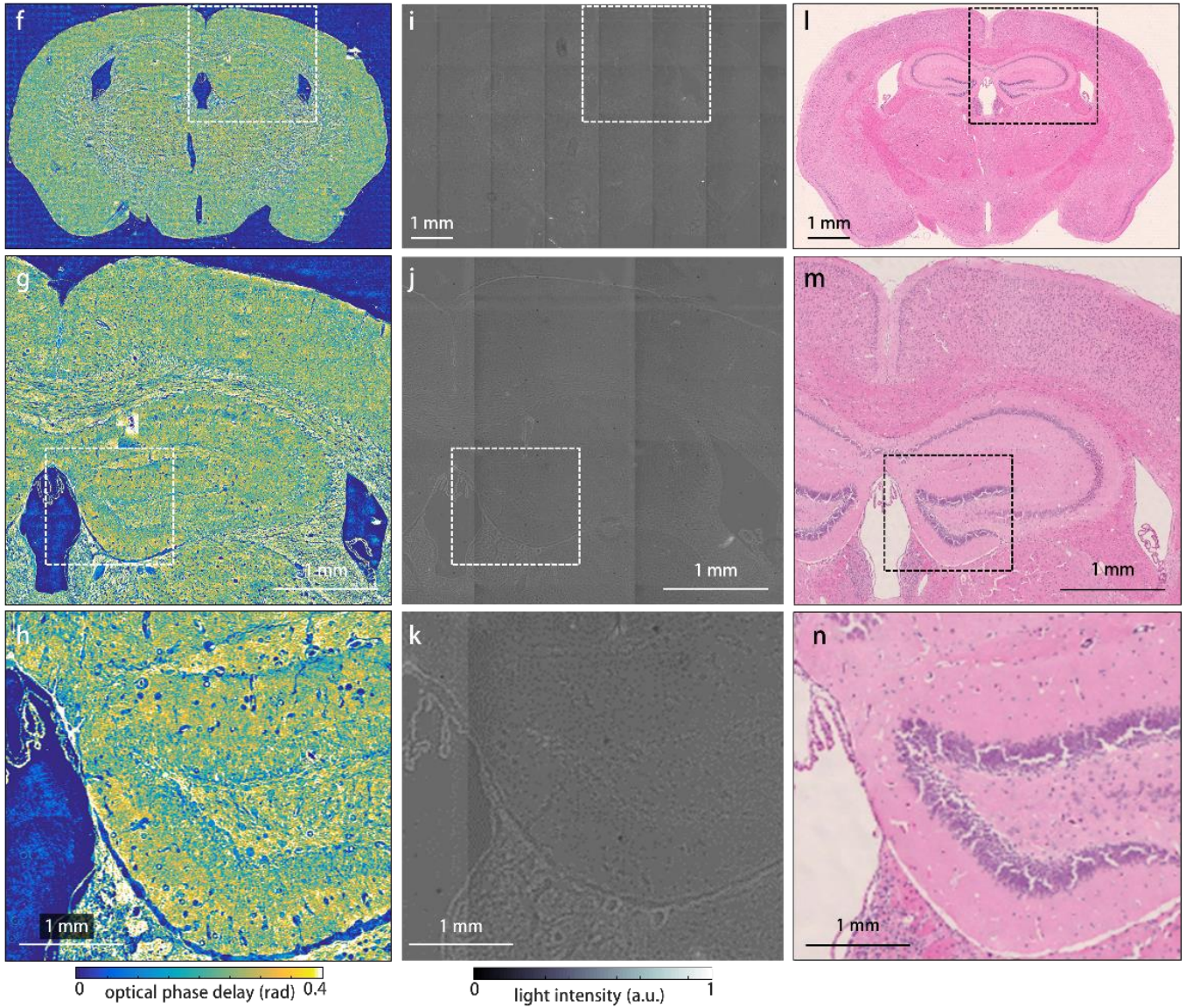
5x 0 00:00:00.000 Repeat Skip

# WHAT TOMOCUBE SEE ?



# WHAT TOMOCUBE SEE ?

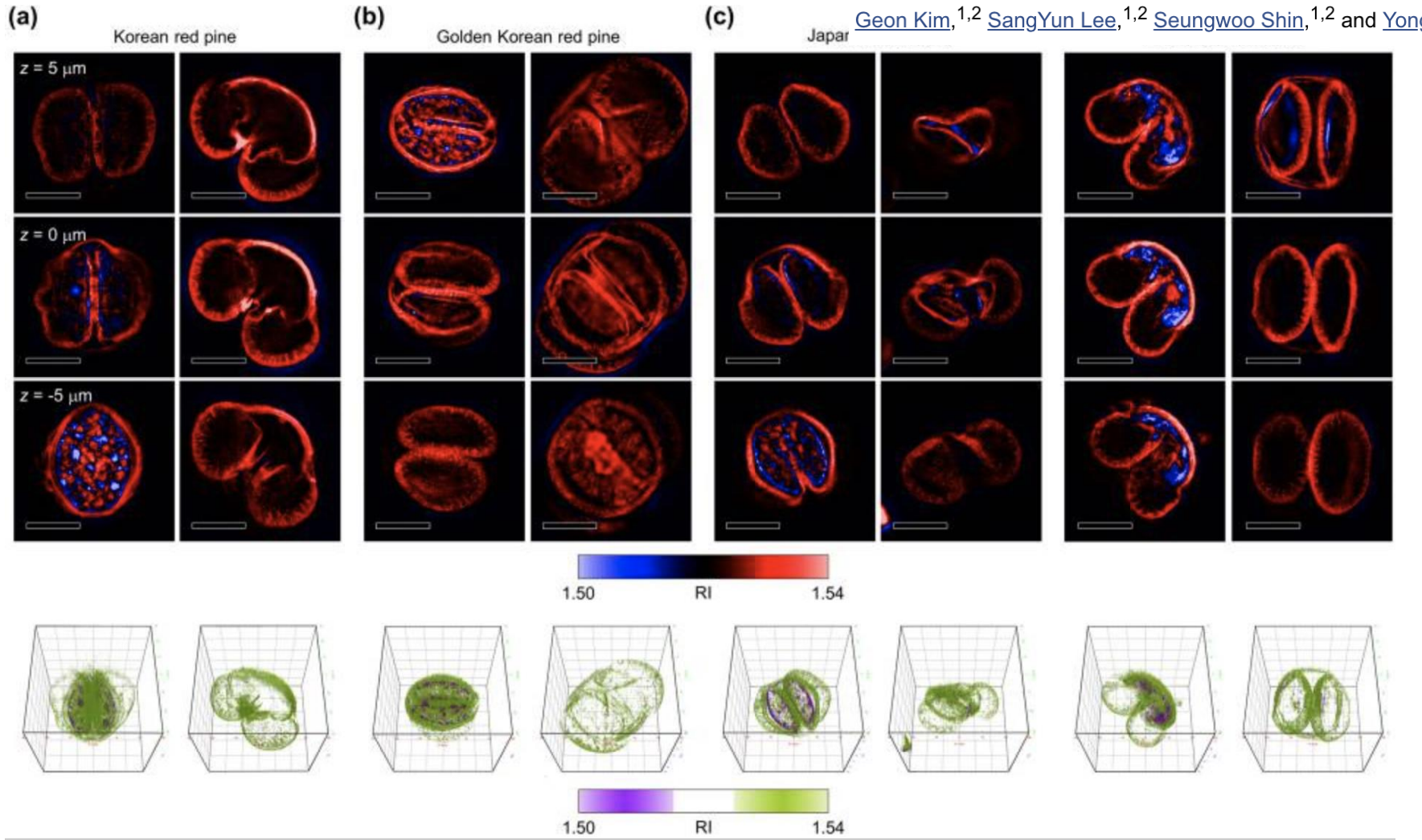


# WHAT TOMOCUBE SEE ?

Sci Rep. 2018; 8: 1782.
Published online 2018 Jan 29. doi: [10.1038/s41598-018-20113-w]
PMCID: PMC5788986
PMID: 29379106

Three-dimensional label-free imaging and analysis of *Pinus* pollen grains using optical diffraction tomography

Geon Kim,[1,2] SangYun Lee,[1,2] Seungwoo Shin,[1,2] and YongKeun Park[1,2,3]

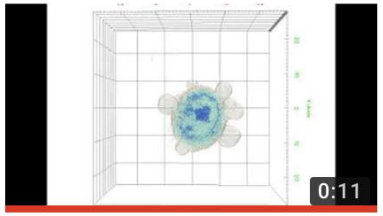


# WHAT TOMOCUBE SEE ?

Tomocube Inc.

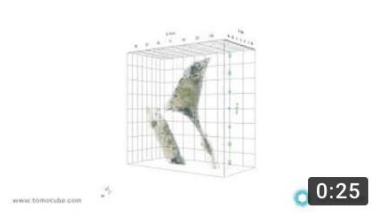
홈 동영상 재생목록 채널 정보

Image of the week 모두 재생



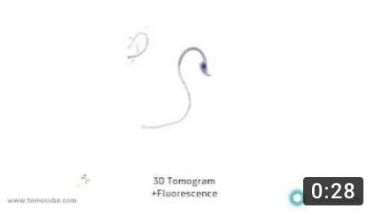

[Image of the week, 18 Jul 2018]

Tomocube Inc.
조회수 76회 • 4개월 전



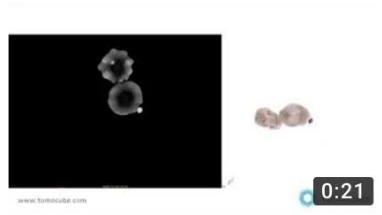

[Image of the week, 25 Jul 2018]

Tomocube Inc.
조회수 42회 • 4개월 전




[Image of the week, 2 Aug 2018]

Tomocube Inc.
조회수 77회 • 4개월 전




[Image of the week] 9 Oct 2018

Tomocube Inc.
조회수 94회 • 1개월 전

# Introducing

## 3D Correlative Microscopy, the HT-2

3D holotomography meets **3D fluorescence microscopy**

## Start from 3rd of July 2017

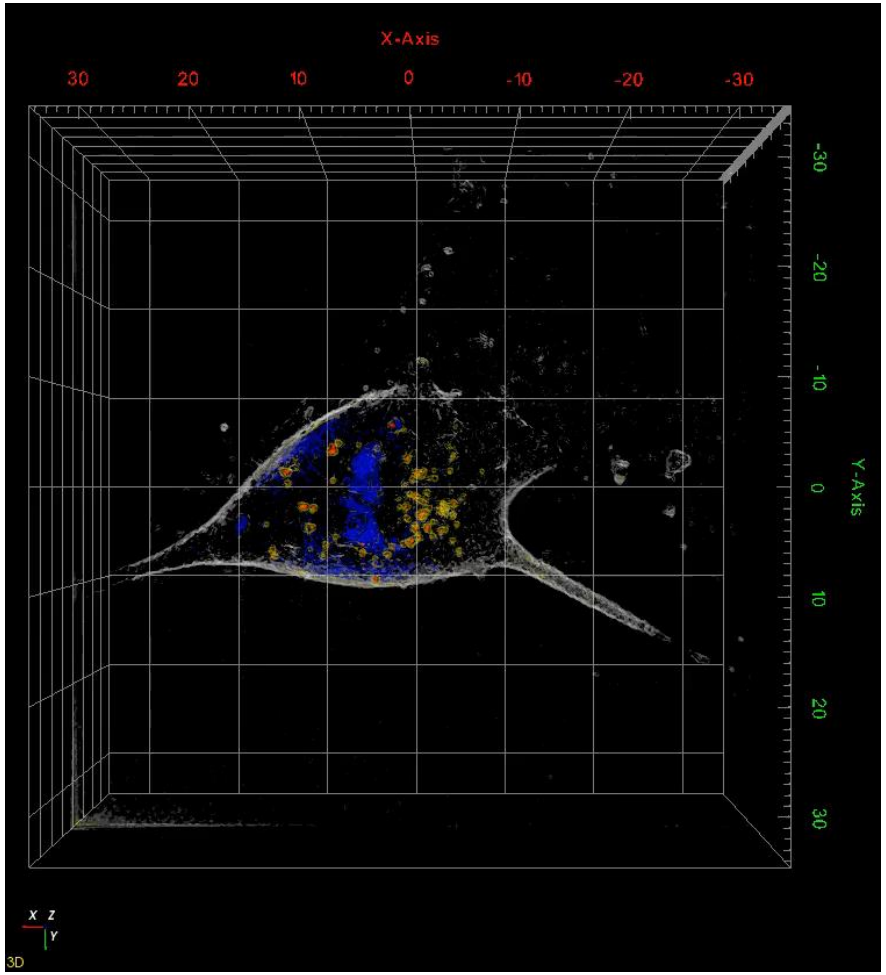
" Tomocube is pleased to announce a **new HT-2 system** for holotomography with **3D fluorescence** imaging capability. "

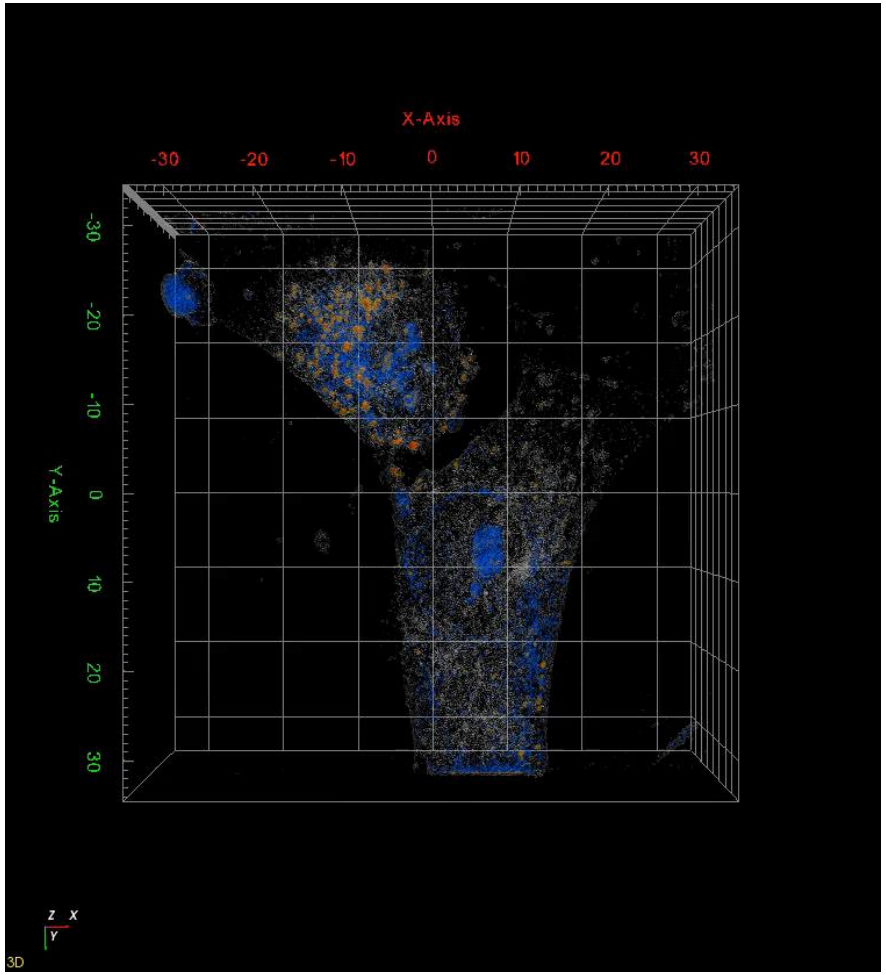
Tomocube

Tomocube, Inc.
2F, 48, Yuseong-daero 1184beon-gil, Yuseong-gu, Daejeon, Korea
T +82-42-863-1100 info@tomocube.com www.tomocube.com

# WHAT TOMOCUBE SEE ?

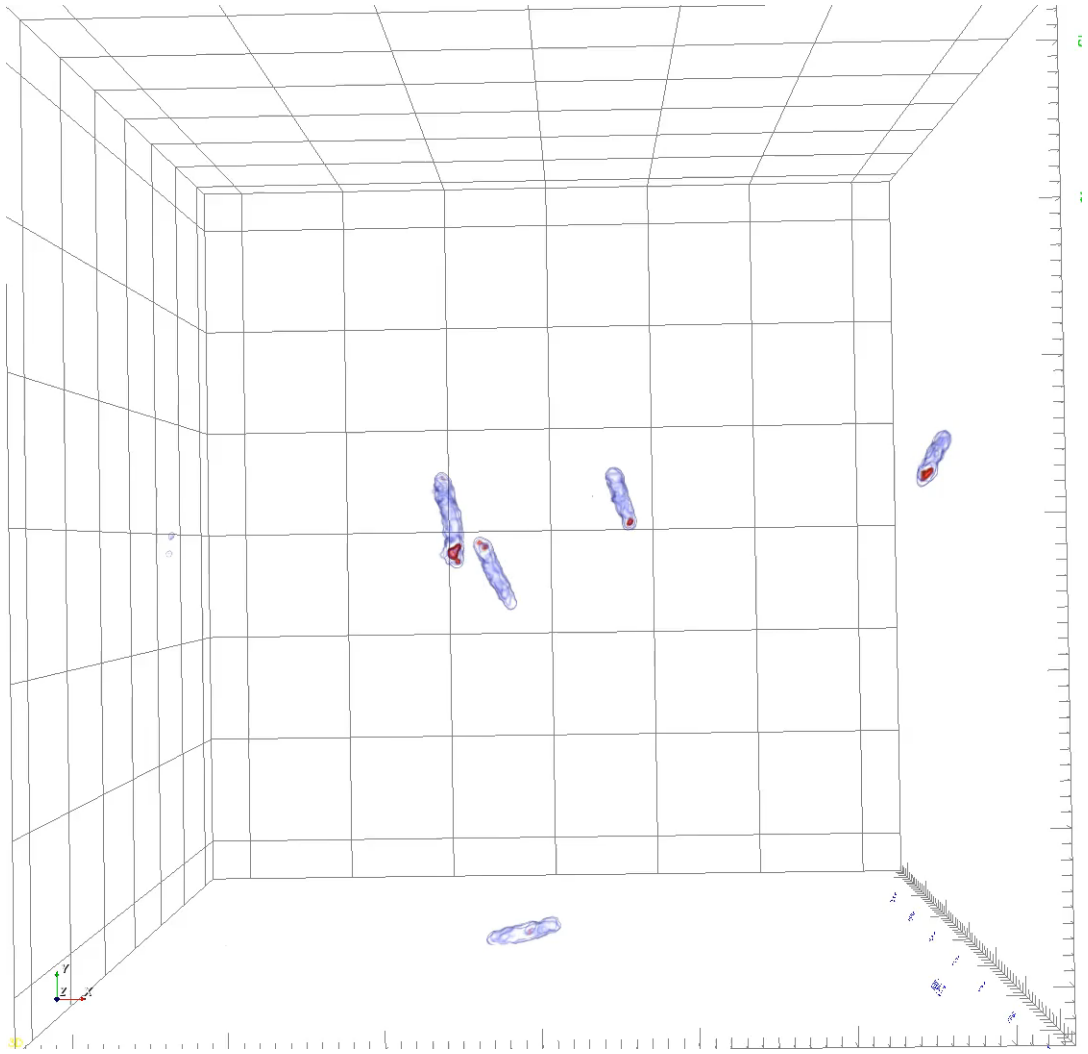
Stem Cell (Wharton jelly5)



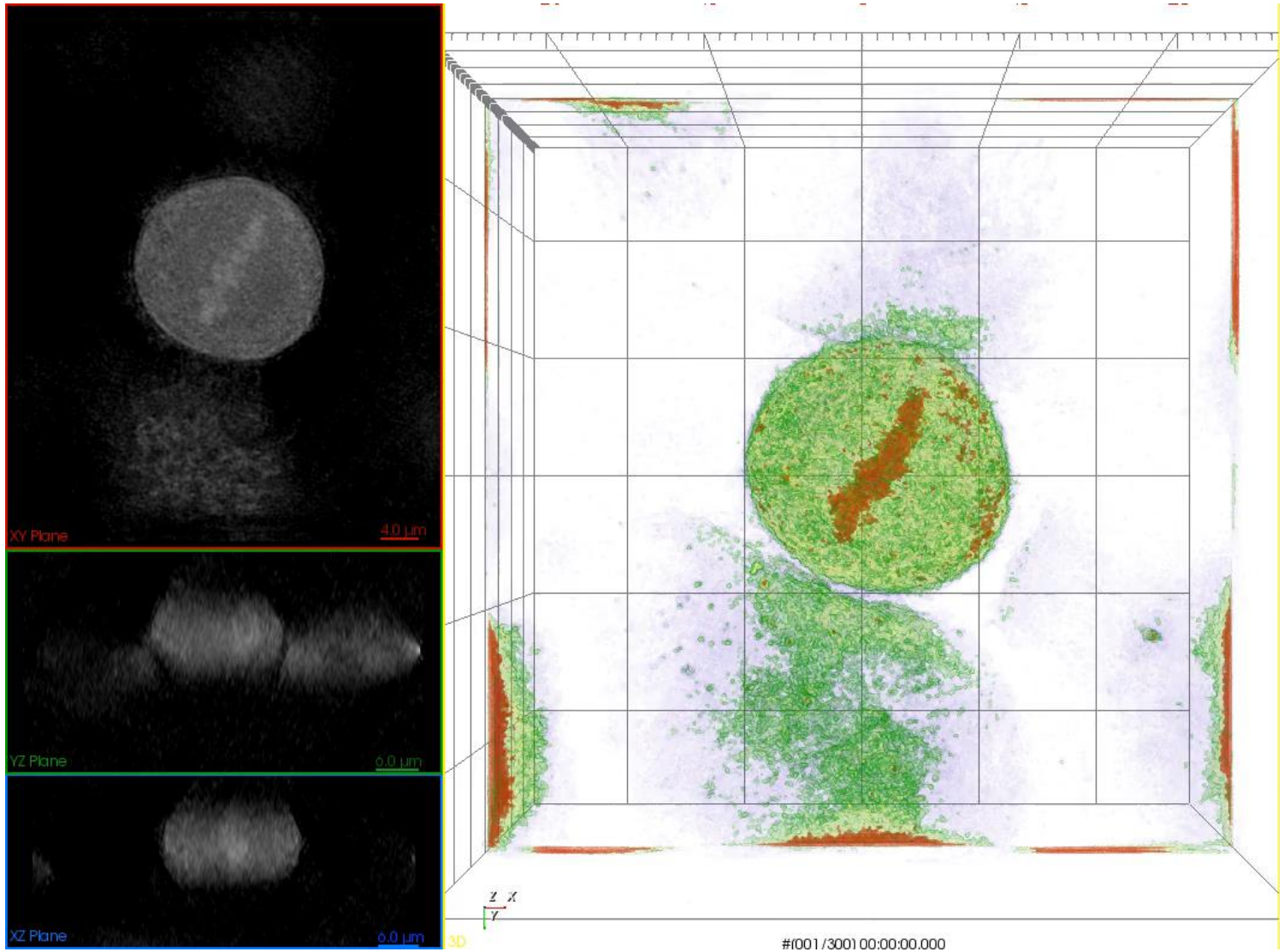
# WHAT TOMOCUBE SEE ?

Bacterial division

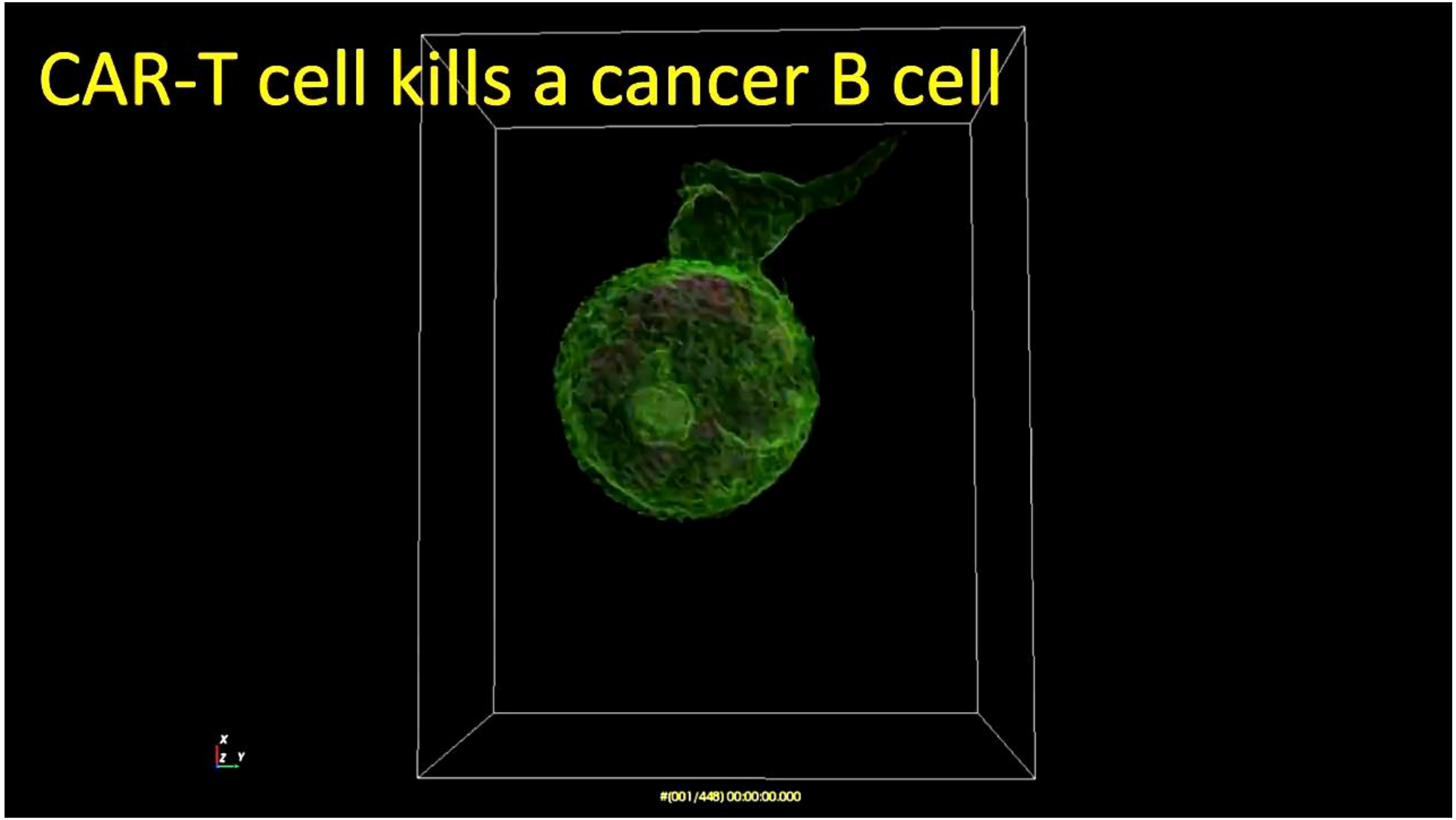


# WHAT TOMOCUBE SEE ?

Cell Division



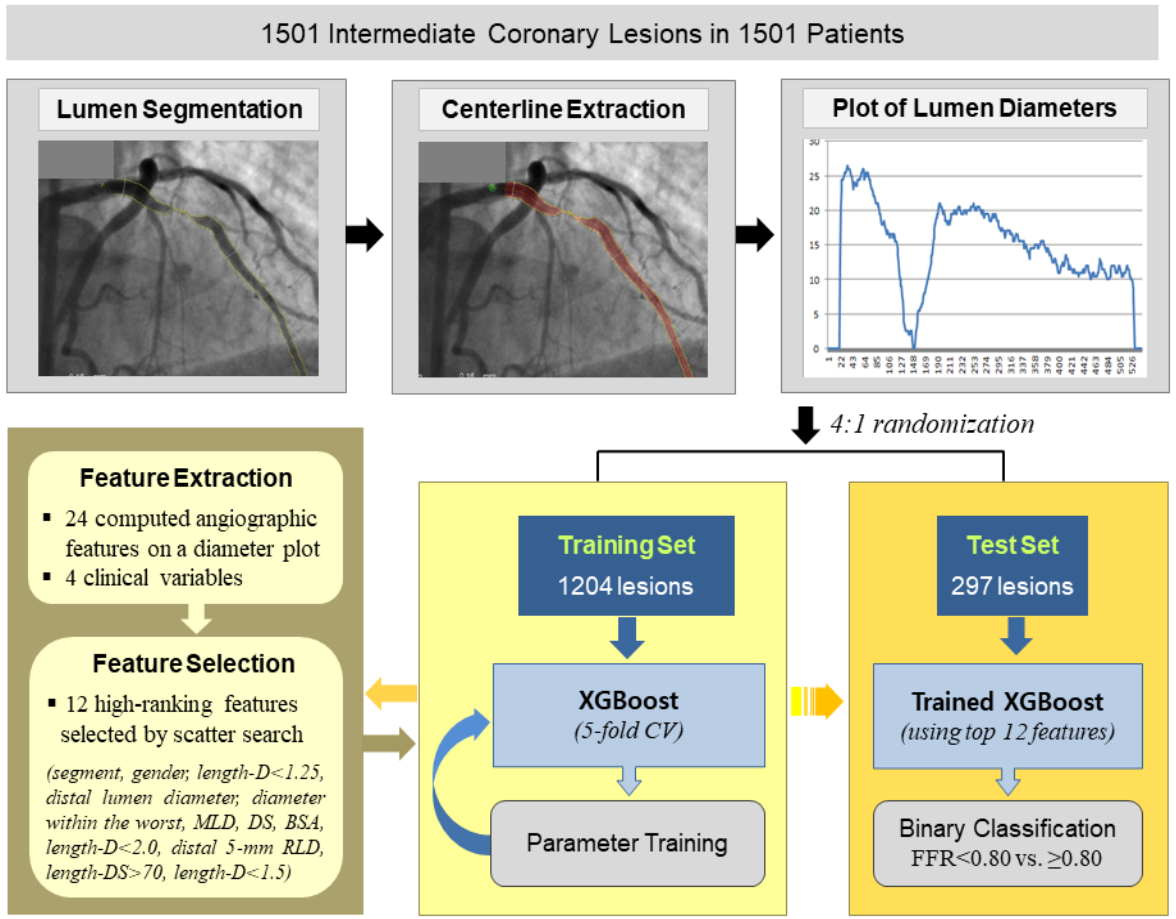
# WHAT TOMOCUBE SEE ?

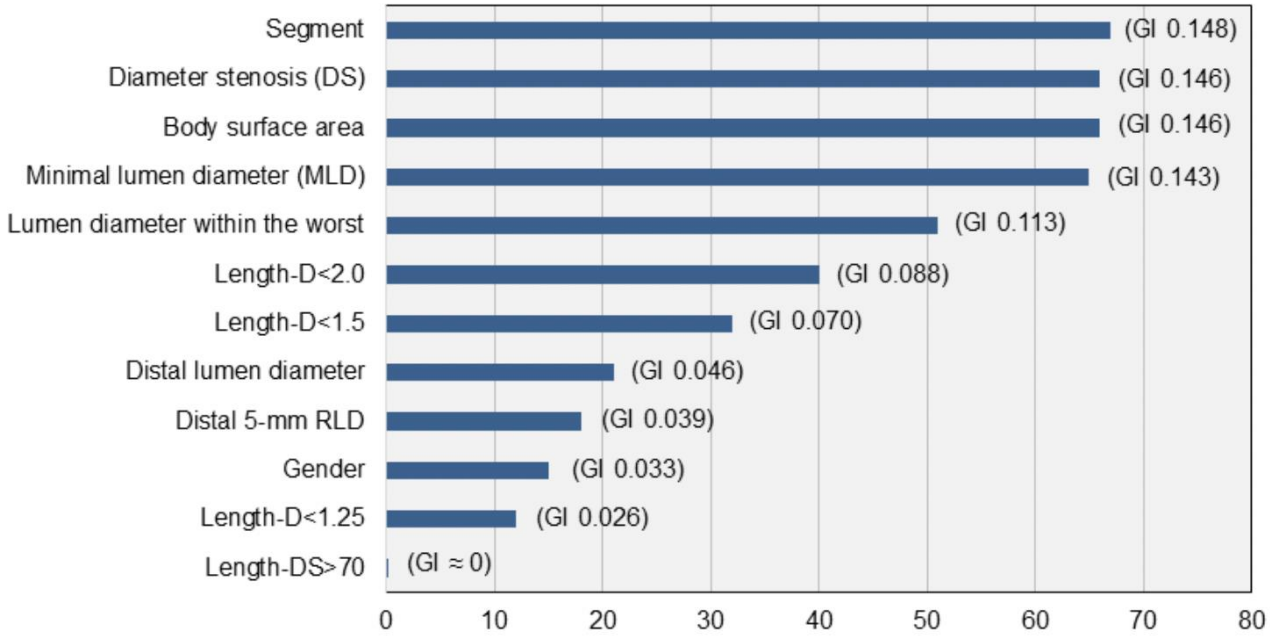



so basically we want to know how bacteria and higher cells
actually regulate their

# WHAT AI CAN DO ?

## What we did – classification (conventional ML + feature extraction)

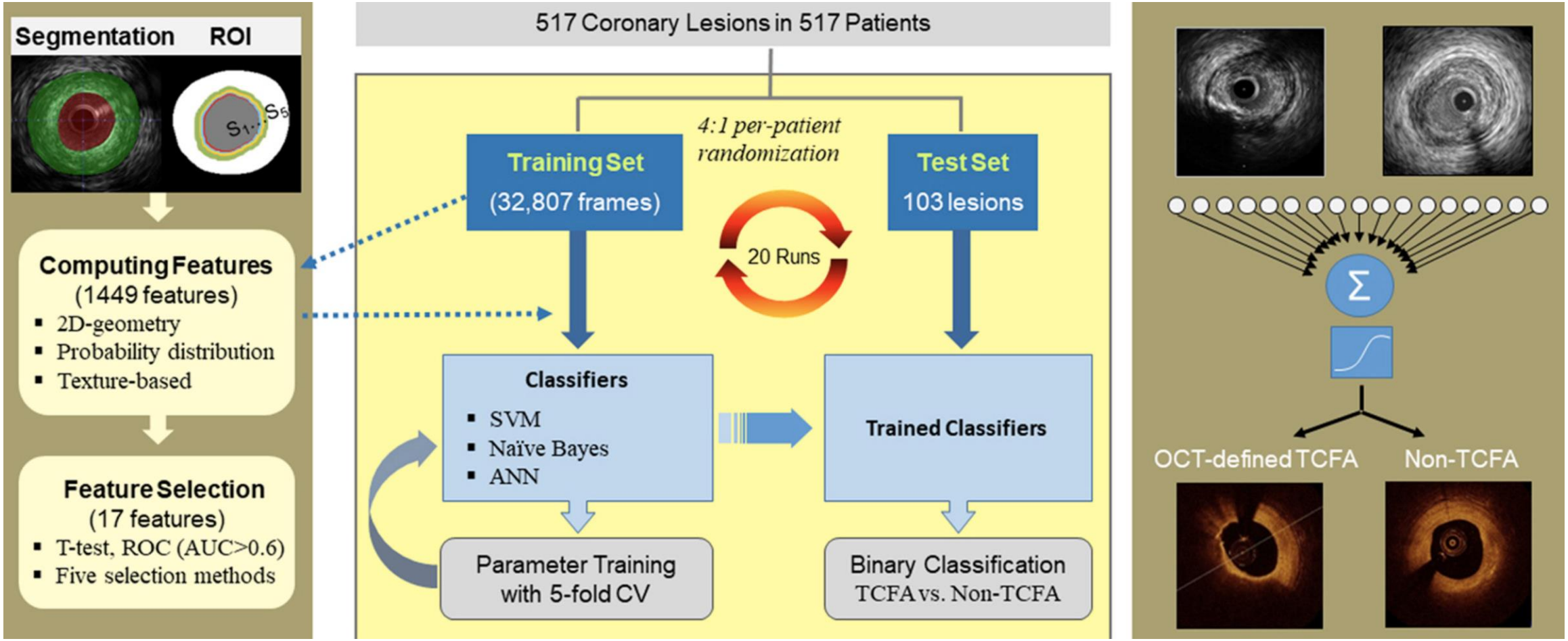



JAHA: Journal of the American Heart Association

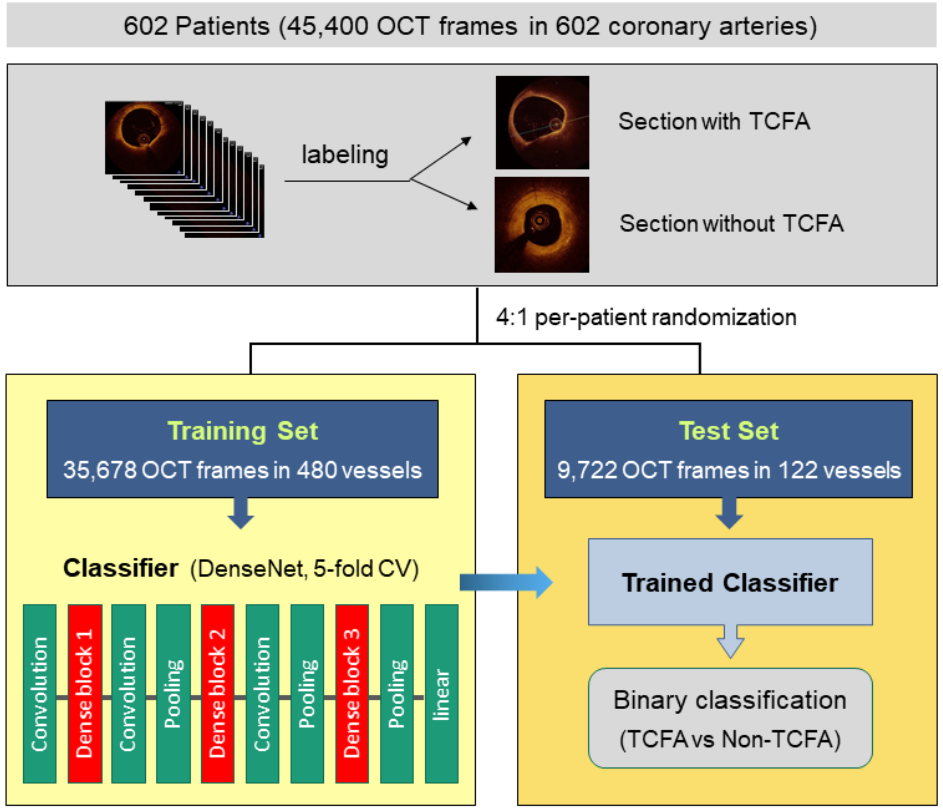
# WHAT AI CAN DO ?

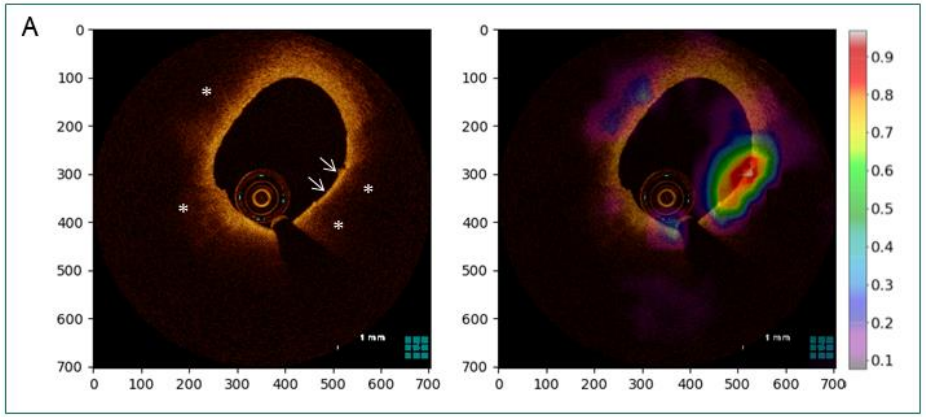
## What we did – classification (conventional ML + feature extraction)

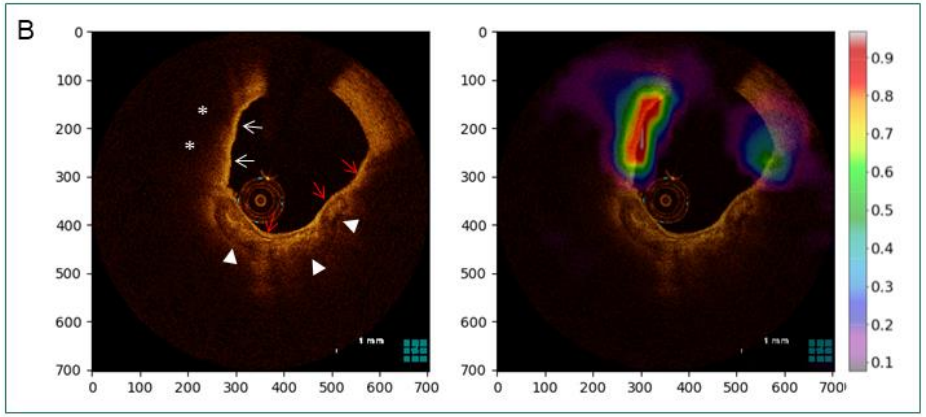


# WHAT AI CAN DO ?

## What we did – classification (deep learning)



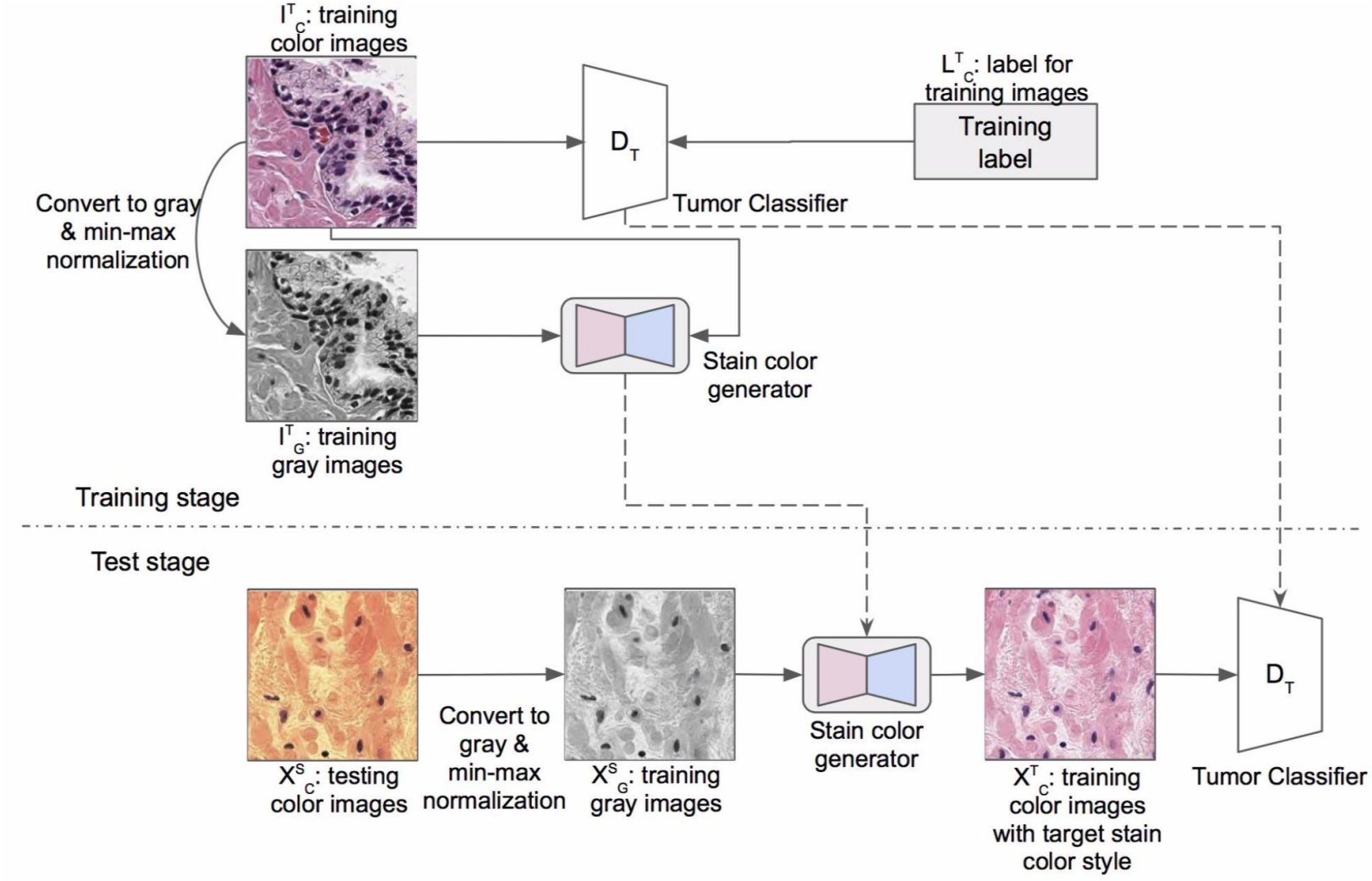




Under revision – European Heart Journal - Cardiovascular Imaging

# WHAT AI CAN DO ?

## What we did – translation, generation (GAN, encoder-decoder structure)



# WHAT AI CAN DO ?

## What we did – translation, generation

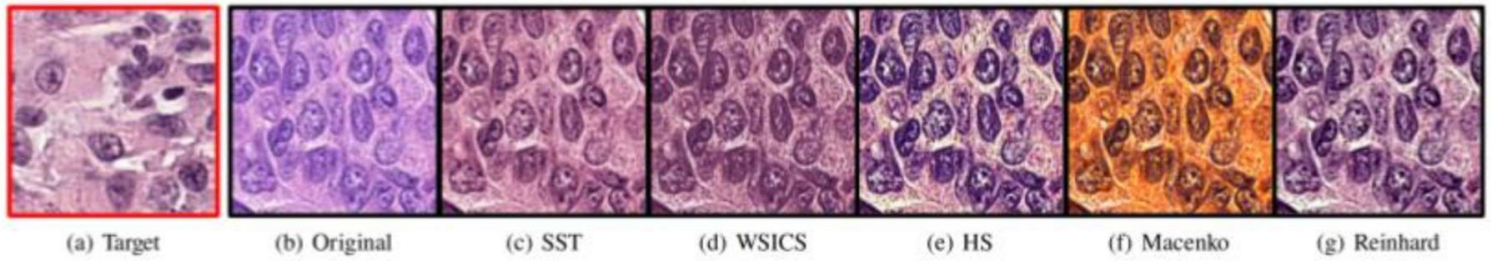


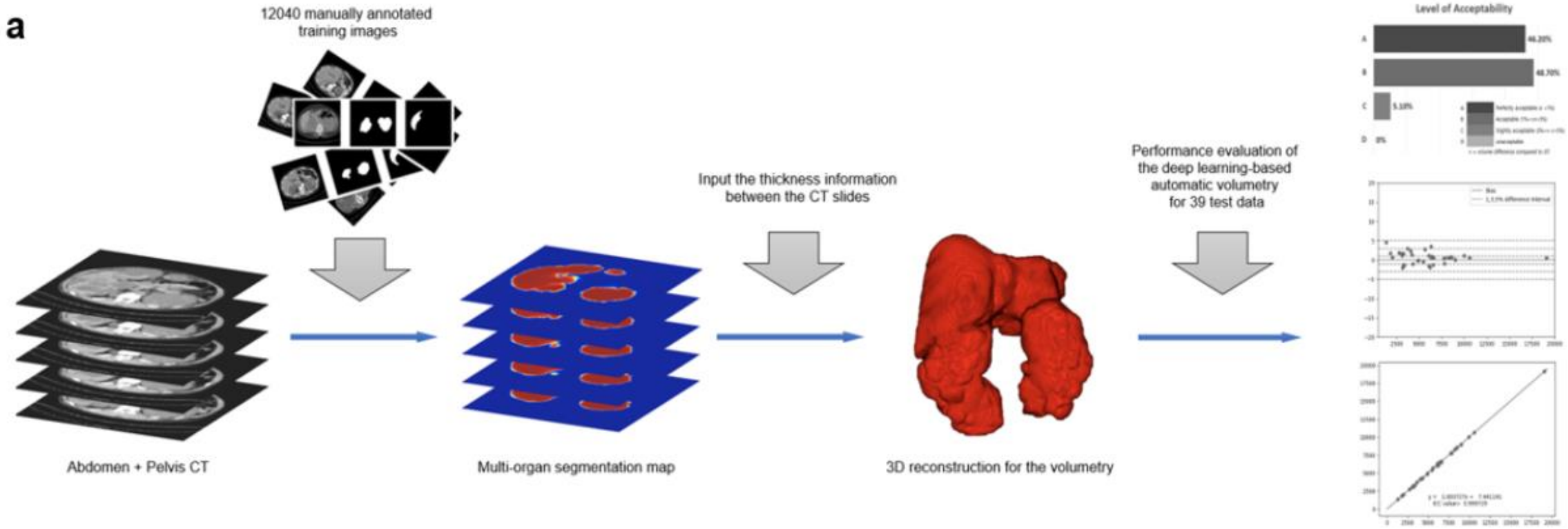

**Fig. 4.** Comparison between SST and others: (a) Target image for transfer (b) Original input image to be transferred (c) SST (d) WSICS (e) HS (f) Marcenko (g) Reinhard

**Table 1.** Performance of CNNs based tumor classifiers among different stain color normalization methods. SST model shows classification improvement compared to naive application to original (untransferred image) and outperforms the others.

| Model | Target | Original | **SST** | Reinhard | Macenko | HS | WSICS |
|---|---|---|---|---|---|---|---|
| AUC | 0.9760 | 0.8900 | **0.9185** | 0.5611 | 0.7169 | 0.4245 | 0.6408 |
| Precision | 0.9114 | 0.8098 | **0.8440** | 0.6114 | 0.6983 | 0.4987 | 0.5989 |
| Recall | 0.9126 | 0.8111 | **0.8460** | 0.6119 | 0.6956 | 0.4986 | 0.5957 |
| Specificity | 0.9583 | 0.8014 | **0.8371** | 0.5471 | 0.6500 | 0.4162 | 0.6010 |

# WHAT AI CAN DO ?

## What we did – detection, segmentation (3D Unet + attention)

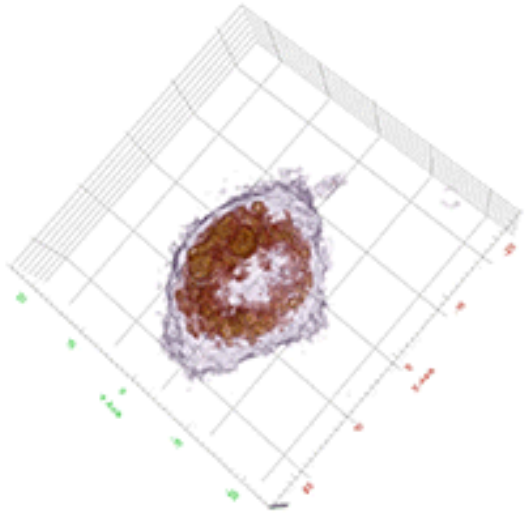



*We will submit ^^ …*

# WHAT WE CAN DO?

## What tomocube see

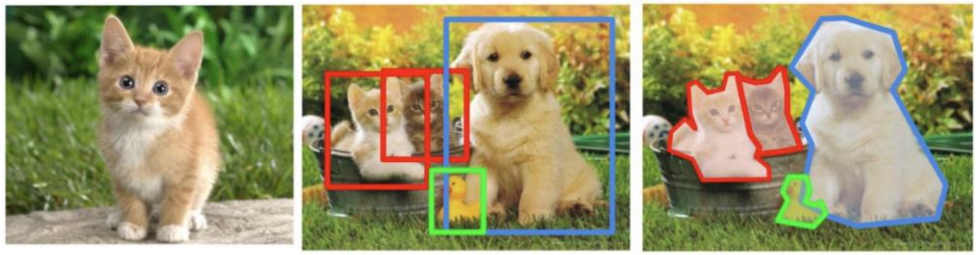
Tomocube



+

## What AI can

Classification, detection, segmentation



CAT

CAT, DOG, DUCK

CAT, DOG, DUCK

Translation, Generation


...

= ?

# WHAT WE CAN DO? –
# [3D holography + Segmentation] for finding new marker

**Deep-learning based three-dimensional label-free tracking and analysis of immunological synapses of chimeric antigen receptor T cells**

Moosung Lee, Young-Ho Lee, Jinyeop Song, Geon Kim, YoungJu Jo, HyunSeok Min, Chan Hyuk Kim, YongKeun Park

Posted February 04, 2019.

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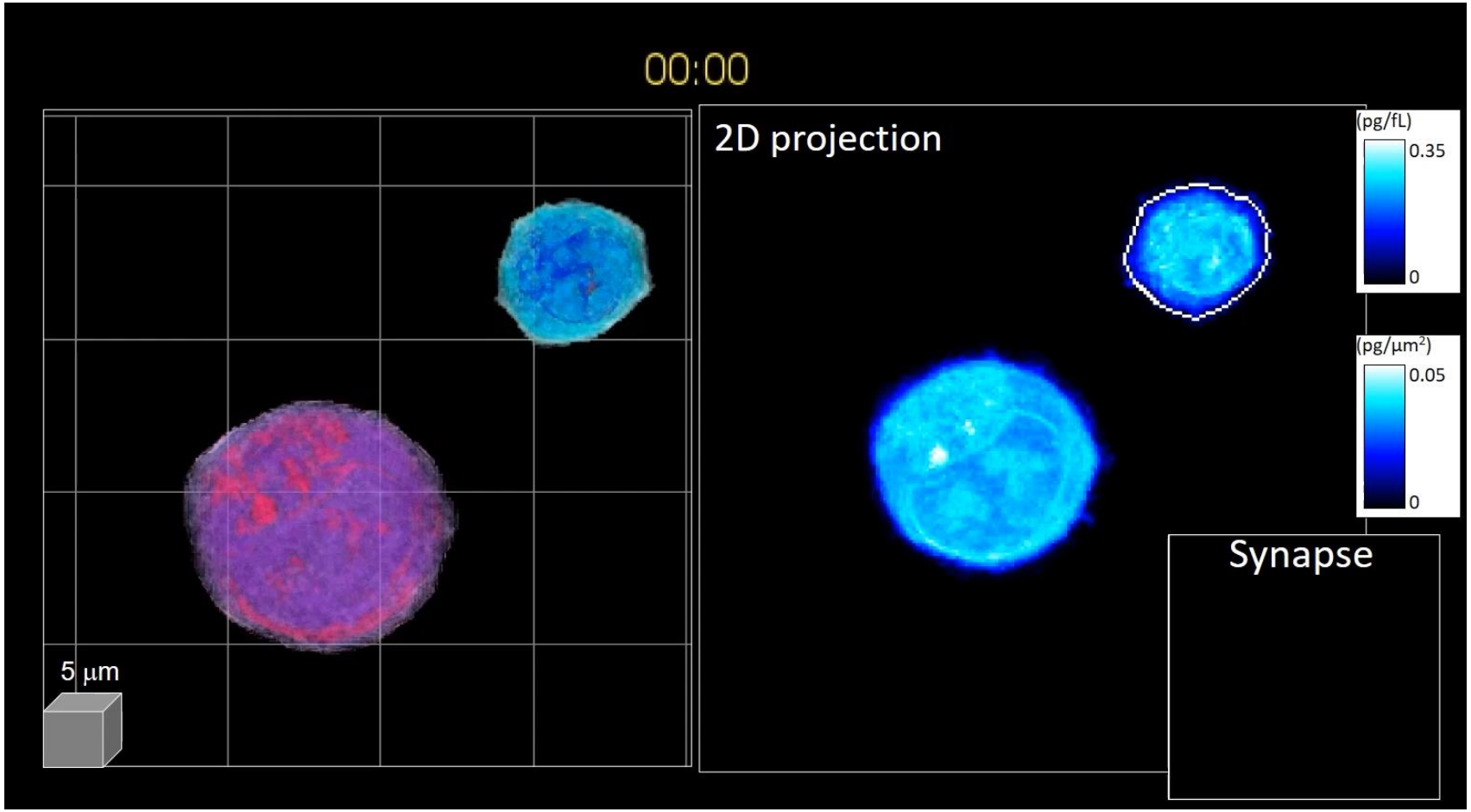
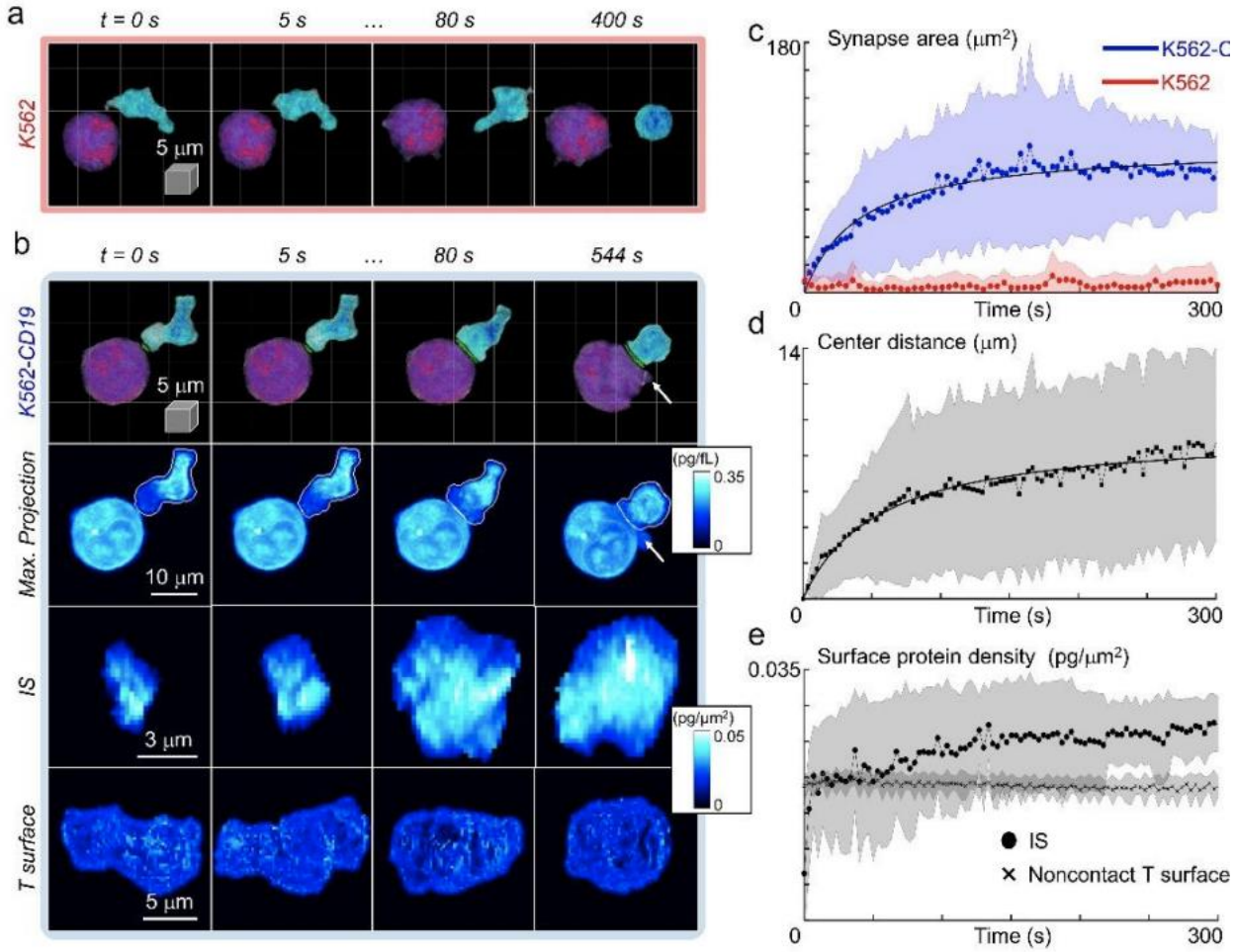
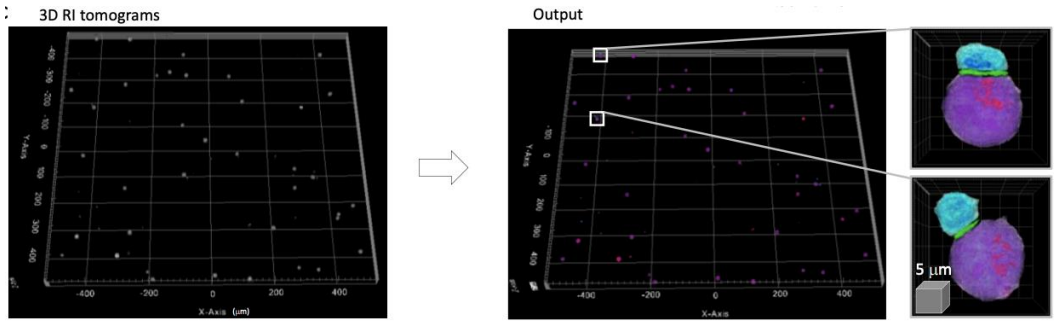
Supplementary Material



# WHAT WE CAN DO? –
# [3D holography + Segmentation] for finding new marker



# WHAT WE CAN DO? –
# [3D holography + translation] for data improvement

Research Article | Vol. 27, No. 4 | 18 Feb 2019 | OPTICS EXPRESS 4927
Optics EXPRESS

## Cycle-consistent deep learning approach to coherent noise reduction in optical diffraction tomography

GUNHO CHOI,[1,6] DONGHUN RYU,[2,3,6] YOUNGJU JO,[1,2,3,5] YOUNG SEO KIM,[1,2,4] WEISUN PARK,[1,2,3] HYUN-SEOK MIN,[1] AND YONGKEUN PARK[1]

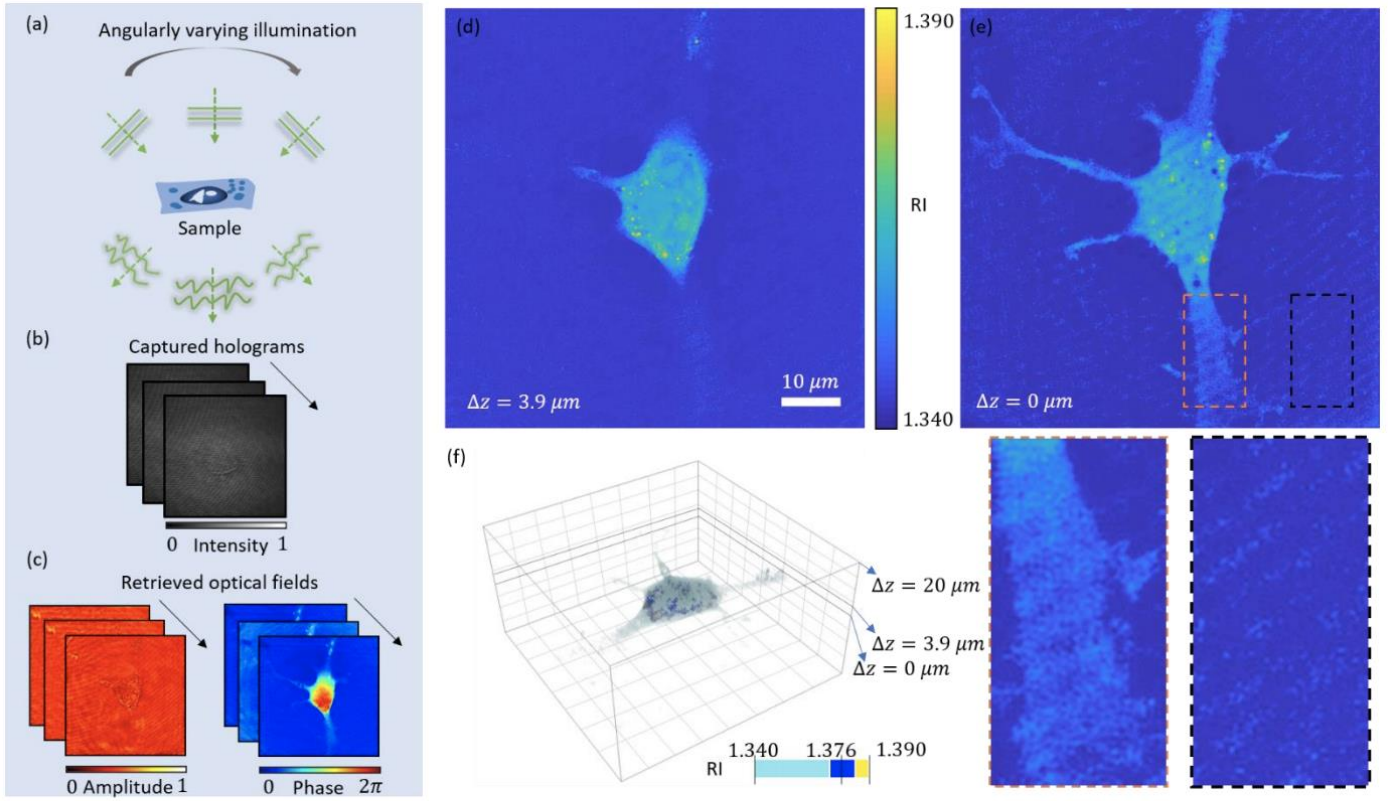



Fig. 1. Coherent noise problem in optical diffraction tomography (ODT). (a-b) The ODT employs angularly varying illumination to capture off-axis holograms. (c) Each complex optical field is reconstructed from the obtained holograms. (d) 2D sliced image of 3D reconstructed tomogram at $\Delta z = 3.9\ \mu m$ e) 2D sliced image of 3D reconstructed tomogram at focus $\Delta z = 0\ \mu m$ corrupted with the coherent noise. (f) 3D rendering of the whole reconstructed tomogram.

*Optics Express, (2019)*
*•https://doi.org/10.1364/OE.27.004927*

# WHAT WE CAN DO? –
# [3D holography + translation] for data improvement

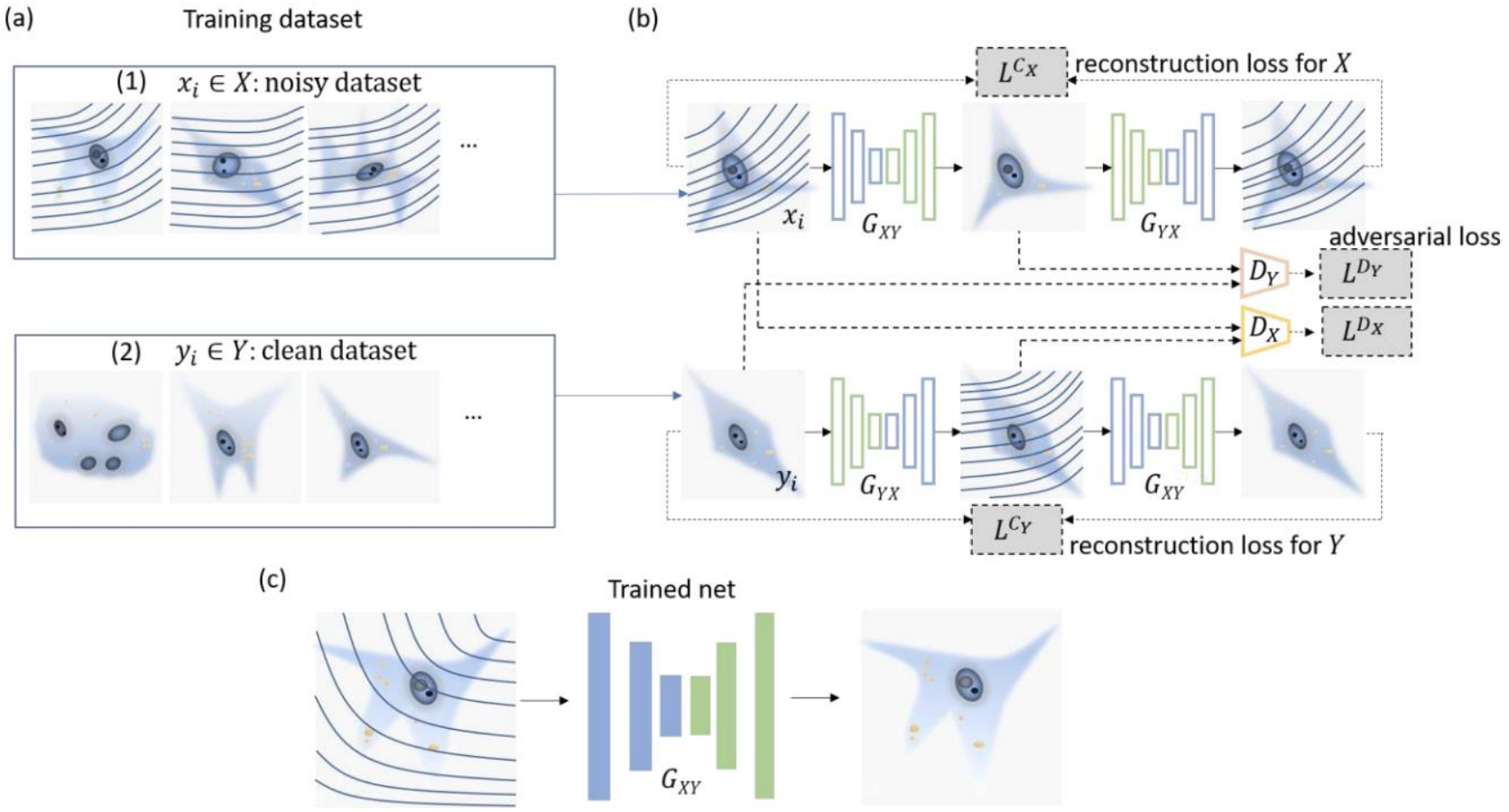



Fig. 2. Overview of the present network for de-noising: training and testing (a) Two classes of dataset for training were prepared. $x_i \in X$: noisy tomogram and $y_i \in Y$: clean tomogram. (b) Training process of the proposed network. $G_{XY}$: Generator that maps $x$ to $y$. $G_{YX}$: Generator that maps $y$ to $x$. $D_y$: Discriminator to determine if given input is a generated clean image from $G_{XY}$ or a real data $y$. $D_X$: Discriminator to determine if given input is a generated noisy image from $G_{YX}$ or a real data $x$. $L^{D_Y}$ : Adversarial loss for $D_Y$. $L^{D_X}$ : Adversarial loss for $D_Y$. $L^{C_X}$ : cycle-consistency loss for $x$. $L^{C_Y}$ : cycle-consistency loss for $y$. (c) Trained network, $G_{XY}$ removes the coherent noise of 2D sliced tomogram.

# WHAT WE CAN DO? –
# [3D holography + translation] for data improvement

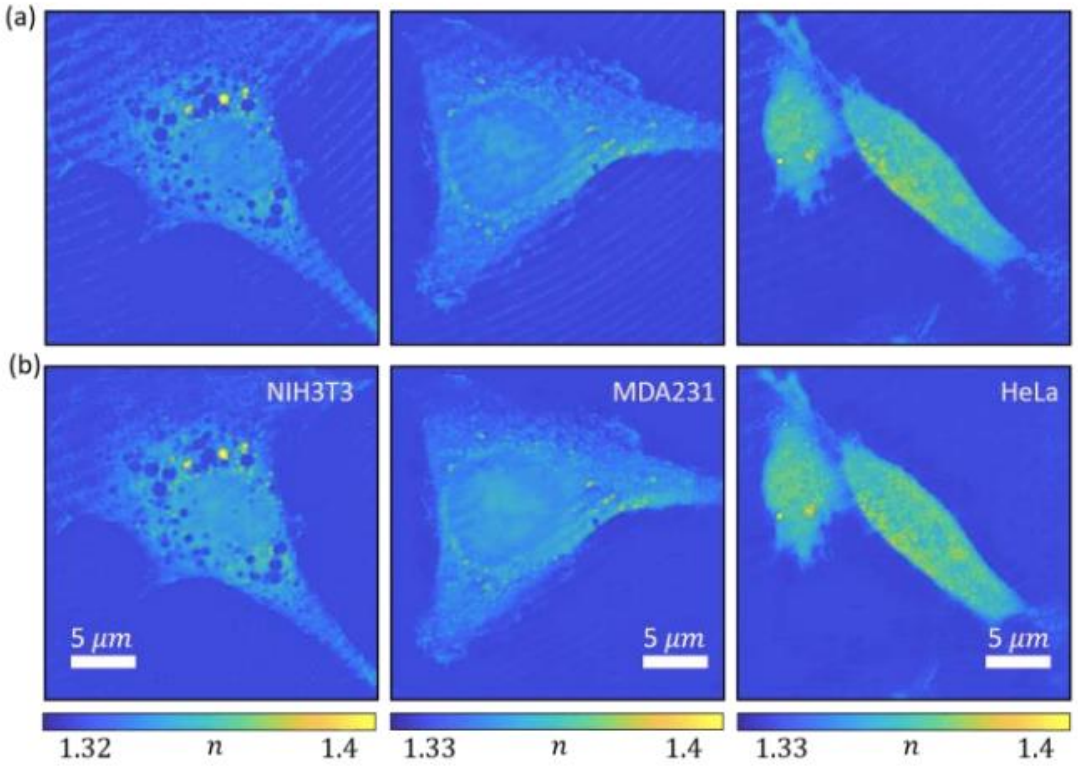



Fig. 5. Experimental validation of the present method. Tomograms of NIH3T3, MDA231, and HeLa (a) in the presence of coherent noise, in the shape of the fringe pattern and (b) after coherent noise removal using our deep neural network.

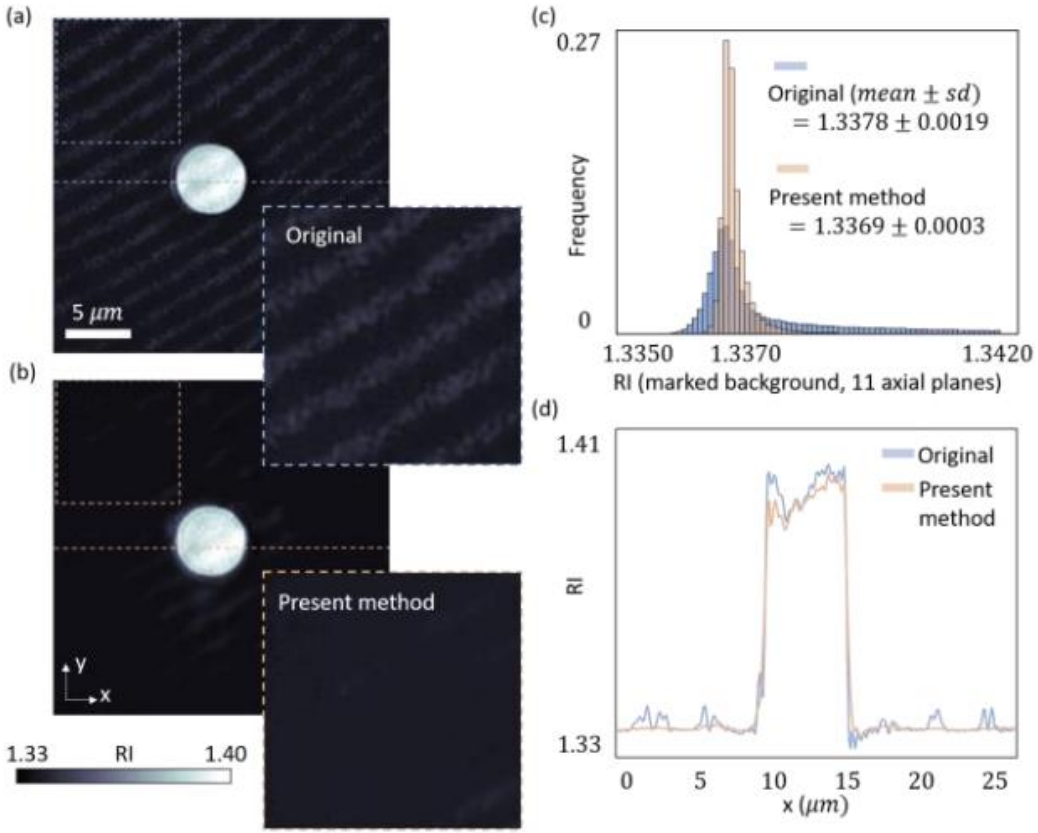
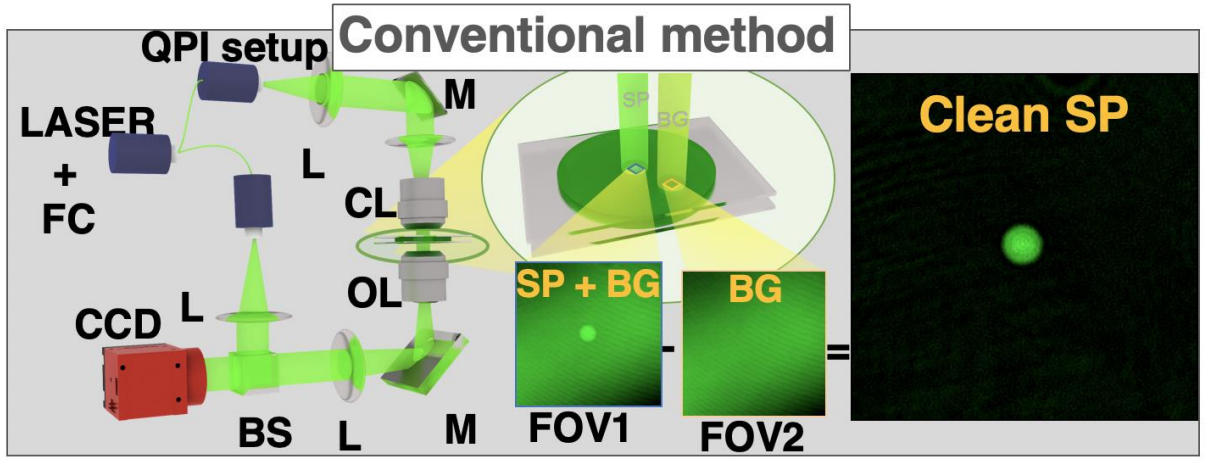


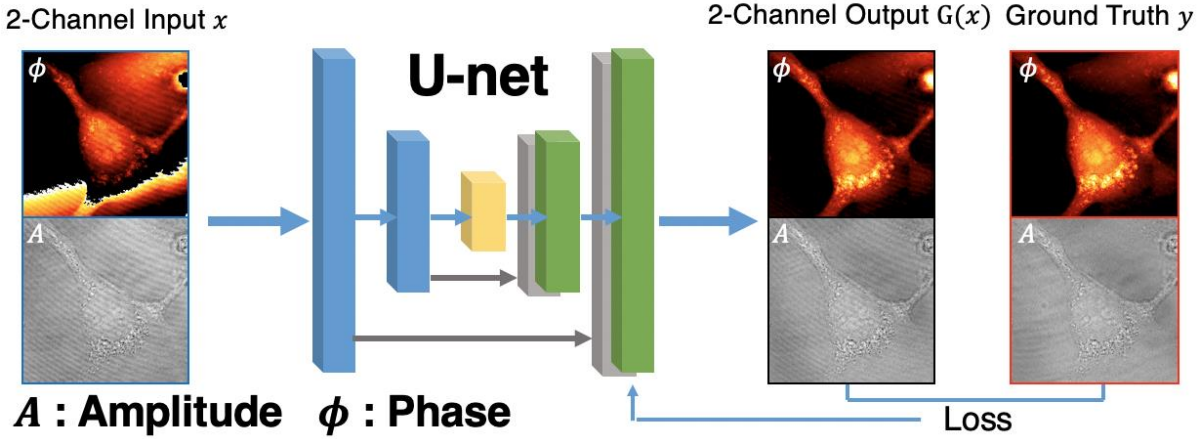

Fig. 4. Quantitative analysis of the proposed network. (a) Original tomogram of the silica microbead degraded by the coherent noise. (b) Tomogram denoised via our method. (c) 2D tomogram slices in the background region (number of slices = 11), marked by top-left corner box, acquired in the axial direction; the RI distributions are shown for comparison to highlight the denoising effect. (d) Line profiles along the horizontal way are visualized.

# WHAT WE CAN DO? –
# [3D holography + classification] for robust imaging

## Deep Learning Aberration Compensation in Quantitative Phase Imaging

Taean Chang[1], YoungJu Jo[1,2], Hyun-Seok Min[2], Gunho Choi[2] and YongKeun Park [1,2,*]
[1]Department of Physics, Korea Advanced Institute of Science and Technology (KAIST), Daejeon 34141, Republic of Korea
[2]Tomocube Inc., Daejeon 34051, Republic of Korea
*yk.park@kaist.ac.kr




241 Images ( 366×366 ) with Augmentation ( Random crop, 90° Rotation, Flip )

Objective $G = L_{L1} + \lambda L_{SSIM}$

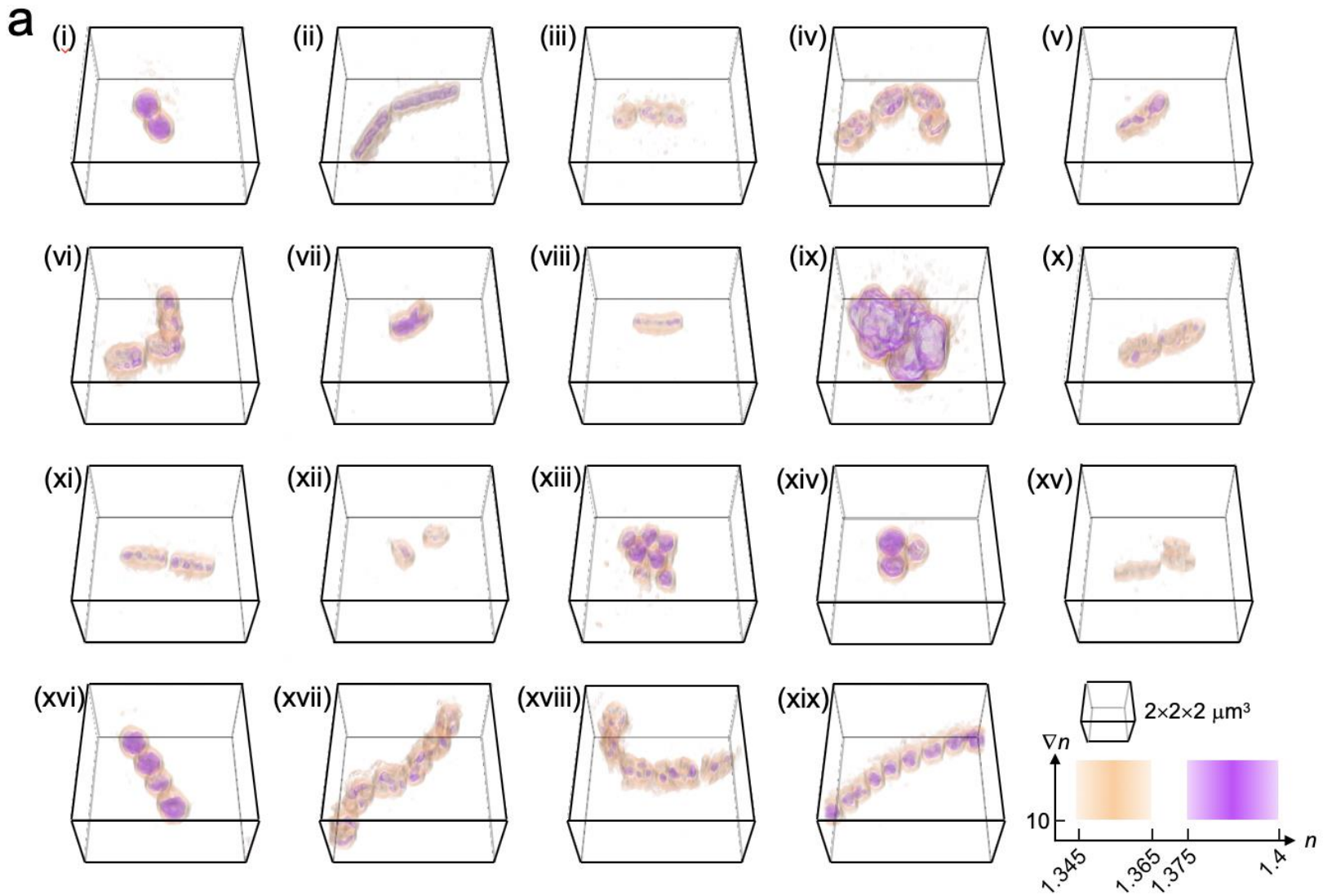
$L_{L1}(G) = E_{x,y,z}[\|y - G(x,z)\|_1]$

$Loss_{SSIM}(G) = 1 - SSIM(G(x), y),$

$[\, l(x,y) = \frac{2\mu_x\mu_y + c_1}{\mu_x^2 + \mu_y^2 + c_1}, c(x,y) = \frac{2\sigma_x\sigma_y + c_2}{\sigma_x^2 + \sigma_y^2 + c_2}]$

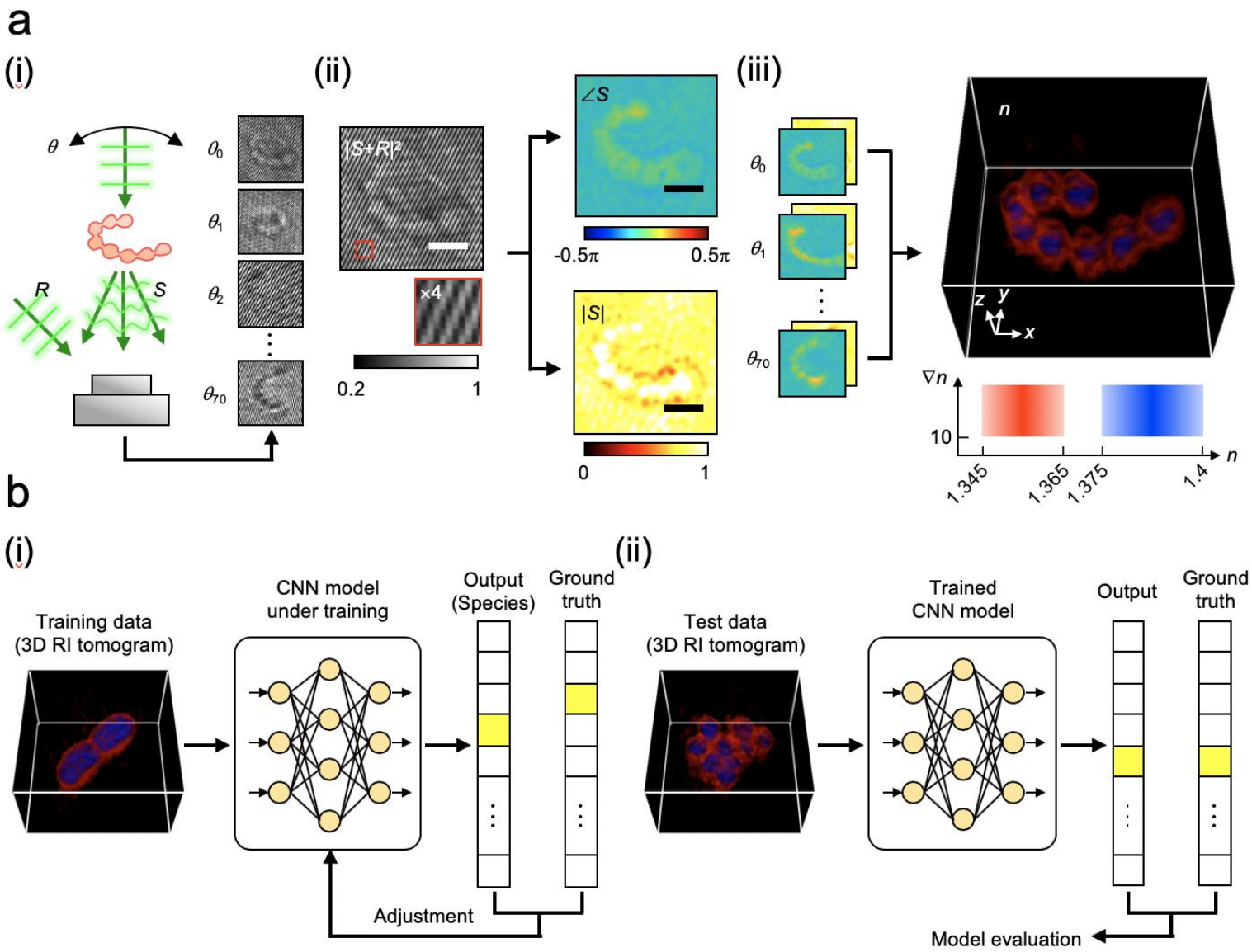
$SSIM(x,y) = \lambda \cdot [l(x,y) \cdot c(x,y)^{\alpha}]$

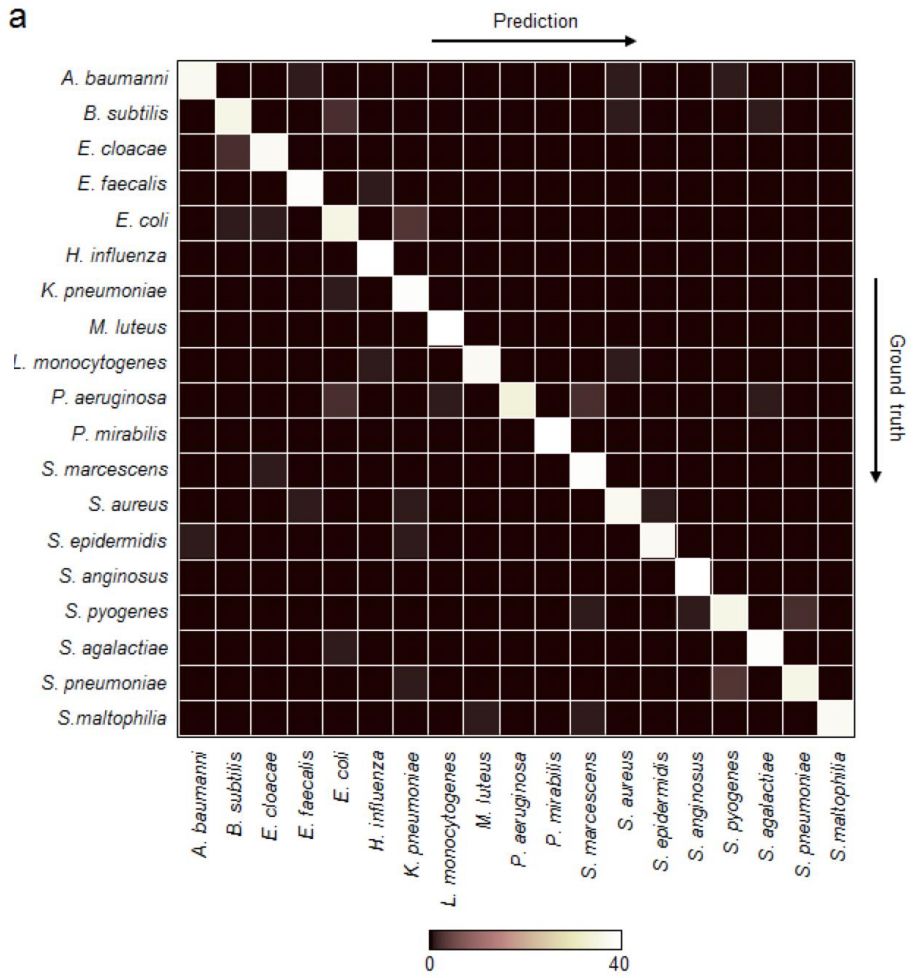
# WHAT WE CAN DO? –
# [3D holography + classification] for diagnosis

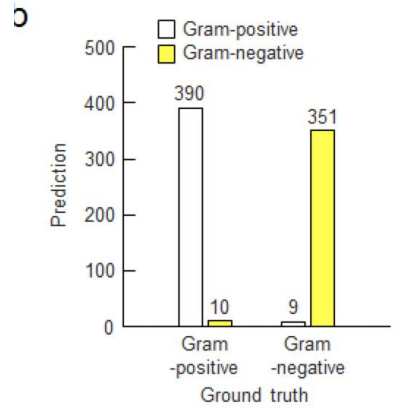


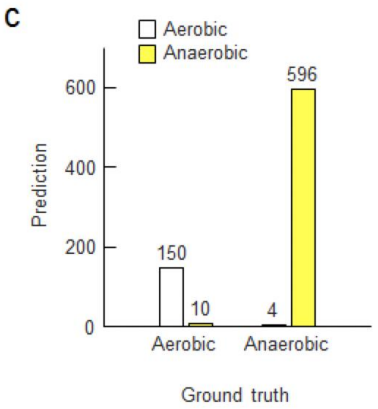

*To be submitted*

# WHAT WE CAN DO? –
# [3D holography + classification] for diagnosis

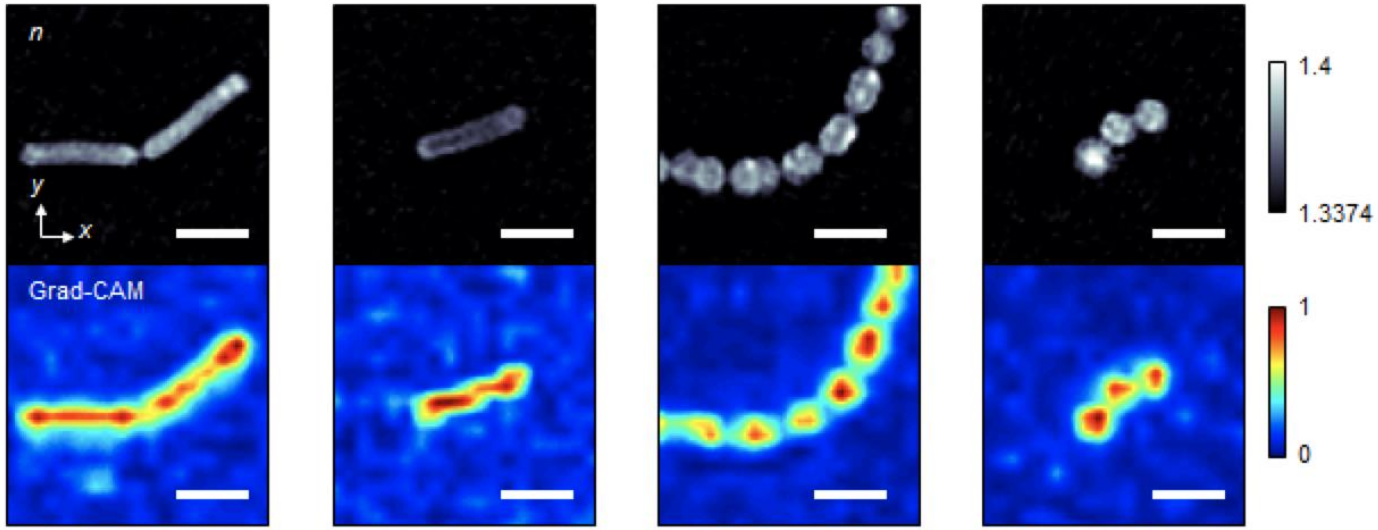


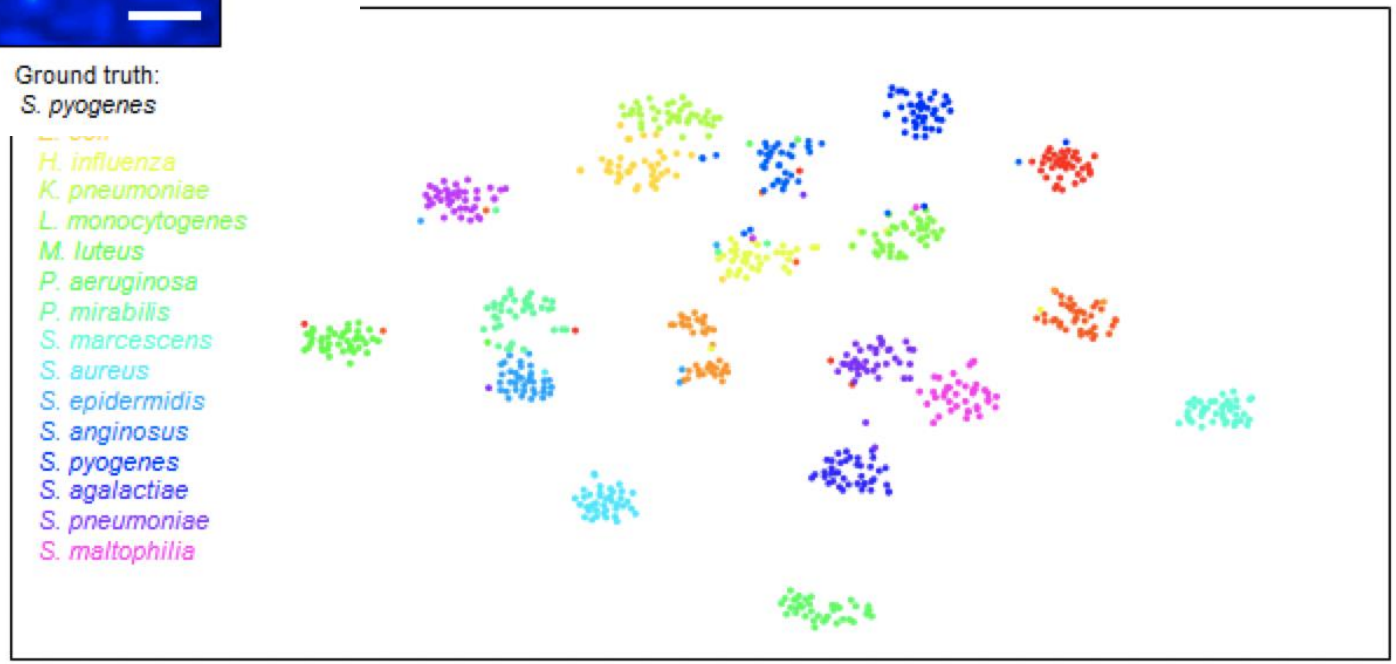



# WHAT WE CAN DO? –
# [3D holography + classification] for diagnosis

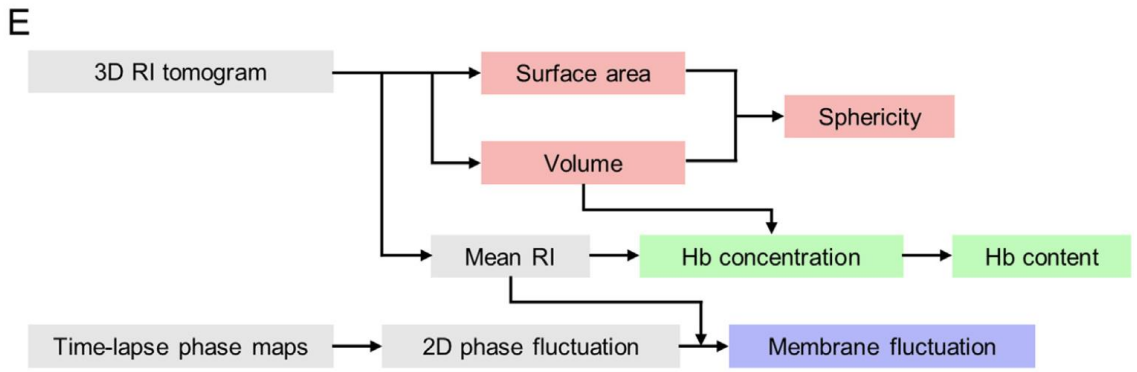


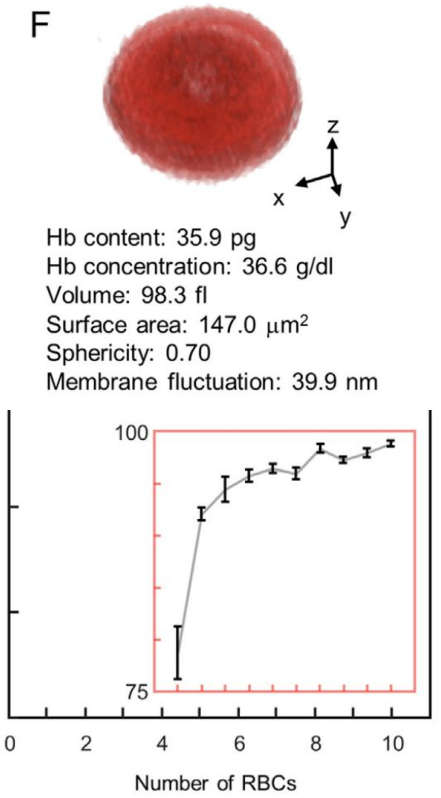



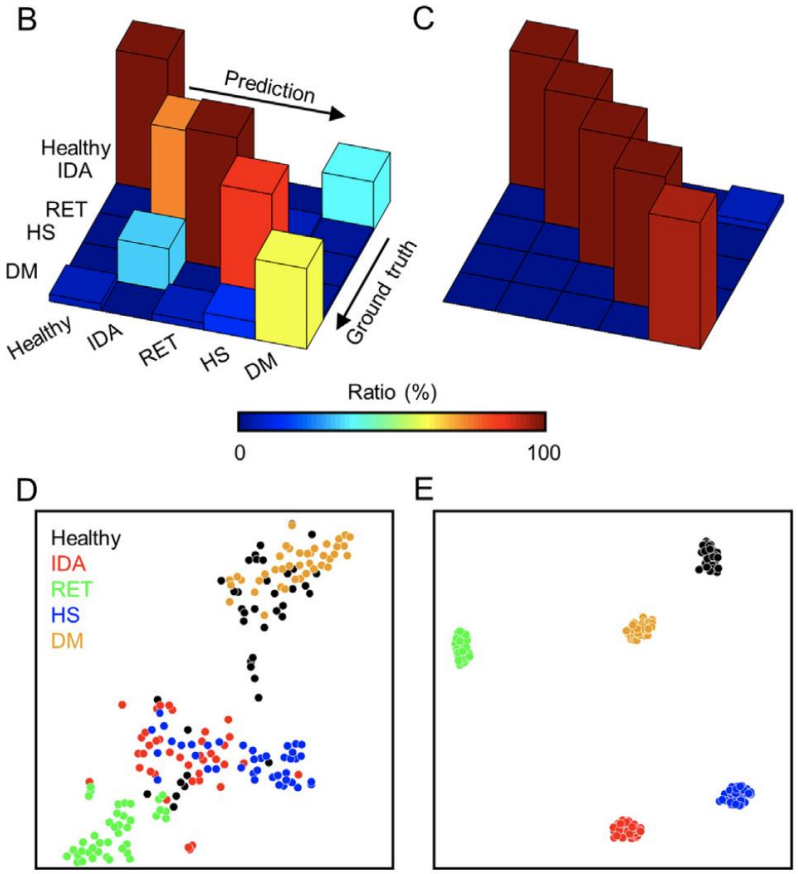
# WHAT WE CAN DO? –
# [3D holography + classification] for diagnosis

| | Antiserum test | Culture and susceptibility test | DNA microarray | Real-time PCR | Proposed method |
|---|---|---|---|---|---|
| Time | Hours | Hours to days | Days | Hours | Minutes |
| Manual analysis | Required | Required | Required | Required | Not required |
| In vitro culture | Not required | Required | Not required | Not required | Not required |
| Specialized biochemical agents | Required | Optional | Required | Required | Not required |
| Sub-species discrimination | Capable | Capable on condition | Capable | Capable | Undetermined |

# WHAT WE CAN DO? –
# [3D holography + classification] for diagnosis

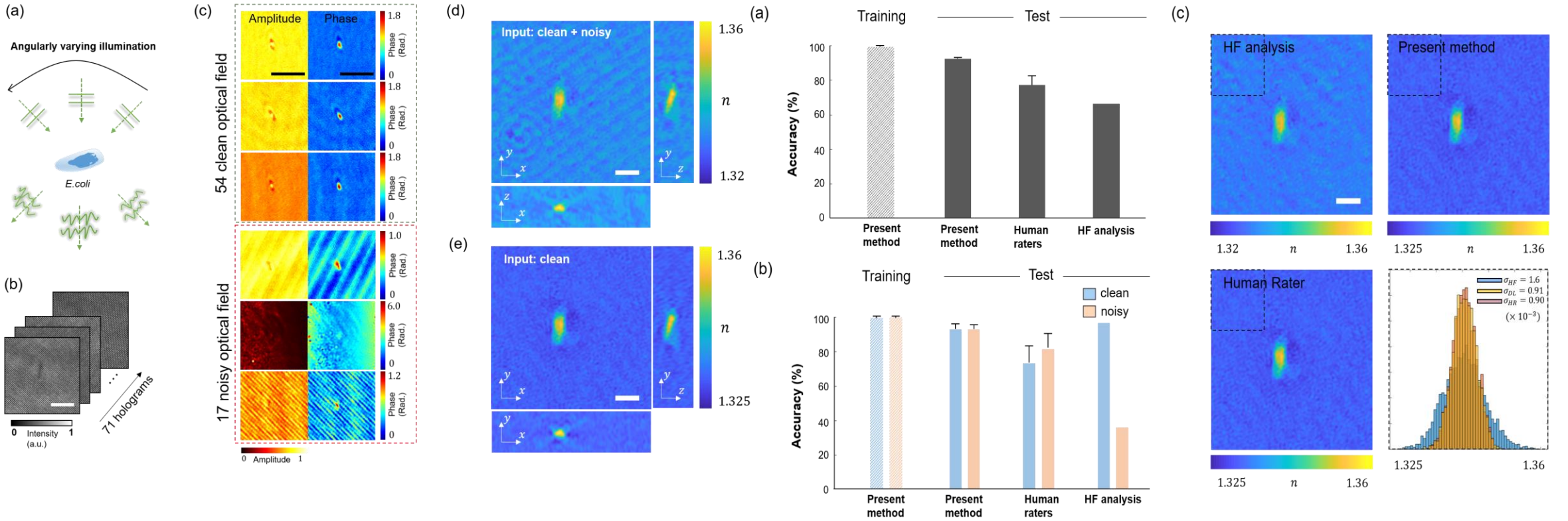



*Biosensors and Bioelectronics, (2019)*

# WHAT WE CAN DO? –
# [3D holography + classification] for robust imaging




*To be submitted*

# WHAT WE CAN DO? –
# [3D holography + Segmentation] for finding new marker

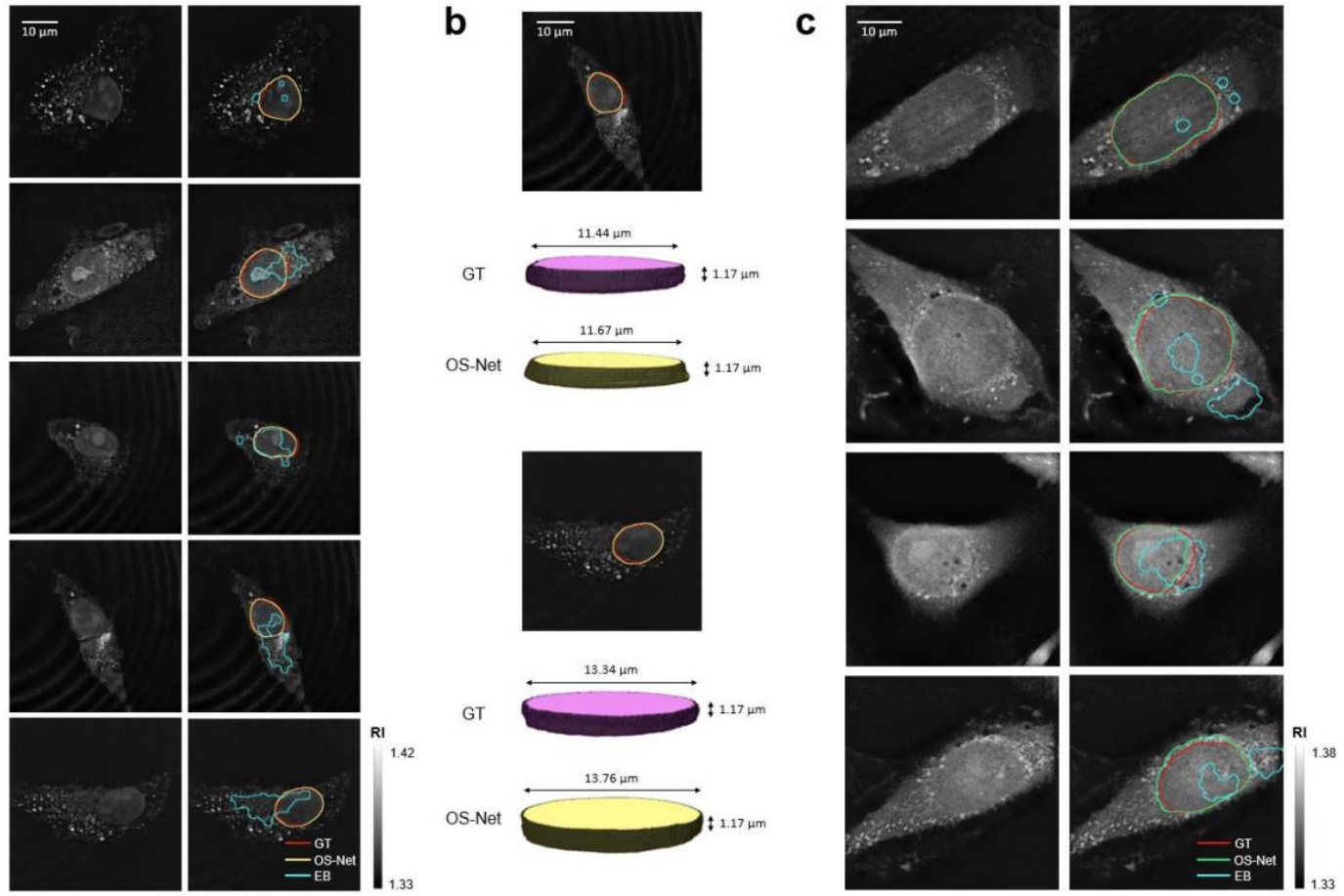
**Deep-learning-based label-free segmentation of cell nuclei in time-lapse refractive index tomograms**

Jimin Lee[1], Hyejin Kim[1], Hyungjoo Cho[1], YoungJu Jo[2,3,4,†], Yujin Song[5], Daewoong Ahn[6], Kangwon Lee[5], YongKeun Park[2,3,4], Sung-Joon Ye[1,7,8,*]

[1]*Program in Biomedical Radiation Sciences, Department of Transdisciplinary Studies, Graduate School of Convergence Science and Technology, Seoul National University, Seoul 08826, Republic of Korea*

[2]*Department of Physics, Korea Advanced Institute of Science and Technology (KAIST), Daejeon 34141, Republic of Korea*

[3]*Tomocube Inc. Daejeon 34051, Republic of Korea*



# WHAT WE CAN DO? –
# [3D holography + AI] for something new

## WHAT WE CAN DO?

# WHEN **DATA** MET **TOOL**

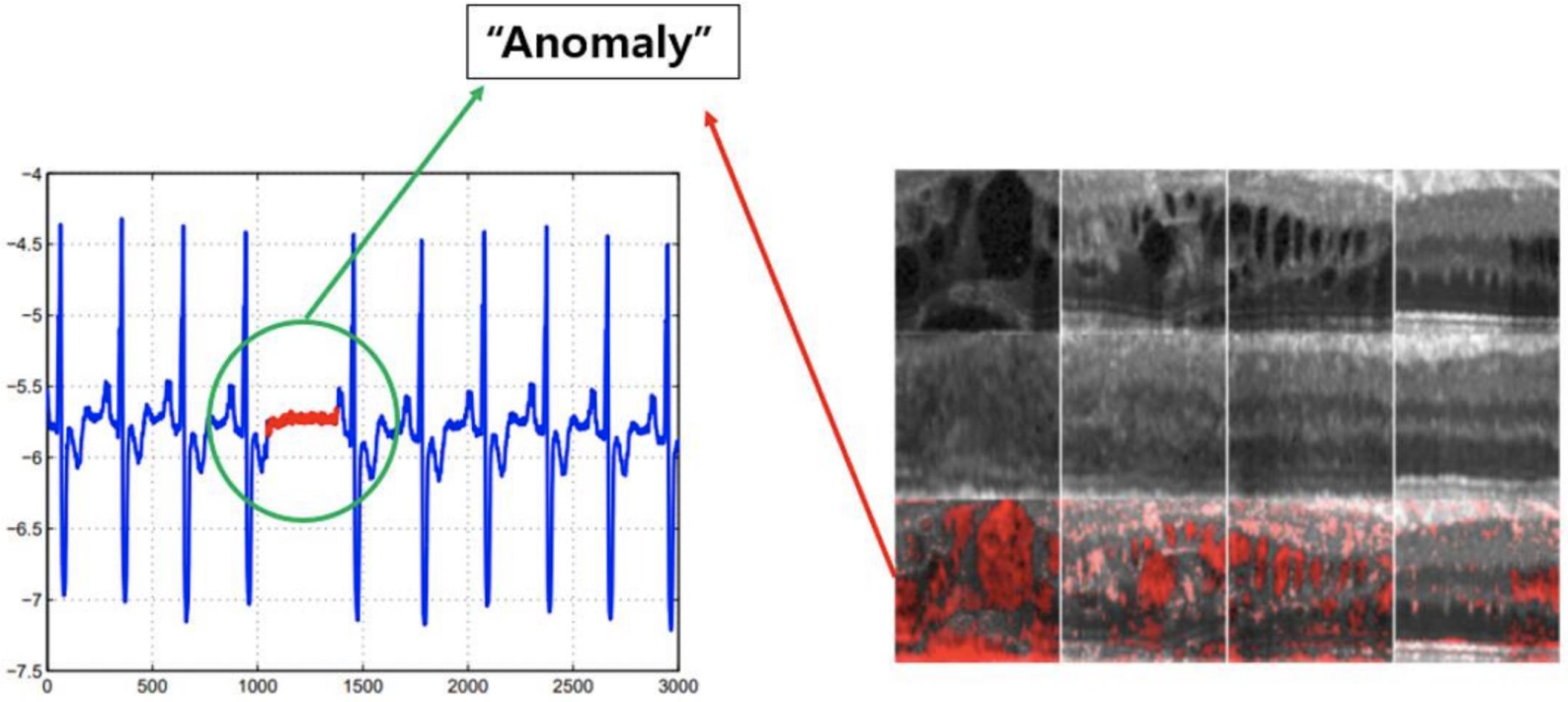
# HOW WE CAN DO?

## Everything happened in six months!! With (3+2) members..


# HOW WE CAN DO?
# Communication!! AI is just a Tool, but AI is a good Tool !!

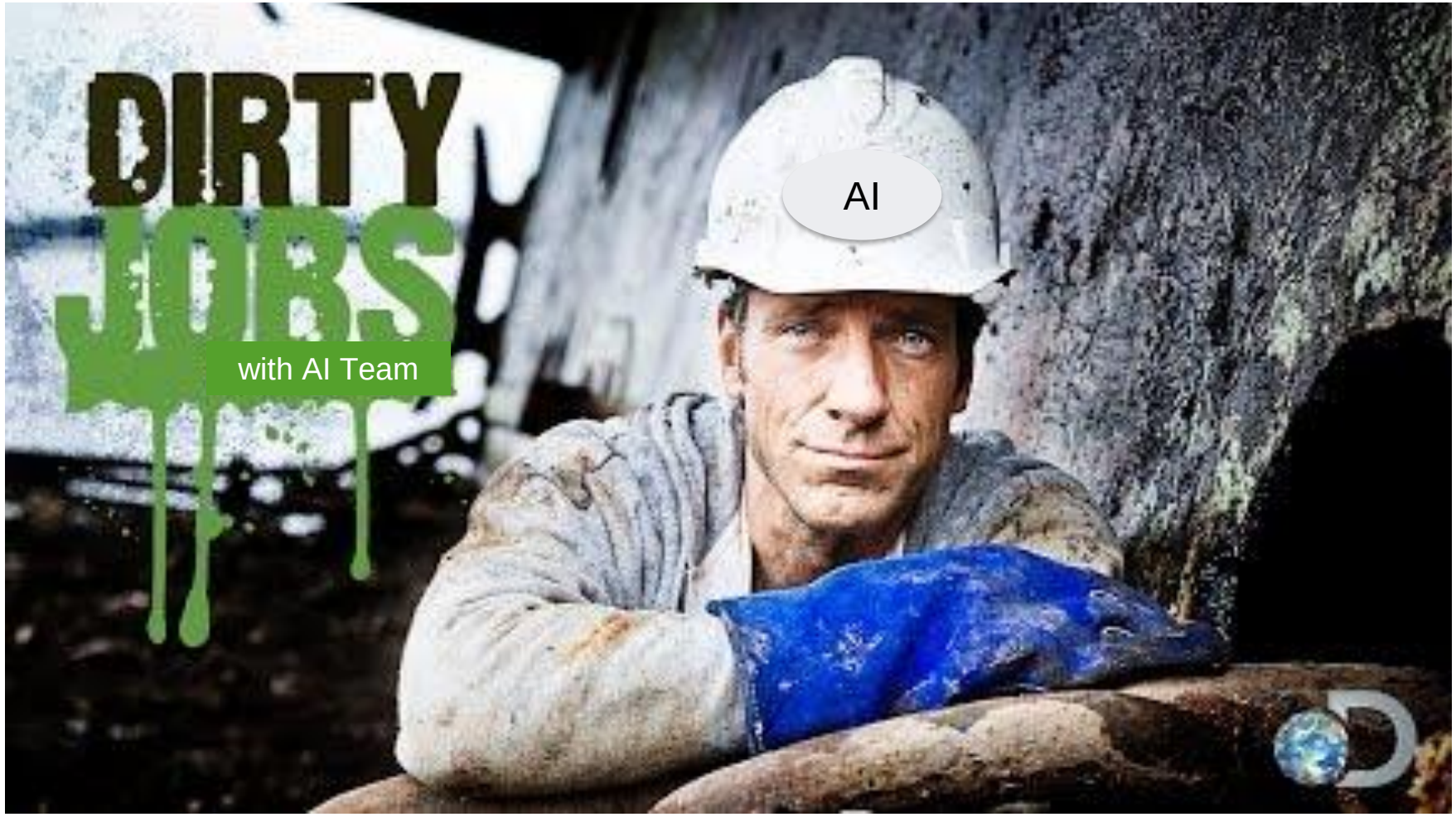
# HOW WE CAN DO?
# Communication!! AI is just a Tool, but AI is a good Tool !!

Normality  = Majority ?
Normality != Majority !




Reference
[1] Anomaly Detection of Time Series, 2010
[2] Unsupervised Anomaly Detection with Generative Adversarial Networks to Guide Marker Discovery, 2017

# HOW WE CAN DO?
# Dirty Job First!!

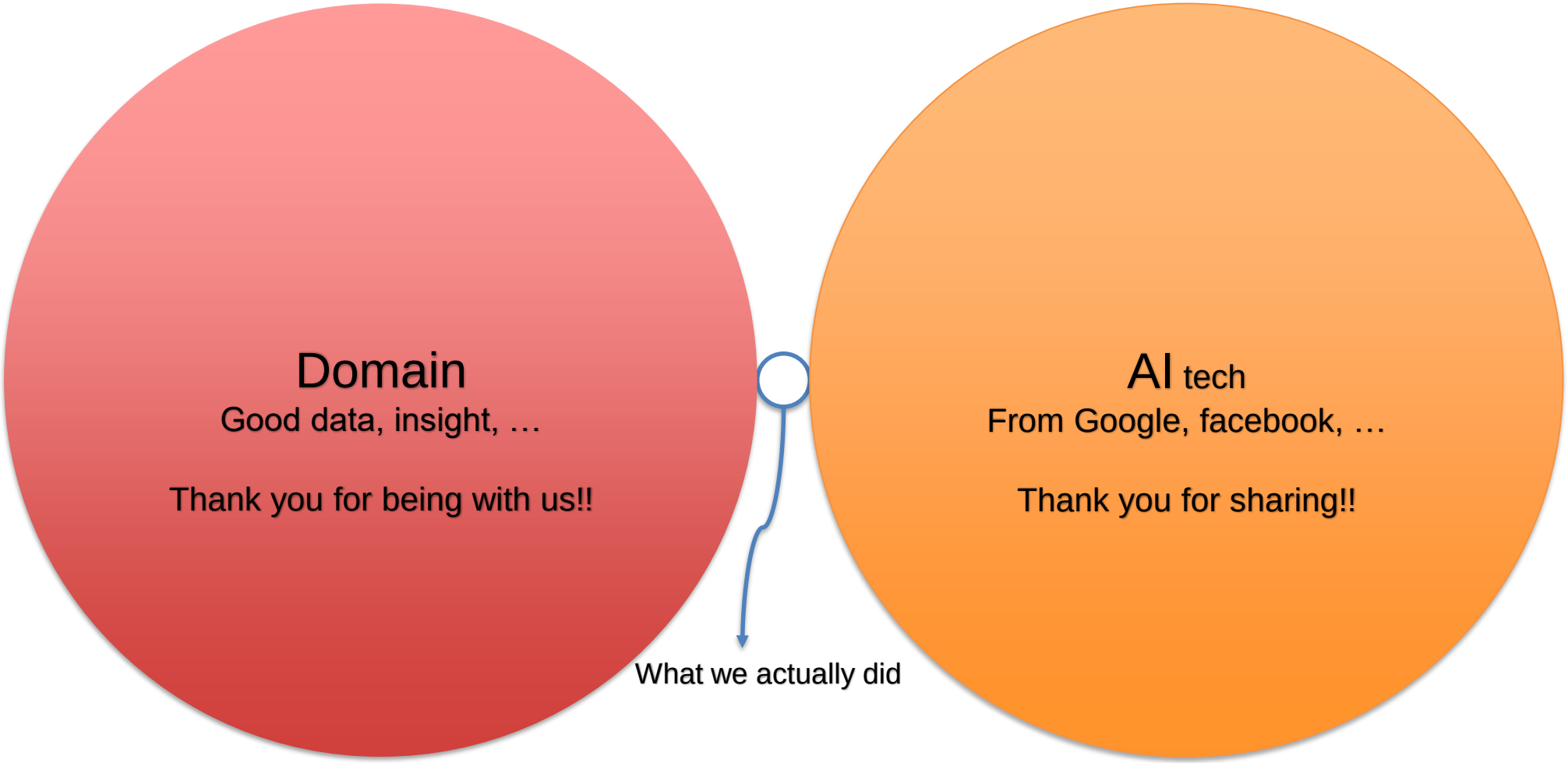


# HOW WE CAN DO?
# We are a STARTUP!!

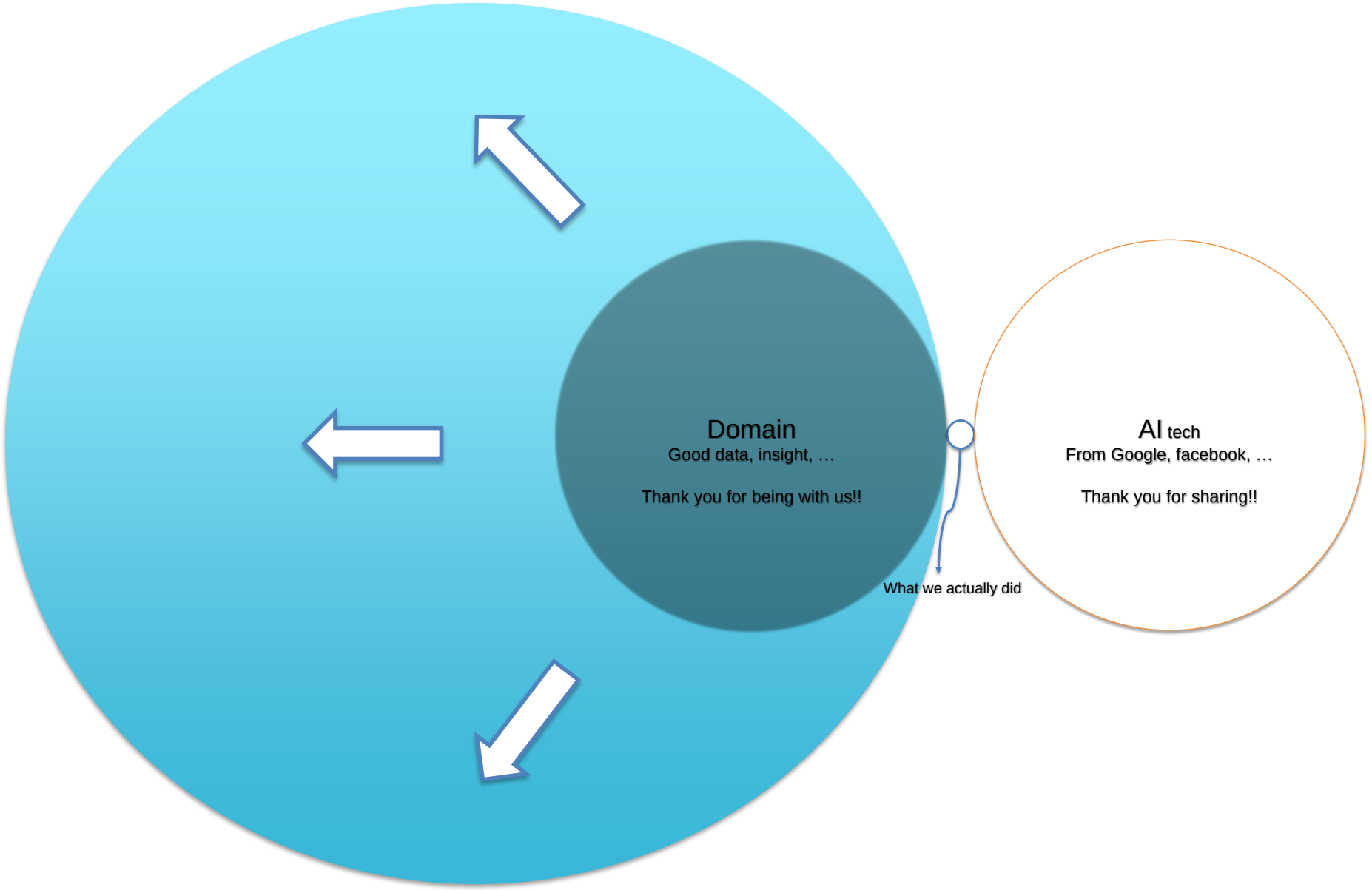

## 2,4,8 weeks process

2 weeks → feasibility check
4 weeks → first POC
8 weeks → Paper POC
Otherwise…
Give up and wait for Google to do it!!
Focus on impact and speed!!
For not fancy AI, but For domain & user!!

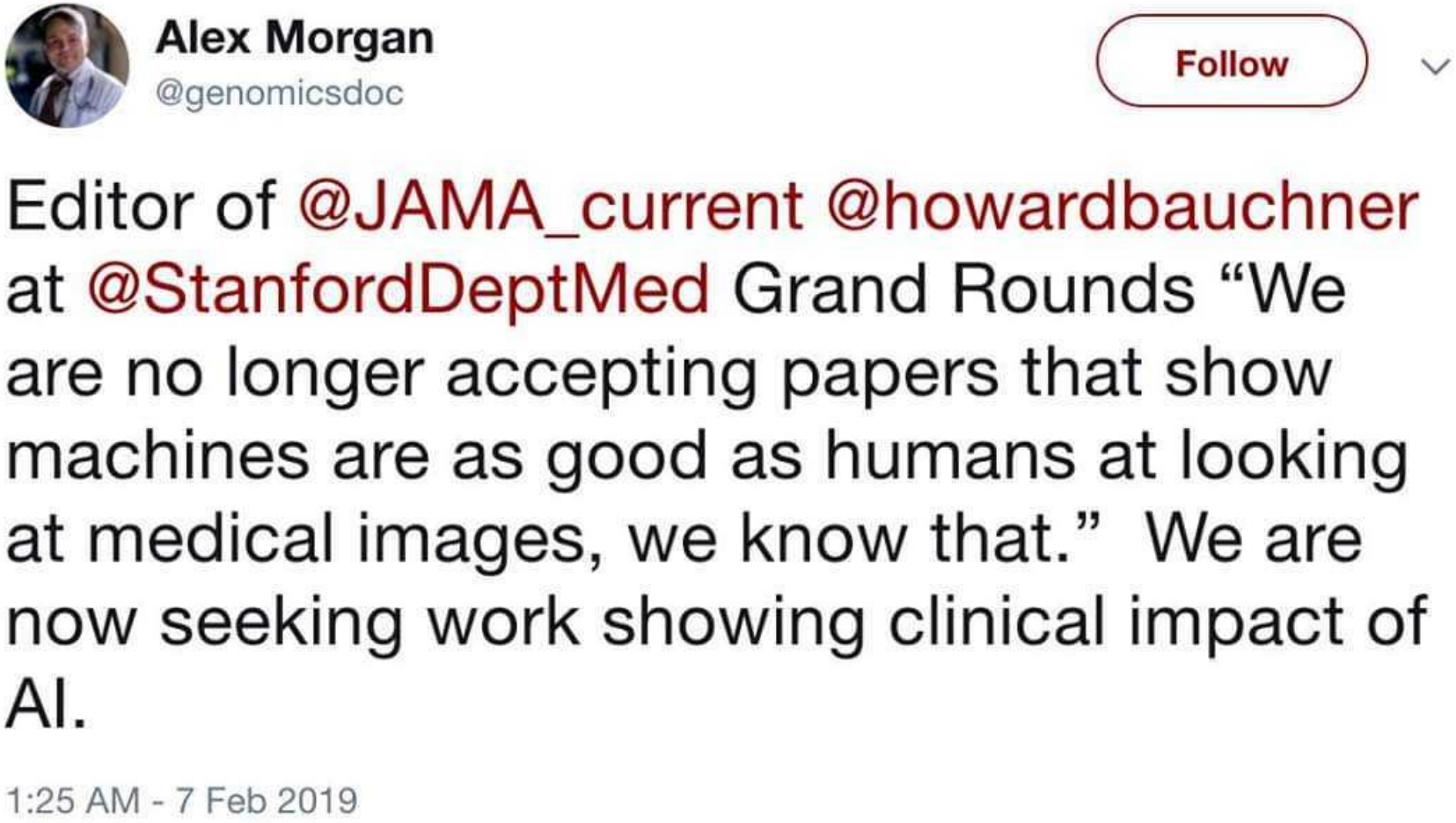
# HOW WE CAN DO?
# We do not make AI, but make use of AI!!



# WHAT WE WANT?


Domain
Good data, insight, …
Thank you for being with us!!
AI tech
From Google, facebook, …
Thank you for sharing!!
What we actually did

# WHAT WE KNOW ?



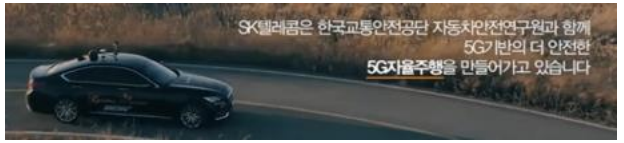
Alex Morgan
@genomicsdoc

Follow

Editor of @JAMA_current @howardbauchner at @StanfordDeptMed Grand Rounds “We are no longer accepting papers that show machines are as good as humans at looking at medical images, we know that.” We are now seeking work showing clinical impact of AI.

1:25 AM - 7 Feb 2019

# WHAT WE KNOW ?





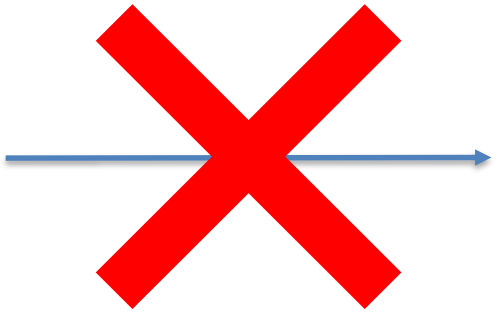

정말 상용화된다고 하면 → 정말 안전한 드라이빙이 가능

# WHAT WE KNOW ?



정말 안전한 드라이빙이 가능하면 → 정말 상용화될 수 있다.

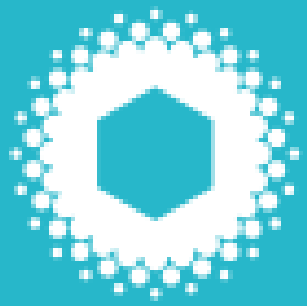
We have
Clinical papers, Patents, Fancy AI papers, ….



You can use …

REMEMBER

2014. 4. 16




# 고맙습니다!