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Ultrasound Guided Radiotherapy for Pancreatic Cancer

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Disclosure

- This research is supported in part by
  - USGRT: NCI CA161613, Elekta
  - EUSGRT: JHU Rad Onc Discovery Grant, Augmenix

Learning Objectives

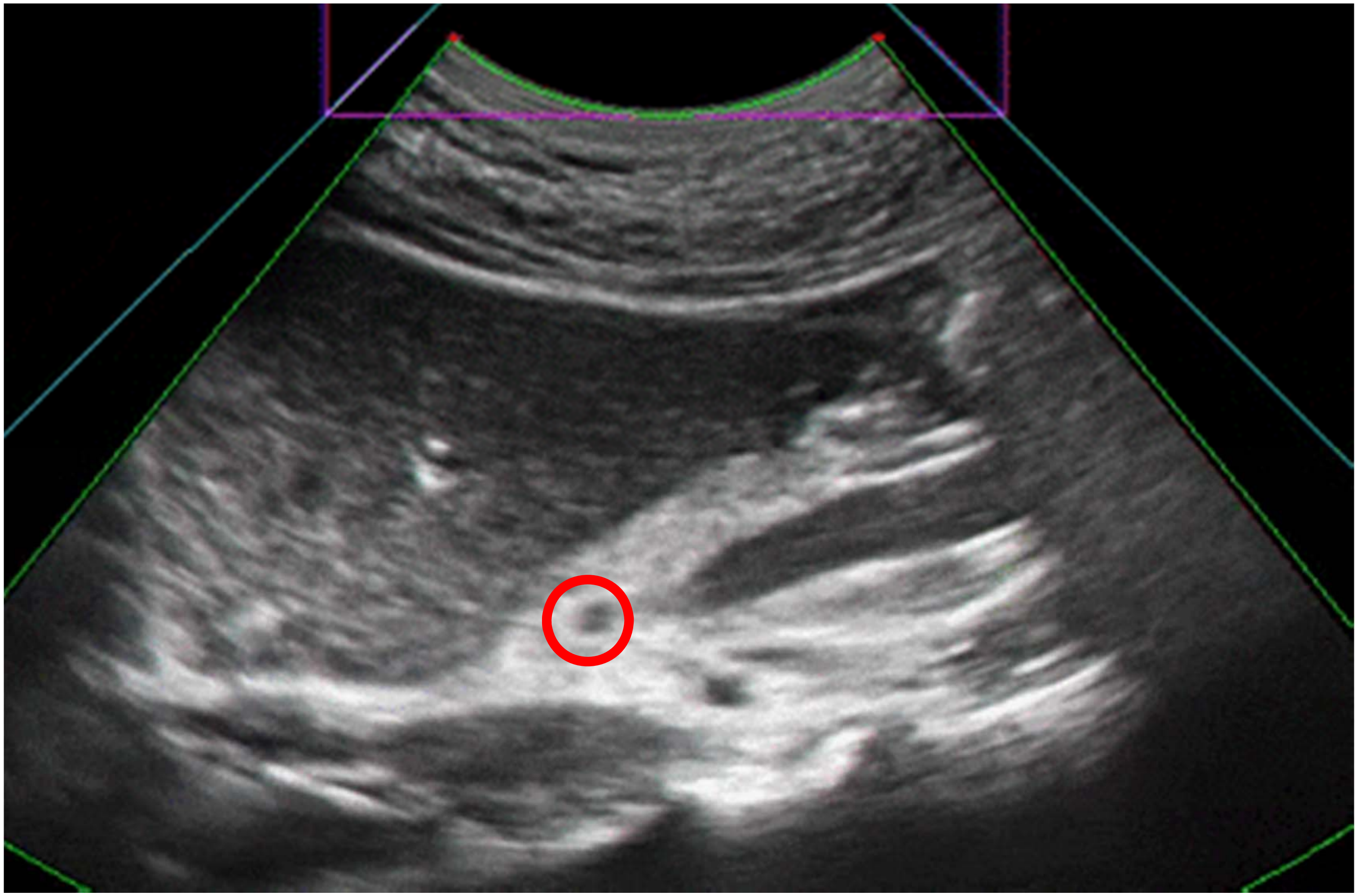
- The audience will learn the major components including ultrasound imaging, coordinate calibration, probe positioning and image tracking for ultrasound monitoring in radiotherapy for pancreatic cancer

- The audience will learn how to incorporate the real-time ultrasound monitoring with existing pancreatic cancer treatment clinical workflow

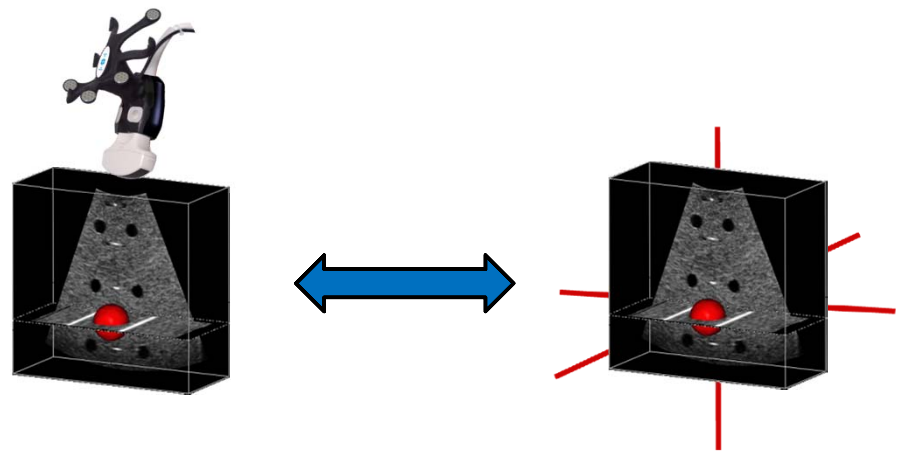
Pancreas Cancer

- 4th leading cause of cancer-related death in US
- Typically late presentation of disease
  - Only 15-20% of patients are considered resectable
- 5-year overall survival after pancreaticoduodenectomy (whipple surgery)
  - 25-30% for node-negative disease
  - 10% for node-positive disease
- More recent data suggest outcomes may be improving over time

Breath hold monitoring during pancreas SBRT



USGRT components



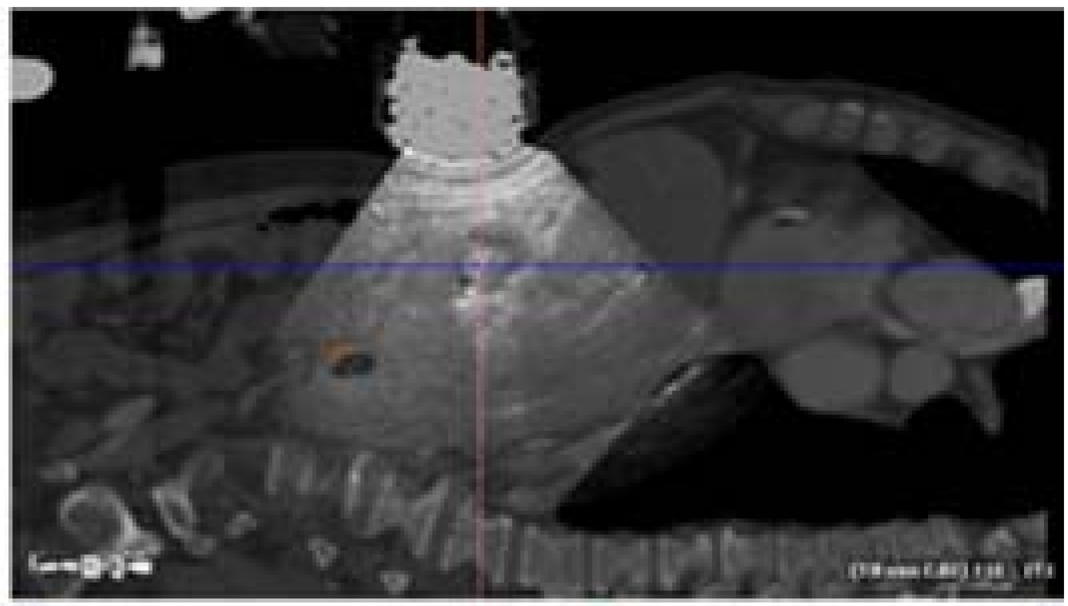
Clarity™

ELEKTA

*Elekta Clarity user manual

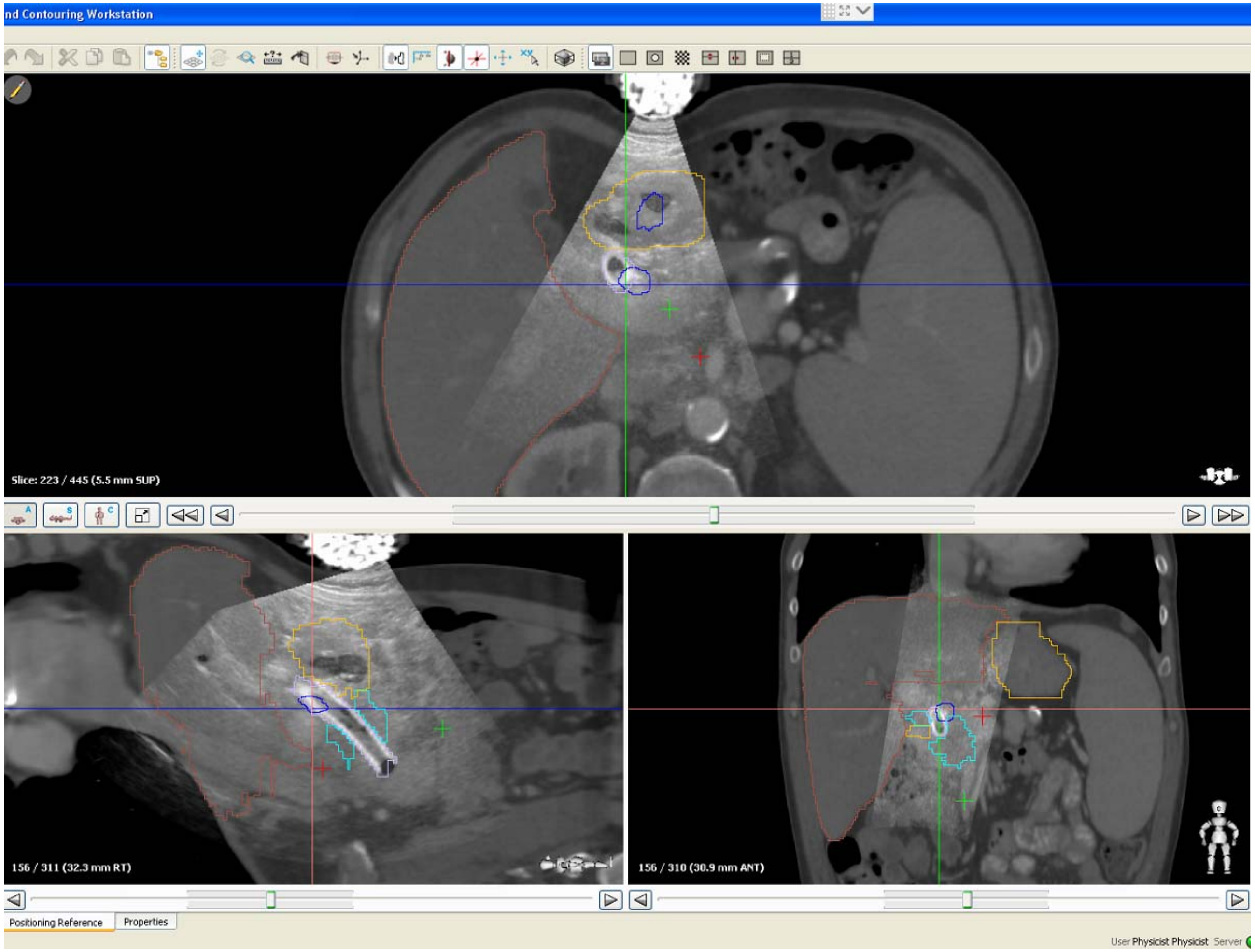
*L.S. Thomas, Diagnostic ultrasound imaging: inside out. Elsevier academic press, 2017.

CT/US Sim

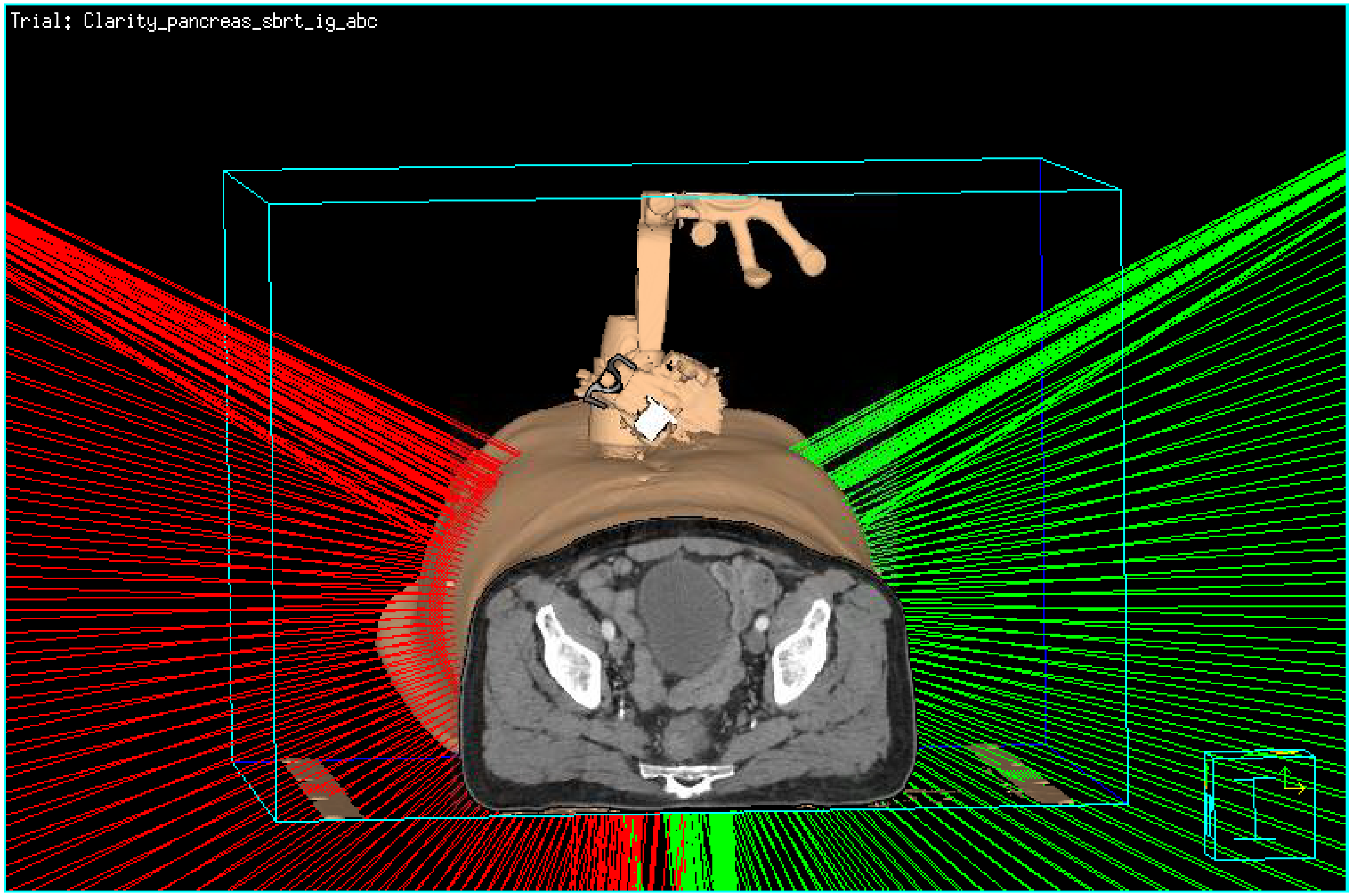


*L. Su et al, Feasibility study of ultrasound imaging for stereotactic body radiation therapy with active breathing coordinator in pancreatic cancer, JACMP 2017

Ultrasound contouring



Probe impact on planning



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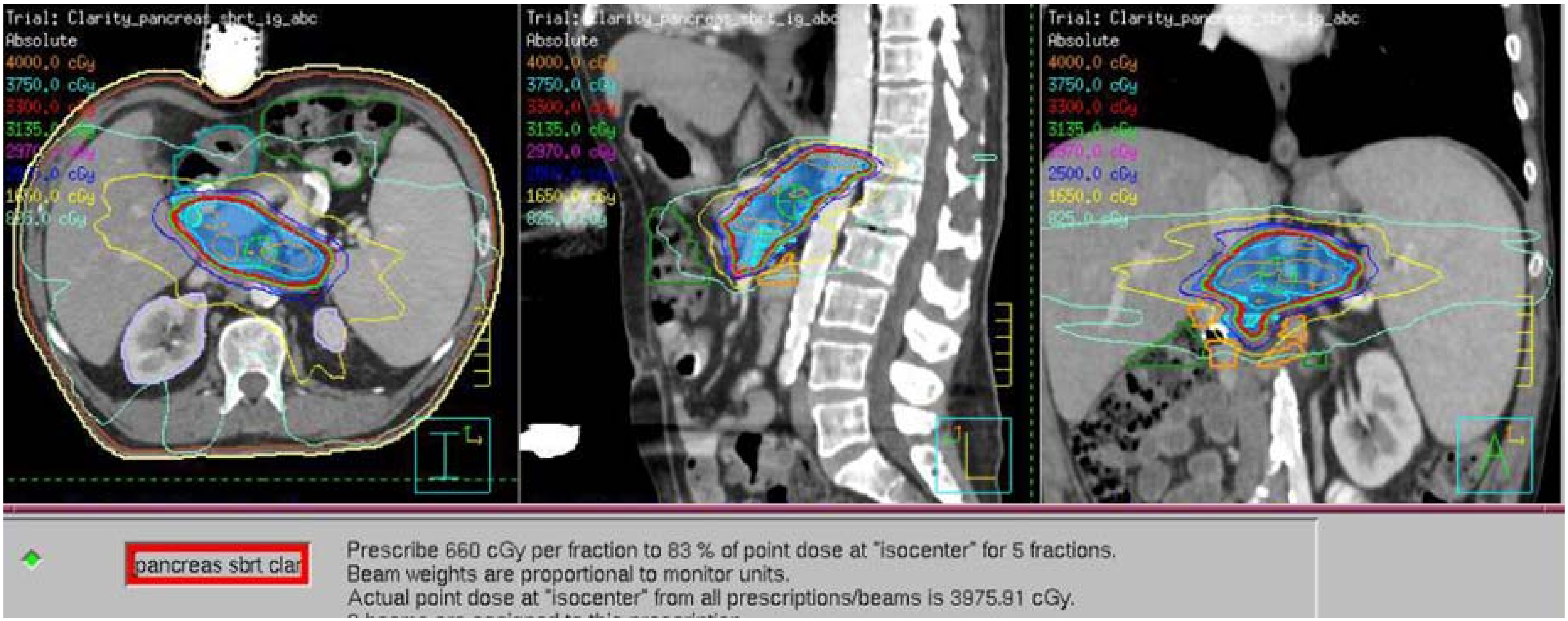
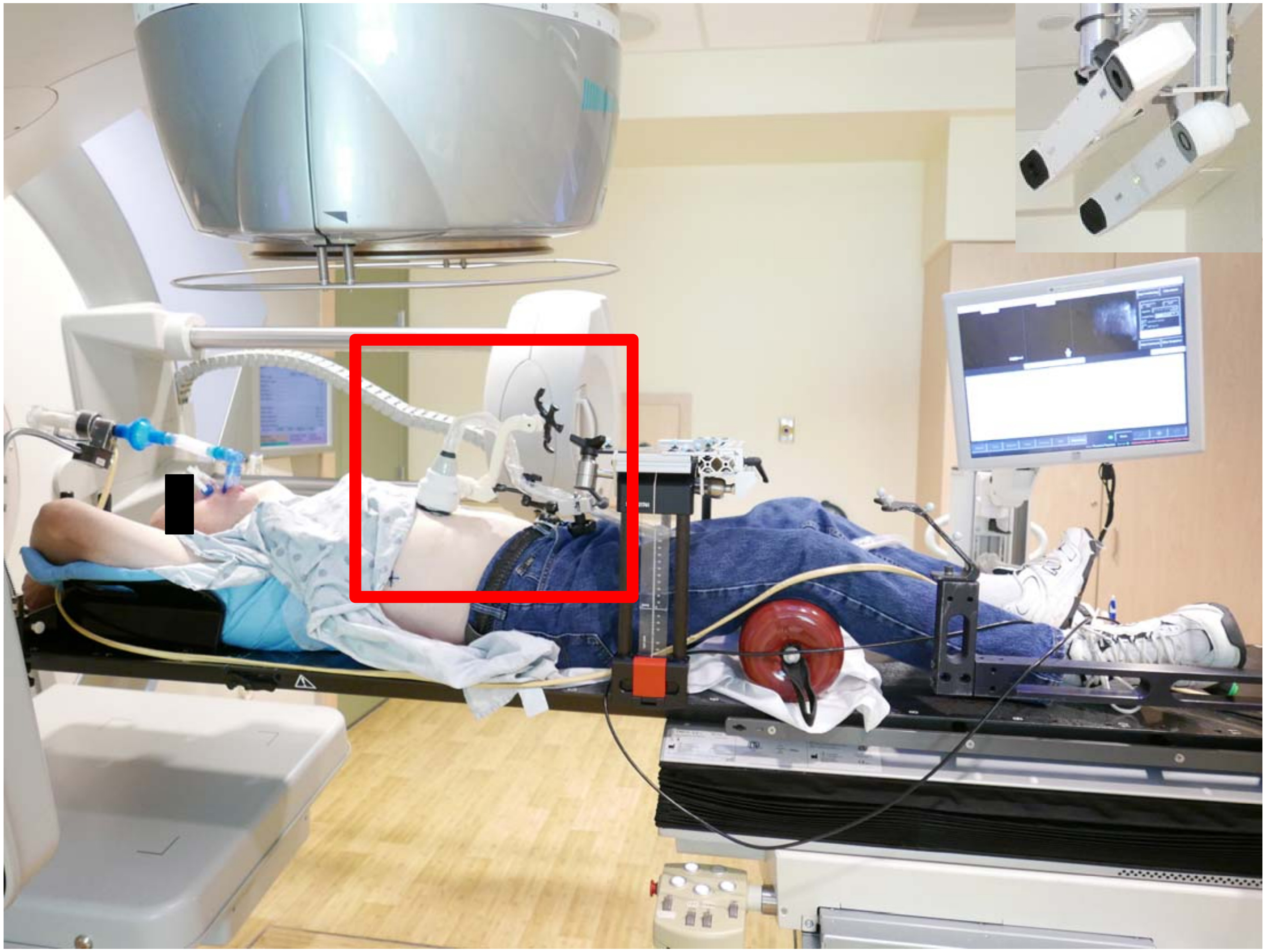


Duo V15 = 5.96 cc < 9cc
Duo V20 = 1.59 cc < 3cc
Duo V33 = 0.0 cc < 1cc
PTV V33 = 90.09% >90%

Sto V15 = 8.52 cc < 9cc
Sto V20 = 1.45 cc < 3cc
Sto V33 = 0.0 cc < 1cc

Bowel V15 = 6.68 cc < 9cc
Bowel V20 = 1.44 cc < 3cc
Bowel V33 = 0.0 cc < 1cc

Treatment setup



CBCT initial setup

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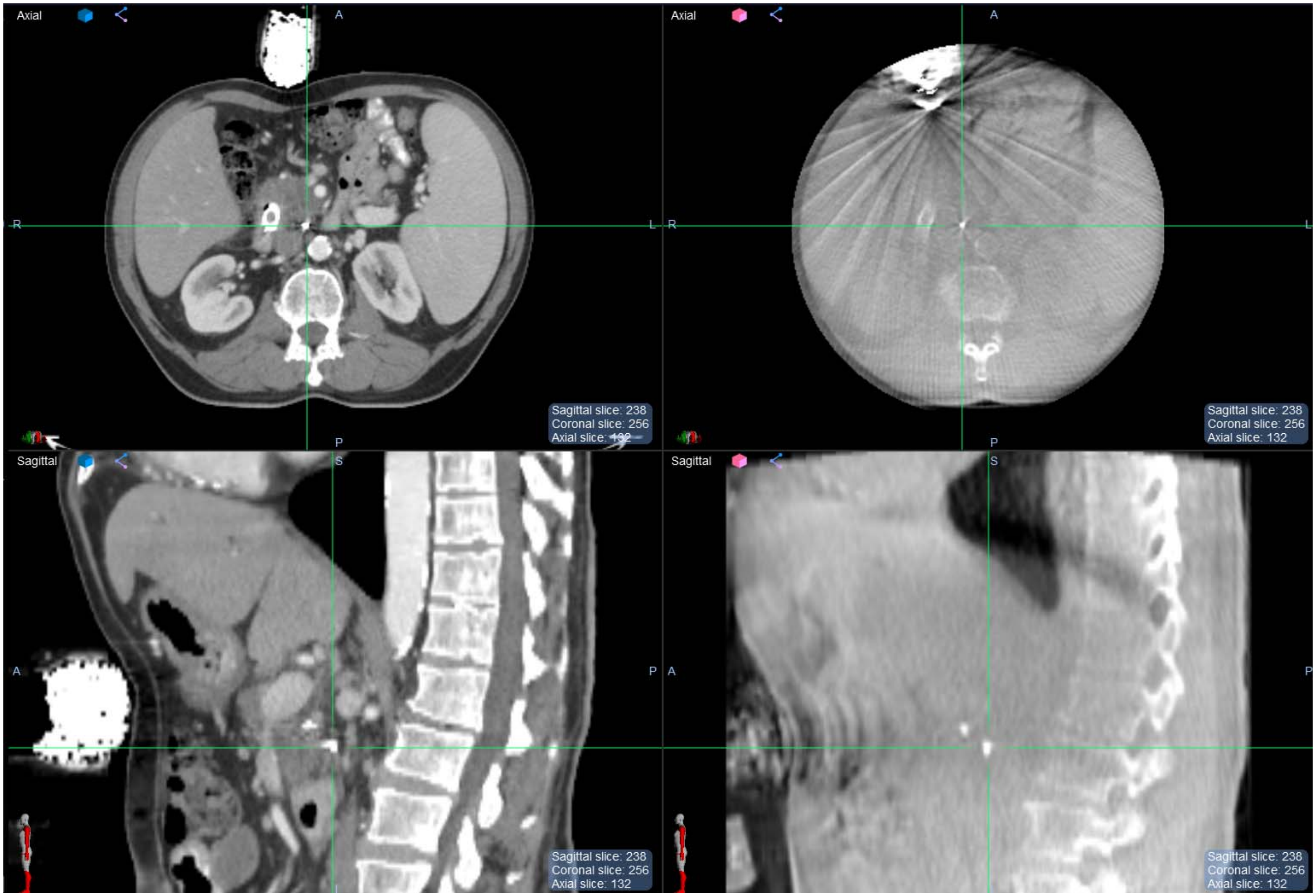
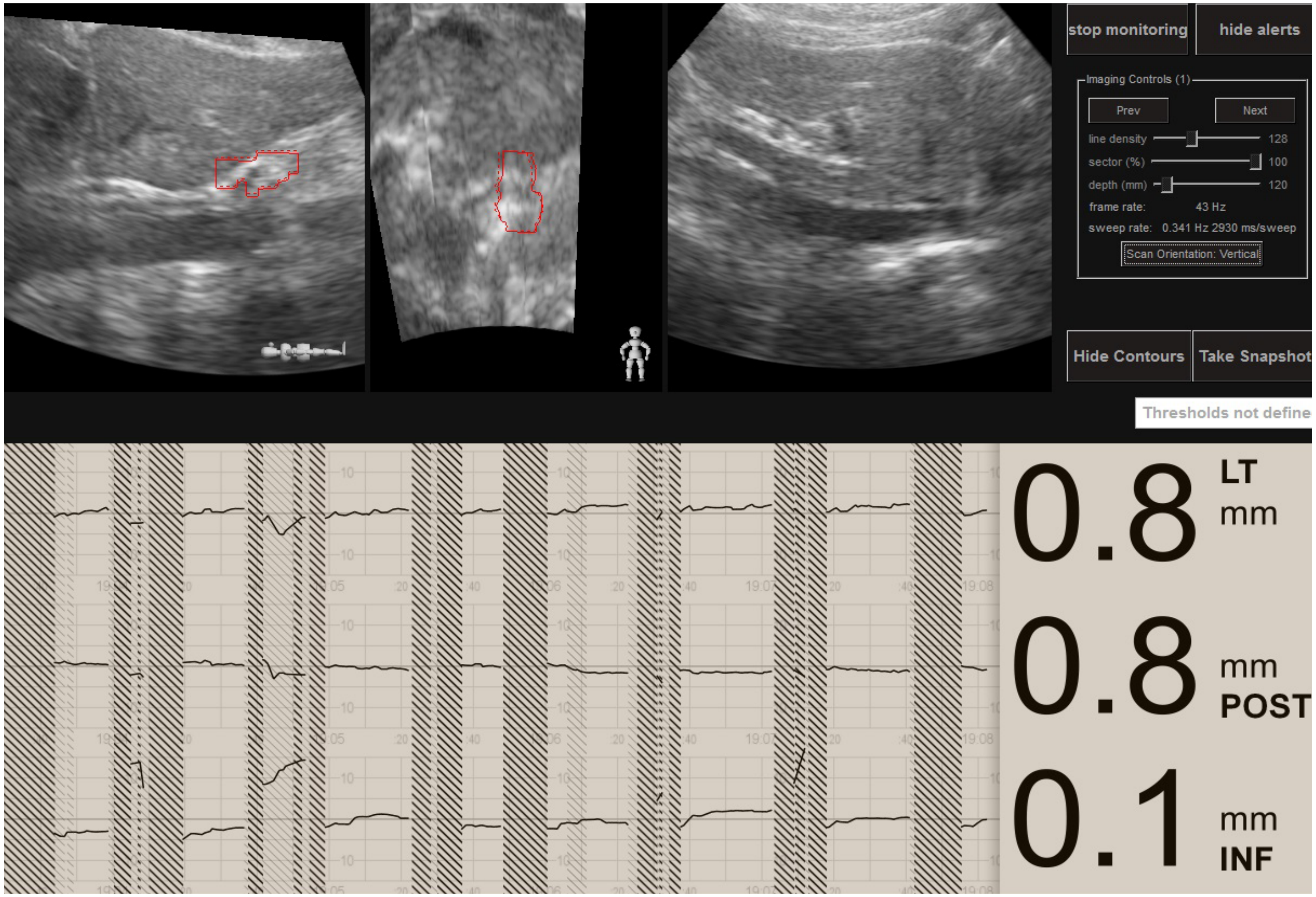


Ultrasound monitoring

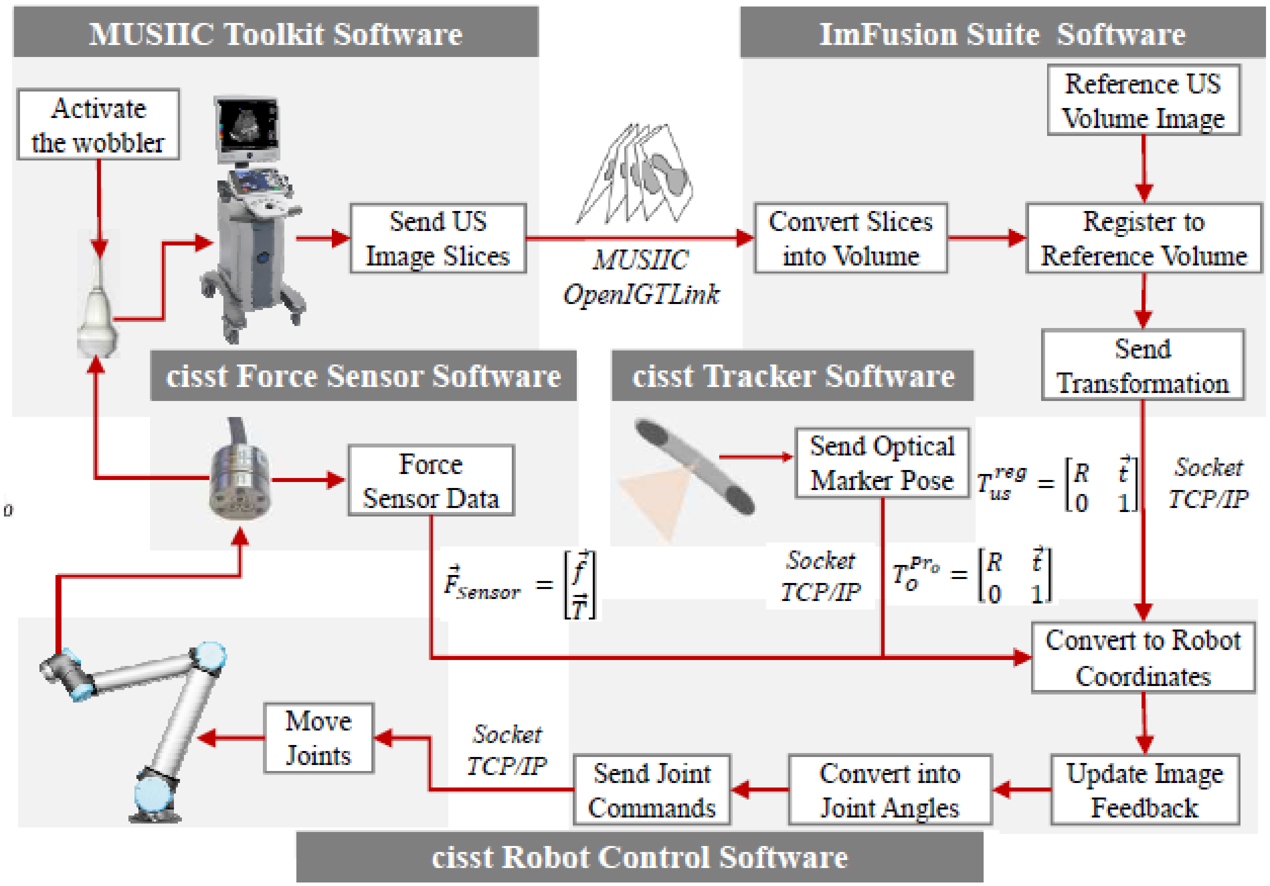


*L. Su et al, Feasibility study of ultrasound imaging for stereotactic body radiation therapy with active breathing coordinator in pancreatic cancer, JACMP 2017, Issue 4

Robotic arm for gated proton therapy

*Collaboration with Dr. Haibo Lin, University of Pennsylvania Proton Center

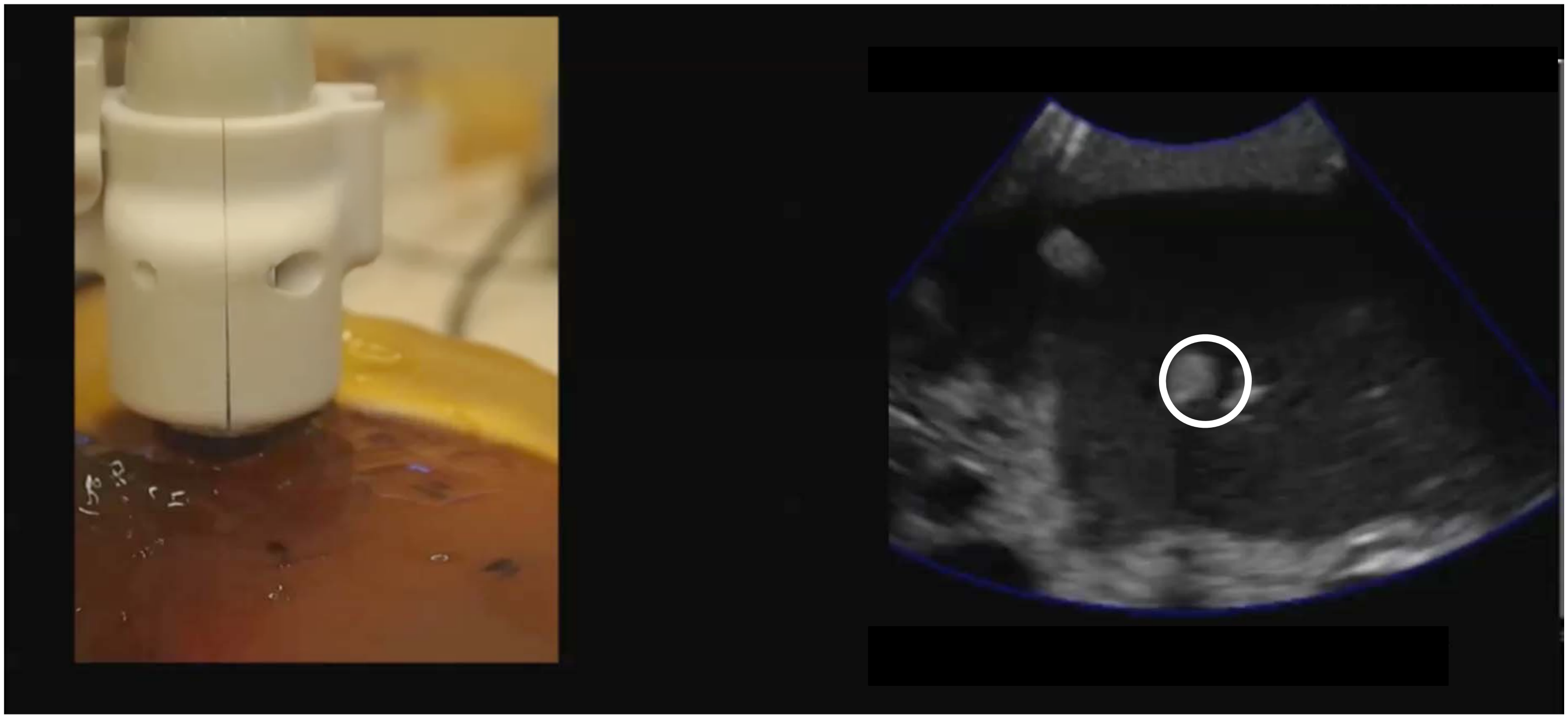
Visual servoing automatically place probe



*H.T. Sen et al, Cooperative control with ultrasound guidance for radiation therapy, Frontier Oncology 2016

*H.T. Sen et al, System Integration and In Vivo Testing of a Robot for Ultrasound Guidance and Monitoring During Radiotherapy, IEEE TBME, 2017(7), Issue Highlight

Visual servoing automatically place probe



Ultrasound probe controlled by robotic arm

Real time ultrasound image being registered to reference image

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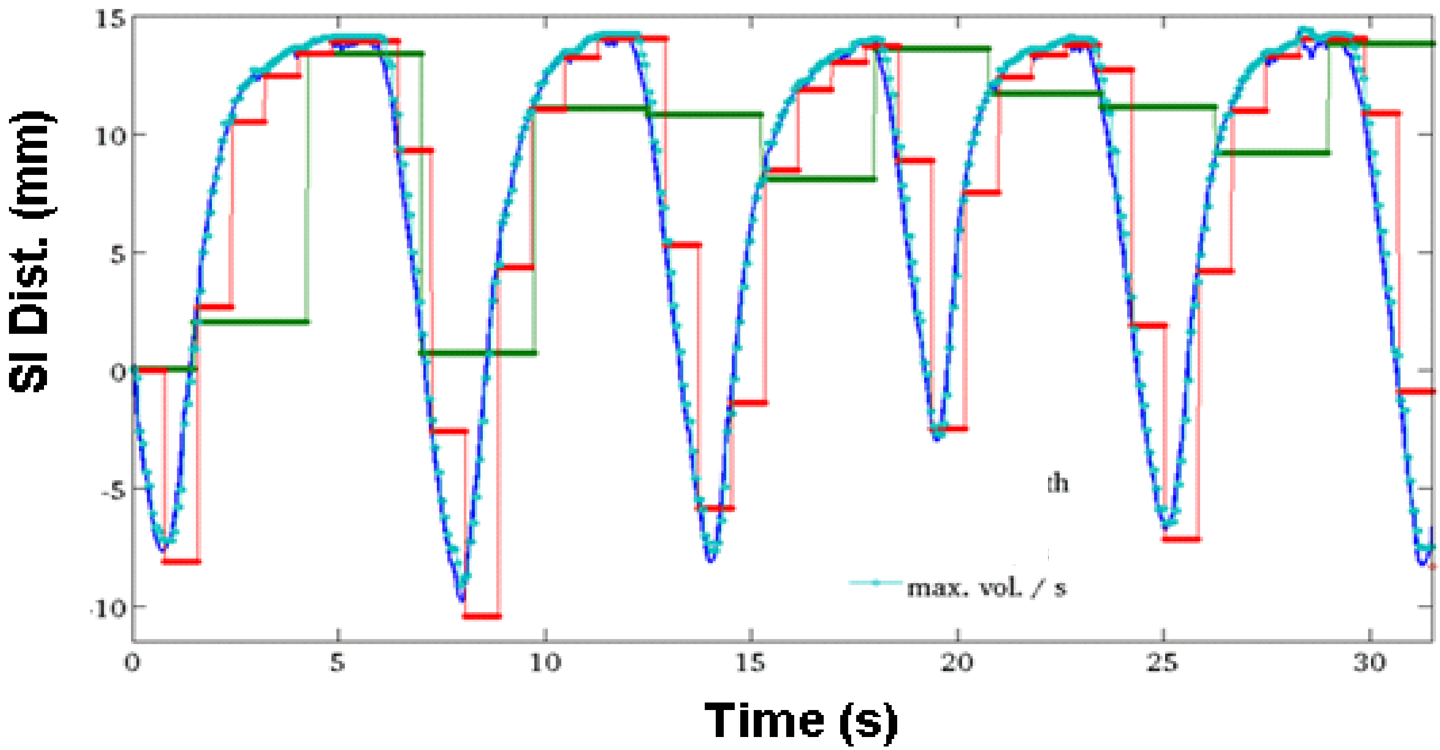
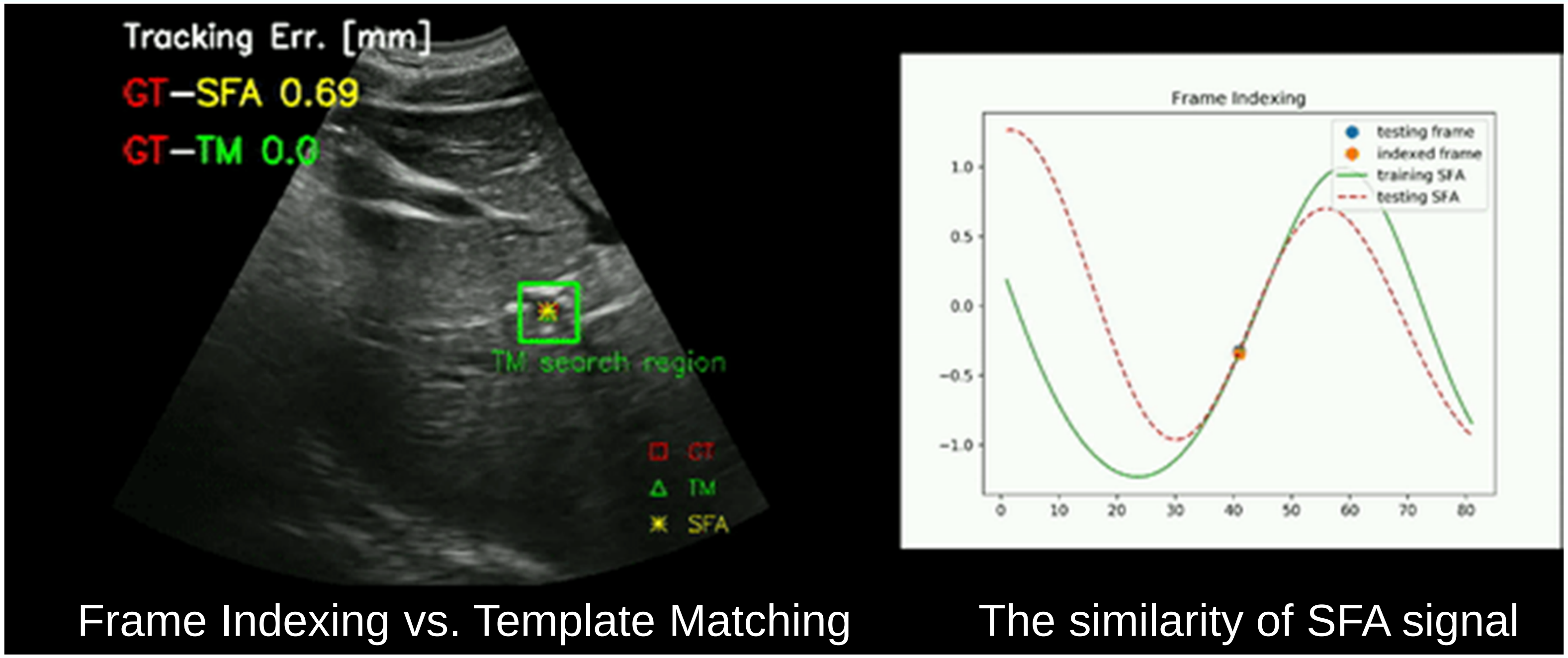
Tracking relies on imaging speed

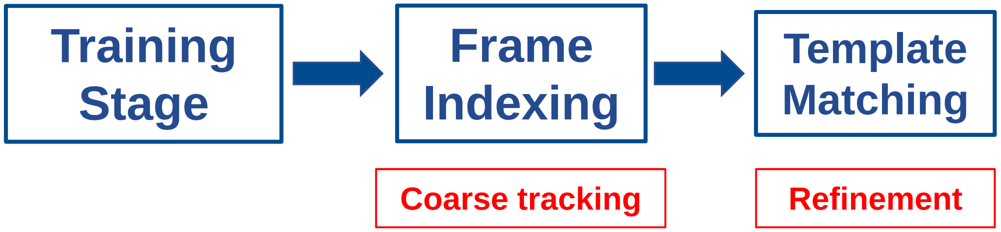


Ground truth (optical tracking)
0.3 Hz, 45º sweeping angle
1 Hz, 15º sweeping angle
11 Hz, 3º sweeping angle

*Collaboration with Drs. Tuathan O'Shea and Emma Harris PhD, Institute of Cancer Research, Royal Marsden

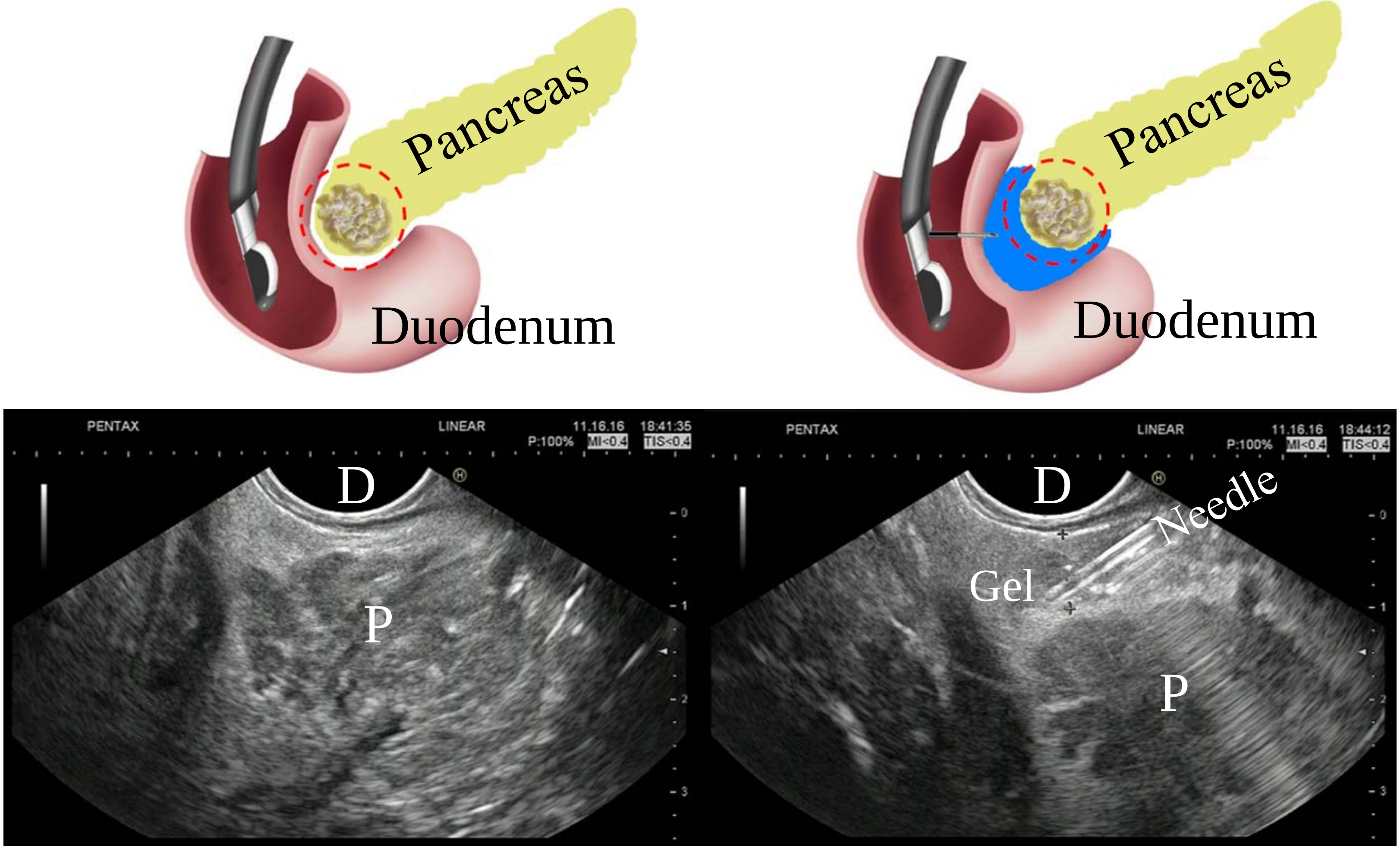
Fast tracking (15ms/frame)





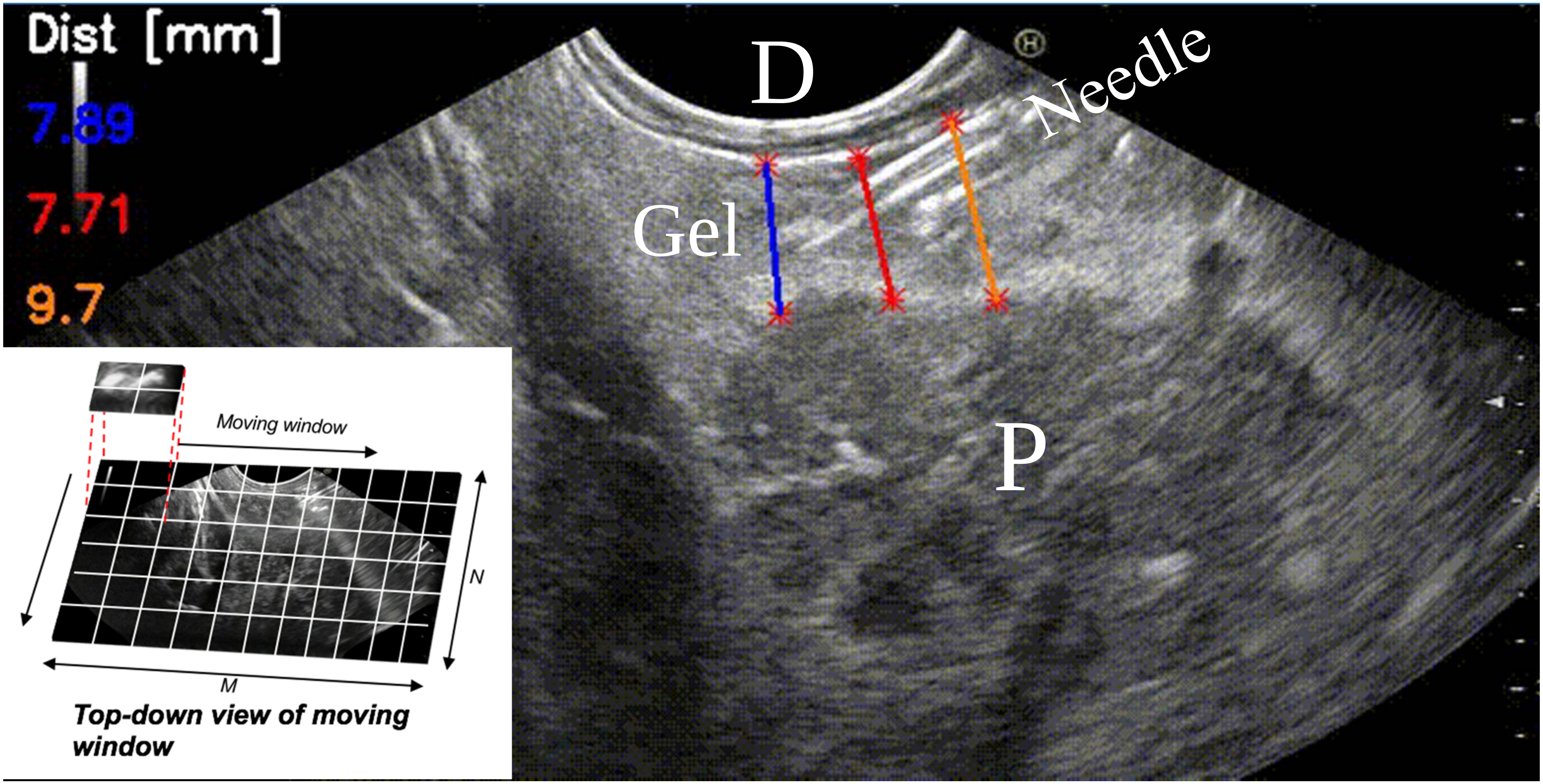
*P. Huang et al, Respiration-Induced Landmark Motion Tracking in Ultrasound Guided Radiotherapy, AAPM 2017, Abstract SU-F-708-4

Biodegradable hydrogel with endoscopic ultrasound guidance



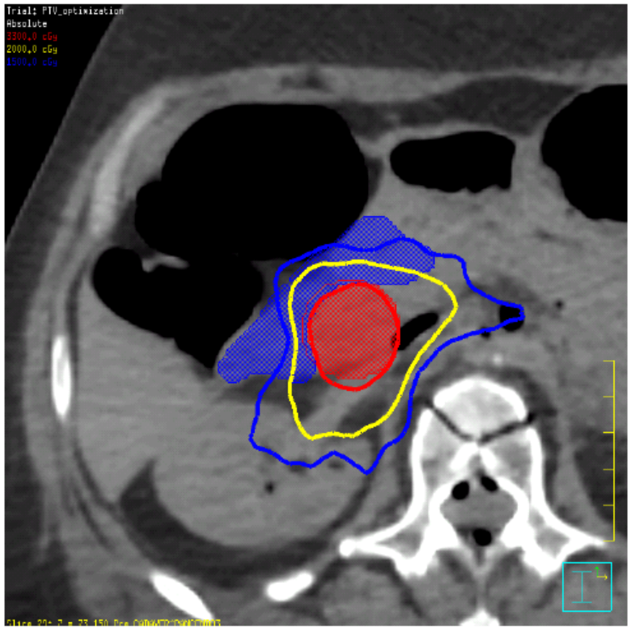
*Z. Feng et al, A Dose Predication Model for Duodenum Sparing in Pancreatic Cancer with Biodegradable Hydrogel Spacer, AAPM2017, Abstract SU-K-FS1-1

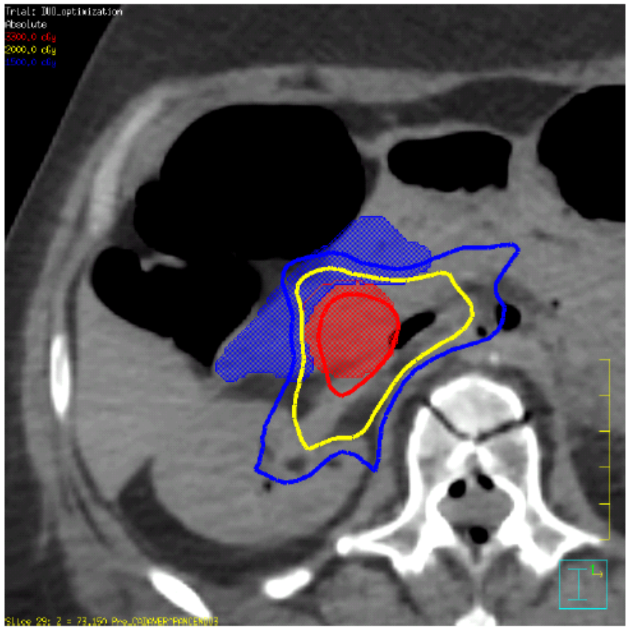
Biodegradable hydrogel with endoscopic ultrasound guidance

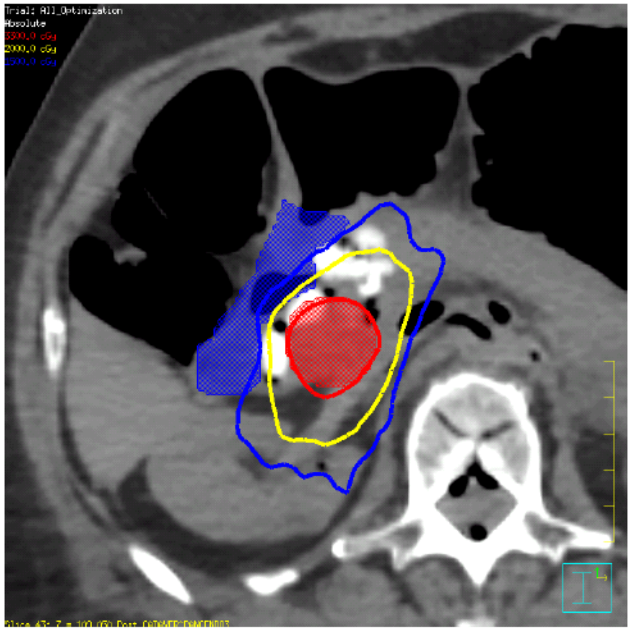


*P. Huang et al, Real-Time Tracking of Endoscopic Ultrasound Guided Hydrogel Injection Using Template Matching, AAPM 2017, Abstract SU-K-601-17

Biodegradable hydrogel with endoscopic ultrasound guidance







Pre-Injection Plan with PTV priority

Duo V15 = 7.07 cc
Duo V20 = 3.86 cc (!)
Duo V33 = 0.15 cc
PTV V33 = 95.01%

Pre-Injection Plan with Duo priority

Duo V15 = 3.33 cc
Duo V20 = 1.27 cc
Duo V33 = 0.01 cc
PTV V33 = 80.36% (!)

Post-Injection Plan

Duo V15 = 2.02 cc
Duo V20 = 0.36 cc
Duo V33 = 0.0 cc
PTV V33 = 97.87%

*A. Rao et al, Novel Use of a Hydrogel Spacer to Separate the Head of the Pancreas and Duodenum for Radiotherapy for Pancreatic Cancer, ASTRO 2017

Conclusions

- Ultrasound guidance can be used for motion monitoring in radiotherapy for pancreatic cancer
- Clinical workflow has to be adapted to incorporate the changes
- Endoscopic ultrasound can guide the injection of hydrogel to potentially reduce the duodenum dose

Acknowledgement
USGRT team

- Radiation Oncology
  - John Wong, Lin Su, Yin Zhang, Sook Kien Ng, Junghoon Lee, Ken Wang, Ted Hooker, Joseph Herman, Harry Quon, Phuoc Tran, Danny Song
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- University of Pennsylvania Radiation Oncology
  - Haibo Lin
- Shandong Normal University
  - Dengwang Li, Pu Huang, Ziwei Feng

Acknowledgement EUSGRT team

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- Shandong Normal University
  - Dengwang Li, Pu Huang, Ziwei Feng

Questions