Istituto Nazionale di Fisica Nucleare

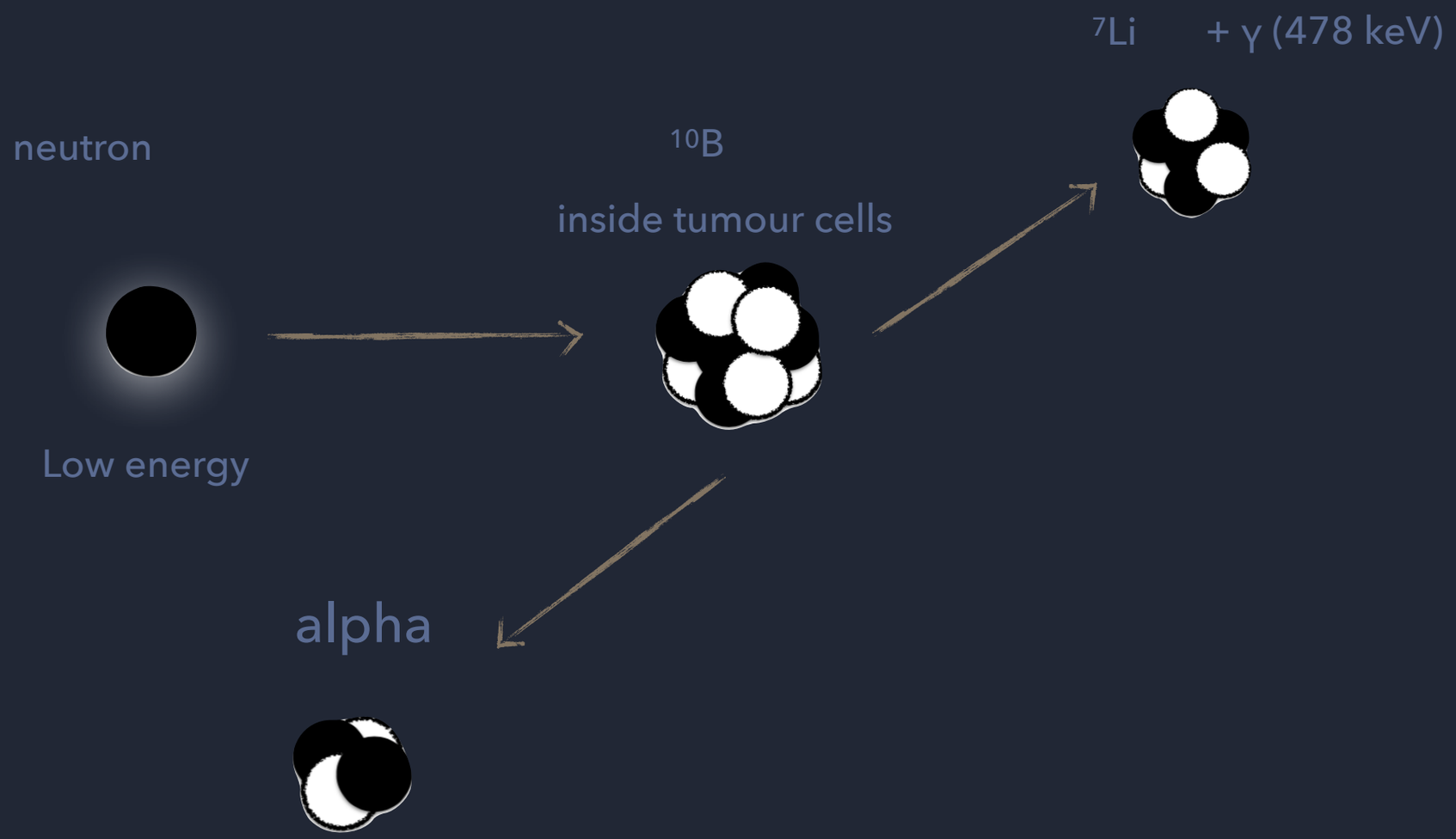
1st December 2021

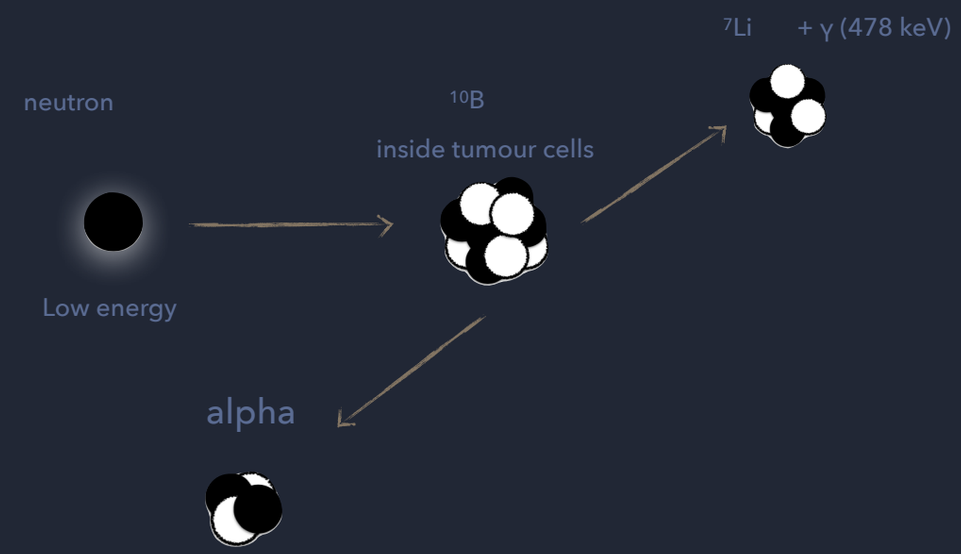
Setareh Fatemi

AI_MIGHT

Artifi cial **I**ntelligence methods applied to **M**edical **I**ma**G**es to en**H**ance and personalize BNCT **T**reatment planning

BORON NEUTRON CAPTURE THERAPY


neutron
^{10}B
inside tumour cells
^{7}Li
+ γ (478 keV)
Low energy
alpha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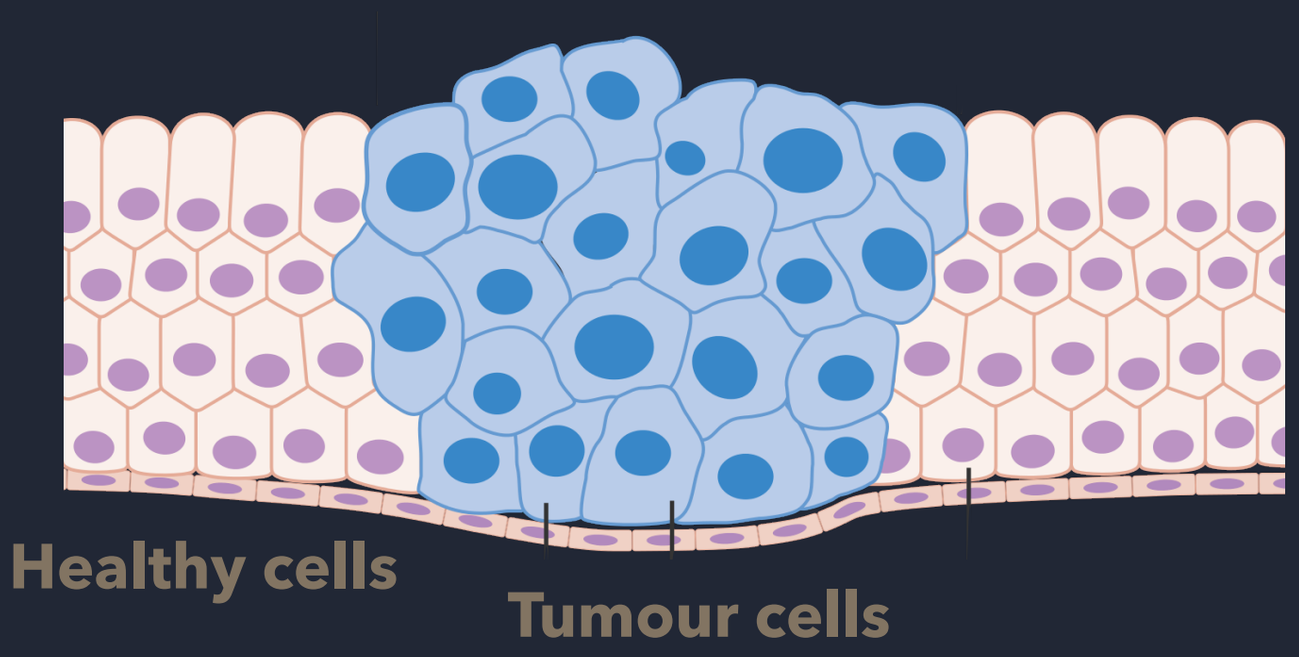
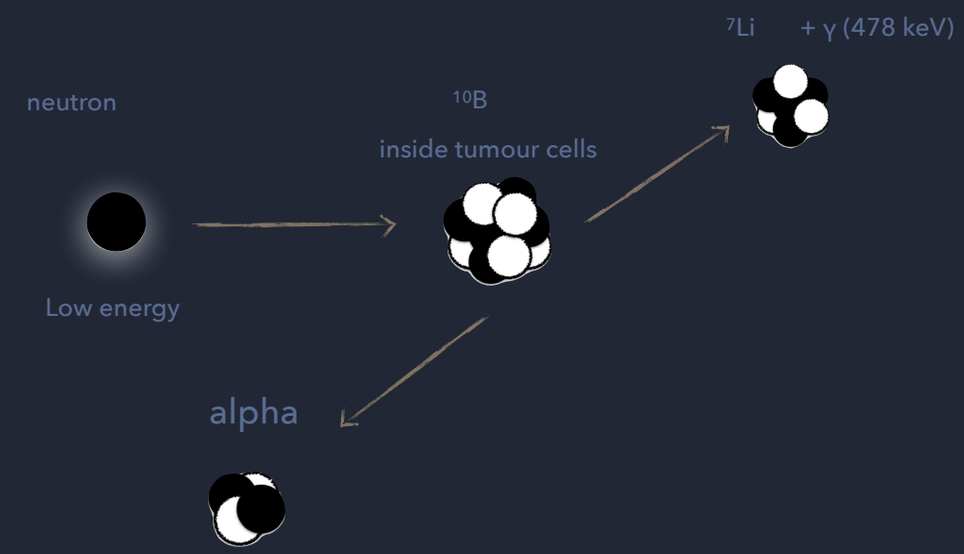

Healthy cells
Tumour cells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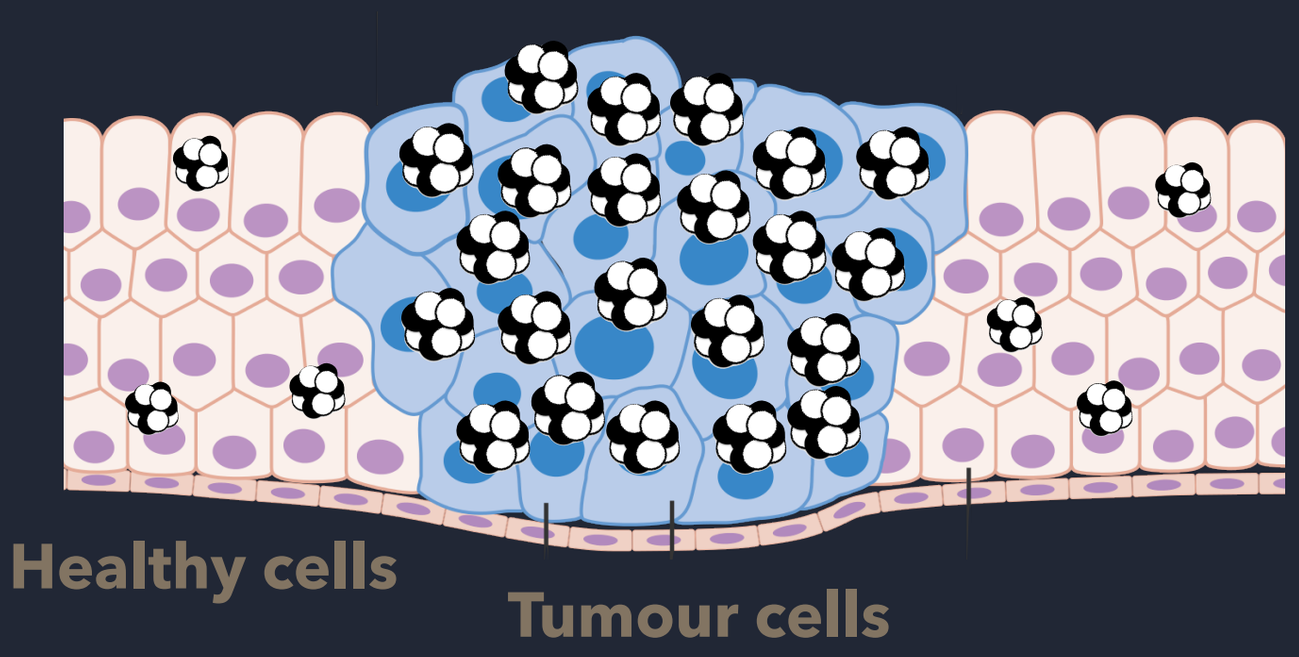
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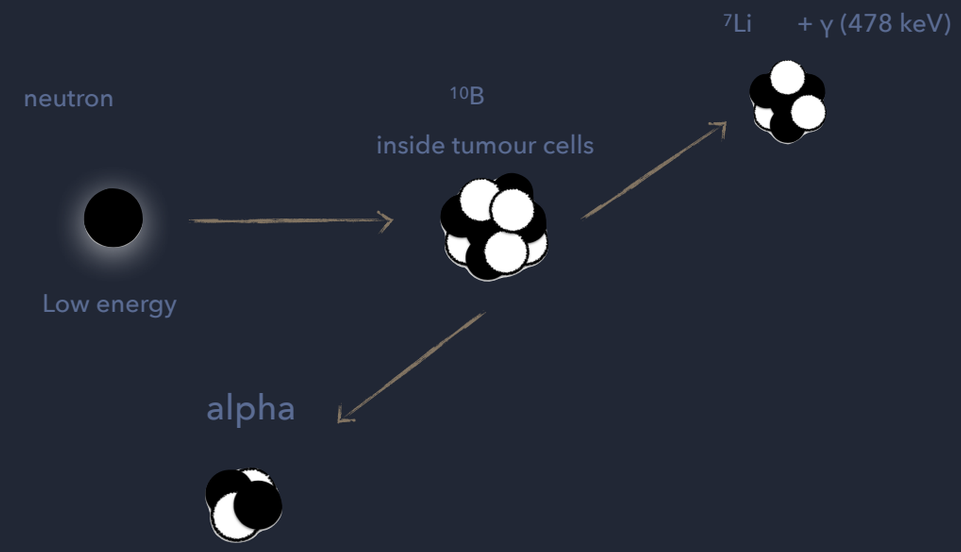
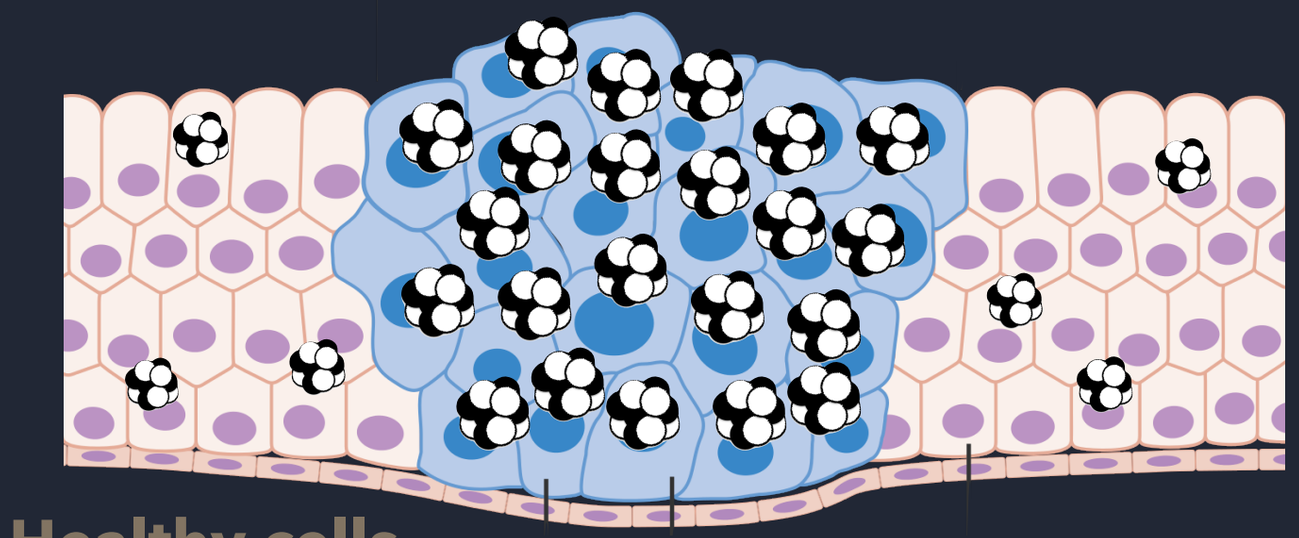
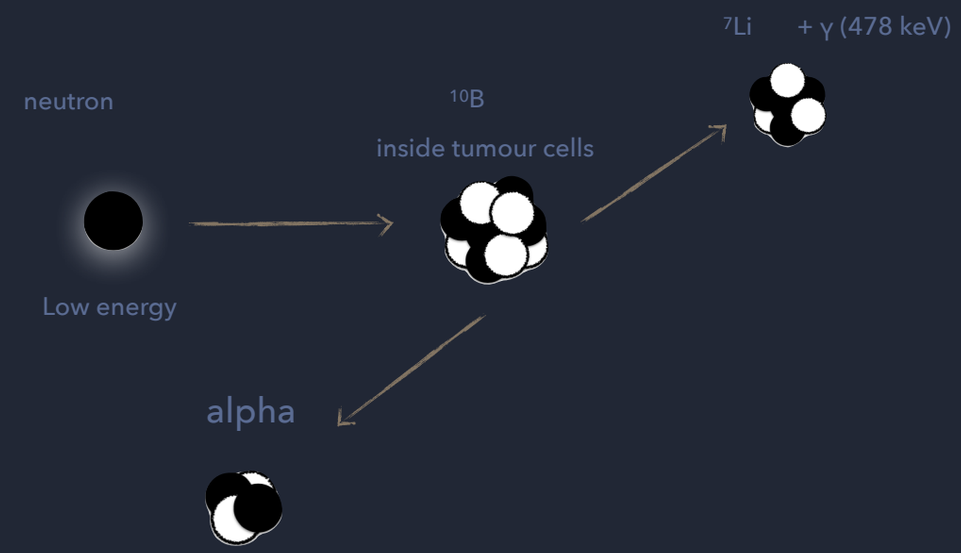


Thermal/Epithermal neutrons

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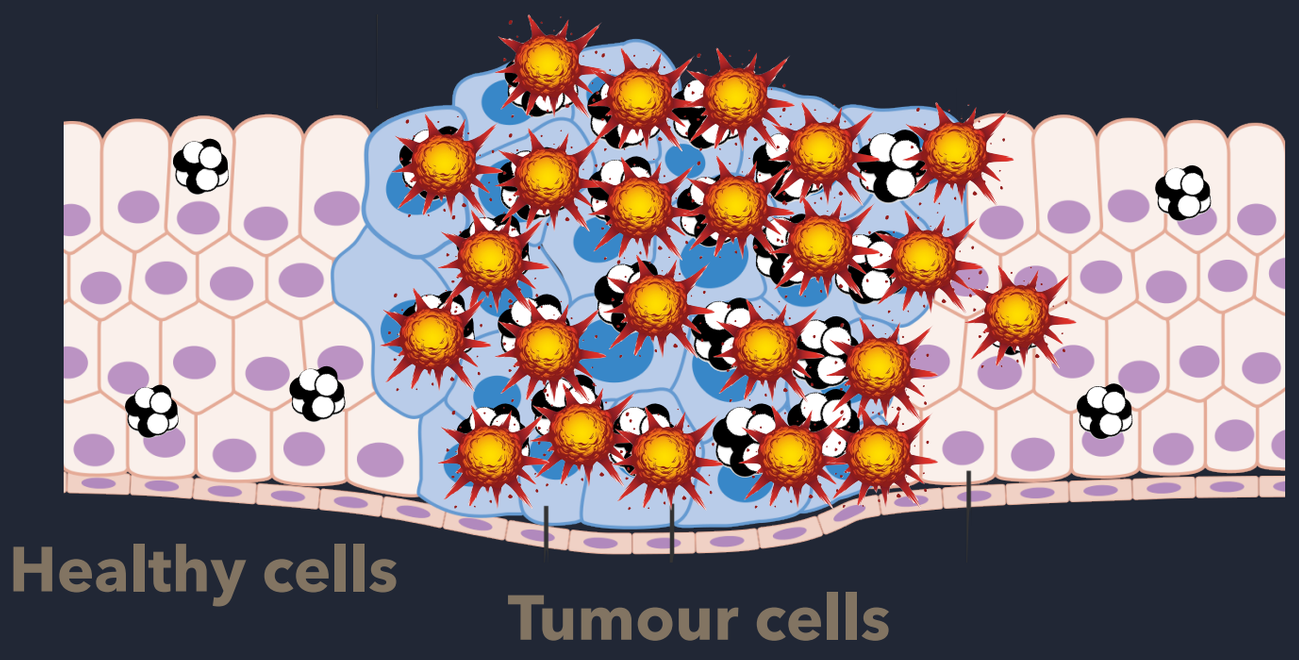
Healthy cells
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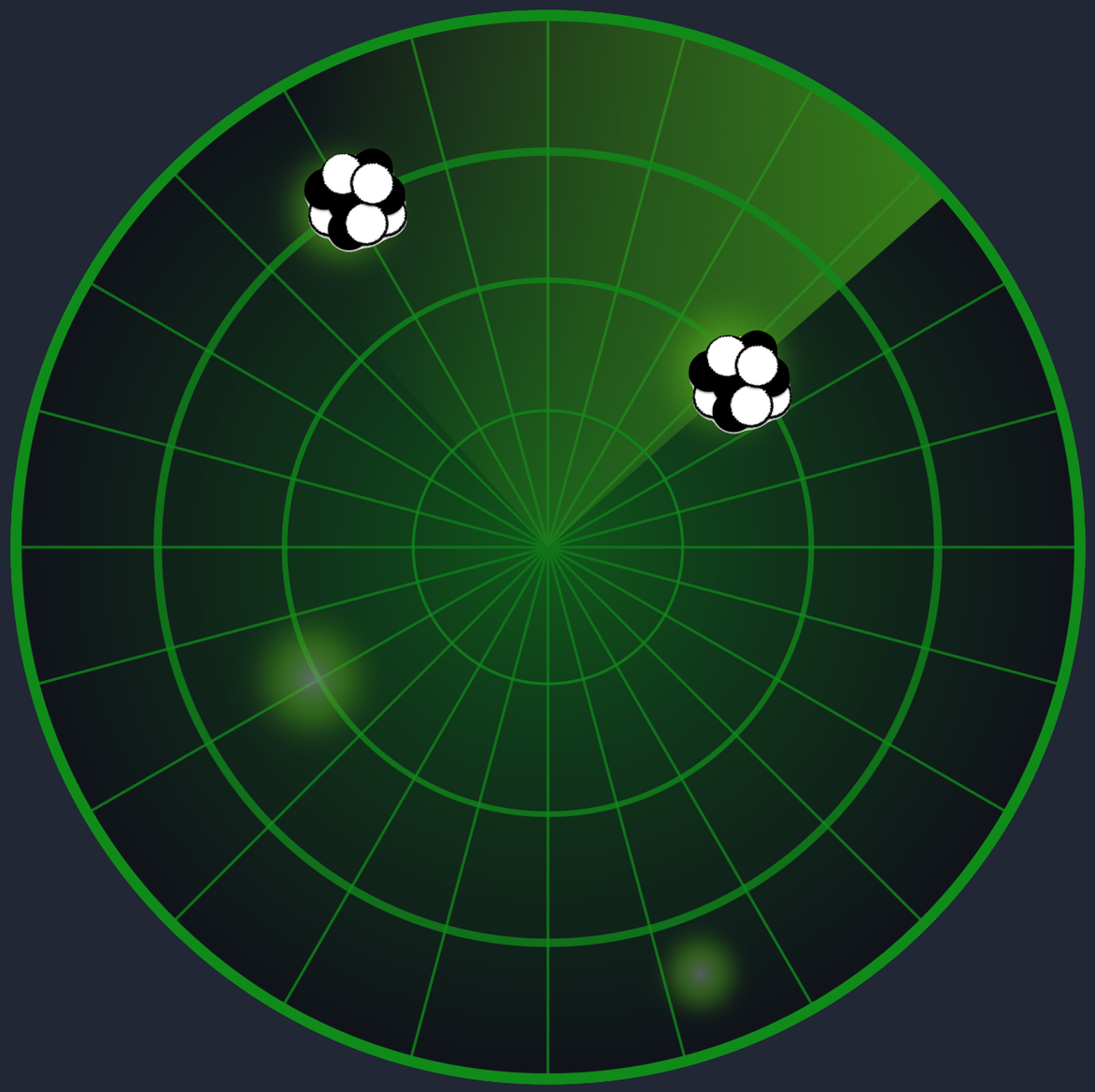
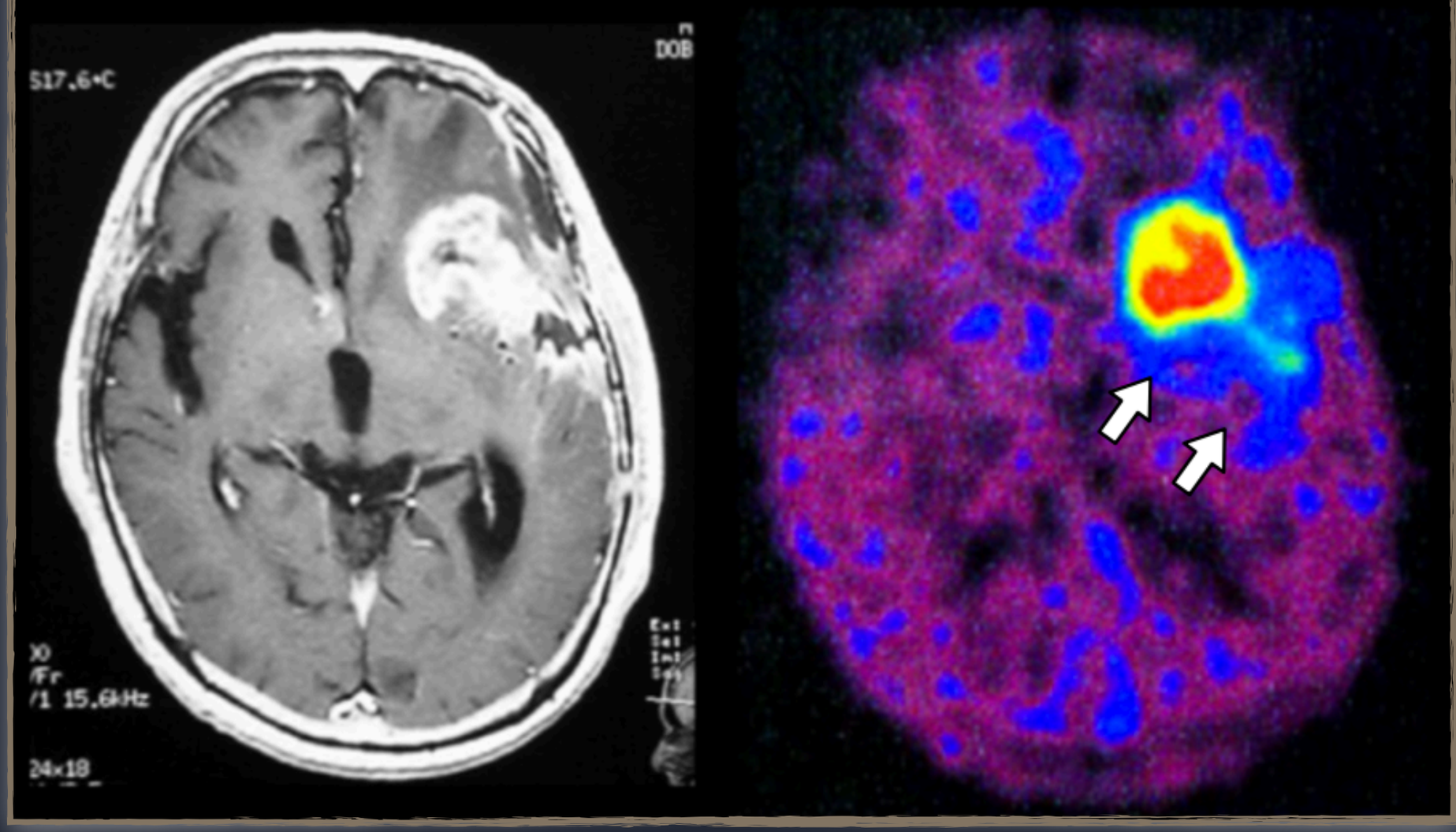


LOCALIZATION & QUANTIFICATION OF ^{10}B

Pre-BNCT MRI and BPA-PET



Contrast-enhanced T1-weighted MRI of representative glioblastoma patient and 18 F-labeled BPA-PET image after initial debulking surgery.

RF Barth et al, 2012

CLINICAL BNCT

18F-BPA

18F-BPA

PET
IMAGING

18F-BPA

PET
IMAGING

ROI
INDIVIDUATION

18F-BPA

PET
IMAGING

ROI
INDIVIDUATION

18F-BPA

PET
IMAGING

ROI
INDIVIDUATION

BNCT
CLINICAL
CENTER

18F-BPA

PET
IMAGING

ROI
INDIVIDUATION

TPS

BNCT
CLINICAL
CENTER

BPA

18F-BPA

PET
IMAGING

ROI
INDIVIDUATION

BNCT
CLINICAL
CENTER

BPA

IRRADIATION

TREATMENT PLANNING SYSTEM

Image Registration

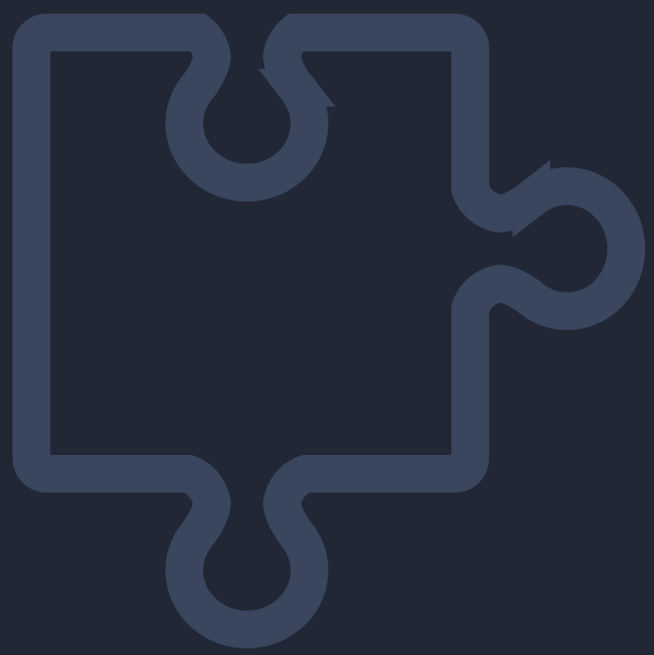
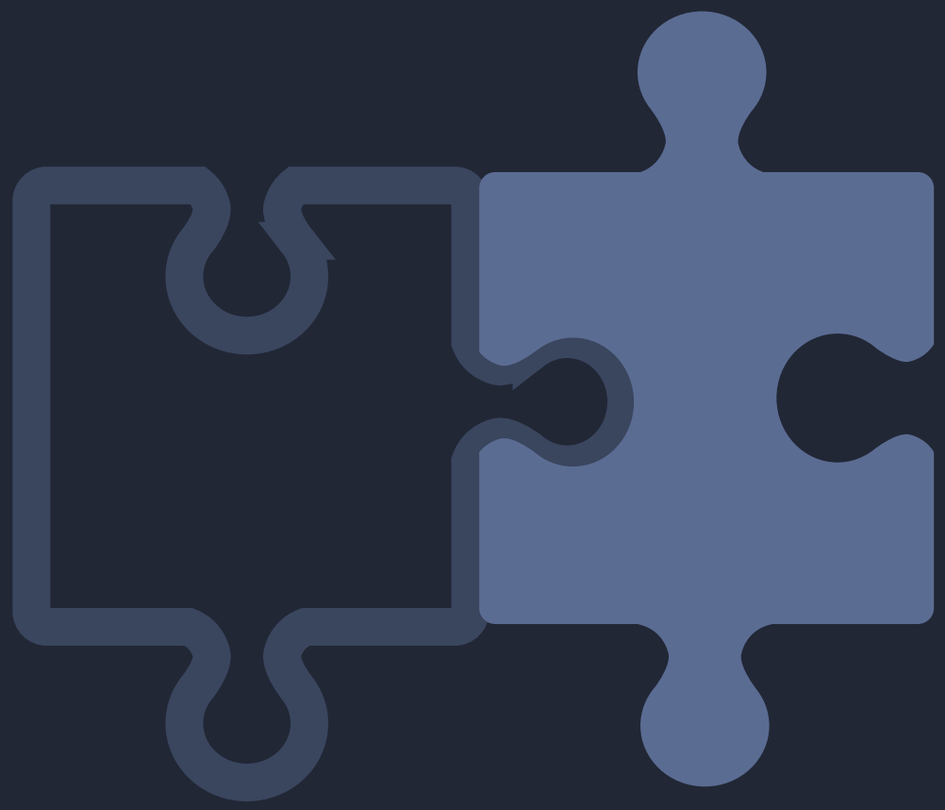


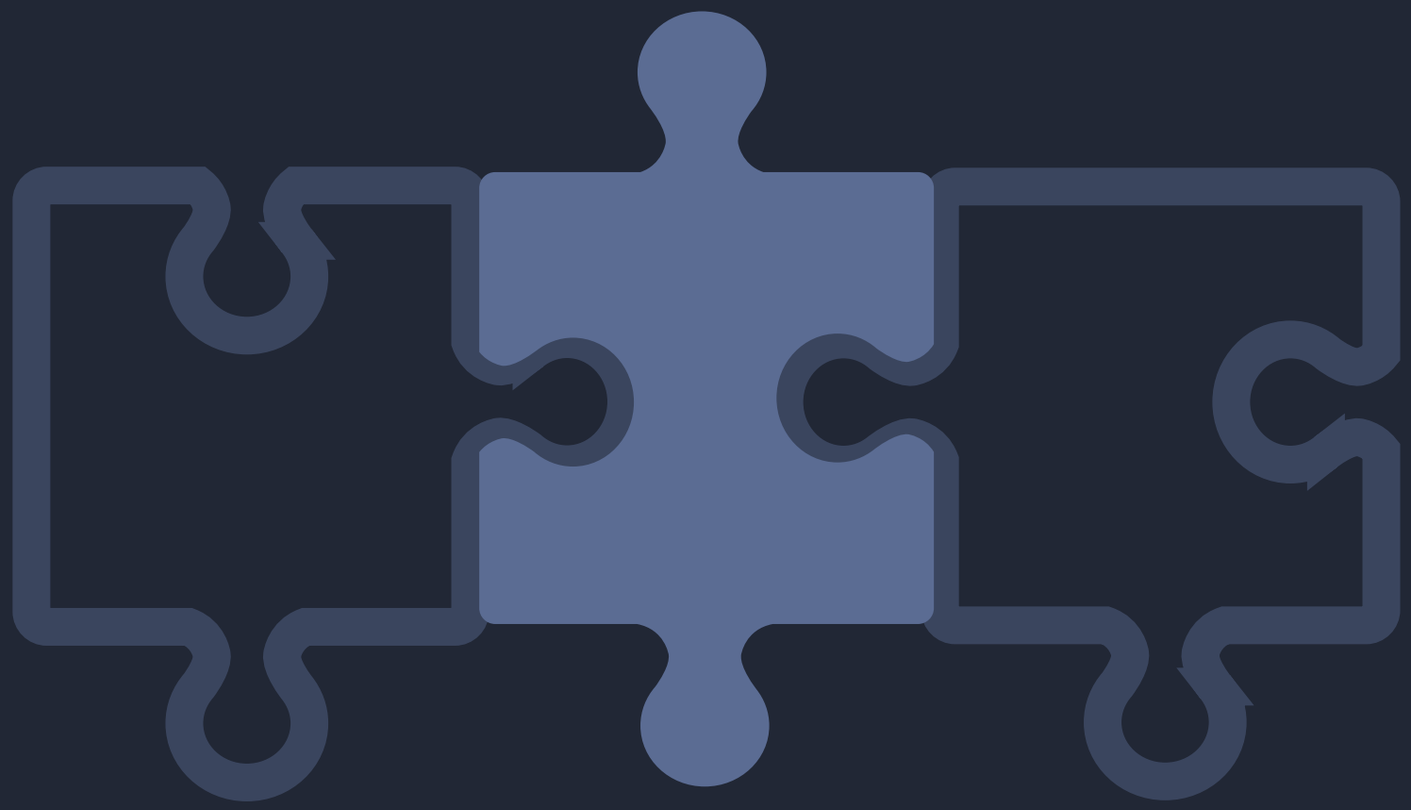
Image
Registration



ROI upload

Image Registration

Geometry creation



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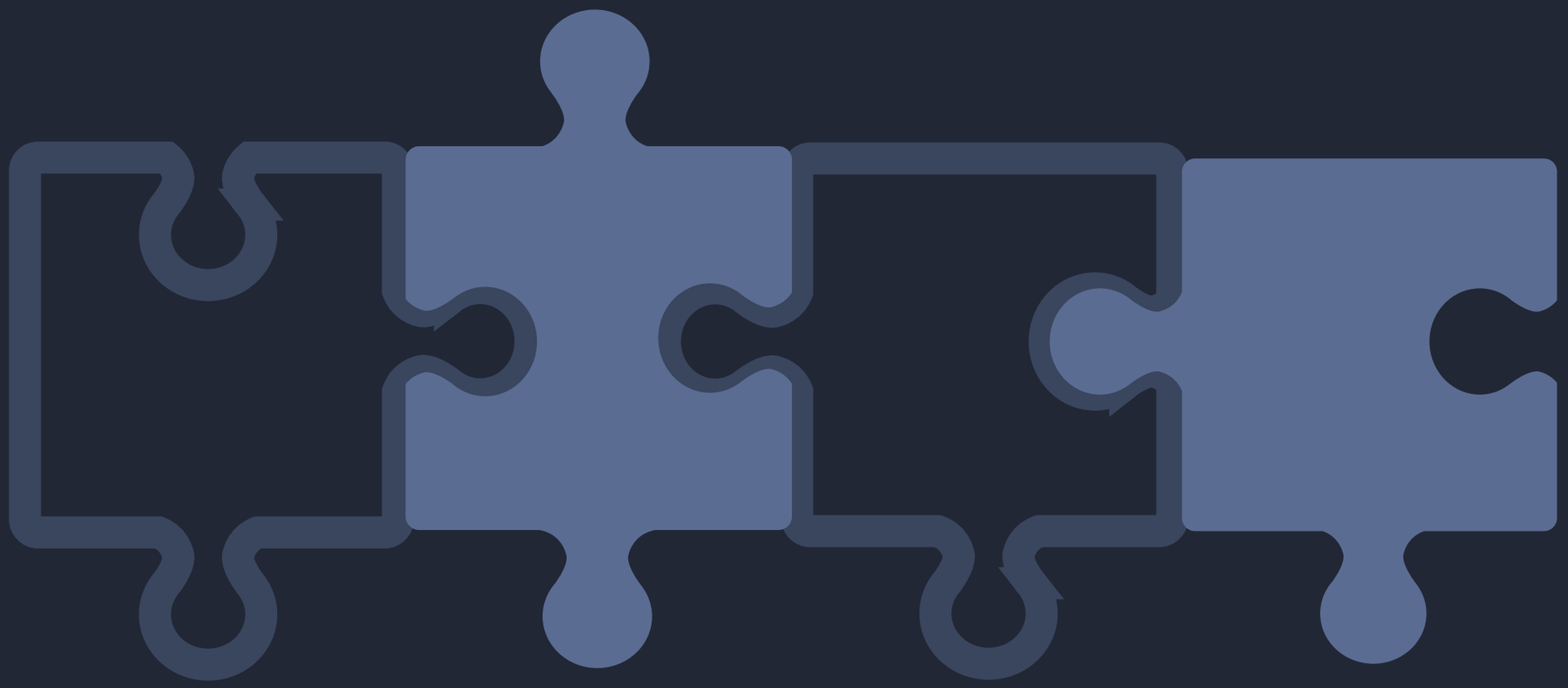


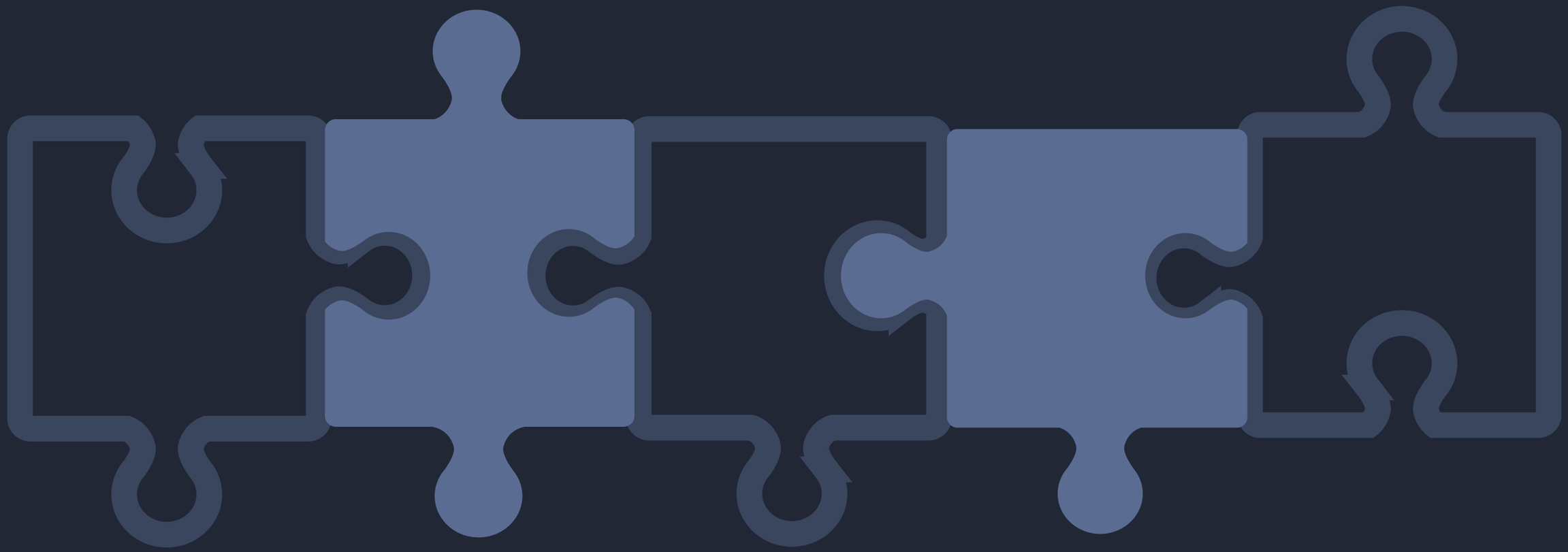
ROI upload

Monte Carlo Simulation

Image Registration

Geometry creation

Dosimetric Information



ROI upload

Monte Carlo Simulation

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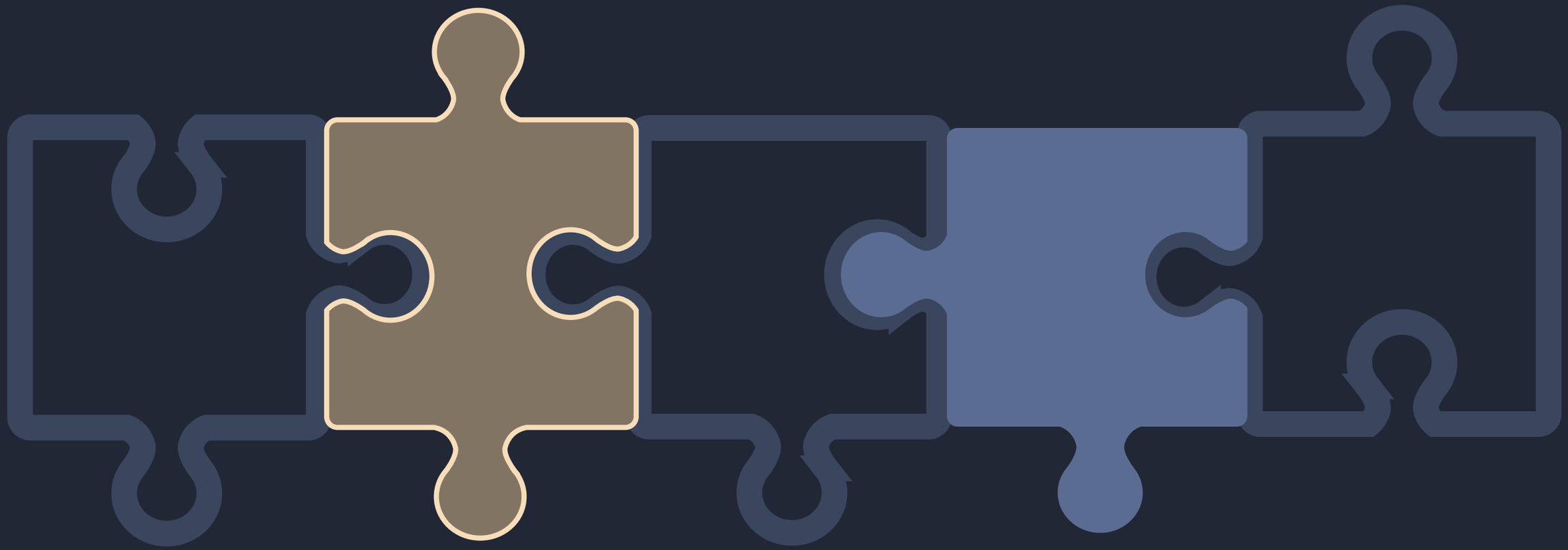


ROI individuation and automatic segmentation

Monte Carlo Simulation

MIGHT

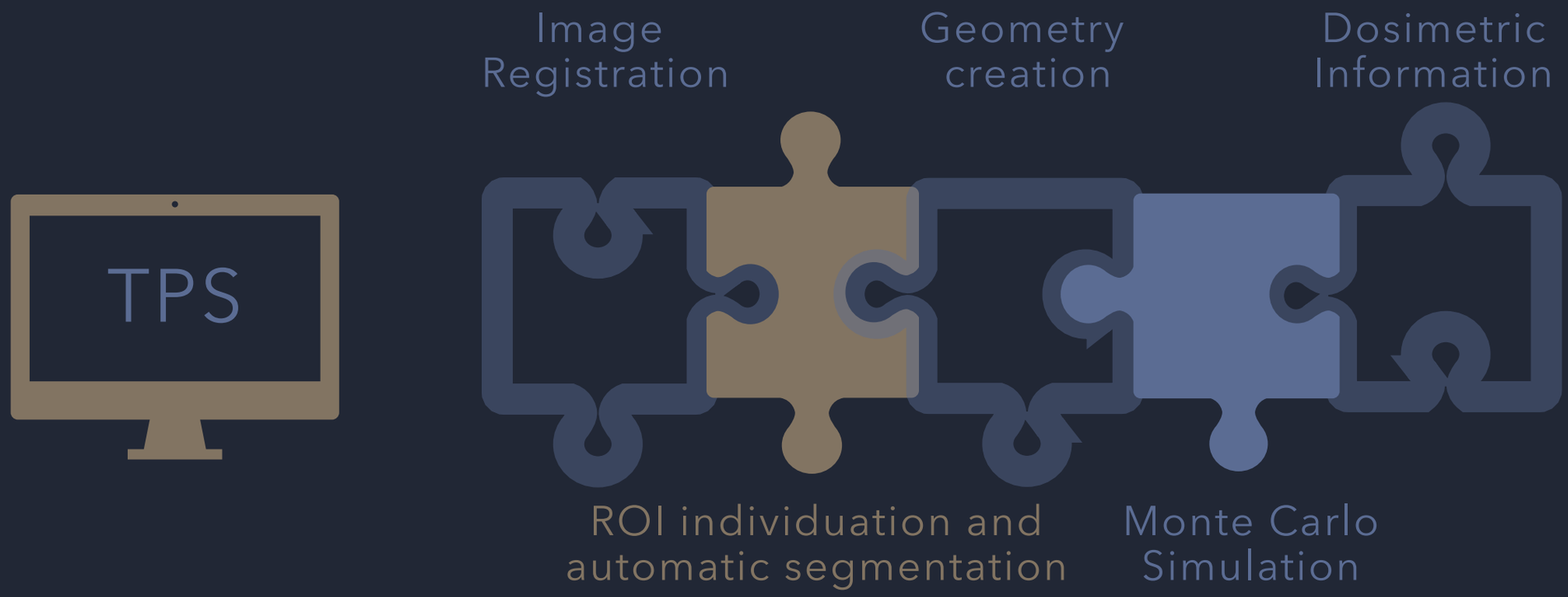
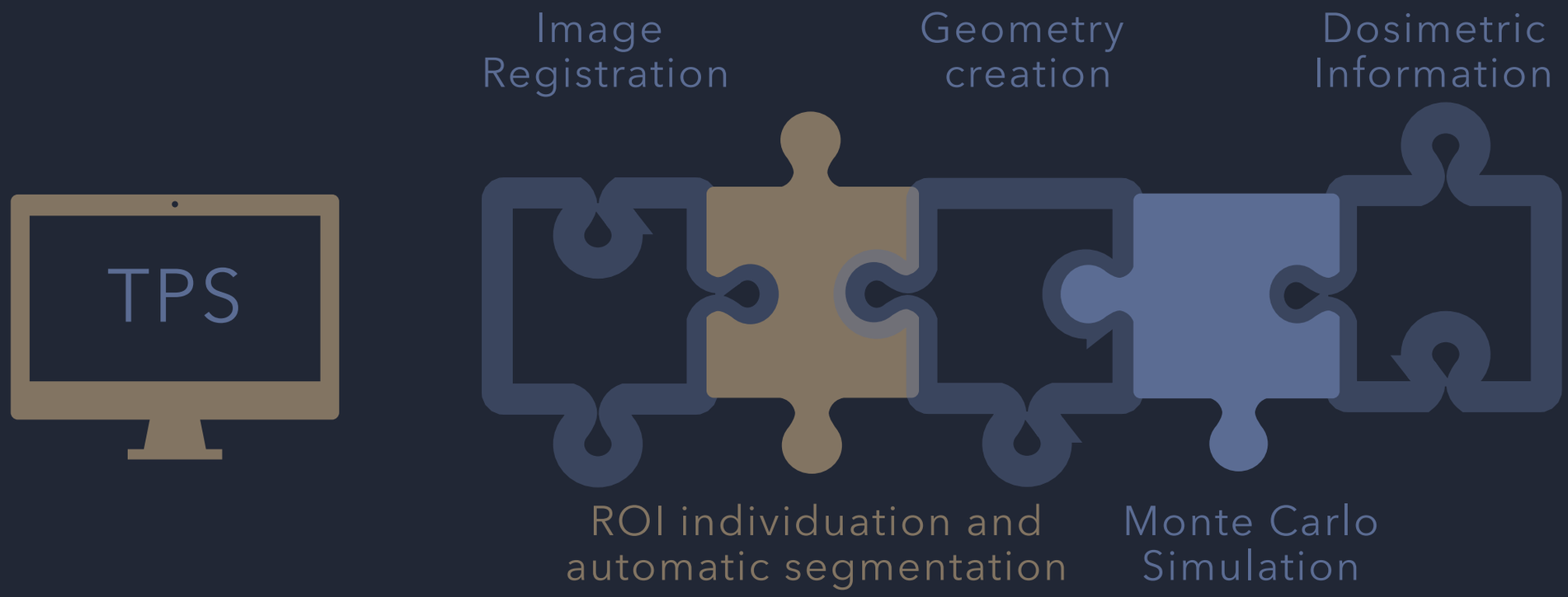
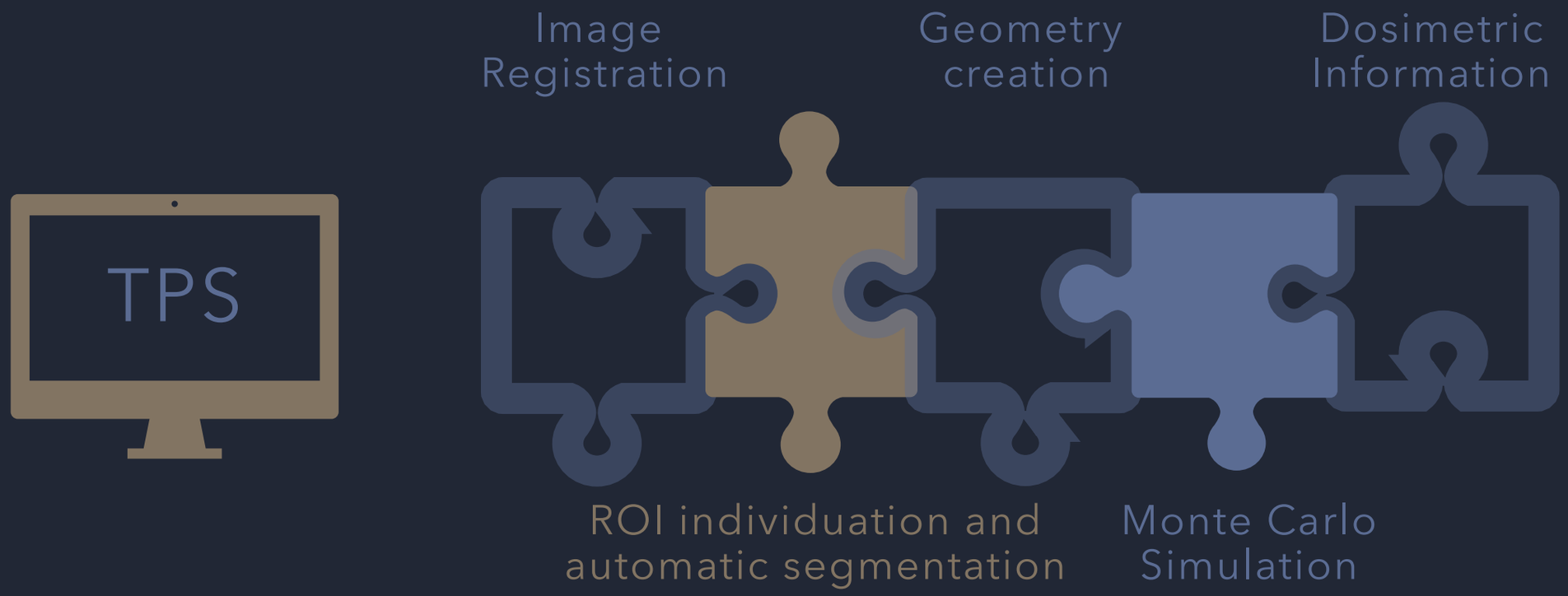


Image
Registration
Geometry
creation
Dosimetric
Information
TPS
ROI individuation and
automatic segmentation
Monte Carlo
Simulation



CLINICAL

Aid physicians in detecting ROIs



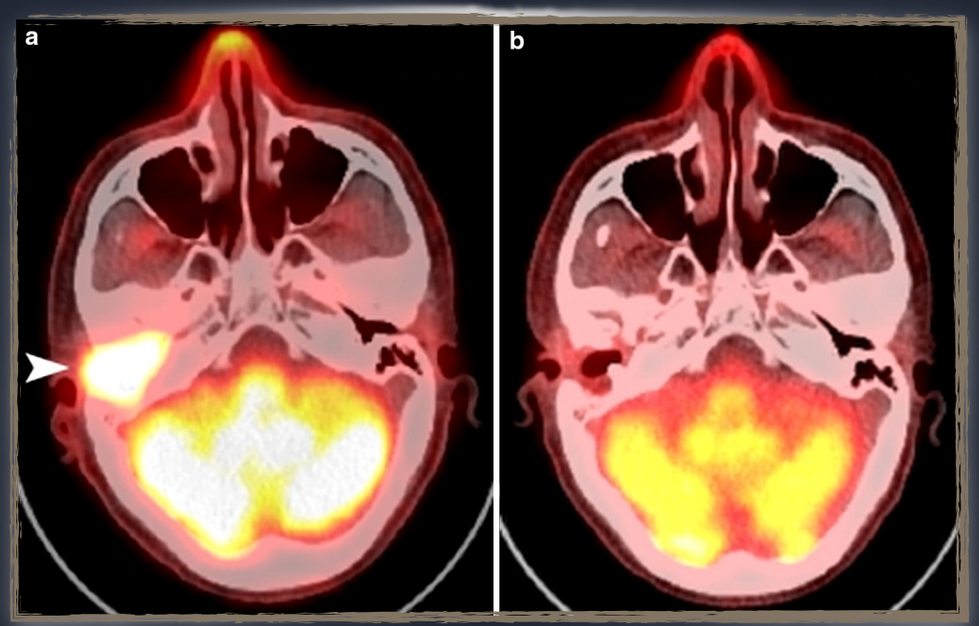
CLINICAL

Aid physicians in detecting ROIs

RESEARCH

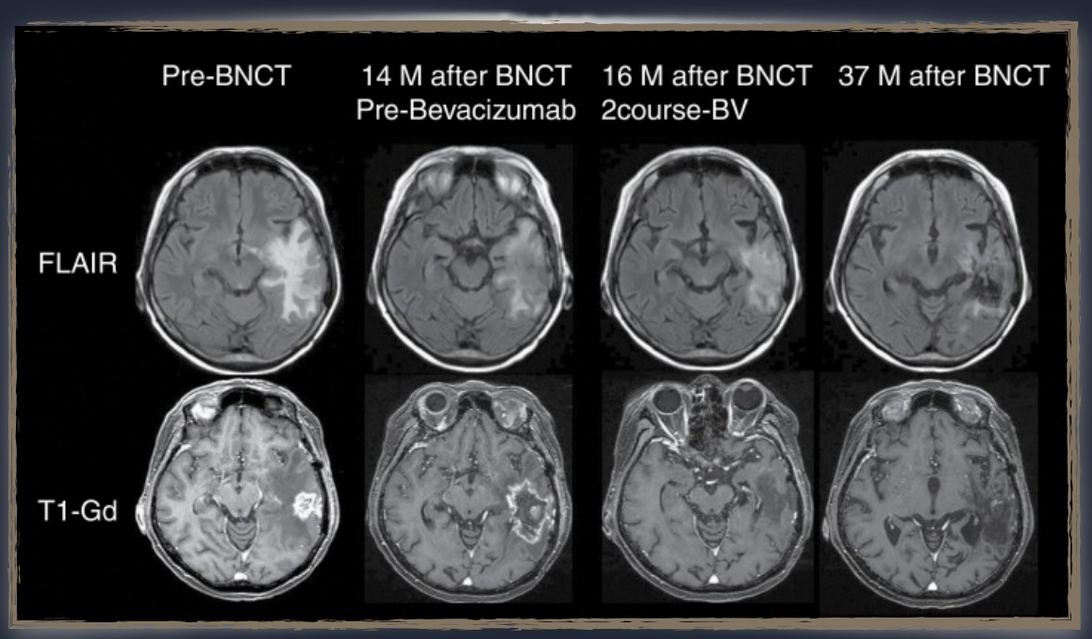
Speed up database creation to improve TPS

HEAD & NECK CANCER



Wang LW, Liu YH, Chou FI, Jiang SH. Clinical trials for treating recurrent head and neck cancer with boron neutron capture therapy using the Tsing-Hua Open Pool Reactor. Cancer Commun (Lond). 2018 Jun 19;38(1):37. doi: 10.1186/s40880-018-0295-y. PMID: 29914577; PMCID: PMC6006853.

GLIOBLASTOMA MULTIFORME



Kawabata S, Suzuki M, Hirose K, et al. Accelerator-based BNCT for patients with recurrent glioblastoma: a multicenter phase II study. Neurooncol Adv. 2021;3(1):vdab067. Published 2021 May 20. doi:10.1093/noajnl/vdab067

DATABASE

HEAD & NECK CANCER

GLIOBLASTOMA MULTIFORME

MRI and CT images of both cancer types are available on open access databases

Taipei Veterans General Hospital has agreed to share their anonymized BNCT patients images In particular for H&N cancer

Trial in progress

For both cancer types the chosen database need to be STANDARDIZED and TRAINING and TESTING group of images will be created

SEGMENTATION ALGORITHM

DEEP NEURAL NETWORK

will be used to segment the images for both image modalities and both cancer types

MRI segmentation algorithm

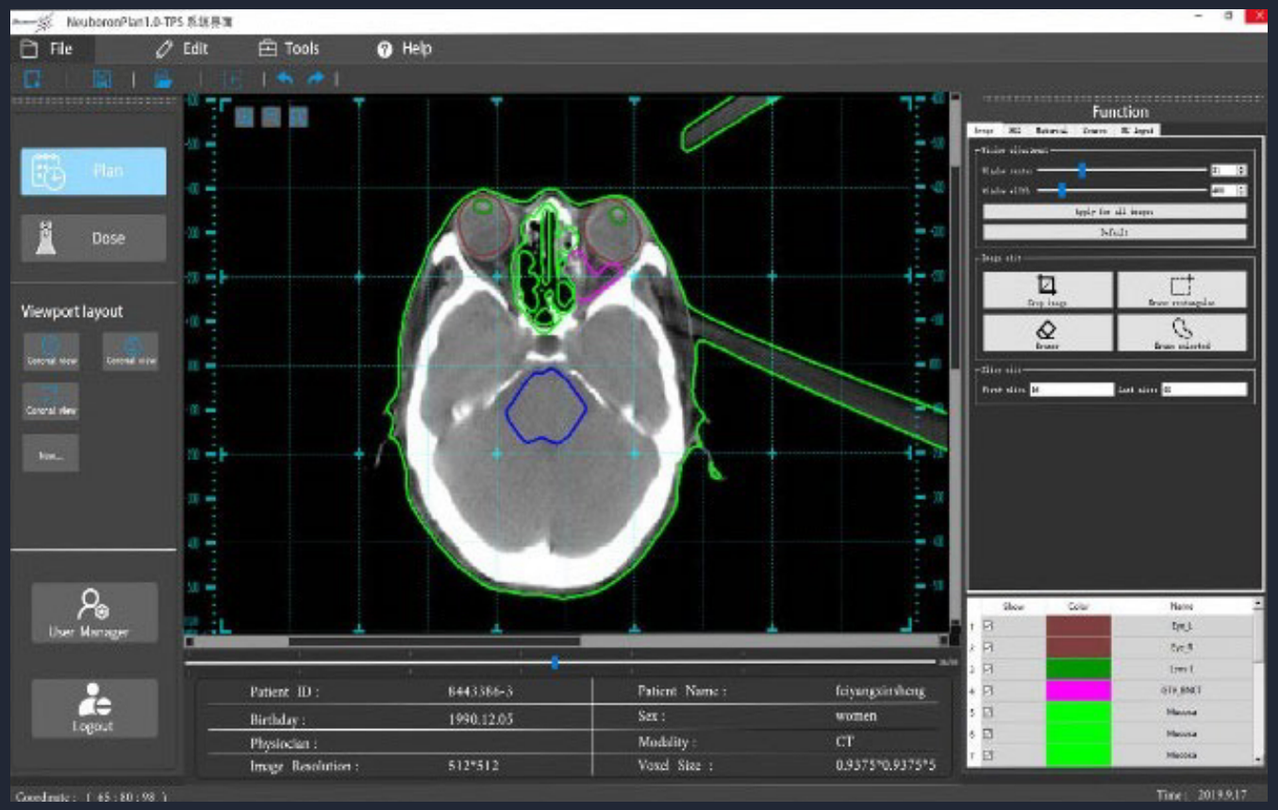
CT segmentation algorithm

The algorithms will be TRAINED and TESTED using a GPU dedicated facility

Aiming to obtain high sensibility and high specificity

TREATMENT PLANNING SYSTEM

INPUT:
SEGMENTED ROIS



OUTPUT:
DOSIMETRIC CALCULATION

HEAD & NECK CANCER

BNCT PATIENTS @ TVGH

GLIOBLASTOMA MULTIFORME

	Q1	Q2	Q3	Q4	Q5	Q6
W1						
W2						
W3						

	Q1	Q2	Q3	Q4	Q5	Q6
W1	**M1** Datasets & Pipelines		**M2** Standardisation of the datasets			
W2			**M3** Segmentation algorithm CT		**M4** Segmentation algorithm MRI	
W3				**M5** Testing TPS for CT & MRI		**M6** Test on real BNCT cases from Taipei Hospital

1ST YEAR

WP 1: Acquisition and standardisation of the medical images

WP 2: Training and testing of the segmentation algorithms

2ND YEAR

WP 3: Implementation of the automatically segmented ROIs as input for the TPS.

1ST YEAR

WP 1: Acquisition and standardisation of the medical images

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2ND YEAR

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	Cost k€
Consumables	2
Instrumentation	67
License	0.5
Travels	4
Total	73.5

1ST YEAR

WP 1: Acquisition and standardisation of the medical images

	Cost k€
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Instrumentation	67
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Total	73.5

2ND YEAR

WP 2: Training and testing of the segmentation algorithms

WP 3: Implementation of the automatically segmented ROIs as input for the TPS.

	Cost k€
Consumables	2
Instrumentation	0
License	0.5
Travels	4
Total	6.5

TEAM

BNCT

Setareh FATEMI

Ian POSTUMA

Silva BORTOLUSSI

MRI

Francesca BRERO

AI

Francesca LIZZI

PARTNERS

NEUBORON

臺北榮民總醫院
Taipei Veterans General Hospital

NEUBORON_PLAN

BNCT PATIENTS DIAGNOSTIC IMAGES

1ST CHINESE ACCELERATOR BASED CLINICAL FACILITY

BUILDS BNCT COMPLETE CLINICAL SYSTEM

R&D ON DIFFERENT TOPICS TO ENHANCE BNCT

TAIWANESE REACTOR BASED CLINICAL FACILITY

PHYSICIANS WITH BNCT KNOWLEDGE AND EXPERIENCE WITH PATIENTS

HEAD & NECK CANCER CLINICAL TRIALS

SYNERGIES AND APPLICATIONS

INFN
Istituto Nazionale di Fisica Nucleare

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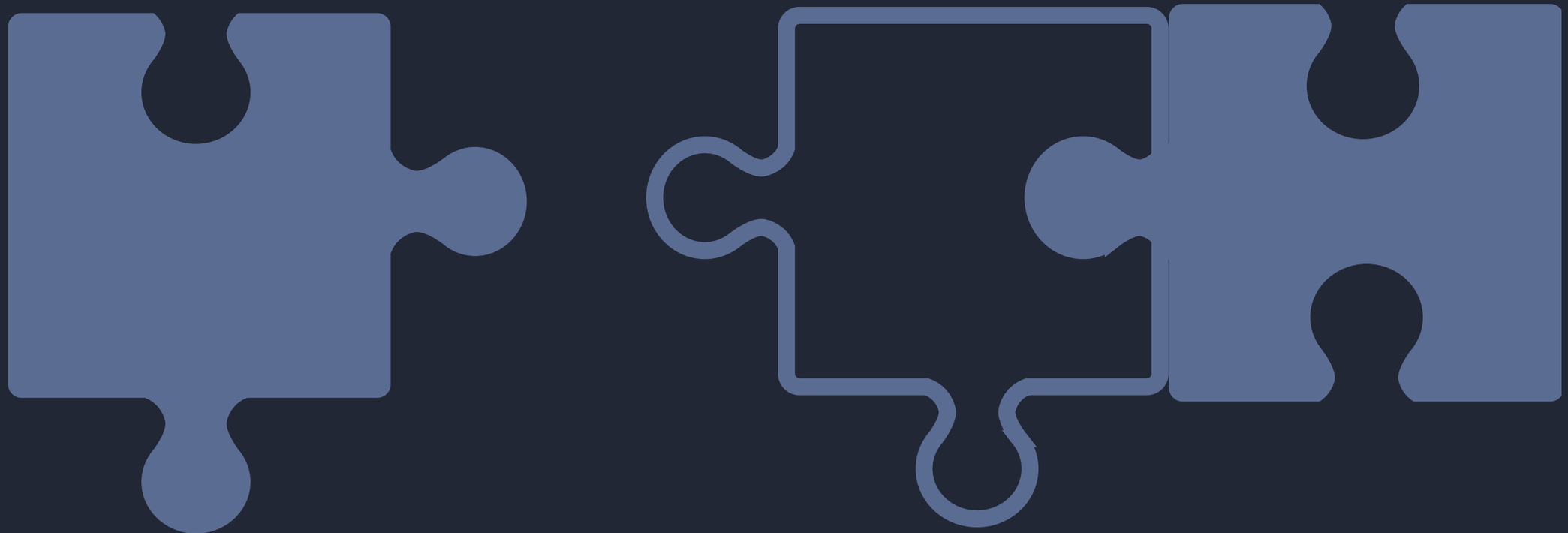
NEXT_AIM

ENTER_BNCT

Istituto Nazionale di Fisica Nucleare

IT_STARTS



NEXT_AIM

ENTER_BNCT

Istituto Nazionale di Fisica Nucleare

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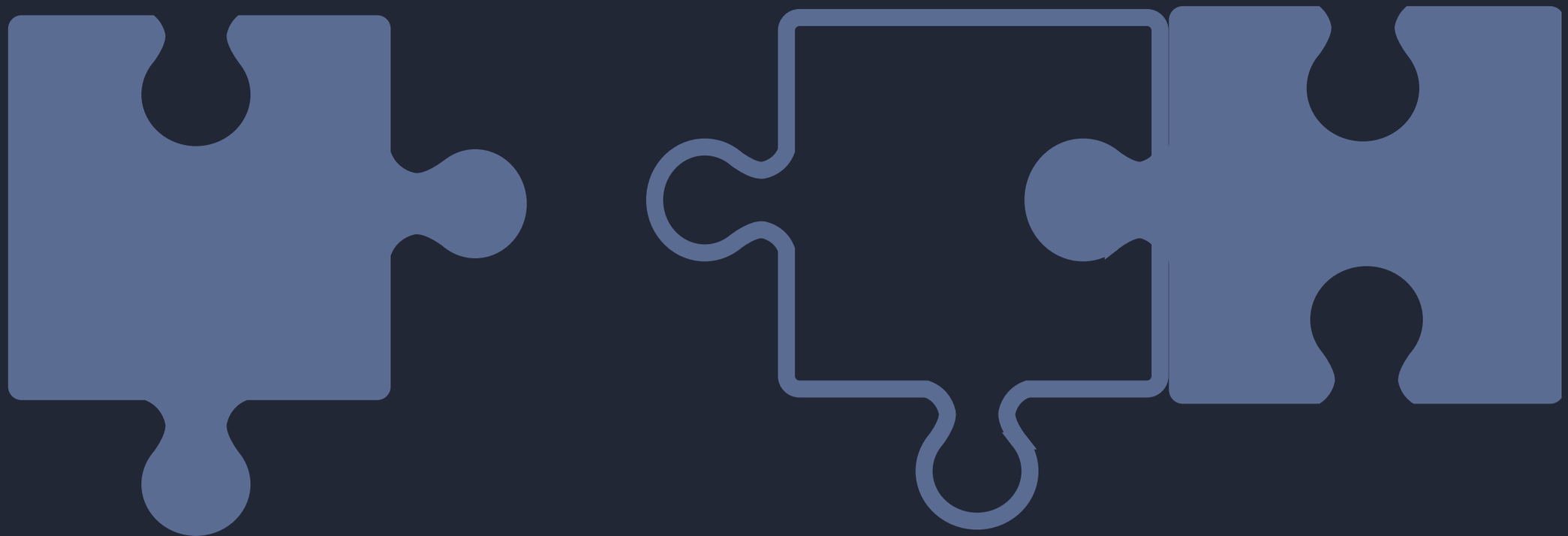


NEXT_AIM

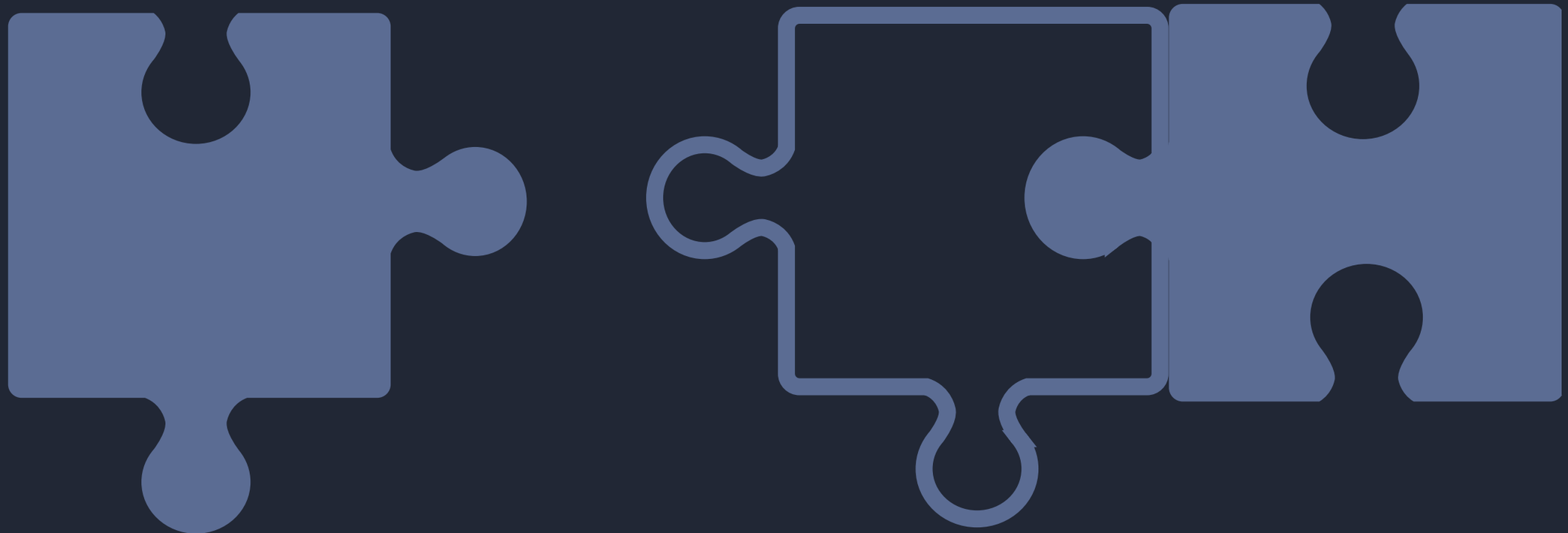
ENTER_BNCT

INNOVATIVE TPS FOR CLINICAL APPLICATION

CAN BE USED TO COMBINE BNCT AND HADRONTHERAPY

Istituto Nazionale di Fisica Nucleare

IT_STARTS

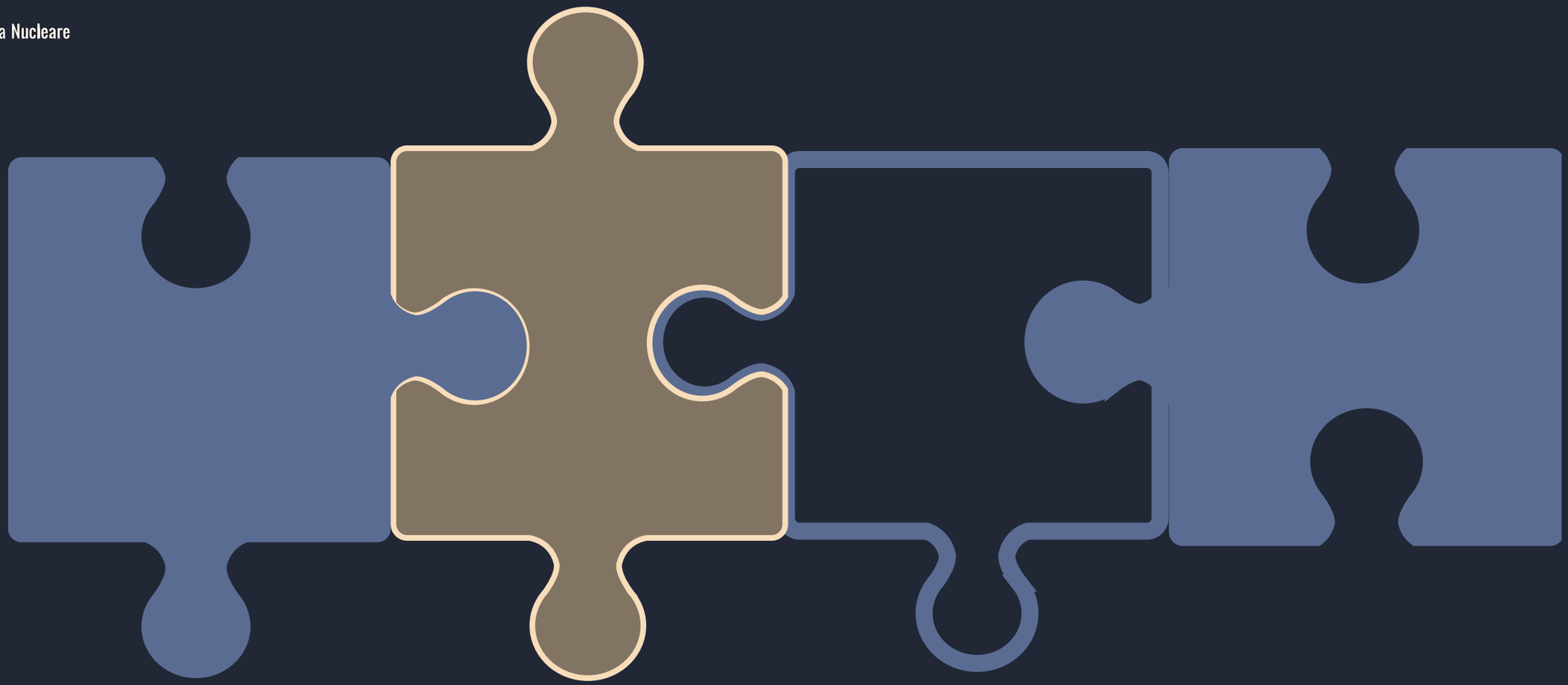


NEXT_AIM

ENTER_BNCT

Istituto Nazionale di Fisica Nucleare

AI_MIGHT IT_STARTS



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Istituto Nazionale di Fisica Nucleare

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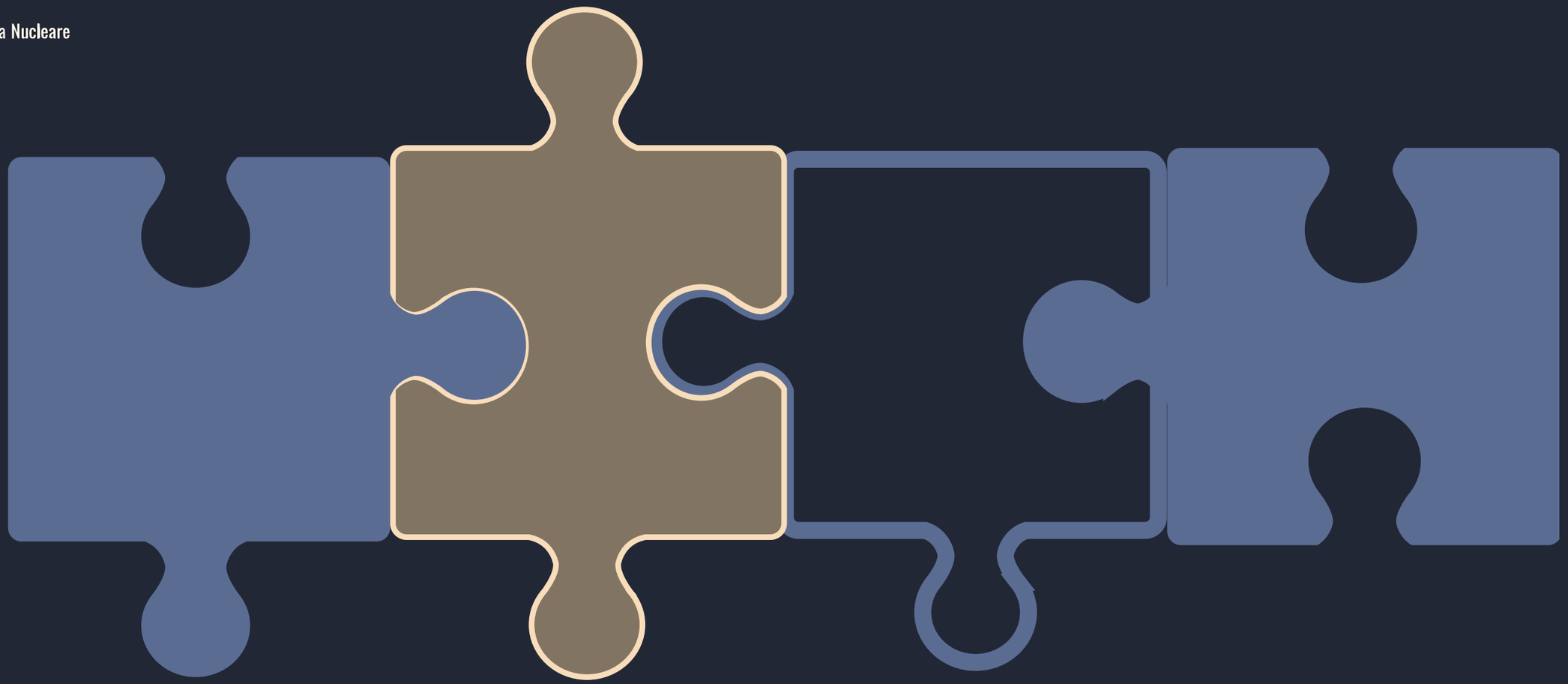

NEXT_AIM ENTER_BNCT

STATE OF THE ART TOOL FOR AUTOMATIC SEGMENTATION OF MRI AND CT IMAGES

POSSIBILITY TO ANALYZE LARGE AMOUNT OF IMAGES IN A SHORT TIME

VARIOUS CLINICAL CENTERS AND RESEARCHERS IN BNCT OF THE ISNCT COMMUNITY

ADD TUMOR TYPES APPLY TO OTHER DISEASE

+

HADRON THERAPY TPS OR BNCT COMBINED THERAPY

THANK YOU!