

Towards Clinical Upright Particle Therapy: Commissioning, Strategies and Challenges

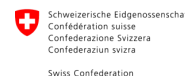
María Plana

17.09.2026

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UK Research
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Roughly, 50% of cancer patients are indicated for radiotherapy as part of their treatment course WHO/IAEA 2021

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How can we make cancer treatment more precise and more accessible?

Overview

1. Radiotherapy today – and its limits
2. Particle therapy – precision at a cost
3. Upright radiotherapy – accessible precision
4. Tackling the open problems
5. Early results

Intro to radiotherapy



CLB 2025

Intro to radiotherapy



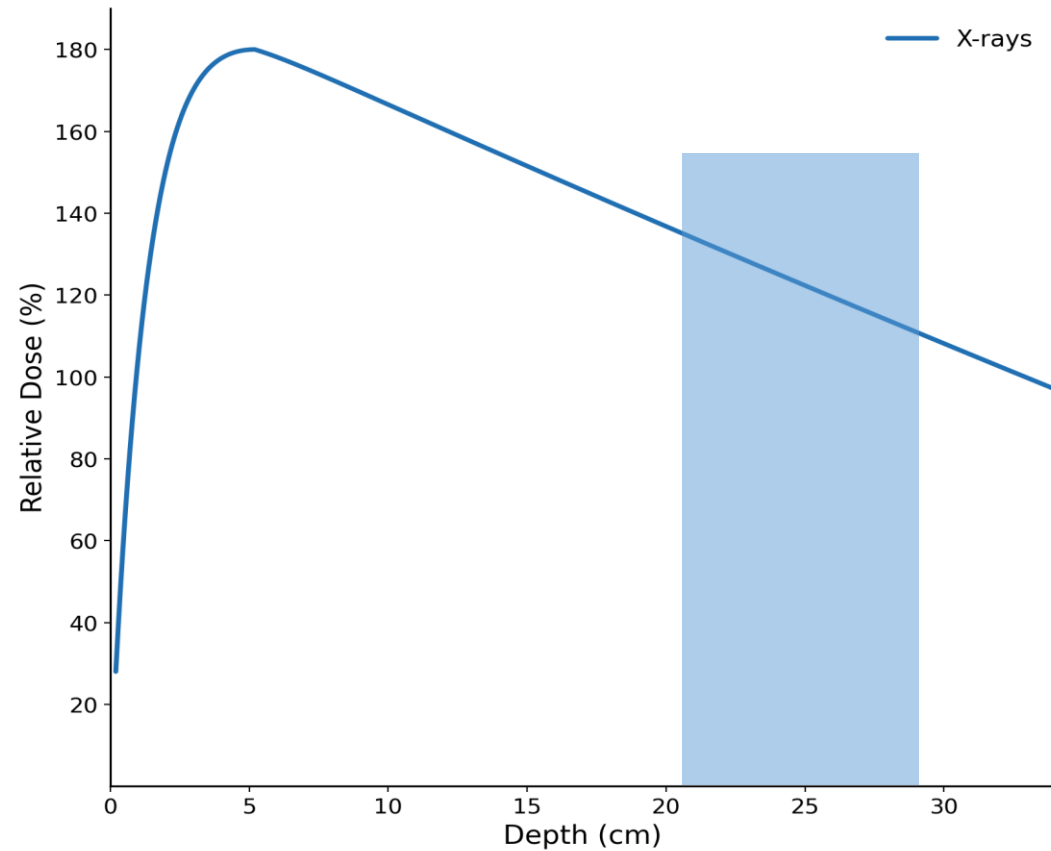
CLB 2025

99% photon therapy
VMAT/IMRT

Intro to radiotherapy



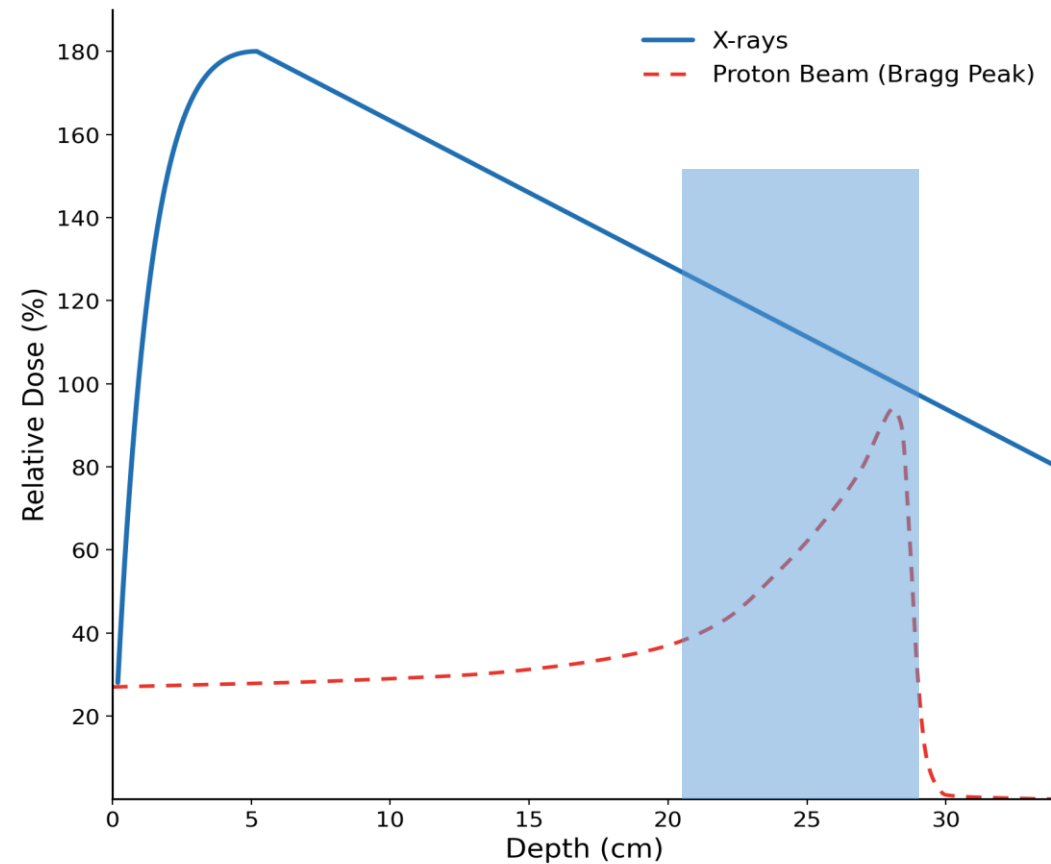
CLB 2025



99% photon therapy
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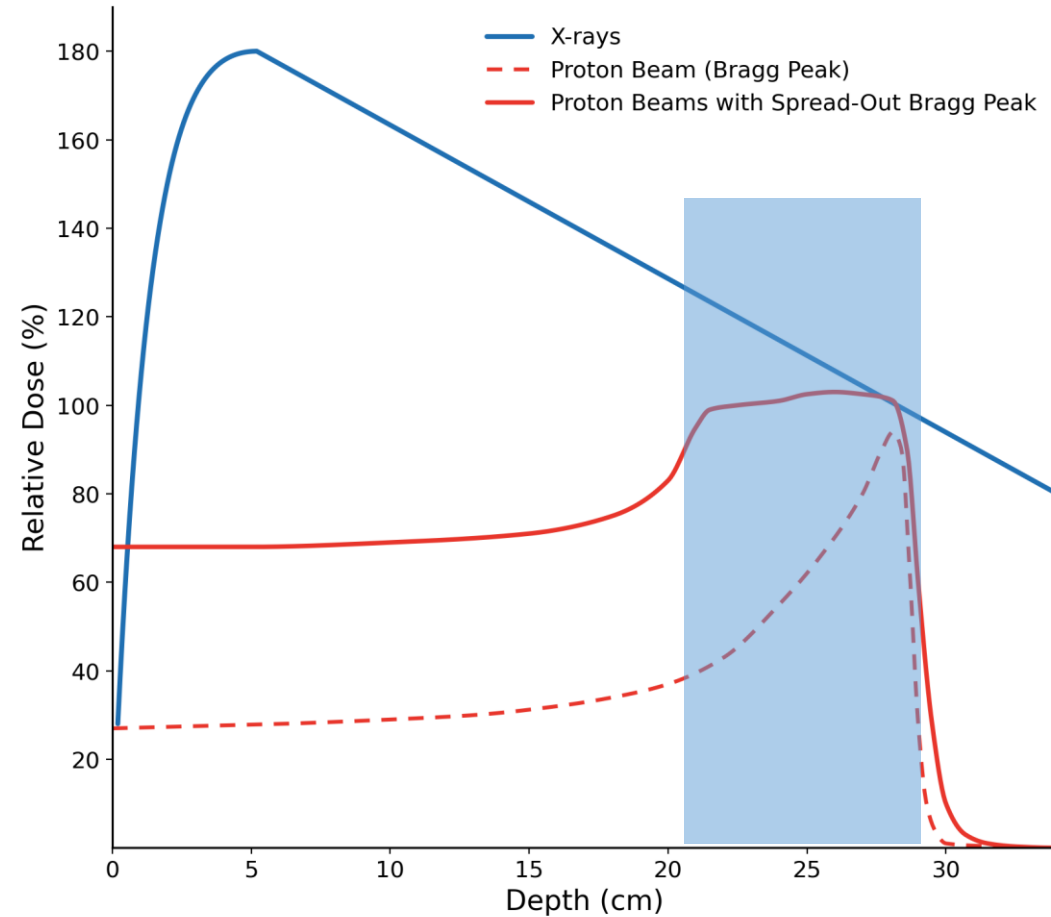
Adapted from Deycmar et al. 2019

Intro to radiotherapy



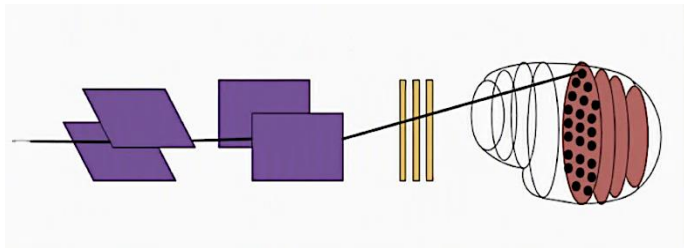
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Intro to radiotherapy

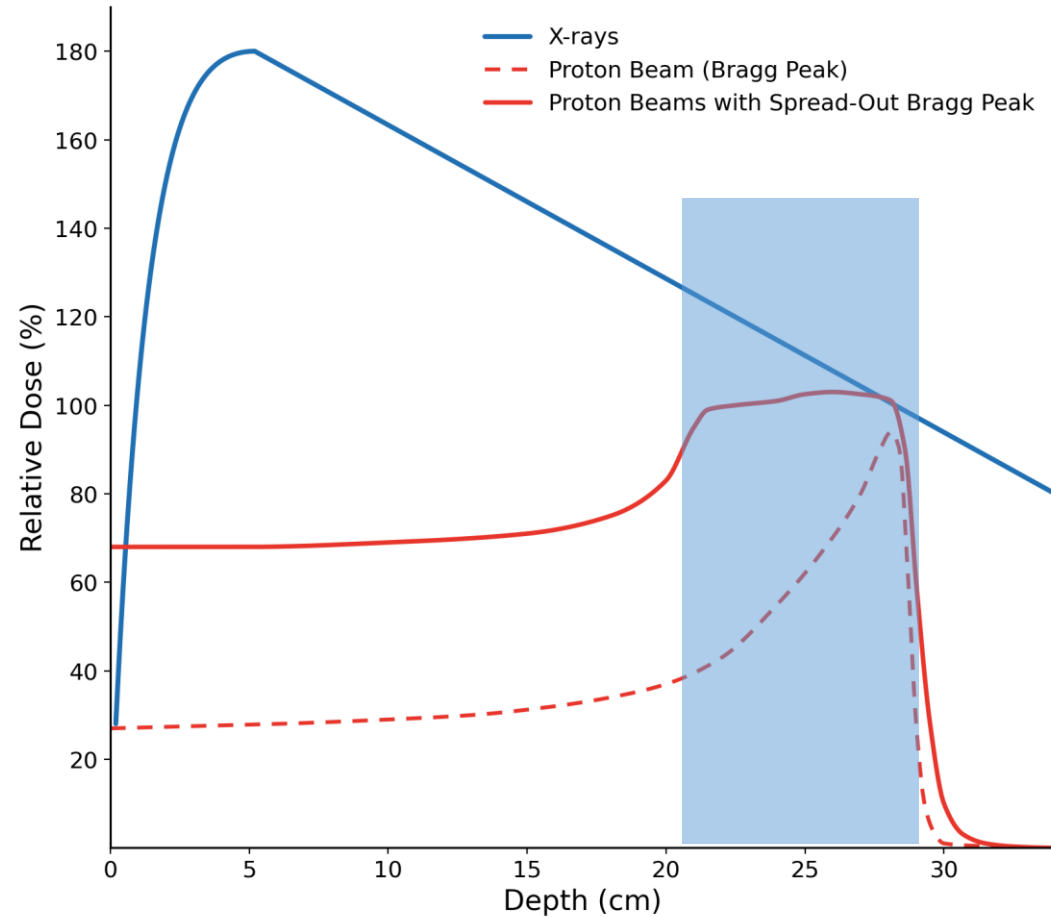


Adapted from Deycmar et al. 2019

Intro to radiotherapy

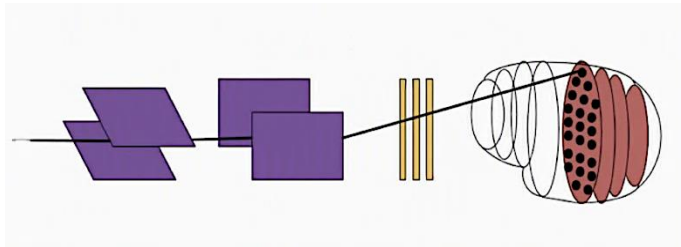


Adapted from Huang et al. 2024

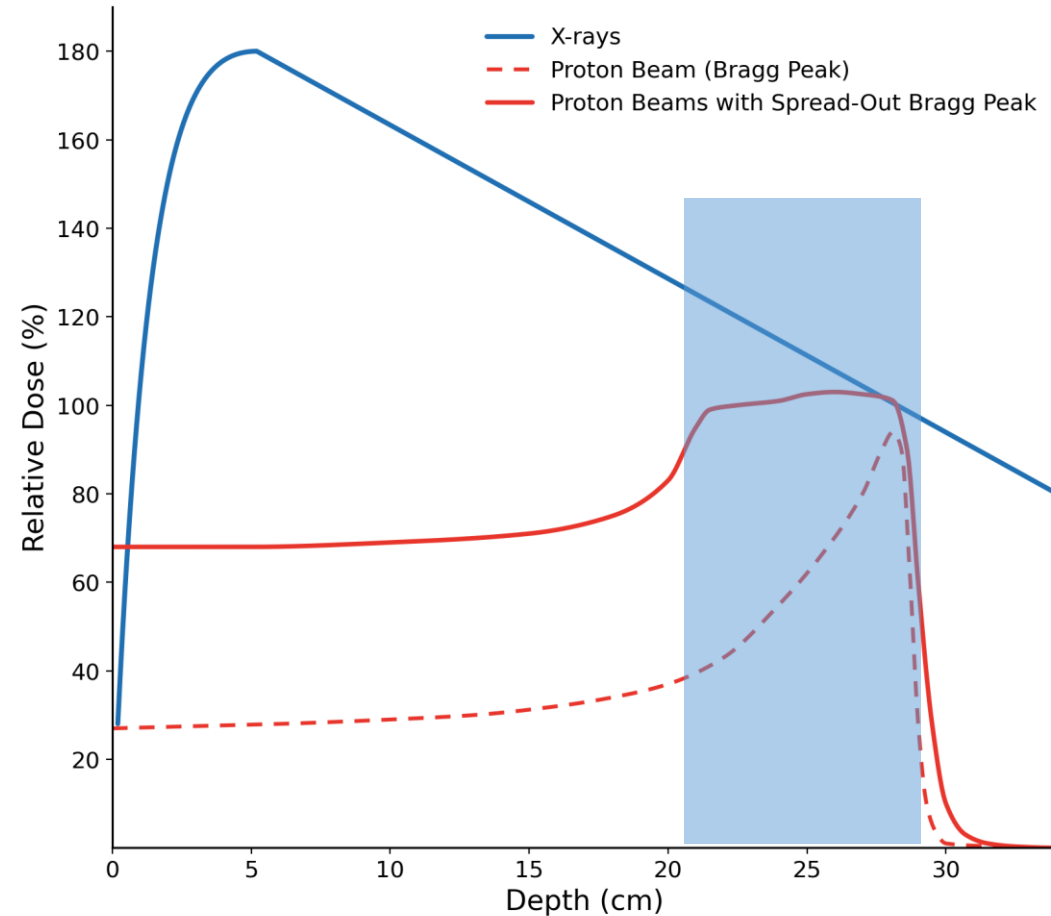


Adapted from Deycmar et al. 2019

Intro to radiotherapy



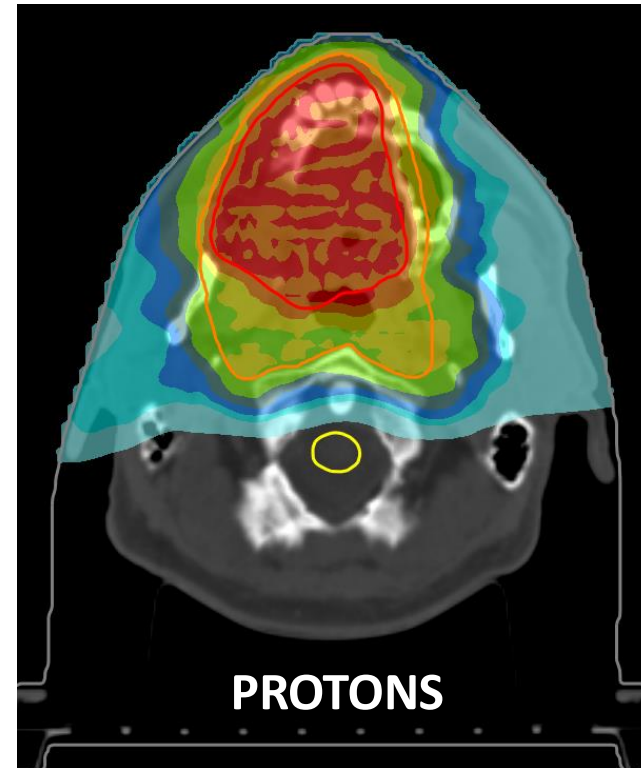
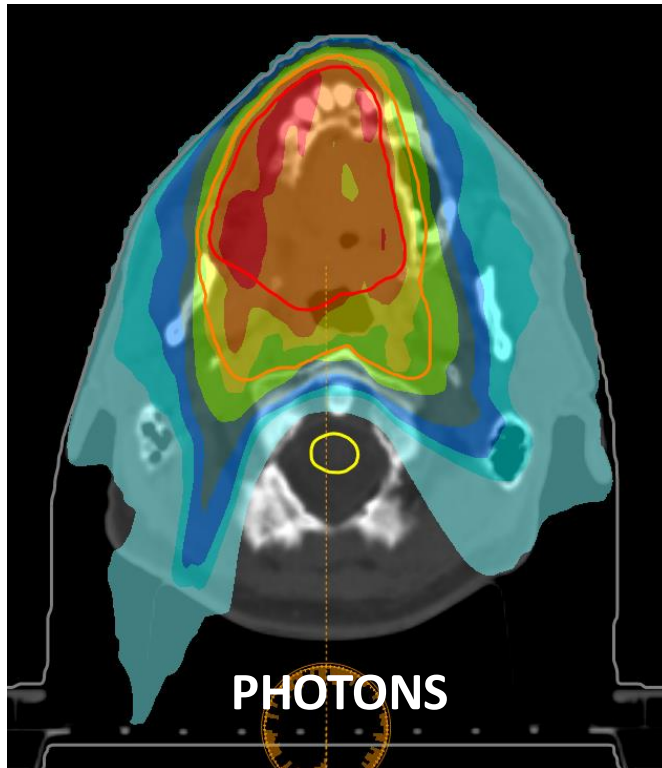
Adapted from Huang et al. 2024



Adapted from Deycmar et al. 2019

1% particle therapy
IMPT, PBS
LET, RBE

Intro to radiotherapy



**How can we make cancer treatment more precise
and more accessible?**

**How can we make cancer treatment more precise
and more accessible?**

PARTICLE THERAPY

Particle therapy – why or why not?

PHOTONS

PARTICLES

Particle therapy – why or why not?

PHOTONS



CLB 2025

PARTICLES

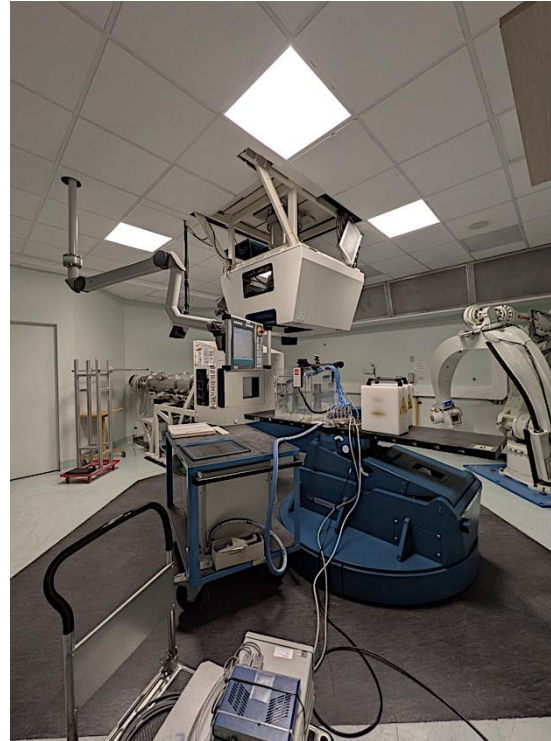
Particle therapy – why or why not?

PHOTONS



CLB 2025

PARTICLES



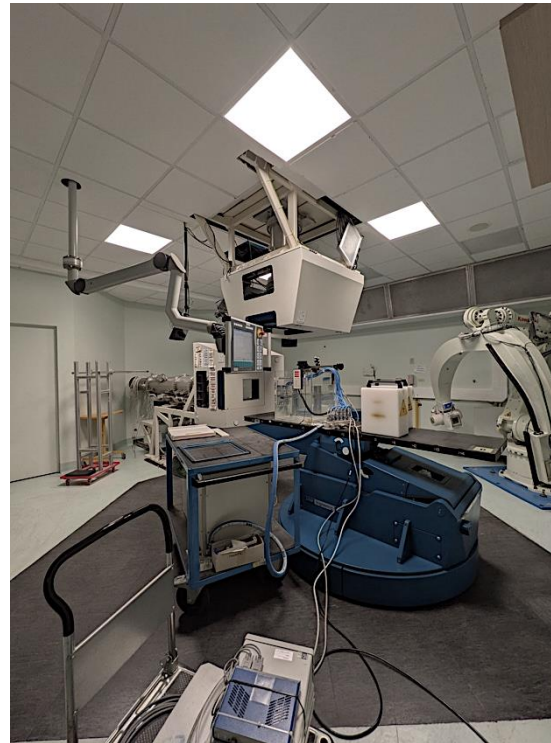
CNAO 2025

Particle therapy – why or why not?

PHOTONS



CLB 2025



CNAO 2025

PARTICLES

Madrid 2026

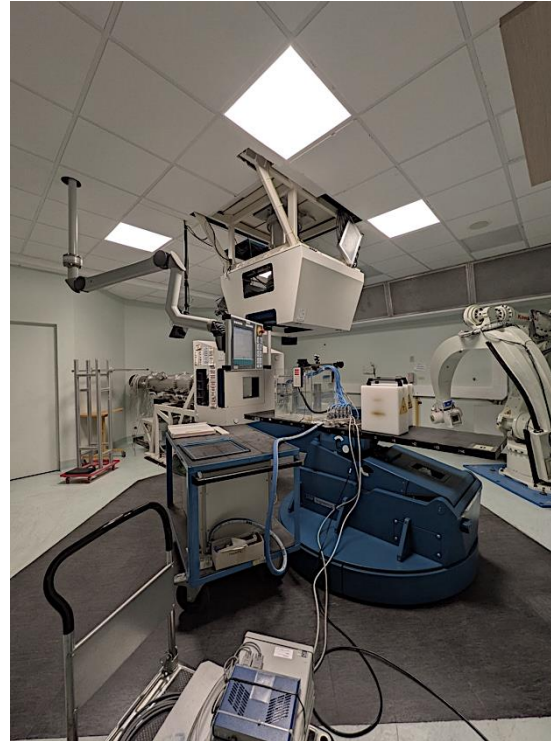


Particle therapy – why or why not?

PHOTONS



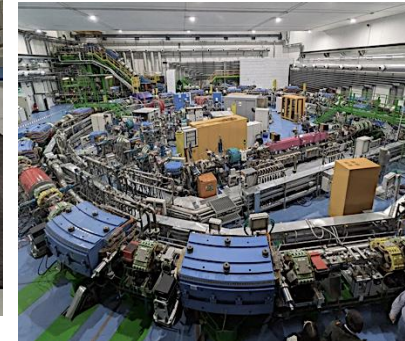
CLB 2025



CNAO 2025

PARTICLES

Madrid 2026



CNAO 2026

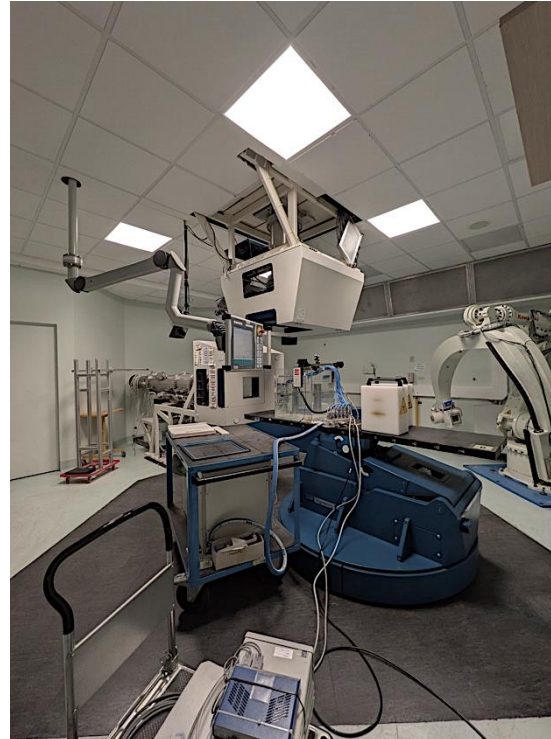
Particle therapy – why or why not?

PHOTONS

100-150 m²
<€5M



CLB 2025



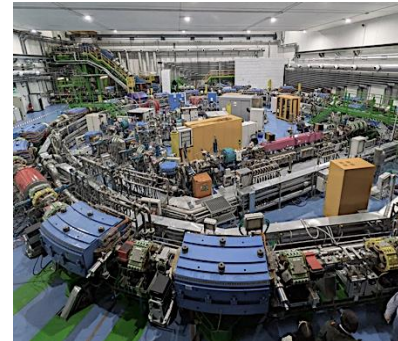
CNAO 2025

PARTICLES

Madrid 2026



200-500 m²
€20-40M



10000-
20000 m²
€100-150M

CNAO 2026

Particle therapy – landscape



130 facilities in clinical operation

17 carbon-ion facilities

PTCOG 2026

How can we make cancer treatment more precise
and more accessible?

PARTICLE THERAPY

?

Particle therapy – landscape



CNAO 2025

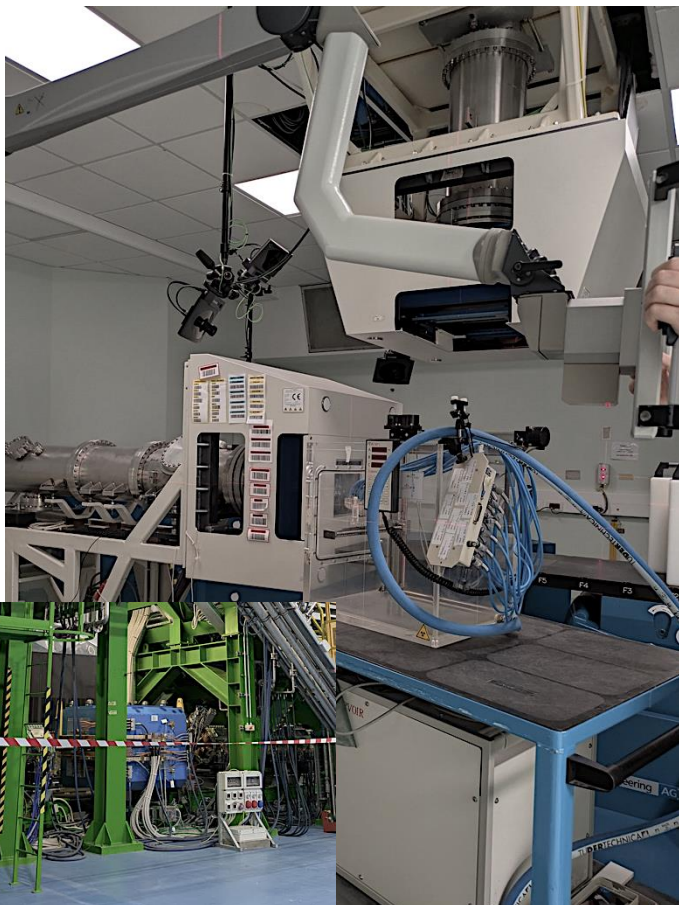
FIXED BEAMLINE



HIT 2024

GANTRY

Particle therapy – landscape



CNAO 2025

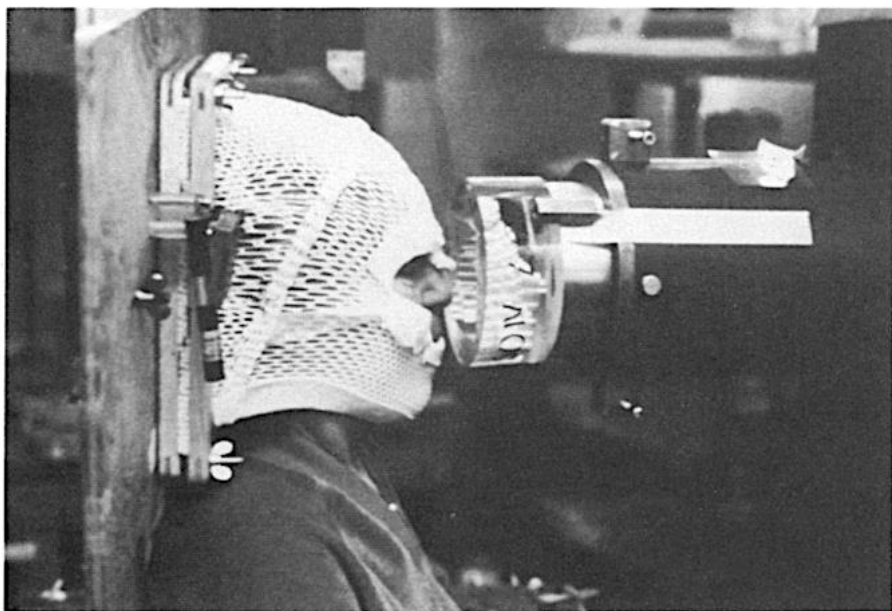
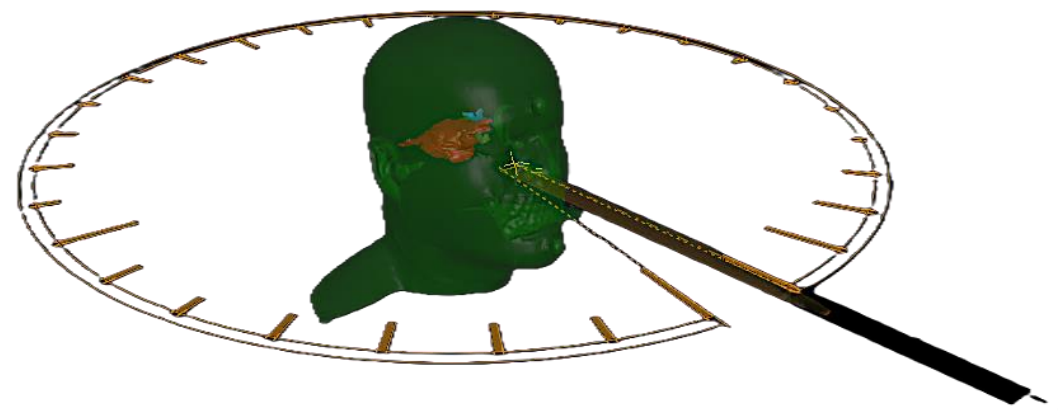
FIXED BEAMLINE



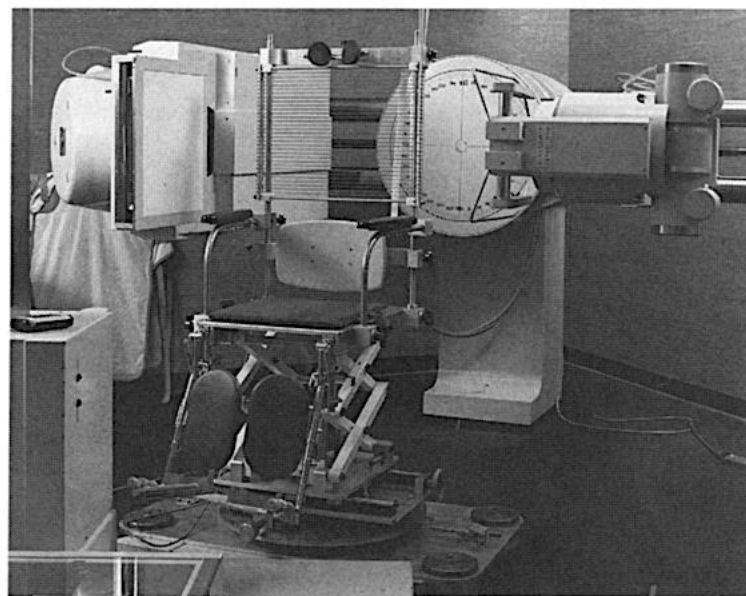
HIT 2024

GANTRY

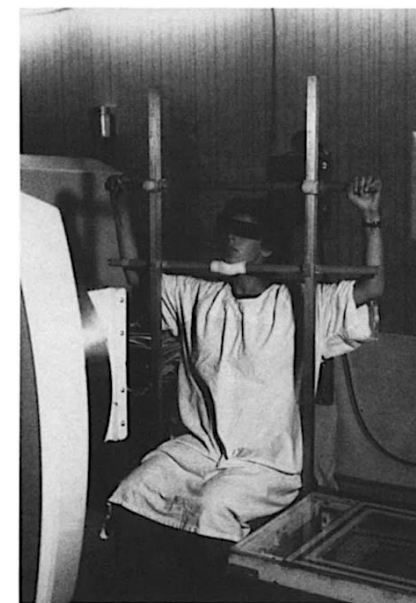
Upright radiotherapy - history



Verhey et al. 1982

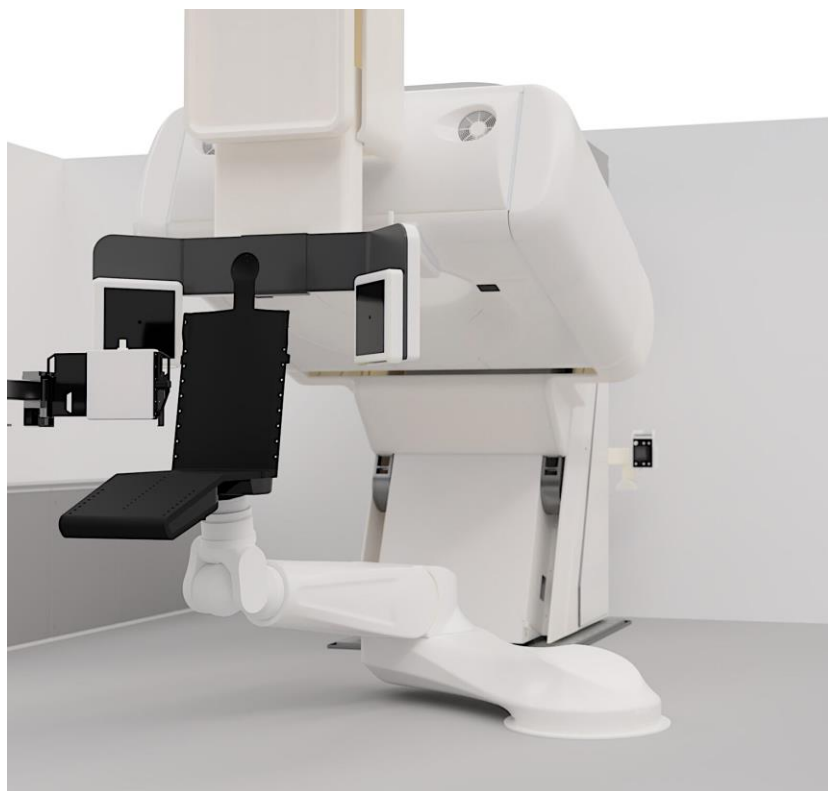


Miller et al. 1991



Marcus et al. 1992

Upright radiotherapy - current

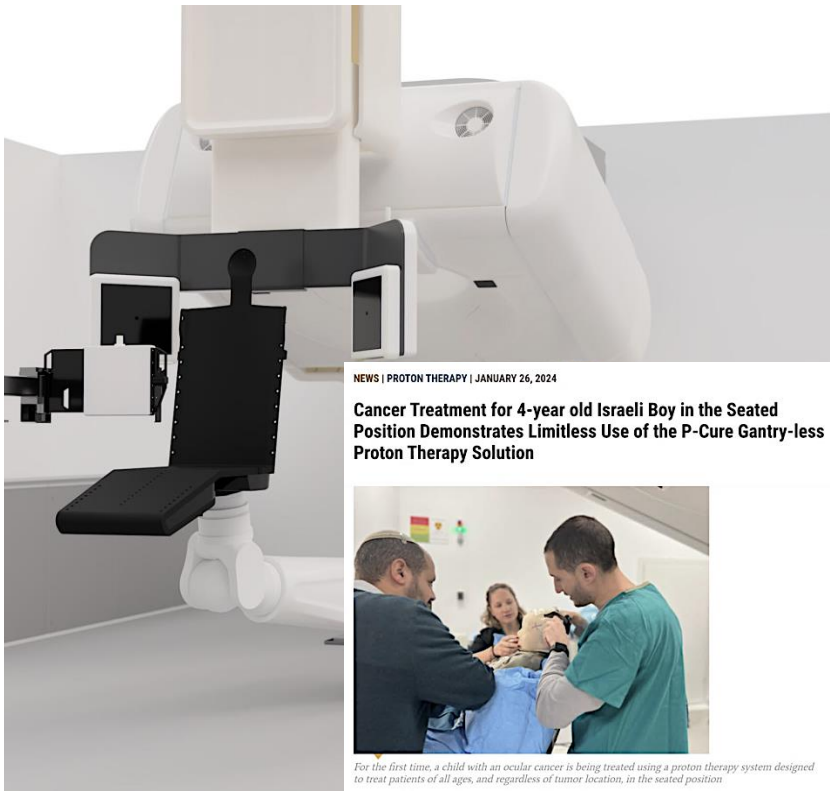


P-Cure



Leo Cancer Care

Upright radiotherapy - current



P-Cure



Leo Cancer Care

How can we make cancer treatment more precise
and more accessible?

PARTICLE THERAPY

UPRIGHT PARTICLE THERAPY!

How can we make cancer treatment more precise
and more accessible?

PARTICLE THERAPY

UPRIGHT PARTICLE THERAPY!

How do we bring it to the clinic?

Development of a clinical workflow

Development of a clinical workflow

Who do we treat?

*How is the treatment
planned?*

*How do we deliver it
safely and accurately?*

Development of a clinical workflow

Who do we treat?

Clinical indications and patient selection

How is the treatment planned?

Treatment planning strategies

How do we deliver it safely and accurately?

Range accuracy, immobilization techniques, quality assurance protocols, commissioning...

Development of a clinical workflow

Who do we treat?

Clinical indications and patient selection

How is the treatment planned?

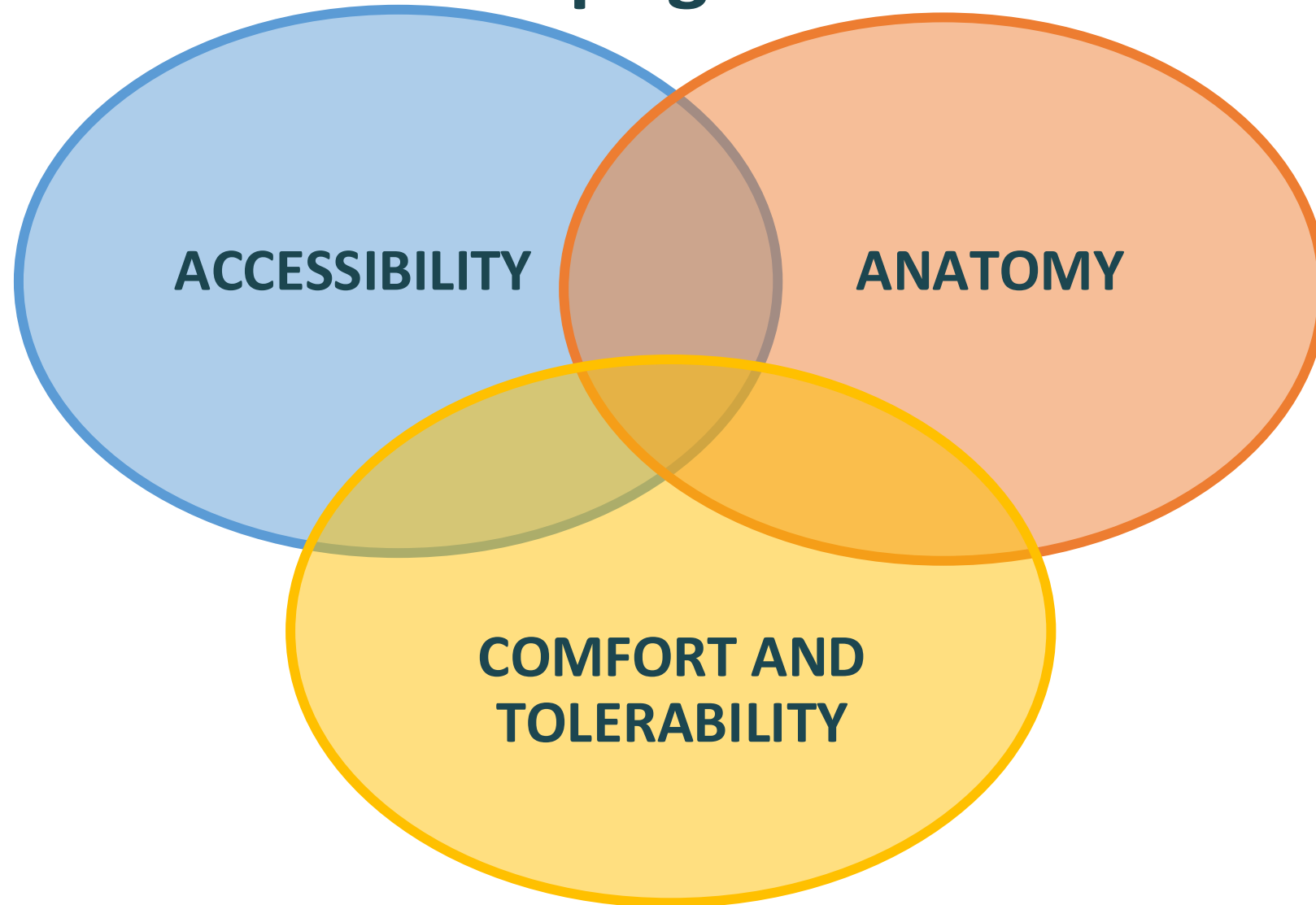
Treatment planning strategies

How do we deliver it safely and accurately?

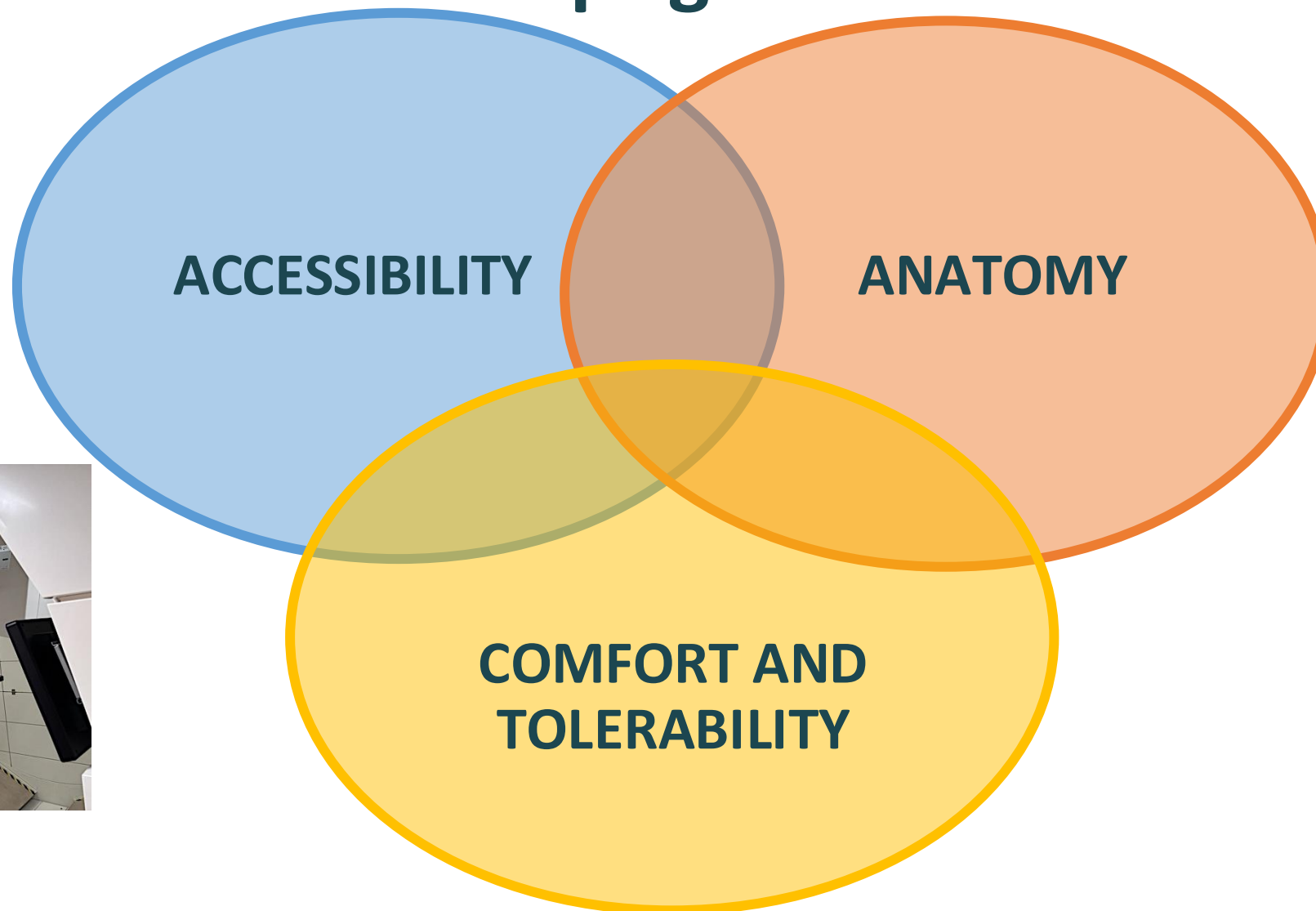
Range accuracy, immobilization techniques, quality assurance protocols, commissioning...

Who benefits the most from upright particle therapy?

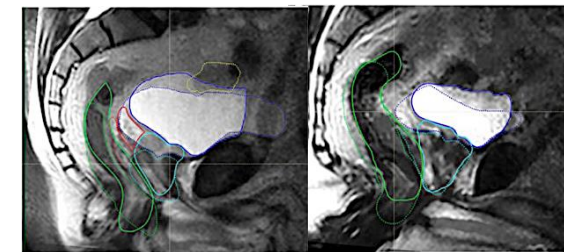
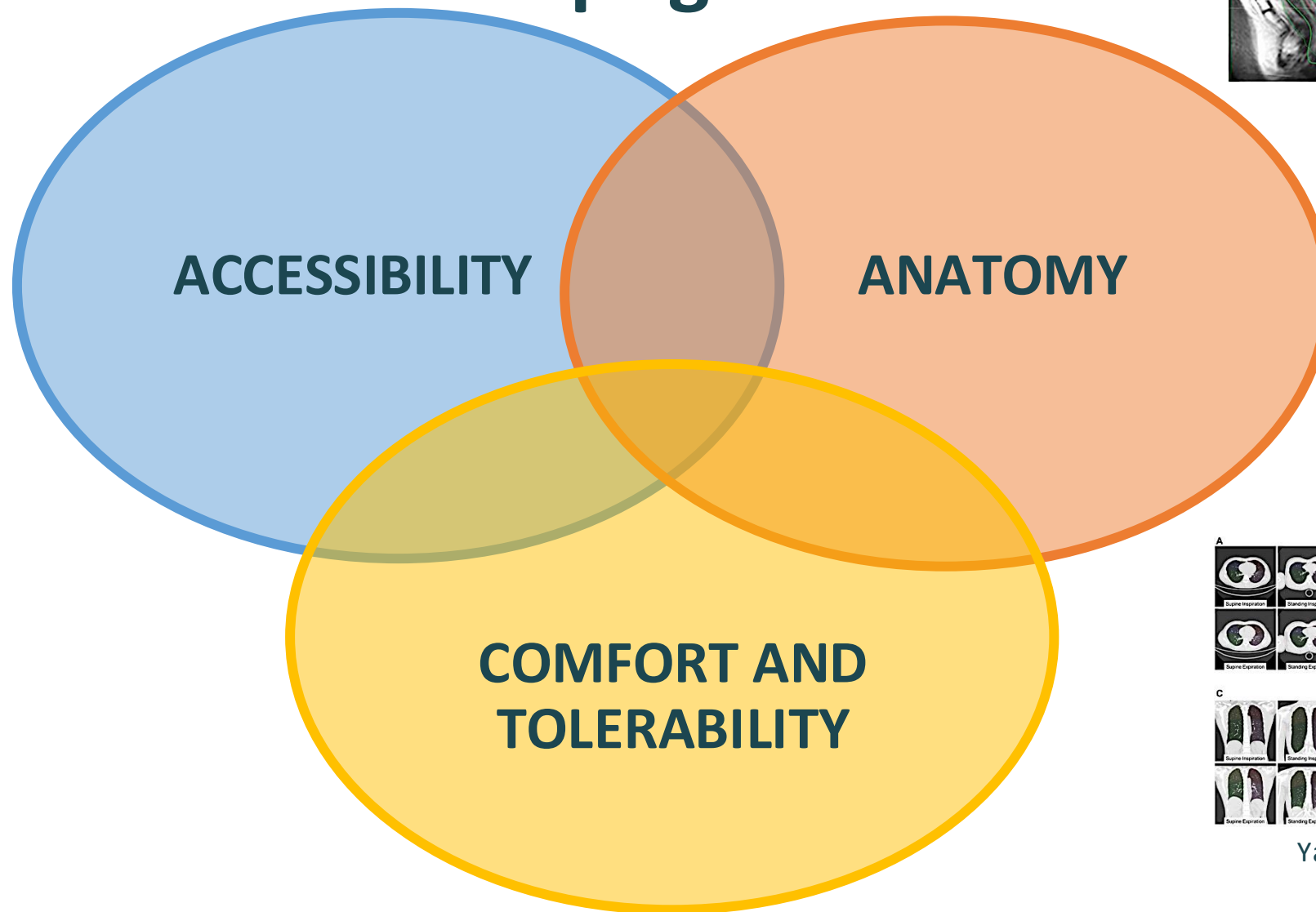
Clinical indications for upright PT



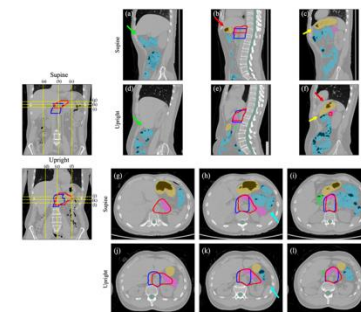
Clinical indications for upright PT



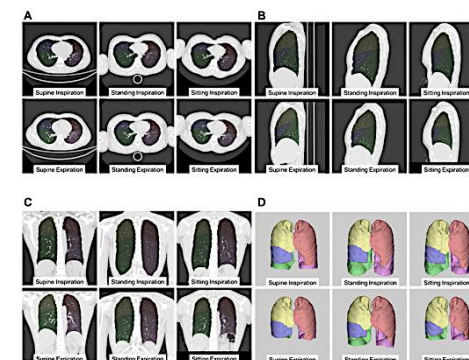
Clinical indications for upright PT



Schreuder et al. 2023

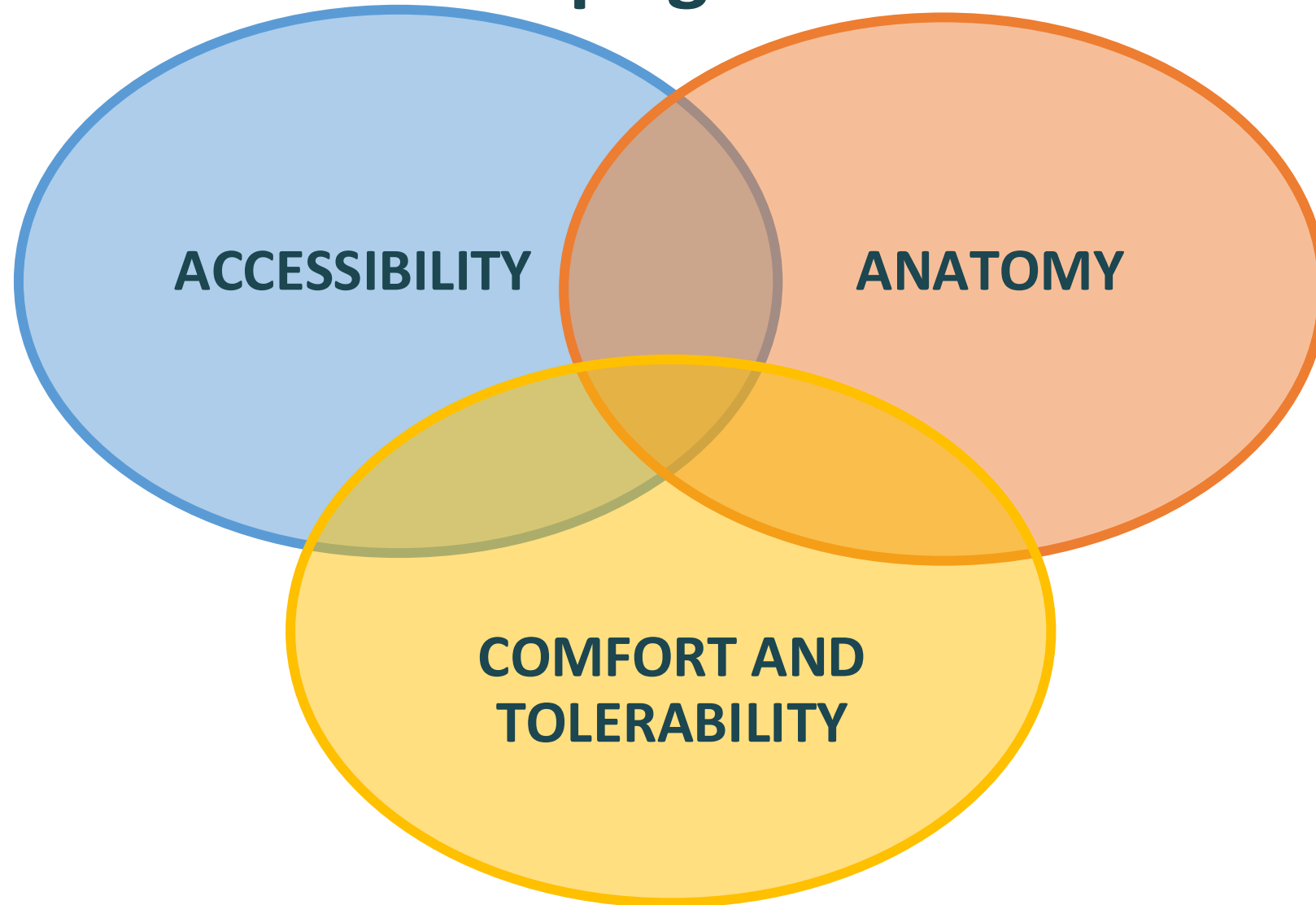


Nomura et al. 2026



Yamada et al. 2020

Clinical indications for upright PT



How do optimize the treatment plan?

Treatment planning – Bragg peak challenges

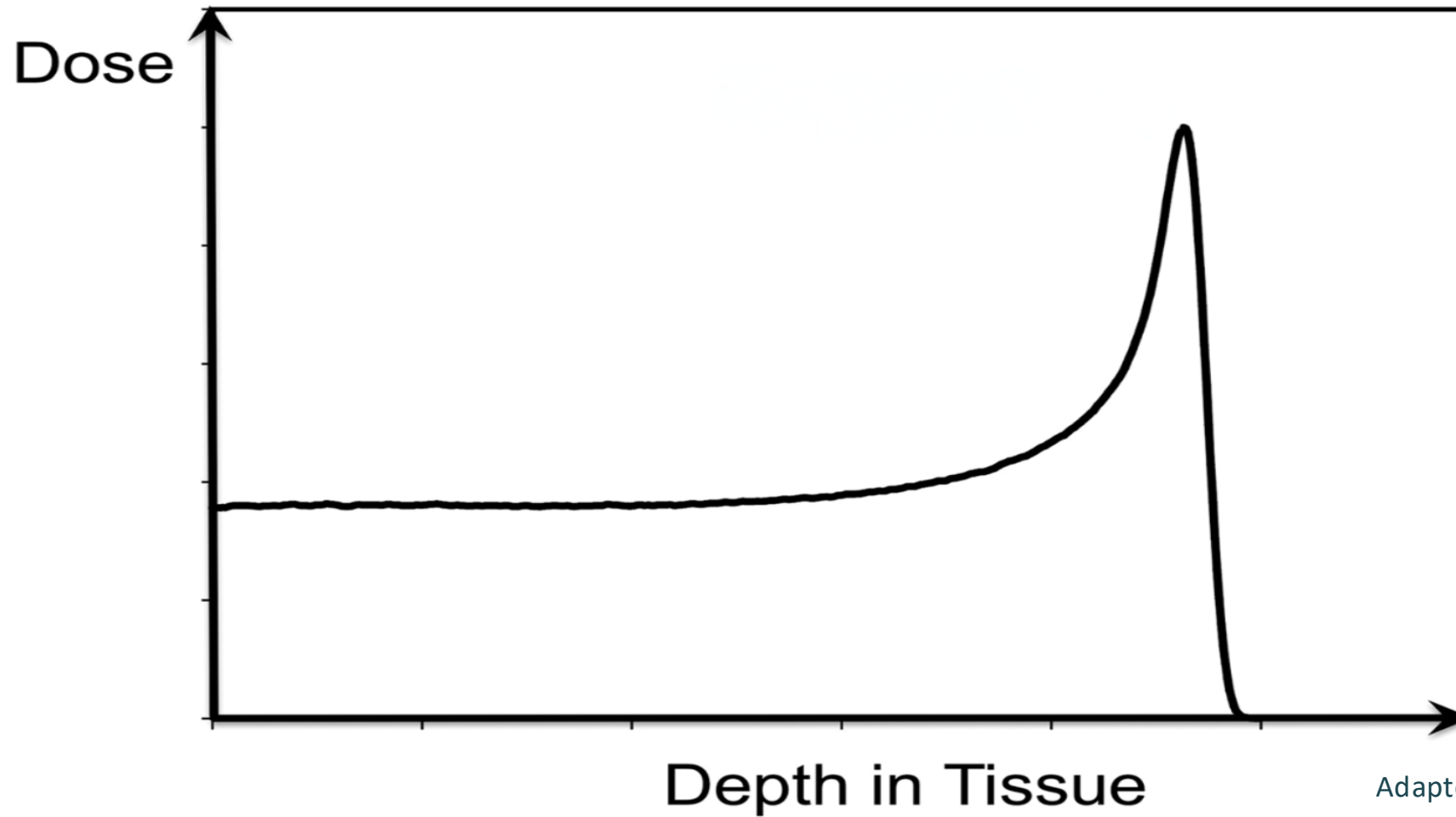
Lateral dose distribution in complex anatomies

Treatment delivery time (IMPT)

Robustness – anatomy changes and implants

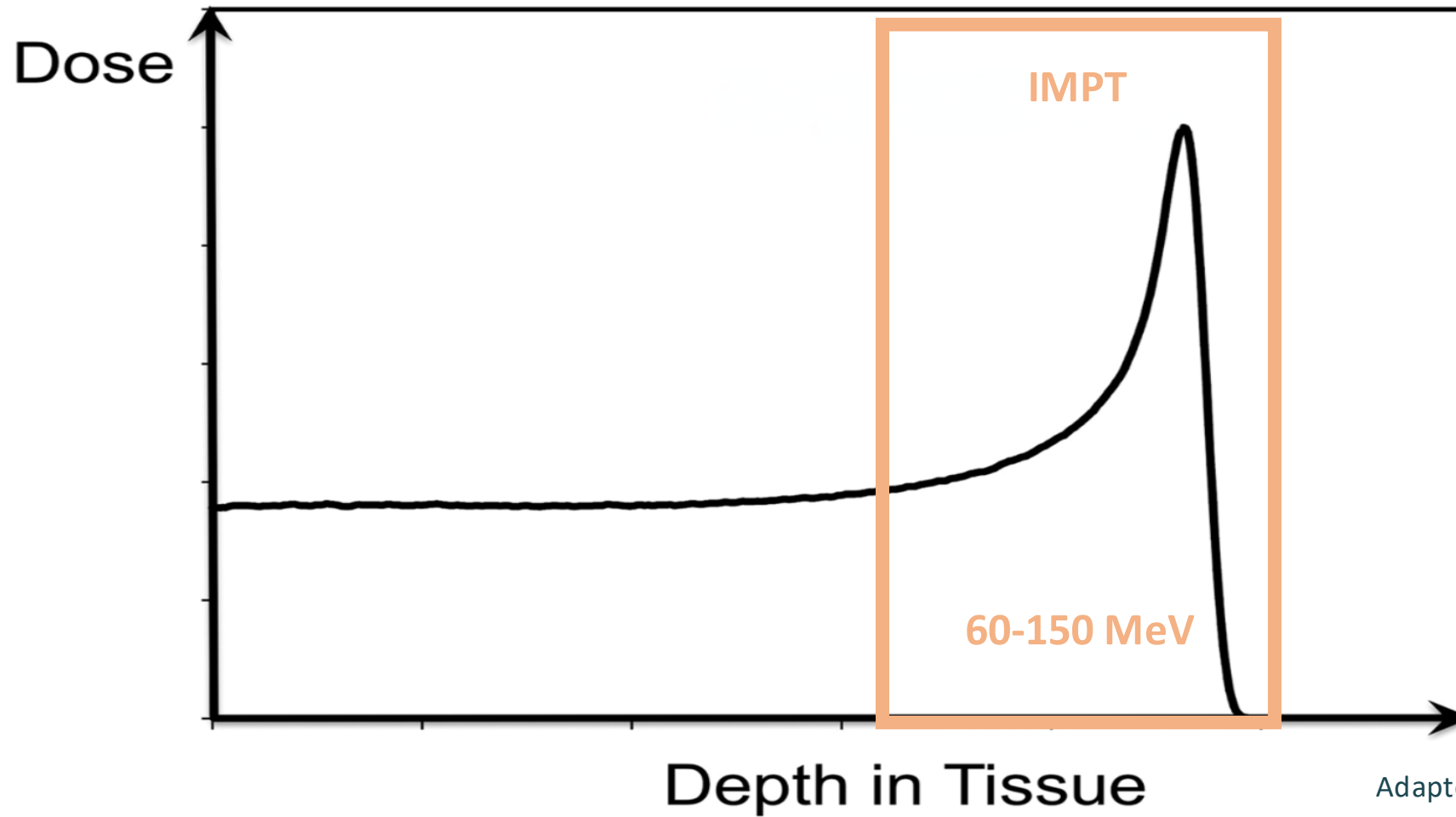
Limited imaging – intra/inter-fractional changes

The Bragg curve



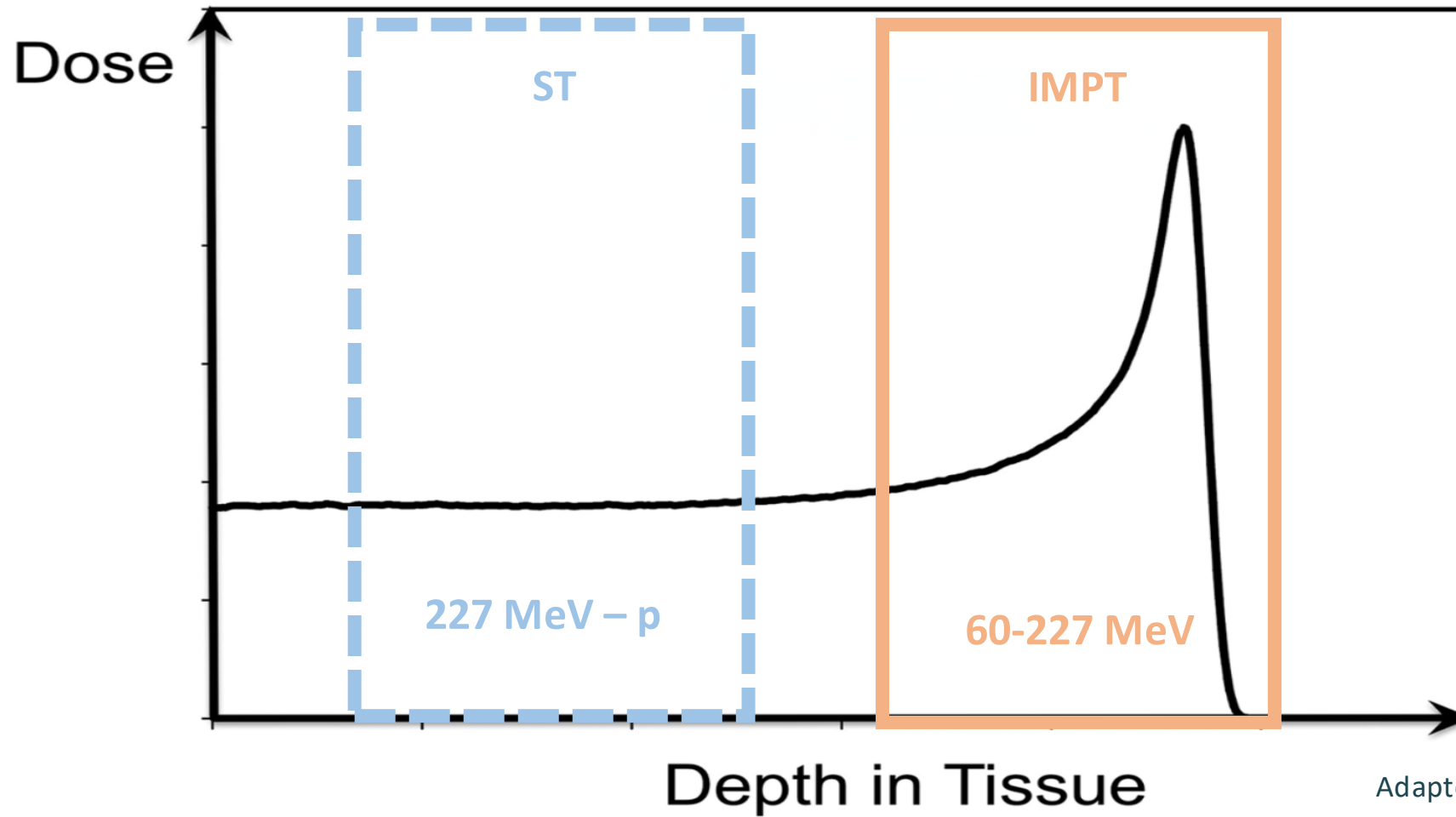
Adapted from Paganetti 2025

The Bragg curve



Adapted from Paganetti 2025

The Bragg curve



Adapted from Paganetti 2025

Treatment planning – Bragg peak challenges

Lateral dose distribution in complex anatomies

Treatment delivery time (IMPT)

Robustness – anatomy changes and implants

Limited imaging – intra/inter-fractional changes

Treatment planning – ST solutions

Lateral dose distribution in complex anatomies

Sharper lateral penumbra – higher energies

Kong et al. 2024

Robustness – anatomy changes and implants

Inherently more robust

Vai et al. 2025

Treatment delivery time (IMPT)

Only ST plans delivery time -67%

Vai et al. 2025

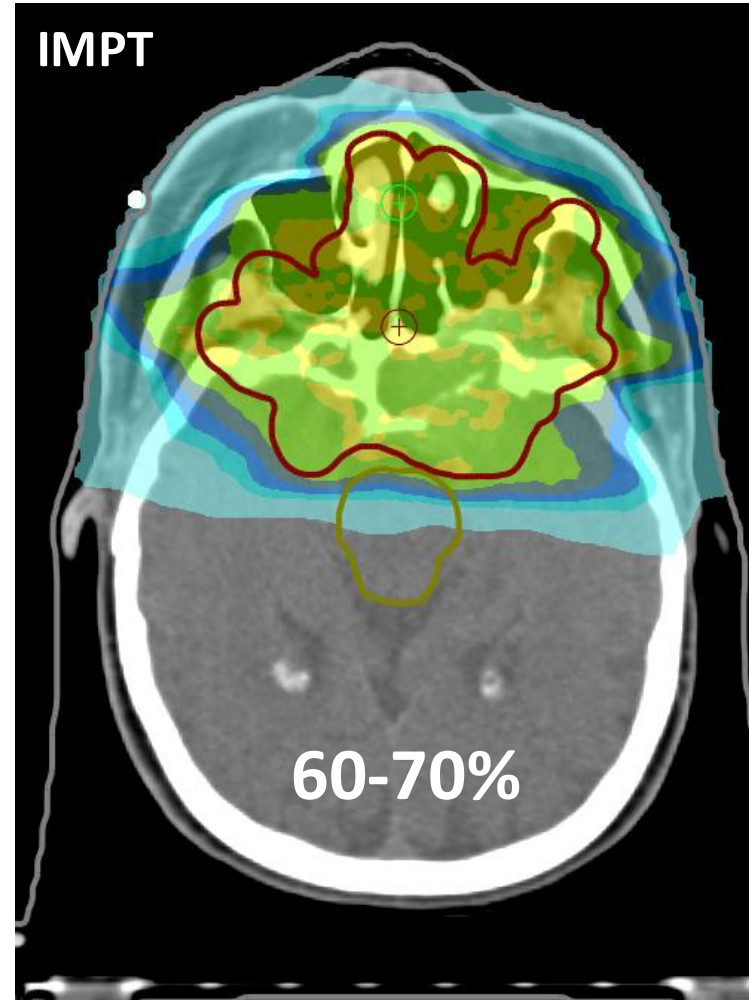
Limited imaging – intra/inter-fractional changes

Built-in per-fraction range monitoring

Meijers et al. and Seller Oria et al. 2021

Treatment planning strategies – the vision

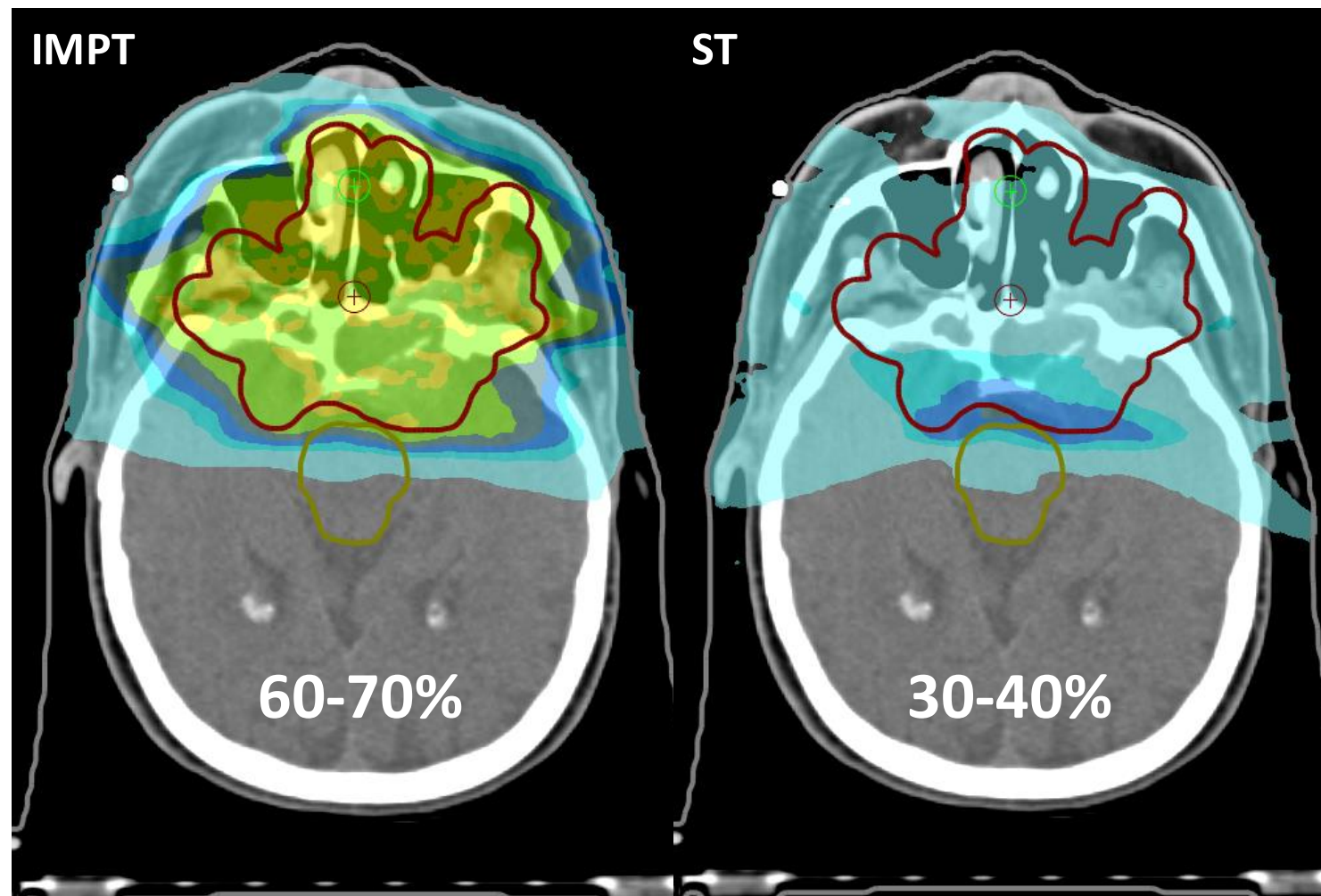
Standard IMPT particle fields for
high dose



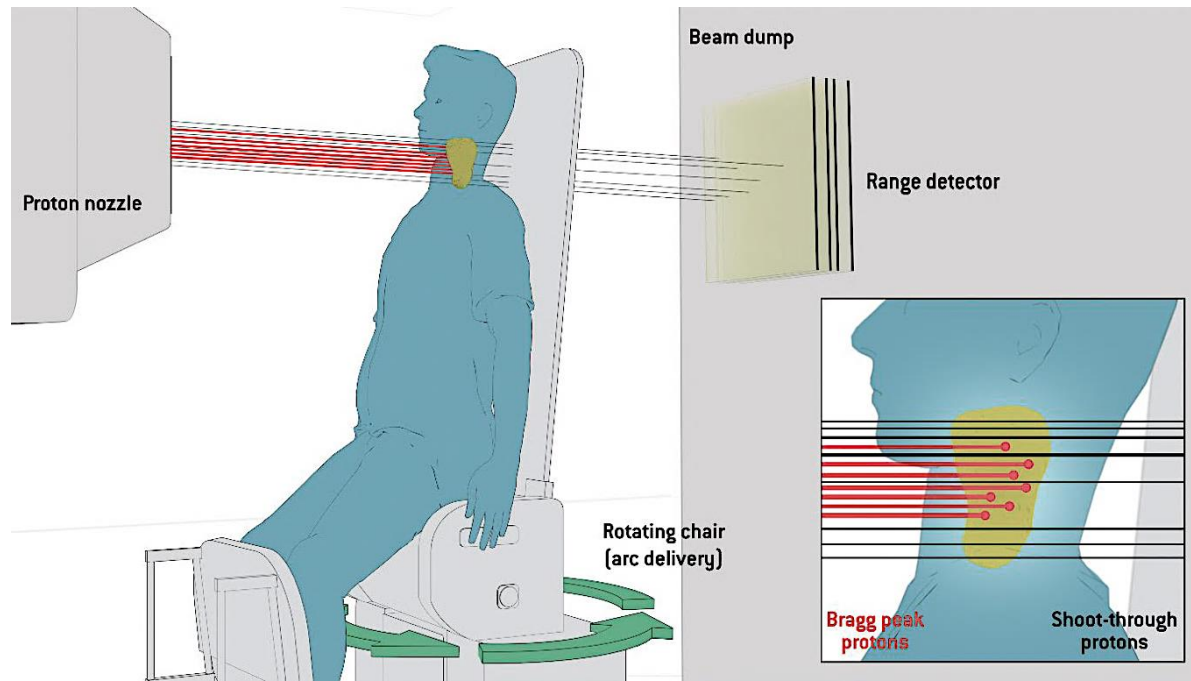
Treatment planning strategies – the vision

Standard IMPT particle fields for **high dose**

ST particle fields for **low dose**
and contribution to **conformity**
and **robustness**

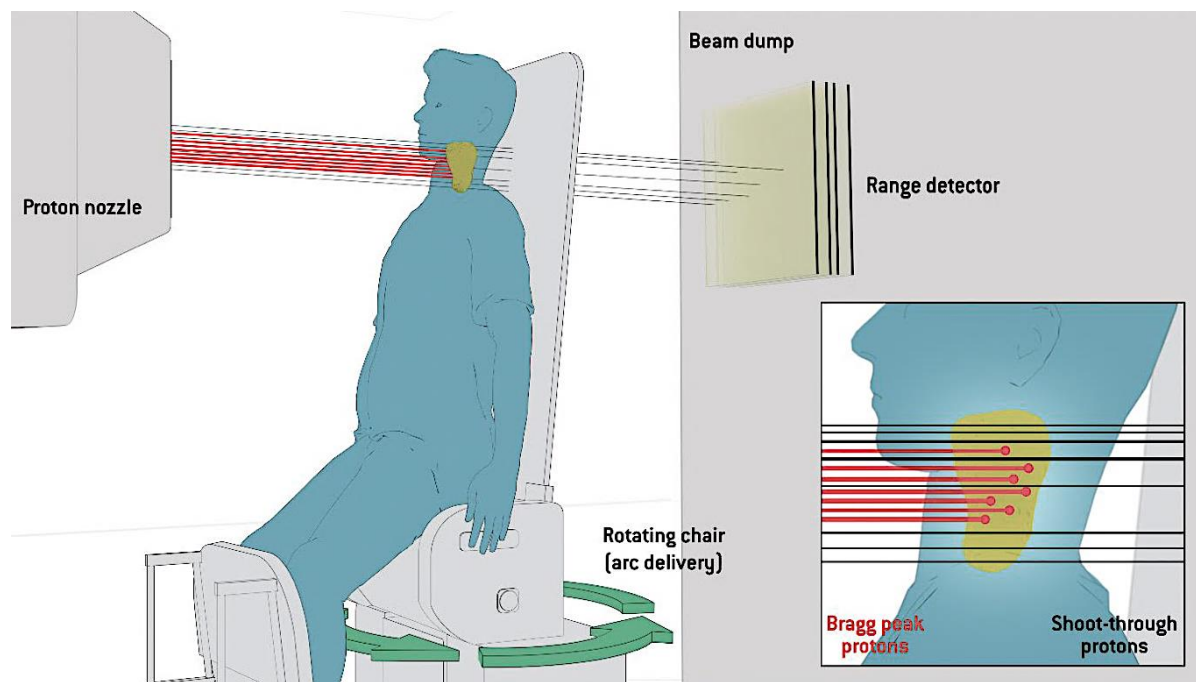


Tackling the imaging issue – ST bonus

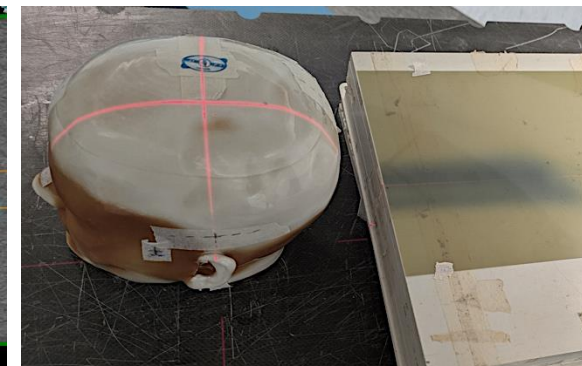
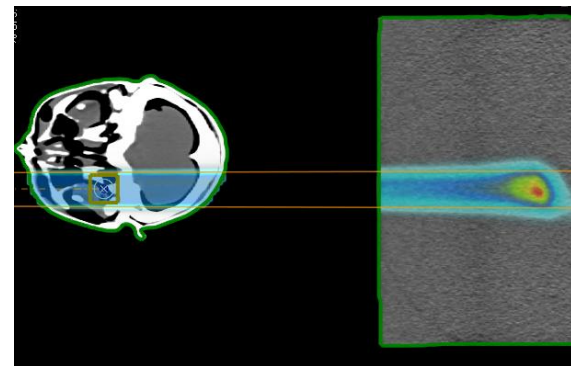


Engwall et al. 2025

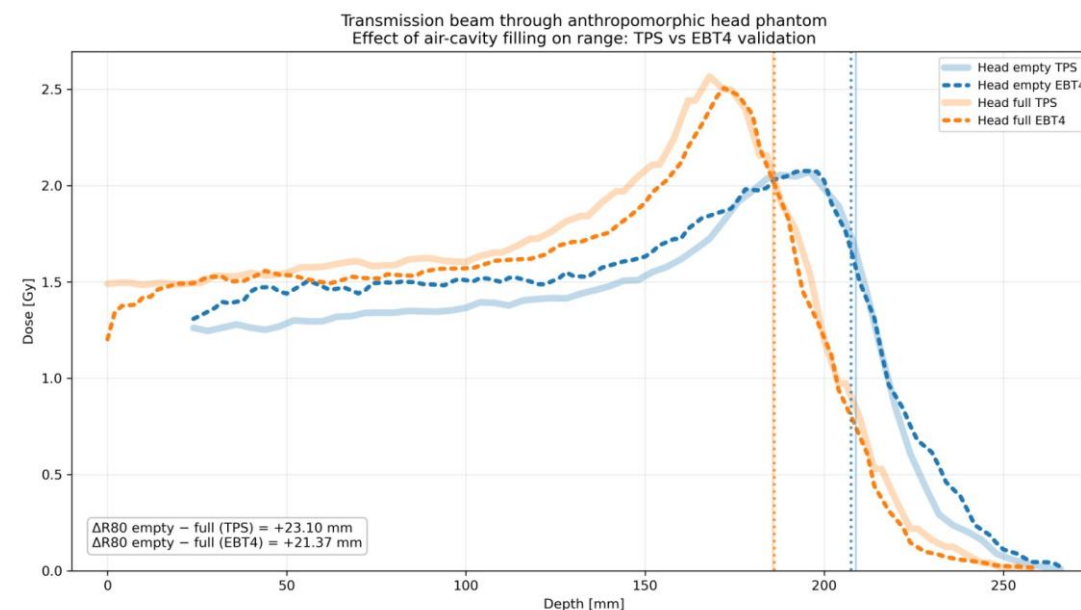
Tackling the imaging issue – ST bonus



Engwall et al. 2025



Preliminary work at CNAO



Conclusion & next steps

Upright particle therapy as a promising path toward
precision and accessibility

ST beams are a highly integrable tool for particle therapy

Next: continue current studies, commission chair at CNAO,
develop full workflow

¡GRACIAS!

Questions?

