JST CREST / Kobe University
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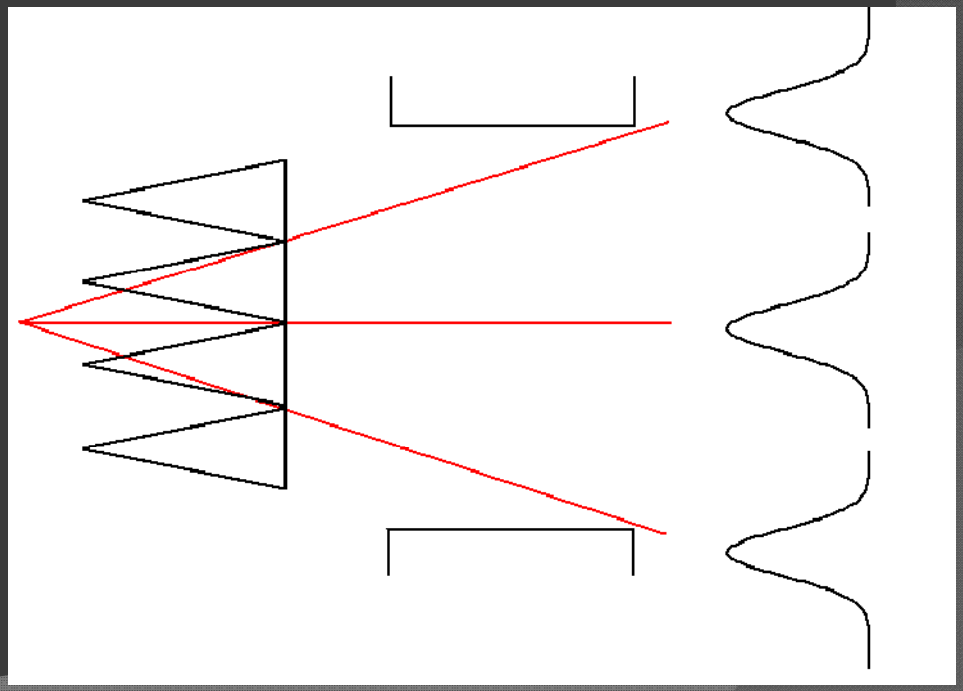
GEANT 4 SIMULATION OF HIBMC FACILITY USING DICOM

Outline

I. Proton simulation with DICOM
   1. Introduction
   2. Software framework
   3. Facility
   4. DICOM interface
   5. Plan
II. Carbon ion simulation
   1. Introduction
   2. Simulation
III. Summary

I Proton simulation
1. Introduction

- Pencil beam algorithm is widely used
  - Sum contributions from each pencil beam in vicinity
  - Does not take into account contributions from
    - Secondary particles
    - Particles scattered at collimator edge
- How accurate in inhomogeneous regions?



I Proton simulation
2. Software framework

- Development of Software framework for particle therapy based on Geant4 has started 2003
  - General purpose
    - This framework reduces effort to write source
    - Beam modules common to particle therapy systems are provided
      - Ridge filter, Wobbler magnet
      - The user only needs to give parameters
    - Once source is written, setup is changeable through UI of Geant4
      - Remove or add beam module
  - Including DICOM interface
    - Not yet for all facility

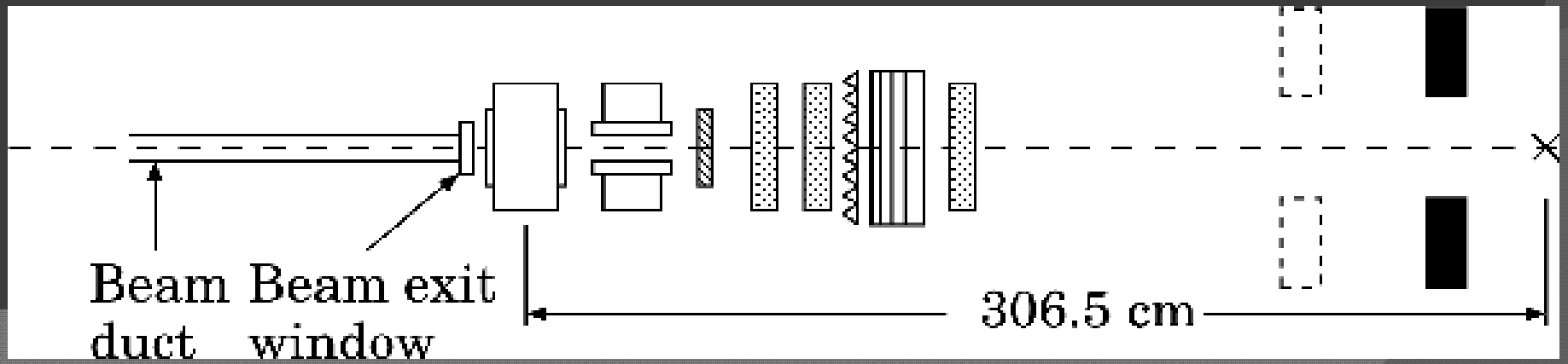
I Proton simulation
3. Facility(1)

- Hyogo Ion Beam Medical Center(HIBMC)
  - Synchrotron
    - protons up to 230 MeV
    - carbon ions up to 320 MeV u^{-1}
  - 6 Beam lines
    - 2 Gantries, only for proton
    - 4 fixed angle (2 horizontal, vertical and 45 degree)

      For proton & carbon

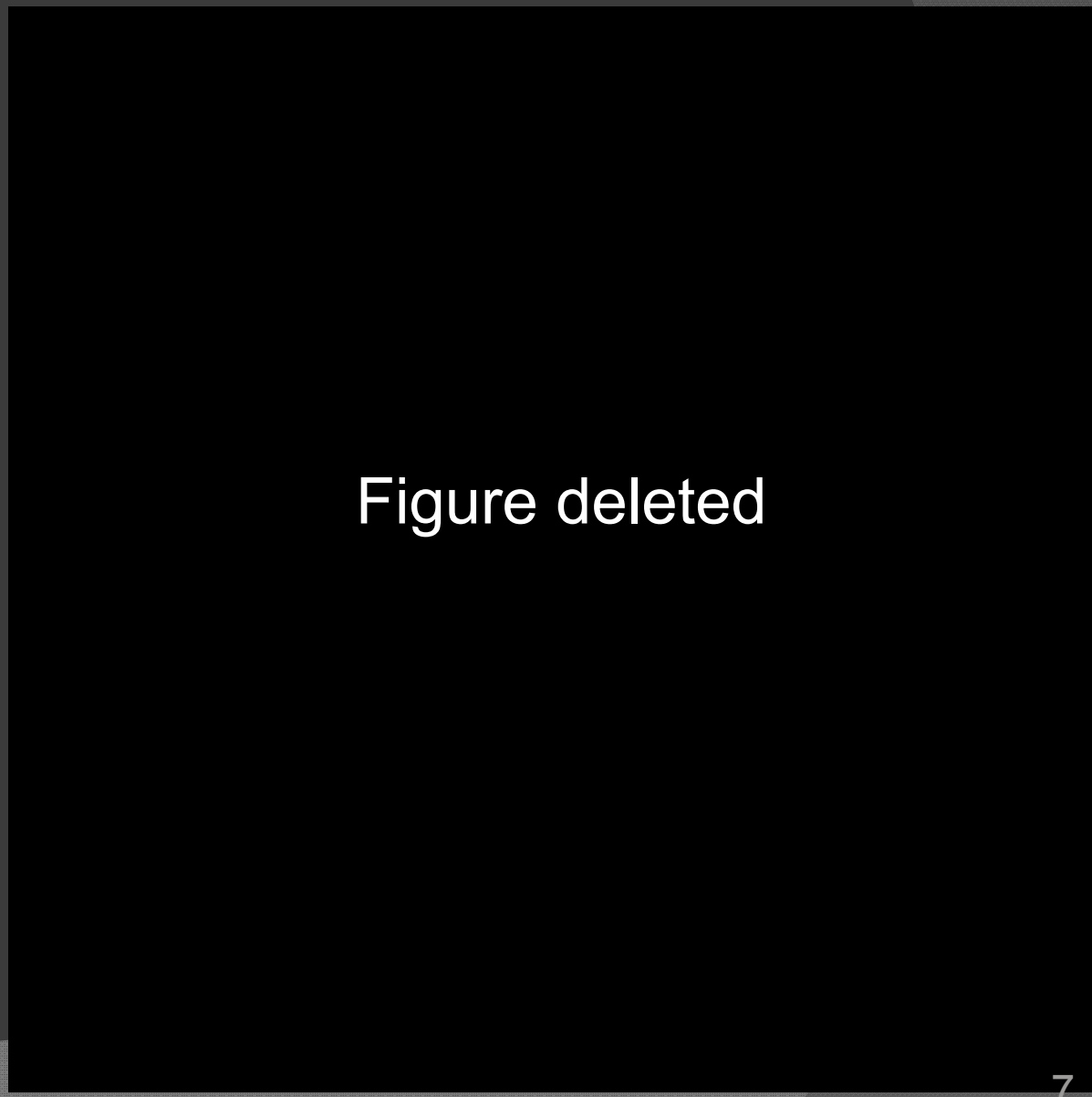
I Proton simulation
3. Facility(2)

- HIBMC
  - Wobbler magnets and scatterer
    - Lateral beam spreading
  - Ridge filter
    - As a range modurator
  - MLC and range compensator
    - Shape and modify the beam



I Proton simulation
4. DICOM inteface(1)

- Use CT images stored in DICOM
- DICOM-RTPlanX holds beam module setup
- Example
  - Head
    - 512 x 512 pixels, 199 slice
    - 0.625 x 0.625 x 1 mm



I Proton simulation
4. DICOM interface(2)

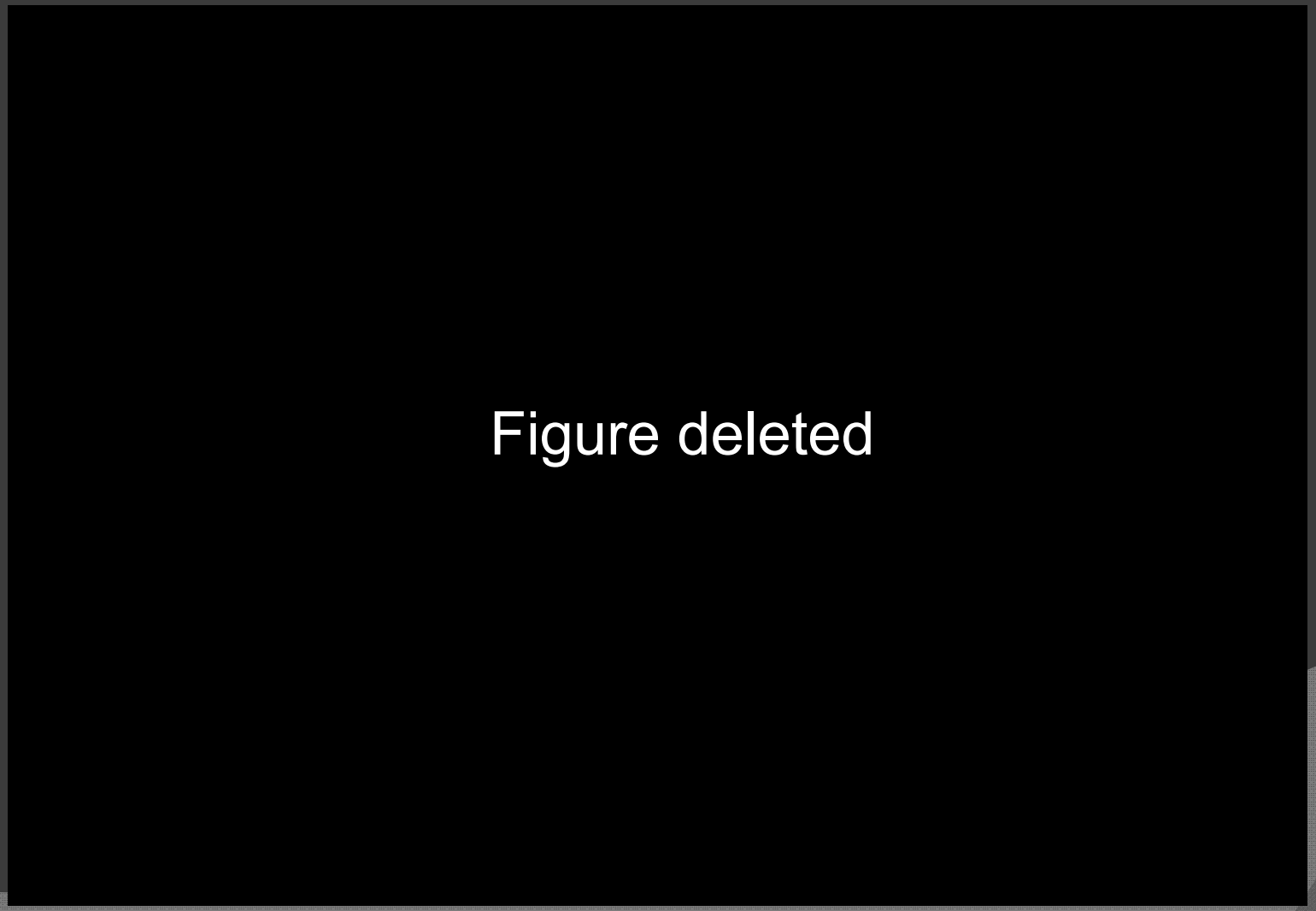
- CT images stored in DICOM are read through the interface
- Implemented as a set voxels filled by water with different density values
  - Remeshed

    160 x 160 x 97 voxels, 2 x 2 x 2 mm each
  - CT-numbers are converted to density values, rounded off to 2 decimal places

    …, 0.99, 1.00, 1.01, …
- Beam module setup stored in DICOM-RTPlanX is also read through the interface
  - Beam energy, Range shifter, Ridge filter and etc.

gMocren

- Visualization of CT images and dose



I Proton simulation
4. DICOM interface(3)

- Confirm the interface
  - Position, module setup

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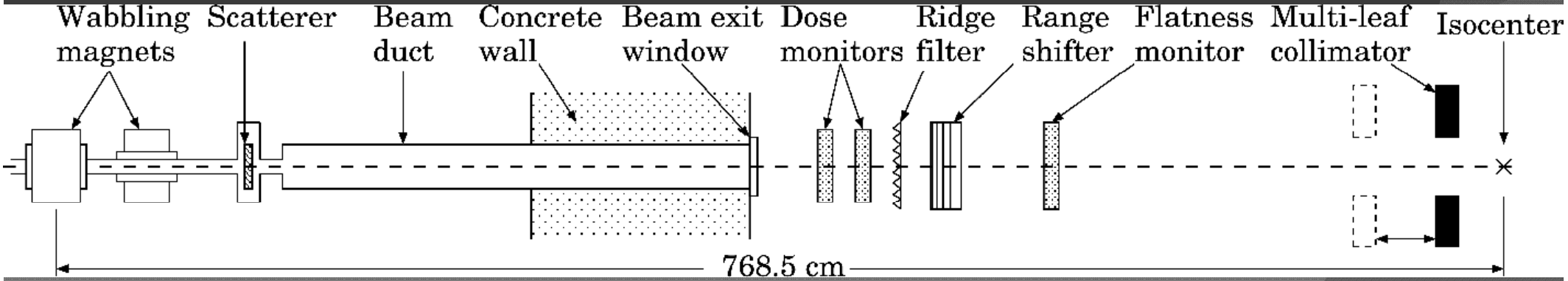
I Proton simulation
5. Plan

- Validation
  - Comparison between Geant4 and measurement in water phantom
- Tissue substitutes or water
- Comparison between Geant4 and pencil beam algorithm
  - Source of difference

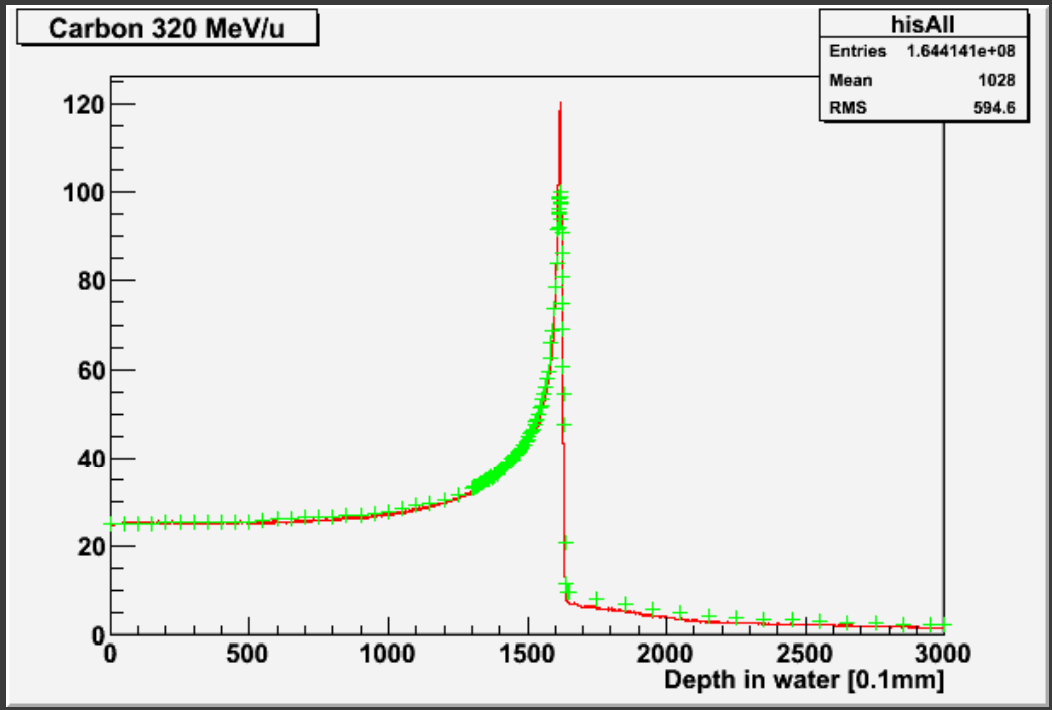
II Carbon ion simulation
1. Introduction

- High LET
  - Better local control
- Nuclear reaction plays more important role
  - projectile ion can fragment into lighter species
- More difficult than proton



II Carbon ion simulation
2. Simulation

- Comparison between Geant4 and measured dose-depth curve



Red histogram
Geant4
Green cross
Measured dose

- Detail study is under way

Summary

- Software framework for particle therapy is almost ready to use
- DICOM interface (for HIBMC) was confirmed to be working properly
- Started comparison between Geant4, pencil beam algorithm and measured depth-dose curve in water phantom
- Detail study of carbon ion simulation is under way

Thank you for your attention!