

# Particle Therapy Patient Scheduling: First Heuristic Approaches

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## 1 Test Instances

We created artificial benchmark instances related to the expected situation at MedAustron and real particle treatments. The main characteristic of an instance is its number of therapies  $n_T$ . We consider 5 instances for 10, 20, 50, 70, 100, 150, 200, and 300 therapies. In the used naming schema we encode first the number of therapies followed by a consecutive number.

## 2 Input Format

The instances are encoded in JSON. Note that the instance format described below allows to state instances for a more general problem, hence it contains elements that are not relevant for the Particle Therapy Patient Scheduling Problem (PTPSP). An instance is represented by the following JSON-object:

- **GENERAL**: object, contains globally relevant problem information

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- **H-unit**: not relevant for PTPSP
- **beam-resource-id**: integer, id of the Beam resource
- **proton-resource-id**: not relevant for PTPSP
- **carbon-resource-id**: not relevant for PTPSP
- **IR-rooms**: array of integers, ids of the irradiation room resource, not relevant for PTPSP
- **working-days**: array of arrays of objects, MedAustron working days partitioned into weeks sorted in increasing order of the day index
  - \* **d**: unique positive integer, index of day  $d \in D'$
  - \* **start**: integer, opening time  $\widetilde{W}_d^{\text{start}}$  in minutes
  - \* **end**: integer, closing time  $\widetilde{W}_d^{\text{end}}$  in minutes
- **RESOURCES**: array of objects, all resources and their availabilities
  - **id**: unique positive integer, resource id
  - **name**: string (optional), name for resource
  - **scatter**: not relevant for PTPSP
  - **W**: array of objects
    - \* **d**: unique integer, day  $d$
    - \* **start**: integer (optional, default:  $\widetilde{W}_d^{\text{start}}$ ), start time  $W_{r,d}^{\text{start}}$  in minutes
    - \* **end**: integer (optional, default:  $\widetilde{W}_d^{\text{end}}$ ), end time  $W_{r,d}^{\text{end}}$  in minutes
    - \* **unavailable**: array of objects (optional), unavailability periods
      - **start**: start time  $\overline{W}_{r,d,w}^{\text{start}}$  in minutes
      - **end**: end time  $\overline{W}_{r,d,w}^{\text{end}}$  in minutes
- **THERAPIES**: array of objects, all therapies with their data
  - **id**: unique positive integer, therapy id
  - **name**: string (optional), name of the therapy
  - **n-twmin**: integer (optional, default: 4), minimum number of treatments per week  $n_t^{\text{twmin}}$
  - **n-twmax**: integer (optional, default: 5), maximum number of treatments per week  $n_t^{\text{twmax}}$
  - **delta-min**: integer (optional, default: 1), min. number of days between two consecutive DTs  $\delta_t^{\text{min}}$

- **delta-max**: integer (optional, default: 5), max. number of days between two consecutive DTs  $\delta_t^{\max}$
- **daily-treatments**: array of objects, all DTs are given in the required order
  - \* **id**: unique positive integer, DT id
  - \* **name**: string (optional), name of DT
  - \* **d-min**: integer (optional, default: 1), earliest possible day  $d_{t,u}^{\min}$
  - \* **d-max**: integer (optional), latest possible day  $d_{t,u}^{\max}$ ; if not specified or -1 no bound is assumed (an implicit limit is given through the number of considered days)
  - \* **activities**: array of objects, all activities that must be scheduled in this order at a single day
    - **id**: unique positive integer, activity id
    - **name**: string (optional), name of activity
    - **p**: positive integer, processing time  $p_{t,u,a}$  in minutes
    - **resources**: array of integers (optional), id's of required resources
  - \* **min-lag**: array of objects (optional), minimum EtS time lag constraints
    - **a1**: integer, id of first activity  $a$
    - **a2**: integer, id of second activity  $a'$
    - **time**: integer, minimum EtS time lag  $L_{t,u,a,a'}^{\min}$  in minutes
  - \* **max-lag**: array of objects (optional), maximum EtS time lag constraints
    - **a1**: integer, id of first activity  $a$
    - **a2**: integer, id of second activity  $a'$
    - **time**: integer, maximum EtS time lag  $L_{t,u,a,a'}^{\max}$  in minutes