Experience with the RayOcular TPS

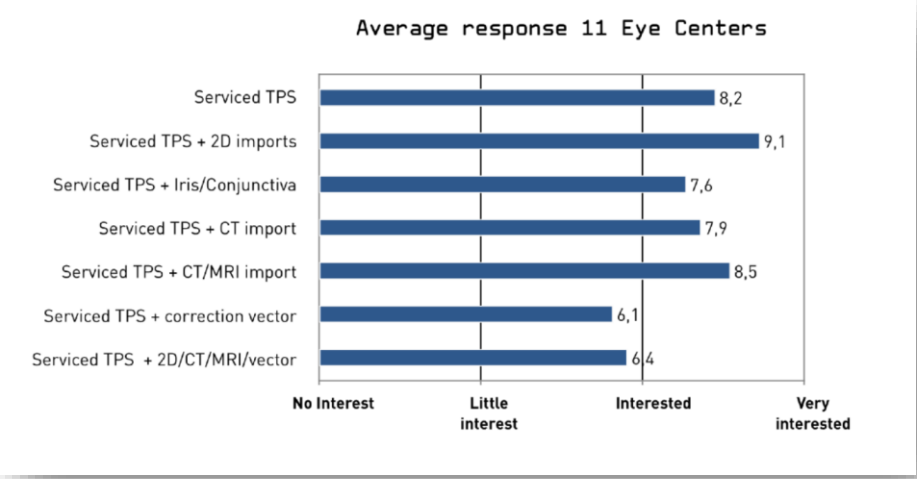
from initial requirements to treated patients at WPE

Jörg Wulff & Benjamin Koska

Cling together, swing together – WPE and RSL

- RaySearch/ WPE contract from 2009: "*The TPS must include the ability to plan eye treatments …*"

- What do we need? What do we want?
  - Ask someone who knows! *J. Heufelder & J. Verwey* *(ex PSI)*
  - survey on desired features to all proton centers treating ocular patients 2018
  - wishlist influenced by EYEPLAN & OCTOPUS

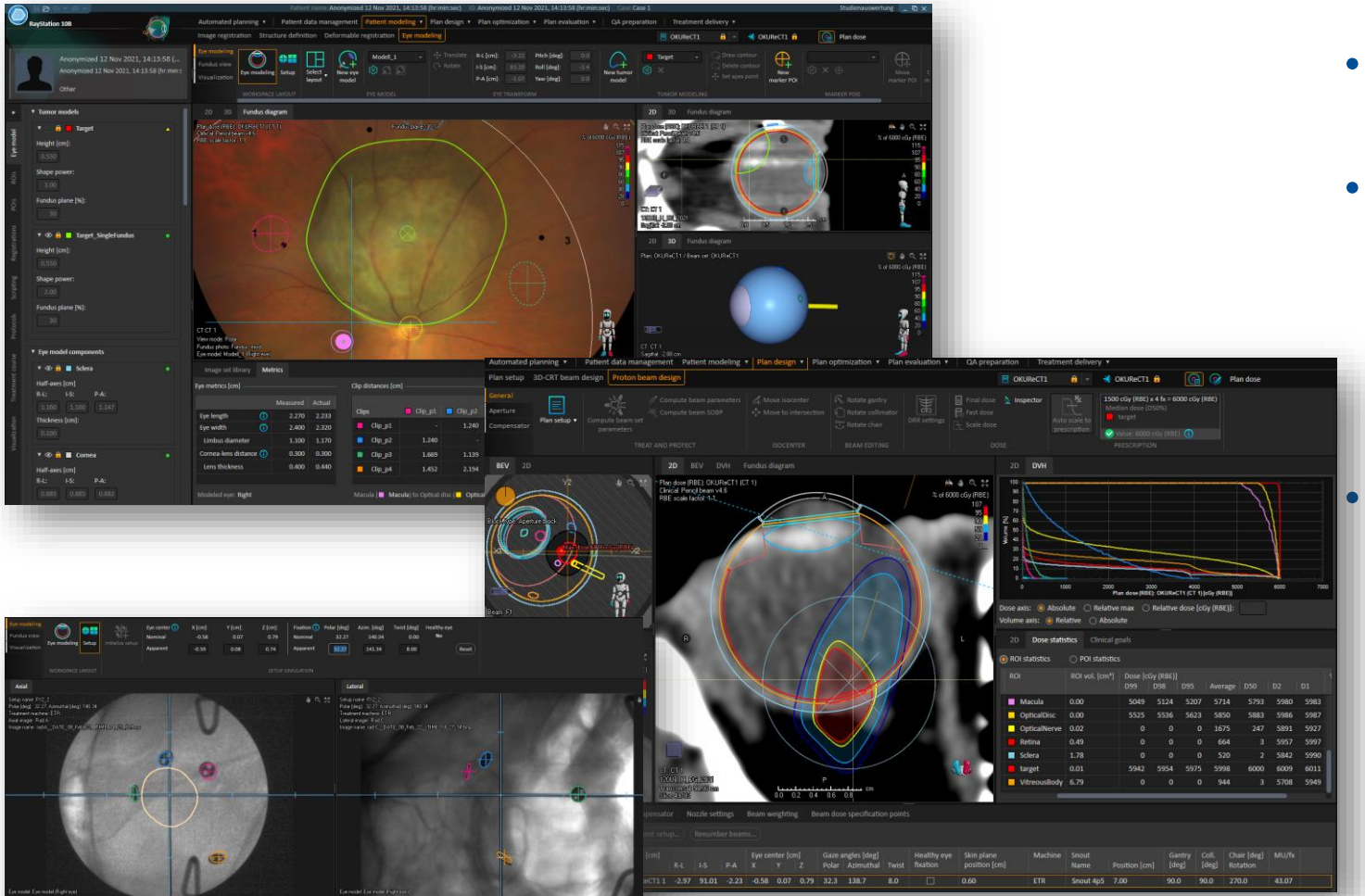


survey results 2018

- workshops with RSL in Essen/ Stockholm 2018
- bi-weekly meetings with RSL (*M. Janson/ E. Vidholm* + J. Heufelder)
- testing of evaluation versions

- first ocular patient treated in Nov. 2021 completely based on RayOcular

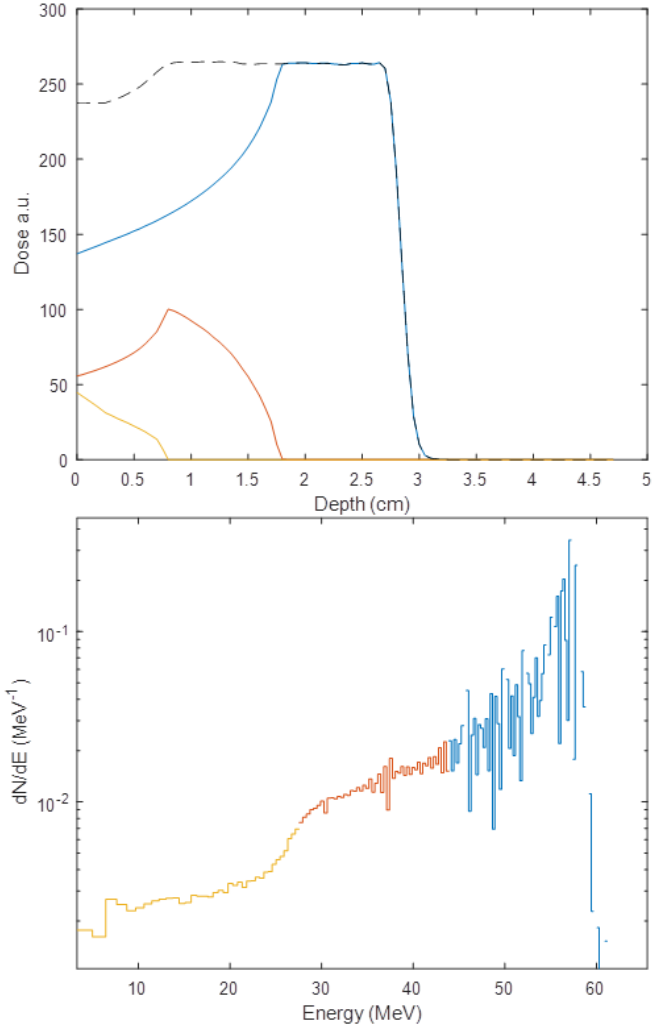
RayOcular (10B) – same same, but different



- RayOcular as integral part of RayStation
  - contouring, image registration etc.
- specifics to OPT
  - hierarchic eye-model + clips
  - metrics (e.g. clip-to-clip distances)
  - fundus overlay
  - X-ray image matching
- new things to EYEPLAN users
  - CT based model creation
  - density overrides
  - robustness analysis
  - scripting
  - PBA dose calculation

Dose calculation in RayOcular

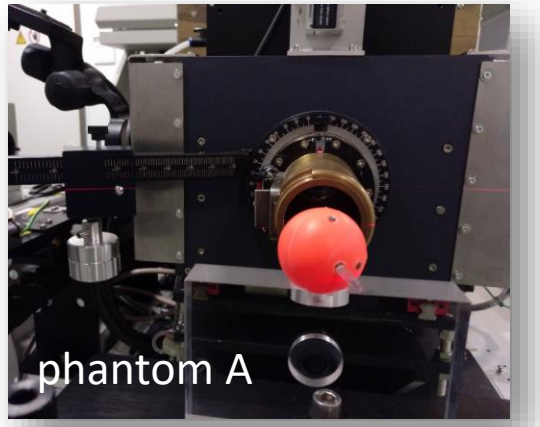
- established pencil-beam algorithm of RayStation
- beam modelling/ fluence calculation
  - initial energy spectrum for each SOBP, discretized into “layers”
  - angular variance & mean direction from virtual point source
  - → (flat) fluence grid behind the aperture opening
  - explicit modelling of scatter & energy loss in wedges
- dose calculation
  - MC pre-calculated monoenergetic IDDs
  - calculation of energy loss in material traversed (not just water!)
  - MCS + nuclear scattering
  - final dose calculation in a user-chosen dose grid <u>down to 0.2 mm</u> (2-5 seconds)
  - no MU calculation

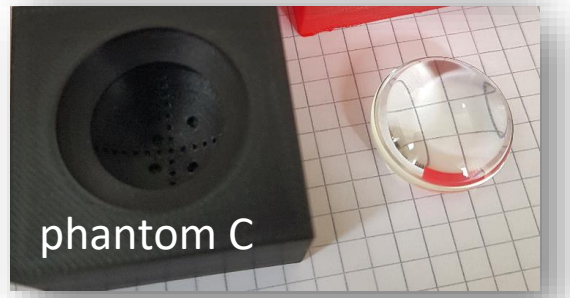


courtesy M. Janson

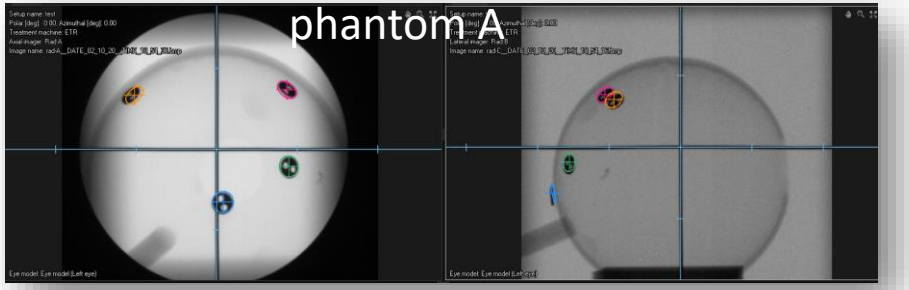
Commissioning & Validation Methods

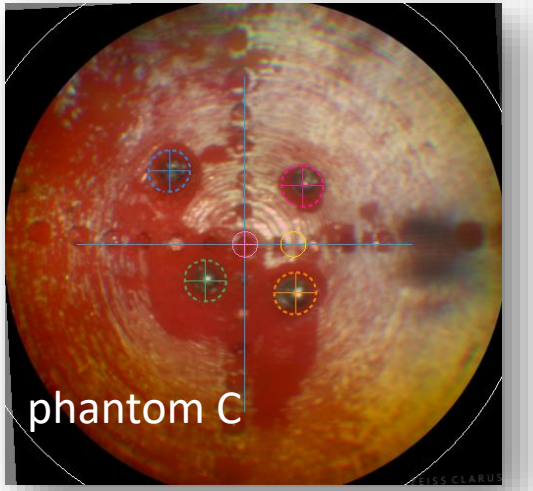
- beam-model creation and validation
  - water-tank scans for each available SOBP (depth dose + lateral)
  - conversion into RSL data format → beam-model
  - validation by comparison of profiles via 1D gamma-test
- geometry validation
  - clip projections/ orientation in X-ray overlay
    - phantoms with tantalum clips/ fiducials
    - indexing for different gaze angles
  - fundus overlay validation
    - 3D printed with “landmarks”
    - filled with water + lens (matching refraction of human)
    - single wide-field fundus image (Zeiss Clarus 500)

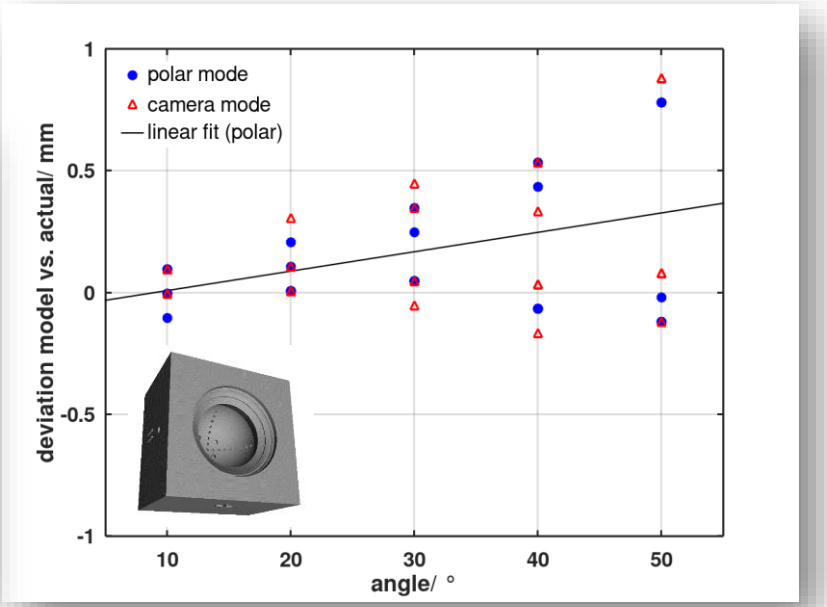




Geometry validation



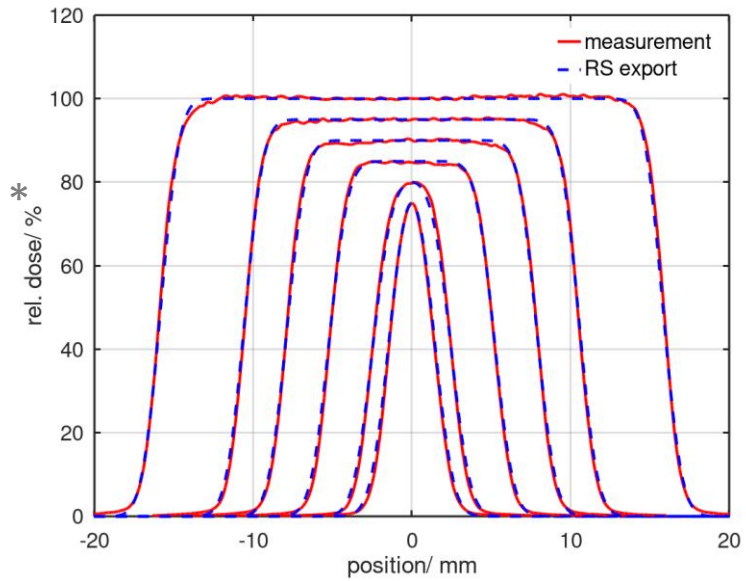


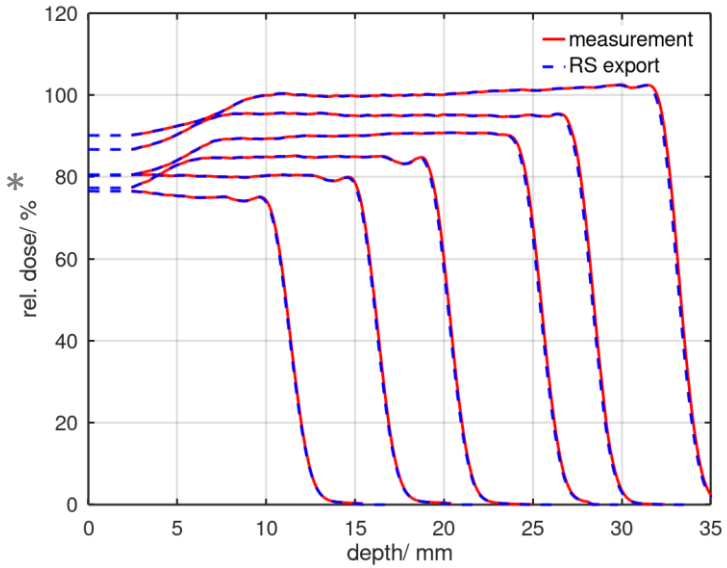


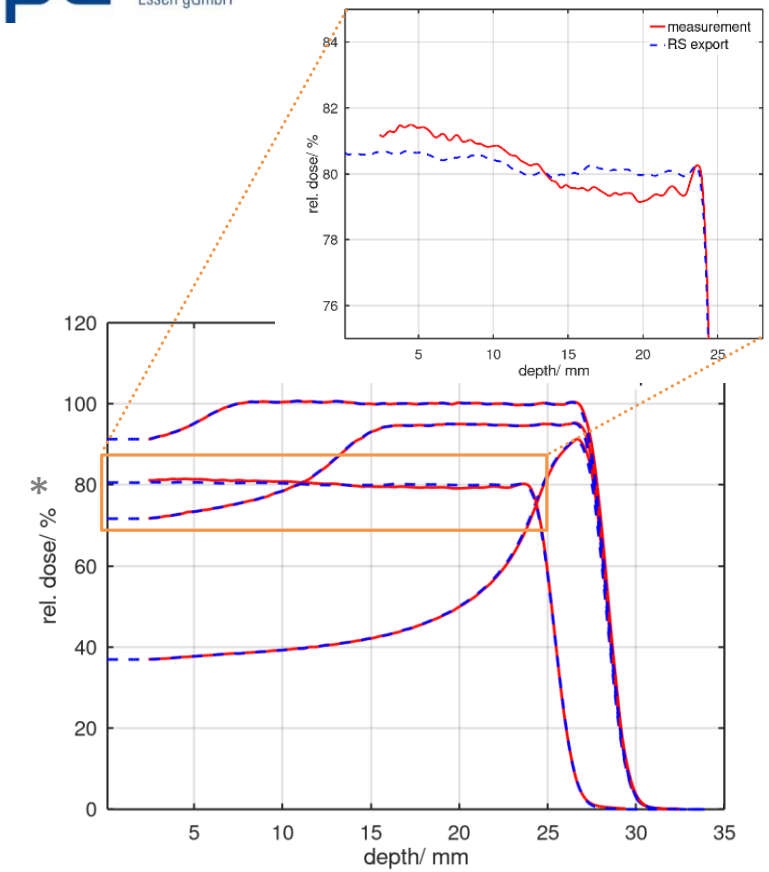
- clip projection for various orientations
  - well within few tenth of a mm
  - rotations correctly represented

- funduscopy
  - working in camera and polar mode
  - whole chain with uncertainty of 0.5-1 mm (after proper scaling/ registration)

Dosimetric validation

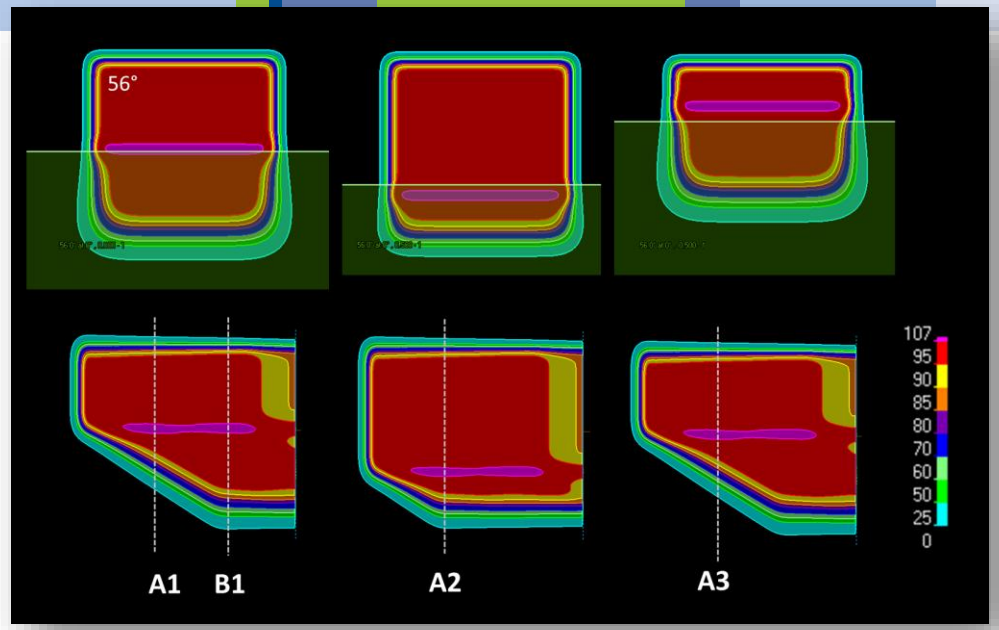




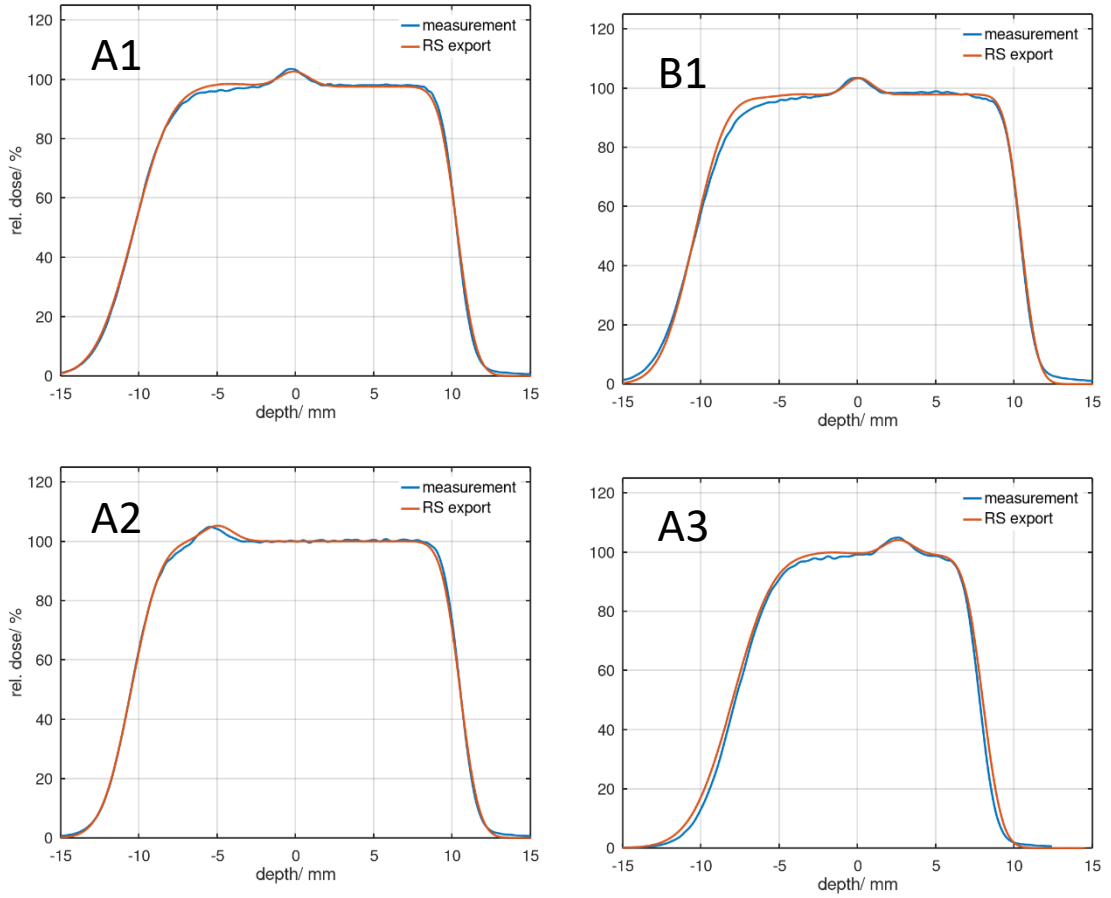


- all profiles with Γ (2%/0.3 mm) 95-100%
- lateral/ distal profiles penumbra agree well within 0.3 mm
- range change per option as a simple shift of depth profile
- *shallow (in-air)* lateral profiles in IBA system not flat → not modelled in RayOcular

(*profiles maximum scaled to avoid overlap)

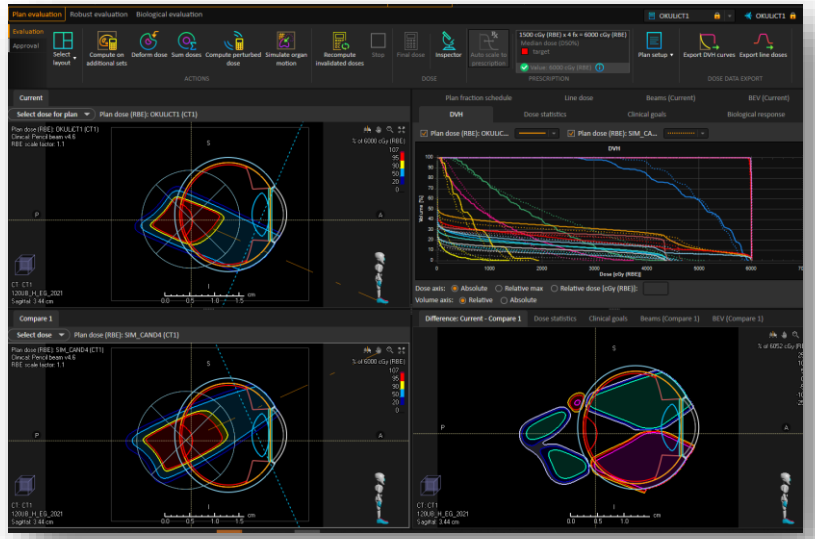


dosimetric test – wedges!



- Γ (3%/0.3 mm) 90-100%
- lateral penumbra agrees within ~0.4 mm
- scatter “excess dose” reproduced
- clinically not released yet

General planning experience



- adaptability of plans
  - plans can be copied, edited & summed
  - ad-hoc during simulation when loading X-ray images
  - plans can be compared with one another
- time to plan
  - model creation, matching to CT, fine-tuning, evaluation: **60 min**
  - (optional) registration to MRT: **20 min**
  - registration fundus, contouring: **30 min** (more complicated: iris melanoma)
  - defining gaze angle/ adjustment & dose-calculation: **30 min**
  - adjustment of plans during/ after simulation: **30 min**

  [note: no practical experience with EYEPLAN/ OCTOPUS]
- structures out of the eye model (+ iris)
  - many possibilities with RayStations standard contouring tool-box…

Summary & Outlook

- RayOcular combines all features of a modern TPS for ocular treatments
  - high confidence in the accuracy of dose-calculation
  - maintained system with (expected) constant evolution
  - high usability (list of enhancement requests to RaySearch …)

- by now used at WPE for >15 patients (including iris-melanoma)

THANK YOU