

OPTIMIZATION OF QA PROCEDURES FOR SCANNED PROTON BEAMS

Including simulation tools for independent dose calculation

Loïc Grevillot, PhD

DISCLAIMER

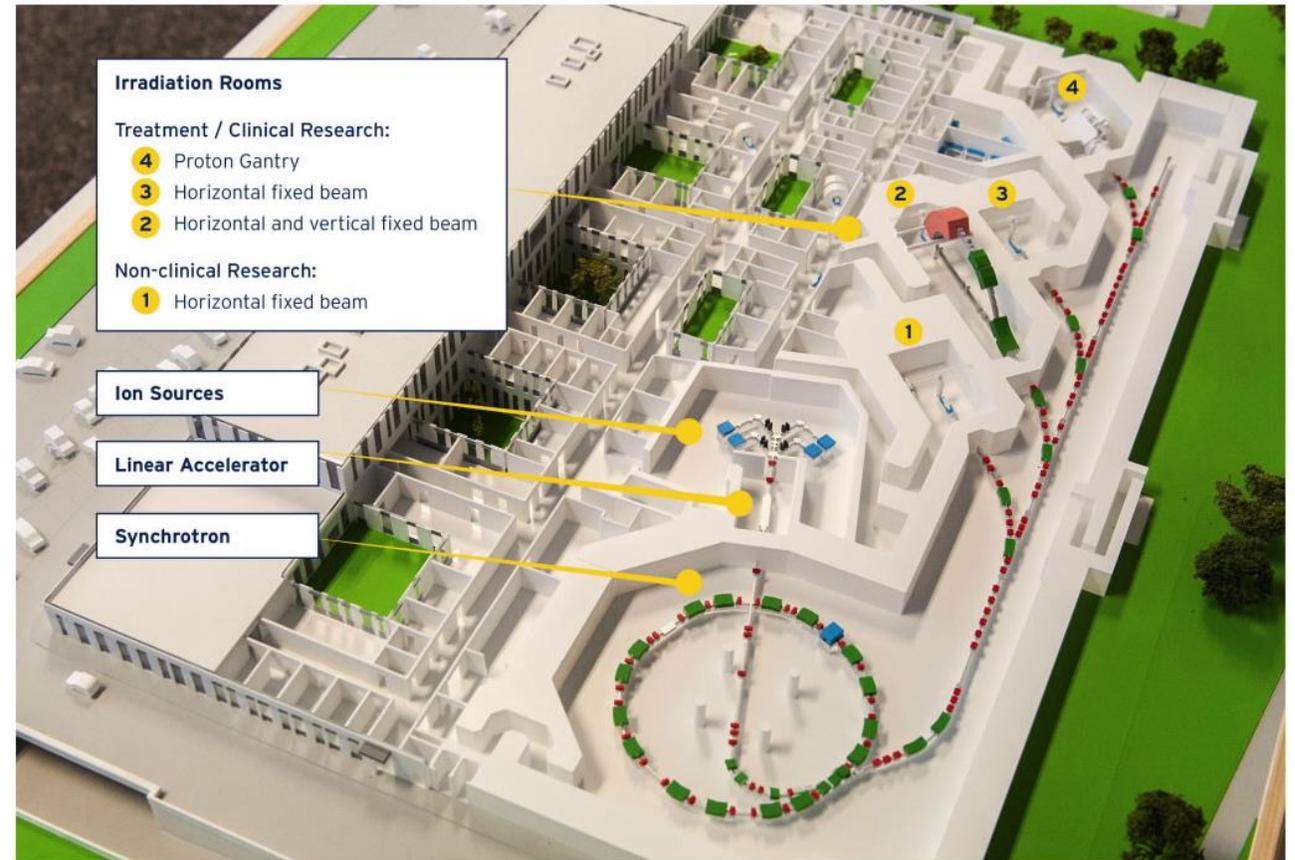
- No conflict of interest
- Collaboration with IBA-Dosimetry company

GENERAL INFORMATION

- MedAustron is a dual particle therapy facility, delivering proton and carbon ion beams.
 - This talk focuses on protons.

7 “beamlines” to QA:

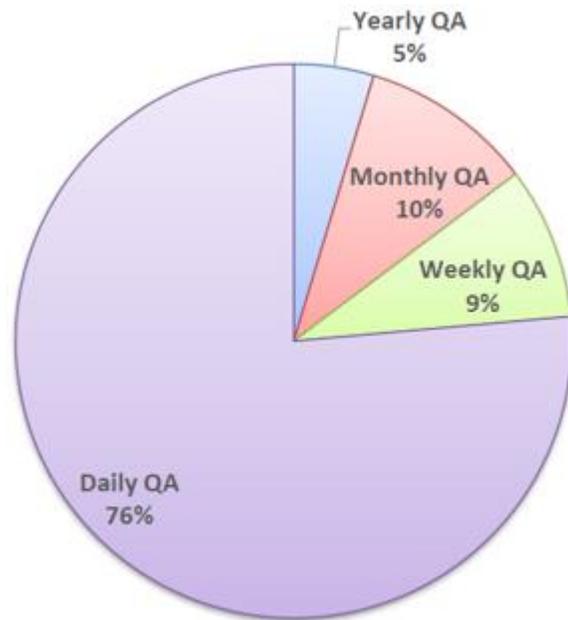
- 4 protons
- 3 carbon ions



MOTIVATION

- **Beam delivery QA workload**

- Average beam time / year



Courtesy of Michele Togno, PSI

Based on an ESTRO study from 2019, considering 17 centers

- **Dosimetric Patient specific QA workload**

- **Resource consuming**

- Every treatment beam must be measured
- Medical physicists working outside treatment hours

- **Limited sensitivity**

- **IMRT:**
 - IDC was 12 times more sensitive at detecting treatment failures for IMRT than measurement-based PSQA. **Kry et al, Med Phys 2019**
- **Protons:**
 - “The implementation of a Monte Carlo (MC) algorithm in an IDC system was shown to illuminate dose computation issues from analytical algorithms implemented in TPS, which would not otherwise be detected using traditional measurement-based PSQA.” **Jhonson et al, PloSOne 2019**

DAILY QA

- **First implementation, 2016**



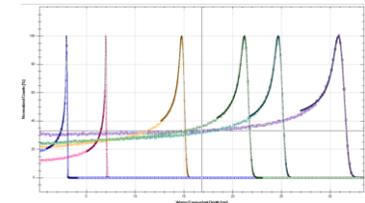
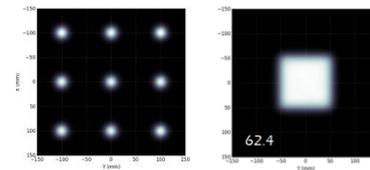
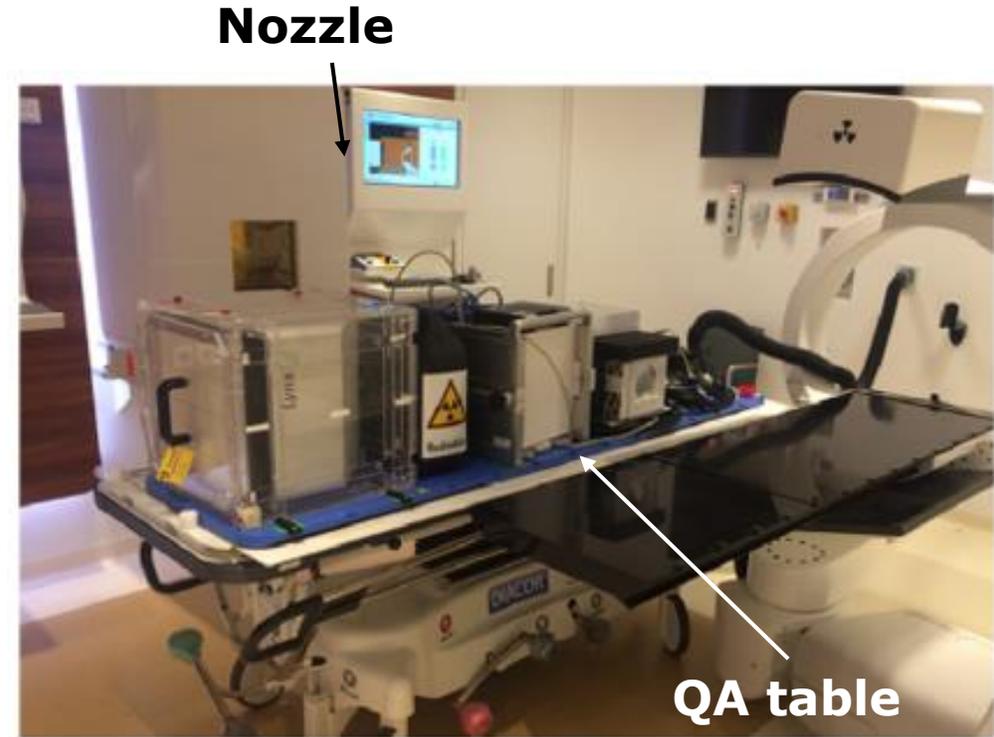
Range

Dose

Spot

Performed for 5 key energies

- Spot maps
- Homogeneity
- Ranges
- Dose in RW3



⇒ **Each test is specific**
⇒ **Limited to beam delivery**

DAILY QA

- Current implementation, since 2018

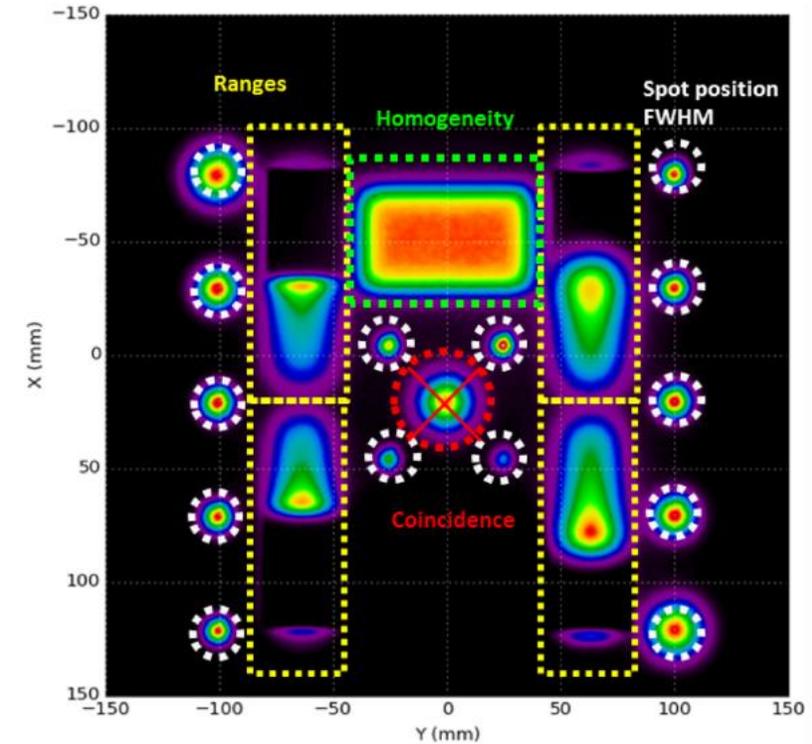
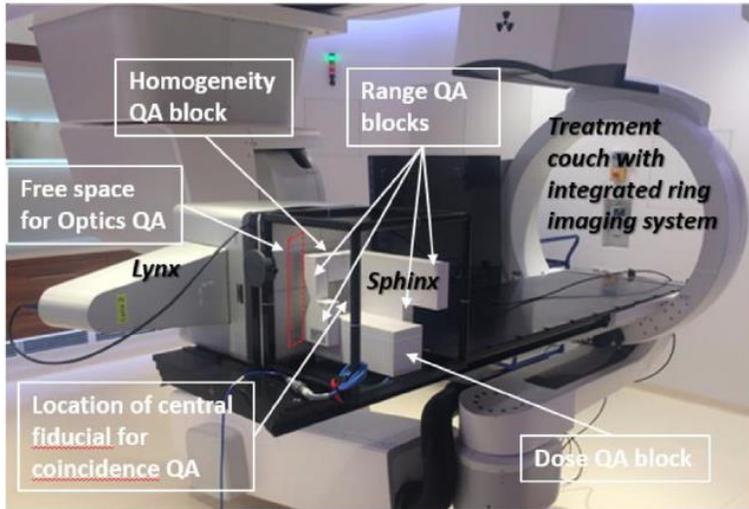


FIGURE 1 Setup of the equipment (Lynx, Sphinx, ionization chamber) for the measurements in a horizontal beam line.

Performed for 5 key energies

- Spot maps
- Homogeneity
- Ranges
- Dose in RW3
- **Imaging**
- **Registration**
- **Coincidence**
- **Lasers**

⇒ **Integrated tests**
⇒ **Clinical workflow**
(including registration)

DAILY QA

2016:

- 1 beam line
- 1 particle type
- Daily QA = 2hrs



2023:

- 7 “beamlines”
- 3 rooms
- 2 particle types
- Daily QA < 1.4hrs



- **Daily QA Efficiency increase:**
 - Integrated daily QA equipment
 - Improved machine performance (intensity)
 - Improved in-room workflow (robot speed, registration, control from outside, etc.)
 - Multi-room optimization
 - User training & experience

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Implementation of Sphinx/Lynx as daily QA equipment for scanned proton and carbon ion beams

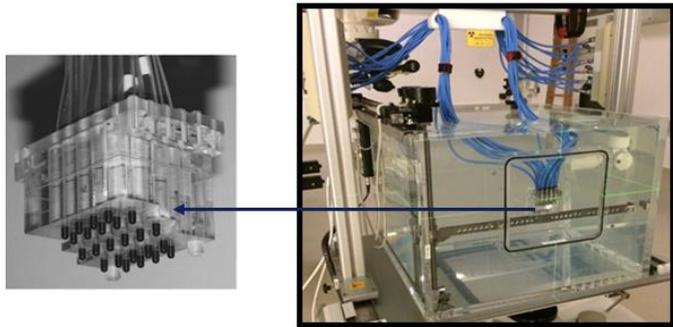
Loic Grevillot ✉, Jhonnatan Osorio Moreno, Hermann Fuchs, Ralf Dreindl, Alessio Elia, Marta Bolsa-Ferruz, Markus Stock, Hugo Palmans

First published: 27 January 2023 | <https://doi.org/10.1002/acm2.13896>

Daily QA efficiency increased by a factor 10!

PATIENT SPECIFIC QA

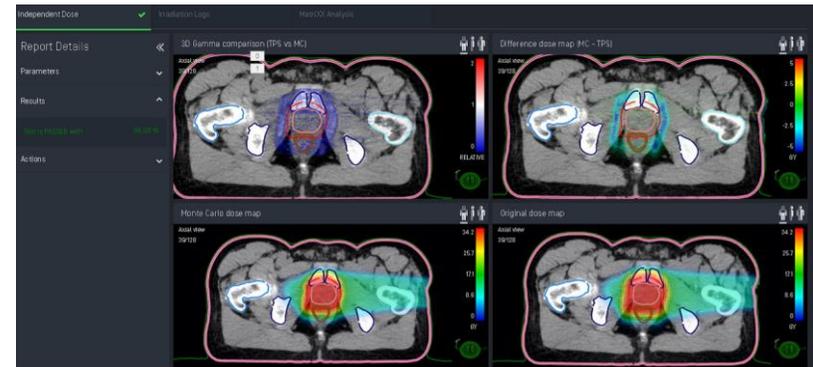
- **From dosimetric PSQA to Independent Dose Calculation (IDC)**



Measurement set-up using 3D-block

- 24 pin-point measurements "only"
- Limited to low gradient dose regions
- **Includes file transfer check**
- **Includes beam delivery check**

⇒ **Each beam individually**
⇒ **Limited to dosimetric check in water with low dose-gradient**



IDC using myQAiON (IBA-dosimetry)

- **Full 3D patient geometry**
- **Account for high gradient dose regions**
- Does not include file transfer check
- Does not include beam delivery check

⇒ **Full treatment plan**
⇒ **Independent dosimetric check in patient geometry**

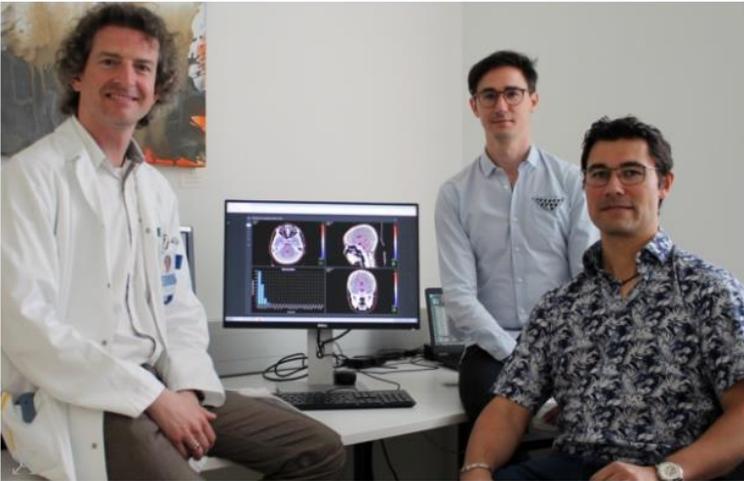
PATIENT SPECIFIC QA

- **From dosimetric PSQA to Independent Dose Calculation (IDC)**

Reimagining patient-specific QA in proton and ion therapy facilities

26 May 2021 Sponsored by IBA Dosimetry

Medical physicists from the Austrian particle therapy centre MedAustron explain how – and why – they've put an independent QA solution at the heart of their patient treatment programme

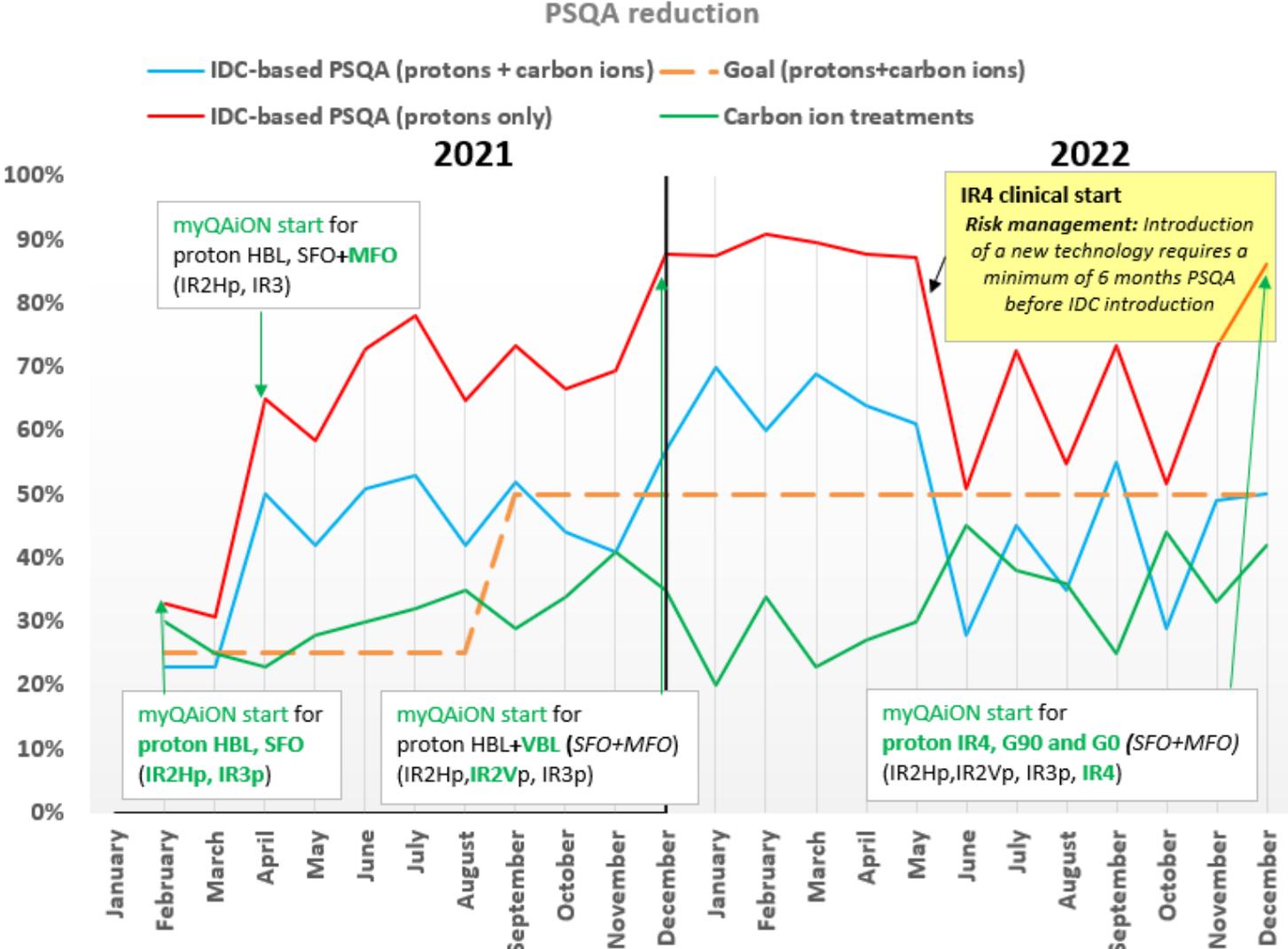


- **Full 3D patient geometry**
- **Account for high gradient dose regions**
- Does not include file transfer check
- Does not include beam delivery check



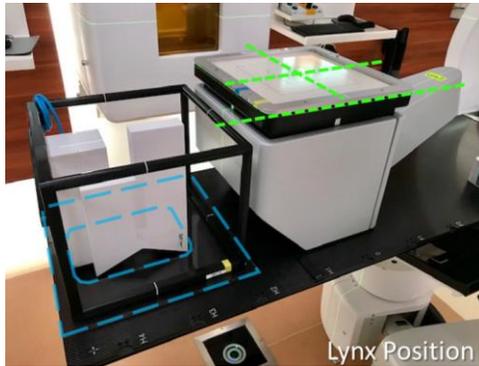
- **File transfer** check at the first fraction.
- Additional **beam delivery** QA:
 - To compensate for the lack of PSQA
 - 3D beam delivery monthly QA tests were added:
 - 1 reference box
 - 2 SFO fields
 - 2 MFO fields
 - Incl. head and pelvic regions
 - Beam time ~ **30 min/month/beamline**

PATIENT SPECIFIC QA



PERSPECTIVES

- **Beam delivery QA workload**
 - Further optimization of daily QA set-up for vertical beamlines



- **Patient specific QA workload**
 - IDC for carbon ion beam treatments



The GATE-RTion/IDEAL Independent Dose Calculation System for Light Ion Beam Therapy

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SUMMARY

- **Daily QA**

- Daily QA reduction from 2hrs/beamline (2016) to 12 min (2023)
- Multifactor optimization required!
 - *Integrated QA device, in-room workflow optimization, multi-room workflow and task optimization (incl. setup for multiple beam-lines and rooms in parallel for 2 particle species)*

- **Independent dose calculation**

- Additional **monthly** beam delivery QA only cost ~ **30min/beamline**
- **2021**: 397 patients treated (~65% protons) – **245 hrs of beam time saved**
- **2022**: 423 patients treated (~65% protons) – **324 hrs of beam time saved**
 - ~ **90% of the proton patients are simulated**
- **Same goal for carbon ions!**

Optimization of QA procedures is a continuous process!

THANK YOU FOR YOUR ATTENTION !!



Do you have
any
Questions? 😊

Beam delivery & Monte Carlo simulation group 2023!