

# End Station Dose

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WP6 Meeting

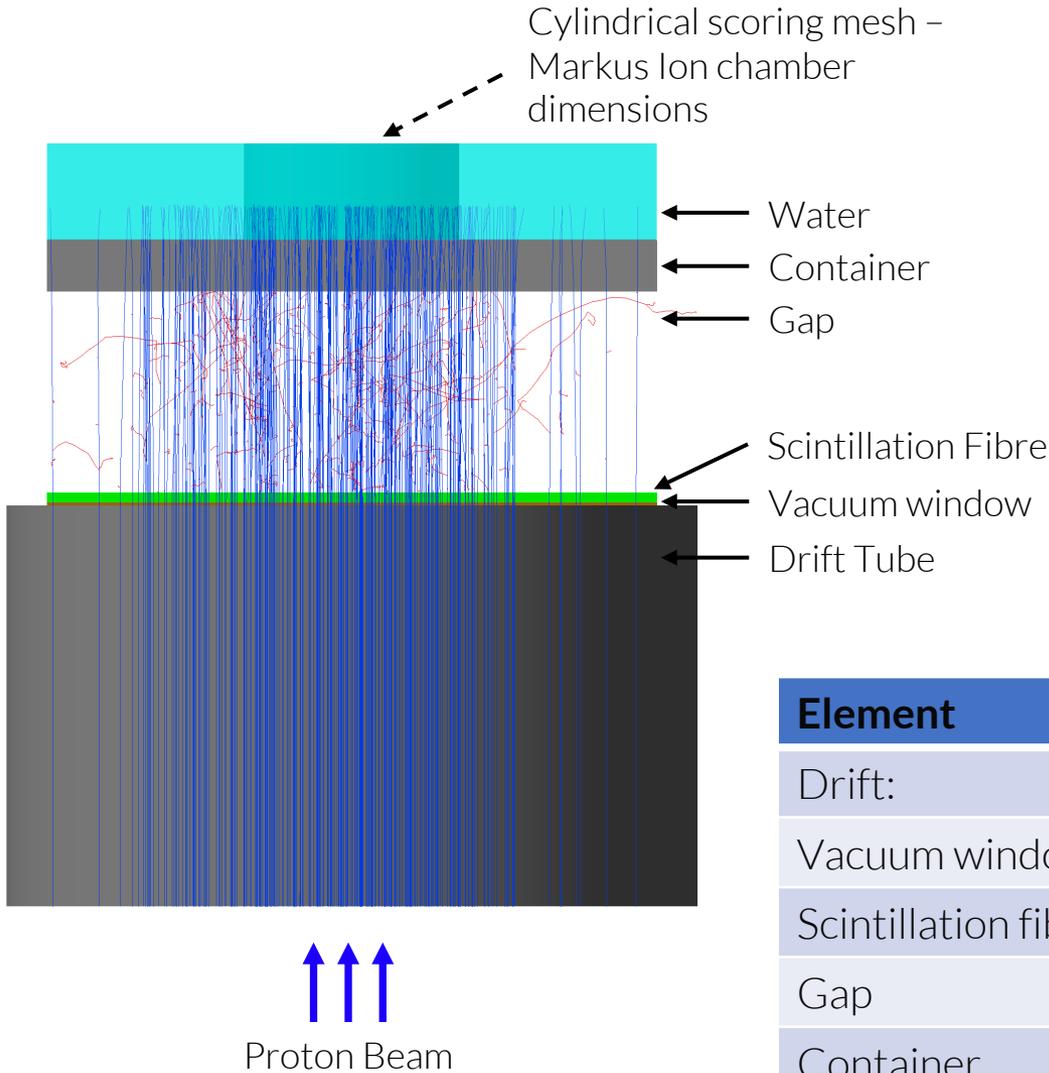
15<sup>th</sup> August 2023



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- Cross check pre-CDR dose calculations
  - 12.8 Gy / shot
- Pre-CDR data: unknown analysis methodology
  - Known dose volume (Markus Ion Chamber - water), unknown volume location
  - Wrong data file found – initial beam incorrect.
    - Original data lost.
- New BDSIM models
  - Two independent dose calculation methods
    - Rebdsim (bdsim analysis tool):
      - User-defined histogram of energy loss (radial & z cutoff) in GeV
      - Manual conversion to Gy
    - Scoring mesh:
      - Dose in GeV, dose in Gy

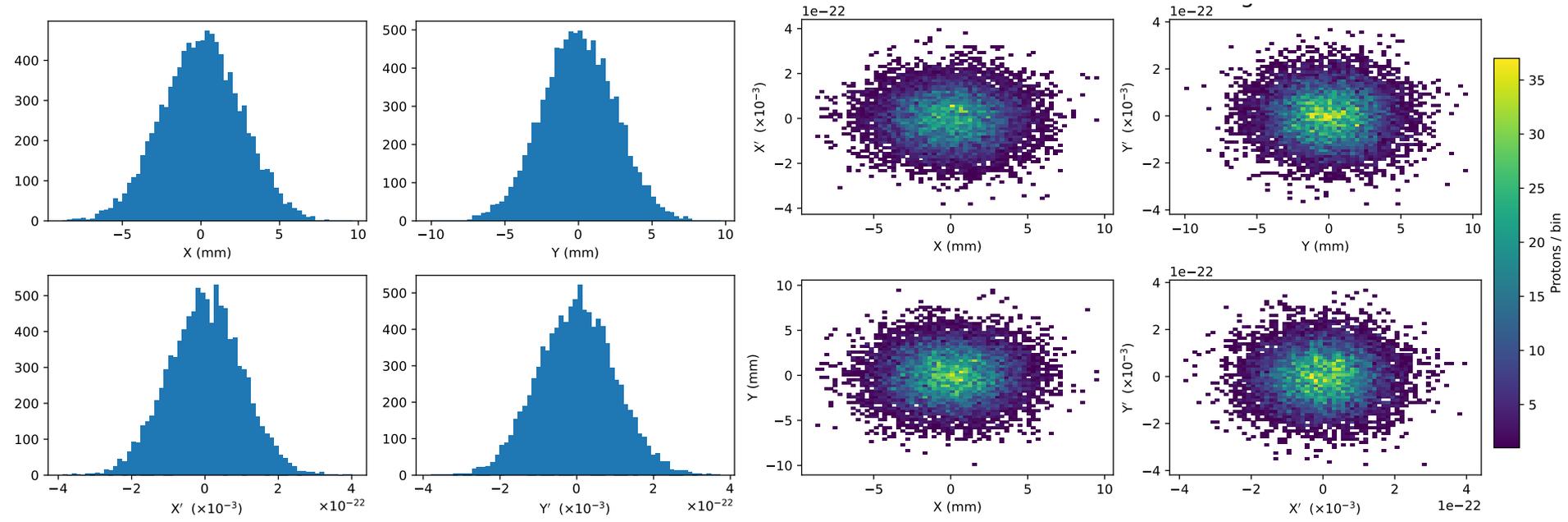


- No cell layer
- **1.0 cm spot size beam**
  - Gaussian
  - 2.5mm sigma
- 15 MeV mono-energetic
- PhysicsList: "g4QGSP\_BIC\_EMZ"<sup>1</sup>
- Markus Ion Chamber (cylinder):
  - 2.65 mm radius
  - 2.00 mm length

Element	Material	Length (m)
Drift:	Vacuum	0.01
Vacuum window	Mylar	75e-6
Scintillation fibre	Polystyrene	250e-6
Gap	Air	5e-3
Container	Polystyrene	1.3e-3
Water Block	Water	2.4e-3

1. Geant4 medical physics list recommendations:  
<https://doi.org/10.1002/mp.14226>

# Initial Beam Phase Space



## End Station Dose

### Dose per proton (event)

Scored Dose in GeV : 3.362E-03 +/- 3.908E-05  
Calculated Dose in GeV: 3.361E-03 +/- 2.090E-05  
Calculated Dose in J : 5.386E-13 +/- 3.348E-15  
Calculated Dose in Gy : 1.221E-08 +/- 7.588E-11  
Scored Dose in Gy : 1.221E-08 +/- 1.419E-10

### Dose scaled to $10^9$ protons per bunch

Scored Dose in GeV : 3.362E+06 +/- 3.908E+04  
Calculated Dose in GeV: 3.361E+06 +/- 2.090E+04  
Calculated Dose in J : 5.386E-04 +/- 3.348E-06  
Calculated Dose in Gy : 1.221E+01 +/- 7.588E-02  
Scored Dose in Gy : 1.221E+01 +/- 1.419E-01

- Dose re-simulated to be **12.21 ± 0.14 Gy / shot**
- Instantaneous dose rate:  $1.7 \times 10^9$  Gy/s
  - Based on pre-CDR bunch length of 7.0 ns
- Average dose rate: **122.1 ± 1.4 Gy/s**

- Done:
  - Reconstructing HTs end station simulations
  - Recalculated deliverable dose
- Ongoing:
  - Optimisation routines for smaller spot sizes
  - Optimisation validation for smaller spot sizes
  - Comparison to baseline design
- Todo:
  - Performance evaluation of  $\pm 5\%$  beams
    - No optimisation. Transport & transmission assessment.
  - Alternative space charge codes & model validation.
    - RF-track, OPAL, IMPACT-T, ...?
  - Update models of alternative baseline design (v5.5)
  - Develop OPAL model of FFA