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# Fluidized Tungsten-Update Feb ‘25

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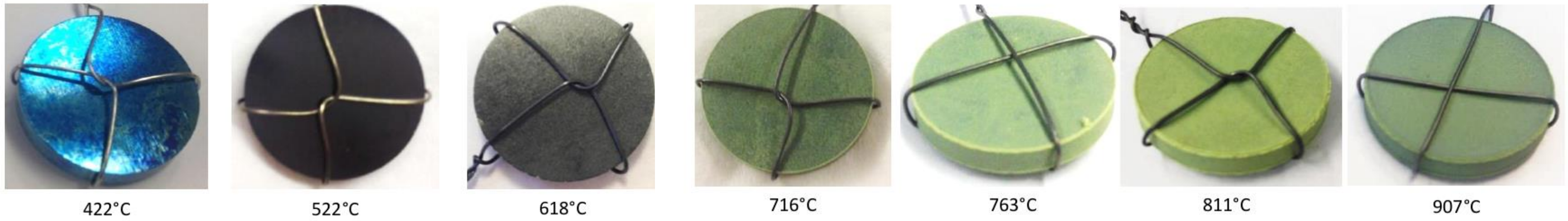
- Beam Heating
- Beam Power Limits and Beam Shaping
- Warwick Physics Update

# Beam Heating – Temperature Limits

- Tungsten produces an unstable oxide above ~700°C [ESS and CERN work]
- For now, we assume we can mange the oxygen in the helium circuit to prevent excessive oxidation below this level
- Short pulsed nature of beam and flowing medium means we care only about heat deposition per pulse, not heat transfer
- For $\Delta T < 600K$ This resolves to a limit of $1.5 J/mm^3 \cdot pulse$




[J. Habainy et al.]

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# Beam Heating – Profile on target

- Target heat deposition depends on delivered beam profile
- The reasonable worst case would be a pure Gaussian beam
- Actual delivered proton beam will **not** be Gaussian
- If we shape our beam we can reduce the heating intensity on the centre of the target
- How flat topped can we get it? Proton driver team considering this
  - Benefit to all target concepts?
  - Effect on downstream infrastructure

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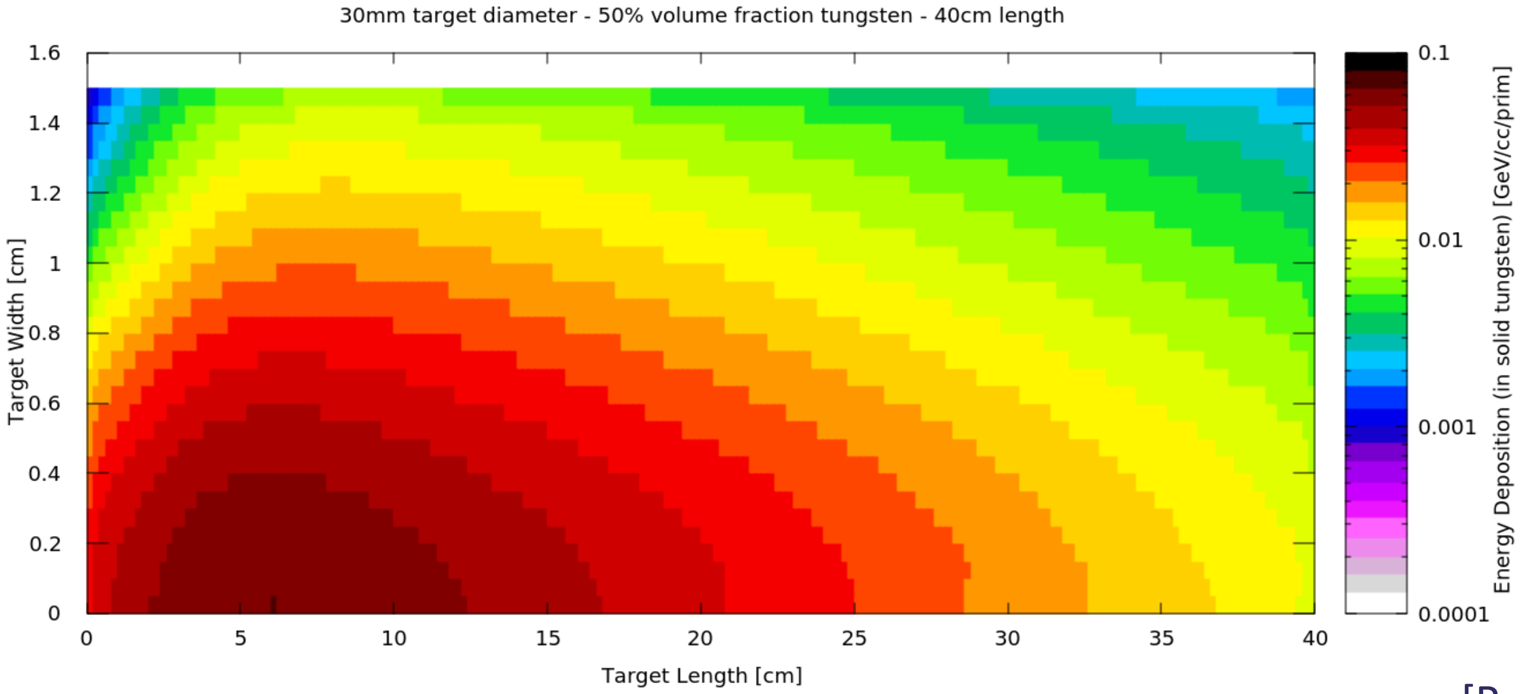
# Beam Heating – A Test Case

- Flowing tungsten target of same diameter as Carbon target. Length defined by previous studies for UKNF
- Densest tungsten flow ~50% volume fraction


- 10GeV Gaussian beam, $\sigma = 5mm$
- Ignore engineering reality and imagine a floating rod in space

# Heat deposition

- Quick, simple FLUKA
- Maximum pulse temperature rise is over 1900K @ 4MW
- Allowable beam power is 1.17MW

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[R. Cowan FLUKA STUDY]

# Routes to reducing temperature

- Target Geometry
  - Increase Diameter
    - dT ~$\propto$ $1/D^2$
    - Pion Reabsorption?
  - Decrease Volume Fraction
    - dT reduces with lower volume fraction
    - Longer target for same interaction mass
- Beam Parameters
  - Increase Pulse Frequency
    - dT $\propto$ number of protons
    - Less intense muon pulse
  - **Flat-top beam**
    - Spreads protons across the target more efficiently
    - More particle interactions closer to target surface- lower reabsorption?
    - More difficult beam to produce?
    - Beam effect on downstream infrastructure

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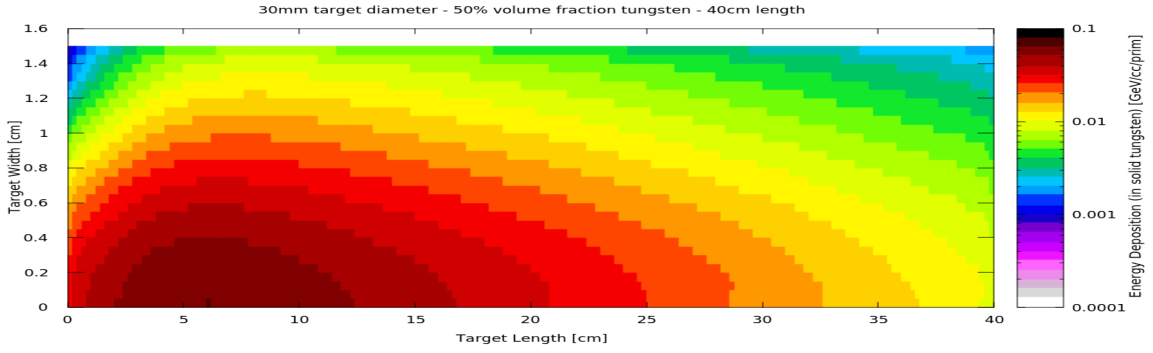
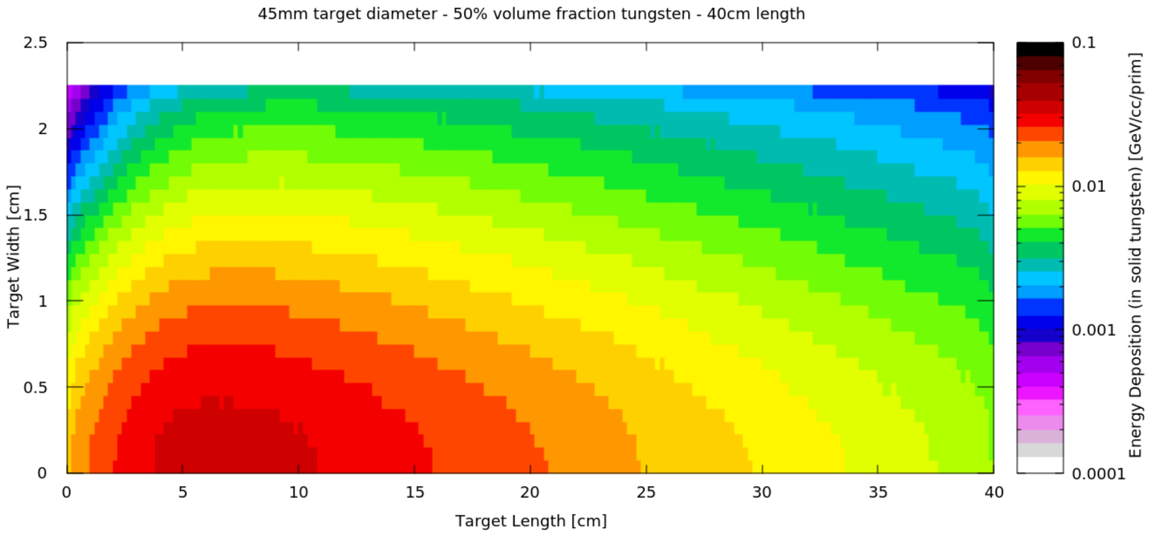
# Repeat for Various Parameters

- Gaussian Ø30mm




- Allowable Beam Power 1.17MW

- Gaussian Ø45mm




- Allowable Beam power 2.02MW

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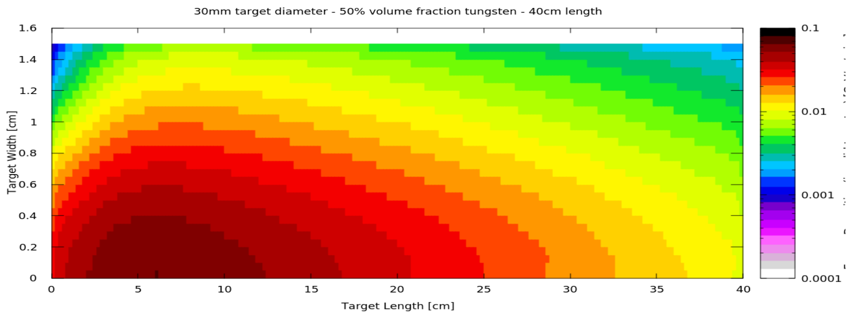
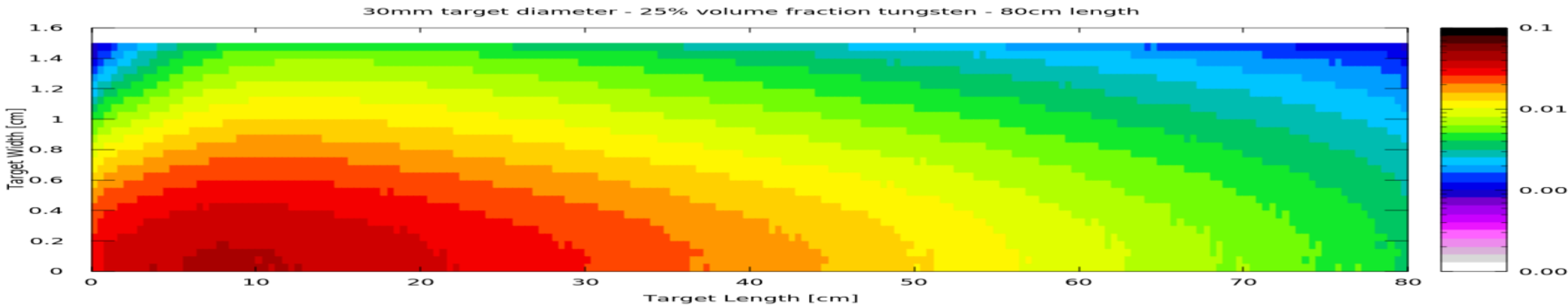
# Repeat for Various Parameters

- Gaussian Ø30mm, 50% dense




- Allowable Beam Power 1.17MW

- Gaussian Ø30mm, 25% Dense




- Allowable Beam power 1.68MW

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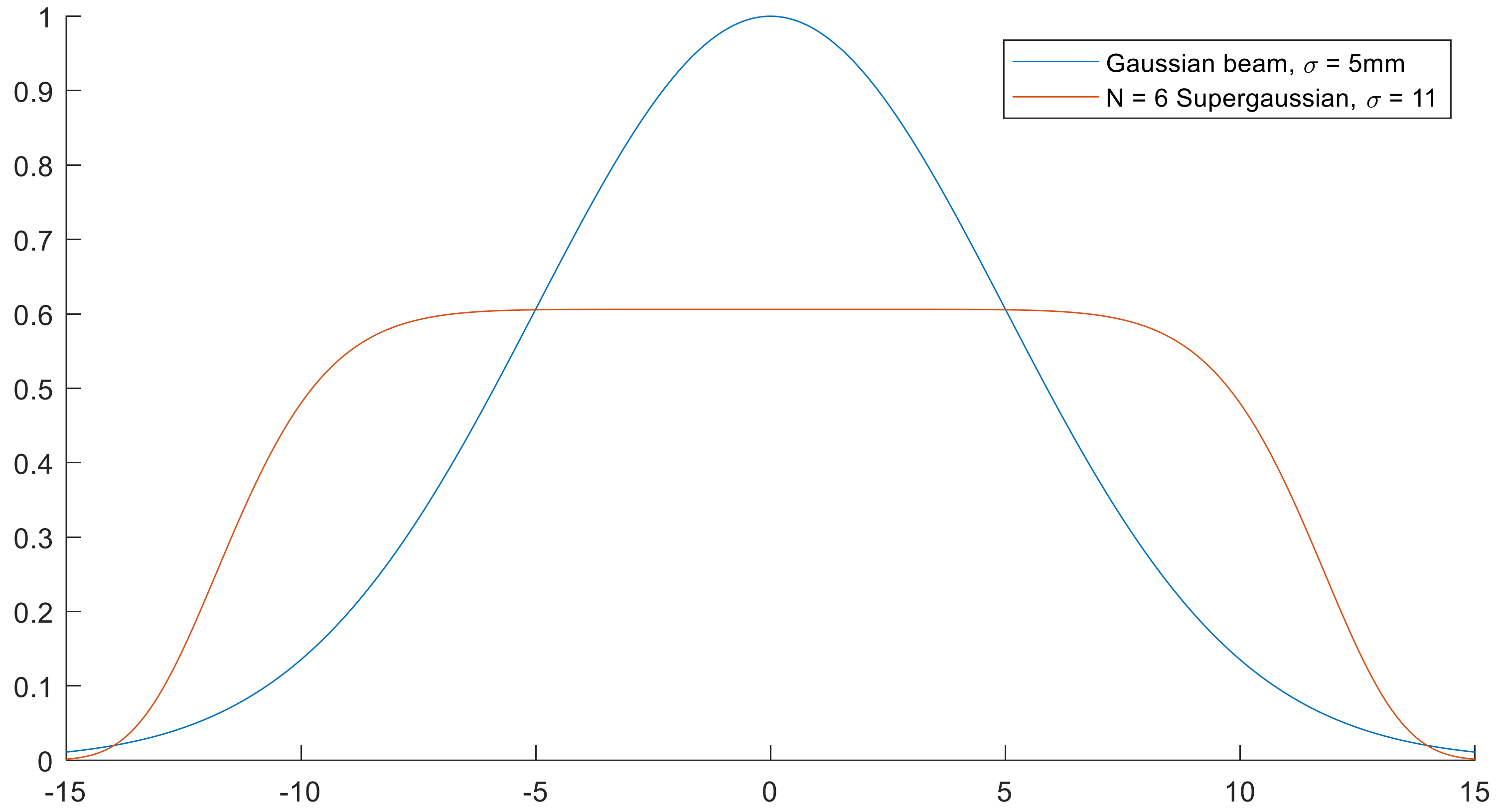
# Now, a "Supergaussian" beam

- Equation of form $A\exp\left(-\frac{1}{2}\cdot\left(\frac{|x|}{\sigma_x}+\frac{|y|}{\sigma_y}\right)^N\right)$ , N = 6

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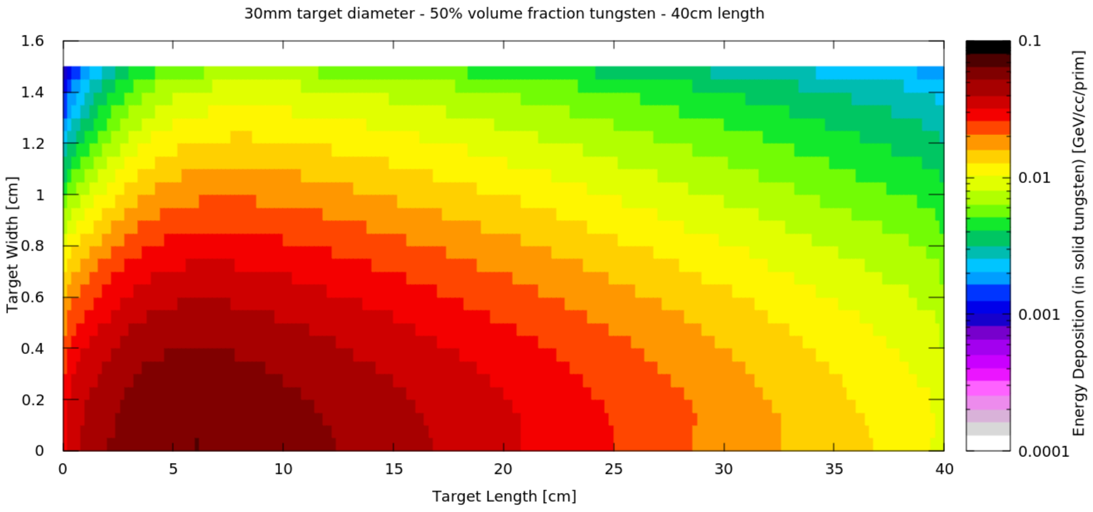
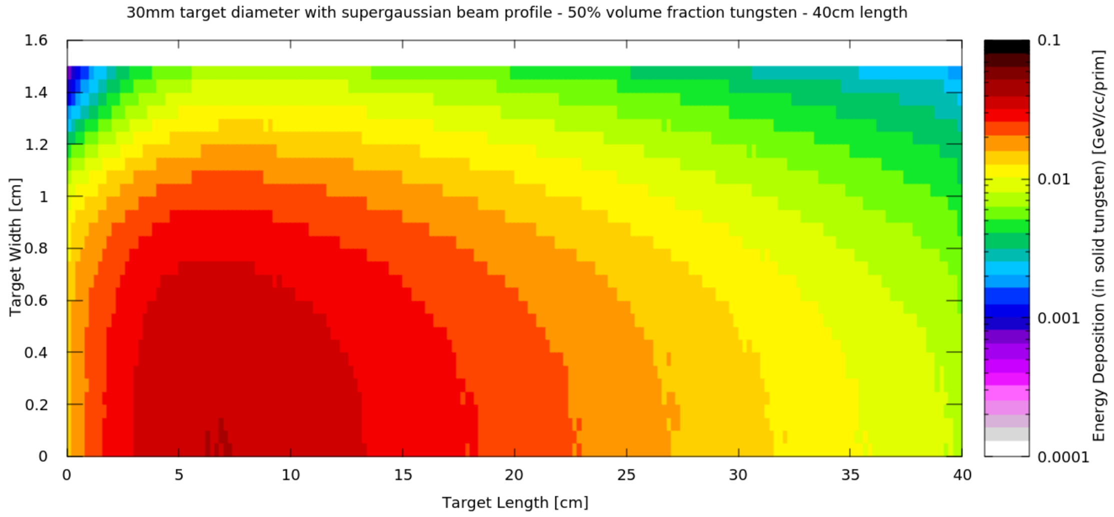
# Now, a "Supergaussian" beam

- Gaussian Ø30mm




- Allowable Beam Power 1.17MW

- Supergaussian Ø30mm




- Allowable Beam Power 1.85MW

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# Parameter Sweep

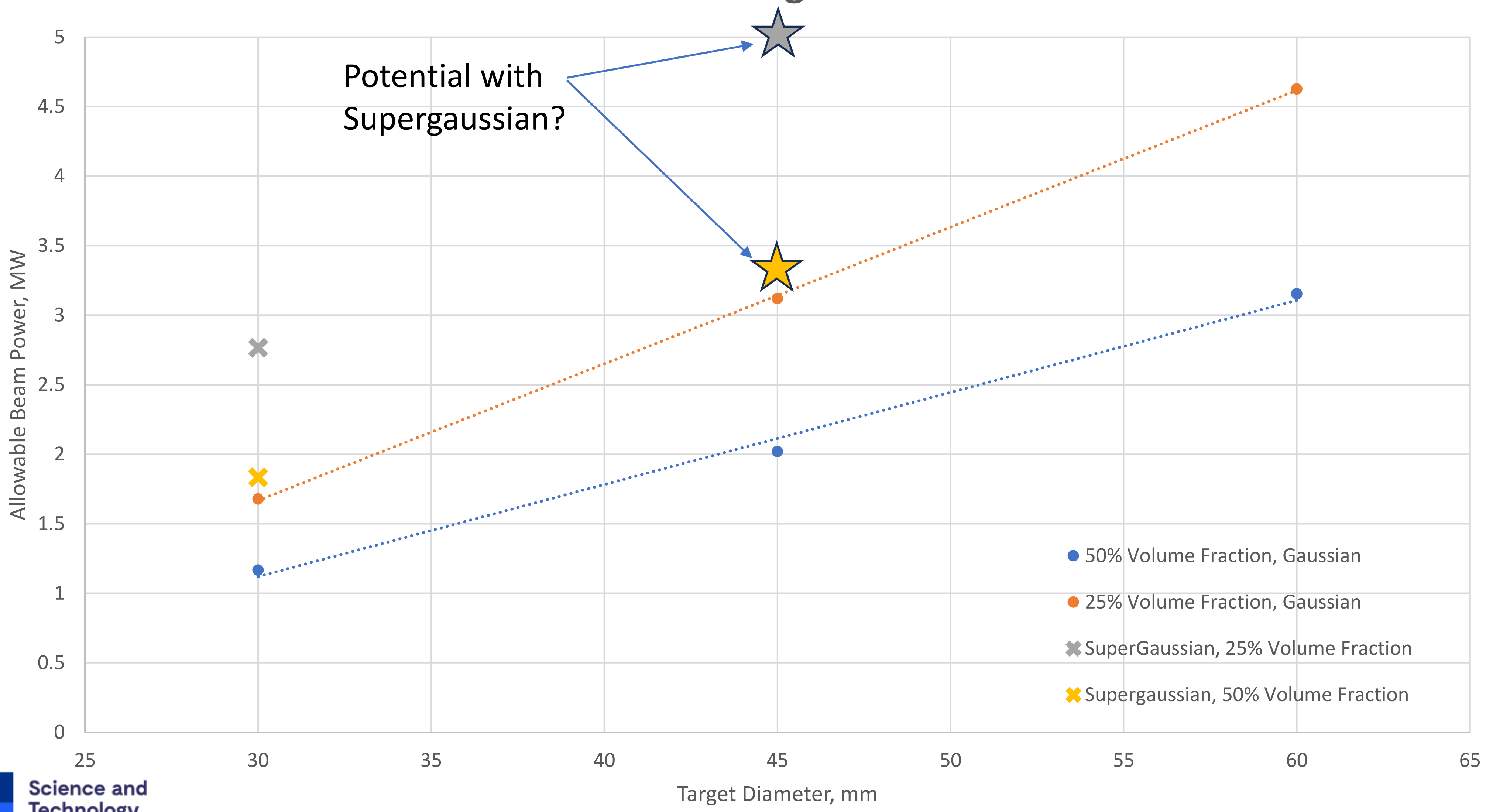
- Supergaussian gains ~60% allowable beam power
- A flatter beam will perform even better

| Allowable Beam power, MW | Target Density | |
|---|---|---|
| Target diameter | 25 | 50 |
| 30 | 1.68 | 1.17 |
| 45 | 3.12 | 2.02 |
| 60 | 4.63 | 3.15 |

| *30mm Diameter* | Target Density | |
|---|---|---|
| Allowable Beam Power, MW | 25 | 50 |
| Gaussian | 1.68 | 1.17 |
| Supergaussian | 2.76 | 1.83 |

x1.6 x1.6

# Beam Power vs Target Diameter

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# Questions to be answered later

- Can we handle the unintended consequences of a flat-topped beam?
    - Beam tails
    - Chicane heating
- Physics studies yet to come

# Physics Study Update

## FLUKA target model

- Will there be an updated version of the CERN graphite target & chicane geometry & B field in MuonCollider-WG4/radiation-load-and-yield?
  - taper_chicane_v1_18_coils_exp.inp (2 years old, contains 20 not 18 coils)