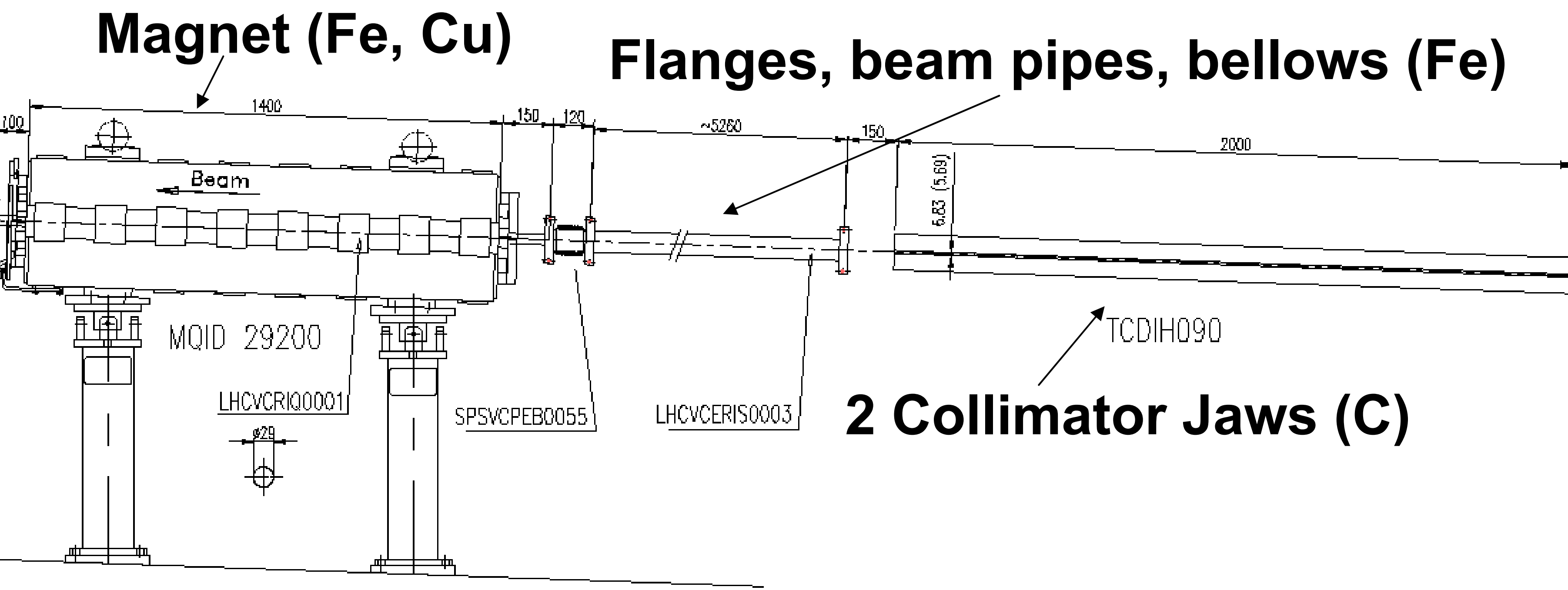
Simulations for TCDI – Collimators in the Transfer Line

- Locations and Settings of the TCDI collimators: HB
- Length of the collimators.
  - Criteria: Protection of equipment downstream in case of beam loss.

  → FLUKA simulations: calculation of temperature rise in equipment

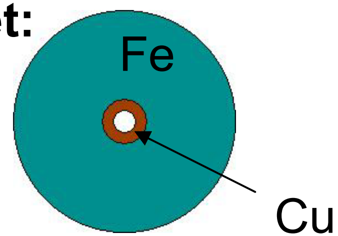
Geometry for Simulations:



Gap between collimator jaws: 5.69 mm

Simulation for simplified model: cylinders, parallelepipeds

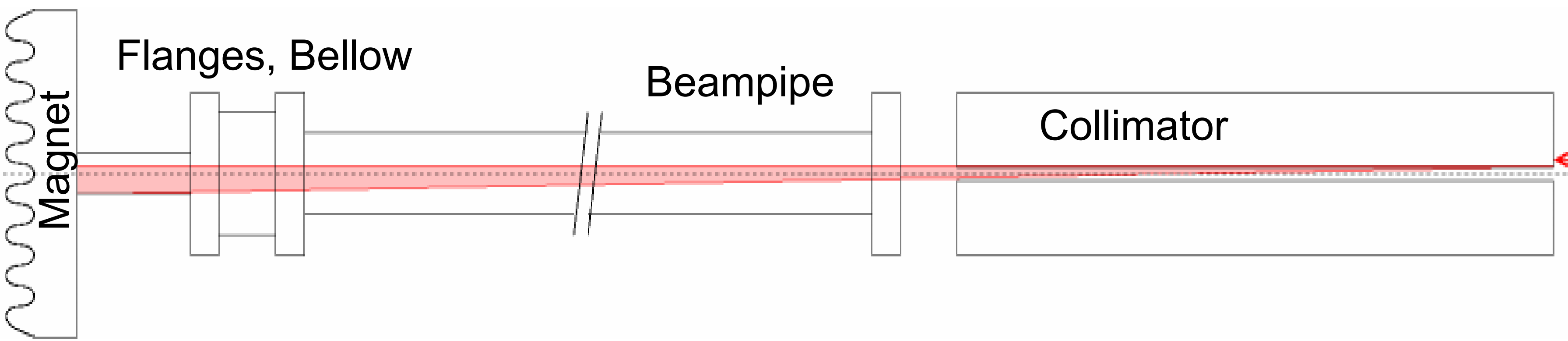
Magnet:



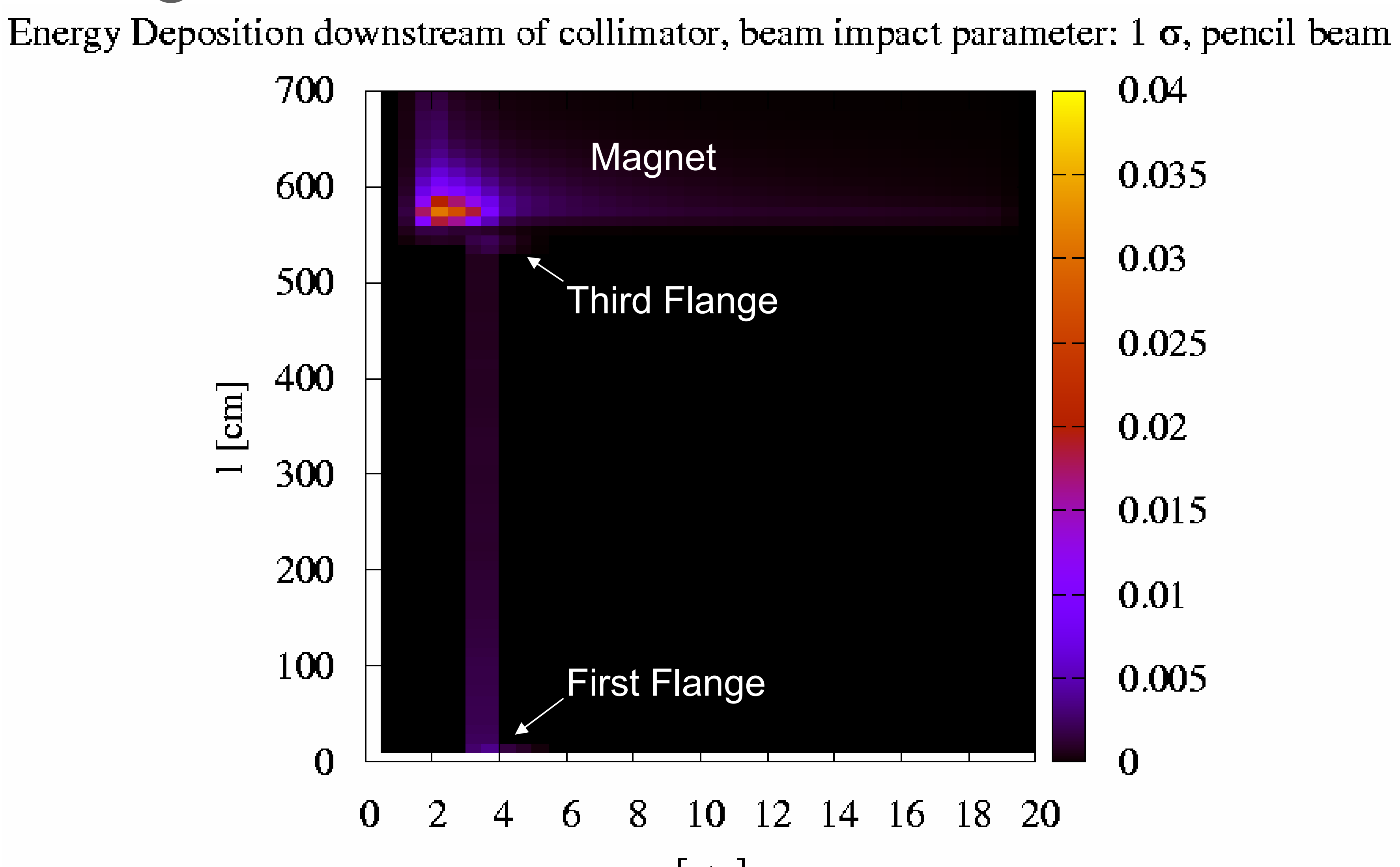
Input for Simulation

- Scenario:
  full batch (288 bunches, 450 GeV) impacting with
  1σ impact parameter on collimator jaw. Pencil Beam. Nominal Intensity. (Simulation: $2*10^3$ particles)
- Jaw length: 2m, 2.5m, 3m
- Transverse dimensions: 4cm x 5cm

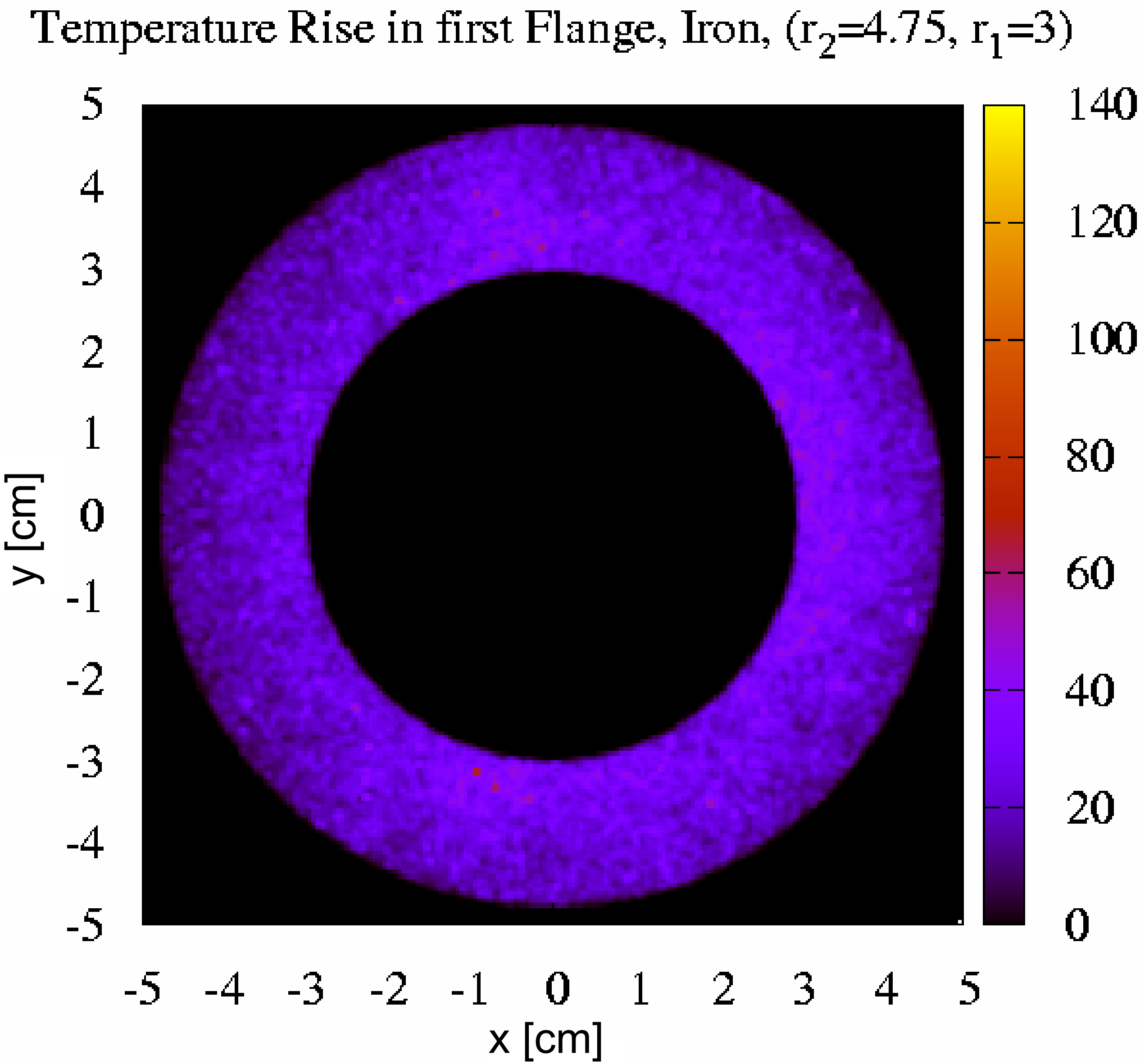
1σ impact parameter → Out-scattering from the jaw surfac



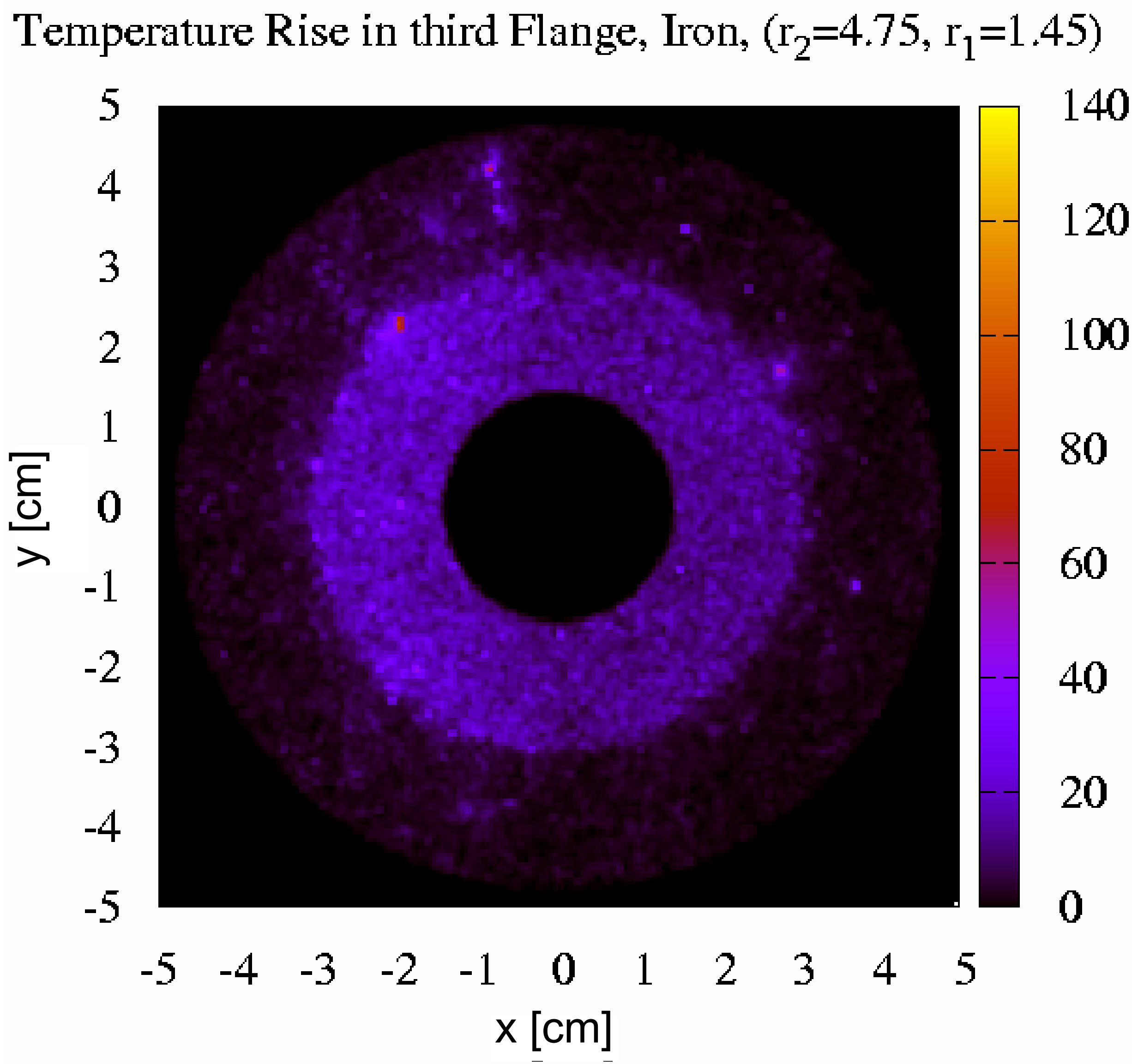
Most Energy Deposition in the Magnet



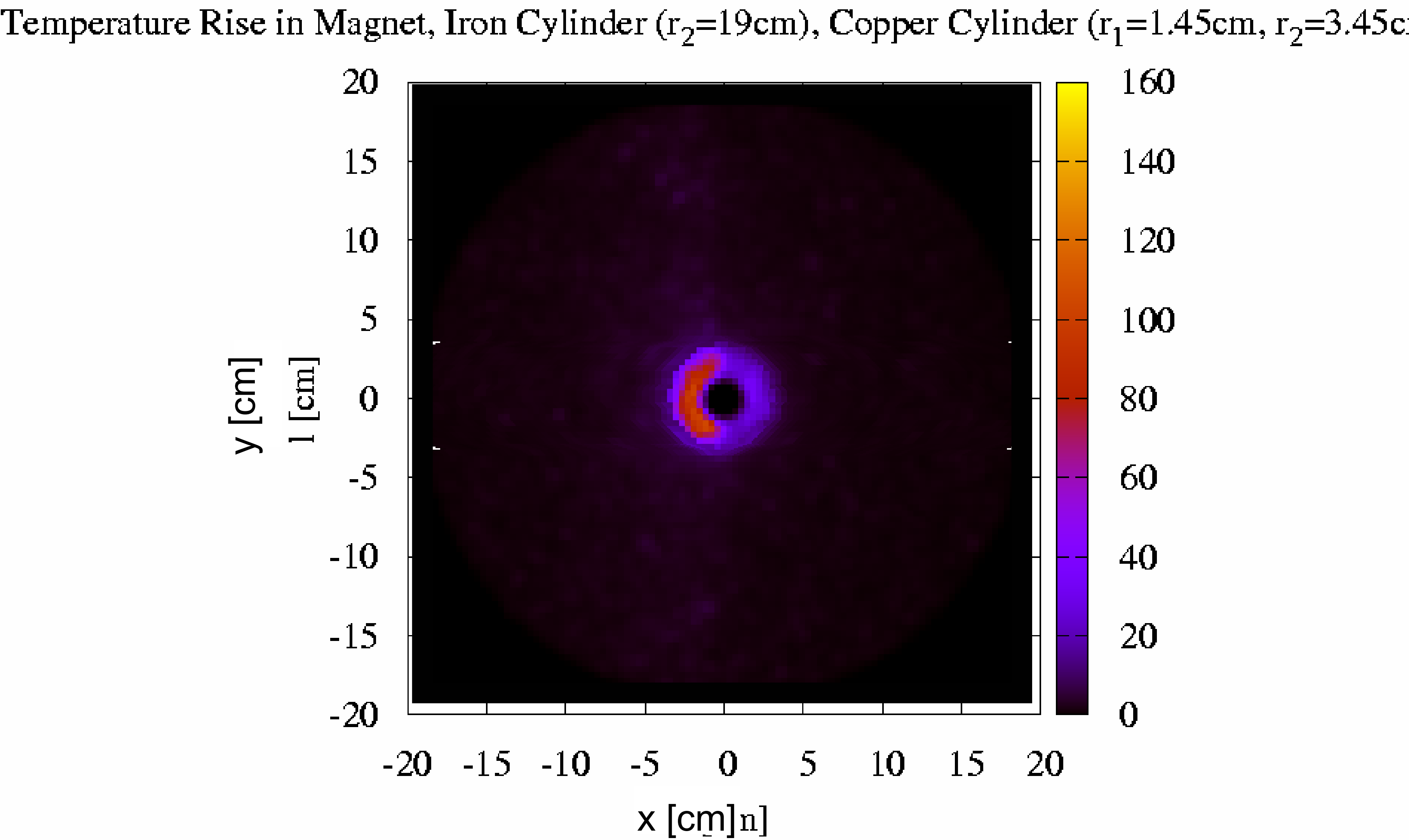
2m Collimator Jaw: 1σ impact parameter



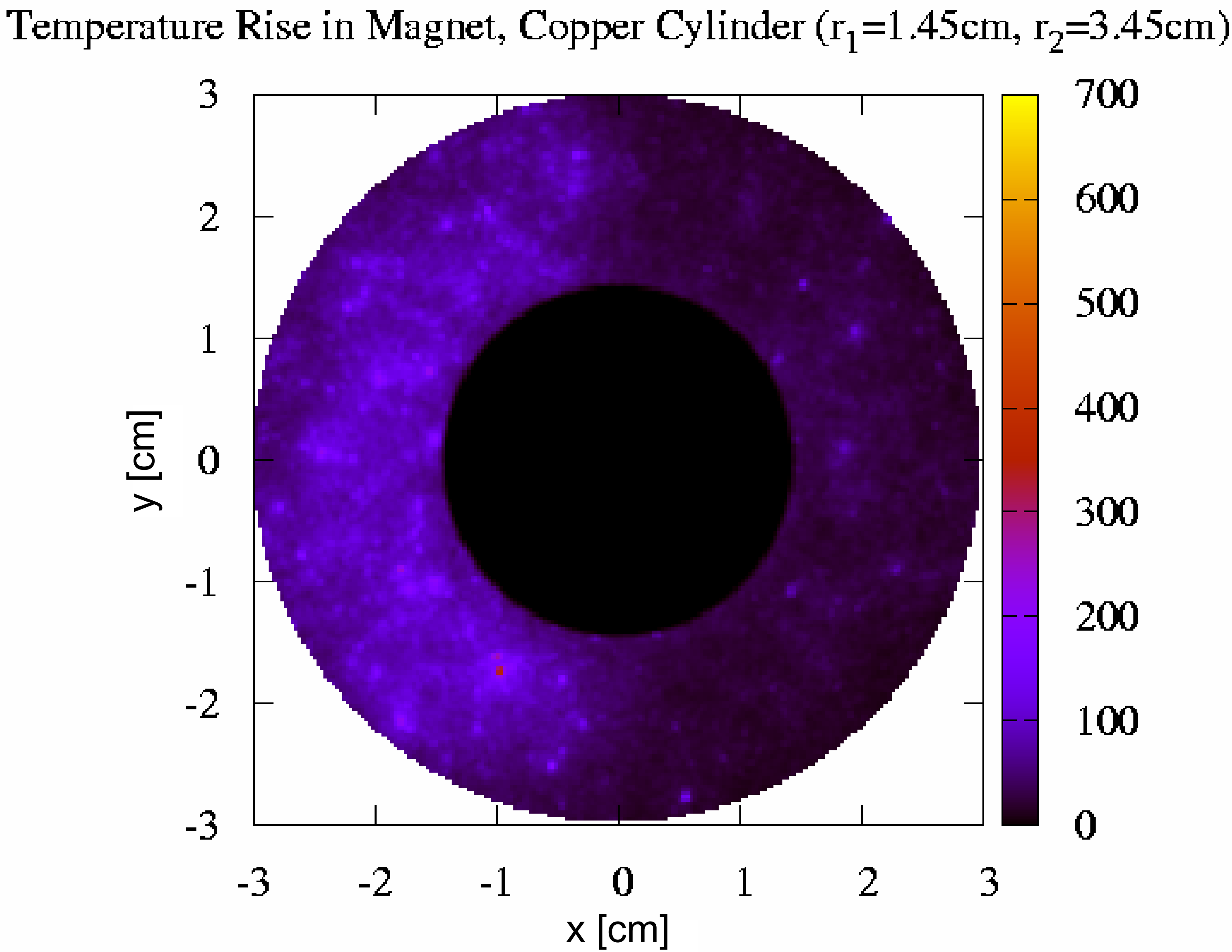
2m Collimator Jaw: 1σ impact parameter



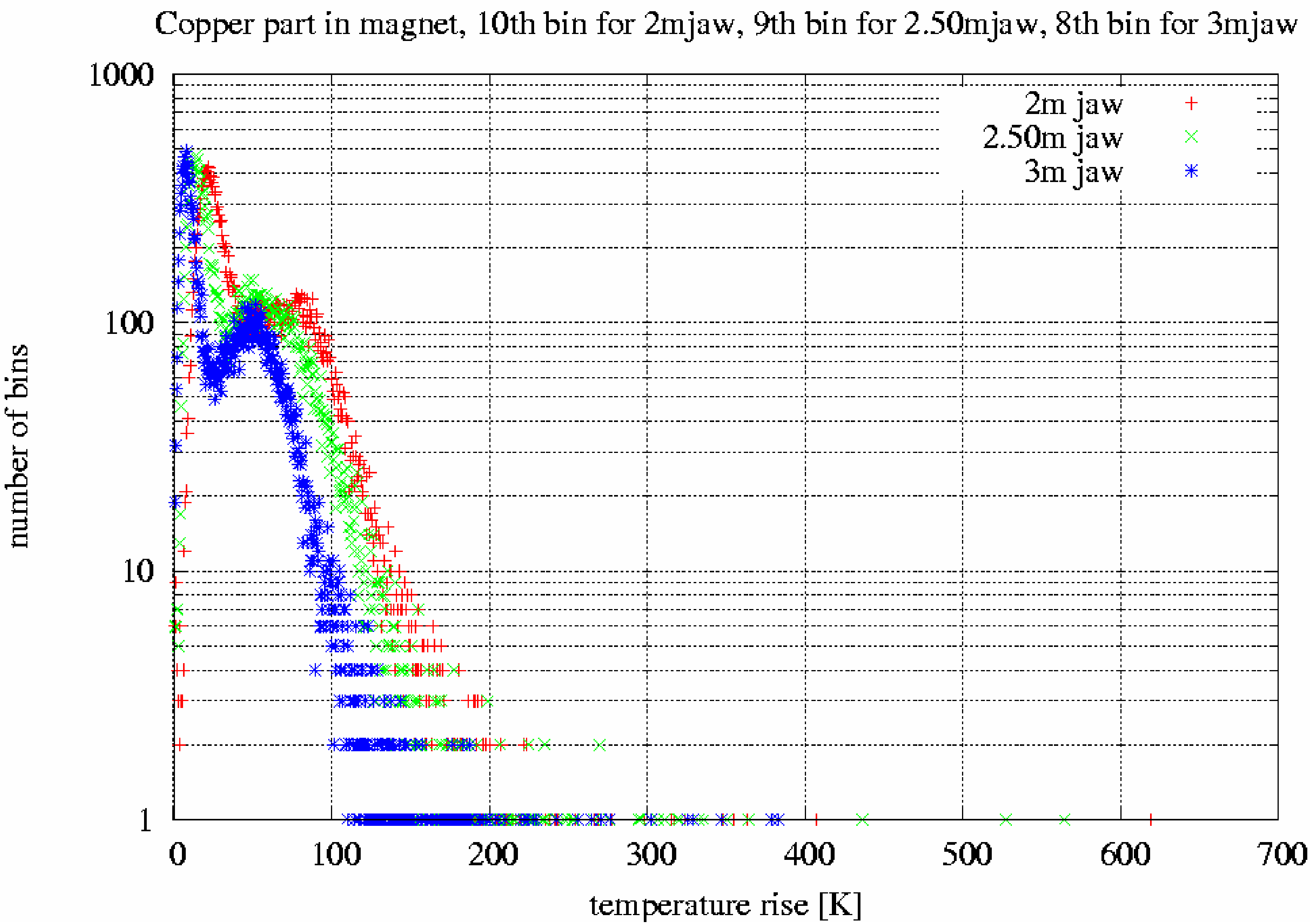
2m Collimator Jaw: 1σ impact parameter



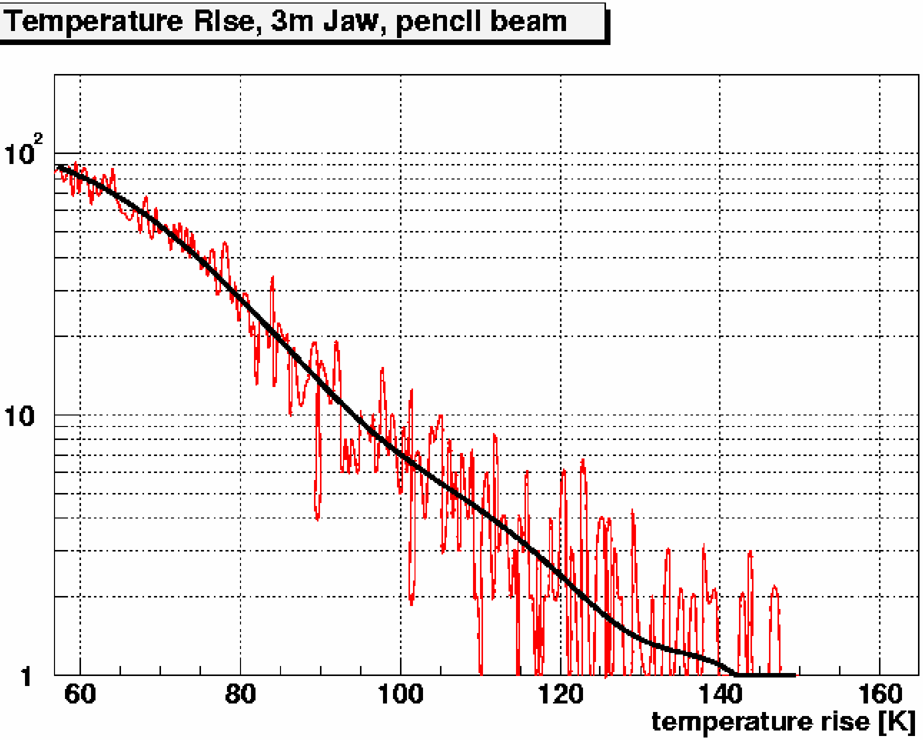
2m Collimator Jaw: 1σ impact parameter



Jaw length 2m, 2.5m and 3m: Comparison: Magnet



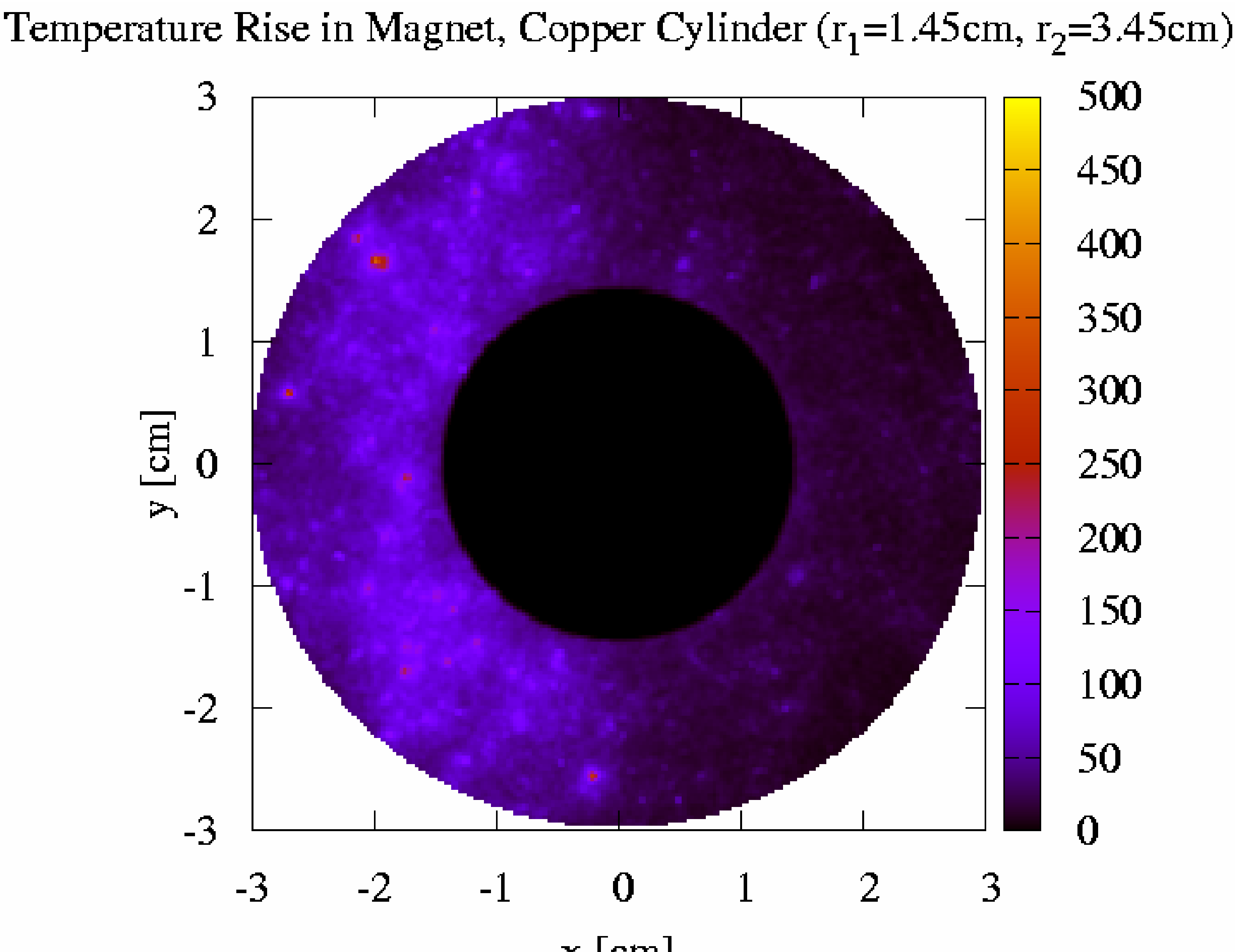
Approximate Numbers: pencil beam, 1σ impact parameter



Temperature Rise [K]

	flange1	flange3	Cu
3m	50	35	140
2m	60	40	210

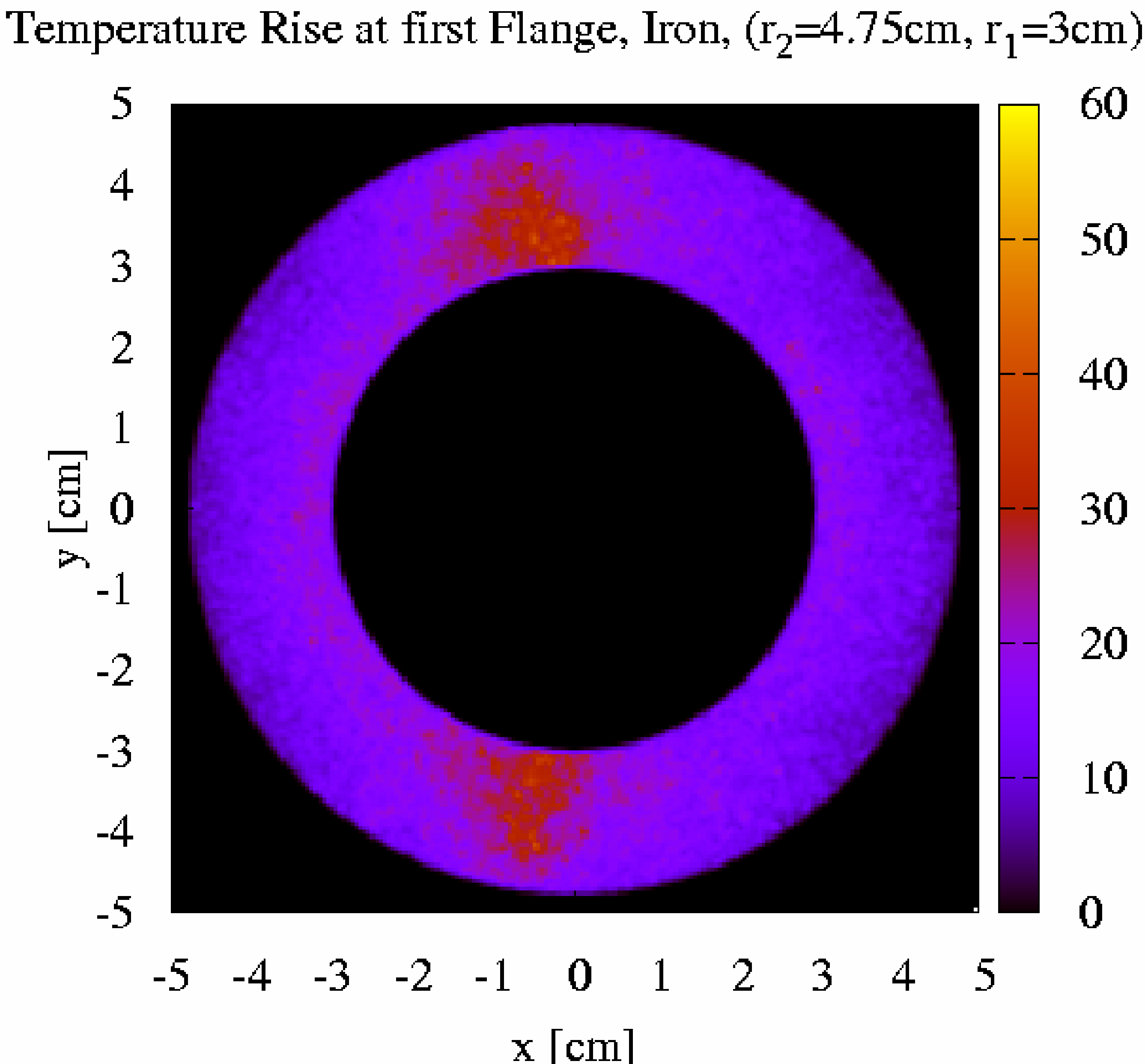
3m Collimator Jaw: 1σ impact parameter



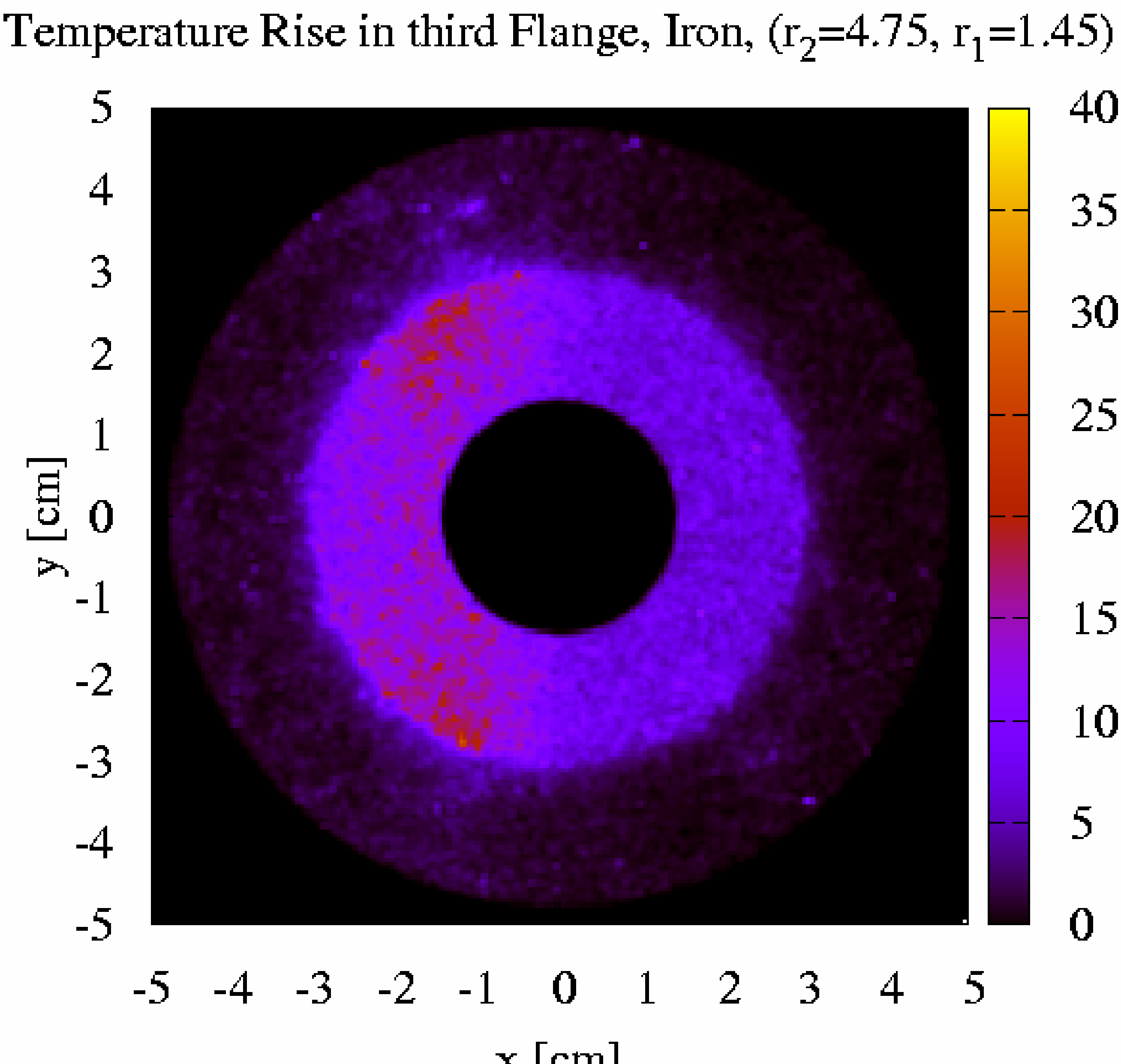
Other Scenarios and Checks…

- 3m jaw, 10^4 particles, 1σ impact parameter, pencil beam
- 2m jaws: longer longitudinal gap, wider gap between jaws
- Simulations with Gaussian distribution in x and x'
  - full batch (288 bunches, 450 GeV). Nominal Intensity.
  - Jaw length: 2m, 3m
- Different impact parameters:
  - full batch (288 bunches, 450 GeV). Nominal Intensity.
  - 3m jaw: 0σ, 0.25σ, 0.5σ, 1.5σ
- Impact parameter of (1.5cm-gap/2):
  - full batch (288 bunches, 450 GeV). Nominal Intensity. Gaussian Beam.
  - Jaw length: 2m, 3m

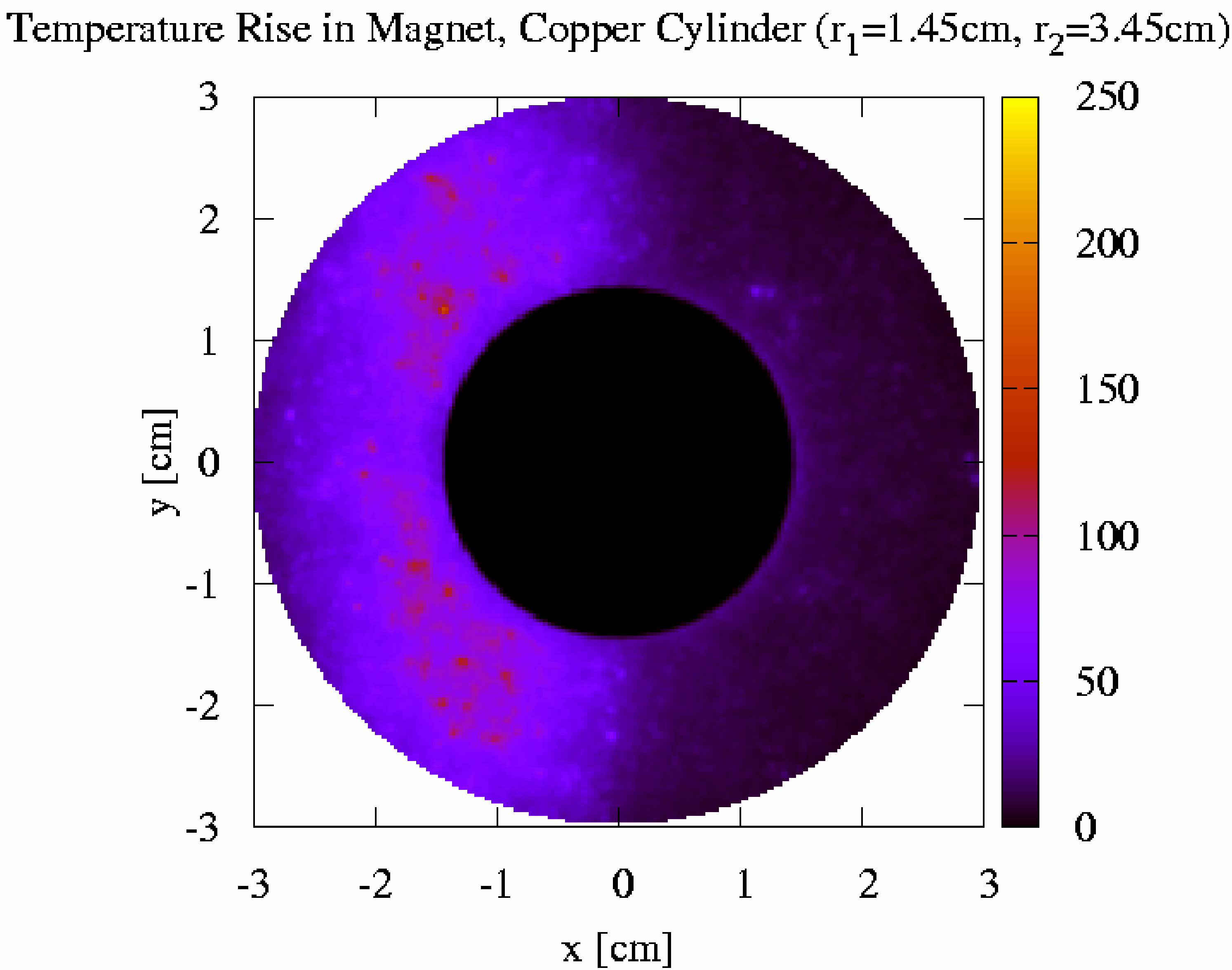
3m jaw: 10k particles, 1σ impact parameter



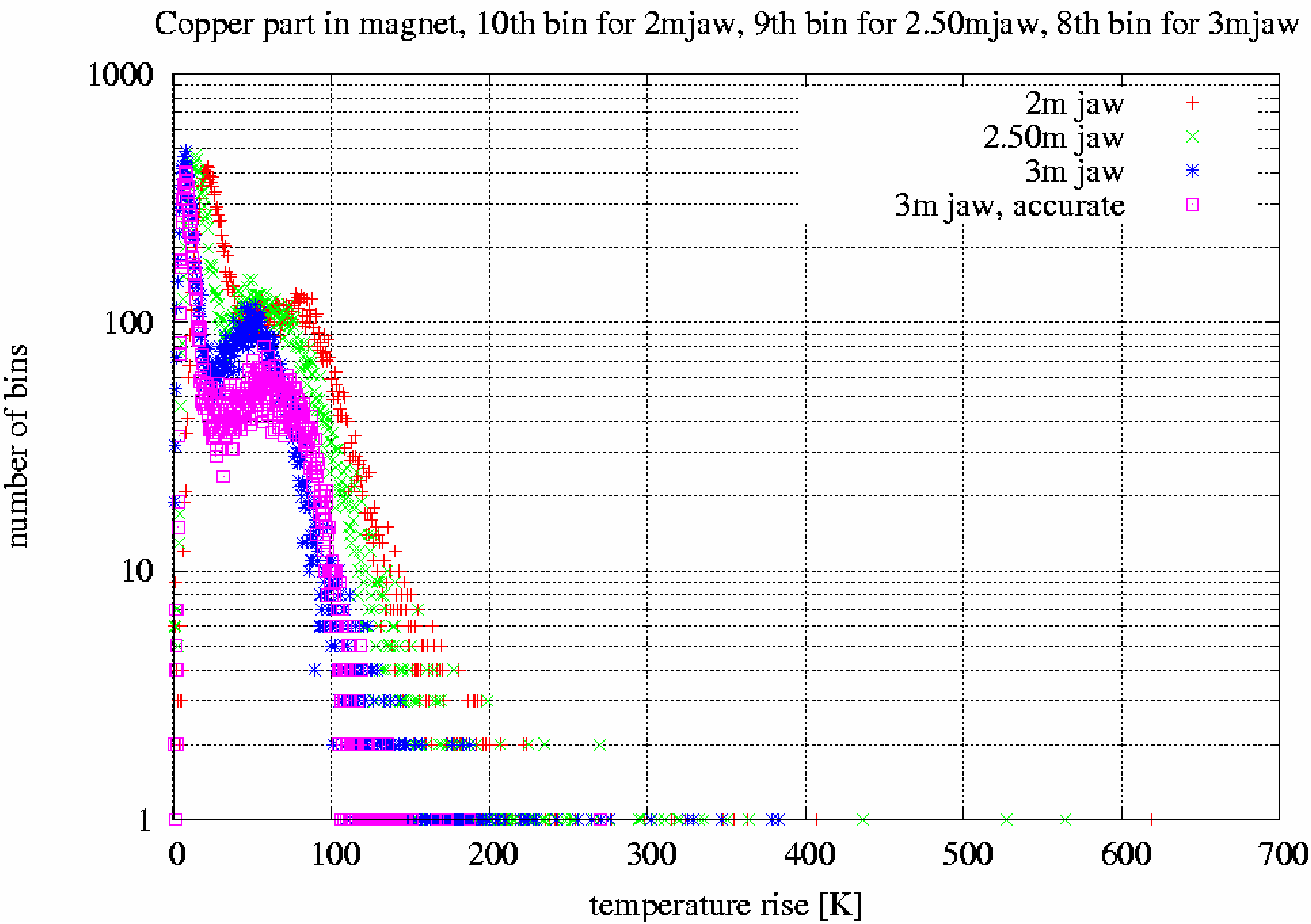
3m jaw: 10k particles, 1σ impact parameter



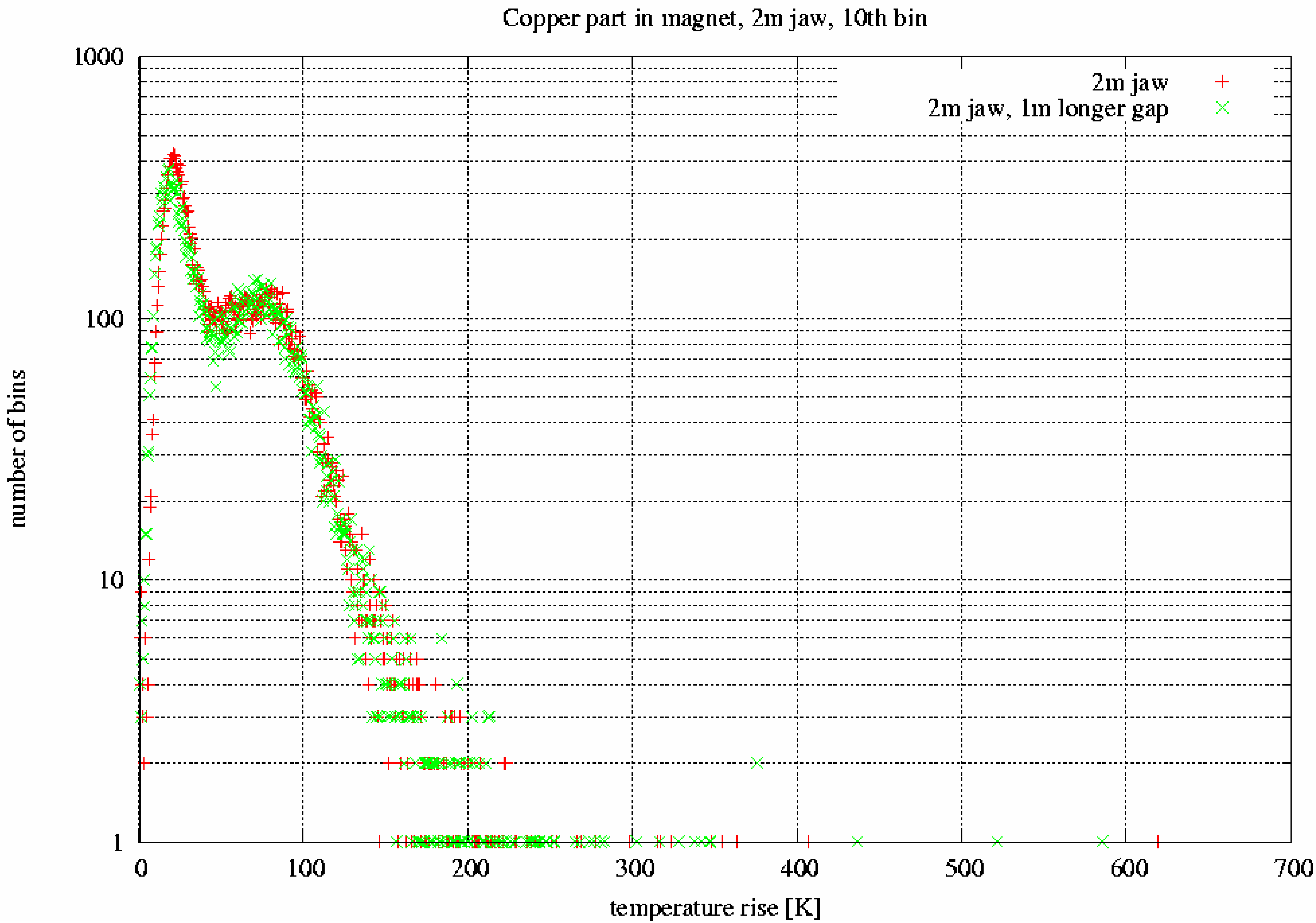
3m jaw: 10k particles, 1σ impact parameter



3m jaw: 10k particles, 1σ impact parameter



2m jaw: 1m longer gap before first flange



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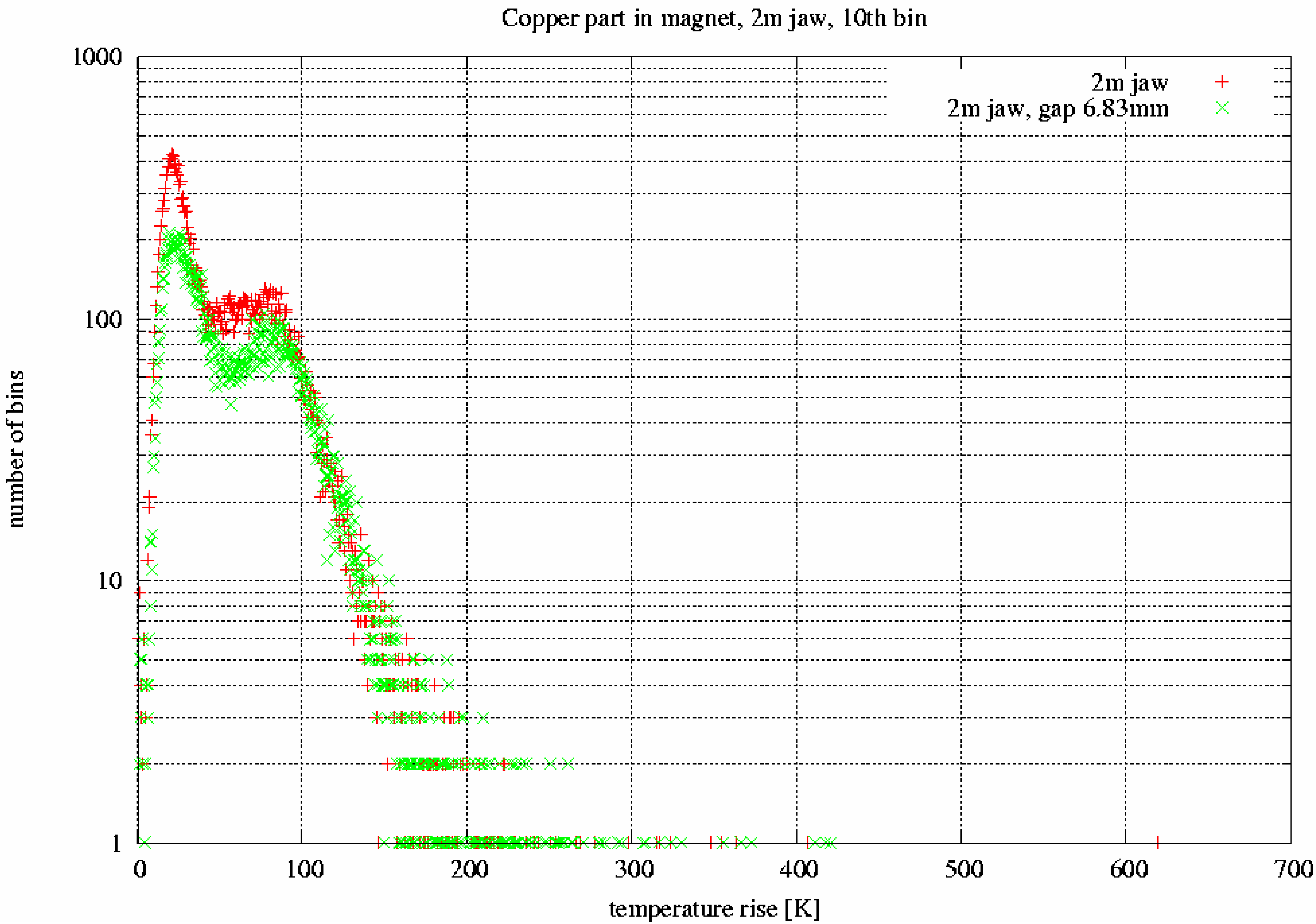
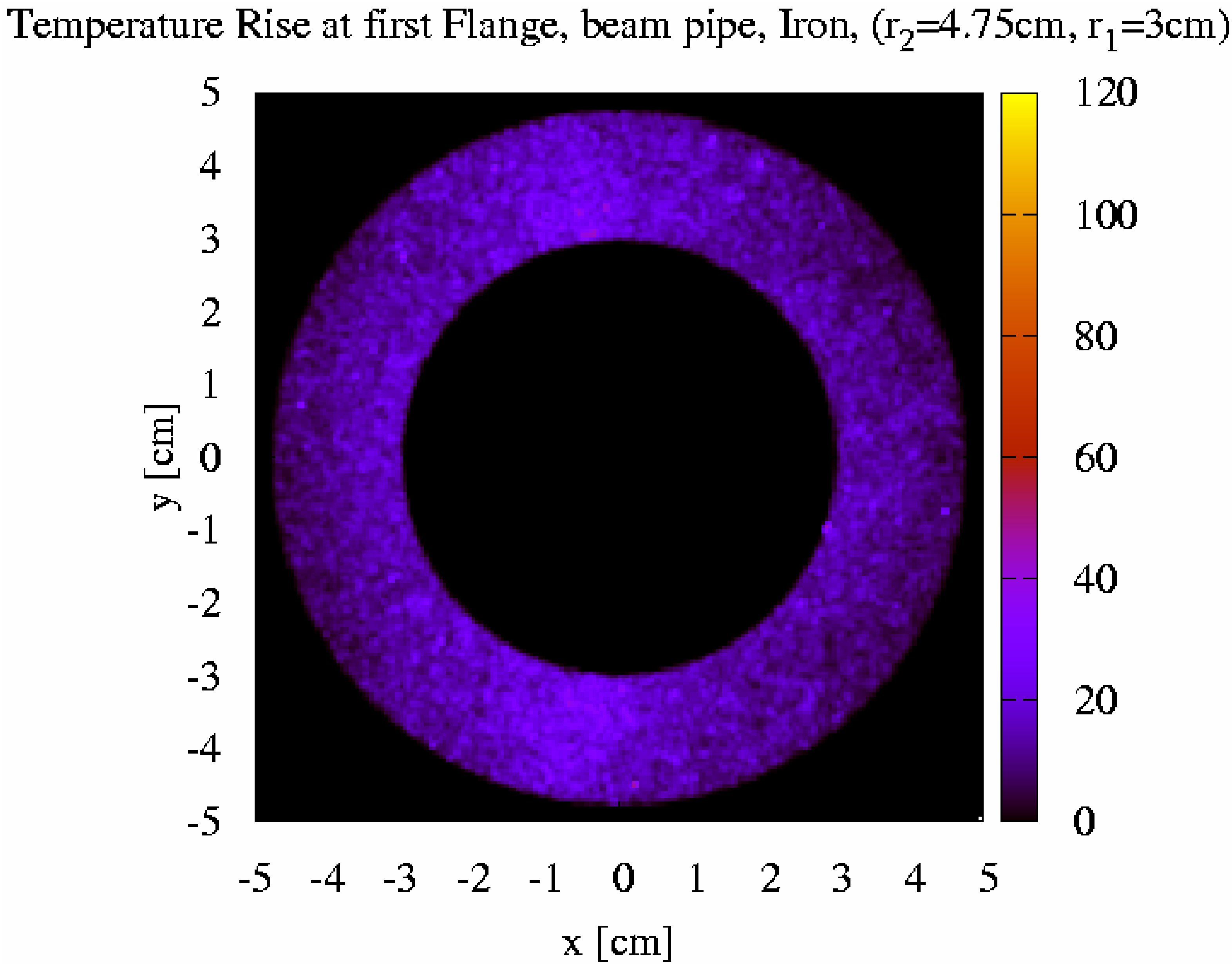
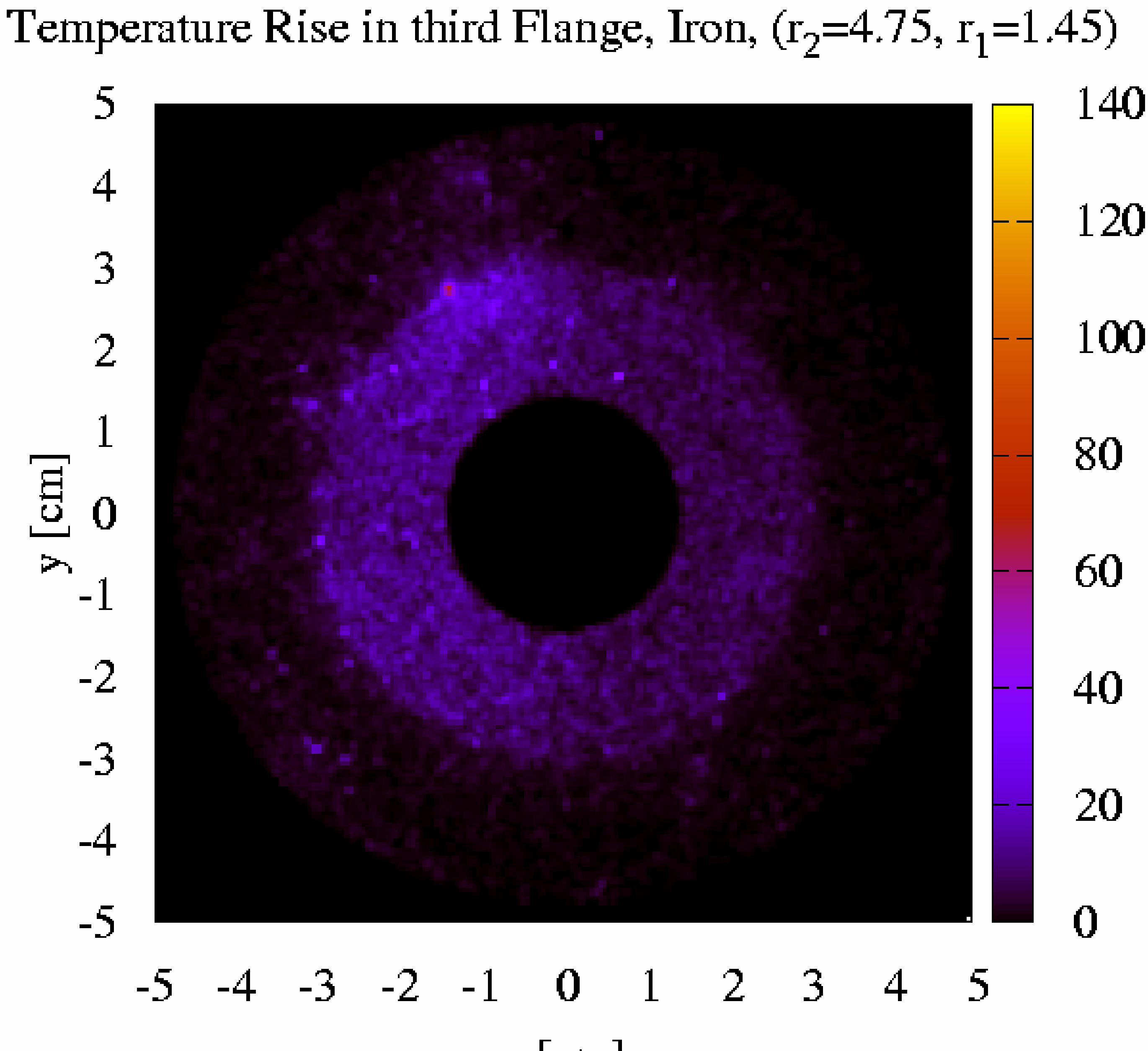
2m jaw: gap of 6.83 mm between jaws



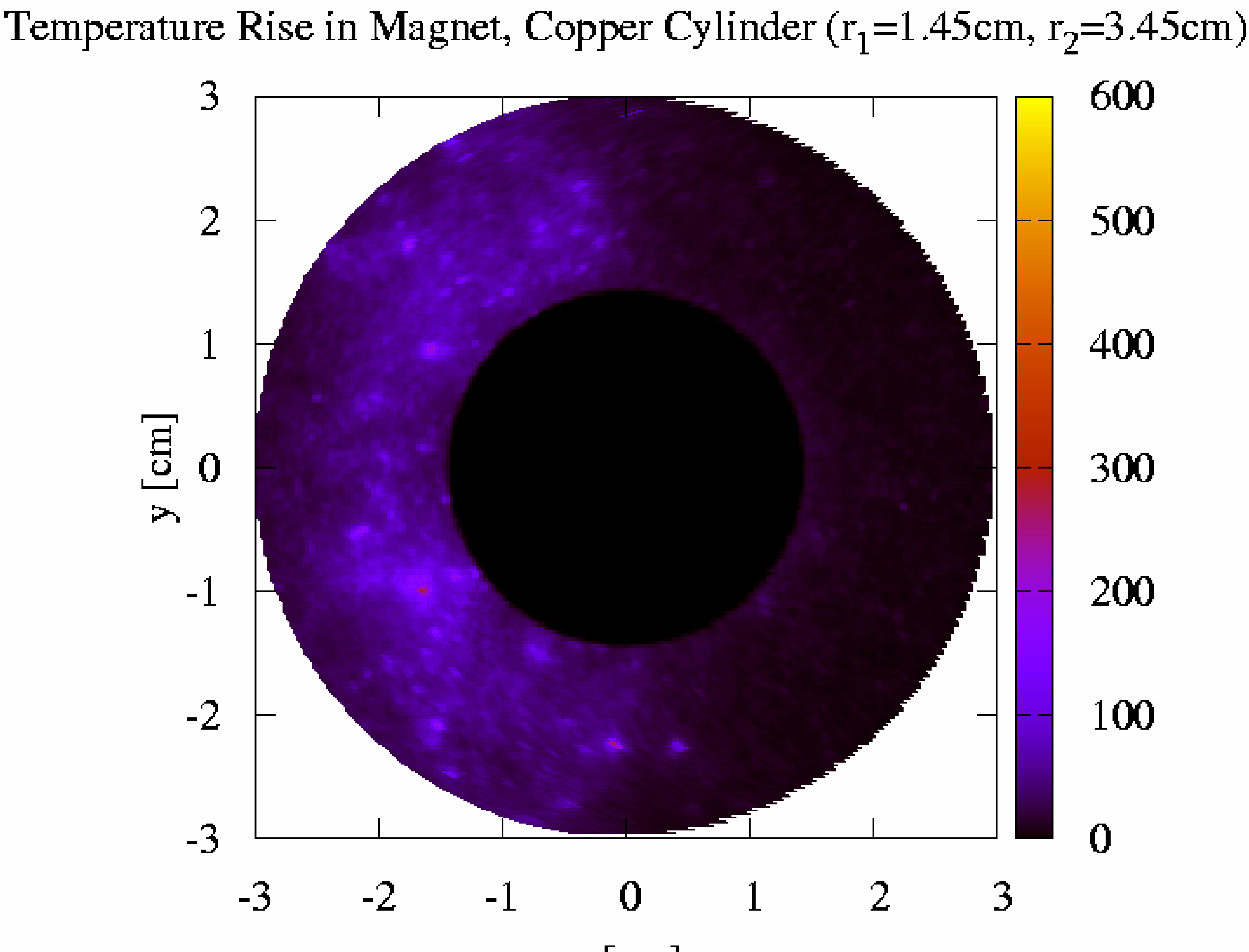
3m jaw: Gaussian beam, 1σ impact parameter

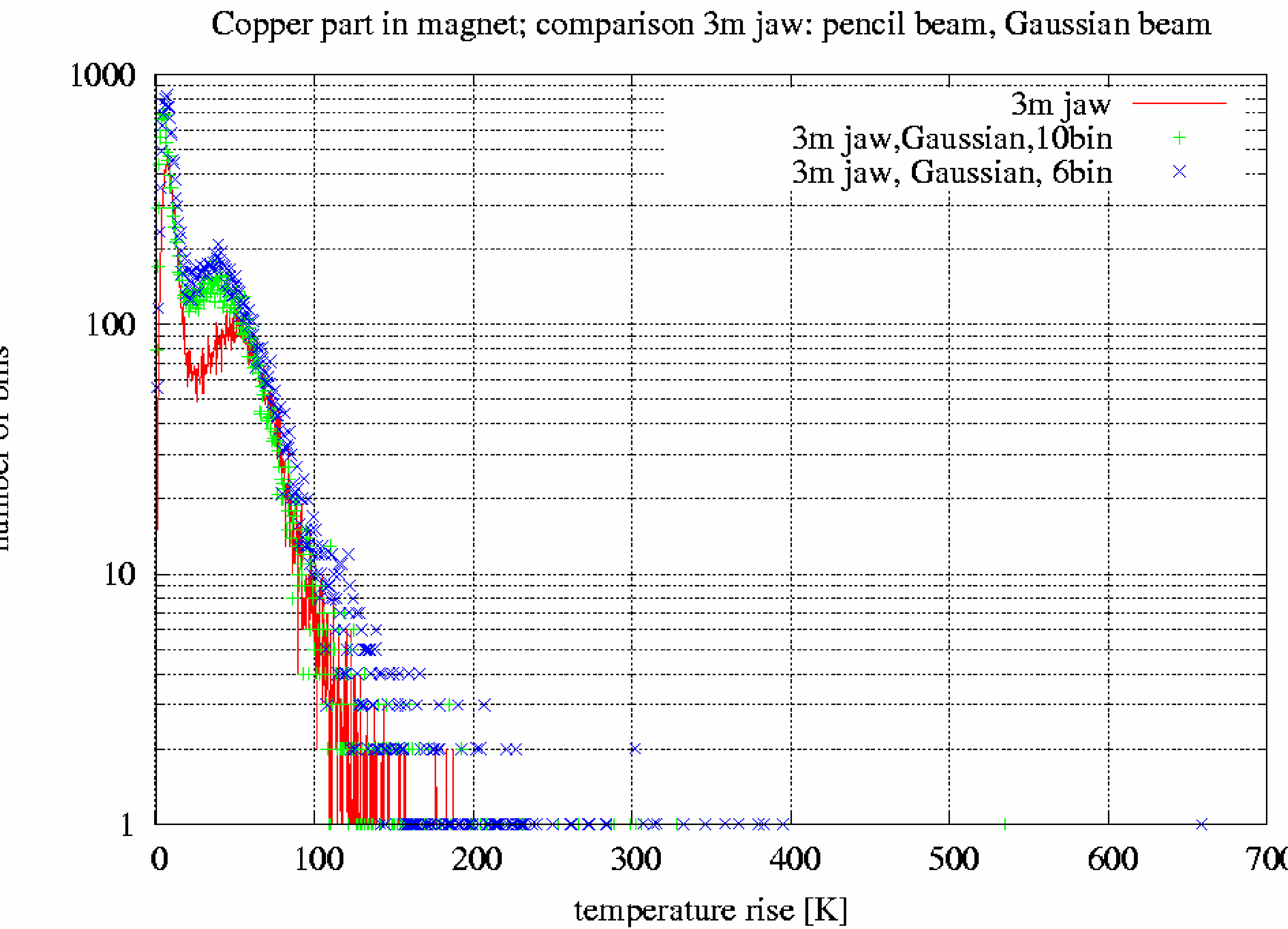


3m jaw: Gaussian beam, 1σ impact parameter



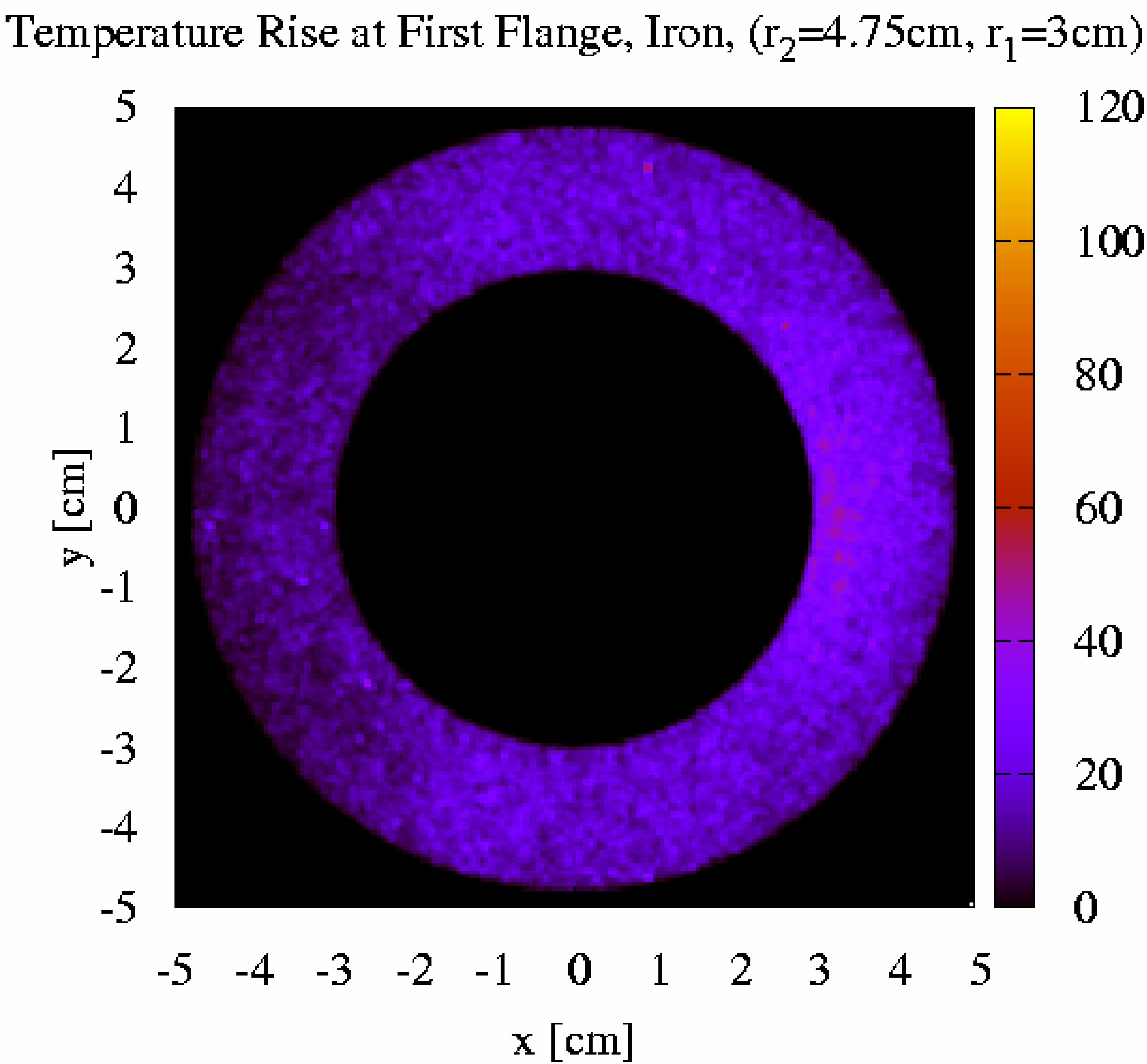
3m jaw: Gaussian beam, 1σ impact parameter



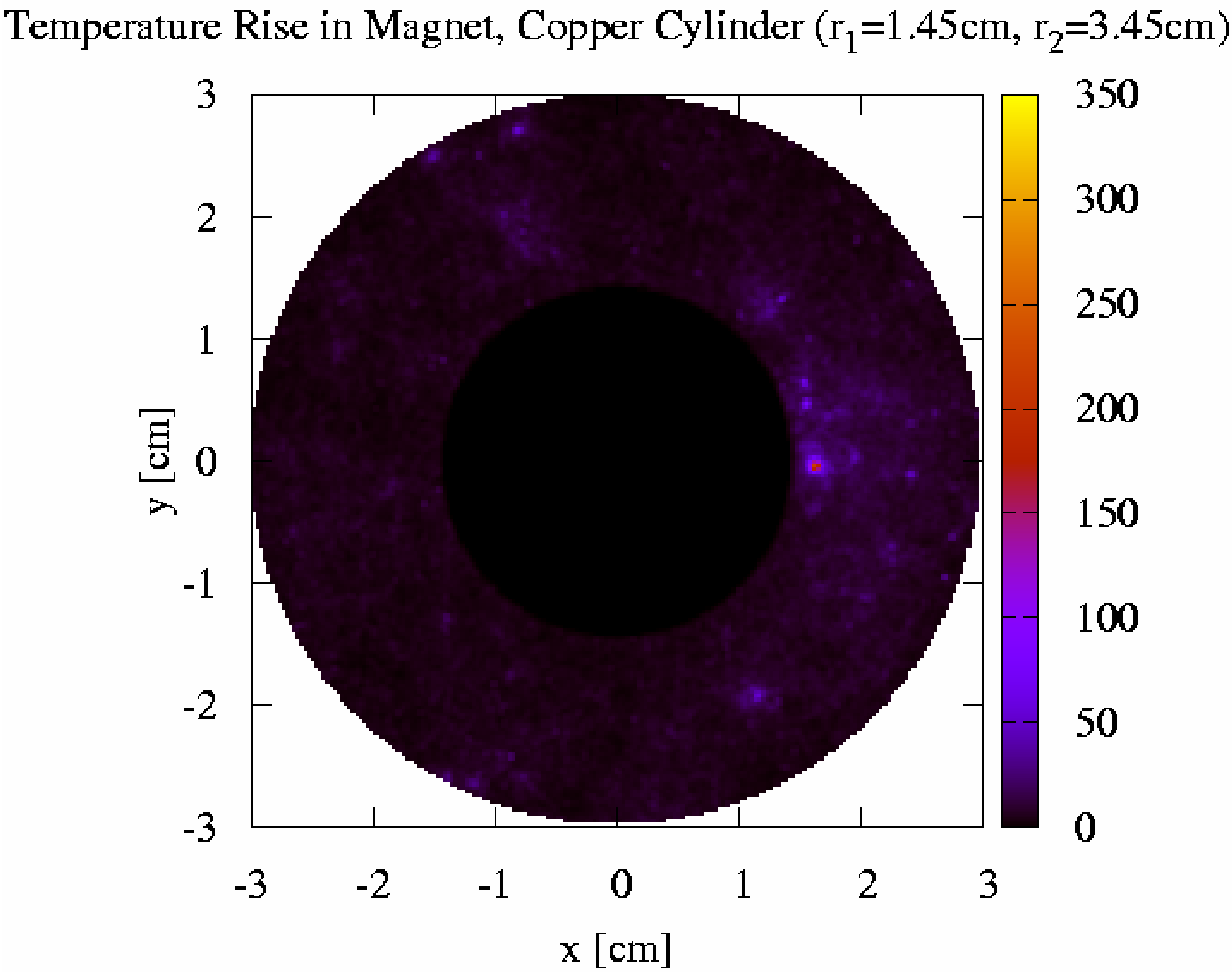


Copper part in magnet; comparison 3m jaw: pencil beam, Gaussian beam
3m jaw
3m jaw,Gaussian,10bin
3m jaw, Gaussian, 6bin
1000
100
10
1
0
100
200
300
400
500
600
700
temperature rise [K]
number of bins

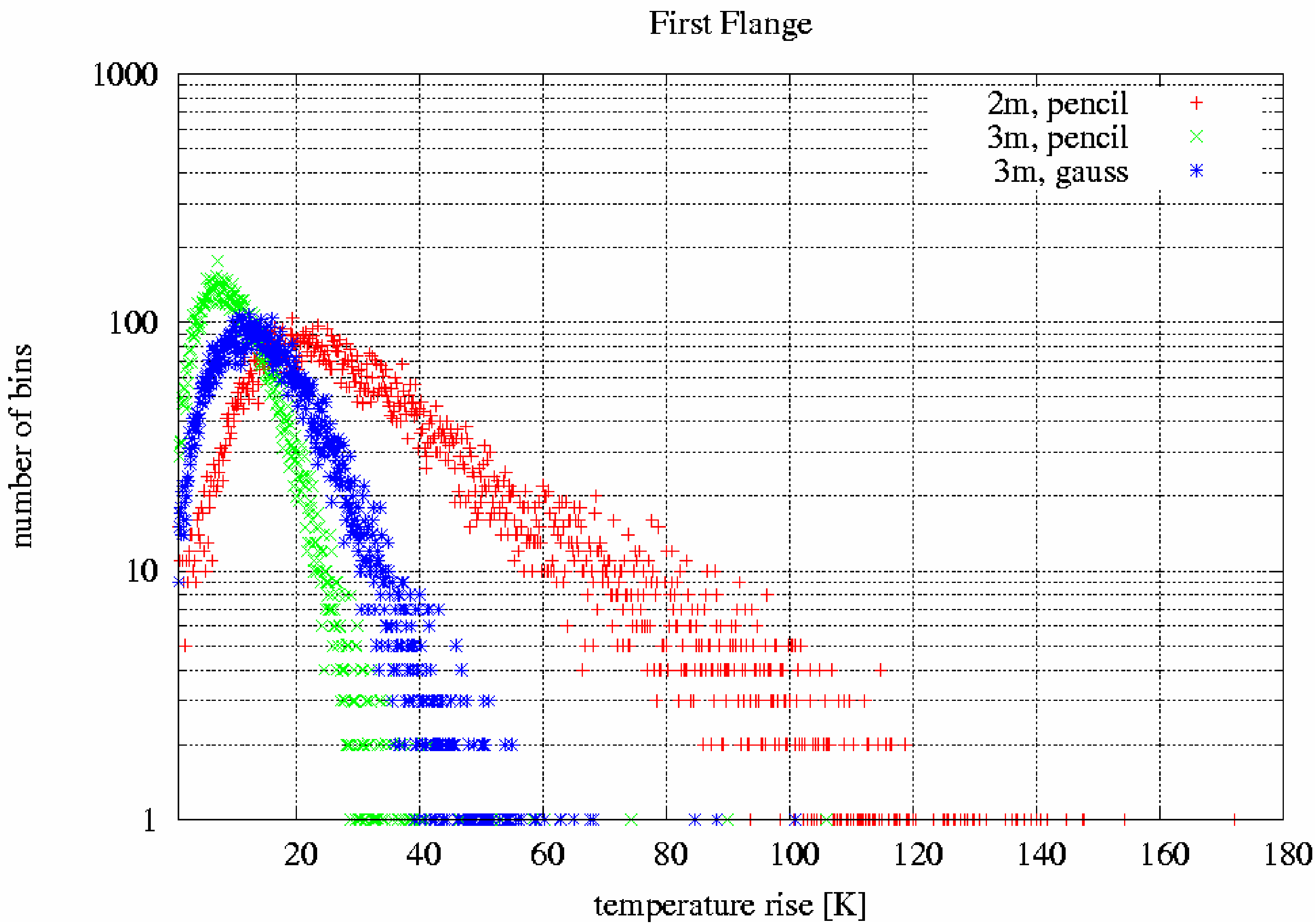
3m jaw: Gaussian beam, 1.5cm-gap/2 impact parameter



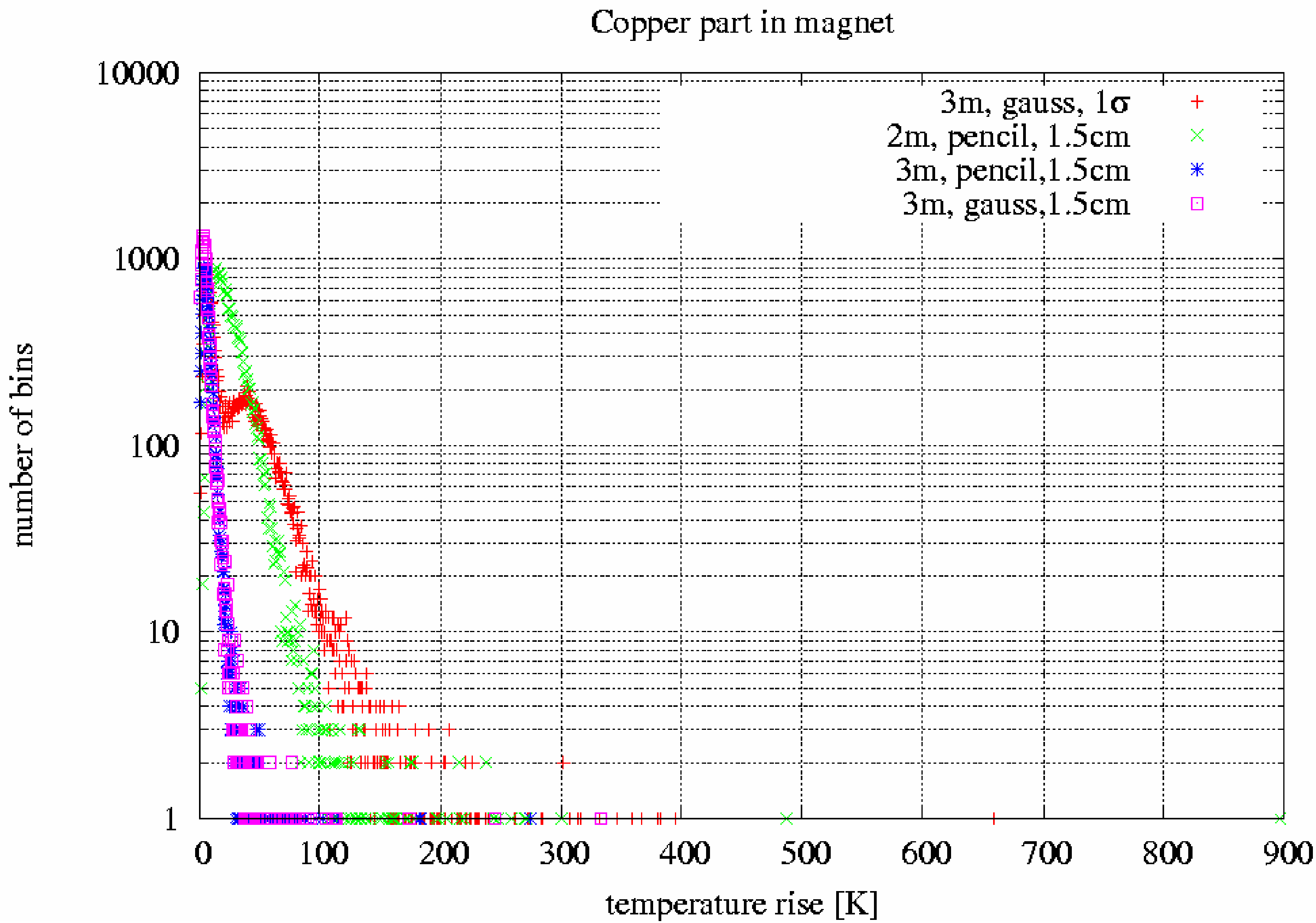
3m jaw: Gaussian beam, 1.5cm-gap/2 impact parameter



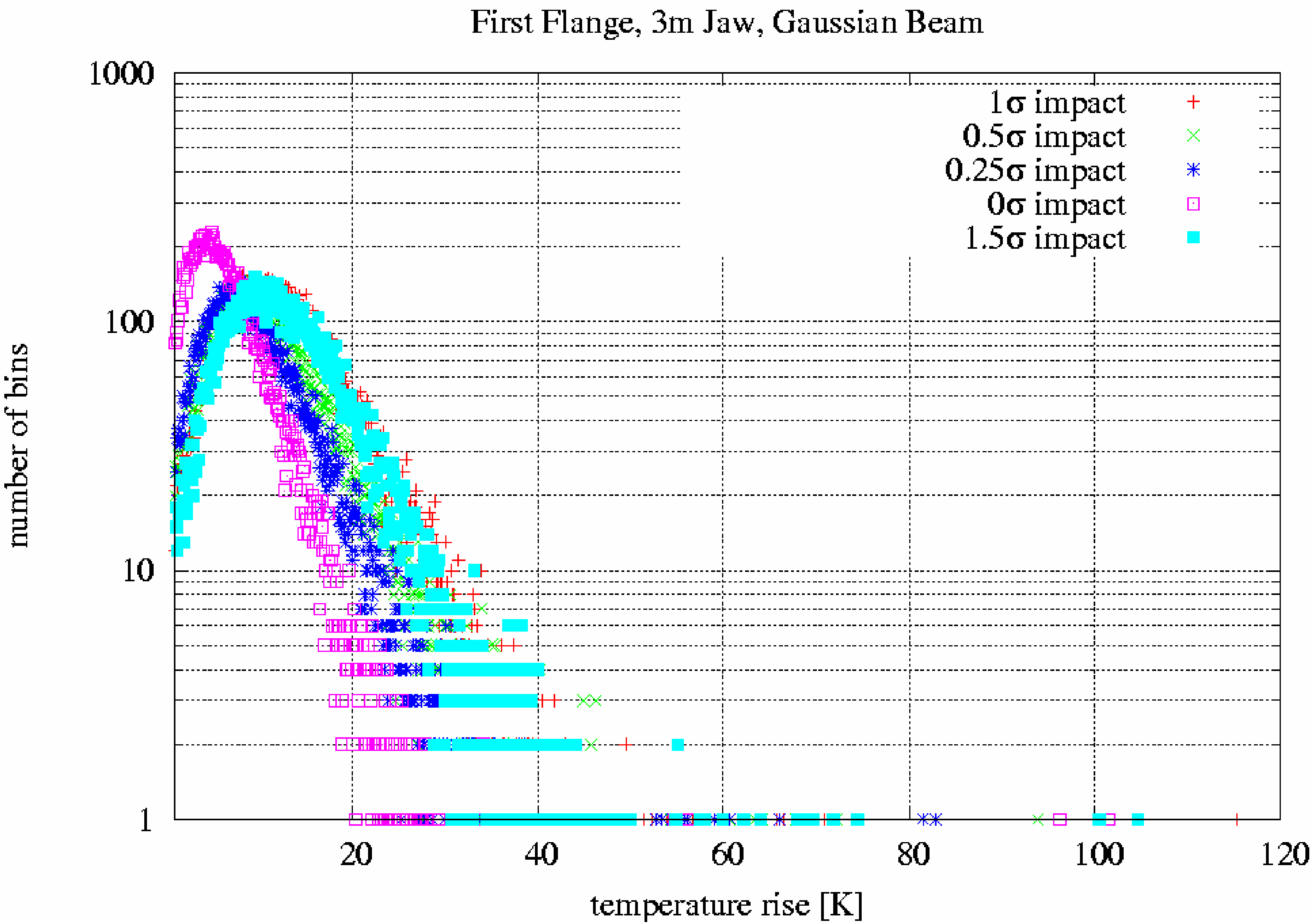
1.5cm-gap/2 impact parameter



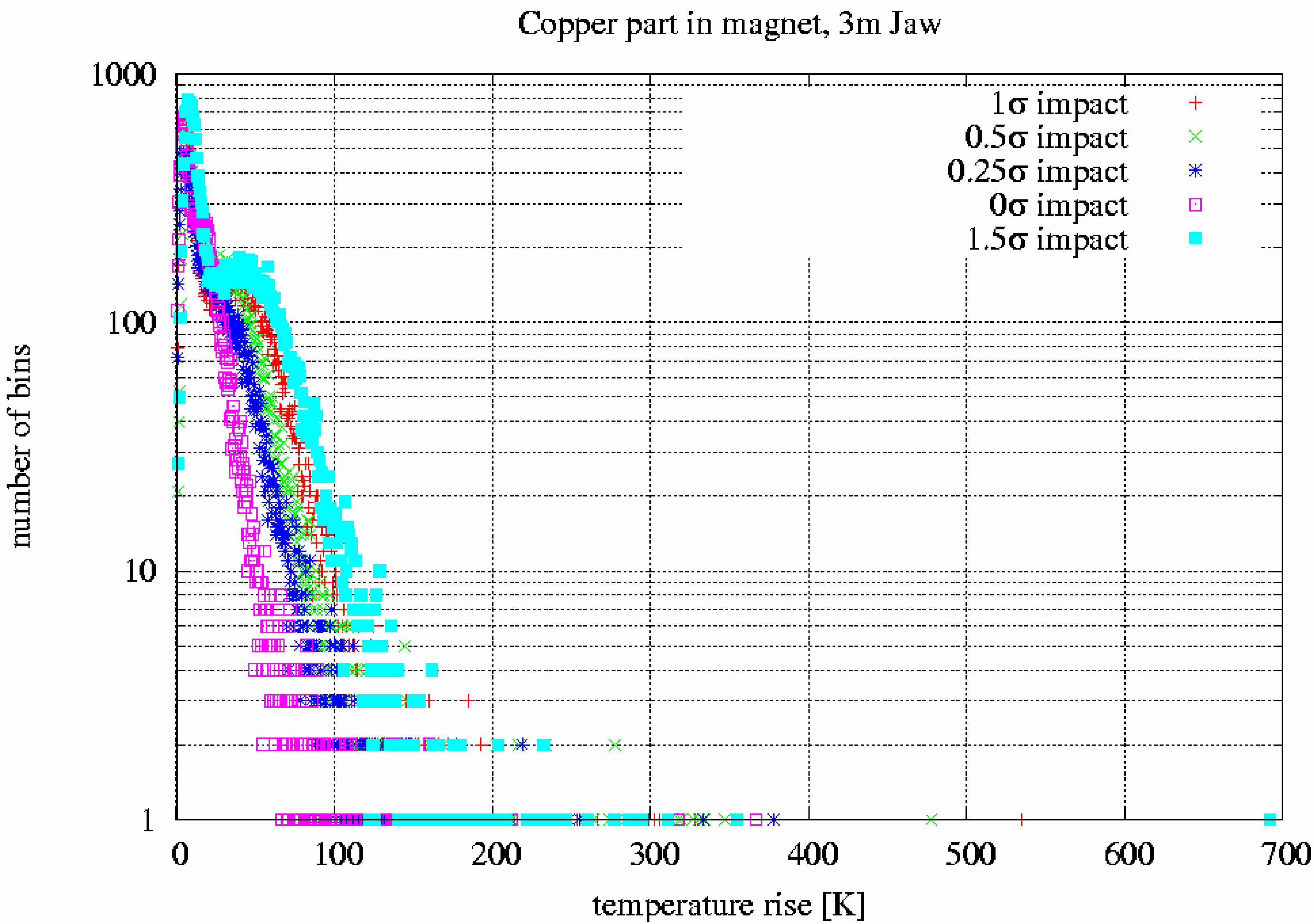
1.5cm-gap/2 impact parameter



3m Jaw, Gaussian Beam, different Impact Parameters



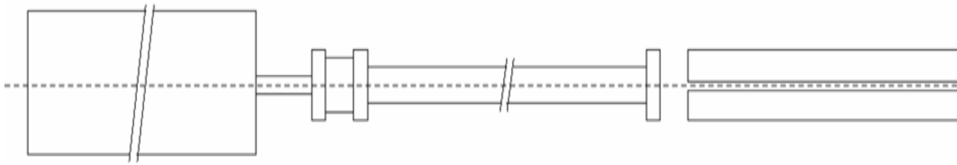
3m Jaw, Gaussian Beam, different Impact Parameters



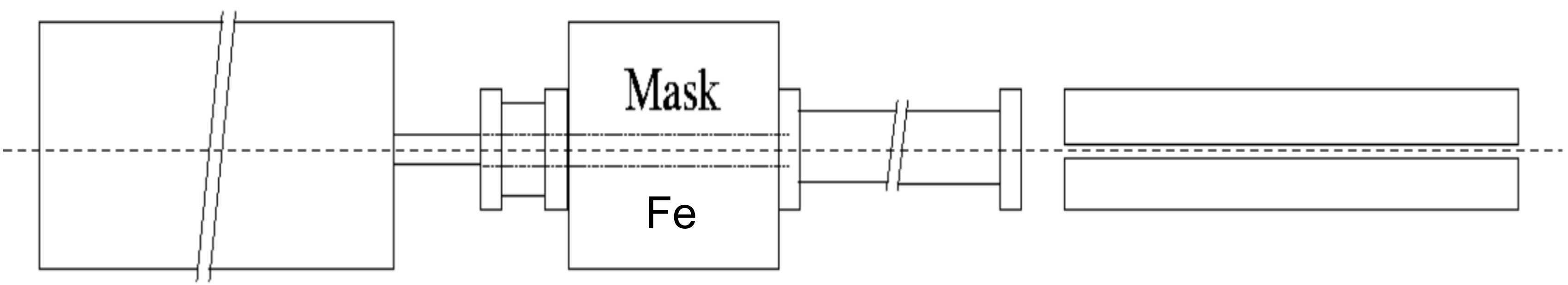
Out-scattering might be a problem…

- 3m Jaws (Gaussian beam): ΔT~180K in Cu of magnet
- Solution: Additional shielding (Mask, Fe) to protect magnet

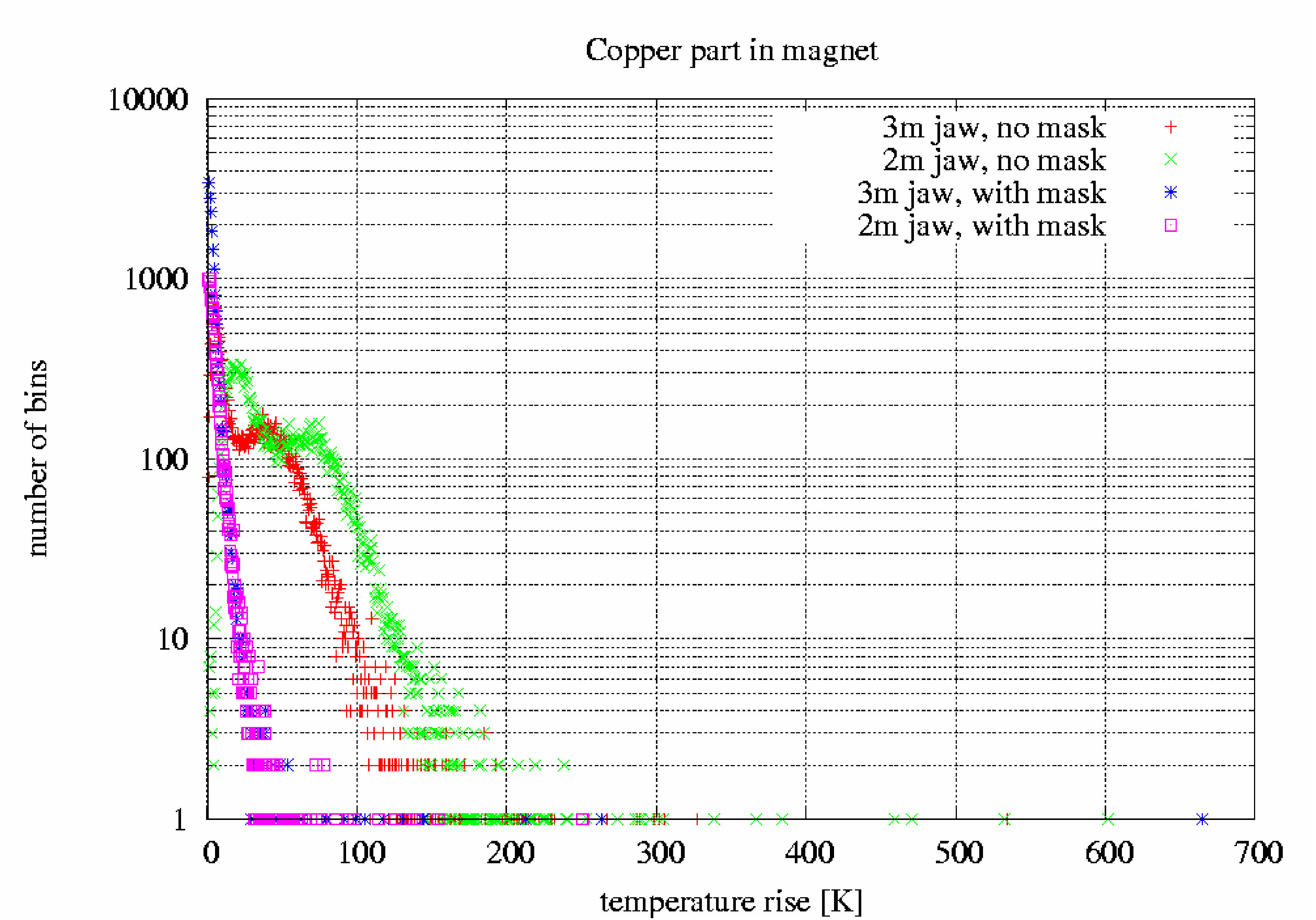
Original Layout



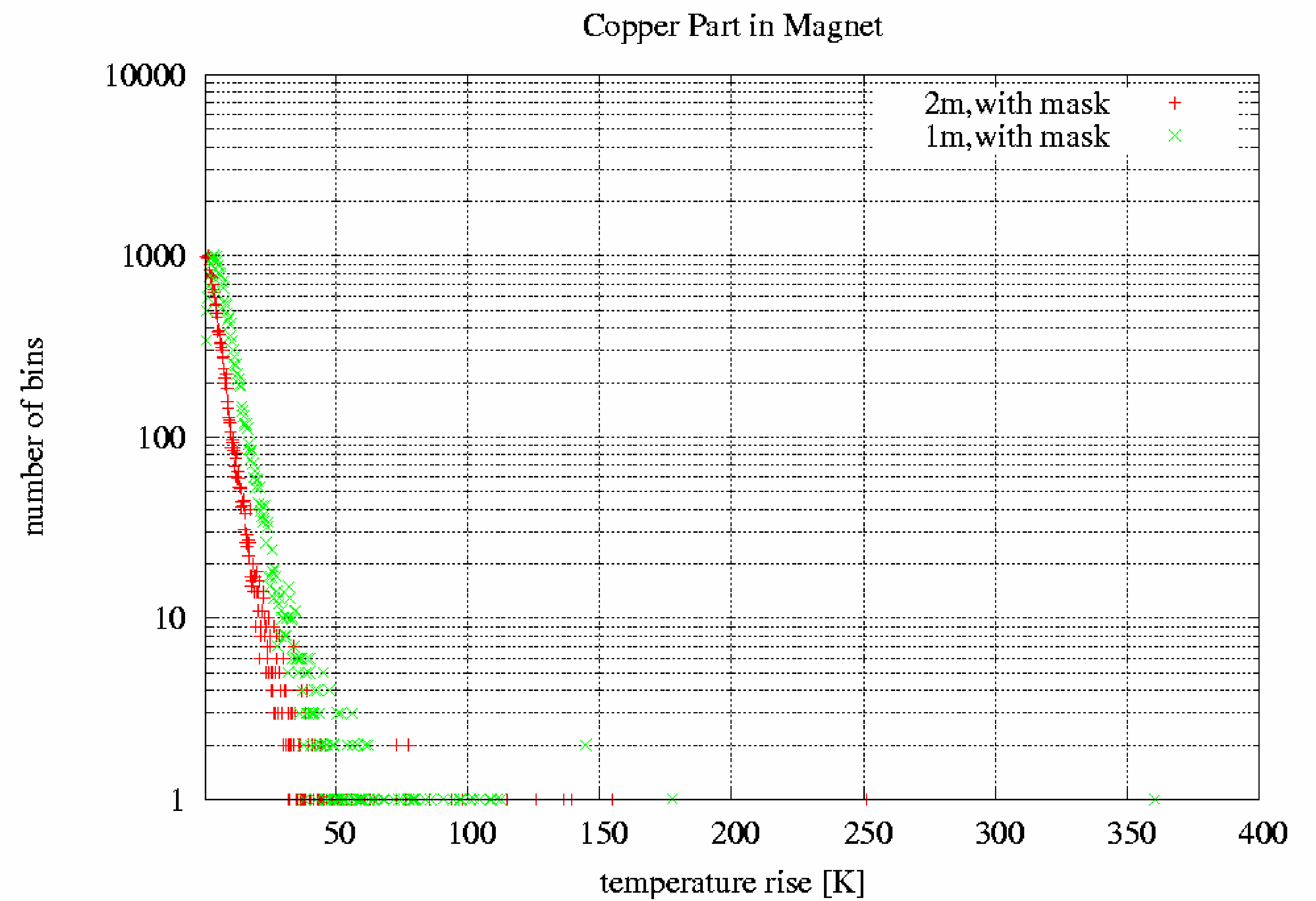
Layout with Mask (same diameter as magnet), additional flang



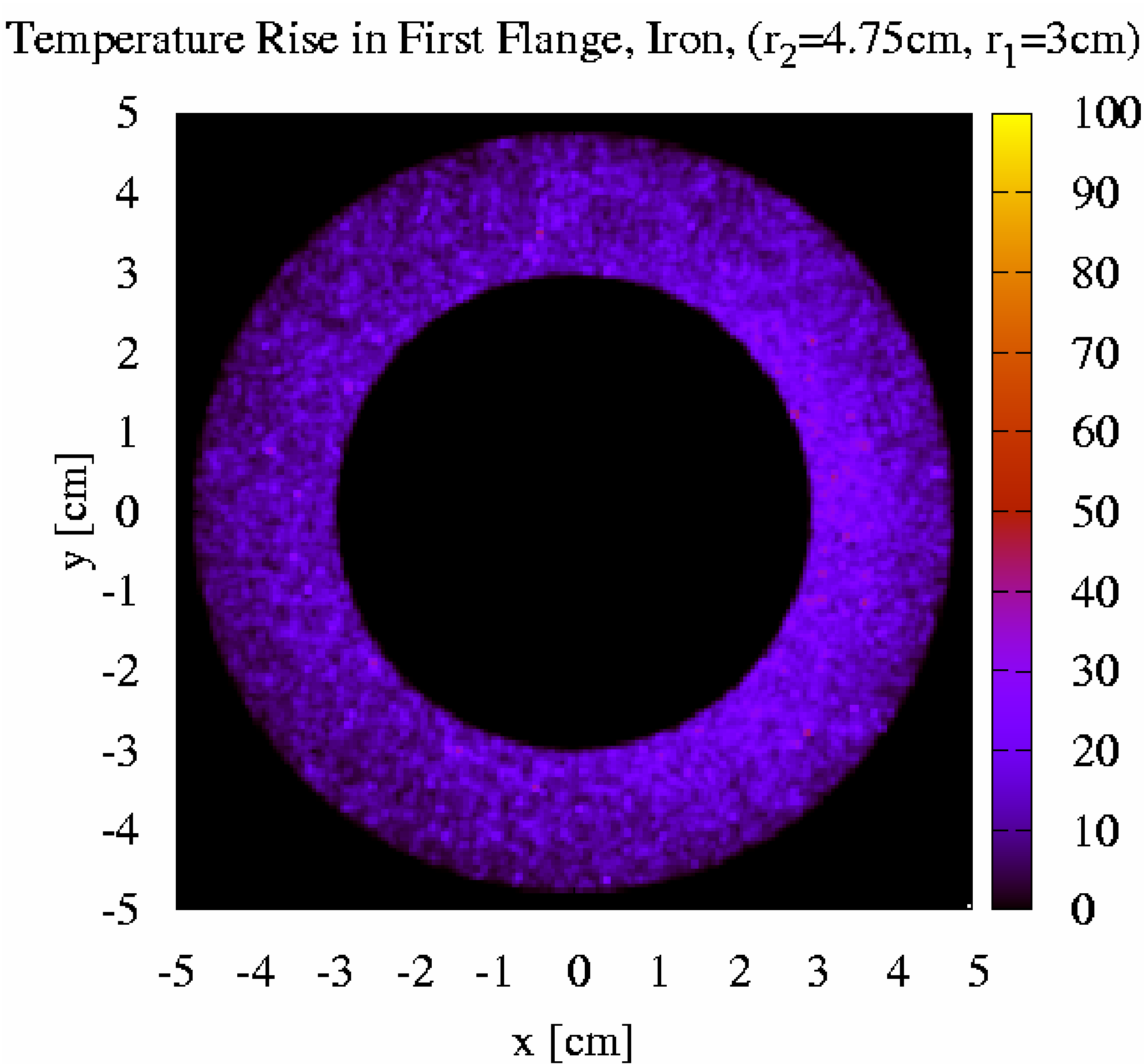
Mask: 1σ impact, Gaussian beam



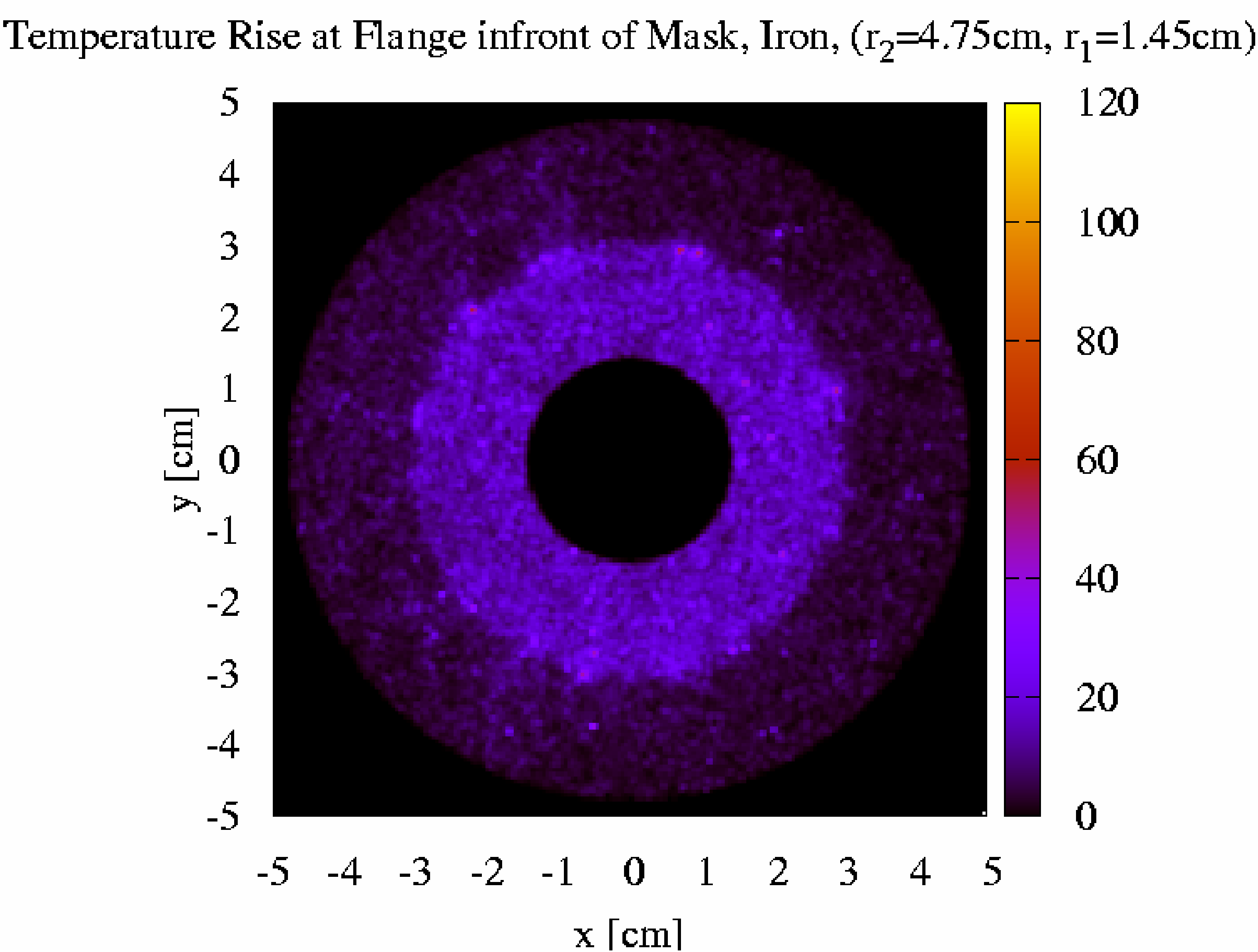
Mask: 1σ impact, Gaussian beam; Comparison with 1m Jav



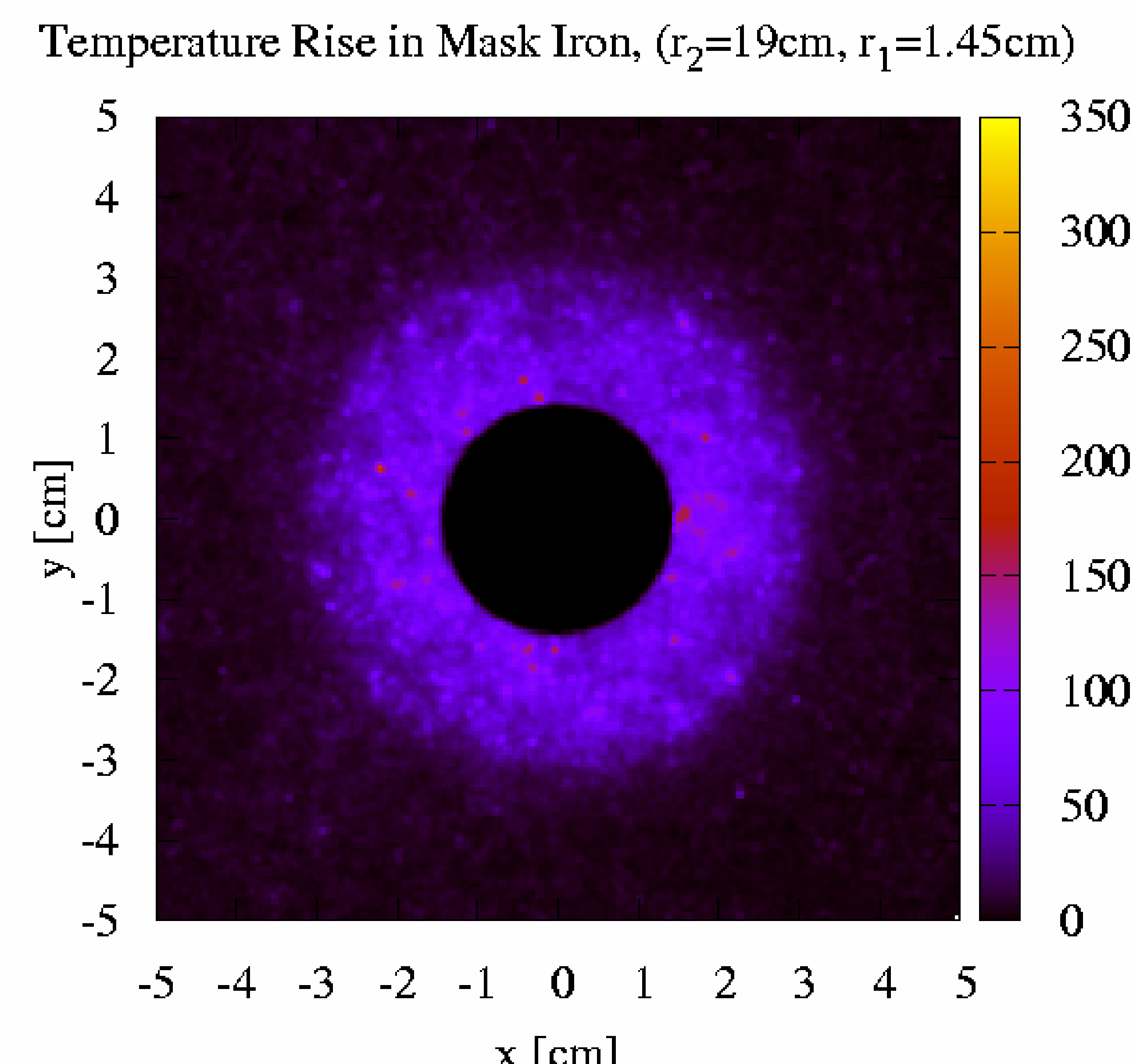
Mask: 1m Jaw, 1σ impact, Gaussian beam



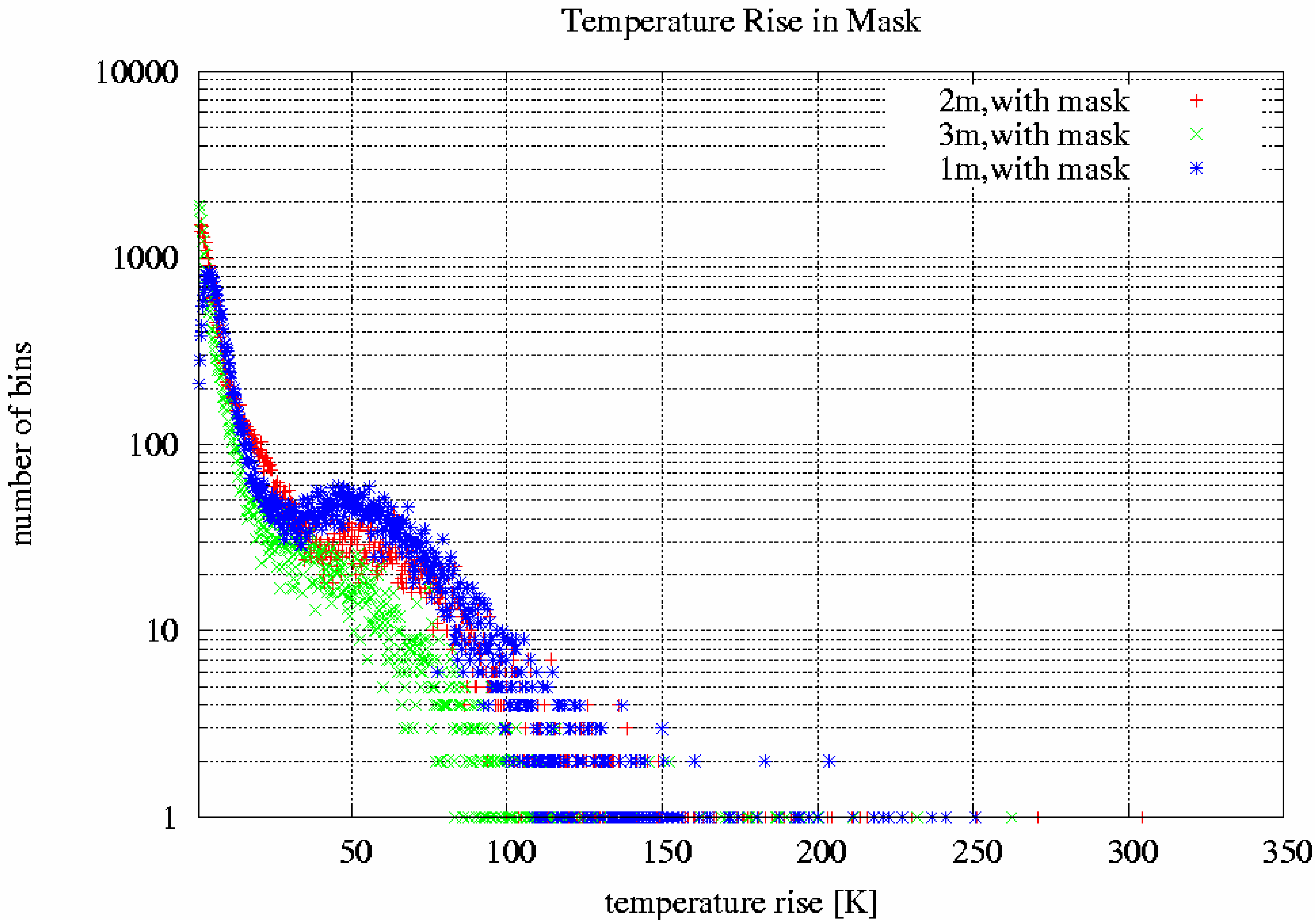
Mask: 1m Jaw, 1σ impact, Gaussian beam



Mask: 1m Jaw, 1σ impact, Gaussian beam



Mask: 1σ impact, Gaussian beam



Numbers… Peak Temperature Rise [K]

3m Jaw, Gaussian Beam

Impact Par.	flange 1	Cu
1.5 σ	50	200
1 σ	50	180
0.5 σ	40	160
0.25 σ	35	140
0 σ	30	110

Impact parameter: 1.5cm-gap/2

Jaw	flange 1	Cu
2m, pencil	110	140
3m, pencil	35	50
3m, gauss.	50	60

Mask: impact par.1σ, Gauss. bear

Jaw	fl@mask	mask	Cu
1m	40	145	65
2m	35	135	50
3m	25	115	40

All simulations for impact of 288 bunches, nominal intensity.

Conclusion

- **No Mask**:
  - Small impact parameters: out-scattering:
    - Flanges, beam pipes: OK for all jaw lengths
    - Cu-part in Magnet:
      - even 3m jaws (1σ impact parameter): peak temperature rise ~180K
      - Impact parameters <1σ less severe
  - Big impact parameter:
    - Cu-part in Magnet: OK for 3m jaw
    - first flange: not too short collimator jaws (max. impact parameter to be checked)
- **Mask**:
  - out-scattering: solution works
  - 3m long jaws not necessary
  - Cu-part in Magnet: 1m jaw (1σ impact parameter) : peak temperature rise ~65K
  - → LHC-type secondary collimators (length: 1.2m)?
- **Concept for TCDI**:
  - "Shorter" (<2m) collimator as diluter plus additional shielding to protect the magnet downstream of the collimator