L. Keller, SLAC

Phase 2 Specification and Implementation Meeting,
28 November, 2008

Asynchronous Beam Dump

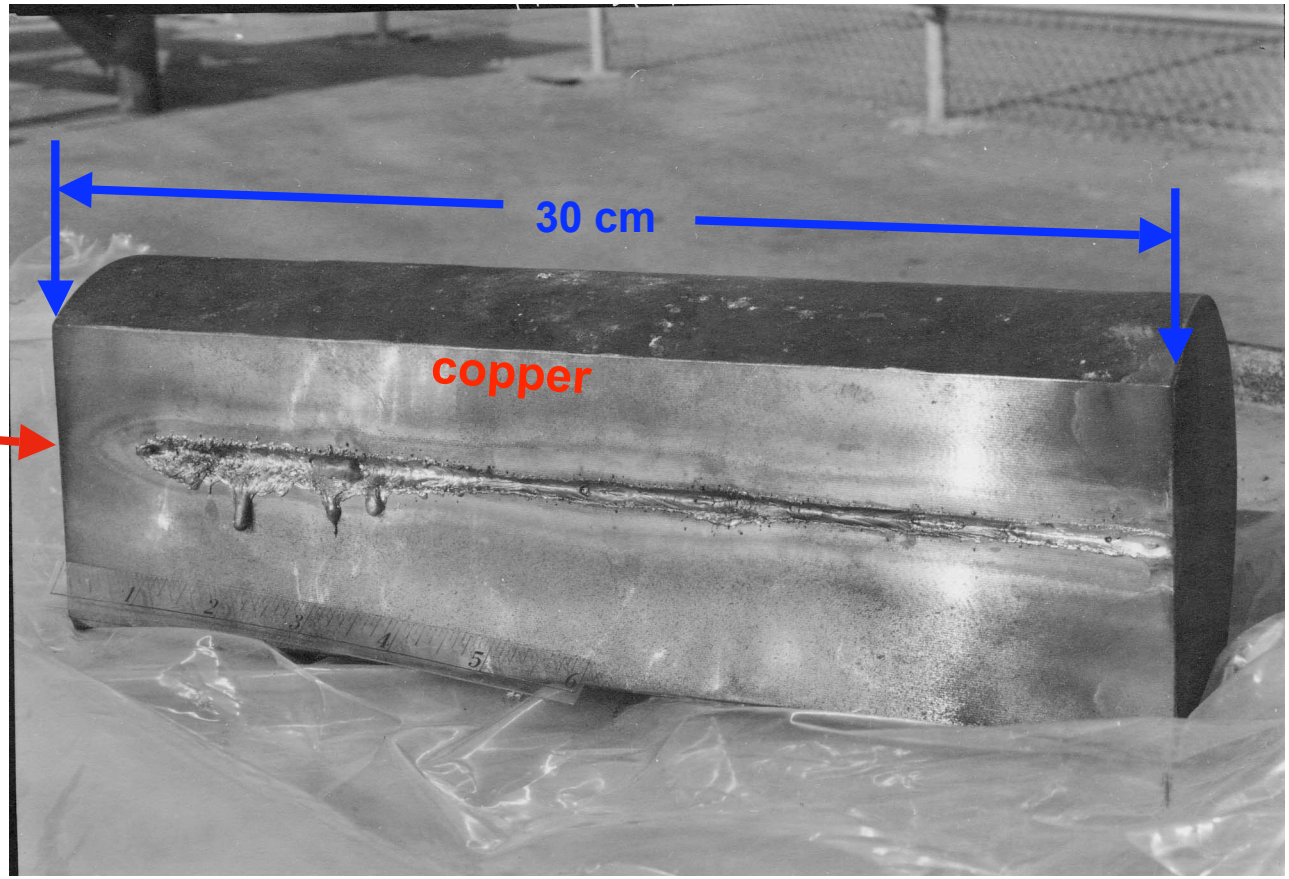
Impact Secondary Collimator 6R7 @ 7 TeV

Estimate Energy Deposition and Instantaneous Temperature Rise in Downbeam Absorber Jaws

SLAC Damage Test - 1971

Beam entering a few mm from the edge of a 30 cm long copper block

The length and depth of this melted region is comparable to the ANSYS simulation for the LHC accident.



500 kW beam
{ 0.65 MJ in 1.3 sec }

Beam diameter ~ 2000 μ

It took about 1.3 sec to melt thru the 30 cm block, but for this relatively large beam, the front two radiation lengths remain intact.

Accident Simulation – 6R7

Method:

1. Start with 23 mis-steered bunches at the location of TCSG.6R7 (or TCSM.6R7) with centroids ranging from 1.522 σ_x to 14.79 σ_x. Each bunch has σ_x = 0.0404 cm and σ_y = 0.0152 cm.

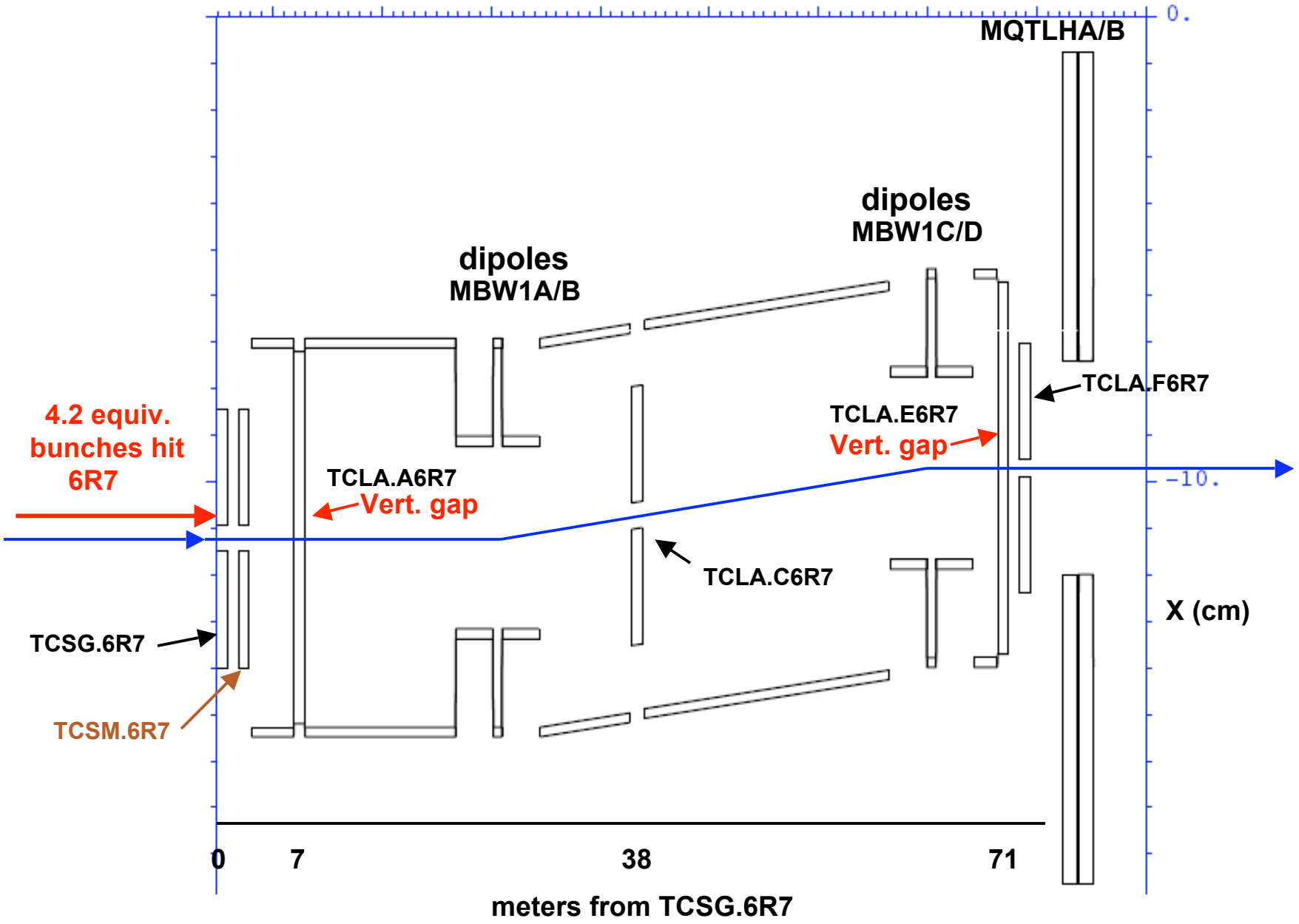
2. With the horizontal gap in 6R7 set to 7 σ_x (0.283 cm), transport each bunch toward 6R7. Place a 10 σ_x cut on all trajectories entering 6R7, i.e. assume that any proton > 10 σ_x does not reach collimator 6R7. Set the absorber half-gaps = 10 σ

3. Using the FLUKA IR-7 model (checked with TURTLE), find that:

   11 bunches with centroids from 5.08 to 12.26 σ_x contribute hits on TCSG.6R7 (this is equivalent to 4.2 full intensity bunches or 4.6 x 10^{11} protons).

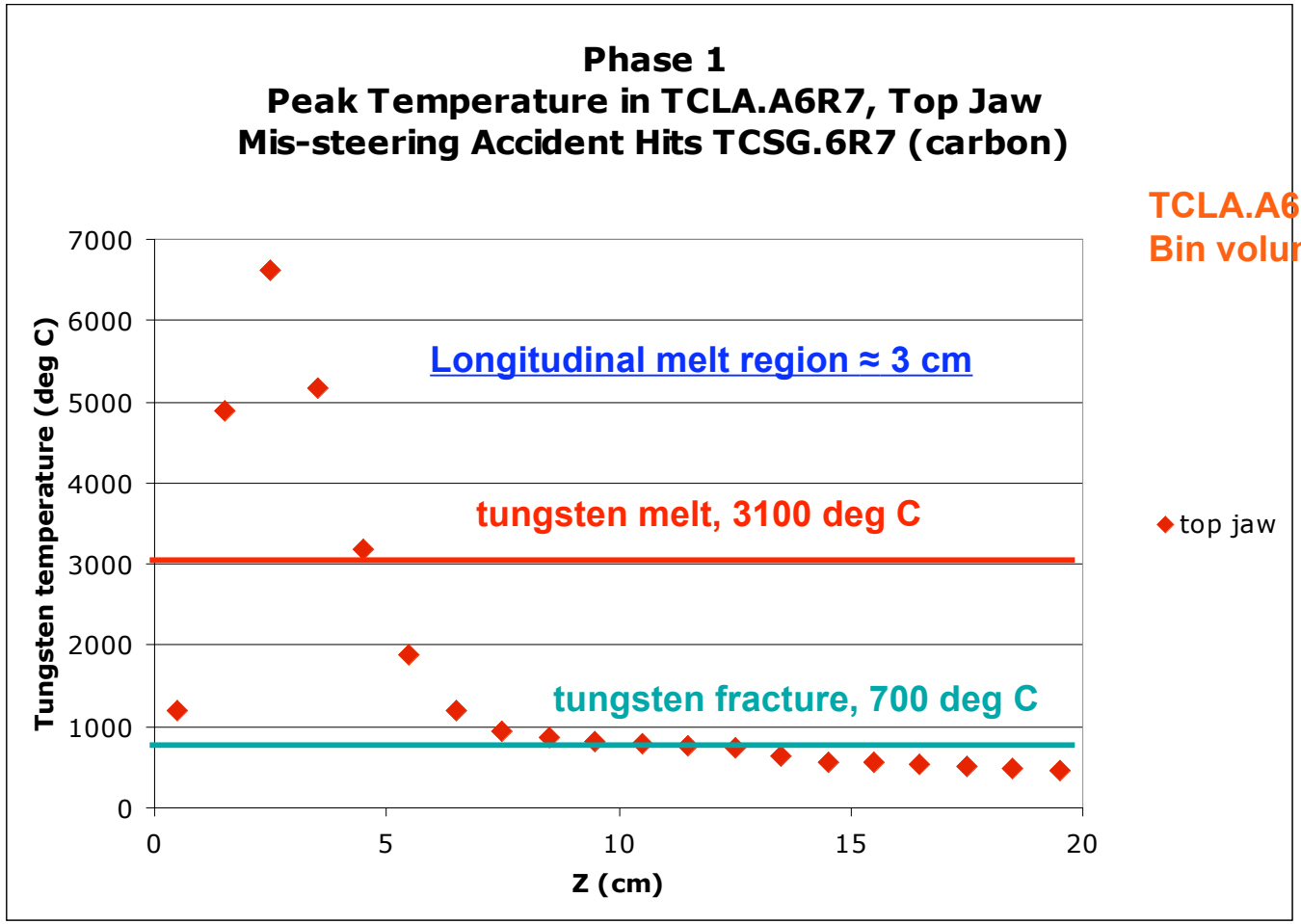
4. With FLUKA, record the energy deposited in small volume elements of the four tungsten absorbers by each of the 11 bunches hitting 6R7. This gives the instantaneous temperature rise throughout the tungsten absorber jaws.

FLUKA Simulation Model



Longitudinal Temperature in TCLA.A6R7 - Accident Hitting TCSG.6R7 - Phase 1

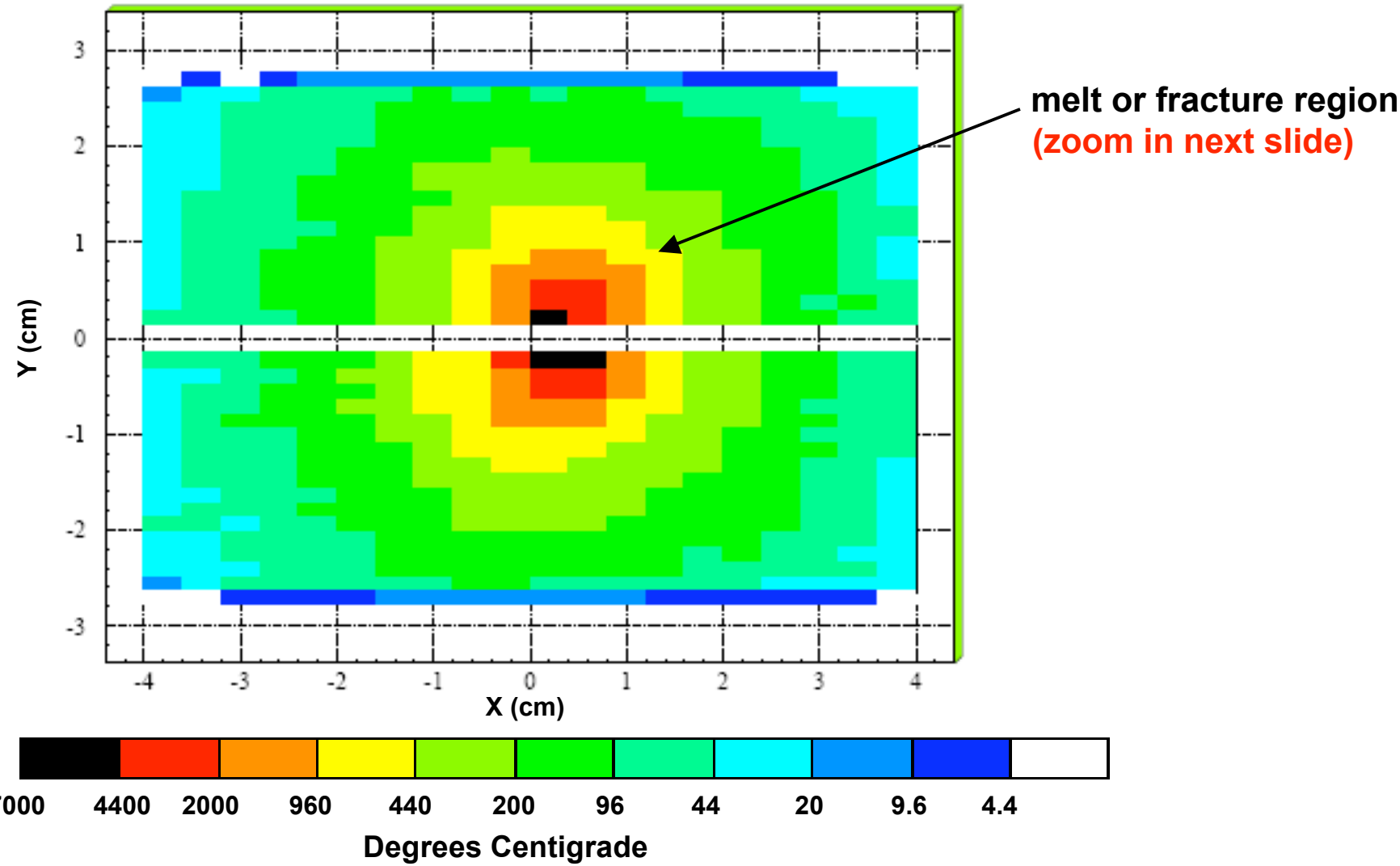
4.2 equivalent bunches hit TCSG.6R7, 7 to 10 σ_x



TCLA.A6R7 half-gap = 10 σ
Bin volume is 0.4 x 0.25 x 1 cm

Temperature Distribution in TCLA.A6R7 at Shower Maximum, Phase 1

4.2 equivalent bunches hit TCSG.6R7, 7 to 10 σ_x



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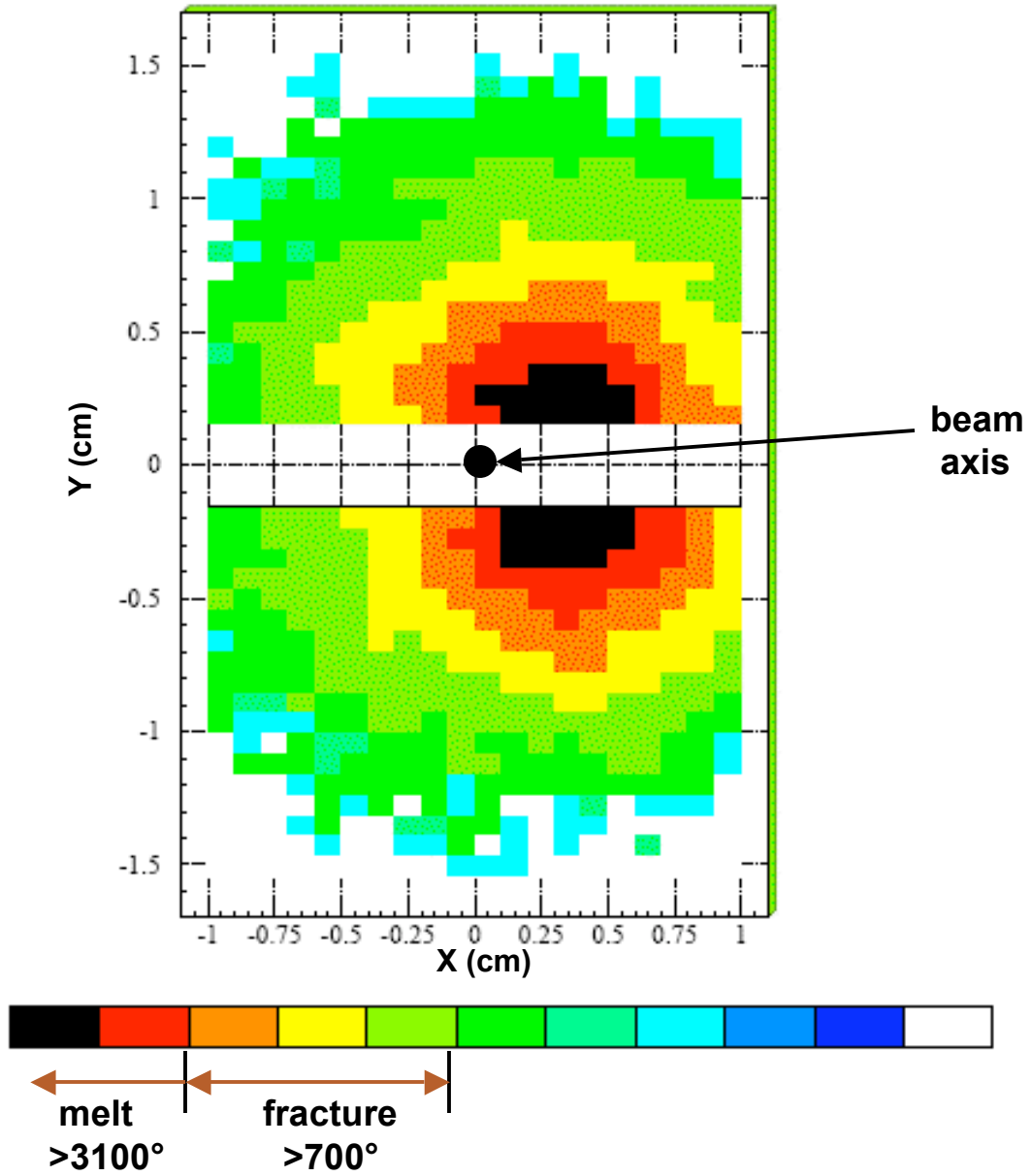

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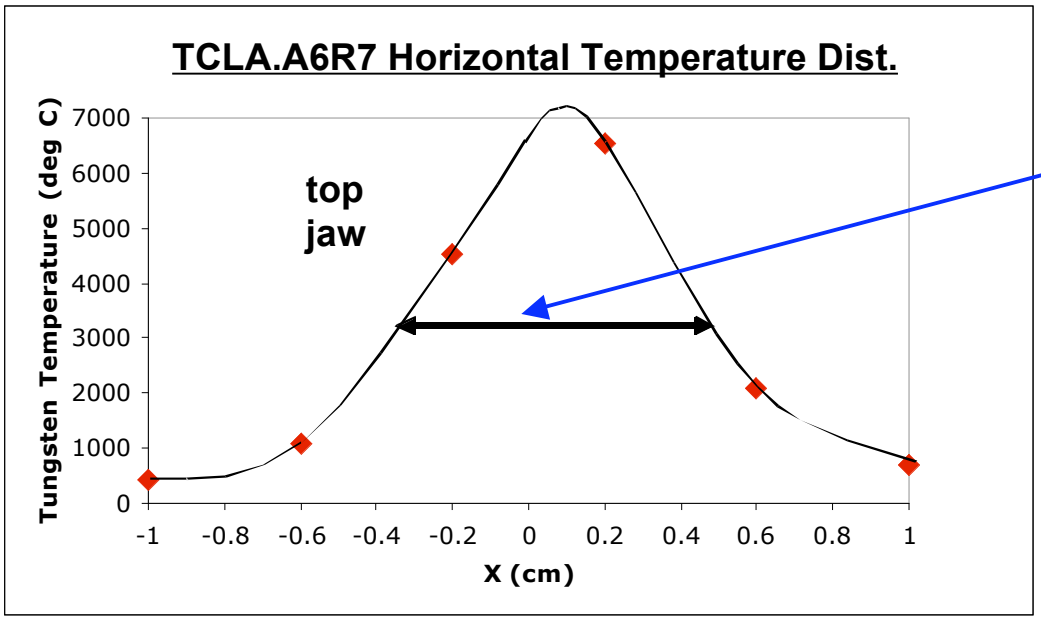
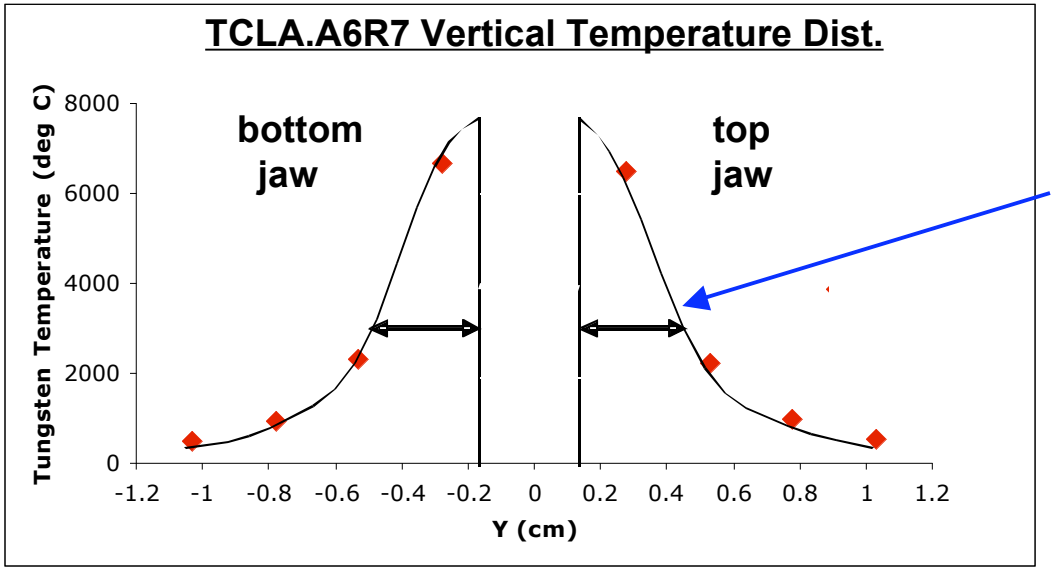


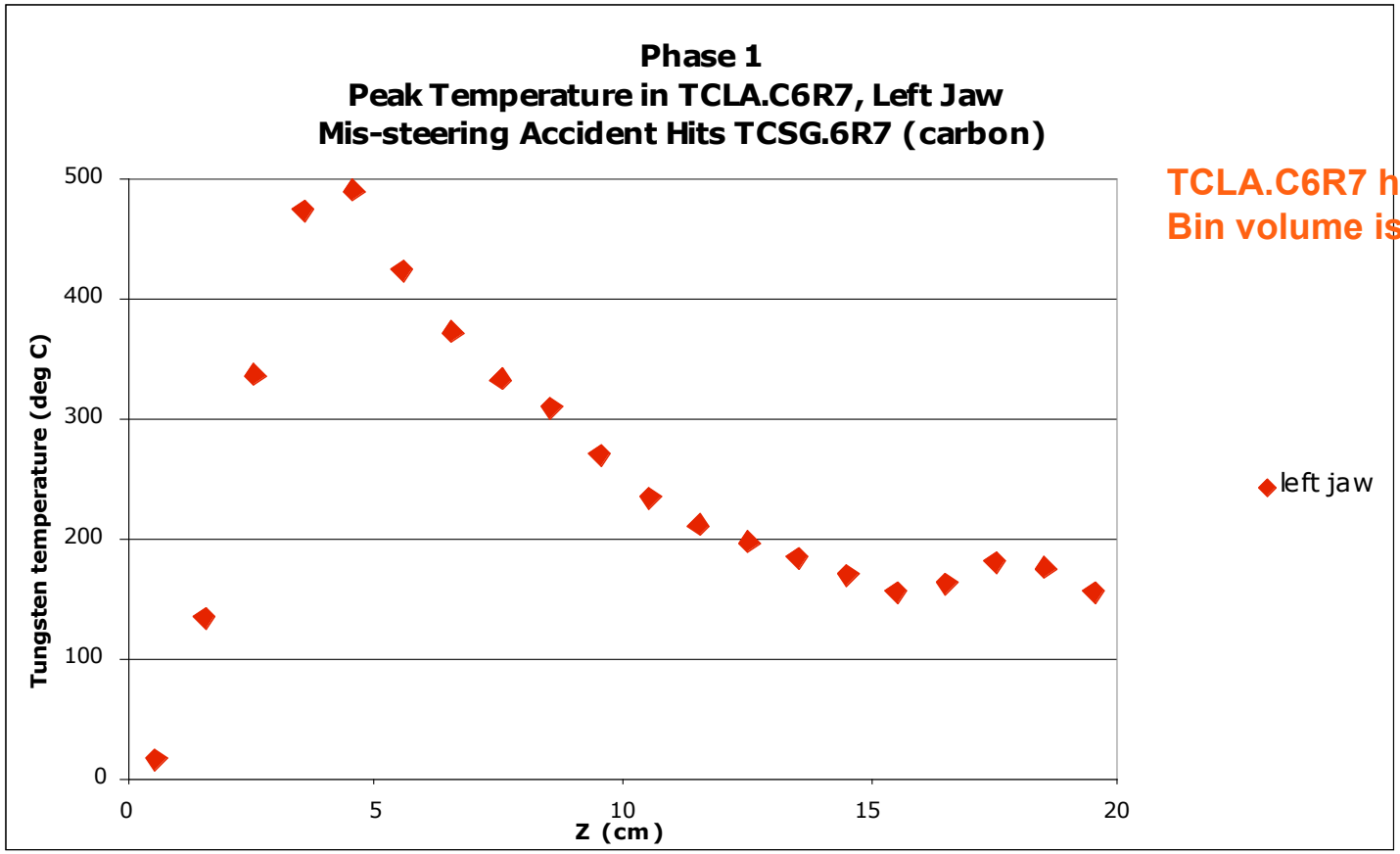
Horizontal melt region ≈ 0.8 cm at shower max.



Vertical melt region ≈ 0.3 cm at shower max.

Longitudinal Temperature in TCLA.C6R7 - Accident Hitting TCSG.6R7 - Phase 1

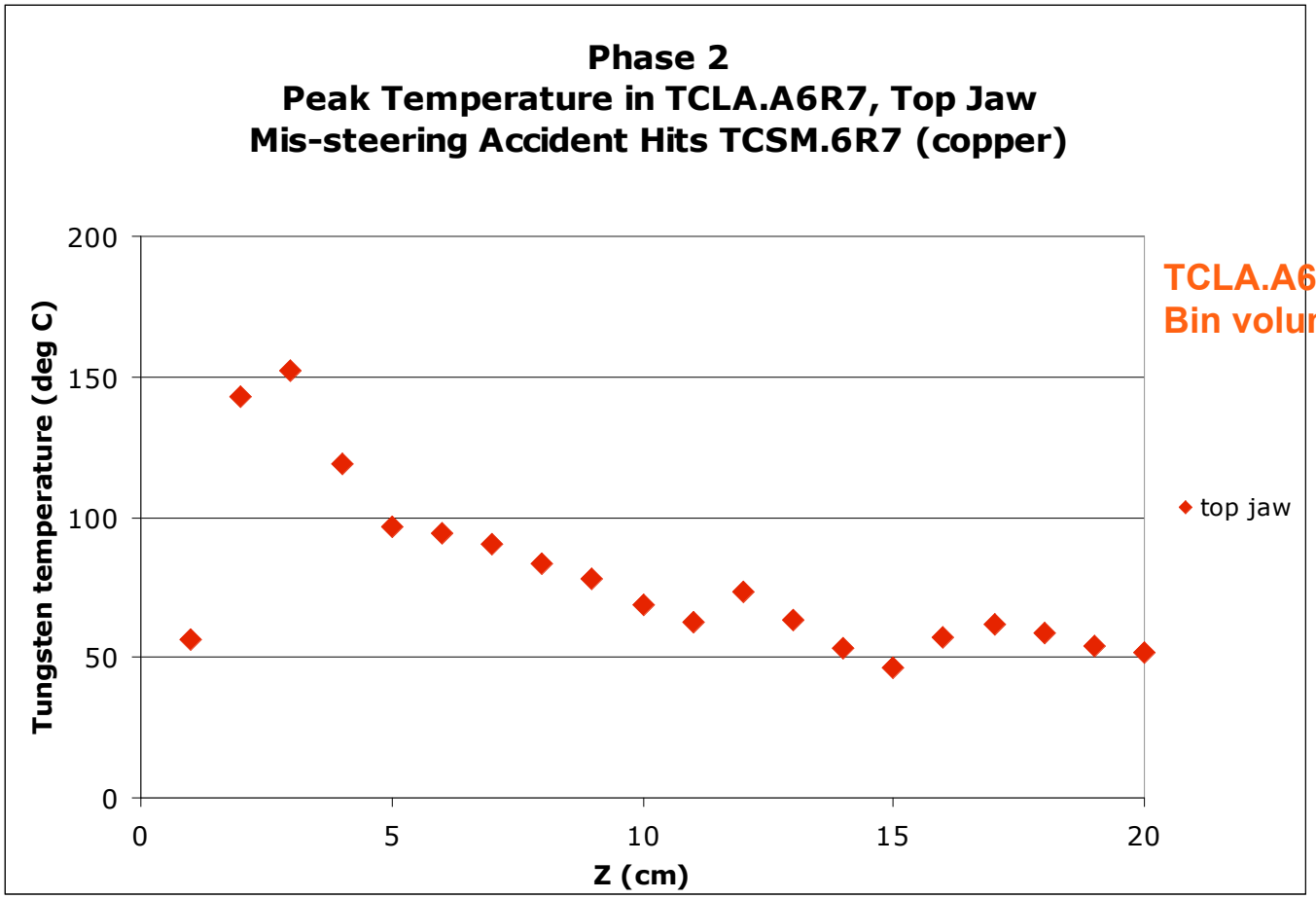
4.2 equivalent bunches hit TCSG.6R7, 7 to 10 σ_x



TCLA.C6R7 half-gap = 10 σ
Bin volume is 0.8 x 0.25 x 1 cm

Longitudinal Temperature in TCLA.A6R7 - Accident Hitting TCSM.6R7 - Phase 2

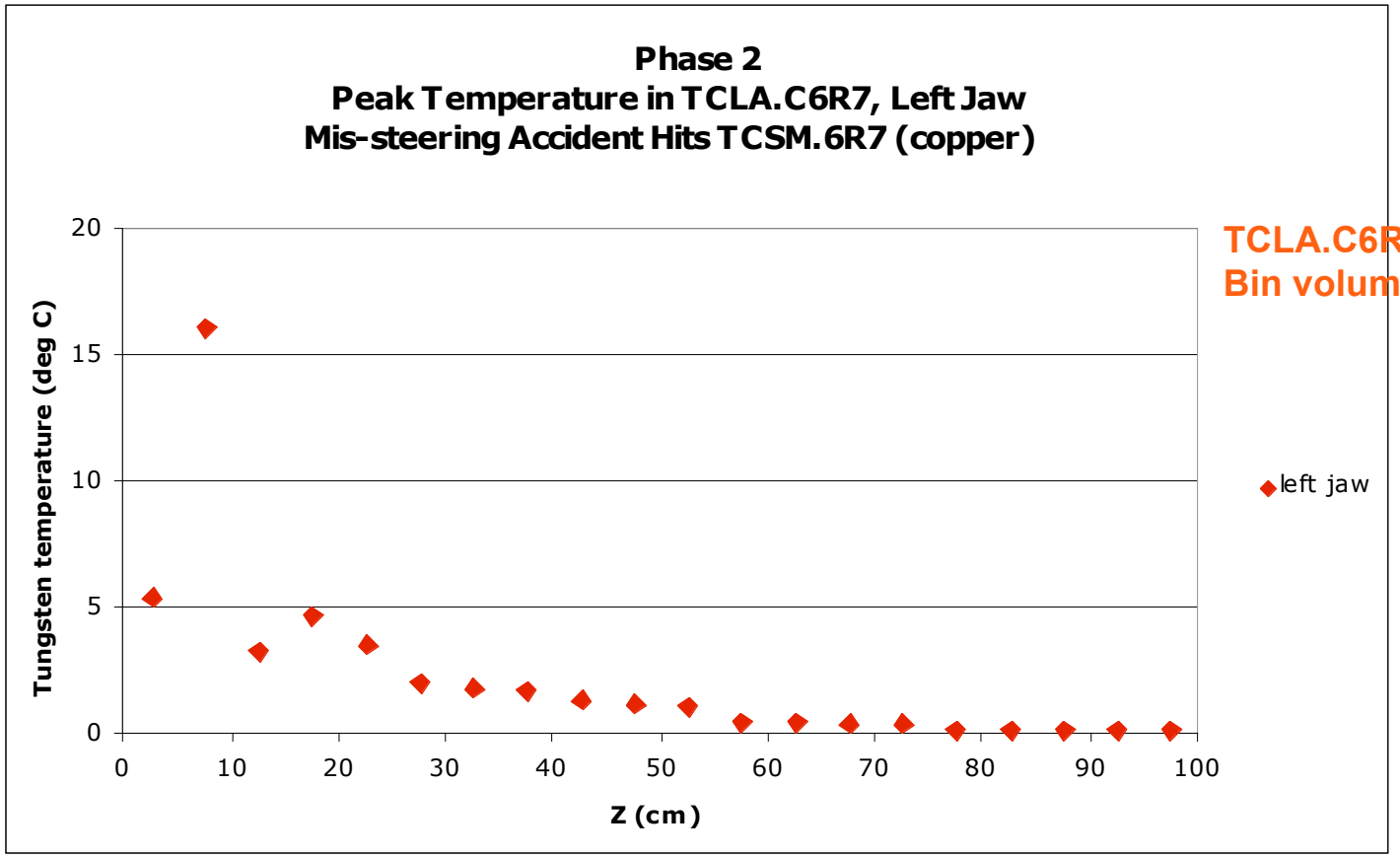
4.2 equivalent bunches hit TCSM.6R7, 7 to 10 σ_x



TCLA.A6R7 half-gap = 10 σ
Bin volume is 0.4 x 0.25 x 1 cm

Longitudinal Temperature in TCLA.C6R7 - Accident Hitting TCSM.6R7 - Phase 2

4.2 equivalent bunches hit TCSM.6R7, 7 to 10 σ_x



TCLA.C6R7 half-gap = 10 σ
Bin volume is 0.8 x 0.25 x 5 cm

Summary

1. This was a FLUKA simulation of an asynchronous beam dump in which an equivalent of 4.2 full intensity bunches impact secondary collimator TCS.6R7.

2. In Phase 1 (6R7 carbon) enough energy is deposited in the nearest tungsten absorber, TCLA.A6R7, to cause melting in the top and bottom jaws over a considerable volume. Each jaw of TCLA.A6R7 receives ≈80 kJ. There appears to be no damage to absorbers further downstream.

3. In Phase 2 (6R7 copper) there is no damage to any of the four tungsten absorbers. The highest temperature reached in TCLA.A6R7 is 150 °C. Each jaw of TCLA.A6R7 receives ≈20 kJ.