Accident Scenarios

Preliminary estimates for asynchronous dump

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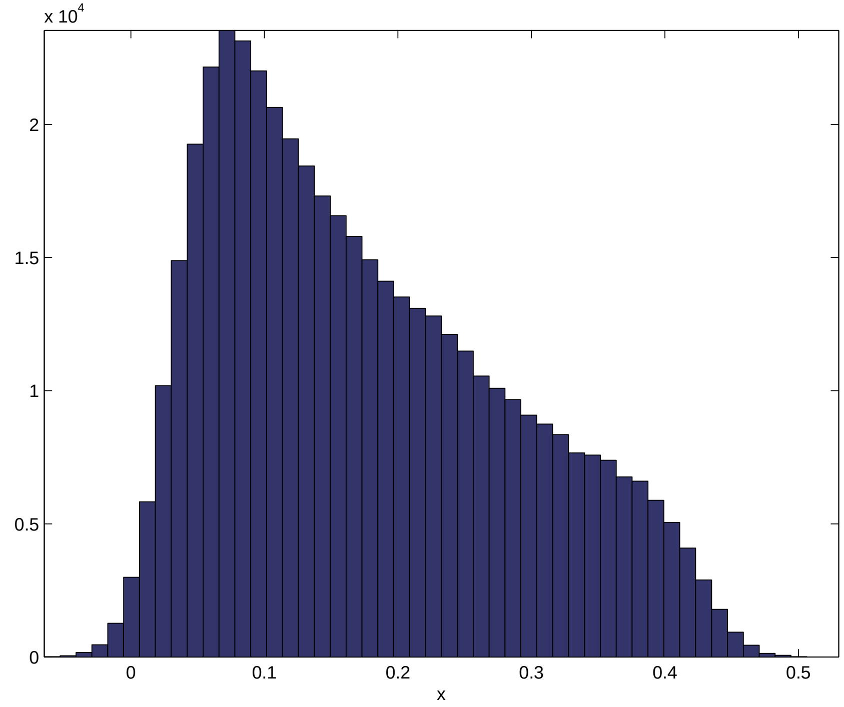
Introduction

- Motivation
  - Prediction of ΔT and total load w.r.t. damage limits
    - graphite jaws
    - copper cooling
- Scope
  - realistic asynchronous dump distribution
  - usual (detailed) IR7 geometry
  - simple adiabatic model for ΔT calculation
- Changes from previous simulation
  - finer data mesh around impact positions
    - avoids "dilution" of energy during scoring (now 100 micron in x,y)
  - Cp(T) quoted for °K in reference but it is actually for °C

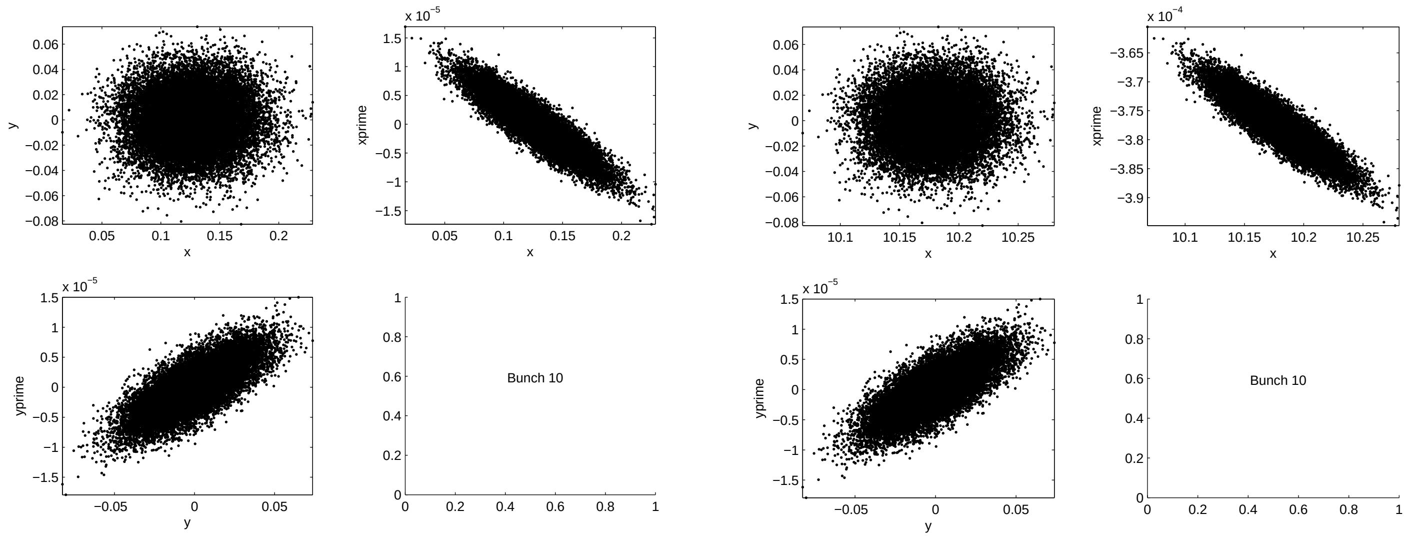
Input Data

- Proton distributions
  - from MAD
  - 23 bunchs in total
  - (x,y,z) and (x',y') at TCP.C6L7 front face
  - sampled in simulation to give 20K simulated p+/bunch (460K total)



Pre-processing

- Input data was preprocessed in MatLab to give correct rotational and transverse transforms to the simulation coordinate system



Simulation

- TCDQ removes swept beam beyond 10σ
  - totally removes outer 3 bunches
  - truncates some remainder bunches
- Simulation handles 20 innermost bunches
  - each processed separately
  - 10 σ cut applied at runtime
- Output
  - outputs summed to give expected full sweep load
  - output data are per primary proton (post-process)

Post-processing (2)

- ΔT calculation
  - takes scaled J/cm^3 data as input
  - employs temperature dependant specific heats

$$c_p^{graph}(T) = 528.75 - 205.9T^{1/3} + 154.21T^{1/2} - 1.53T + 9.15\times10^{-5}T^2$$

$$c_p^{Cu}(T) = 381.12 + 0.16T - 1.09\times10^{-4}T^2$$

  - ΔT can be extracted, assuming system is initially at 20°C, by solving numerically the upper limit of

$$\frac{dE}{dV} = \rho\int_{T_0}^{T_0+\Delta T} c_p(T)\,dT$$

Post-processing (1)

- MatLab used to post-process data.
  - Input data
    - GeV/cm^3 per proton in a Cartesian mesh
  - Scaling
    - scale to expected 1.1×10^{11} protons per bunch
    - adjust for TCDQ scraping (9.5%)
  - Processing
    - convert to J/cm^3
    - integrate per material region (total load)
    - locate positions of max deposit per material region
    - create profiles intercepting max in each coordinate

Results: Jaw loads

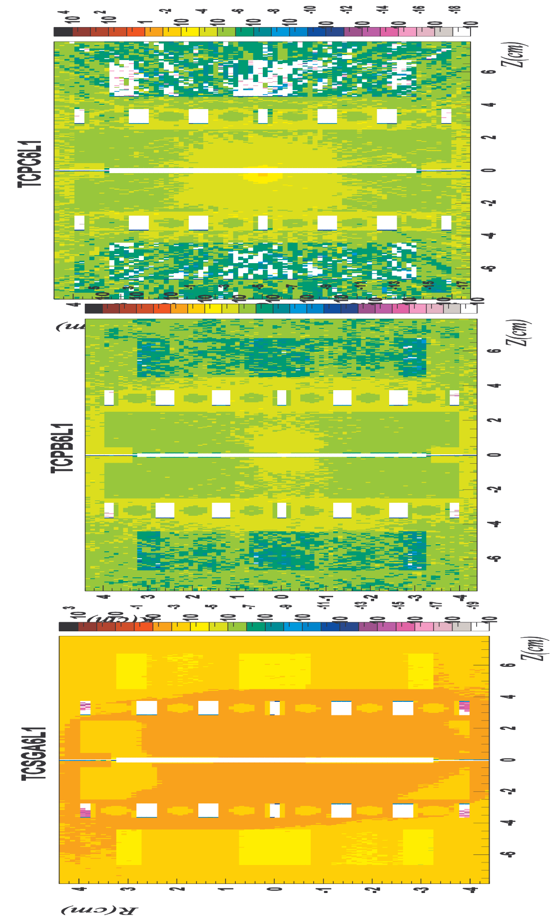


Table 1 Total deposited energy per region in Horizontal collimator TCPC6L1

	Total Deposit (J)	Statistical Error
Graphite Left Jaw	74.8	? 31 %
Graphite Right Jaw	27.59	? 30 %
Copper Left Jaw	22.12	? 31 %
Copper Right Jaw	20.55	? 31 %

Table 2 Total deposited energy per region in Skewed collimator TCPB6L1

	Total Deposit (J)	Statistical Error
Graphite Left Jaw	186.6	? 31 %
Graphite Right Jaw	182.5	? 31 %
Copper Left Jaw	213.4	? 32 %
Copper Right Jaw	270.9	? 32 %

Table 3 Total deposited energy per region in Secondary collimator TCSGA6L1

	Total Deposit (J)	Statistical Error
Graphite Left Jaw	9390	? 8 %
Graphite Right Jaw	9155	? 4 %
Copper Left Jaw	6161	? 16 %
Copper Right Jaw	8099	? 4 %

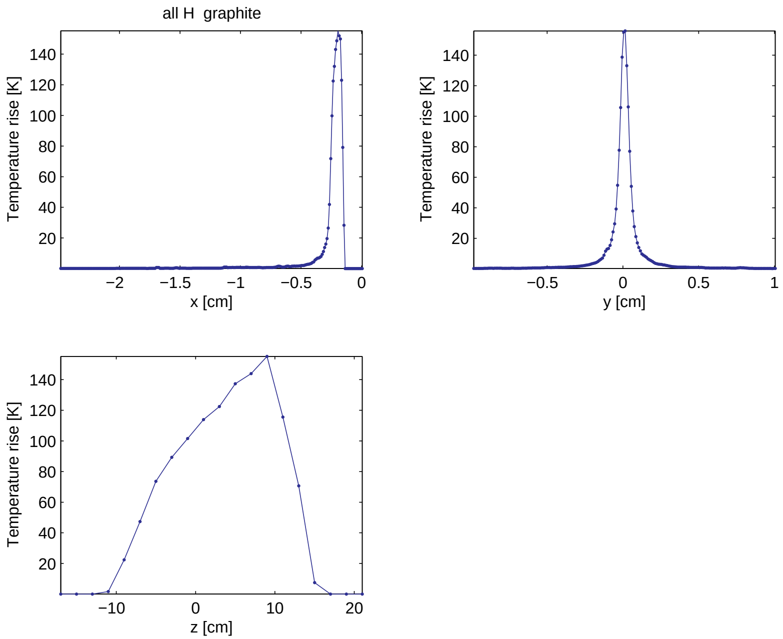
Results: Flange loads

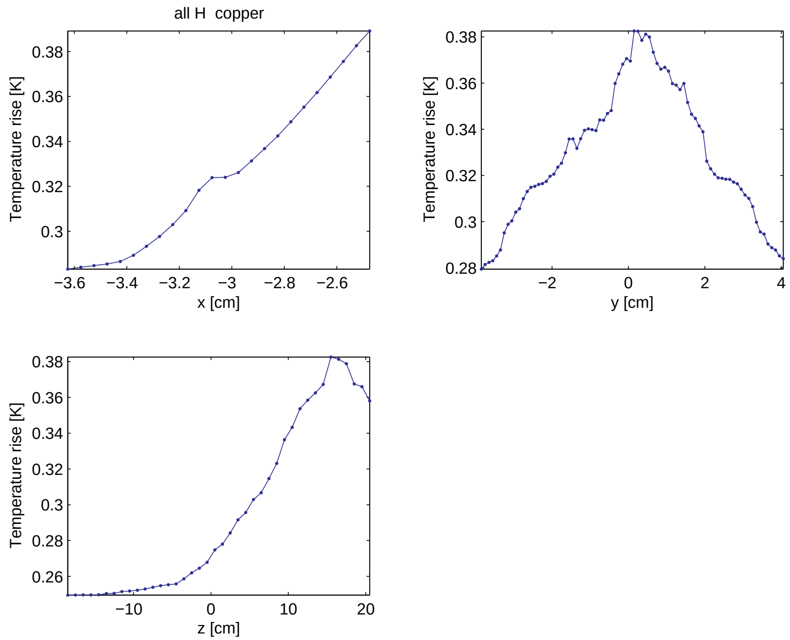
- Only TCSGA6 flanges are in geometry

upstream	inner	363.3 ± 6% J
upstream	outer	142.0 ± 6% J
downstream	inner	730.3 ± 9% J
downstream	outer	171.9 ± 10% J

Results: ΔT

TCPC6 (Prim. Horizontal) impacted jaw.

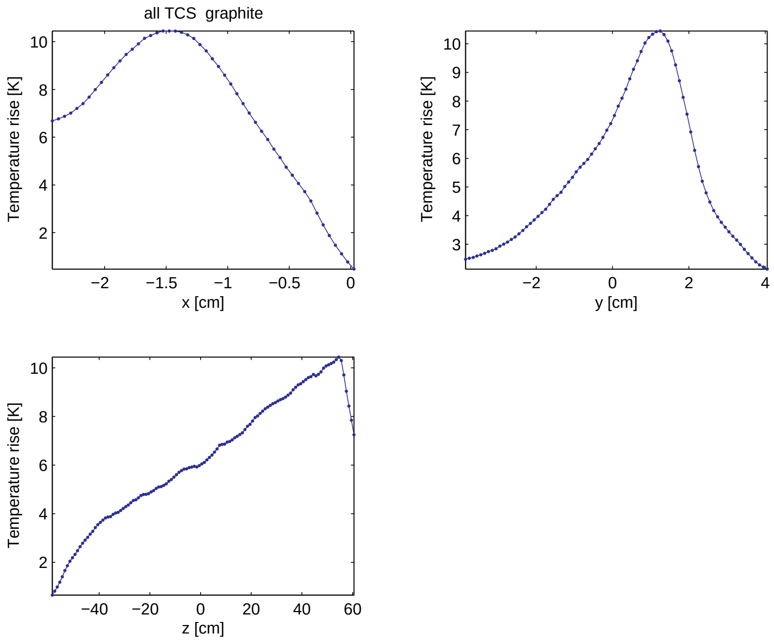


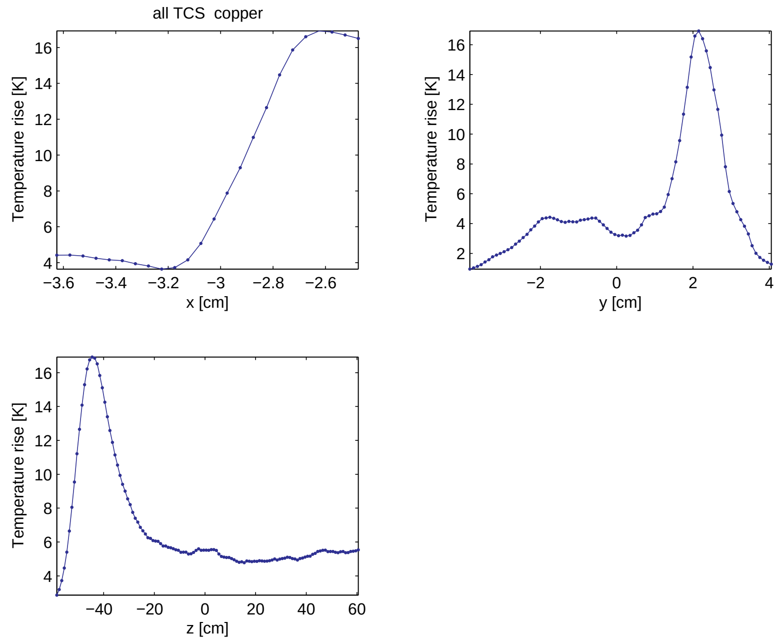


$$\Delta T_{\max}^{graphite} \approx 160°C \qquad \Delta T_{\max}^{Cu} \approx 0.38°C$$

Results: ΔT

TCSGA6 (secondary)





$$\Delta T_{\max}^{graphite} \approx 11°C \qquad \Delta T_{\max}^{Cu} \approx 17°C$$

Comments

- Reasonable agreement now exists with previous (simple) model.
  - Differences attributed to greater level of detail
    - pencil beam → diverging beam
    - interpolated Cp → integrated function of T
    - no chamfers → chamfers

- Data previously handed to Alessandro still valid for everything except TCPC6 (fine mesh)
  - His interest was in TCS so everything is OK