Loading to IR7 Collimators

Preliminary estimates for asynchronous dump

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Introduction

- Motivation:
  - estimates required of instantaneous temperature rise and total load w.r.t. damage limits
    - graphite jaws
    - copper cooling
- This study
  - investigates asynchronous dump case
    - a simple adiabatic model is used
    - consider it as only a cursory look
    - ANSYS analysis by A. Bertarelli will give better picture

Input Data

- Proton distributions
  - from MAD simulations
    - thanks to Stefano
    - sampled distributions
    - total 23 bunches
    - 20K p+ per bunch
  - given at TCP.C6L7.B1
    - primary horizontal
    - We assume no impacts on primary vertical

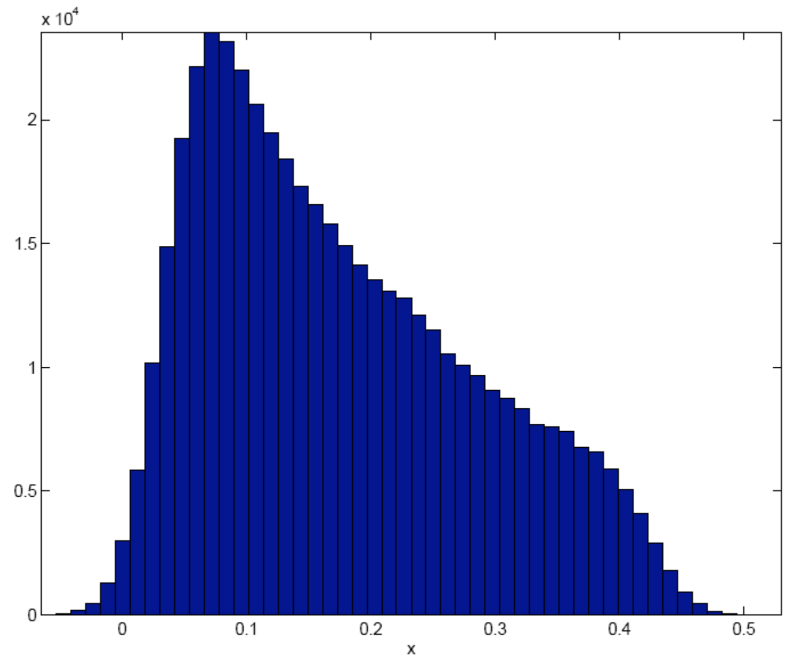


Figure 1 Horizontal distribution of beam protons from 23 bunches for the accidental beam dump

Preprocessing

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

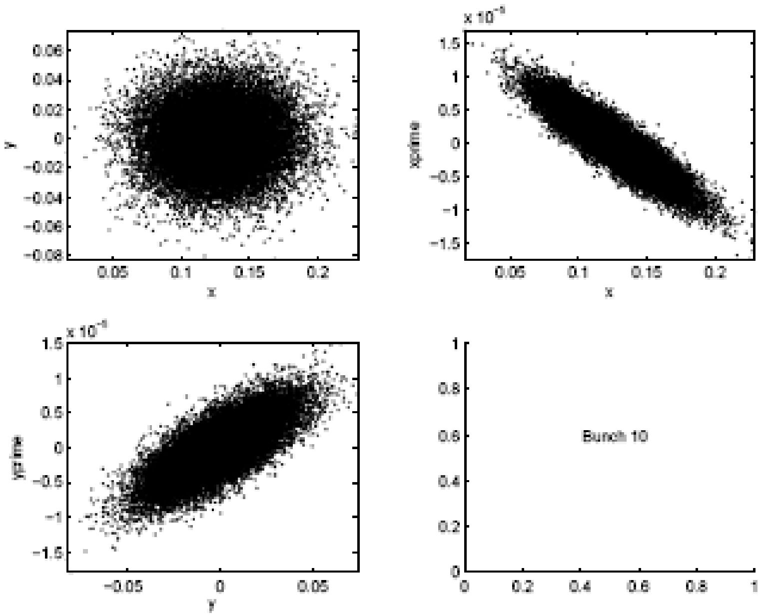


Figure 2 Untransformed beam distributions

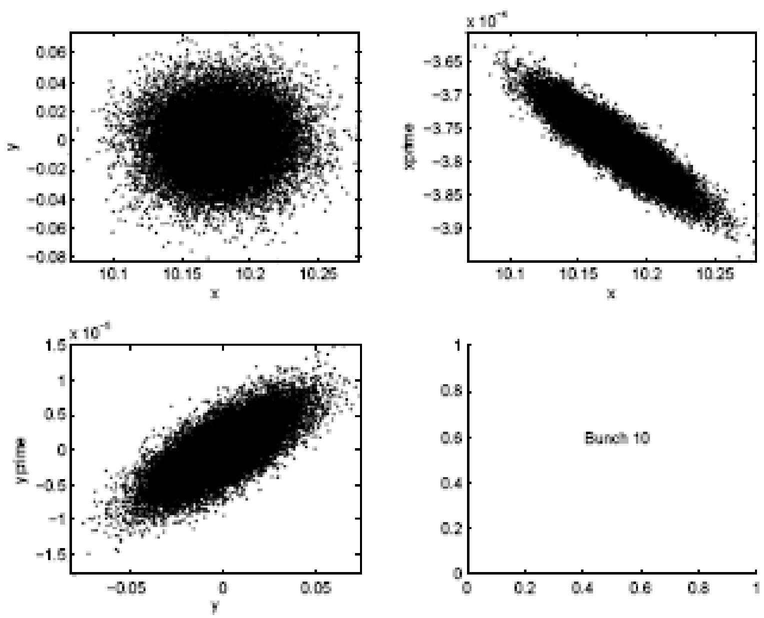


Figure 3 Transformed beam distributions

Simulation

- TCDQ removes fraction of swept beam beyond 10 σ
  - totally removes the 3 outer bunches
  - truncates some remaining bunches
- Simulation handles 20 innermost bunches
  - each bunch processed separately
  - distributions input proton by proton
  - 10 sigma cut applied at runtime
  - secondaries tracked through complete IR7 geometry
- Output
  - outputs summed to give full sweep
  - output data are per primary proton

Post-processing (1)

- MatLab used to post-process data.
  - Data
    - GeV/cm^3 per simulated proton in Cartesian mesh
  - Scaling
    - scale to the expected 1.1_10^{11} protons per bunch
    - adjust for TCDQ scraping (9.5% from sims)
  - Processing
    - converted to J/cm^3
    - integrate loading per material region
    - locate positions of max deposit per material region
    - create profiles intercepting max in each coordinate

Post-processing (2)

- ΔT calculation

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

$$c_p^{graph}(T) = 528.75 - 205.9T^{1/3} + 154.21T^{1/2} - 1.53T + 9.15\times10^{-5}T^2$$
$$c_p^{Cu}(T) = 381.12 + 0.16T - 1.09\times10^{-4}T^2$$

  - Now ΔT can be extracted, assuming initially at 300 Kelvin, solving numerically the upper limit of the integral

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

Results: Integrated loads

Tabulated results are per proton

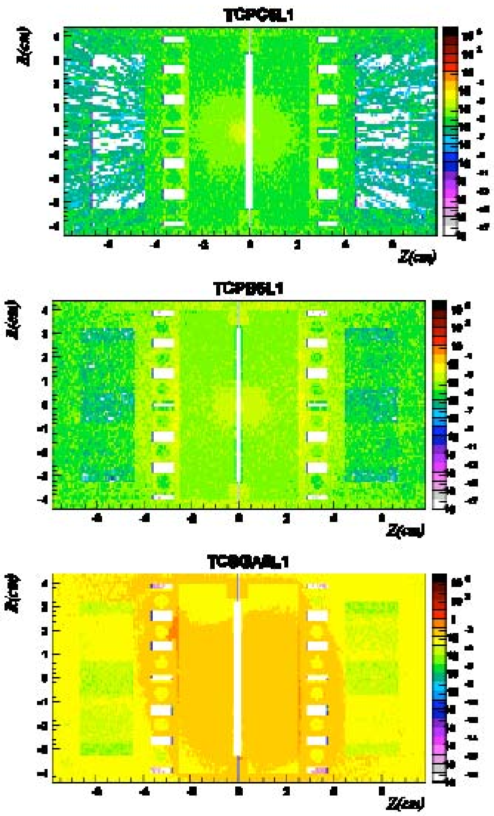


Figure 4 Deposited energy averaged along beam direction

Table 1 Total deposited energy per region in Horizontal collimator TCPC6L1

	Total Deposit (J)	Statistical Error
Graphite Left Jaw	4.613×10^{-11}	± 32 %
Graphite Right Jaw	1.426×10^{-11}	± 31 %
Copper Left Jaw	2.145×10^{-11}	± 30 %
Copper Right Jaw	1.816×10^{-11}	± 33 %

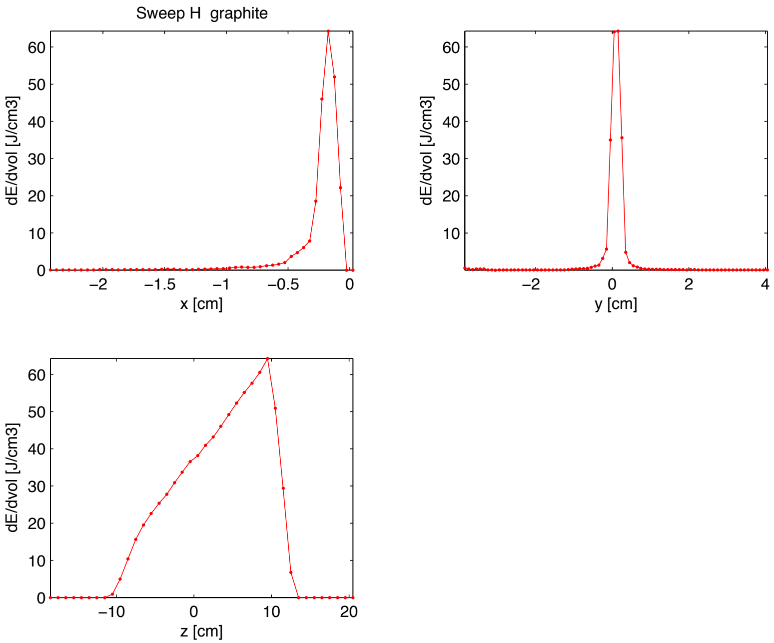
Table 2 Total deposited energy per region in Skewed collimator TCPB6L1

	Total Deposit (J)	Statistical Error
Graphite Left Jaw	8.146×10^{-11}	± 31 %
Graphite Right Jaw	9.411×10^{-11}	± 31 %
Copper Left Jaw	1.819×10^{-10}	± 31 %
Copper Right Jaw	2.072×10^{-10}	± 31 %

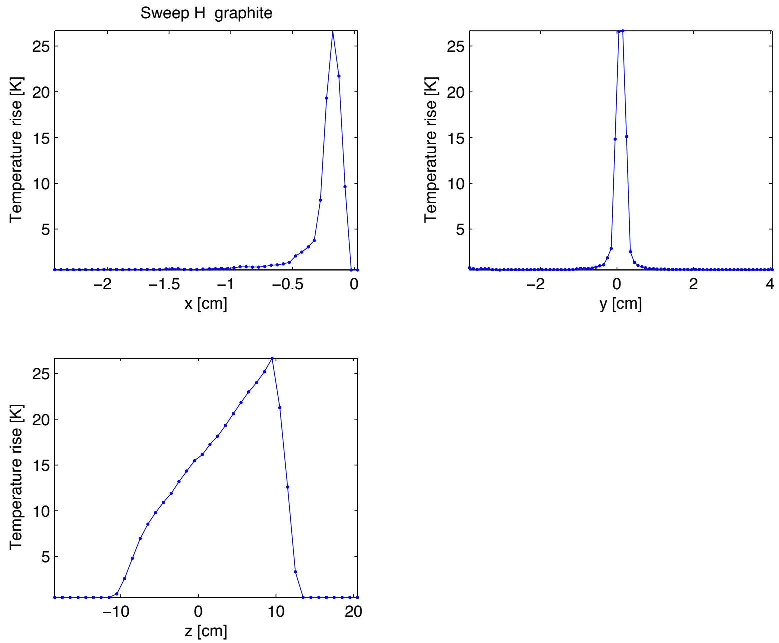
Table 3 Total deposited energy per region in Secondary collimator TCSGA6L1

	Total Deposit (J)	Statistical Error
Graphite Left Jaw	5.443×10^{-9}	± 7 %
Graphite Right Jaw	5.184×10^{-9}	± 3 %
Copper Left Jaw	4.264×10^{-9}	± 17 %
Copper Right Jaw	5.631×10^{-9}	± 3 %

Results: Profiles



Prim. Horizontal E density (J/cm^3)



Prim. Horizontal ΔT (°K)

Comments

- Primary objective of simulation
  - provide mesh data for ANSYS
    - conclusions should be based on that study
    - will be interesting to see how results compare
      - verify my method for TCDQ and TDE window
- Much more data available
  - /afs/cern.ch/user/p/presland/ALESSANDRO