Estimated energy deposition for beam-gas collisions near the triplet

Anton Lechner

06/03/2024

Beam-gas collisions

- The shower-induced **power deposition in equipment** near a vacuum pressure spike is proportional to the rate of inelastic nuclear collisions between protons and gas nuclei (**dN/dt** = local proton loss rate)
- Following relation applies: **dN/dt** = $I_b \cdot f_r \cdot P$ where
  - I_b=stored beam intensity,
  - f_r=revolution frequency,
  - P=collision probability= $1 - \exp\left(-\int_{s_a}^{s_b} \sum_{j=1}^{N} \sigma_j A_j(s')\mathrm{d}s'\right)$

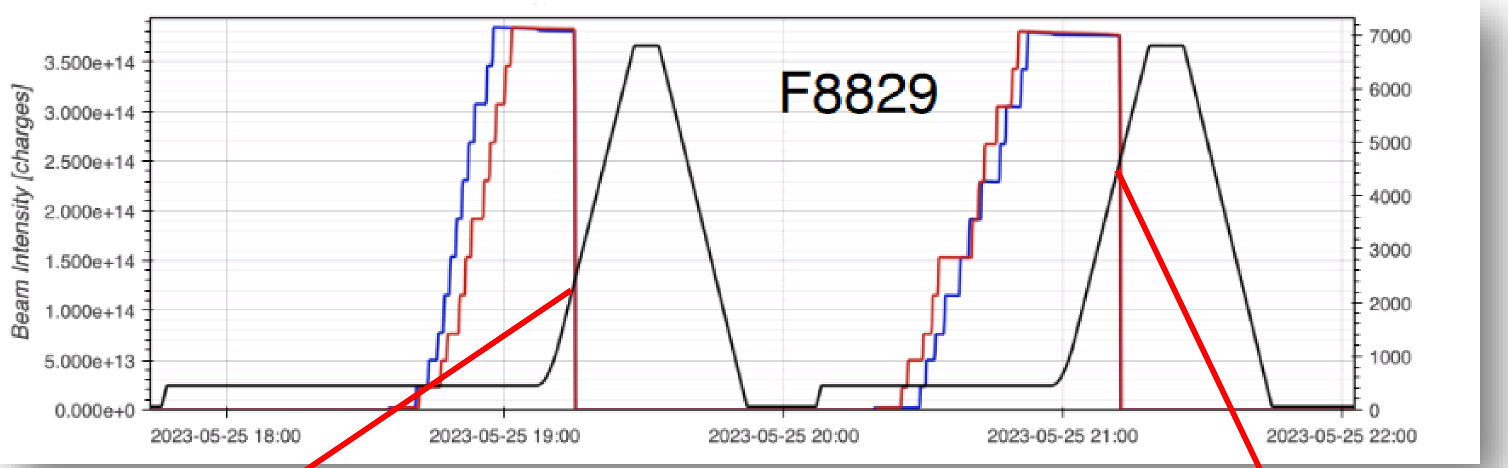
Sum over gas constituents

Atom density for gas constituent *j* as a function of *s*-coordinate

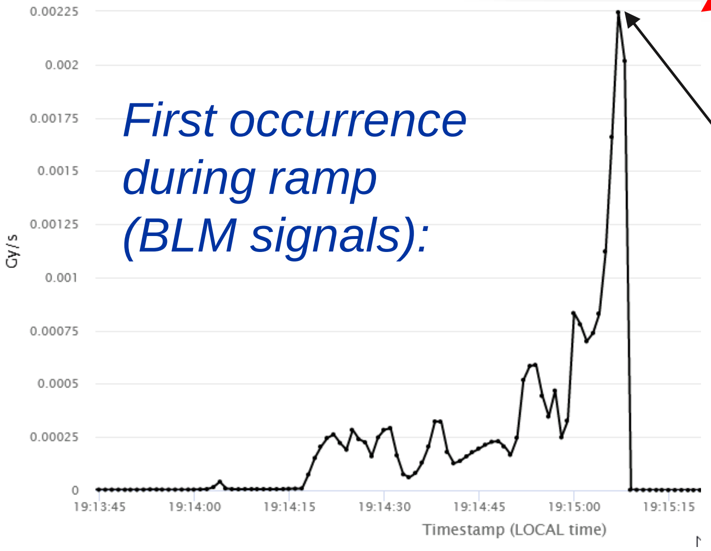
Inelastic nuclear x-sec for gas constituent *j*

Of course, the atom density distribution A(s) for elemental constituents is not exactly known, BUT we can estimate dN/dt indirectly by comparing BLM simulations with measurements

04L1 events in 2023

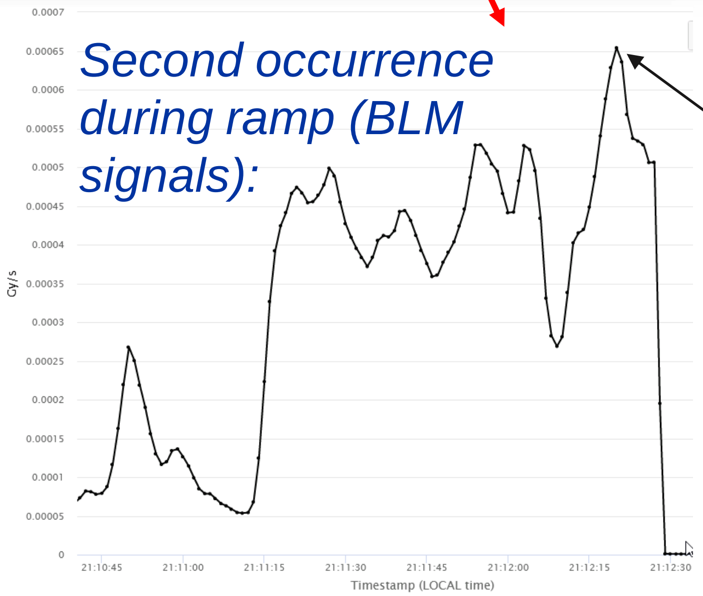


First occurrence during ramp (BLM signals):



Estimated inelastic collision rate ***dN/dt*** *of* ***$2x10^8$ s^{-1}*** *(but then beam was dumped)*

Second occurrence during ramp (BLM signals):

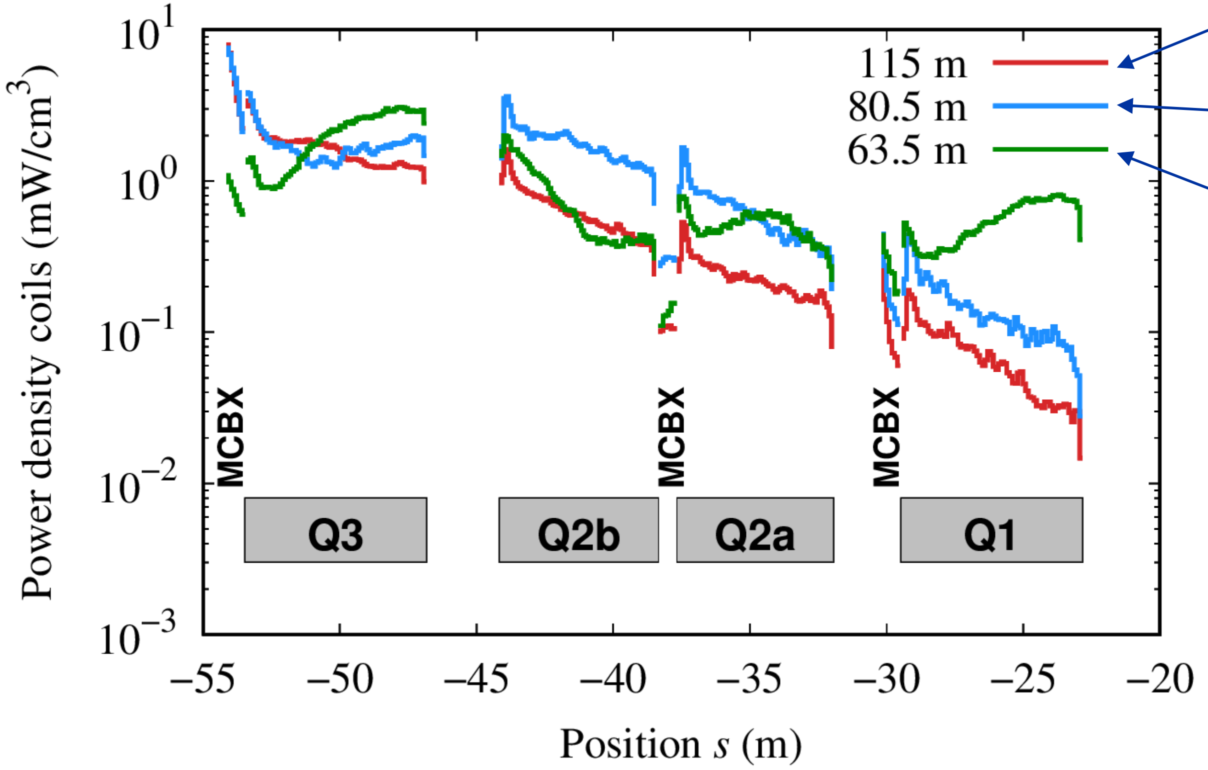


Estimated inelastic collision rate ***dN/dt*** *of* ***$4x10^7$ s^{-1}*** *(but then beam was dumped)*

Quench risk assessment for triplet

*from inelastic collisions

Results are **normalized to a proton loss rate* of 2x10⁸ s⁻¹**:
*For this loss rate the peak power density in the Q3 coils reaches about **4 mW/cm³** (comparable to collision debris) – about 4 times below the assumed quench level*



Location of 2023 incident

Interconnect between the two MBXW at the non-IP side

Interconnect between the two MBXW at the IP side

Longitudinal power density profile changes, but peak power doesn't increase significantly

Conclusion

- Depending on the proton loss rate, the power deposition density in the triplet might still be acceptable in case of a pressure spike in the D1 region in IR1/5
- However, pressure spikes and the resulting loss rate can be subject of unpredictable variations – much less controllable than the power density from collision debris
- In addition, one has to consider that the beam-gas collisions come on top of the pp debris-induced power deposition (although the power hot spots in the coils might be different)
- To minimize risks, **recommend** that the max allowed power density for beam-gas collisions in the IR should stay at least **X times lower (X=5?)** than the debris-induced power density (there is also some uncertainty in the simulation results) – this translates into a max local proton loss rate of a few 10^7 s^{-1}
- Important point to be followed up: FT corrections at the triplet are set 3.33 times higher than collision-debris signal (to avoid constant warnings) – how to effectively interlock a certain beam-gas collision rate in case there is a pressure spike near the triplet?

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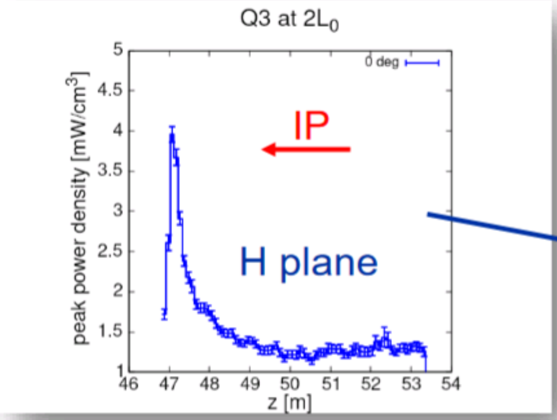
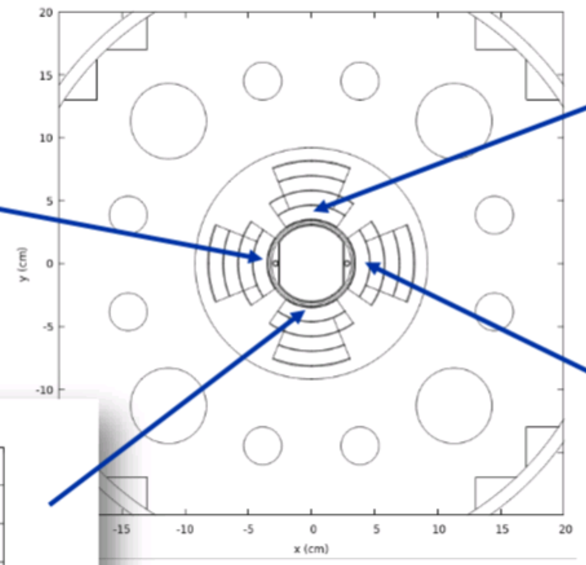
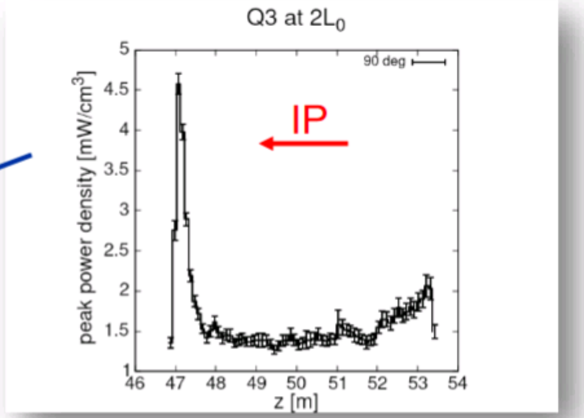
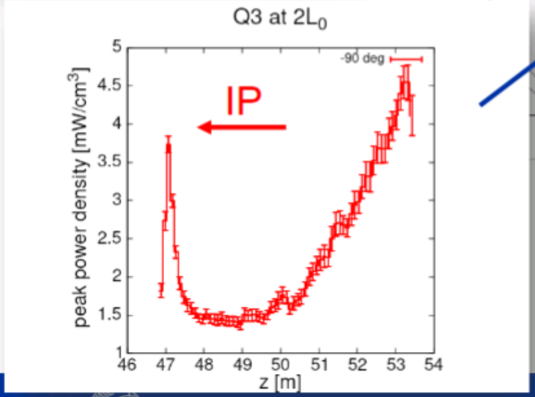
Power density in coils due *pp collisions*

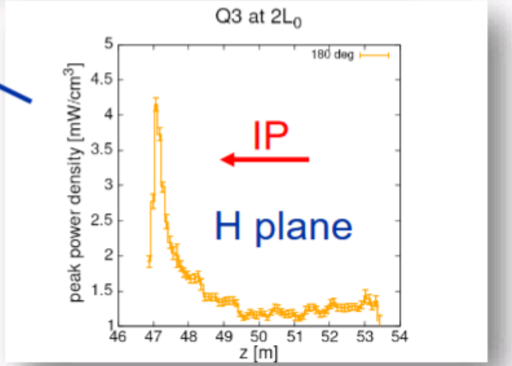
pp-collision debris induced power density in *inner* Q3 coils for **$L=2x10^{34}$ $cm^{-2}s^{-1}$**











Note the different IP side compared to the previous slide!

F. Cerutti