Evaluation of electron cloud in RHIC: Warm sections, Interaction Regions, and dipoles

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0. Contents

1.a. Experience at the straight sections

- Correlation between electron cloud (EC) activity and pressure rise detected in Run 3 using electron detectors (ED). *

- Solution tests: solenoids and NEG. NEG is preferred solution †

- Bunch pattern tests: most sparse bunch patterns help to minimize electron cloud effects ‡

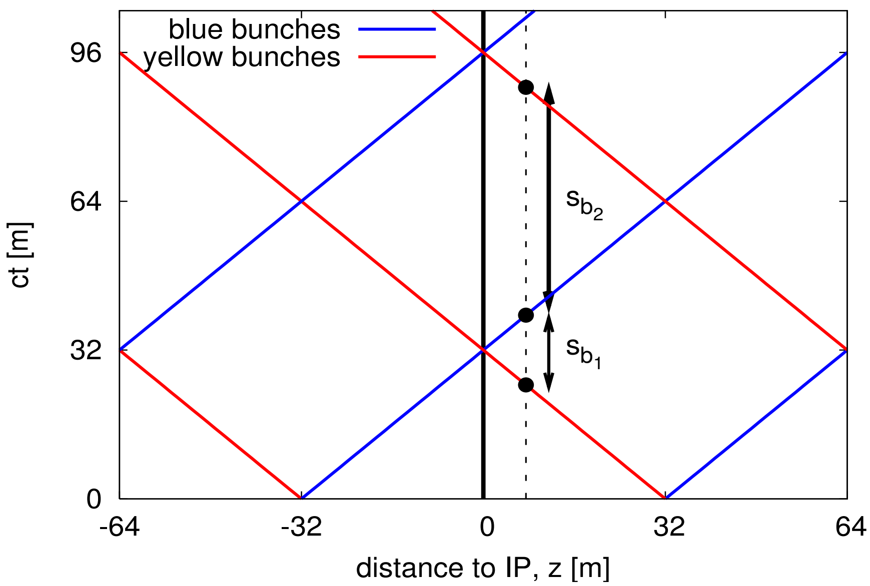
*U. Iriso et al, C-A/AP/129

†W. Fischer et al, Proceedings of ECLOUD'04

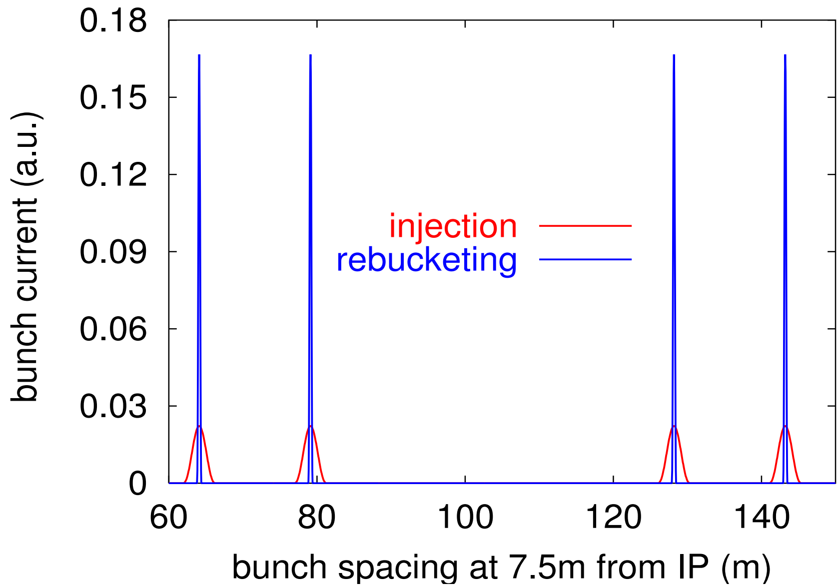
‡U. Iriso and S. Peggs, in Proceedins of ECLOUD'04; W. Fischer and U. Iriso, C-A/AP/118

1.b. Experience at the Interaction Regions

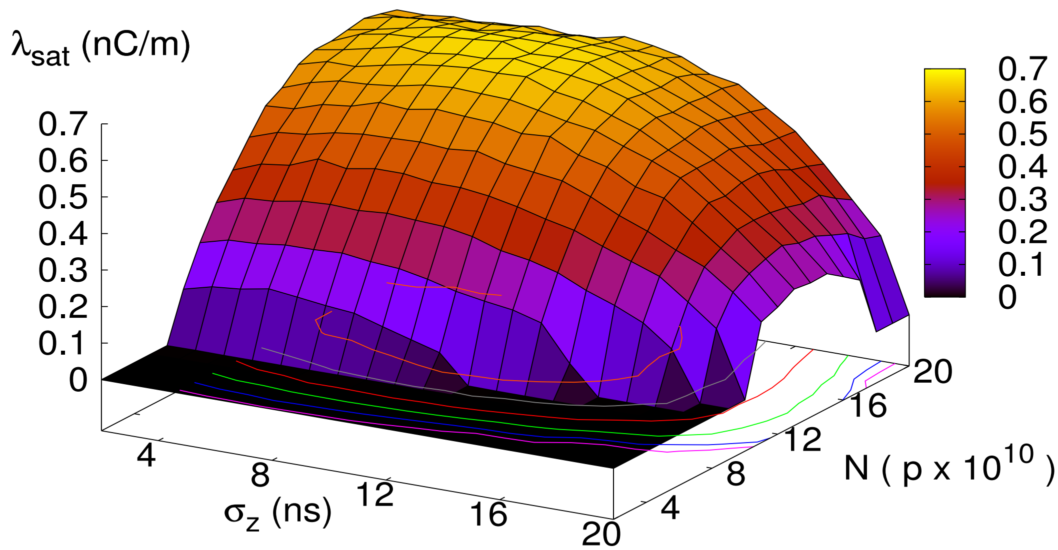
Two beams circulating in opposite directions:

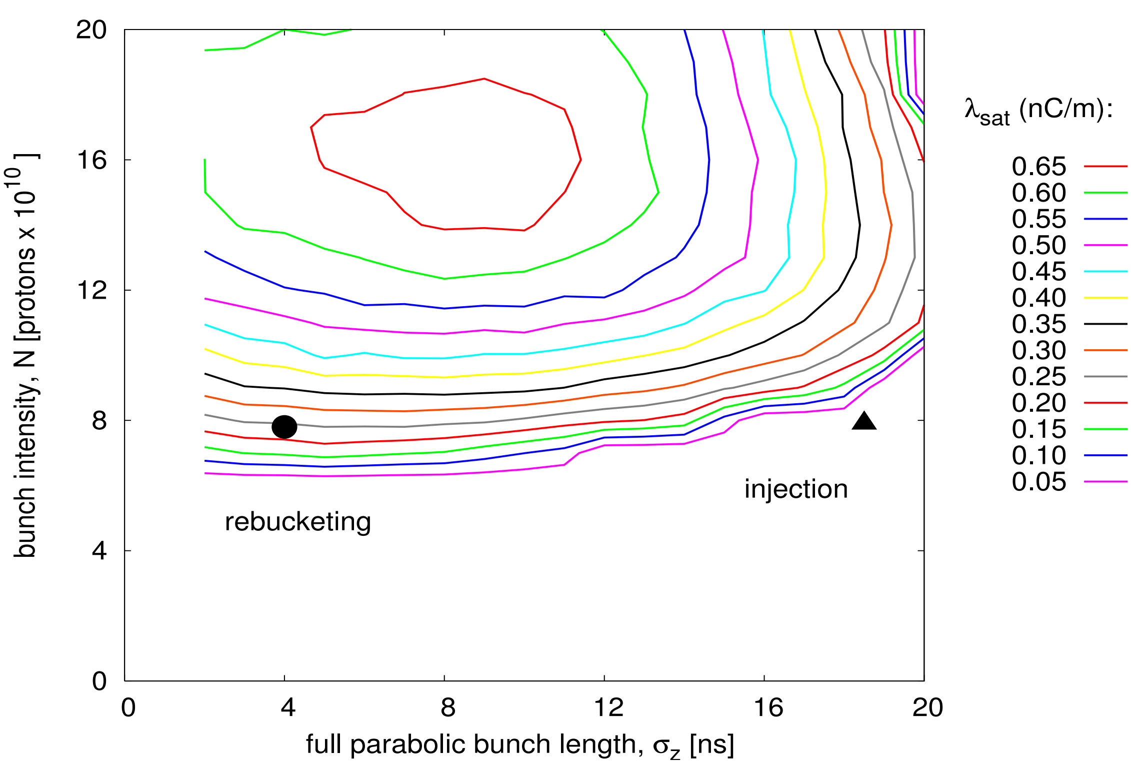


Changing bunch length strongly influences EC activity:



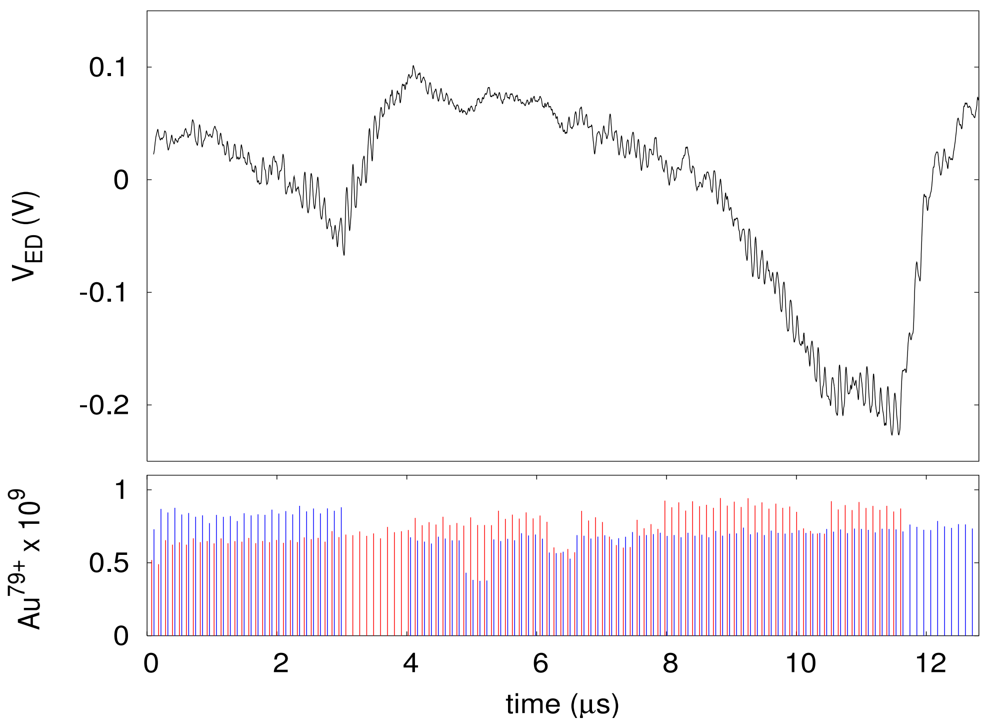
Simulated EC at 7.5 m from IP6 after cogging:





Experimental data at IR12:

- Bunch intensity: $N_b = 0.8 \cdot 10^9$ gold ions/bunch
- Single bunch spacing: $s_b = 108$ ns (32 m)
- ED placed 1 m from IP, fill 4791.



$\longrightarrow$ No electron activity if only one beam present.

1.c. Experience at the arcs: a RHIC dipole

- No special EC instrumentation in the arcs

- Fill # 5350 showed pressure rise in the arcs, although no heat load was detected

- Tune shift (PLL) + e- flux into the wall (ED) measurements can be used to *decouple* the influence of warm vs cold sections

- Use of simulations (ECLOUD) to evaluate EC at both warm and cold regions, specially, the spatial cloud distribution

Evaluation of EC from tune shift: *

$$\Delta Q = \frac{r_p}{\gamma} \oint \beta \rho \; ds$$

→ Direct measurement of ΔQ (using PLL, Artus)
→ Indirect measurement of ρ, EC density (using ED)

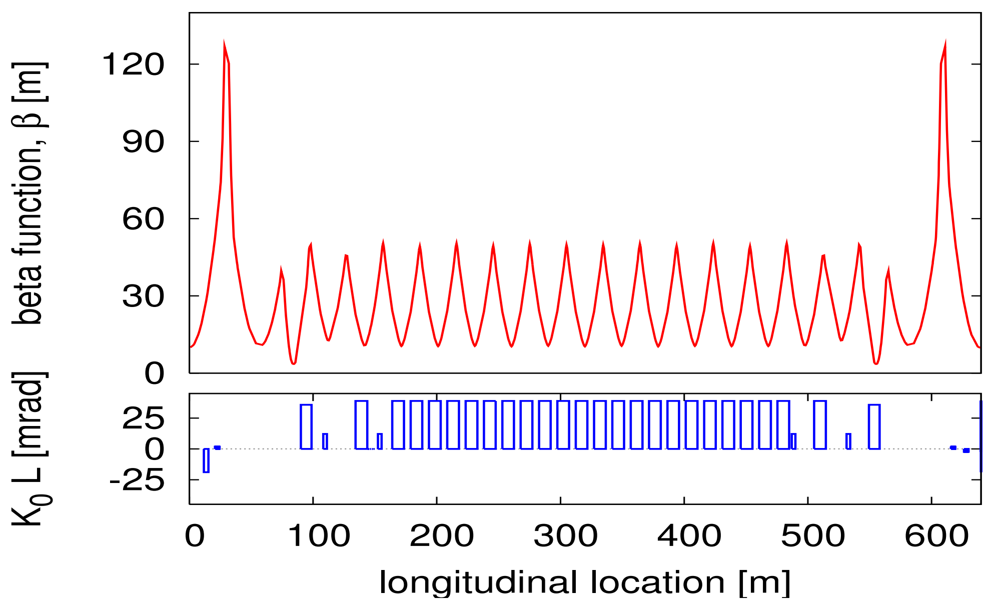
Assuming round beams (injection):

$$\Delta Q \approx \frac{r_p}{\gamma} \cdot \sum \overline{\beta_i} \overline{\rho_i} L_i = \frac{r_p}{\gamma} (\overline{\beta_w} \overline{\rho_w} L_w + \sum \overline{\beta_i} \overline{\rho_i} L_i)$$

w stands for *warm sections*; i for the rest

*W. Fischer, M. Blaskiewicz et al, PRST-AB, 5, 12440

RHIC beta function at injection and total dipoles:



Warm straight sections length/ring: ≈ 700m

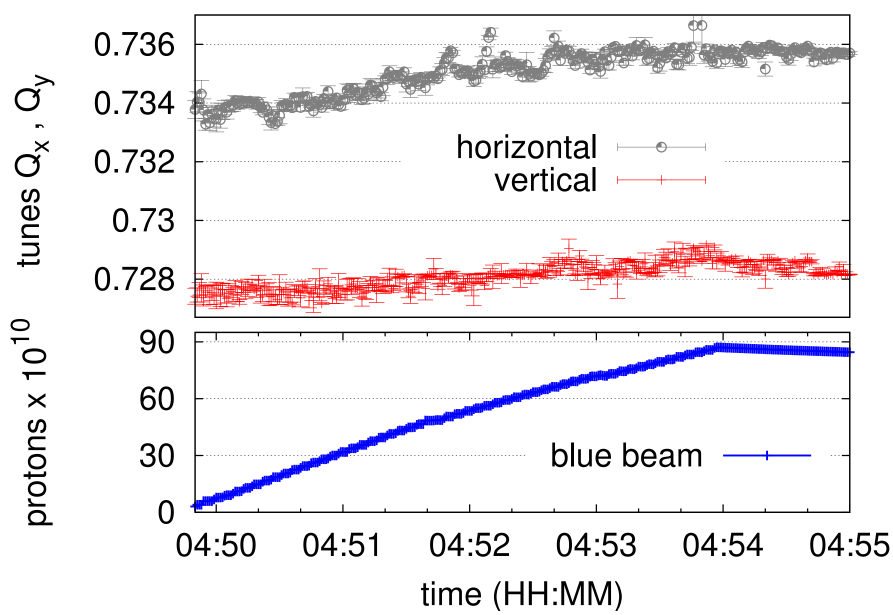
Total arcs length/ring:≈ 3100m

Since $\Delta Q = \sum \Delta Q_i$ *, we can see if the measurements show ΔQ consistent with EC presence ONLY in warm regions, or we need an extra contribution (from the arcs).

*addition of the ΔQ_i at the different elements through the RHIC circumference

One attempt last year: Fill # 5350.

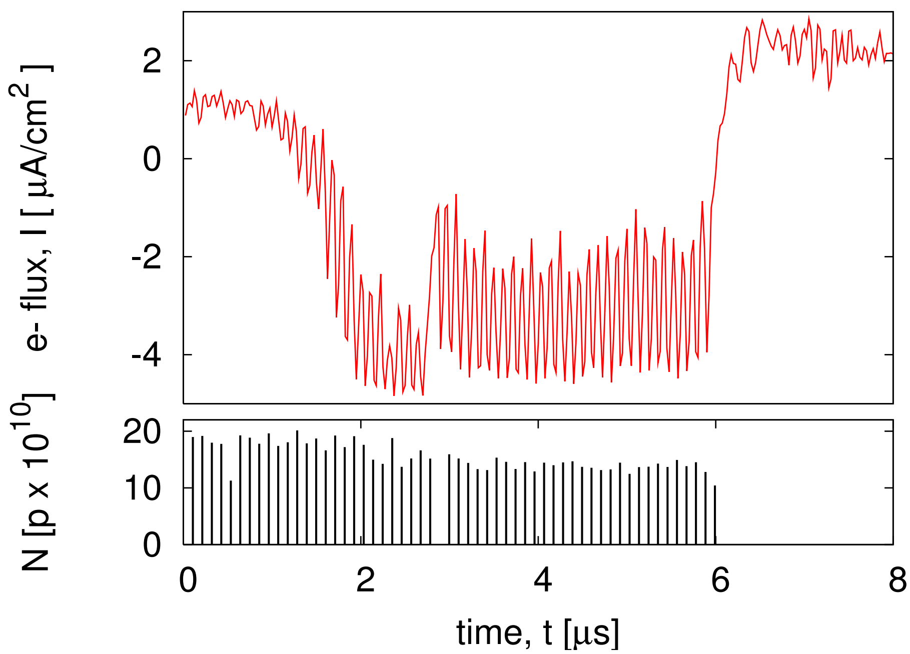
→ 60 bunches at injection
→ $N_b = 1.56 \cdot 10^{11}$ protons (average)
→ $s_b = 108$ns
→ ΔQ measured with PLL *
→ Flux into the wall measured at IR12

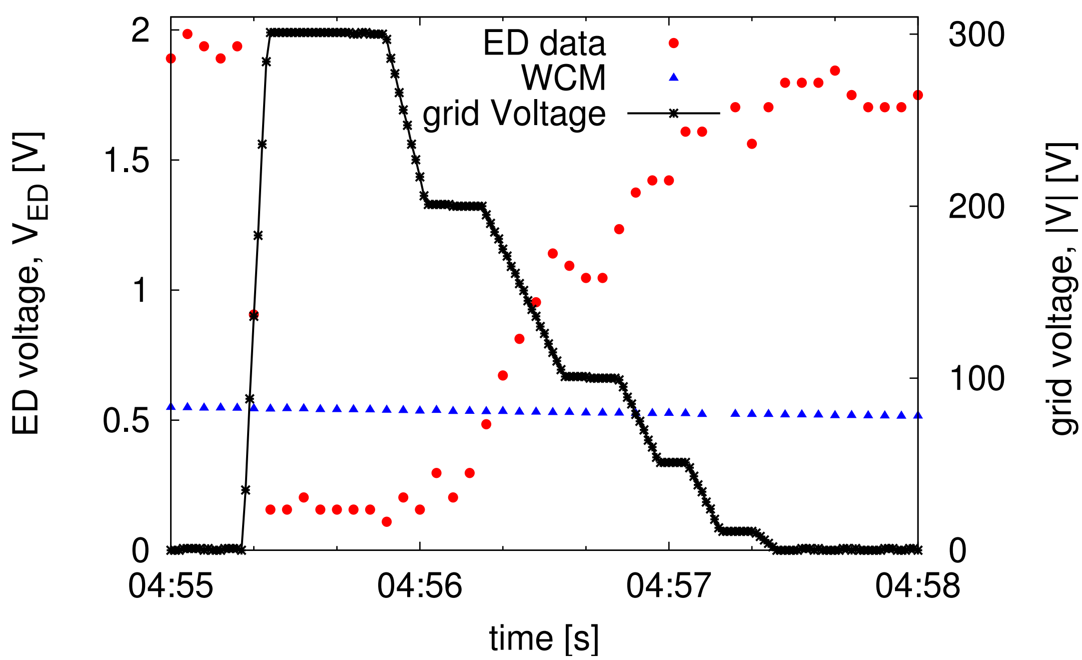


NOTE: $\Delta Q_h = 0.002$, $\Delta Q_v = 0.001$

*Thanks Pete Cameron!

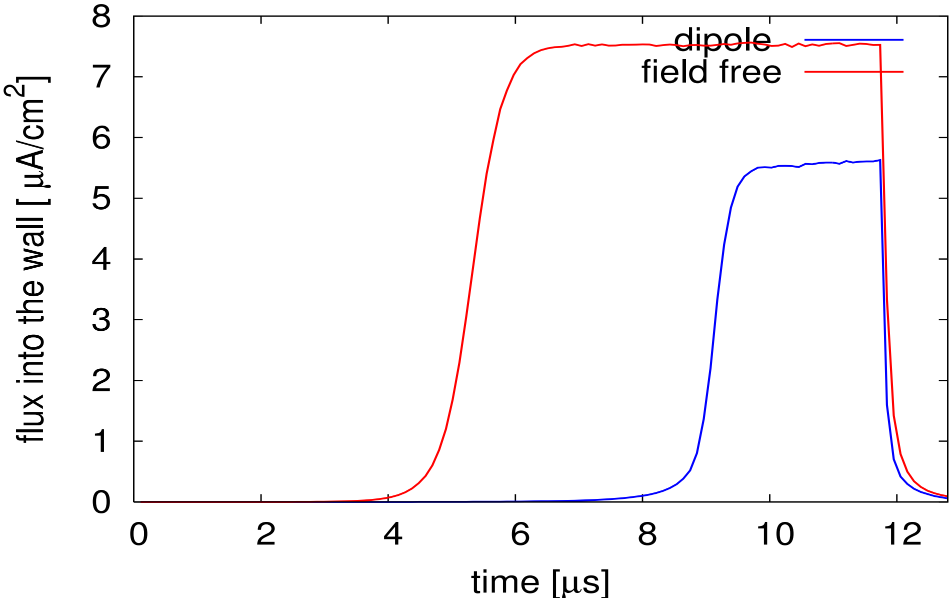
Simulation are calibrated with measurements from flux into the wall and energy spectrum:

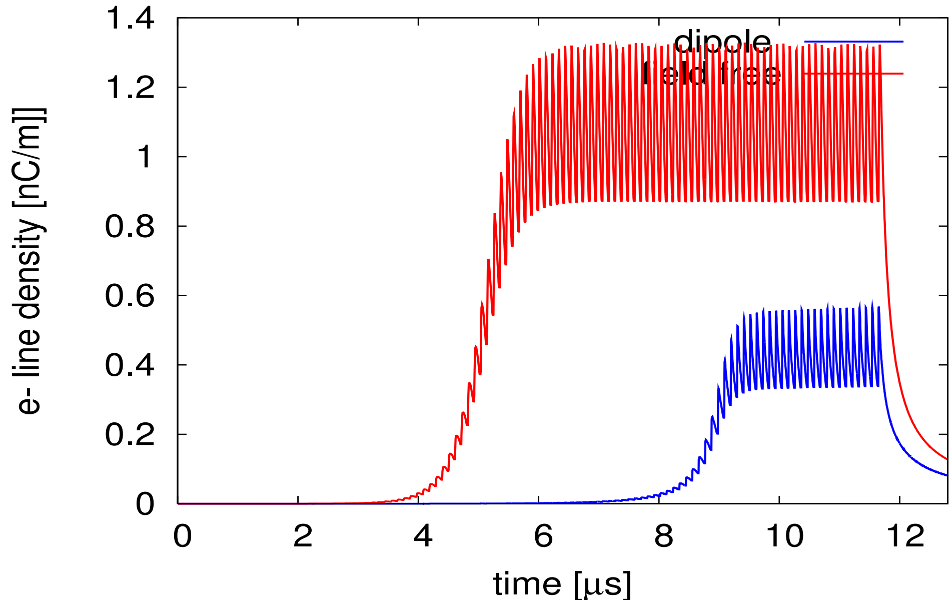


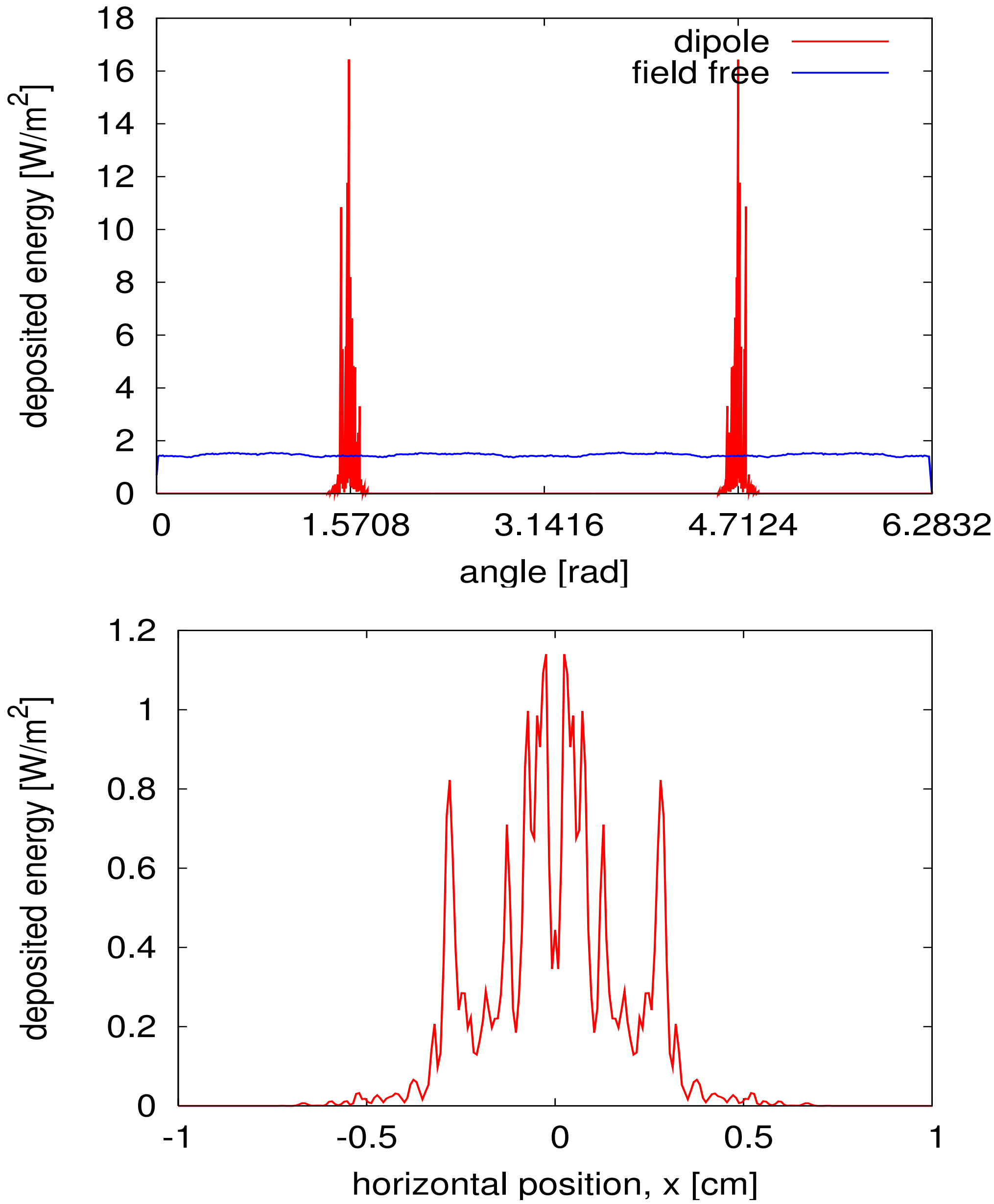


PRELIMINAR Simulation Results

Dipole field: 0.4 T; δ_{max}=2.2; Rpipe=4cm
Field Free: δ_{max}=1.9; Rpipe=6cm







Uneven distribution of EC in a dipole field. EC present in dipoles → assymetries in ΔQ_h vs ΔQ_v

Discussion

Simulation vs experimental data about the flux into the wall is acceptable (exp. data is ≈5$\mu A/cm^2$; sim. shows ≈7$\mu A/cm^2$)

→ Can get better agreement lowering δ_{max}

However,

1. using calibrated simulation results for ρ, we find $\Delta Q \approx 0.005$ JUST due to influence from warm regions.
2. using PLL measurement, $\frac{\Delta Q_h}{\Delta Q_v} = 2$

So,

1 indicates that, numerically, no presence of EC in the dipoles is needed to explain this ΔQ.
2 indicates presence of EC in the arcs (assimetries due to multipolar magnetic fields) *
Therefore,

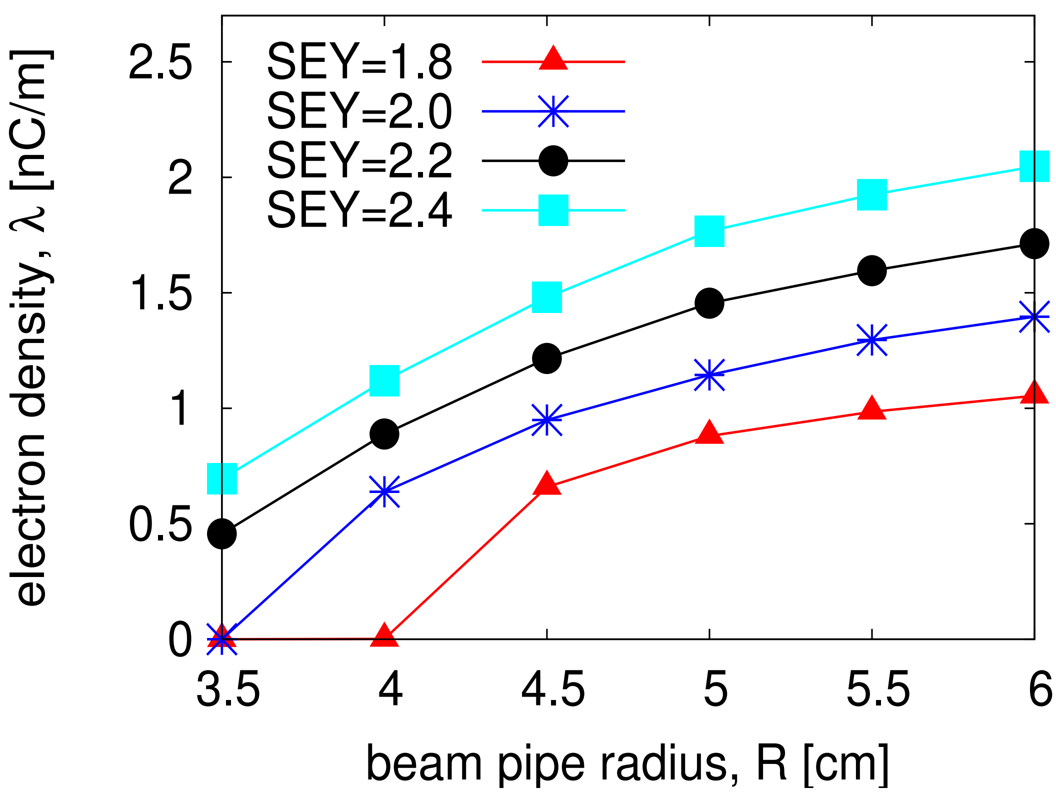
→ NEED REPRODUCIBILITY

*pressure rise detected as well in blue arcs for this fill indicates presence of EC in the arcs

Why threshold for EC is lower at the arcs?

For RHIC parameters, a smaller radius produces a larger threshold.

Simulation for $s_b = 108$ ns, $N_b = 1.6 \cdot 10^{11}$ protons, scan in radius and SEY:



Average pipe radius: $R_{arcs} = 3.5$ cm; $R_{warm} = 6$ cm

2. Conclusions and outlook

PRIORITY: **Diagnostics at RHIC arcs**

Need Beam Experiments time to reproduce tune shift measurements with high intense fills.

INSTRUMENTATION:

- PLL + (Artus)
- ED + pressure gauges
- Improve heat load detectors for arcs

BEAM REQUIREMENTS:

- High bunch charge $\geq 1.5 \cdot 10^{11}\ e$
- Smallest bunch spacing $s_b = 108$ ns
- Round beams *

*Can we change the optics so that the average β at the warm sections is smallers? (larger β_*?)