# Which kind of measurements do we need to constrain electron cloud simulations?

Summary of discussion between G. Arduini, F. Ruggiero, F. Zimmermann and D. Schulte

# Aim of Benchmarking ECLOUD

Verification that code can be used to predict electron cloud effects in the LHC, this requires

correct modelling of physics processes

- low energy electron reflection model
- angular dependence of reflection, secondary emission

correct implementation of modelling in the code

- bugs

correct knowledge of experimental system

- surface conditions (secondary emission yield) change globally and locally
- beam parameters
- beam trajectory
- local vacuum level (for rise times)

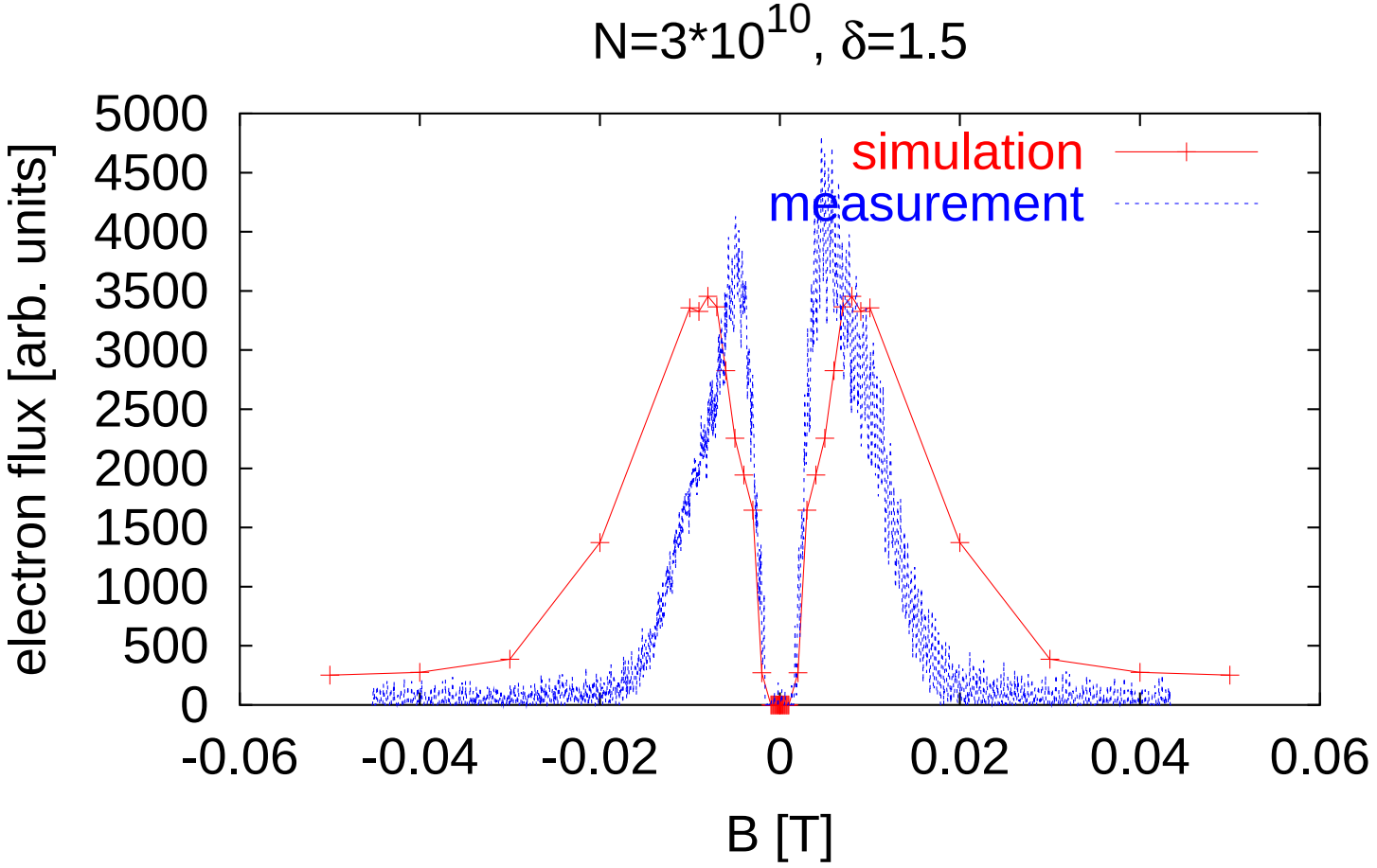
correct measurement of effects

- detector effects

$\Rightarrow$ scans are more useful than single point measurements

e.g. magnetic field scan rather than field/no field

# Example


N=3*10^10, δ=1.5
electron flux [arb. units]
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
-0.06
-0.04
-0.02
0
0.02
0.04
0.06
B [T]
simulation
measurement

# Code Status

Last year ECLOUD code has been significantly improved

- made to run on new system
- removed bugs
- improved modelling of reflection at chamber wall
- improved modelling of detectors
- improved modelling of fields, etc
- increased speed

should be mostly ready to do new simulation campaign

a few points need continued effort

- detailed modelling of detectors (magnetic field)
- modelling of surface effects (needs contraints from experiment)

$\Rightarrow$ make sure we have enough data for these points

# Measurement of Time Evolution of Cloud Build-Up

- Measurement of build-up along train

  predicted to depend on magnetic field

  in case of no field, quantitative agreement between experiment and simulation can be improved

  measurement at different field and vacuum levels could help to find explanation

- different batch distances (at different fields)

  measure electron flux during gap

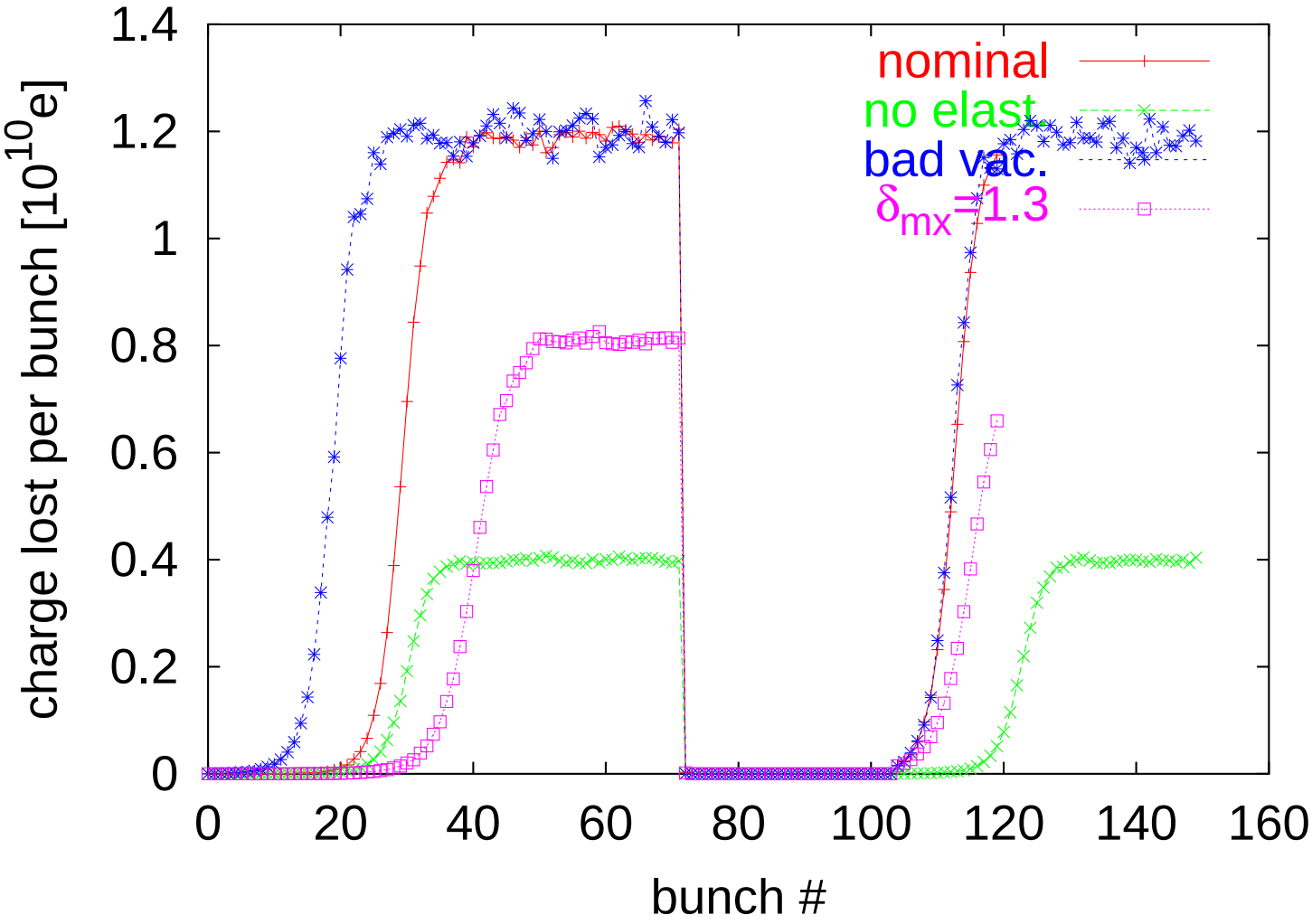
  rise time in second batch

  relatively simple situation

  sofar agreement

  $\Rightarrow$ more data helps to constrain reflection model

# Example


charge lost per bunch [10^10 e]
bunch #
nominal
no elast.
bad vac.
δmx=1.3
0
0.2
0.4
0.6
0.8
1
1.2
1.4
0
20
40
60
80
100
120
140
160

# Beam Intensity Scan

- Measure threshold of electron cloud

  in dipole field, simulations are not inconsistent with measurements

  but are not well enough constrained

  $\Rightarrow$ should do fast scans at different intensities, e.g.

  magnetic field

  chamber height

  setting-up of machine is time consuming

  main problem: to get equal bunch intensities

  $\Rightarrow$ simulations should establish before experiment at which level variations can be accepted

# Other Measurements

- Tune shift of bunches should be recorded

  $\Rightarrow$ integral of electron cloud around ring

- variation of local beam orbit after some limited scrubbing to measure yield at different $x$

- variation of bunch length

  $\Rightarrow$ constrains simulations

  $\Rightarrow$ strong predictions for electron energy spectrum

- emittance growth with stored beam (some minutes)

  while chromaticity is still needed to stabilise beam

  try to replace chromaticity by coupling etc.

  $\Rightarrow$ benchmarking of headtail code

- electron cloud during and after ramp

  possible after scrubbing run

  interesting also before

- micro wave reflection/phase change at electron cloud

# Remarks on Some Detectors

- WAMPAC 3 experiment and simulation disagree strongly

  but WAMPAC 1 is in good agreement

  $\Rightarrow$ check simulation

  $\Rightarrow$ check experiment

- strip detectors absolute level of flux disagrees

  but relative levels seem OK

  $\Rightarrow$ detailed modelling of detector

  $\Rightarrow$ verify calibration

  $\Rightarrow$ perform field scans

  - remanent field
  - disagreement for high fields

  $\Rightarrow$ can constrain detector effects

  $\Rightarrow$ cross checks with other detectors

- variable chamber height (at more than 80mm)

  $\Rightarrow$ have clear predictions of program (maximum at 80mm)

- measurement in quadrupole

  $\Rightarrow$ benchmarking of quadrupole simulations

# Remarks Continued

- in situ measurement of secondary emission yield (in dipole field)

  $\Rightarrow$ effect of scrubbing

  $\Rightarrow$ ensure that secondary emission yield measurement is relevant for detector considered

  $\Rightarrow$ removes one of the largest uncertainties

# Scans and Duration

| Type of Scan | Approximate Typical Duration | Repetitions |
|---|---|---|
| Magnetic Field | minutes | Frequently |
| Batch Distance | minutes | Several times as scrubbing progresses |
| Bunch Spacing | minutes or more | At the beginning for free, maybe once or twice more |
| Bunch Length | minutes | A few times |
| Chamber Height | minutes? | A few times |
| Horizontal orbit scan | minutes | A few times |
| Intensity | hours | Once at beginning? |
| Vacuum Pressure | ? | ? |

$\Rightarrow$ magnetic field scan should be optimised because it will slow down some other measurements

# Conclusion

Most important points seem to be to understand

- WAMPAC 3
- absolute flux in stripe detector
- build-up along bunch train
- survival of electrons between bunch trains
- variable chamber height

some measurements should be centrally triggered and (later?) correlated

- choose stable beam
- easier to correlate data
- essential for orbit variations