Working point optimization and space-charge studies

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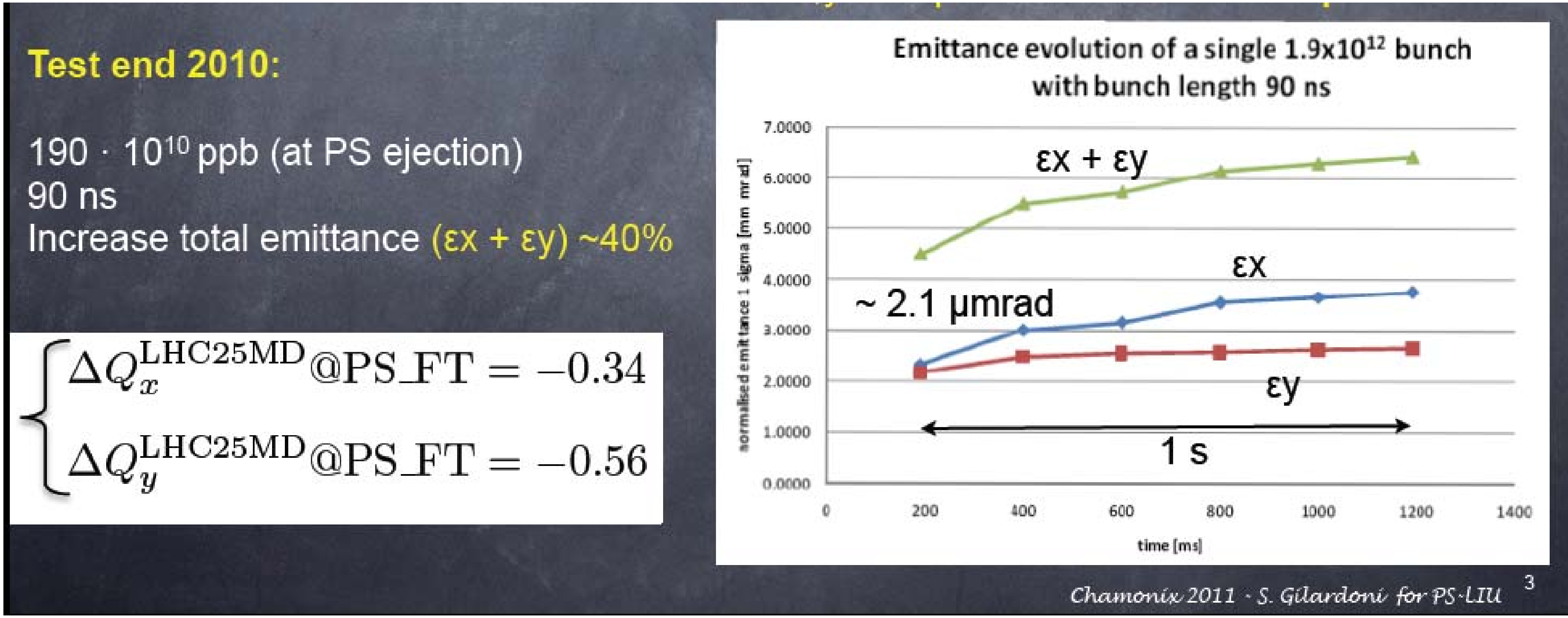
…with input, material (and beam) from many colleagues in ABP, OP and RF

LIU-PS Meeting, 17-5-2011

Motivations

- **LIU-PS:** Deliver high beam intensities required by HL-LHC & preserve transverse emittance
- Space-Charge (SC) at inj. (1.4 GeV) induces blow-up:
  - If Laselett $|\Delta Q|$ >0.3
  - If double-batch injection (long flat bottom)
- Mitigation:
  - Go to 2 GeV & further optimize Working Point (WP)
- Machine Development (MDs) studies:
  - WP scan → identify destructive resonances
  - Emittance growth measurements → get max. allowed ΔQ
- Other high-intensity beams will profit: n-Tof, CNGS and Fixed Target, **Beta-Beams**

Emittance growth measurements



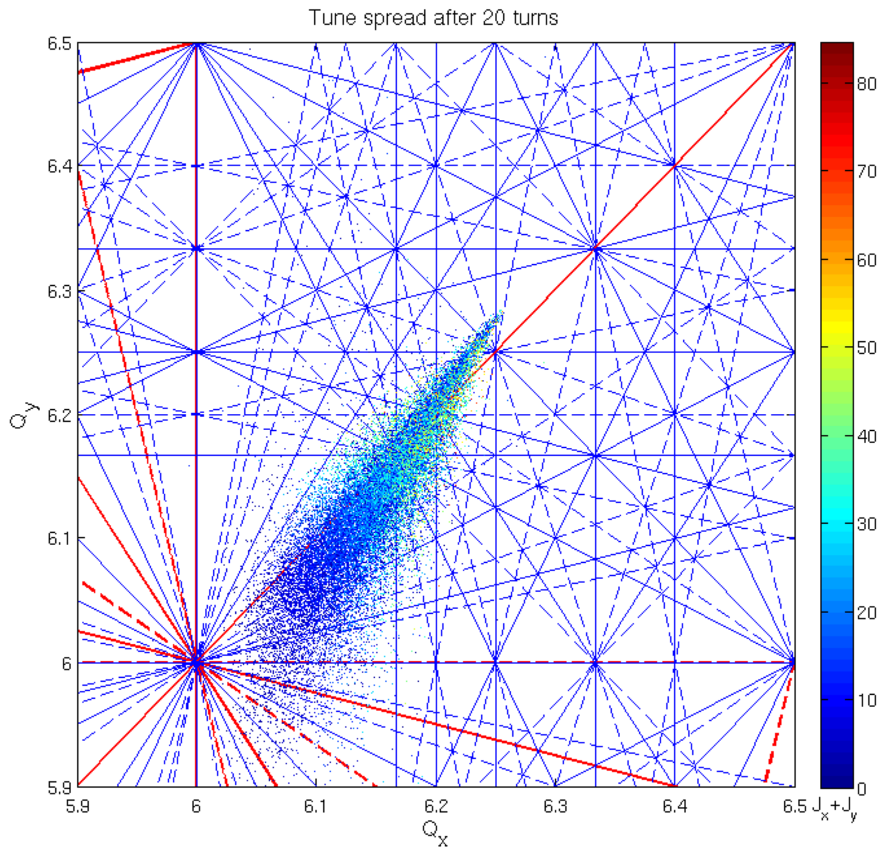
- Compare with *R.Cappi et al., PAC'93*: different growth rate, why?
- Repeat @ 2 GeV and once optimized WP

WP scan (and optimization)

- Determine best WP to accommodate the largest SC neck-tie

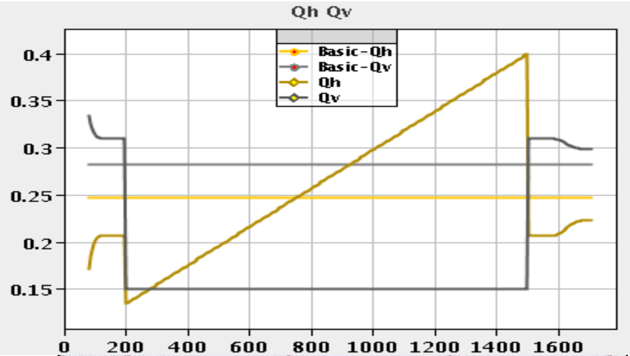
- Particles cross betatron resonance lines and
  - either lost
  - either emittance blow-up

- If $|\Delta Q_{Laselett}| > 0.2$ the SC neck-tie extends down to the integer



WP scan (and optimization)

- Identify dangerous resonance lines in tune diagram
- Loss measurements:
  - Low intensity beam (not SC-dominated) → 130 x 10^{10}
  - Large emittance (to fill the chamber & provoke immediate losses)
  - Long flat bottom @ 1.4 GeV
  - Tune program:
    - Scan between (0.1 - 0.4)
    - Vertical tune constant
    - Sweep of the horizontal tune



  - Slope in the intensity signal indicates importance of the crossed resonance line

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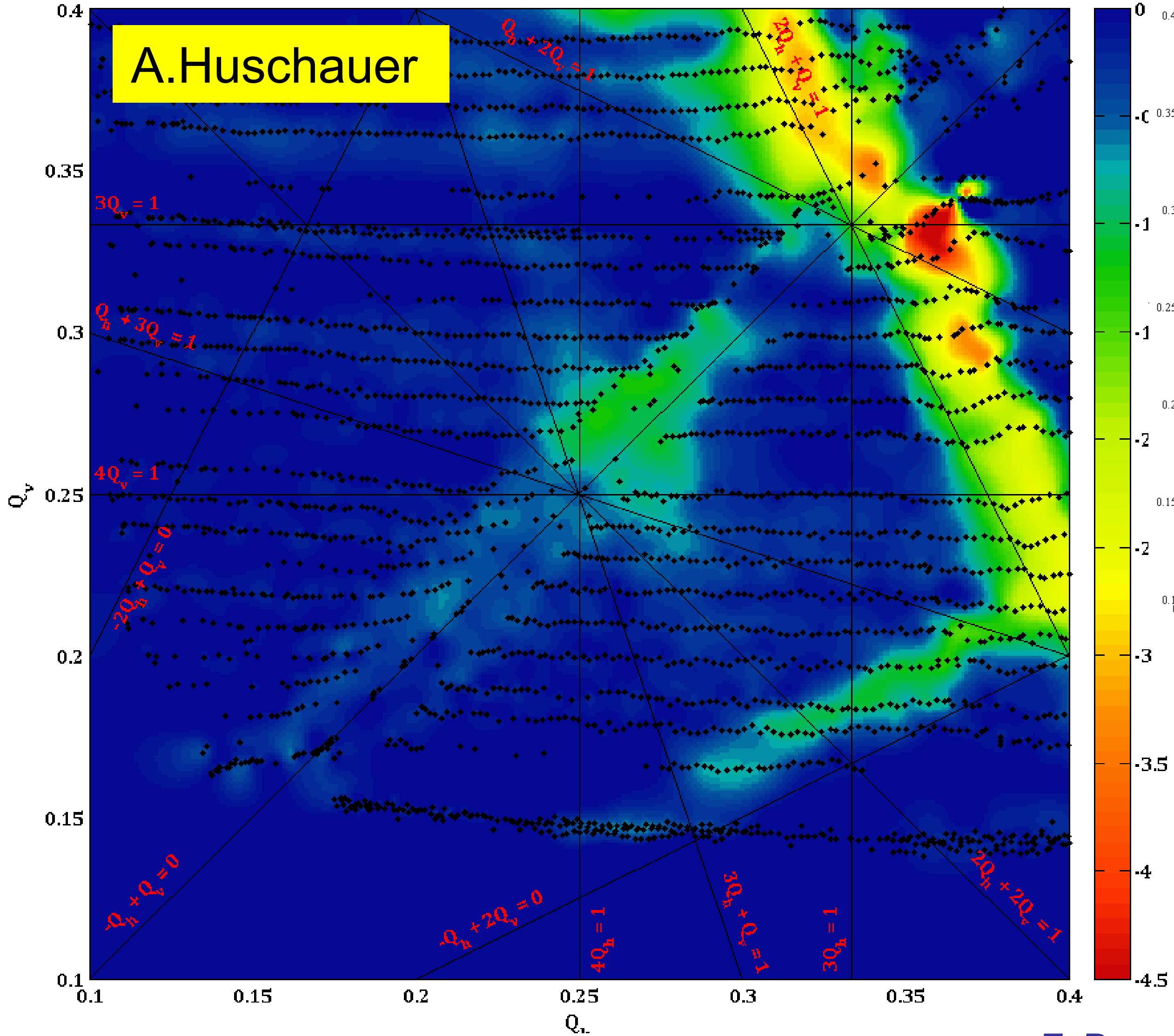
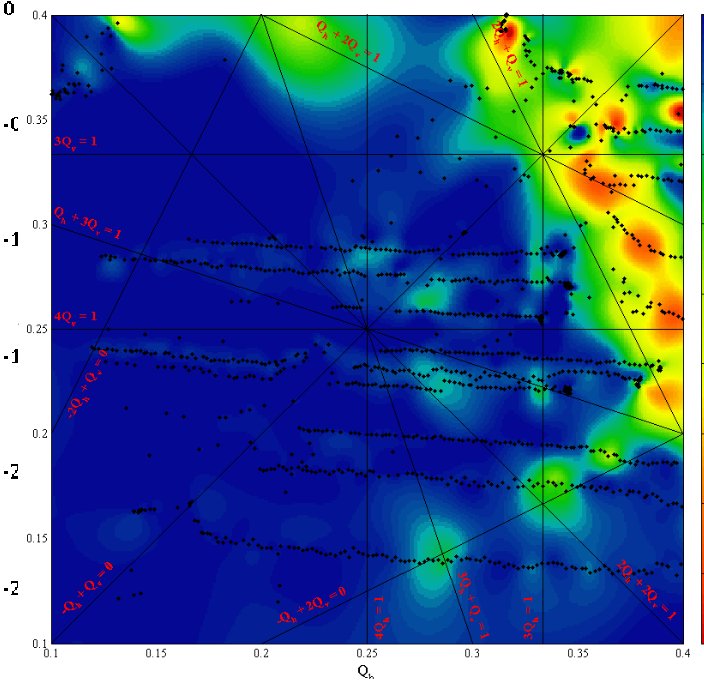
WP scan - bunched

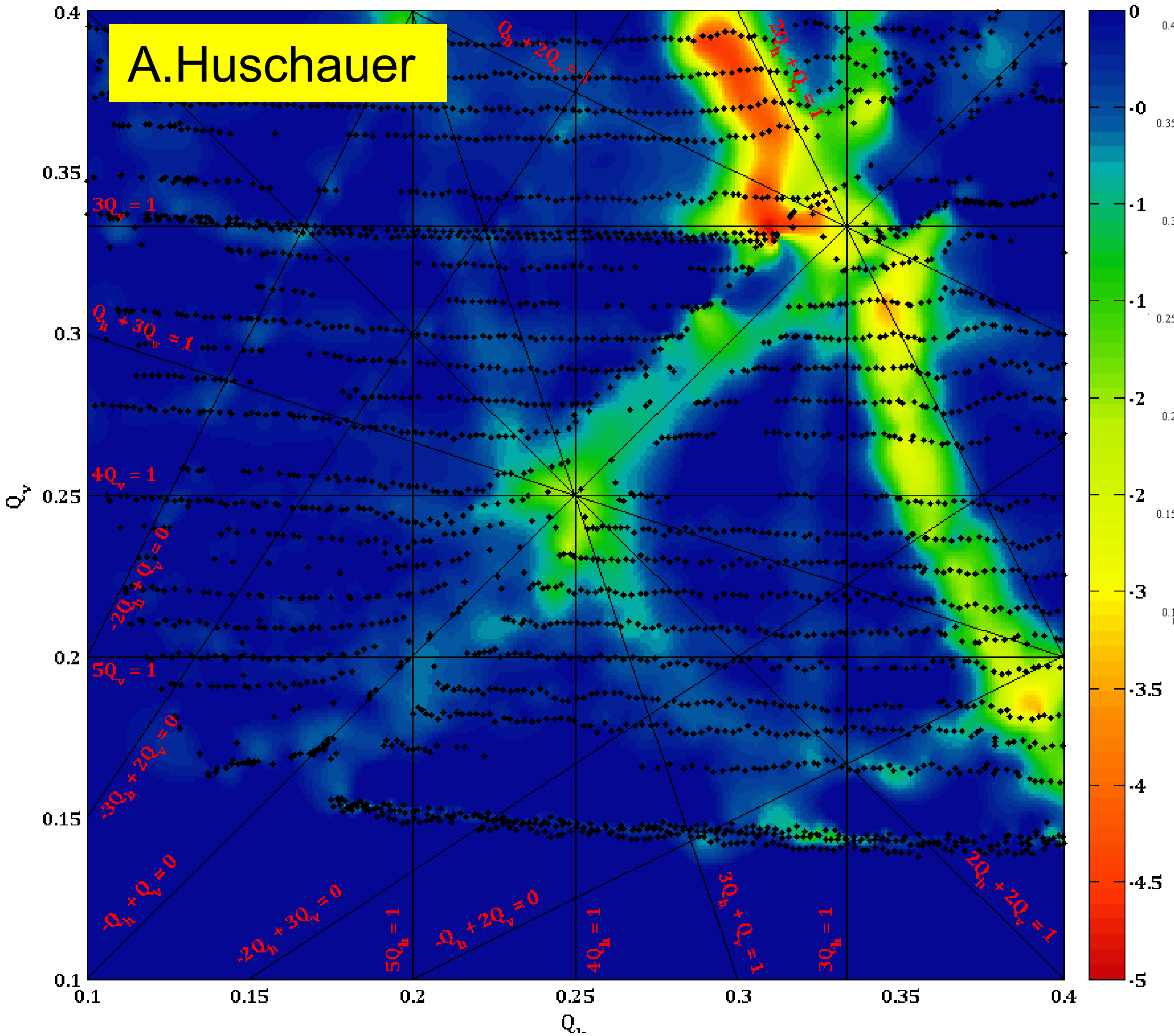


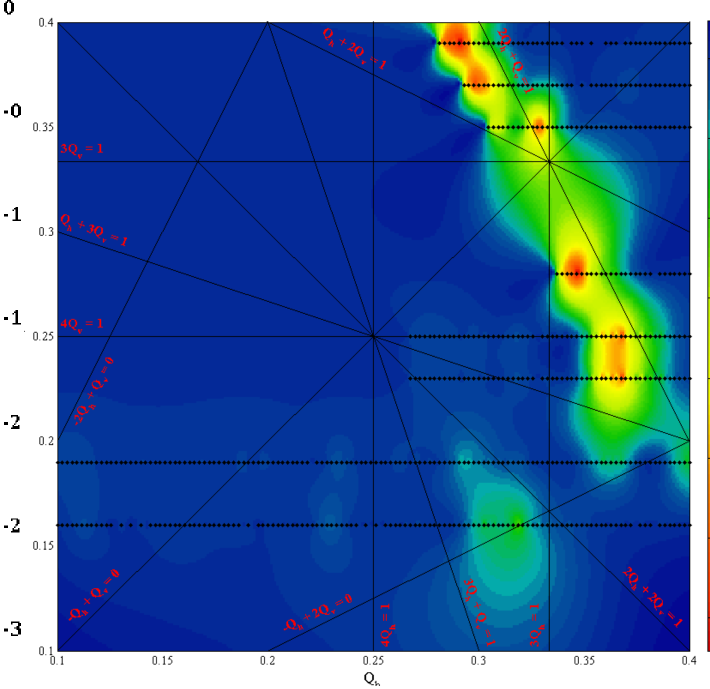


Sweep $Q_h = 0.4 \rightarrow 0.1$

✓ OK!

WP scan - debunched





Sweep Q_h=0.4 → 0.1

✓ OK!

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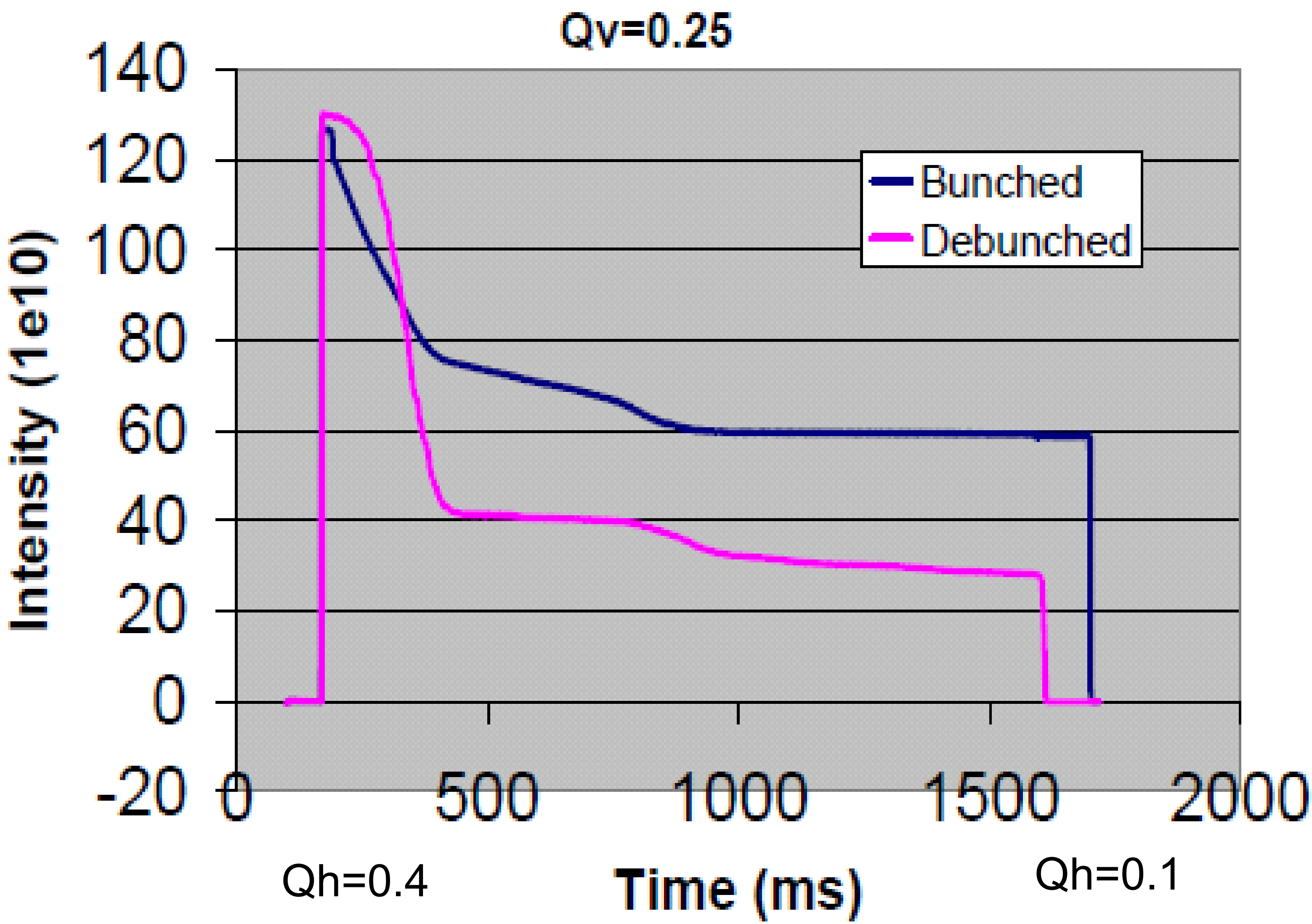
WP scan


Qv=0.25
Intensity (1e10)
140
120
100
80
60
40
20
0
-20
0
500
1000
1500
2000
Bunched
Debunched
Qh=0.4
Time (ms)
Qh=0.1

Conclusions

- WP scan @ 1.4 GeV done (by Alex) to identify resonances
- Method (horizontal tune sweep) is validated
- Better to use debunched beam (no Q' effect)

Next steps:

- Repeat WP scans @ 2 GeV
- Correct Q' with PFW
- Identify optimum WP @ 2 GeV, with large SC neck-tie
- Emittance blow-up measurements
  - Extract growth time
  - Check transverse & longitudinal profiles
  - (If resonance crossing we expect bunch shortening)