# RF Meeting: RCS -> PS Issues

on Friday 13/05/2011; Present: A.Blas, H.Damerau, M. Fitterer, S.Hancock, K.Hanke,G.Rumolo, H.Schönauer

- **Bunch Area for PS at 2 GeV $\Rightarrow$ 2 eVs**

- Up to 500 ms waiting time at 2 GeV $\Rightarrow$ bunches have to stand it $\Rightarrow$ risk of transverse (head-tail) instabilities $\Rightarrow$ What is the admissible local line density? No clear answers yet…

- Bunches should be stationary in PS buckets $\Rightarrow$ can PS buckets be matched to RCS bunches.

- Blow-up takes many (100-1000?) synchrotron periods $\Rightarrow$ excluded in RCS. Maximum achieved in PS : 50%

- PS requires a bunch length of 140 ns for LHC25A/B beam: Requires RF voltage reduction to only 2 kV $\Rightarrow$ essentially non-adiabatic process $\Rightarrow$ but rotation seems to work $\Rightarrow$ are the rotated bunches acceptable?

- Longitudinal Painting problem? Energy ramping speed of Linac4 is limited $\Rightarrow$ Too many turns to populate 2 eVs?

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# Potential LHC Beams at an Upgraded PSB
## (B. Mikulec)

|  |  | h=1 | h=1 |  |  |  |  |
|---|---|---|---|---|---|---|---|
|  |  | lb ns | phi1,2 deg | Nbunch / E12 | Ex rms | Ey rms |  |
| **LHC25A/B** |  | **180** | **77** | **2.43** | **2.5** | **2.5** |  |
| LHC25,50,75 |  | 140 | 60 | 3.25 | 2.5 | 2.5 |  |
| LHCPILOT |  | 85 | 36 | 0.005 | 2.5 | 2.5 |  |
| LHCPROBE |  | 70 | 30 | 0.005 | 2.5 | 2.5 |  |
| LHCINDIV |  | 80 | 34 | 0.135 | 2.5 | 2.5 |  |
| CNGS |  | 180 | 77 | 4 | 10 | 8 |  |
| SFTPRO |  | 180 | 77 | 3 | 6 | 5 |  |
| AD |  | 190 | 81 | 4 | 8 | 6 |  |
| TOF |  | 230 | **98** | 9 | 10 | 10 |  |
| EASTA/B/C |  | 150 | 64 | 0.45 | 3 | 1 |  |
|  |  |  |  |  |  |  |  |
| NORMGPS/HRS |  | 250 | 107 | 1 | 15 | 9 |  |
| STAGISO |  | 230 | 98 | 3.5 | 8 | 4 |  |
|  |  |  |  |  |  |  |  |

# Voltage Reduction to 2 kV
# Bunch epsL=1.35 eVs on h=1+2
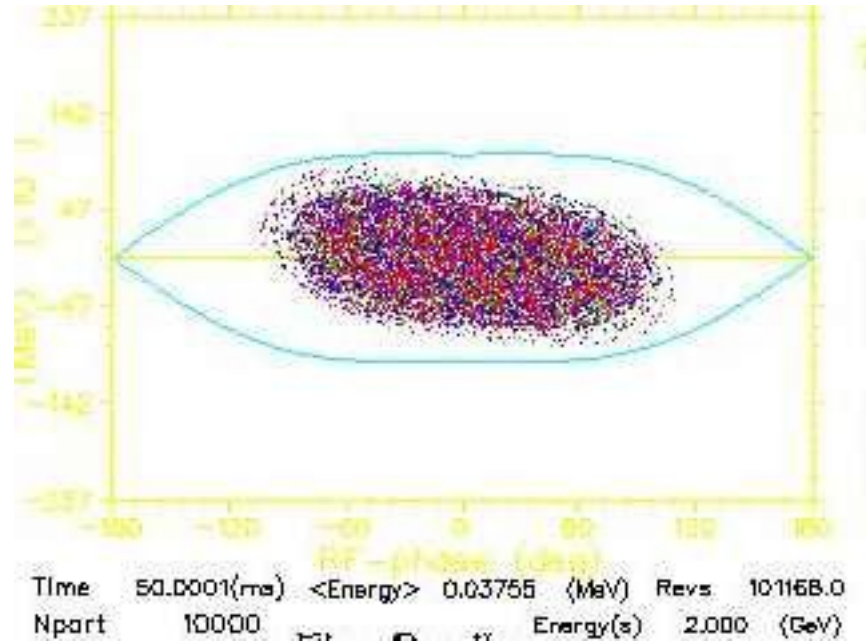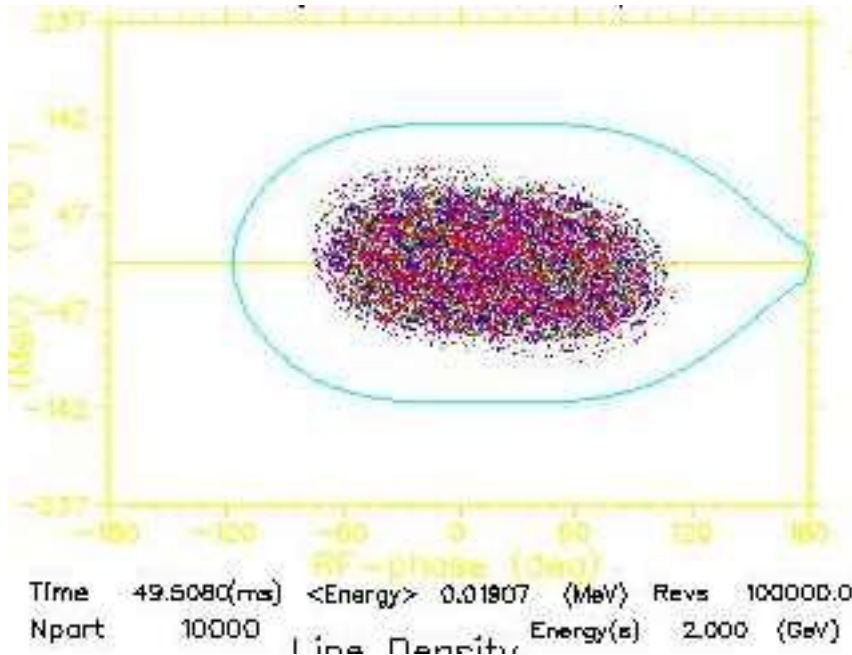


Bunch 1.35 eVs at 2 GeV at 59.5ms and 50ms:

Vrf=2kV :  ~ +-80deg essentially non adiabatic…

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# Bunch Rotation at 2 GeV
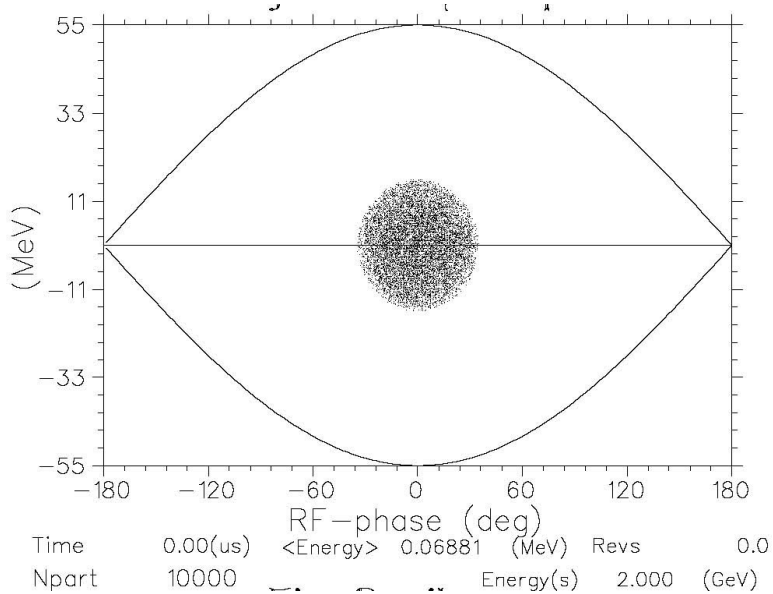


Bunch 2 eVs at 2 GeV:

Vrf=60kV :  +-34deg x +-16 MeV

After Rotation (1ms):
Vrf=8kV :   +-110deg x 5 MeV
With h=2 : +-120 deg x 4.7 MeV

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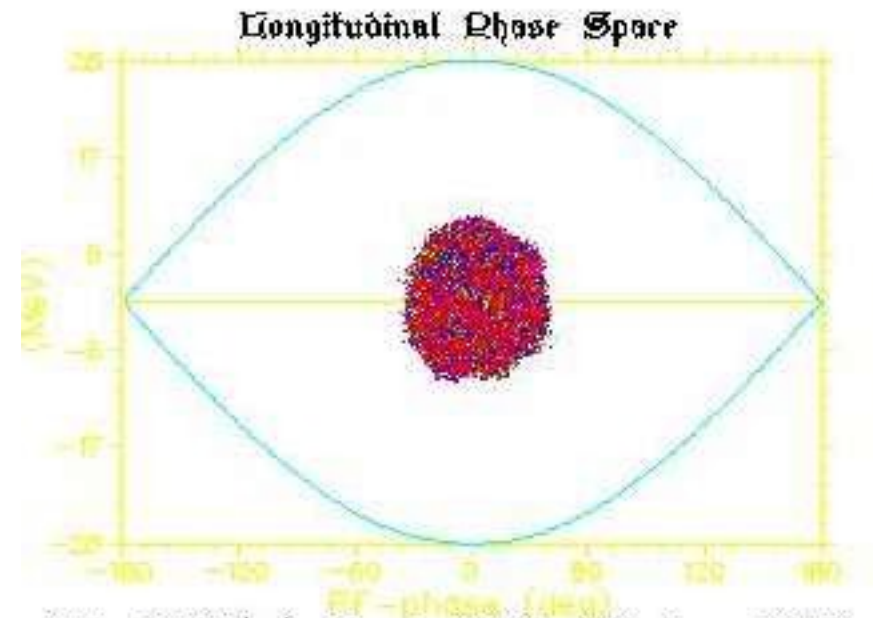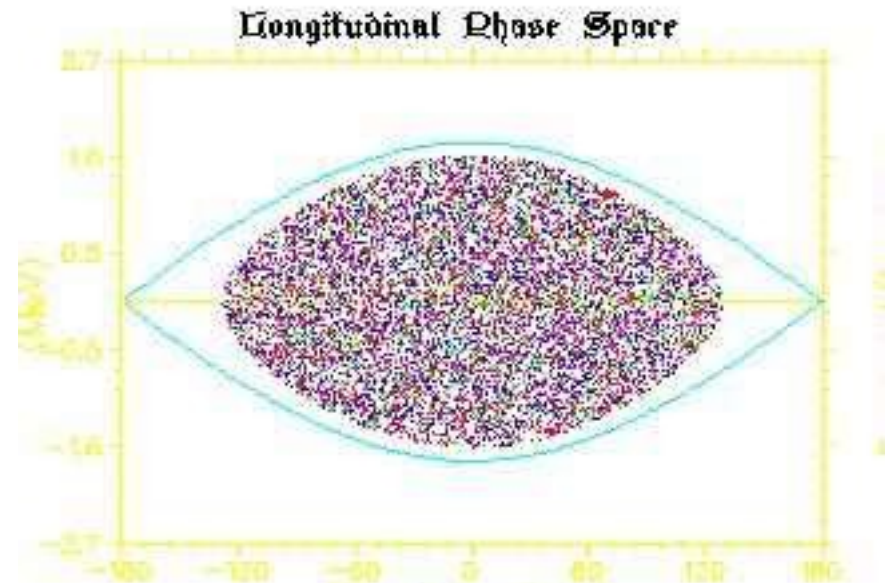                                Group 19/05/2011
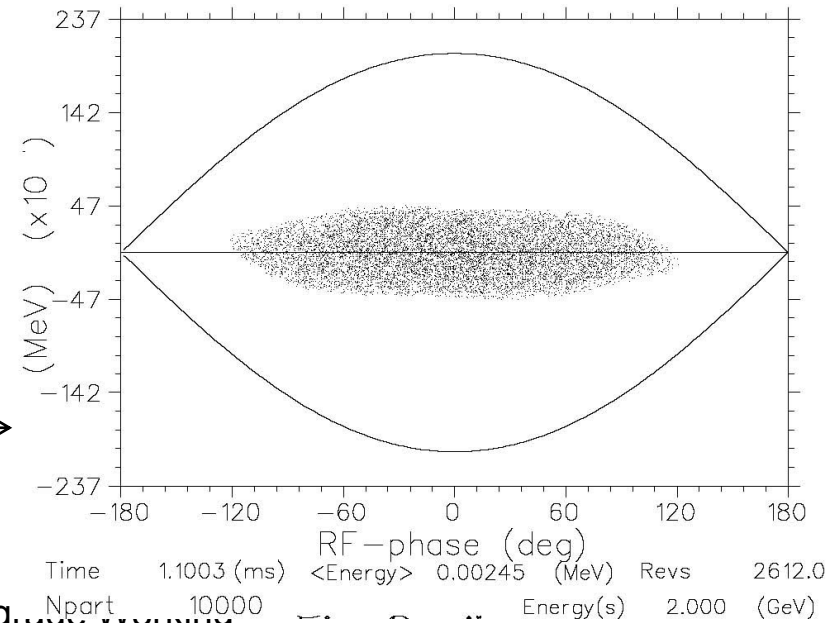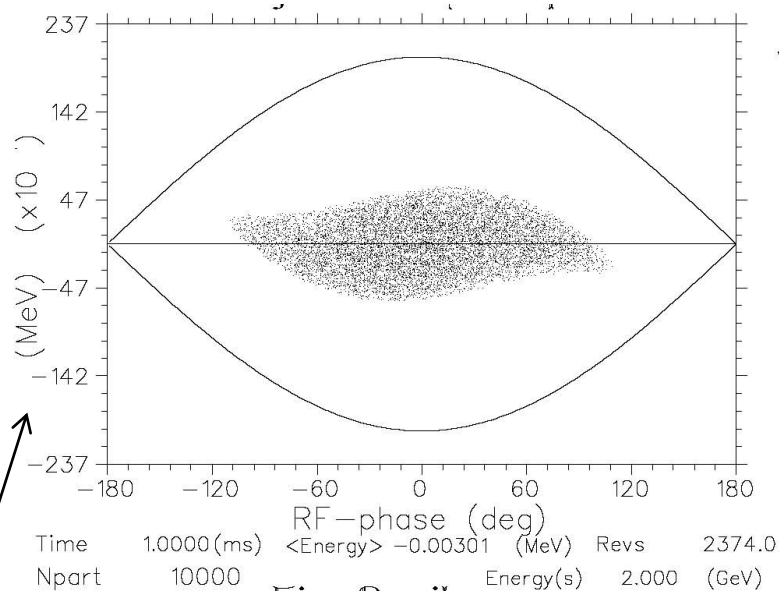
# Acceleration of Bunch epsL=0.35 eVs on h=4



Bunch 0.35 eVs at 2 GeV:

Vrf=60kV :  +-37deg x +-11 MeV

$\Rightarrow \Rightarrow$ **Lbunch = 14 ns !**

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# Magnet Cycle & Sp.Ch. Tune Shift:
## Injection on Linear Ramp ? Extreme Case: 75ms Ramp
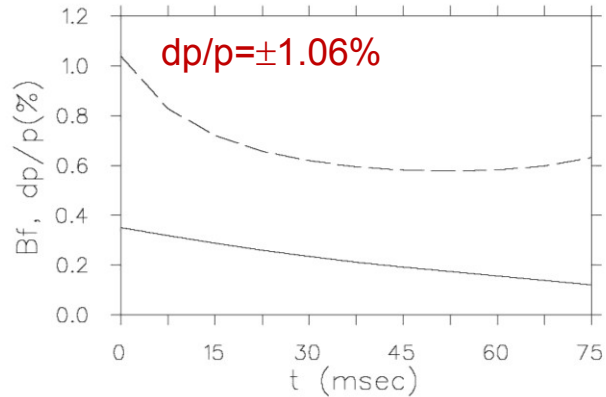## e.g. LHC25A Beam: Tune Shift surprisingly small:
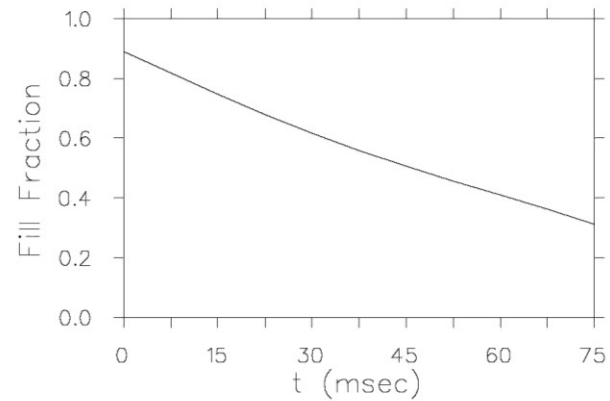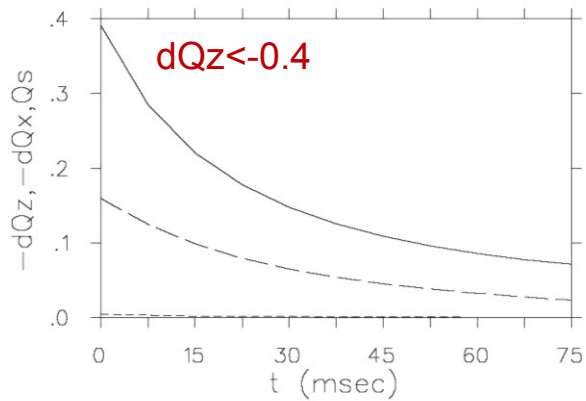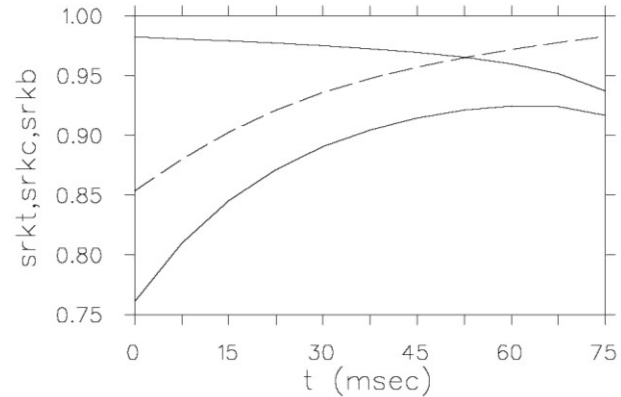
# Space Charge Tune Shift: Momentum spread helps!

$$\Delta Q_{s.c.} = -\frac{N_b}{\varepsilon_n}\frac{r_p}{\pi}\frac{1}{\beta\gamma^2}\frac{FGH}{B_b}$$

H …Aspect Ratio Factor:

$B_b$…Bunching Factor,
   aver./peak line density of <u>single</u> bunch
$\beta, \gamma$ …Lorentz Factors

$$H_y \propto \left\langle \frac{1}{b(a+b)} \right\rangle;$$
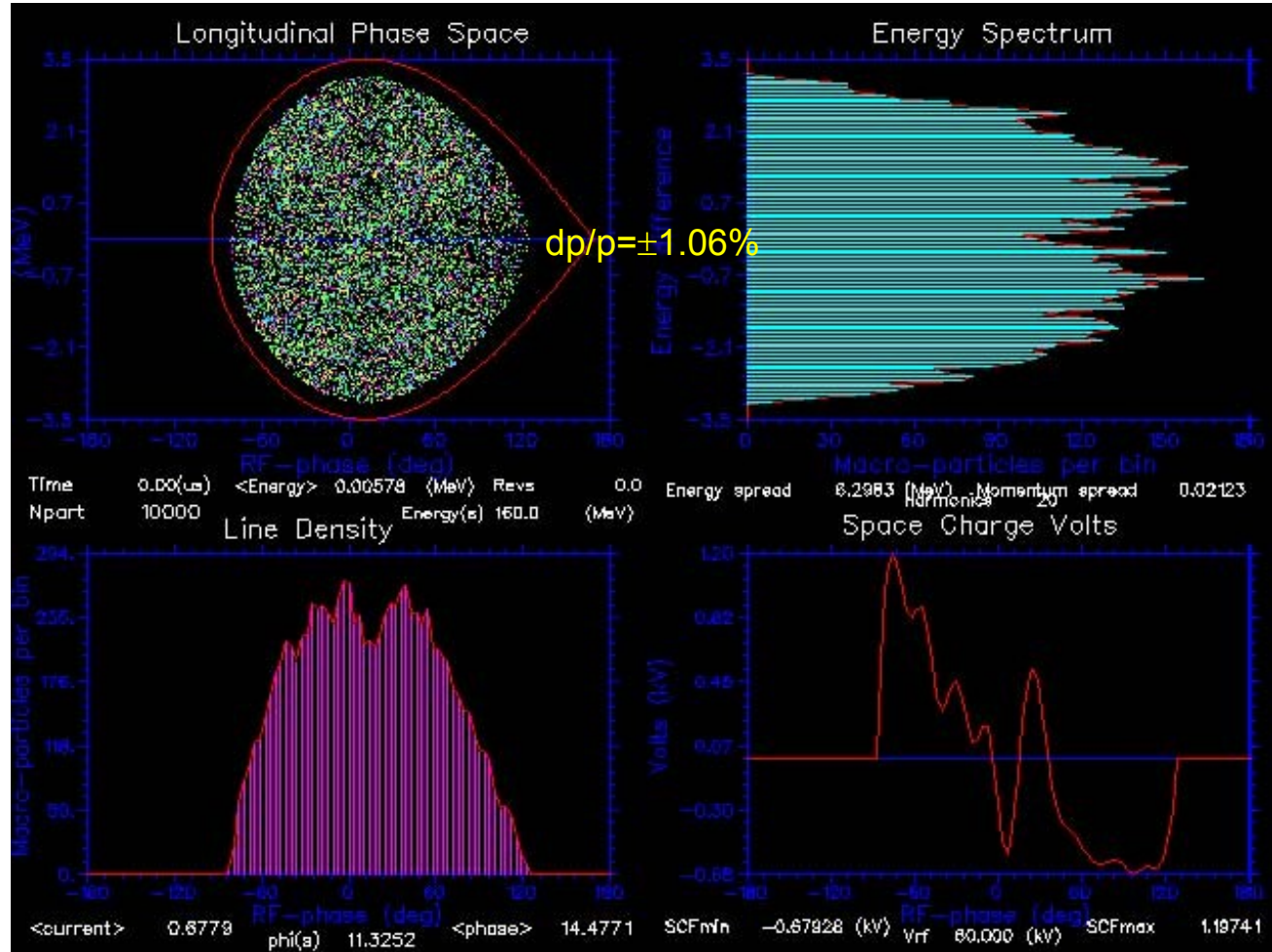
$a$ …hor. Beam radius,
contains $<D\,dp/p>$
$N_b$…p/bunch
F  …Image Factor ~1
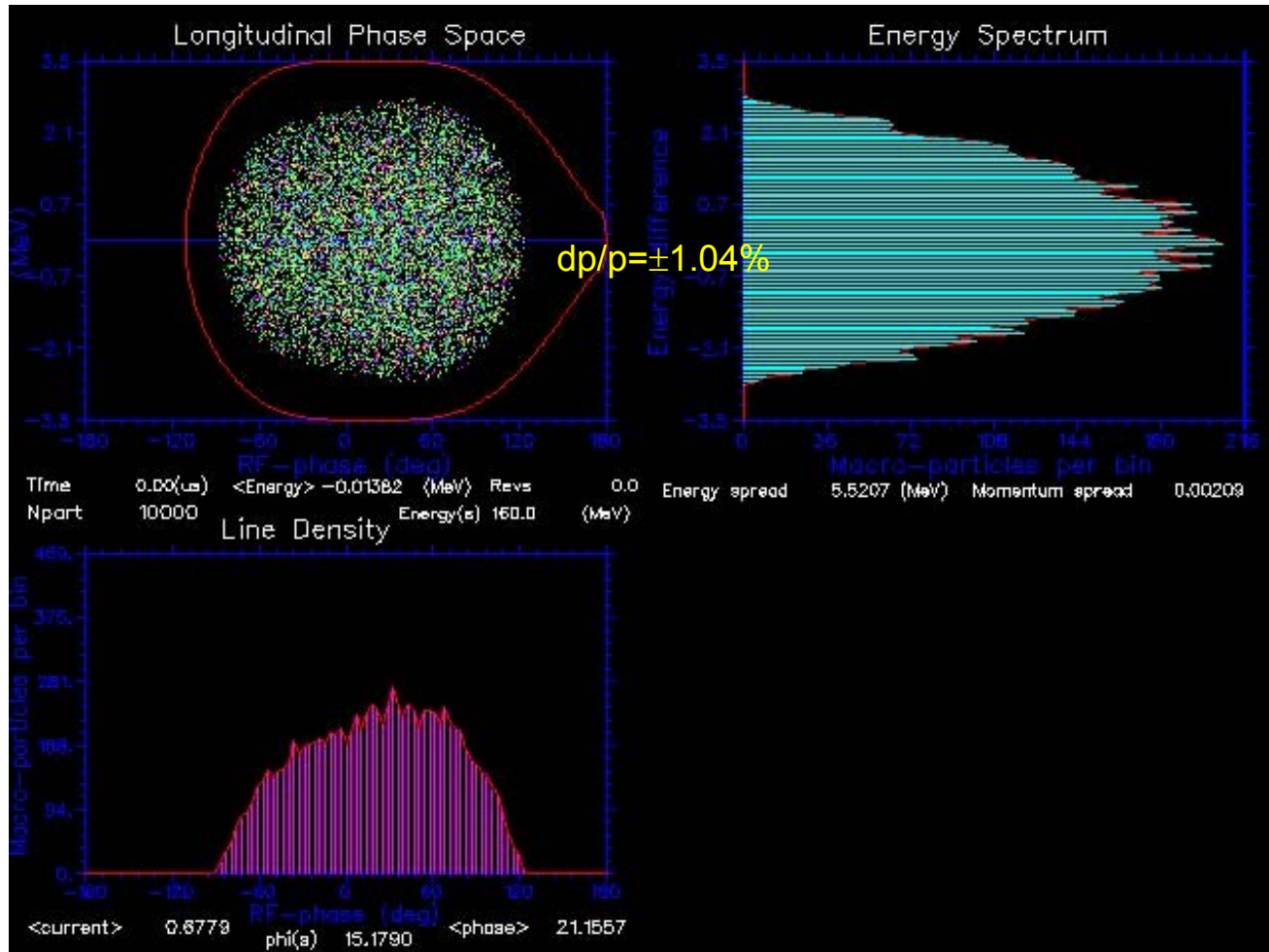G …Distribution Factor (transverse)
   Gaussian =2, uniform =1 (for $\varepsilon(2\sigma)$)

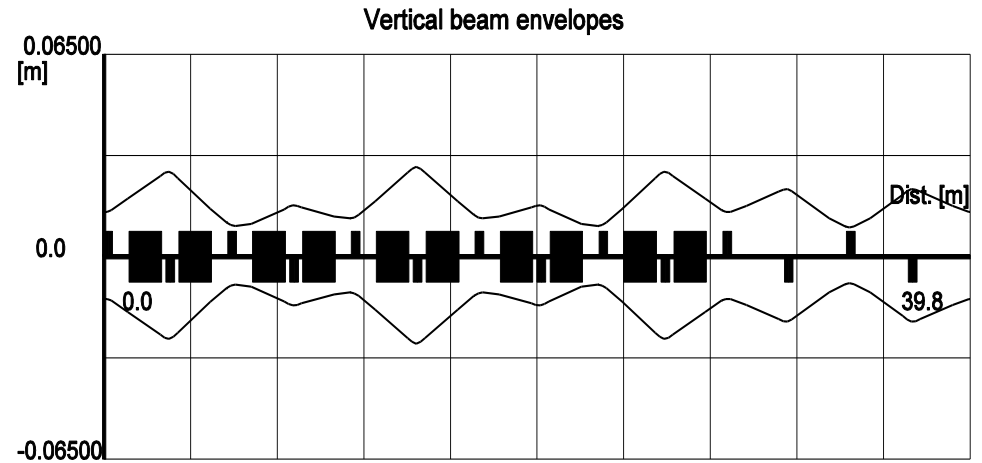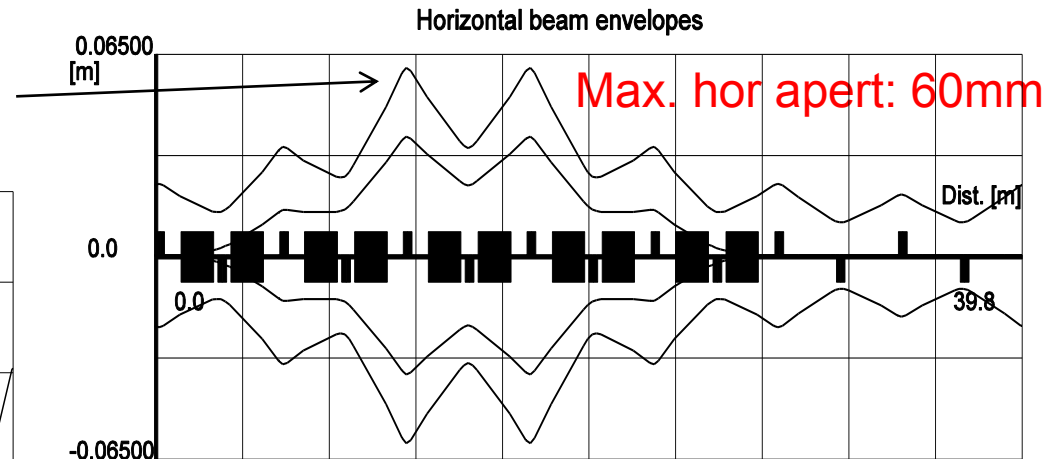# Injection on Linear Ramp ? 75ms Ramp
## e.g. LHC Beam h=1:



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# Injection on Linear Ramp ? 75ms Ramp
# e.g. LHC Beam h=1 + 2:

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# Magnet Cycle & Sp.Ch. Tune Shift:
## Injection on Linear Ramp ? Extreme Case: 75ms Ramp

## Price for Low Tune Shift:
Aperture…here for TOF beam



Horizontal beam envelopes

Max. hor apert: 60mm

Betatron amplitude functions [m] versus distance [m]

Vertical beam envelopes

Horizontal ——————    Vertical - - - - - - - -

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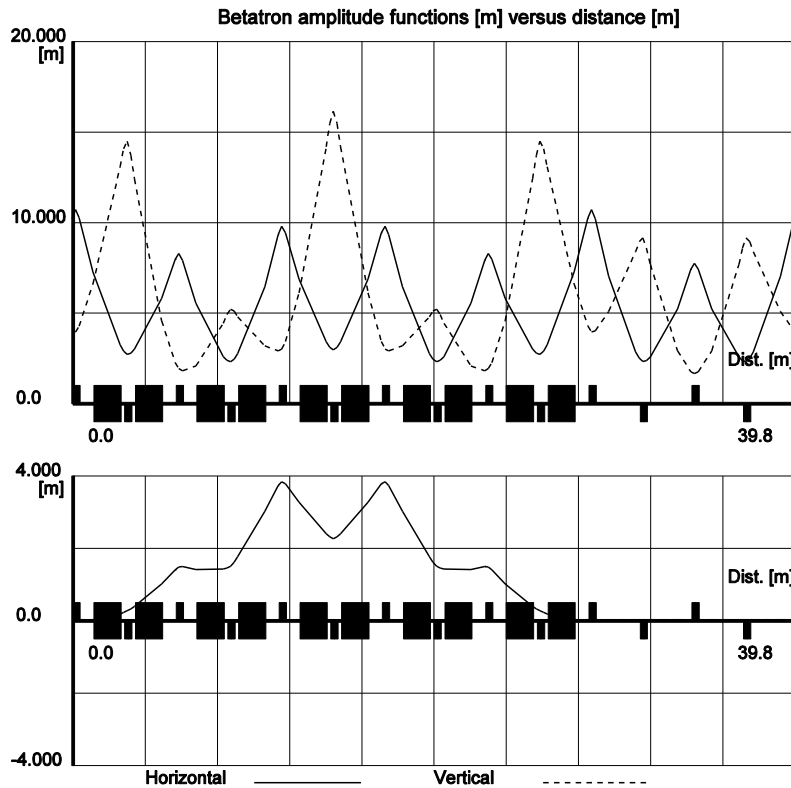
# Still to be done:

- Find best magnet cycle w.r.t.
  - Tune shifts
  - Aperture requirements
  - Feasibiltiy of longitudinal painting
- Check effect of Eddy currents
  - Stainless steel vacuum chamber ok?
- RF voltage programs
- …