

# **HIGH INTENSITY/DENSITY IN THE PSB**

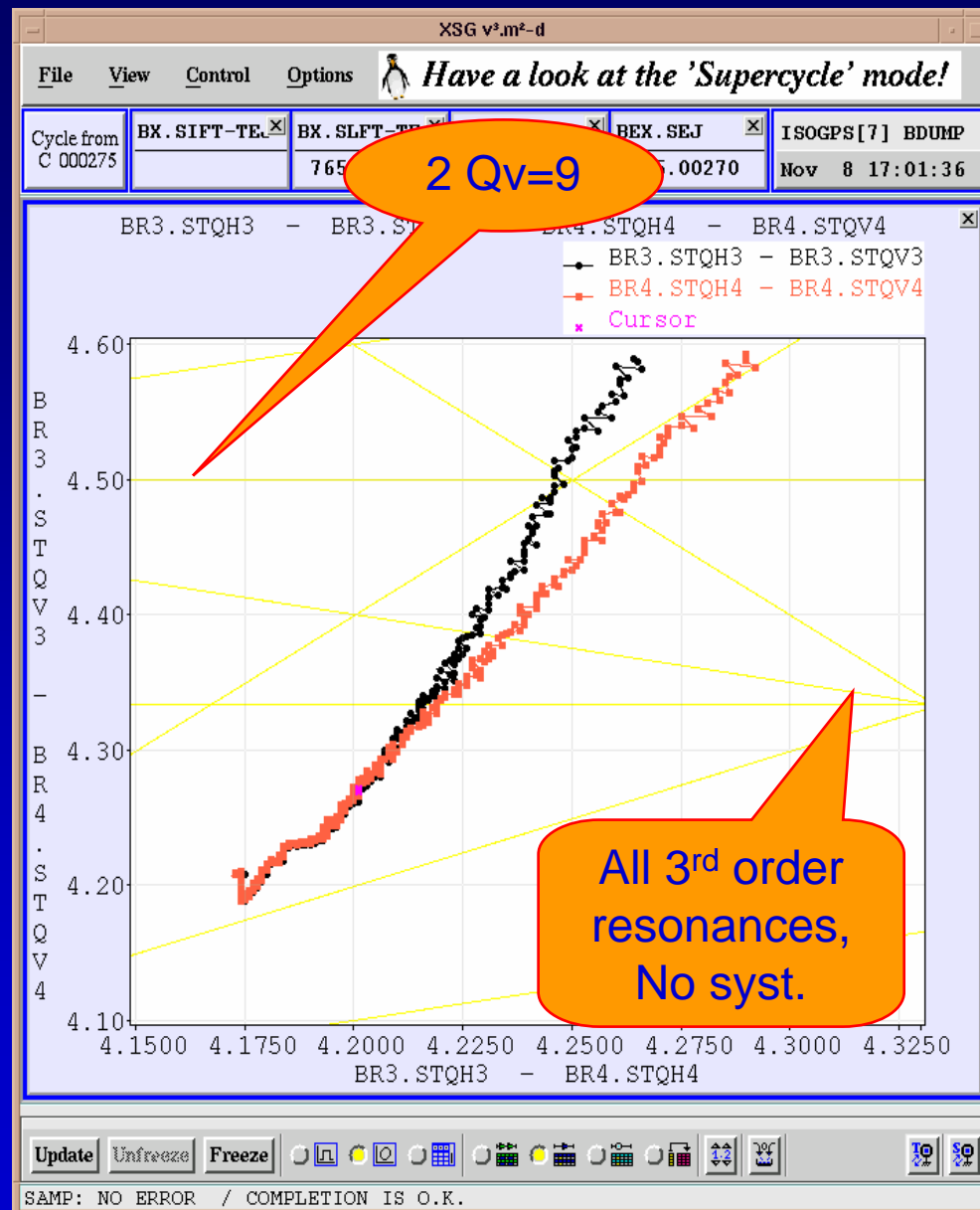
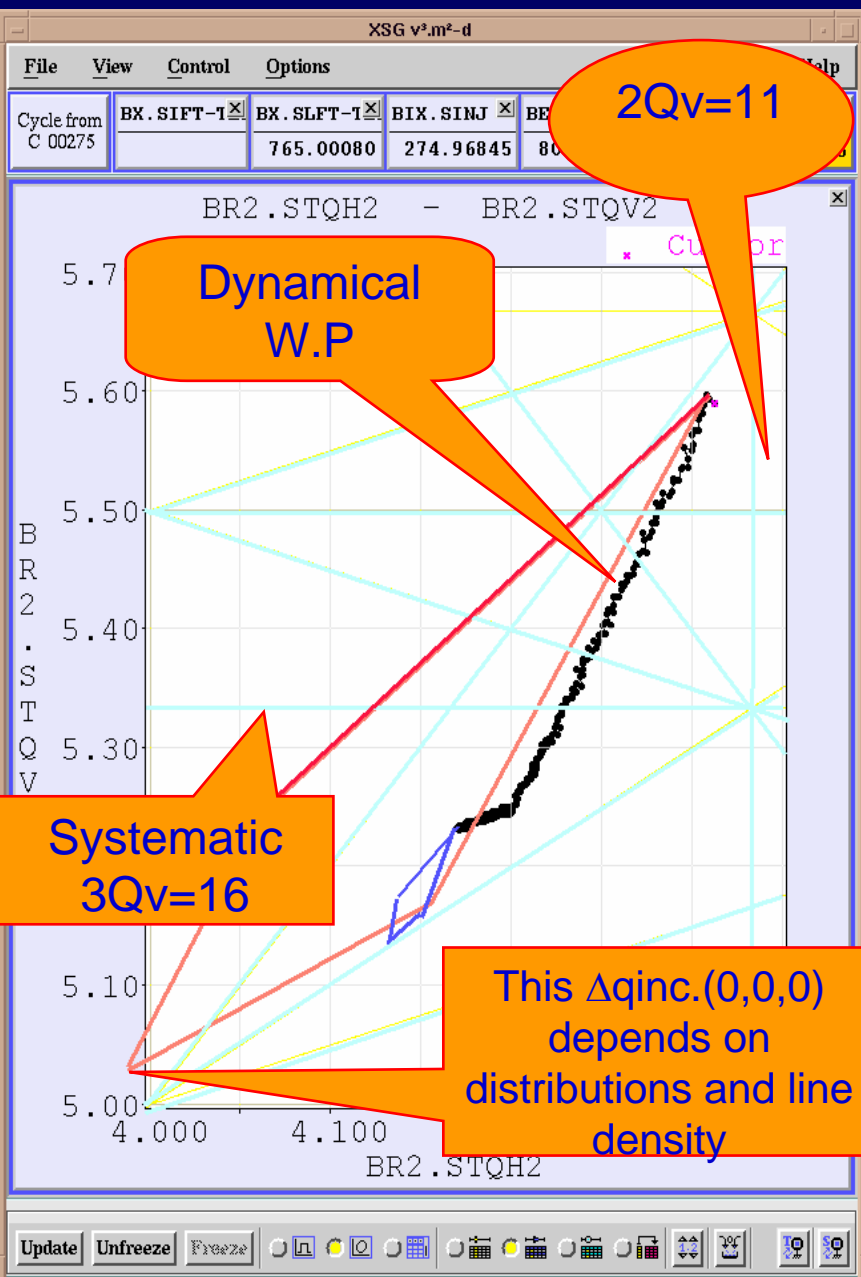
**What is known?**

**which tests to benchmark simulation  
prog's?**

**M. Chanel**

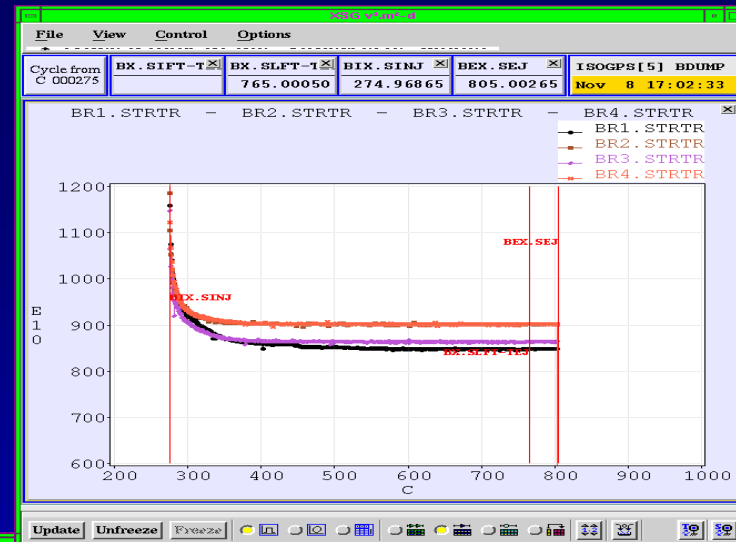
# TUNE SHIFT and WP's for $N > 8 \cdot 10^{12}$

- ◆ Protons Multiturn injection (1mm septum + decreasing bump) with mismatch,  $D_{inj}=0$ , misteering in Vplane and coupling at injection to fill the H+V acceptances (low  $V_{rf}$ )
- ◆ Inc. tune shift  $>0.5$  (transverse dist.+ bunch shape  $h=1+2$ ). Vert. Coh. Tune shift  $\sim 0.13$ .
- ◆ Dynamical WP for high N starts (4.28,5.56) down to (4.17,5.23)
- ◆ Dynamical Working point changes depending on N and emittances(vertical)



# ISOLDE TYPE BEAM

- ◆ Linac >165mA
- ◆ Routinely possible around 3700E10
- ◆ 4 rings equal, 4 bunches, about 3200E10 with  $(\epsilon_h, \epsilon_v)(2\sigma) = (20, 13)\pi\text{mmrad}$
- ◆ Max ever obtained 4200E10(not operational)



OPERATION DISPLAY

File View Option Help

opdisp ISOGPS 4 Jun 18 19:07:51 2003

Beam State	PSB User	PS User	Particule	Harmonique	Destination	Energy
NORMAL	ISOGPS	EASTB	PROTON	H1	ISOGPS	1400

Unit : 1e+10	1	2	3	4	Sum
LTB. TRA55	2355	1824	2000	2068	8247
BI. TRA10	2346 100%	1817 100%	1992 100%	2054 99%	8210 100%
BI. TRA20	2340 100%	1795 99%	1904 96%	2029 99%	8068 98%
INJECTION	1164 50%	1002 56%	976 51%	1059 52%	4201 52%
CAPTURE	861 74%	910 91%	857 88%	878 83%	3505 83%
ACCELERATION	785 91%	830 91%	807 94%	826 94%	3248 93%
BT. TRAS	771 98%	774 93%	767 95%	644 78%	3102 96%
BTY. TRA112					2940 95%
BTY. TRA213					2918 99%
BTY. TRA325					-2
BTH. TRA					-11
BTP. TRA					-1
Increment	Nb turns	Nb turns	Nb turns	Nb turns	All rings
0.0	13.4	10.3	11.2	12.0	-1.0

LINAC->PSB INJ\_RING\_1 INJ\_RING\_3 Magnetic SHAVERS

INJ\_COMMON INJ\_RING\_2 INJ\_RING\_4 BTP\_LINE

One Shot Unfreeze Freeze

No message

File View Option Help

opdisp ISOGPS 13 Jun 18 19:10:16 2003

Beam State	PSB User	PS User	Particule	Harmonique	Destination	Energy
NORMAL	ISOGPS	ZERO	PROTON	H1	ISOGPS	1400

Unit : 1e+10	1	2	3	4	Sum
LTB. TRA55	2299	2305	2299	2262	9166
BI. TRA10	2282 99%	2289 99%	2287 99%	2243 99%	9102 99%
BI. TRA20	2293 100%	2257 99%	2208 97%	2199 98%	8958 98%
INJECTION	1143 50%	1292 57%	1111 50%	1143 52%	4689 52%
CAPTURE	848 74%	1094 85%	951 86%	924 81%	3817 81%
ACCELERATION	776 91%	1023 93%	900 95%	878 95%	3577 94%
BT. TRAS	774 100%	937 92%	861 96%	454 52%	3158 88%
BTY. TRA112					2998 95%
BTY. TRA213					2972 99%
BTY. TRA325					2
BTH. TRA					-10
BTP. TRA					-1
Increment	Nb turns	Nb turns	Nb turns	Nb turns	All rings
0.0	13.0	13.0	13.0	13.0	-1.0

LINAC->PSB INJ\_RING\_1 INJ\_RING\_3 Magnetic SHAVERS

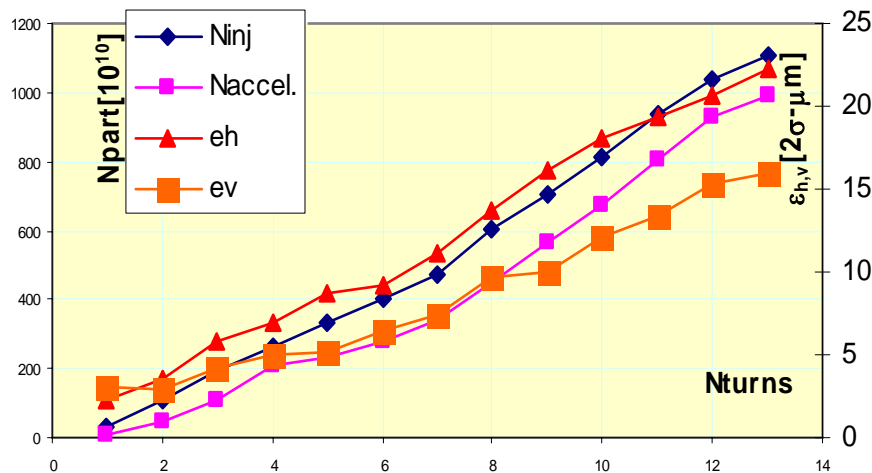
INJ\_COMMON INJ\_RING\_2 INJ\_RING\_4 BTP\_LINE

One Shot Unfreeze Freeze

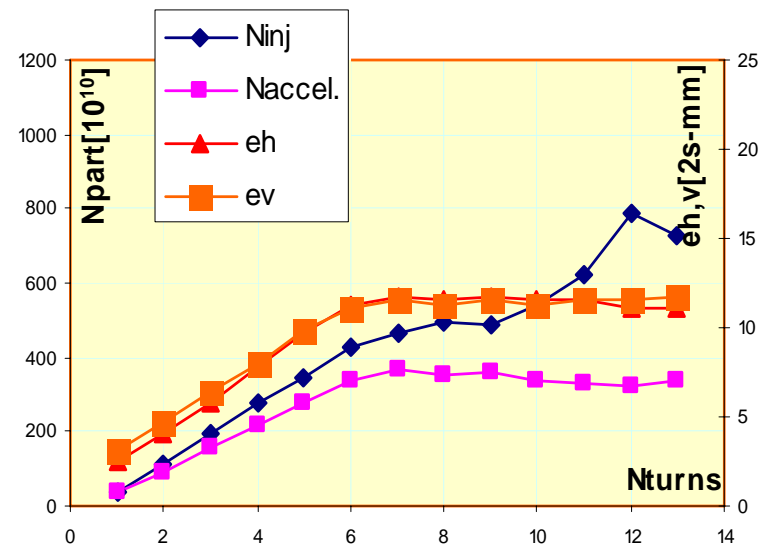
No message

# Dynamic tune effect

injected and accelerated number of particles  
tunes=4.26,5.56



injected and accelerated number of particles  
tunes=4.26,5.29

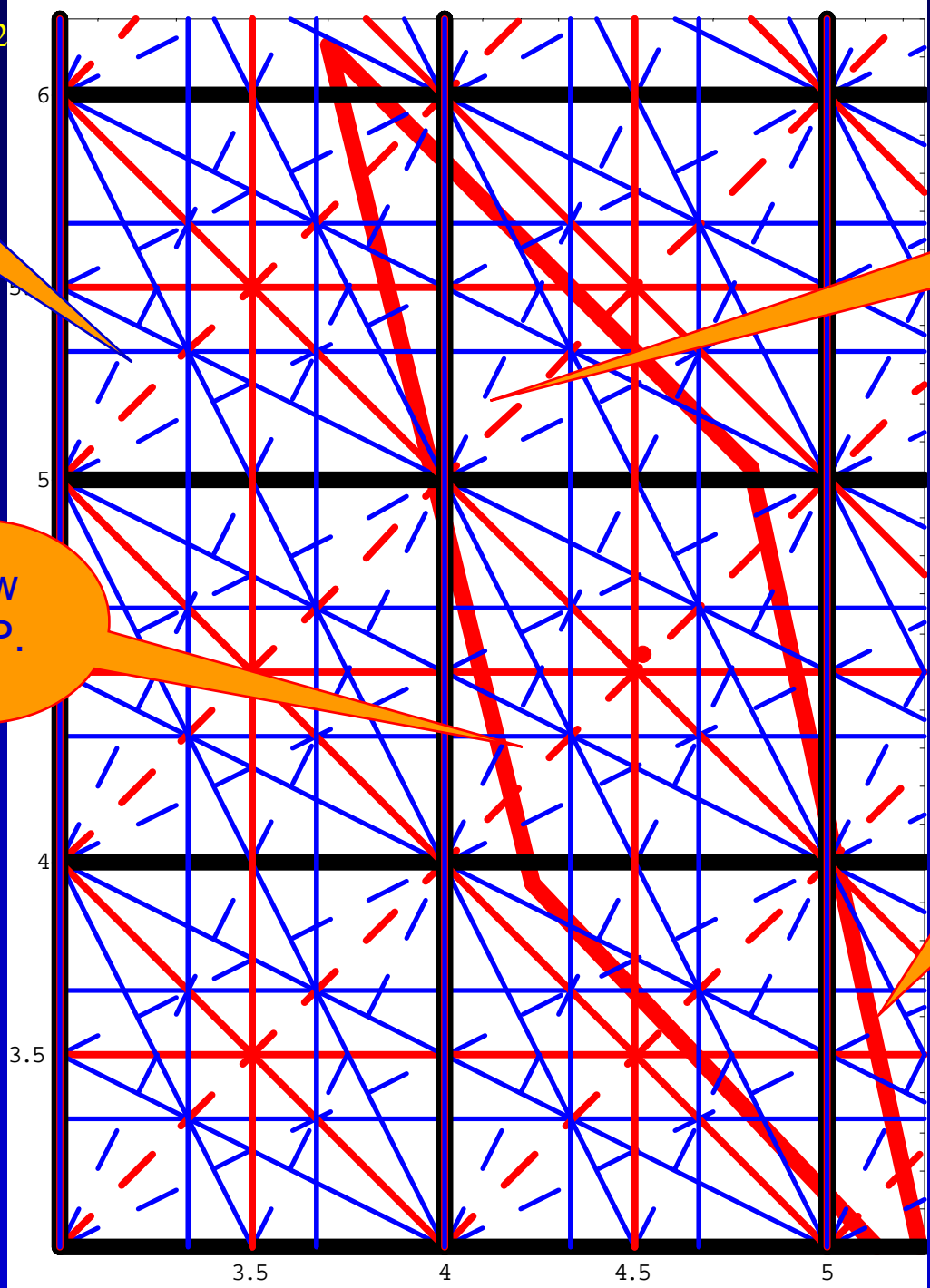


Could be tested at L.E.

Low W.P.

High W.P.

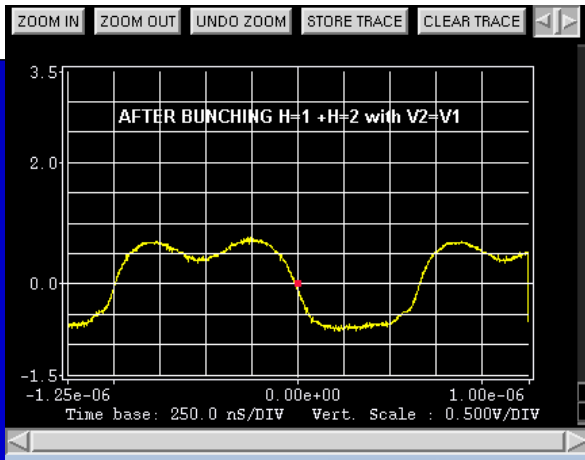
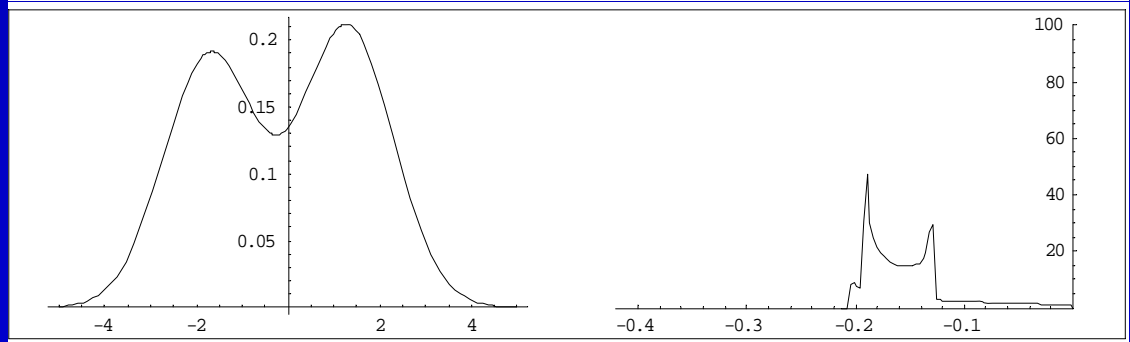
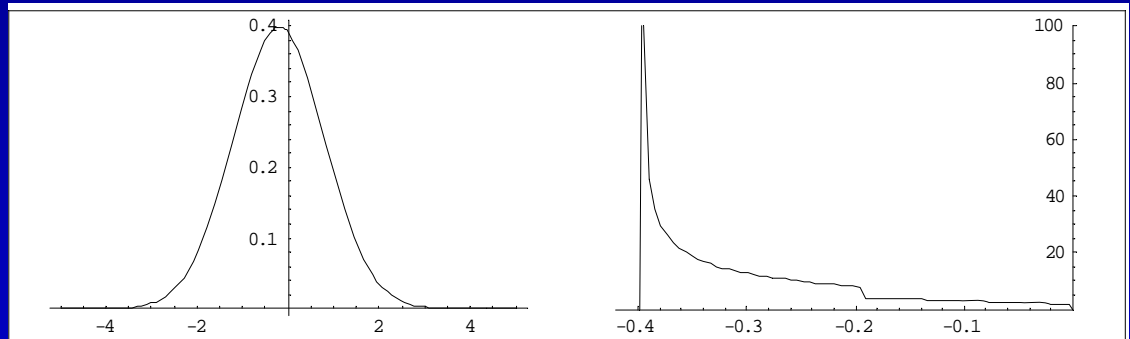
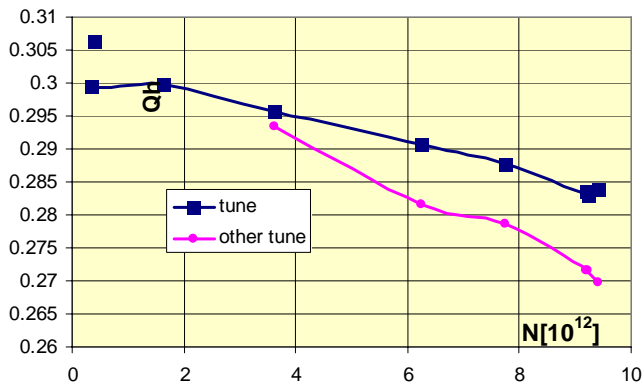
Limits at 1.4 GeV by actual P.Supplies



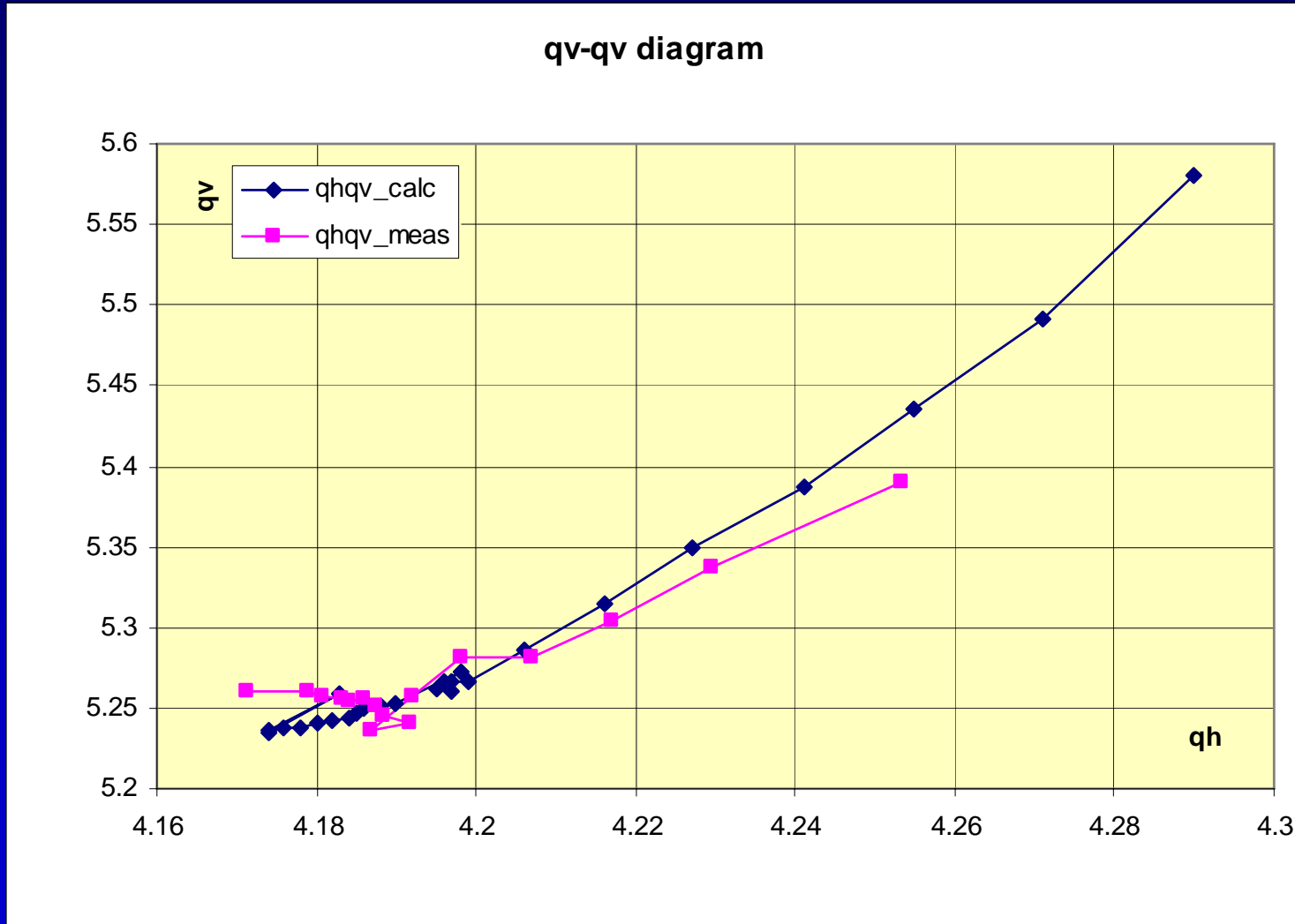
# Coherent tune(1)

- ◆ If the beam is oscillating as a whole (rigid body), the image currents (vacuum ch., magnets) give additional force on the whole beam and change its coherent tune.
- ◆ Due to density change along the bunch there is a coh. tune dist. In the case of  $h=1+2$ , two peaks appear.

hcor tune versus N particles at 20ms



# Coherent tune (2)

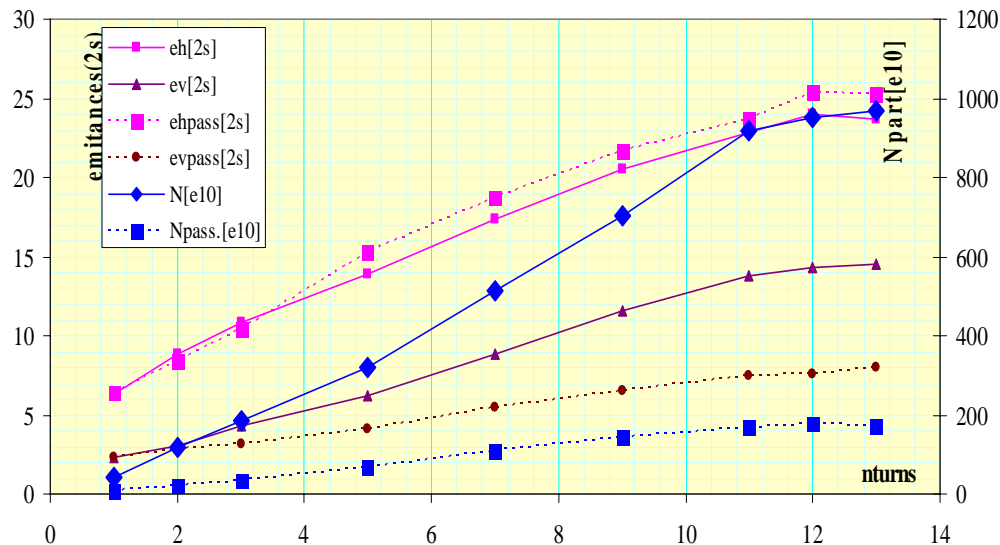




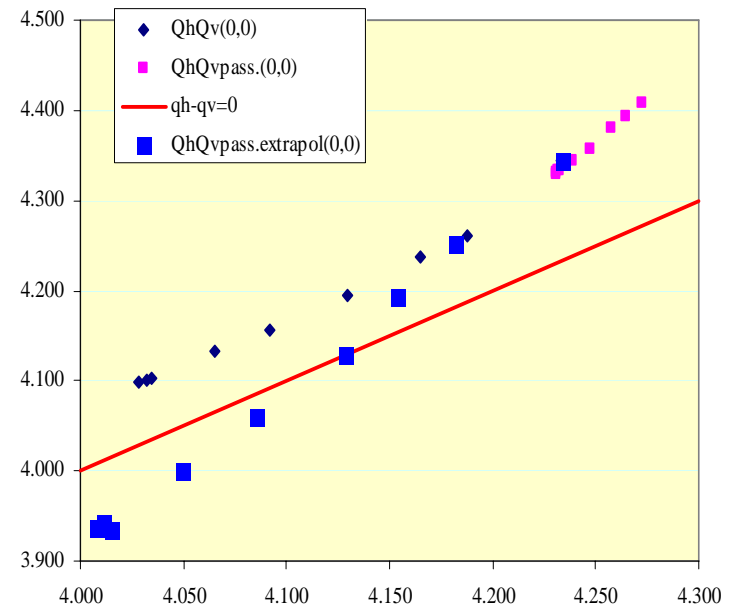
# Emittances(1)

- ◆ Measurements taken after acceleration, in ML
- ◆ Difference between normal/sieve is only important in V plane
- ◆ Calculated zero-ampl tune is made with some assumptions , the accelerated emittances and N!!!
- ◆ Extrapolated is dq sieve\*N normal/Nsieve

Nparticles and emittances versus number of turns with(dashed)  
and without sieve

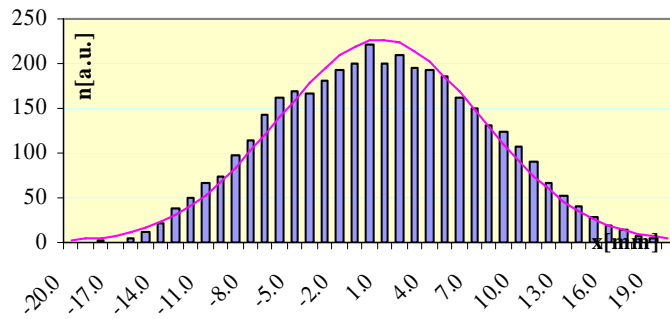


calculated tune of the zero-amplitude particle

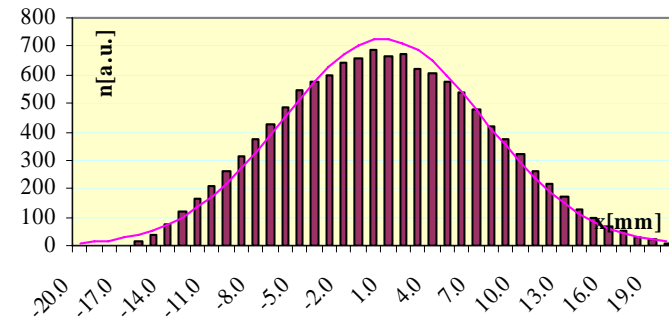


# Emittances(2)

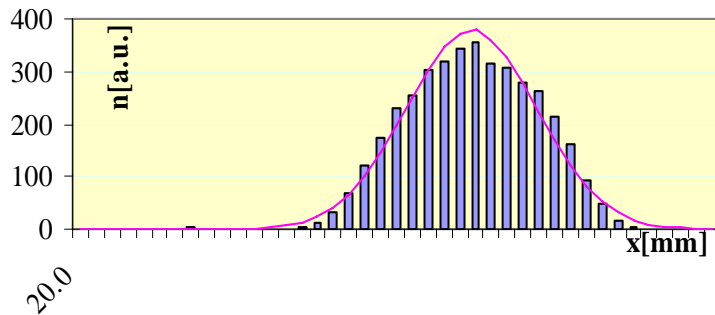
MF01,13 tours, horizontal, no passoire



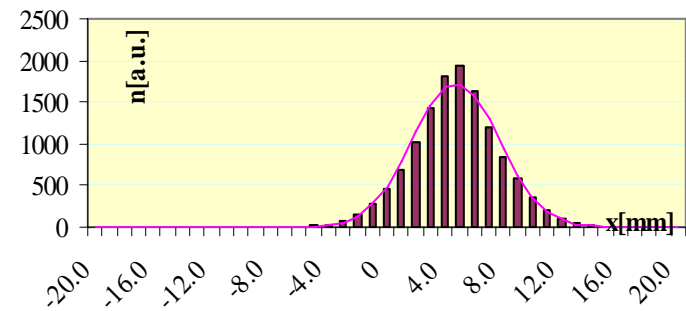
mf01, 13 tours, horizontal, avec passoire



MF01,13 tours, vertical, no passoire

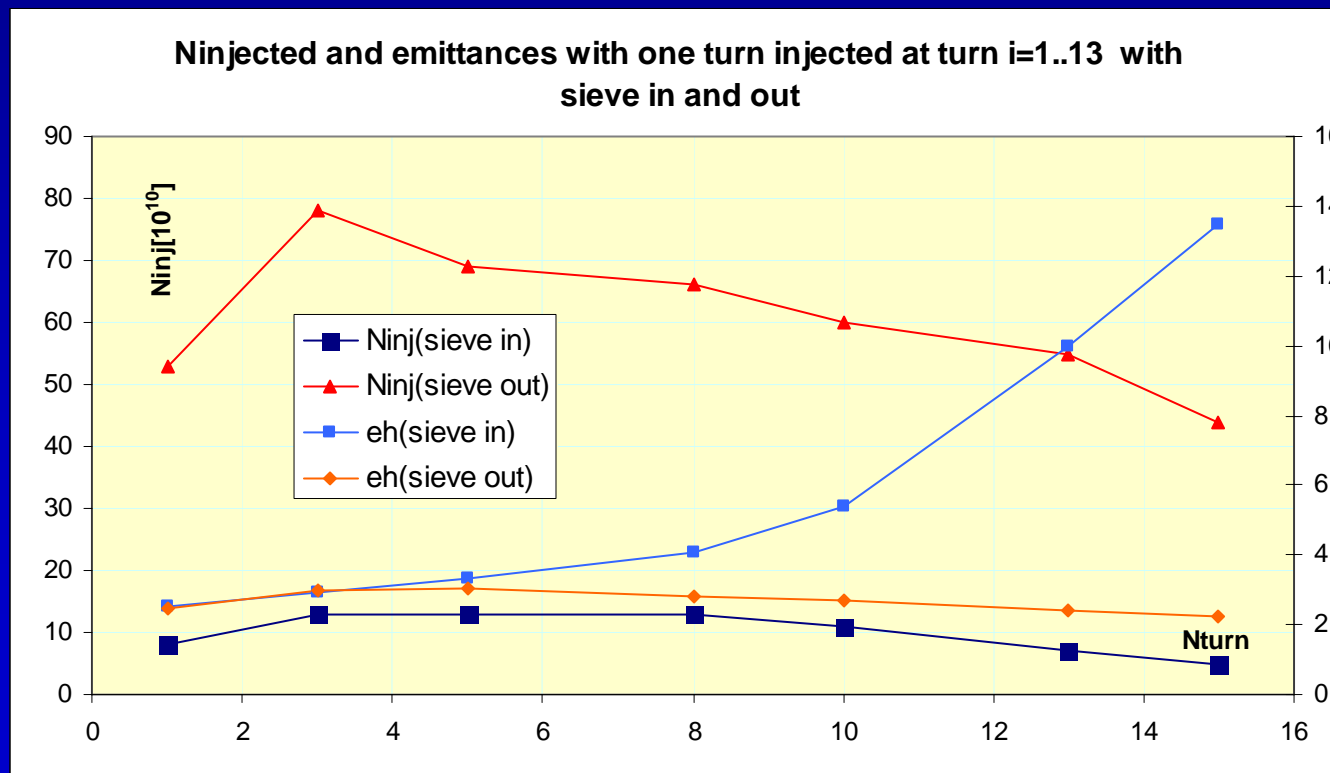


mf01, 13 tours, vertical, avec passoire



# Emittances(3)

- ◆ One turn injected as turn 1 to 13
- ◆ Note the emittance with sieve seems “follows” the large amplitude oscillation for large N (filamentation present)
- ◆ Note the density effect which seems to indicate that the beam is a rigid body (no filamentation)
- ◆ The large oscillations without sieve continue for ms and are damped!!!

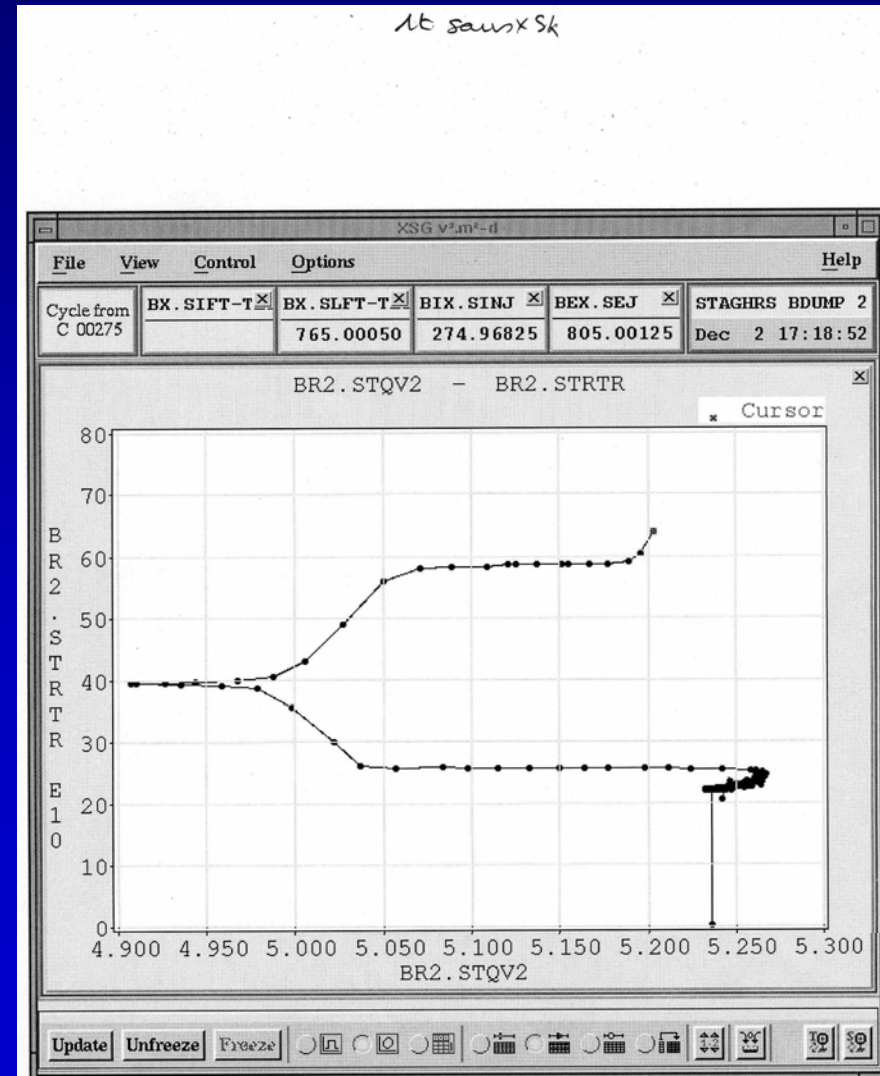


# Resonances(1)

- ◆ 2  $Q_v=9/11$  no pb for compensation
- ◆ Third order
  - HIGH wp PB WITH 3  $Q_v=16!$
  - Low WP ...no syst then less pb with external rings.
- ◆ Coupling
  - $q_h-q_v=-1$  used for coupling injection and fast stop (HWP)
  - $q_h-q_v=0$  compensated (LWP)

# Integer resonances(2)

- ◆  $Q_h=4$  not possible/success
- ◆  $Q_v=4$  not tried
- ◆  $Q_v=5$  possible (dipole+quad+sext.) but no positive effect onto the beam and performances



# Which measurements systems(1)

- ◆ Tunes calculated( $N=1$ ), measured( $N \gg 1$ ) and tune dispersion
- ◆ Emittances
- ◆ Oscillations and dampings
- ◆ Quad oscillations (incoherent tunes)
- ◆ With/without sieve
- ◆ Bunch shape, bunching factor
- ◆ Beam position along bunch
- ◆ Beam H/V at high freq. (wide band PU connections modified)
- ◆ Spectrum/network analysers
  
- ◆ Same parameters for simulations

# Which tests

- ◆ Tune, tune shift/spread, emittances versus ....
- ◆ Evolution of beam on ft, bunched/coasting
- ◆ Tests bunching factor versus losses
- ◆ Are there electrons in the beam (vacuum influence)...get rid of them
- ◆ Damper efficiency (H,V)
  
- ◆ Tests integer resonances
- ◆ Tests other WP (3.7,3.7)...(3.2,6.3)
- ◆ Tests effect of ramping rate

# Which energy

- ◆ Most at 50 MeV, on ramp or on FT(hard to keep beam stable)
- ◆ Tests 160MeV...for extrapolation



# Space charge versus tune

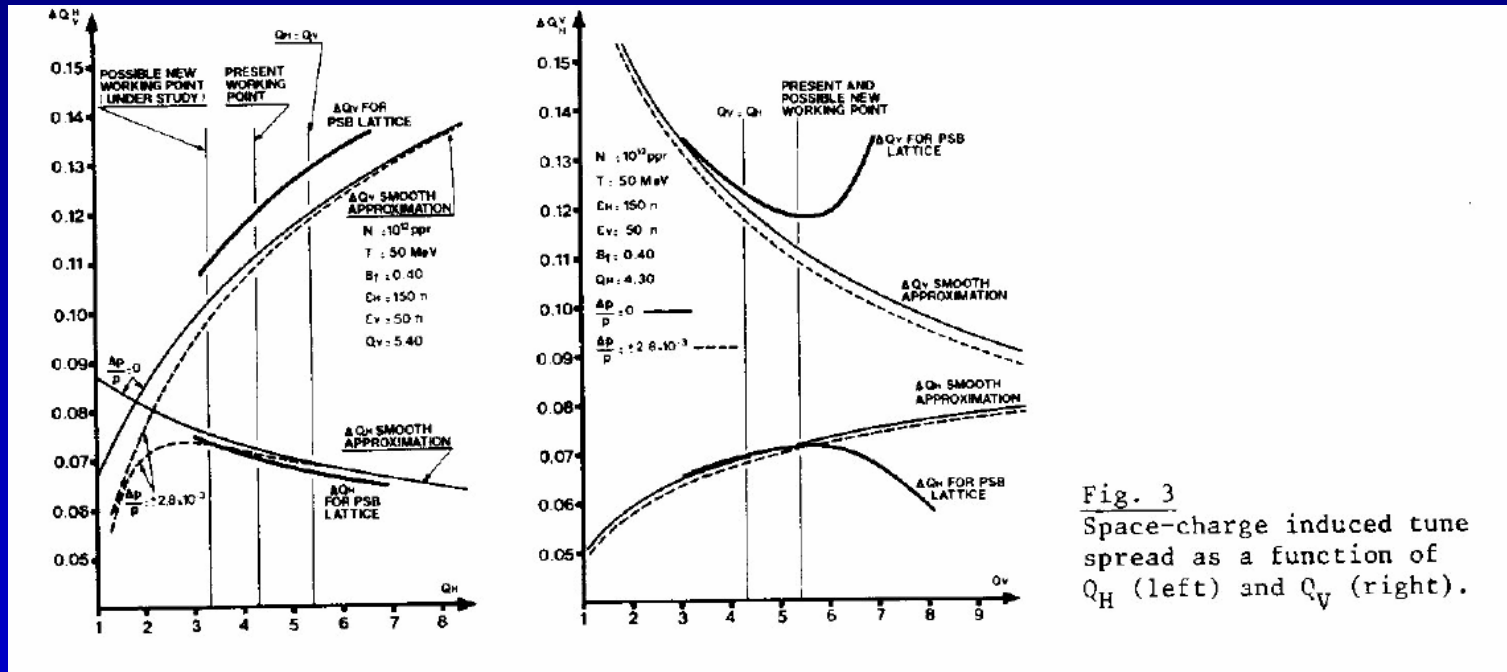


Fig. 3  
Space-charge induced tune spread as a function of  $Q_H$  (left) and  $Q_V$  (right).