RENCONTRE SOLEIL-LAL, 20 mars 2008

(http://users.lal.in2p3.fr/mouton/miroir/LAL-SOLEIL/)

Mesure d'émittance pour le projet ATF2 : vers le final focus d'ILC et de CLIC

(http://flc-mdi.lal.in2p3.fr/)

Work performed by :

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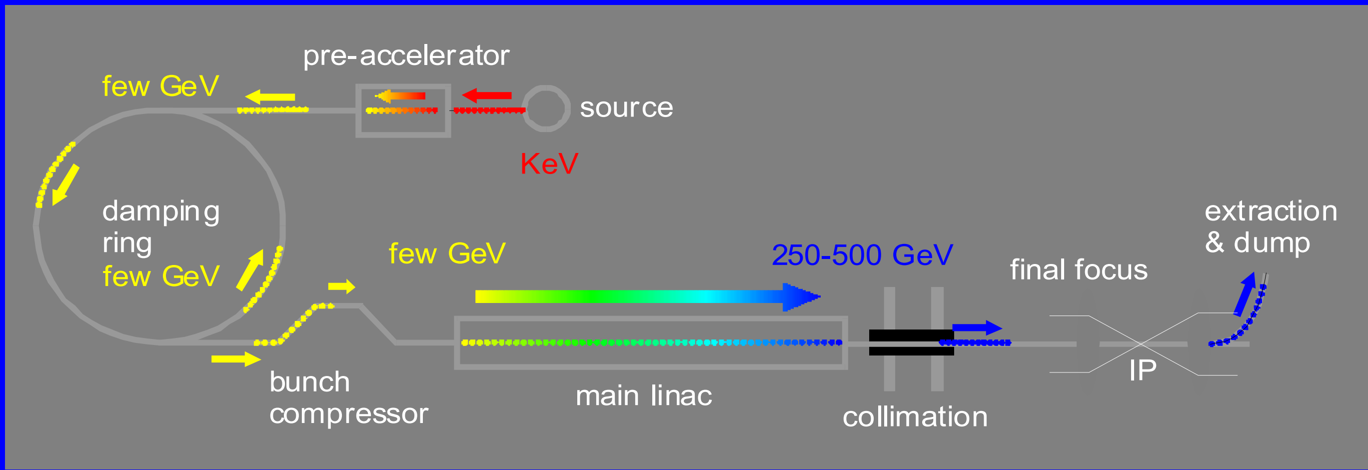
LC needs nanometer-size beams



H_D = disruption enhancement
f = linac repetition rate
N_e = bunch population
n_b = bunches per train
σ = RMS bunch size
ε = emittance
η = power transfer efficiency

$$L \sim \frac{n_b N_e^2 f}{4\pi\sigma_x\sigma_y} H_D$$

$$\sigma^2 = \varepsilon_n \beta / \gamma$$

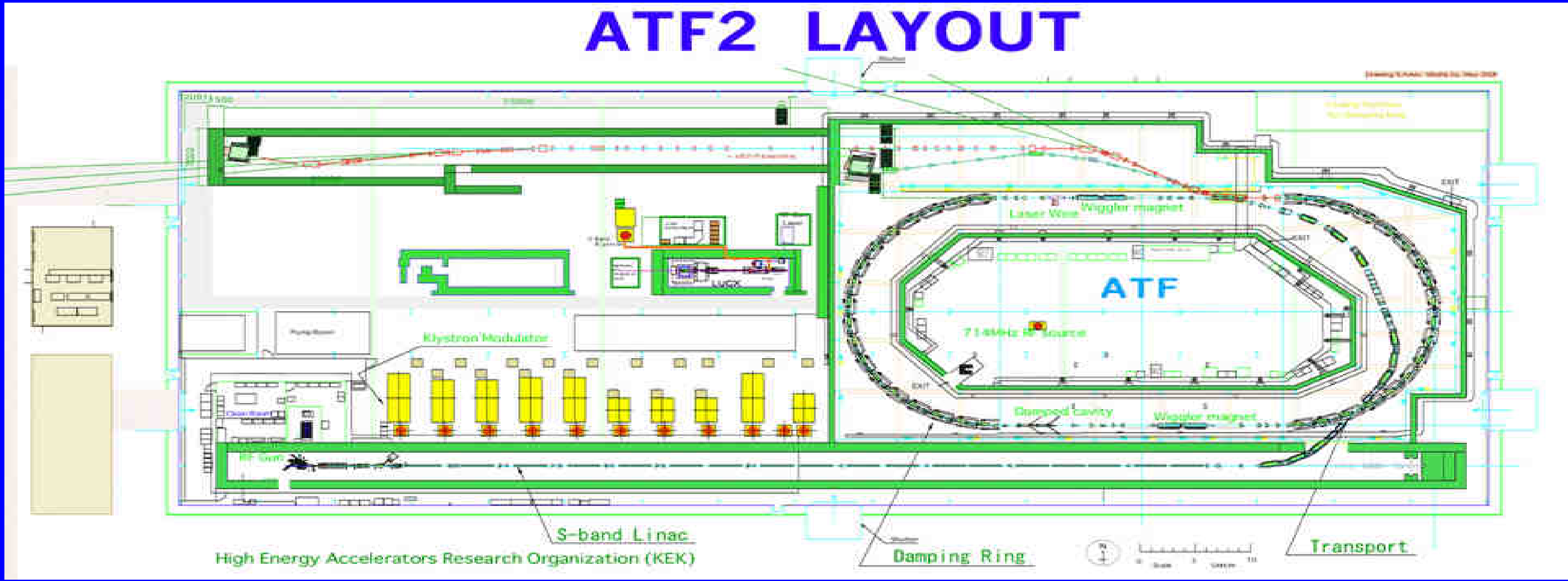
set $\sigma_z = \beta_y$

$$L \sim \eta \frac{P_{\mathrm{electrical}}}{E_{CM}} \sqrt{\frac{\delta_E}{\varepsilon_{n,y}}} H_D$$

- Linac repetition rate ***f*** << ring frequency ⇒ need tiny IP size σ
- Beam-beam mutual focusing → beamstrahlung, disruption

focus
1. RF technology (gradient, efficient power transfer)
2. Beam phase-space control & stability → emittance ε

ATF2 final focus test @ KEK



1. Expert training on real system
2. Instrumentation for nano-beams
3. Accelerator RD & operation by multi-partner collaboration

Goal A : nanometer beam size
- obtain σ_y ~ 35 nm at focal point
- reproduce reliably σ_y and maintain in time

Goal B : trajectory stabilization
- 1-2 nm at focal point
- intra-train feedback (ILC-like trains)

- 2008 end construction & installation
- November 2008 first beams
- 2009 commissioning

COST : ~ 3 + 1 M$ → Asia, EU, US

R. Sugahara (KEK)

Pictures of installation

4. The last magnet is going to the destination

5. Installation is finished

10 - 20 Dec. 2007 19 concrete base blocks were installed

7 - 9 Jan. 2008 22 movers and 19 quad-systems were installed

3 dipoles and 3 sextupoles not yet

LAPP: Mechanical support & stability of FD

Characterisation & impact in beam operation

A.Jérémie,, G.Gaillard, N.Geffroy

B.Bolzon → continues as ANR post-doc

LLR: Background evaluation (algorithm, GEANT4)

Instrumentation & experimentation for validation

M. Verderi, H.Guler (ANR post-doc)

LAL: Beam tuning & control / slow feedback controller

Commissioning & operation / optimization

Flight simulator tool, instrumentation studies

P.Bambade, J.Brossard, C.Rimbault, F. Touze, G. Lemeur

Y.Rénier, M.Alabau (Valencia), S.Bai (IHEP)

+ ANR post-doc from end of 2008 (F.Gournaris)

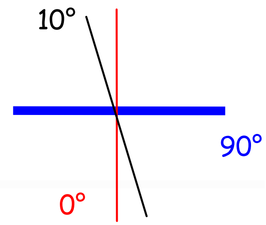
KEK direct partner + UK, SLAC, CERN, IHEP, Valencia

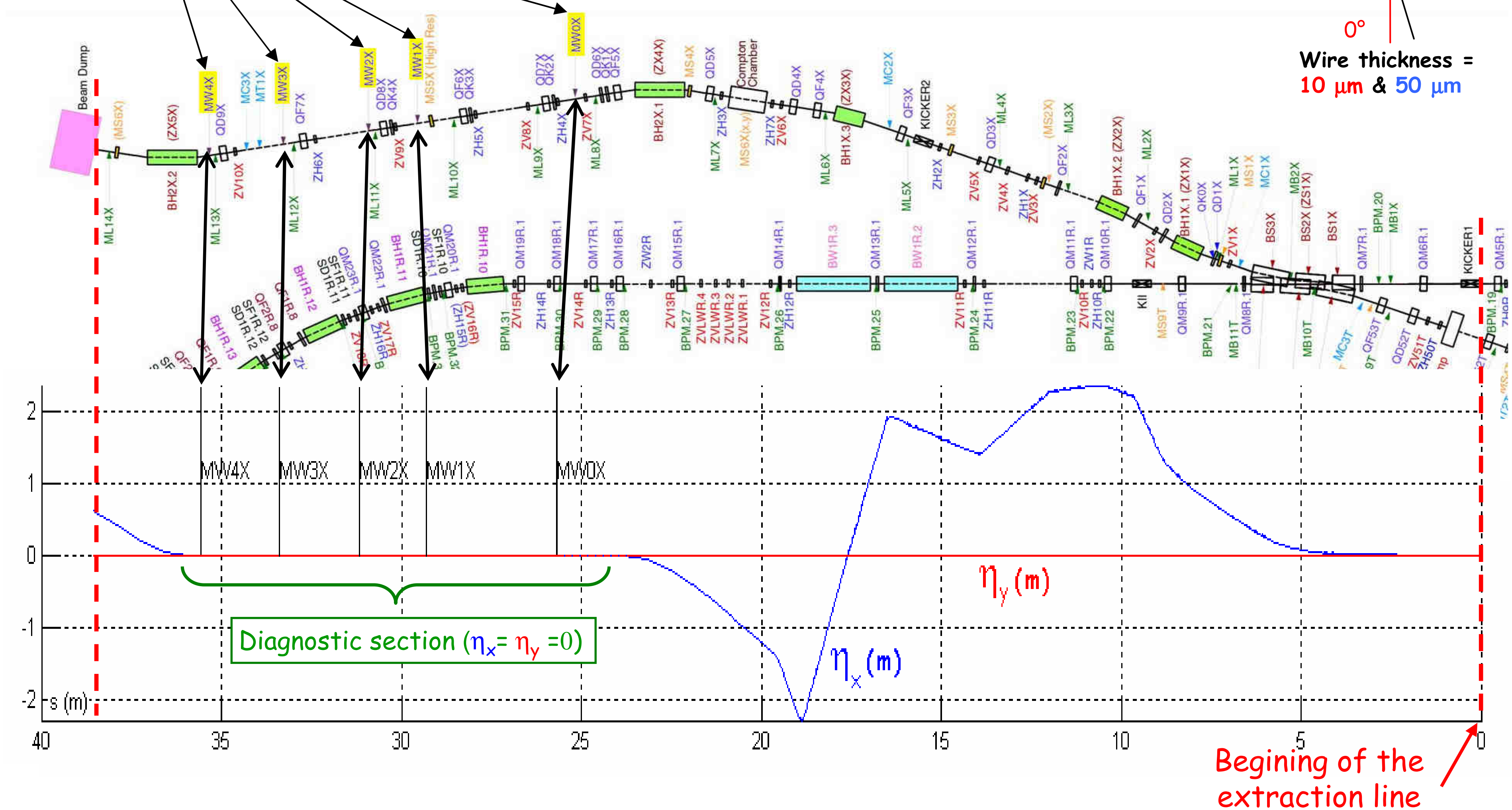
ATF EXT line description & wire scanner position

Nominal geometric emittance : ε_x=2nm.rad & ε_y=20 pm.rad

5 positions for wire scanners

Each position is equipped with 3 wire scanners oriented at 0, 90 and 80° for y,x and 10° beam-size measurement.





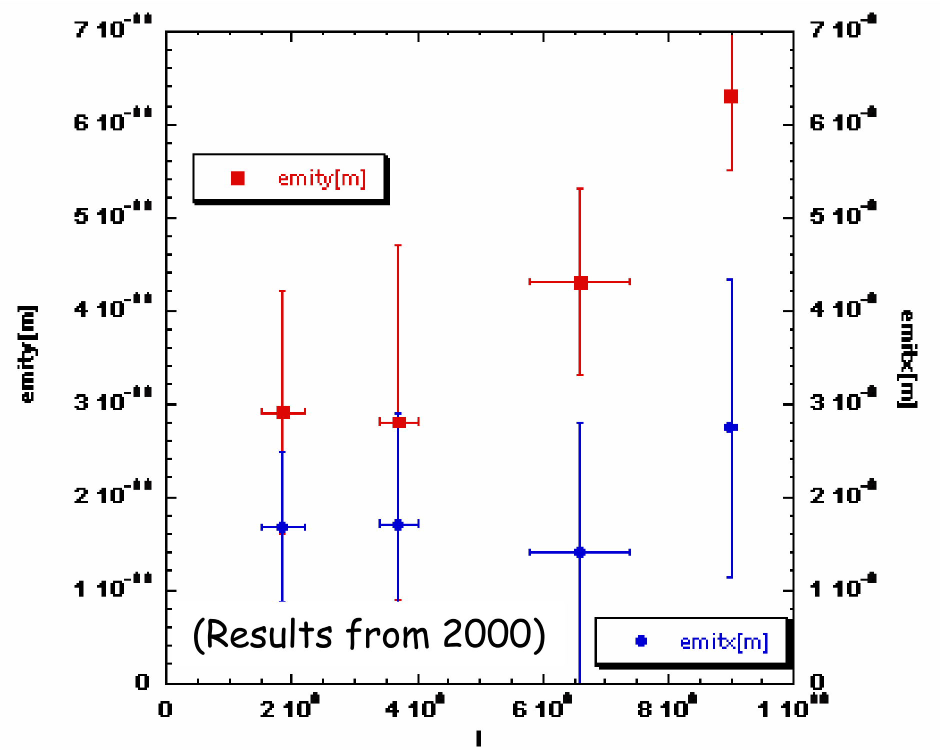
Vertical emittance growth in ATF Extraction Line

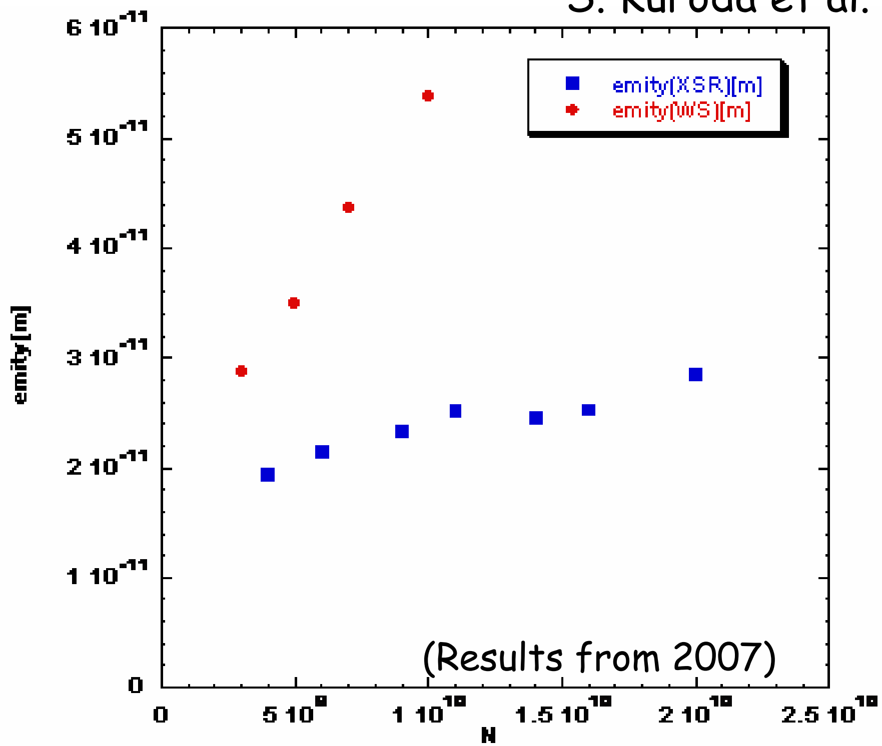
Measured vertical emittances are higher than expected, and there is a dependence with the beam current.

Vertical emittance in the DR

Vertical emittance in the EXT line

S. Kuroda et al.





Hypotheses

- Non linearity → coupling

-Intensity dependence: wakefields, orbit (BPM) ?

→ Emittance measurement accuracy ?

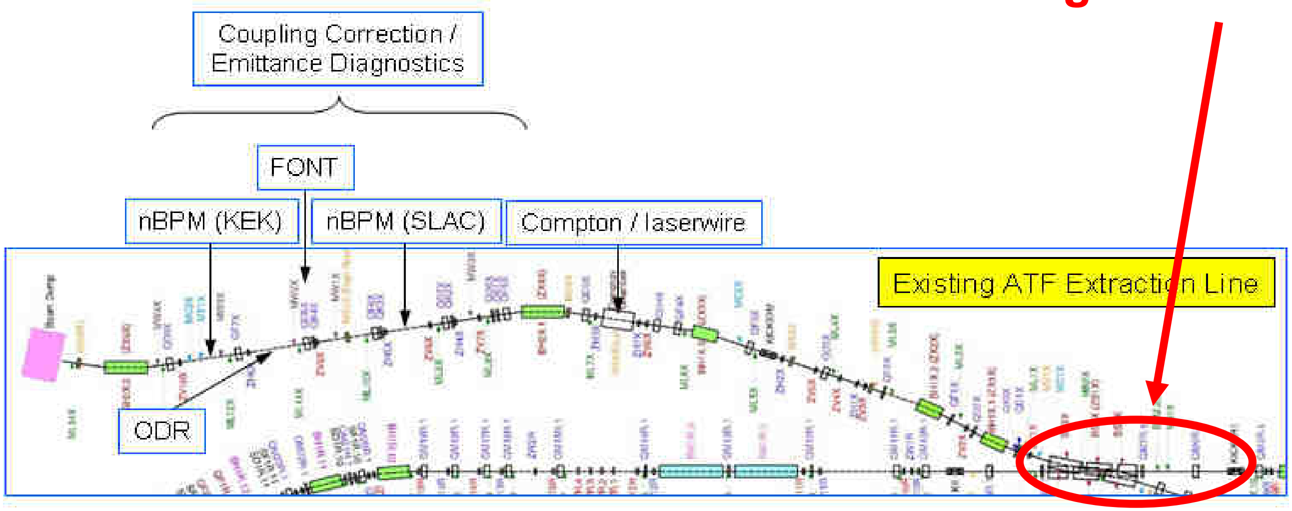
Vertical emittance growth in ATF Extraction Line

Study the effect of the non-linearities of the magnets shared with the DR on the vertical emittance

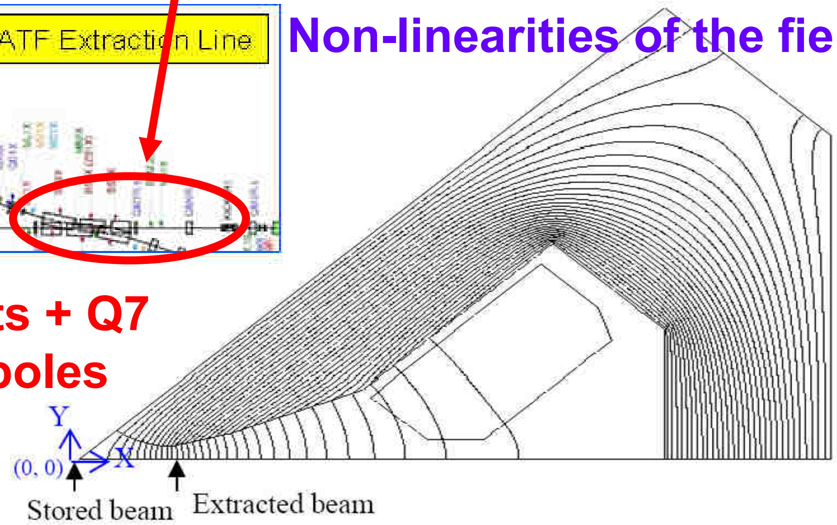
Shared magnets with the Damping Ring

The extracted beam passes off-axis

Non-linearities of the field



Septum magnets + Q7 and Q6 quadrupoles



x= 2.2 cm

Emittance measurement in ATF EXT line using 2 differents methods

1/ Multi-wire emittance reconstruction method

Relation bewteen sigma beam matrix between 2 point in linear optic approximation

$$\sigma^B = R^{(A->B)} \sigma^A \left(R^{(A->B)}\right)^T$$

Without optic coupling between A and B we obtained

$$\sigma_{33}^B = (R_{33}^2)\sigma_6^A + (2R_{33}R_{34})\,\sigma_9^A + (R_{34}^2)\,\sigma_{10}^A$$

Vertical beam size measured at point B

Elements of the linear optic matrix (assuming no coupling between point A and B)

y-y' elements of the sigma beam matrix at point A

where $\sigma^A = \begin{pmatrix} \sigma_1^A & \sigma_2^A & \sigma_4^A & \sigma_7^A \\ \sigma_2^A & \sigma_3^A & \sigma_5^A & \sigma_8^A \\ \sigma_4^A & \sigma_5^A & \sigma_6^A & \sigma_9^A \\ \sigma_7^A & \sigma_8^A & \sigma_9^A & \sigma_{10}^A \end{pmatrix}$

$$\varepsilon_y = \sqrt{\sigma_6^A \sigma_{10}^A - \left(\sigma_9^A\right)^2}$$

With multi-vertical (>=3) beam size measurement, the y-y' Twiss parameters at point A can be deduced. For n>3, a least mean square method is used to find a solution.

2/ Emittance reconstruction using quad scan

Under thin lens hypothesis, R can be decomposed R=SQ where $S = \begin{pmatrix} S_{11} & S_{12} & 0 & 0 \\ S_{21} & S_{22} & 0 & 0 \\ 0 & 0 & S_{33} & S_{34} \\ 0 & 0 & S_{43} & S_{44} \end{pmatrix}$ $Q = \begin{pmatrix} 1 & 0 & 0 & 0 \\ k & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & -k & 1 \end{pmatrix}$

And the beam size curve versus quadrupole strength is a parabola : $\sigma_{33}^S = A_y(k - B_y)^2 + C_y$

Where A_y, B_y and C_y are function of Twiss parameter at the entrance of the quadrupole.

Results from 12 march 2008 shift

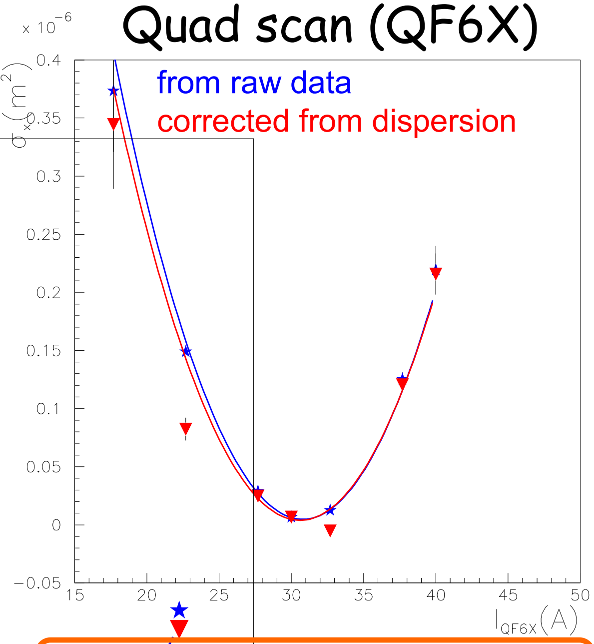
The vertical emittance in the DR was measured :

ε_x = 5 nm.rad (?)

ε_y = 34 pm.rad

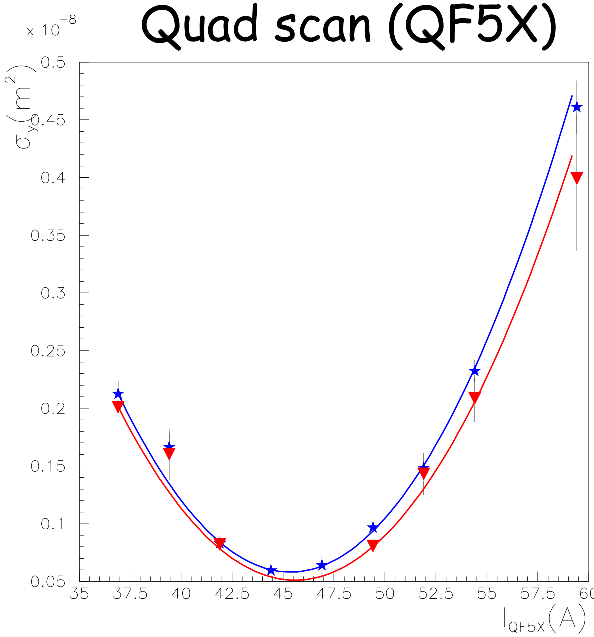
$$\sigma_y = \sqrt{\varepsilon_y \beta_y + (\eta_y \delta)^2}$$

Quad scan (QF6X)

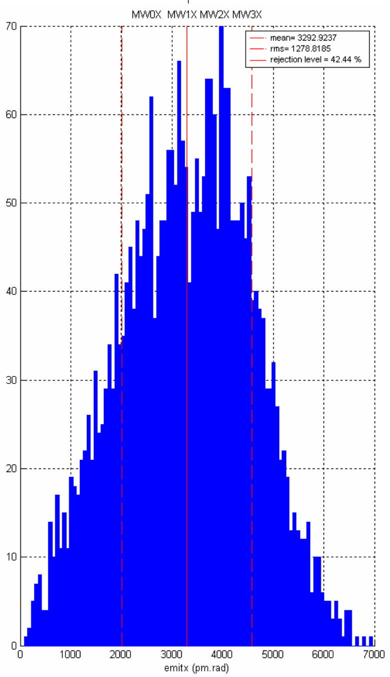


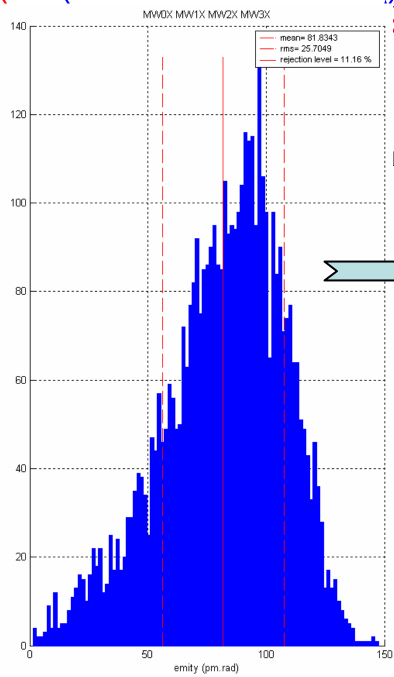
ε_x= (3.3 +/- 0.4) nm.rad

Quad scan (QF5X)



ε_y= (114 +/- 13) pm.rad





Multi-wire emittance reconstruction based on Monte-Carlo simulation :

ε_x= (3.3 +/- 1.3) nm.rad ~ 0.66% DR value (?)

ε_y= (82 +/- 26) pm.rad ~ 300 % DR value

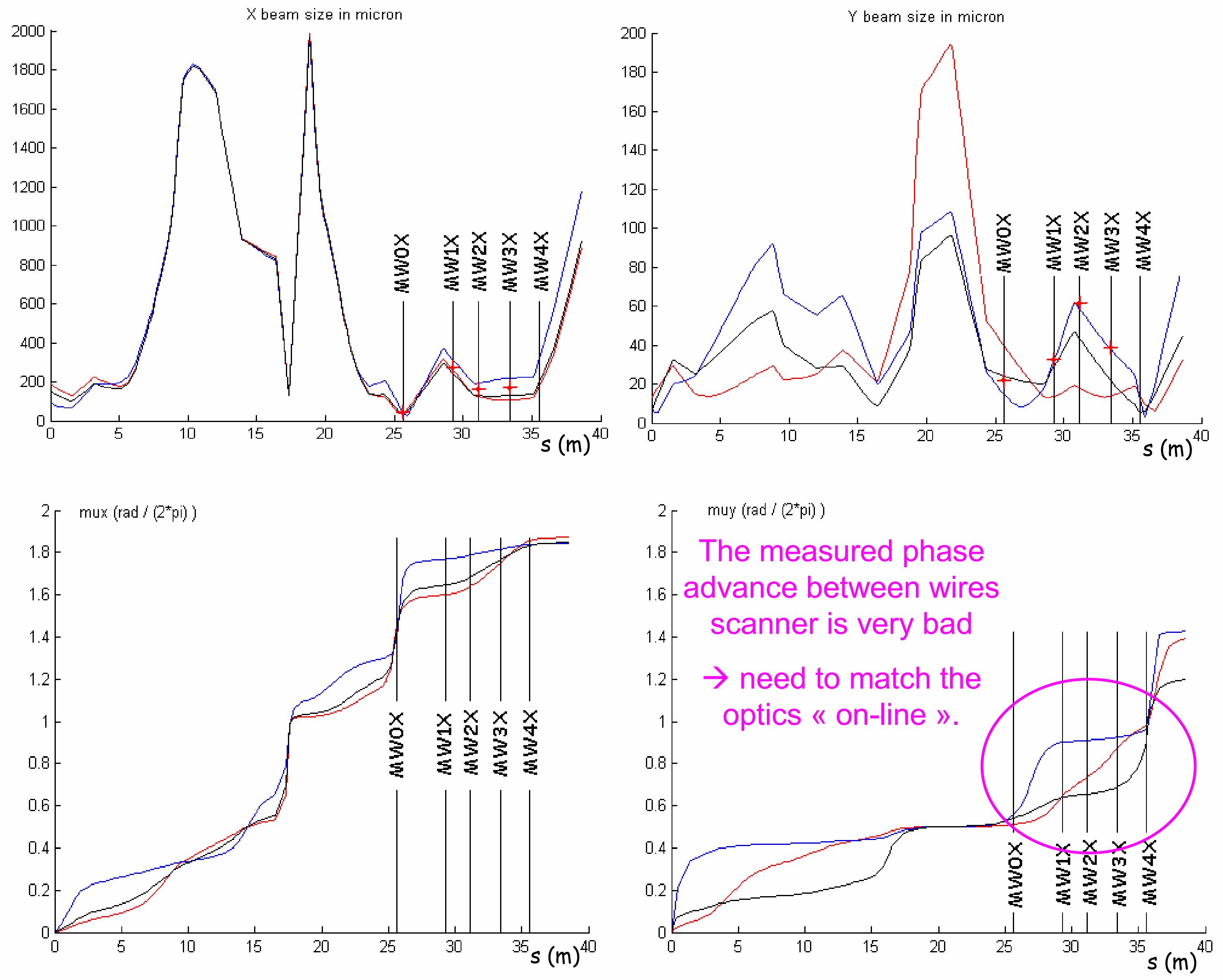
Results from 12 march 2008 shift

X	Measured	Back propagated to IEX0 (entrance of EXT line)
at QF6X from scan	ε_x= 3.3 ± 0.4 nm β_x= 24.3 ± 1.3 m α_x= -8.4 ± 0.7	β_x= 6.7 **m** α_x= **1.6**
at MW0X from Multi wire	ε_x= 3.3 ± 1.3 nm β_x= 0.45 ± 0.15 m α_x= 0.66 ± 0.79	**β_x= 2.5 m** **α_x= 1**

Y	Measured	Back propagated to IEX0 (entrance of EXT line)
at QF5X from scan	ε_y= 114 ± 13 pm β_y= 9.1 ± 0.5 m α_y= 10.5 ± 0.6	**β_y= 0.51m** **α_y= –1.04**
at MW0X from Multi wire	ε_y= 82 ± 25 pm β_y= 3.01 ± 2.16 m α_y= 1.8 ± 2.0	**β_y= 0.68 m** **α_y= 1.1**

Beam size and phase advance for 3 differents input Twiss parameter set in extraction line (optics from 12th march shift)

Results from 12 march 2008 shift



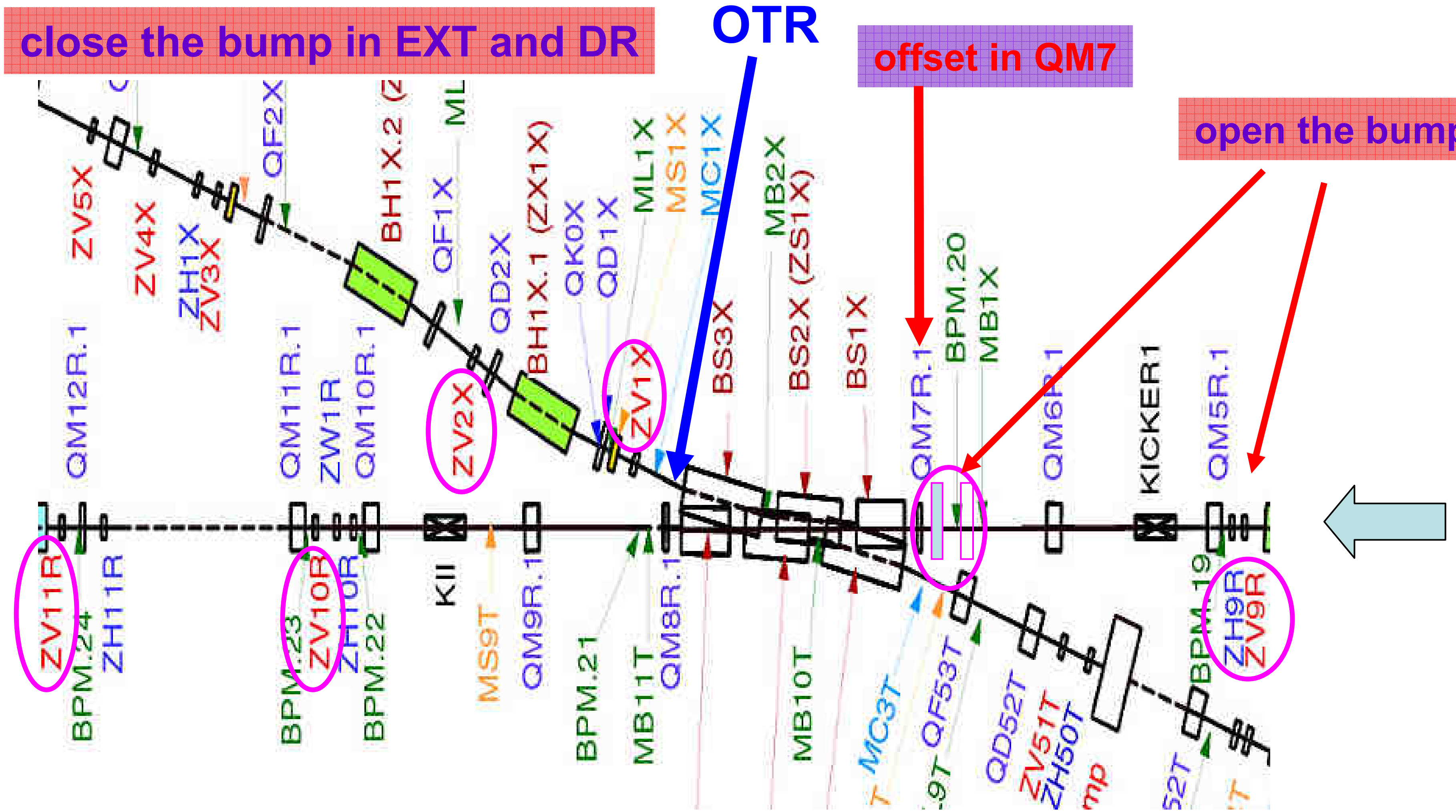
Input from the « DR solution » :
β_x=10.6329 m
α_x=2.3933
β_y= 2.11082 m
α_y=-1.6144

Input from multi-wire meas. :
β_x=2.5m
α_x=1.0
β_y= 0.68 m
α_y=1.1

Input from quad scan meas. :
β_x=6.7m
α_x=1.6
β_y= 0.51 m
α_y=-1.04

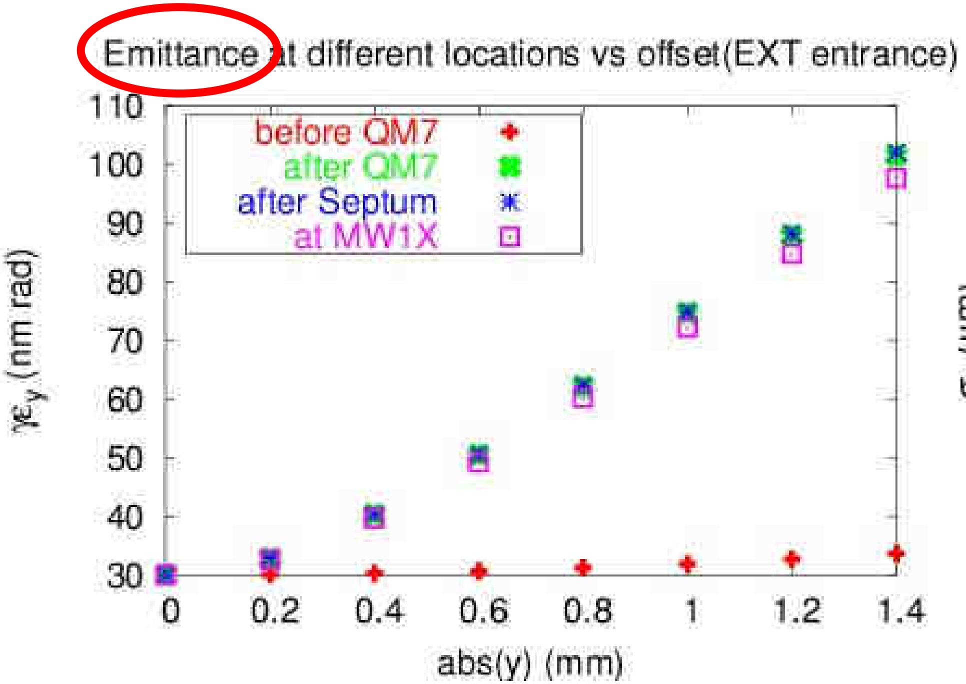
Experimental Proposal

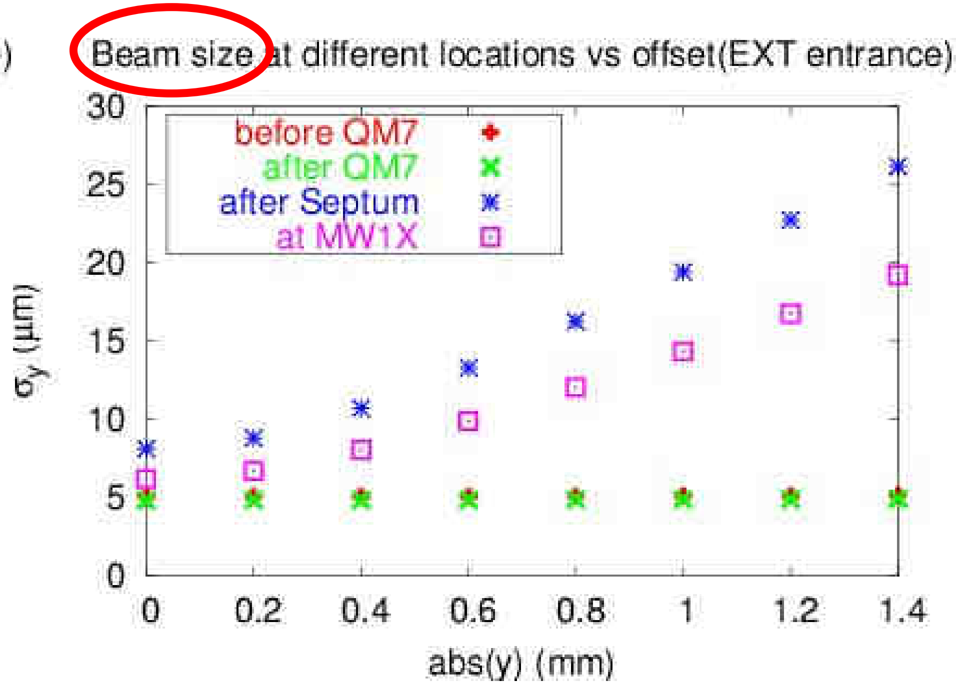
Creating bumps in QM7 to probe effects on the vertical emittance



Tracking simulations along the Extraction Line including non-linearity in QM7

Emittance and beam size vs vertical offset at the entrance of the Extraction Line





Beams with small vertical displacements with respect to the nominal trajectory experience emittance growth while passing through the non-linear fields in QM7

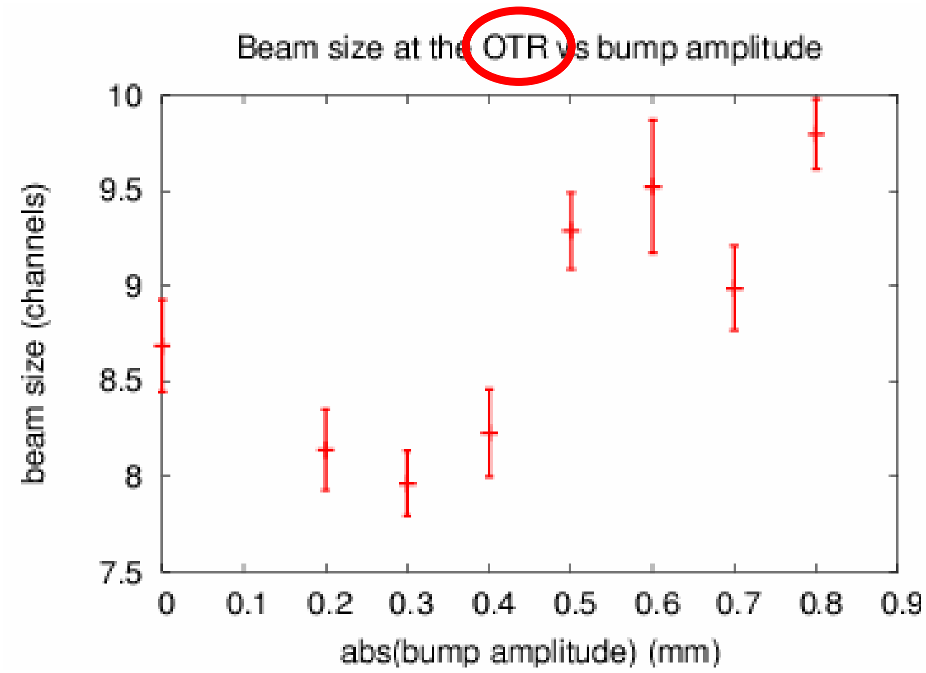
Experimental work (Dec07)

Beam size after the shared magnets is correlated with the emittance:

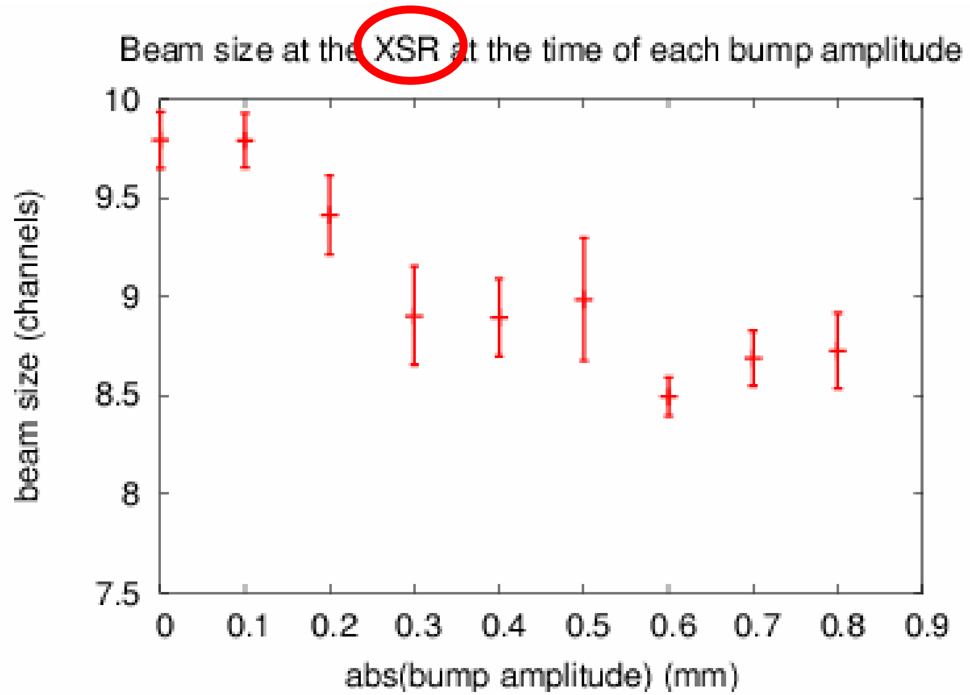
1. **Create bump in QM7**
2. **Measure beam size with the OTR just after the septum**

Vertical beam size vs vertical bump amplitude at QM7

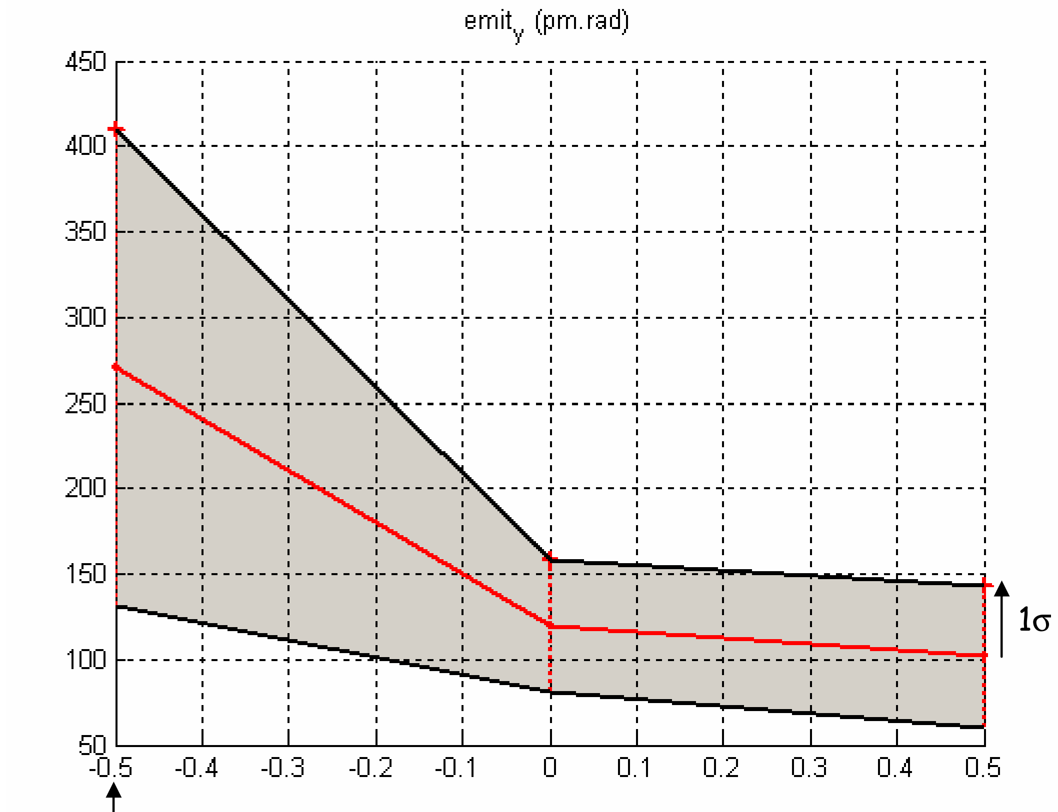
Extraction Line



Damping Ring



Vertical emittance estimation for vertical bump in QM7 using multi-wire measurement



Results from 14 march 2008 shift

[for -0.5 mm bump amplitude,
3 wire scanner only have been used
(MW1X, MW2 and MW3X)]

	Vertical bump amplitude (mm) in QM7		
	-0.5	0.0	0.5
y-emittance (pm.rad)	270.6	119.8	101.5

Needs to be compared with simulation based on the real status of the machine.

Conclusions and prospects

-Twiss parameters and emittance reconstruction based on both « quad scan » and « multi-wire » measurements give similar results with « small » descrepancy.

-The accuracy of the DR emittance measurement needs to be improved.

- EXT line emittance variation from vertical bump in QM7 has been demonstrated. A detailed comparison with numerical simulation is required to obtain more quantitative results.

-A coupling correction estimation in EXT line (based on quad scan measurement and simulation) has been established (not shown here).

-This preceeding coupling correction has been tested (not shown here). Data analyses are on going.

<u>What to do about QM7 for ATF2 ?</u>

QM7 vertical beam stablity analysis is required; feed back might be mandatory (precision ?)

Switch off QM7 ? (→ new optics in DR !?)

For ATF2, the optics design of the diagnostic section is much improved (for both wires et skew quad phase advance) → easier phase-space measurement and correction

What are the requirements on input Twiss parameters, to maintain good enough conditions for phase-space correction and measurements in ATF EXT and in ATF2 ?

END

Present aims of French **ATF2** involvement

(2008 □2010)

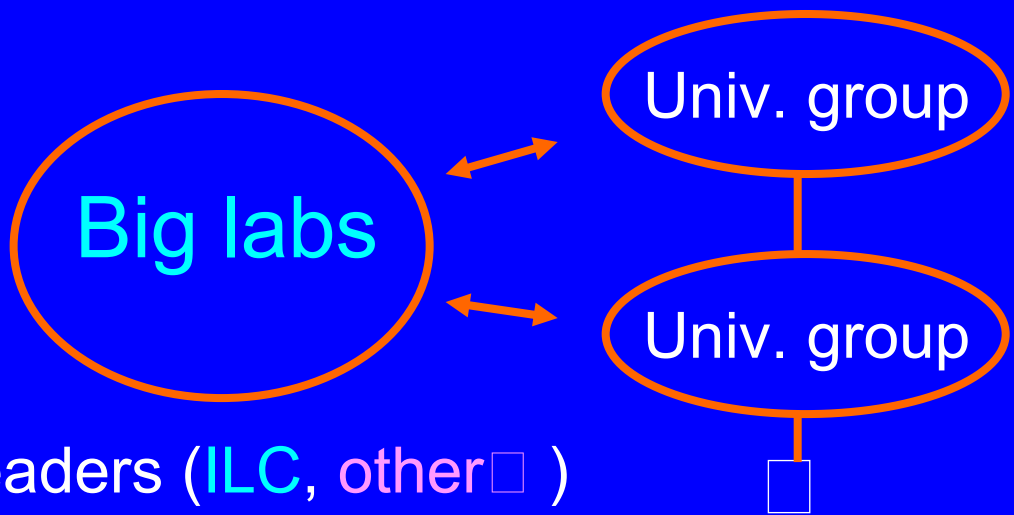
- Significant impact on ATF2 commissioning and beam experimentation, characterization of IP stability, understanding and control of beam-induced backgrounds, instrumentation → presence at KEK□

- Research within international collaborative environment for accelerator R&D, as HEP experiments

□project □tasks□
□practical learn by doing

□academic endeavor
□publish or perish□

□research bids / contracts



Training impact : future leaders (ILC, other□)