WILL PS & SPS BE READY FOR CNGS START-UP IN 2006?

E. Métral (15 + 5 min, 19 slides)

- **Introduction**
- **CERN commitment**
- **Operational results of the CNGS tests in September 2004**
  - **PSB**
  - **PS**
  - **SPS**
- **Transverse emittances : comparison with 1997**
- **Potential problems**
- **Conclusion**

INTRODUCTION

- This talk is focused on operational issues for the re-start in 2006
- E. Shaposhnikova will address the beam dynamics issues and the more distant perspectives (effect of rebunching in the PS,…)
- The nominal 1.2 s basic period in the PS complex is assumed $\Longrightarrow$ M. Benedikt will talk about the 0.9 s

CERN COMMITMENT

- Fast extracted (in 2 halves) proton beam from the SPS at 400 GeV/c sent to a carbon target

- The quality of the experiments depends directly on the total number of protons sent annually onto the target
  $\Longrightarrow$ Specified flux : $4.5\ 10^{19}$ pot/year

- $4.8\ 10^{13}$ p/p initially foreseen (1997 SPS intensity record)

- $4.4\ 10^{13}$ p/p now foreseen (HIPWG $\Longrightarrow$ CERN-AB-2004-022 OP/RF)

OPERATIONAL RESULTS OF THE CNGS TESTS IN SEPT. 2004

IN THE PSB

- **Linac2 : 175 mA**
- **New working point since 2004 : 4.17/4.23**
- **H1+H2 since 1998 (H5 before)**
- **Maximum intensity accelerated**

  993+1020+889+935 = 3837 10^{10} p/p

- **“Normal" operation**

  940+1010+835+914 ≈ 3700 10^{10} p/p

IN THE PS (1/5)

- **What was expected before the tests?**
  - **No beam stability limitations**
  - **Limitations come from losses at extraction and machine acceptance (alignment, small vertical emittance required at injection…)**
  - **Several improvements made during the last years (1 to 1.4 GeV kinetic energy in 1999, working point, fast instability at transition, alignment of some equipments…)**

Intensity record of 1997 (before ejection) : 3.2×10^{13} p/p

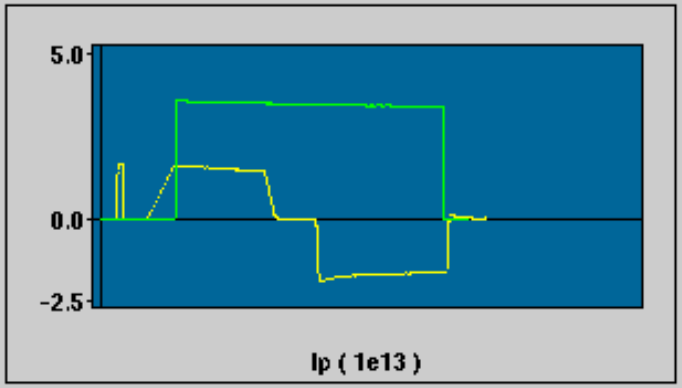
IN THE PS (2/5)

- **What did we obtain?**

New intensity record

opdisp — MDPS 11 Sep 28 05:07:06 2004

Beam State	INJ User	PS User	Particule	Harmonique	Destination
SPARE	PSB MDPRO	MDPS	PROTON	H420	TT2_D3



MBL	NC
	0

		Aquisition	Losses	Eff (%)	
1	ring 1 acc	982.86			
2	ring 2 acc	1019.99			
3	ring 3 acc	879.30			
4	ring 4 acc	945.74			
5	Sum PSB acc	3827.89			
6	BTP.TRA	3460.00	368	90.4	5
7	Injected	3571.67	256	93.3	5
8	Bef.Trans	3466.62	105	97.1	7
9	Aft.Trans	3447.07	20	99.4	8
10	Bef.Eject	3417.76	154	95.7	7
11	Aft.Eject	-0.57	3418	-0.0	10
12	TRA126	3210.09	208	93.9	10
13	TRA203	3154.50	263	92.3	10
14	TRA386	3231.00	187	94.5	10

BLM's Plot

	INT
16	234
41	159
42	227
43	175
44	131
45	116
f16	64

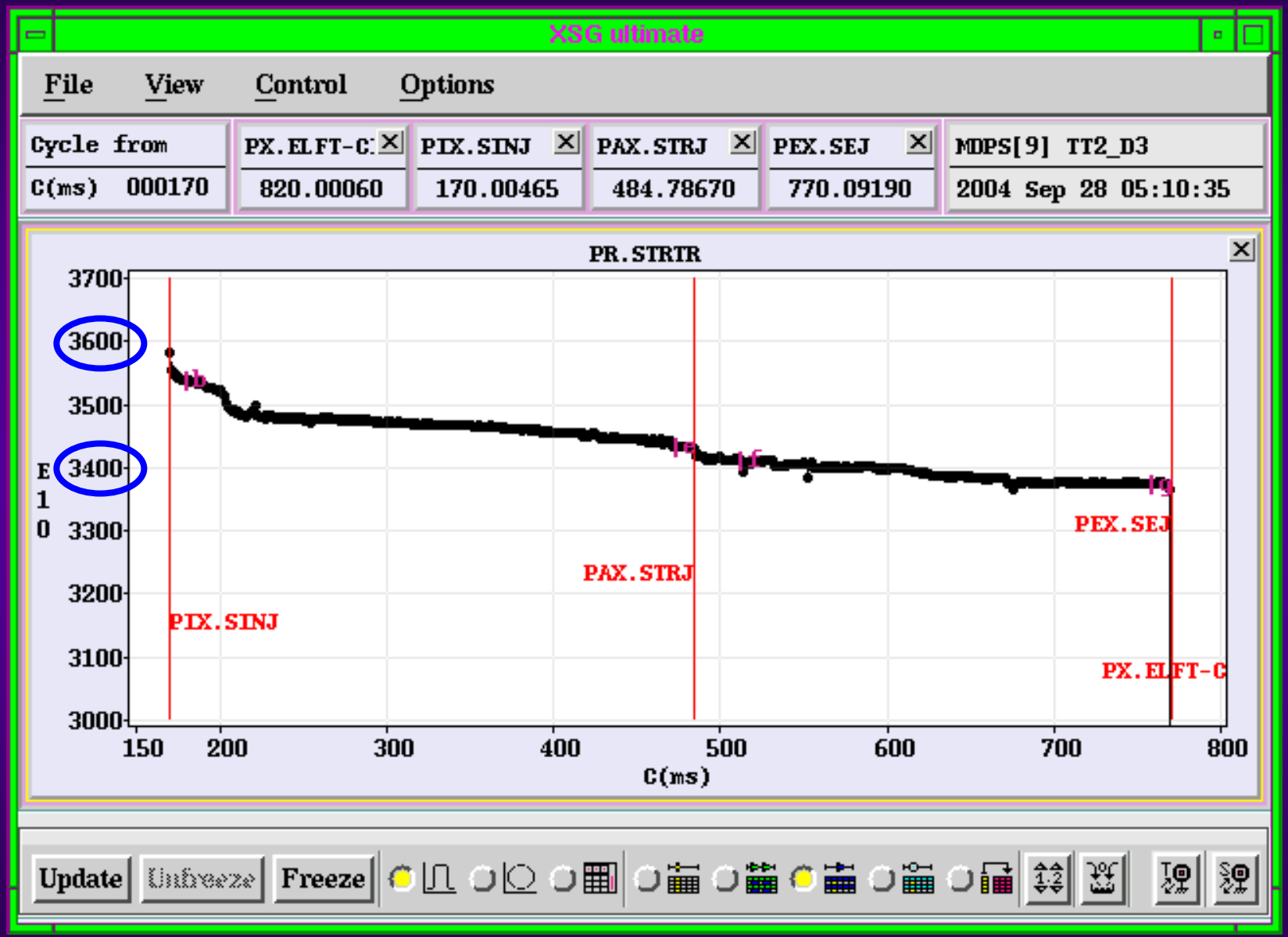
$\Longrightarrow$ > 3.4 10^{13} p/p before ejection

$\Longrightarrow$ > 3.2 10^{13} p/p after ejection

BUT ~ 250 10^{10} p (7%) lost at injection !

~ 6% of losses due to the CT

IN THE PS (3/5)


XSG ultimate
File
View
Control
Options
Cycle from
C(ms) 000170
PX.ELFT-C
820.00060
PIX.SINJ
170.00465
PAX.STRJ
484.78670
PEX.SEJ
770.09190
MDPS[9] TT2_D3
2004 Sep 28 05:10:35
PR.STRTR
E10
3700
3600
3500
3400
3300
3200
3100
3000
150
200
300
400
500
600
700
800
C(ms)
PIX.SINJ
PAX.STRJ
PEX.SEJ
PX.ELFT-C
Update
Unfreeze
Freeze

IN THE PS (4/5)

~ 250 10^{10} lost between PSB accelerated and PS injected

~ 150 10^{10} lost in the PS

~ 200 10^{10} lost in the CT

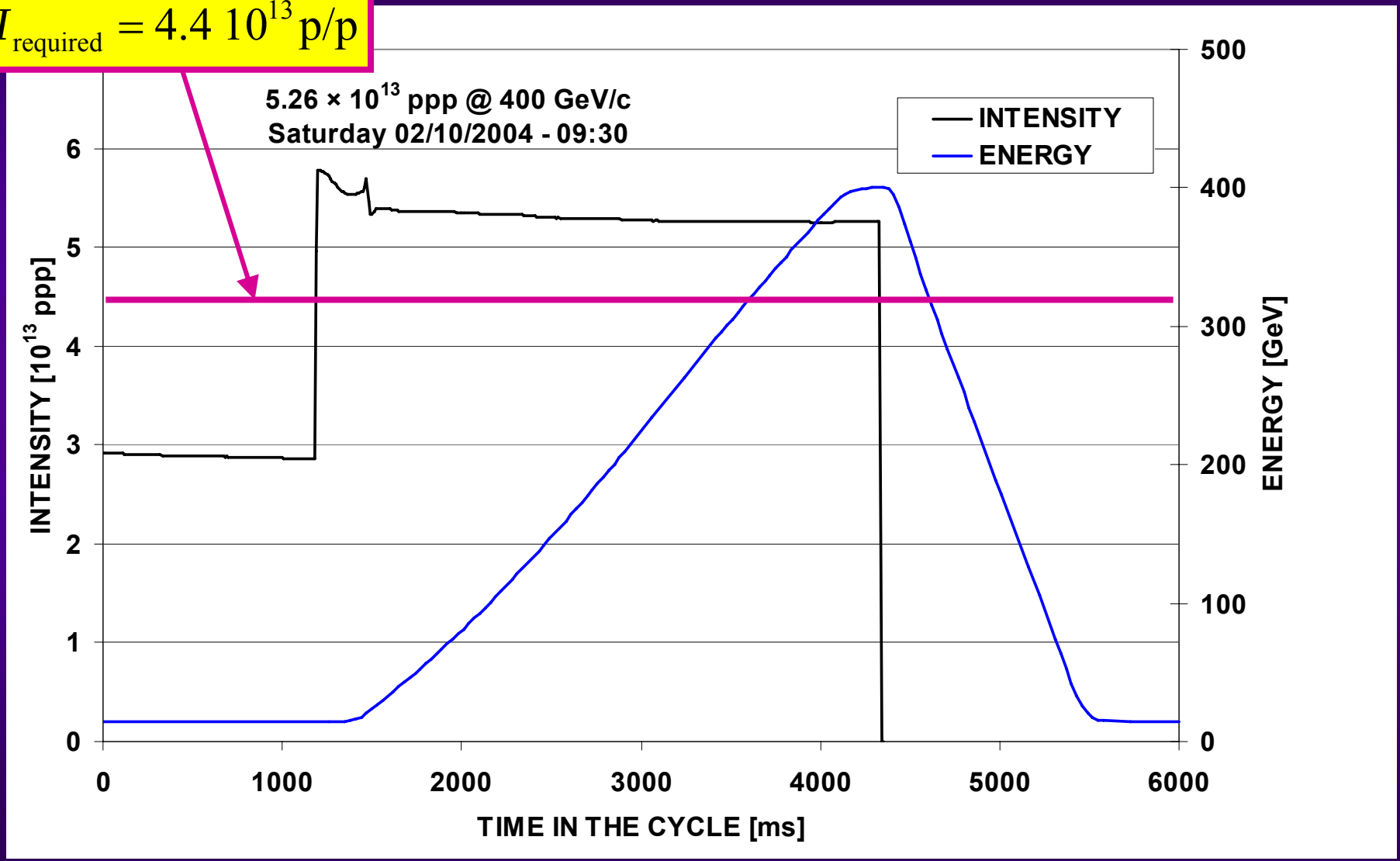
IN THE PS (5/5)

- For the 1997 intensity record
  - Higher intensity $\Longrightarrow$ Larger gap in SEH31 (24 $\Rightarrow$ 26 mm)
  - SEH31 gap at 26 mm $\Longrightarrow$ Increase voltage to 190 kV
- For the 2004 intensity record
  - The gap of SEH31 was not increased (better for the SEH31)
  - The beam is smaller in H $\Longrightarrow$ Should be better for the SPS

IN THE SPS (1/4)

New intensity record

$I_{\text{required}} = 4.4\ 10^{13}$ p/p



IN THE SPS (2/4)

	# p [10^{13} p]	Losses [%]
FTA212	3.1	
BFCT102834	3.06	~1.6
SPS INJ.	2.92	~4.6*
END FB	2.86	~2
F. PORCH	5.53	~3.3
> TRANS.	5.39	~2.5
400 GeV/c	5.26	~2.4
EXT.		~1?

Hot-spot at switching magnets

Mechanical aperture

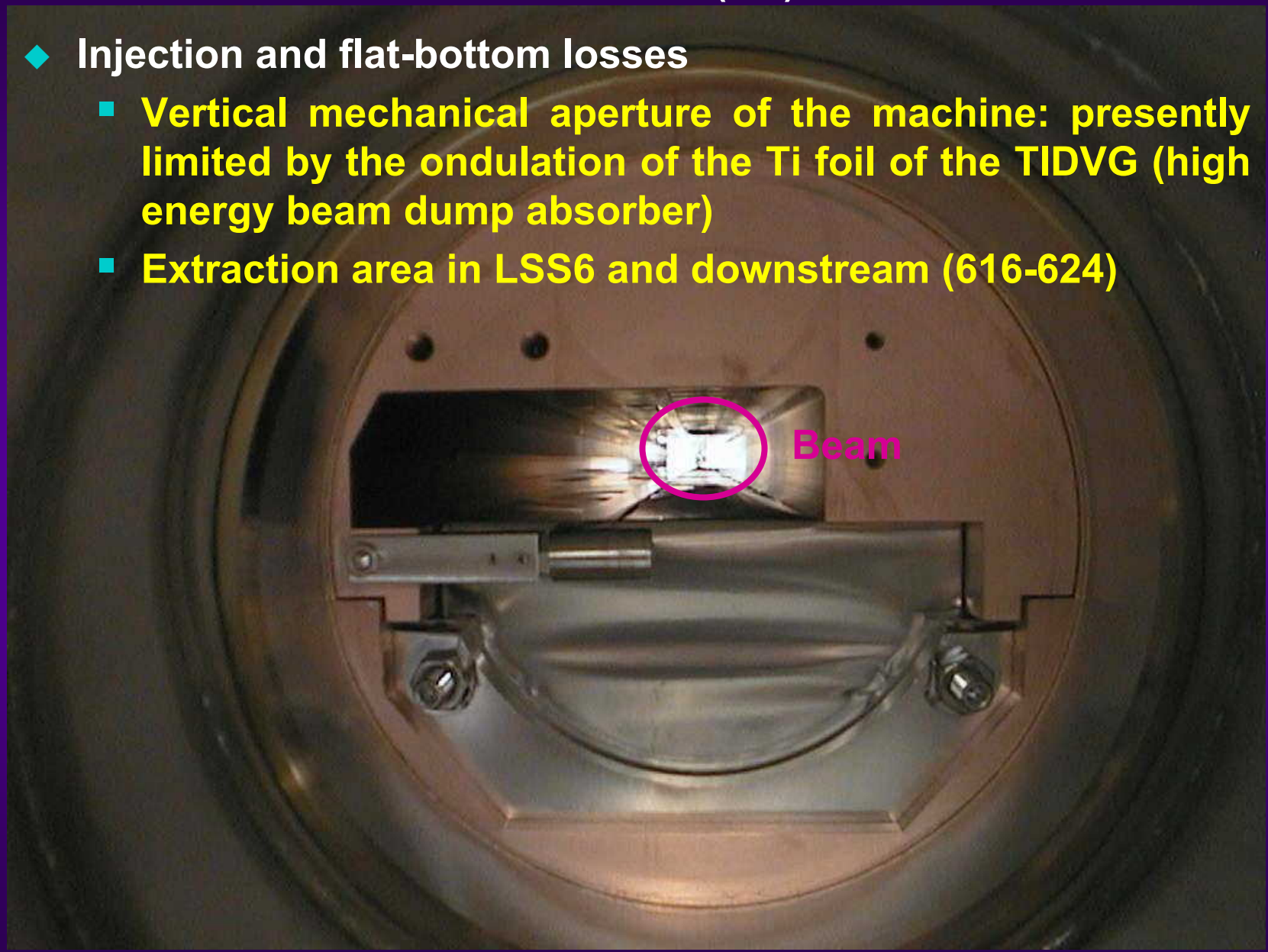
RF (see next talk be Elena) + H scrap. at transition ?

Ghost bunches in the kicker gap

* Injection losses to be verified – calibration (≠ kinds of BCTs)

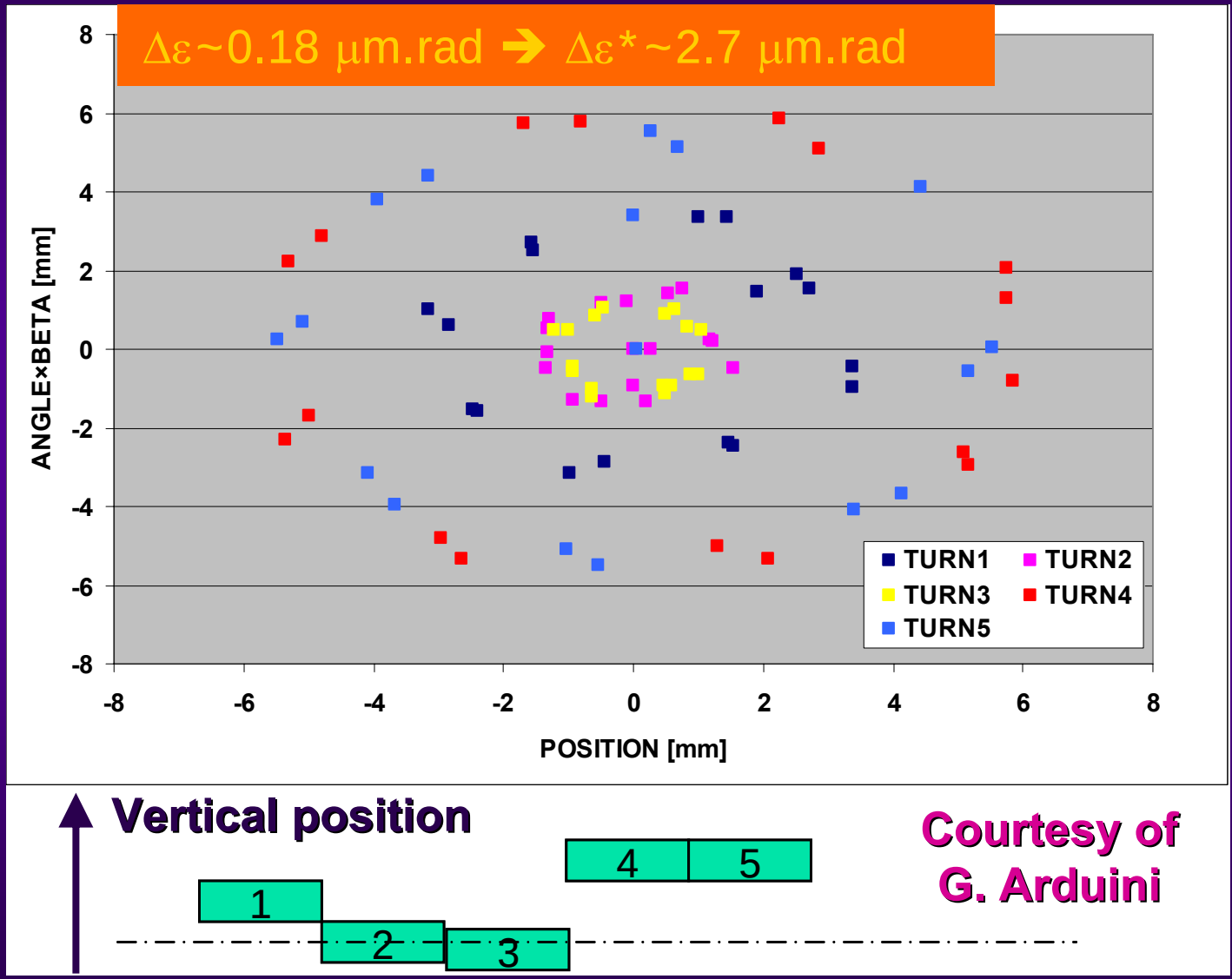
IN THE SPS (3/4)

- Injection and flat-bottom losses
  - Vertical mechanical aperture of the machine: presently limited by the ondulation of the Ti foil of the TIDVG (high energy beam dump absorber)
  - Extraction area in LSS6 and downstream (616-624)



IN THE SPS (4/4)

- **Tight vertical aperture ⟹ The alignment of the 5 CT-turns is critical**



TRANSVERSE EMITTANCES : COMPARISON WITH 1997

(1σ,norm) in μm

$$\varepsilon_{x,y}^{\text{required}}\left(1\sigma,\text{norm}\right)\leq 12\ \mu\text{m}\ @\ 400\ \text{GeV/c}$$

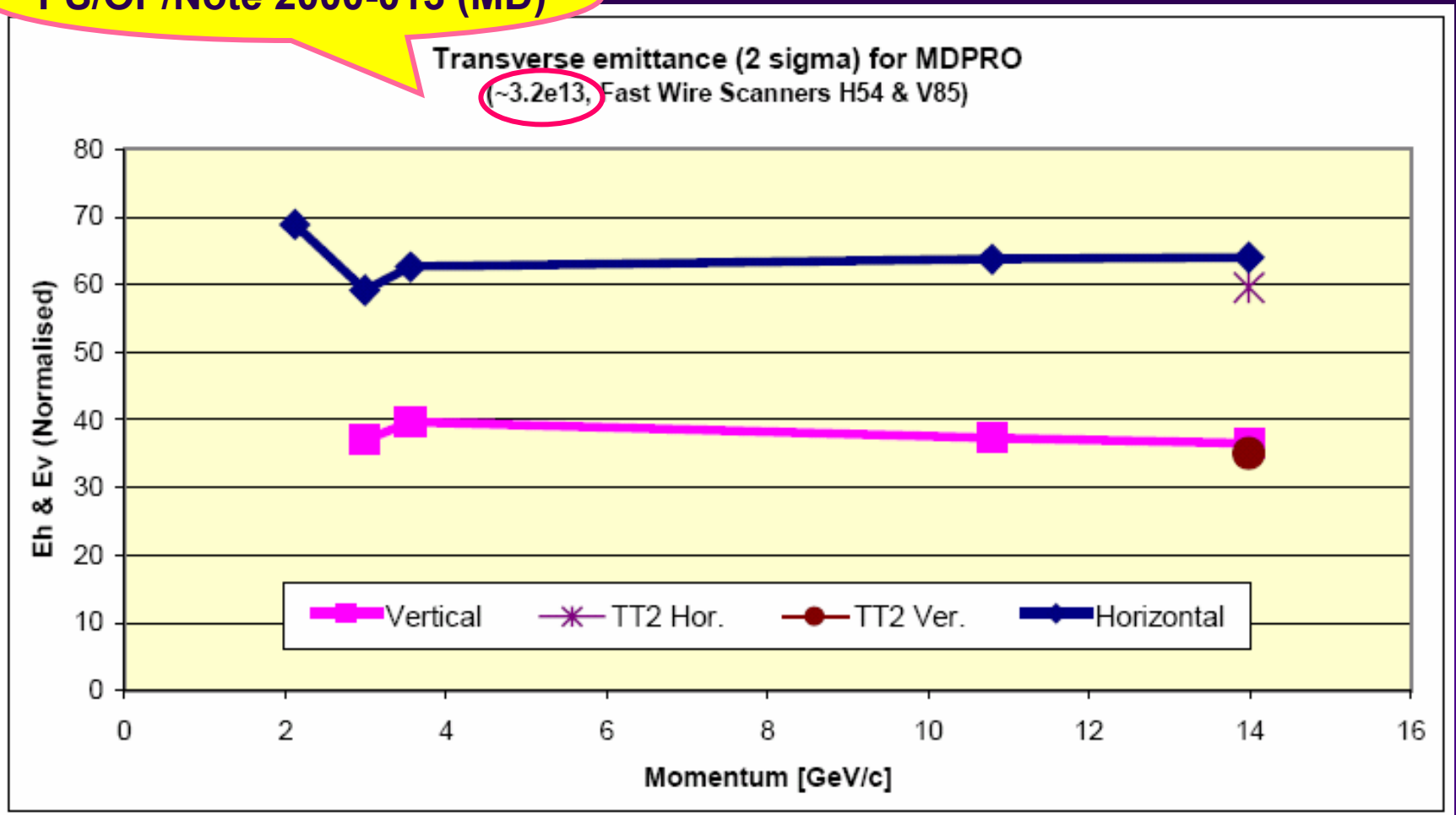
		PSB (SEMG-BTM)		PS (FWS)	PS (SEMG-TT2)	SPS (SEMG-TT10)	SPS (FWS) inj	SPS (FWS) top
Oct. 1997[1]	H	12.7		16.6	CT → 4.6	10.1	11.6	
	V	7.8 min	7.8 max	8.3	7.5	6.9	6.4	
Sept. 2004[2]	H	11.4	13.1	9.3	CT → 3.3		8.5	8
	V	6.8	8.0	9.1	6.4		5	4.3

[1] ~ 3.1 10^{13} p accelerated in the PSB (SL-MD Note 251)

[2] ~ 3.7 10^{13} p accelerated in the PSB

PS/OP/Note 2000-013 (MD)

PS MD in 2000



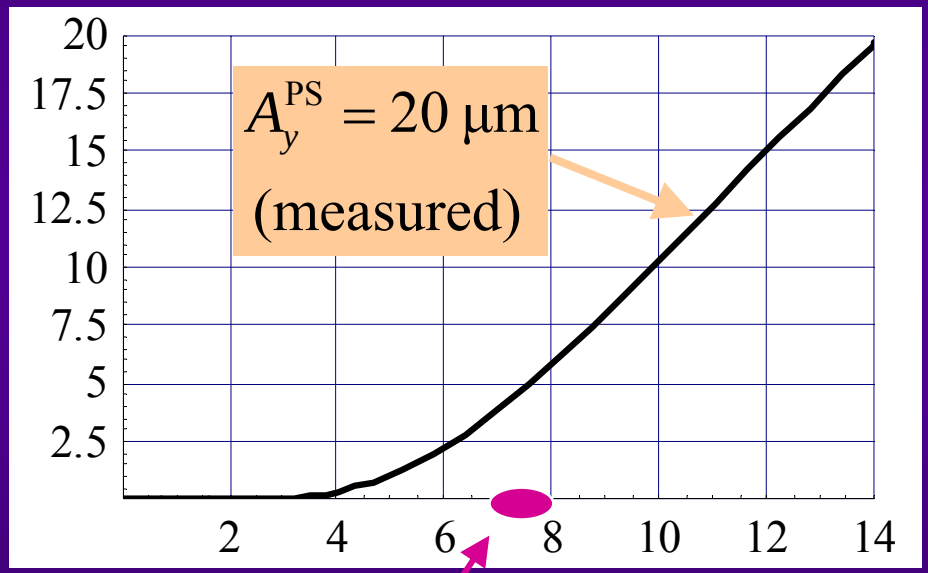
$\Rightarrow \varepsilon_x$ (1σ, norm) ≈ 16 μm and ε_y (1σ, norm) ≈ 9 μm before CT

in 1997 $\Longrightarrow$ 1 GeV kinetic energy at PS injection
MD in 2000 $\Longrightarrow$ 1.4 GeV kinetic energy at PS injection
} ~ Same result

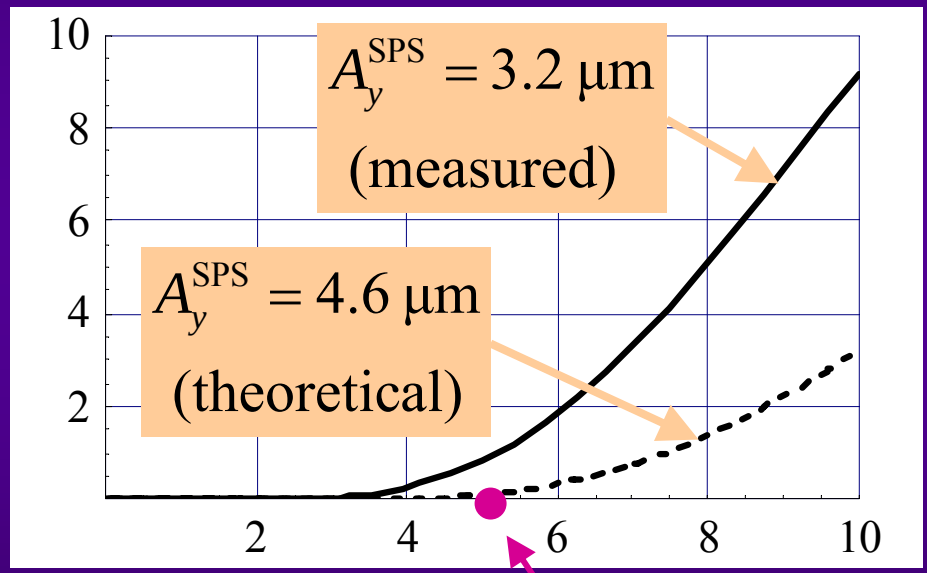
PS and SPS vertical acceptances

Assuming a bi-Gaussian
$\Longrightarrow$ Slightly pessimistic

Beam losses at PS injection [%]



Beam losses at SPS injection [%]



Vertical emittance from the PSB

$$\varepsilon_y \left(1\sigma, \text{norm}\right)\ [\mu m]$$

Vertical emittance measured at SPS injection

POTENTIAL PROBLEMS (1/2)

- **PSB**
  - RF power on C04 cavities (H2)
  - BTP.TRA transfo (between PSB and PS) needs to be operational to see where the losses are $\Longrightarrow$ To be calibrated
- **PS**
  - Vertical aperture $\Longrightarrow$ Alignment
  - Losses at extraction with present CT
  - RF spare policy $\Longrightarrow$ More frequent changes (gap relays, tubes…)
  - Radiation issues
    - PAX.S43 (South Hall)
  - Operational rule for the losses in the PS complex : "< ~250 10^{10} p lost between accelerated beams in the PSB and PS"
    $\Longrightarrow$ The record beam cannot be operational like this (~400 10^{10})
    $\Longrightarrow$ Decrease the intensity to reach this limit of losses
    $\Longrightarrow$ Change the rule… other mode of operation…

POTENTIAL PROBLEMS (2/2)

- **SPS**
  - Vertical aperture $\Longrightarrow$ TIDVG replacement, verification LSS6 extraction area and downstream (616-624)
  - Horizontal / momentum aperture
  - Tools needed for the alignment of the 5 CT-turns
  - RF spare policy $\Longrightarrow$ More frequent changes of the tubes
  - e^-cloud appears @ ~100 GeV/c even for conditioned machine! $\Longrightarrow$ Higher spark rate on the electrostatic septa (used for the FT slow extraction) for operation in parallel CNGS/FT (in two different cycles) $\Longrightarrow$ Scrubbing is vital
  - Interlock $\Longrightarrow$ Not fully ppm
  - Radiation issues
    - Increase in ambient dose-rate at the exit of the BA1 ventilation through the TT10-TT2 tunnel (beam dump)
    - Remanent radiation (TIDVG&TIDH, TIDP and high dispersion areas, TT2-TT10 transfer line to be checked)

CONCLUSION

- **We managed to push the intensity about 20% above the nominal intensity (4.4 10^{13} p/p), which should give us some margin to provide this beam operationally**

- **To further increase the intensity per pulse for CNGS $\Longrightarrow$ See next talk by Elena**

ACKNOWLEDGEMENTS

Many thanks to all the people involved in this subject (See Elena's talk) !