SOLEIL Current Performances

And

Futur Developments

Amor Nadji

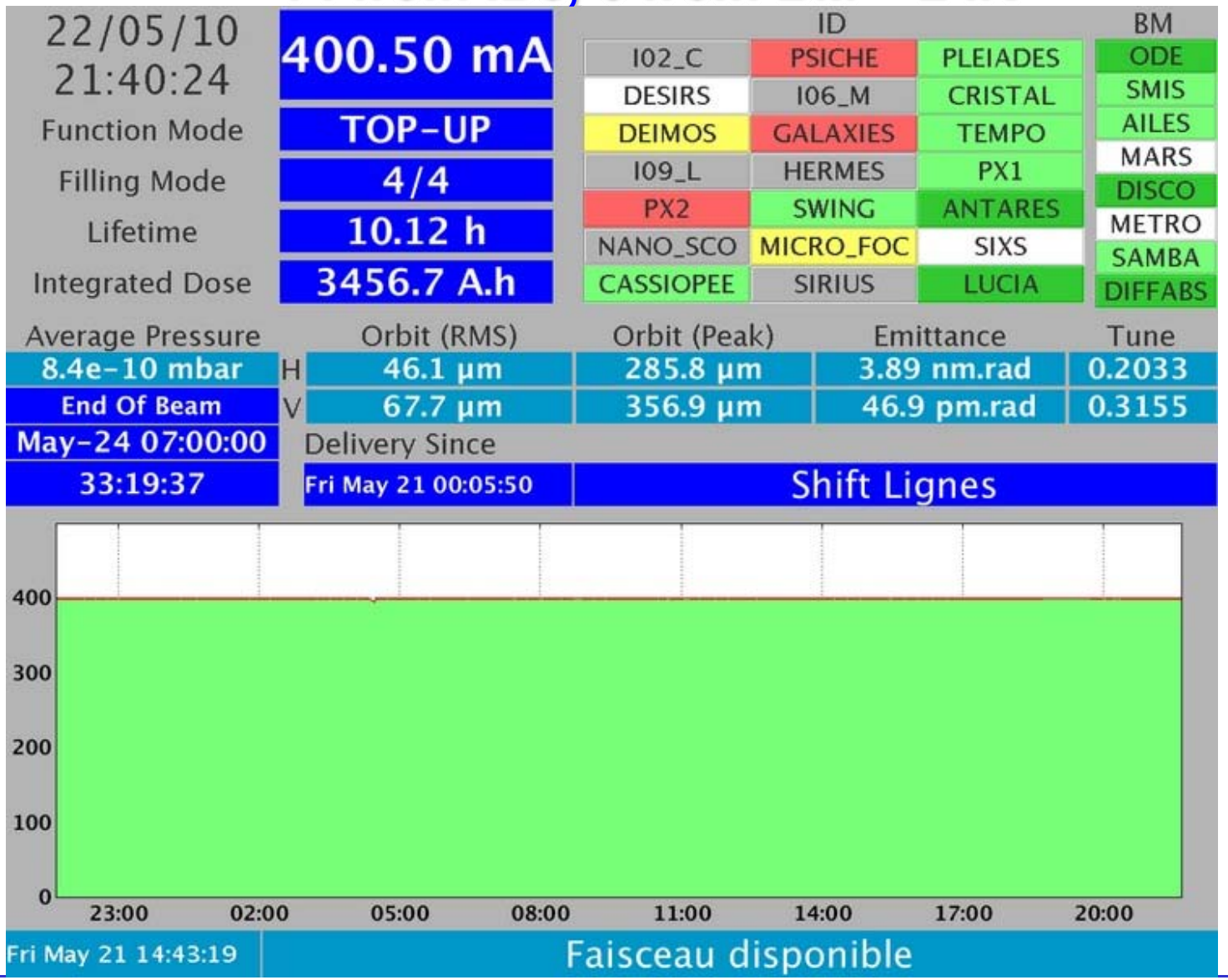
On Behalf of the SOLEIL Team

Main Parameters

Energy (GeV)	2.75
Emittance H (nm.rad)	3.7 0.2
Coupling, $\varepsilon_V/\varepsilon_H$ (%)	Minimum achieved = 0.11 Operation ≈ 1 – 1.4
Energy Spread	1.0×10^{-3}
Betatron Tunes H / V	18.2020 / 10.3170
Chromaticities H / V	2 / 2.6
Multibunch Mode Current (mA)	500 (400 for users)
Average Pressure (mbar)	(< $1\ 10^{-9}$ @ 500 mA); $7\ 10^{-10}$ @ 400 mA
Beam Lifetime (h) @ 400 mA	11 - 18 depending on the IDs configuration
Single Bunch Current (mA)	20 (11 for users)

22 Beamlines are taking Photons

14 from IDs, 6 from BM + 2 IR

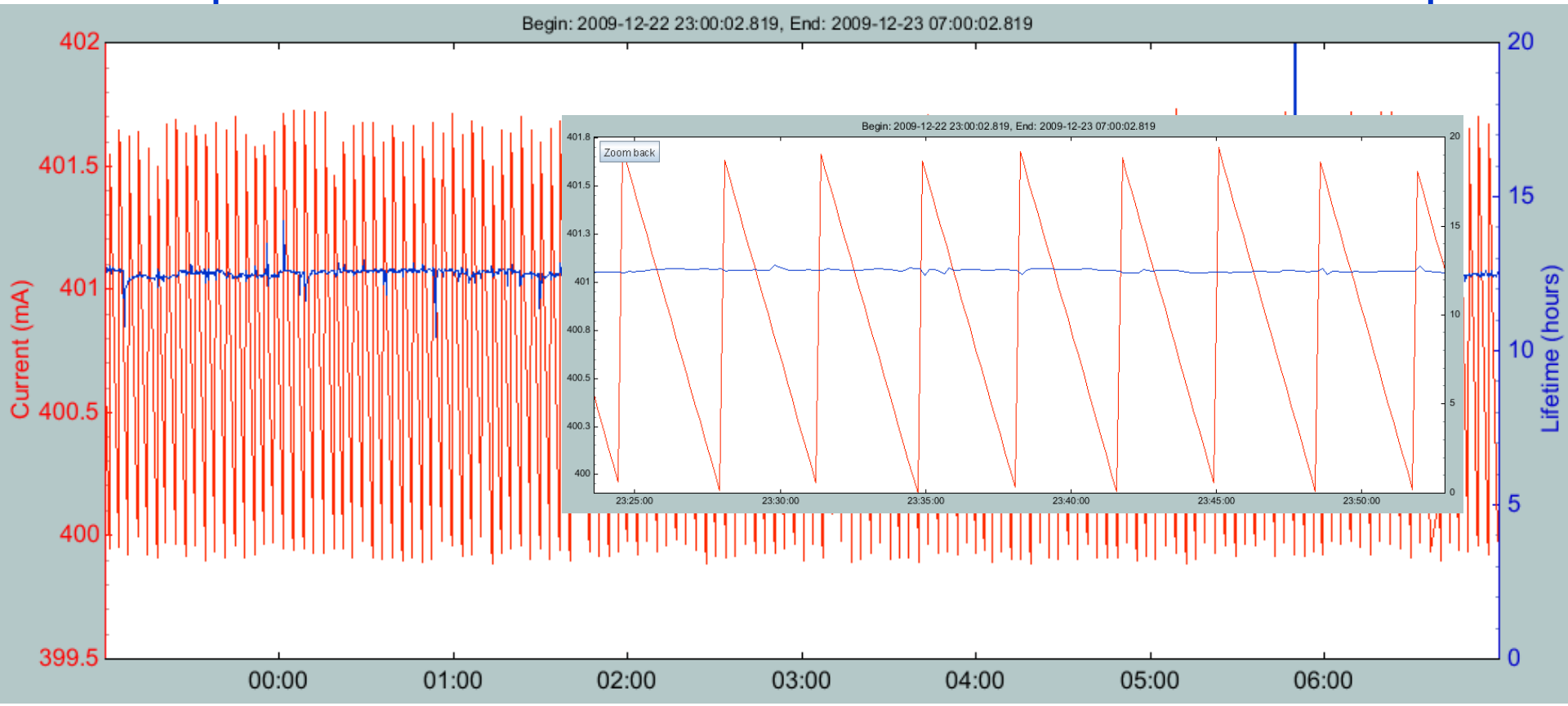


Machine Operation: Top Up mode

I = **400 mA** +1.5 mA => 0.4% Current stability

Lifetime ~11 to 18 h (**uniform filling pattern**)

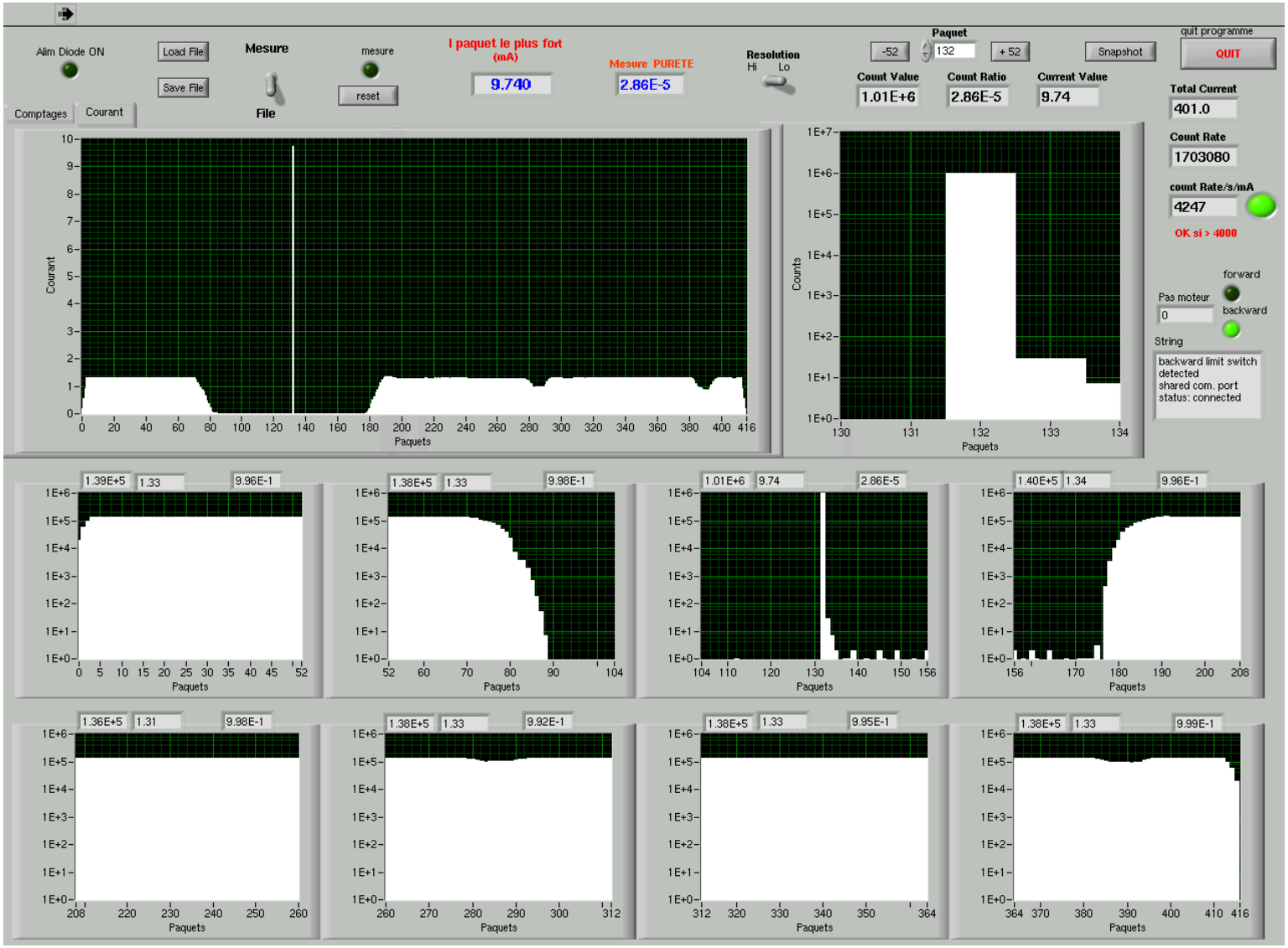
A single 300 ns Linac pulse of 1.5 mA is injected every 3 to 5 mn



Longuest uninterrupted beam delivery reached 144 hours

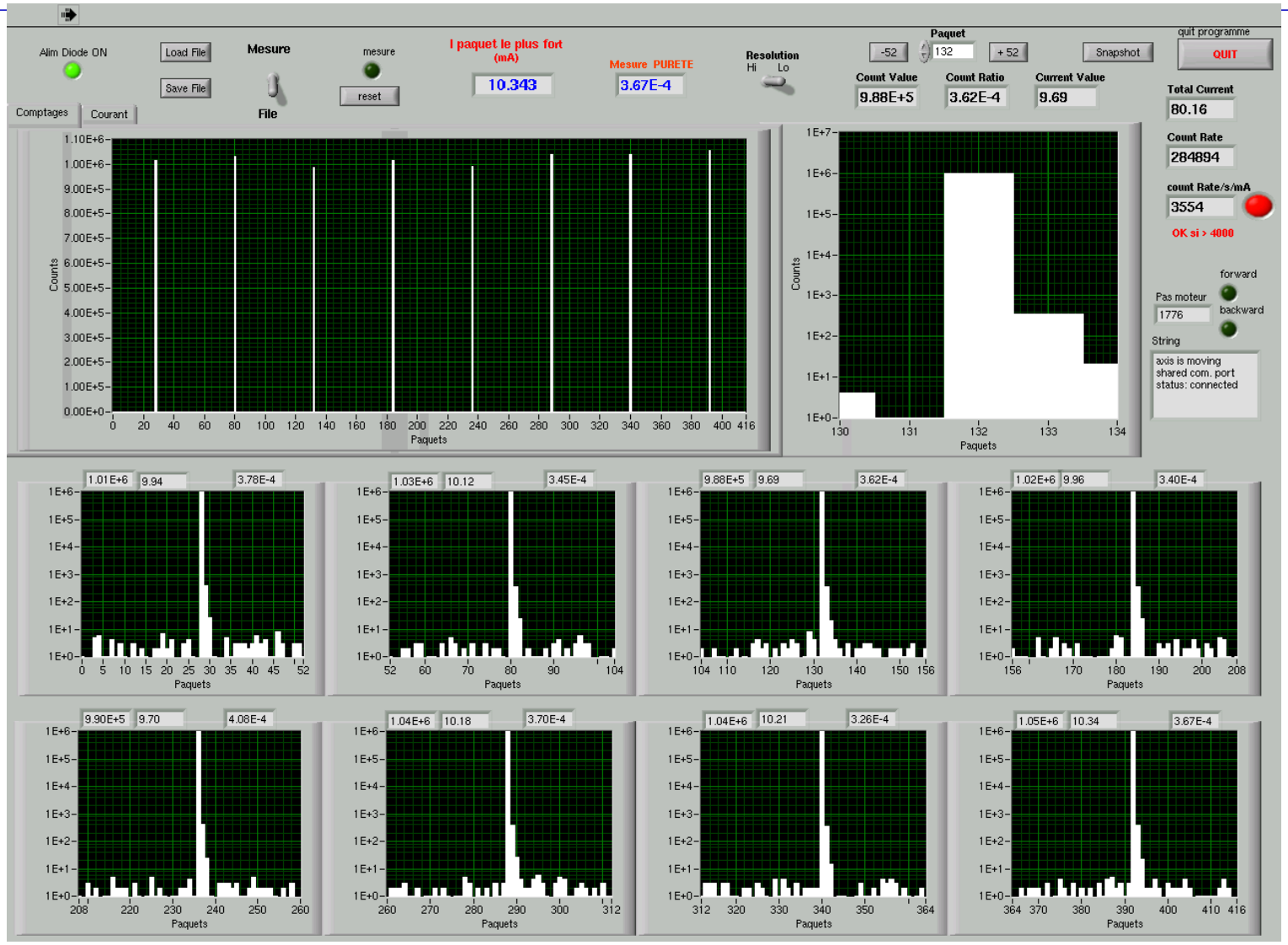
Machine Operation

Hybrid mode at 400 mA (392 mA + 8 mA), Top up.

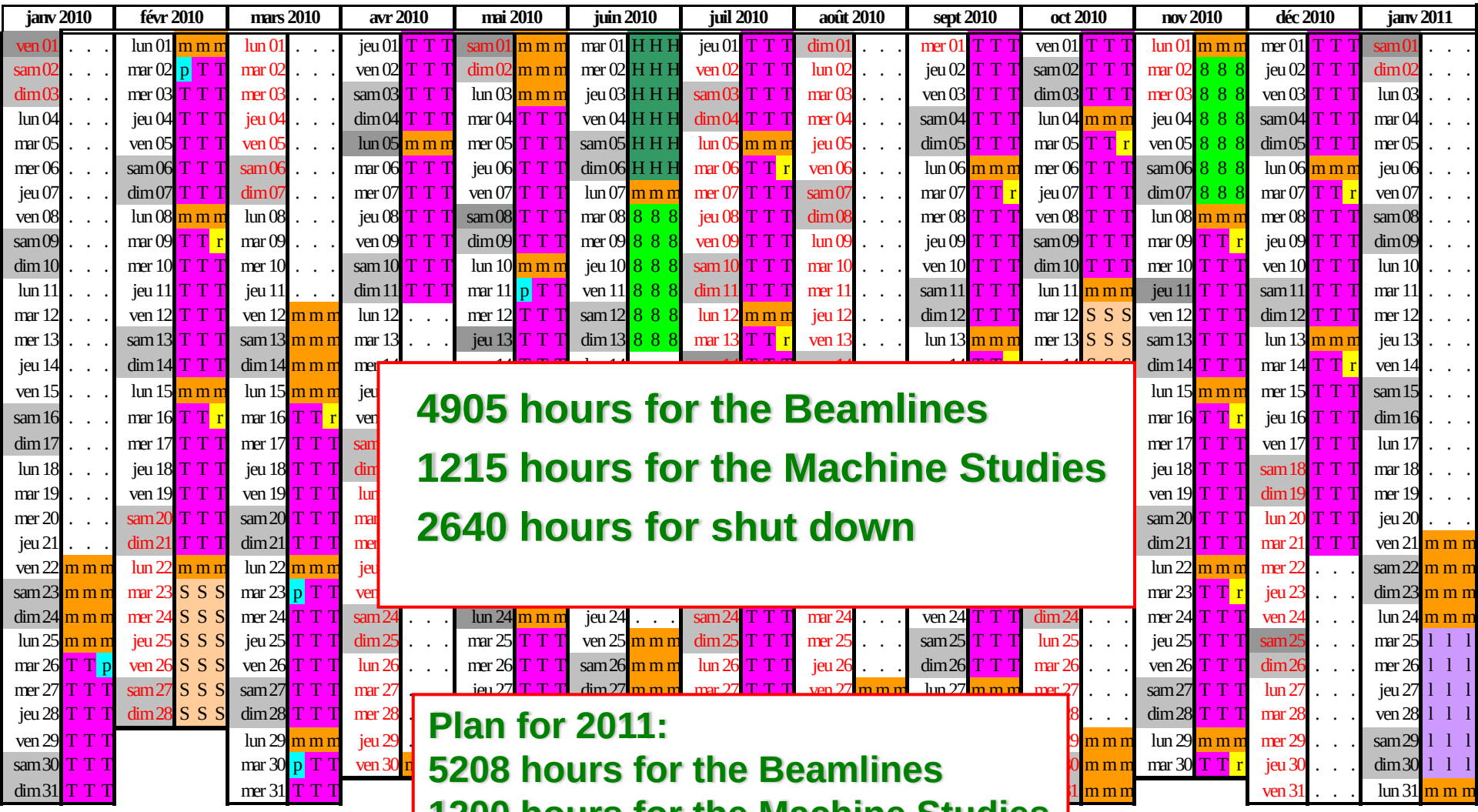


Machine Operation

8 bunch mode at 95 mA (Lifetime ~4 hours), Top up.



2010 Operation Schedule



Machine Operation

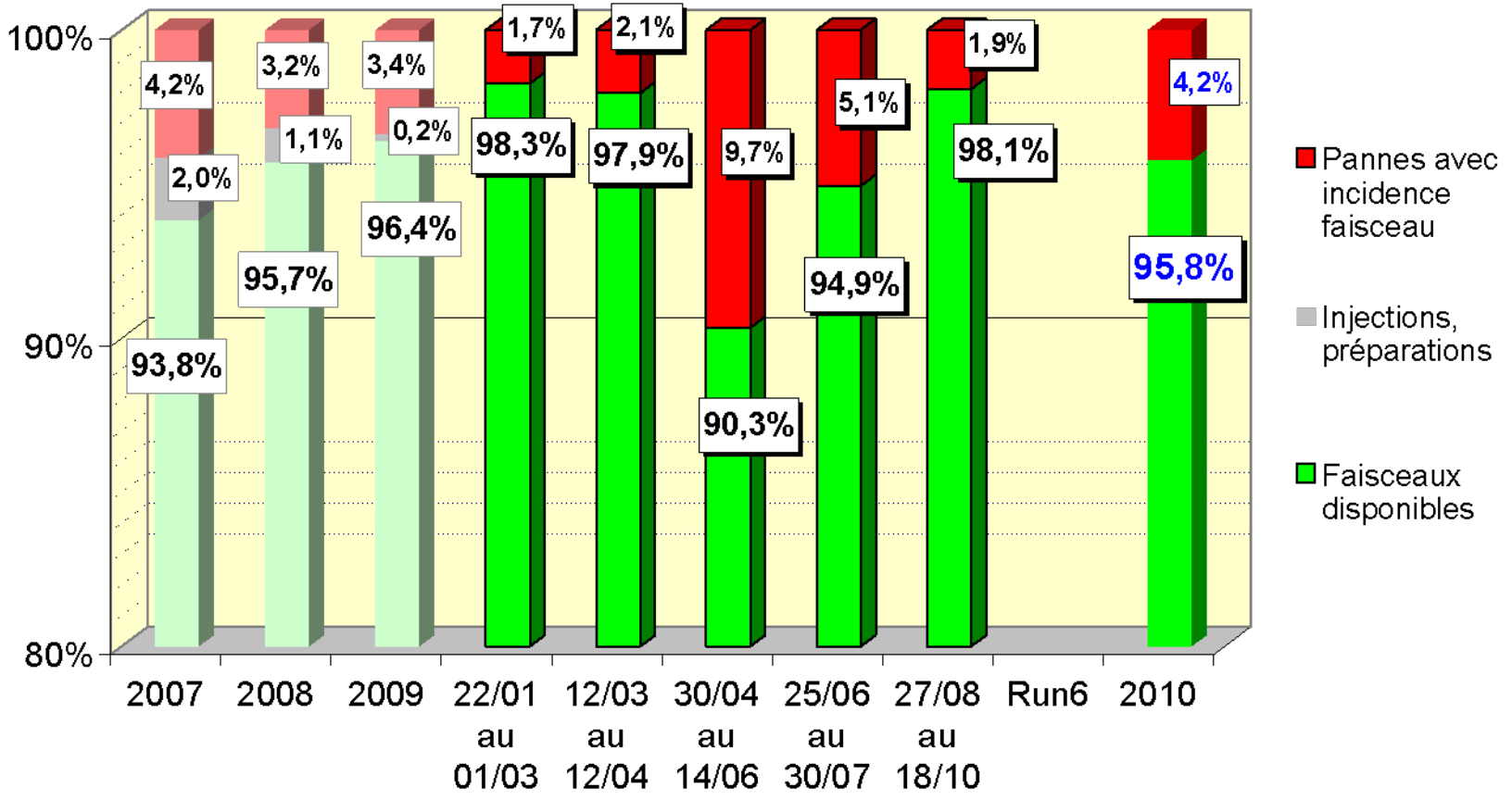
Good progression in the availability of the beam

95.7% in 2008 (3 882 hours del.)

96.4% in 2009 (4 423 hours del. over 4588 h as scheduled)

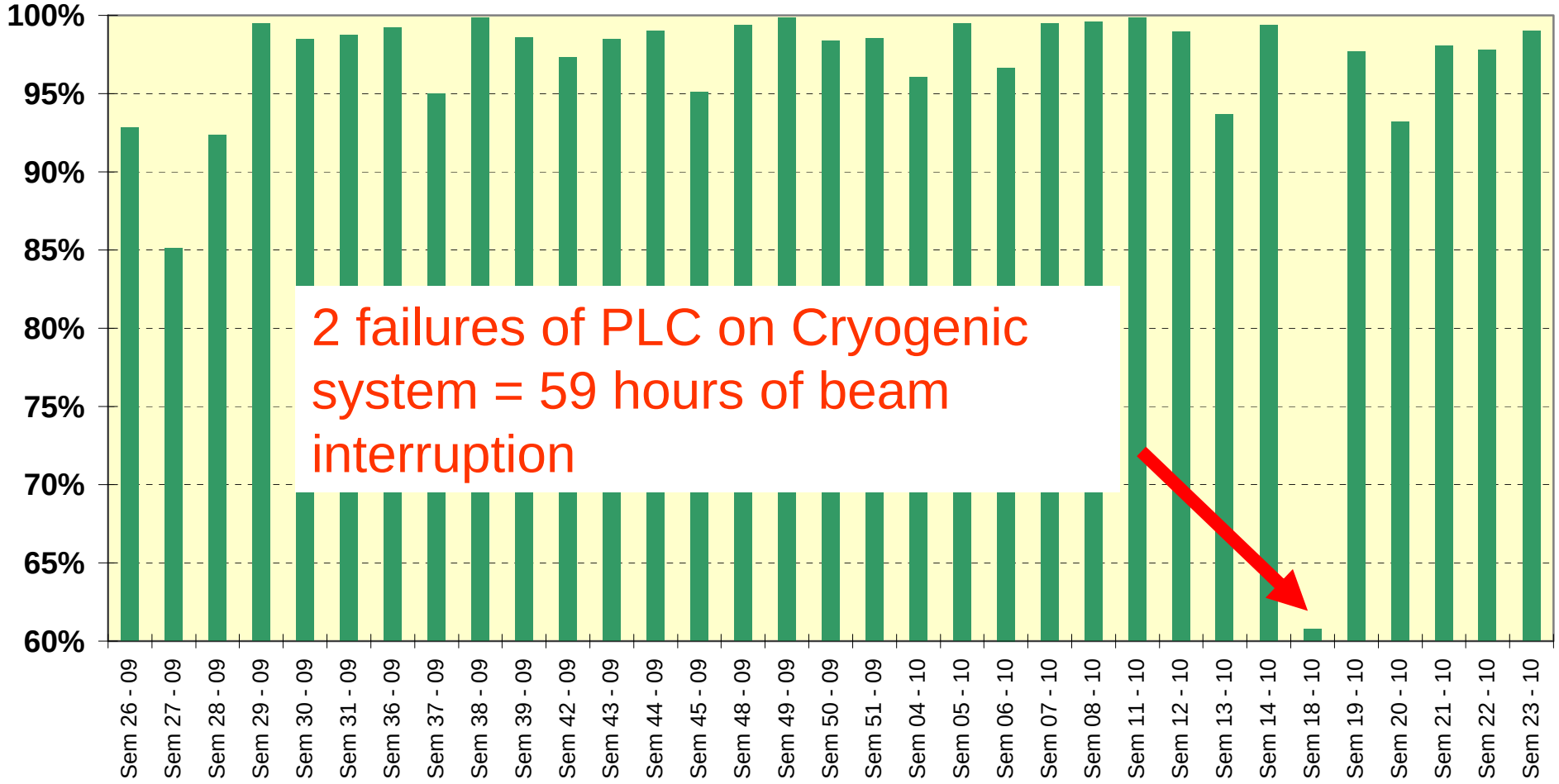
97.3% from June 2009 till April 2010 (3858 h)

96.1% in 2010 (4115 hours del. as of 22 November 2010)



Machine Operation

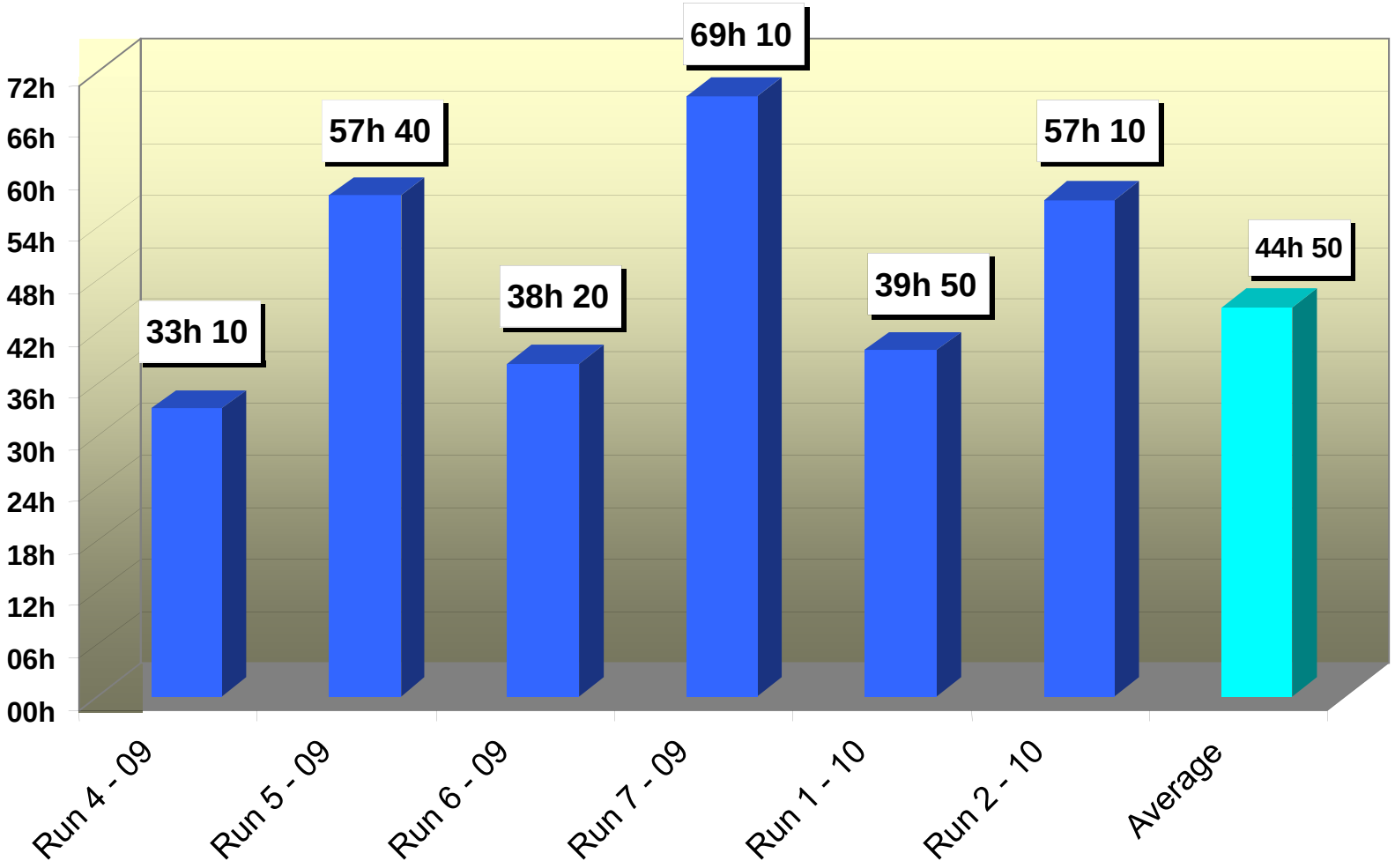
Beam availability on a weekly basis from June 2009 till June 2010



recently 2 weeks with 100% availability!

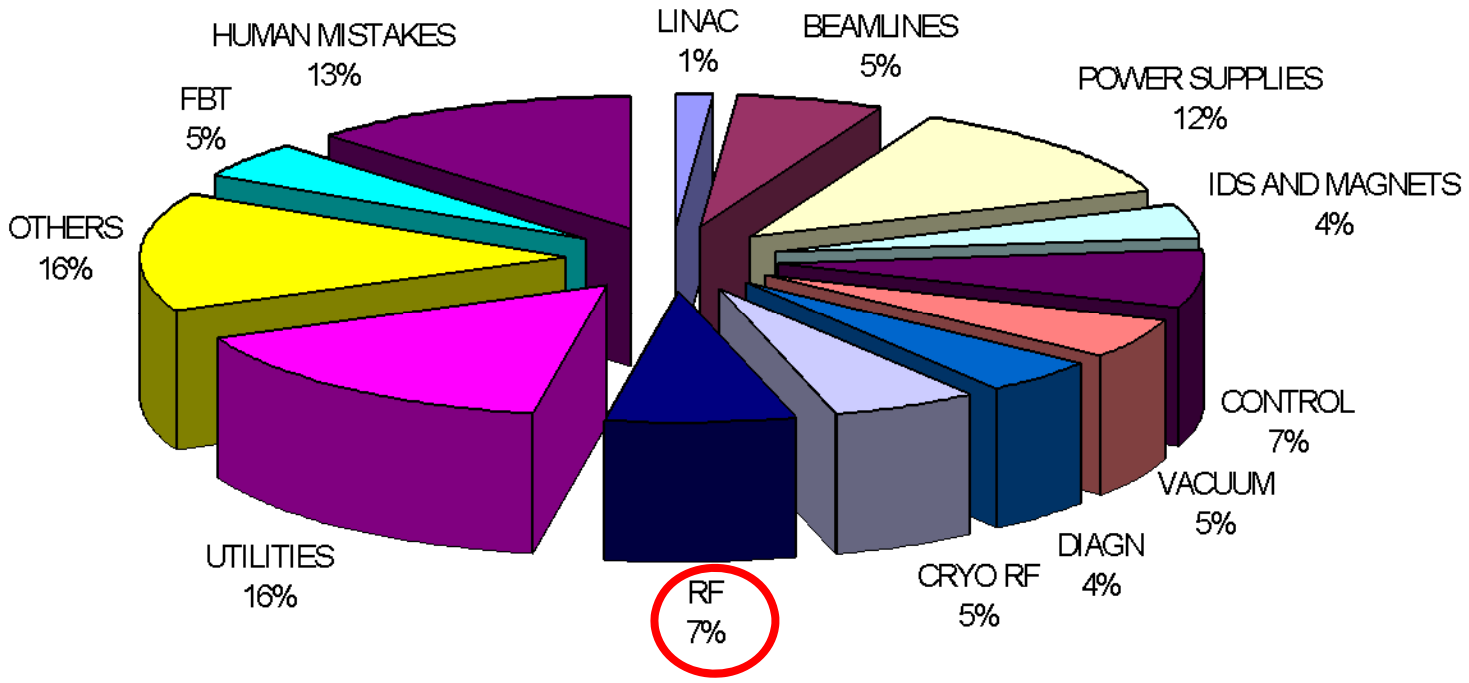
Machine Operation

Mean Time Between Failure = 45 h over 3858 hours from June 2009 till April 2010



Machine Operation

Beam time lost due to failures of equipment.
The total time lost reached 156 hours over 2009.



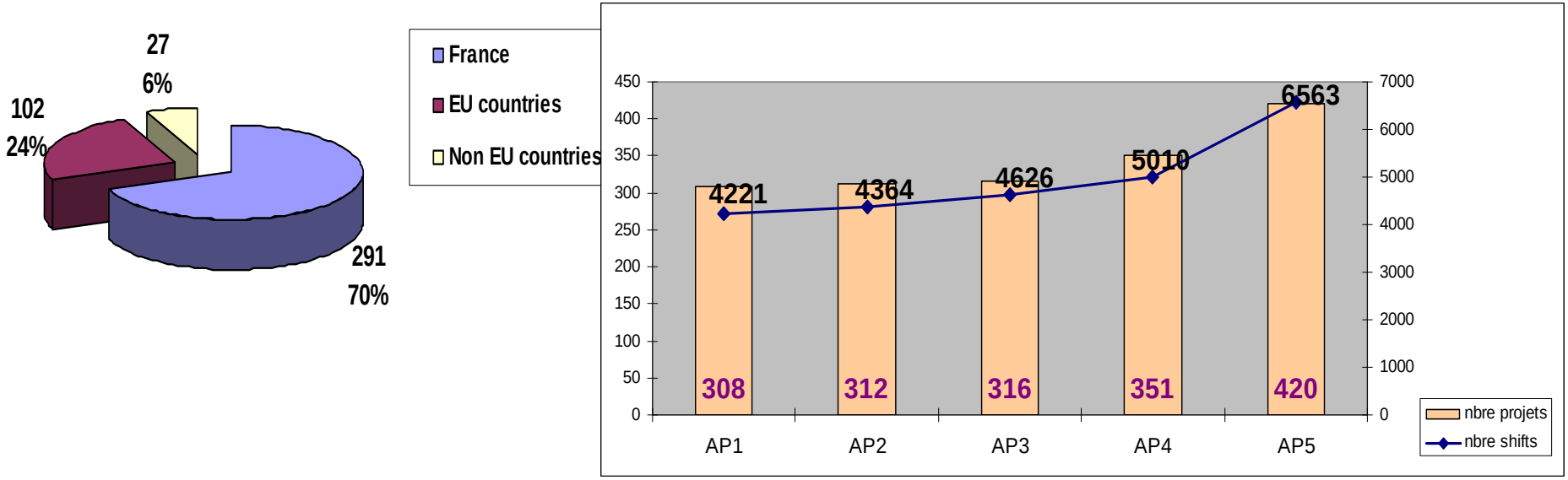
SOLEIL Customers

AP5- Jan - July 2010

The request is beyond the offer!

Number of shifts (8h) requested: **6563**

Number of shifts allocated: **2225**



Insertion Devices

Beamline Name	Ring Location	Photon Energy	Source Type	Useful length (m)	Polarization	Technology
Already installed on the ring						
DESIRS	I 05-L	5 – 40 eV	HU640	10	Circ./lin/phasevar	HU640
CASSIOPEE #1	I 15-M	10 – 1000 eV	HU256	3,1	Circ./lin.	HU256
PLEIADES #2	I 04-M	10 – 1000 eV	HU256	3,1	Circ./lin.	HU256
ANTARES #1	I 12-M	10 – 1000 eV	HU256	3,1	Circ./lin.	HU256
PLEIADES #1	I 04-M	35 – 1500 eV	HU80*	1,6	Circ./lin.	APPLE II
TEMPO #1	I 08-M	45 – 1500 eV	HU80	1,6	Circ./lin.	APPLE II
SEXTANT #1	I 14-M	45 – 1500 eV	HU80	1,6	Circ./lin.	APPLE II
CASSIOPEE #2	I 15-M	100 eV – 4 keV	HU60	1,6	Circ./lin.	APPLE II
ANTARES #2	I 12-M	100 eV – 4 keV	HU60	1,6	Circ./lin.	APPLE II
DEIMOS #1	I 07-M	500 eV – 6 keV	HU52	1,6	Circ./lin.	APPLE II
LUCIA	I 16-M	500 eV – 6 keV	HU52	1,6	Circ./lin.	APPLE II
TEMPO #2	I 08-M	1 – 5 keV	HU44	1,6	Circ./lin.	APPLE II
SEXTANT #2	I 14-M	1 – 5 keV	HU44	1,6	Circ./lin.	APPLE II
SIRIUS	I 15-C	2 – 12 keV	HU36	1,6	Circ./lin.	APPLE II
PROXIMA1	I 10-C	4 – 30 keV	U20	1,96	Lin.	Hybrid in vacuum
SWING	I 11-C	4 – 30 keV	U20	1,96	Lin.	Hybrid in vacuum
CRISTAL	I 06-C	4 – 30 keV	U20	1,96	Lin.	Hybrid in vacuum
SIXS	I 14-C	4 – 30 keV	U20	1,96	Lin.	Hybrid in vacuum
GALAXIES	I 07-C	4 – 30 keV	U20	1,96	Lin.	Hybrid in vacuum
PROXIMA2	I 11-M	5 – 20 keV	U24	1,96	Lin.	Hybrid in vacuum
PSICHE	I 03-C	10 – 50 keV	WSV50	2	Lin.	Wiggler in vacuum
Under construction						
DEIMOS #2	I 07-M	350 – 900 eV	HU65	1,6	Circ./lin.	EMPHU
NanoScopium	I 13-L	4 – 30 keV	U20	1,96	Lin.	Hybrid in vacuum
Prototype		4 – 30 keV	U18	2,0	Lin.	CPMU
Under design						
HERMES #1	I 10-M	100 eV – 2 keV	HU64	1,6	Circ./lin.	APPLE II
HERMES #2	I 10-M	1.5 – 3 keV	HU40	1,6	Circ./lin.	APPLE II
PUMA/SLICING	I 06-M	15 – 60 keV	W164	3,0	Lin.	Wiggler PPM

21 installed on the SR

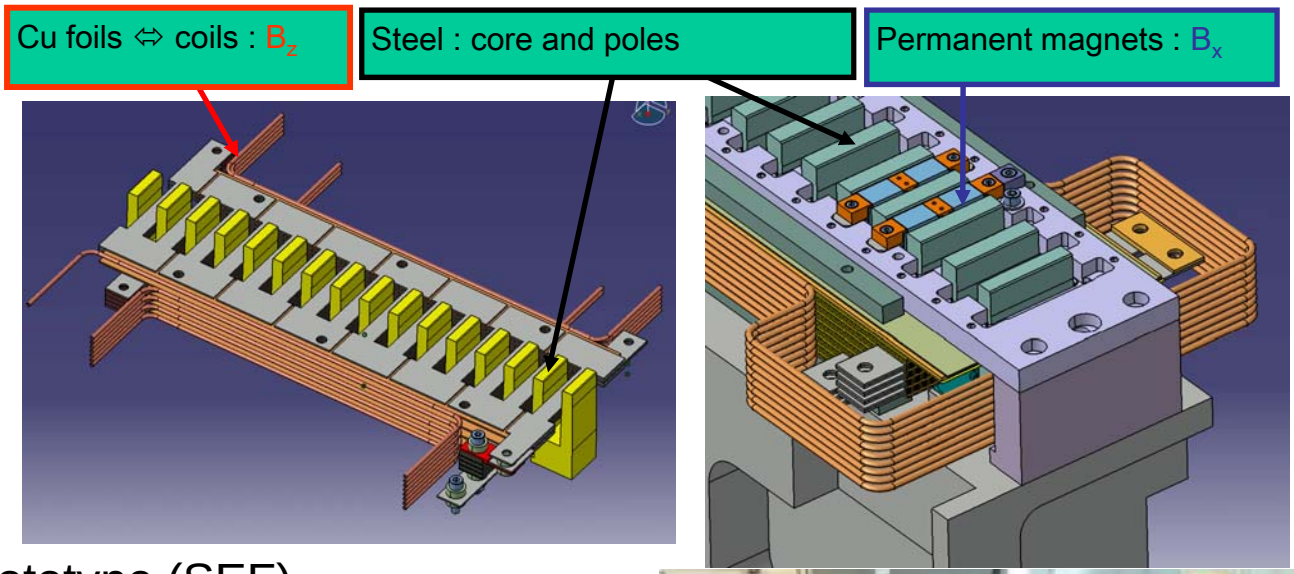
3 under construction

4 under design

To be installed: EPU with fast polarization switching

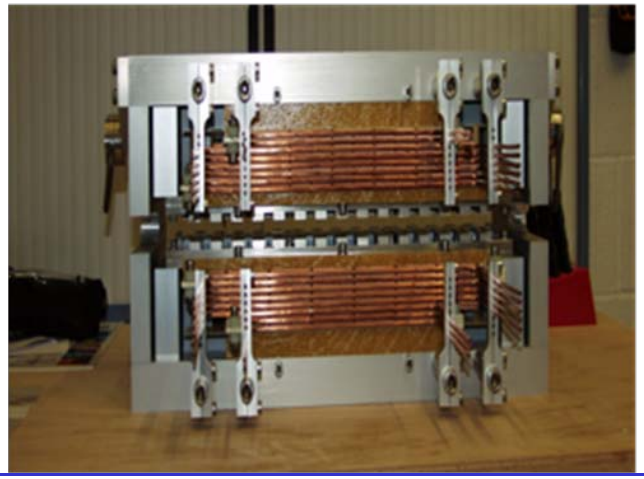
EMPHU

Polarisation switching in 60 ms



Bx=Bz=0.24 T

Prototype (SEF)

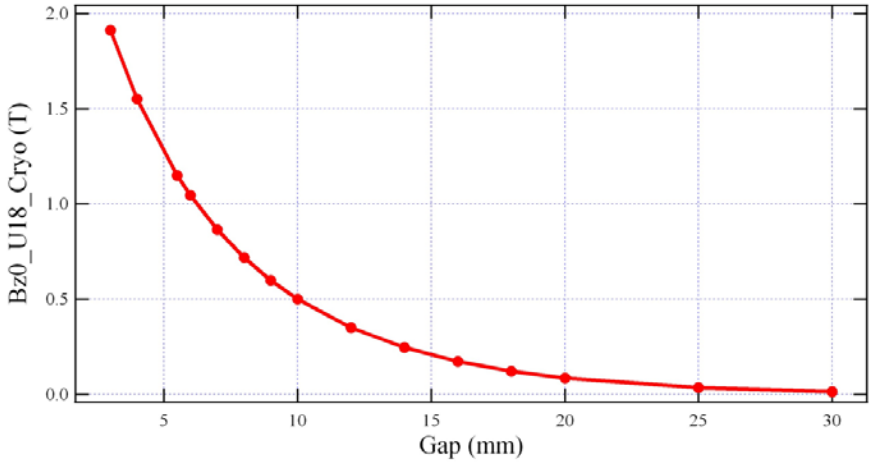


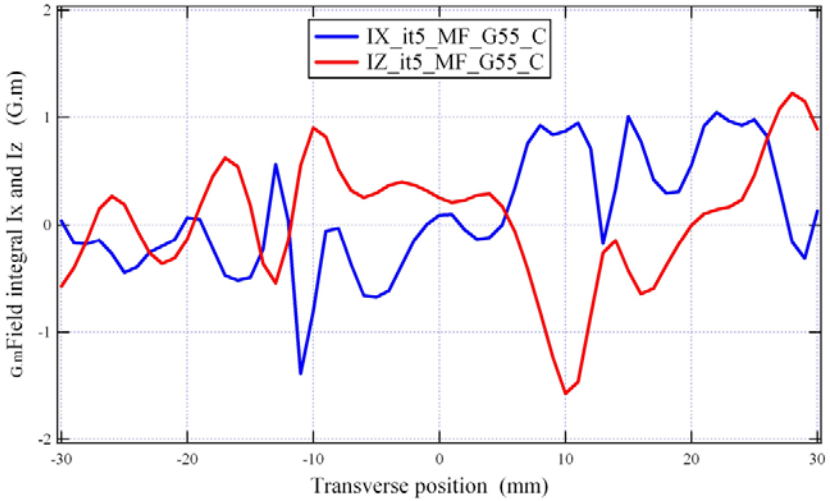
R&D activities and future plans: Cryogenic Undulator

with PrFeB magnets

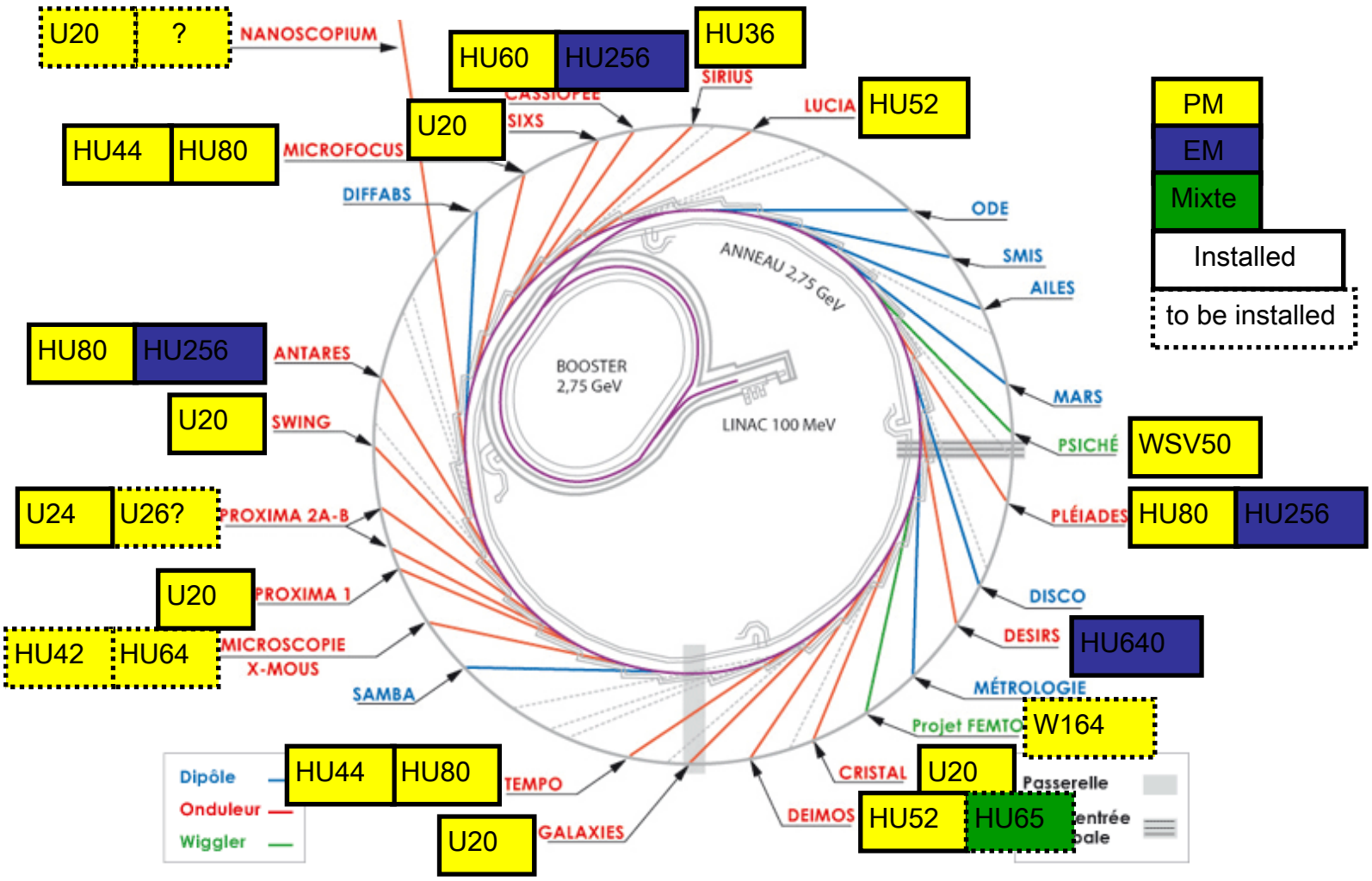
Room temperature assembly

phase error : 3.5 °

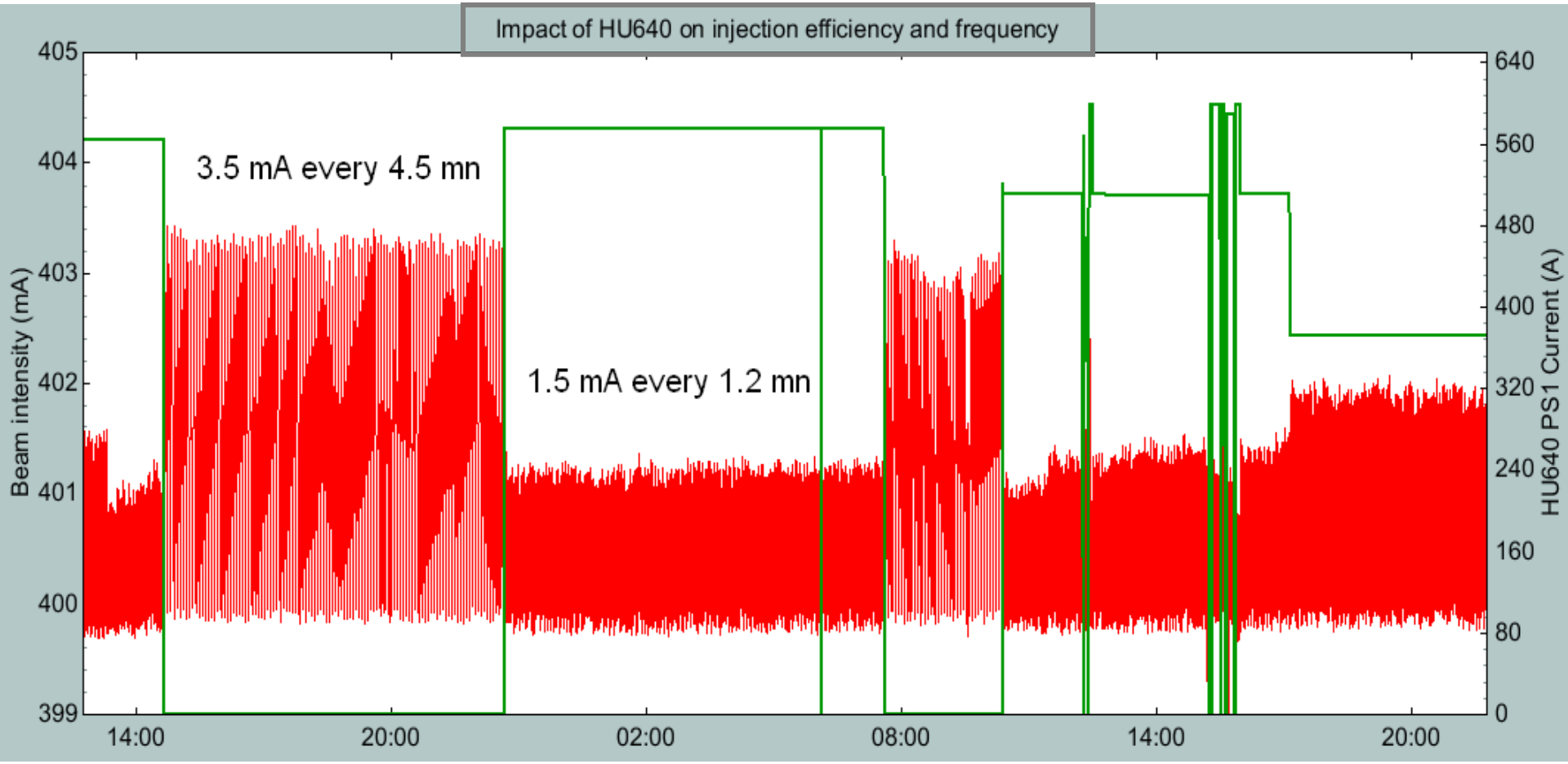




Implementation of the Insertion Devices



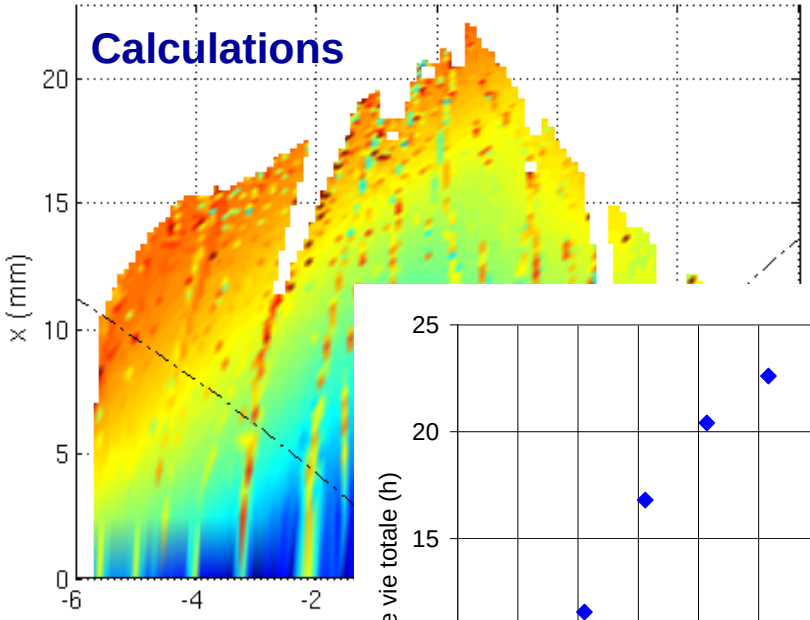
Effect of the Insertion Devices

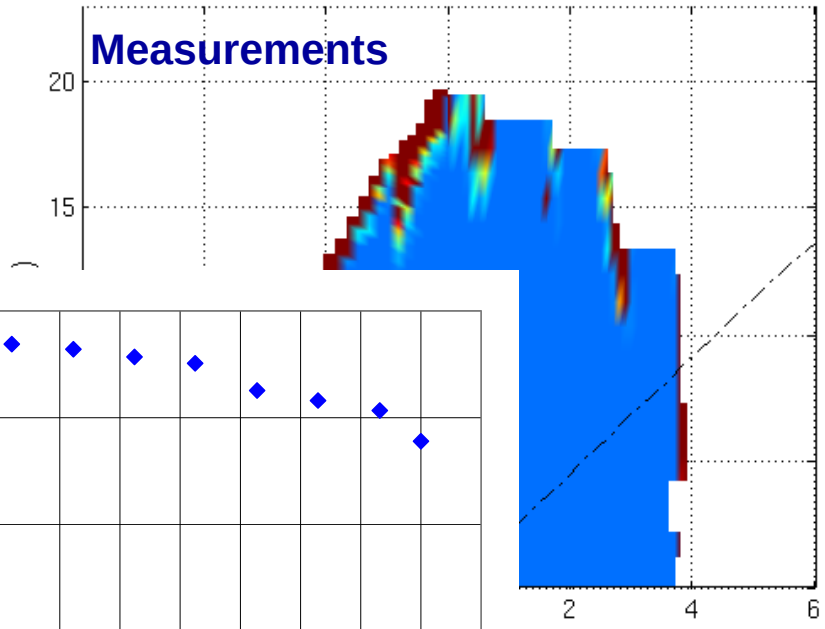


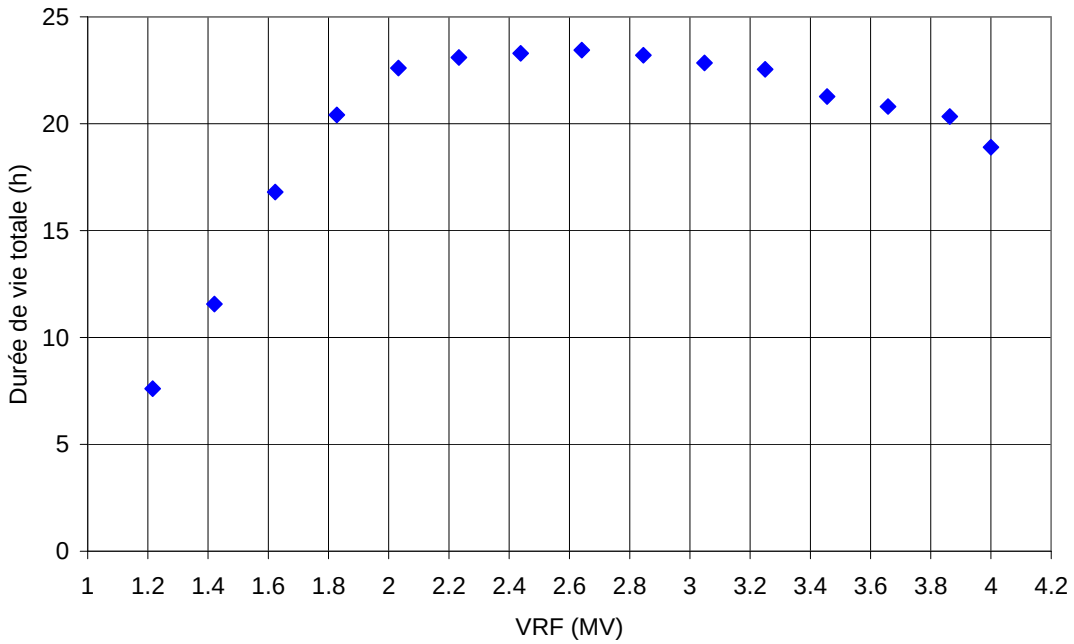
Energy Acceptance of the Bare Machine

The energy acceptance of the bare machine is large : +/- 4%.

Off-momentum FMA experiments have confirmed calculation results

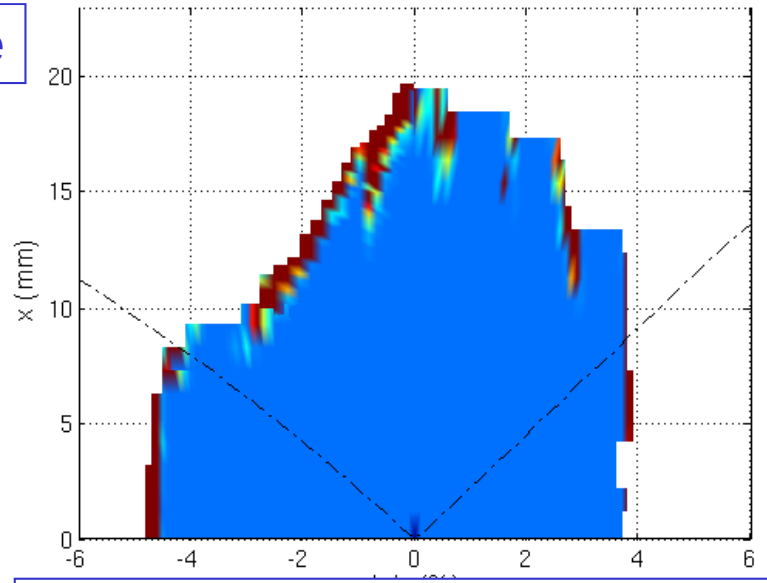






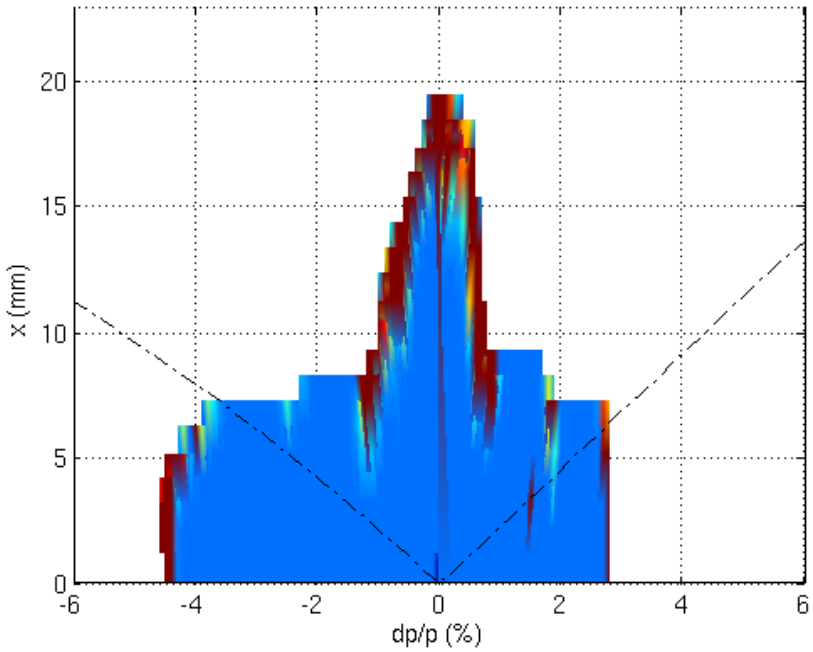
Effect of the Insertion Devices

Bare machine

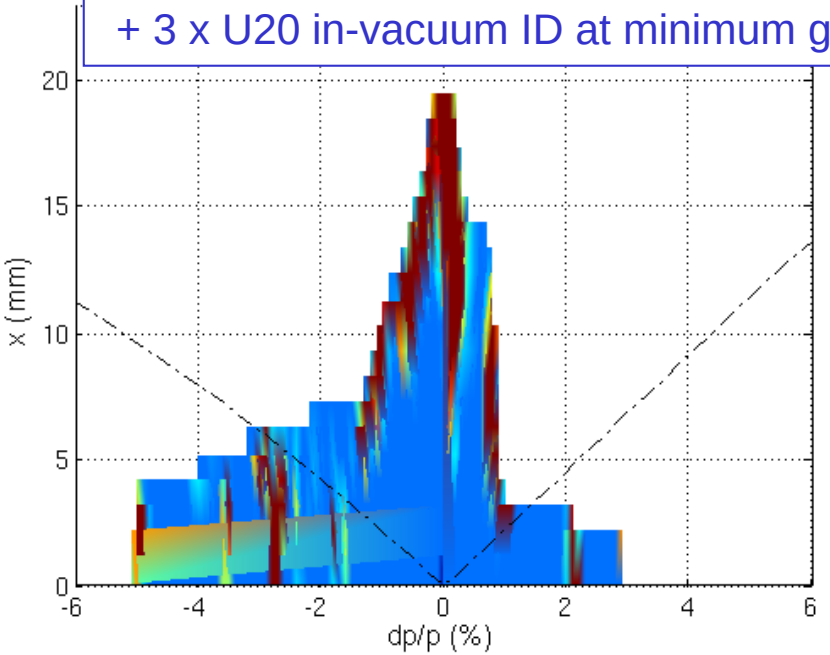


The measured energy acceptance is significantly reduced in the presence of IDs

HU640 ID at maximum field in LV-mode

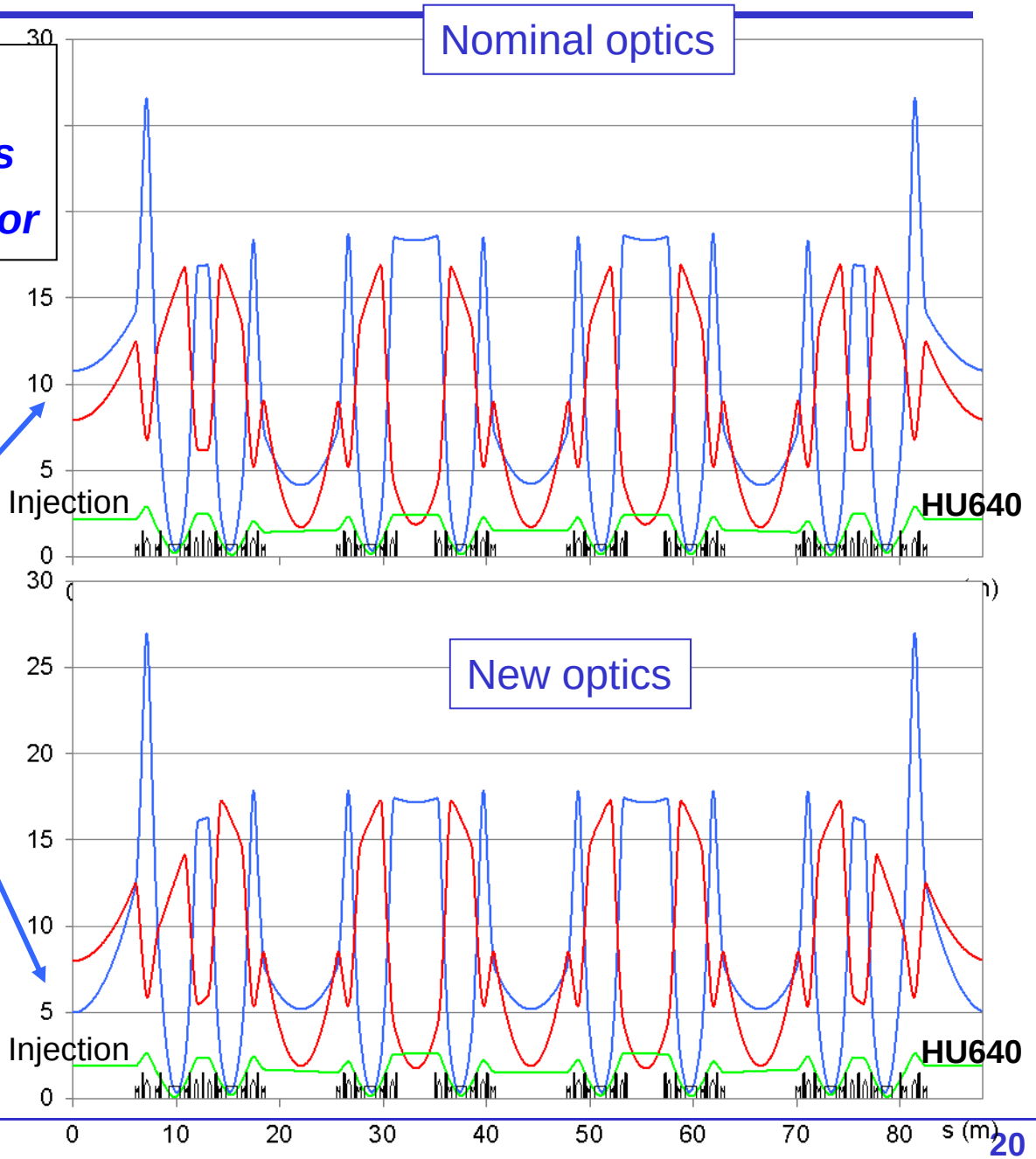


HU640 ID at maximum field in LV-mode
+ 3 x U20 in-vacuum ID at minimum gap



A new optics
to reduce the non linear effects
of the 10m long HU640 undulator

The horizontal β-function
is reduced from **10** m
to **5** m



- *The tunes remain unchanged : 18.2020 – 10.3170*
- *The nominal horizontal emittance remains unchanged : 3.7 nm.rad*
- *The injection rate of the bare machine remains unchanged by scaling the kickers by a factor of 1.04*
- *The beam lifetime is a little bit reduced for the bare machine but is improved in the presence of IDs*

Beam lifetime (h) @ 400 mA (416 bunches)	Nominal Optics	New Optics
Bare machine	20	18
HU640 at maximum field in LV-mode	12	16
HU640 at maximum field in LV-mode + 5 x U20 in-vacuum IDs at minimum gap	7	10

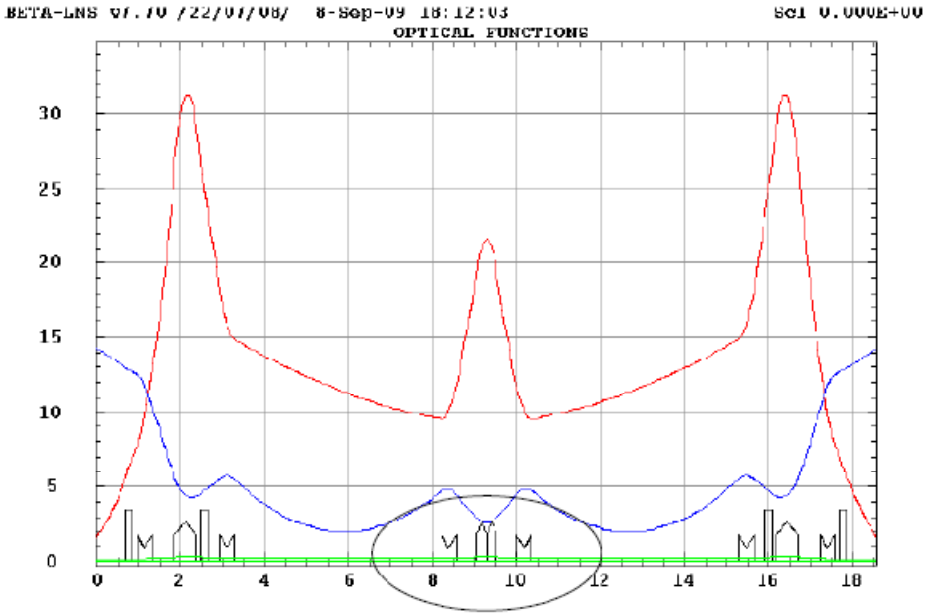
Double mini-β_z Optics

- Nanoscopium and Tomography : ~150 and ~200 m long beamlines will exploit high brilliance and coherence characteristics of the X-ray (5-25 keV) photon beam, both for diffraction limited focusing and for phase contrast imaging.

- Two canted in-vacuum undulators will be accommodated in a 12 m long straight section, with a 6.5 mrad separation angle.

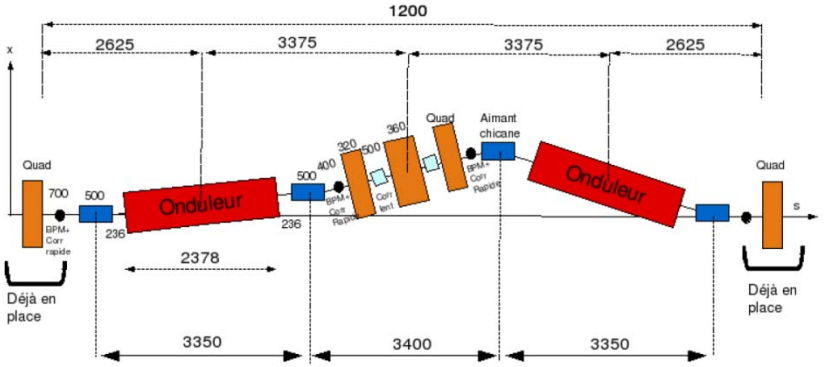
- To provide low vertical beta functions at each undulator, an extra triplet of quadrupoles is added in the middle of the section.

- First operation with insertions planned for **Autumn 2011**



Double low beta optics

Extra quadrupoles triplets



In order to test the new machine optics, a triplet of quadrupoles has been installed temporary.

Experiment with Double mini-β_z Optics

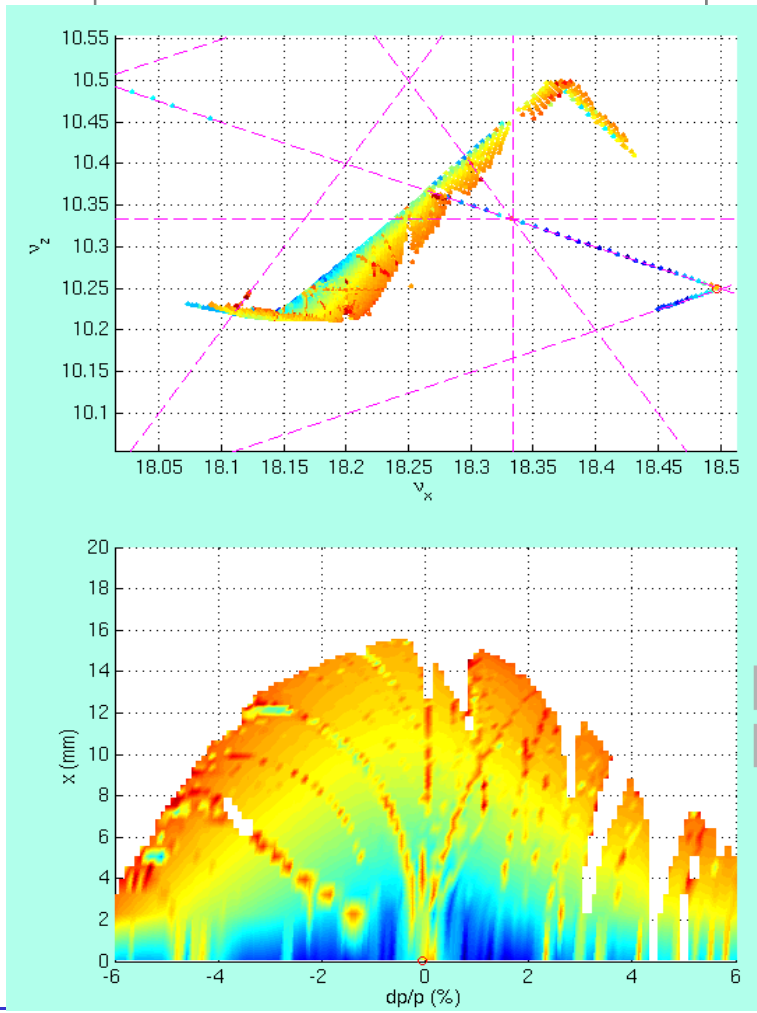
- The 4th symmetry of the machine is broken ⇒ machine symmetry = 1

Measured Beam Lifetime at 400 mA multibunch mode

Optics	Working Point	Beam lifetime (h) : Bare Machine	Beam lifetime (h) : 5 in-vacuum at mini gap
Present	**18.2 - 10.3**	**20**	**11**
Modified 1 (different sextupole setting)	**18.2 - 10.3**	**6**	**6**
Modified 2 (different sextupole setting)	**18.17 - 10.25**	**20**	**15**

Working Point still under investigation as well as sextupoles tuning, from experience and simulations (BETA & Tracy & OPA codes)

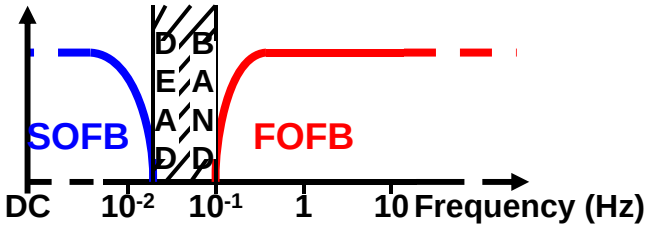
Simulation (Tracy): optics Modified 2



Slow and Fast Orbit Feedback together

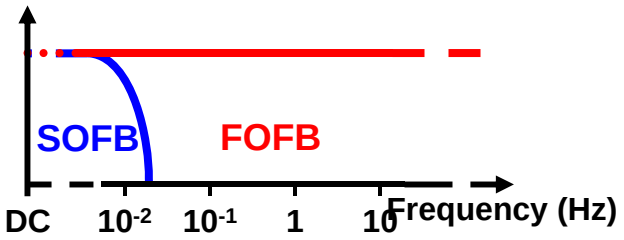
Up to now with 2 different sets of correctors (Slow and Fast):

- **'Dead Band' solution**:
  - SOFB and FOFB are efficient on different frequency ranges.
  - No suppression of ID disturbances



We have combined SOFB and FOFB

- Common frequency range.
  - ID disturbances are well suppressed
- Interaction between SOFB and FOFB:
  - Download of DC part in the fast correctors by the slow ones
  - FOFB reference orbit is updated runtime by SOFB



With two orbit feedback systems working together, machine stability benefits from:

- The slow system that provides good long term stabilization at all source points (also at bending magnets)
- The fast system that suppresses shorter term beam perturbations

The use of a different set of fast correctors for fast corrections seems to be a good choice for:

- New machines:
  - Requiring high frequency corrections (above 100 Hz)
  - Requiring large kick strength with high resolution
  - With Aluminum vacuum sections at strong corrector locations
- Older machines:
  - That want to upgrade their orbit feedback system at a reasonable cost

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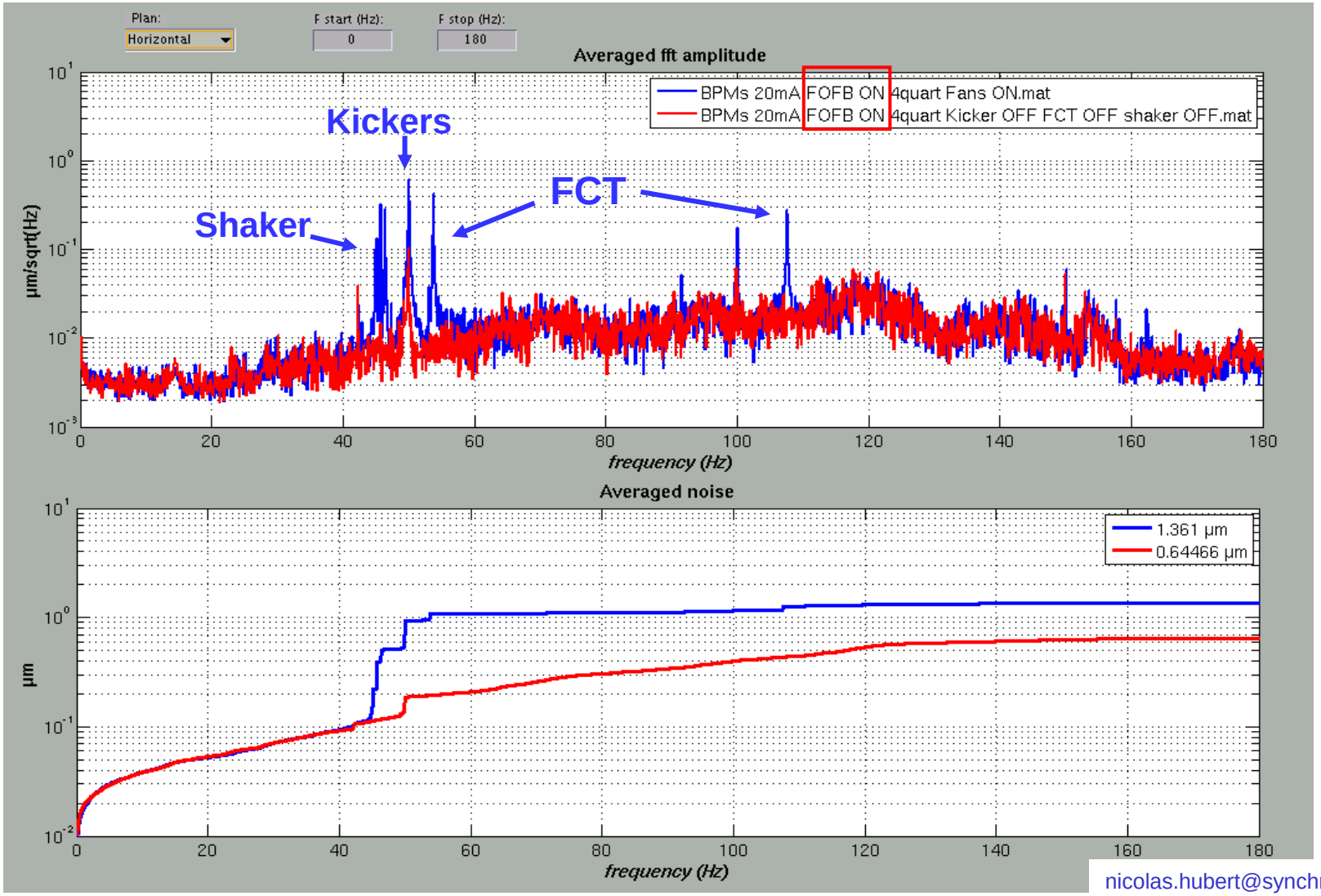
Perturbation by Fans

Power Spectral Density (PSD) and integrated PSD averaged on 120 BPMs in the horizontal plane



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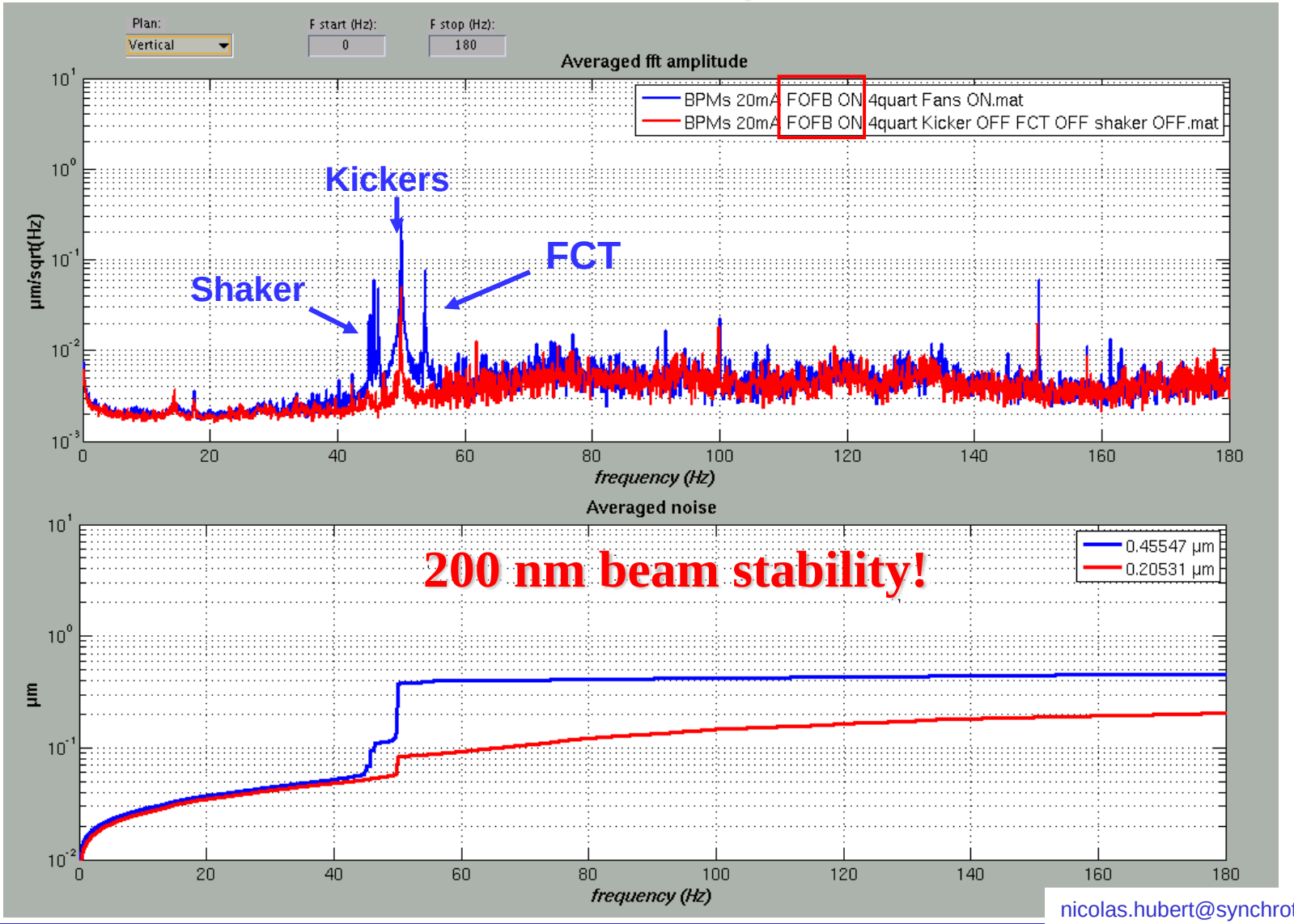
Perturbation by Fans

Power Spectral Density (PSD) and integrated PSD averaged on 120 BPMs in the vertical plane:



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Two main issues prompted the workshop:

1. Dark current growth in one or two years of operation on XBPMs
2. Clear requirements for Instrumentation Technologies Libera photon

Conclusions:

1. Dark currents: Analysis of black deposits shows metallic traces (Al, Fe,Ni, etc…) but the method is blind to carbon. The metals could be vaporised impurities in tungsten blades if high power photon beam accidentally hits a blade. It could also be the same process of carbon formation seen on SOLEIL beamline mirrors. An additional analysis sensitive to carbon will be performed.
   Solution: whatever the cause, the deposition speed must be slowed down with a **chicane-like shield of the insulators**.
2. Libera-Photon requirements. The requirements will be sent to IT by Nov. 30th
3. **Common statement**: Photon BPMs have a very good resolution, even better than electron BPMs. The workshop participants are going to share data in order to prove the XBPMs are reliable and can be used in orbit feedback systems.
4. **Another workshop next year is proposed by SLS**. It will address orbit feedback issues in addition to the XBPM ones.

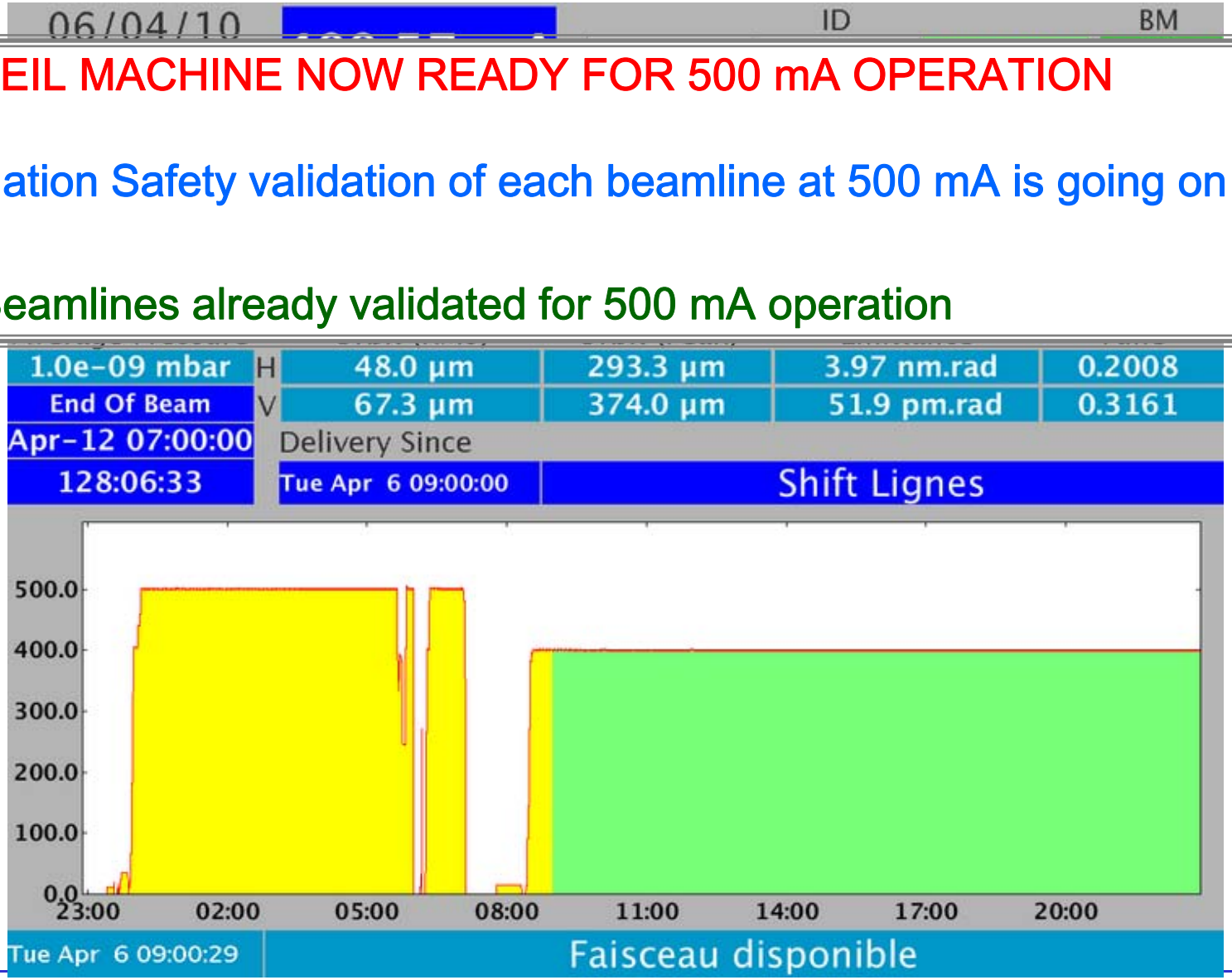
500 mA

Successful test and Radiation control on April 6, 2010

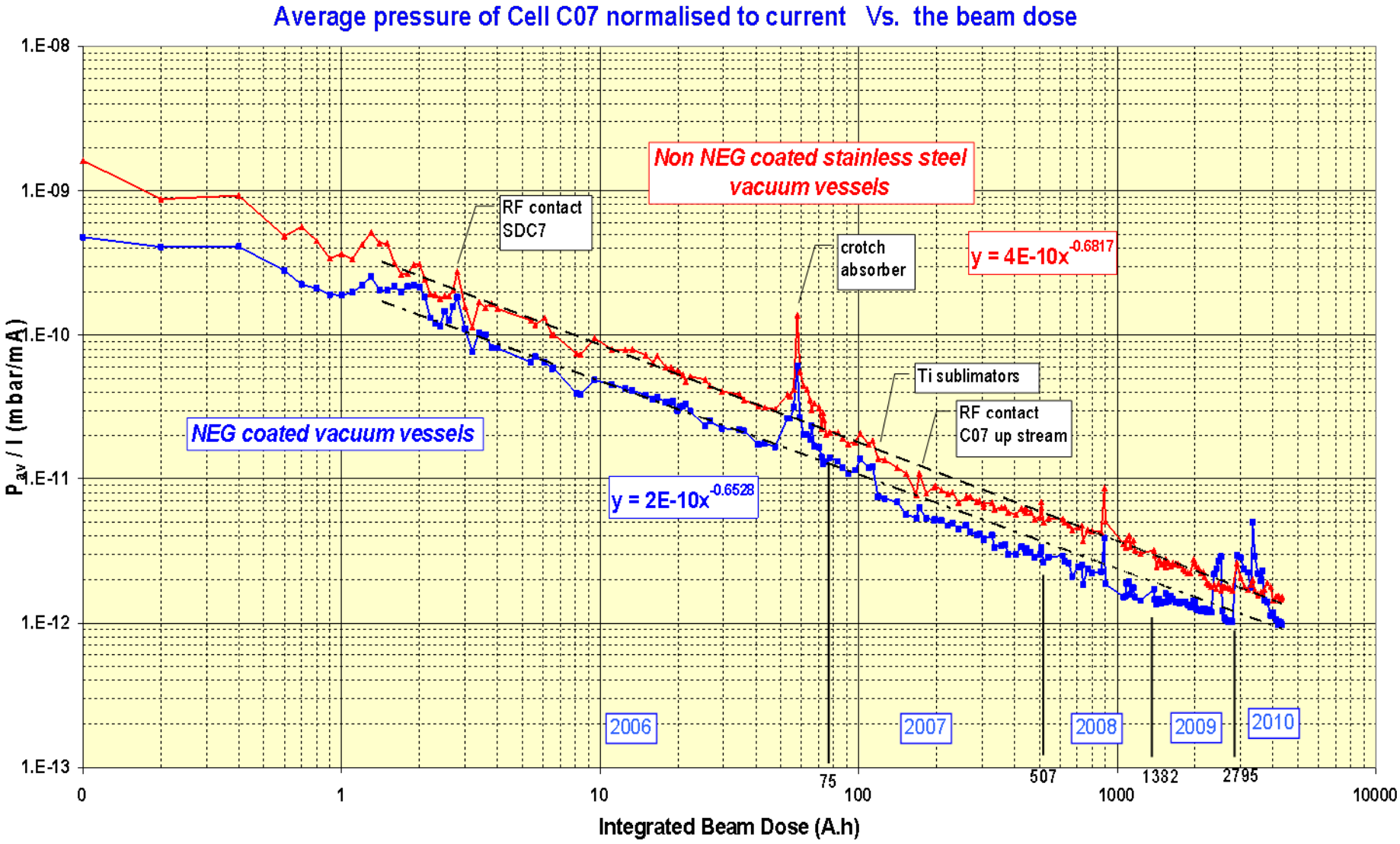
SOLEIL MACHINE NOW READY FOR 500 mA OPERATION

Radiation Safety validation of each beamline at 500 mA is going on

12 Beamlines already validated for 500 mA operation



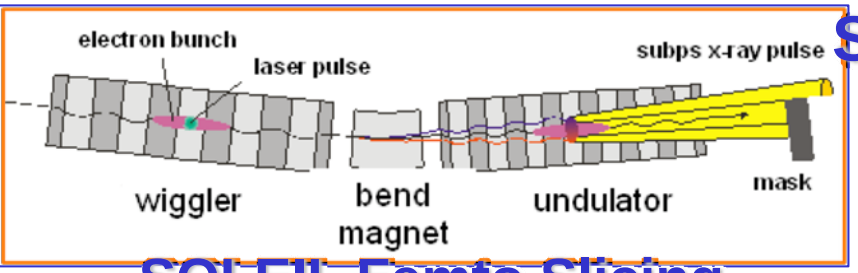
Vacuum Chambers Conditioning



Goal for a pressure < 10^{-9} mbar at 500 mA has been achieved !

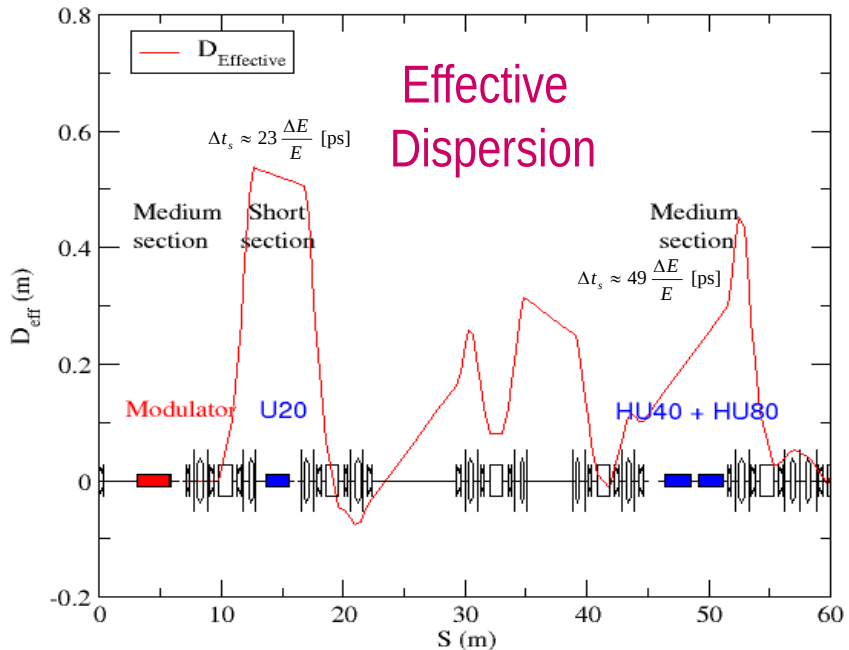
Femto-Slicing

Principle

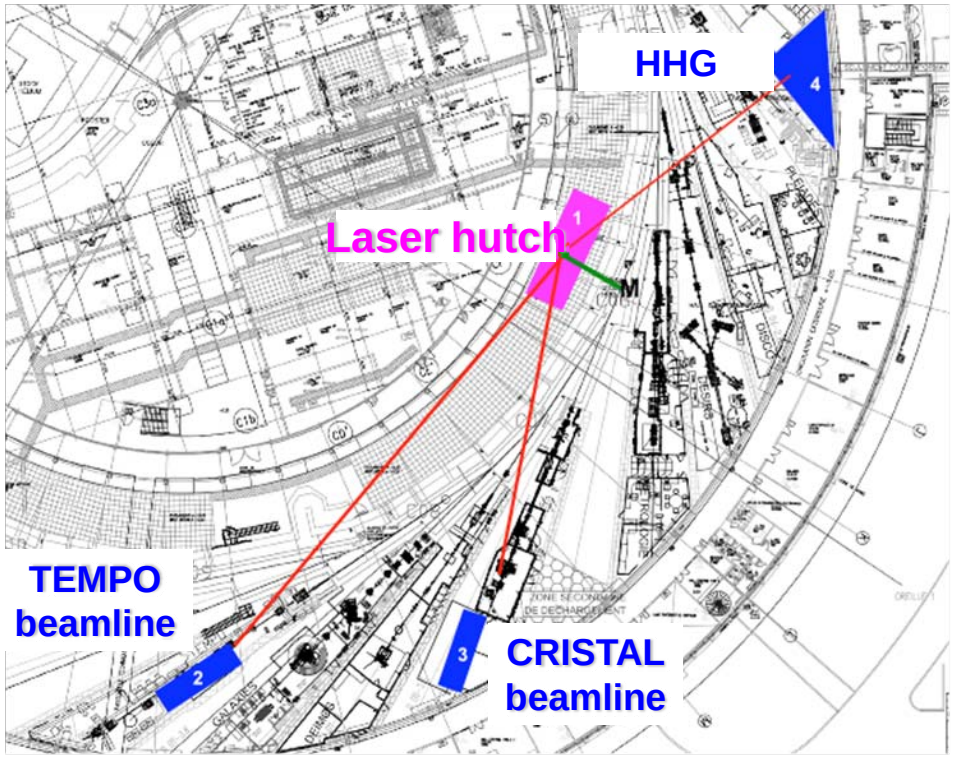


SOLEIL Femto Slicing parameters

Laser system : 800 nm, 10 kHz, 30 fs, 5 mJ
Wiggler : period 164 mm, 3 m length, first harmonic at 800 nm
Slicing provided on 2 beamlines
Transverse separation via the natural dispersion



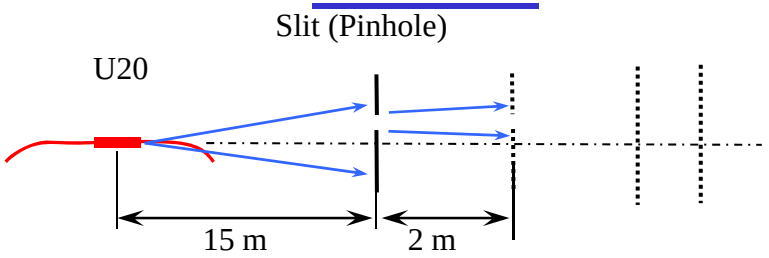
SOLEIL scheme: under construction

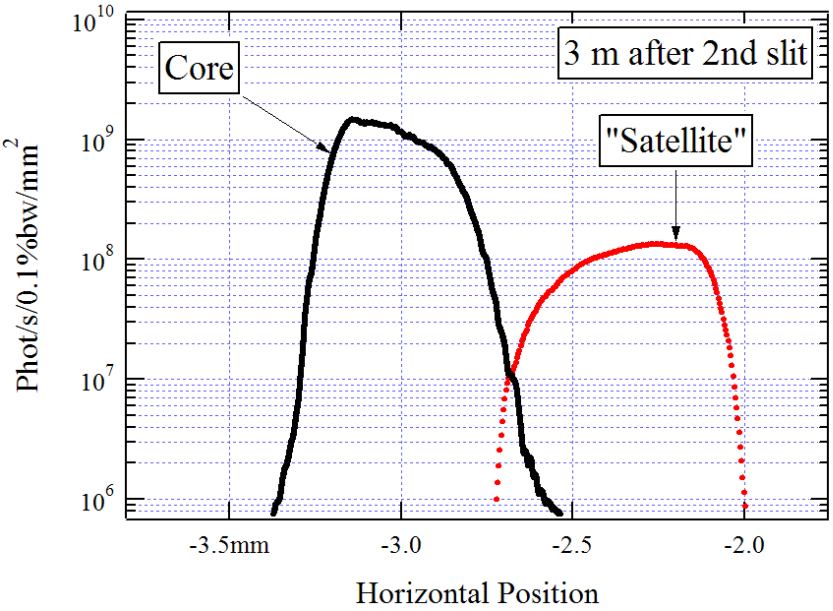


A minimum of 2 beamlines can profit from the process with high efficiency separation (2012)

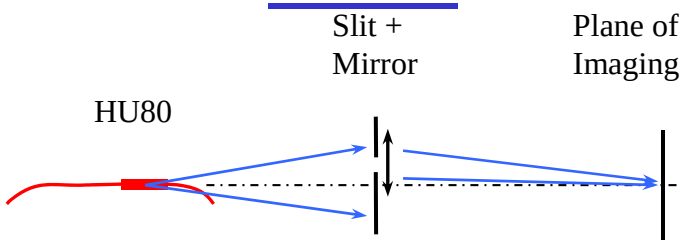
Femto-Slicing

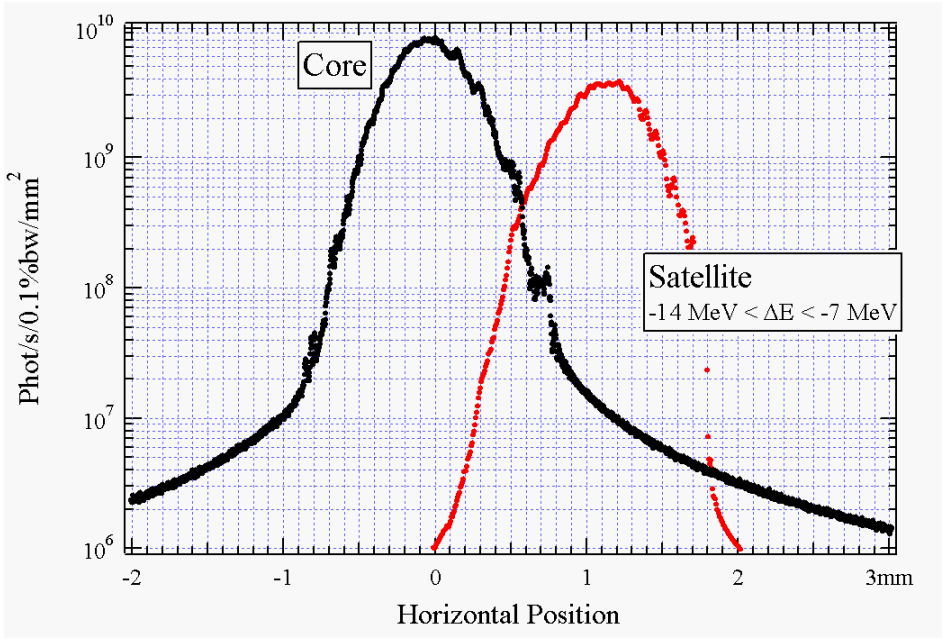
CRISTAL





TEMPO





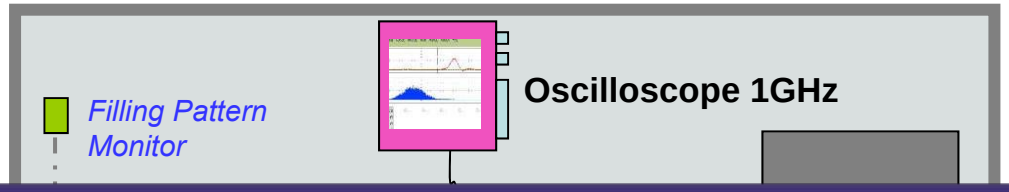
Durée totale de l'impulsion (FWHM en fs).

Radiateur	Laser	Slippage	Emittance	Dispersion en énergie	Total
CRISTAL	50	53	54	52	104
TEMPO	50	53	47	117	145

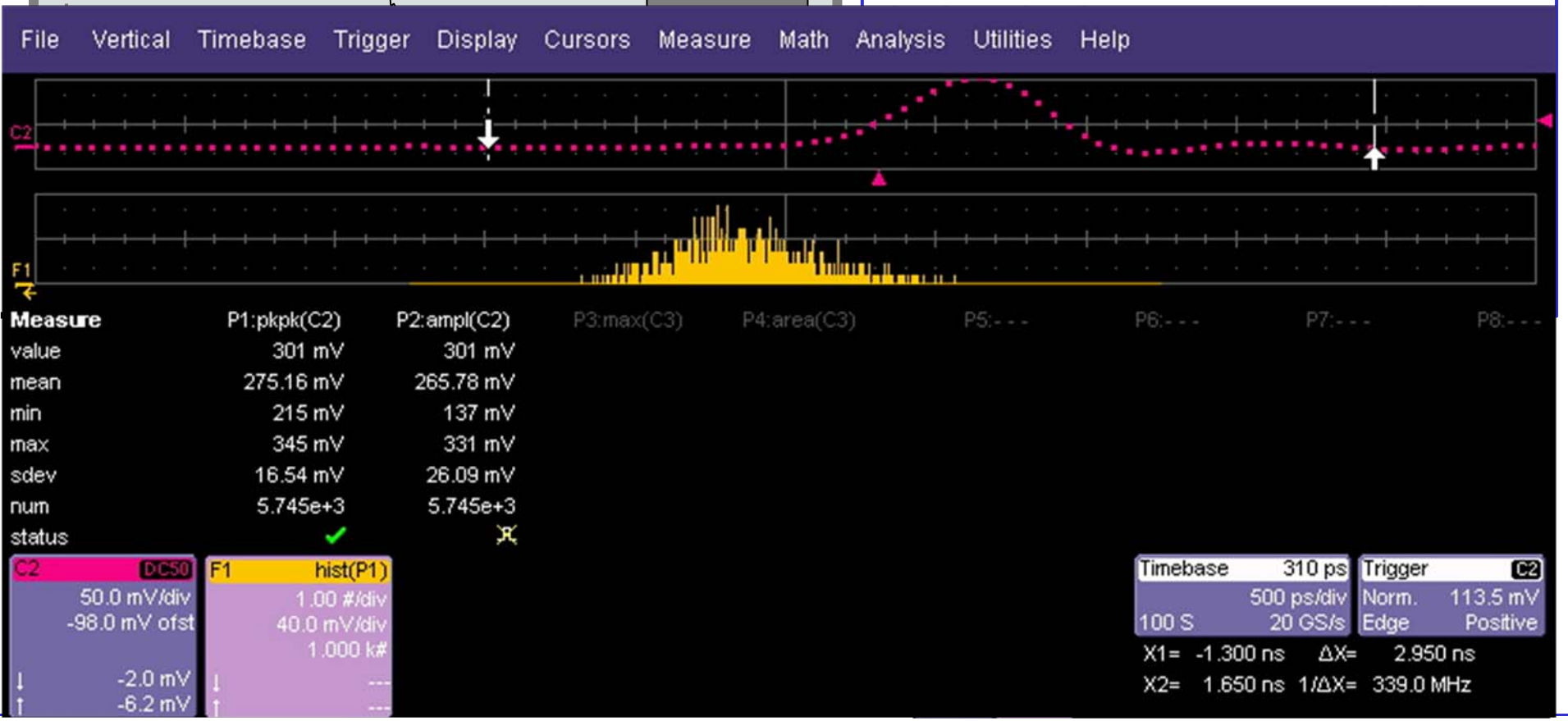
Electron Bunch Length Measurement

using the Incoherent Radiation Fluctuation

Visible light diagnostic hutch



Simple bunch length measurements can be achieved at low cost. The shorter



R&D with solid state amplifiers

6th generation transistors (V_{dc} = 50 V) + SOLEIL expertise → fast progress

→ P_{mod} ~ 700 W, G > 20 dB, η > 70% @ 352 MHz

[Current module (V_{dc} = 28 V) : P = 315 W, G = 13 dB, η = 62 % @ 352 MHz]

→ Huge improvement : P_{mod} x 2.2 , better performance (G > 20 dB, η > 70 %)

& thermal stress strongly reduced (T_{max} : 130 °C → ~ 70 °C) → longer lifetime

→ Similar performance @ 500 MHz

→ Beg. 2009, transfer of technology agreement concluded with ELTA-AREVA

→ ESRF contract for 7 SOLEIL type amplifiers of 150 kW (14 x 75 kW towers)

Collaboration agreements

- LNLS (Brazilian LS) : 2 x 45 kW @ 476 MHz under commissioning
- SESAME (LS in Jordan) : 4 x 150 kW @ 500 MHz

R&D at other frequencies

- FM band (88 – 108 MHz) → 1 kW module with G > 25 dB and η ~ 80 %
- L band (1.3 & 1.5 GHz) for 4th generation LS → P_{mod} > 400 W
- Applicable to any frequency from FM to L Band

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