TIARA GENERAL MID-TERM MEETING
CIEMAT, MADRID, SPAIN

Report from WP6 SVET

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With input from the TIARA/SVET collaborators

June14th, 2012

WP6 - SVET

- SVET: “SLS Vertical Emittance Tuning”
- Objectives:
  - Allow the Swiss Light Source (SLS) to be used as an R&D Infrastructure
  - Demonstrate ultra-small vertical emittances as required for future Linear Collider Damping Rings and B-factories (e.g. 5 nm normalized, 0.9pm @ 2.86 GeV for CLIC)
  - Enable to extend tests to lower energies (IBS dominated regime).

Budget and team members

	CERN	INFN	PSI (MAXIV)			total
Person month	16.5	11.5	45.5	PM	→	73.5 PM = 557 k€
Material	0	0	215	k€	→	215 k€
Travel	16	9	11	units	→	36 units = 23 k€
	40% from E.U. = 318 k€				⇐ ⇐ ⇐	total 795 k€

WP-leader *Yannis Papaphilippou* (CERN)

Deputies *Andreas Streun* (PSI), *Marica Biagini* (INFN/LNF)

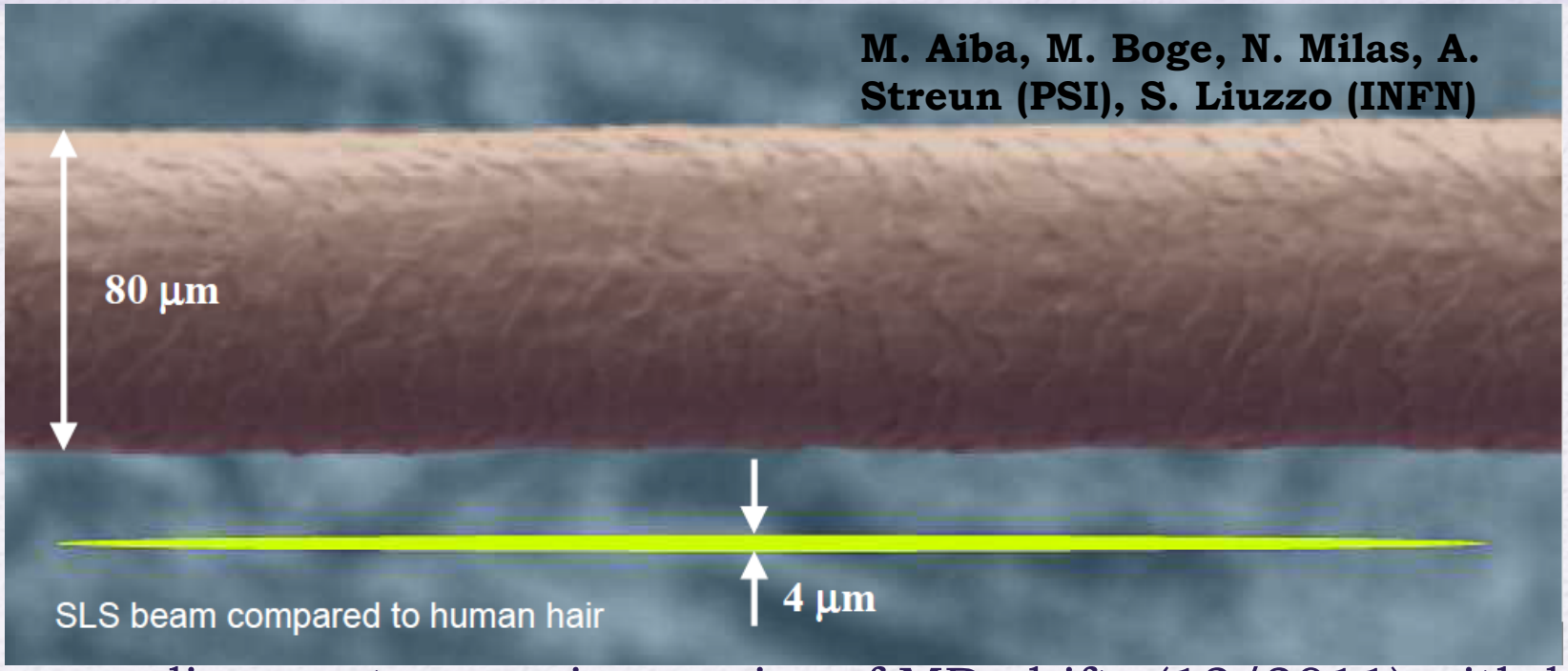
at PSI *Masamitsu Aiba, Michael Böge, Natalia Milas, Ángela Saá Hernández Terence Garvey, Andreas Lüdeke, Martin Rohrer, Volker Schlott, & PSI technical staff for building the new emittance monitor*

at CERN *Fanouria Antoniou, Eirini Koukovini, Enrico Bravin, Aurelie Goldblatt, Erk Jensen, Thibaut Lefevre, Federico Roncarolo, Panos Zisopoulos*

at INFN/LNF *Simone Liuzzo (now at ESRF), Theo Demma (now at LAL), Susanna Guiducci, Fabio Marcellini, Mario Serio*

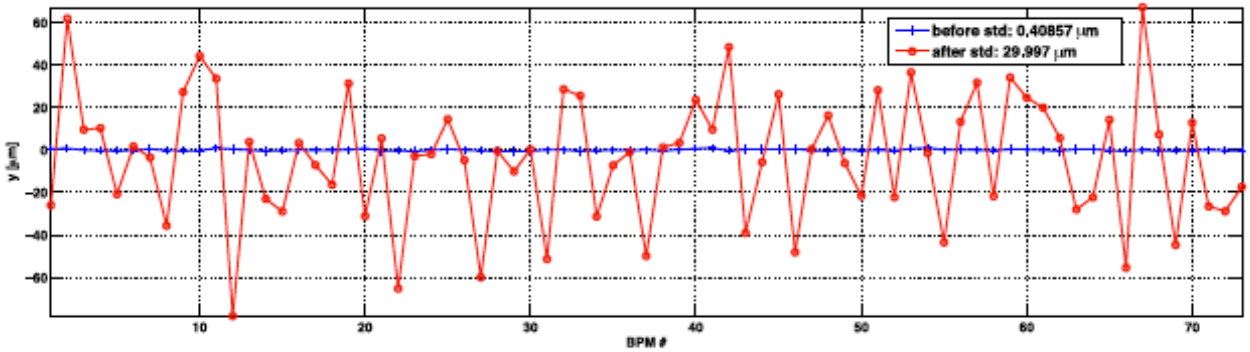
at Max-IV Lab *Åke Andersson, Jonas Breunlin*

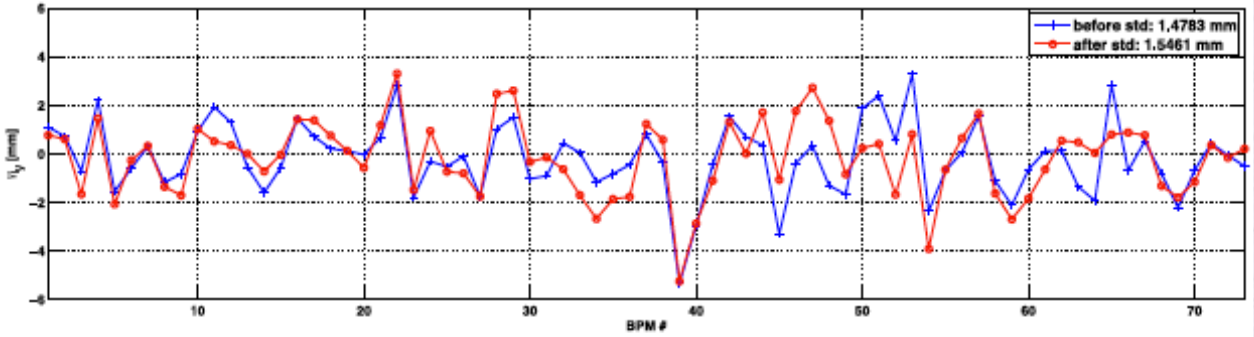
Vertical emittance WORLD RECORD

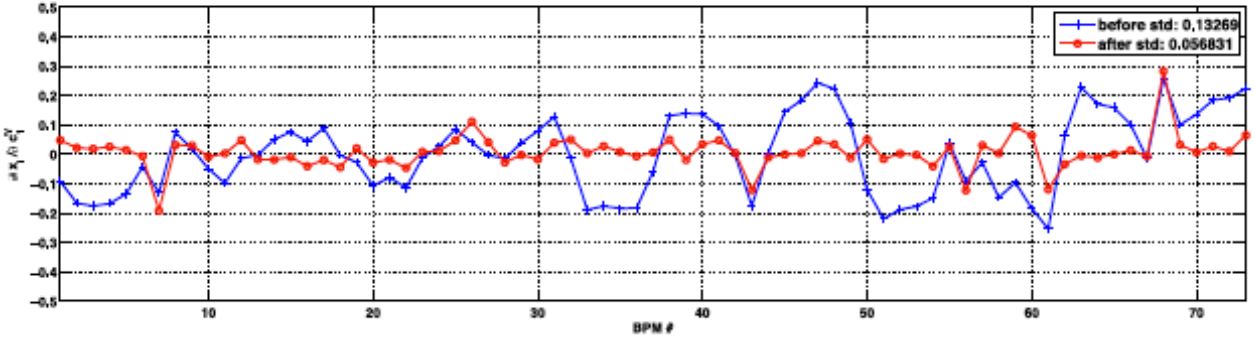


- After re-alignment campaign, series of MD shifts (12/2011) with beam of 400 mA stored in top up mode
- Performance of existing emittance monitor stretched for beam sizes of 3-4μm
- Coupling suppression using 36 skew quadrupoles and combination of response matrix based correction and random walk optimisation
- Vertical emittance reduced to a minimum value of **0.9±0.4pm** (CLIC damping rings target vertical emittance) which is a **new world record**

Low Emittance Tuning @ SLS



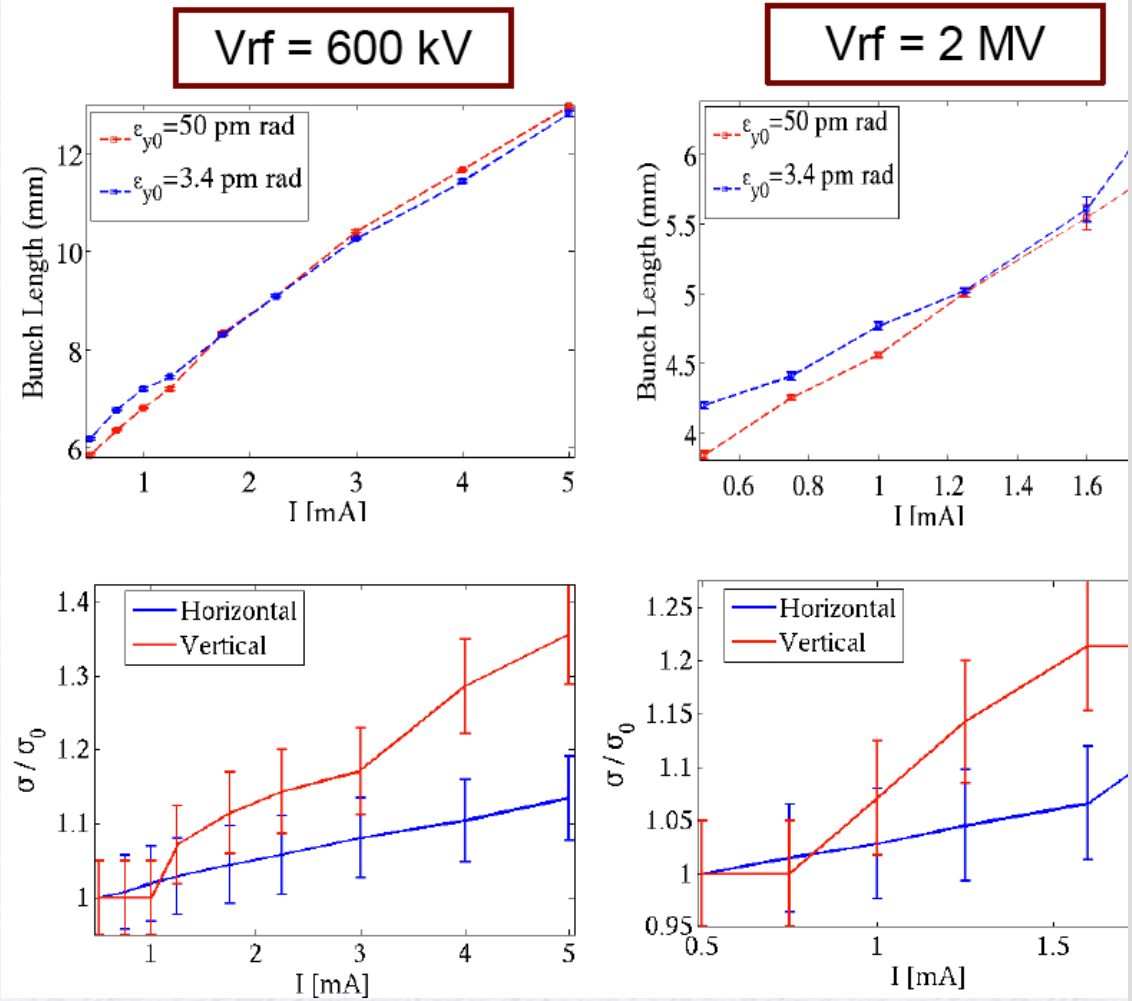




S. Liuzzo, et al. IPAC 2012

- Confirmation of ultra-low emittance using Dispersion Free Steering
  - Simultaneous correction of orbit, coupling and dispersion
- Best results after including BPM roll errors
  - Beam size of 4.4μm corresponding to 1.3pm.rad

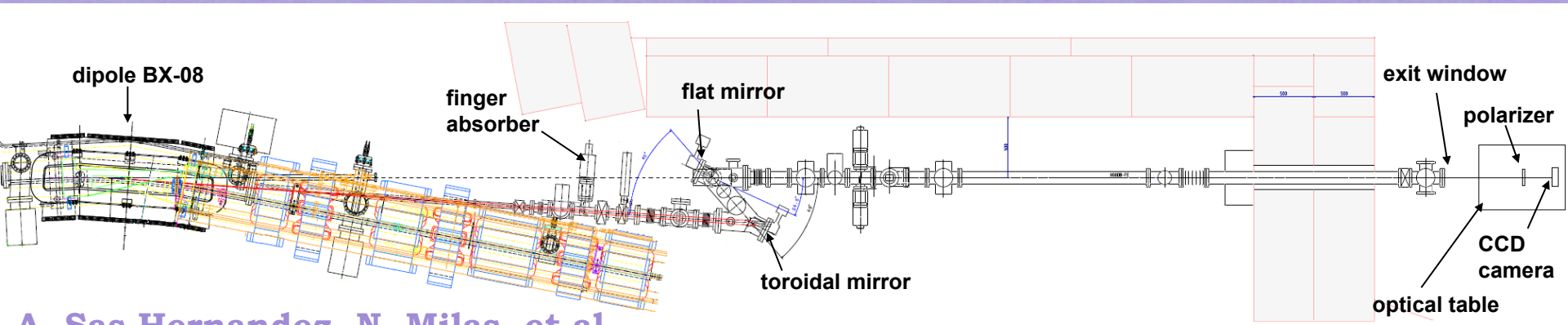
IBS experiments @ SLS



F. Antoniou, N. Milas et al.

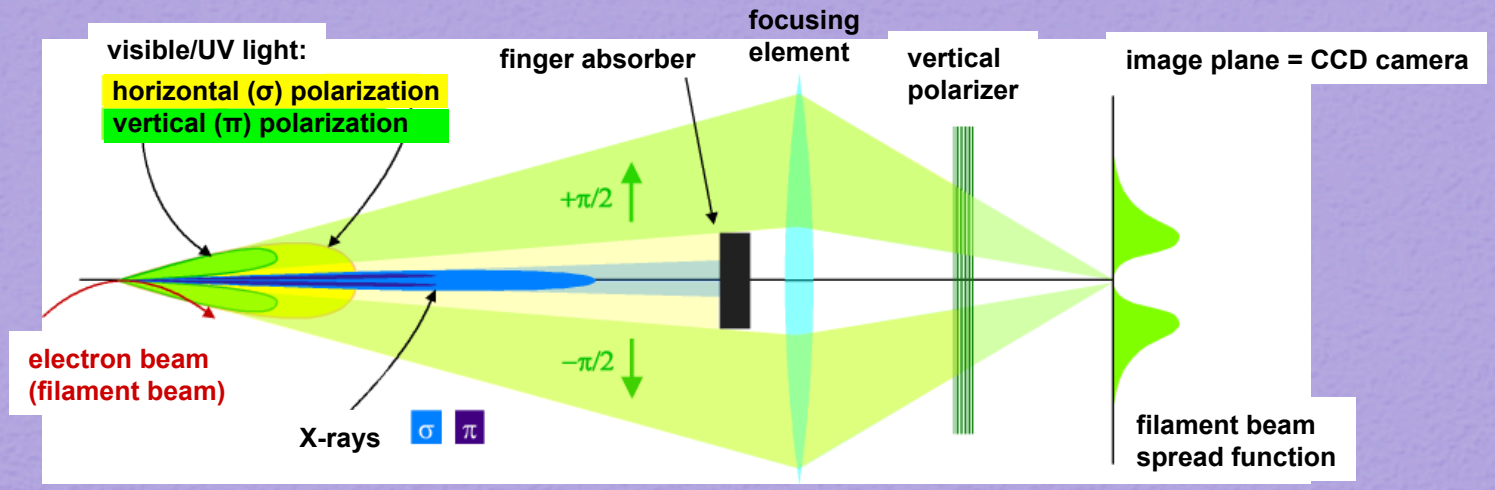
- 2 set of measurements for different RF Voltage settings (V1=600kV, V2=2MV)
- For each voltage, measurements at corrected vertical emittance at 3.4 pm-rad and vertical emittance blown up at 50 pm-rad
- IBS indications
  - At low voltage (longer bunch) the bunch length dominated by the MI
  - At high voltage (shorter bunch) larger bunch length blow up for the small vertical emittance and larger blow up in horizontal and vertical beam size
- The MI model for the energy spread and bunch length very important for the comparison with theoretical models
  - Energy spread measurement methods currently under investigation

New emittance monitor beamline



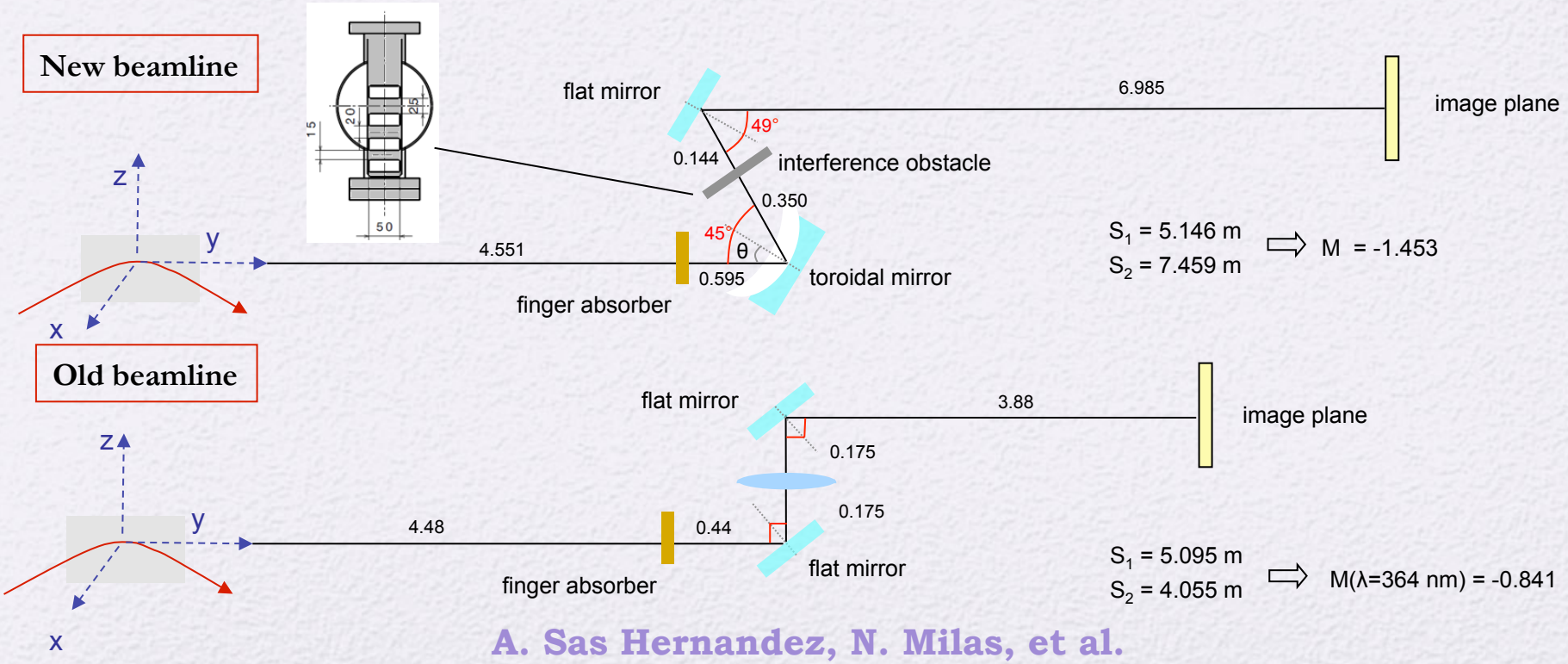
A. Sas Hernandez, N. Milas, et al.

measurement principle: π -polarization method



Why a new beamline?

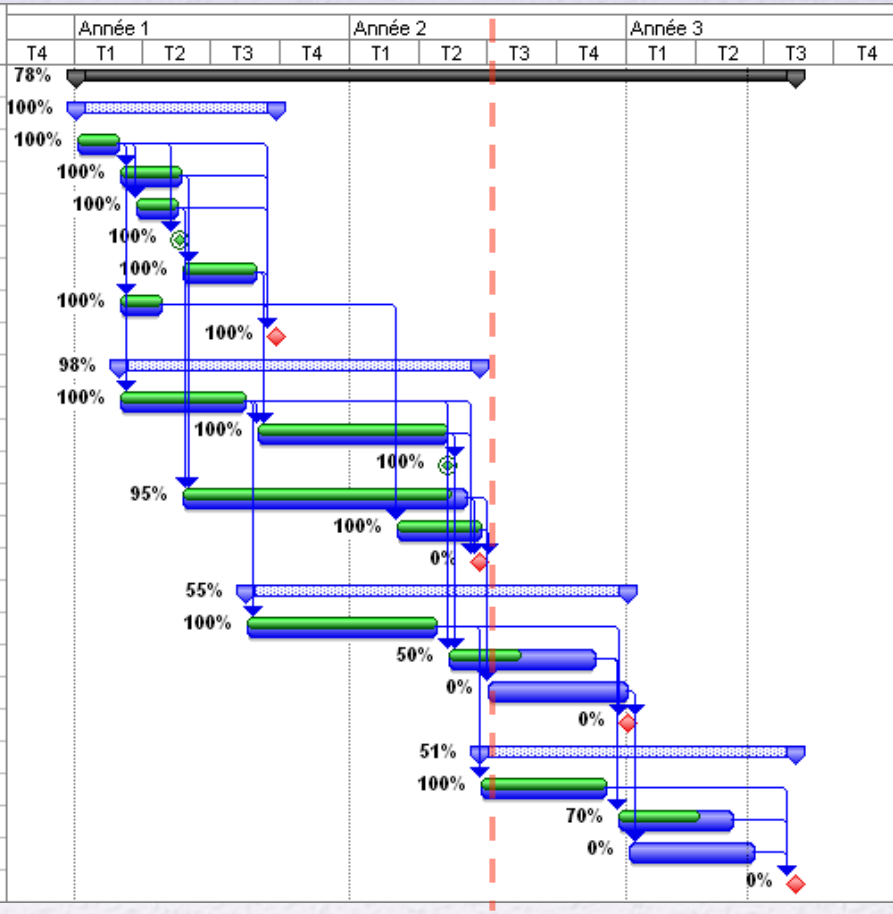
- Increase sensitivity to small beam sizes (< 3 μm):
  - Wavelength independent (only reflective elements) → shorter wavelengths (266nm)
  - Allows interferometric method
- Increase measurement precision → better magnification ratio
- Full-time accessible → outside the SLS tunnel
- Use different wavelengths and two measurement methods



A. Sas Hernandez, N. Milas, et al.

Gantt chart

N°	WBS	Task Name
1	WP6	**WP6 Upgrade of SLS vertical emittance tuning system**
2	6.1	**6.1 SLS_NOW: Experimental tests at SLS with existing systems**
3	6.1.1	6.1.1 EPS_Limit: emittance limit
4	6.1.2	6.1.2 EPS_Sens: emittance sensitivity
5	6.1.3	6.1.3 MON-RES: profile monitor resolution
6	M6.1	**M6.1 M_INSTR: Interim report on existing beam instrumentation**
7	6.1.4	6.1.4 COUPLING: coupling theory
8	6.1.5	6.1.5 MAG_Scale: magnet scaling
9	D6.1	**D6.1 D_SLS_NOW: Report on existing hardware situation and limitations**
10	6.2	**6.2 SPEC: Specification of necessary upgrades**
11	6.2.1	6.2.1 ORB_C_SPEC: Orbit Control Specifications
12	6.2.2	6.2.2 KNOB_SPEC: emittance knobs
13	M6.2	**M6.2 M_KNOBS: Specification of emittance knobs ready**
14	6.2.3	6.2.3 MON_SPEC: Monitor specification
15	6.2.4	6.2.4 ENERGY: Specification of knob for energy scaling
16	D6.2	**D6.2 D_SPEC: Specifications ready**
17	6.3	**6.3 IMPL: Implementation of the specified upgrade**
18	6.3.1	6.3.1 ORB_C_IMPL: Orbit Control upgrade
19	6.3.2	6.3.2 COUPL_IMPL: Coupling automation
20	6.3.3	6.3.3 MON_IMPL: Monitor installation
21	D6.3	**D6.3 D_IMPL: Hardware ready and installed**
22	6.4	**6.4: COMM**
23	6.4.1	6.4.1 ORB_C_COMM: Orbit Control Commissioning
24	6.4.2	6.4.2 COUPL_COMM: Coupling control
25	6.4.3	6.4.3 MON_COMM: Monitor commissioning
26	D6.4	**D6.4 FINAL_R: Commissioning report**



- Task 1 (Experimental tests) and 2 (Specification of upgrades) completed
- Task 3 (implementation) and 4 (commissioning) in very good progress

Task 3

Implementation of the upgrade

- Implementation of upgrade:
  - Down-select most important hardware to be implemented (financial constraints):
    - improved BPM's and/or **alignment**
    - correction knobs and feedback algorithms (**automated coupling control**)
    - improved resolution/sensitivity **beam profile monitor**
    - Specification of energy scaling (**done**)
  - Fabricate hardware (on-going)
  - Install hardware in SLS
    - Shifted on July 2012 and due by January 2013
- **Result:** An improved SLS, allowing to reach smaller vertical emittances at different energy levels
  - Implementation due by Month 25, January 2013

Task 4
Commissioning

- Commissioning:
  - Commission improved BPM and/or alignment system (not an issue)
  - Verification of the automated coupling control
    - Methods verified, automation is on-going and minimisation steps with new monitor to be repeated
  - Commission new beam profile monitor
    - Starting January 2013 until March 2013
    - Measurements from April 2013 until June 2013
- **Result:** Final report on obtained results, due Month 30, June 2013

Status of deliverables and milestones

- Deliverables
  - Report on hardware limitations and upgrade ready
  - Specifications almost ready

Num	Short name	Description	Month	Status
D6.1	D_SLS_NOW	Report on existing hardware limitations and needed upgrades	9	**Achieved in month 10**
D6.2	D_SPEC	Specifications ready	18	Almost Ready
D6.3	D_IMPL	Hardware installed	24	
D6.4	FINAL_R	Final report	30	

- Milestones
  - Interim report delivered
  - Specification report delivered

Num	Short name	Description	Month	Status
MS25	M_INSTR	Interim report on existing beam instrumentation	5	**Achieved month 5**
MS26	M_KNOBS	Specification of emittance knobs ready	16	**Achieved month 17**

Meetings and machine developments

Date	Venue	Attendance	Objective(s)
23-24 Feb 11	CERN	≈ 20	Launch TIARA-PP
28-30 Mar 11	SLS	9	Measurements shift at SLS
11 Apr 11	CERN	7	IBS codes and estimations for SLS
2 May 11	webex	3	SLS low energy running
15 Jun 11	SLS	≈ 15	New emittance monitor for SLS
30 Aug 11	SLS	≈ 5	2nd measurement shift at SLS
2-4 Oct 11	Creta, Greece	≈ 5	Discussion on instrumentation report and low energy running
31 Jan 12	webex	3	MD shift scheduling
13-14 Mar 12	SLS	≈ 5	3rd measurement shift at SLS
22-23 Mar 12	MAXlab	6	Discussion on implementation of new profile monitor
27-28 Mar 12	SLS	≈ 5	4th measurement shift at SLS
01-02 May 12	SLS	≈ 5	5th measurement shift at SLS
12-14 Jun 12	CIEMAT, Spain webex	≈ 10	TIARA general mid-term meeting

- More shifts to be scheduled during summer 2012
  - Low energy and IBS
  - Impedance and instabilities

Documents produced

Title	Type*	Deliverable / Milestone	(Foreseen) achieved month
Interim report on existing beam instrumentation at SLS TIARA-REP-WP6-2011-01	Report	MS25	6
SLS Vertical Emittance Tuning TIARA-REP-WP6-2011-004	Conference paper (IPAC 2011)	-	9
Report on existing hardware limitations and needed upgrades TIARA-REP-WP6-2011-004	Report	D6.1	(9) 10
Specification of emittance knobs TIARA-REP-WP6-2012-008	Report	MS26	(16) 17
Preparation of SLS for IBS measurements	Conference papers (IPAC 2012)	-	18
Intrabeam Scattering studies at the SLS			
Random walk optimization in accelerators - vertical emittance tuning at the SLS			
Tests of the low emittance tuning techniques at SLS and DAΦNE			
Ultra low vertical emittance at SLS through systematic and random walk optimization	Journal paper (NIMA)	-	Submitted

Newsletter

New world record vertical emittance in the SLS Storage Ring

by Yannis Papaphilippou (CERN); Andreas Streun (PSI); Marica Biagini (INFN)

At the end of 2011, the Swiss Light Source (SLS) team reduced the vertical emittance to 0.9±0.4 picometer-radian, a new world record, only five times larger than its limit.

Cross section of the SLS beam (in green) is superimposed on an electron microscope picture of a human hair (click image to enlarge). Image credit: Andreas Streun (PSI).

This accomplishment was based on careful magnet re-alignment, application of different steering methods and extending the emittance monitor performance. The blade-shaped electron beam is only 4 micrometers thick (see picture), proving that emittance levels required by future linear collider projects (e.g. CLIC) could indeed be reached.

Emittance, the product of particle beam size and divergence, represents the extent to which beams can be concentrated and defines the performance of light sources, colliders and particle factories. In electron storage rings, emittance is determined by synchrotron radiation. Horizontal emittance is largely specified by beam energy and ring circumference. Vertical emittance however has ideally a very small natural limit although positioning errors of the ring magnetic elements can lead to much larger values.

The SLS Vertical Emittance Tuning (SVET) Work Package within TIARA preparatory phase is a collaboration between PSI, CERN and INFN on instruments and methods for establishing an R&D infrastructure on vertical emittance reduction at the SLS storage ring of PSI.

The TIARA-SVET collaborators are now working on the application of further emittance reduction methods and on a new emittance monitor with higher resolution.

OUTLINE

- Great results since the beginning of TIARA
  - Girder realignment and stretching performances of old monitor
  - New methods for low emittance tuning
  - **New Emittance Record**
  - Low energy measurements (IBS)
  - Starting impedance and instabilities measurements
  - Specifications and fabrication of new emittance monitor with better resolution
  - ~15 meetings and MD shifts
  - ~10 reports-publications
- On our way towards Quantum Limit Of Vertical Emittance