Diagnostics during the ALBA Storage Ring Commissioning

U. Iriso, M. Alvarez, F. Fernandez,
A. Olmos and F. Pérez

Accelerator Division, CELLS

10th European Workshop on Beam Diagnostics and Instrumentation for Particle Accelerators

DIPAC11 – Hamburg, May 16-18, 2011

Contents

1. Introduction: ALBA Facility

1. Introduction: ALBA Facility

- ✓ Synchrotron Light Source in Barcelona
- ✓ Up to 30 beamlines (7 on day one)
- ✓ Full energy Booster for Top-up injection
- ✓ 3 GeV Storage Ring, 268m circumference
- ✓ Designed emittance: 4.3nm*rad
- ✓ Maximum design current: 400mA

- ✓ SR Commissioning started 8 March 2011
- ✓ BeamLine Commissioning Autumn 2011
- ✓ First Users: Spring 2012

1. Introduction: SR Commissioning

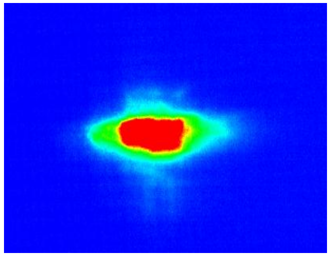
March 8th : Commissioning Start. (Shifts from 7am – 10pm)

March 9th : 1st Turn

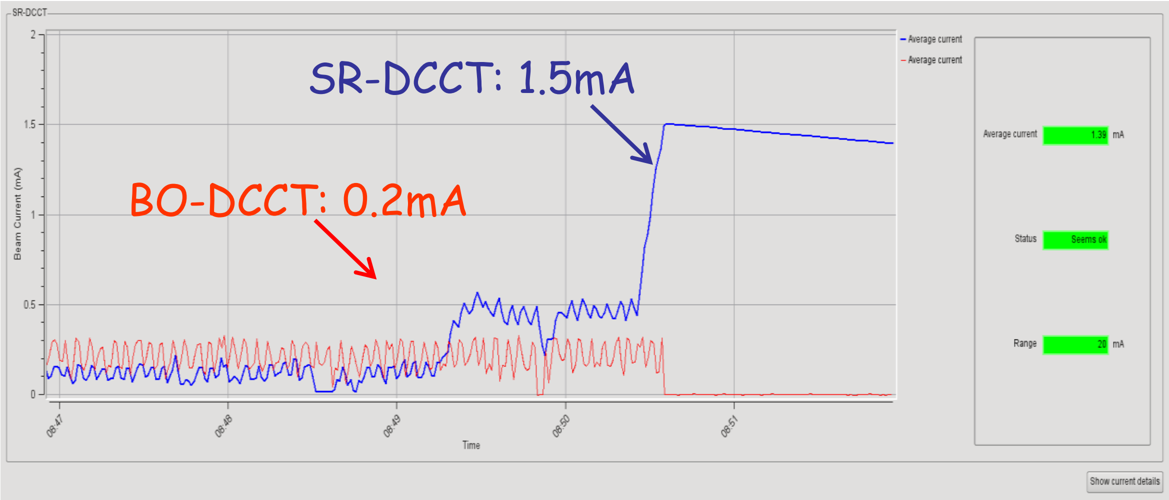
March 13th : Stored Beam

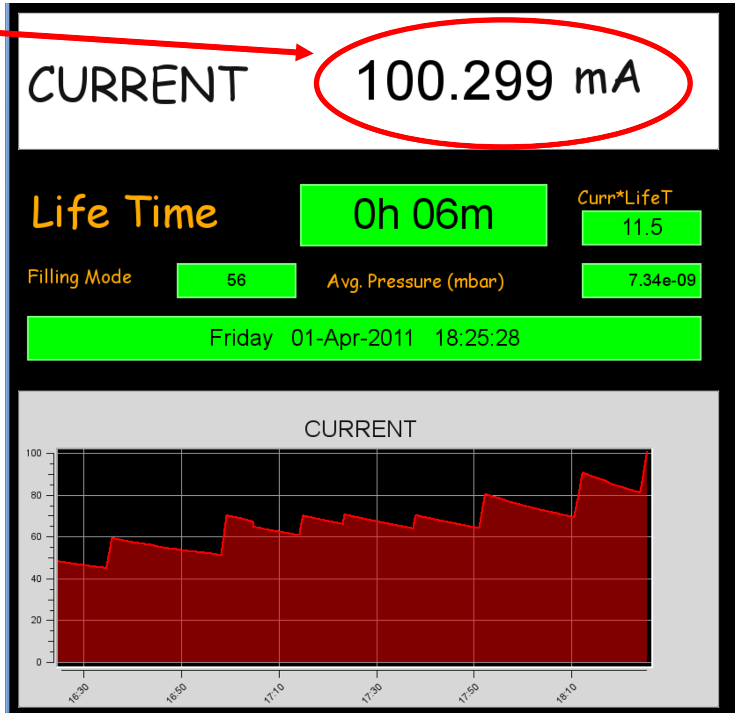
March 16th : Beam Accumulated

March 16th : Synchrotron Light out to Diagnostics Hutch



April 1st: Stored 100mA



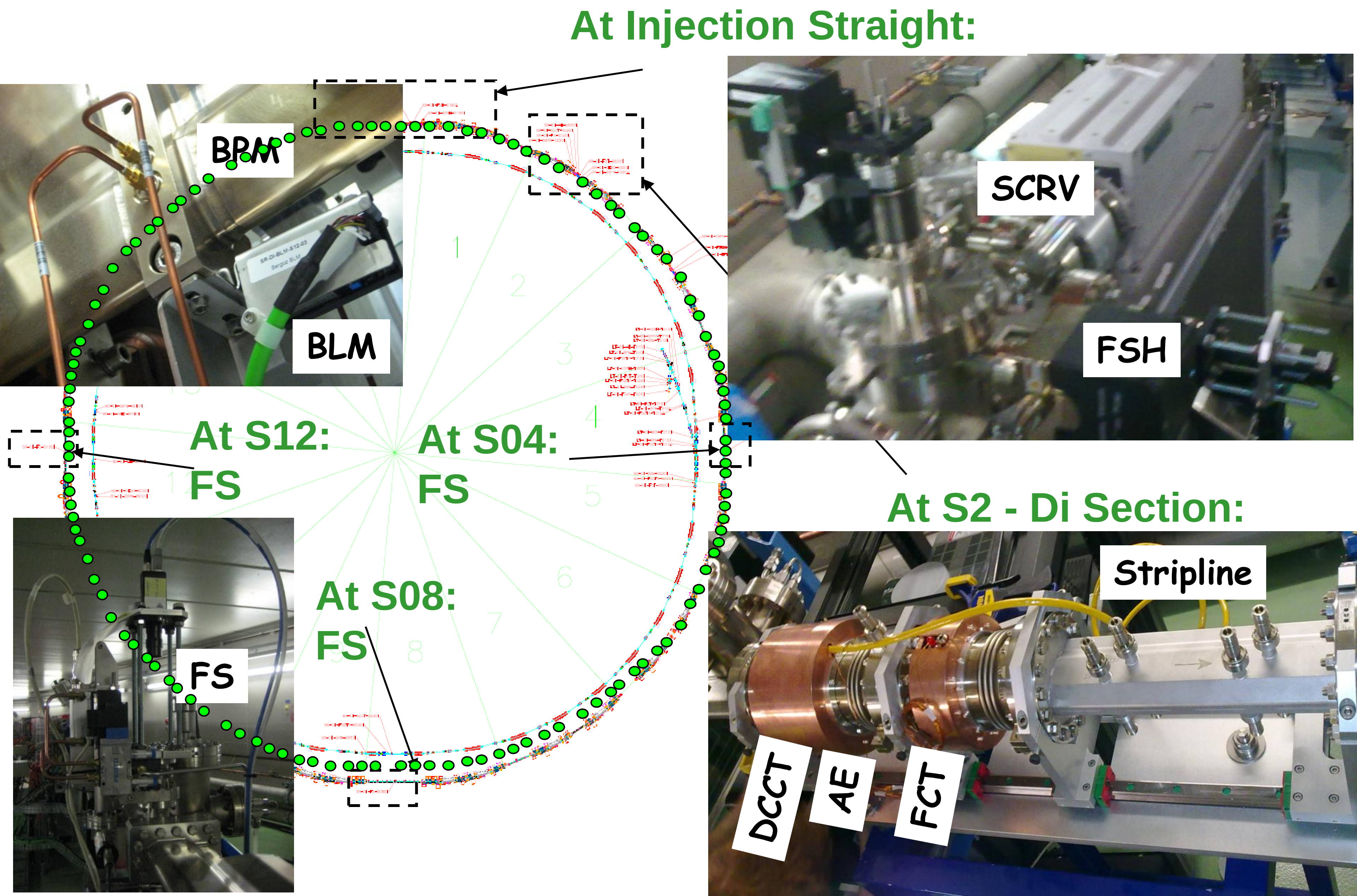


1. Introduction: Di components

Standard components:

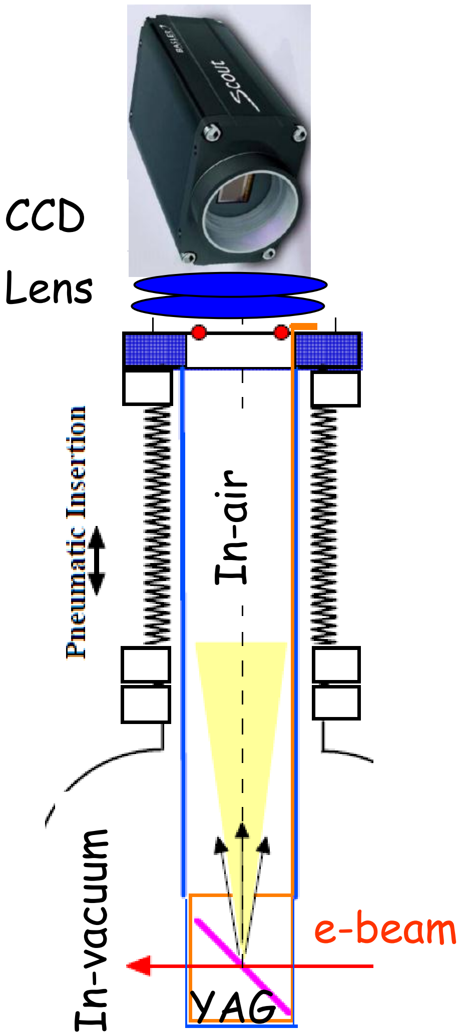
Component	Acronym	# units
Fluorescent Screen “In-air”	FS	5
Fluorescent Screen Horizontal	FSH	2
Beam Position Monitors	BPM	123
DC Current Transformer	DCCT	1
Fast Current Transformer	FCT	1
Annular Electrode	AE	1
Stripline BPM	SBPM	1
Scraper (Hor & Ver)	SCRH & SCRV	1 & 1
Beam Loss Monitors	BLM	128
X-Ray Pinhole Camera	Pinhole	1
Visible Light Monitor	BL34	1

1. Introduction: Di location



Contents

2. Fluorescent Screens



• Conventional "in-air" model*

•YAG:Ce screen is kept inside a closed shaft that keeps it away from vacuum

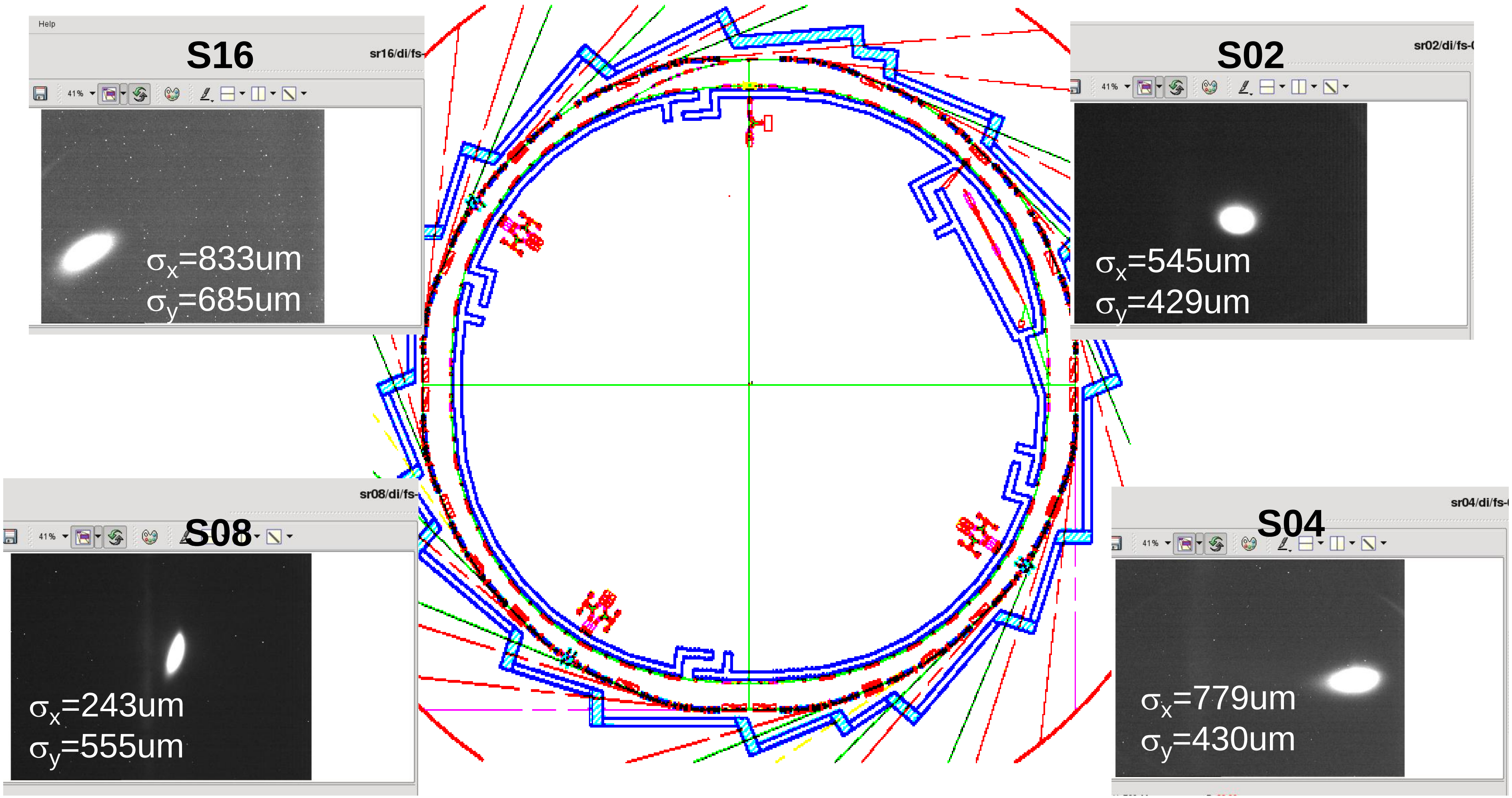
•Inserted vertically with a pneumatic actuator

•Screen center, Optics and CCD camera (Ethernet Basler Scout) are in the same axis

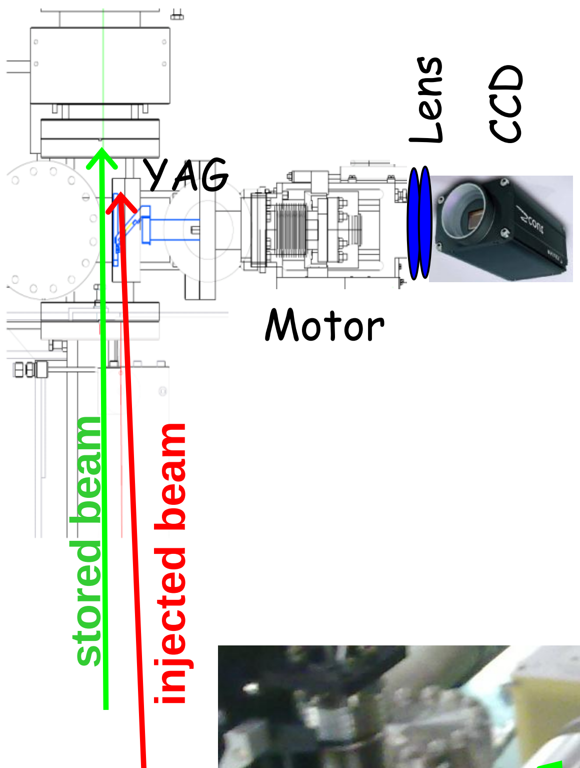
*K. Scheidt. *Upgrade of the ESRF Fluorescent Screens*, Proc. of DIPAC'03.

2. Fluorescent Screens

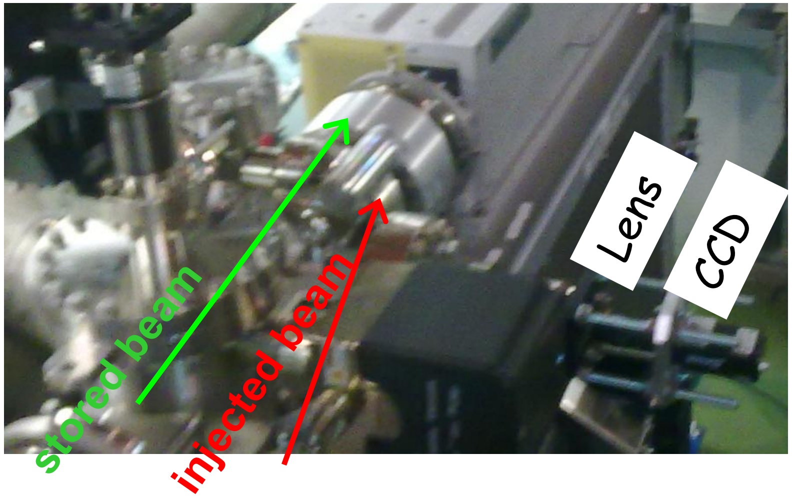
- Essential element to perform the 1st turn



2. Hor Fluorescent Screens

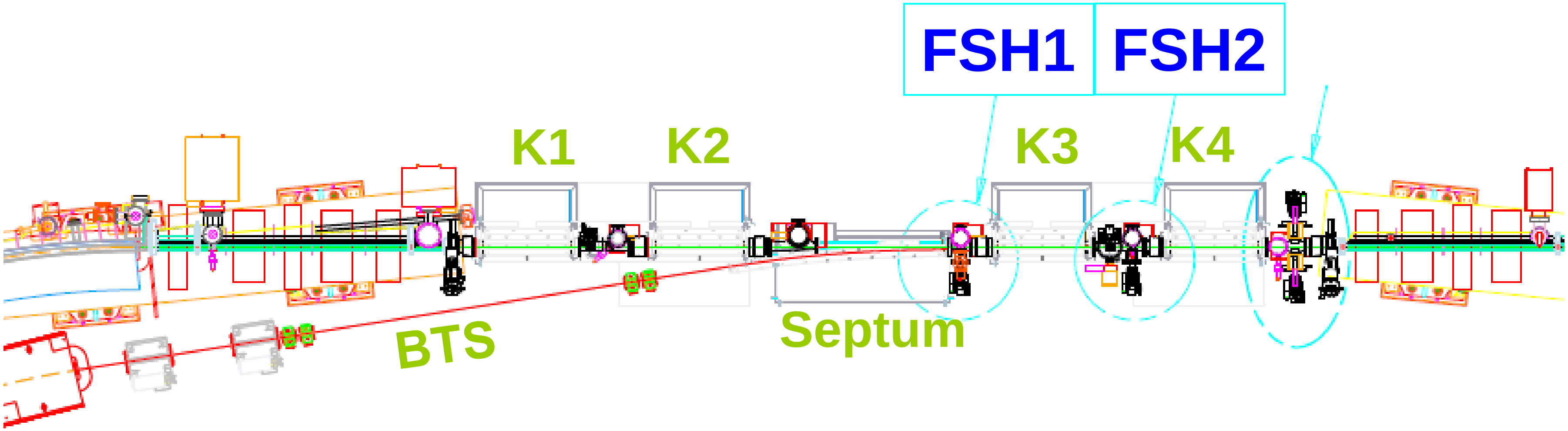


- Located at Injection Straight
- Inserted horizontally with a motor
- Beam centroid inferred after beam analysis, adding calibration offset of YAG screen wrt stored beam
- Screen center, Optics and CCD camera are in the orbit plane

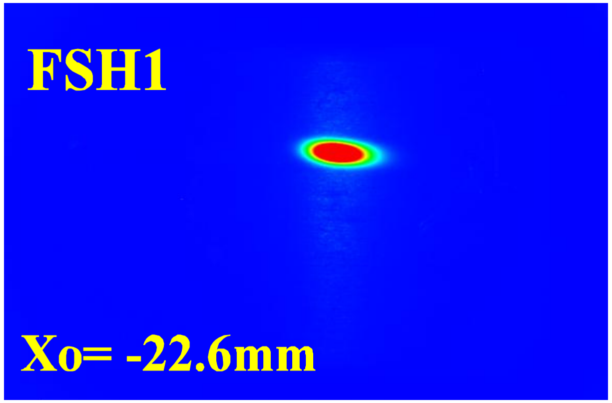


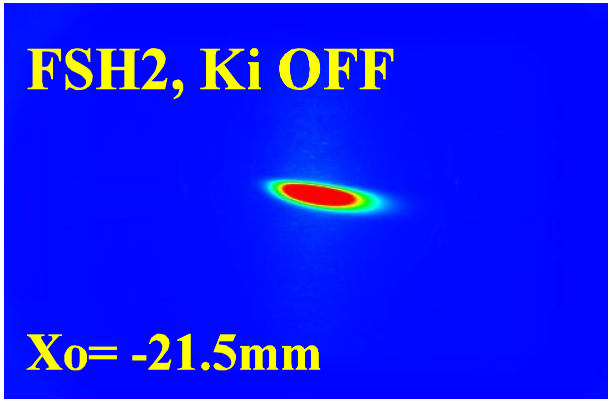
- Location:
FSH1: downstream septum
FSH2: downstream kicker

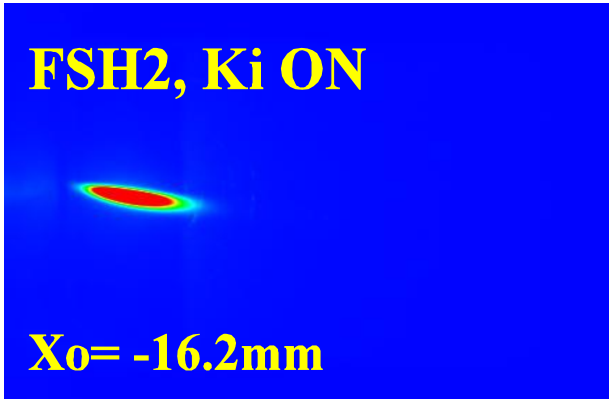
2. Hor Fluorescent Screens



• Very useful during all commissioning to optimize injection efficiency through the calculation of injected and kick angle.





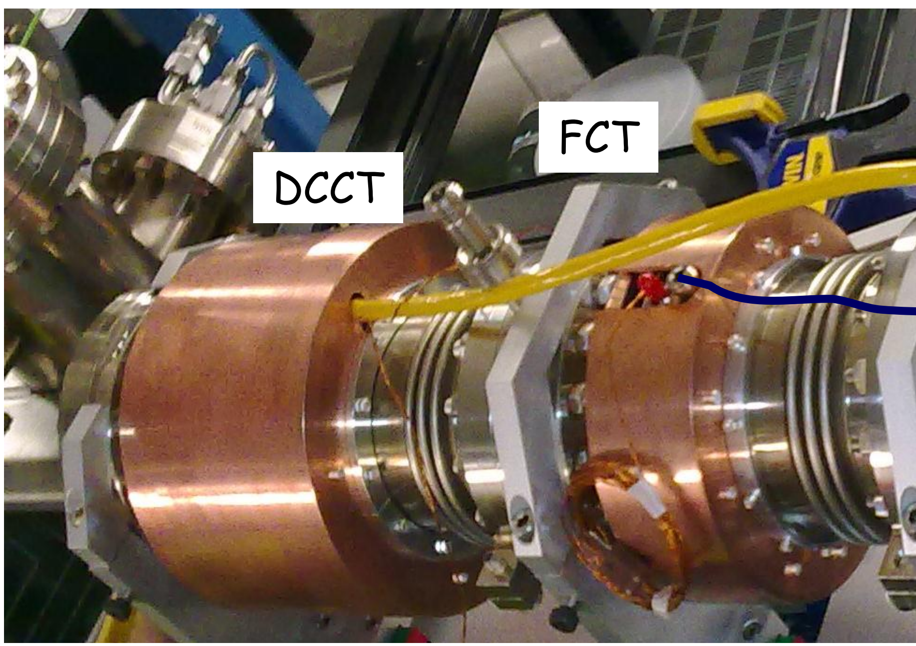


Contents

3. Current Monitors

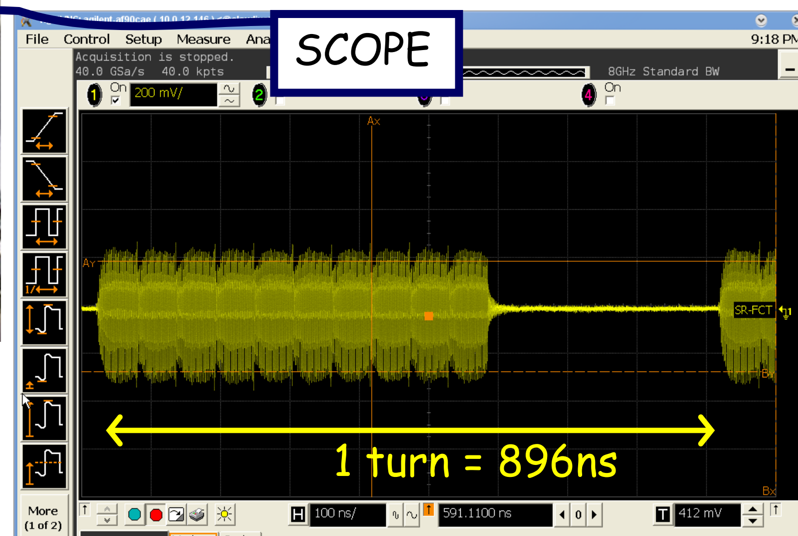
Fast and DC Current Transformers (FCT & DCCT):

- Mechanical design for ALBA SR in-house
- Coils: off-the-shelf products (Bergoz)
- Air-cooling circuit installed to prevent overheating
- Available from day-1 w.o. problems

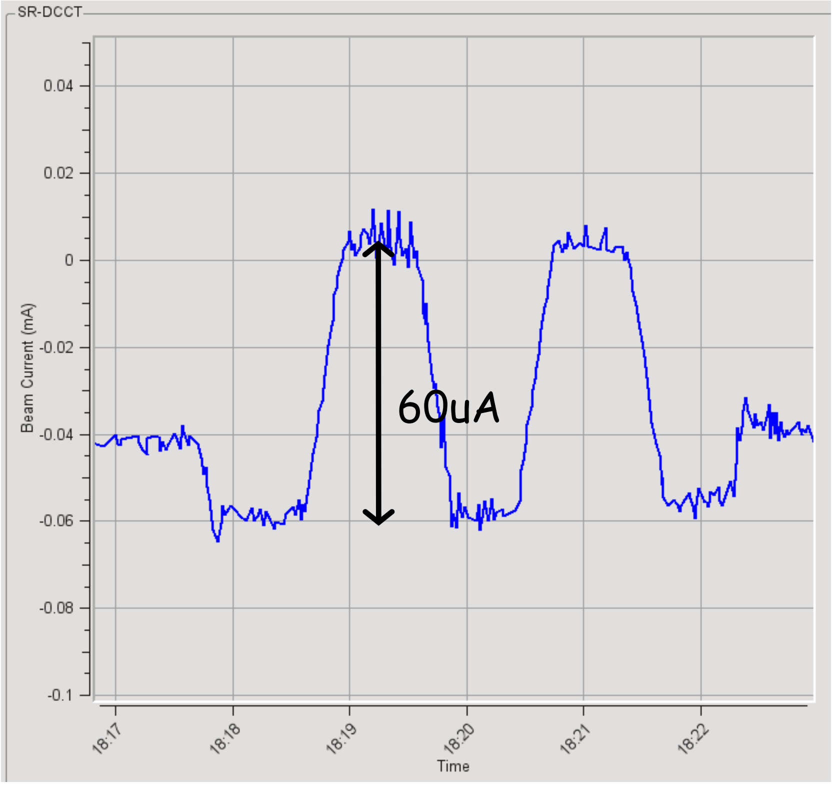


Bergoz NPCT Card

6-1/2 Digit PXI
Multimeter
Adlink SMX-2040



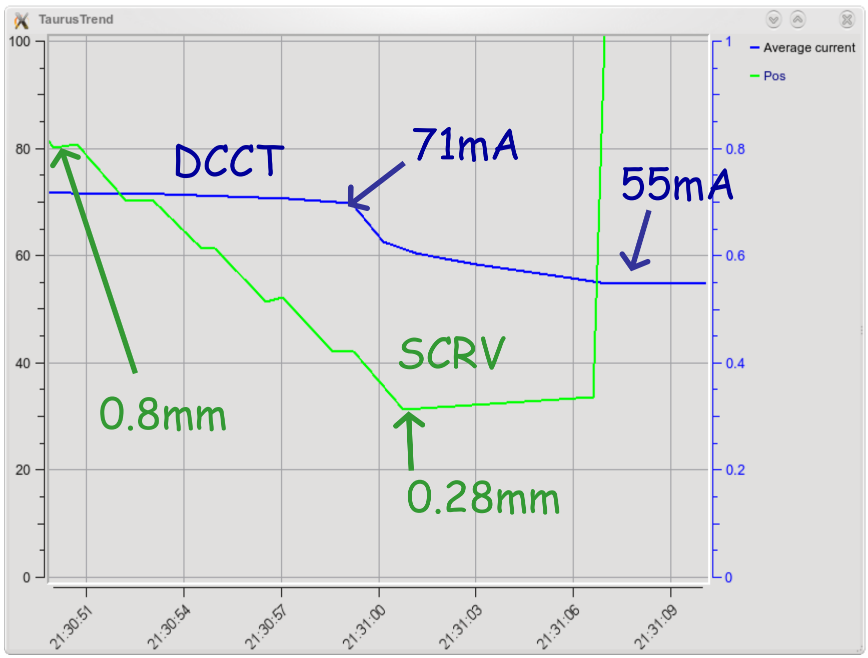
DCCT Performance:

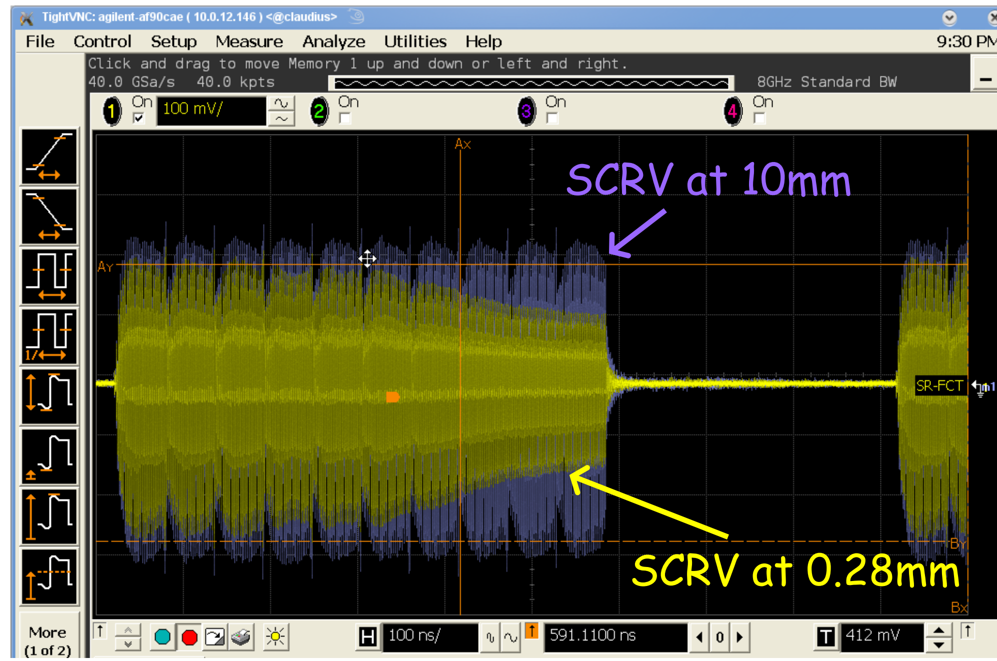


- DCCT rms noise: +/- 2uA
- DCCT sensible to dipole cycling and Ta drifts (+/- 30uA)
- No overheating problems (so far, 100mA injected)

3. Current Monitors:

- Continuously used to check machine performance
- Example of analysis of a vertical instability:





SCRV closed from 10mm to 0.28mm produces beam losses (16mA) mainly in the last bunches of the train (suspected to be Fast Ion Instability)

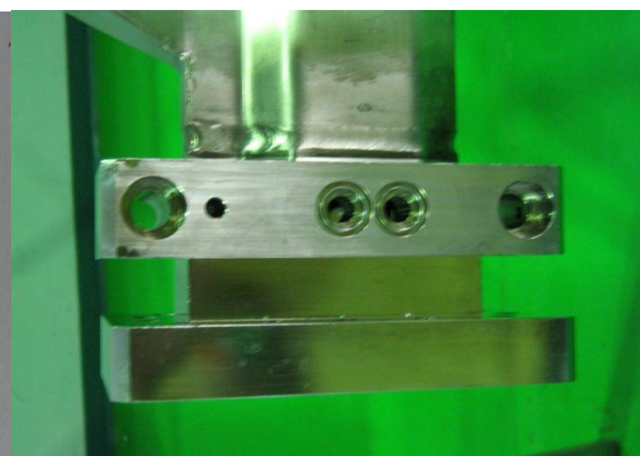
Contents

4. BPMs

- 7 or 8 BPM/cell (120 BPMs): orbit control and interlock system
- 2 BPMs for Bunch-by-Bunch Feedback System
- 1 spare BPM for Beam Dynamics (Tune measurements)

- BPM block is composed by 7mm diameter button type feedthroughs
- Small electrode size and button-shell gap to reduce buttons heating

- Semi-Rigid PEEK cables as transition from feedthrough to RF coax cables
- Low-loss phase matched (<10deg) RF cables of wide variety of lengths [15m – 45m]

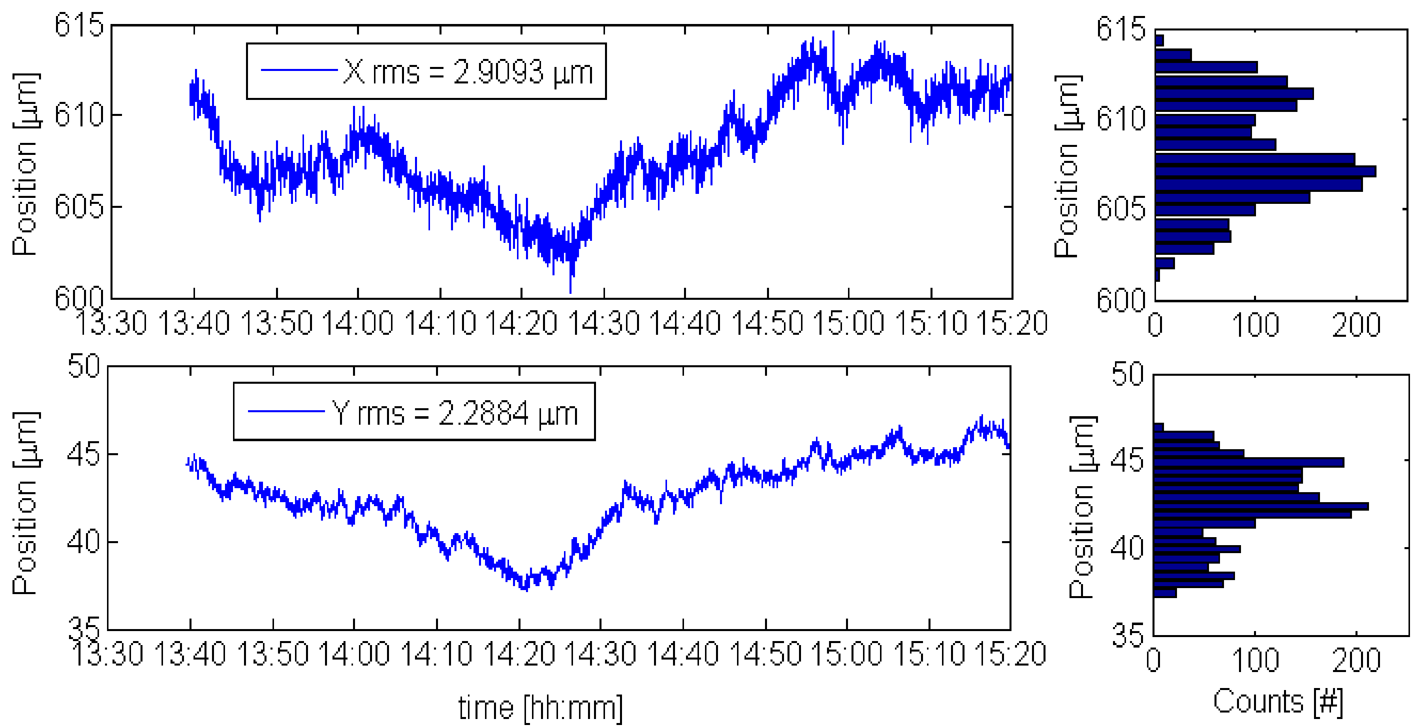


4. BPMs

- Reading Electronics: Libera Brilliance
- Non-controlled temperature area/rack
- Digital conditioning (DSC) and calibration not yet applied
- BPMs used from SR commissioning day-1

<u>Raw position meas during 40min @20mA:</u>

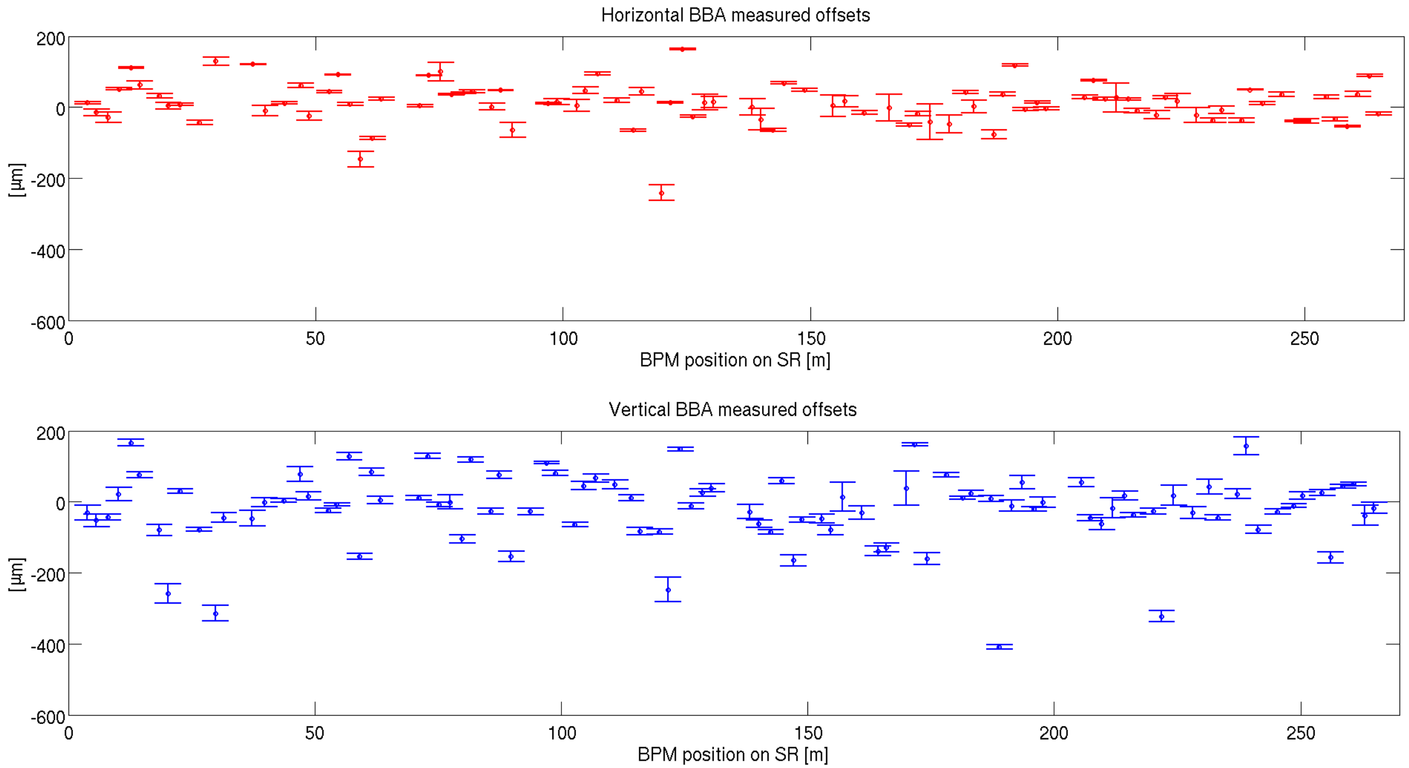
- Not yet proper temperature regulation inside tunnel (+/- 0.1deg) neither on service area (+/- 1deg)



U. Iriso

4. BPMs

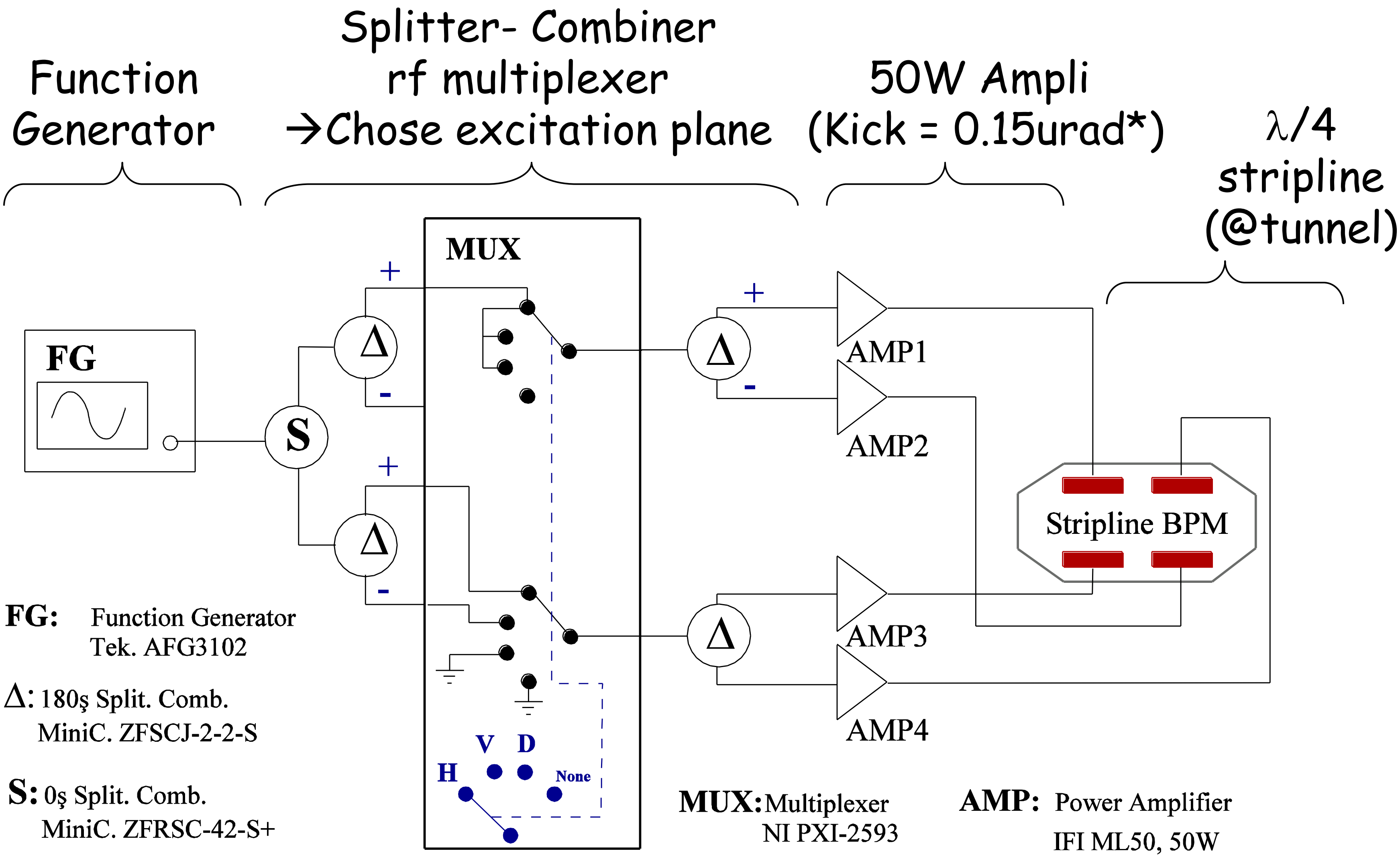
- BBA routine partially ran on BPMs (90/120 Ver, 96/120 Hor)
- Most of the offsets inside +/- 200um (some BPMs to be measured again or crosschecked by alignment team)



No slow orbit correction for the time being (use Orbit Correction Application from MML -> beam within +/-0.5mm)

Contents

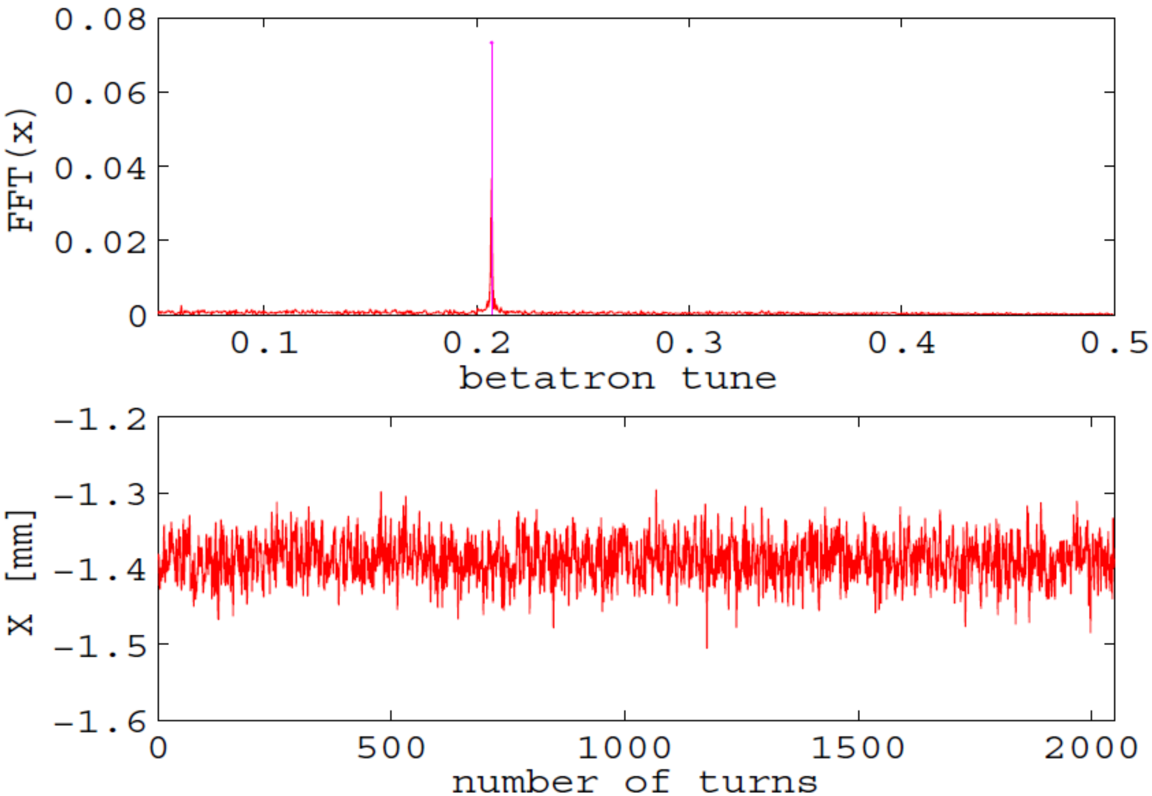
5. Tune Measurement System



* U. Iriso, et al. Design of the stripline kickers for ALBA, Proc. DIPAC09

5. Tune Measurement System

- Oscillations produced by a ***white noise*** signal around tune freq.
- Excitation are produced continuously → no trigger or synchronization is required
- Very useful for beam dynamics applications (chromaticity measurements)

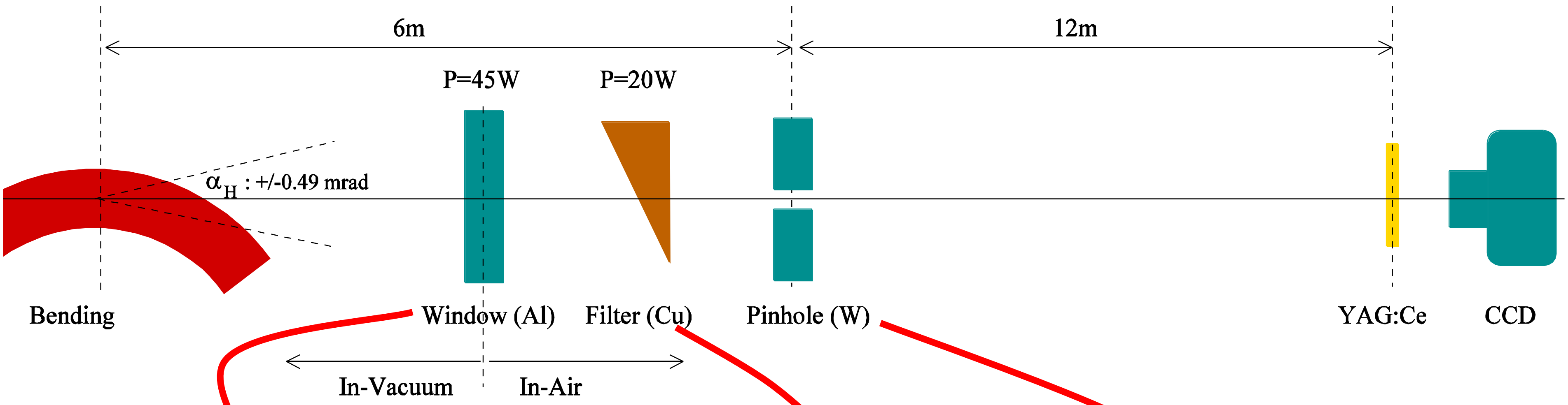


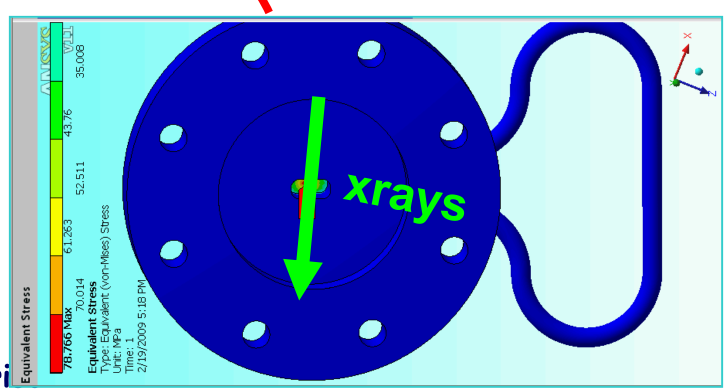
Hor Transverse oscillations (+/-50um)

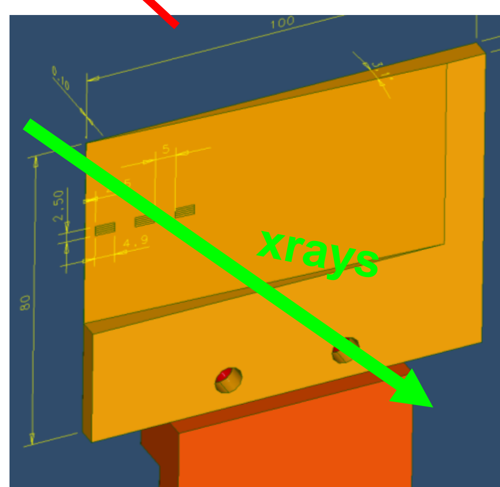
Contents

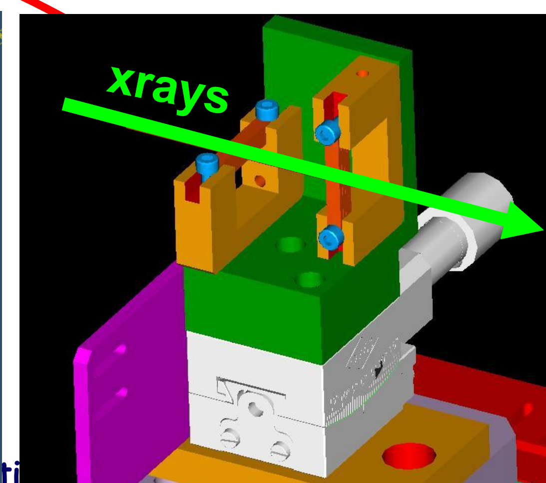
6. X-Ray Pinhole Camera

- Transverse beam sizes → emittance measurements
- To avoid diffraction limit, use xrays from a bending magnet
- Magnification factor: **2**







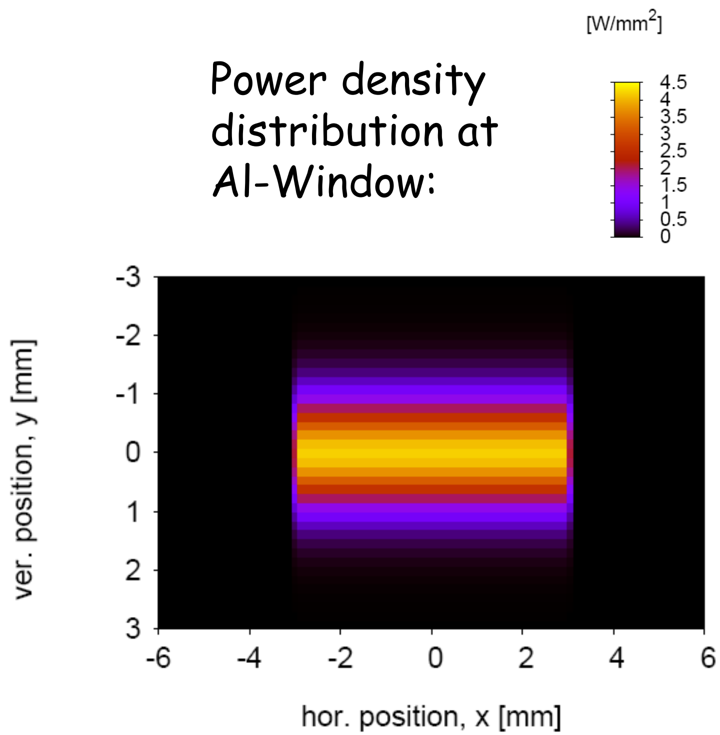


6. X-Ray Pinhole Camera

➔ Water cooling for the 1mm thick Al-Window:

Max Heat Load: **4.7 W/mm^2**
Max Tª: **129ºC**
Max Stress: **79 MPa**

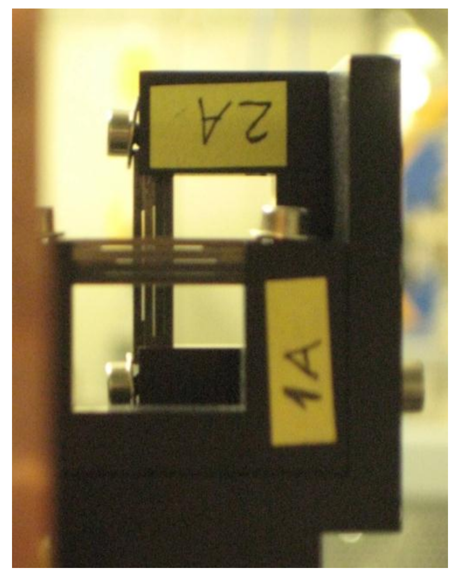
Power density distribution at Al-Window:



➔ Pinhole construction*:
Two arrays of 4 W-bars, with slits spaced by [10, 50, 100um]

Placed perpendicular one to another

Four motors allow controlling pinhole position and chose the desired hole

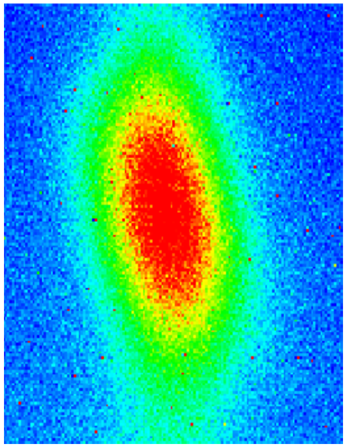


*Thanks to K.Scheidt & F. Ewald(ESRF)

6. X-Ray Pinhole Camera

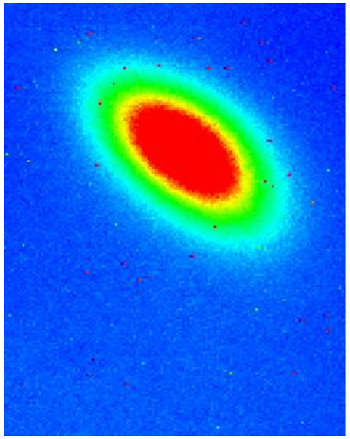
- Pinhole Commissioning took 1-day after stored beam.

2011.03.25: one QP polarity swapped



25mA, X_V=0

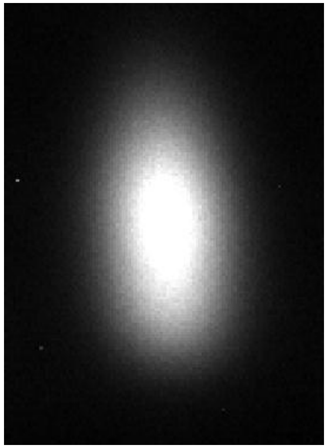
σ_x=121um
σ_y=218um



25mA, X_V=+3

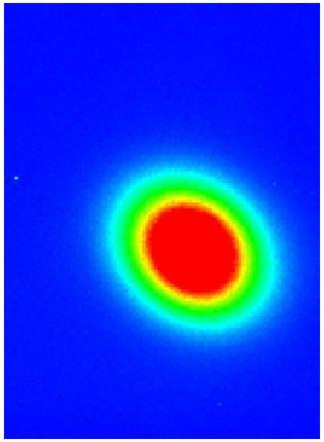
σ_x=108um
σ_y=103um

2011.03.28: QP polarity corrected during shutdown



20mA, X_V=0

σ_x=86um
σ_y=186um

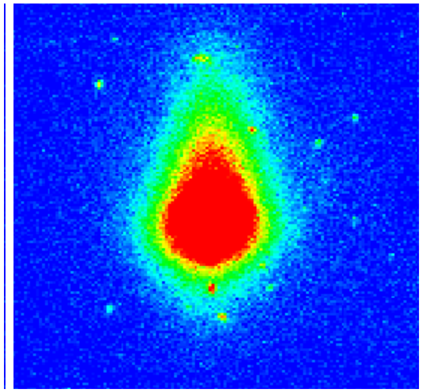


20mA, X_V=+3

σ_x=89um
σ_y=105um

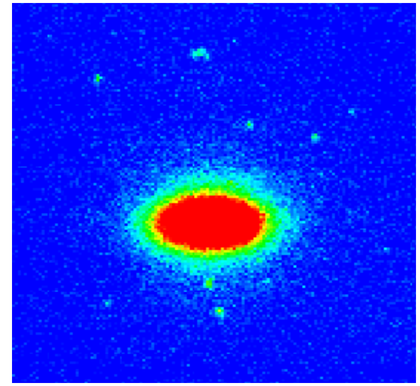
6. X-Ray Pinhole Camera

2011.05.11: After BBA and correct coupling



30mA, Xv=0.2

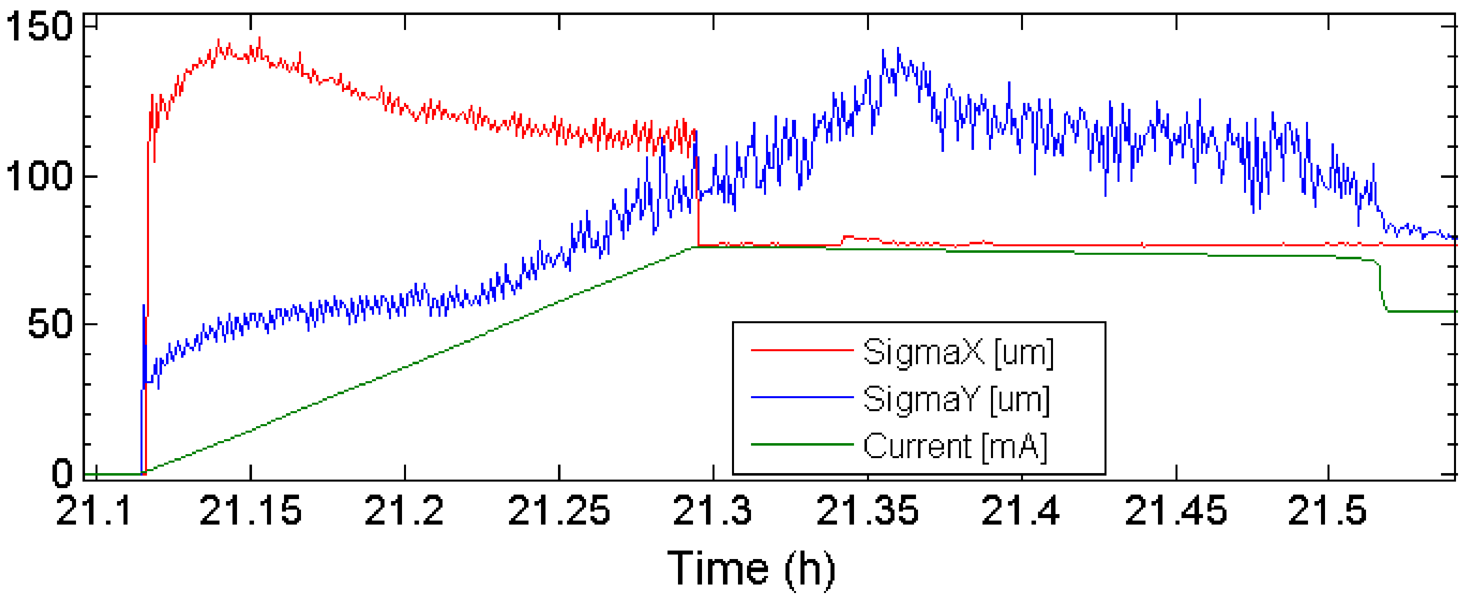
σ_x=72um
σ_y=124um



20mA, Xv=0.2

σ_x= 74um
σ_y= 41um

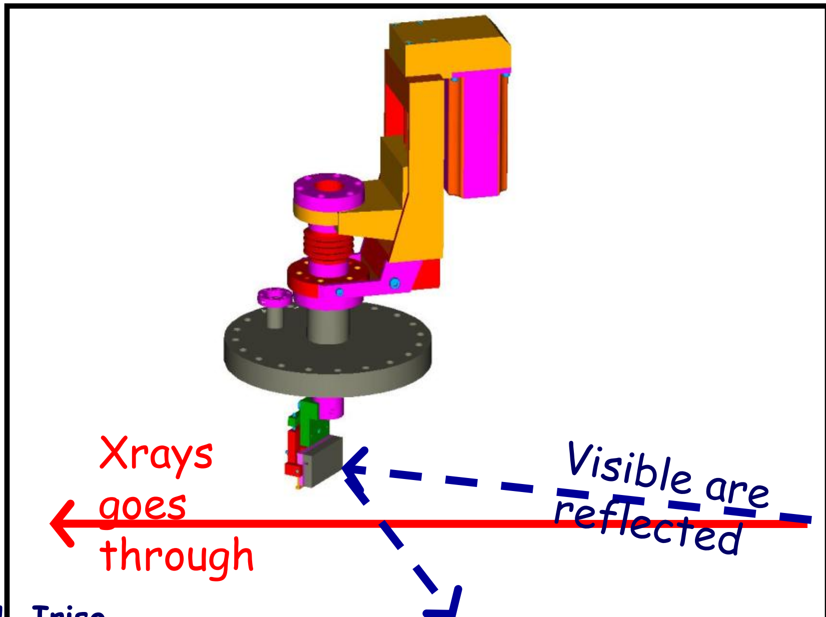
2011.05.11: Ver and Hor Beam size continously monitored

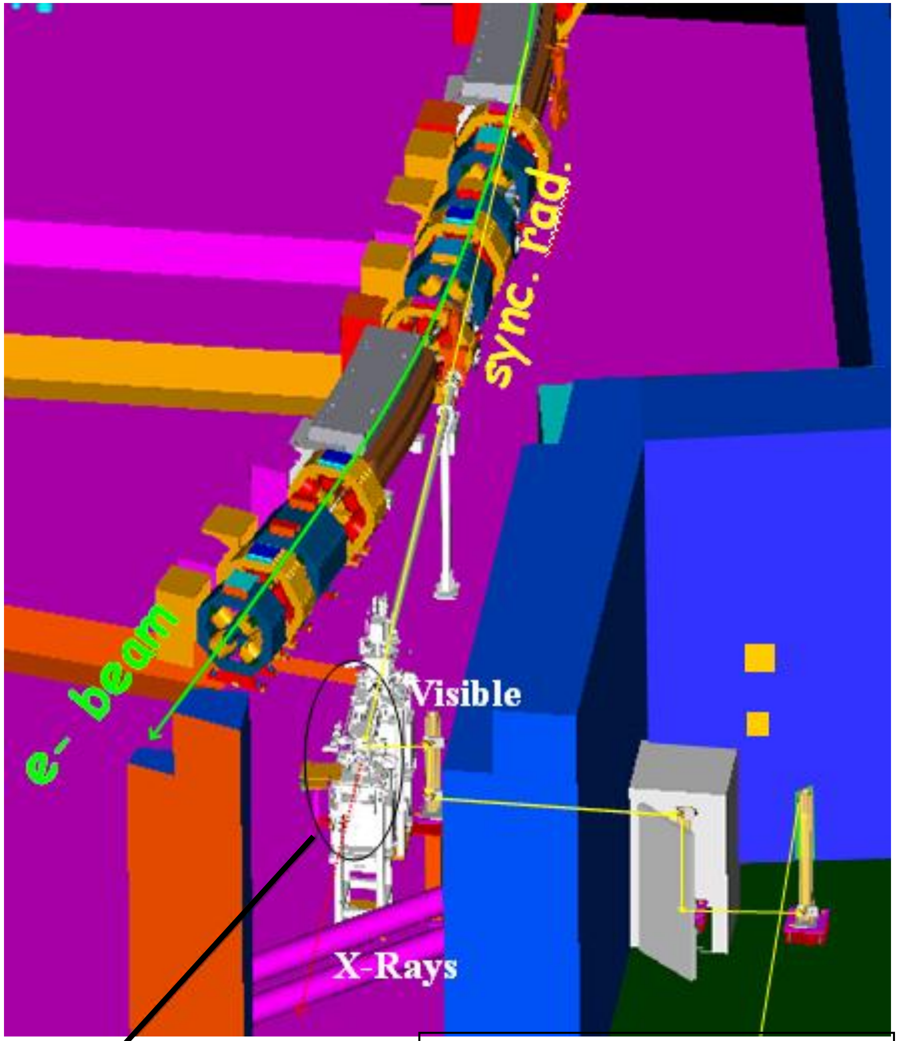


Contents

7. Visible Light Monitor

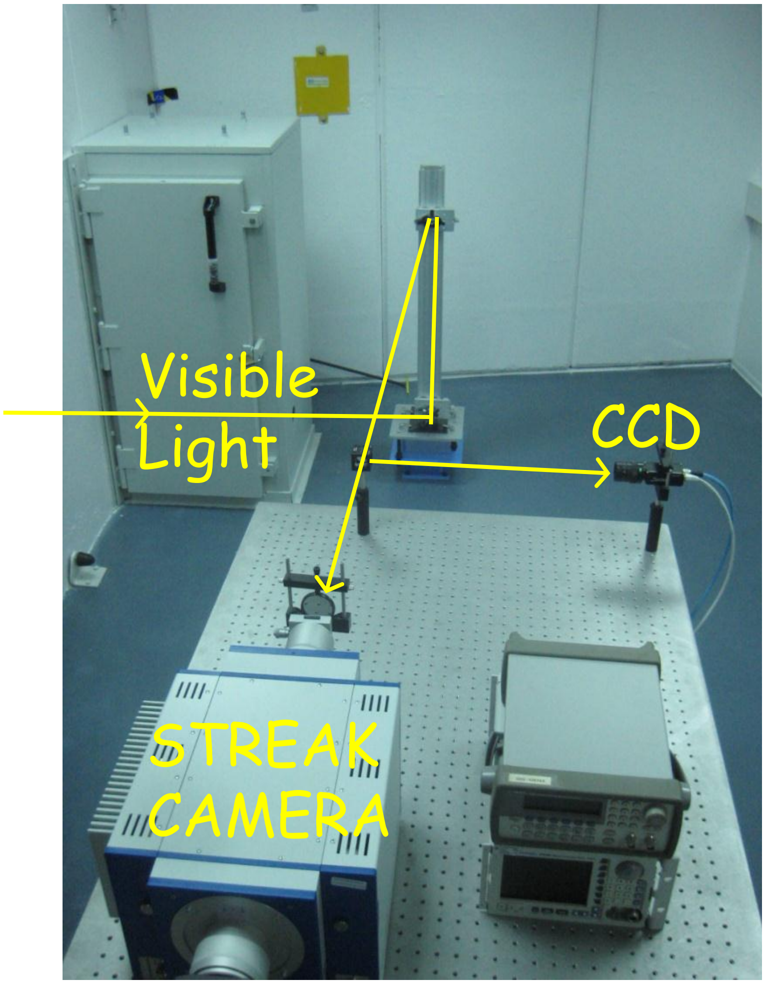
- Radiation wavelength from a dipole emitted at different vertical angles
- Select the visible range by placing the mirror at different vertical position
- Mirror position (in-vacuum) controlled with thermocouples





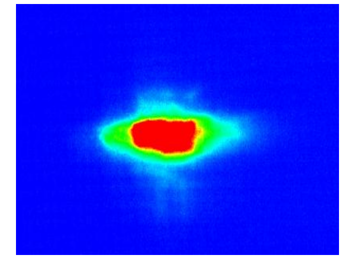
DIAGNOSTICS HUTCH

7. Visible Light Monitor

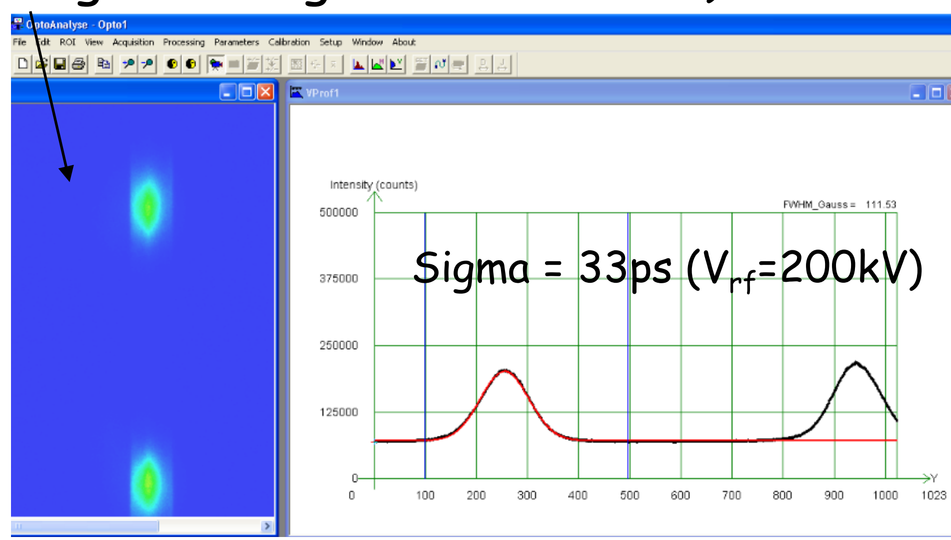


- At the Diagnostics Hutch:

→CCD:
Reference beam image

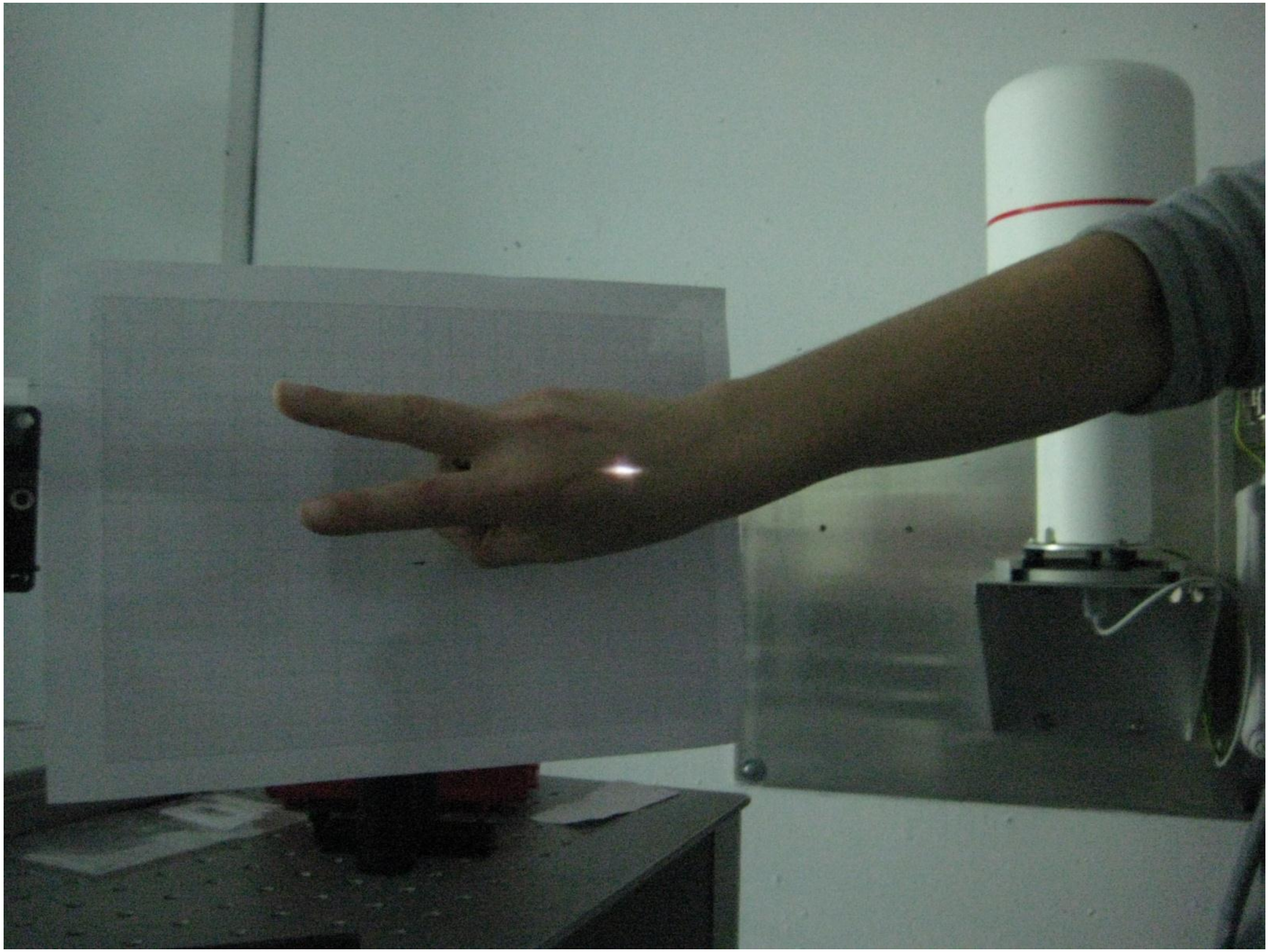


→**Streak Camera:**
Precisely infer longitudinal time bunch structure
Slow sweep unit not yet working (image is integrated over 1ms)



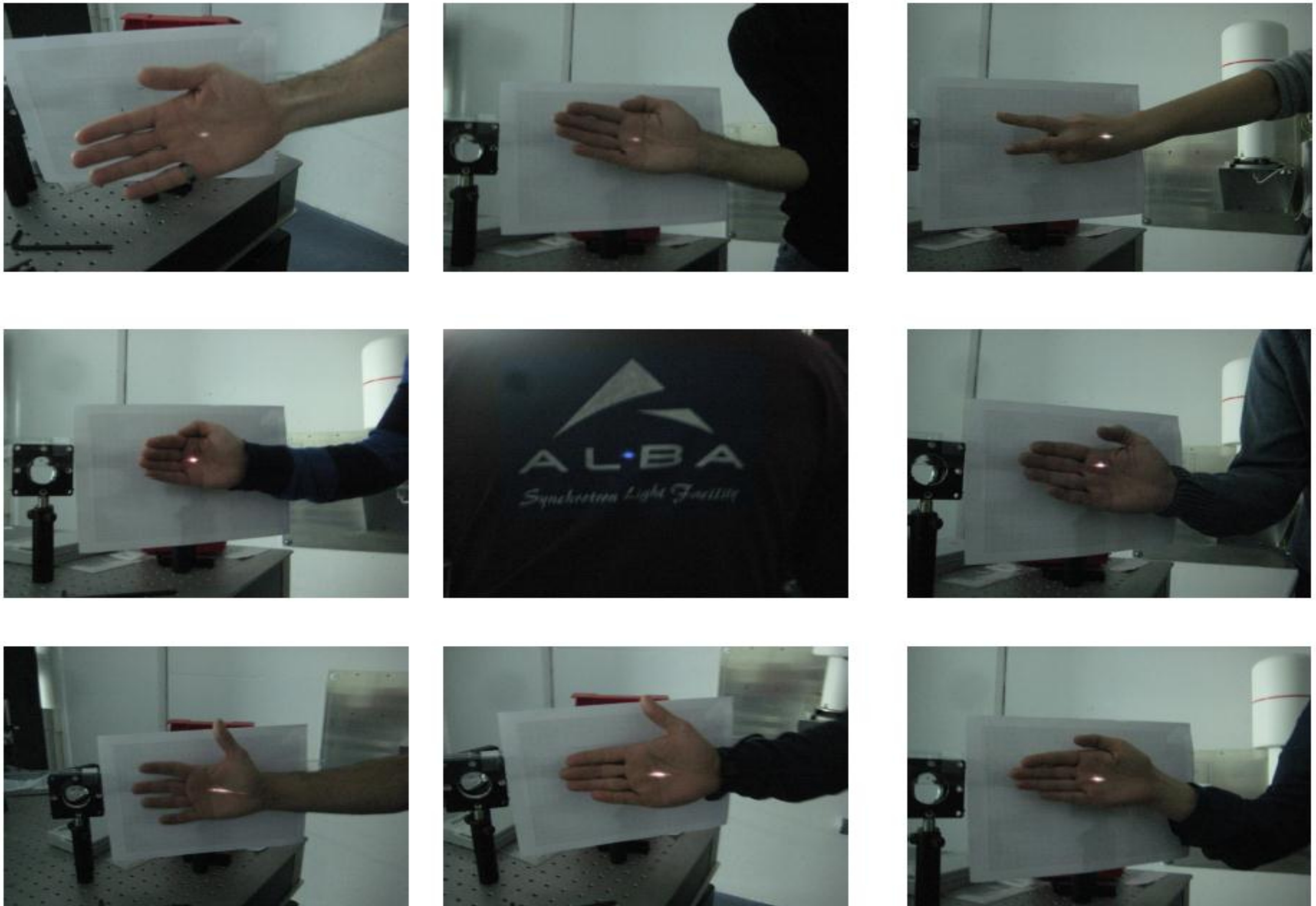
7. Visible Light Monitor

FIRST SYNCHROTRON LIGHT!!



7. Visible Light Monitor

FIRST SYNCHROTRON LIGHT!!



7. Visible Light Monitor

7. Visible Light Monitor

8. CONCLUSIONS

- Diagnostics components at ALBA combine off-the-shelf products with ad-hoc designs → Easy Di Commissioning
- FS, FSH, FCT, DCCT, BPMs worked since day-1 of commissioning without problems
- Diagnostics FE (pinhole and visible light) worked right after beam was accumulated
- Diagnostics components at ALBA eased an efficient commissioning

- **Future plans**:
    - Fine adjustments to increase Di performance
    - Implement Slow and Fast Orbit Correction
    - Install Fast Feedback Kickers to correct CBI
    - Streak camera measurements

Acknowledgements

→ thanks to the rest of the Accelerator Division (M. Pont, G. Benedetti, Z. Marti, M. Munoz, D. Einfeld…)
→ thanks to people in other divisions: J. Pasquaud (Engineering Div.), and D. Fernandez, S. Blanch, J. Moldes (Computing Div.)

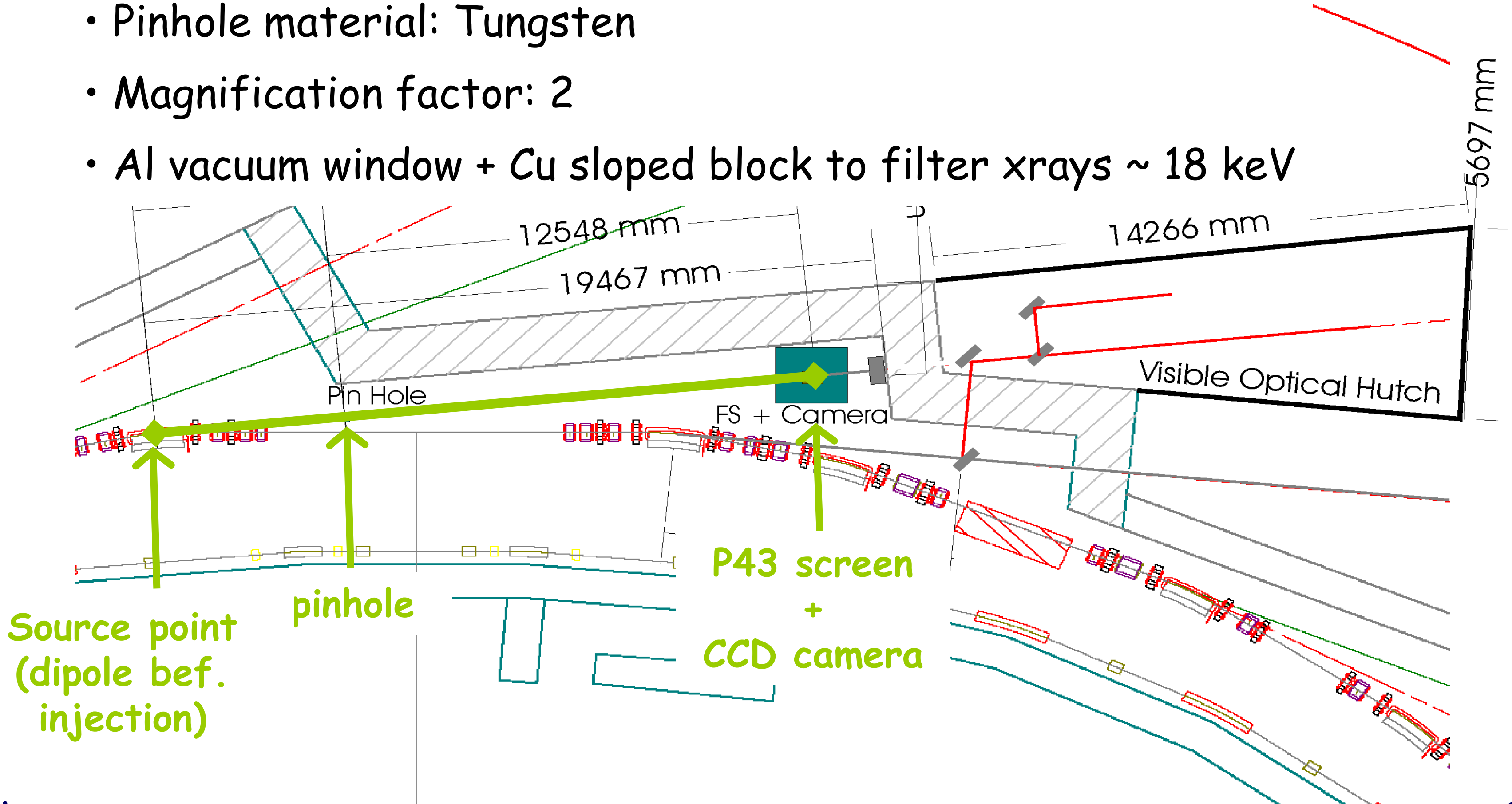
→ Thanks for the advices from many colleagues in other machines:
G. Rehm and C. Thomas (Diamond), J.-C. Denard and L.Cassinari (Soleil), V. Schlott (SLS), K. Scheidt and F. Ewald (ESRF), P.Kuske (BESSY)

Extra slides

X-ray Sync. Rad. front end (XSR)

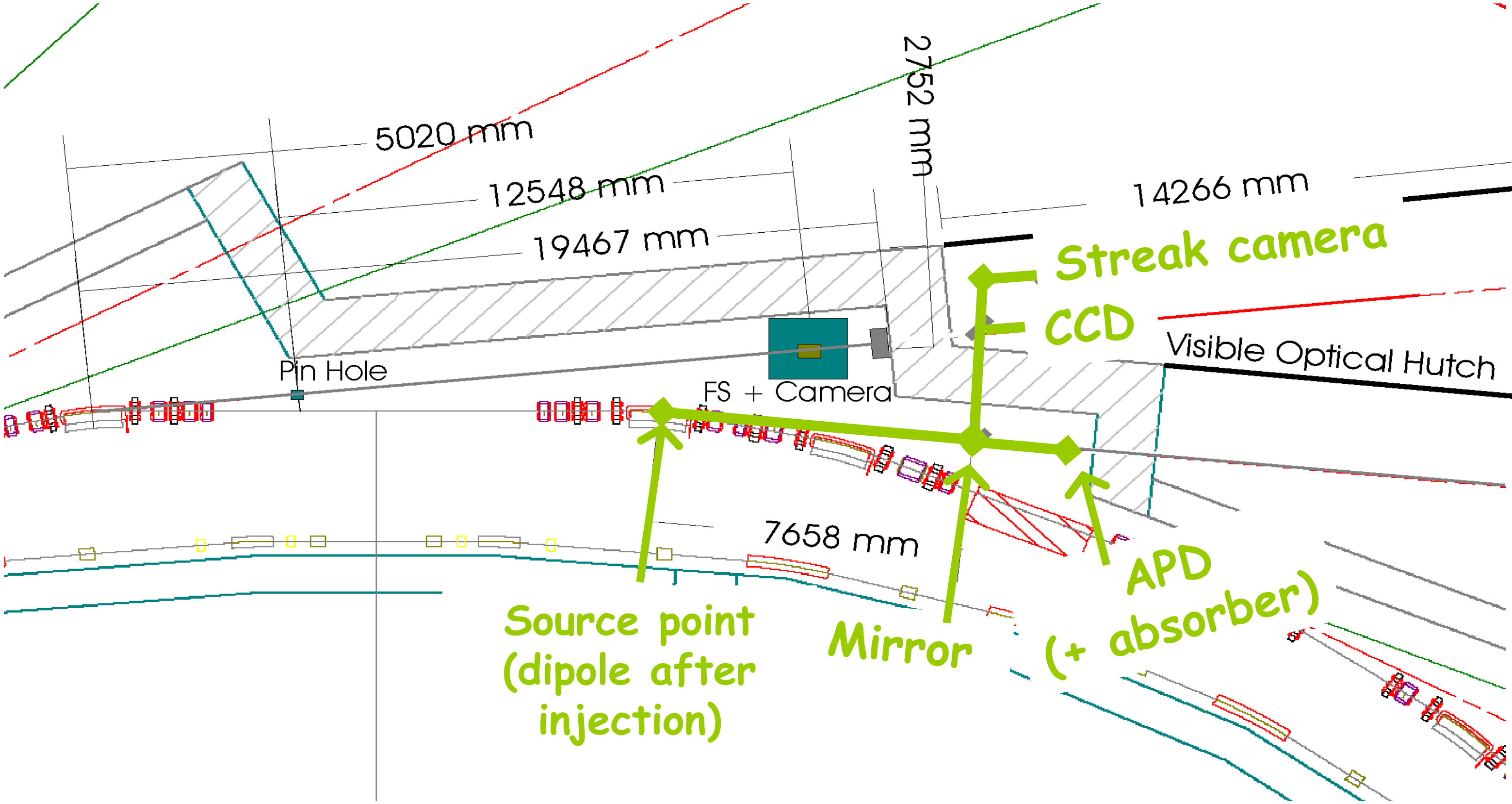
XSR or pinhole camera

- Transverse beam sizes → emittance measurements
- Simple pinhole system (no need for pinhole array)
- Pinhole material: Tungsten
- Magnification factor: 2
- Al vacuum window + Cu sloped block to filter xrays ~ 18 keV



Visible Sync. Rad. front end

- Need to build a **mirror*** with thermocouples to reflect just the visible part
- Light analysis is done in the optical hutch
- Bunch length measurements with **streak camera**
- Qualitative beam image with **CCD** camera



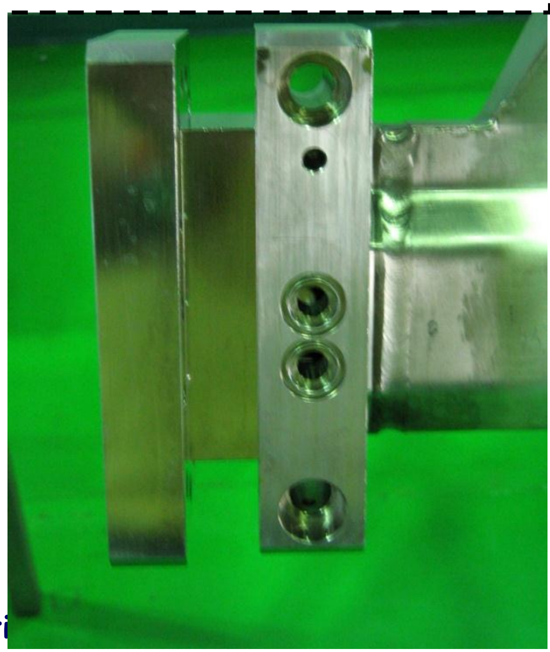
*K.Scheidt, *UV and Vis. Light diagnostics at the ESRF*, Proc. of EPAC'96

BPM Buttons

	SR	Booster
Hor. Sensitivity (mm^{-1})	0.080	0.093
Ver Sensitivity (mm^{-1})	0.075	0.093
Capacitance (pF)	2.7	3.2
Intrinsic resolution (μm)	11 (@0.1 mA and 4kHz)	45.5 (@0.1 mA and 1.2 MHz)

First 20 BPM buttons & Blocks just manufactured

BPM block welded to vac. chamber



BPM electronics

- One type of electronics for one type of monitor
- Contract signed with I-Tech for all BPMs (SR, Booster, LTB, BTS)

  Keeps system simple, eases maintenance…
- Sub-micron resolution, stability depending on current, temperature…
- Slow & Fast Orbit Correction schemes
- BPMs equipped with data acquisition for:

  -> Turn By Turn (1.1MHz)

  -> Fast Orbit Correction (4 kHz)

  -> Slow orbit Correction (4 Hz)

  -> Post Mortem buffer

  -> Other data acq. options on demand

TESTS STATUS:

- 30 Libera units & 4 Clock Splitters arrived for tests in Jan. 2007
- Res. around -40 dBm was out of the specs due to a wrong gain scheme → Corrected in 2 weeks → Acceptance Tests for approved for all units