JAGIELLONIAN UNIVERSITY IN KRAKOW

SOLARIS
NATIONAL SYNCHROTRON RADIATION CENTRE

Status of SOLARIS

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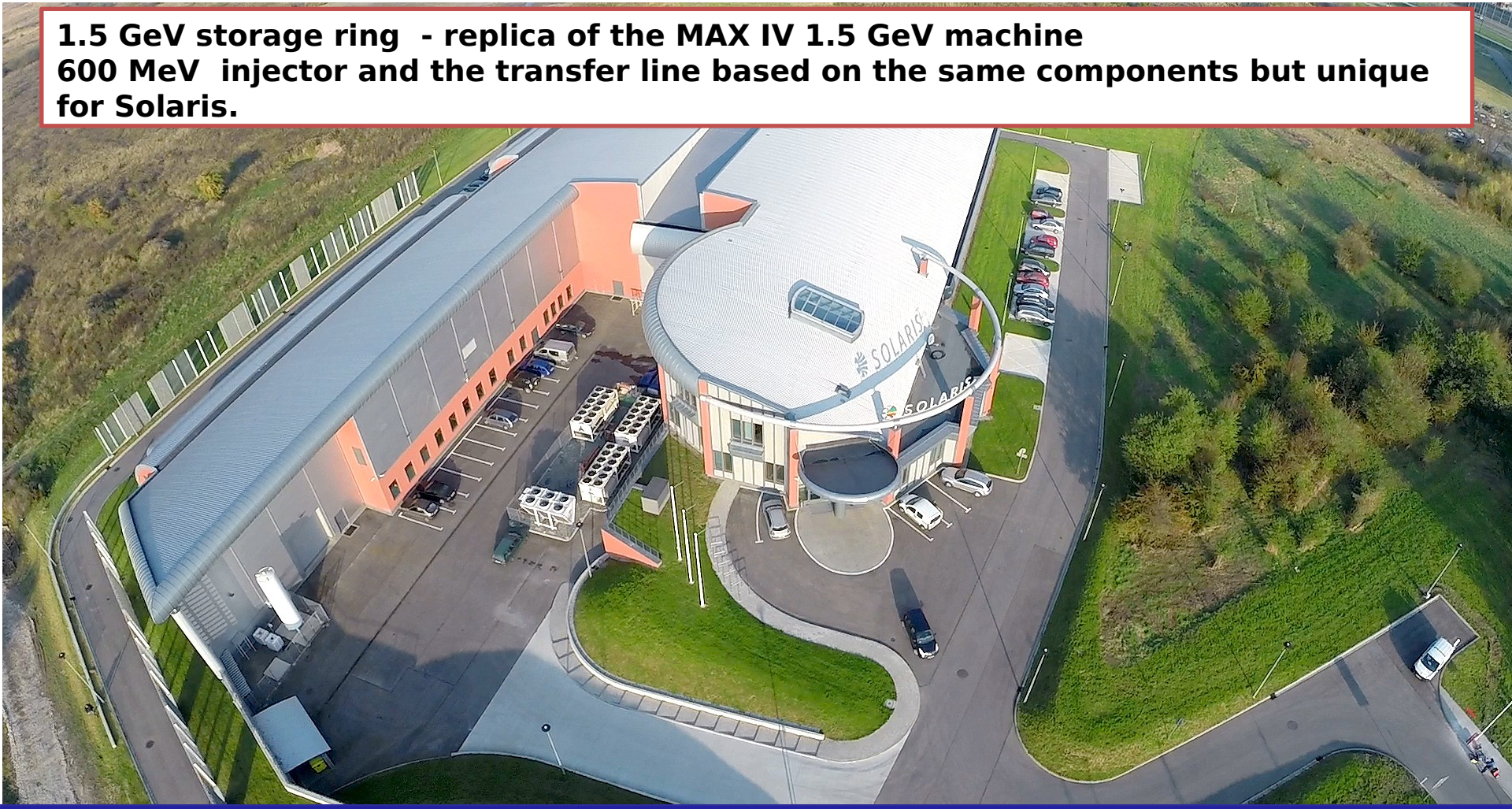
Outline

- Solaris overview
- Previous year status
- Curent status and problems during commissioning
- Near and far future
- Summary

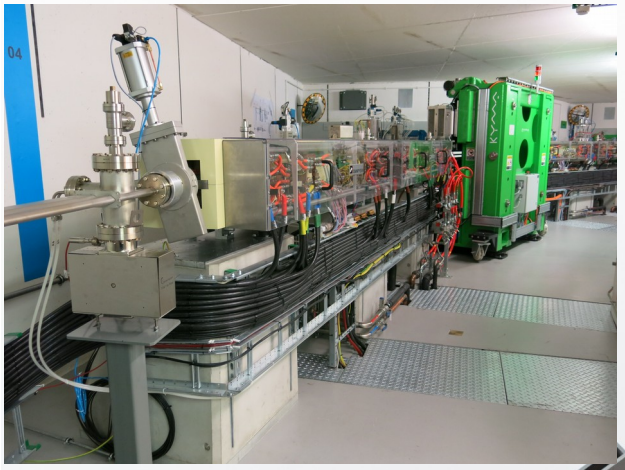
Solaris Overview

SOLARIS - 3rd generation light source facility built in Krakow, Poland at the Jagiellonian University Campus.

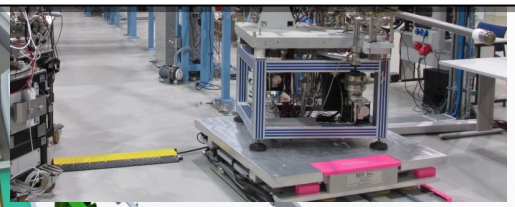
1.5 GeV storage ring - replica of the MAX IV 1.5 GeV machine
600 MeV injector and the transfer line based on the same components but unique for Solaris.



Solaris



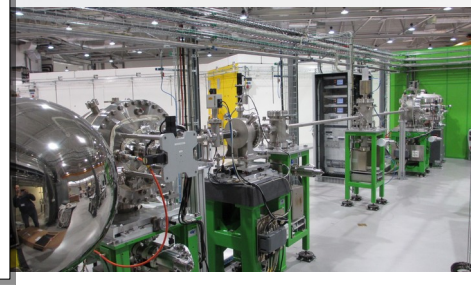
1.5GeV Storage ring
12 DBA Cells – 96 m circ.
Space for ID's (10 sections) ~3.5 m
10 straight sections for Ids
100 MHz RF system
300 MHz Landau Cavities
Injection dipole kicker
Ramping



PEEM/XAS beamline

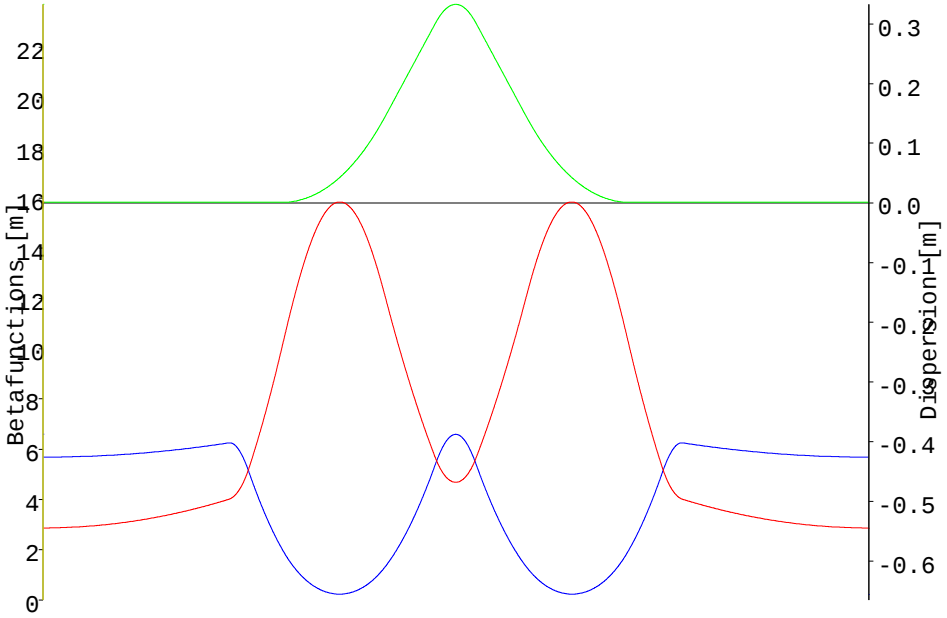
600 MeV Linac with RF Thermionic Gun
6 accelerating structures combined in 3 units
Accelerating gradient 20 MeV/m
S-band – 2998.5 MHz
3 RF Units :
- ScandiNova K2 modulators
- Toshiba klystrons
- SLED cavities

U-ARPES beamline



Storage Ring

Storage Ring Lattice



Storage Ring Parameters	Value
Energy	1.5 GeV
Current	500 mA
Circumference	96 m
Number of cells	12
Harmonic number	32
Horizontal emittance	5.982 nm rad
Coupling	1%
Tunes Q_x, Q_y	11.22, 3.15
Natural chromaticities ξ_x, ξ_y	-22.96, -17.14
Momentum compaction	3.055×10^{-3}
Momentum acceptance	4%
Bunch length without/with LC	1.4 cm / 6 cm
Overall Lifetime	13 hrs

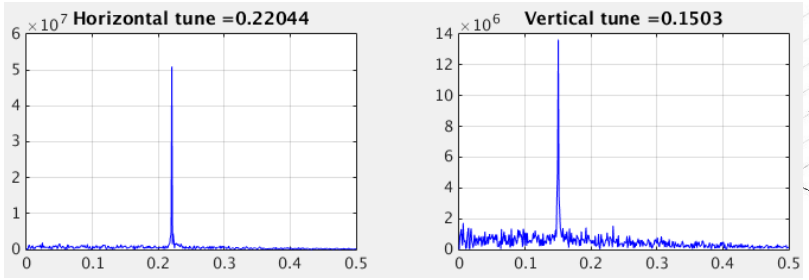
Optics design by S.C. Leemann - MAXIV

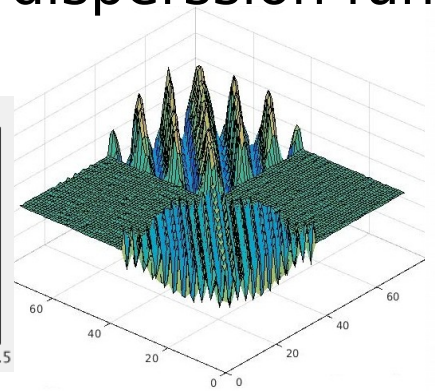
MAXIV Facility, DDR, § 3, http://www.maxlab.lu.se/maxlab/max4/DDR_public

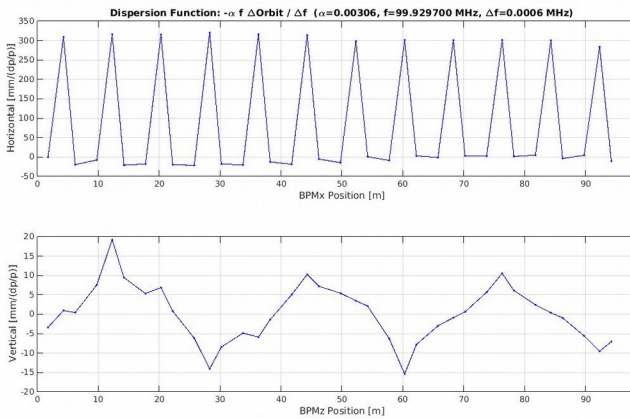
Last year status

- Basic accelerator physics studies were optimized:

tunes: Q_x=11.2204, Q_y= 3.1503, chromaticity: ξ_x= +0.91, ξ_y= +0.89, orbit response, disperssion function







- Max. injected beam current: 200 mA @ 517 MeV
- Max. ramped beam current: 132 mA @ 1505 MeV (lossy ramping)
- Beam lifetime: 2.6 h @ 20 mA current ($I*\tau$ = 0.052 A.h)

Last year aims

- Improvement of stored beam current at nominal energy

- Installation of Landau cavities

- Reducing RMS of closed orbit

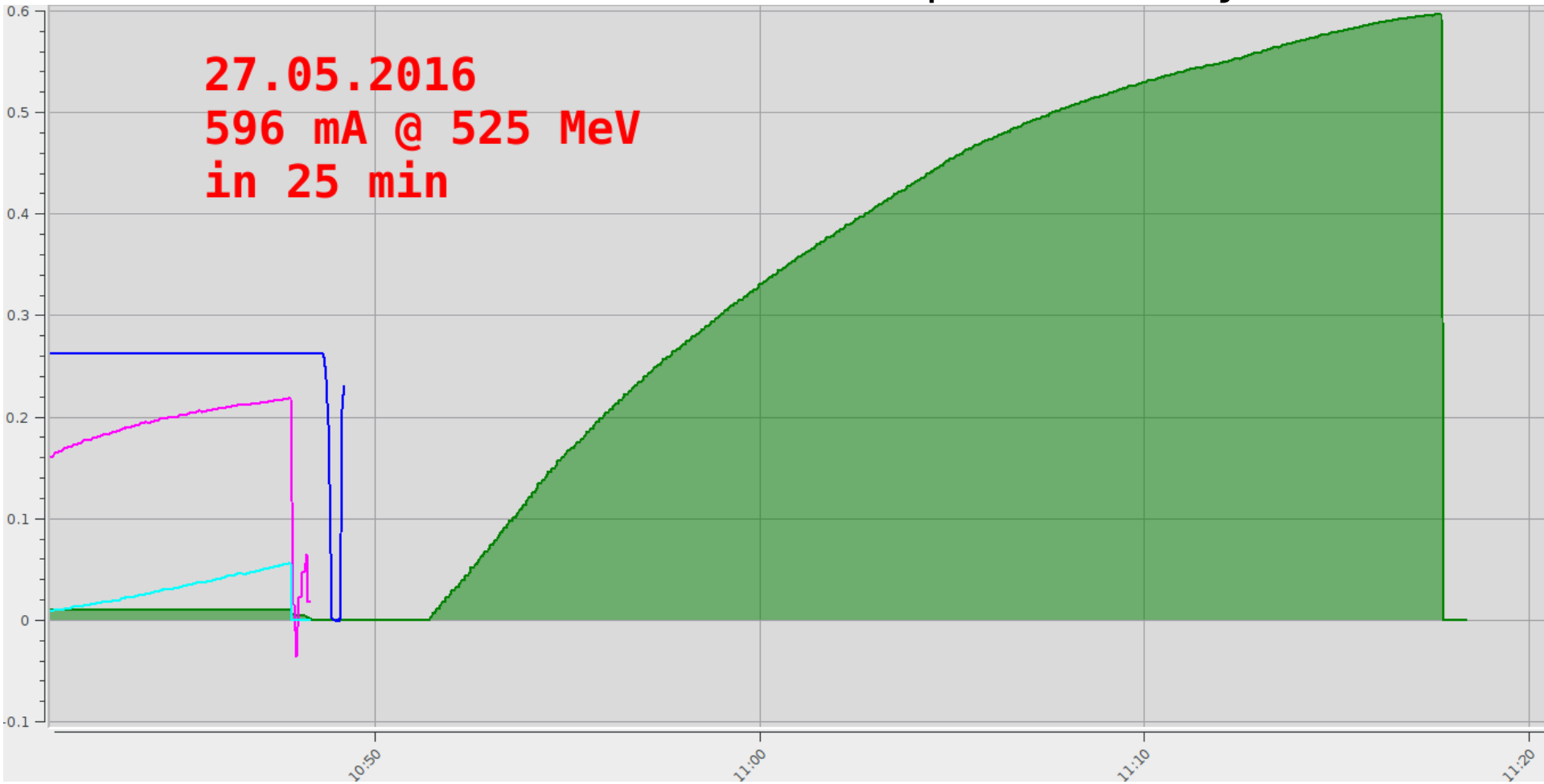
- Starting of beamlines commissioning

- Beam lifetime improvement

Beam current

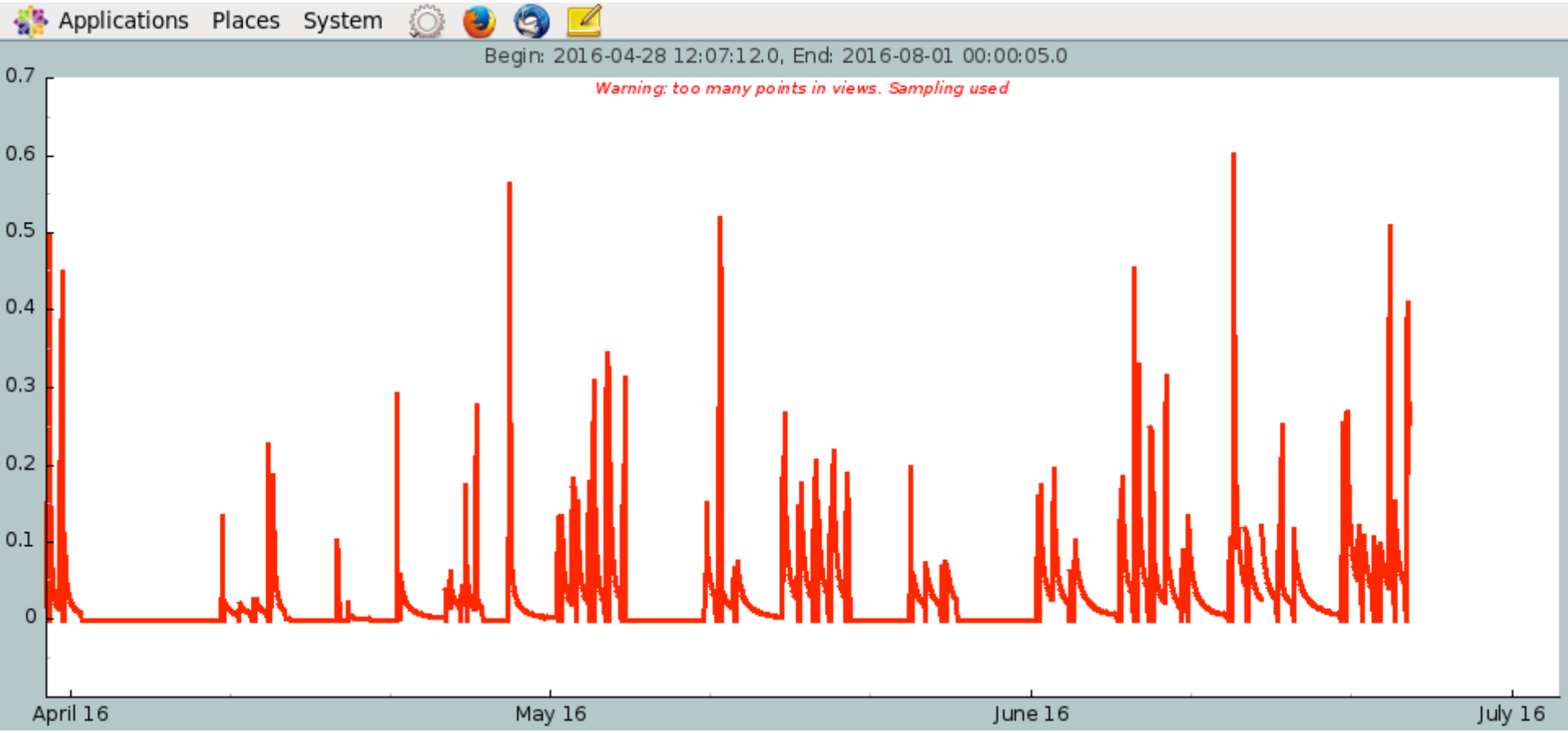
- 27th May 2016 596 mA at the injection energy

- then interlock due to the vacuum trip in RF cavity



Beam current

- from **June 2016** up to **600 mA** possible to accumulate without interlocks (at 525 MeV energy)



History of stored beam current

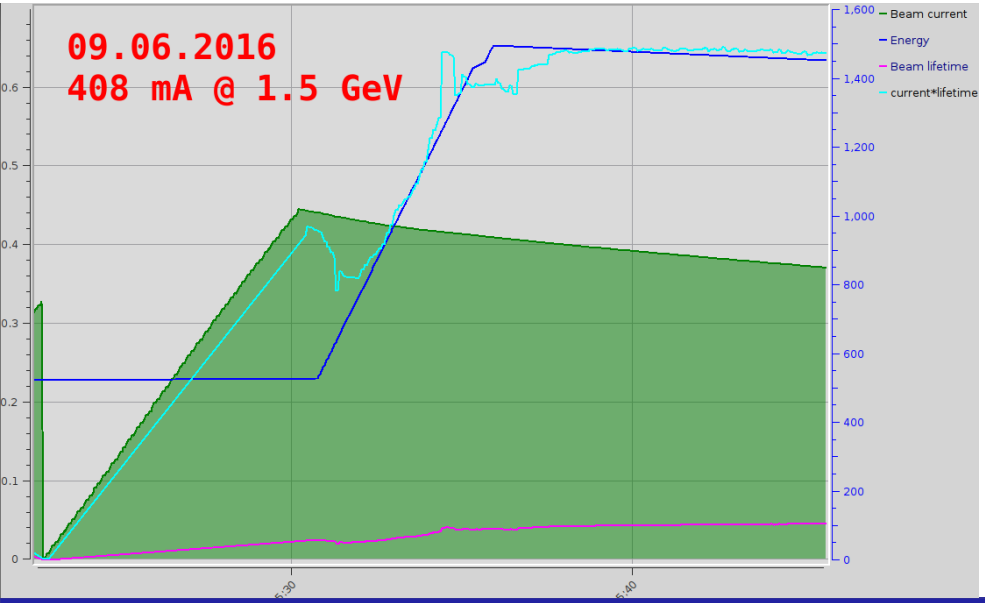
Beam current

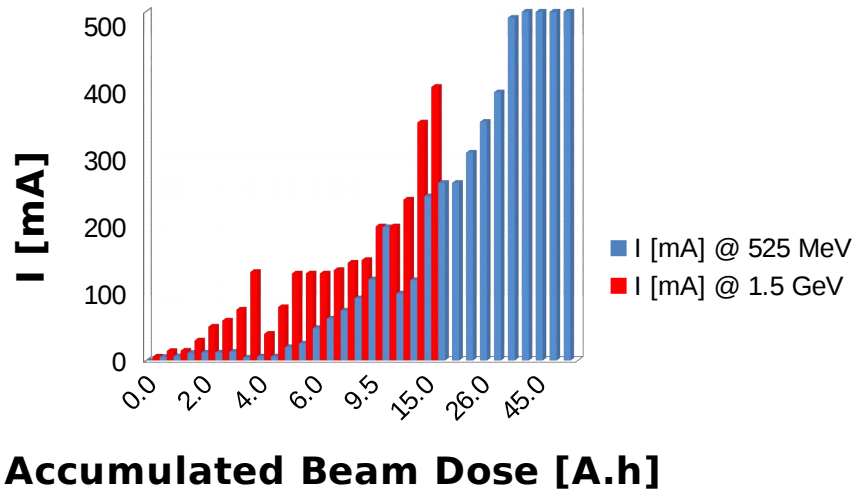
- 9th June 2016:

408 mA ramped to final **1.5 GeV** energy, I*τ = **0.62 A.h**

- beam were stored for about **20 min** then vacuum interlock in main RF cavity occured

- then vacuum leak on first cavity were observed





Broken ceramic

- ceramic on the main cavity pickup was broken

- it happened several times

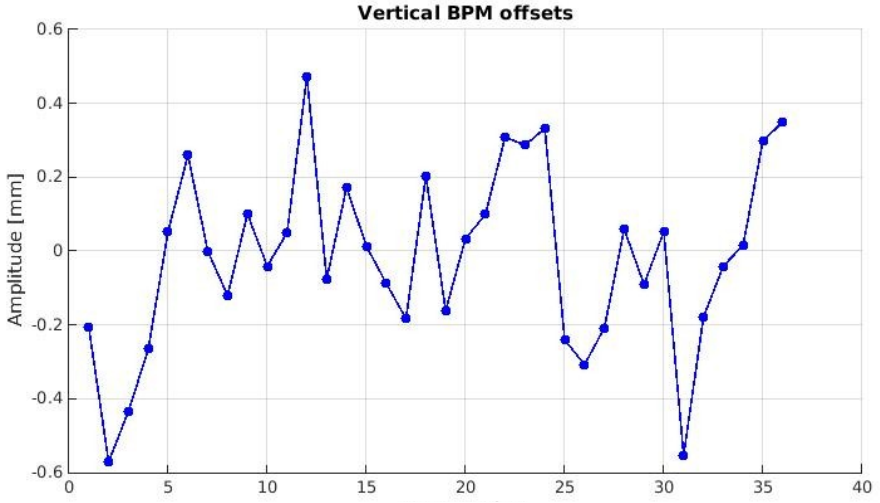
...for example last week

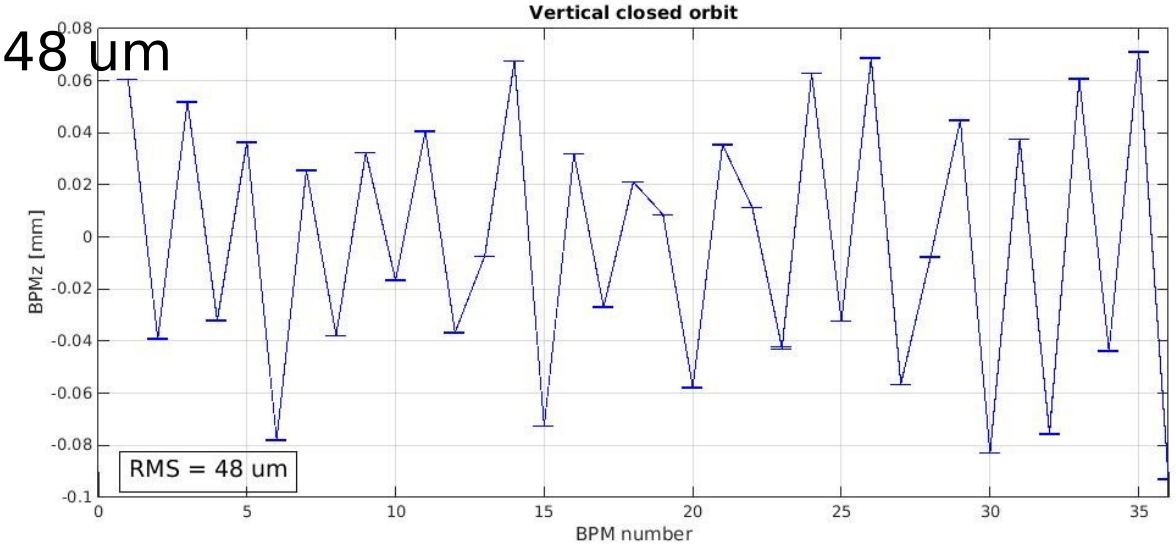
Closed orbit - BBA

- Beam Based Alignment was performed to optimize the SVD based global orbit correction

- All offsets are < 0.6 mm

- RMS of vertical closed orbit was decreased from 170 um (before BBA) down to 48 um



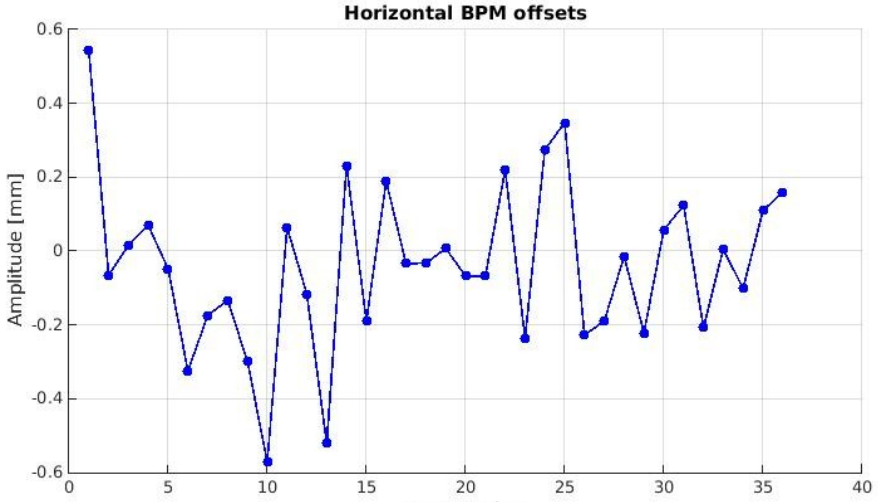


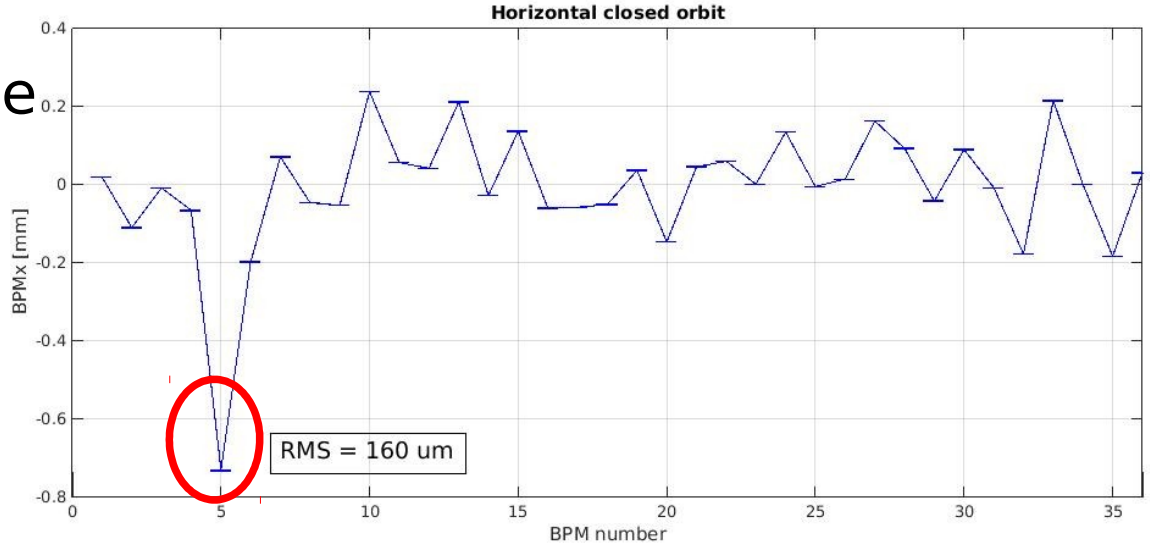
Closed orbit - BBA

- Beam Based Alignment was performed to optimize the SVD based global orbit correction

- All offsets are < 0.6 mm

- RMS of horizontal closed orbit was **NOT** decreased due to huge ''*misalignment*'' in the centre of DBA2





What was the cause of this problem?

DBA2 investigation

- This achromat is a **prototype** one and differs from others (different manufacturing process, performance).

- It does not seems to affect the optics, but it has some consequences in orbit correction.

- It was corrected in software by applying fixed **offset** to the **BPM.**

Final closed orbit

After few BBA iterations:

Horizontal RMS:

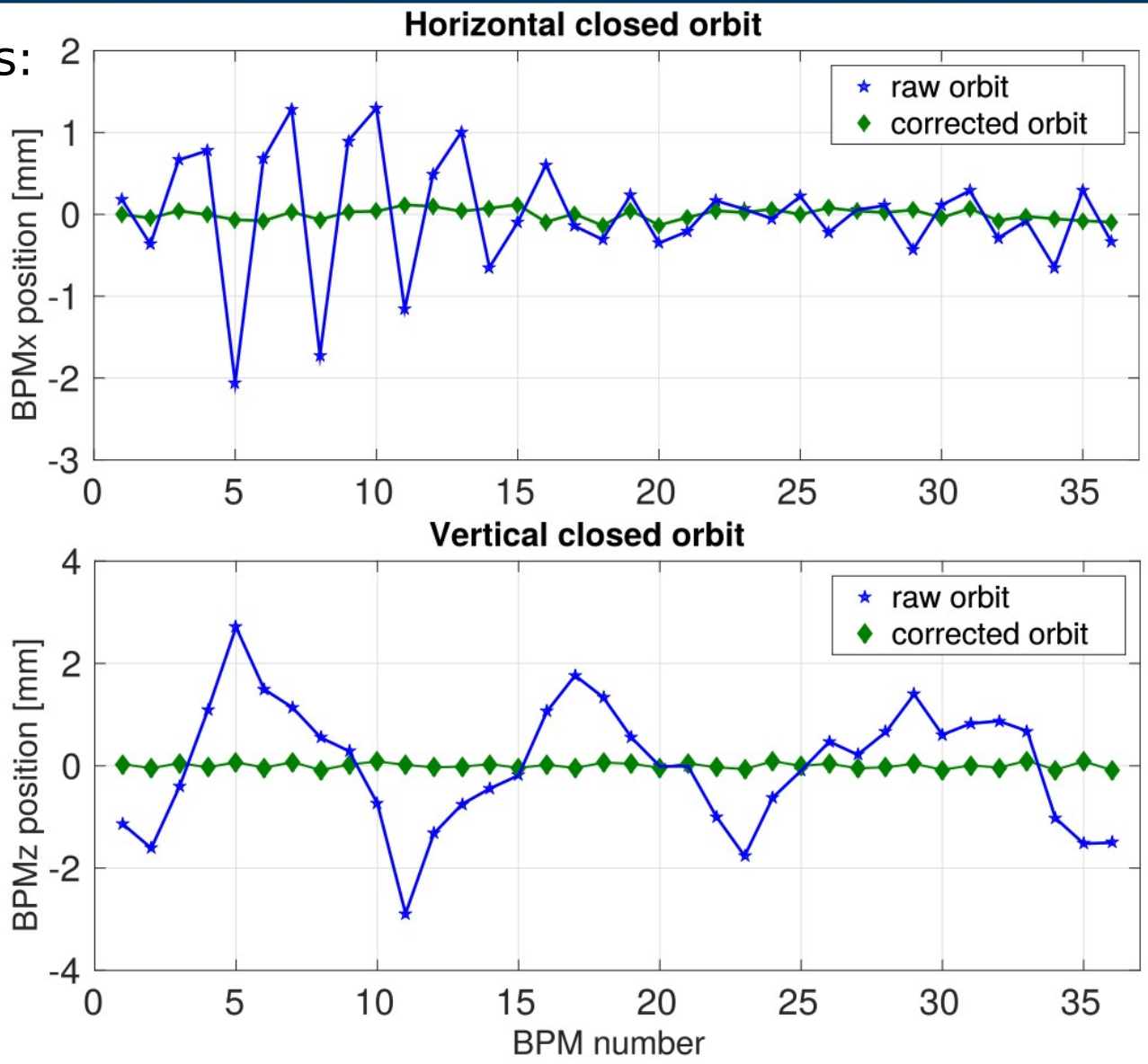
from **700 um**

to **66 um**

Vertical RMS:

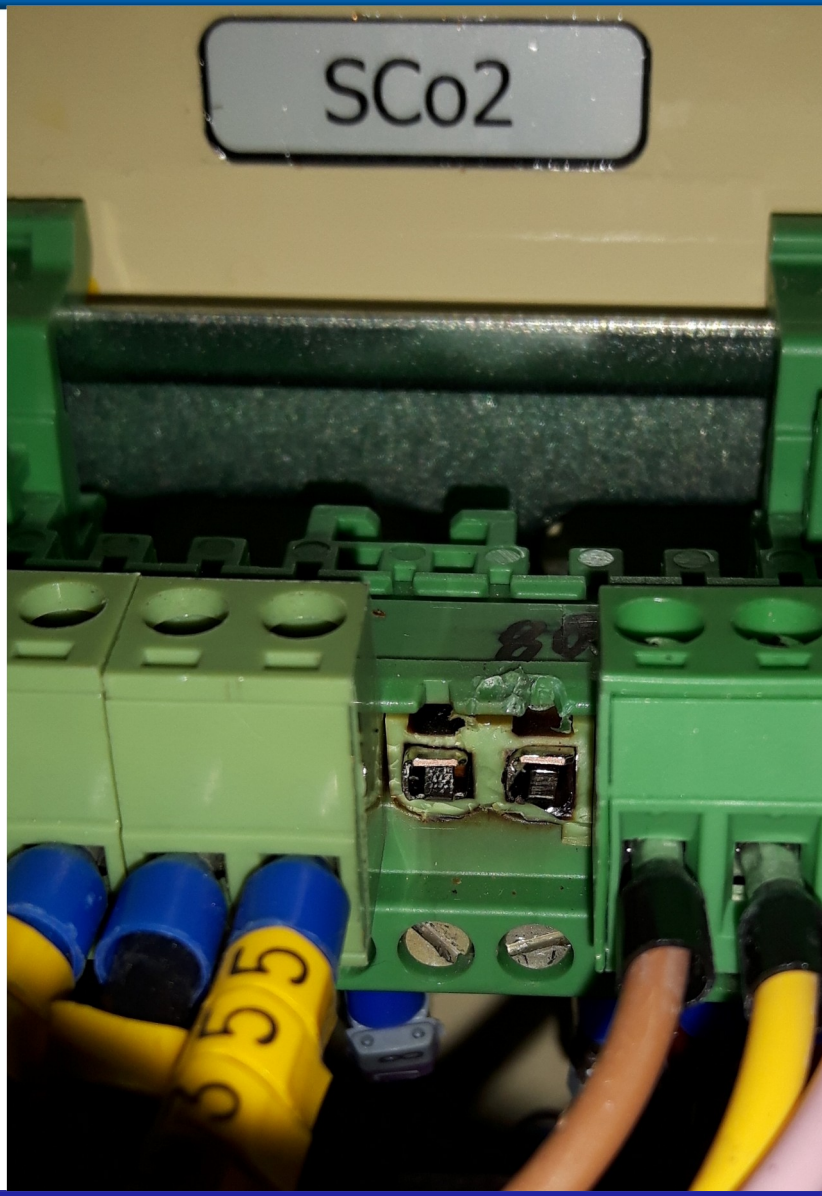
from **1090 um**

to **52 um**



Consequences

- one corrector magnet is operating at almost full current (**9.8 A/10 A_{max}**)
- global orbit correction stops after some time (few hours max.) due to exceeding 10 A current limit on power supply
- connector on DBA was **burned** and shielding were **melted** – all connector pannels should be **replaced**.



Other malfunction

- **Shunting** resistor plate had to be **changed** because original design were not suitable for the power dissipation.

- Shunting of DBA2 is needed to be reconsideren in order to compensate the difference of this achromat relative to others

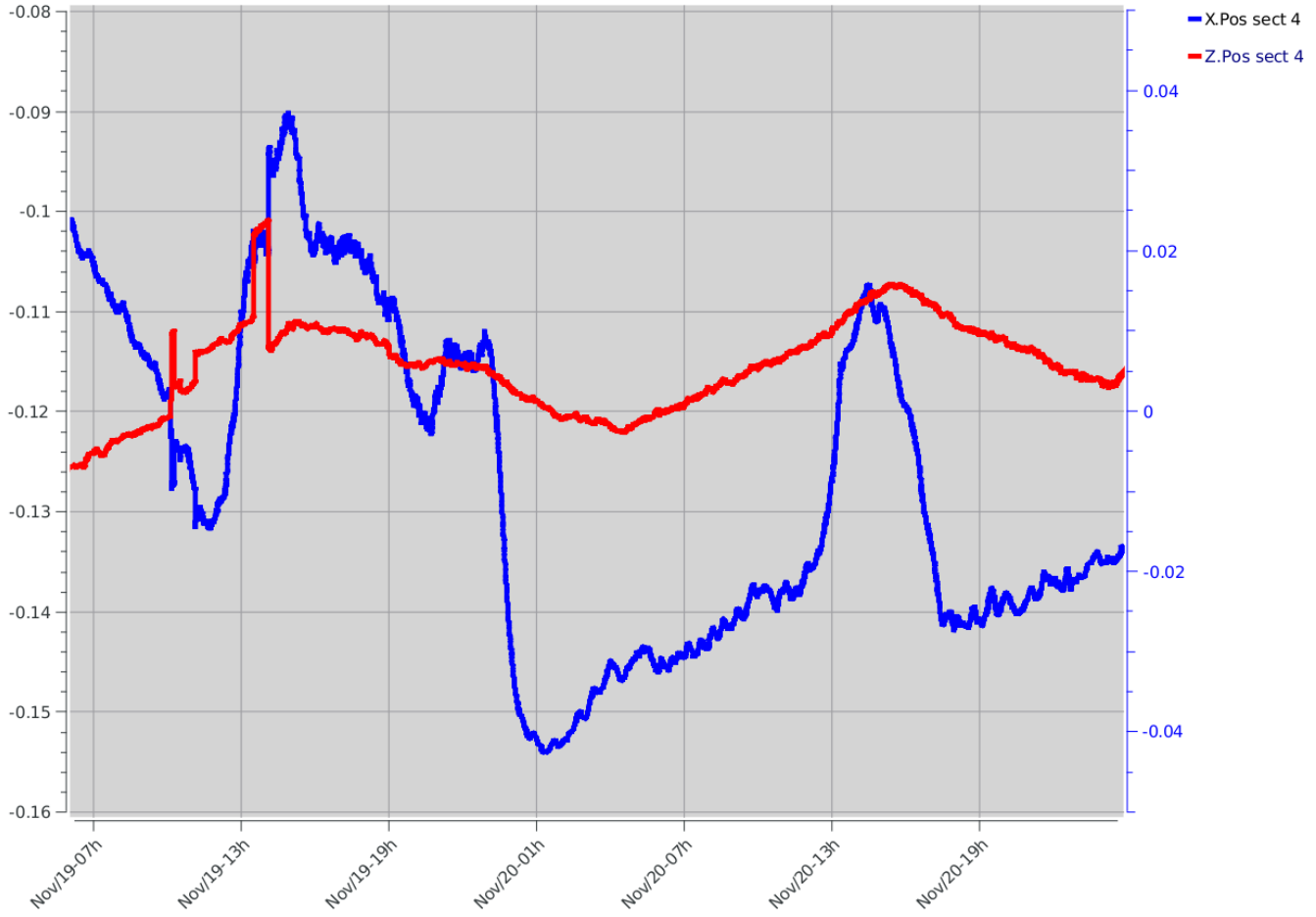
Orbit drift

Automatic orbit correction switches off during beam decay what causes long-term orbit drifts as presented on the picture:

Beam decay for **36 hours**:

- Horizontal drift: **~65 um**

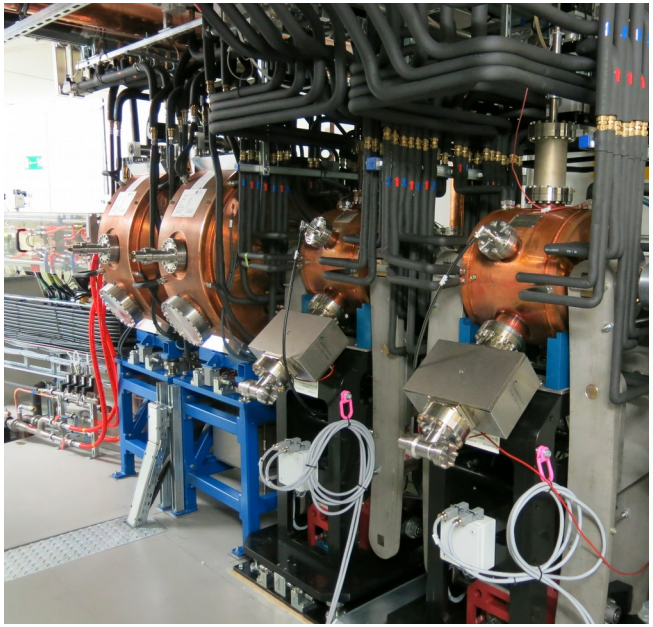
-Vertical drift: **~27 um**

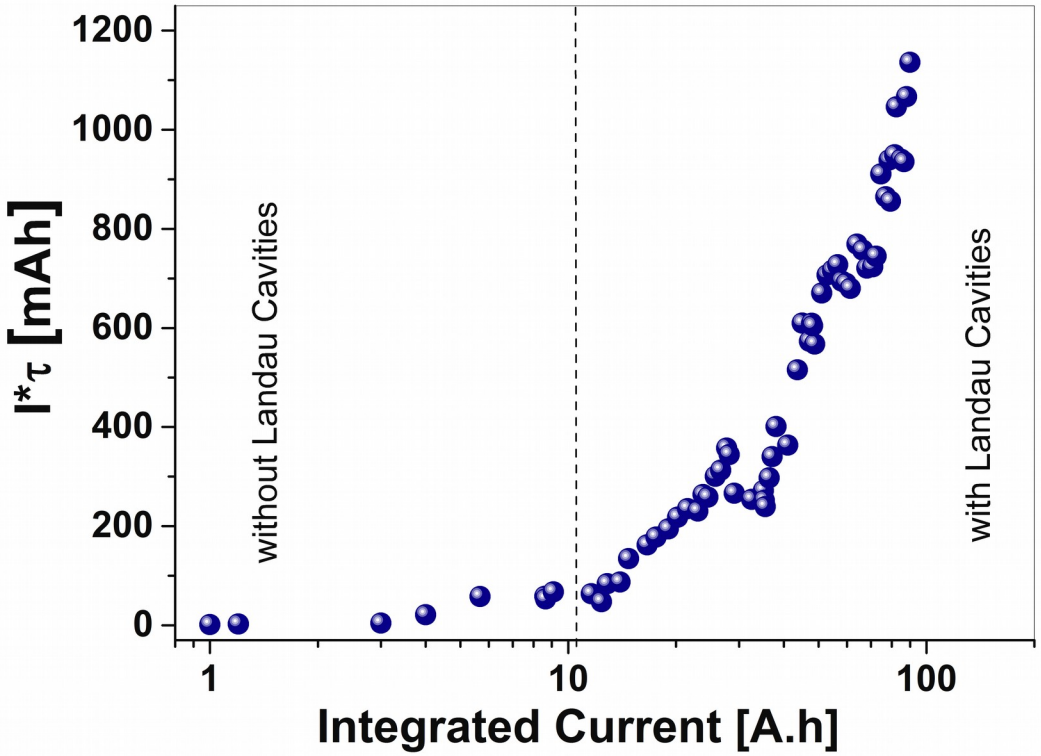


Landau cavities

- two 3rd harmonic (300 MHz), normal conductive Landau cavities were installed to dump longitudinal instabilities and improve beam lifetime

- passive cavities can be detuned from the resonance by insterting the plunger





Tuning Landau cavities

- Two types of tuning mechanisms are used in Landau cavities: **endplates** (slow detuning) and **plunger** (fast detuning).
- Plungers can be moved in the range from **0 mm** (extracted) to **80 mm** (inserted).
- This allows to change the frequency by **600 kHz** above the resonance.
- Now, with extracted plunger, Landaus are tuned **30-60 kHz** above the 3rd harmonics of main cavity.
- Proper Landau tuning is very difficult due to no possibility to measure bunch length or shape (diagnostic beamline needed)

Tuning Landau cavities

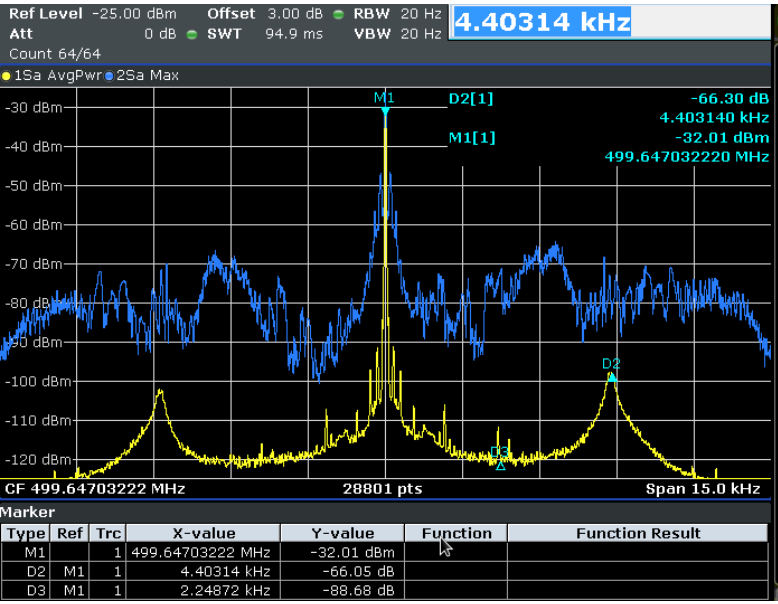
- Without Landau Cavities- bunch lenth is ~**1.5 cm**.

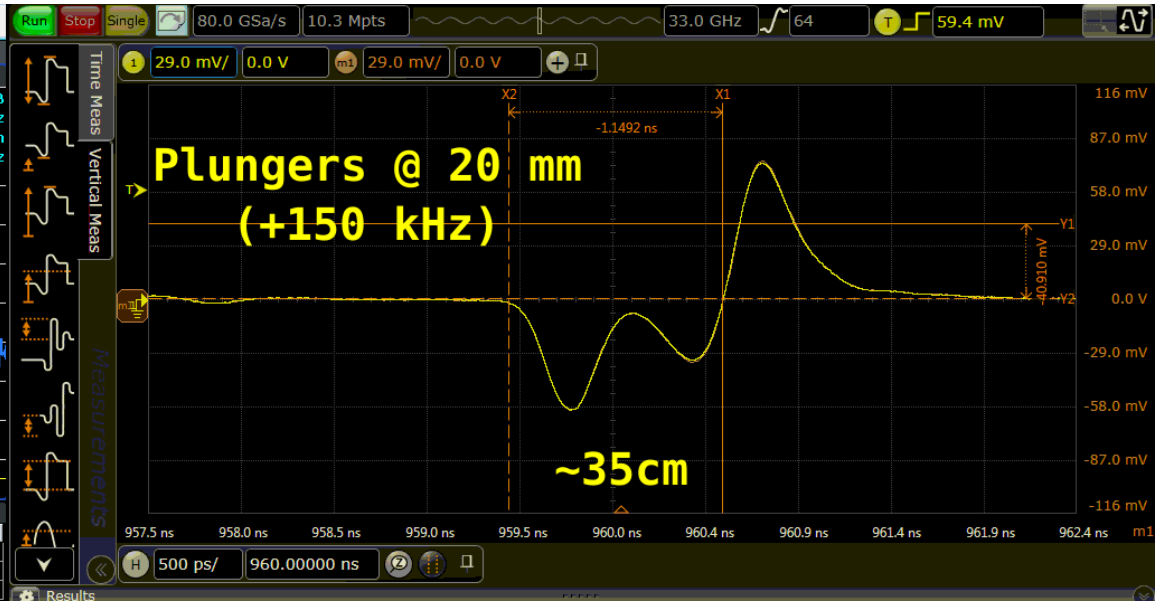
- Signal from pickup indicates ~10 times more (button BPM with long cabling seems not be suitable for measuring high frequencies)

Beam signal spectrum around 500 MHz (left) and single bunch pulse in time domain (right)

Tuning Landau cavities

- Signal **width increased** and **shape influenced** by detuning toward 3rd harmonic, beam **lifetime increased** (from 6hr to 9.5 hr)
- Less sidebands on the spectrum



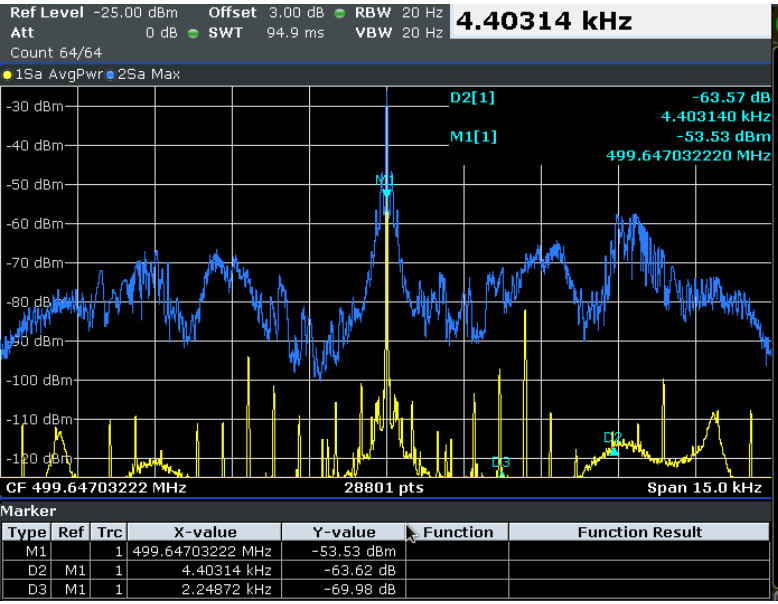


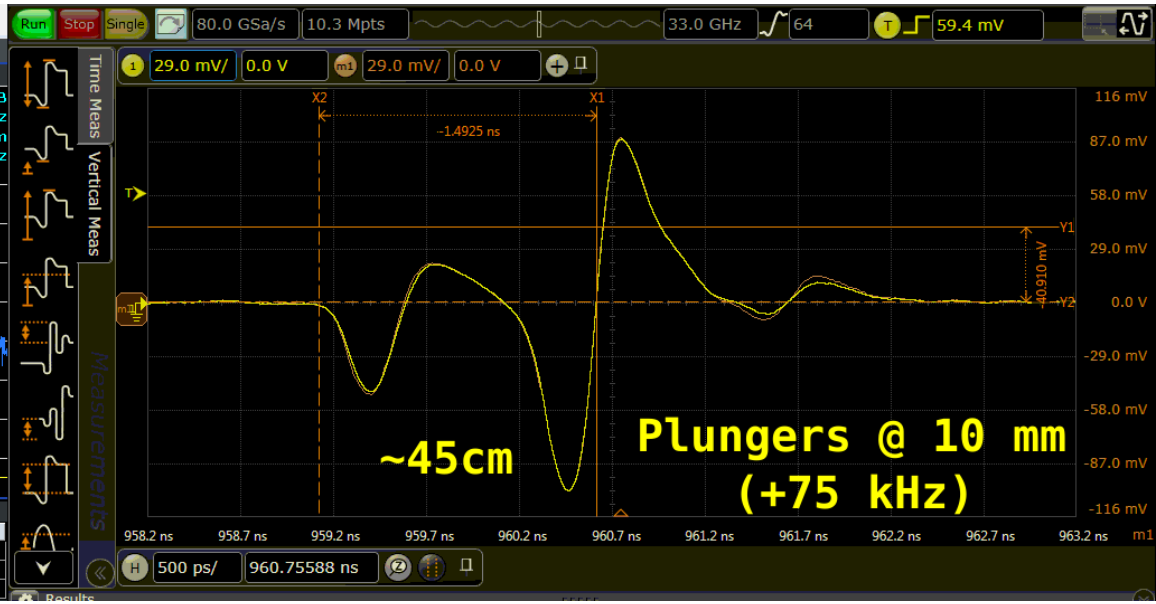
Beam signal spectrum around 500 MHz (left) and single bunch pulse in time domain (right)

Tuning Landau cavities

- Signal width increased and **bunch splitted(?)**, beam **lifetime decreased** (from optimal 9.5 hr to 7 hr)

- A lot of sidebands on the spectrum

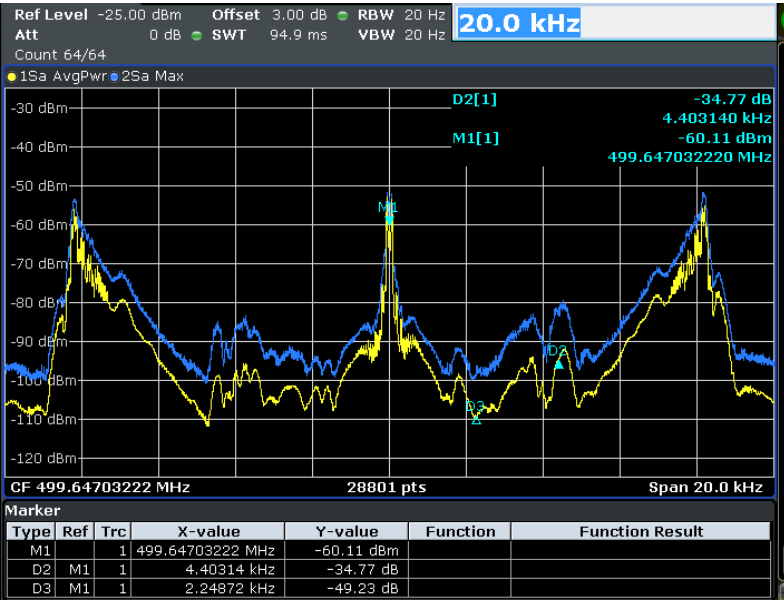


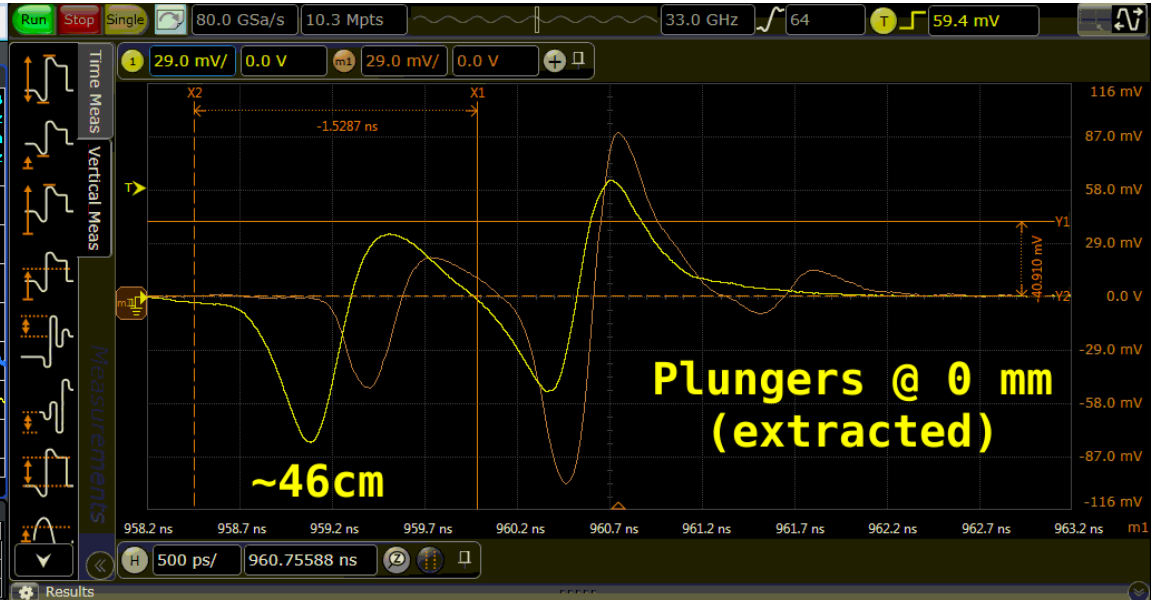


Beam signal spectrum around 500 MHz (left) and single bunch pulse in time domain (right)

Tuning Landau cavities

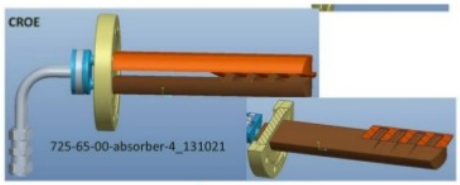
- Signal width increased and **bunch splitted and far apart(?)**, beam **lifetime increased** much more than at 20 mm (**9 hr** with plungers @ **20 mm**, **13.5 hr** with plungers @ **0 mm**)





Beam signal spectrum around 500 MHz (left) and single bunch pulse in time domain (right)

Vacuum system

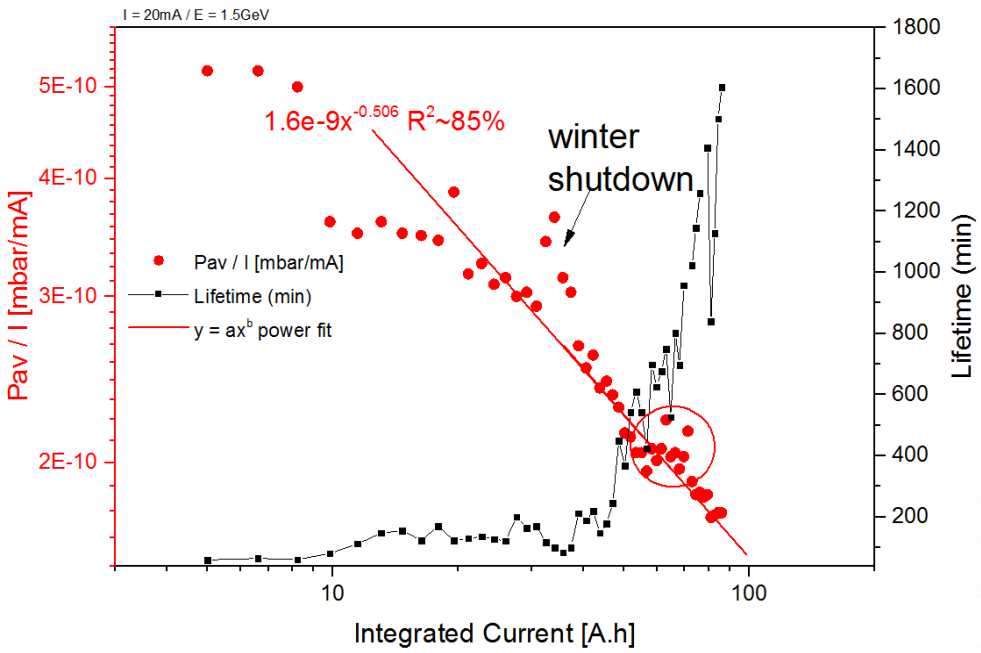


Poor vacuum in straght sectins.

Conditioning very slow and non efective.

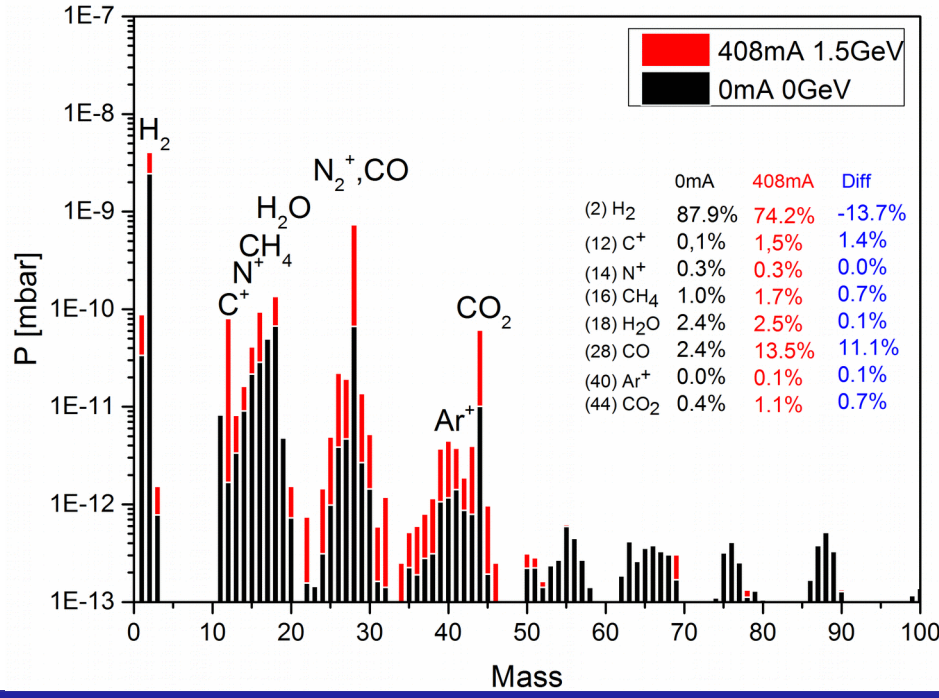
SIP – Sputter Ion Pump

Vacuum system



Installation of Landau cavities during the winter shutdown and commissioning start marked with red circle

H_2 has major impact on gas composition. During normal operation with the beam H_2 decreases and CO increases.

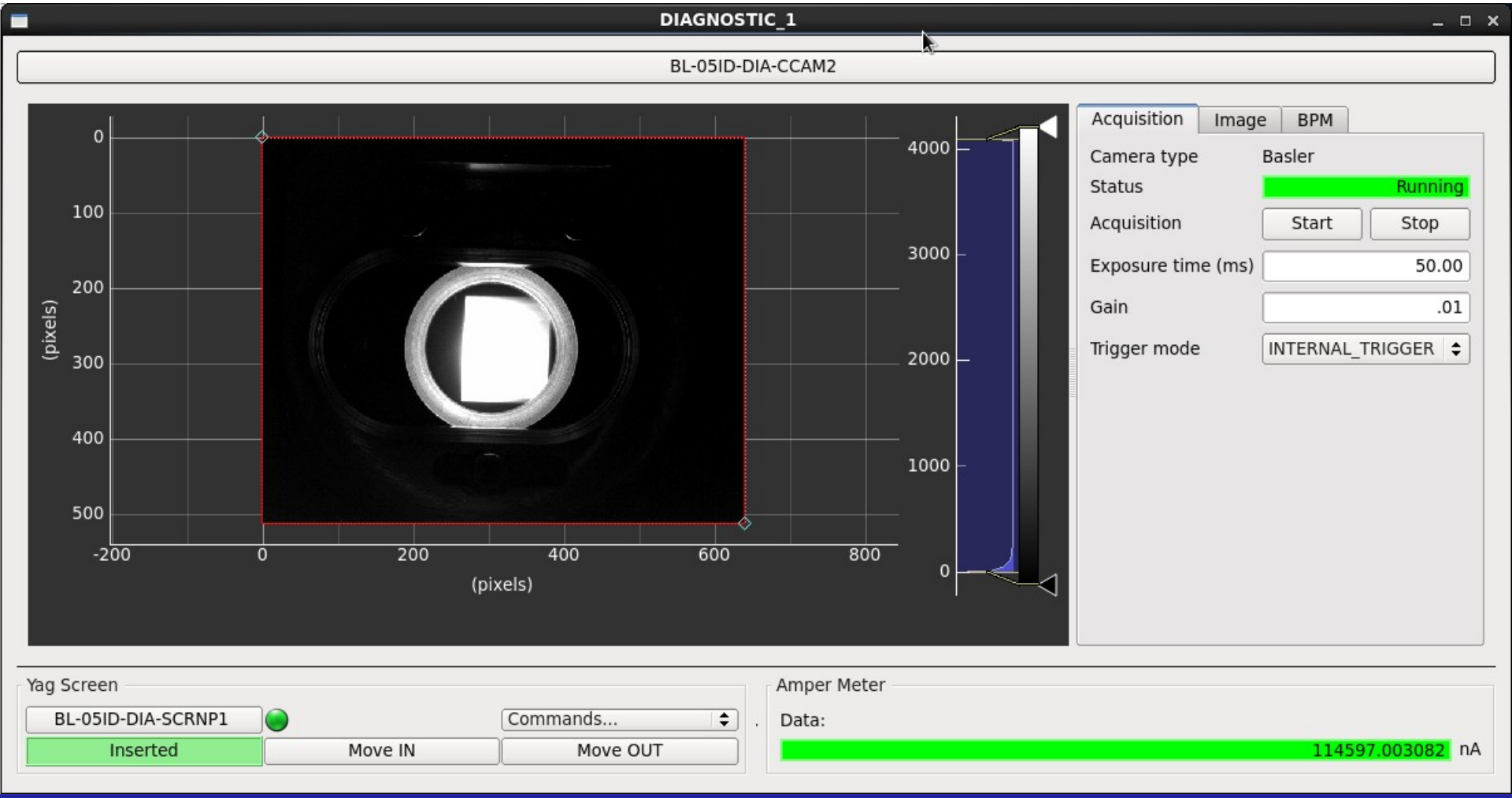


UARPES beamline

UARPES beamline parameters

Source	Elliptically polarizing undulator (EPU) APPLE II type, quasiperiodic	Magnetic period length: 120 mm
Available energy range	Total NIM PGM	8–100 eV 8 eV–30 eV 16 eV–100 eV
Light polarisation	Linear vertical, linear horizontal, circular, eliptical Linear skewed	For the linear skewed polarisation the lower energy limit is 12 eV
Resolving power (RP)		20 000
Beam size at sample (H x V)	NIM PGM	350 µm x 60 µm 270 µm x 30 µm
Photon flux at a sample		min. 5 x 10^{11} photons/s @ 20 000 RP
Available techniques		Angle-resolved photoelectron spectroscopy (ARPES) at sample temperature 8–500 K, low energy electron diffraction (MCP-LEED), Auger electron spectroscopy (AES)
Electron spectrometer energy resolution		1.8 meV
Angular resolution		0.1°
Available sample preparation techniques		Cleaving, thermal annealing up to 1800 K, Ar^+ ion bombardment, thin firm growth, surface reactions in the gas phase

22.04.2016 first light after first mirror!



UARPES first results

JAGIELLONIAN UNIVERSITY IN KRAKOW

SOLARIS NATIONAL SYNCHROTRON RADIATION CENTRE

SES 3D Viewer

Survey

Survey

View Data

Energy [eV]-Thetax [deg]-Thetay [deg]

Low High

Yellow Hot

Valid Region

0 100

2d-planes (complementary axis)

Energy [eV]

Thetax [deg]

Thetay [deg]

Data Axes

Thetay [deg]

First 0.0789795

Last 0.0789795

Thetax [deg]

First 1.90307

Last 1.90307

Energy [eV]

First 42.705

Last 42.705

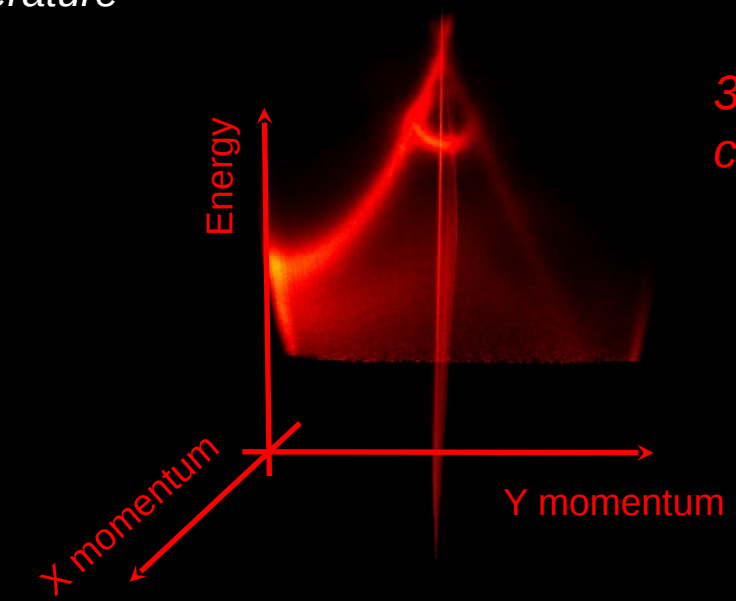
Export...

Show Info

```
High Energy=44.5
Energy Step=0.035
Step Time=882
Detector First X-Channel=1
Detector Last X-Channel=1024
Detector First Y-Channel=1
Detector Last Y-Channel=1000
Number of Slices=1000
Energy Offset=0
File=C:\Users\LabComputer\Desktop\Test
\Graphen0041.pxt,.ibw,.txt
Sequence=D:\SES_1.4.0-r25_Win64 Package\SES_1.4.0-
r25_Win64\Sequences\factory.seq
Spectrum Name=Survey
Instrument=DA30L-9ES211
Location=Solaris
User=Solaris
Sample=Graphen
Comments=
```

First angle-resolved experiment at the UARPES beamline…. Graphene on SiC(0001) – Dirac cone

Mean ring current: 40 mA
Photon energy 50 eV
3D mode – time 4h 30 min (full dataset)
Electron energy resolution ~20 meV
Room temperature



3D projection film coming….

Piotr Ciochon, Mariusz Garb, Karolina Szamota-Leandersson, Jacek Kolodziej

Future plans

1. Second beamline (PEEM/XAS) is being preapared to open for the synchrotron radiation.
2. Next beamline PHELIX (soft X-ray beamline) was founded in May 2016 and the construction has started – operation in 2020
3. Old MAX-Lab beamline I1011 transferred to Solaris – waiting for financial support for installation
4. Application for money for next two beamlines (Infra red beamline and hard X-ray beamline)
5. Start of user operation in 2017
6. Accelerator studies:
   - LOCO
   - Touschek lifetime
   - Beam instabilities
   - Dynamic aperture

Future plans

7.Increasing the performance of the storage ring: much more accumulated current, better vacuum conditions, more stable beam.

8. Installation of HOM filters

9. Machine improvements: completing the chopper, changing pickup in main cavities to non-ceramic, diagnostic beamline, emittance measurement setup etc.

Summary

- After one year of commissioning a good performance of the Solaris light source has been achieved.
- **Injection** to the storage ring occurs at **525 MeV** and the **beam is ramped** to the operating energy of **1.5 GeV**.
- The **injection efficiency** has been improved reaching now **20%** and is still under optimisation.
- The **maximum injected current** achieved at **525 MeV** has been **596 mA** at the **filling pattern** of **2/3.**
- The **maximum current** ramped to the final energy of **1.5 GeV** is above **400 mA** due to poor performance of the ceramic gap in main cavity pickup.
- The optics was corrected close to the design one. However some adjustments are still needed.
- Next step is to calculate the linear optics from the orbit (LOCO) and optimise the beta functions with the UARPES EPU in operation.
- Taking into account the closed orbit – some of the magnets need realignment, which should improve the orbit and relax the corrector strengths.
- **Commissioning of UARPES** beamline in progress

Thank you
for your attention!