XXIII European Synchrotron Light Source Workshop

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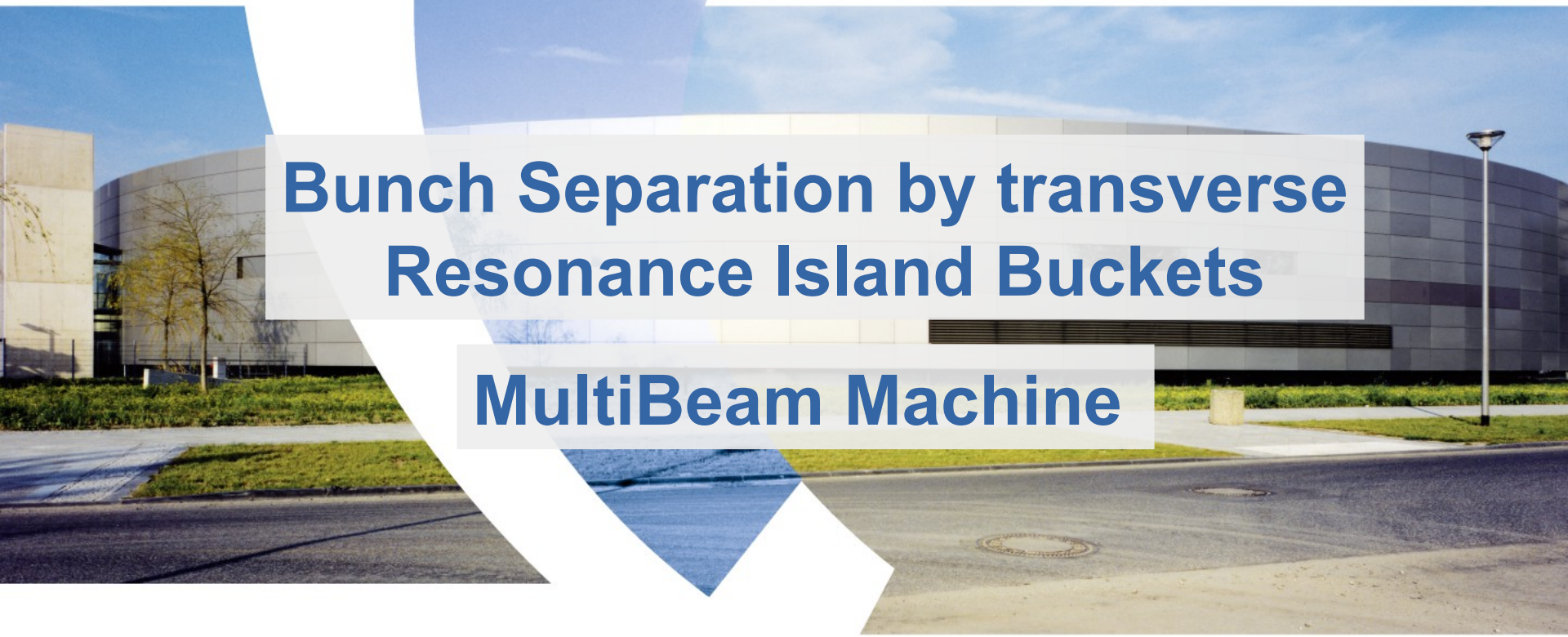

Bunch Separation by transverse Resonance Island Buckets

MultiBeam Machine

P. Goslawski, M. Ries, G. Wüstefeld and HZB acc. team
Helmholtz-Zentrum Berlin

XXIII ESLS Workshop
23rd – 25th November 2015
SLS - PSI, Villigen, Switzerland

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Motivation

Island buckets
2nd orbit in storage rings: BESSY & MLS

Experiments at BESSY II with BeamlineManager / In-HouseUsers

Conclusions & Summary

Motivation

Motivation: User demands – Flexible fill pattern

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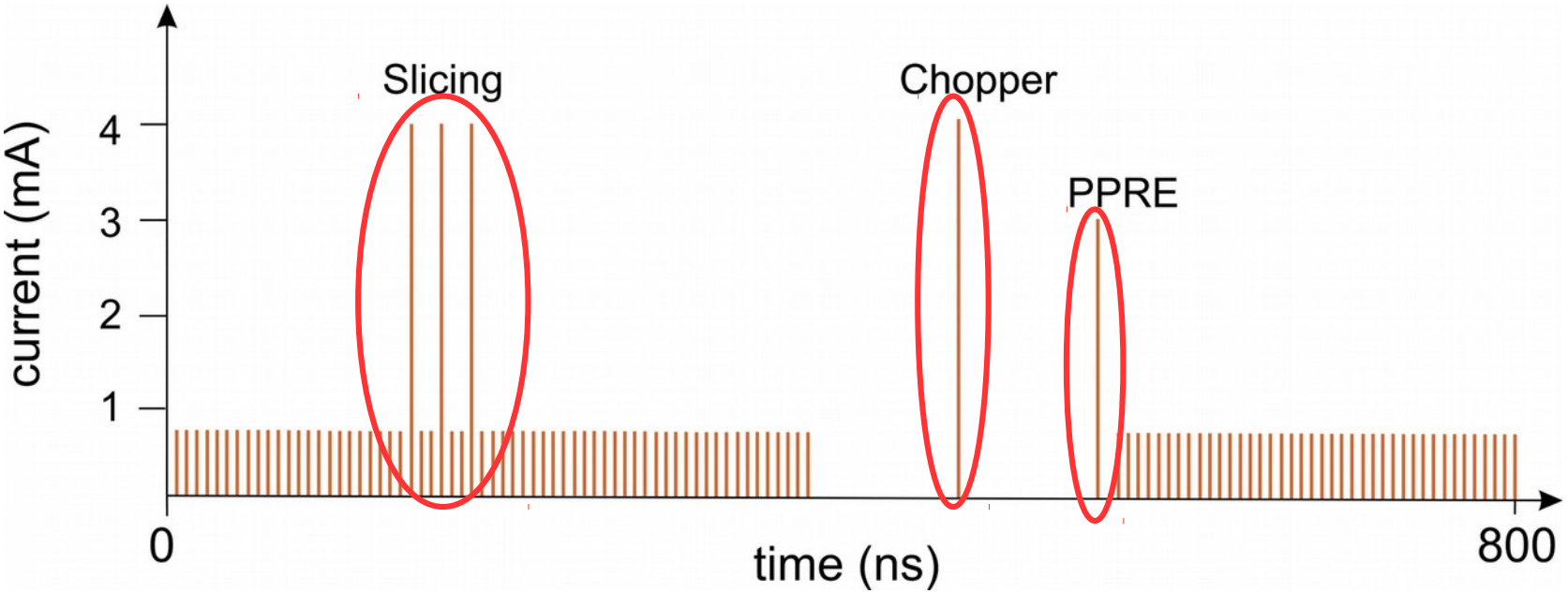
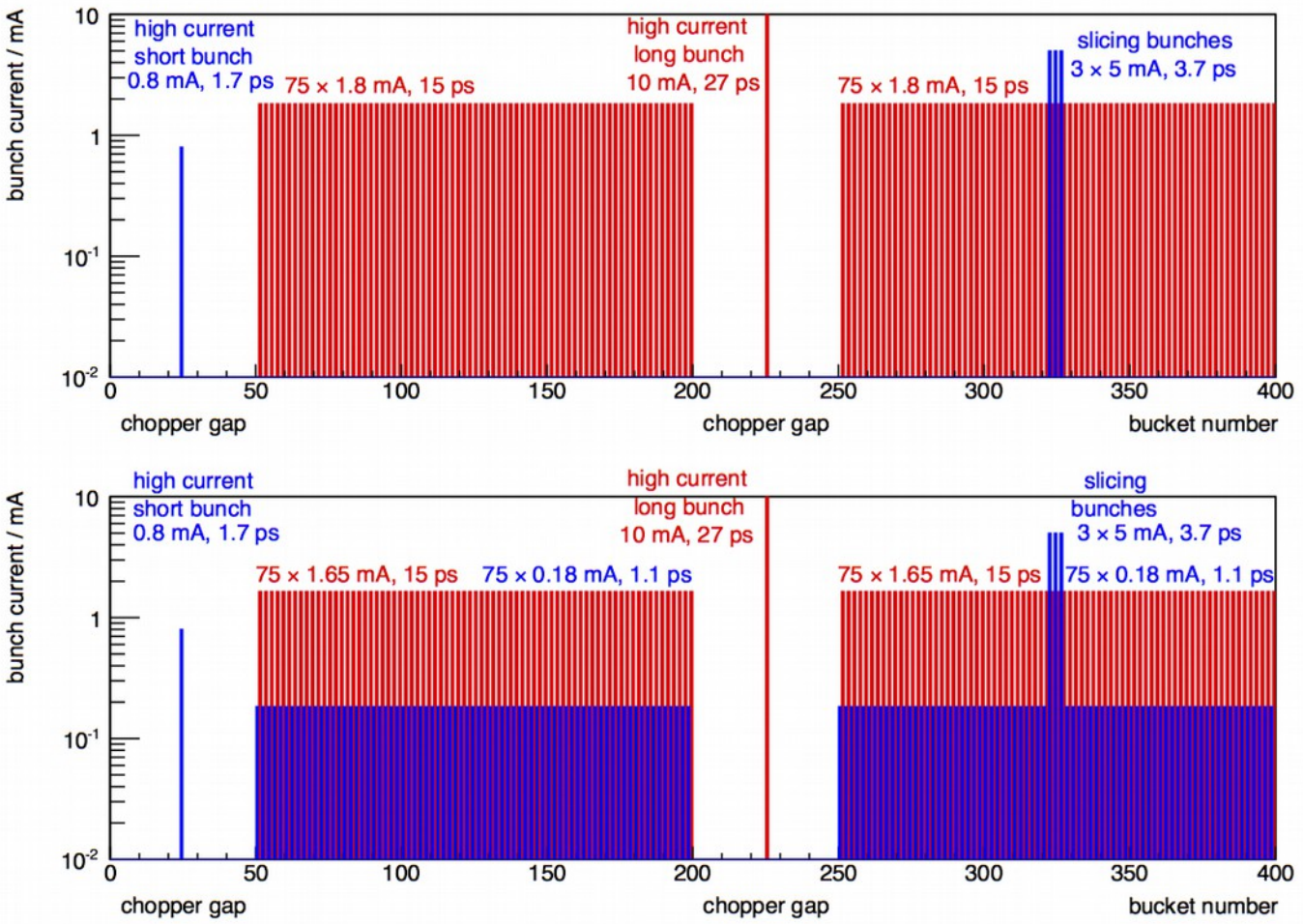
BESSY II fill pattern - standard user mode



- MultiBunch train of 300 buckets > Average brilliance
- SingleBunch in ion clearing gap > Time resolved exp.
- Pulse Picking Resonant Excitation > ARTOF (reduced intensity)
- Slicing bunches > Ultra short γ pulses

Motivation: VSR fill pattern – more flexible



Separation of different photon pulses !

Motiviation: Separation of different photon pulses … or electron bunches

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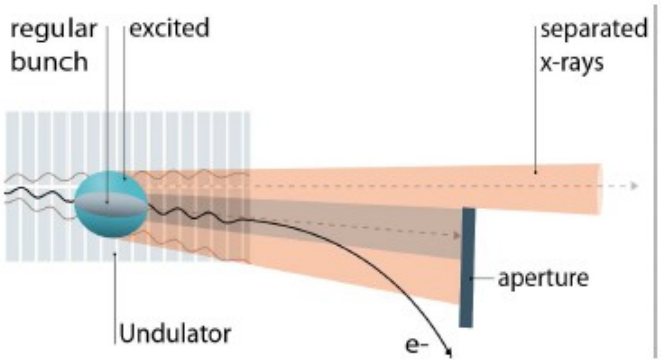
Dynamic methods
→ disturbing

1. Pulse picking, established!
   ARTOF at UE52 and UE56/2

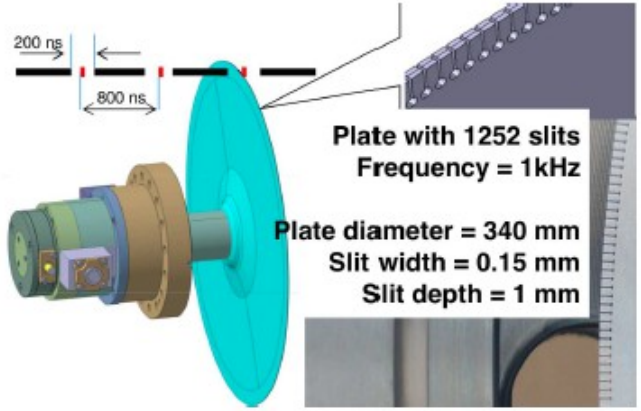


K. Holldack et.al., Nature Com. 5, 4010, 2014

2. Pulse excitation
   → Fast kicker
   → Transverse deflecting cavity

Static methods
→ non-disturbing

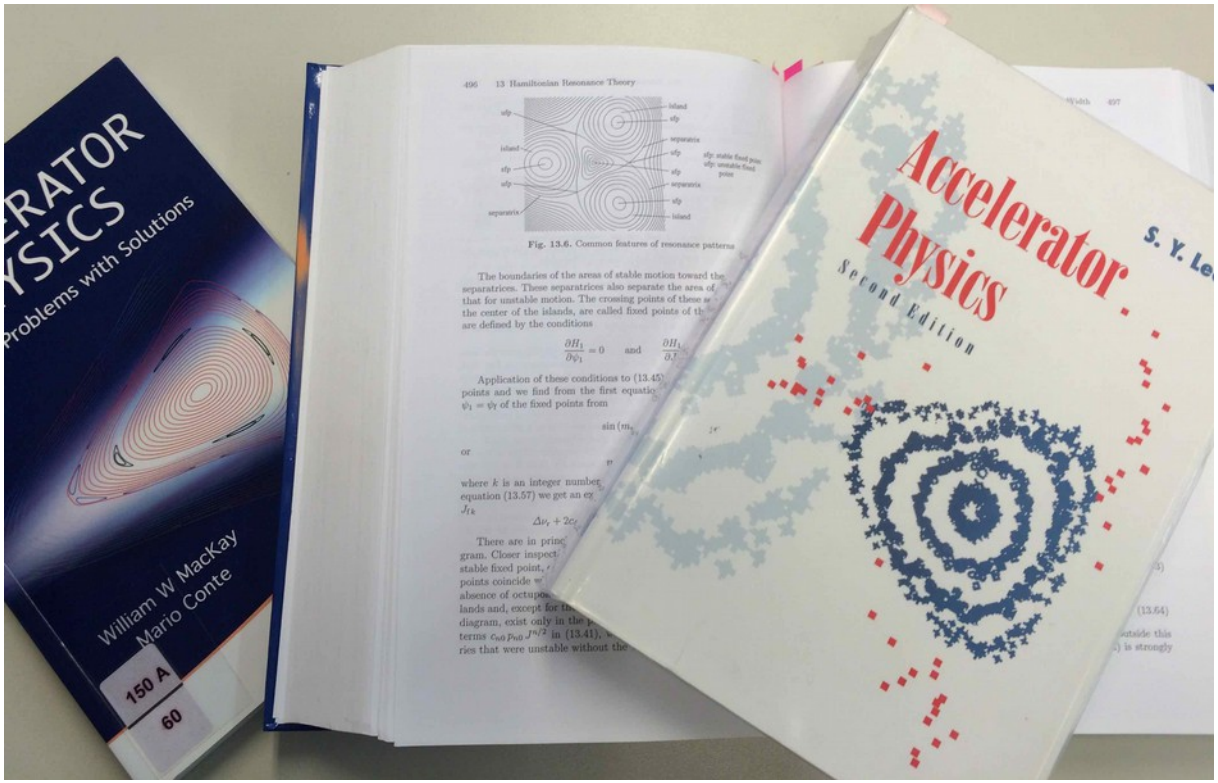
1. Chopper system, established!



FZ Jülich and BESSY

2. **Resonance Island Buckets**
   → **Next slides**

Motivation: Island buckets - Not really new!



No app. at Lightsources

- Do not store beam on resonance

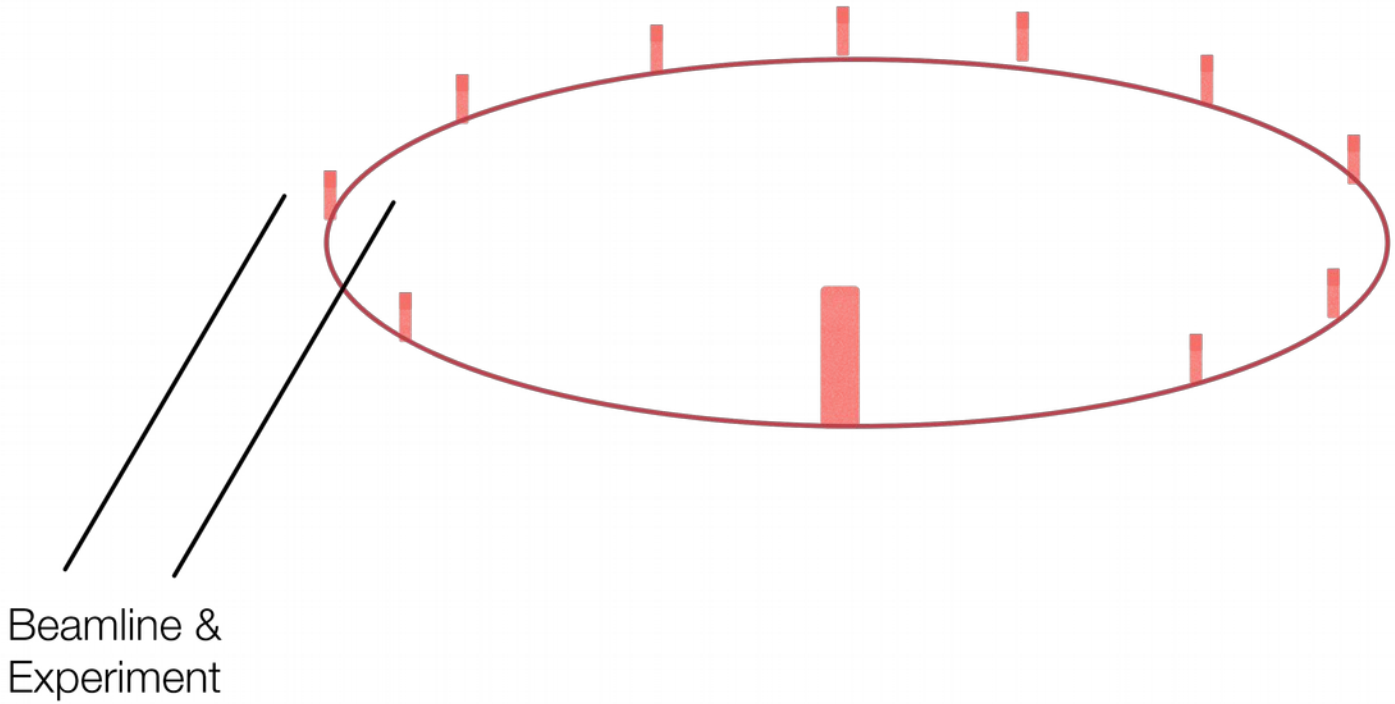
- "Accelerator operators are keen to avoid low order strong resonances because of visibly short lifetime."
- "Accelerator physicists are eager to to apply their skill to correct or compensate the resonance for minimizing their effects on the **beams**."

- Known app. at hadron acc: MultiTurnExtraction
  R.Cappi and M.Giovannozzi, "Multiturn extraction and injection by means of adiabatic capture in stable islands of phase space", Phys. Rev. ST Accel. Beams 7, 024001 (2004)

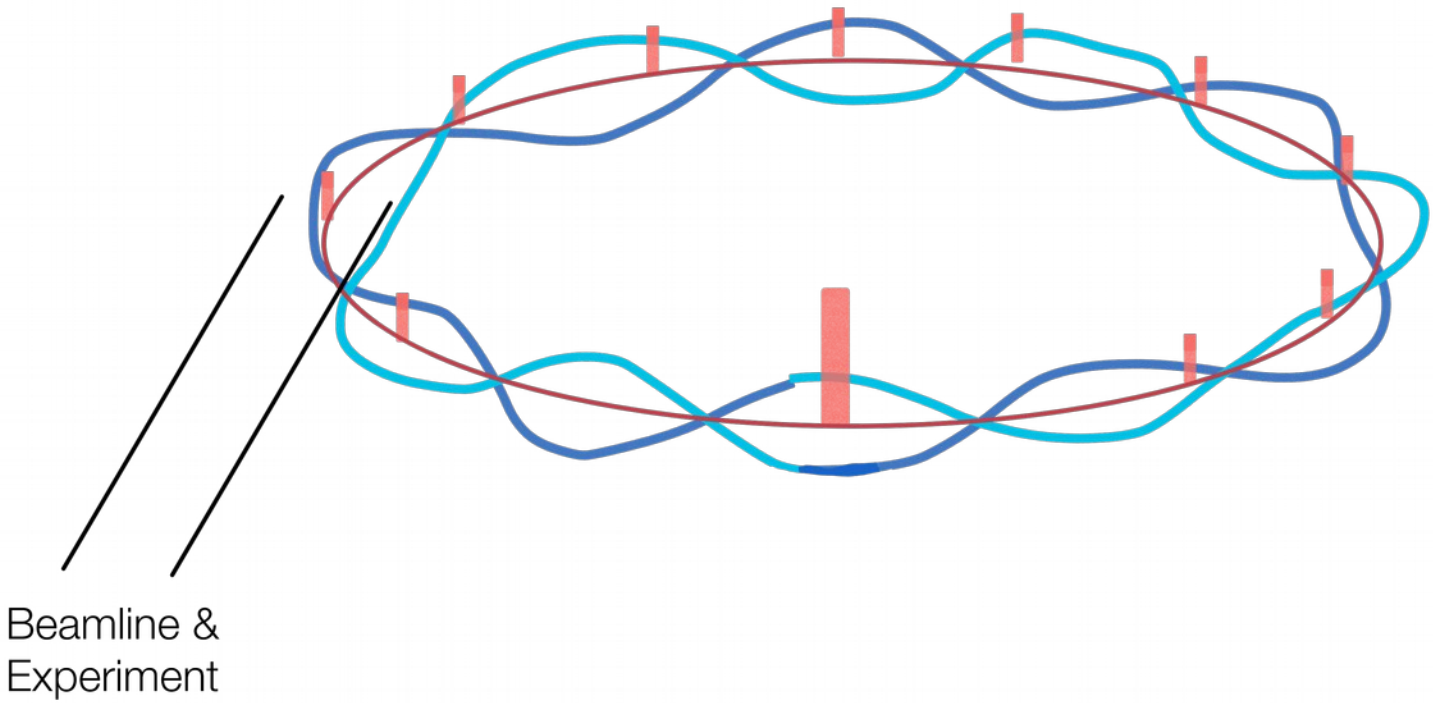
New: stable 2nd orbit for bunch separation

Aim: stable operation on resonance

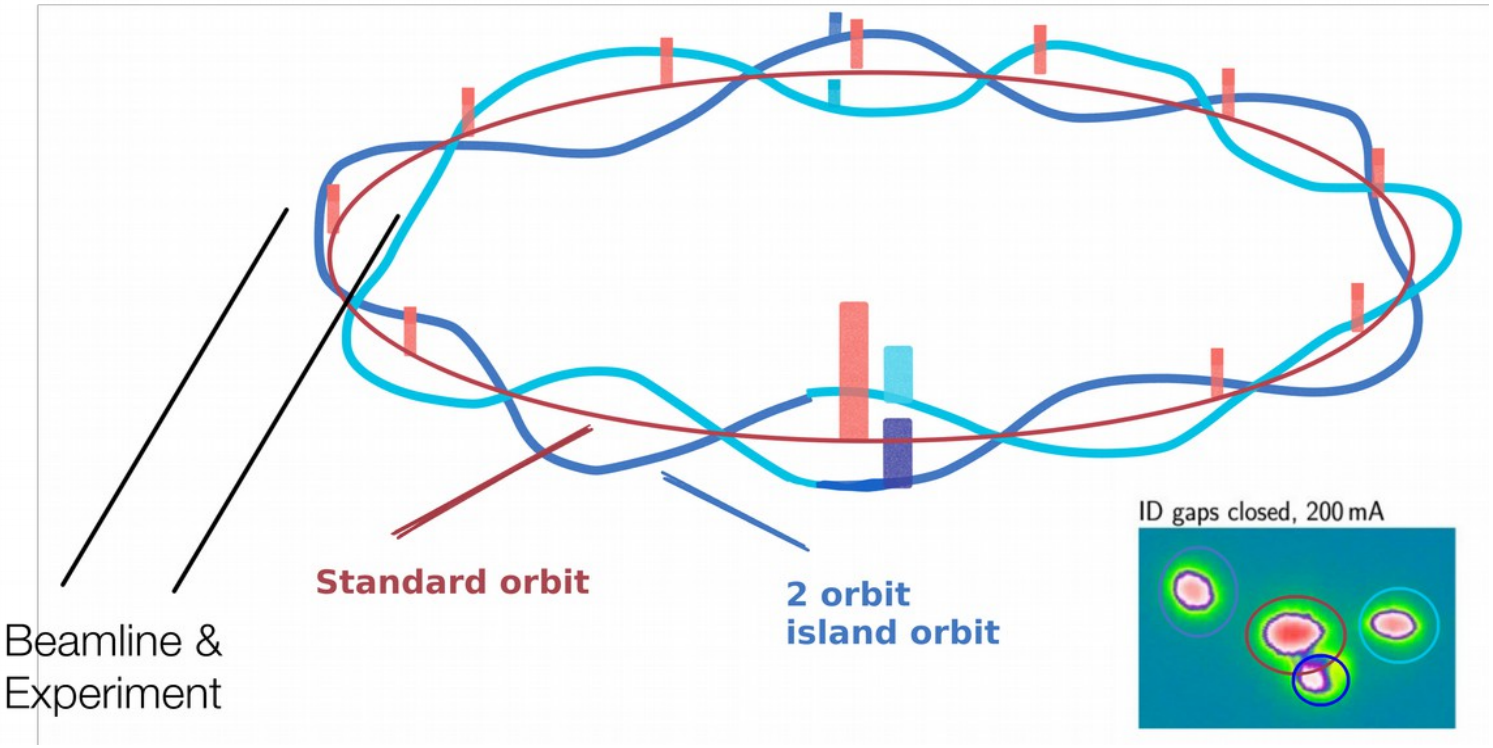
Motivation: Idea for daily operation



Motivation: Idea for daily operation



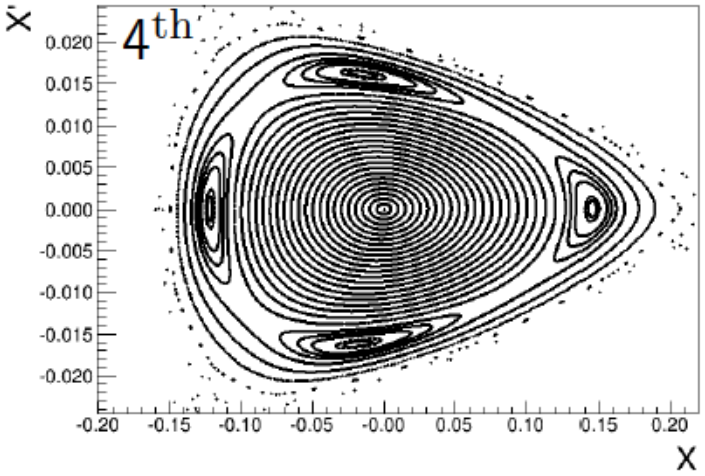
Motivation: Idea for daily operation

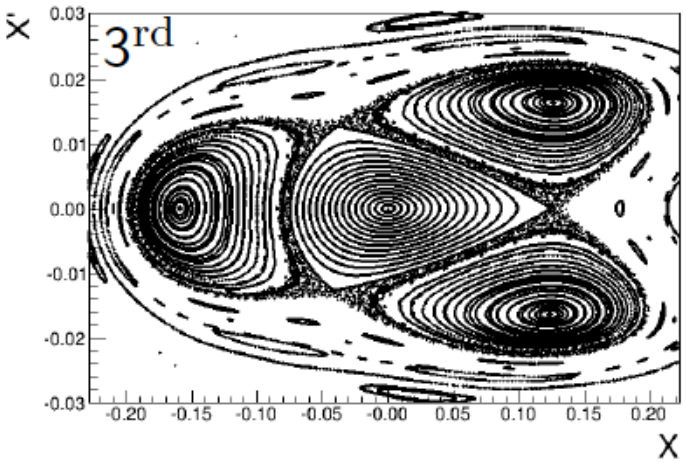


Island buckets
2nd orbit in storage rings: BESSY & MLS

Transverse resonance island buckets

(x, x') phase space simulations

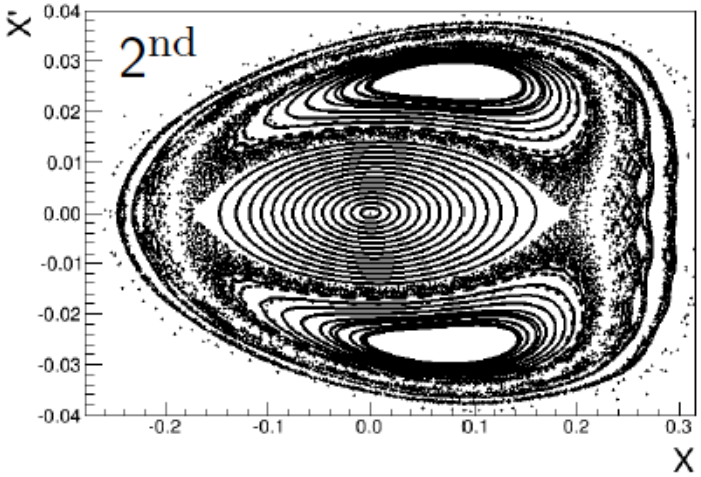




Near resonance

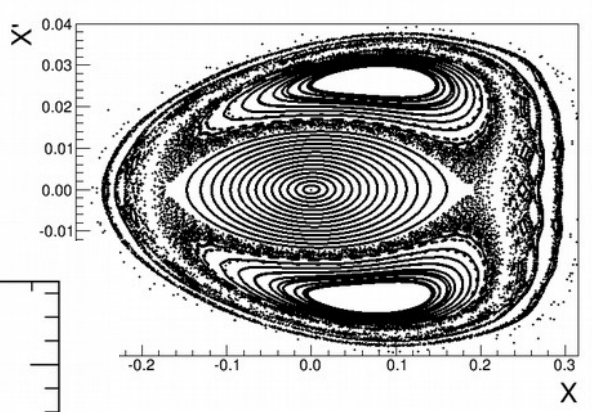
- Additional stable buckets
- Number of buckets = order of resonance

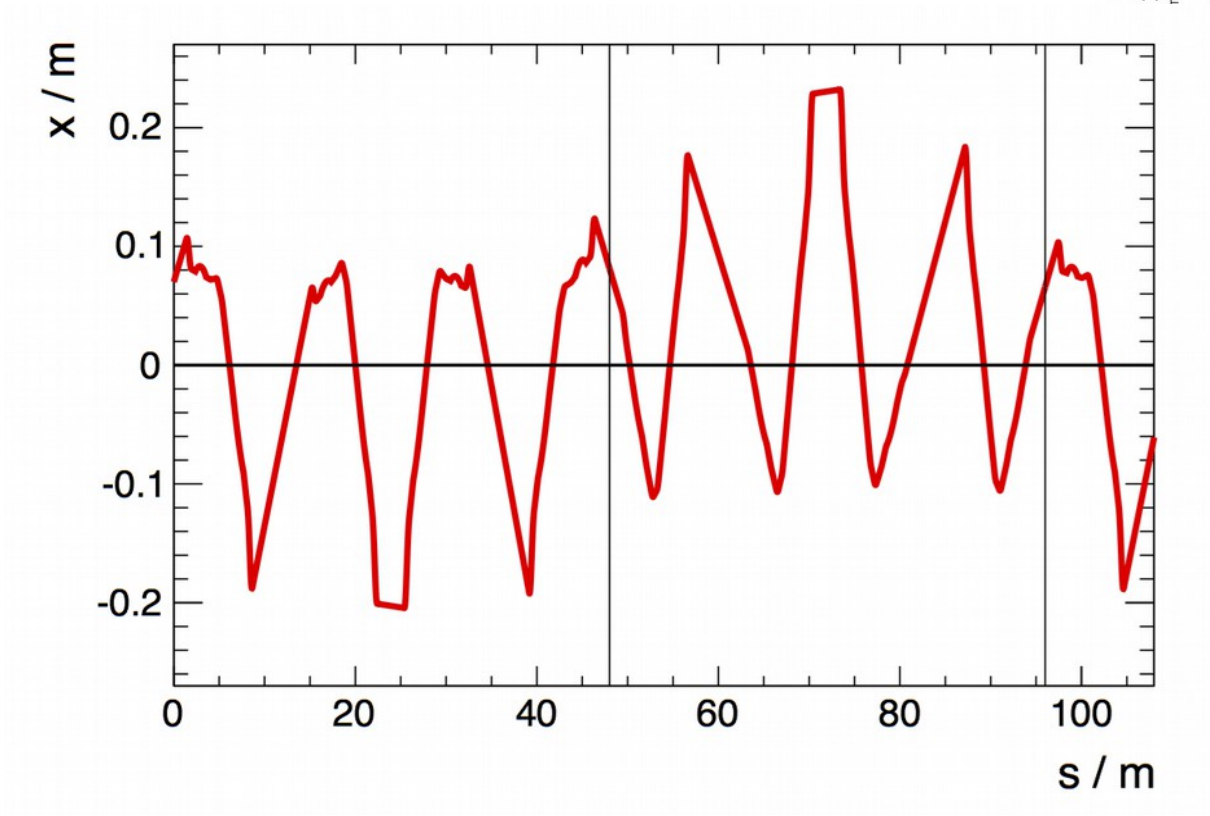
→ Transverse resonance island buckets



Transverse resonance island buckets

MultiBeam storage - orbits

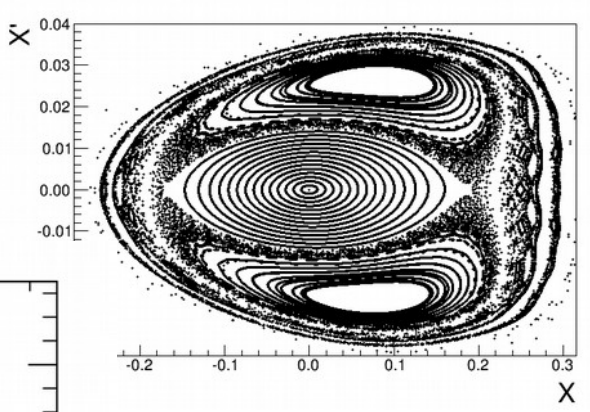


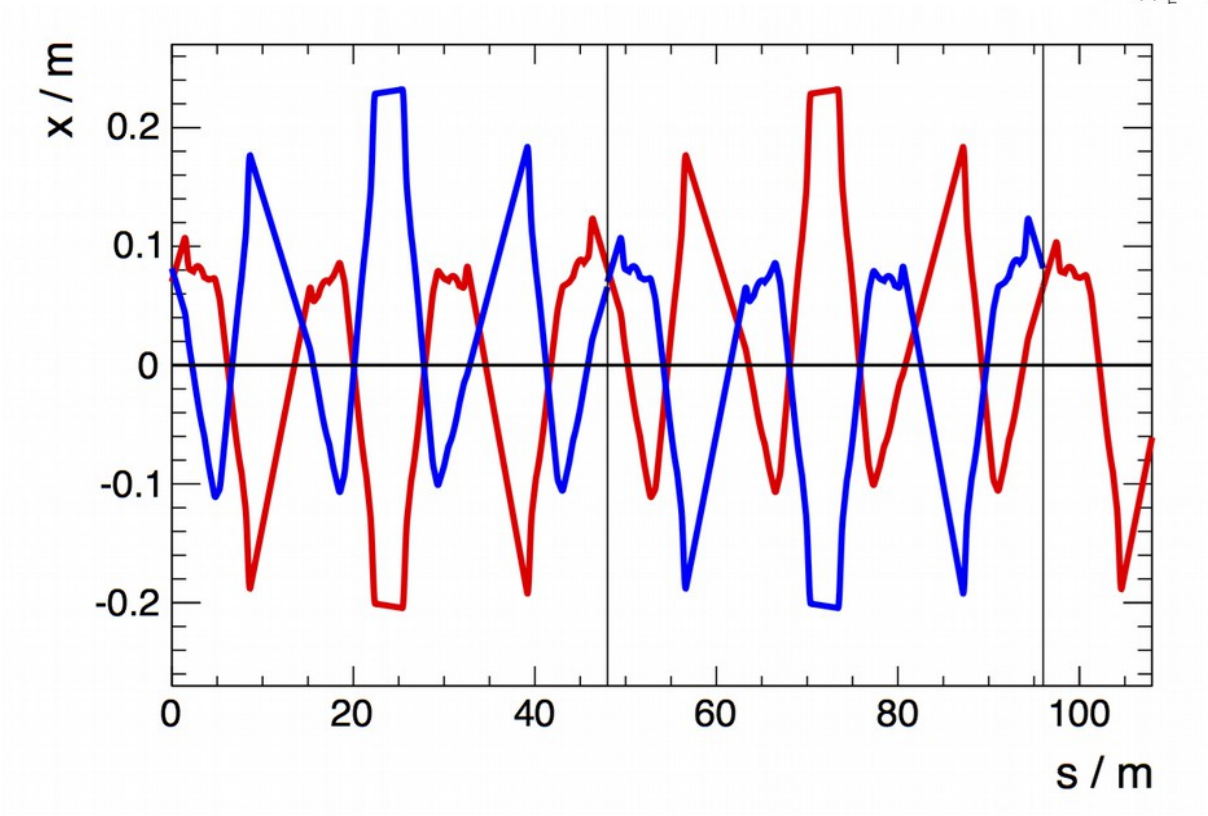


Orbit closed after two revolutions

Transverse resonance island buckets

MultiBeam storage - orbits





Orbit closed after two revolutions

Trans. res. island buckets: WorkingPoint

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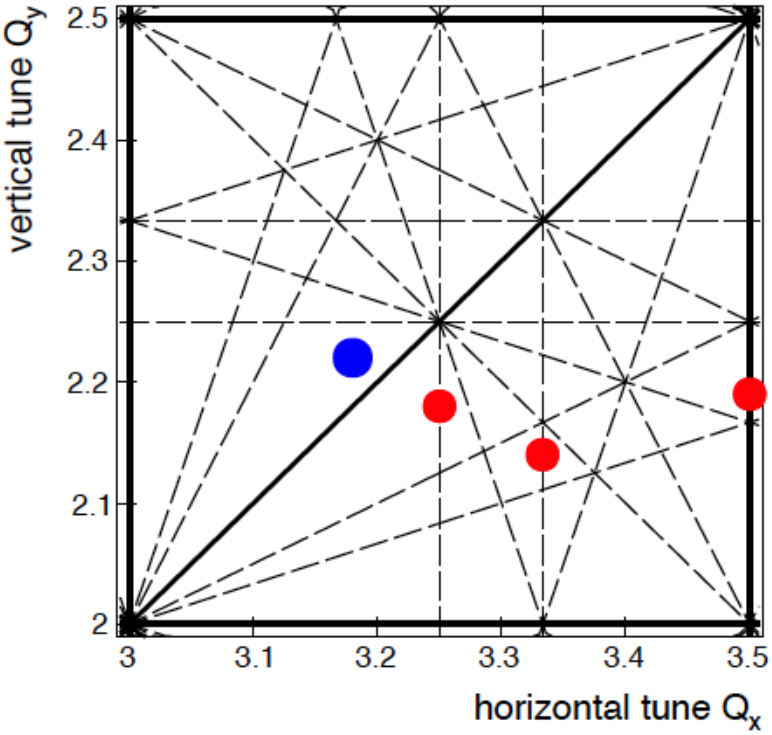
Island buckets at MLS



Operating machine close to resonance

- Only small de-tuning needed to move on resonance

→ Minor impact on linear beam optics

→ No big change of β functions and dispersion

- Working point (3.18, 2.22)
- Resonance tunes
  - 4^{th} order resonance ($Q_x = 3.25$, $Q_y = 2.18$)
  - 3^{rd} order resonance ($Q_x = 3.33$, $Q_y = 2.14$)
  - 2^{nd} order resonance ($Q_x = 3.5$, $Q_y = 2.19$)

Island buckets at BESSY
Working point (3^{rd} order)

- From (17.85, 6.74)
- To (17.66, 6.79)

Trans. res. island buckets: Source Point, Tune

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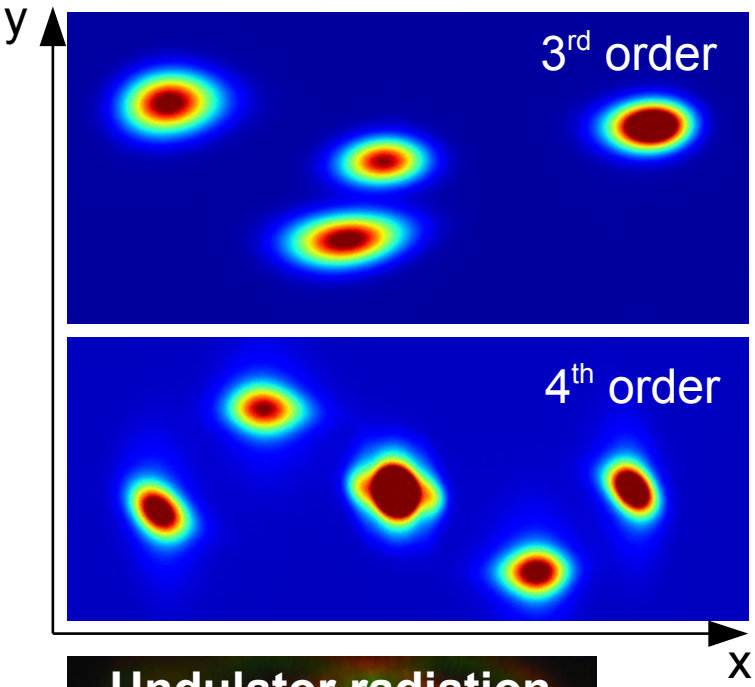
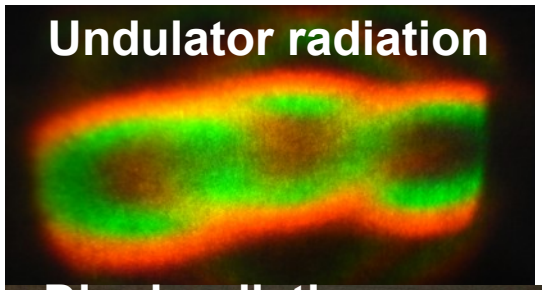
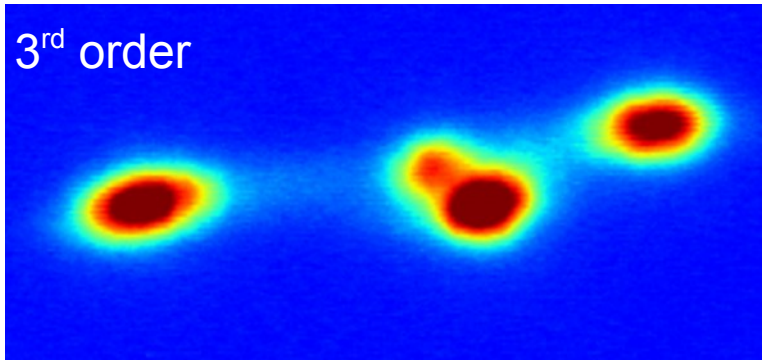
At MLS





At BESSY II

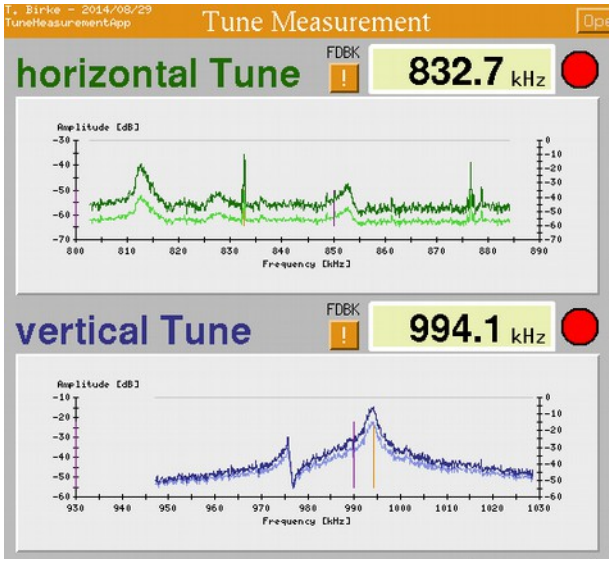


Recipe:

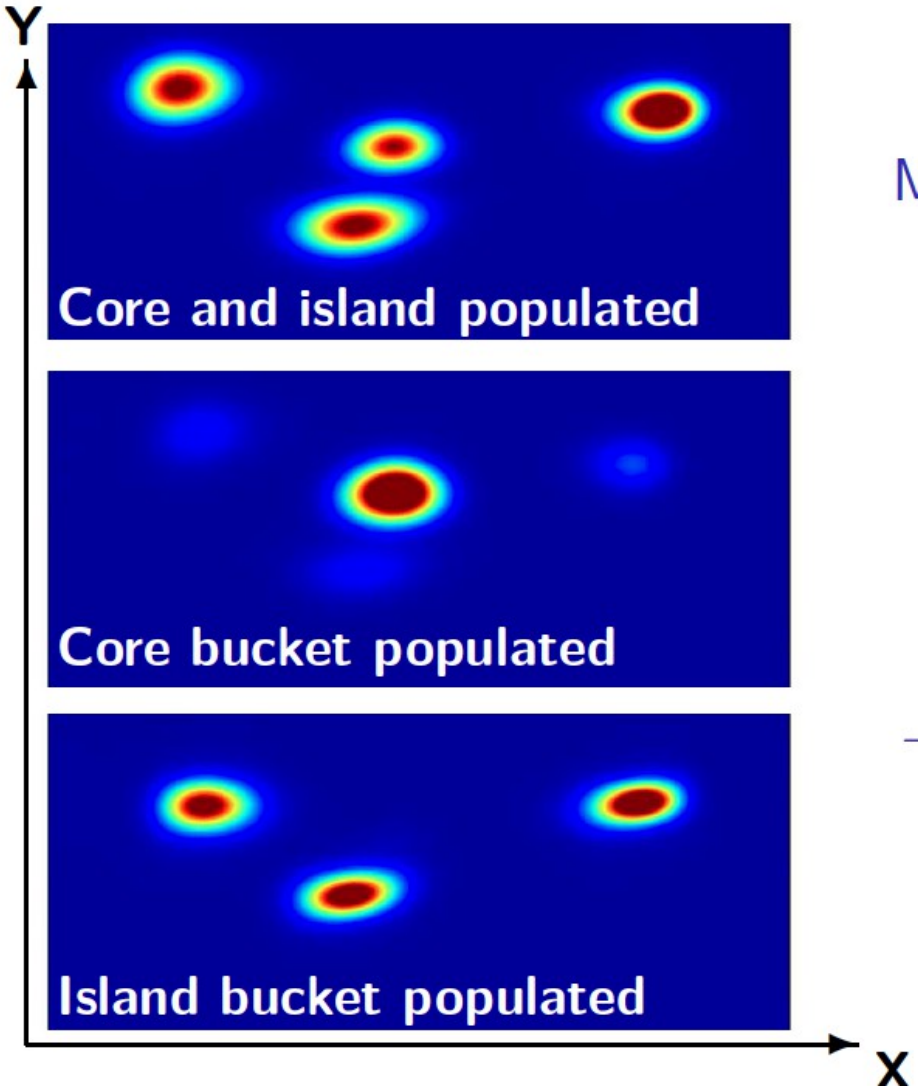
Move tune towards res. and manipulate x,x' phase space using sextupoles

> Lifetime, loss rate, source point, tune

>Tune shows Deformation near res. Sharp peak at res. Tunes of core and island different and separated by res.



Trans. res. island buckets: Current manipulation



Manipulating the buckets

- Position of islands shift by quads, sextupoles, octupoles
- Rotated by skews, i.e., x-y coupling
- Current manipulation by transverse excitation

→ Single bunch in resonance island buckets using Bunch-to-Bunch Feedback

Comparison of different machines

MLS (0.63 GeV, 100nm rad)	**BESSY II** (1.7 GeV, 5nm rad)	**???** (>4 GeV, x pm rad)
Established first user experiments	Decay mode, TopUp possible?	First tests? We are interested
Optimised for non-linear optics >Sextupoles and octupoles	2 families of harmonic sextupoles to fight resonances	Best match: very flexible lattice > non-linear elements
Large emittance > Higher diffusion rates	Medium emittance > Lower diffusion rates	Low emittance > Diffusion?

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Experiments at BESSY II with BeamlineManager / In-HouseUsers

(3 shifts with users)

Feedback needed for further development!

Towards user operation

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Define proof of principle experiment

- **Is the single bunch on island orbit useable?**
  - Focus Dipole/ID beamline on 2nd orbit
  - Purity, Diffusion rates, SNR?
  - At all beamlines at the same time?

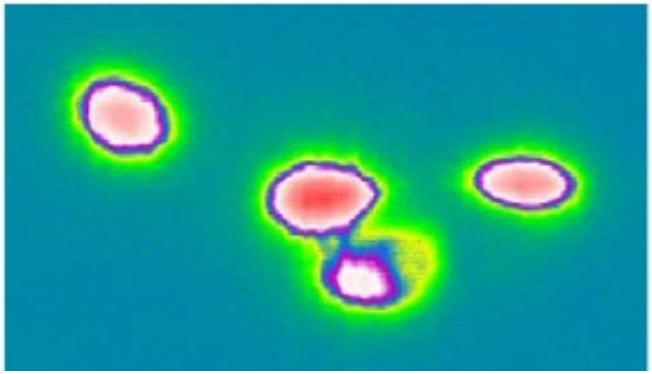
- **Difference between new WP (17.66) and old one (17.85)**
  - Negative influence of resonance:
    LT reduced by a factor of 1.8; emittance?

- **Impact of light from island orbit on standard orbit?**
  - Set up beamlines on standard orbit and then push all current to island buckets/orbit

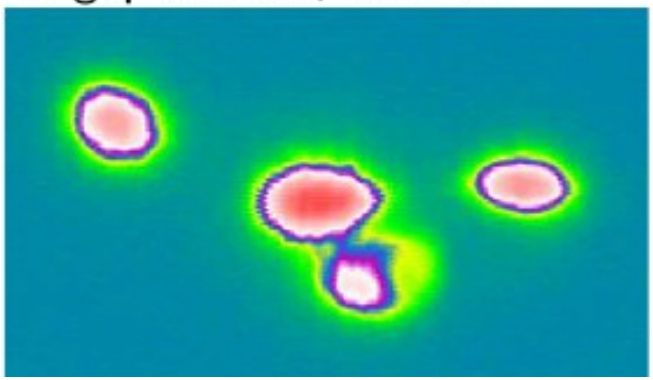
Towards realistic user operation

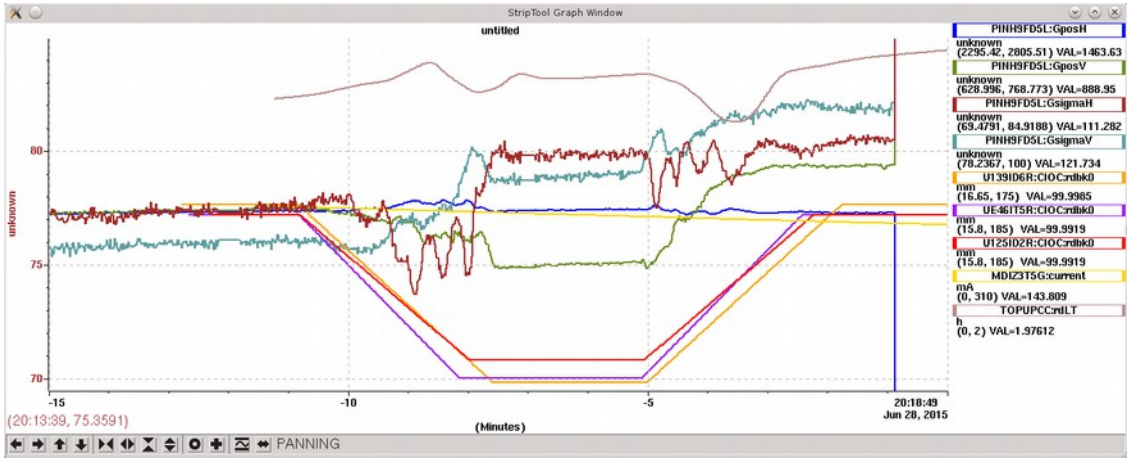
- High current operation → 200 mA setting
- Insertion Devices → close gaps of 10 IDs

ID gaps open, 200 mA



ID gaps closed, 200 mA





Single bunch on island orbit

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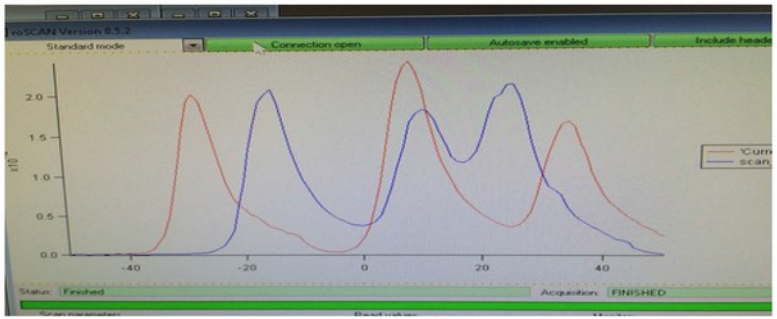
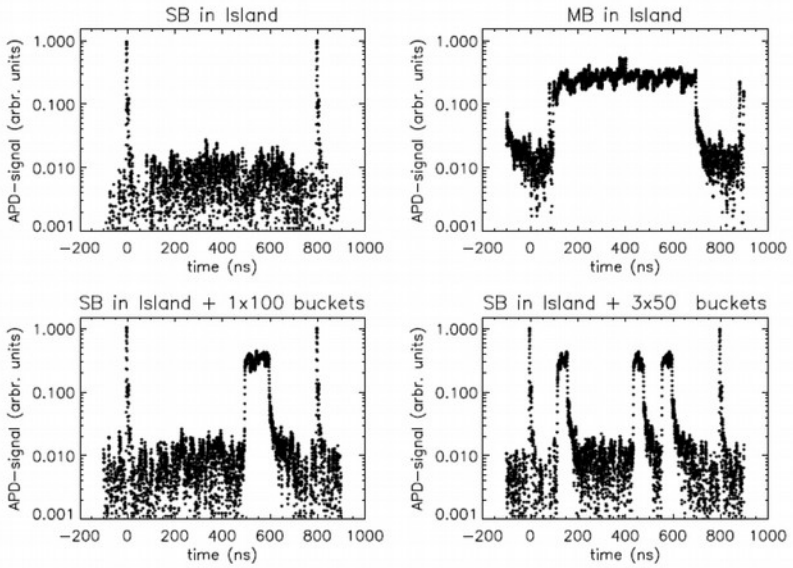
First in-house user experiments with K.Holldach & R. Ovsyannikov

- Dipole PM4
  - The purity was excellent...
  - ARTOF-spectra on gold at high purity from island SB photons" in parallel to a complete MB fill on the normal orbit
  - Conclusion: Use of Island buckets at PM4 is straightforward



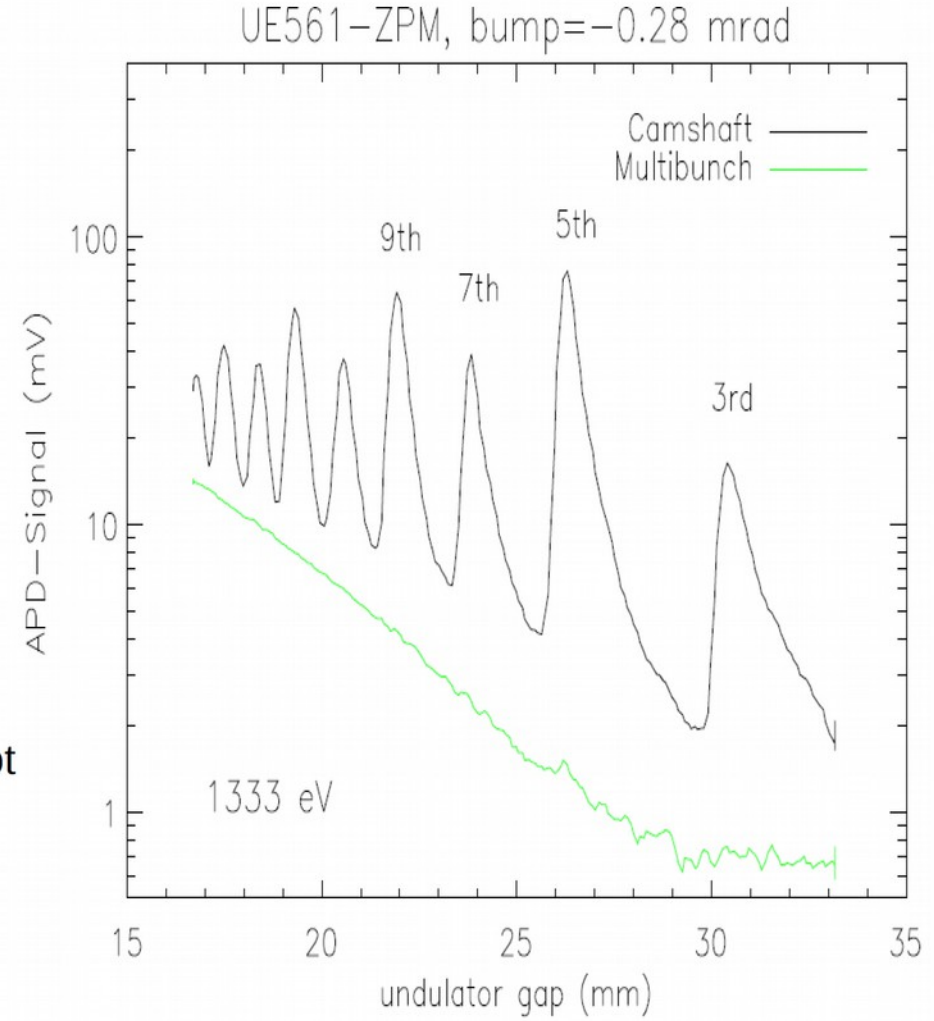
- ID UE56/1 ZPM
  - the separation is high, such that the ID beamlines usually don't see the islands since the beamline acceptance is only ~0.2 mrad
  - angular separation of ~0.3mm rad at about 0.8mm horizontal source displacement in high beta straight > femtobump by 0.23 mrad



Single bunch on island orbit

K. Holldack UE56/1 ZPM, with orbit bump

- SB island orbit
  MB standard orbit
  - elliptical mode (shift 25), regular XMCD setvalues for slicing
  - 1333 eV, femtobump -0.28 mrad
  - SB in island orbit on axis through ID, other beams blocked by front-end apertures
  - MB fill on standard orbit shows no undulator harmonics since it produces far-off-axis red-shifted radiation
  - Purity up to 100 at 5th harmonic not bad but could be better



Single bunch on island orbit

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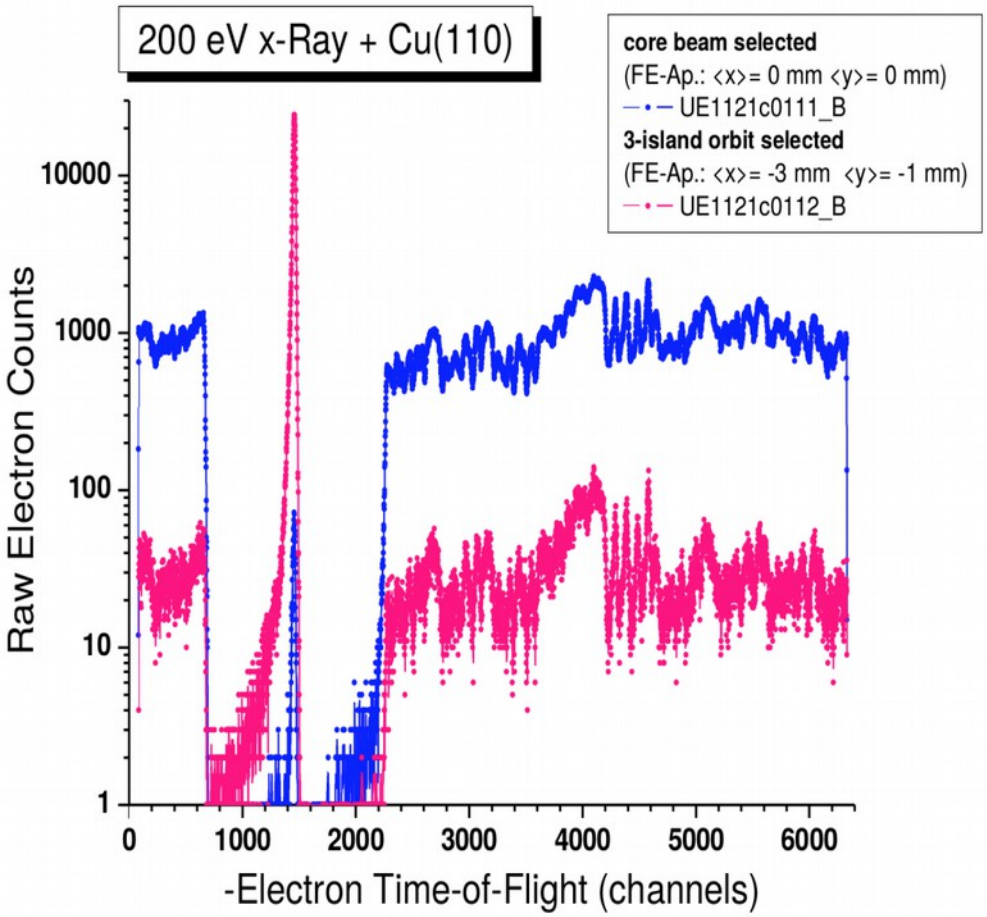
G. Schiwietz UE112 PGM1, without orbit bump

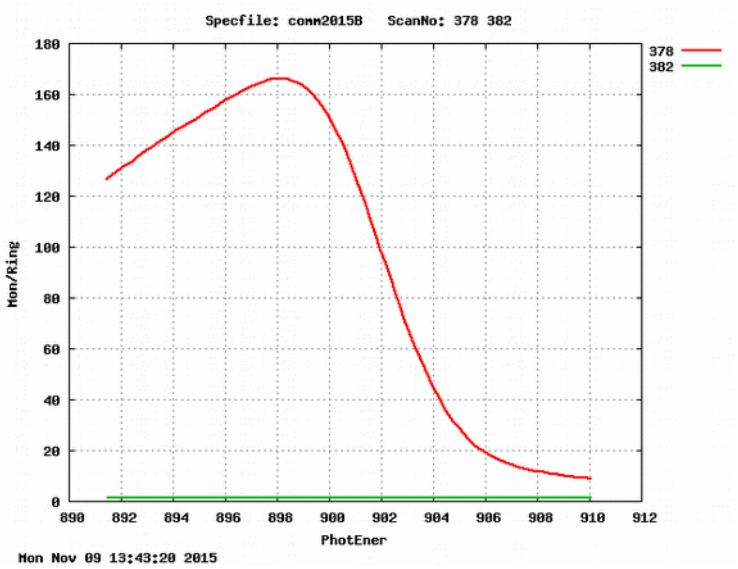
- SB island orbit
  MB standard orbit
  - e- detection of Cu valence-band photo-ionization with RBB spectrometer,
    e- energy 192 eV = 200 eV photon
  - Sensitive to
    1. harmonic from undulator
    1. order refraction
    horizontal polarisation
    specific time structure
  - Beamline on MB standard orbit
    - Camshaft bunch suppressed by factor 15
  - Beamline on SB island orbit
    - SB signal about a foctor of 600 above the multibunch background
    - Measurements with PhotoDiode shows ratio of 250:1 between light from core and island orbit



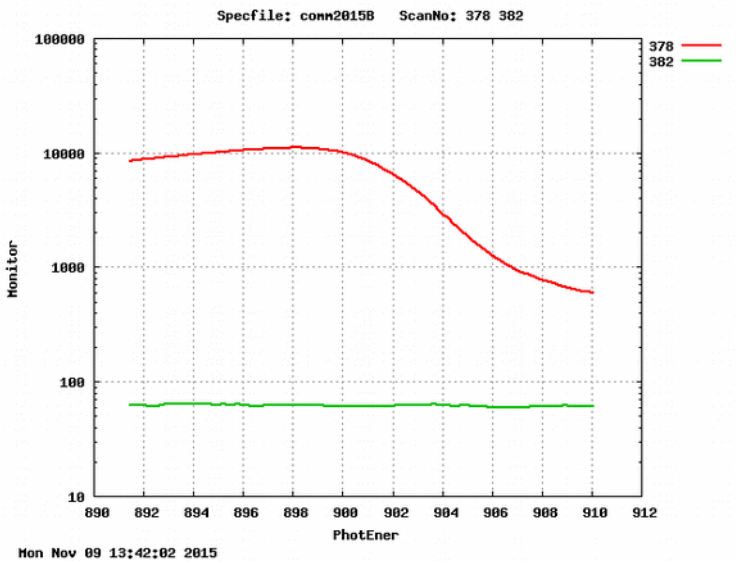
All current on island orbit

E. Schierle UE46, ID beamline on standard orbit

- **All current on standard orbit on resonance**
  - In principle no difference from BESSY II standard optics
  - No difference to standard BII nitrogen spectrum with typical resolution



- **All current pushed to islands**
  - No intensity in beamline
  - Within resolution no undulator harmonics visible



Island oribt and 7T-Wiggler

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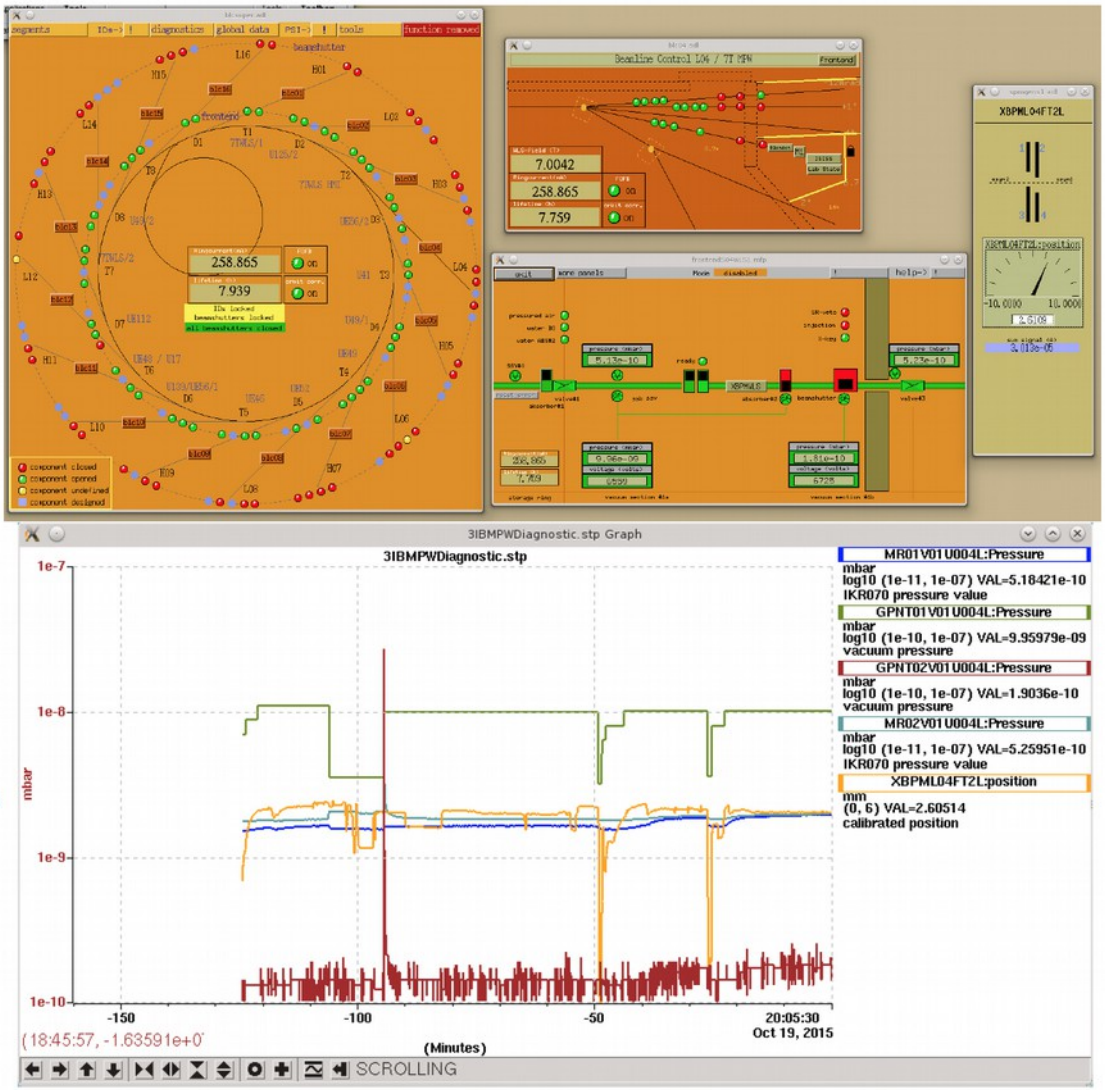
M. Klaus, C. Genzel 7T-MPW

- MultiBeam Machine and the 7T MPW
  - Synchrotron Radiation at fluorescence screen at the end of beamline (17 m)
  - Tests with 50mA, 100mA and 250mA
  - No visible decrease of intensity when pushing current from standard orbit to island orbit!
  - XBPML04T2L shows no dramatic change of the photon x-ray beam position, when pushing currents in islands



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Summary

- MLS and BESSY II operates successfully on resonance (3rd order)
- First user exps. at MLS
- First promising user tests at BESSY II
- Motivated by complex fill pattern and VSR

Outlook

- Push for TopUp: Combine
  - Inj. on resonance
  - Nice island, good sep.
  - POSSIBLE?
- Define further user experiments
  - Separation at each beamline, Rotation Skews, Slits at beamlines
  - ID TuneFF for new WP

Thank you for your attention

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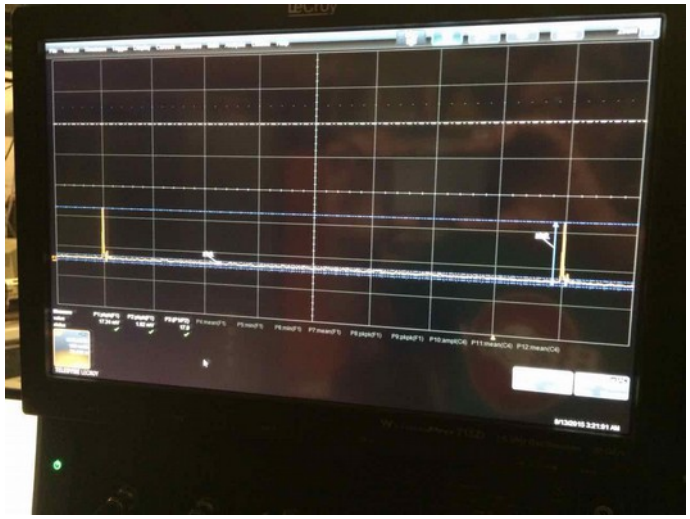
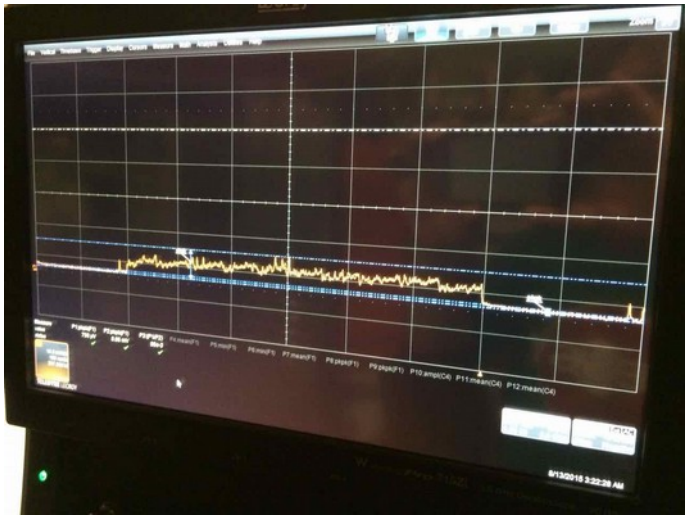
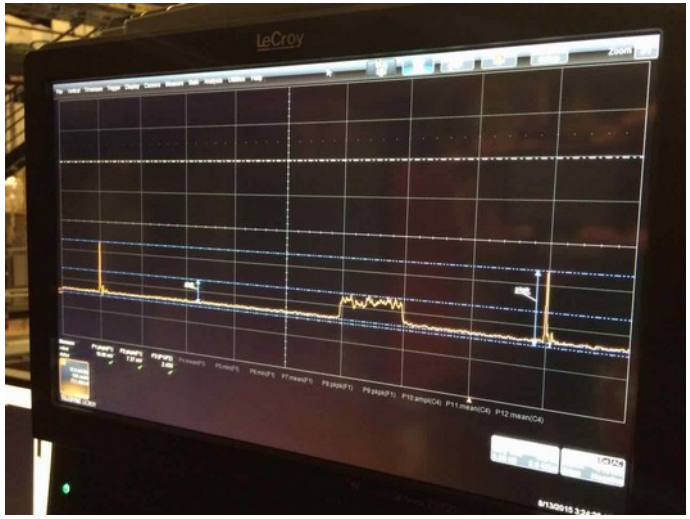
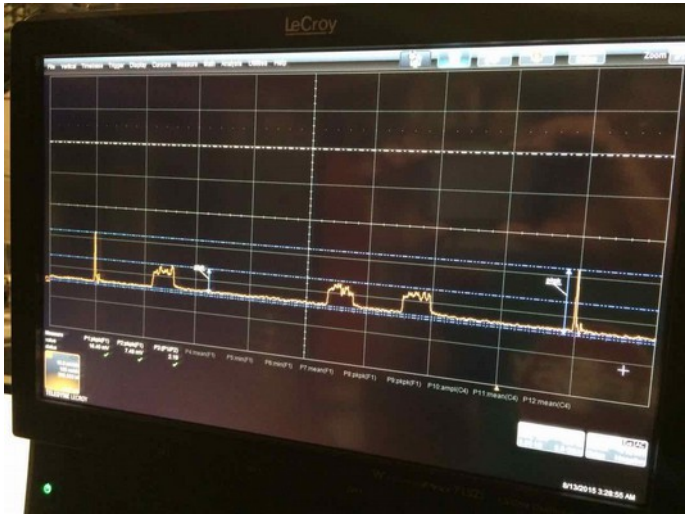
Last impressions









Title

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