HZB Helmholtz Zentrum Berlin

# STATUS BESSY II

P. Kuske

Introduction: Some Facts about BESSY II

On-going Projects:
- new 50 MeV LINAC
- Fast Orbit Feedback
- Top-Up Operation
- EMIL
- Modernization

Future Projects:
- BESSY_VSR

Other Projects @ HZB:
- BER*Lin*Pro

Outlook

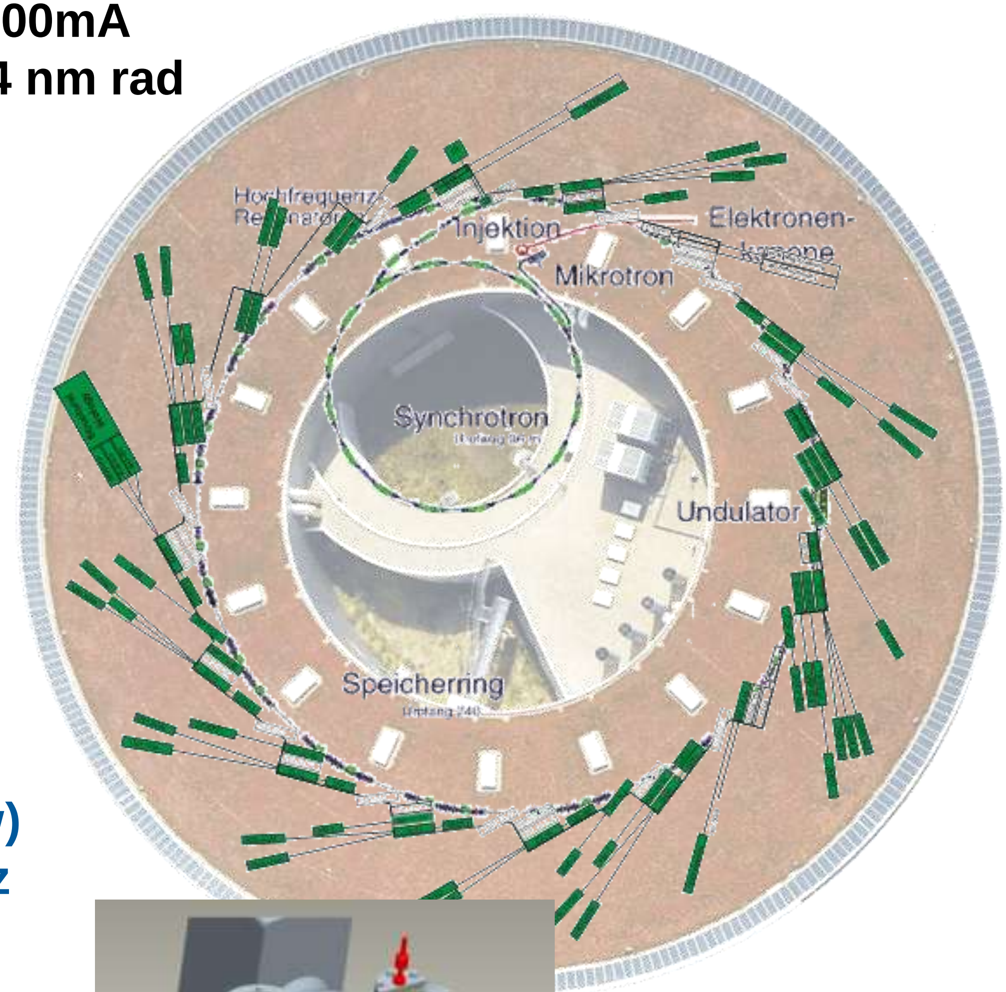
slides „borrowed“ from A. Jankowiak, D. Schüler, R. Müller, K. Bürkmann, ….

# BESSY II – The Storage Ring

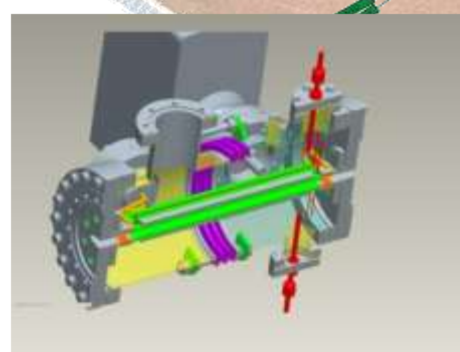
| | |
|---|---|
| Energy/current | **1.7GeV / 300mA** |
| Emittance | **~~6 nm rad~~ 4 nm rad** |
| Straight sections | **16** |
| Undulators / MPW+WLS | **10 / 1+3** |
| ID / dipole beam lines | **32 / 20** |
| end stations (fixed+var) | **52** |

**~ 5000 h/a user service**
**~ 2400 users / a**
**~ 1000 h/a beam test + commiss.**
used for accelerator research

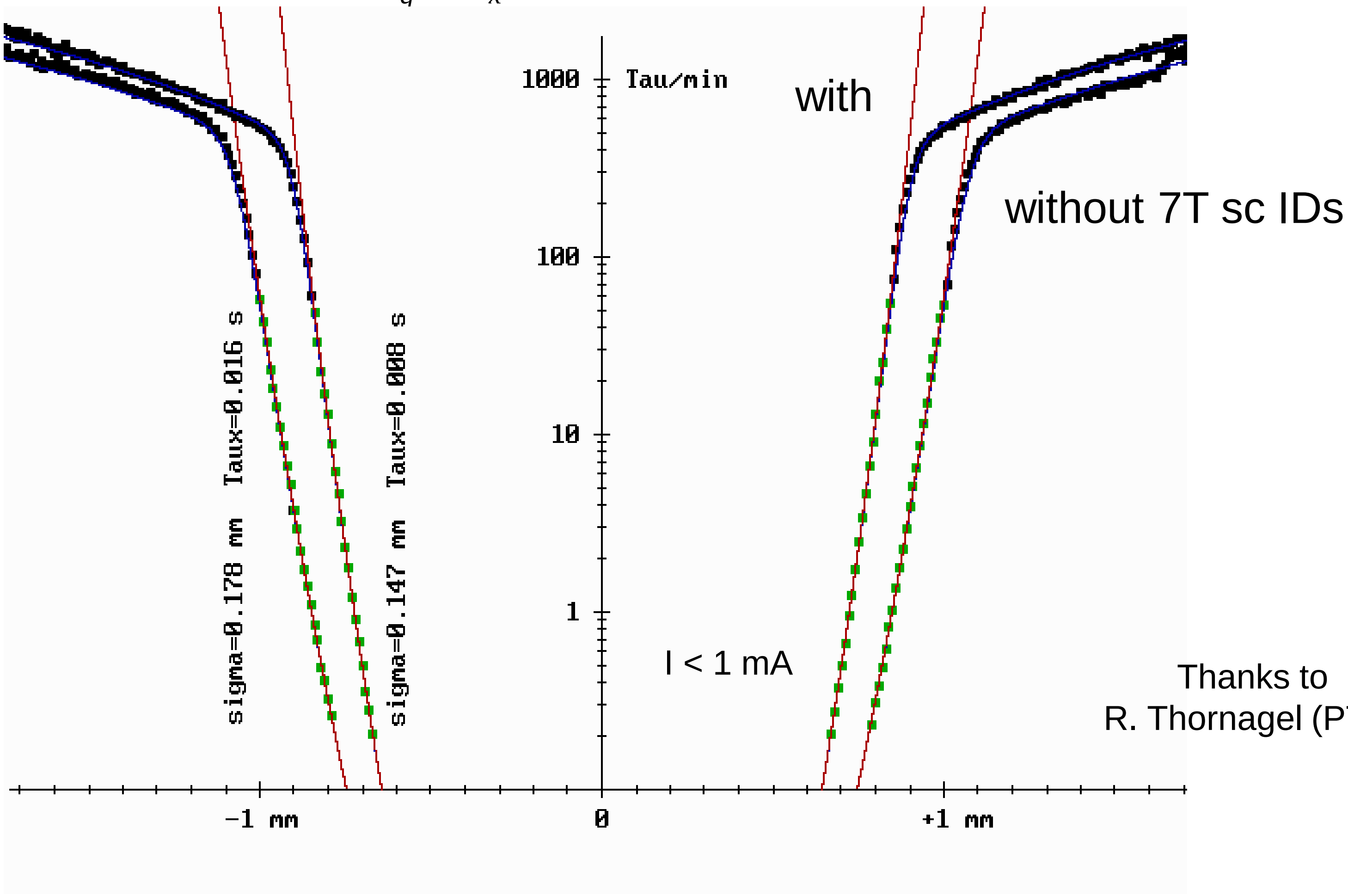
**Running up-grades:**
- **new injector linac for 30x higher charge in single bunch injection (under commissioning right now)**
- **Fast Orbit Feedback, up to 100Hz**
- **Top-Up (will start 2012)**




R+D project**: Development and tests of a new non-linear injection kicker**
(NO field on axis)



$$\tau_q \approx \tau_x \cdot \sigma^2 / A^2 \cdot e^{(A^2/2\sigma^2)}$$




Thanks to
R. Thornagel (PTB)

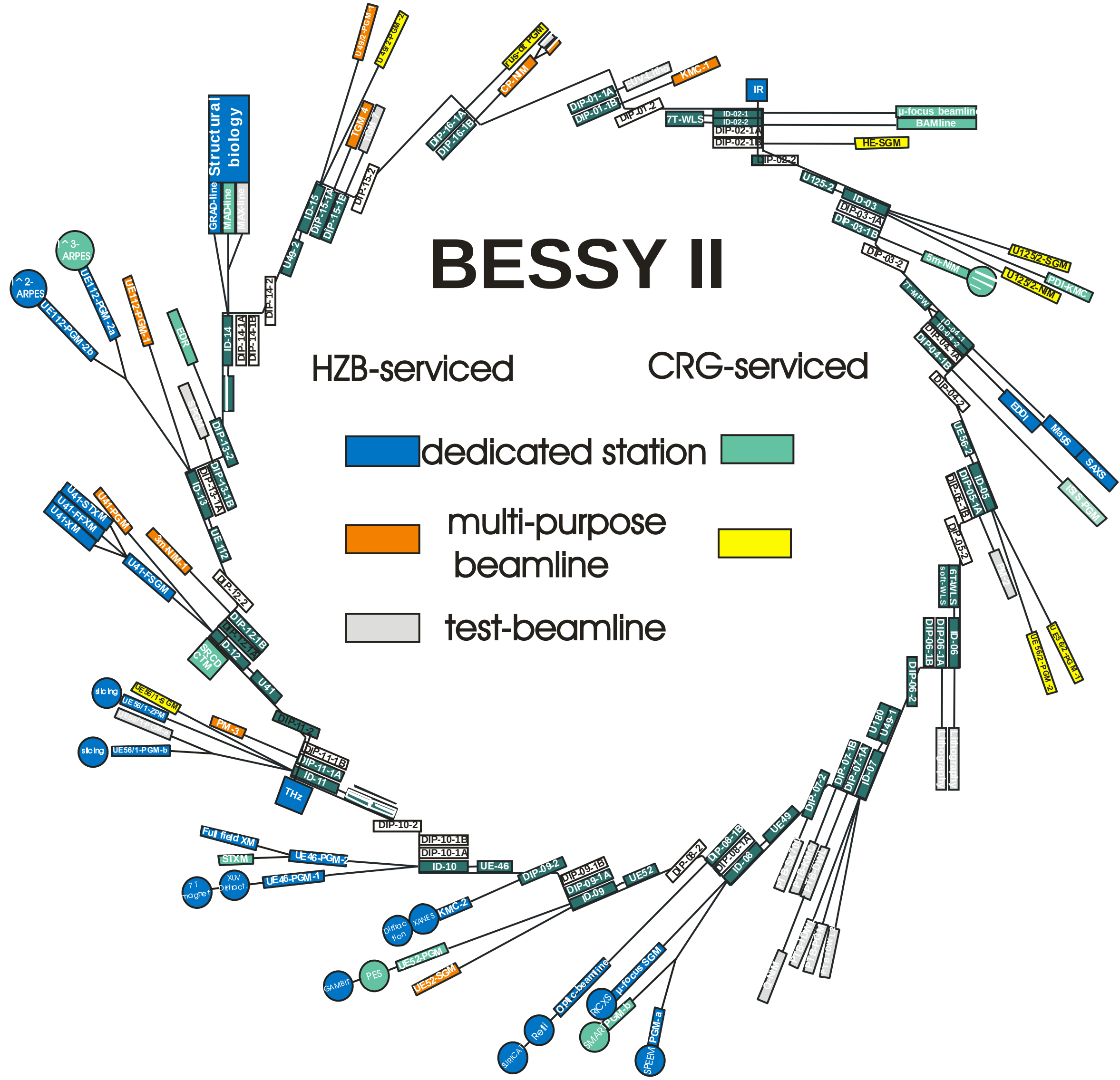
Measurement of the aperture dependent quantum lifetime with scrapers

30 % emittance reduction in agreement with theoretical expectations

# BESSY II – Outstanding Versatility and Flexibility

## >> from THz to keV <<

- spectroscopy & scattering
- imaging & lithography
- dynamic studies




### pioneered low $\alpha$

**ps beams (3ps), CSR, THz**

### femto slicing

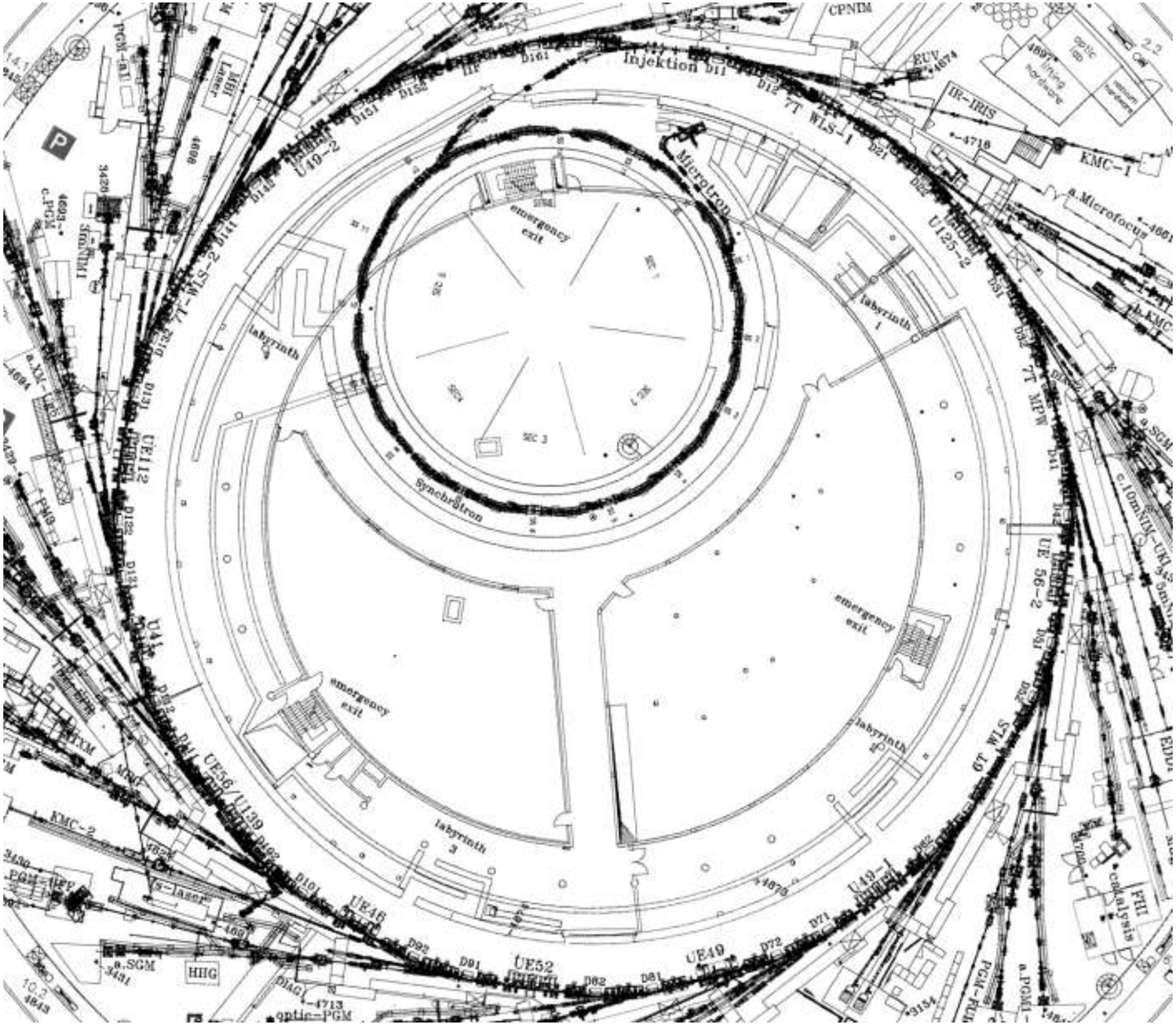
**100fs, polarized x-rays**
**6kHz and variable**
**pump probe laser**

### flexible fill patterns

**single bunch, hybrid, …**

# Integration of the Linac in the Synchrotron-Tunnel (Dirk Schüler)

HZB Helmholtz Zentrum Berlin

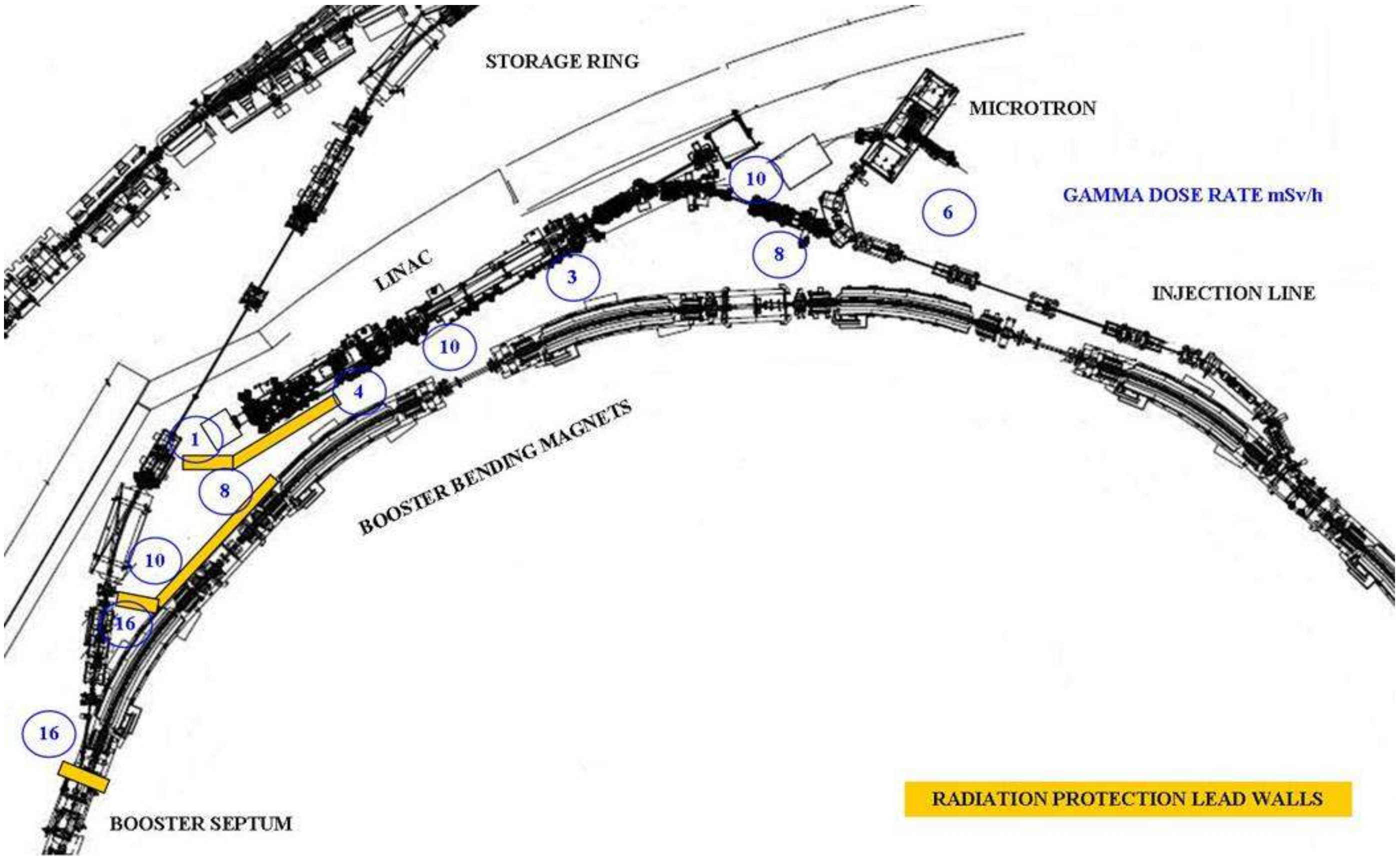


HZB Helmholtz Zentrum Berlin

# Limited space and radiation from booster

**During injection with the Microtron into the Booster we observed approx 20 mSv/h in Linac area. This radiation induces problems in the Gun Cabinet and in the 500 MHz-Prebuncher.**

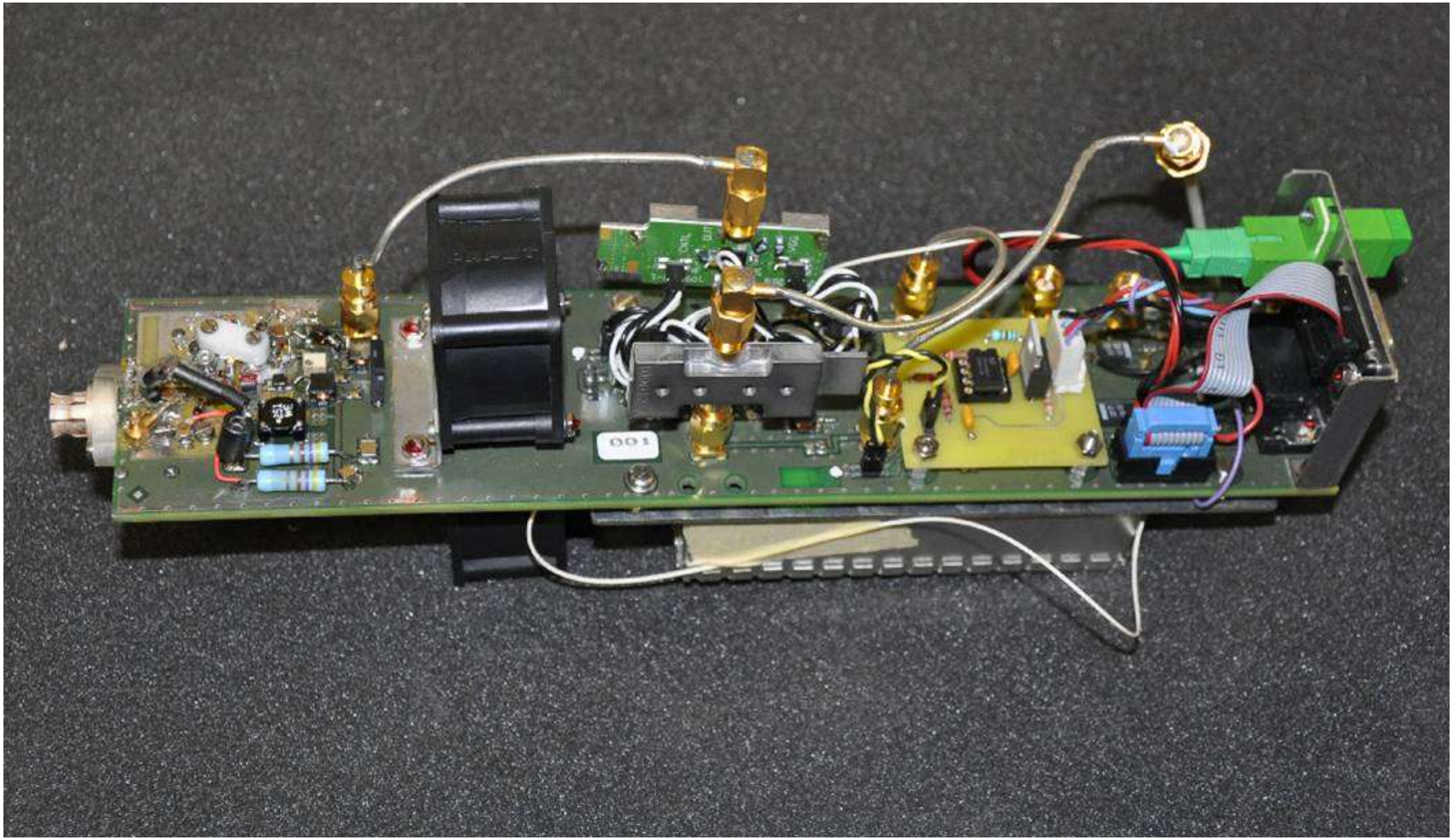
**The picture shows the radiation survey after shielding and orbit correction.**



HZB Helmholtz Zentrum Berlin

# Cathode Driver Board

**The Driver Board is designed and made by Thales. During commissioning HV sparks in the Gun cabinet destroyed the very fast and over-sensitive output transistor.**



## Water leak

**In November 2010 after one month of commissioning a water leak between the structure cooling water tube and the vacuum occurred.**
**Thales and PMB needed 4 months to find a solution and complete repair.**
**The cooling tube was repaired in the BESSY Synchrotron tunnel.**

**BESSY got a 12 Year warranty for the Linac Structure. This warranty includes a newly desgined structure.**

HZB Helmholtz Zentrum Berlin

## All specified Beam parameters were achieved

| SAT results | spec. SB | measured | spec. MB | measured |
|---|---|---|---|---|
| Energy (MeV) | 50 | 50.9 | 50 | 50.6 |
| Transmission (%) | 61 | 64 | 68 | 88 |
| Charge (nC) | 0.35 | 0.34 | 2.00 | 2.15 |
| Energy Spread (% rms) | 0.40 | 0.24 | 0.40 | 0.39 |
| norm. Emittance h/v (π mm mrad) | 50/50 | 38.6/32.7 | 50/50 | 12.2/10.7 |

**Todays Booster current for MB 1.7 mA and for SB 0.1 mA**

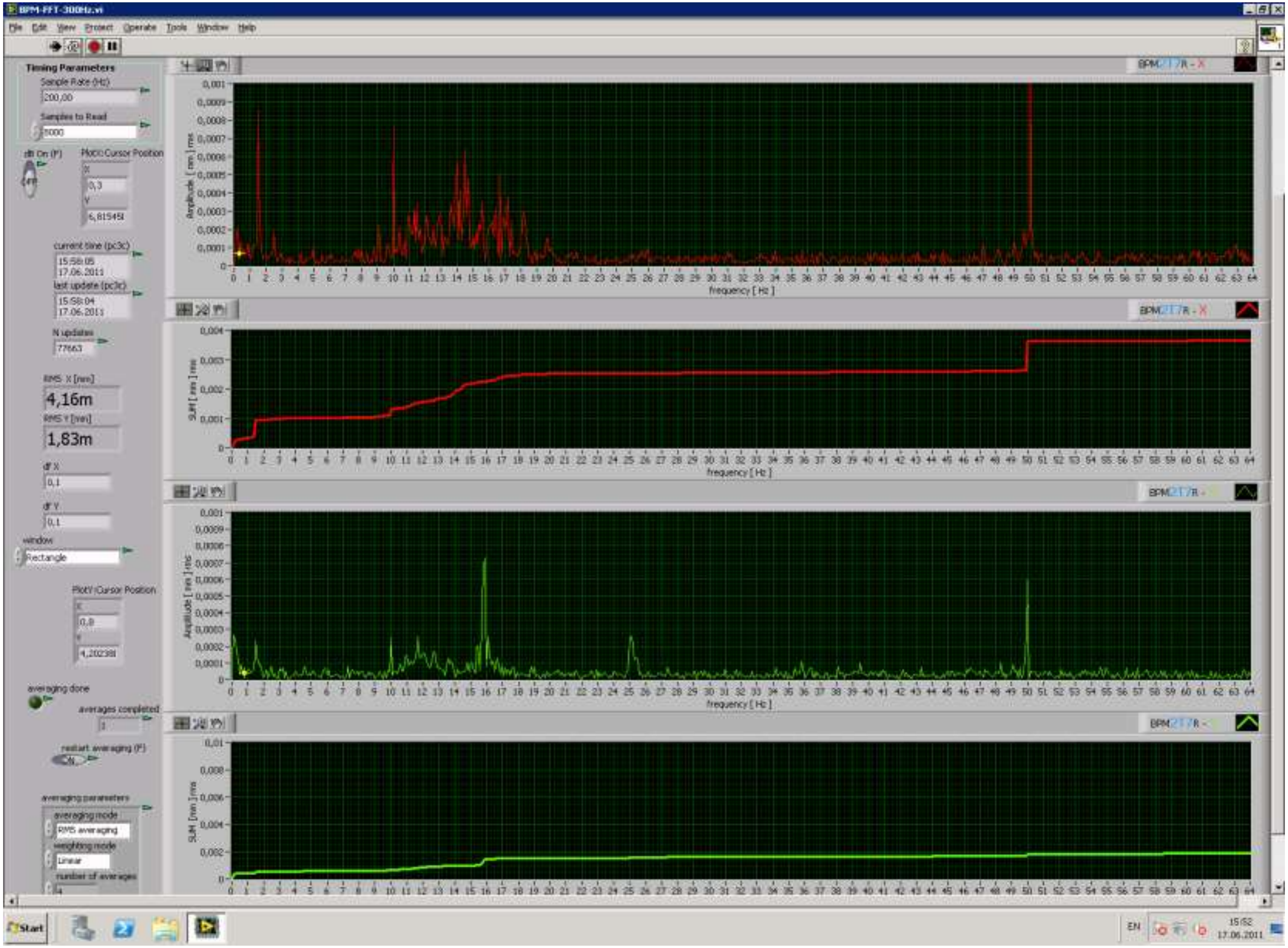
this is already comparable to the Microtron

**First injection in the storage ring with SB on 29/09/2011**

**It is possible to use the existing injection line optic with both injectors**

**Charge restrictions in place due to radiation protection**

# Orbit Quality and Fast Orbit Feedback (Roland Müller)



HZB Helmholtz Zentrum Berlin

## Status by Components

Fast BPM Data Acquisition: Existent (100%)

- 2.4 kHz Sampling Rate
- FFT Diagnostic Use: 0.5 – 200Hz

New Fast Powersupplies: 8/112 Installed

- Transfer function: up to 200Hz
- Control flexibility
- Comparable Specs @ +/- 8A, 40V

Fast Set Point Distribution: Operational (100%)

- Digital I/O board modified
- Reflective Memory: BPM DAQ, PS IOCs
- Known Time Budget: < 8ms/cycle

Optimized Algorithms: currently tuned (20%)

- Rapid Prototyping: Matlab Middle Layer (MML)
- Verification: Slow FOFB == proven SOFB
- Closed Loop Tests (Beam Time Needed)

## Open questions

Interplay of SOFB/FOFB

- Removal of FOFB DC component
- Inference of golden Orbit
- Role of RF

Control system integration

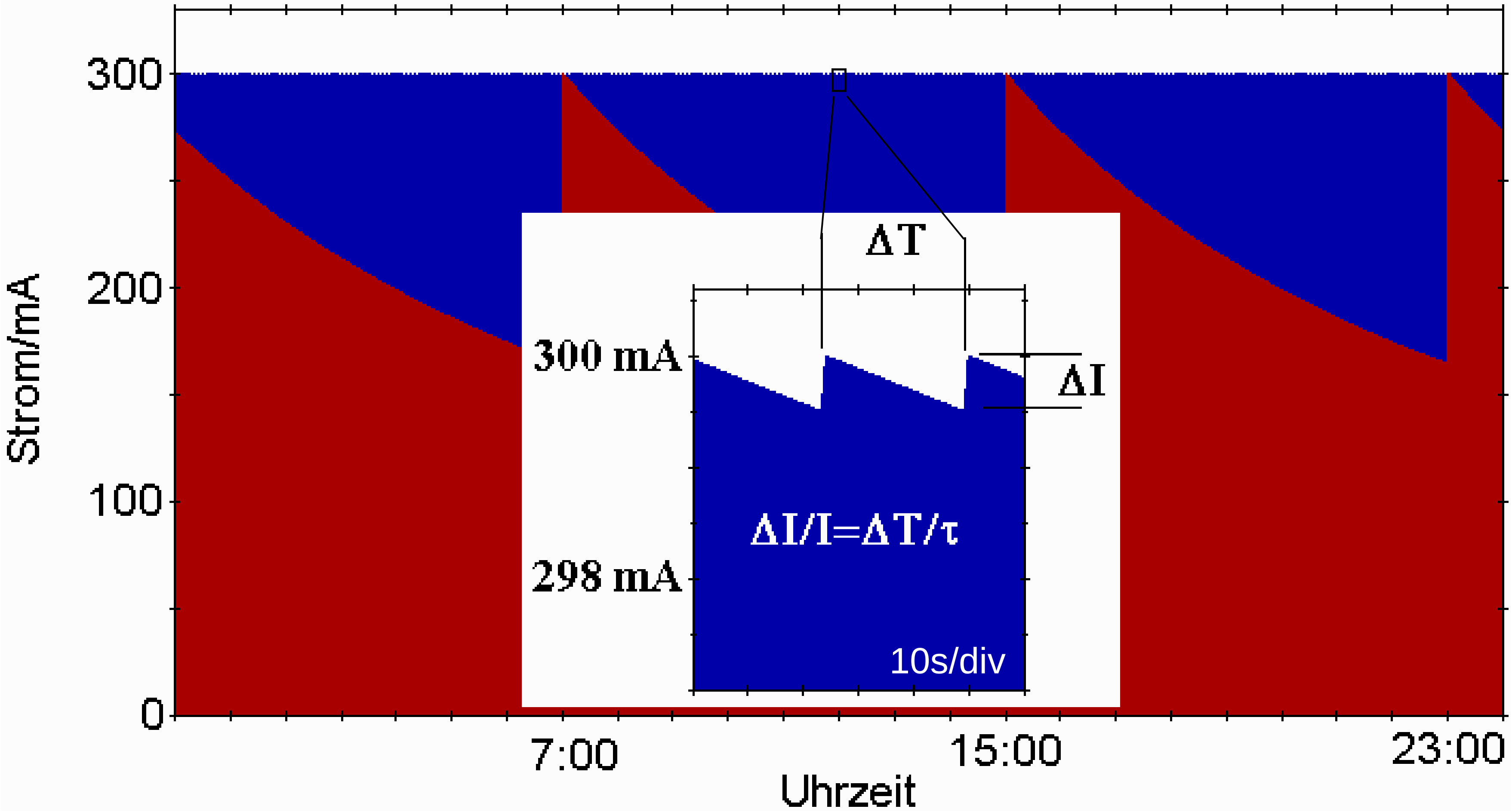
- Performance monitoring, supervision, control
- Detection of faults, misreadings
- Countermeasures

## Phase II = New BPMs

improved position precision, fast diagnostics

- New, innovative solutions available (NSLS-II)?

# Top-Up Operation at BESSY II

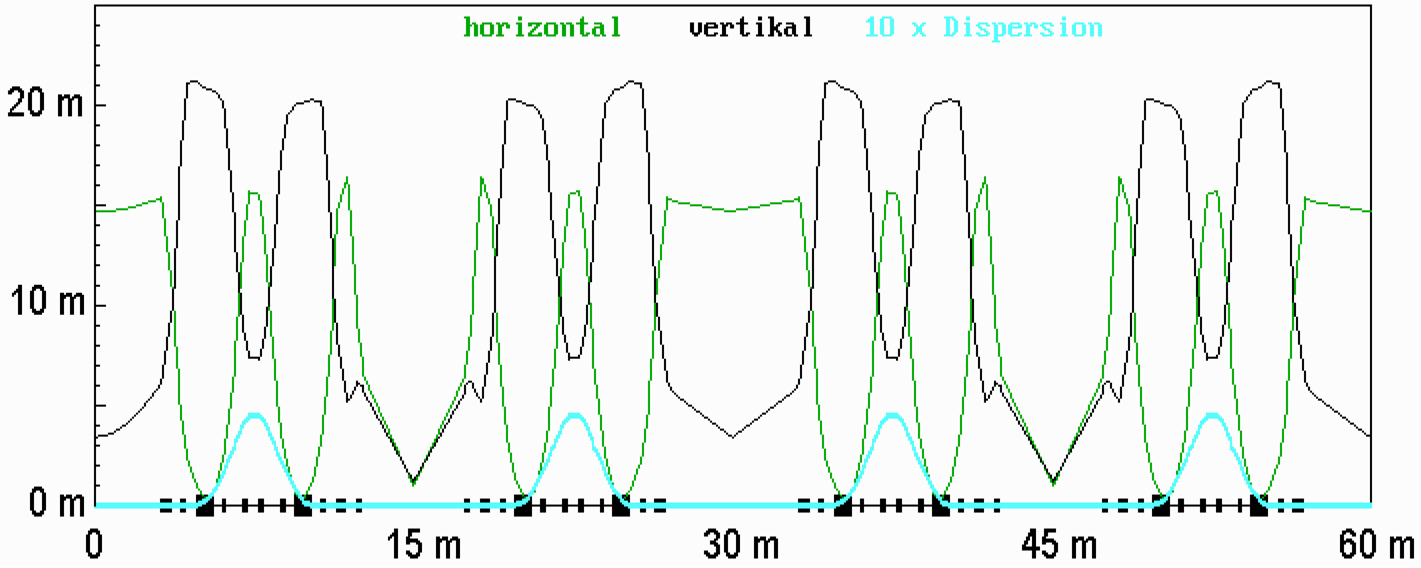



Beam current limitation I < 300 mA (7 T Wiggler)

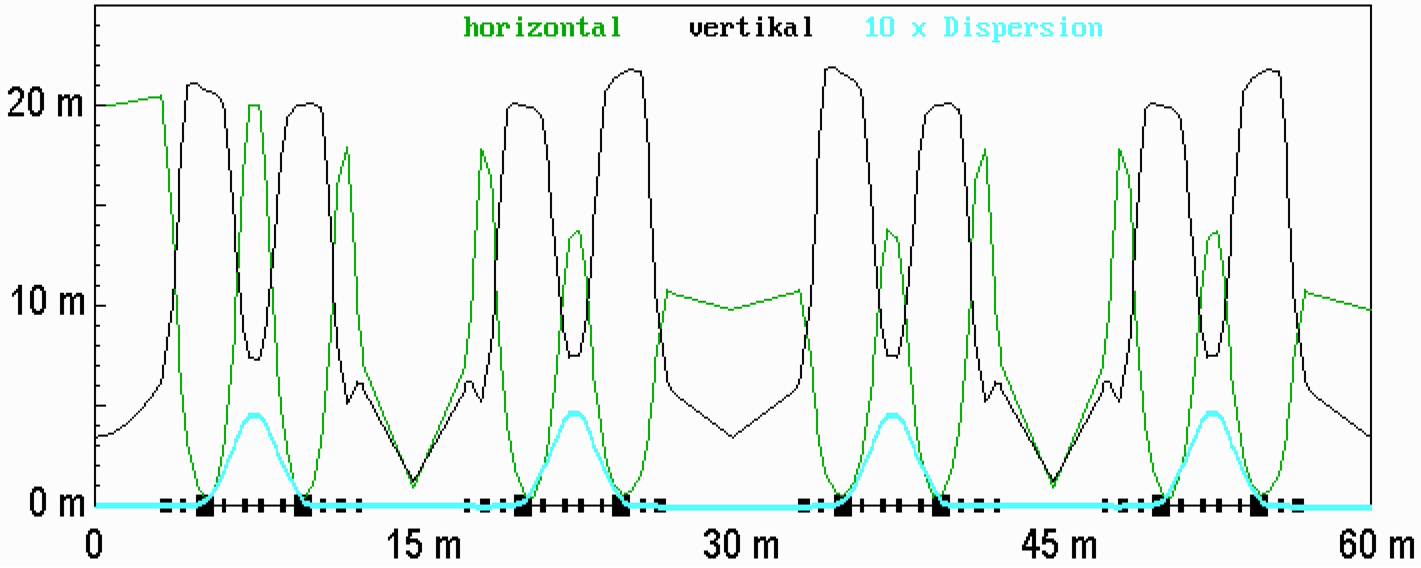
Lifetime requirement $\tau$ > 5 h (radiation shielding), $\tau$ > 10 h in routine operation

Booster current $I_{syn}$ > ~1 mA (efficiency determination with <1 % accuracy)

$\Rightarrow \Delta T$ ~ 20-40 s and $\Delta I_{SR}$ ~ 0.4 mA, also for top-up of intense single bunches standard optics with strong negative impact of IDs in the doublet straights:

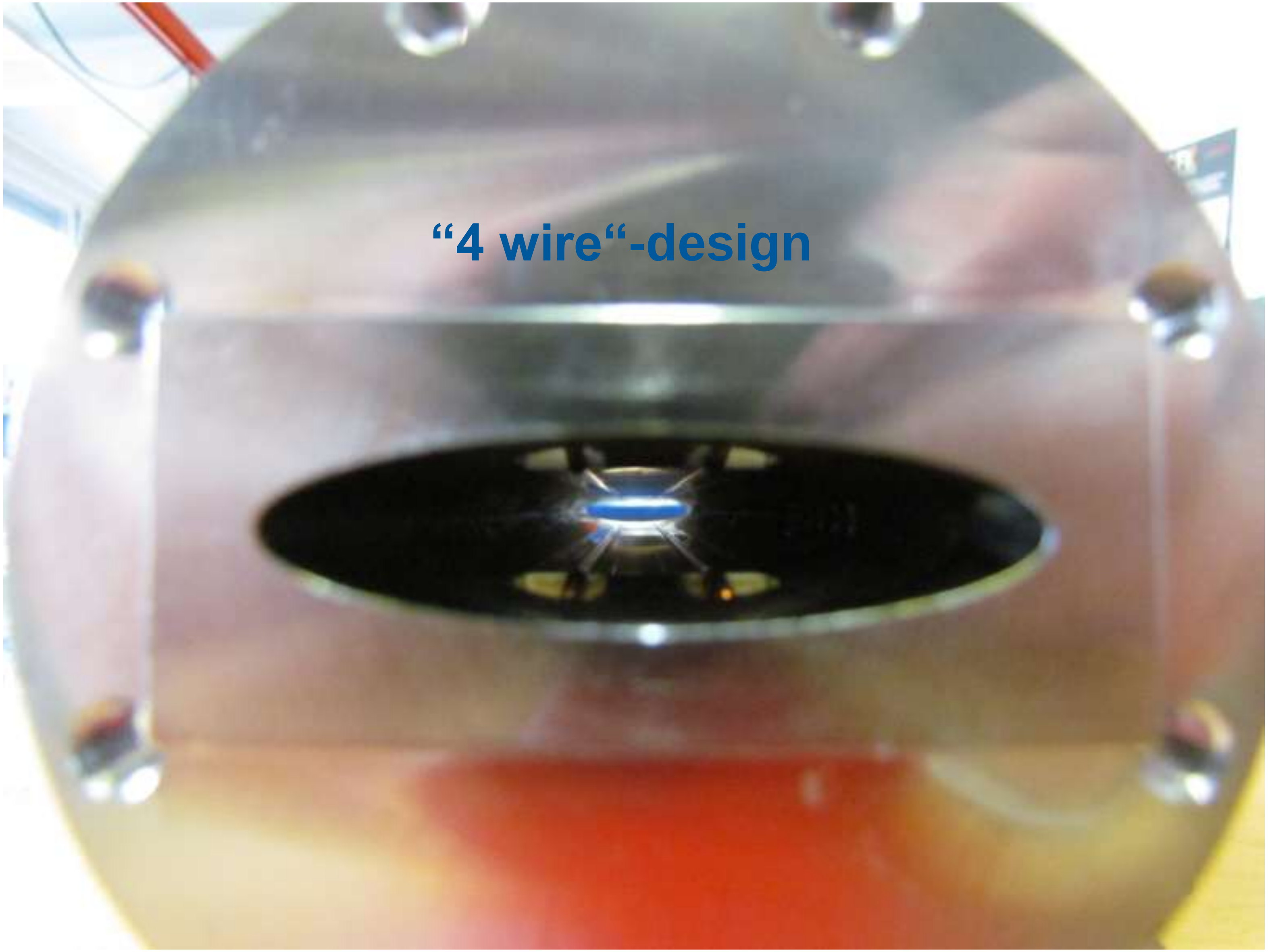


reduce impact of IDs in the doublet straights by smaller horizontal ß-function:



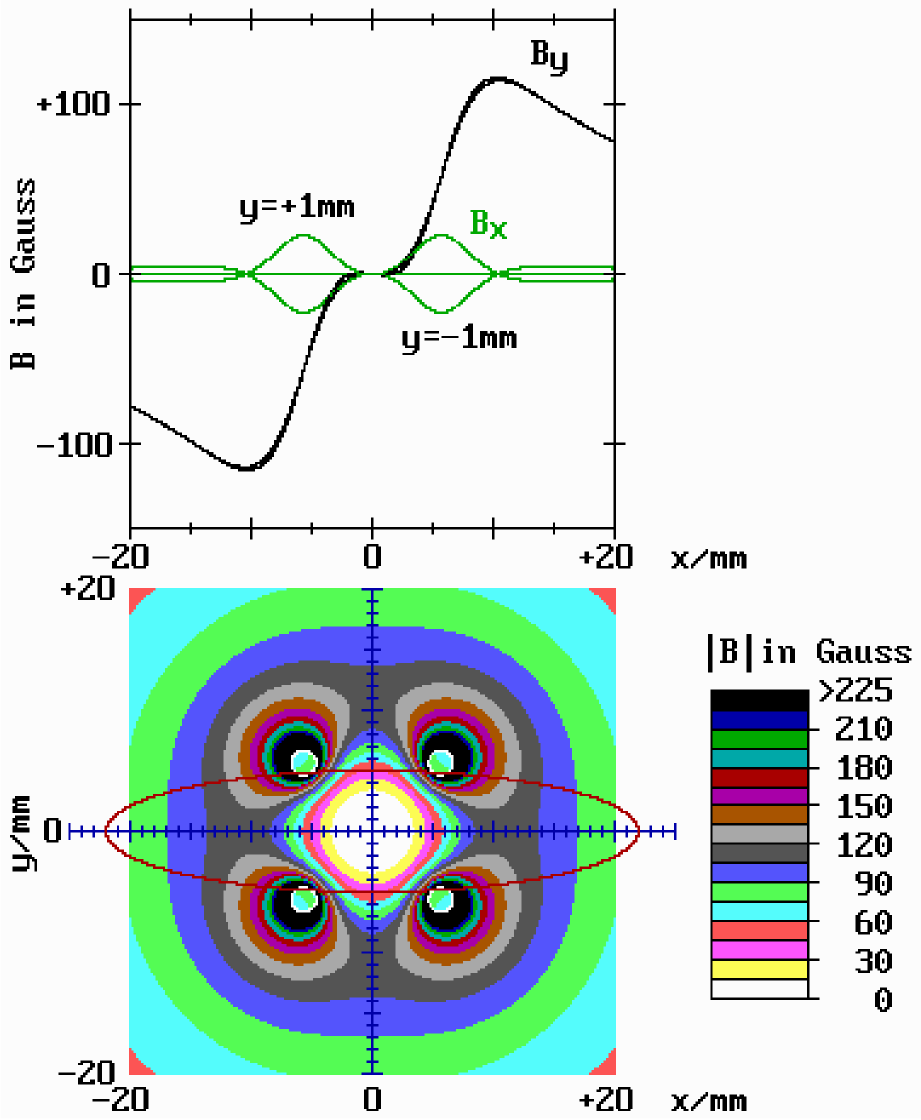

horizontal ß-function 20 m/rad in the injection straight and 10 m/rad elsewhere;

should make oscillation of injected beam smaller at IDs

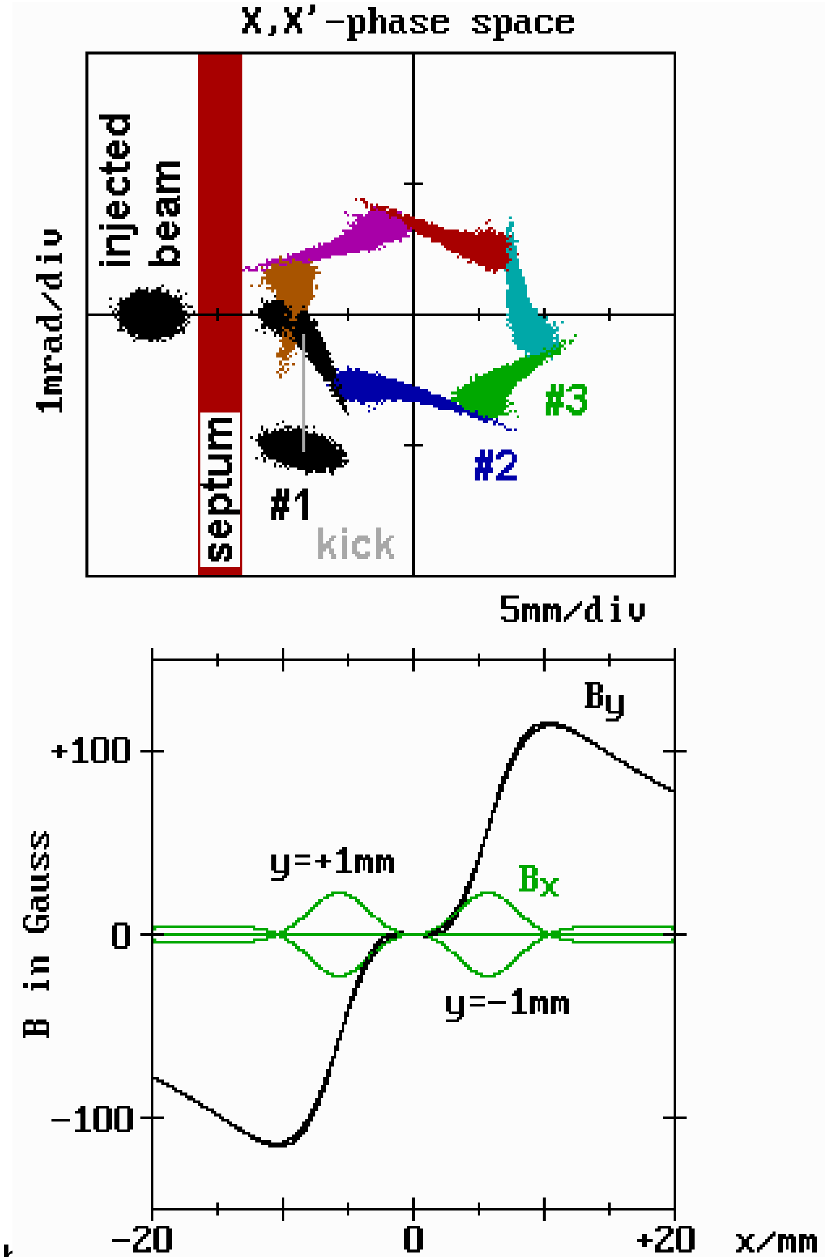


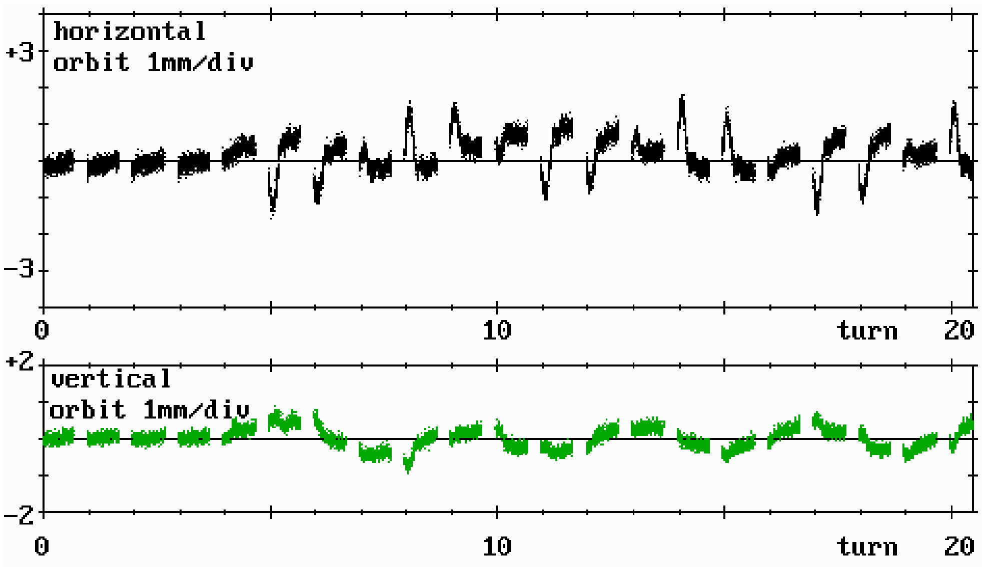

O. Dressler, M. Dirsat, T. Atkinson

# In-vacuum stripline-type design



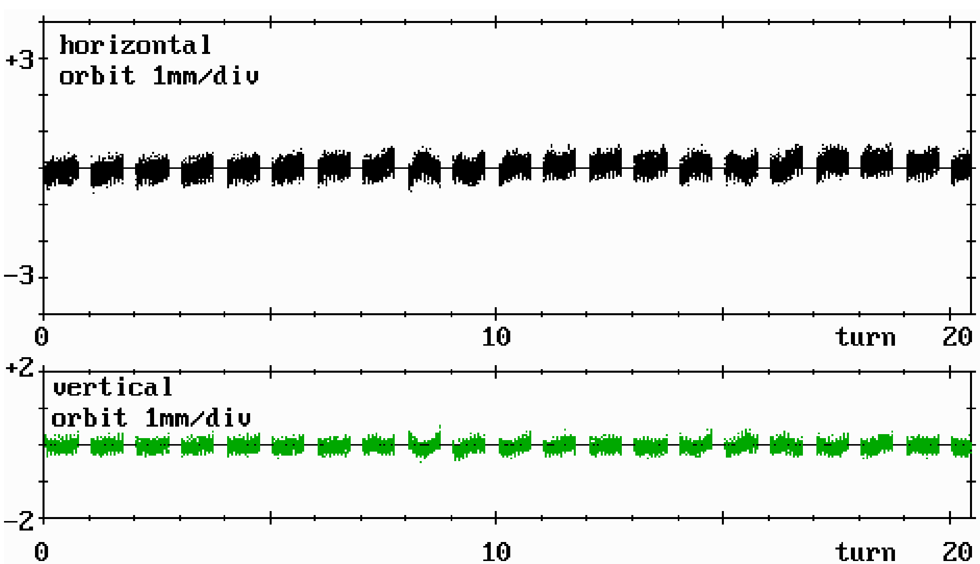

4 wires with 200A each


X,X'-phase space
injected
beam
septum
1mrad/div
#1
kick
#2
#3
5mm/div
By
Bx
y=+1mm
y=-1mm
+100
0
-100
B in Gauss
-20
0
+20
x/mm




4-kicker injection bump optimized for small orbit perturbation

injection efficiency ~ 80 %




single, non-linear injection kicker – not fully optimized:

horizontal < 60 μ

vertical < 15 μ

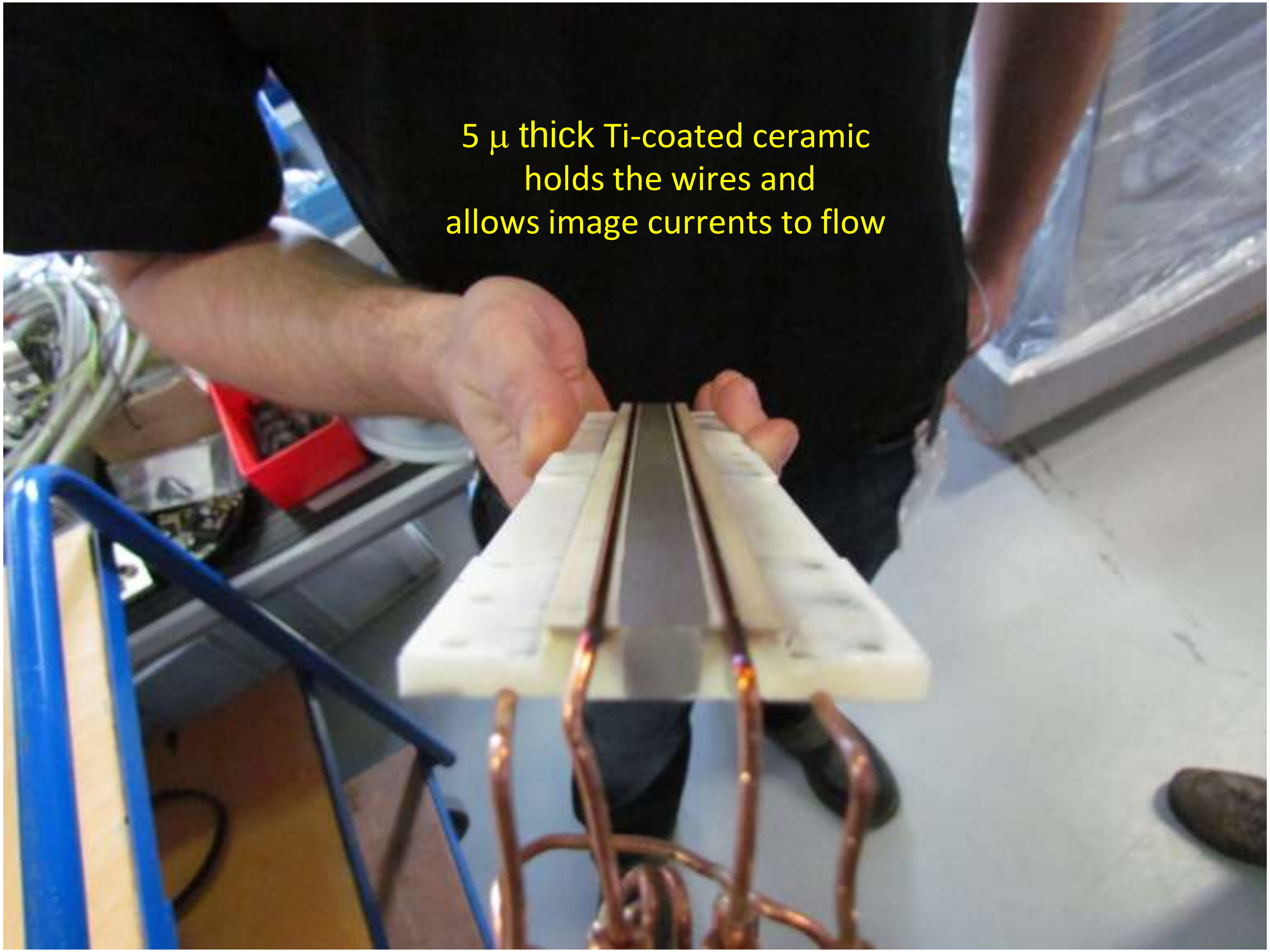
injection efficiency ~80 % up to 300 mA

## *After the tests the kicker had to be removed*

**Thermal and Vacuum Problems**: Temperature at the outside of the kicker tank increased within 20-30 min to 60° C with $I_{mb}$=300 mA or $I_{sb}$=15 mA, along with severe vacuum degradation

**Beam Dynamics Issues**: Except for vacuum related beam blow-up no coupled bunch instability was observed

**Injection Efficiency**: was as good as with the 4 kicker injection bump, stored beam was far more stable


5 μ thick Ti-coated ceramic
holds the wires and
allows image currents to flow

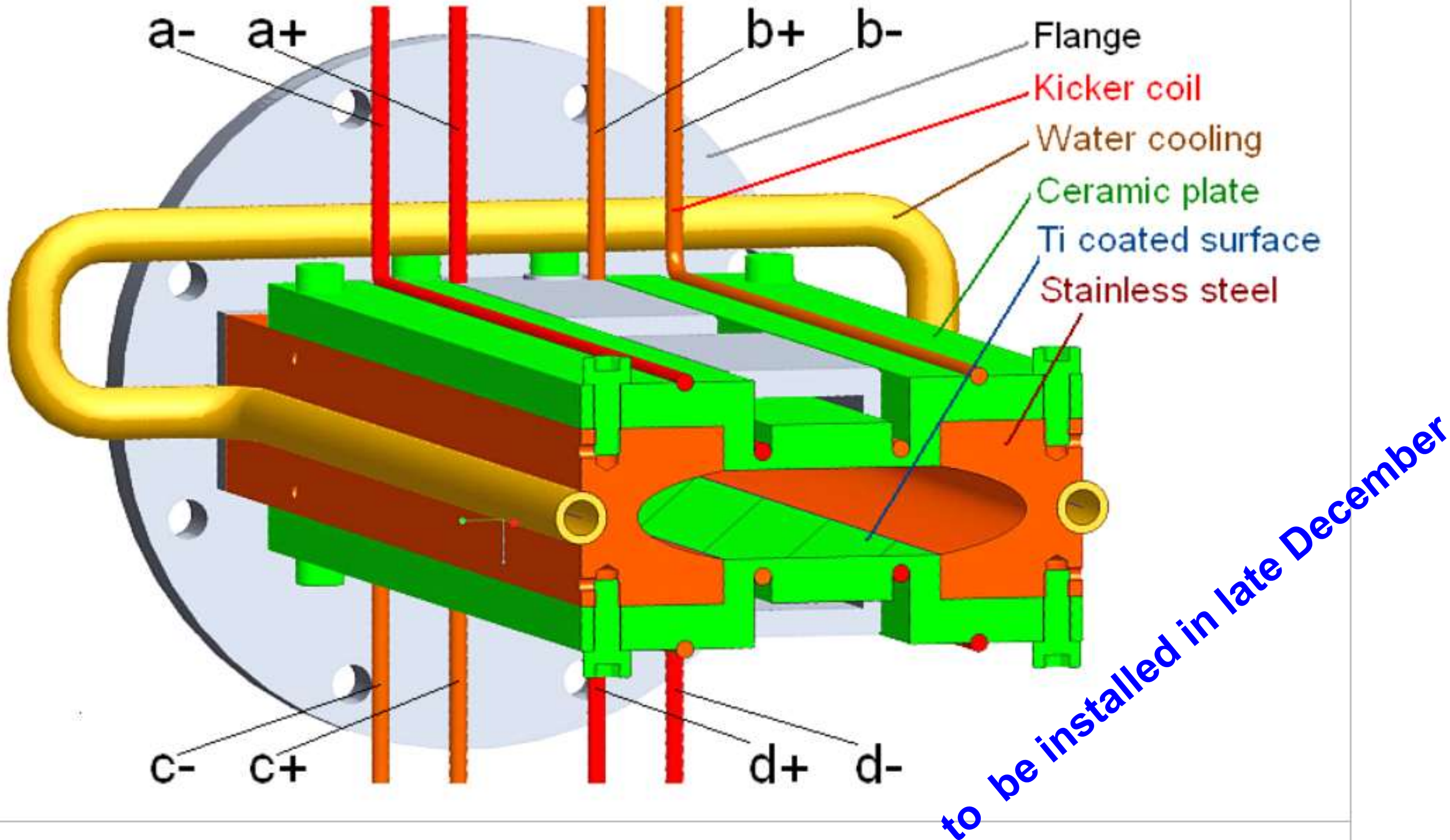



Figure 3: Sectional view of kicker magnet structure, second magnet design.

O. Dressler, M. Dirsat, H. Rast

## At first it was

**SISSY - Solar Energy Material In-Situ Laboratory at the Synchrotron**

## Than it became

**EMIL - Energy Material In-Situ Laboratory Berlin**

**SISSY – Catalysis – 60to6**


## And all this is part of

**DOMINO**

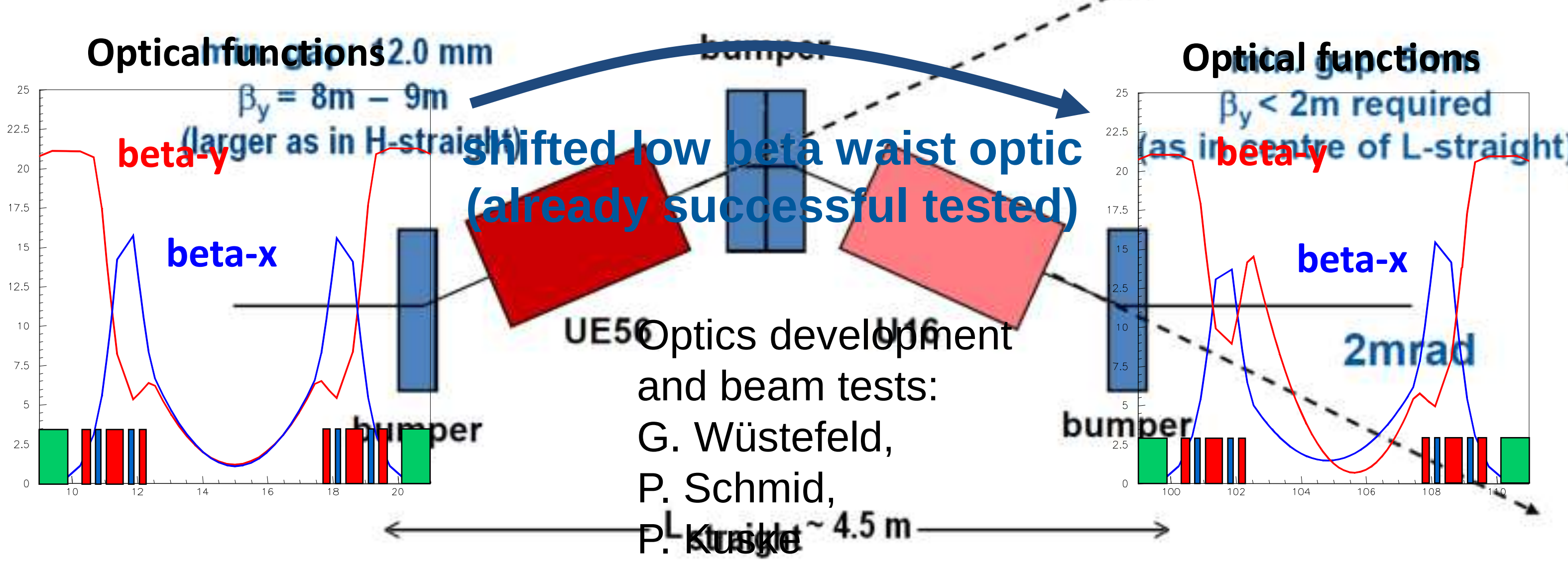
**restructuring the user floor**

**Targets given by EMIL:**

- spectral range (60 eV – 10 keV)
- small focal spots
- high brilliance over large spectral range in „one“ beamline

**Solution - 2 insertion devices in one straight section**:

1. 60eV ... 2000eV covered by conventional out-of-vacuum APPLE II undulator
2. 2 … 8 keV in the 1st to 7th harmonic covered by **planar hybrid in-vacuum cryogenic undulator (to be developped by G-A3, Undulators, J. Bahrdt)**




Optics development and beam tests:
G. Wüstefeld,
P. Schmid,
P. Kuske

## Running annual Budget ~ 1 M€ / a

**maintenance, licenses, small replacement, small R&D, consumables, travelling**

### 800 k€ / a

**operation, app. progs., control system, electronic, power supplies, diagnostic, vacuum**

### 200 k€ / a

**rf, cryo**

## Projects: preservation, modernisation, up-grade:

running + approved projects

| projects | up to 2010 | 2011 | 2012 | 2013 ... |
|---|---|---|---|---|
| Linac | 2654 | 1015 | 90 | |
| Top-Up | 751 | 175 | 324 | |
| FOFB | 80 | 625 | 275 | |
| HOM cavities | | 370 | 380 | |
| 7T MPW | | 175 | 175 | |
| **Sum** | **3485** | **2360** | **1244** | |

**From 2012 on:**

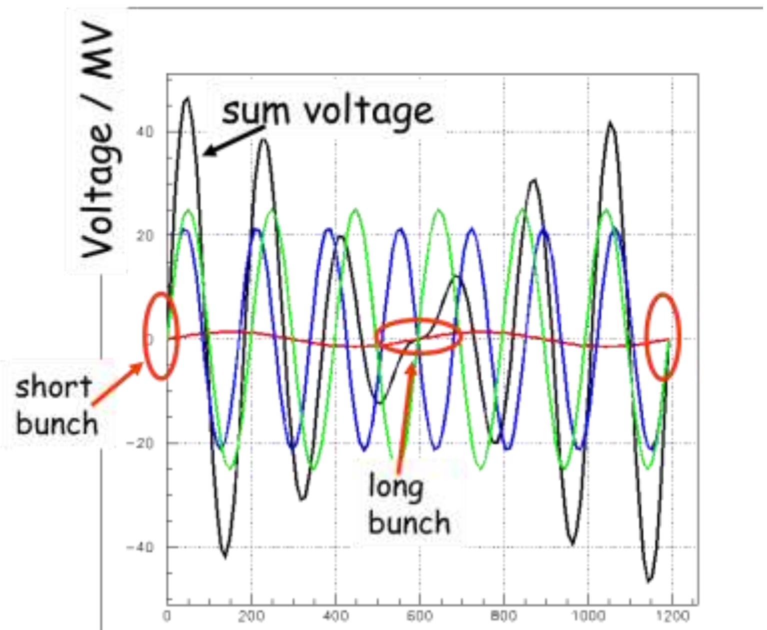
**2000 k€ / a is available for photon projects (machine + user floor)**

**On average per year: 1000 k€ for the machine !**
**(projects needs to be negotiated within BESSY II steering com.)**

**pioneered short pulse operation in low-$\alpha$ mode (IR, THz, coherent THz)**
**(special mode, not compatible with most other users)**

**provides << ps pulses from femto-slicing facility**
**(limited flux, only one ID)**

## → provide short pulses (ps and shorter) at all end stations simultaneously with high flux, high brilliance

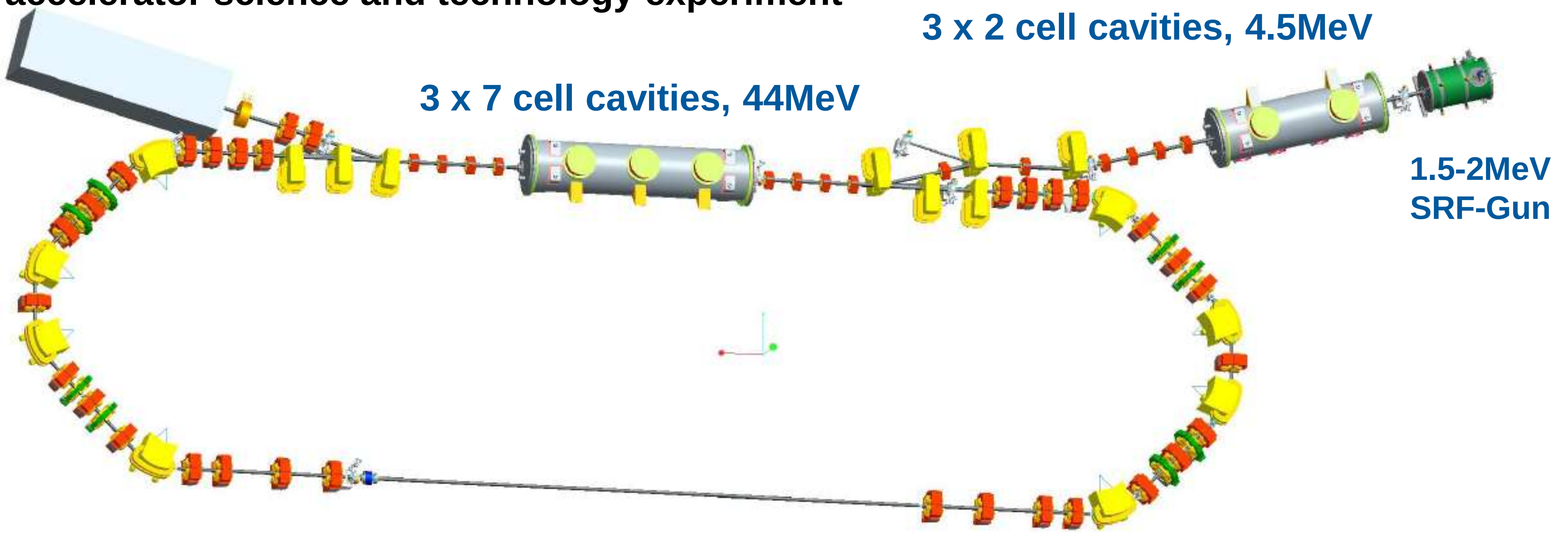

$$\sigma_l \sim \frac{\sqrt{\alpha}}{\sqrt{\frac{dV}{ds}}}$$

# BERLinPro – Project definition (Andreas Jankowiak)

## BERLinPro = Berlin Energy Recovery Linac Project

HZB Helmholtz Zentrum Berlin

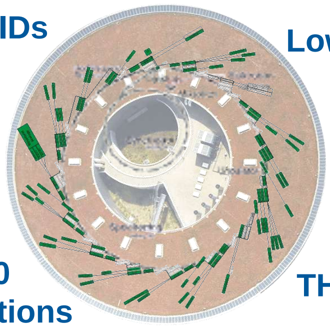
**100mA / low emittance ERL demonstrator, including all the key aspects of large scale ERL**
**An accelerator science and technology experiment**




| | Basic Parameter | Advanced |
|---|---|---|
| max. beam energy | 50MeV | 50MeV |
| max. current | 100mA | |
| nominal bunch charge | 77pc | up to some10pC |
| pulse length | ~ 2 ps | down to ~ 100fs |
| Rel. energy spread | $\sim 10^{-4}$ range | $\sim 10^{-2}$ |
| rep. rate | 1.3GHz | variable |
| normalized emittance | < 1mm mrad | ~ mm mrad |

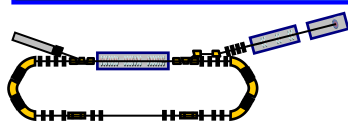
# Outlook - BESSY II Time Line

**1998 Start** → **2011 today** → **BESSY II perspective** → **2025**




**Linac, Top-Up, FOFB, + Phases II**

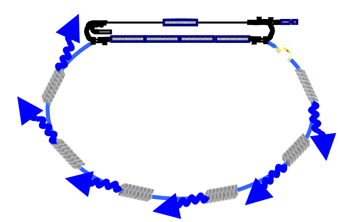
**B*ERL*inPro**



**BESSY$^{VSR}$**

## Up-Grade = Providing new and unique capabilities
## Bridging the gap to the future

**~ 2020**
**Decision on a future facility**



## To allow BESSY II to reach the future:

### Preservation
(continuous replacement of worn out and out dated components, e.g. standard power supplies, control hardware, ...)

### Modernisation (better than only preservation)
(e.g. new solid state rf-transmitters replacing old klystron systems → higher reliability, lower phase noise = higher beam quality)