Summary: Diagnostics and Instrumentation

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Humboldt-Innovation GmbH, Helmholtz-Zentrum Berlin, Germany

TWIICE 2, 8-10, February, 2016, The Cosener's House, Abingdon, UK

8 Talks

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I. **Beam Dynamics Meets Diagnostics, Giuliano Franchetti**
II. Longitudinal Bunch-By-Bunch Feedback at DLS, Günther Rehm
III. Triangle and Concave Pentagon Electrodes for an Improved Frequency Response of Stripline Beam Position Monitors, Yong Ho Chin
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EuCARD²

X EXTREME BEAM RING

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Beam Dynamics meets Magnets

Dec. 2013, Darmstadt

eV × B
2nd workshop
Beam Dynamics meets Magnets

by PSI, Dec. 2014

Advanced Optics Control Workshop 2015, CERN

Mechanisms

Collaboration meeting 2014, CERN

Space charge, Oxford 2015

Beam Dynamics

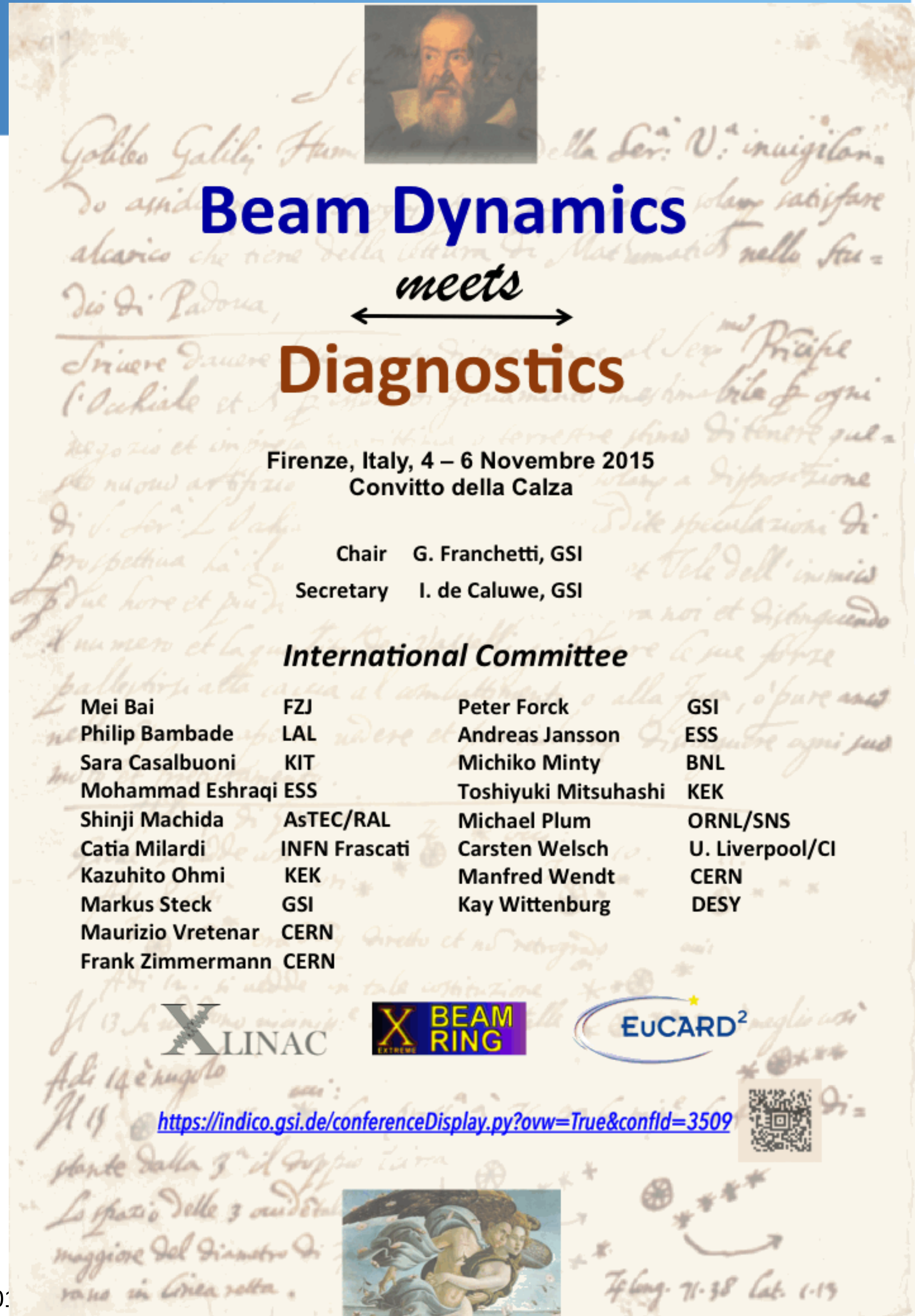
Surfaces, damages, vacuum

1-3 July 2016

G. Franchetti

Beam dynamics meets Diagnostics

November 2015


Beam Dynamics
meets
Diagnostics
Firenze, Italy, 4 – 6 Novembre 2015
Convitto della Calza
Chair G. Franchetti, GSI
Secretary I. de Caluwe, GSI
International Committee
Mei Bai FZJ
Philip Bambade LAL
Sara Casalbuoni KIT
Mohammad Eshraqi ESS
Shinji Machida AsTEC/RAL
Catia Milardi INFN Frascati
Kazuhito Ohmi KEK
Markus Steck GSI
Maurizio Vretenar CERN
Frank Zimmermann CERN
Peter Forck GSI
Andreas Jansson ESS
Michiko Minty BNL
Toshiyuki Mitsuhashi KEK
Michael Plum ORNL/SNS
Carsten Welsch U. Liverpool/CI
Manfred Wendt CERN
Kay Wittenburg DESY
XLINAC
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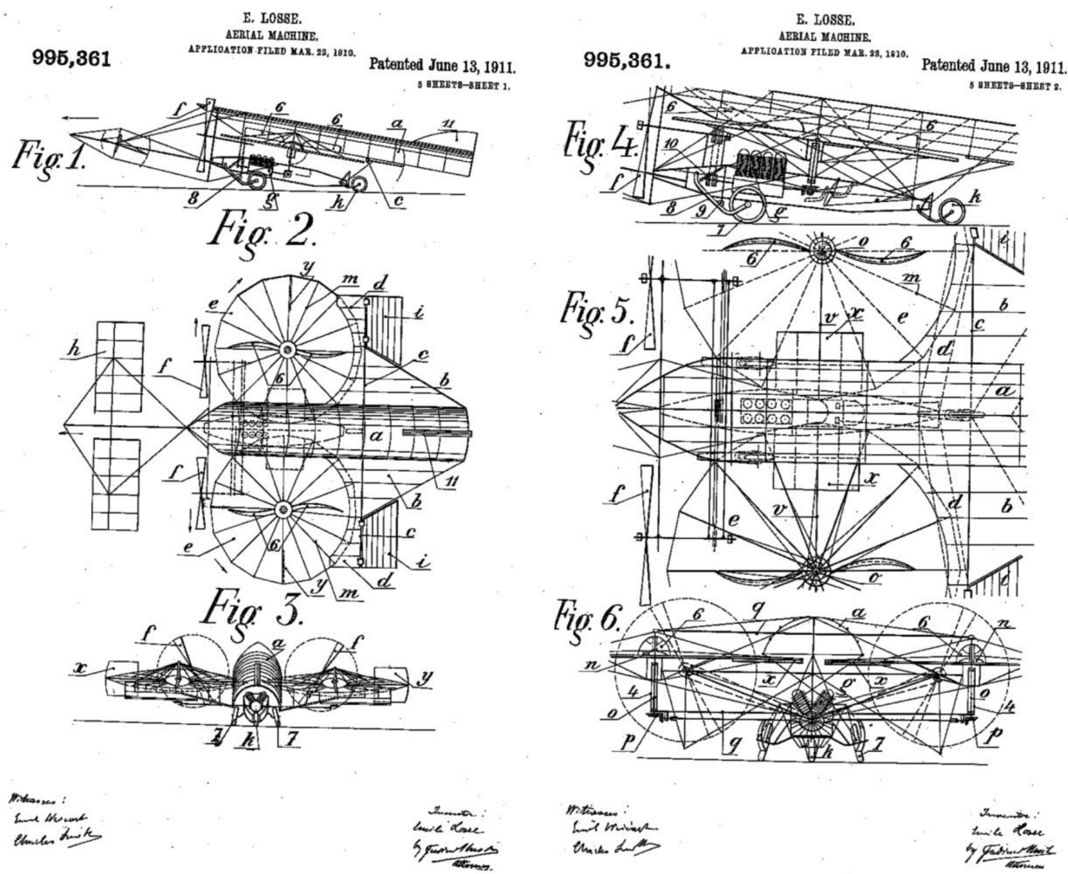
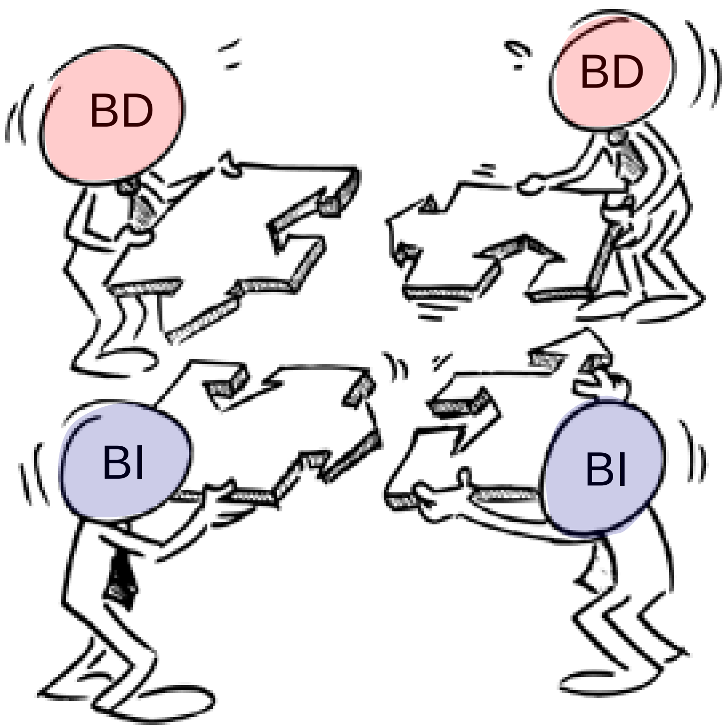
https://indico.gsi.de/conferenceDisplay.py?ovw=True&confId=3509

2) Beam instrumentation participants say that it is **mandatory** clear specification of the feature of the devices required by the beam dynamics colleagues



7) It was suggested that the beam dynamics people should be involved with beam diagnostics in the early design of devices to optimize design and be aware of what is possible to measure and what not.



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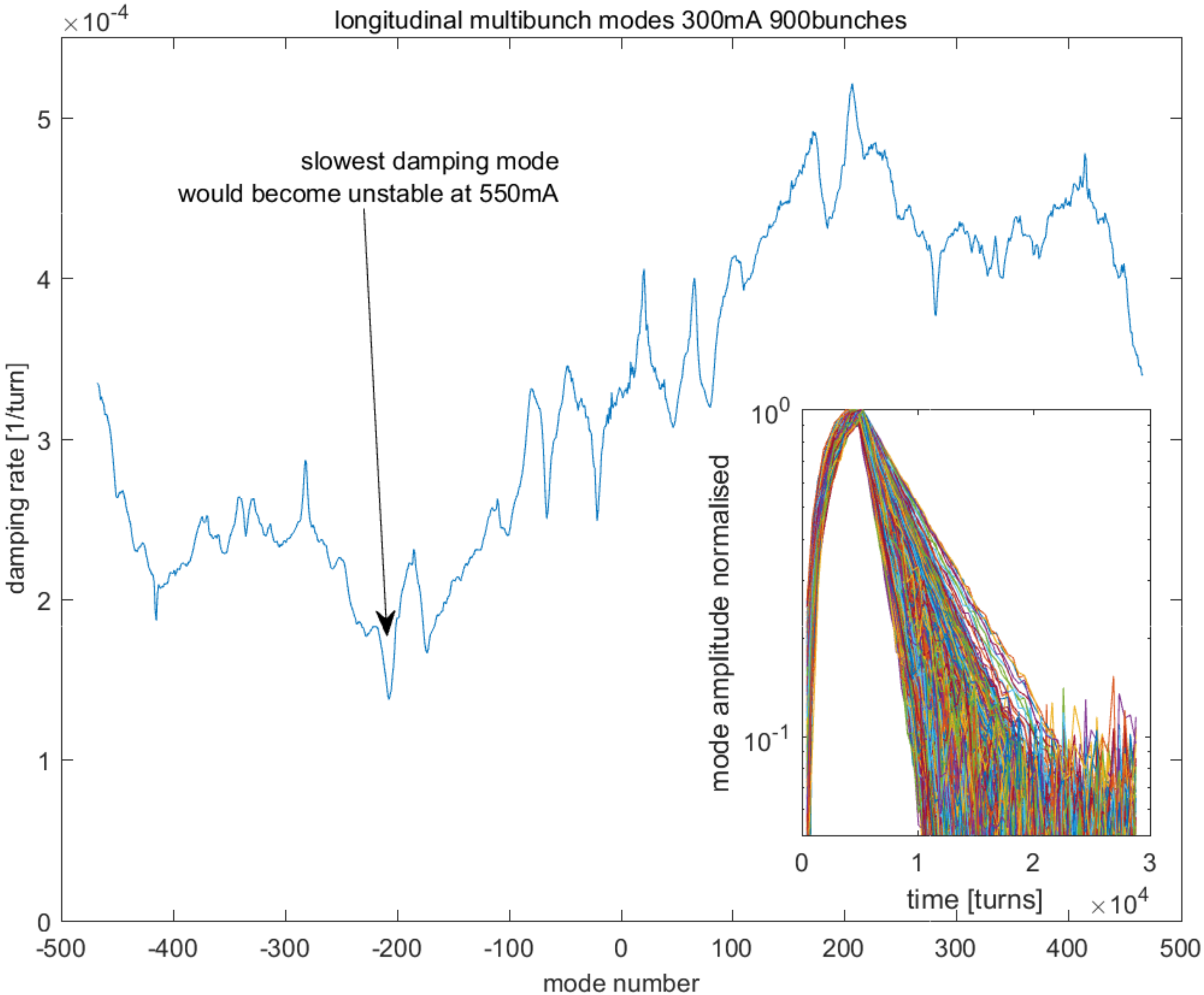
Embedded or Modular Processor

Embedded	Modular
Extremely compact (1/2 size 1U)	Compact 2U
Fixed ADC/DAC	Choice of ADC/DAC through FMC
Fixed FPGA size	Choice of FPGA through carrier
Fixed CPU	Choice of CPU through crate / module
Standalone	Crate could house several channels
One specific use	Adaptable use
All built for one purpose with system performance in mind	Combination of modules with reliance on standardised interfaces
Significant development cost/time	Available 'off the shelf'


longitudinal multibunch modes 300mA 900bunches
×10^-4
slowest damping mode
would become unstable at 550mA
damping rate [1/turn]
mode number
-500
-400
-300
-200
-100
0
100
200
300
400
500
0
1
2
3
4
5
mode amplitude normalised
time [turns]
×10^4
10^0
10^-1
0
1
2
3

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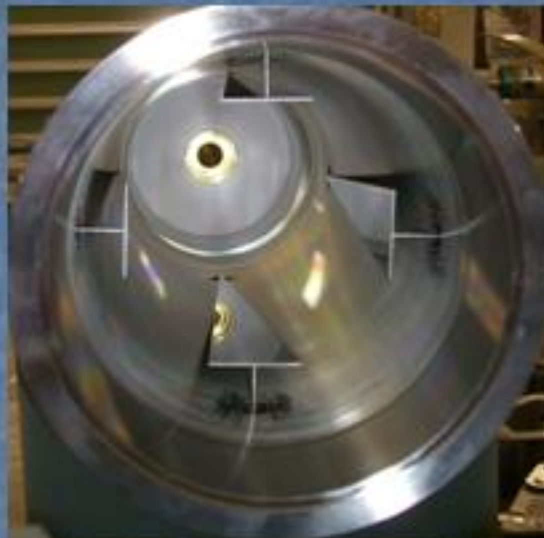
Rethinking for a Better Approach

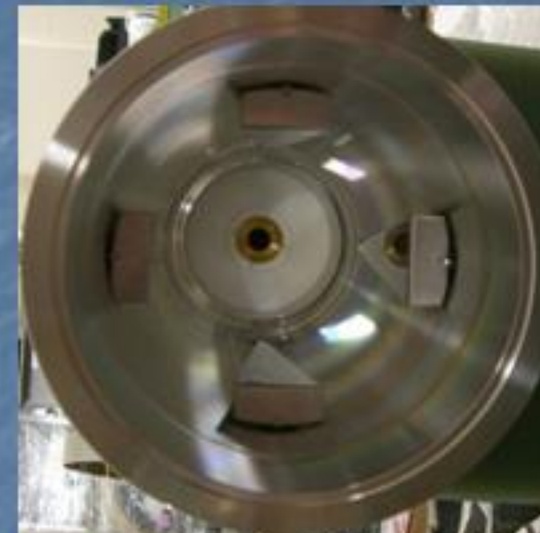
- During the bus tour to the Sicilian Pantheon in the Erice workshop, I thought
  - We should better take a 180 degree opposite approach instead.
    - Start with a simple shape, easy to fabricate and set up, and gradually increase its complexity to improve the frequency performance.
    - The frequency performance will be saturated quickly as the complexity of the shape is increased, since the potential merit by a sophisticated shape (idealism) will be offset by the difficulty in compliance of the engineering requirement (reality).

Prototypes

Triangle
w/o apron



Triangle
with apron



Pentagon
w/o apron

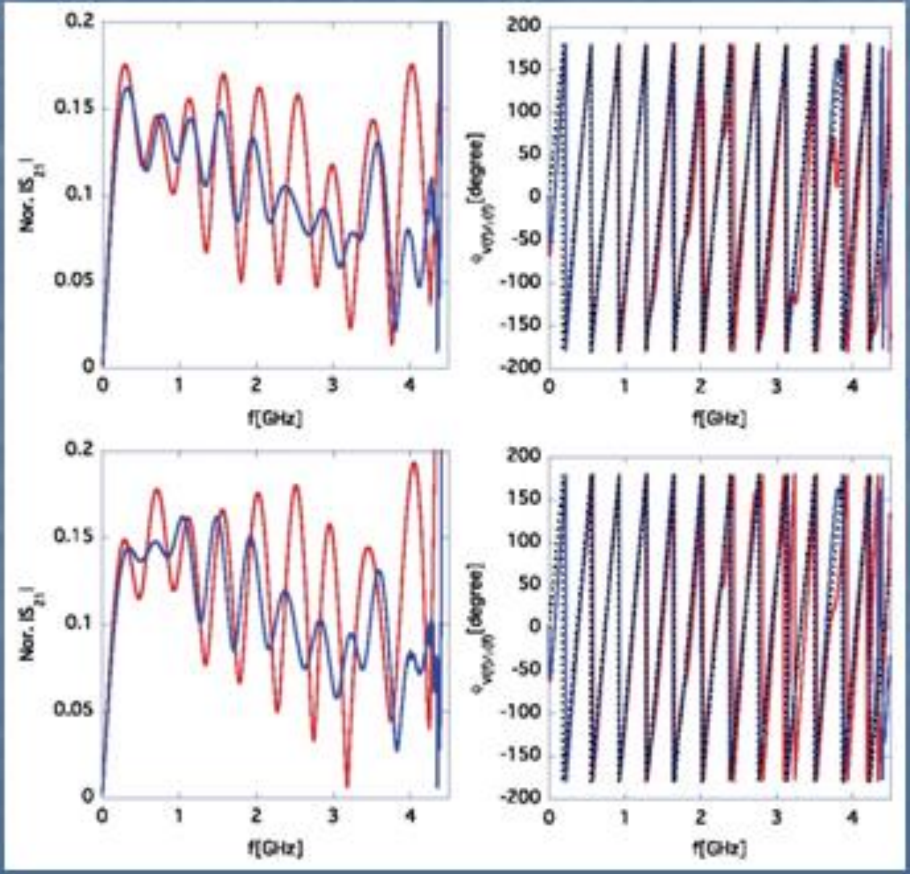
Pentagon
with apron

Measurement Results

- Not as good as the simulations, but the frequency response of the concave pentagon is good up to 4GHz.

Triangle
Red: w/o apron
Blue: with apron

Concave pentagon
Red: w/o apron
Blue: with apron



Dotted lines

$$\phi = 2\pi f t_2 \cdot 180/\pi$$

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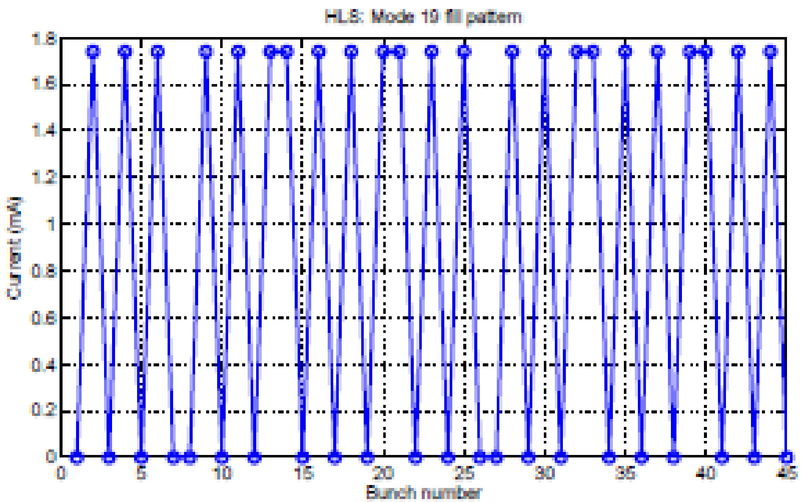
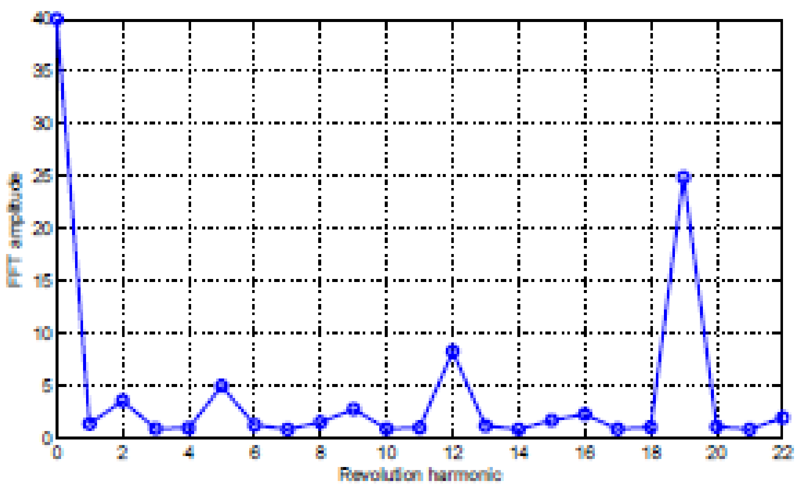
Fill Patterns and Coupled-bunch Instabilities

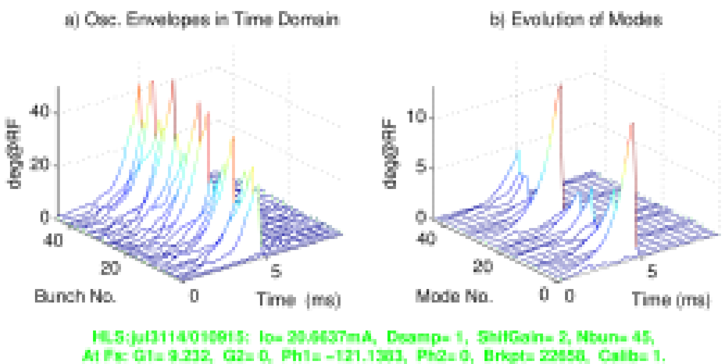


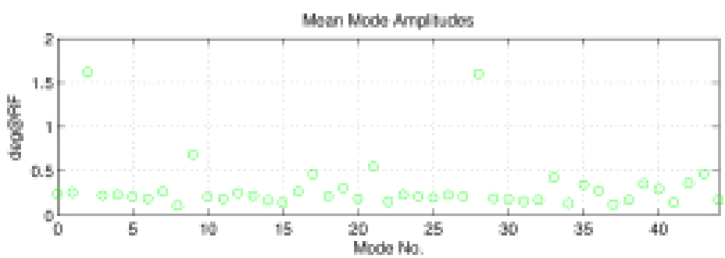


- Uneven fill patterns can reduce or increase growth rates;
- Theory developed in the late 90s [1];
- To damp mode 13, couple it to -13 (32);
- Fill pattern to maximize revolution harmonic 19 (32 – 13).

[1] S. Prabhakar, PhD thesis, Stanford University, 2000, SLAC-R-554

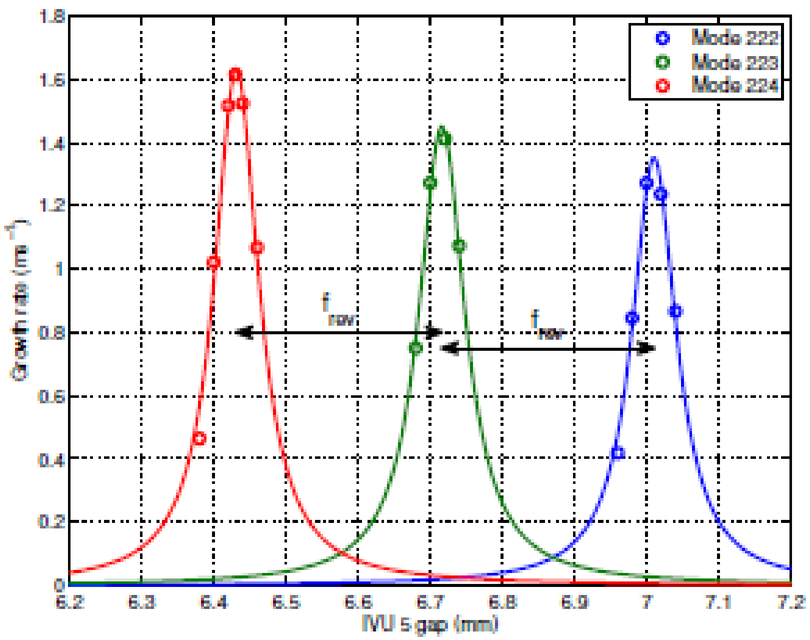
Observations in Rev19 Fill Pattern





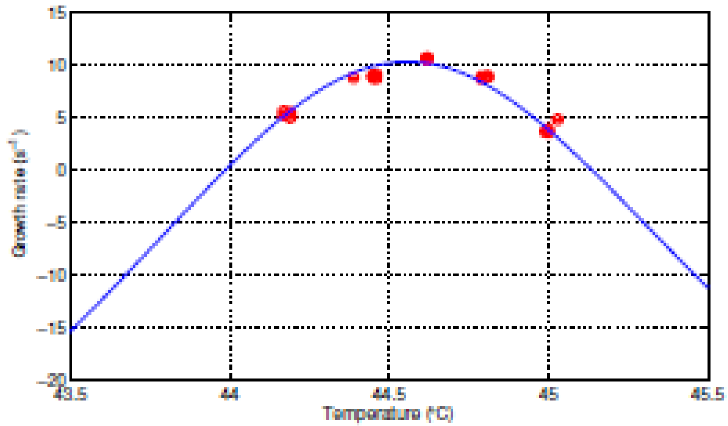
- No quadrupole instabilities below 150 mA;
- Mode 13 is stable;
- Spectrum is now dominated by mode 28.

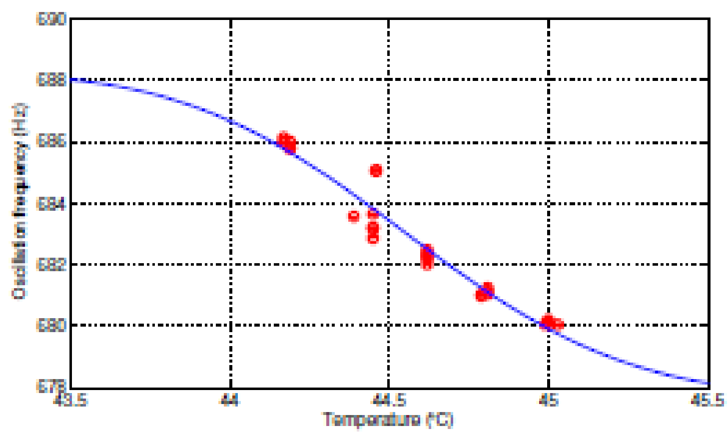
IVU Impedance Conclusions



- HOM frequency seems to change linearly with the gap position:
  - Two revolution harmonic distances are within 3%;
- Tuning sensitivity 4.8 MHz/mm;
- Bandwidth of 76 μm translates to 365 kHz;
- If the HOM is really at 7.3 GHz its Q is 20,000.

Cavity 20 Temperature Scan





- Moved cavity temperature from nominal 35 °C;
- Growth rate peak seen around 45 °C — mode 167;
- Detailed scan at 0.2 °C steps reveals a clear resonance;
- Fit second-order resonator response:

Parameter	Value
T_{center}	44.56 °C
Bandwidth	2.64 °C
Rad. damping	54 s^{-1}

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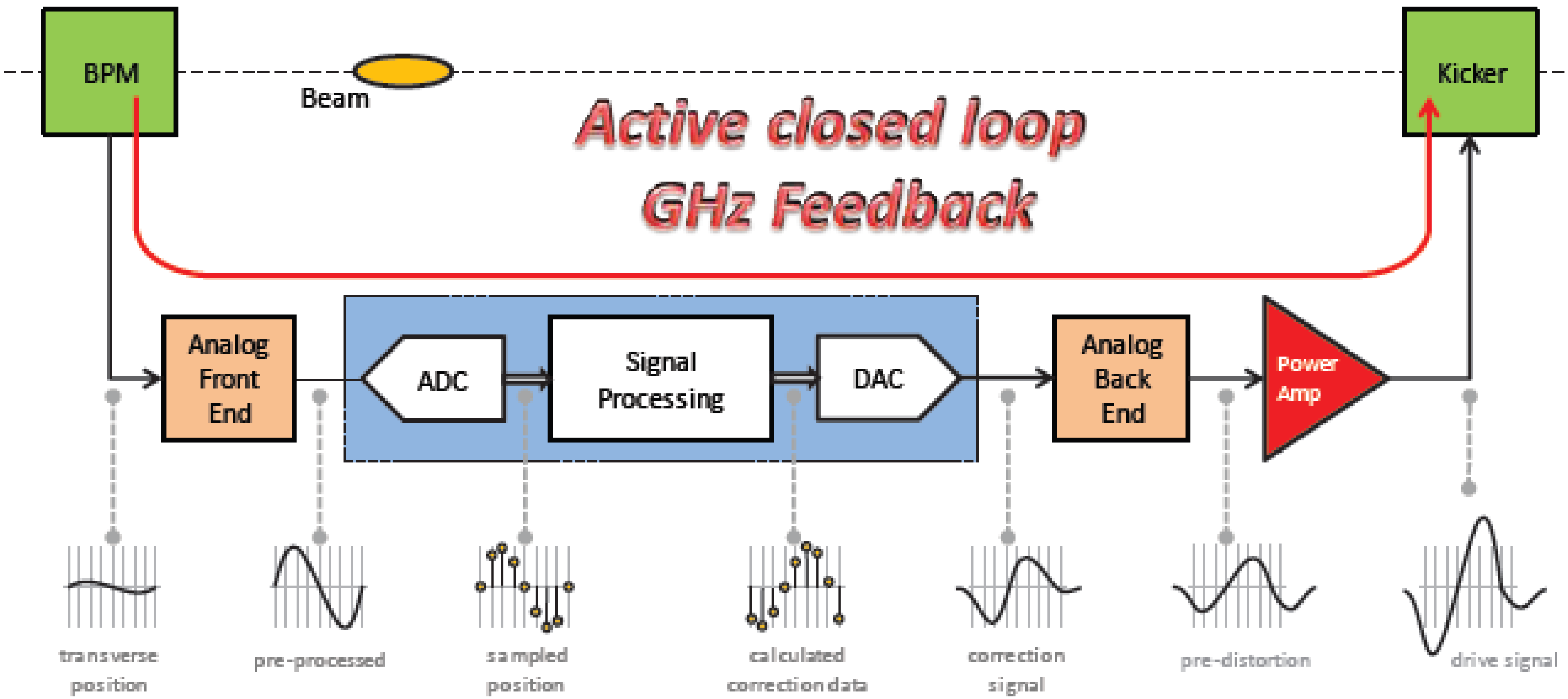
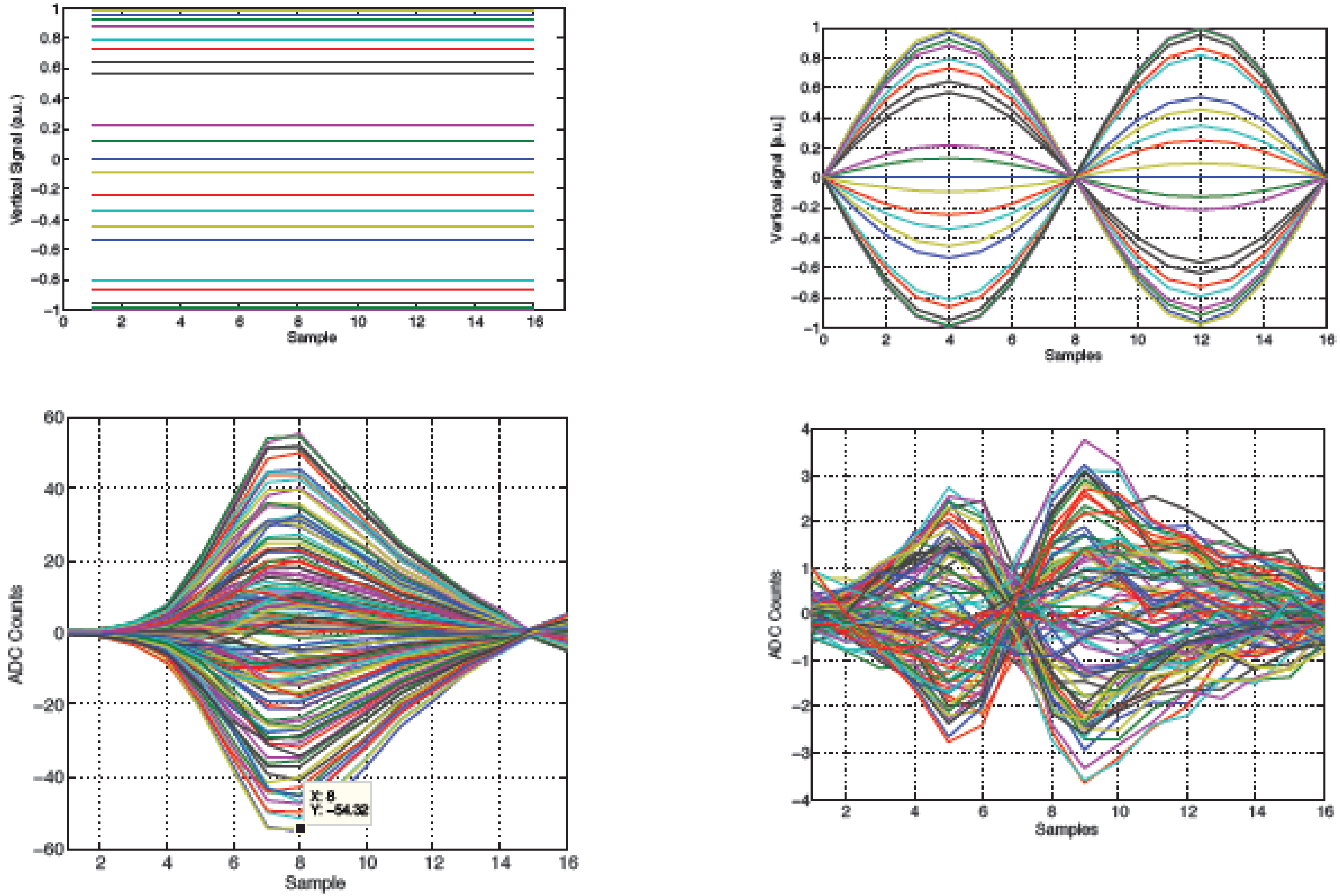
Essential Features



- Control of Non-linear Dynamics (Intra-bunch)
- GHz Bandwidth Digital Signal Processing - 4 GS/s ADC and DAC
- Optimal Control Formalism - allows formal methods to quantify stability and dynamics, margins
- Research Phase uses numerical simulations (HeadTail), Reduced Models, technology development, Demonstrator System, SPS Machine Measurements
- Demonstrator system 1 - 64 bunches, modest kicker power with 1 GHz bandwidth

Measuring the dynamic system - Beam response



- Pickup requires equalization, Timing the front and back-ends is tricky

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Experimental investigations of CSR instabilities at SOLEIL: recent results using high-repetition rate electro-optical sampling

C. Evain, M. Le Parquier, C. Szwaj, S. Bielawski
PhLAM, Université Lille 1, France

E. Roussel, **FERMI**, Italy

L. Manceron, J.-B. Brubach, M.-A. Tordeux, J.-P. Ricaud, L. Cassinari, M. Labat, M.-E. Couprie, P. Roy
Synchrotron SOLEIL, France.

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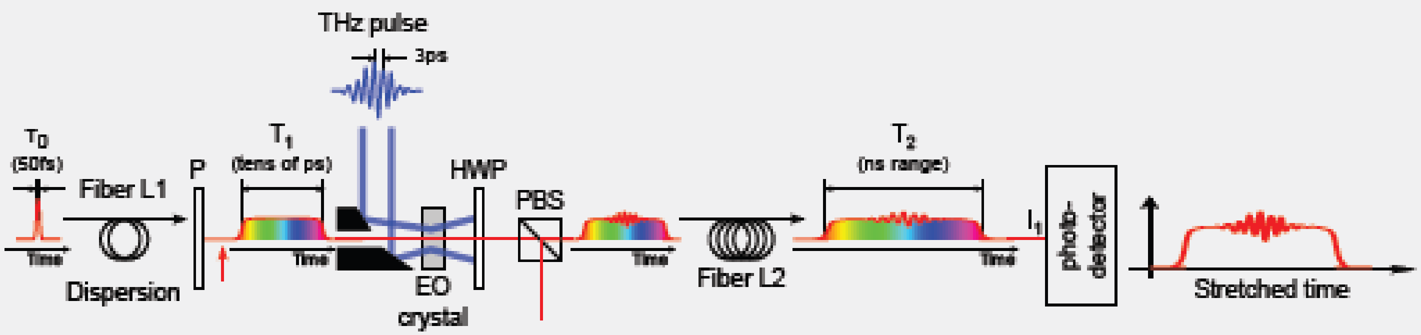
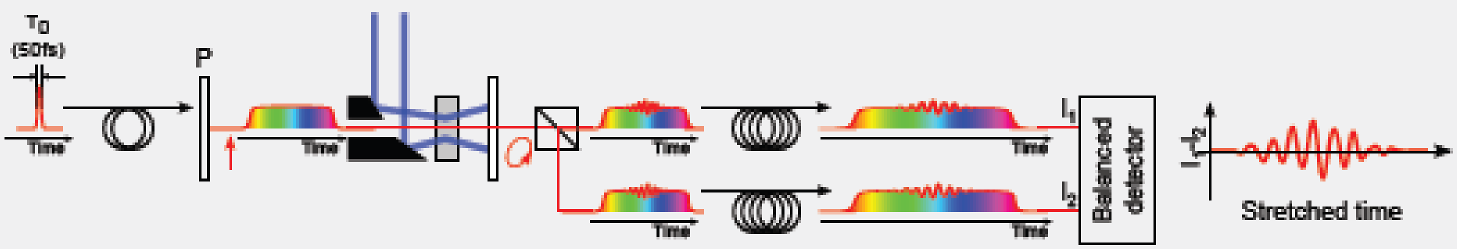
Sensitivity: the choice of the first step (EOS) is crucial

EO crystal between polarizers "close to extinction": High responsivity



Balanced detection between the two polarizer ports: Laser noise cancellation

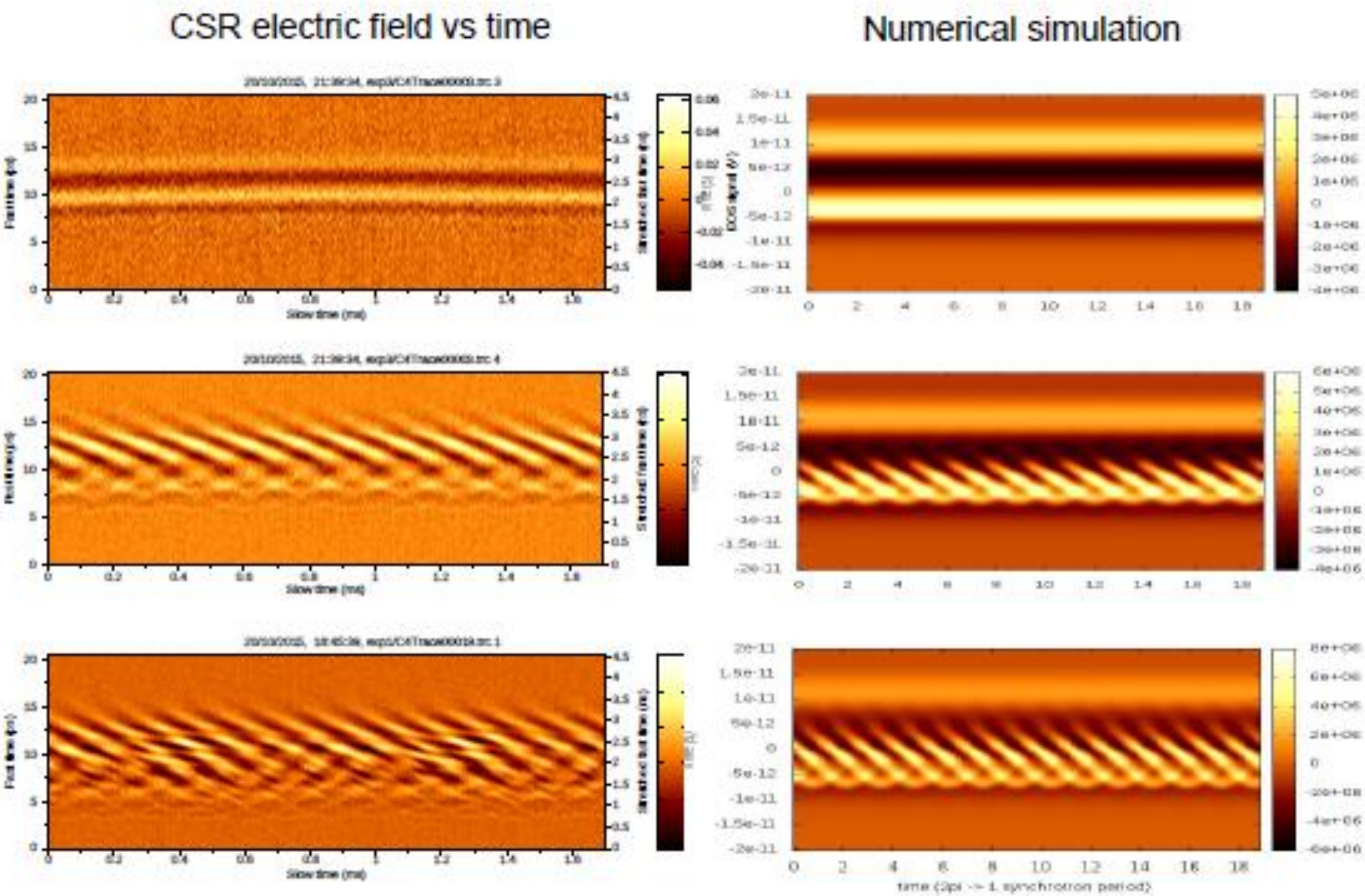


- Incompatible strategies?

Note: time resolution is the same as for classical EOS: $T_{min} = \sqrt{T_0 T_1}$*, with* T_0 *the compressed laser pulse duration, and* T_1 *the time window.*

Low alpha: Preliminary tests of models

- Wakefield: parallel plates + CSR only [Murphy et al., Part Acc 57, 9 (1997)]
- Parallel Vlasov, and Macroparticle code (PIC) using real number of particles



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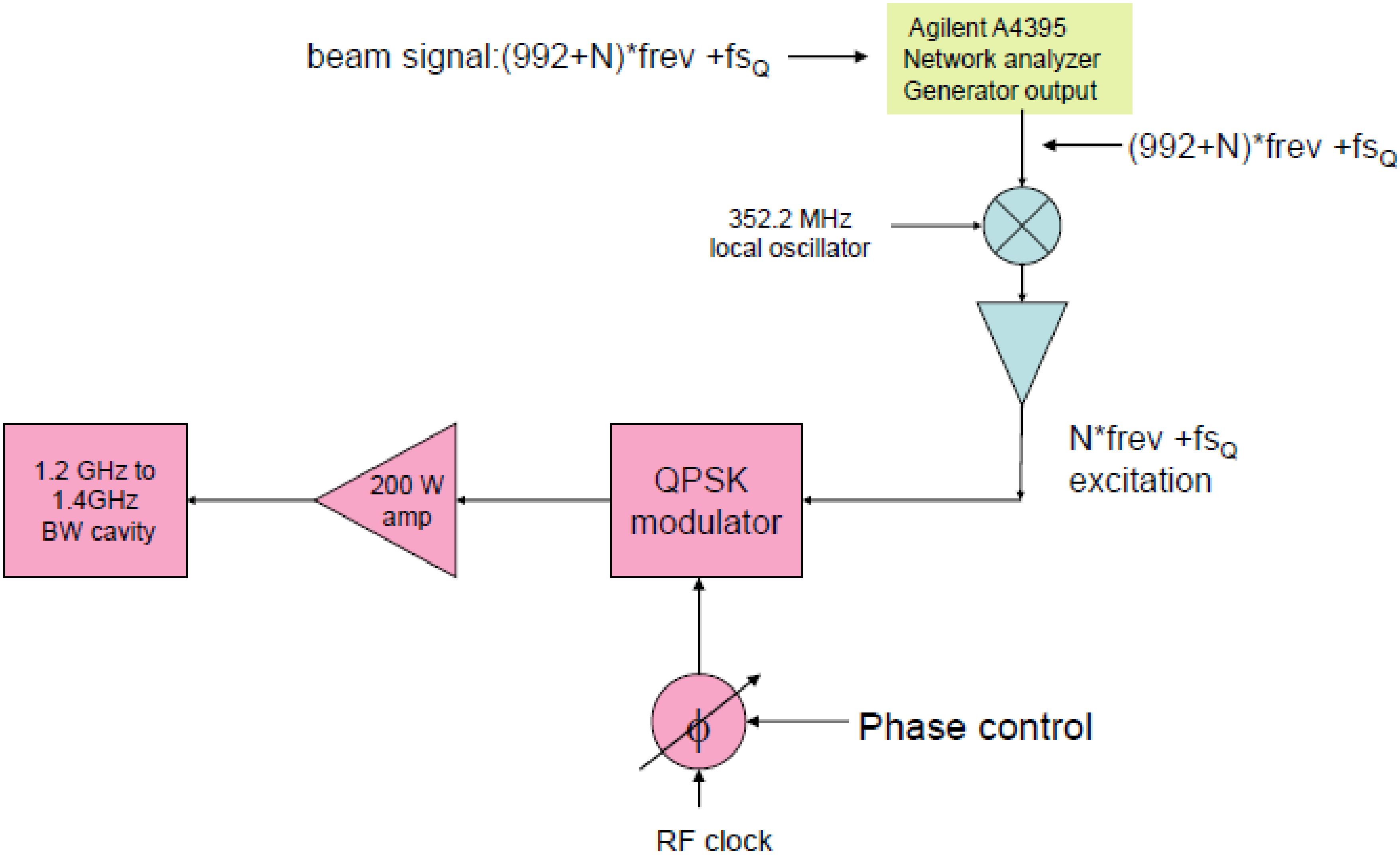
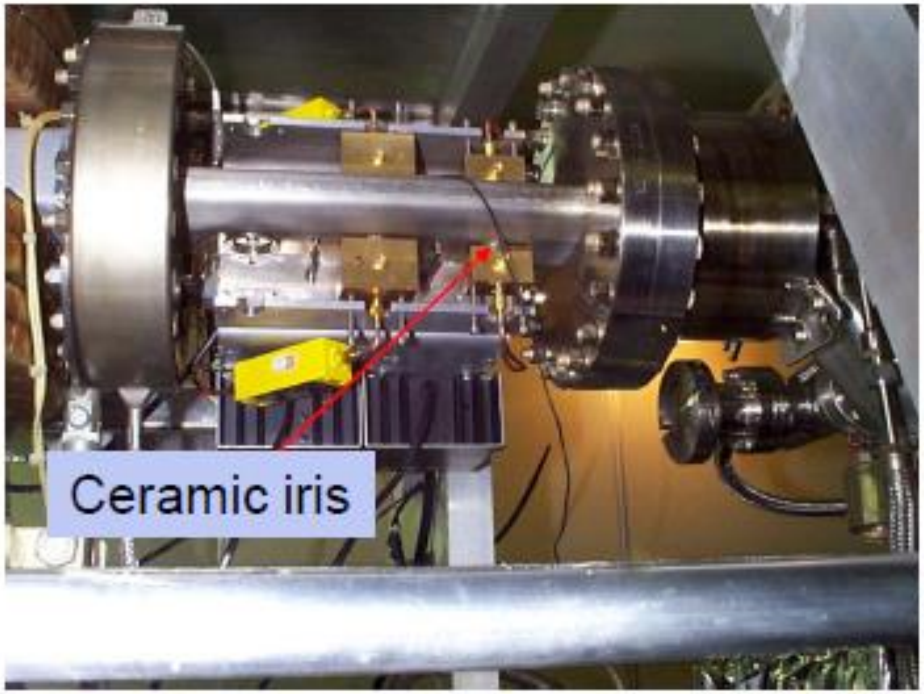
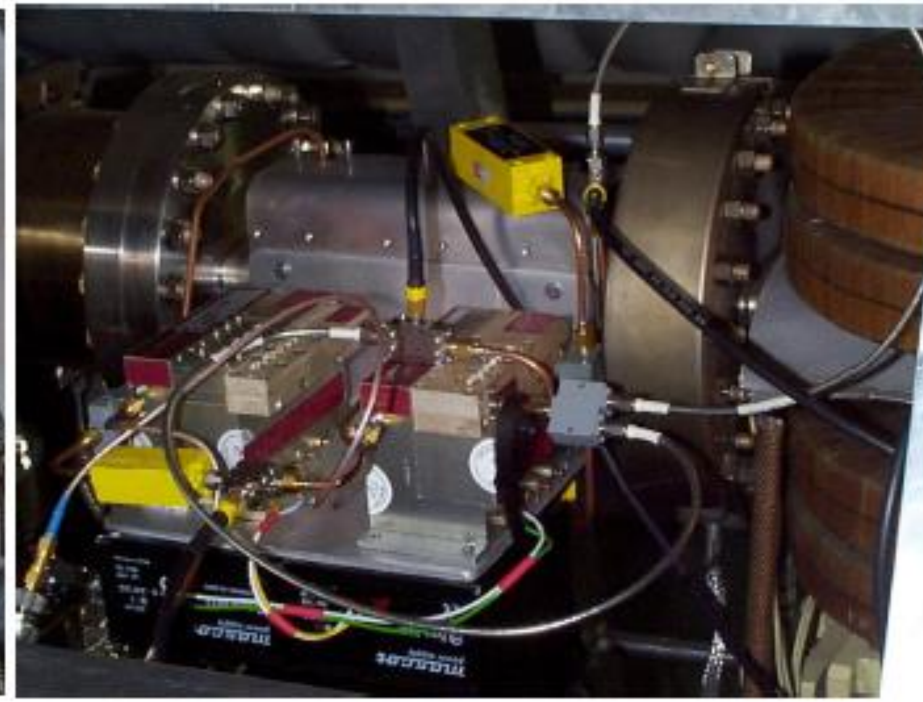
LONGITUDINAL FEEDBACK BACK END



CAVITY PICK UPS SET UP

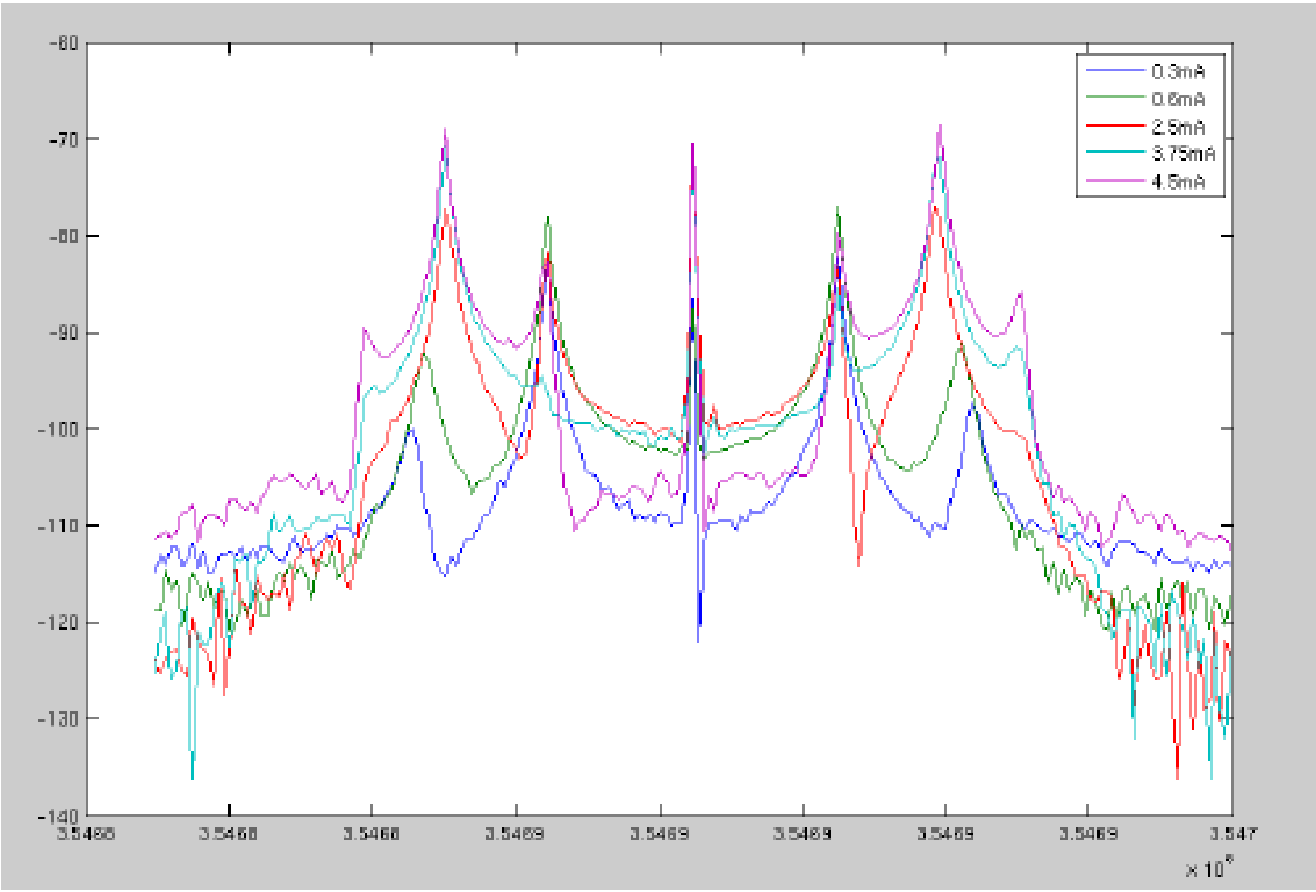




CAVITY PICKUPS (left)

MICROWAVE SIGNAL FREQUENCY DOWN CONVERSION (right)

SPECTRUM OF THE BEAM LONGITUDINAL RESPONSE



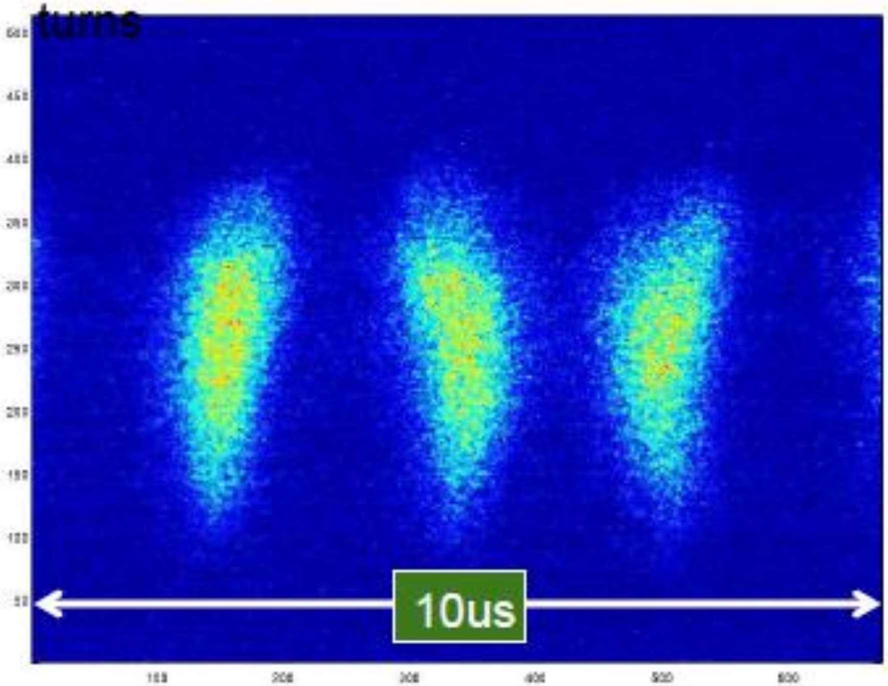
Filling pattern:
16 bunches
I: .3 to 4.5mA/bunch

LOOKING FOR **HEAD-TAIL INSTABILITIES** X TURNS AFTER A HORIZONTAL BEAM KICK

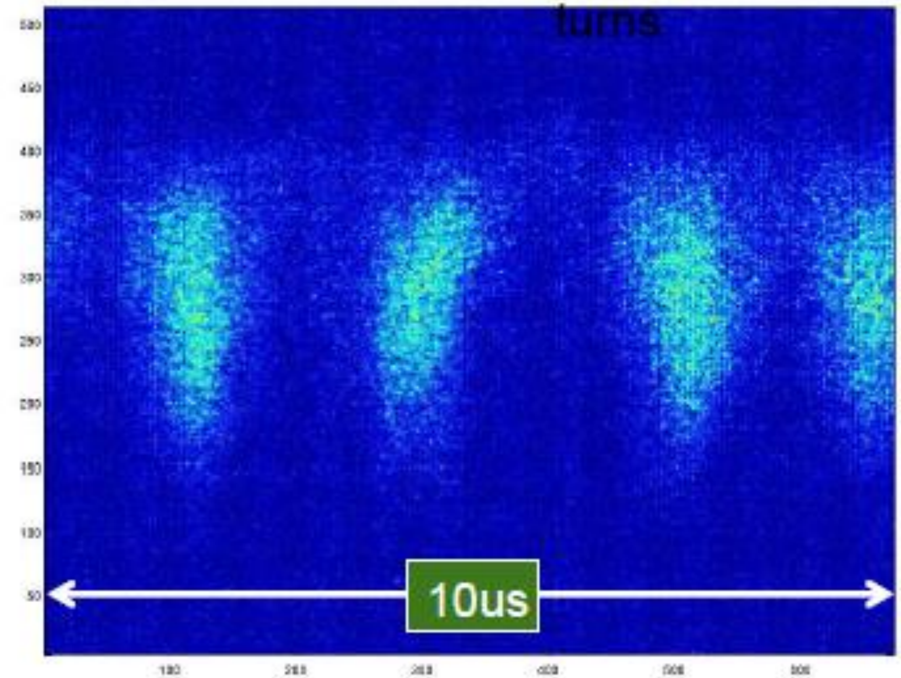
2/ Find the instabilities x turns after the kick

Single bunch @ 2mA, chromaticity 0.3

kick + 37 turns



kick + 96 turns



→ tilted and bent profiles:
modes ±1 and ±2 mixed

→ general blow up reduces the intensity and dilutes the instabilities

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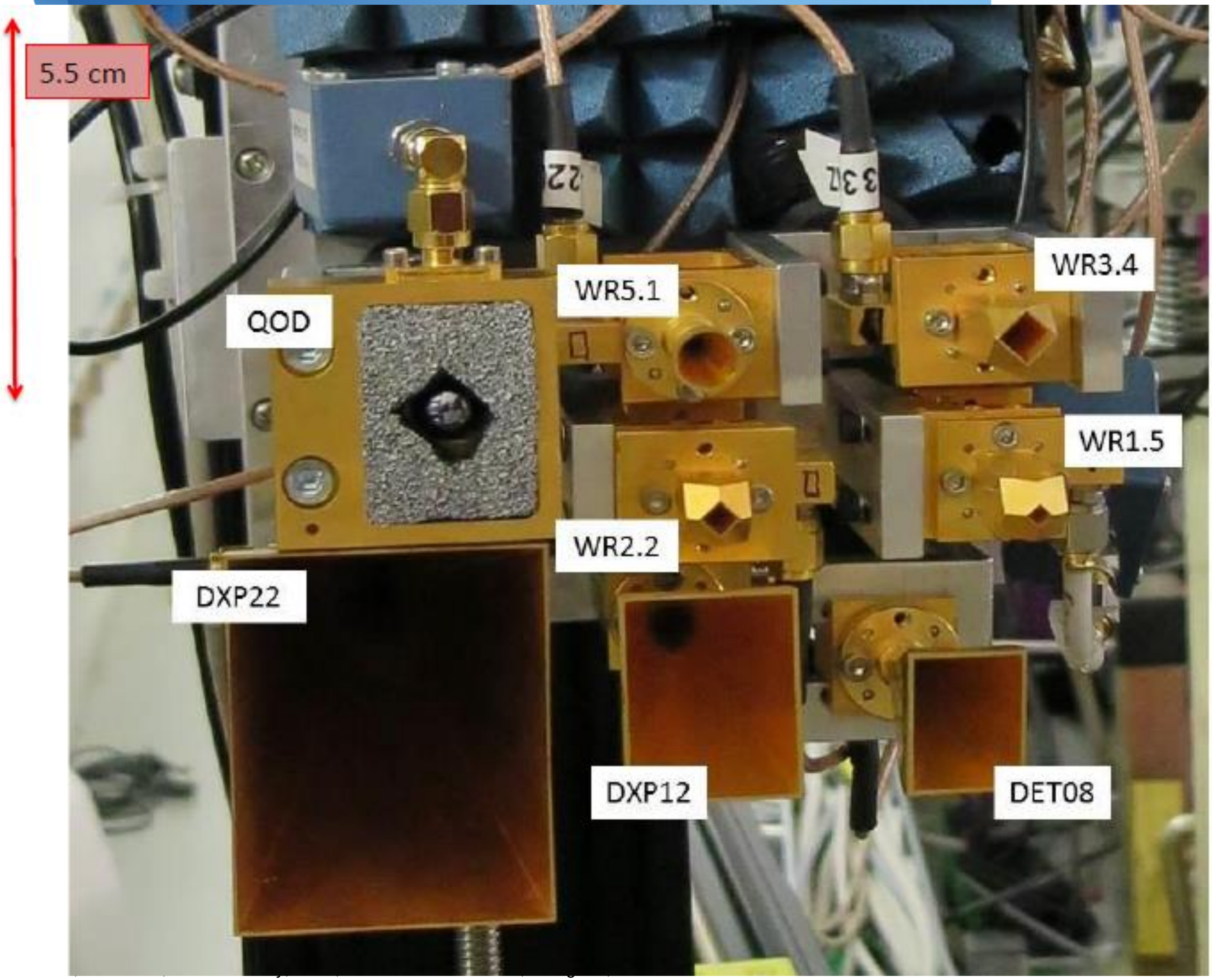
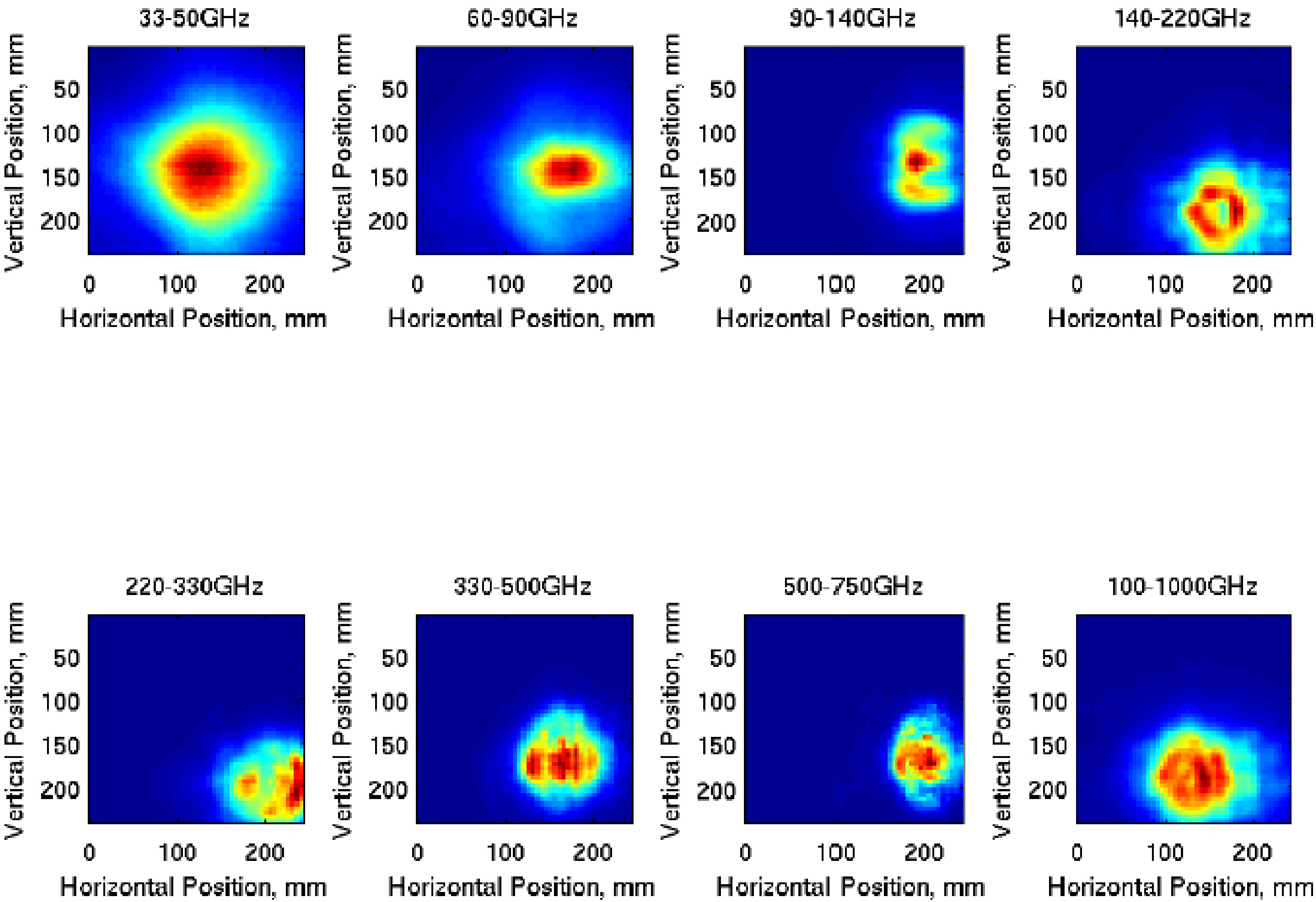
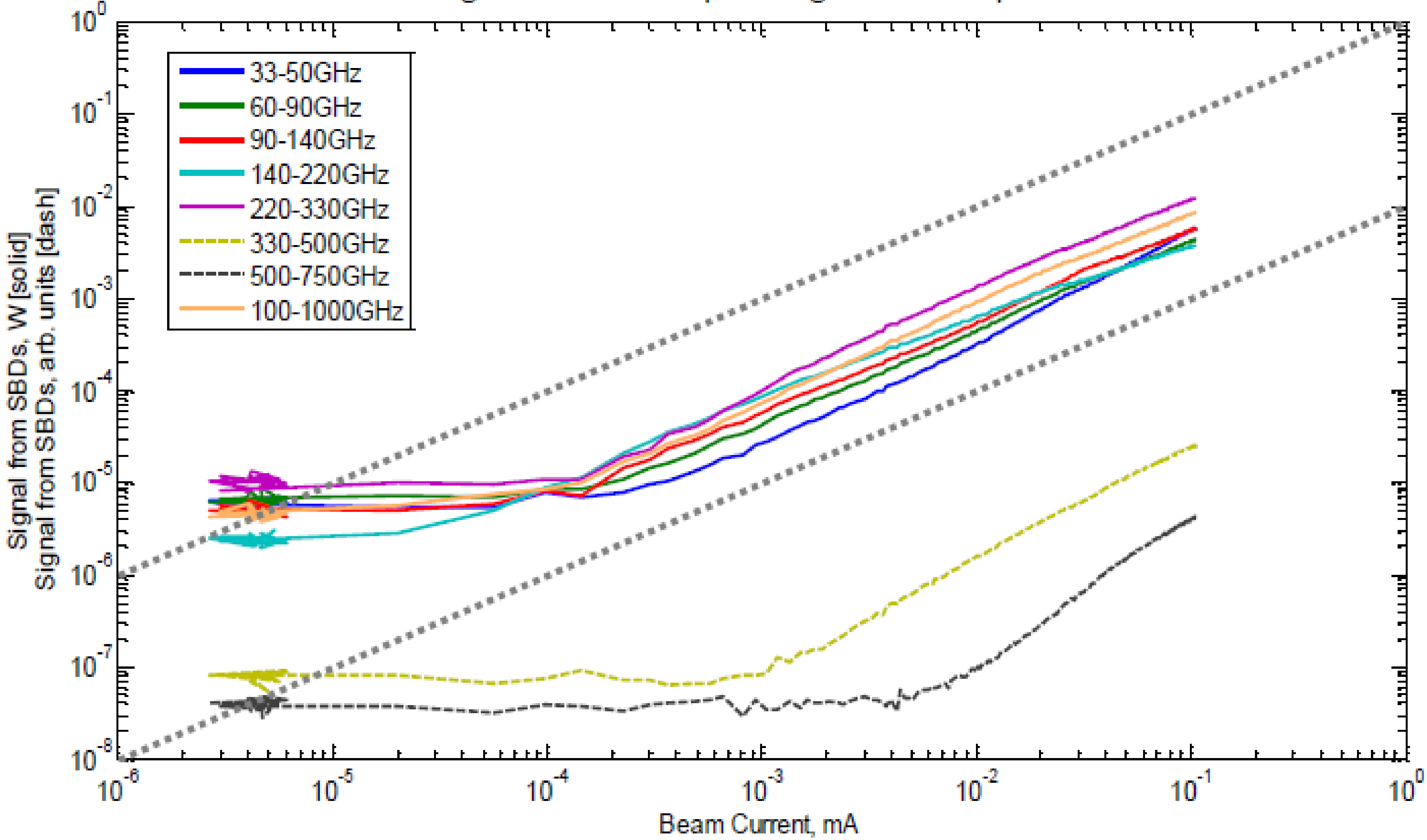

5.5 cm
QOD
WR5.1
WR3.4
WR1.5
WR2.2
DXP22
DXP12
DET08

Low Alpha B22 10mA Raster Scan



Low Alpha (4e-6) Single Bunch Current Ramp
Signal with corresponding Effective Apertures



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diamond

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