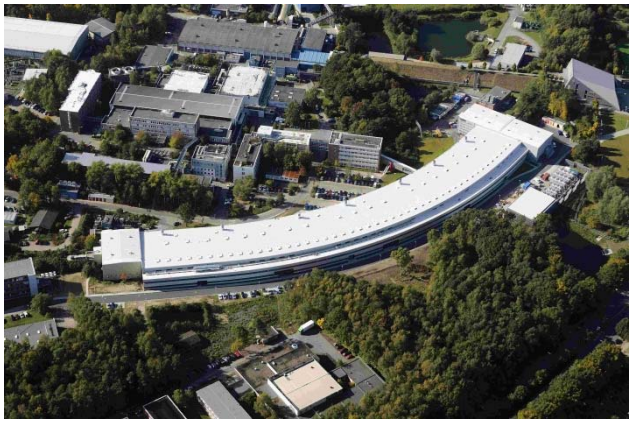
PETRA IV – 100 MHz cavity.

- **PETRA IV and MAX IV 100 MHz Cavity**



Martin Dohlus,
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DESY

Collaboration meeting
Jan 23, 2016

HELMHOLTZ ASSOCIATION

DESY

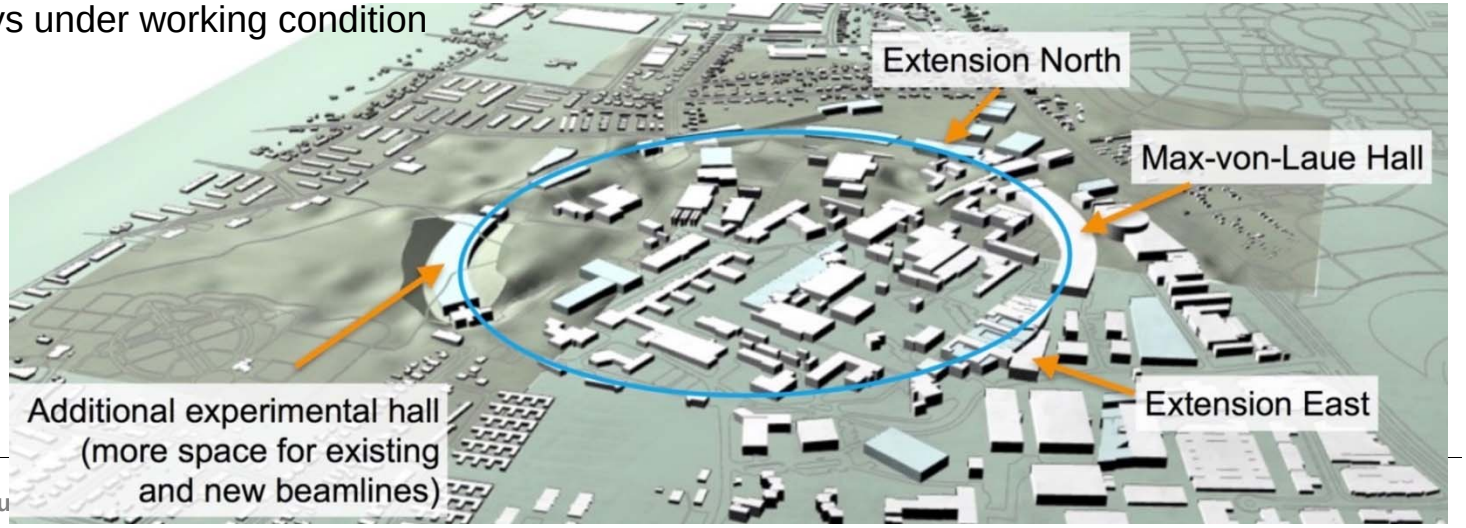
PETRA IV – Decoding the Complexity of Nature

PETRA IV – The ultimate 3D process microscope has the potential:

- to address individual organelles in living cells and follow metabolism pathways with elemental and molecular specificity
- to image the chemistry inside a battery down the atomic level and understand their aging processes
- to map interfaces in functional materials, e.g., for a thorough understanding of frictional processes on the way to enhance energy efficiency and reduce emissions
- to study the synthesis of novel materials and catalytic reactions inside a chemical reactor on all relevant length scales
- to image individual grains in novel materials and alloys under working condition

Parameters and parameter range:

PETRA IV Parameter		
Energy	6 GeV	(4.5 – 6 GeV)
Current	100 mA	(100 – 200 mA)
Number of bunches	~ 1000	
Emittance horz.	10 pm rad	(10 – 30 pm rad)
vert.	10 pm rad	(10 – 30 pm rad)
Bunch length	~ 100 ps	



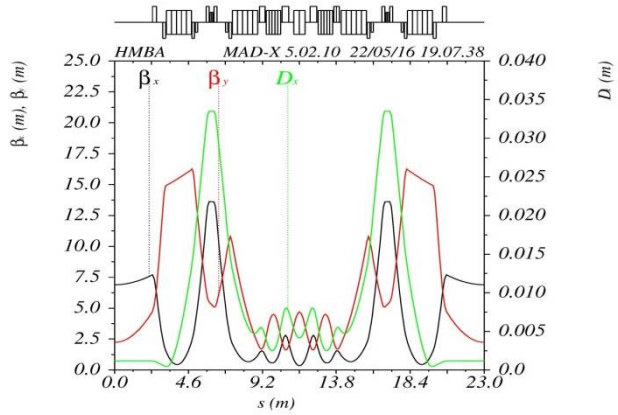
Lattices Investigated for the PETRA Upgrade

➢ Started to investigate two different lattice types

1. Based on the ESRF-HMBA cell
2. Based on 4D-phase space exchange and MBAs with non-interleaved sextupoles

1. Lattice based on HMBA Cells

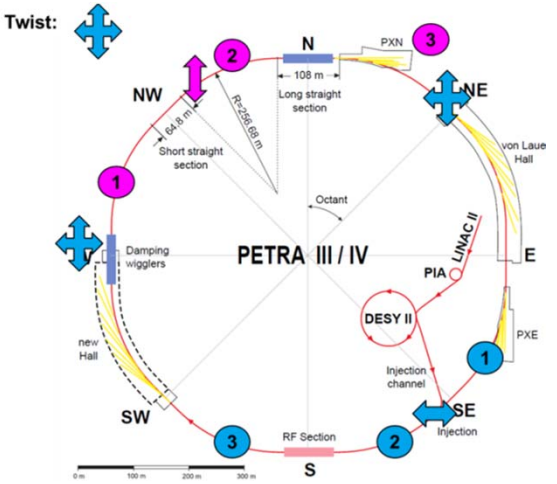
- Arcs: 9 HMBAs cells to build a 45° arc
- 8 identical arcs
- Straight sections: FODO cells

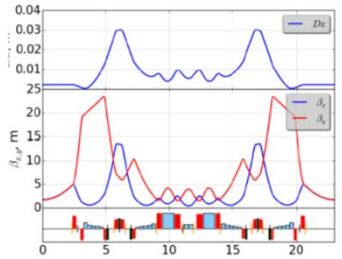


Horz. emittance of HMBA-based ring is 12 pm·rad at 6 GeV ✓
Cell not yet optimized,
(small dynamic aperture) ✗

2. 4D-phase space exchange and MBAs

- arc cells with non interleaved sextupoles
- Undulator section, preliminary version with HMBA





Emittance ~ 20/20 pm ✓
(5 GeV, wigglers not yet included)
Undulator cell not yet optimized ✗

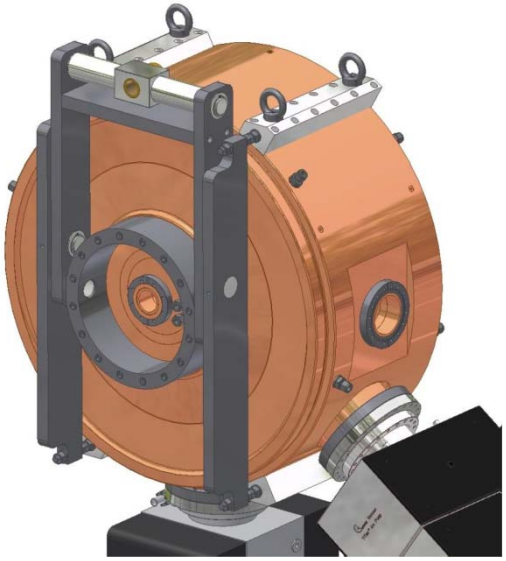
Intra Beam Scattering

Small transverse beam size

➔ Emittance growth due to multi Coulomb scattering

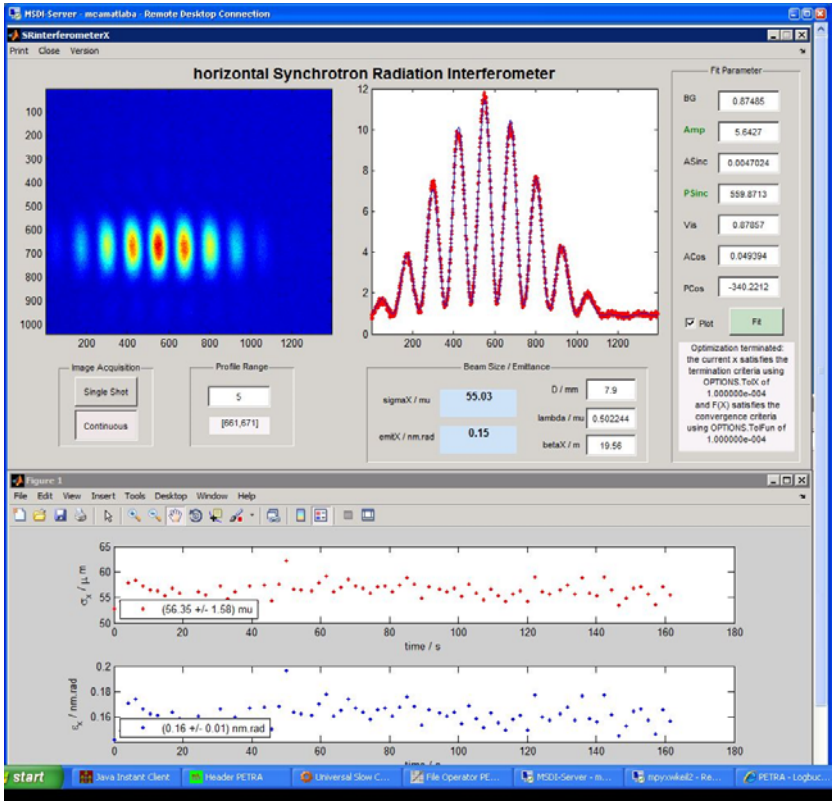
Mitigation: longer bunches,
lower RF frequency 100 MHz

MAX IV cavity:



Test Runs at Low Energy (3 GeV) and Low Emittance

July 16, 2013
PETRA III, 3 GeV,
horz. Emittance 160 pm rad
I = 5 mA in 480 bunches,
N = 5 x 10^8 / Bunch



July 2013
Several test runs at low energy

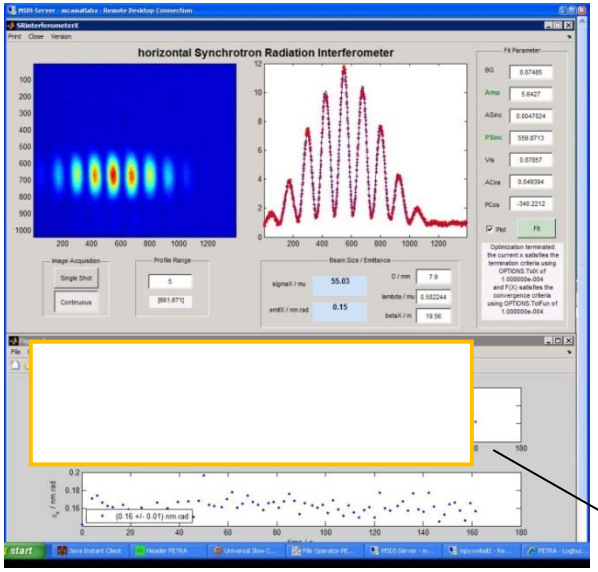
FODO arcs: 72 deg lattice
wiggler section matched,
predicted emittance:
3 GeV: 160 pm rad

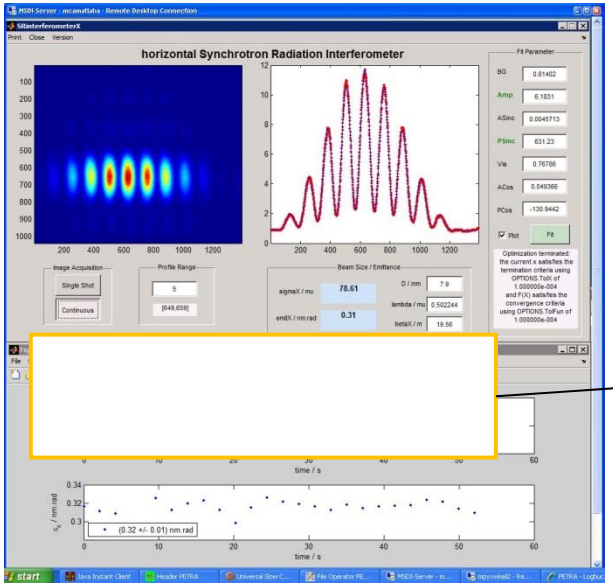
Intrabeam scattering:

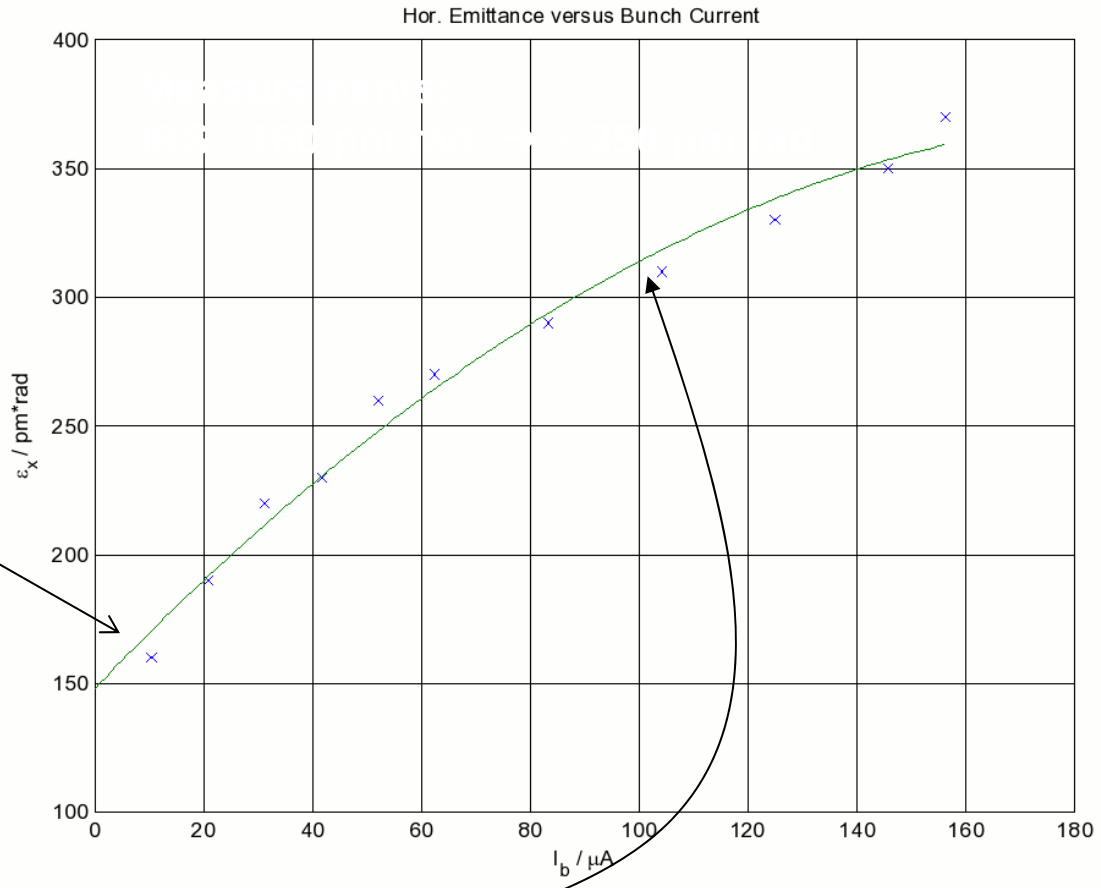
$$A \sim \frac{N_0}{\gamma^4 \, \epsilon_x \, \epsilon_y \, \sigma_s \, \sigma_p}$$

$$\frac{1}{\tau_x} = \left\langle A \left[f(1/a, b/a, q/a) + \frac{{D_x}^2 \, {\sigma_h}^2}{\sigma_{x\beta}{}^2 \, f(a,b,q)} \right] \right\rangle$$

Intra Beam Scattering / Emittance Growth







100 MHz Cavity

	MAX IV and SOLARIS design	ASTRID2 design
RF specifications		
Frequency mode 1	99.931 MHz	104.9 MHz
Required tuning range		+/- 1 mm
Accelerating voltage	300 kV	
Copper power loss	30 kW	15 kW
Coupler power		120 kW
Q		19000

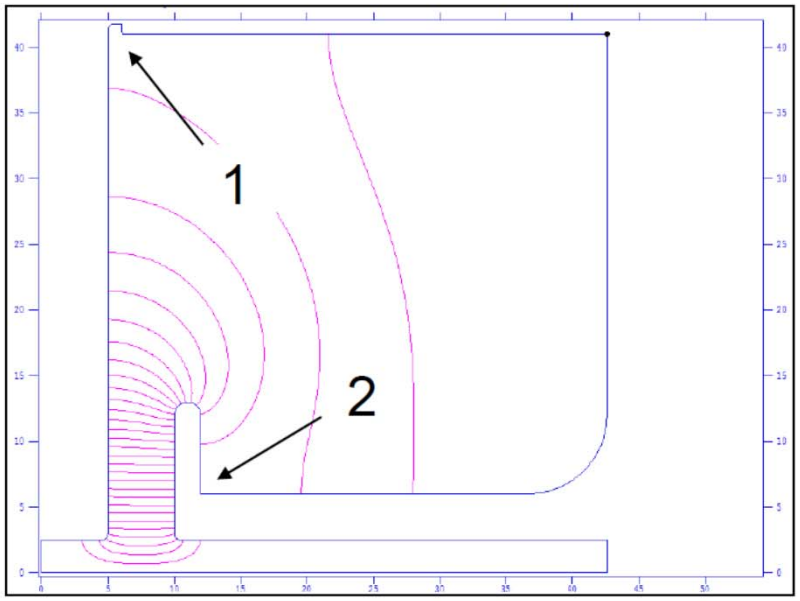
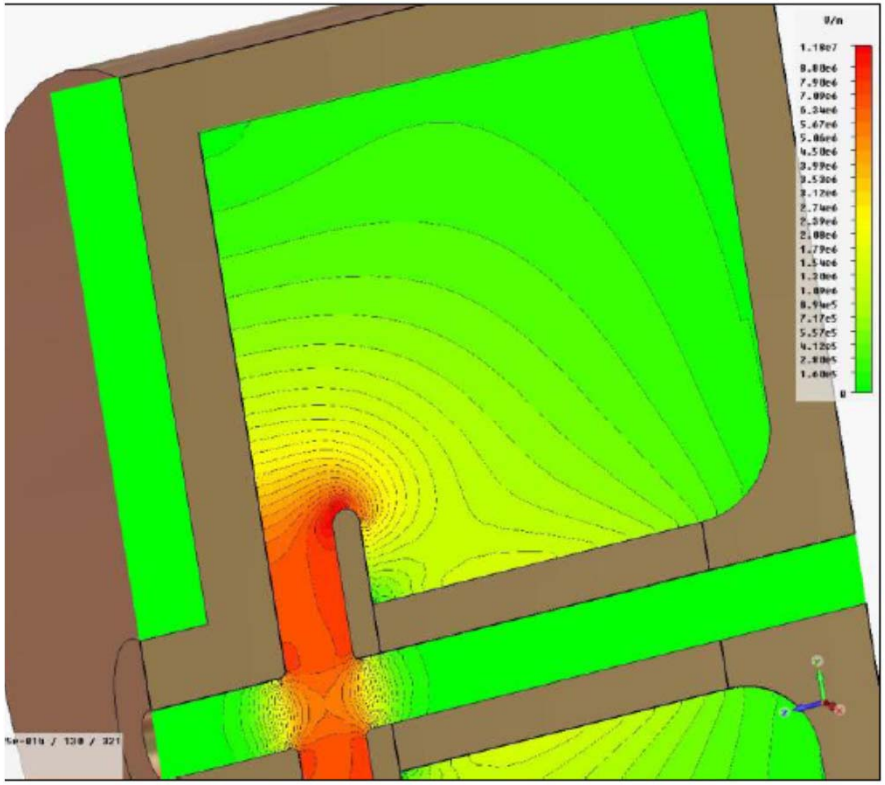


Figure 2 : 2D inner shape deviations from specification

MAX IV 100 MHz Cavity

HOMs



: Electric field at the unperturbed resonator

Higher modes		
	Q	Frequency [MHz]
1	20847	100.0
2	34022	408.5
3	28926	419.3
4	28702	419.5
5	35996	461.3
6	42849	469.3
7	42825	470.6
8	51847	528.8
9	49451	529.4
10	27698	554.3
11	27665	554.6
12	62878	600.2
13	62240	601.4
14	47416	620.0
15	30828	621.5
16	62134	622.9
17	56877	629.9
18	44327	656.7
19	44410	657.0
20	42778	718.0

PETRA IV 100 MHz Cavity

1. **Calculation of basic parameters for an 100 MHz cavity**

   f, R/Q , Q

   Max E, H field

2. **HOM calculations**

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2. **coupler design**

3. **multi pactoring**

Thank you for your attention !