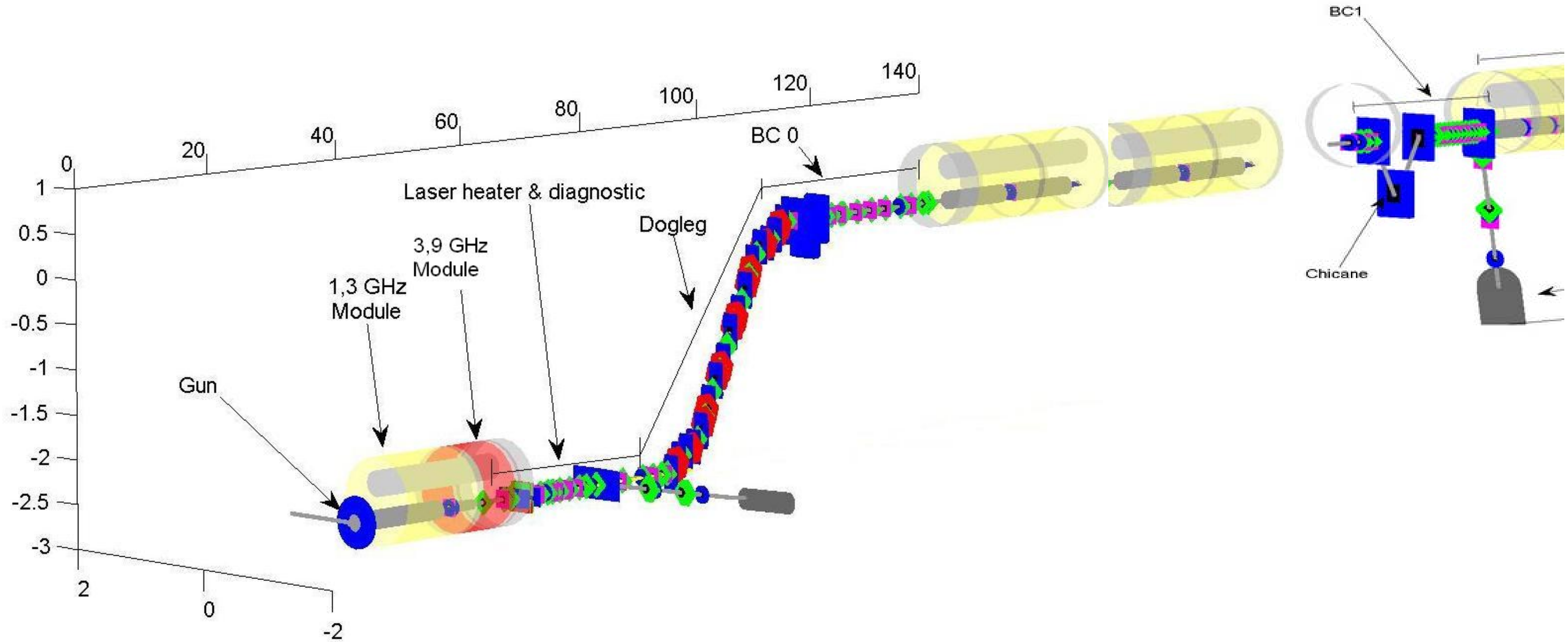
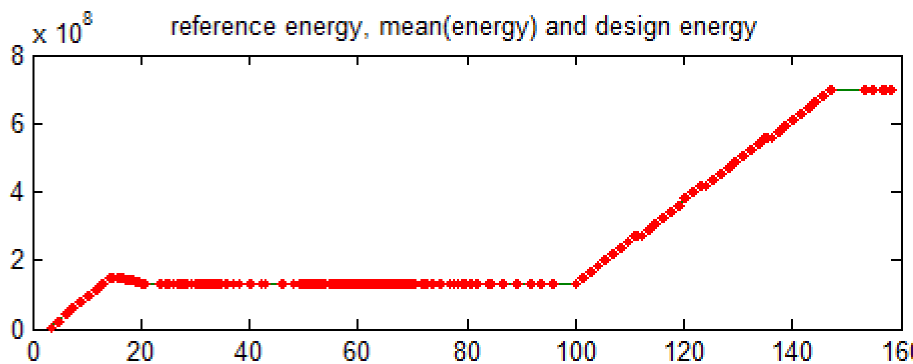
Coupler Kicks, CSR and Petra-Cavity

Martin Dohlus

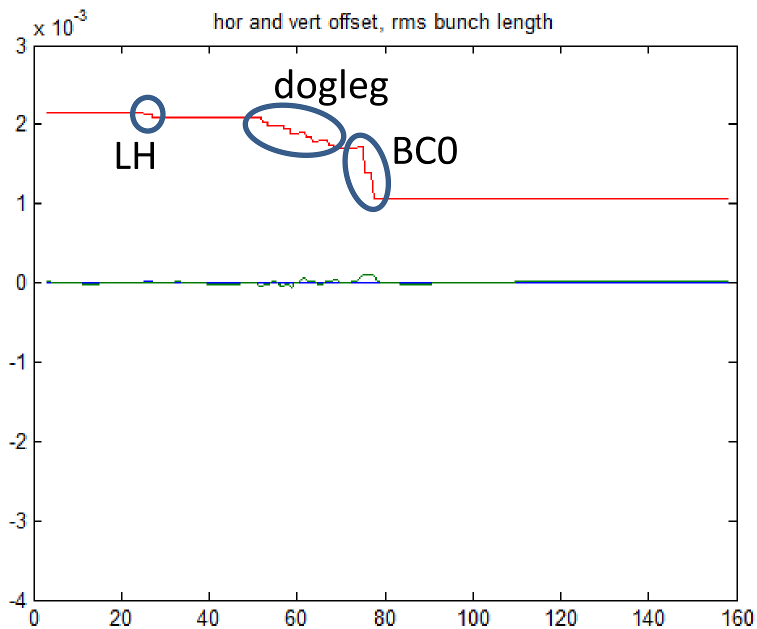
Effect of Coupler Kicks before BC1

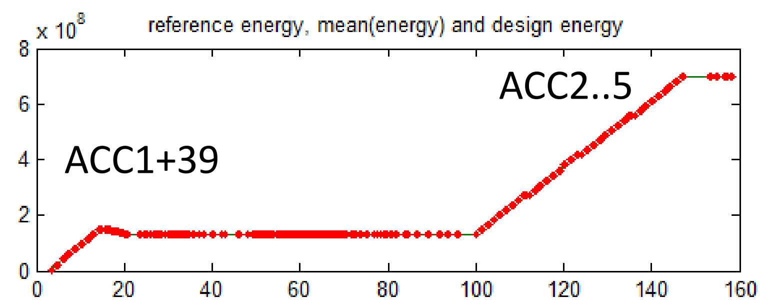




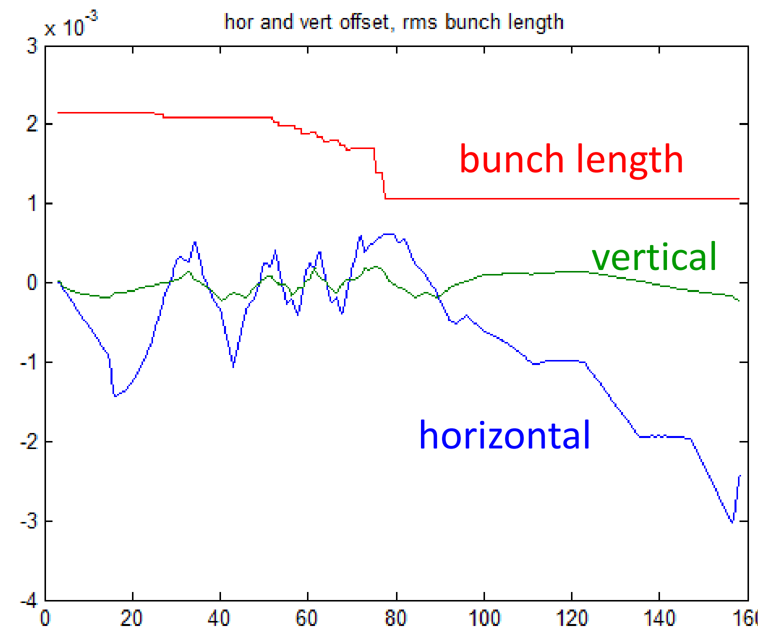
horizontal and vertical offset

no kicks



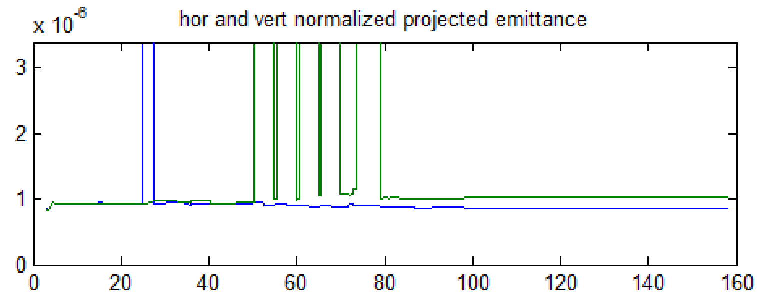


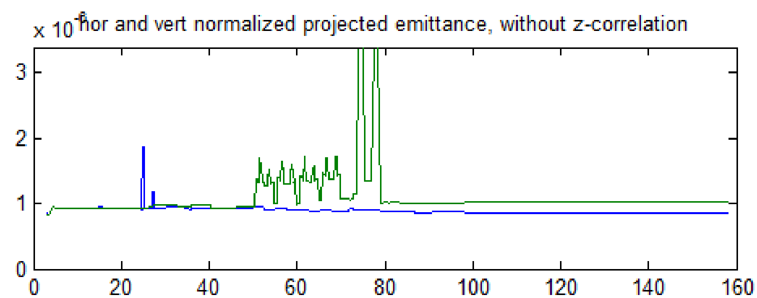
with kicks:
matched, 6 mm penetration depth

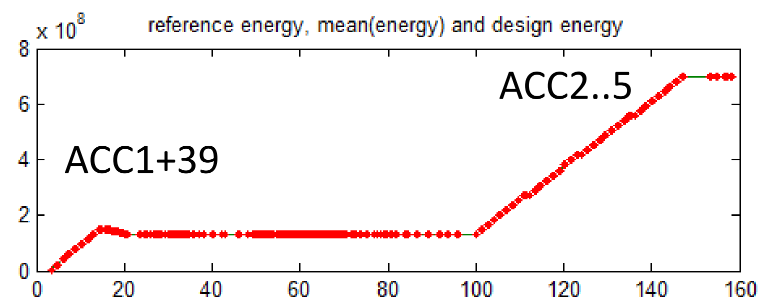


horizontal and vertical normalized projected emittance

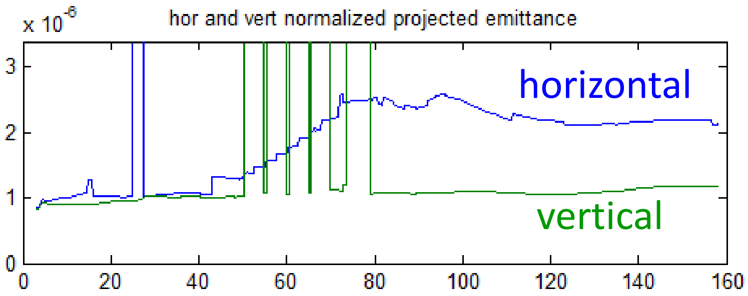
no kicks

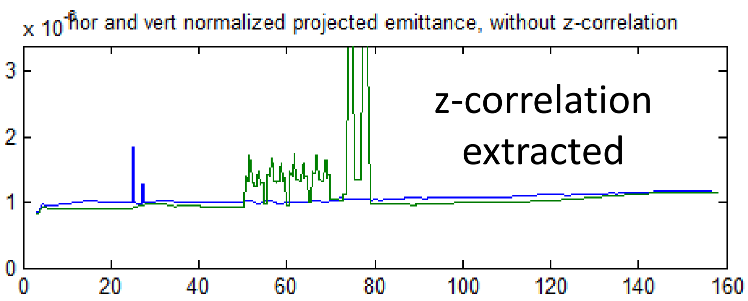






with kicks:
matched, 6 mm penetration depth

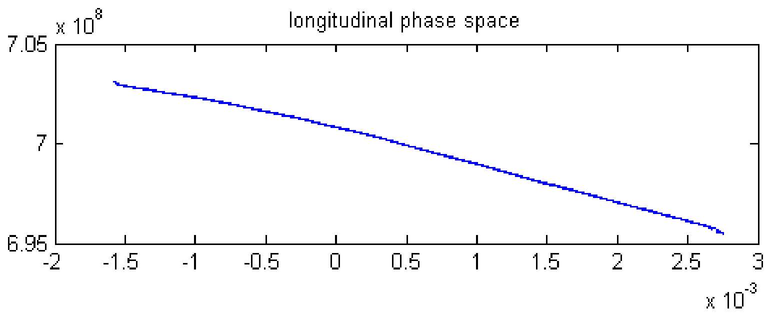


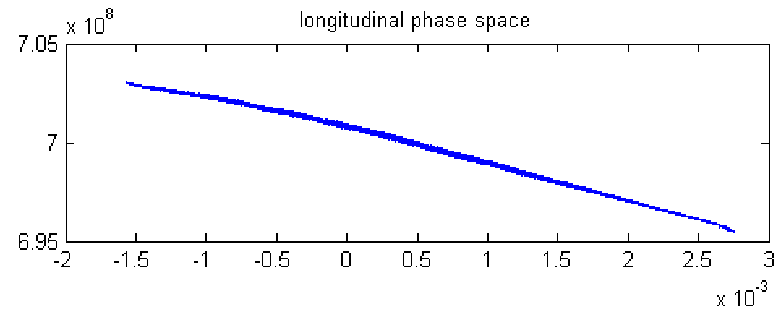


longitudinal phase space and top view

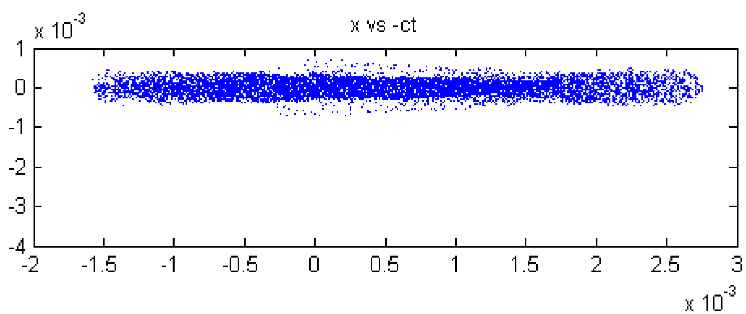
no kicks

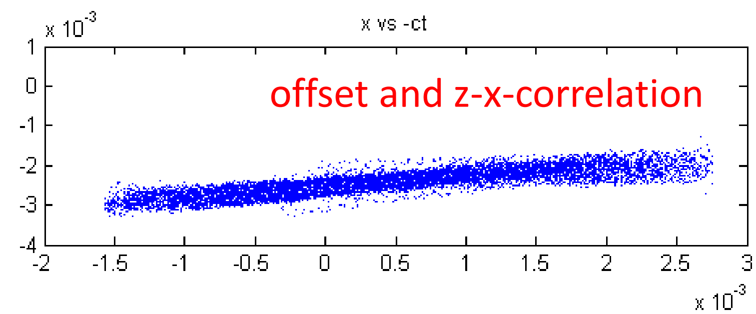
with kicks:
matched, 6 mm penetration depth





“top view”

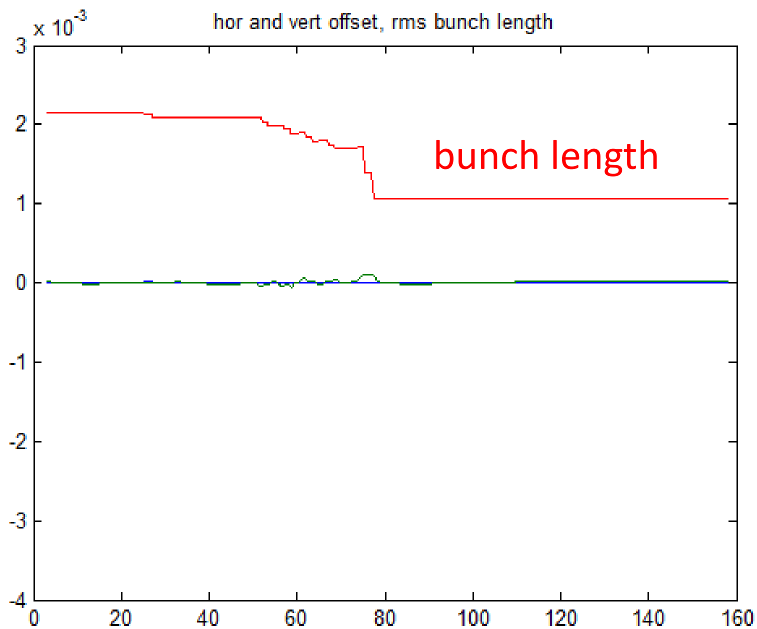


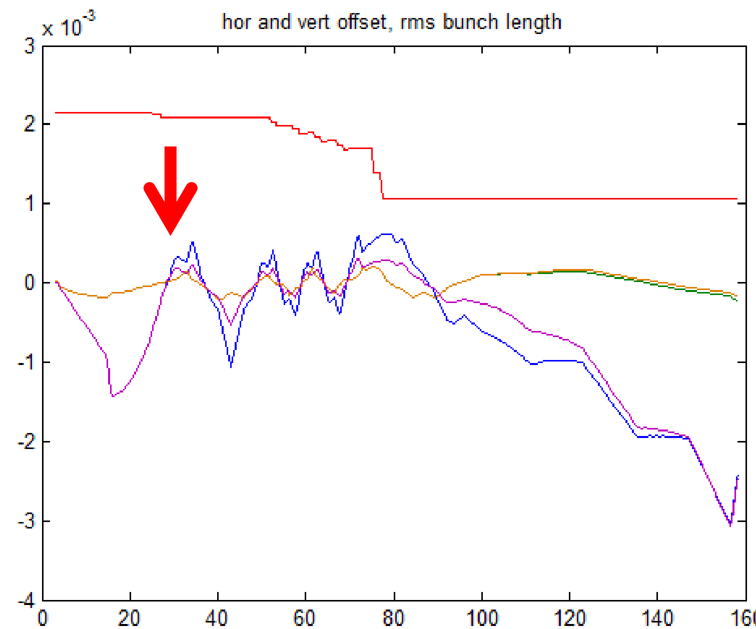


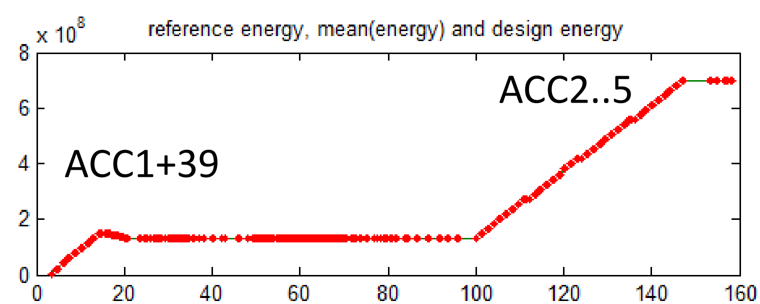
effect of one corrector: horizontal and vertical offset

no kicks

with kicks:
matched, 6 mm penetration depth





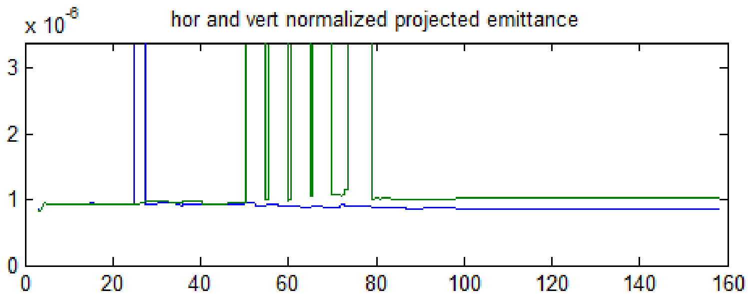


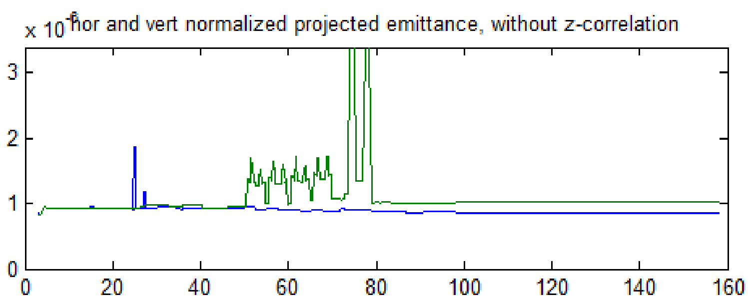
vertical
horizontal
} no corrector

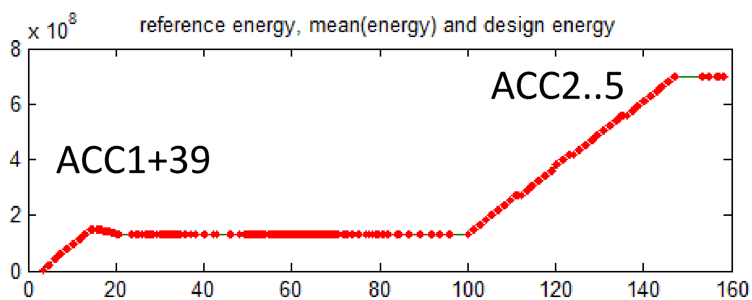
vertical
horizontal
} **one corrector**
horizontal, after ACC39
(-80 µrad)

effect of one corrector: emittances

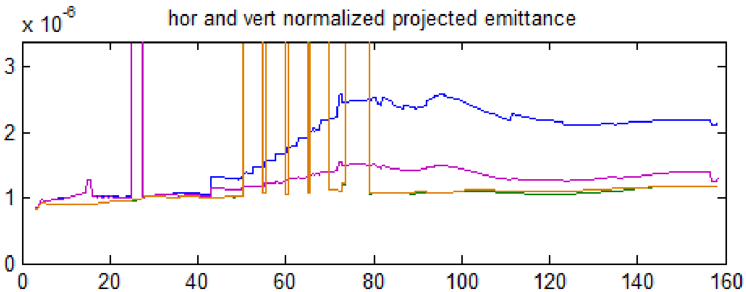
no kicks

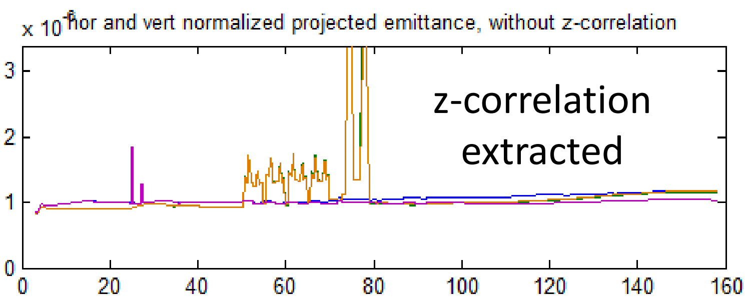






with kicks:
matched, 6 mm penetration depth





vertical
horizontal
} no corrector

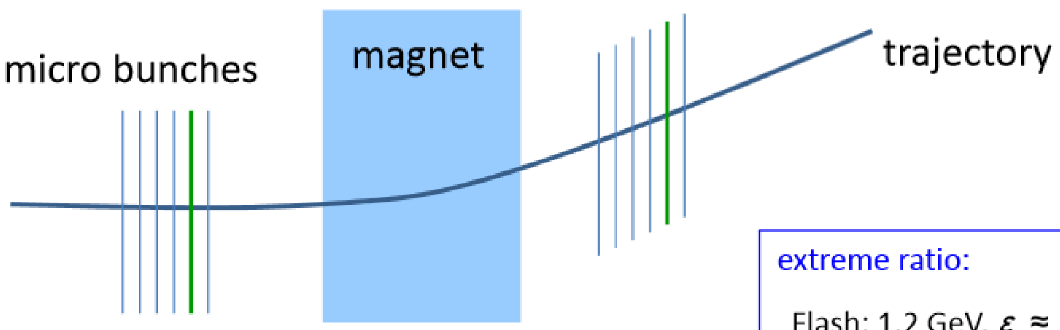
vertical
horizontal
} **one corrector**
horizontal, after ACC39
(-80 µrad)

Question from 2012:

EM Field for some (predefined) Source Fields

field 2d object: solve 2d integral

a) stiff 2d object f.i. disc



extreme ratio:

Flash: 1.2 GeV, $\varepsilon_n \approx 1$ µm, $\beta \approx 5$ m
$\rightarrow \sigma_r \approx 50$ µm, $\lambda_{ph} \approx 5$ nm
ratio 1E4 : 1

XFEL: 15 GeV, $\varepsilon_n \approx 1$ µm, $\beta \approx 5$ m
$\rightarrow \sigma_r \approx 10$ µm, $\lambda_{ph} \approx 0.1$ nm
ratio 1E5 : 1

SC ampl.: 300 MeV, $\varepsilon_n \approx 0.2$ µm, $\beta \approx 0.5$ m
$\rightarrow \sigma_r \approx 10$ µm, $\lambda_{ph} \approx 100$ nm
ratio 100 : 1

b) time dependent 2d object

Gaussian spherical bunch in shift-motion

see: TESLA-FEL-2003-05

M. Dohlus, Two Methods for the Calculation of CSR Fields

Gaussian spherical bunch: $$\rho_s(\mathbf{r}) = \frac{q}{(2\pi)^{3/2}\sigma^3}\exp\left(-\frac{1}{2}\frac{\|\mathbf{r}\|^2}{\sigma^2}\right)$$

"shift-motion": $$\rho(\mathbf{r},t) = \rho_s(\mathbf{r} - \mathbf{r}_t(t)) \ ,$$

$$\mathbf{J}(\mathbf{r},t) = \rho_s(\mathbf{r} - \mathbf{r}_t(t))\mathbf{v}_t(t)$$

for arbitrary trajectory: $\mathbf{r}_t(t)$

$$\Phi(\mathbf{r},t) = \frac{1}{4\pi\varepsilon}\int\frac{\rho(\mathbf{r}',t')}{\|\mathbf{r}-\mathbf{r}'\|}dV' = \frac{q}{\varepsilon(2\pi)^{3/2}\sigma^2}\int_0^\infty f\left(\frac{r'}{\sigma},\frac{R(r',\mathbf{r},t)}{\sigma}\right)dr'$$

1D integration

1D integration $$\Phi(\mathbf{r},t)=\frac{q}{\varepsilon(2\pi)^{3/2}\sigma^2}\int_0^\infty f\left(\frac{r'}{\sigma},\frac{R(r',\mathbf{r},t)}{\sigma}\right)dr'$$

with $$f(a,b)=\exp\left(-\frac{a^2+b^2}{2}\right)\frac{\sinh(ab)}{b}$$

$$R(r',\mathbf{r},t)=\left\|\mathbf{r}-\mathbf{r}_t\left(t-r'/c\right)\right\|$$

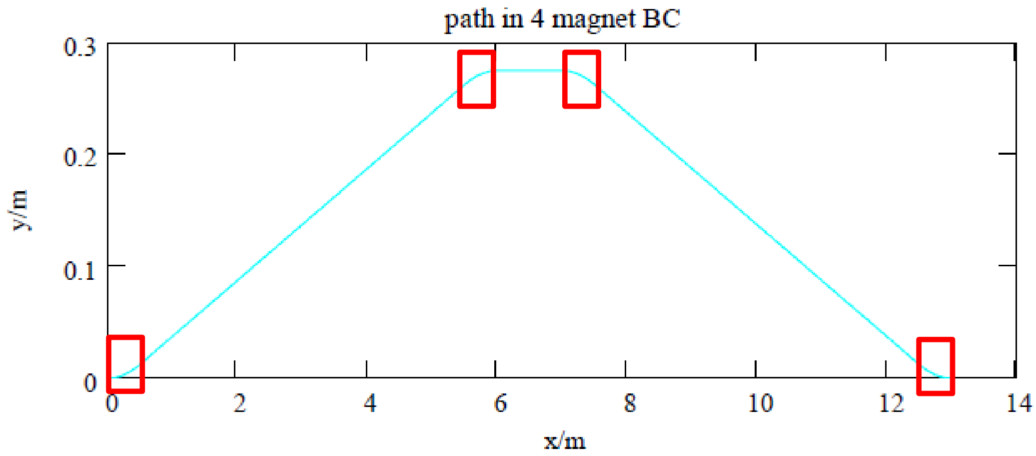
vector potential and E-, B-fields correspondingly

needs some skill in analysis

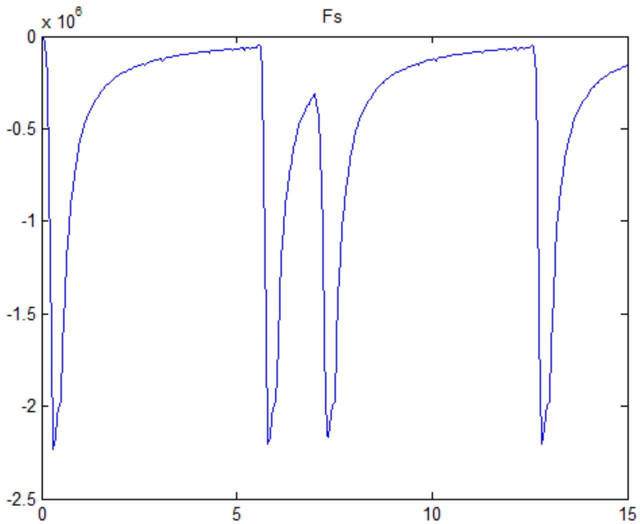
as $$\mathbf{B}(\mathbf{r},t)=\frac{q\mu}{(2\pi)^{3/2}\sigma^3}\int_0^\infty \mathbf{n}\times\mathbf{v}\,\tilde{f}\left(\frac{r'}{\sigma},\frac{R(r',\mathbf{r},t)}{\sigma}\right)dr'$$

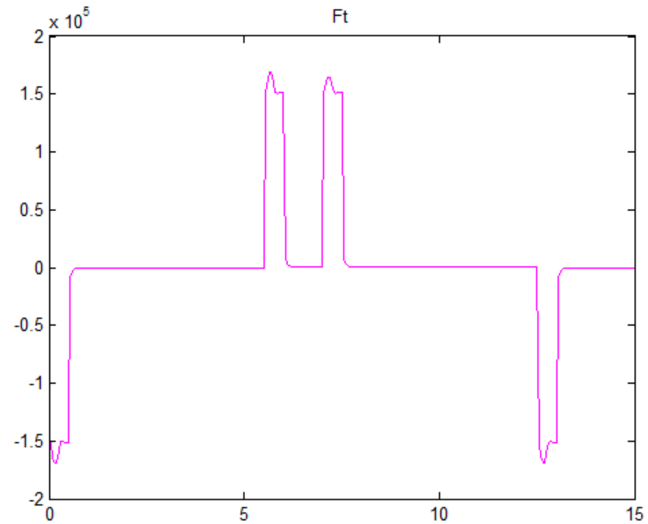
with $$\tilde{f}(a,b)=\frac{\partial}{\partial b}f(a,b)$$

example: 4-magnet bunch compressor chicane



longitudinal and transverse component of Lorenz-force,
In bunch center, along trajectory





1D integration

needs some skill in numerical computation

a) boundaries

r_{max}

$$\Phi(\mathbf{r},t)=\frac{q}{\varepsilon(2\pi)^{3/2}\sigma^2}\int_0^\infty f\left(\frac{r'}{\sigma},\frac{R(r',\mathbf{r},t)}{\sigma}\right)dr'$$

r_{min}

search problem

"find retarded source"

b) complicated integrand: sharp spikes or long weak tails

adaptive integrator

c) simultaneous integrations of all quantities and components

vector integrator

adaptive vector integrator: VASimps (needs definition of a scalar error function)

Uniform disc bunch in shift-motion

uniform disc bunch: $\rho_d(\mathbf{r}) = q\delta(z)\psi(\mathbf{r}_\perp)$

with $\psi(\mathbf{r}_\perp) = \frac{1}{\pi R^2}\begin{cases} 1 & \text{if } \|\mathbf{r}_\perp\| \le R \\ 0 & \text{otherwise} \end{cases}$

"shift-motion": $\rho(\mathbf{r},t) = \rho_d(\mathbf{r} - \mathbf{r}_t(t))$

$$\mathbf{J}(\mathbf{r},t) = \rho_d(\mathbf{r} - \mathbf{r}_t(t))\mathbf{v}_t(t)$$

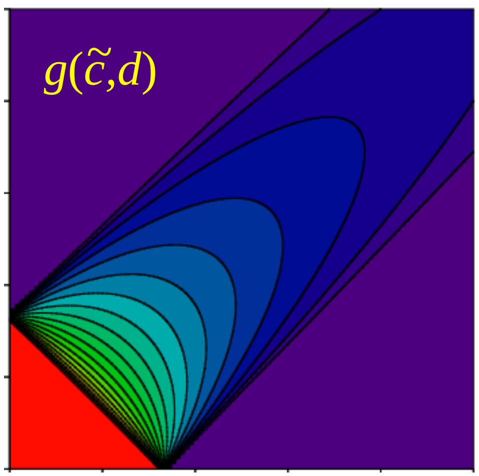
1D integration:

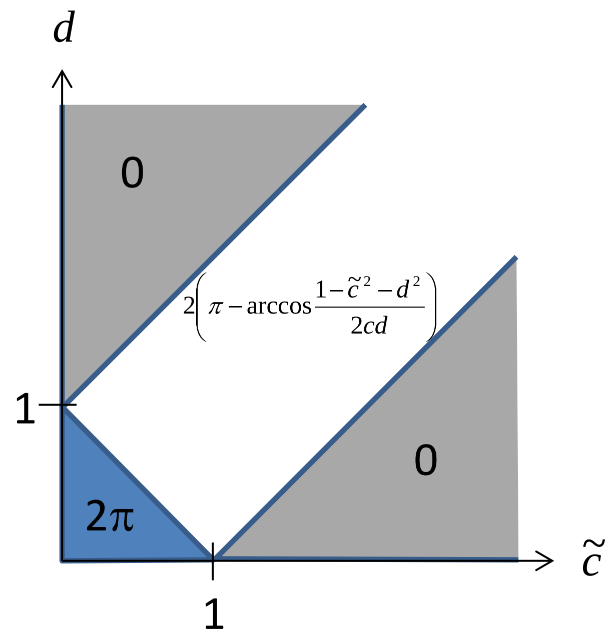
$$V(\mathbf{r},t) = \frac{1}{4\pi\varepsilon}\frac{q}{\pi R^2}\int_0^\infty f\left(\frac{r'}{R}, \frac{\mathbf{r} - \mathbf{r}_t(t - r'/c)}{R}\right)dr'$$

function: $f(a,\mathbf{b}) = \begin{cases} 0 & \text{if } a \le |b_z| \\ g(\tilde{c}, d) & \text{otherwise} \end{cases}$

$$\tilde{c} = \|\mathbf{b}_\perp\|$$

$$d = \sqrt{a^2 - b_z^2}$$



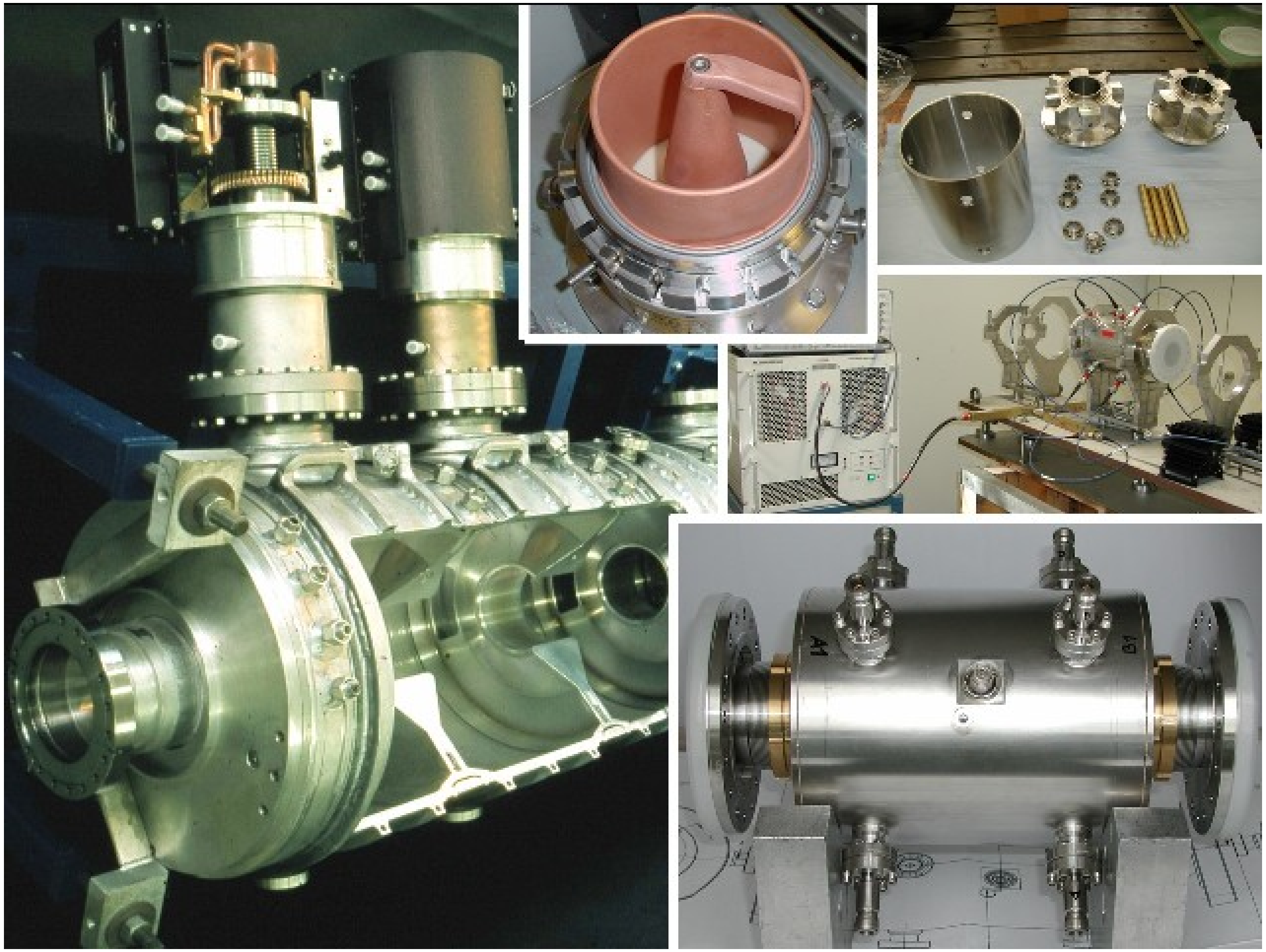


derivatives include Dirac-function

Eigenmode Computation for Petra 7-cell cavity

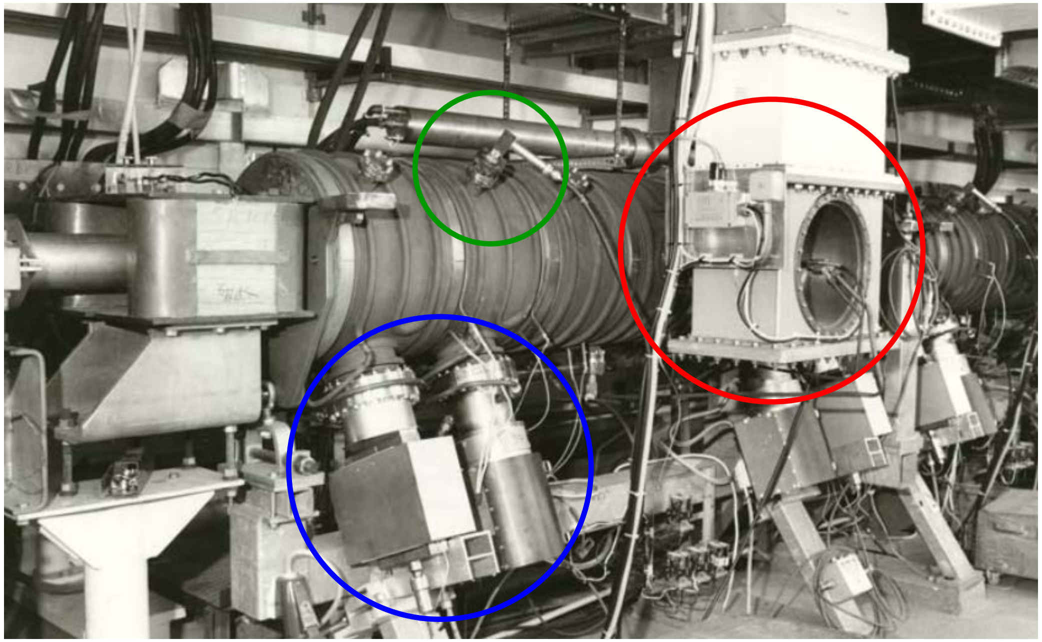
compare: DESY M-84-006

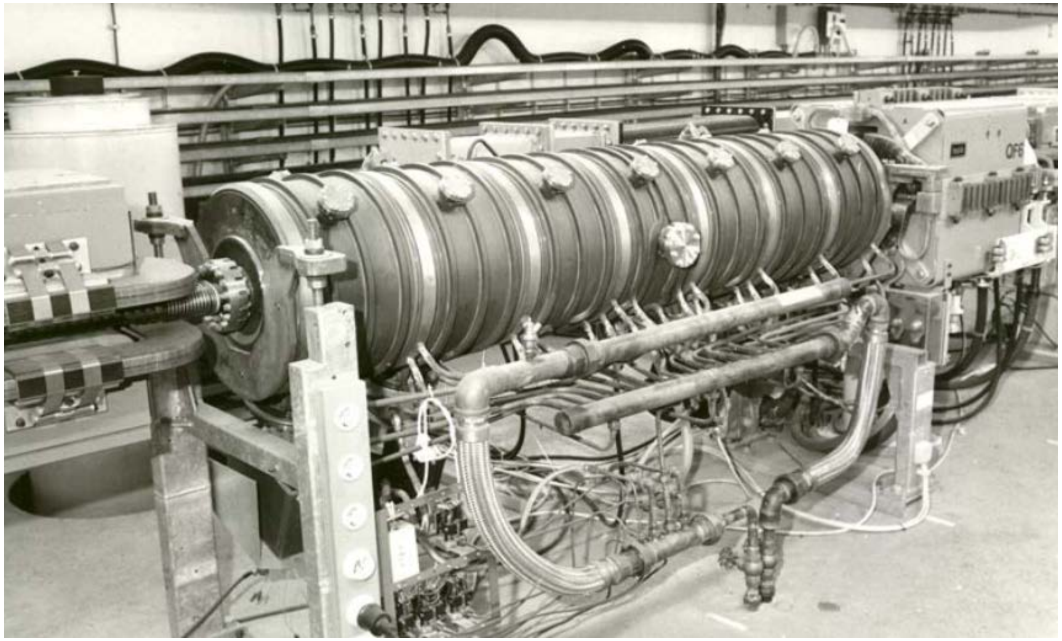
T. Weiland, On the numerical solution of Maxwell's equations and applications in the field of accelerator physics



contact: Rainer Wanzenberg

http://mhf-e.desy.de/e5/e63/
--> Datenblätter / Data Sheets
Data Sheet 500MHz 7-Cell Cavity





input coupler waveguide transition, doorknob

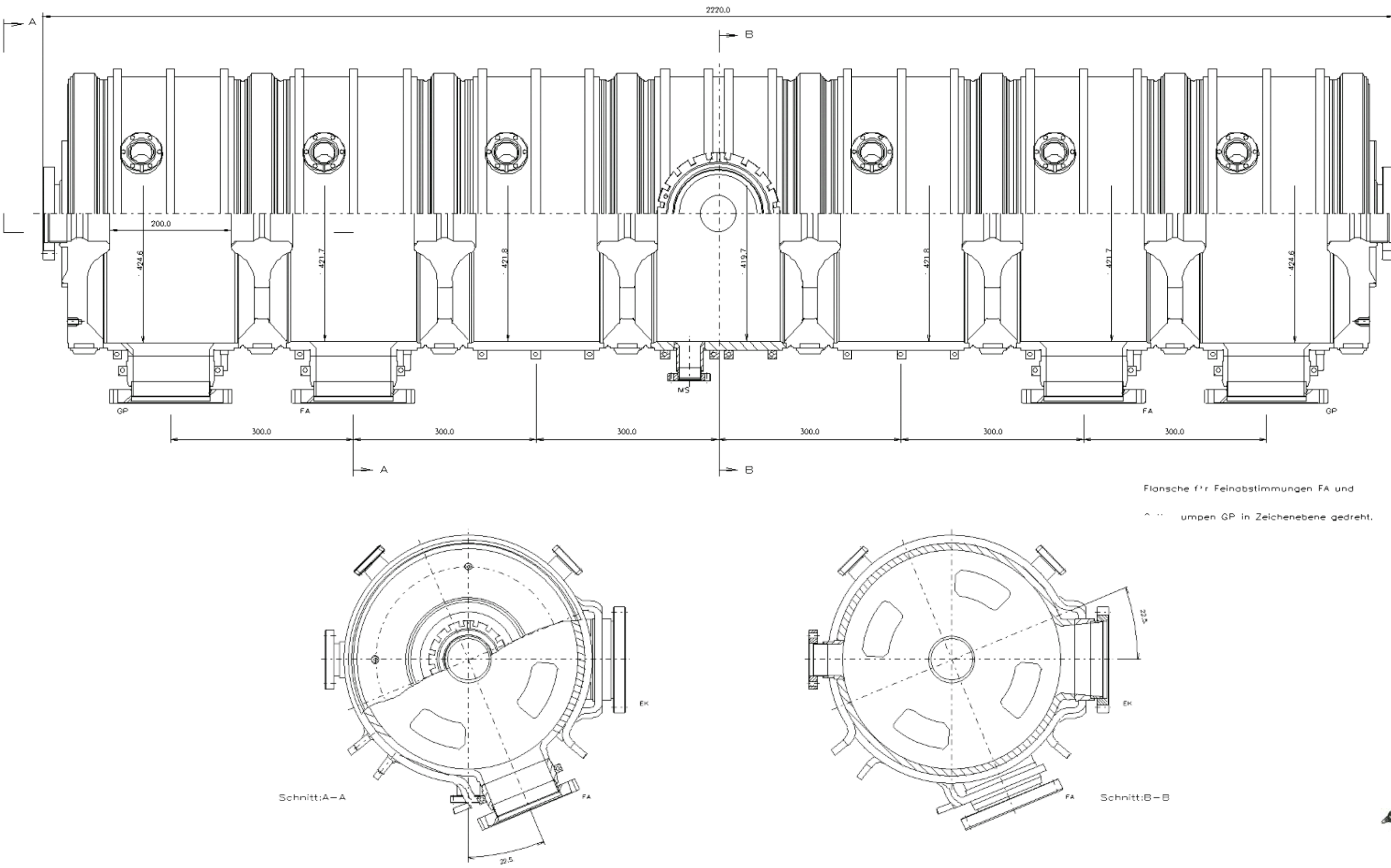
tuning plunger

cavity pick-up loop (Messschleife)

http://mhf-e.desy.de/e5/e63/

--> Übersichtszeichnungen / Overview Drawings

7-Cell Cavity, Type PETRA (7-zelliges 500-MHz Cavity)



http://mhf-e.desy.de/e5/e63/
--> Übersichtszeichnungen / Overview Drawings
7-Cell Cavity, Type PETRA (7-zelliges 500-MHz Cavity)
Input Coupler and Waveguide Transition (Einkopplung mit Übergang)
Tuning Plunger (Feinabstimmung, Abstimmstempel)
Cavity Pick-Up Loop (Messschleife)