A single bunch injector for ELSA

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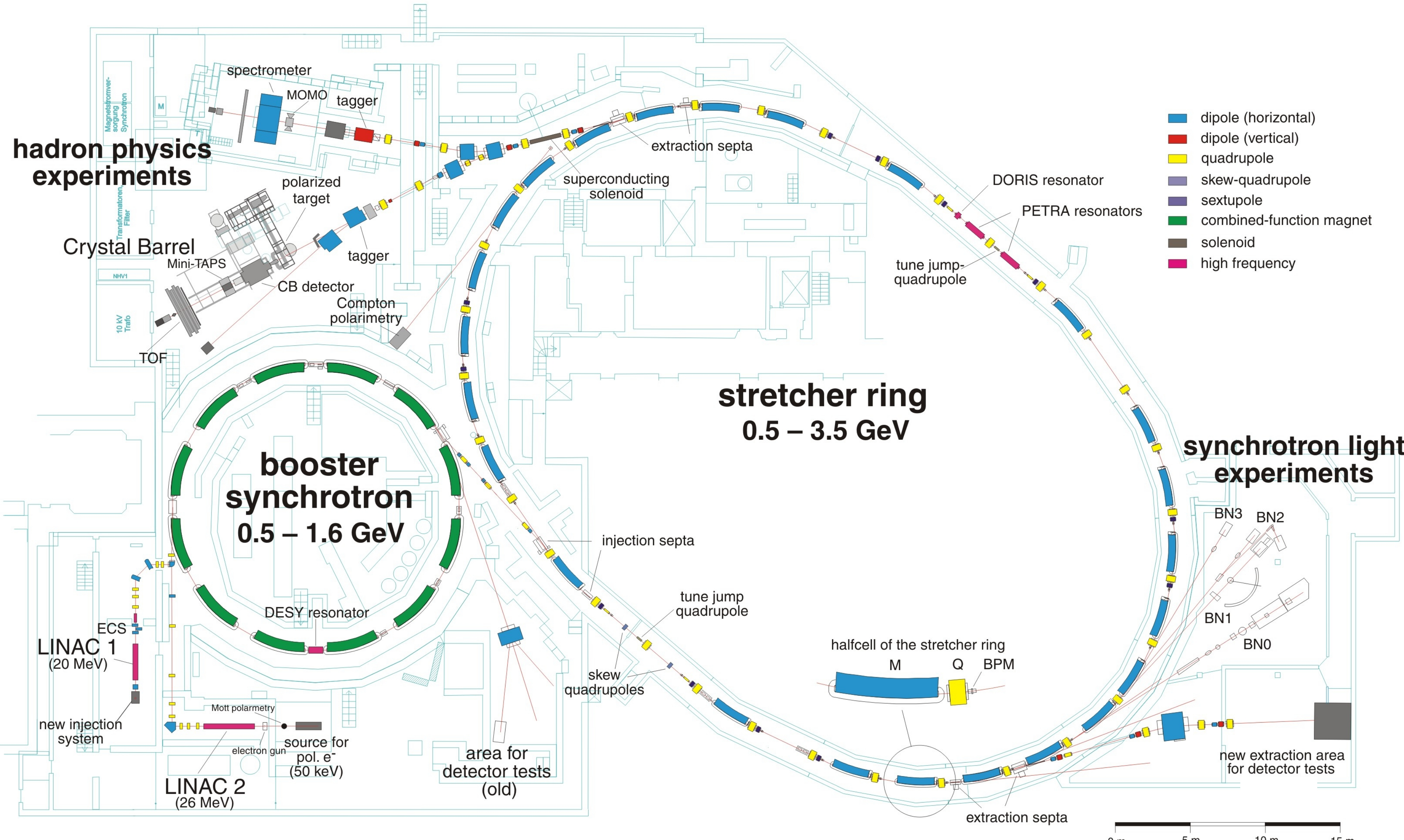
Elektronen-Stretcher-Anlage (ELSA)



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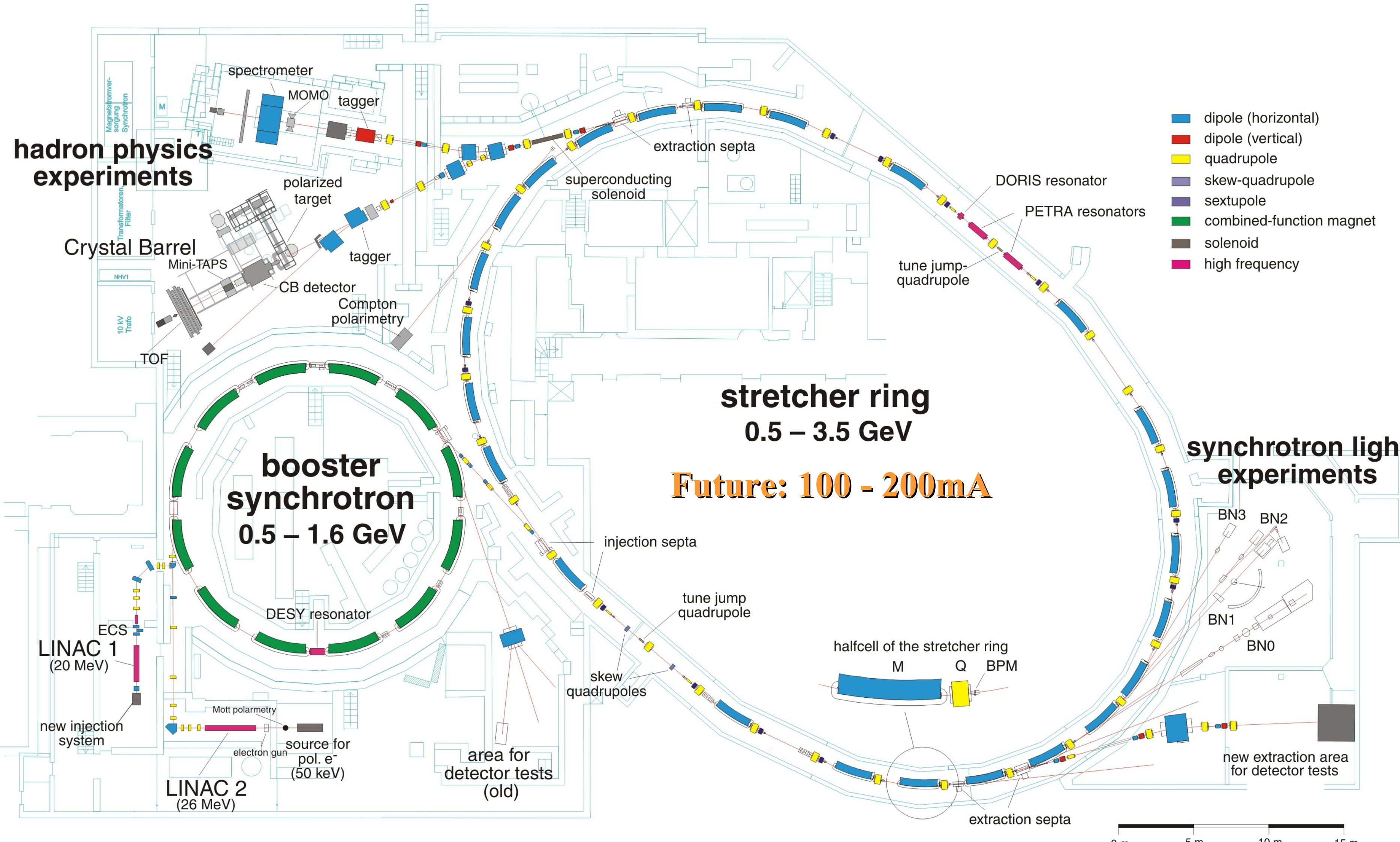
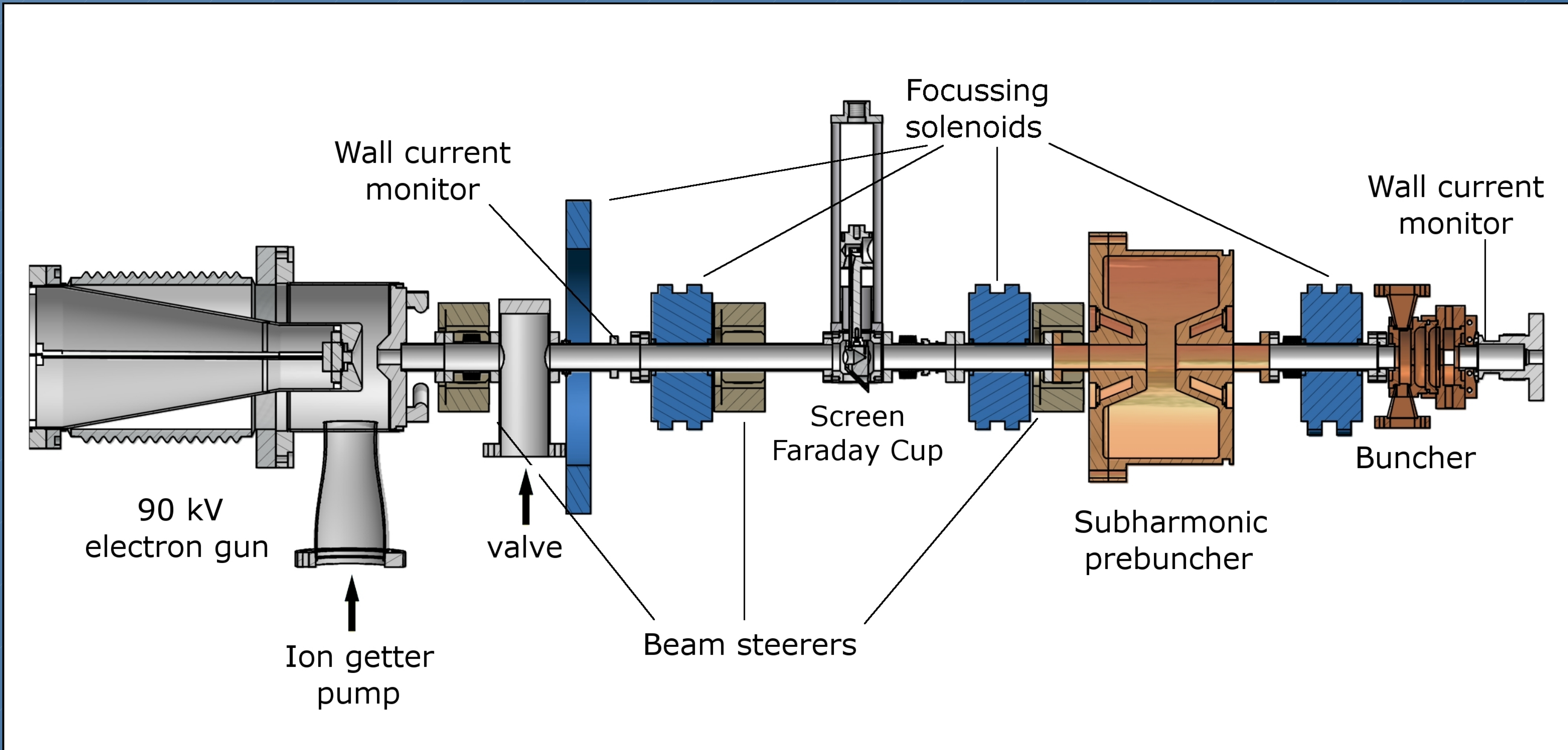


The new injector for Linac 1



<u>electron source:</u>

- short pulse: 2 A, 1 - 1,5 ns
- long pulse: 500 mA, 2 µs

<u>bunching:</u>

- 500 MHz prebuncher
- 3 GHz 4-cell TWB:

<u>focussing and steering:</u>

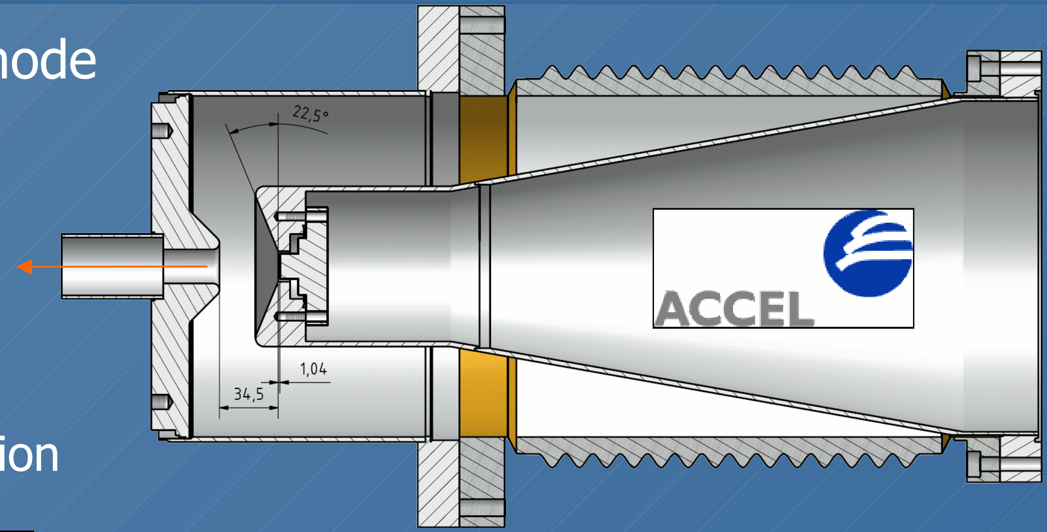
- monitoring
- solenoids
- beam steerers

Electron source

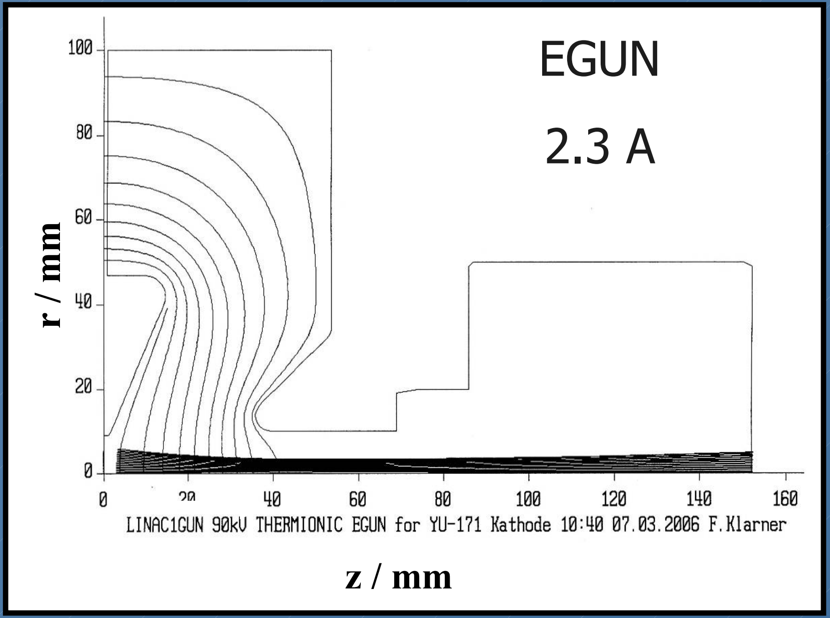
SBTF : 6A SB and multi bunch mode

ELSA : 2A SB and long pulse

→ Adaption necesary



Startvalues required for beam simulation



Avoid space charge limited operation

$\Rightarrow \quad I_{space\ charge} = 4.3\ A$

$\& \quad I_{grid\ limited} = 2.3\ A$

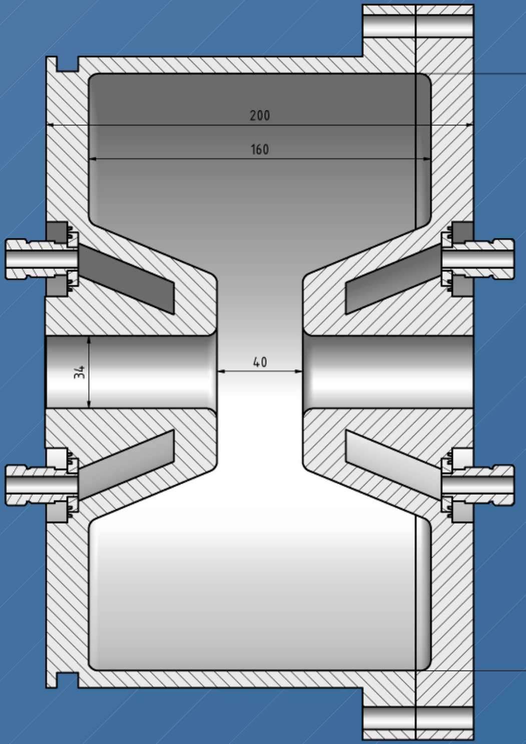
$\Rightarrow \quad d_{anode-cathode} = 34.5\ mm$

emittance: $\varepsilon_n = 19.8\ \pi$ mm mrad

Prebuncher

- lowest prebunching frequency due to ELSA RF Frequency

$\Rightarrow$ 499.67 Mhz



Max. bunching length to reduce longitudinal effects : ~ 30 cm

SBTF Prebuncher: Stainless Steel

→ $Q_0 = 2616 \pm 71$, $R_S = (252 \pm 52)$ kW → $P_G = 5$ kW

ELSA Prebuncher from Accel: Copper

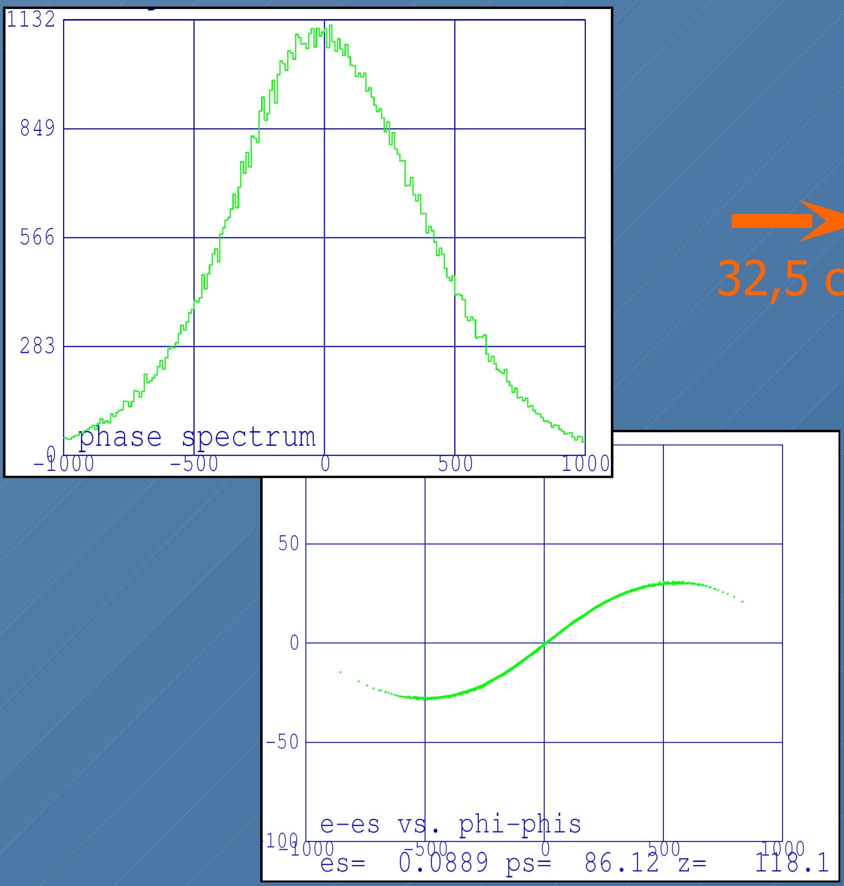
$Q_0 = 15220 \pm 196$

$R_S = (1.53 \pm 0.05)\ \mathrm{M\Omega}$ $\Rightarrow$ $P_G = 400$ W

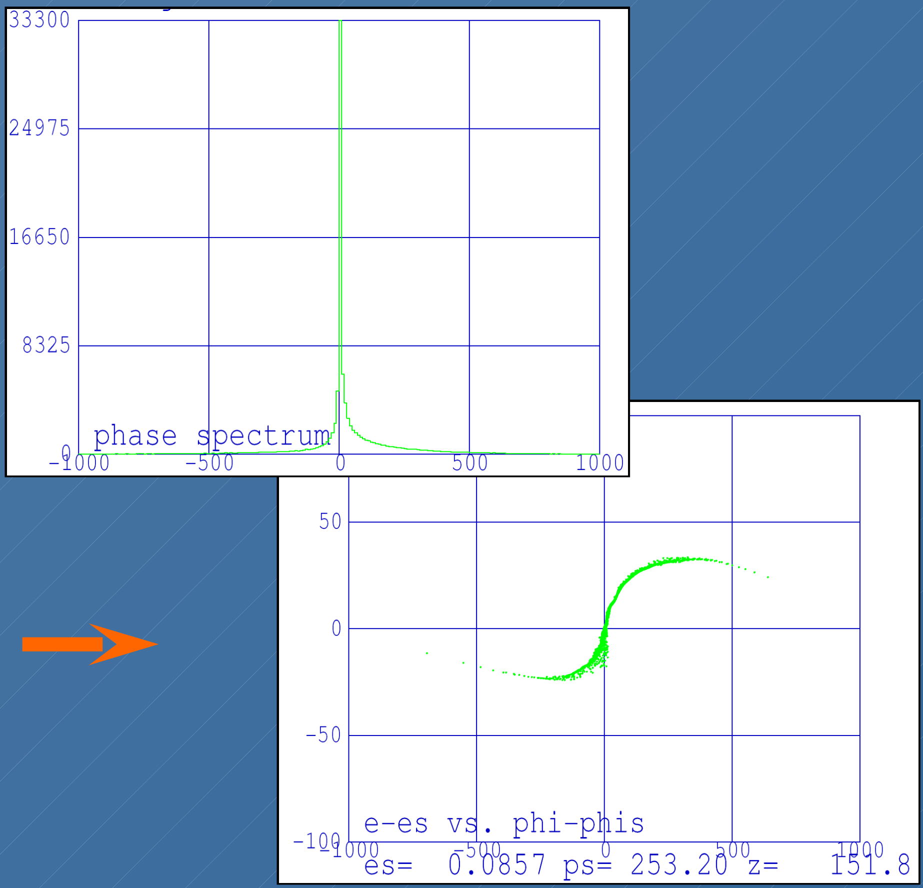
Prebuncher

PARMELA: „Phase and Radial Motion in Electron Linear Accelerators"

- Particle tracking code
- longitudinal and transversal 2-D/3-D Space Charge Calculations



32,5 cm



Four cell travelling wave buncher

- 90 kV $\Longrightarrow$ $\beta_e = 0{,}526$

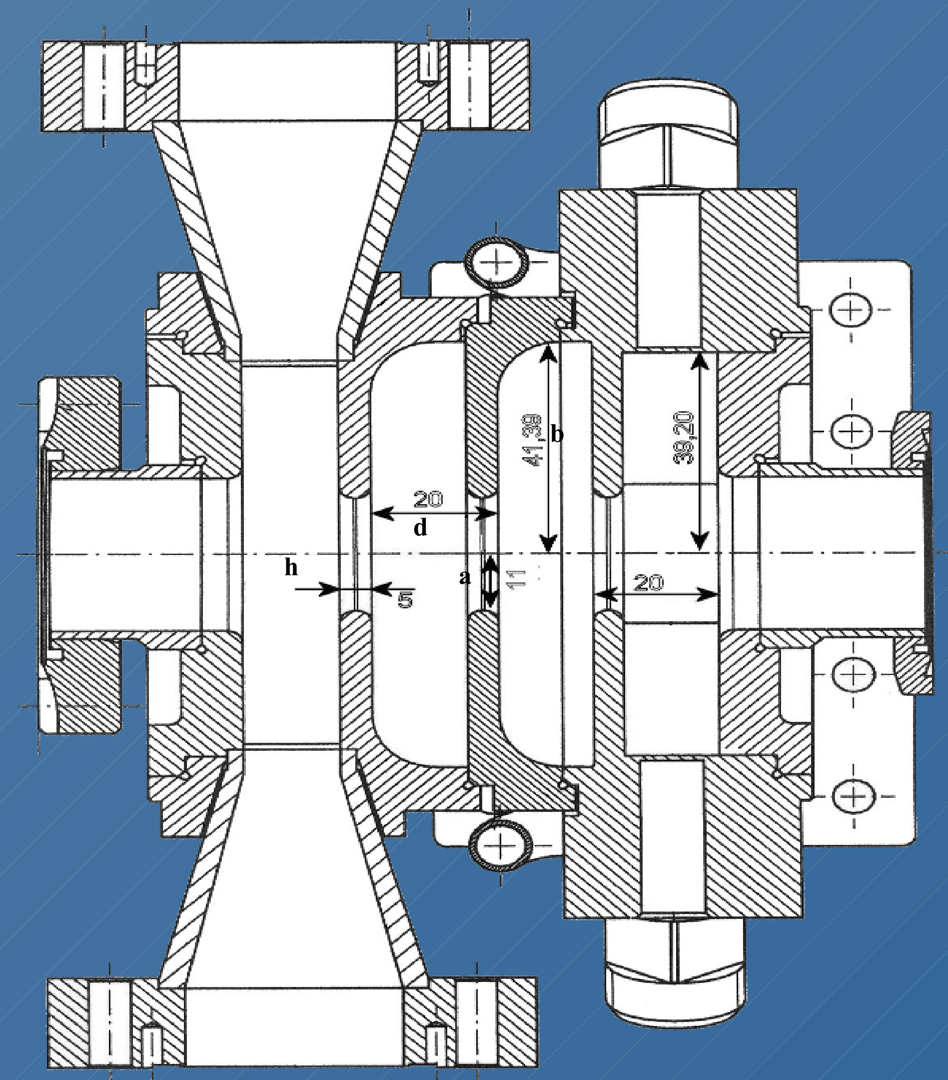
TWB:

$\Psi = 2\pi/3$, $U_0 = 7$ MV/m

<u>Phase velocity:</u>

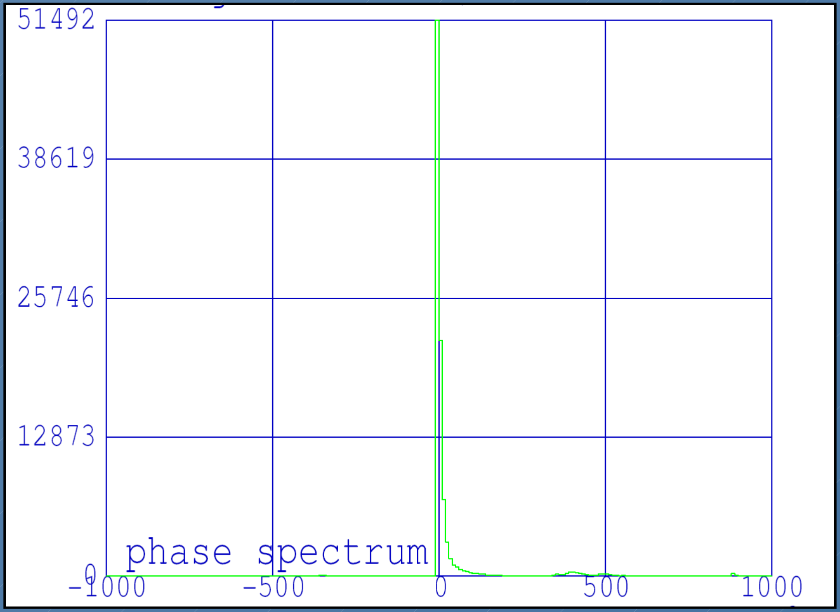
$$v_{\varphi}^{\text{couple}} = 0{,}6091\ c$$

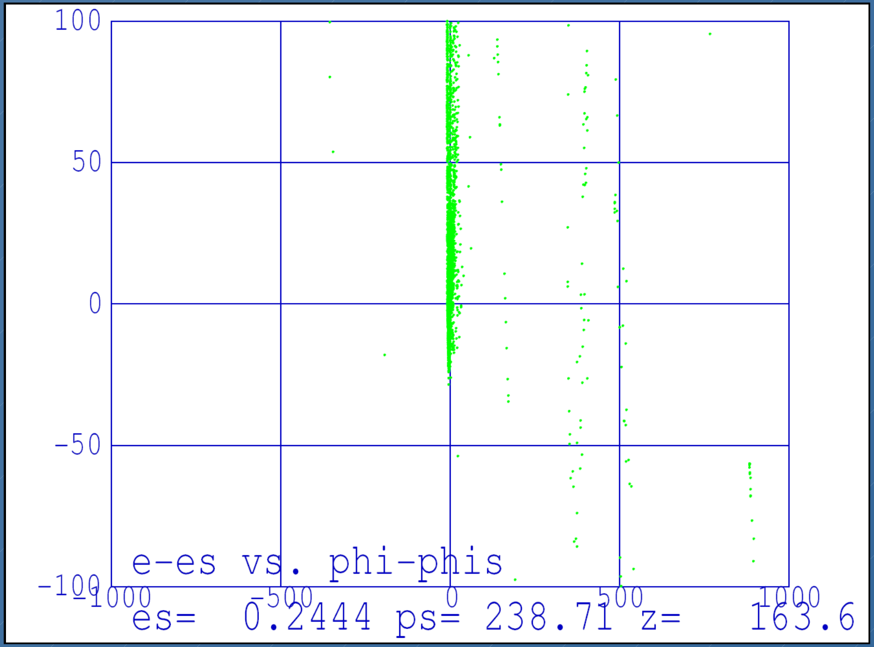
$E_{kin} = 615$ keV $\Longrightarrow$ $\beta_e = 0{,}891$



Bunching im TWB

- Bunch < 100° of 3Ghz
- Nearly only one bucket is filled





beam transport

Considering transverse beam dynamics

Simple assumption:
- cylindrical constant beam
- homogenic charge distribution

space charge-term (repellent coulomb forces)

\+ emittance-term (distribution of particles in phase space)

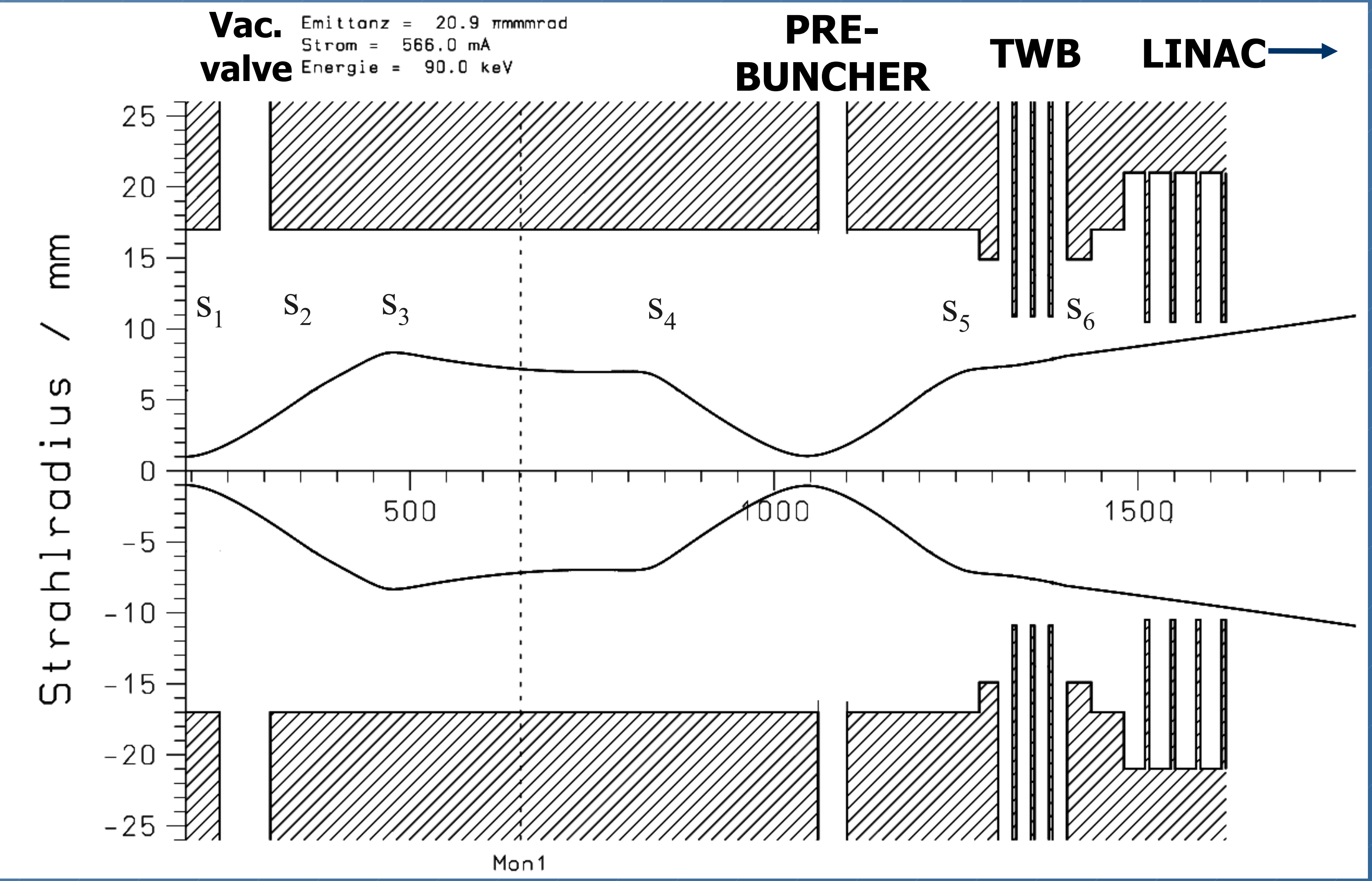
\+ solenoid-term (force compansating fieldstrength)

Σ = paraxial differential equation in cylinder symmetry

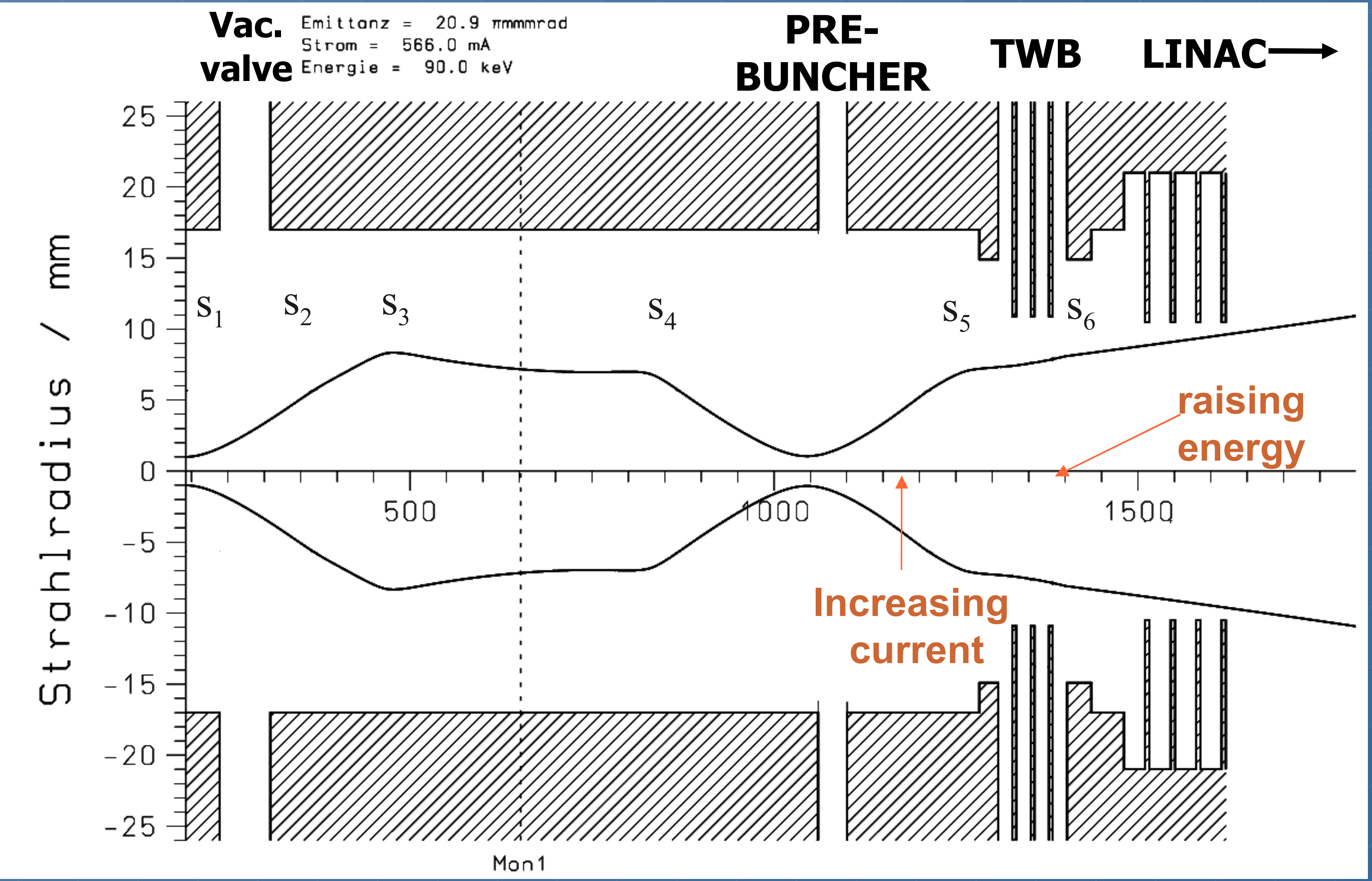
$$R'' - \frac{eI}{2\pi\varepsilon_0 m_0 (\beta\gamma c)^3} \cdot \frac{1}{R} - \frac{\varepsilon_r{}^2}{R^3} + \left(\frac{eB_s}{2\gamma m_0 \beta c}\right)^2 \cdot R = 0$$

Simulation of the beam propagation to determine the position and field strength of the solenoids

beam transport



beam transport



Summary

- Single bunch mode: determination of single bunch instabilities, etc.

- Electron source: - beam production and focussing
  - 2 A, 1 ns short pulse; 500 mA, 2 µs long pulse
  - 90 kV , $\beta_e = 0{,}526$

- Prebuncher: - Bunching length L = 32,5 cm
  - copper
  - $P_G = 400$ W

- Buncher: - $\beta_e = 0{,}526 \longrightarrow \beta_e = 0{,}891$

- Linac : - 800 mA @ 20 MeV
  - 17 MV/m > 7,71 MV/m

- beam propagation : - transverse beam dynamics via paraxial differential equation
  $\longrightarrow$ Solenoid position and fieldstrength

Thank you for your attention

outlook

- All components are present and tested with the exception of the TWB
- At the moment we are in the testing phase of the PFN for the TWB and linac RF and mounting the vaccumcomponents of the Injector
- Conditioning of linac and TWB when PFN tests finished
- The monitoring is tested and calibrated
- Beam Spring 2010 ?