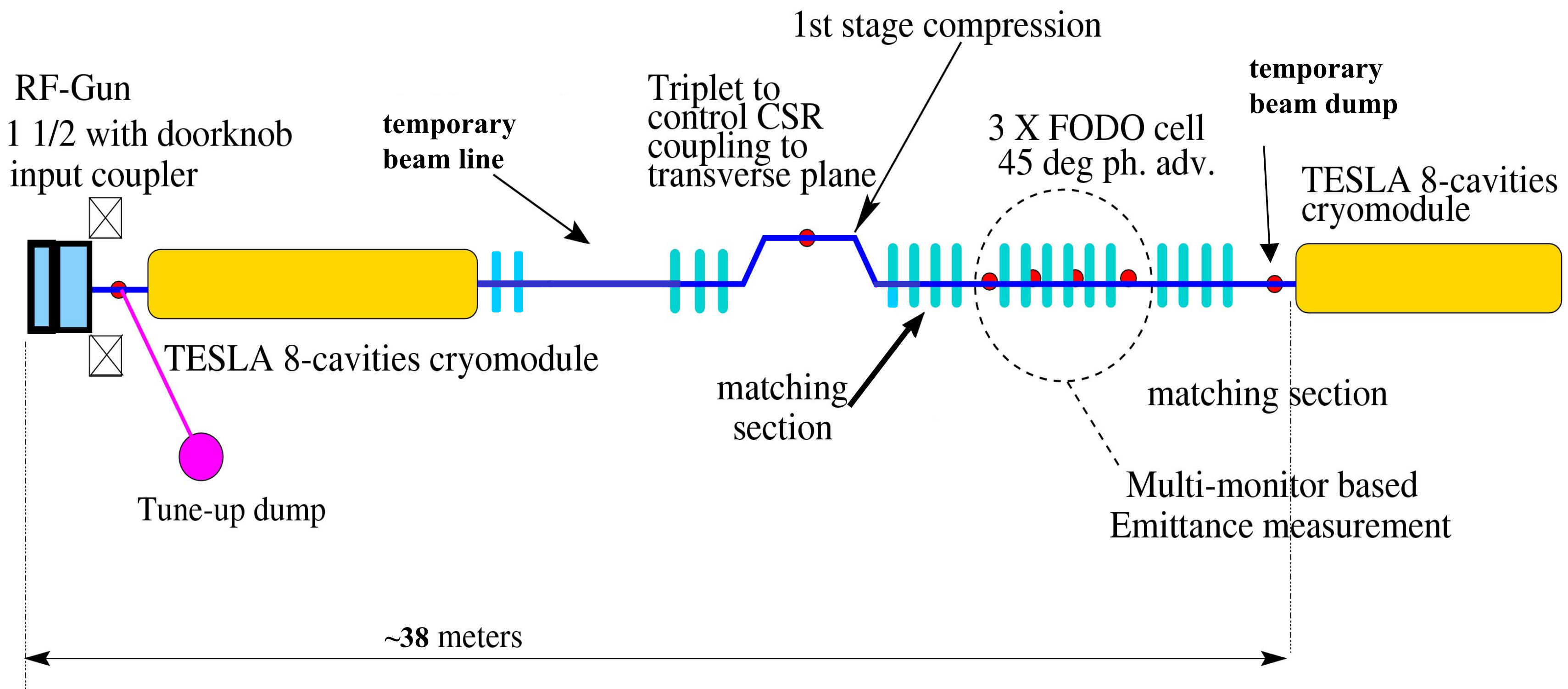
Commissioning of Injector III

TESLA Collaboration Meeting

Jan. 22, 2004

Klaus Floettmann

Schematic overview of the TTF Injector III



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The Gun in the Tunnel

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The Bunch Compressor and Diagnostics Section

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Injector Commissioning: Part 1 Gun area

A Operation without beam

The primary goal is to establish stable operation of the gun and its subsystems for short RF pulses (~50-100 μs) at typically 2 Hz rep. rate. Operation with long RF pulses and at various rep. rates should be tested as time permits.

- get modulator and klystron 3 back into operation
- test magnets, steerers, movers
- check technical interlocks
- personal interlock test, if not yet done
- basic low level rf operation (open loop)
- basic water system operation – tune gun to 1.3 GHz
- start-up with rf:
  - low rep rate, short pulses: 2 Hz, 30 μs, solenoid off, later on, Mo cathode

Injector Commissioning: Part 1 Gun area

A   Operation without beam

- increase power up to 3 MW
- increase pulse length up to 500 μs (900 μs)
- increase rep rate: 5 Hz, 10 Hz

- adjust water regulation system
- improve llrf, try closed loop
- verify interlocks
- at some point change cathodes Mo → Cs Te
- commission Farady cups with dark current as far as possible and required
- measure dark current (Mo cathode, CsTe cathode(s))
- observe dark current on screens incl. screens in spectrometer arm, measure energy

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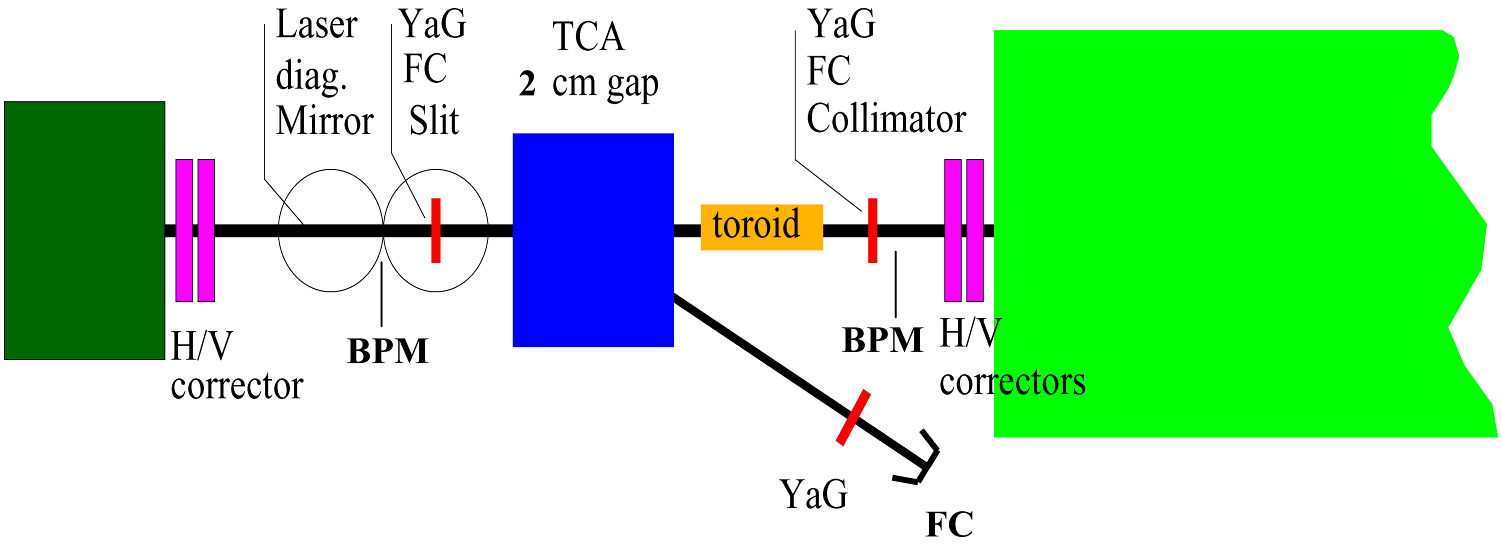
Diagnostic Components in the Gun Area



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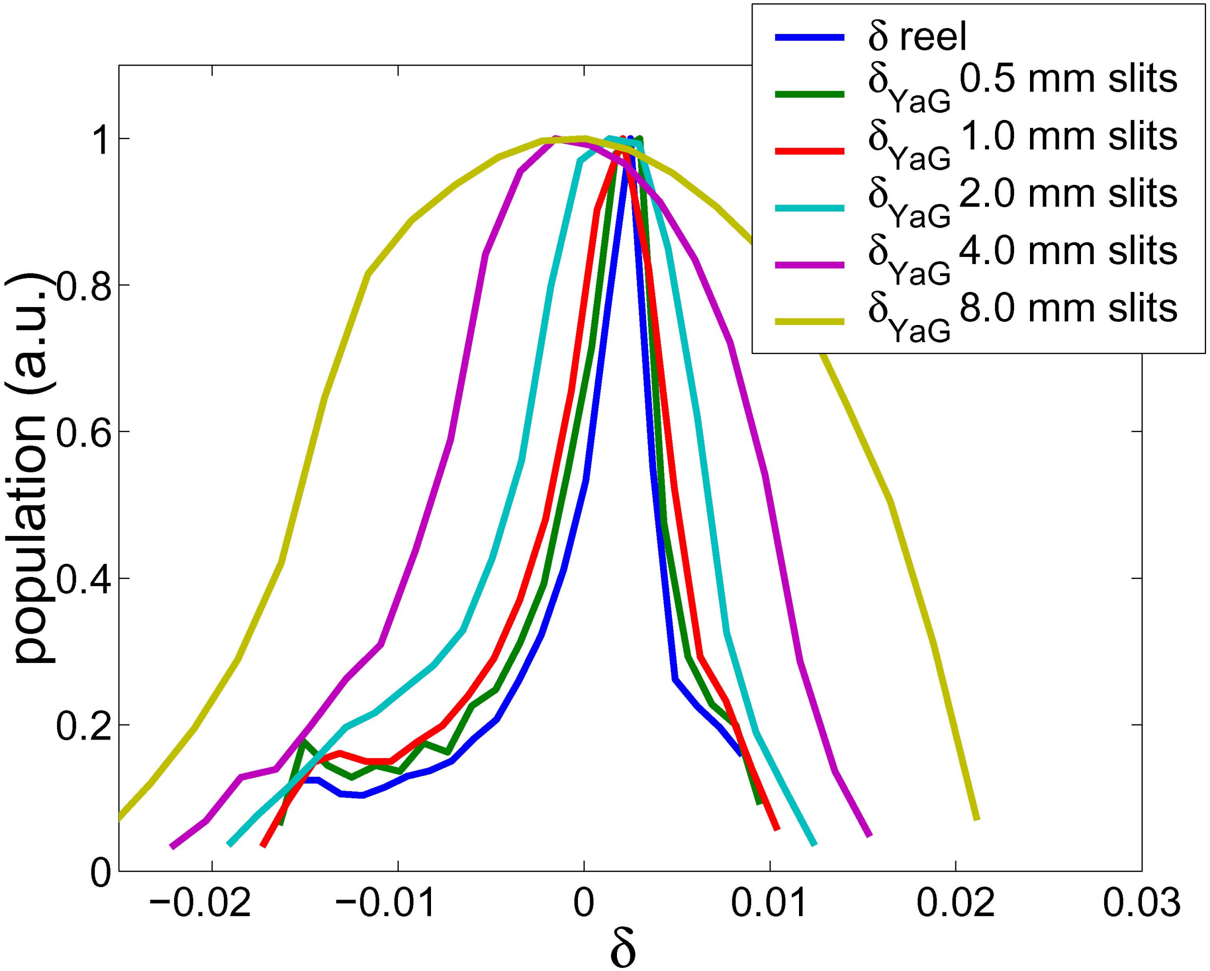
Energy Spread Measurements with Slit



Measured energy profile as function of the slit width

Injector Commissioning: Part 1 Gun area

B Operation with beam

Assumption: Laser is operating; laser beam line has been set-up (incl. basic technical checks).

The goal is to commission the diagnostics in the gun area, to check/improve the alignment of the laser on the cathode and the solenoid and to establish/verify basic machine parameters (rf and magnet settings).

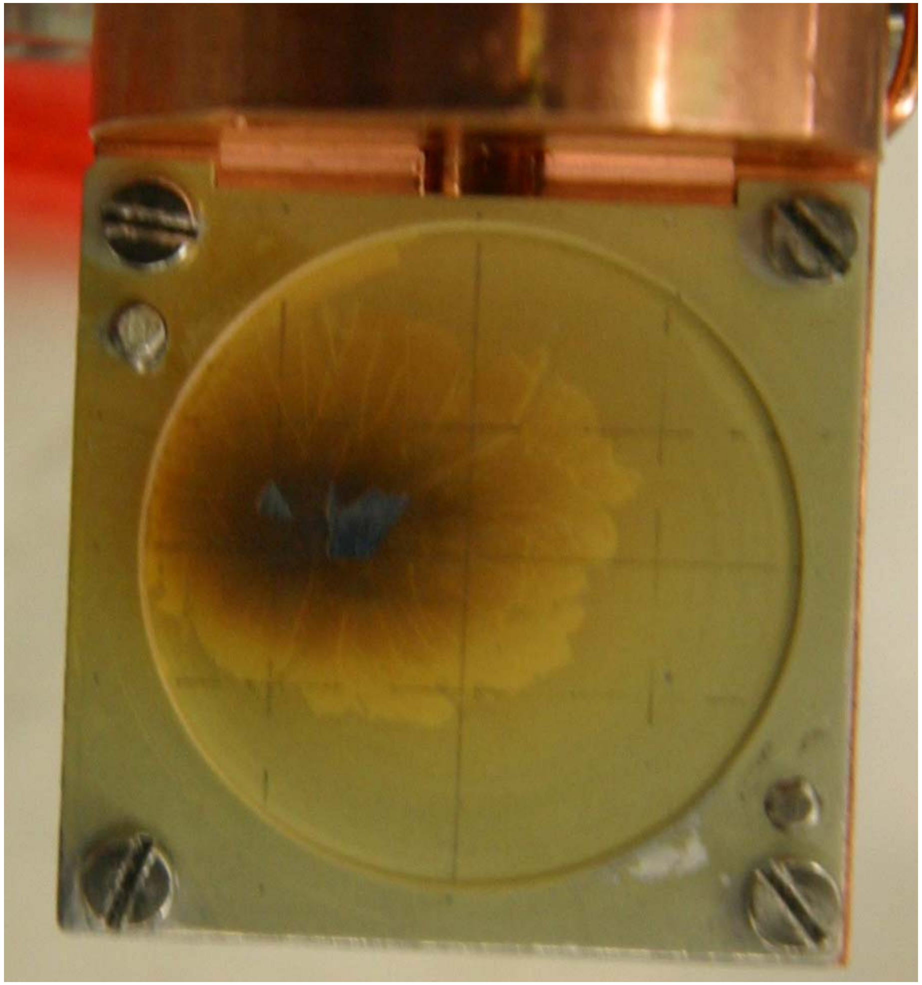
- get laser on cathode, large laser spot, later nominal size (3mm diameter)
- commission Faraday cups and toroid incl. ADC's
- phase scan
- get beam into dispersive arm, measure energy and energy spread
- commission BPM
- Beam Based Alignment of solenoid and laser spot position
- compensate solenoid field on the cathode

Injector Commissioning: Part 1 Gun area

B Operation with beam

- measure beam size on screens vs. z and solenoid current, estimate transverse emittance
- investigate/minimize effect of laser mirror
- try pulse stacker, optimize laser parameters, check solenoid current for envelope matching
- basic measurements with cathodes:
  - dark current
  - QE: charge vs. laser beam energy for various gradients
  - space charge effects, Schottky effect
- short bunch trains, closed loop operation, finite state machine
- phase stability of the laser: fast diode vs. RF
- try long pulse trains into spectrometer arm

Injector Commissioning: Part 1 Gun area



Attention

YAG screens can be damaged by long pulse trains!

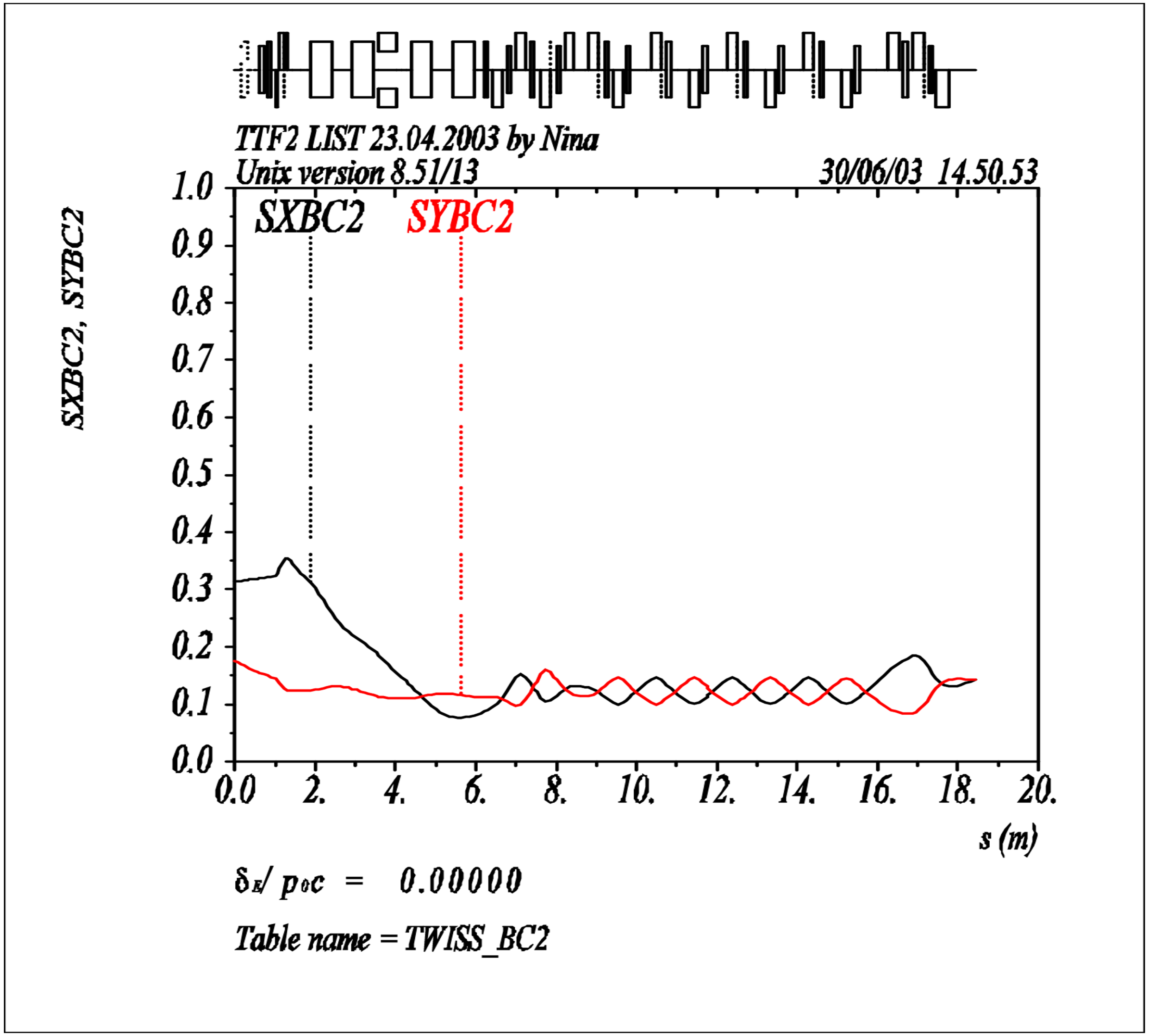
Injector Commissioning: Part 2 Module

Assumption: Module is cold and conditioned. All cavities are operated with the same gradient in the beginning. Technical checks of all magnets have been done, magnet polarities are ok.

The goal is to get the beam through the module, adjust phases and gradient and check the transfer of the beam.

- get the beam through the module up to the dump and adjust phases, either using transients (requires high charge operation 30-50 nC) or energy measurements in the bunch compressor and remote control of stub tuners.

Bunch Compressor and Diagnostics Section

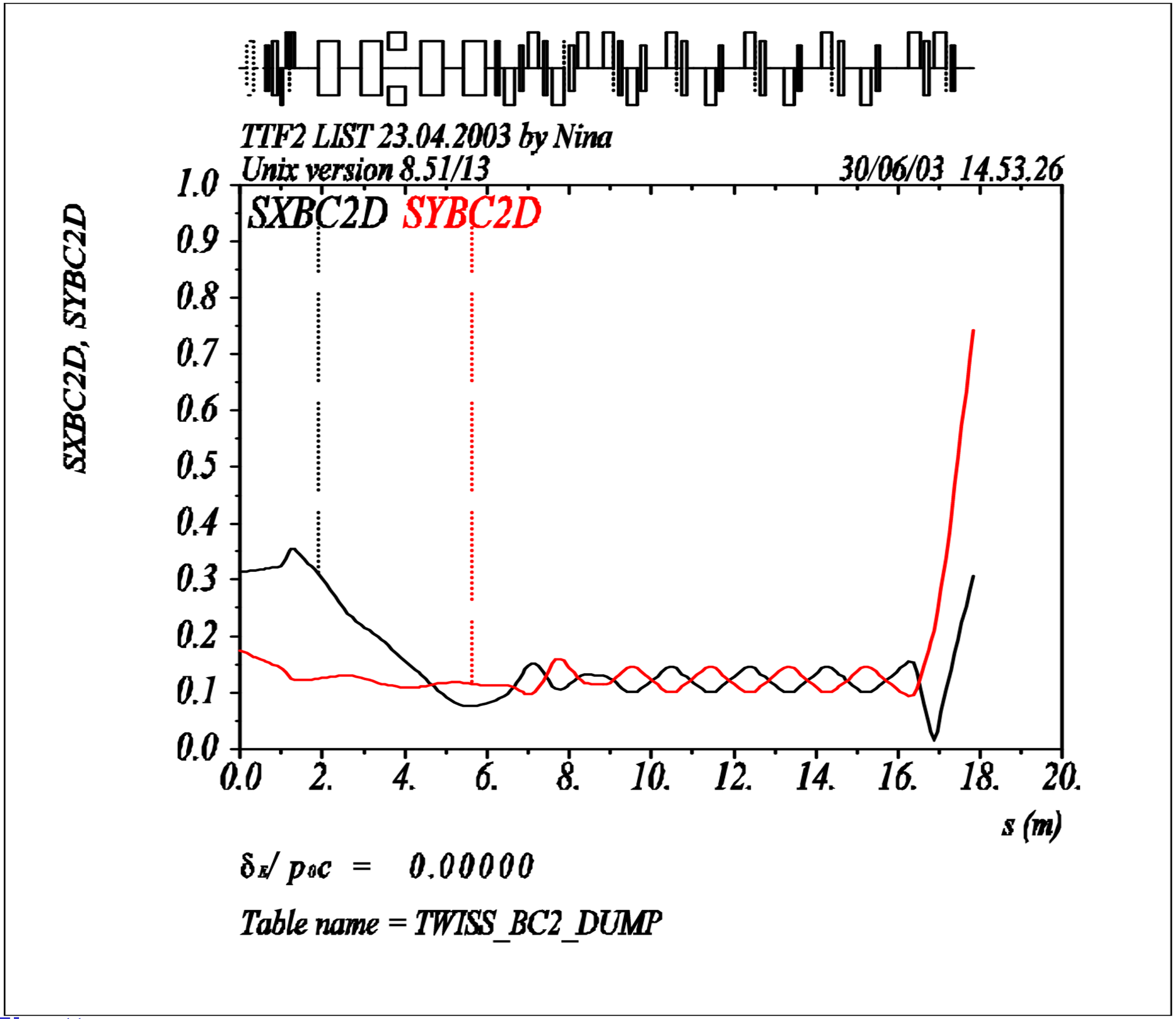


Beam Size in the Bunch Compressor and Diagnostics section with nominal optics

$\varepsilon = 1 \cdot 10^{-6}$ m

(N. Golubeva)

Bunch Compressor and Diagnostics Section

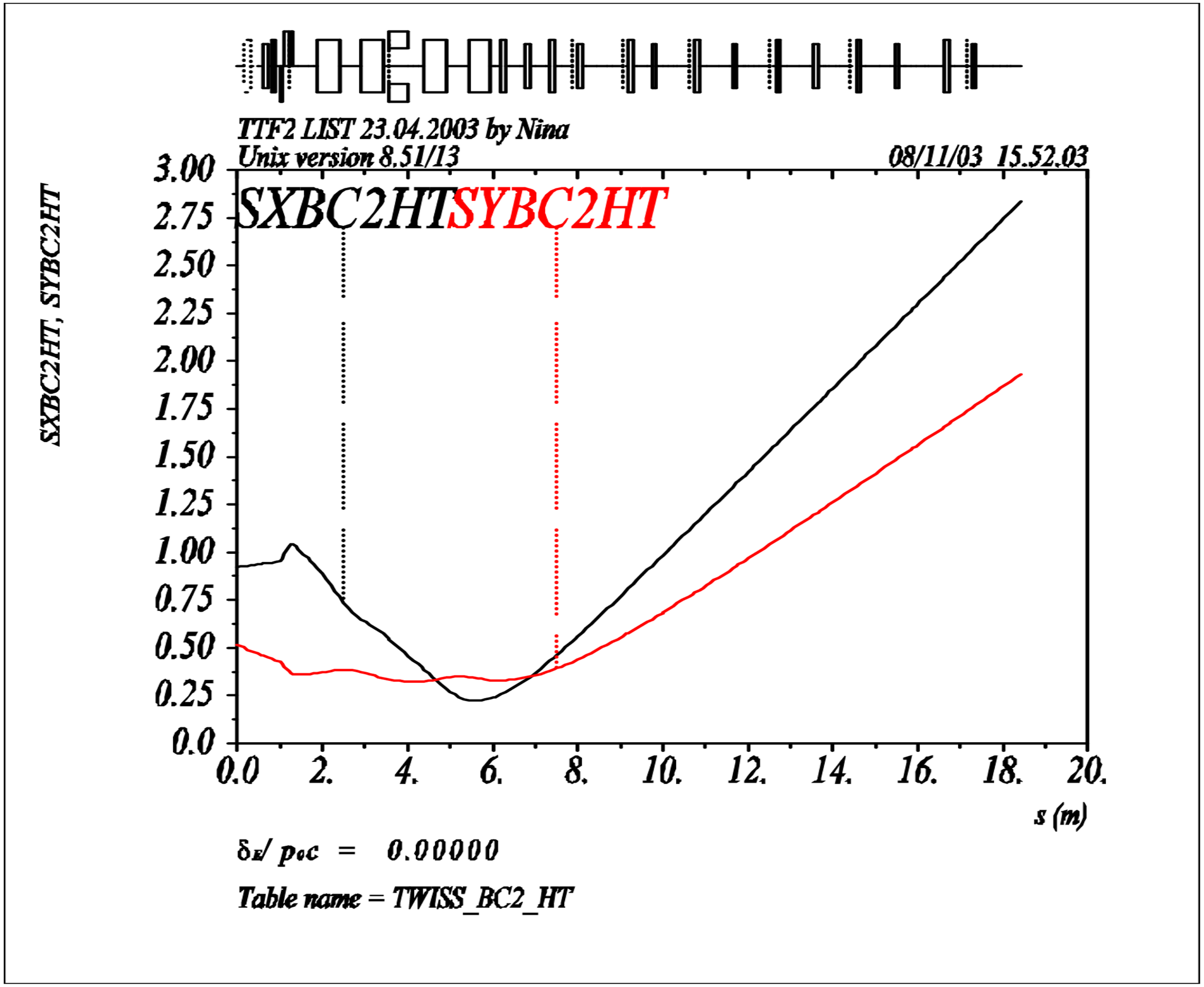


Beam Size in the Bunch Compressor and Diagnostics section with commissioning optics

$\varepsilon = 1 \cdot 10^{-6}$ m

(N. Golubeva)

Bunch Compressor and Diagnostics Section

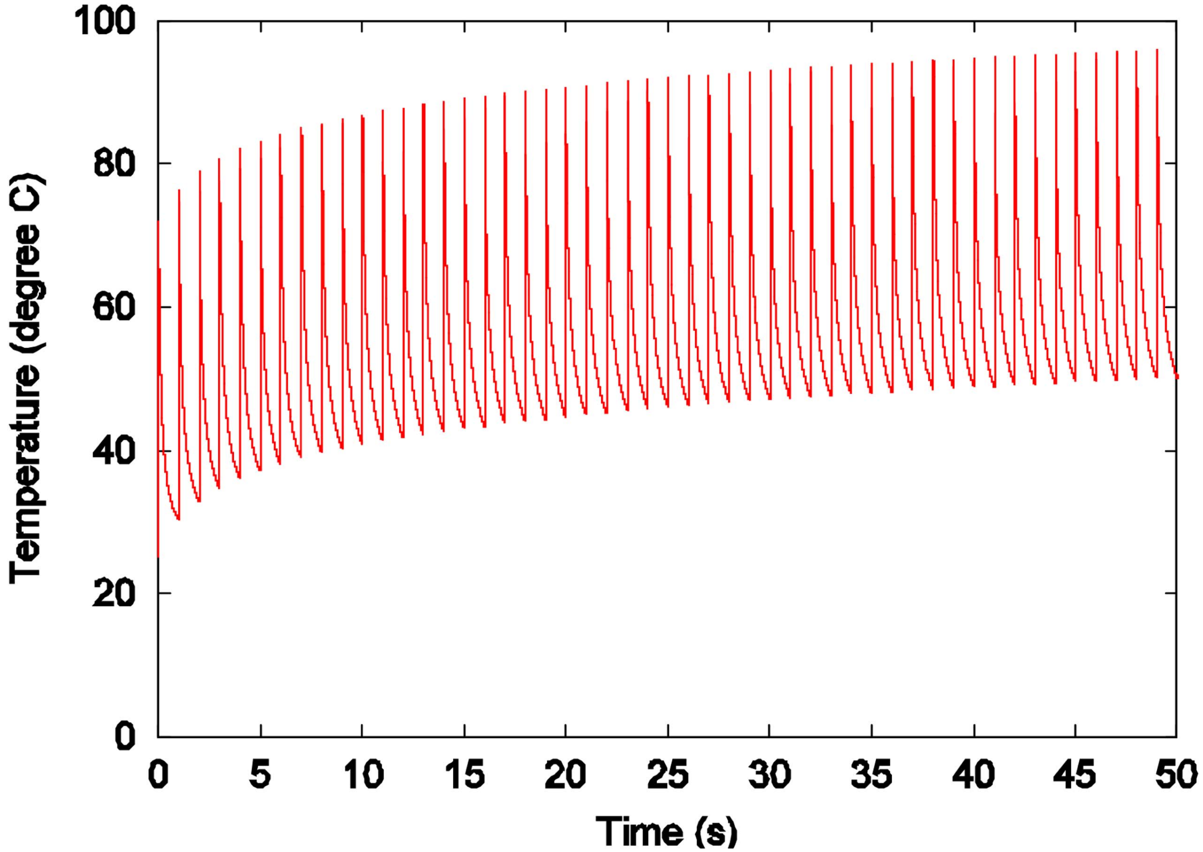


Beam Size in the Bunch Compressor and Diagnostics section with high current optics,

$\varepsilon = 10^{-5}$ m

(N. Golubeva)

Bunch Compressor and Diagnostics Section



Example of the temperature development in the center of the exit window; high current optics, 125 bunches, 8nC, 1 Hz

(N. Golubeva)

Bunch Compressor and Diagnostics Section

	nominal	commissioning	high current
Q_{bunch}	1 nC	1 nC	8 nC
$\sigma_{x,y}$	0.1 mm	0.5 mm	1 mm
rep. rate	10 Hz	10 Hz	1 Hz
N_{bunch}	1	< 100	< 60

Injector Commissioning: Part 2 Module

Assumption: Module is cold and conditioned. All cavities are operated with the same gradient in the beginning. Technical checks of all magnets have been done, magnet polarities are ok.

The goal is to get the beam through the module, adjust phases and gradient and check the transfer of the beam.

- get the beam through the module up to the dump and adjust phases, either using transients (requires high charge operation 30-50 nC) or energy measurements in the bunch compressor and remote control of stub tuners.
- commission llrf.
- observe beam spot on first screen(s) as function of the initial beam position and angle, check for coupling and strange effects (coupler influence??)
- check envelope matching (gradient and solenoid setting).
- at some point try operation with higher gradient in the last four cavities, if operational constrains (limited flexibility in beam current) permits.

Injector Commissioning: Part 3 Bunch Compressor and Diagnostics Section

Assumption: Beam is already at the temporary beam dump. Technical checks of diagnostic components, streak camera beam line etc. are done as far as possible.

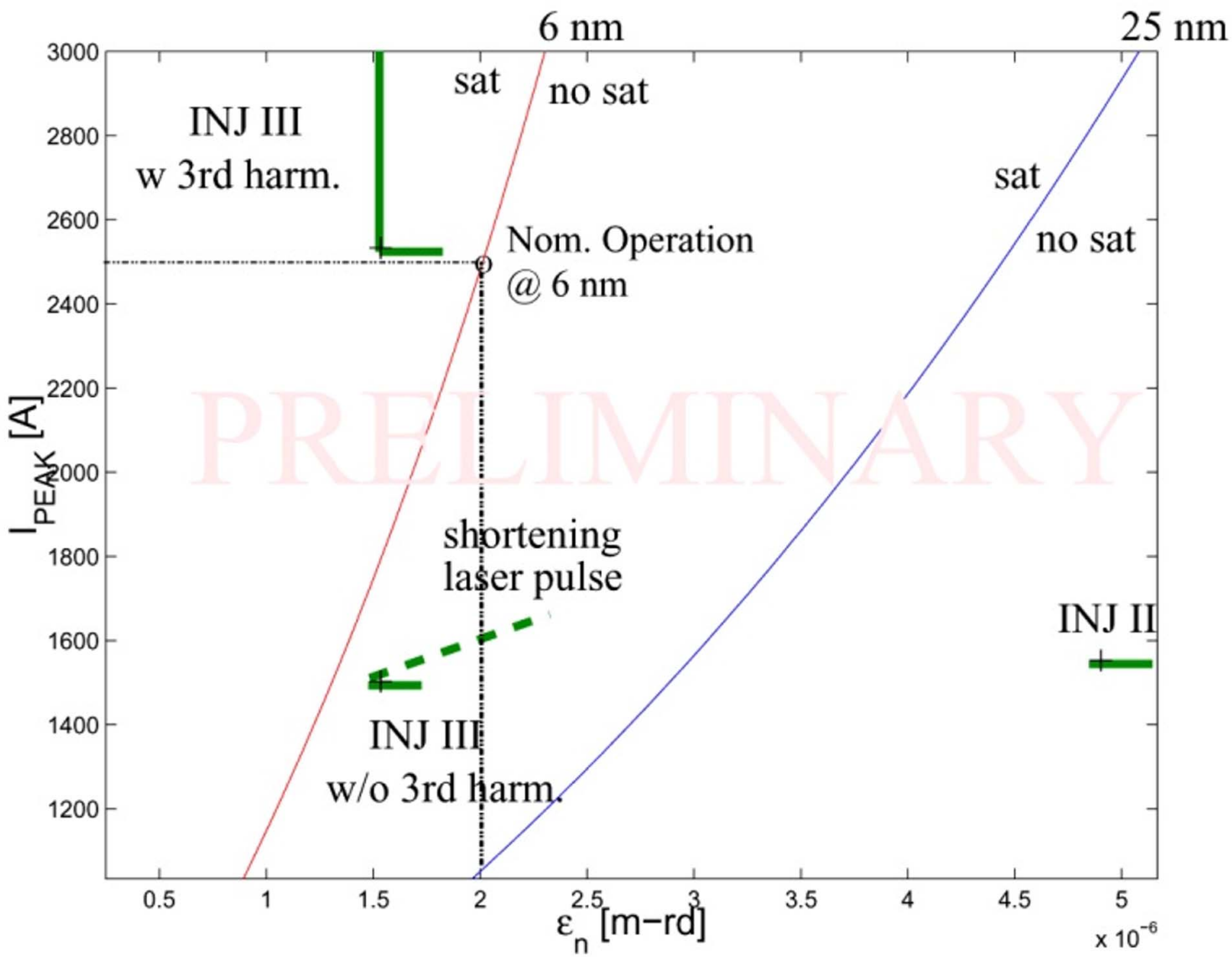
The goal is to get the diagnostics section into operation, find a good operation point for the transverse emittance and optics and compress the bunch using velocity and/or magnetic compression.

- commission toroids, BPMs and other diagnostic components
- check dark current, try dark current collimator in the gun area
- check/improve orbit, full transmission
- get emittance measurement in operation, beam in BC through straight section, start with commissiong optics
- improve optics and emittance, scan solenoid, gun phase, module gradient and phase, laser pulse size and length (with stacker), etc.
- get beam through bunch compressor, measure energy and energy spread check/compensate dispersion behind BC

Injector Commissioning: Part 3 Bunch Compressor and Diagnostic Section

- commission streak camera beam line, measure bunch length
- try velocity bunching, measure bunch length and form, energy spread and transverse emittance, start with beam through straight section, aim for $\sigma z \leq 0.8$ mm with good transverse emittance
- compress in bunch compressor, measure bunch length and form and transverse emittance
- try dark current collimator in BC2
- commission TOF (Time Of Flight) measurement
- establish 'golden set-up' for the commissioning of the rest of the machine with and without compression.

Parameter Expectations for TTF II



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