

Summary WG3

Zeuthen, 23.01.2004

WG3 Agenda

Hardware status:

- TTF Cryogenic Installations 2003
 - Status of Modulators / Klystrons / Waveguides
 - Low Level RF for the RF Gun and ACCs
 - Machine Protection with toroids
 - Laser / Laserbeamline
 - Diagnostics (mainly OTR)
 - LOLA commissioning
- R. Lange
S. Choroba
S. Simrock
M. Jablonka
W. Kohl
K. Honkavaara
M. Nagl

WG3 Agenda (cont.)

Measurements / Experiments:

- gun rf studies/regulation (water cooling)
- laser performance, pulse stacking
- cathode: darkcurrent and space charge studies
- beam based alignment laser / solenoids
- energy/energy spread at gun
- emittance in BC2
- bunch length in BC2
- diamond halo detector

J.-P. Carneiro
S. Schreiber
D. Sertore
M. Krasilnikov
D. Lipka
K. Honkavaara
O. Grimm
W. Lohmann

Schedule / Planning:

- overall injector commissioning program
- overall commissioning program

K. Floettmann
P. Castro

WG3 Agenda

Hardware status:

- **TTF Cryogenic Installations 2003**
- **Status of Modulators / Klystrons / Waveguides**
- **Low Level RF for the RF Gun and ACCs**
- **Machine Protection with toroids**
- **Laser / Laserbeamline**
- **Diagnostics (mainly OTR)**
- **LOLA commissioning**

R. Lange

S. Choroba

S. Simrock

M. Jablonka

W. Kohl

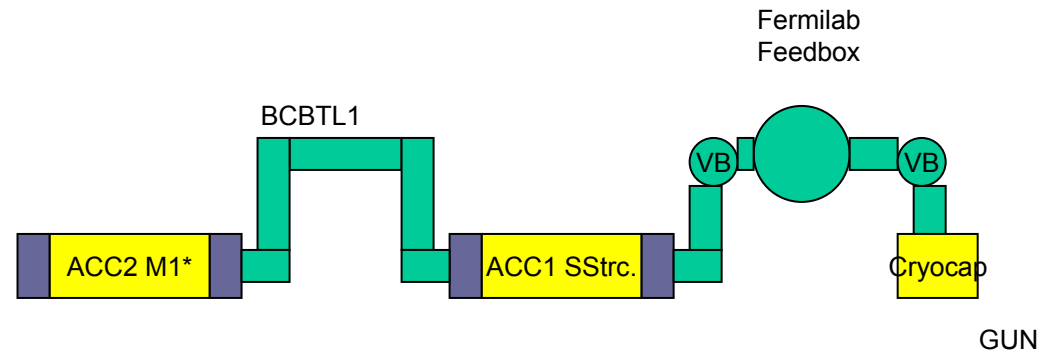
K. Honkavaara

M. Nagl

TTF Cryogenic Installations



TTF Cryogenic Installations Status 01/2003

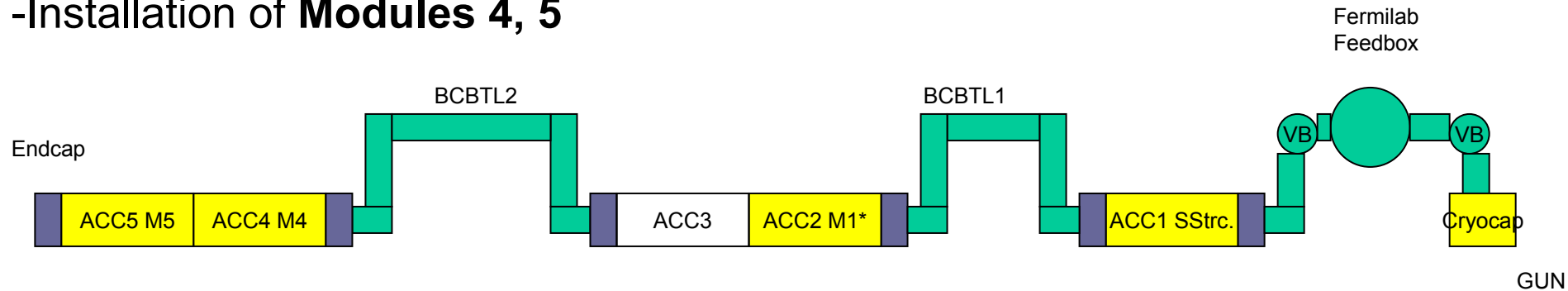


**Module 1* and the
Superstructure-Module**

TTF Cryogenic Installations

Work done 01-03/2003

-Installation of **Modules 4, 5**



Installation:

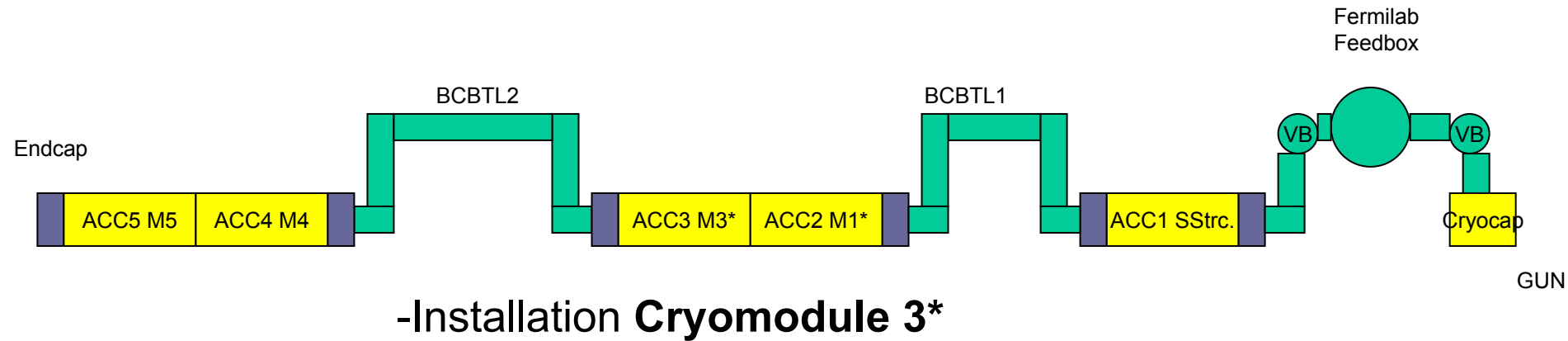
- BunchCompressorBypassTransferline2
- New Endcap ACC5

M3*

-Assembly **Module 3***

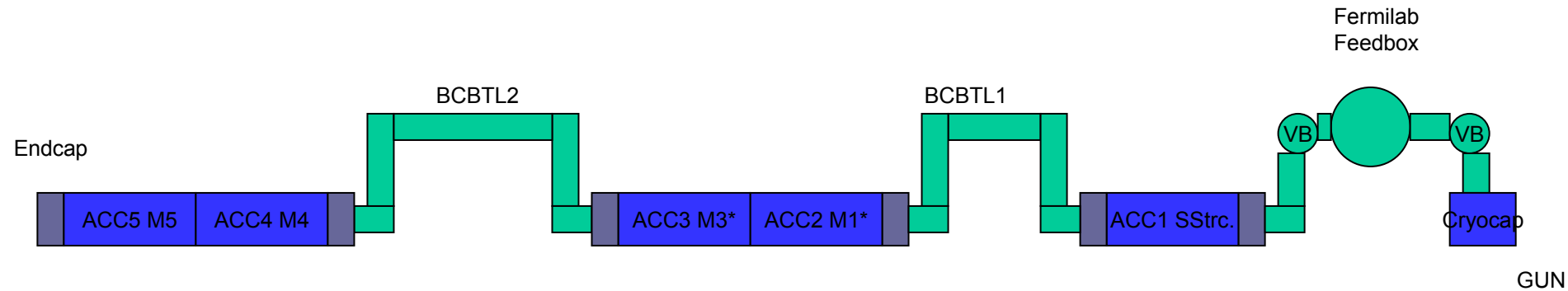
TTF Cryogenic Installations

Work done 04-06/2003



TTF Cryogenic Installations

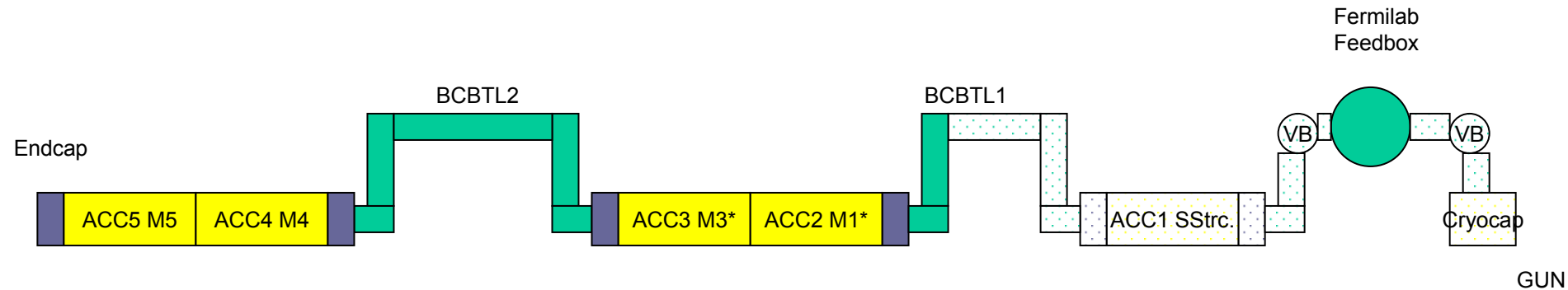
Operation 06-09/2003



**Cold RF Test of
Modules 4 and 5**

TTF Cryogenic Installations

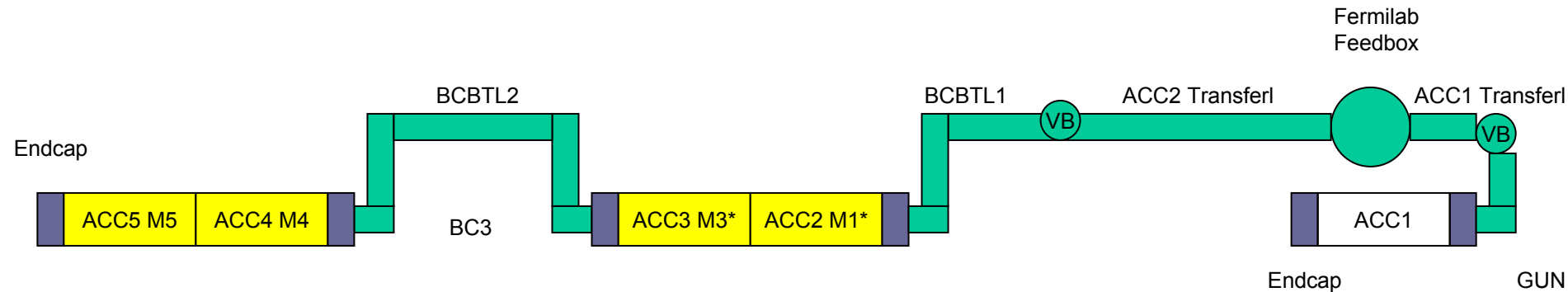
09/2003 THE Big Removal



Removal of

- Superstructure-Module**
- Cryocap (Capture Cavity)**
- 1/2 BunchCompressorBypassTransferline1
- Valve boxes ACC1 and Cryocap

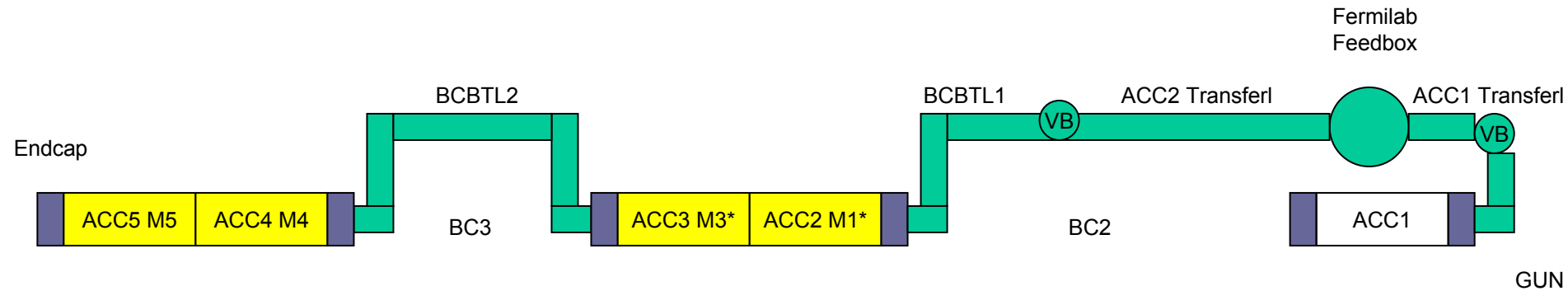
TTF Cryogenic Installations Reconstruction 11-12/2003



Reconstruction the injector area

ACC1-Position ~11m upstream

TTF Cryogenic Installations NOW 01-02/2004



M2*

Assembly **Cryomodule 2***
Ready 06.Feb.04

Module 2* (18.Jan.04)

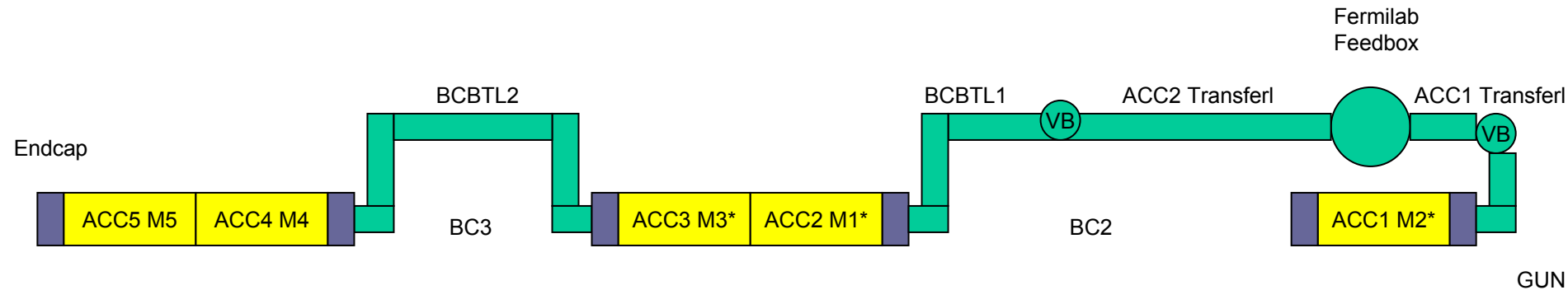


TTF Cryogenic Installations

Schedule 02-03/2004

Installation Cryomodule 2*

10.Feb.04



Cryomodule connections

Ready 02.Mar.04

Ready for cool down

09.Mar.04

Be careful! Otherwise...

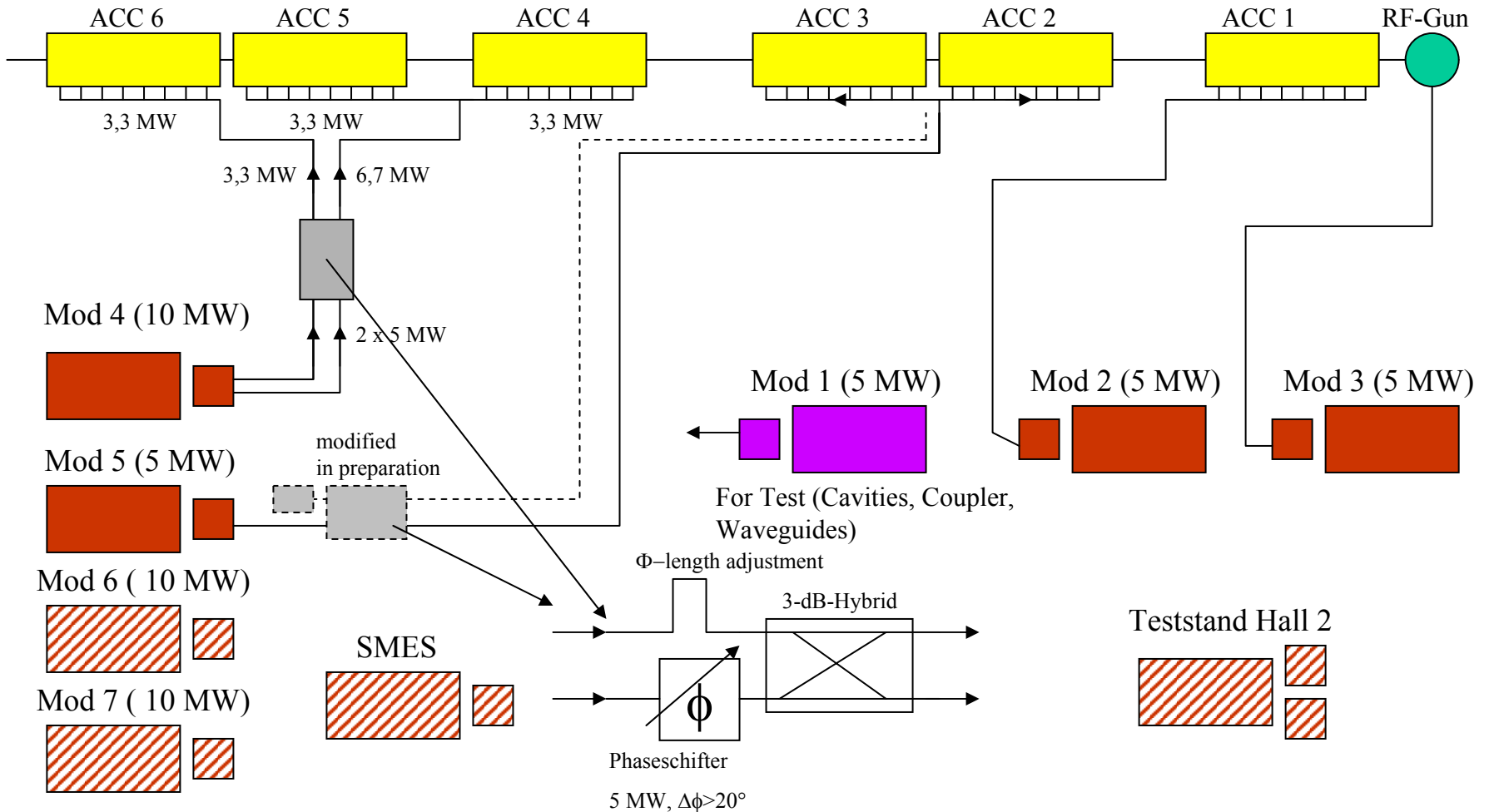


WG3 Agenda

Hardware status:

- TTF Cryogenic Installations 2003 R. Lange
- **Status of Modulators / Klystrons / Waveguides** S. Choroba
- Low Level RF for the RF Gun and ACCs S. Simrock
- Machine Protection with toroids M. Jablonka
- Laser / Laserbeamline W. Kohl
- Diagnostics (mainly OTR) K. Honkavaara
- LOLA commissioning M. Nagl

TTF2 RF System



Klystrons

- THALES TH2104C Klystrons (5MW) available
- THALES TH1801 Klystron (10MW MBK)

prototype at DESY, increased gun arcing rate

series #1 and #2 at THALES for repair and modification

more tubes are ordered

Tentative delivery schedule:

#1 May of 2004

#2, #3,#4 in 2004

#5, #6, ... in 2005

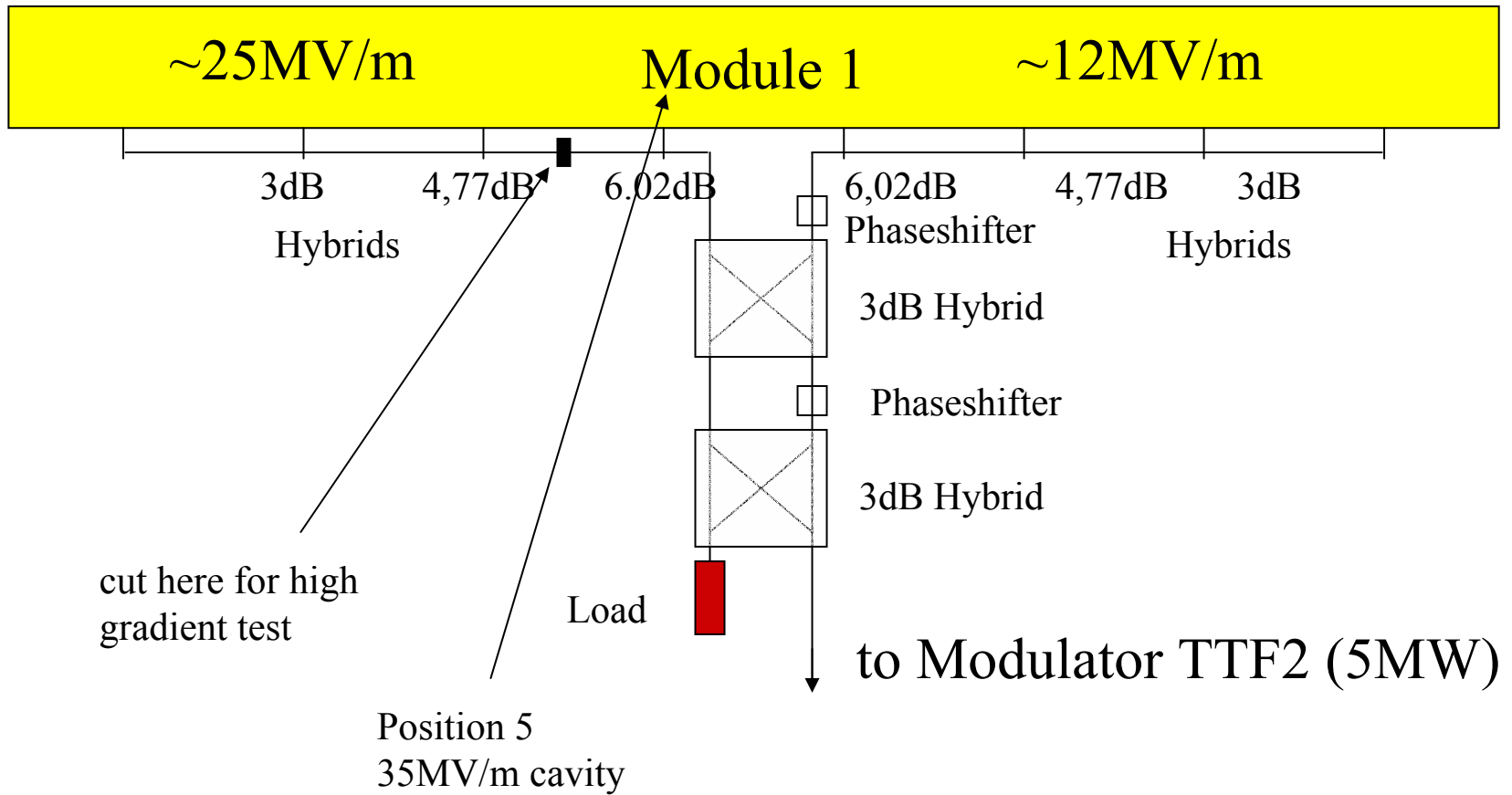
Klystrons cont.

- **CPI VKL-8301 10MW MBK** ready for bake out on January 15th, test foreseen at CPI for end of February, delivery to DESY in 2004
- **TOSHIBA E3763 10MW MBK** test at Toshiba in 2004, more information by Yong Ho Chin

Modulators



Waveguides



WG3 Agenda

Hardware status:

- TTF Cryogenic Installations 2003
- Status of Modulators / Klystrons / Waveguides
- **Low Level RF for the RF Gun and ACCs**
- Machine Protection with toroids
- Laser / Laserbeamline
- Diagnostics (mainly OTR)
- LOLA commissioning

R. Lange

S. Choroba

S. Simrock

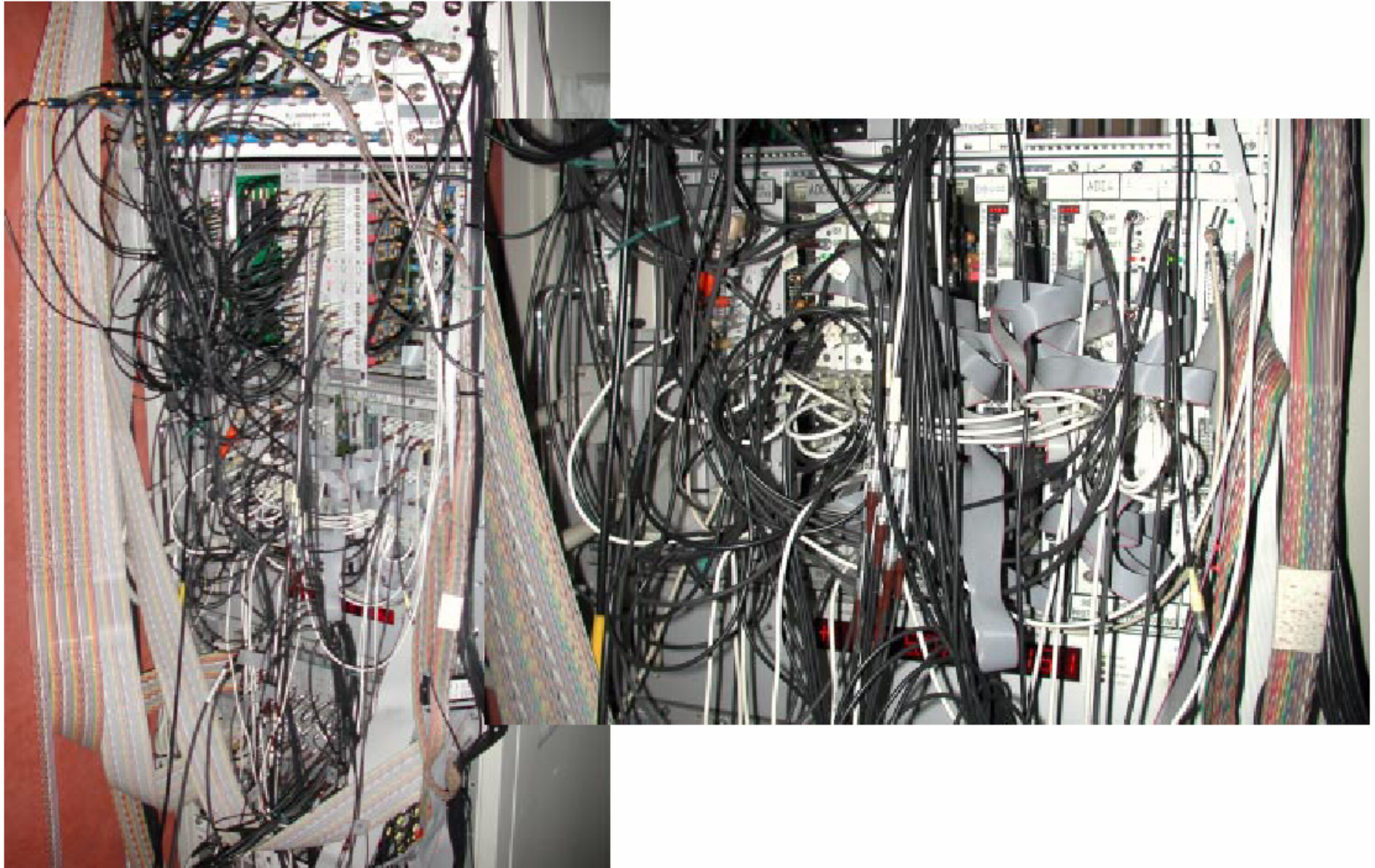
M. Jablonka

W. Kohl

K. Honkavaara

M. Nagl

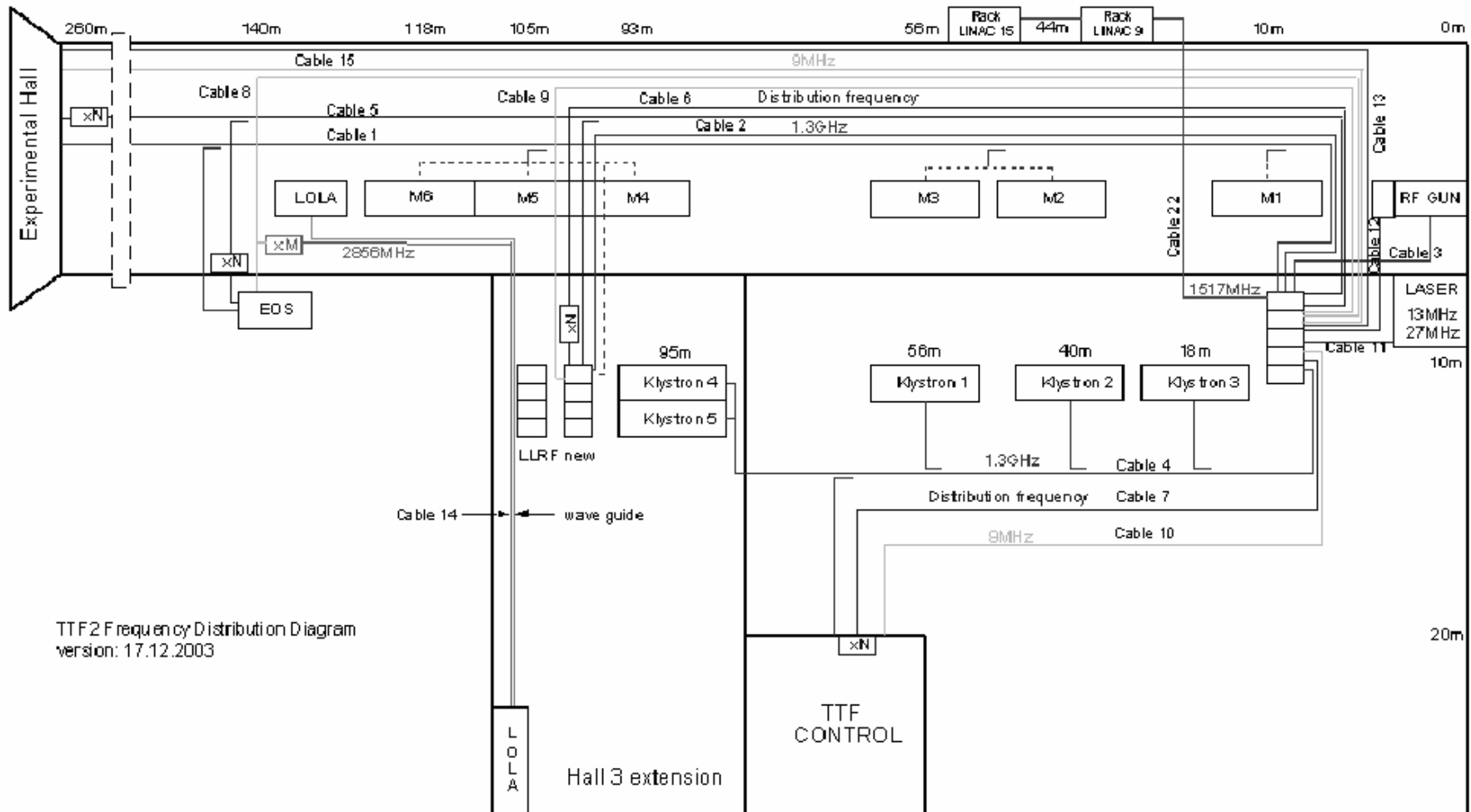
Rack Layout and Cabling for TTF I



Installation Status of LLRF for ACC 2-6



TTF2 cable distribution layout:



TTF2 Frequency Distribution Diagram
version: 17.12.2003

Summary

- Commissioning of LLRF for TTF II is well underway
 - Feedforward for ACC 4,5,6 (old IQ drivers) available
 - New C67 based DSP System for RF Gun and ACC1 under commissioning. In operation with cavity simulator
 - New “field” detectors for RF Gun
 - Prototype of FPGA based controller and cavity simulator
- Master oscillator and frequency distribution are presently being installed
 - New frequencies (2856 MHz, 13.5 MHz)
 - Temperature stabilized coaxial distribution
 - Highly stable fiber optic monitoring system
- Automation of LLRF operation under development

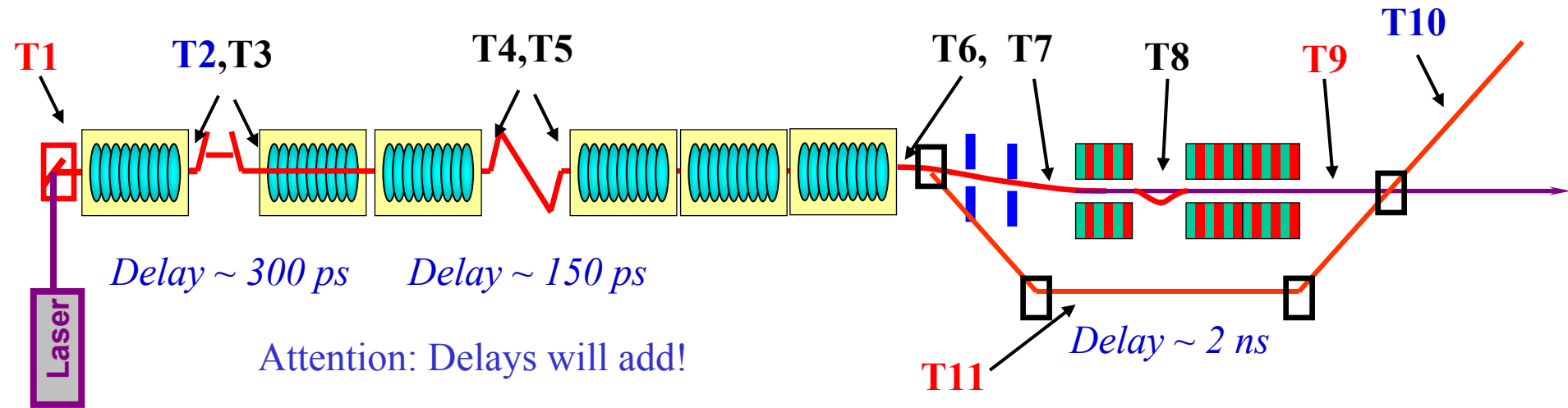


WG3 Agenda

Hardware status:

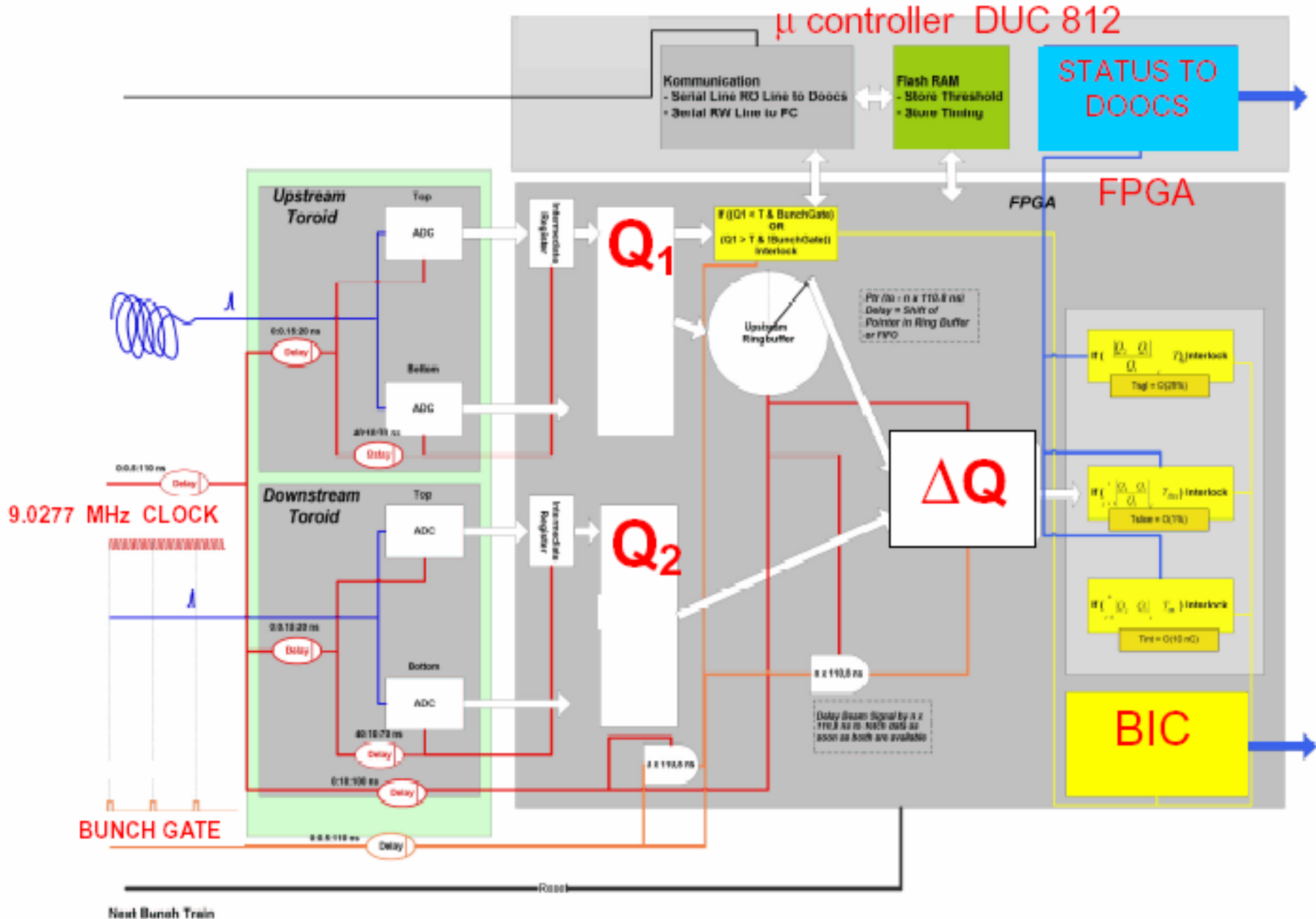
- TTF Cryogenic Installations 2003
 - Status of Modulators / Klystrons / Waveguides
 - Low Level RF for the RF Gun and ACCs
 - **Machine Protection with toroids**
 - Laser / Laserbeamline
 - Diagnostics (mainly OTR)
 - LOLA commissioning
- R. Lange
S. Choroba
S. Simrock
M. Jablonka
W. Kohl
K. Honkavaara
M. Nagl

Transmission Based Protection System for TTF II



Tor	Name	Z-Position	Toroid	Name	Z-Position	Comment
T1	Toroid/3Gun	1,25 m	T9	Toroid/12Exp	244,97m	FEL Beamline, total length
T1	Toroid/3Gun	1,25	T11	Toroid/16Byp	161,254m	Bypass Beampath, total length
T2	Toroid/2UBC2	20,548 m	T10	Toroid/?Dump	Ca. 248,9 m	Make sure beam reaches the dump (FEL Beamline)
T2	Toroid/2UBC2	20.548 m	T10	Toroid/?Dump	Ca. 248,9 m	Make sure beam reaches the dump (Bypass)

Electronics for the toroid protection system



Toroid protection system

ADC board

2 units built

Clock 9.0277 MHz

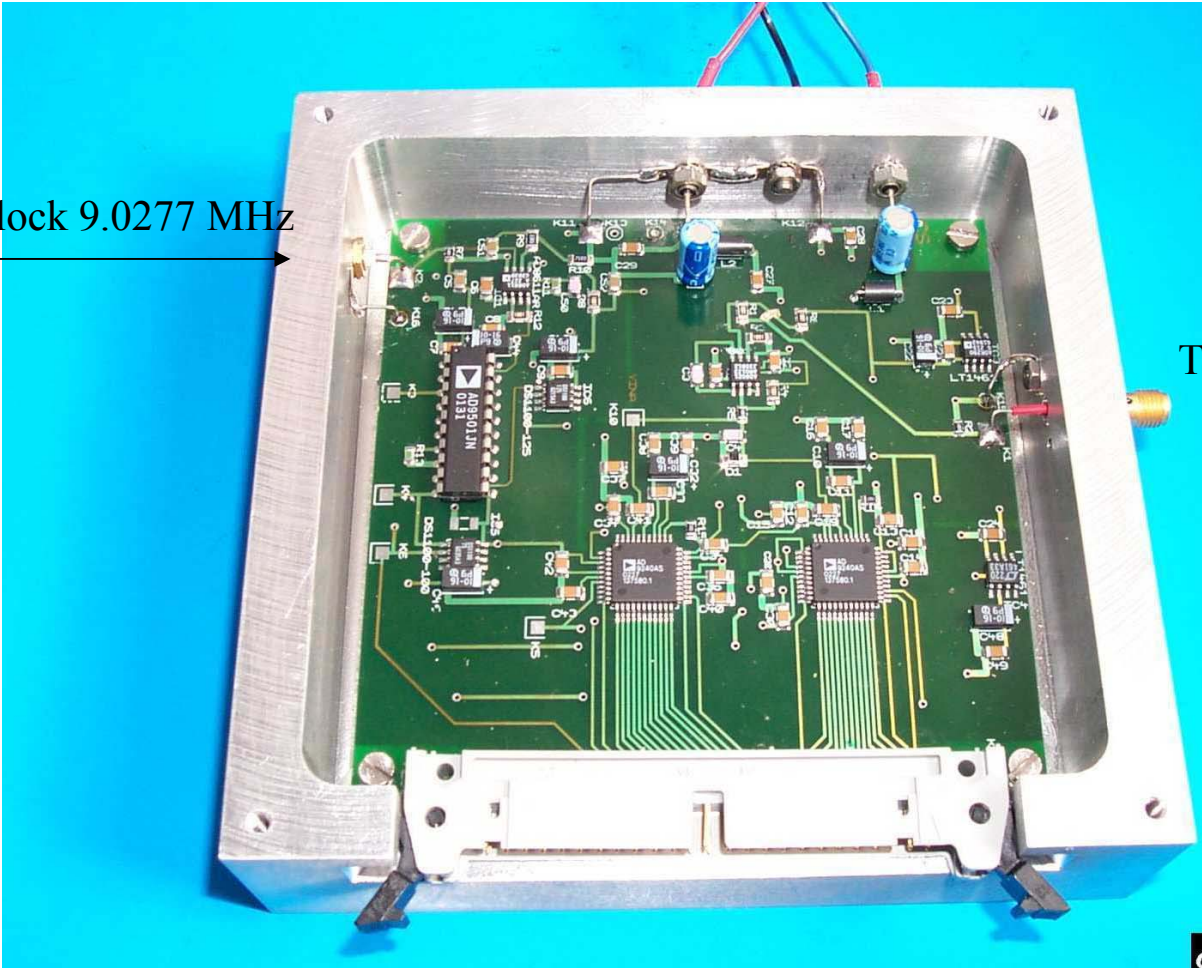
Continuous clock

14 bits

10 MS/s

Programmable delay

Toroid signal



Delay (8 bits)



FPGA (2X 14 bits)

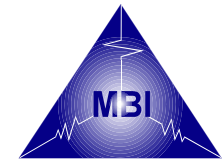


WG3 Agenda

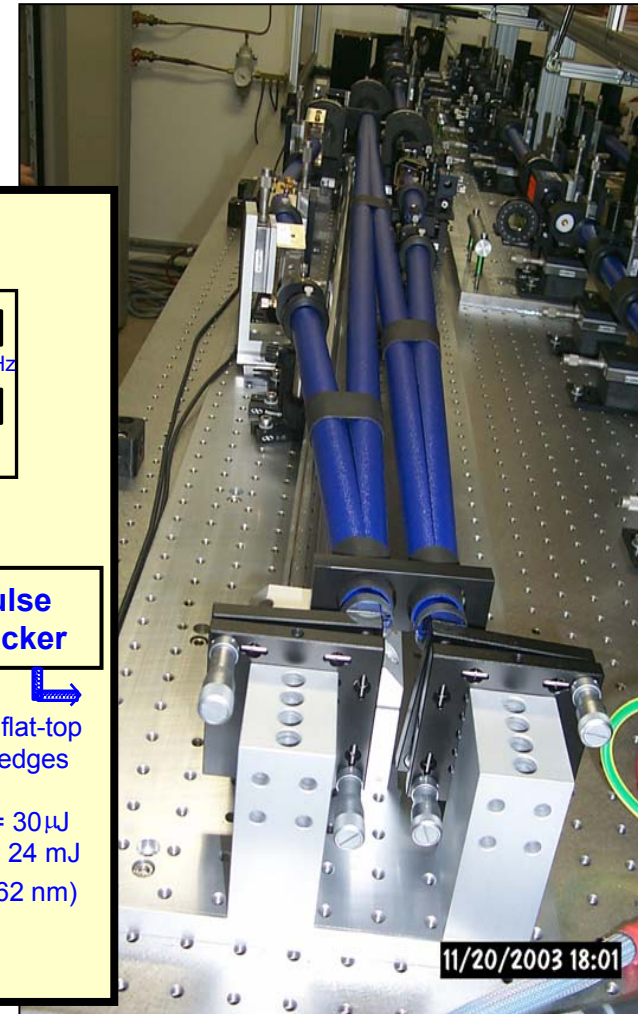
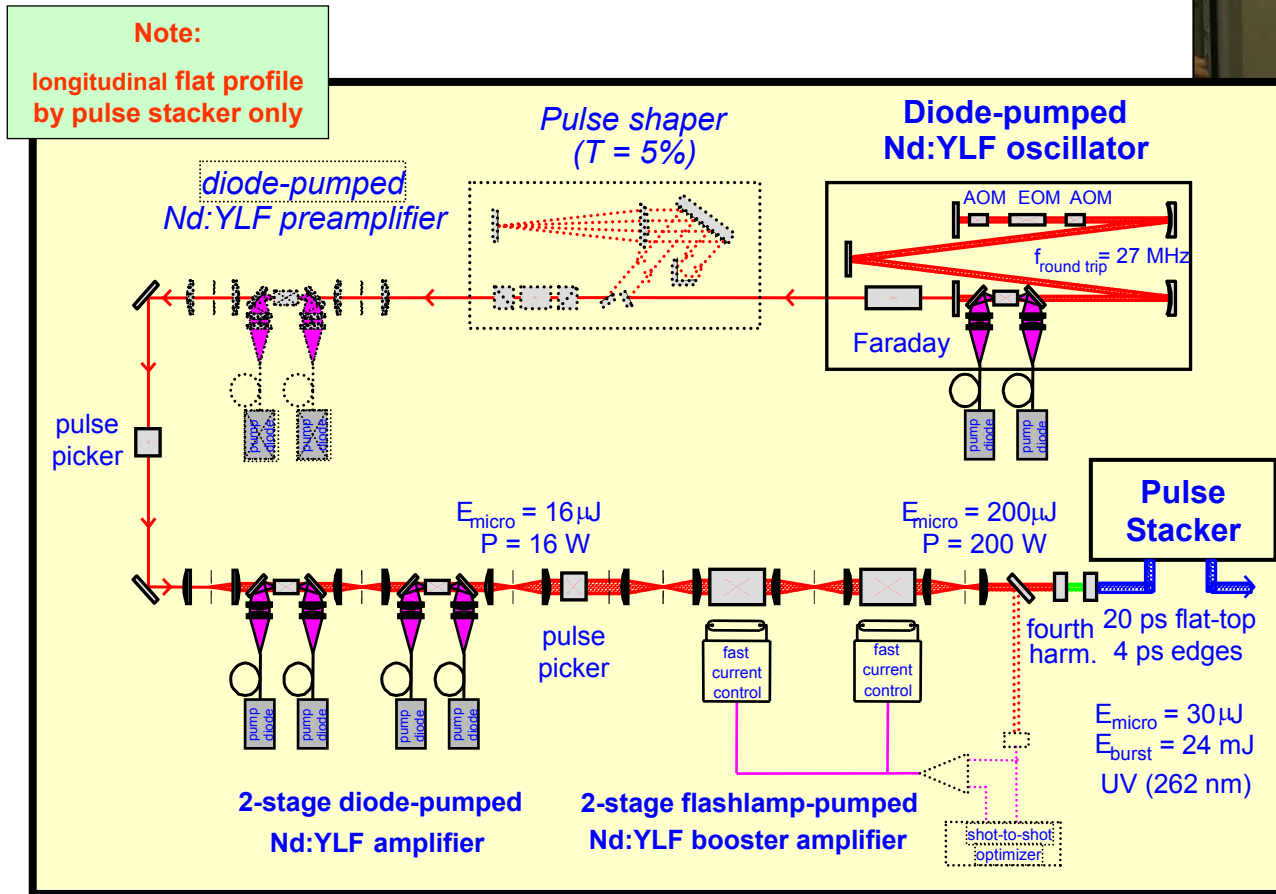
Hardware status:

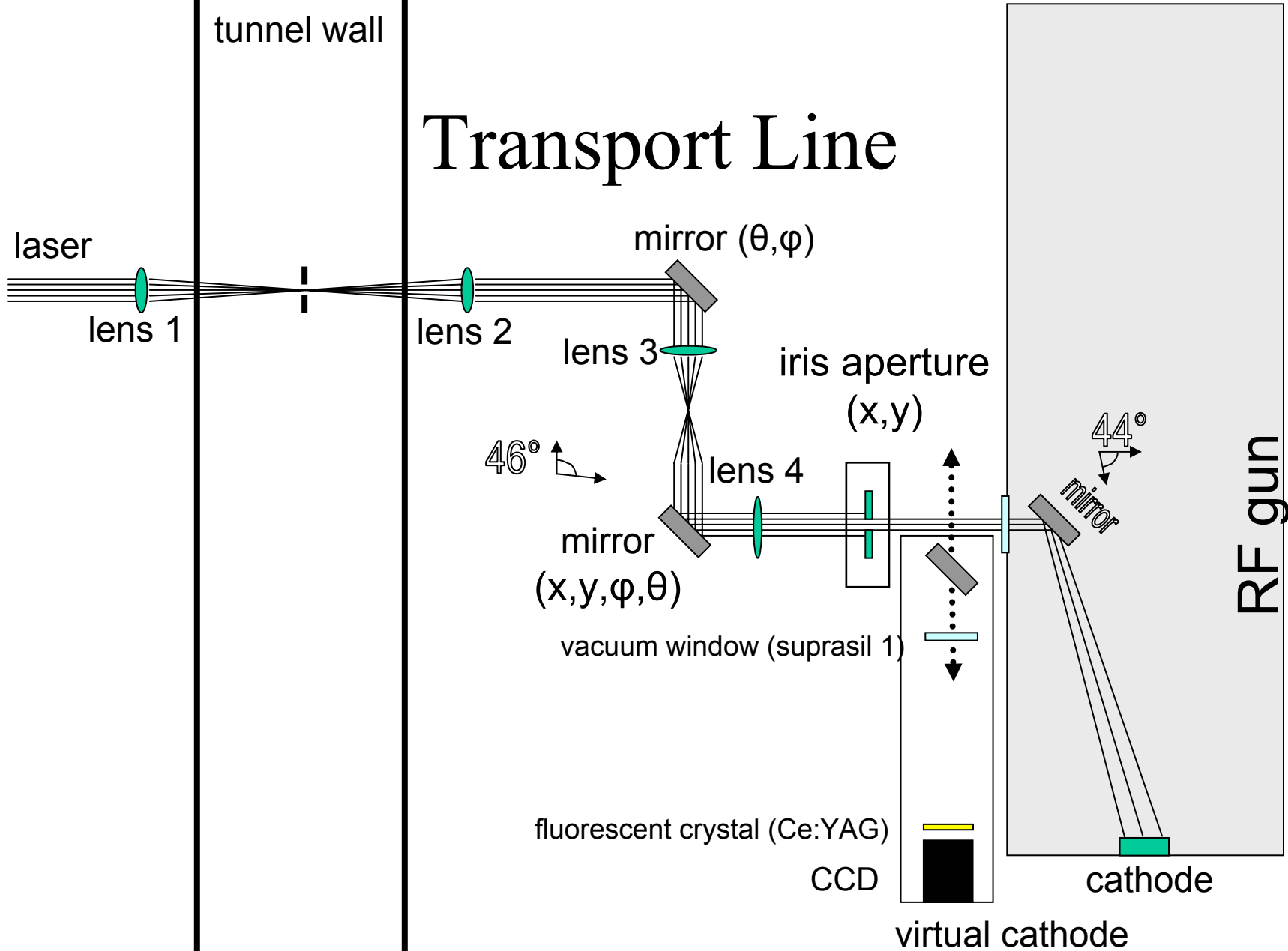
- TTF Cryogenic Installations 2003
 - Status of Modulators / Klystrons / Waveguides
 - Low Level RF for the RF Gun and ACCs
 - Machine Protection with toroids
 - Laser / Laserbeamline
 - Diagnostics (mainly OTR)
 - LOLA commissioning
- R. Lange
S. Choroba
S. Simrock
M. Jablonka
W. Kohl
K. Honkavaara
M. Nagl

TTF 2 Laser Upgrade



- Together with Max-Born-Institute, Berlin (I. Will et al.)
- Upgrade has been tested at PITZ





Laser Upgrade

- The **first step of the upgrade** of the laser system is **almost finished** by now:
 - **new diode pumped oscillator, 2 diode pumped amplifiers**
 - to do: **replace last 2 flashlamp pump amplifiers** by diode pumped amplifiers, **longitudinal pulse shaper**
- **New beam mode selection and interlock electronics**
- **Pulse stacker** for close to flat top longitudinal profile tested
- **improved laser beam transport line**
- **second laser hut** ready for the backup laser system

WG3 Agenda

Hardware status:

- TTF Cryogenic Installations 2003
- Status of Modulators / Klystrons / Waveguides
- Low Level RF for the RF Gun and ACCs
- Machine Protection with toroids
- Laser / Laserbeamline
- **Diagnostics (mainly OTR)**
- LOLA commissioning

R. Lange

S. Choroba

S. Simrock

M. Jablonka

W. Kohl

K. Honkavaara

M. Nagl



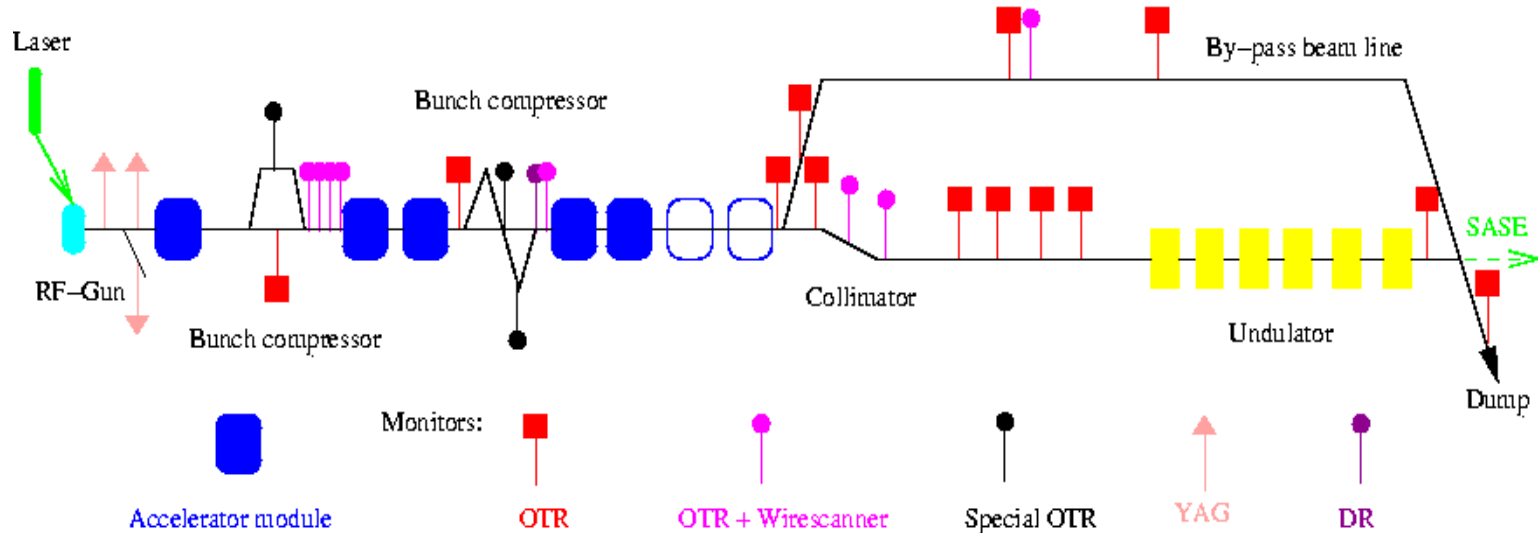
Status and commissioning of TTF2 OTR System

K.Honkavaara, DESY



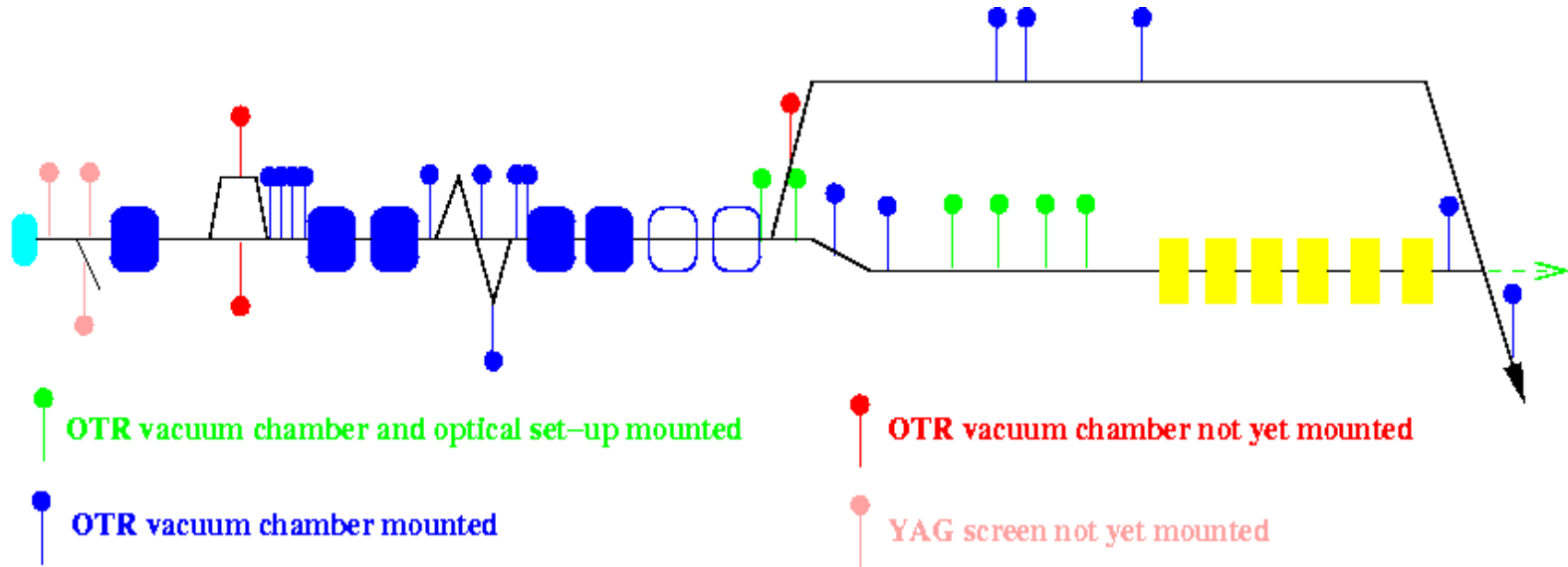
TTF2 OTR system is designed
and constructed in collaboration
between DESY and INFN-LNF
and INFN-Roma2

OTR monitors along the TTF2



- 13 standard OTR monitors
- 8 combined OTR and Wire scanner monitors
- 3 special OTR monitors in bunch compressors
- 3 Ce:YAG screens in RF-gun section
- 1 Diffraction Radiation (DR) radiator

Status of OTR monitors



- **22** of the 25 OTR vacuum chambers mounted to the linac
- **6** of the 18 standard optical set-ups mounted to the linac

WG3 Agenda

Hardware status:

- TTF Cryogenic Installations 2003
- Status of Modulators / Klystrons / Waveguides
- Low Level RF for the RF Gun and ACCs
- Machine Protection with toroids
- Laser / Laserbeamline
- Diagnostics (mainly OTR)
- **LOLA commissioning**

R. Lange

S. Choroba

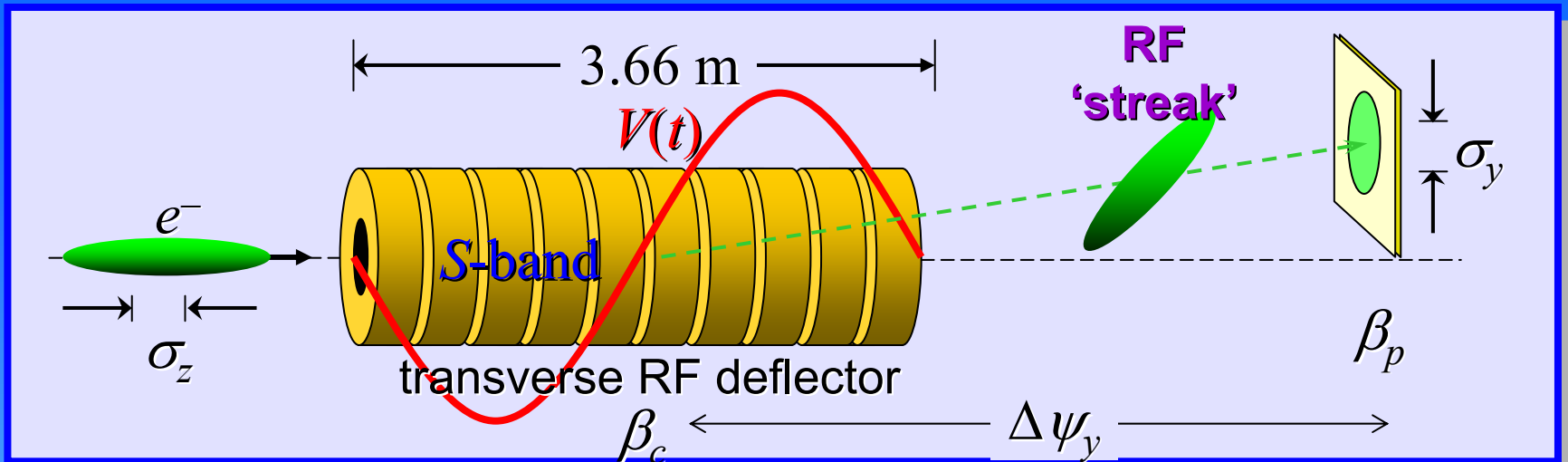
S. Simrock

M. Jablonka

W. Kohl

K. Honkavaara

M. Nagl



$$\sigma_y = \sqrt{\sigma_{y0}^2 + \sigma_z^2 \beta_c \beta_p \left(\frac{2\pi e V_0}{\lambda E_0} \sin \Delta\psi_y \cos \varphi \right)^2}$$

$$\langle \Delta y \rangle = \frac{e V_0}{E_0} \sqrt{\beta_c \beta_p} \sin \Delta\psi_y \sin \varphi, \quad V_0 \approx (1.6 \text{ MV/m/MW}^{1/2}) L \sqrt{P_0}$$

$$\sigma_z \approx 25 \mu\text{m}$$

$$E_0 \approx 0.6 \text{ GeV}$$

$$(\beta_c \beta_p)^{1/2} \approx 51 \text{ m}$$

$$\gamma \varepsilon_y \approx 5 \mu\text{m}$$

$$\Delta\psi_y \approx 15.8^\circ$$

$$\varphi \approx 0^\circ$$

$$\lambda \approx 105 \text{ mm}$$

$$\sigma_{y0} \approx 317 \mu\text{m}$$

$$L \approx 3.66 \text{ m}, \quad V_0 \approx 25 \text{ MV},$$

$$P_0 \approx 18 \text{ MW}$$

$$\sigma_y \approx 925 \mu\text{m}$$

For negative n are also negative phase velocities possible, but for all space harmonics we get the **same group velocity** :

$$\frac{1}{v_g} = \frac{d}{d\omega} \cdot \beta_n = \frac{d}{d\omega} \left(\beta_o + \frac{2\pi n}{L} \right) = \frac{d\beta_o}{d\omega}$$

or

$$\frac{c}{v_g} = \frac{c}{v_{p,n}} - \frac{\lambda_o}{L} \frac{d(c/v_{p,n})}{d(\lambda_o/L)}$$

The Fourier-analyzed field components of the **fundamental space harmonic** in the aperture of the irises ($r < a$) of **LOLA** at the velocity of light are

$$\underline{E}_r = \underline{E}_o \left[\left(\frac{kr}{2} \right)^2 + \left(\frac{ka}{2} \right)^2 \right] \cos \theta$$

$$E_\theta = \underline{E}_o \left[\left(\frac{kr}{2} \right)^2 - \left(\frac{ka}{2} \right)^2 \right] \sin \theta$$

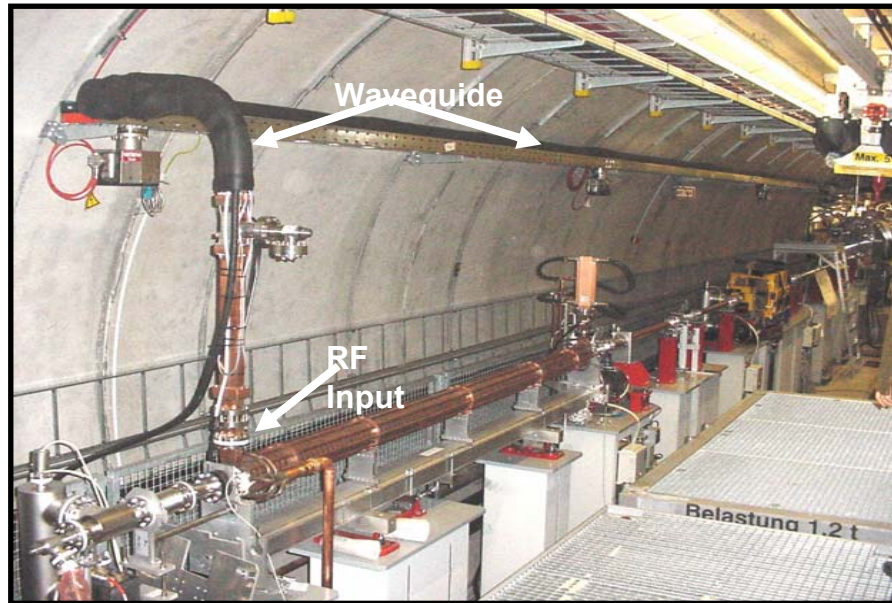
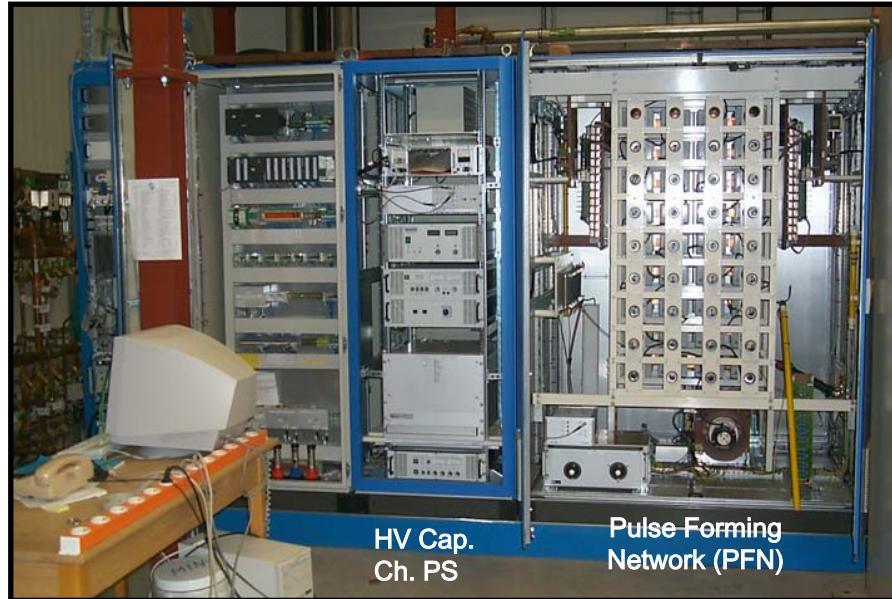
$$\underline{E}_z = j \underline{E}_o k r \cos \theta$$

$$Z_o H_r = - \underline{E}_o \left[\left(\frac{kr}{2} \right)^2 - \left(\frac{ka}{2} \right)^2 + 1 \right] \sin \theta$$

$$Z_o H_\theta = \underline{E}_o \left[\left(\frac{kr}{2} \right)^2 + \left(\frac{ka}{2} \right)^2 + 1 \right] \cos \theta$$

$$Z_o H_z = -j \underline{E}_o k r \sin \theta$$

With : $k = 2\pi/\lambda_o$: free-space wave number
 Z_o : free-space impedance



WG3 Agenda (cont.)

Measurements / Experiments:

- **gun rf studies/regulation (water cooling)**
- laser performance, pulse stacking
- cathode: darkcurrent and space charge studies
- beam based alignment laser / solenoids
- energy/energy spread at gun
- emittance in BC2
- bunch length in BC2
- diamond halo detector

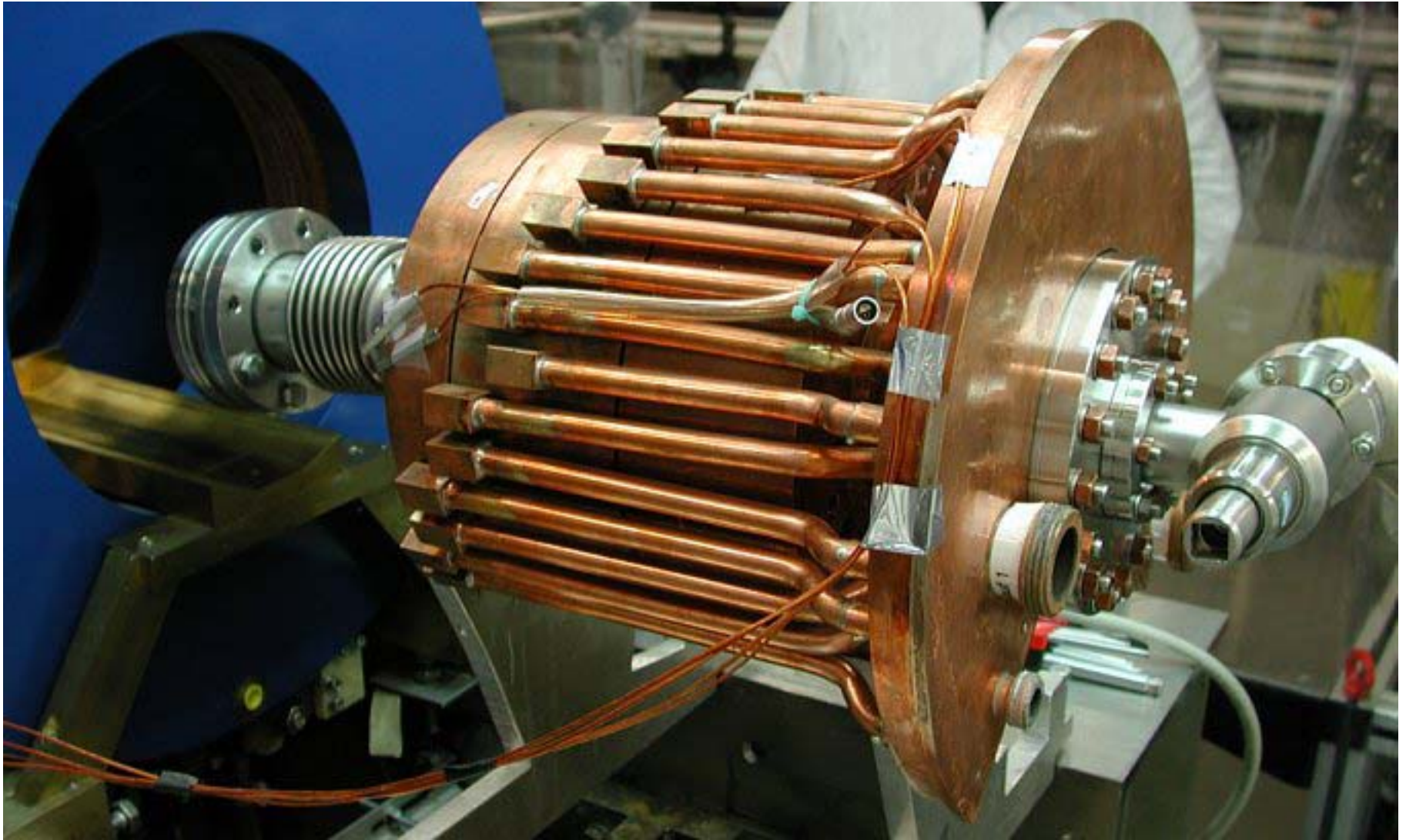
J.-P. Carneiro
S. Schreiber
D. Sertore
M. Krasilnikov
D. Lipka
K. Honkavaara
O. Grimm
W. Lohmann

Schedule / Planning:

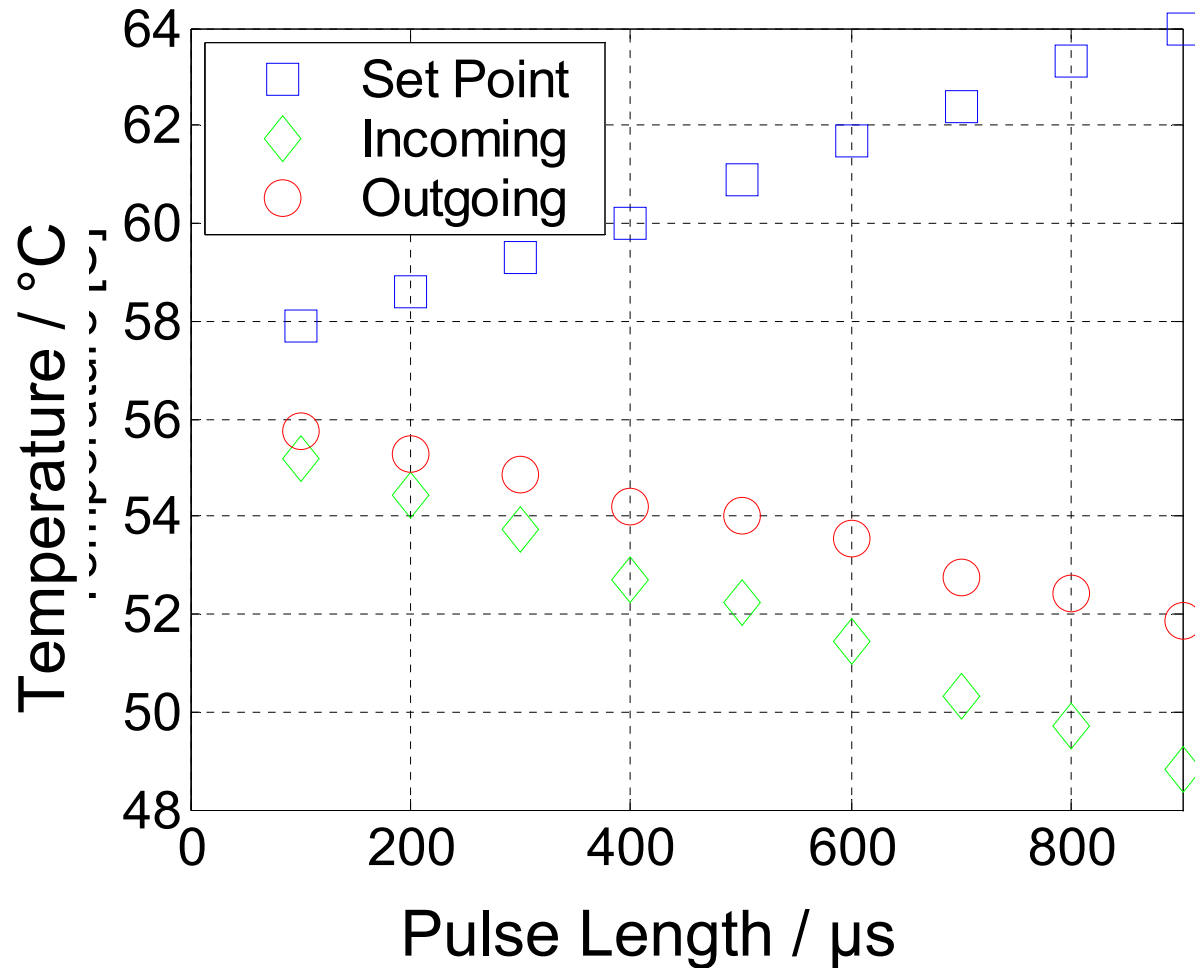
- overall injector commissioning program
- overall commissioning program

K. Floettmann
P. Castro

TTF2 RF GUNAT PITZ



Up to 20 kW (10 Hz, 900 μ s, 2.2 MW)



WG3 Agenda (cont.)

Measurements / Experiments:

- gun rf studies/regulation (water cooling)
- laser performance, pulse stacking
- cathode: darkcurrent and space charge
- beam based
- e
- e
- b
- detector

J.-P. Carneiro

S. ...

D. ...

M. ...

D. Lipka

K. Honkavaara

O. Grimm

W. Lohmann

Schedule / Planning:

- overall injector commissioning program
- overall commissioning program

K. Floettmann

P. Castro

Should have been there...

WG3 Agenda (cont.)

Measurements / Experiments:

- gun rf studies/regulation (water cooling)
- laser performance, pulse stacking
- **cathode: darkcurrent and space charge studies**
- beam based alignment laser / solenoids
- energy/energy spread at gun
- emittance in BC2
- bunch length in BC2
- diamond halo detector

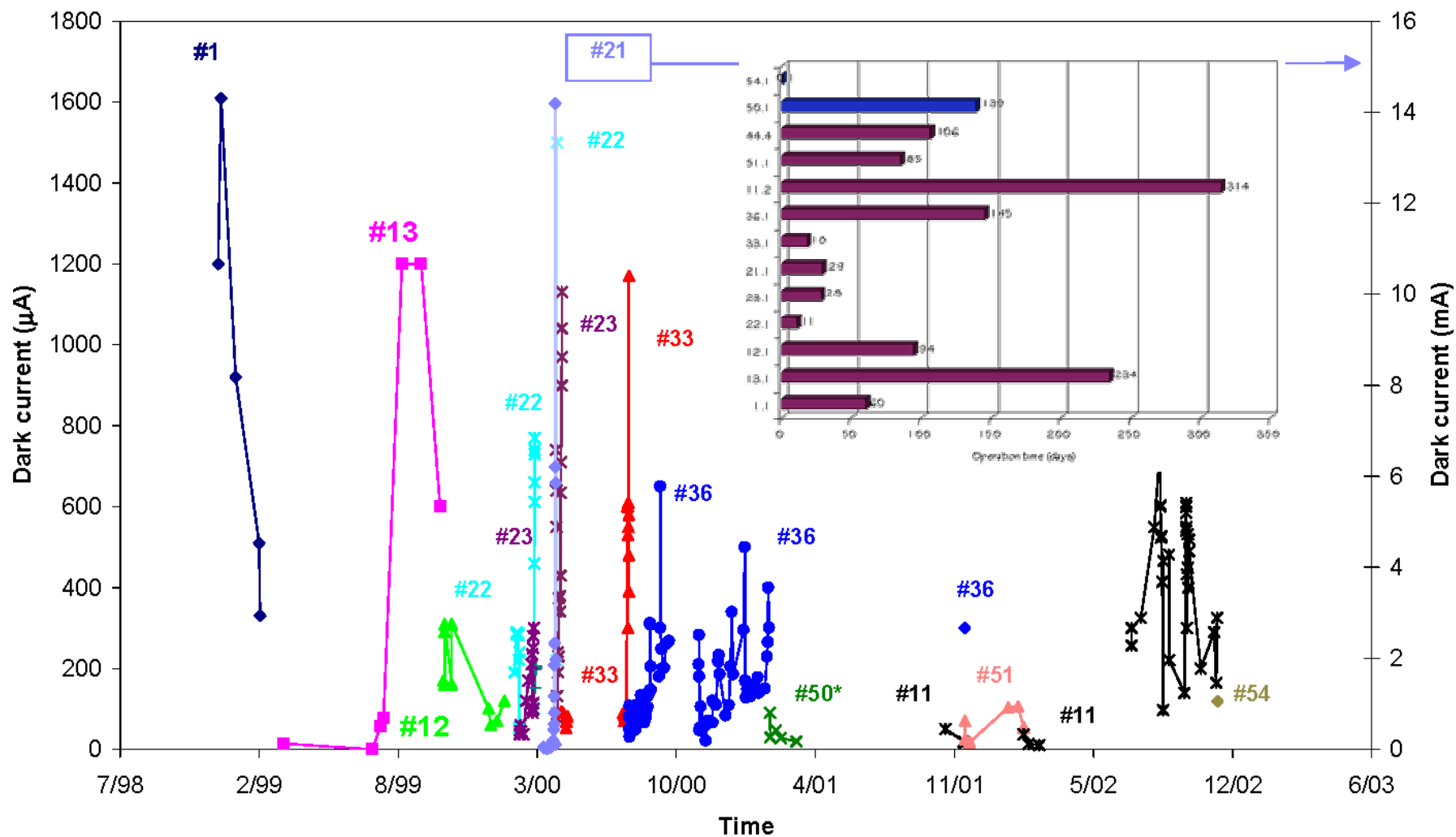
J.-P. Carneiro
S. Schreiber
D. Sertore
M. Krasilnikov
D. Lipka
K. Honkavaara
O. Grimm
W. Lohmann

Schedule / Planning:

- overall injector commissioning program
- overall commissioning program

K. Floettmann
P. Castro

Dark Current Data



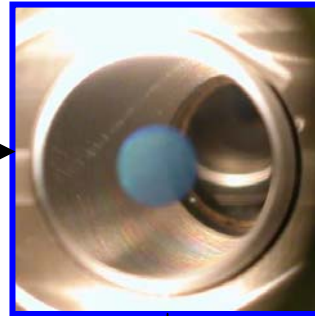
Dark Current

- **Dark current** was the main reason for **changing cathode** during TTF-I
- **To correlate** it with other cathode and plug parameters, a **database** is running in Milano accessible by WEB interface
- We have now updated the **database** with the information from the previous run but now we would like to have it **updated “daily”**

IMPROVED Database Scheme



Deposition



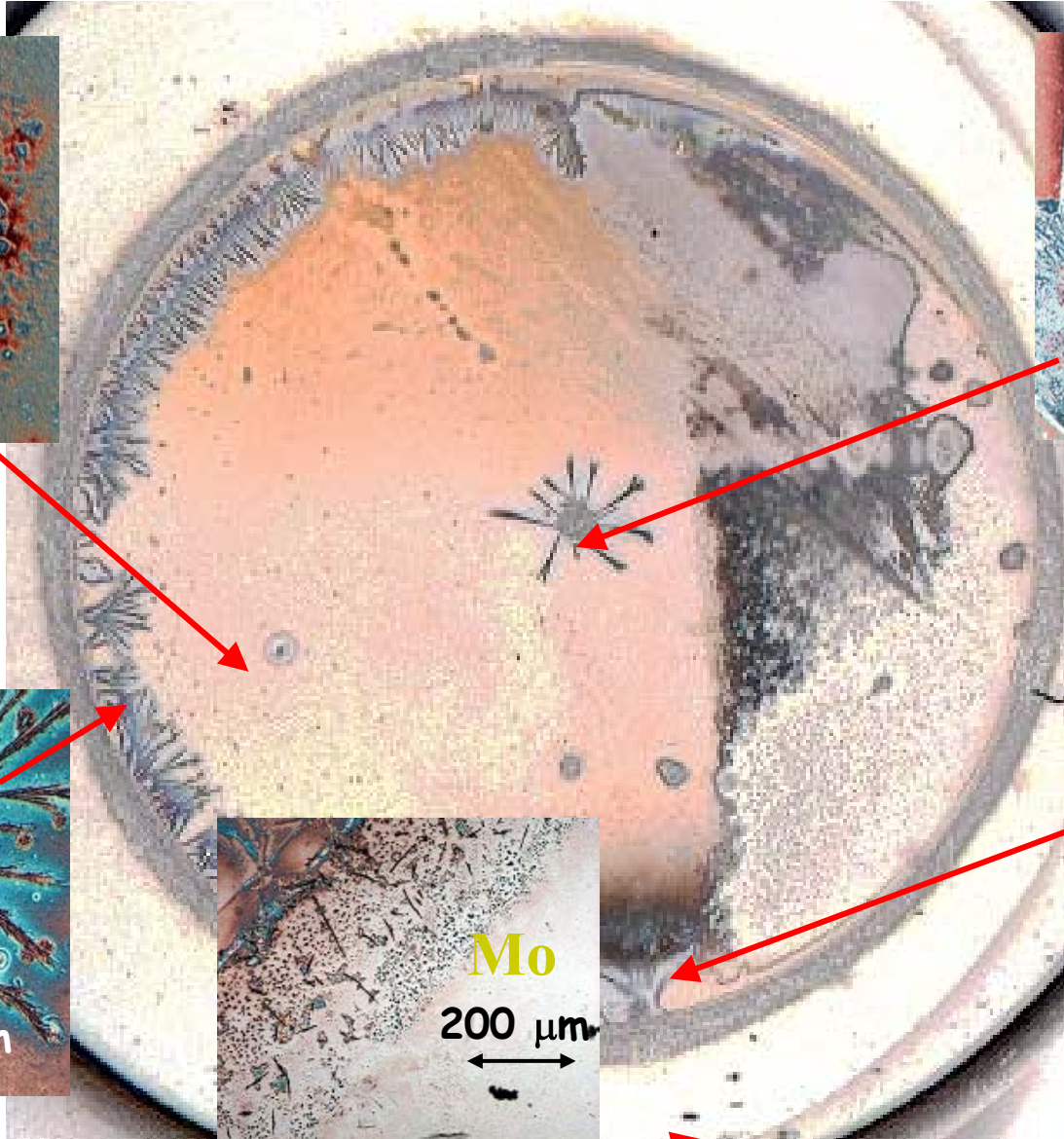
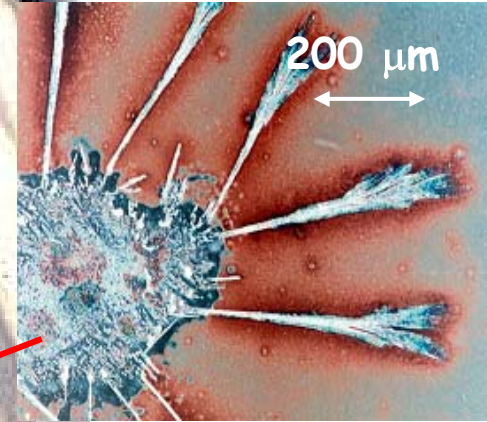
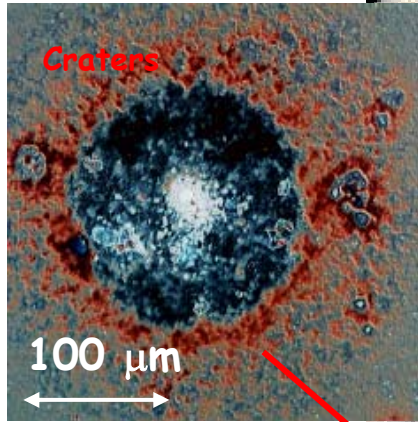
PLUG

- Molybdenum bar
- Machining procedures
- Cleaning
- Polishing
- In Vacuum Treatment
- ***Reflectivity***

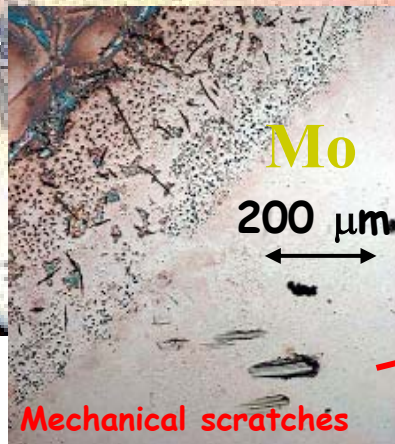
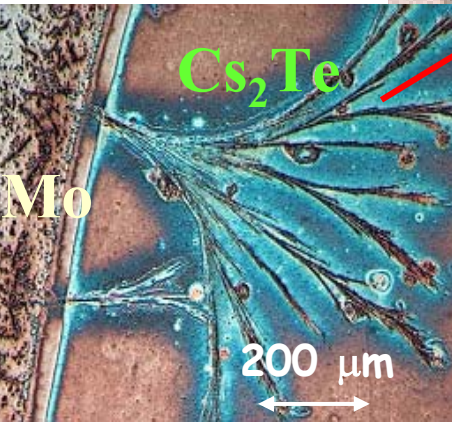
CATHODE

- Plug
- QE
- Dark Current
- ***QE maps***
- ***Pictures***
- ***Microscope scan***

Cathode Visual Analysis



PITZ
44.2 Cs_2Te
May-Sept '03



WG3 Agenda (cont.)

Measurements / Experiments:

- gun rf studies/regulation (water cooling)
- laser performance, pulse stacking
- cathode: darkcurrent and space charge studies
- **beam based alignment laser / solenoids**
- energy/energy spread at gun
- emittance in BC2
- bunch length in BC2
- diamond halo detector

J.-P. Carneiro
S. Schreiber
D. Sertore
M. Krasilnikov
D. Lipka
K. Honkavaara
O. Grimm
W. Lohmann

Schedule / Planning:

- overall injector commissioning program
- overall commissioning program

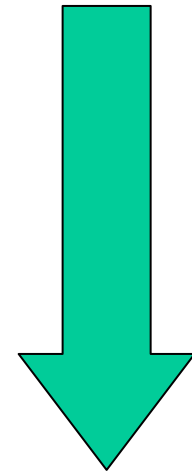
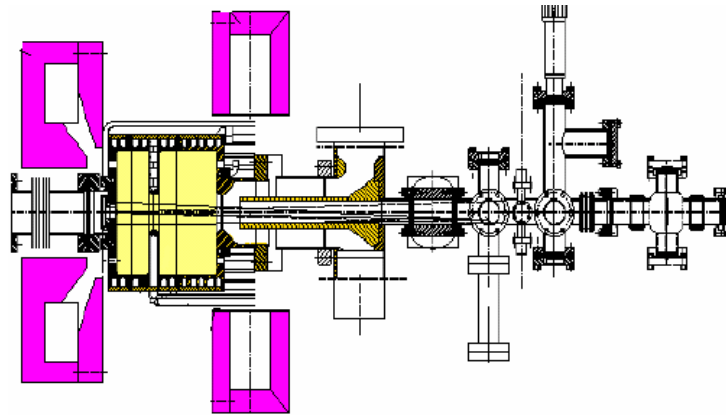
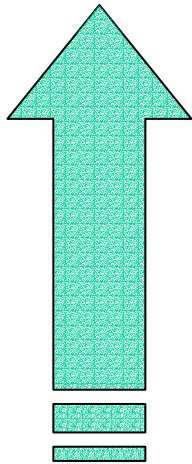
K. Floettmann
P. Castro

Beam Based Alignment Principles

Sweep RF gun and solenoid parameters



Electron beam position measurements

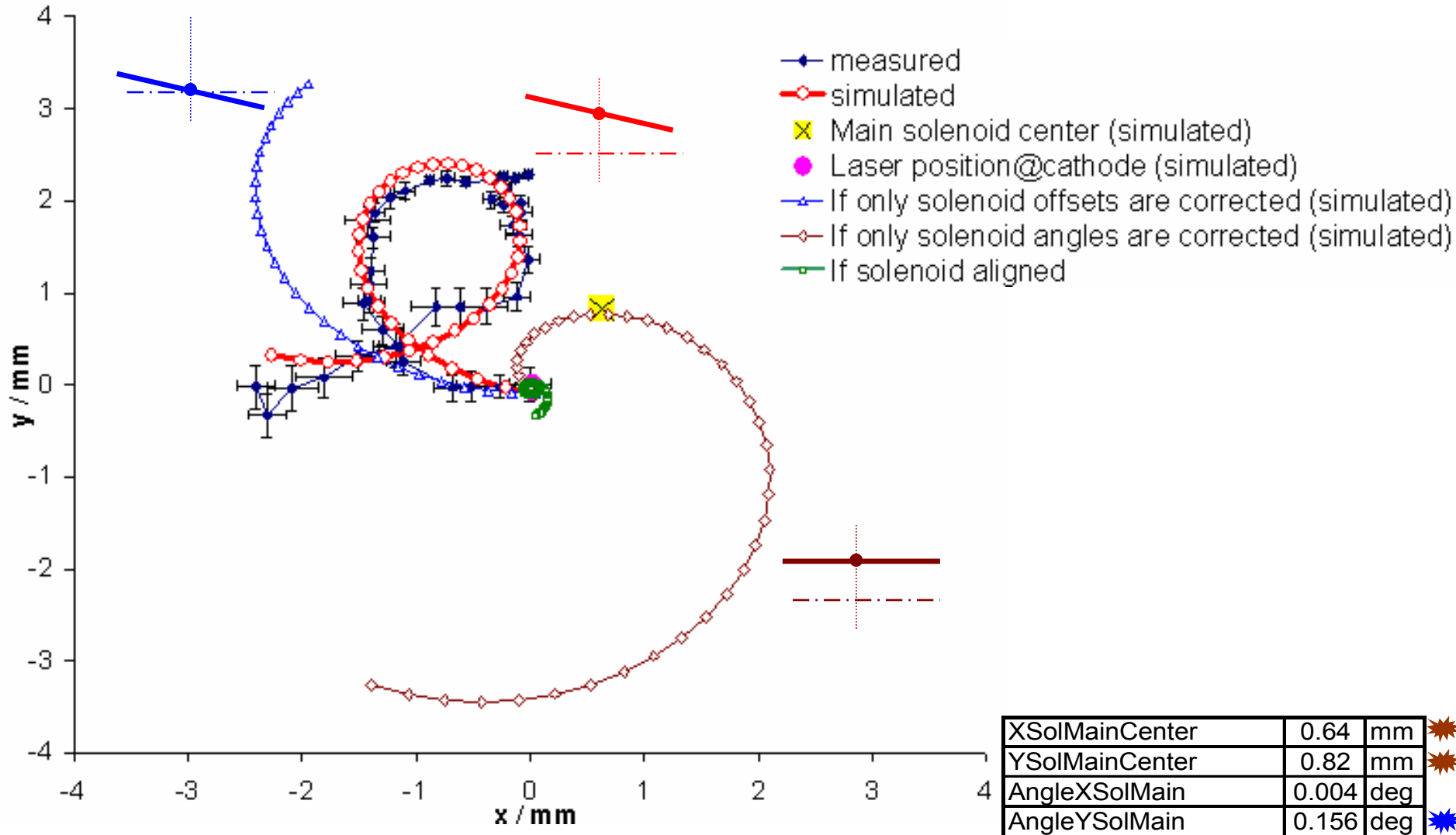


Correction of misalignment



Simulation of misalignment

Simulations of Solenoid Misalignments



XSolMainCenter	0.64	mm	✶
YSolMainCenter	0.82	mm	✶
AngleXSolMain	0.004	deg	✶
AngleYSolMain	0.156	deg	✶
Laser_Beam_CenterX	0.01	mm	
Laser_Beam_CenterY	-0.03	mm	

WG3 Agenda (cont.)

Measurements / Experiments:

- gun rf studies/regulation (water cooling)
- laser performance, pulse stacking
- cathode: darkcurrent and space charge studies
- beam based alignment laser / solenoids
- energy/energy spread at gun
- emittance in BC2
- bunch length in BC2
- diamond halo detector

J.-P. Carneiro
S. Schreiber
D. Sertore
M. Krasilnikov
D. Lipka
K. Honkavaara
O. Grimm
W. Lohmann

Schedule / Planning:

- overall injector commissioning program
- overall commissioning program

K. Floettmann
P. Castro

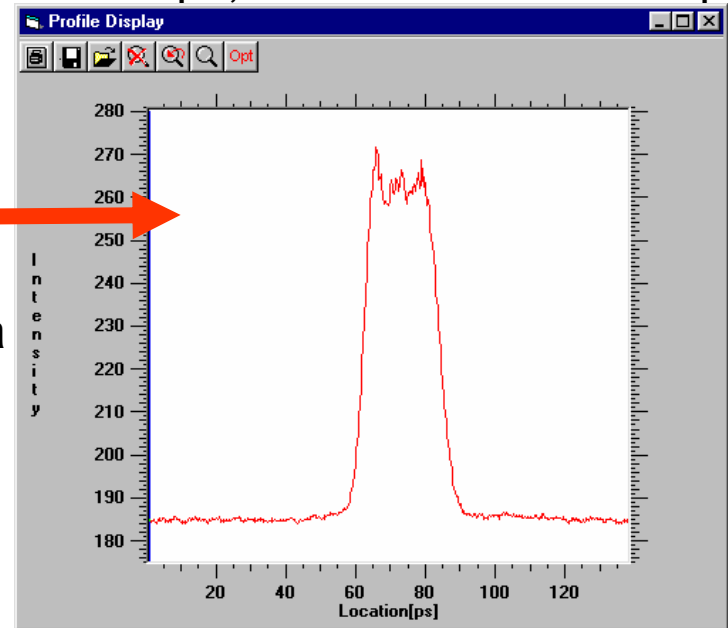
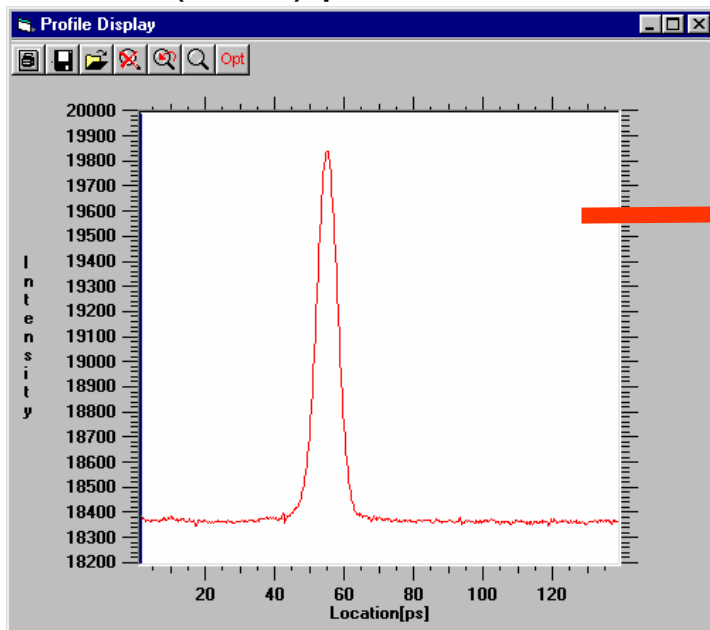
Longitudinal laser pulse property

An important component of the photo injector: photo cathode laser for the production of the electron bunch at the photo cathode

The longitudinal shape of laser beam is changed:

Gaussian shape
FWHM = (7 ± 1) ps

changed to **flat top**
FWHM ~ 24 ps, rise and fall time 5-7 ps



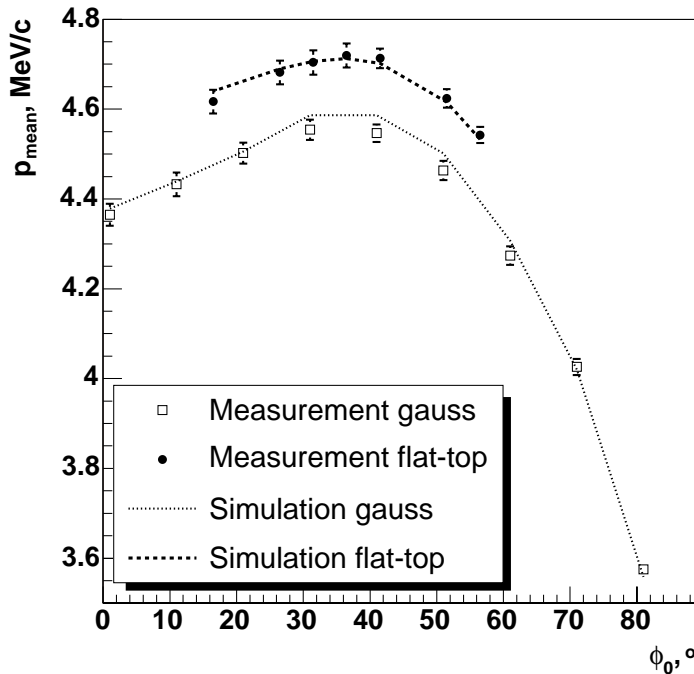
Measured
by using a
Streak-
camera

Inhomogeneous space charge

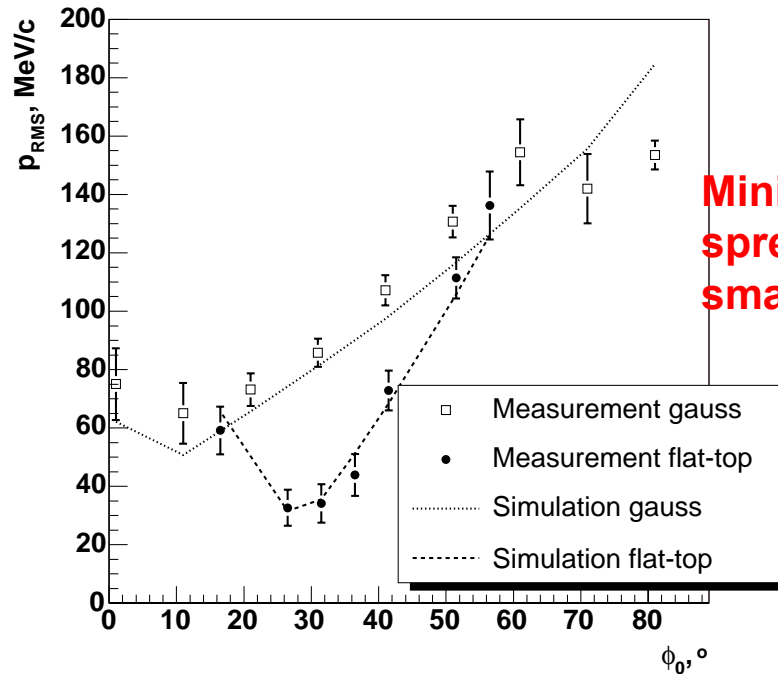
homogeneous space charge density

Momentum measurement: comparison

Mean momentum



Momentum spread



Minimum momentum spread with flat-top smaller by a factor 2

Maximum momentum at same phase

Phase with smallest momentum spread with flat top laser pulse nearer to phase with highest momentum

Field amplitude and maximum phase chosen such that simulation matches the measurement

WG3 Agenda (cont.)

Measurements / Experiments:

- gun rf studies/regulation (water cooling)
- laser performance, pulse stacking
- cathode: darkcurrent and space charge studies
- beam based alignment laser / solenoids
- energy/energy spread at gun
- **emittance in BC2**
- bunch length in BC2
- diamond halo detector

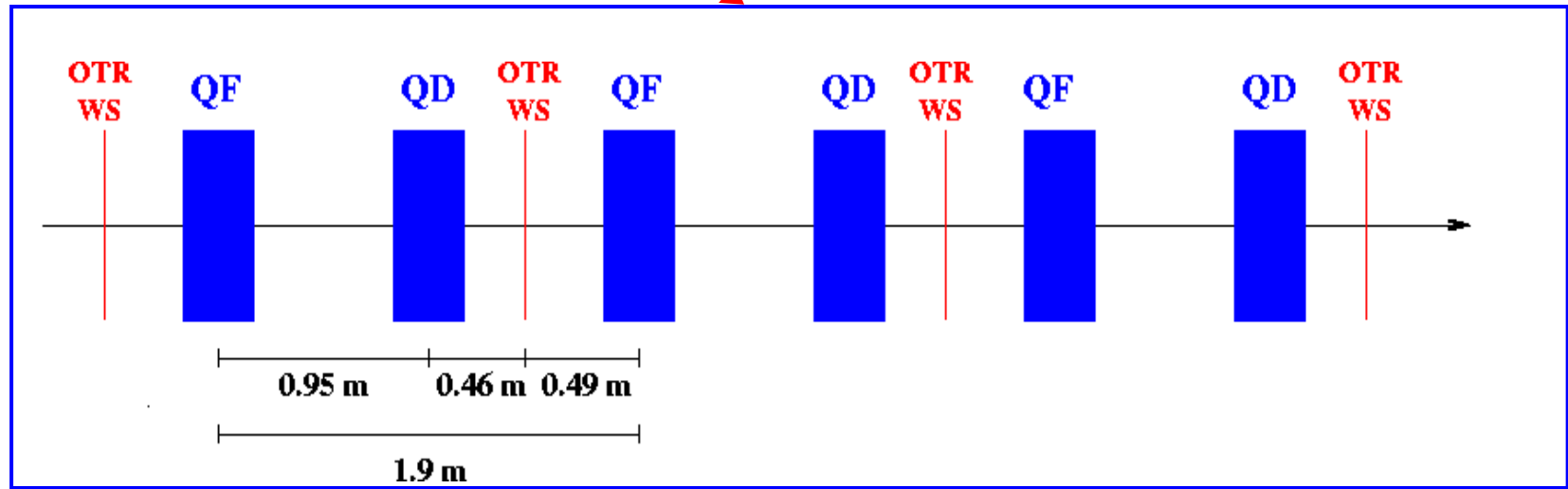
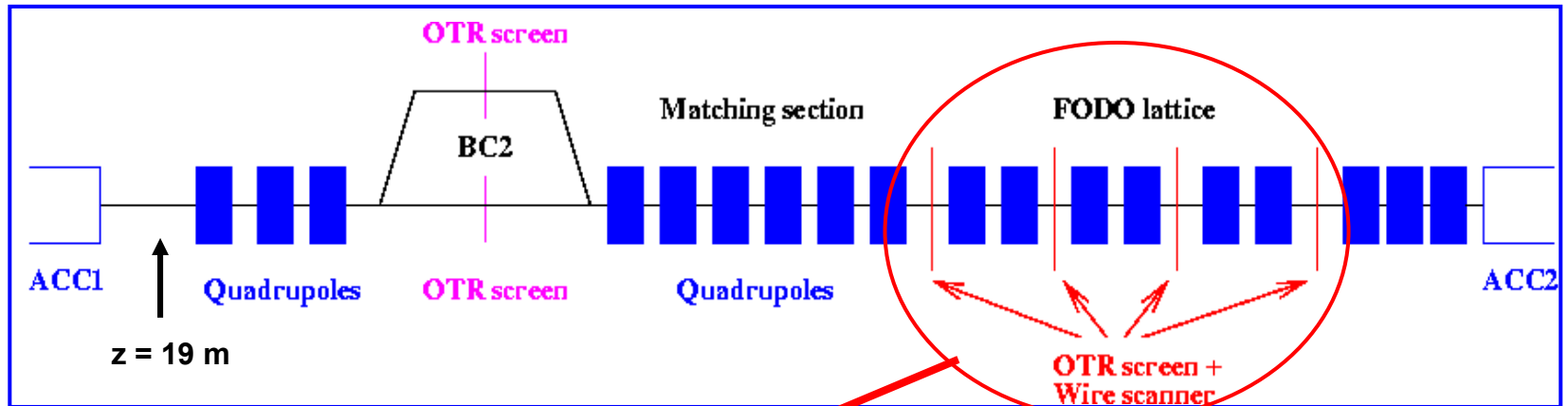
J.-P. Carneiro
S. Schreiber
D. Sertore
M. Krasilnikov
D. Lipka
K. Honkavaara
O. Grimm
W. Lohmann

Schedule / Planning:

- overall injector commissioning program
- overall commissioning program

K. Floettmann
P. Castro

Schematic of the BC2 section



WG3 Agenda (cont.)

Measurements / Experiments:

- gun rf studies/regulation (water cooling)
- laser performance, pulse stacking
- cathode: darkcurrent and space charge
- beam seeding
- emittance
- electron
- beam
- detector

J.-P. Carneiro

S. Schlegler

M. G. H. Cozzani

M. V. Ivanov

D. Lipka

K. Honkavaara

O. Grimm

W. Lohmann

Schedule / Planning:

- overall injector commissioning program
- overall commissioning program

K. Floettmann

P. Castro

Join the measurement...

WG3 Agenda (cont.)

Measurements / Experiments:

- gun rf studies/regulation (water cooling)
- laser performance, pulse stacking
- cathode: darkcurrent and space charge studies
- beam based alignment laser / solenoids
- energy/energy spread at gun
- emittance in BC2
- **bunch length in BC2**
- diamond halo detector

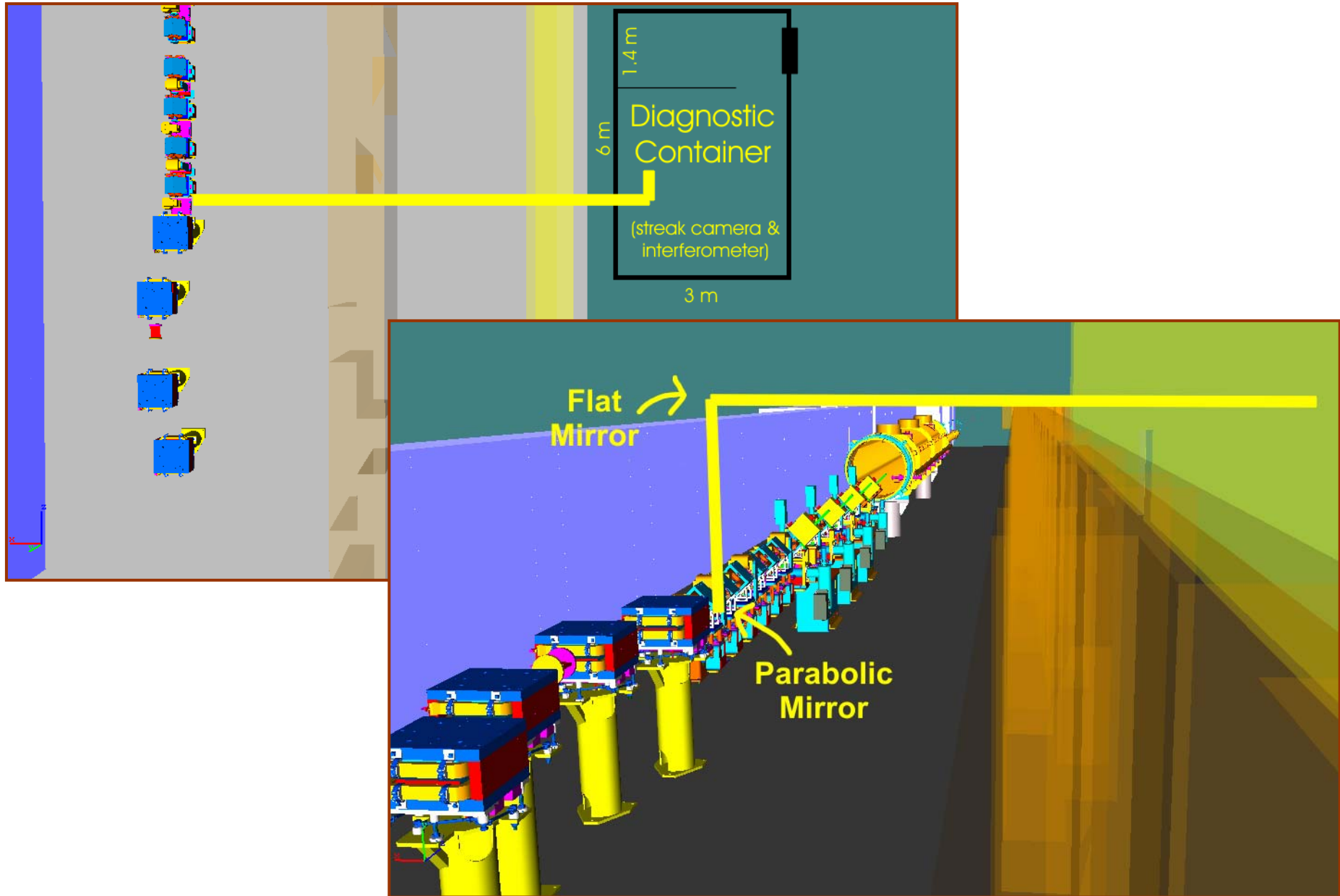
J.-P. Carneiro
S. Schreiber
D. Sertore
M. Krasilnikov
D. Lipka
K. Honkavaara
O. Grimm
W. Lohmann

Schedule / Planning:

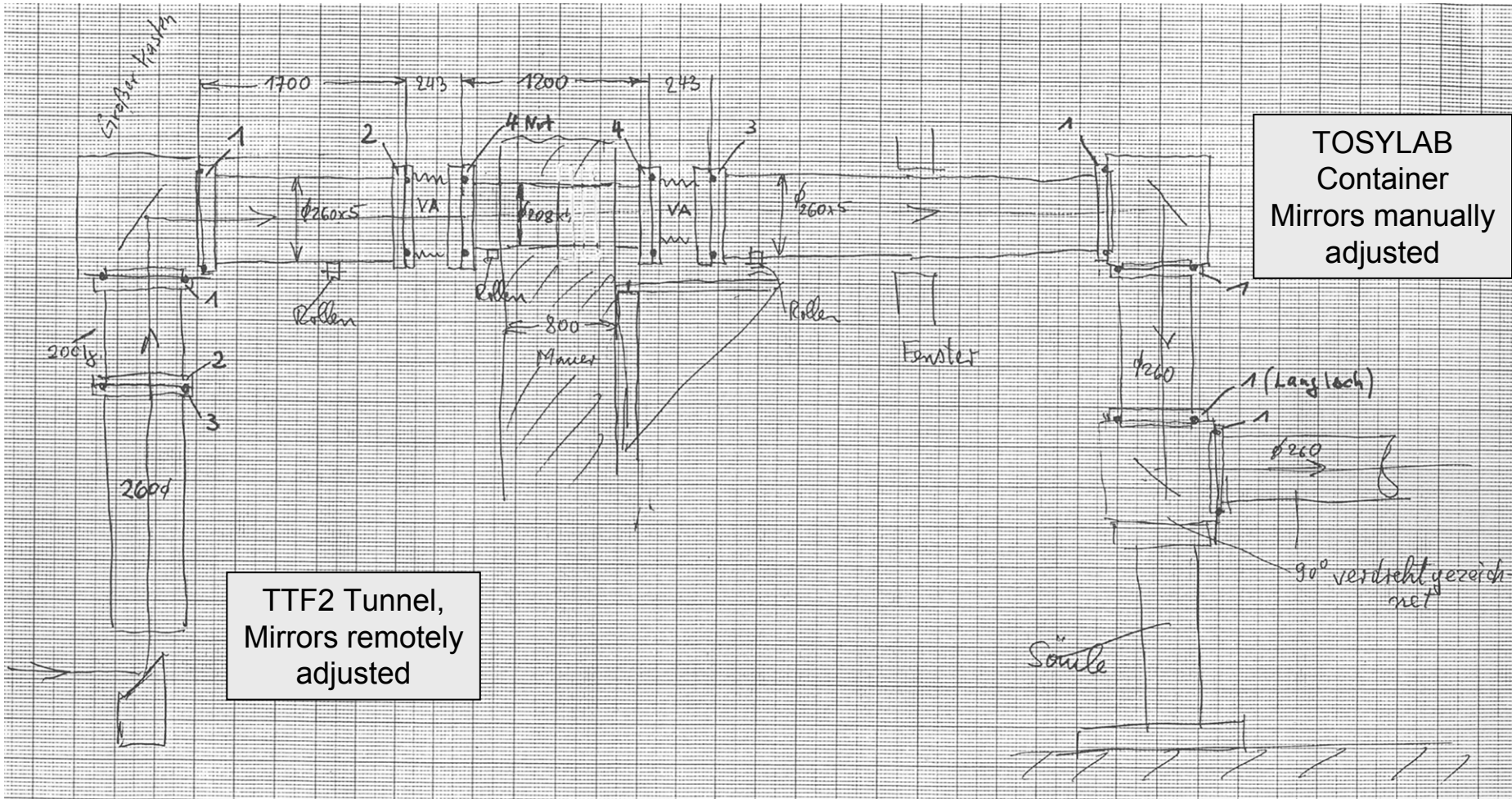
- overall injector commissioning program
- overall commissioning program

K. Floettmann
P. Castro

Layout of BC2 Infrared & Optical Beam Line



Design of Beam Line



Beam pipes $\text{Ø}260 \times 5$, over radiation protection wall $\text{Ø}208 \times 4$.
 Projected sizes: Parabolic mirror $\text{Ø}100$, first flat mirror $\text{Ø}177$,
 remaining mirrors $\text{Ø}108$.

Status of beam line construction

- Double I-beam carrier system ready
- Aluminium beam pipes in hand (Ø260 black anodized, Ø208 grey anodized, will be painted black)
- Mirror chamber parts, flanges etc. currently machined or already in hand (will be black anodized or painted as far as practical)
- Carrier system including large mirror chamber planned to be installed **first week of February** (or later if closing of tunnel roof is delayed)
- Remaining components **mid February**
- Small flat mirrors in hand
- Delivery of **parabolic** and **large flat mirror beginning of March (??)** (company tries to deliver earlier)
- Construction by **Otto Peters**, Manufacturing supervised by **Mathias Böttcher** (ZM31)

WG3 Agenda (cont.)

Measurements / Experiments:

- gun rf studies/regulation (water cooling)
- laser performance, pulse stacking
- cathode: darkcurrent and space charge studies
- beam based alignment laser / solenoids
- energy/energy spread at gun
- emittance in BC2
- bunch length in BC2
- **diamond halo detector**

J.-P. Carneiro
S. Schreiber
D. Sertore
M. Krasilnikov
D. Lipka
K. Honkavaara
O. Grimm
W. Lohmann

Schedule / Planning:

- overall injector commissioning program
- overall commissioning program

K. Floettmann
P. Castro

WG3 Agenda (cont.)

Measurements / Experiments:

- gun rf studies/regulation (water cooling)
- laser performance, pulse stacking
- cathode: darkcurrent and space charge studies
- beam based alignment laser / solenoids
- energy/energy spread at gun
- emittance in BC2
- bunch length in BC2
- diamond halo detector

J.-P. Carneiro
S. Schreiber
D. Sertore
M. Krasilnikov
D. Lipka
K. Honkavaara
O. Grimm
W. Lohmann

Schedule / Planning:

- overall injector commissioning program
- overall commissioning program

K. Floettmann
P. Castro

Injector Commissioning

Part 1 Gun area

A Operation without beam

B Operation with beam

Part 2 Module

Part 3 Bunch Compressor and Diagnostics Section

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 commissioning 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 Diagnostics 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.

WG3 Agenda (cont.)

Measurements / Experiments:

- gun rf studies/regulation (water cooling)
- laser performance, pulse stacking
- cathode: darkcurrent and space charge studies
- beam based alignment laser / solenoids
- energy/energy spread at gun
- emittance in BC2
- bunch length in BC2
- diamond halo detector

J.-P. Carneiro
S. Schreiber
D. Sertore
M. Krasilnikov
D. Lipka
K. Honkavaara
O. Grimm
W. Lohmann

Schedule / Planning:

- overall injector commissioning program
- overall commissioning program

K. Floettmann
P. Castro

COMMISSIONING

hardware +
sub-systems

- cryogenics + vacuum + klystrons + interlocks + ...
- RF cavities: gun + cold modules + LOLA
- collimators + wire scanners + cameras + ...
- laser ...

3 weeks

1st beam
(bypass)

- re-commissioning of gun + injector
- setup cavity phases ACC2-5 → beam energy
- commissioning of diagnostics

10 weeks

FEL 30 nm
1 bunch

- setup collimation
- emittance measurements and optics matching
- beam-based alignment in undulator section
- commiss. of photon diag. with spon. emission

8 weeks

Saturation
+ 6-100 nm

- commissioning of FEL diagnostics
- study of FEL beam, compression schemes, etc.
- establish reproducible settings, etc.