PITZ Shutdown 2007

J.Bähr

PITZ, DESY

Technisches Seminar 3.Juli 2007

Outline

- Outline

1. Introduction
2. Explanations: PITZ, XFEL, Emittance,…
3. PITZ more detailed
4. Shutdown: Why and what
5. Manpower and coordination
6. Outlook

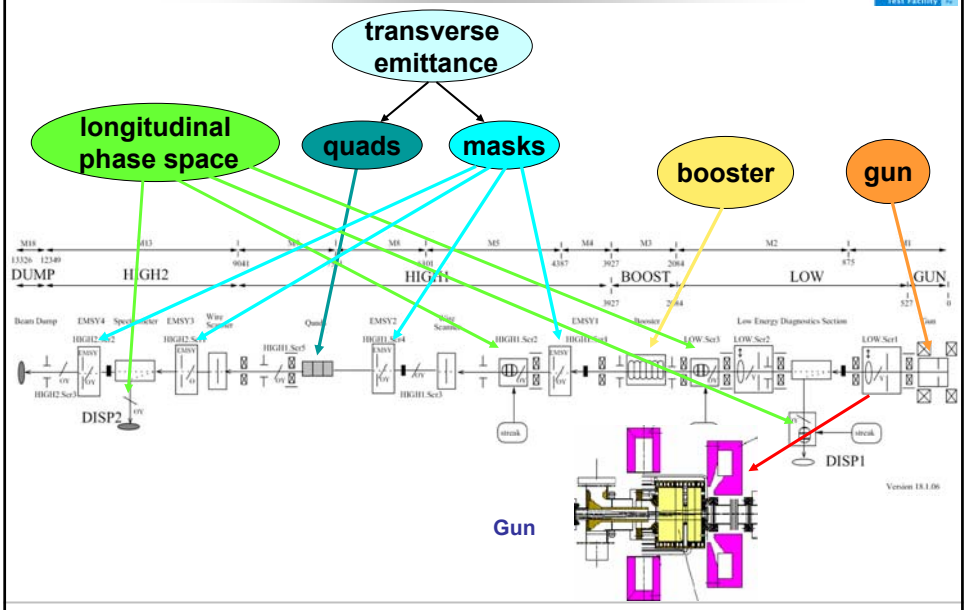
1.Introduction

- A long shutdown at PITZ is planned starting from 20/08/2007 until beginning of November
- Most modules of the vacuum beamline will be dismounted and re-mounted in a new scheme
- The Conditioning Test Stand (CTS) will be mounted in the tunnel bearing gun 4.1
- The rf system 1 will be re-organized for the use of a 10 MW klystron
- Many further tasks

2. Explanations: PITZ, XFEL, Emittance …

- What is that:
- PITZ,XFEL,FLASH,emittance, laser, SASE, space charge, electron gun…
- What is the connection between:
  - FEL and emittance
  - Emittance and space charge
  - A gun and a TV tube
  - PITZ and the XFEL,FLASH
  - …

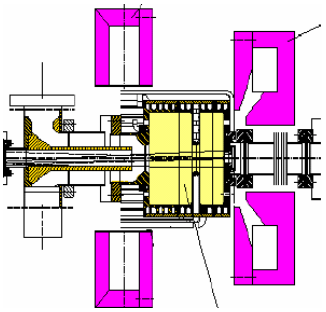
Setup PITZ1.6 completed !



PITZ

- PITZ:“ Photo injector Test Facility“
- Test and optimize electron sources for FELs: FLASH,XFEL
- X-FEL:
  European X-ray FEL project

- ➔ e-gun



„FEL-Microscope“

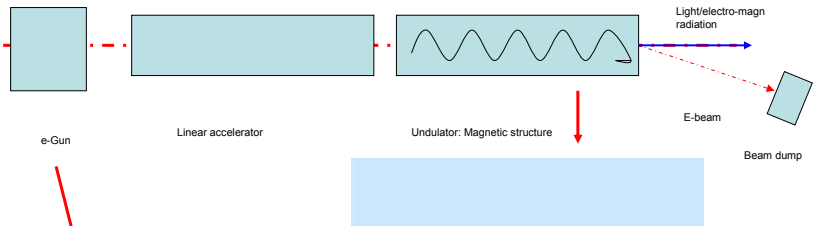
- FEL: „Free Electron Laser“: ➔ „Microscope“
- ➔ Motivation!!!
- Resolution R: about wavelength R~ λ for microscopes
- The higher the beam energy , the smaller
- better) the resolution R of the „microscope“
- c=vλ ,E=hv ➔E=hc/λ ➔ λ~1/E
- Resolution ~ λ~1/E

- Resolution of microscopes

Device	Energy Electron/ photon	Resolution	Object
Light micro-scope	1 eV (light)	1 µm	Biologic cell
Electron micro-scope	~70 keV	~O(10 nm) Magnifica-tion: 10**5	Big molecules
FLASH	500 MeV/ 200eV	~7nm	Molecules
XFEL	3 GeV	~1 Angstr.	Atoms

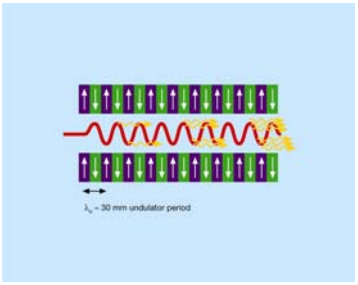
FEL

- FEL: Free electron laser :SASE principle

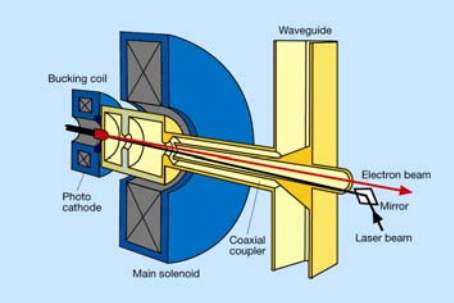


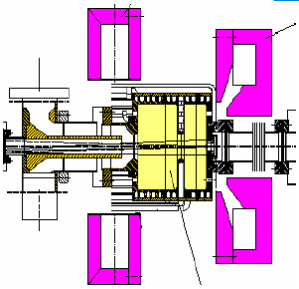
PITZ

SASE principle: „Self amplified radiation by stimulated emission“



The gun

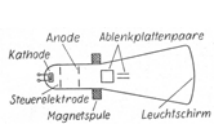
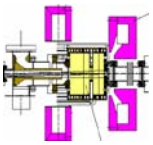




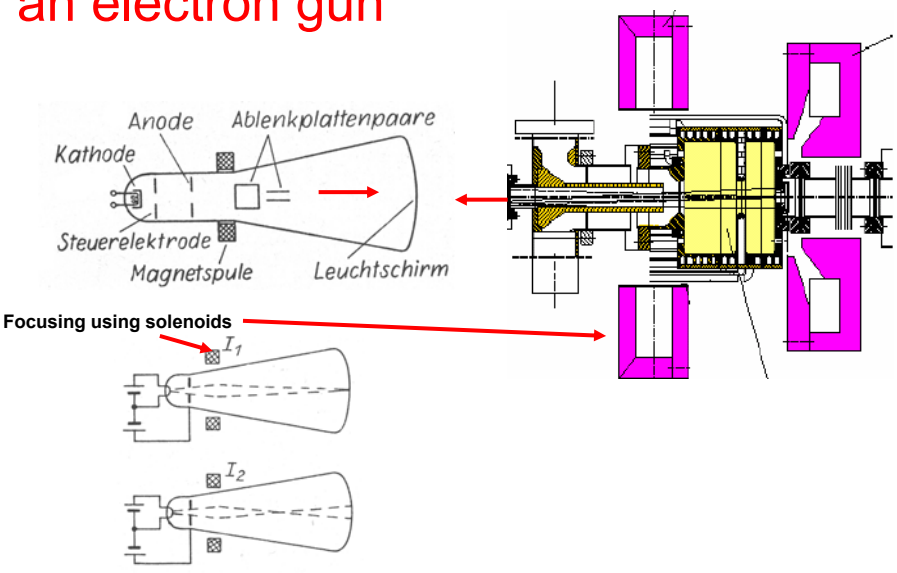
- The gun:
  - Laser input port
  - Cathode
  - rf coupler
  - Solenoid magnets
  - Resonator
  - Vacuum tubes

Comparison of an e-gun and a TV tube

Gun-TV

	TV	Gun
	Bild 	Bild 
Cathode	thermal	Photo effect
acceleration	Electro static	Rf
Voltage accel.	~4kV	~6 MV
Electron energy	~4 keV W=Q*U=1e*4kV	6 MeV
El. Field strength	E=U/d=4kV/0.2m=20kV/m	60MV/m
Deflection	Electro static	Dipole magnet (if wanted
visualisation	TV screen + eye	Flourescence screen + TV camera (no access)
radiation	X-rays	X-rays
Create image	deflection	Move laser spot

Comparison between TV tube and an electron gun

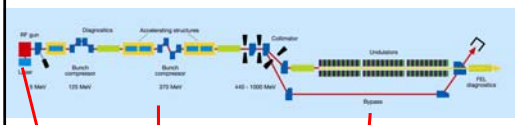


Mis-unerstanding

- If one does not consider the motivation and the context one could assume:
- PITZ is a not effective designed, rather huge built TV tube with enormous running parameters, where one has no access and the TV program is not interesting for typical citizens and difficult to regard and only remotely because there is no access possible. The screen size is much too low (about 2“).

FLASH

- FLASH: Free electron LASer in Hamburg
- (earlier TTF)



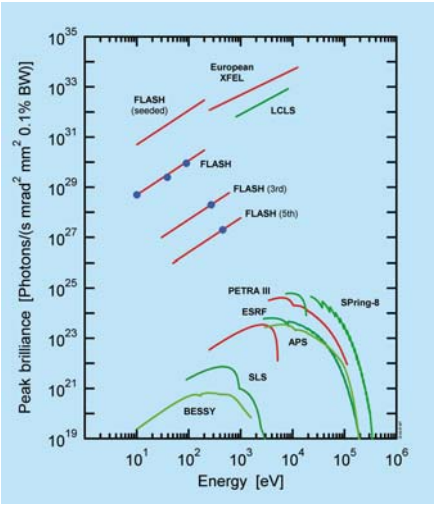
Gun

LINAC

Undulator

PITZ

Brilliance: Photons in solid angle and per area unit pro wavelength intervall

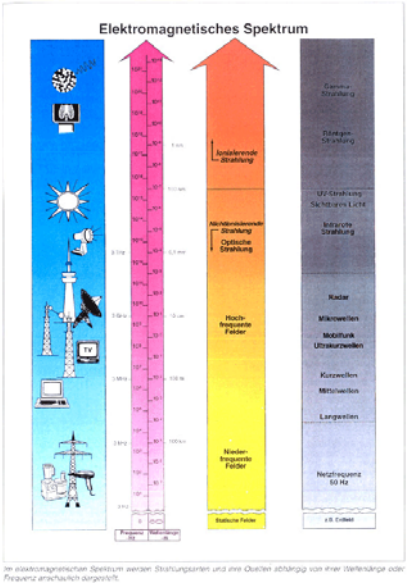


Laser

- LASER: „Light Emission by Stimulated Emission of Radiation“
- Characteristics of laser light:
  1. High energy density :“parallel“ ray of light instead of divergent bundle
  2. Coherence: phase relations between parts of the light ray: possibility of interference ➔ Holography
  3. Monochromatic light: only one wavelength (visible-invisible)

Resolution R~ λ~1/E

Electromagnetic spectrum

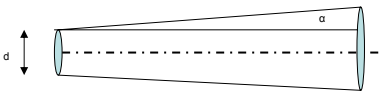


Resolution R~ λ~1/E

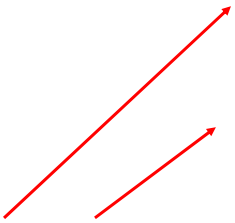
Emittance

- Emittance :
- ➔ Characteristic of electron beam
- For FEL small emittance necessary!!!
- Optimization of e-gun: Minimalization of transverse emittance
- - EMSY: Emittance measurement system
- Emittance cannot be improved after the source!!

- Emittance



- Divergent electron beam
- ε : diameter * angle
- ε = d * α in mm *mrad
- Example :
- Beam diameter : 1mm
- Divergence α =0.05 °= 1mrad
- ➔ ε = 1mm mrad

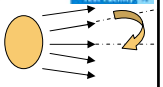


Emittance

1. What emittance has been measured by PITZ?
2. What are the goals?
3. World record?

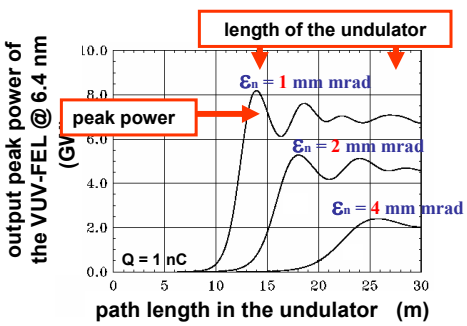
Why injector so important ?

What is emittance ? $\varepsilon_{x,y}$ ~ (e⁻ beam size) • (e⁻ beam angular divergence)

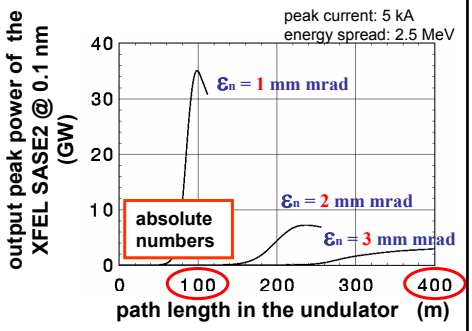


Why it must be small ?

VUV-FEL



XFEL



- **XFEL goal: 0.9 mm mrad@injector = 1.4 mm mrad@undulator**
- **smaller emittance ⇒ new horizons: shorter wavelength, higher repetition rate**

Emittance

- Emittance results:

Results fromPITZ1:
2005 (Gun1)

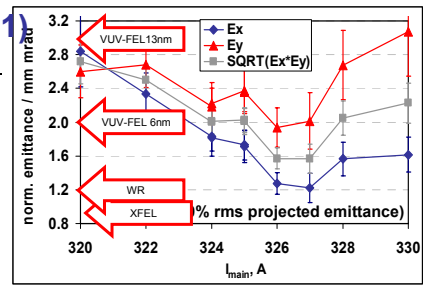
measured @ PITZ:

p = 5.2 MeV/c

Q = 1 nC

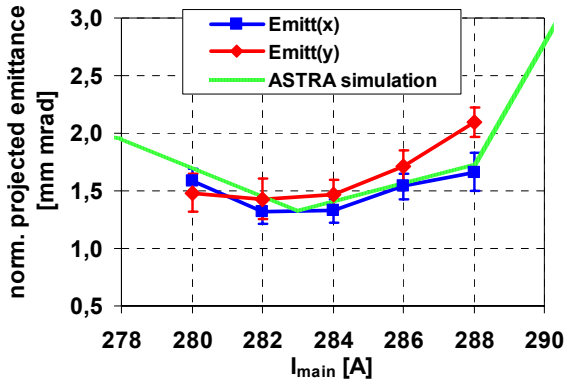
$\Phi = \Phi_m$

$I_{buck} = I_{main} * 0.075$

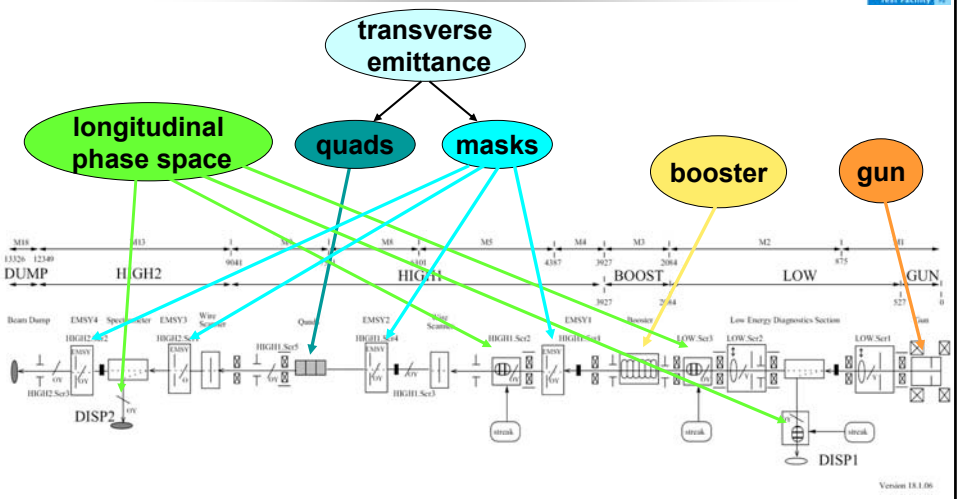


Emittance

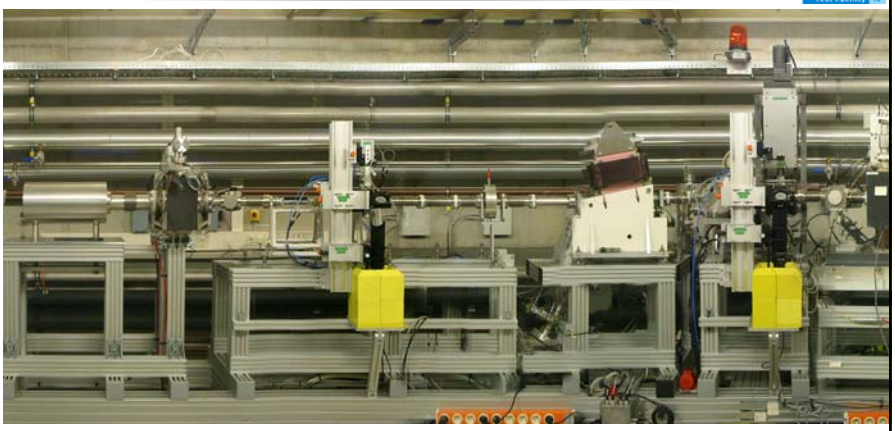
- Results 2006: Gun3.1

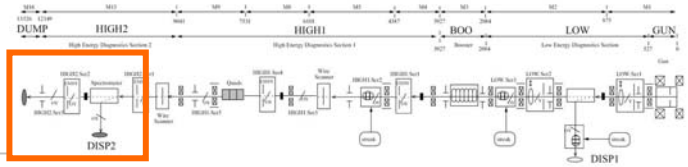


Setup PITZ1.6 completed !



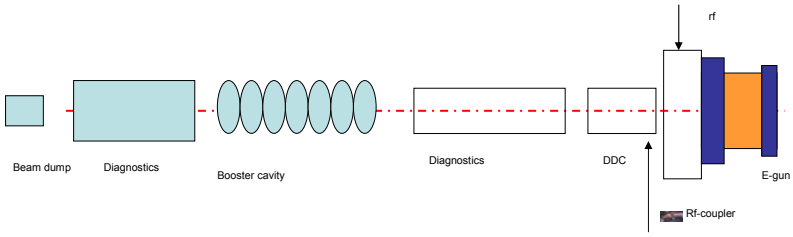
Present layout of PITZ





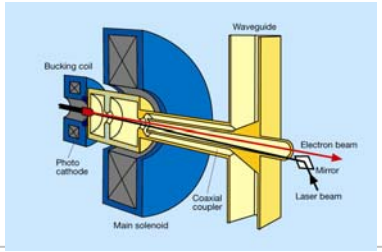
PITZ

- Simplified scheme



Laser beam

Not in scale!!



PITZ diagnostics

Measure	Device
Beam:Profile, diameter	Screen station (TV), wire scanner
Charge	Faraday cup, ICT (Integrating current transformer)
Beam energy	Spectrometer, dipole magnet
Bunch length	Streak camera
Emittance	EMSY

PITZ : Auxiliary system

- Auxiliary systems
- Vacuum
- Photocathode laser and laser beamline
- Cooling and climatization
- Rf system: 2 Klystrons 5-10 MW, modulators,…
- Electronics
- Controls

PITZ history

PITZ history

Year	Gun	Project stage	Remarks
1999			Decision directorate
2000			Construction
2001	Gun2	PITZ1	Commissioning
13/01/2002	Gun2	PITZ1	1st photoelectrons
2003	Gun2	PITZ1	Nov.:Gun2:➔ HH
2004	Gun1		Dec.: upgrad
2005	Gun1	PITZ1.5	Upgrade, booster, 10MW klystron
2006	Gun1	PITZ1.6	57MW/m
	Gun3.1		Conditioning, Characterization, Gun3.1➔HH
2007	Gun3.2	PITZ1.6	Cond.,Charact.
2007		PITZ1.7	

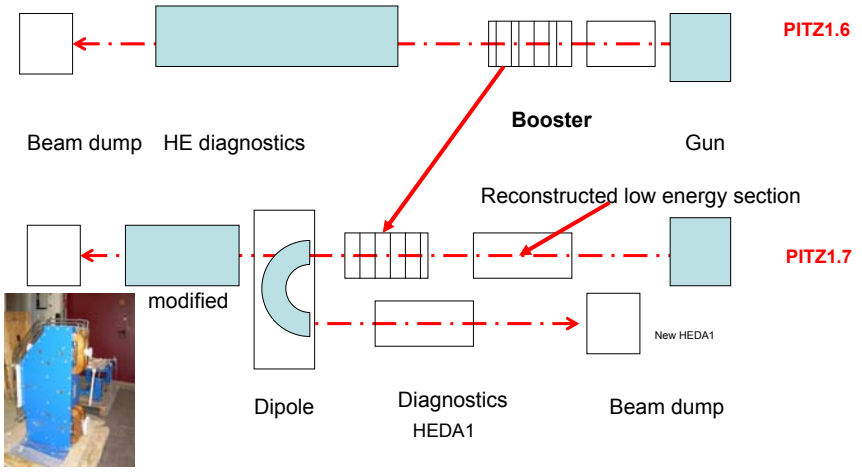
PITZ : The shutdown

- Why?
- Insert HEDA1: High energy dispersive arm
- Move booster downstream (higher gun gradient)
- Space for new CDS booster (2008)
- Minor change of sequence of diagnostics elements
- Prepare for PITZ 2 beamline ➔ 2008
- Reconstruction of low energy section (New DDC,..)

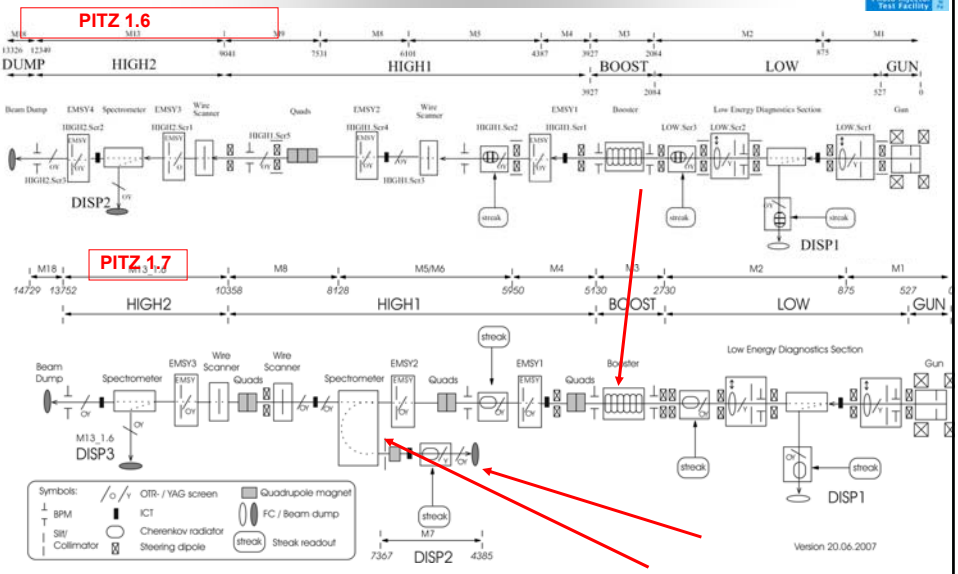
- Further tasks
- Extension of laser hutch
- New laser
- New klystron 10MW for rf1
- New technical interlock
- Many small tasks
  - TV system
  - Exchange YAG screen
  - EMSYs…
  - …
- PITZ1.6 ➔PITZ1.7

PITZ : The shutdown

- Major changes in beam line



PITZ 1.6, PITZ 1.7



PITZ : The shutdown

- Vacuum work:
  - Dismount modules
  - CTS: Conditioning test stand: Gun 4.1
  - Mount modules
  - Mount HEDA1
  - Reconstruction Low energy section:
    - DDC
    - Dipole…
  - ……
  - Parallel work of two teams

New dipole HEDA1 – 180 grad

PITZ : The shutdown

- RF group:
- Reconstruction rf system1
- Exchange klystron 5MW➔10MW
- Waveguides to CTS
- Investigation of T-combiner
- ……
- Electronics:
- New technical interlock
- Connect all new/moved components, tests
- …….

PITZ : The shutdown

- Controls
- Control and data aquisition of elements of reconstructed beam line and CTS
- Control for new laser
- Control of rf1
- …..

PITZ : The shutdown

- Technical infrastructure
- Second crane in tunnel
- Reconstruction laser hutch
- New climatisation and cooling for laser and laser hutch
- Extension of cooling in tunnel new elements and CTS
- Upgrade of cooling systems
- ……
- Partially done by external firms

PITZ : The shutdown

- Laser hutch and laser
- Extension of Laser: longitudinal profile: flat top with rise and fall time of 1-2ps(10**-12)
- Dismount laser
- Extension of laser hutch
- Climatisation, cooling , network, electric power
- Cleaning
- Mount new laser table
- Mount new laser
- Commissioning of laser: Beginning of November

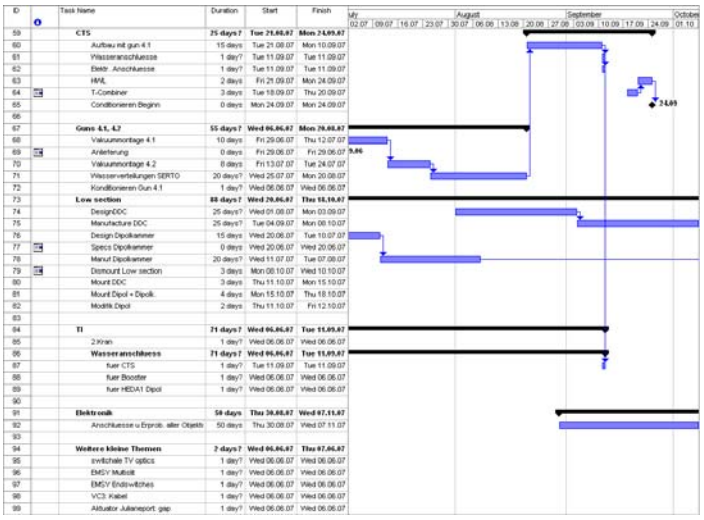
PITZ : The shutdown

- To do: Preparation and during shutdown
- Sequence of work
- Coordination between technical groups
- Delivery of components

- End of shutdown
- Start running with new laser in test mode: Beginning of November

PITZ : The shutdown

- Flow chart



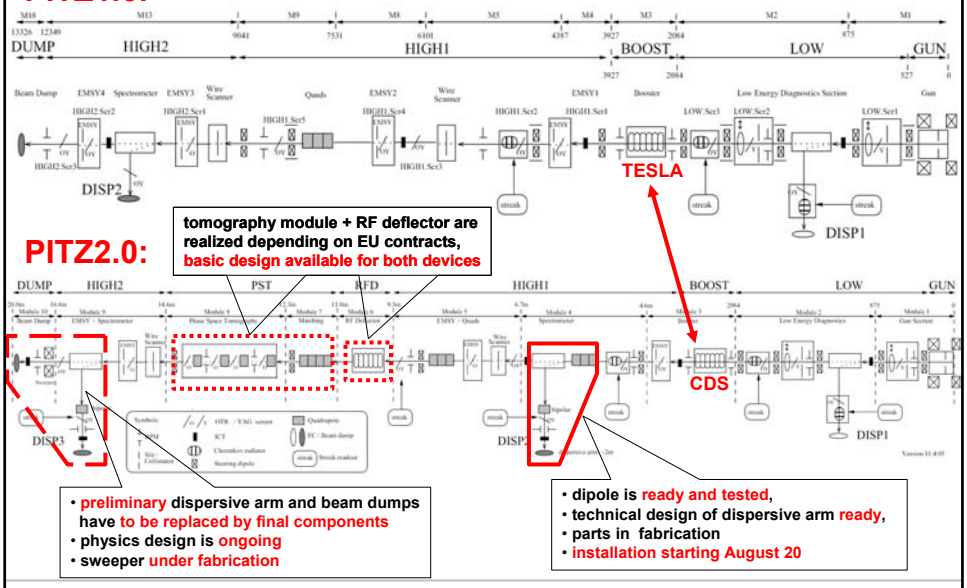
PITZ : Outlook

- Outlook

- PITZ1.7 ➔ PITZ 2 : 2008
- HEDA2 :July 2008
- Tomography module (March 2008)
- Magnets
- Rf deflector as option
- CDS Booster (Jan. 2008)
- Beam dump : 2m³ concreteJuly 2008

Comparison: PITZ1.6 ↔ PITZ2.0

PITZ1.6:



PITZ2.0:

tomography module + RF deflector are realized depending on EU contracts, basic design available for both devices

- preliminary dispersive arm and beam dumps have to be replaced by final components
- physics design is ongoing
- sweeper under fabrication

- dipole is ready and tested,
- technical design of dispersive arm ready,
- parts in fabrication
- installation starting August 20

Acknowledgement

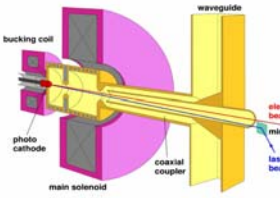
- Thanks to F.Stephan, S. Rimjaem and S. Khodyachykh for providing transparencies and photos
- Thanks to S.Niedworok and Chr. Iezzi for the poster

PITZ shutdown 2007

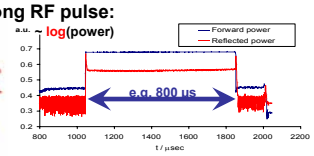
• The end

Particularities, Results from PITZ1

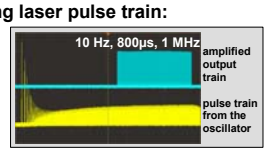
• PITZ source must drive super conducting linac → **long pulse trains, i.e. high average power, good stability**



long RF pulse:



long laser pulse train:



• XFEL goes to very short wavelength → **very good emittance required**

Results from PITZ1:

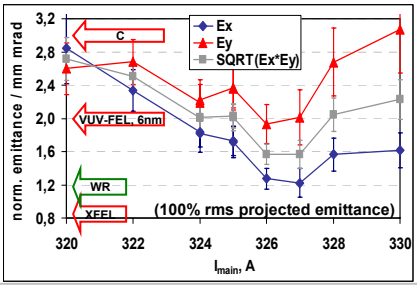
measured @ PITZ:

p = 5.2 MeV/c

Q = 1 nC

$\Phi = \Phi_m$

$I_{buck} = I_{main} * 0.075$



→ **PITZ gun installed at VUV-FEL in 2004**

measured @ VUV-FEL:

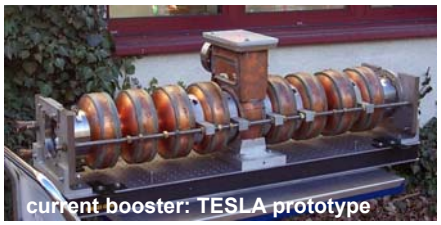
p = 127 MeV/c

Q = 1 nC

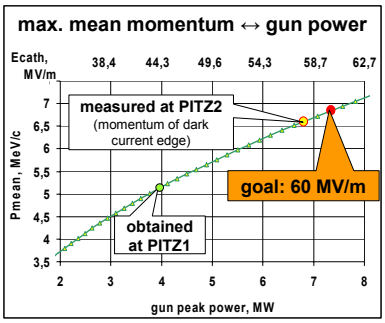
• regularly obtain **2.1 mm mrad** (100% rms projected emittance)

• minimum **1.1 mm mrad** (90% rms projected emittance)

First Results from PITZ2



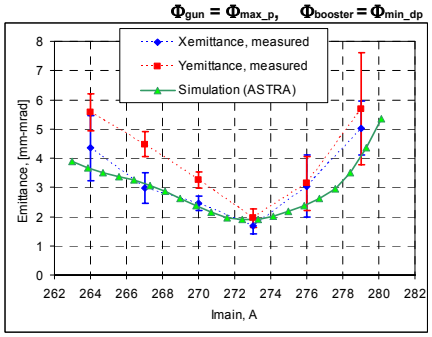
in operation: gun + booster → 13.7 MeV/c



first preliminary emittance results (not optimized yet !)

p = 12.8 MeV/c, Q = 1 nC,

$\Phi_{gun} = \Phi_{max\_p}$, $\Phi_{booster} = \Phi_{min\_dp}$



Status:
- new gun cavity (#3) installed and under conditioning now
- upgrade of beamline ongoing