

# Introduction

- The X-ray free-electron laser (XFEL) planned at DESY in cooperation with European partners needs ~ 30..40 Radio Frequency (RF) Stations for generating high power RF bunches with klystrons
- Part of the XFEL RF Stations will be the Modulator which produces High Voltage pulses for the klystron
- Modulator will be an integral part of the whole RF Station (LLRF, klystron, pulse transformer, control, Interlock) and has to fulfill a lot of requirements

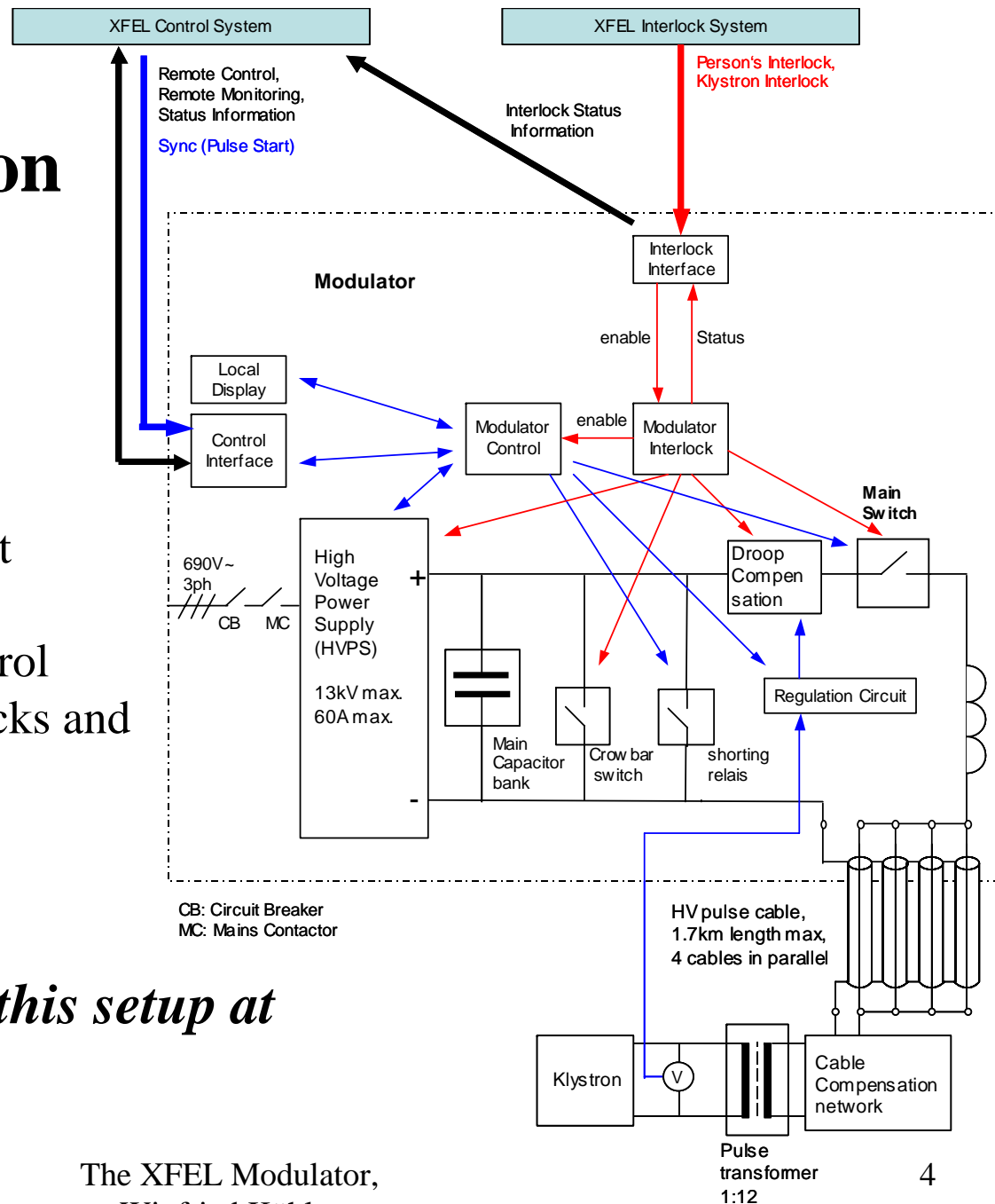
# Main Requirements

- Connected to klystron via pulse cable, cable compensation network and pulse transformer (ratio 1:12)
  - HV at pulse transformer output: 130kV max., ~16 MW peak power
  - HV at modulator output: ~12kV max.
  - Modulator mean output power: 280kW max (250kW +10%)
  - Pulse length: 1.57msec max.
  - Pulse repetition rate: 30Hz max. (limitations are klystron mean power, pulse length and pulse voltage)
  - Pulse flatness, pulse to pulse stability, high availability, modular design (fast repair) , interlock connections, materials..
- *There are a lot of other requirements which are not listed here.*

# Preferred Solution

## Main Components:

- HV power supply
- Main Capacitor Bank
- Main Switch
- Droop compensation circuit
- Crowbar Switches
- Internal Interlock and Control
- Connections to ext. Interlocks and Remote Control



→ *Experiences with this setup at FLASH and PITZ.*

# Bouncer Type Modulator

- well known modulator technology
- Modulators produced by Fermilab and industrial vendors (PPT, F.U.G., ABB) used at TTF / Flash
- Improvement/Adaptions needed for XFEL:
  - Reliability / MTTR
  - Interlock and Control
  - external Connections
    - Power
    - Water
    - Pulse Cable
  - EMI/Noise



Image: Bouncer Type Modulator used at TTF / Flash

# Schedule

- Specification: done.
- Ordering Prototypes: done.
- Preparing test facility: started.
- Prototype Tests and detailed study to be finished in 2008/2009
- Request for quotations expected for 2008/2009
- Factory Acceptance Tests and Side Acceptance Tests
- Main delivery of 30..40 Modulators 2009-2011
- Latest parts delivered in 2012

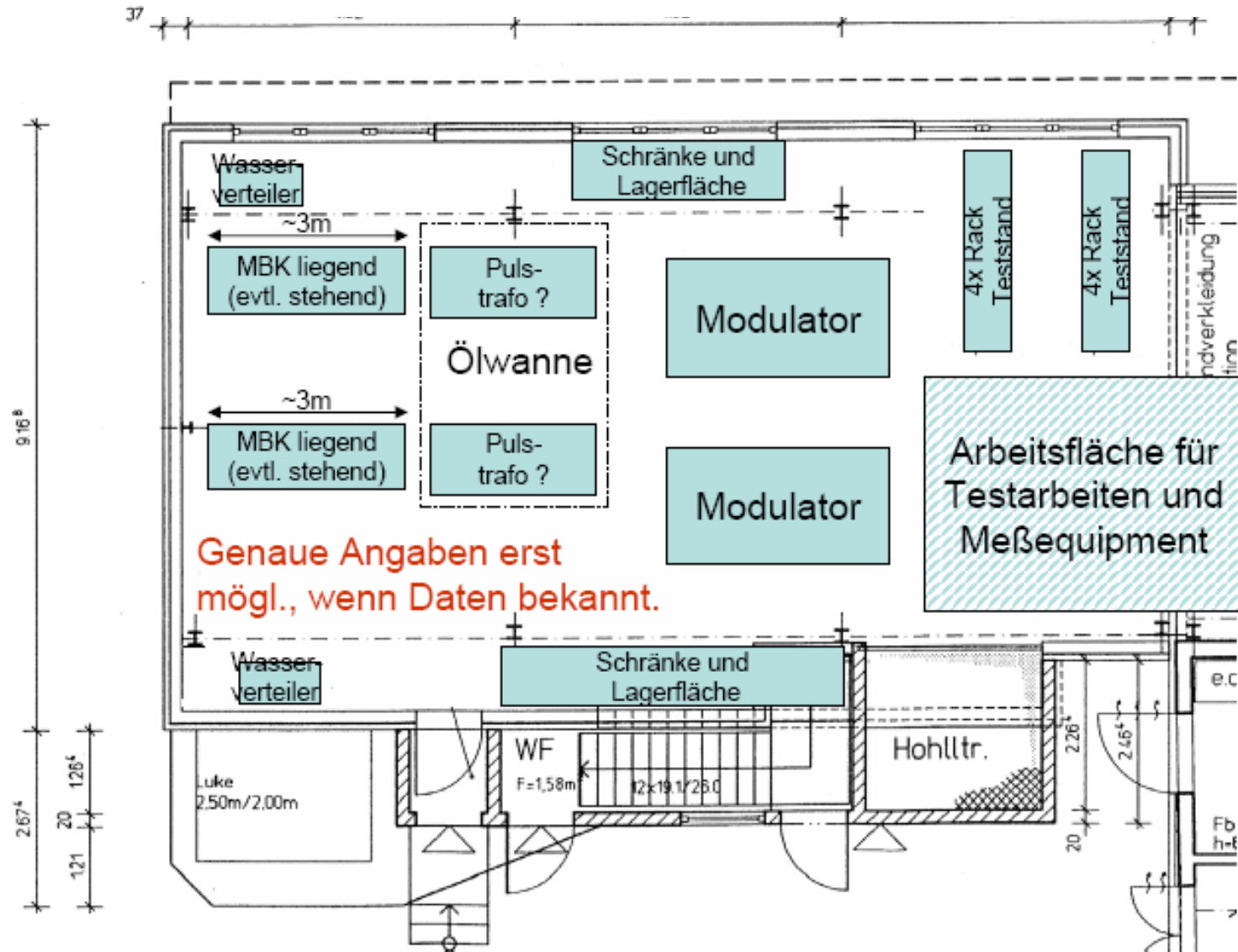
***→ Start commissioning of RF stations planned as soon as modulators and other parts arrive.***

# Modulator Test Facility

- XFEL Modulator – complex system
- perform measurements → test facility needed
- investigate open technical details
- long term testing
- integrating the modulator control into the DOOCS environment
- final goal: improve (optimize) the final design of the XFEL modulator

**→ *Will be tested in a special Modulator Test Facility at DESY***

# Modulator Test Facility (cont.)





# Modulator Test Facility



2007-01-19

The XFEL Modulator,  
Winfried Köhler

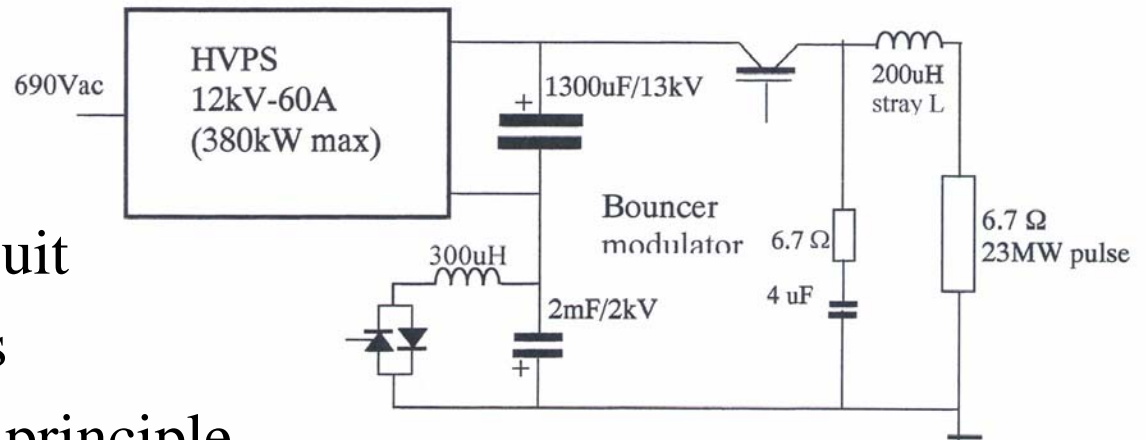
9

# Prototypes

- Two different prototypes from two vendors
  - Imtech-Vonk
  - Thomson
- Delivery time 12..14 month, starting from Dec. 2006
- Will be tested in complete RF stations
  - Modulator
  - Cable
  - Pulse Transformer
  - Klystron
  - Interlock & Remote Control
  - Ext. Connections

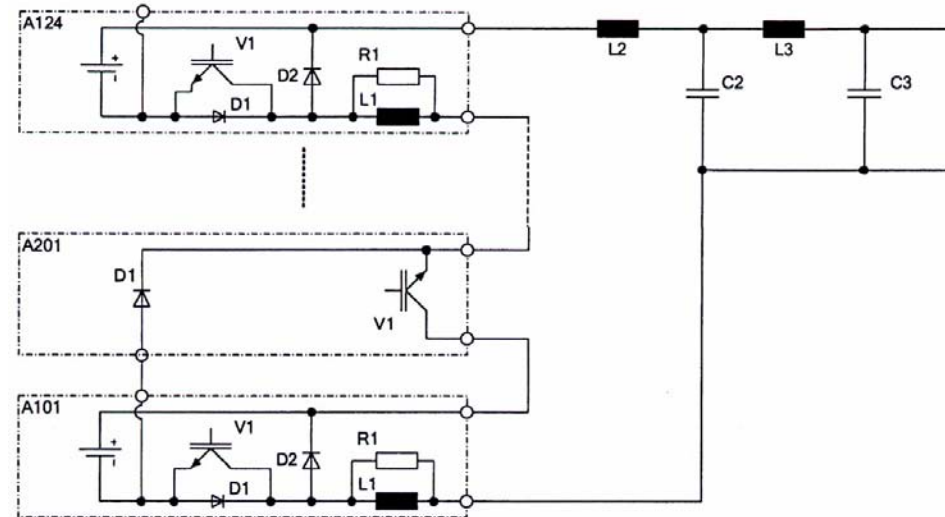
# Prototype #1 (Imtech-Vonk)

- Bouncer Type, as specified by DESY
  - 12kV HVPS
  - Bouncer 300uH/4.6kA
- 7st IGCT main switch
- Digital Regulation Circuit
- Analog In- and Outputs
- Well known and tested principle
- delivery time: 12 month



## Prototype #2 (Thomson)

- Different Type:
  - 12kV/2kA w. transformer
  - Pulse Width Modulation
  - 24 switching stages in series
  - FPGA based control
  - 2 stages for redundancy
- Slew rate and pulse shape controllable
- detailed description available, principle already successfully tested (worldwide, i.e. W7/X)
- delivery time: 14 month



# Summary

- Time Schedule shown
- Specification Modulator: done
- Ordering Prototypes: done
- Preparations Modulator Test Facility:
  - as planned in Schedule
  - New Klystron hall was build
  - Infrastructure (Water, Power, Cooling) so for ready
  - Electronics installation already started
  - Preparations finished End 2007/Beginning 2008
- A lot of work in the next months

*Thank you for attention.*