

# ACCEL cost study of XFEL coupler production

Michael Pekeler  
RI Research Instruments GmbH  
Friedrich-Ebert-Str. 1  
51429 Bergisch Gladbach  
Germany

# Basis of the XFEL industrialization and cost study

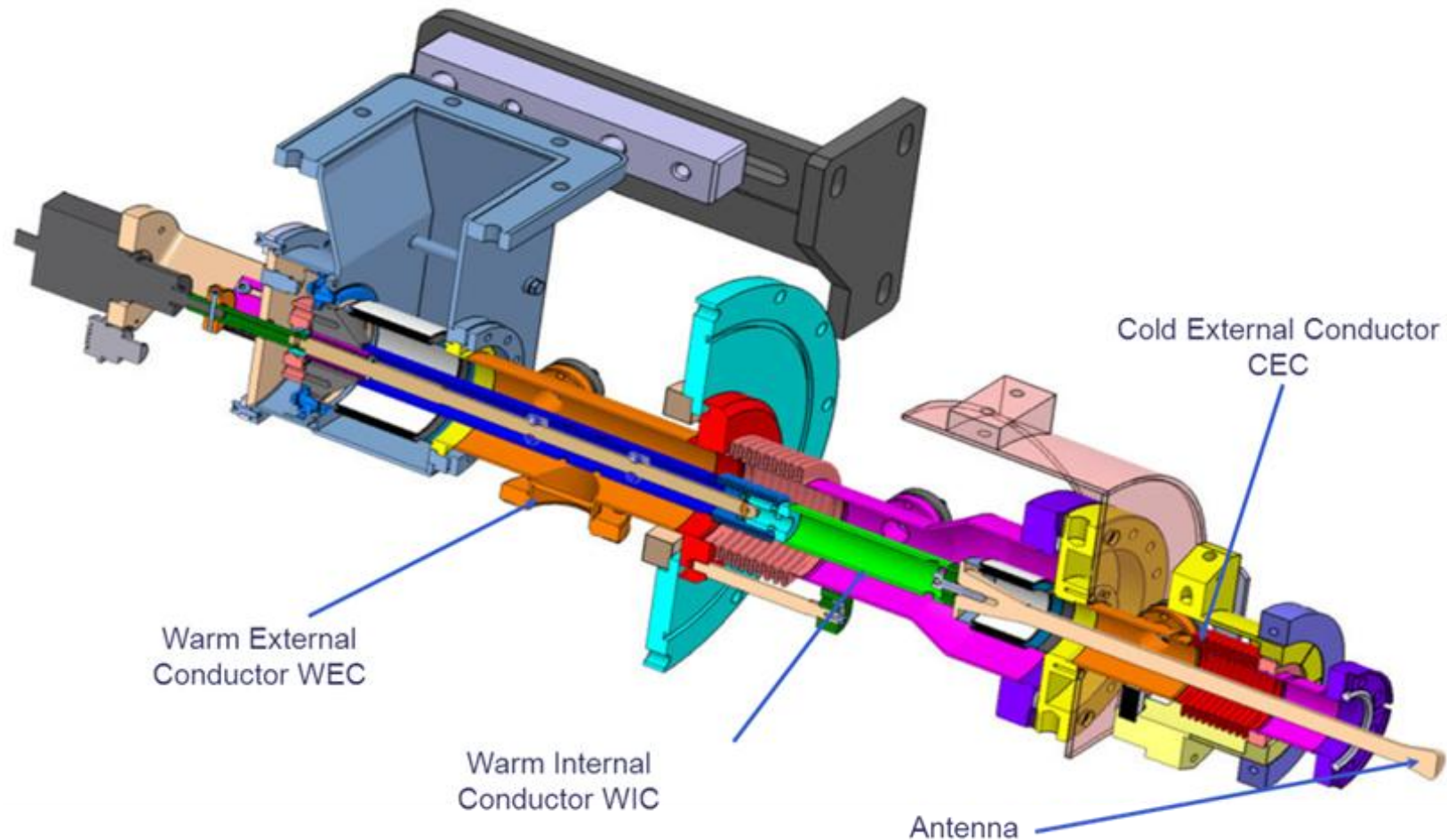
The industrialization study was contracted by LAL and carried out between 2006 and 2008 at ACCEL (now RI). It included:

- Review of the TTF3 design/drawings
- Proposal for design improvements in view of simplicity, cost saving and series production
- Understanding of all production steps like brazing, EB welding, copper plating, TiN coating, TIG welding
- Production of 2 prototype couplers reflecting the proposed improvements
- Cost study for the XFEL coupler production

In the study the cost for production of 840 or 420 couplers within a 3.5 years production (1.5 year ramp up, 2 years series production) was analyzed.

**For this talk we will only report on the 840 couplers production. Compared to that the difference for 420 couplers was a price increase of 11% per coupler.**

# Scope of the study



- Mechanical manufacturing
- Cleaning and assembly for RF test, including erection of necessary infrastructure
- Transport to LAL
- Processing at LAL using LAL infrastructure

# Processes involved and analyzed during the study

Process	Cost (1-6)	Risk (1-6)
Copper coating	4	3
TiN-coating	4	2
Mechanical processing	4	1
EB-welding	4	3
Ceramic manufacturing	4	4
Truing	4	2
Cleanroom assembly	4	2
Conditioning	4	2
Dimension control	3	1
Leak check	3	1
TIG welding	3	3
Brazing (Cu-Ceramic)	2	2
Brazing (Cu-Stainless)	1	1
Soldering	1	1
Degreasing/Cleaning	1	1
Heat treatment	1	1
Electrical control	1	1

# Basis of the cost evaluation

## **Raw material for stainless steel and copper:**

The prices are based on 2008 market price and semi finished products used for former TTF 3 production

## **Ceramics:**

The prices were based on an offer from WESGO

## **Bellows:**

The prices were based on an offer from Skodock

## **Motor and electrical components:**

Prices were based on offers from possible vendors

## **Machining of stainless steel and copper:**

Scaled from earlier production and scaled to higher numbers

## **TIG welding:**

The required welding machine and operators to carry out the TIG welding in 2 years were analyzed

## **Copper plating:**

Based on an information from Leybold

## Basis of the cost evaluation (2)

### **Brazing:**

Vacuum brazing was analyzed on load capacity and useful lot sizes

### **EB welding**

The time needed per electron weld was determined from the previous experience assuming good welding tools

### **TiN coating:**

The time needed for the TiN coating of all ceramics was determined from the experience gained during TTF3 production

### **Waveguide parts:**

Prices are based on subcontractor offers

### **Capacitor:**

Prices were based on subcontractors offers and in house production times on the prototype couplers

### **Assembly parts**

Prices were based on subcontractor offers

# Manpower and facilities

Operation	Manpower		facilities
	430 coupler	860 coupler	
Turning of copper	One operator (one shift)	Two operators (two shift)	One dedicated CNC turning machine
Brazing	15% furnace operator	25 % furnace operator	Existing vacuum furnace
TIG welding	50% welder	One welder	New welding automatic welding machine
EB welding	One operator, one metal worker, both 50%	One operator, one metal worker	Existing welding machine
TiN coating	One operator, 50%	One operator	Existing TiN coating apparatus
Leak check	One operator 50%	One operator	New clean and dry leak checker
Soft brazing	One technician 50%	One technician	Seperated work place

## Manpower and facilities (2)

Operation	Manpower		facilities
	430 coupler	860 coupler	
Winding of capacitor, electrical check	One technician 25%	One technician 50%	Seperate work place, seperate test room
Degreasing, cleaning single parts	Degreasing department, no significatn extra load	Degreasing department, no significant extra load	Degreasing department
Assembly and baking, packing	4 technicians, all trained for clean room, one of them leak checker	7 technicians, 4 trained for clean room, two of them leak checker	Upgraded clean room in building 21 platform in buliding 21 or building 19c for the baking
Conditioning	One RF engineer	One RF engineer, one RF technician	Working at LAL
Total	10	18	

All other parts and services were assumed to be subcontracted

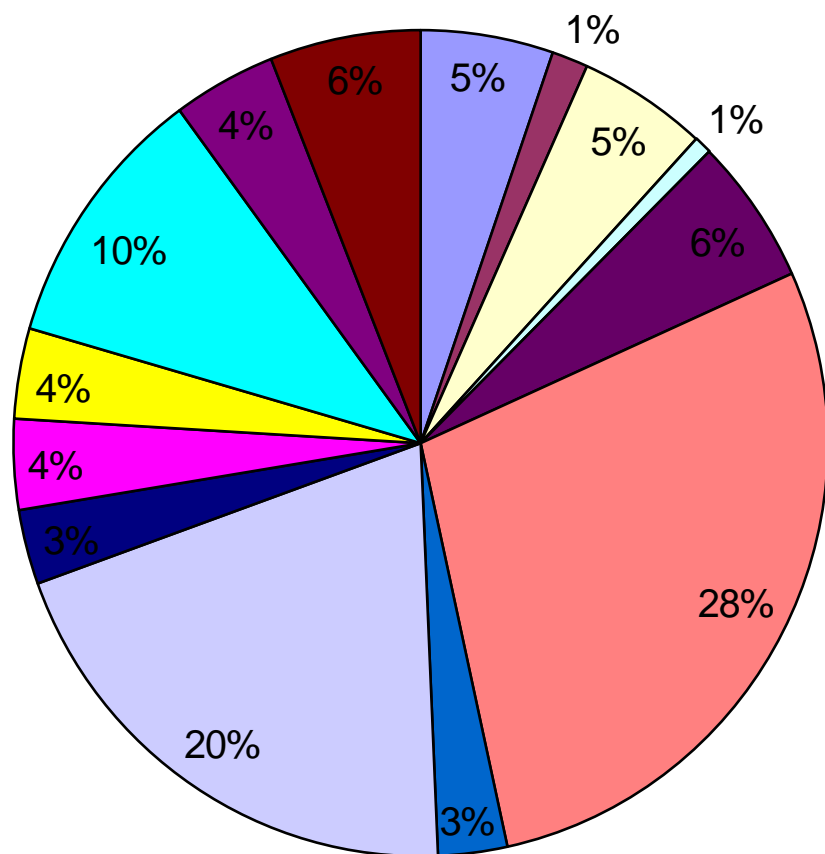


# Cost distribution (864 XFEL couplers)

Project management costs	1%	
Engineering, Manufacturing file, drawings, methods, procedures	4%	
Quality assurance, quality control plan, audits	1%	
Documentation	1%	
Infrastructure for clean room	2%	Assembly
Equipment for cleaning and assembly: ultra-pure water generator, US wash tanks, rinsing tank, Ohmmeter, Ionizing gun, Clean benches, particule counter, active drying cabinets, baking tent, ion pumps	2%	Assembly
Test stands, valves, connexions, ion pumps, gauges, crosses	4%	Assembly
coupler manufacturing	66%	Manufacturing
Quality control	4%	
Cleaning, assembly and preparation for conditioning	12%	Assembly
Packing and transport	1%	
Conditionning	4%	
Total project cost for 864 couplers	100%	

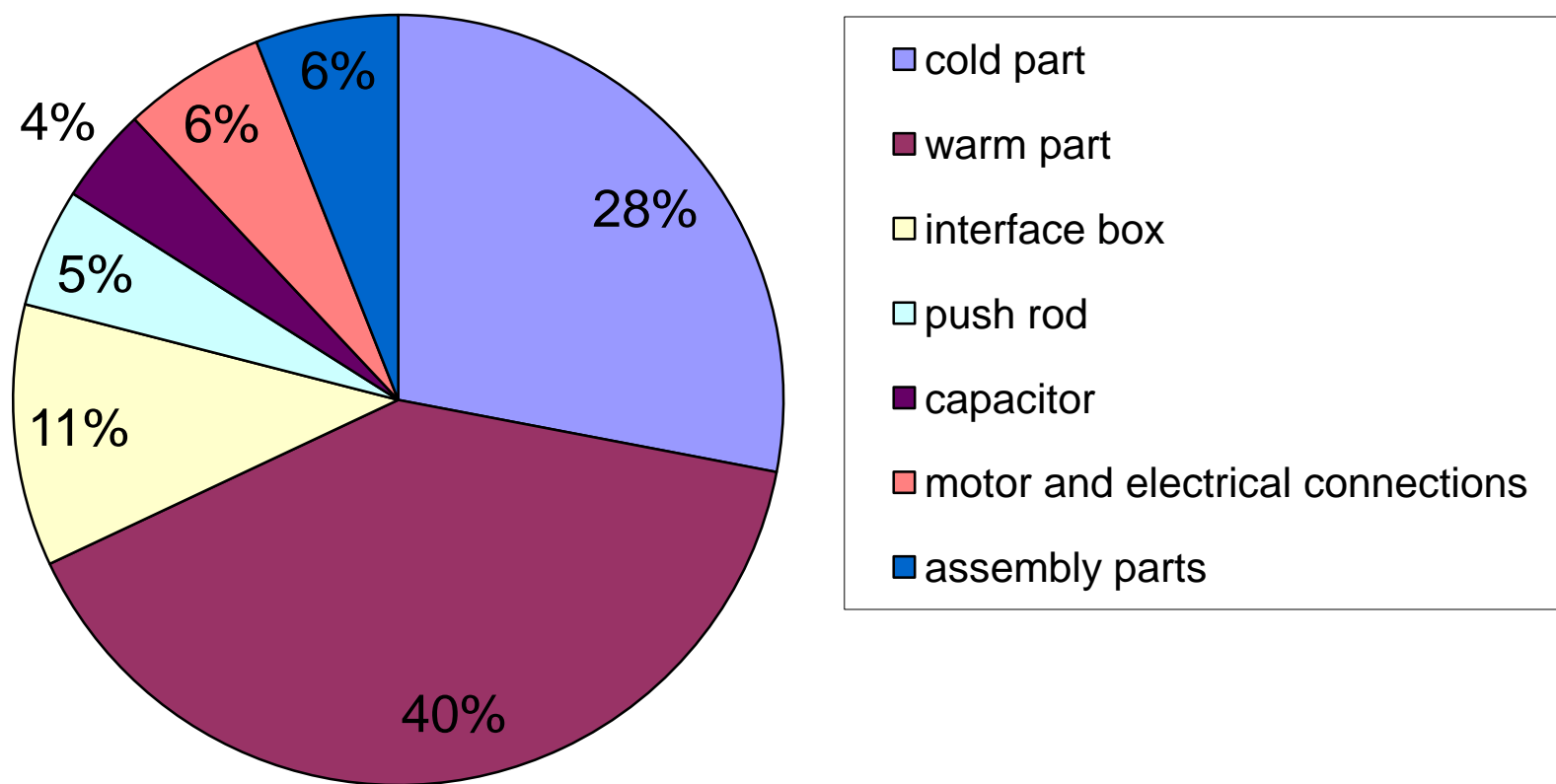
**Cost for assembly (including infrastructure) compared to coupler manufacturing: ratio 20:66 = 30%**

# Cost breakdown of mechanical manufacturing (864 XFEL couplers)



- Raw material stainless steel (warm part, cold part, push rod)
- Raw material copper (warm part, cold part)
- Ceramics
- bellows
- motor and electrical connections
- machining copper and stainless
- TIG welding
- copper plating
- brazing
- eb welding
- TiN coating
- interface box machining (including raw material, single parts machining)
- capacitor (all included, material, work)
- assembly parts (including raw material and machining)

# Cost breakdown of mechanical manufacturing (864 XFEL couplers)



**Savings from fixed coupling is 4% of total cost**