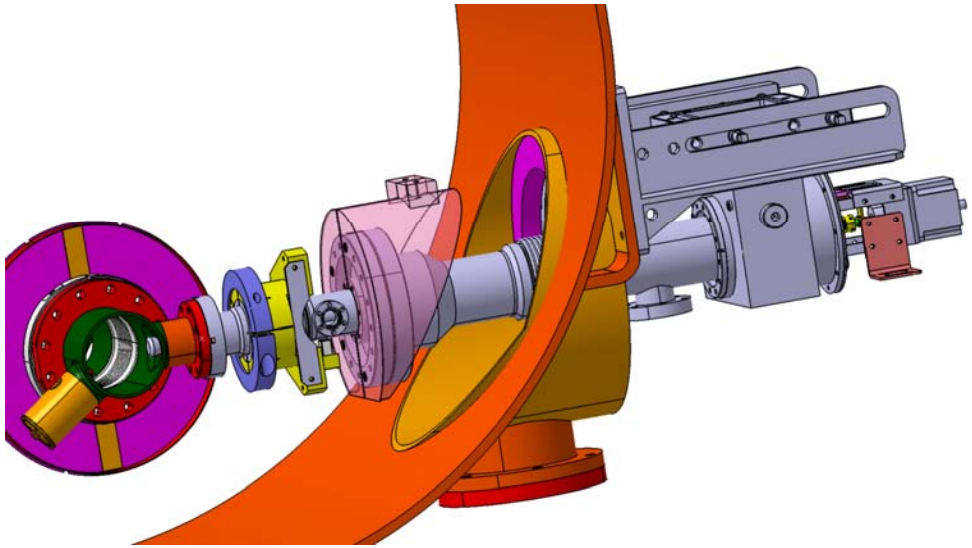
Status report on "Industrialization studies" at LAL
on power couplers for XFEL

SCRF Meeting

Fermi Lab
21-25 April 2008



LAL conducted industrialization studies to clarify the mass production of couplers

Award of 3 contracts in March 06: ACCEL, e2v, TOSHIBA

System Design Review:

- functional analysis

SDR

Preliminary Design Review:

- feasibility of the manufacturing processes
- samples for parts and joining

PDR

Critical Design Review:

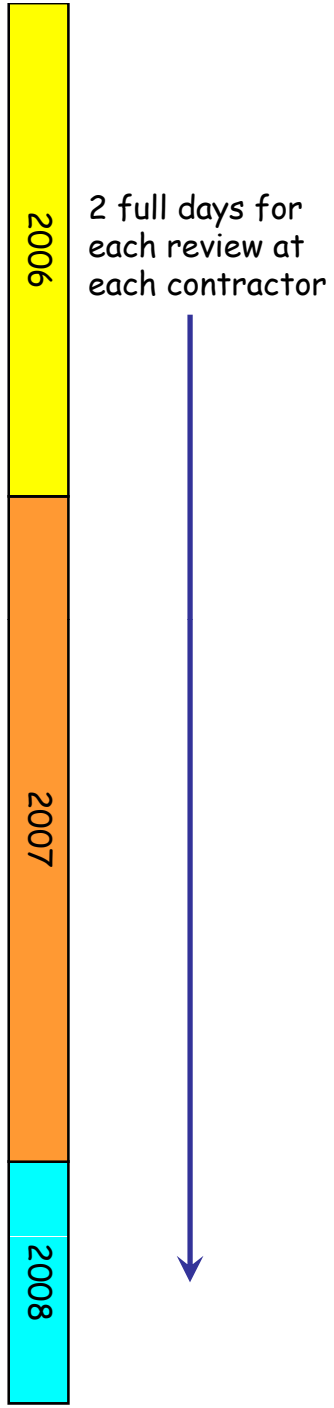
- detailed drawings
- organization of the mass production
- risks analysis
- samples of Cu plating and TiN coating

CDR

Final Project Review:

- deliver 2 prototypes
- volume manufacturing plan
- costs estimate for XFEL couplers

FPR



Industrialization studies were essentially *INTELLECTUAL WORK*

Main documents delivered from industrialization studies

- TDR
- RF and Thermal analyses
- Detailed drawings + 3D model
- Production Plan: *organization, facilities, equipment, manpower, WBS*
- Control Plan for mass production
- Logistics for assembly, conditioning and tests
- Documents Management Plan: *big amount of data to issue*
- Configuration Management Plan: *traceability, control of changes*
- Risks analysis
  - *technical risks*
  - *organizational risks*
- Financial report:
  - *Price breakdown analysis*
  - *Price table*

→ Good assurance that industry having performed this work will succeed in the mass production

Intellectual property issues

clauses of IP were defined precisely in the contract

BASIC PRINCIPLES:

- All informations existing in the industry prior to contract: remain exclusive property of industry
- Inventions, know-how acquired, created or perfected during collaboration work:

Inventions, methods and know-how acquired		Obligation of disclosure to CNRS	Rights of LAL - CNRS		
			Circulate and publish	Use and reproduce	Adapt
1	Procedures for welding, brazing, Cu coating, TiN coating	No		X [1]	
2	Other methods, procedures and sequences of fabrication, WBS, Specific piece part drawings, Special tooling and fixtures developed for fabrication, assembly and control, Cost proposal information	Yes		X [1]	X [1]
3	What is subject to a patent application in Europe	Yes [2]		X [3]	
4	Sub-assembly and assembly drawings, PBS, Types of connexions and methods of assembly, All technical documents not covered by industrial property	Yes	X	X	X

Notes :

1. At the condition that manufacturing is performed by the inventor
2. Supplier shall inform CNRS of his intentions. Disclosure after patent application.
3. Licence of use is royalty free for CNRS, worldwide

Status for XFEL prototypes

Pair no1 received Feb 28th from TOSHIBA

Pair no2 received March 5th from ACCEL

Pair no3 abandonned: E2v decided to give up (2 weeks before final review !)

Better now than during production !

Next Actions on prototypes

- RF condition prototype pairs: → analyze results
- dismount couplers and inspect inside/outside → quality evaluation and ranking

Call for tenders for XFEL couplers

- based on:
  - functional specifications
  - organizational requirements pointed out by indus. studies:
    - management
    - documents
    - logistics
- known candidates:
  - 2 industries which took part in industrialization studies: ACCEL + TOSHIBA
  - 2 other industries: CPI (60 prototypes) + THALES (2 prototypes)

Scenario for couplers production – XFEL

Principles:

- 2 industrial contracts: each for 400 couplers
- Separate production at each industry
- Responsibility of industry includes RF conditioning

Limit of responsibility for industry

Type 1 → Type 1

Type 2 → Type 2

Manufacturing

Assembly

4 pairs/week

Orsay

(LAL)

1 RF Conditioning station

- 1.3 GHz tuning
- RF conditioning
- acceptance tests
- dismount
- pack (double bag)
- ship or store

Saclay

(IRFU)

Cryomodules assembly

- Cavity string assembly
- Cryomodules assembly

Ship 1/week

DESY

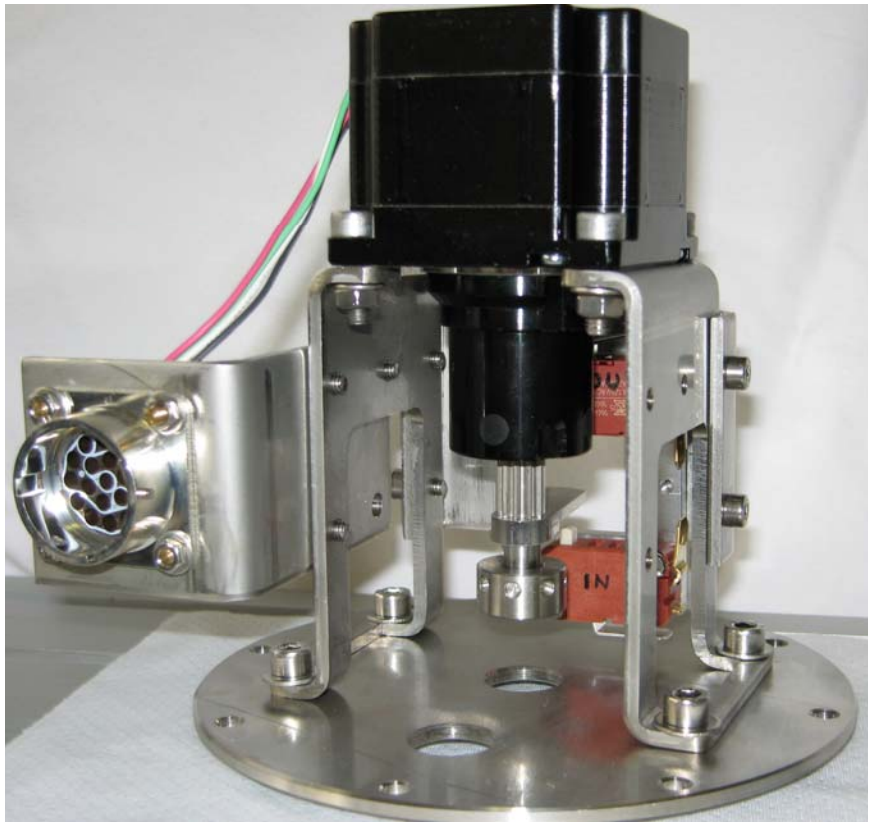
Cryomodule test

At each industry:

Clean rooms operations:

- wash
- rinse
- dry
- assemble
- vacuum pumping
- He leak test
- bake

Example of systems engineering result



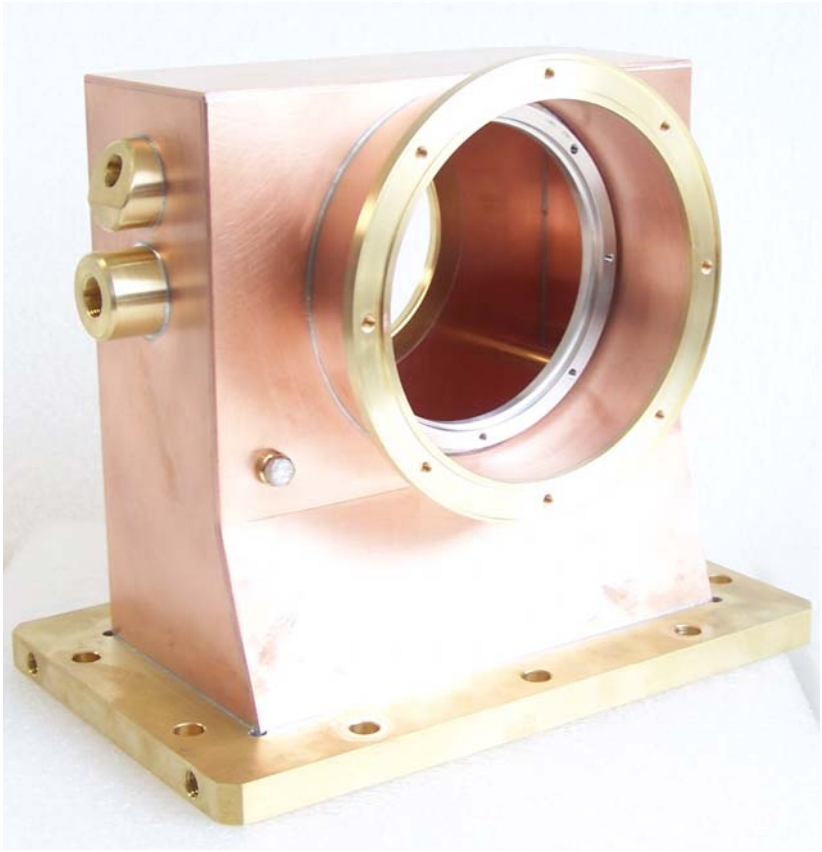
Prototype design for motorized tuning

Industrial design

Design to minimize assembly time

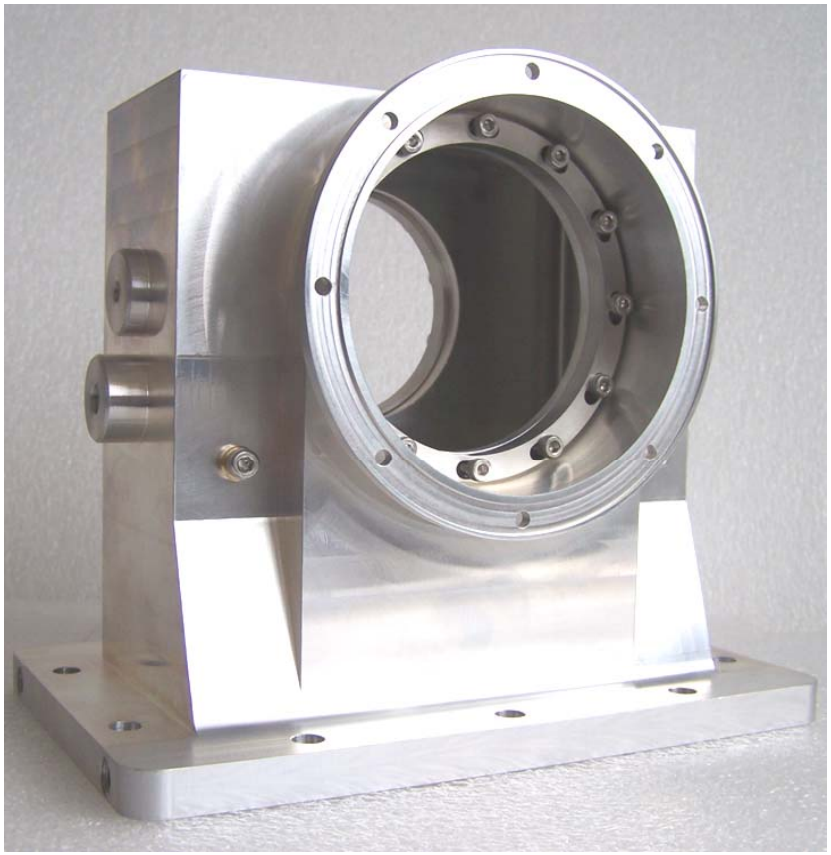
(original design: counter flanges + 14 screws

Waveguide to coax interface part



Copper + stainless steel + brass: 13 parts

brazed and soldered



Al alloy: 1 single part

- Prototypes: machined from single block
- Mass production: casting

Cost reduction was one of the main objectives :

Phase 1: **functional analysis of existing design**

Functions & requirements for each sub-assembly, each part
Analysis of requirements for each interface
Functionality of global breakdown:
- analyze limits of each sub-assembly
- what are the purposes of this design ?

Phase 2: **systems engineering**

- reduce number of parts
- reduce number of junctions
- reduce number of different junctions, types of junctions

Phase 3: **design for manufacturability**

analysis of manufacturing method for each part:
- prefer deformation process instead of material removal process
- optimize design of parts connected to interfaces (functional analysis results)

Phase 4: **lean manufacturing methods**

- optimise the design in terms of functions
- analyse bar chart of components costs:
  concentrate efforts of cost reduction on most expensive components
- think about production with less of everything:
  . less human resources, less specific competences
  . less manufacturing equipments and space
  . less raw material, less tooling & jigs
  . less stock, less spares, less energy, less waste

Phase 5: **analysis of final assembly**

- decompose assembly operations in successive sequences
- what are the consequences of assembly on each component ?
- what parts could be simplified ?
- how to save manpower and assembly time ?

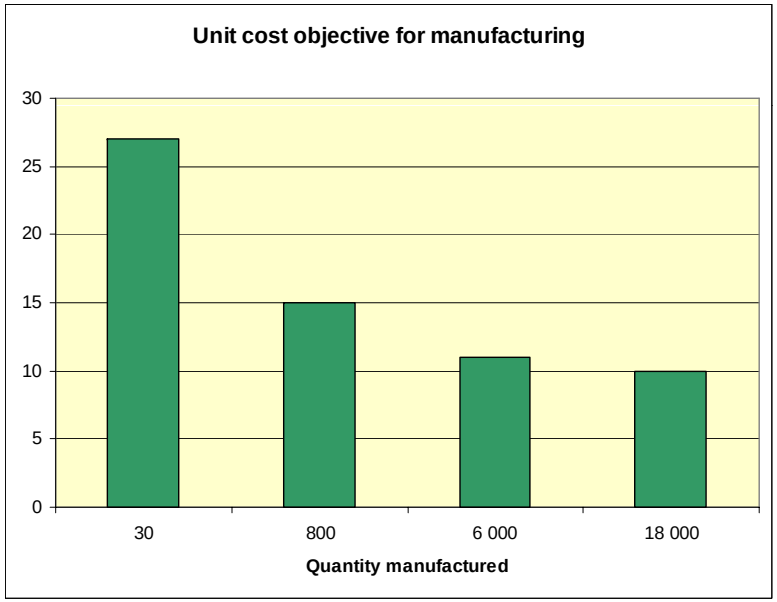
Do this Again for ILC

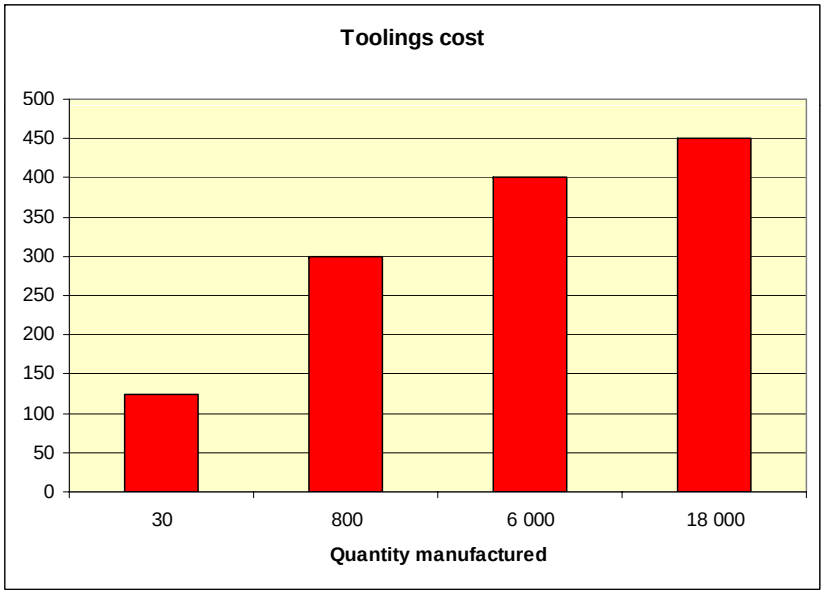
Costs objectives versus quantity

Number of parts

	Prototype coupler	XFEL coupler	ILC coupler
Cold assembly	13	9	5
Warm assembly	22	14	9
Total	35	23	14

→ Industrialization studies for ILC couplers is strongly recommended !!!

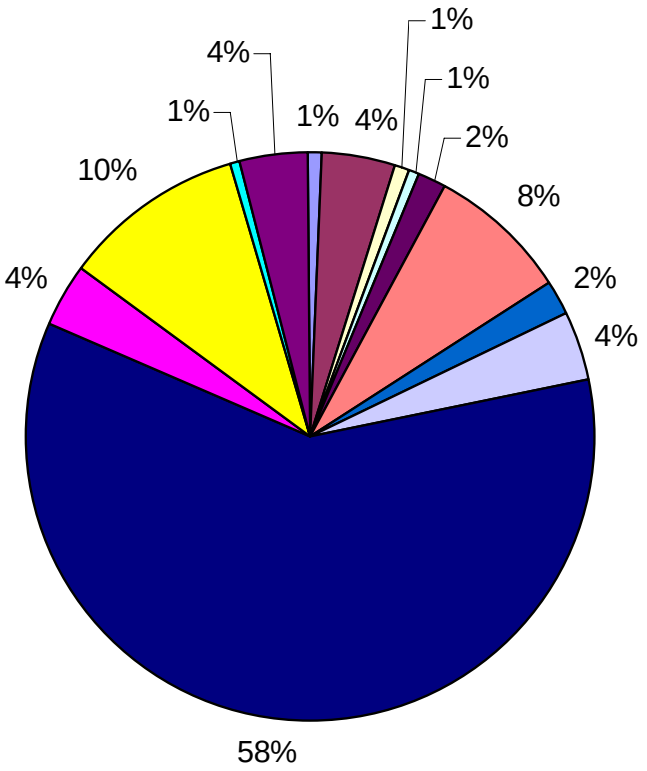




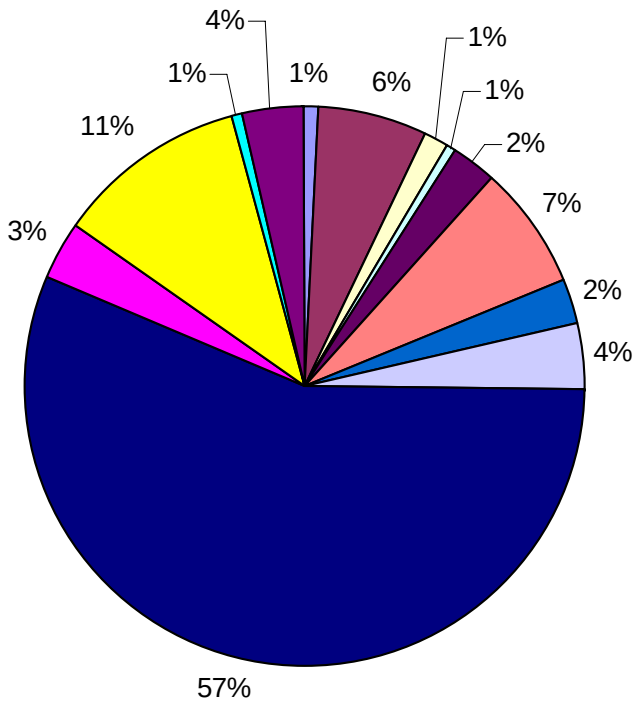
Effect of mass production on unit cost and toolings cost (estimation)

Results of industrialization studies

Project cost breakdown for 800 couplers



1 x 800



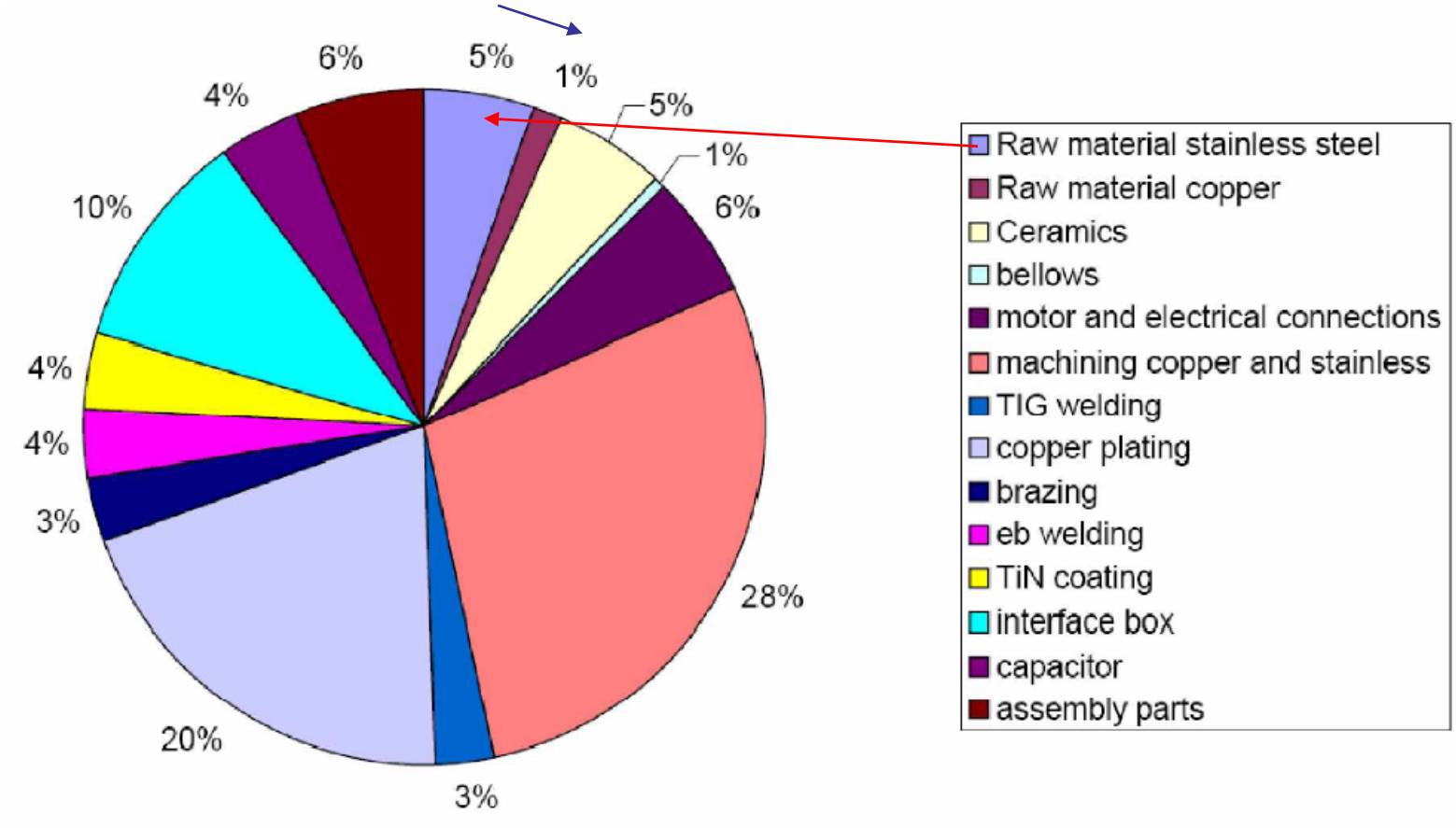
2 x 400

Tasks at industry:

- Management
- Engineering
- QA
- Documentation
- Infrastructure: clean room
- Infrastructure: RF power station
- Equipment
- Test stands + accessories
- Manufacturing
- QC
- Cleaning, assembly, baking, test
- Packing + transport
- Conditioning

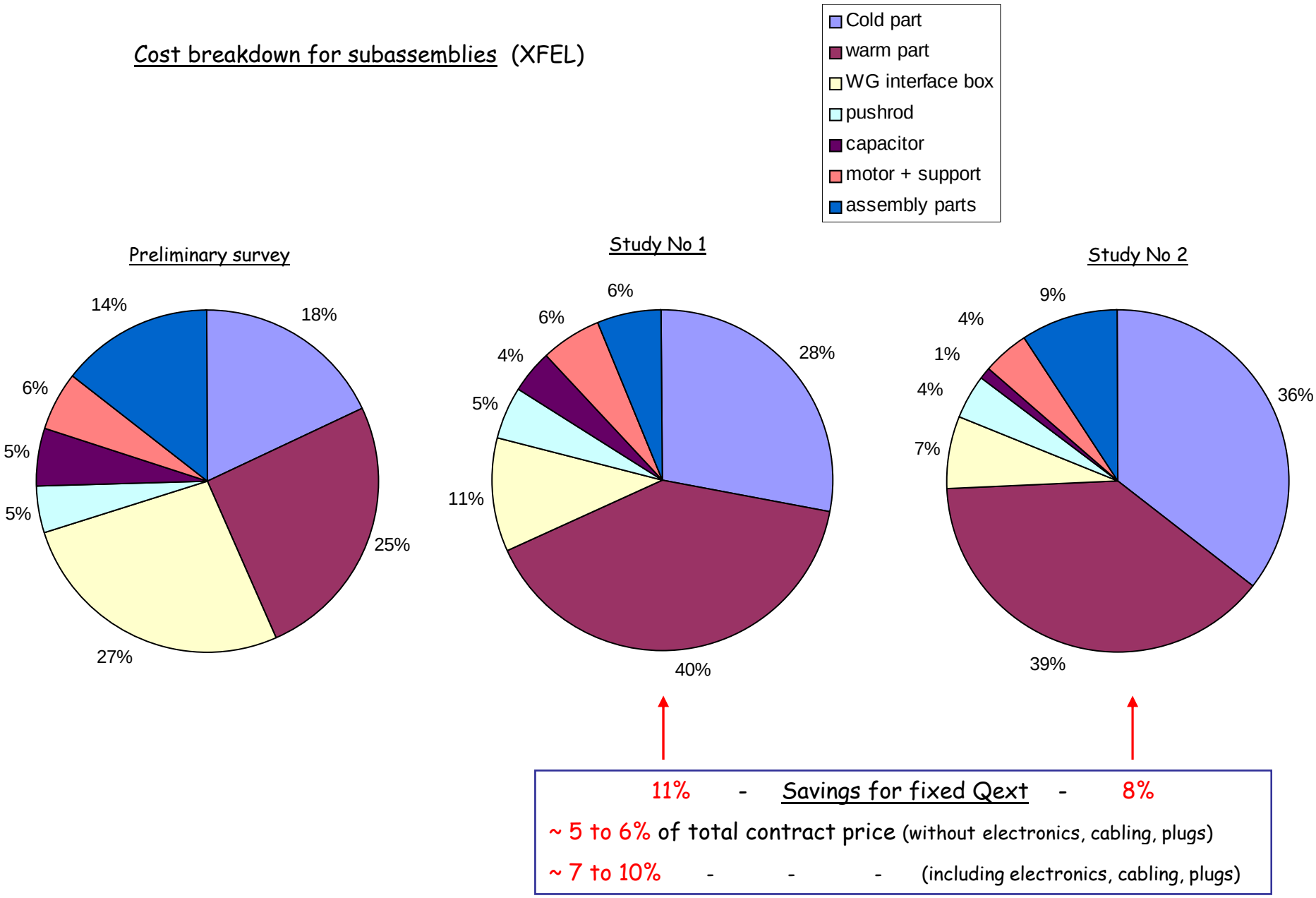
1 x 800 versus 2 x 400: save 10% on total

Manufacturing cost breakdown for materials and processes
(XFEL)



Total raw material cost ~ 20 %

Cost breakdown for subassemblies (XFEL)

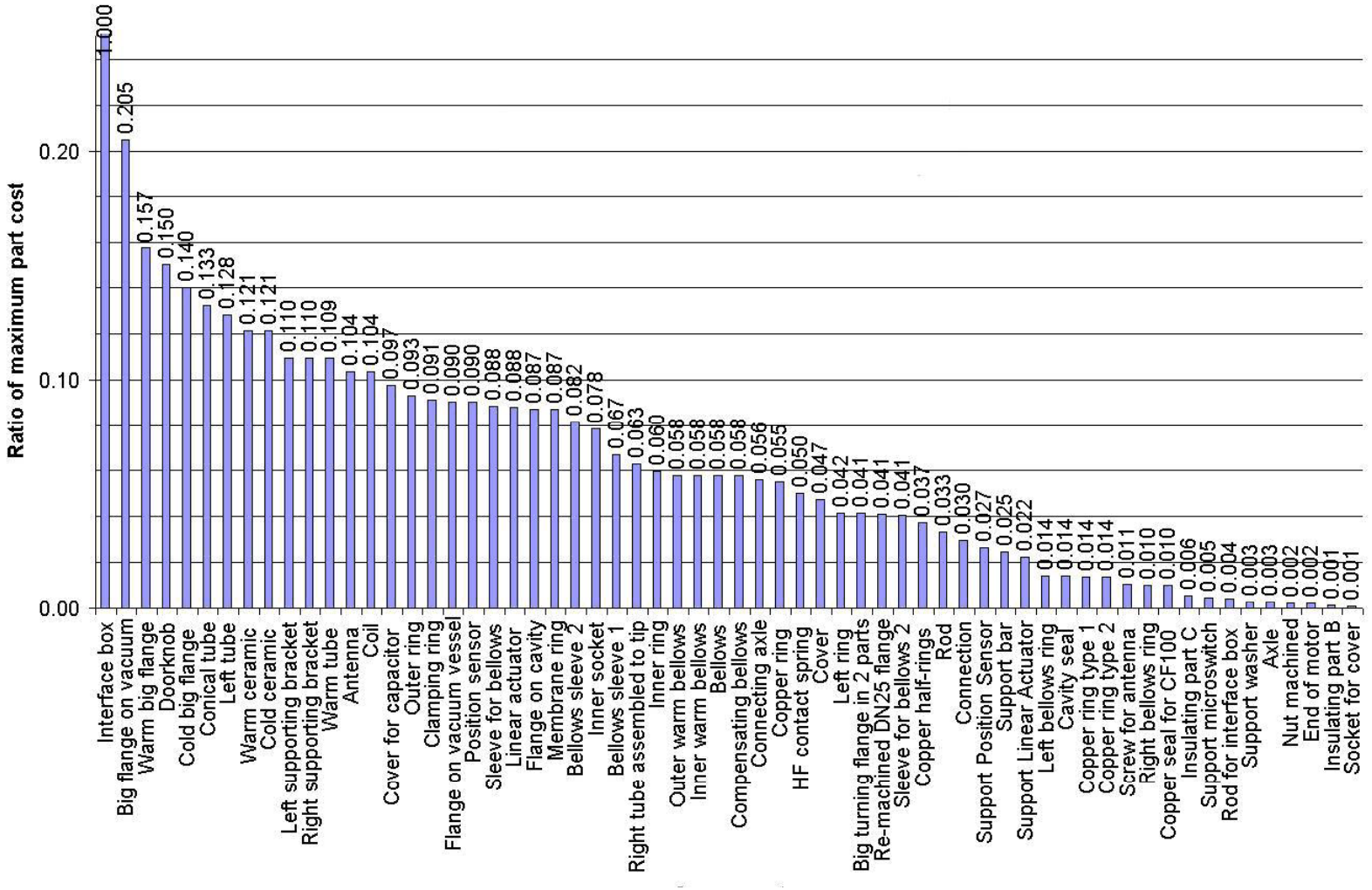


11% - Savings for fixed Qext - 8%

~ 5 to 6% of total contract price (without electronics, cabling, plugs)

~ 7 to 10% - - - (including electronics, cabling, plugs)

Bar chart for each part



This is the basis for future round of cost reduction: → concentrate efforts on expensive items

Preliminary schedule for XFEL couplers procurement