Technical systems: Cavity Report

- Overview on costing activities for ILC
  - European costing method
    - Overview industrial methods
    - General comments on industrialization, risk in costing
  - American costing method
  - Asian costing method

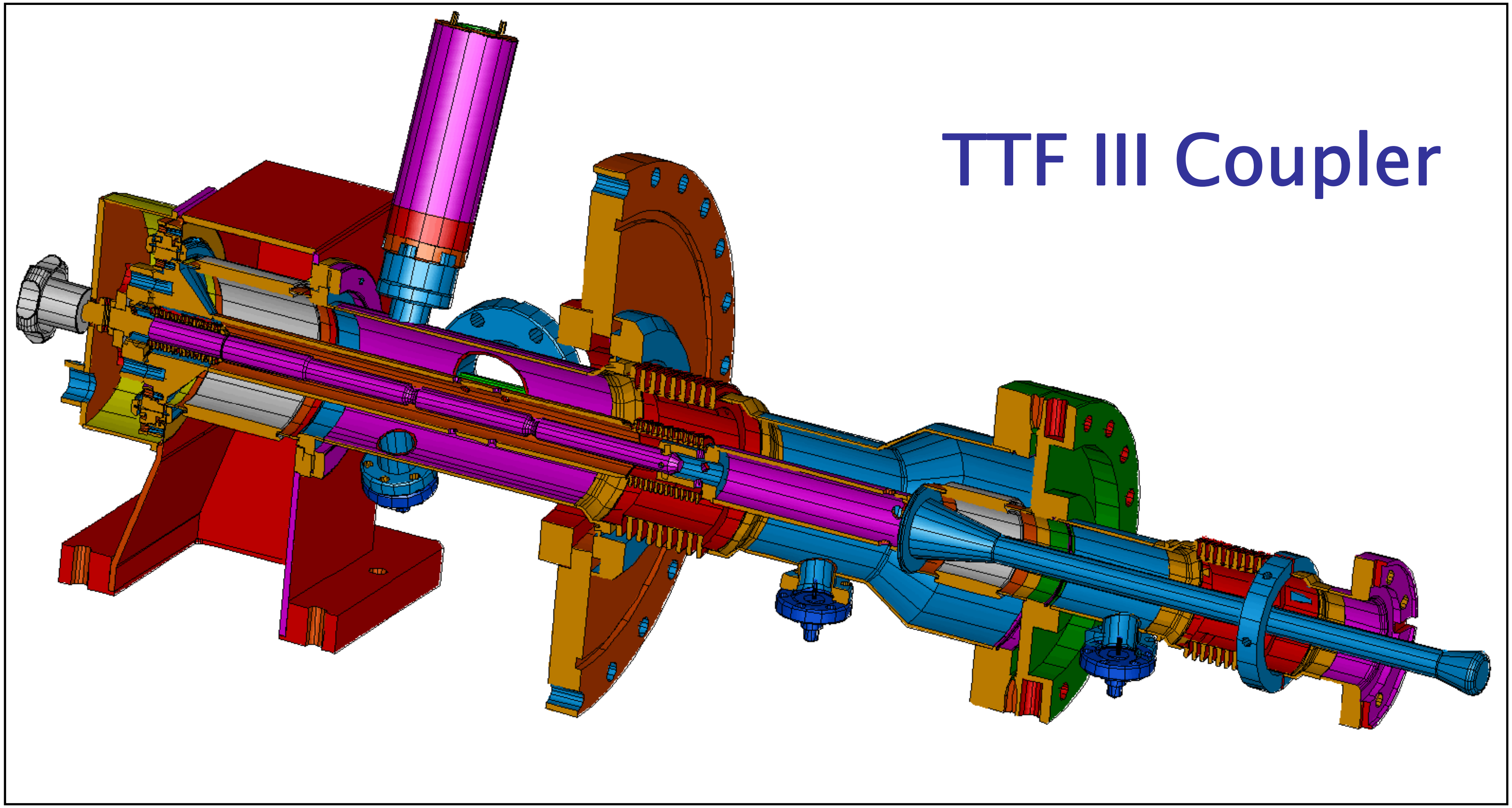
Technical systems: Cavity Report

- Elements in cavity system
  - Niobium material
  - Cavity fabrication
  - Input coupler
  - HOM coupler
  - Cavity treatment
  - Tuning system

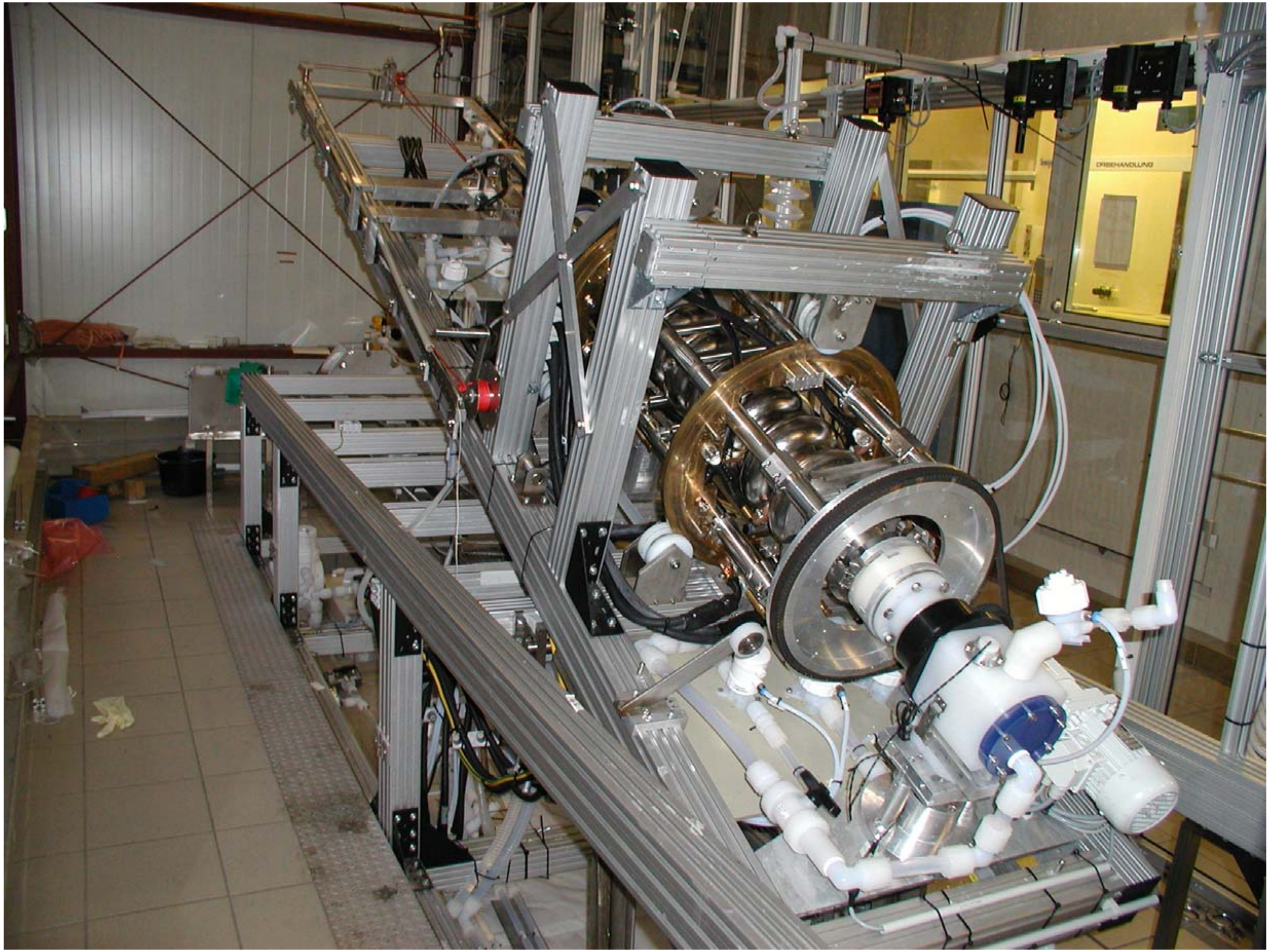
500KW electron beam cold hearth furnace

Cavity production

FLASH LINAC RF Power Coupler

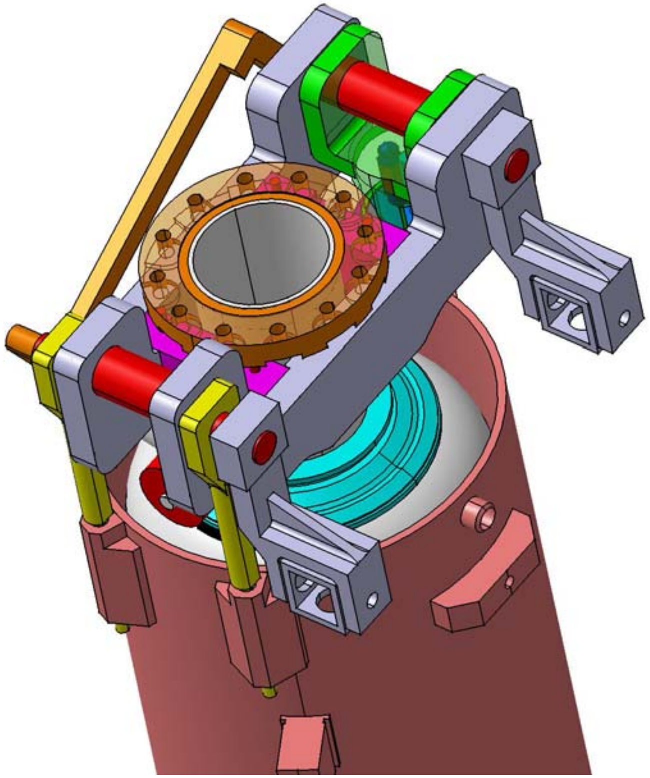


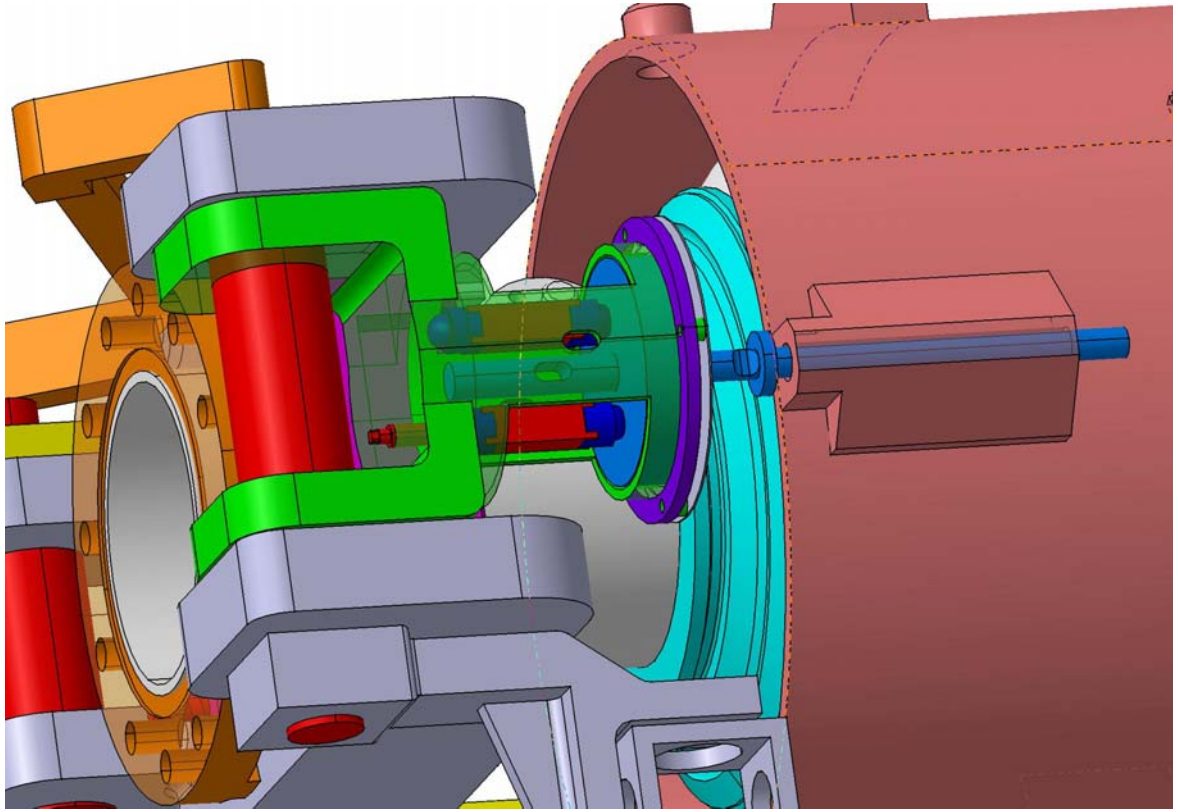
DESY Electro-polishing machine



D.Proch, DESY; GDE meeting
Vancouver 06

Cavity preparation in clean-room





Design of the new slow & fast cold tuner

CARE JRA-SRF Partner Cooperation between :
TUL (Polen), CNRS Orsay, CEA and INFN Mi

D.Proch, DESY; GDE meeting
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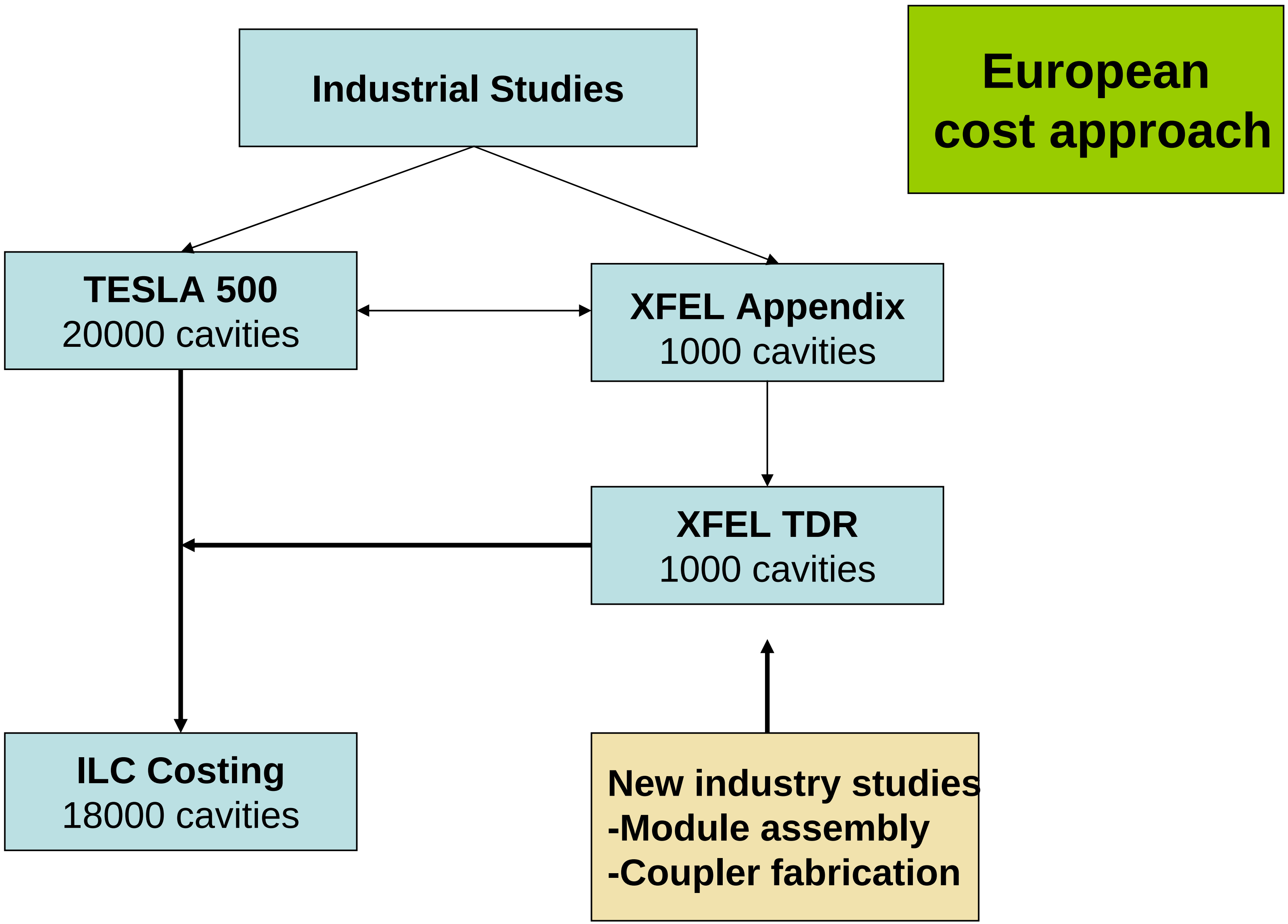
European Cost Approach

- Industrial studies for TESLA (20000 cavities) at 2001
- Appendix to TESLA: XFEL part at 2001
  - 1000 cavities
- Revised XFEL TDR at 2006
  - Corrections for
    - Increased material costs
    - Risk assessment for costs
    - Inflation
- For ILC: Corrections / modifications to TESLA costs based on findings in XFEL part


Industrial Studies
European cost approach
TESLA 500
20000 cavities
XFEL Appendix
1000 cavities
XFEL TDR
1000 cavities
ILC Costing
18000 cavities
New industry studies
-Module assembly
-Coupler fabrication

Cost evaluation by Industrial Studies

- **Analyze production of TTF components**
  - Describe present fabrication process
  - Determine cost drivers, critical procedures
  - Define core technology, outsourcing possibility
- **Implementation of mass production methods**
  - Evaluate investment of machinery, tooling, roboting
  - Cost optimize flow of fabrication
  - Describe layout for “core tech” factory

Cost evaluation by Industrial Studies, cont.

- **Complete planning of new “core tech” factory**
  - Determine costs for buildings, investment, man power, ramp up & production & ramp down, overhead, consumables, QC,…
  - Get bits for outsourced parts
  - Sum up total cost of component fabrication

- **NO** learning curve assumed (e.g. -10% for doubling the production)
- But assumption: stable production after about 50 cavities, couplers,…
  - **Is verified e.g. by LHC magnet production: assembly time reached stable (and predicted) level after about 40 magnets**

- **This cost model is valid because it was developed by experienced companies. Additional studies would require time, money and competent industry.**

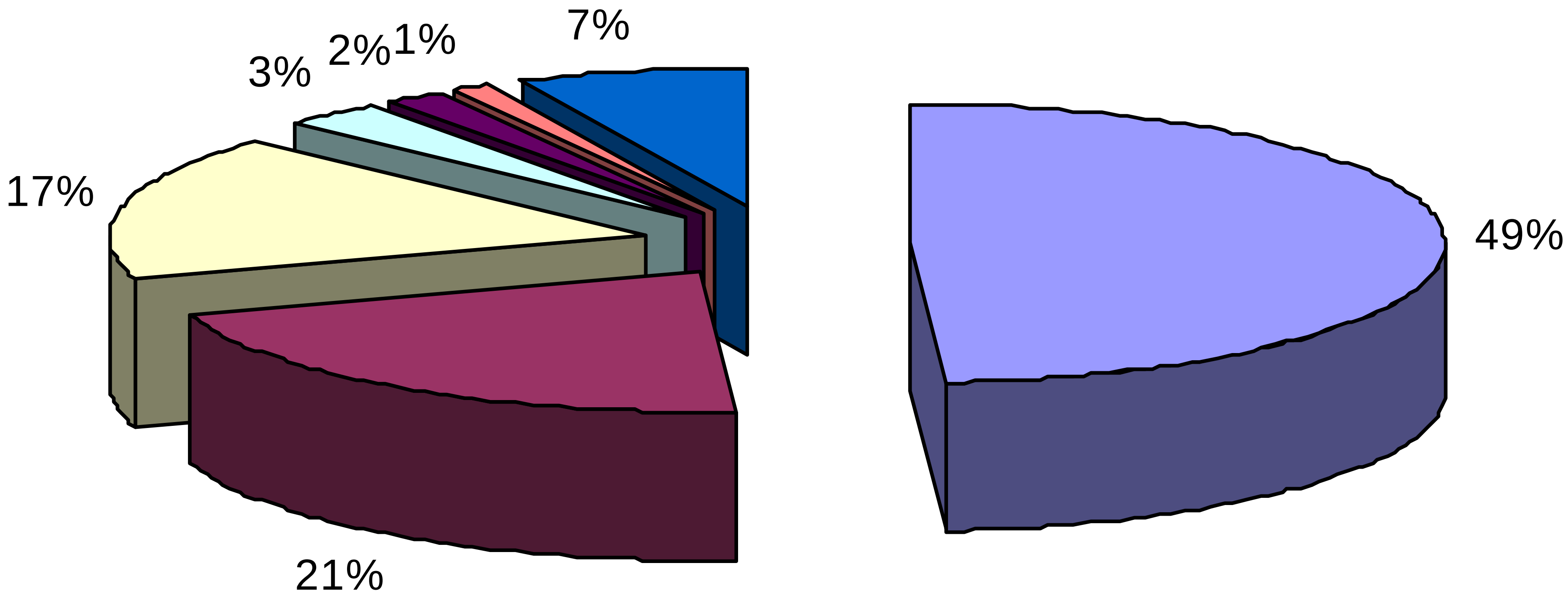
Components with Industrial Studies

- Niobium fabrication, done
- Cavity fabrication, done
- Cavity treatment, done
- Module assembly, done
  - Revised study is in progress
- Input coupler fabrication
  - Study in progress

Comments to cost evaluation

- **Nb Material** (high purity, RRR 300)
  - No shortage of raw Nb material (40.000 tons annual production, ILC needs around 500 tons
  - But limited number of high purity melting facilities
    - Today there are 4 qualified companies, but only one is capable of producing full yield
  - Marginal savings in mass production (from industrial study)
    - Size of melting furnace is limited
    - But some saving can be realized by
      - Disc rather than rectangular sheet (scrap can be recovered)
      - Other material produced ready for fabrication, e.g. flange material
- The result is robust costing

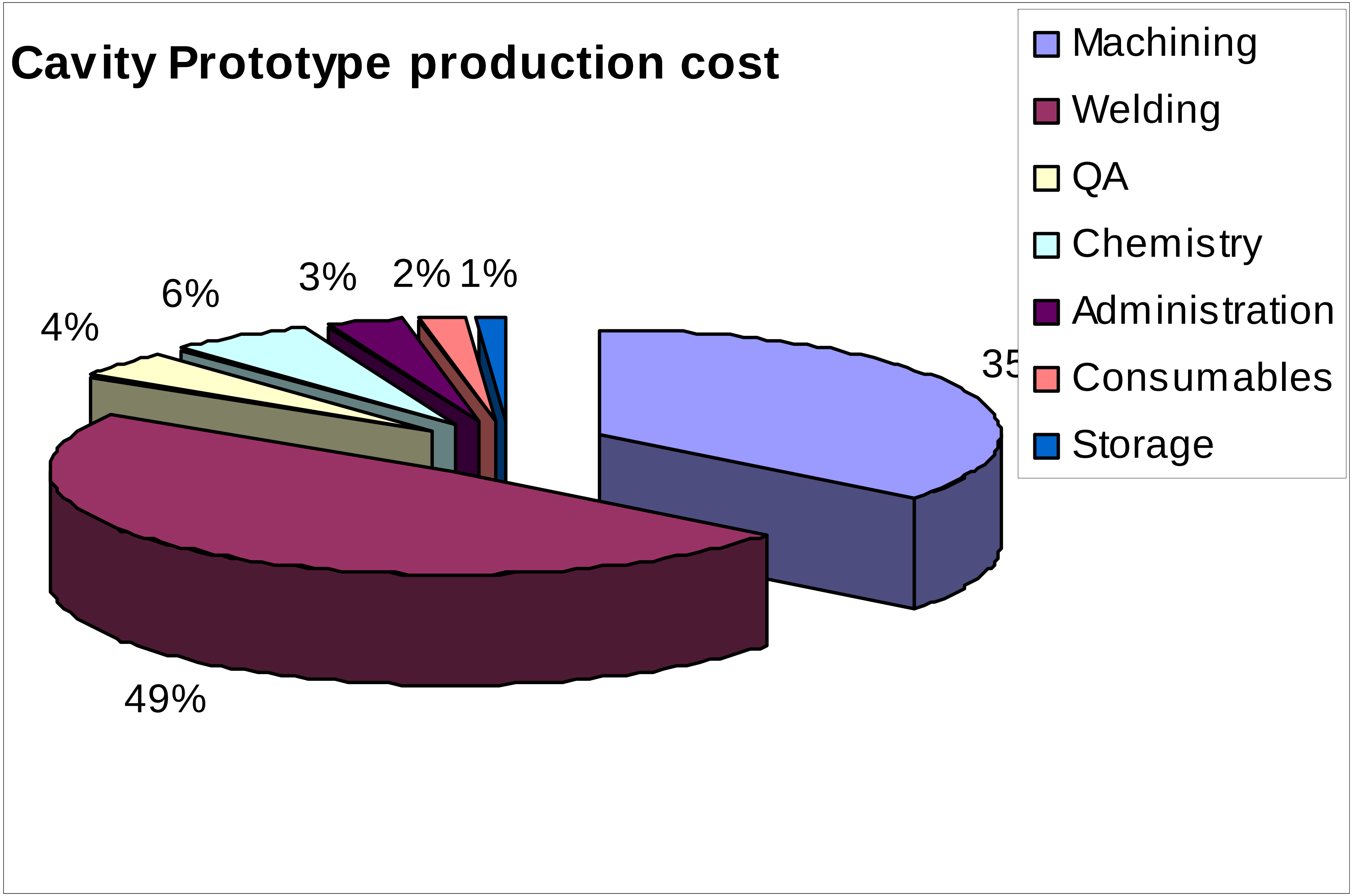
High purity Niobium production

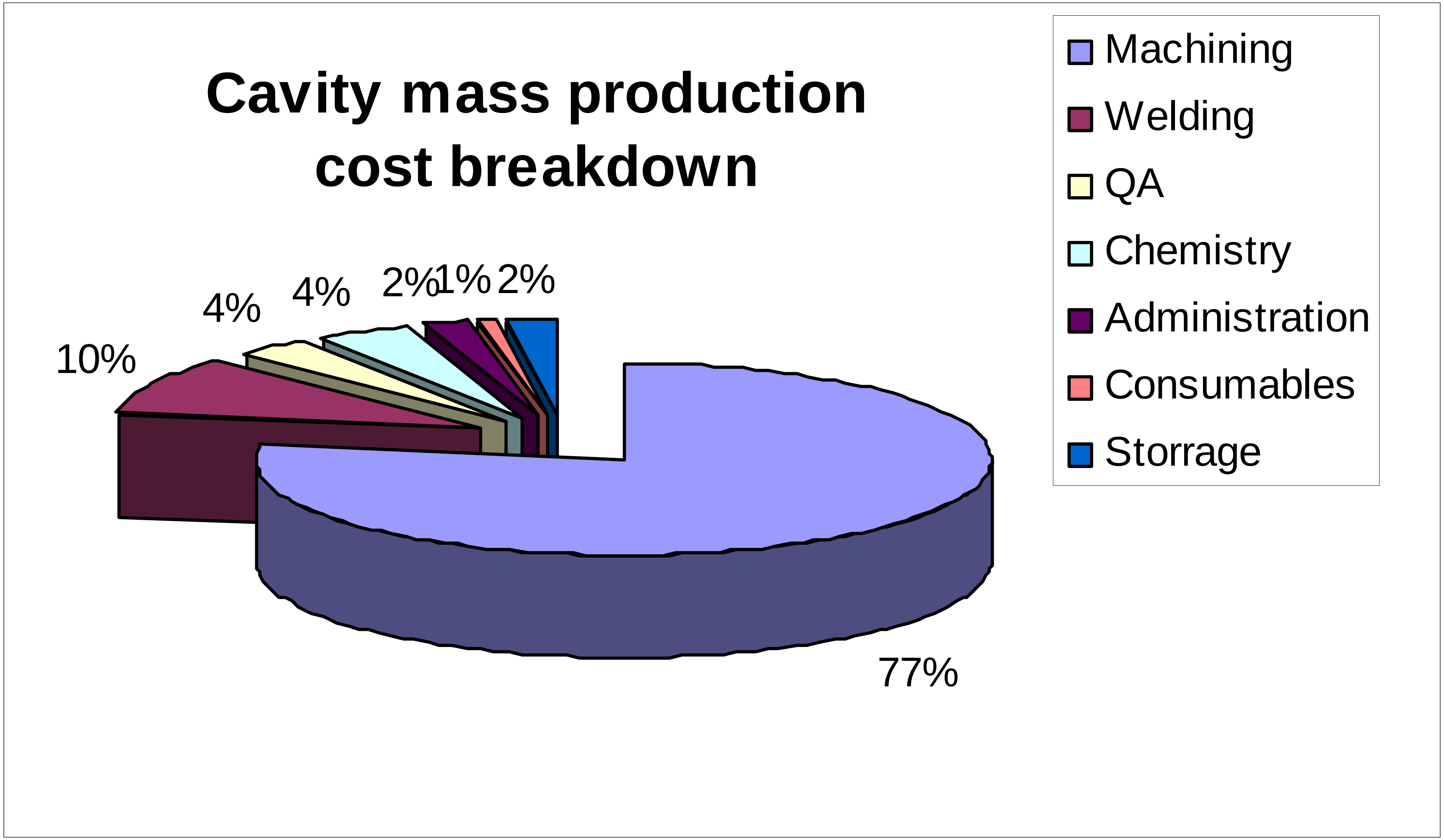


Melting | Raw material | Rolling | Firing | Forging | Chemistry | scrap

Comments to cost evaluation

- **Cavity fabrication**
  - Experienced companies in Europe
    - More than 500 type TESLA cavities have been fabricated so far
    - Fabrication process is well understood and stable
    - Cost drivers: EB welding process (50% total cost)
      - Cure: reduced pump down time by multiple vacuum chambers welder
      - Cure: mass production welding tooling
    - Cost saving in large scale production is well understood
- The result is robust costing


Cavity Prototype production cost
Machining
Welding
QA
Chemistry
Administration
Consumables
Storage
35
49%
4%
6%
3%
2%
1%



Cavity mass production
cost breakdown
10%
4%
4%
2%
1%
2%
77%
Machining
Welding
QA
Chemistry
Administration
Consumables
Storrage

Comments to cost evaluation

- **Cavity treatment**
  – Standard treatment is EP, 130°C bake, high pressure water cleaning, clean-room assembly
  – Technology transfer to industry just started
    - Cost evaluation has some uncertainty
    - Industrial involvement is needed to develop procedures which produce higher performance yield
- Costing result has risk:
  – Uncertainty in cavity treatment

Comments to cost evaluation

- **Input coupler**
  - Cost is high, comparable with cavity fabrication !!
  - Present industrial fabrication around 80 couplers. Industry identified cost savings which were included, e.g. standardized tube sizes
  - Ongoing industrial study (XFEL) on mass production will deliver a reliable cost number
- Present costing has some risk
  - But ongoing industrial study will deliver robust costing

Comments to cost evaluation

- **Tuner**
  - No BCD design exists
  - Two alternative designs are being developed (beam axis and center vessel design)
  - Critical path for both designs is the fast tuner (piezo element)
  - Costing is based on incomplete design
  - Industry must be involved after completion of the design
- Costing result has risk

American costing method

- There is fabrication experience in some laboratories from earlier projects
- American industry was only involved to minor extend
- A new industrial study on cavity mass production is on the way
- Costing is based on prototype fabrication and learning curve for mass production

Asian costing method

- In Japanese culture industry has been involved in early stage in accelerator projects, e.g. Tristan, KEKB
- Industry is a major driver in EP (electro polishing) and coupler development
- In house (KEK) cryo-module development is under way
- Costing is a combination of industrial involvement and learning curve