FROM RESEARCH TO INDUSTRY

PIP-II RISK WORKSHOP: CEA VIEW

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on behalf of
CEA, DRF/Irfu

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CEA Scope: LB650 Cryomodules, Assembly, Tests

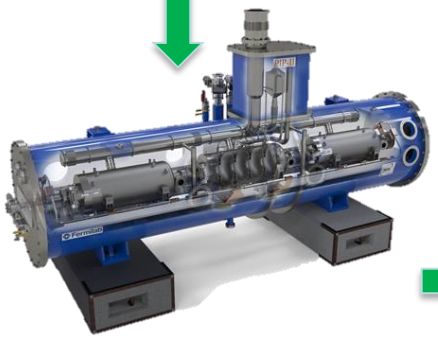
- Specific plans to be developed, but general vision is:

Dressed/Qualified Cavities
- Lab-sourced prototypes
- Indian industry sourced production
- Lab Prep&Test

Dressed/Qualified Cavities
- Established EU Vendors
- Industrial Processing
- Lab qualification

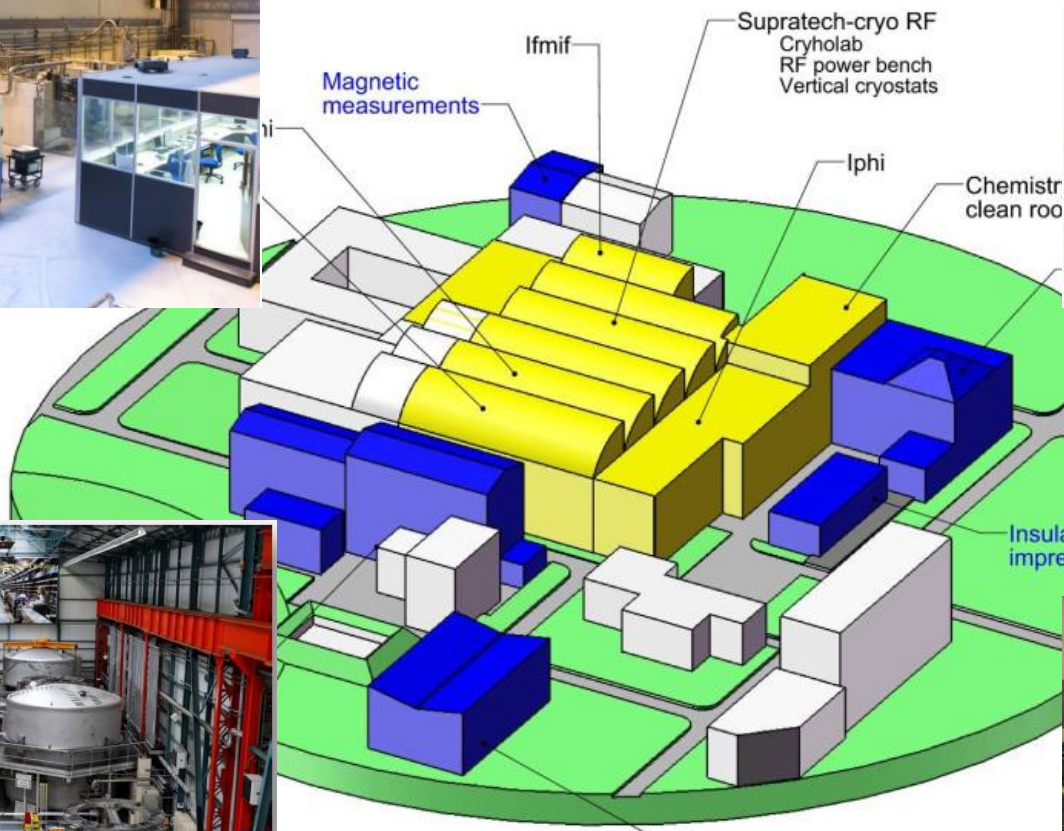
Cryomodule Components
- Established EU Vendors
- RF couplers
- Other opportunities

CM Integration
- Possible CM Qualification
- Overseas Shipment



CM Qualification

CEA technological infrastructures (25 000 m²)

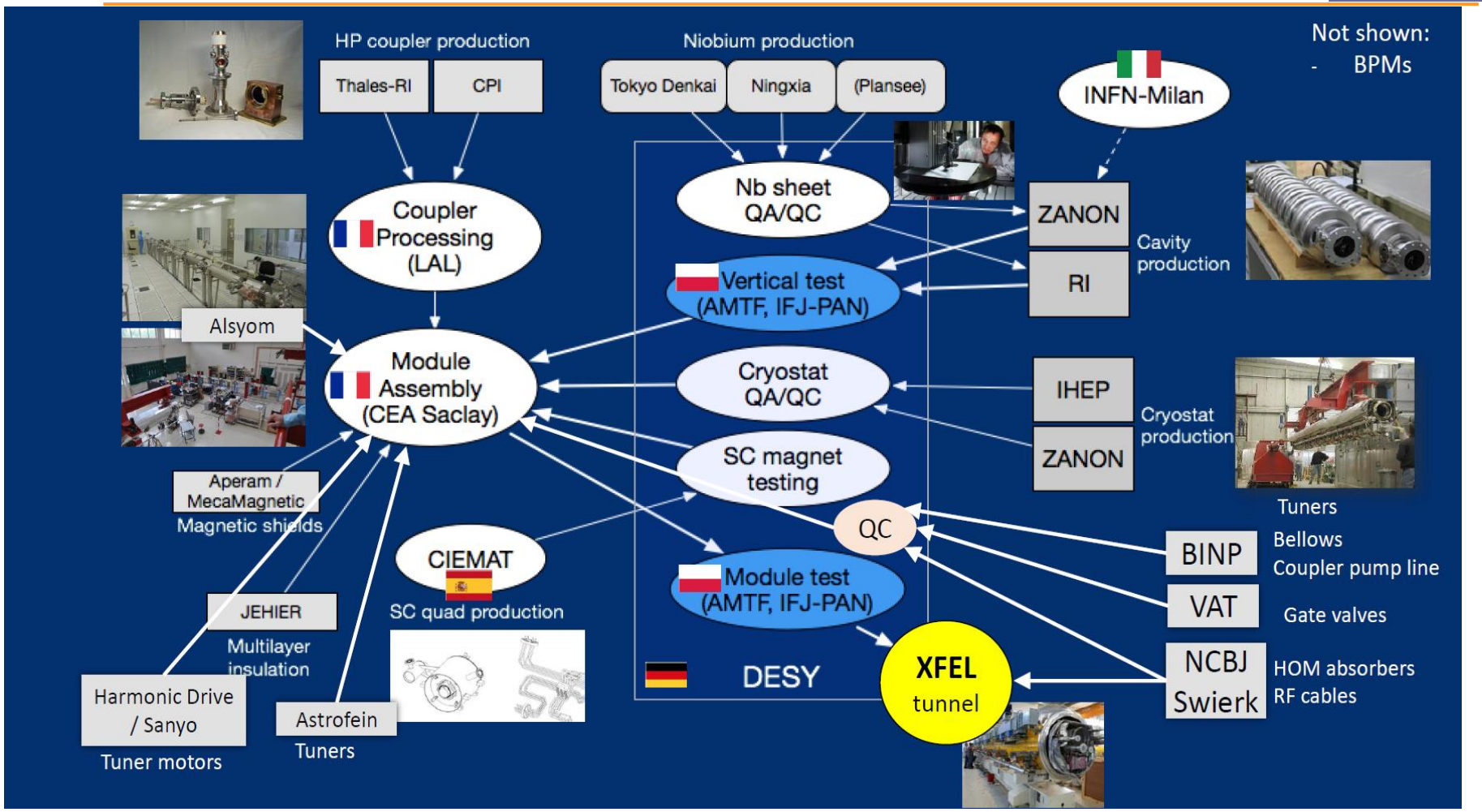


In-Kind Contributors

to E-XFEL Cold Linac

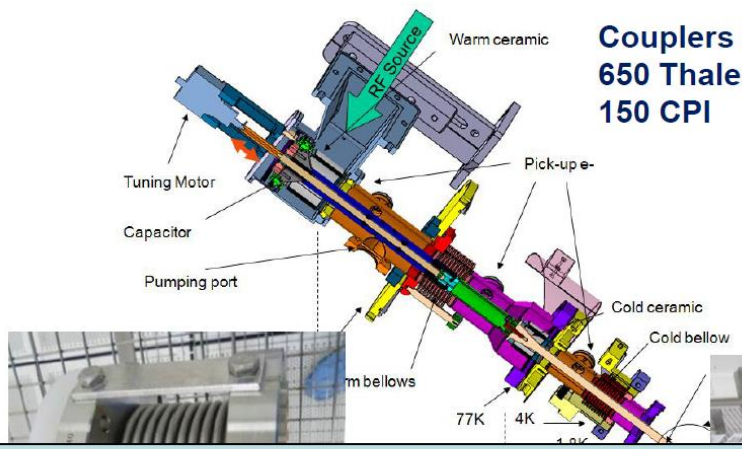
In one shot !

In-Kind Contributors to E-XFEL Cold Linac



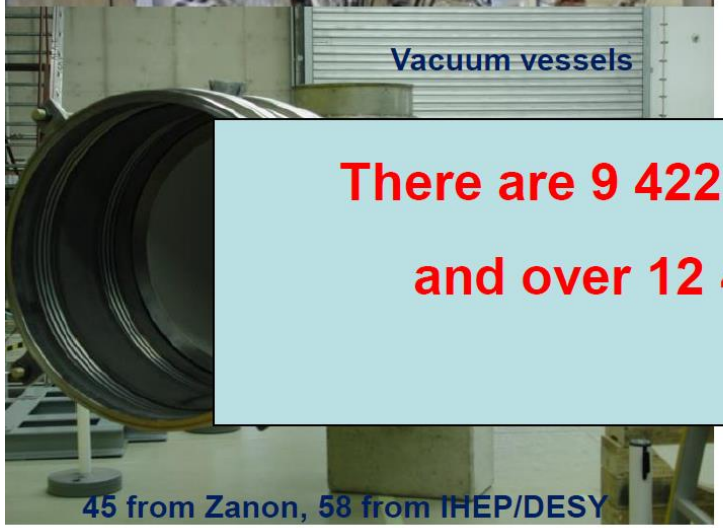
The PM is like a symphony orchestra director trying to get all sections synchronized: an impossible task with a risk occurence of 100% ⇒ **work impact on the critical path**.

Cryomodule In-Kind Procurements

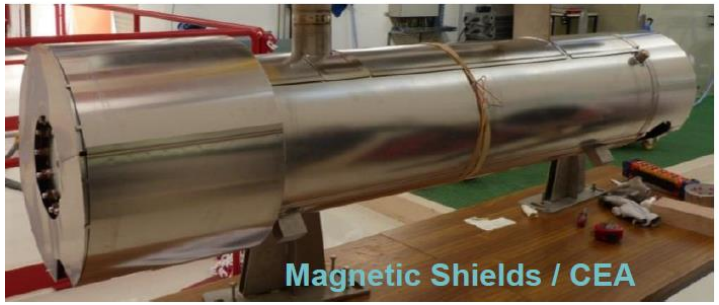


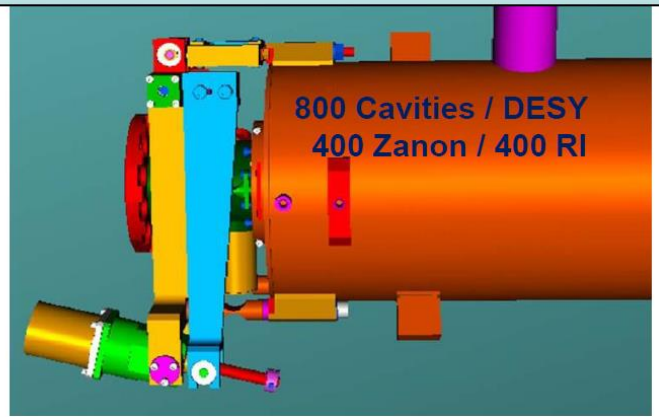
Couplers / IN2P3
650 Thales-RI
150 CPI

Quadrupole-BPM / DESY
103 Magnets / Ciemat
BPM / 72 DESY – 31 CEA
206 Gate Valves / DESY

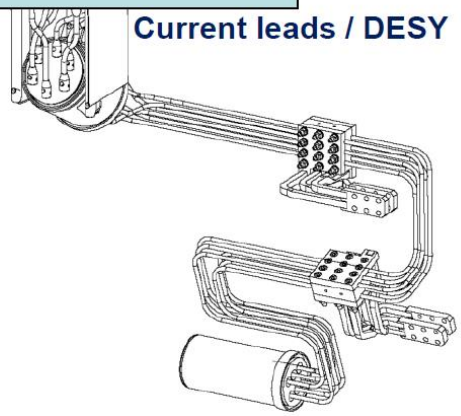


There are 9 422 individual components integrated and over 12 400 individual parts manipulated per cryomodule



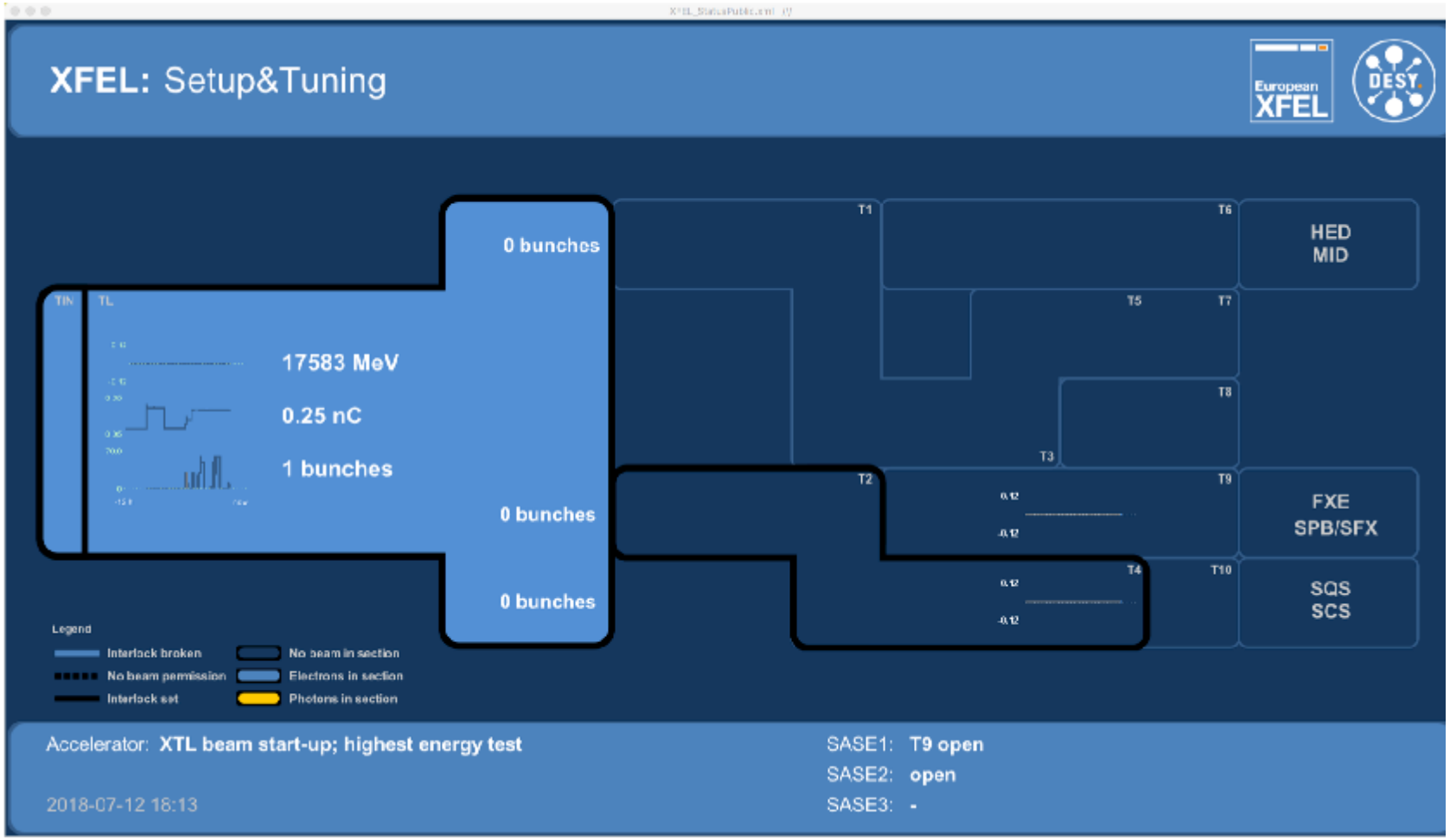


Current leads / DESY



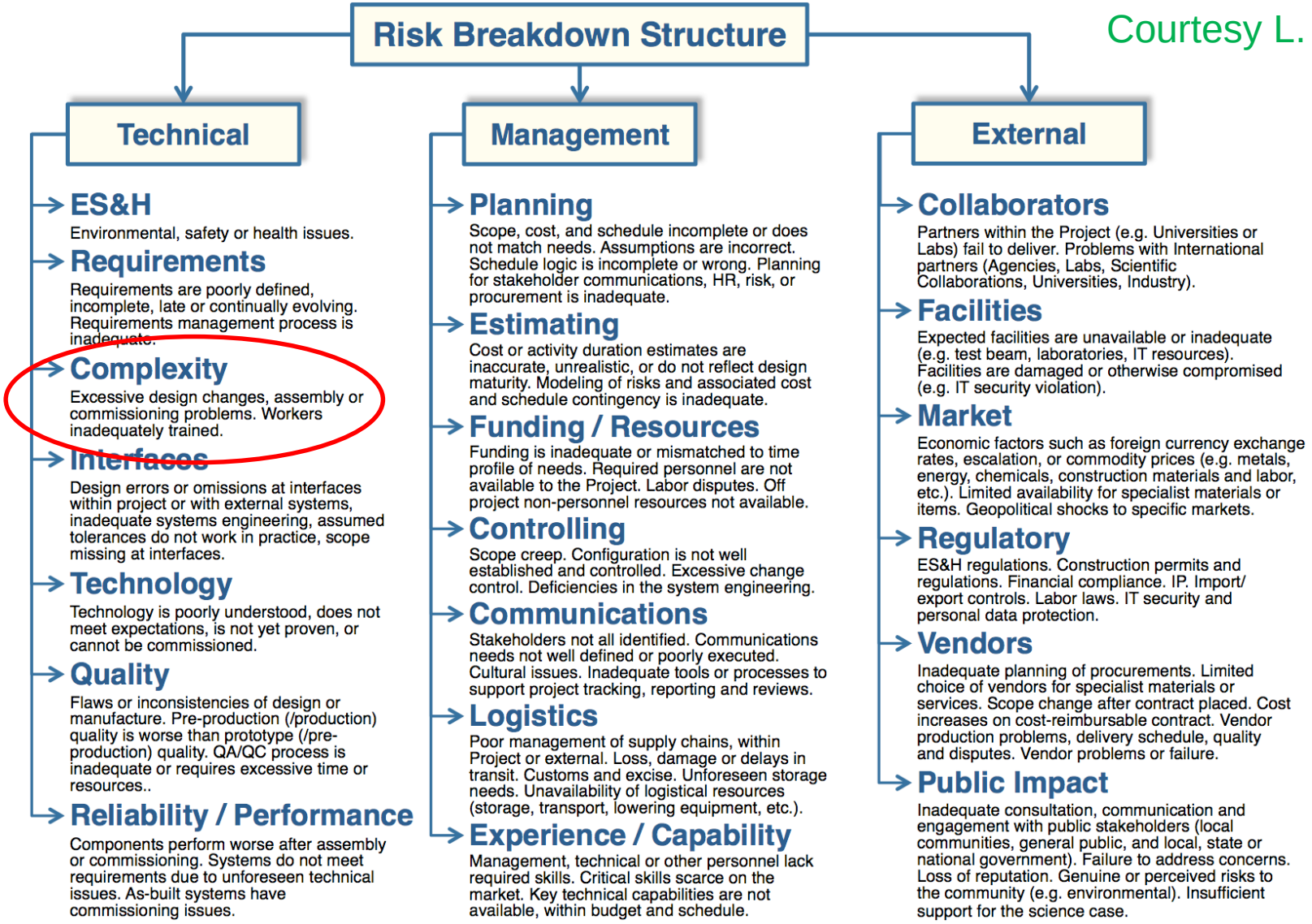
E-XFEL Cold Linac @ 17.5 GeV

« Yesterday, 12.07.2018 at 18:00, the superconducting accelerator of the European XFEL has for the first time accelerated electrons up to its design energy of 17.5 GeV »



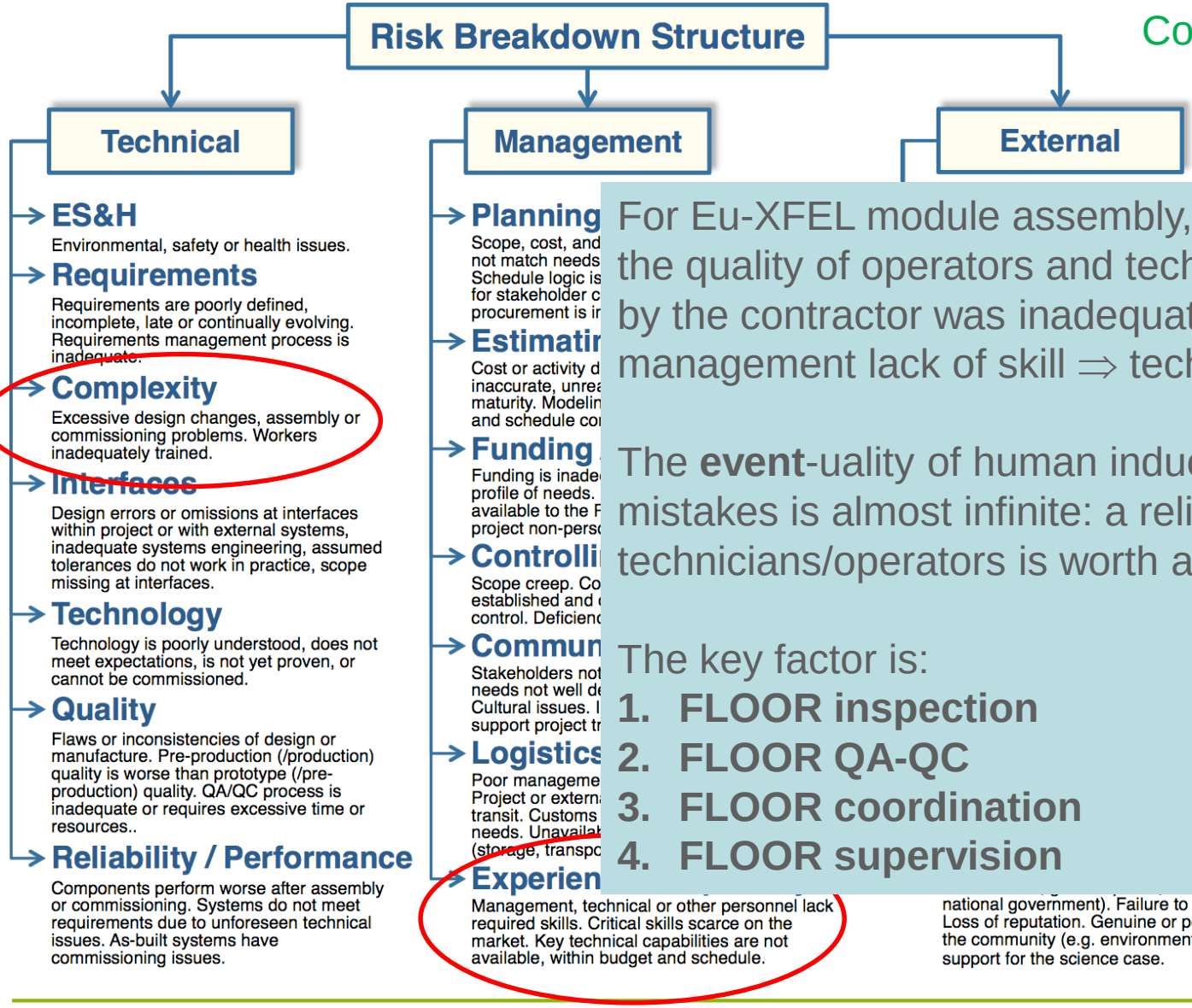
Accelerator Construction : Complexity

Courtesy L. Taylor



Accelerator Construction : Human Factor

Courtesy L. Taylor



For Eu-XFEL module assembly,
the quality of operators and technicians hired by the contractor was inadequate:
management lack of skill ⇒ technical mistakes.

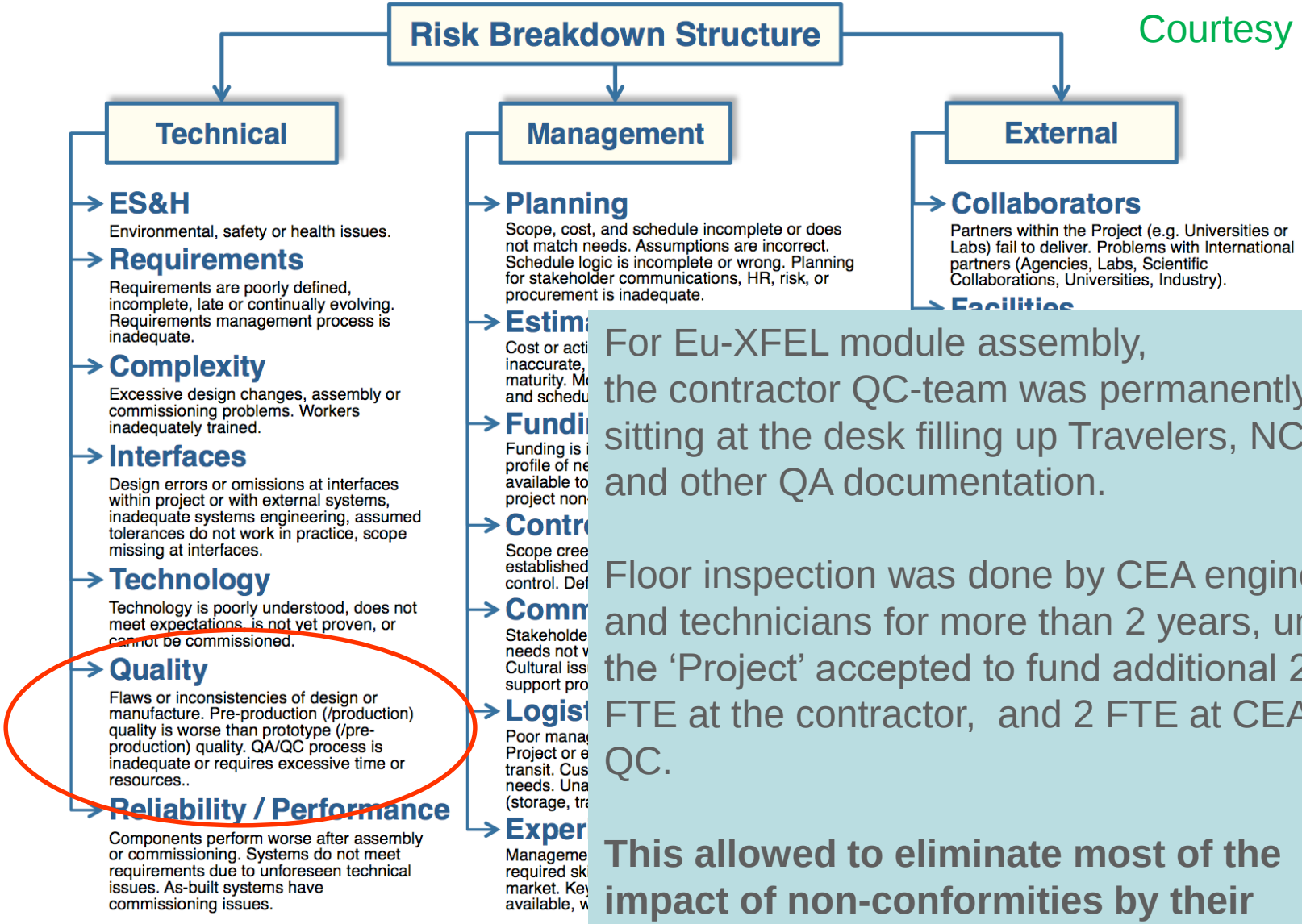
The **event**-uality of human induced technical mistakes is almost infinite: a reliable team of technicians/operators is worth any QA/QC Plan

The key factor is:

1. **FLOOR inspection**
2. **FLOOR QA-QC**
3. **FLOOR coordination**
4. **FLOOR supervision**

Accelerator Construction : Quality

Courtesy L. Taylor



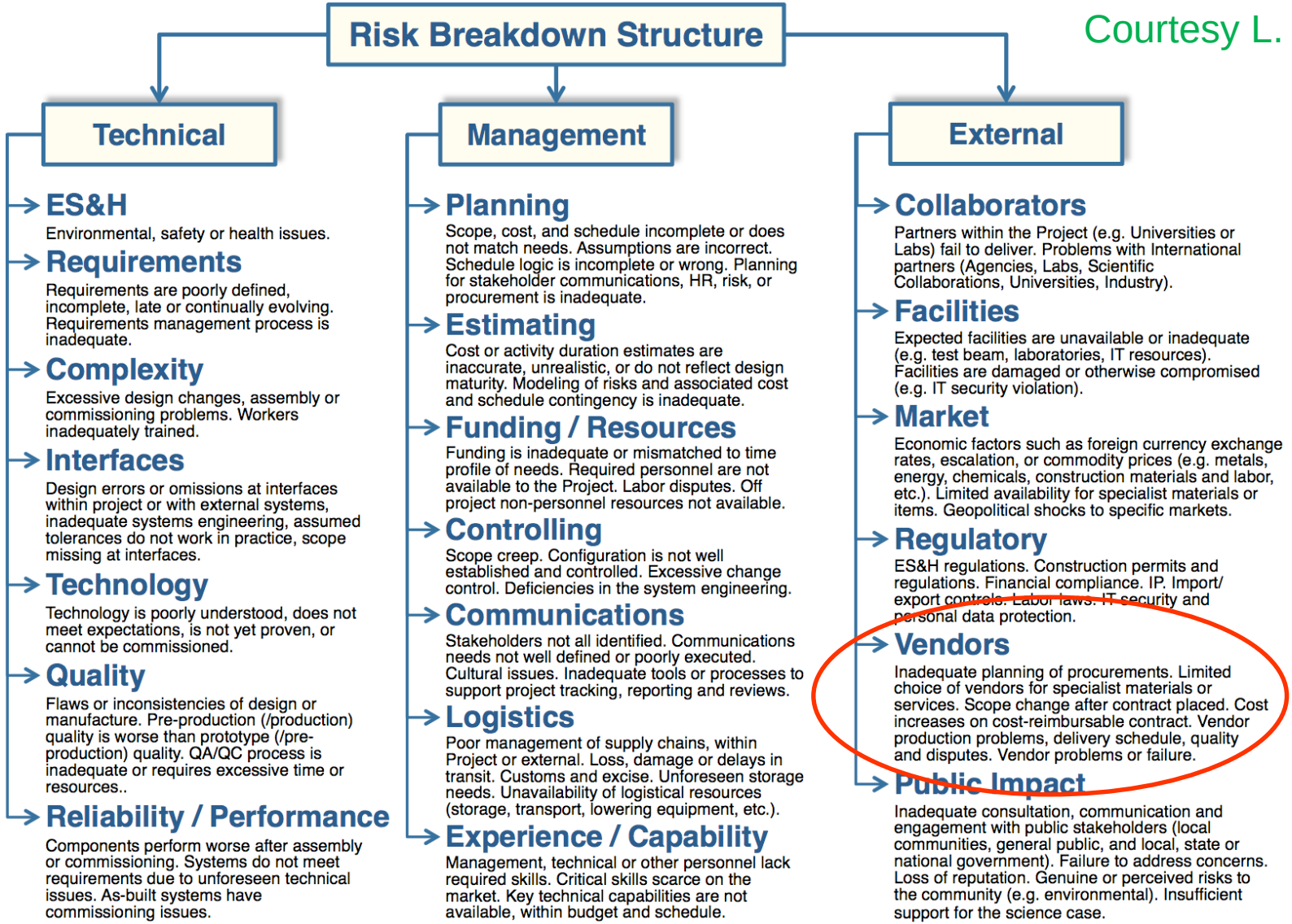
For Eu-XFEL module assembly, the contractor QC-team was permanently sitting at the desk filling up Travelers, NCRs, and other QA documentation.

Floor inspection was done by CEA engineers and technicians for more than 2 years, until the 'Project' accepted to fund additional 2 FTE at the contractor, and 2 FTE at CEA for QC.

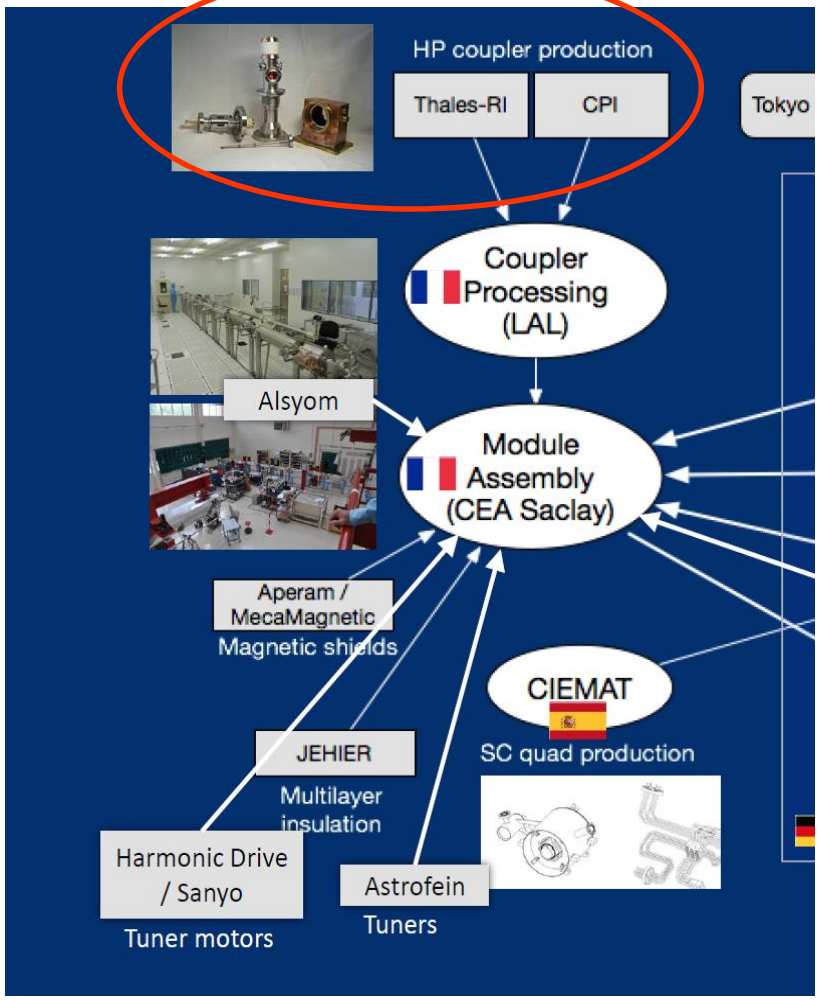
This allowed to eliminate most of the impact of non-conformities by their 'timely' detection.

Accelerator Construction : Vendors

Courtesy L. Taylor



Accelerator Construction : Vendors



Key accelerator technology components are produced by a very small set (1,2,3…) of vendors.

For XFEL power couplers, the Cu-coating know-how was lost by **all** of them.

It resulted in 1-year delay, officially recognized by the Eu-XFEL Council, and ~100 M€ overcosts.

The good news is that Cu-coating capability has been recovered.

Risk Methodology: Risk = Event

In Special Relativity, an **event** is a '*point in spacetime*'.

In Accelerator Construction, we may assume that space-time is not continuous by discrete, with grid sizes:

$\Delta t \sim 5$ minutes

$\Delta x \times \Delta y = 10\ m^2$ (actually, we need a variable mesh size)

$\Delta z \sim 5$ m

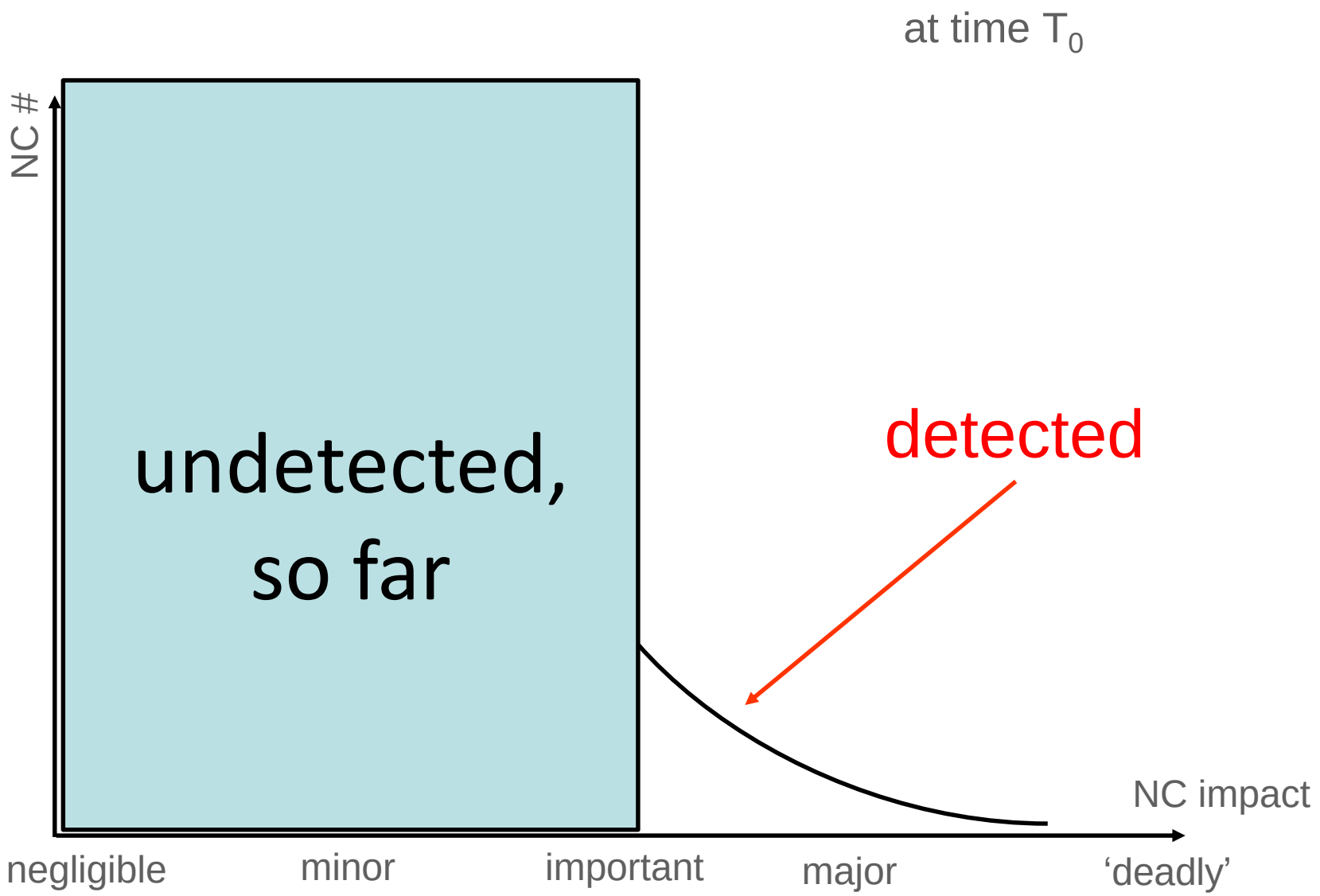
Over ~10 years of design and construction, over 5 x 10,000 m^2 of construction plants at **partners** labs + *n* x S m^2 of fabrication plants at industries + transportation routes:

$\Rightarrow$ there is an infinite number of events *when* $\times$ *where* non-conformities can occur.

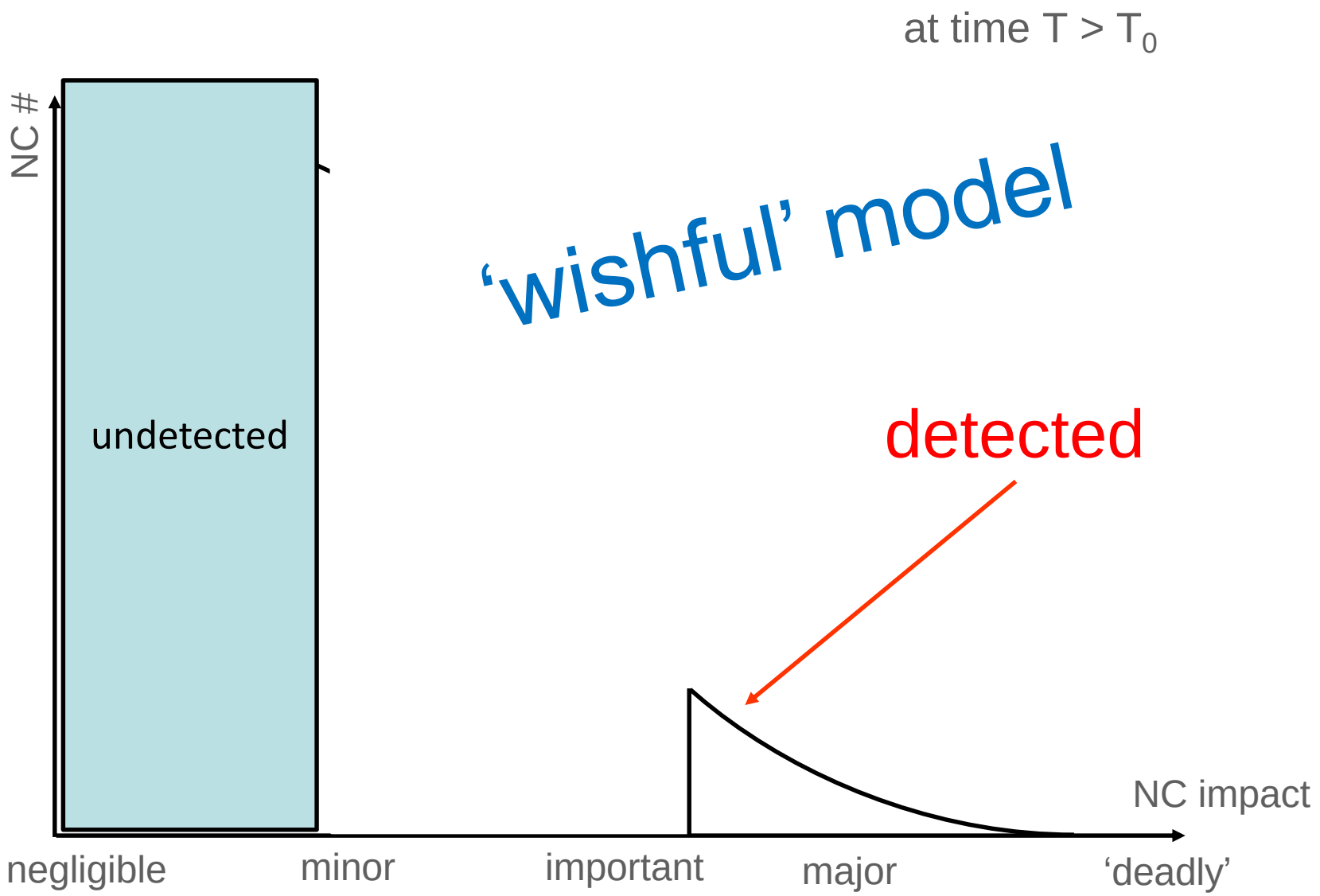
Risk ‘Event’ during transportation

- One Toshiba Klystron was on board of this vessel… and is finally lost; replacement by Toshiba within schedule is possible.

Non-Conformities Statistics



Non-Conformities Statistics



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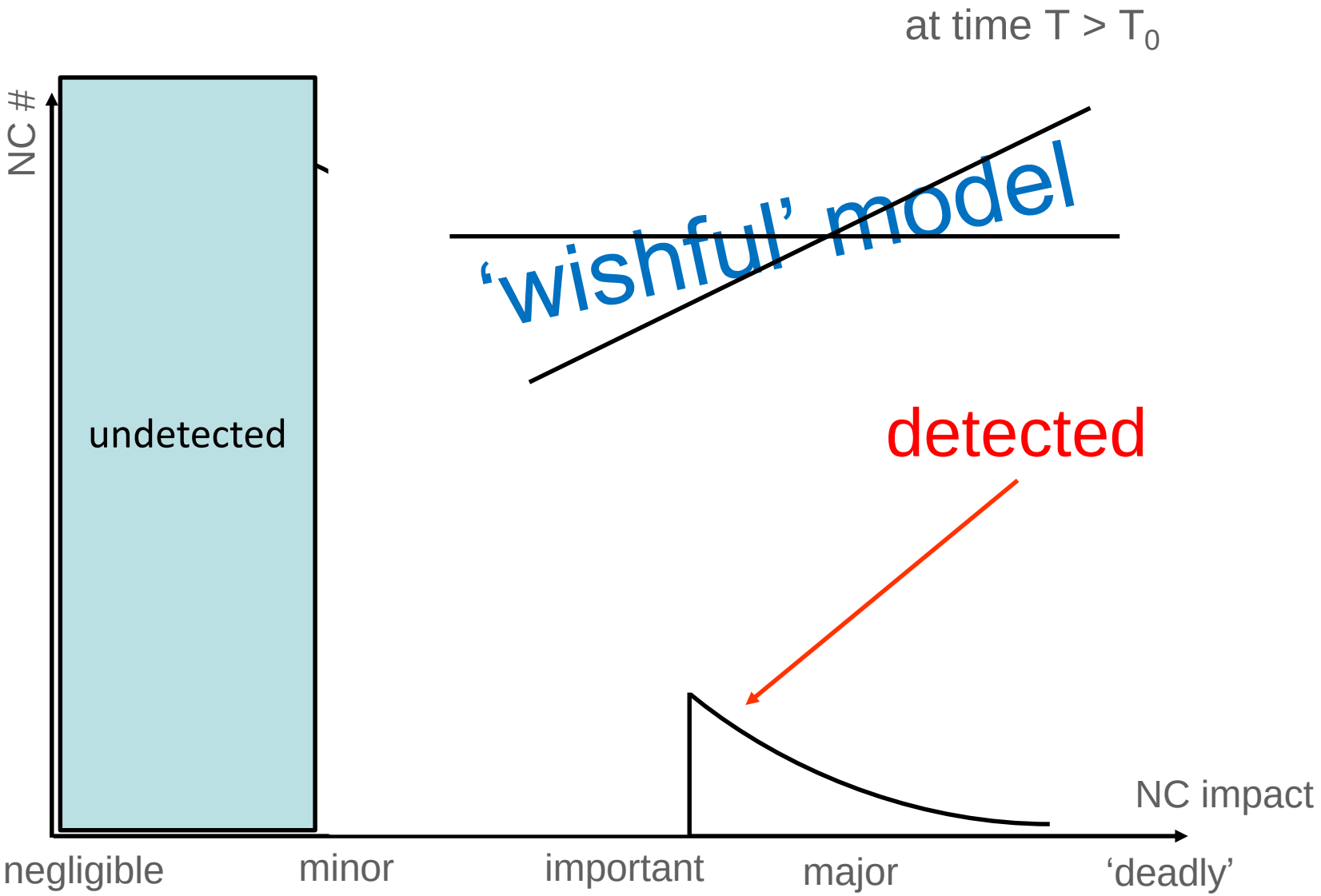

Non-Conformities Statistics

at time $T > T_0$

‘Iceberg’ model

True model as long as d(NC#)/dT is large