ILC-HiGrade Scientific and Annual Meeting

CERN, February 25th 2010

WP8 - Tuners Report

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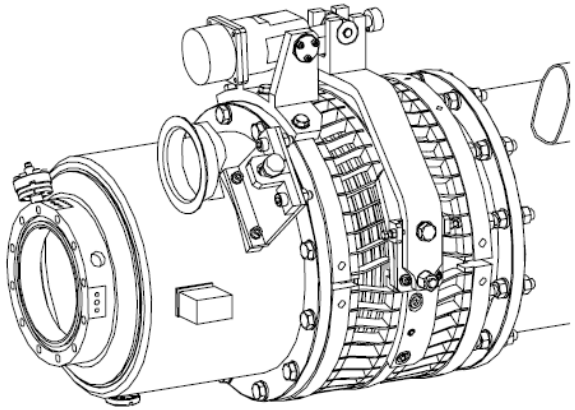
On behalf of LASA team: **C. Pagani, A. Bosotti, R. Paparella**

Outline of the talk

- Introduction and overview of Year 1 results
  - Key concepts about Blade Tuner
  - From prototyping to the final design
- Year 2: recent results and achievements
  - Production and purchasing
  - Cold tests and installations
- Year 2 budget report
  - Preview of main numbers, report under completion

Introduction

- A coaxial design for a cold tuning system was needed to operated the 2-cavity “super-structure” resonators at DESY.
  - “Blade” concept: through thin “blades” transform the rotation of the two center ring halves in a longitudinal axial motion that changes the cavity frequency modifying its length.
- The experience with the super-structures tuner ended up successfully, each cavity has been tuned to its nominal frequency and operated.



Blade Tuner development

- The interest for a different design of TESLA cavity tuning system, alternative to the existing TTF lateral tuner, was still there after super-structures
- Key features in view of Tev-range linacs as TESLA or ILC:
  - Coaxial grants the possibility of renewal of cavity end-region design, and to reduce inter-cavity space.
  - Continuously increasing gradients led to critical LFD and to the need of fast actuators: a coaxial tuner can benefit of an higher fast tuning efficiency.
- Piezo introduced in the design:
  - In series with the tuner mechanism: highest tuning efficiency
  - Two actuators installed, positioned in the mid-plane
- A standard TTF cavity and tank assembly has been adapted as a starting point. Anyway, since no further testing slots were available a **deep redesign activity started**.

Blade Tuner "Slim" Prototype

Lighter

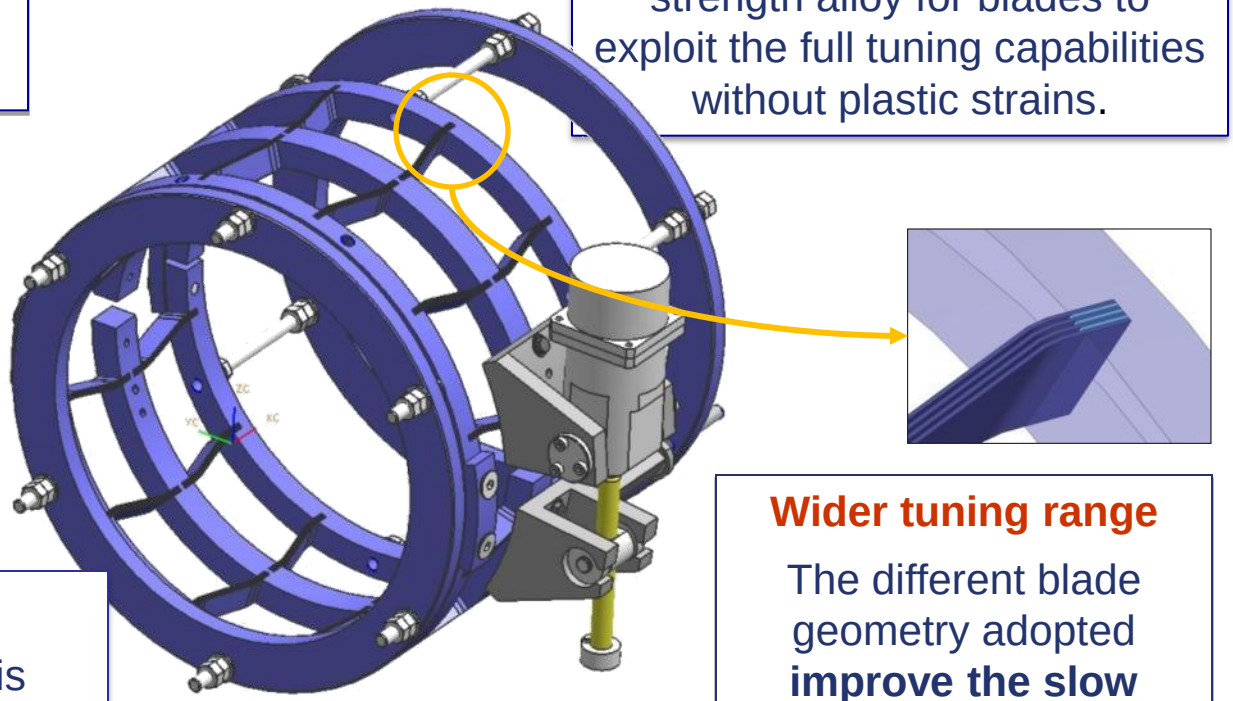
The redesign of rings allowed an important **weight reduction** (about 40%) maintaining the full symmetry with collinear blades.

Ready for future SS tank

The tuner can be **built both with titanium or stainless steel rings**. We used a high strength alloy for blades to exploit the full tuning capabilities without plastic strains.

Cheaper

The new geometry and mechanism lead to an **important reduction of costs**.



New driving mechanism

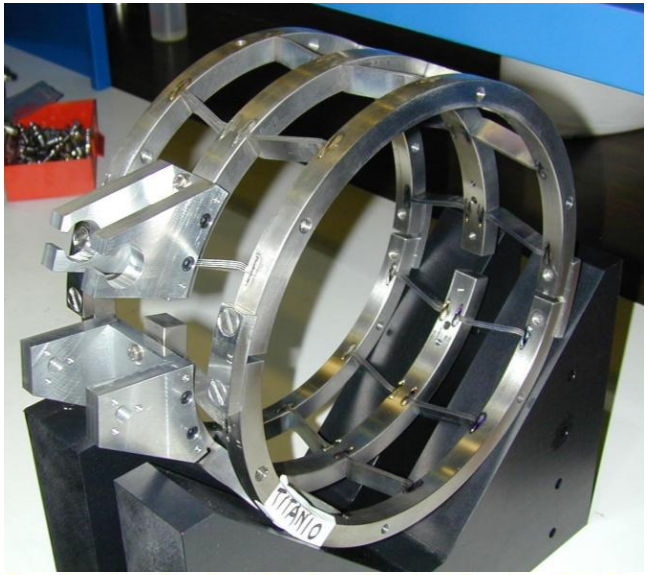
The new driving mechanism is simpler, **cheaper and more compact**, simplifying the installation of an external **magnetic shield**.

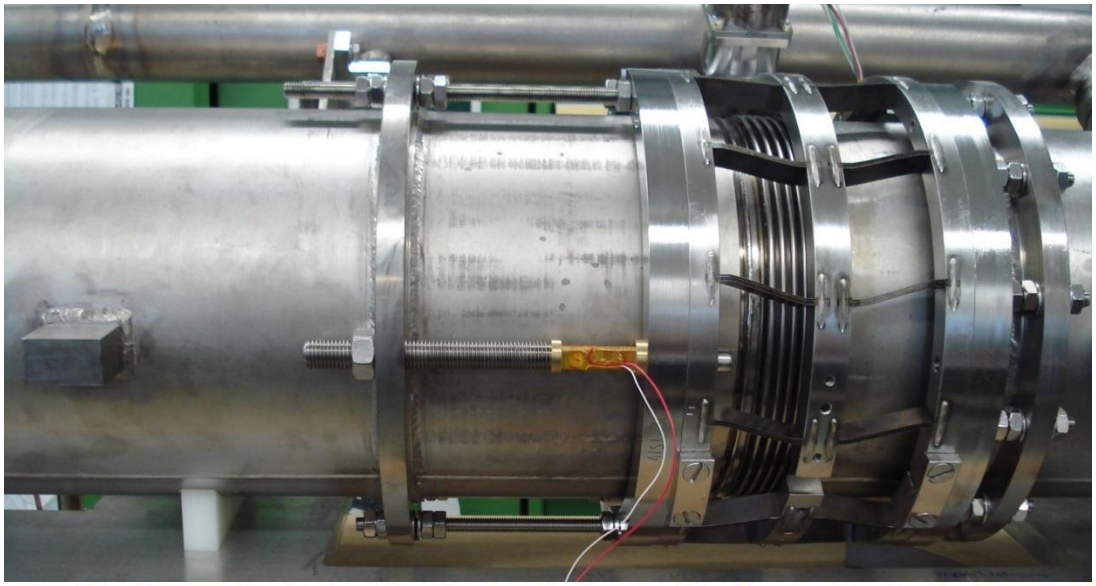
Wider tuning range

The different blade geometry adopted **improve the slow tuning capabilities** to more than 1.5mm at the cavity level.

Blade Tuner prototypes

- Two units, a SS+INCONEL and a Titanium prototypes, realized for testing.
- The former one has been characterized also at cold:
  - Sept. 2007 in the CHECHIA horizontal cryostat, DESY. Installed on the Z86 TESLA cavity equipped with a modified TTF He vessel, 2 Noliac 40 mm standard piezoelectric actuator installed.
  - Feb. to Apr. 2008 in the HoBiCaT horizontal cryostat, BESSY.
- Several analyses and data have been collected during this experimental prototyping phase, leading to a deep understanding of its behaviour.

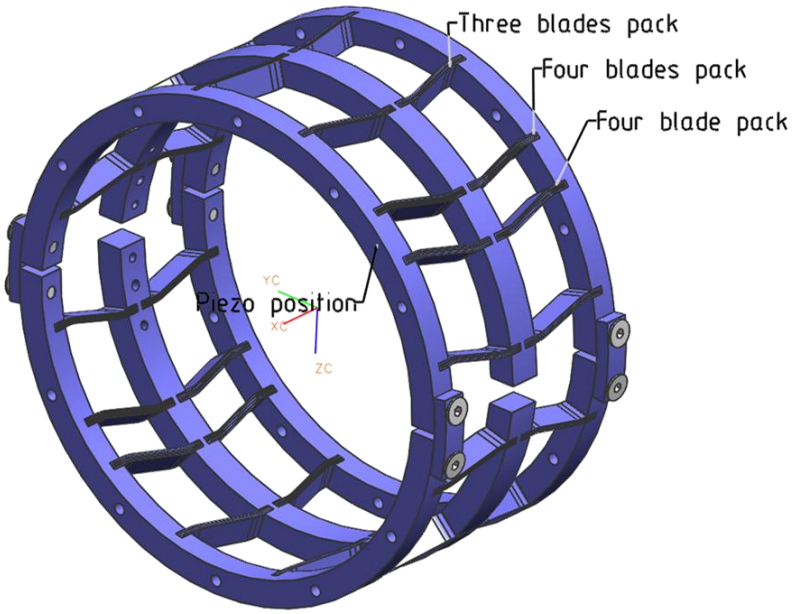


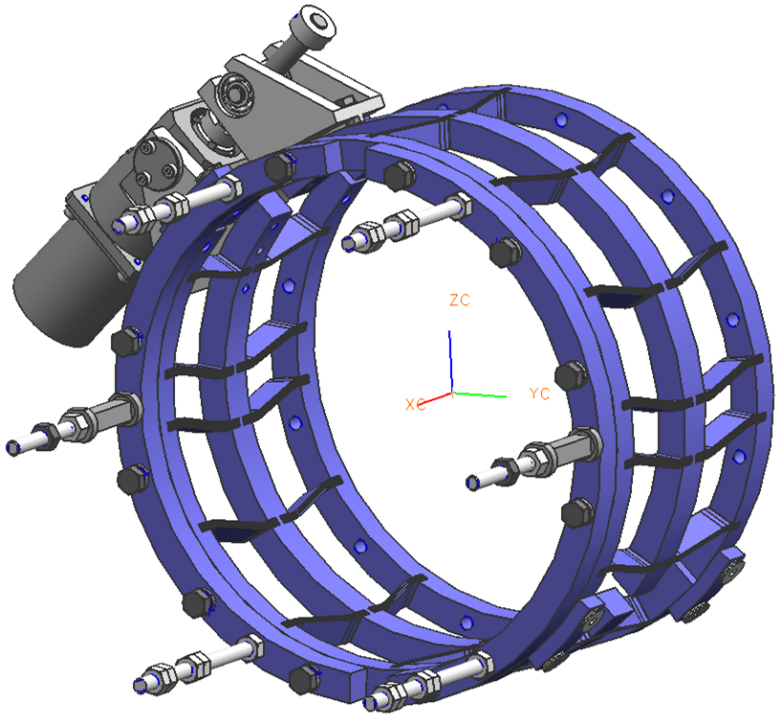


From prototypes to the ILC Blade Tuner

By 2008, the prototyping phase of the tuner development could be considered as positively concluded.

The experience gained so far converged in the final revision of Blade Tuner design.



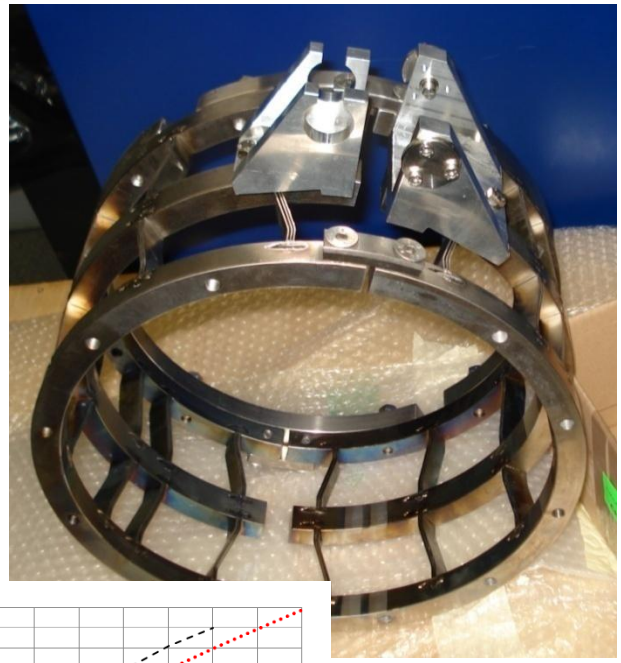


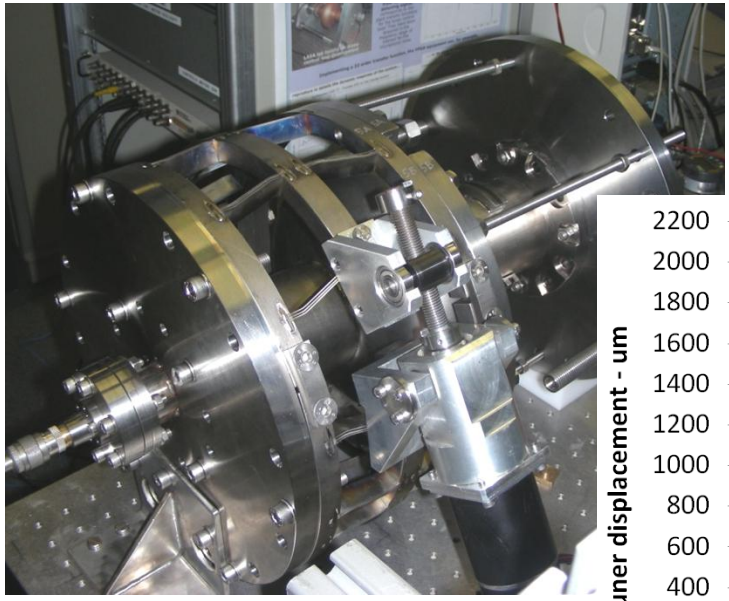
The tuner is now designed to address and fulfill all the XFEL and ILC specifications:

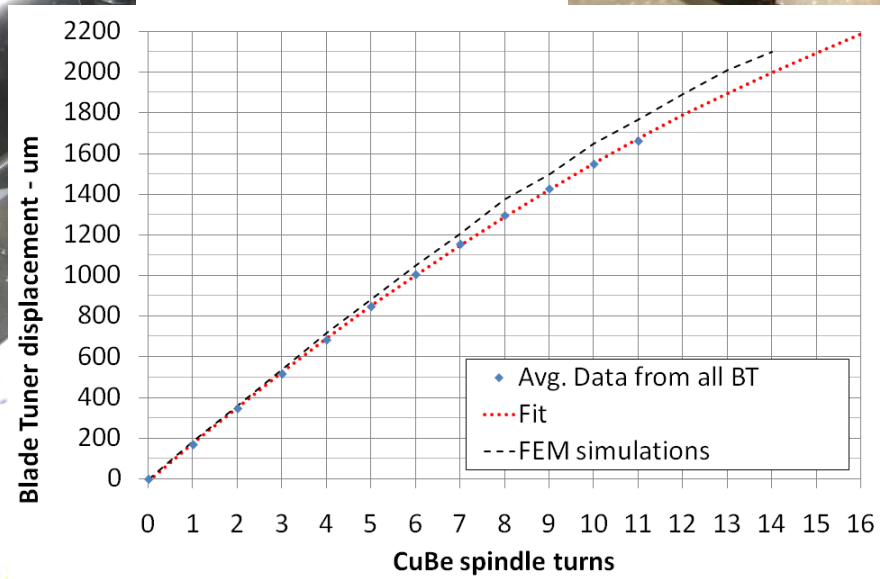
- LFD compensation with significant performance margin, for affordable high gradient operations.
- Increased tuner strength to satisfy ASME safety codes, both in compression and in traction.

From Year 1 report

- The first 8 units of revised Blade Tuner have been already manufactured. Two shipped to Fermilab.
- Acceptance test at room temperature at LASA on each unit: results met expectations in terms of homogeneity and predictions





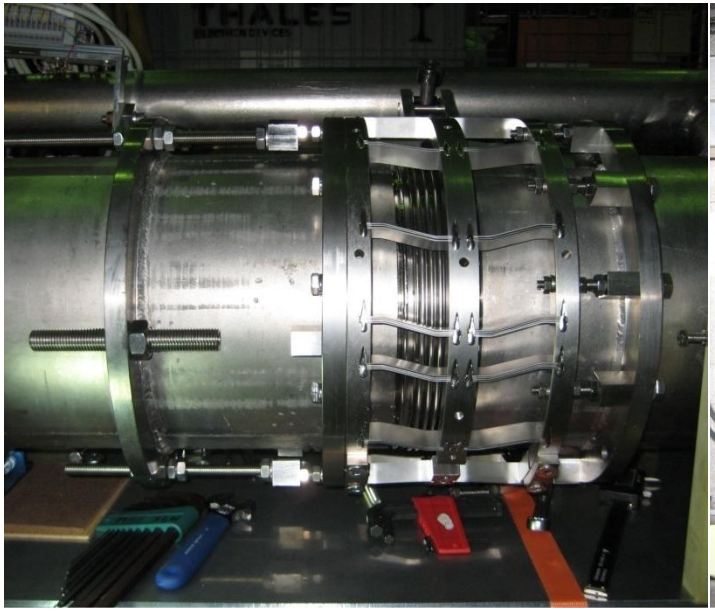
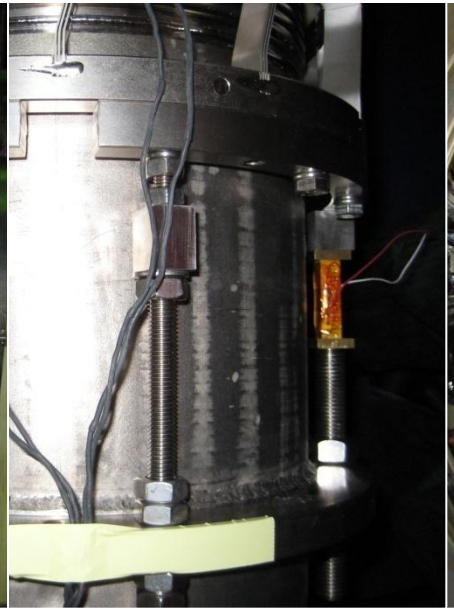
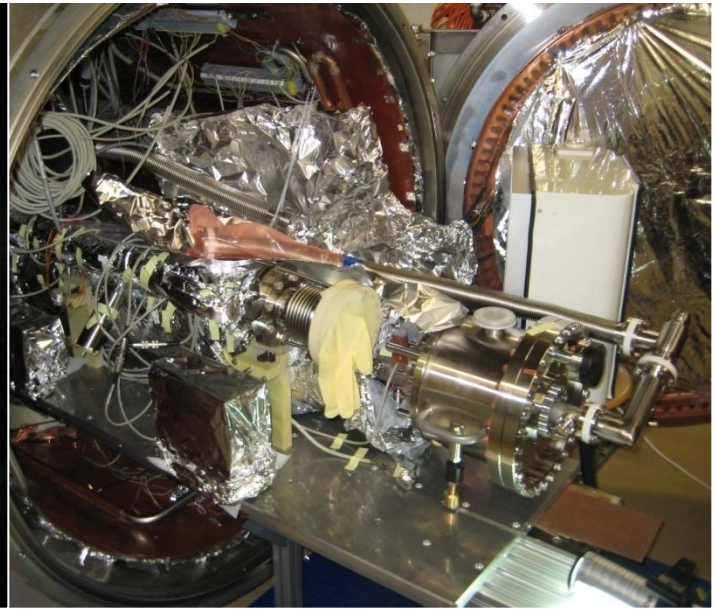


Year 2: production

- Experience with ordering and manufacturing has been further extended over this last year.
- At present:
  - A total of 10 units produced and subjected to RT acceptance test. Results and uniformity of performances as expected.
  - 6 more units already ordered, delivery expected by April 2010.
  - Frequent and extensive interactions with the manufacturer E. Zanon (Schio, Italy):
    - Several issues within the manufacturing process have been optimized, with a deep impact on both the tuner final quality and unit cost!
    - A first feedback will come with the next tuner production, if proved to be effective this will be a major step forward within the ILC-HiGrade WP8 task.

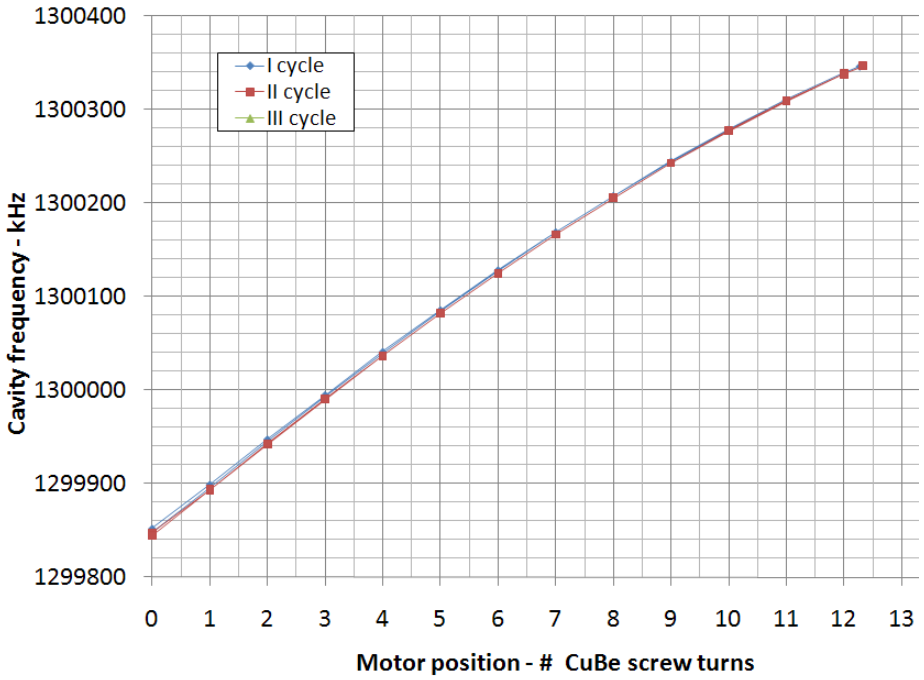
Tuner studies and cold testing

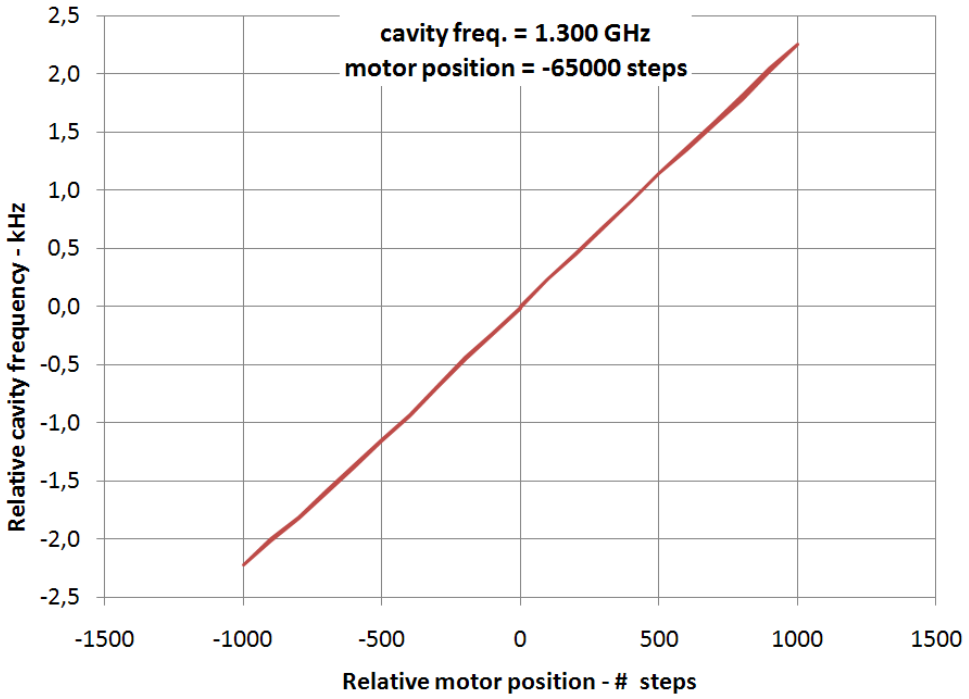
- Extensive cold testing session for the ILC Blade Tuner successfully performed:
  - Installation at HoBiCaT horizontal cryostat at BESSY on Dec. 2009. The cavity assembly used was the same as for prototypes (Z86)
  - One week tuner CW cold testing session performed at BESSY in Jan. 2010.
  - Some limitations to the measurements due to the DCM installed on Z86

Cold tests results

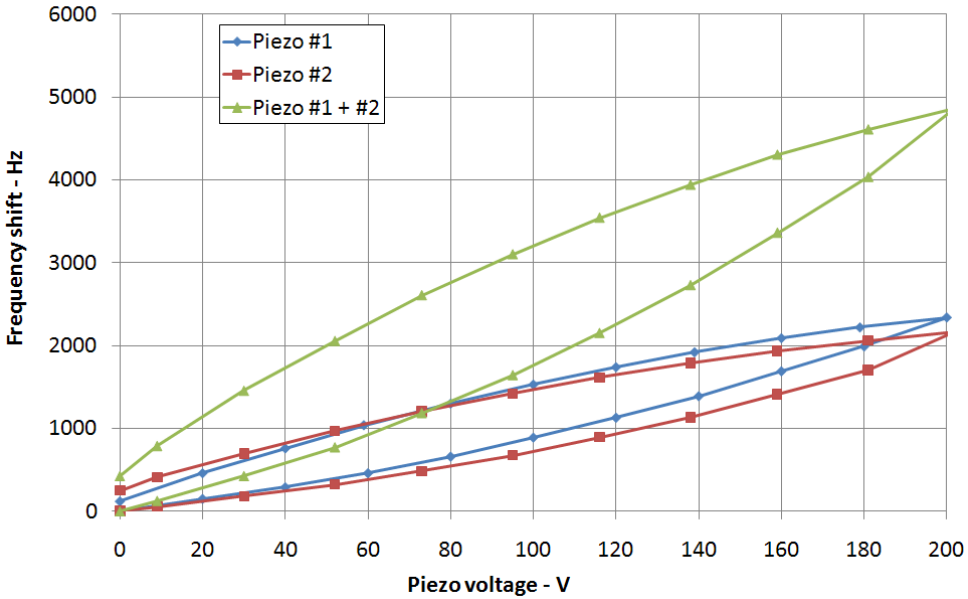
- Optimum coarse and fine tuning results:
  - 500 kHz measured tuning range, with margin. Resolution of 1.3 kHz/half-step.
  - Extremely small hysteresis over the full tuning range: an additional benefit related to the increased stiffness of this new design.
  - High reproducibility in the tuning action in a small range around the nominal working point of 1.300 GHz

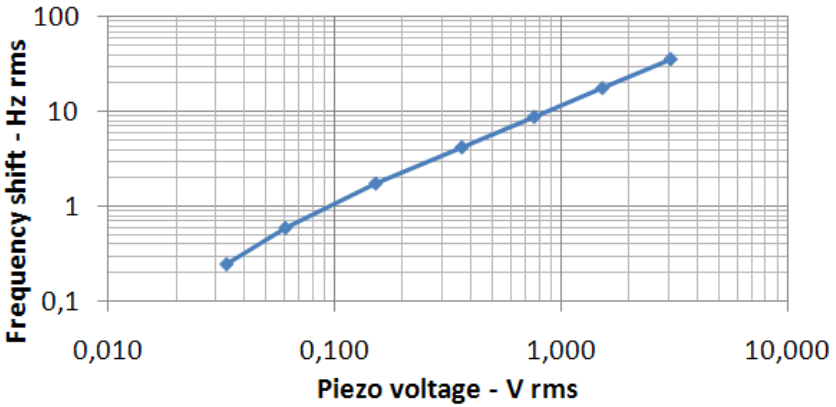




Cold tests results

- Also fast tuning capabilities met design expectations:
  - 5 kHz static piezo tuning range, almost symmetricallyy distributed on the two actuators: high margin for operations at ILC goal gradient when about 1 kHz of LFD is expected.
  - Extremely smooth coupling between piezo actuators and cavity up to nm level: no sticking or threshold effects in piezo tuning!
  - Several additional measurements, transfer functions and microphonics acquisition.

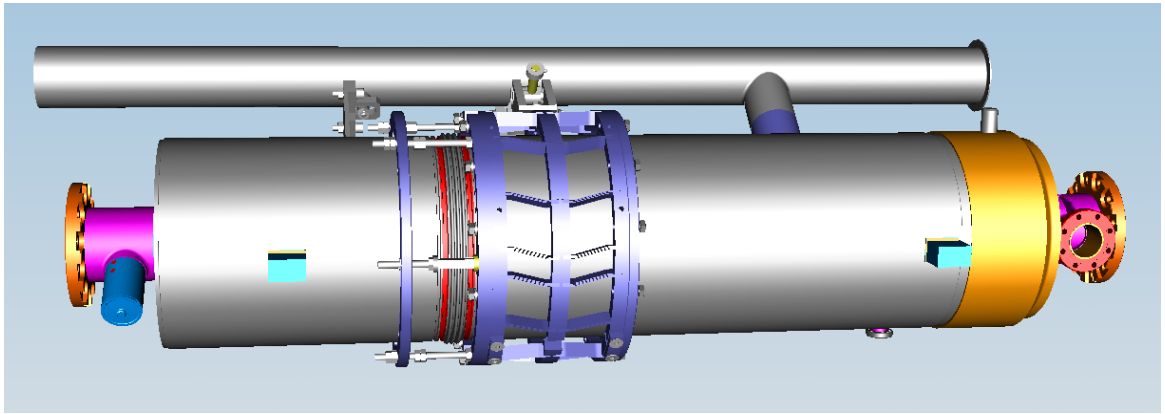




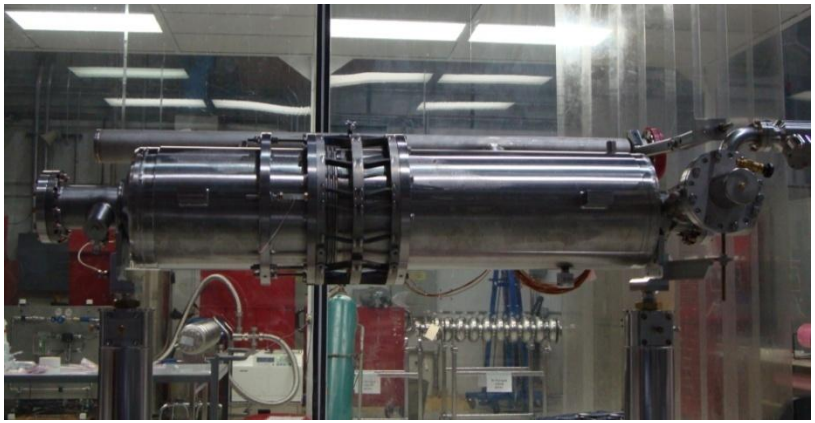
Major installations: CM2 at Fermilab

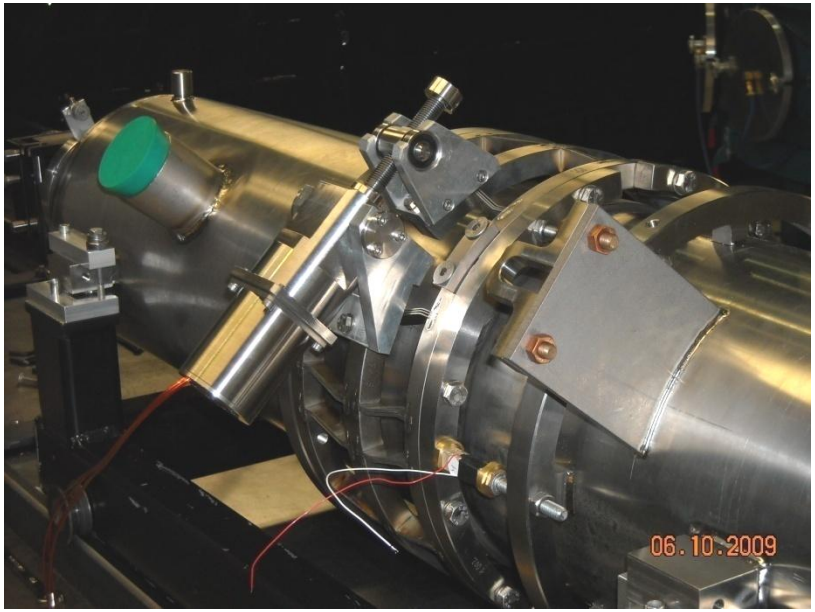
The second cryo-module for the ILC-TA facility at Fermilab will be fully equipped with Blade Tuners:

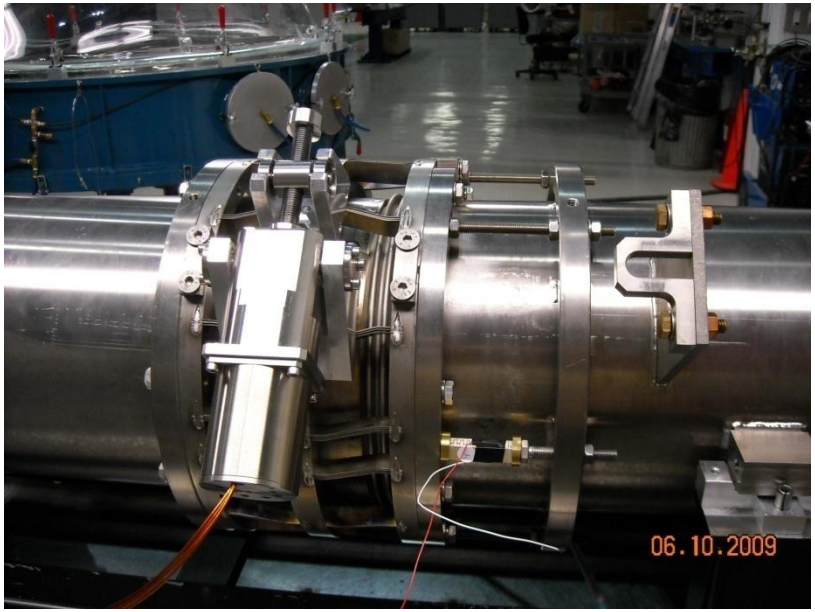
- A key step toward ILC: these are the first cavity units specifically designed for Blade Tuner, including a new helium tank design, new magnetic shielding and MLI wrapping.
- Today 6 complete tuner units out of the 8 needed for CM2 are at FNAL, the two remaining units will be shipped by March. FNAL, in addition, already expressed interest for two additional Blade Tuner units among the next bench under production.
- The first units of new helium tank have been manufactured and 3 cavities have been equipped. Tuner installation have been completed for two cavities, the latter being right now in HTS horizontal cryostat for cold testing, tuner testing results will follow shortly.

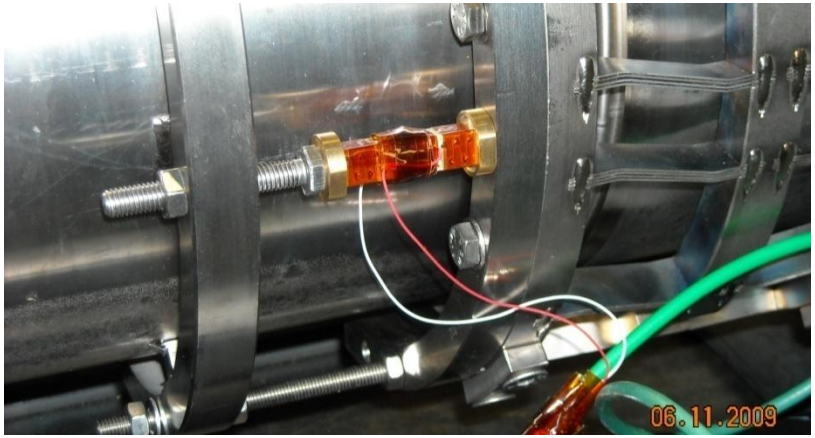


Major installations: CM2 at Fermilab









Major installations: S1-Global at KEK

The S1-Global project in KEK (Japan):

- Demonstration of effective cryo-module operations at the ILC goal gradient
- Realization of an actual comparison of different cavity and cold tuning solutions, a step toward the concept of plug-compatibility
- Two complete Blade Tuner units have been shipped and delivered to KEK by the end of last year.

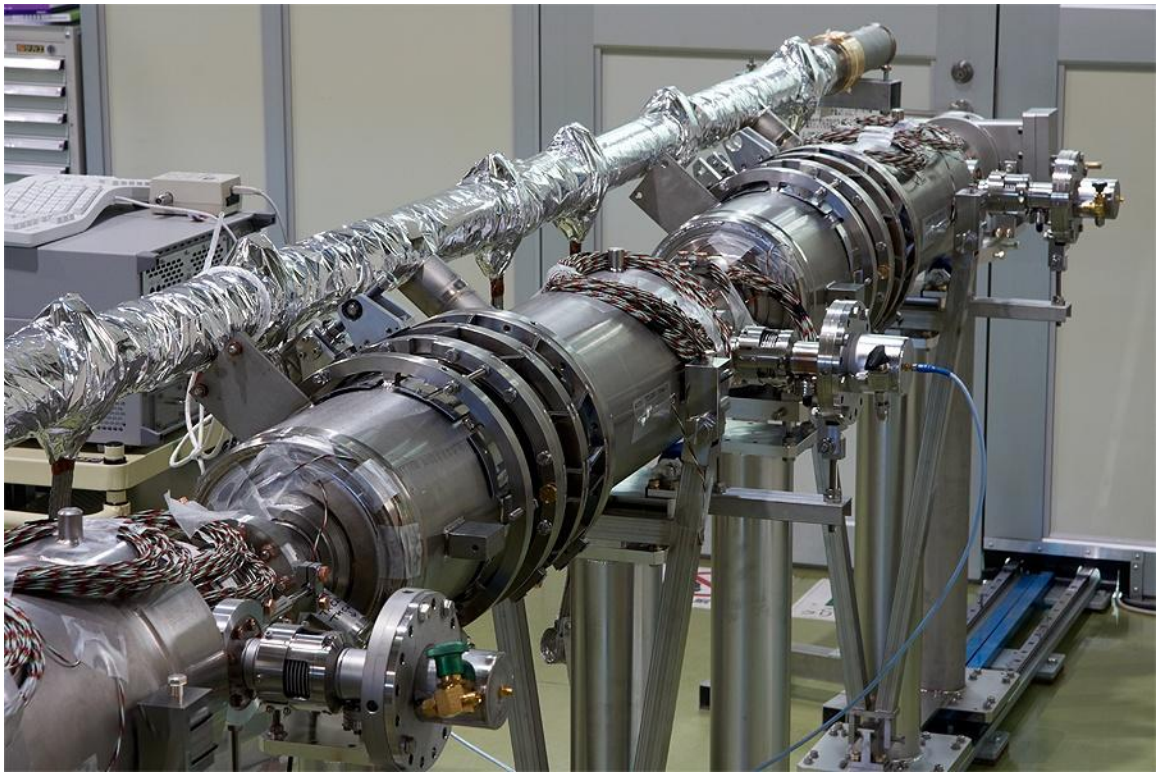
Cryo-module C is a 4 cavity vessel with a mixed configuration:

- Cav. 1 from AES, equipped with Blade Tuner
- Cav. 2 from Accel, equipped with Blade Tuner
- Cav. 3 and 4 from Zanon, equipped with the latest FLASH tuners

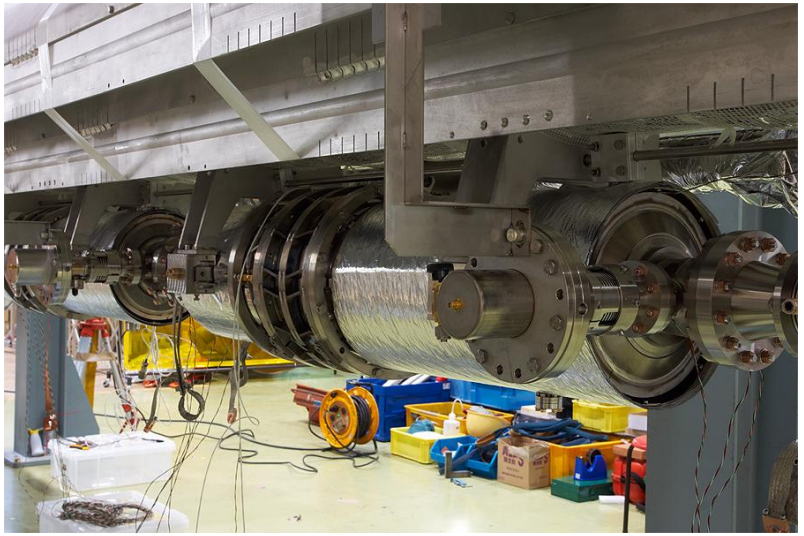
Major installations: S1-Global at KEK

The installation of all 4 tuning systems on the cold string took place from the 8th to 12th of February, 2010:

- A joint group composed by experts from INFN, FNAL and KEK took charge of all operations

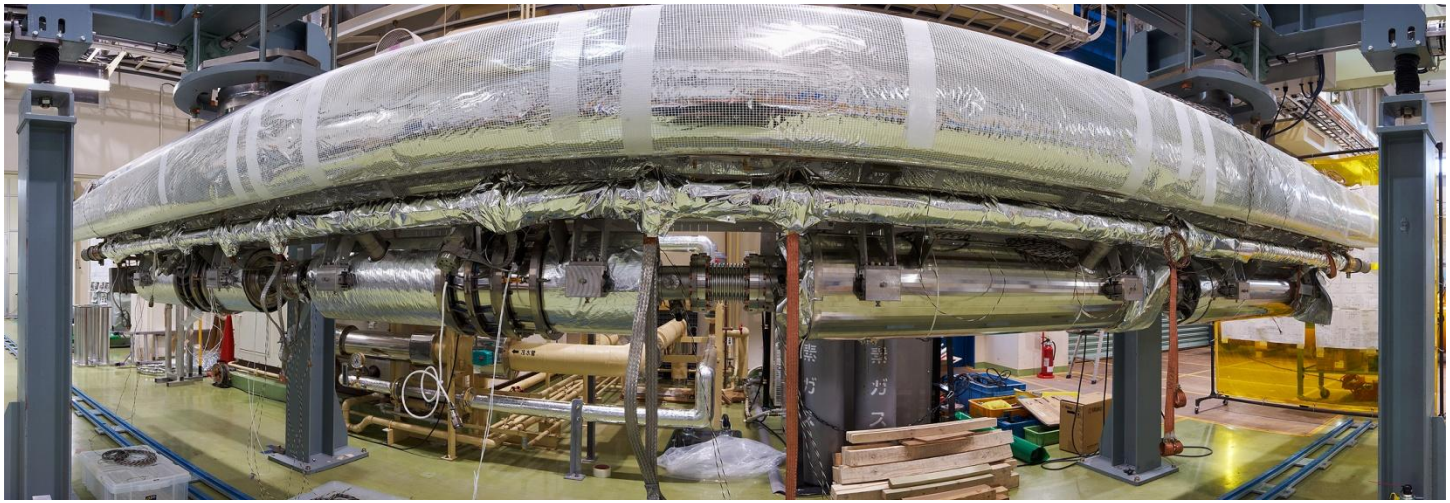


Major installations: S1-Global at KEK



Major installations: S1-Global at KEK

- Cold string installation experience was extremely positive and fruitful in terms of possible procedure optimization
- Minor problems emerged. Concerning the Blade Tuners cavities:
  - Small machining of two of the tuner connecting plates required
  - Existing cavity supports didn't allowed for an easy magnetic shield installation
- Anyway each one has been solved with the collaboration of KEK and company employees and the schedule has been matched.
- Each tuning system has been subjected to a basic acceptance test after installation: frequency shifts induced by motor unit and by piezos have been measured and matched expectations.



Perspectives

- As of today a large amount of data and information are already available concerning both tuner production and experimental validation, to be gathered in the Tuner Report due for Deliverable 8.2.
- In addition, within few months from now further more data will be collected to complete the experimental characterization of the ILC Blade Tuner:
  - Horizontal test are ongoing right now at Fermilab, this will be the first experimental verification of the complete Blade Tuner system.
  - Shortly after, between June and July, the S1-Global cryo-module cold test at KEK will be an outstanding testing environment, one entire month of low power CW operations is already scheduled just for cold tuning measurements.

The first Financial Report

Several issues were included one year ago in the **ILC Hi-Grade Year One Financial Report**:

- INFN personnel
- External travelling, participation to meetings and testing of tuner prototypes.
- Realization of Blade Tuner prototypes. Purchasing of Blade Tuner assembly key components (piezo actuators, stepper motors and control electronics)
- Realization of a coaxial tuner test assembly for room temperature qualification

FP7 - Grant Agreement - Annex VI - Combination of CP & CSA

Form C - Financial Statement (to be filled in by each beneficiary)

Project nr.	206711	Funding scheme	Combination of CP & CSA
Project Acronym	ILC-HiGrade		
Period from	01/02/2008	Is this an adjustment to a previous statement?	No
To	31/01/2009		
Legal Name	ISTITUTO NAZIONALE DI FISICA NUCLEARE	Participant Identity Code	
Organisation short Name	INFN	Beneficiary nr.	5
Funding % for RTD activities (A)	75.00	If flat rate for indirect costs, specify %	60.00 %

1. Declaration of eligible costs/lump sum/flate-rate/scale of unit (in €)

	Type of Activity					
	RTD (A)	Coordination (B)	Support (C)	Management (D)	Other (E)	Total (A+B+C+D+E)
Personnel costs	47,046.38	0.00	7,807.18	0.00	0.00	54,853.56
Subcontracting	0.00	0.00	0.00	0.00	0.00	0.00
Other direct costs	32,756.08	0.00	0.00	0.00	0.00	32,756.08
Indirect costs *	47,881.48	0.00	546.50	0.00	0.00	48,427.98
Access costs			0.00			0.00
Lump sums/flat rate/scale of unit declared	0.00	0.00	0.00	0.00	0.00	0.00
Total	127,683.94	0.00	8,353.68	0.00	0.00	136,037.62
Maximum EC contribution	95,762.95	0.00	8,353.68	0.00	0.00	104,116.63
Requested EC contribution						104,116.63

* Indirect costs relating to:
- "Coordination" and "Support" activities are reimbursed up to a maximum of 7% of the direct eligible costs relating to these activities excluding the direct eligible costs for subcontracting and the costs of resources made available by third parties which are not used on the premises of the beneficiary,
- "RTD", "Management" and "other" activities are reimbursed in accordance with the various options foreseen in Article II.15.2 a), b) and c) of the grant agreement.

Preview of the second Financial Report

The work on the report is ongoing, just few comments:

- Ing. N. Panzeri, partially funded within ILC-HiGrade last year, left INFN. Nevertheless we expect to achieve almost the same amount for permanent staff personnel cost, about 55 k€.
- In addition, this year about 20 k€ will be added to the overall personnel costs as the funding of temporary staff personnel. Therefore we're expecting a total amount of about **75 k€**.
- Expected amount for direct cost is about **30 k€**, detailed analyses are on-going. Several different elements included as shown for the first year report.
- Further Blade Tuner units have already been ordered and have been paid within HiGrade funding, anyway they will be accounted in the next year-3 financial report.