

# Lorentz force detuning system for Linear Collider TESLA and X-FEL

Work Package #8

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# Main Points

Lorentz force detuning system:

Why... ?

How...?

What ... ?

Who... ?

When...?



# Why do we need a Lorentz force detuning system? (1/2)

The cavities are pulsed at high field.

The field generates the radiation pressure, which interacts with cavity walls.

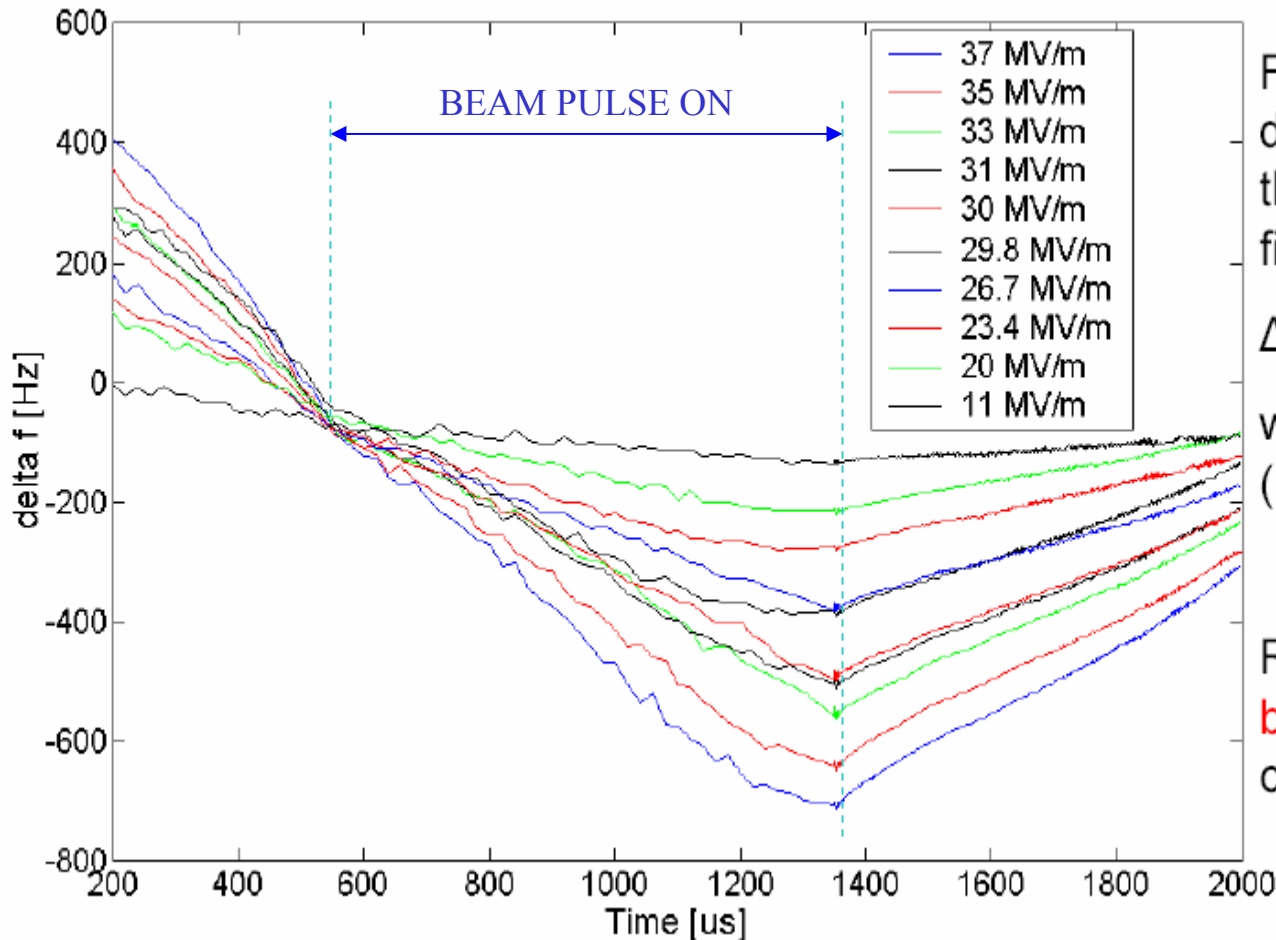
The cavity changes its dimensions,

The change of the resonant frequency of the cavity,

The master oscillator frequency is constant.

**De-tuned cavity**

# Why do we need a Lorentz force detuning system? (2/2)



Frequency detuning due Lorentz forces of the electromagnetic field in the cavities:

$$\Delta f = K \cdot E_{\text{acc}}^2$$

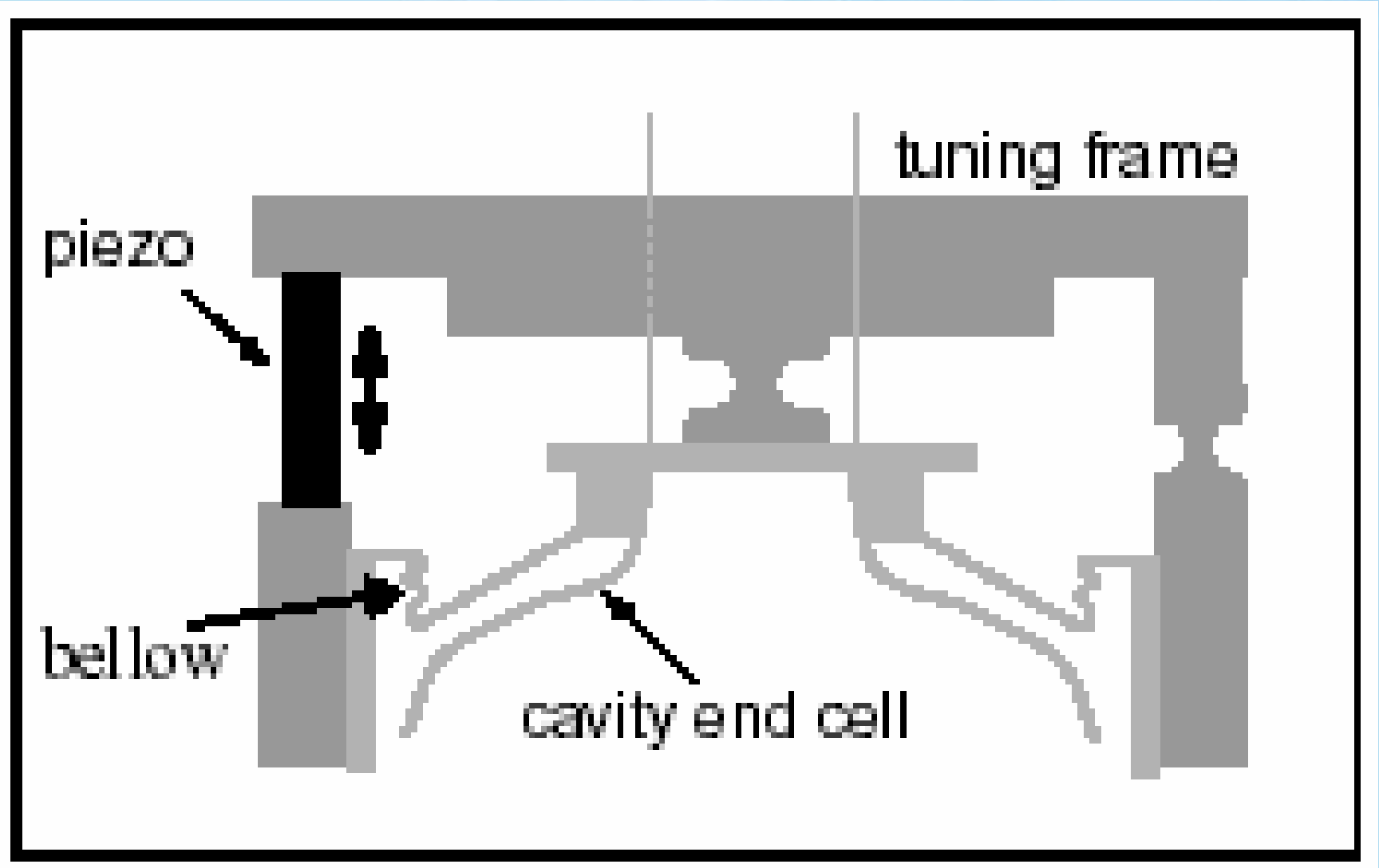
where  $K \approx 1 \text{ Hz} / (\text{MV/m})^2$

Remember: **Cavity bandwidth** with main coupler is  $\approx 300 \text{ Hz}$

# How to maintain the constant phase and amplitude during the RF pulse ?

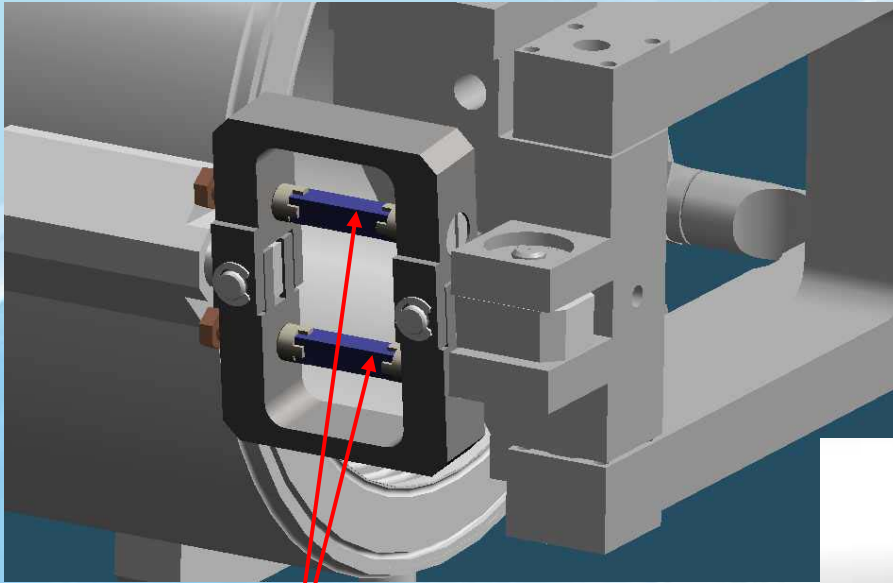
1. Additional RF power for **field control** could be used
2. **Passive detuning system** (stiffness rings, stiffer cavity, fixture) could be used
3. **Active detuning system** with piezoelectric or magnetostrictive device could be used

# What shall we do? (1/3)

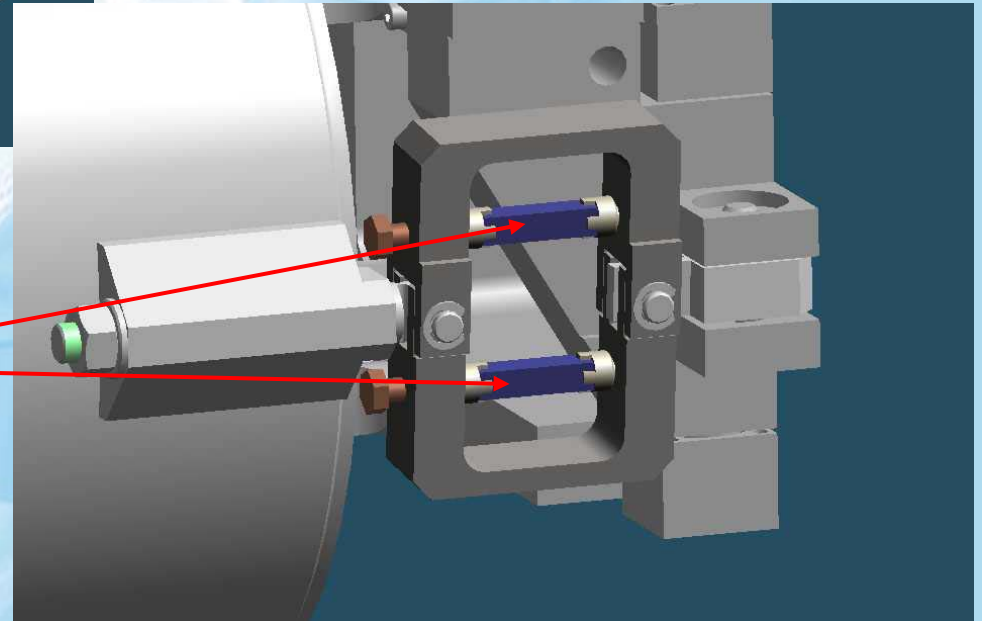


# What shall we do? (2/3)

**Force measurements at 2K**  
on the tuner is needed  
to guarantee correct piezo  
pre-load  
(i.e lifetime)

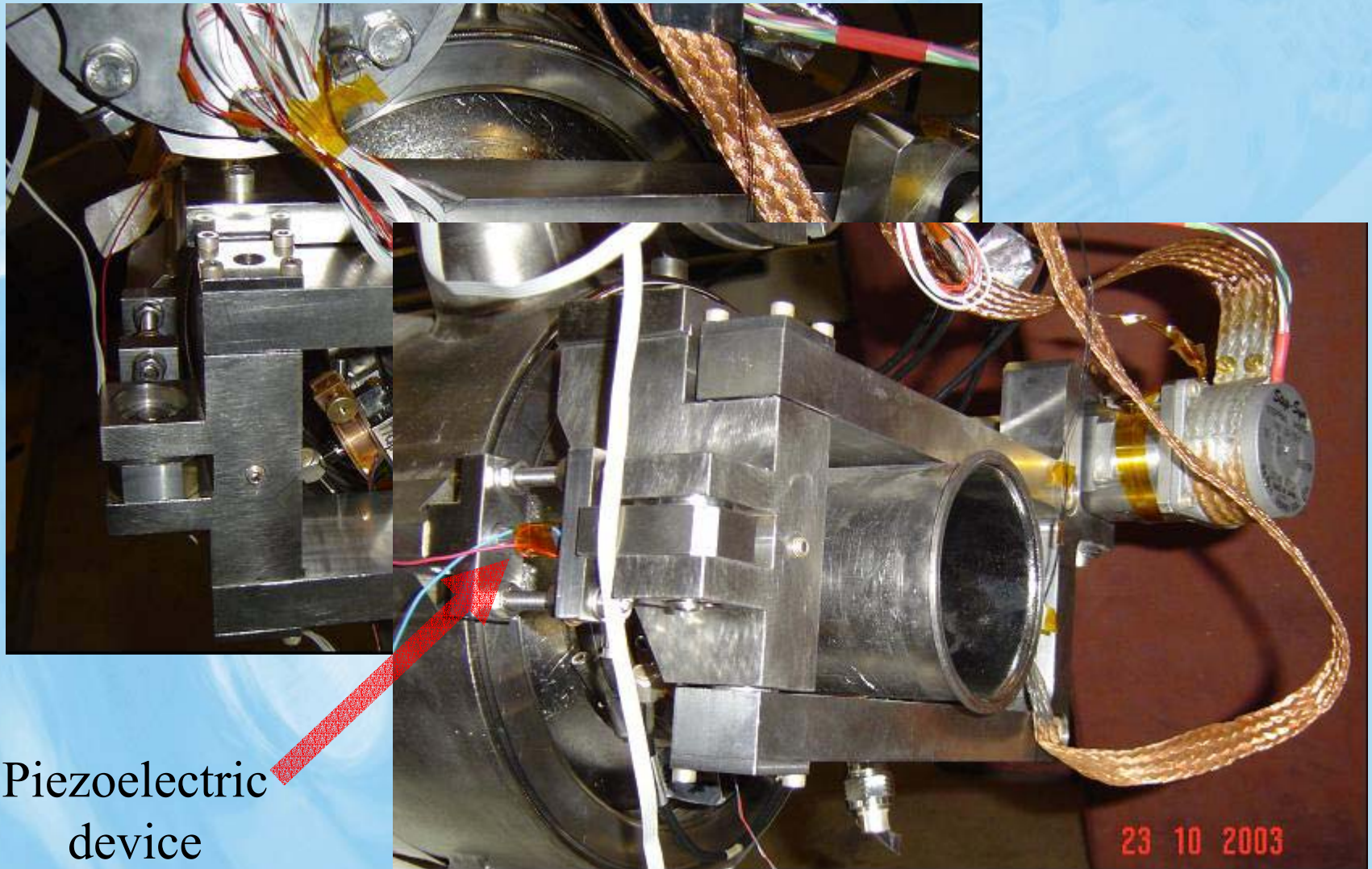


Piezoelectric or  
magnetostrictive  
devices





# What shall we do? (3/3)



Piezoelectric  
device



# Who is involved in WP #8?

- DESY - *Stefan Simrock, Lutz Lilje*  
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- TUL - *Andrzej Napieralski, Przemyslaw Sekalski*  
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Technical University of Lodz, Poland
- INFN - *Angello Bosotti*  
Italian National Institute for Nuclear Physics, Milan, Italy
- IN2P3 - *Mohammed Fouaidy*  
Institut National de Physique Nucléaire et de Physique des Particules,  
Orsay, France
- CEA Saclay - *Olivier Napoly*



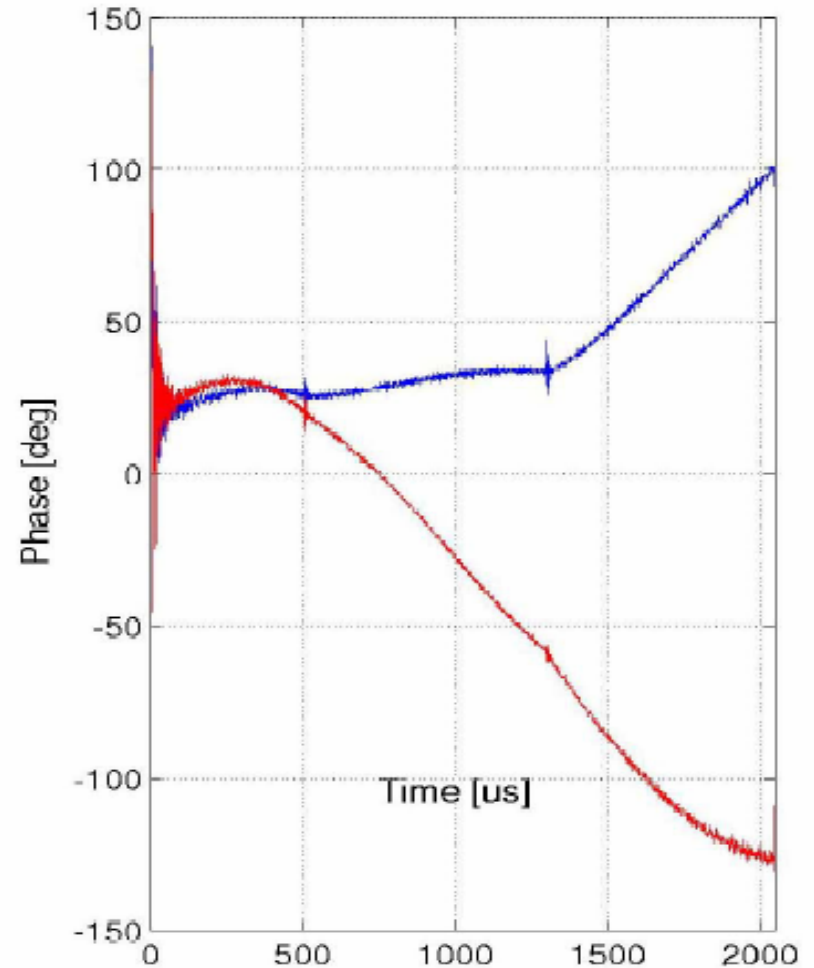
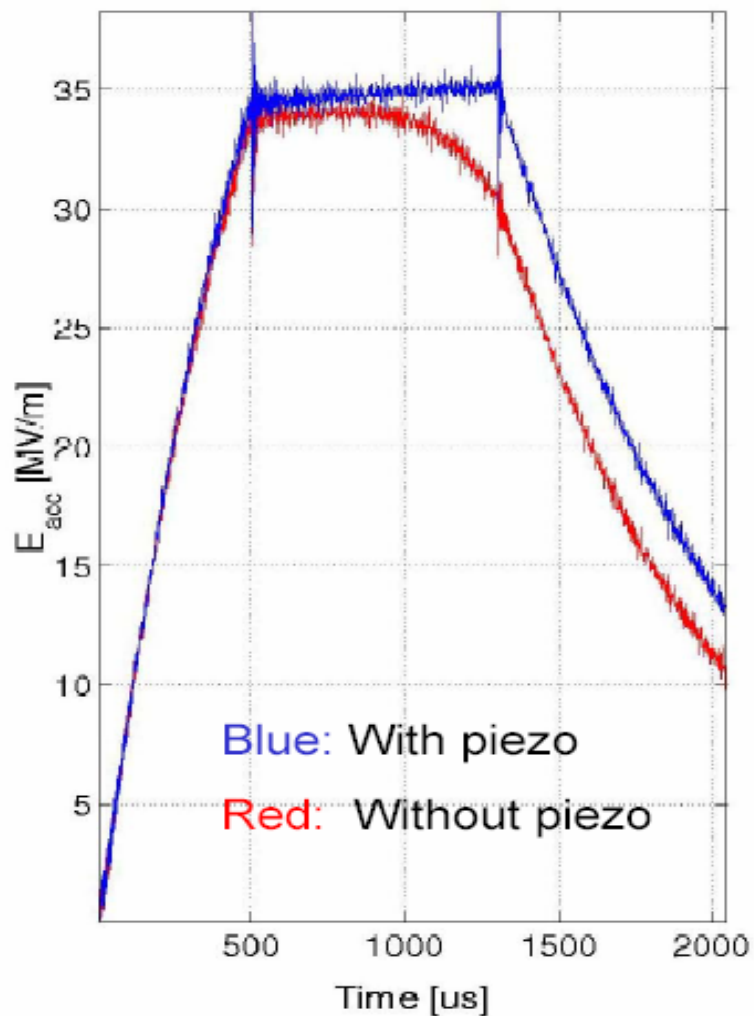
# Schedule

| Task Name                                       | Milestones                | Deliverables     | 2004 |    |    |    |    |    |    |    |    |    |    |    | 2005 |    |    |    |    |    |    |    |    |    |  |  |
|---|---------------------------|------------------|------|----|----|----|----|----|----|----|----|----|----|----|------|----|----|----|----|----|----|----|----|----|--|--|
|   |                           |                  | 12   | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12   | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 |  |  |
| <b>WP8 Tuners</b>                               |                           |                  |      |    |    |    |    |    |    |    |    |    |    |    |      |    |    |    |    |    |    |    |    |    |  |  |
| <b>8.1 UMI tuner</b>                            |                           |                  |      |    |    |    |    |    |    |    |    |    |    |    |      |    |    |    |    |    |    |    |    |    |  |  |
| 8.1.1 Develop control electronics               |                           |                  |      |    |    |    |    |    |    |    |    |    |    |    |      |    |    |    |    |    |    |    |    |    |  |  |
| 8.1.2 Mechanical design of tuner                |                           |                  |      |    |    |    |    |    |    |    |    |    |    |    |      |    |    |    |    |    |    |    |    |    |  |  |
| 8.1.3 Study leverage system/motor               |                           |                  |      |    |    |    |    |    |    |    |    |    |    |    |      |    |    |    |    |    |    |    |    |    |  |  |
| 8.1.4 Integration of piezo design               |                           |                  |      |    |    |    |    |    |    |    |    |    |    |    |      |    |    |    |    |    |    |    |    |    |  |  |
| 8.1.5 Choice of transducer / actuator           |                           |                  |      |    |    |    |    |    |    |    |    |    |    |    |      |    |    |    |    |    |    |    |    |    |  |  |
| <b>8.1.5.1 Report on UMI tuner</b>              | <b>Design Report</b>      |                  |      |    |    |    |    |    |    |    |    |    |    |    |      |    |    |    |    |    |    |    |    |    |  |  |
| <b>8.2 Magneto-strictive tuner</b>              |                           |                  |      |    |    |    |    |    |    |    |    |    |    |    |      |    |    |    |    |    |    |    |    |    |  |  |
| 8.2.1 Complete specification                    |                           |                  |      |    |    |    |    |    |    |    |    |    |    |    |      |    |    |    |    |    |    |    |    |    |  |  |
| 8.2.2 Conceptual design                         |                           |                  |      |    |    |    |    |    |    |    |    |    |    |    |      |    |    |    |    |    |    |    |    |    |  |  |
| 8.2.3 Prototype and performance                 |                           |                  |      |    |    |    |    |    |    |    |    |    |    |    |      |    |    |    |    |    |    |    |    |    |  |  |
| 8.2.4 Finalize drive electronics                |                           |                  |      |    |    |    |    |    |    |    |    |    |    |    |      |    |    |    |    |    |    |    |    |    |  |  |
| 8.2.5 Installation and test of tuner            |                           |                  |      |    |    |    |    |    |    |    |    |    |    |    |      |    |    |    |    |    |    |    |    |    |  |  |
| <b>8.3 CEA tuner</b>                            |                           |                  |      |    |    |    |    |    |    |    |    |    |    |    |      |    |    |    |    |    |    |    |    |    |  |  |
| 8.3.1 Design piezo tuning system                |                           |                  |      |    |    |    |    |    |    |    |    |    |    |    |      |    |    |    |    |    |    |    |    |    |  |  |
| 8.3.2 Fabrication of prototype                  |                           |                  |      |    |    |    |    |    |    |    |    |    |    |    |      |    |    |    |    |    |    |    |    |    |  |  |
| 8.3.2 Installation of driver electronics        |                           |                  |      |    |    |    |    |    |    |    |    |    |    |    |      |    |    |    |    |    |    |    |    |    |  |  |
| <b>8.3.4 CEA tuner ready for experiment</b>     |                           | <b>Prototype</b> |      |    |    |    |    |    |    |    |    |    |    |    |      |    |    |    |    |    |    |    |    |    |  |  |
| <b>8.4 IN2P3 activities</b>                     |                           |                  |      |    |    |    |    |    |    |    |    |    |    |    |      |    |    |    |    |    |    |    |    |    |  |  |
| 8.4.1 Characterize actuator/piezo sensor        |                           |                  |      |    |    |    |    |    |    |    |    |    |    |    |      |    |    |    |    |    |    |    |    |    |  |  |
| <b>8.4.2 Report on actuator/piezo sensor</b>    | <b>Status report</b>      |                  |      |    |    |    |    |    |    |    |    |    |    |    |      |    |    |    |    |    |    |    |    |    |  |  |
| 8.4.3 Test radiation hardness                   |                           |                  |      |    |    |    |    |    |    |    |    |    |    |    |      |    |    |    |    |    |    |    |    |    |  |  |
| <b>8.4.4 Report on radiation hardness tests</b> | <b>Status Report</b>      |                  |      |    |    |    |    |    |    |    |    |    |    |    |      |    |    |    |    |    |    |    |    |    |  |  |
| 8.4.5 Integration of piezo and cold tuner       |                           |                  |      |    |    |    |    |    |    |    |    |    |    |    |      |    |    |    |    |    |    |    |    |    |  |  |
| 8.4.6 Cryostat tests                            |                           |                  |      |    |    |    |    |    |    |    |    |    |    |    |      |    |    |    |    |    |    |    |    |    |  |  |
| <b>8.4.7 Ready for pulsed RF test</b>           | <b>Start of operation</b> |                  |      |    |    |    |    |    |    |    |    |    |    |    |      |    |    |    |    |    |    |    |    |    |  |  |

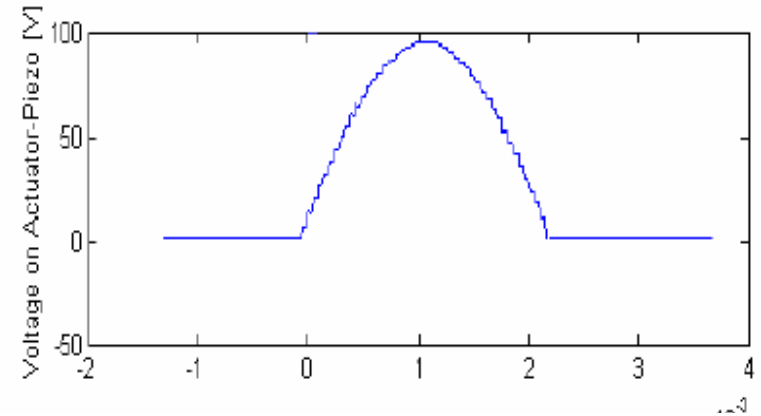
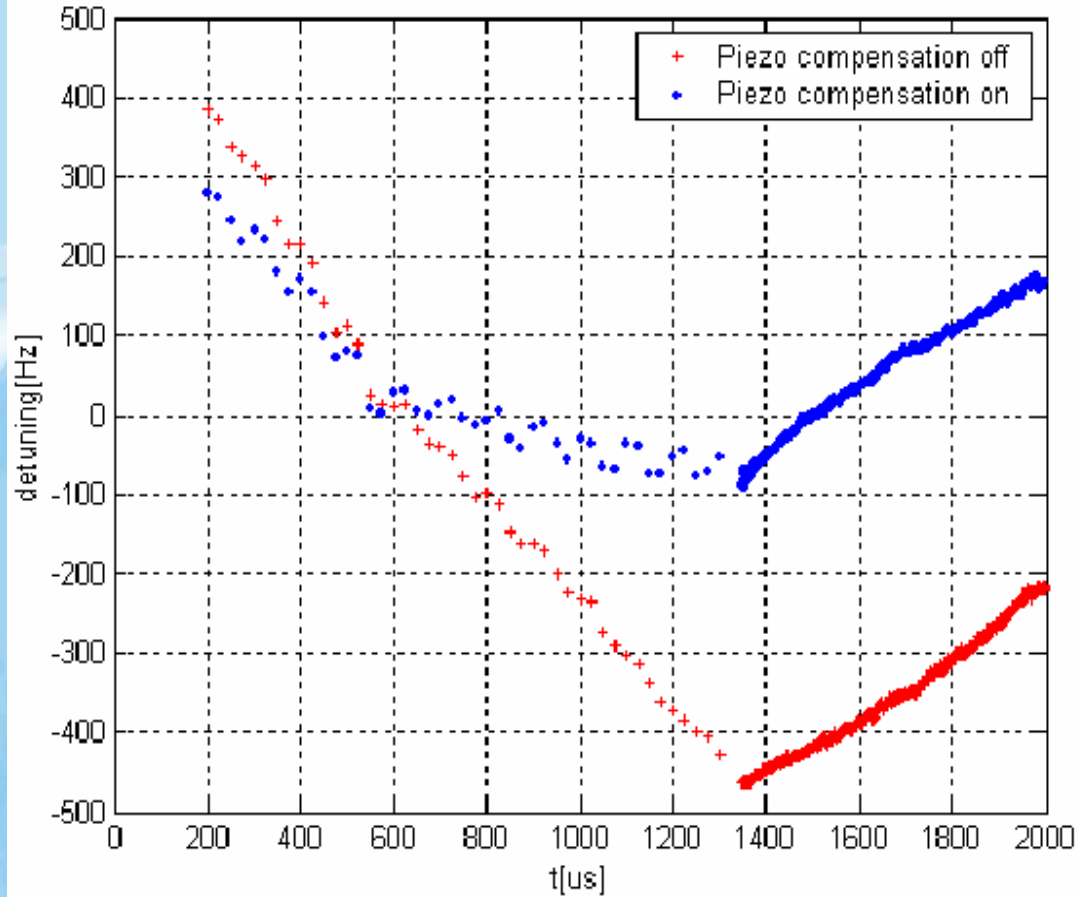


# Current results <sup>(1/2)</sup>

## RF signals at 35 MV/m



# Current results (2/2)



Frequency detuning of 500Hz  
is compensated by the 100V  
voltage pulse applied to  
piezoelement

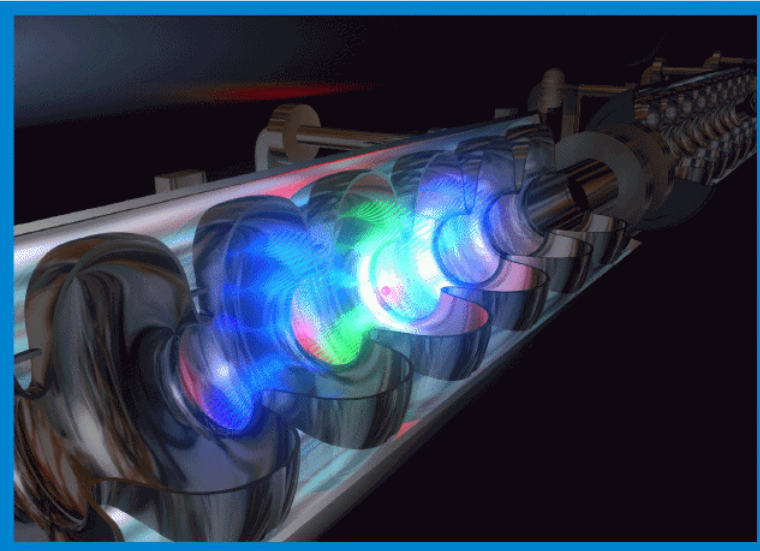
Stability of piezo compensation of Lorentz force detuning  
has been shown (more than 700 hours of working)

# Conclusions

Active piezoelectric/magnetostrictive tuner is needed to counteract the so-called Lorentz de-tuning effect.

Our deliverable is to develop and design the tuning system prototype.

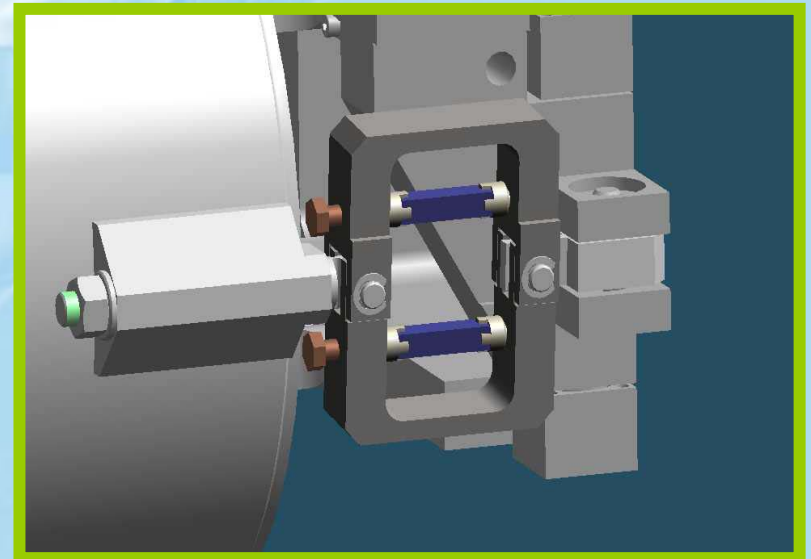




Thank you for your attention

**IN2P3**

INSTITUT NATIONAL DE PHYSIQUE NUCLÉAIRE  
ET DE PHYSIQUE DES PARTICULES



# What shall we do?

## General specifications:

- Step motor tuner should compensate 400kHz, tuner movement up to 1 mm,
- Piezo tuner should compensate 1kHz (up to 2kHz) piezo length change – several  $\mu\text{m}$ ,
- Should consist of 2 piezos,
- Dimension limited,
- Working condition: 2K, 10mBar vacuum,
- Can't spread too much power,
- Stiffness higher than 30 kN/ $\mu\text{m}$ ,
- Force sensor in prototype,