KUG
Introduction, overview of WP8 work and possible contributions to WP11

EuCARD2 KickOff Meeting
09.12.2013
Daniel Deboy (PhD Student)
on behalf of KUG

LHC Collimation Project
CERN

Introduction

Institute of Electronic Music and Acoustics

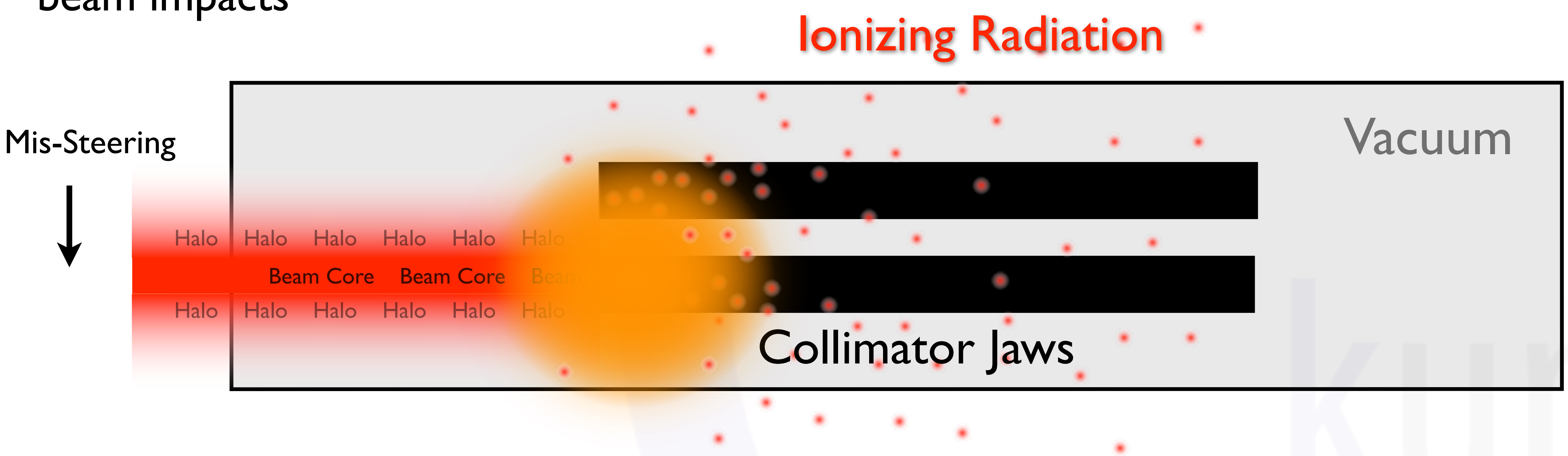
* founded 1965

- Interface between Arts and Science
  - R&D supports Arts
    - New technologies create new musical performances

Artistic Research	**Signal Processing and Acoustics**	**Computer Music**
Sound and Space	Spatial Audio	Sonification
Embodiment	Audio Signal Processing	Interaction Design
Algorithmic Composition	Psychoacoustics	

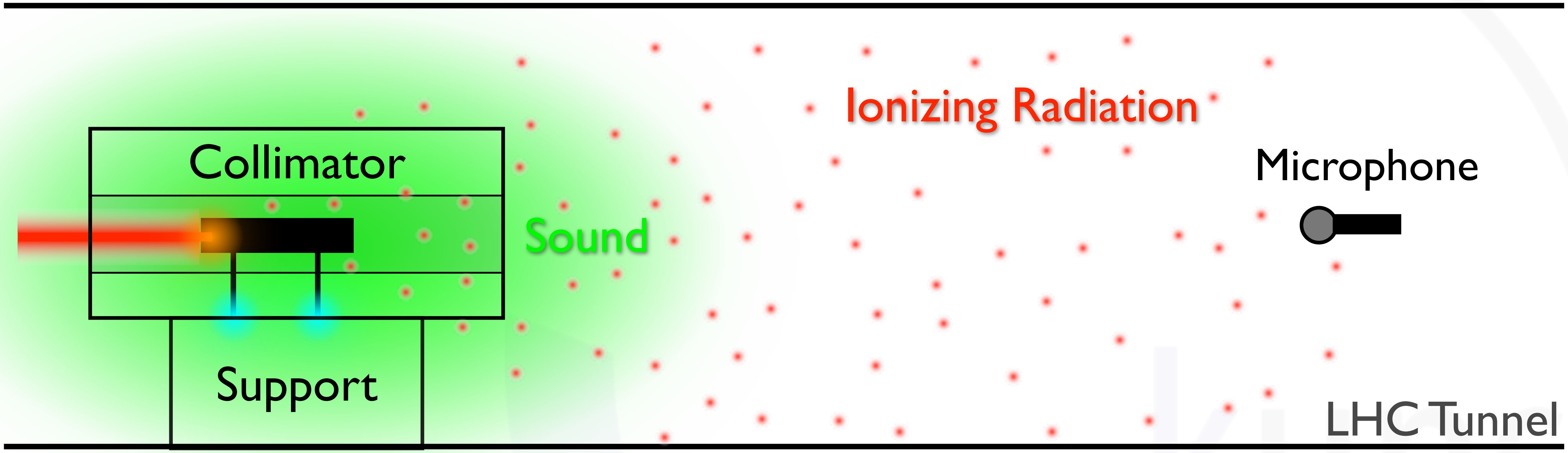
Overview on WP8 work

- Remote estimate of collimator material damage after unintended high-intensity beam impacts



- Worst case scenarios of mis-steered beam:
  - Example: **Asynchronous beam dump** (1 nominal LHC bunch)
  - Energy of up to 100 kJ deposited in jaw material
  - **Sudden** impact
  - Damage of collimator jaw

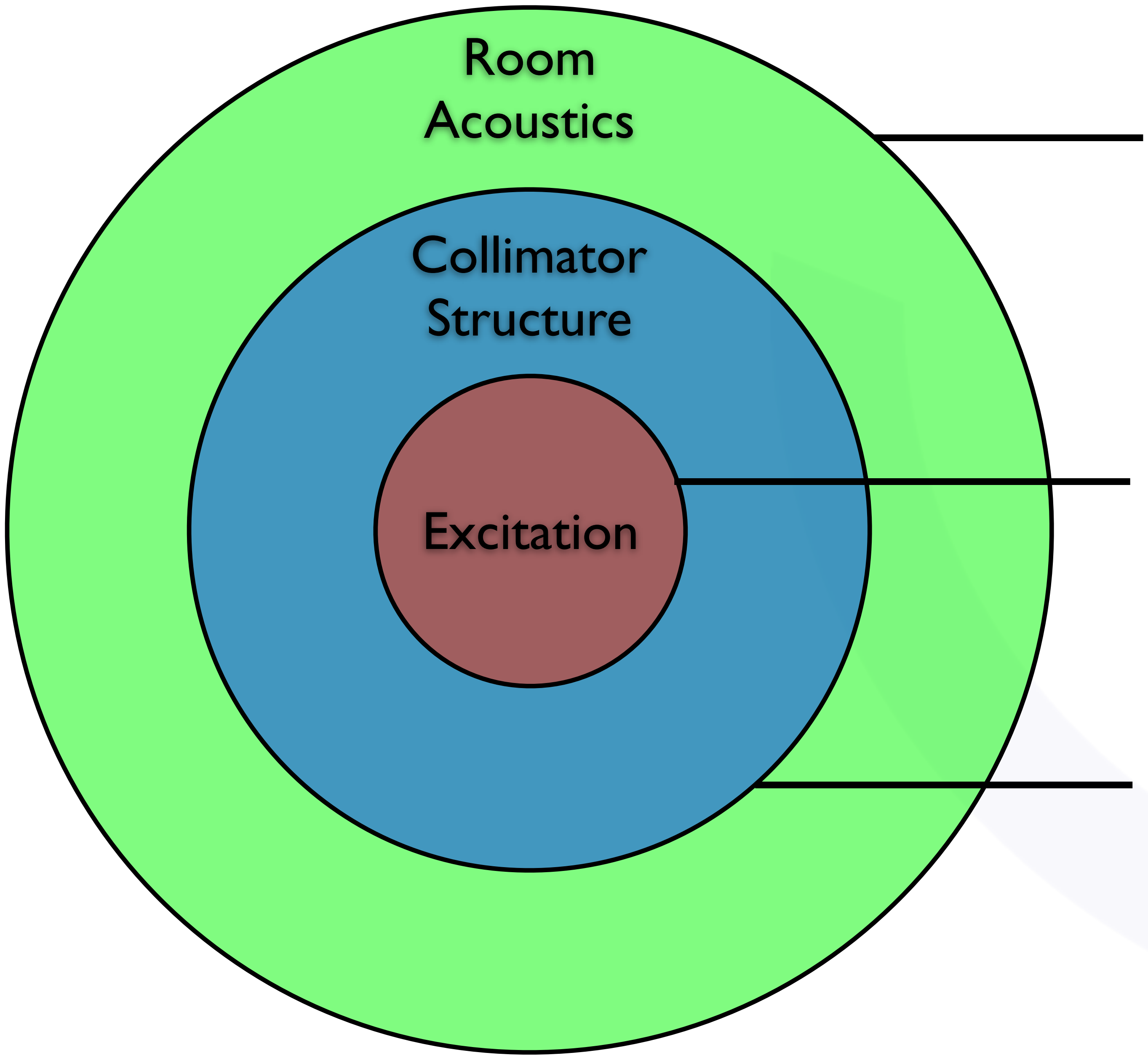
Overview on WP8 work



- **Impact** of particles deposits energy on collimator jaw
  - Sudden **heat-up** of jaw creates pressure wave
    - **Vibrations** are transferred to the whole collimator structure
      - **Sound** is created in the LHC tunnel and recorded with microphones
        - Signal Analysis yields **estimate of impact location** (which collimator?) and **damage level** (intervention necessary?)

Overview on WP8 work

- Layers of sound recorded with microphones in tunnel



Air borne sound generated by surface vibrations propagates through tunnel area

- Obstacles (beam line, etc...)
- Resonances (air condition pipes, etc...)
- Reflections (tunnel walls)

Excitation from sudden beam impact

- Impulse from pressure wave/shockwave
- Relation to deposited Energy given by equation of states

Structure borne

- Mounts of collimator jaw
- Vibration of outer shell (tank, support, etc...)

Overview on WP8 work

- Test during Material tests at HiRadMat facility (August 2012) - (M. Cauchi's presentation)

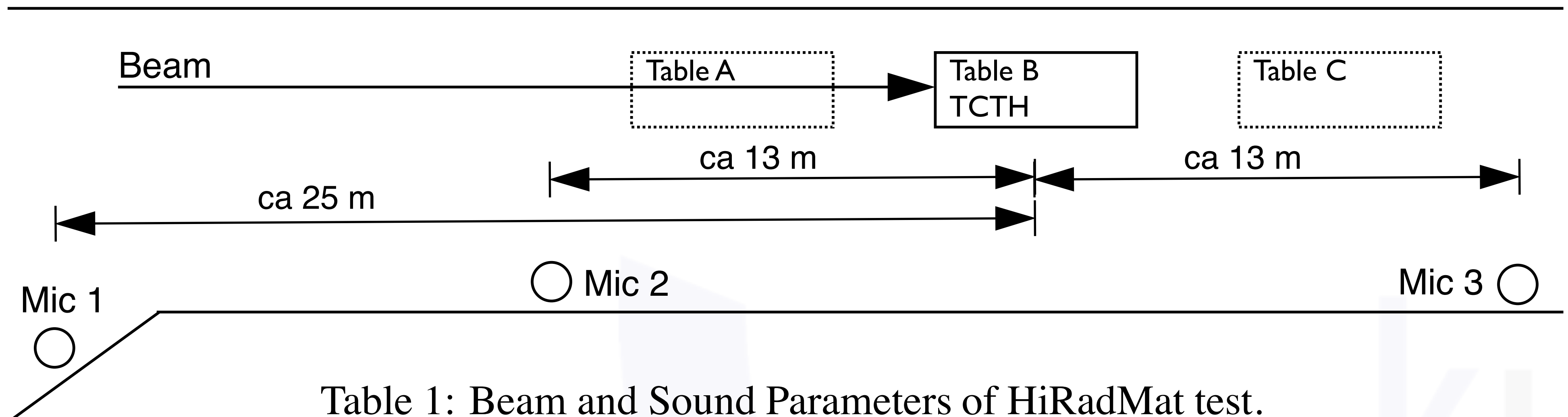


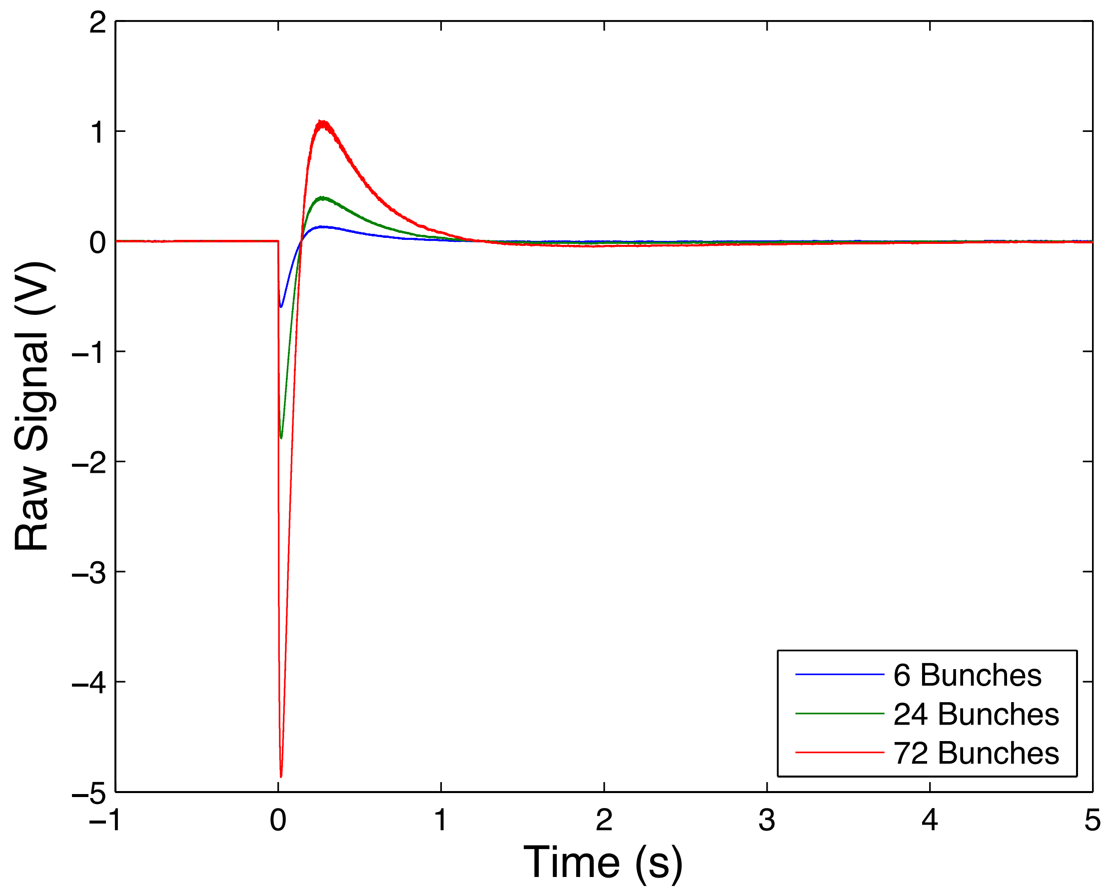
Table 1: Beam and Sound Parameters of HiRadMat test.

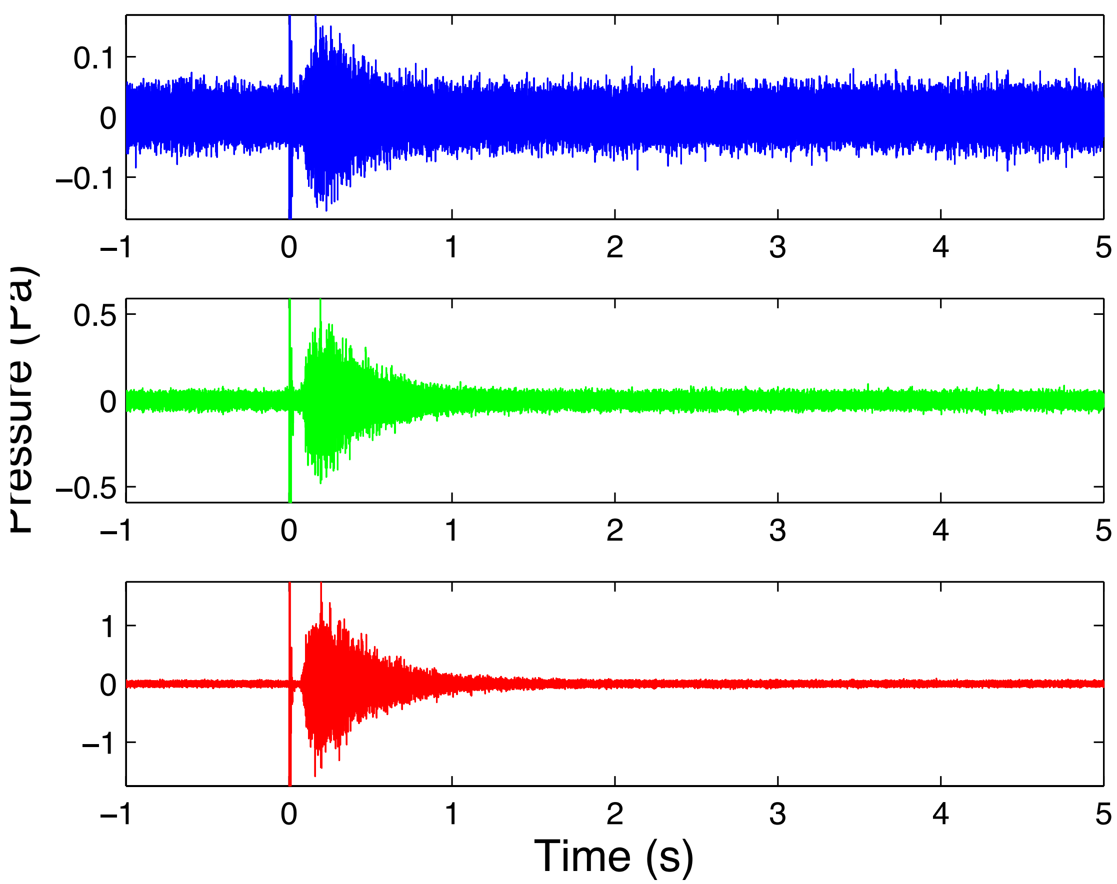
Test	**1**	**2**	**3**
SPS extraction intensity [E12 p]	3.36	1.04	9.34
No of HRM bunches	24	6	72
Energy on Jaw [kJ]	87.89	27.72	249.87
Max L_p, Mic 1 [dB]	77.1	66.3	86.8
Max L_p, Mic 2 [dB]	87.2	77.1	NA
Max L_p, Mic 3 [dB]	NA	76.9	NA

Test 1 – Design Error Case: Asynchronous Beam Dump in operation of during collimator setup
Test 2 – Shot just below damage limit to collect reference data to assess damage
Test 3 – Disruptive scenario for Asynchronous Beam Dump

(M.Cauchi)

Overview on WP8 work

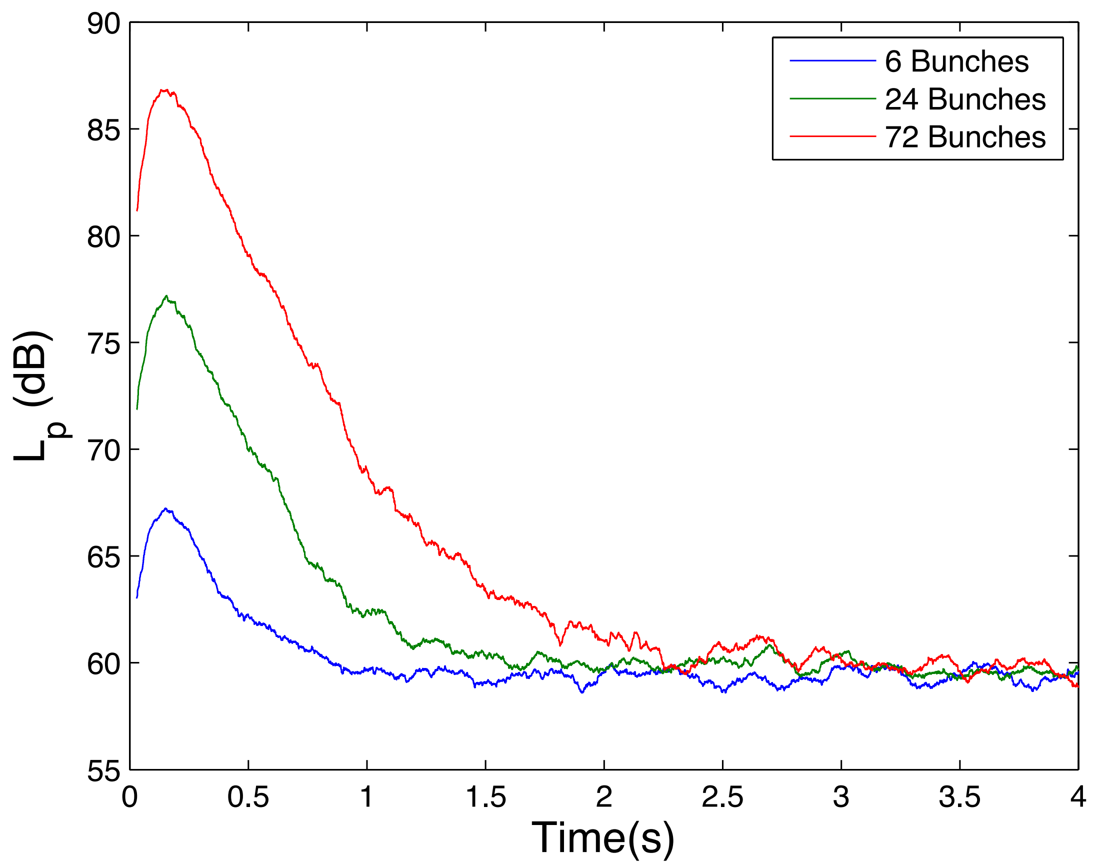


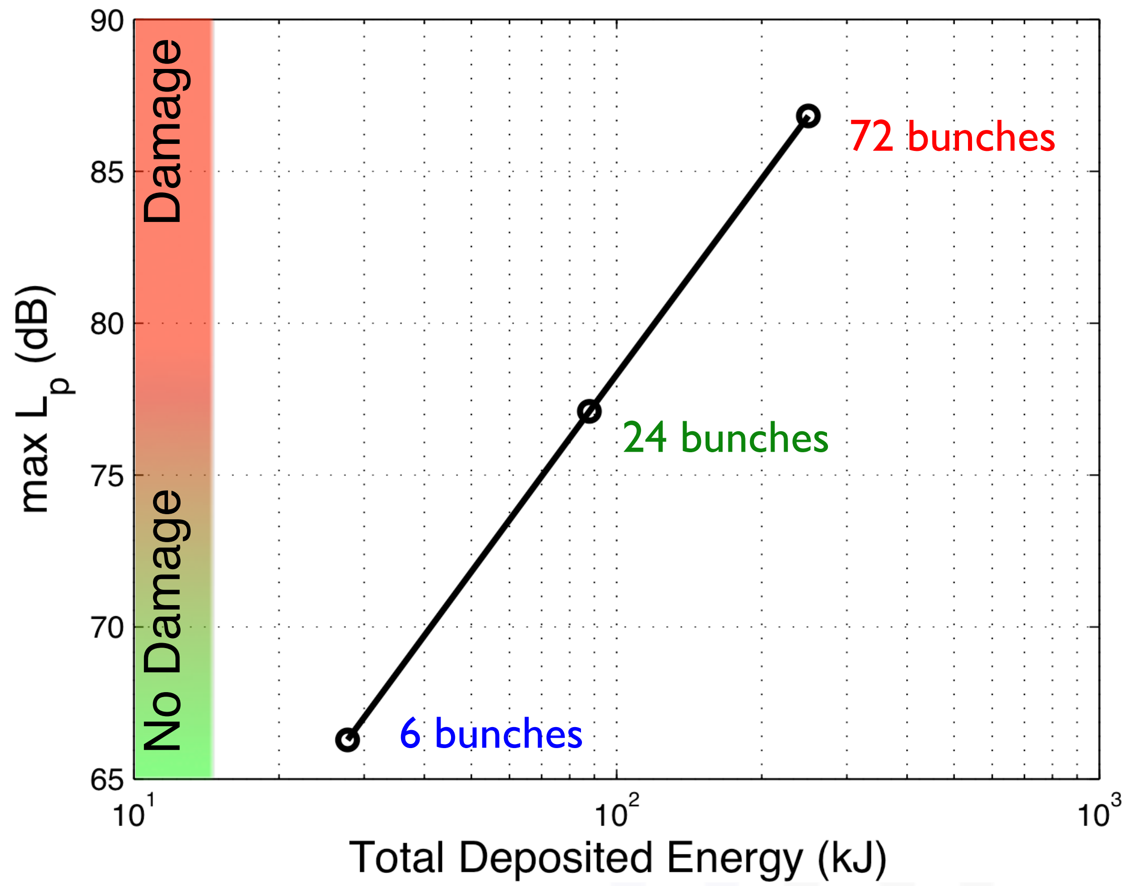


- Raw signals during the impact show large spikes from radiation effects in the sensor electronics (R2E).
- Refraction from spike is super-imposed to real sound data.

- A high-pass filter with a cutoff frequency of 100 Hz is applied to remove the slow refraction.
- Time delay between R2E spike and arrival of sound determines distance.

Overview on WP8 work





- RMS averaging with a time constant of 125 ms is used to determine sound pressure level L_p.
- The R2E spike is cut out before calculation of L_p.

- "Damage Level Meter"
- Max L_p increases with the total deposited energy.
- Can be used to determine expected damage extend from L_p.

Overview on WP8 work

Conclusion on HRM Tests

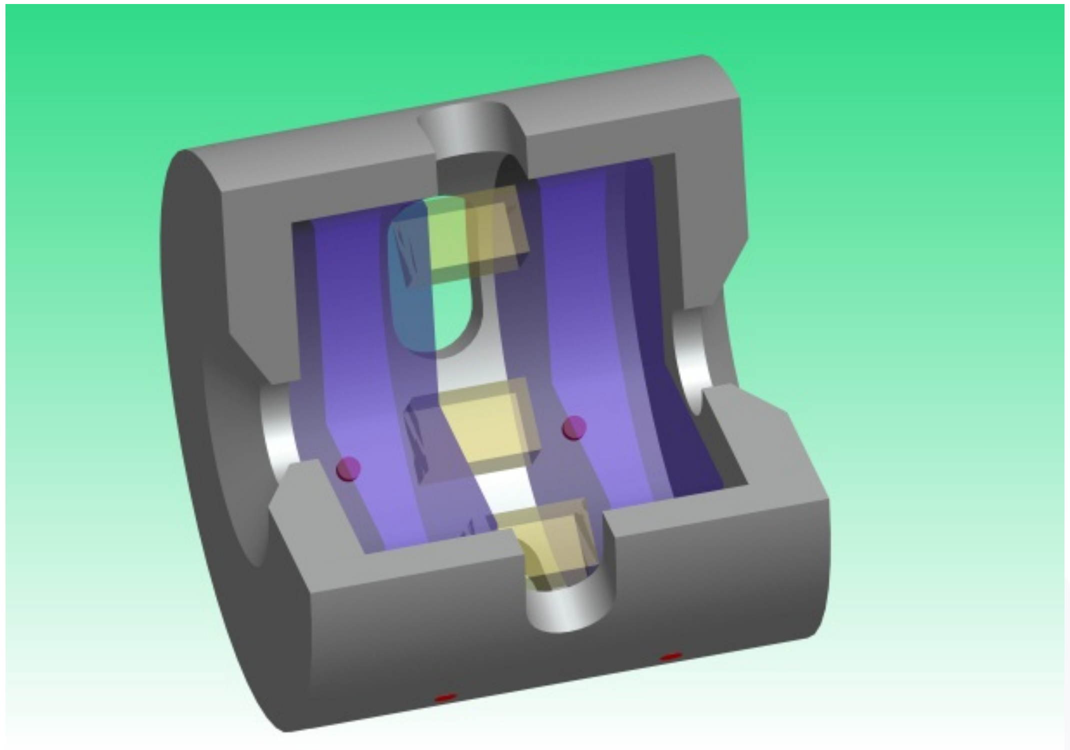
- **Sound** recorded in surrounding experimental area can be **correlated to deposited beam energy**.
- **Remote estimate** of damage level possible under „lab“ conditions (experimental setup and beam parameters well known, reference measurement available)
- **Location of impact** can be determined roughly, therefore several collimators can be monitored using only one microphone.
- Excitation signal is convolved by **collimator structure** and **room impulse response**.
- Sound pressure levels of **> 100 dB SPL** peak measured in far field

Main issues

- Strong **background noise** (mainly induced in long asymmetrical analog signal cables)
- **R2E noise spike** during beam impact

Possible Contributions to WP11

- Adaptation of a new optical microphone sensor and testing of a prototype during HiRadMat 2 run (in cooperation with XARION, Vienna)



Courtesy: Balthasar Fischer (XARION)

Developed at Vienna University of Technology (MEOS)

Sensor Head:
Rigid Fabry-Pérot etalon in aluminum housing; Si02 glass, dielectric coatings (5µm thick; TiO2. MgO), aluminum, steel, glue.

The lab-proven 780nm setup of MEOS is redesigned for a fiber-based 1550nm version.

Expected features (best effort):
All-optical, electronics separated with optical fiber
Noise: 60 dB (rel 20µPa)
Dynamic range: 100dB
Distortion limit (THD 5%): **160 dB** (rel 20µPa)
Frequency response: 100Hz-50kHz

Possible Contributions to WP11

Foreseen improvement with all-optical solution:

- Higher gain factor in amplifier yields **lower** (electronically induced) **background noise**
- **No radiation issues** during high-intensity impacts
- Can be installed **closer to target** to reduce room reflection components

Other contributions

- Further simulation and measurement of structure borne sound from material impacts
- Multi material tests - **Relate sound pressure level to material models** and predicted/measured shockwaves (in cooperation with other EuCARD partners)
- ???

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Thanks for your attention!