HIGH GRADIENT RF 2006

High Gradient 2006 Worskhop

Welcome

Objectives

W.Wuensch: Workshop chairman

The objective of the workshop is to bring the high-gradient rf community together to present and discuss recent theoretical and experimental developments.

Significant progress has been made by a number of groups in recent years to understand the basic physics of rf breakdown and develop techniques for achieving higher gradients.

We hope with this workshop to help maintain the momentum of this effort and to promote contacts and collaborations

World-wide context

- **Large effort (and resources) during many years invested by the whole community on high accelerating fields developments in the frame of Linear Colliders R&D**
- **Cold RF technology selected for ILC in TeV range with gradients of 25 to 35 MV/m:**
  - R&D to reduce spread on performances and cost
- **Warm RF technology development for NLC/JLC/CLIC**
  - 65 MV/m successfully demonstrated by the NLC/JLC collaboration
  - Keep momentum building up on accumulated knowledge and taking advantage of the hardware development and theoretical understand.
- **Quest for high(er) acceleration fields to push further the HEP high energy frontier into the Multi-TeV range in the future and other possible applications**

European Strategic Plan

- **LHC**
- **Accelerator R&D: beyond LHC (incl. CLIC)**
- **ILC**
- **Global Neutrino Prog.**
- **Astrophysics (ApPEC)**
- **Flavour Physics**
- **Nuclear Physics (NuPECC)**

36 | The European strategy for particle physics

The European strategy *for particle physics*

Particle physics stands on the threshold of a new and exciting era of discovery. The next generation of experiments will explore new domains and probe the deep structure of space-time. They will measure the properties of the elementary constituents of matter and their interactions with unprecedented accuracy, and they will uncover new phenomena such as the Higgs boson or new forms of matter. Long-standing puzzles such as the origin of mass, the matter-antimatter asymmetry of the Universe and the mysterious dark matter and energy that permeate the cosmos will soon benefit from the insights that new measurements will bring. Together, the results will have a profound impact on the way we see our Universe; *European particle physics should thoroughly exploit its current exciting and diverse research programme. It should position itself to stand ready to address the challenges that will emerge from exploration of the new frontier, and it should participate fully in an increasingly global adventure.*

General issues

1. European particle physics is founded on strong national institutes, universities and laboratories and the CERN Organization; *Europe should maintain and strengthen its central position in particle physics.*

2. Increased globalization, concentration and scale of particle physics make a well coordinated strategy in Europe paramount; *this strategy will be defined and updated by CERN Council as outlined below.*

Scientific activities

3. The LHC will be the energy frontier machine for the foreseeable future, maintaining European leadership in the field; *the highest priority is to fully exploit the physics potential of the LHC, resources for completion of the initial programme have to be secured such that machine and experiments can operate optimally at their design performance.* A subsequent major luminosity upgrade (SLHC), motivated by physics results and operation experience, will be enabled by focussed R&D; *to this end, R&D for machine and detectors has to be vigorously pursued now and centrally organized towards a luminosity upgrade by around 2015.*

4. In order to be in the position to push the energy and luminosity frontier even further it is vital to strengthen the advanced accelerator R&D programme; *a coordinated programme should be intensified, to develop the CLIC technology and high performance magnets for future accelerators, and to play a significant role in the study and development of a high-intensity neutrino facility.*

5. It is fundamental to complement the results of the LHC with measurements at a linear collider. In the energy range of 0.5 to 1 TeV, the ILC, based on superconducting technology, will provide a unique scientific opportunity at the precision frontier; *there should be a strong well-coordinated European activity, including CERN, through the Global Design Effort, for its design and technical preparation towards the construction decision, to be ready for a new assessment by Council around 2010.*

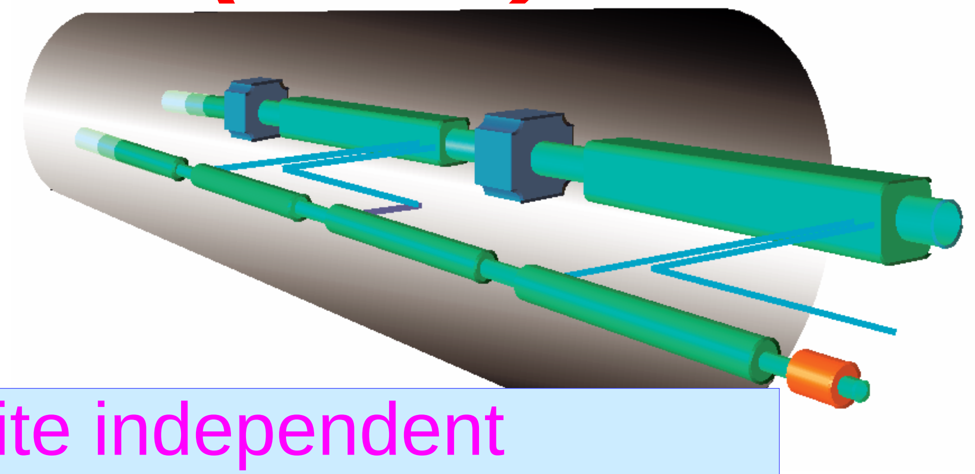
6. Studies of the scientific case for future neutrino facilities and the R&D into associated technologies are required to be in a position to define the optimal neutrino programme based on the information available in around 2012; *Council will play an active role in promoting a coordinated European participation in a global neutrino programme.*

7. A range of very important non-accelerator experiments take place at the overlap between particle and astroparticle physics exploring otherwise inaccessible phenomena; *Council will seek to work with ApPEC to develop a coordinated strategy in these areas of mutual interest.*

European Strategic Plan
Recommendations on Accelerators R&D

4. In order to be in the position to push the energy and luminosity frontier even further it is vital to strengthen the advanced accelerator R&D programme; *a coordinated programme should be intensified, to develop the CLIC technology and high performance magnets for future accelerators, and to play a significant role in the study and development of a high-intensity neutrino facility.*

THE COMPACT LINEAR COLLIDER (CLIC) STUDY

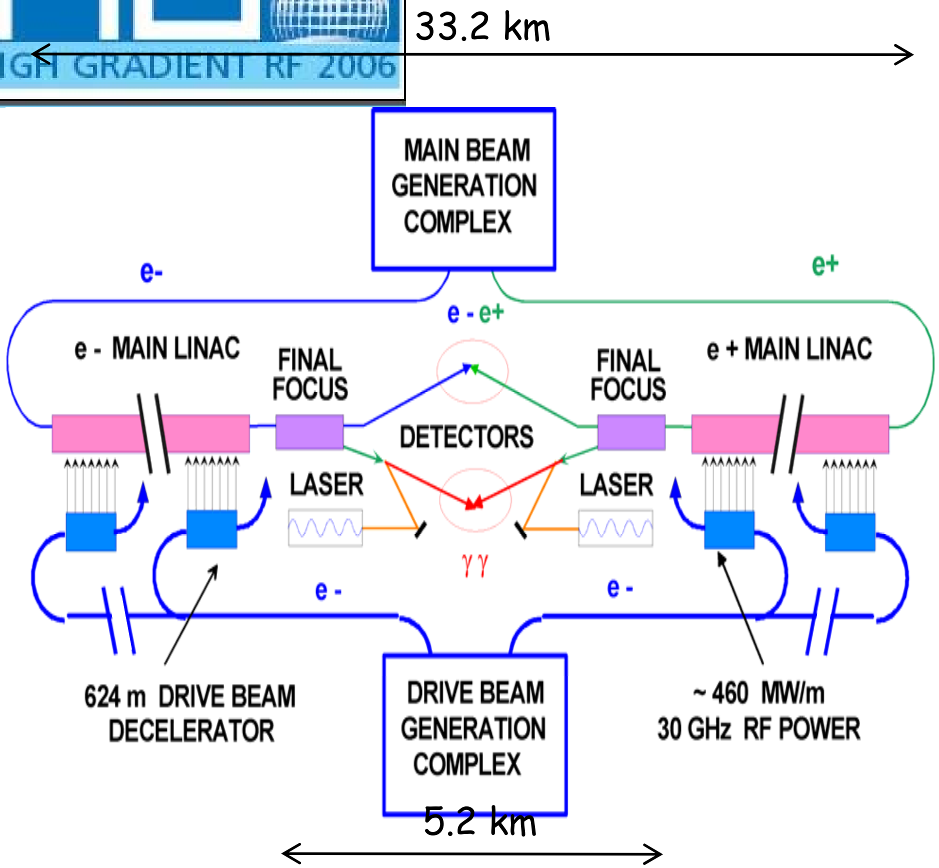


The CLIC study is a site independent feasibility study aiming at the development of a realistic technology at an affordable cost for an e± Linear Collider in the post-LHC era for Physics in the multi-TeV center of mass colliding beam energy range.

http://clic-study.web.cern.ch/CLIC-Study/

CERN 2000-008, CERN 2003-007, CERN 2004-005

CLIC technology for Multi-TeV Linear Colliders

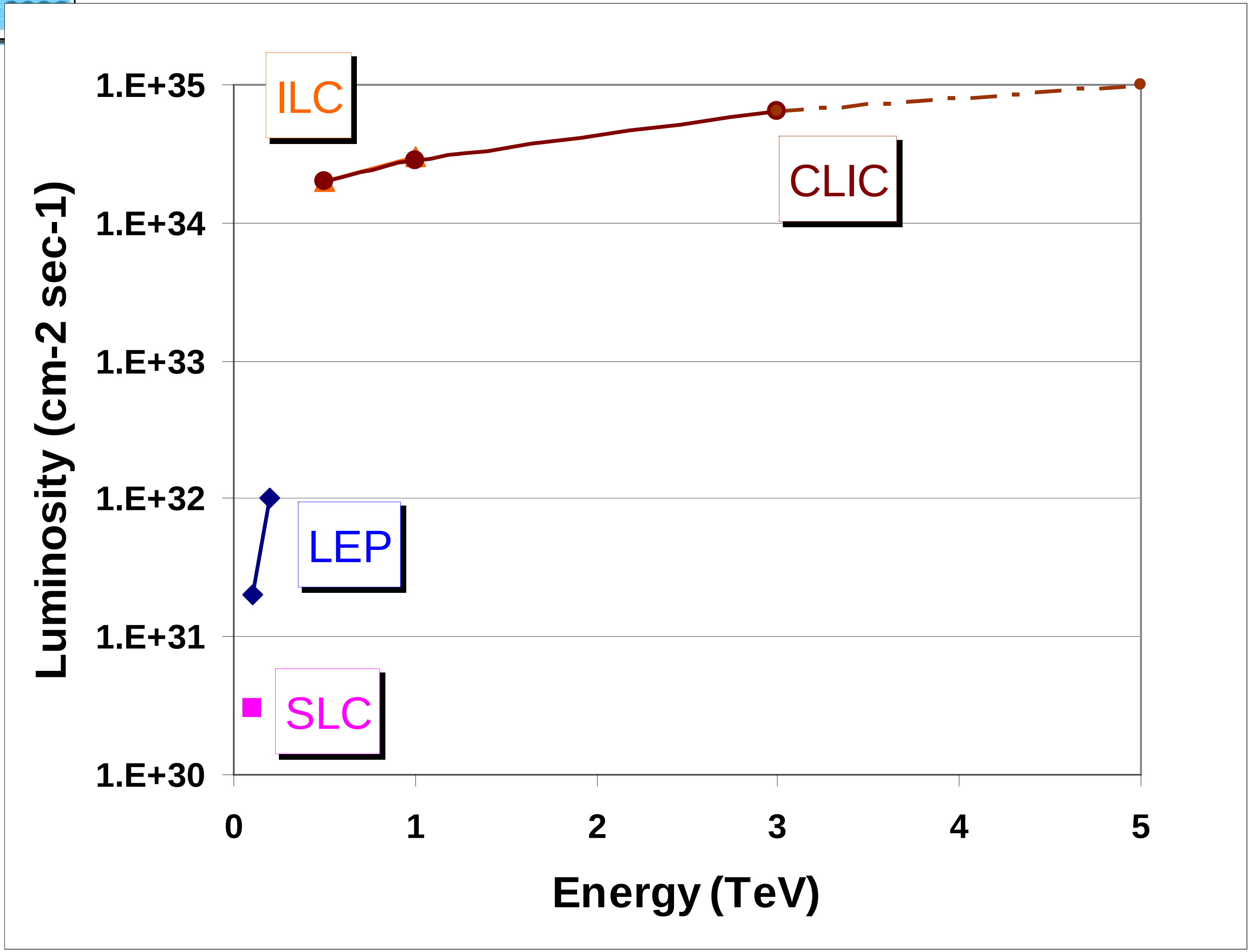


Overall layout for a center of mass energy of 3 TeV/c

Two specific key features

- **High acceleration gradient**
  - **"Compact" collider-overall length**
- **Two-Beam Acceleration Scheme**
  - **Efficient and cost effective RF power source**

Performances of Lepton Colliders



HIGH GRADIENT RF 2006

Work Plan for the US Collaboration on High Gradient Research for a Multi-TeV Linear Collider

Editors:

Ronald Ruth, SLAC (Collaboration Spokesman)
Wei Gai, ANL
Christopher Nantista, SLAC
Gregory Nusinovich, UMD
Sami Tantawi, SLAC
Richard Temkin, MIT

1.0 Work Plan Summary

The purpose of the collaboration is to harness the nation's expertise to advance our understanding of RF breakdown and accelerating gradient limits in normal conducting RF powered particle accelerators, the specific goal being to establish the best frequency and accelerator structure design for a future multi-TeV two-beam linear collider. Specifically, the collaboration will explore the possibility of pushing the useable acceleration gradient from the 65 MV/m reliably achieved in NLC structures up towards 180 MV/m or higher.

An initial organizational meeting to establish a U.S. Collaboration on High Gradient Research was held in July, 2005. During the meeting, 20 proposals were made. After the meeting, 10 more detailed proposals have been submitted. We edited these proposals, and based on them we formed our collaboration work plan. This work is assumed to span a period of 5 years.

SLAC will be the host of this collaboration. Its experimental facilities will be available to collaborators for experiments supported within the collaboration. The collaboration members at the moment include universities, national laboratories and five small business companies. In the following, we will summarize our proposed exploration of the RF breakdown phenomenon through a set of experimental, theoretical and simulation programs.

1.0 Work Plan Summary

The purpose of the collaboration is to harness the nation's expertise to advance our understandin breakdown and accelerating gradient limits in normal conducting RF powered particle accelerat specific goal being to establish the best frequency and accelerator structure design for a future m two-beam linear collider. Specifically, the collaboration will explore the possibility of pushing the acceleration gradient from the 65 MV/m reliably achieved in NLC structures up towards 180 MV/m or

An initial organizational meeting to establish a U.S. Collaboration on High Gradient Research was July, 2005. During the meeting, 20 proposals were made. After the meeting, 10 more detailed pr have been submitted. We edited these proposals, and based on them we formed our collaborati plan. This work is assumed to span a period of 5 years.

SLAC will be the host of this collaboration. Its experimental facilities will be available to collabora experiments supported within the collaboration. The collaboration members at the moment universities, national laboratories and five small business companies. In the following, we will summa proposed exploration of the RF breakdown phenomenon through a set of experimental, theoreti simulation programs.

1.1 DIRECT TESTING OF RF BREAKDOWN AT MICROWAVE FREQUENCIES

In spite of intensive and lengthy efforts at many laboratories throughout the world, we still have onl limited understanding of surface breakdown at microwave frequencies. Very little is known about ge effects and the response of simple materials, let alone alloys and composites. The initial progran characterized by an intensive experimental program. This program has to address the basic ph breakdown phenomena and its frequency scaling. Because of its exploratory nature, we expect to dc number of experiments, addressing different aspects of geometrical change and material variation. priority must be given to establishing experimental facilities.

1. The major experimental work will be conducted at SLAC, initially at 11.424 GHz ar successful RF source development, at higher frequencies.
2. The NRL facilities will also be used to debug new concepts and devices.
3. Research at 17 GHz will be conducted at MIT using an existing facility and, at a late an upgraded facility.
4. Work at 17 GHz will also be conducted at University of Maryland.
5. Work at higher frequencies will require the development of RF sources.

1.2 RF SOURCE DEVELOPMENTS

At the moment there is no high repetition rate/high average power operational RF source at high freq (>11.424 GHz). These are needed to study RF breakdown and understand its scaling with frequer propose to:

1. Develop a multi-purpose gyrotron oscillator which can be operated using a SLAC m with operating frequency of 22.8 GHz and 30 GHz,
2. Develop an active pulse compression system that can operate with oscillator sources. also be used with the CERN CTF-3 facility to provide a source at 30 GHz,
3. Test, using a SLAC modulator, the 10 MW, 91 GHz gyroklystron produced by CCR, In course of an SBIR project,
4. Upgrade the MIT accelerator facility to operate at higher repetition rate for improved st breakdown and novel accelerator structures at 17 GHz,
5. Upgrade the University of Maryland GKL facility to operate at high repetition rate. Ther its high frequency gyroklystrons can be used as a source for RF processing at 17 G above,
6. Upgrade and maintain the Omega-P/Yale magnicon facility by combing its four ou provide an initial source at 34 GHz.

1.3 NON-RF EXPERIMENTAL PROGRAMS

There are two programs aimed at exploring surface phenomenon under high field.

1. Experiments at ANL using an RF electron gun to understand the nature of the field enhancement factor, β.
2. Experiments with atom probe tomography to understand the structure and the dynamics of surface atoms under high field conditions. This is done at Northwestern University in collaboration with ANL.

1.4 THEORY AND SIMULATIONS

The theoretical work and simulations are closely coupled to the experimental program. Several groups are going to be involved in these efforts:

- SLAC
- MIT
- University of Maryland
- ANL
- LBNL

The proposed theoretical research from each of these groups is described in detail in this Work Plan.

1.5 NOVEL ACCELERATOR STRUCTURE DEVELOPMENTS

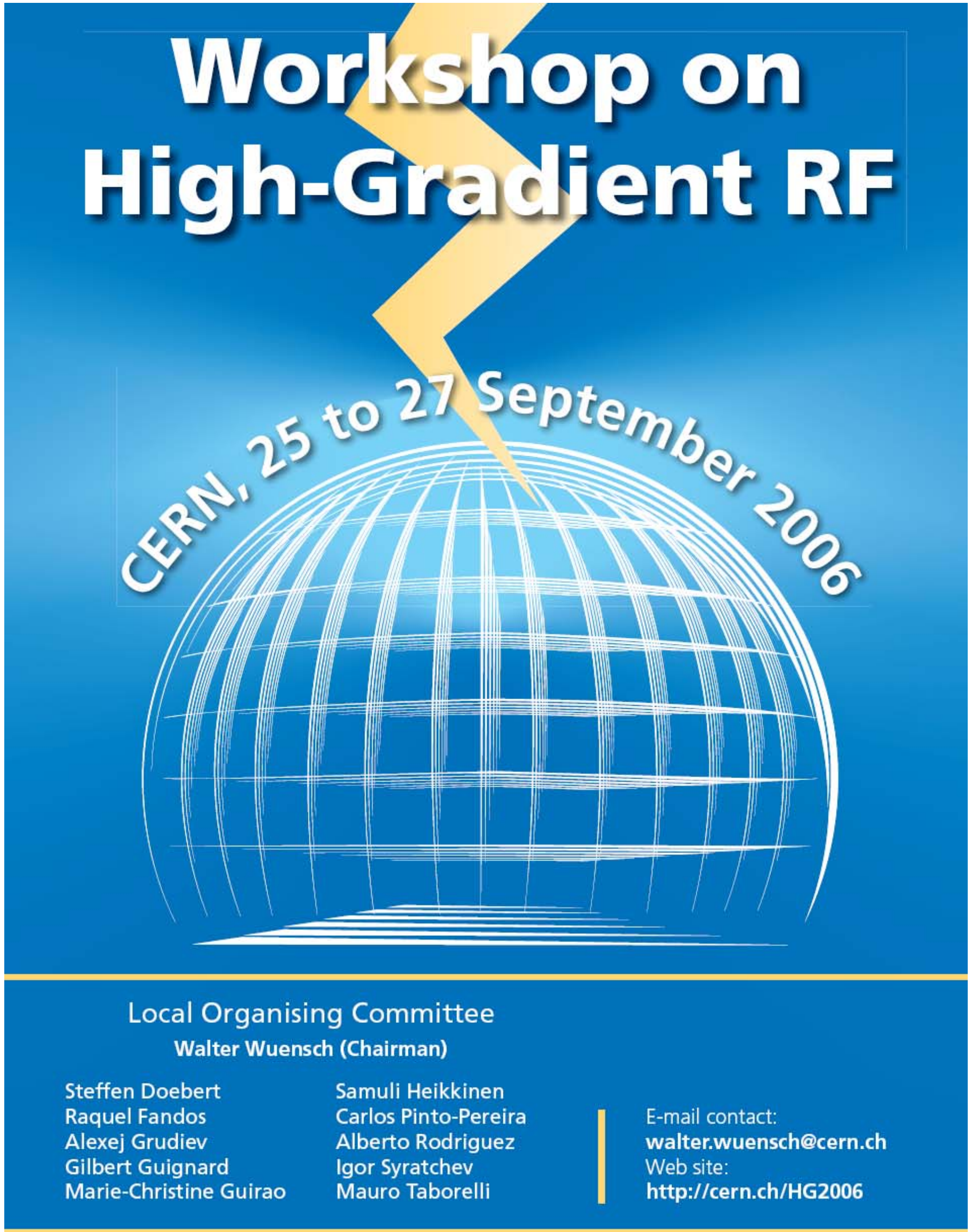
Although the initial part of work plan is characterized with an exploratory effort, the available information and past experience could point the way to RF structures that can sustain higher gradient. It is well known that shorter pulse width results in higher gradient, although the scaling laws for this effect are still in debate. To utilize this effect structures with high damping of long range wake field will permit closer electron bunch spacing and hence a shorter overall pulse length. These types of structures are being developed at CERN, MIT, and the University of Colorado.

Also, it has been observed that shorter structures with small group velocities behave better than longer structures. Ultimately, one would conjecture that a standing wave accelerator structure should behave better than a traveling wave accelerator structure. Novel structures with distributed coupling are being developed at SLAC. Also, a mixture of traveling and standing wave accelerator structures are being developed at UCLA.

Finally, dielectric accelerator structures are being studies at ANL, NRL, SLAC and UCLA.

HG06 Goals

- **Critical analysis of experimental results and theoretical models**
- **Constructive exchanges on understanding of RF structure limitations**
- **Elaboration of development and action plans towards high(er) accelerating fields**
- **Reinforcement of existing collaborations and identification of possible new ones**


Workshop on
High-Gradient RF
CERN, 25 to 27 September 2006
Local Organising Committee
Walter Wuensch (Chairman)
Steffen Doebert
Raquel Fandos
Alexej Grudiev
Gilbert Guignard
Marie-Christine Guirao
Samuli Heikkinen
Carlos Pinto-Pereira
Alberto Rodriguez
Igor Syratchev
Mauro Taborelli
E-mail contact:
walter.wuensch@cern.ch
Web site:
http://cern.ch/HG2006