

# **RD50 - Radiation hard semiconductor devices for very high luminosity colliders**

Some experiences in forming, running and  
keeping alive an approved CERN R&D project

**Michael Moll (CERN-PH-DT2)**

## **OUTLINE**

- **Introduction to the RD50 Collaboration (Objectives – Members)**
- **History – How the collaboration was formed**
- **Scientific Organization**
- **MoU and internal rules (common fund, publications, workshops, ...)**
- **Organization of common projects (examples)**
- **Interaction with LHCC**
- **Administration**



**RD50: Development of Radiation Hard Semiconductor Devices for High Luminosity Colliders**

- **Main objective:**

**Development of ultra-radiation hard semiconductor detectors for the luminosity upgrade of the LHC to  $10^{35} \text{ cm}^{-2}\text{s}^{-1}$  (“Super-LHC”).**

**Challenges: - Radiation hardness up to  $10^{16} \text{ cm}^{-2}$  required**

- **Fast signal collection** (bunch crossing remaining at 25 ns ?)

- **Low mass** (reducing multiple scattering close to interaction point)

- **Cost effectiveness** (big surfaces have to be covered with detectors!)

- **Further objectives:**

- Replacement of LHC detectors

- Generic research on radiation damage in detectors : Link to ILC community

- **Presently 258 members from 50 institutes**

**Belarus** (Minsk), **Belgium** (Louvain), **Canada** (Montreal), **Czech Republic** (Prague (3x)), **Finland** (Helsinki, Lappeenranta), **Germany** (Berlin, Dortmund, Erfurt, Freiburg, Hamburg, Karlsruhe), **Israel** (Tel Aviv), **Italy** (Bari, Bologna, Florence, Padova, Perugia, Pisa, Trento, Turin), **Lithuania** (Vilnius), **The Netherlands** (Amsterdam), **Norway** (Oslo (2x)), **Poland** (Warsaw (2x)), **Romania** (Bucharest (2x)), **Russia** (Moscow), St.Petersburg), **Slovenia** (Ljubljana), **Spain** (Barcelona, Valencia), **Switzerland** (CERN, PSI), **Ukraine** (Kiev), **United Kingdom** (Exeter, Glasgow, Lancaster, Liverpool), **USA** (Fermilab, Purdue University, Rochester University, SCIPP Santa Cruz, Syracuse University, BNL, University of New Mexico)



- **10/2000: Last RD48 (ROSE) Workshop – End of RD48 collaboration**
  - Leaving behind a list of open questions regarding radiation damage in silicon and a community that is willing to form a new collaboration
- **2000-2001 Difficult time to form collaboration (CERN financial crises)**
  - Keep low profile in R&D at CERN (e.g. No CERN member in collaboration management allowed)
- **11/2001: 3 days workshop with discussions on how to set up collaboration**
  - Formation of editing team for proposal (3 persons: C.DaVia, C.Joram, M.Moll)
  - Appointment of Spokesperson Search Committee (3 wise men: W.de Boer, E.Heijne, P.Weilhammer)
  - Collection of interested institutes (Every institute to submit a letter of interest stating: motivation, present work, man-power, resources, infrastructure, ....)
- **2/2002: Submission of proposal to LHCC (signed by 45 Institutes)**
- **2/2002: Formation of the collaboration**
  - Formation of Collaboration Board, decision on election procedures, election of CB chair and deputy, decision on organizational structure of collaboration, common fund, role of industrial partners, publication guidelines, ...
  - Election of spokesperson and deputy, nomination of budget holder, CERN contact person, ...
  - second CB meeting in 10/2002: establishment of MOU based on discussions in first meeting
- **5/2002: LHCC recommends approval**
- **6/2002: Experiment approved as RD50 by Research Board**

“Today”



**Strategy:** Allow for a wide range of R&D approaches in the beginning (~ first 3 years) and then focus on the most promising options.

- **Material Engineering -- Defect Engineering of Silicon**

- Understanding radiation damage
  - Macroscopic effects and Microscopic defects
  - Simulation of defect properties & kinetics
  - Irradiation with different particles & energies
- Oxygen rich Silicon
  - DOFZ, Cz, MCZ, EPI
- Oxygen dimer & hydrogen enriched Silicon
- Pre-irradiated Silicon
- Influence of processing technology

- **Material Engineering -- New Materials** (work concluded within RD50)

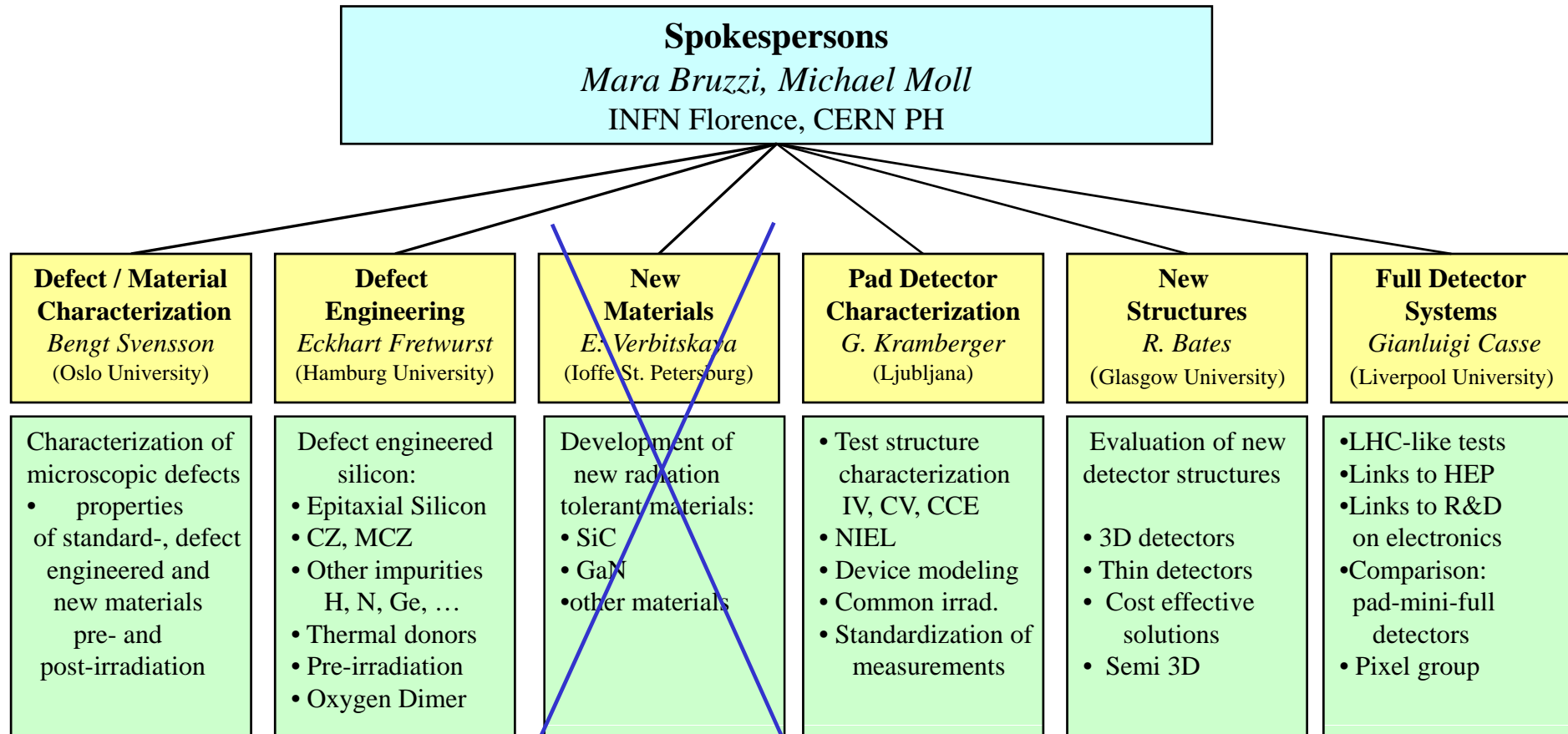
- Silicon Carbide (SiC), Gallium Nitride (GaN)

- **Device Engineering (New Detector Designs)**

- p-type silicon detectors (n-in-p)
- thin detectors, 3D detectors
- Simulation of highly irradiated detectors
- Semi 3D detectors and Stripixels
- Cost effective detectors

**Related Works – Not conducted by RD50**

- “Cryogenic Tracking Detectors” (CERN RD39)
- “Diamond detectors” (CERN RD42)
- Monolithic silicon detectors
- Detector electronics  
(Some work within RD50 on SiGe electronics)



• 2006: Research Line “New Materials” suppressed

- R&D performed by RD50 on SiC and GaN did not show promising results
- Activity within RD50 reduced on Working Group level to conclude the started work program



- CERN template for Collaboration Agreements appeared to be to ‘heavy’ and formal for an R&D collaboration; so far no problems in having created a ‘lighter’ version:
  - **RD50 Memorandum of Understanding (5 pages only)**
    - I. Introduction
    - II. Regulations of the RD50 Collaboration Board
    - III. Nominations and Elections
    - IV. Task for the Spokesperson and Deputy
    - V. Task for the Project Conveners
    - VI. Policy concerning Publications and Presentations
    - VII. Common Collaboration Fund
    - VIII. Status of Industrial Partners
    - IX. Relation to other experiments
  - **Changed only 2 times since 2002 (2/3 majority needed to change)**
  - **Some supplementary rules laid down in CB meeting minutes**  
(simple majority for decisions, higher flexibility)
- e.g.:
- Common fund spending scheme
  - Rules for funding of common projects
  - Application procedure for new members



- Being member of an approved CERN R&D collaboration will allow to access national/european funding for the collaboration members
- **Common Fund with Team account at CERN**
  - **Annual contribution from each member institute (presently 2000 CHF)**
  - **RD50 spending scheme:**
    - **70% on common projects**
    - **15% on mobility of researchers/students**
    - **10% on support for common irradiation campaigns, test beams**
    - **5% workshop organization, etc...**
- **Common Projects (funded by RD50)**
  - **Method to steer R&D and force stronger collaborations between members**
  - **Rules** (max 70% of total project costs, max 30KCHF/project depending on number of participating institutes)
  - **2 calls to RD50 members to apply for RD50 funds every year**
  - **Funding Committee consisting of Spokespersons and Conveners**
  - **Examples:**
    - **Common wafer order at TOPSIL (850 wafers, 90 KCHF)**
    - **Common 6" wafer production at Micron (96 wafers, 120 KCHF)**
    - **Bump bonding of pixel sensors, 3D detector production, .....**



## Publication Policy (as written down in the RD50 MOU)

- **Status Reports** (All members are authors) **1 proposal + 4 status reports**
  - **Reviews on collaboration work** (All members are authors)  
(If page number limited → “On behalf of RD50” with reference to full publication list on web) **12 publications since 2003**
  - **Reviews on subset of collaboration work**  
(Conveners plus members involved are authors) **no publication in this category**
  - **Work performed in the framework of the collaboration**  
(Needs acknowledgement “performed in framework of RD50”) **> 50 publications no complete list**
  - **Internal RD50 notes** **8 notes**
- ## Presentations at Workshops and Conferences
- **Contributed talks** (Abstract to be discussed with project convener) **? talks**
  - **Invited talks** (Choice of speaker by spokesperson) **36 talks**





### **LHCC & Research Board**

- Presentation of Status Report towards the LHCC once a year
- Submission of written Status Report to LHCC once a year
- Based on status report LHCC will recommend or not to prolong the approval of the project by a further year
- Decision on approval taken by the CERN Research Board
- Depending on LHCC referee: Further meetings during the year to present research status

### **CERN**

- CERN contact person needed to represent collaboration against CERN (if spokesperson not from CERN)
- Once a year: Annual report to be submitted to CERN



- **Organization and Administration - Not to be under-estimated!**
  - **Common Fund administration (Budget holder)**
    - Collection of annual contributions
    - Handling of common orders (profit from TVA exemption at CERN!)
    - Handling of project funds (several projects running in parallel)
  - **List of members** (database of members, list of authors, liaison to users office, mailing lists, ...)
  - **Web-page of collaboration**
  - **Handling of common publications, internal notes and publications in the framework of the collaboration. ... Organization of internal review!!**
  - **Co-ordination of common irradiation runs and test beams.**
  - **Administration of common projects (Call for projects, review of projects, ...)**
  - **Organization of Workshops (2 per year; one at CERN; one outside of CERN)**
  - **Computer accounts, offices, laboratories, .....**



## Setup of collaboration

- **Good and ambitious editing team needed for proposal**
- **Spokesperson search committee was helpful**  
(Make sure to find spokesperson(s) that can and do contribute a significant fraction of their time for this task!)

## Organization of collaboration

- **Scientific organization into research lines with conveners was and is successful concept for RD50** (try to distribute work and get the real experts to work for the collaboration); **difficult to find motivated conveners**
- **RD50 MOU could be used as template for RD51**  
(a set of clear rules is certainly needed!)
- **Common Fund and Common Projects are important tools to steer collaborative work. Having team account is very valuable!**
- **Administration is not negligible, try to distribute tasks on several persons!**



## What could be better within RD50?

- **Handling of publications certainly not very strict within RD50**  
(However, a better organized approach would certainly increase the administrative load significantly and so far: no complains within RD50 about publications)
- **Could be more strict with ‘little active institutes’?**

## What works well?

- **Scientific output + Transfer of results into LHC/SLHC experiments**
- **Common projects** (with and without RD50 internal funding)
  - Certainly to the profit of all participating institutes and the scientific community

## More recommendations?

- Keep close contacts to the LHC/ILC Experiments
- RD50 has a set of recommendations on how to measure certain properties. This kind of “internal standard” is very helpful to compare data obtained by different groups. Should be established early in order to be most profitable.



**Good Luck  
in forming RD51**