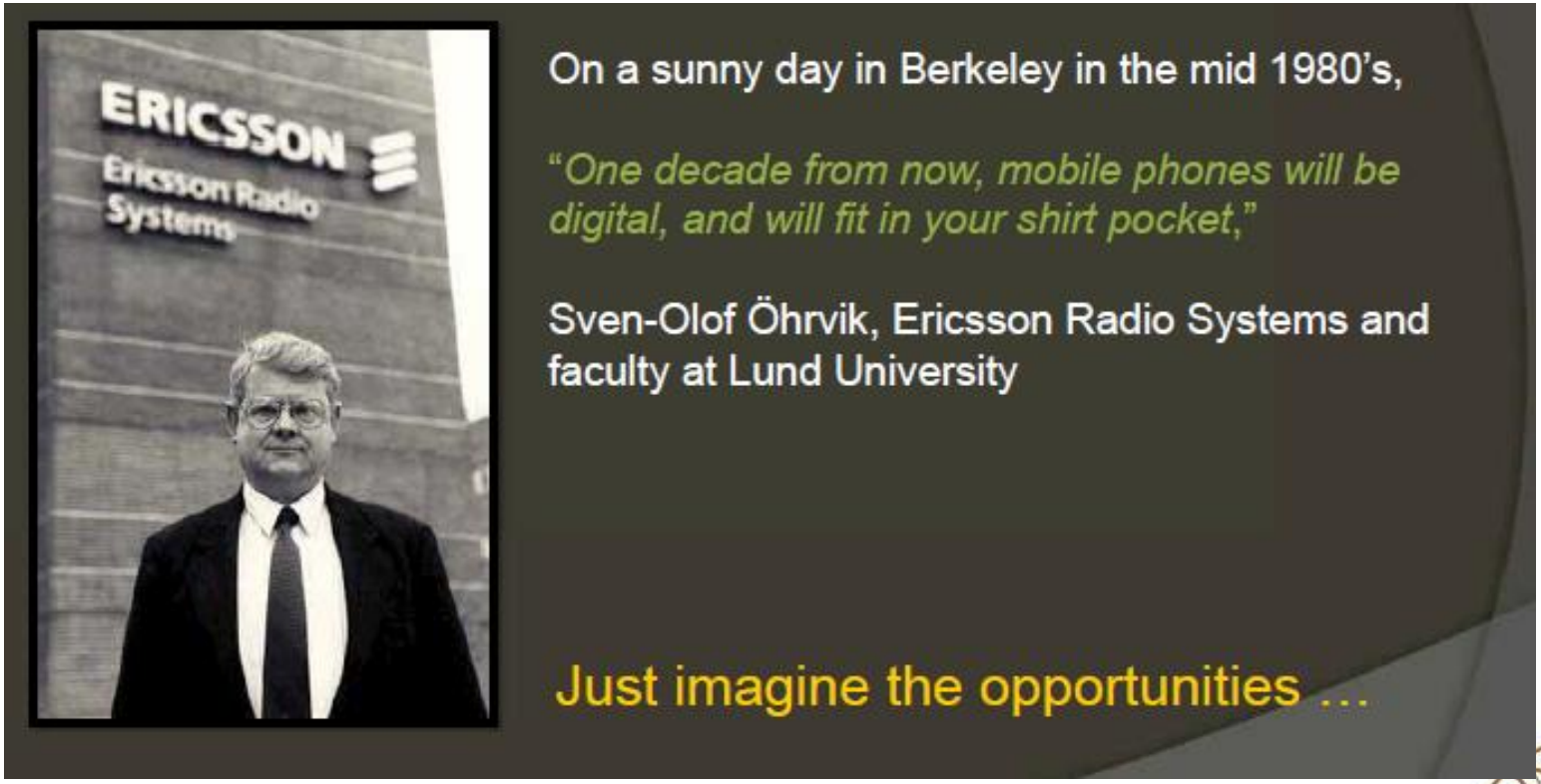
# Lund Circuit Design Workshop

# Welcome and Introduction

**VIKTOR ÖWALL**

# A great visionary left us during 2014!

**Sven-Olof Öhrvik, one of the founding fathers of wireless communication as we know it, passed away in April.**




**From *Professor Jan Rabaeys (UC Berkeley)* Honorary Doctor Lecture at Lund University in 2012.**

# Welcome to two exiting days!

## Together with 150 of your colleagues.


You have received a folder including

a program and presentations of:

- Invited speakers
- Faculty
- PhD students
- International Advisory Board
- SoS Board

# Thematic Sessions

**Day 1**

- **Session 1: Mixed Techniques**
- **Session 2: Digital Processing**
- **Session 3: Low Power Design**

**Day 2**

- **Session 4: millimeter Wave**
- **Session 5: RF Techniques**
- **Closing: Sven Mattisson, Chairman of SoS**

# Invited Speakers, day I

- **Jan Rabaey**, UC Berkeley/BWRC
  The Return of Neuro-inspired Computing - Why now?

- **Ivo Bolsens**, CTO Xilinx
  Beating Moore's Law with the All Programmable SOC aka FPGA

- **Johan Svenér**, Sony Mobile
  Sony Key Use Cases and low power Platform focus for Wearables

# Invited Speakers: Pre-dinner talk!

## Heard about MAPCI?
## What is it all about?

# Invited Speakers: Pre-dinner talk!

**Heard about MAPCI?**
**What is it all about?**

**Ask Scientific Director**
**Professor Björn Landfeldt, LU.**

# Invited Speakers, day II

- **Jonas Hansryd**, Ericsson
  mm-Wave Communication Beyond 2020

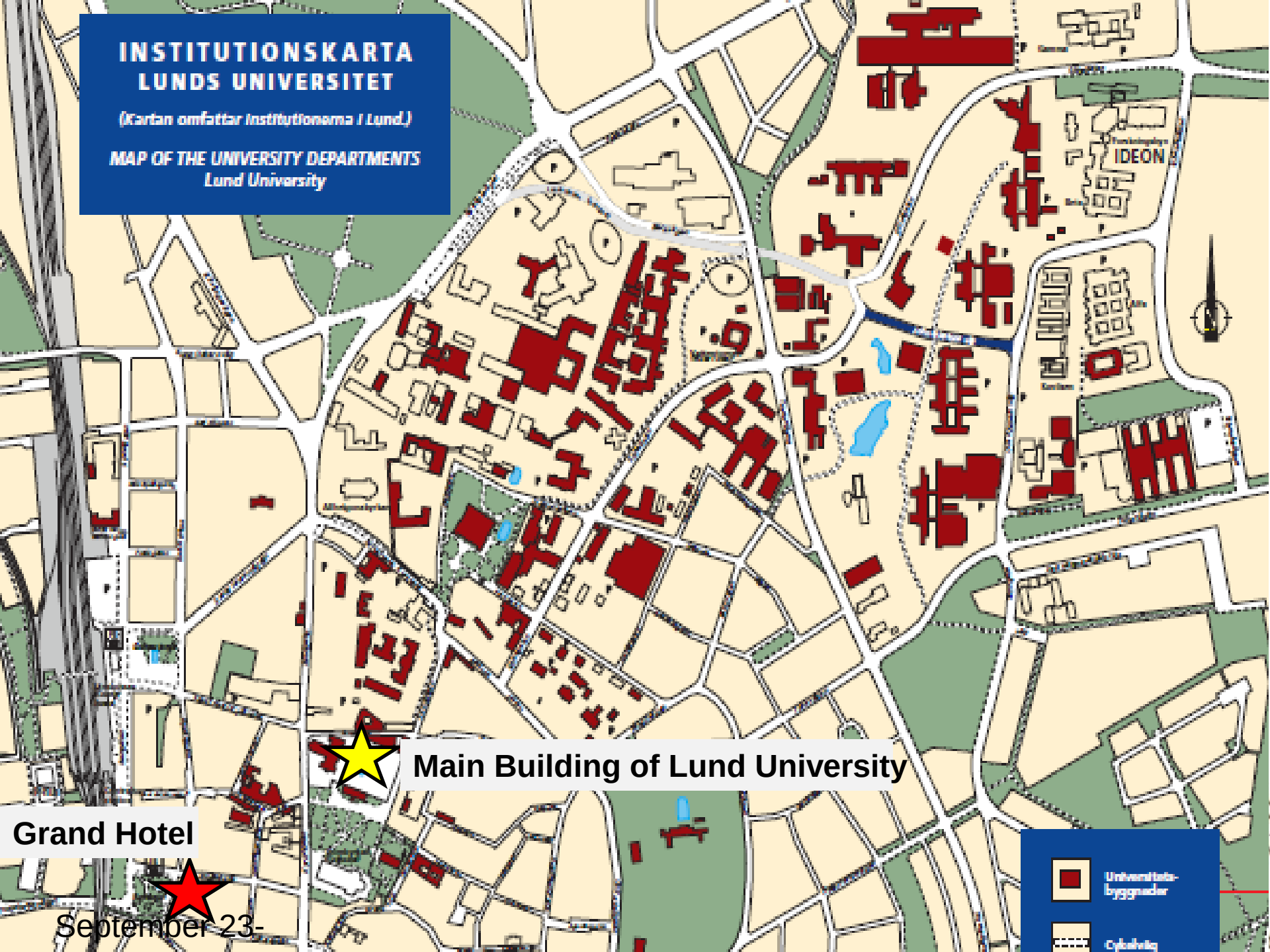
— **Mustafa Özen**, Chalmers
Wideband and Energy Efficient Power Amplifiers for Wireless Communication

together with **Christian Fager**

# Some Logistics!

- Today's program is at Grand Hotel including Lunch.
- Dinner in the Main Building of Lund University, *7pm*.
- Tomorrows programs is at the Faculty of Engineering, Lund University.

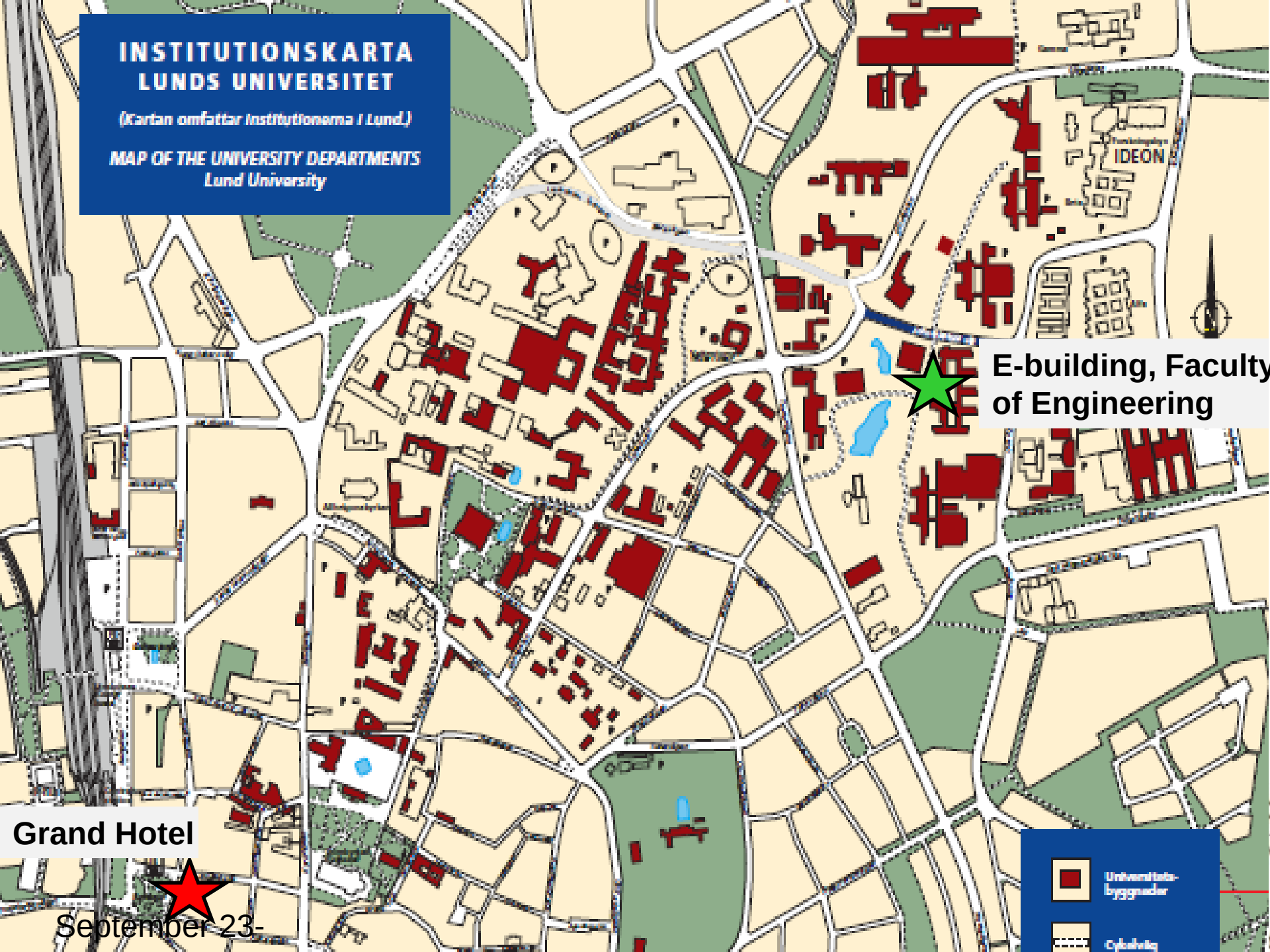
# Dinner : Main Building of Lund University


INSTITUTIONSKARTA
LUNDS UNIVERSITET
(Kartan omfattar institutionerna i Lund.)
MAP OF THE UNIVERSITY DEPARTMENTS
Lund University
IDEON
Main Building of Lund University
Grand Hotel
September 23-
Universitets-
byggnader

# Some Logistics!

- Today's program is at Grand Hotel including Lunch.
- Dinner in the Main Building of Lund University.
- Tomorrow's program is at the Faculty of Engineering, Lund University.
  Approximately 25min walk from Grand Hotel.

**E:A in the Main Entrance Hall**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E-building, Faculty of Engineering
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# E-building: faculty of Engineering

# The Hosts

Industrial Excellence Center in

System Design on Silicon

**From VINNOVA´s evaluation 2011: "SoS builds on strong long-term relations with top industry partners in the international arena in the Center's strategic area which is highly relevant to the Swedish economy. The SoS team represents an impressive range of research talent and experience, including many staff with international records of achievement and clearly shows that they can compete on an international level. "**

# The Hosts

SoS was evaluated during spring 2014 by VINNOVA:

**"SoS is functioning well, has a strong research profile, and is a good example of the INDEC concept."**

**Has been asked to send in an Operational Plan for the period 2015-2017.**

**Fr… top industry partners in the international arena in the Center's strategic area which is highly relevant to the Swedish economy. The SoS team represents an impressive range of research talent and experience, including many staff with international records of achievement and clearly shows that they can compete on an international level. "**

# People in SoS

Director: Viktor Öwall, Co-director: Piertro Andreani
Chairman of the Board: Sven Mattisson, Ericsson AB

## International Advisory Board

- Professor Jan Rabaey, BWRC, UC Berkeley, USA
- Professor Mike Faulkner, Victoria University, Australia
- Professor Qiuting Huang, ETH, Zürich, Switzerland

# People in SoS

Director: Viktor Öwall, Co-director: Piertro Andreani
Chairman of the Board: Sven Mattisson, Ericsson AB

**From SoS IAB report 2013: "Finally, the fact that the results of the research are now finding their way to the most prestigious conferences and journals in the field speaks for the international quality of the work.""**

# The Hosts: the SSF programs

**DARE**
Digitally Assisted Radio Evolution
Piero Andreani

**Distrant**
Distributed Antenna Systems
Fredrik Tufvesson

**2011-2015/16**

Swedish Foundation for Strategic Research

**2009-2013/14**

**WWW**
Wireless with Wires
Lars-Erik Wernersson

**UPD**
Wireless Communication for Ultra Portable Devices
Henrik Sjöland

# The Hosts: the SSF programs

DARE
Digitally Assisted Radio Evolution
Piero Andreani

2011-2015/16

Distrant
Distributed Antenna Systems
Fredrik Tufvesson

Swedish Foundation for Strategic Research

Last Year

La ion for
s
Henrik Sjöland

# Funding and Projects



- MAMMOET
- BASTION
- E²-SWITCH

DARE

DISTRANT

HiPEC

SoS

System Design on Silicon

VINNOVA

VR

ELLIIT

**Strategic Research Area (SFO)**

# We are the people!

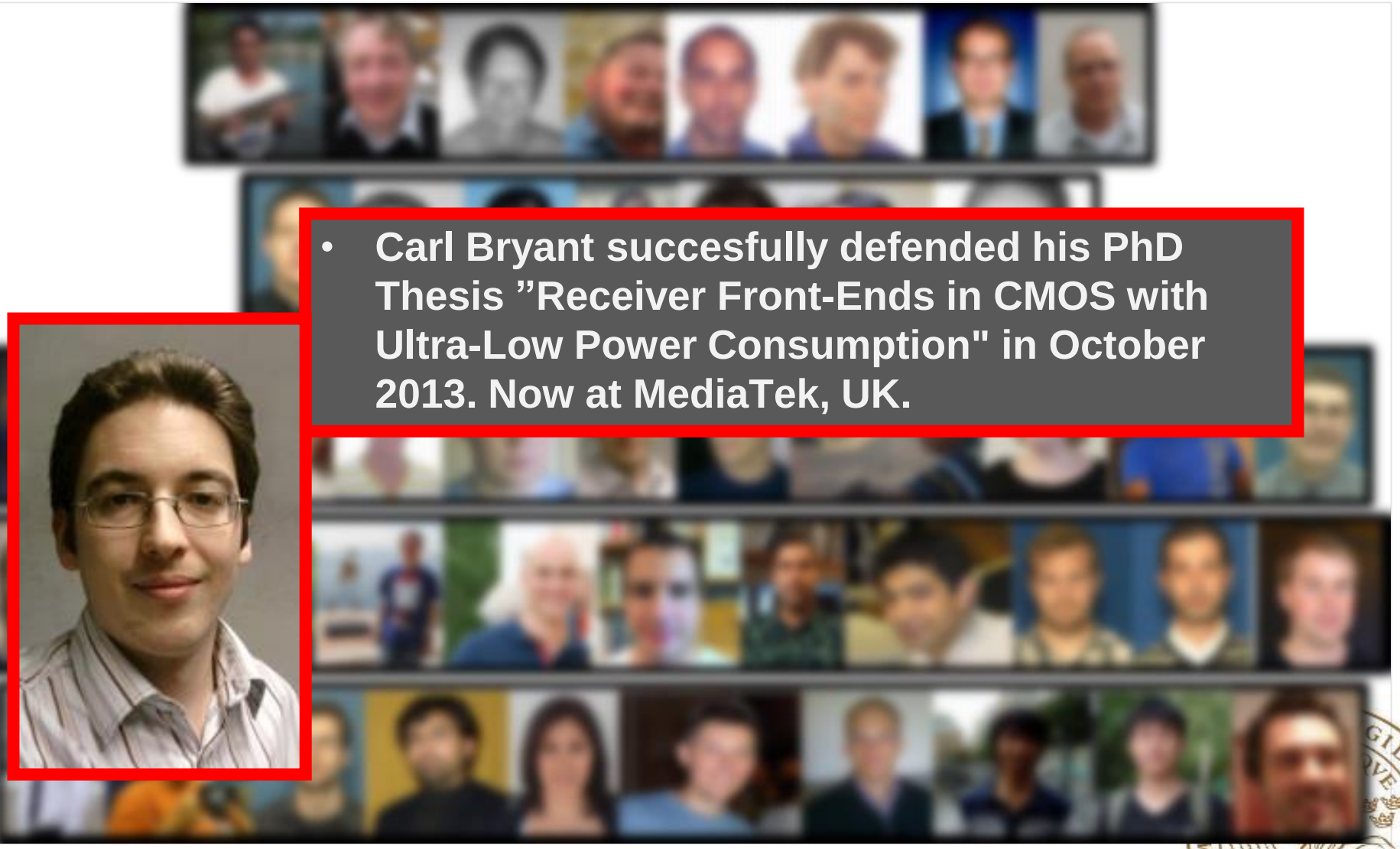
# A central KPI*: the people!

* A business term moving into the academic environment.

# Recent Graduates

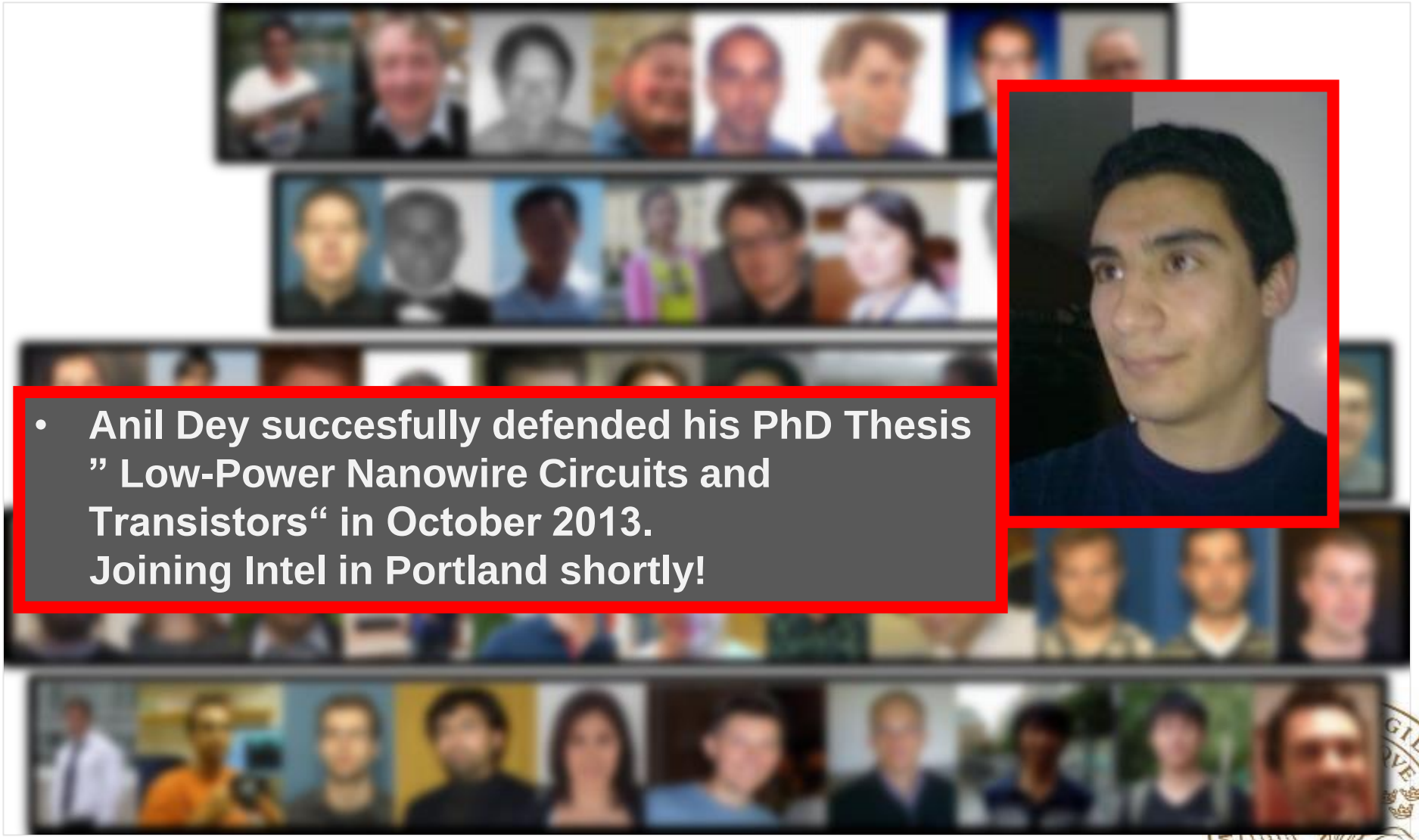
- **Mattias Anderssons succesfully defended his PhD Thesis ”Continuous-Time Delta-Sigma Modulators for Wireless Communication." in March 2014. Now at Ericsson Research, Lund.**

# Recent Graduates



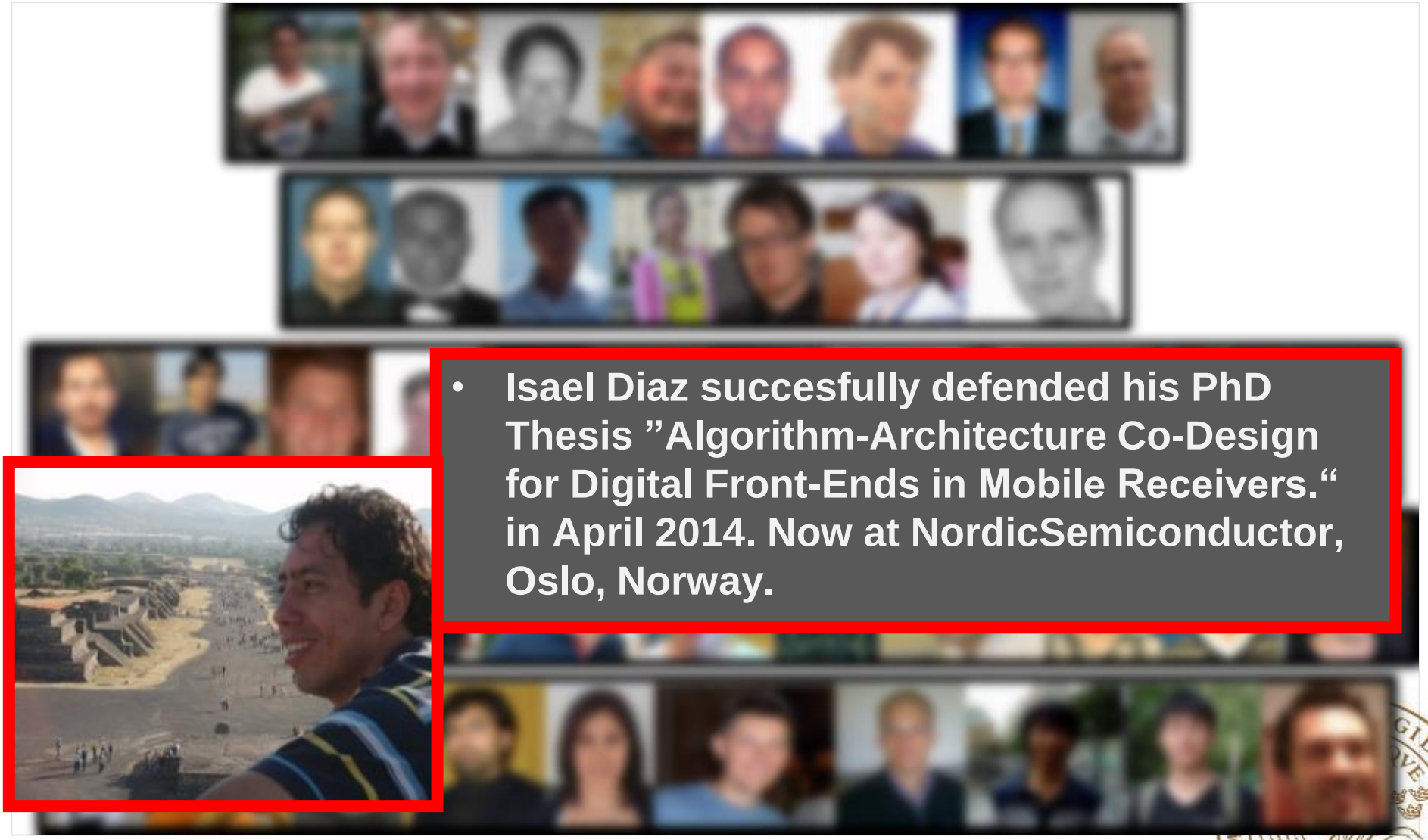
- Carl Bryant succesfully defended his PhD Thesis ”Receiver Front-Ends in CMOS with Ultra-Low Power Consumption" in October 2013. Now at MediaTek, UK.

# Recent Graduates



- Anil Dey succesfully defended his PhD Thesis ” Low-Power Nanowire Circuits and Transistors“ in October 2013.
  Joining Intel in Portland shortly!

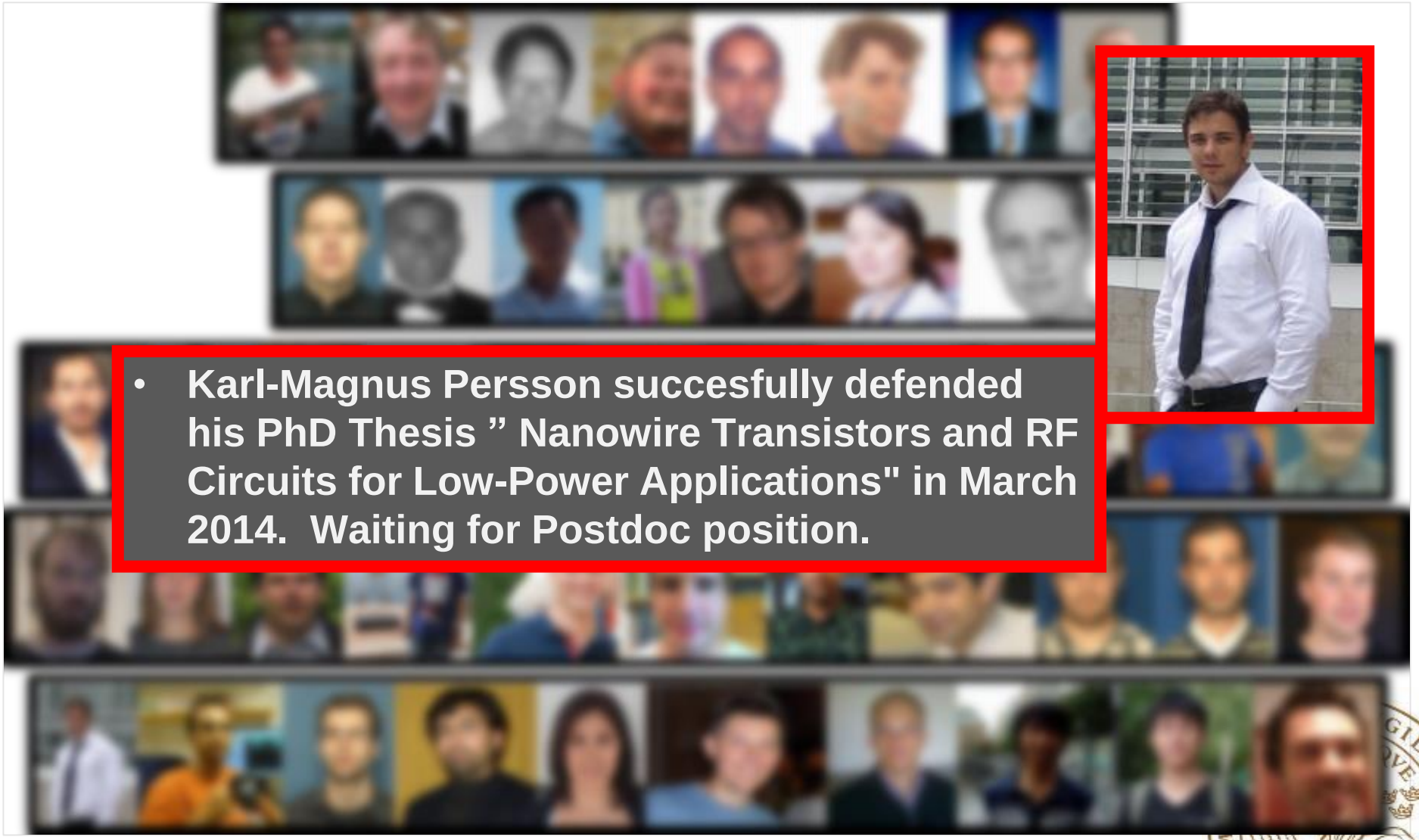
# Recent Graduates



- **Isael Diaz succesfully defended his PhD Thesis ”Algorithm-Architecture Co-Design for Digital Front-Ends in Mobile Receivers.“ in April 2014. Now at NordicSemiconductor, Oslo, Norway.**

# Recent Graduates

# Recent Graduates

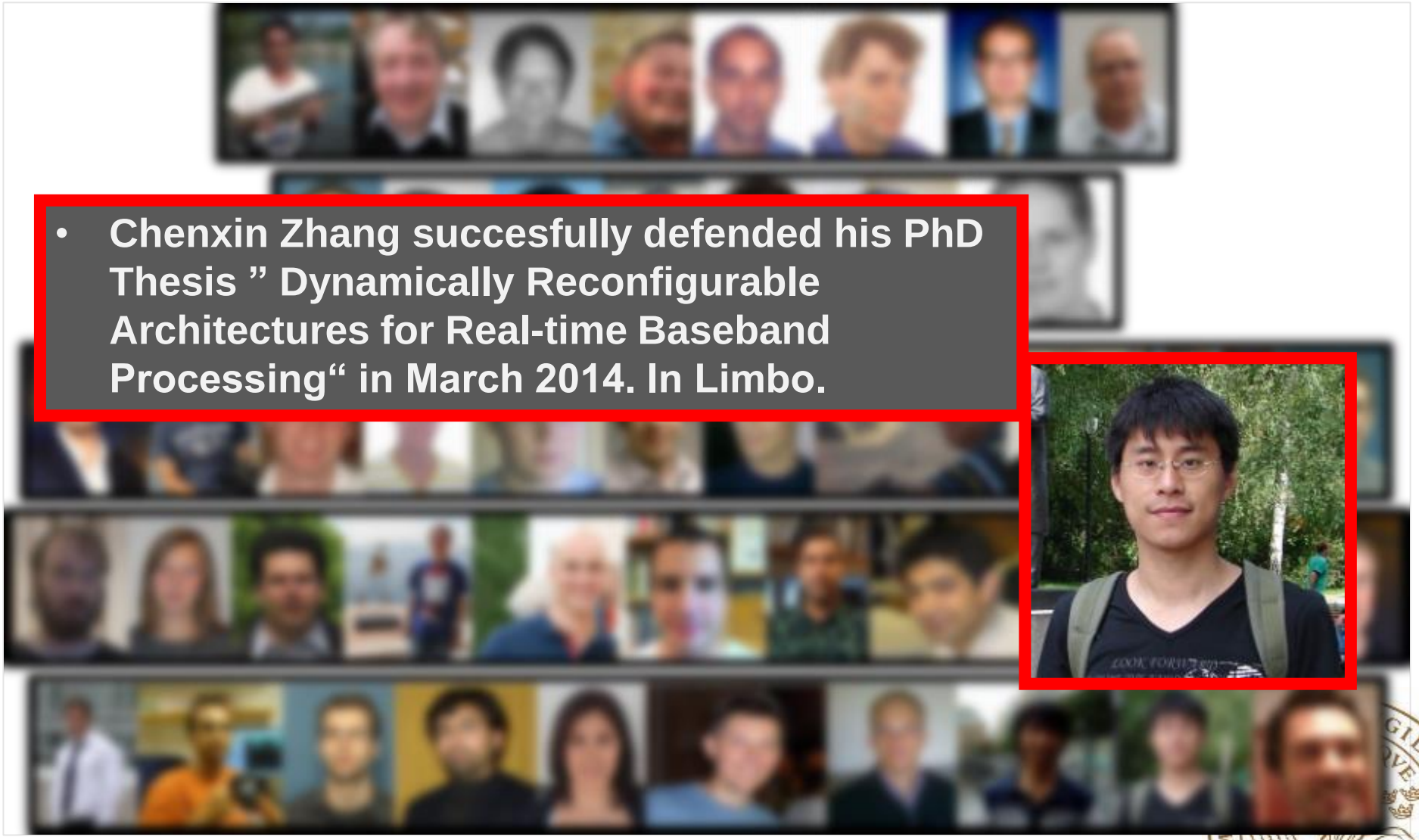


- **Karl-Magnus Persson succesfully defended his PhD Thesis ” Nanowire Transistors and RF Circuits for Low-Power Applications" in March 2014. Waiting for Postdoc position.**

# Recent Graduates

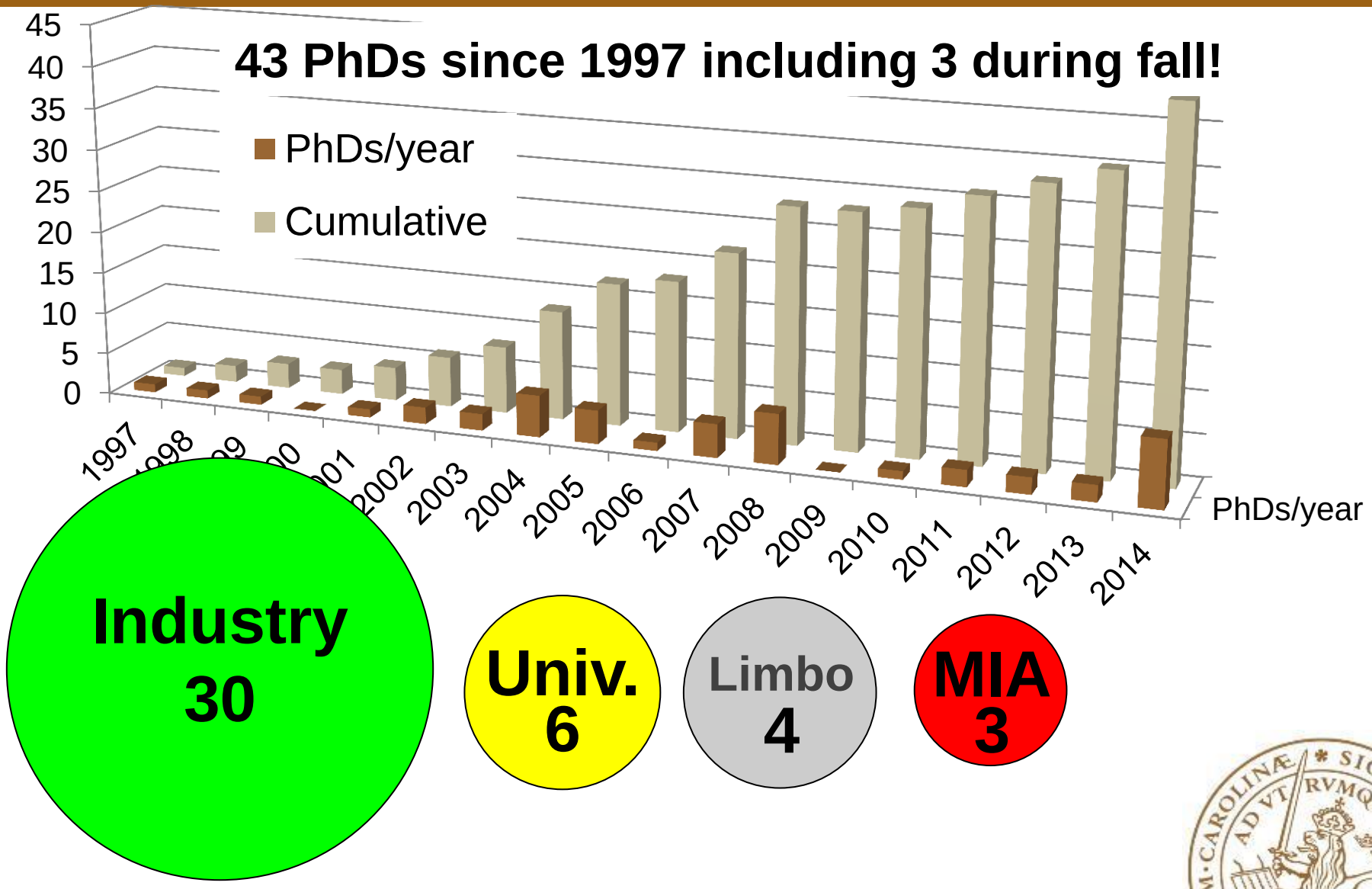
- **Yasser Sherazi succesfully defended his PhD Thesis ” Design Space Exploration of Digital Circuits for Ultra-low Energy Dissipation" in January 2014. Now at IMEC, Belgium.**

# Recent Graduates

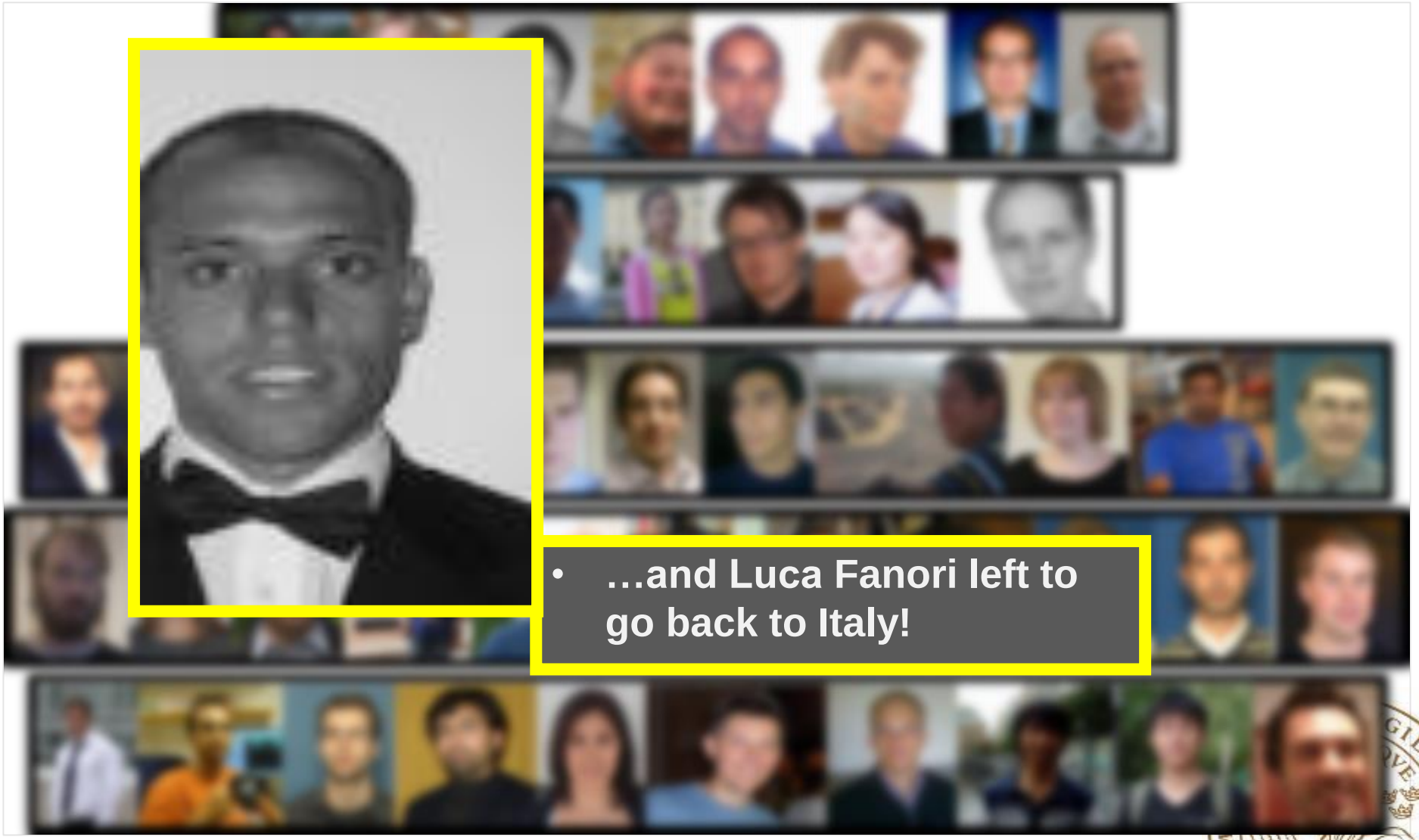


- Chenxin Zhang succesfully defended his PhD Thesis ” Dynamically Reconfigurable Architectures for Real-time Baseband Processing“ in March 2014. In Limbo.

# PhDs graduated since the start of CCCD.



# Going home!



- …and Luca Fanori left to go back to Italy!

# …and we got some new names!

**Federico Pepe as a postdoc**

**…and PhD students:**

**Sebastian Heunisch**

**Yangxurui Liu**

**…and the test and verification group: Dimitar Nikolov, Breeta SenGupta and Farrokh Ghani Zadegan**

# More people, more papers!

# 5 papers at ESSCIRC 2014!

**in Venice September 22-26!**

# 5 papers at ESSCIRC 2014!

- ”A 4th Order Gm-C Filter with 10MHz Bandwidth and 39dBm IIP3 in 65nm CMOS” by Mohammed Abdulaziz, Markus Törmänen, and Henrik Sjöland.

- “A 2.45GHz, 50µW Wake-up Receiver Front-end with 88dBm Sensitivity and 250kbps Data Rate” by Carl Bryant and Henrik Sjöland.

- ”A Low Band Cellular Terminal Antenna Impedance Tuner in 130nm CMOS SOI Technology” by Jonas Lindstrand, Ivaylo Vasilev, and Henrik Sjöland.

# 5 papers at ESSCIRC 2014!

- "A Class-D CMOS DCO with an on-chip LDO" by Luca Fanori, Thomas Mattsson, and Pietro Andreani.

- “A 35 fJ/bit-access Sub-VT Memory Using a Dual-Bit Area-Optimized Standard-cell in 65 nm CMOS” by Oskar Andersson, Babak Mohammadi, Pascal Meinerzhagen, and Joachim Neves Rodrigues.

# IEEE JSSC special issue on ESSCIRC 2013

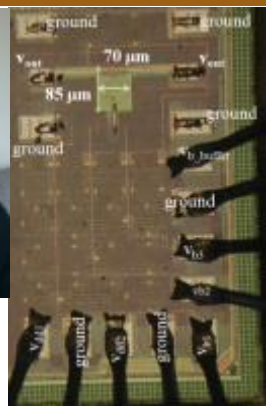

**M. Andersson, M. Andersson, L. Sundström, P. Andreani, ”A Filtering Delta Sigma ADC for LTE and Beyond”, IEEE Journal of Solid-State Circuits, Vol. 49, No. 7, pp. 1535-1547, 2014.**

# IEEE JSSC special issue on ESSCIRC 2013


**This also marked Piero's 20th article in JSSC! Congratulations!!!**

**Dinner Quizz: How many are related to VCOs?**

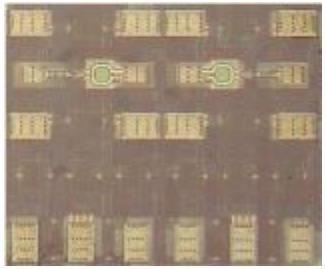
# 3 invited mm-wave papers to ISIC 2014!

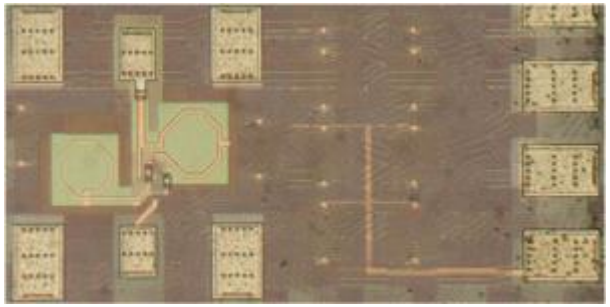



- **T. Tired, H. Sjöland, C. Bryant, M. Törmänen, "A 28 GHz SiGe QVCO with an I/Q phase error detector for an 81-86 E-band transceiver".**

- **T. Forsberg, H. Sjöland, M. Törmänen, "A 65 nm CMOS varactorless mm-wave VCO".**

- **M. Törmänen, "mm-Wave Pulse-Generation Circuits in 65nm CMOS".**

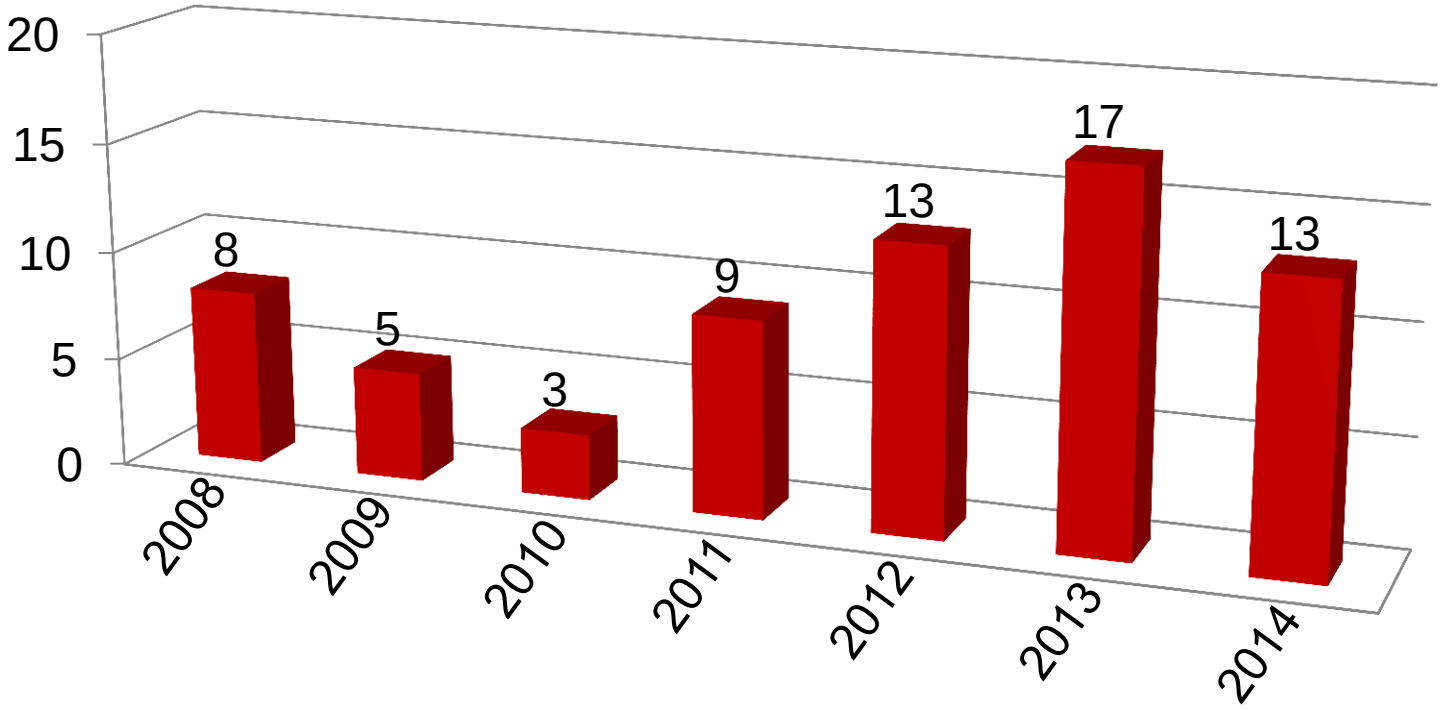




# RFIC 2014 paper invited to JSSC!


**A. Nejdel, H. Sjöland and M. Törmänen, "A Noise Cancelling Receiver Front-End with Frequency Selective Input Matching".**

# Journal publications in Circuit Design.

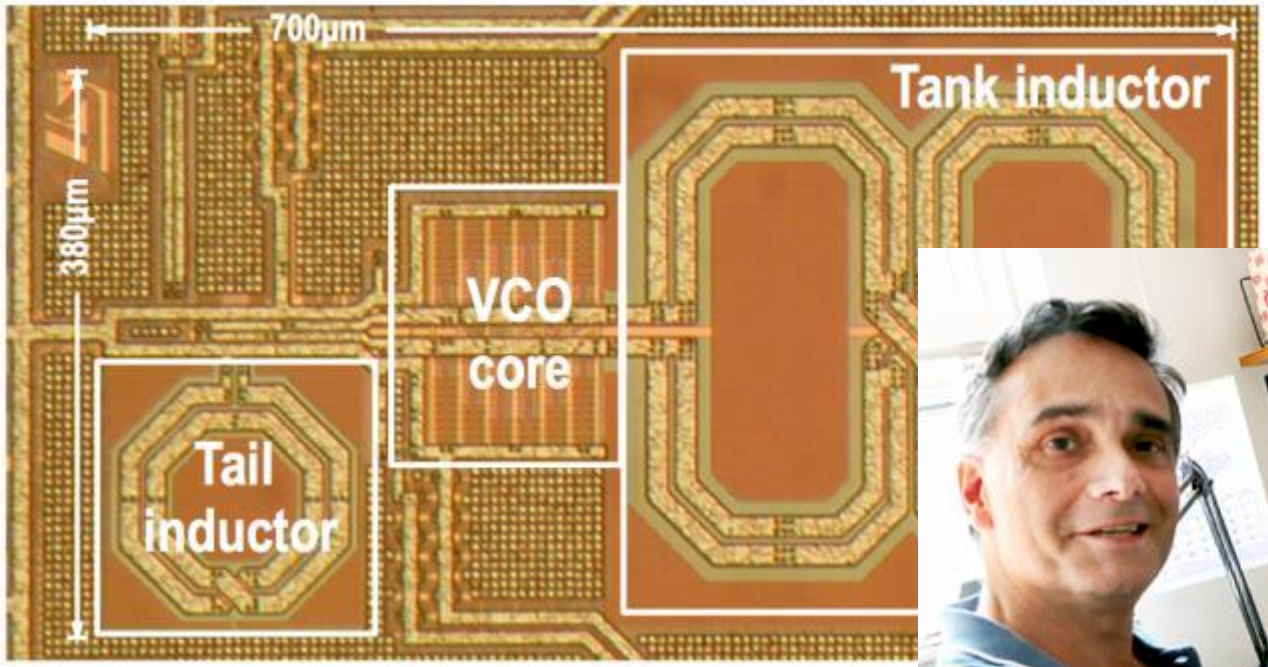


# Some Research Highlights!

(Based on sessions)

# First VCO in 28nm FDSOI!

**Tuning range of more than an octave 2.8-5.8GHz!**




# EU FP7 MAMMOET

**MAMMOET = MAssive MiMO for Efficient Transmission**

**Partners:** **Ericsson, Infineon, Telefonica, Lund Univ., Linköping Univ., IMEC, KU Leuven, Technicon**

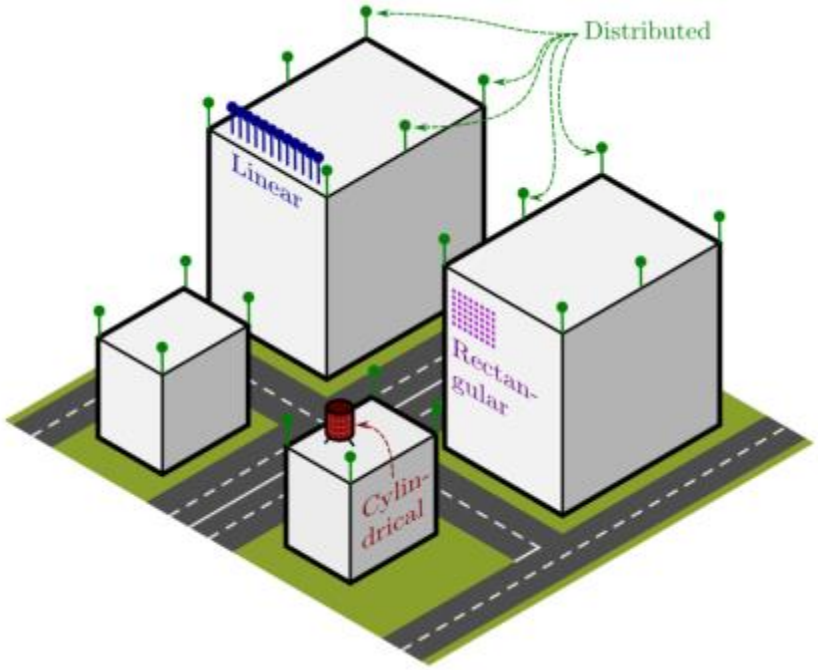
**Time:** **2014-2016**

**Workshop in Lund Tuesday-Wednesday this week. Lots of discussions and open issues!**

**Lund team: Ove, Fredrik Tufvesson, Viktor, Liang, Ghassan, João, Steffen, Xiang, Hemanth, Jose, ...**

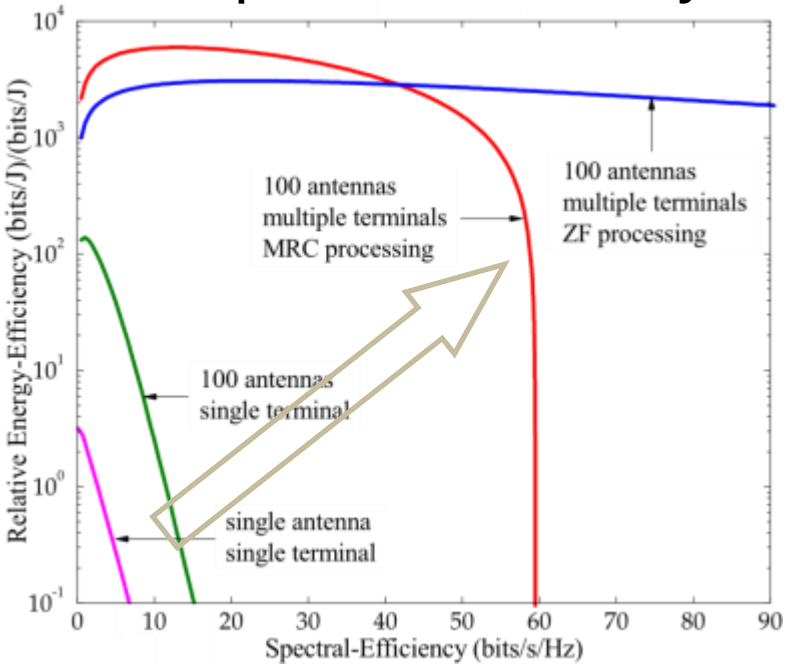
# Massive MIMO

**Massive BS arrays** with orders of magnitude more antenna elements




**Simple single-antenna terminals**

**Massive gains** in both energy and spectral efficiency




[Efficiency plot from H. Q. Ngo, E. G. Larsson, and T. L. Marzetta, "Energy and spectral efficiency of very large multiuser MIMO systems," IEEE Trans. Commun., vol. 61, pp. 1436–1449, Apr. 2013.]

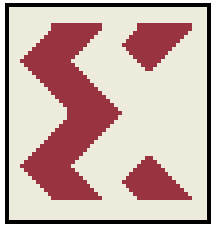
# Unique Massive MIMO testbed!


- 300kg
- 5kW@start-up
- Lots of cables!

# LuMaMi: Lund Massive Mimo Testbed

**50 NI USRP-RIO**

**Xilinx Kintex-7**

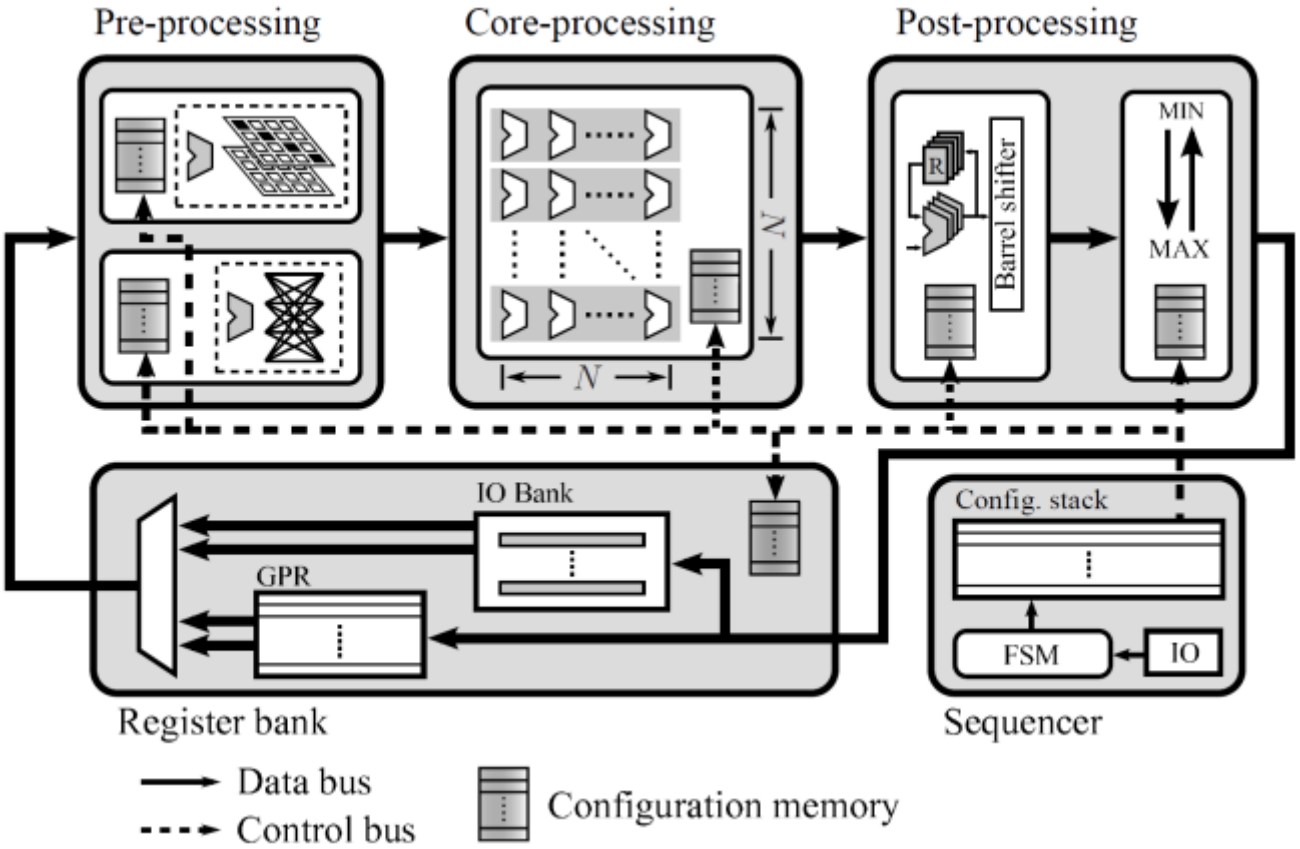
**Interleaver/De-interleaver**
**Viterbi Decoder**
**3GPP Turbo Decoder**
**LTE FFT**

**Donation by Xilinx!**

# LuMaMi team relaxing!

# Highlight in Digital Baseband!

## Dynamically Reconfigurabe Processor for MIMO Processing.



# Highlight in Digital Baseband!

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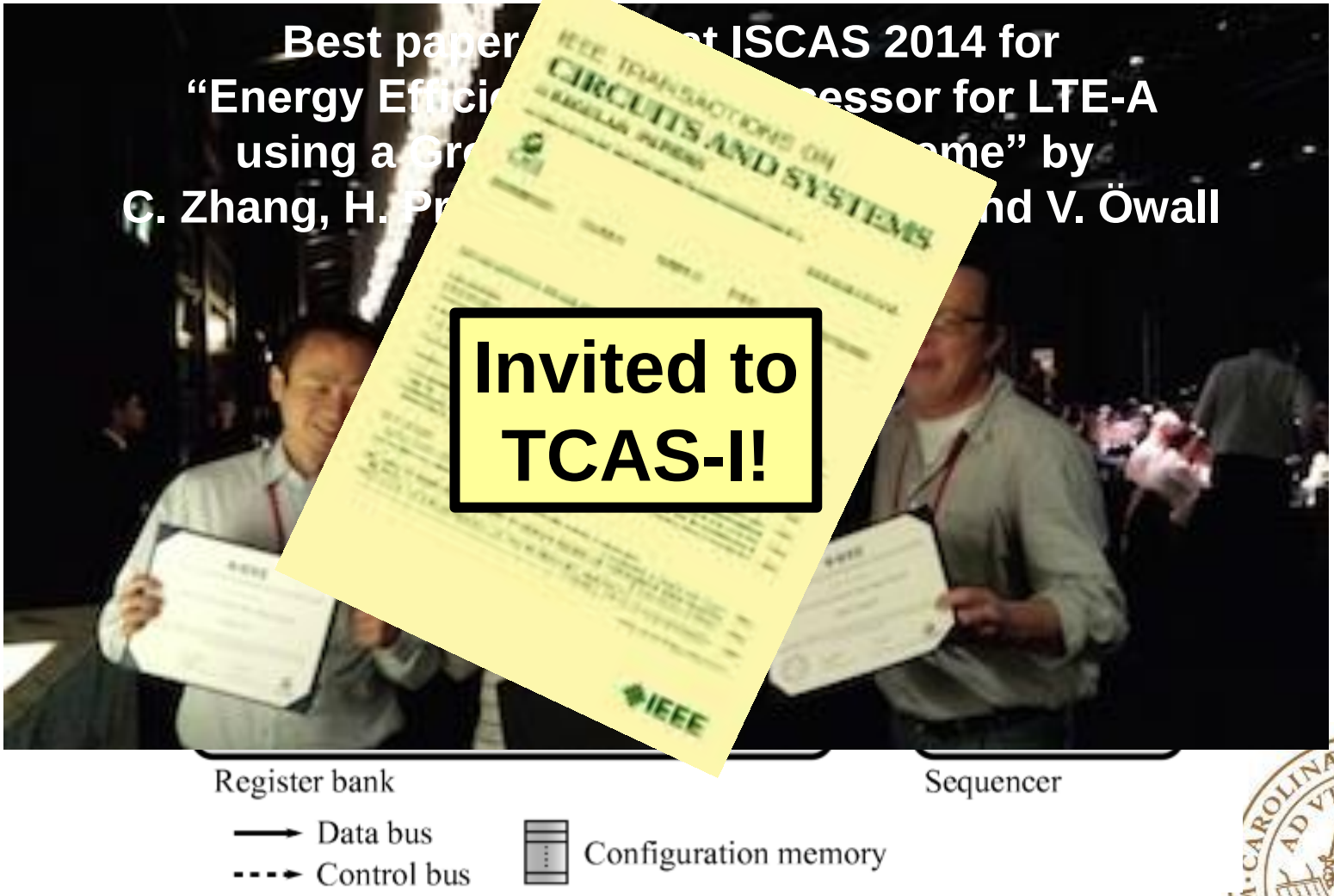
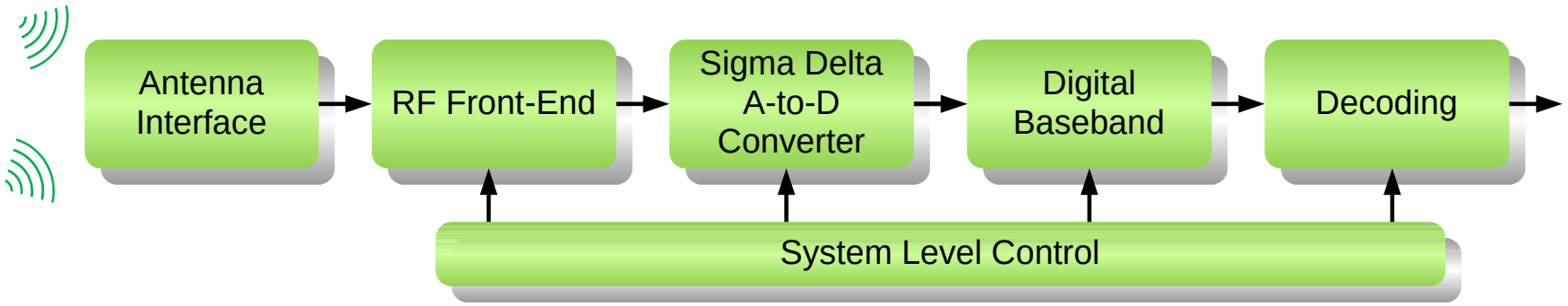


# UPD is closing the books succesfully!

## Wireless Communication for Ultra Portable Devices




**SSF Framework Program**

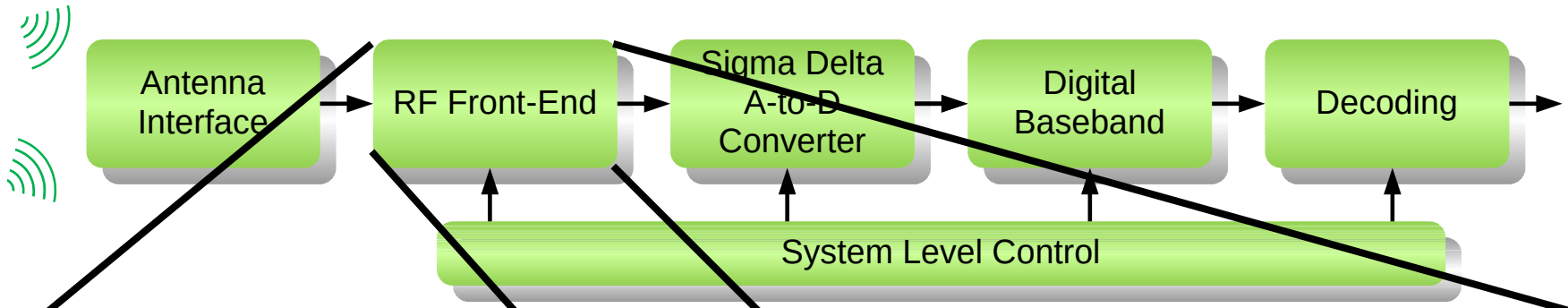
- 22.4MSEK
- 2008-2014
- 6 PhD Students
- 9 Senior Researchers
- Circuits, Antennas, Systems

**Targets**

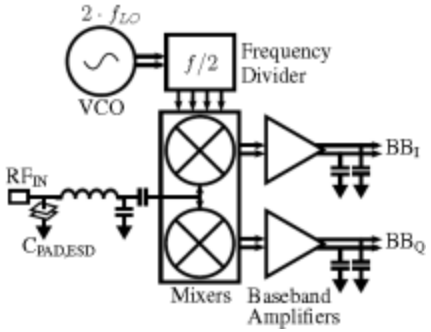
- 1mW in active mode
- 1uW in standby
- 1mm$^2$ chip area in 65nm CMOS
- 250 kbit/s
- 2.45GHz

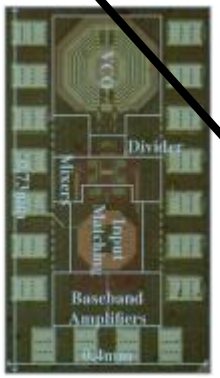
# UPD is closing the books succesfully!

## Wireless Communication for Ultra Portable Devices

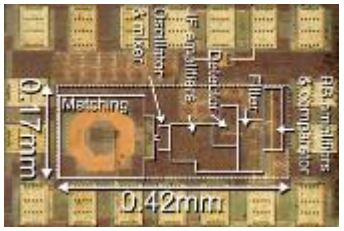


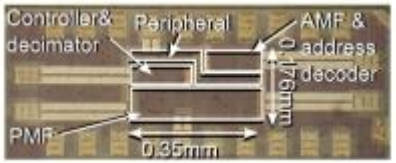

### SAW-less receiver front-end



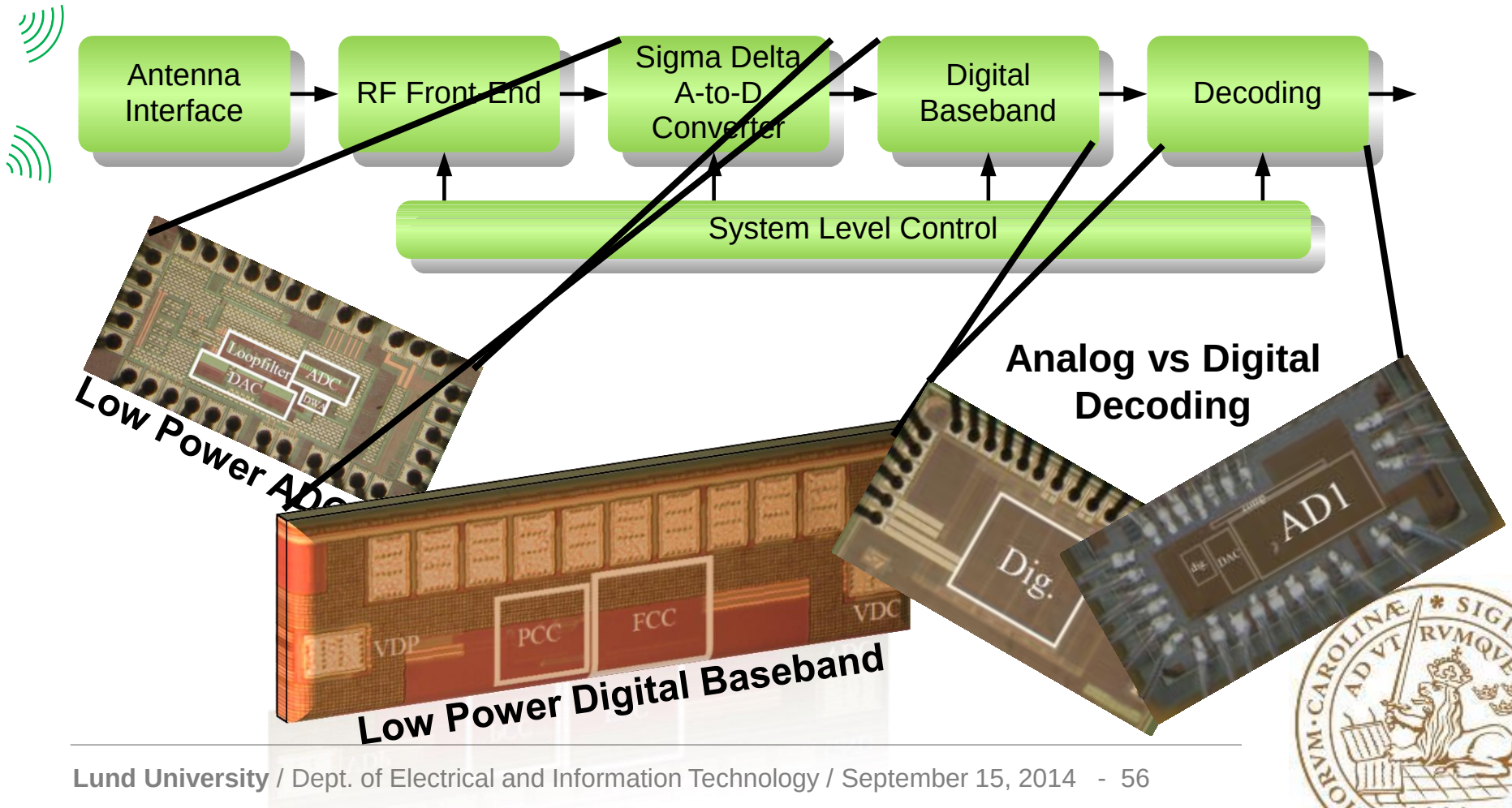

### Wake-up receiver at 50µW



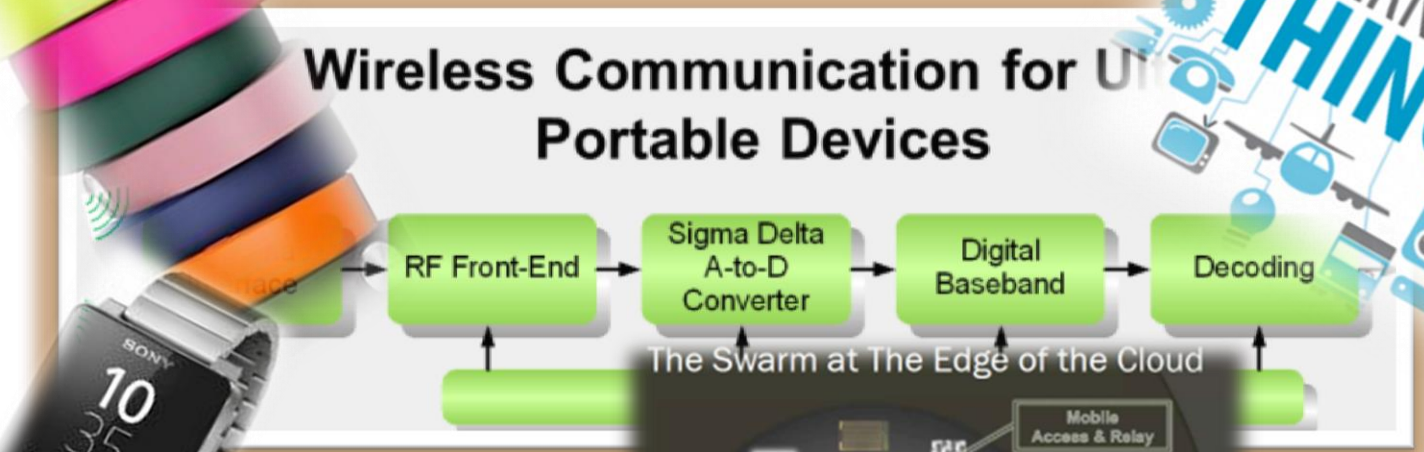



# UPD is closing the books succesfully!

## Wireless Communication for Ultra Portable Devices



# Future: Wearables, Swarm, IoT, …



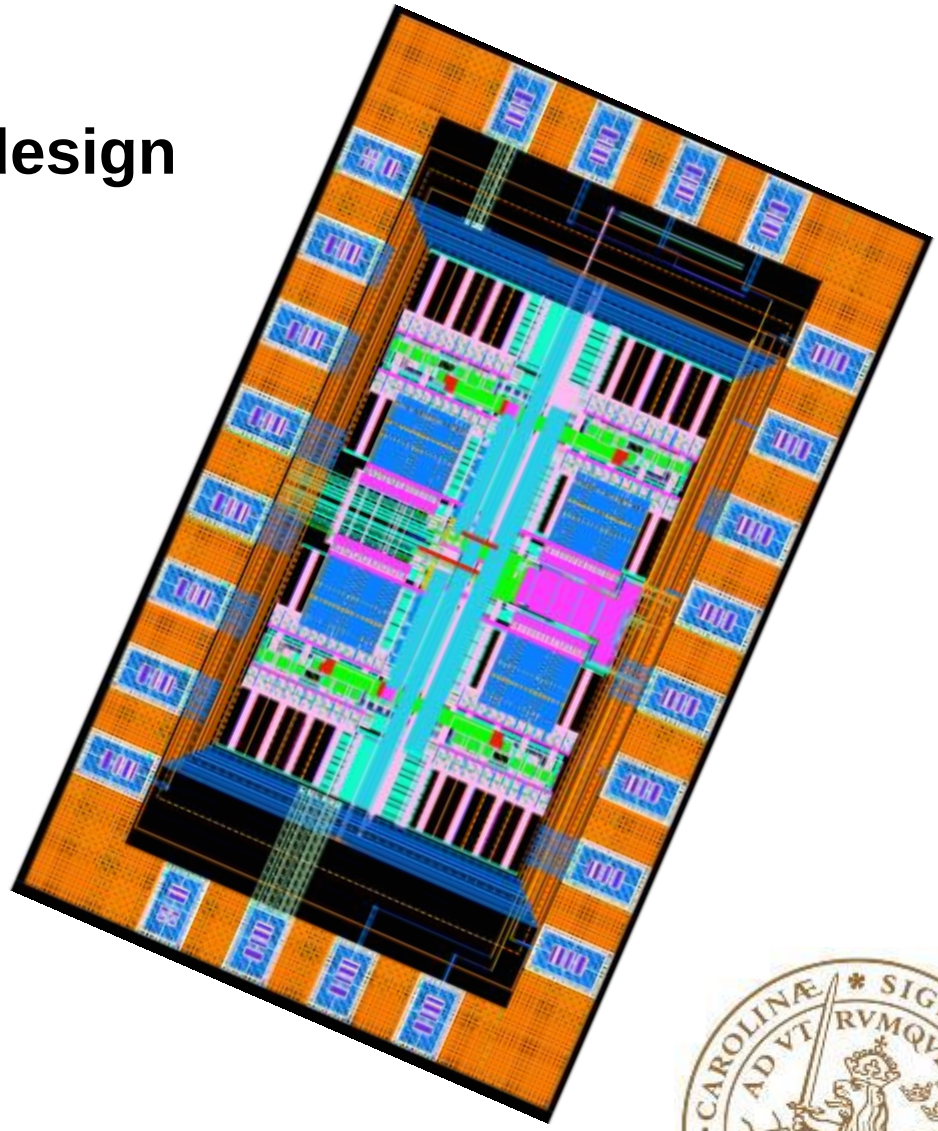


# …but we NEED the circuits!

## Ultra Low Voltage memory design

- Novel SRAM approach
- Less leakage
- Fabrication in 28FD-SOI

- Babak doing internship at STM



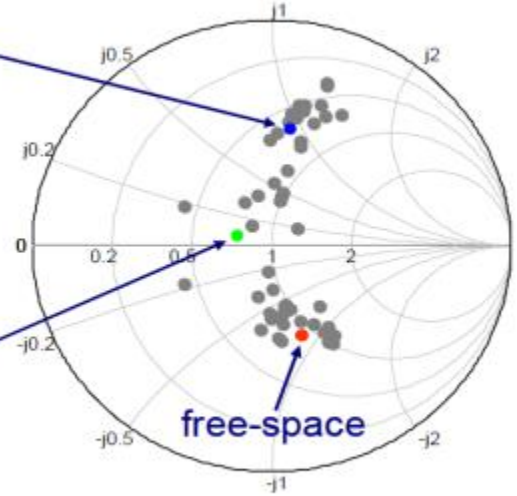
# Wideband PA and adaptive matching

A Low Band Cellular Terminal Antenna Impedance Tuner in 130nm CMOS SOI Technology

**Motivation – User Interaction**



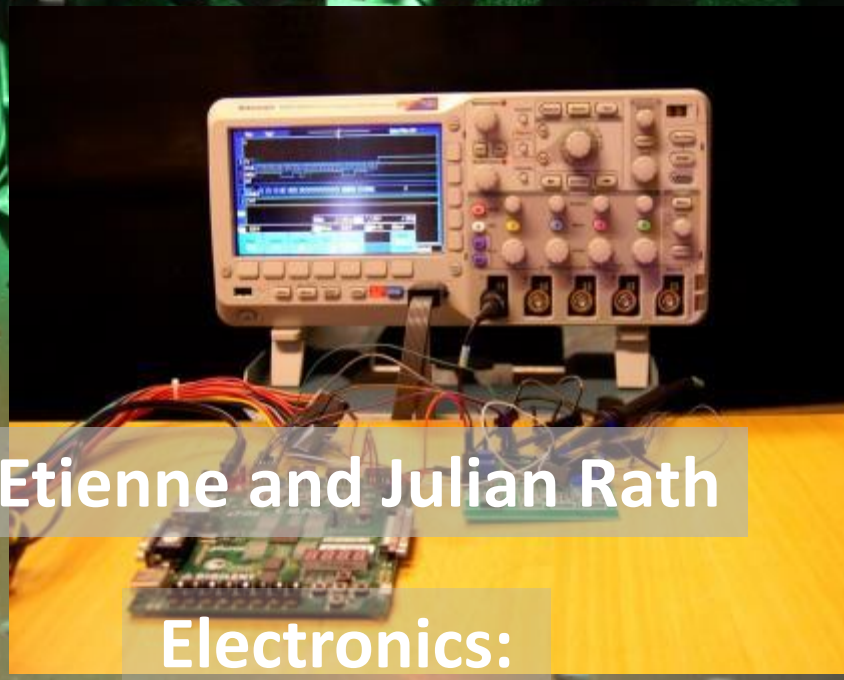
Commercial Phone Antenna





AND NOW FOR
SOMETHING
COMPLETELY
DIFFERENT

# Electronics as an Enabler: Measurement of Ultrafast Laser Pulses



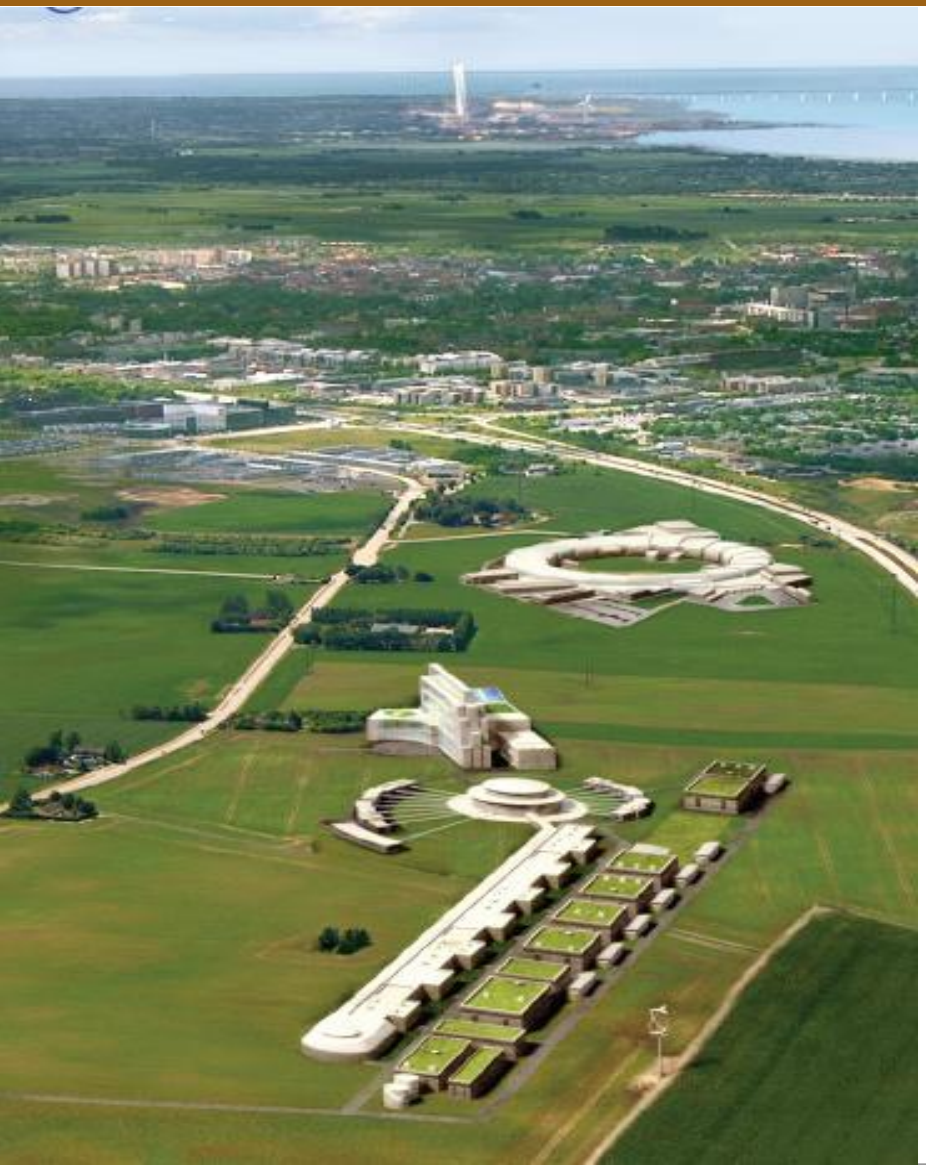
Master's Students: David Etienne and Julian Rath

Atomic Physics:
Cord Arnold
Anne l'Hullier

Electronics:
Liang Liu
Viktor Öwall

**Donation of Kintex-7 board by Xilinx. Thanks!**

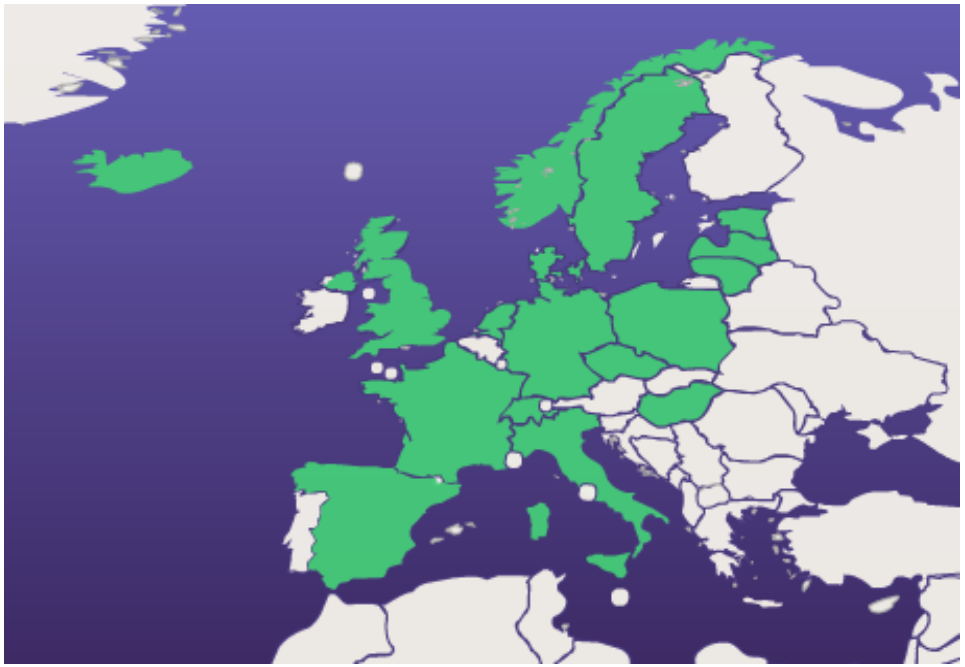
# So what has happened to ESS?



**European Spallation Source (ESS)**
ESS a joint European project, like CERN in Geneva. Neutrons are a good instrument for probing material – everything from molecules and medicines to plastics and proteins.
Cost: 1.5 B€ and counting…

# Ground-breaking last week!

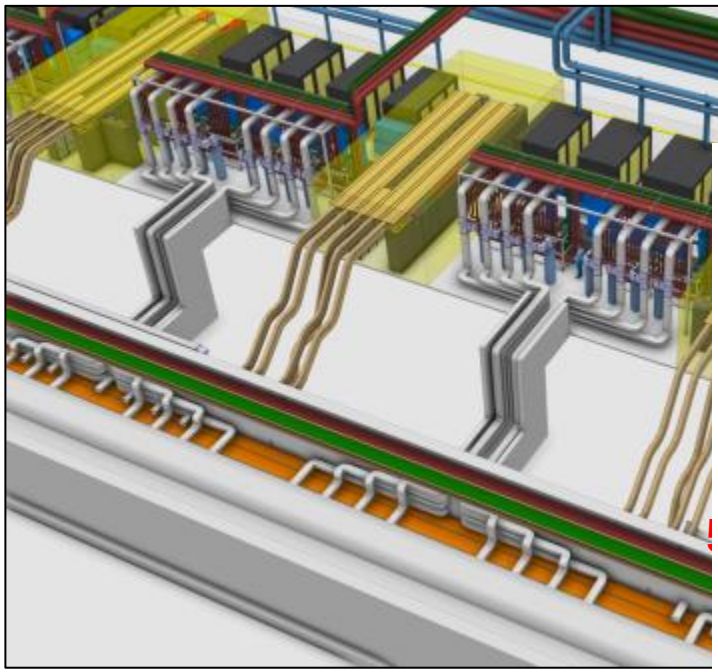
- **Project is financed to 97.55% by 14 of the 17 member states.**

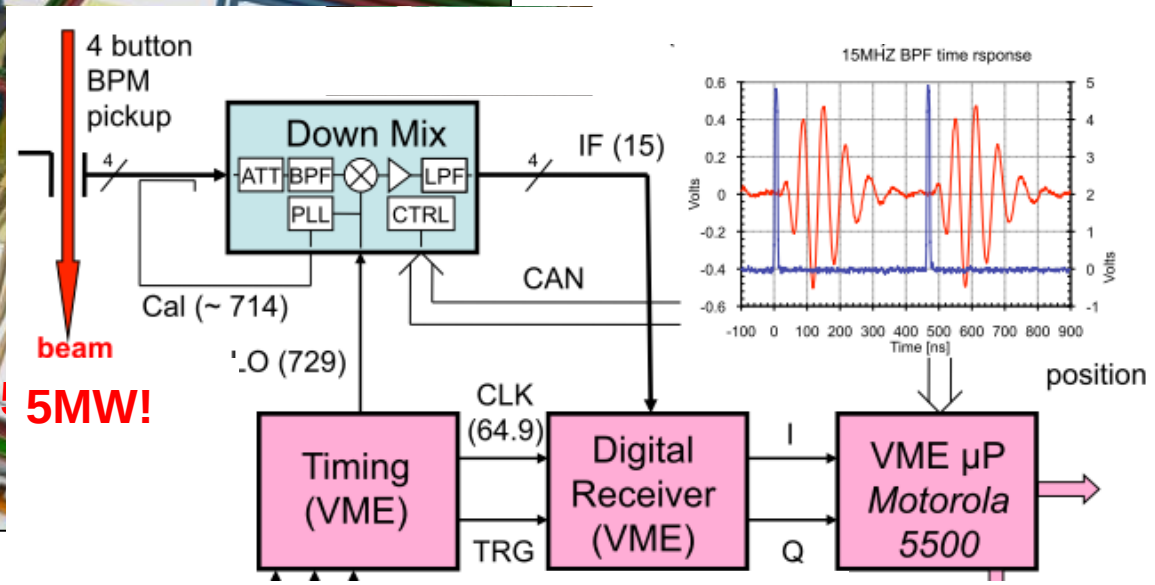


**Groundbreak by Danish Minister for Science and Higher Education, Sofie Carsten Nielsen, and Swedish Minister of Education and Research, Jan Björklund on the 2nd of September 2014.**

# We're ramping up our ESS activities!

EUROPEAN SPALLATION SOURCE

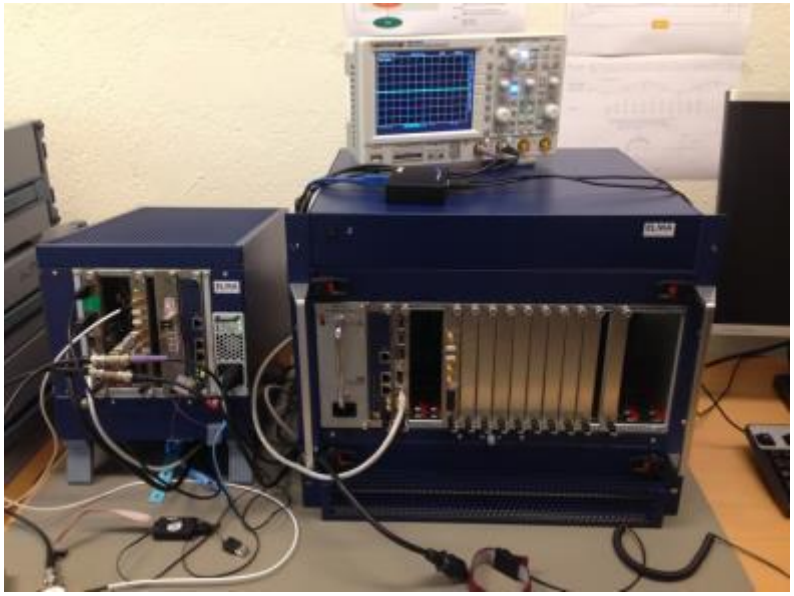





**Lund University will design the Low-level RF systems for the ESS Linear accelerator.**

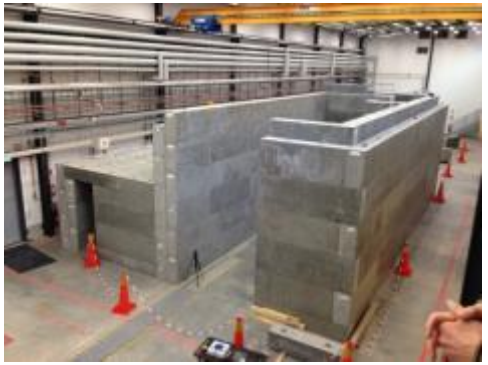
The LLRF system is responsible for controlling the phase and amplitude of the accelerating cavities to within 1 degree and 1 %. The output of the LLRF system is fed to a power amplifier klystron, which delivers a power of 1 MW to each cavity.

# The Low Level RF system



**LLRF prototype for field regulation of 352.21 MHz superconducting spoke cavities. Direct sampling IQ-receiver with control algorithm implemented in Xilinx Virtex6 FPGA.**

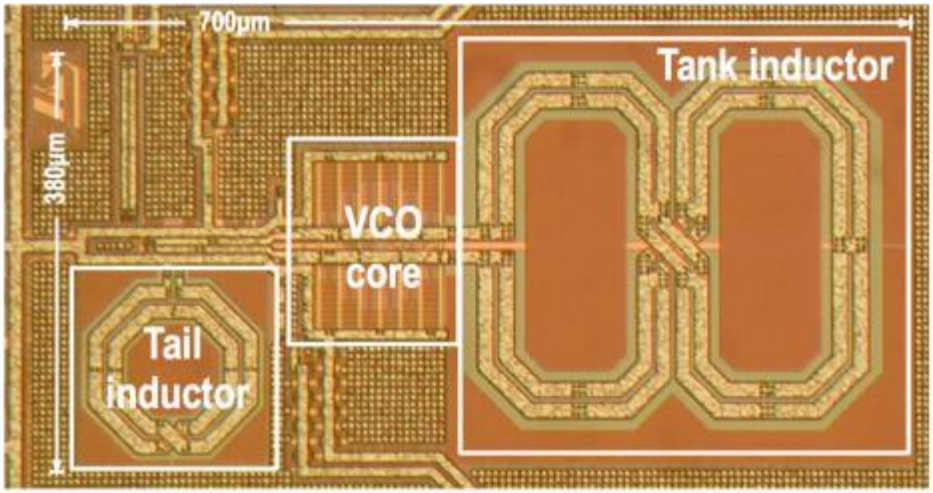
**”Our” guys:**
Fredrik Kristensen
and
Anders Svensson



**Bunker in Uppsala in which accelerating cavities will be tested att 300 kW power and at 2K.**

# What's Next?

**We're one of the few groups that actually do chips!**

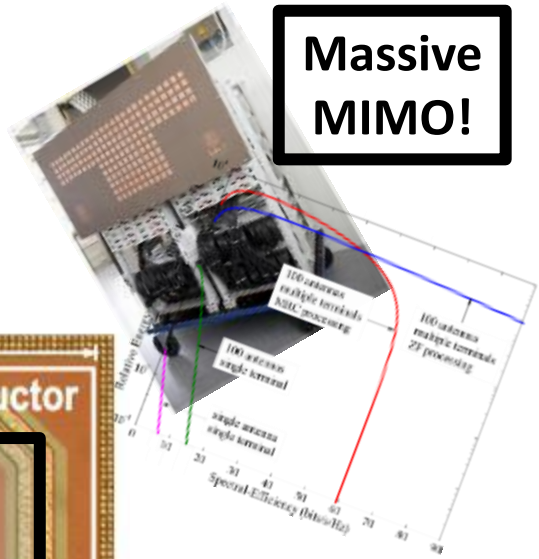


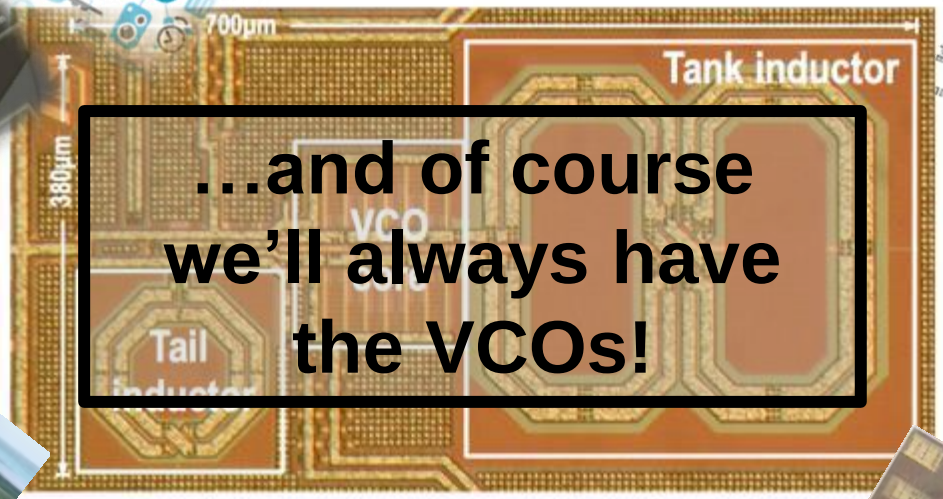

**And we want to continue doing so!!!**

# But for what?

Low Power Connectivity!


Massive MIMO!

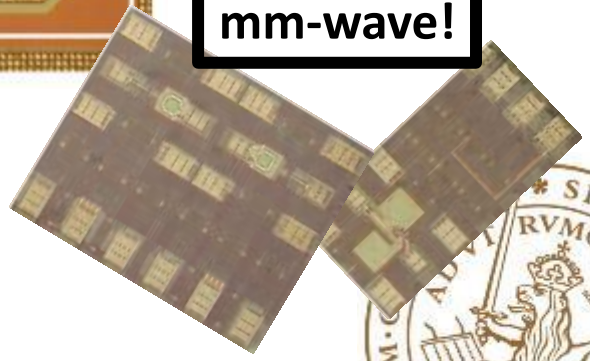





…and of course we'll always have the VCOs!

ESS and…

mm-wave!



# Thank You and Enjoy!