2015 Lund Circuit Design Workshop
Welcome and Introduction

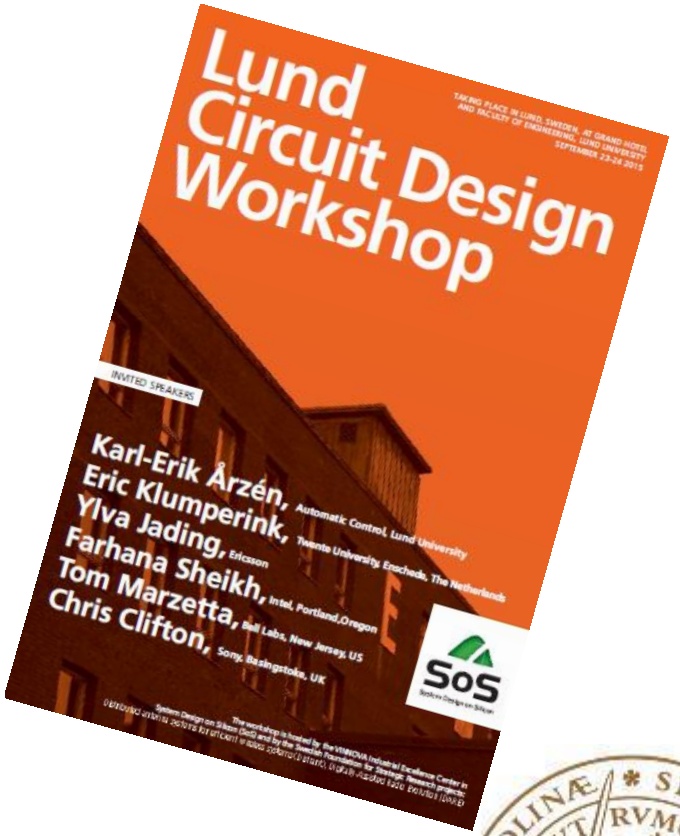
PIETRO ANDREANI

Welcome to two exciting days with SoS!

Together with 150 colleagues!

You have received a folder containing

- **Workshop program**
- **Invited speakers**
- **Senior researcher**
- **PhD students**
- **International Advisory Board**
- **SoS Board**



Thematic Sessions

Day 1

- **Session 1: 5G**
- **Session 2: Low Power Applications**
- **Session 3: Massive MIMO**

Day 2

- **Session 4: RF and mm-Wave Communication**
- **Session 5: Radio Front-End Techniques**
- **Conclusion: Sven Mattisson, Chairman of SoS**

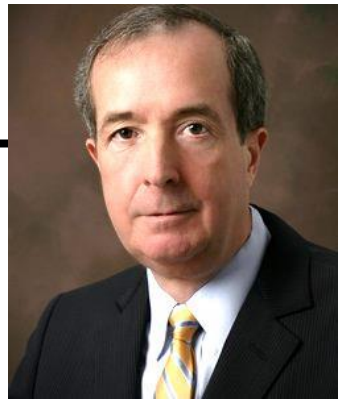
Invited Speakers, day I (a)

- **Ylva Jading**, Ericsson, Kista
  Network Energy Performance of 5G Systems

- **Farhana Sheikh**, Intel Portland, Oregon
  Reconfigurable and Selectively-Adaptive Signal Processing for Multi-Mode Wireless Communication

Invited Speakers, day I (b)

- **Tom Marzetta**, Bell Labs, New Jersey
  Massive MIMO – Fundamentals and System Issues

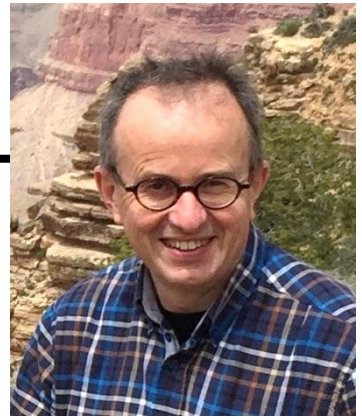


- **Karl-Erik Årzén**, Reglerteknik, Lund University
  The Wallenberg Autonomous Systems Program (WASP)

Invited Speakers, day II

- **Chris Clifton**, Sony, Basingstoke, UK
  High Efficiency Wideband RF Front-End Technology to Satisfy the Demands of Next Generation Terminal and Infrastructure Requirements

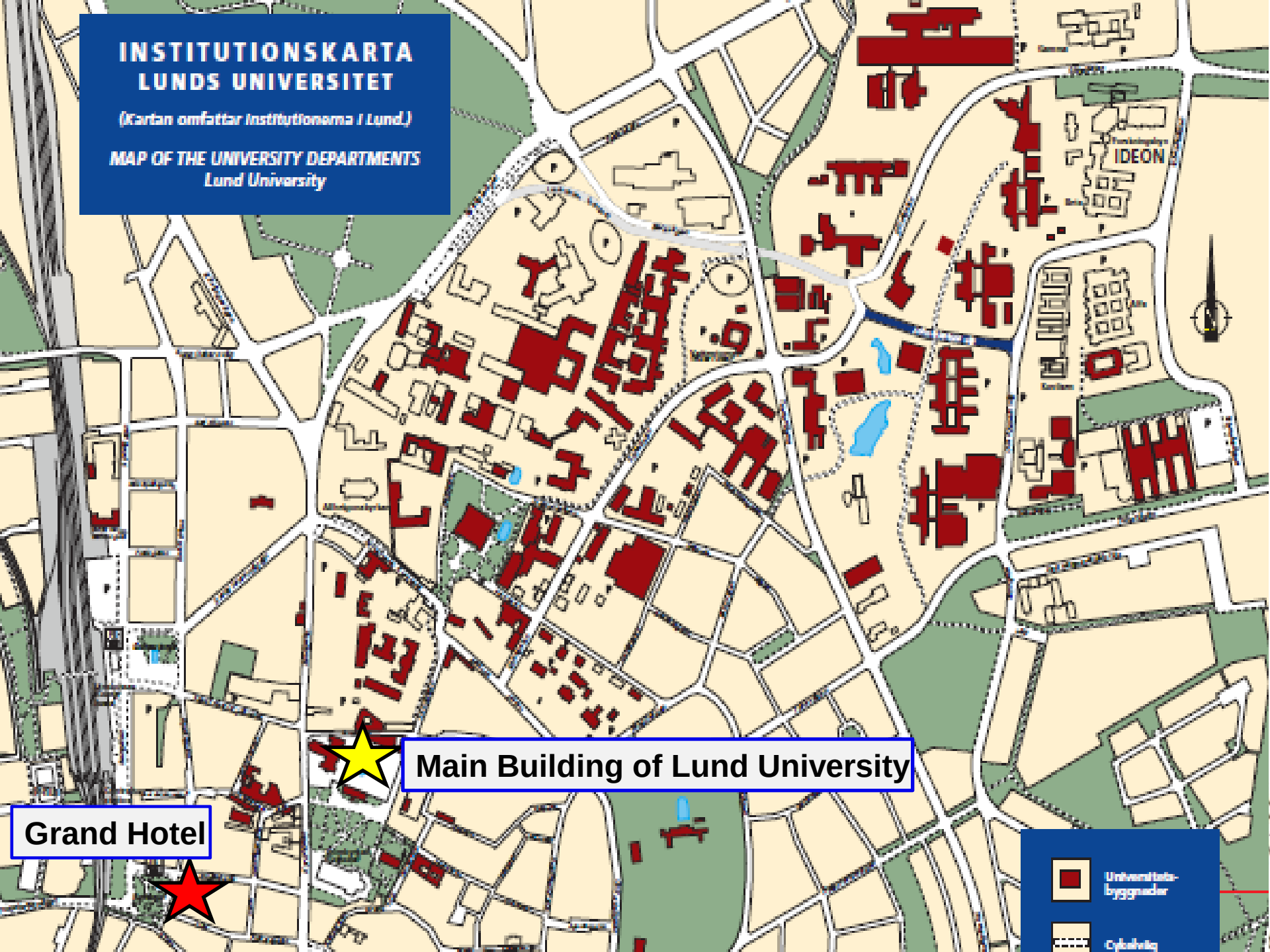
- **Eric Klumperink**, Twente University, Enschede, The Netherlands
  CMOS Switched-R-C Techniques for Interference Rejection and Self-Interference Cancellation



Some Logistics

- **Today we are at Grand Hotel, including lunch**
- **Dinner is in the main building of Lund University at 7pm**
- **Tomorrow we are at the Faculty of Engineering, LU**

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
Universitets-
byggnader
Cykelväg

Some Logistics

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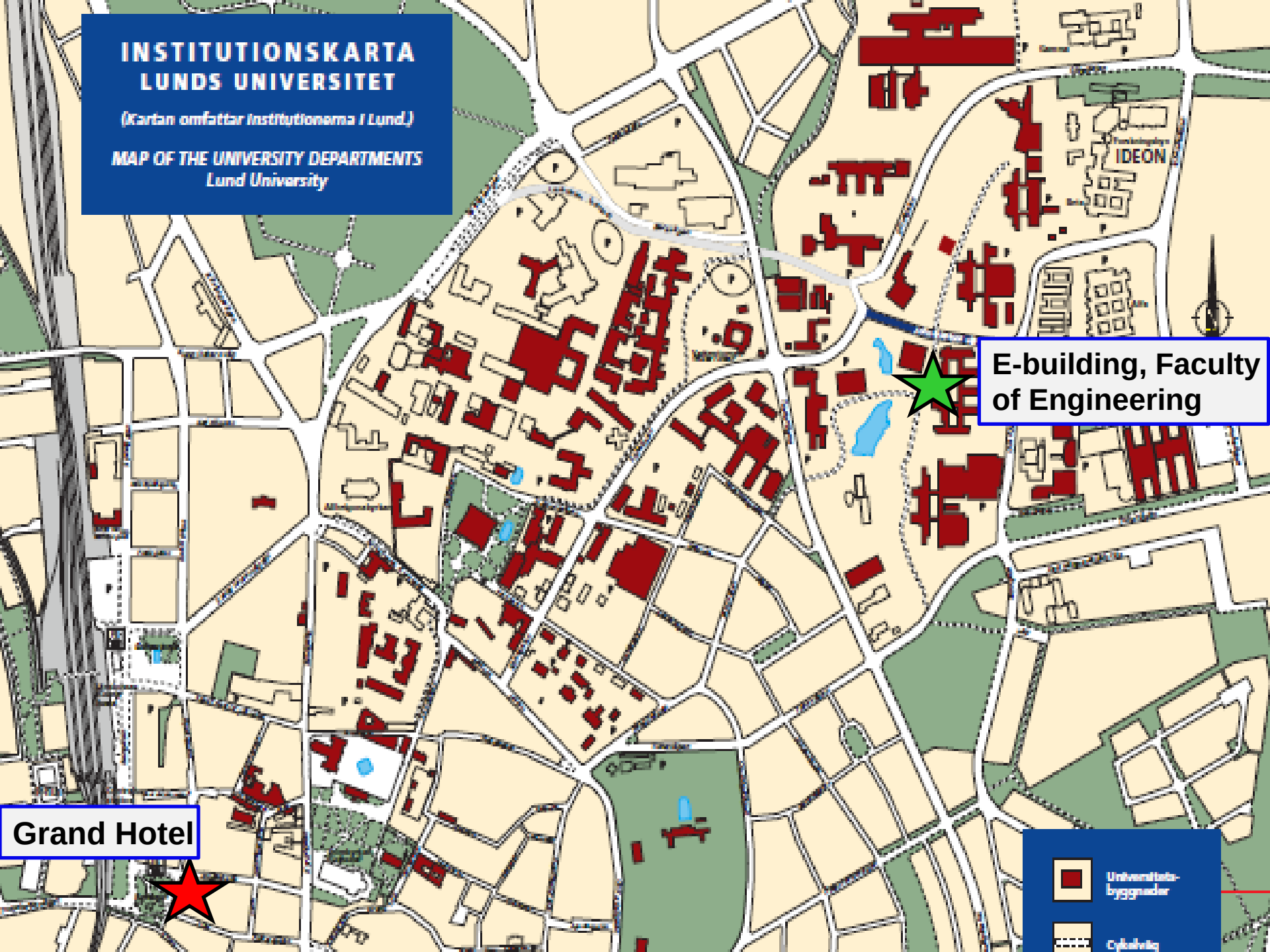
- **Tomorrow we are at the Faculty of Engineering, LU**
  - **A 25-minute walk from Grand Hotel**

Room E:1406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E-building: Faculty of Engineering

The Hosts

cadence

ERICSSON

Industrial Excellence Center in

SONY
make.believe

SoS
System Design on Silicon

VINNOVA

infineon

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 again in 2014:

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

The operational plan for 2015-2017 has been approved by VINNOVA

VINNOVA

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."

People in SoS

Director: Pietro 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."

Our director emeritus Viktor Öwall

Liesbet van der Perre, new honorary doctor at LU

Director at IMEC, Belgium, and professor at KU Leuven, Belgium; very strong bonds with SoS

Massive MIMO now a part of SoS!




Ove Edfors

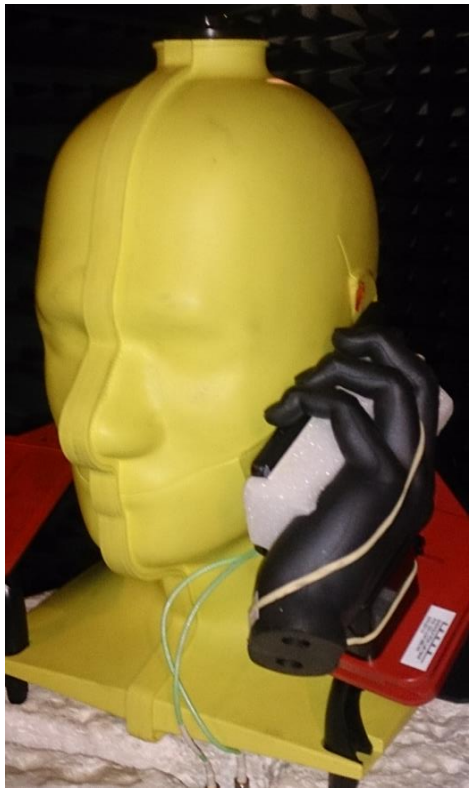
Fredrik Tufvesson

Liang Liu

Fredrik Rusek

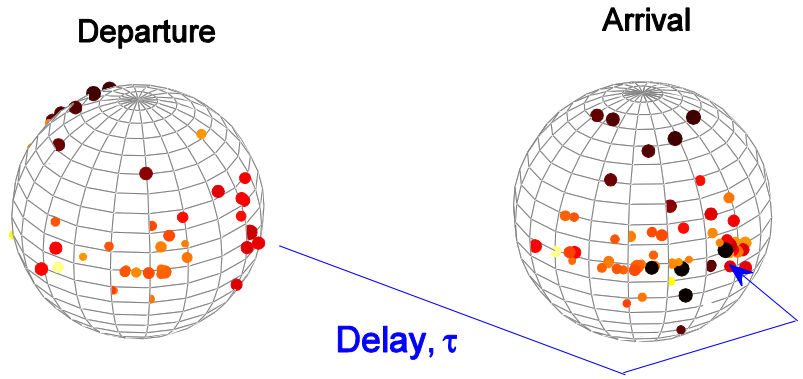
Massive MIMO now a part of SoS!

Massive MIMO from a terminal perspective



SONY
make.believe

LuMaMi



mm and cm wave channel characterization

ERICSSON

The Hosts: the SSF programs

DARE

Digitally Assisted Radio Evolution

Pietro Andreani

2011-2015/16

Distrant

Distributed Antenna Systems

Fredrik Tufvesson

More programs

Swedish Foundation for Strategic Research

Med stöd från: VINNOVA Energimyndigheten formas STRATEGISKA INNOVATIONS-PROGRAM

Horizon 2020

SEVENTH FRAMEWORK PROGRAMME

- MAMMOET
- BASTION

DARE

DISTRANT

HiPEC

SoS

System Design on Silicon

VINNOVA

VR

ELLIIT

Strategic Research Area (SFO)

New Projects – Vetenskapsrådet (VR)

Future communications, Massive MIMO, efficient signaling

1 PhD position funded by VR, new PhD student Mojtaba Mahdavi

Project Manager: Viktor Öwall

New Projects – Smartare Elektroniksystem

TX front-end building practices for 5G Massive MIMO systems

3 MSEK over two years: August 2015 to July 2017

Project Manager: Markus Törmänen

Project Partner: Ericsson Research

New Projects – H2020

Flex5Gware

Two years: July 2015 to July 2017

Project Manager at LTH: Henrik Sjöland (60GHz LO generation)

Project Partner: Ericsson Research

New funds

Concurrent massive MIMO energy and information transfer

1-year postdoc position funded by MAPCI

Project Manager: Fredrik Tufvesson

New funds

Mätning och modellering av radiokanalens egenskaper för millimetervågskommunikation

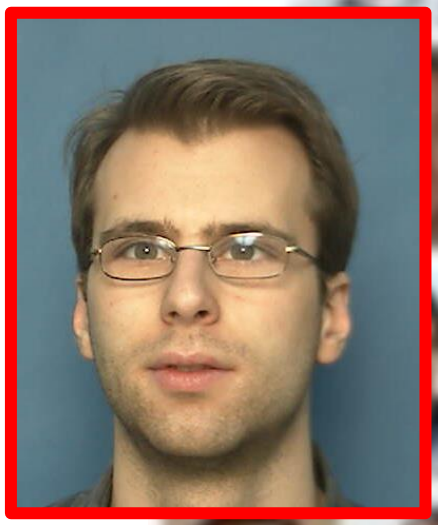
200 KSEK from Crafoord, plus additional funds from MAPCI

Project Managers: Fredrik Tufvesson and Carl Gustafson

Measurement capabilities in the 15-30 GHz range

Faces in SoS

Recent graduates



- Dejan Radjen, ”*Continuous-Time Delta-Sigma Modulators for Ultra-Low-Power Radios*“, Sept. 2014.
  Now traveling around the world (?)

Recent graduates

- Reza Meraji , ”*Low Power Decoding Circuits for Ultra Portable Devices*“, Oct. 2014.
  Now looking for a job…

Recent graduates

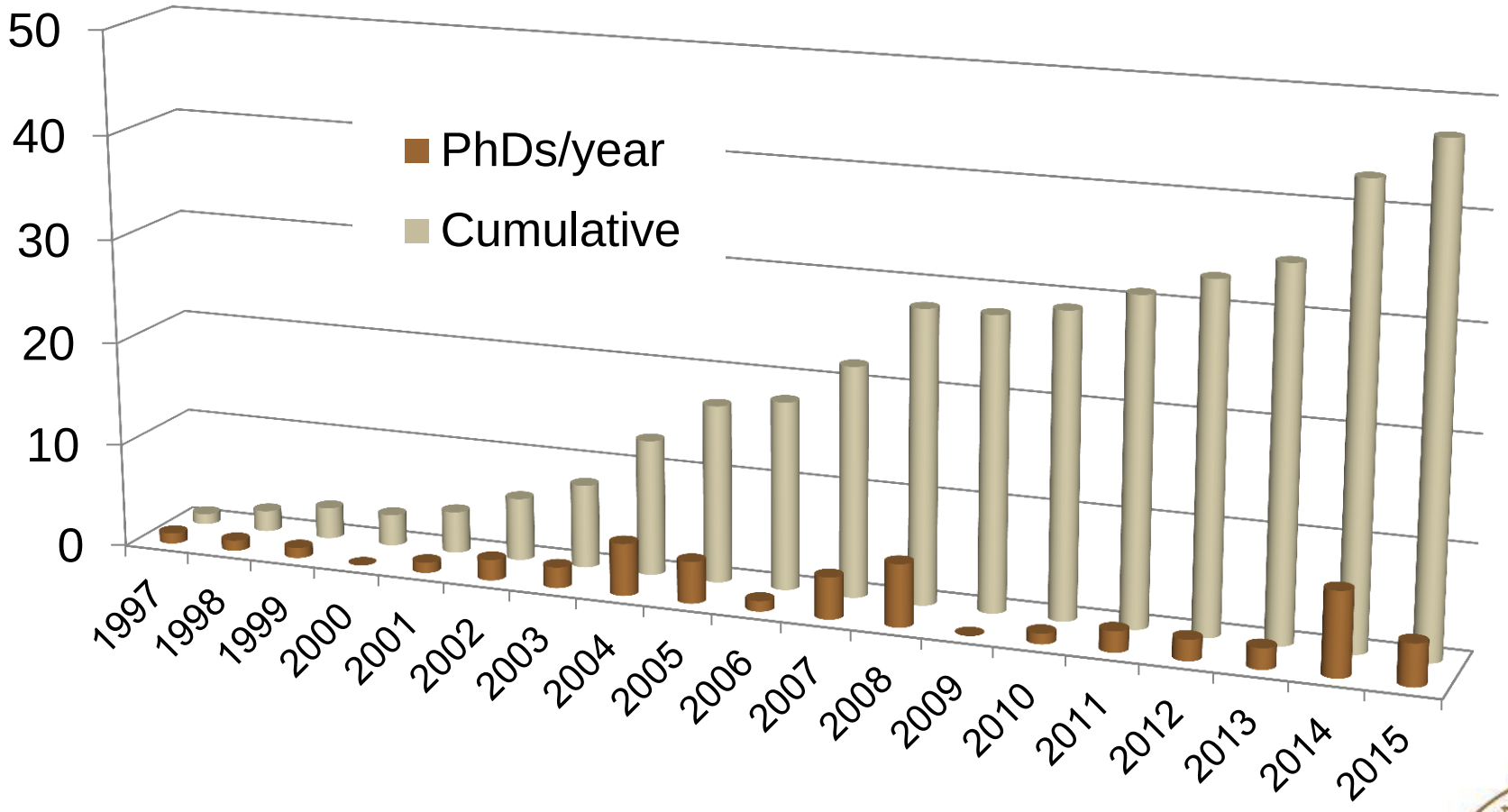
- Carl Gustafson, "60 GHz Wireless Propagation Channels: Characterization, Modeling and Evaluation“, Dec. 2014. Now postdoc with us.

Recent graduates

- Dimitar Nikolov, ”*Fault Tolerance for Real-Time Systems*“, Jan. 2015. Now postdoc with us.

PhDs graduated since the start of CCCD

47 PhDs since 1997



Some Research Highlights

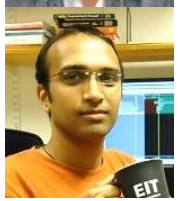
Internships

- Anders Nejdel at Marvell, Pavia, Italy

- Babak Mohammadi at STMicroelectronics, Grenoble, France

- Oskar Andersson at Intel Portland, Oregon

- Michal Stala at Ericsson, Lund



- Hemanth Prabhu at Xilinx, Cork, Ireland

- Steffen Malkowski at
  National Instruments, Austin, Texas

3 papers + 1 workshop presentation at RFIC 2015

in Phoenix, AZ, May 17-19

3 papers at RFIC 2015

- A. Nejdel, M. Abdulaziz, M. Törmänen, and H. Sjöland, ”*A Positive Feedback Passive Mixer-First Receiver Front-End*”

- L. Fanori, A. Mahmoud, T. Mattsson, P. Caputa, S. Rämö, and P. Andreani, ”*A 2.8-to-5.8 GHz Harmonic VCO in a 28 nm UTBB FD-SOI CMOS Process*”

- Y. Wu, P. Lu, and R. B. Staszewski, ”*A 103f_{srms} 1.32mW 50MS/s 1.25MHz Bandwidth Two-Step Flash-ΔΣ Time-to-Digital Converter for ADPLL*”

1 workshop presentation at RFIC 2015

- H. Sjöland, J. Lindstrand, I. Vasilev, and V. Lau, ”*Cellular terminal antenna impedance tuners in CMOS-SOI technology*”

1 paper at ESSCIRC 2015

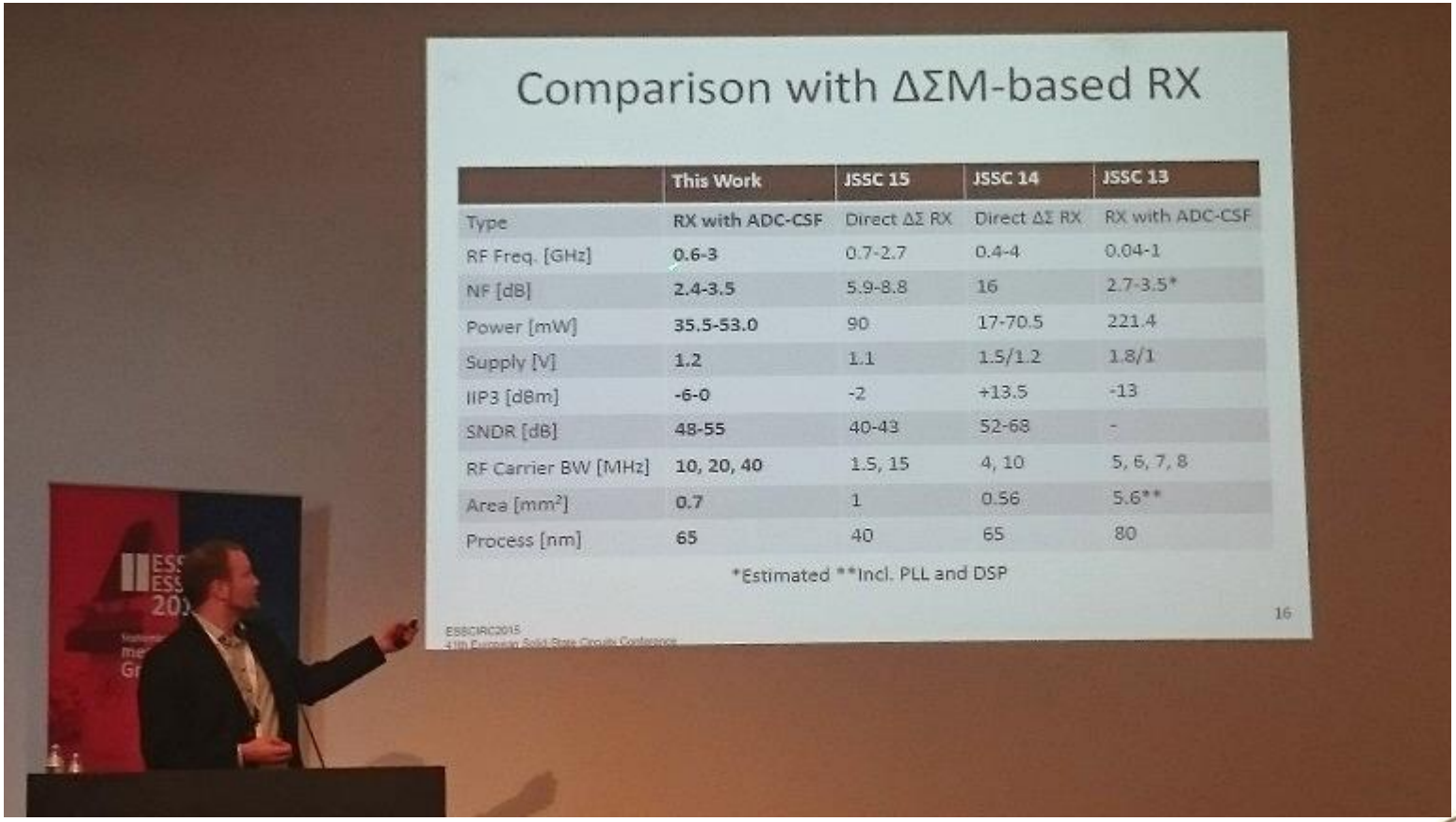
in Graz, September 14-18

1 paper at ESSCIRC 2015

- A. Nejdel, X. Liu, M. Palm, L. Sundström, M. Törmänen, H. Sjöland, and P. Andreani, ”*A 0.6-3.0GHz 65nm CMOS Radio Receiver with ΔΣ-based A/D-Converting Channel-Select Filters*”

  (demo tomorrow)

1 paper at ESSCIRC 2015



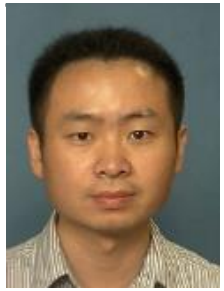
Photograph courtesy of Markus Törmänen

2 papers + 1 workshop at Globecom 2014

in Austin, December 8-12

2 papers + 1 workshop at Globecom 2014







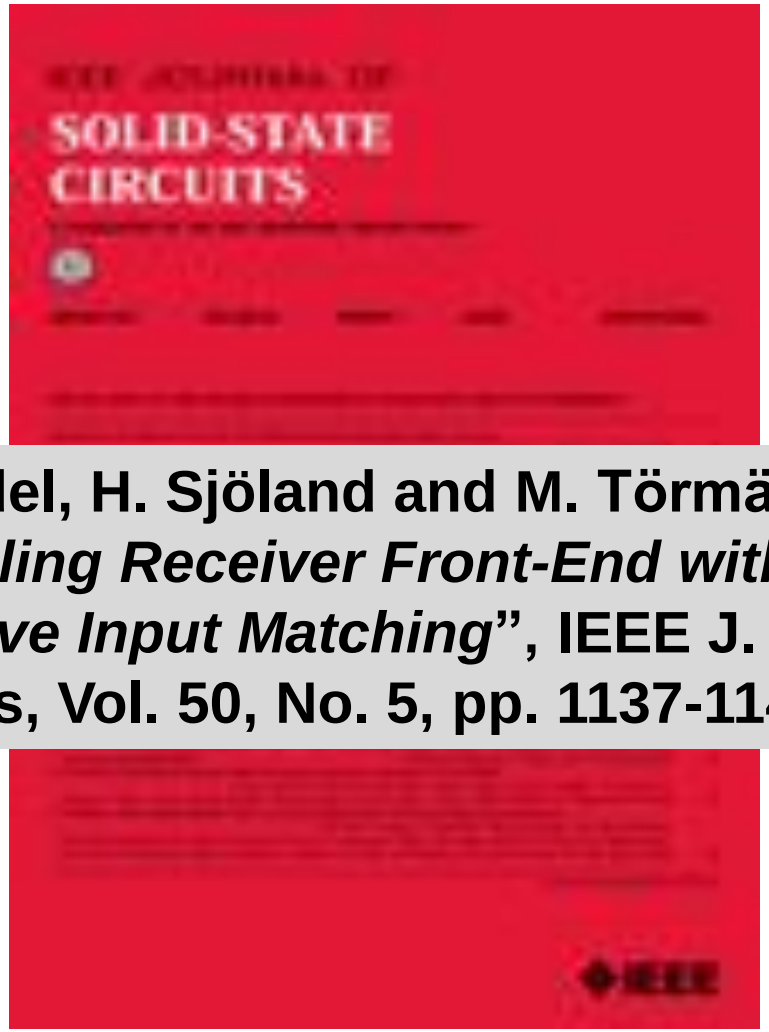

- J. Vieira, S. Malkowsky, K. Nieman, Z. Miers, N. Kundargi, L. Liu, I. Wong, V. Öwall, O. Edfors, F. Tufvesson: ”*A flexible 100-antenna testbed for Massive MIMO*”

- J. Vieira, F. Rusek, F. Tufvesson: “*Reciprocity calibration methods for Massive MIMO based on antenna coupling*”

Massive MIMO tutorials, presentations, panels

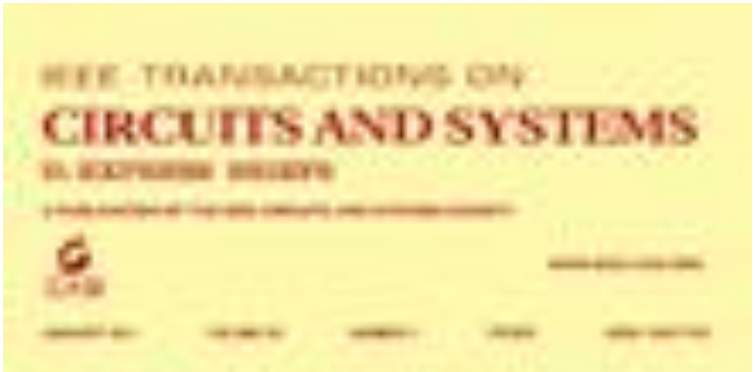
- “Massive MIMO for 5G: From Theory to Practice”, Tutorial at ICC 2015, (jointly with IMEC and Linköping Uni), London, U.K.
- ISSCC 2015, ”More Bits via the Same Spectrum - Massive MIMO Opportunities”, San Francisco, USA, Feb. 2015
- “MIMO Goes Massive – Prototyping the Ultimate MU-MIMO Real-Time 5G Testbed”, 5G summit, NI week, Aug 2015
- ” Massive MIMO Technology for 5G and LTE-A below 6 GHz”, Brooklyn 5G summit, New York, April 2015

IEEE JSSC special issue on RFIC 2014

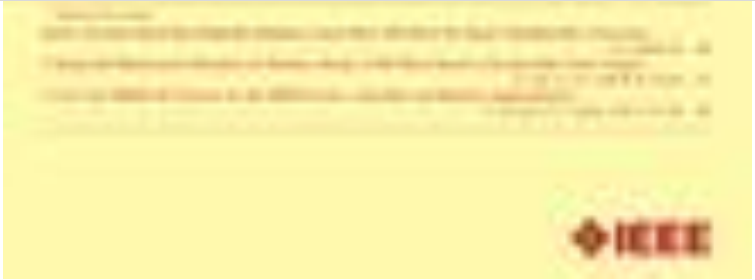


A. Nejdel, H. Sjöland and M. Törmänen, "*A Noise Cancelling Receiver Front-End with Frequency Selective Input Matching*", IEEE J. of Solid-State Circuits, Vol. 50, No. 5, pp. 1137-1147, May 2015.

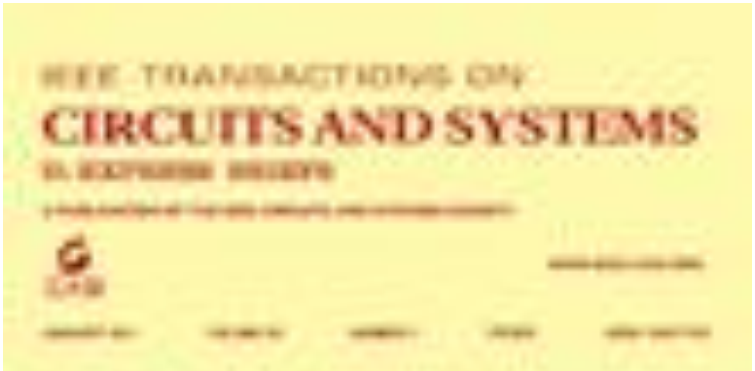
IEEE TCAS-I paper



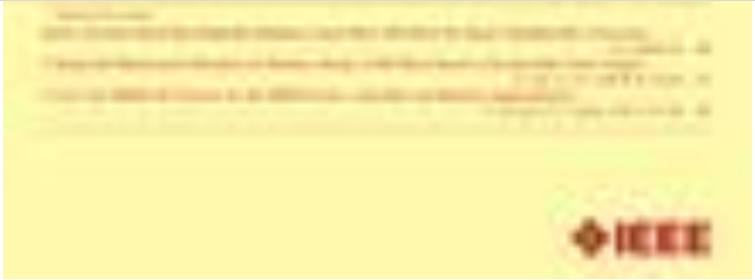
C. Zhang, L. Liu, D. Markovic, V. Öwall: "*A Heterogeneous Reconfigurable Cell Array for MIMO Signal Processing*", IEEE Trans. Circuits Syst. I, Reg. Papers, Vol. 62, No. 3, pp. 733-742, March 2015.



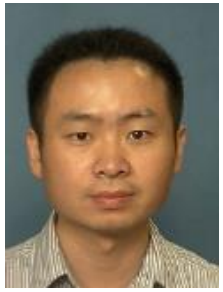
IEEE TCAS-I paper



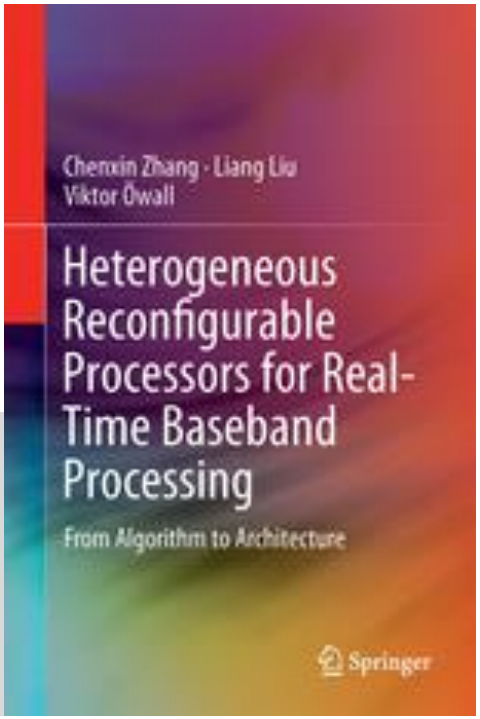
C. Zhang, H. Prabhu, Y. Liu, L. Liu, O. Edfors, V. Öwall: "*Energy Efficient Group-Sort QRD Processor with On-line Update for MIMO Channel Pre-processing*", IEEE Trans. Circuits Syst. I, Reg. Papers, Vol. 65, No. 5, pp. 1220-1229, May 2015.



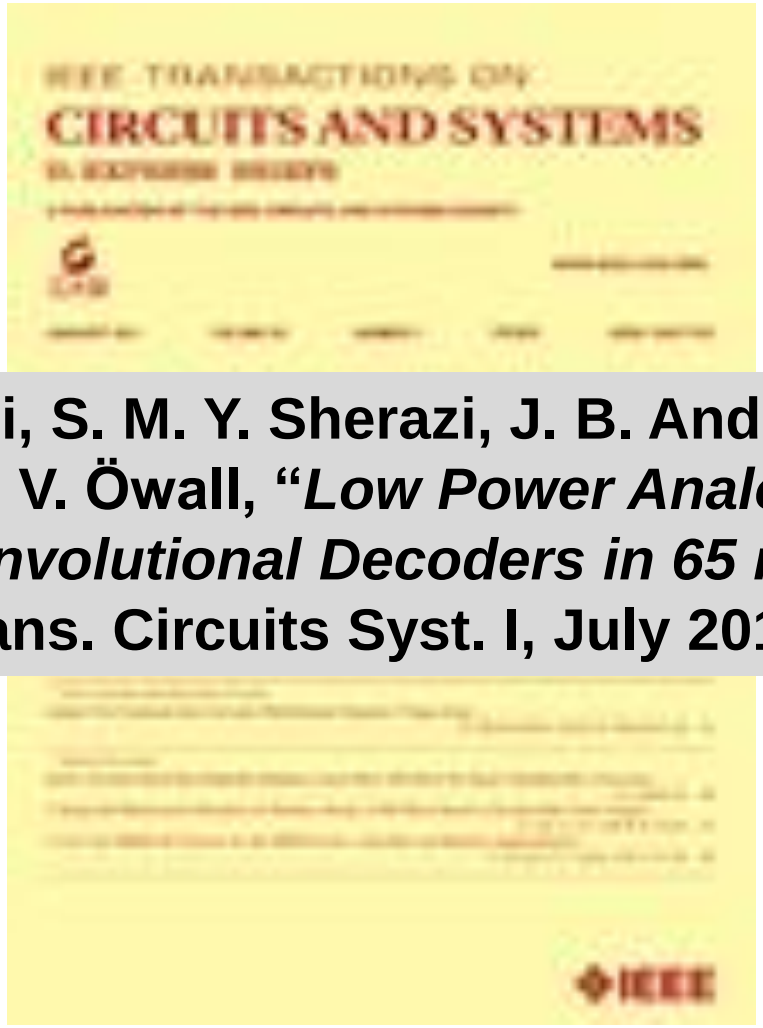
Springer thesis book


C. Zhang, L. Liu, V. Öwall: "*Heterogeneous Reconfigurable Processors for Real-Time Baseband Processing: From Algorithm to Architecture*"



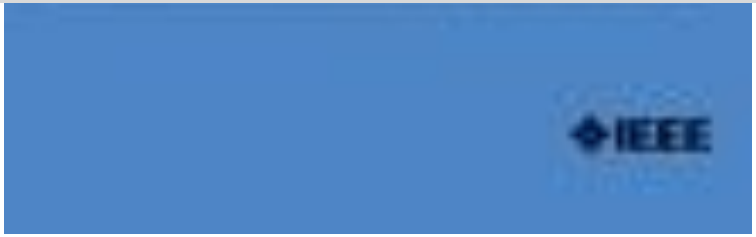
IEEE TCAS-I paper



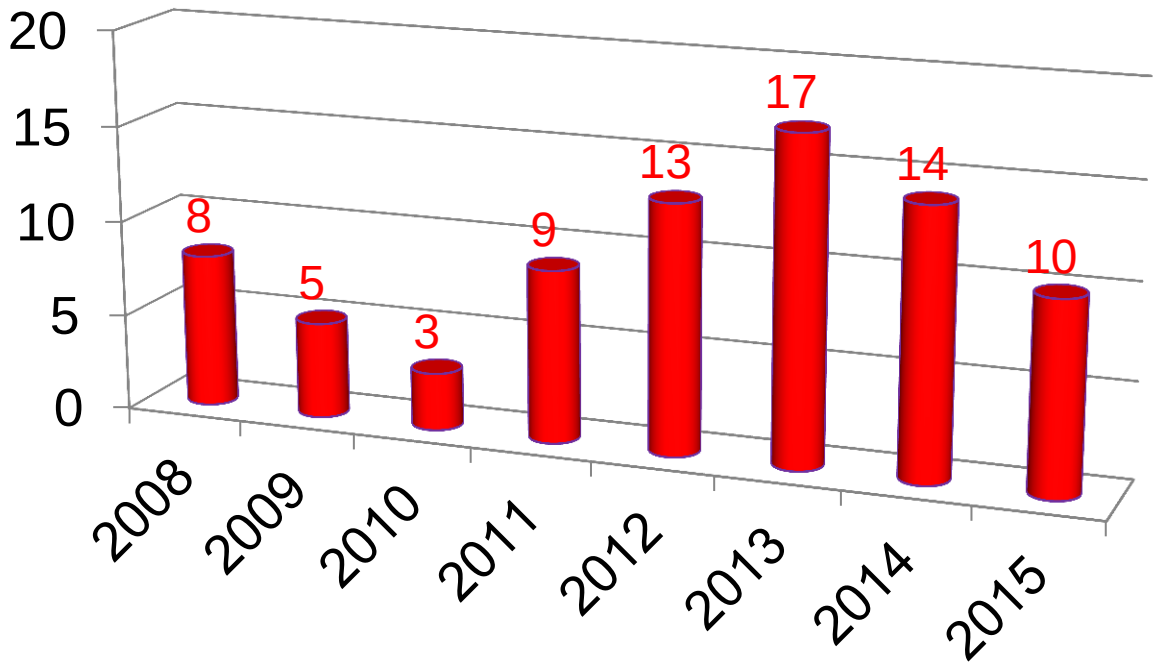
R. Meraji, S. M. Y. Sherazi, J. B. Anderson, H. Sjöland, V. Öwall, "*Low Power Analog and Digital (7,5) Convolutional Decoders in 65 nm CMOS*", IEEE Trans. Circuits Syst. I, July 2015.

IEEE TBIOCAS papers

O. Andersson, K. H. Chon, L. Sörnmo, J. Rodrigues: "*A 290mV sub-V_T ASIC for Real-Time Atrial Fibrillation Detection*", IEEE Trans. on Biomedical Circuits and Systems, Vol. 9, No. 3, pp. 377-386, March 2015.



Journal publications in circuit design

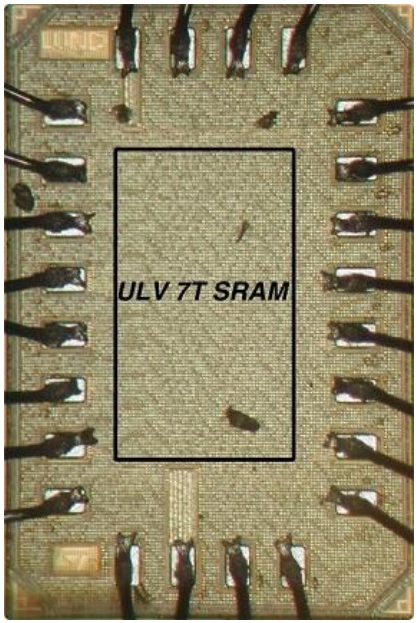


And some unpublished results...

Ultra low-voltage memory design

- Novel SRAM in 28nm UTBB FD-SOI CMOS
- Simplest, fastest, most efficient ever (8.4 fJ/bit-access @ 300 mV)

Is it going to be the first-ever digital SoS design at the ISSCC??

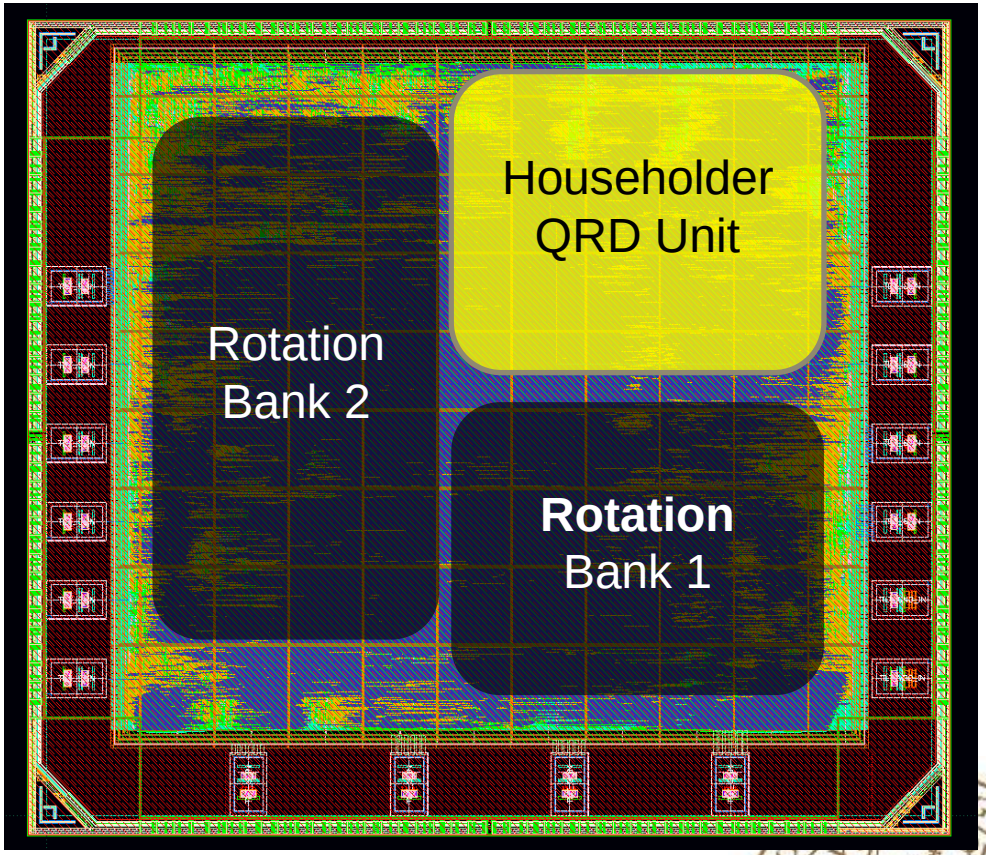





Digital 28nm UTBB FD-SOI CMOS by STM

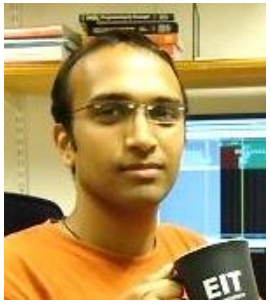
Adaptive QR decomposition for LTE-A

- 4x4 MIMO
- 190k Gates, 125MHz
- 20mW at 25M QRD/s (5-band carrier aggregation)
  - 10x lower than previously published QRD processors



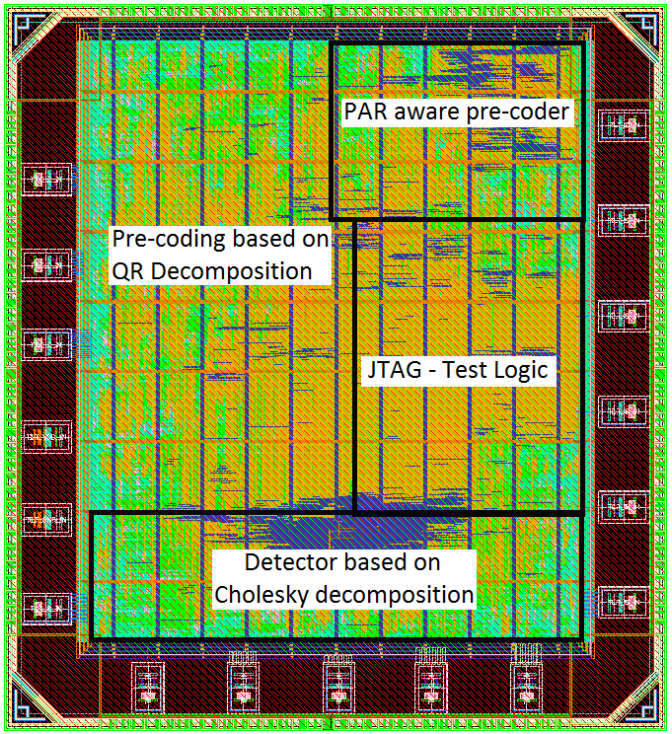
1mm^2

Digital 28nm UTBB FD-SOI CMOS by STM



Massive MIMO - Hardware Accelerators

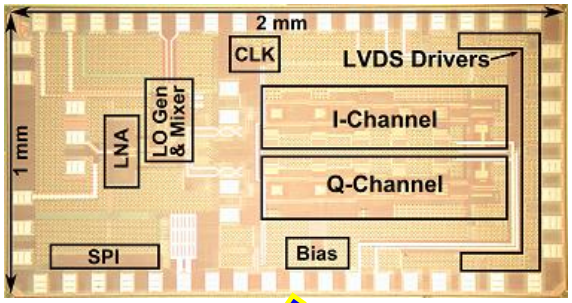
- 128x8 MIMO
- 1V, 29mW, 250MHz
- 3 configurations:
  - 8x8 QRD in 72 cycles
  - 8x8 Cholesky-based data detection in 325 cycles
  - ”Antenna reservation”-based PAR aware pre-coding



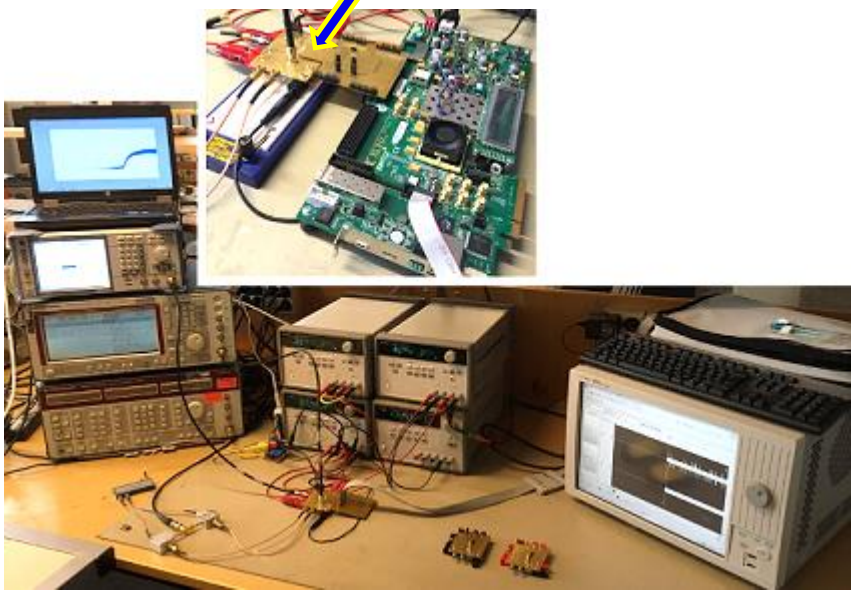
1mm^2

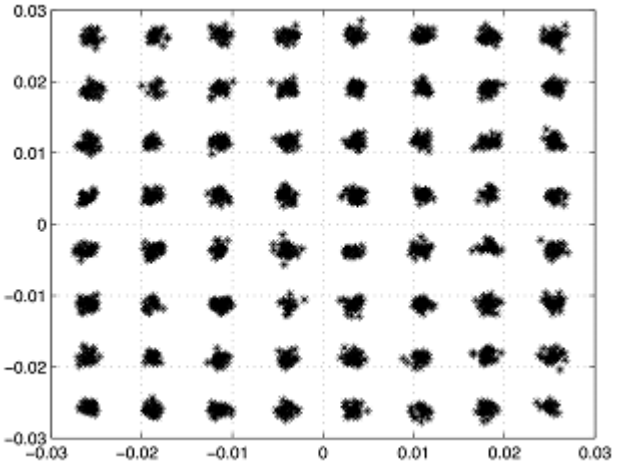
More Research Highlights

DARE – demonstrator of complete radio RX



From antenna to constellation, demo tomorrow at LTH!





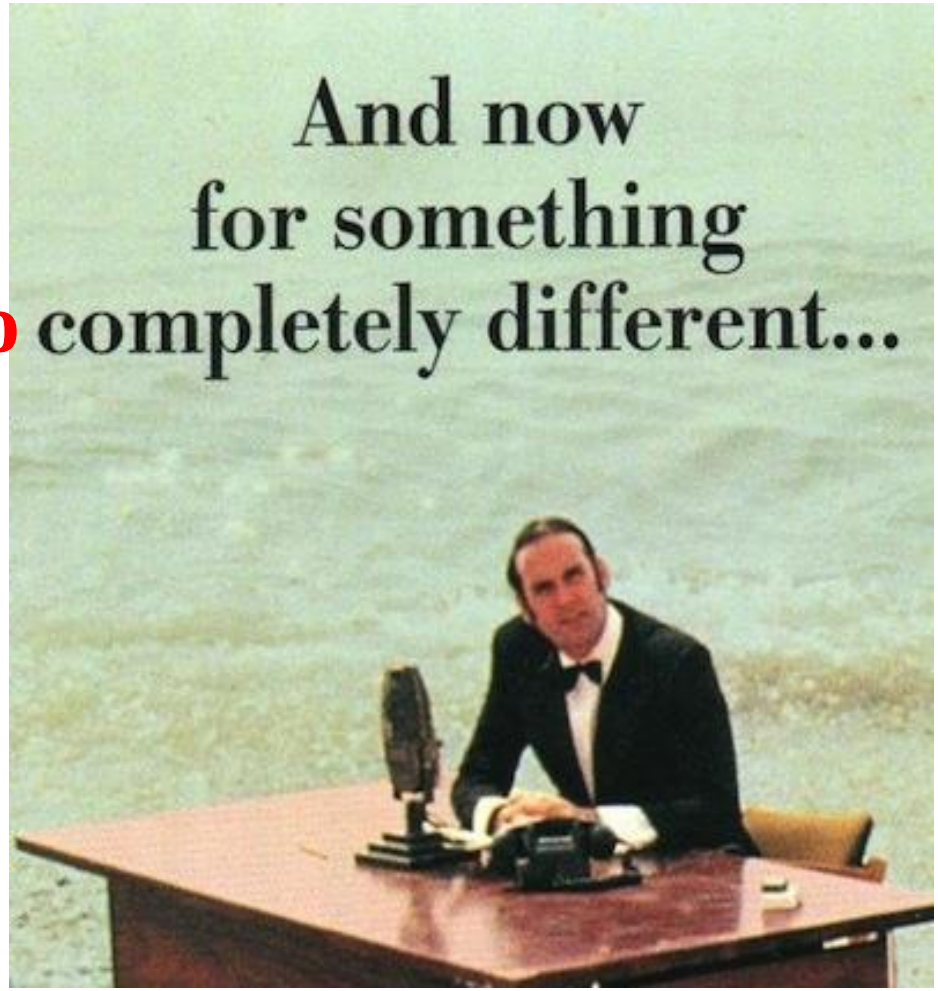
Unique Massive MIMO testbed!

- 300kg
- 5kW@start-up

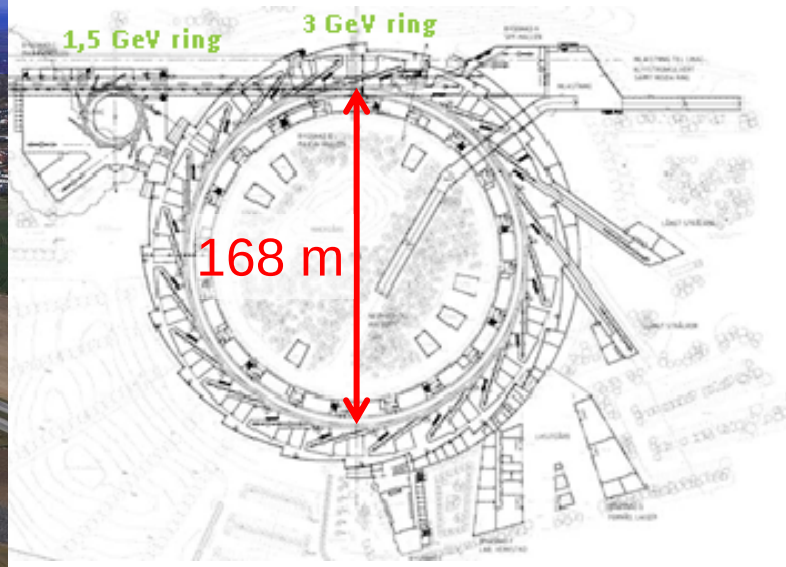
Massive MIMO real-time transmission

Real-time video transmission with Massive MIMO spatial multiplexing (presentation this afternoon)

not so completely different...



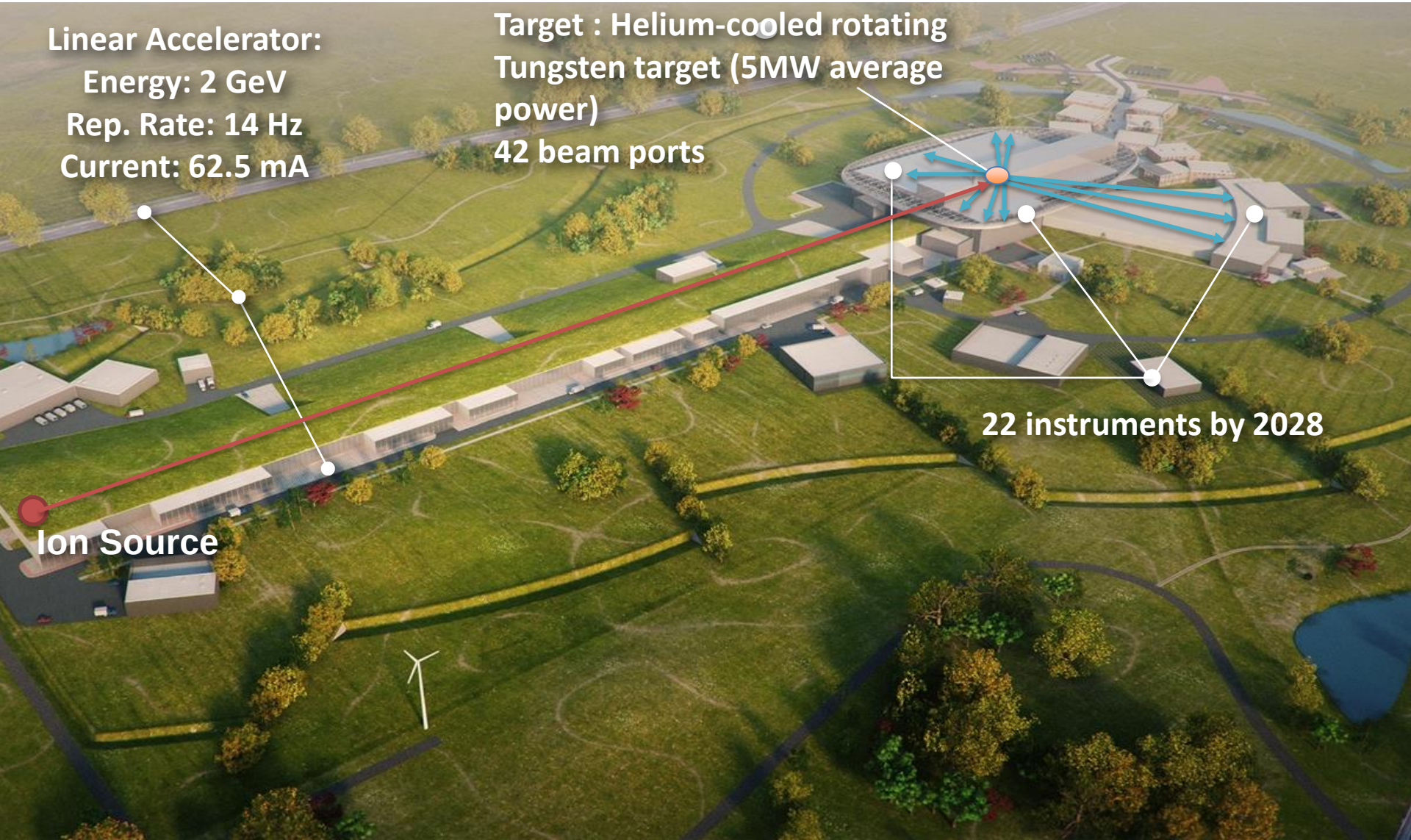
MAX IV – first electrons around the large ring



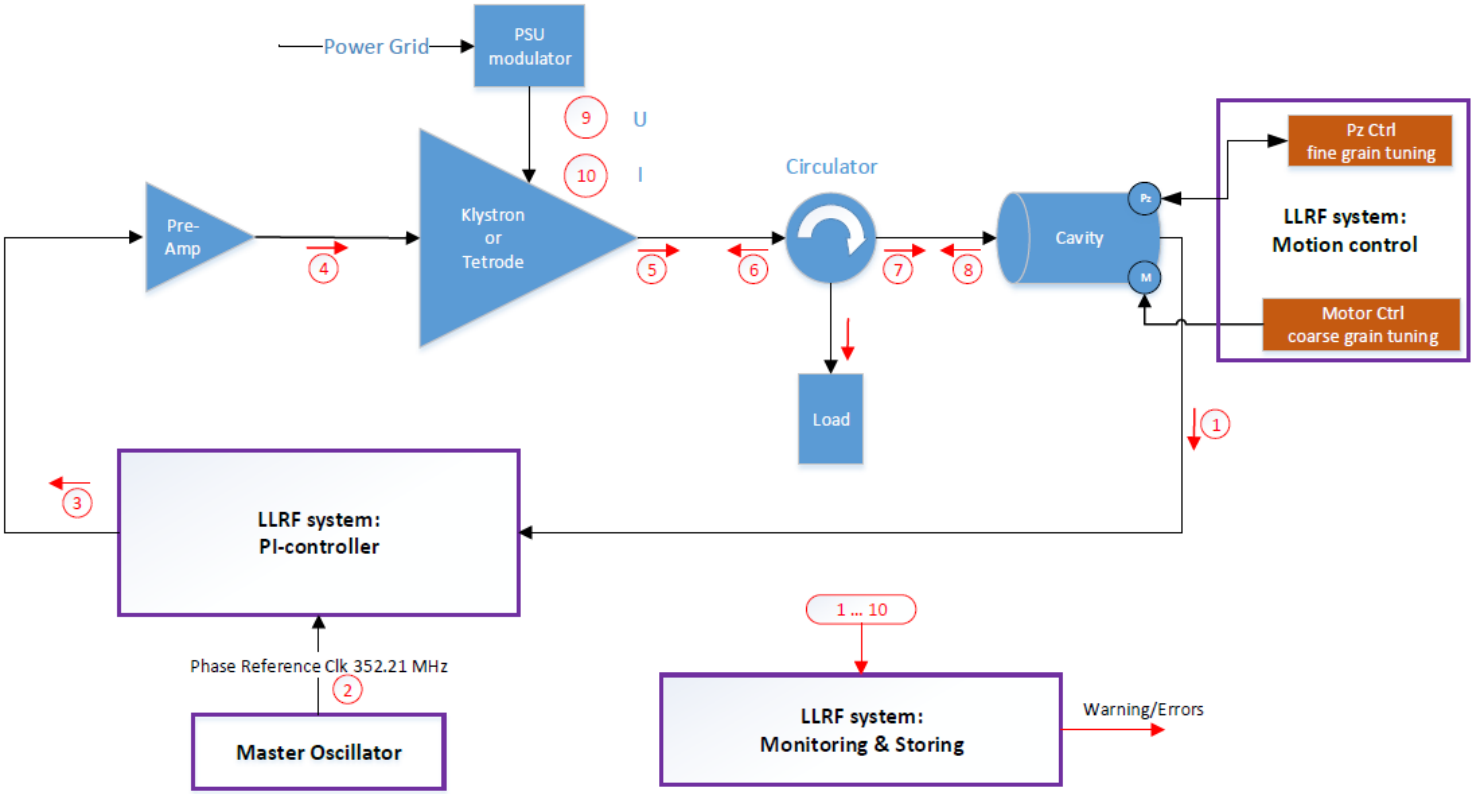
A few days ago, the accelerator group has succeeded in directing the electron beam all the way around the 3 GeV ring for the first time

European Spallation Source (ESS)

ESS – the way it will be



LTH activities for the ESS accelerator



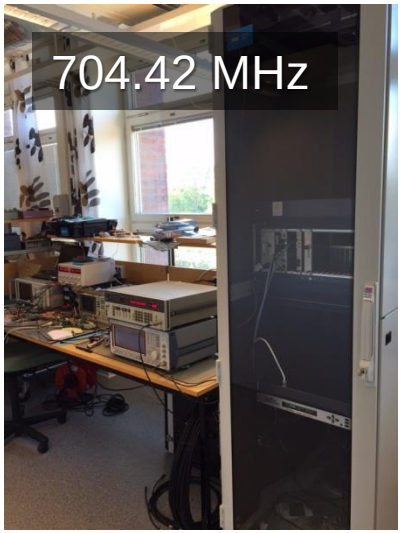
Lund University will design part of the low-level RF (LLRF) system for the linear accelerator

The LLRF system controls phase and amplitude of the electric field at the accelerating cavities to within 0.1° and 0.1% (the klystron PA delivers 1 MW to one cavity)

LTH activities for the ESS accelerator – II

120 kV power-supply modulator

- pulsed @14 Hz
- 5% duty cycle



What's next?

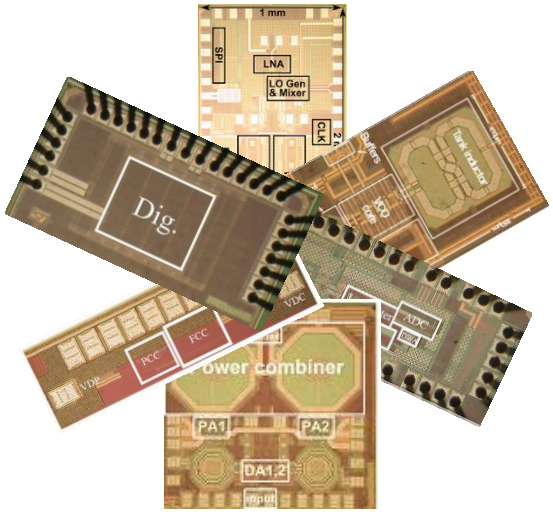
We are one of the few groups that actually design and test ICs…

… and we want to continue!

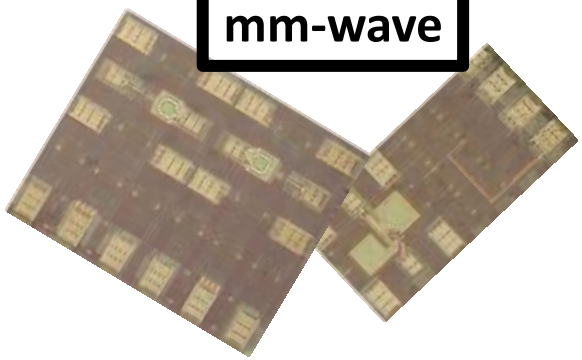
The IC!

Massive MIMO

MAX IV and ESS



mm-wave



Low Power Connectivity

Thank You and Enjoy!