

# SOPC basierendes Datenerfassungsmodul für das Auger Engineering Radio Array (AERA)

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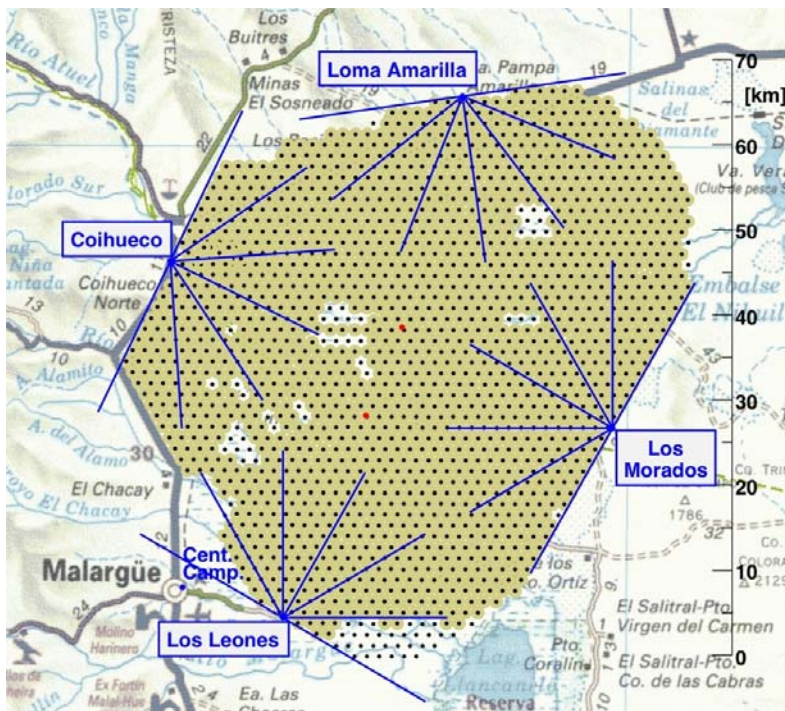


KIT – University of the State of Baden-Wuerttemberg and National Laboratory of the Helmholtz Association

100. SEI Tagung DESY

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## Pierre Auger Experiment



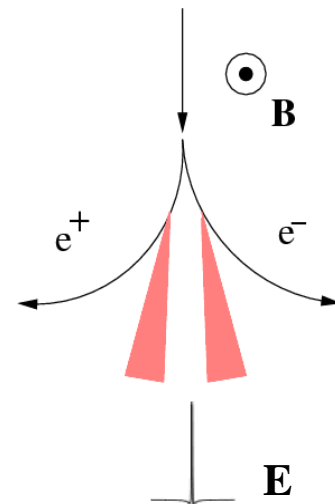
1660 Oberflächen Detektoren:  
Wassertanks-Cherenkov  
Im Grid von 1.5 km



4 Fluoreszenz Detektor  
Stationen  
(24 Teleskope)

# Radio Strahlung von kosmischen Teilchen

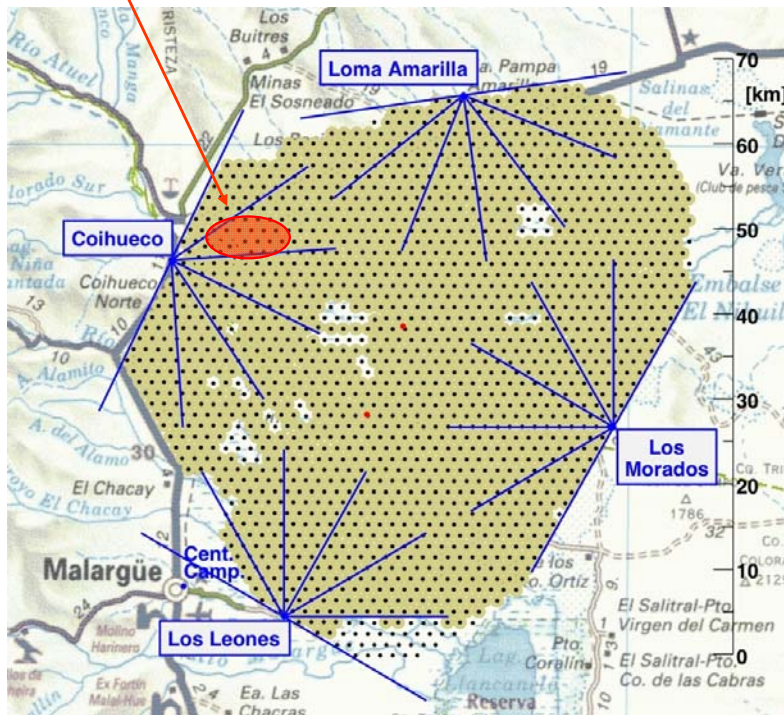
- Schauarentwicklung
- Geo-Synchrotron Effekt
- Messbare Radioimpulse
- Frequenzbereich 10 – 200 MHz



# Kollaboration Partner

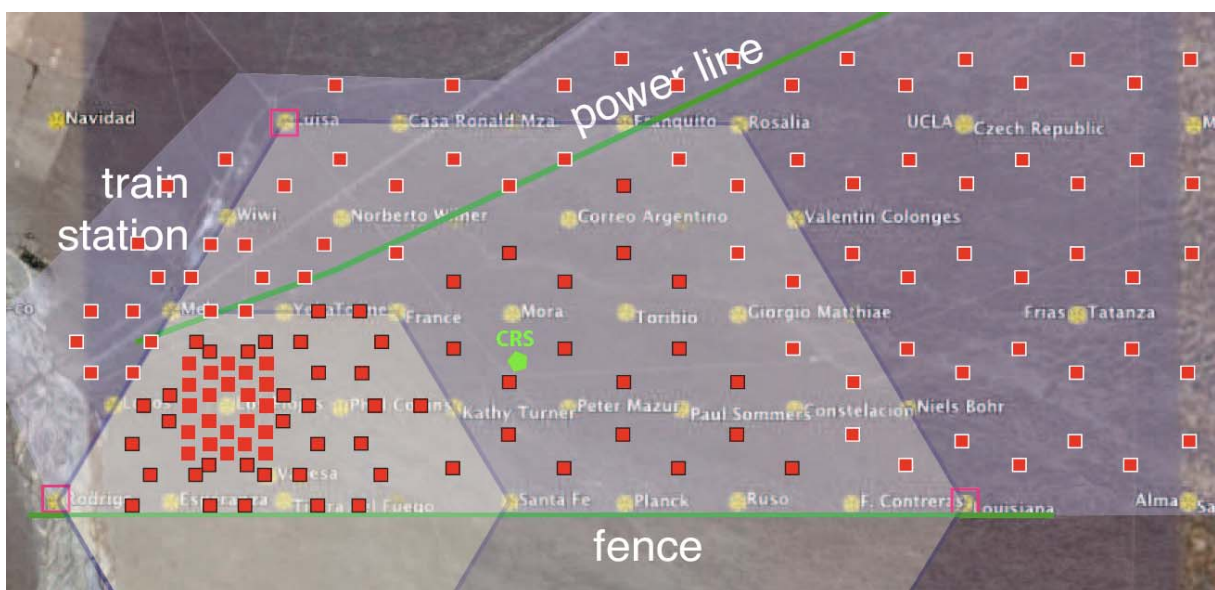
- Bergische Universität, Wuppertal, Germany
- IEKP, KIT, Karlsruhe, Germany
- IK, KIT, Karlsruhe, Germany
- IMAPP, Radboud University, Nijmegen, the Netherlands
- **IPE, KIT, Karlsruhe, Germany**
- KVI, University of Groningen, Groningen, the Netherlands
- LPSC, Grenoble, France
- Nikhef, Amsterdam & Nijmegen, the Netherlands
- RWTH Aachen University, Aachen, Germany
- SUBATECH, Nantes, France

# Lage von AERA



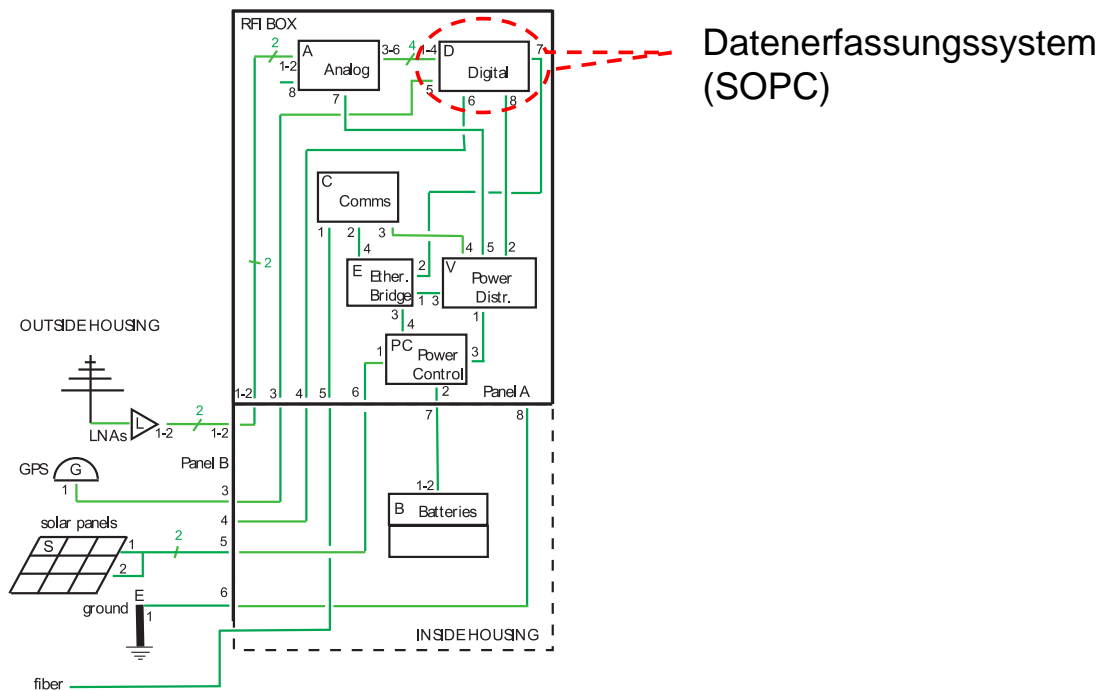
# Auger Engineering Radio Array (AERA)

- 150 Radio Stationen (Local Station)
- Abstände einige 100 m



# Local Station

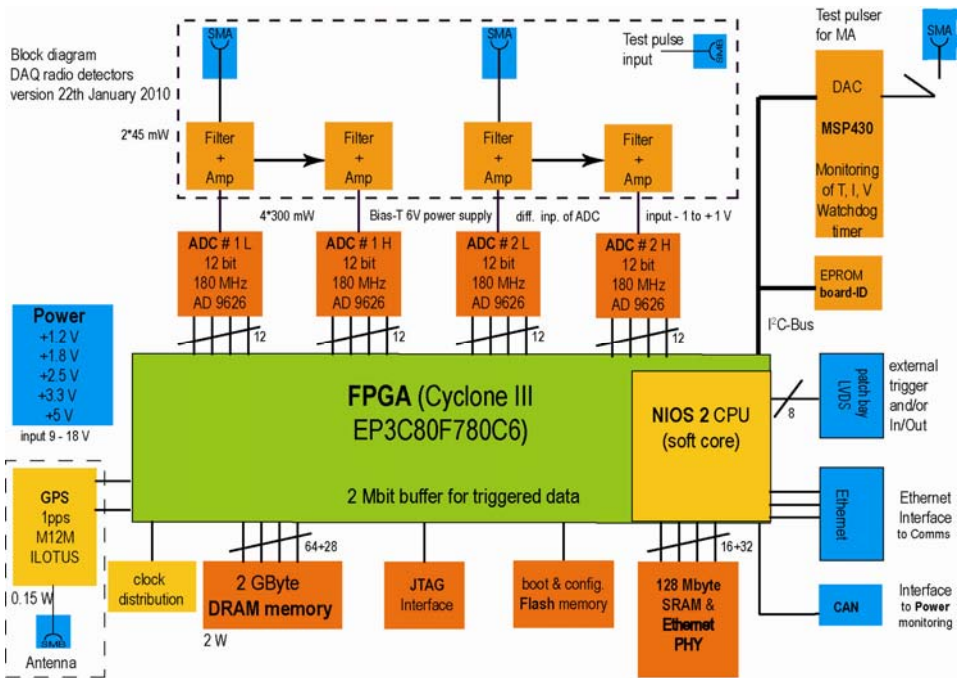
AERA Phase I Station Interfaces (v1.2, 11/11/09)



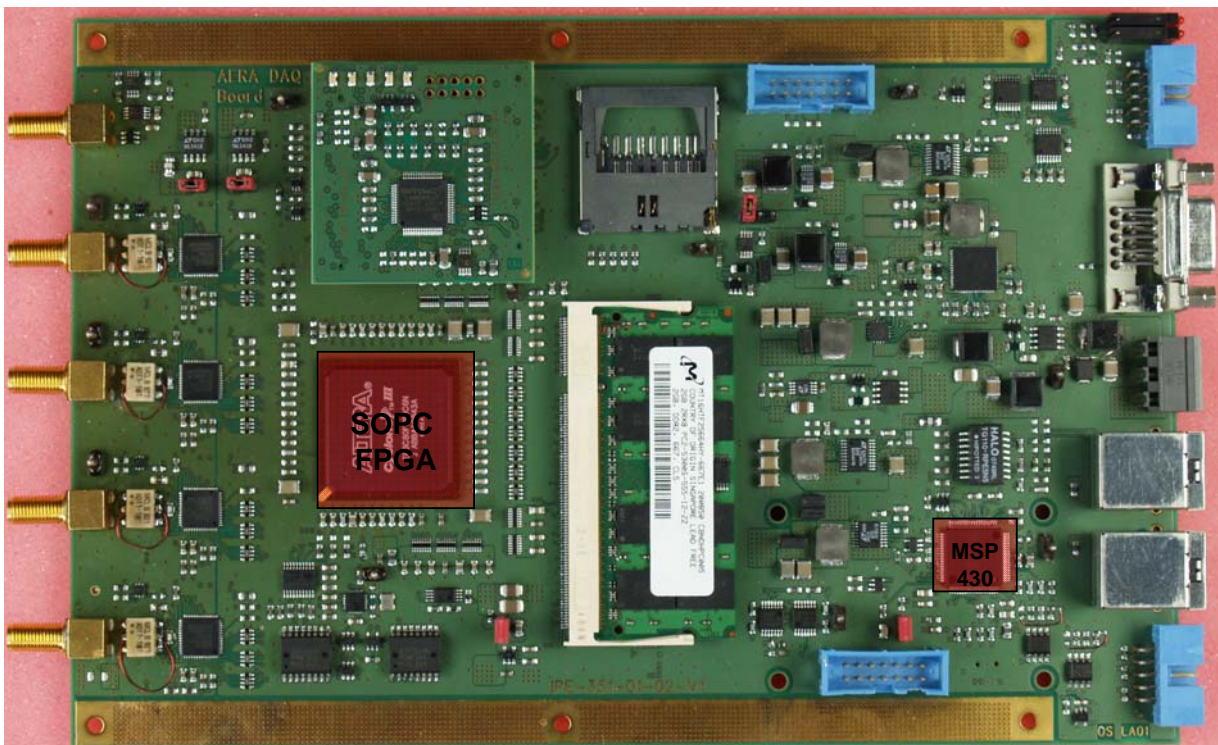
# Aufgaben

- High und Low Gain für jede Polarisationsrichtung
- 4 Digitalisierung 12bit@180MHz
- Filterung und Triggerung
- Event Message
  
- Ringspeicher für 3 Sekunden
- Zeitstempel (GPS)
- Board Monitoring
  
- Kommunikation
- Remote Parametrisierung
- Remote Firmware Update

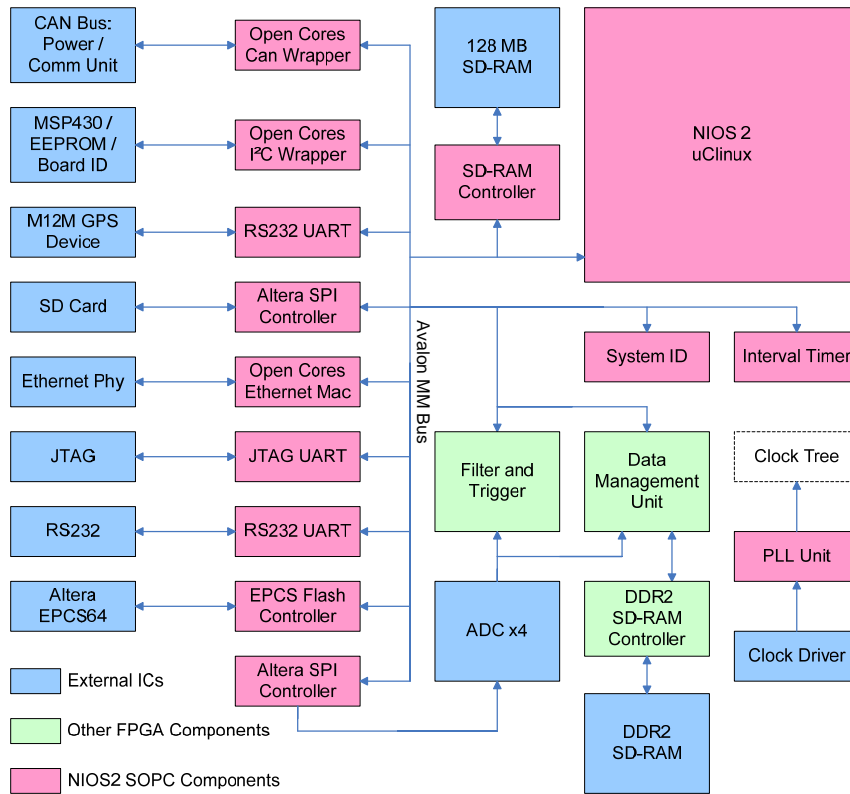
# Datenerfassungssystem



# Datenerfassungssystem

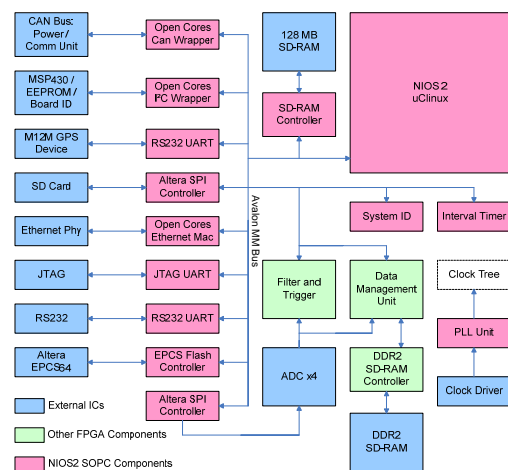


# SOPC



# NIOS 2

- OS  $\mu$ Clinux
- Verwendung von vorhandenen Treibern
  - Ethernet
  - CAN
  - Serial Interface (RS232)
  - I2C
  - SD Card
  - Flash Programming (EPCS)
- Treiberentwicklung
  - Filter und Trigger
  - Data Management Unit

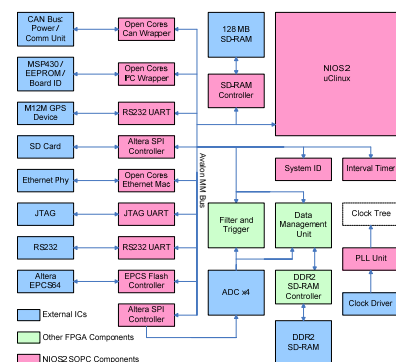


## Konfiguration & Boot File

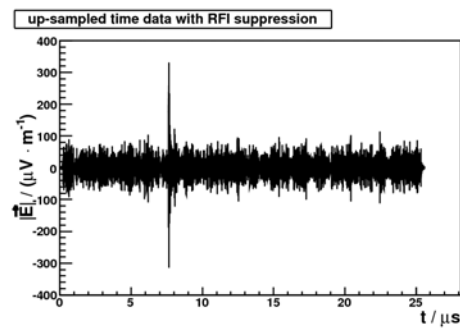
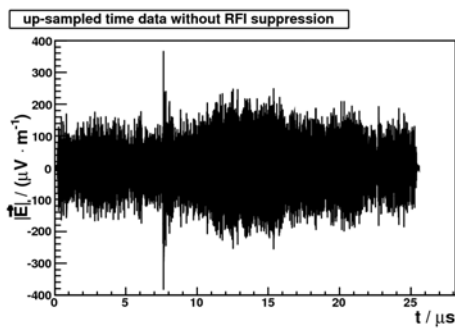
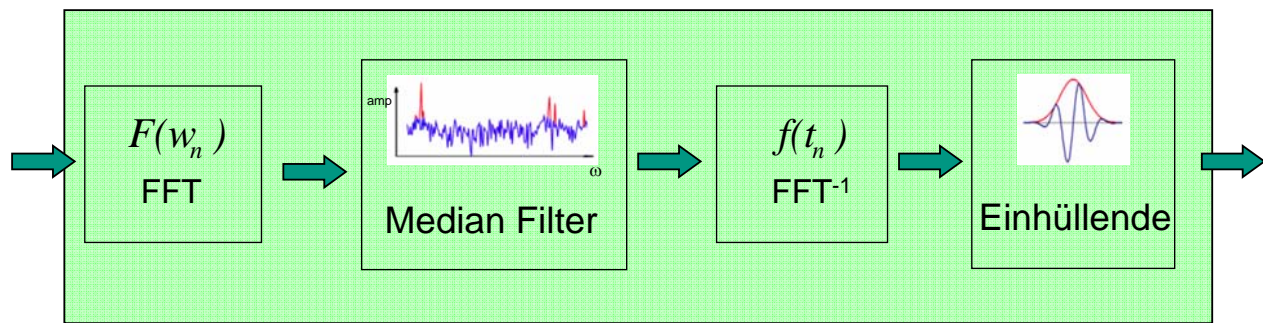
- FPGA Konfiguration                    EPCS (ALTERA Flash)
- µClinux Operating System        EPCS
- Linux filesystem                    SD CARD
  - Applikationsfirmware
  - Parameterfiles
- Sicherheitskonfiguration (2. EPCS)

## Anwenderspezifische Einheiten

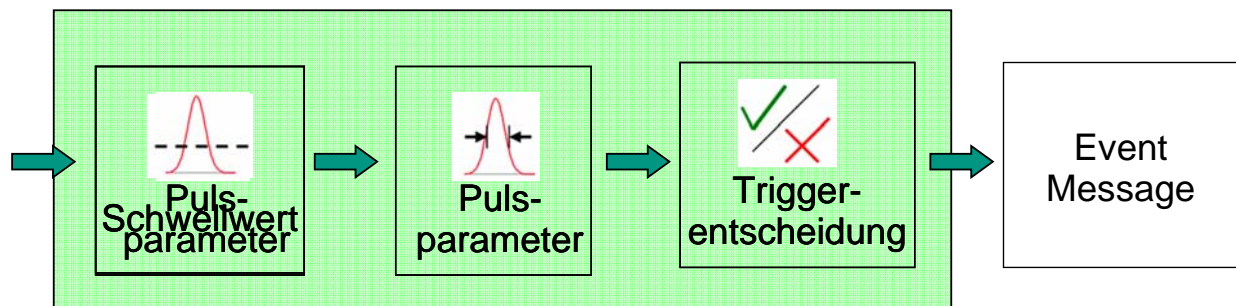
- **Filter und Trigger Unit**
  - Filterung von 2 High Gain Channels
  - Triggerbildung von allen 4 Channels
- **Data Management Unit**
  - Abspeicherung der High Gain Daten  
Ringspeicher für 3 Sekunden
  - Transienten Recorder für Low Gain Daten  
2 x 2 x 2048 Samples
  - Auslesen von angefragten Eventdaten 4 x 2048 Samples



# Filter

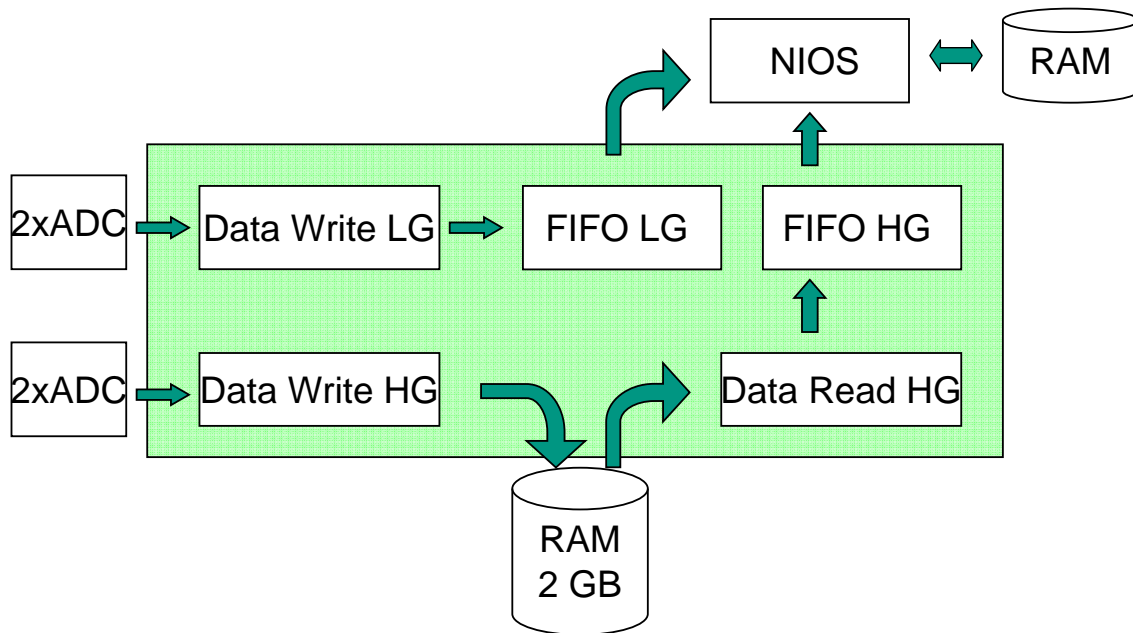


# Trigger



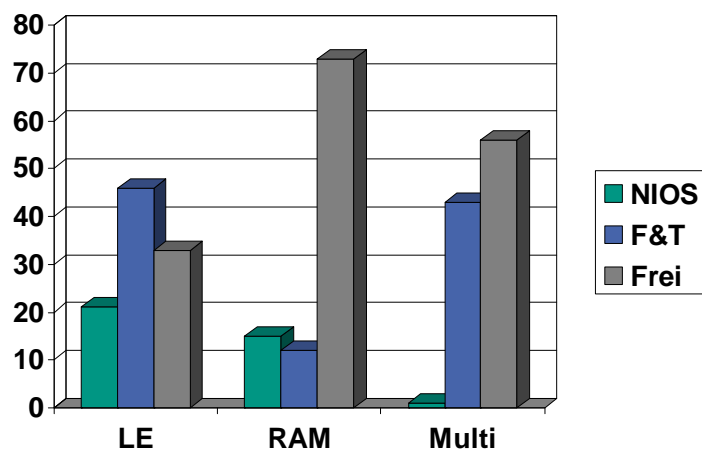


# Data Management Unit



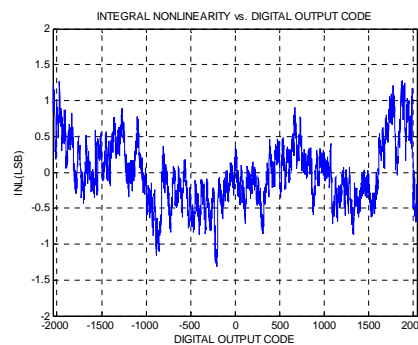
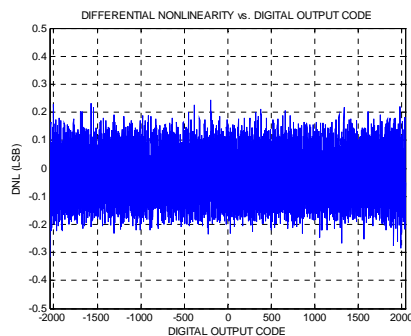
# Resourcen ALTERA FPGA EP3C80C780C6

- 81264 LE
- 2,8 Mbit RAM
- 488 9x9 Multiplier
- 429 User I/Os (312 used)



## Analoge Eigenschaften

- Noise (Kurzgeschlossene Eingänge)
  - 1.62 LSB
  
- Crosstalk
  - -82dB
  
- Differential Non Linearity (DNL) and Integral Non Linearity (INL)



## Zusammenfassung

- Rauscharmes Messsystem
  
- Schnelle Realisierung des SOPC
  - Vorhandene Treiber ( $\mu$ Clinux)
  - Verfügbare IPs
  - Einfache Einbindung von Custom IPs
  
- Flexibles System
  - Adaption der analogen Eingangsstufen
  - Verschiedene Schnittstellen für eine Kommunikation
  - FPGA mit ausreichenden Ressourcen