Waveform Digitizing and Processing Front-end Microelectronics for Particle Physics Experiments

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ABOUT NALU SCIENTIFIC

Fast Growing Startup in Honolulu, Hawai’i
Located at the Manoa Innovation Center
Over $11M in committed funding, 18 staff members
Access to advanced design tools
Rapid prototyping and testing lab

Scientific Expertise
Particle physics detection and tracking
Radiation detection
Readout electronics for Particle Physics detectors

Technical Expertise
Analog + digital System-on-Chip (SoC)
Field Programmable Gate Arrays (FPGA)
Complex multi-layer Printed Circuit Boards (PCBs)

Nalu = ‘wave’ in Hawaiian language
1. Front-end Chips:
- Event based digitizer+DSP
- 4-32 channel scope on chip
- 1-15 Gsa/s, 12 bit res.
- Low SWaP-C
- User friendly: FW/SW tools

2. Integration:
- SiPM
- M/A PMTs
- LAPPD
- Detector arrays

3a. Main application:
- NP/HEP experiments
- Astro particle physics

3b. Other applications:
- Beam Diagnostics
- Plasma/fusion diagnostics
- Lidar
- PET imaging
WHERE WE STARTED

A Search for New Physics – The Belle II Experiment

Tsubuka City
Located 60 mi north of Tokyo

High Energy Accelerator Research Facility (KEK)
in Tsukuba

Interaction point inside the electron/positron collider

Belle II Youtube page
HISTORY - BELLE II

Belle II Upgrade is a 26+ Country, 900 Member Collaboration

2015
Nalu Staff designed and implemented front-end electronics and FW for KLM (muon system) and iTOP (Cerenkov-based PID) sub-detectors.

Belle II: e+ e- experiment at 40x luminosity of Belle -> Detector needs to operate at severe beam background.
L1 trigger at 30 kHz

2018
**LESSON ONE**

**HOW DO PARTICLE PHYSICS EXPERIMENT WORK?**

**Needs:**
- Survive harsh environments
- High performance
- Accommodate long trigger delay
- Low cost, low power
- User friendly

**Solution:** New System-on-Chip Integrated Circuit

**Opportunity:** Not many commercial options available

**Funding:** US Department of Energy

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**LESSON TWO**

**Proposed Solution:**
Chip level integration of switched capacitor array (analog) with digital processing.
Funding, Collaboration and Workforce Development

**FY16-21**

- $11 M Secured by Nalu
  - 9x SBIR Phase I
  - 6x SBIR Phase II
  - Various matching grants
  - Misc. contracts

**FY16-20**

- $1.2M Sponsored Research
  - University of Hawaii
  - National Labs
  - 4x post docs
  - 4x graduate students
  - Misc. materials and supplies

**FY21-23**

- New possibilities:
  - New tech-dev based on capabilities
  - Sensor integration
  - Custom design
  - New partnerships

**Why Hawaii?**

- Strategic location - Asia <> US
- University of Hawaii
- Greater impact on State
- “Hawaii Brand”
- Retain local expertise

2x MS and 2x PhDs had their first jobs at Nalu Scientific.
Getting the Word Out

- Awards (40U40, most innovative, ...)
- Attending conferences, trade shows, pitch competitions
- Media attention on restarting/diversifying economy in Hawaii esp post COVID
- **New website, Social Media handles: FB, LinkedIn, Twitter**

Virtual Interview on COVID-19: Isar Mostafanezhad, Founder and CEO, Nalu Scientific
Factors attributing to funding success

- Business is main focus and career:
  - Full time founder/CEO willing to go the extra mile and do what it takes - persistence

- Started small (DOE Phase 0 - check it out)

- Leveraged ‘Hawaii brand’ and relationship with University

- Revise and resend based on feedback

- Always going back asking for more money:
  - It’s never enough money! Need to keep workforce busy.
  - Propose new tech to create coverage in tech offering (faster, cheaper, better, smaller, etc)
  - Talk to PMs to see what else is on their minds
  - Leverage the team
  - Leverage new relationships - Universities, National Labs, consultants

- Failure is an opportunity to do better next time
Summary

● Our journey:
  ○ SBIR Funding
  ○ Team Growth
  ○ Tech Development
  ○ Collaboration

● Workforce development
  ○ Hiring
  ○ Retaining Institutional Knowledge

● Industry Relations
  ○ Distributors
  ○ System integrators
  ○ Commercialization Pathway

● Get help from wherever and whomever you can!
  ○ HTDC
  ○ UH
  ○ SBDC
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