1-minute Colloquium
Sep 26, 2019

University of Hawaii at Manoa
Physics & Astronomy Department

WATCHMAN (WATer CHerenkov Monitor for ANtineutrinos)

Brian Crow – crowbc@hawaii.edu

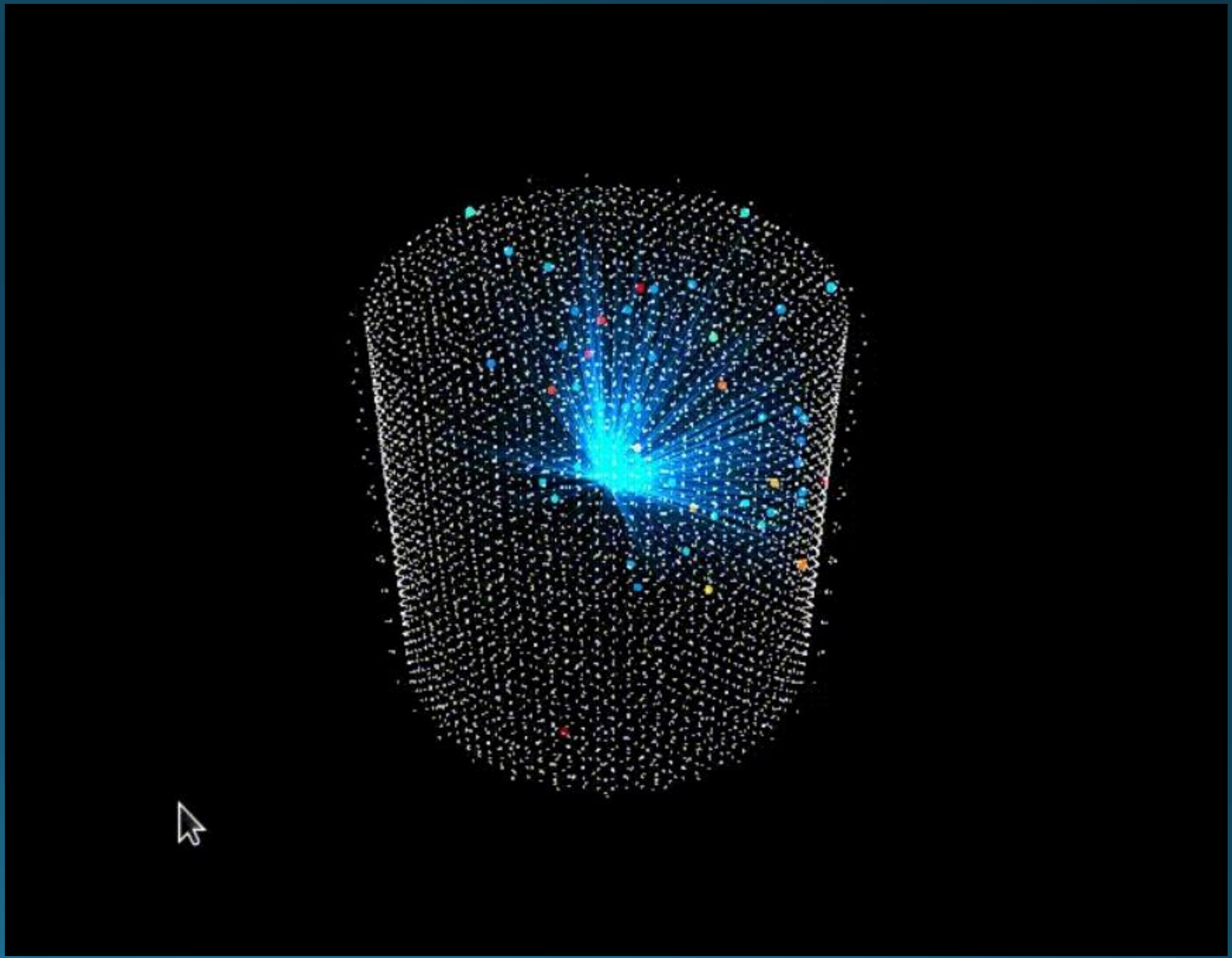
- ~1kt fiducial volume
- ~3600 PMT's
- Using rat-pac for detector simulations:

✓IBD events

❑Backgrounds (muons, radioactivity, etc.)

❑Supernova IBD's

- Looking for more grad students
- Photo courtesy of Morgan Askins via the SAS Workshop: 30 June – 3 July, 2019 at LLNL.



Simulated Cherenkov Light Cone from Inverse Beta Decay

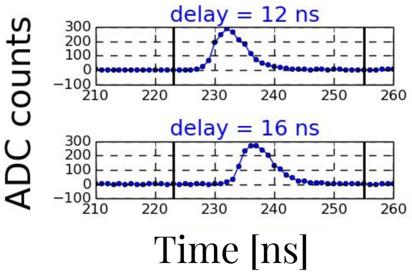
Data Acquisition for WATCHMAN Project

Salvador Ventura
venturag@hawaii.edu

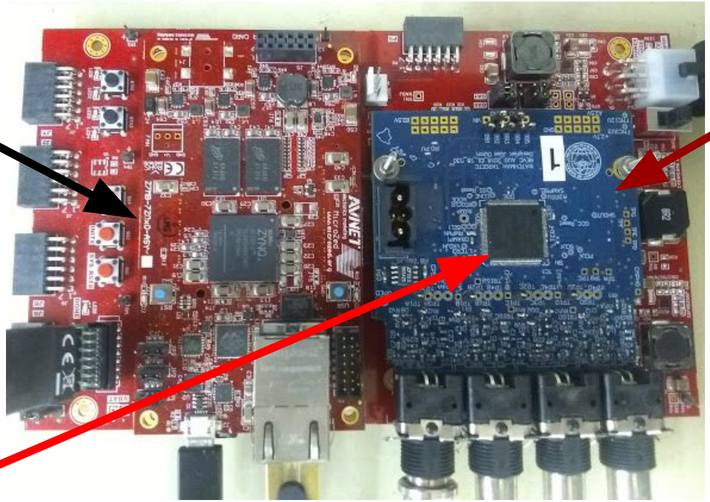
IDLAB HAWAII

TARGETC. Multichannel 1 GSPS ADC developed by IDLAB at Astronomy and Physics Department, UH-MANOA.

MicroZed Board
Zynq-7000 SOC
FPGA+ ARM Proc.



Current working DAQ prototype

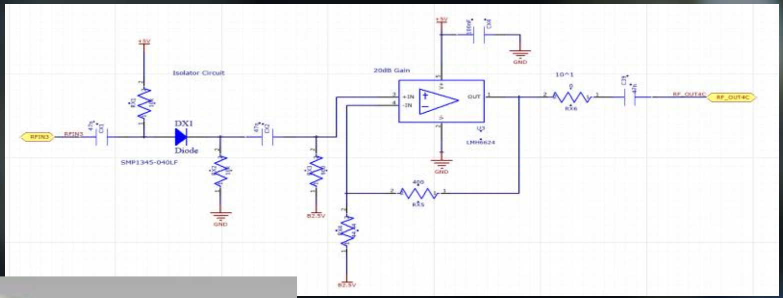


FMC BOARD
(see Jose's slide)

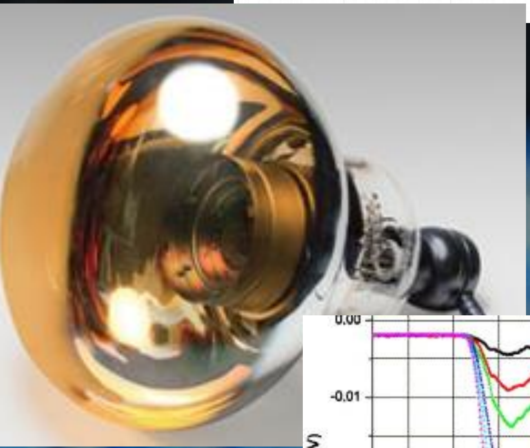
TARGETC

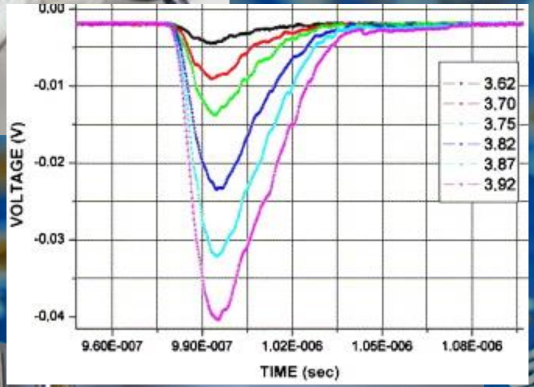
Ongoing work:
- New prototype board assembly for 16 channels
- Firmware
- Software

Jose Duron – IDLAB



Readout Electronics for WATCHMAN Cherenkov Anti-Neutrino Detector





Electronics Design

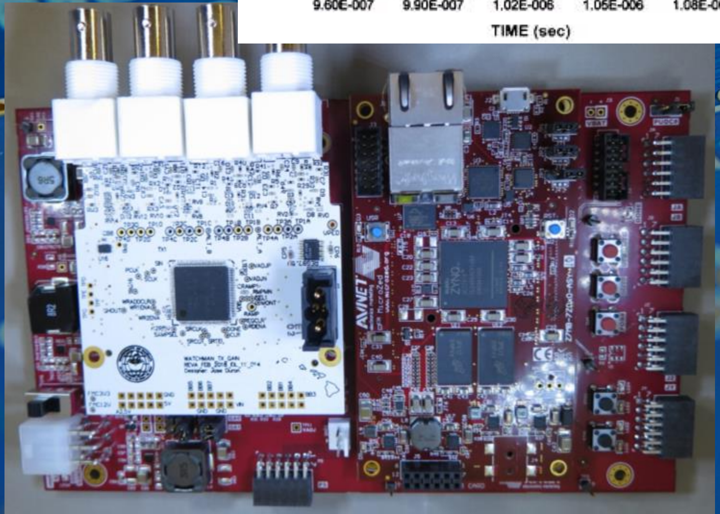
-Simulation/Schematics

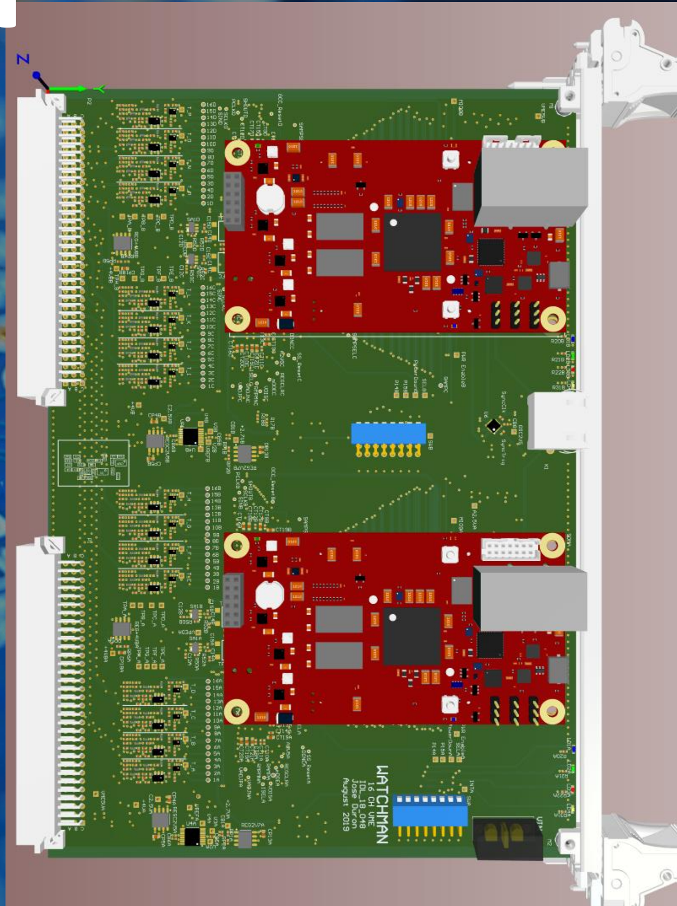
-PCB Layout

-Assembly/Testing

Firmware (FPGA)

Software



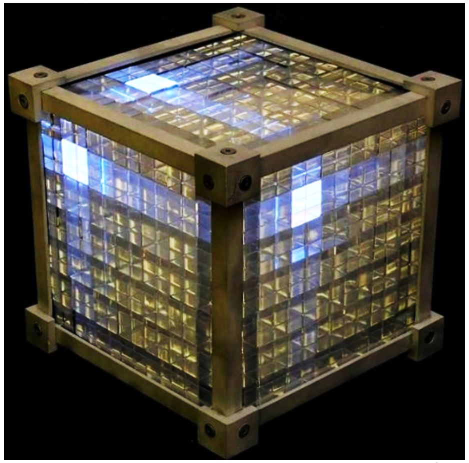


jduron@hawaii.edu

NuLat: A Compact, Segmented, Mobile Anti-neutrino Detector

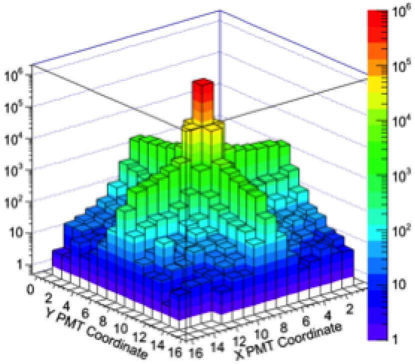
Presented by Ryan Dorrill for the NuLat Collaboration: www.phys.hawaii.edu/~nulat/

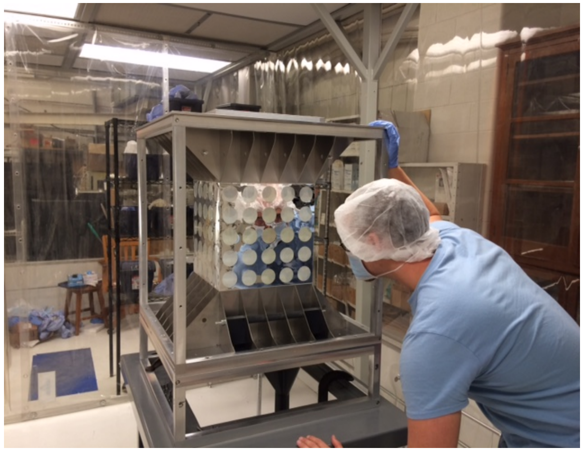
dorrill@hawaii.edu

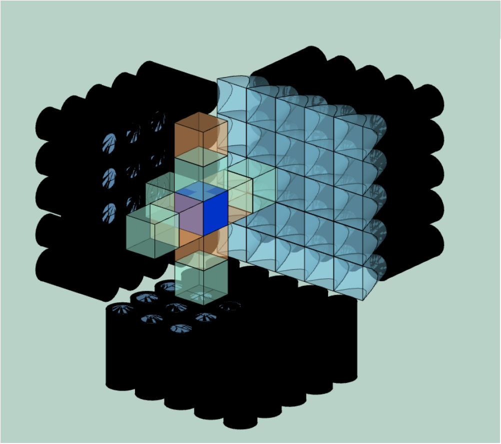


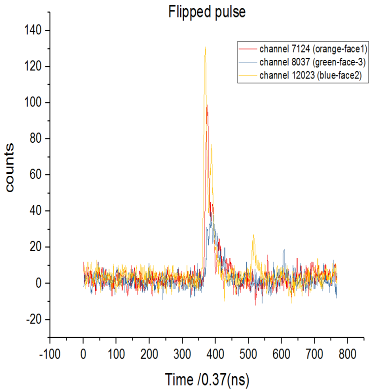
Key Features:

- Lithiated plastic scintillator(2.5” cubes) for strong neutron capture signals
- Fast-timing electronics and readout developed at UH and tested with miniTimeCube
- The segmented design aids in event localization and reconstruction and was proven by LENS
- Relative small size and portability compared to conventional neutrino detectors (Super-K is > 50,000 tons)
- Pulse shape discrimination helps reject background signals (cosmic muons, gammas, etc)







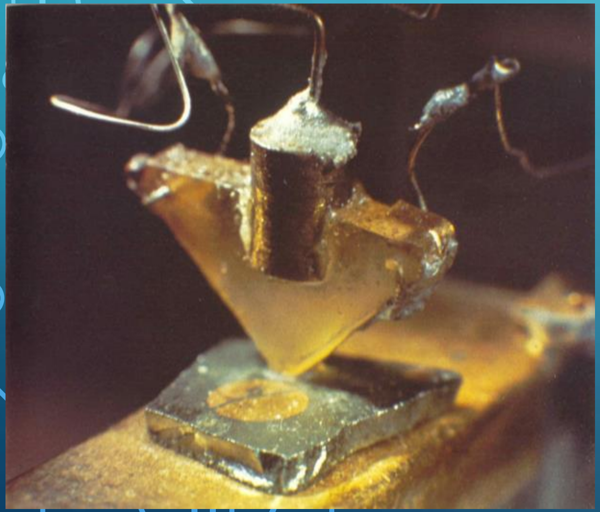


Instrumentation Development LAB

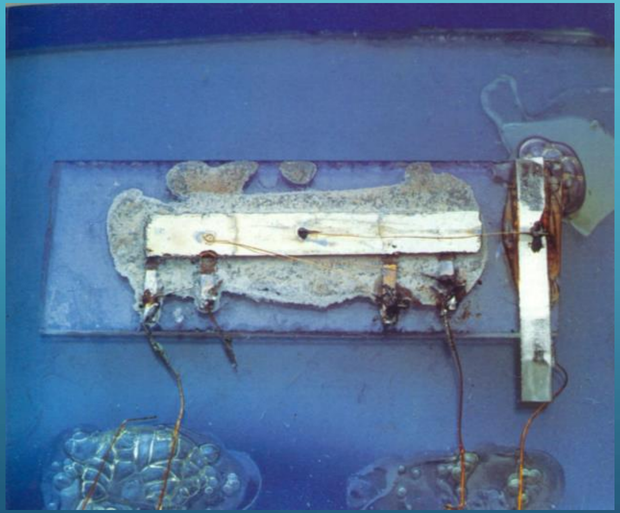
Application Specific Integrated Circuit Design (ASIC)

Ehsan Yavari ehsan@Hawaii.edu

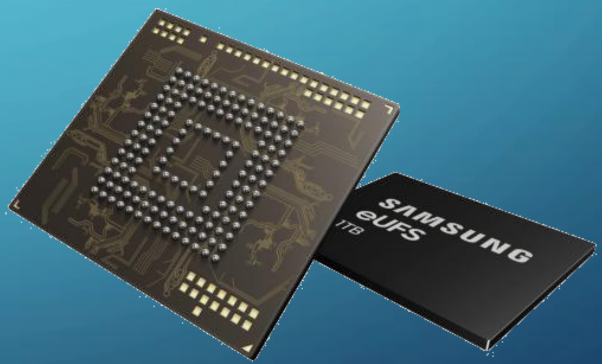
First transistor
Bell Labs, 1948



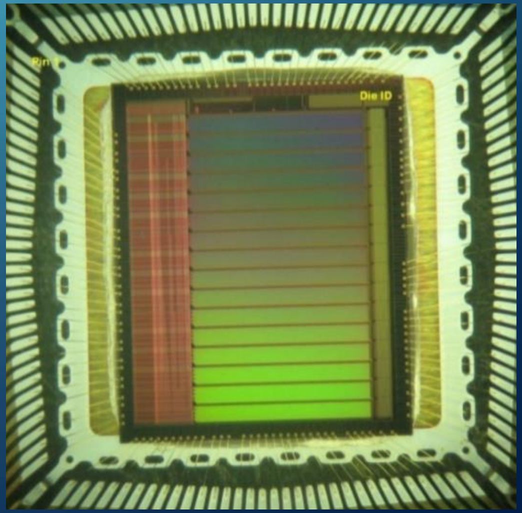
First IC, Texas Instruments
1958



Samsung's (1 TB) flash memory
chip, 2T transistors, 2019



ASIC Design (Target X)
IDL lab



University of Hawai'i at Mānoa
Department of Physics & Astronomy

Instrumentation Development Lab (IDL)
Ruth Perron
ruthsenn@hawaii.edu

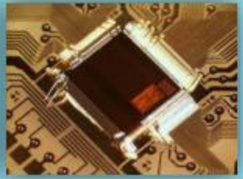
Application Specific Integrated Circuit (ASIC)

IC dedicated for one specific application

ASIC Examples

Machine Learning
(Google TPU)

Bitcoin Miner
(Samsung)



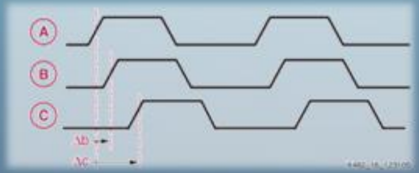
Readout Chip
(LHC @ CERN)

ID Lab ASIC Chips: ASoC, AARDVARC

- Data acquisition
- Particle detection and tracking applications
- Waveform sampling, self-calibration, signal processing

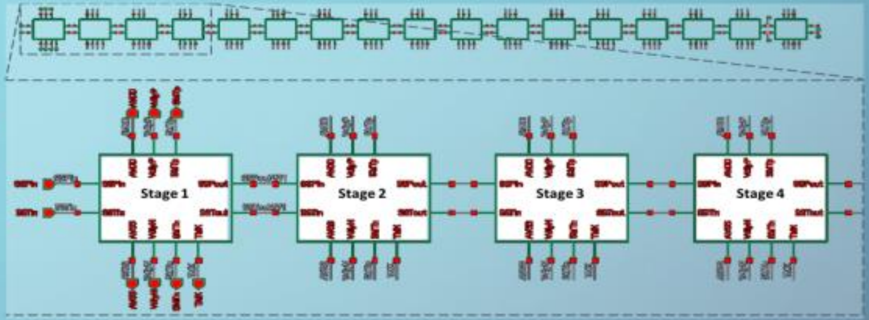
Delay Line

- Control clock signal
- Deterministic delay



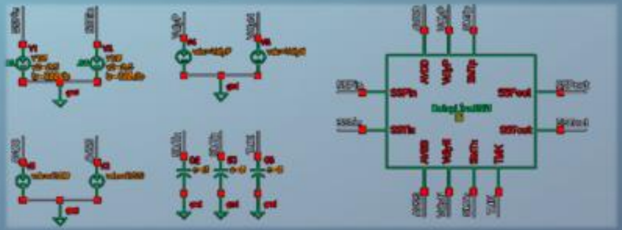
Delay Line Design Flow

Schematic



Layout

Verification



Fabrication

Testing

Nalu Scientific
Data Acquisition Systems

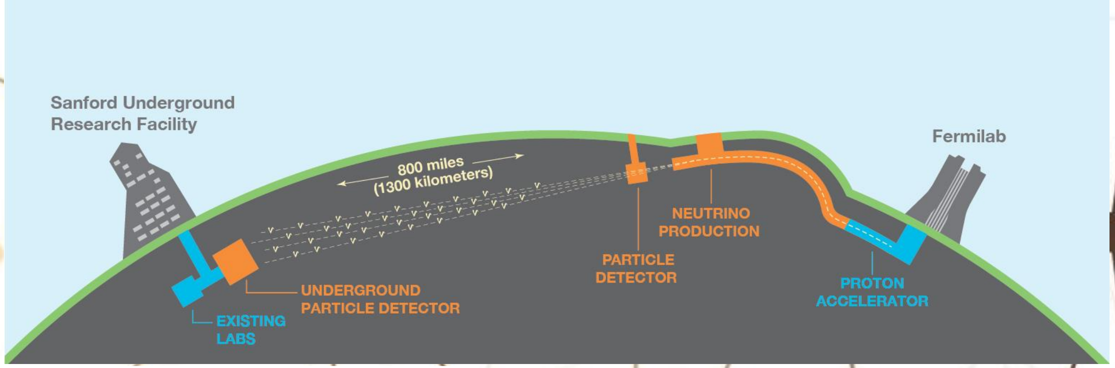
Sponsored by Nalu Scientific and US DOE

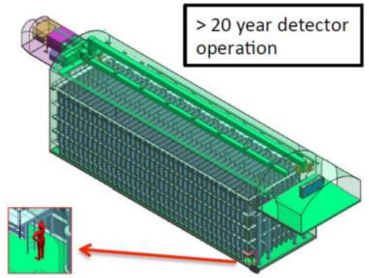
THE **Q-PIX** INTEGRATED CIRCUIT

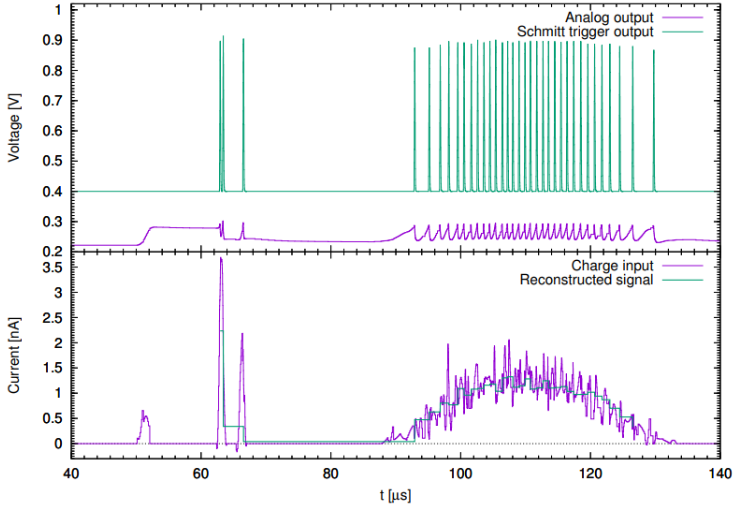
- A PIXELATED READOUT FOR CRYOGENIC TIME PROJECTION CHAMBERS (DUNE FAR DETECTOR)
- WIRES → PIXELS FOR HIGH FIDELITY RECORD OF EACH EVENT.
- … BUT THAT'S A HUGE NUMBER OF CHANNELS (10^8)! HOW DO WE KEEP POWER/COMPLEXITY TRACTABLE?
    - READ TIME PER CHARGE INSTEAD OF FULL WAVEFORM.
    - ALL Q-PIX ICS OPERATE INDEPENDENTLY – AVOID POWER DRAW FROM DISTRIBUTED CLOCK NETWORKS.
    - ASICS FORM A SELF-ASSEMBLING NETWORK TO RELAY DATA BACK TO CENTRAL SYSTEM.
    - NETWORK IS ALSO SELF-REPAIRING!
    - DIGITAL DESIGN STUDIES JUST STARTING NOW…

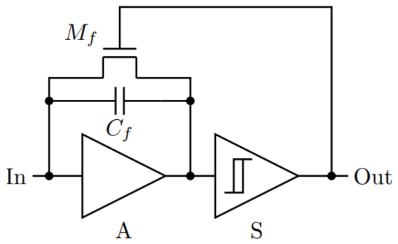
LOOKING FOR GRADUATE STUDENT TO CONTRIBUTE TO THE DIGITAL DESIGN!

CONTACT: KURTIS NISHIMURA (KURTISN@PHYS.HAWAII.EDU)

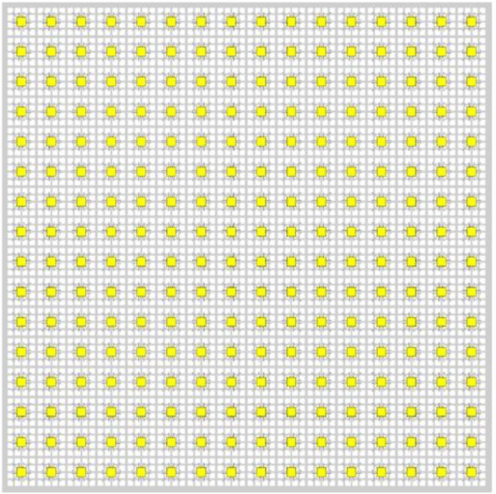


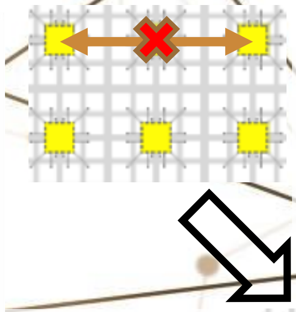






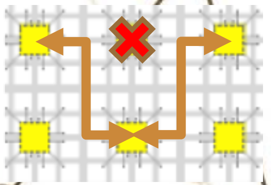
Only one connection to outside world required per 4096 pixels!





Dead chip breaks data pathway…

…automatic re-routing to repair.



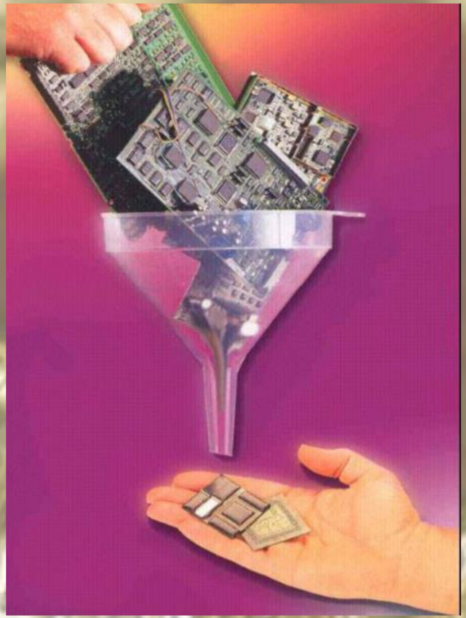
Instrumentation Development LAB

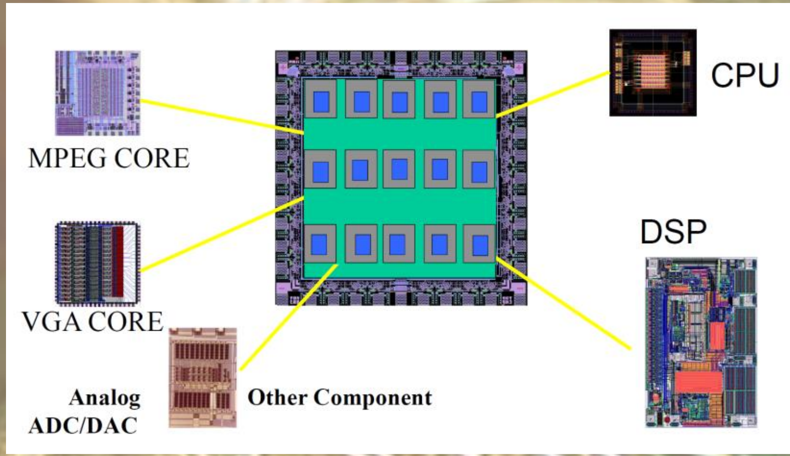
ASIC Design - *A*pplication *S*pecific *I*ntegrated *C*ircuit

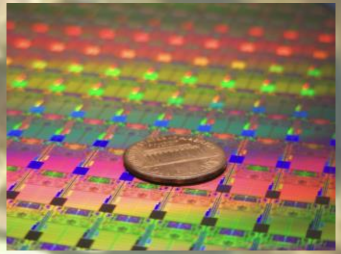
Gang Liu : liugang@hawaii.edu

SoC & Challenges

- HW/SW Co-design
- Mix signal integration
- High density & low power
- Yield & Productivity

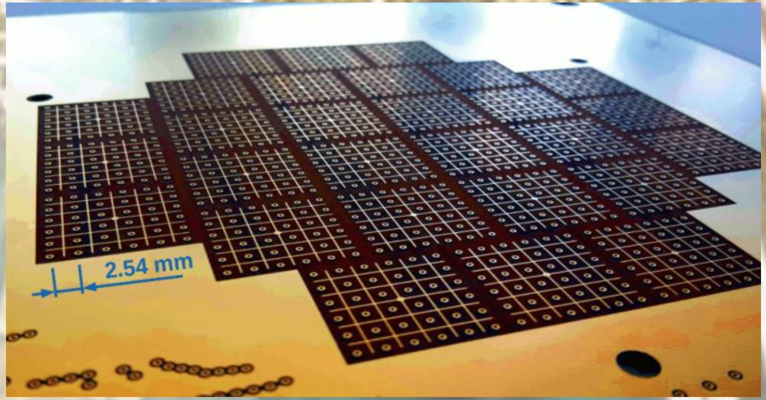


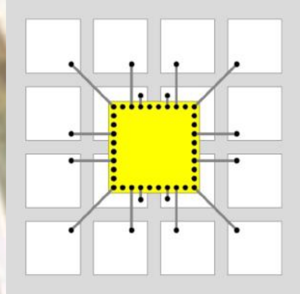


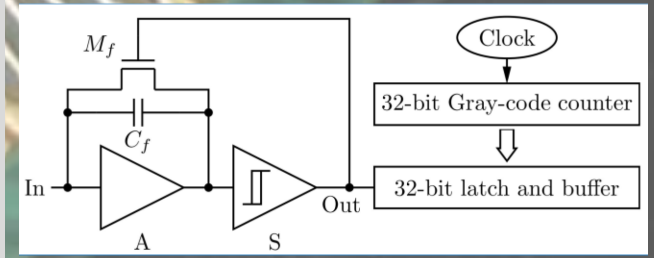


Q-Pix collaboration

- Kiloton scale LarTPC
- Pixel based readout
- Hundred million channels
- Electronic principle of least action







TCAD Detector Simulations at UH

Shahab Kohani

kohani@hawaii.edu

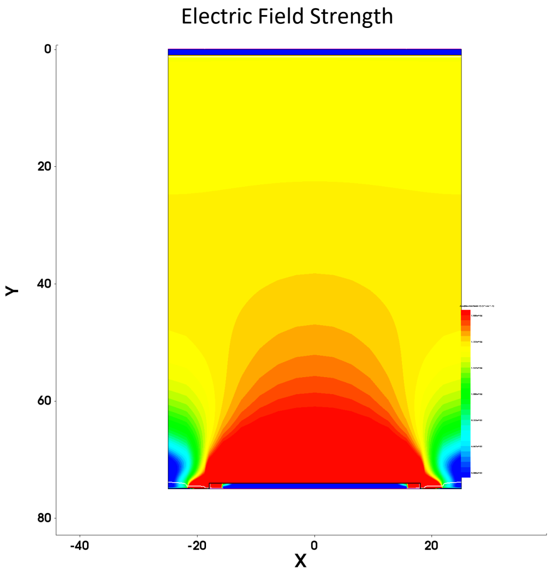
- Technology CAD software are used to simulate the silicon detectors electrostatic and transient response.

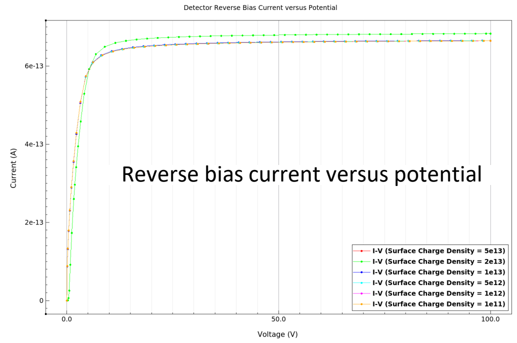
- Radiation damage resistant detector design and semiconductor detectors with onboard amplification and other readout electronics are of particular interest.

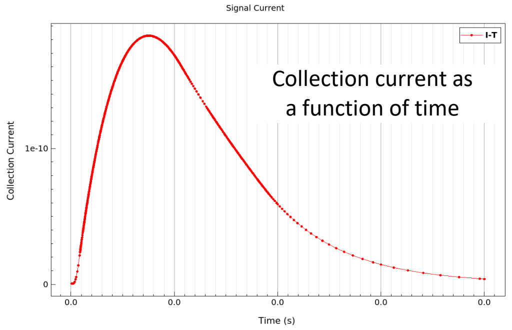
- Currently charge collection and radiation damage simulations for the X-ray monitor at KEK is underway here at the UH.

Resources in Hawaii:

- A multi-use academic license SYNOPSYS software suite is purchased by IDLAB.
- TCAD software can be installed and run from the HPC.



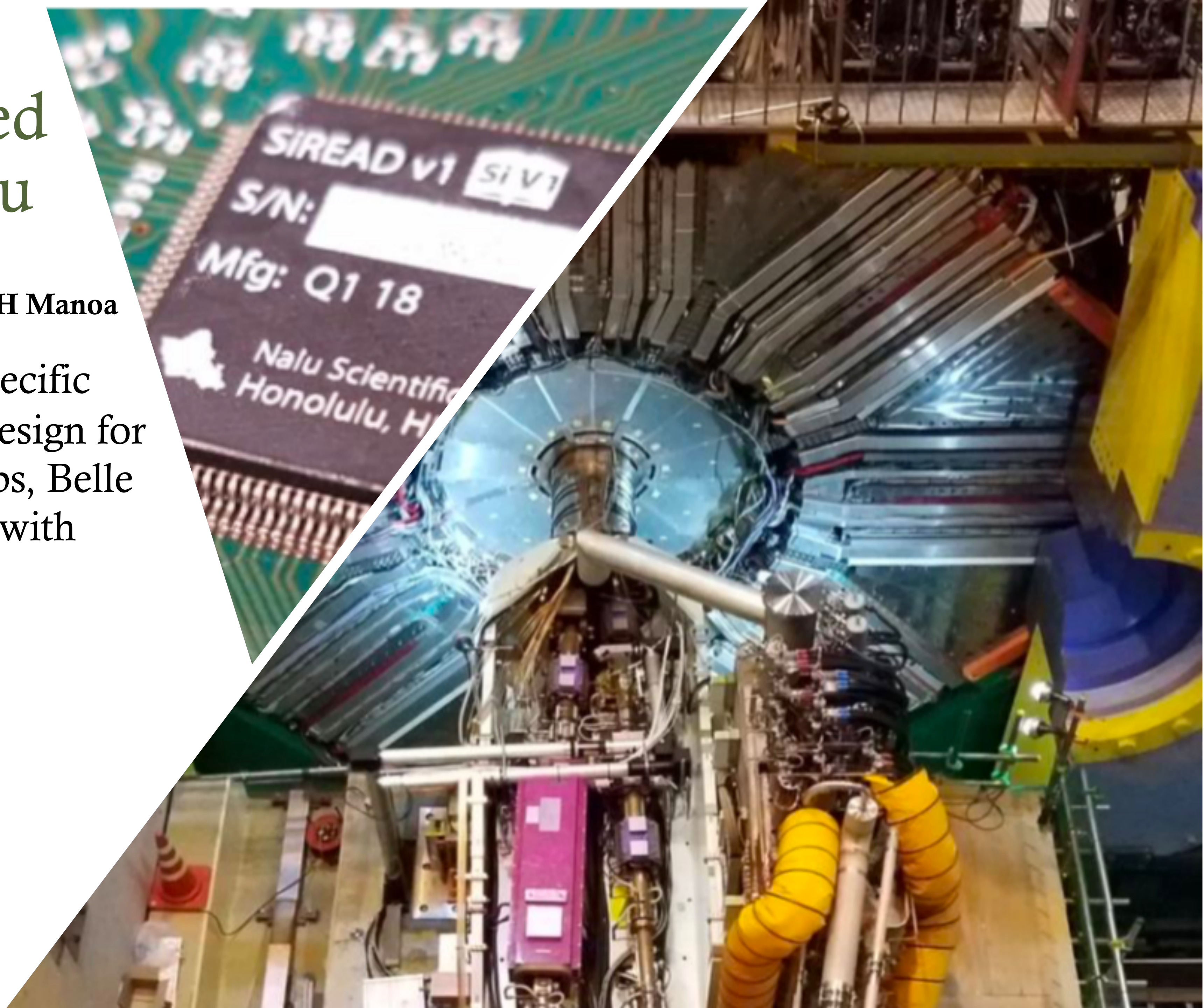


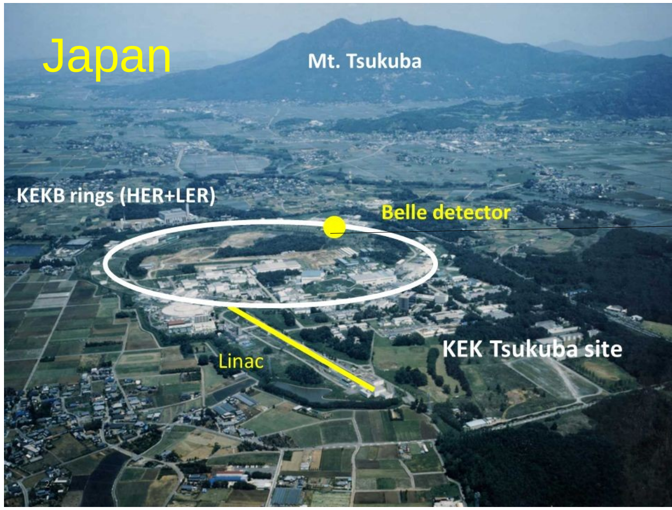


Noha Mohammed
noha@hawaii.edu

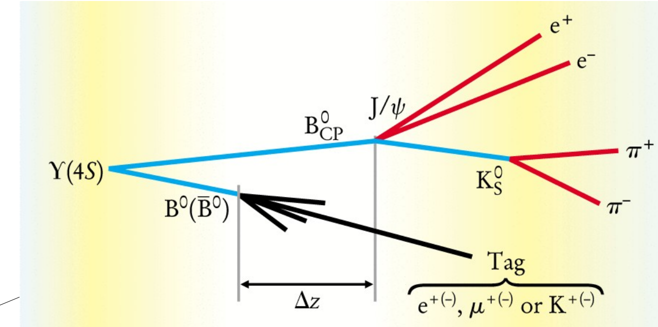
MSc student in Electrical Engineering, UH Manoa

Radio-Frequency Application-Specific Integrated Circuits (RF ASIC) Design for Particle Collider Experiment chips, Belle II KEK, Japan, in collaboration with Nalu Scientific company.

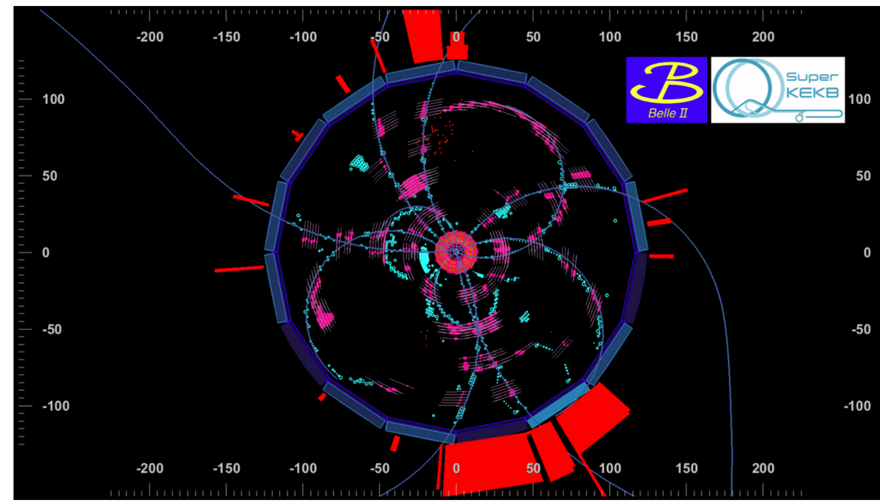


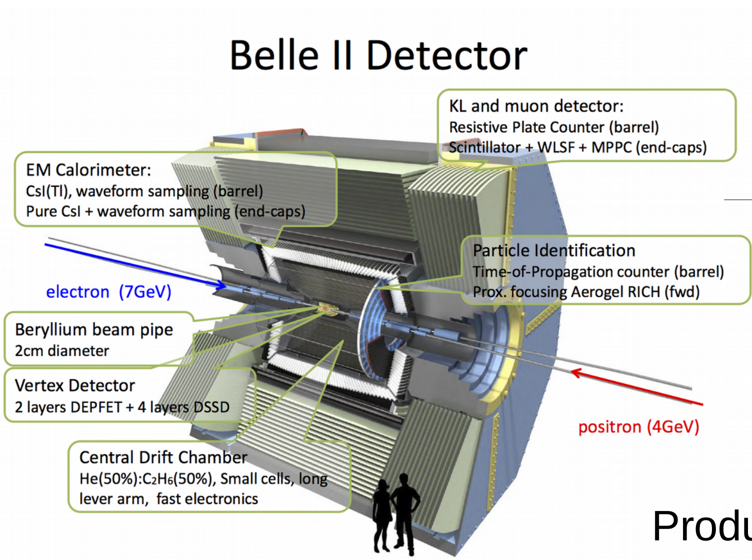


e- e+ → Y(4S) → B anti-B → stuff



(IC: https://physicstoday.scitation.org/doi/full/10.1063/1.1381091)





Produce particles called “B mesons”

- **B meson = 1 anti-b quark + 1 (u,d,s) quark**
- Belle II gives high precision measurements
- used to study many things about SM; search for new physics
- upcoming slides will give examples
- already hints of new physics in lepton (e, mu, tau) flavor
- UH Belle II group heavily involved in Belle II electronics
- come to the physics open house Nov. 9 to learn more (w/ Oculus Rift)

Belle2.org
IG: @belle2collab
Twitter: @belle2collab
FB: Belle II Collaboration

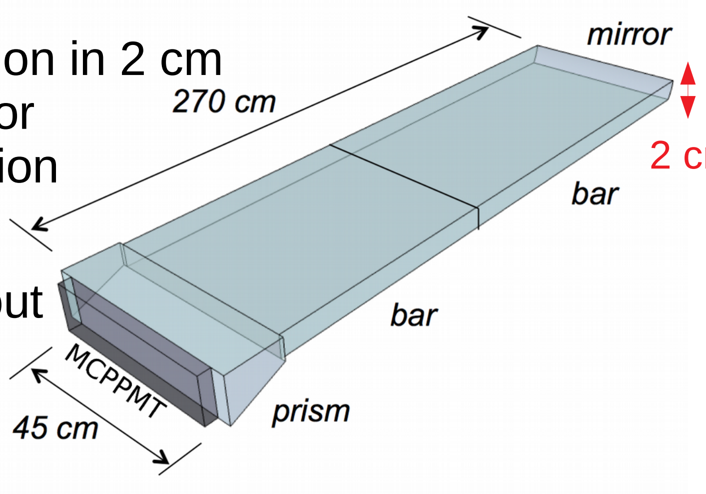
S. Dubey for the UH Belle II group

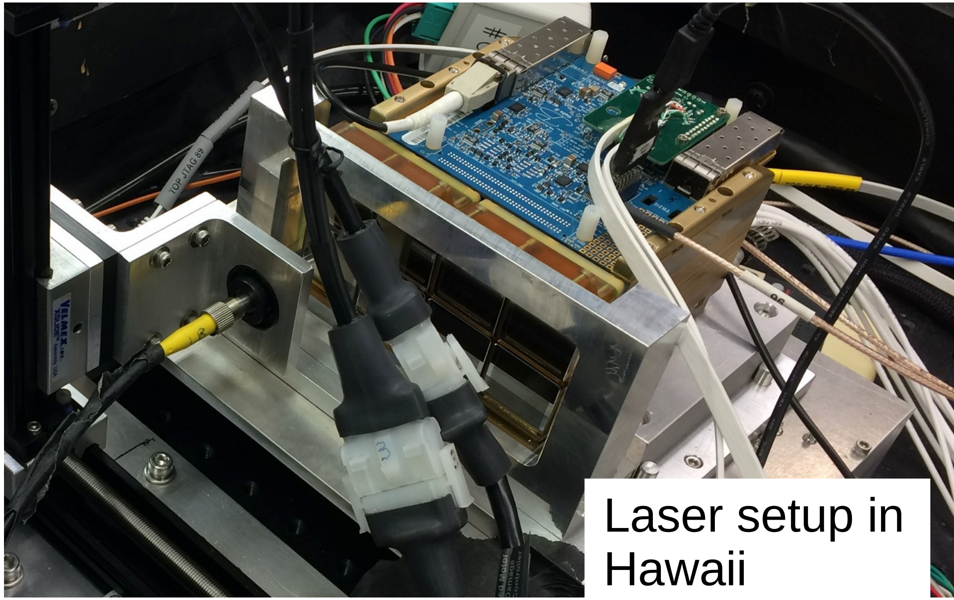
Martin Bessner
bessner@hawaii.edu

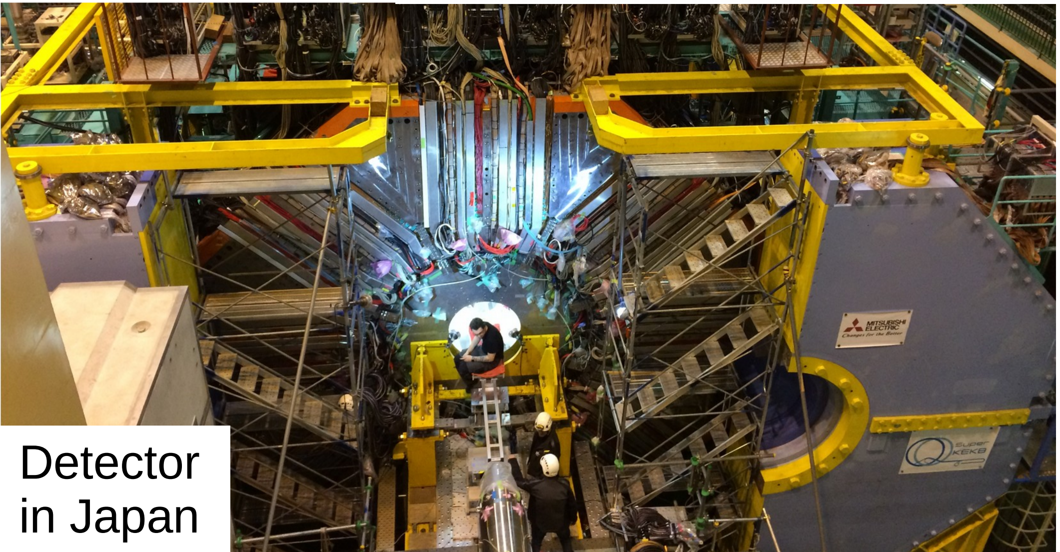
TOP in Belle II

Particle identification in 2 cm
Cherenkov detector
Time Of Propagation

Readout




Laser setup in Hawaii

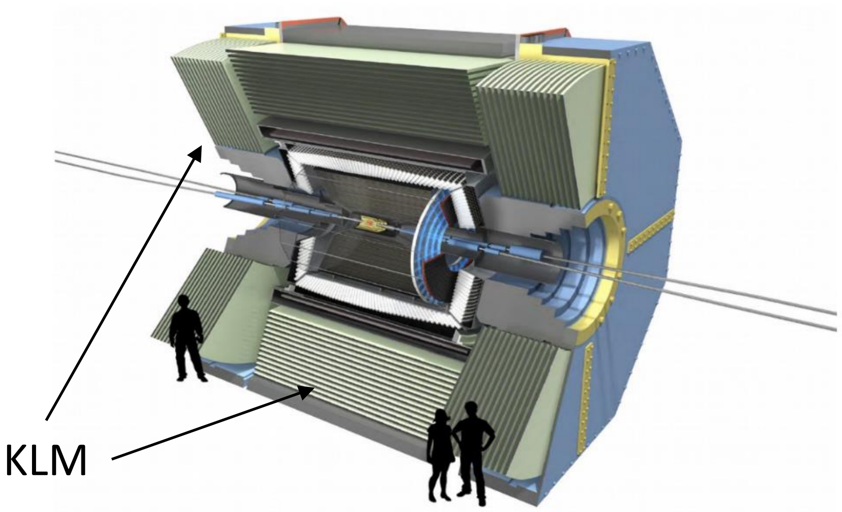

Detector in Japan

Travel around the world!
Particle accelerators!
High voltage!
Radioactivity!
Lasers!
~~Rockets!~~ working on it

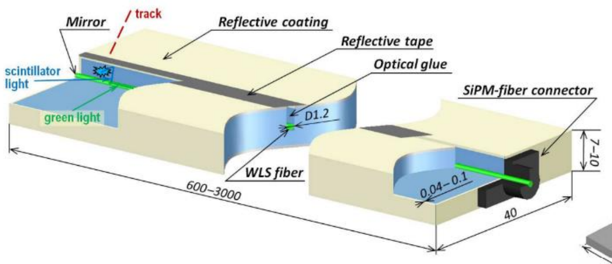
Join our group!

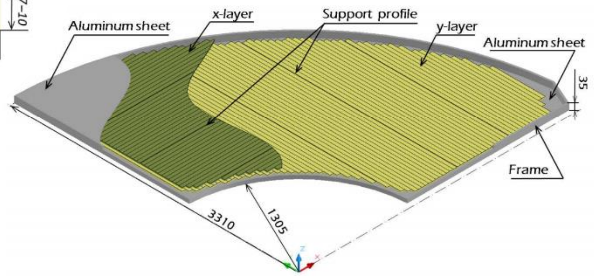
K_L^0 and Muon Detector (KLM)

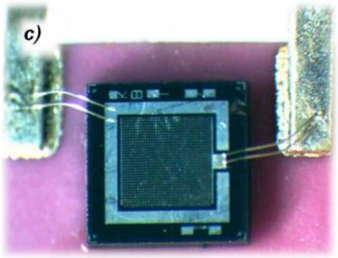
Richard Peschke
Peschke@Hawaii.edu



Scintillator Strip Detector

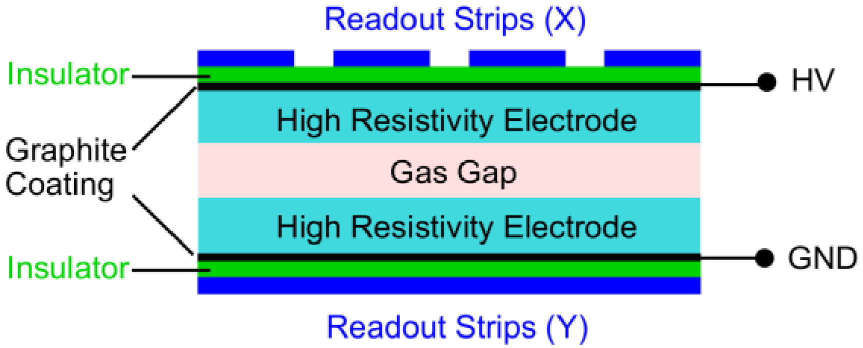


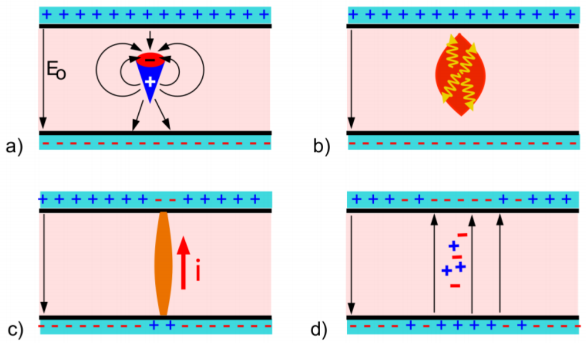




Aushev, T. et al. “A Scintillator Based Endcap KL and Muon Detector for the Belle II Experiment.” Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment 789 (2015): 134–142. Crossref. Web.

Resistive Plate Chamber

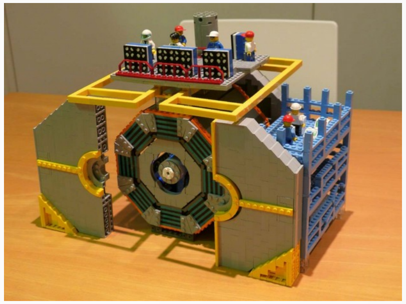




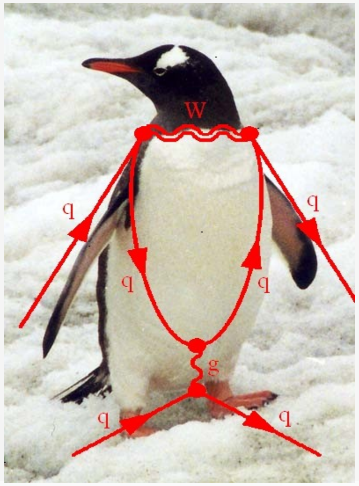
K0 L identification studies for Belle II | Jo-Frederik Krohn

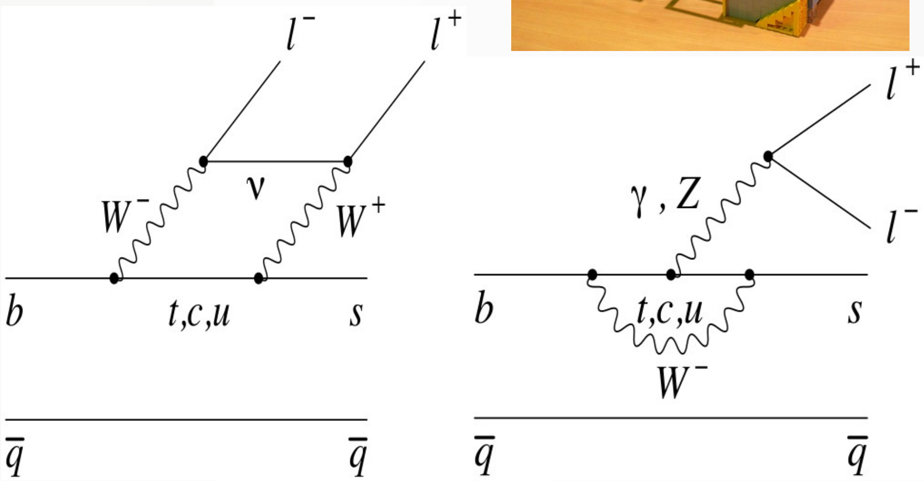
Search for $B^+ \to K^+ \tau^+ \tau^-$ @ Belle

§ Chris Ketter § 26 September 2019 § cketter@hawaii.edu §



- Flavor-changing neutral current (forbidden at tree level)
- Involves W^+W^- box diagrams or electroweak penguin diagrams
- Third in the family $B^+ \to K^+ \ell^+ \ell^-$ which has shown SM tension
- R_K anomaly in tau mode may reveal more SM tension



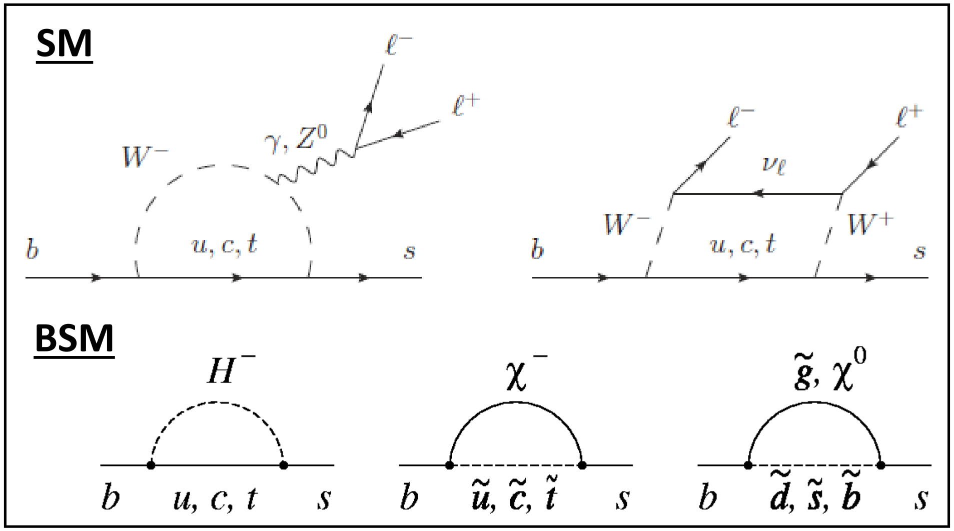


- Heavy τ mass provides larger couplings to new particles
- SM branching fraction prediction is 1-2 x 10^{-7} (but any non-SM couplings would enlarge actual branching fraction)
- Belle recorded 772×10^6 $B\bar{B}$ pairs, so should have several dozen, but tau reconstruction is hard

Discovery Flavor Physics at Belle II

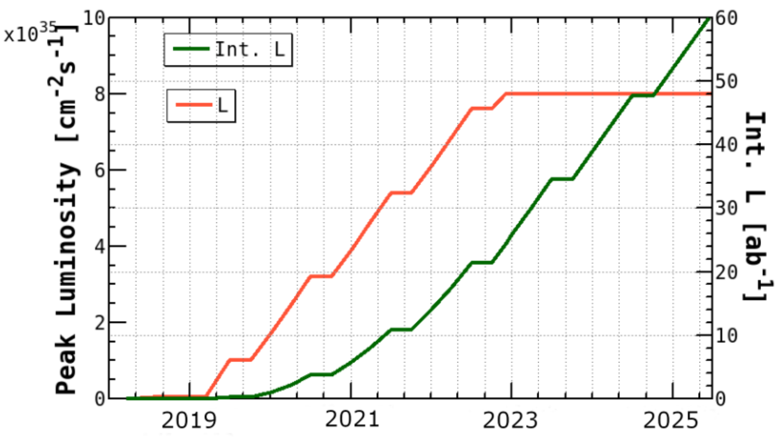
Kevin Flood (Watanabe 224),
kflood@hawaii.edu

- $b \to s l^+ l^-$ is a FCNC SM process forbidden at tree-level which proceeds via one-loop radiative and electroweak penguin diagrams, as well as through W^+W^- box diagrams. These SM processes are both theoretically and experimentally clean.
- Since BSM particles can enter the diagrams at the same order as SM processes, these transitions are ideal for new physics searches.
- Belle II is an ideal environment for studying these processes, with excellent charged hadron ID (UH lead), charged lepton ID, precision photon reconstruction, and excellent charged particle tracking and vertexing.



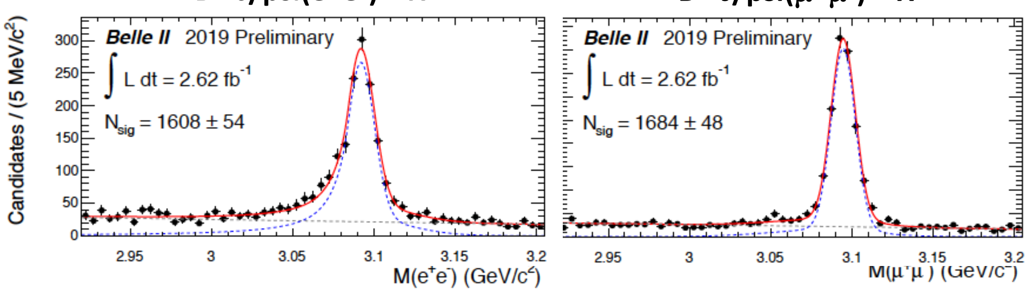
- Three families of $b \to s l^+ l^-$ Belle II analyses:
  - Exclusive modes, $B \to K(*) l^+ l^-$ (e/mu, ~1-10 ab^{-1})
  - Semi-inclusive, $B \to X_s l^+ l^-$ (e/mu, ~1-10 ab^{-1})
  - Fully inclusive, tagged $B \to X l^+ l^-$ (e/mu, >10 ab^{-1})
- Rate and angular observables to be differen-tially measured in bins of di-lepton mass^2.
- B->J/psi + X dataset provides comparatively huge data control samples in precisely the same final states as $b \to s l^+ l^-$ penguin decays.

SuperKEKB/Belle II Luminosity Profile



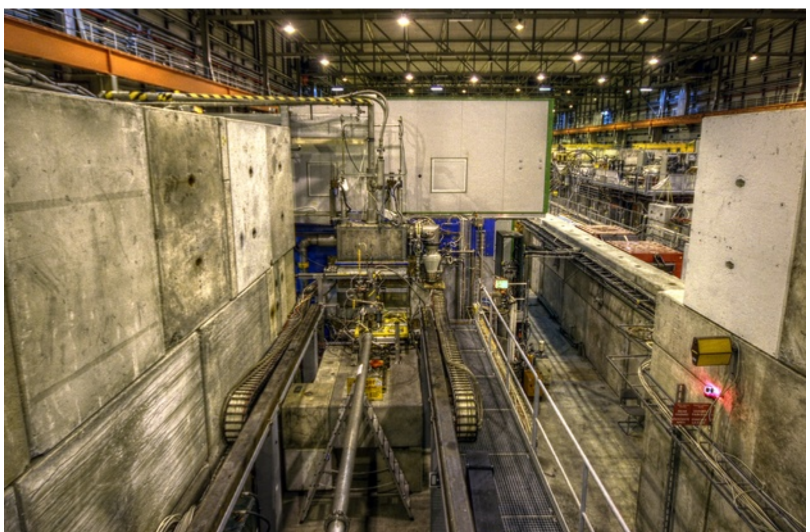
B->J/psi(e+e-) + X

B->J/psi(μ+μ-) + X



Cosmic-ray Antinuclei

- Measurement of cosmic-ray antinuclei is a promising way to search for “new” physics
- Detection of cosmic-ray antinuclei is experimentally challenging
  → multiple experiments needed
  - AMS-02 on the ISS since 2011
  - GAPS first balloon flight in 2021
- cross section measurements needed to improve understanding of antinuclei production: NA61/SHINE



Ground-based measurements with NA61/SHINE

Diego Gomez
Posdoctoral Researcher

P. von Doetinchem
Associate Professor

Search for Cosmic Ray Antinuclei

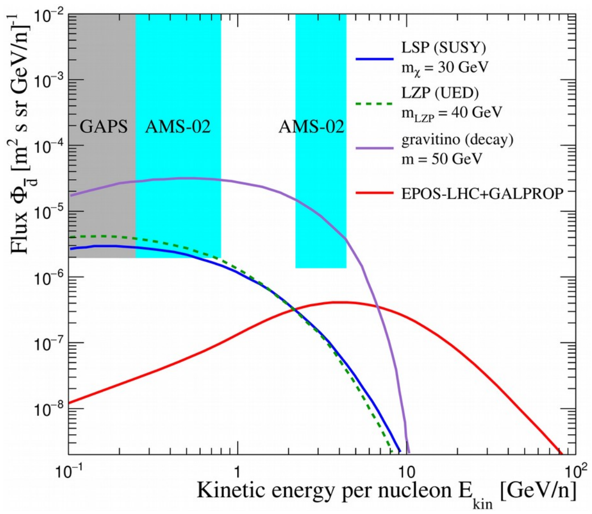
Indirect detection of Dark Matter

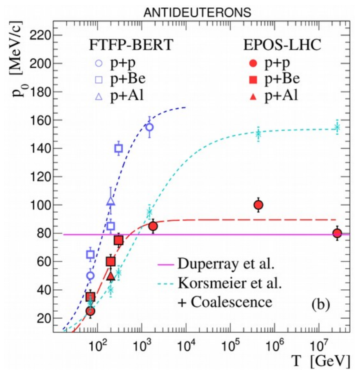
Data analysis from AMS experiment

Antinuclei identification using TOF/RICH (β) and Tracker/Magnet (R, Z)

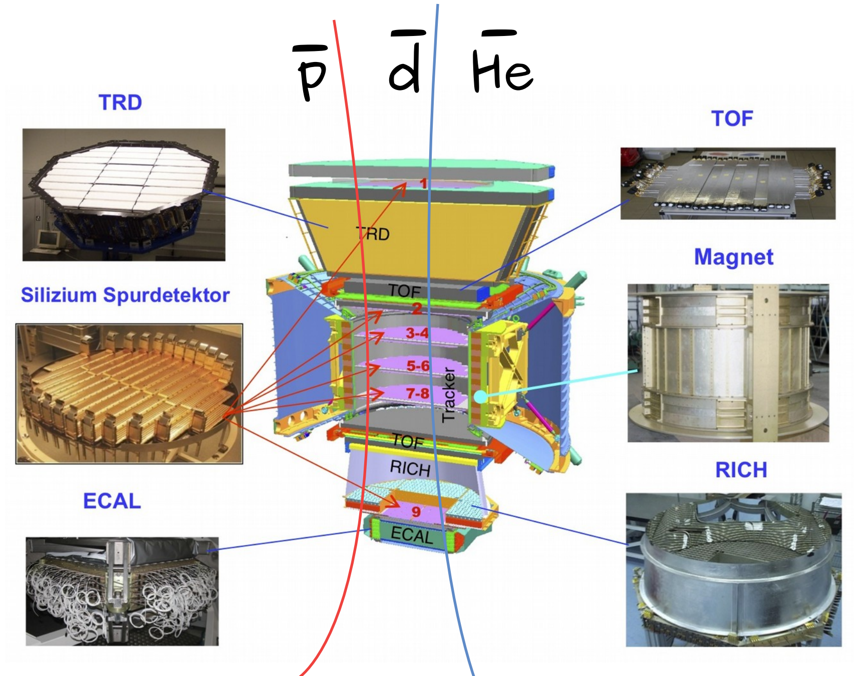
Modeling antinuclei production

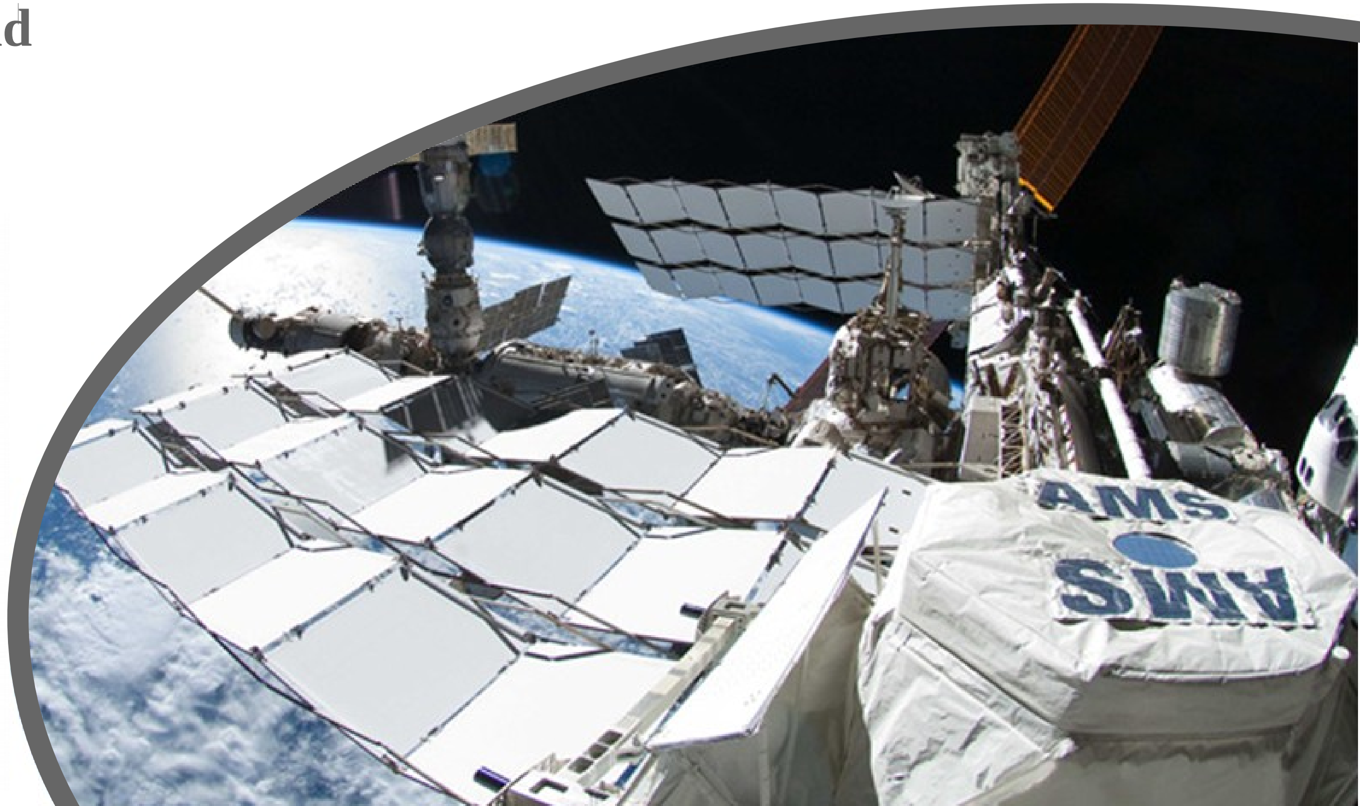
Nucleon collisions experiments and coalescence model.





D. Gomez-Coral et al., PHYS REV D 98, 023012 (2018).





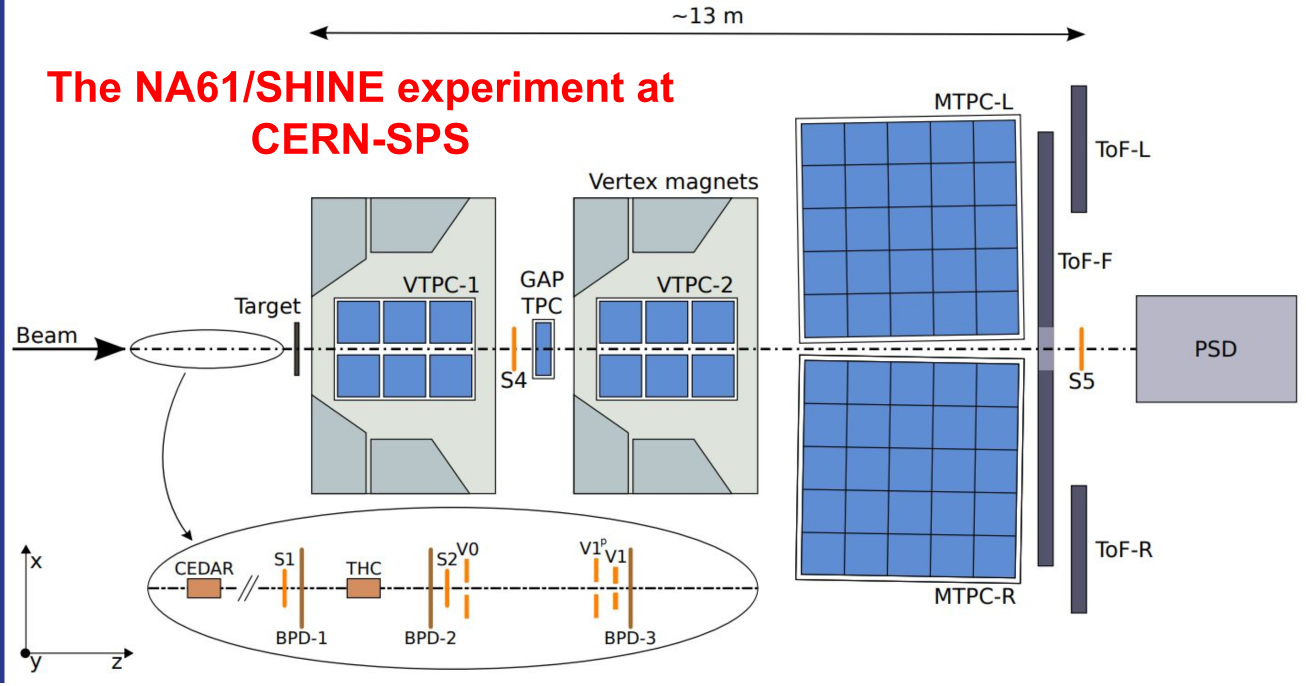
Anirvan Shukla

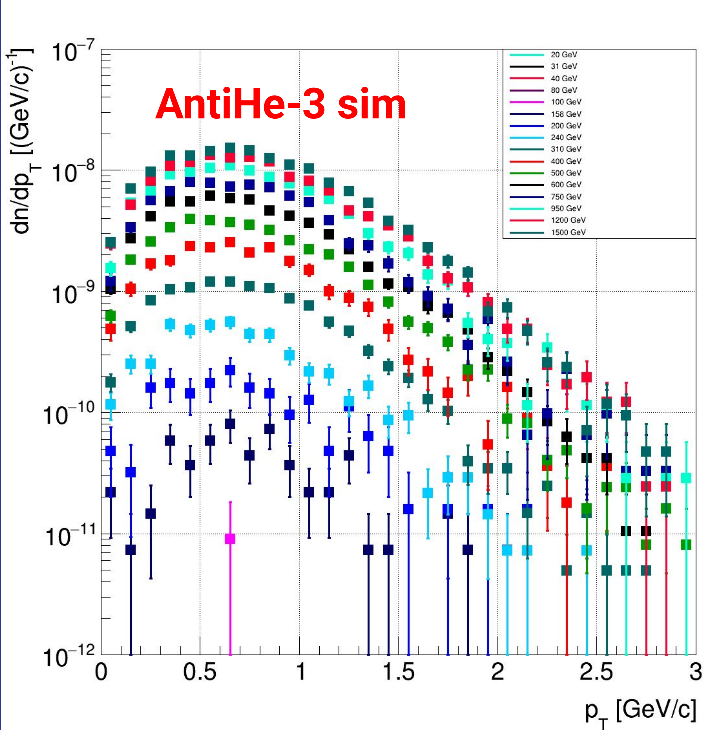
anirvan@hawaii.edu

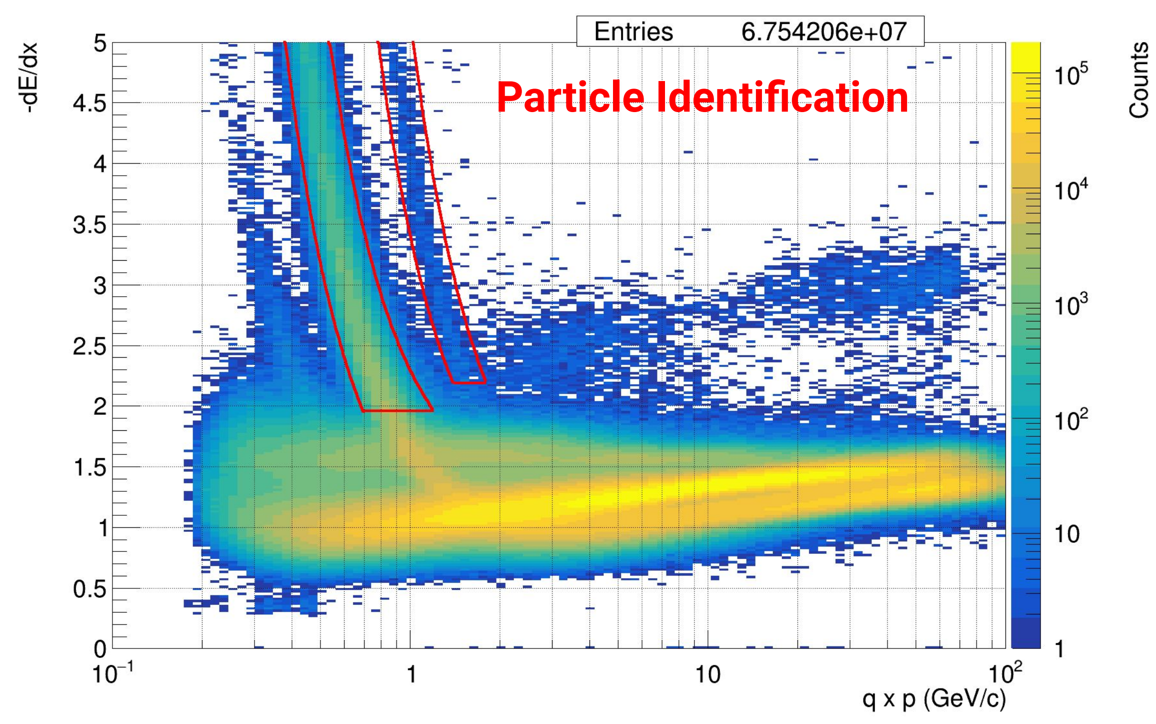
I am a graduate student, and I work with Philip on:

- Understanding the production of light nuclei in p-p collisions at the NA61 experiment at CERN.
- Simulating the production of light antiparticles in the interstellar medium, and their propagation through our galaxy.

The NA61/SHINE experiment at CERN-SPS



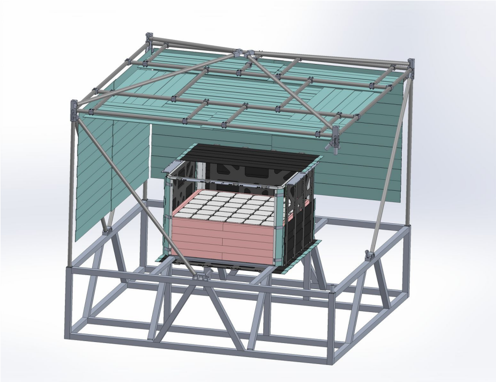




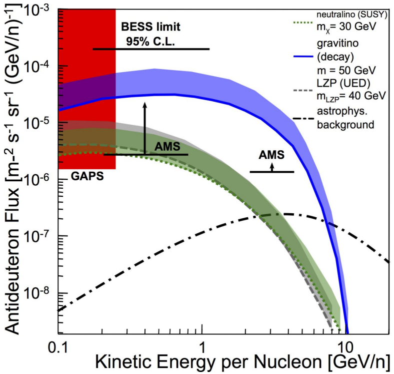
Achim Stoessl

stoessl@hawaii.edu

Postdoctoral researcher, GAPS experiment, Philip von Doetinchem



GAPS experiment



GAPS - *General AntiParticle Spectrometer*
Balloon experiment to study antimatter in cosmic rays

GAPS has two major detectors:
Time of flight and Si(Li) tracker

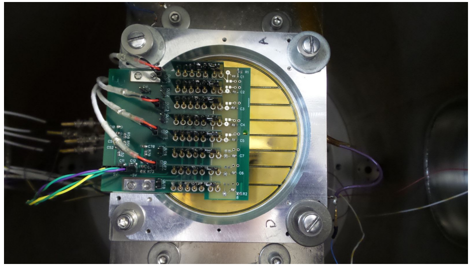
Dark matter models predict hadronic antimatter from annihilations

<u>Personal work focused on:</u>

Software development & coordination

Participation in analysis

Detector testing and calibration

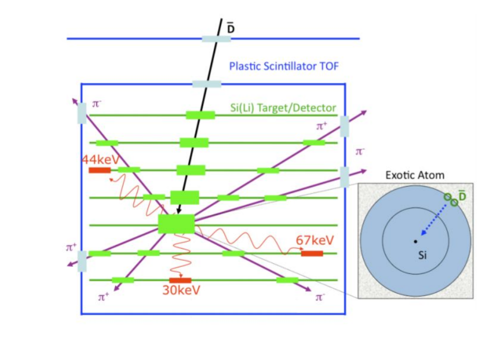


Si(Li) detector

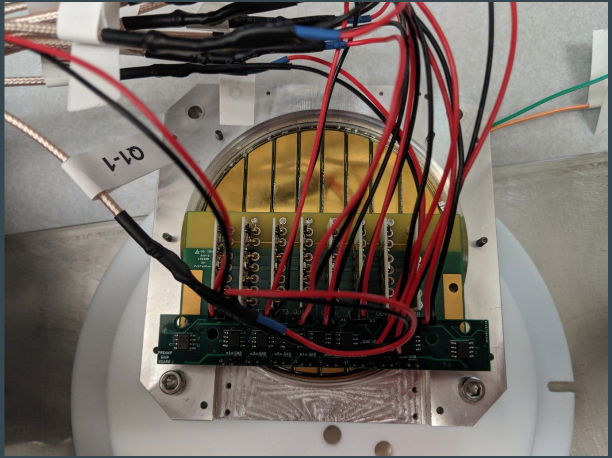
This year's effort: Build up a Si(Li) test/calibration facility at UH

The General Anti-Particle Spectrometer (GAPS)

Cory Gerrity cgerrity@hawaii.edu
Professor Philip von Doetinchem's group

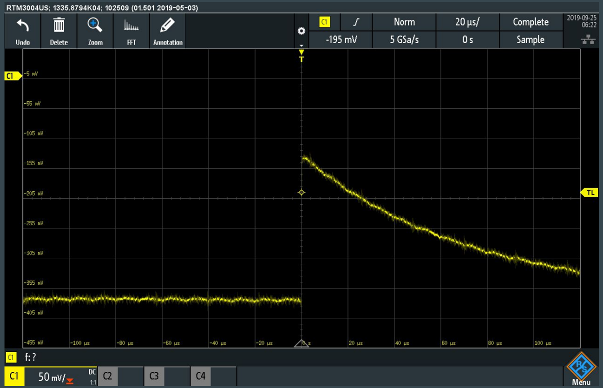


Si(Li)
Wafer
Detector
←



Detector Mounted with Preamp

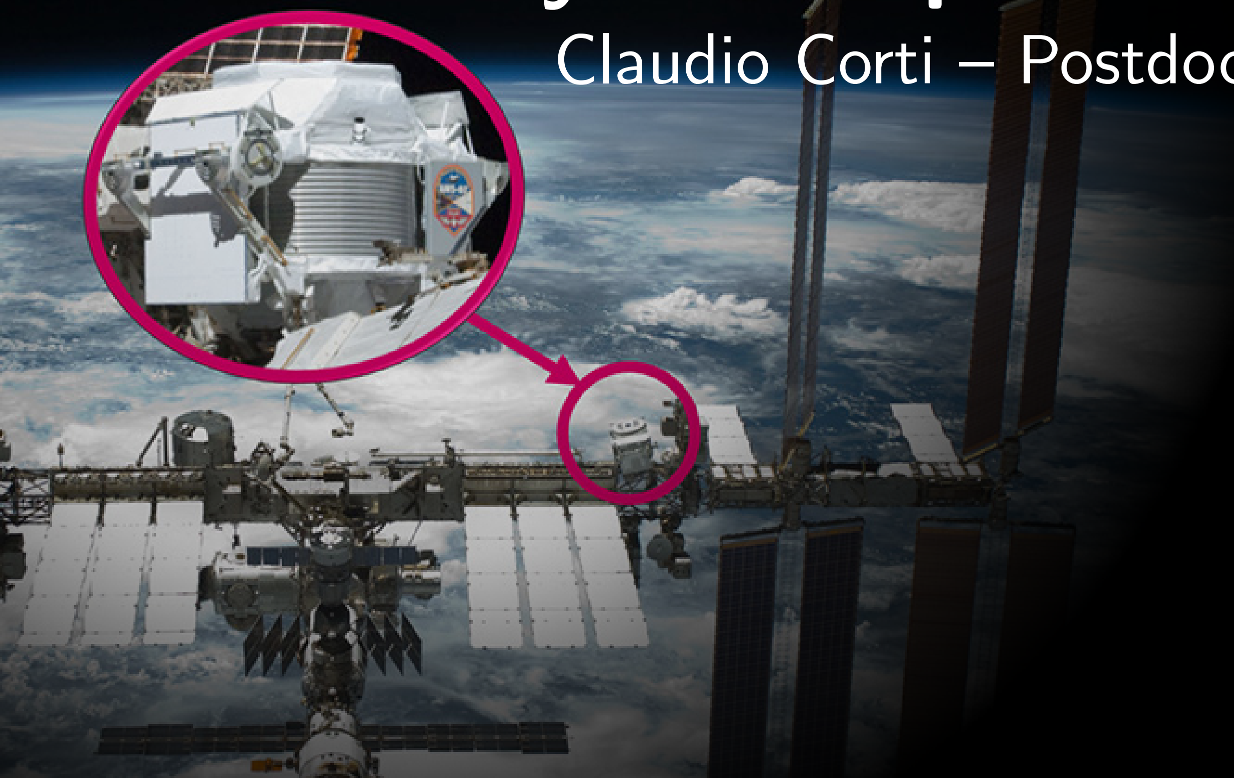
A Lab!

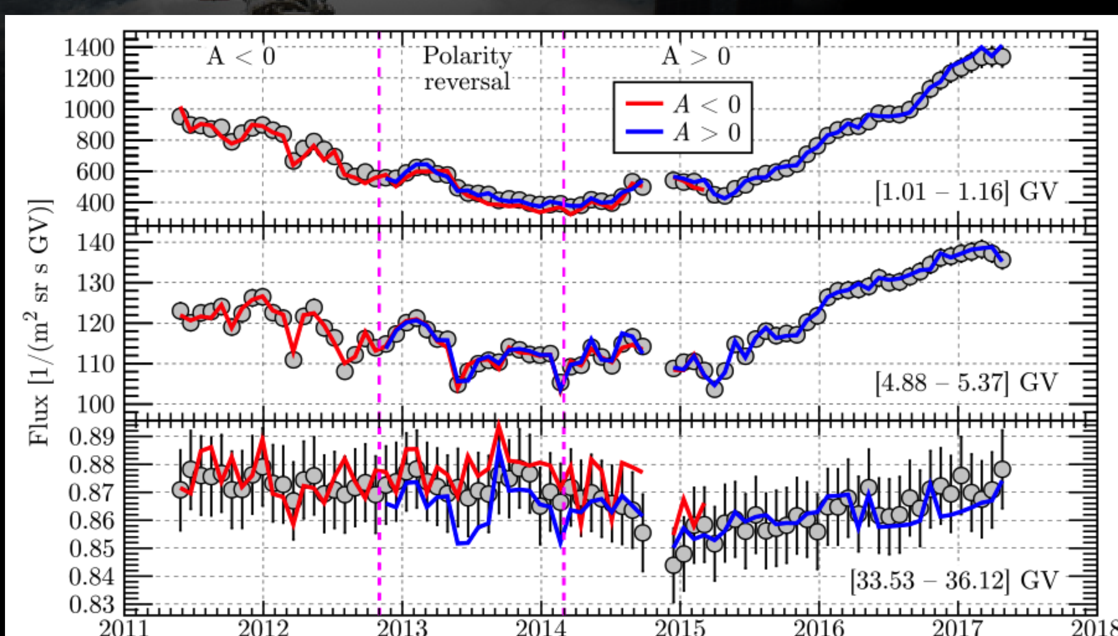


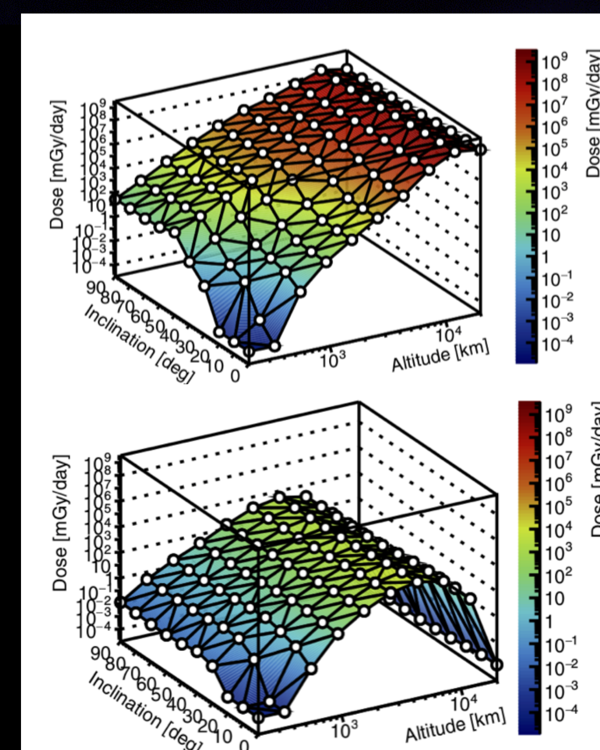
A Muon!

AMS analysis & Space radiation modeling

Claudio Corti – Postdoc (Prof. Bindi's group)







Dr. Bindi's Heliophysics Group

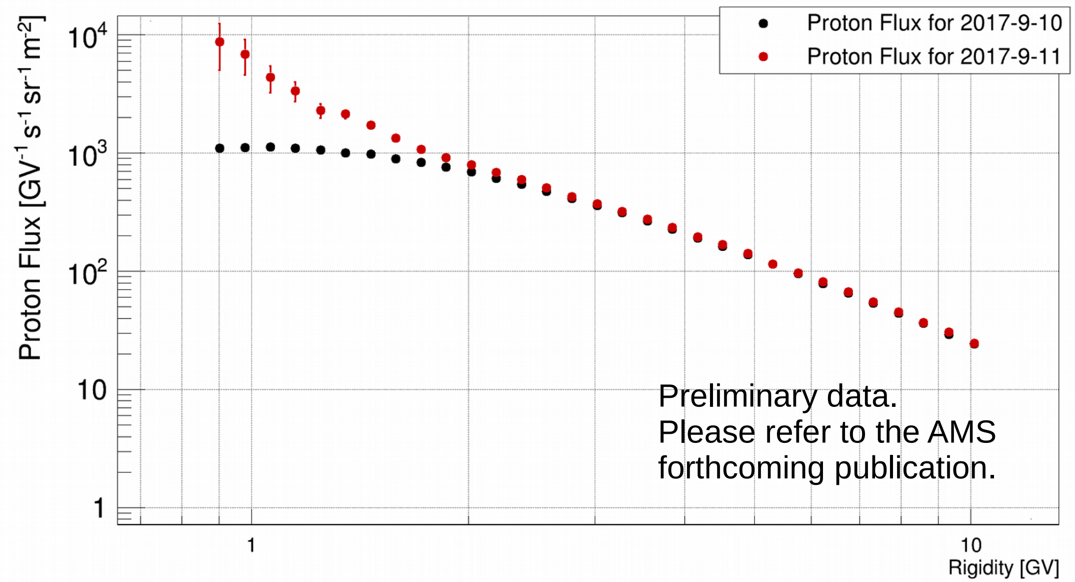
SEPs and CMEs

Christopher Light : lightc@hawaii.edu

Solar Energetic Particle (SEP) event measured by AMS

September 2017

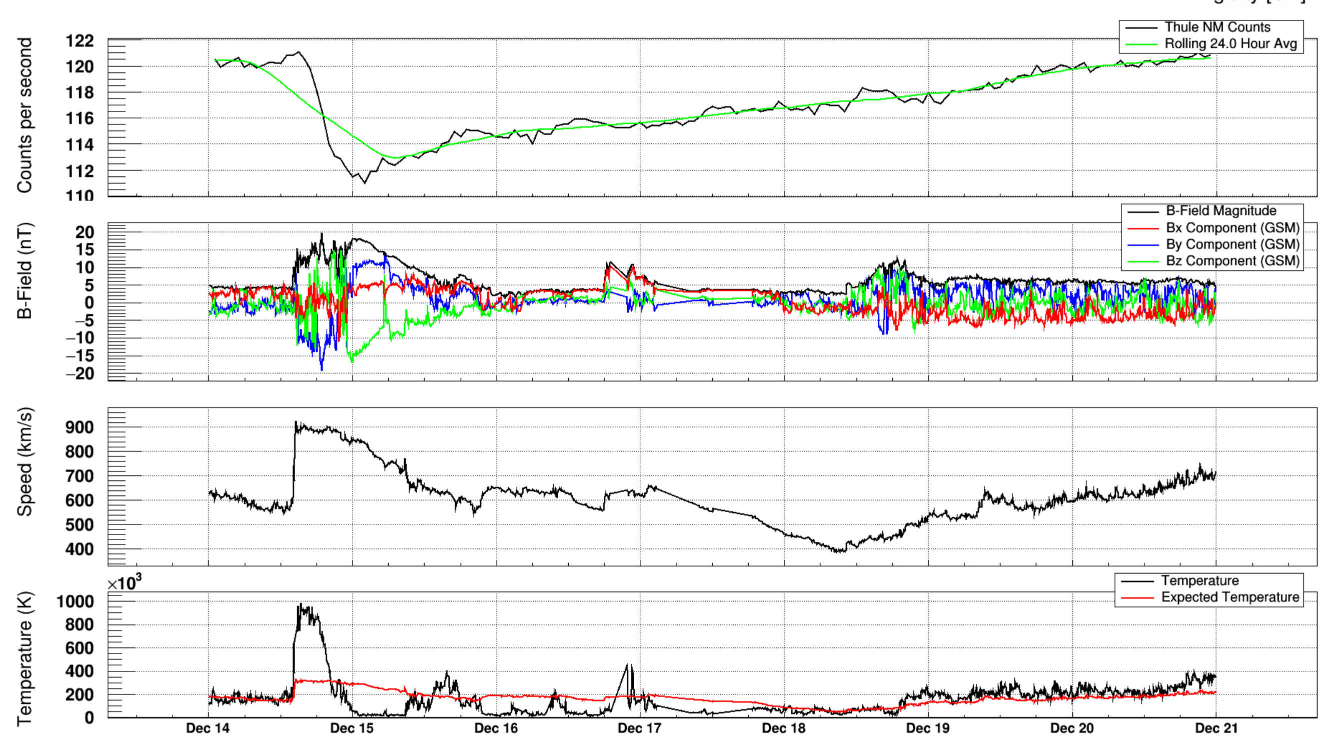
- Most recent Ground Level Enhancement (GLE) SEP event.
- X8.2 Flare at 16:06 on the 10th of Sept.
- Fast (2868 km/s) Halo CME associated with this event.

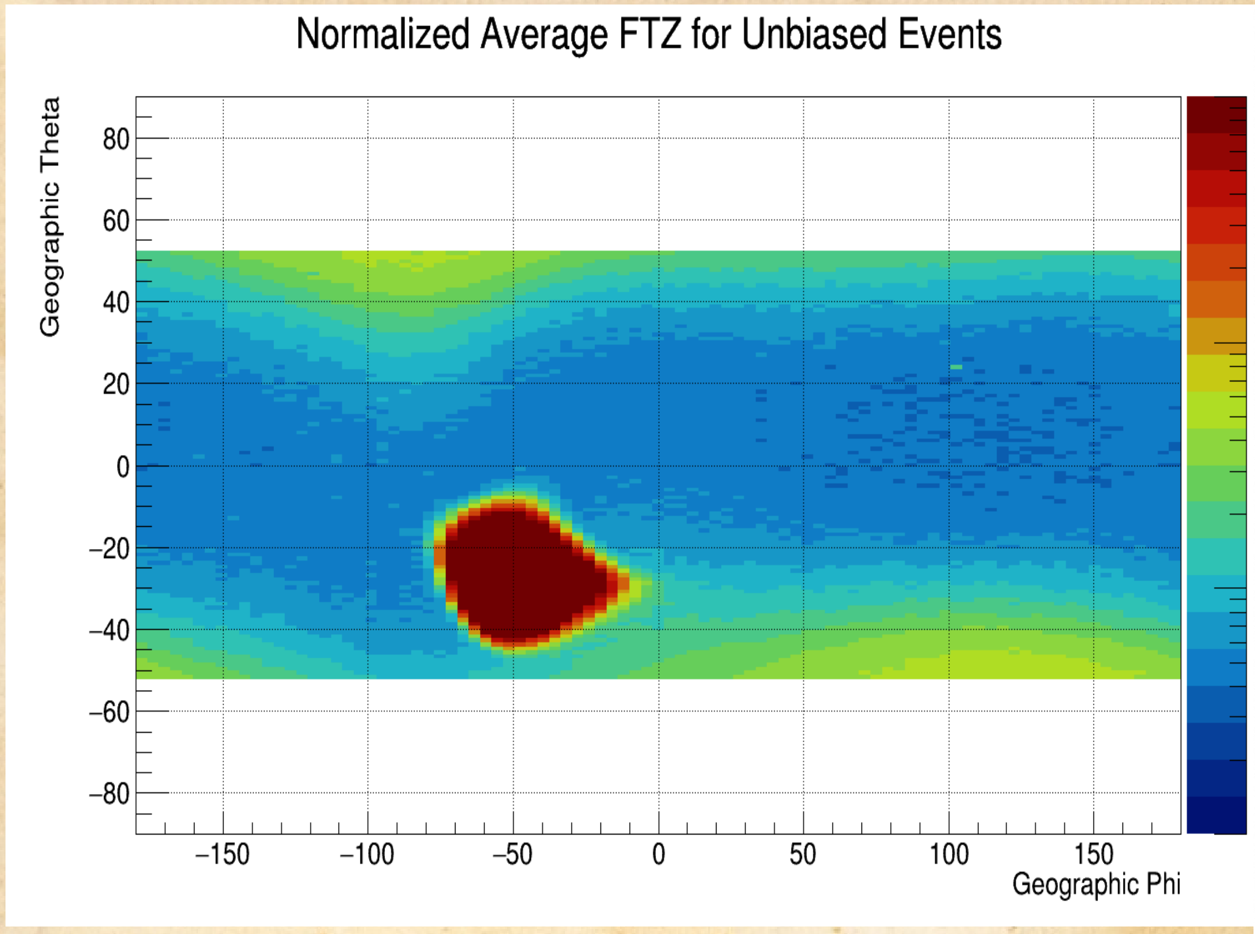


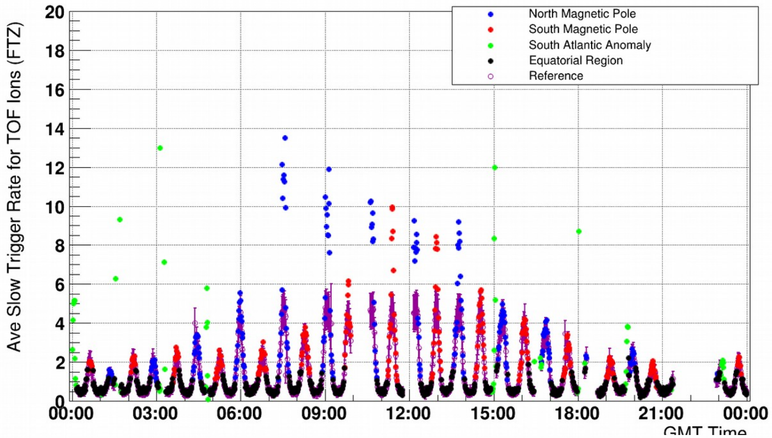
Coronal Mass Ejection (CME) measured by Thule neutron monitor and multiple instruments from NASA satellites

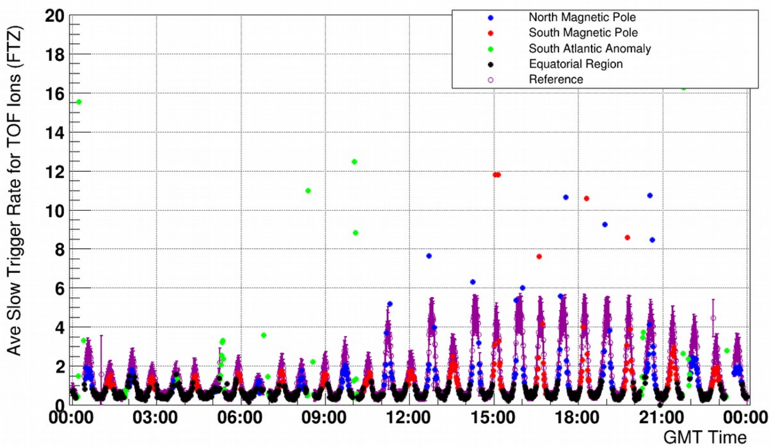
December 2006

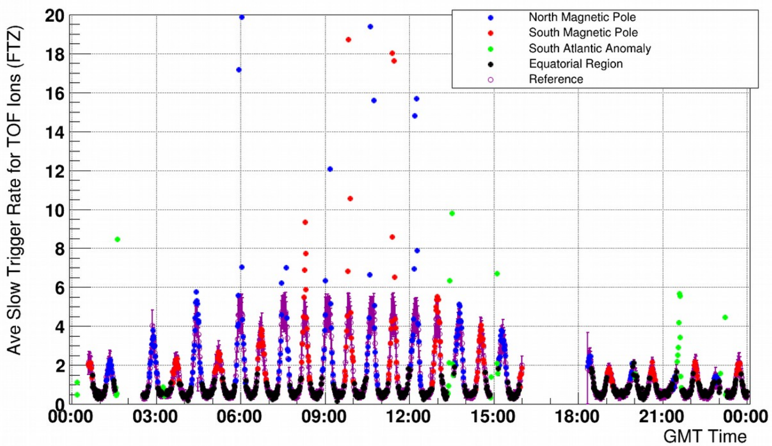
- This CME caused a significant Forbush decrease
- The event is visible here during an otherwise relatively quiet period.







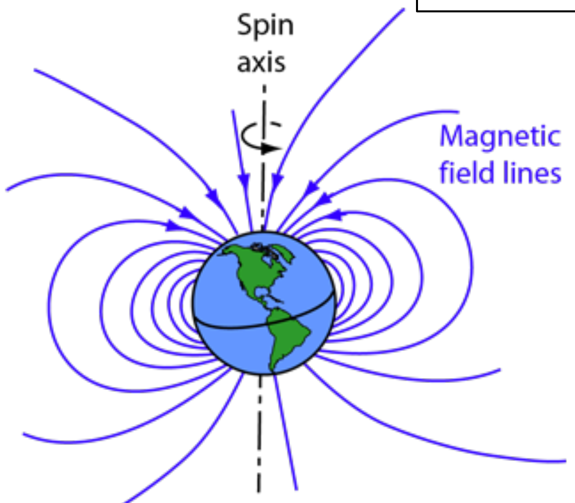




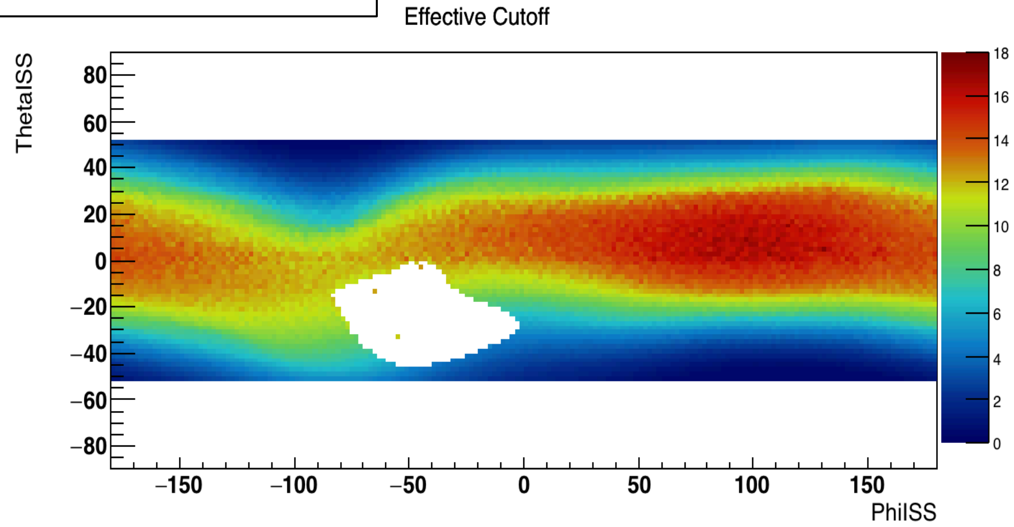
Chris Freeman

Hunting for SEPs

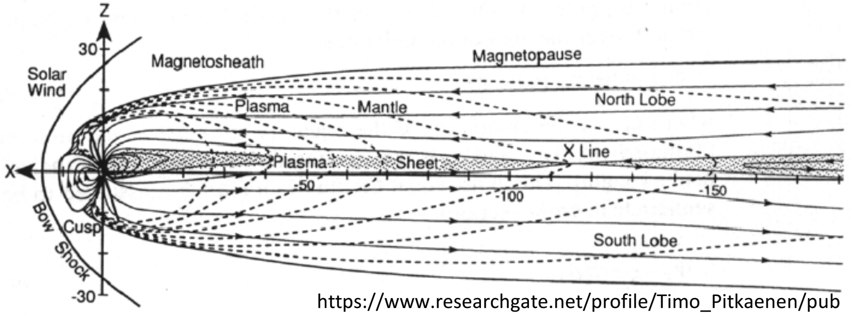
Calculating the Geomagnetic Cutoff



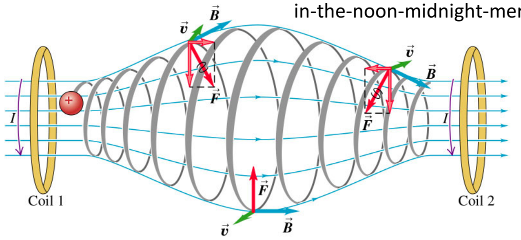
http://hyperphysics.phy-astr.gsu.edu/hbase/magnetic/imgmag/mearth.png



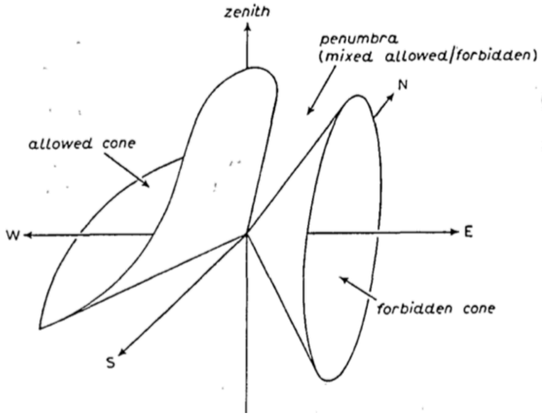
$$\vec{F} = q\left[\vec{E} + \vec{v}\times\vec{B}\right]$$



https://www.researchgate.net/profile/Timo_Pitkaenen/publication/233742440/figure/fig1/AS:298554611519498@1448192375014/Schematic-illustration-of-the-magnetosphere-in-the-noon-midnight-meridional-plane-drawn.png



https://i.stack.imgur.com/y45wc.jpg



D. J. Cooke, J. E. Humble, M. A. Shea, et al. On cosmic-ray cut-off terminology. *Il Nuovo Cimento C*, 14(3):213–234, May 1991. URL: https://doi.org/10.1007/BF02509357, doi:10.1007/BF02509357.

$$\alpha(R) = \begin{cases} 0 & : \text{ if trajectory is forbidden for rigidity } R \\ 1 & : \text{ if trajectory is allowed for } R \end{cases}$$

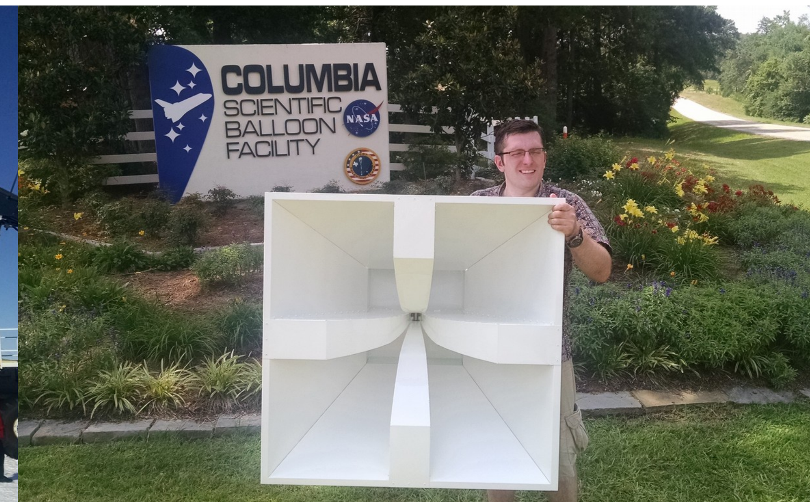
R. Bütikofer. *Cosmic Ray Particle Transport in the Earth's Magnetosphere*, pages 79–94. Springer International Publishing, Cham, 2018. URL: https://doi.org/10.1007/978-3-319-60051-2_5, doi:10.1007/978-3-319-60051-2_5.

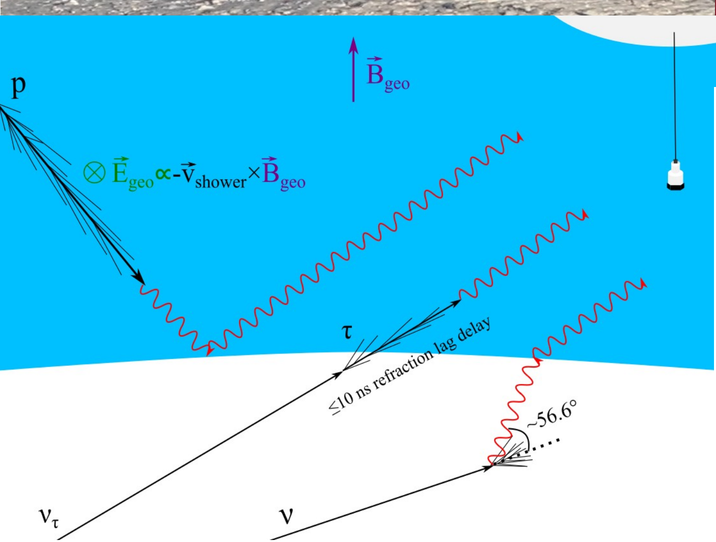
Andrew Kuhlman
ackuhlma@hawaii.edu

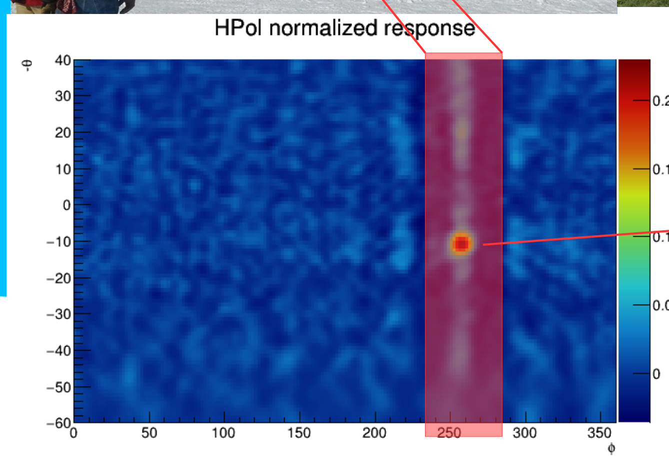
The ANtarctic Impulsive Transient Antenna (ANITA)

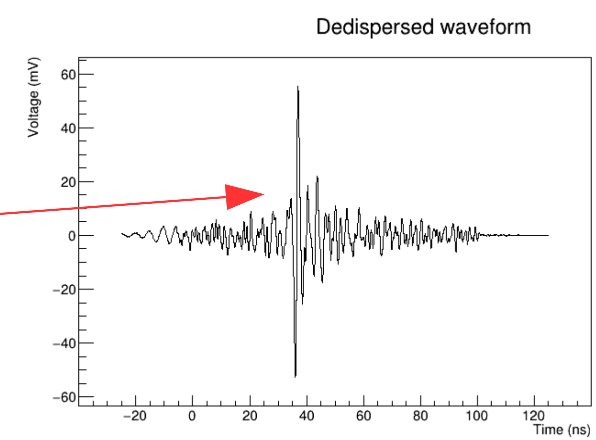
Presented for the ANITA Collaboration
by John Russell (jwruss@hawaii.edu)
P.I. Peter Gorham

A balloon-borne antenna array which floats ~37 km above the Antarctic ice sheet, ANITA is designed to detect radio pulses produced either from within the ice through the Askaryan effect with UHE (10^{18}-10^{23} eV) neutrinos, or in the atmosphere by cosmic rays and then reflected off the ice.





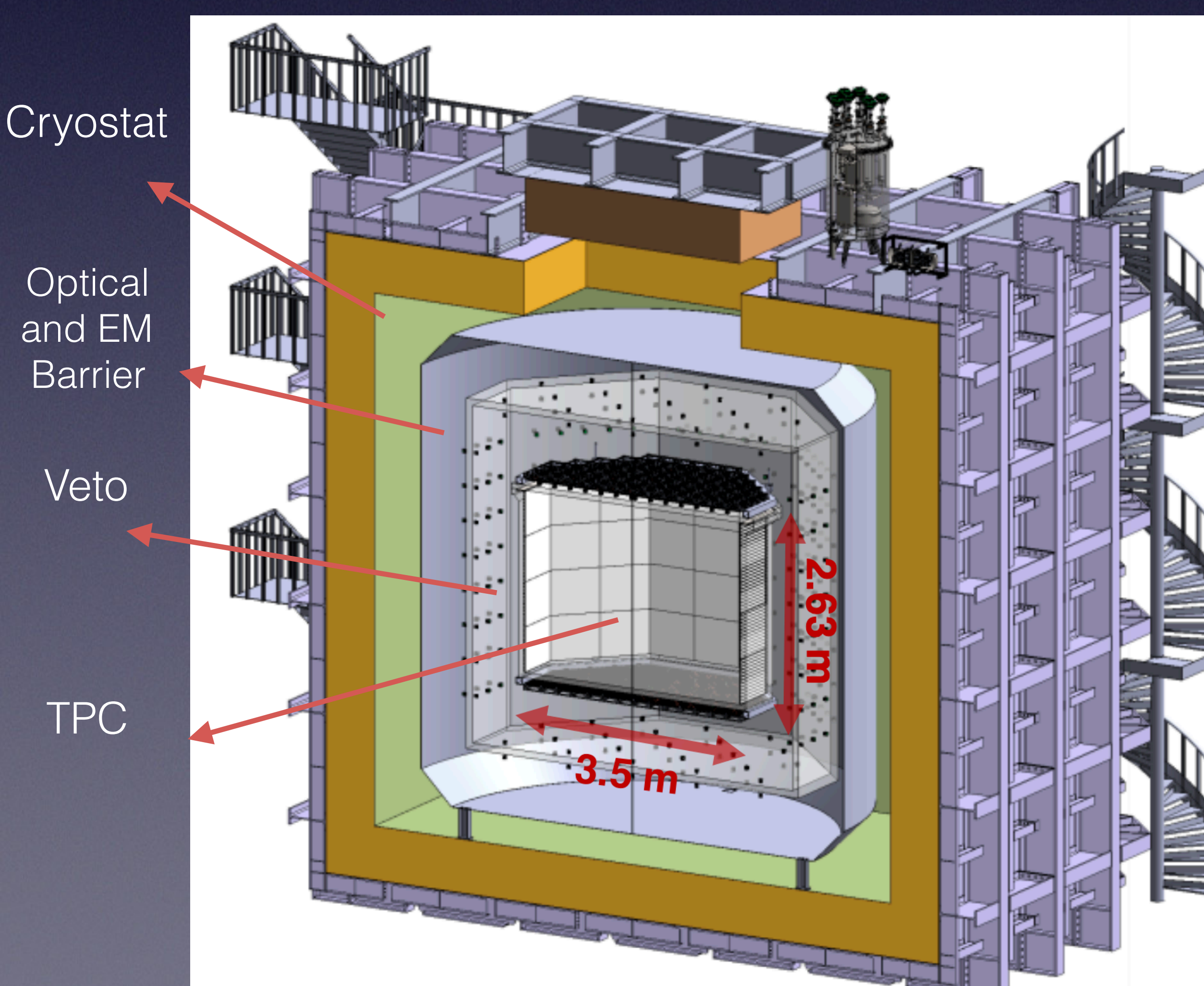


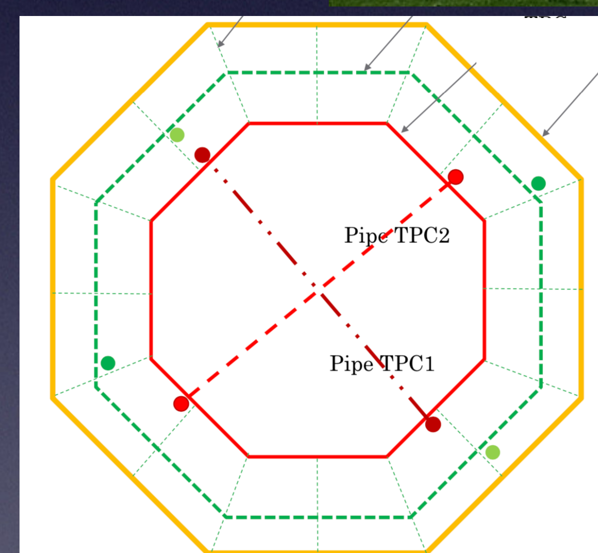


DarkSide 20k

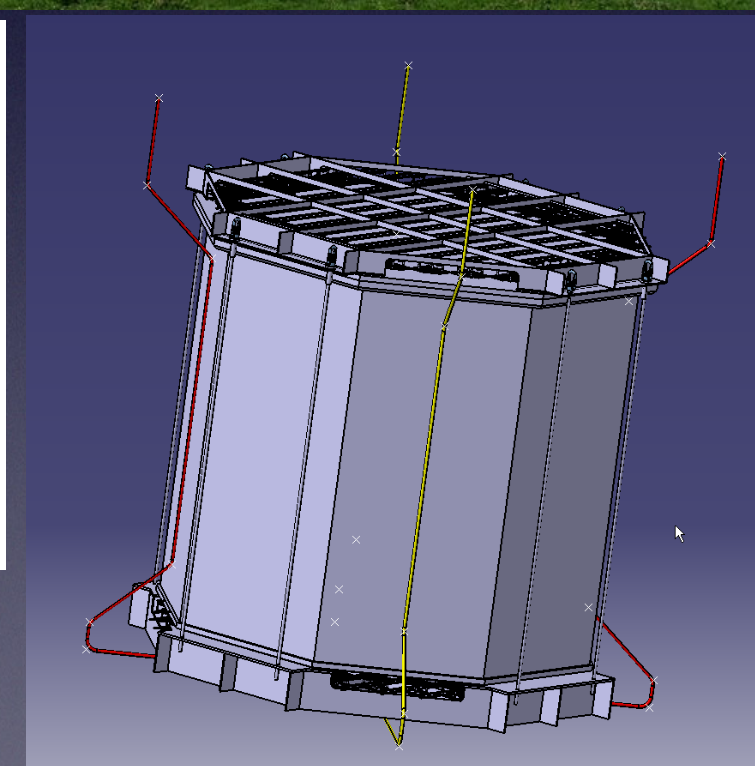
Victor Goicoechea Casanueva - victorgc@hawaii.edu

- Latest experiment of the DarkSide Project @ Gran Sasso, Italy
- Two phase Time Projection Chamber filled with liquid Argon for dark matter (WIMP) direct detection
- 20 ton of fiducial volume, projected sensibility in the order of 10^{-47} cm^2 for WIMP mass of 1TeV/c^2
- Argon extracted from underground (Urania) and depleted for higher purity (Aria)
- Background free





Top view

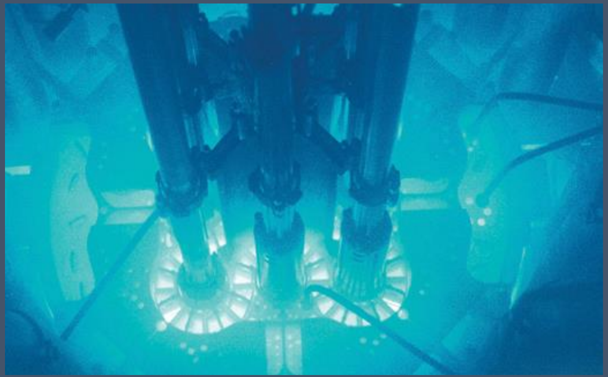


Lateral view

Precision Reactor Oscillation and Spectrum Experiment (PROSPECT)

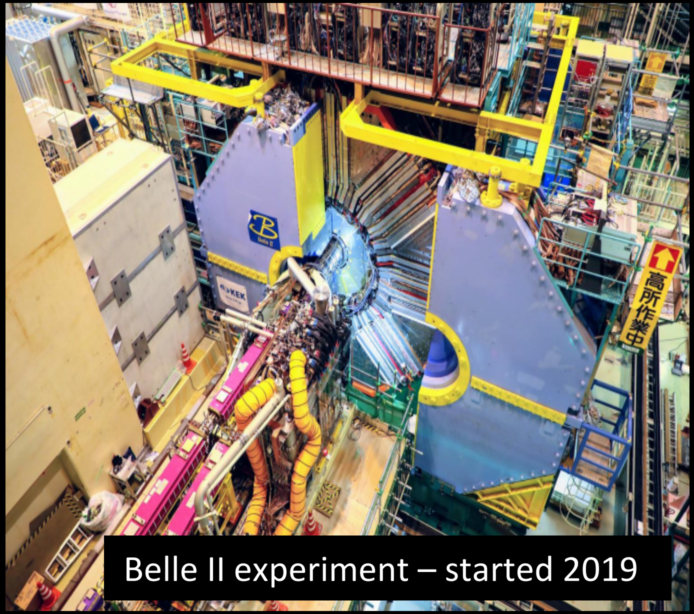
- PROSPECT is a Neutrino Experiment at Oak Ridge National Laboratory (ORNL)
- Detector is a 11x14 grid of Lithium-loaded Liquid Scintillators
- PROSPECT seeks to explain the anomaly between predicted models of reactor neutrino flux and observations
- Maybe Sterile Neutrinos?
- I'm working on calibration measurements and modelling detector efficiency

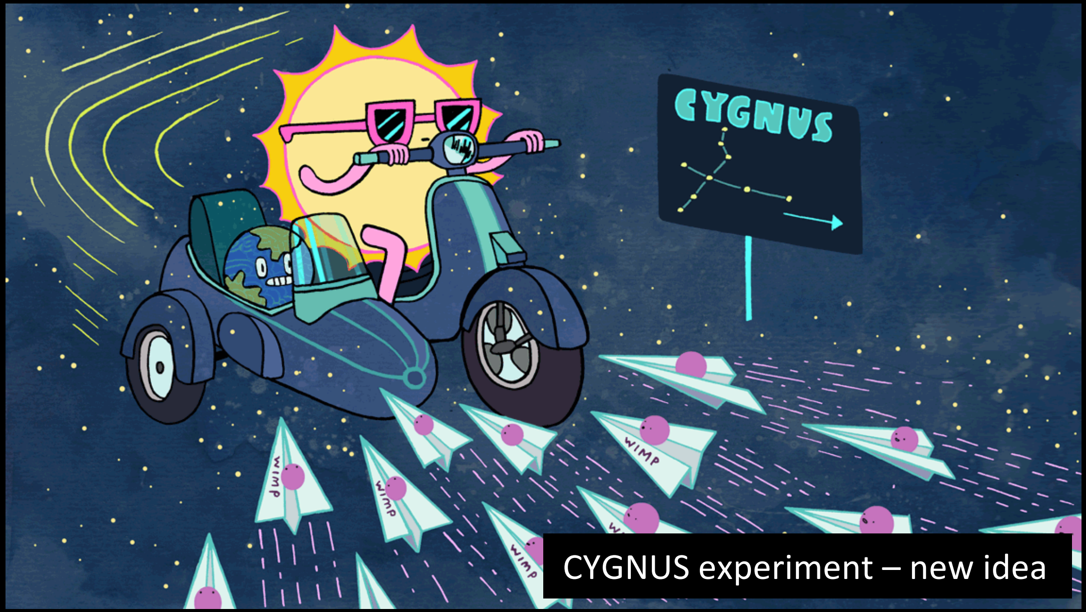
PROSPECT



Can we produce dark matter in the lab?

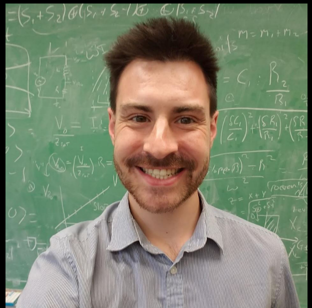
Can we detect the dark matter wind?

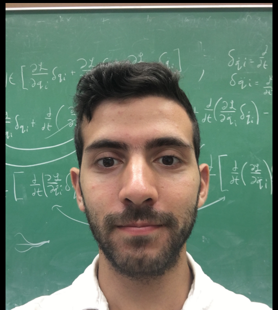




Undergraduates wanted!

Contact Sven Vahsen, sevahsen@hawaii.edu

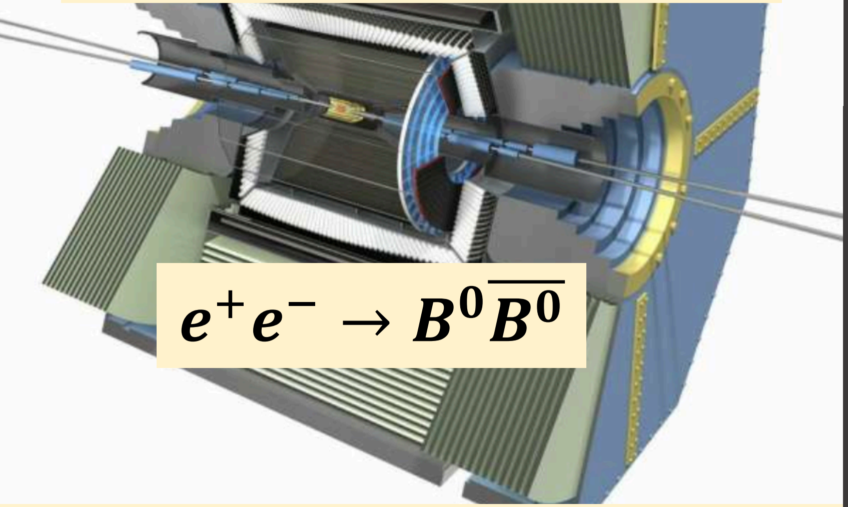




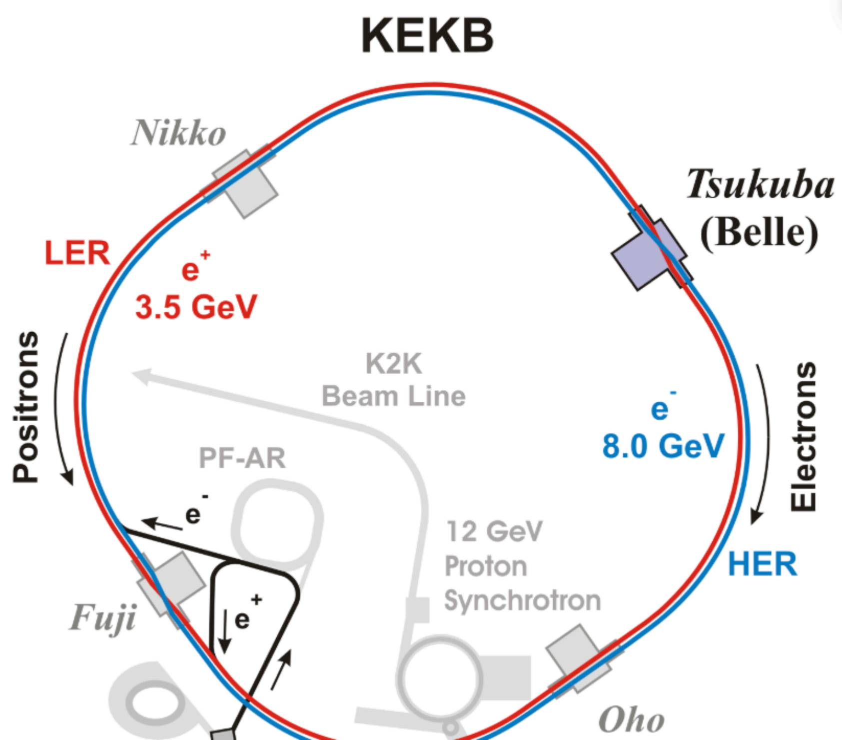
Testing Quantum Mechanics at Belle

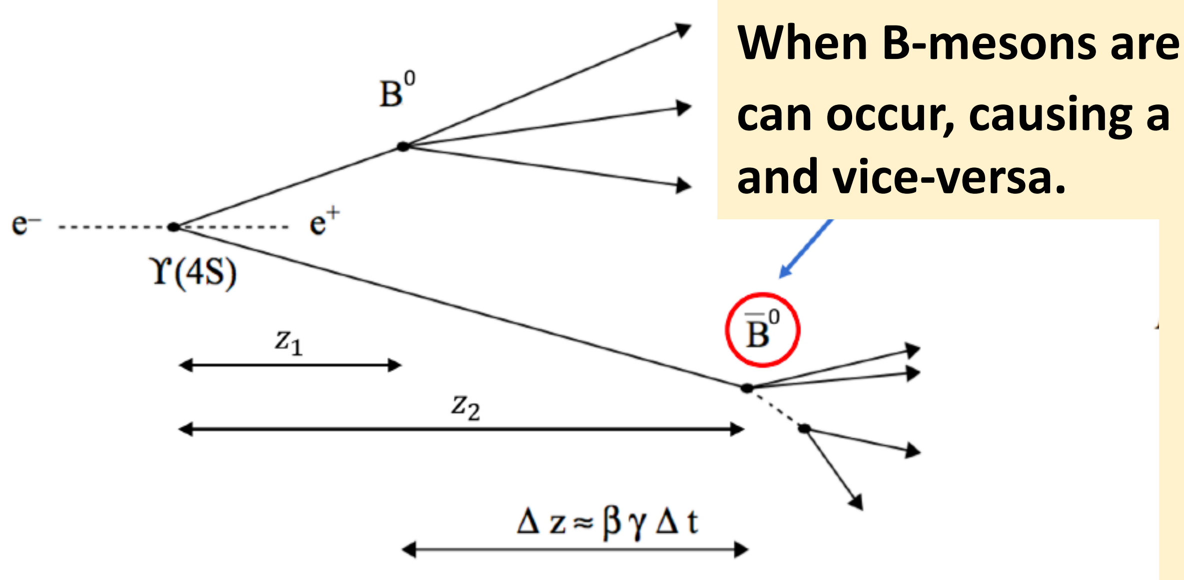
Jeff Schueler - Email *jschuel@hawaii.edu*
PI: Sven Vahsen - Email *sevahsen@hawaii.edu*

Beams collide and produce B-meson pairs:



$$e^+e^- \rightarrow B^0\overline{B^0}$$

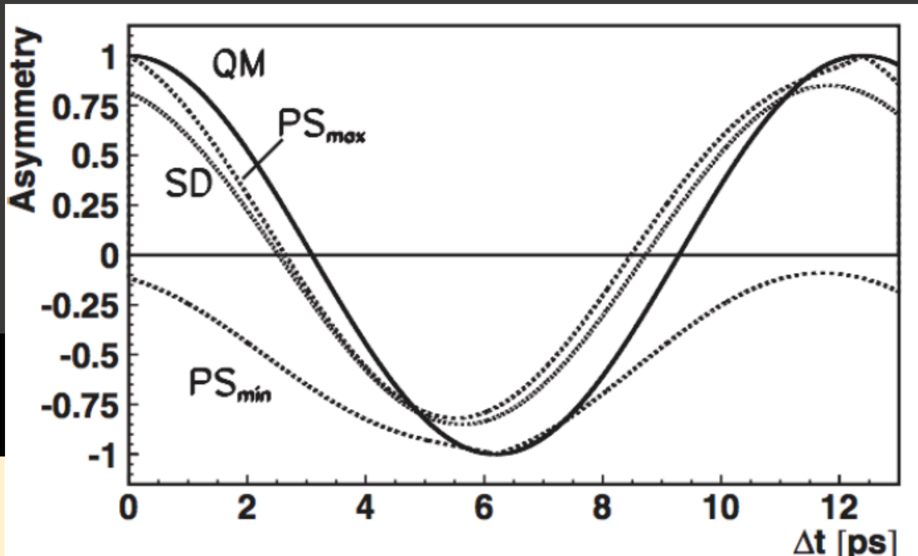


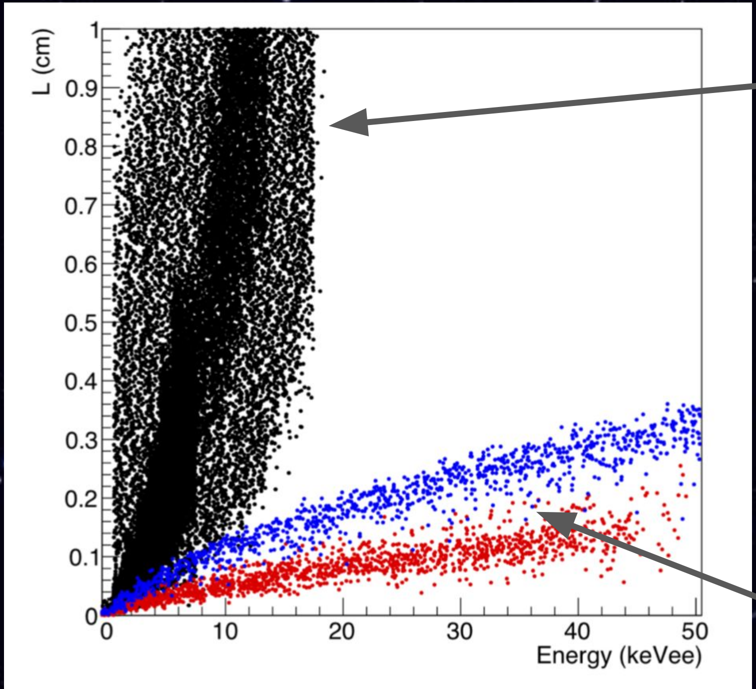


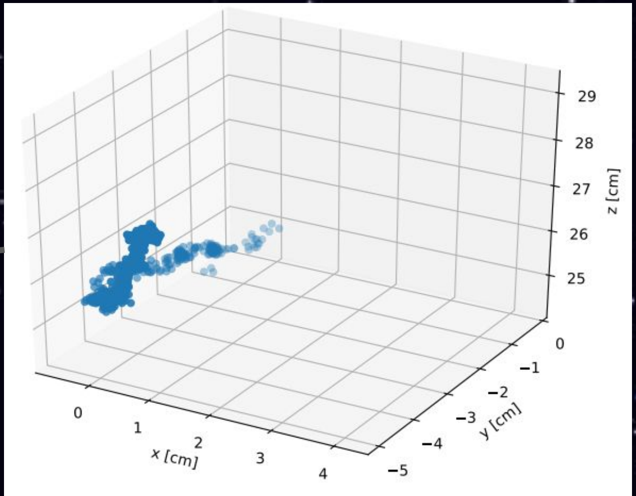
When B-mesons are produced, *mixing* can occur, causing a B^0 to turn into a $\overline{B^0}$ and vice-versa.

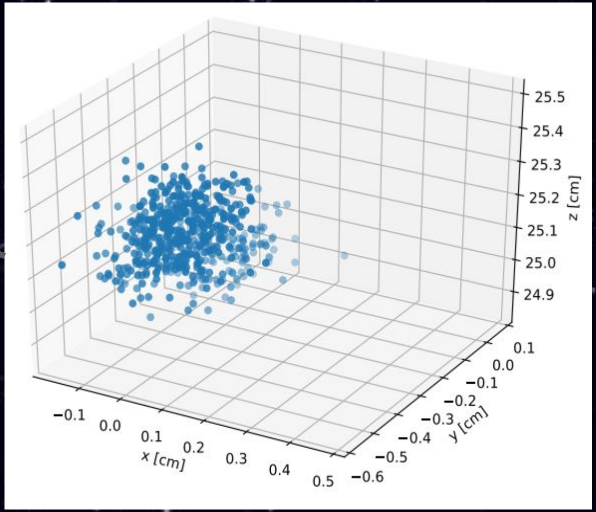
Quantum mechanics predicts that the *flavor asymmetry* due to mixing depends on $\cos(\Delta m_d \Delta t)$

WE CAN TEST THIS!









Majd Ghrear
majd@hawaii.edu

COLLEGE OF SOCIAL SCIENCES
MATSUNAGA INSTITUTE FOR PEACE
University of Hawai'i at Mānoa™

Beginning and End of the Bomb Exhibition

The role of nuclear weapons since 1945 and reducing the threat in the future.

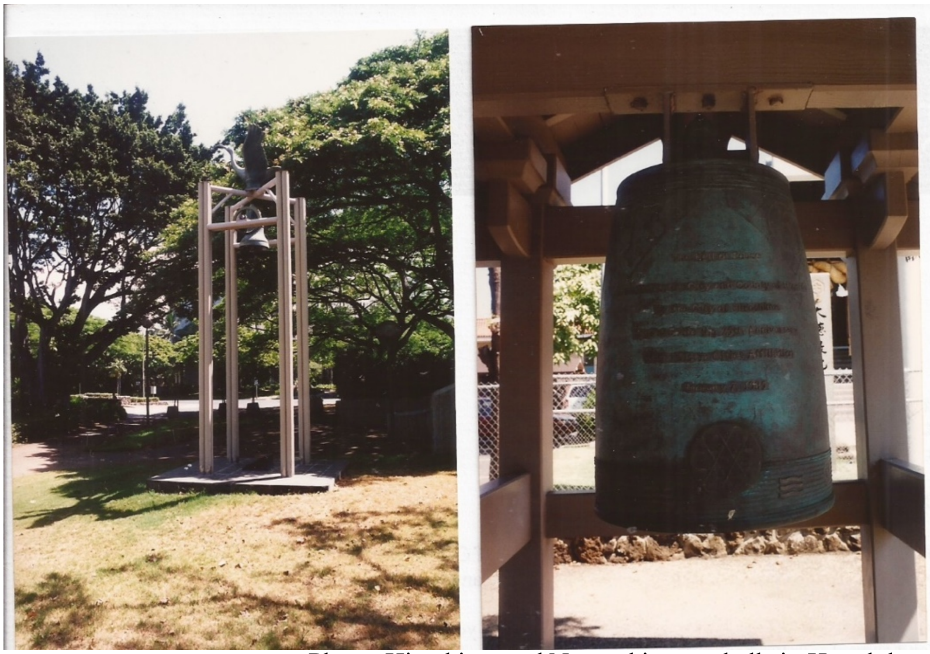


Photo: Hiroshima and Nagasaki peace bells in Honolulu.

SPRING 2020 EXHIBITION

Monday, March 2 - Thursday, April 30
UH Mānoa, Hamilton Library, Bridge Gallery

FALL 2020 PARTIAL EXHIBITION

Monday, August 3 - Friday, September 25
UH Mānoa, Hamilton Library, Elevator Gallery

EXHIBITION HOURS

Monday - Thursday: 8 AM - 10 PM
Friday: 8 AM - 6 PM
Saturday: 9 AM - 5 PM
Sunday: 12 PM - 10 PM
Closed on Holidays

EXHIBIT STATEMENT

The false alarm in Hawaii of an incoming missile on 13 January 2018 is a reminder of the threat posed by nuclear weapons. It is also a reminder that we all need to become better informed about the origins, history, and possible solutions to this existential threat. The goal of the "Beginning and End of the Bomb" exhibit is to illustrate the role of nuclear weapons since 1945 and to stimulate critical thinking about reducing the threat in the future.

This year is the 75th anniversary of the development and use of nuclear weapons during World War II. The exhibit originated in 1995 as "Fifty Years with the Bomb" to mark the 50th anniversary of the development and use of nuclear weapons during World War II. It included sections on the first nuclear test in New Mexico in July 1945, the atomic bombings of Hiroshima and Nagasaki in August 1945, newspaper reports near war's end, and nuclear tests on the U.S. mainland, in the Pacific, and near Hawaii. The final section looked to the next fifty years and presented different perspectives. The current exhibit includes most of these materials plus some new features. In particular, it includes an interactive simulation of the effects of a nuclear explosion on Oahu. The partial exhibit in Fall 2020 will feature only newspaper front pages from August 1945 and documents highlighting recent developments.

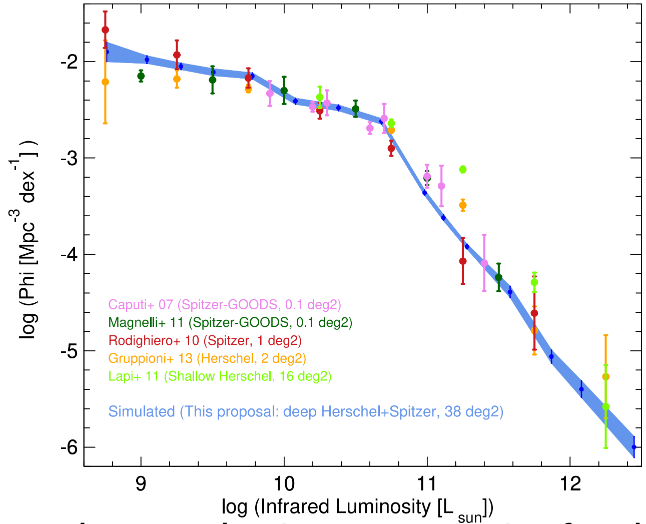
While the "beginning" of the bomb is clear, the "end" is not. Efforts to bring about nuclear disarmament continue but so do modernizations of existing arsenals. Many important questions remain. Can this threat be ended? Will it continue indefinitely? Will nuclear weapons be used by countries or terrorists? What can people in Hawaii do? We hope this exhibit will be the catalyst for informed dialogue on these questions.

For more information, contact Matsunaga Institute for Peace at uhip@hawaii.edu.

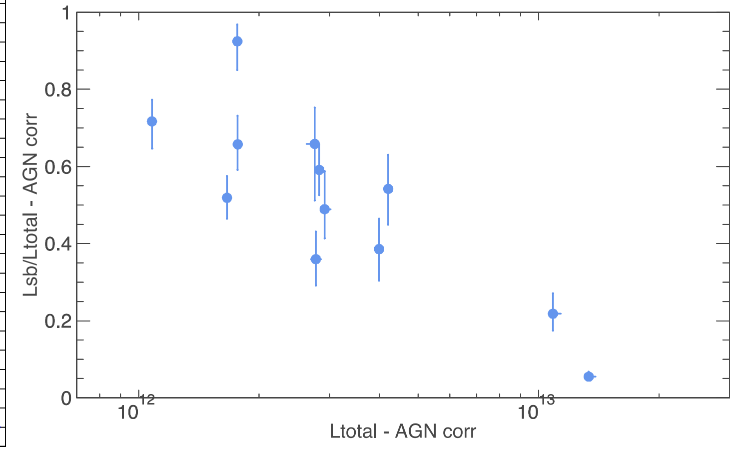
Duncan Farrah

dfarrah@Hawaii.edu

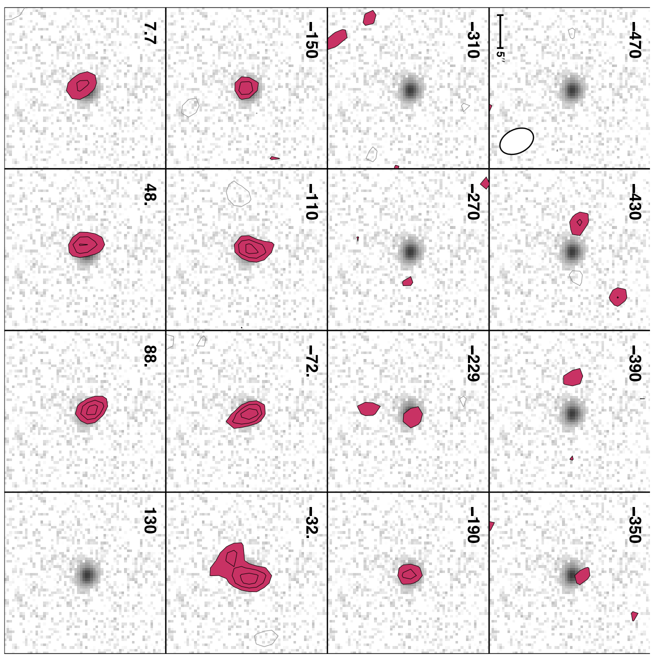
I work on observations of stellar and black hole mass assembly over 0<z<6:



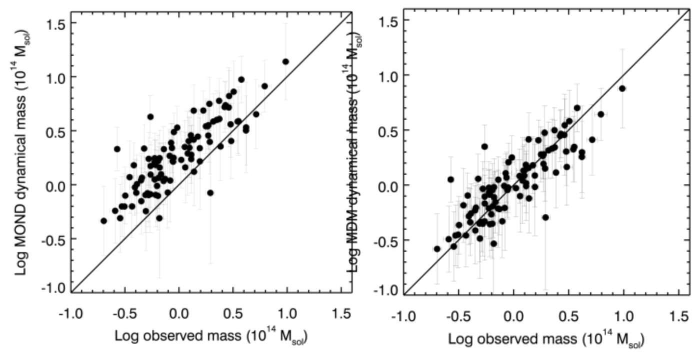
z>0.5 obscured AGN LFs – NSF funded!



The SEDs of local ULIRGs



BAL quasars and starburst quenching



Obs. Tests of alternative DM models

Community Activities

- **Member: JWST Users Committee** – please come rant to me about anything JWST related
- **Co-Chair: FIR Science Interest Group** – activities that promote the FIR community in the USA and beyond

Symmetries imply properties of different objects/various states are related.

We understand some symmetries (isospin, C or P as accidental symmetries of some interactions) and others (Lorentz and gauge invariance) as fundamental.

- ⋆ Local symmetries lead to dynamics (gravity, gauge interactions).

However, all known symmetries relate bosons to bosons and fermions to fermions.

In the early 1970's a novel symmetry relating bosons to fermions was discovered (supersymmetry, or SUSY)....a new level of synthesis! Unfortunately, the known bosons and fermions are not related by SUSY.

Either (softly broken) SUSY is not realized, or there are as yet undiscovered SUSY partners of all known particles, with predicted spins and gauge interactions, but unknown masses. None have been found at the LHC.

The discovery of the Higgs boson accentuates the need for SUSY. I believe SUSY remains the best answer to key theoretical issues, and is phenomenologically perfectly viable. DoE, and some colleagues, do not agree.

- ⋆ Discovery of SUSY would be a paradigm shift in fundamental physics.

Quantum computing

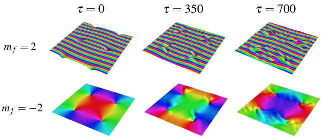
Lattice models of classical and quantum field theories

Research goals:

1. New quantum algorithms for gauge field theories developed for future scalable Feynman quantum computers and (with approximations) implemented on supercomputers today
2. Quantum entanglement in nonlinear many-fermion systems
3. Strongly-correlated fermionic matter with applications related to quantum simulation
   - topological quantum computing
   - ultracold quantum gases (spinor Bose-Einstein condensates and Fermi condensates)
   - non-Abelian superfluidity and superconductivity in Fermi condensates
   - quark condensates in quantum chromodynamics
   - non-Abelian Higgs model

Spin-2 Bose-Einstein condensate:

- Non-Abelian BEC superfluidity
- Spin-2 Fermi condensate model (mitigate BCH catastrophe by splitting kinetic and interaction operators into distinct subgroups)
- Energy functional of a *d*-wave superconductor (e.g. planar YBCO high-T_c superconductor)
- Scattering of quantum vortices in a spin-2 superfluid:



Recent group paper:
arXiv:1907:12834 [cond-mat.quant-gas]

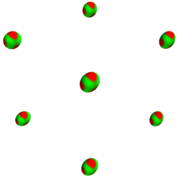
Superconductive quantum gravity:

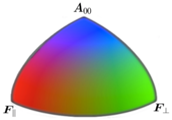
- Approach: Fermionic gauge field theory that is dual to the Einstein-Hilbert Lagrangian can serve as a quantum computational model of quantum gravity
- Lagrangian: $\mathcal{L} = \frac{1}{2}\sqrt{-g}\nabla^{\mu}\mathrm{Tr}[\phi_\circ g^{\alpha\beta}]\nabla_{\mu}\mathrm{Tr}[\phi_\circ g^{\gamma\delta}] + \sqrt{-g}R\,\mathrm{Tr}[\phi_\circ g^{\alpha\beta}]$
  $\mathcal{L}^{\mathrm{dual}} = \sqrt{-g}\left[i\bar{\varepsilon}\hat{g}^{\mu\nu}\gamma_\mu\left(\partial_\nu + i\mathfrak{e}A_\nu{}^{a}\hat{\Upsilon}^{(1)}_a\right)\varepsilon - \frac{1}{4}F_{\mu\nu a}F^{\mu\nu a}\left(\mathrm{Tr}[\phi_\circ g^{\alpha\beta}] - 2\phi_\circ\right)\right]$
- Estimate of the Higgs boson mass in arXiv:1907.13427 [gr-qc]

Quantum computing

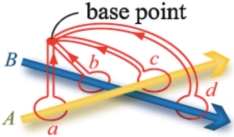
Simulating spin-2 BECs

$$i\,\frac{\partial \psi_m(r)}{\partial t} = \left(-\nabla^2 + g_0\left|\psi(r)\right|^2\right)\psi_m(r) + g_1\hat{\boldsymbol{F}}\cdot\boldsymbol{f}\,\psi_m(r) + g_2\left|A_{00}\right|^2\psi^*_{-m}(r),\ \text{for } m = -2, -1, 0, 1, 2$$





(a)

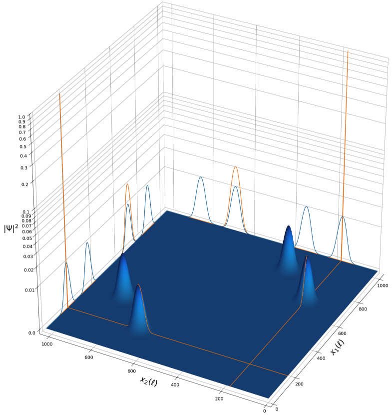


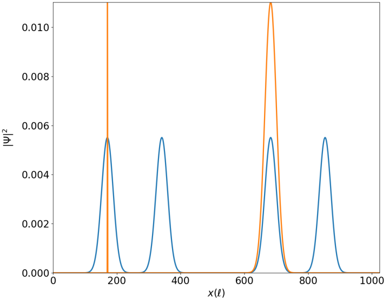
(b)

(a) The colormap used for the 3D quantum simulations
(b) Combinations of the paths a, b, c and d taken around the two linear quantum vortices A and B correspond to topological charges AB, BA, AB^{-1}, $A^{-1}B$, $B^{-1}A$, $A^{-1}B^{-1}$ and $B^{-1}A^{-1}$

Quantum computing

Probing two-fermion Schrödinger dynamics with a quantum lattice gas





$$p = Tr(\hat{\rho}_r{}^2) = \sum_{x_i=0}^{L-1} \psi(x_1, x_2)\psi^*(x_3, x_2)\psi(x_3, x_4)\psi^*(x_1, x_4)$$

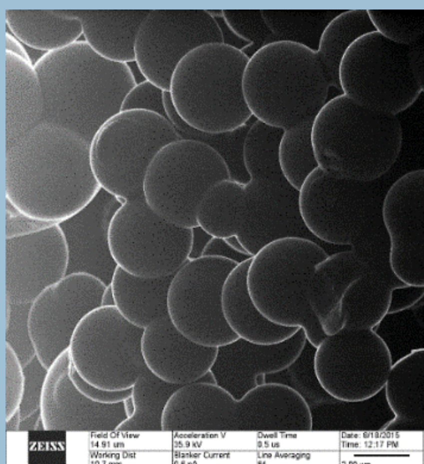
$$\mathcal{E} = 1 - 2p$$

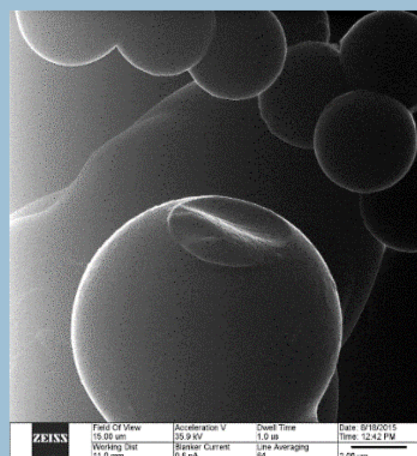
Nanophysics Klaus Sattler sattler@hawaii.edu

Production of novel Metastable Nanomaterials

Ultralight Carbon Nanofoam

Colloids of Carbon Micropearls





- **Density: ~5% of graphite**
- **Composed of Micropearls**
- **2D-3D Graphene Network**
- **Highly Porous on Nanoscale**
- **Very High Storage Capacity**
- **Fluid Dynamics in Nanochannels**
- **Colloidal Pearl Stability (by DLS)**

Methods used: SEM, TEM, HIM, XPS, Raman, FTIR, DLS

Collaborations with Japan, Germany and Switzerland. We are part of the *UH Materials Science Consortium*.

Many applications: NASA space missions, supercapacitors, hydrogen storage, cancer cell labeling, drug delivery to brain tumor cells, …

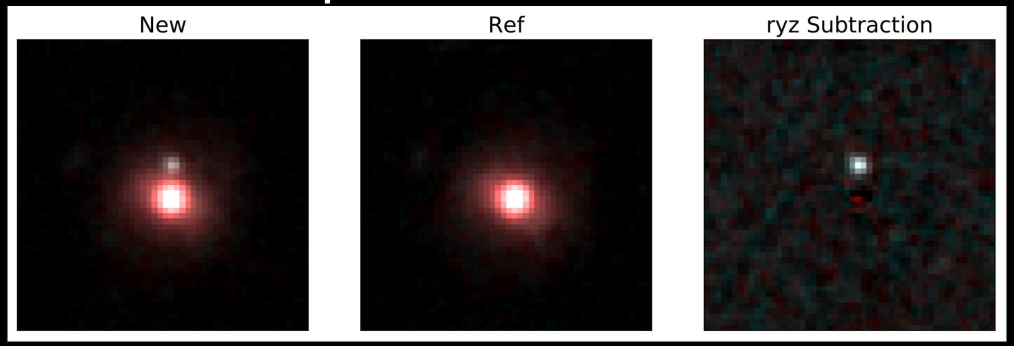
David Rubin: (Mostly) SN Cosmology

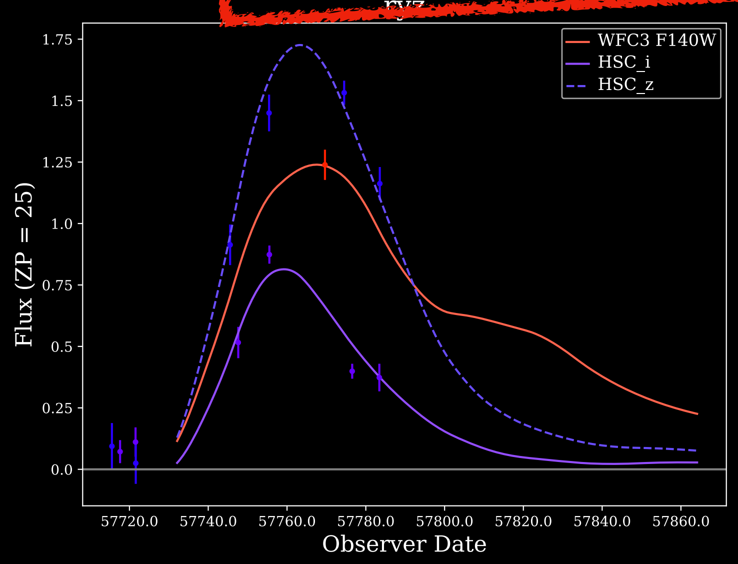
drubin@hawaii.edu

Now Hiring!

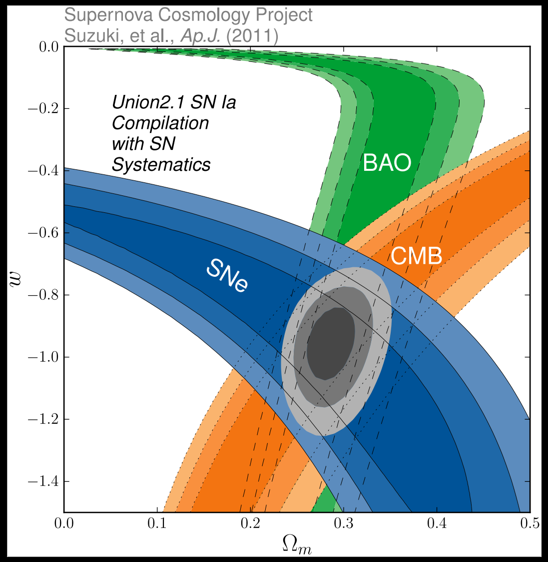
Cosmology Surveys

- E.g., SUbaru Supernovae with *Hubble* Infrared, (SUSHI)
- Ground and Space-Based Observations

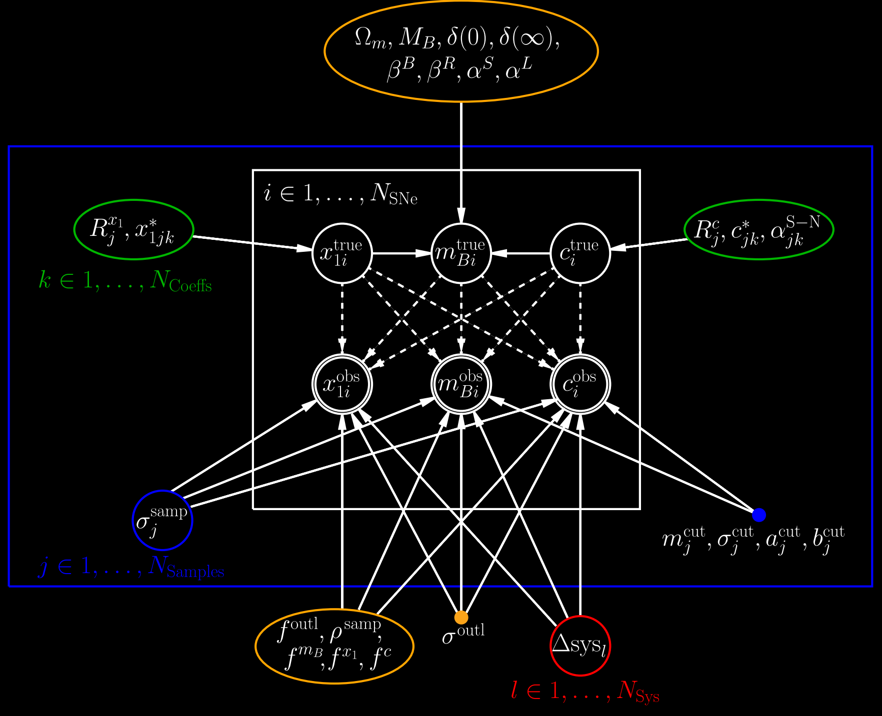




SN Standardization and Cosmology Analyses

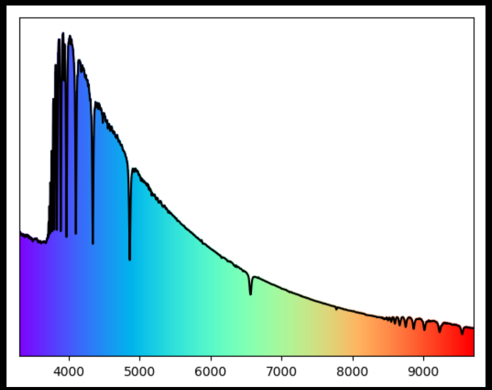


- Unified Nonlinear Inference for Type Ia cosmologY
- Twin SN Statistics
- Union Cosmology Analyses
- Blinded Analysis



Calibration

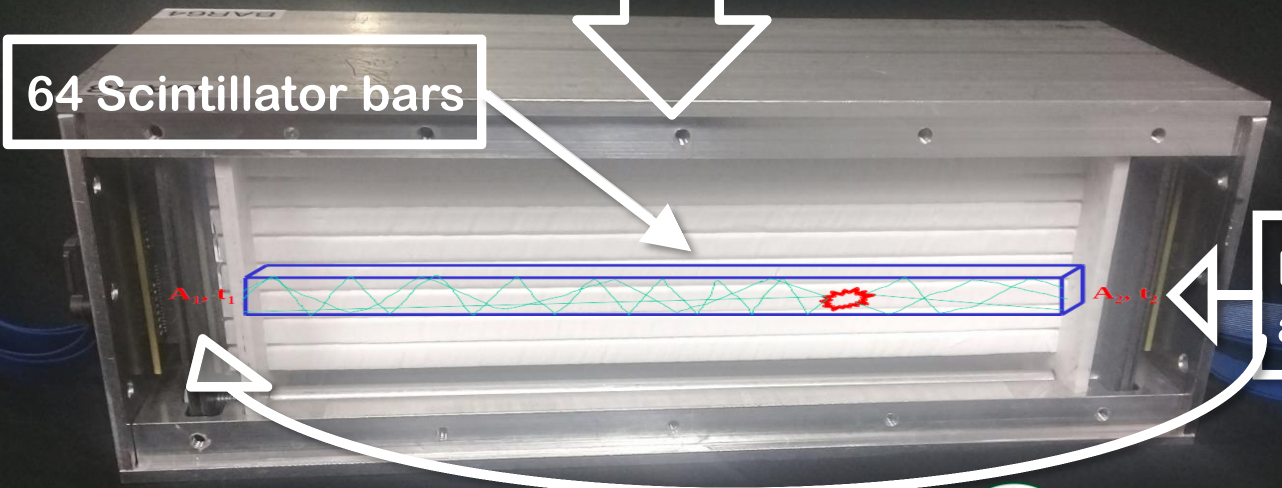
- Photometry methods
- Calibration methods
- Flux scale



Optically-segmented Single-Volume Scatter Camera (SVSC)

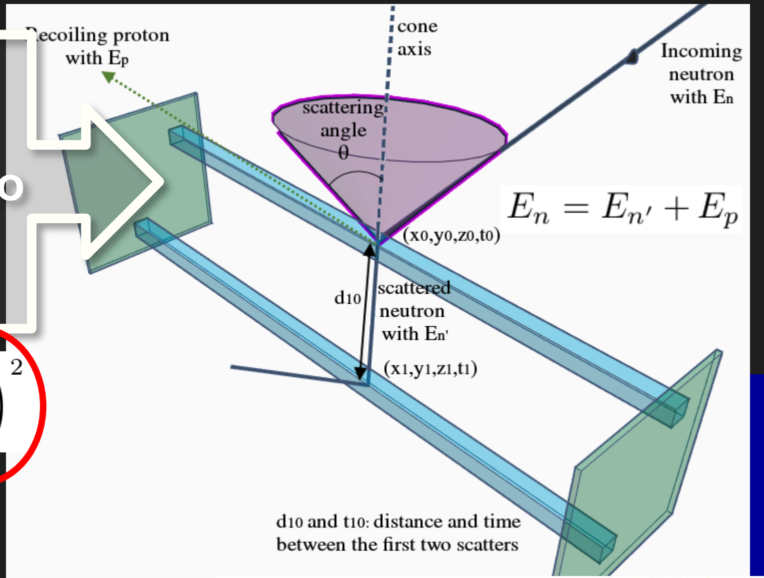
It aims to reconstruct images of neutron sources for the detection of special nuclear material, non-proliferation, astrophysics, and other applications.

64 Scintillator bars



Photodetector arrays

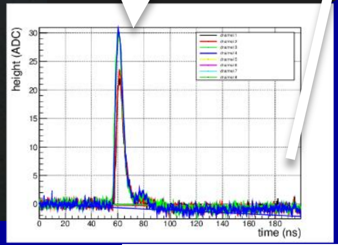
Neutron-scatter in two different bars must occur to reconstruct a cone

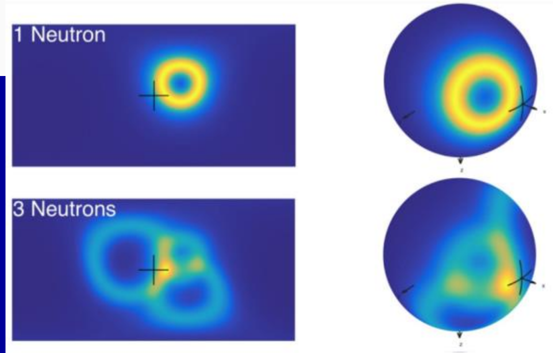


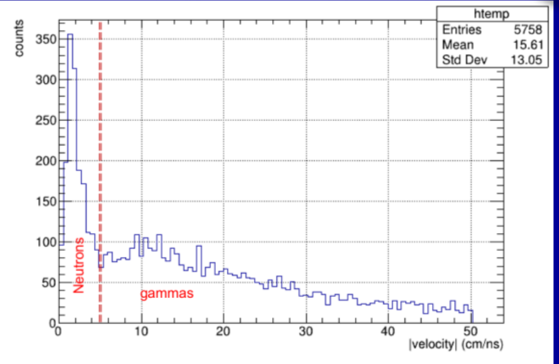
$$E_n = E_{n'} + E_p$$

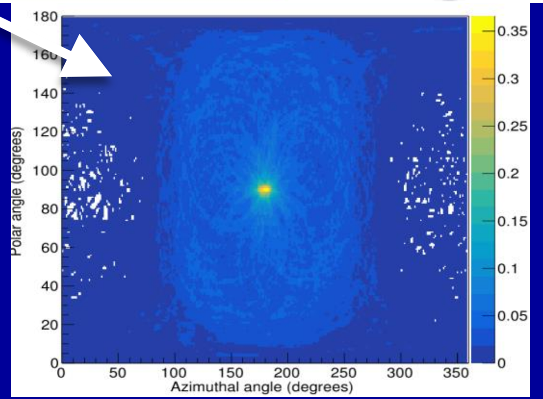
$$E_{n'} = \frac{1}{2} m_n v^2 = \frac{1}{2} m_n \left(\frac{d}{\Delta t}\right)^2$$

$$\cos\theta = \sqrt{\frac{E_{n'}}{E_n}}$$









SVSC team @ UH:

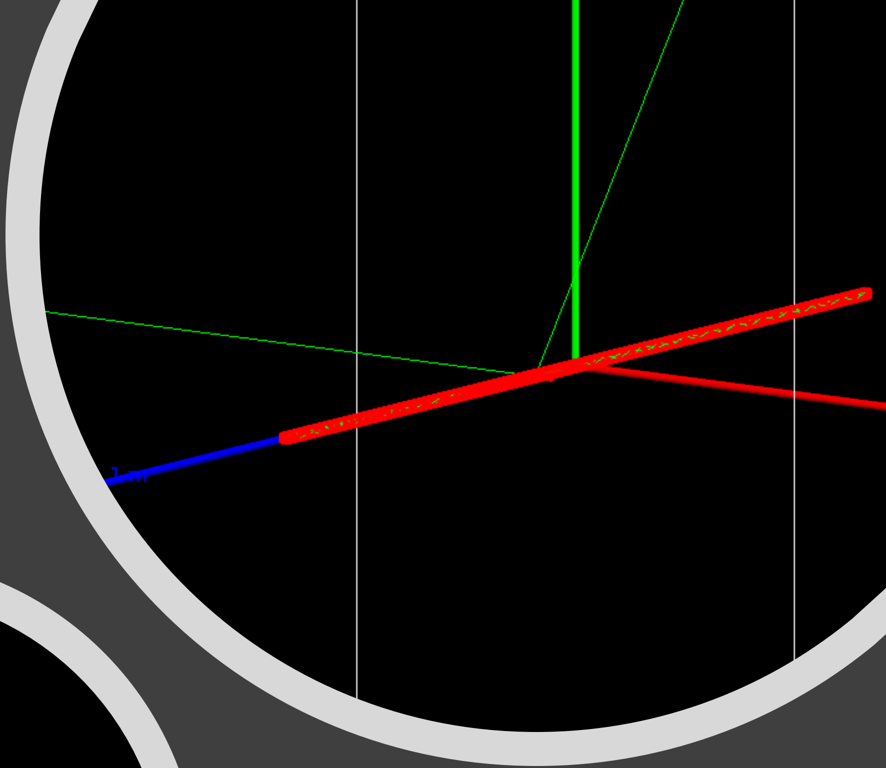
- R Dorryl
- A Druetzler
- K Keefe
- J G Learned
- Z Jabbar
- C Felix
- E Takahashi
- K Nishimura
- D Schoen
- B Crow
- B Pinto
- A Galindo

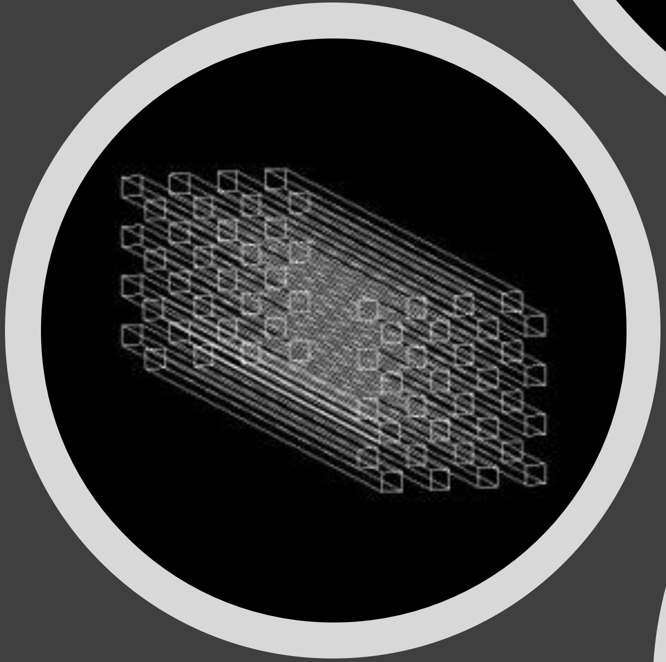
Looking for research assistants!!!

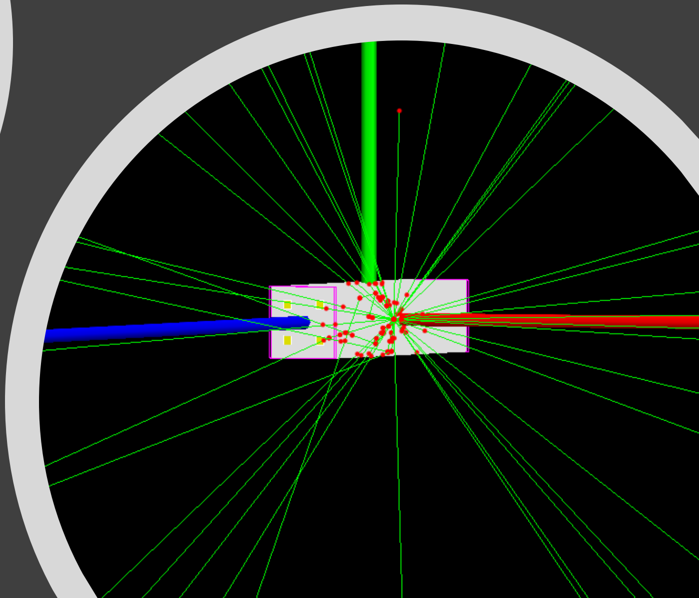
Aline Galindo Tellez (Postdoc)
alinegt@hawaii.edu

SVSC Simulations

- Modeling Detector Efficiency Given:
  - Geometry – Length, Width, Spacing, Source Position
  - Materials – Scintillator, Reflective Coatings
- Determining Efficiency Metrics
  - Light Yield, Energy Deposition, Timing Resolution, Double Scatter Probability
- Testing Model Robustness
  - Comparison Between Experimental Lab Results and Simulation Predictions

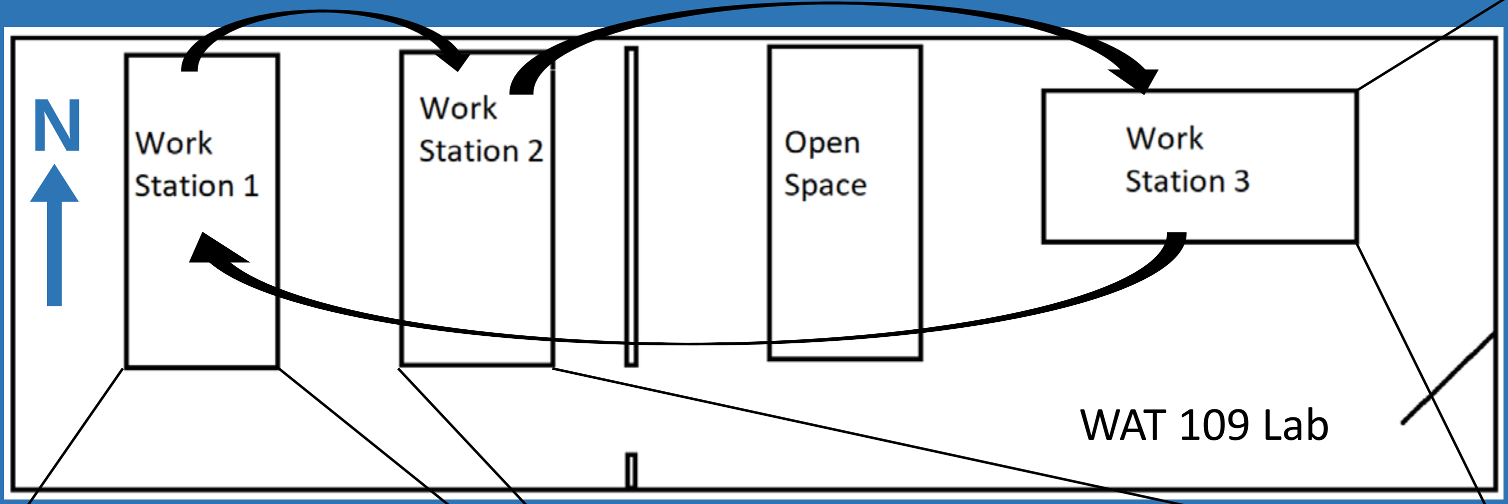


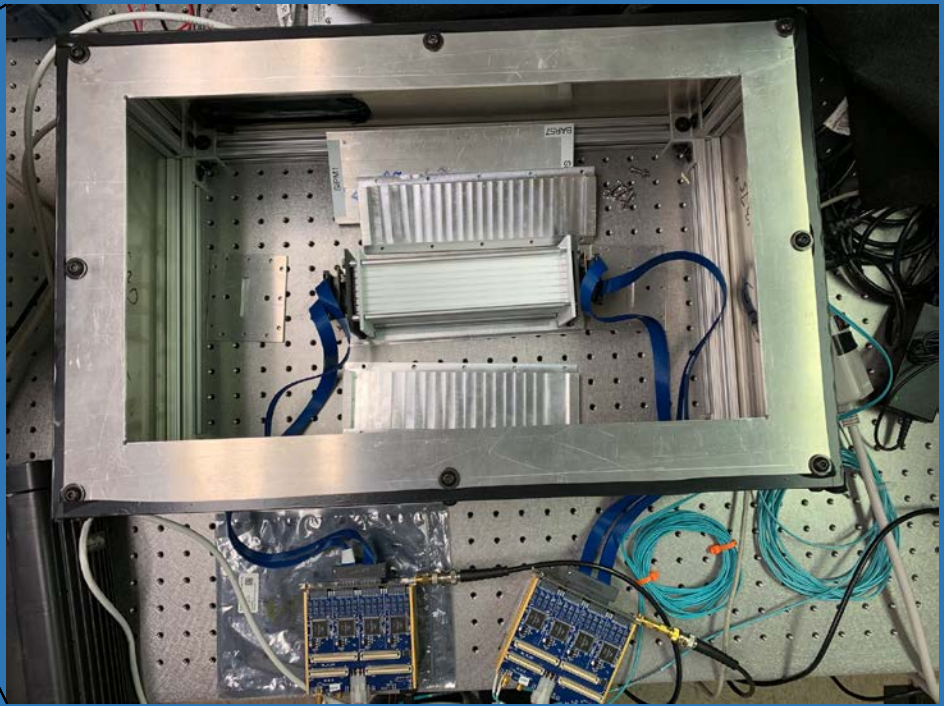




Devin Schoen • dschoen@hawaii.edu

Neutron Time Camera Development Process:





2 8x8 SiPM arrays & 1 IRS3D module

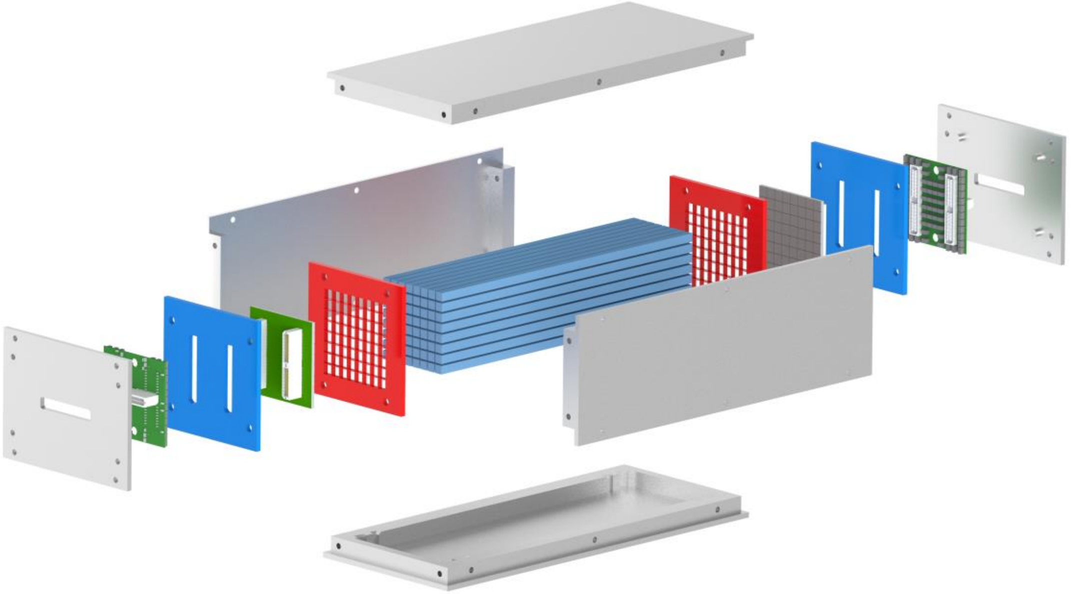
2 SiPM eval. boards & 1 DRS4

2 8x8 SiPM arrays & 2 DRS4s daisy chained

- **WS1 – Single bar & individual component characterization**
- **WS2 – Multi-bar & crosstalk investigation**
- **WS3 – Full array & system testing**
- **Open space – Assembly, temp. staging, Tranloc testing**

Andrew Druetzler
adruetzl@hawaii.edu

SVSC Prototype Development in Solid Edge:

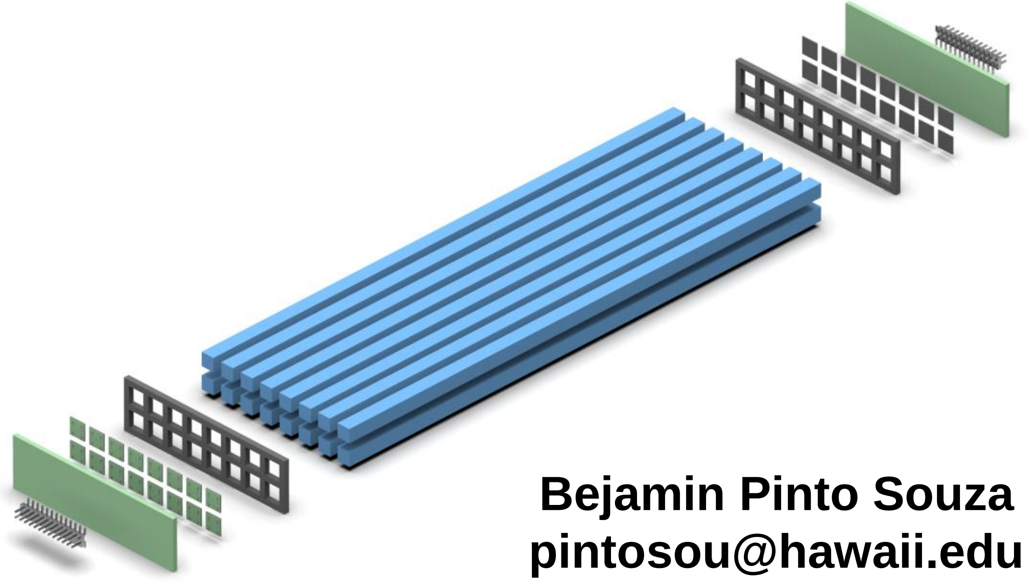


Current Prototype Design:

- 8x8 array
- Ultralytics Slow Ouput Card
- ON Semiconductor's J-Series silicon photomultiplier (SiPM) sensors

New Prototype Design:

- 2x8 array
- Increased spacing between SIPMs
- 26 pin Digi-Key connectors
- SIPMs bonded onto the scintillator.



Bejamin Pinto Souza
pintosou@hawaii.edu

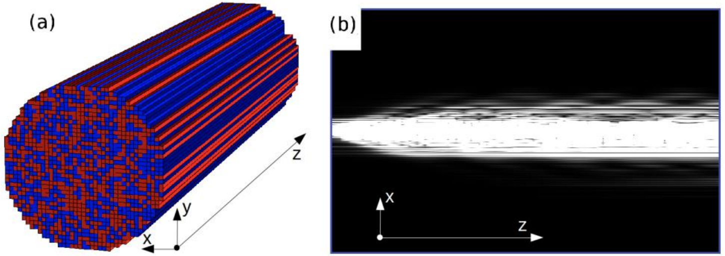
Theory:

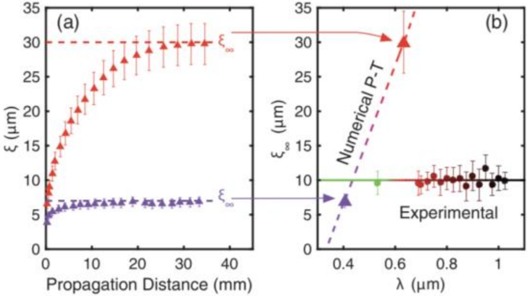
Anderson Localization:

- Wave-Interference effect
- Not wavelength dependent?

General Material properties:

- Random array of two different indices of refraction
- Larger difference of index of refraction yields stronger localization



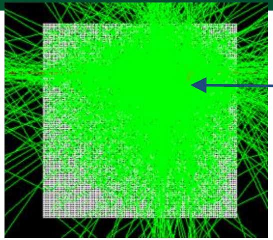


From: A. Mafi, Transverse Anderson localization of light: a tutorial review

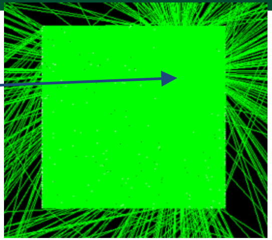
What is the Right Theory for Anderson Localization of Light? An Experimental Test

PHYSICAL REVIEW LETTERS 120, 067401 (2018)

Experiment:



Identical isotropic photon events. (Green paths are photons)

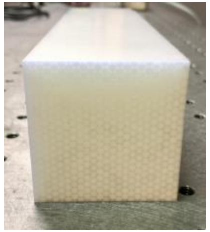


Localizing Scintillator (LS) Example:

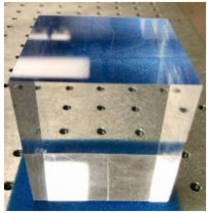
Pure Scintillator (PS) Example

Sample Comparisons:

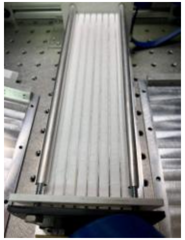
LS (50/50):



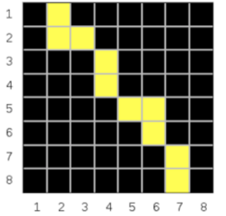
PS:

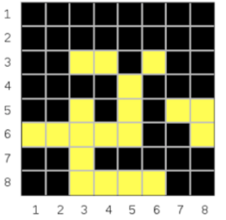


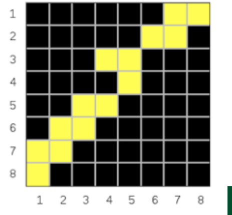
PS array:



"Average Trigger Camera" Results For Cosmic Muon Tracks:







(Waveform analysis coming soon)

Kevin Keefe
kevinpk@hawaii.edu

Jason Kumar

HEP theory group, jkumar@hawaii.edu

- I work on *dark matter* theory
- since the 1930's, astronomical evidence has suggested that most of the mass in the universe (~80%) is of a type different than found here
  - dark matter ... doesn't interact (much) with light
  - the idea I focus on → it is a *new particle*

Sculptor, believed to be a dark matter-dominated dwarf galaxy

- my work mostly focused on two prongs
  - developing new models for what dark matter could be
  - developing new ways of testing with experiments
- this field has great overlap between theory, experiment and observation, and between cosmology, particle physics and astrophysics