Contribution plans for VD-PD at the University of Iowa

Jane Nachtman, Paul Debbins, Yasar Onel
UI machine and electronics shop staff, UI Postdocs, Engineers, Graduate and Undergraduate students, Adjunct Faculty and Affiliated Scientist

U of Iowa Experimental Particle Physics (Onel, Nachtman)

THE UNIVERSITY OF IOWA

History

- **CMS group** established by Yasar Onel in 1994, after loss of SSC lab in Texas
- Brought years of experience in Calorimetry, Silicon Tracking and MPWC (fixed target experiments at Fermilab)
- Proposed, designed, built, commissioned, installed Hadronic Forward (HF) Calorimeter at CMS, led upgrade effort, currently R&D for future upgrades.
- Moved to **DUNE about 4 years ago and involved in APA Frame Construction until the NSF proposal was declined and was member of HD PD Project without funding and ProtoDUNE Dual Phase. Currentlly getting involved in VD- CRP project and also interested in VD-PD Production.**

Our group members

- Current: 2 faculty (+1 phenomenology DUNE), 2 research scientists, 1 pos-doc, 8 graduate students, 3 engineers, 6 undergraduates, Quarknet outreach program to Iowa High School teachers (28 teachers) and students (3/year) and 2 Adjunct faculty, 2 Affiliated scientist
- Past Students
  - Onel graduated 22 Ph.D.'s – 4 faculty in US, 8 faculty abroad
  - Nachtman graduated 4 Ph.D.'s – 2 faculty abroad, 1 teaching at community college

Our group's locations

- Based at Iowa – undergraduate, graduate students, research scientist, faculty
  - Hardware development, data analysis
- Fermi National Accelerator Laboratory **CMS and LHC Physics** Center (Illinois) and **DUNE experiment**
  - Research scientist/ some of our graduate students are resident there, rest of group travels there often
- CERN (Switzerland) – Project research associates (3), Postdoc (1), engineers (2) resident and others travel frequently for the CMS ops only. We will transition some of them to **DUNE (proto-Dune) in appropriate time.**

THE UI Experimental HEP CMS AND DUNE

Professors: Y.Onel, J.Nachtman (2)

Collaborating Professors: Ugur Akgun COE college, Iowa ; Erhan Gulmez , Bogazici University, Istanbul Turkey; Kerem Cankocak, Istanbul Technical University, Istanbul Turkey. (3)

Adjunct Professors and Affiliated Scientists: Burak Bilki (Beykent**-Istanbul- Dual Phase**; James Wetzel; Emrah Tiras (Erciyaz U. Kayseri, NOVA, ANNIE) (3)

Graduate Students: Mohammad Alhusseini ; Dylan Blend, Nilay Boston; Gurkan Karaman; Ohannes Koseyan; Matt Nelson, Orgho Neogi , Christina Snyder (8)

Undergraduate students: Thomas McDowell; Julien Cook; Max Hermann; Adam Edwards; Cole Dorman; James Thompson; Ryan Parian (7)

CERN-based and Iowa-based Engineers and Project Scientist: Paul Debbins; J.P Merlo; Alexi Mestvirishvili; Mike Miller; Aldo Penzo; I.Schmidt; David Southwick. (7)

Overview

University of Iowa has years of experience building detectors, and would like to take this opportunity to help build the DUNE Far Detector.

Facilities at UI Department of Physics and Astronomy:

- NASA-certified machine shops
- NASA-certified electronics shops
- Experienced engineers from UI CMS group, also UI departmental support
- Physical spaces:
  - our lab (old Van de Graaf experimental area) in Van Allen Hall
  - Warehouse facility just off campus (“Sand Road”), accessible by flatbed semi
  - Possible storage facility with loading dock (Independence Road)
- Working with a pool of Iowa Departmental engineers to understand process to ensure uniform, high quality products. QA/QC services.
- Y.Onel was Horizontal PD – Integration and installation group coordinator-worked hard but unfortuntaly no funding made available for Iowa.

Staffing Model at Iowa

- PI's: Jane Nachtman and Yasar Onel (uncosted scientific labor) (Project Mgmt)
- Dedicated engineers in our HEP group, supported through projects:
  - Paul Debbins -- already contributed to APA effort which is now terminated (will provide Technical and Production Management/Supervision)
  - Ianos Schmidt -- currently working on CMS upgrade projects- will transition
  - Mike Miller -- EE/ME
  - Department has QA/QC engineer
- UI staff engineers
  - Other engineers in Physics and Astronomy can be hired as needed
- UI staff machinists (assume 3 FTE)
  - Trained machinists provide services to the department, hourly rate-**$78**
- UI students (assume 6 FTE from students, 1postdoc)
  - Talented undergraduate students, both physics and industrial/mechanical engineering majors, already working in our group
    - Assist in cleaning, storage, construction (under supervision), inventory control
  - Graduate students can take on roles in construction
    - Graduate students can be supported as departmental TA's and still work on this project.

Our facilities: Machine shops and Lab in Van Allen

Onel and Nachtman's lab space is labeled 5AC and 5AC-B.

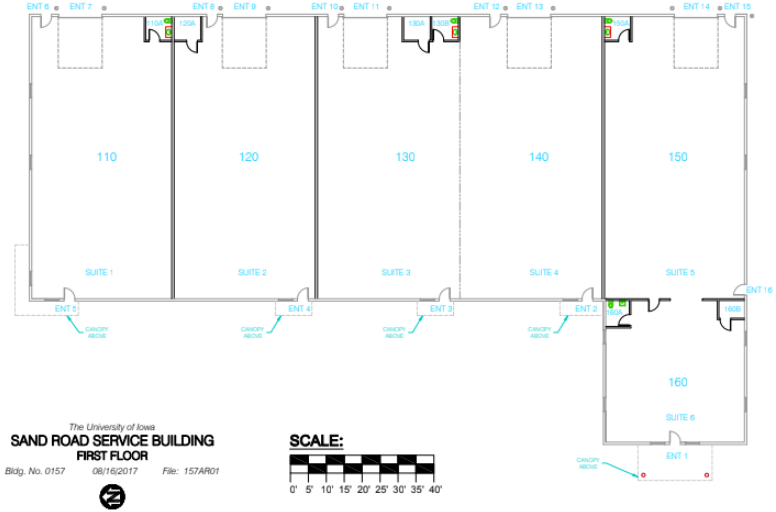
Offices for engineers are in 3AC and 4AC.

The department's machine shop is located in 116, with an exit to the loading dock.

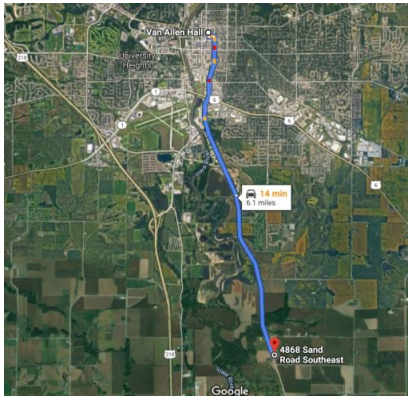
1AC, 2AC are Chemical, Vacuum systems, Evaporation equipment for coating materials.

6AC Advanced Photodetector Facility.

Sand Road Facility - Uncommitted space available for custom factory/process



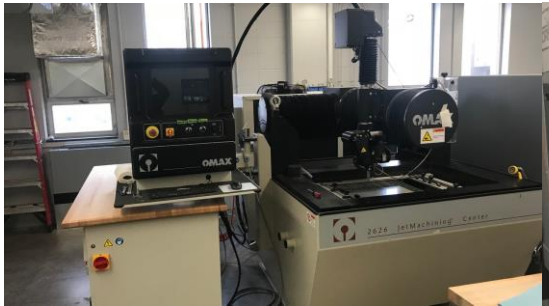
- Bays 130 and 140 are available to us
- 6400 square feet
- Working with Safety on factory layout
  - Cleaning
  - Welding
  - Assembly
  - Metrology
  - Packaging
  - Storage

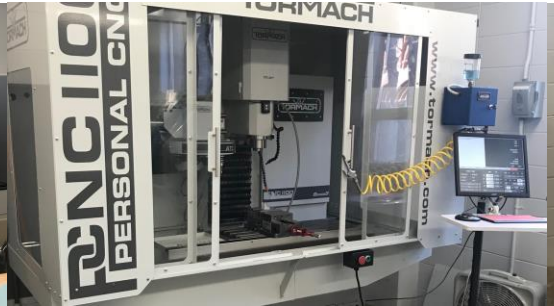


IOWA Milling & Machining

Iowa Machine Shop staffed by 3 machinists offering CAD/CAM design, Machining, Welding/Fabrication for clients such as CERN, JPL, NASA

- 5 CNC milling machines (Tormach, Omax)
- CNC lathe (Tormach slant)
- Four manual lathes
- Drill presses, saws, welding equipment, sheet metal fabrication equipment
- Measuring tools calibrated yearly by standards traceable to NIST per the guidelines specified in the latest revisions of ANSI/NCSL Z540-1 and ISO/IEC 17025



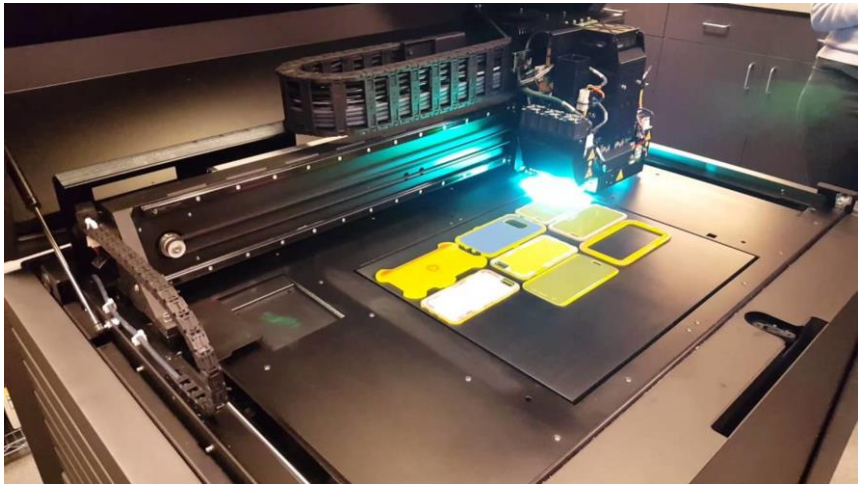


Machining and Manufacturing Facilities - Uiowa based

University of Iowa Prototype Studios
http://www.protostudios.org/

Available processes

- 3D printing
- 3D scanning
- 4 axis CNC machining
- CNC lathe turning
- Laser cutting and etching
- CAD work
- Circuit board fabrication and assembly
- Water jet machining
- Silicon and plastic injection molding
- Vacuum casting
- Precision micro-welding



Laser Cutting

IOWA Milling & Machining

Materials

- Metals including steel, aluminum, and titanium
- Plastics
- Garolite
- Specialty material

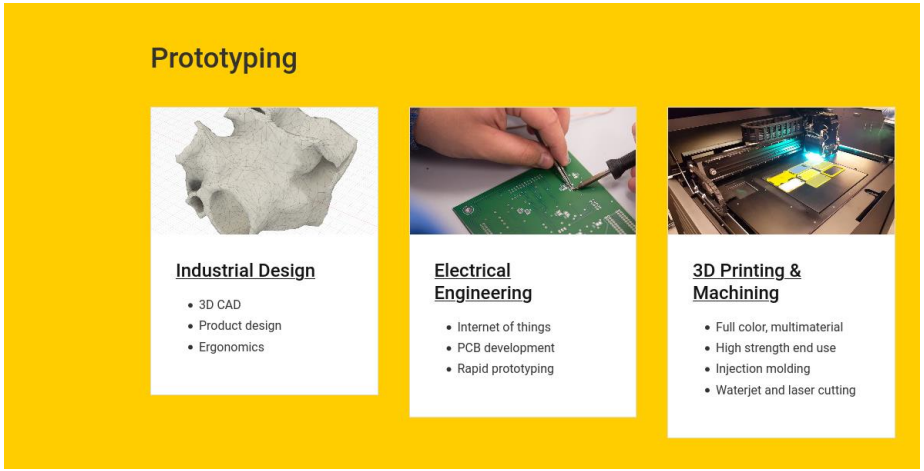
Additional Services

- Carpentry
- Laser plastics
- Water jet cutting
- 3D Printing

IOWA Prototyping

Iowa Machine Shop is complimented by Iowa **ProtoStudios**

- Staffed to provide state-of-the-art rapid prototyping to the university and local community



IOWA Prototyping

Certified IPC/NASA for construction of spaceflight hardware, cable and wire harness assembly, instruction

Electronics equipment

- LPKF circuit board plotter
- Orion micro arc welder
- LPKF reflow oven
- Markforged Mark two polyjet 3D printer
- Stereolithography 3D printer

Large Milling & Machining

- There are several shops close to campus with large machines and a wide variety of vertical and horizontal mills, staff with expertise in tooling and CNC programming, and talented operators to machine large and small parts to precise sizes and shapes.

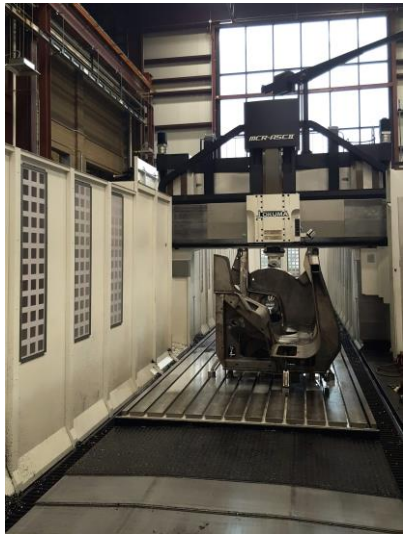
- Their newest mill, the Okuma MCR-A5Cii, is a large-capacity vertical machining center with a 90° head for five-sided machining with one setup (see specs below).

Machining and Manufacturing - Local Industry Based

- Local heavy industry provides large size and high production volume capabilities all located within Iowa City area.

  Water Jet facility - Fairfield, IA
  Steel Fabrication and Machining - Cedar Rapids and Davenport, IA

These facilities are useful for production of large precision fixtures for module assembly and testing.




OKUMA

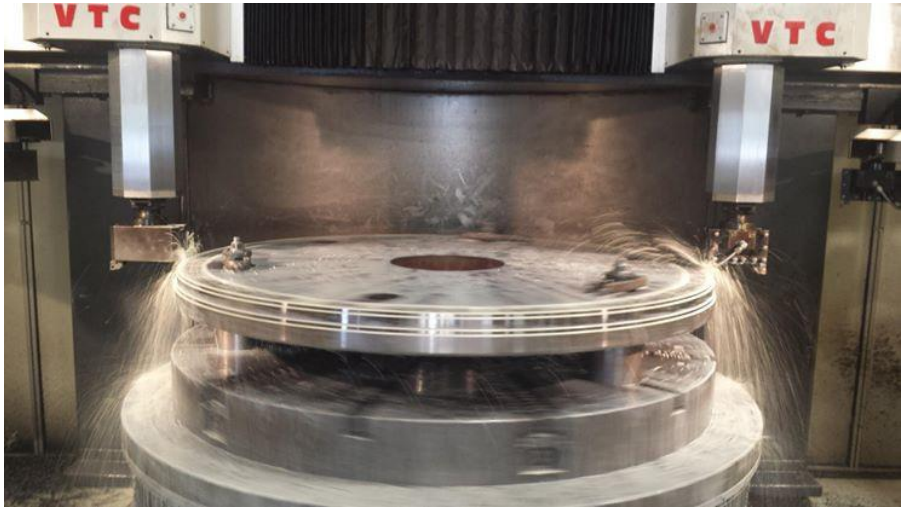
Vertical and Horizontal mills

VERTICAL MILLS

- Okuma MCR-A5CII Double Column Vertical Machining Center, 144”x 322” 5-sided machining
- Mori Seiki MV653 Double Pallet Vertical Machining Center, 60” x 30” pallets
- Mazak MTV 515 Vertical Machining Center, 43” x 20” x 25”
- Haas VF3 Vertical Machining Center w/ Midaco pallet changer, 40” x 20” x 25”
- Haas MDC500 Vertical Machining Center, 20” x 13” pallets
- Visionwide VTEC 2000 Bridge Mill, 86” x 90” x 36”
- Chevalier 2443 Vertical Machining Center, 43” x 24” x 30”
- Takang DCM-1422 Double Column Machining Center, 86.6” x 55.1” x 35.4”
- Okuma M560V Twin pallet, 20” x 40”, 1200 ipm feed rate

HORIZONTAL MILLS

- Okuma MA-500-HB Double Pallet Horizontal Machining Center, 19.5” pallets
- Mazak H-20 Horizontal Machining Center, 43.3” x 33.5” x 29.5”
- G & L CNC Horizontal Boring Mill, 132” x 96” table-type
- G & L 6” Horizontal Machining Center, Manual


VTC
VTC

Large Turning

HORIZONTAL LATHE

- Takang LD45X6150 Turning Center, Ø45" swing x 252", heavy duty up to 24,000 lbs. between centers, 45" swing over bed, 28" swing over slide
- Johnford ST70A Turning Center, Ø25" turn x 63", 12" power chuck
- Haas SL40 Turning Center, Ø25" turn x 44", 15" power chuck
- Haas HL-6 Turning Center, Ø25" turn x 44", 15" power chuck
- Yama Seiki GTS150X Twin Spindle Turning Center, Ø1-5/8" bar, shaft magazine loader/unloader up to 48" long, 6" power chucks
- Yama Seiki GTS200X Twin Spindle Turning Center, Ø2" bar, shaft magazine loader/unloader up to 48" long, 8" power chucks
- Paramount CNC Lathe, Fanuc 18T, 45hp, 48" turn x 108", 45" swing over bed, 31.4" swing over slide

VERTICAL LATHE BORING MILL

- Tongil TNL-80V-2 Twin Spindle Vertical Turret Lathe w/ Ø21" chucks
- New Century-Stanko CNC Vertical Boring Mill, Fanuc 18T, 60 hp, 110" table, 126" swing
- New Century-Bullard CNC Vertical Boring Mill, Fanuc 18T, 60 hp, 56" chuck, 68" swing
- New Century CNC Vertical Boring Mill, 100 hp, 78" (6) jaw power chuck, 90" swing

Proposal – Possible options

- **Work on continuing refinements to mechanical design and component integration**
- **Work on the production of PD (X-Arapuca module mechanics).**
- **Work on the testing of the modules with LED, Lasers and radioactive sources**
- **Work on the QA/QC of photodetectors using Advanced Photodetector Lab**
- **Calibration and monitoring system using LED drivers(LED and Laser Diode) and radioactive sourcing systems.**
- **Detector Tile Assembly (Tile frame fabrication, assembly and testing), WLS plates, Filter assemblies, Ganging Amplifier)**
- **Coating the scintillators with PEN and/or high reflective films for WLS.**
- **Building mechanical structures, frames and tooling and cables.**

Current preparations for possible PD work

- Currently discussing with UIowa Facilities and Safety Personnel the options for outfitting our spaces for PD work

- Talking with University Machine Shop to outline the type of work involving them with PD production

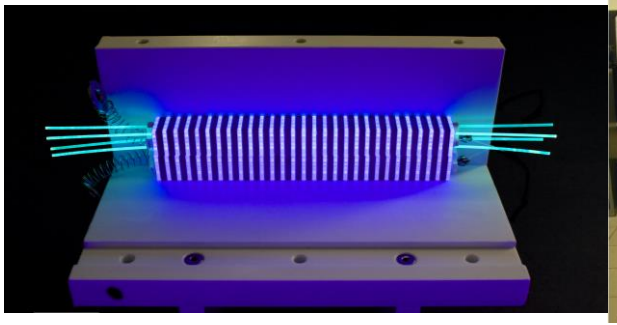
Supplementary Information on the capabilities

Iowa Past Construction:CMS Forward Calorimetry HF

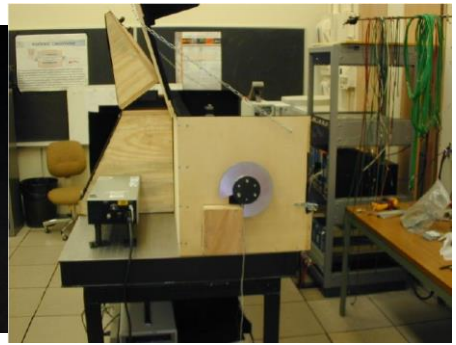
Equipment Designed, Built, Tested at Iowa

CMS Radioactive source drivers

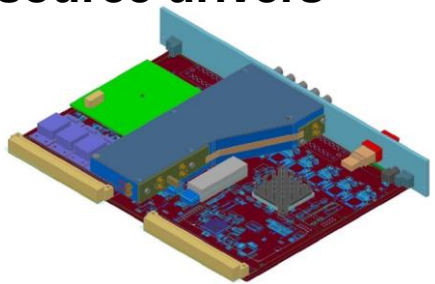
ZDC Crane in LHC tunnel



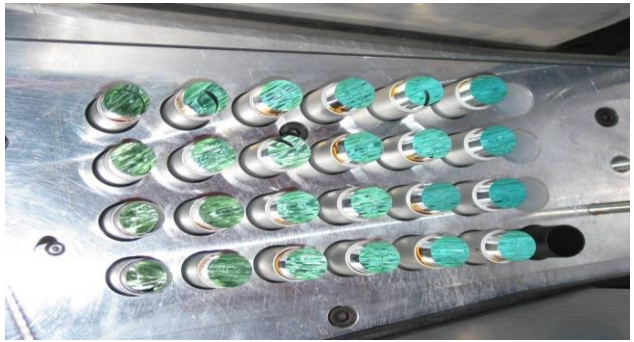
Prototype Shashlik calorimeter module



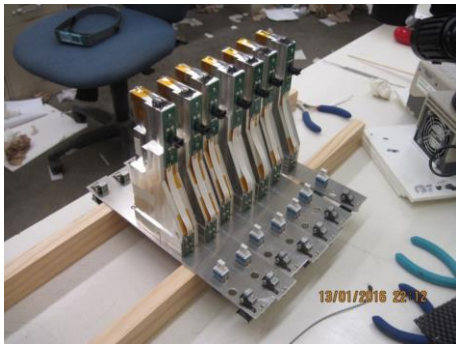
2000 Photodetectors characterized at UI



CMS HF Calibration Module



CMS HF Readout Boxes and Light Guides



Light Mixers

Recent Upgrade Projects successfully executed

The following slides for our CMS work on Readout Modules (RM), HF, HB, HE. BTL, and calibration modules. This is exactly the type of work that the VD-PD's will be, Integrating optics, electronics and mechanics.

we have lots of experience in precision mechanical design that integrates all the components together.

The RM design that has to bring all sub- components together so our mechanical engineering is involved with a variety of issues; electronics, optics, cooling, etc.

To install the crane in the LHC tunnel required passing the engineering and construction through the highest levels of review. As painful as it was, that project demonstrates a level of commitment and design excellence.

Univ. of Iowa has extensive experience in hardware design and construction

- CMS Hadron Forward (HF) Readout Boxes (PMT based)
- CMS Hadronic Barrel and Endcap Readout Modules
- CMS Source Drivers
- CMS Zero Degree Calorimeter (ZDC)/ Remote Handling System for ZDC (HXTC Crane)

CMS HF Calorimeter

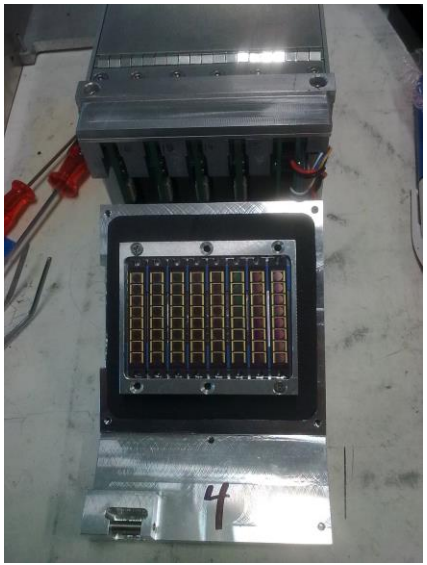
Showing Readout Boxes and Services routing, designed by Univ. of Iowa

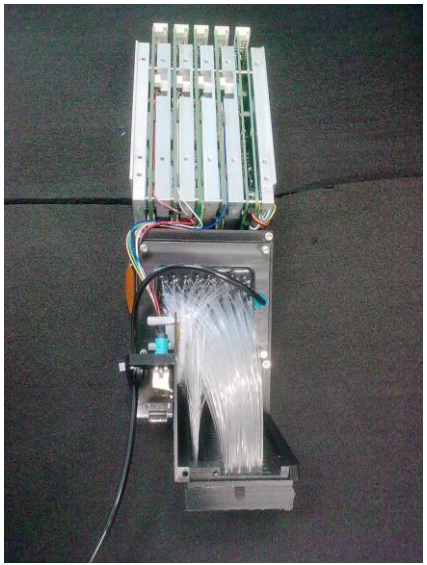
HF Readout Box
Upgrade to 4 Anode PMT's

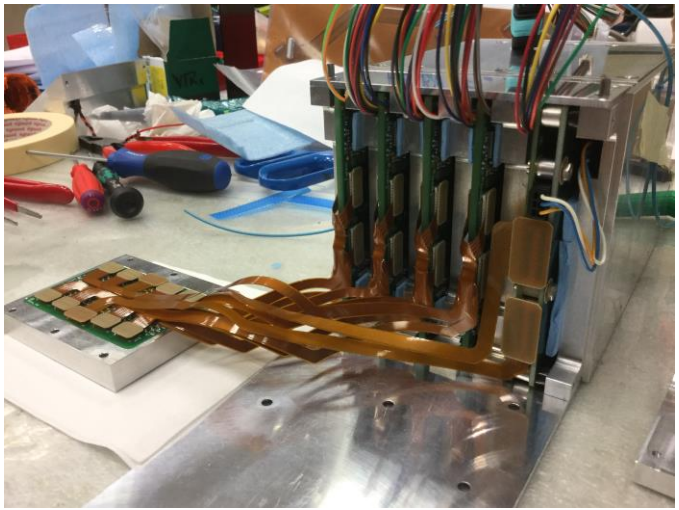
Modified design and execution of upgrade and testing performed by Univ. of Iowa

CMS HB Readout Module Upgrade

Engineering by Univ. of Iowa; providing integration of optical, electronic, mechanicals, and cooling.







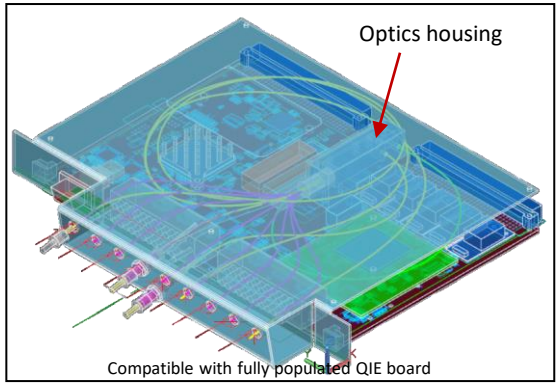
Mechanical design

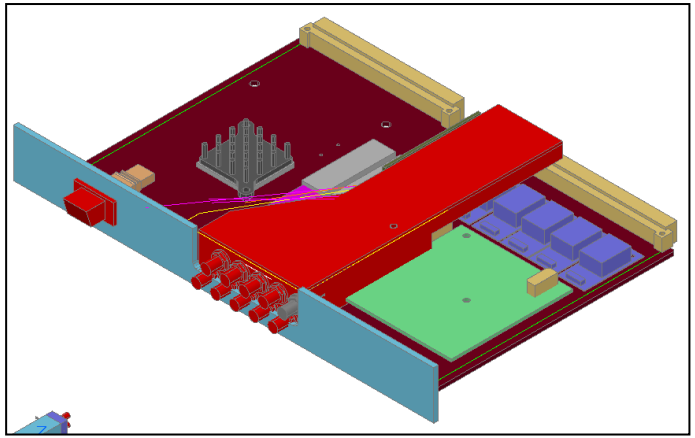
Prototype mechanical evaluation

- Fiber jacketing complicated assembly and increased stiffness of fibers/ fiber bundle.
- Some conflict b/t LED's and fiber PIN diode complicated assembly (imposed by space constraints)
- Fibers too stressed to be viable for final production

Proposed solution (Expand housing to enclose fibers)

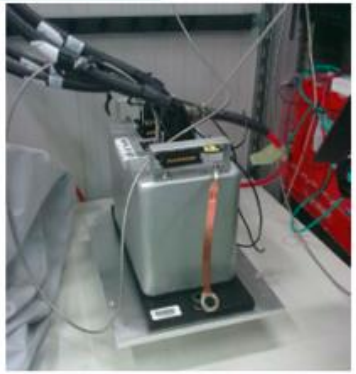
- Minimum stress on fibers
- Easier to produce fiber bundle assembly.
- Easier to light tight
- More robust
- Better fiber PIN diode integration.
- Space highly constrained but solution possible.





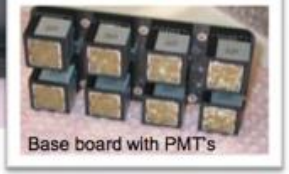
1-channel → 2-channel Readout

36 PMT boxes each end

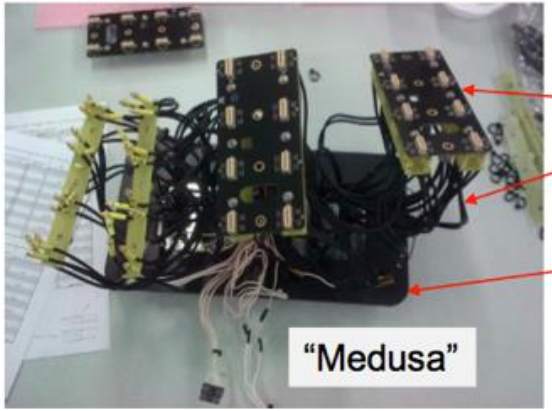


PMT box insides

Adapter boards attached to base boards



Base board with PMT's



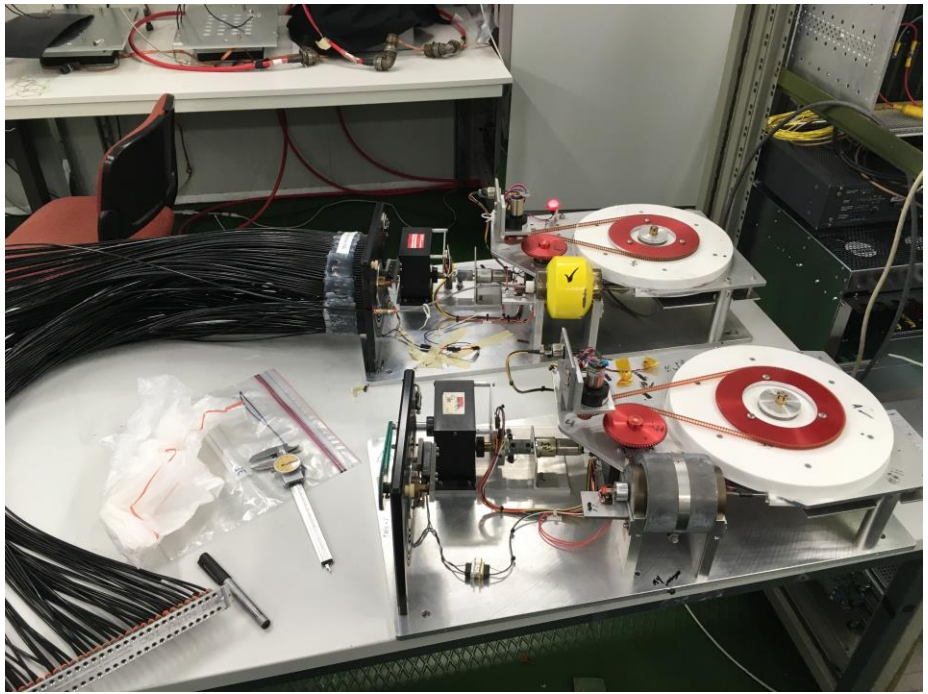
"Medusa"

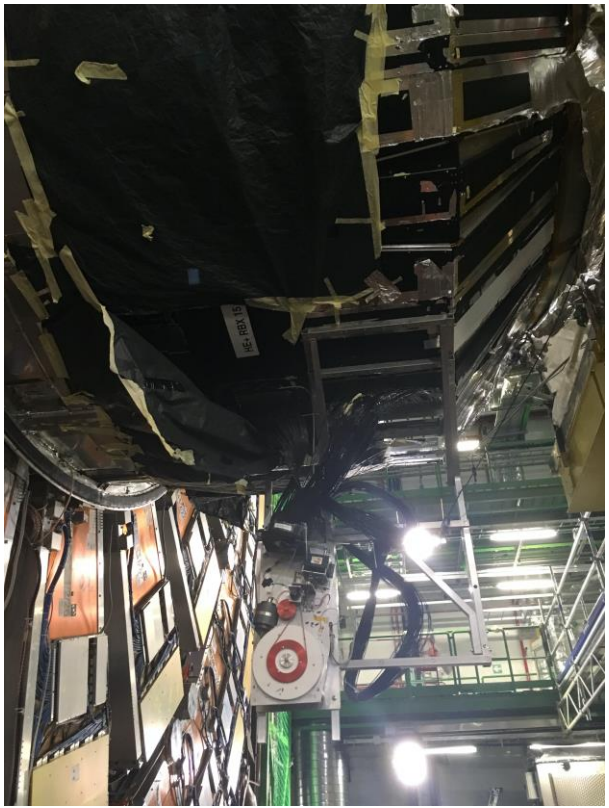
Adapter board, gangs anodes

Winchester to MMCX coax cables (96 per box)

"plate 3" holding connectors

Source Drivers - examples of precision mechanics.



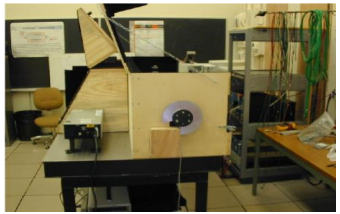


Back-up and detailed info

University of Iowa Facilities & Equipment

UI Nuclear Physics/High Energy Physics labs:

automated photodetector testing facility (SiPM, PMT)



coating chamber

pulsed N2 lasers

LED sources

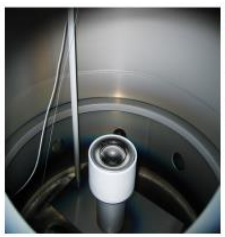
optical optical benches and dark boxes

automated neutron density filter systems

cosmic ray detection set-up

Iowa RadCore facility

dosimetry; autoradiography; chemi lumenescent qualification; high dose and low dose rate radiation; x-ray source capable of delivering filtered or unfiltered x-rays, with maximum x-ray energy of 300 kVp; gamma ray source low or high dose rates of monoenergetic (0.667 MeV) gamma radiation, the range being from 10-3200 cGy/minute.



NASA certified Machine shop

Water Jet, Laser-cutter and Metal 3D printer ++

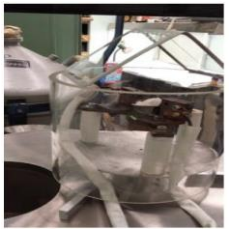
NASA certified Electronics Shop

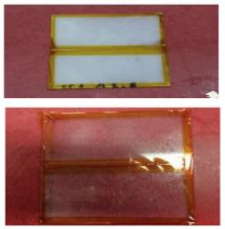
3D Composites printing facility

A new cost-effective Composite-based Additive Manufacturing (CBAM)

University of Iowa – Other Facilities

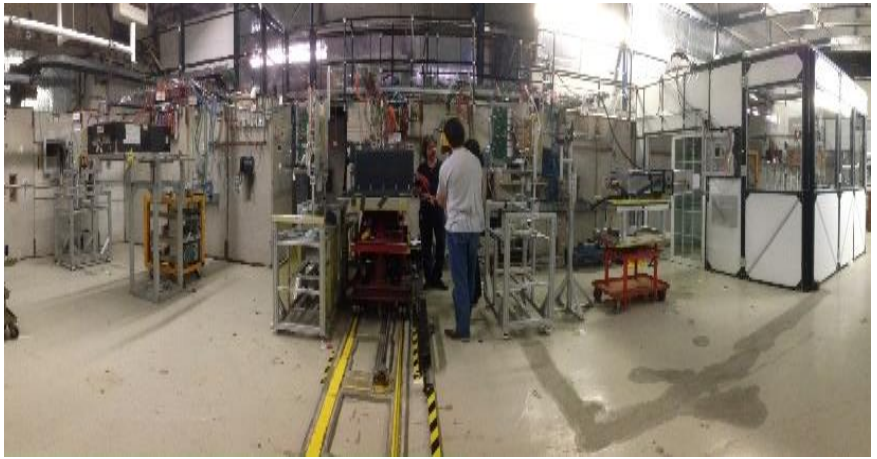
- molecular beam epitaxy lab
- III-V semiconductors growth
- optical spectroscopy lab
- microfabrication laboratory
- central microscopy research facility,
- spectroscopy facility
- cw laser; glove-box and clean-room for fabrication or organic light-emitting diodes and solar cells, magnetoresistance measurement setup, ultrafast lasers, cryogenic capabilities, photon-counting equipment, and magneto-optical instrumentation



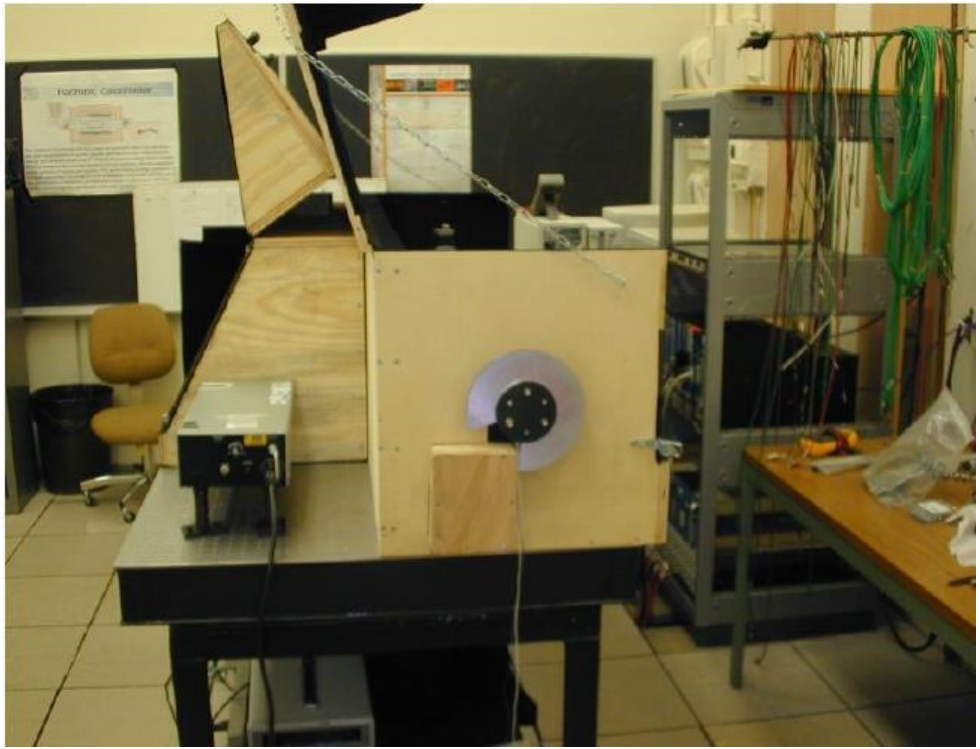


Test Beam(T-1041)

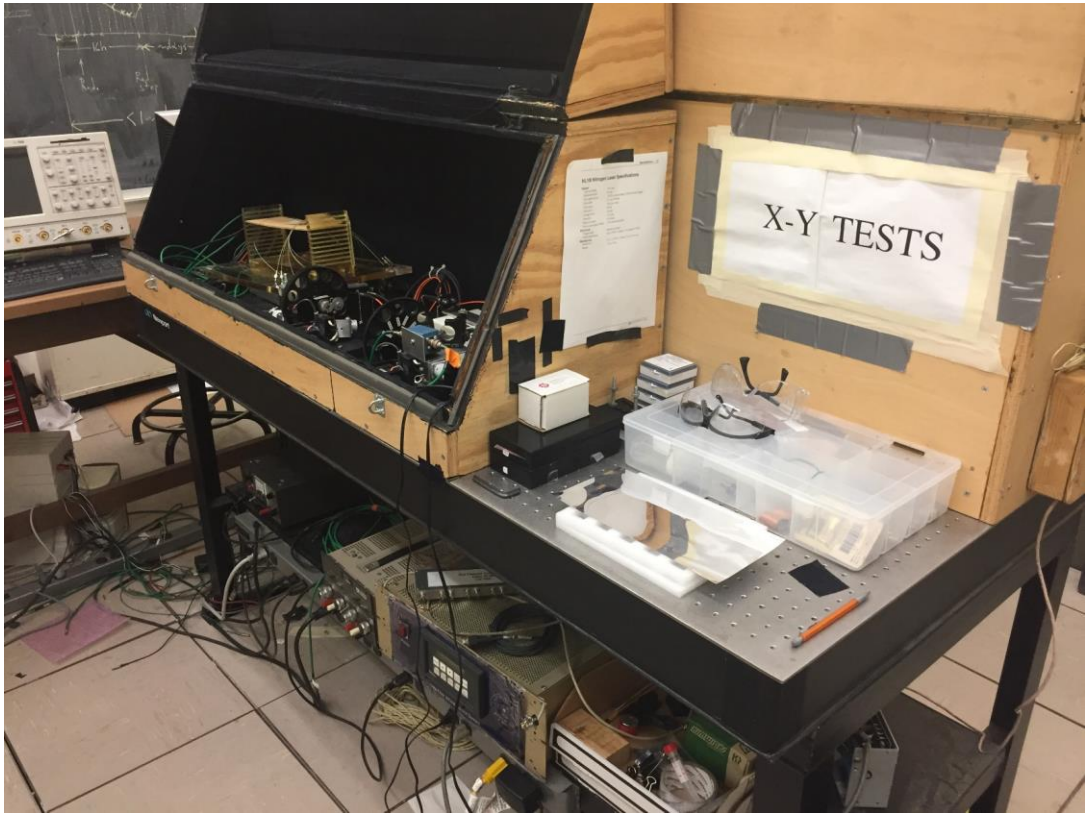
Onel-Co-Spokeperson

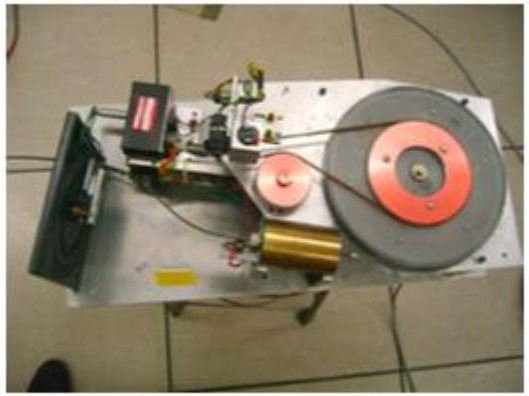


PMT Test Laboratory-UI



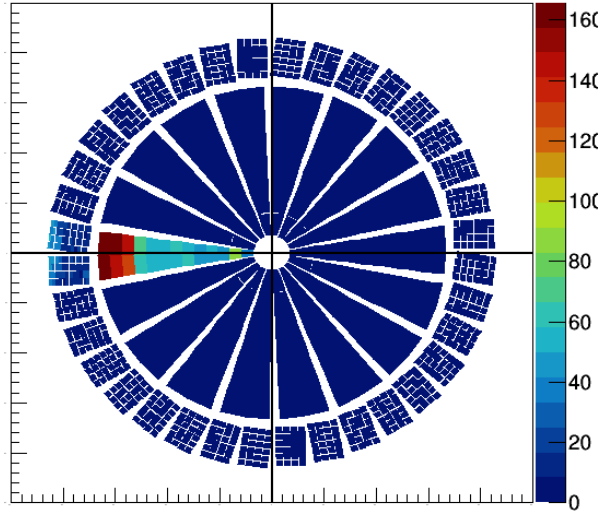
- 3 dark boxes
- VME and CAMAC DAQ systems
- Computer controlled XY scanner and n.d.f. wheels
- 3 picoammeters
- 3 digital scopes
- UV and visible power meters
- UV and Blue LED light source
- 2 nitrogen lasers
- Nitrogen Dye Laser
- 2 dark boxes has DC light source (tungsten light bulbs)
- Optical table with all mounts and stands
- Pico second LED pulsers and 1 double pulse generator

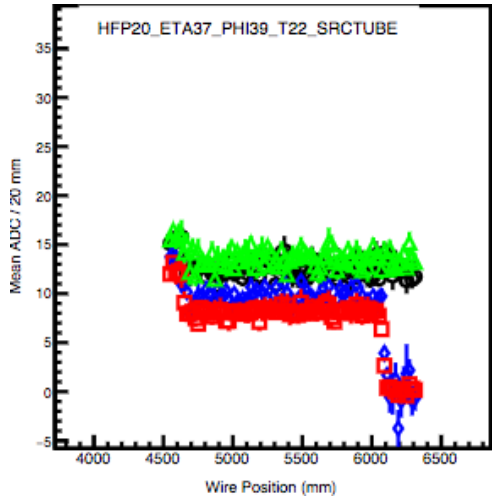

X-Y TESTS



HF source driver

http://feynman.physics.uiowa.edu/HFSourcing/





Depth index: **1 - E (1+2)** ; **2 - H (1+2)** ; **3 - E (3+4)** ; **4 - H (3+4)**

FTBF

Test Beams

Fermilab

Two beam-lines:

120 GeV protons; up to 60 GeV secondaries

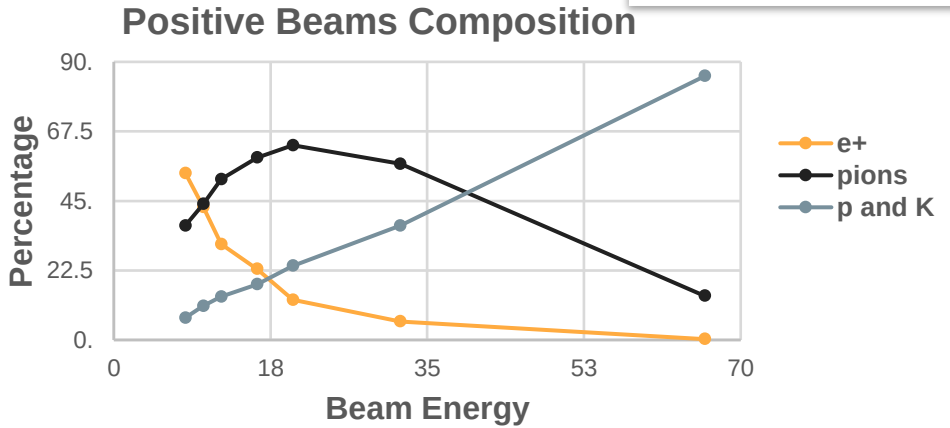
Tertiary beamline down to 200 MeV

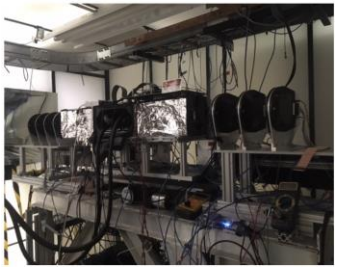
Infrastructure at MTest

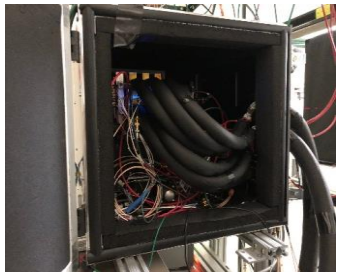
Laser Alignment, Crane Coverage (30 tons),

Climate controlled Huts, 2 Cerenkov Detectors,

Pixel and MWPC Tracking, TOF System

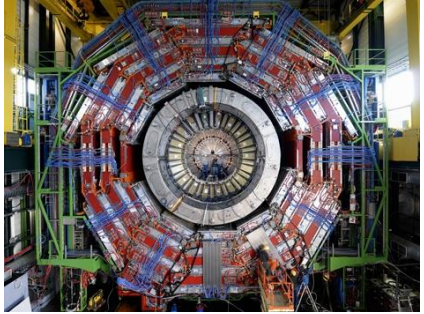


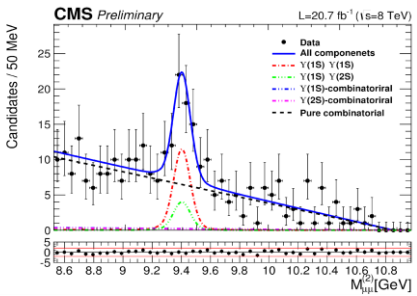


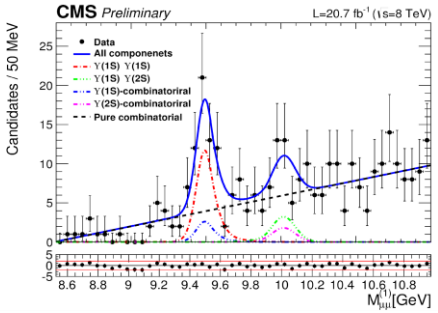


T-1041, B.Bilki, Y.Onel
Co-spokesman

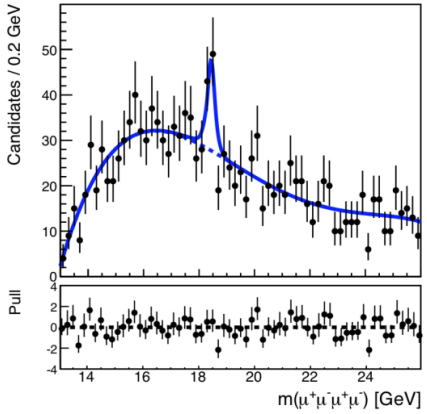
CMS Experiment : Yasar Onel and Jane Nachtman Recent Results



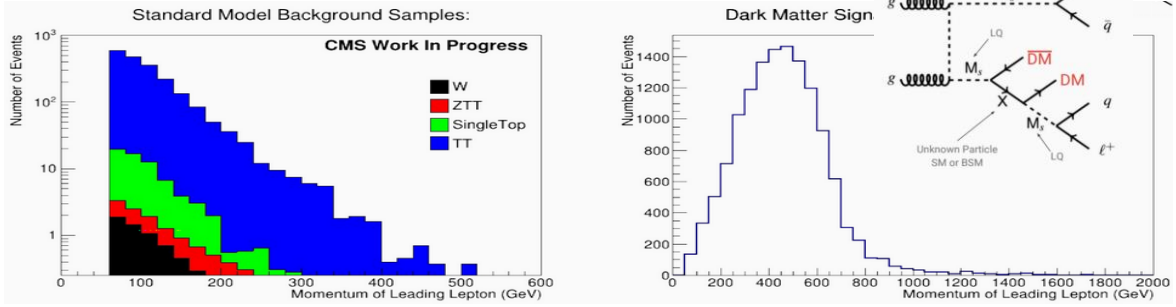




Observation of Double Upsilon production (thesis of Maksat Haytmuradov).

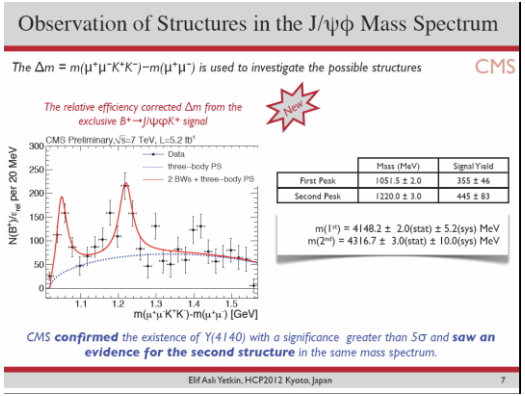


Evidence of a new structure in the four-muon final state (thesis of Suleyman Durgut)



Dark Matter Search in the Coannihilation Codex Model. Christina Snyder (thesis topic)

Discovered by Our Group



2012: Discovery of a new and unexpected particle in B+ → J/Psi Phi K

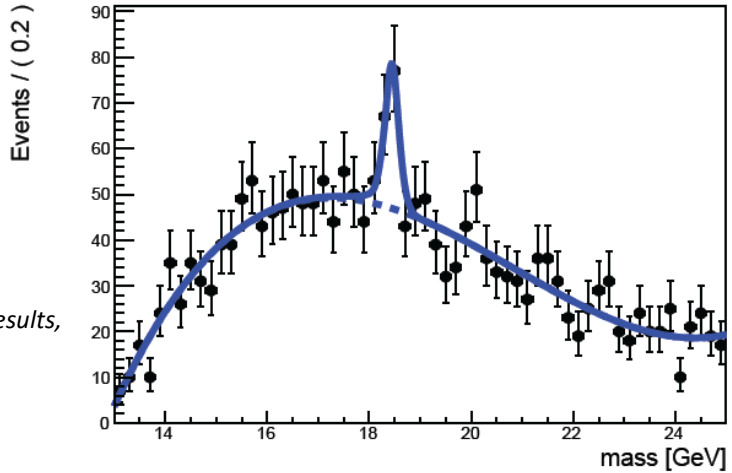
Not predicted by theorists

Confirmed by other experiments

NEW! Discovery of a resonance in the four-muon mass spectrum

Will be approved for public presentation in near future

This is a new and unexpected particle – it could be a hint of an entirely new type of physics!



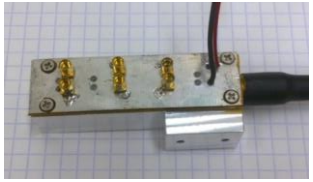
In addition, our group has contributed to many other physics results, including searches for Supersymmetry, Standard Model measurements, observation of rare processes

QIE Card

ngCCM

Calibration Module

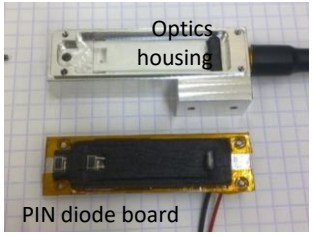
CU Optics prototype



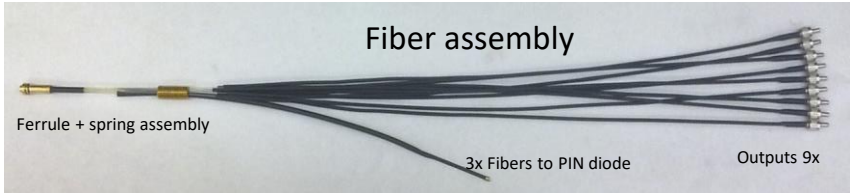
Housing made to be maximally compatible with new QIE boards

Goals:

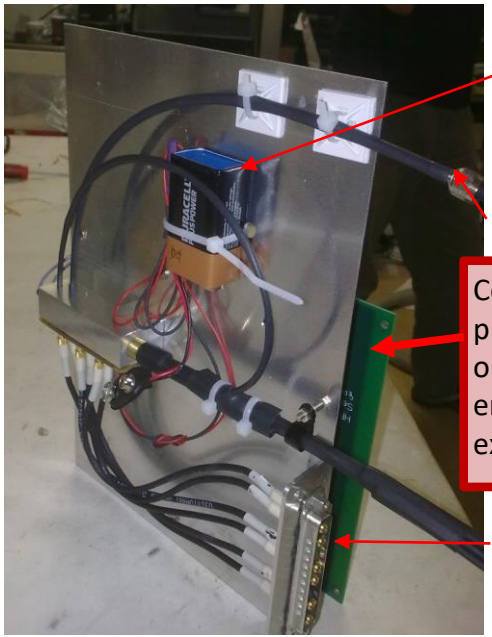
- Understand fabrication, polishing and assembly of optical components
- Evaluate space constraints with respect to the fiber assembly
  - Concern about stress on fibers (600u core quartz fibers are stiff).
  - Less than half the module width of the original CU
  - Many tall components on the QIE(DC-DC converters, heat sinks, mezzanine boards, connectors…)
- Compare performance to existing system

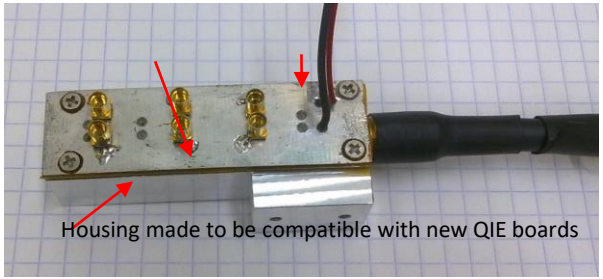


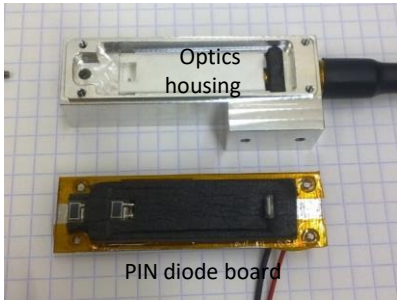
Connected to an original HF LED pulser board to be able to operate with existing HF front end. →For direct comparison to exitsing CU

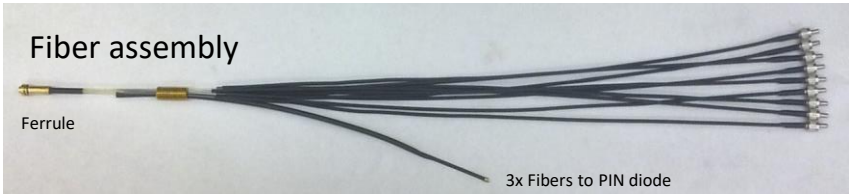


`Prototype


Battery for PIN diode bias
LASER input
Connected to an original HF LED pulser board to be able to operate with existing HF front end. →For direct comparison to exitsing CU
PIN Diode signals to QIE readout

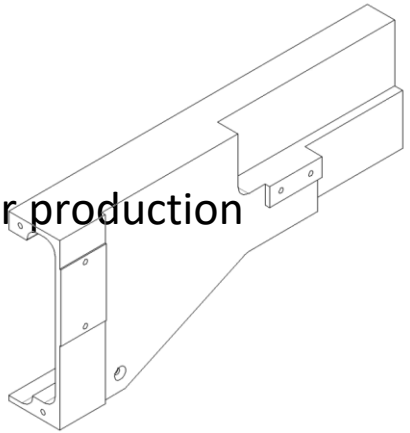

Housing made to be compatible with new QIE boards

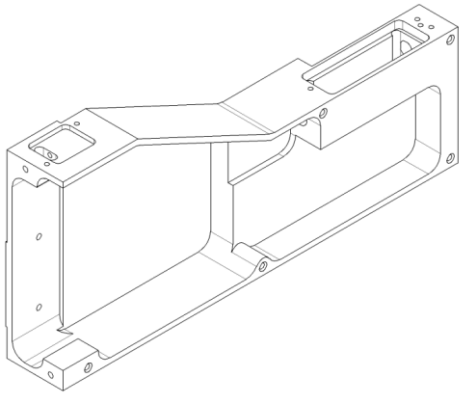

Optics housing
PIN diode board

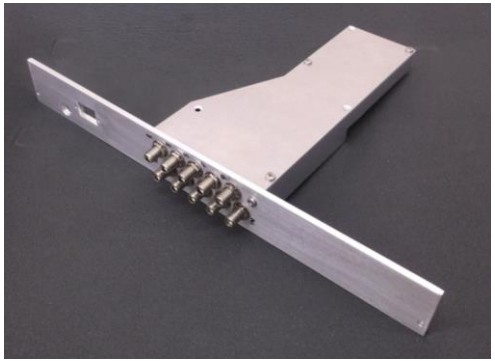

Fiber assembly
Ferrule
3x Fibers to PIN diode
Outputs 9x

Status

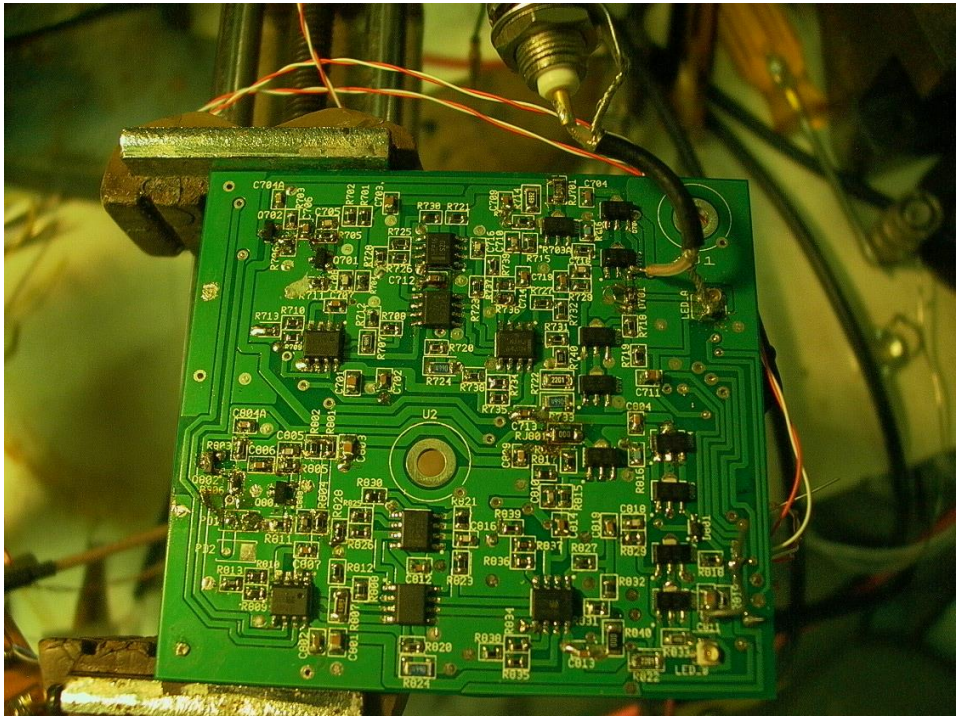
- Housing design complete
- CNC/CAM processing + tooling established for production
- Housing produced, and assembly checked
- PIN diode PCB’s designed
- Quick prototype boards produced
- Assembly started







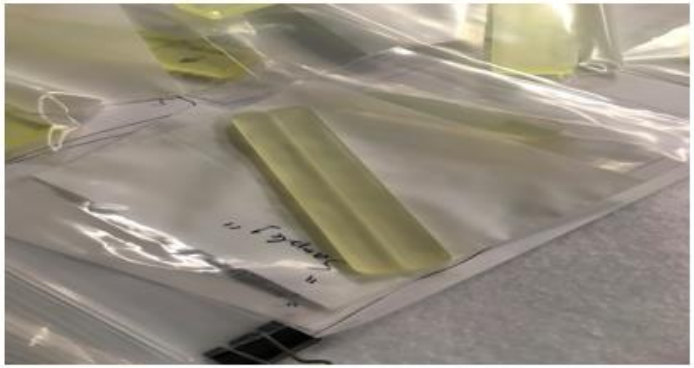
Pulser with short cable



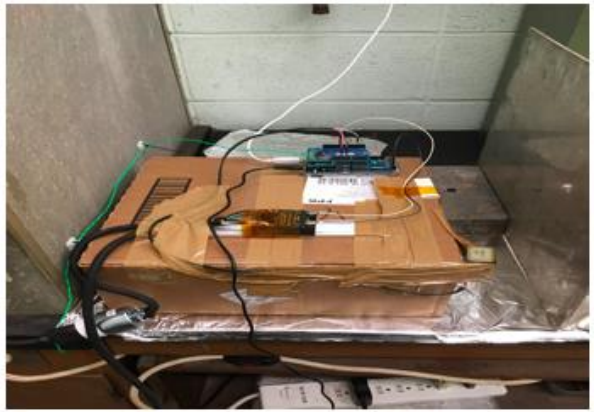
SX Production

Finger Tiles

Grooved Tiles



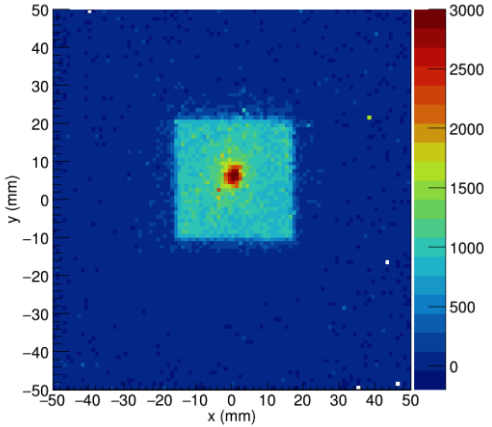
Control Circuits

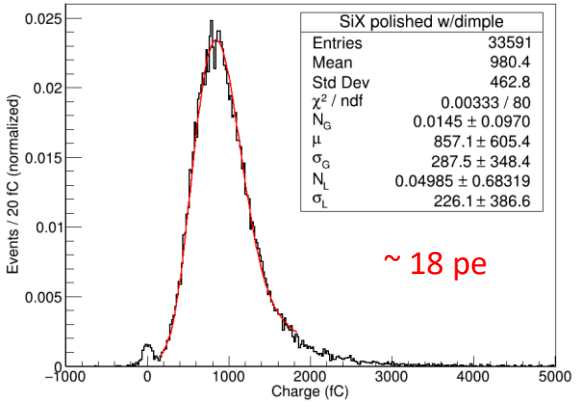


Modified Owen

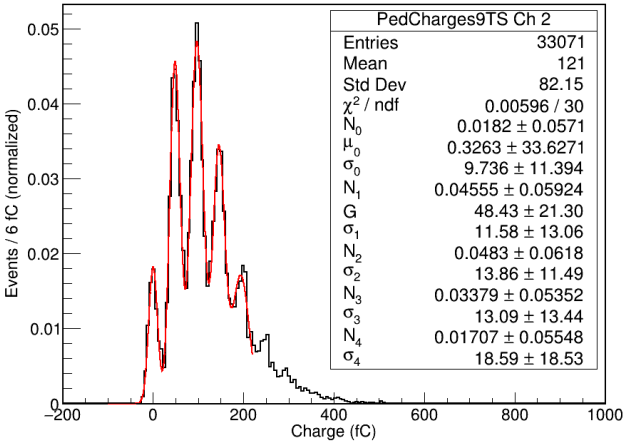
SX in Test Beam

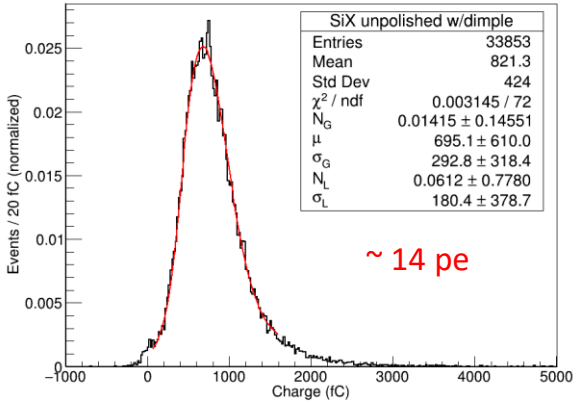
Scintillator-X response to 150 GeV muons
SiPM directly coupled to dimple (Hamamatsu S12572-010)
Tile size 3 cm x 3 cm
Select the muons passing through the tile and 1 mm away from the SiPM





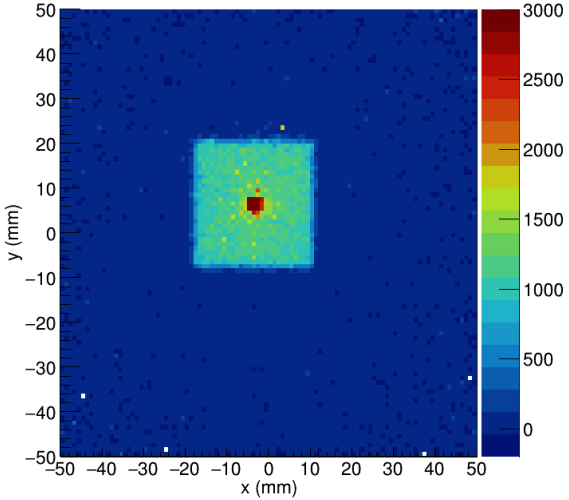
Gain ~ 50 fC

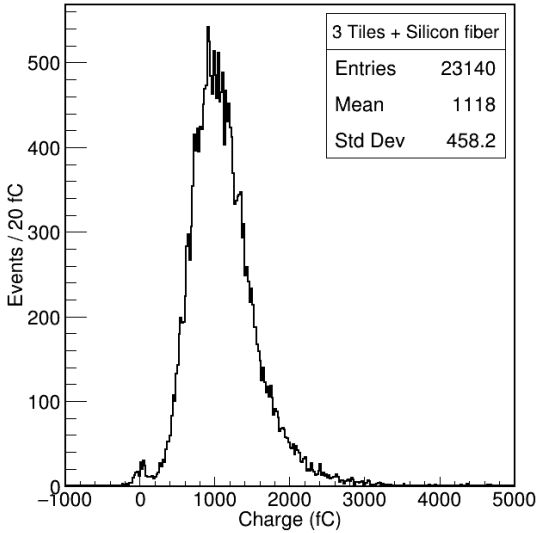




Fit to a Gaussian + Landau

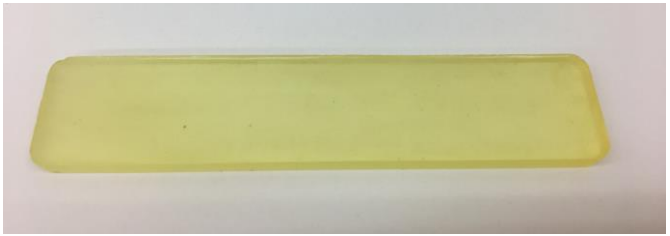
Response to 150 GeV muons
Three blue scintillators with Silicon fiber going through and coupling to a SiPM
Tile size 2.5 cm x 2.5 cm
Select the muons passing through the tile and 1 mm away from the Fiber/SiPM

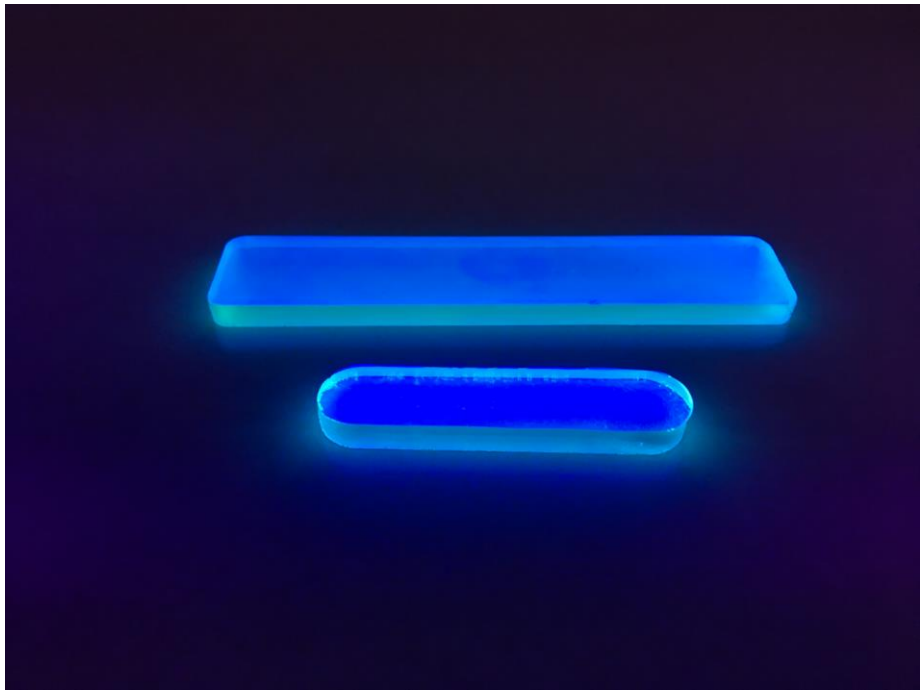




Mean=1100 fC
1 pe ~ 20 fC ➒ 55 pe!

SX- Iowa is the only US Institution that can manufacture radiation hard scintillators.
The UI has applied for a patent.





FACILITIES AND OTHER RESOURCES University of Iowa

- We have excellent facilities at the University of Iowa and Iowa labs at CERN in terms of photodetector testing, which we have utilized for the calibration of approximately 4000 photomultiplier tubes both for Phase 0 and Phase I of the CMS experiment.

- Our machine shop can produce high-end technological products that have been utilized in the construction of high energy physics and spacecraft instrumentation.

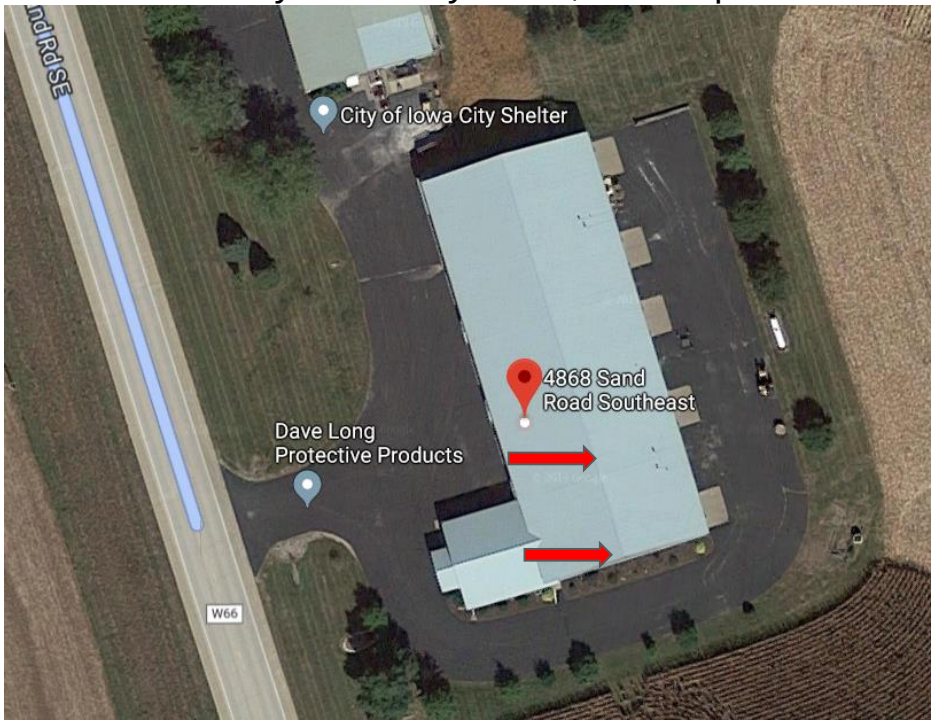
- Our group has access to the central computing center with two large clusters. Available from our Iowa group collaborators is a CMS Tier 3 cluster, a CMS Tier-2 Pilot (proof-of-concept system), one 64-core cluster, one 20-core cluster, and a new GROW Tier 3 cluster.

FACILITIES AND OTHER RESOURCES University of Iowa

- University of Iowa We have a high scale high energy physics research laboratory at Iowa and Iowa labs at CERN with the equipment inventory including: oscilloscopes, spectrometer, power supplies, NIM, CAMAC and VME crates and modules, photomultiplier tubes and dark box assembly, cosmic ray test station. The high energy physics lab is fully equipped with photodetector testing equipment, pulsed laser and UV LED systems, low noise voltage and current, preamps, quartz fiber optics, optical benches and dark boxes with fiber optic, power, signal and HV interfaces, together with modest temperature control and measurement. Neutral density filters, HV and x-y-z movement are computer controlled through LabView. A fairly extensive set of NIM logic and CAMAC modules are available, as well as faster few channel DAQ as interfaced to the oscilloscopes (up to 1 GHz sampling) and a picoscope. A suite of components for reconfigurable cosmic ray telescopes are available with a wide variety of sizes of scintillator and PMT assemblies. Our equipment has been used to measure hysteresis for the PMT and bases systems in the HF calorimeter, proving that the system was stableover 3 orders of magnitude in alternate pulses. Small alpha, beta, gamma and neutron sources with variable size collimators are available, as well as an x-ray machine with 100KV endpoint to test optical sensors and signals. One lab is equipped with a hood, chemical drains, vacuum, propane gas and DI water. An older CVD rig, sputtering, PVD, and e-beam evaporator are available to this project. Thin film analytics include SEM with xafs and charge injection, ellipsometry, Kelvin probes, and an AFM. Equipment includes a high vacuum system, tube furnaces, thin film deposition capability including e-beam and thermal evaporation, and sputtering. Glassblowing and a vacuum glovebox are also available.
- Details of other facilities in our department. https://clas.uiowa.edu/shops/physics-astronomy-shop, https://clas.uiowa.edu/shops/clas-research-design-services , Department of Physics & Astronomy MBE Lab

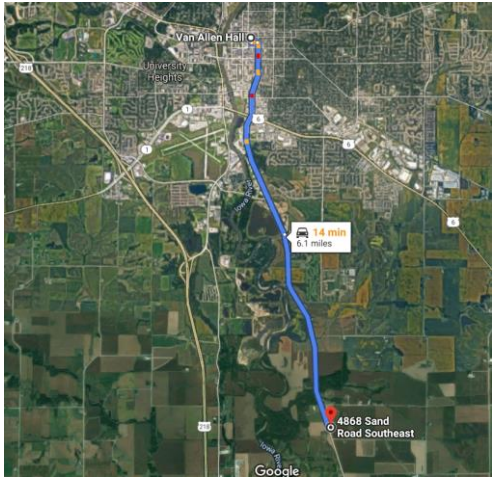
Need semi access for transport of frames

Sand Road facility -- two bay doors, 6400 sq ft



- Our labs in Van Allen are big enough to build frames, but no overhead door
- Sand Road facility has overhead doors.
- Assembly space as well as storage space

Facilities overview



- Our labs in Department of Physics and Astronomy (Van Allen Hall)
  - Old Van de Graaf beam/experimental area
- University owns a warehouse building south of campus (Sand Road) within close proximity
  - Currently used for university storage
  - we can use free of charge
- Additional facility east side of town
  - Old factory, larger, better loading facilities
  - But unclear as to condition and availability