

A novel ionizing particle beam fluence and position detector array using the Micromegas technology with multi-coordinate readout

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U.S. DEPARTMENT OF
ENERGY

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Project Goals



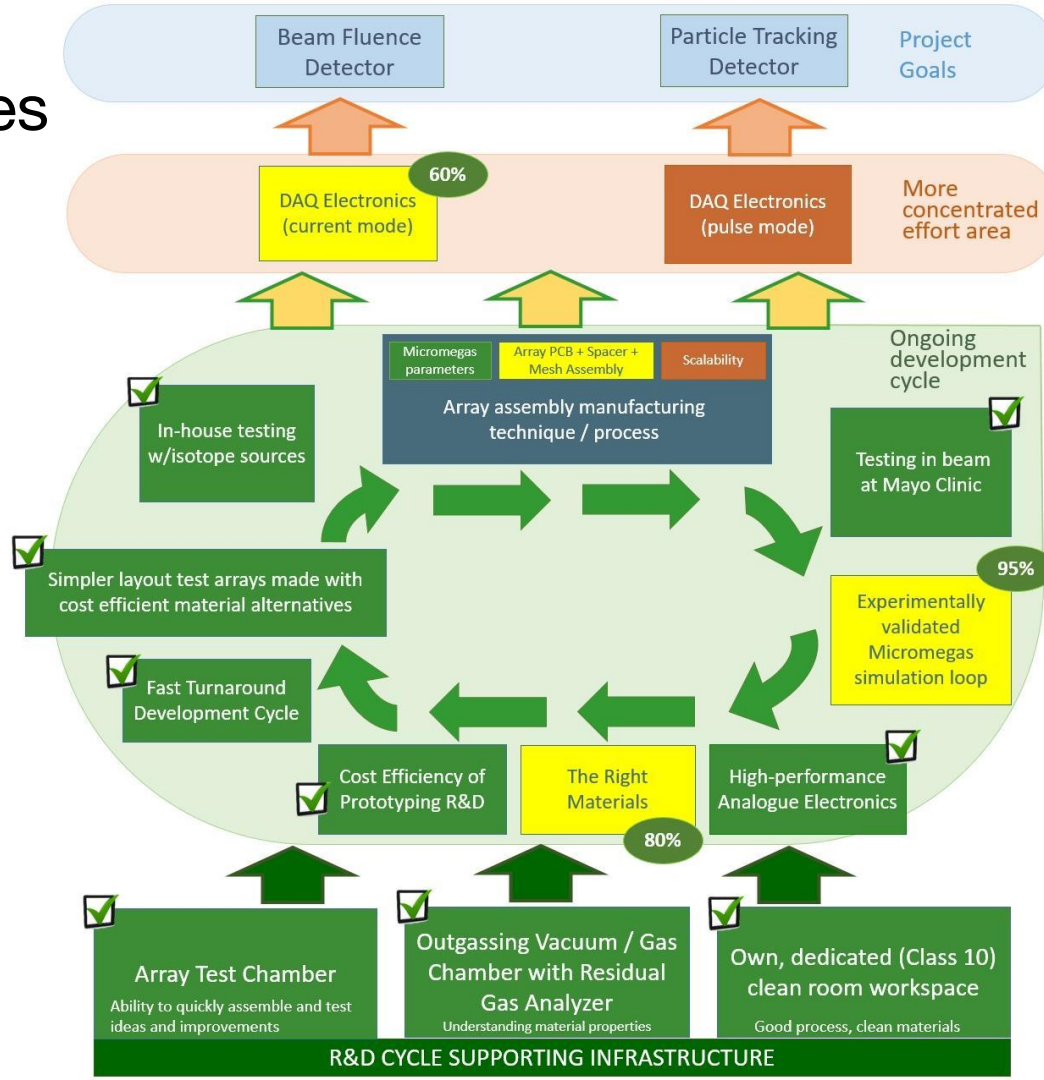
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To develop a cost-effective commercial MicroMegs (Micro-mesh gaseous structure) fluence detector with a high dynamic range of nearly 2^{12} , a position resolution of greater than 1 mm, and a radiation hardness able to withstand 300 kGy (~10 years clinical use).

RDI Capabilities



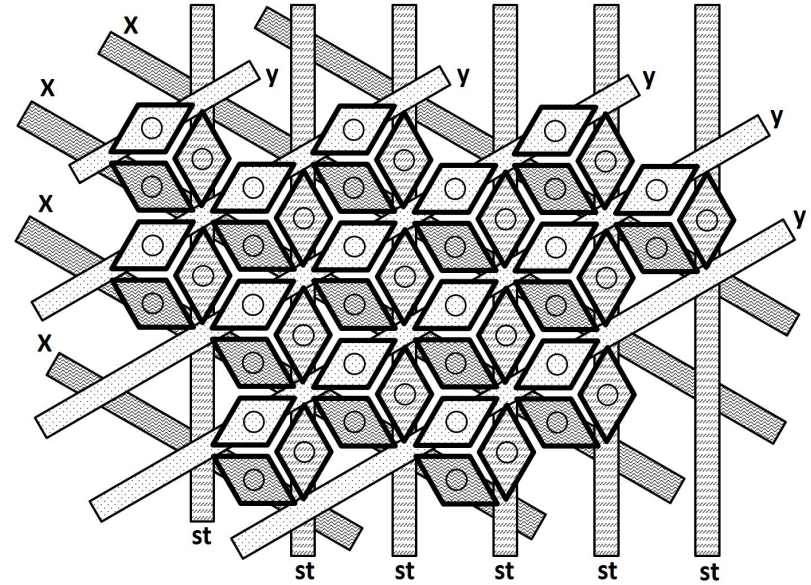
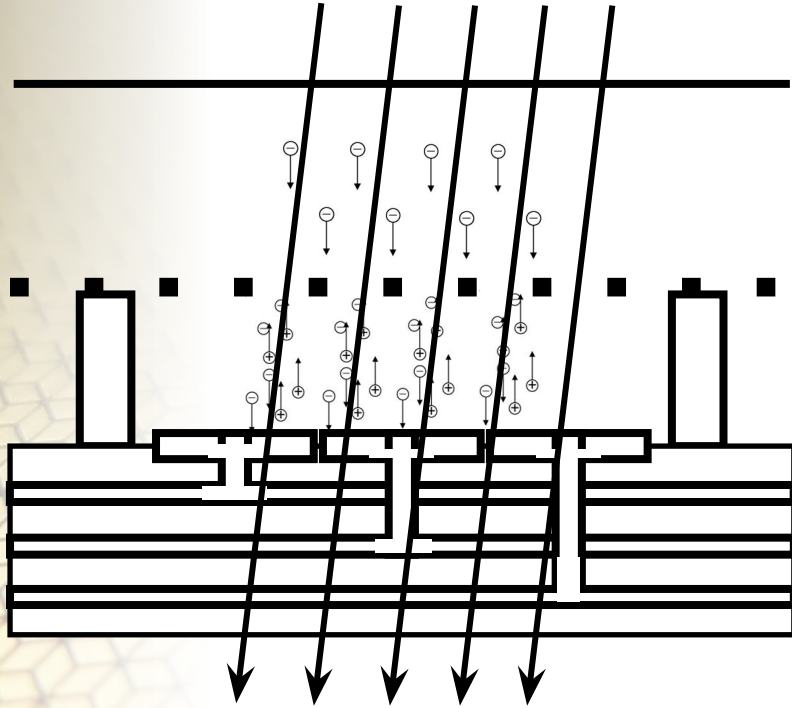
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RDI Capabilities

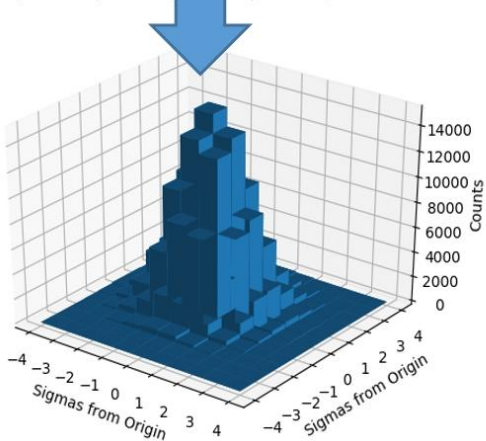
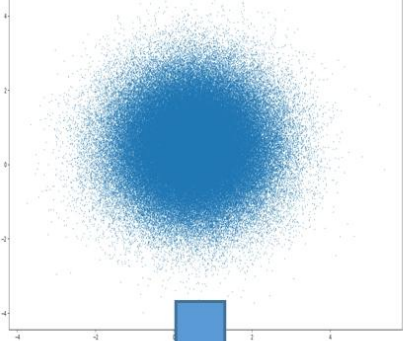


Micromegas

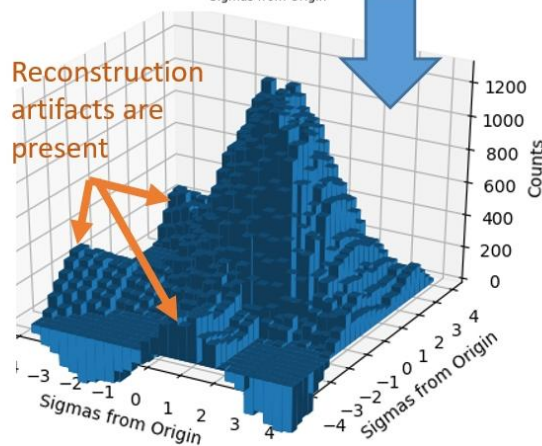
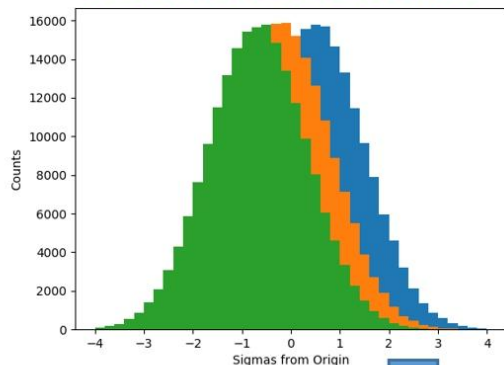


3D-Readout Imaging

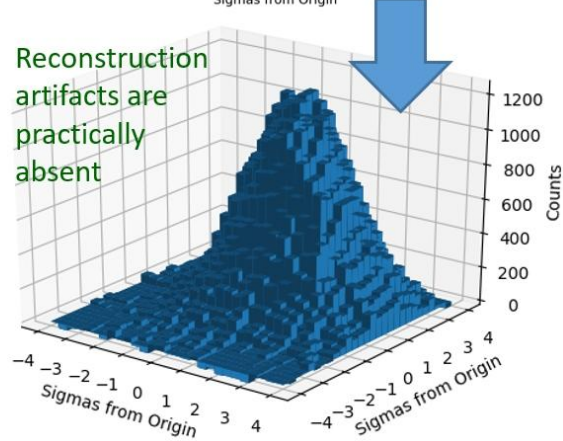
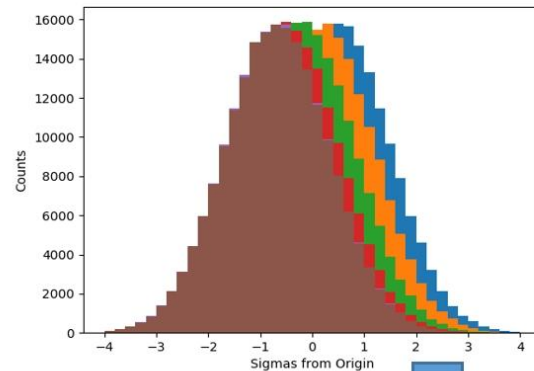
Original 'Gaussian' distribution
simulating beam intensity map



Projections as registered via 3
coordinate readout directions

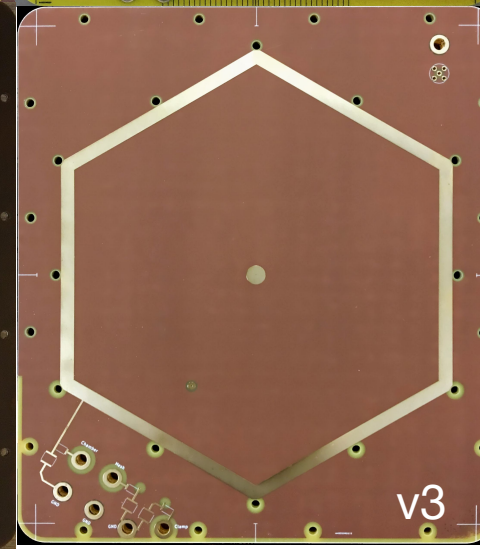
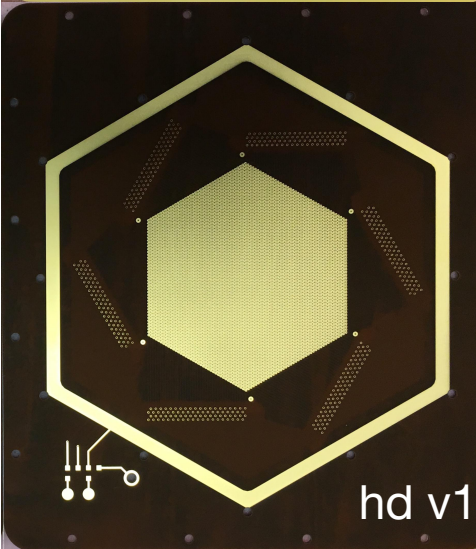
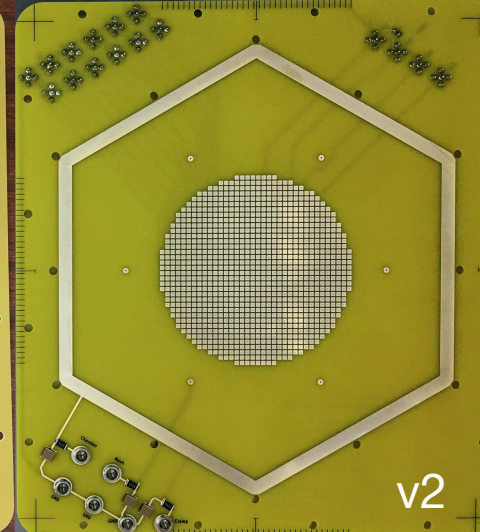
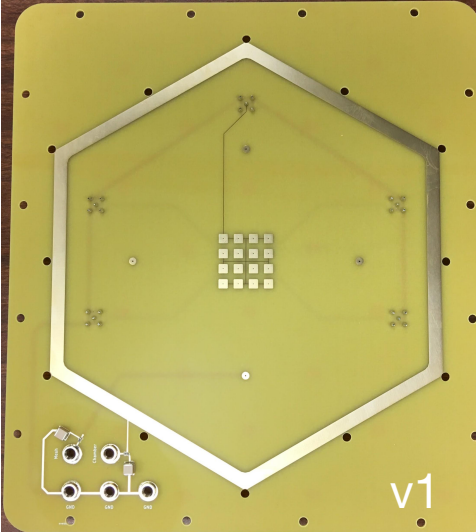


6 coordinate directions



Micromegas Array Designs

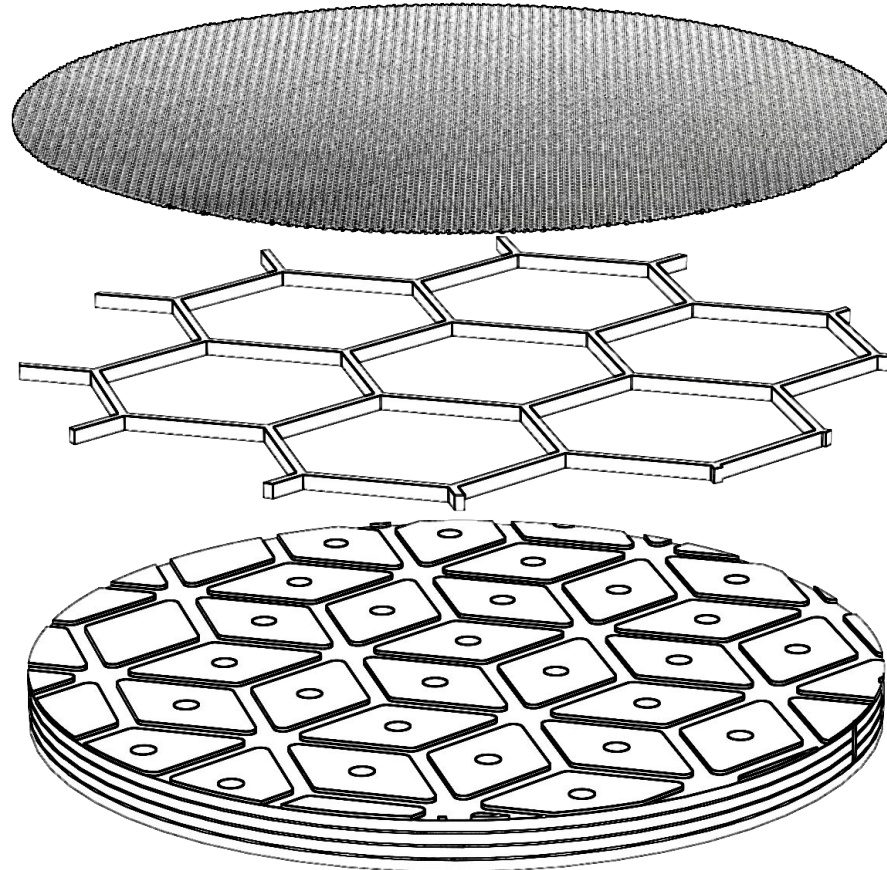
- high density (hd v1) and simple low-cost (v1-v3)
- simpler boards → rapid prototyping



Micromegas Build Process

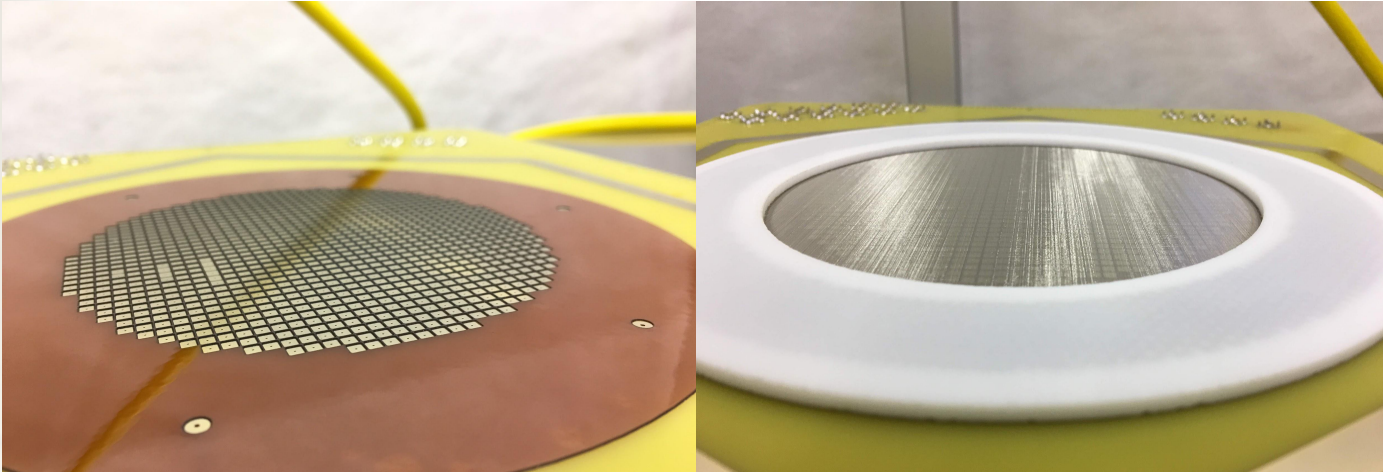


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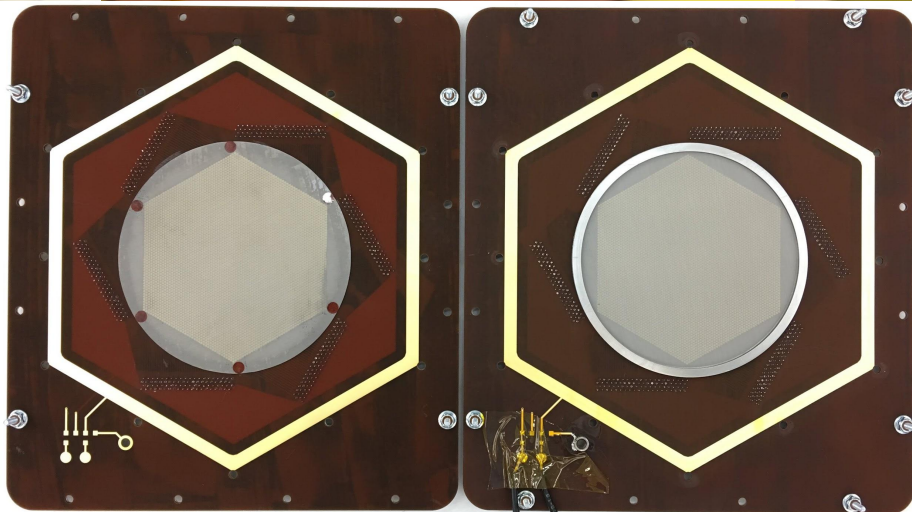


Micromegas Build Process

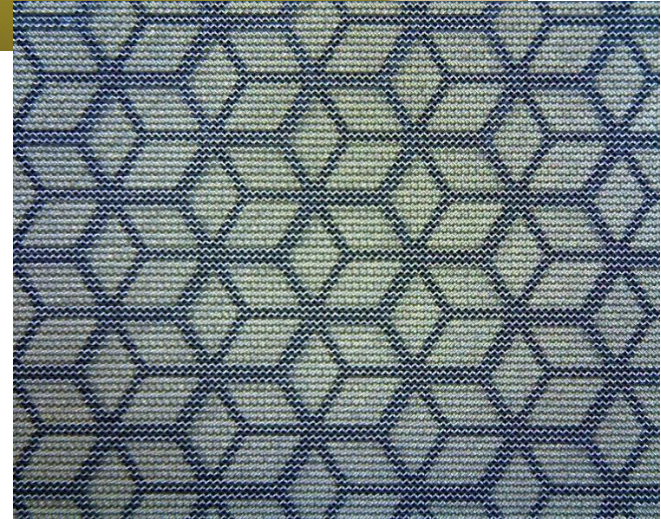
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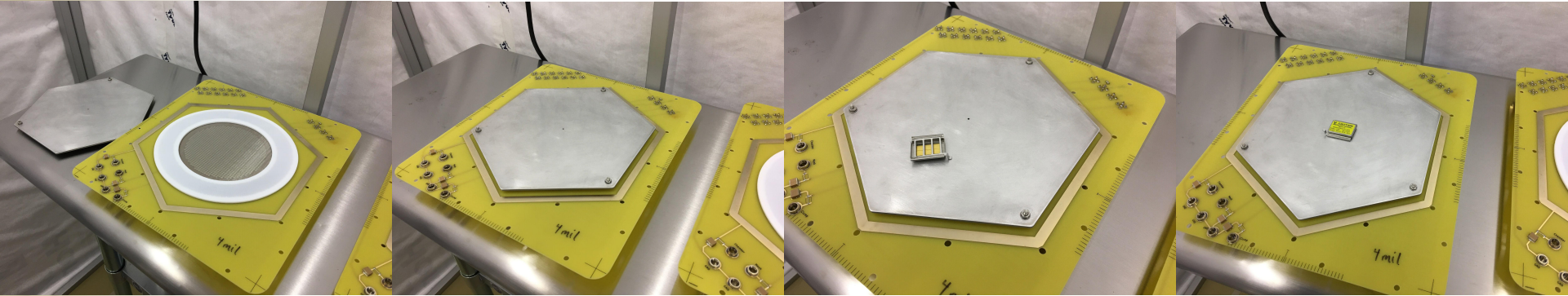
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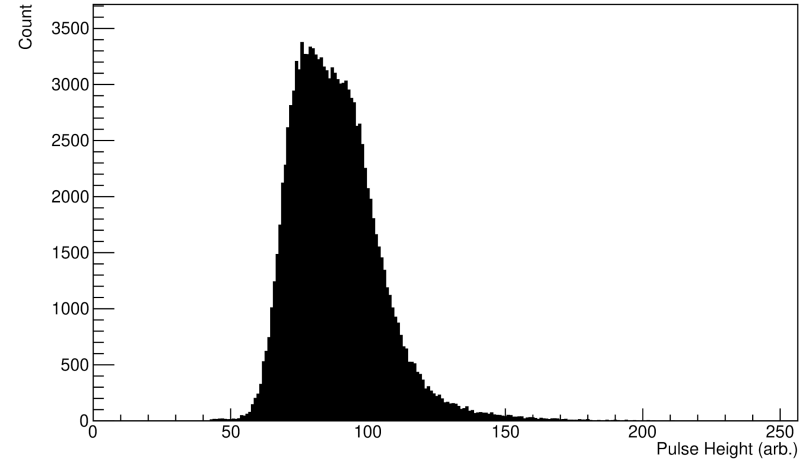
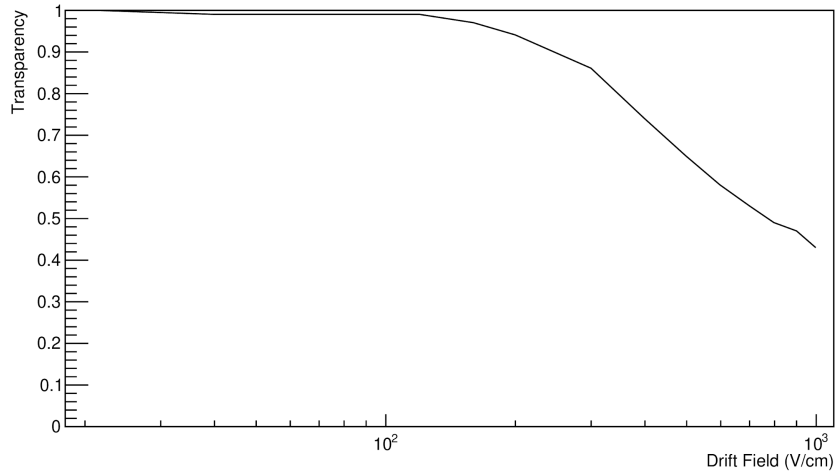
1



Source (Po-210) Testing

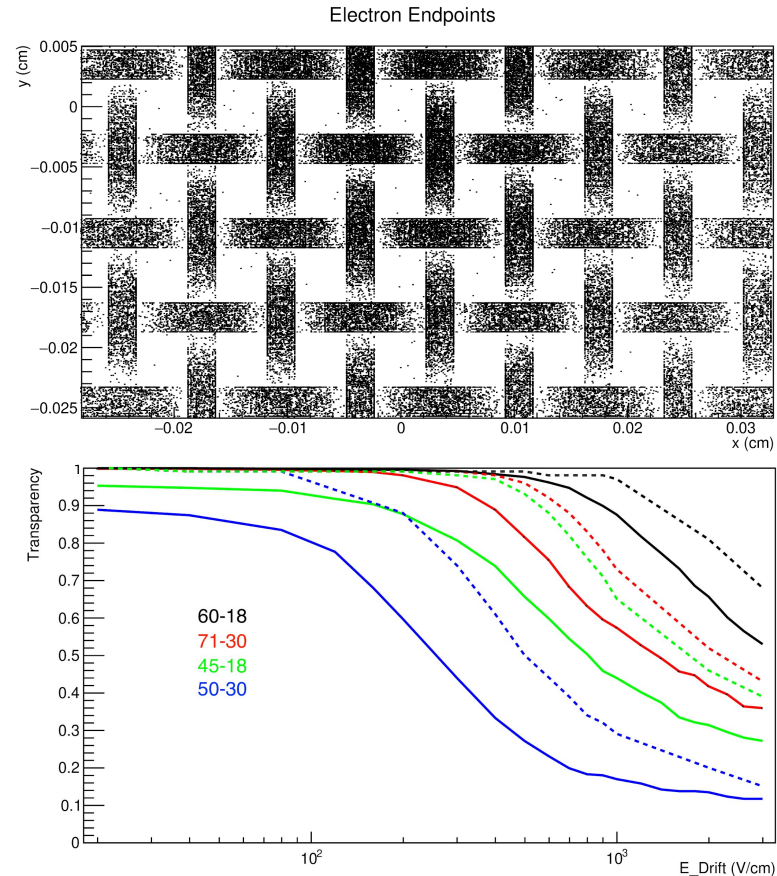


Simple Array v2 (4x4 pad, 68-22 mesh)



Physics Simulation

- Goal: To improve real detector designs through accurate simulation
- Garfield++ – simulation of tracking detectors, electrons
- Geant4 - the simulation of the passage of particles through matter
- OPERA - FEA multiphysics



Kuger et al, Mesh geometry impact on micromegas performance with an exchangeable mesh prototype

Mayo Clinic Testing

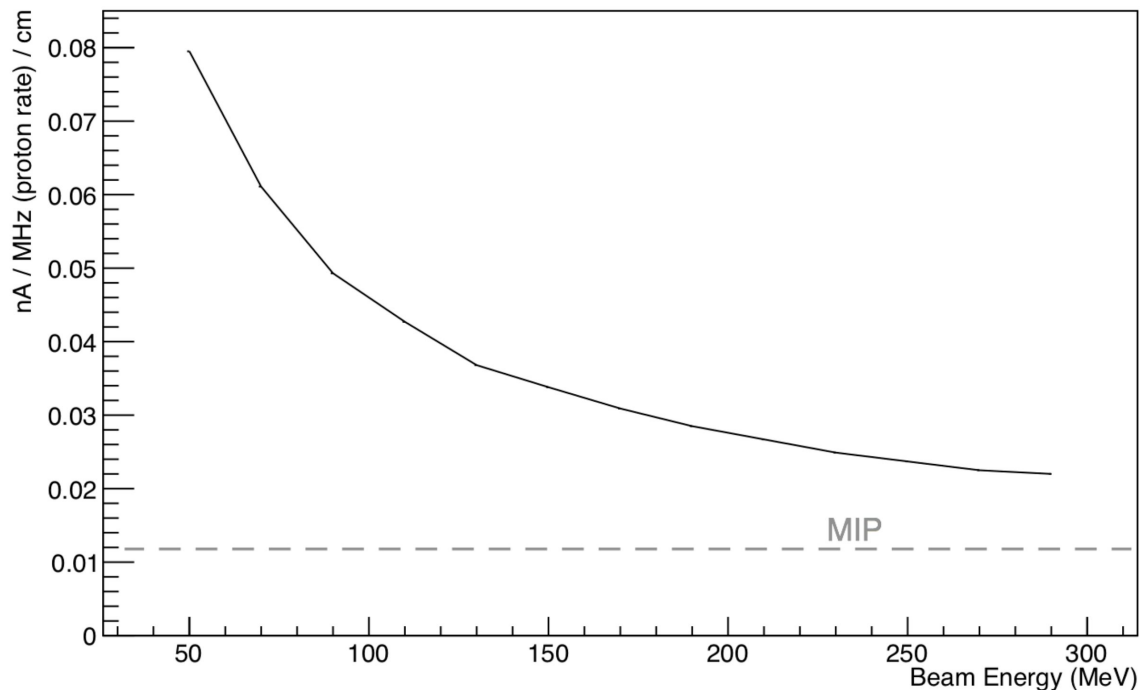
- Hitachi PROBEAT proton therapy system
- Synchrotron accelerator
- 71.3 MeV - 228.8 MeV
- Increments of about 2 mm depth in water
- Delivers beam in spots
- 5 ms, 10^7 protons



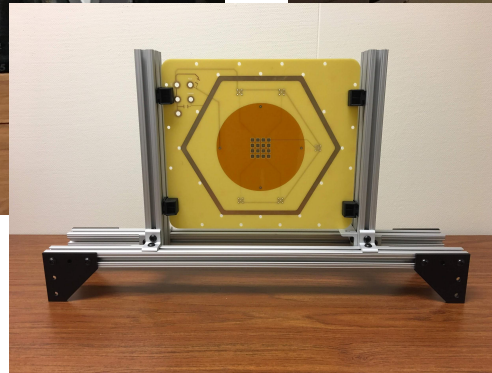
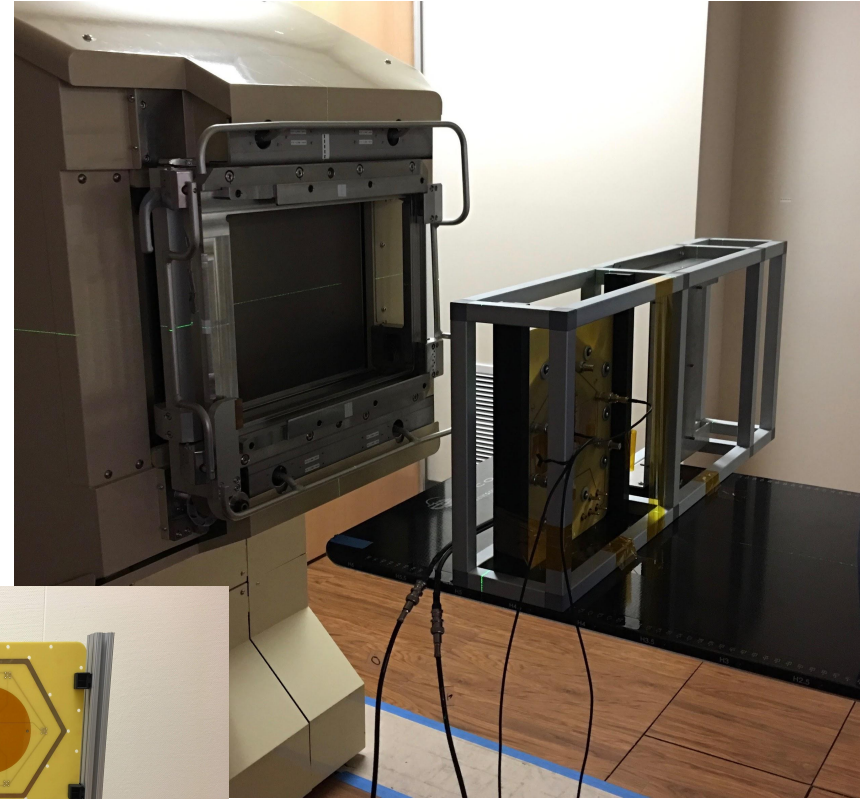
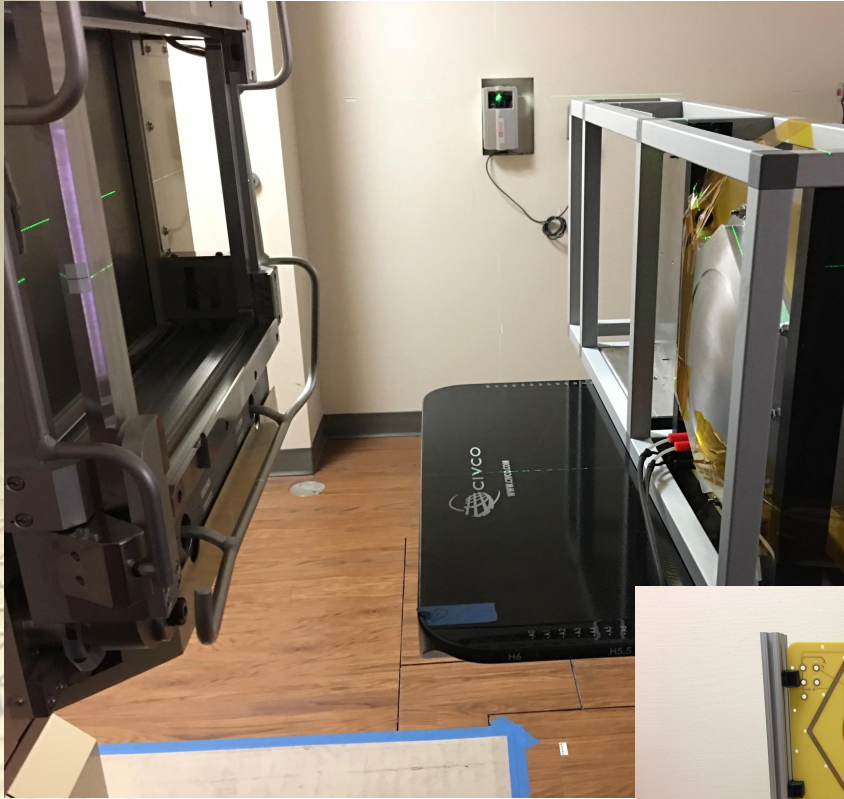
Mayo Clinic Testing

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Ionization Current for Argon-based Gas Detector in Proton Beam

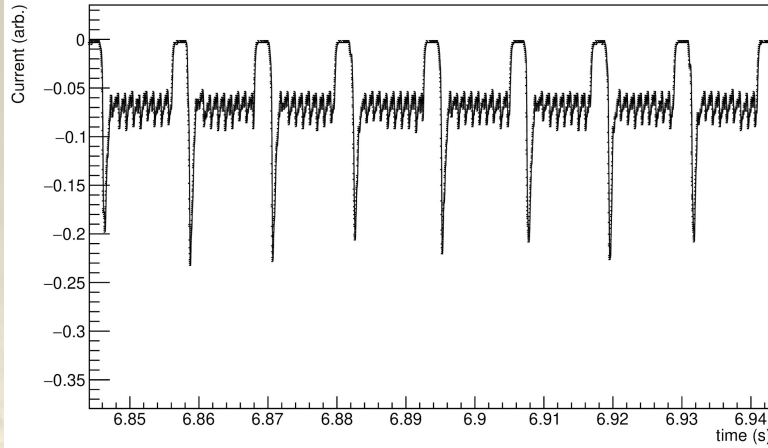


Mayo Clinic Testing

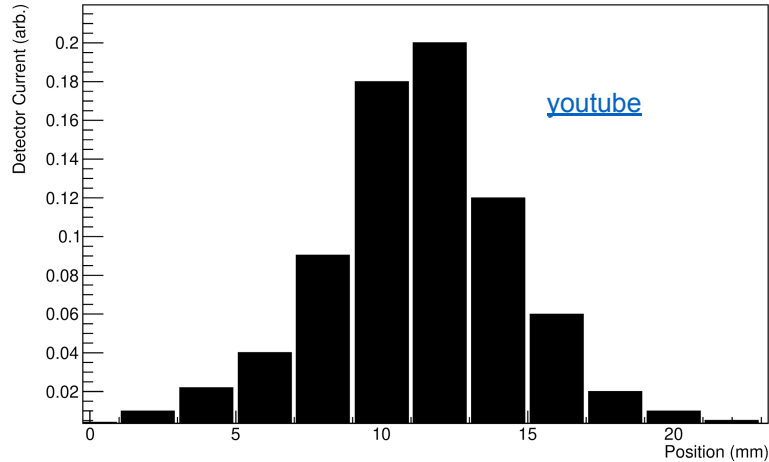
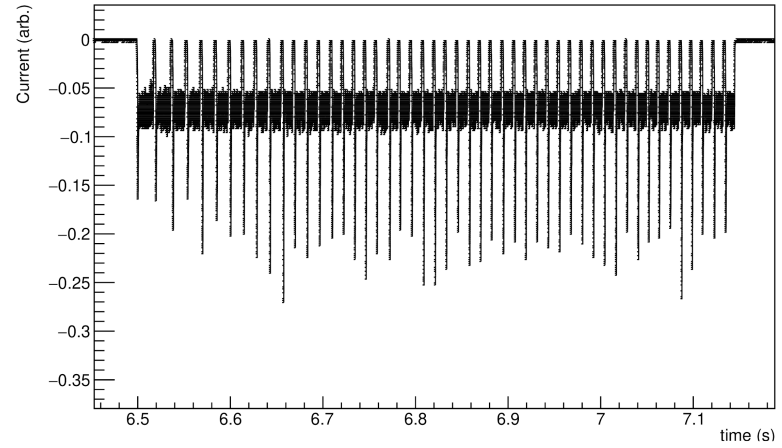


Mayo Clinic Testing

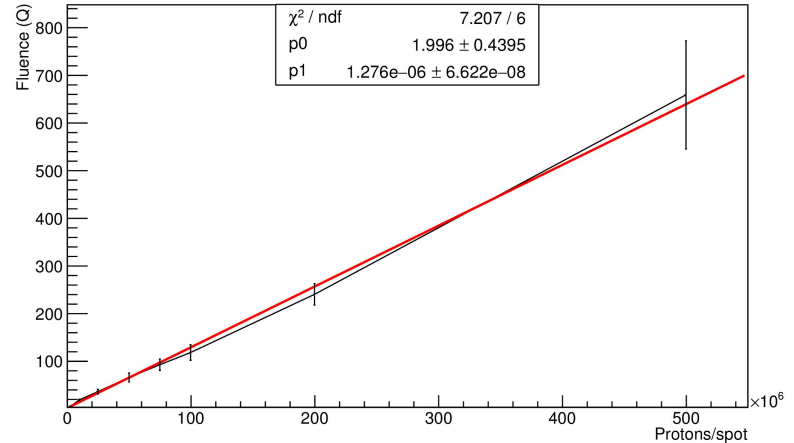
8 Spots



50 Spots

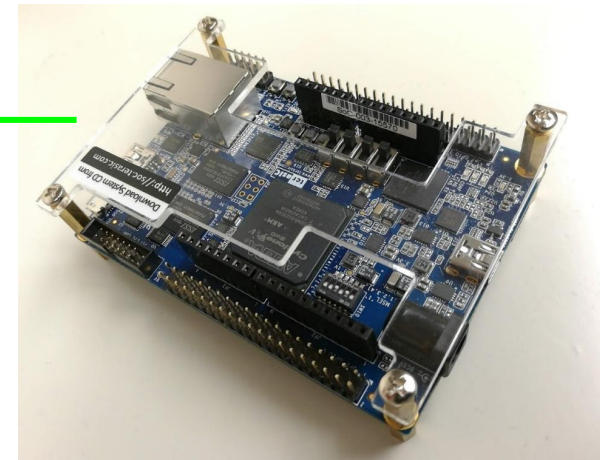
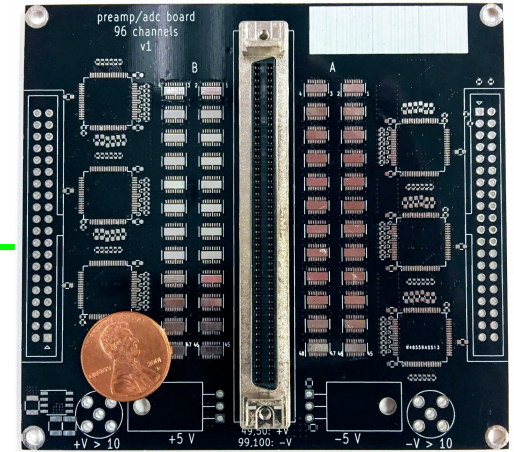
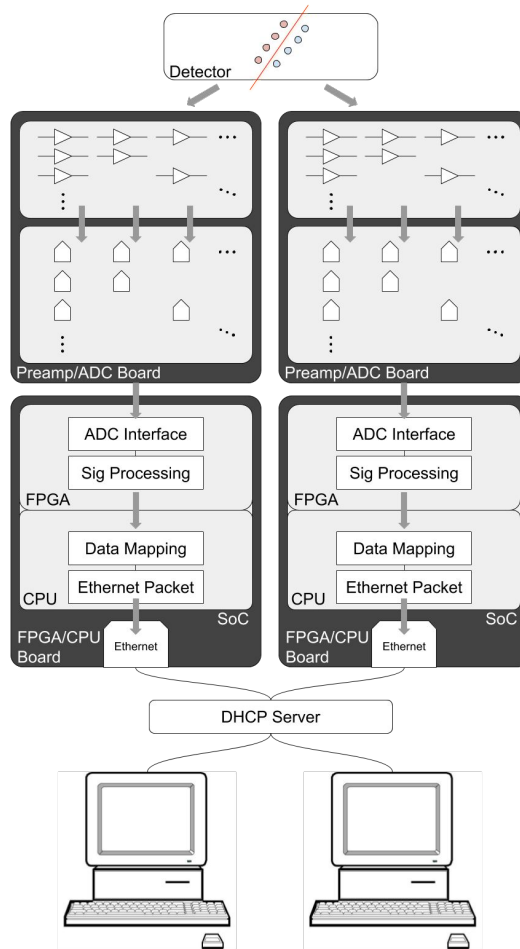


Micromegas Fluence Response to Proton Beam (PBS)



Data Acquisition

- Analog bandwidth is 10 kHz
- 18 bit depth ADCs
- Altera FPGA/CPU-based system
- 96 channels
- Future/ongoing work: merge boards



Nuclear Physics



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- New techniques for constructing Micromegas
- Studies underway with publishing plans to add to a more complete understanding of Micromegas for the scientific community
- Talks are underway with Olympus II collaboration on a new experiment that may be suitable for our detectors (trying to solve proton form factor measurement discrepancies).
- Ongoing search for more projects (suggestions welcome)







Summary

- New micromegas construction techniques are working and being optimized
- Beam tests have begun, early results are promising
- Complete simulation loop currently in verification stage
- Full imaging capable DAQ is in early stages of testing

Future

- Scalability of designs to as large as 40 cm x 40 cm.
- Pulse mode DAQ system
- Sell lots of these detectors
- Take over the world

A grid of six team member profiles, each with a photo, name, title, and a "Get In ..." button. The profiles are: Evgeny Galyaev (Founder and CTO), Jason Holmes (Principal Scientist), David Blyth (Consulting Scientist), Benjamin Fox (Research Associate), Rafael Acuna Briceno (Electronics Design Engineer), and Kevin Scheuer (Research Assistant).

 <p>Evgeny Galyaev Founder and CTO</p> <p>Get In ...</p>	 <p>Jason Holmes Principal Scientist</p> <p>Get In ...</p>	 <p>David Blyth Consulting Scientist</p> <p>Get In ...</p>	 <p>Benjamin Fox Research Associate</p> <p>Get In ...</p>
 <p>Rafael Acuna Briceno Electronics Design Engineer</p> <p>Get In ...</p>	 <p>Kevin Scheuer Research Assistant</p> <p>Get In ...</p>	<h1>Thank you!</h1>	

