



Galactic Cosmic Rays and Cloud Formation

Seeding the discussion toward a joint Climate-
Particle Physics effort to study cloud nucleation at a
US based accelerator facility

Points of Contact:

David Asner (PNNL - particle physicist)

david.asner@pnnl.gov

Alex Guenther (PNNL – atmospheric scientist)

alex.guether@pnnl.gov

Cosmic Rays from Space Ionize Atmospheric Molecules

Interest to Particle Physics for fundamental studies of the Universe

Interest to Atmospheric Science because of influence on Atmosphere

- ▶ Particle Physics detectors like cloud chambers use the principle of cloud seeding to study particle tracks
- ▶ Accelerator based Particle Physics experimental sites have elementary particle beams that allow experimental studies of particle induced phenomena
- ▶ Simulation algorithms and codes developed over the years for particle tracking can be adapted for non particle physics environments.
- ▶ Vacuum technology (Particle Physics) may help design Atmospheric Experiments

SYNERGY I: Cosmic Rays from Space Ionize Atmospheric Molecules

Elementary Particle Physicists

- ▶ Have studied cosmic rays for decades
- ▶ Well established data of fluxes, energy loss and ionization channels
- ▶ Well established models and simulation codes for passage through the atmosphere and different media

Atmospheric Science

- ▶ Ionization of atmospheric molecules by Cosmic rays
- ▶ Possible influence of cosmic ray particles on ion population in the atmosphere
- ▶ Related possible effects on cloud nucleation
- ▶ Possible relation of these effects on composition and spectra of cosmic rays

<http://www.auger.org/> (Pierre Auger Observatory)

Synergy II: Cloud Chambers

Elementary Particle Physics

- ▶ One of the earliest particle physics detectors – developed around 1912
- ▶ Uses cloud formation along ionization trail of charged particle to detect and identify elementary particles
- ▶ Now overtaken by sophisticated advanced detectors and electronics but expertise remains

Atmospheric Science

- ▶ Since the principle uses cloud formation along ionization path of particles – it mimics the atmosphere as an environment
- ▶ European Experiments recently used particle physics Laboratory resources and expertise to design cloud nucleation experiments
- ▶ Would additional interdisciplinary efforts yield new science opportunities?

Synergy III

Particle Physics Experimental Sites

Elementary Particle Physics

- ▶ Accelerator based particle physics experimental facilities develop precision particle beams that include common components of atmospheric cosmic rays like protons, pions, and muons
- ▶ Energies and fluxes of these beams can be controlled.

Atmospheric Science

- ▶ Use of such controlled cosmic ray components may allow precision studies of atmospheric conditions
- ▶ Examples: CERN CLOUD Experiment, others?

<http://home.web.cern.ch/about/experiments/cloud>

Synergy IV

Vacuum Technologies

Elementary Particle Physics

- ▶ Particle physics experiments and accelerator technology use sophisticated vacuum technology and 'Clean Room' environments for precision experiments

Atmospheric Science

- ▶ These technologies were recently used in the CERN Experiment

<http://connect.physicsworld.com/categories/vacuum-technologies/201005.category>

Understanding the broader impact of particle physics and developing scientific connections is part an ongoing decadal

- ▶ The High Energy Physics Advisory Panel (HEPAP) advises the Federal Government on the national program in experimental and theoretical high energy physics (HEP) research that is funded by both DOE and NSF. Recently, a Particle Physics Project Prioritization Panel (P5) has been formed to synthesize the output of the recent decadal HEP community planning exercise and budget scenarios to update the strategic plan for U.S. High Energy Physics for next 10 years.
- ▶ In parallel to this process P5 and DOE-SC-HEP is assessing the broader impacts of HEP on science and technology and considering connections with and opportunities for collaboration between SC offices as well as other government agencies and industry.
- ▶ A panel tasked by HEP is working on such connections and seeks input on potential Cloud Nucleation Experiments at US based Particle Physics experimental facilities.

More details on the requested White Paper

- ▶ As additional input for this panel study, a white paper would be valuable before the end of January 2014
 - Additionally, a few slides and a paragraph or two of text in advance of the December 15-18 P5 meeting at Brookhaven would be helpful
- ▶ The white paper should address
 - the synergies between climate science supported by BER and particle physics research supported by HEP
 - scientific achievements of the CLOUD experiment
 - expected scientific reach of the CLOUD experiment in the future.
 - What science remains to be done?
 - How could the CLOUD experiment be improved?
 - Describe the US community engaged in Cloud Formation research
 - Opportunity for US based researchers to lead the scientific program
- ▶ The audience for this white paper includes program managers at DOE-SC-BER, DOE-SC-HEP, NSF, the program advisory committee (PAC) of Fermi National Accelerator Laboratory (FNAL) and other US based accelerator labs, P5, HEPAP and presumably BERAC.

► Points of Contact:

- David Asner – PNNL Research Manager for HEP david.asner@pnnl.gov
- Alex Guenther – alex.guether@pnnl.gov
- Gary Geernaert, Division Director, BER Gerald.Geernaert@science.doe.gov
- Lali Chatterjee, Program Manager, HEP Lali.Chatterjee@science.doe.gov