

High Energy Experimental Physics at UIUC

Who?

▶ HEPG Experiment

- Debbie Errede: CDF/MuCool
- Steve Errede: ATLAS/CDF
- Bob Eisenstein: CLEO
- George Gollin: CLEO/Linear Collider
- Lee Holloway: LSST/LIGO
- Inga Karliner: CLEO/Physics Education & Outreach
- Tom Junk: (ATLAS)/CDF
- Tony Liss: CDF/(LSST)
- Kevin Pitts: CDF
- Mats Selen: BTeV/CLEO
- Jon Thaler: CLEO/LSST
- Jim Wiss: BTeV/FOCUS

▶ HEPG Post Docs

- Chris Cawfield (CLEO)
- Lucio Cerrito (CDF)
- Catalin Ciobanu (CDF)
- Doris Kim (FOCUS/BTeV)
- Hyunsoo Kim (CDF)
- Kyoko Makino (MuCool)
- Kevin Paul (MuCool)
- Anyes Taffard (CDF)
- Greg Veramendi (CDF)

▶ HEPG Grad Students

- Michael Bates (Liss)
- Zachary Conway (D. Errede)
- Ulysses Grundler (Liss)
- James Kraus (Pitts)
- Kevin Lannon (S. Errede)
- Suzanne Levine (Pitts)
- Norman Lowrey (Gollin)
- Chris Marino (Pitts)
- Paras Naik (Selen)
- Chris Sedlack (Selen)
- Trevor Vickey (S. Errede)
- Jeremy Williams (Gollin)

▶ HEPG Engineering

- Mike Haney
- Mike Kasten
- Todd Moore
- Viadas Simaitis (25%)

▶ HEPG Computing

- Dave Lesny
- Larry Nelson

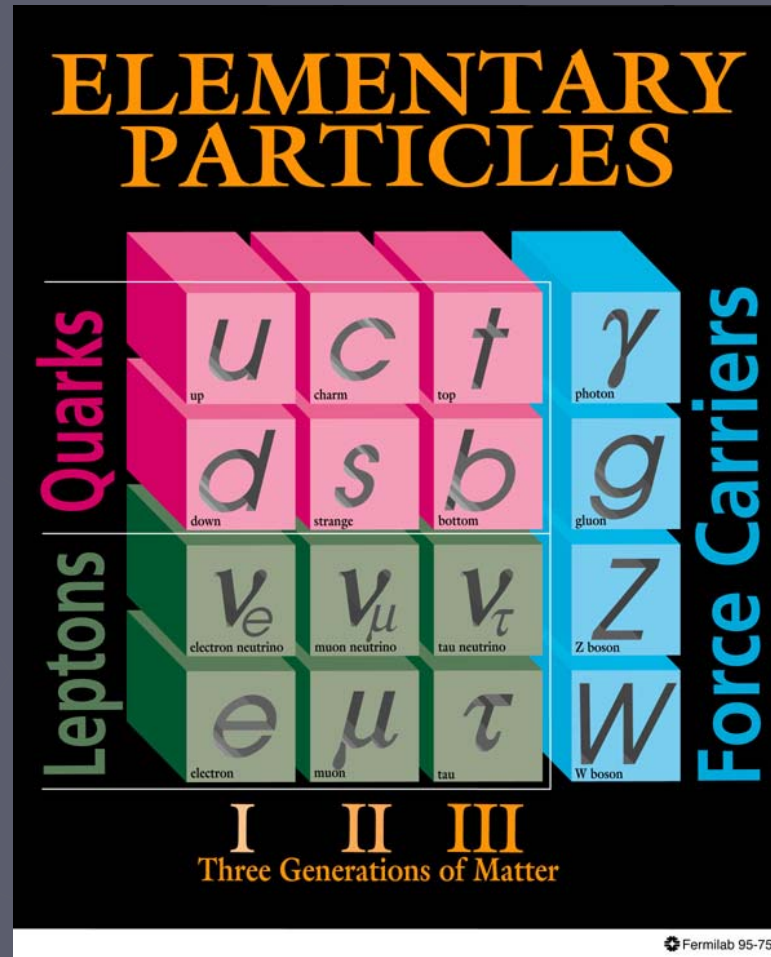
▶ HEPG Technicians

- Derek Duzan
- Dave Forshier
- Harold Scott
- Allison Sibert

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& IBHE/ICAR

What?

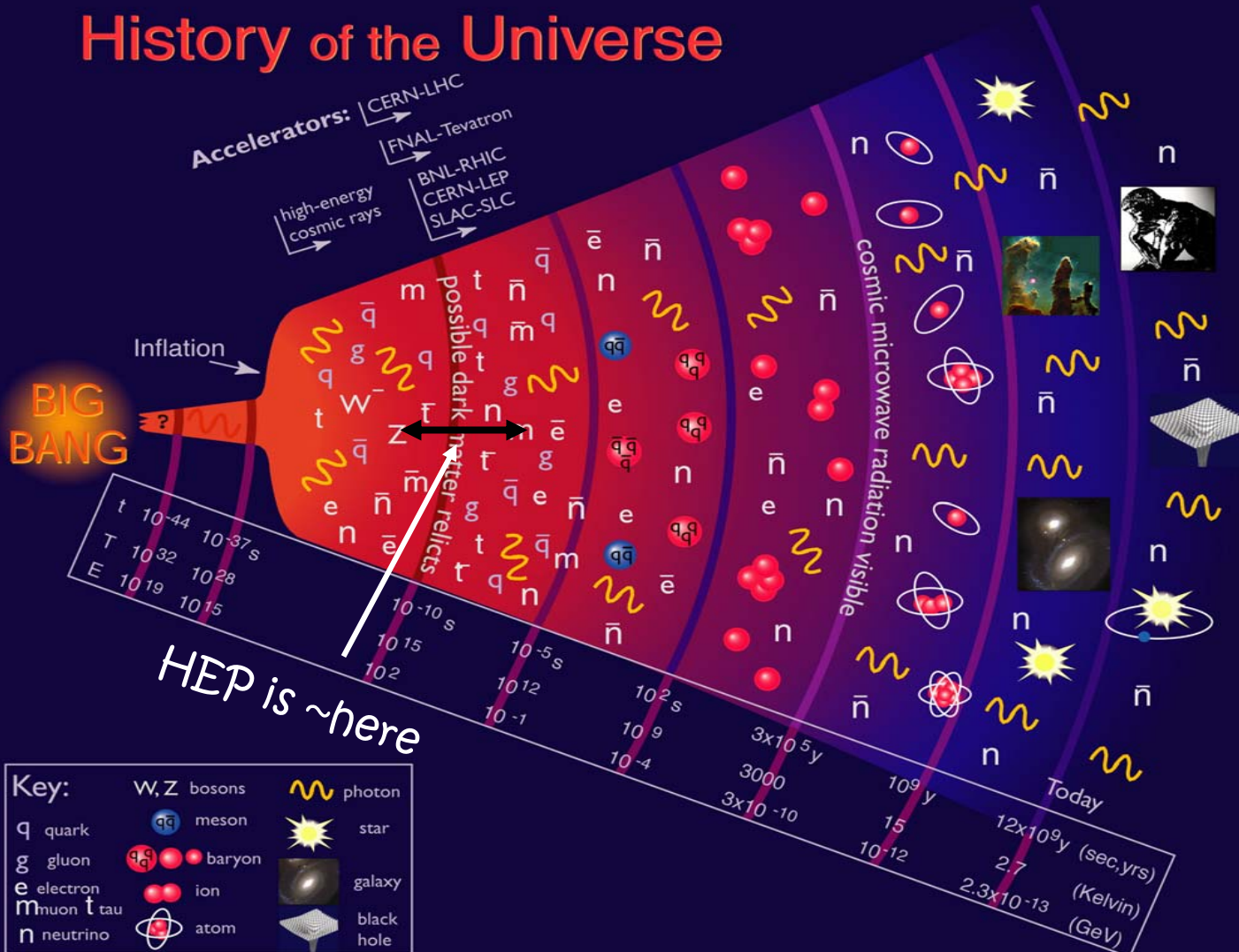
What the universe is made of (so far...):



And what holds it together

Why?

History of the Universe



Big Questions

- ▶ What is the origin of mass (or why is the top quark so heavy and the electron so light?)?
 - Higgs boson?
- ▶ What is the PBSM (Physics Beyond the “Standard Model”)?
 - Neutrino mass, for starters (but there’s no theory!)
 - Supersymmetry?
 - Something else?
- ▶ Why is the Universe made of matter?
 - CP violation (is it SM, or PBSM?)
 - CP violation in the lepton sector?
- ▶ Where does gravity fit in?
 - String theory? Extra dimensions?

Answering the questions (or trying to)

- ▶ **Experiments at the energy frontier**
 - Direct production of new particles
- ▶ **Precision experiments at lower energies**
 - Observation of indirect effects of new physics
- ▶ **Non-accelerator experiments**
 - Observation of cosmological effects of new physics
 - ▶ Dark matter
 - Direct observation of new particles (but the rates are *really* small in most cases)
 - ▶ What is dark matter?
 - Surveys of the universe with things *other than photons*.
- ▶ **Neutrino experiments**
 - A class by themselves – Not at the energy frontier, not really precision exp. either. Some accelerator, some non-accelerator.

Where is UIUC

✓ =UIUC involvement

▶ The Energy Frontier

- Fermilab (CDF & D0) until ~2007 ✓
- LHC (ATLAS & CMS) 2007 - ? ✓

▶ The precision frontier

- BaBar & Belle – physics of bottom quarks ✓
- CLEO/Focus – physics of charm quarks ✓
- CDF – Physics of bottom & charm ✓
- BTeV ~2009 – physics of bottom quarks ✓
- LHC-B ✓
- Linear Collider (maybe) ✓

▶ Neutrino masses and mixing

- Accelerator experiments at FNAL and CERN
- Solar neutrinos
- Neutrino-less double β decay (underground exps.)

▶ Non-Accelerator Experiments

- SDSS
- GLAST
- SNAP
- LSST ✓
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- ▶ Two basic criteria drive the experiments in which our group participates: They must address fundamentally important questions and we must be in a position to make a major contribution to the experiment.

HEPG Strengths

- ▶ Building big detector components (not many University groups can do this)
 - CDF muon system & central drift tubes
 - FOCUS muon system
 - ATLAS Tile Calorimeter
- ▶ Trigger/DAQ/control systems
 - CLEO Trigger, Si power, Si software
 - CDF Trigger and front-end electronics

Incomplete List of Leadership Positions

▶ CLEO

- Thaler: Spokesman (2000?)
- Selen: Head of CLEO trigger (likely CLEO spokesman next year)

▶ CDF

- Analysis group conveners (S. Errede, D. Errede, Holloway, Liss, Pitts)
- Pitts: "Trigger & Dataset" working group leader, Run 2b Trigger upgrade leader.
- Liss: Physics Coordinator

▶ OPAL

- Junk: Higgs working group leader

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► Current Experiments

- CDF at Fermilab (D. Errede, S. Errede, Junk, Liss, Pitts)
 - At the energy frontier: Higgs search, physics beyond the SM, physics of the top quark.
 - Precision bottom quark, electroweak (W,Z boson), QCD physics.
- CLEO at Cornell (Gollin, Karliner, Selen, Thaler, Eisenstein)
 - Precision bottom, charm quark and tau lepton physics: precision SM measurements, searches for physics beyond the SM.
- FOCUS at Fermilab (Wiss)
 - Precision charm quark physics: precision SM measurements, searches for physics beyond the SM.

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► Future Experiments in Progress

- ATLAS at CERN's Large Hadron Collider (LHC) (Errede, Junk)
 - Near the end of the decade the LHC in Geneva, Switzerland will take over as the world's highest energy machine. This will provide the continuation of our physics program at the energy frontier for the foreseeable future.
- BTeV at Fermilab (Selen, Wiss)
 - This experiment will study the physics of bottom quarks with ultra-high precision. It will start taking data near the end of the decade. It provides a continuation of the group's precision measurements away from the energy frontier.
 - UIUC has key role in muon system:
 - Mechanical design & construction
 - Trigger electronics

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▶ Longer Term Efforts

- Future Accelerator R&D

- ▶ MuCool experiment at Fermilab (D. Errede)

- R&D for a future muon collider/neutrino factory (at FNAL)

- ▶ Linear Collider R&D (Gollin)

- An electron-positron linear collider in the TeV energy range is the consensus choice for the next new accelerator facility after the LHC.

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► New Directions

- The Large Synoptic Survey Telescope (LSST) (Holloway, Karliner, Liss, Thaler)
 - UIHEP (+Astronomy/NCSA) is joining the LSST project, currently in the design phase, which will make the first 3-d map of the distribution of dark matter in the universe. To this project we will bring our expertise from HEP in very large, fast, data acquisition systems.
- National Underground Laboratory (?)
 - Plans to build a very large underground facility are underway. Such a facility would be a site for experiments that require very low backgrounds from cosmic rays and/or a very large target mass provided by the earth. Neutrino physics experiments are a prime example.

Conclusions

- ▶ The next 10 years in HEP will be very exciting
 - Between the experiments at the energy frontier and the precision experiments at lower energy, tremendous progress *will* be made. For example:
 - ▶ We will know if there is a SM Higgs
 - ▶ We will know if the observed CP has its origins in SM or PBSM
 - ▶ We will either find evidence of SUSY or rule out the most attractive models.
 - ▶ We will know *much much* more about neutrinos.
 - ▶ With the energy frontier increasing by (almost) 10x we'll have a great shot at what is "not yet thought of".
 - The synergy between HEP and astro will be more and more important, and we will be there.
 - ▶ Mapping dark matter
 - ▶ Directly searching for dark matter at accelerators
 - ▶ Searching for new sources of CP violation to explain the matter/antimatter asymmetry
 - ▶ ...

Conclusions

- ▶ UIUC HEP experiment is in a strong position to be a major contributor to these advances
 - 8 tenured/tenure-track faculty
 - ▶ 2 assistant profs
 - Size matters
 - ▶ The experiments are big, to be a major contributor requires a big commitment. So far we have been very successful at this.
- ▶ There is great synergy between HEP experiment and theory
 - Willenbrock: Higgs/top, PBSM
 - El-Khadra: Lattice QCD (charm/bottom physics)
 - Stack -> SUSY
 - Leigh/Katz: Strings – no direct connection yet...
