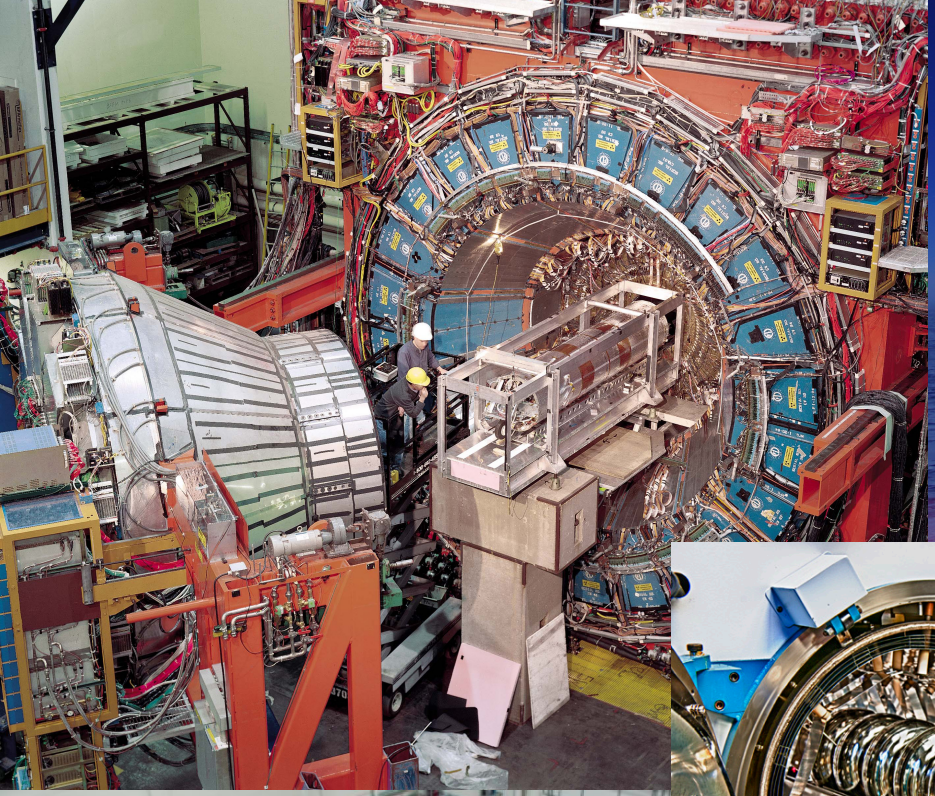
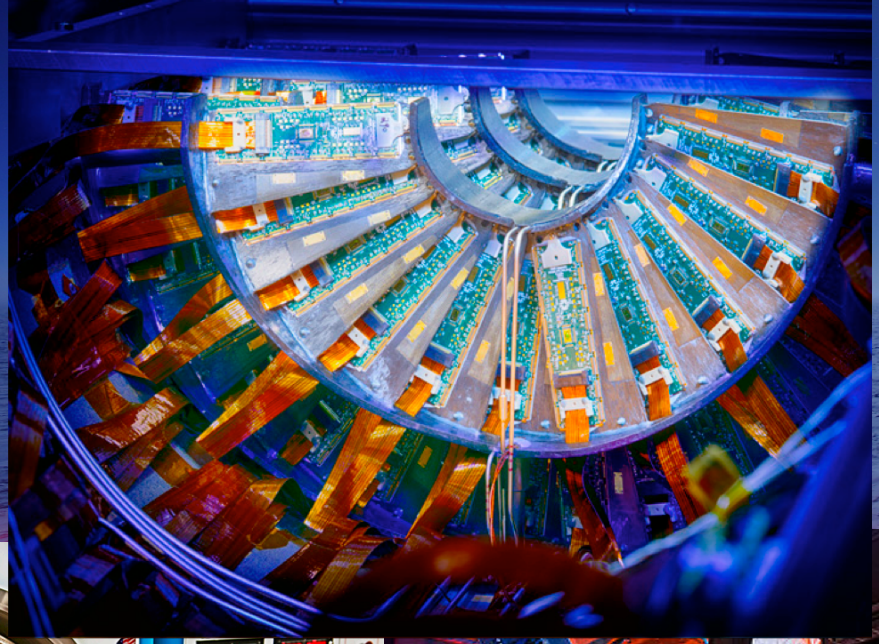
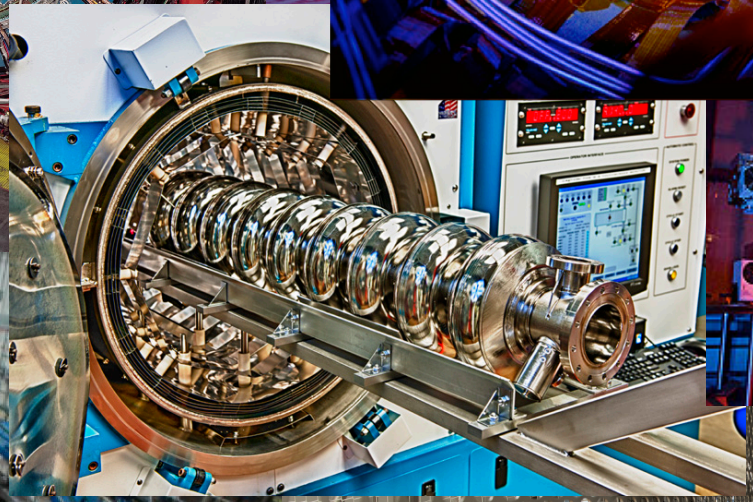
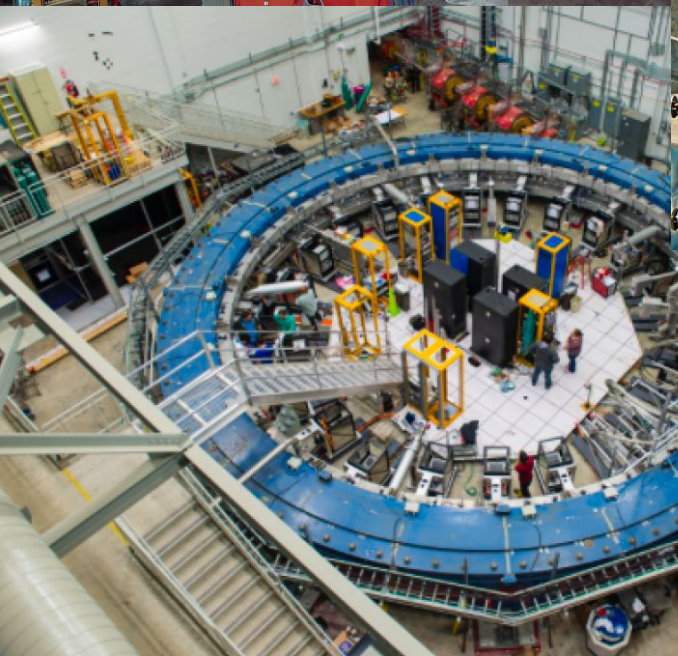
Welcome to EDIT@Fermilab

Petra Merkel – Detector R&D



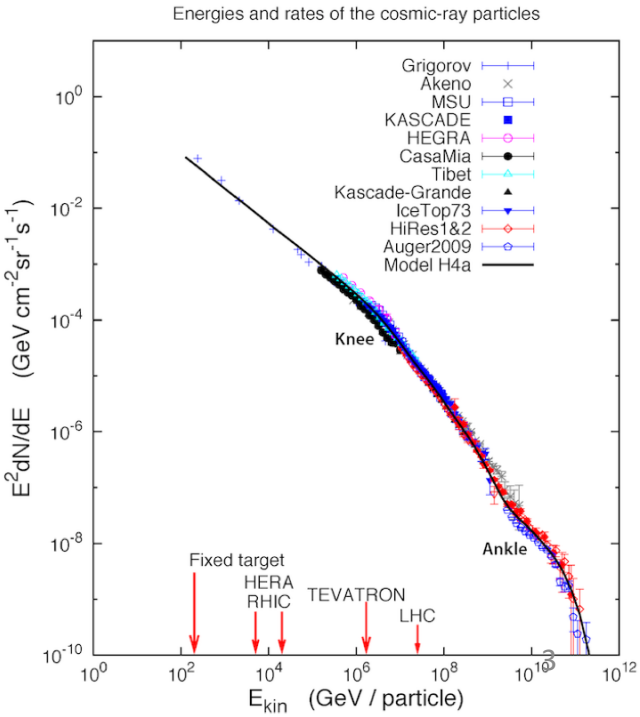
The spectrum of particle detection in HEP

- Energy regimes:
  - < 1 meV: ν masses & axions: STJ, MMC
  - 1 eV: astrophysics photometry: CCD, MKID
  - 1 KeV: X-ray physics; dark matter: TES, Pixel Arrays,
  - 1 MeV: Solar/supernova ν : Water cerenkov, Liquid Scint.
  - 1 GeV: ν osc., rare decays: LAr, GEMs
  - 1 TeV: Colliders EW, SUSY: Silicon tracker, calorimetry
  - > 1 EeV: Cosmic rays: Ground arrays, satellites

>18 orders of magnitude !!

- Particles exhibit dramatically different properties:
  - Photon, electron, proton, kaon, neutron, muon, eta, B mesons, neutrino, pi0, pentaquark, etc.

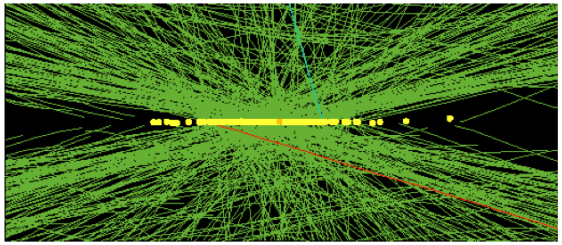
- Because of this range, the field has had a rich tradition of detector innovation and development.



What challenges do we face now, and foresee in the future?

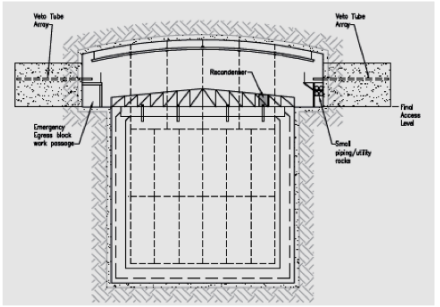
Collider detectors:

- Vertex sensors that can withstand an extremely high radiation environment, with 200 events per 25 nsec crossing
- Innovative triggering at level 1 to keep up with the flood of data
- New calorimeter designs with high degree of pixelation and potentially fast timing
- Common ideas for lepton collider?



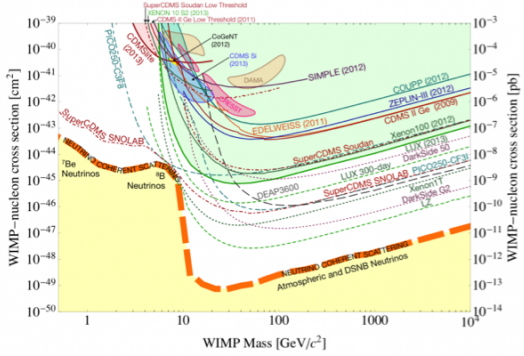
Neutrino detectors:

- Very high mass, high-performance, low cost liquid Argon or water cerenkov for beamline neutrino detection
- Low background and very high resolution double beta decay detectors
- Detection of coherent neutrino/nucleus scattering



Astrophysics detectors:

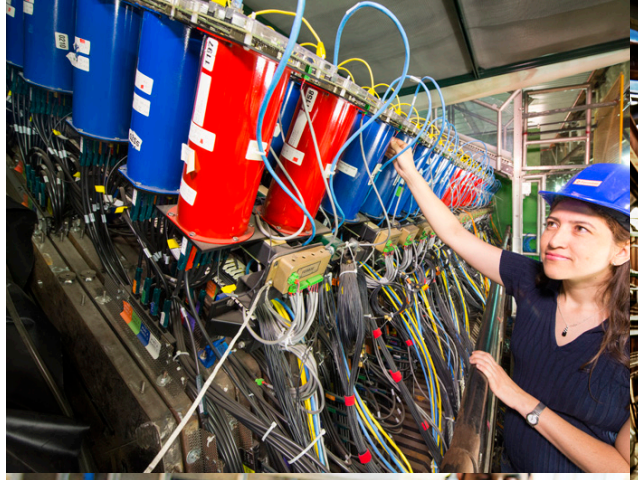
- Dark matter detectors with ultra-low background
- Directional detectors for weakly interacting particles.
- Huge scale up of sensor count for CMB polarization
- Innovations in axion detection
- Detection of relic neutrinos, at milli-eV energy

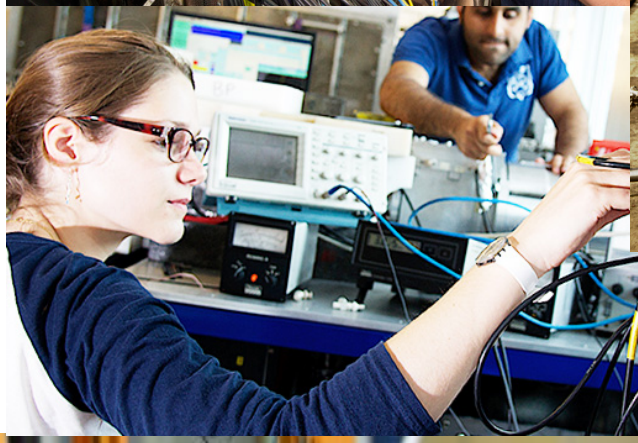
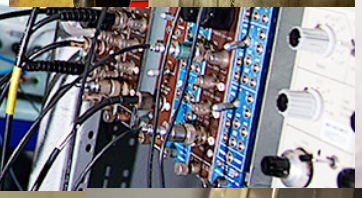


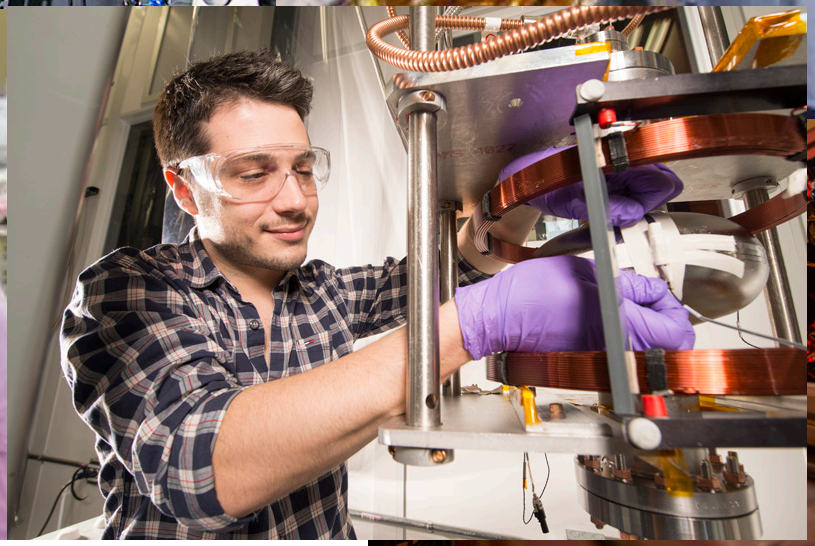
Improvement in Performance

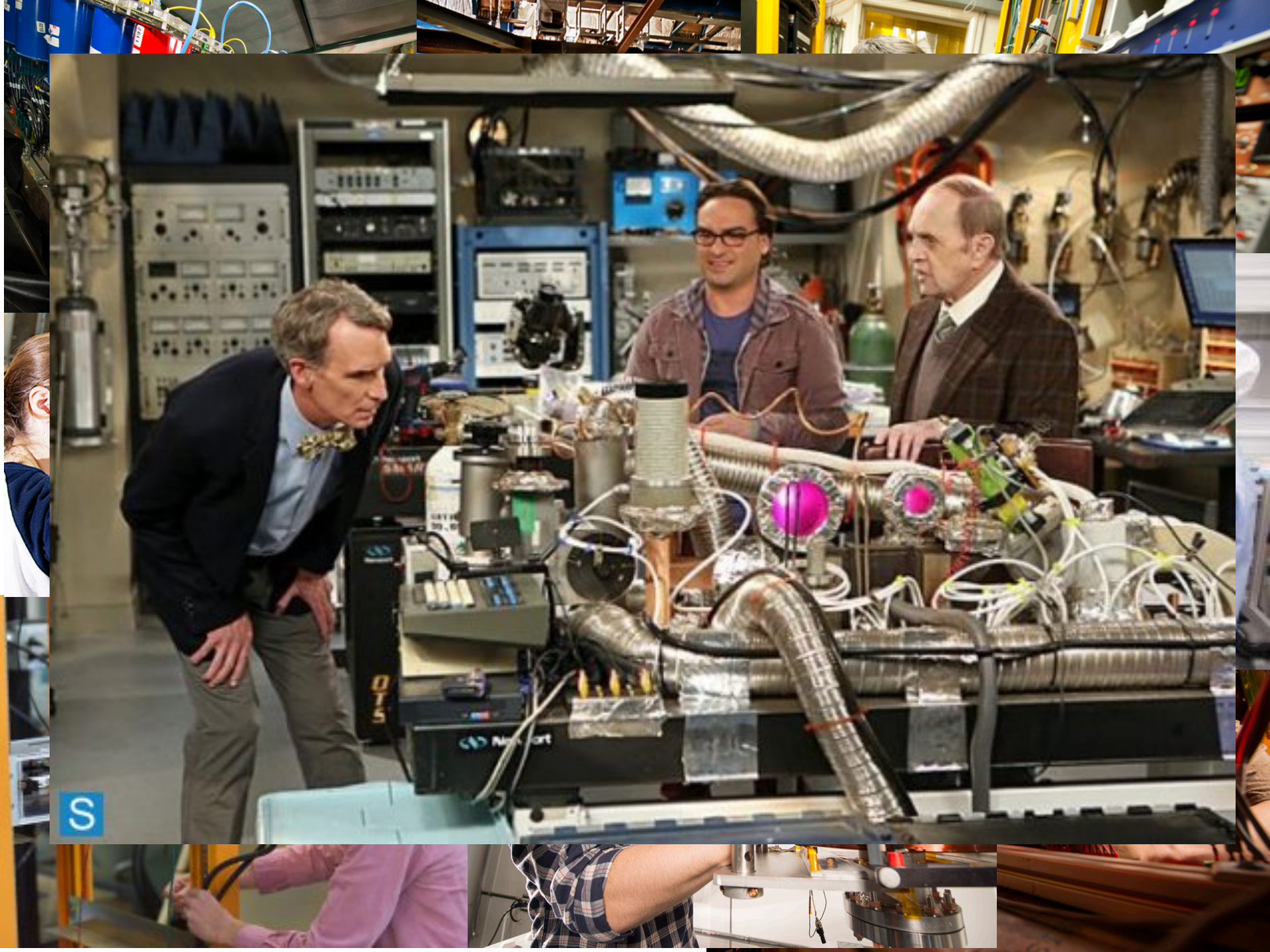
- Typically, one doesn't have to invent a radically new type of detector but instead make improvements in performance of x10, x5, or even only x2 to make a big difference

Where we are at now:	→ Where we want to be
Time resolution for tracks or photons of 50 psec	→ 10 psec
Spatial resolution for tracks of 5 micron	→ 1 μm
Low mass silicon sensors and ROC of thickness 100μ	→ 25 μm
Radiation hard detectors to withstand 10^{15} particles/cm^2	→ 10^{16}
Optical quantum efficiency (QE) of 30%	→ 60%
Liquid Argon drift distance of 3 meters	→ 5 m
In $0\nu\beta\beta$, gamma ray resolution of 3%	→ 1%
Radiation hard optical links at 2 Gbit/sec/fiber	→ 20 Gbit/sec/fiber
Level 1 trigger decisions at 100 kHz	→ >500 kHz



Enjoy your time at Fermilab

While you train to become the

Next generation of detector experts!