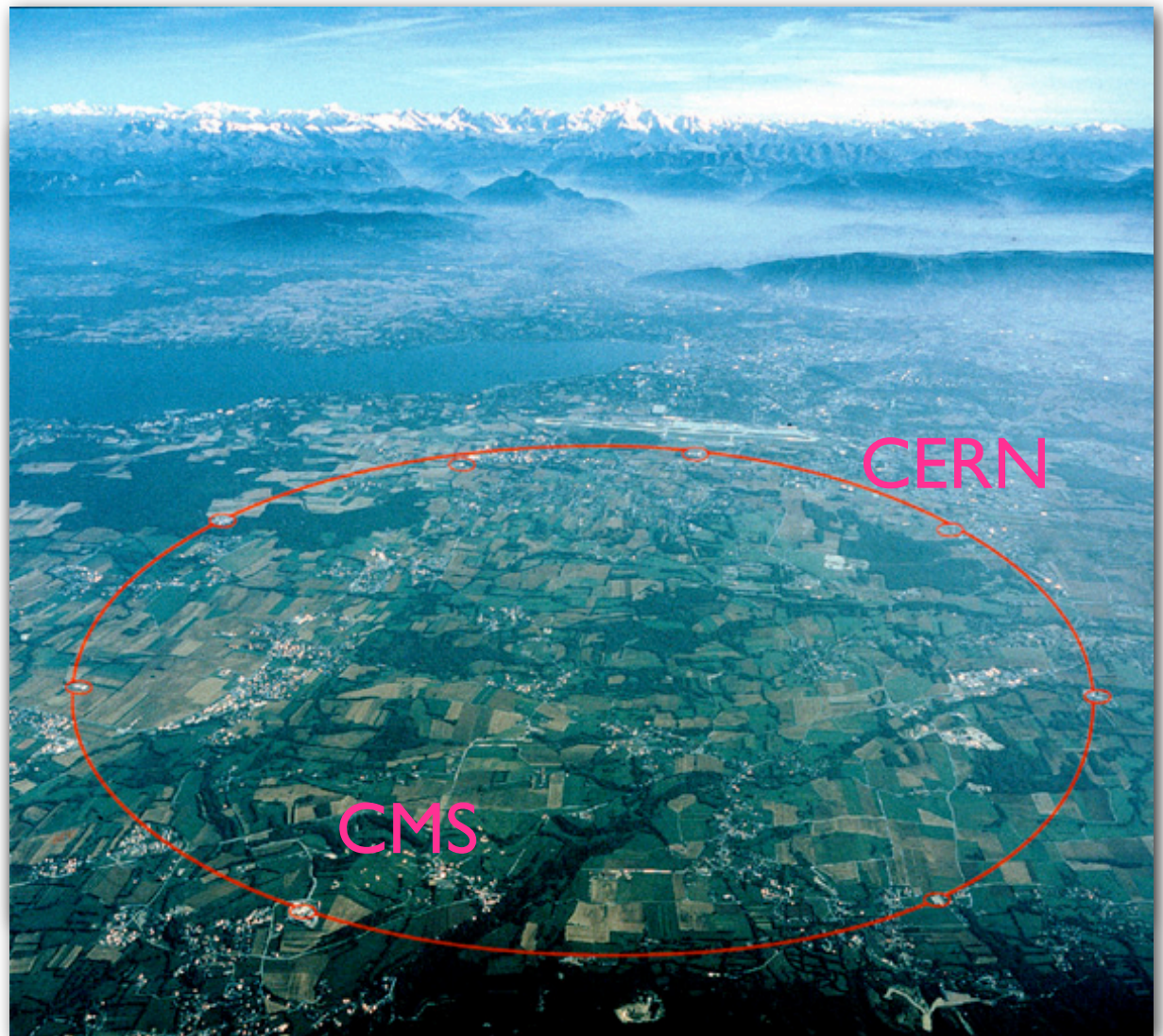# UC Davis
in CMS at the LHC
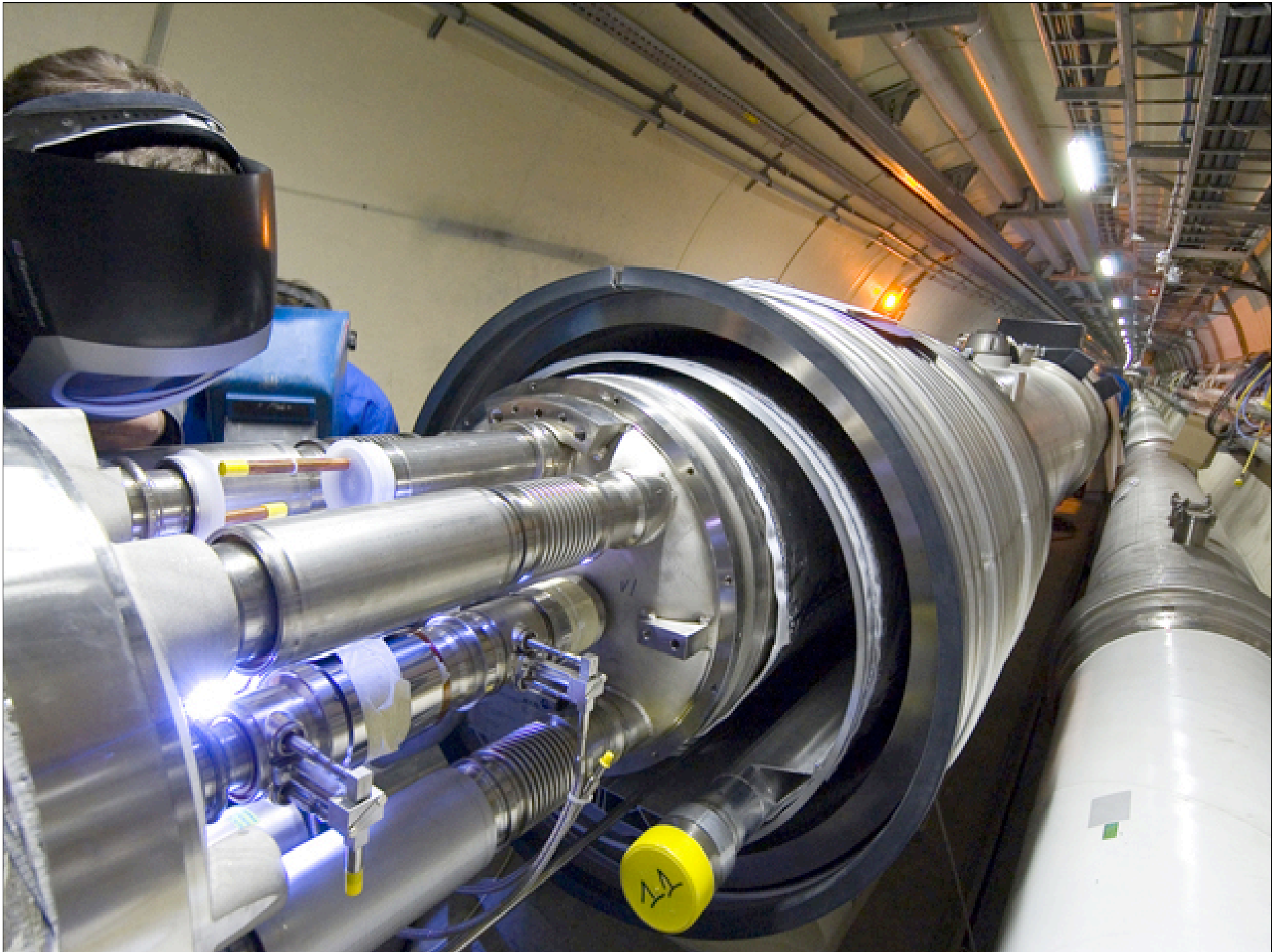
John Conway
Tier-3 Networking Meeting
15 March 2007

The LHC

Will be world's highest energy proton collider: 7 TeV on 7 TeV

Construction nearing completion by end of 2007

Physics in 2008!

LHC in Numbers
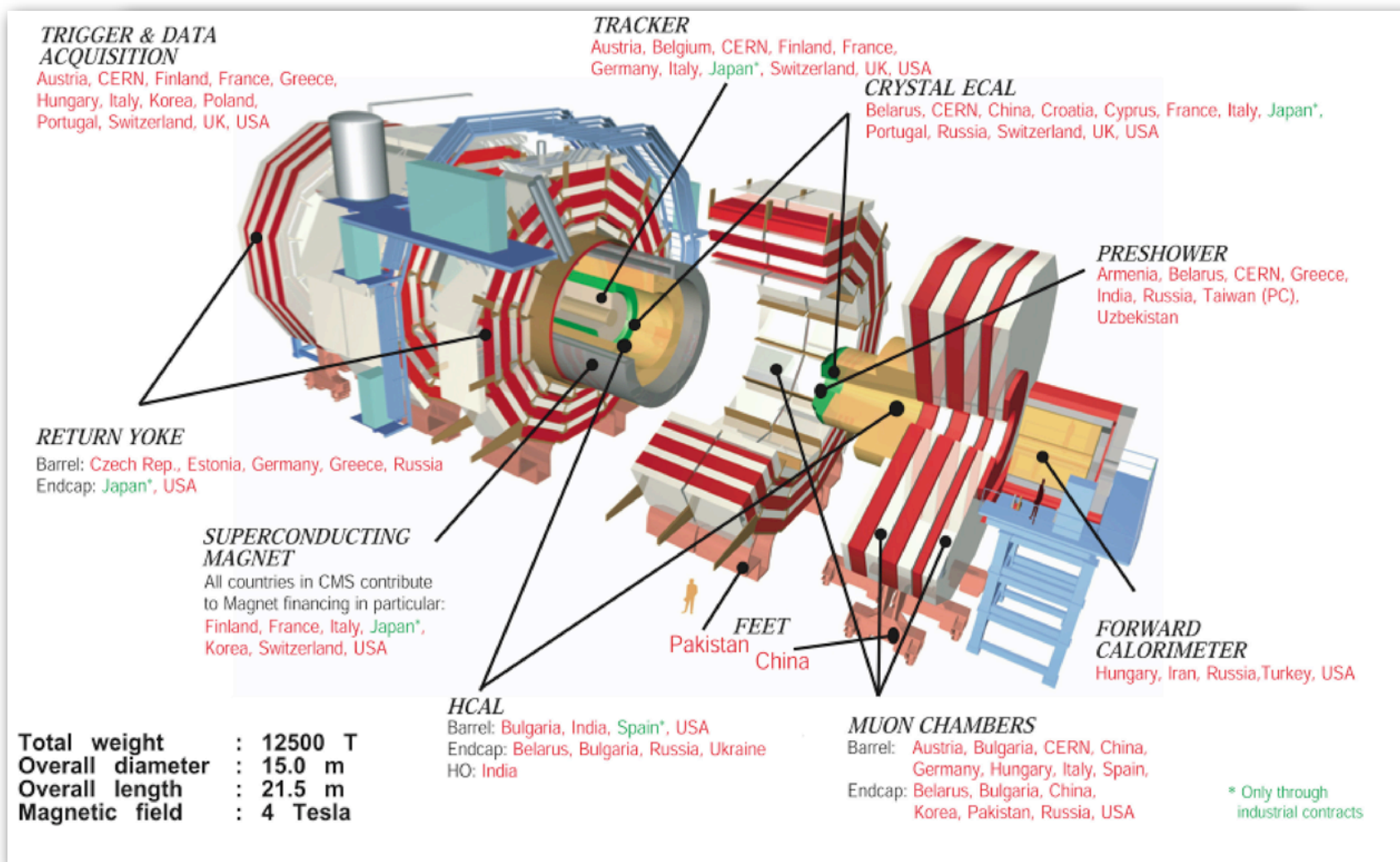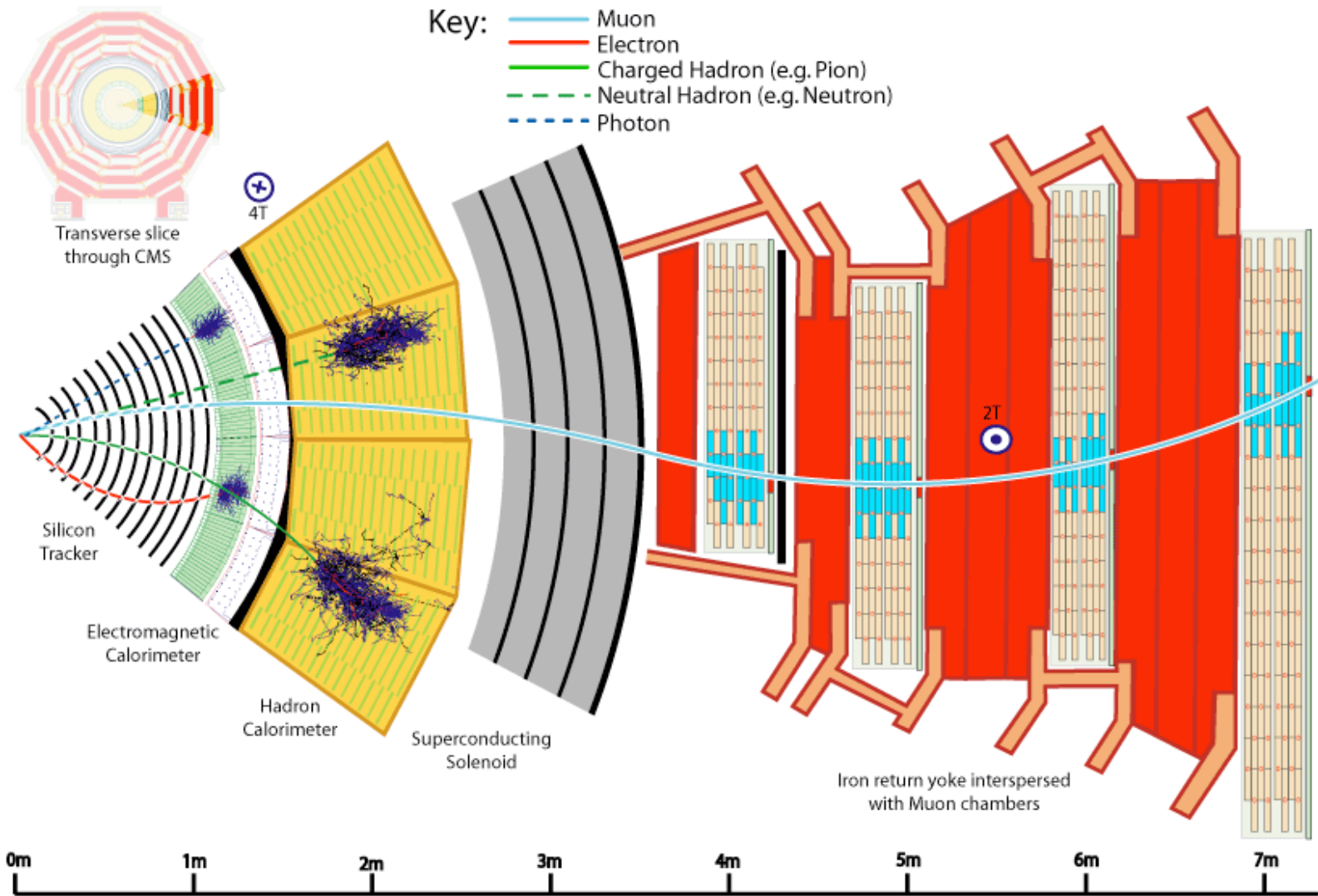
beam energy	7 TeV
magnetic field	8.4 T
circumference	27 km
bunch collision rate	40 MHz
dipole magnets (14 m)	1232
luminosity	10^{34} cm^{-2} s^{-1}
total stored beam energy	300 MJ

CMS
Compact Muon Solenoid experiment

TRIGGER & DATA ACQUISITION
Austria, CERN, Finland, France, Greece, Hungary, Italy, Korea, Poland, Portugal, Switzerland, UK, USA

TRACKER
Austria, Belgium, CERN, Finland, France, Germany, Italy, Japan*, Switzerland, UK, USA

CRYSTAL ECAL
Belarus, CERN, China, Croatia, Cyprus, France, Italy, Japan*, Portugal, Russia, Switzerland, UK, USA

PRESHOWER
Armenia, Belarus, CERN, Greece, India, Russia, Taiwan (PC), Uzbekistan

RETURN YOKE
Barrel: Czech Rep., Estonia, Germany, Greece, Russia
Endcap: Japan*, USA

SUPERCONDUCTING MAGNET
All countries in CMS contribute to Magnet financing in particular:
Finland, France, Italy, Japan*, Korea, Switzerland, USA

FEET
Pakistan   China

FORWARD CALORIMETER
Hungary, Iran, Russia, Turkey, USA

HCAL
Barrel: Bulgaria, India, Spain*, USA
Endcap: Belarus, Bulgaria, Russia, Ukraine
HO: India

MUON CHAMBERS
Barrel: Austria, Bulgaria, CERN, China, Germany, Hungary, Italy, Spain,
Endcap: Belarus, Bulgaria, China, Korea, Pakistan, Russia, USA

* Only through industrial contracts

Total weight : 12500 T
Overall diameter : 15.0 m
Overall length : 21.5 m
Magnetic field : 4 Tesla

CMS

Key:
- Muon
- Electron
- Charged Hadron (e.g. Pion)
- Neutral Hadron (e.g. Neutron)
- Photon

Transverse slice through CMS

4T

2T

Silicon Tracker

Electromagnetic Calorimeter

Hadron Calorimeter

Superconducting Solenoid

Iron return yoke interspersed with Muon chambers
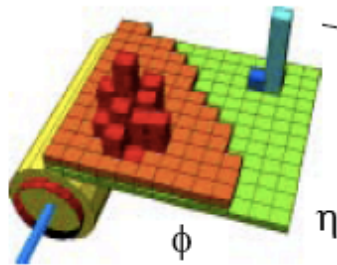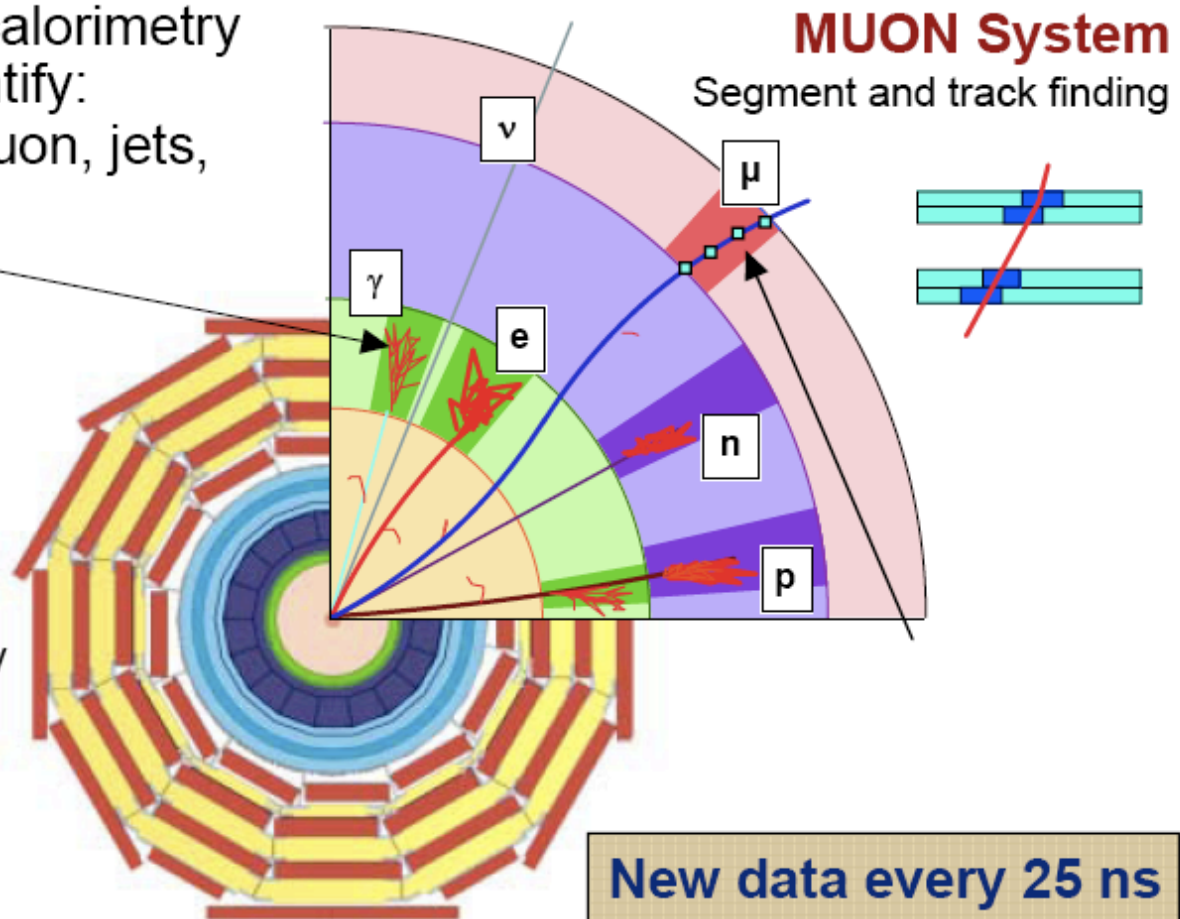
0m   1m   2m   3m   4m   5m   6m   7m

CMS Trigger

Use prompt data (calorimetry and muons) to identify:
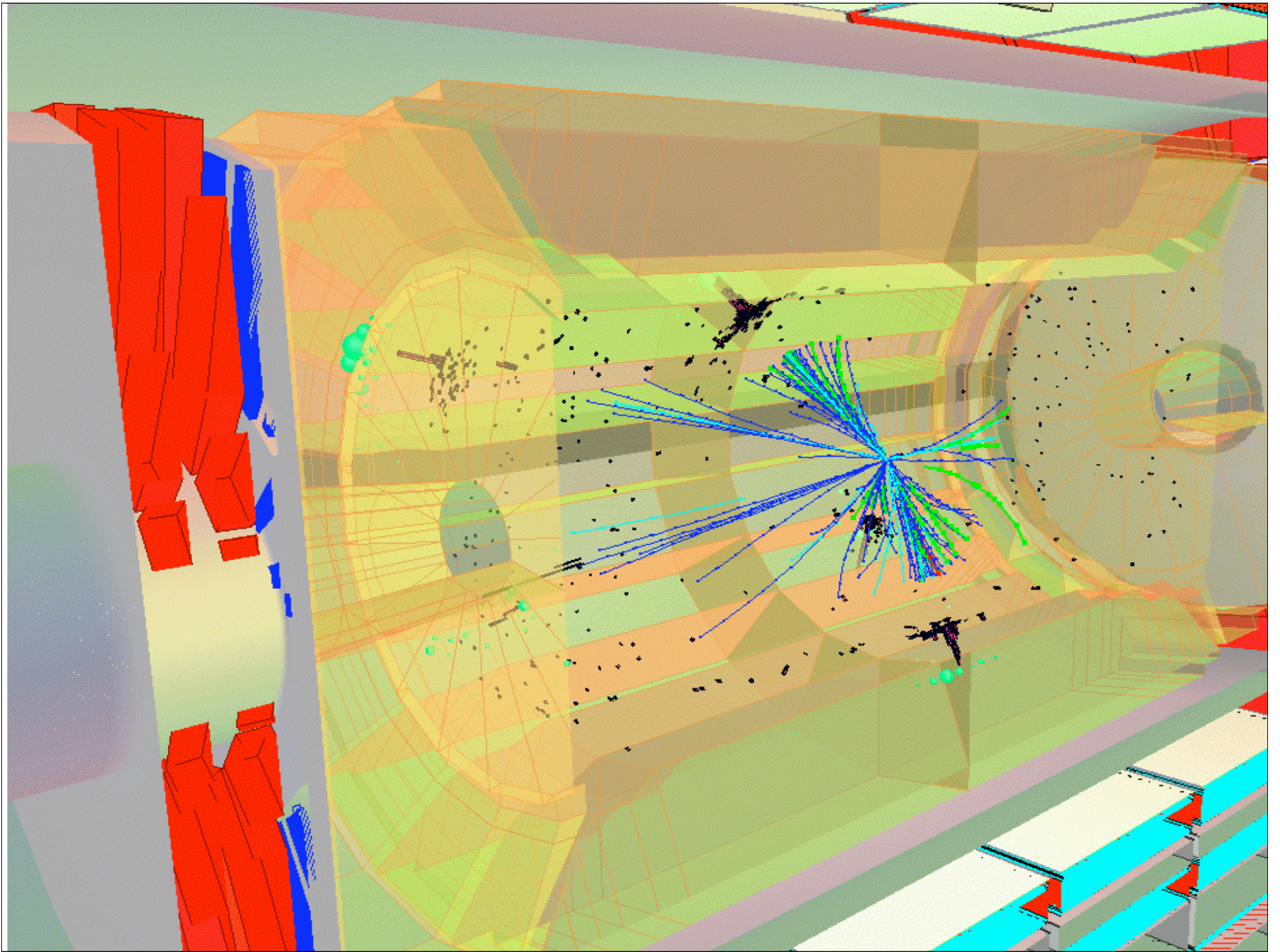High p_t electron, muon, jets, missing E_T

CALORIMETERs
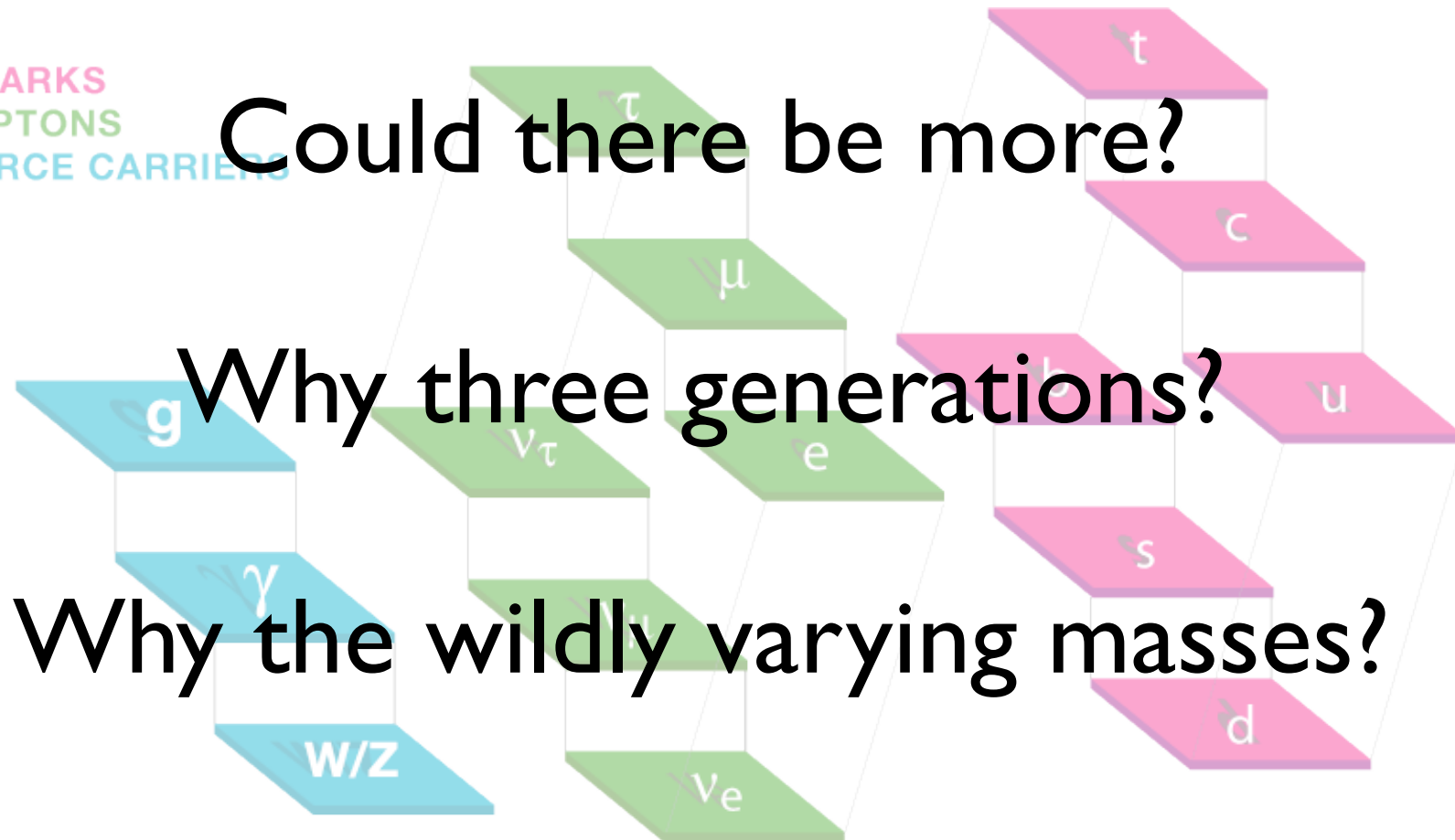Cluster finding and energy deposition evaluation

MUON System
Segment and track finding

New data every 25 ns
Decision latency ~ μs

The Physics

Could there be more?

Why three generations?

Why the wildly varying masses?

The Physics

Is this the theory of the world?

$$\mathcal{L}_{GWS} = \sum_f (\bar{\Psi}_f(i\gamma^\mu \partial\mu - m_f)\Psi_f - eQ_f\bar{\Psi}_f\gamma^\mu\Psi_f A_\mu) +$$

$$+ \frac{g}{\sqrt{2}}\sum_i(\bar{a}_L^i\gamma^\mu b_L^i W_\mu^+ + \bar{b}_L^i\gamma^\mu a_L^i W_\mu^-) + \frac{g}{2c_w}\sum_f\bar{\Psi}_f\gamma^\mu(I_f^3 - 2s_w^2 Q_f - I_f^3\gamma_5)\Psi_f Z_\mu +$$

$$-\frac{1}{4}|\partial_\mu A_\nu - \partial_\nu A_\mu - ie(W_\mu^- W_\nu^+ - W_\mu^+ W_\nu^-)|^2 - \frac{1}{2}|\partial_\mu W_\nu^+ - \partial_\nu W_\mu^+ +$$

$$-ie(W_\mu^+ A_\nu - W_\nu^+ A_\mu) + ig'c_w(W_\mu^+ Z_\nu - W_\nu^+ Z_\mu|^2 +$$

$$-\frac{1}{4}|\partial_\mu Z_\nu - \partial_\nu Z_\mu + ig'c_w(W_\mu^- W_\nu^+ - W_\mu^+ W_\nu^-)|^2 +$$

$$+\frac{1}{2}M_\eta^2\eta^2 - \frac{gM_\eta^2}{8M_W}\eta^3 - \frac{g'^2 M_\eta^2}{32M_W}\eta^4 + |M_W W_\mu^+ + \frac{g}{2}\eta W_\mu^+|^2 +$$

$$+\frac{1}{2}|\partial_\mu\eta + iM_Z Z_\mu + \frac{ig}{2c_w}\eta Z_\mu|^2 - \sum_f \frac{g}{2}\frac{m_f}{M_W}\bar{\Psi}_f\Psi_f\eta$$

Higgs mass

Hff̄ coupling

The Higgs Boson

- may be the way particles get their mass

- "couples" to particles in proportion to their mass

- may be among the first things discovered at the LHC

- may be simple "Standard Model" Higgs or may be complex (as in supersymmetry)

The Higgs Boson

- at the LHC, after about one year of running, this may be our first glimpse of the Higgs boson

- classic "needle in haystack" problem

- next way: tau lepton pair decays
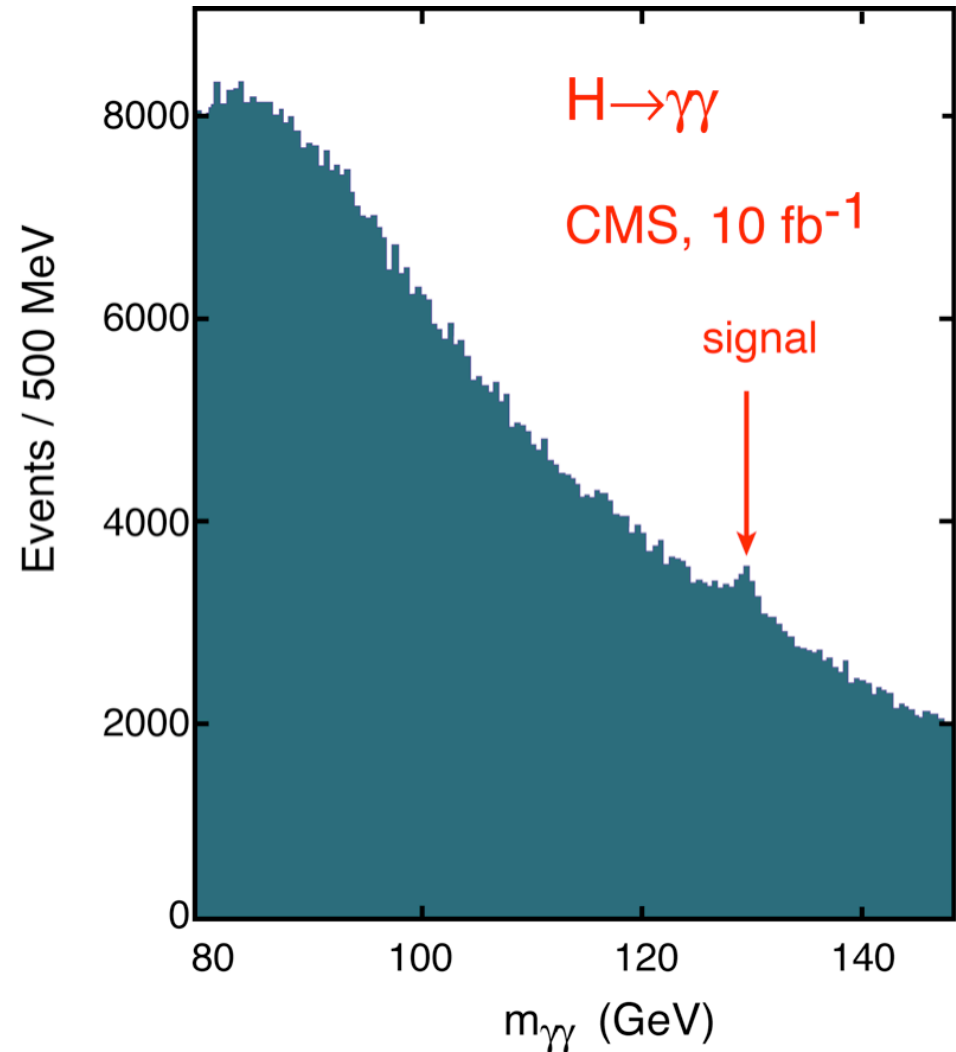
Higgs boson
decaying to two
high energy
gamma rays
in CMS
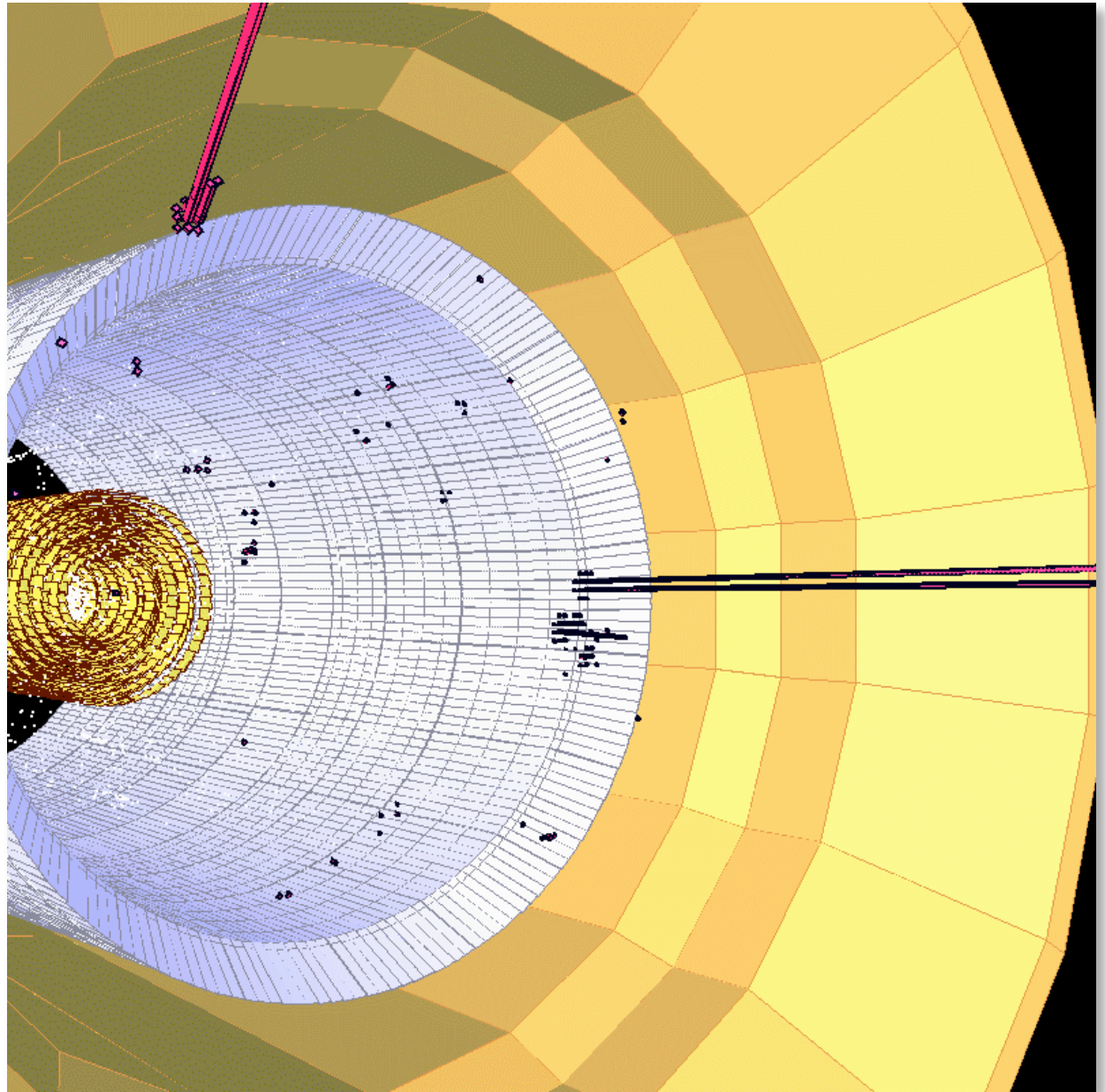
UC Davis in CMS

- founding member of US CMS in 1992

- faculty: Ko, Lander, Pellett, Tripathi, Chertok, Conway, Erbacher

- scientists: Breedon, Cox

- engineer: Case

- postdocs: Veelken, Vasquez, Soha, Lister

- students: Friis, Maruyama, Searle, Kopecky, ...

- computing: Squires

Davis Tier 3 Cluster

- presently have 14-node (dual CPU) cluster

- have ordered hardware to begin larger scale Tier 3 cluster in Data Center at Davis

- eventually ~100 dual quad-core Opteron

- ~100 Tb storage (we hope)

- will be part of OSG serving the CMS VO

- can devote local resources to Davis-specific physics projects when required

- will publish a few datasets

Networking Needs

- from cluster in Data Center to world, rate into cluster will exceed rate out

- could make use of lower priority/off peak times for very large dataset transfers

- need large on-demand rates for OSG jobs

- Mani: "As fast as possible" Is this right?

The networking capabilities available to us will influence how we do our physics analyses, rather than the other way around! (We'll use it all...)

next...

- Mike Squires (BA, CS/Physics)

  - will describe cluster plans in detail

  - security, grid, batch, CMSSW, etc.

- Sho Maruyama

  - will show example physics analysis

  - will describe measurements of network performance

Dawn of a New Era!

Thank you for your efforts
in bringing us "up to speed"!