

*Particle Physics  
a Techie's dream*

**Frank Wuerthwein  
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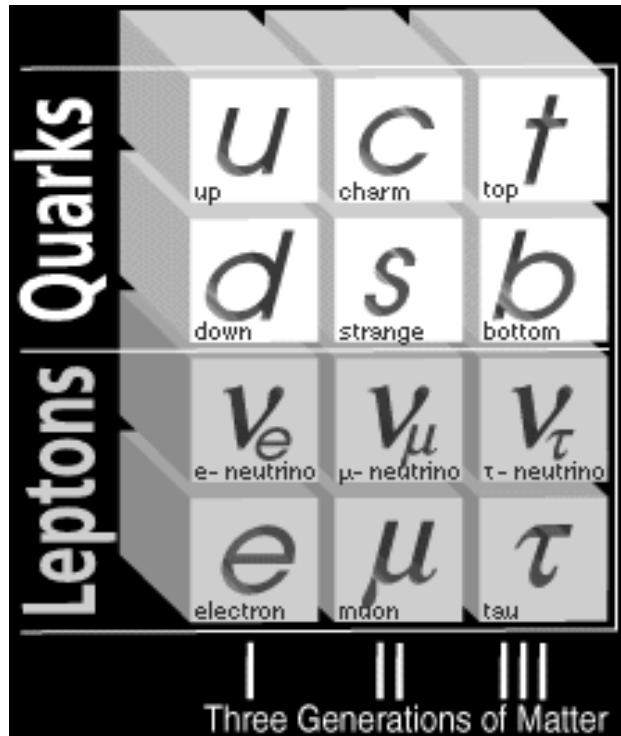
*Science, Fiction & Technology*

*Science*

*the present state of affairs*

**Matter is composed of**  
**Spin  $\frac{1}{2}$  particles**

**Forces are mediated by**  
**Integer Spin particles**



- Electroweak: W,Z,photon
- Strong: gluon
- Gravity: “graviton”  
(not yet observed)

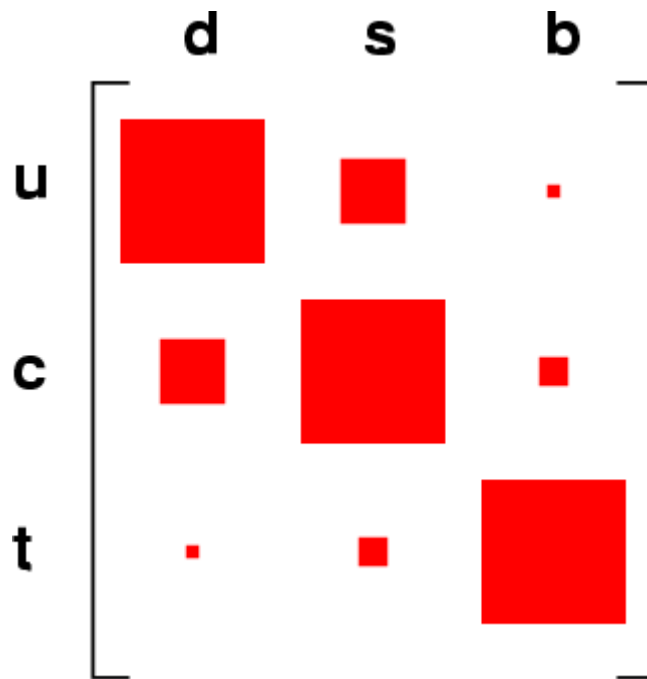
*Is there a unifying principle ? (SUSY)*

# *Couplings*

***understanding the way the  
particles couple to each other.***

***Weak & Strong Force don't  
share the same eigenstates***

***=> Mixing of Quarks & Leptons***



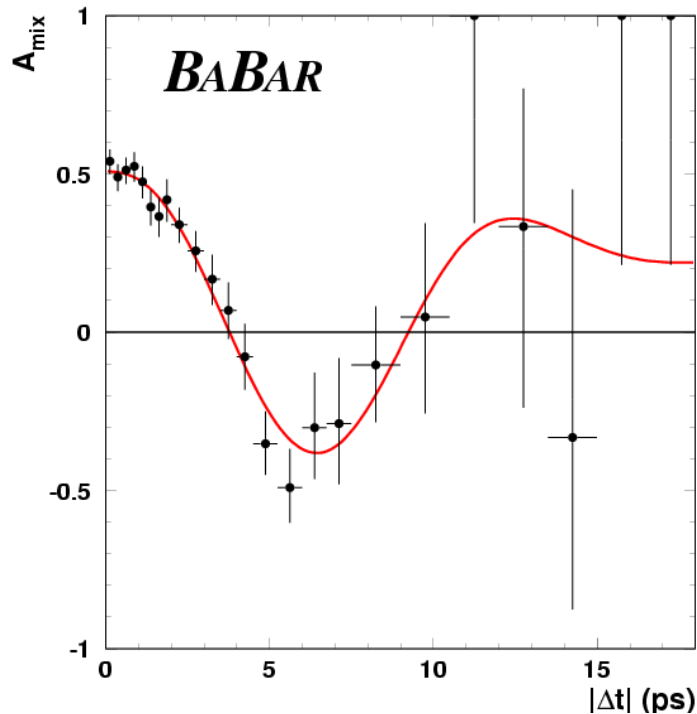
***Quark mixing matrix.  
Area proportional to  
modulus of element.***

***Mixing matrix for leptons  
as yet poorly known.***

***How large is lepton mixing ?***

## Mixing leads to

## Matter - Antimatter Oscillations



$$A_{\text{mix}}(t) = (B - \text{Anti-B}) / (B + \text{Anti-B})$$

**Shown is the raw yield asymmetry, as well as the fit to the data.**

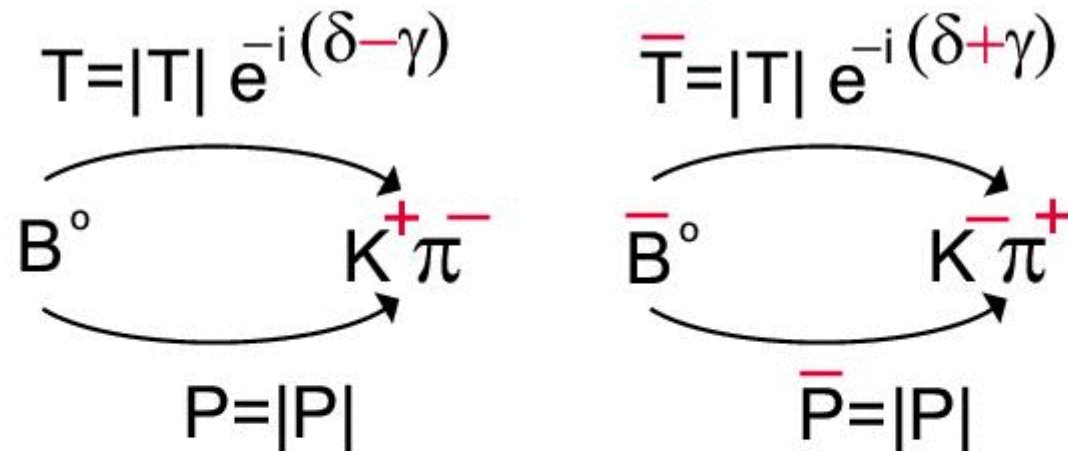
**Fit function is cosine convoluted with resolution function.**

**Total yield follows exponential decay.**

*Connecting time reversal &  
Matter – Antimatter Symmetry*

# *Simple Example of Matter - Antimatter Asymmetry*

Direct CP Violation



$\delta =$  strong phase shift

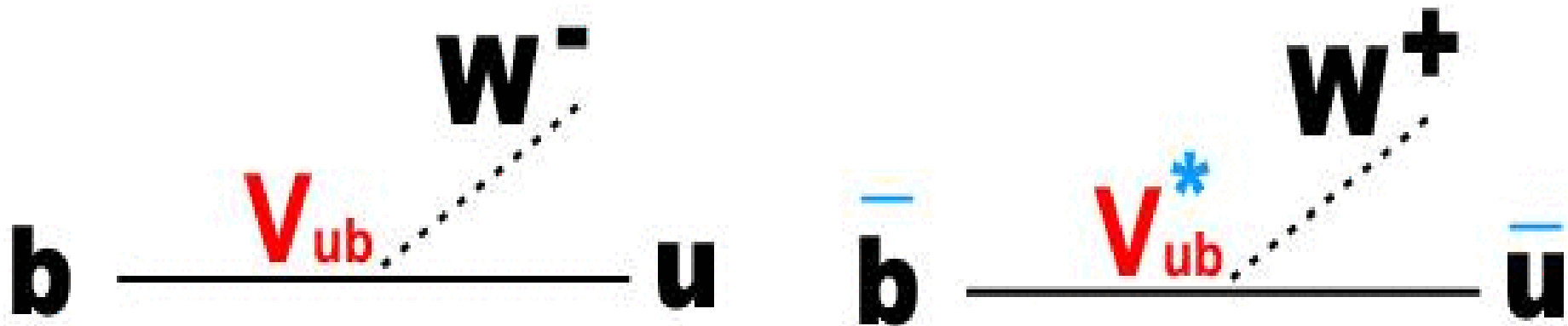
$\gamma =$  difference in weak phase

CP  $\gamma = -\gamma$       CP  $\delta = +\delta$

**Mathematical digression:**  
**simple complex algebra to calculate**  
**matter-antimatter asymmetry**

$$A_{cp} = \frac{\mathcal{B}(B^0 \rightarrow K^+ \pi^-) - \mathcal{B}(\bar{B}^0 \rightarrow K^- \pi^+)}{\mathcal{B}(B^0 \rightarrow K^+ \pi^-) + \mathcal{B}(\bar{B}^0 \rightarrow K^- \pi^+)}$$
$$= \frac{-2|TP| \sin \gamma \sin \delta}{|T|^2 + |P|^2 + 2|TP| \cos \gamma \cos \delta}$$

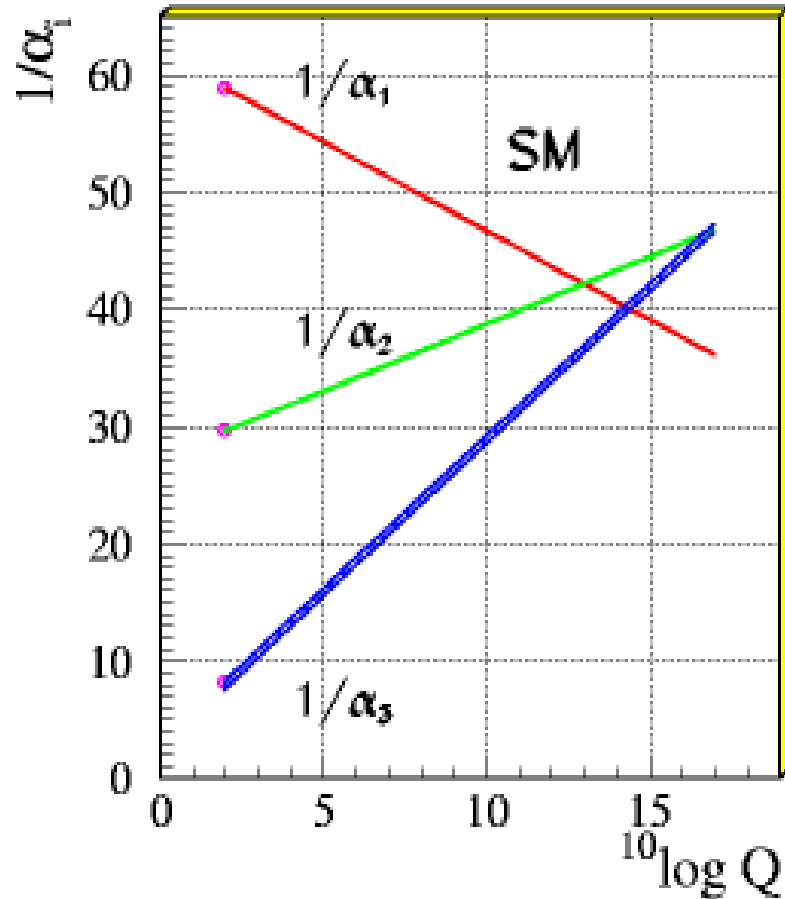
*Matter - Antimatter Asymmetry*  
*is a generic feature of all QFT's*



*But: Forces we know have  
only  $O(1e-3)$  effects.  
Why so little ?*

# Forces and their couplings

## Coupling Strength is function of Energy



**The energy dependence of coupling constants of EWK and strong forces is well understood.**

**Unification might make sense if one believes in Big Bang Cosmology.**

*What's needed for couplings to unify?*

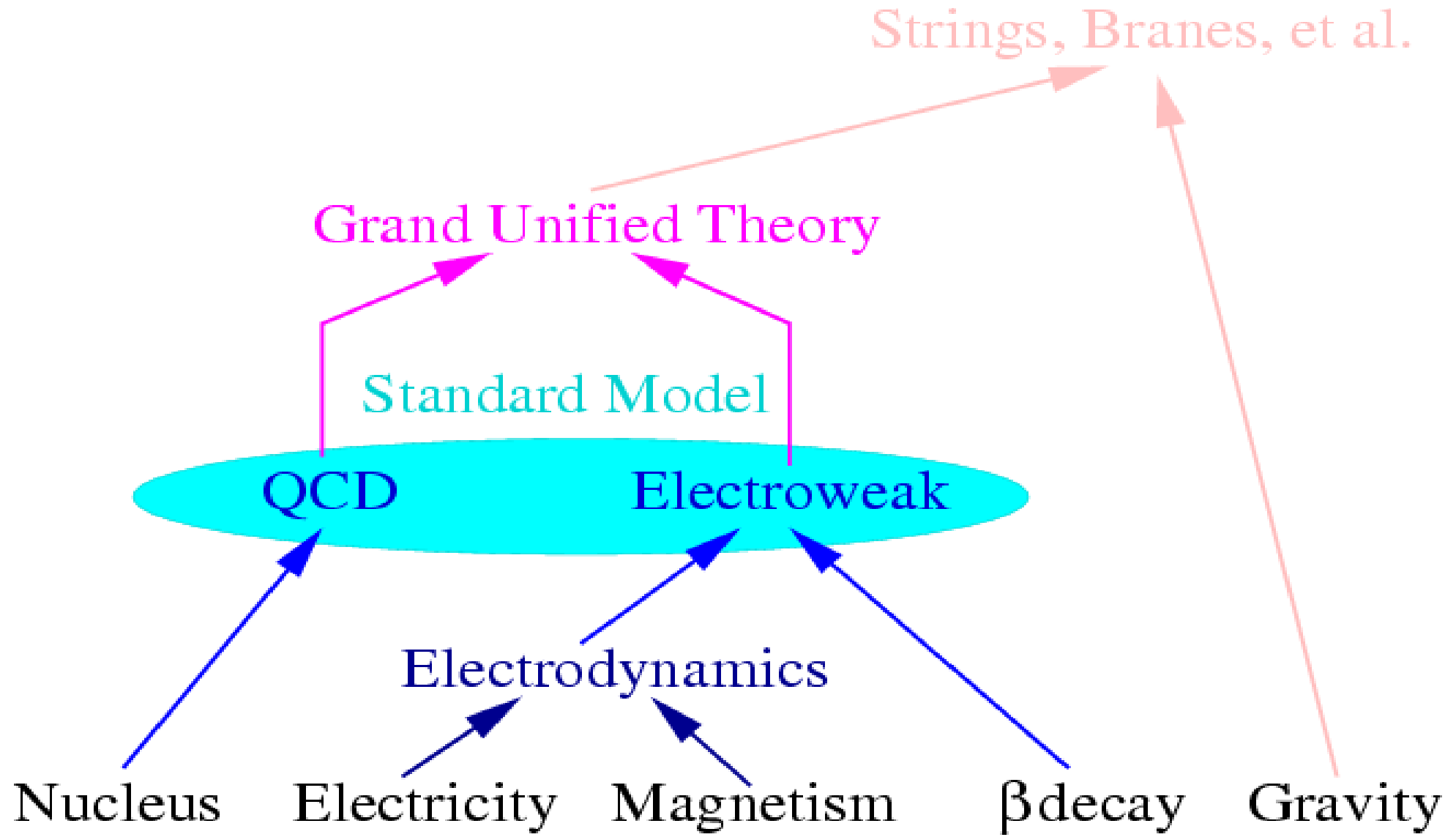
*Open Questions  
lead to fiction*

# *Two of many Questions*

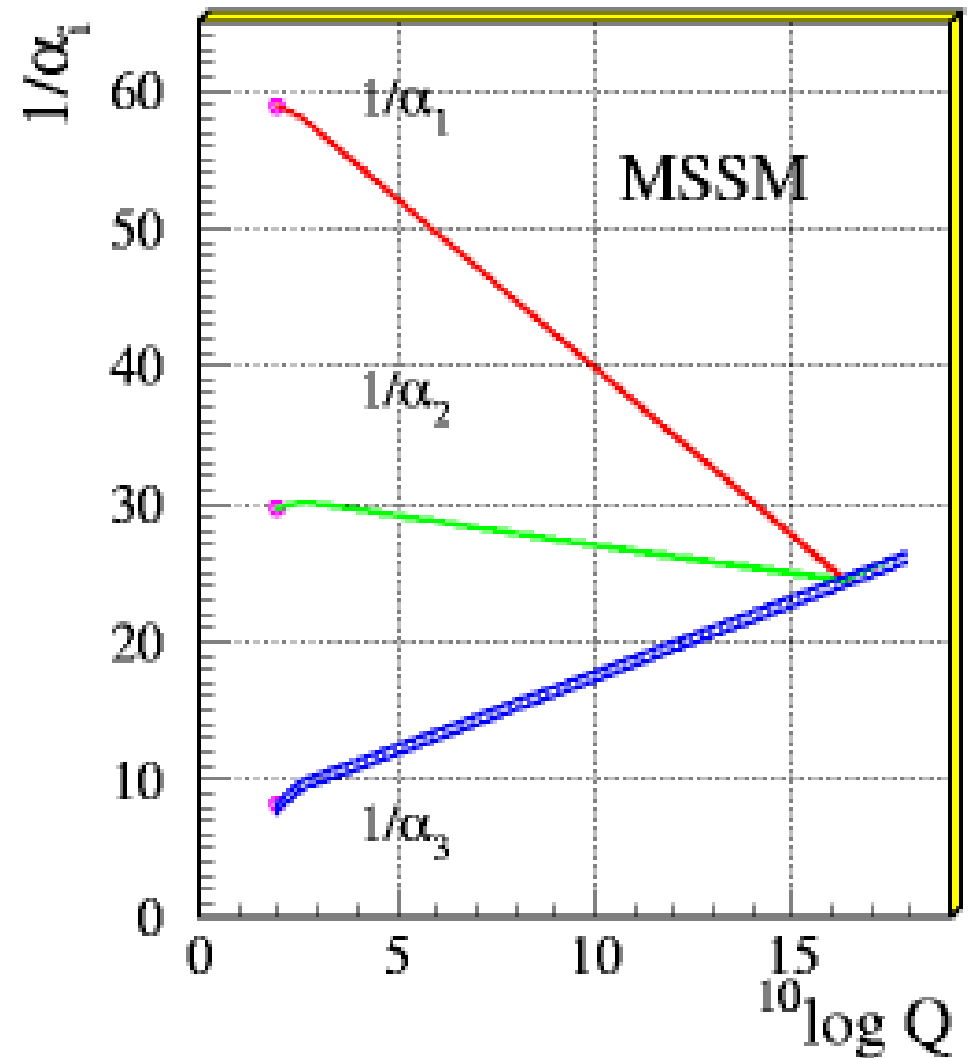
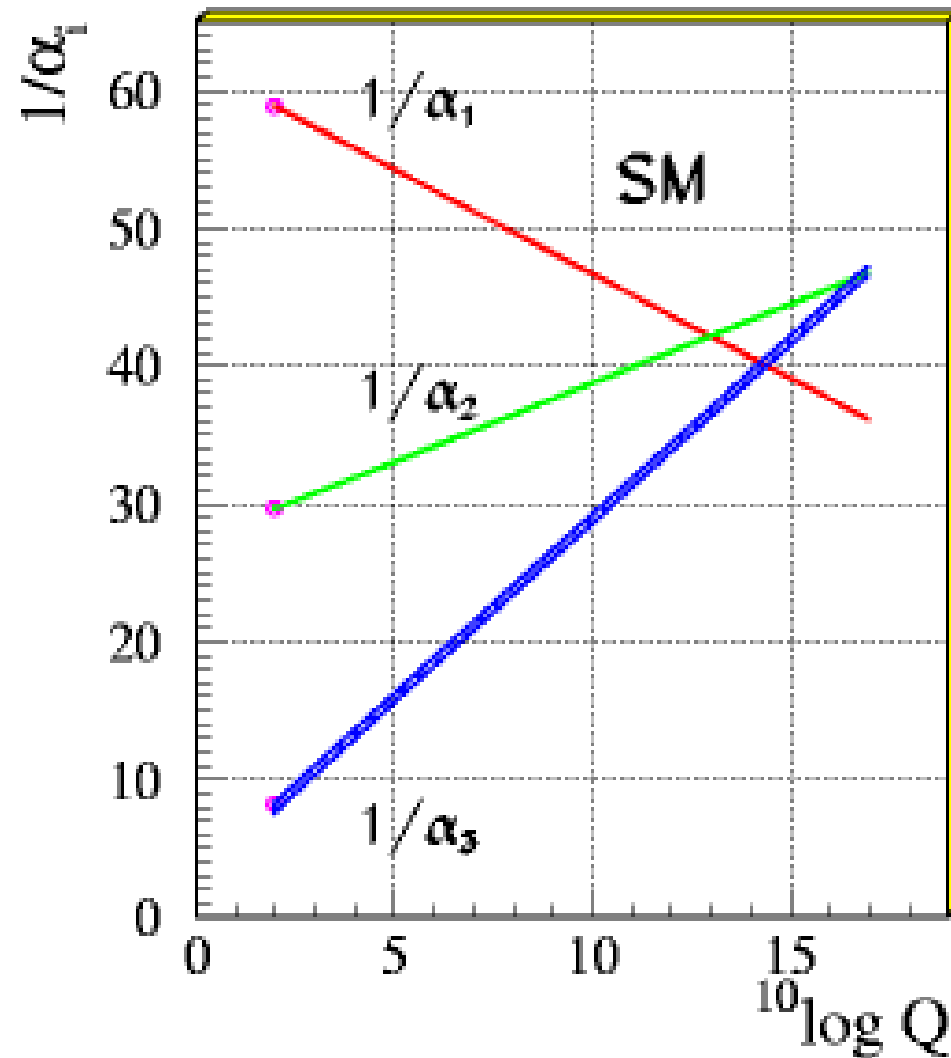
***Do the couplings unify ?***

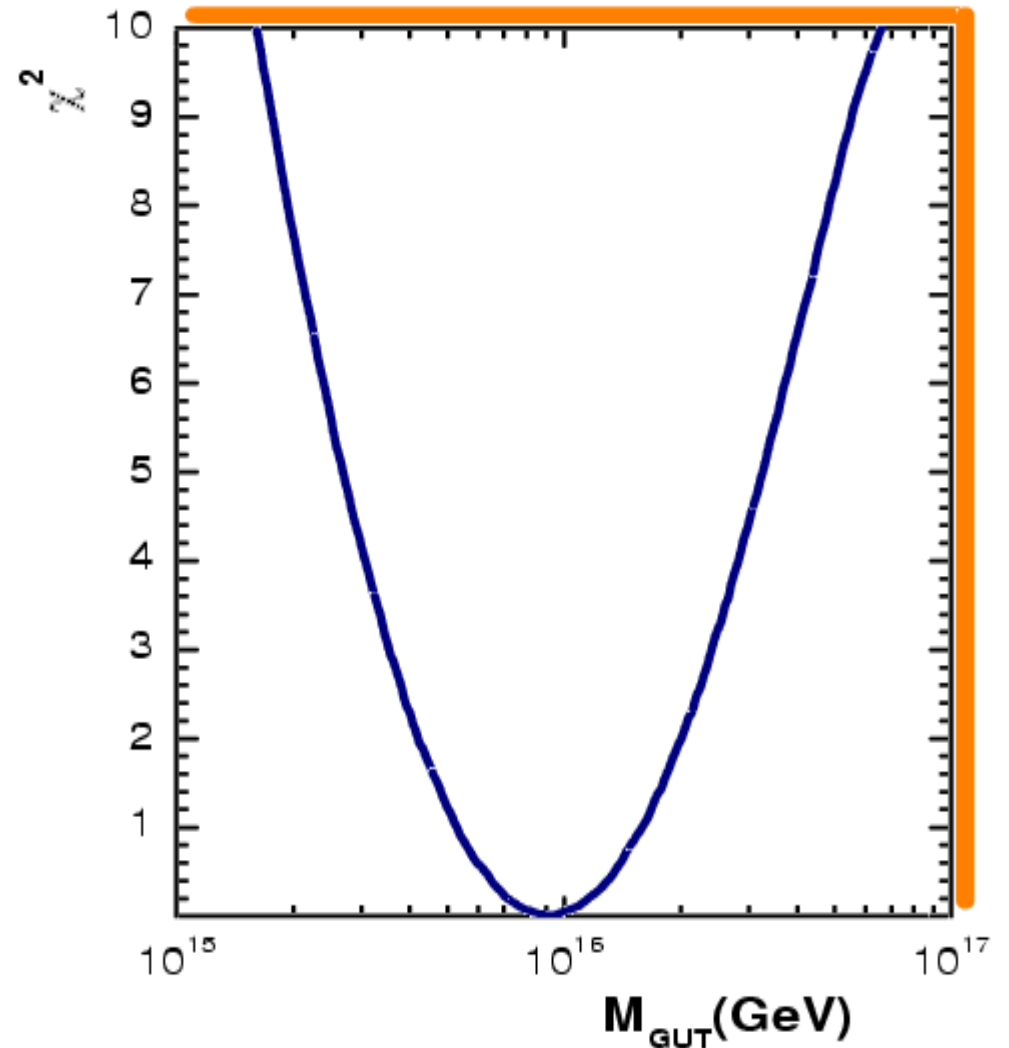
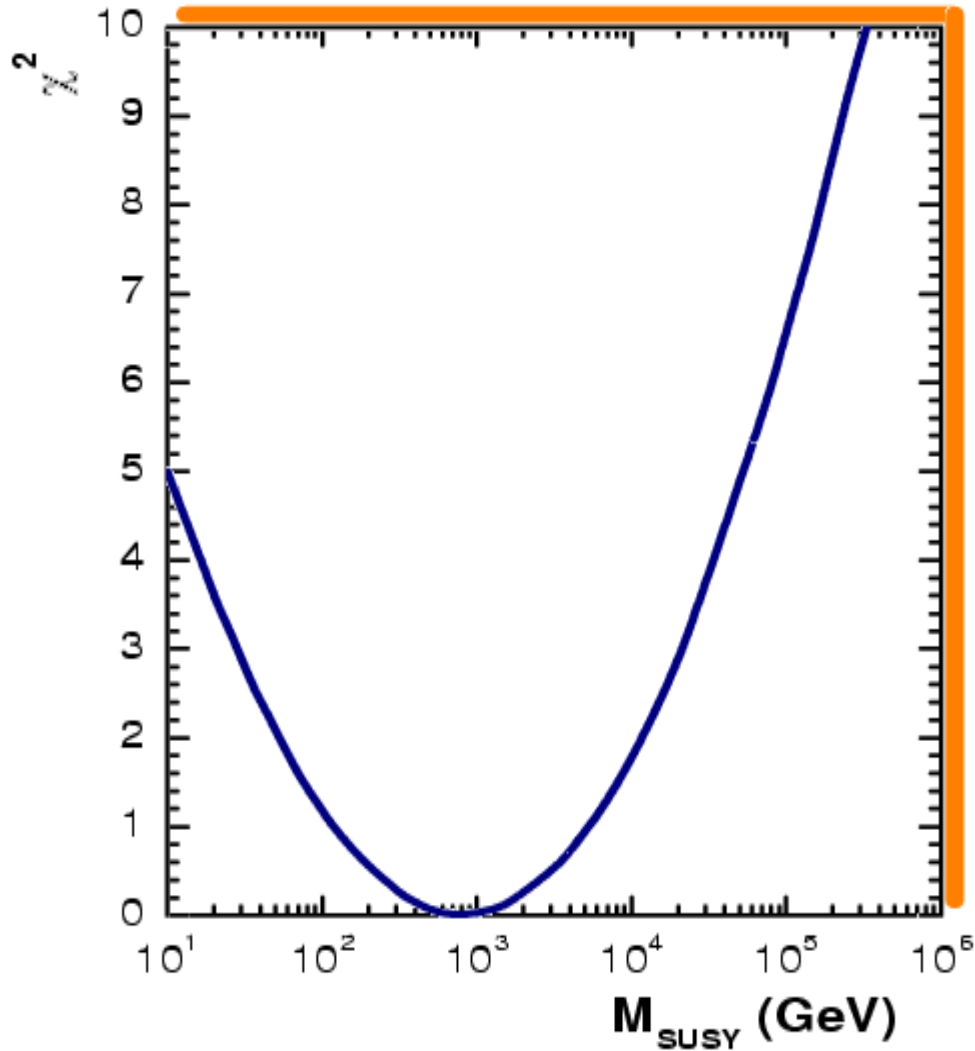
***Where did all the Antimatter go ?***

# *The Story*



# Unification of the Coupling Constants in the SM and the minimal MSSM





***SUSY scale  $\sim 1\text{TeV}$  ( $\sim 20\text{GeV} - 50\text{TeV}$  @  $2\sigma$ )***

***GUT scale  $\sim 1e12$  to  $1e14$  TeV***

# ***Big Bang Cosmology & Matter - Antimatter Asymmetry***

***At the beginning there was "light".***

***"stuff" produced via matter-antimatter pair production.***

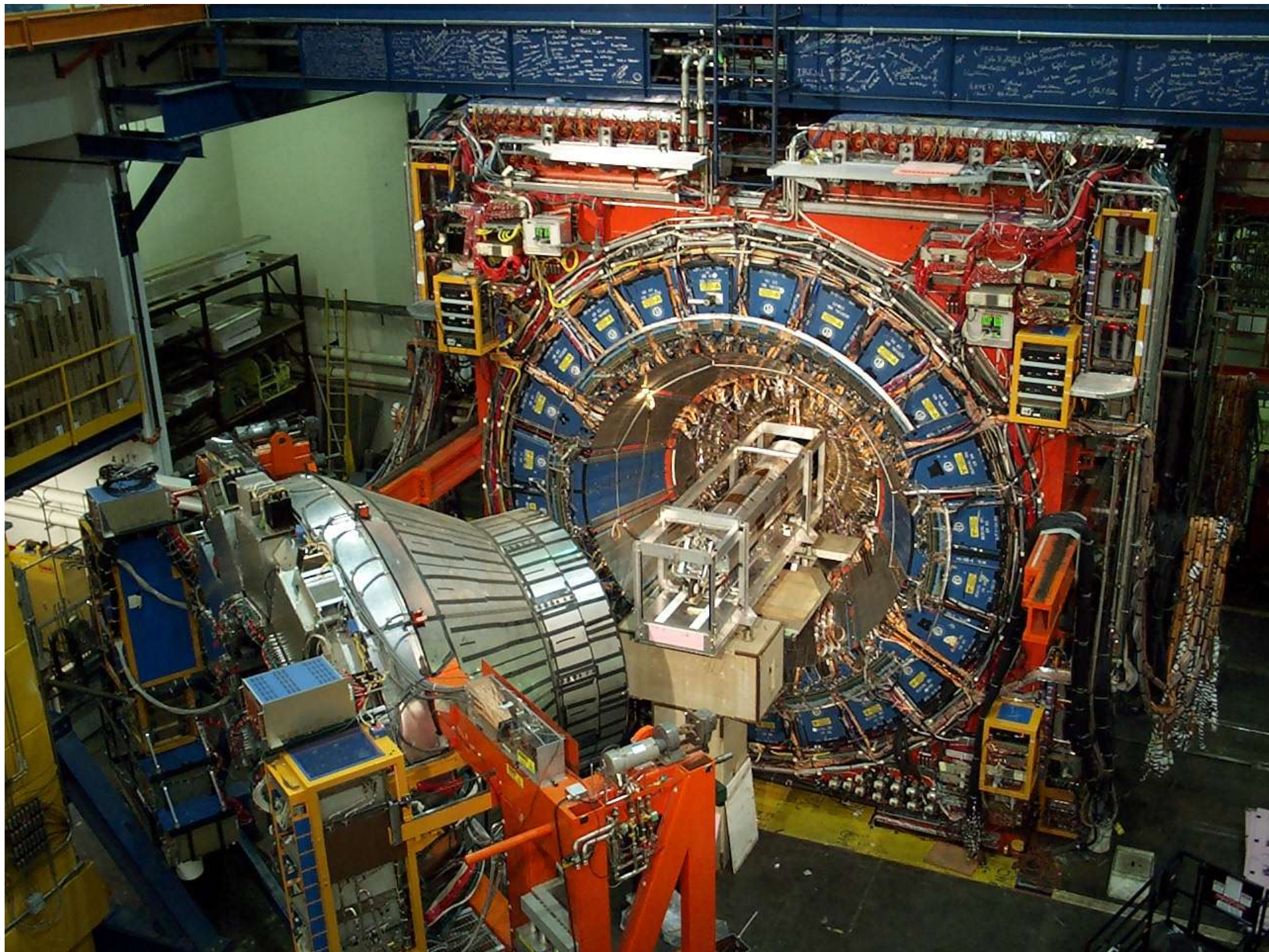
***Today's Universe: many orders of magnitude imbalance.***

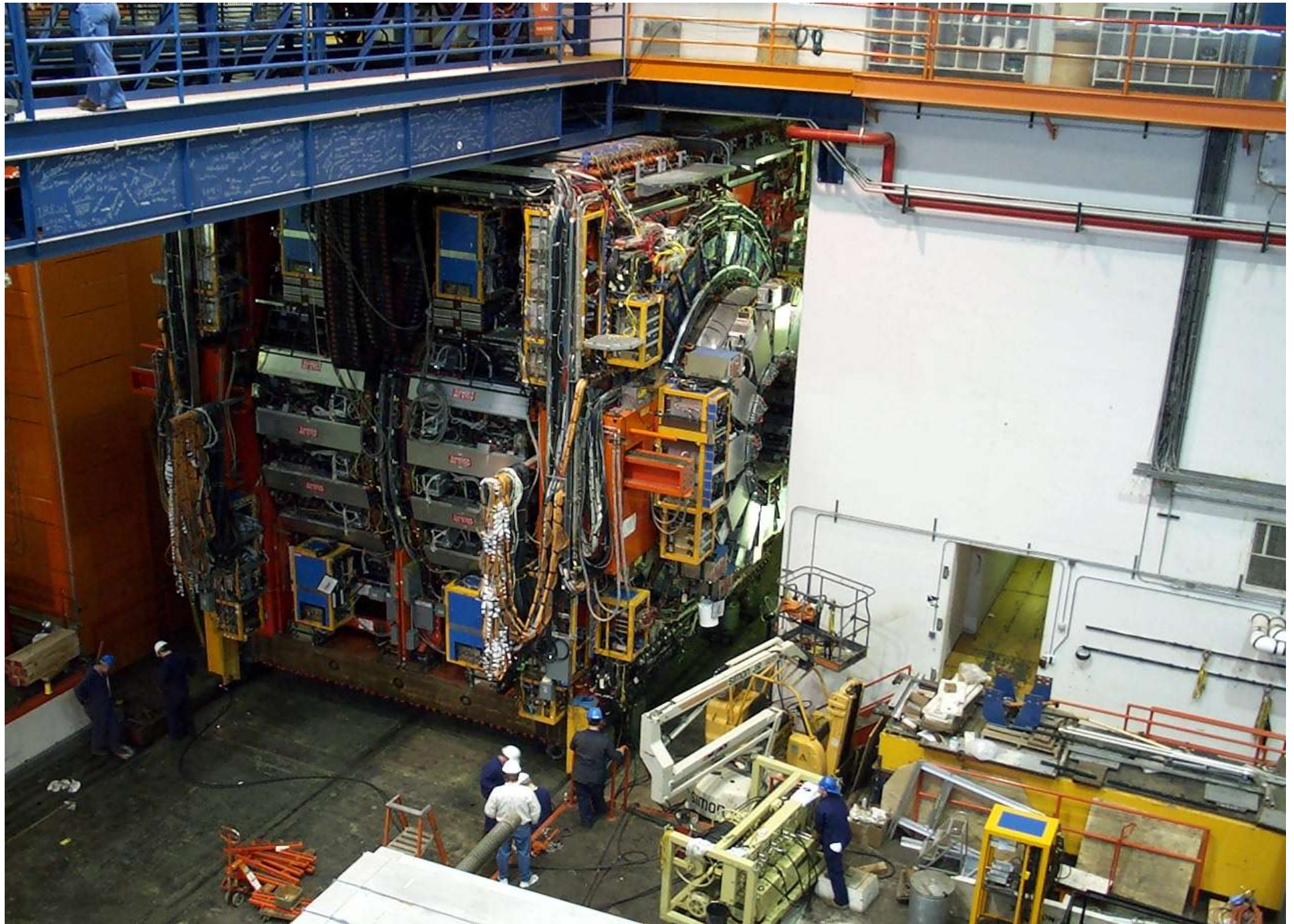
***Where did all the antimatter go ?***

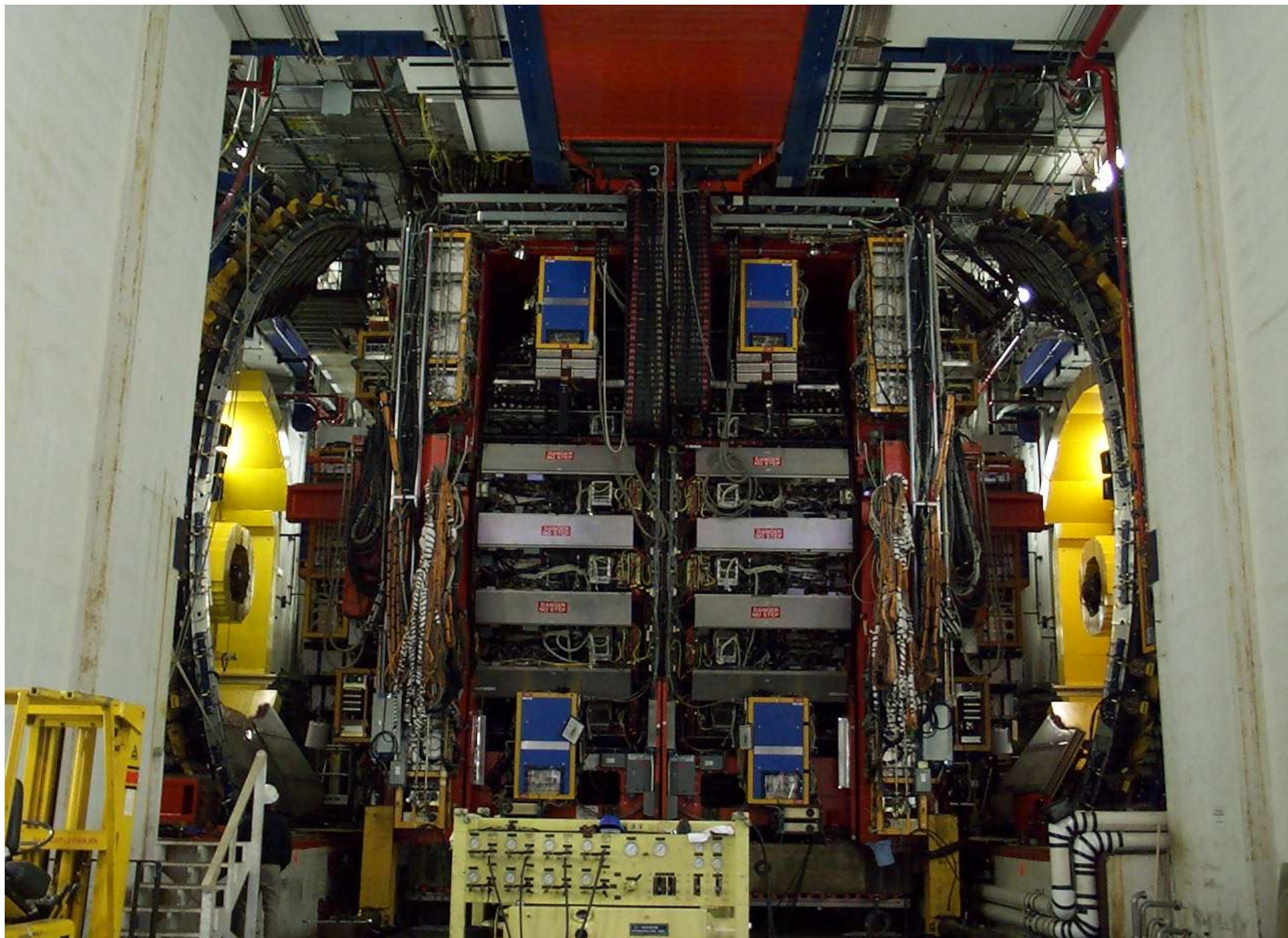
*Experiments*

*&*

*Technology*







## ***CDF by Numbers***

**# of crossings/s = 2.5 MHz**

**# of electr. Channels = 750,000**

**total information rate = 7TeraByte/sec**

**I/O to tape = 20MByte/s**

**# of events so far = 800 Millions**

**# of physicists = 800**

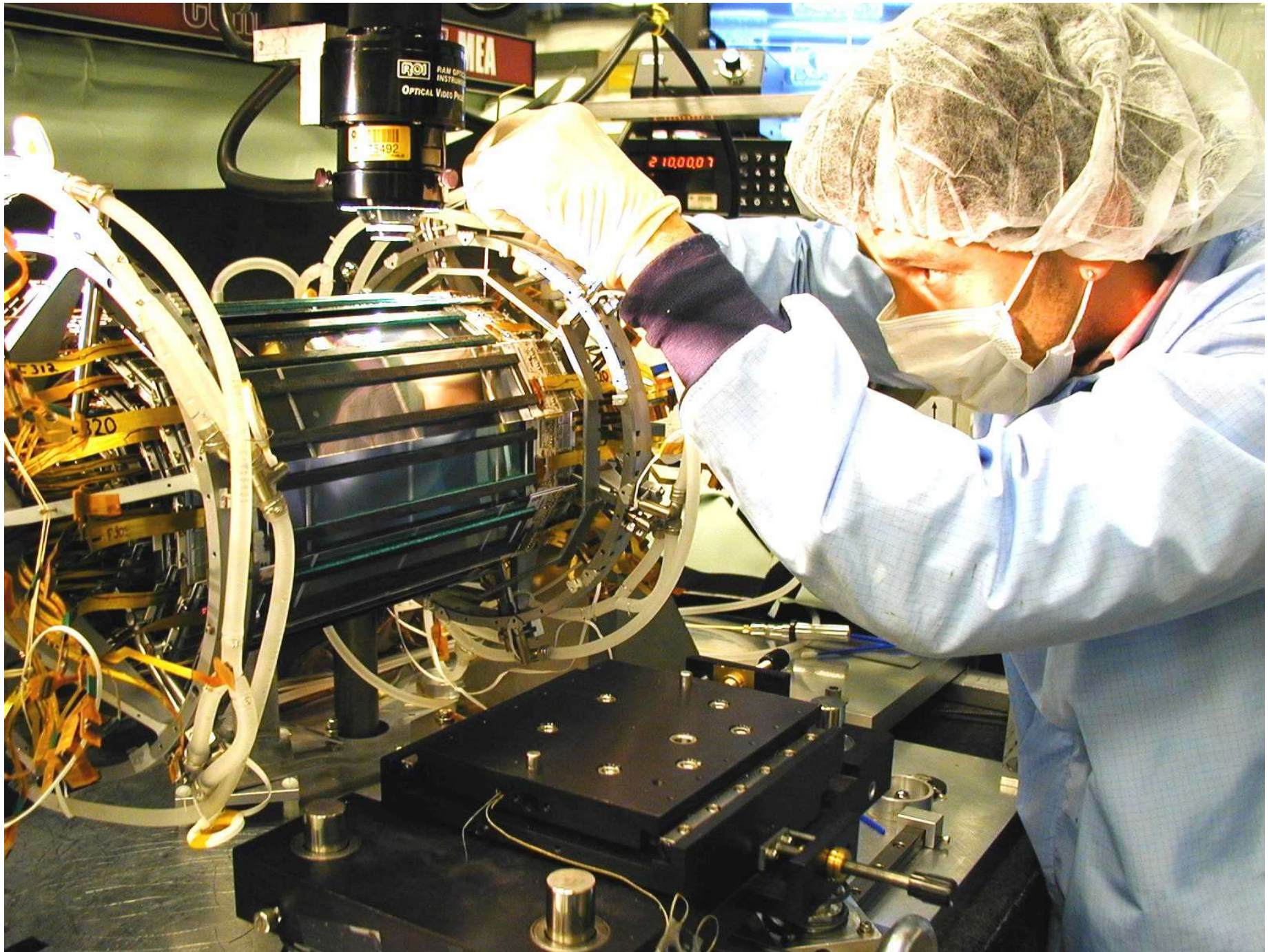
*Custom Hardware Filtering*

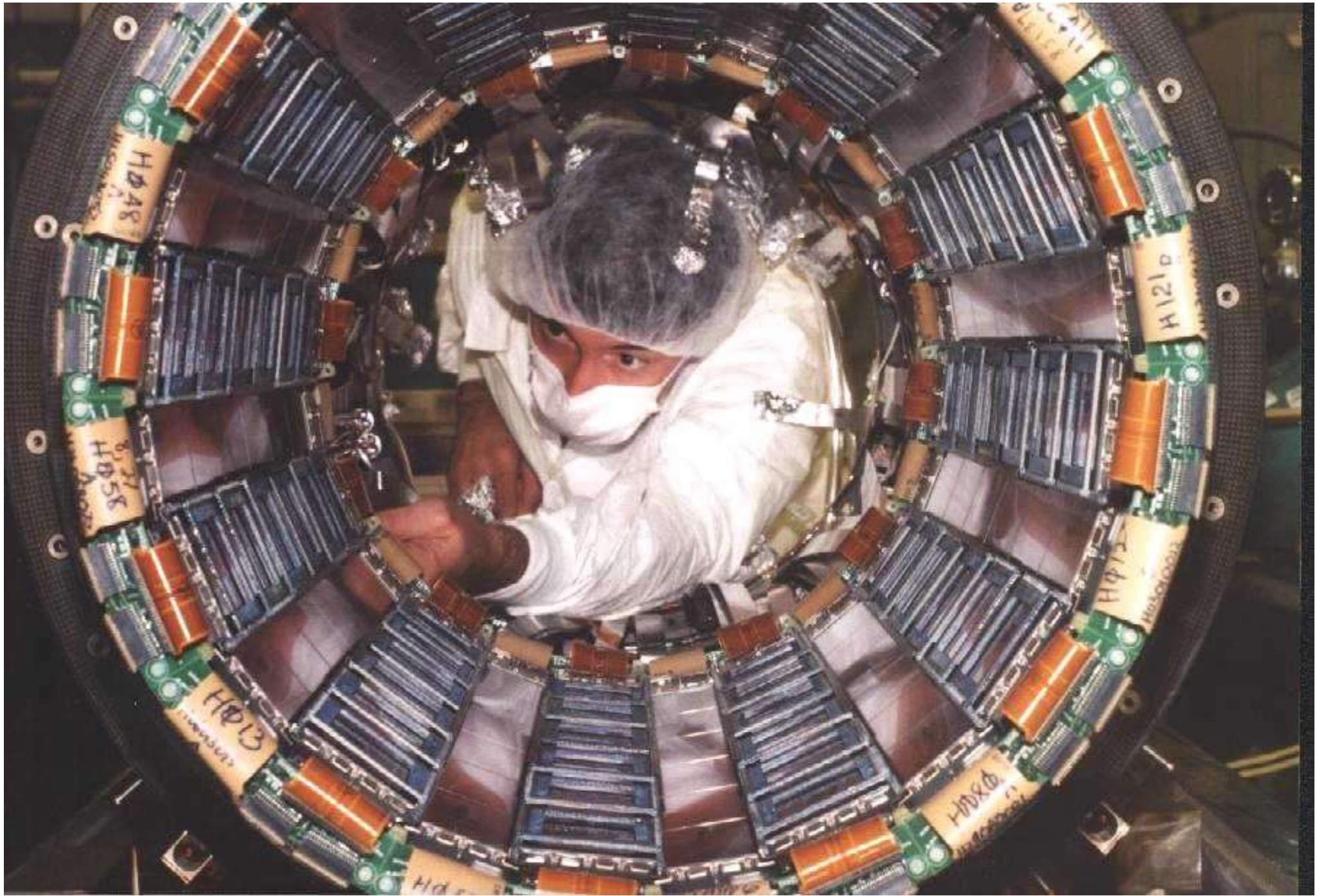
*&*

*Commodity Computing*

# *My Favorite Technologies*

*Silicon Tracker*  
*Trigger Electronics*  
*Computing*







NOV 22 2000

XTC Mezzanine - Michigan



XFT FINDER - FNAL



DIRAC



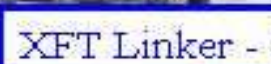
CRATESUM



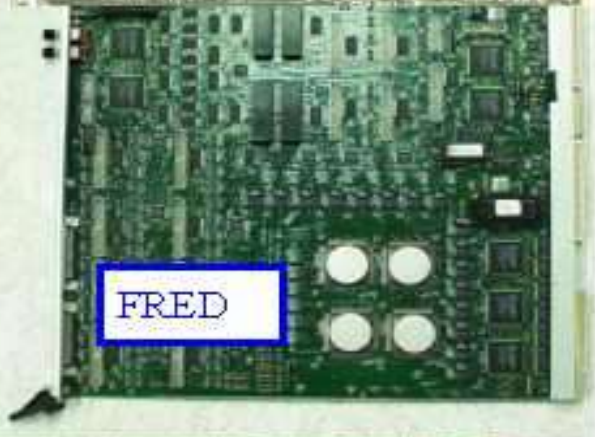
PreFRED



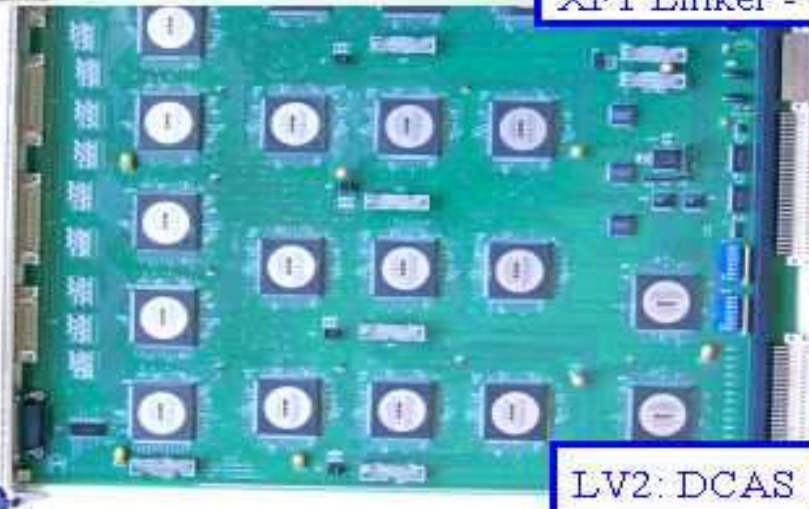
XFT Linker - OSU



FRED



LV2: DCAS



LV2: LOCUS





# Computing Hardware



**Code Server**

**File Servers**

**Worker Nodes**

**Linux 8-ways  
(interactive)**



# Hardware: Servers

**Servers (~300TB total, 110 4U & 5U):**

IDE RAID50 hot-swap  
old 4U = 2TB, new 5U = 5TB  
price today: ~\$2.5k per TB





# Hardware: Workers

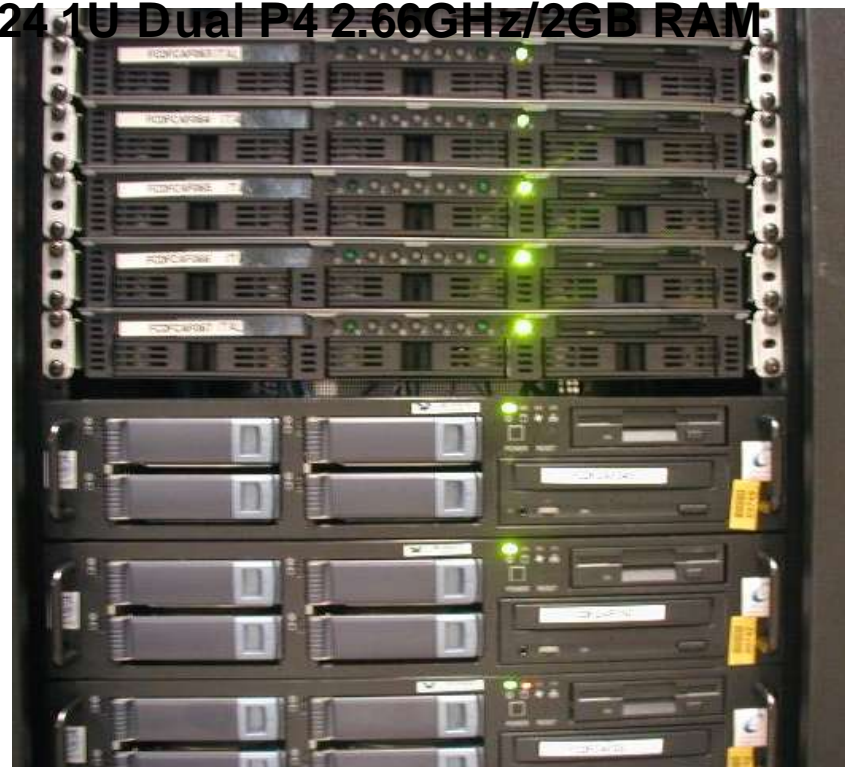
**Workers (1100 CPUs, 1U+2U rackmnt):**

**16 2U Dual Athlon 1.6GHz / 1.5GB RAM**

**48 1U/2U Dual P3 1.26GHz / 2GB RAM**

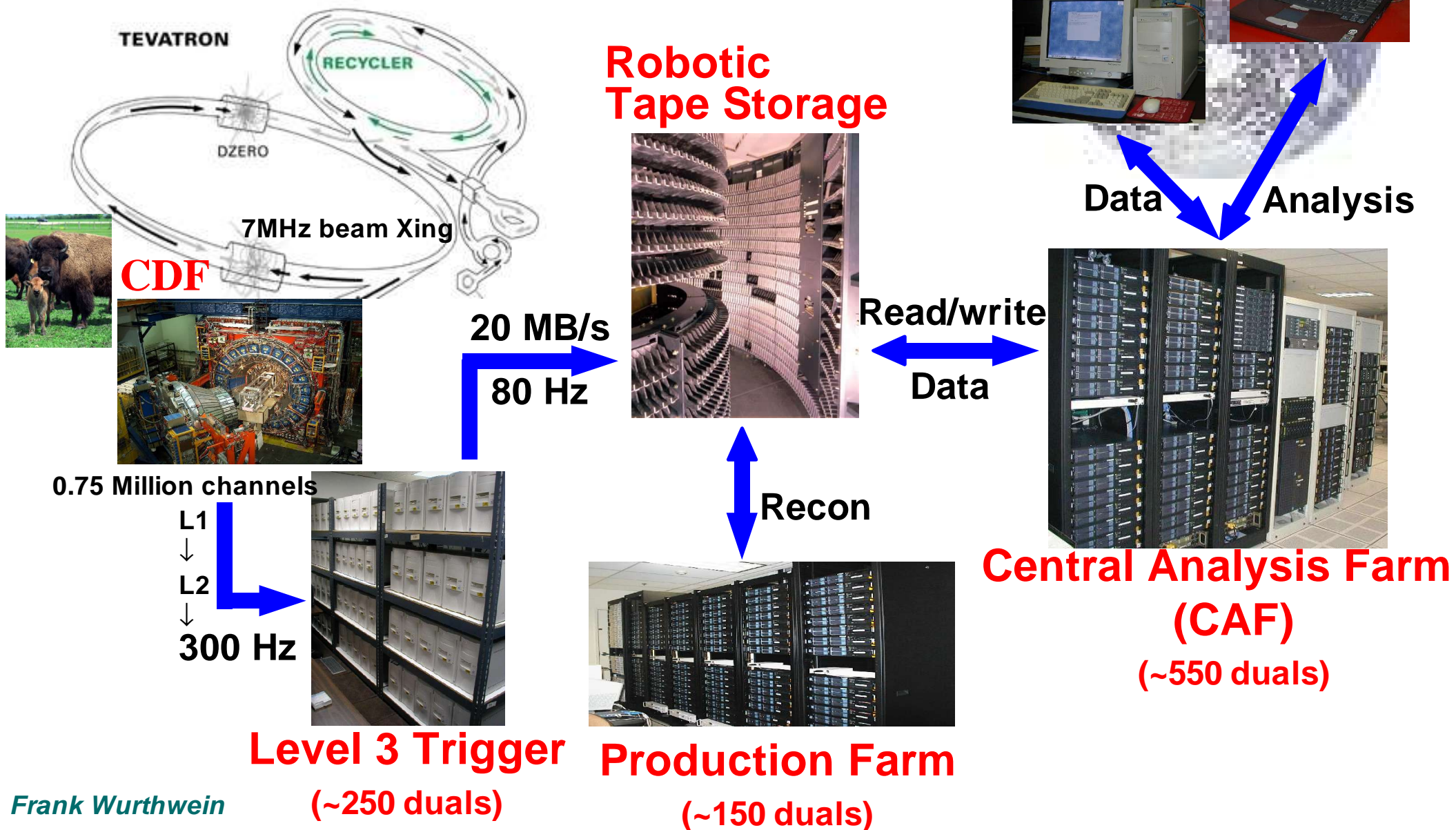
**236 1U Dual Athlon 1.8GHz / 2GB RAM**

**224 1U Dual P4 2.66GHz/2GB RAM**



*A few words about  
CDF Computing*

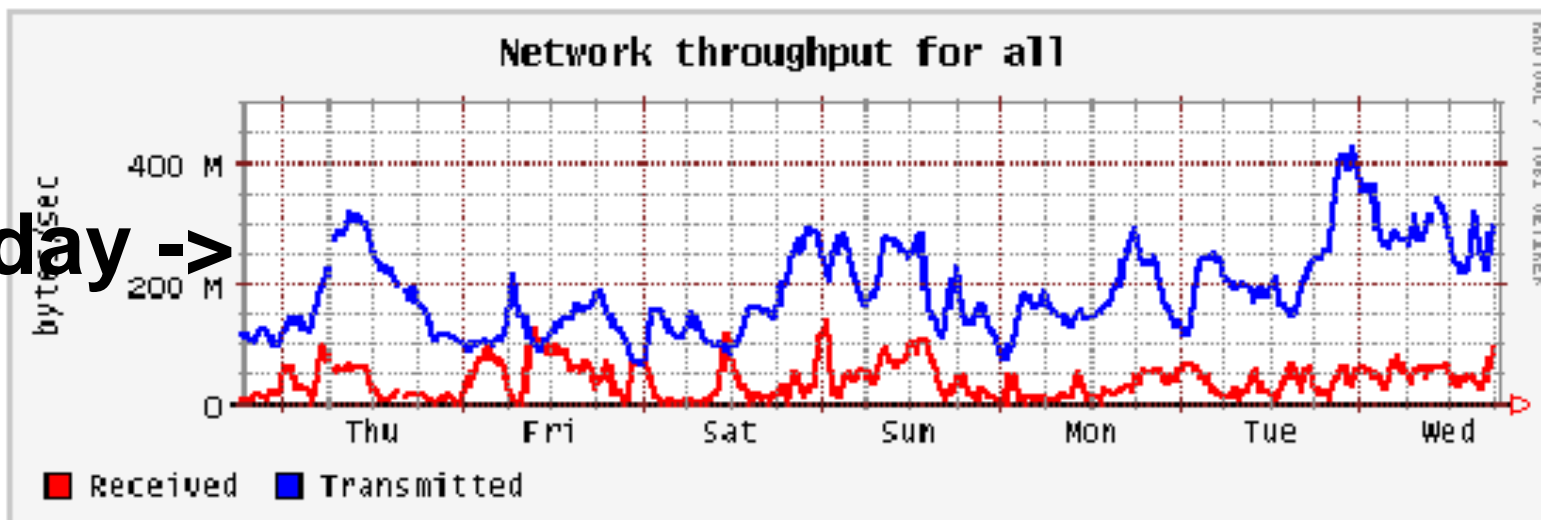
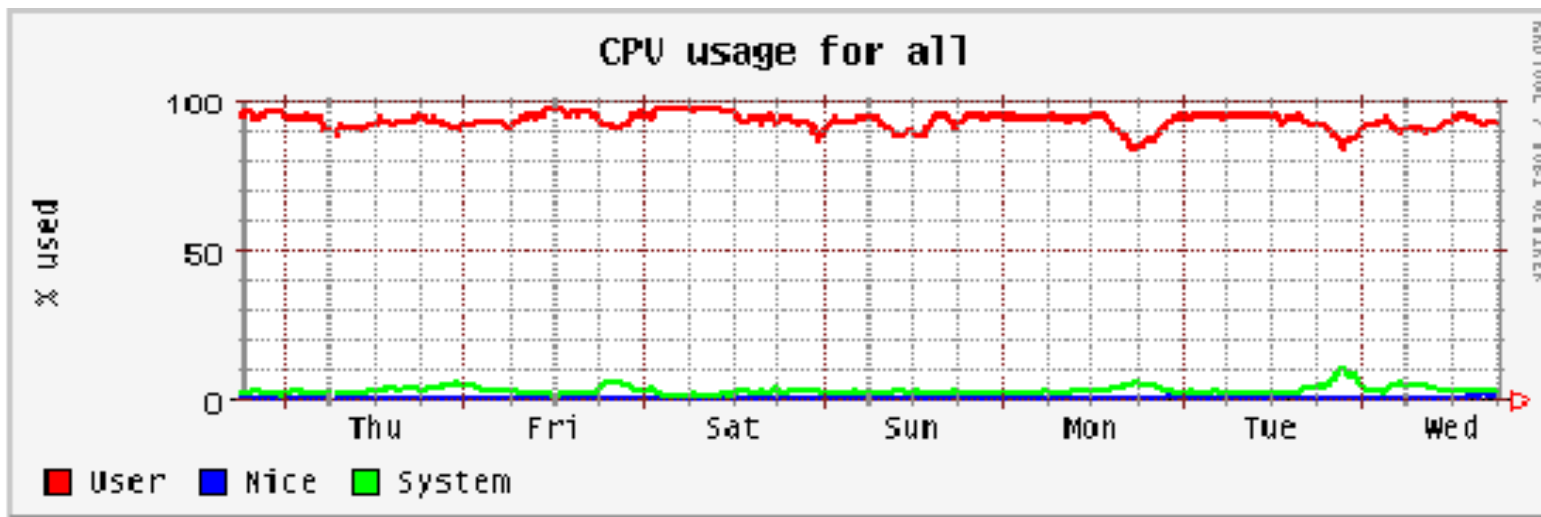
# CDF DAQ/Analysis Flow



Frank Wurthwein



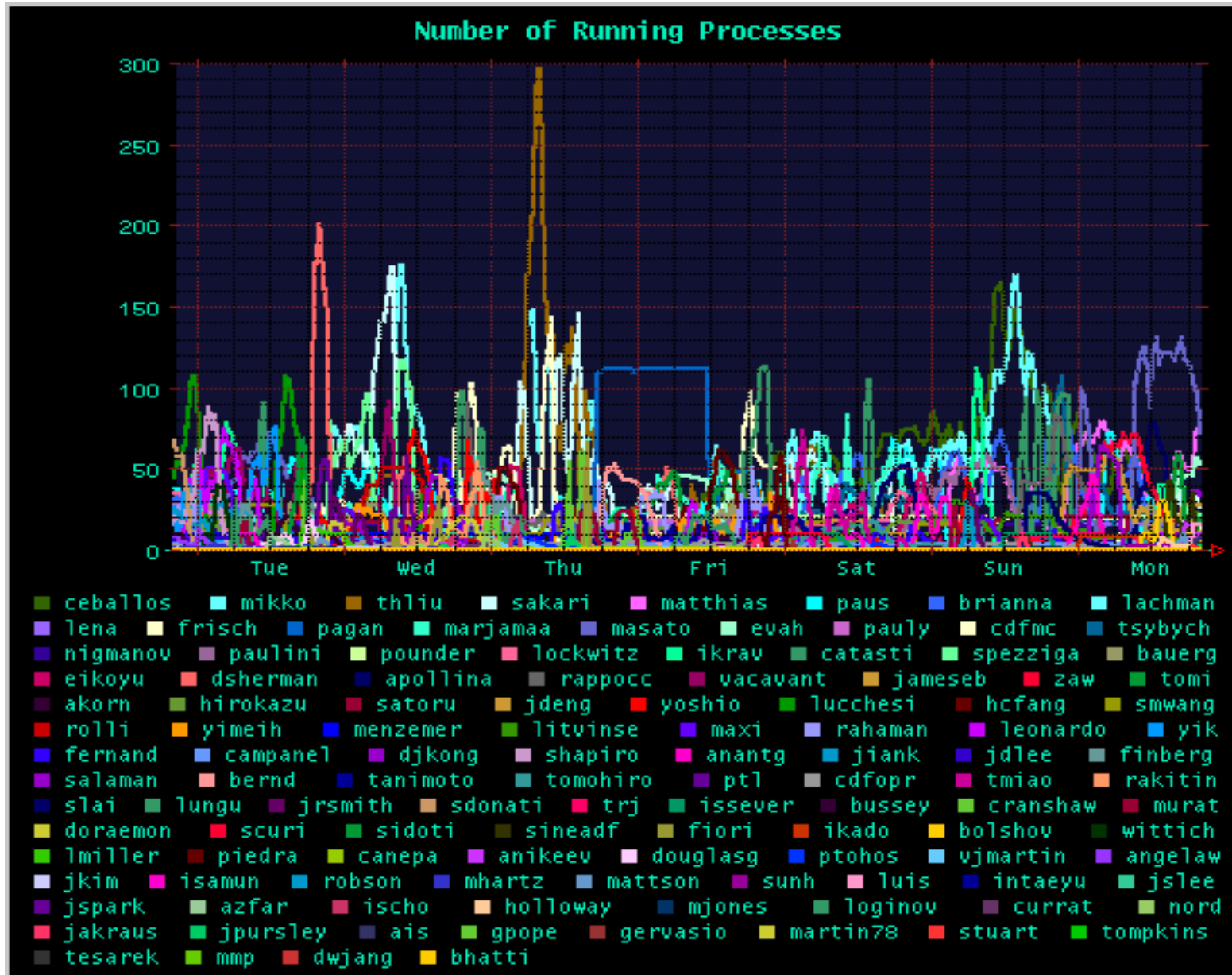
# CAF Utilization



20TB/day ->



# CAF Utilization





# "Services"

***Batch submission from desk/laptop anywhere.***

***Individual & group based fair share***

***DH services to desk/laptop & batch.***

***Metadata catalogue***

***file transfer (read, working on write)***

***posix-style file access (read only)***

***ls,tail,cat,gdb access to running processes.***



## Future Directions

***Fully virtualized multi-site services.***

***50% of resources outside FNAL by 2005***

***complete migration to "Grid middleware"***

***Interactive Grid services.***

***Prototype for SC03: 5 GB of data in 20s.***

***scheduling on 3 time scales:***

***"grid times" ~ hours***

***"session setup time" ~ minutes***

***"query times" ~ seconds***

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