



DARK MATTER

*and the use of
Social Media in an Unsocial Environment*



First... some science



Fritz Zwicky

Early evidence for Dark Matter

1: 1933: Looked at
Galaxy clusters

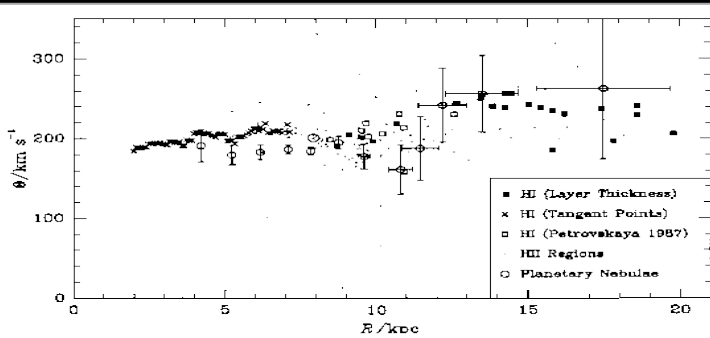
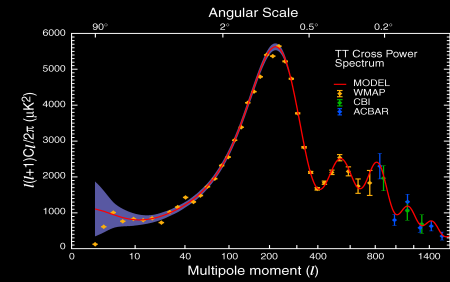
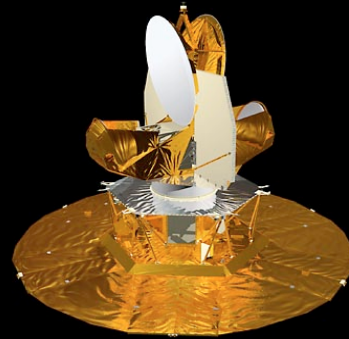
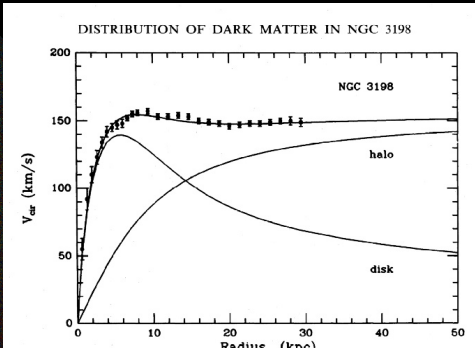
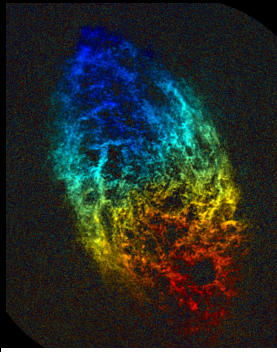
2. Observed their
motion

3: Applied the laws of physics
that we know

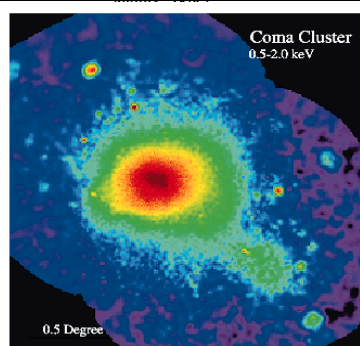
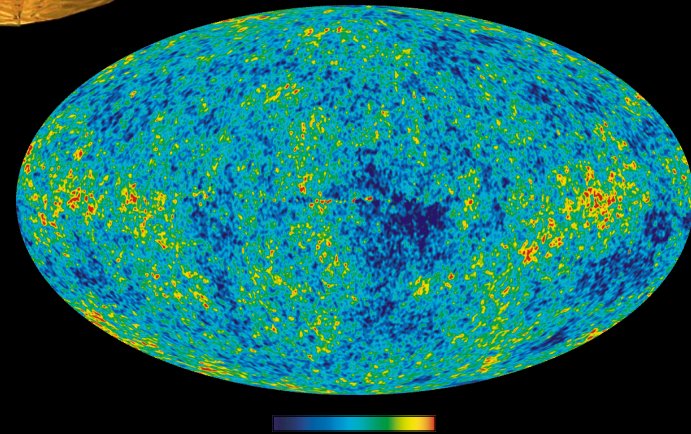
4: Deduced that there must be
more mass present than is seen





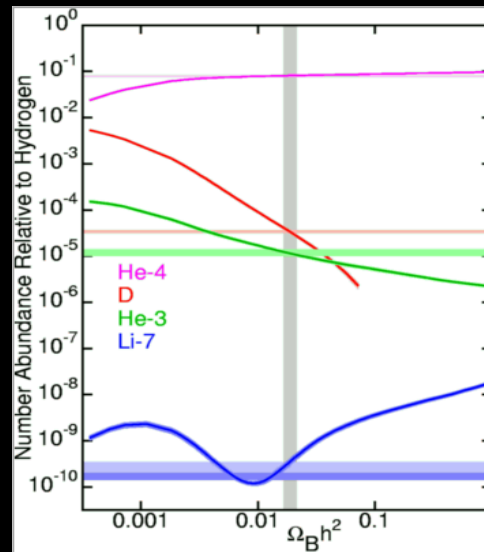


Comparison of the rotation curves calculated by all the methods discussed (assuming $R_0 = 7.0$ kpc and $\Theta_0 = 200$ km s $^{-1}$).



(a)
Copyright © Addison Wesley.

(b)



So what is this *Dark Matter*

Where did it come from?

Particle Physics to the Rescue

The 'Standard Model'

Fundamental particles: Electrons, quarks, gluons...

Fundamental forces: Electromagnetic, weak, strong

Works very very well at saying 'HOW'

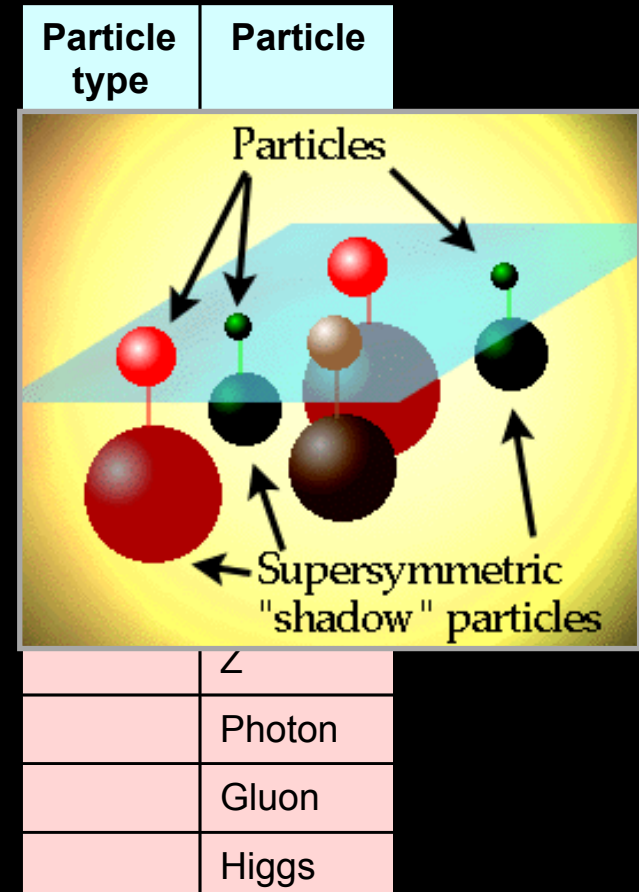
But it doesn't really answer 'WHY?'

But there is a theory that does!

SUPERSYMMETRY

SUPERSYMMETRY

- Explains why we see the range of particles and forces that we do
- Predicts more particles we have yet to see
- The lightest of these, the WIMP, has just the right properties to be dark matter
- Would have been made in the Big Bang; stable; big influence on cosmology
- It's an independent prediction!



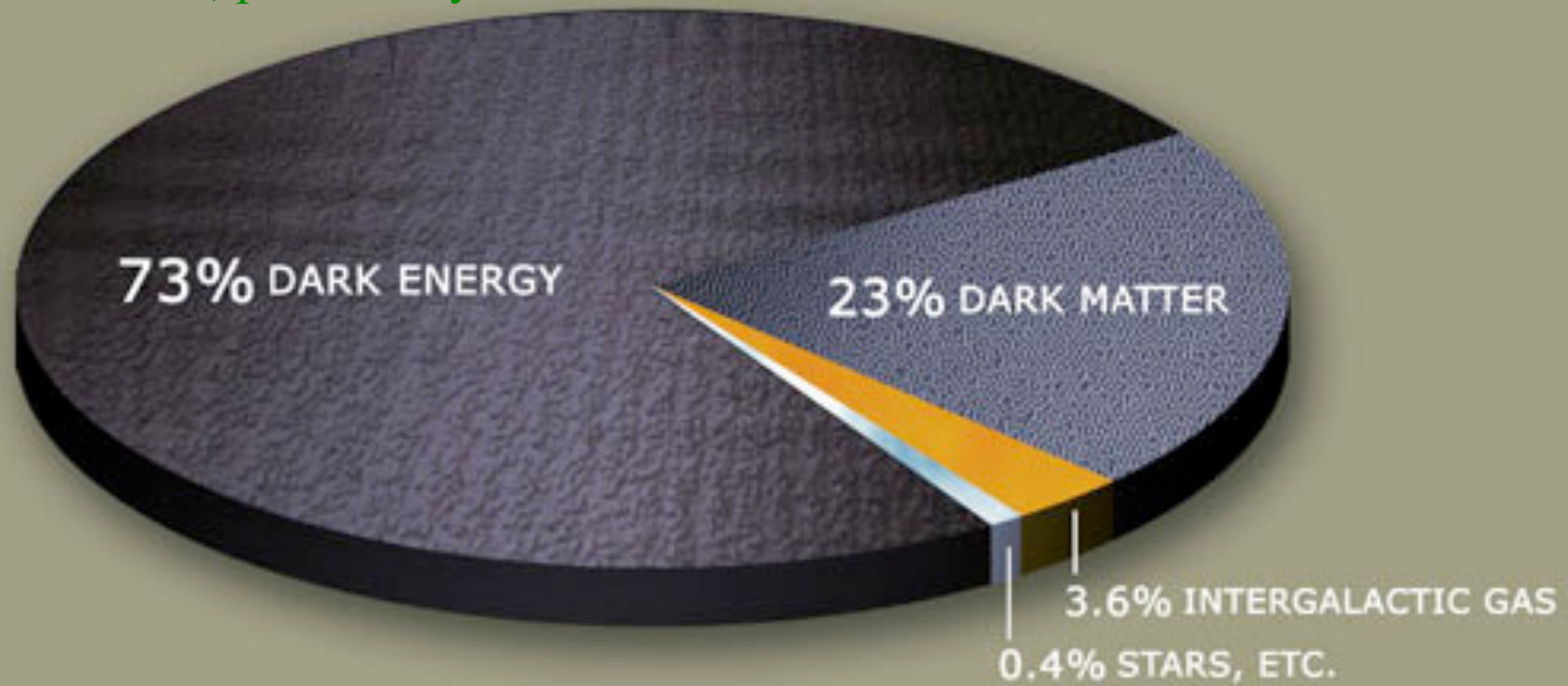
Conclusion: There is more matter out there than we can see in stars, planets etc.

This 'dark matter' is fundamentally different to normal matter

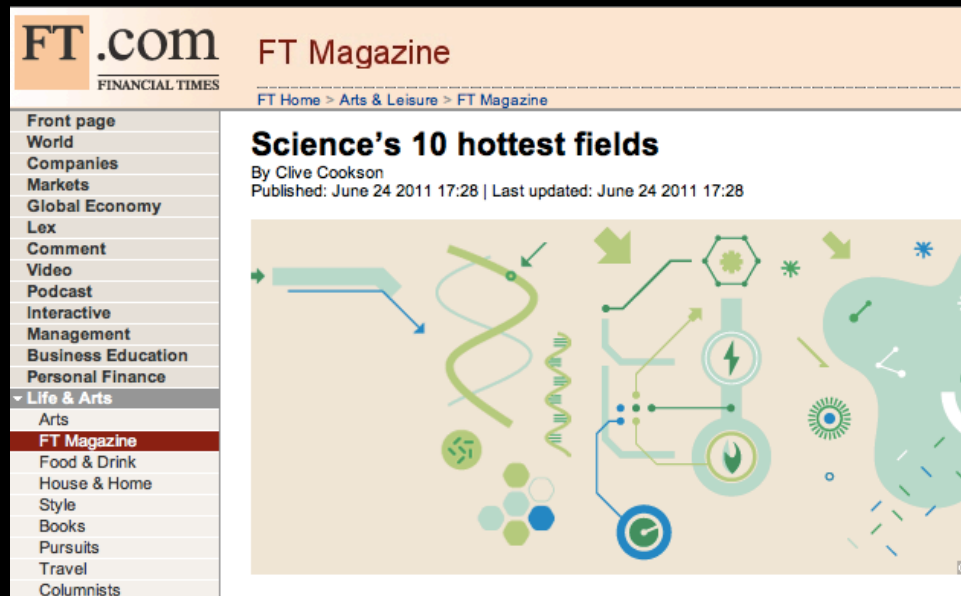
We have theories of what this stuff might be, but its never been seen

Summing it all up

Our Universe, present day



How important is this???



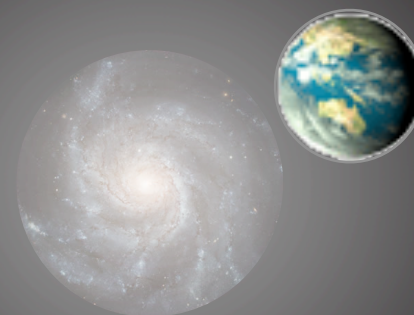
24 June 2011

- Understanding the genome
- Extra planets and extraterrestrials
- The composition of the universe - dark matter and dark energy
- Leap for quantum computing
- Graphene, the wonder material
- Embryonic stem cells and regenerative medicine
- Global warming
- Plants to feed the world
- The 'plastic' brain
- Disaster management

The Challenge

WIMP-like DM
hypothesis...

- Earth should be passing through a halo of weakly interacting massive particles
- We search for the rare collisions of WIMPs with normal matter here on Earth.



Basic method

Make a device that should see nothing
from normal physics

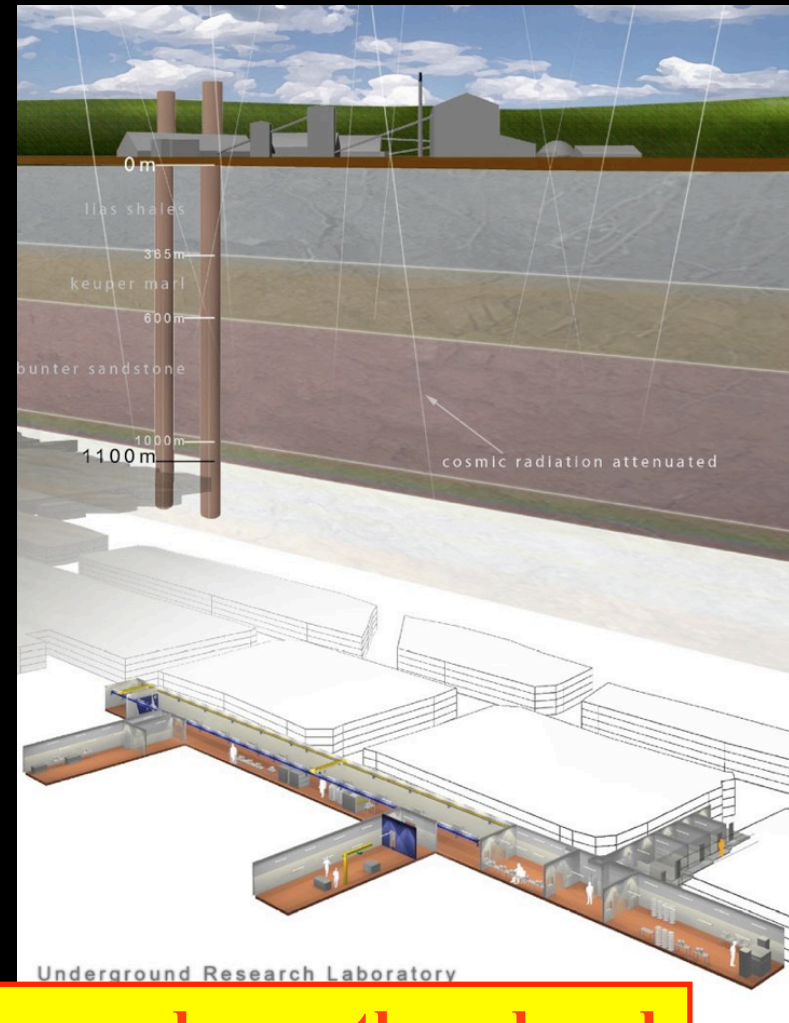
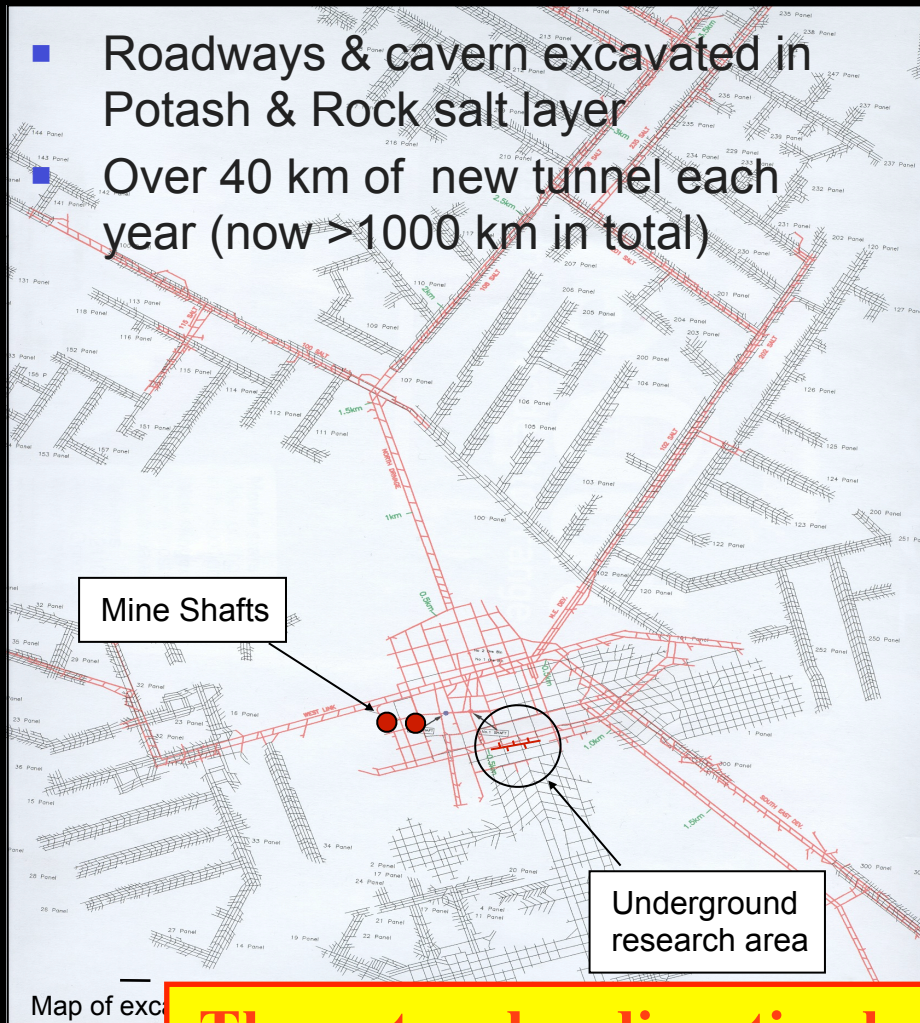
And see if there's anything still there...

WHERE SHALL WE SEARCH?

The Boulby Mine - A very dark place!



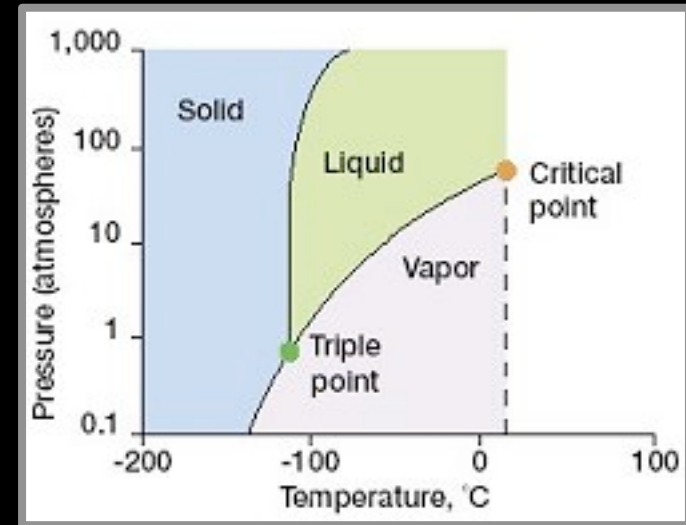
An active salt and potash mine



The natural radioactive backgrounds greatly reduced

The nature of the beast

- High voltages (up to 17kV)
- Liquid xenon
 - Requires fine temperature control
 - Potential for explosive release
- ~30 slow control readings monitored and logged
- ~120 channels of data reading out 20 us timelines at 10 ns sampling, at ~1/2 Hz, 23 hours a day, 320 days continuous operation (c. 100s Tb)
- Daily automated calibration - radioactive source
- Located in a salt mine - 'fluid' surroundings



The harsh and remote environment

- Minimum 4 hours from IC or Edinburgh
- Access to u/g lab takes at least another hour
- Environment is hot, dry, dusty... tiring
 - Detectors housed in separated clean-room
- Subsistence costs ~£100/day
- Inherently hazardous - safety is paramount
- Constant monitoring and adjustments necessary

Monitoring via the Web

NASDAQ DRIFT Watch

Jun 29 2011 14:19:03 UTC (15:19:03 Local, +1:00)

Overview

Detector Crate Slow Fast Add +
drift2d 1 okay running Modify [icon] Drop [icon]
Log Archive Disk Space 262 GiB Database: okay

Watch

User Daniel Walker
E-mail Daniel.Walker@Sheffield.ac.uk
Text
Clear [icon] Set [icon] Test [icon]

Gas System Slow Control Add Channel +

Gas Mixer: 75 / 25 %

	Pressure	Target	Minimum
Vessel	39.9993 Torr	40 Torr	39.9 Torr
Mix. Cyl.	193.584 Torr	320 Torr	140 Torr

Normal Gas 1 (CS₂) → Mix. Cyl. [icon] [icon] [icon] [icon] [icon]

Gas 1 (CS ₂)	Gas 2 (CF ₄)	⇒Supply	⇒Vessel
100% / 77%	Closed	Closed	11% / 11%

Analog Inputs

Channel	Reading	Limit	[icon]	[icon]	[icon]	[icon]
CS_2 Weight	14.0713 kg	<11.5	[icon]	[icon]	[icon]	[icon]
HHV Current	-53.7443 uA	<-55	[icon]	[icon]	[icon]	[icon]
HHV Voltage	35.4805 kV		[icon]	[icon]	[icon]	[icon]
Left Grid Current	-9.32081 uA	<-9.5	[icon]	[icon]	[icon]	[icon]
Left Grid Voltage	2.85088 kV		[icon]	[icon]	[icon]	[icon]
MFC1 Flow	3.86083 V		[icon]	[icon]	[icon]	[icon]
MFC2 Flow	-0.00663463 V		[icon]	[icon]	[icon]	[icon]
MFC3 Flow	0.00406386 V		[icon]	[icon]	[icon]	[icon]
MFC4 Flow	0.534907 V		[icon]	[icon]	[icon]	[icon]
MFC4 Set Point	0.532161 V		[icon]	[icon]	[icon]	[icon]
PG1 Pressure	194.432 Torr	<139	[icon]	[icon]	[icon]	[icon]
PG2 Pressure	131.016 Torr	<80	[icon]	[icon]	[icon]	[icon]
Right Grid Current	-9.09754 uA	<-9.3	[icon]	[icon]	[icon]	[icon]
Right Grid Voltage	2.85102 kV		[icon]	[icon]	[icon]	[icon]
Vessel Pressure	40.0016 Torr	<39.9	[icon]	[icon]	[icon]	[icon]
Vessel Temperature	61.1668 C		[icon]	[icon]	[icon]	[icon]

Fast, Waveform Acquisition

Start [icon] Configure [icon] Rate Limit [icon] Stop [icon]

Waveform Plotter Rate Plotter

Status	running
Cycle	norm
Trigger Rate	1.3989 Hz
Rate Limits	0.5 Hz
Range	±1.25 V
Trigger Mode	wire
Write Rate	1.36338 Hz
Left Trigger Rate	0.596246 Hz
Right Trigger Rate	0.802658 Hz
Run	20110629-02
File Name	drift2d-20110629-02-0003-wimp.ndd
Run Time	1h 13m 27s (4407 s)
Run Live Time	1h 6m 28s (3988.52 s)
Cycle Time	1h 7m 7s (4027 s)
Cycle Live Time	1h 6m 8s (3968.52 s)
Run Events	7072
Cycle Events	5072
Left Run Events	3305
Right Run Events	3767
Left Cycle Events	2305
Right Cycle Events	2767
Comment	Background run, 2.84kV, 30-10 CS ₂ -CF ₄ , 1x flow.

Monitoring via the Web

ZEPLIN III Real-Time Status
29 May 2011, 08:59:29 GMT

[[DAQ/Veto](#)] [[SlowCon](#)] [[HV/Vac/Env](#)] [[Plots](#)] [[Sensor map](#)] [[Wiki](#)] [[Time machine](#)]
[[Idiot's guide](#)] [[Calendar](#)] [[Dione webcam](#)] [[Titania webcam](#)]

Team: CG(op.), CG, PAM

High Voltage

Quick Check

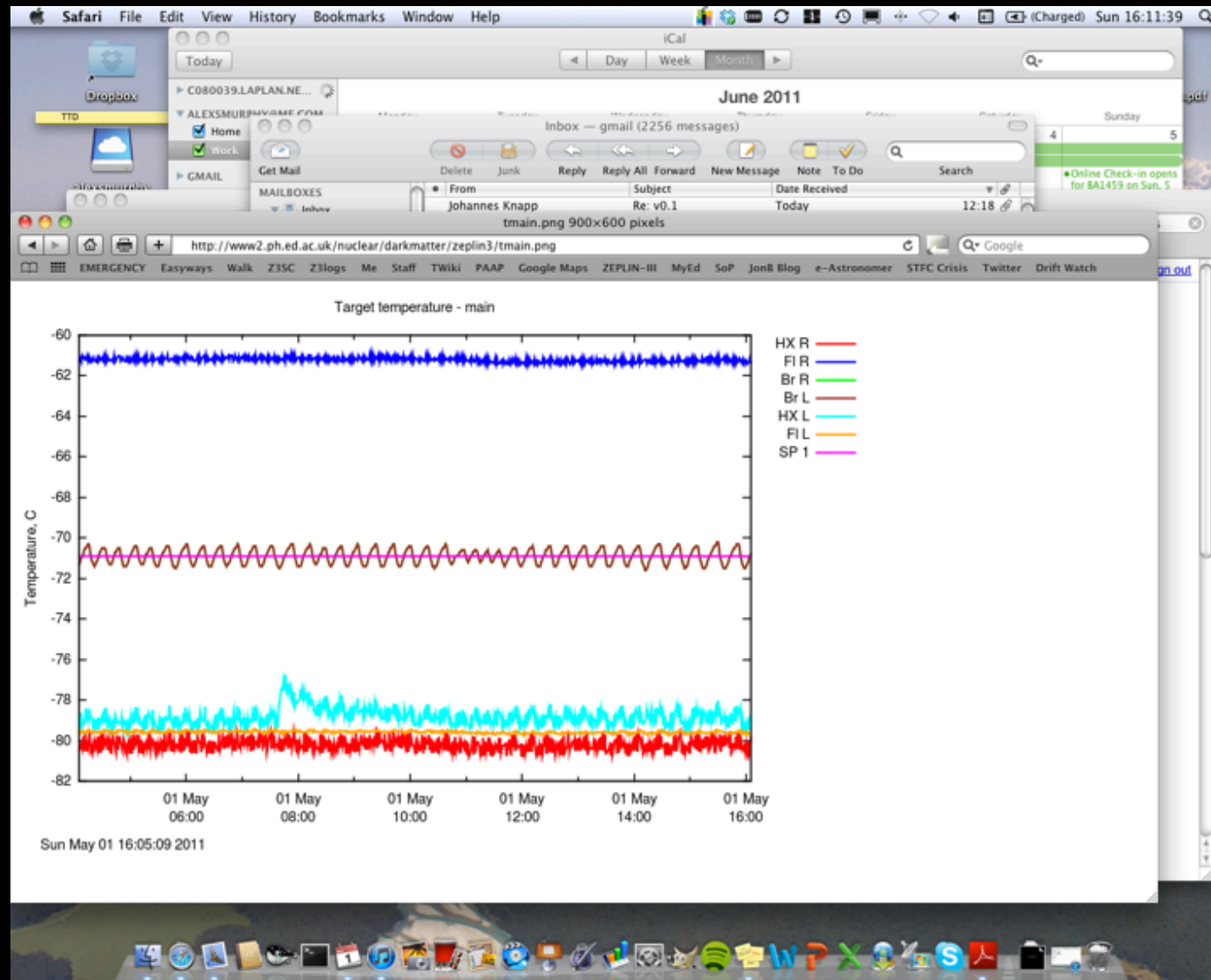
Parameter	Value	Range
TARC	-0.003	1.62 ± 0.01
LFS.SP	-67.50	-70.5 ± 1.0
Br.L	-67.00	$SP \pm 0.7$
FLL	-77.01	-80.5 ± 0.5
Vacuum	1.23e-08	$< 1.0e-7$
Amb.T	28.60	26 ± 2

	Status	V	I
Anode	✓	-162.40	-52.14
Cathode	✓	18430.00	117.63
PMT	✓	900.00	4580.00

Z3 DAQ and Veto

	Status	Rate	Events	HDD Free
Z3 DAQ	running	0.33	31820	631.58
Veto	stopped	0.00	0	\$VF\$

“Slow control”



Remote adjustments

- Xdisplay, Remote desktops, ssh, etc
- Can control voltage, temperature, data acquisition
- Site-wide power failures are a problem!
 - UPS power for ~ 8hours
 - When power comes back on, there's often things you don't want to re-start!
 - USB controlled power sockets

Network speed issues

- Link between surface and underground is *fast*
 - But has a high failure rate
 - Phone-line modem backup ('shutdown' signal)
- Link between the mine and civilisation is slow
 - Low bandwidth applications vital
 - e.g. Twitter feed
 - non-video skype
- Data are sent to surface and written to tape/
usb disk, then physically transported to RAL

Twitter

The screenshot shows a Twitter home page in a Safari browser window. The browser's address bar displays the URL <http://www.ph.ed.ac.uk/people/a-to-z>. The Twitter interface includes a search bar, navigation links (Home, Profile, Messages, Who To Follow), and a user profile for GrumpyScientist. The main content area is divided into two columns. The left column, titled 'What's happening?', shows a timeline of tweets from the user zeplin3, all from the account ZEPLIN III. The tweets report on the status of the TARC (Tera-Range Accelerator) and its DAQ (Data Acquisition) system, including bar pressure, DAQ status, and free space. The right column shows 'Your Tweets' (277), 'Following' (26), 'Followers' (32), 'Favorites' (2), and 'Listed' (4). It also features 'Trends' and 'Who to follow' suggestions. The bottom of the screen shows a Mac OS X desktop with various application icons in the dock.

What's happening?

Timeline @Mentions Retweets Searches Lists

zeplin3 ZEPLIN III
11:04:06 P(TARC): 1.613 bar, DAQ: stopped (0 events), 206.29 GB free
17 minutes ago

zeplin3 ZEPLIN III
10:56:44 Refilled in 572 seconds
24 minutes ago

zeplin3 ZEPLIN III
10:47:12 LN2 refill started
34 minutes ago

zeplin3 ZEPLIN III
10:03:54 P(TARC): 1.615 bar, DAQ: running (1360 events), 242.97 GB free
1 hour ago

zeplin3 ZEPLIN III
09:03:41 P(TARC): 1.615 bar, DAQ: running (36040 events), 246.04 GB free
2 hours ago

zeplin3 ZEPLIN III

Your Tweets 277

30 Apr: Ow. My sides hurt
<http://www.losteyeball.com/index.php/2007/06/19/56-worstbest->

Following 26

Followers 32

Favorites 2

★ Shuchan @GrumpyScientist
Thanks - looks like it's working!
Look at me, totall...

Listed 4

Recently listed in: Science and Scientists, Science, science etc, STFC

Trends

Worldwide · change
#Everything2Prove Promoted
#ileftyoubecause
#deminem
#javamusikindo17
ThirtySecondsToMars
JPII
Camden Crawl
Masterchef
MotoGP
Sundays

Who to follow

Suggestions for you · view all

fring · Follow
fring
Promoted

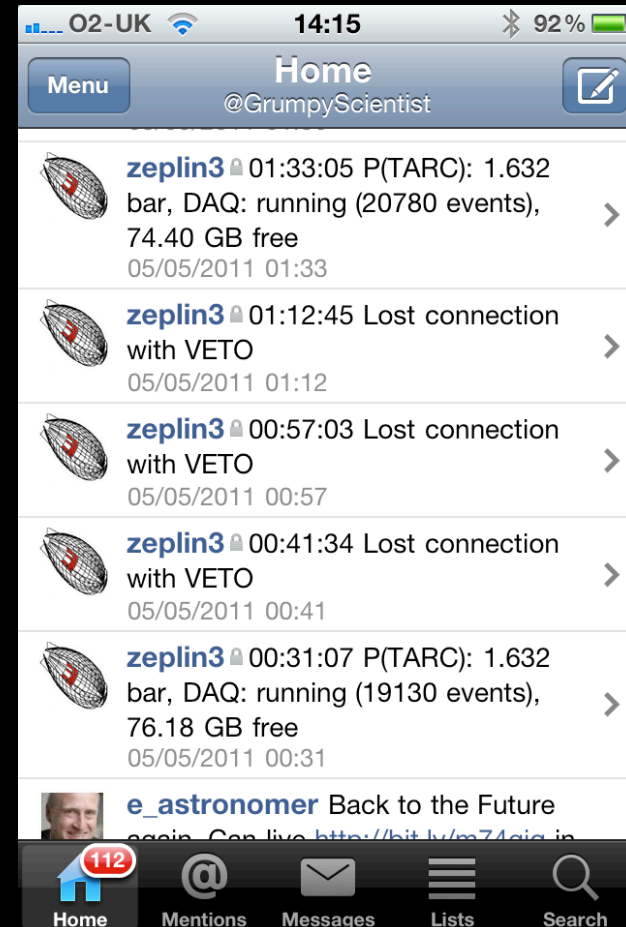
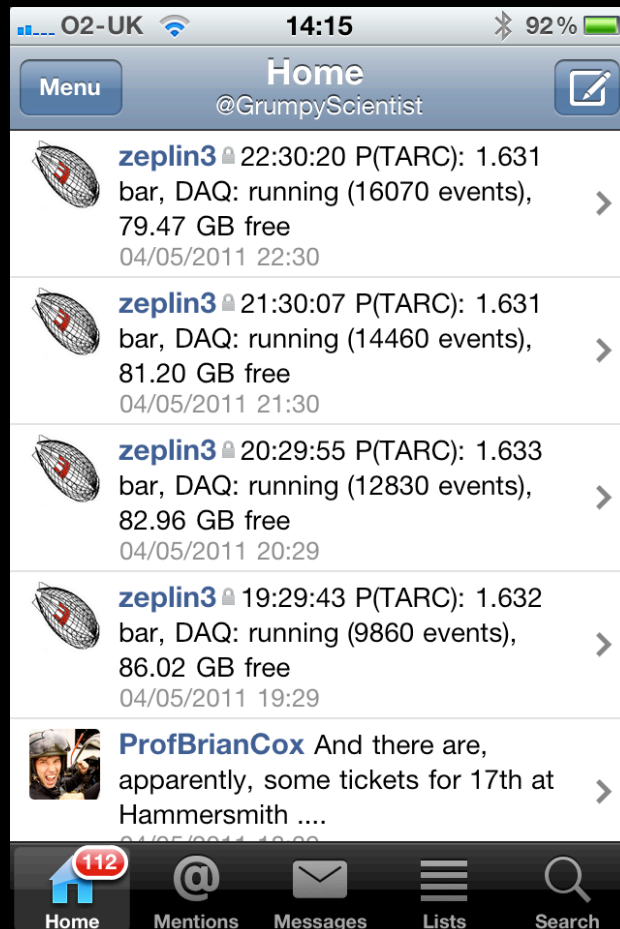
science · Follow
science

SKY SkyandTelescope · Follow
Sky and Telescope

jameswilsdon · Follow
James Wilsdon

Refresh suggestions
Browse interests · Find friends

and on an iPhone*



Key facts, 'anywhere', fast, reliable, useful formatting

*Other handheld mobile devices are available...

How did we do?

- Successful 320-day run.
- 'Fully' remote operation (1 morning/wk access to perform liquid nitrogen refill)
- 24hr monitoring somewhere in the world
- Stable operation within operating margins
 - 1 excursion due to 2 day site-wide power outage
- **0 health and safety occurrences**
- Publication of world-class science result imminent (many publications already)



Thank You!