DARK MATTER

and the use of

Social Media in an Unsocial Environment

First... some science

Fritz Zwicky

Early evidence for Dark Matter
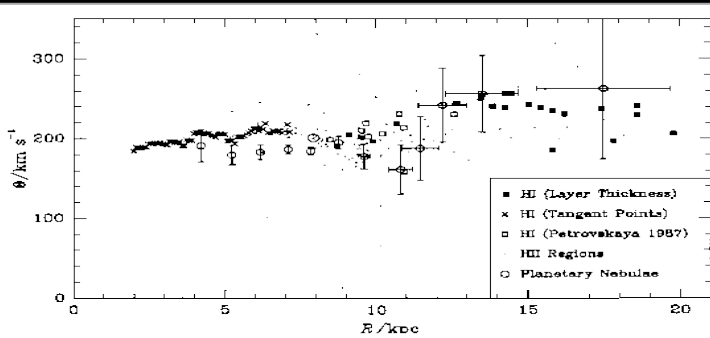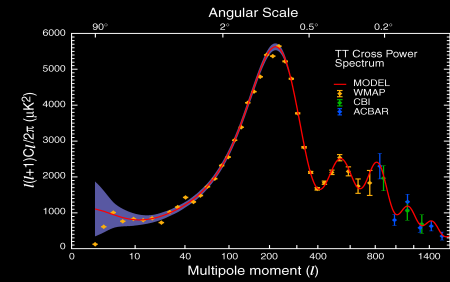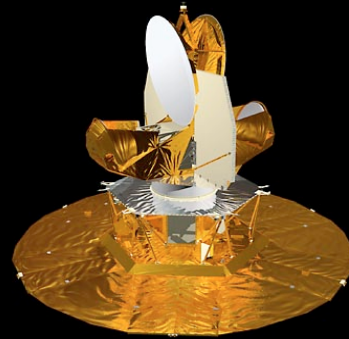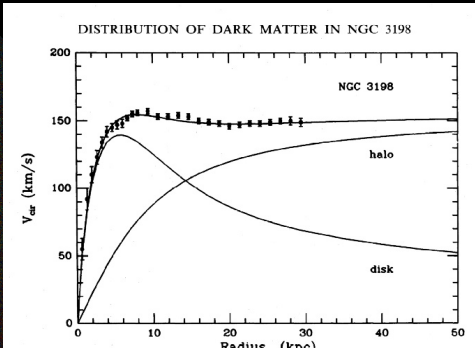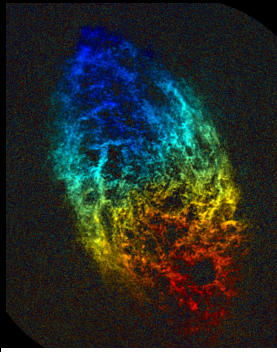
1: 1933: Looked at Galaxy clusters

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

© GALAXYZOO

DISTRIBUTION OF DARK MATTER IN NGC 3198

NGC 3198

halo

disk

V_{cir} (km/s)

Radius (kpc)

Angular Scale

TT Cross Power
Spectrum

MODEL
WMAP
CBI
ACBAR

$l(l+1)C_l/2\pi$ (μK^2)

Multipole moment (l)

Θ/km s^{-1}

■ HI (Layer Thickness)
× HI (Tangent Points)
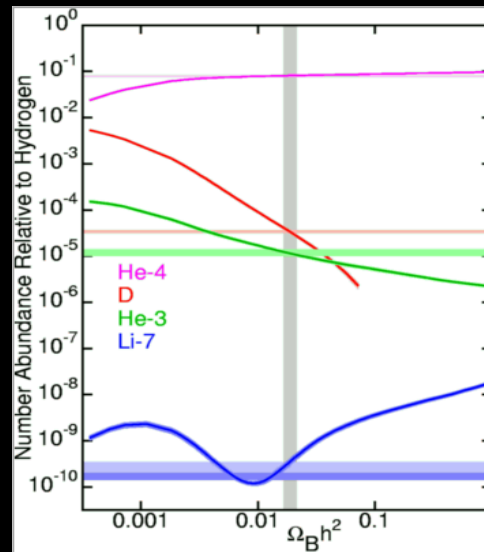□ HI (Petrovskaya 1987)
· HII Regions
○ Planetary Nebulae

R/kpc

Comparison of the rotation curves calculated by all the methods discussed
(assuming $R_0 = 7.9$ kpc and $\Theta_0 = 200$ km s^{-1}).

Coma Cluster
0.5-2.0 keV

0.5 Degree

(a)

(b)
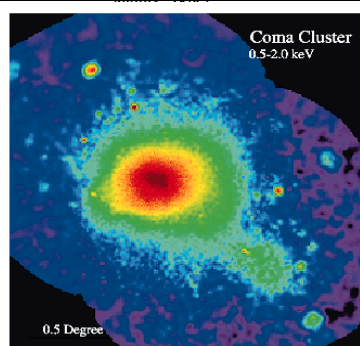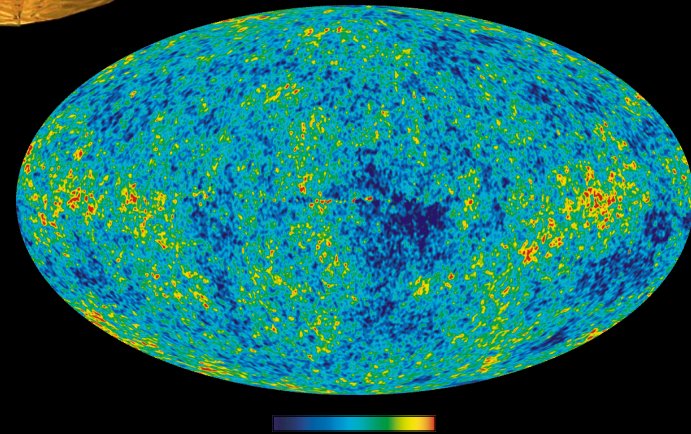
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Number Abundance Relative to Hydrogen

He-4
D
He-3
Li-7

$\Omega_B h^2$

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
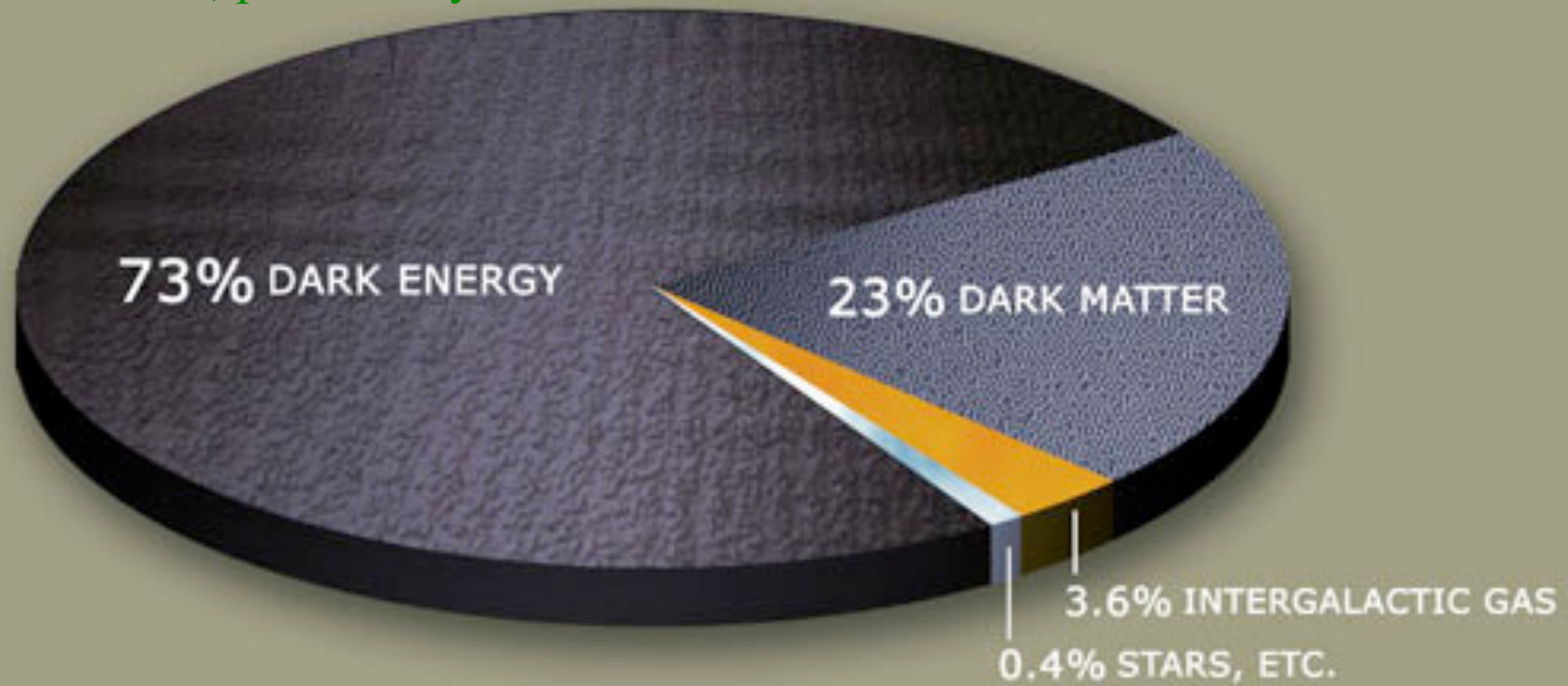- It's an *independent* prediction!

Particle type	Particle
	Z
	Photon
	Gluon
	Higgs

Particles

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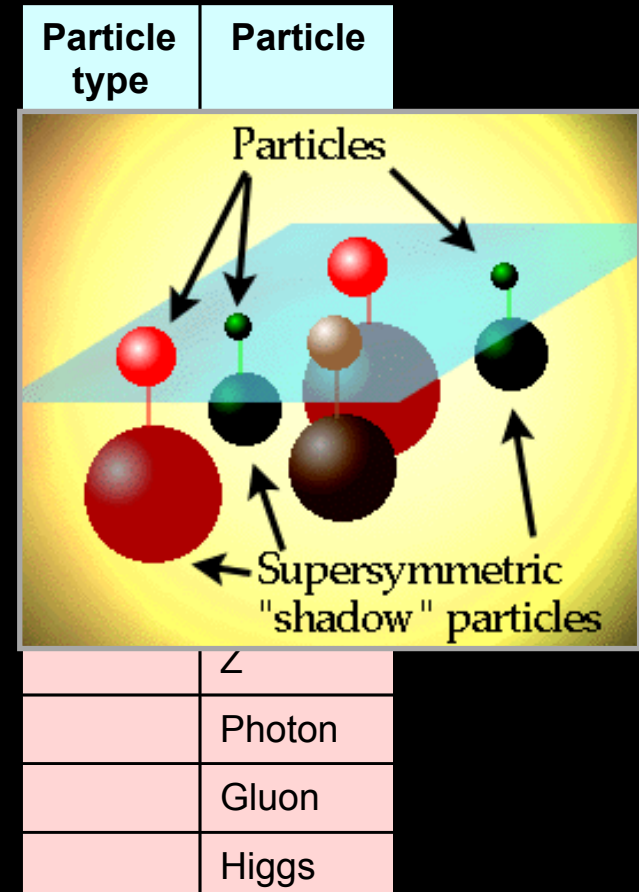
Conclusion: There is more matter out there than we can see in stars, planets etc.

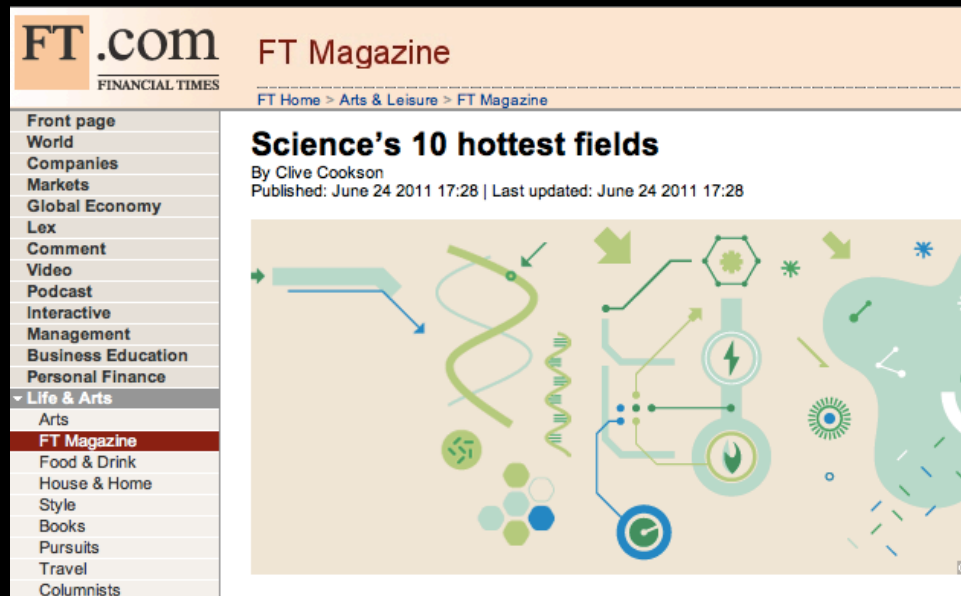This 'dark matter' is fundamentally different to normal matter

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

Summing it all up

Our Universe, present day

73% DARK ENERGY   23% DARK MATTER

3.6% INTERGALACTIC GAS

0.4% STARS, ETC.

How important is this???

FT.com — FINANCIAL TIMES

FT Magazine

FT Home > Arts & Leisure > FT Magazine

Science's 10 hottest fields
By Clive Cookson
Published: June 24 2011 17:28 | Last updated: June 24 2011 17:28

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.
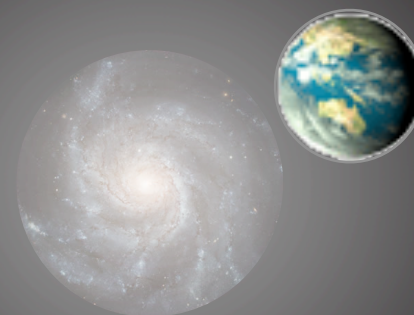
Basic method

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

- Roadways & cavern excavated in Potash & Rock salt layer
- Over 40 km of new tunnel each year (now >1000 km in total)

Mine Shafts

Underground research area

Map of exc...

0 m
lias shales
385m
keuper marl
600m
bunter sandstone
1000m
1100 m
cosmic radiation attenuated

Underground Research Laboratory
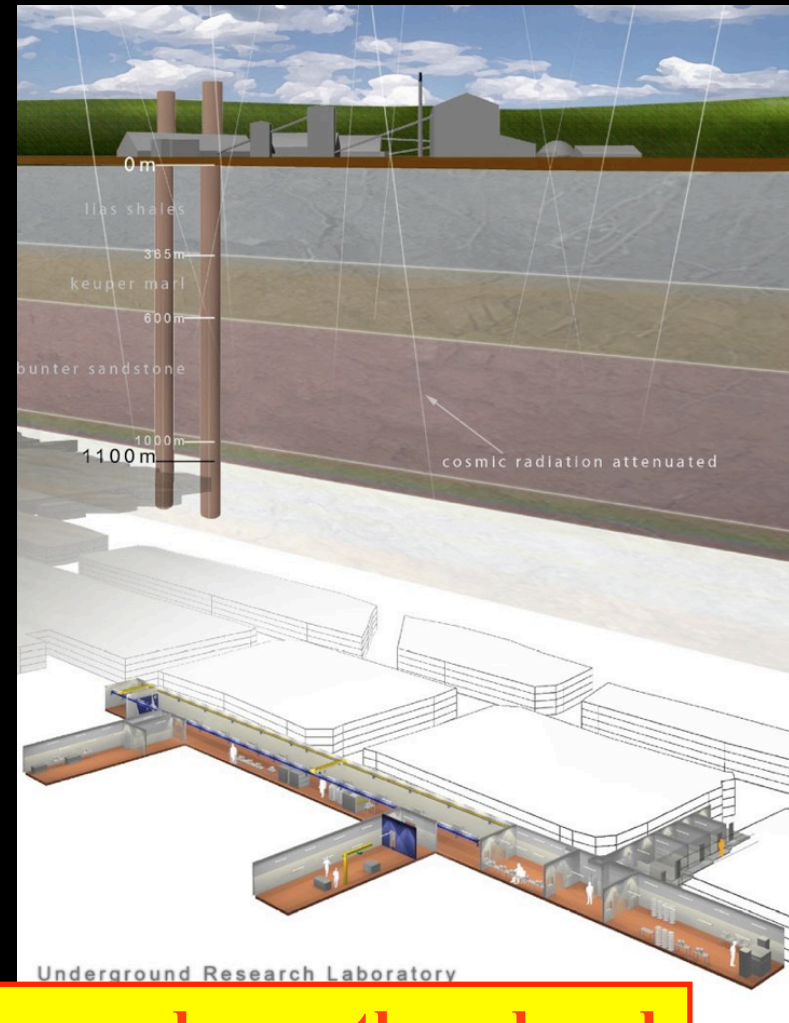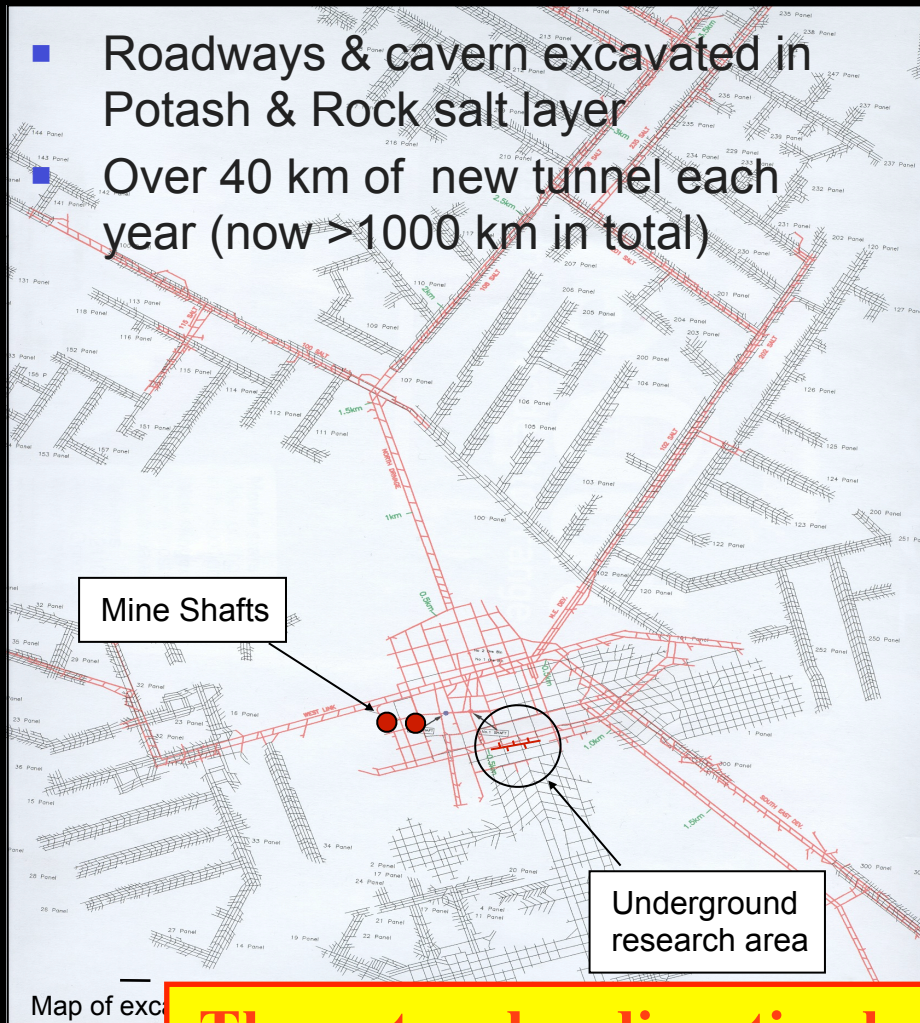
The natural radioactive backgrounds <u>greatly</u> reduced

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
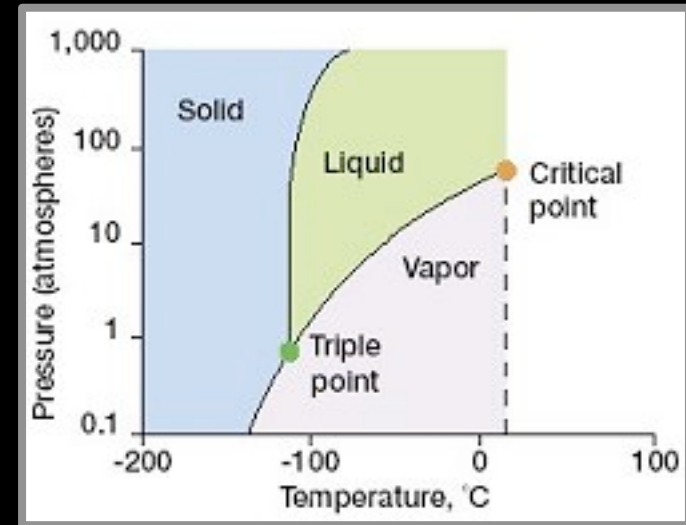
The harsh and remote environment

- 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

Monitoring via the Web

"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

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!