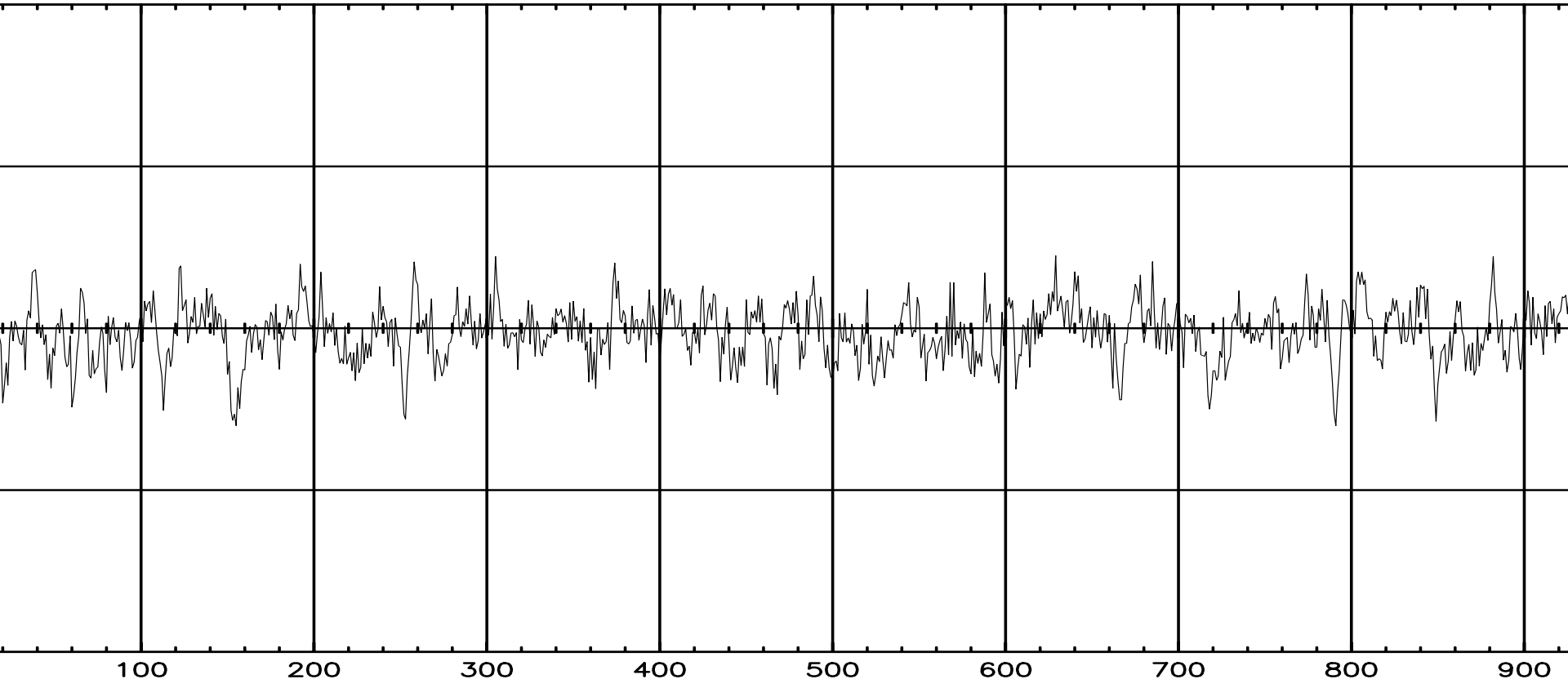
Life at the Confusion Limit

Life turns on a dime…..

Are the dime-turning points always recognizable?

Jasper Wall (+ Tessa Vernstrom)
2018-12-07

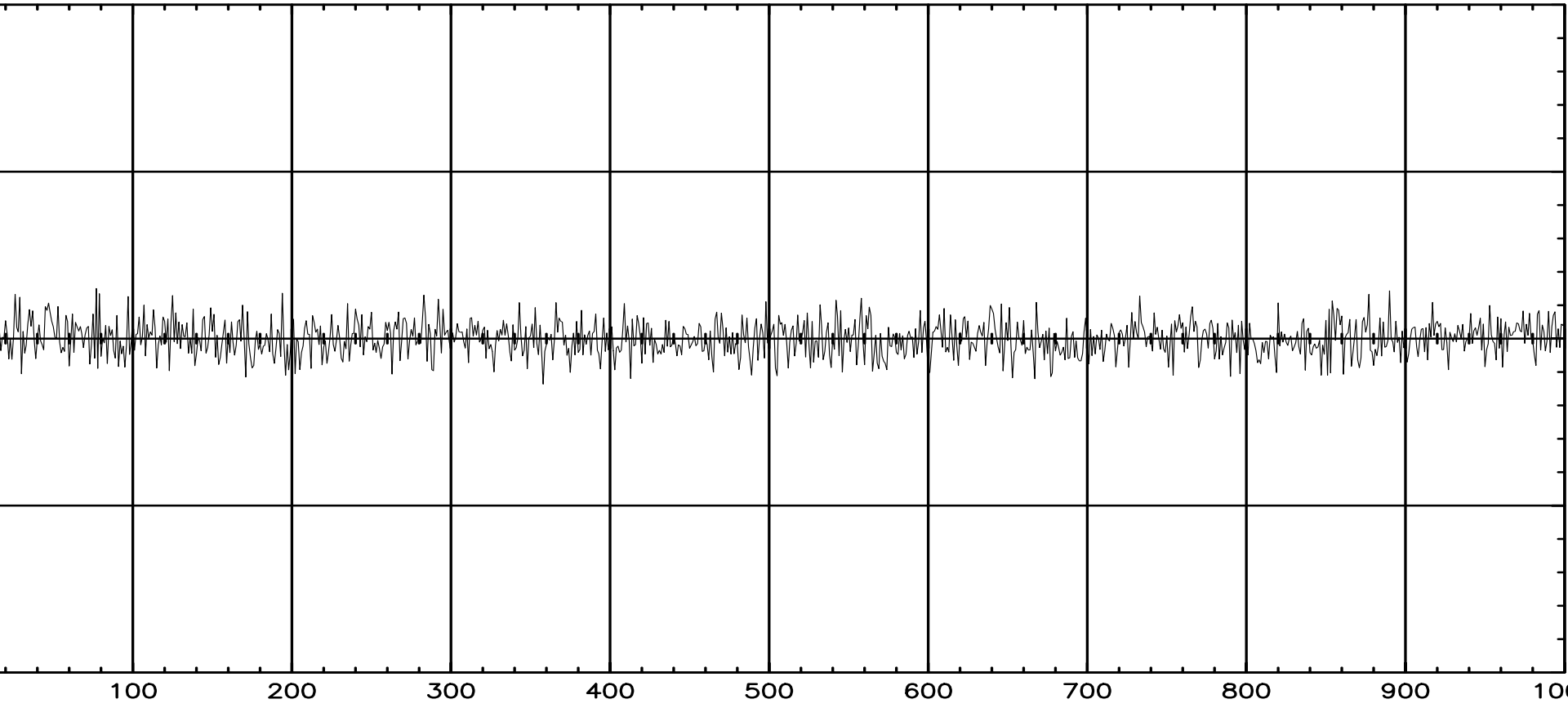
1973: lunch time, 2.7-GHz …….



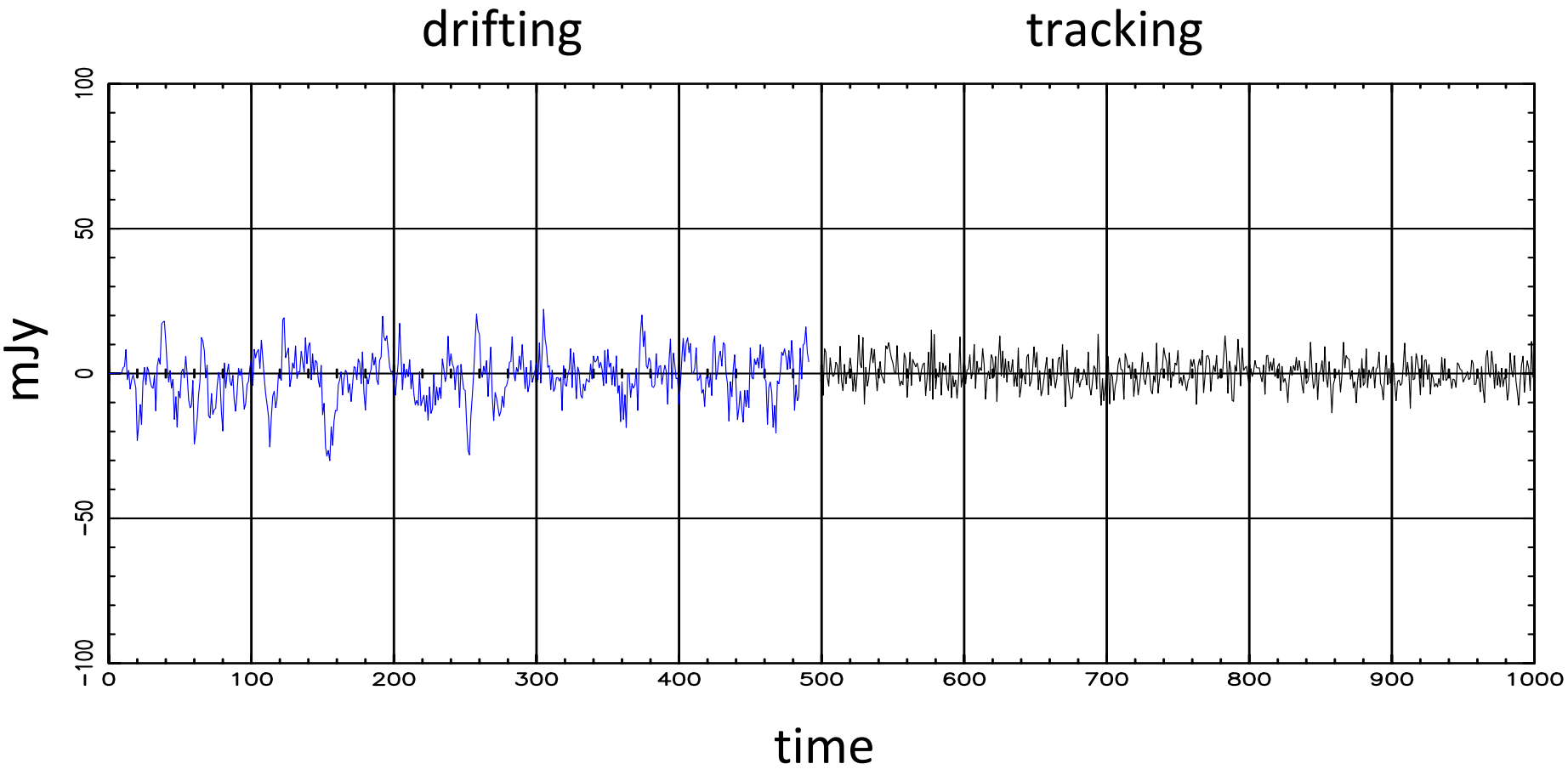
`Someone' forgot to turn off the chart recorder

Dish stowed (zenith sky sliding by……)

Dish pointed to start of survey scan − tracking on

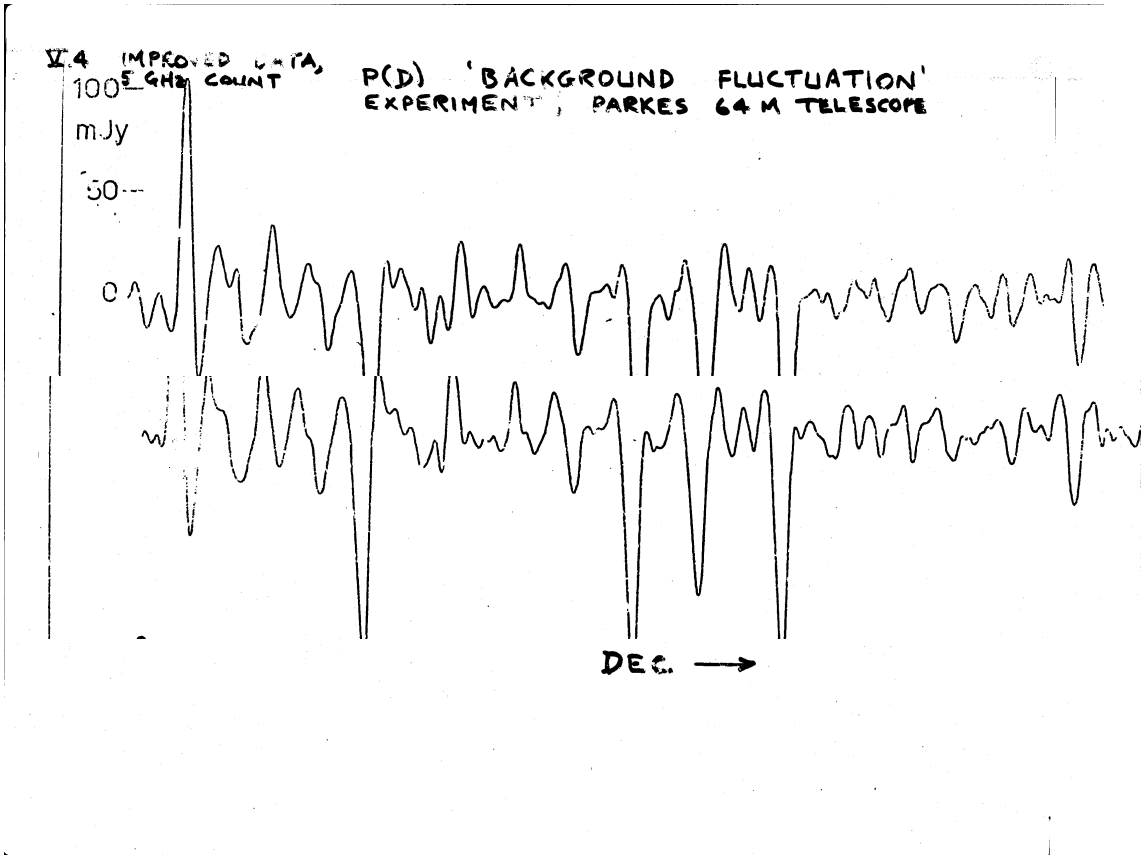


……what??
different noise??



Direct comparison. Lower noise when tracking? Why?

Confusion !!!



A (double) 2.7-GHz sky integration to the confusion limit
Second integration, same track: all features are duplicated

NB - dual-beam differencing feed system, HPBW 8 arcmin
- only believe sources at level of > 30 beam-areas per source
- perhaps the 4 largest deflections represent real sources
- confusion `noise' is highly non-Gaussian

Integration can measure deflection distribution P(D)
But how to get cosmological info?? Like this:

FLUCTUATIONS IN THE X-RAY BACKGROUND

P. A. G. Scheuer

(Received 1973 August 16)

SUMMARY

The fluctuations in the X-ray background at high galactic latitudes give an upper limit to the counts of extragalactic X-ray sources near the intensity level corresponding to one source per beam width. The general mathematical relation between the source counts and the probability distribution of the resulting contribution to the fluctuations is known, and is here computed for various extrapolations of the observed source counts to fainter sources. The observed limits to background fluctuations are consistent with a uniform distribution of sources in space.

CONFUSION AND FLUX-DENSITY ERROR DISTRIBUTIONS

J. J. CONDON

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Received 1973 March 5

ABSTRACT

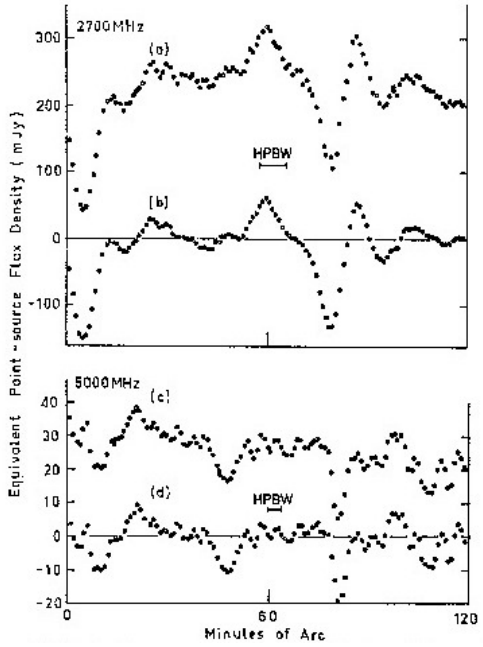
The amplitude distribution of apparent flux densities due to background or "confusion" sources observed by a pencil-beam telescope in a universe randomly populated by unresolved sources obeying a power-law number–flux-density relation is derived. It is shown that the detailed form of the distribution depends only on the number-count exponent and that the distribution width scales with beam shape and area in a way which also depends on this exponent, in disagreement with some earlier results. The confusion probability distributions are used to compute error distributions for confusion-limited flux-density measurements. A method for observing moving or variable sources weaker than the confusion limit is analyzed.

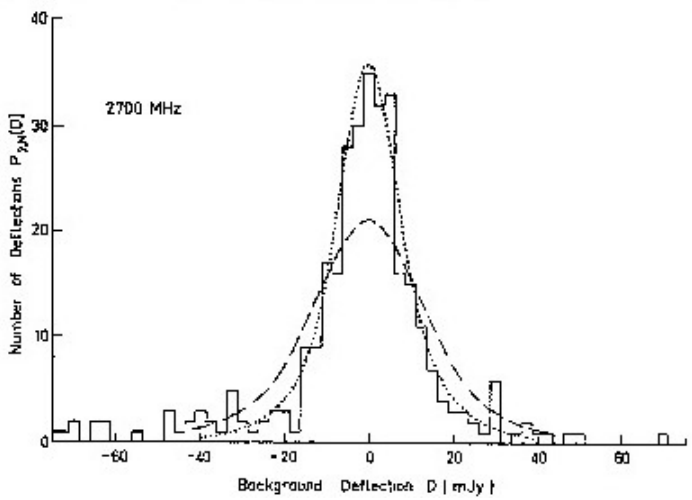
Subject headings: radio radiation — radio sources

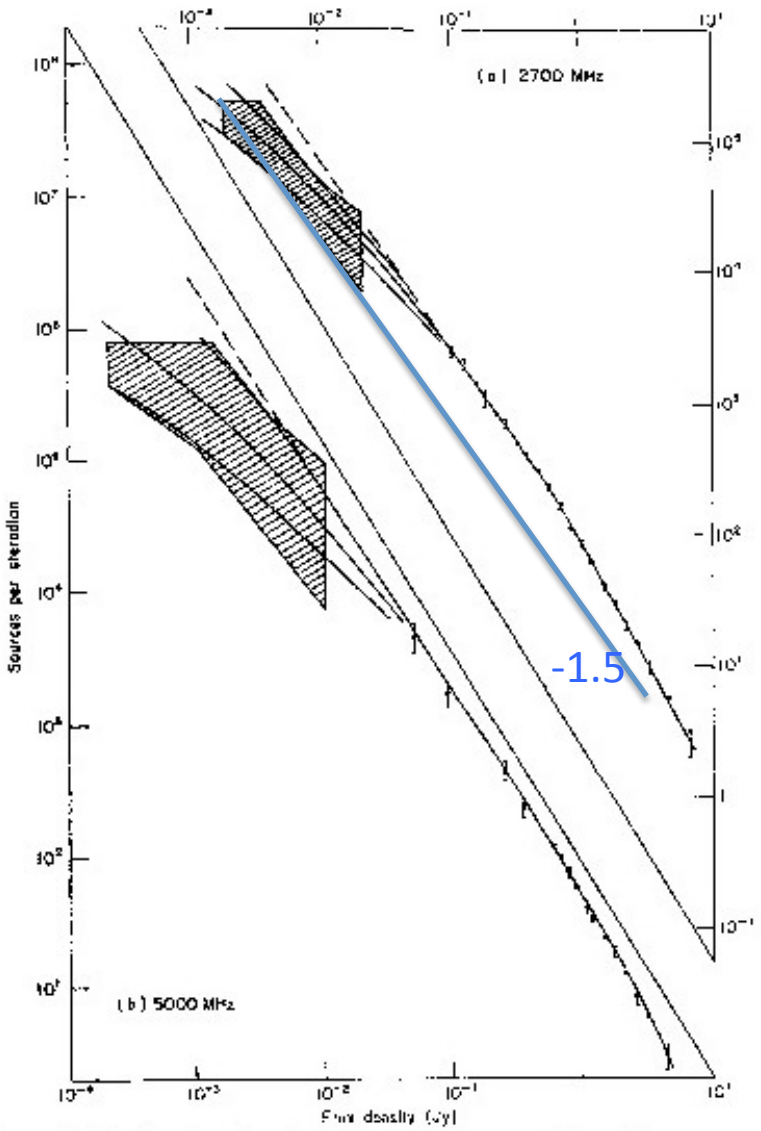
I. INTRODUCTION

the sky, the antenna temperature fluctuates due to many confusio
deflection at any point may be expressed in units of flux

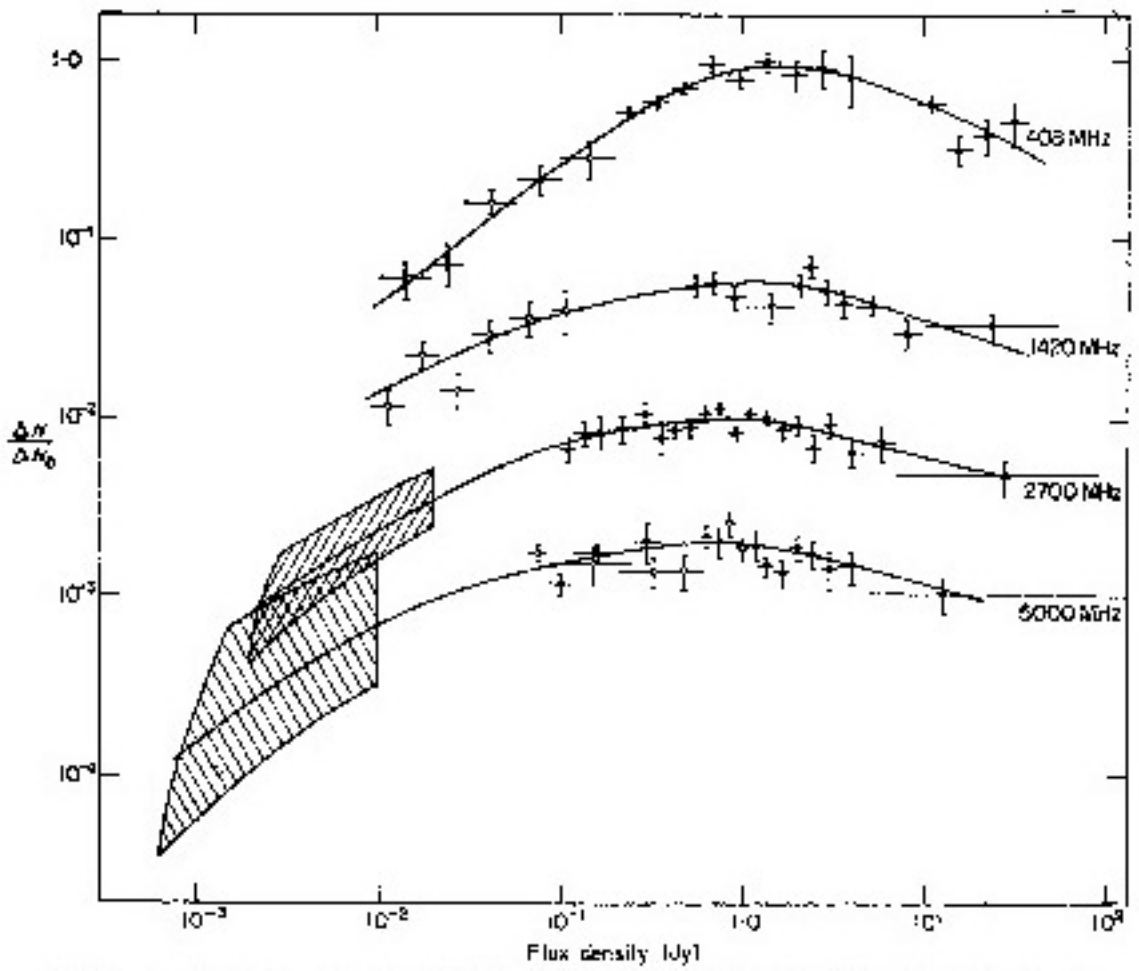
Wall & Cooke 1975: data and results







Counts at frequencies 151 MHz to 5 GHz



Conclusions (1975-1980)

- 2.7-GHz relative count `diminishes', like all others
- P(D) plus direct counts consistent at 2.7 GHz
- No `unknown' population popping out
- Overall picture of counts shows they **`broaden'** as frequency increases

- Why???
- Carole Jackson has told you the story; Ken Kellermann gave me the hint as soon as he saw my counts compilation:

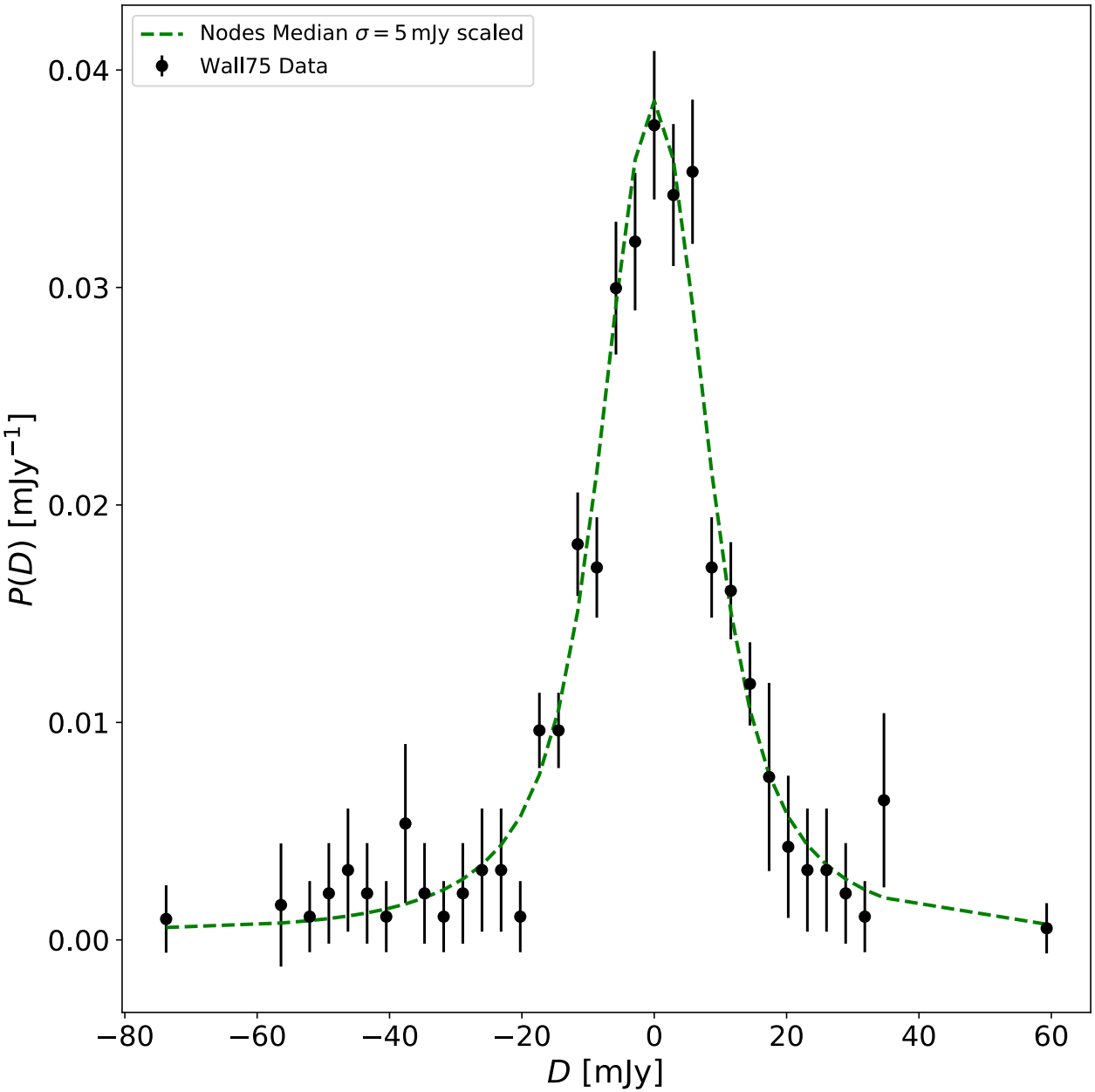
- - it's the flux-boosted population found at $\nu > 2$ GHz.

But……

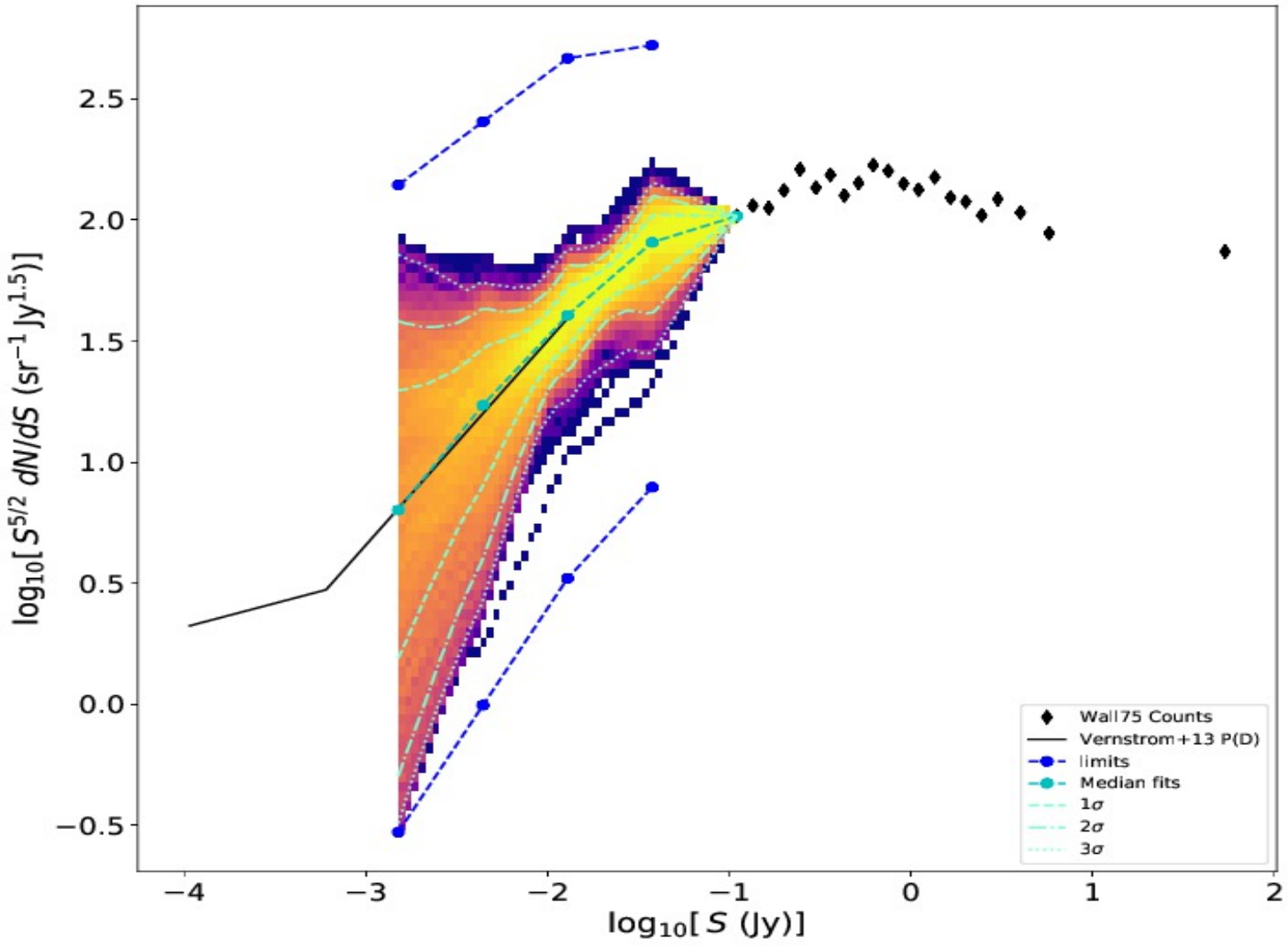
- Can P(D) done with such crude stats methods be believed? Do modern methods properly applied to the same data give the same answer?

- (More importantly): In the face of modern data, much deeper surveys, is this answer correct? Can we therefore believe modern P(D) results?

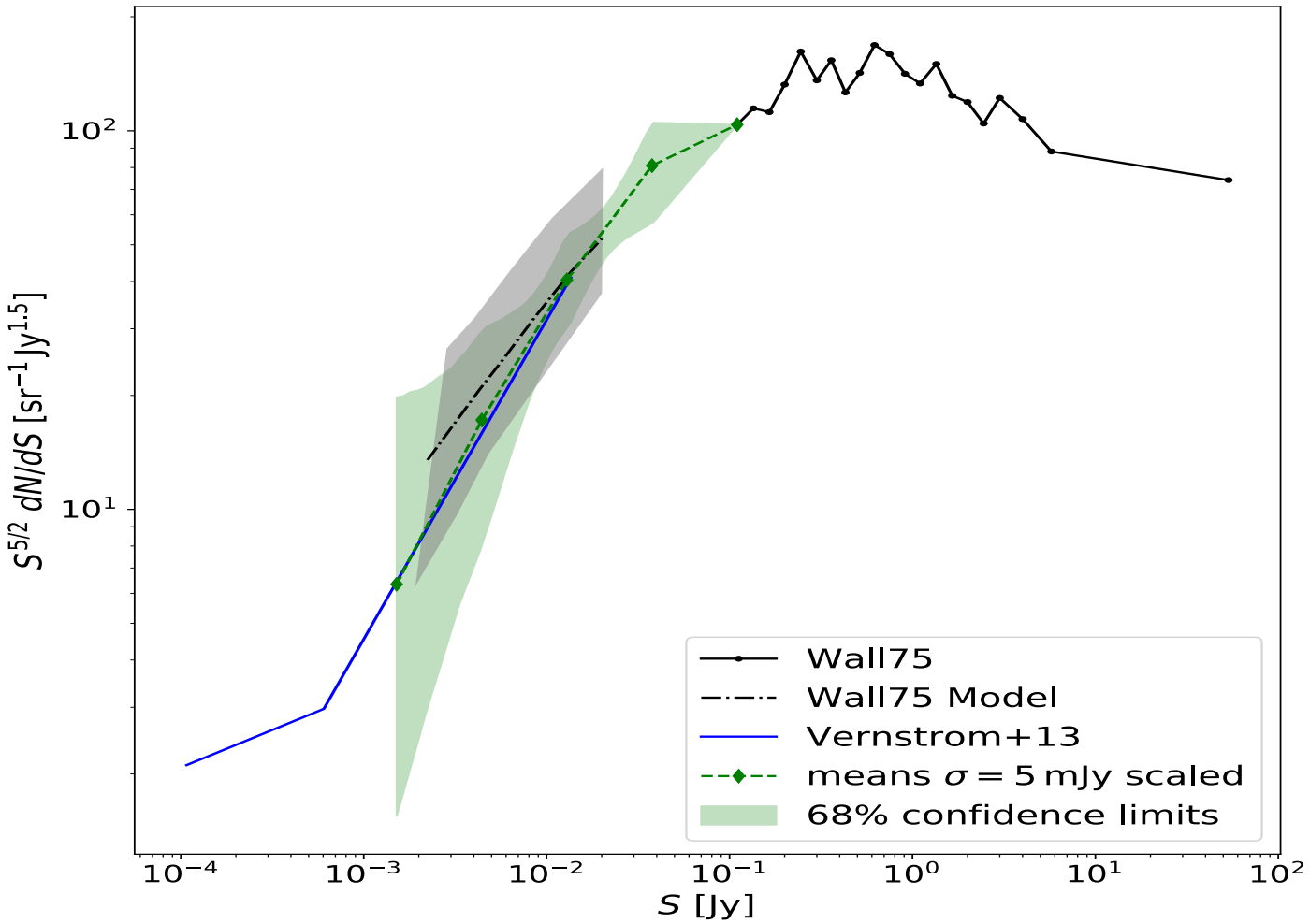
The Bayesian Look at the 1974 W&C data:



The Bayesian analysis
TV and JVW 2018

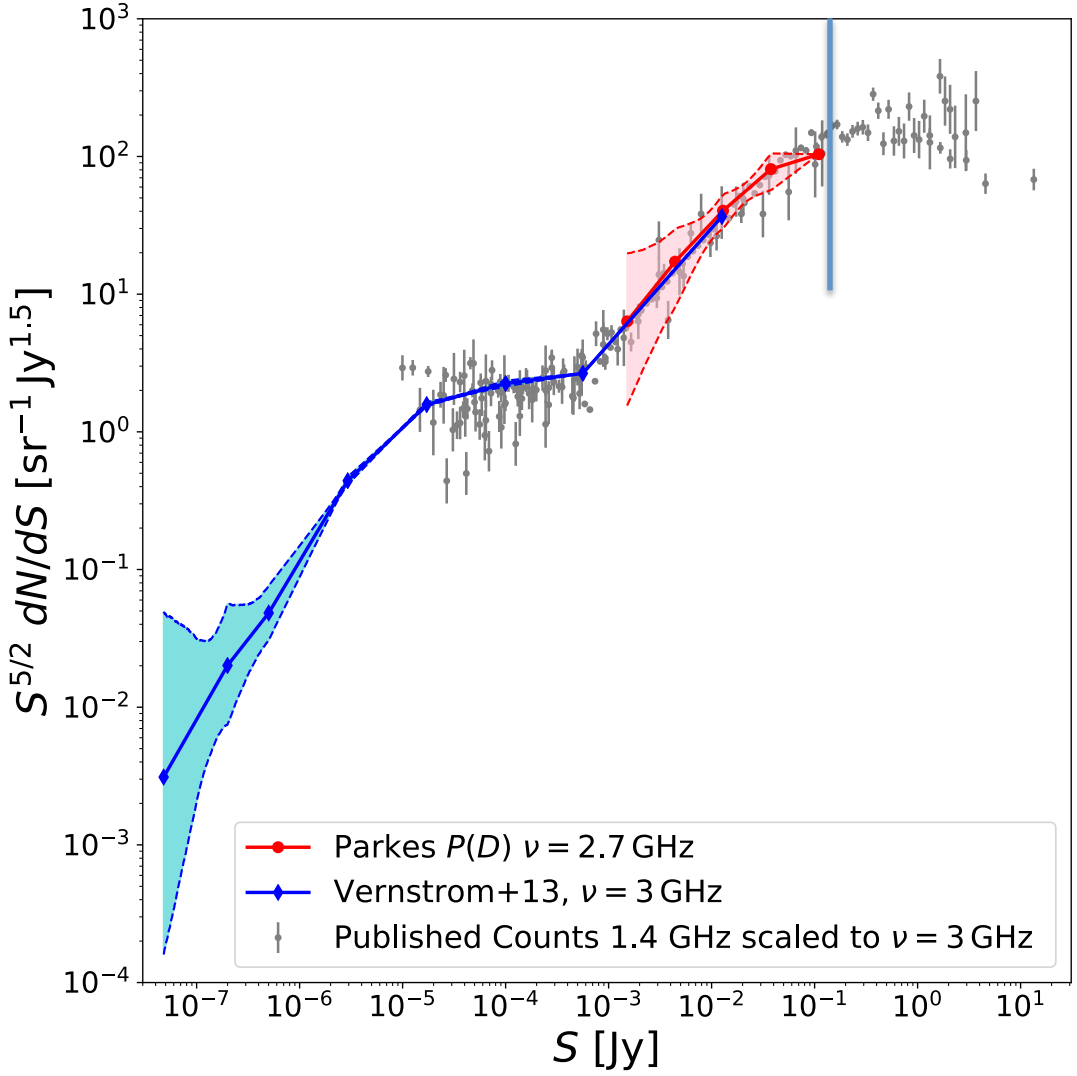


How did W&C 1975 do?



- OK, but very poor error estimation

And now?

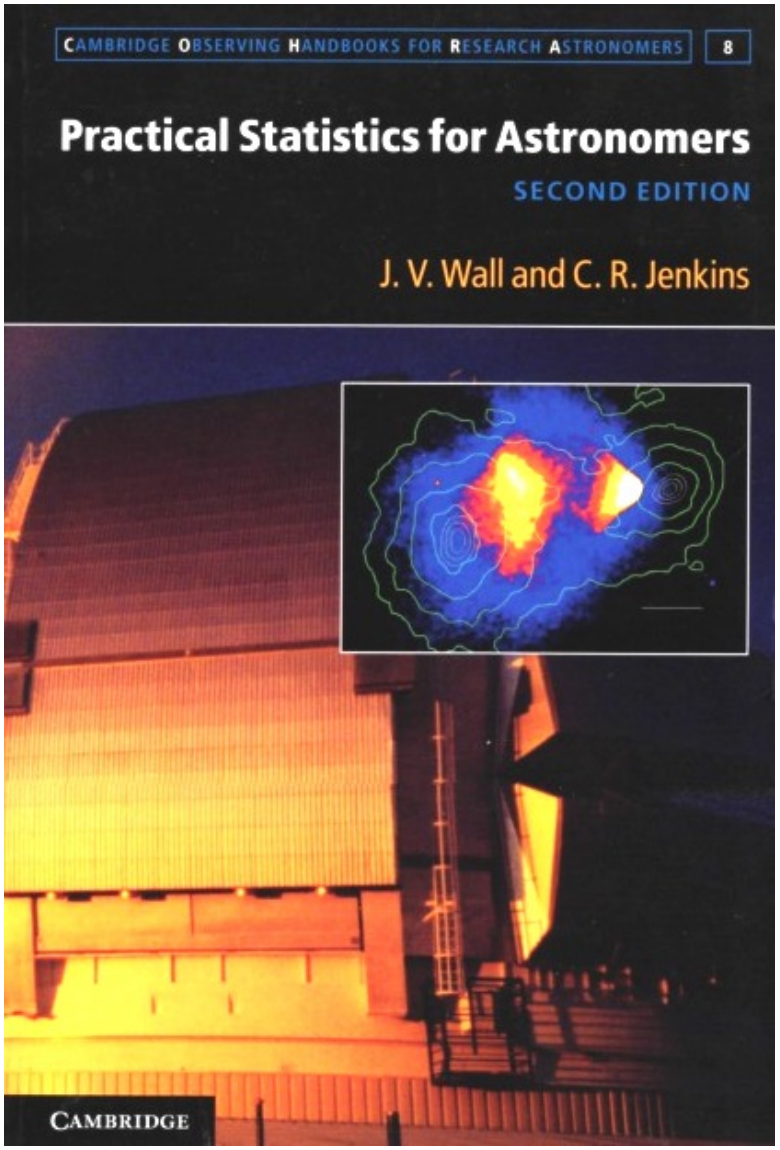


- Modern surveys + TV et al P(D) -> 5 orders of mag deeper

P(D) Conclusions

- P(D) works; it can be trusted.
- Old data does not mean bad data; it too can be trusted.
- Essential to use best statistical technique.
- From a lunchtime moment in 1973 - **a long interest in astrostats –** as the moment taught me how stats can extract good science from apparently nothing much.

One result of this:



Book Review:

(2nd ed 2012) – "…a much-needed improvement over the 1st edition. However, ….."

Anon:

"Buy this book!"

Bear with me: some notes of an optimist

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Since my grandfather's time we have conquered the **three greatest threats** faced by the human race. In its time, each killed substantial fractions of the race.

In threat order:

1. Famine

- We now **know how to feed the world**. We have enough food.
- All famines are now political, by either political design or lack of political will.
- There are more deaths now from over-eating than from famine.

2. Plague

- all **major epidemics and killer diseases have been defeated**, with exceptions: cancer (much progress); AIDS/HIV (much progress); even malaria (250,000 deaths a year, mostly children). Mass testing of a malaria vaccine is in progress - thank you Bill and Melinda Gates for the $1 billion.

3. War

- there are fewer deaths/capita due to war than ever in history.
- we **expect to live in times of peace**, perhaps punctuated by times of war.
- my parents and all their forefathers **expected to live in times of war**, perhaps punctuated by times of peace.

The future

We can foresee new global existential problems: horrific environment issues; hideous moral and ethical issues re medical and AI; drugs; bending of politics by commercial giants, social media.

For the most part, the human race knows what the causes are and what the solutions are. We don't need to revert to idol worship, human sacrifice, blind faith.

In addition to what we can foresee, of course let us not be naïve: there remains nature with its the unknown unknowns: e.g. asteroid strikes, catastrophic earthquakes, volcanoes (Krakatoa explosion was only 1883 – it's still there), fires, storms, a rogue virus.

The future II

We have conquered existential threats before. Look at the magnitude of what we have done. How can you doubt that we'll do it again?

Sitting and hand-wringing in pessimism is a stupid waste of perfectly useful emotion.

Get up, be informed and vigilant, be active, and remember that all it takes for evil to triumph is for the good to do nothing.

As for those existential threats: as one of my more controversial colleagues said frequently (to the deep annoyance of administrators, technicians, engineers, astronomers and all):

It is merely a matter of implementation

Cosmology, start of my career:

- We knew about the Big Bang (1965). We needed but **two** numbers to `finish' cosmology (Sandage mid 60s), H_o and $q_{o.}$

- We were hazy about the physics of how it all worked to form and arrange the galaxies as we see them now.

- **We knew the nature 100% of the mass/energy of the Universe. And just a few more observations would see us right…..**

- **We didn't know the nature of 0% of the Universe.**

Cosmology mid-career:

- Ah. Those few more observations…..
- Cold Dark Matter needed and CDM `observed'
- CDM must be ~25% of mass/energy budget – but we don't know what it is (WIMPs?)
- **~1990: We didn't know the nature of 25% mass/energy density of Universe**

Cosmology as I finish:

- We agree the Hot Big Bang, but know we need the fudge of a math description (inflation) of a following instant for it to work.
- As well as CDM, we need ~70% Dark Energy, accelerating the whole show. What is this ???
- We know the nature of 4% of the mass/energy of the Universe (baryons, etc.), but we are still hazy about how it works to form the galaxies of today.
- **Now we don't know the nature the 26+70 = 96% of the mass/energy density of the Universe.**

Thus before we know the nature of even less than 4%, it's best that I stop whatever I'm doing.

So I will.

Your presence here is a great honour.

Thank you.

Appendix: notes on slides (reminder notes: not for display)

Slide 4: My simulation is >50% overestimated to make the difference clear here. It was the differing nature of the noise that really caught my attention.

Slide 6: Yet another of the lucky coincidences in my life. Just as I was pondering how to do this analysis, these two papers appeared. Thank you Peter and Jim.

Slide 7: The 'source counts' shown left are the simplest statistical result obtainable from a sky survey, namely the number of sources *N* having intensity ('flux density') greater than a value *S* (i.e. the N(S) curve, usually on logarithmic scales and thus also known as the 'log *N* − log *S* curve'.) The blue line is a Euclidean integral source count, a power law of slope -1.5. The `relative differential' form of the count used subsequent to 1974 essentially amplifies the difference between observed counts and the Euclidean count.

Slide 8: These are now in the "relative differential" form. Each point represents the number of sources detected in a sky survey with observed intensities within the bin boundaries, divided by the number within the bin as calculated from a Euclidean source count. The error bars reflect Poisson statistical uncertainties due to numbers observed in the survey, namely √N/N.

Slide 12: Tessa's P(D) Bayesian analysis following the methods of Vernstrom et al. 2014. Her priors are shown as the blue envelope − they never came into play. The model is a power law segmented at given flux densities, with segments chosen to be of insignificantly short length. The `height' of the nodes is varied by 1000's of Bayesian trials.

Notes on slides continued (not for display)

Slide 13: Modern surveys go 5.5 orders of magnitude deeper than my 'Deep Sky Survey at 2700 MHz' (thesis title; see vertical blue line). The motivation for the 3-GHz JVLA survey of Condon, Kellermann, Vernstrom, Cotton, Scott, Wall (2012-2018) , the deepest to date as shown, was the disparity amongst N(S) results from preceding surveys. I've always maintained that the only way to know if your survey is complete is to do a better and deeper one.

Slide 18:

(1) Famine and overeating − we evolved in famine times, from which our systems developed the urge to eat all in front of us, just in case. The problem is that unlike the past, it is all in front of us again tomorrow. Same with our lethal craving for salt.

(2) Plague − There is some threat now from those who resist vaccination. The death rate from measles in the Western world is rising as a result.

(3) War − The result must be smoothed over decades; of course there are spikes. Much of war probably relates to famine − protecting the food supply for our own requires banding into tribes of likes for strength, giving much warfare the tribal 'Law of Jungle" origin. Religion is a complicating factor.

The daily news cycle strongly suggests that we have gone to hell in a handcart. Real news or fake news − it does not matter: you get the same impression. It is incorrect.

I do not expect agreement. However it is indisputable that by any objective measure, average life on this planet has improved dramatically with time − through the will, ability and effort of the human race.