The accepted APs

An unbiased study of rotation, stochastic variability and flaring

and

Convection and short term activity

observational requirements, feasiblity, expectations

Suzanne Aigrain, IoA, Cambridge

3 co-ordinated APs

- Stellar variability & micro-variability
  - I - An unbiased study of rotation, stochastic variability and flaring
  - II - Spot maps & modelling
  - III - Convection & short term activity

Common rationale

- Systematic exploration of ALL the CoRoT light curves
- Phenomenological characterisation of stellar variability
- First AP concentrates on periodic behaviour (rotation) and discontinuities (e.g. flaring, accretion...)
- Second AP concentrates on short-term stochastic variability (e.g. small-scale activity, convection)

An unbiased study of rotation, stochastic variability and flaring

- Participants:
  - Fabio Favata (ESA/ESTEC) ffavata@rssd.esa.int
  - Ettore Flaccomio, Giusi Micela, Salvatore Sciortino, Antonio Maggio (Palermo)
  - Isabella Pagano, Nucio Lanza (Catania)
  - Suzanne Aigrain (IoA Cambridge)
- Immediate goals
  - to measure rotation periods in as many of the CoRoT target stars as possible
  - to provide an objective, non-parametric characterisation of variability in the target stars

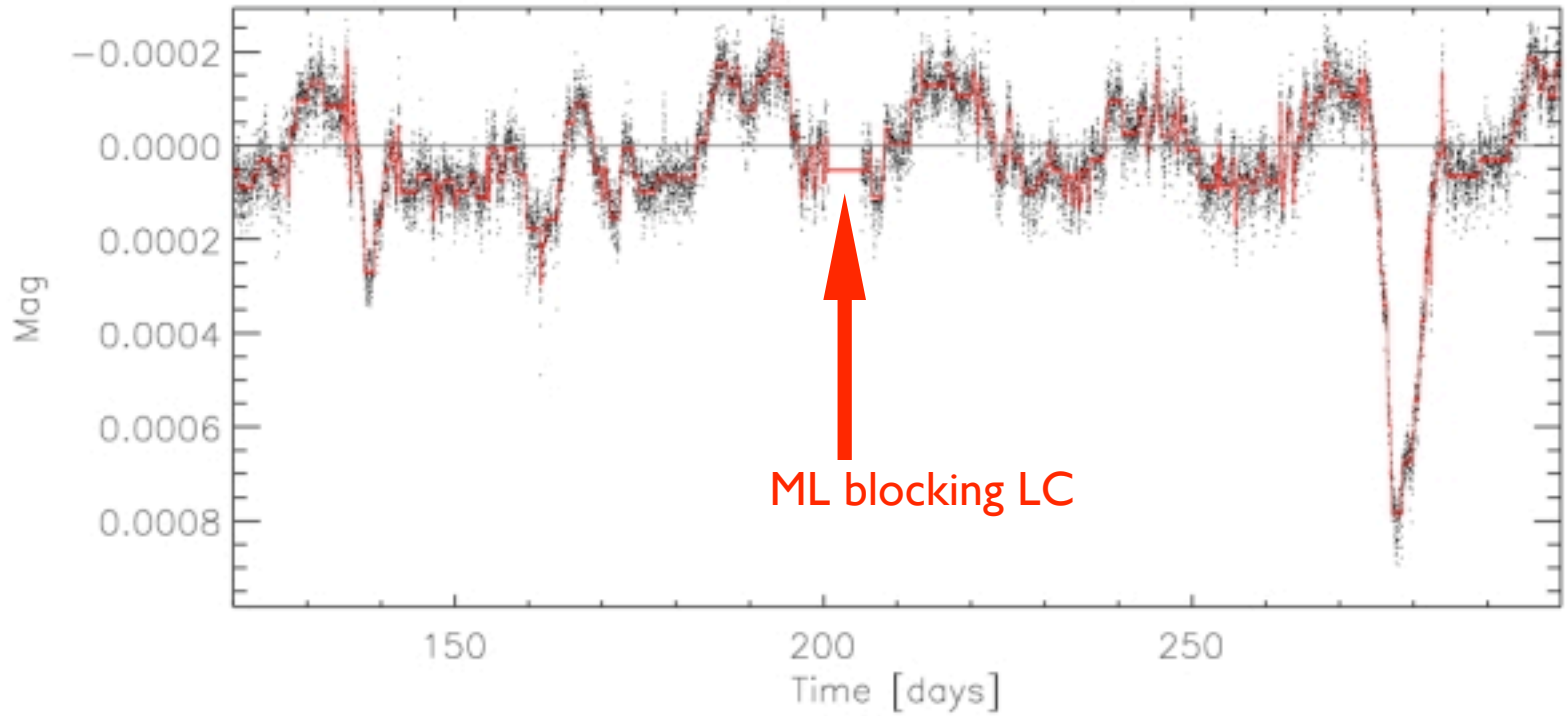
Requirements

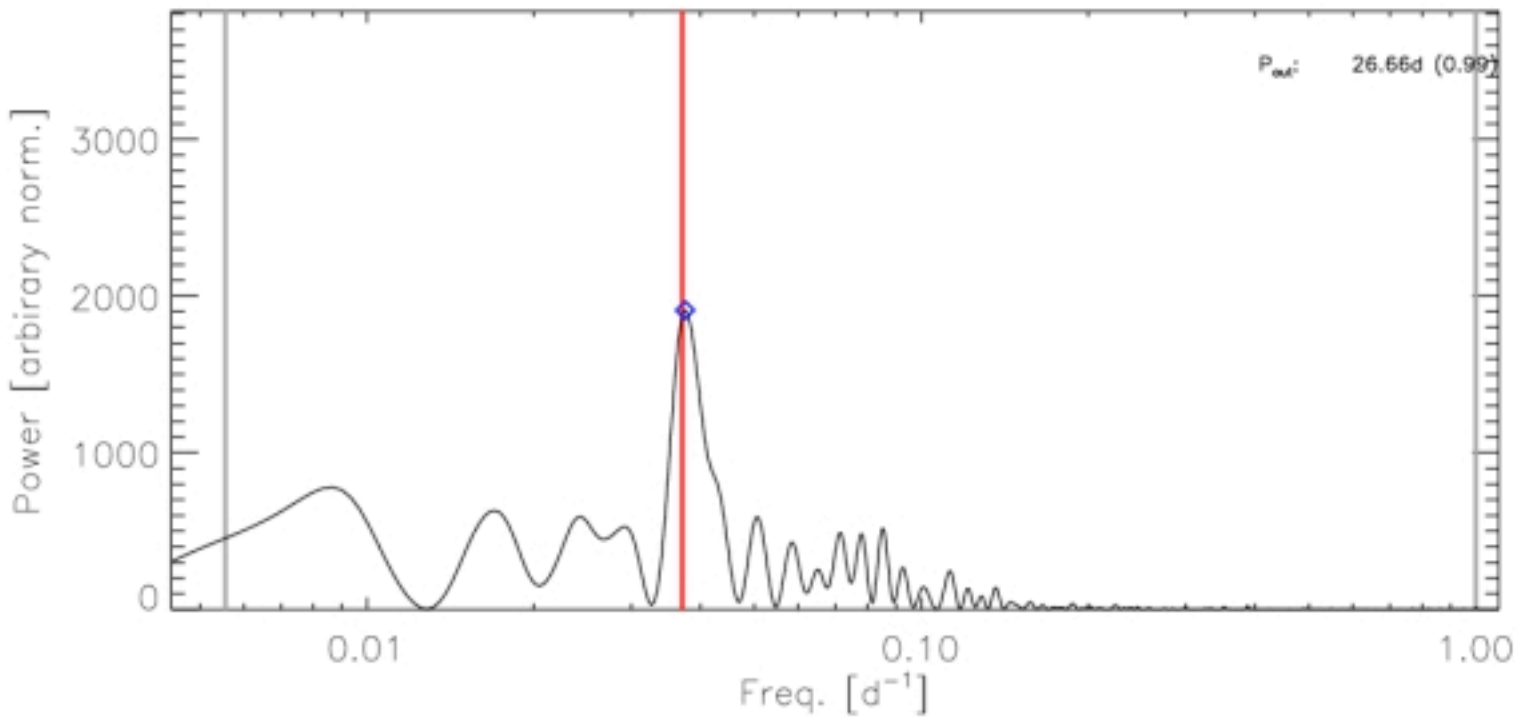
- ... none! (beyond those of the core programme)
- simply use all light curves collected by CoRoT for whatever reason and in whatever configuration
- scientific return will be maximised through access to databases such as EXODAT and GAUDI

Feasibility

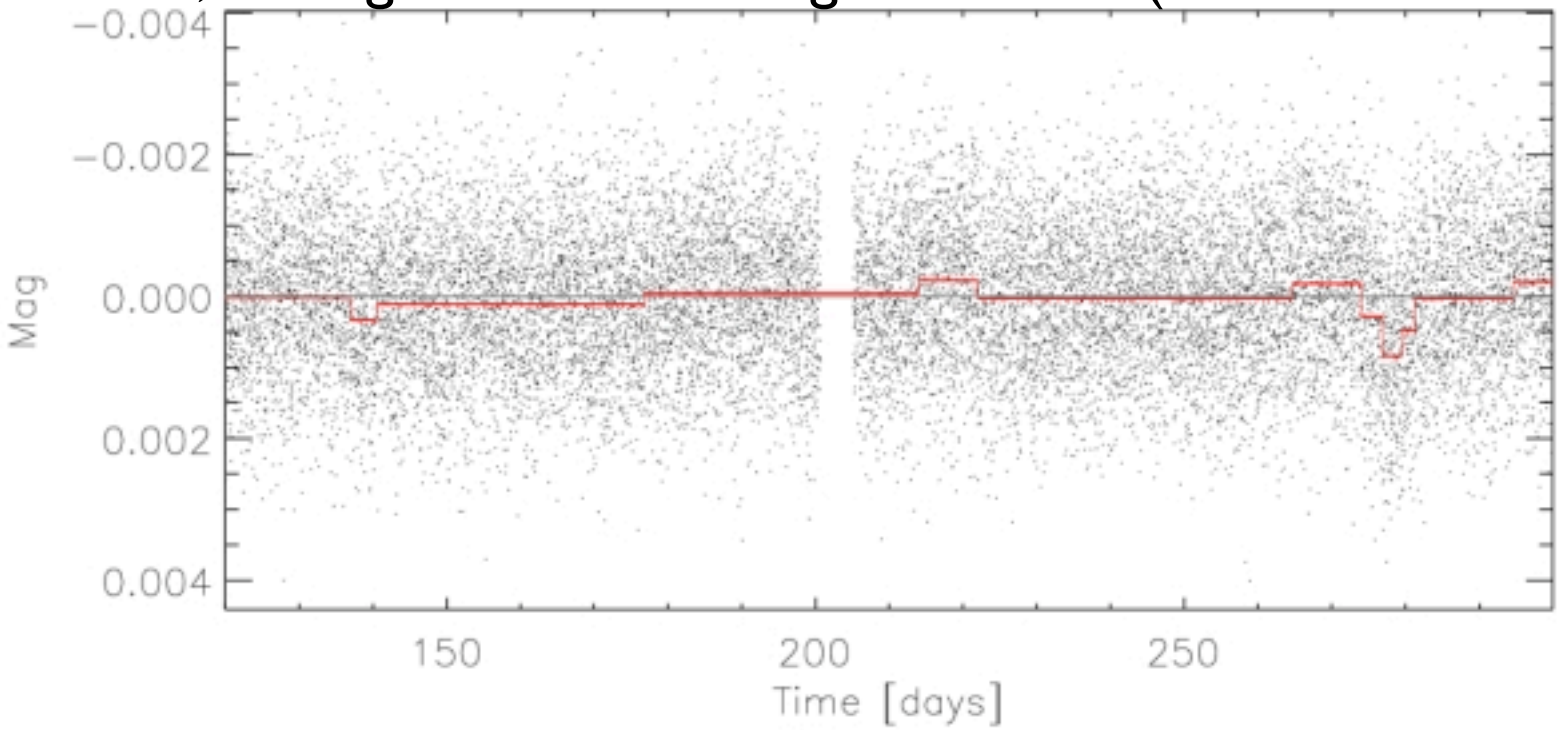
- Robust periodogram approach allows recovery of rotation period even for slow-rotating, weakly active stars, even with the worst CoRoT precision in some cases (down to V=15 in most cases)
- Will need to investigate impact of changes in spot dist.
- New maximum likelihood blocking algorithm allows one to define a "baseline" level (most probable level) in each light curve and identify individual departures

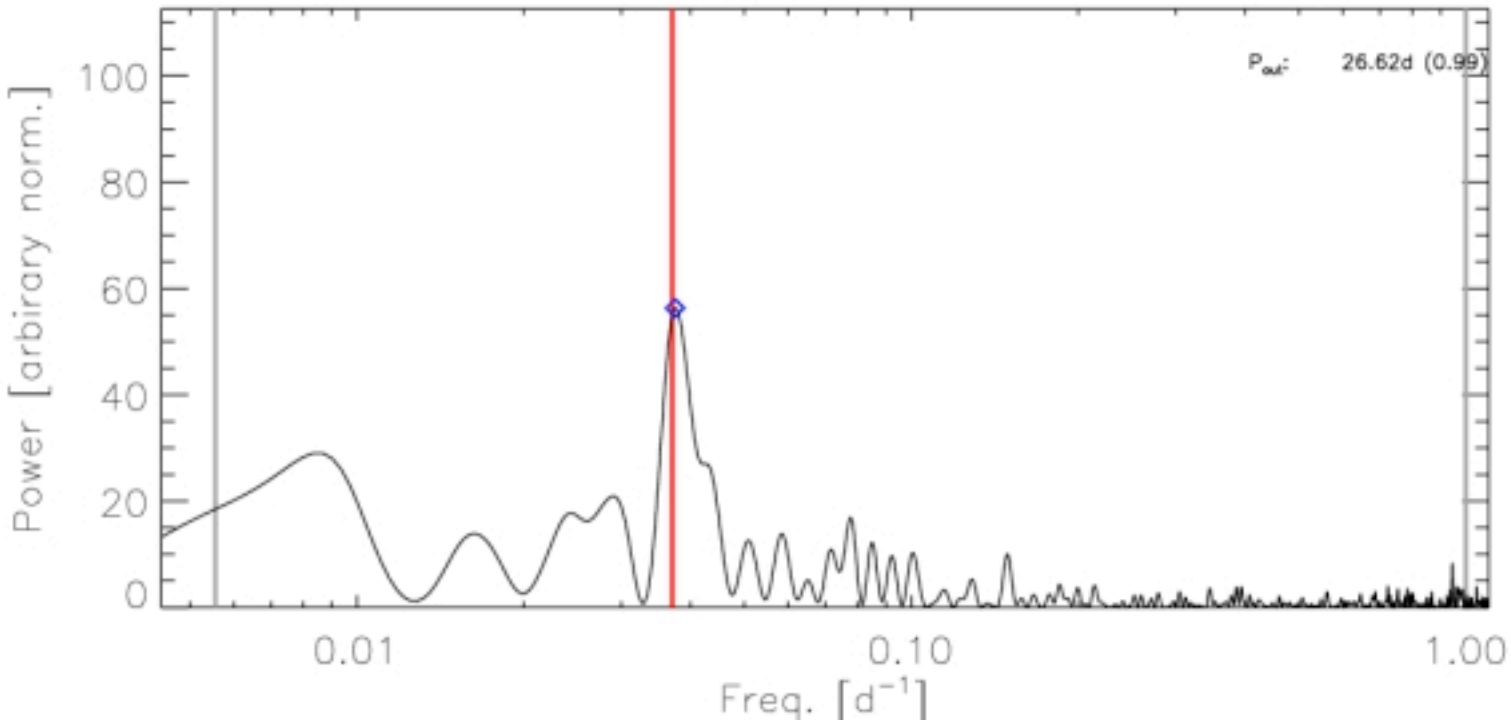
SoHO/VIRGO total solar irradiance data, low activity (15 min sampling)



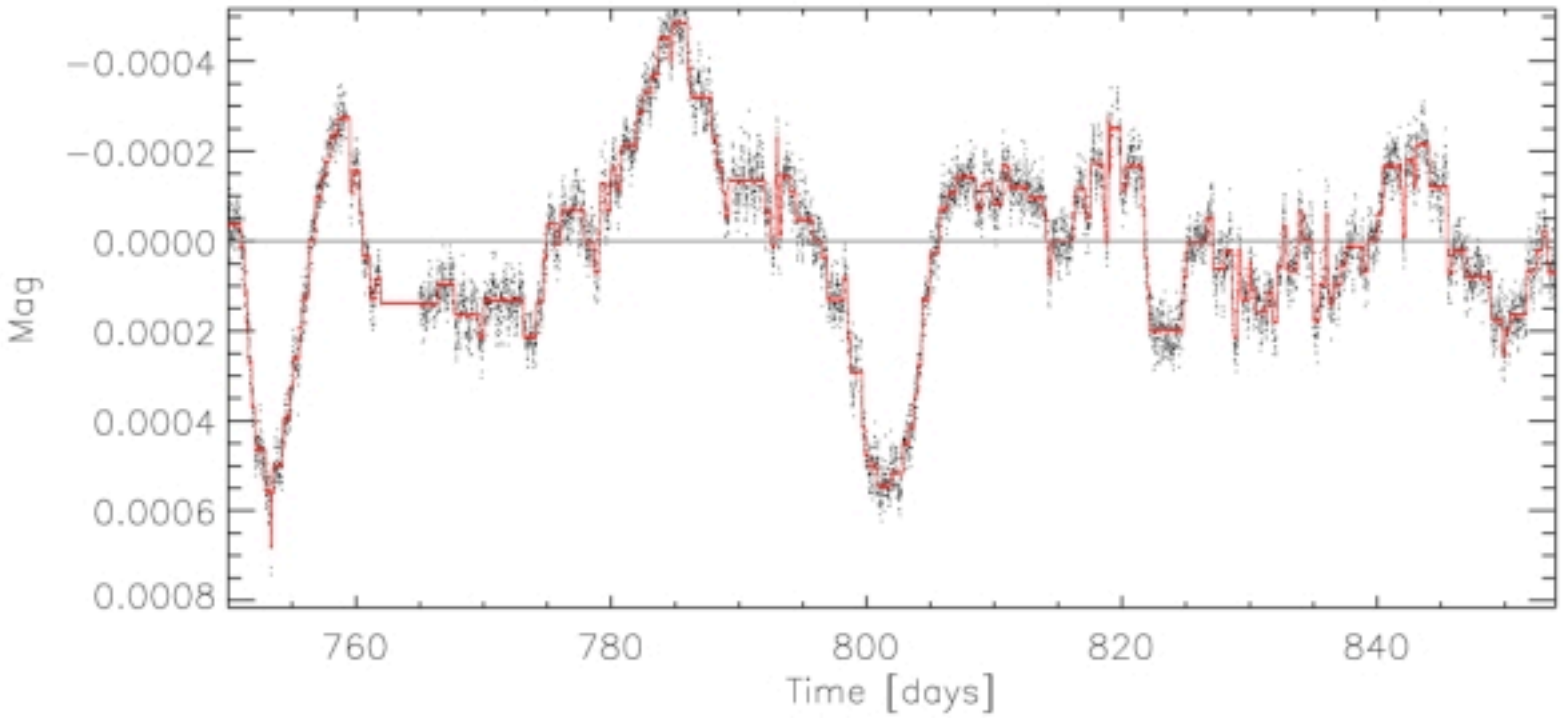


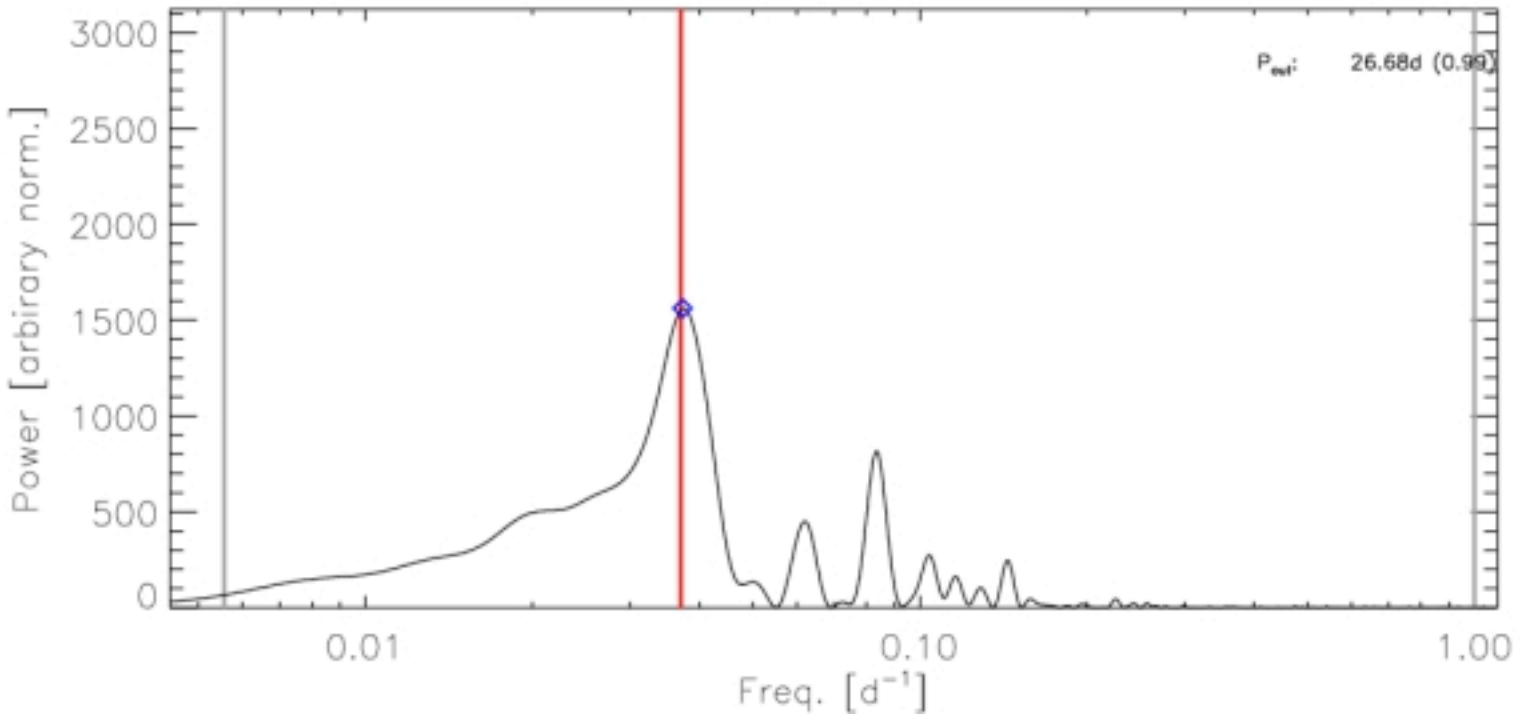
same data, downgraded to 1 mmag noise level (V=15 with COROT)



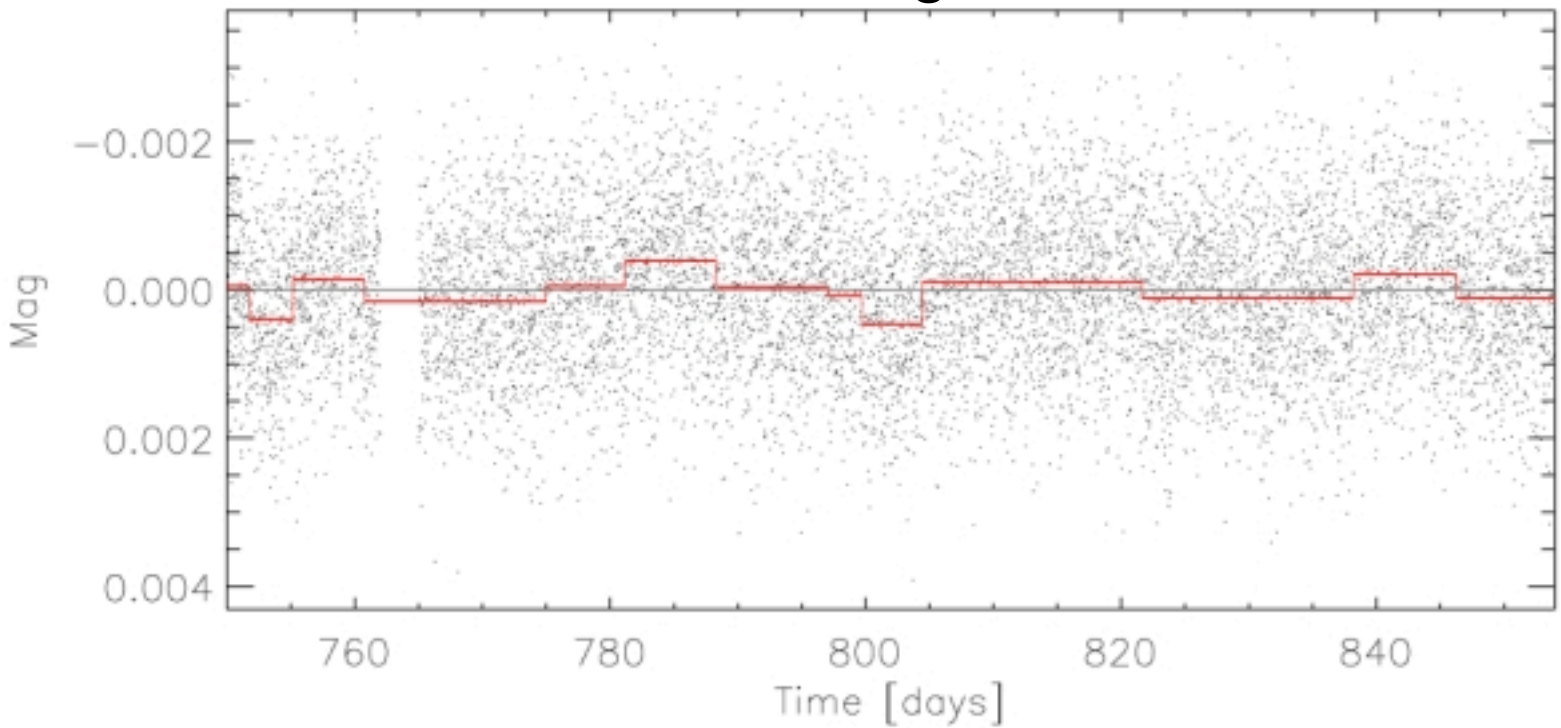


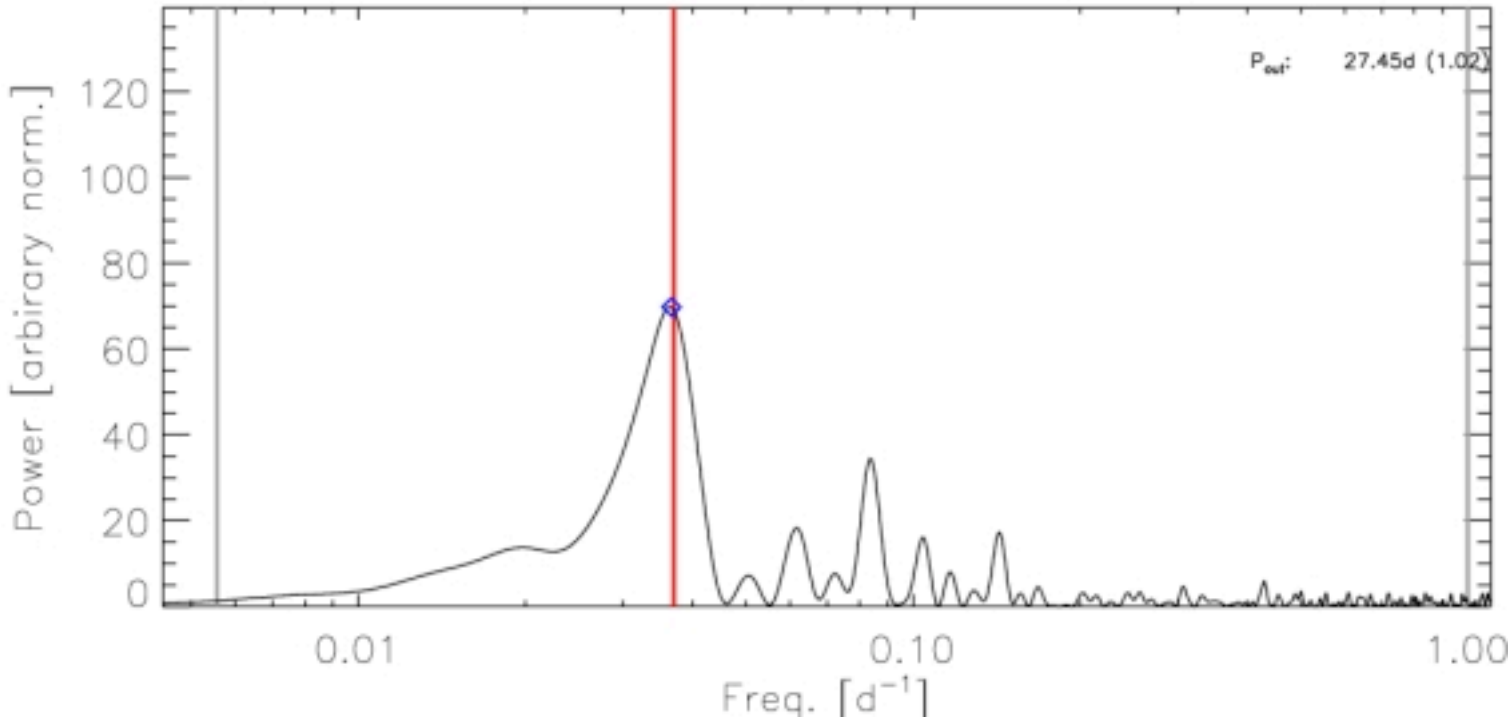
SoHO/VIRGO total solar irradiance data, high activity





same data downgraded





Expectations

- Many (thousands?) of rotation periods across HR diagram and activity range
  - Window into one of the fundamental parameters governing stellar evolution
  - Quantitative understanding of the processes driving magnetic field generation and angular momentum evolution
  - Gyrochronology? Would give unprecedented sample of field stars with known ages: potential for population studies

Expectations

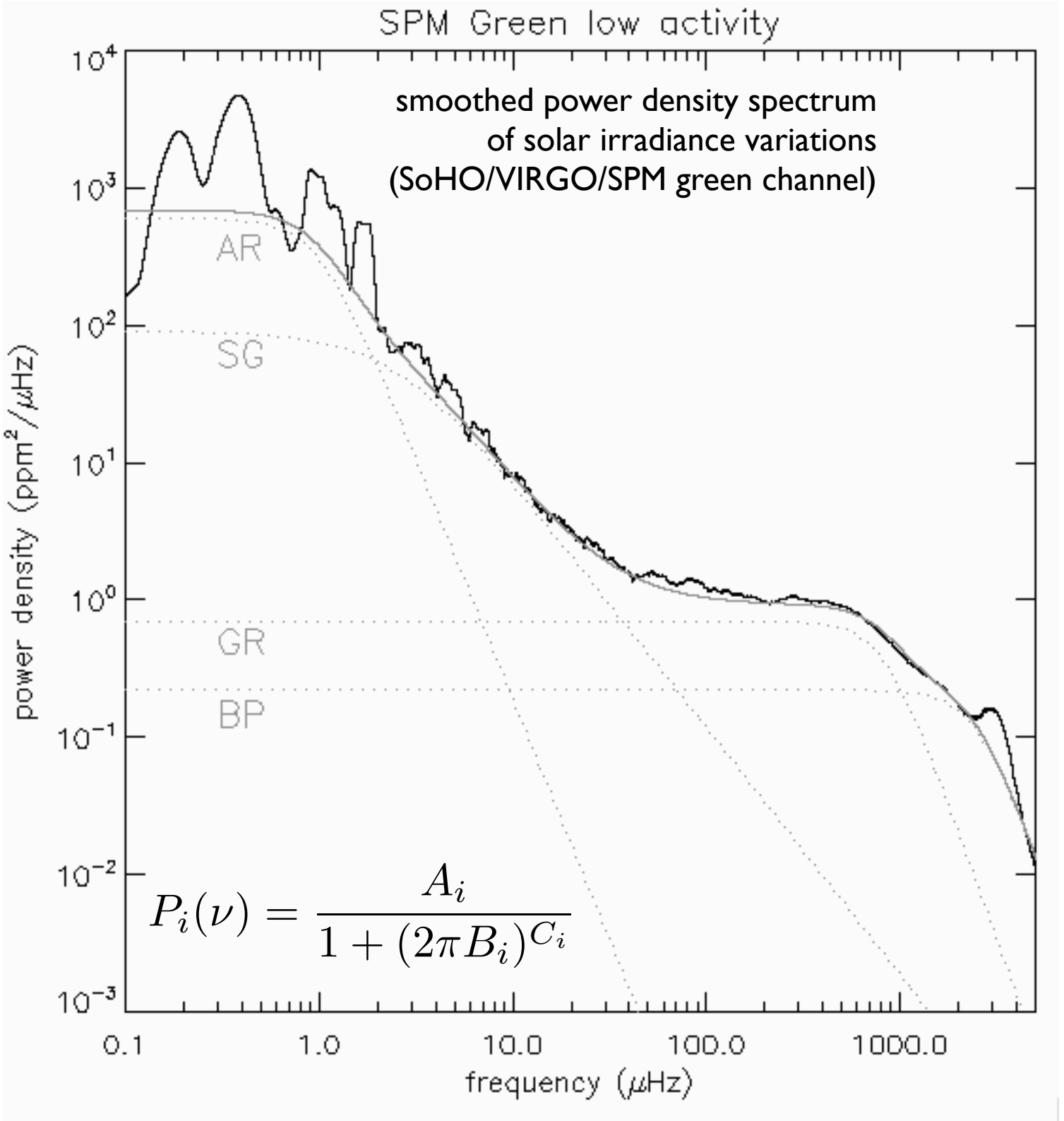
- Many (thousands?) of rotation periods across HR diagram and activity range
- Event database
  - statistics (event rates, durations, amplitudes...)
  - fraction of time spent above or below characteristic level (i.e. fraction of time dominated by spots / faculae)
  - exceptional events (large spots, white light flares)
  - serenditipitous discovery potential

Convection and short-term activity

- Participants:
  - Suzanne Aigrain (IoA Cambridge) suz@ast.cam.ac.uk
  - A. Collier-Cameron, J. Barnes (St Andrews)
  - S. Solanki, N. Krivova (MPIS Lindau)
  - F. Favata, B. Foing (ESA/ESTEC)
  - A. Lanza, G. Cutispoto, I. Pagano, S. Messina (Catania)
  - C. Régulo, T. Roca Cortés, F. Pérez Hérnandez, H. Vázquez Ramió (IAC)
  - Y. Unruh (Imperial)
- Goals
  - systematically characterise short term instrinsic variability on timescales of seconds to days (excluding oscillations) of all long run light curves (exo AND seismo fields)

Basic approach

- fit multi component powerlaw models to the power spectra
  - each component represents a class of structure on the star's surface
  - characterised by amplitude, timescale and slope
- identify trends and degree of scatter between parameters of the best fit models and stellar parameters
- investigate time dependence by splitting long run light curves into subsets
- will investigate other characterisation techniques (e.g. wavelet analysis)


SPM Green low activity
smoothed power density spectrum
of solar irradiance variations
(SoHO/VIRGO/SPM green channel)
AR
SG
GR
BP
power density (ppm²/μHz)
frequency (μHz)
0.1
1.0
10.0
100.0
1000.0
$P_i(\nu) = \frac{A_i}{1 + (2\pi B_i)^{C_i}}$

Oversampling

- In addition to analysing all 'normal' light curves, we plan to request oversampling for ~50 targets per exoplanet field
- Motivation
  - only way to study variability on timescales of minutes and less
  - test bench for automatic analysis techniques to be applied to all LCs after
  - test predictive ability of theoretical models of activity / granulation on a case by case basis
  - this will be a particularly well characterised sample on which it will be feasible to perform ground-based follow-up if appropriate

Oversampling

- In addition to analysing all 'normal' light curves, we plan to request oversampling for ~50 targets per exoplanet field
- Sample definition
  - complement seismo targets to span full parameter space
  - design sample to cover SpT F to M and wide range of activity levels
  - include a few giants / subgiants, high / low metallicity stars
  - concentrate on mag range 11.5 - 12.5 to ensure sufficient sensitivity
  - pre-selection in 1st 2 fields will start now, based on info in COROTsky, GAUDI, EXODAT
  - VLT/FLAMES observations (ECOWG) - refine selection
  - high res. spectro for follow-up - clearly room for collaboration with Jose/ Renan's APs.

Requirements

- In terms of CoRoT data
  - All the light curves from the CoRoT long runs in both seismo and exoplanet fields
  - oversampling for ~50 targets per exo field (OK if later dropped from oversampling list)
- For the selection of oversampled stars:
  - Teff, log g, metallicity, binarity, activity for stars with V<13 (in GAUDI / EXODAT) → would like to discuss with the relevant people
  - what is the status / scope of the proposed ESO observations?
  - can envisage our own preparatory obs but need to know SOON

Feasibility

comp. name	timescale B (s)	amplitude A ($ppm^2/\mu Hz$)	V-mag	6	10	12	14
			σ ($ppm^2/\mu Hz$)	0.14	12.3	66	590
AR	1,000,000	600	detect-ability	✔	✔	✔	~
SG	40,000	90		✔	✔	~	✘
G	240	0.7		✔	✘	✘	✘
BP	70	0.25		~	✘	✘	✘

Feasibility
(pessimistic values)

- CoRoT's noise level over a single characteristic timescale will be below the amplitude seen in the Sun for:
  - Active regions over the entire 6 < V <16 mag range
  - Super-granulation down to V~13
  - Granulation & bright points in the seismo field
- Expect granulation signal up to 10 or 100 times stronger than in the Sun in some stars...detectable well into exo field
- True sensitivity will be much better, because the variability, although not periodic, will gain coherence (hence SNR) over many realisations
- we are in the process of investigating wavelet methods to detect "transiently coherent" signals

Expectations

- Characterisation of short term variability accross the HR diagram
- A sample of specially well-studied stars for future reference
- Tests of and constraints on theoretical models of granulation and small scale activity, and consequent progress in physical understanding of underlying processes
- Understanding the distinction / interplay between magnetism and convection
- feedback into transit finding

Resources

- Ample computing facilities are available to both proposal teams
- In addition, Catania observatory and IAC have access to telescopes for preparatory / follow-up observations
- Expertise with theoretical modelling (e.g. Lindau group for active regions)
- Keen to coordinate with other teams to ensure efficient analysis