

rsHRF: retrieving the hemodynamic response function in resting state fMRI

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<https://github.com/guorongwu/rsHRF>

Statistical analysis of fMRI data

Two main objectives

- ▶ Establishing the link between neural activity and the measured signal
- ▶ Determining distributed brain networks that correspond to brain function

Statistical analysis of fMRI data

- ▶ General linear model (GLM)
- ▶ Functional and effective connectivity

BOLD Signal: General linear model (GLM)

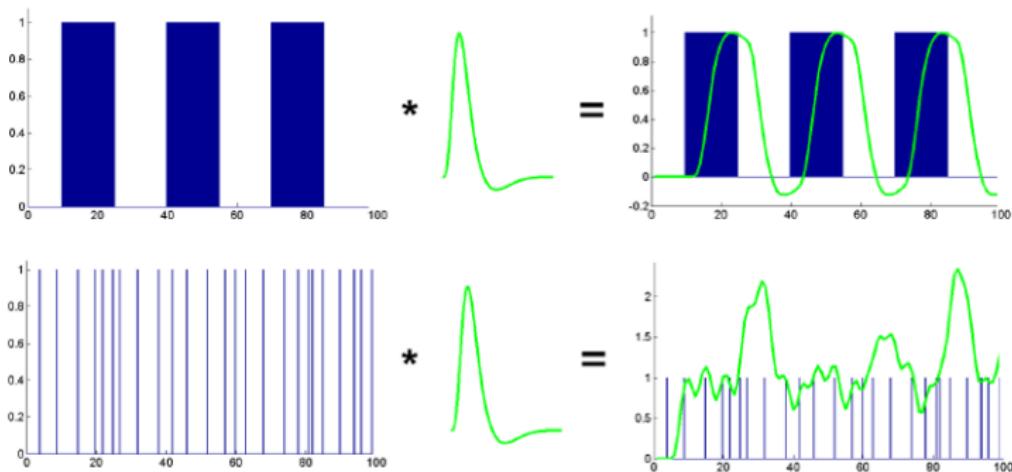


Figure: cartoon of the BOLD signal resulting from blocked and event-related stimuli, without noise

BOLD Signal: General linear model (GLM)

Linear Time Invariant model

The processed BOLD signal at time t , $y(t)$ (partial out confounds: motion parameters etc.), is modeled as the convolution of neural state $s(t)$ and hemodynamic response function $h(t)$, i.e.

$$y(t) = s(t) \otimes h(t) + c + \epsilon(t)$$

where c indicates the baseline magnitude.

- ▶ $\epsilon(t)$ can be modelled by $AR(p)$ to account for the temporal correlation.
- ▶ in task-related fMRI, $s(t)$ could be substituted by stimulus function $\hat{s}(t) = \sum_{i=1}^K \alpha_i \delta(t - t^i)$
- ▶ in resting-state fMRI there is no explicit stimulus and timing for HRF onset

Point Process

Specific BOLD events govern the dynamics of the brain at rest
(Tagliazucchi et al. 2012, Petridou et al. 2013)

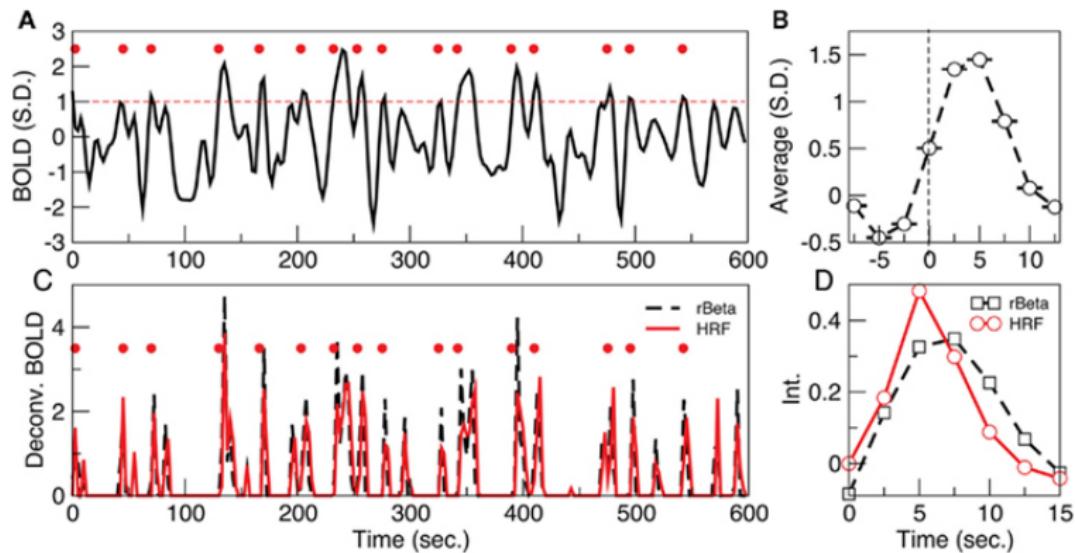


Figure: from Tagliazucchi et al. 2012. BOLD point process: $S_b(t)$

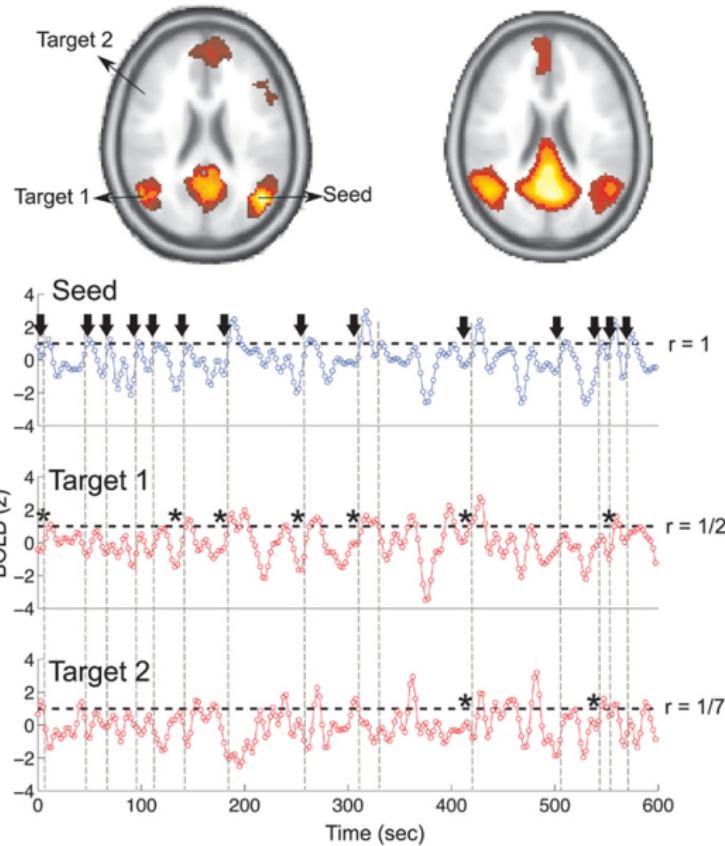


Figure: Simultaneous BOLD peaks reproduce whole series FC patterns, see also Logothetis 2012, Liu and Duyn 2013, Logothetis 2015

From neuronal pseudo-events to BOLD peaks

we assume the peak of BOLD response lags behind the peak of spontaneous point process event is $L = \kappa \cdot TR/N$ seconds ($0 < L < PST$).

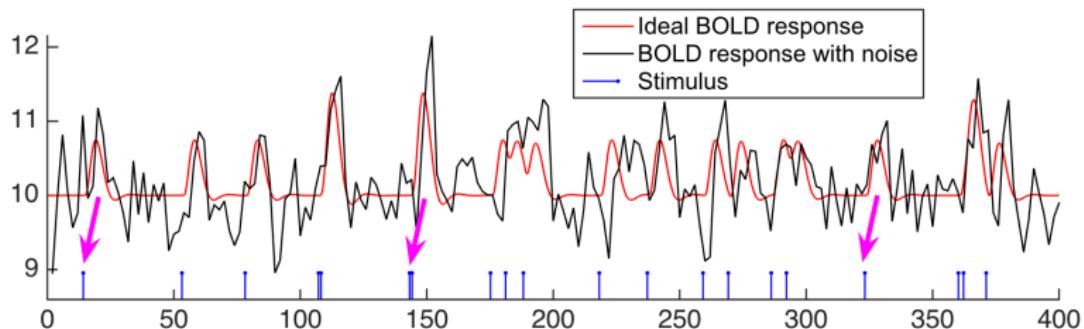


Figure: Time lag from stimulus to BOLD peak. To obtain the time lag κ , we search all integer values in the interval $[0, PST \cdot N/TR]$, where PST is the peristimulus time, choosing the one for which the noise squared error is smallest (i.e. $\min_{\forall 0 < L < PST} |y(t) - s_b(t - L) \otimes h(t)|^2$), indicating the spontaneous event onset.

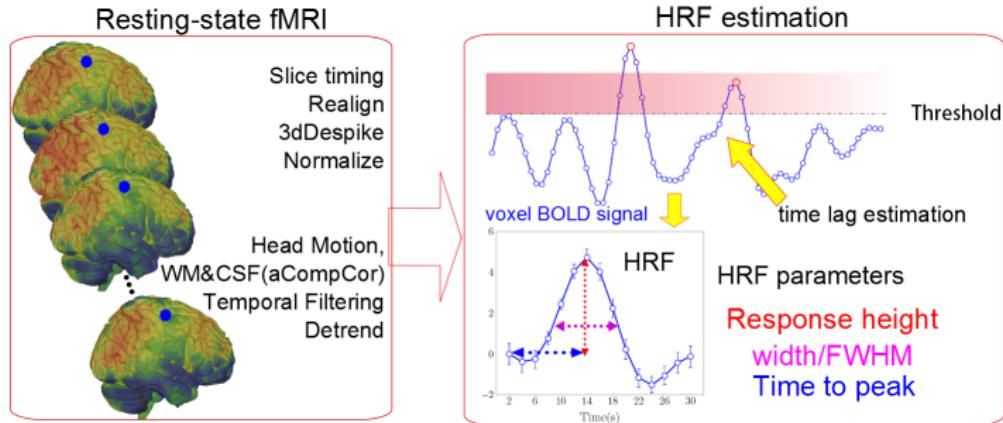
HRF basis vectors

- ▶ Reduce the bias in the linear estimation framework especially for the low signal noise ratio dataset.
- ▶ Decrease computational cost.

We assume that the hemodynamic responses for all resting state spontaneous point process events and at all locations in the brain are fully contained in an d -dimensional linear subspace H of R^d . then, any hemodynamic response h can be represented uniquely as the linear combination of the corresponding basis vectors, such as:

- ▶ Canonical HRF with its delay/dispersion derivatives (canon2dd),
- ▶ (smoothed) Finite Impulse Response (sFIR)

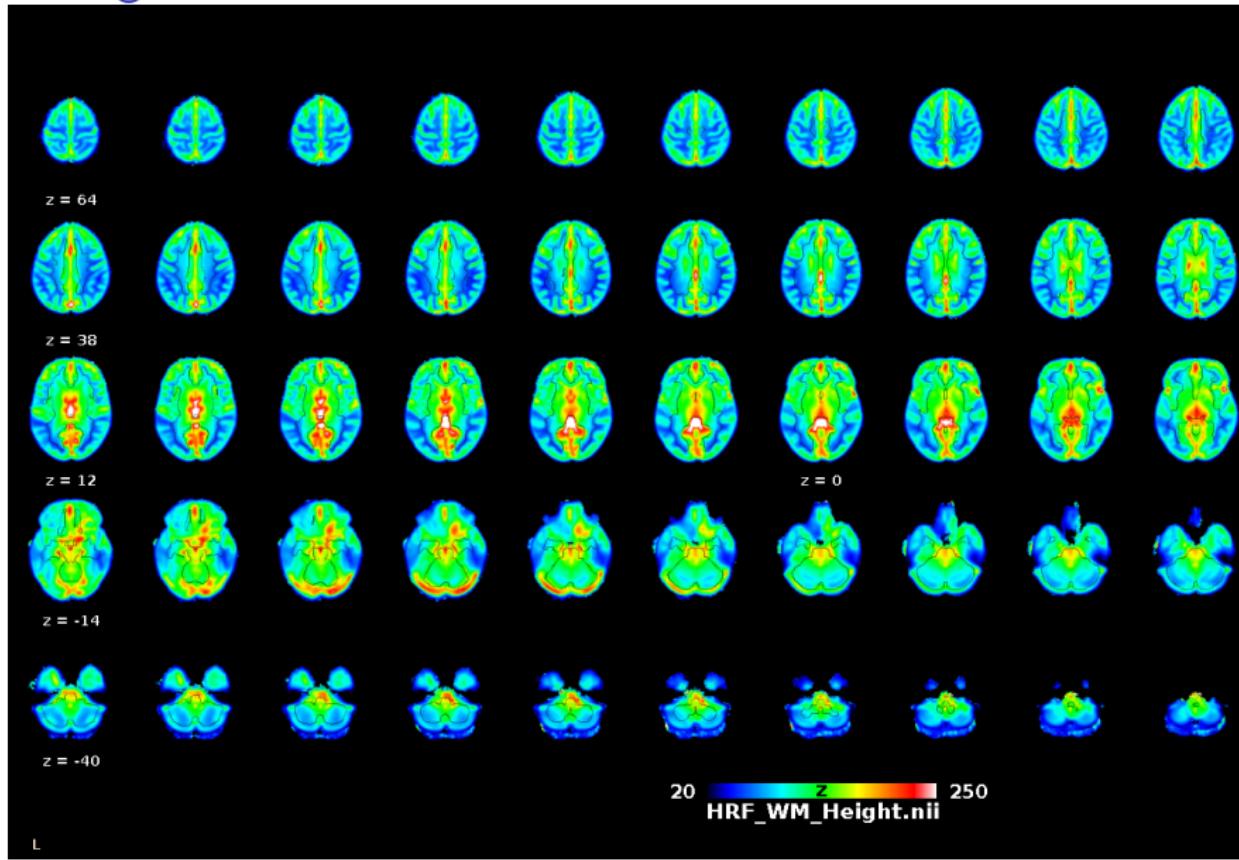
Recap of the procedure



Once the RS-HRF is retrieved it can be used to:

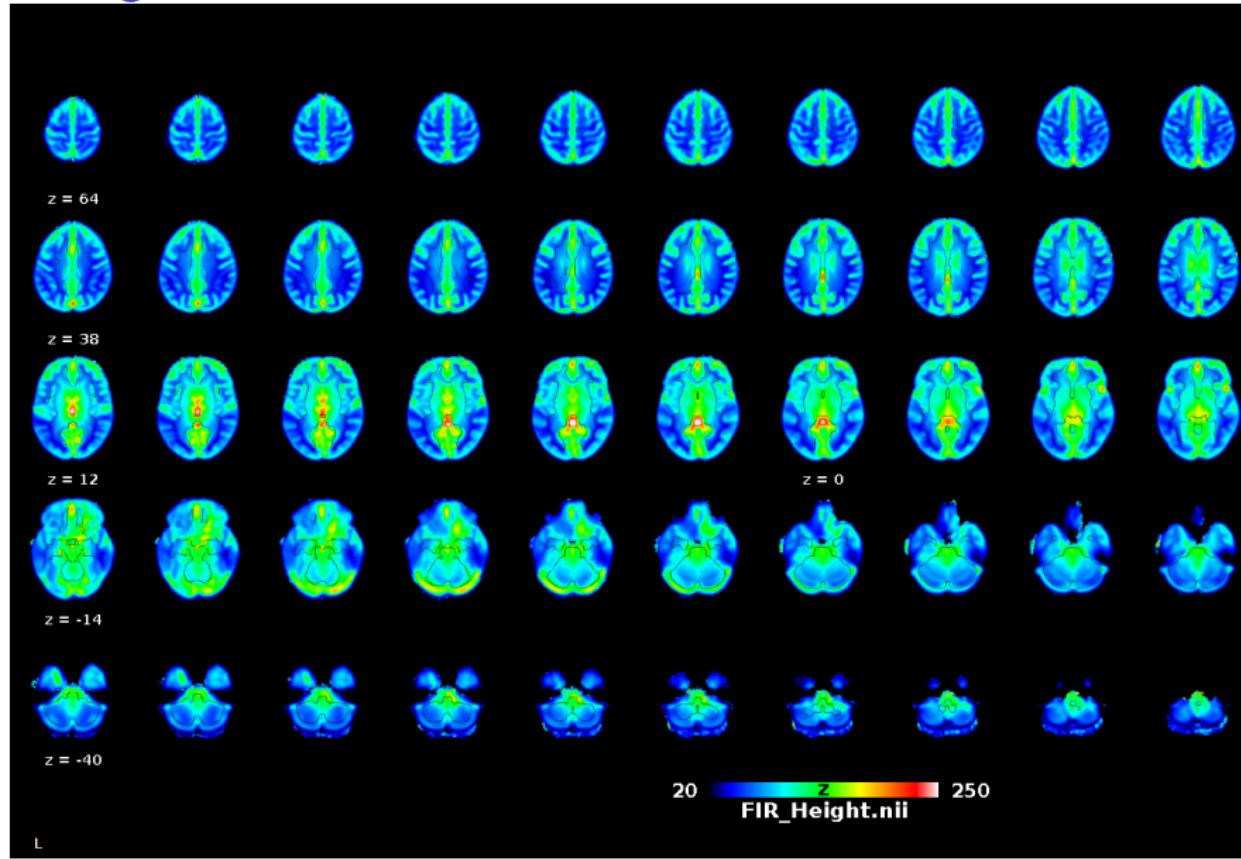
- ▶ deconvolve BOLD data in order to eliminate confounders on temporal precedence
- ▶ map it onto the brain surface and use it as a pathophysiological indicator

HRF height - Canonical-2DD



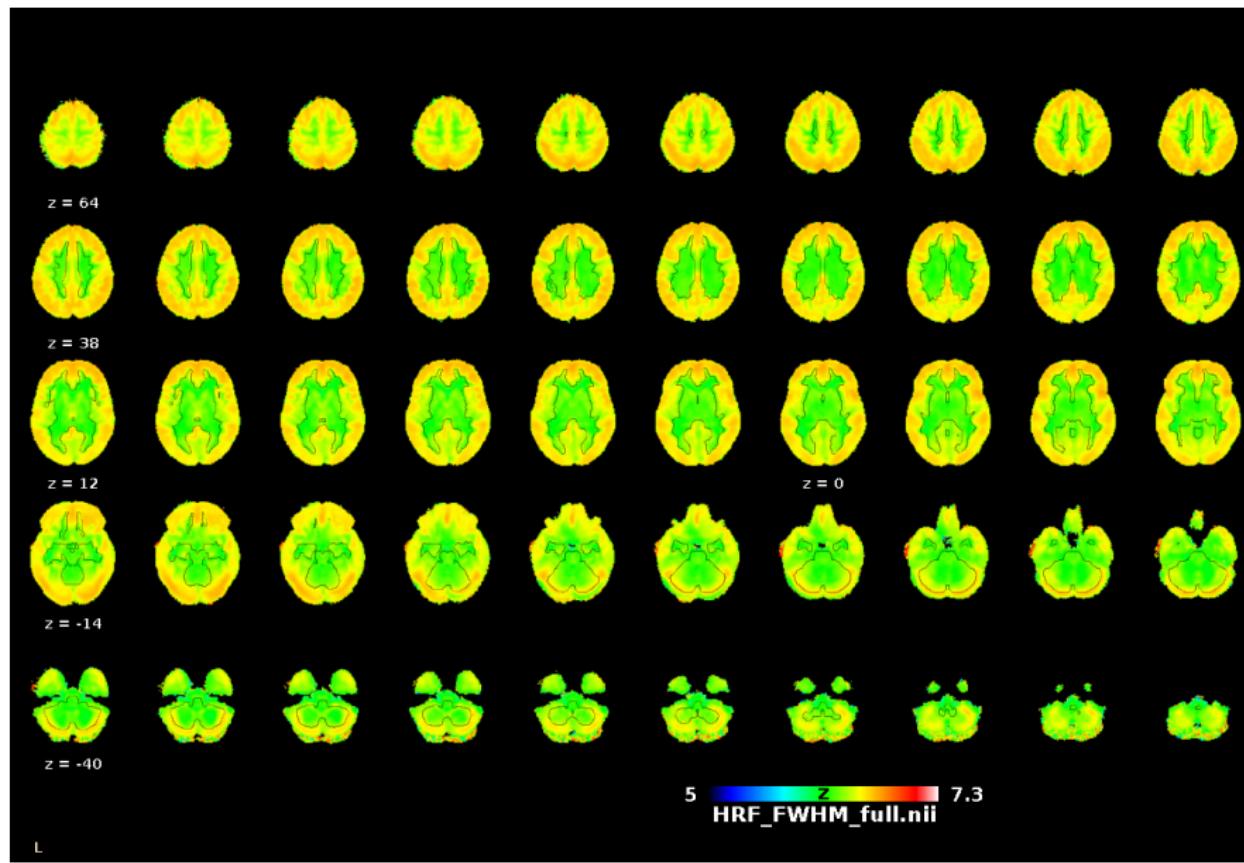
<https://neurovault.org/collections/3584/>

HRF height - FIR

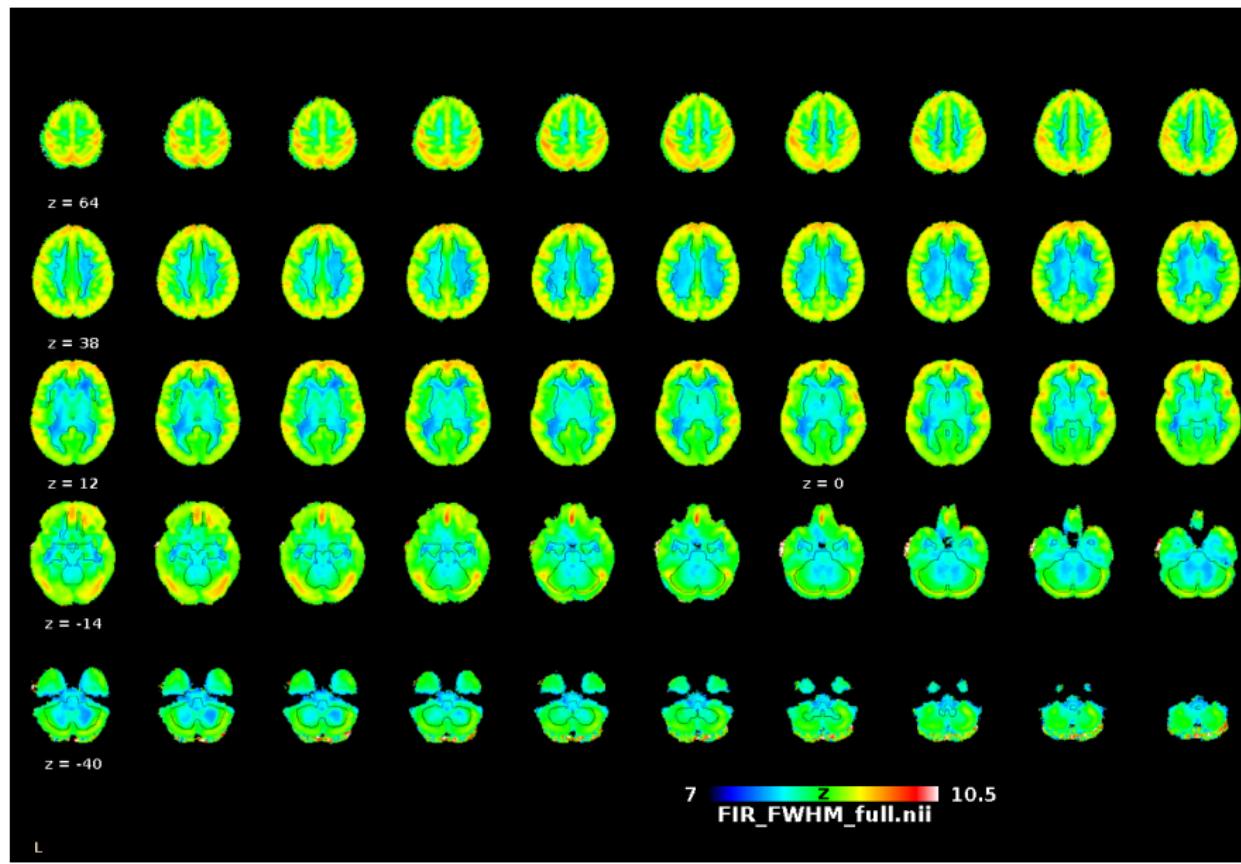


<https://neurovault.org/collections/3584/>

HRF FWHM - Canonical-2DD

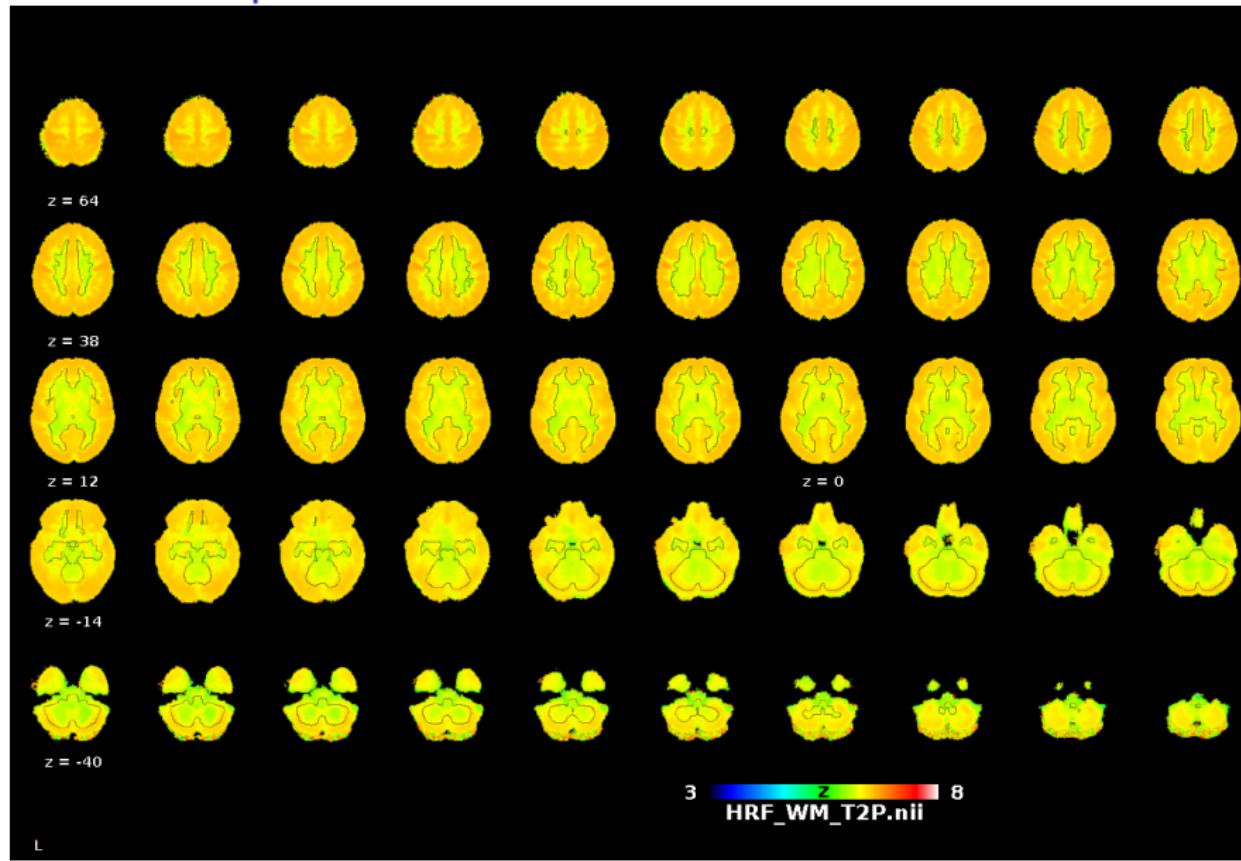


HRF FWHM - FIR



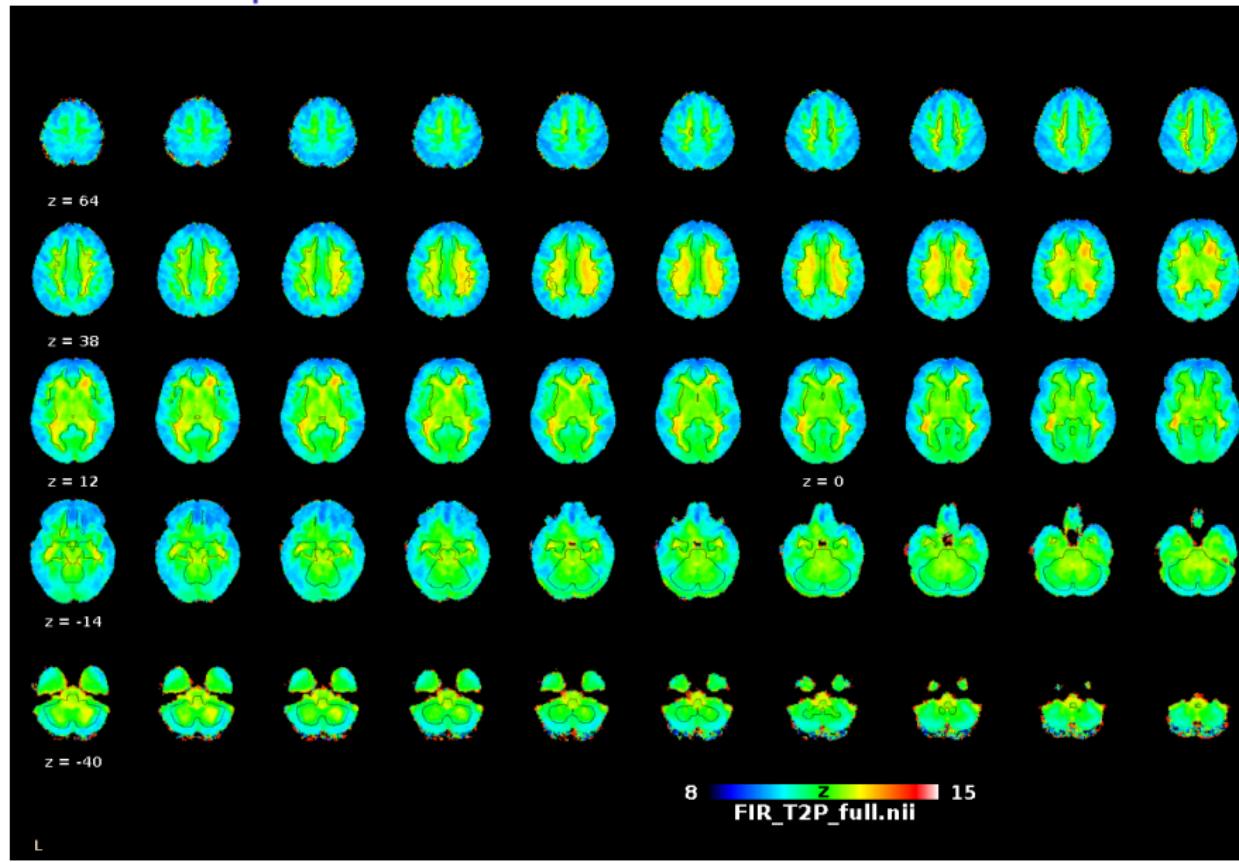
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HRF Time to peak - Canonical-2DD



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HRF Time to peak - FIR



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Posters @OHB2018

Submission No	Title
2376	Resting-state functional connectivity is confounded by the hemodynamic response function
2646	A demonstration of grey and white matter HRF retrieval from resting state BOLD fMRI

GSoC 2018: translation to Python and BIDS app

The image shows a screenshot of the Google Summer of Code 2018 Projects website. At the top, there's a dark header with the text "Google Summer of Code 2018 Projects". Below it is a search bar with the placeholder "Search for a project, organization, or student" and a "VIEW BY ORGANIZATION >" link. The main content area features a project card for "madhur.tandon".
Project Summary:
- **STUDENT:** madhur.tandon
- **PROJECT NAME:** Building a portable open pipeline to detect the hemodynamic response function at rest
- **ORGANIZATION:** INCF
- **MENTORS:** Asier Erramuzpe, Daniele Marinazzo, Nigel Colenbier
- **SHARE LINK:** A button with a clipboard icon.

Project Description (from card):

Building a portable open pipeline to detect the hemodynamic response function at rest

Project Description (from right panel):

Most of the currently used data is task-based fMRI data i.e. the data acquired when the subject performs an explicit task (such as finger-tapping). It is clear however, that the brain is active even when the subject is not performing a task. In fact, according to certain estimates, task-related changes in neuronal metabolism only account for about 5% of the brain's total energy consumption. Resting state fMRI is a comparatively newer approach used to identify synchronous BOLD changes in multiple brain regions while the subjects lie comfortably in the scanner without performing a task. The correlations between spontaneous BOLD signals can be used to study intrinsic functional connectivity. The analysis is also useful in situations where it is advantageous to explore the brain's functional organization in neurological or psychiatric diseases. INCF currently has a tool to retrieve the hemodynamic response function at rest from resting state fMRI, however, the code is currently written in MATLAB. In order to increase its diffusion and portability, the repository has to be converted to Python and follow the BIDS - Standards to eventually create the portable neuroimaging pipeline.