Andrea Chincarini

INFN

nextMR
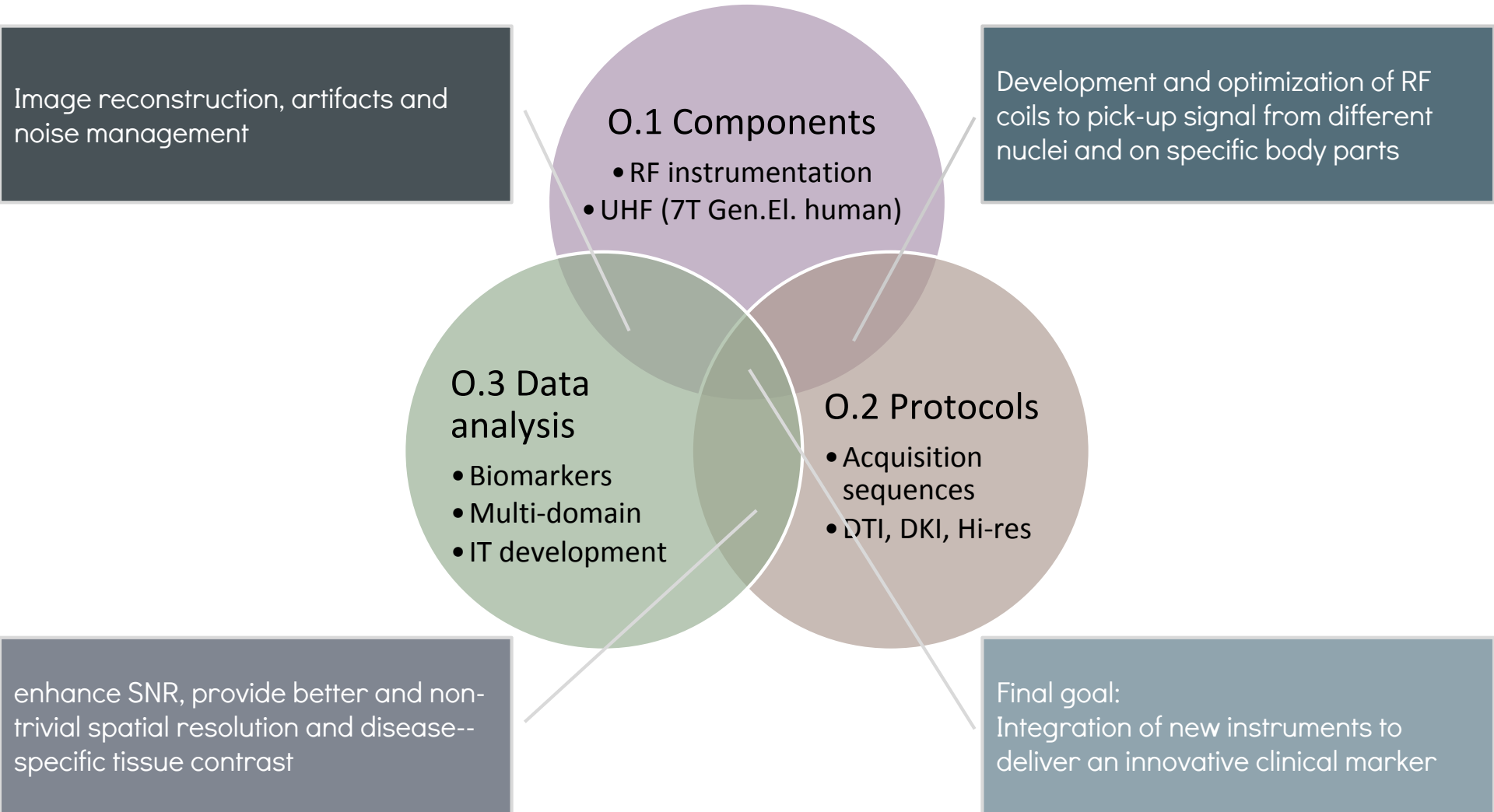
advancing magnetic resonance imaging and medical data analysis

INFN - CSN5   2015 - 2017

CdS - Luglio 2015
Sezione di Genova

objectives

Image reconstruction, artifacts and noise management

Development and optimization of RF coils to pick-up signal from different nuclei and on specific body parts

O.1 Components
- RF instrumentation
- UHF (7T Gen.El. human)

O.3 Data analysis
- Biomarkers
- Multi-domain
- IT development

O.2 Protocols
- Acquisition sequences
- DTI, DKI, Hi-res

enhance SNR, provide better and non-trivial spatial resolution and disease--specific tissue contrast

Final goal:
Integration of new instruments to deliver an innovative clinical marker

medical applications

nextMR

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interdisciplinary physics - synergy driven
focus on brain

developing knowledge in physics, mathematics and information technology targeted at clinical data

significant involvement of the medical community

multidisciplinary approach requiring the interplay of several expertise

nextMR - all sites	18.5 FTE

INFN	Clinical partners

| GE | PI | TS | AQ | PA | BA | LE | IRCCS S. Martino GE | Osped. Riuniti TS | IMAGO 7 PI | IRCCS Stella Maris PI | IRCCS Fatebenefratelli BS | EADC (EU) | A.O.U. Policli. PA | Scien. Instit. "Vita-Salute" MI | Osp. Francesco Ferrari LE | Osp. San Salvatore AQ |

Ricerca Finalizzata (Min. Salute)
• Computer--aided diagnosis of brain amyloidosis (A. Chincarini, GE)

Ricerca Finalizzata (Min. Salute)
• Sodium imaging at ultra-high-filed MR (A. Retico, PI)

Ricerca Finalizzata (Min. Salute)
• Protein and microRNA expression profiles of multiple sclerosis patients (G. de Nunzio, LE)

European Alzheimer's Disease Consortium (EADC)
• Evaluation of the impact on the confidence of diagnosis of five algorithms for the assessment of MTA (A. Chincarini, GE)
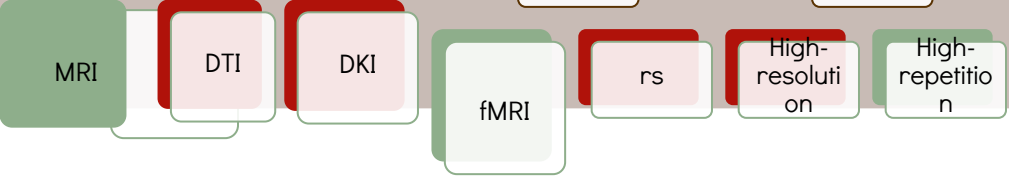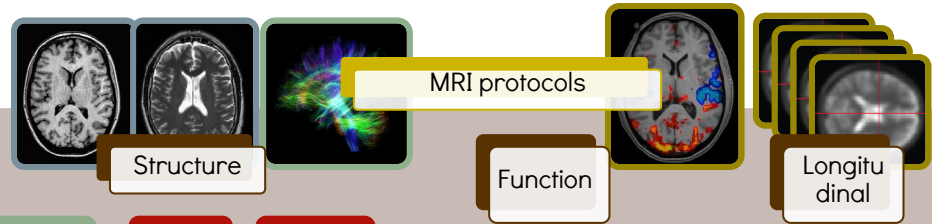
To advance in the understanding of imaging-based biomarkers

To serve as better quantitative measurements in clinical practice

To increase the neuroimaging prognostic value.

developments

Design

Simulation

SAR estimation

$$AR = \int_{sample} \frac{\sigma(\mathbf{r})|\mathbf{E}(\mathbf{r})|^2}{\rho(\mathbf{r})} d\mathbf{r}$$

INFN

MRI components

7T human scanner @PI is the only Italian site.

Electronics

Prototyping

Imaging & MRS

MRI protocols

Structure

Function

Longitudinal

MRI

DTI

DKI

fMRI

rs

High-resolution

High-repetition

protocols

Signal contribution	Physics, scanner, protocols	Image modality	Clinical input	Information theory	Data set	Raw data 10^7 DoF / image
Processing	Quality assessment	Normalization	Characterization	Feature extraction	Classifier	Abstraction layer $10^2 - 10^3$ DoF
Noises	Acquisition noises	Physiological	Processing, Gold standard	Data processing	Gold standard	1-2 DoF

data analysis

continuity

^{next}MR is the offspring of **MIND** (2012-2014)
[Medical Imaging for Neurodegenerative Diseases]

collaboration grown from 3 INFN sites to 6 sites + an upcoming spin-off participation

Publications by the MIND / ^{next}MR collaboration [2014 - today]

❏ SUVr-independent evaluation of brain amyloidosis; *(2015) Alzheimer & Dementia, submitted.*

❏ Integrating longitudinal information in hippocampal volume measurements for the early detection of Alzheimer's disease; *(2015) NeuroImage, submitted*

❏ Standardized evaluation of algorithms for computer-aided diagnosis of dementia based on structural MRI: The CADDementia challenge; *(2015) NeuroImage. Article in Press.*

❏ Predictive Models Based on Support Vector Machines: Whole-Brain versus Regional Analysis of Structural MRI in the Alzheimer's Disease; *(2014) Journal of Neuroimaging. Article in Press.*

❏ Feature selection based on machine learning in MRIs for hippocampal segmentation; *Computational and Mathematical Methods in Medicine, 2015*

❏ Automated voxel-by-voxel tissue classification for hippocampal segmentation: Methods and validation (2014) *Physica Medica, 30 (8)*

❏ Quadrature birdcage coil with distributed capacitors for 7.0 T magnetic resonance data acquisition of small animals (2015) *Concepts in Magnetic Resonance Part B: Magnetic Resonance Engineering, 44 (4), pp. 83-88.*

❏ Neuroimaging-based methods for autism identification: A possible translational application? *(2014) Functional Neurology, 29 (4), pp. 231-239.*

expertise in GE

models and methods development

link to GW data analysis

advanced analysis on clinical data

extending the concept of measure
to theory-less environments
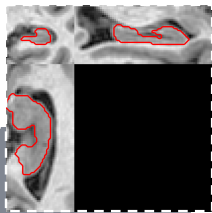
next

imaging-based biomarkers for the early diagnosis of
neurodegenerative diseases

provide verifiable quantification methods to extract
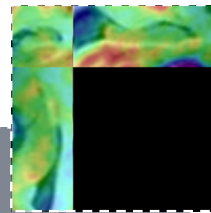a pathological "*signal*" from a normalcy "*background*"

[MRI atrophy score validated and currently under blind test in >20 EU centers]
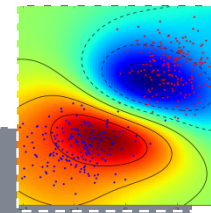[amyloid-PET SUVr-independent quantification under validation]

Segmentation
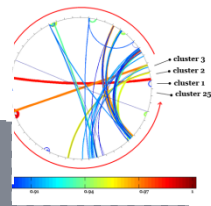- Hippocampus
- MTL atrophy

Multi-domain
- PET + MRI
- Amyloid imaging

Abstraction
- Machine learning
- VBM
- TFA and PCA

Coherence
- Structural networks
- Disease fingerprint

INFN-GE 2016

national coordination

human resources

4 staff	= 1.9 FTE
(Chincarini, Boccacci, Calvini, Squarcia)	
1 PhD student	= 1.0 FTE
with INFN scholarship	
IT department	= 1.0 month eq.

INFN services

potential impact - 2016

human resources mainly (grants, scholarships) depending on external funds

nextMR

tech. transfer
quantification methods in nuclear medicine

Lilly

IASON

patent

elba
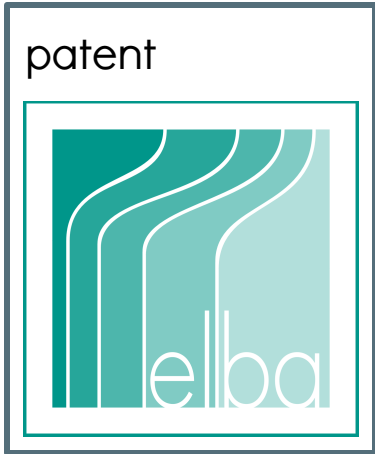
Ministero della Salute - Ricerca finalizzata	pending
Compagnia di San Paolo - prog. VERA	pending
Compagnia di San Paolo - prog. LUNA	pending
IASON pharma	pending
AAA pharma	pending
Fondazione Piaggio	funded
Lilly pharma	funded
GE healthcare	rejected