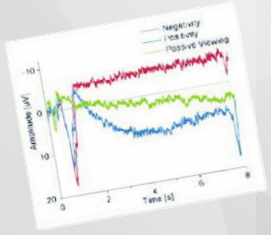
Bidirectional BMI – Overall Process

SAND2012-2027P

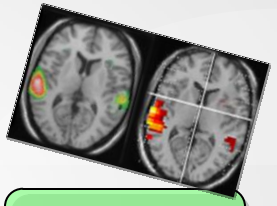
Neuroimaging

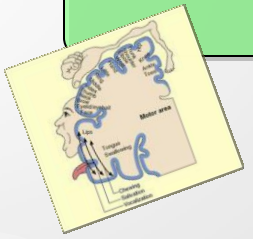
ID Requirements

Determine necessary / sufficent resolution



Signal Processing

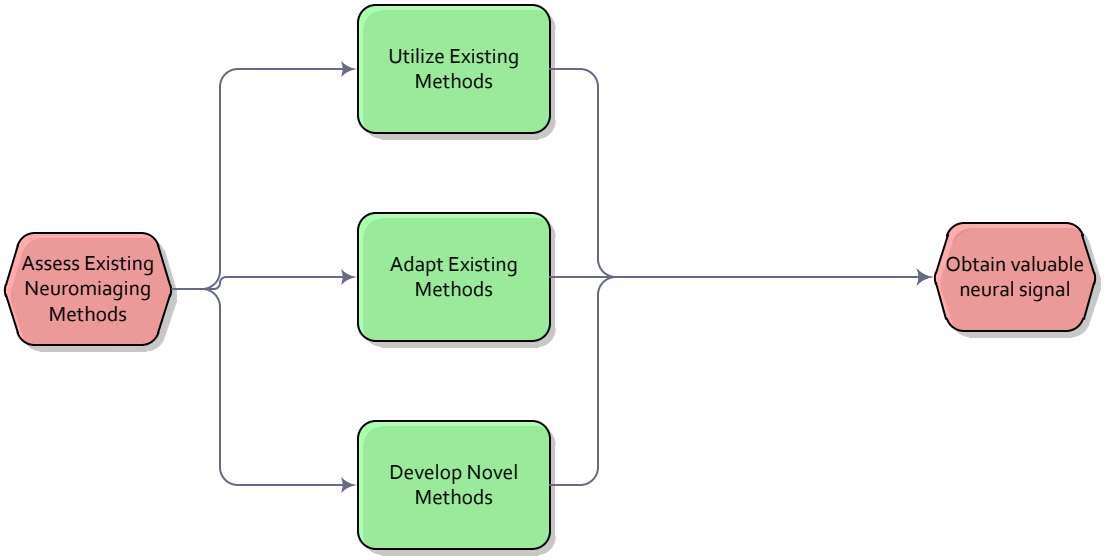




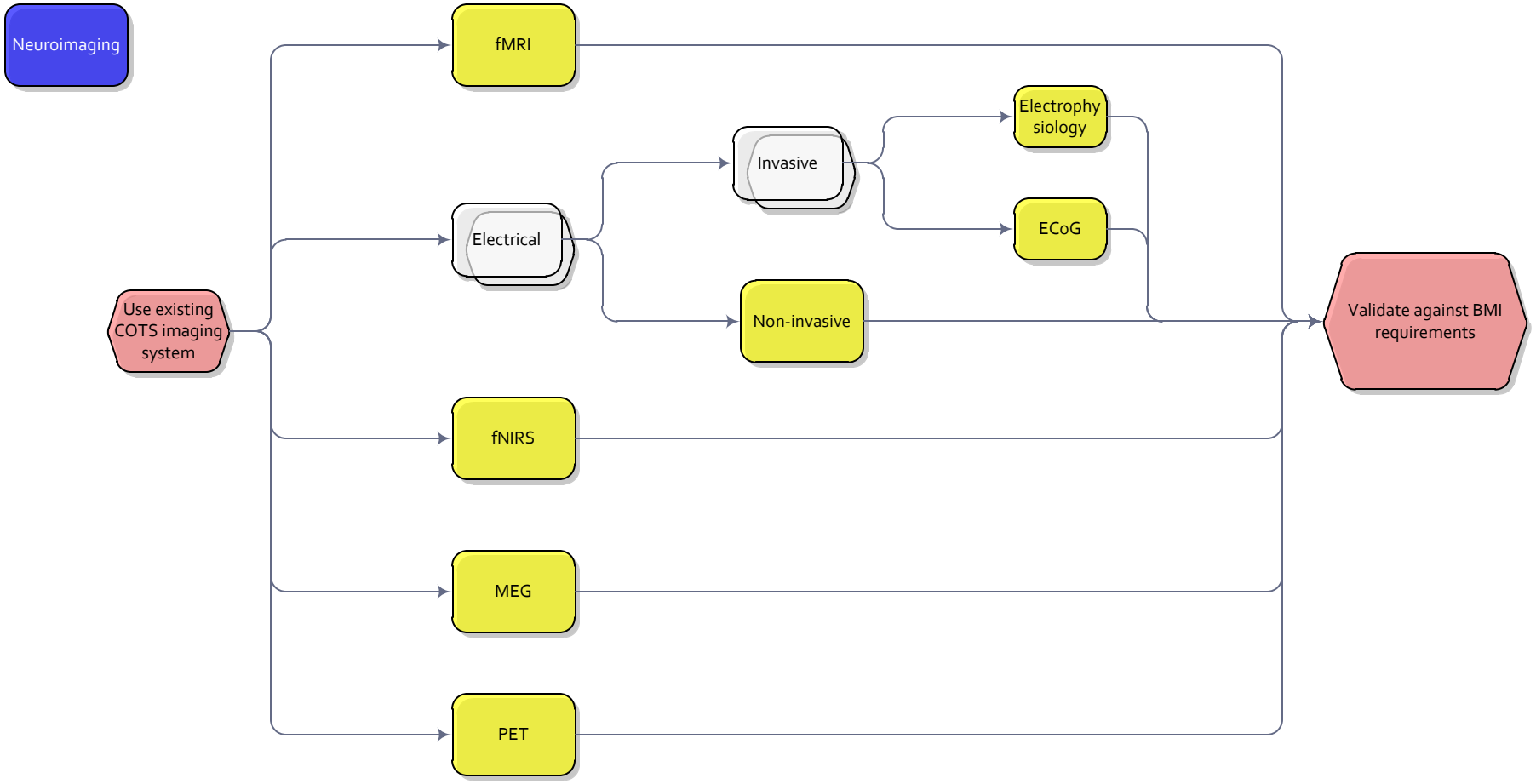
Neuroscience

BMI System

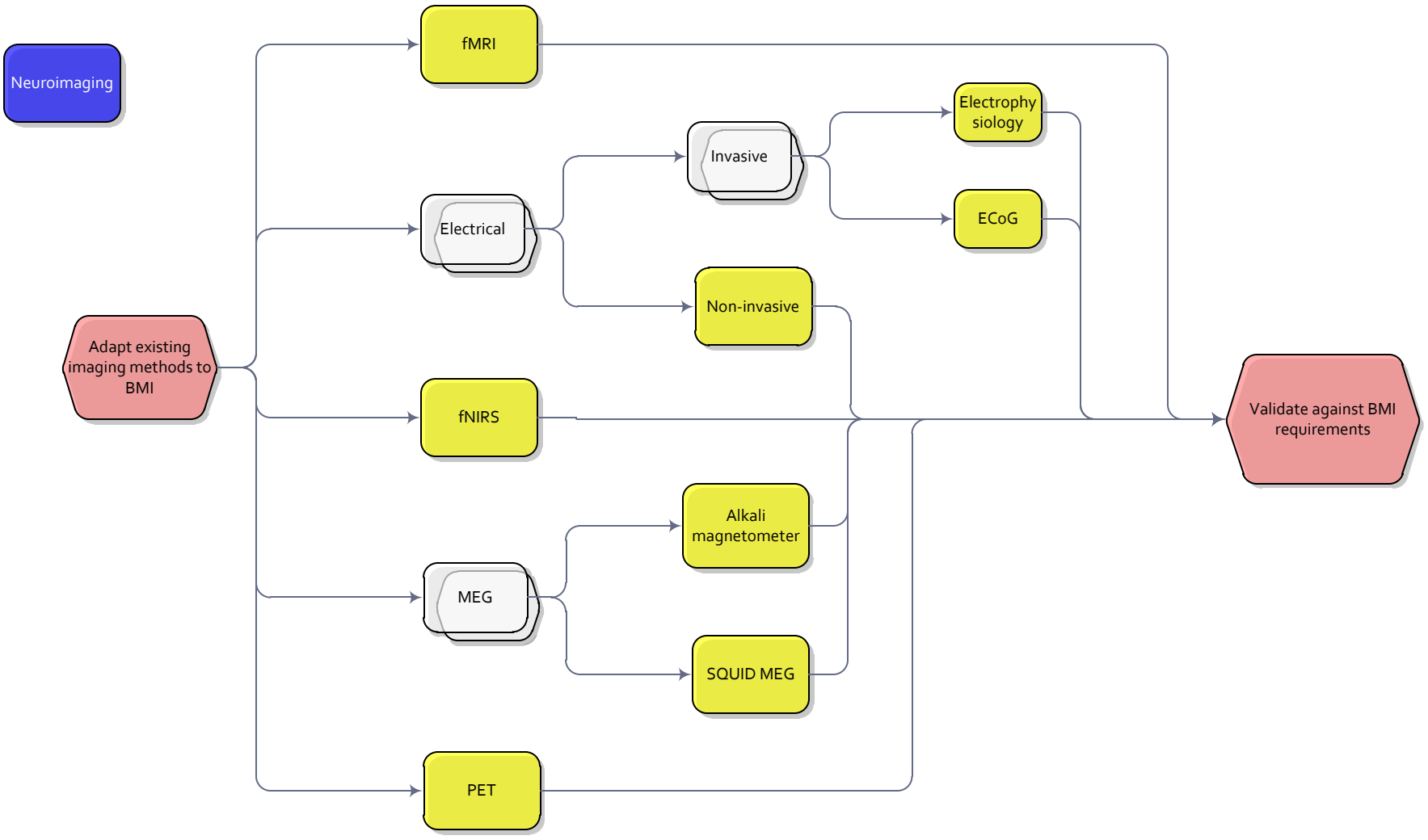
Neuroimaging



Utilize Existing Neuroimaging Techniques

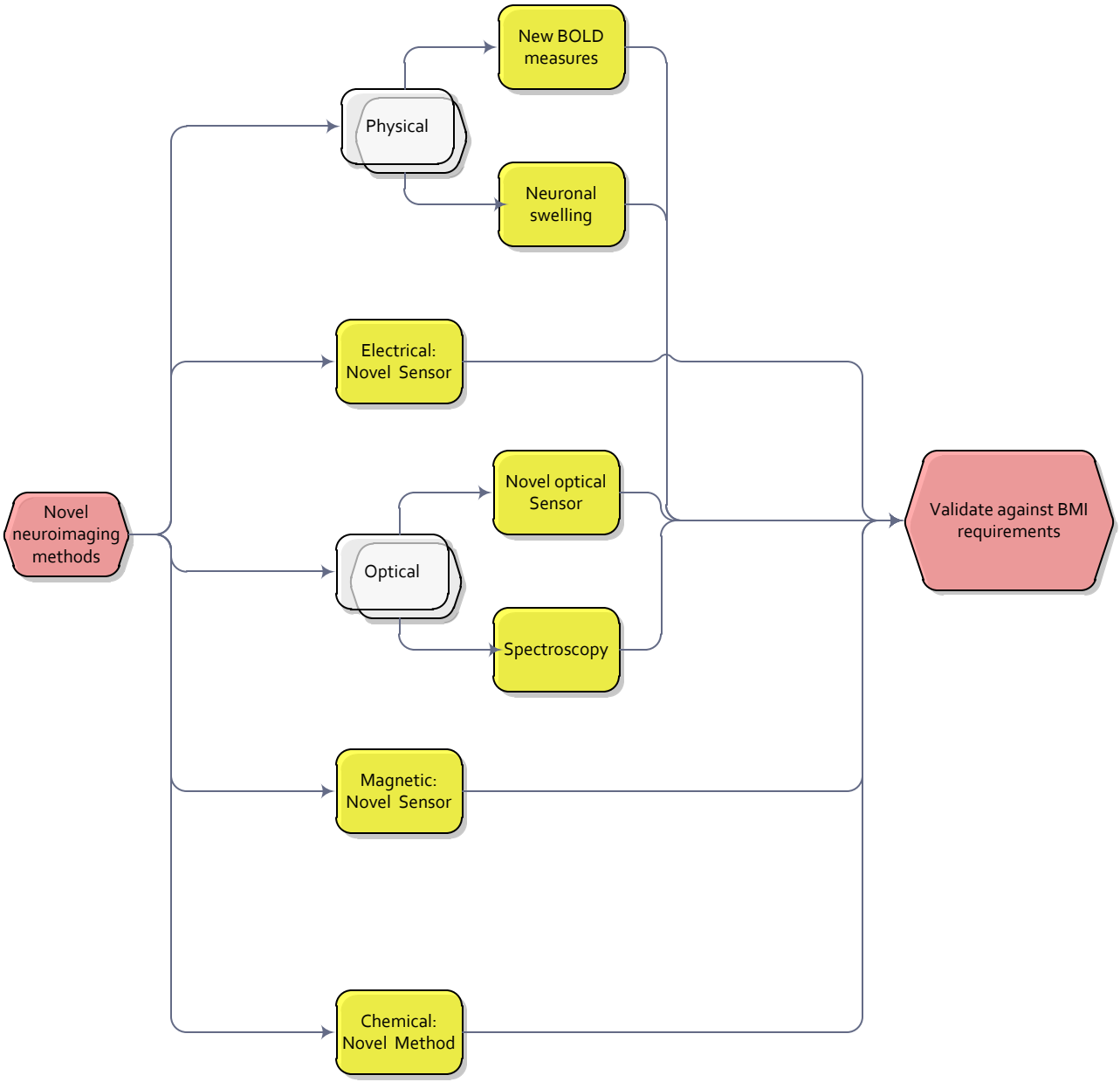


Adapt Existing Neuroimaging Techniques

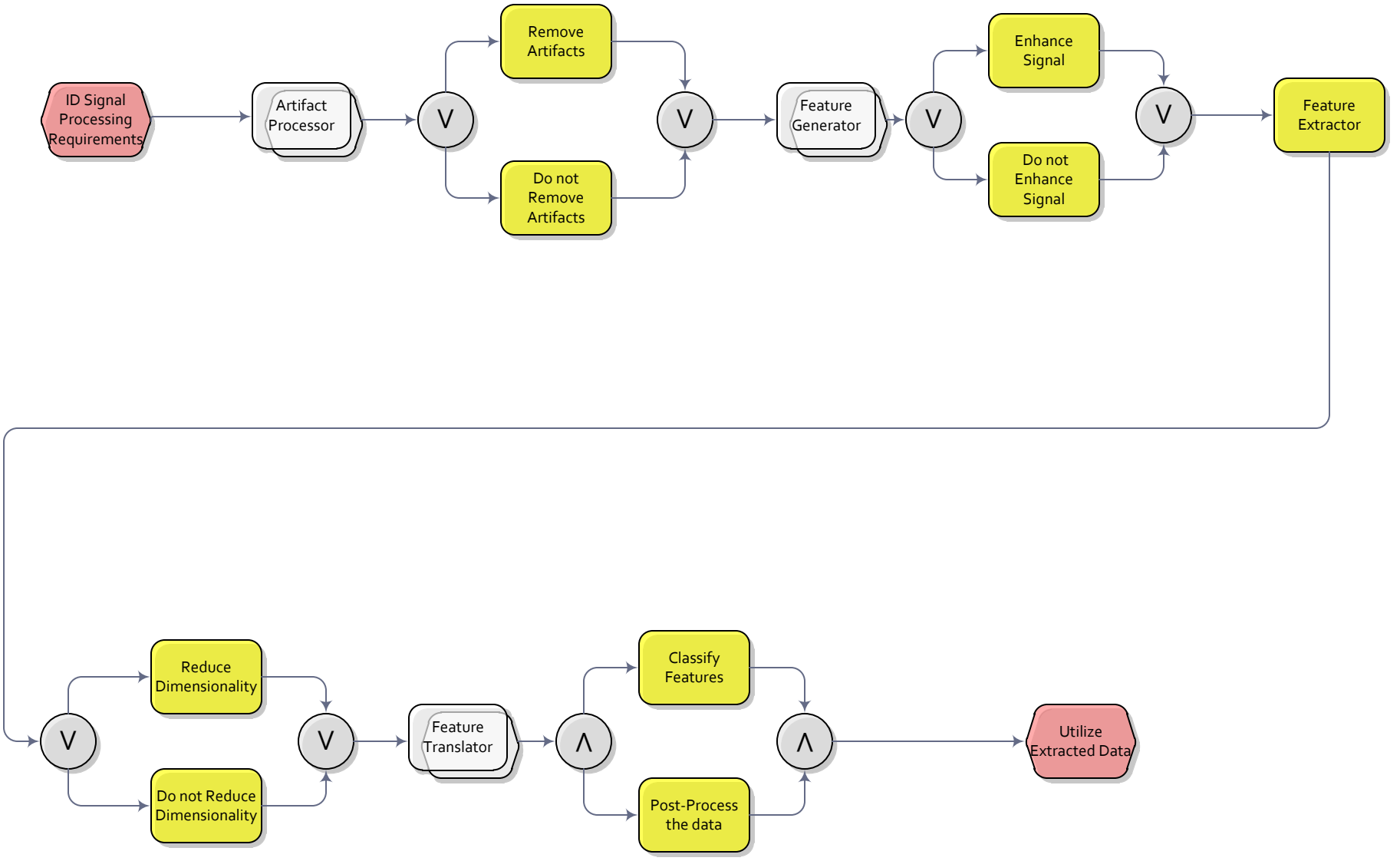


Neuroimaging

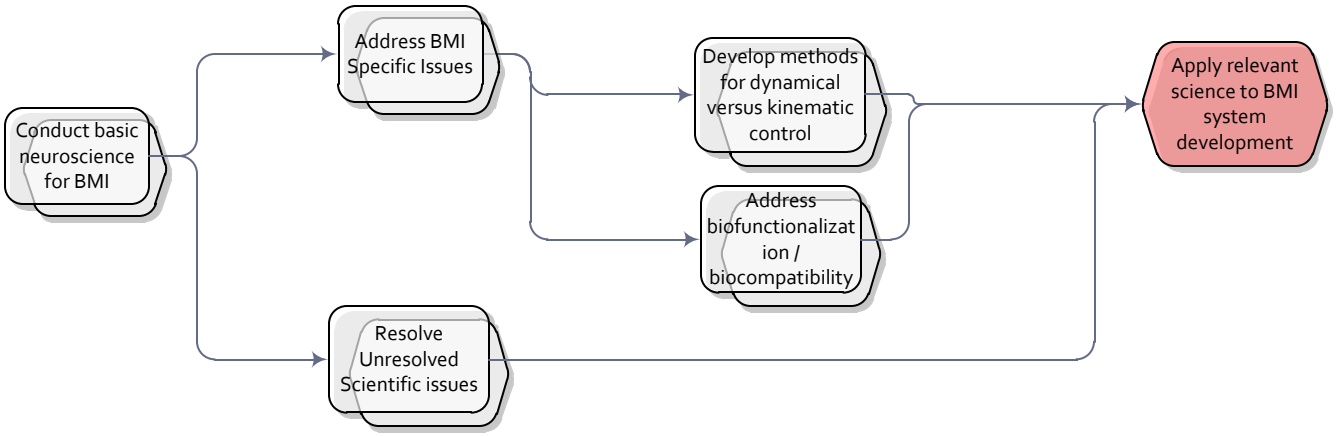
Develop Novel Neuroimaging Techniques

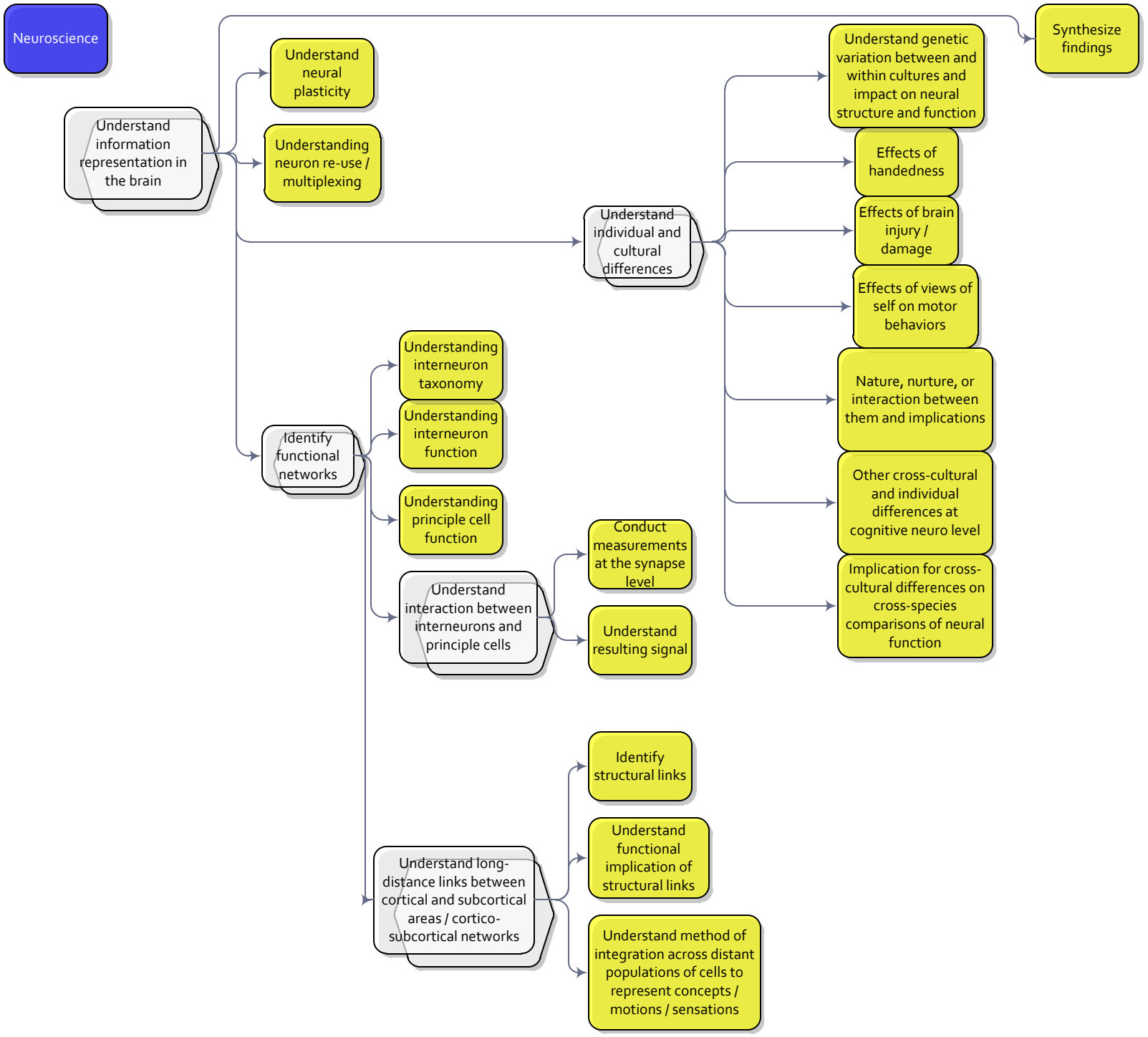


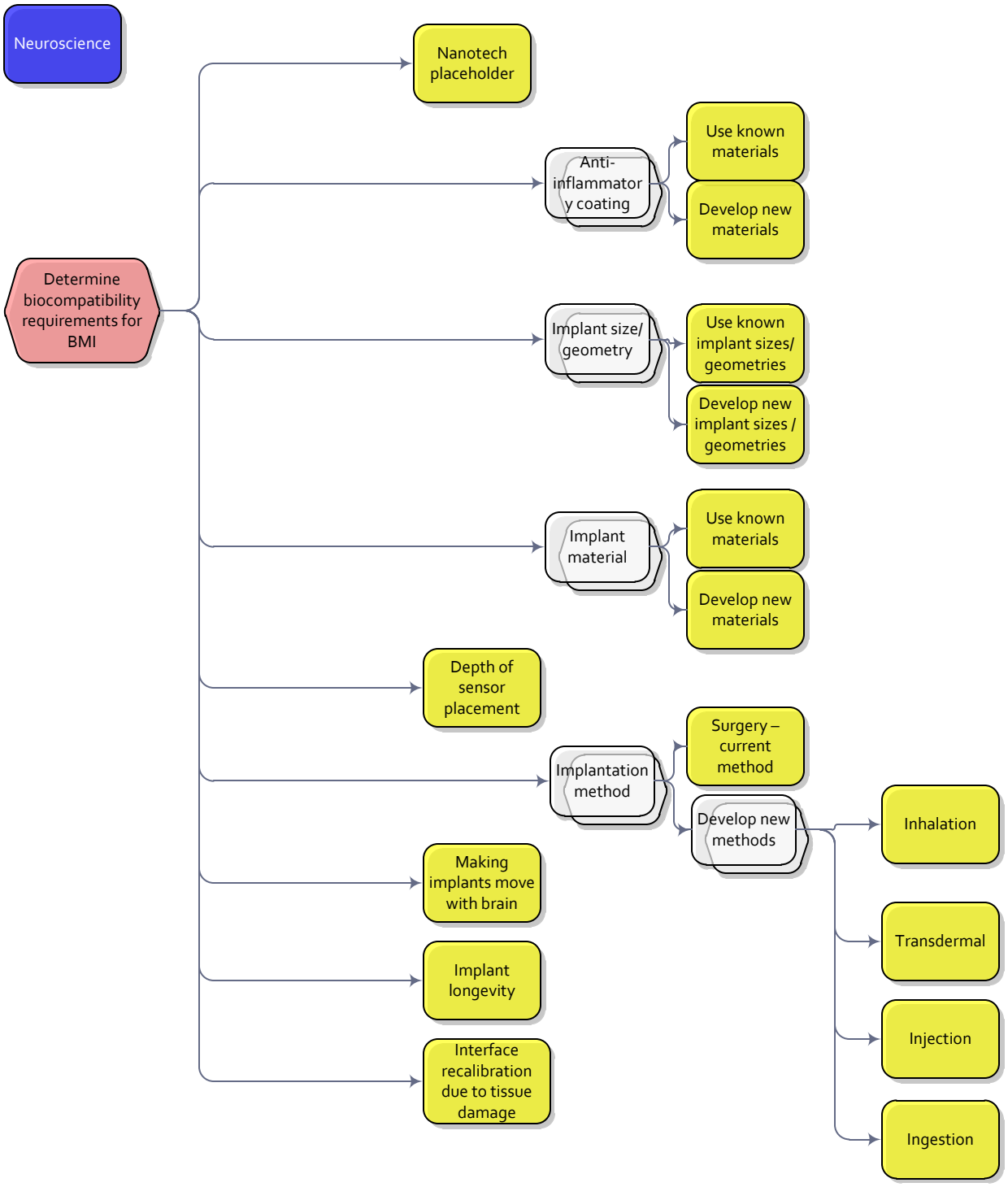
Signal Processing

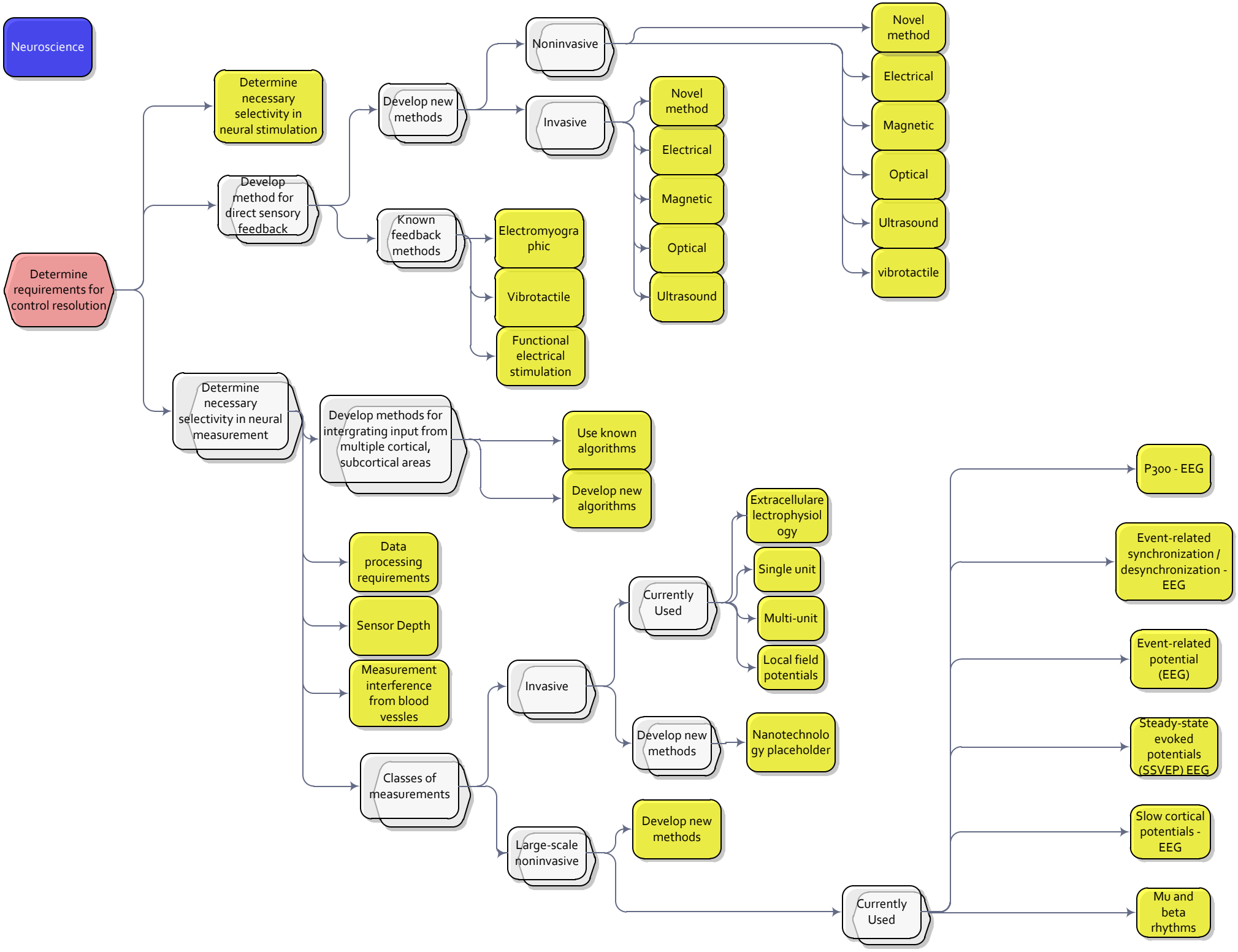


Neuroscience

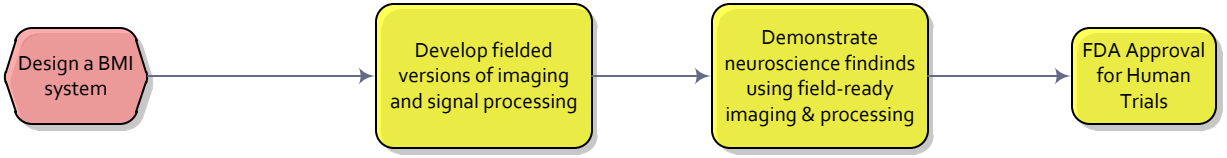



Neuroscience
Understand information representation in the brain
Understand neural plasticity
Understanding neuron re-use / multiplexing
Identify functional networks
Understanding interneuron taxonomy
Understanding interneuron function
Understanding principle cell function
Understand interaction between interneurons and principle cells
Conduct measurements at the synapse level
Understand resulting signal
Understand long-distance links between cortical and subcortical areas / cortico-subcortical networks
Identify structural links
Understand functional implication of structural links
Understand method of integration across distant populations of cells to represent concepts / motions / sensations
Understand individual and cultural differences
Understand genetic variation between and within cultures and impact on neural structure and function
Effects of handedness
Effects of brain injury / damage
Effects of views of self on motor behaviors
Nature, nurture, or interaction between them and implications
Other cross-cultural and individual differences at cognitive neuro level
Implication for cross-cultural differences on cross-species comparisons of neural function
Synthesize findings


Neuroscience
Determine biocompatibility requirements for BMI
Nanotech placeholder
Anti-inflammatory coating
Use known materials
Develop new materials
Implant size/ geometry
Use known implant sizes/ geometries
Develop new implant sizes / geometries
Implant material
Use known materials
Develop new materials
Depth of sensor placement
Implantation method
Surgery – current method
Develop new methods
Inhalation
Transdermal
Injection
Ingestion
Making implants move with brain
Implant longevity
Interface recalibration due to tissue damage


Neuroscience
Determine requirements for control resolution
Determine necessary selectivity in neural stimulation
Develop method for direct sensory feedback
Develop new methods
Noninvasive
Invasive
Novel method
Electrical
Magnetic
Optical
Ultrasound
vibrotactile
Novel method
Electrical
Magnetic
Optical
Ultrasound
Known feedback methods
Electromyographic
Vibrotactile
Functional electrical stimulation
Determine necessary selectivity in neural measurement
Develop methods for intergrating input from multiple cortical, subcortical areas
Use known algorithms
Develop new algorithms
Data processing requirements
Sensor Depth
Measurement interference from blood vessles
Classes of measurements
Invasive
Currently Used
Extracellulare lectrophysiology
Single unit
Multi-unit
Local field potentials
Develop new methods
Nanotechnology placeholder
Large-scale noninvasive
Develop new methods
Currently Used
P300 - EEG
Event-related synchronization / desynchronization - EEG
Event-related potential (EEG)
Steady-state evoked potentials (SSVEP) EEG
Slow cortical potentials - EEG
Mu and beta rhythms

BMI System


Design a BMI system
Develop fielded versions of imaging and signal processing
Demonstrate neuroscience findinds using field-ready imaging & processing
FDA Approval for Human Trials