ANTS2

Short introduction

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ANTS2: origins

Dark Matter

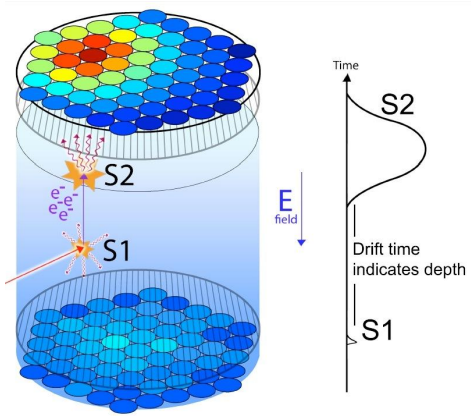
Mercury

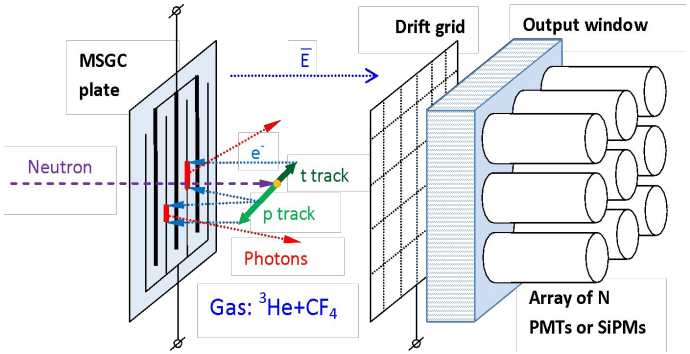
- Spline library for LRF fitting
- MINUIT minimization
- Tools for gain equalization
- Set of ROOT scripts

Neutron detectors

ANTS

- Tabulated LRF
- Custom minimization
- 2D simulation
- Integrated environment with nice GUI



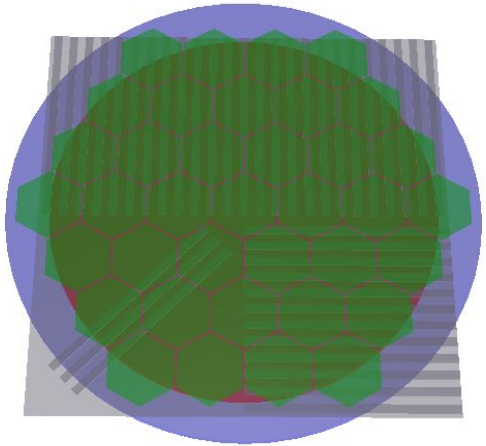


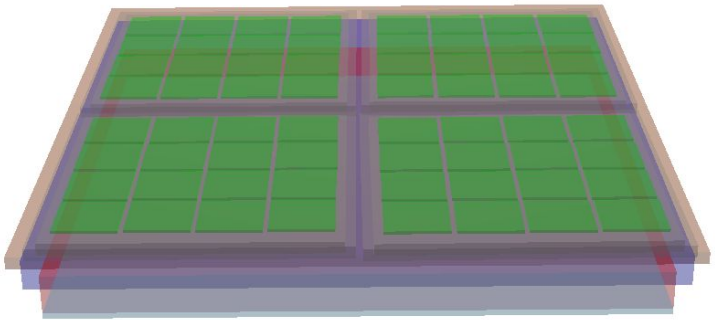
ANTS2: origins

Gamma cameras

ANTS2

- Integrated environment
- Photon tracking in 3D geometry
- Spline LRFs
- MINUIT minimization
- Event filters (cuts)
- Nice GUI (Qt) + Visualization (ROOT)

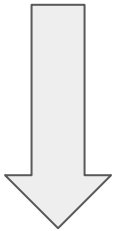


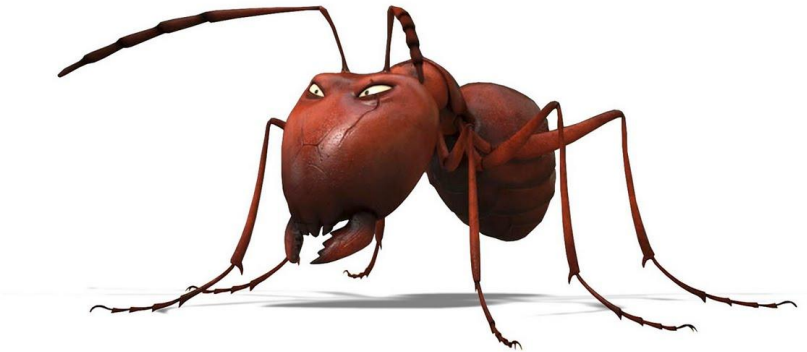


ANTS2: expansion

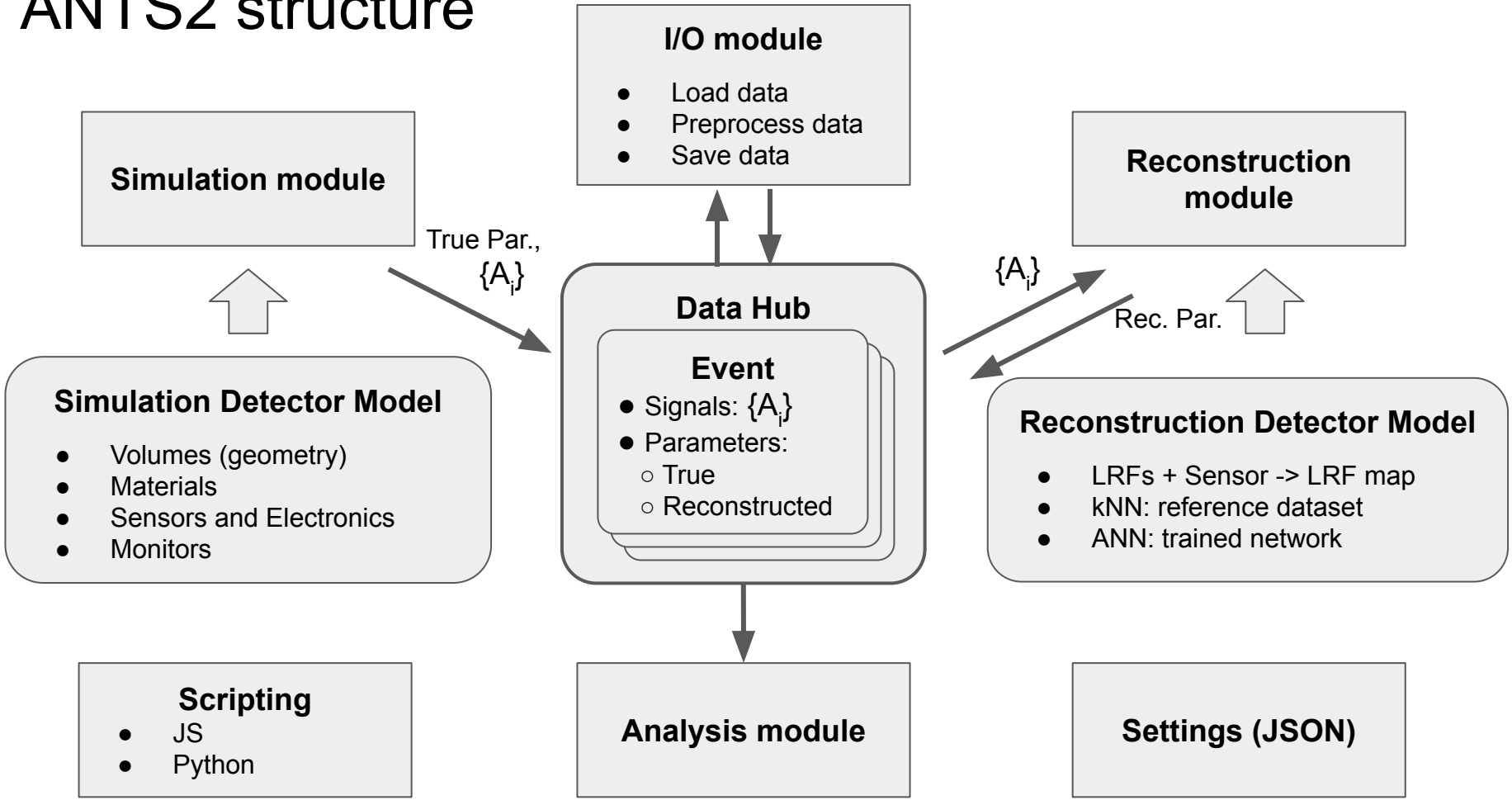
I. We get experimental data! -> Make more realistic simulation and reconstruction to explain/reproduce it
   - Particle tracking
   - Time resolved
   - Wavelength resolved
   - PMT/SiPM and electronics response
   - 2D and 3D LRFs

II. We get other people interested in it! -> Make it an attractive general-purpose tool
   - JS scripting
   - Python interpreter
   - Geant4 integration
   - Docker containers
   - Distributed ANTS2
   - Project on GitHub

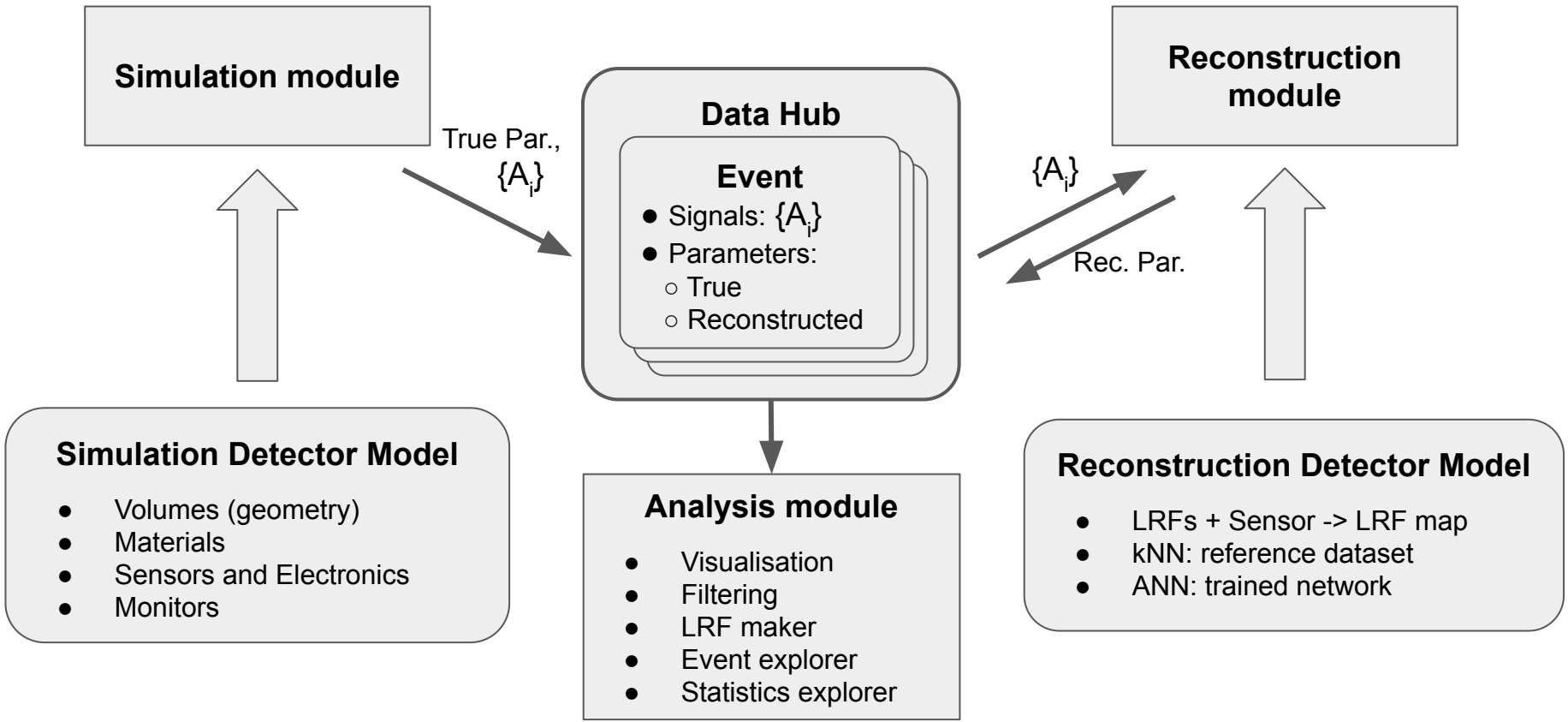




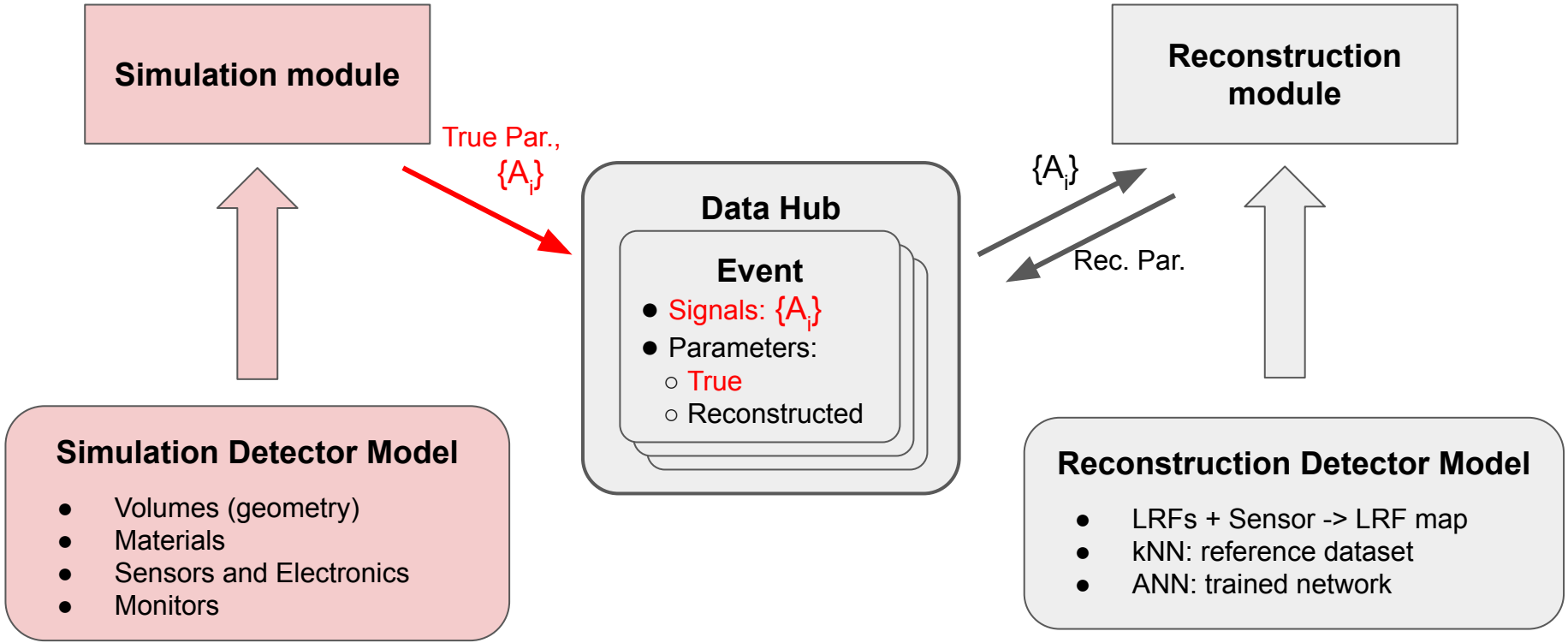
ANTS2 structure



ANTS2 structure (simplified)



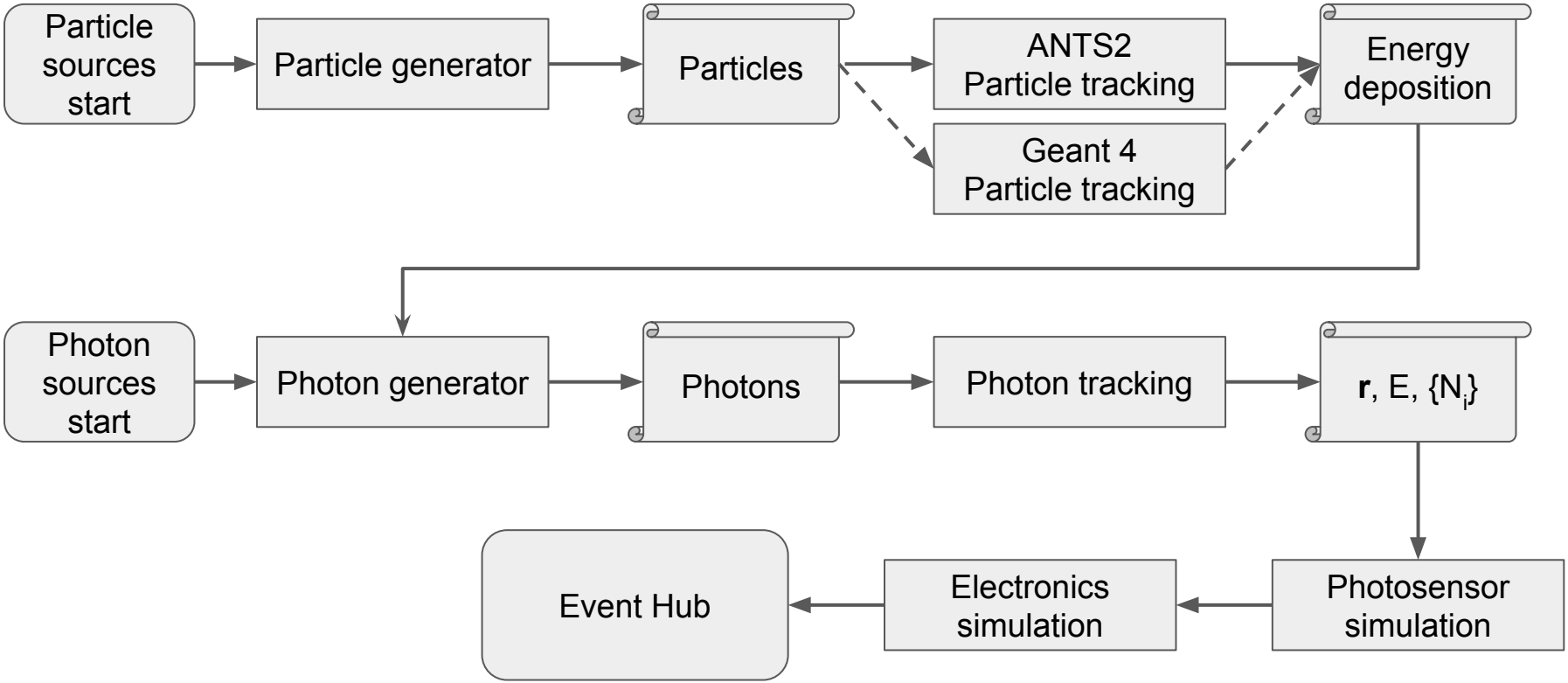
Simulation mode



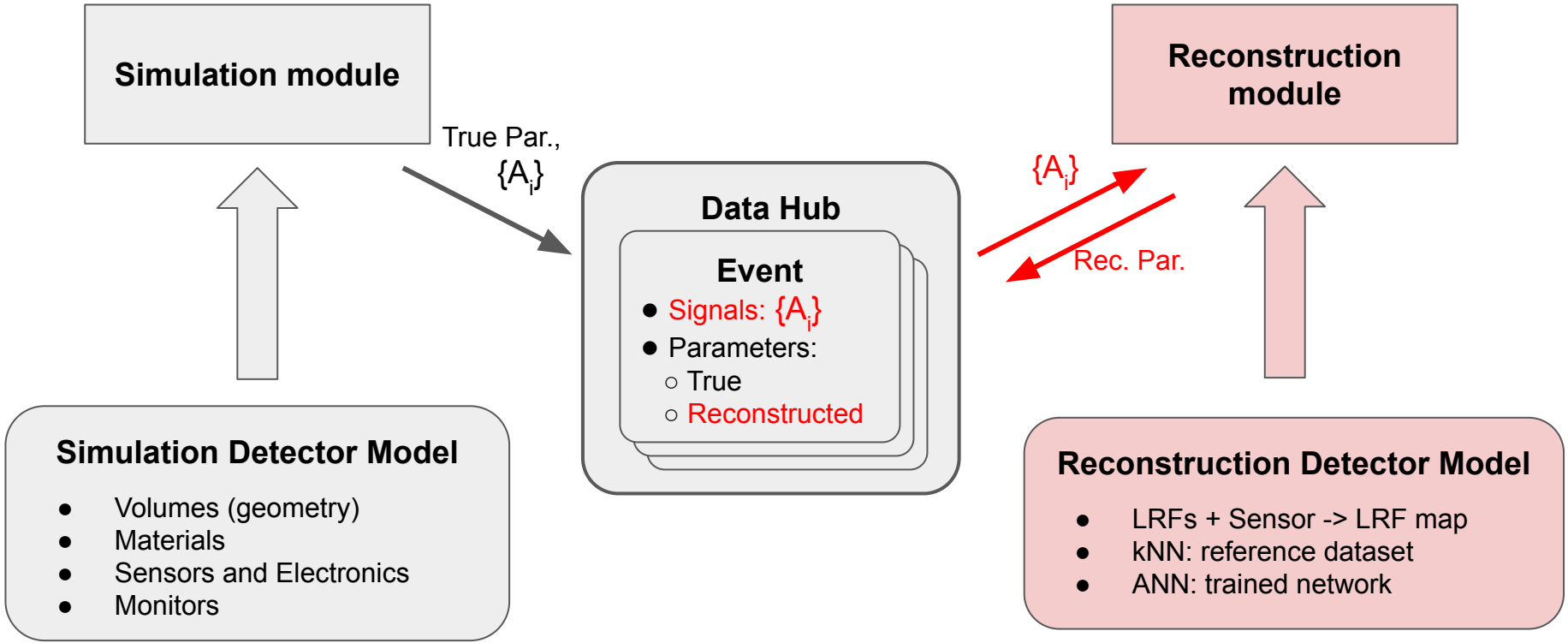
Simulation detector model

- Geometry is based on ROOT geometry model (TGeo)
  - Standard volume types organized into a tree structure with CSG option
  - ANTS2 provides some “syntactic sugar” on top: stacks, groups and arrays
  - Close enough to Geant4 geometry to exchange data via GDML
- Materials
  - Element composition: custom, GDML exchange facility is provided
  - Optical properties
    - Bulk: $n(\lambda)$, $L_{att}(\lambda)$, $L_{scatt}(\lambda)$, $L_{Rayleigh}$
    - Interfaces (overrides): Lambertian, metal, PTFE, WLS
  - Scintillation properties
- Optical sensors
  - Spectral sensitivity, angular and area response, dark counts, single photoelectron response; also saturation and crosstalk for SiPMs
- Electronics and ADC
  - Electronic noise, ADC quantization

Simulation


Particle sources start
Particle generator
Particles
ANTS2 Particle tracking
Geant 4 Particle tracking
Energy deposition
Photon sources start
Photon generator
Photons
Photon tracking
r, E, {N_i}
Photosensor simulation
Electronics simulation
Event Hub

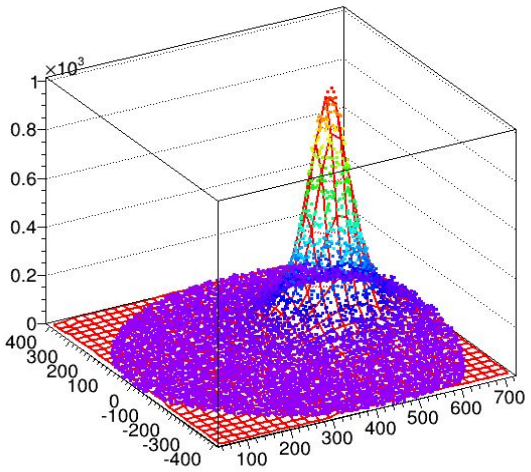
Reconstruction mode



Reconstruction detector model & LRFs

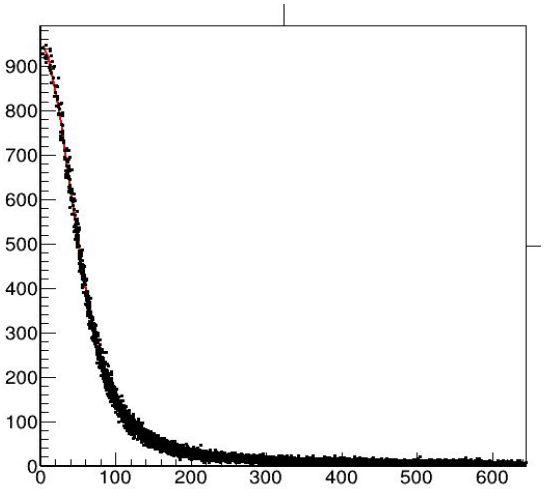
Light response functions (LRF) $\eta_i(x,y)$, is the probability for a photon isotropically emitted at position (x,y) to be detected by the i-th PMT

Detector model needed for statistical reconstruction is just a set of LRFs:



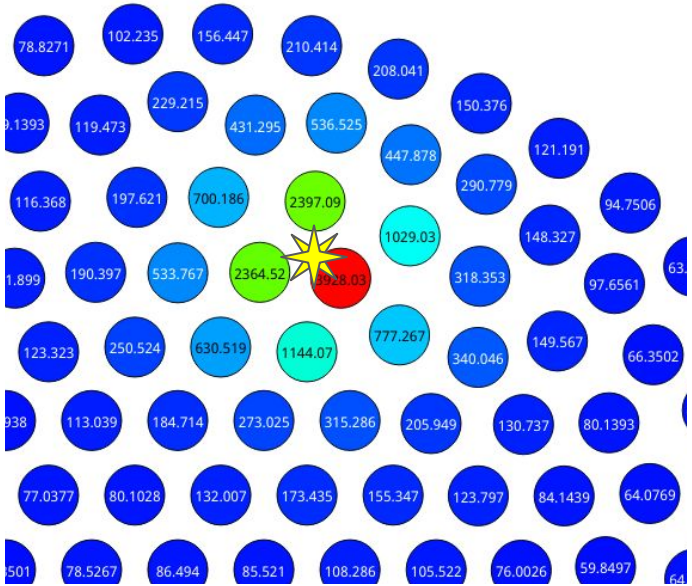
$$a_i = N\eta_i(x,y)$$

In many practical cases, LRFs have axial symmetry and can be reduced to $\eta_i(r)$ where r is the distance from the i-th PMT axis



Statistical reconstruction in 2D

Reconstruction of event position **(x, y)** and "brightness" (total number of emitted photons) **N** by finding the best match between the measured hit pattern **{A_i}** and the expected pattern **{a_i}** calculated from the detector response model.



^{83m}Kr S2 (MDC2)

Event Detection

event
(x, y, N)

Detector + electronics
+ DAQ (+ LZAP)

Hit
pattern
{A_i}

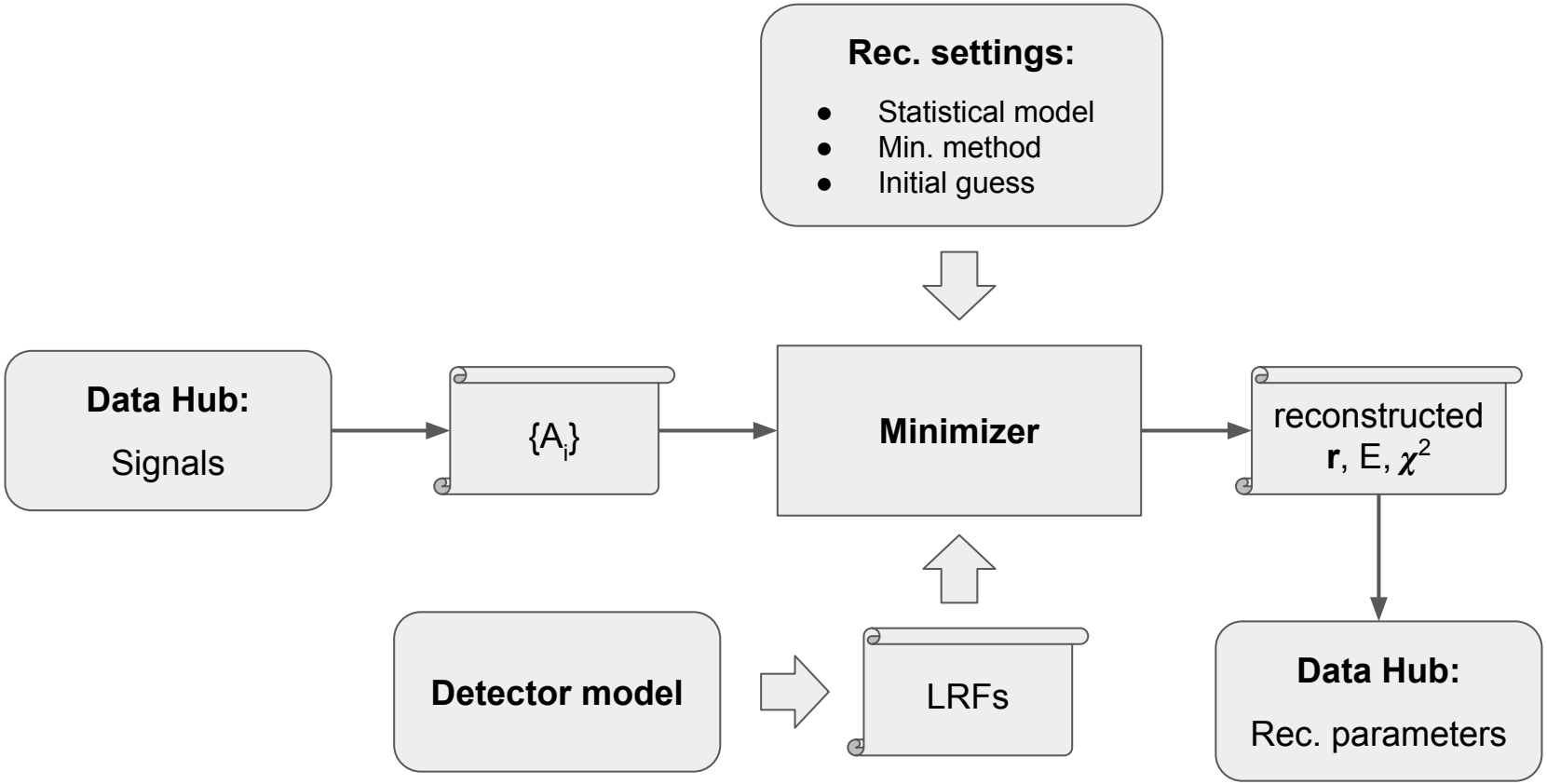
Detector model

event
(x, y, N)

$a_i = N\eta_i(x,y)$

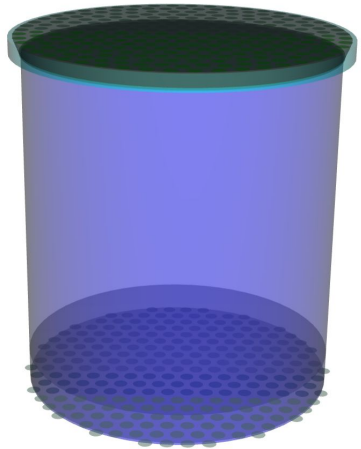
Expected
pattern
{a_i}

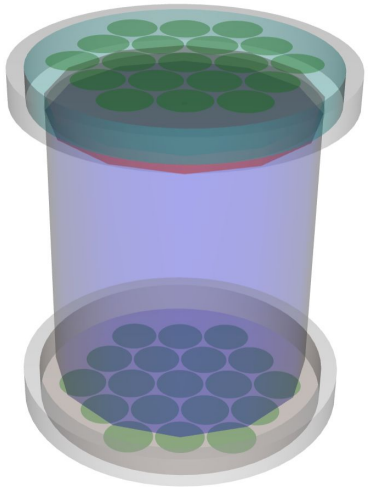
Reconstruction

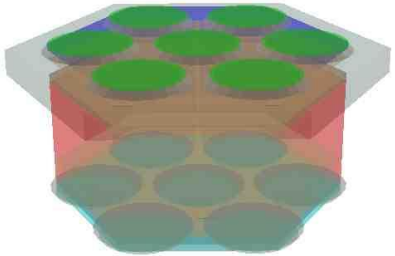


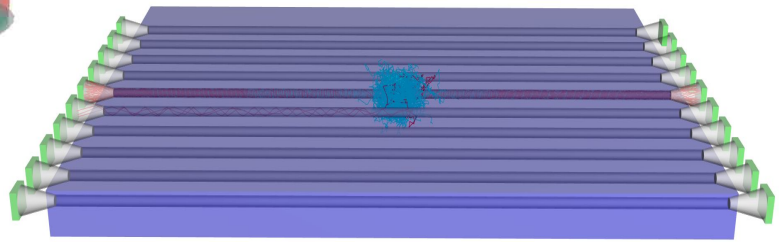
ANTS2: adoption

- LIP
  - Gamma cameras
  - Dark matter / 0νββ decay
  - Neutron detectors
  - Proton therapy
- Politecnico di Milano
  - MRI SPECT
  - 3D gamma detector
- University of Berkeley
  - Liquid xenon detectors
- MEPhI (Moscow)
  - Neutriono detectors
- FZ Julich
  - Neutron Anger camera
- RAL
  - ISIS neutron source









Thank you!