PMT Signal Simulation

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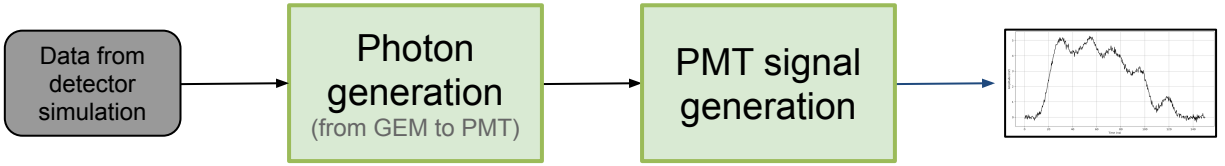
CYGNO Collaboration Meeting 2022

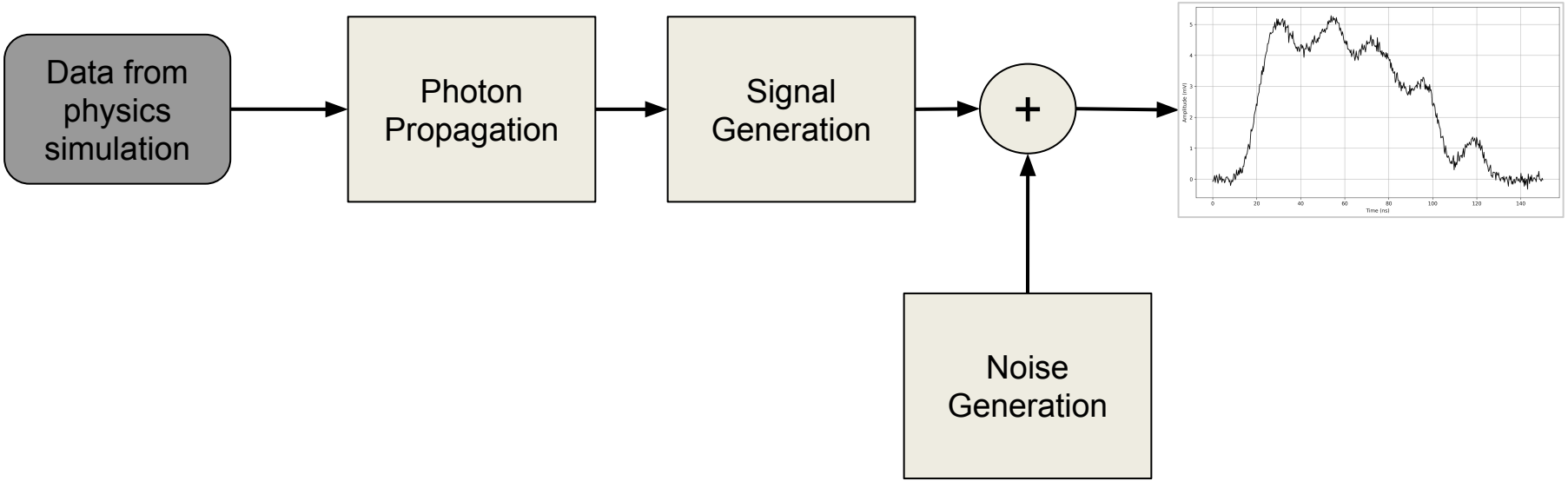
Summary



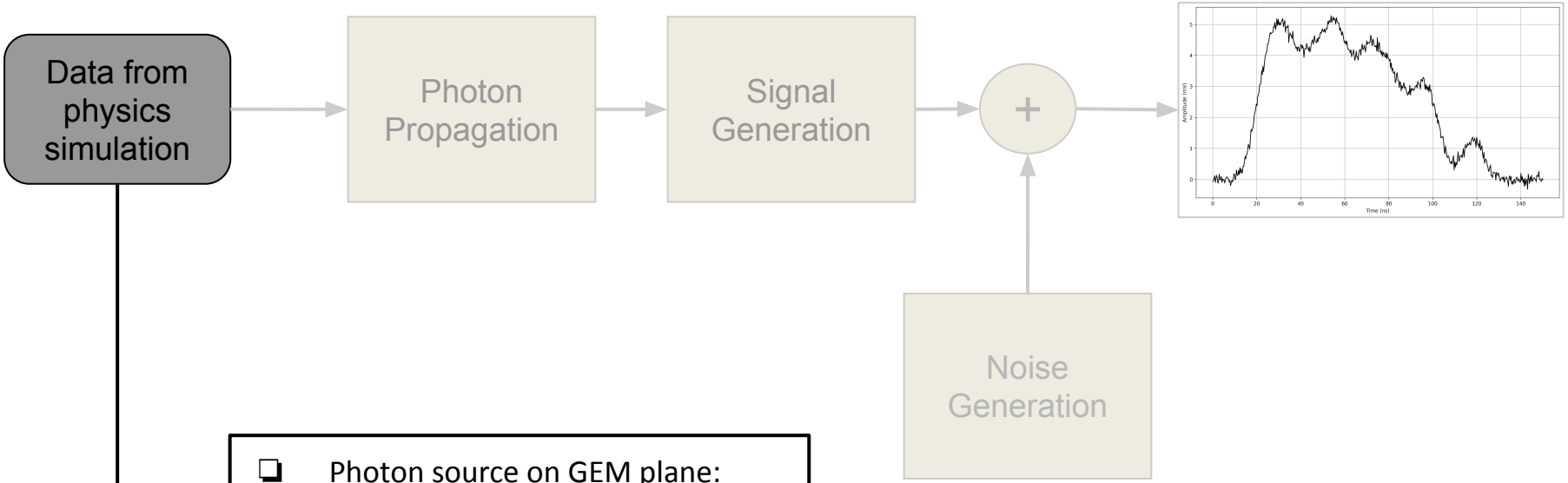
- PMT Signal Simulation
  - General Description
  - Preliminary Tests
  - Status and Next Steps

General Description

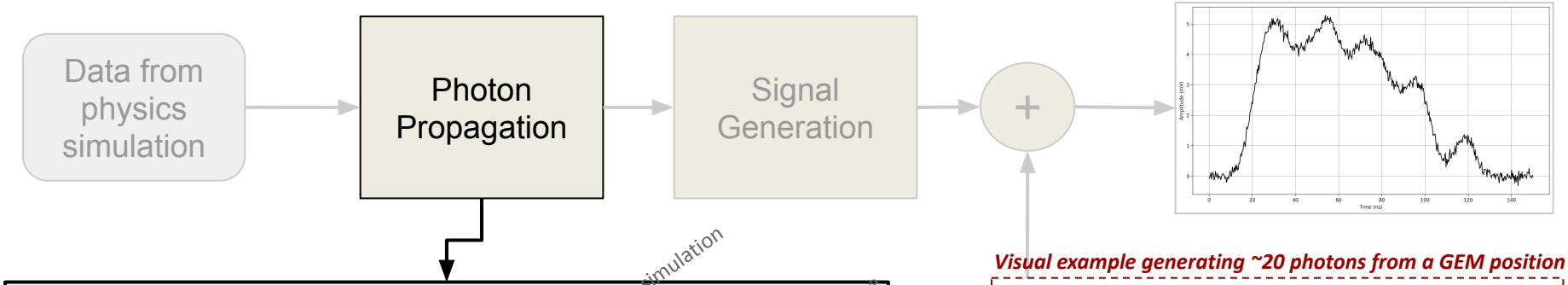
Simulation block diagram



Simulation block diagram



Simulation block diagram



- Equation of a line in the space:

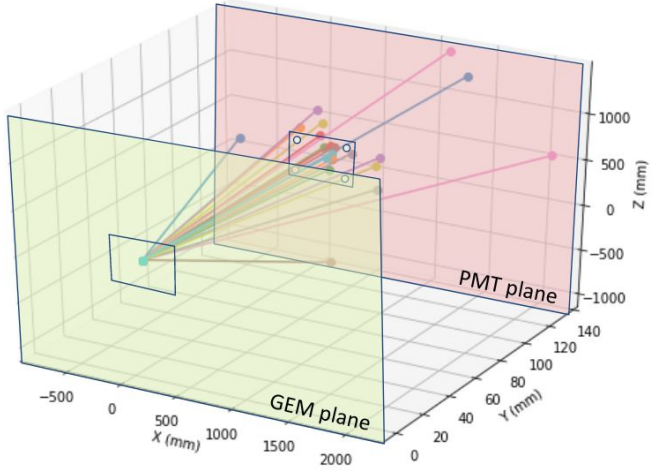
$$(x, y, z) = (x_0, y_0, z_0) + t(v_x, v_y, v_z)$$

from detector simulation

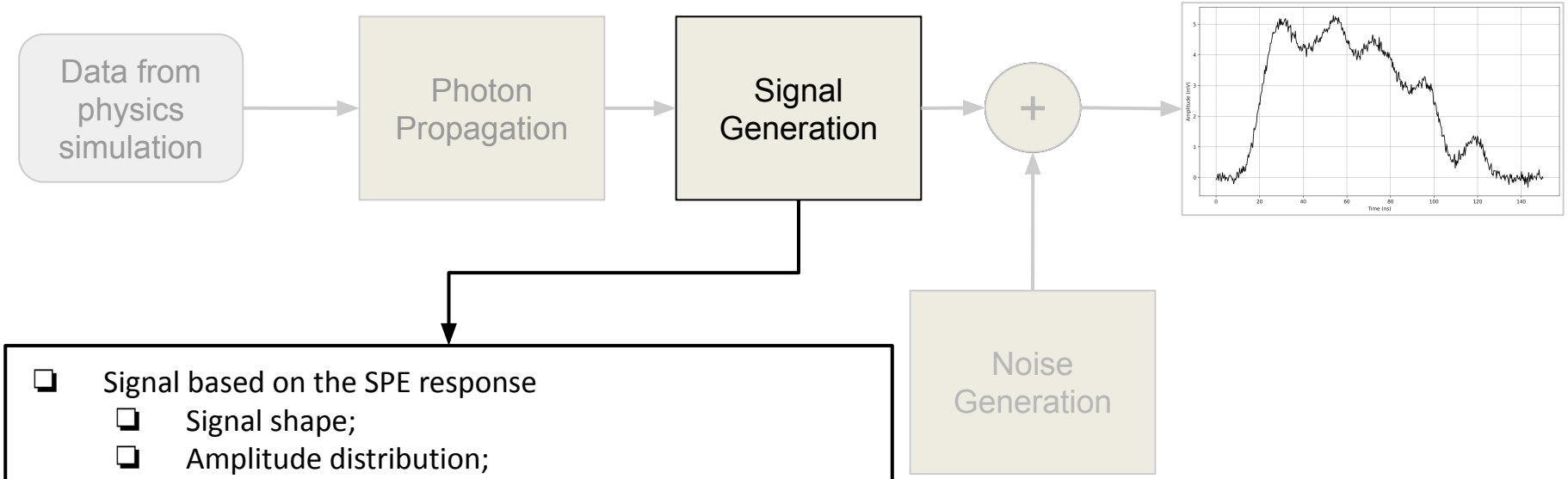
isotropic source

- x_0, y_0 and z_0 = photon initial position (GEM plane)
- t is a scalar parameter;
- v is the vector that describes the direction of the photon;
  - generated with a uniform spherical distribution (isotropic source).

Visual example generating ~20 photons from a GEM position

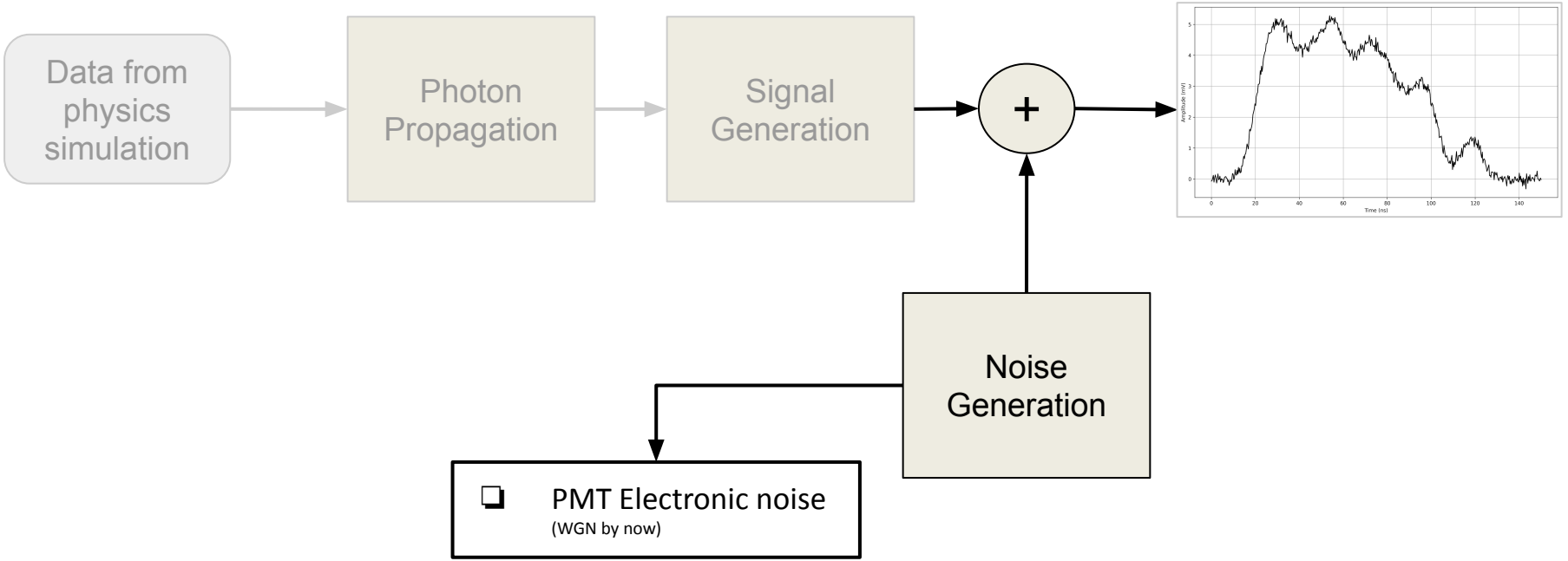


Simulation block diagram

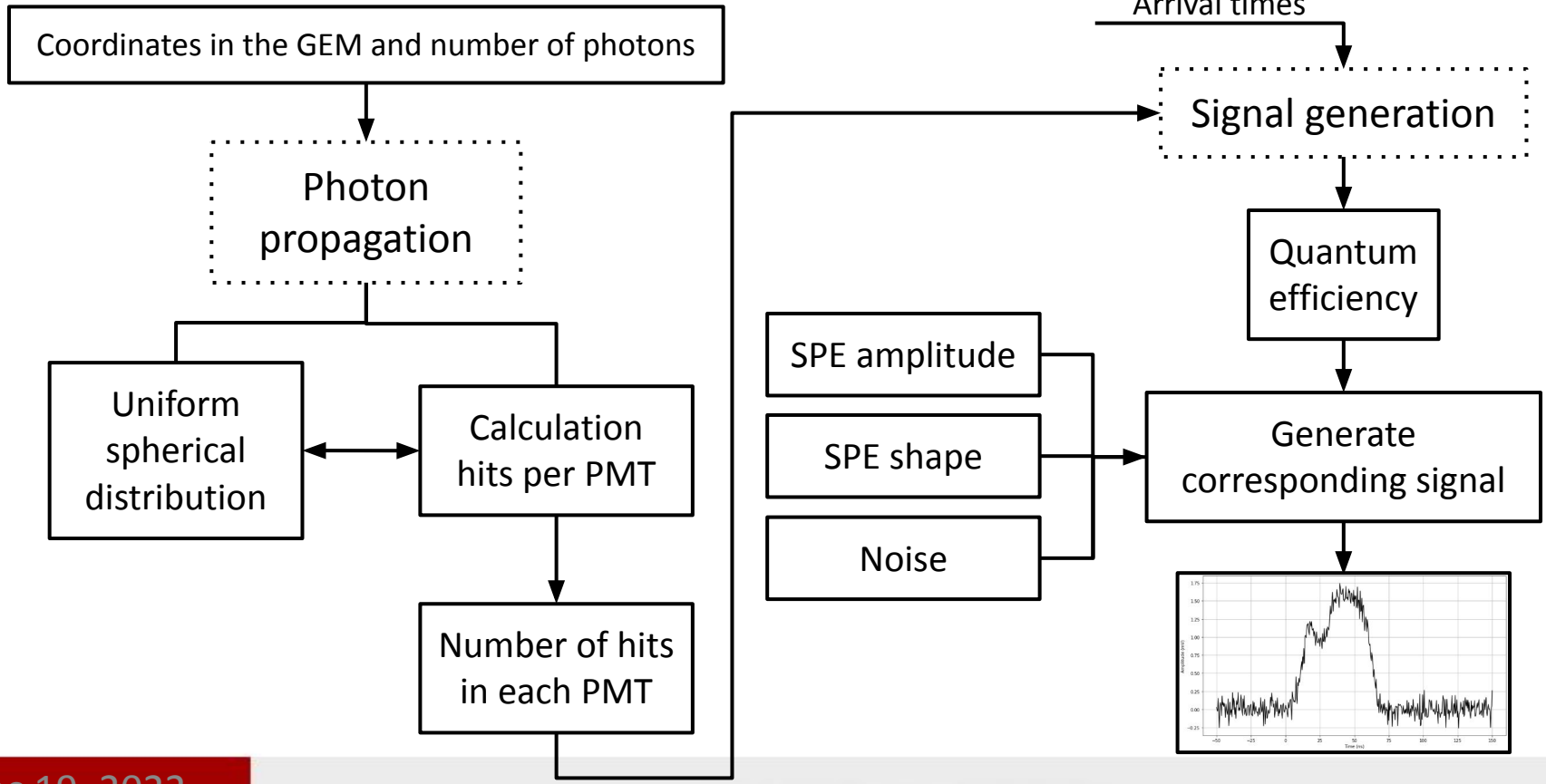


- Signal based on the SPE response
  - Signal shape;
  - Amplitude distribution;
- Quantum efficiency and other PMT characteristics (dark current, after pulse, response time, etc)

Simulation block diagram

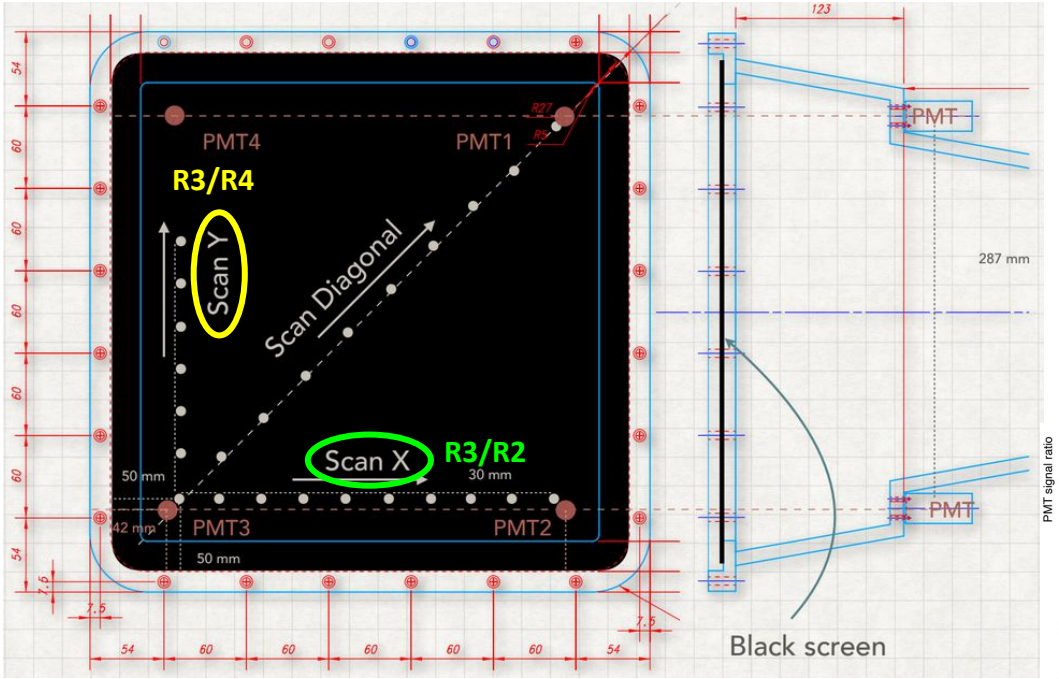


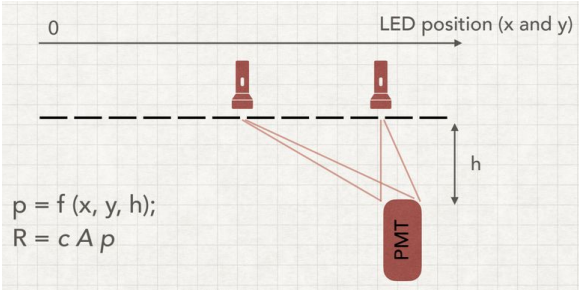
Modular implementation



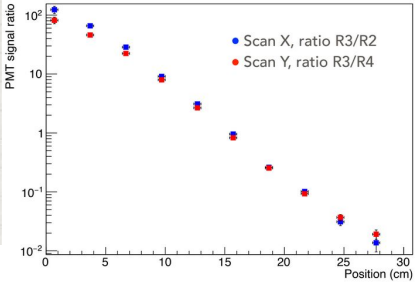
Preliminary Tests

Preliminary tests

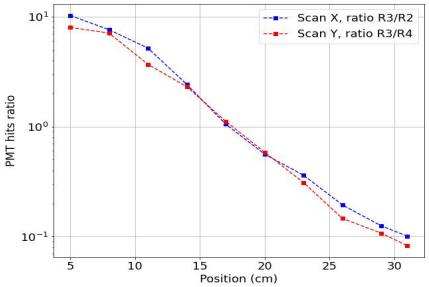




REAL DATA

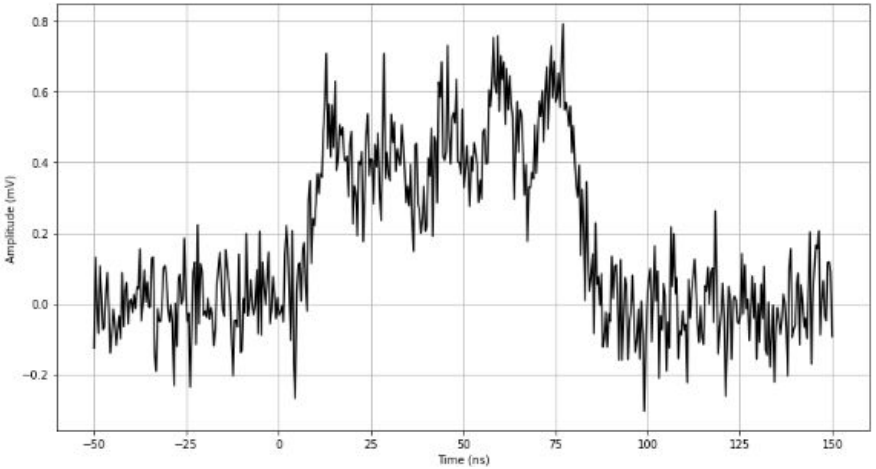


SIMULATION



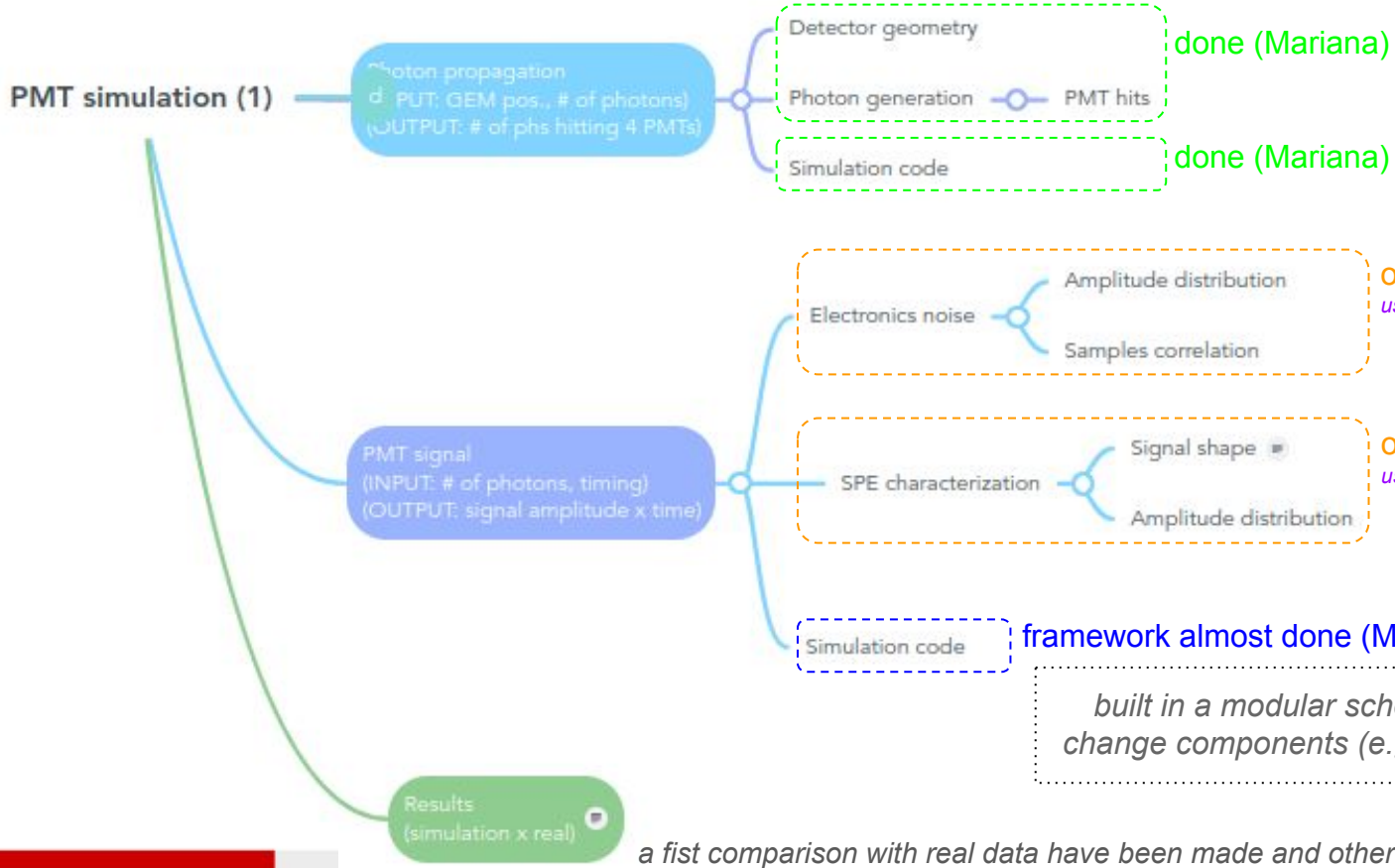
Preliminary tests

- Internal signal generation code testing:
  - 5 photons hitting one PMT were simulated with a difference of 15 ns between them:



Status and Next Steps

Status - *first version to be delivery soon*



built in a modular scheme to make it easy to change components (e.g. noise part, shape, etc)

a fist comparison with real data have been made and other tests are planned

Next steps

- Generate an estimation of the PMT SPE response and noise;
- Investigate for other PMT characteristics that might be important for the simulation to improve its signal generation algorithm;
- Validation of the real and simulated results;
- Make it available for the Collaboration

Thank you!

Preliminary tests

- To test the photon propagation module, three light sources were created in different positions of the GEM;
- Each of them generated 20k photons;
- The algorithm returns how photons hit each PMT, as we can see below:

```
{'ptc_0': {'pmt1': 5, 'pmt2': 4, 'pmt3': 68, 'pmt4': 8},
 'ptc_1': {'pmt1': 4, 'pmt2': 14, 'pmt3': 26, 'pmt4': 8},
 'ptc_2': {'pmt1': 8, 'pmt2': 12, 'pmt3': 14, 'pmt4': 13}}
```