DEPARTMENT OF
PHYSICS

UNIVERSITY OF OXFORD

A reciprocal look at air shower radio emissions

Philipp Windischhofer *(Oxford)*, Werner Riegler *(CERN)*
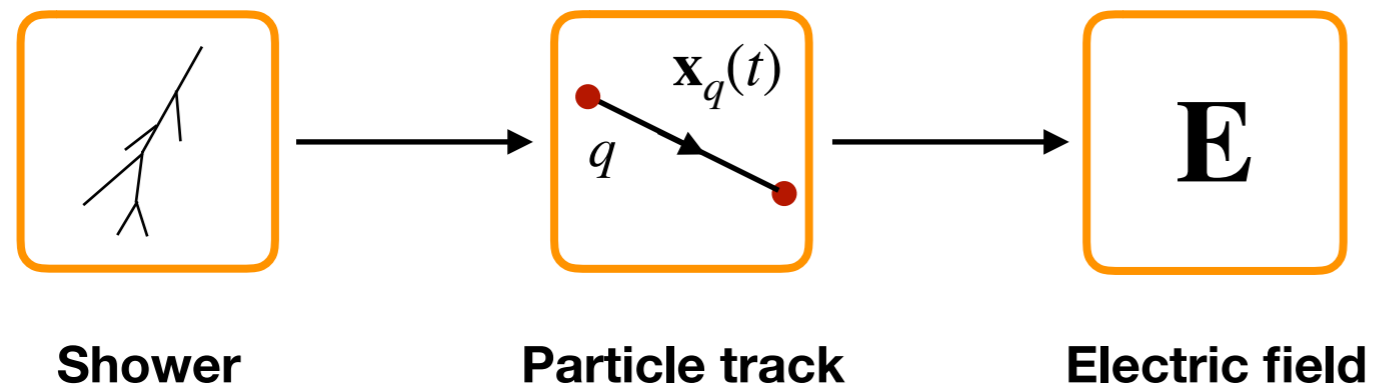
philipp.windischhofer@physics.ox.ac.uk

37th International Cosmic Ray Conference

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Radio signature: conventional simulation

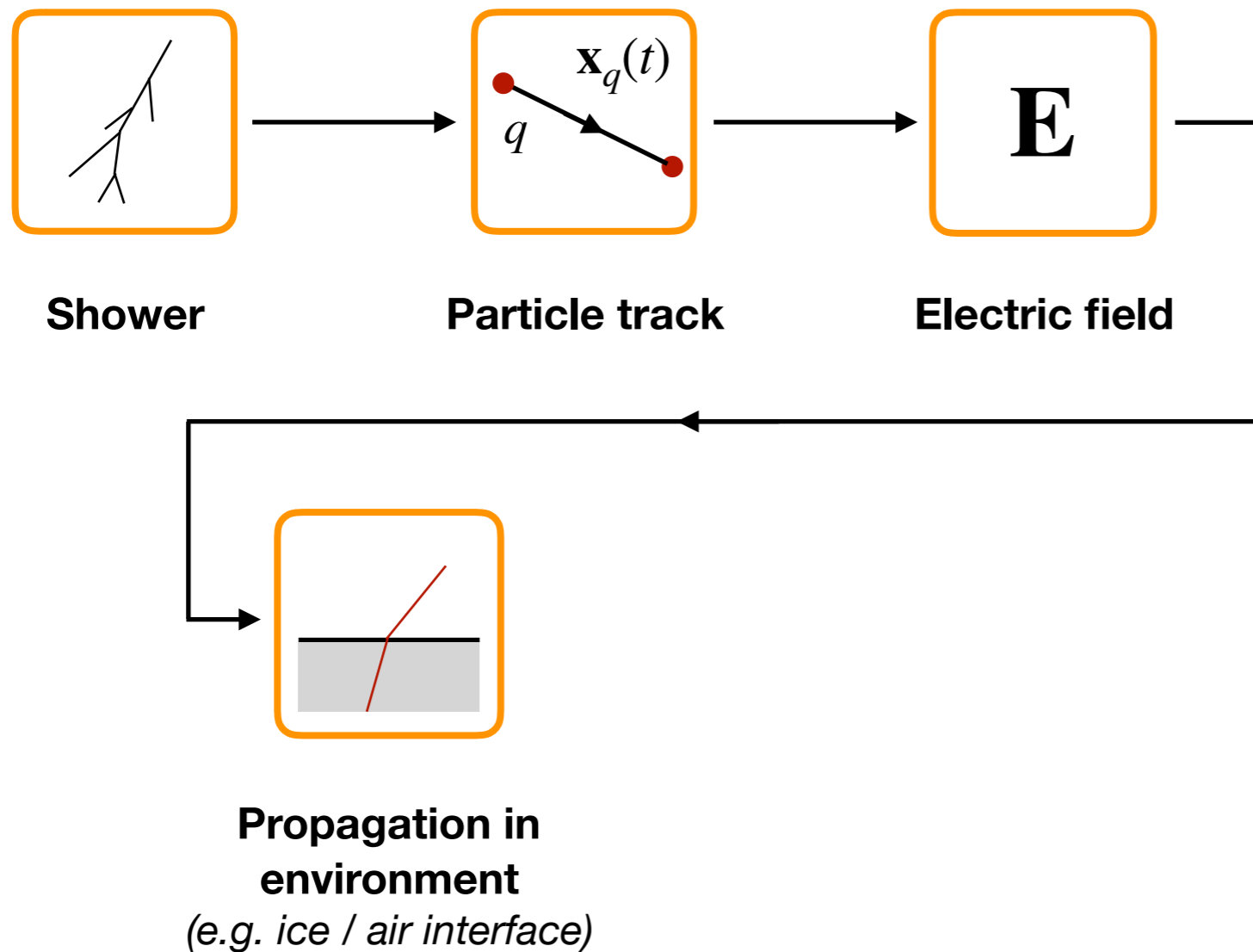**Simulating radio signature of atmospheric showers is important!**

E.g. CORSIKA + REAS:

Shower   **Particle track**   **Electric field**

Radio signature: conventional simulation

Simulating radio signature of atmospheric showers is important!

E.g. CORSIKA + REAS:

Shower

Particle track

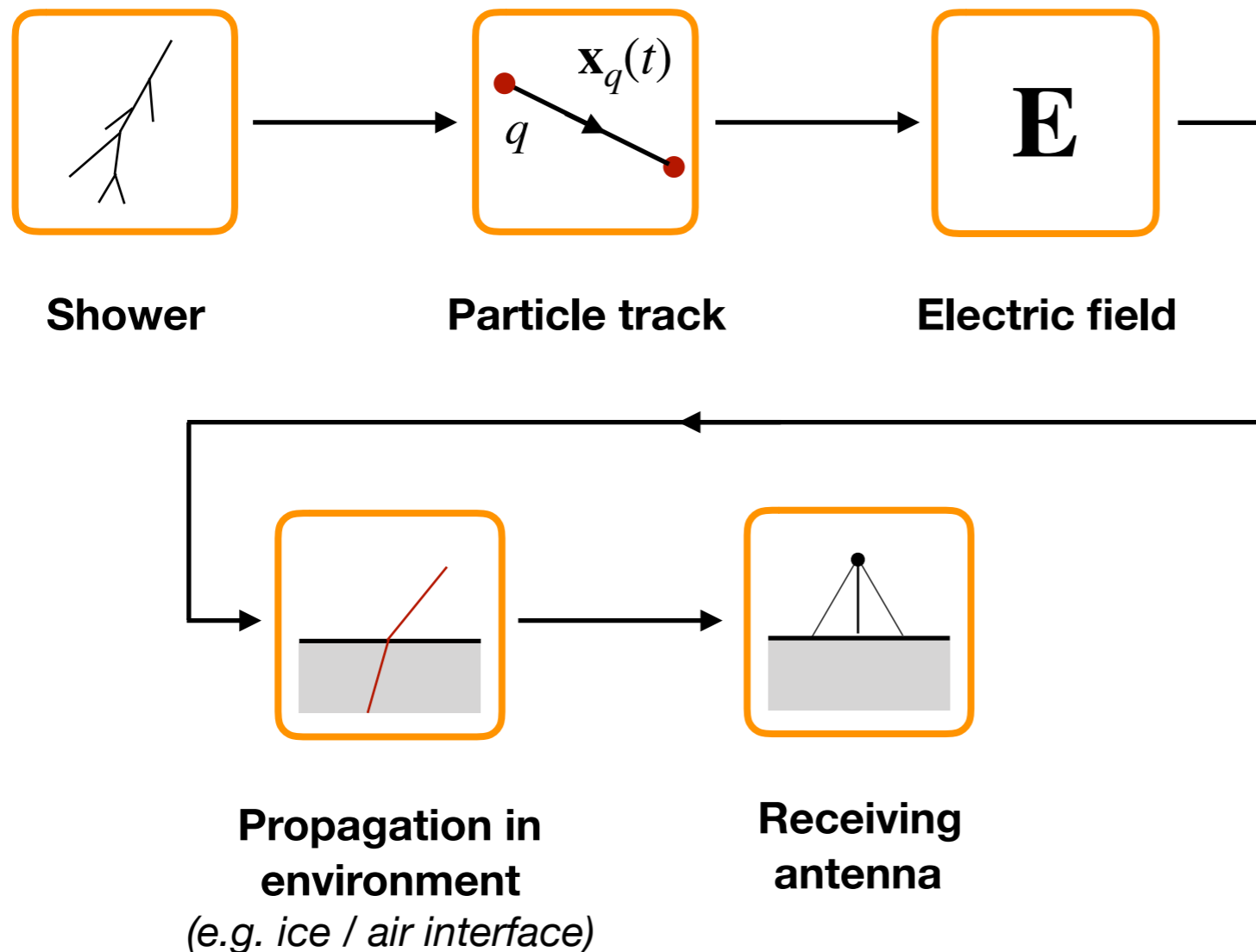**Electric field**

Propagation in environment
(e.g. ice / air interface)

Radio signature: conventional simulation

Simulating radio signature of atmospheric showers is important!

E.g. CORSIKA + REAS:

Shower

$\mathbf{x}_q(t)$

q

Particle track

$\mathbf{E}$

Electric field

Propagation in environment

(e.g. ice / air interface)

Receiving antenna

Simulating radio signature of atmospheric showers is important!

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Receiving antenna

Signal processing, linear filtering
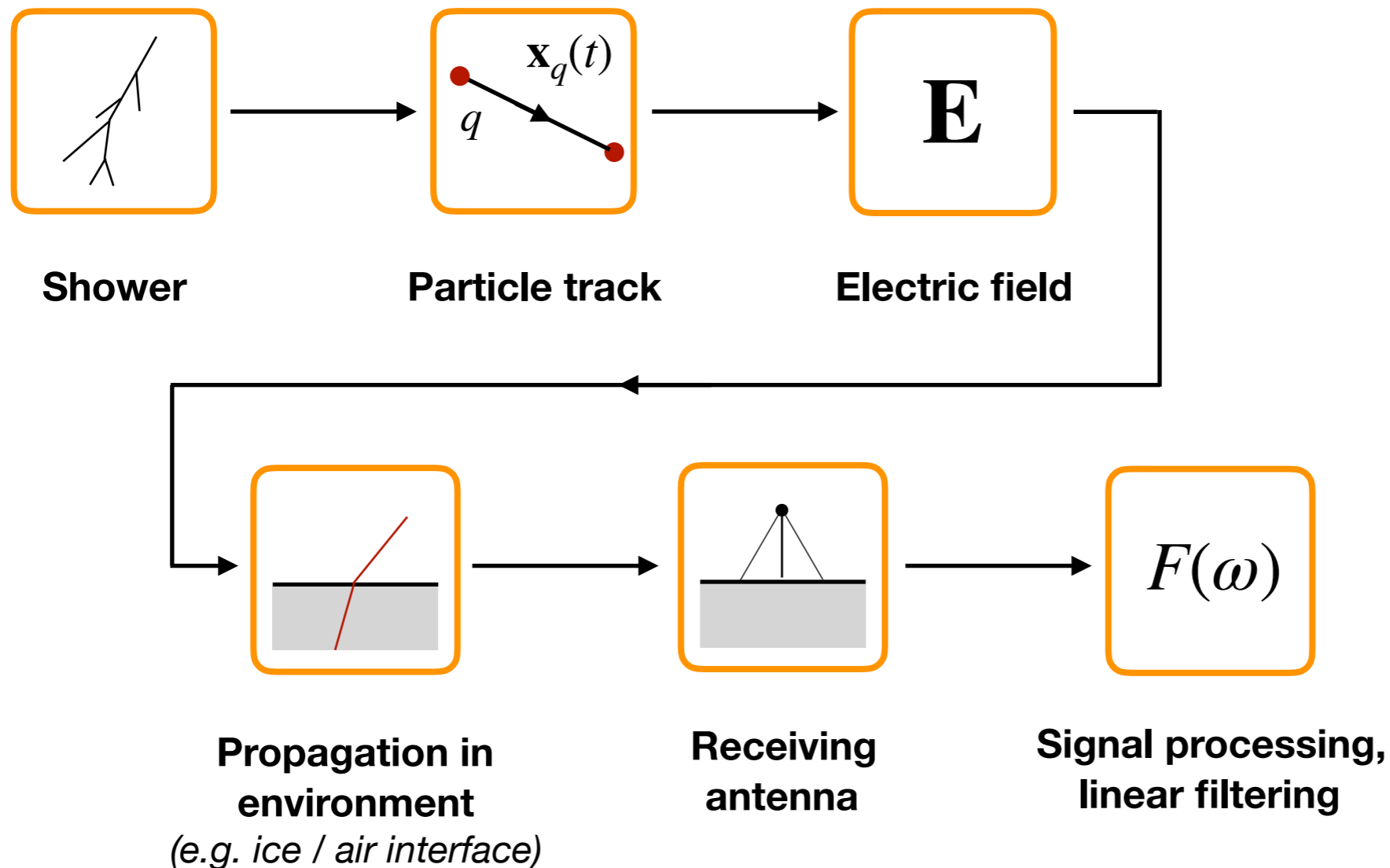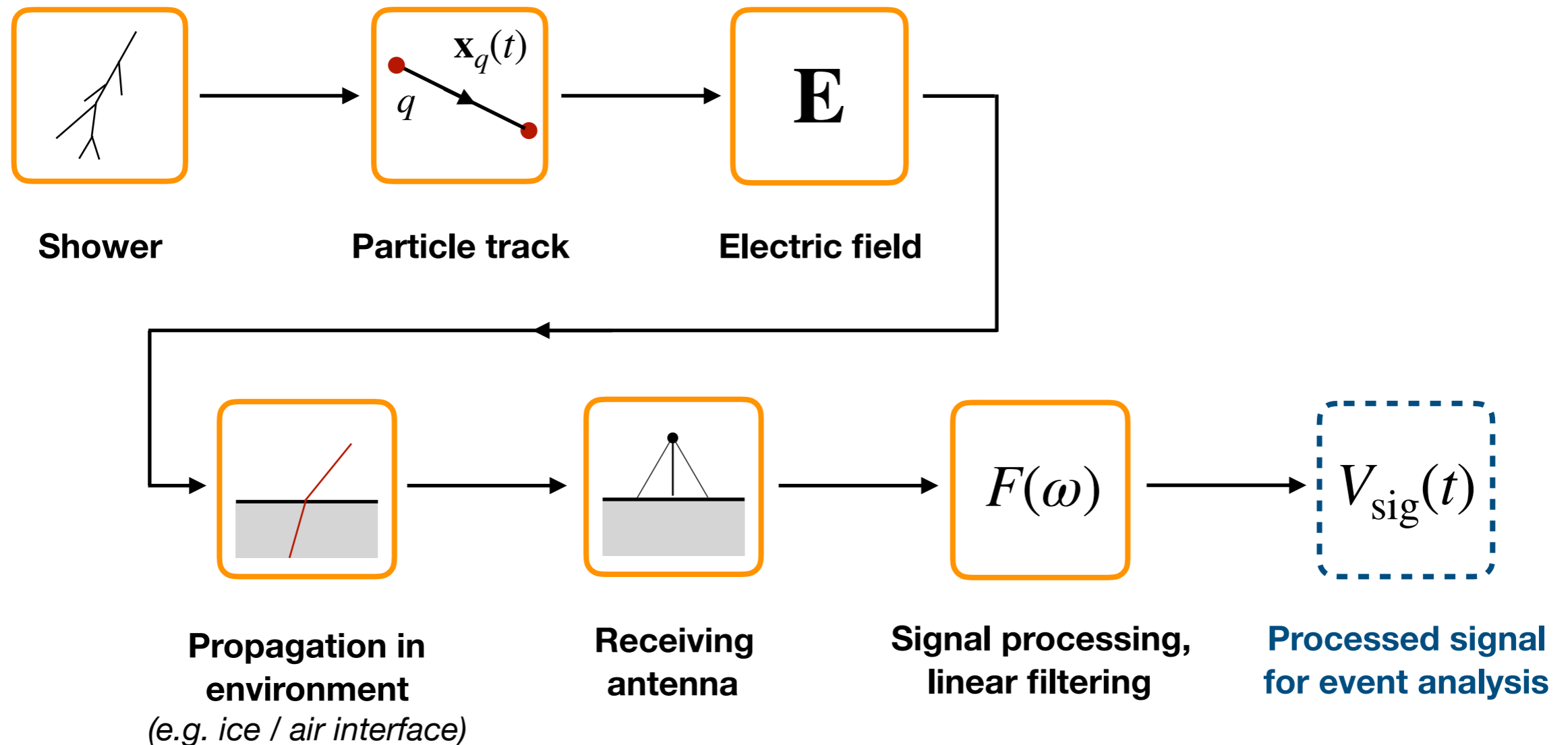
Radio signature: conventional simulation

Simulating radio signature of atmospheric showers is important!

E.g. CORSIKA + REAS:

"shower-centric"

Shower

$\mathbf{x}_q(t)$

q

Particle track

$\mathbf{E}$

Electric field

Propagation in environment
(e.g. ice / air interface)

Receiving antenna

$F(\omega)$

Signal processing, linear filtering

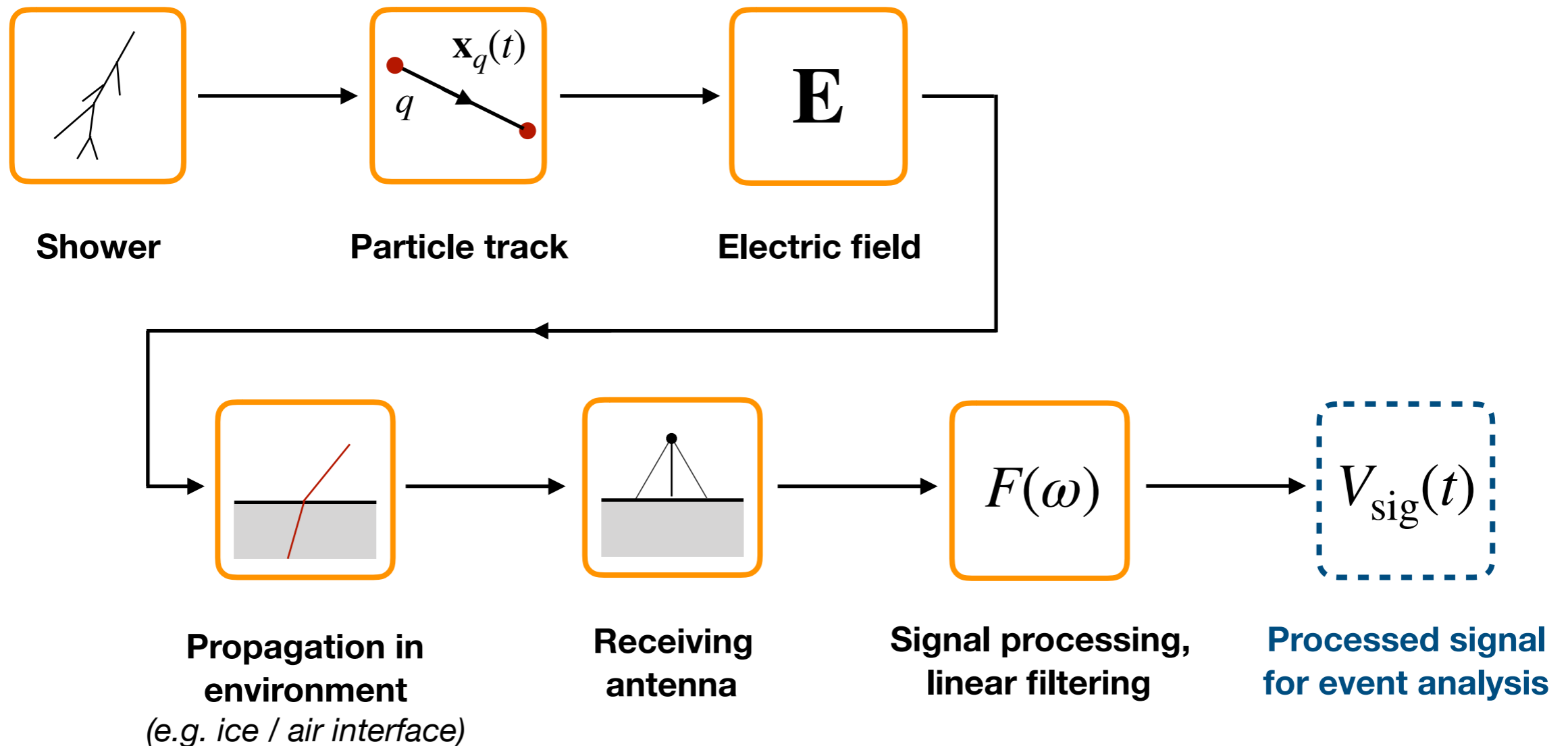$V_{\mathrm{sig}}(t)$

Processed signal for event analysis

Radio signature: conventional simulation

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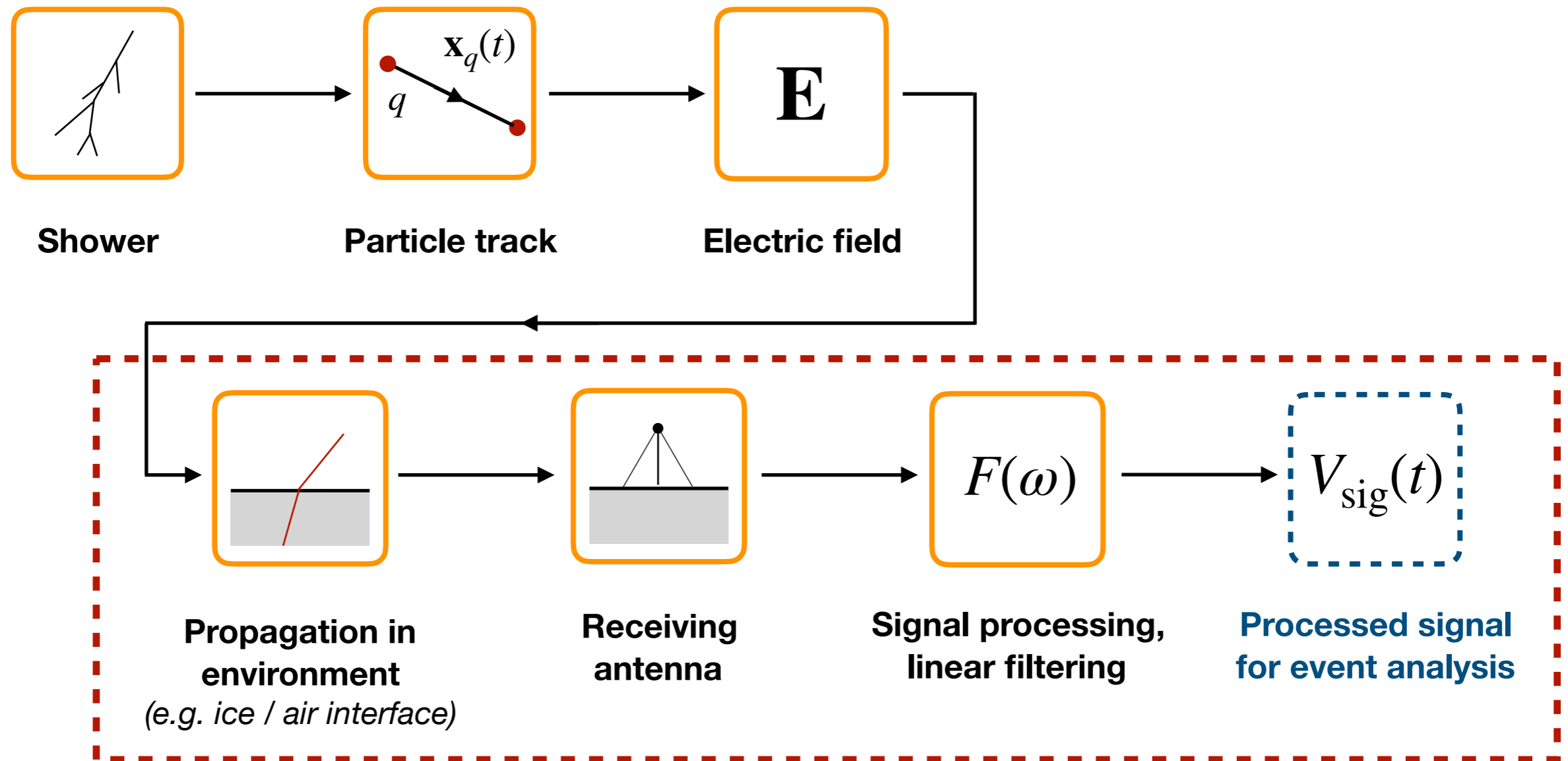
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"shower-centric"

Shower **Particle track** **Electric field**

Propagation in environment
(e.g. ice / air interface)

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Inefficient: redo computations for each shower!

Reciprocity of electrodynamics:

Detector "feels" presence of shower in the same way
as shower "feels" presence of detector!

A reciprocal look at shower radio emissions

Reciprocity of electrodynamics:

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"detector-centric"

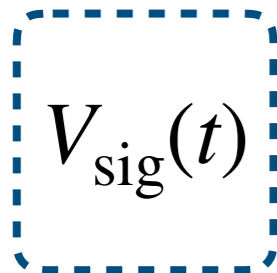# A reciprocal look at shower radio emissions

Reciprocity of electrodynamics:

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as shower "feels" presence of detector!

"detector-centric"

$$V_{\mathrm{sig}}(t) = -q \int_{-\infty}^{\infty} dt' \; \mathbf{K}_w(\mathbf{x}_q(t'), t - t') \cdot \dot{\mathbf{x}}_q(t')$$

Particle trajectories
in shower

$$V_{\mathrm{sig}}(t)$$

**Processed signal
for event analysis**

Shower

A reciprocal look at shower radio emissions

Reciprocity of electrodynamics:

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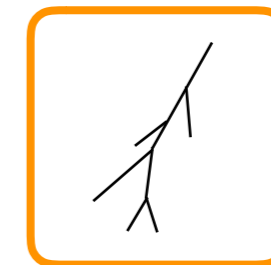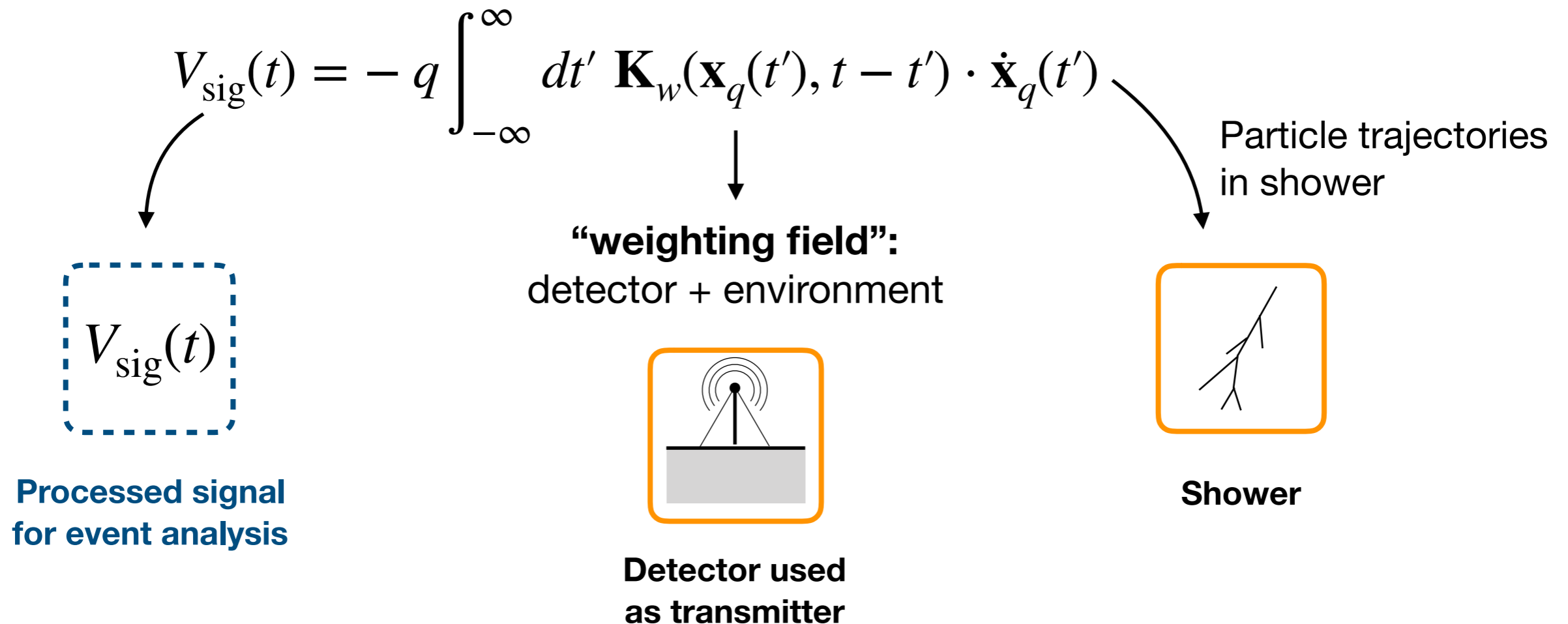**as shower "feels" presence of detector!**

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"weighting field":
detector + environment

$V_{\text{sig}}(t)$

**Processed signal
for event analysis**

**Detector used
as transmitter**

Shower

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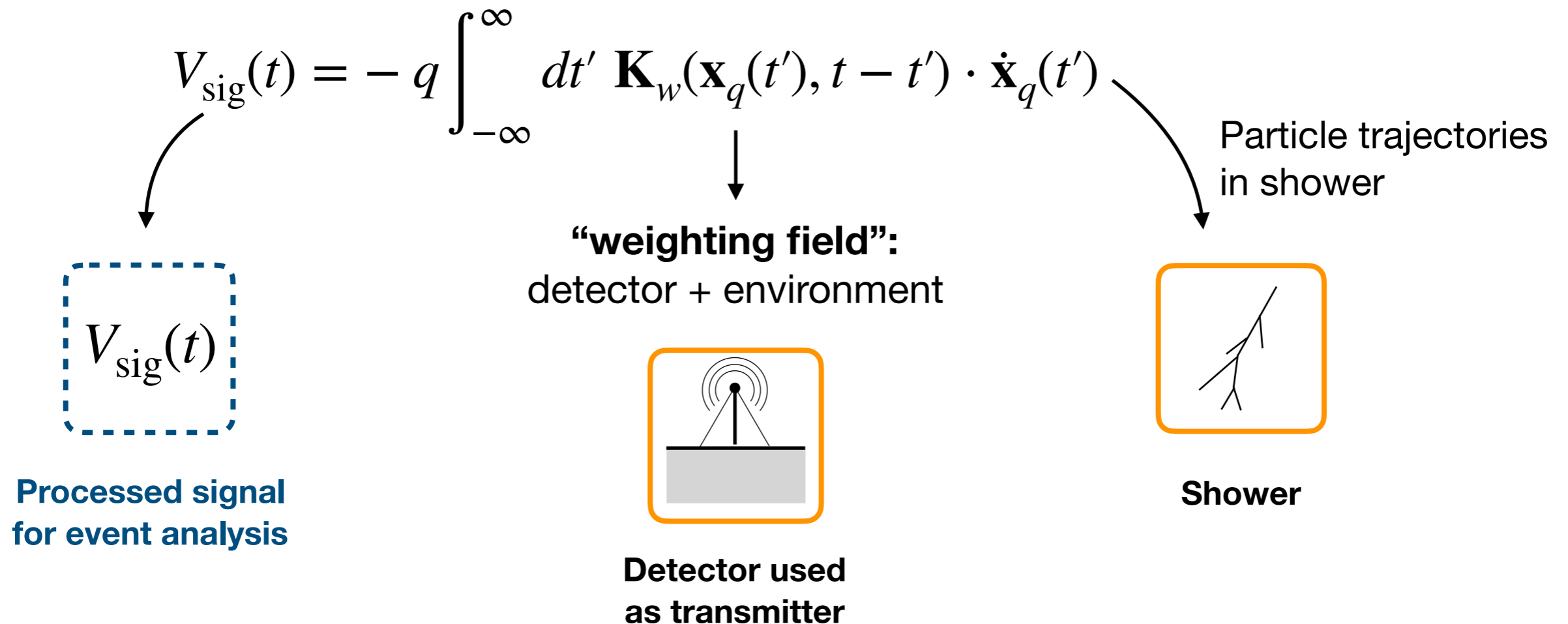**as shower "feels" presence of detector!**

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**Processed signal
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Shower

Weighting field precomputed and stored; simulator only performs convolution

Questions?

See you in the discussion session on

Wednesday 21 July 2021 @ 12:00 CEST