

GAZELLE.

GAZELLE (GAZELLE is the Approximately Zero-background Experiment for Long-Lived Exotics)

Torben Ferber (torben.ferber@desy.de)
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S. Dreyer,¹ T. Ferber,^{1,*} A. Filimonova,² C. Hearty,^{3,4} S. Longo,¹
R. Schäfer,⁵ M. Tammaro,^{6,7} K. Trabelsi,⁸ S. Westhoff,^{5,*} and J. Zupan⁶

¹*Deutsches Elektronen-Synchrotron, 22607 Hamburg, Germany*

²*NIKHEF, NL-1098 XG Amsterdam, The Netherlands*

³*Department of Physics and Astronomy, University of British Columbia, Vancouver, British Columbia V6T 1Z1, Canada*

⁴*Institute of Particle Physics (Canada), Victoria, British Columbia V8W 2Y2, Canada*

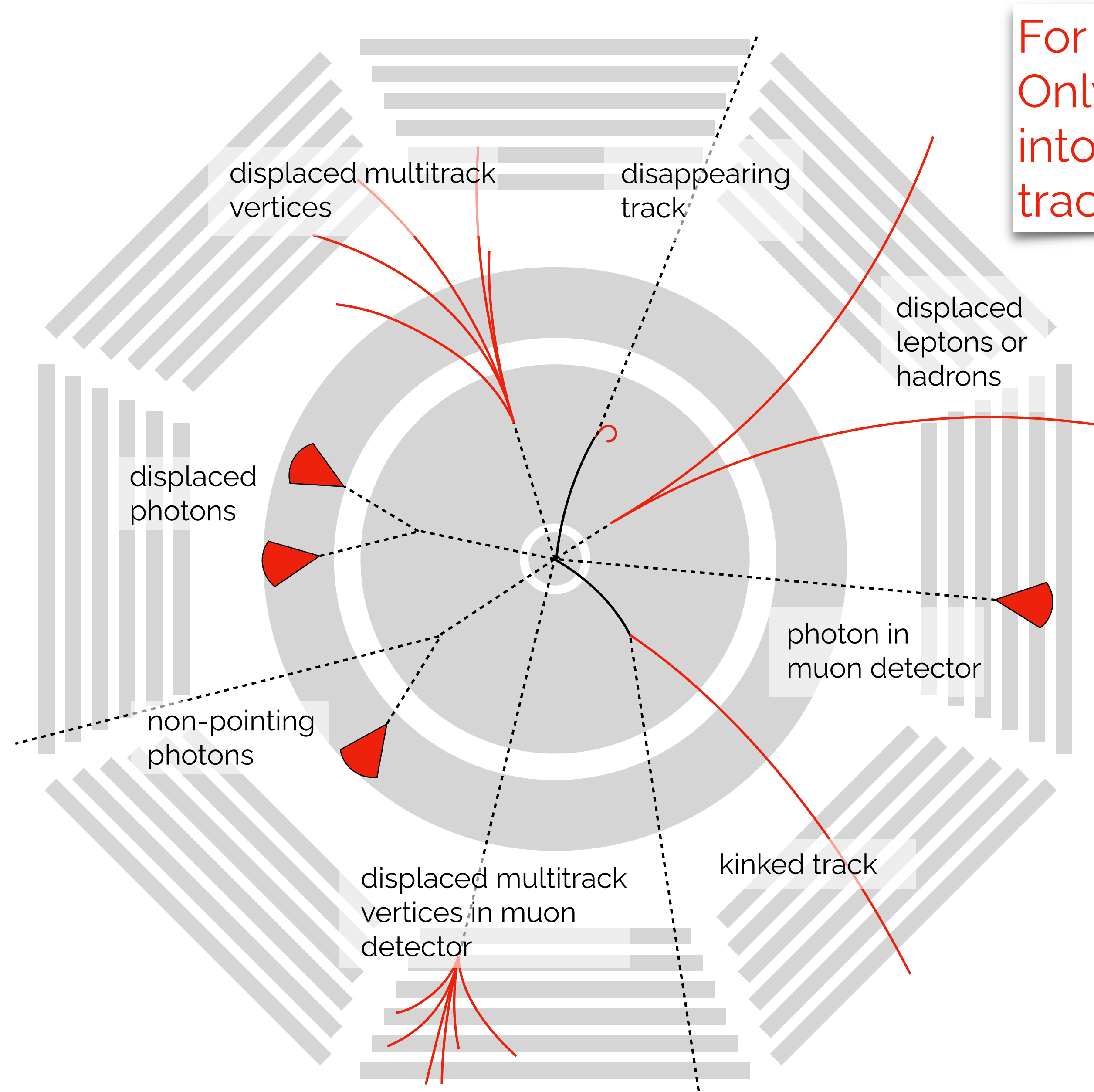
⁵*Institute for Theoretical Physics, Heidelberg University, 69120 Heidelberg, Germany*

⁶*Department of Physics, University of Cincinnati, Cincinnati, Ohio 45221, USA*

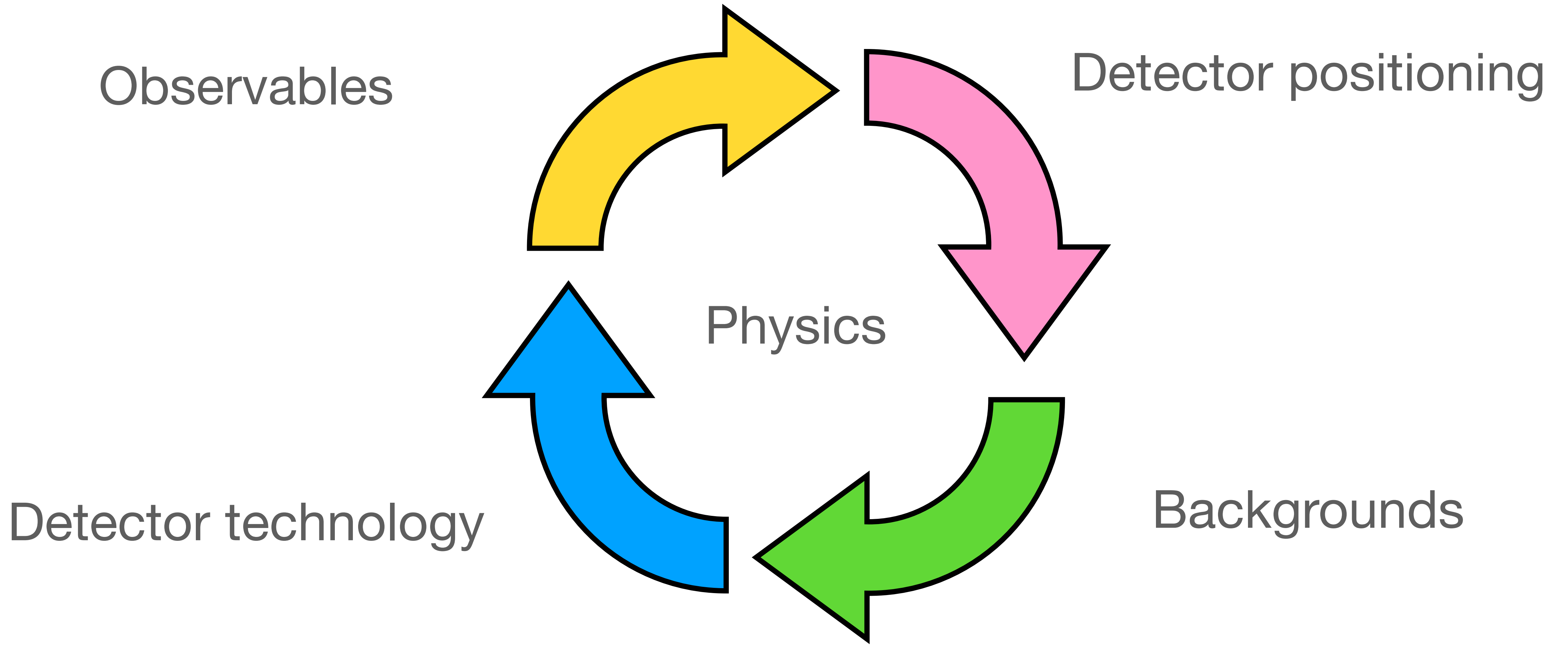
⁷*Jozef Stefan Institute, Jamova 39, Ljubljana, Slovenia*

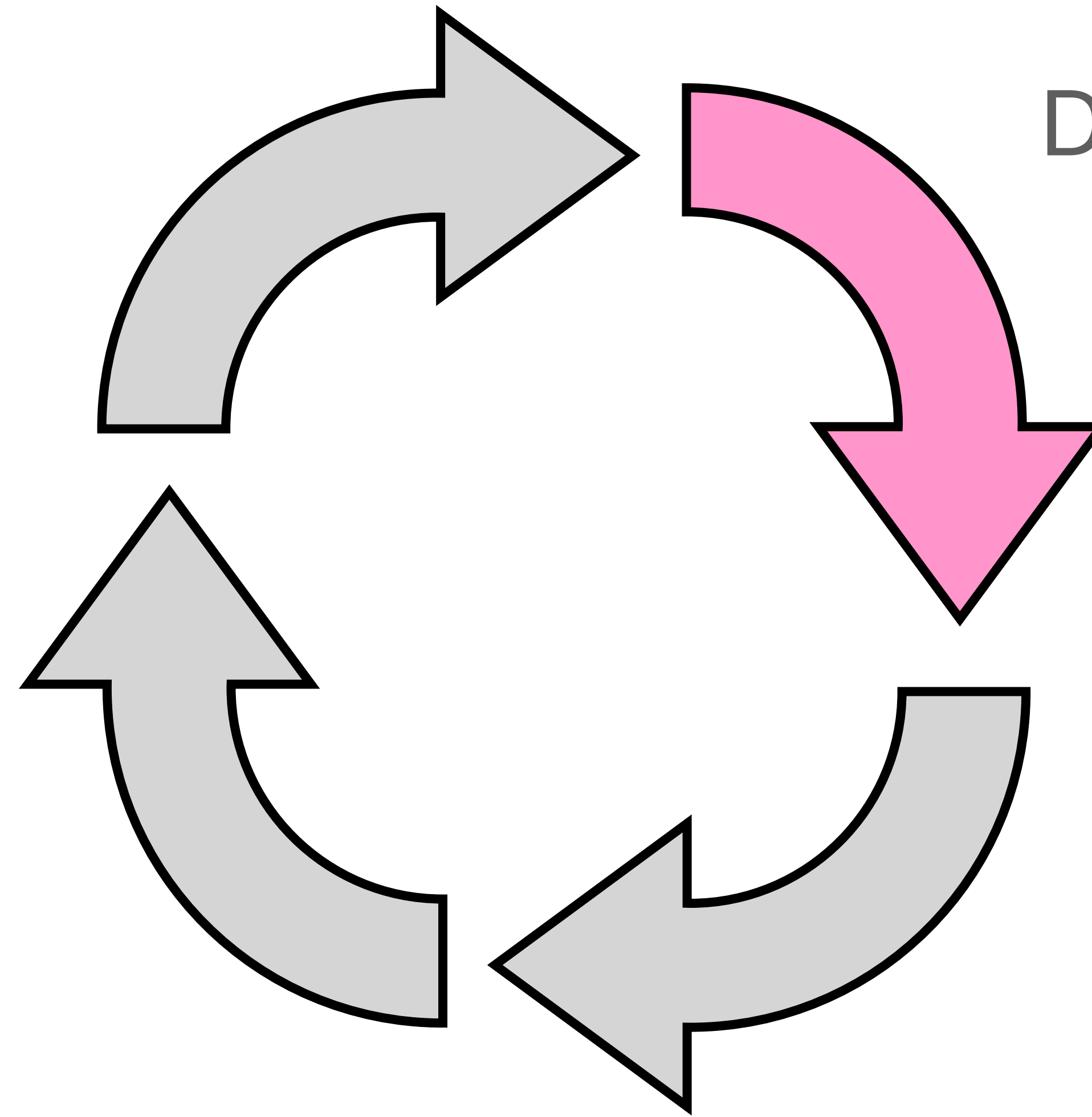
⁸*Université Paris-Saclay, CNRS/IN2P3, IJCLab, 91405 Orsay, France*

LLPs in Belle II



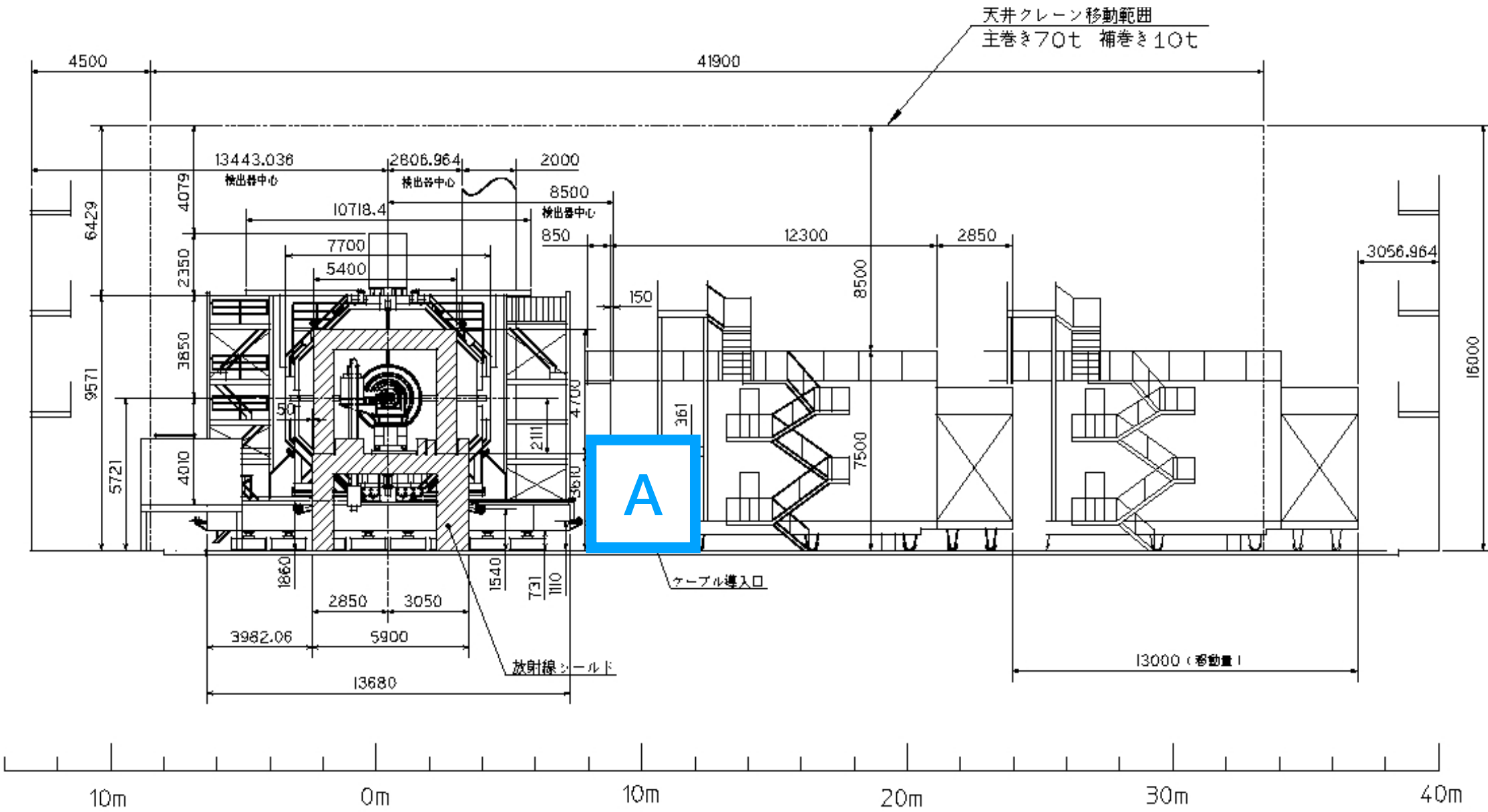
For the this talk:
Only LLPs decaying
into two charged
tracks ("Vos")





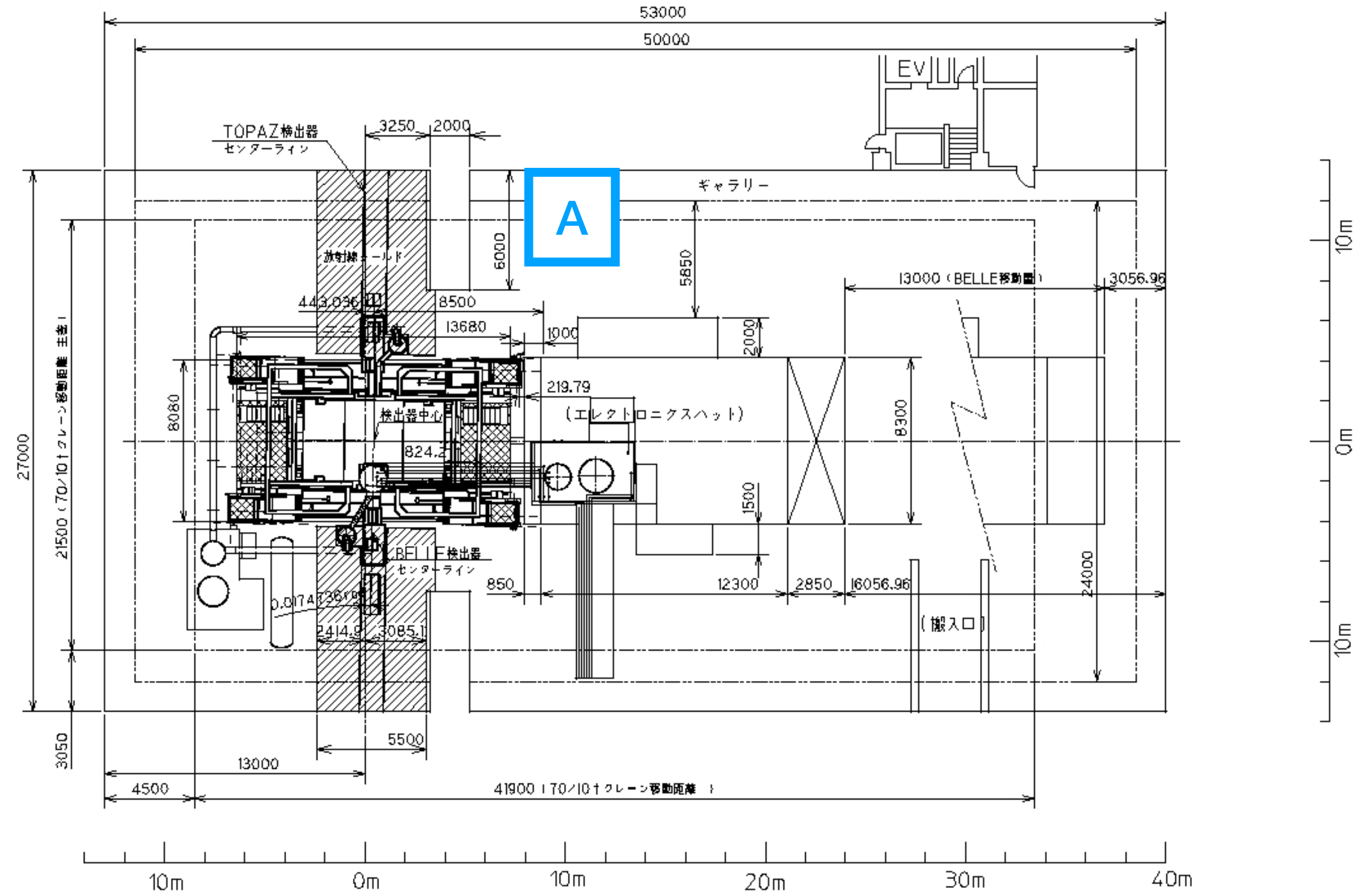
Detector positioning

Detector positions

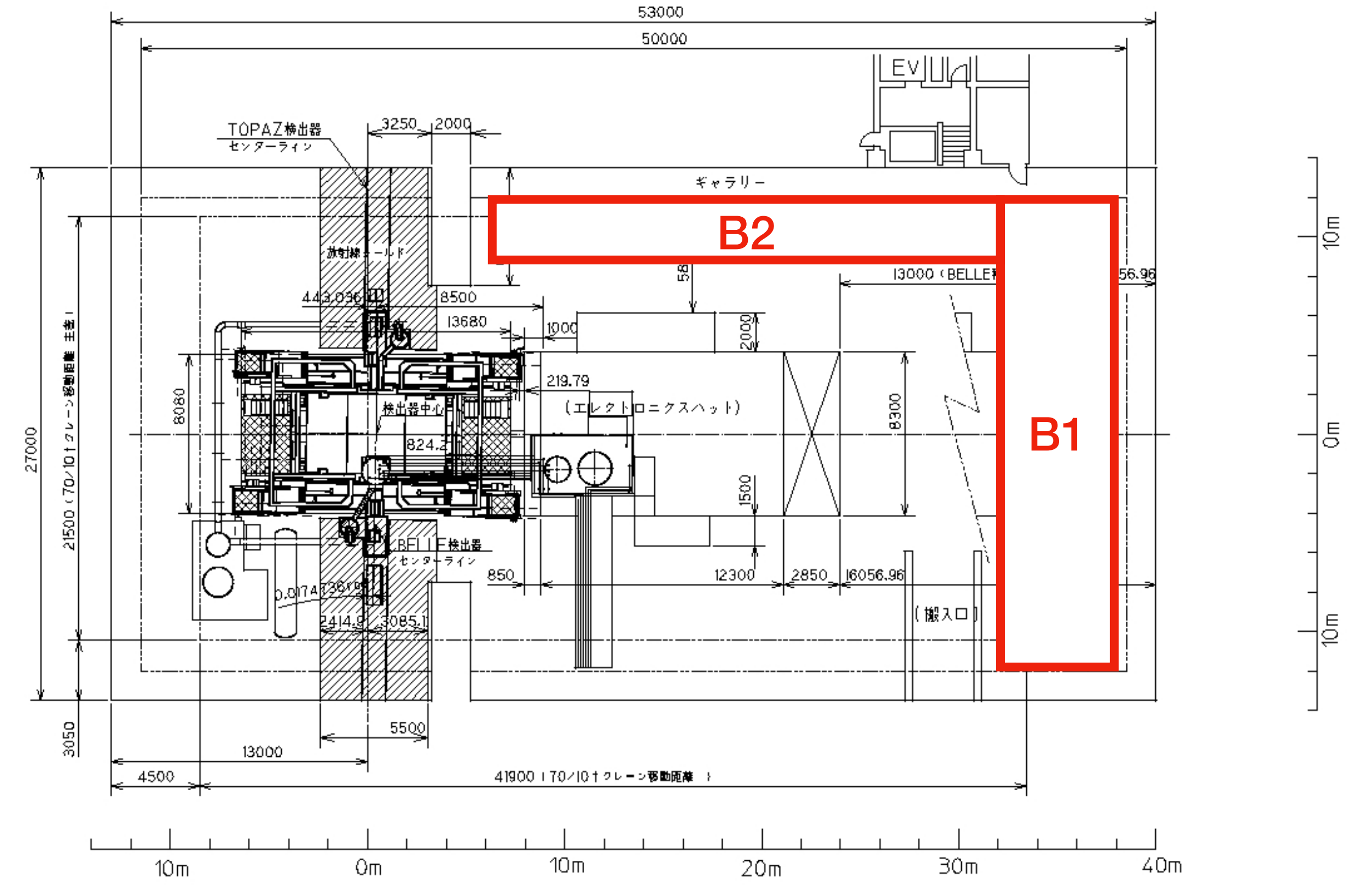
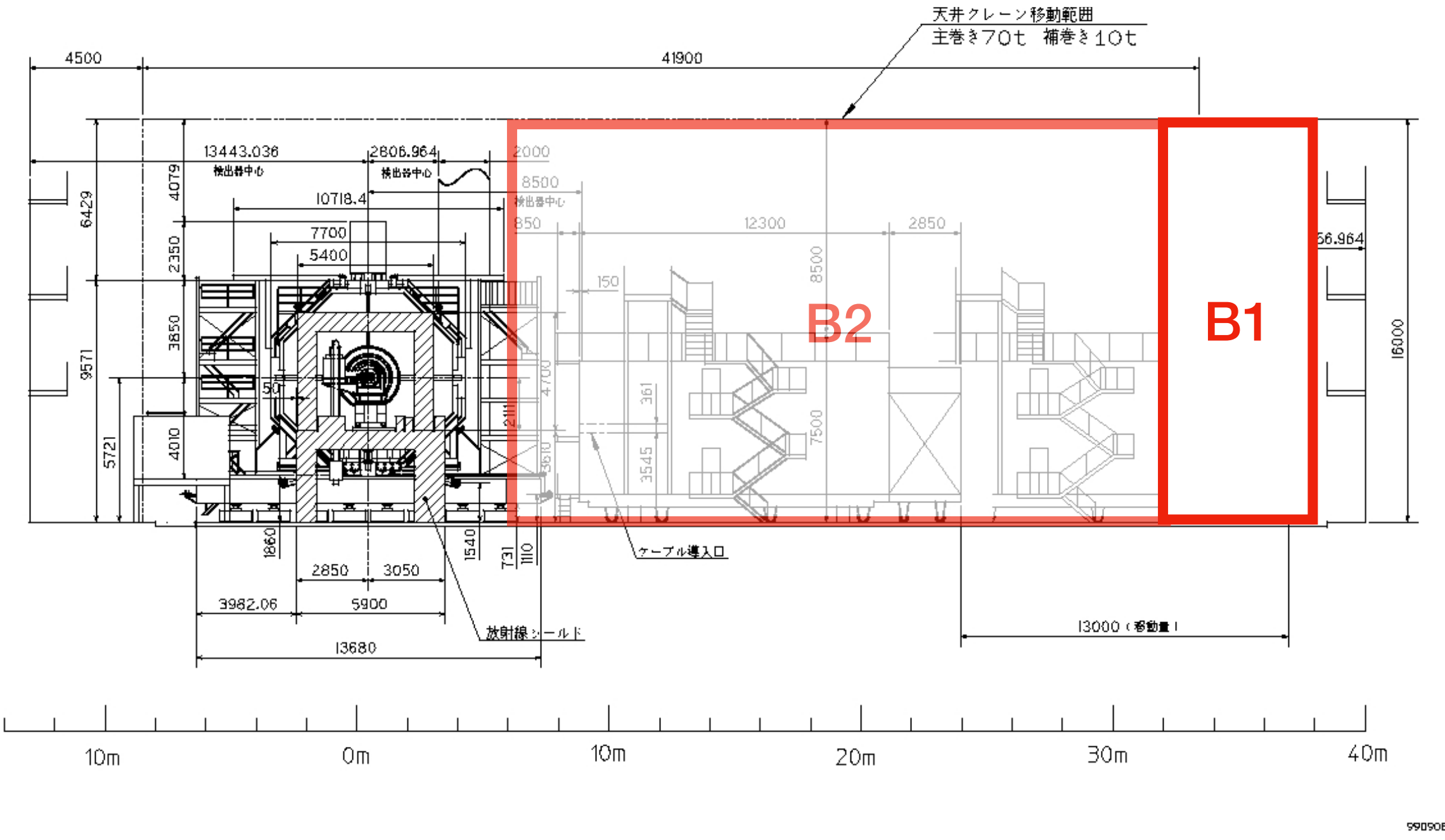


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babyGAZELLE
4x4x4m cube

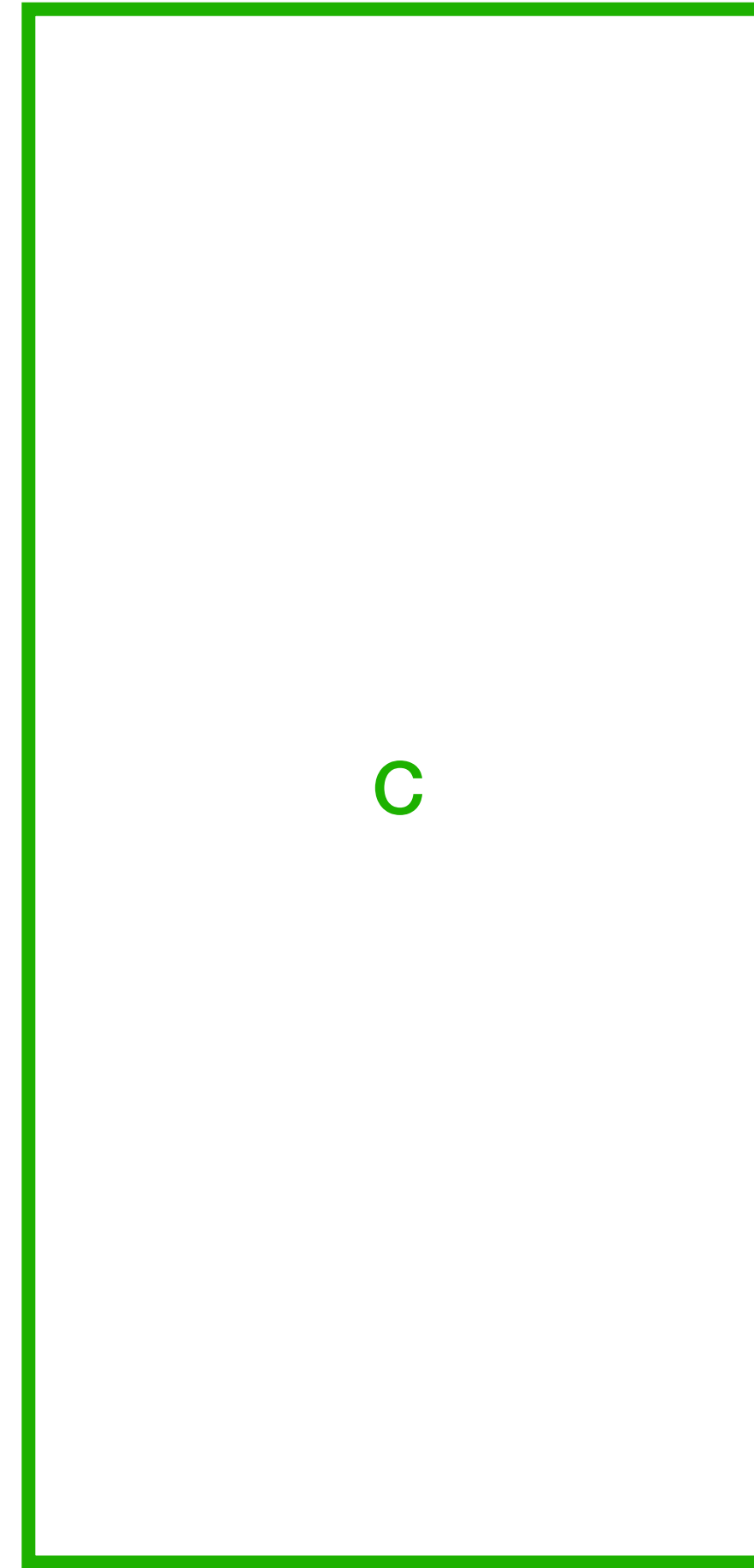


Detector positions

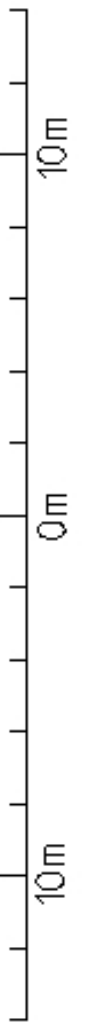
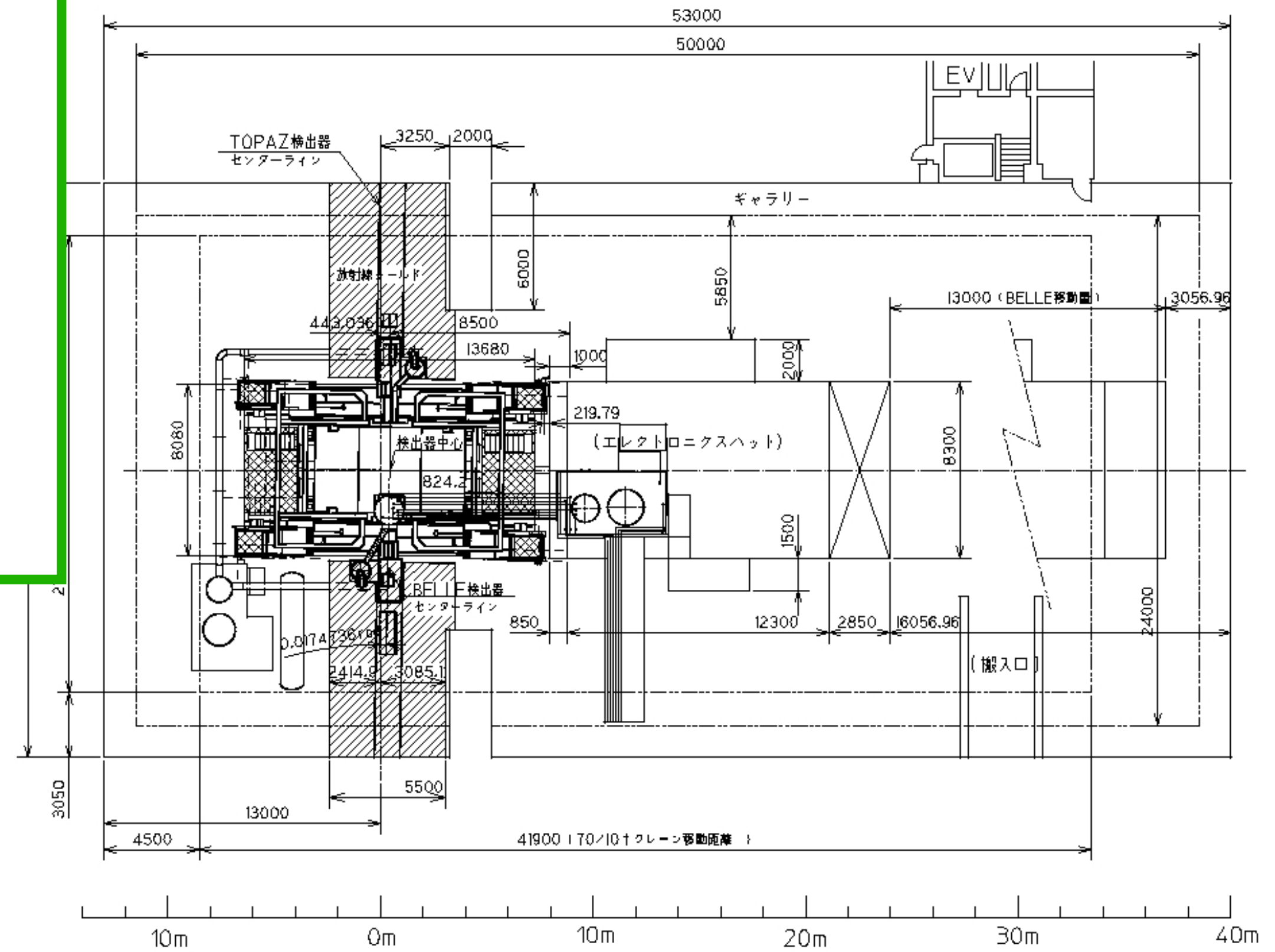


L-GAZELLE
B1: 6×16×24 m
B2: 26×16×3 m

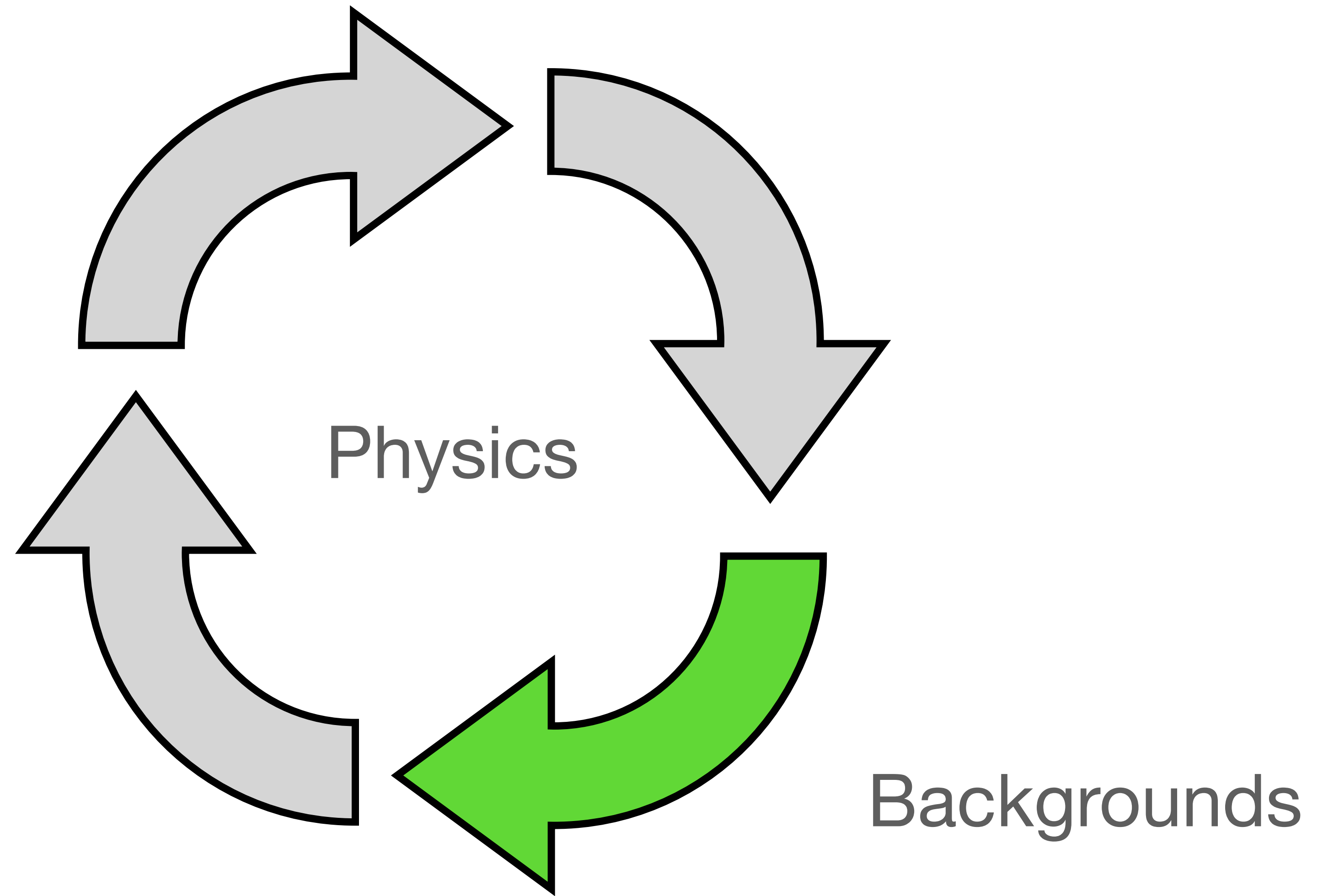
Detector positions



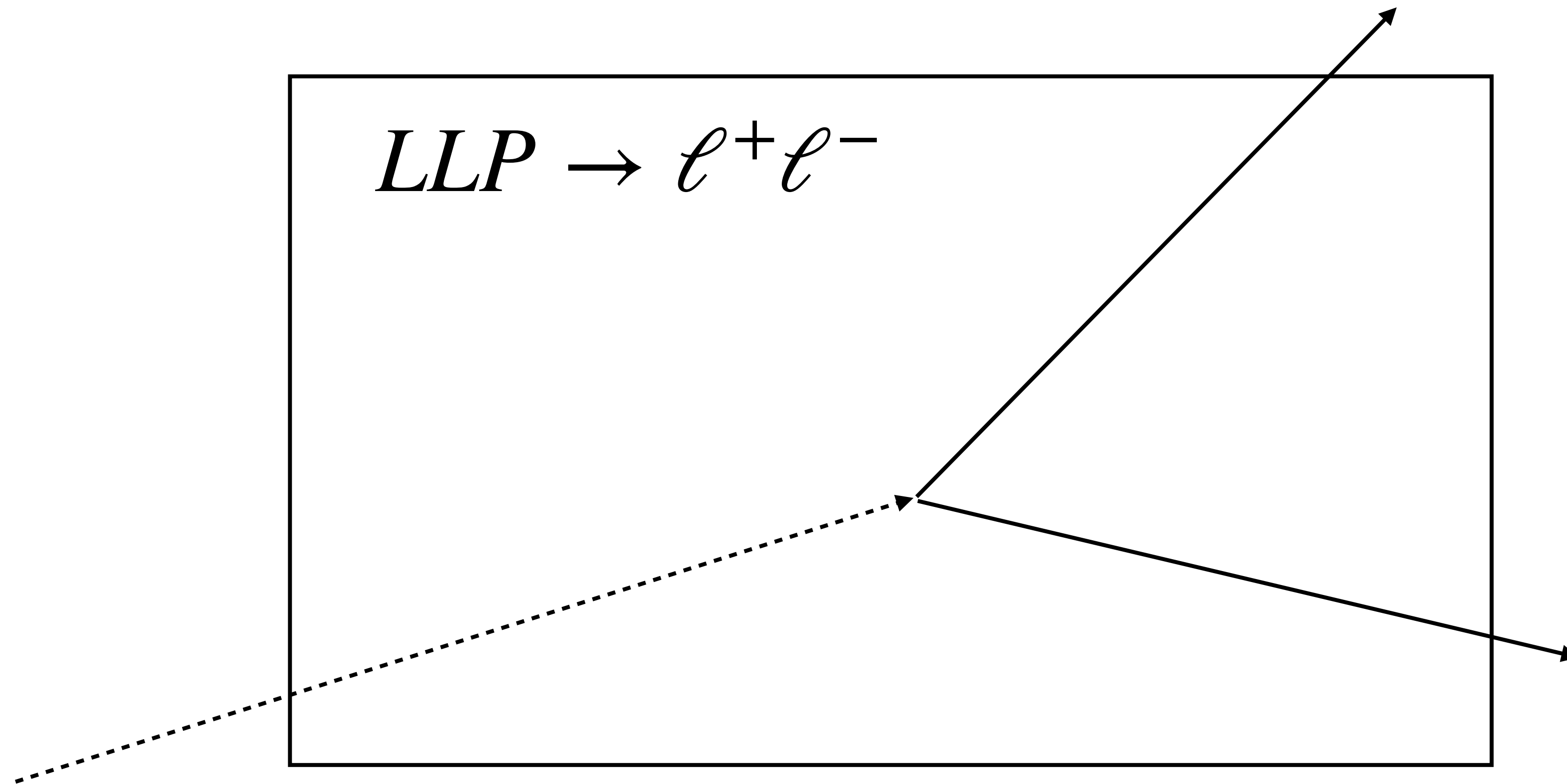
GODZILLA (ground level outside Tsukuba hall)
C: 25×10×50 m



Overview

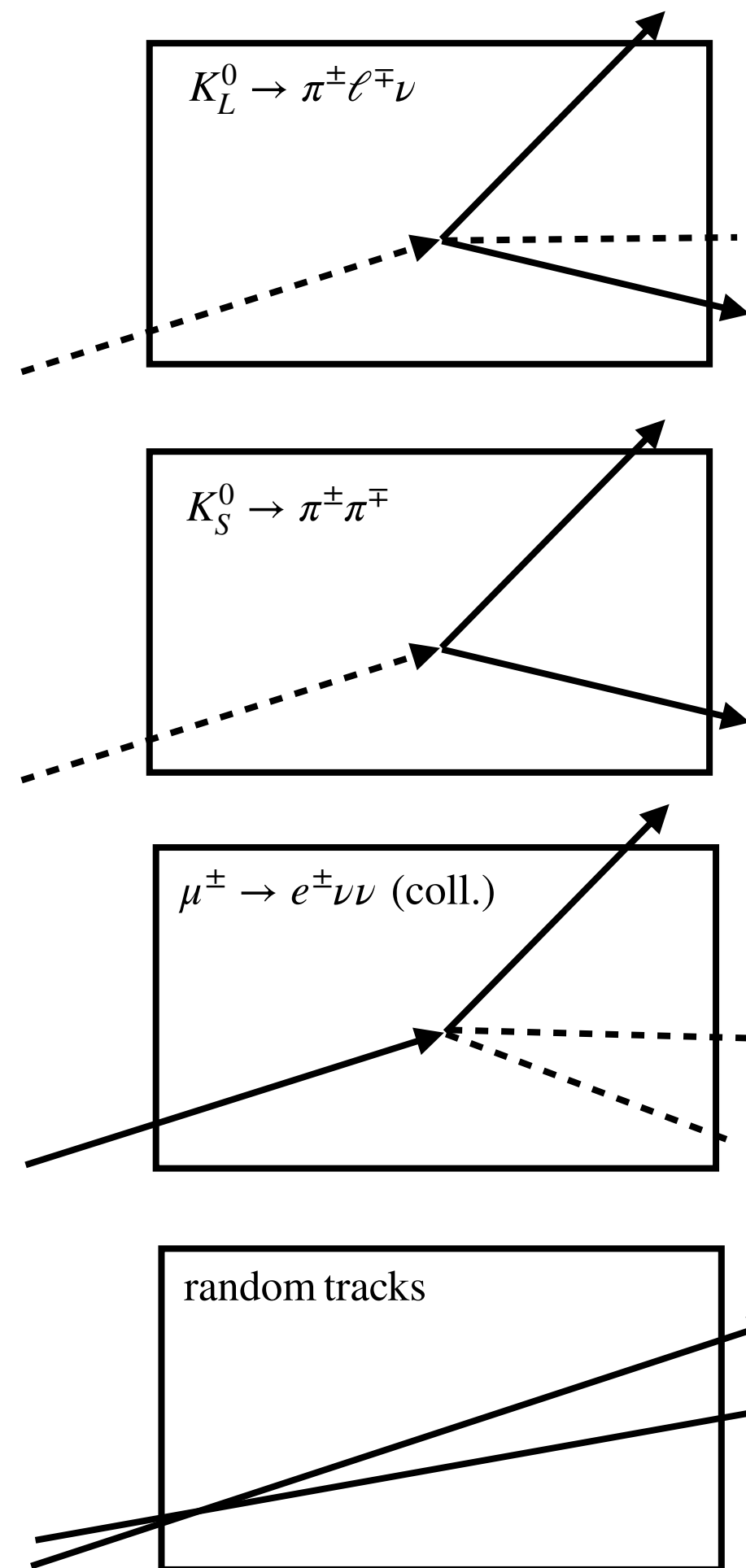


Signatures: Signal

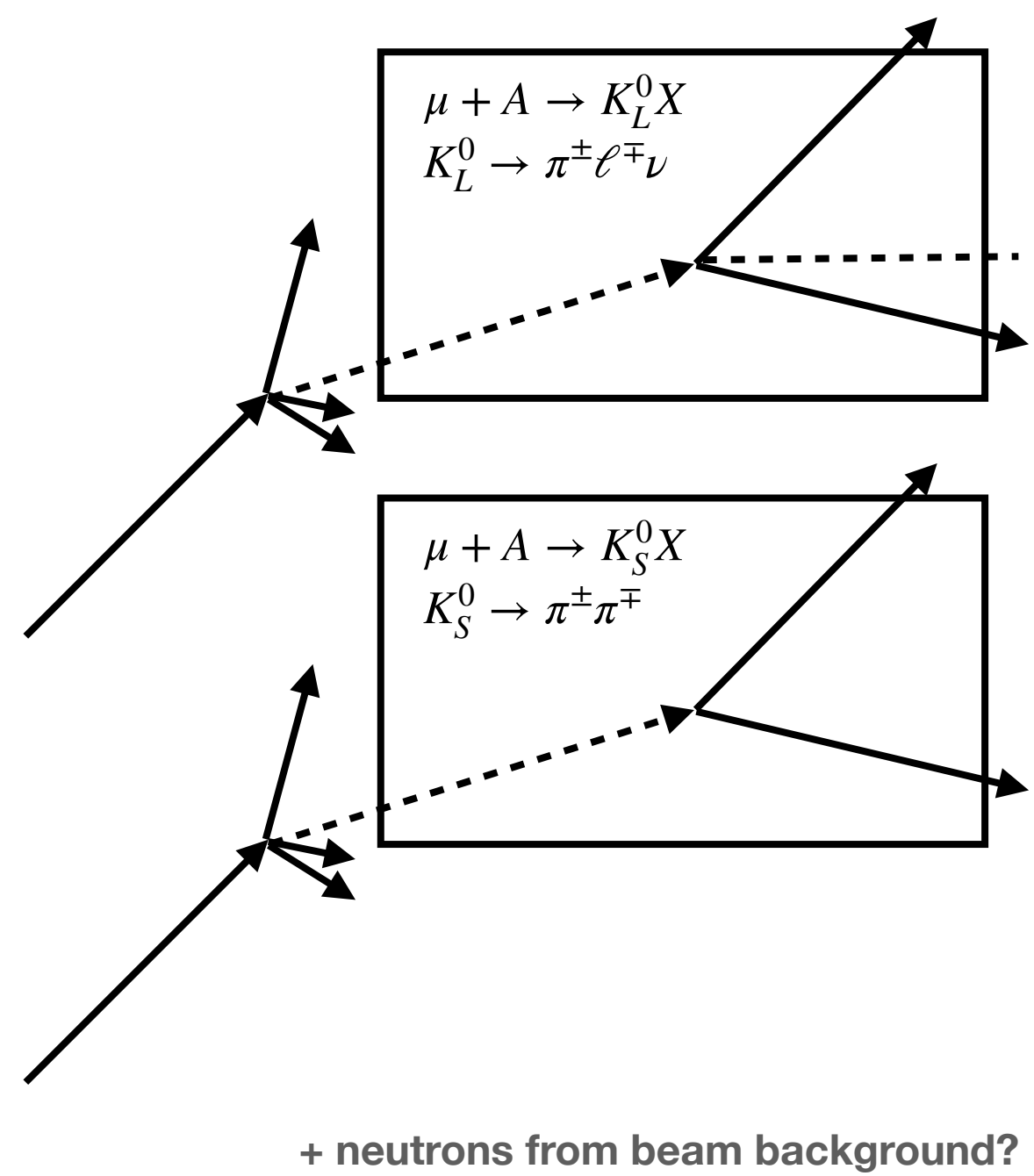


Signatures: Background

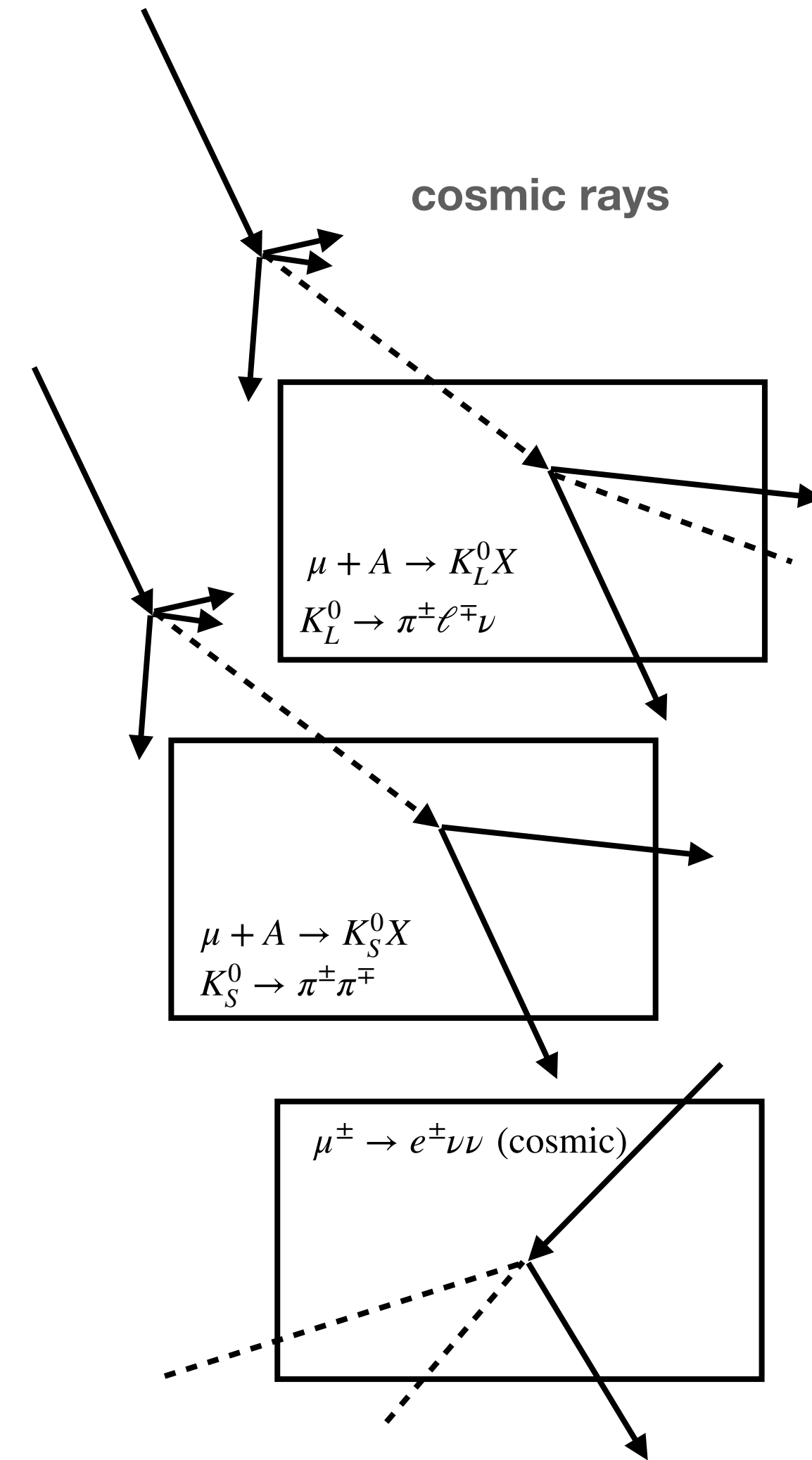
produced in primary e+e- collision



secondaries from particles produced in primary e+e- collision

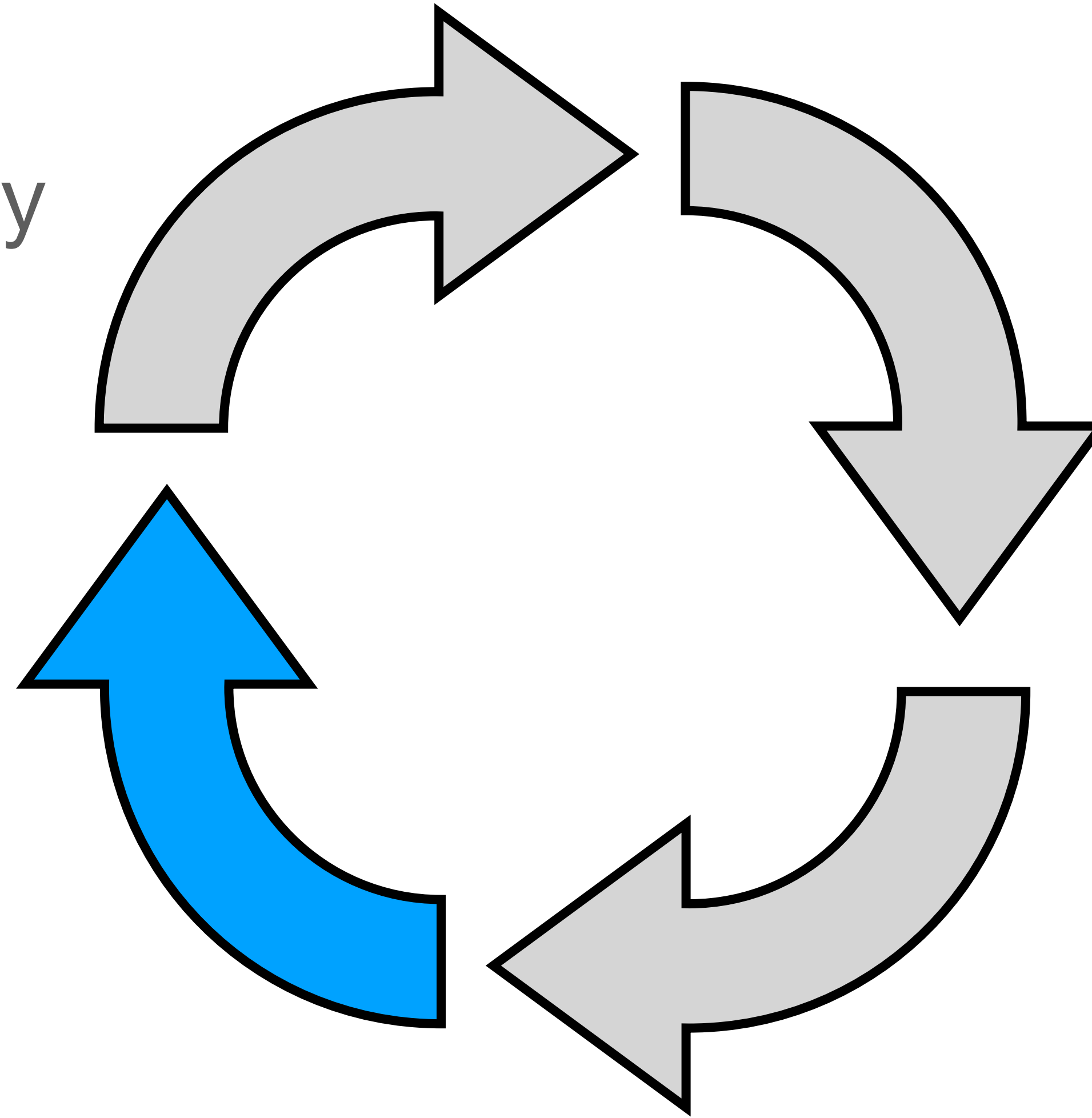


cosmic rays



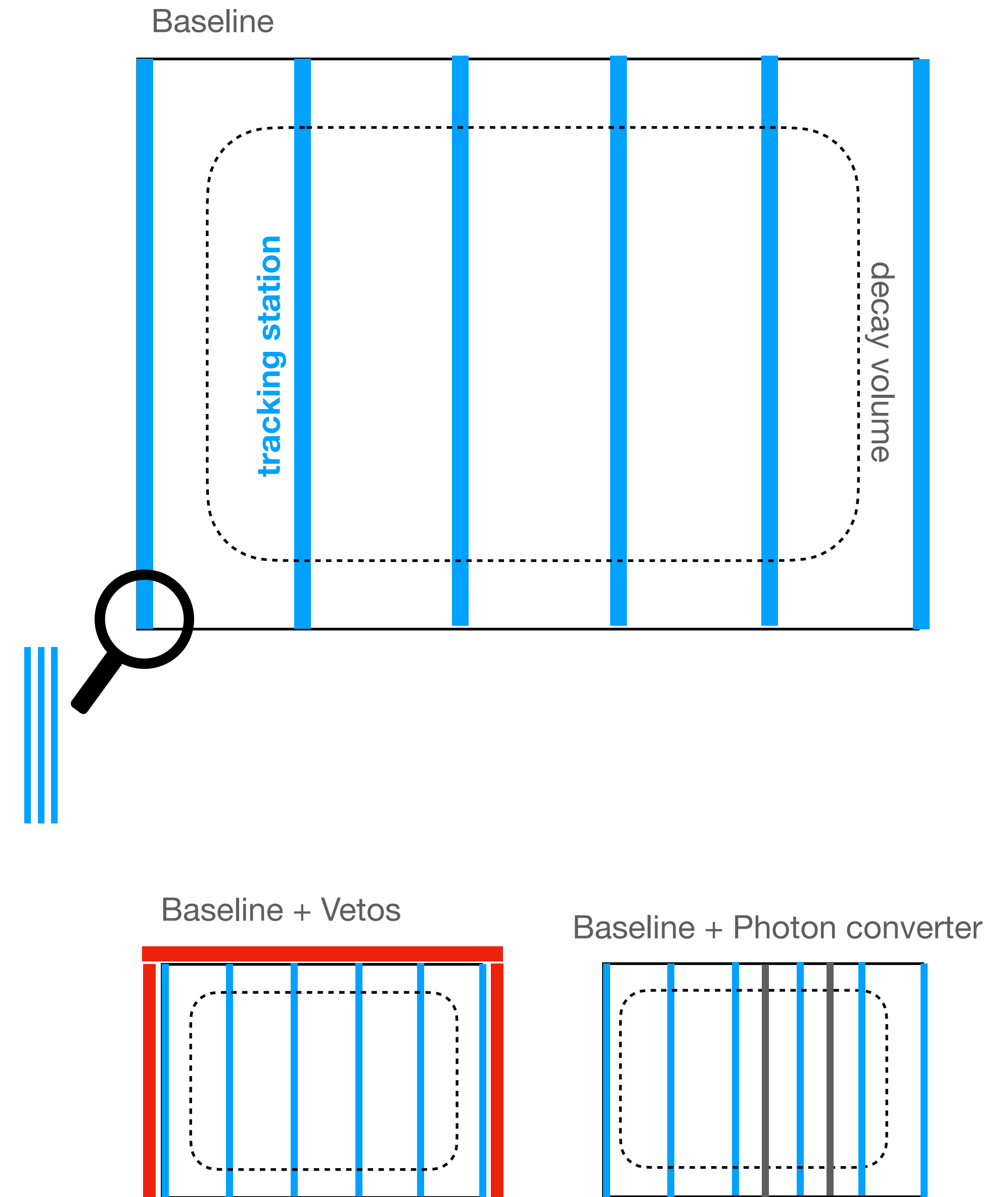
Overview

Detector technology



Detector technology

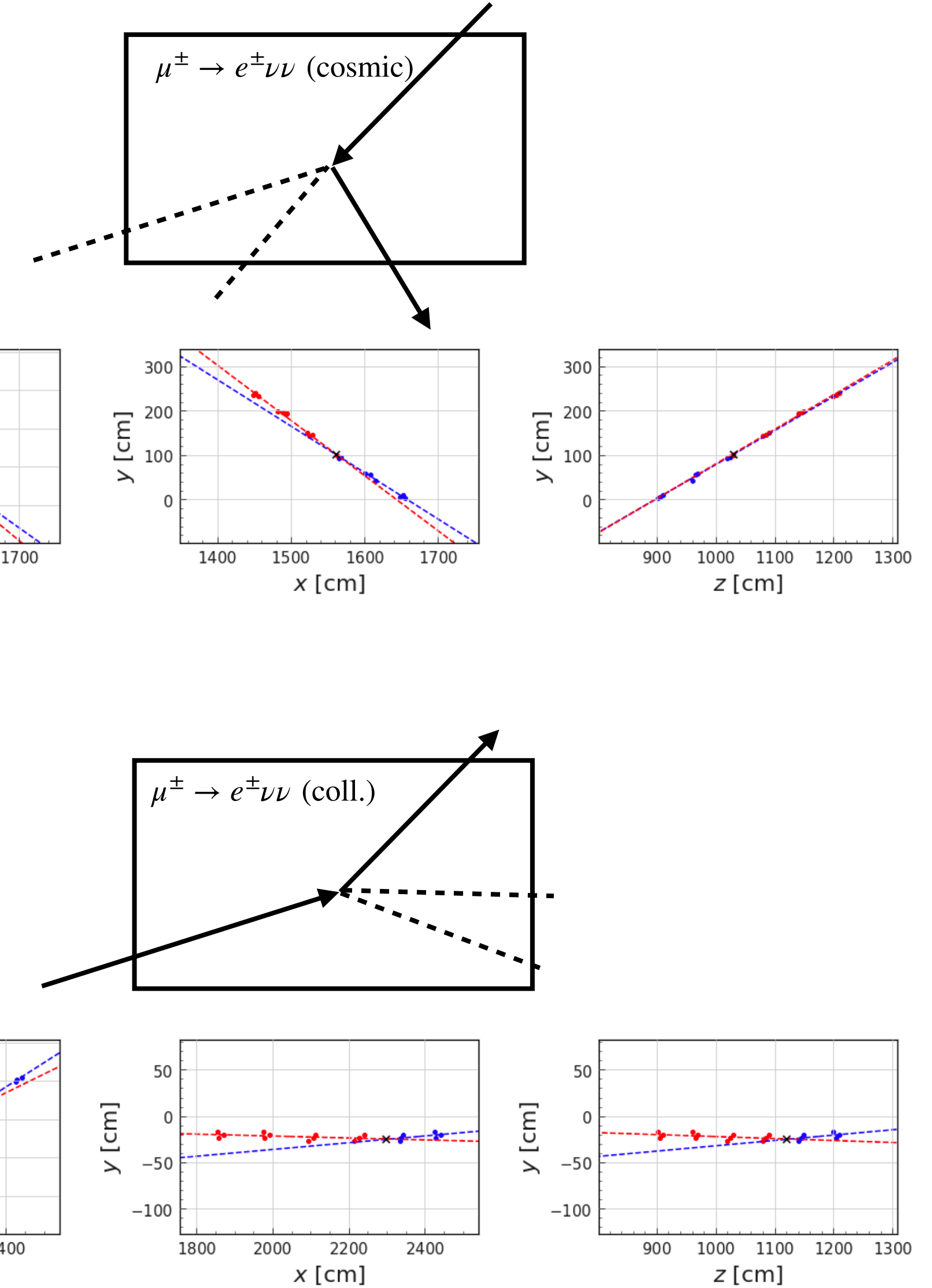
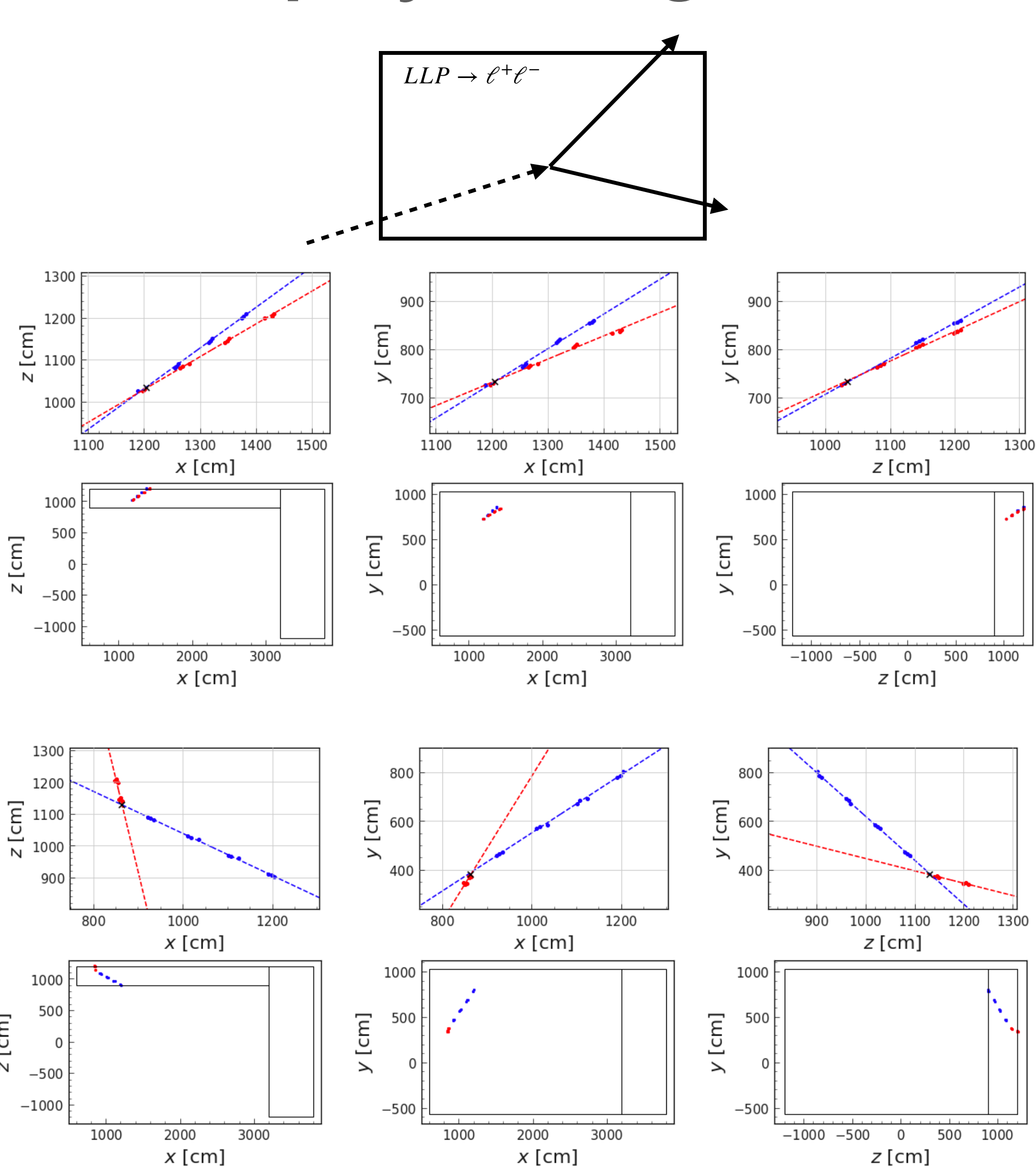
- Baseline 6 tracking stations, 3 tracking layers each, 2 tracking planes (x-y, u-v)
 - No magnetic field
 - Tracking $O(10\text{cm})$ “pixels”
 - Timing $O(500\text{ps})$
 - Optional: Calorimeter? Converterplates? PID?
- Synchronize with Belle II readout:
 - trigger GAZELLE with Belle II (and vice versa?)
 - **Unique but also hardest to study: exploit known e^+e^- kinematics**



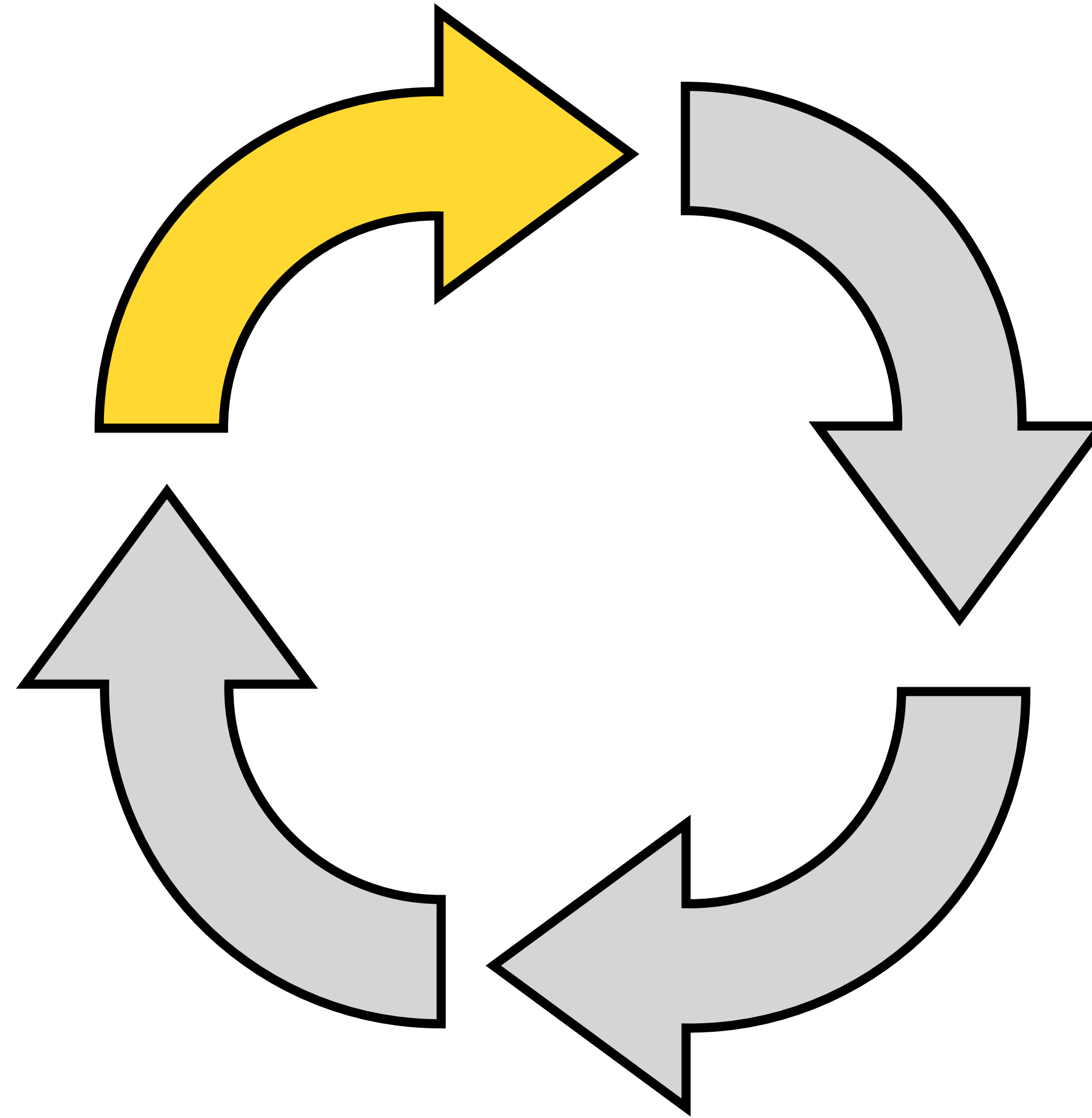
Event displays for signal and background

$B \rightarrow Ka, a \rightarrow \mu\mu(m_a = 0.3 \text{ GeV})$

$B \rightarrow Ka, a \rightarrow ee(m_a = 4.0 \text{ GeV})$

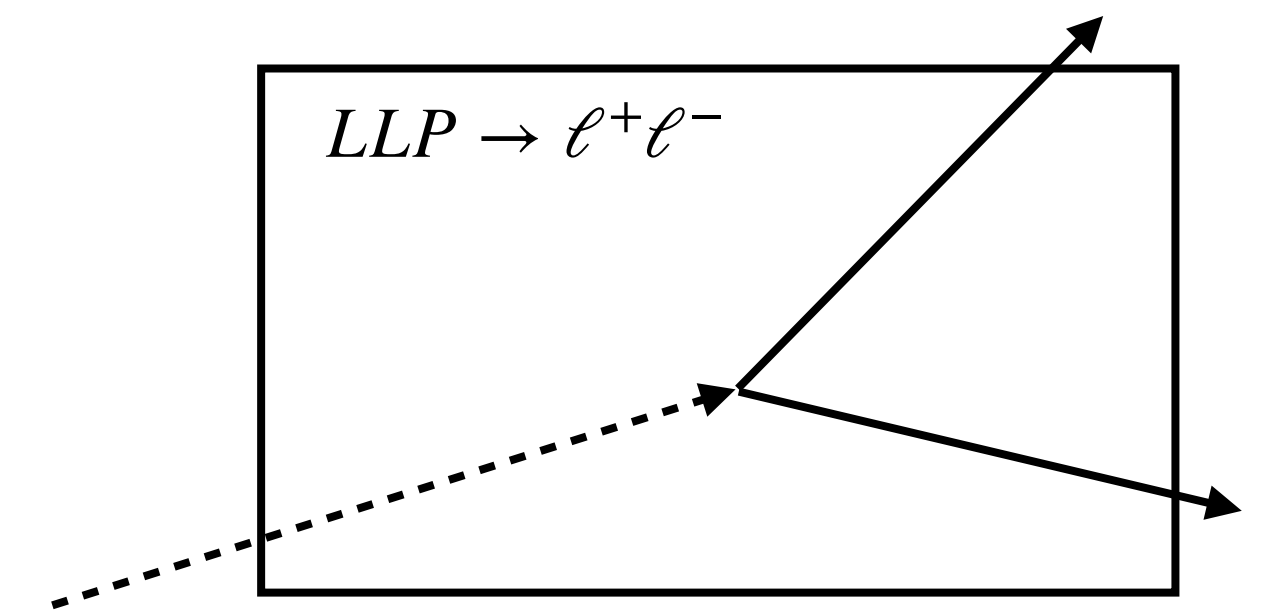


Observables

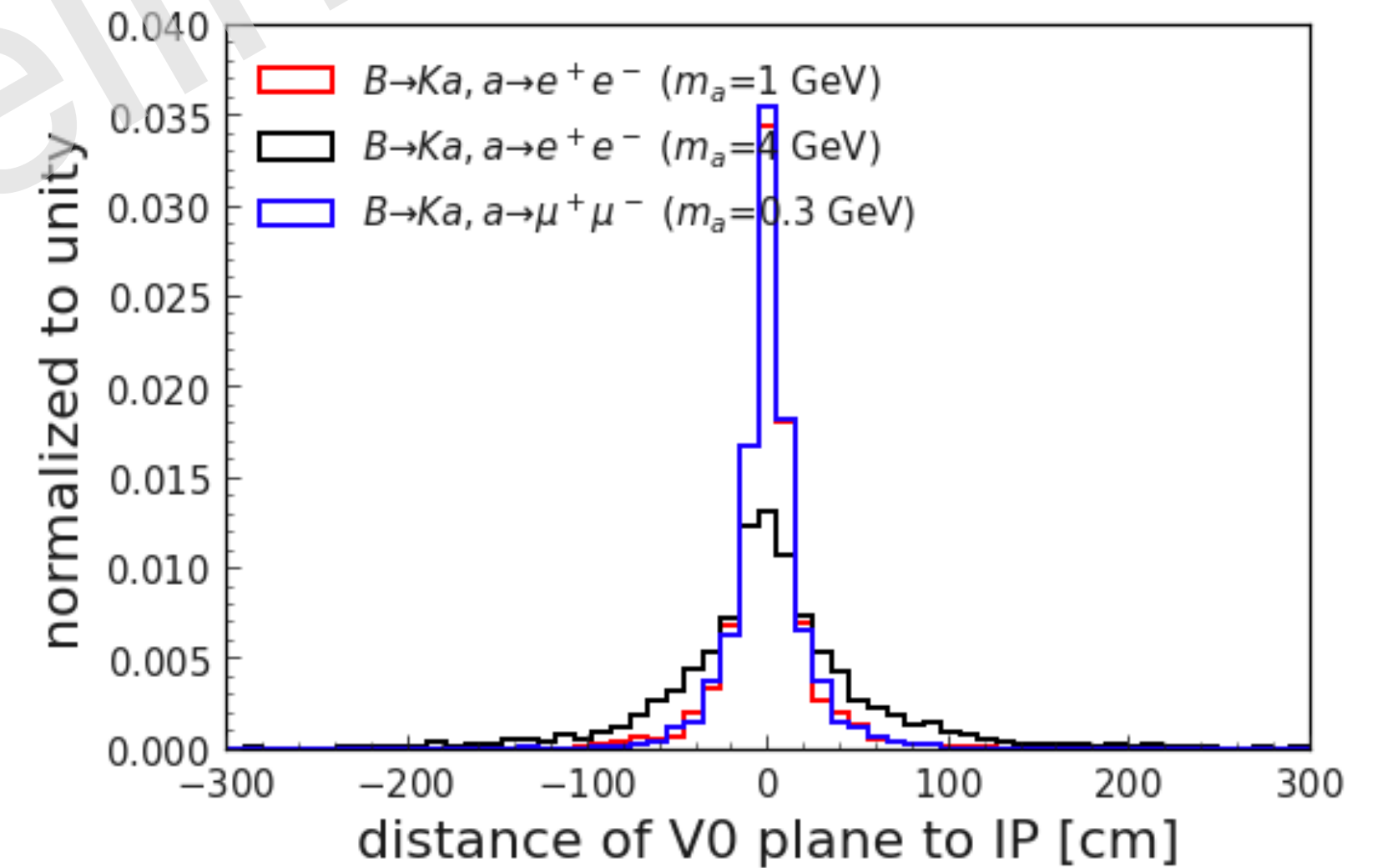
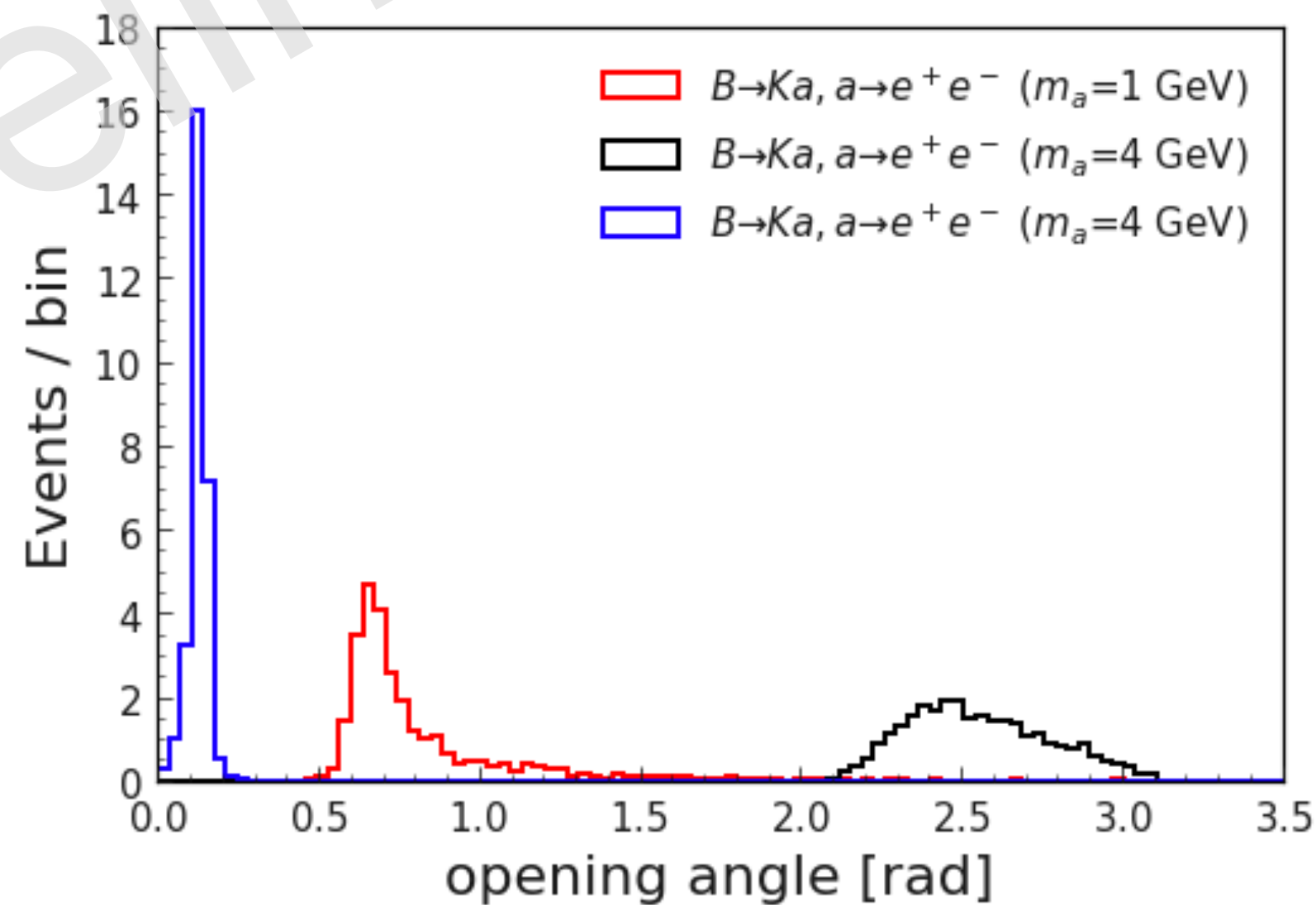
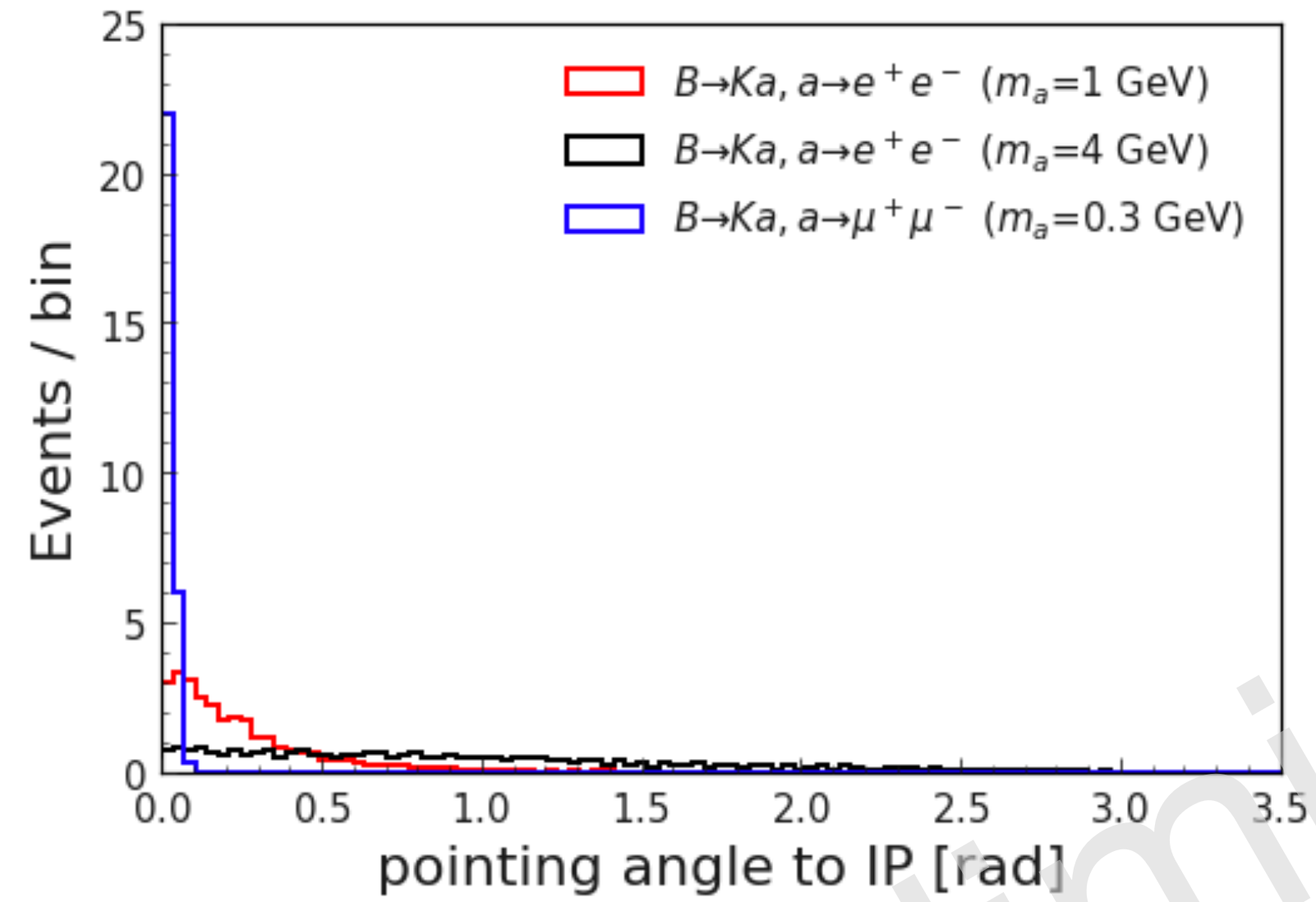
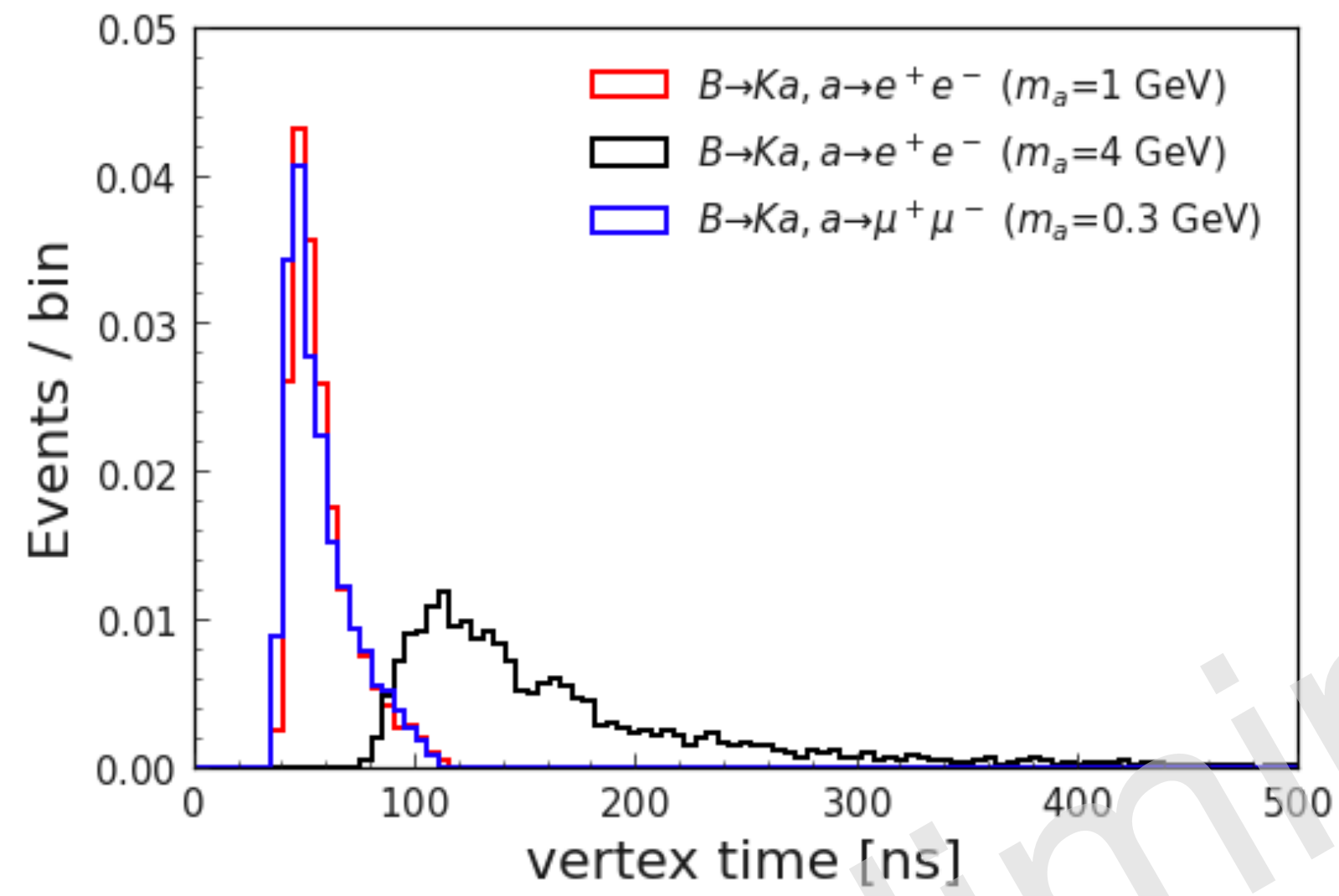


Observables

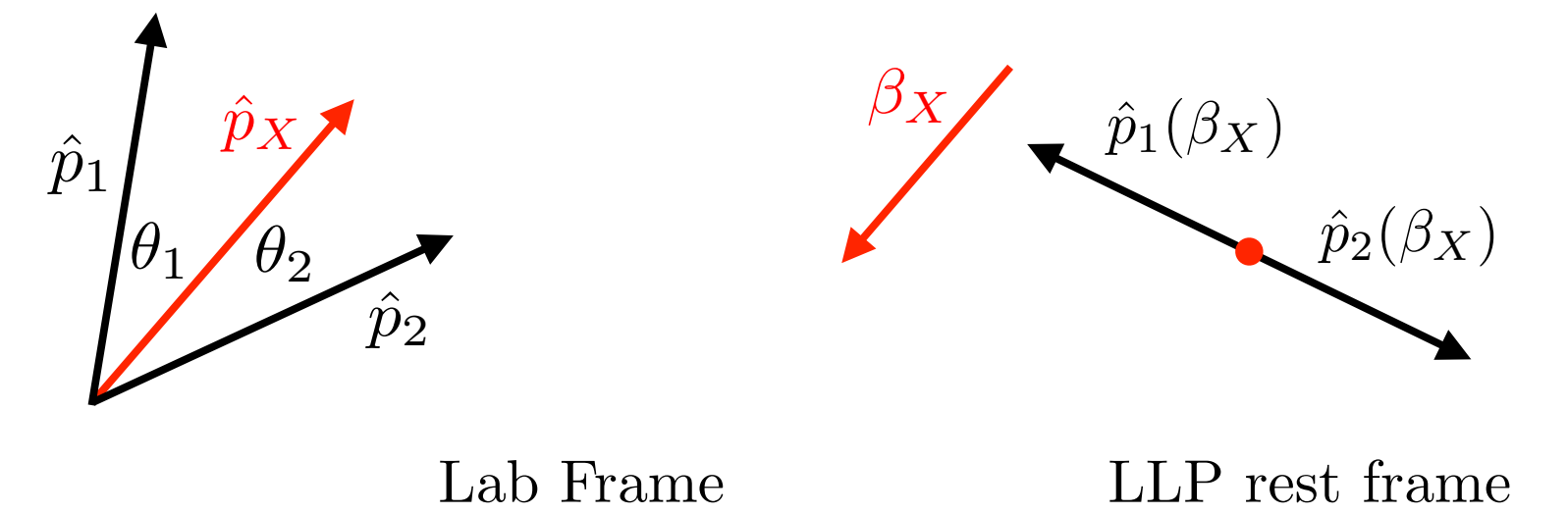
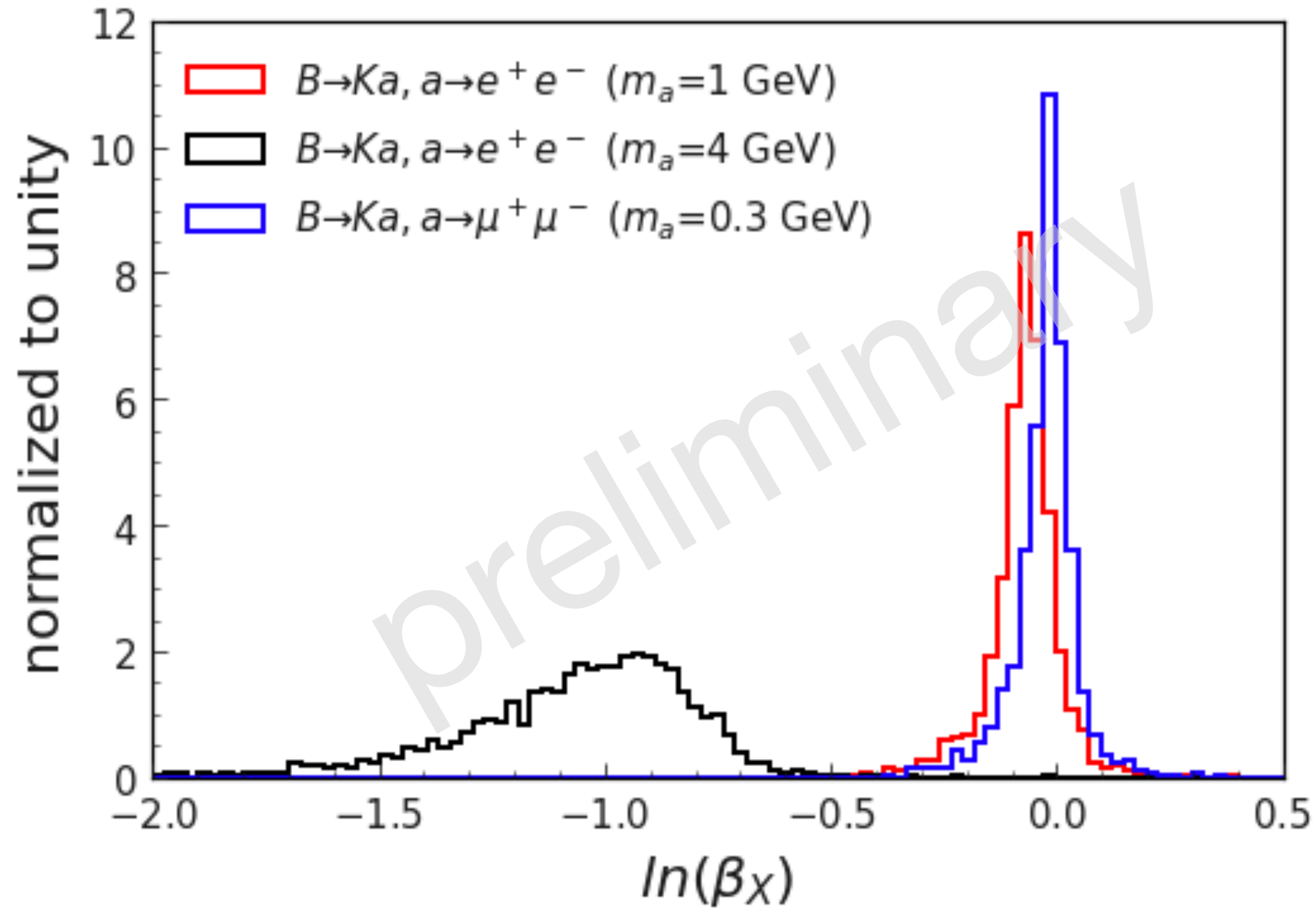
- track direction: from inter-station timing
- absolute timing: from all station timings and time consistency of both tracks
- plane to IP: distance of V0 plane to the e^+e^- collision point
- opening angle: correlated with LLP boost, usually small
- pointing direction: V0 children direction pointing back to e^+e^- collision point
- hits before vertex: hits not used in track fits
- Belle II: synchronized events, rejects charged particles with >99% efficiency
- shielding: additional concrete shielding close to GAZELLE
- veto: high efficiency, good timing to reject entering muons



Observables for $B \rightarrow Ka$



Observables for $B \rightarrow Ka$: Mass reconstruction



$$\beta_X = \frac{\beta_1 \beta_2 \sin(\theta_1 + \theta_2)}{\beta_1 \sin \theta_1 + \beta_2 \sin \theta_2}$$

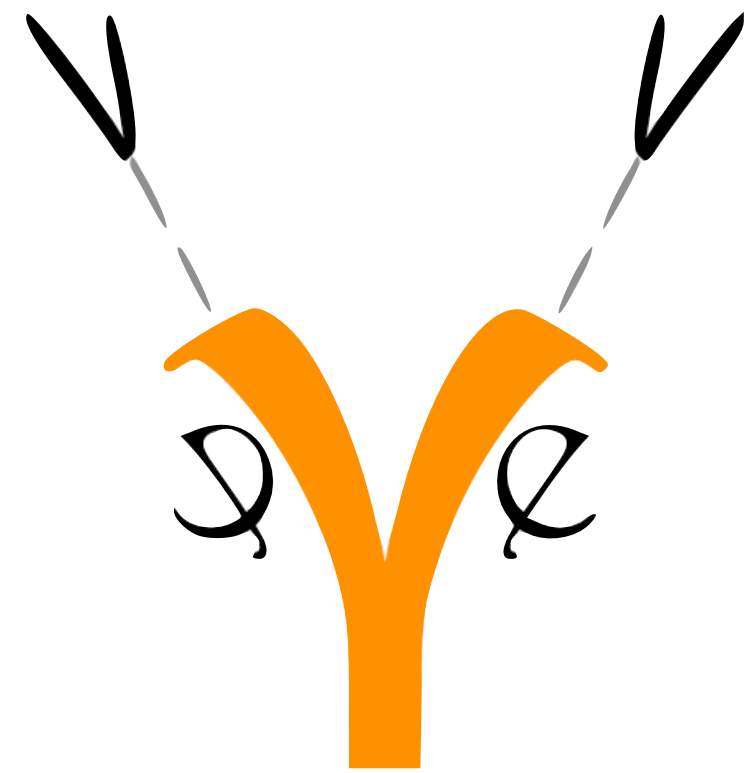
Background rejection

+: rejection power -: no rejection power	μ DIF (cosmic / coll.)	random tracks	K0L from μ (cosmic / coll.)	K0S from μ (cosmic / coll.)
track direction	+	-	-	-
absolute timing	+/-	-	+/-	+/-
plane to IP	+/-	-	+	+
opening angle	very large	-	-	-
pointing direction	+	-	+	+
hits before vertex	-	+	-	-
Belle II	-/+	+	-/+	-/+
shielding	-*/reduced	reduced	-*/reduced	-*/increased(!)
veto	+	+	-	-

* (almost) no shielding from above possible

Summary

- GAZELLE is a possible new sub-detector for Belle II for GeV-range LLPs
- (some of the) open questions being studied now:
 - $\mu+A \rightarrow K_0L+X$ is a very rare process: How to simulate? How good is GEANT4?
 - Cosmic rejection requires multiple combined rejection methods using timing and kinematics rejection. Are the methods orthogonal?
 - Can the fiducial volume be extended into the experimental hall?
- Unique features:
 - Belle II and GAZELLE are physically close: Common DAQ and trigger system to reject backgrounds
 - Mass determination using the full Belle II reconstruction is extremely powerful (overconstraint kinematic fits!)



Contact

DESY.

Deutsches Elektronen Synchrotron
www.desy.de

Torben Ferber
torben.ferber@desy.de
ORCID: 0000-0002-6849-0427