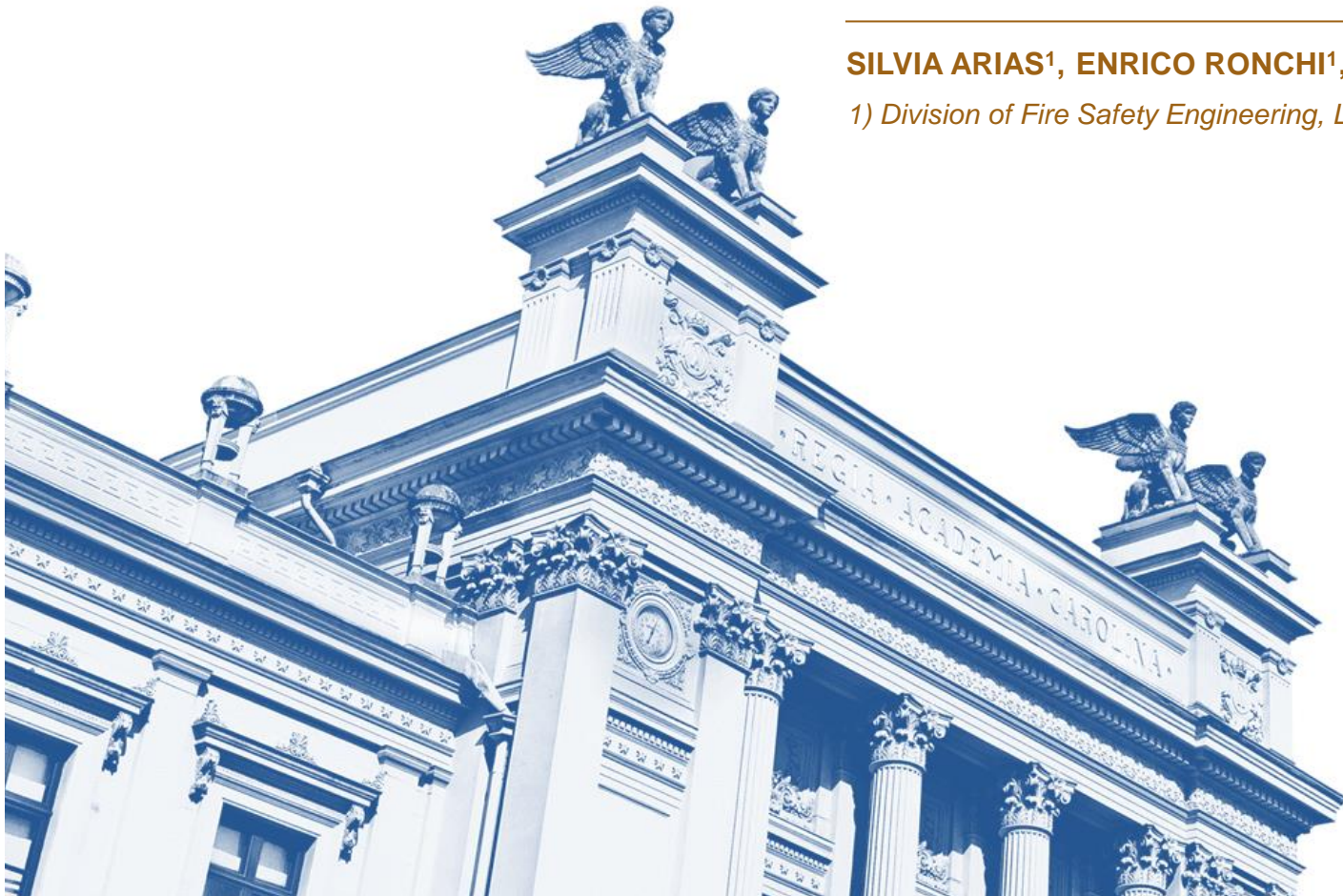




Evacuation experiment using VR

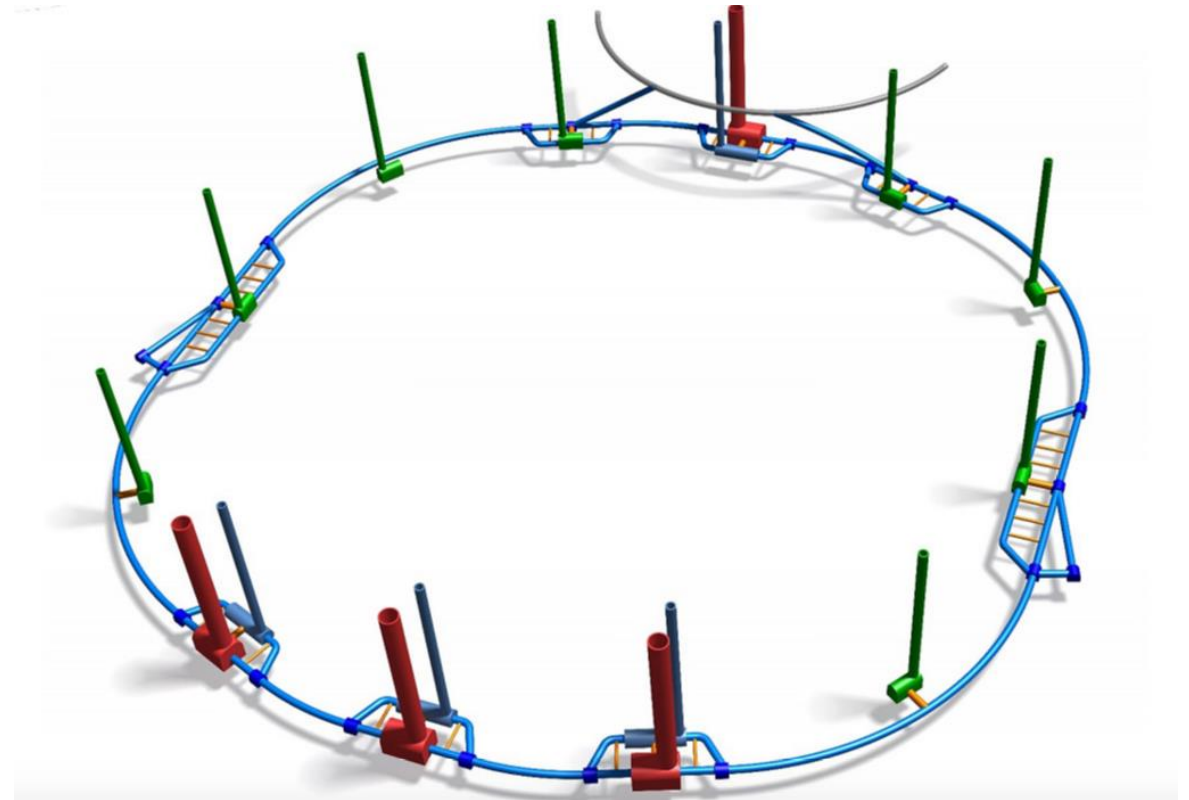
SILVIA ARIAS¹, ENRICO RONCHI¹, JONATHAN WAHLQVIST¹, ORIOL RIOS², SAVERIO LA MENDOLA²

1) Division of Fire Safety Engineering, LTH, Lund University, 2) CERN HSE/OHS



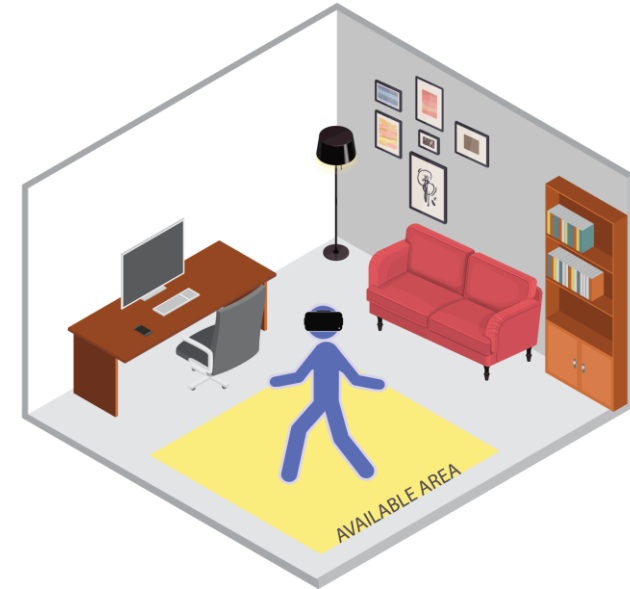
Evacuation of the FCC

- Hundreds of meters deep
- Access shafts every 10 km
 - Walking speed of 5 km/h



Virtual reality

- Digital representation of a scenario
- Simulate physical presence

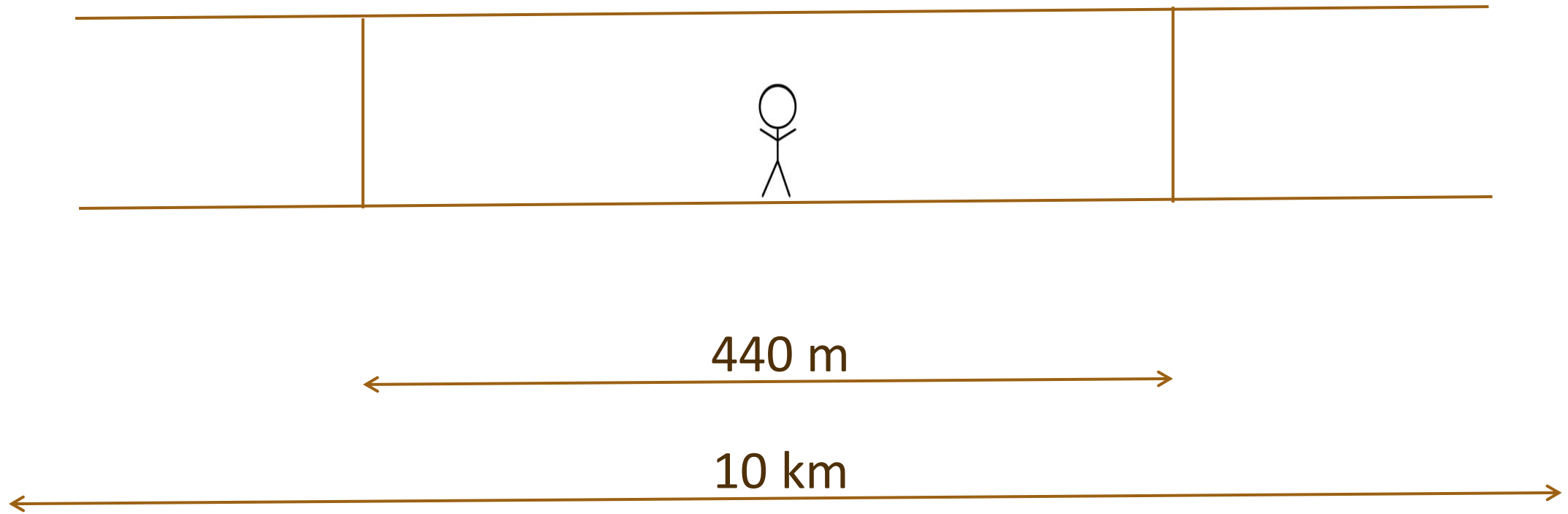


– Application of virtual reality for evacuation research

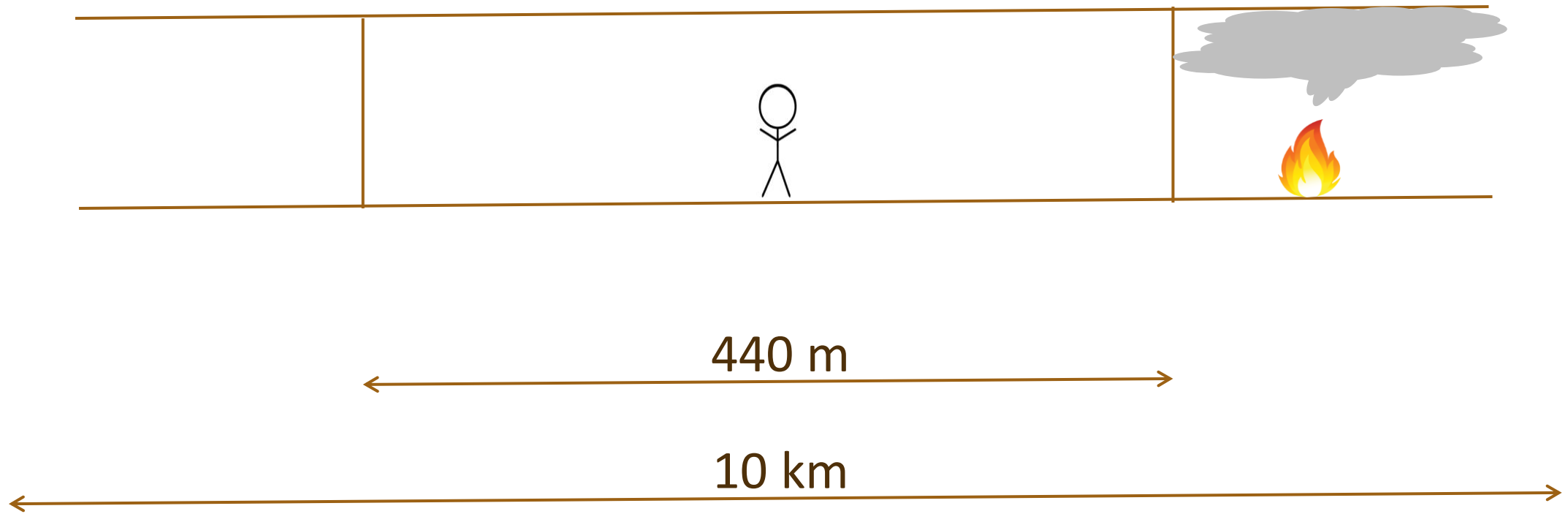
Objectives

- Indicate the correct evacuation direction
 - No visible threat
 - Change the decision made
- Test way-finding system based on SPS safety upgrade
- Test additional possible safety systems for FCC – robot
- Application to HE-LHC

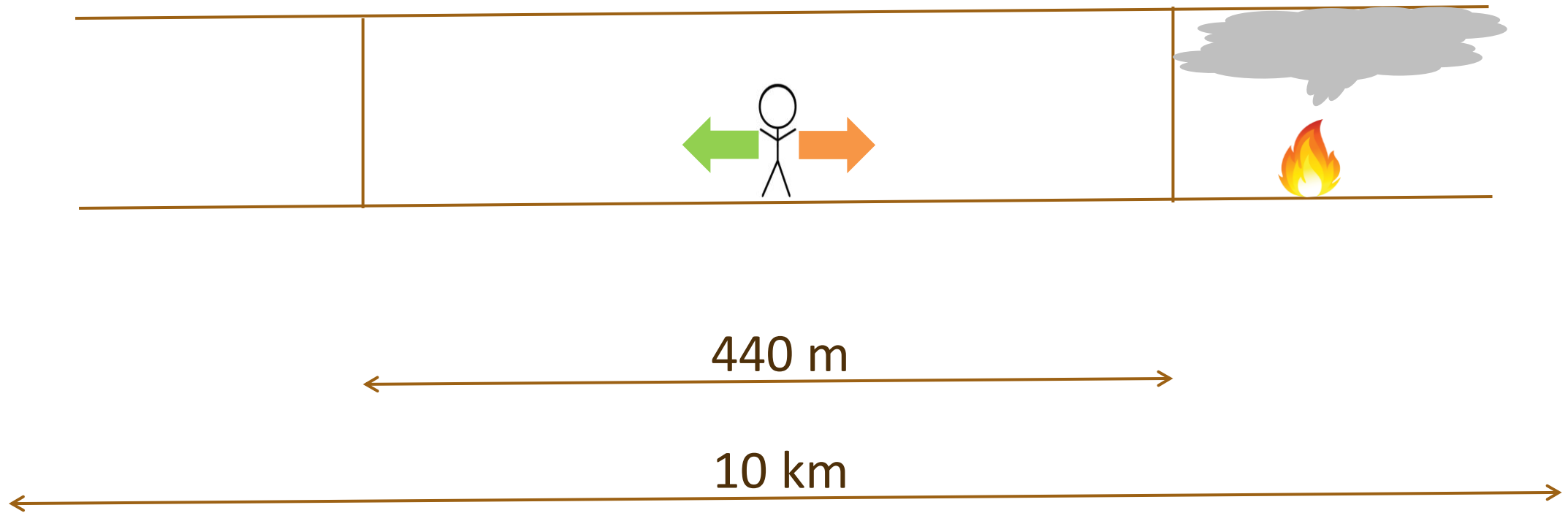
Schematic layout



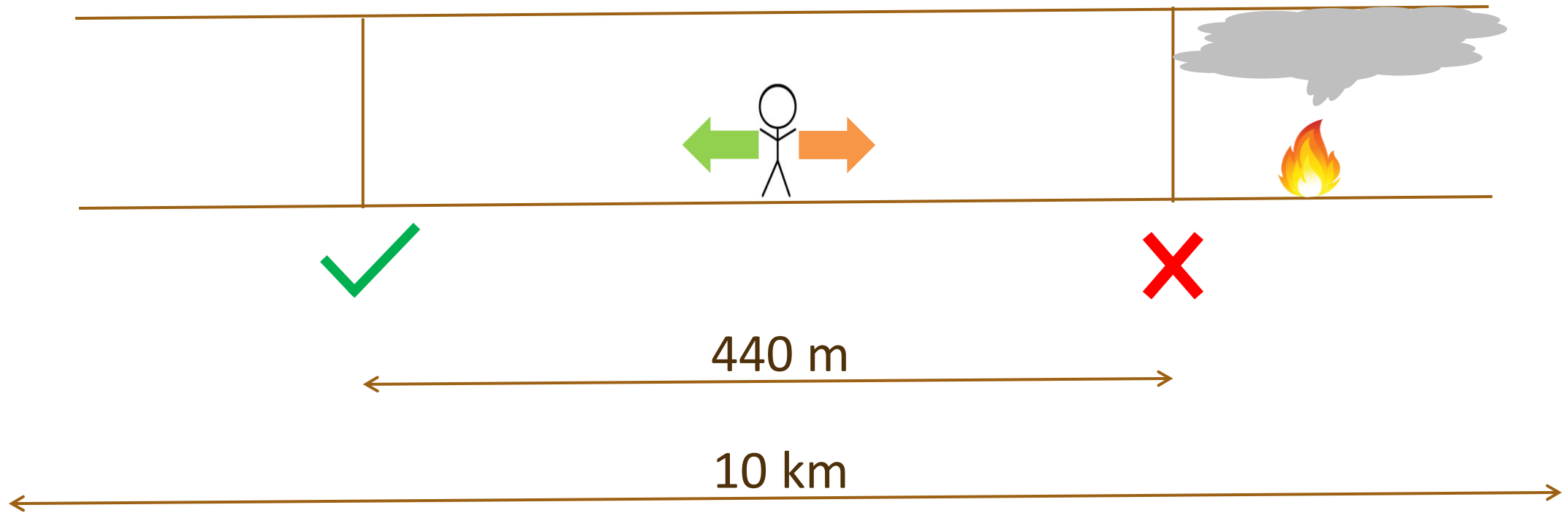
Schematic layout



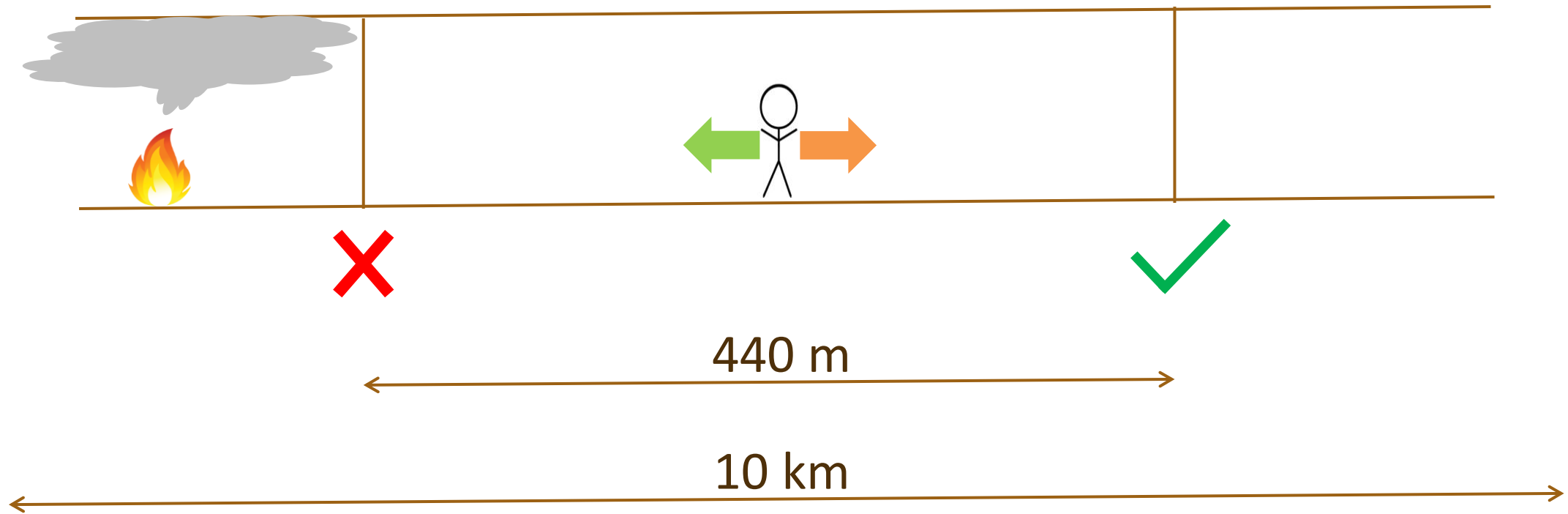
Schematic layout



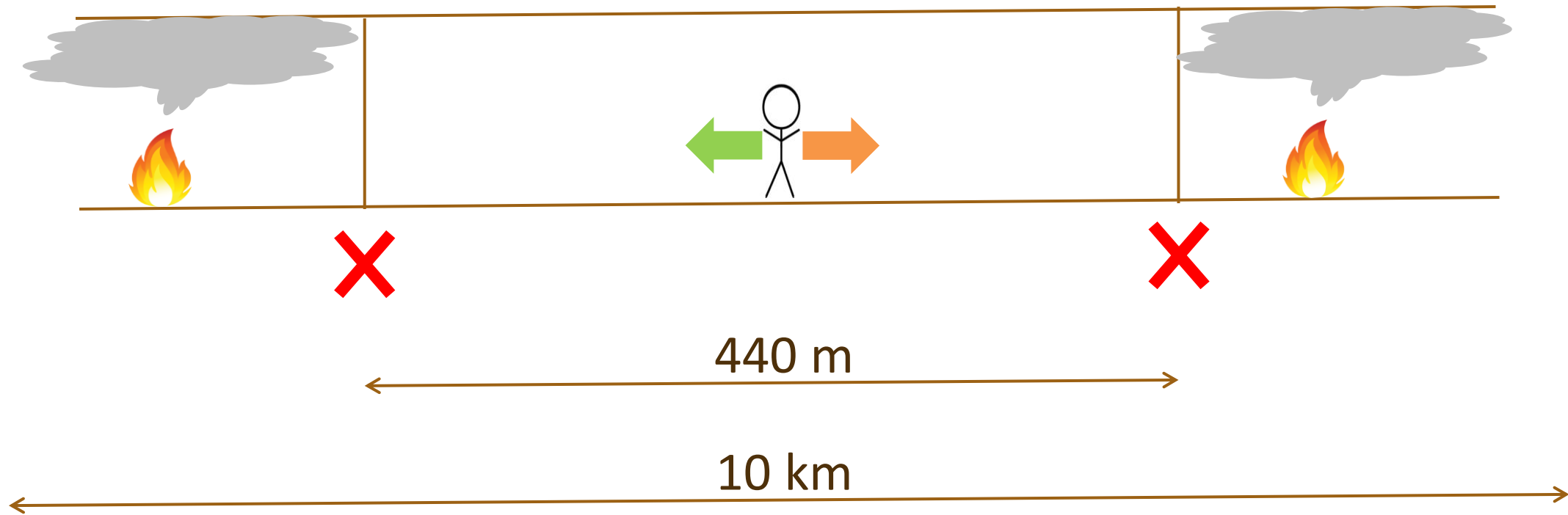
Schematic layout



Change the decision made



One way or another



Designing the VR environment

- Dimensions of FCC – 6 m diameter
- Magnet and overall outlook of LHC
- Any chosen direction was wrong
 - Systems indicated the opposite direction as right
- Simple task was given



LHC vs our VR tunnel



Method

- Start in the center of the arc
- Look for realism
- A small task
- Alarm goes off
- Participant is on their own
- Way-finding systems do the rest

Simple experimental setup



Three scenarios

- Scenario 1: flashing lights
 - According to system designed for SPS
 - Improved with dynamic signage above door
 - 440 m long compartment



Scenario 1 – flashing lights



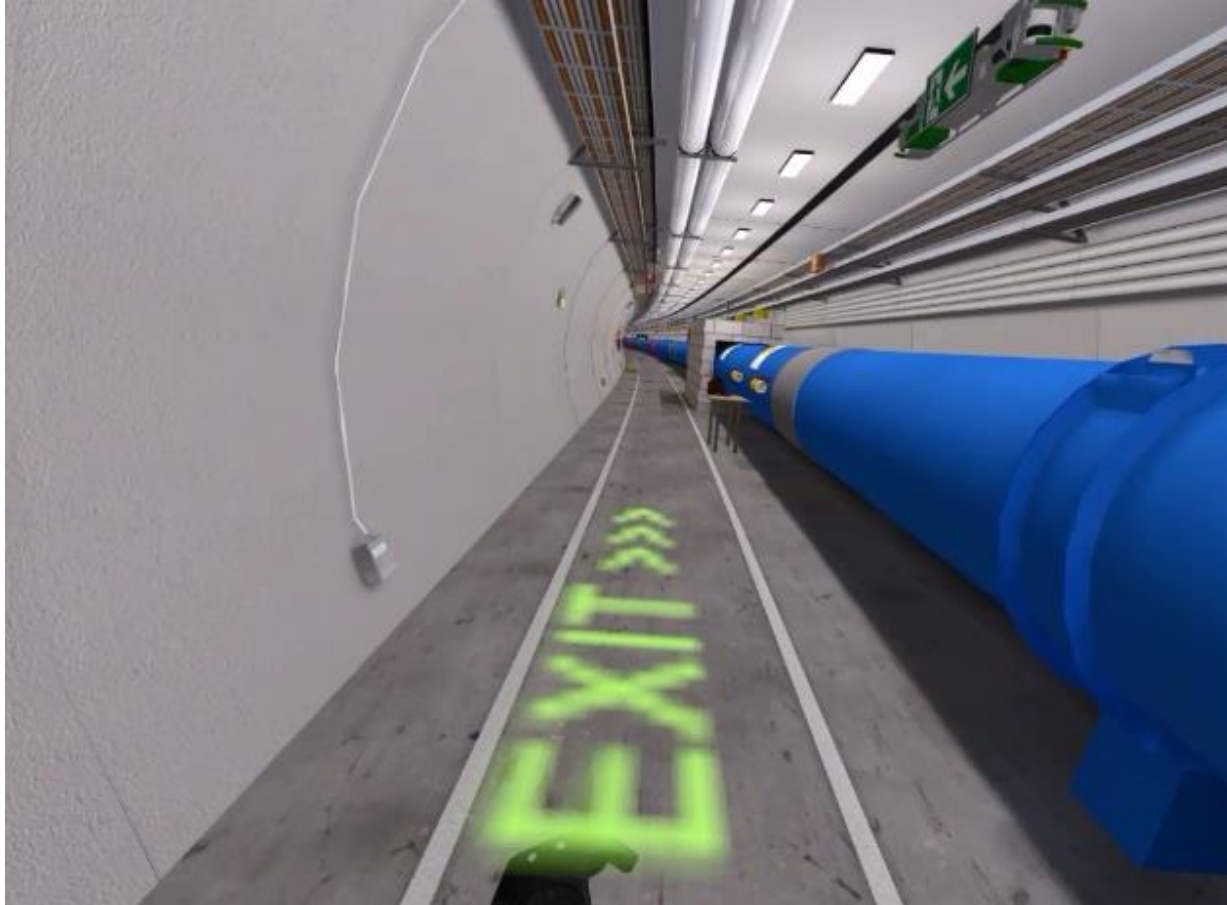
Scenario 1 – flashing lights



Three scenarios

- Scenario 2: evacuation robot
 - Robotics team at CERN – Mario Di Castro EN-SMM
 - Additional function
 - Moves towards the fire
 - Projects message
 - Displays evacuation direction

Scenario 2 – robot



Three scenarios

- Scenario 3: modified robot, dynamic systems
 - Added green flashing light to robot
 - Added dynamic system on the wall



110 participants



- CERN employees
 - S1: 39
 - S2: 40
- ESS and MAX VI employees
 - S3: 31
- 30 min for training, experiment, questionnaire and debriefing

Results

- Scenario 1 – flashing lights
 - 63% compliance
- Scenario 2 – robot
 - 78% compliance
- Scenario 3 – robot and dynamic signage along wall
 - 92% compliance

Significance of results

- S1 vs S2: no significant difference
- S1 vs S3: $p < 0.05$
 - S3: 31 participants, 3 did not follow instructions, ca. 10%
 - » 1 reached door and understood sign and lights
 - » 1 was curious about VR and opened door
 - » 1 unknown

Improvement of scenarios

- Slow robot's bell was not always recognized
- Ambiguity on emergency procedure
 - Not sure of what to do
 - » Maybe no need to evacuate (?)
 - » Emergency unclear
 - Wide range of familiarity with emergency procedure
 - » over 50% never did self-rescue mask training



VR-specific limitations

- Walking speeds
- Novelty – people tried to use every item
 - Use manual call point
 - » The alarm went off already
 - Carry the extinguisher with them
 - » No sign of fire whatsoever
- Curiosity – “what happens if I open this door?”
- Fun – not wanting to end the VR experience



VR-specific advantages

- Test inexistent facility and systems
- Easy to test different systems and scenarios
 - Adapt to any needs
- Researcher observes from participant's perspective
- High level of immersion
 - Participants "forget" where they are
 - Realistic behaviors observed



Publications and deliverables

- VR model given to CERN
- Conference paper International Symposium of Tunnel Safety and Security – Borås, March 2018
 - Smoke spread and movement through smoke
 - Evacuation simulation
- Final report for FCC collaboration
- Publication of current results
 - Comparison of results to hypothetical scenario questionnaire

Conclusions

- Improved understanding
 - Application of VR in evacuation research
 - Human behavior in fire
- More efficient design of evacuation system
 - A more sophisticated design showed better results
 - Several levels of safety





LUND UNIVERSITY