LEMMA Test Beam in North Area - H2 Report

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On behalf of LEMMA group

INFN groups from: Frascati, Como, Trieste, Torino, Padova, Pisa, Roma La Sapienza, Ferrara

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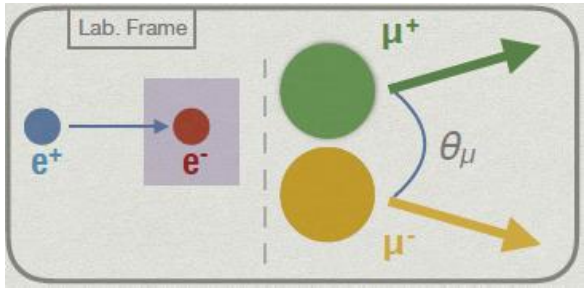
Istituto Nazionale di Fisica Nucleare

Lemma (Low Emittance Mu+ Mu- Accelerator)

New approach to a muon collider: based on low-emittance $\mu^+\mu^-$ pairs production from $e^+e^- \rightarrow \mu^+\mu^-$ just above the production threshold ($\sqrt{s} = 212MeV$), by using a beam of $\sim 45GeV$ e^+ on a thin target
(Nucl. Instrum. Meth. A **807** (2016) [arXiv:1509.04454])

$E(e^+) \sim 45GeV \rightarrow E(\mu) \sim 22GeV, \gamma \sim 200$



- Minimal muon energy spread
- Very small emittance can be obtained
- Low background
- Reduced losses from muon decays

Main issue: small production cross section ($\sim 0.4\mu b$ for 45GeV e^+)

$$N_{\mu\mu} = N_{e^+}\rho_{e^-}L\sigma_{(e^+e^-\rightarrow\mu^+\mu^-)}$$

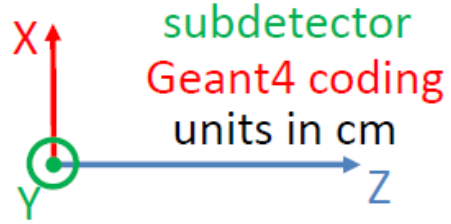
Goals of the 2018 experiment

- Measure momentum and emittance of outcoming muon pairs (need full tracking of muons)
- Measure production rate as a function of √s and other properties of the production process

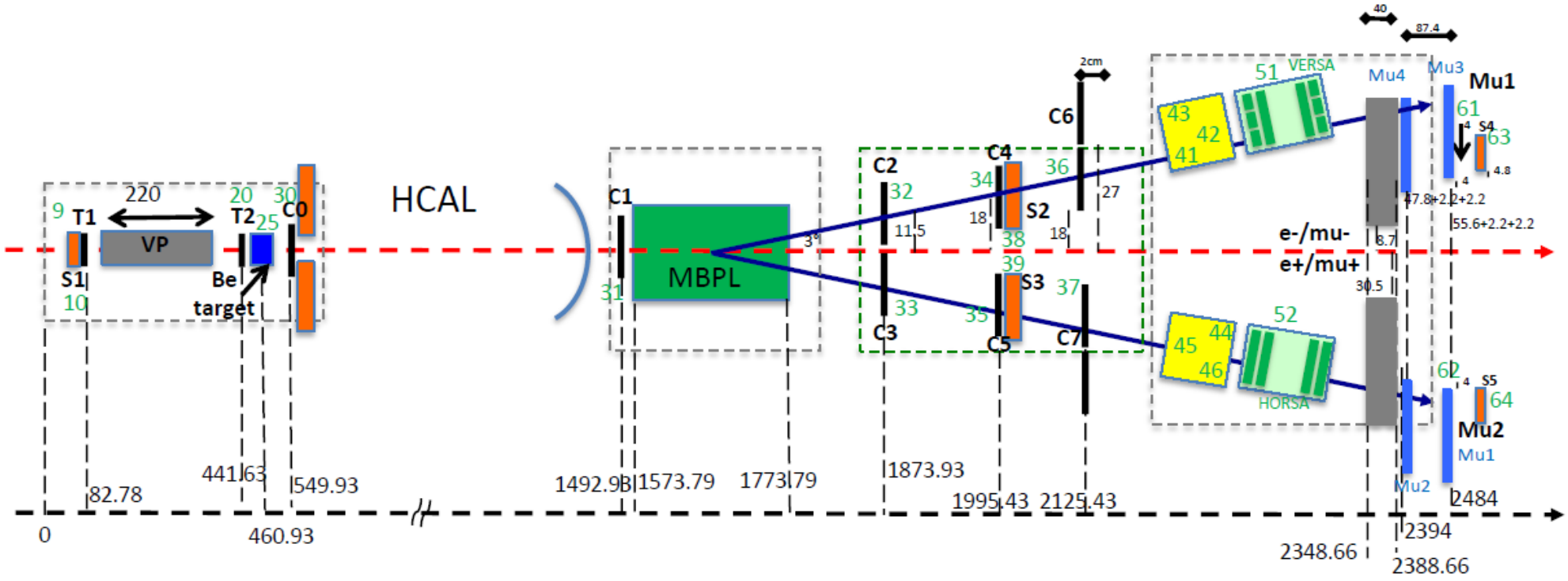
Test beam chronology

- Wed 19th Sep: set up of the experimental apparatus (removing previous experiments equipment, build new platform for hosting the dipole magnet, cabling and alignment of the magnet, installing a new beampipe..)
- Thu 20th Sep: installation and alignment of all detectors
- Fri 21st Sep - morning: calibration with muons beam (22-32 GeV) for calorimeters and mu chambers, without target
- Fri 21st Sep - afternoon: calibration with positron beam (16-28 GeV) for tracking alignment, without target
- Fri 21st Sep - evening: start runs with positron beam with Be target
- Sat 22nd Sep: run with 45GeV positron beam with Be target
- Sun 23rd Sep: run with 49GeV positron beam with Be target
- Mon 24th Sep: run with 46.5GeV positron beam with Be target and run with 45GeV positron beam with 6cm C target
- Mon 25th Sep: run with 45GeV positron beam with 2cm C target

LEMMA Test Beam Setup

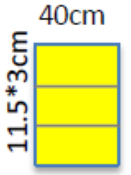


Last update: 25-sep-2018 v. 26

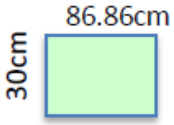


Size in cm:
T1-2: 1.9x1.9
C0-1,4-5: 9.3x9.3
C2-3: 8x8
C6-7: 18x18

FOR 2018b TB!!

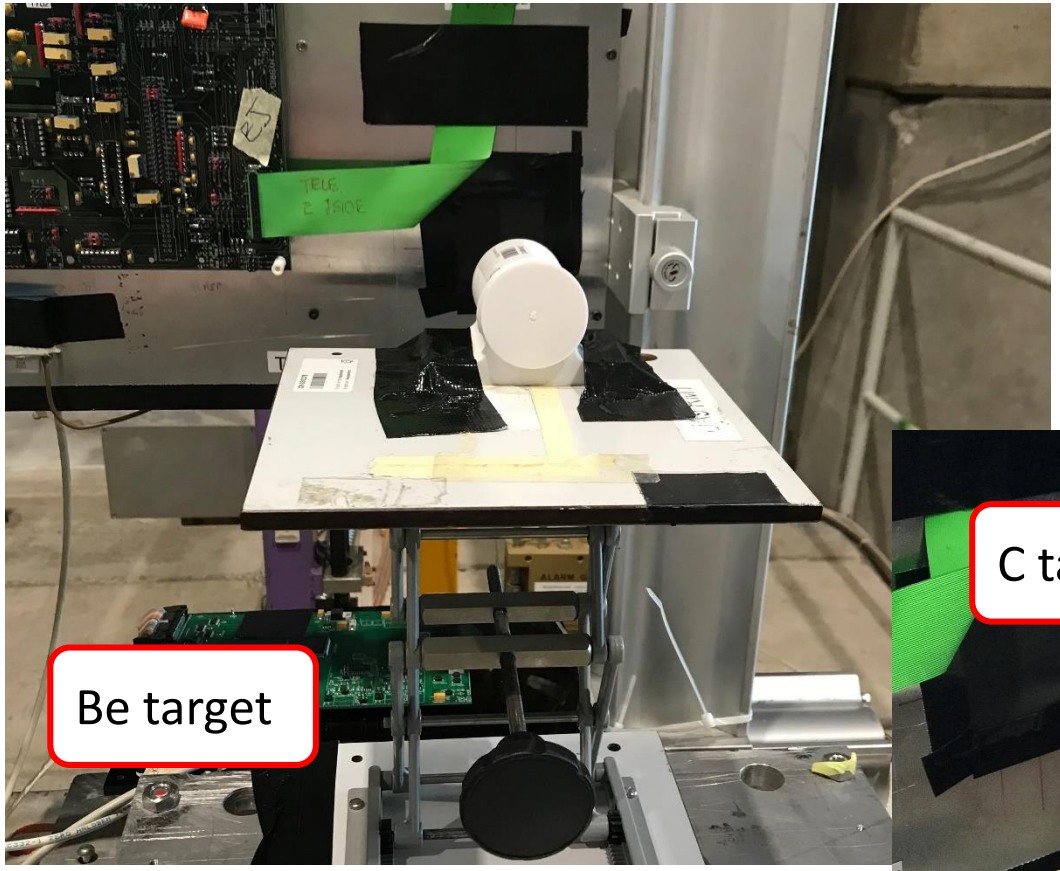


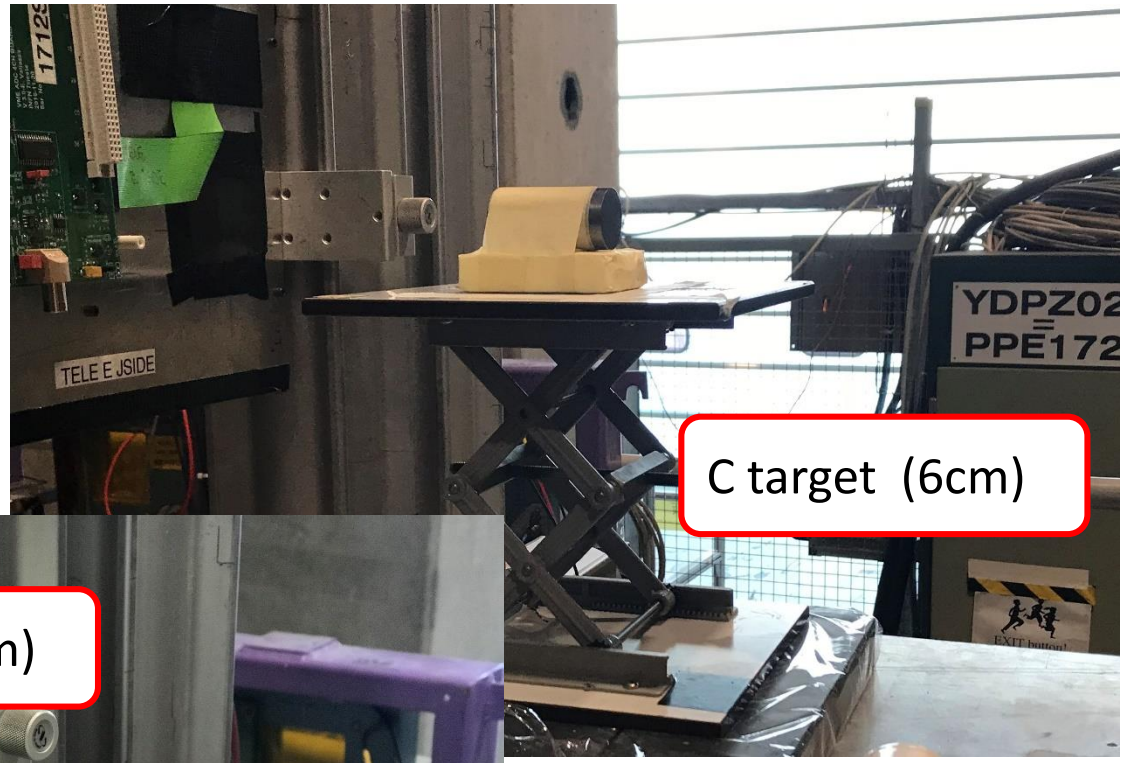
lead-glass
(3 blocks)

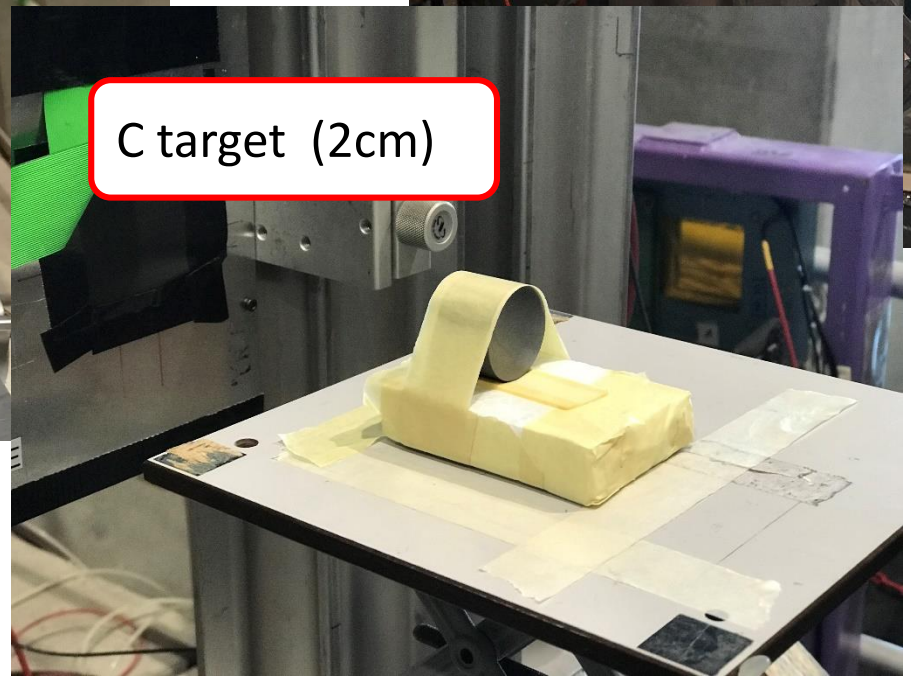


quartz
cherenkov

LEMMA Test Beam Setup - targets







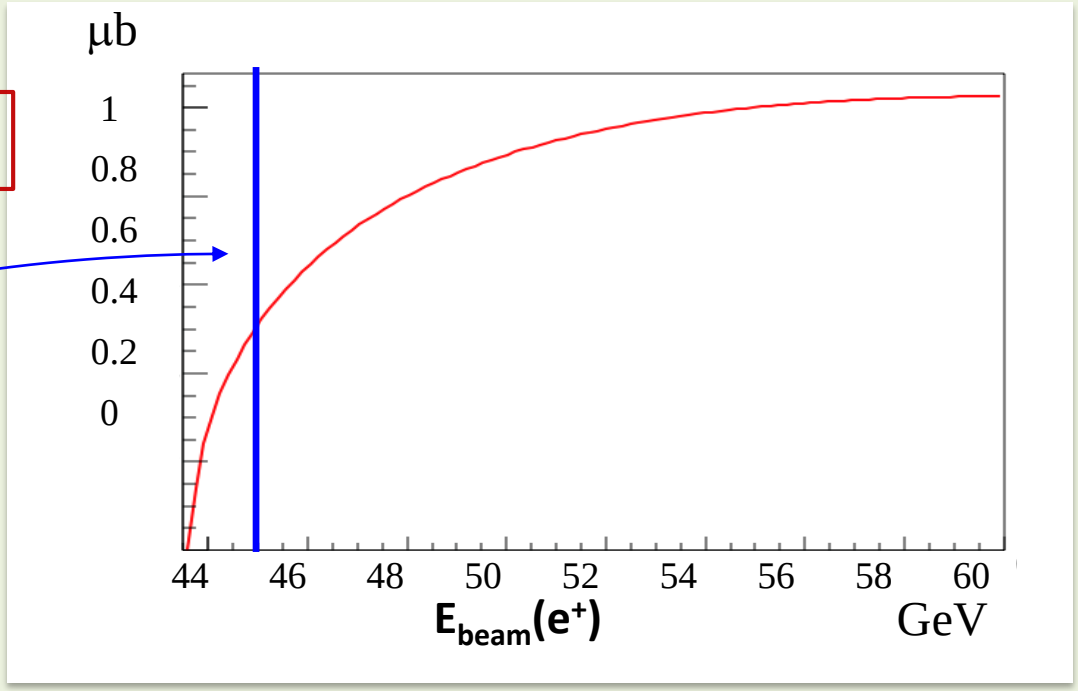
Test Beam Conclusions

- Data analysis quite complex → it requires time and will be done in the next months
- 5 days of smooth data taking (2 days at the beginning were necessary for the setup installation) → we collected several thousands of $\mu^+\mu^-$ events
- We took various runs with a different energy beam (45GeV, 46.5GeV, 49GeV) on Be target → possibly we will manage to complete the program and measure the xsec vs energy from threshold up to ~50GeV
- We took also runs with a different target (C target) with 45GeV positron beam, in 2 different configurations (2cm and 6cm target)

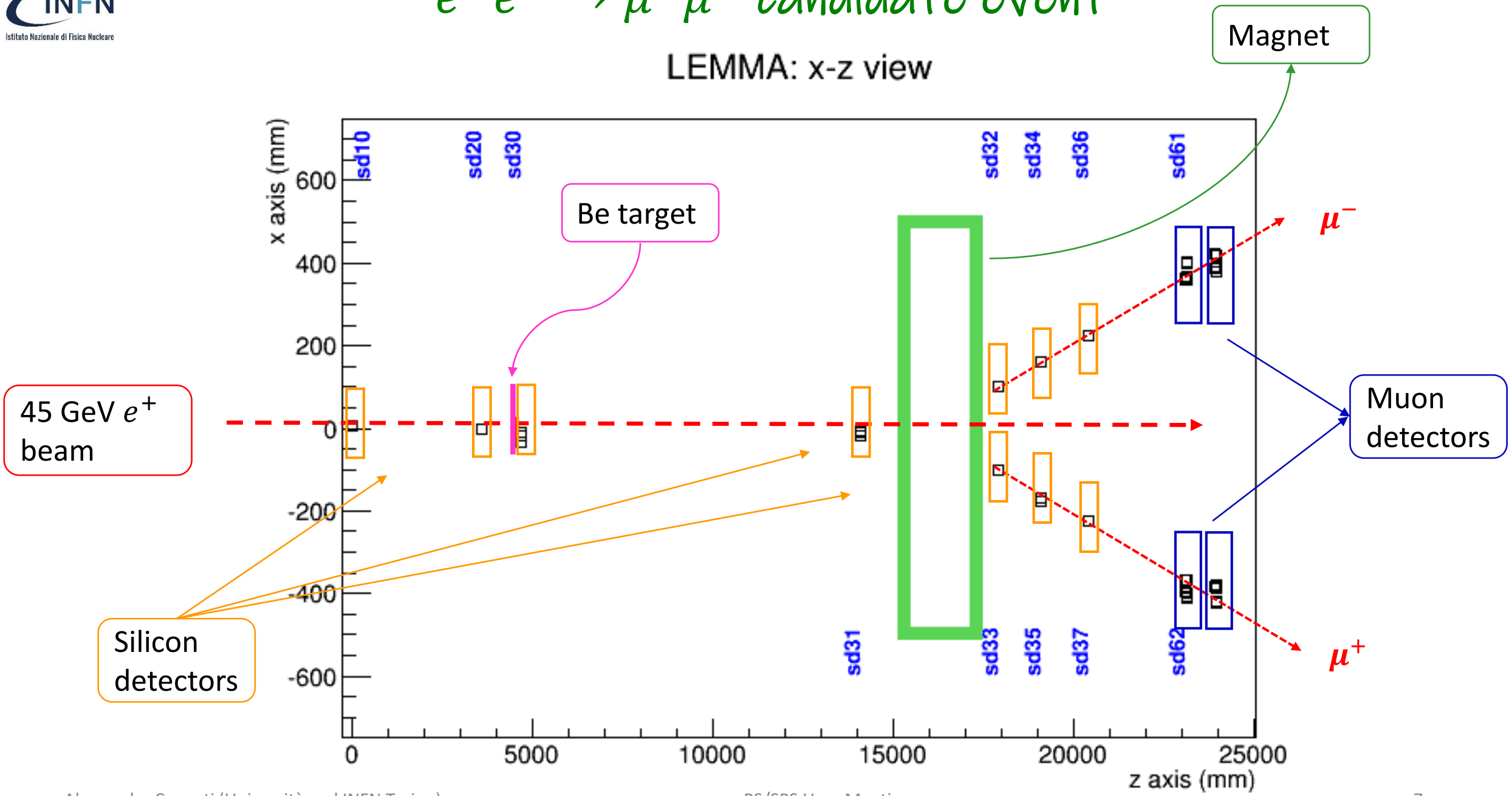
$$\sigma(e^+e^- \longrightarrow \mu^+\mu^-)$$

Working hypothesis:

$E(e^+) = 45\ \text{GeV} \Rightarrow \sqrt{s} \approx 214\ \text{MeV}$

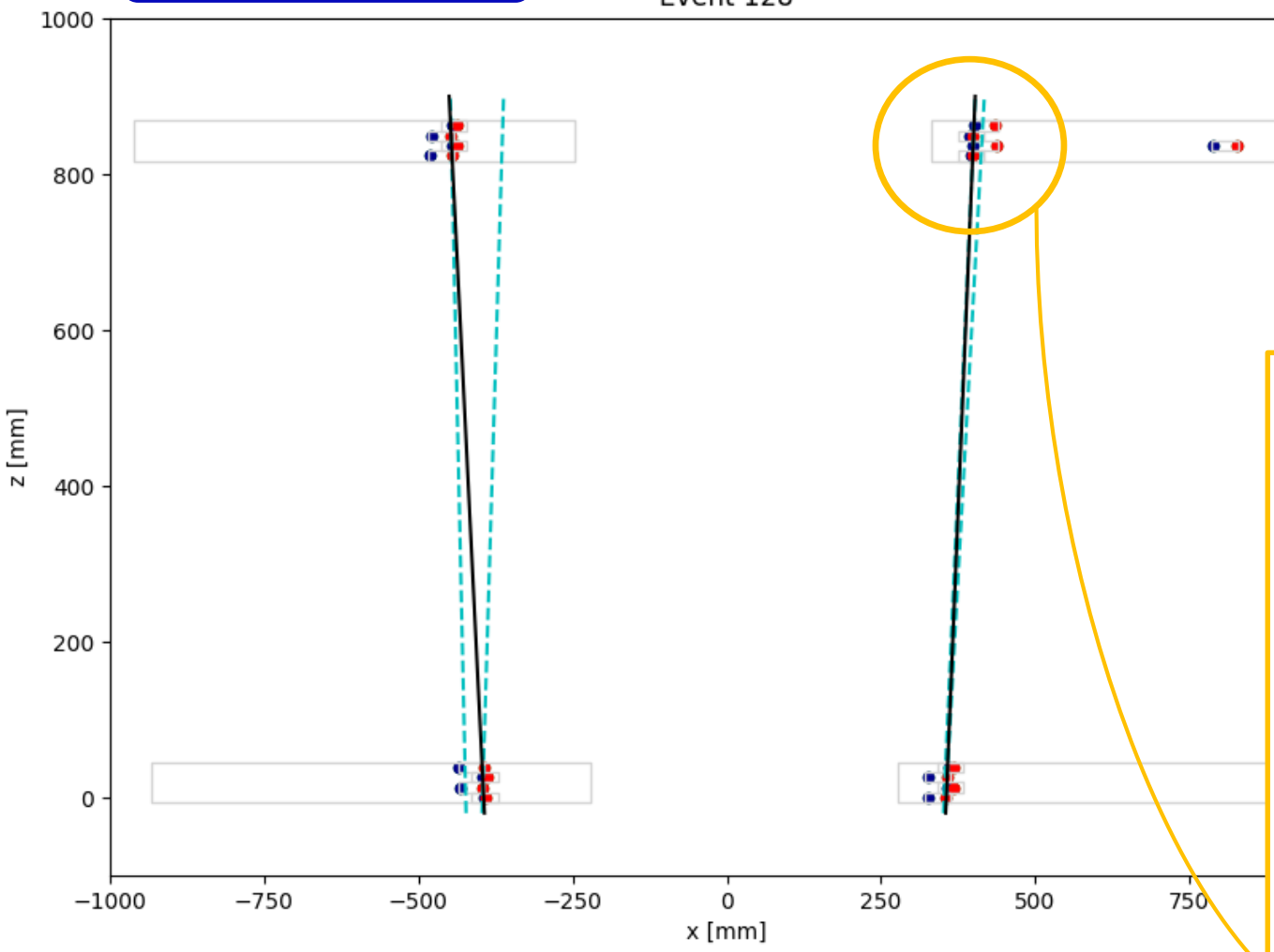


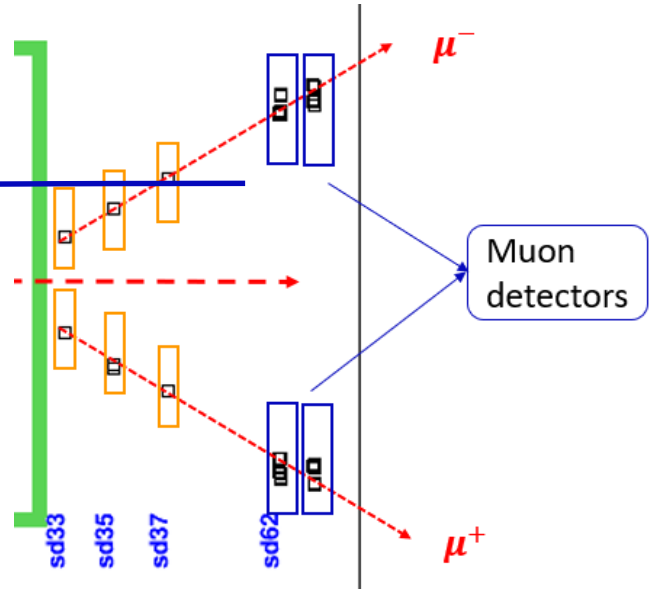
$e^+e^- \rightarrow \mu^+\mu^-$ candidate event

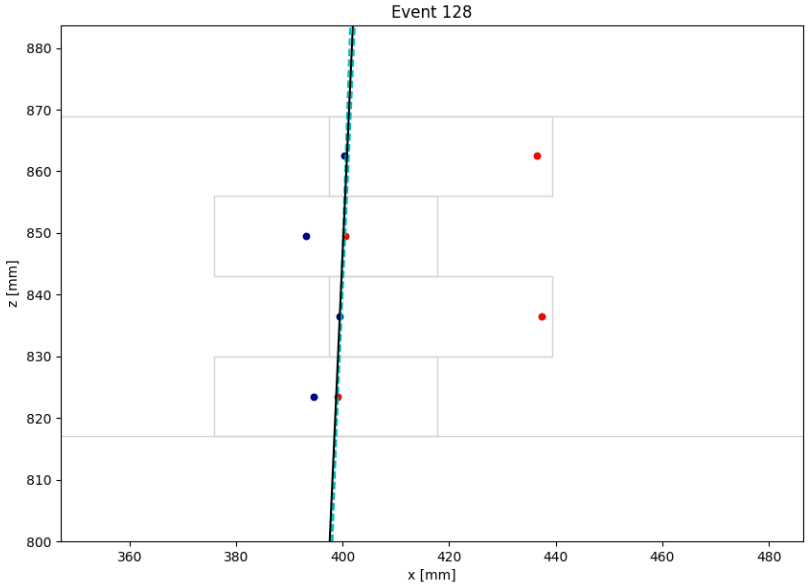


$e^+e^- \to \mu^+\mu^-$ candidate event - zoom

Muon detectors







Summary

- The process $e^+e^- \rightarrow \mu^+\mu^-$ near the production threshold has been studied with a 45 GeV e^+ beam on a Be target
- We did further measurements varying the beam energy and the target
- Collected data will be analyzed in order to measure momentum and emittance of outcoming muon pairs and other properties of the production process
- First events analyzed and presented are very promising

Acknowledgements

We would like to thank many people and groups that helped us and gave us this second opportunity:
- The SPS coordinator and staff for supporting us before and during the beam test
- Nikos and Bastien for providing a beam with the required features
- Nikos, Marcel, and the TE/MSC group for providing us the magnetic field map of the MBPL magnet
- Alexandre Beynel and the surveyors team for the geometry measurements
- Laza and CMS for having made space for our setup
- CMS, PHOTAG/AXIAL teams for kindly providing us some of their instruments
- All the technicians who prepared the experimental area