LEMMA (Low Emittance Mu+ Mu- Accelerator)

(July 26 – August 2, 2017)

LEMMA: novel approach to a muon collider, based on production of low-emittance $\mu^+\mu^-$ pairs by using positrons on target

Nucl. Instrum. Meth. A **807** (2016) [arXiv:1509.04454]

Proposal of the experiment: study critical aspects of the LEMMA concept

- **degradation of the positron beam properties crossing different targets**
- **measurement of muon beam properties**

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Physics motivations

- The muon collider represents an intriguing options for long term strategy of HEP.
- Alternative approaches to the most studied production of muon beams from π/K decays from proton interaction on targets should be explored.

- Low-emittance $\mu^{\pm}$ beams could be obtained in $e^+e^- \rightarrow \mu^+\mu^-$ processes, at a center-of-mass just above threshold, by means of a ~45 GeV positron beam impinging on the electrons of a target.
- Several critical aspects must be experimentally verified to validate the approach (*e.g.*):
  - optimization of the target features
  - degradation of the positron beams (in order to recirculate)
  - efficiency of the $\mu^+\mu^-$ production, and parameters of the produced beams

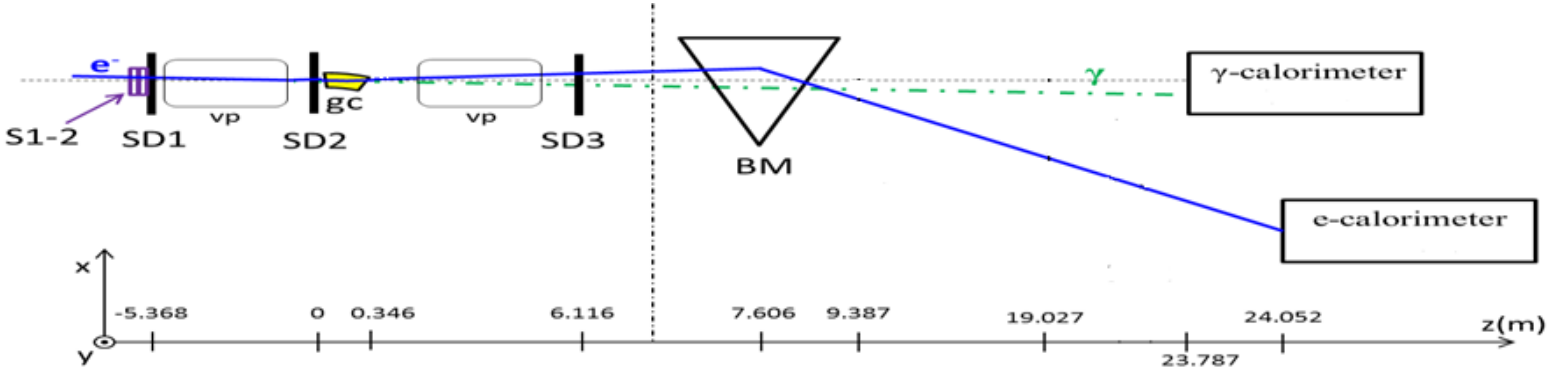
- The proposed experiments includes several measurements with different setups. In order to optimize the beam time two consequent periods with different beam intensities are envisaged:
  - Study of positron beam degradation: 1-2 days at low-intensity beam (45 GeV e^+)
  - Study of muon properties: 5-6 days with high-intensity e^+ beam (preceded by a short run with a ~22.5 GeV muon beam for alignment and calibration)

Day 1 & 2

Low-Intensity beam configuration

- Study of positron beam degradation, comparing results with different targets, including crystals in channeling regime
- Measure positron beam parameters downstream to the target
  - positrons energy spectrum and transverse emittance
  - energy distribution of radiated photons

Experimental setup: the same as PHOTAG/AXIAL (see presentation by Laura Bandiera), with different target and target-holder



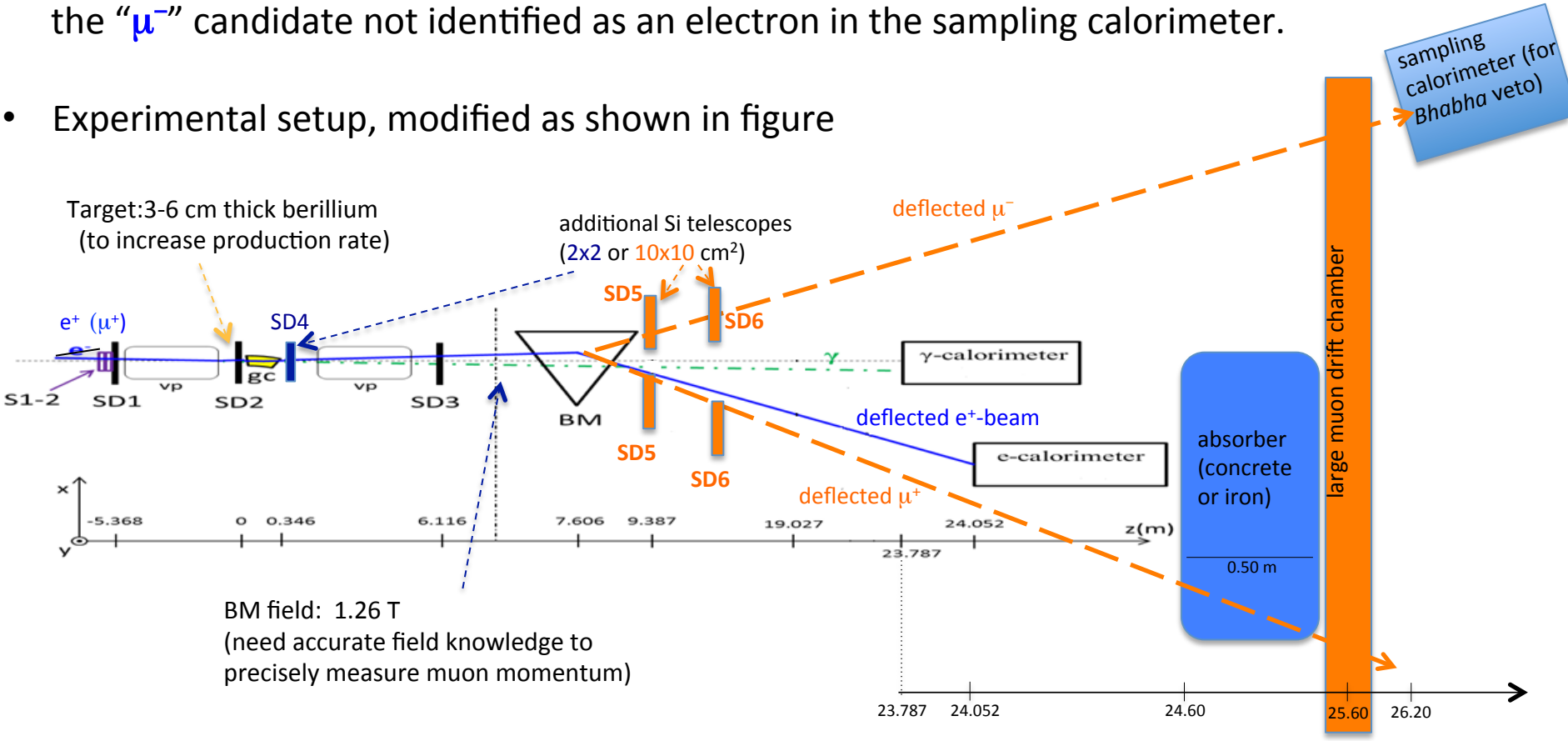
Optimal beam parameters:

- Particle type: positrons
- Energy: 45 GeV; energy spread ~1%
- Beam purity: ~99%

Day 2-7

High-Intensity beam configuration

- Study of kinematic properties of the produced muons
  - Measure the $\mu^+\mu^-$ production rate for the provided positron beam features (momentum and energy spread)
  - Measure muons momentum and emittance (need full tracking of muons)
- Signal events tagged with 2 (opposite charge) tracks in the muon chamber, and the "μ^-" candidate not identified as an electron in the sampling calorimeter.
- Experimental setup, modified as shown in figure



Day 2-7 High-Intensity beam configuration: requests

Beams

- Because of the very low **e+e- → μ+μ−** cross section (~0.4μb for a 45 GeV e^+) we need a beam with the highest possible intensity, and small spot size and energy spread:
  - 45 GeV momentum e^+ beam; energy spread ~1%; beam purity: ~99%
  - $5x10^6$ e+/spill; spot size: ~$1cm^2$ or less

  Under these conditions we expect about 5 event/spill with the 3cm-thick Be target
- For the alignment of muon trackers (SD5 & SD6) we would need $\mu^{\pm}$ beams of ~22.5 GeV, for a few hours at the begin of this test

We need to install several new detectors, that need handling and supports:

- SD4 (Si-tracker) can be hosted by the same supports that hold SD2 and the target
- The two SD5 should be placed as close as possible to the BM exit, while the two SD6 should be at a distance of ~4−5 meters from the BM exit. Both need a support or table
- The sampling calorimeter needs a table for positioning

- We need an iron absorber for stopping the *e+* beam in front of the muon chamber
- The two AXIAL calorimeters might be moved upstream of about 1.5 meters to free space for the new detectors

The BM field should be accurately measured for a precise measurement of the muon momenta: could this be provided?