LEMMA μ source - LoI Snowmass'21 - AF4 Multi-TeV colliders

- LEMMA source: $\mu^{\pm}$ production from a 45 GeV e^+ beam annihilating with e^- of a target close to threshold for pair creation, thus generating muon beams with low transverse emittance for a high energy collider
- Proposed R&D:
  - **TARGETS** → common to e^+ and $\mu^{\pm}$ source. Material studies and experimental tests. Prototype of rotational target (single thick target or ensemble of close thin targets) with an amorphous and a granular amorphous material. Hydrogen target (pellet) studies. Crystal targets studies for muons recombination and post-production cooling. **Synergy with AF7**, separate LoI to be presented by Roma I
  - **DESIGN OF EXTREME BRILLIANT e^+ SOURCE** → **synergy with AF7**, separate LoI to be presented by IJCLab (France)
  - **RF CAVITIES** → high gradient SCRF cavities able to cope with a high average train current (order of 100 mA). **Synergy with AF7**
  - **HIGH FIELD MAGNETS** → need to focus 45 GeV e^+ and 22.5 GeV $\mu^{\pm}$ together in a short low β-function IR → high gradient, large aperture and compact quadrupoles. Design of the multi-targets $\mu^{\pm}$ production line requires efficient 3-beams separation design, aiming at minimising particle losses, with high field, large aperture dipoles. **Synergy with AF1, AF7**
  - **MUON COOLING** → longer $\mu^{\pm}$ lifetime at production allows for introducing moderate cooling mechanism to further reduce production emittance. Different evaluations were done in the past for the cooling efficiency given by stochastic cooling, optical stochastic cooling, crystal cooling. A full revaluation of these mechanisms associated to high energy, low emittance and bunch current needs to be done. **Synergy with AF1, AF7**
  - **MUON RECOMBINATION** → testing muon bunches recombination techniques, that can increase the number of particle per bunch without been drastically affected by the consequent emittance increase. New hypothesis: possible recombination of different muon bunches by injection in a curved crystal. Combining the channeling angle with the volume reflection it should be possible to merge two different bunches with a relative emittance increase, mainly in the distribution tail. The efficiency of this process should be optimized. **Synergy with AF1, AF7**
  - **BEAM PHYSICS** → design e^+ and $\mu^{\pm}$ rings with very high energy acceptance, design of Interaction Region and Separation Region for 3 beams (e^+, μ^+, μ^-). **Synergy with AF1**

LEMMA new scheme in brief
arXiv:1905.05747v2 [physics.acc-ph]

- e^+ for first fill produced by Main e^+ source (MPS) and accelerated to 5 GeV for damping in a 5 GeV Damping Ring (DR)
- Acceleration to 45 GeV in a SC Linac or ERL and storage of 1000 e^+ bunches in a Positron Ring (PR)
- Extraction of e^+ bunches to one or more muon production lines, while produced muons are accumulated in two AR and a muon bunch is "built" by several passages through the targets, to be then delivered to the fast acceleration chain
- Re-injection and damping in the PR @45 GeV of the spent e^+ beam to save on the number of needed e^+, the MPS and a possible γ-embedded source will provide the refilling of lost e^+. Other option: send e^+ back to DR (through decelerating ERL) for damping and top-up