I.N.F.N.
ongoing activities and interests

International Collaboration to develop an integrated muon collider design concept that encompasses the physics, the detectors, and the accelerator

Nadia Pastrone

\[ \sqrt{s} = 3 \text{ TeV} \]

\[ \mu^+ \mu^- \rightarrow HH \nu\bar{\nu} \rightarrow b\bar{b}b\bar{b}\nu\bar{\nu} \]
Ongoing activities: Physics-Experiment

• **Physics Motivation**
  Direct/indirect discovery reach – VBF and VBS – precise Higgs measurements


  Benchmarks at different energies steer machine parameters and experiment design

• **Experiment and Physics Validation**
  Flexible framework - background simulation, detector simulation and event reconstruction
  \( \text{in use to study detector requirements/performances at different center of mass energies} \)

  First full-simulation study \( \mu\mu \rightarrow H\nu\bar{\nu} \rightarrow b\bar{b}\nu\bar{\nu} \) \( \sqrt{s} = 1.5 \text{ TeV} \) J. Inst. 15 P05001, 2020

  D.Lucchesi et al. + US-MAP + CLICdp the core team is growing + SnowMass21 interest

  ➤ **Machine Detector Interface:** beam induced background shaped by machine optics design
  \( \text{at different energies sets constraints on nozzles and experiment design and performances} \)

  10+ TeV is a completely new regime to explore!
Ongoing activities: Experiment-Detectors

- **Experiment Design and Detector R&D**
  Flexible framework to study detector requirements/performances at physics benchmarks
  R&D to exploit state of the art “5D” detectors and beyond are mandatory
  but in synergy with the on-going upgrade of existing experiments and new
  on-going developments with national and international grants
  INFN experts and infrastructures cover many crucial area of interest to be explored:
  – Sensors and read-out for trackers + timing (DMAPS, LGAD...)
  – Calorimeter developments
  – Exploit new ideas for muon detection
  – Common software tools for simulation and reconstruction also ML techniques

*P. Andreetto, N. Bartosik, A. Bertolin, L. Buonincontri, M. Casarsa, F. Collamati,
C. Curatolo, A. Gianelle, D. Lucchesi, N. Pastrone, C. Riccardi, P. Sala, L. Sestini, I. Vai
++ al. joining*

Strong synergy within the **new submitted EU project** AIDAinnova
Ongoing activities: MDI - Machine

**Machine Detector Interface**
Optics design required as part of the collider parameters studies. Fix constraints on nozzles design. Simulation tools. Strong collaboration with CERN.

_F.Collamati, et al. + A.Mereghetti CERN_

**Neutrino Radiation Hazard Studies**
Preliminary full FLUKA simulation: $\mu$ decay (ring/straight sections), $\nu$ interactions. Checked scaling law. Next: simulations with realistic ring geometries and new orbits design. Strong collaboration with machine design.

_Alfredo Ferrari, Anna Ferrari, P. Sala et al._

Dose from 1 TeV $\mu^\pm$ vs distance from ring, pSv/10$^{10}$ decays
Ongoing activities: LEMMA Source

- **Positron-based Muon Source – LEMMA**
  - Positron production and acceleration, muon targets, muon accumulation
    
    *M.Antonelli, M.E.Biagini, M.Boscolo, S.Guiducci, P.Raimondi, A.Variola et al.*
    

  - Positron source studies – collaboration with IJCL + *A.Bacci, I.Drebot et al.*
    
    also on crystal applications: *L.Bandiera, A.Mazzolari et al.*

  - Material simulations and studies for positron and muon production targets
    
    *M.Antonelli, R.Li Voti, G.M. Cesarini et al.* + PoliTO + other interested

    measurements and R&D planned using beam at LNF and CERN

  - Muon accumulator optics and multi-target new layout + *O.Blanco, A. Ciarma*:
    

  - CERN test beam to evaluate targets and emittance *J. Inst. 15 P01036, 20*
    
    ➔ new proposal to run at CERN in 2022 with improved set-up
    
    + *N.Amapane, F. Anulli, A.Bertolin, M.Zanetti et al.*

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Resource plan towards a pre-CDR submitted by Alessandro Variola (10/19)

need consolidation to prove feasibility
to overcome technical limitations and reach higher muon intensities
Interests: Machine

• Fast-ramping SC magnet systems for accelerator ring

• Material studies for targets

• Crystals manufacturing for targets and collimation

Strong synergy within the **new submitted EU project I.FAST**

 ➔ **MUST** – MUon colliders Strategy network

*INFN, CERN, CEA, CNRS, KIT, PSI, UKRI*

*Delivery*: International collaboration plans towards a multi-TeV muon collider

• **Synergies on exploiting neutrino beams at facilities**
  *M.Bonesini, G.Catanesi, D.Orestano, L.Tortorici et al.*
INFN groups involved and starting

- Laboratori Nazionali di Frascati
- Milano
- Padova
- Roma1 – collaboration with SBAI
- Roma3
- Torino – collaboration with PoliTO
- Trieste

- Bari
- Bologna
- Cagliari
- Ferrara
- Genova
- Laboratori Nazionali di Legnaro
- Milano Bicocca
- Pavia
- Pisa