Physics opportunities and detectors at Future Colliders

First ECFA-INFN Early Career Researchers Meeting
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on behalf of INFN Pavia

INFN Pavia activity

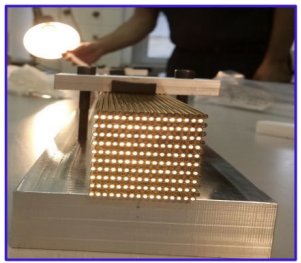
CSN 1
- RD_FCC
- RD_MUCOL

CSN4
- QFT@Colliders

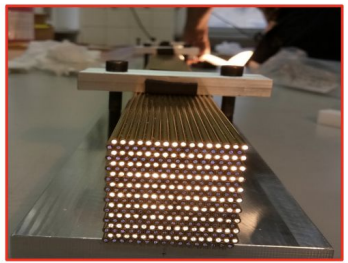
CSN5
- HiDRa2

Dual readout activity - HiDRa

- Dual-readout calorimeter exploits the combination of cherenkov and scintillation light emission in order to estimate the electromagnetic fluctuations in the hadronic showers.
- Pavia is building the prototype of the fibre dual-readout hadronic calorimeter HiDRa (high-granularity dual-readout).
- HiDRa has an high granularity core, readout with SiPM, and readout by PMT in the external ring.
- A prototype has been tested last year (in figure) in a test beam at cern and next August a new test beam has been planned for testing HiDRa.



scintillating fibres

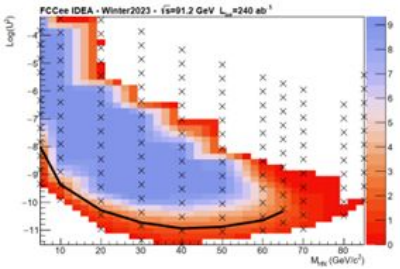


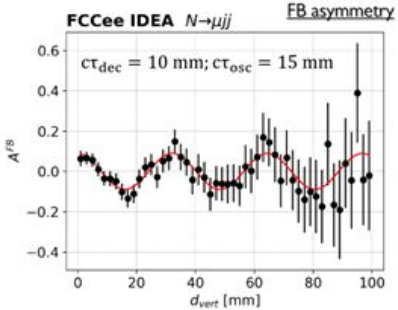
Cherenkov fibres

Physic studies for FCC-ee

Heavy neutrino production and characterization of model parameters

- Channel: Z→Nν, N→μjj
- Simulated in IDEA, in order to extract reach, discovery limits and detector requirement (hadronic resolution, timing)
- Several analyses:
  - Sensitivity to the discovery in all mass spectrum accessible to FCCee (run Z-pole)
  - Mass measurement through time flight
  - Sensitivity to oscillation N→$\overline{\text{N}}$ and Dirac/Majorana nature





Precision luminosity measurements with BabaYaga@NLO

$$\sigma^i_{\text{exp}} = \frac{N^i_{\text{obs}}}{\mathcal{L}} \qquad \frac{\delta\mathcal{L}}{\mathcal{L}} = \frac{\delta N^0_{\text{obs}}}{N^0_{\text{obs}}} \oplus \frac{\delta\sigma^0_{\text{th}}}{\sigma^0_{\text{th}}}$$

- 10^{-4} target precision on luminosity measurements
  - $e^+e^- \to e^+e^-$ at Small Angle NNLO QED
  - $e^+e^- \to \gamma\gamma$ at Large Angle NLO EW

  [Carloni et al., CERN Yellow Report (2020), 71-76]

- BabaYaga@NLO Monte Carlo generator
  can simulate all luminosity processes at 0.1% theoretical precision at NLO+PS matched at $O(\alpha)$
  [Carloni et al., *Nucl.Phys.B* 758 (2006) 227-253]

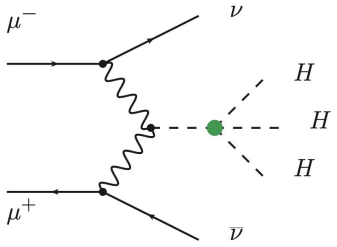
- Future developments
  NNLO QED corrections, Weak corrections to all processes [arXiv:2203.12557]

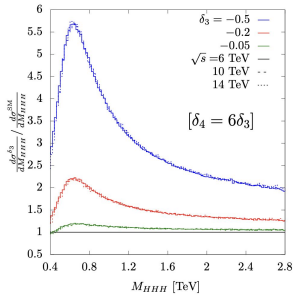
- WG2 ECFA Higgs Factory Studies
  [arXiv:2401.07564]

Muon Collider activity

Multi Higgs production at multi-TeV MuCol

[arXiv:2003.13628][arXiv:2109.10109]





$$V(H) = \frac{1}{2}m_H^2 H^2 + \lambda_3 v H^3 + \frac{1}{4}\lambda_4 H^4$$

- Sensitivity to deviation from the SM quartic self-coupling
  - Study of SMEFT dim-6 operators effect
  - Sensitivity to realistic phase-space cuts and luminosity
- Study of differential distribution for HHH
  - Direct access to quartic coupling
- Expected O(50%) uncertainty on λ_4

Muon Detector

- Performance studies of muon detector
  - Efficiency reconstruction in presence of «beam induced background» (BIB): single muon, ZZ*, HZ
  - Continuing develop algorithm of muon reconstruction
- R&D on Picosec Micromegas technology for muon detector:
  - The Picosec Micromegas detector combines a Cherenkov radiator, a photocathode and a Micromegas-based amplification stage into a high-precision timing detector.
  - Tested a prototype of single channel and with at test beam at CERN, where gas mix and radiator have been studied.
  - Time resolution of single photon have been studied with several photocathods, radiators and gas mixture.