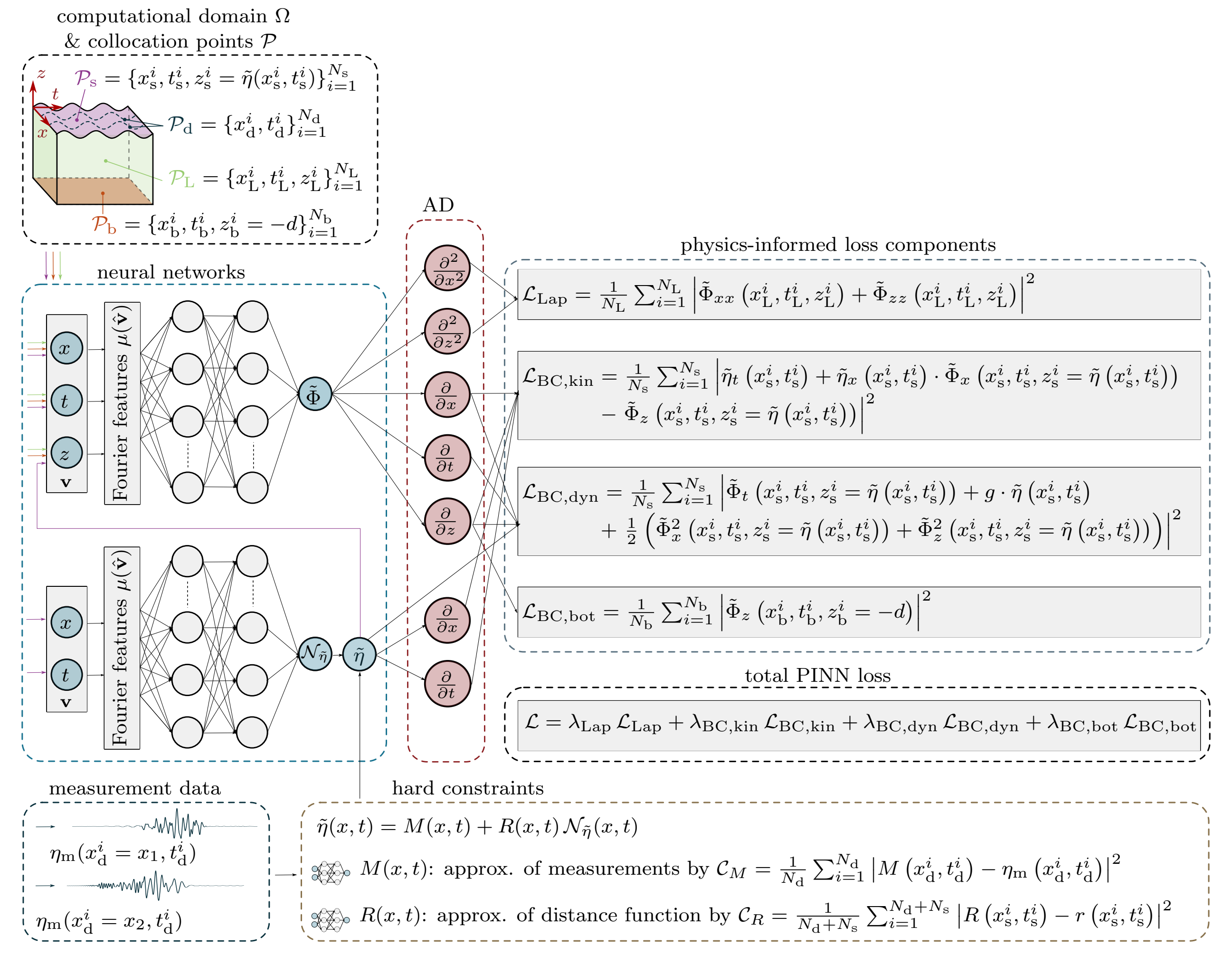

computational domain Ω
& collocation points $\mathcal{P}$
$\mathcal{P}_\mathrm{s} = \{x_\mathrm{s}^i, t_\mathrm{s}^i, z_\mathrm{s}^i = \tilde{\eta}(x_\mathrm{s}^i, t_\mathrm{s}^i)\}_{i=1}^{N_\mathrm{s}}$
$\mathcal{P}_\mathrm{d} = \{x_\mathrm{d}^i, t_\mathrm{d}^i\}_{i=1}^{N_\mathrm{d}}$
$\mathcal{P}_\mathrm{L} = \{x_\mathrm{L}^i, t_\mathrm{L}^i, z_\mathrm{L}^i\}_{i=1}^{N_\mathrm{L}}$
$\mathcal{P}_\mathrm{b} = \{x_\mathrm{b}^i, t_\mathrm{b}^i, z_\mathrm{b}^i = -d\}_{i=1}^{N_\mathrm{b}}$
neural networks
Fourier features $\mu(\hat{\mathbf{v}})$
$\tilde{\Phi}$
$\mathcal{N}_{\tilde{\eta}}$
$\tilde{\eta}$
AD
physics-informed loss components
$\mathcal{L}_\mathrm{Lap} = \frac{1}{N_\mathrm{L}} \sum_{i=1}^{N_\mathrm{L}} \left| \tilde{\Phi}_{xx}\left(x_\mathrm{L}^i, t_\mathrm{L}^i, z_\mathrm{L}^i\right) + \tilde{\Phi}_{zz}\left(x_\mathrm{L}^i, t_\mathrm{L}^i, z_\mathrm{L}^i\right) \right|^2$
$\mathcal{L}_\mathrm{BC,kin} = \frac{1}{N_\mathrm{s}} \sum_{i=1}^{N_\mathrm{s}} \left| \tilde{\eta}_t\left(x_\mathrm{s}^i, t_\mathrm{s}^i\right) + \tilde{\eta}_x\left(x_\mathrm{s}^i, t_\mathrm{s}^i\right) \cdot \tilde{\Phi}_x\left(x_\mathrm{s}^i, t_\mathrm{s}^i, z_\mathrm{s}^i = \tilde{\eta}\left(x_\mathrm{s}^i, t_\mathrm{s}^i\right)\right) - \tilde{\Phi}_z\left(x_\mathrm{s}^i, t_\mathrm{s}^i, z_\mathrm{s}^i = \tilde{\eta}\left(x_\mathrm{s}^i, t_\mathrm{s}^i\right)\right) \right|^2$
$\mathcal{L}_\mathrm{BC,dyn} = \frac{1}{N_\mathrm{s}} \sum_{i=1}^{N_\mathrm{s}} \left| \tilde{\Phi}_t\left(x_\mathrm{s}^i, t_\mathrm{s}^i, z_\mathrm{s}^i = \tilde{\eta}\left(x_\mathrm{s}^i, t_\mathrm{s}^i\right)\right) + g \cdot \tilde{\eta}\left(x_\mathrm{s}^i, t_\mathrm{s}^i\right) + \frac{1}{2}\left(\tilde{\Phi}_x^2\left(x_\mathrm{s}^i, t_\mathrm{s}^i, z_\mathrm{s}^i = \tilde{\eta}\left(x_\mathrm{s}^i, t_\mathrm{s}^i\right)\right) + \tilde{\Phi}_z^2\left(x_\mathrm{s}^i, t_\mathrm{s}^i, z_\mathrm{s}^i = \tilde{\eta}\left(x_\mathrm{s}^i, t_\mathrm{s}^i\right)\right)\right) \right|^2$
$\mathcal{L}_\mathrm{BC,bot} = \frac{1}{N_\mathrm{b}} \sum_{i=1}^{N_\mathrm{b}} \left| \tilde{\Phi}_z\left(x_\mathrm{b}^i, t_\mathrm{b}^i, z_\mathrm{b}^i = -d\right) \right|^2$
total PINN loss
$\mathcal{L} = \lambda_\mathrm{Lap}\,\mathcal{L}_\mathrm{Lap} + \lambda_\mathrm{BC,kin}\,\mathcal{L}_\mathrm{BC,kin} + \lambda_\mathrm{BC,dyn}\,\mathcal{L}_\mathrm{BC,dyn} + \lambda_\mathrm{BC,bot}\,\mathcal{L}_\mathrm{BC,bot}$
measurement data
$\eta_\mathrm{m}(x_\mathrm{d}^i = x_1, t_\mathrm{d}^i)$
$\eta_\mathrm{m}(x_\mathrm{d}^i = x_2, t_\mathrm{d}^i)$
hard constraints
$\tilde{\eta}(x,t) = M(x,t) + R(x,t)\,\mathcal{N}_{\tilde{\eta}}(x,t)$
$M(x,t)$: approx. of measurements by $\mathcal{C}_M = \frac{1}{N_\mathrm{d}} \sum_{i=1}^{N_\mathrm{d}} \left| M\left(x_\mathrm{d}^i, t_\mathrm{d}^i\right) - \eta_\mathrm{m}\left(x_\mathrm{d}^i, t_\mathrm{d}^i\right) \right|^2$
$R(x,t)$: approx. of distance function by $\mathcal{C}_R = \frac{1}{N_\mathrm{d}+N_\mathrm{s}} \sum_{i=1}^{N_\mathrm{d}+N_\mathrm{s}} \left| R\left(x_\mathrm{s}^i, t_\mathrm{s}^i\right) - r\left(x_\mathrm{s}^i, t_\mathrm{s}^i\right) \right|^2$