

# Echo State Network for Dynamic Aperture prediction

*jeudi 21 novembre 2024 16:10 (25 minutes)*

The technological advance of today's storage rings and colliders elevated nonlinear beam dynamics to the forefront of accelerator design and operation. In the field of single-particle beam dynamics, the concept of dynamic aperture (DA), that is, the extent of the phase-space region where bounded motion occurs, is a key observable to guide the design of present, e.g. the CERN Large Hadron Collider (LHC) [2], and future machines (see e.g. [8–15]). Determining how to describe and efficiently predict the value of the DA might solve some fundamental problems in accelerator physics, linked to performance optimization of storage rings and colliders. The high computational cost of direct numerical simulations would be significantly reduced if a reliable model for the time evolution of the DA were available.

In [1], we have investigated the ability of an ensemble reservoir computing approach based on Echo State Networks (ESN) to predict the long-term evolution of DA in hadrons storage rings. We present here further studies aiming to automatize as much as possible the search for optimal data splitting and ESN hyper-parameters for DA application.

References :

- [1] M. Casanova, B. Dalena, L. Bonaventura, and M. Giovannozzi, Ensemble reservoir computing for dynamical systems: Prediction of phase-space stable region for hadron storage rings, *The European Physical Journal Plus*, 138 (2023).  
<https://doi.org/10.1140/epjp/s13360-023-04167-y>
- [2] O.S. Brüning, P. Collier, P. Lebrun, S. Myers, R. Ostojic, J. Poole, P. Proudlock, LHC design report. CERN Yellow Rep. Monogr. CERN, Geneva (2004).  
<https://doi.org/10.5170/CERN-2004-003-V-1>
- [3] R. Appleby, et al., Dynamic aperture studies of the nuSTORM FFAG ring, in *Proceedings of IPAC'14 (JACoW Publishing, Geneva)*, pp. 1574–1577.  
<https://doi.org/10.18429/JACoW-IPAC2014-TUPRI013.pdf>  
<https://jacow.org/IPAC2014/papers/TUPRI013.pdf>
- [4] Y.C. Jing, V. Litvinenko, D. Trbojevic, Optimization of dynamic aperture for hadron lattices in eRHIC, in *Proceedings of IPAC'15 (JACoW Publishing, Geneva)*, pp. 757–759.  
<https://doi.org/10.18429/JACoW-IPAC2015-MOPMN027.pdf>  
<https://jacow.org/IPAC2015/papers/MOPMN027.pdf>
- [5] B. Dalena, et al., First evaluation of dynamic aperture at injection for FCC-hh, in *Proceedings of IPAC'16 (JACoW Publishing, Geneva)*, pp. 1466–1469.  
<https://doi.org/10.18429/JACoW-IPAC2016-TUPMW019.pdf>  
<https://jacow.org/ipac2016/papers/TUPMW019.pdf>

**Auteurs principaux:** Mme DALENA, Barbara (CEA/IRFU/DACM); Prof. BUGIOTTI, Francesca (Centrale-Supélec/LISN); BRUANT, Quentin (CEA/IRFU/DACM); GAUTARD, Valérie (CEA-Irfu)

**Orateur:** GAUTARD, Valérie (CEA-Irfu)

**Classification de Session:** ML for accelerators

**Classification de thématique:** Simulations and surrogate models : replacing an existing complex physical model