Project Progress Review (PPR) 4-2025

WP-02 : Dynamique faisceau

Présenté par: J. Michaud, pour toute l'équipe dynamique faisceau

26 Juin 2026

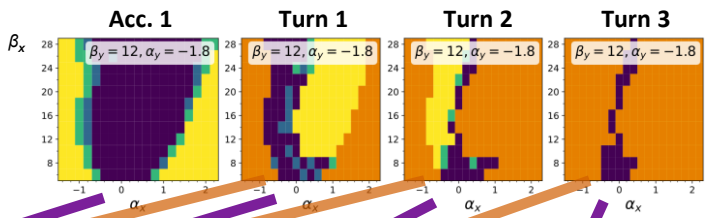
PERLE Lattice

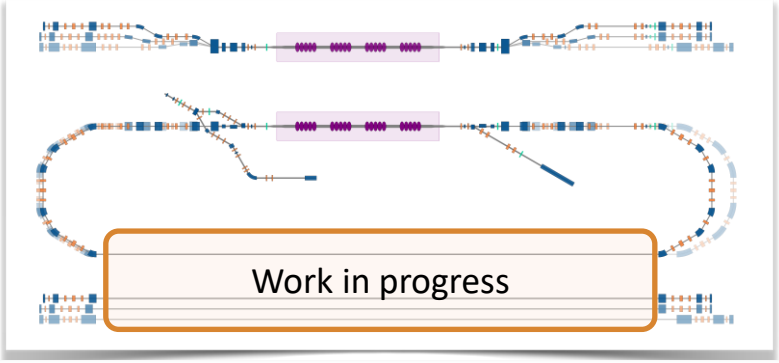
Current status

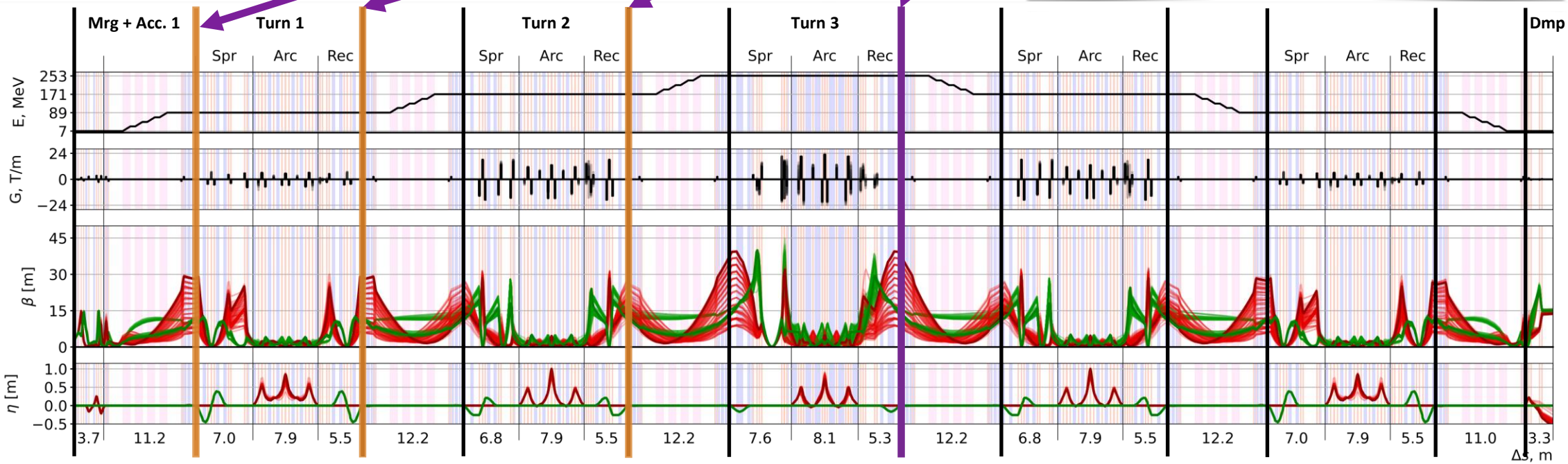
- 3 turn optics (no Straight sec.) matched with flexibility: found all solution respecting major constraints

Ongoing:

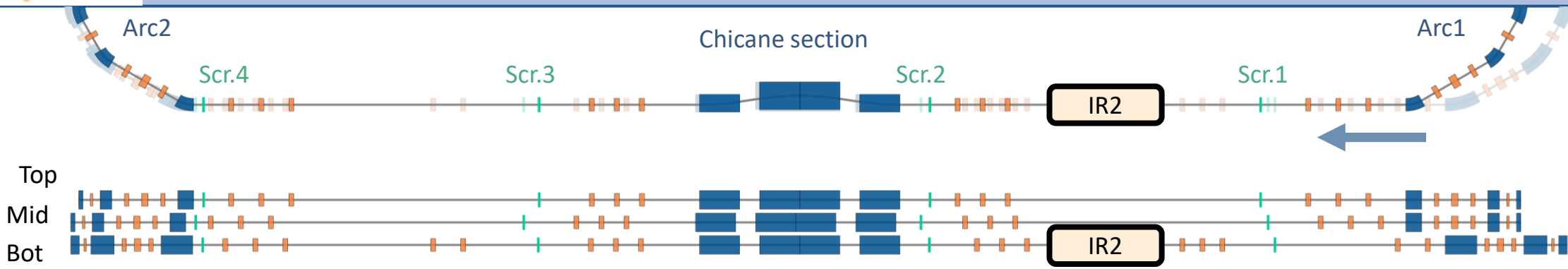
- Design/matching of **3 straight section** with full flexibility (for all tunes)





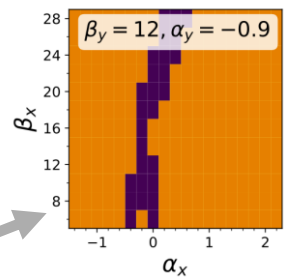


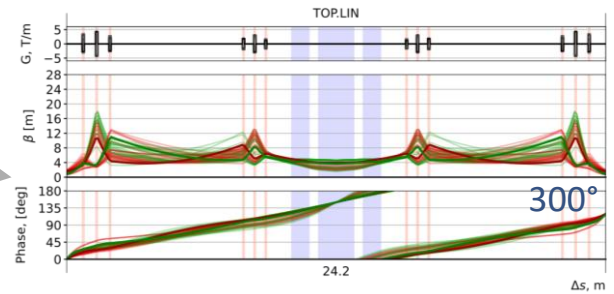
Lattice Design — Three Straight sections

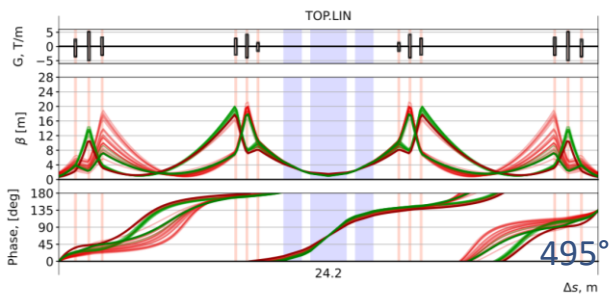


Structure

- Top.Lin (89 MeV) : symmetric, 4 quadruple triplets → **12 quads**
- Mid.Lin (171 MeV) : symmetric, 4 quadruple triplets → **12 quads**
- Bot.Lin (89, 253 MeV) : 2 + 3 + 3 + 3 + 2 + 3 → **16 quads**
- All Lines : chicane sections + 4 screens → **9 dipoles** + **16 screens**



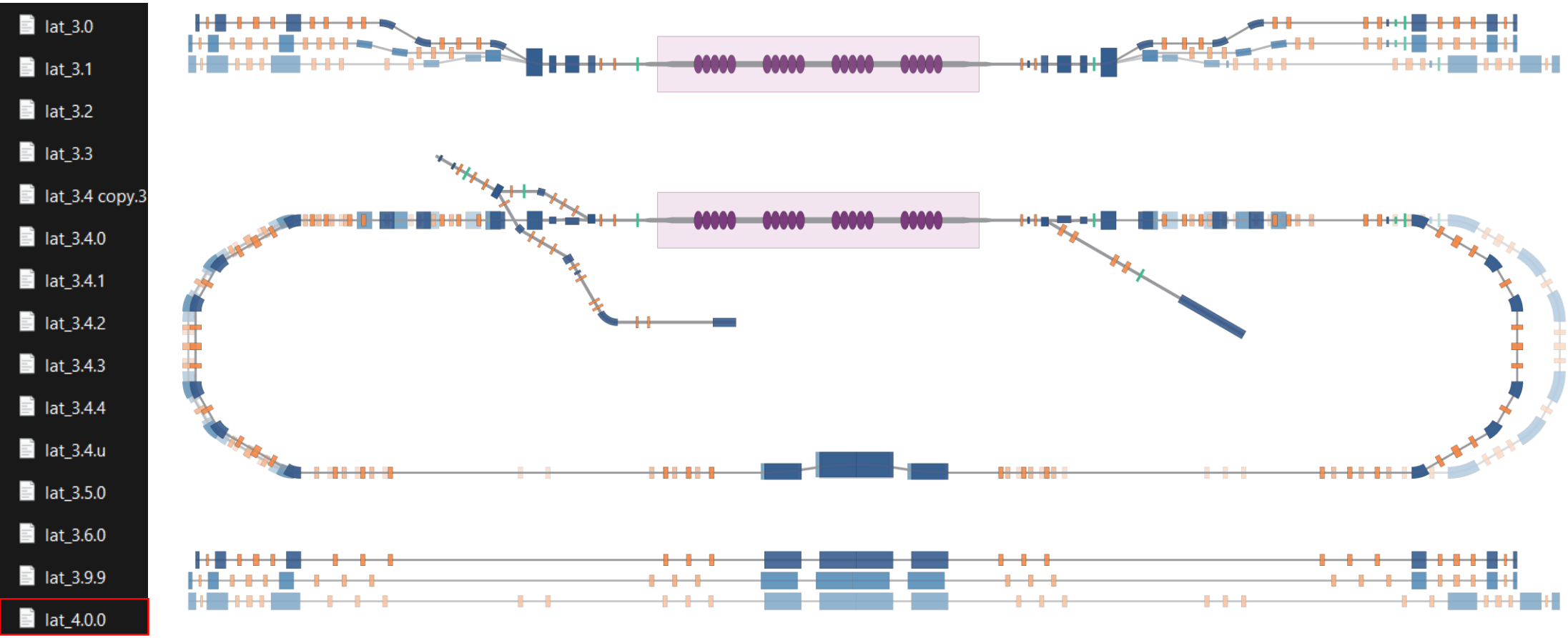




Capabilities:

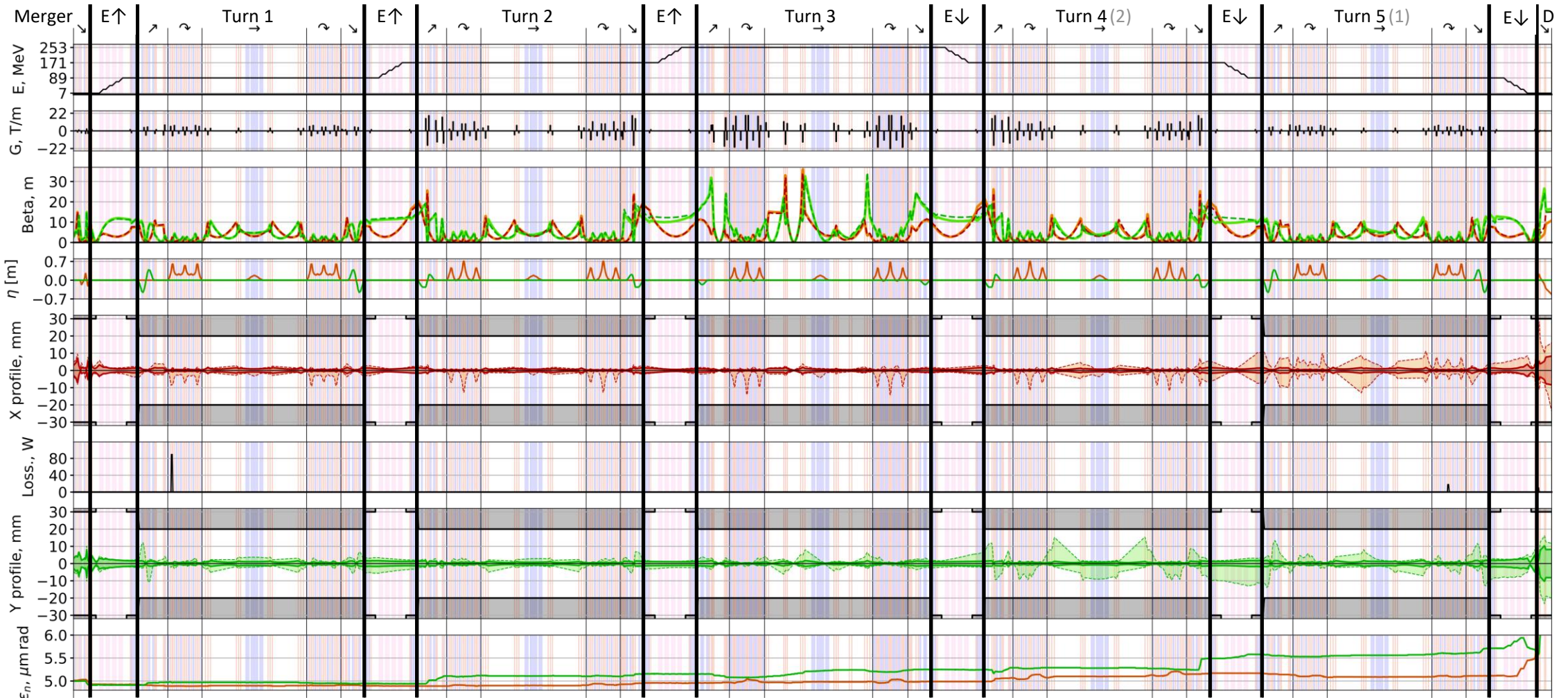
- Flexible matching for **all valid compact-section optics solutions**
- **Transverse phase control** : full 180° rotation in x/y planes → beam **tomography** + **transmission** optimization
- **Longitudinal phase control** : ± 20° (± 20.8 mm) → beam optimization for **transmission and experiments**

Avancement du lattice – version 4.0



Version finale du lattice ➔ vérification **finale** avec la méca

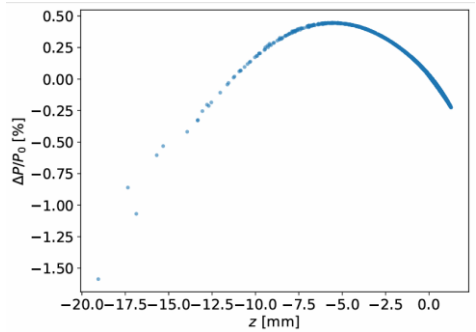
PERLE Lattice v4.0.0 — BMAD Tracking



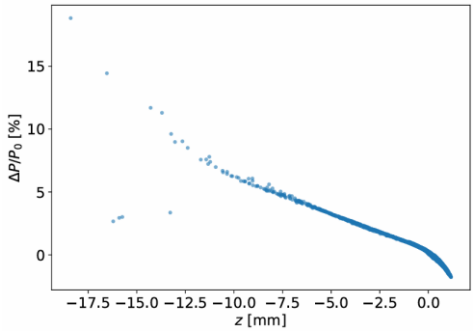
Dynamique longitudinale (thèse Janine)

Absolute Time-Tracking:

After deceleration: Without Time tracking



After deceleration: With Time tracking



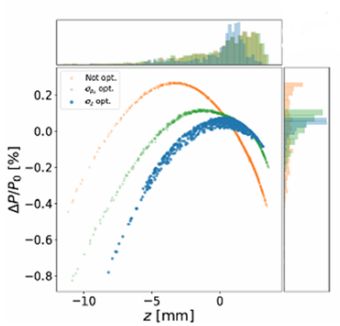
Ongoing Studies:

Adjusting path length leading to deceleration

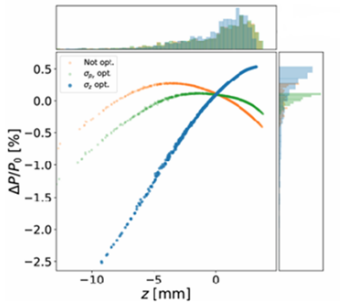
Longitudinal matching at IPs (1 Tour machine) :

- Done with absolute Time tracking
- Introduced a chirp through cavity phase
- Added R56 by Tuning quadrupoles in the merger and arc sections

IP1

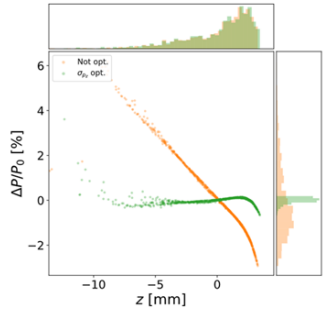


IP2



$\sigma_z: 3mm \rightarrow 2.73mm$
$\sigma_{pz}: 0.2\% \rightarrow 0.17\%$

After Deceleration



Future studies :

- Longitudinal matching for 3 tour machine
- RF field maps

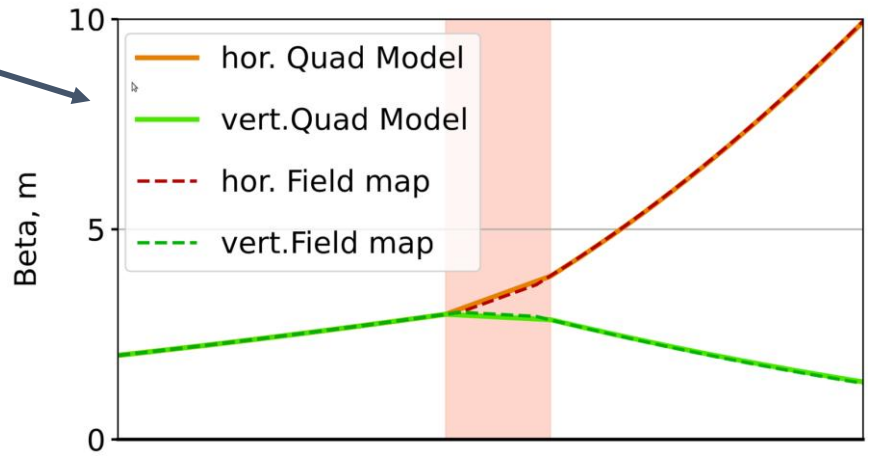
Etude des non linéarités et pertes faisceaux (thèse Arnaud)

Objectif : Étudier l'impact des non-linéarités des aimants du merger sur la formation du halo et les pertes de faisceau dans l'accélérateur.

- **Remplacer les modèle de quadrupole par des cartes de champ (FM)**
  ->Faire correspondre optiquement le model Bmad et la FM
  -> Retuner le merger avec les quad Bmad équivalent FM
  -> Lancer le tracking avec les FM et observer les formation de Halo via le Hfactor
  (-> Réaliser ensuite l'étude avec des mauvais alignements du booster)

- **Comparer les FM avec des modèles multipolaires**
  -> Objectif : simuler la lattice réelle plus rapidement qu'avec les FM

- **Comprendre les différences entre le modèle et les**
- **données fournies par Rasha**
  -> Longueur du modèle quad ~7 cm, et 8.46 cm fournie par Rasha



Reproduction de la field map avec un modèle de quadrupole de Bmad
-> écart de l'odre de 10^-5 dans le plan horizontal et de 3% dans le plan vertical.

Assessing Corrector-Integrated Quadrupoles for PERLE

THP2103 (A. Fomin)

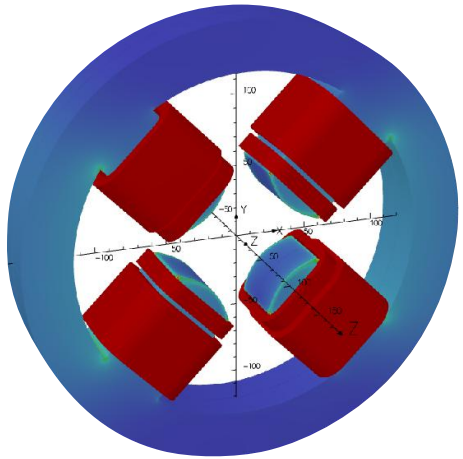
Compact correctors → **nonlinear off-axis fields**

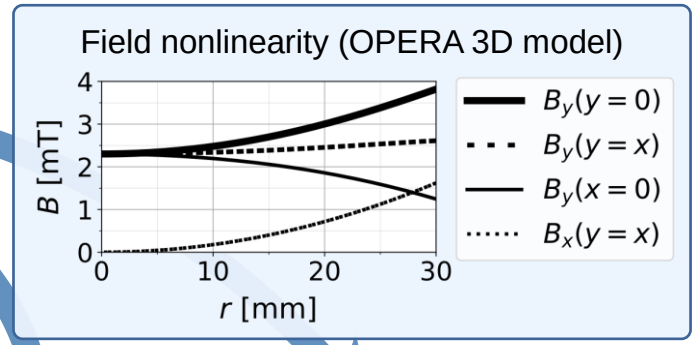
Beam size trade-off: space charge ↔ halo from nonlinearity

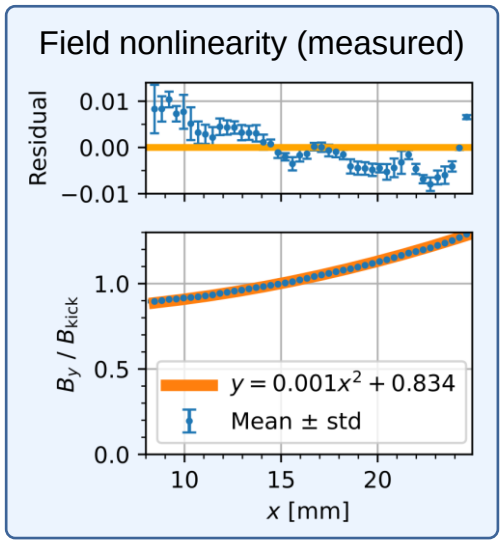
cERL kick maps (measured) → real-field validation

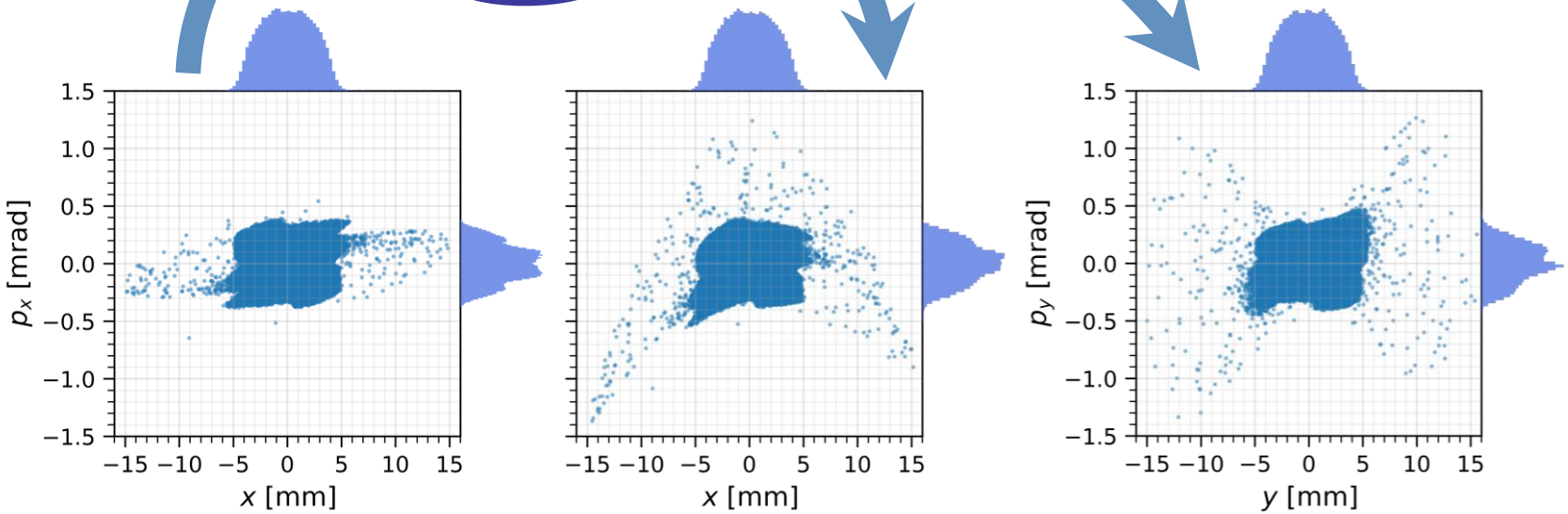
OPERA + BMAD → emittance, steering, halo impact

→ Design limits & lattice placement for PERLE









WP2 contributions :

- **R. Abukeshek** *: Design and Operational Flexibility of the PERLE Injection Chicane for Multi-Energy Operation*
- **A. Cieplak** *: Halo formation and beam losses*
- **A. Fomin** : *Optics Flexibility and Diagnostics in the PERLE Lattice Design*
- **J. Issa** *: Longitudinal Matching and Timing Control Studies for the Three-Turn PERLE ERL*
- **J. Michaud, invited** *: PERLE beam dynamics studies*

Simulation toolkit

OISTERs : *Orsay-based Interface and Simulation Toolkit for Energy Recovery Systems*

- Simulation (bmad)
- Analyse
- Visualisation
- User-friendly
- Fonctionne pour toutes les machines (PERLE, ThomX…)

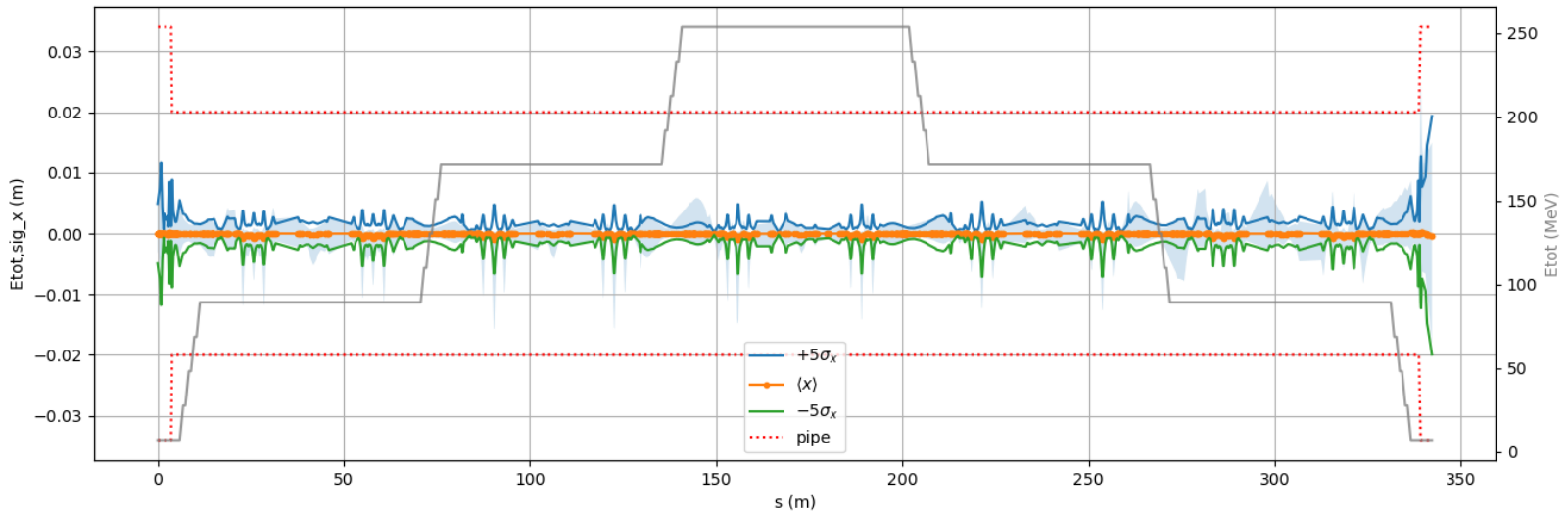
Visualisation efficace

Initialization

Load Lattice | Reload | Simulate | Simulation Name: | Tracking is OFF

Display

Graph



(x, y) = (111.7, -0.0055) | (111.7, 110.2)

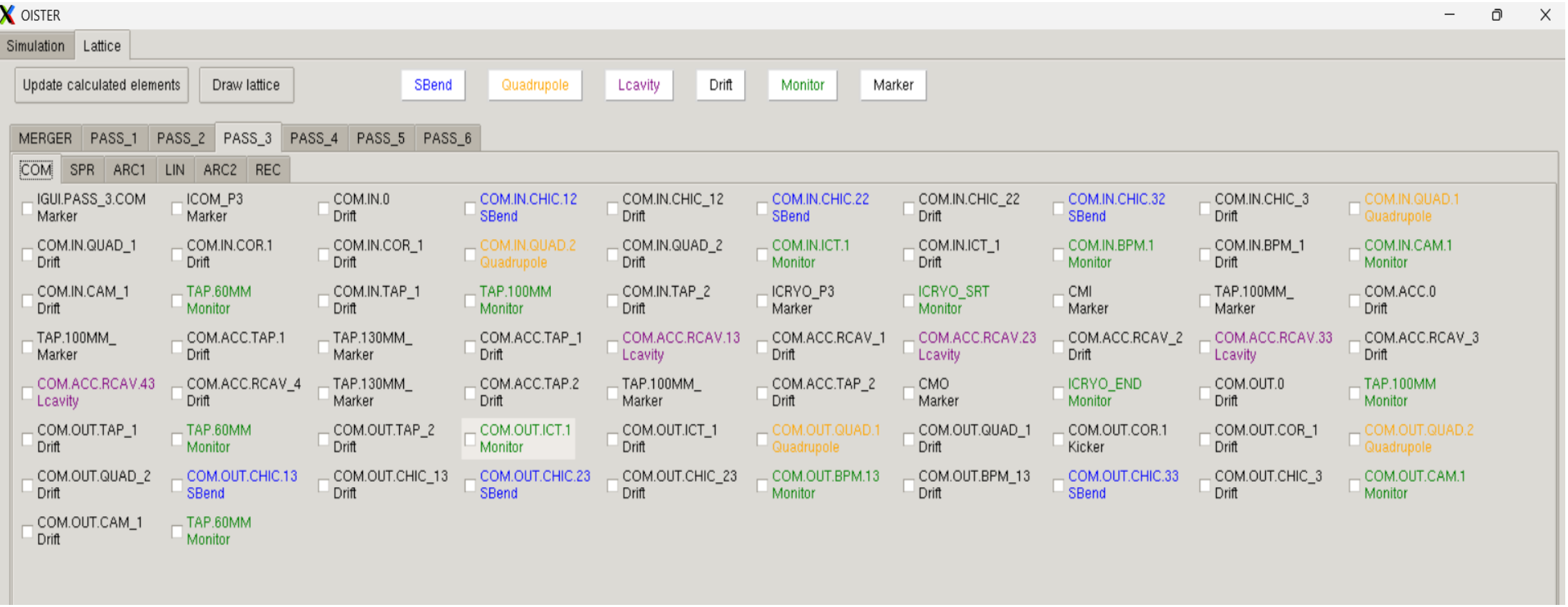
Console

```
Selected file: /bronze/bimp/JMichaud/Per
le/OISTER/lattice_init/tao.init
Working directory set to: /bronze/bimp/J
Michaud/Perle/OISTER/lattice_init
Initializing Tao with command: -init /br
onze/bimp/JMichaud/Perle/OISTER/lattice_
init/tao.init -noplot
Tao initialized successfully.
Number of particles: 10000
Number of particles: 10000
Number of particles: 10000
Number of particles: 10000
Number of particles: 10000
```

Send

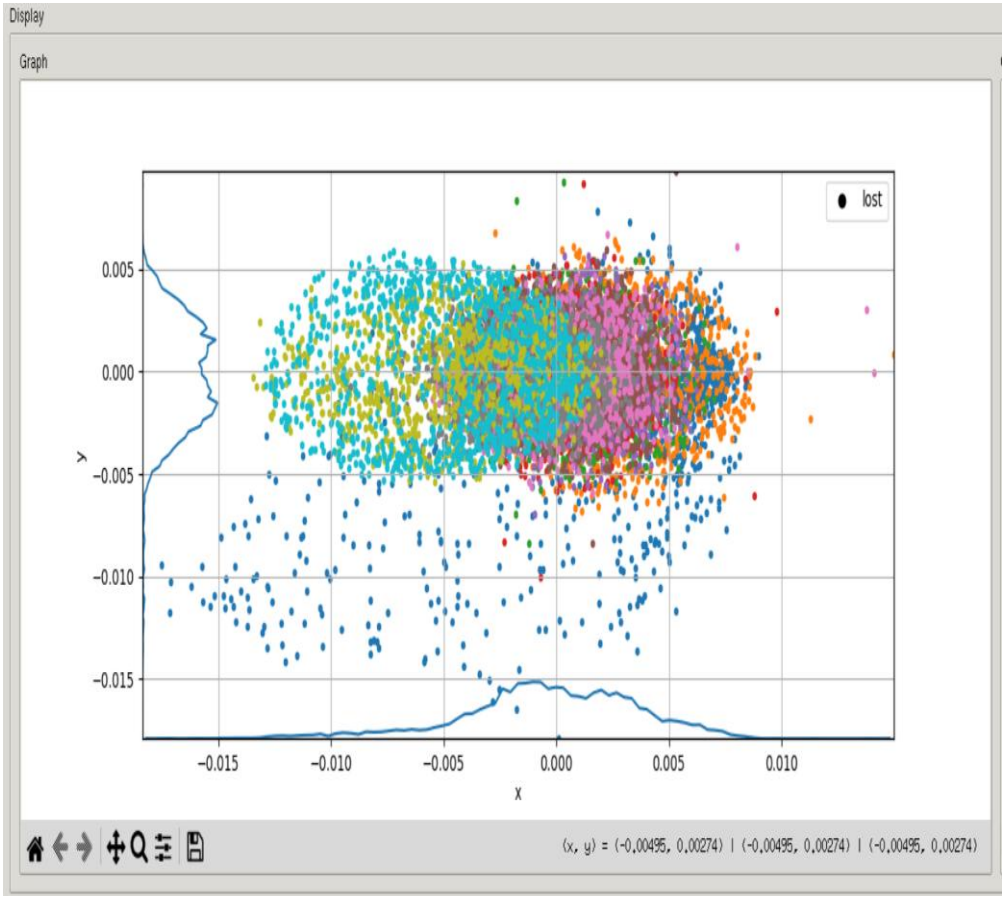
User-friendly

Importe le lattice. Choix de l'élément puis affichage



Simulation/visualisation/analyse

x/y at dump



z/E at DESTIN