Work Package 2 : Accelerator Design

WP2: Accelerator Design

Task 2.1: Lattice and optics	Task 2.2: Beam Dynamics	Task 2.3: PERLE Footprint

Sub-systems

Injection line	• Source • booster • buncher • Connection section
Main ERL	• LINAC • Arcs
Extraction lines	• Extraction section • Junction line to users • Junction line to dump
Full design	• Optics / beam dynamic • Footprint

- **Task leader : IJCLab : Luc Perrot / Jlab : Alex Bogacz**
- **IJCLab members on WP2**
  - Alex Fomin, IN2P3 Post-doc, since February 2022, 100%
  - Rasha Abukeshek, UPSay-IJCLab PhD, WP2 & WP6, 100%
  - Julien Michaud, CNRS researcher, from November 2022, 100%
  - Coline Guyot, UPSay-IJCLab PhD, 50% (Christelle Bruni, CNRS)
- **Partners to WP2**
  - Bertrand Jacquot, CNRS GANIL-SPIRAL2, 30% for WP2
  - Hadil Abualrob, prof. An-Najah National Univ. (Palestine), WP6 lead.
  - Rodolphe Marie, IJCLab workshop, mechanic
  - Connor Monaghan, PhD at Liverpool University, October 2022
  - Robert Apsimon, Cockcroft Institute (UK)
  - Peter Williams, STFC Daresbury (UK)

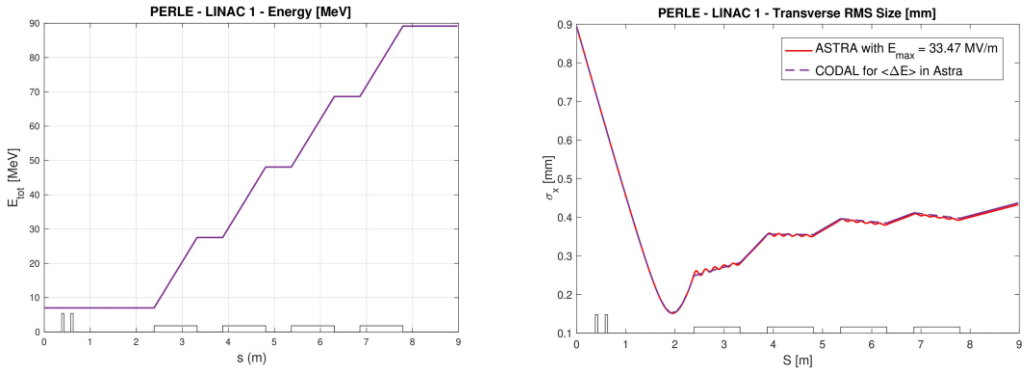
Work Package 2 : Accelerator Design

From last collaboration meeting

- Full knowledge of the 500 MeV ERL design
- 250 MeV ERL studies
- First longitudinal studies on the way to mitigation of collective effects
- Feeling pattern solutions studies
- Interaction points possibilities

Longitudinal beam dynamic from 7MeV to 82MeV with field-map & calculation tool

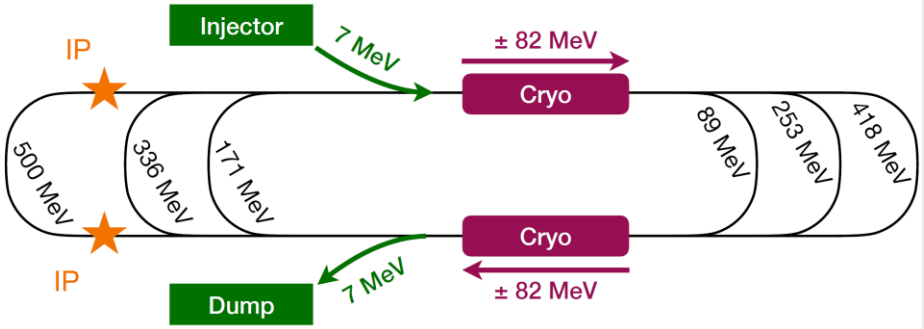
Coline Guyot work

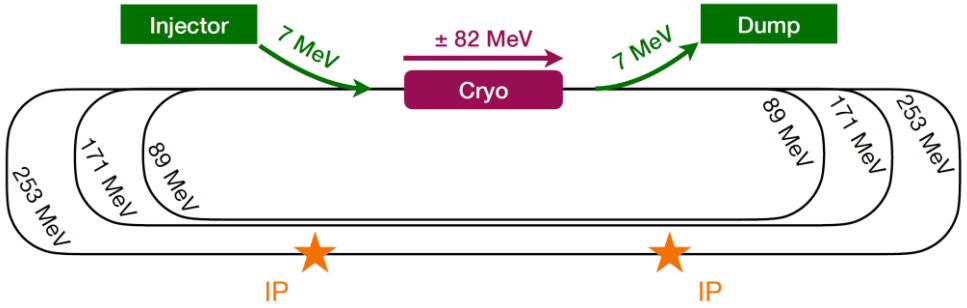


From 250 MeV to 500 MeV stage

Alex Fomin work (see talk + ERL2022 poster)

- Is it 2 different machines specially from integration & costing ?
- We decide to flip the machine : simpler for IP regions (valid for 250 & 500 MeV)
- 250 MeV is it fine for beam physics with 6 passes ?
- 250 MeV seems fine for applications/users (ex. DESTIN project)
- Only One feeling Pattern will be choose

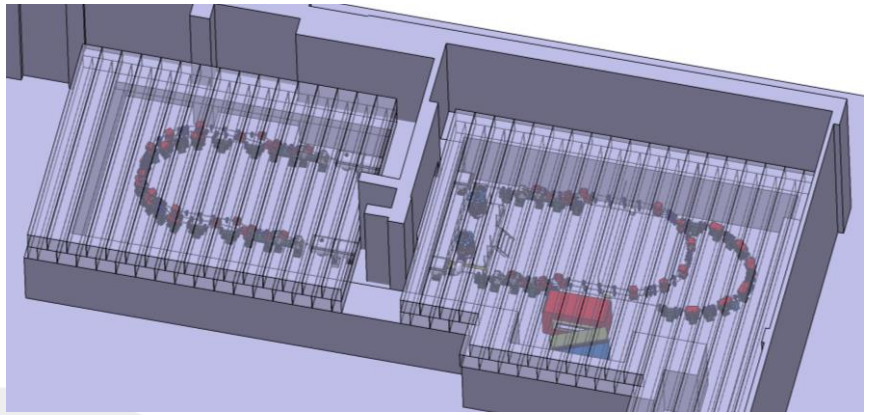




Work Package 2 : Accelerator Design

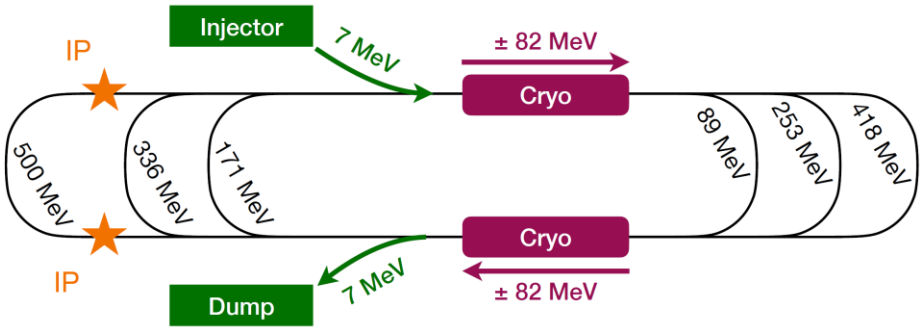
➢ TDR objectives : full accelerator design and crucial topics

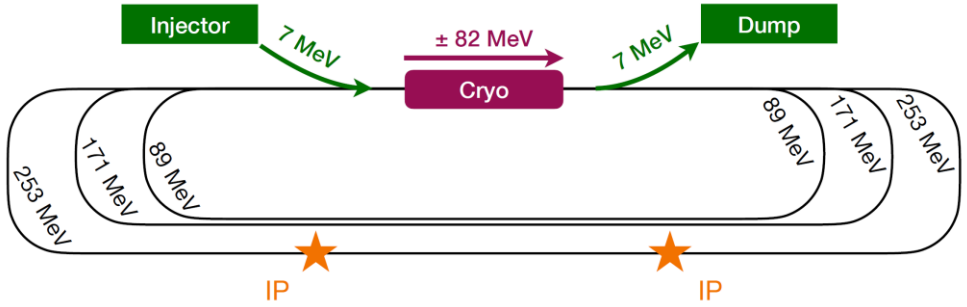
- Fix the optimal filling pattern
- Injection line and merger final design
- Diagnostics types, location and specification
- Interaction point specifications
- Nonlinear aberrations corrections with multipole magnets
- Momentum acceptance and longitudinal match
- Start-to-End simulation with CSR & micro-bunching
- Beam Break-up Instability studies
- Space-charge studies from injection to ERL
- Multi-particle tracking studies, error effects and halo formation
- Impedance analysis and wakefield effect mitigation
- Particle cloud



➢ We have now human resources to reach the TDR objectives

500 MeV → 250 MeV ?





Pros:

→ **reduction of immediate expenses** (second cryo-module and 18 dipoles can be purchased later)

→ **demonstration of ERL with 6 paths at high current** (same as in 500 MeV version, but with half of the power)

→ more space for experimental areas

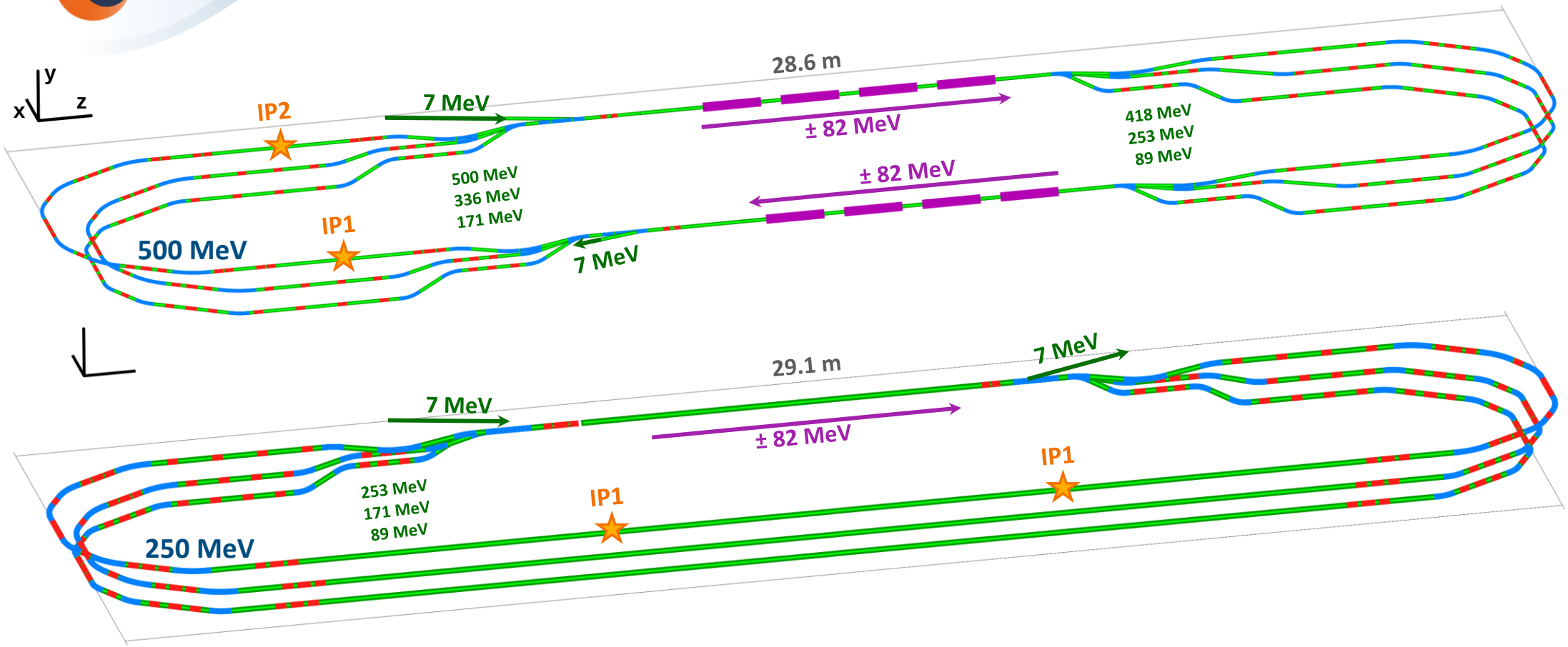
Cons:

→ **additional expenses / manpower / shutdown time** (rebuilding / recommissioning for the full power machine)

→ about 30m of extra beam pipes (all other main elements are chosen to be compatible with both versions)

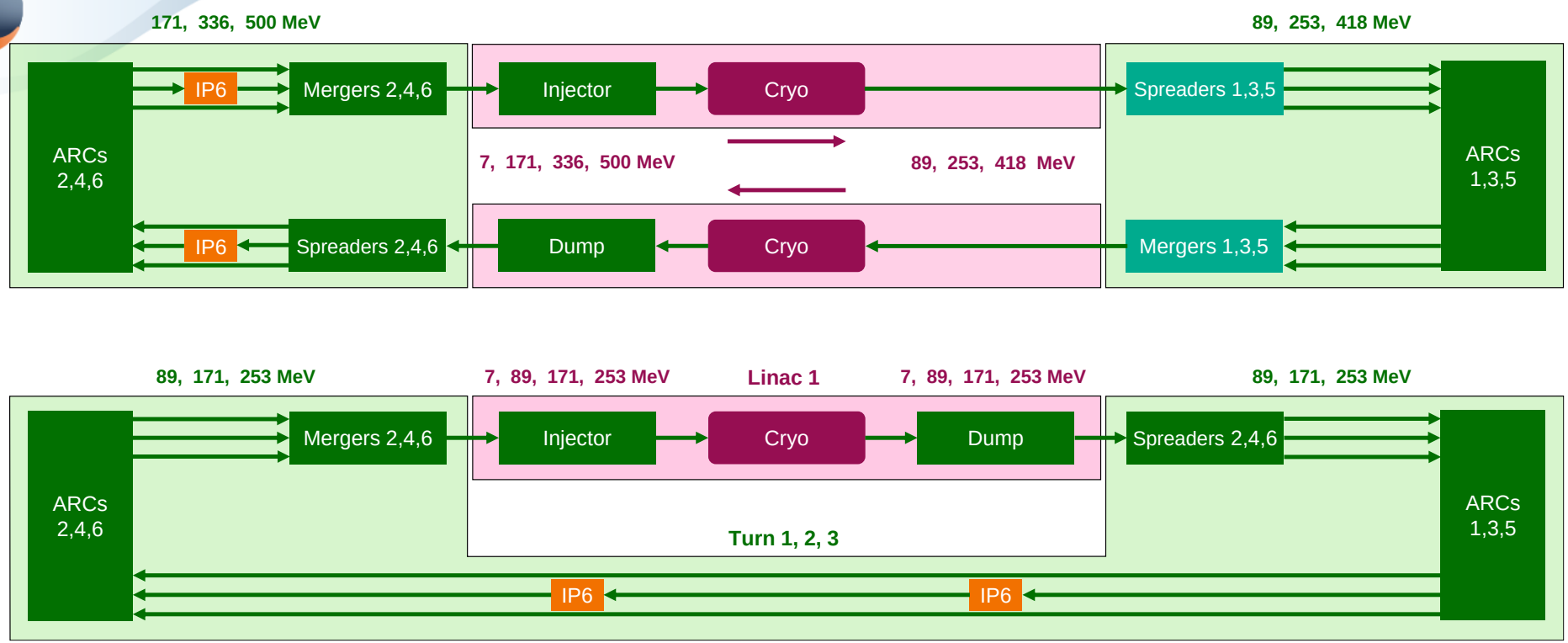
→ a slightly larger footprint ( )

Lattice design. 500 MeV vs 250 MeV versions



* Flipping the lattice vertically → IP with access from the top

Lattice design. 500 MeV vs 250 MeV versions



500 MeV (two cryo-modules)

- two common sections: Injector+Cryo (~10m) and Cryo+Dump (~10m)
- two Spreader and two Merger sections

250 MeV (one cryo-module)

- one common sections: Injector+Cryo+Dump (~12m)
- one Spreader and one Merger sections

Conclusions

Lattice design of 250 MeV version of PERLE

- **compatible with the upgrade to 500 MeV version** (the same elements used, only about 30 meters of extra beam pipes)
- **reduced immediate expenses** (second cryo-module and 18 dipoles can be purchased later)
- **demonstration of ERL with 6 paths at high current** (same as in 500 MeV version, but with half of the power)
- more space for experimental areas
- **additional expenses / manpower / shutdown time** (rebuilding / recommissioning for the full power machine)

Filling pattern (Arc optics architecture)

- the optimal filling pattern for 500 MeV version requires extra space (28.6 m → 30.6 m)
  but current configuration is fine (Alex Bogacz, Peter Williams, Robert Apsimon)
- for the 250 MeV version we consider the optimal filling (more essential at lower energies, inline with the optics)

Benchmarking codes for lattice design and beam dynamics simulation

- small difference between Optim6 and MadX calculations of dipole fringe field effect (~1% correction of the quad field)
- longitudinal beam dynamic from 7MeV to 82MeV with field-map & calculation tool (work of Coline Guyot)

Open questions regarding PERLE energy @ 250 MeV % 500 MeV

Must be see as 2 different machines => various ways

- Did we go to a ERL at 250 MeV maximum ?
- Did we go directly to a ERL at 500 MeV ?
- Stage at 250 MeV before 500 MeV :
  - Beam dump location not the same : safety impact
  - Magnets & supply : same as 500 MeV at the beginning
  - When go to 500 MeV To build & buy : 2nd cryomodule, 2 spreader/merger sections, diag, mechanics, supply …
  - Shut-down time for mounting/installation/authorization (around 1 year)
  - Need to do commissioning at stage 250 MeV and 500 MeV
- Cost impact is changing with the chosen way : build systems, human resources availability => €