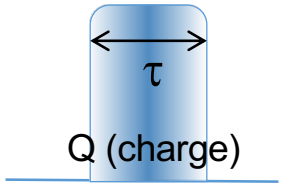
High peak current electron beam transport and diagnostics

C. Bruni for PALLAS and PHIL/DRUM project

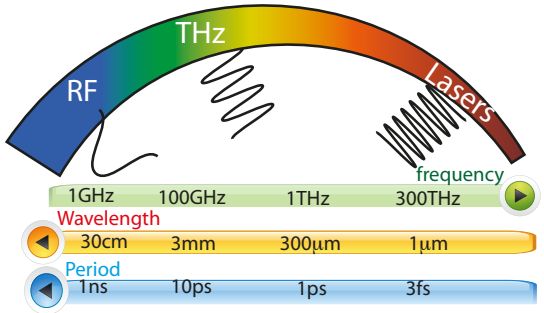
Laboratoire de Physique des 2 Infinis Irène Joliot-Curie (IJCLab)
CNRS, Université Paris-Saclay

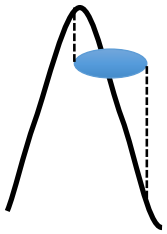
PHIL/DRUM as a Test Facility for PALLAS

Why peak current ?



$I_{peak} = Q/\tau$

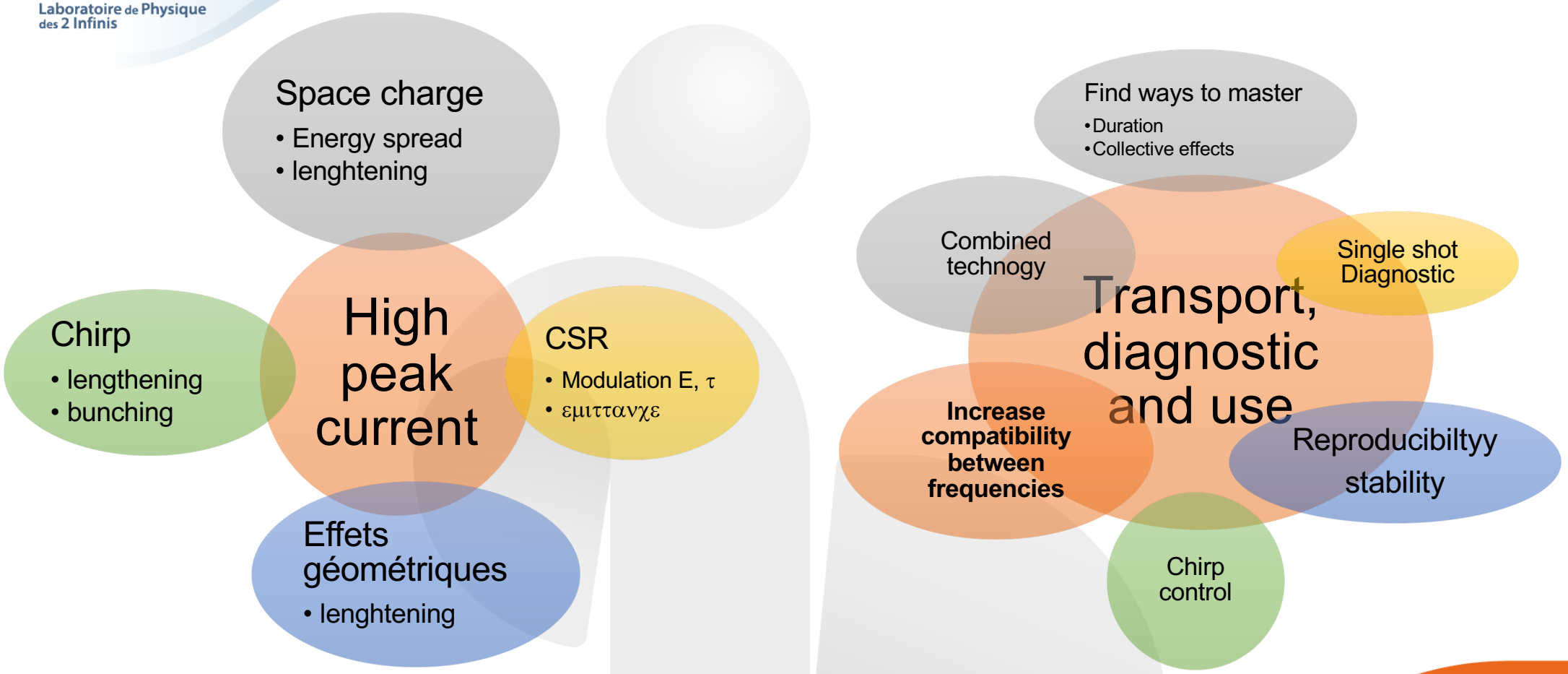




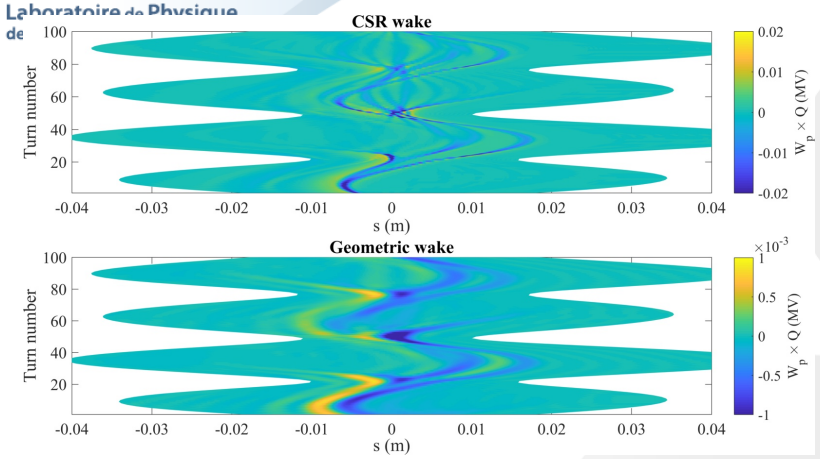
- Accelerators and users needing high charge, short bunches
  - Electron sources based photocathode photoinjectors RF/DC
  - Linac, ring, ERL, high gradient laser based acceleration
- Matching electron beam duration to accelerating field wavelength
  - Decreasing period with lasers based acceleration need very short bunches to preserve beam quality

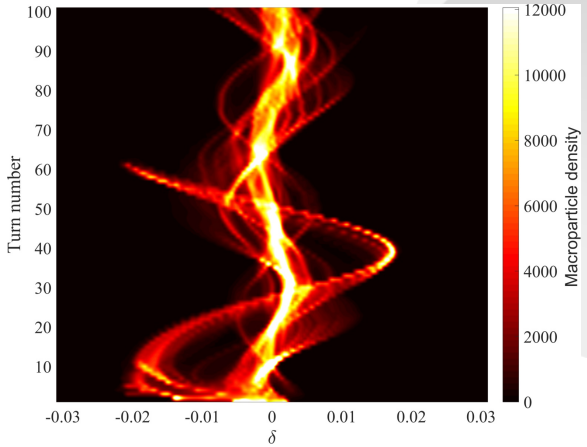
Acceleration	Frequency	1.1° of phase	Gradient
Bande S	3 GHz	1000 fs	~20 MV/m
Bande X	30 GHz	100 fs	100 MV/m
Dielectric THz acc.	~300 GHz	10 fs	~100 MV/m
Laser Plasma	~3 THz	1fs	> GV/m

Beam dynamics for high peak current

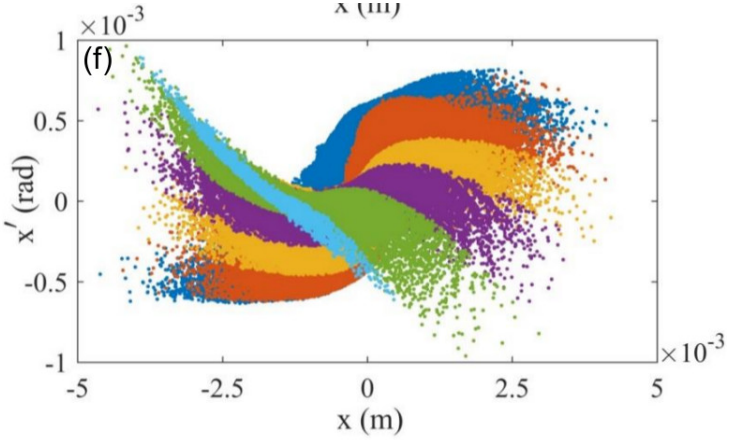


Home made code for simulation tool





- Tracking with external input beams
- Space charge (benchmark with astra)
- Wakefields (CSR, impedance)
- Adapted for laser plasma beams (divergence, energy spread, velocity difference)



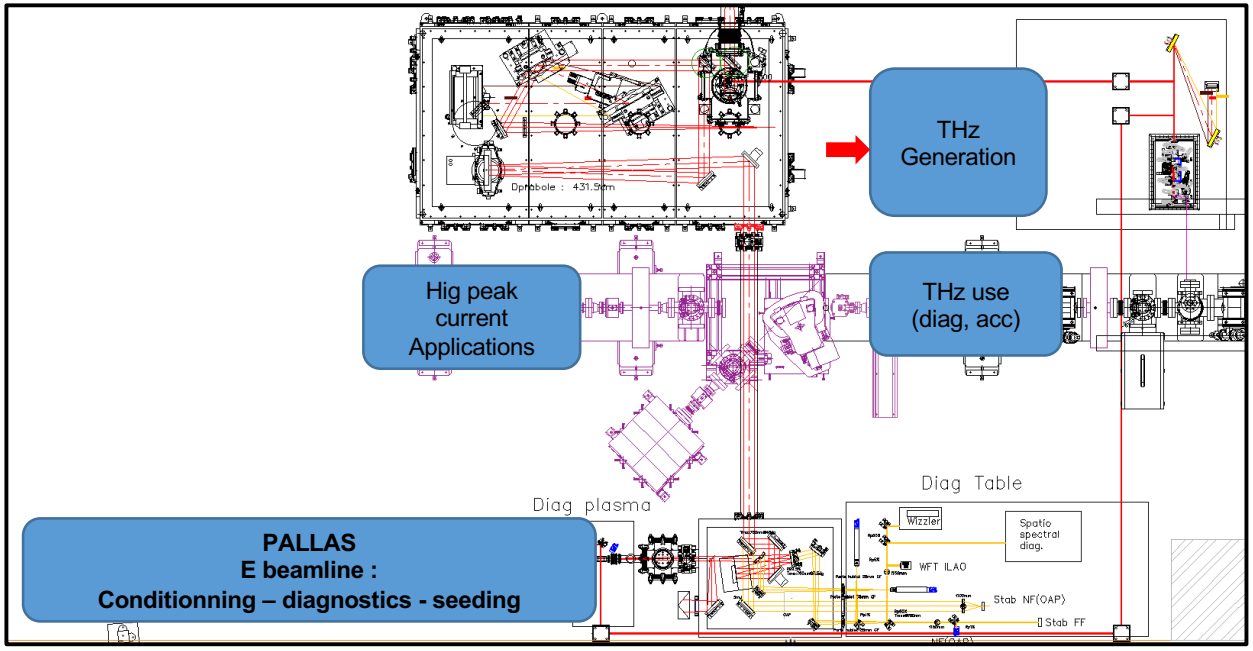
- Some exemple for ThomX storage ring
- Pallas (laser-plasma injector) beam line under study for first measurements

High peak current installations

Environnement of multiphysics for high peak currents studies

→ **PHIL/DRUM** : high peak current photoinjector installation coupled to femtosecond laser for photocathode → booster under conditionning to get shortest beams

→ **Pallas** : laser plasma under construction (beamline at the priliminary simulation stage



→ **Twac** : THz generation for acceleration and longitudinal phase space diagnostics (search for fundings- european proposal submitted)

→ Test of diagnostics for short beam with RF stable beam that can be transfered to pallas

→ Tests of 3D printed complex piece

Questions part 1

1) Where do you see HEP applications of advanced accelerators in 30 years?

2) What intermediate physics applications/steps do you see until a HEP linear collider?

1) Electron beam accelerated with high gradient structure in a reliable and stable way
2) Compact accelerators for medical fields and ultra fast science
3) Free Electron Lasers
4) Partial substitution of RF technology by high gradient technology in existing installations

3) What is the synergy with related fields?

1) Stability, reliability,
2) charge,
3) Beam dynamics, transporting a high peak current beam (versatiile simulation tools for testing models and validation on facilities
4) monochromaticity

4) What is the role of your work here?

1) High gradient structures,
2) tunning reproducibility,
3) high peak current simulations, collective effects and mitigations,
4) use appropriate technology and mix them (if more adapted) to achieve best performances
5) Propose a facility based on short bunches where RF, LPA and DTA can be studies and mixed (if appropriate to the target)

Questions part 2

1-3) What are the important milestones for the next 10 years to get there from today? What should be proposed as deliverables until 2026? Please list in order of priority.

Reduction of the divergence for LPA beams

Demontration of low energy spread, stable and reliable high gradient structures

Tuning reproducibility and shot to shot stability

Increasing the accelerating length for high gradient structure (LPA or dielectric)

Staging high peak current electron beam in a high gradient structures with the possibility to discriminate the additionnal sources of instabilities and shot to shot fluctuations

Increase laser/accelerator interface

Improve compacity and reliability of high power lasers

2) What additional support is needed to achieve these?

Fundings, human ressources

4) Is the R&D work for each of those deliverables already funded and, if not, what additional resources / support would be needed?

Questions part 3

1) What key R&D needs can be achieved in existing R&D facilities?

1) tunning reproducibility in existing facilities
2) Staging high peak current electron beam in a high gradient structures with the possibility to discriminate the additionnal sources of instabilities and shot to shot fluctuations
3) Increase laser/accelerator interface

2) What is the role of the already planned future facilities in Europe and world-wide?

Pallas : stable LPA ans staging
TWAC project : Terahertz wave accelerating cavity on PHIL/LASERIX facility
Facility with mixing technologies

4) Is a completely new facility needed?

Reasearch realised on existing facility even improving them is certainly more efficient in a mid term vision to reduce cost and infrastructure