Status of the High Finesse Fabry-Perot R&D @ Orsay

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for the
Pulsed Laser Injected Cavity
group

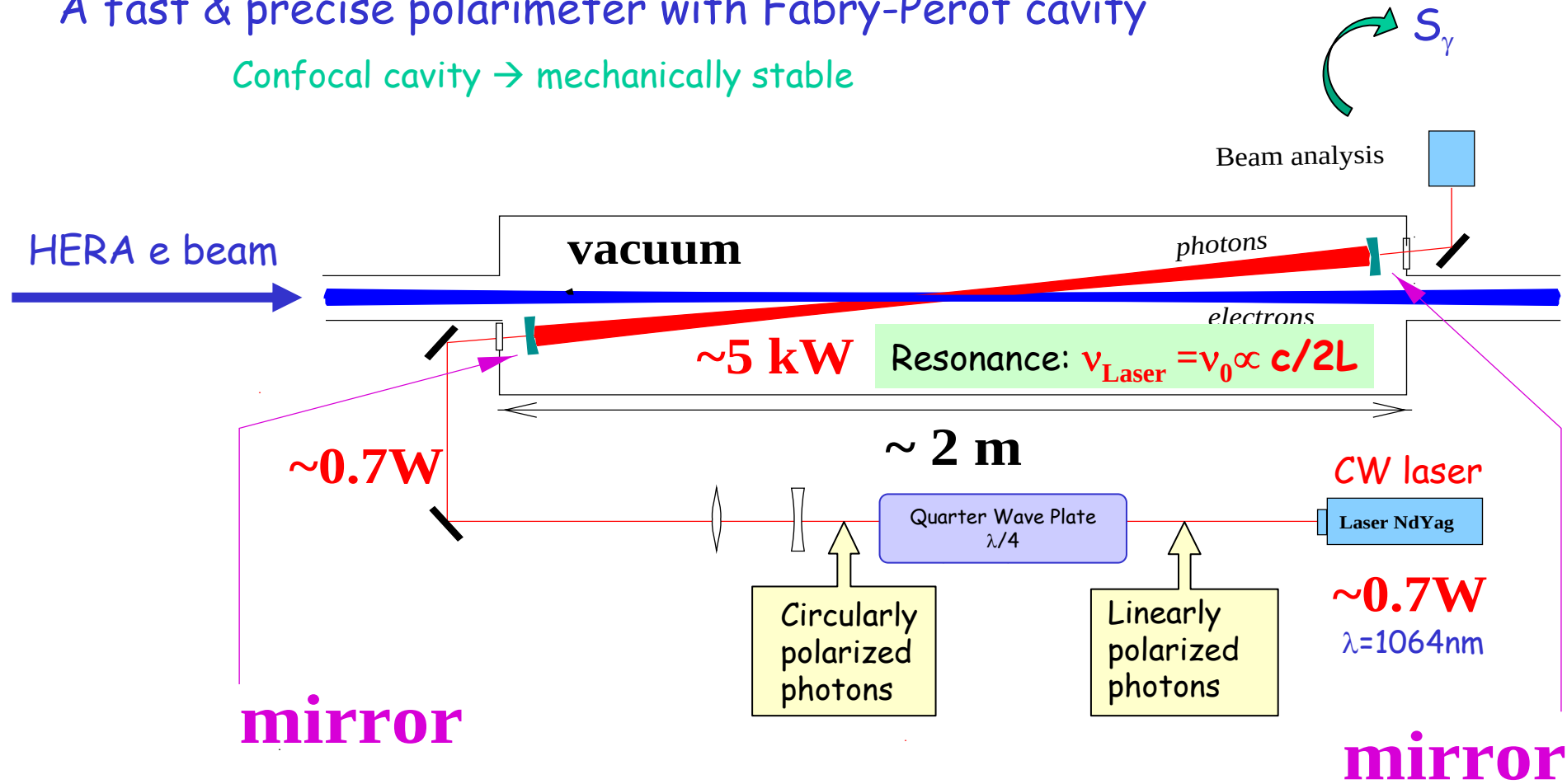
1. Introduction
2. Status
3. Prospects

Previous Successful Realization @ HERA

ep collider @DESY

A fast & precise polarimeter with Fabry-Perot cavity

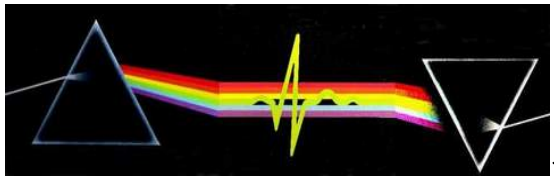
Confocal cavity → mechanically stable



➔Achievement: finesse up to 30 000 (i.e. gain up to 10 000) in a harsh (radiation) HE accelerator environment

Motivations for New R&D

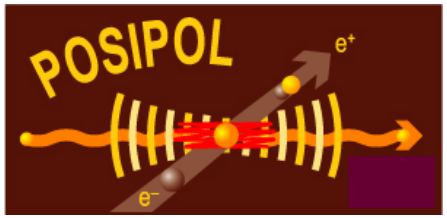
PLIC Technology R&D



High energy applications

Low energy applications

Optical R&D



- γγ collision
- polarized e+
- polarimeter

ThomX

- Compact
- ultrashort
- Monochro-matic

Application in beam

Demonstrator for ILC e+ polarised sources

ATF2 (KEK)

Cavity + Laser prototypes

A common purpose: increase laser power and cavity finesse

1st Phase: Polarimetry for ILC (2005-2007)

Funded by

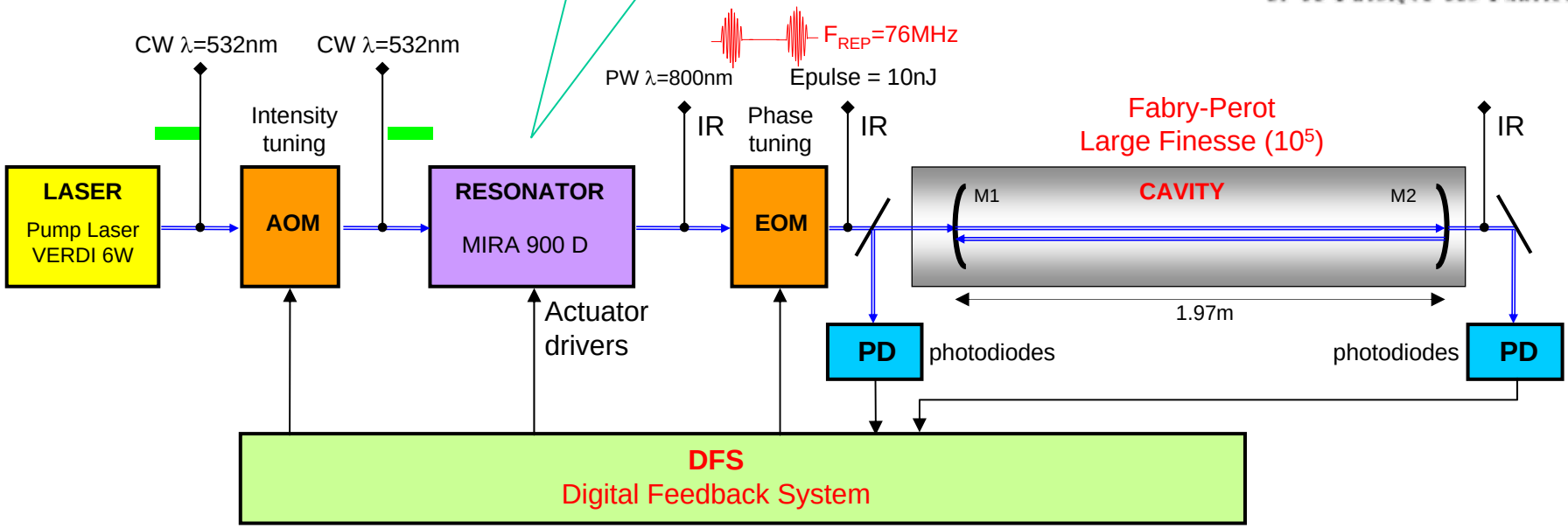
and

IN2P3

Institut National de Physique Nucléaire et de Physique des Particules

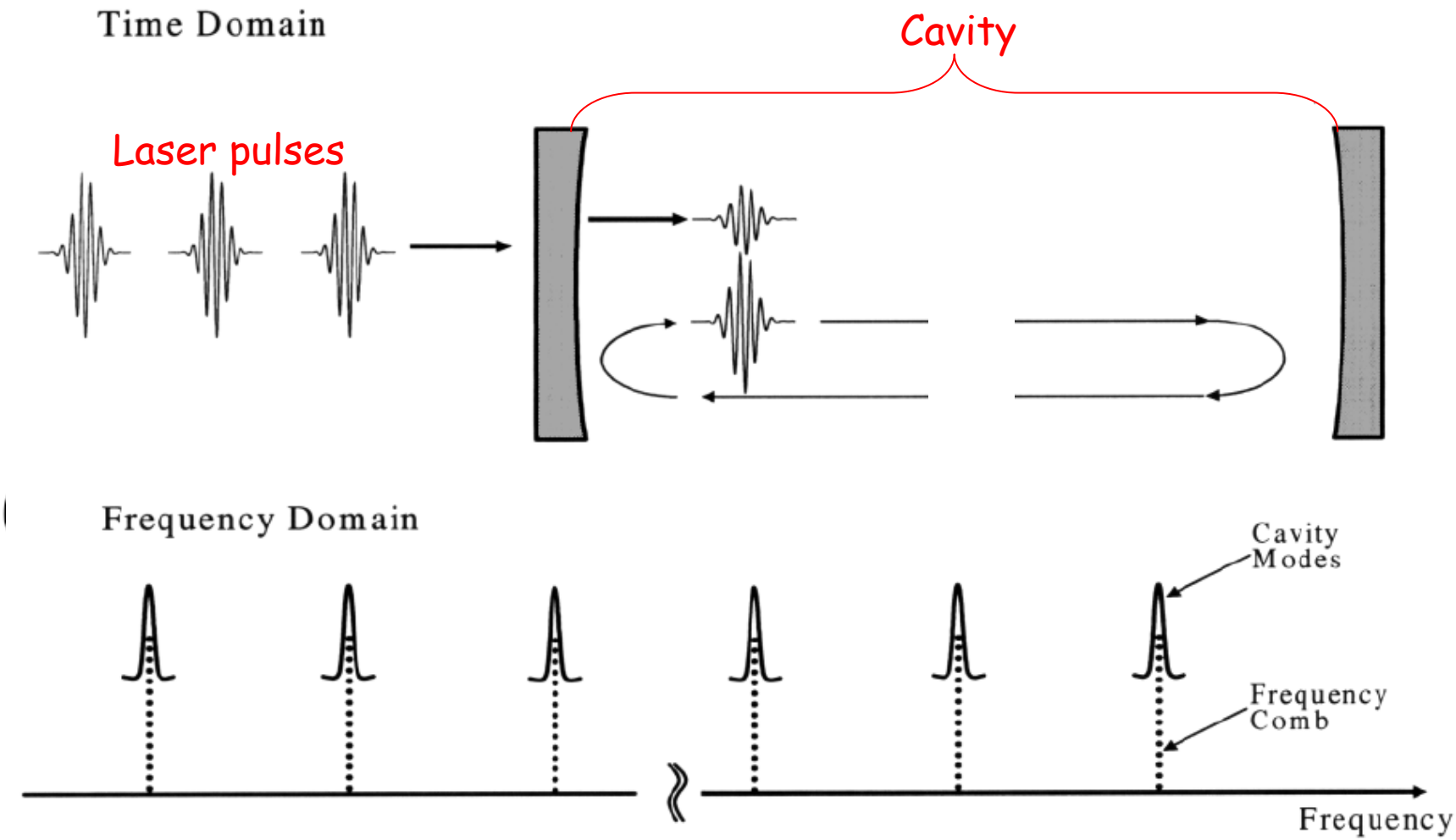
Key new feature: locking high repetition frequency and short pulsed laser:

Repetition rate: 76 MHz
Pulse width: 1 ps
Wavelength: 800 nm
Energy/pulse: 10 nJ

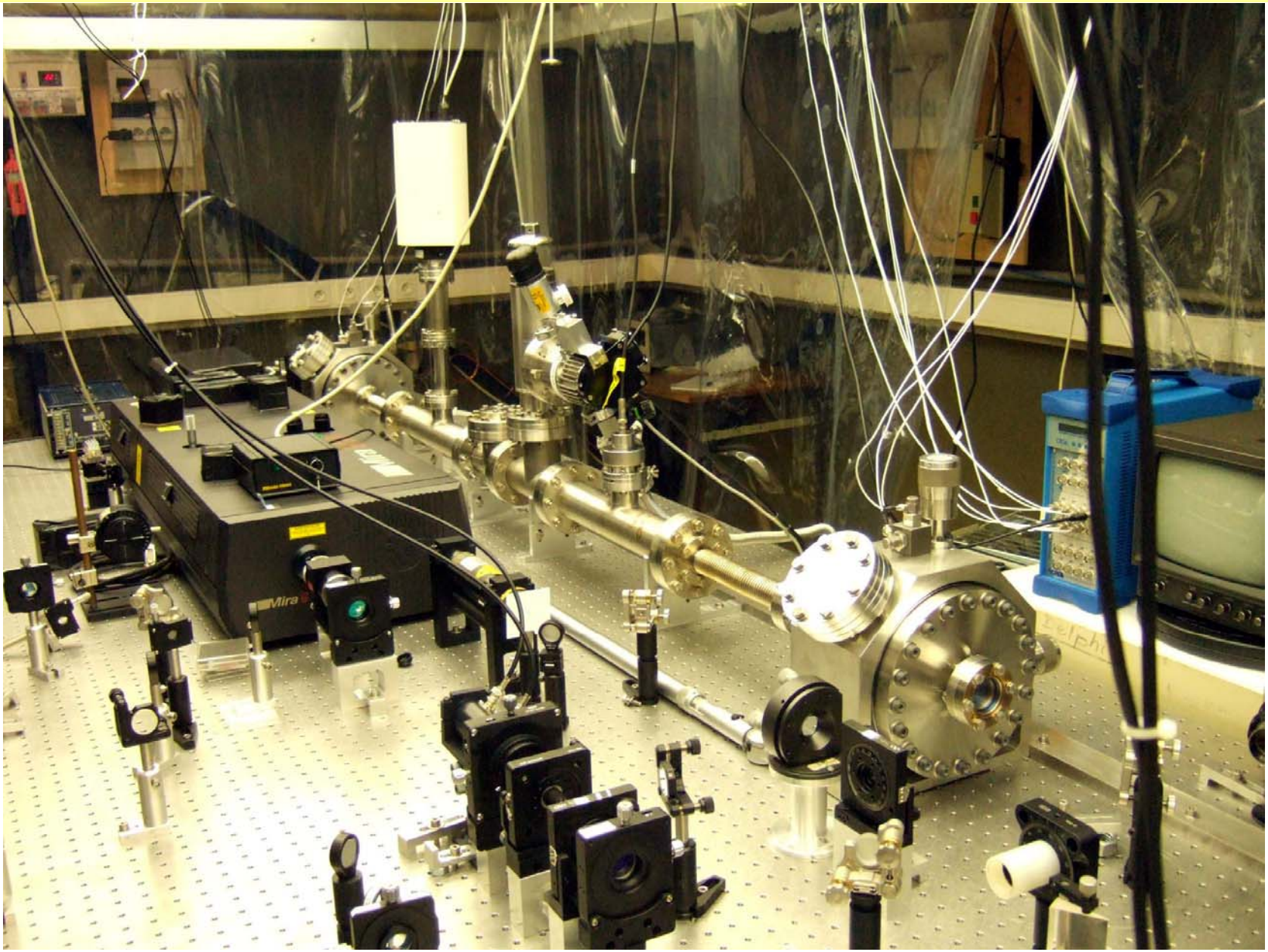


Amplification Principle

Laser pulse repetition period matches with cavity round-trip time



Actual R&D Setup @ Orsay



Milestones

Jul. 20, 2005: Verdi 6W laser & MIRA 900 dual resonator installed

Long period for
- cavity (prototype) and mirror mount design/construction → cf next slide
- digital feedback system design/implementation

May 14, 2007: Cavity under vacuum

Jun. 19, 2007: 1st locking with a finesse ~3600 (ie gain ~1200)

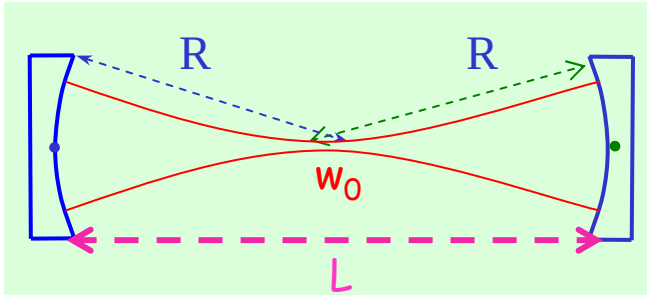
➔ The world record at 1 ps regime

The intensity gain (with new mirrors) is being increased to 10 000

Mechanical Challenges

Two-mirror cavity

- Confocal cavity ($R_{mirror}=L_{cavity}$)
  → Mechanically stable but large waist (w_0)



Solution to reduce the beam waist:

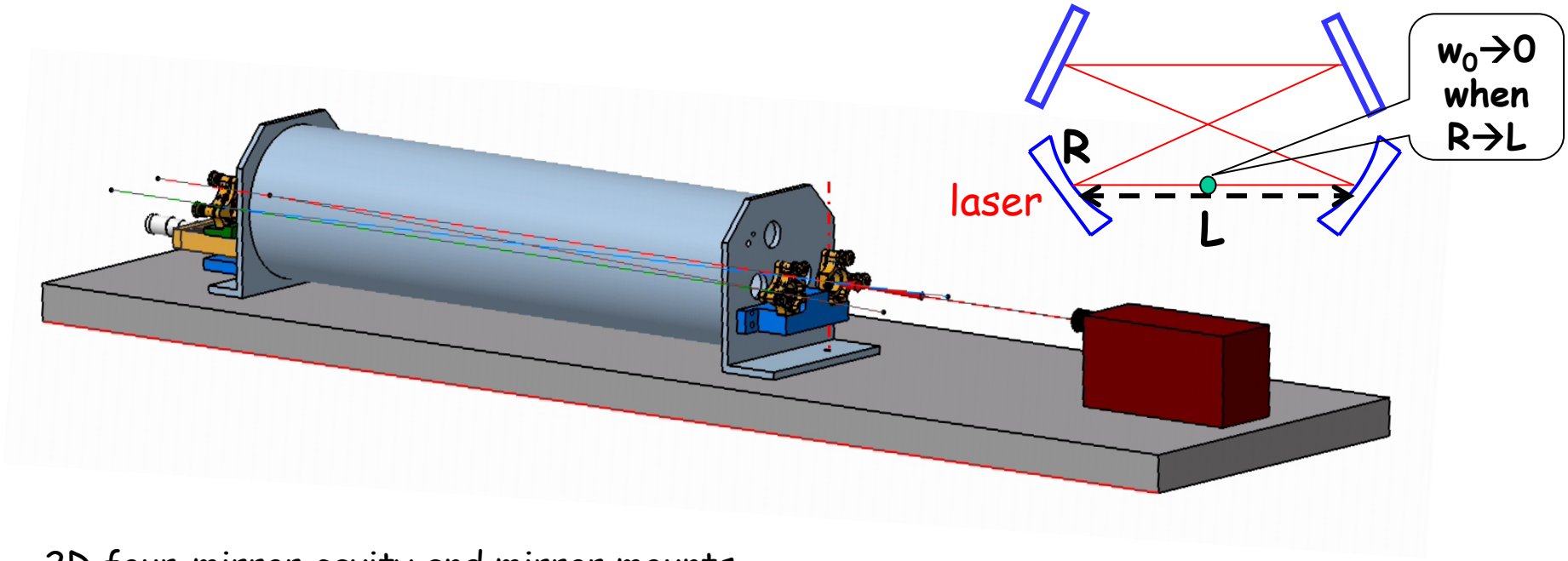
- Concentric cavity (R_{mirror}~>$L_{cavity}/2$)
  → Mechanically unstable
  for w_0=50μm, λ=800nm, a misalignment of 1μm (axial) & 1μrad (angular)
  ➔ spot size shift of 30mm on the mirrors !!!
  ➔ challenge of mechanical design of mirror mounts
  ➔ great care on the environment noises

A solution to improve mechanical stability:

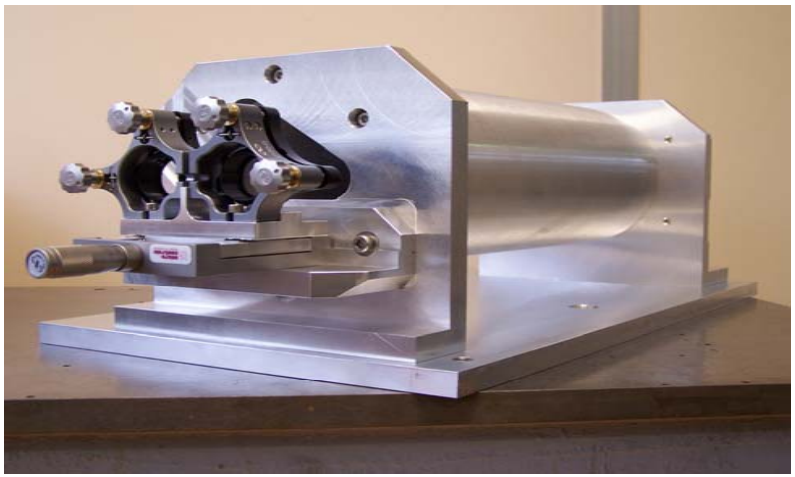
- Four-mirror cavity

➔ detailed studies show this should be a good solution to provide
- small beam waist
- high degree of circular polarization

2D Four-Mirror Cavity



2D four-mirror cavity and mirror mounts



Measured waist size:
$w_{0x} \approx 40\ \mu m$
$w_{0y} \approx 12\ \mu m$

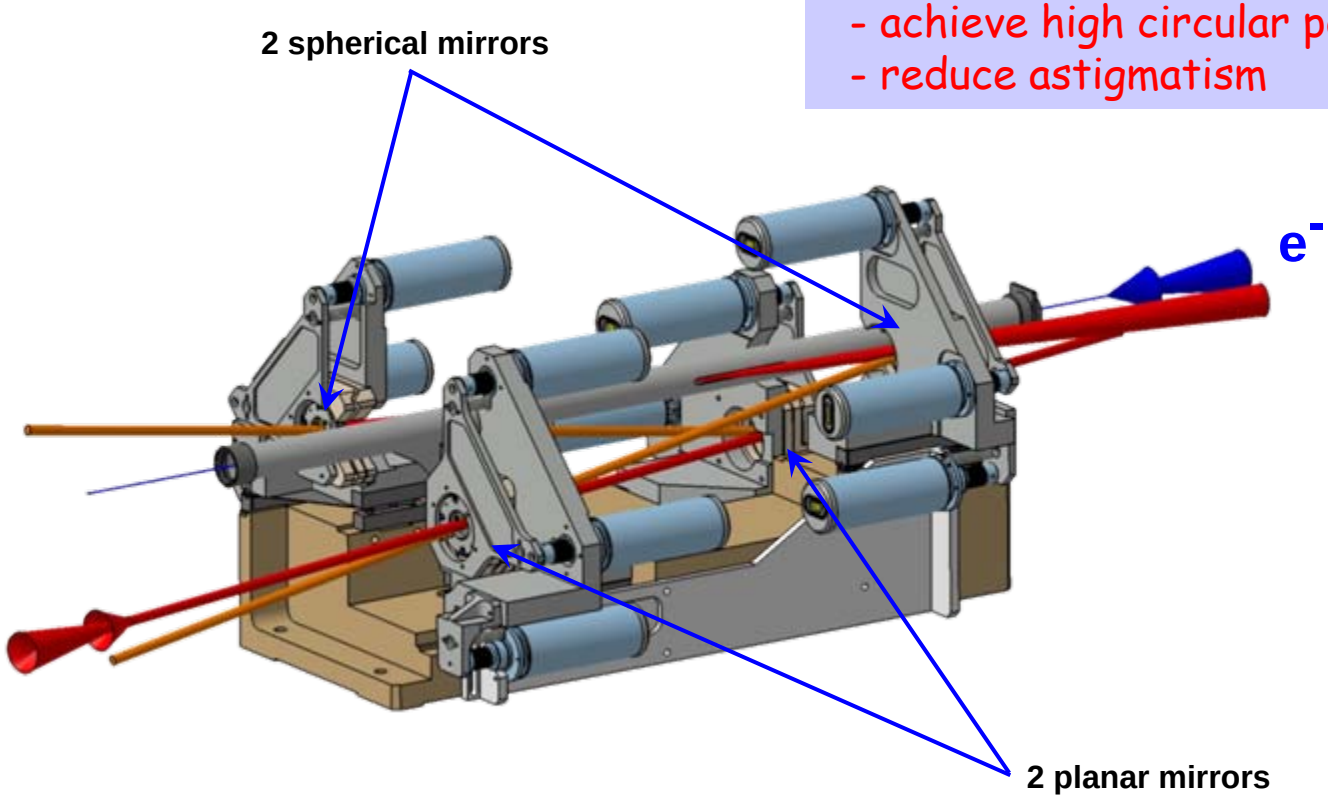
Limited by mirror size

3D Four-Mirror Cavity

Each mirror located in a gimbal mount including
- two micrometric angular adjustments
- one micrometric translation adjustment

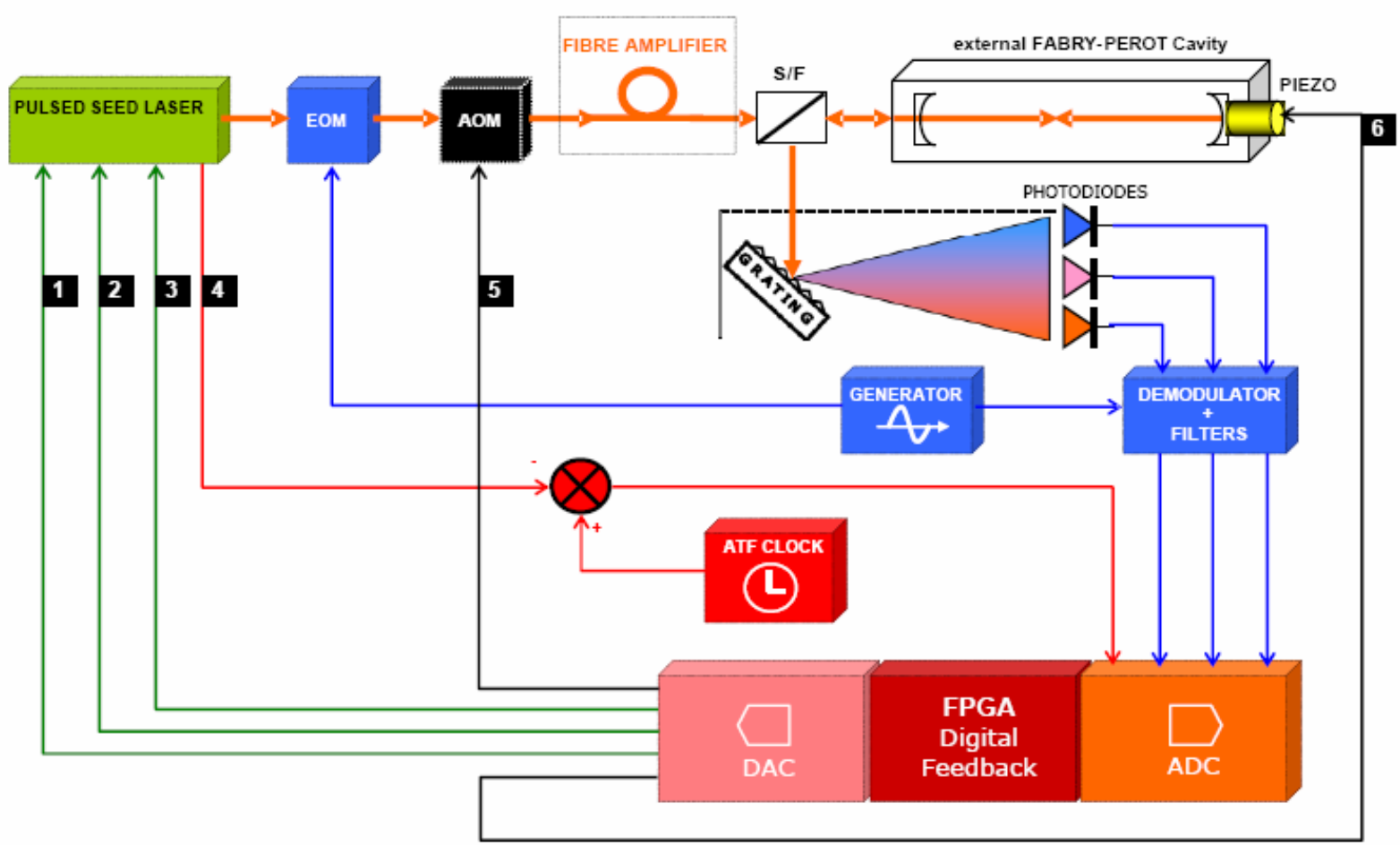
A patent for mirror mounting and alignment system underway

Choose non-planar geometry to
- achieve high circular polarization
- reduce astigmatism



Fast Digital Feedback System (DSF)

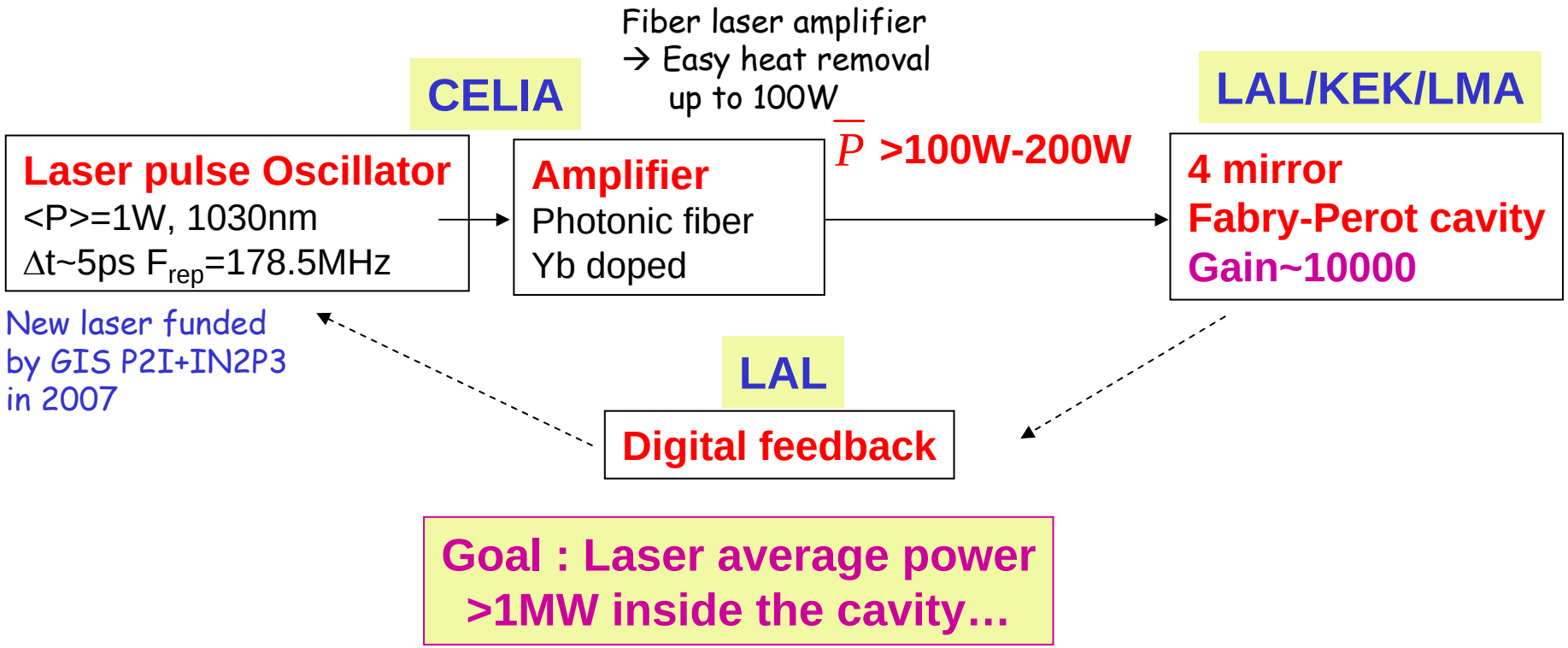
Pound-Drever-Hall technique adapted to the pulsed regime



List of actuators not exhaustive, defining strategies of the DFS is part of the R&D

New R&D Phase: Started since Feb. 2008

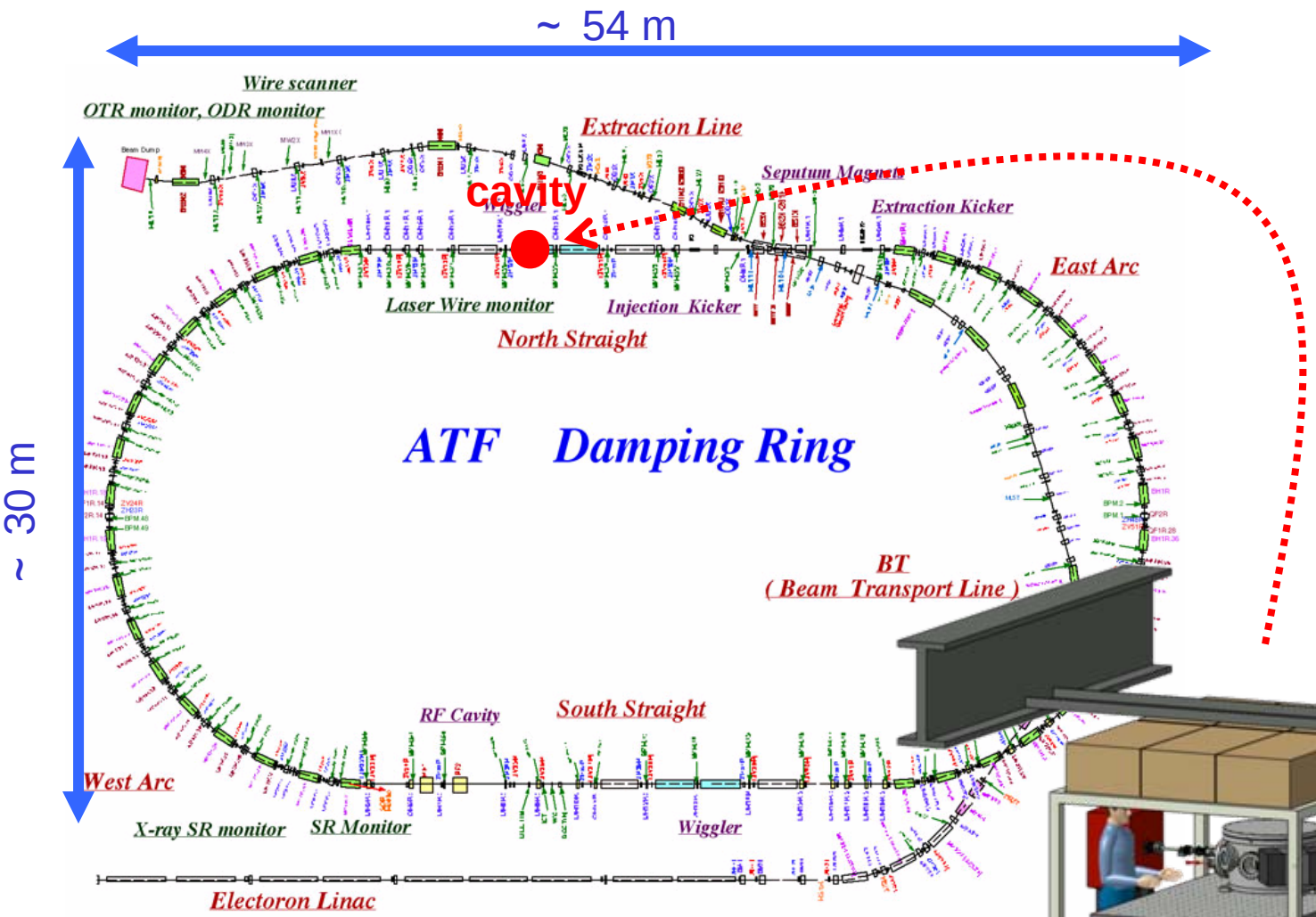
1. Setup the following system with CELIA (Laser Lab. Bordeaux), LMA (mirror coating Lab. Lyon)



2. Installation of the system at ATF2 in collaboration with KEK

R&D at ATF2/KEK: 2009-2010

Within the framework of FJPPL (France-Japan Particle Physics Laboratory)

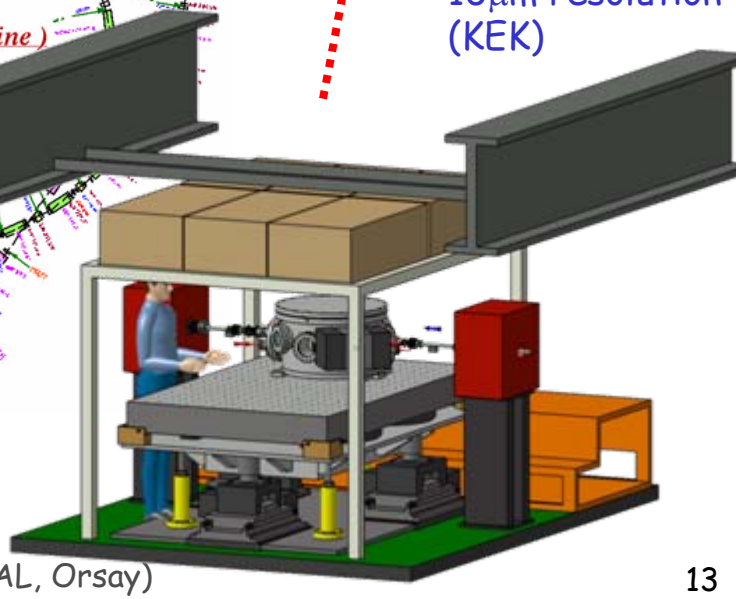


Beam Energy
→ 1.28GeV

Beam Size
→ 100μm×10μm

Emittance →
1.0x10-9 rad.m
1.0x10-11 rad.m
(Ultra Low !!)

Optical table movement has 10μm resolution (KEK)



Summary & Prospects

Since the project has started in 2005,

the scope of the project has largely been extended

with wide applications for both fundamental and applied research (one patent/valorization application underway)

New R&D program in collaboration with CELIA, LMA, KEK

→ production of high flux γ rays at ATF

→ potential technology advance in laser, optics and electronics

Backup Slide: Positron Production Schemes