A_RD_10:

Nanometer stabilization studies at ATF2

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On behalf of the LAL, LAPP and KEK cooperation

TYL-FKPPL joint workshop, Seoul, June 4, 2013

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  - Nanometer beam at KEK; ATF2 project
- FJPPL contribution to ATF2
  - LAL contribution
  - LAPP contribution
- Summary

Nanometer stabilization of e- beam

- Challenge for the extremely stable beam handling
- **Key technique to maintain the luminosity of International Linear Collider (ILC)**
- Global collaboration led by, Oxford, KNU, LAL, LAPP and KEK
- **Worthwhile contributions on the stabilization of the beam monitors (LAL) and the vibration monitoring (LAPP) are ongoing.**

FJPPL (TYL) application 2013-2014

Fiscal year april 1st 2013 – March 31st 2014

In red are example to be replaced by the appropriate data in black

ID[1]:A_RD_10	**Title: Nanometer stabilization studies at ATF2**

	French Group			**Japanese Group**		
	Name	**Title**	**Lab./Organis.[2]**	**Name**	**Title**	**Lab/Organis.[3]**
Leader	Andrea Jeremie	IR1	LAPP	Nobuhiro Terunuma	A.Prof.	KEK
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	Oscar Blanco	PhD	LAL	Junji Urakawa	Prof	KEK
	Shan Liu	PhD	LAL	Kiyoshi Kubo	A.Prof	KEK
	Sandry Wallon	IR2	LAL	Shigeru Kuroda	R.A.	KEK
	Frédéric Bogard	IE2	LAL	Toshiyuki Okugi	R.A.	KEK
	Patrick Cornebise	IE2	LAL	Sakae Araki	Eng	KEK
	Julie Allibe	IR CDD	LAPP	Hiroshi Yamaoka	Eng	KEK

Challenging goals for ATF/ATF2

An important technical challenge of ILC is the collision of extremely small beams of ***a few nanometers in vertical size.***

ATF/ATF2 will address the development of the techniques for following issues:

1. Achieve the small vertical emittance

ATF-DR 4 pm→ 2 pm (ILC) or 1 pm

2. Demonstrate the ILC final focus optics

achieve the ***37 nm*** *vertical beam size at the IP*

3. Stabilize the the beam position in a few nanometer level at the IP.

The ATF international collaboration is strongly promoting these activities.

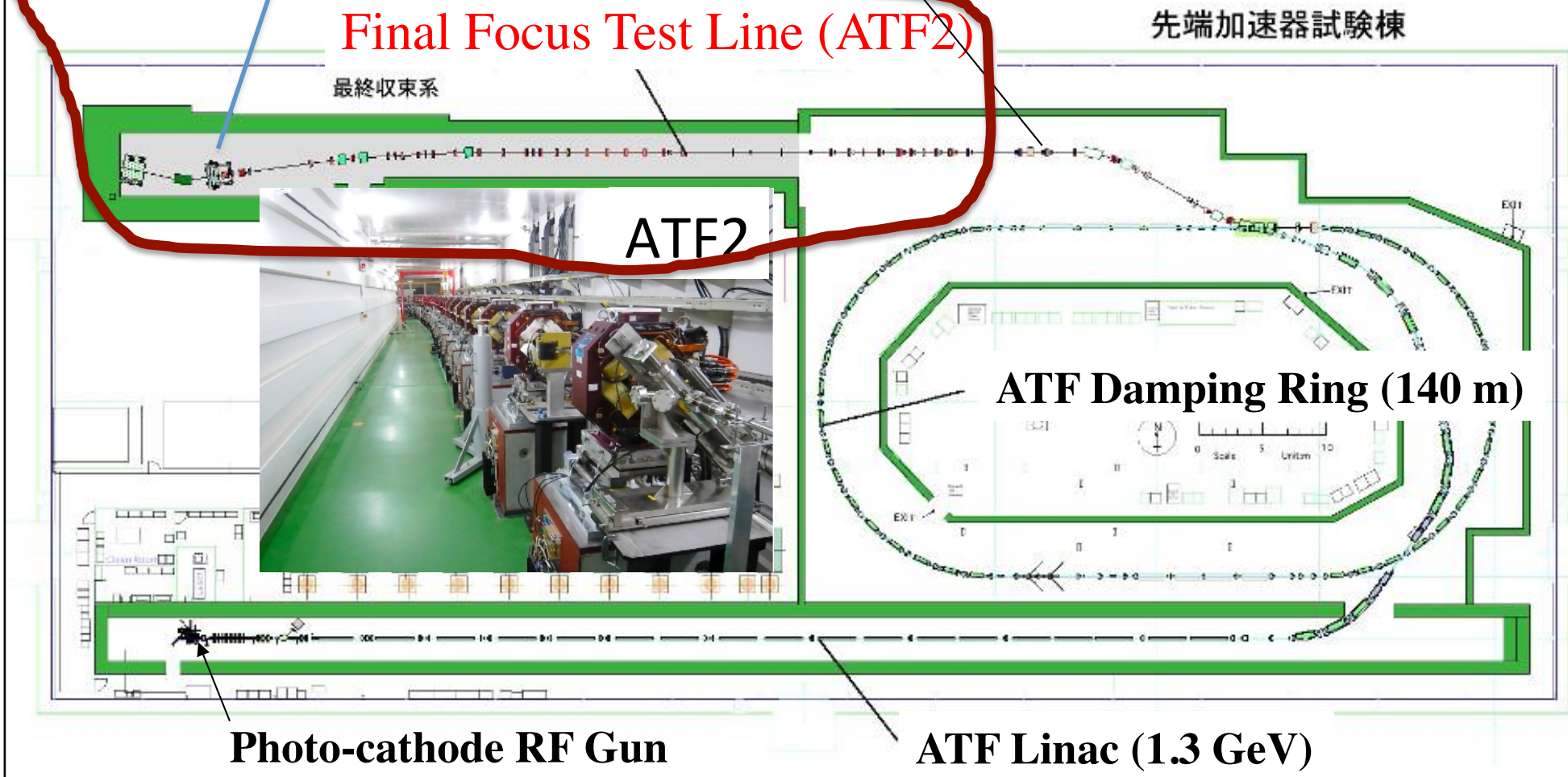
KEK Accelerator Test Facility (ATF)

Energy: 1.3 GeV, Repetition: 1.56 Hz
Intensity: 1x10^{10} e-/bunch (max. 2x10^{10}), 1~20 bunches/pulse
Emittance: Design, 1 nm(H)/ 10 pm(V), Achieved 4 pm(V)

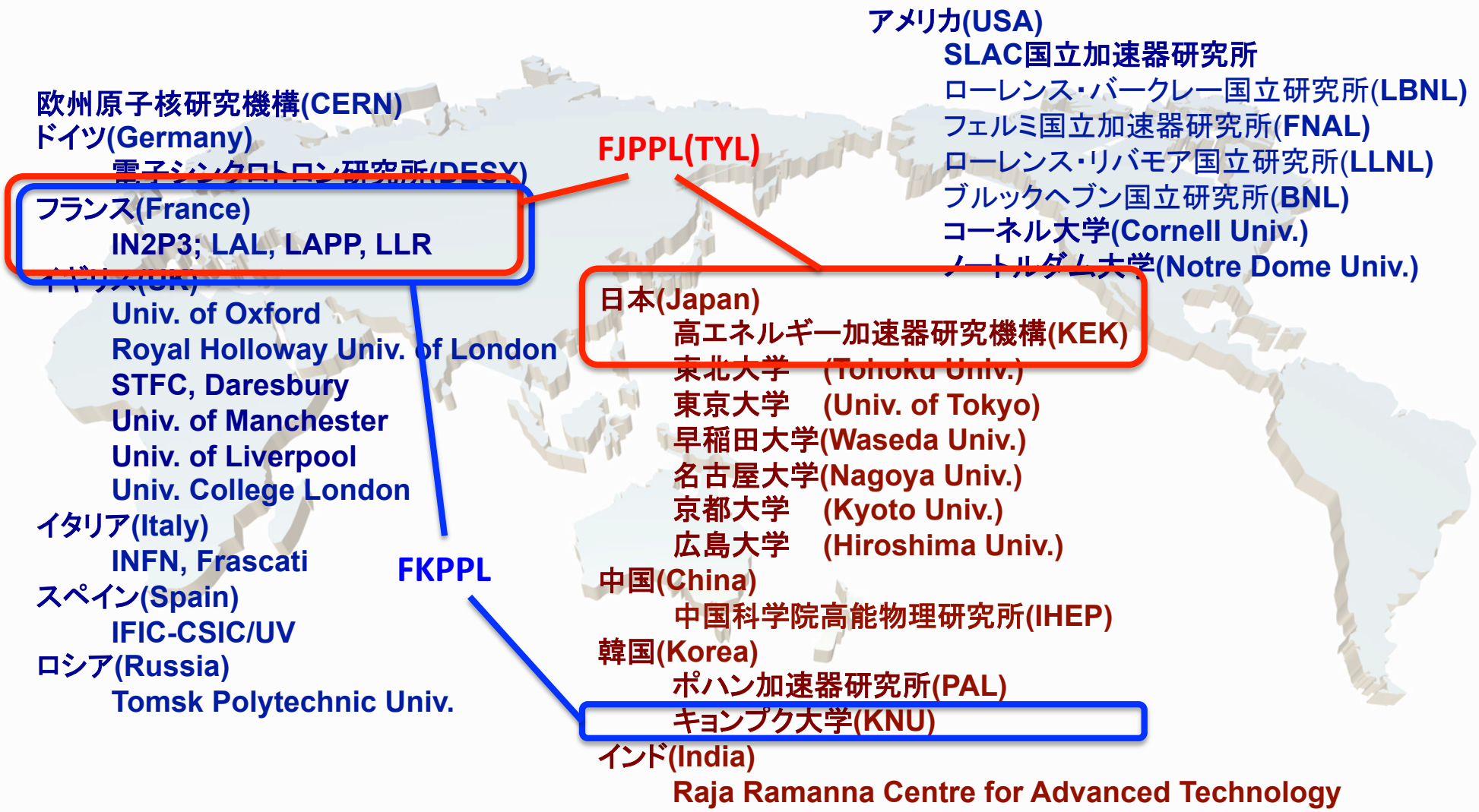
Focal Point
IP; ~40 nm beam

Extraction Line

Final Focus Test Line (ATF2)



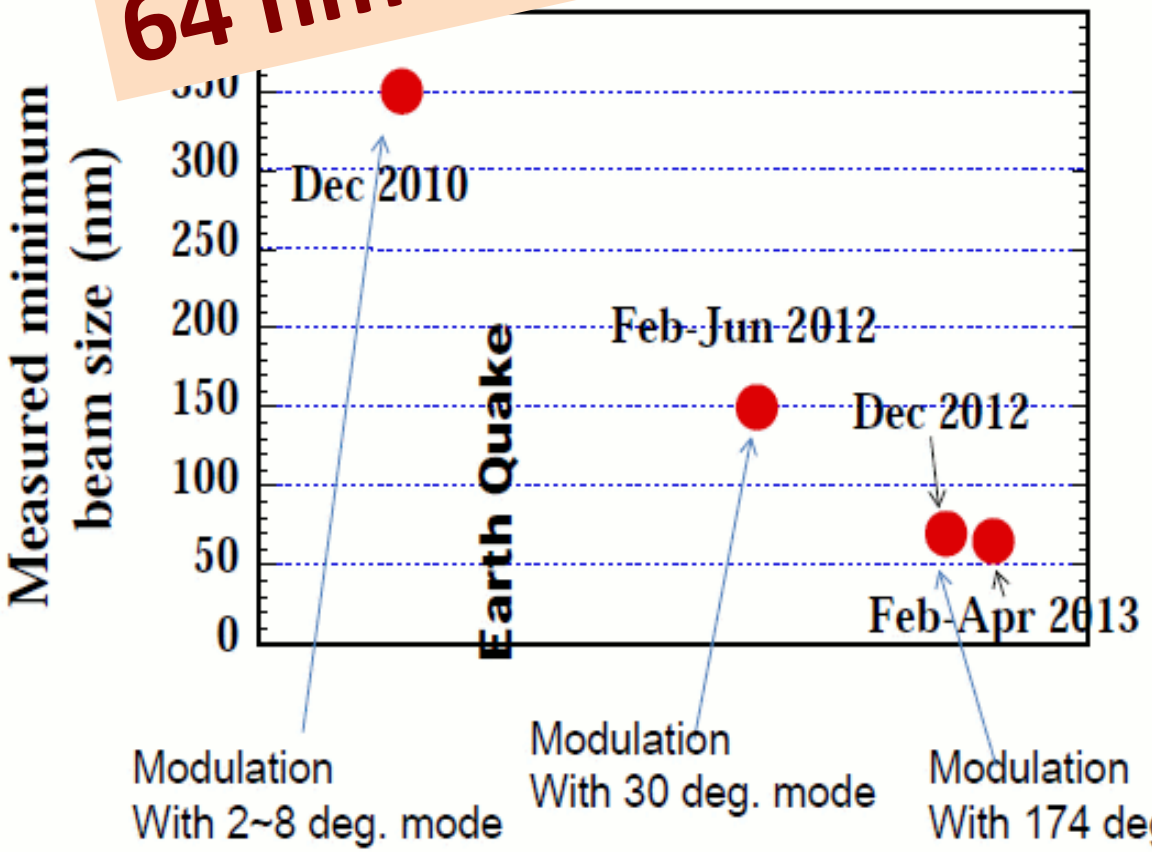
ATFに参加している代表的研究機関
- ATF International Collaboration -



Goal 1: 37 nm

- Reached 64 nm
- Tuning from ~3000 nm
- Suppressi… 90%
  …unch charge ~10^9 e-!!
- **"…successful demonstration of the compact final focus optics and both the linear optics tuning and high-order aberration compensation schemes involved"**

64 nm beam was achieved in April 2013

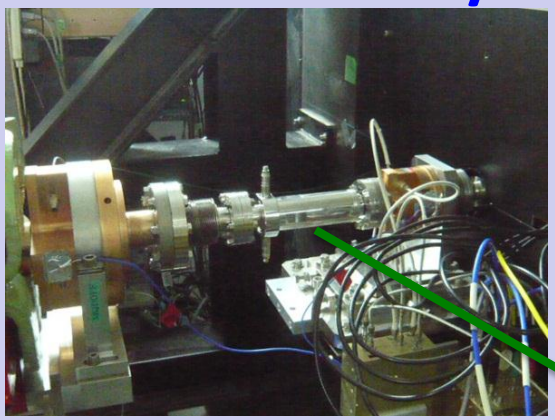


ATF2 goal 2 : nm-beam position stabilization

New FONT-kicker

Installed near the ATF2-IP
Used since autumn 2012

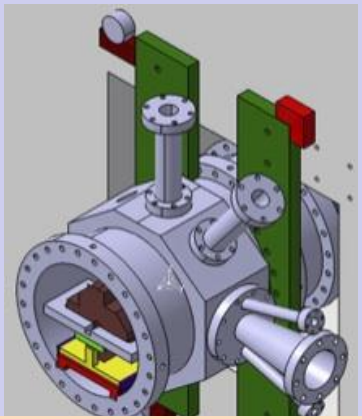
Oxford/KEK



KEK
KNU
LAL
JAI/Oxford

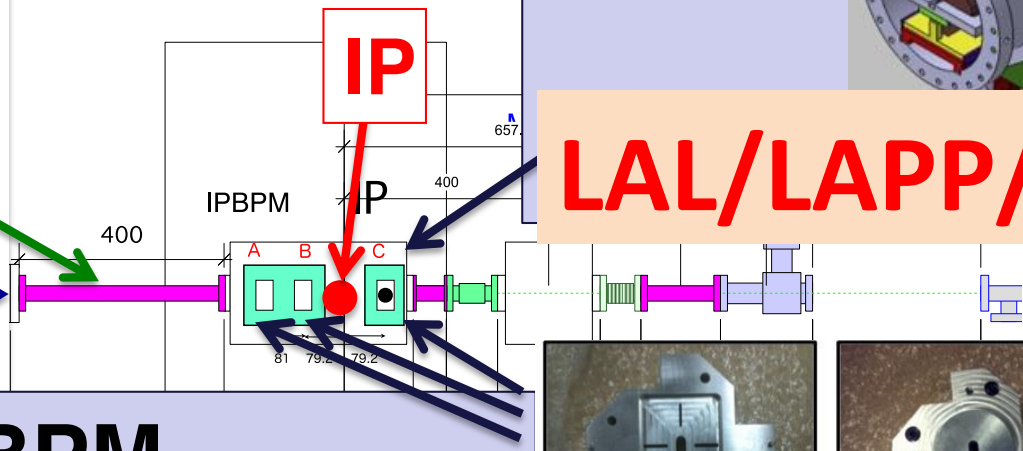
New vacuum chamber

Precise positioning of IPBPM triplet



LAL/LAPP/KEK

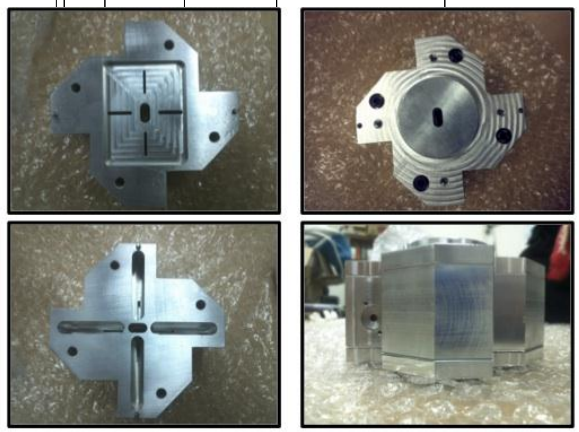
Beam



Triplet of New IPBPM

Low-Q short gap cavity light weight BPM
Sensitivity tested at ATF LINAC
Readout electronics tested at ATF2

KNU/KEK



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KEK's role

- **host of the ATF2 project, including collaboration on commissioning and tuning studies.**

- Goal 1 of ATF2 has almost been obtained recently: 64 nm/37nm (goal)

- We will now concentrate on the Goal 2; nanometer stabilization of the vertical beam position at IP.

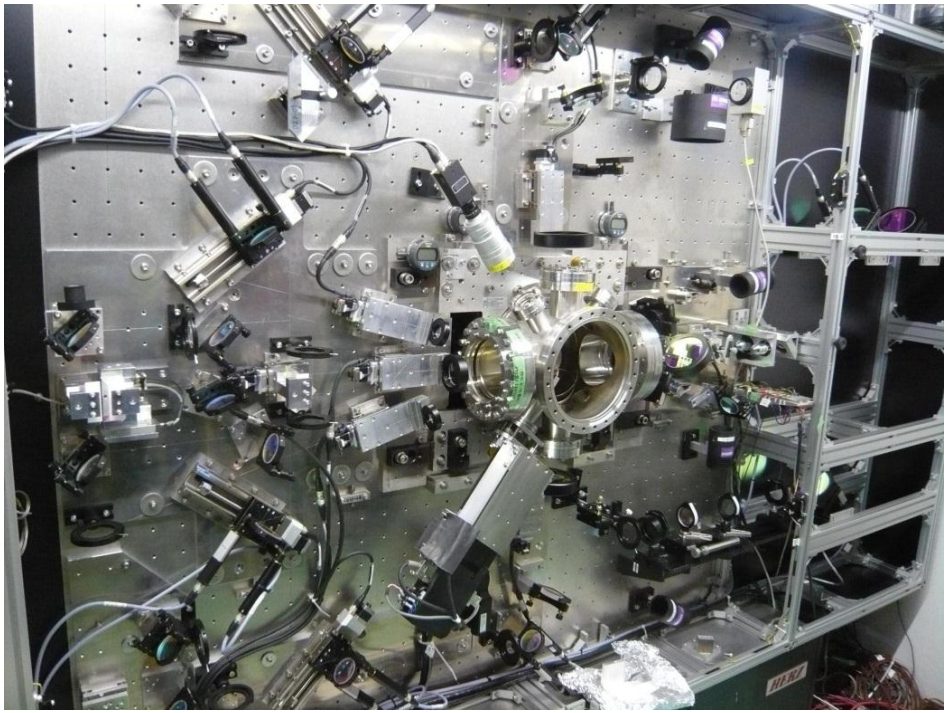
LAL contribution:

pursue two main instrumentation projects at ATF2,

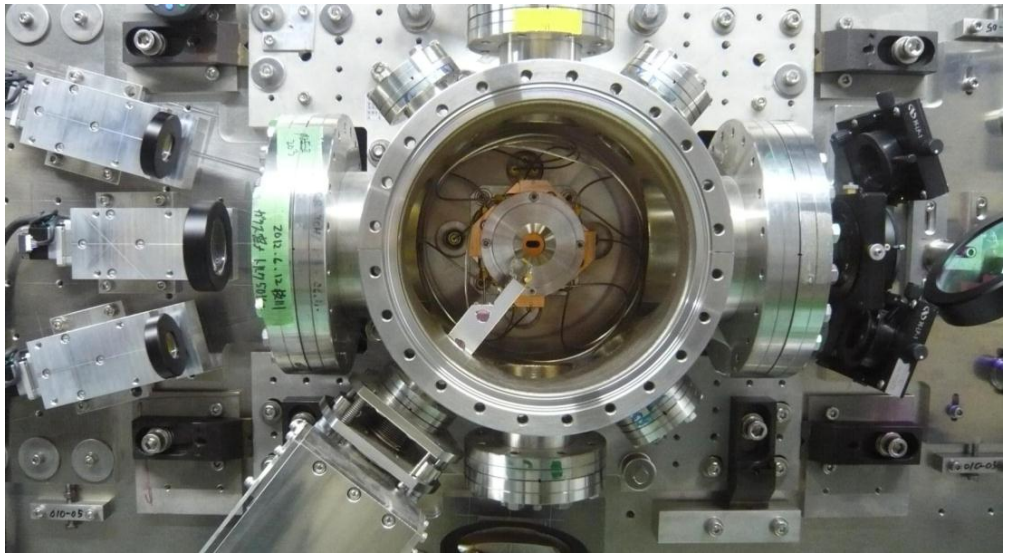
- **the installation and qualification of the IP-BPM chamber with internal moving mechanisms in nm level.**
  - LAL will join the beam experimentation with the IP-BPMs, with the goal to properly evaluate the scale factors for optimal reconstruction of beam parameter and proper resolution studies
- **the diamond sensor implementation for beam halo and linear Compton scattering measurements**
  - to prepare **future non-linear QED experiments**
  - to support **background mitigation studies** in current ATF2 operation.
  - beam tests at the PHIL low energy electron photo-gun facility at LAL
  - in-vacuum tests at ATF2 (2014).

Requirements for new IP chamber

1. Pre-alignment of IP-BPM set with respect to rest of beam line < 200 μm
2. Internal pre-positioning accuracy ~ 50 μm
3. Remote relative positioning via beam based alignment within < 5 μm (dynamic range of IP-BPM electronics)
4. Mechanical calibration of IP-BPM scale factors → 10^{-4}
5. Compatibility with IP-BSM operation (viewports for lasers, wire-scanner, electron / laser beam alignment…)

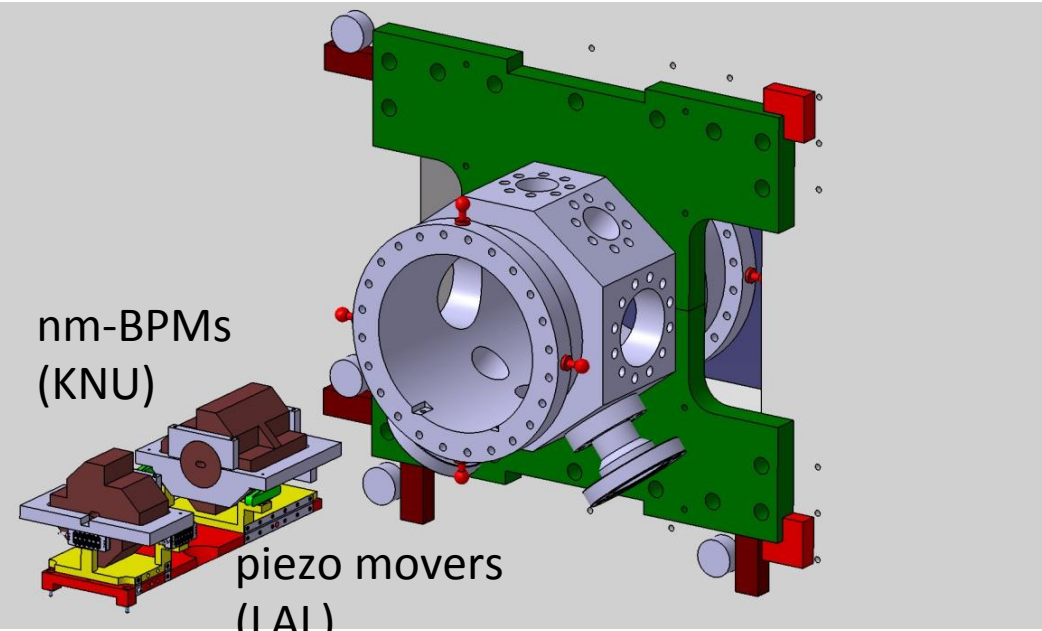


Present IP-chamber (FFTB)

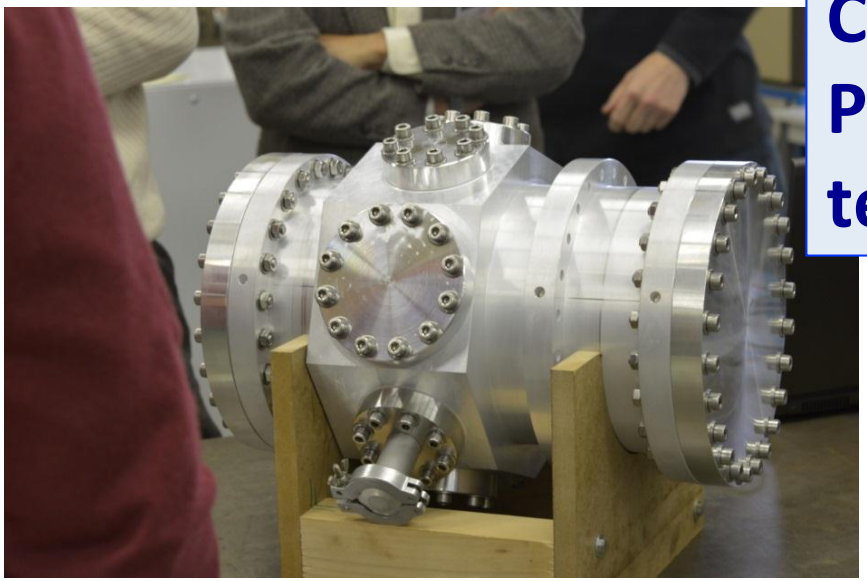


Main features of new IP chamber

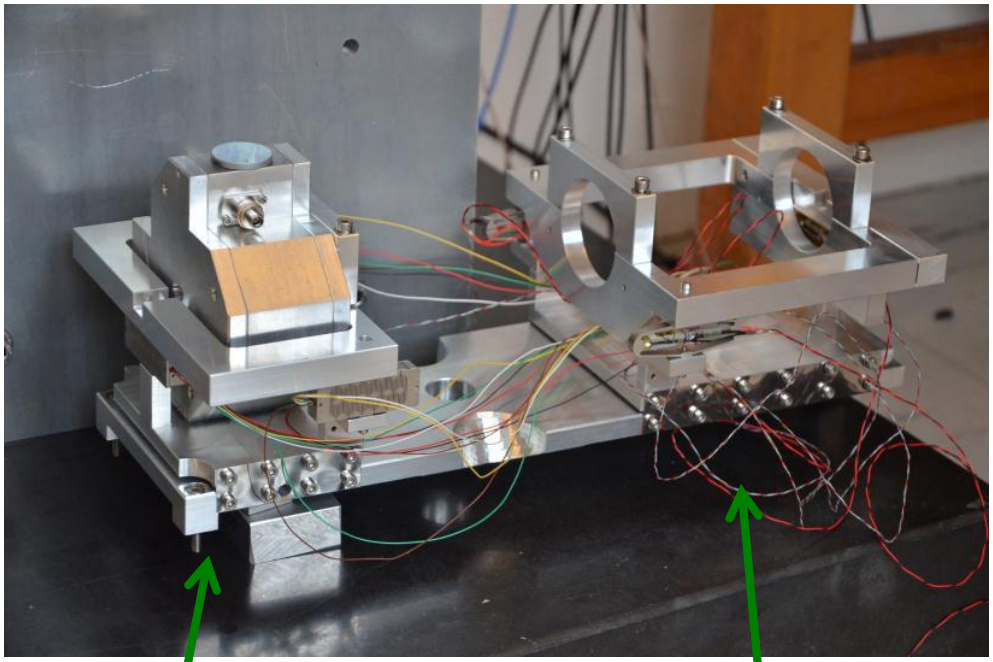
1. Mechanical references for precise pre-positioning and alignment
2. Adjustable fixture for rigid mount on IP-BSM optical table
3. Base-plate + cradles support BPM1-2 and BPM3 in tripod configurations
4. Lateral & vertical adjustments with 8 piezo-movers in 230-300 μm range
5. Positioning within 10^{-4} of the range (strain gauges as input to feedback)
6. In-vacuum temperature monitoring
7. Remote electronics (25 meter cables)



Mechanical parts almost completed



Chamber: manufactured at LAPP
Piezo movers: assembled and tested at LAL

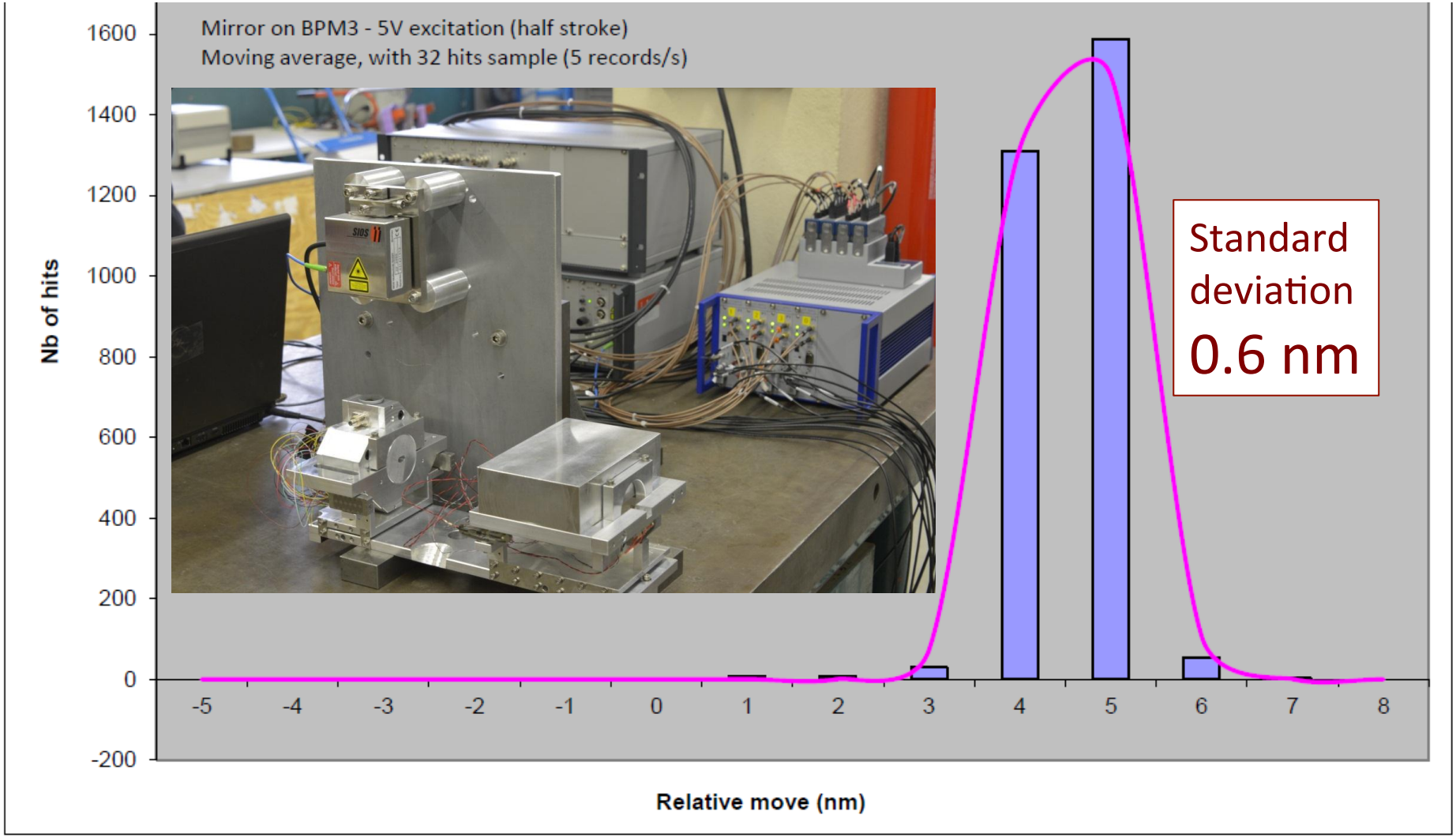


Install them into ATF2-IP in June 2013 (soon)

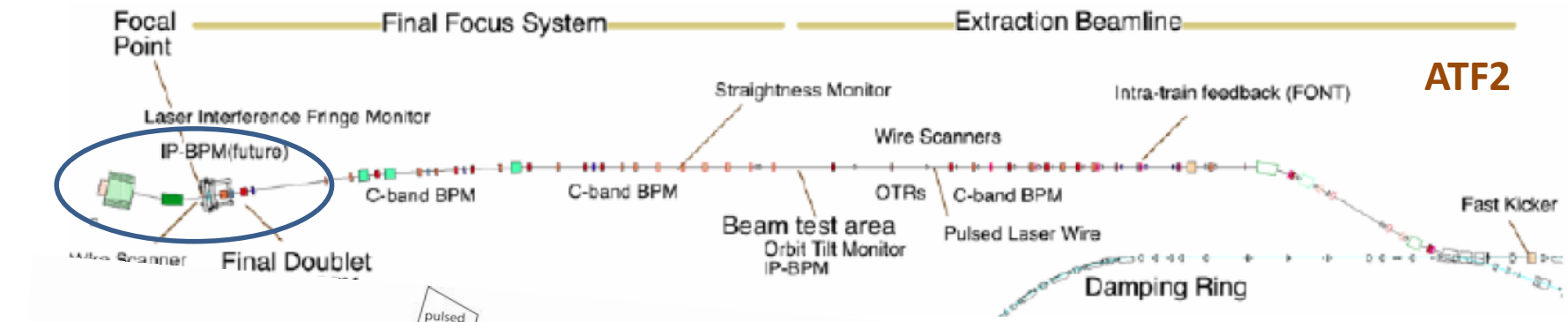
4 PI piezo-actuators

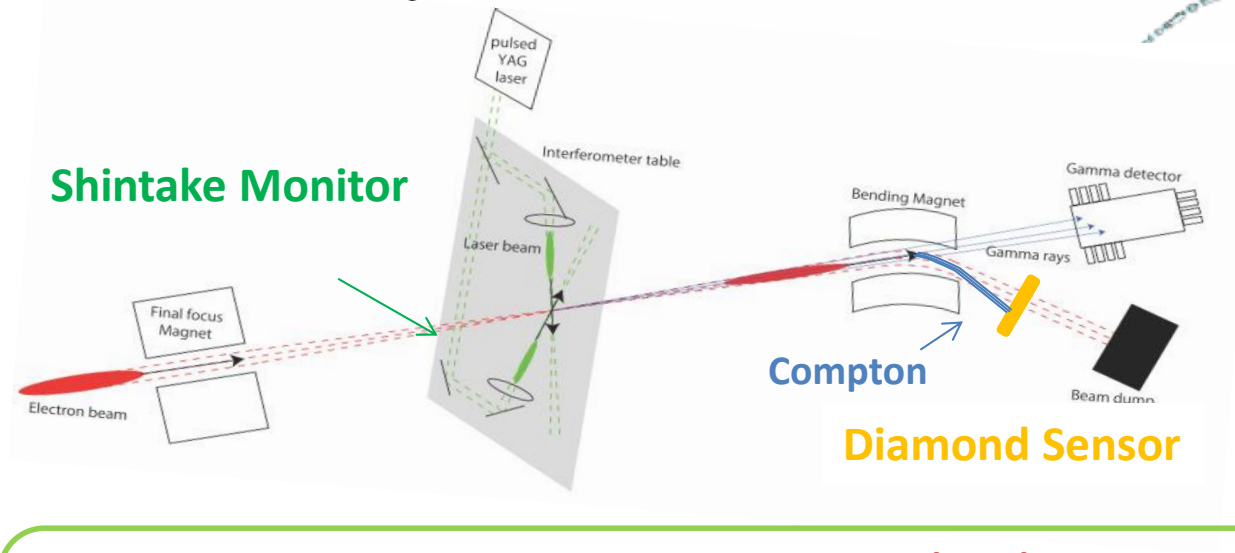
4 Cedrat piezo-actuators

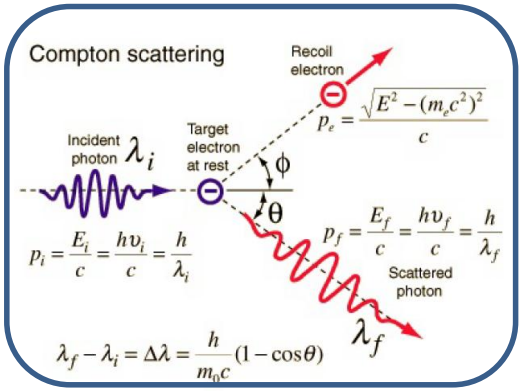
Stability of the piezo mover measured by interferometer at LAL



Diamond sensor implementation for beam halo and linear Compton scattering measurements



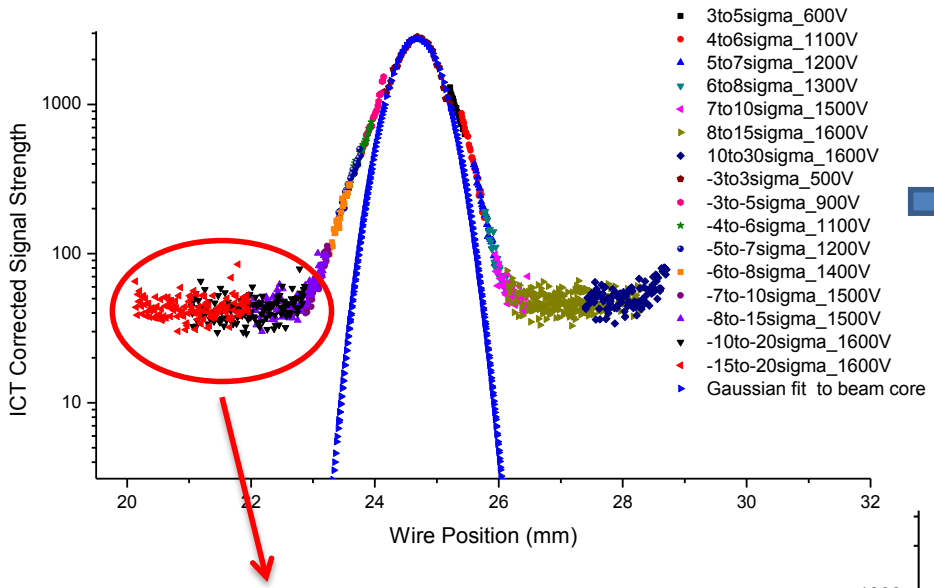




Motivations:

- ***Beam halo transverse distribution unknown → investigate halo model***
- ***Probe Compton recoiled electron→ investigate the higher order contributions to the Compton process (in the future)***

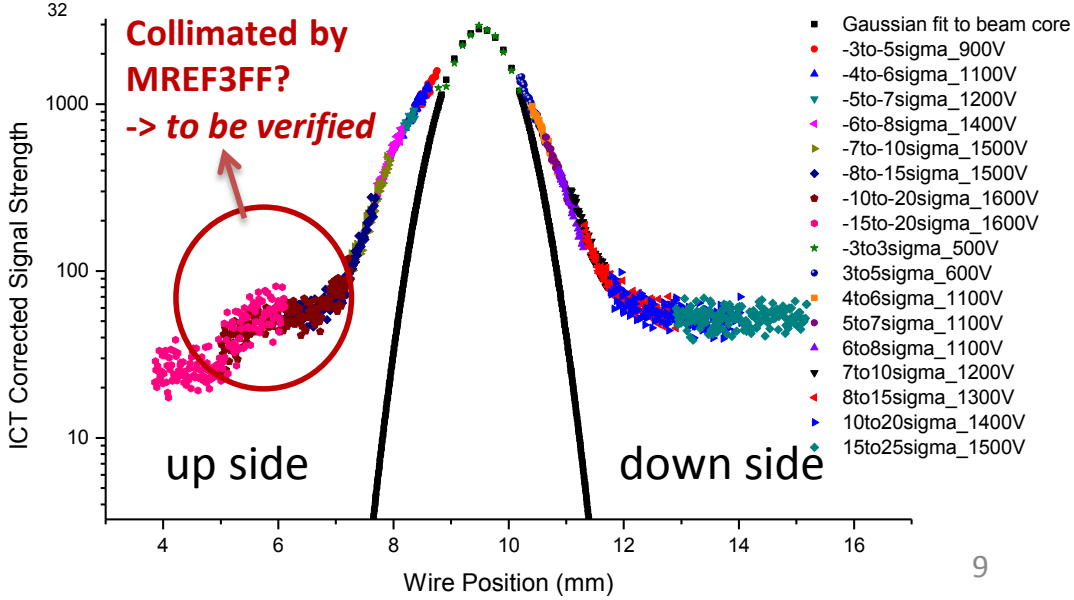
Beam halo measurement by wire scanners at ATF2 – March 2013 -



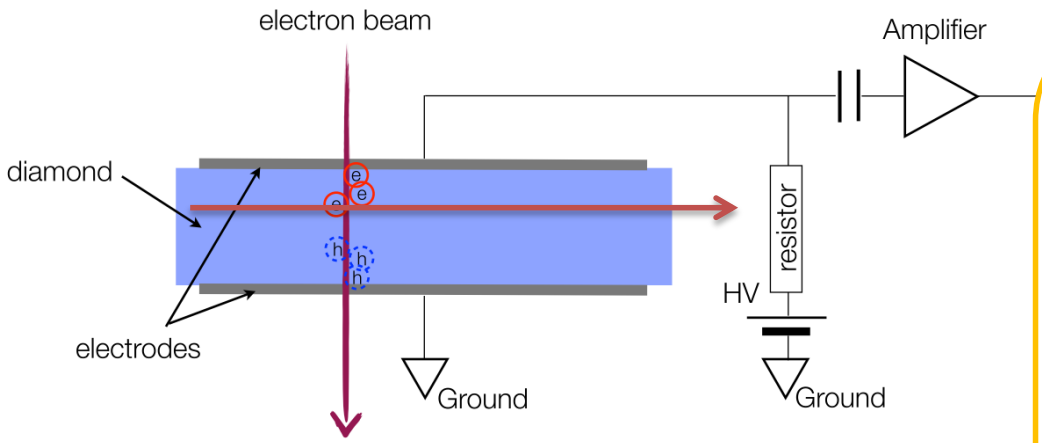
Halo+Pedestal+Background?

Horizontal beam

Vertical beam



Diamond Detector Characteristics



Charge created by 1MIP in diamond → 2.74 fC

Diamond detectors

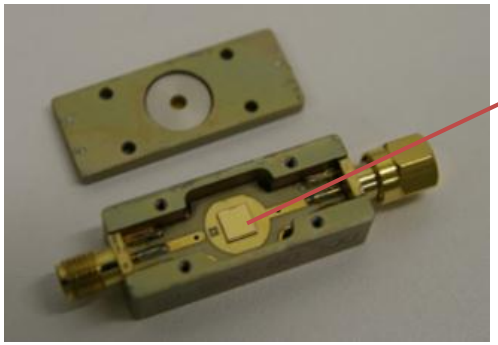
Configurations:

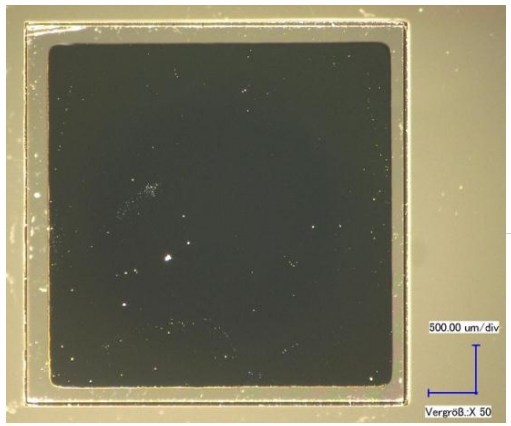
- ***Pads : mm² x 500 μm***
- ***Strips & pixels***
- ***Membranes (→ 5 μm)***
- ***Orthogonal/ Parallel orientation***

Types:

- ***Poly crystalline diamond***
- ***Single crystalline diamond***

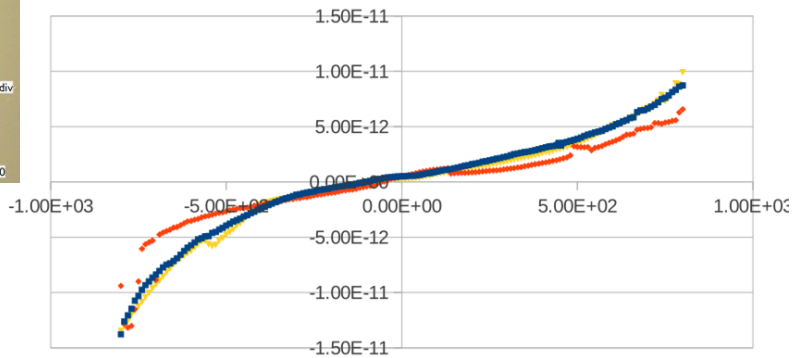
Metallised with
Al or Ti/Pt/Au(100nm)





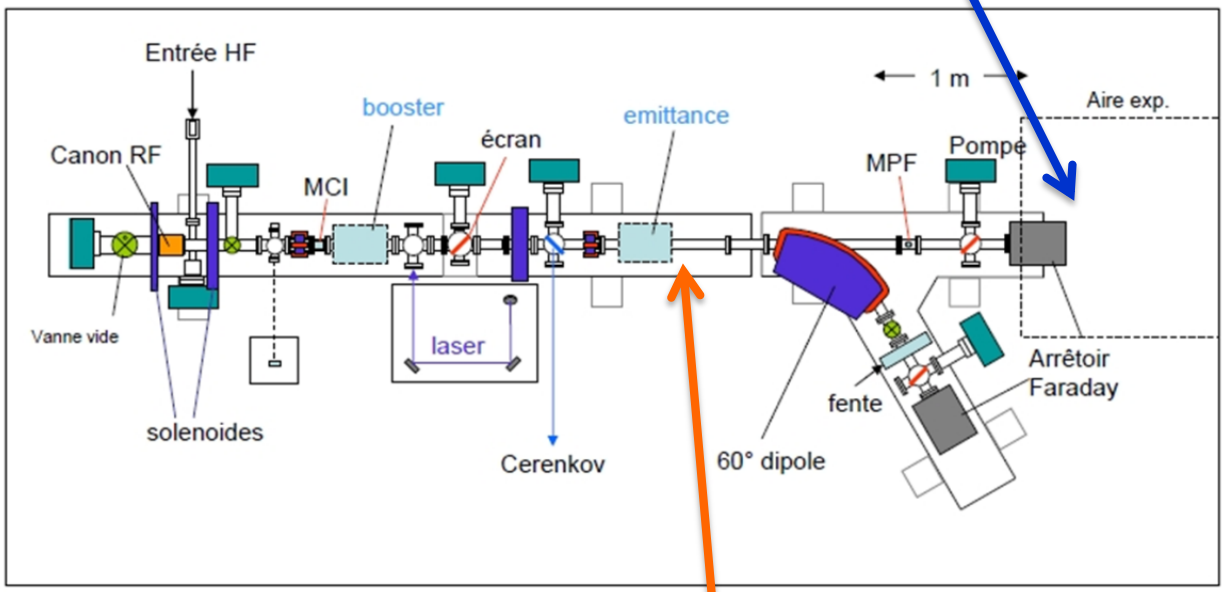
Surface: 4.5X4.5mm²

Dark Current Measurement



Diamond Detector Test @ PHIL

Test of fast remote readout (fast heliax coax cable + ASIC) with particles at end of beam line, using existing single crystal 4.5x4.5mm CVD diamond pad sensor



In-vacuum single crystal CVD diamond sensor profile scanner -> for PHIL diagnostic

PHIL Electron Beam Parameters
(given by ***Hugues Monard***)

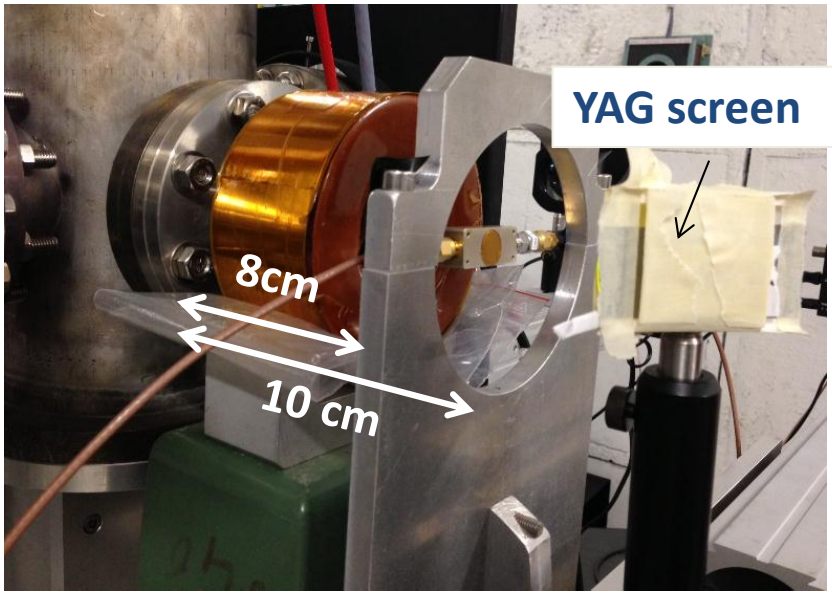
- ✓**Charge: 10 pC-250 pC/bunch (1 bunch per RF pulse) ;**
- ✓**Duration of Charge: 7 ps FWHM;**
- ✓**Charge Stablility: < 2%;**
- ✓**Maximum Energy: 5 MeV;**
- ✓**Minimum Dispersion: < 1%;**
- ✓**Beam Size -> ?**

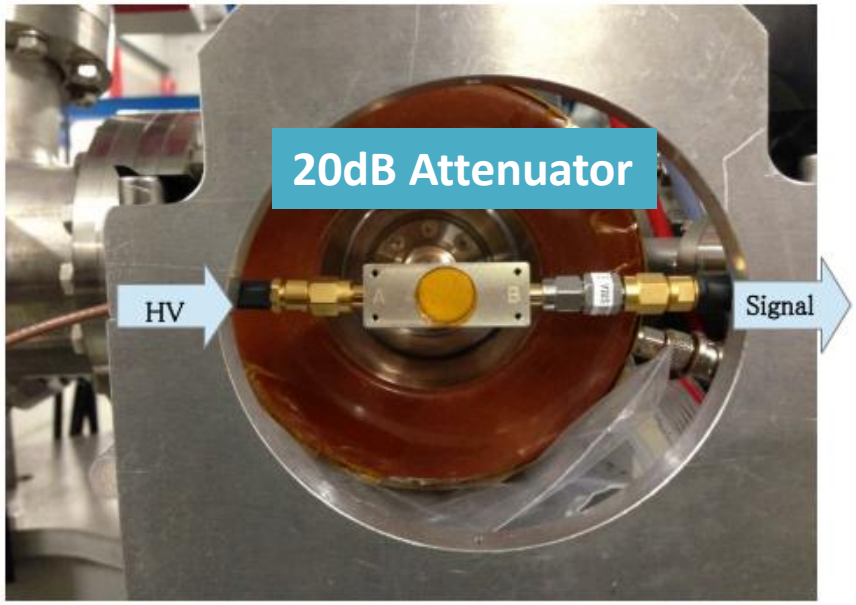
Second Test @ PHIL

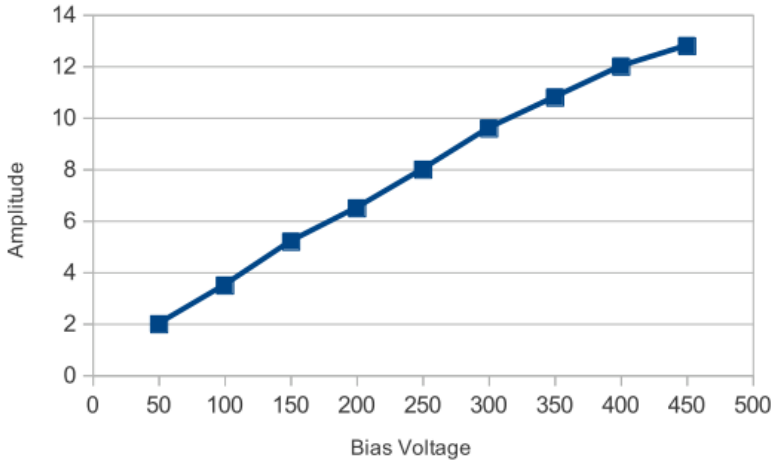
Beam Energy : 3 MeV; Beam Size: σ ≈ 4.5 cm

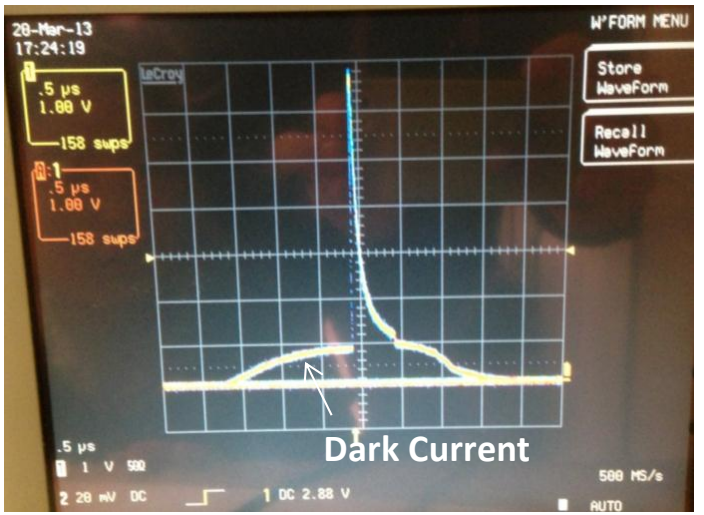
Beam Charge: 33 pC (measured at ICT 1, obtained using a 10% filter on the laser)

Performed on 20.03.2013









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  - LAL contribution
  - **LAPP contribution**
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LAPP contribution:

- **detection of the ground motion effect on the beam**
  - foreseen for the development of a new Ground Motion feedforward acting on the beam stability.
  - **The 15 sets of Ground Motion sensors have been installed at ATF2.**

- **(Re)evaluation of the vibrational performances for nanometer stabilization.**
  - relative displacement of the Final Doublet to the IP
  - New quadrupole, new IP chamber with BPM (LAL,KNU)

- requesting travel for the common measurement campaign and transport of the acquisition system and sensors.

CERN-LAPP ground motion sensor system

- LAPP bought 15 sensors

  (A. Jeremie et al)
- CERN puts the DAQ

  (Kurt et al)

  and the simulations

  (Yves et al)
- System commissioned in Annecy
- Equipment already operational in KEK

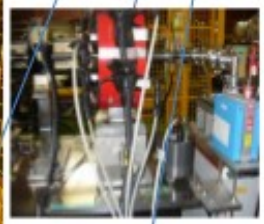
Andrea Jeremie & Yves Renier

QD0FF

QF19X

QD18X

QD16X



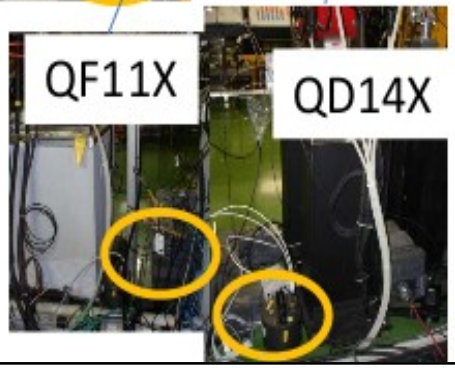
QF15X

QD5X

QF1X

QF13X

QD12X



QF11X

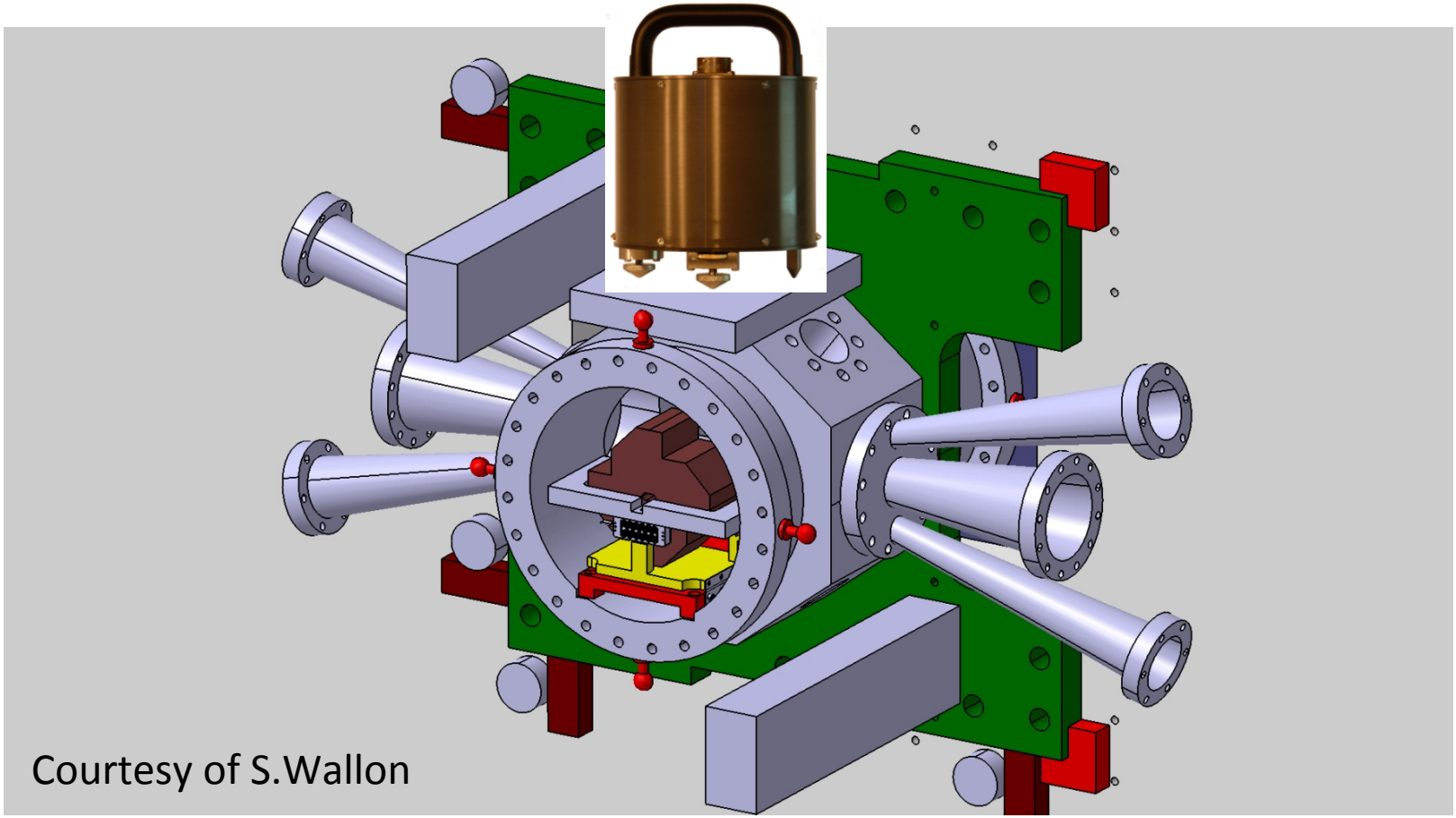
QD14X

QF4X

QF3X

QD2X

sensor support design by LAL
Fabrication on going

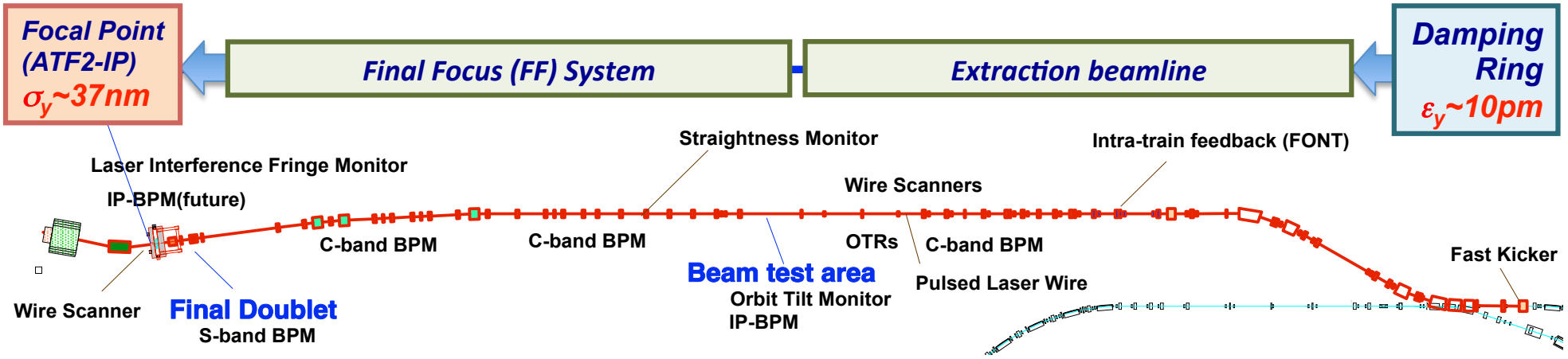


Summary

- The ATF2 is near the first goal of 37 nm vertical beam; **64 nm achieved**. Then, **we are opening the door of the second goal, the nanometer-level beam stabilization.**
- Equipment for the nanometer stabilization has been developed by French-Japanese team (LAL, LAPP and KEK).
  - chamber with the nm stabilization of the BPM and the evaluation of beamline vibrations.
- **This stabilization program will start in this year.**
- **The FJPPL(TYL) program assists our activity very much.**

additions

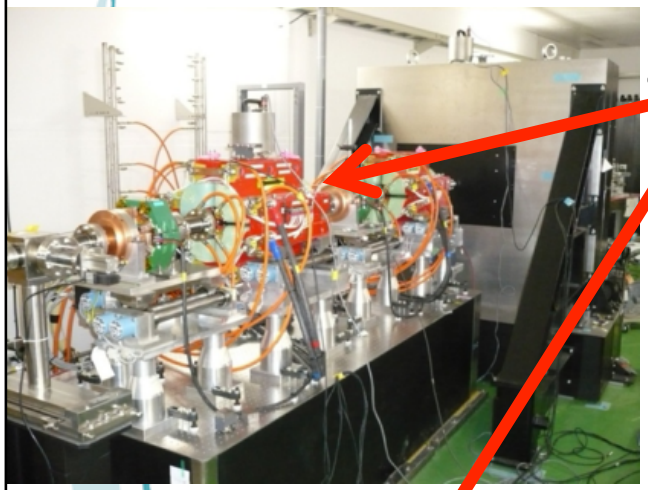
ATF2 Overview

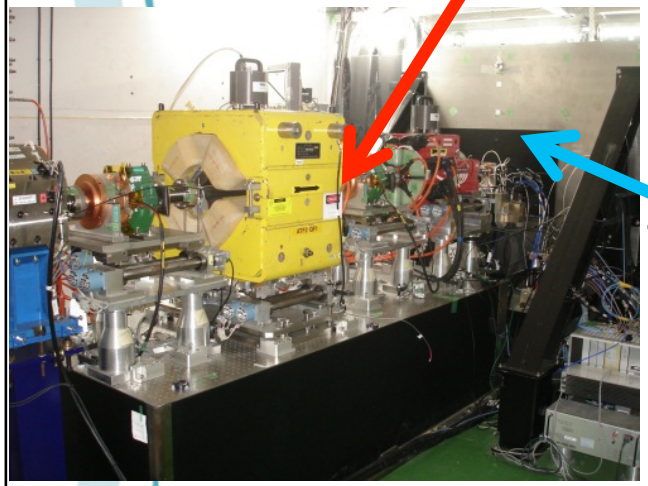


Features

- *uses low emittance beam extracted from ATF DR*
- *ATF2-FF optics is an energy scale down of the ILC final focus system.*
- *Demonstration of compact final focus optics for ILC*
- *Beam instrumentation has been developed with the ILC specifications.*
- *International participation in the commissioning and operation.*

Re-evaluation of vibrational behaviour: 2 main changes





- New Final Doublet (FD) magnet has been installed: 3 times heavier!
  - Vibration resonance will move to lower frequencies
  - Expect degraded vibrational behaviour
  - Compare with previous measurements done by LAPP
- New IP-chamber to be soon installed by LAL (see corresponding slides)