BDS experimental program

→ **main issues**
→ **ATF2 highlights & challenges**
→ **European contributions & future projects**

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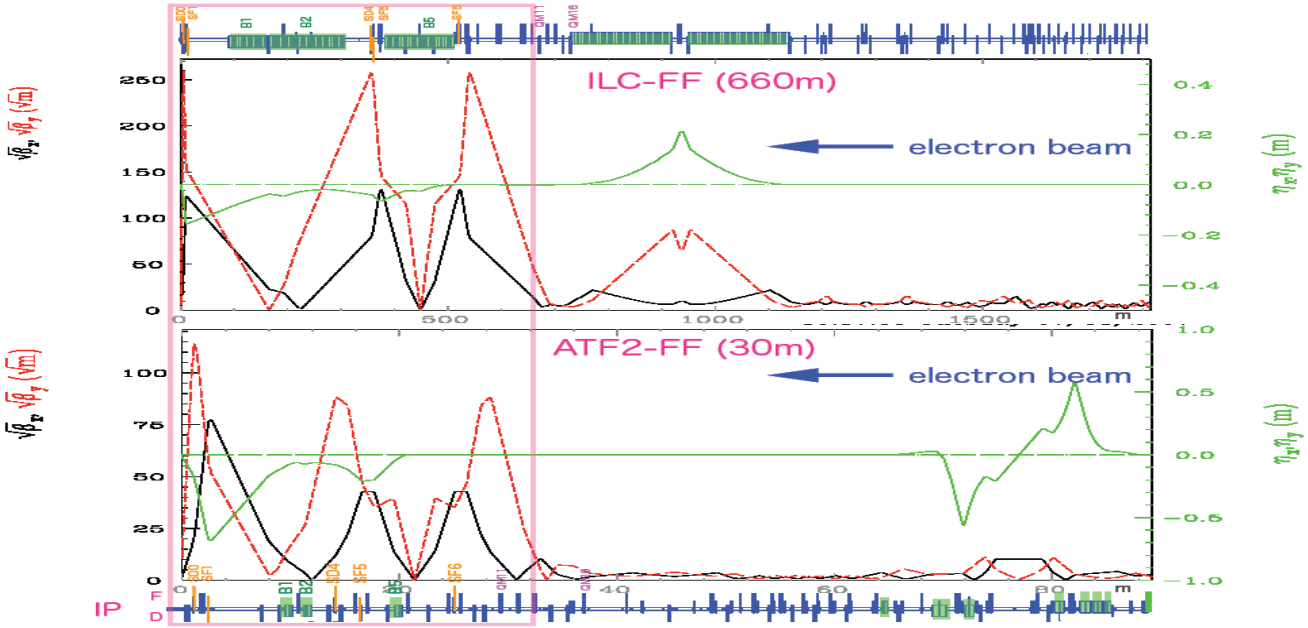
Parameters	ATF2	ILC	CLIC
Beam Energy [GeV]	1.3	250	1500
L* [m]	1	3.5 - 4.5	3.5
$\gamma\varepsilon_{x/y}$ [m.rad]	**5E-6 / 3E-8**	**1E-5 / 4E-8**	**6.6E-7 / 2E-8**
IP $\beta_{x/y}$ [mm]	**4 / 0.1**	**21 / 0.4**	**6.9 / 0.07**
IP η' [rad]	0.14	0.0094	0.00144
δ_E [%]	~ 0.1	~ 0.1	~ 0.3
Chromaticity ~ β / L*	**~ 1E4**	**~ 1E4**	**~ 5E4**
Number of bunches	1-3 (goal 1)	~ 3000	312
Number of bunches	3-30 (goal 2)	~ 3000	312
Bunch population	1-2E10	2E10	3.7E9
IP σ_y [nm]	**37**	**5.7**	**0.7**

ATF2 = scaled ILC
& CLIC final focus



Main BDS issues

validate, develop, practice, train,…

- Beam instrumentation
  - nm-level position
  - profile (x, y, tilt)
- Stabilization
  - passive / active mechanical stabilization
  - beam / vibration measurement based feed-back/forward
- 4+1 dim. phase space tuning & control for IP spot minimization
  - mitigation of 1^{st}, 2^{nd} and 3^{rd} order optical aberrations
  - convergence time $\leftrightarrow$ dynamical errors (sismic & thermal effect)
- Halo control
  - modeling, generation, propagation, monitoring…
  - collimation (physical, optics)

ATF2 Goals

- **Small vertical beam size** *"goal 1"*
  - **achieve σ_y ~ 37 nm (cf. 5 / 1 nm in ILC / CLIC)**
- **Stabilization of beam center** *"goal 2"*
  - **down to ~ 2nm**
  - **bunch-to-bunch feedback (~300 ns, for ILC)**
- **R&D on nanometer resolution instrumentation**
- **Training of young accelerator physicists and engineers on "real system"**

→ *open & unique facility*


IP


Shintake Monitor
Monitor
IP


Final Doublet

ATF International Collaboration

CERN
DESY
IN2P3
- LAL
- LAPP
- LLR

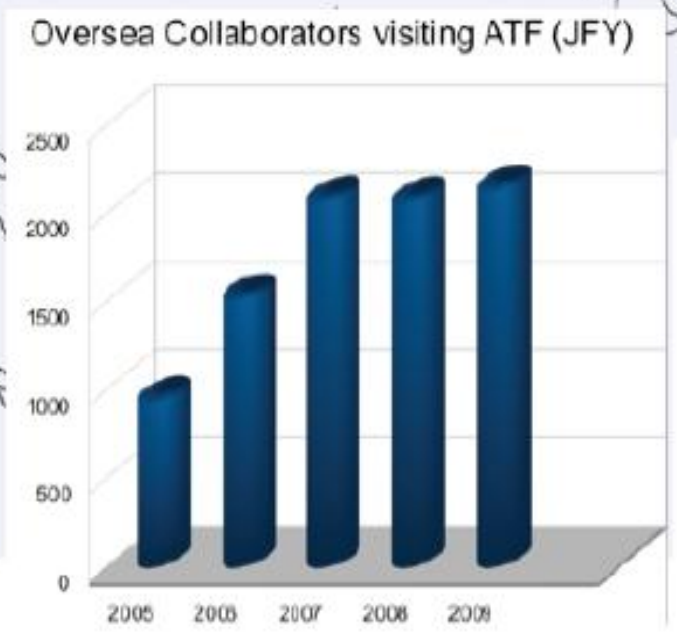
John Adams Inst.
- Oxford Univ.
- Royal Holloway Univ.

Cockcroft Inst.
- STFC, Daresbury
- Univ. of Manchester
- Univ. of Liverpool

University College London
INFN, Frascati
IFIC-CSIC/UV
Tomsk Polytechnic Univ.

KEK
Waseda U.
Nagoya U.
Tokyo U.
Kyoto U.
Tohoku Univ.
Hiroshima U.
IHEP
PAL
KNU
RRCAT

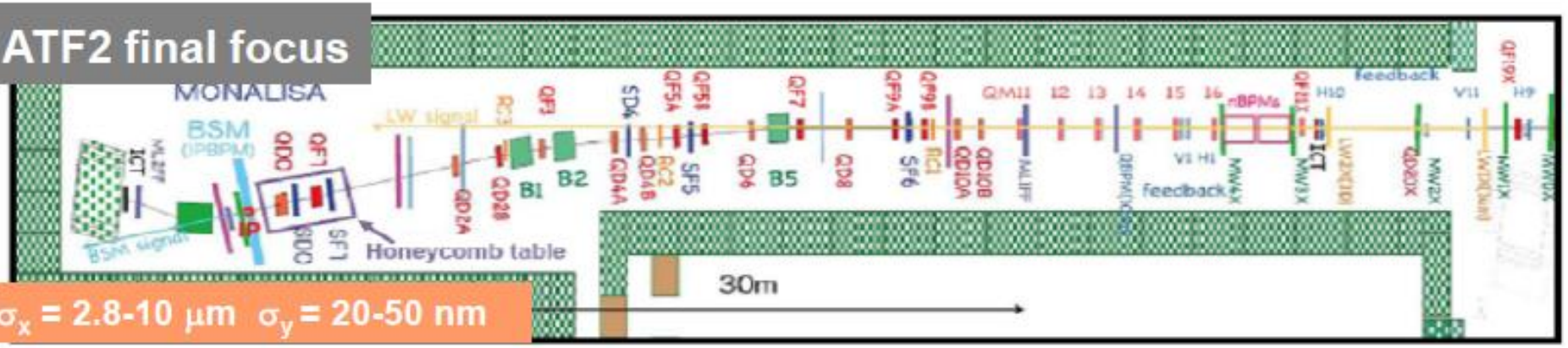
SLAC
LBNL
FNAL
Cornell Univ.
LLNL
BNL
Notre Dome Univ.



Overseas
25 Institutes,
~70 people,
~2000 people-days per year
+
KEK and Japanese Universities(6)

Accelerator Test Facility @ KEK

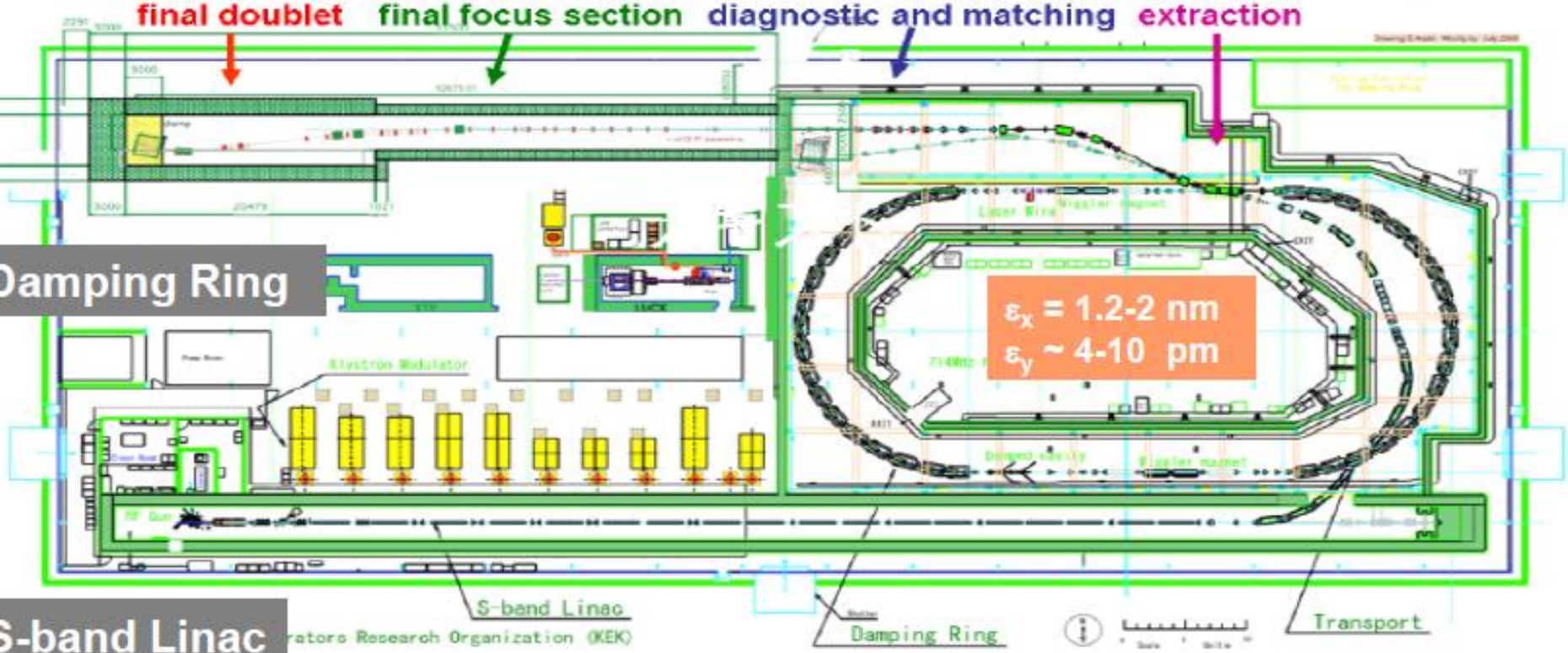
ATF2 final focus



σ_x = 2.8-10 μm σ_y = 20-50 nm

final doublet | final focus section | diagnostic and matching | extraction

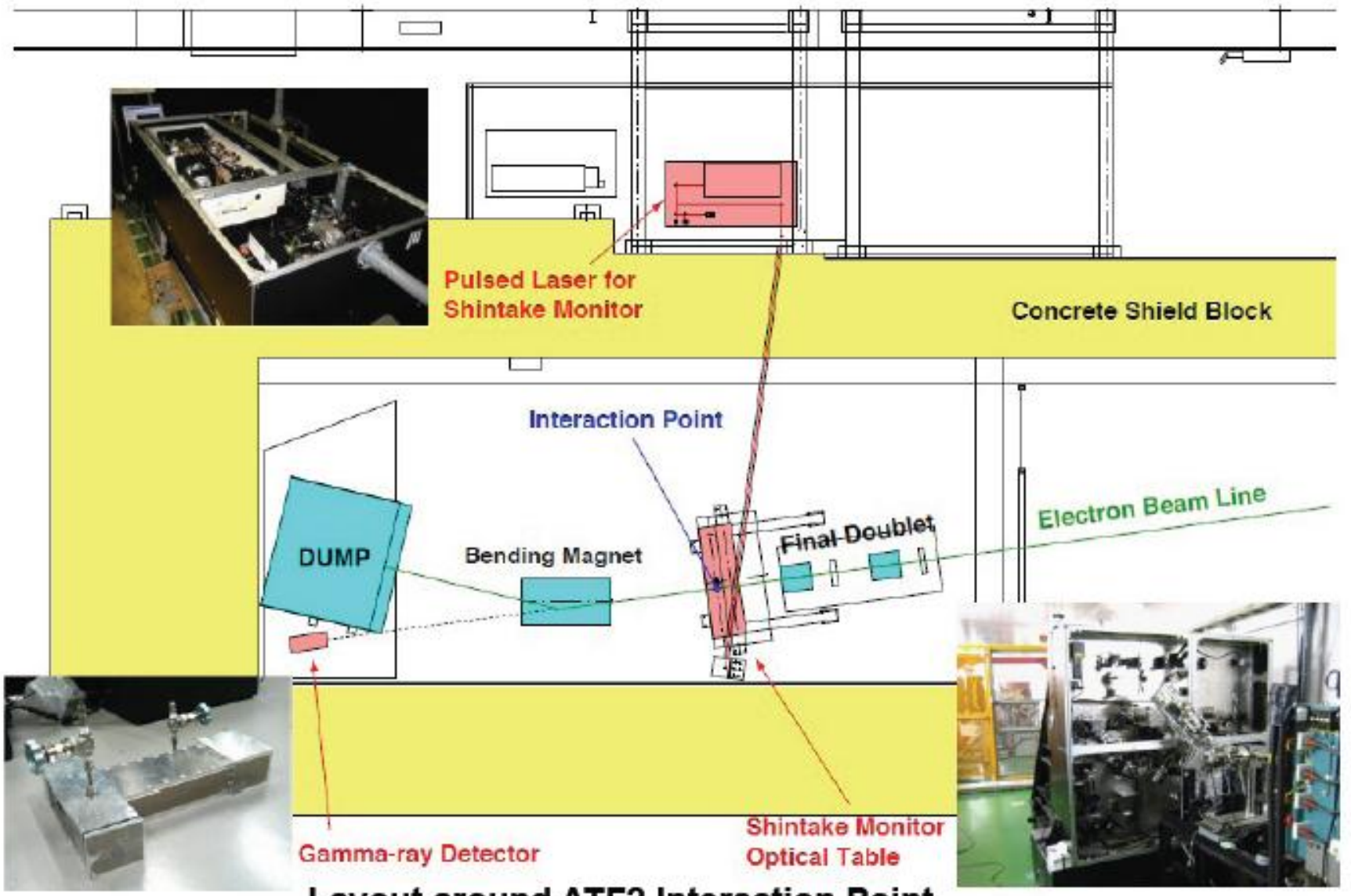
Damping Ring



ε_x = 1.2-2 nm
ε_y ~ 4-10 pm

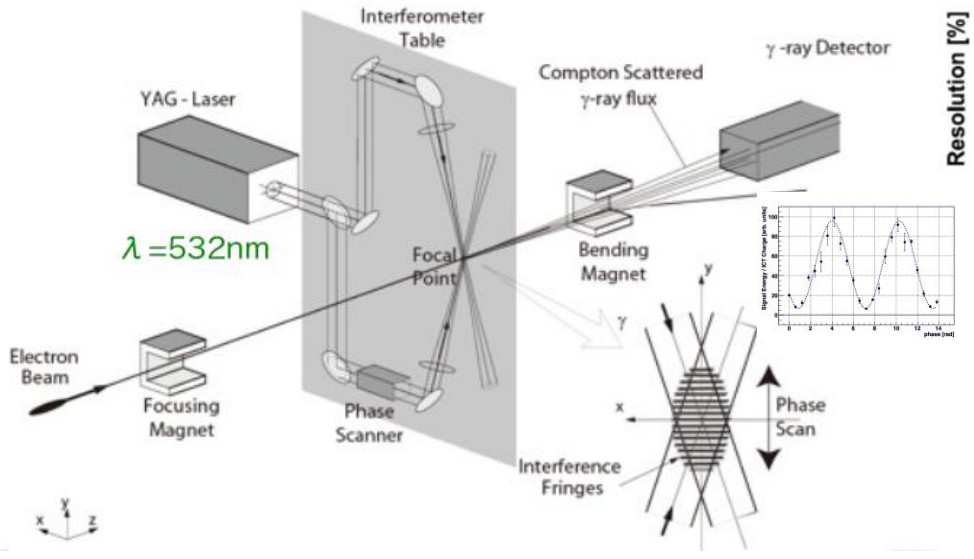
S-band Linac

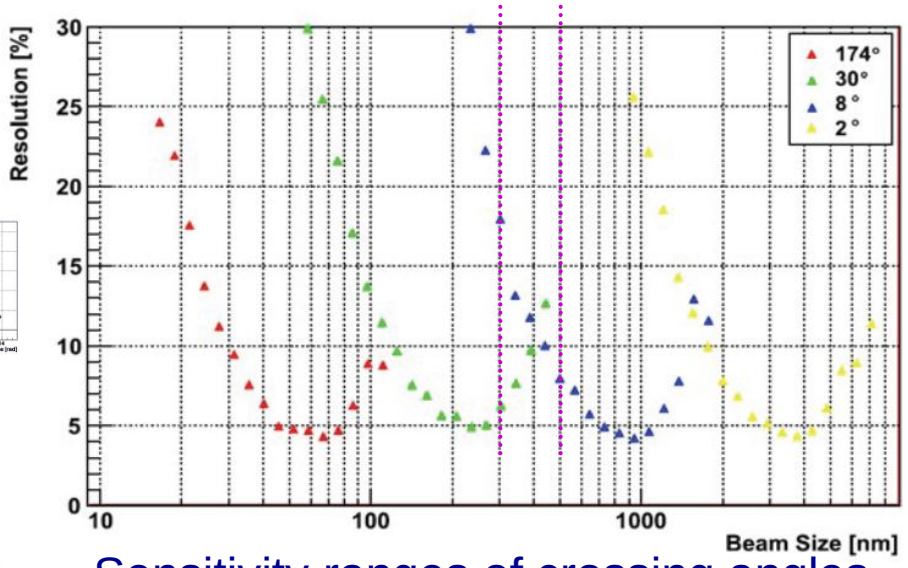
Shintake Monitor : Layout



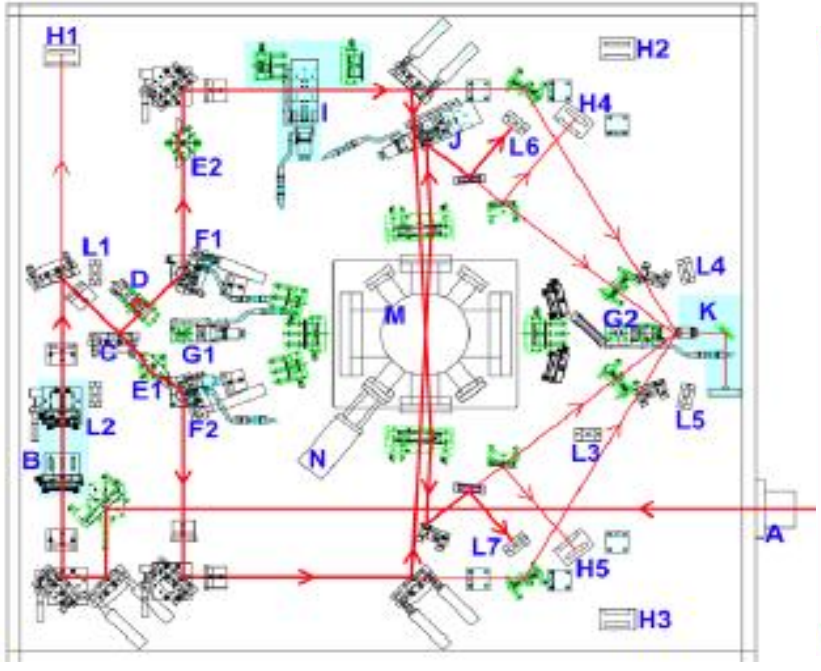
Layout around ATF2 Interaction Point

“Shintake” beam size monitor at IP

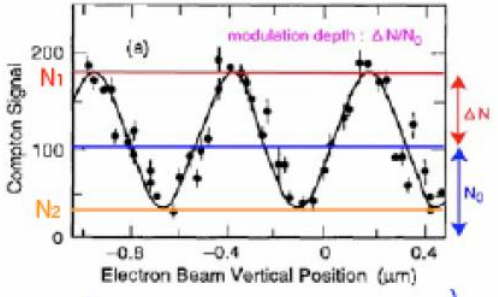




Sensitivity ranges of crossing angles



How it works as follows



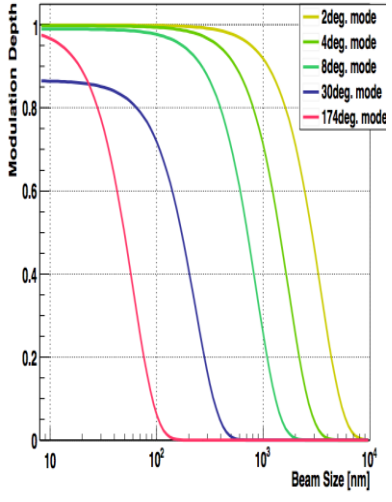
$$\sigma_y = \frac{d}{2\pi}\sqrt{2\cdot\ln(|\cos\theta|/M)} \qquad d = \frac{\lambda}{2\cdot\sin\frac{\theta}{2}}$$

Wave length 532nm, width=8ns

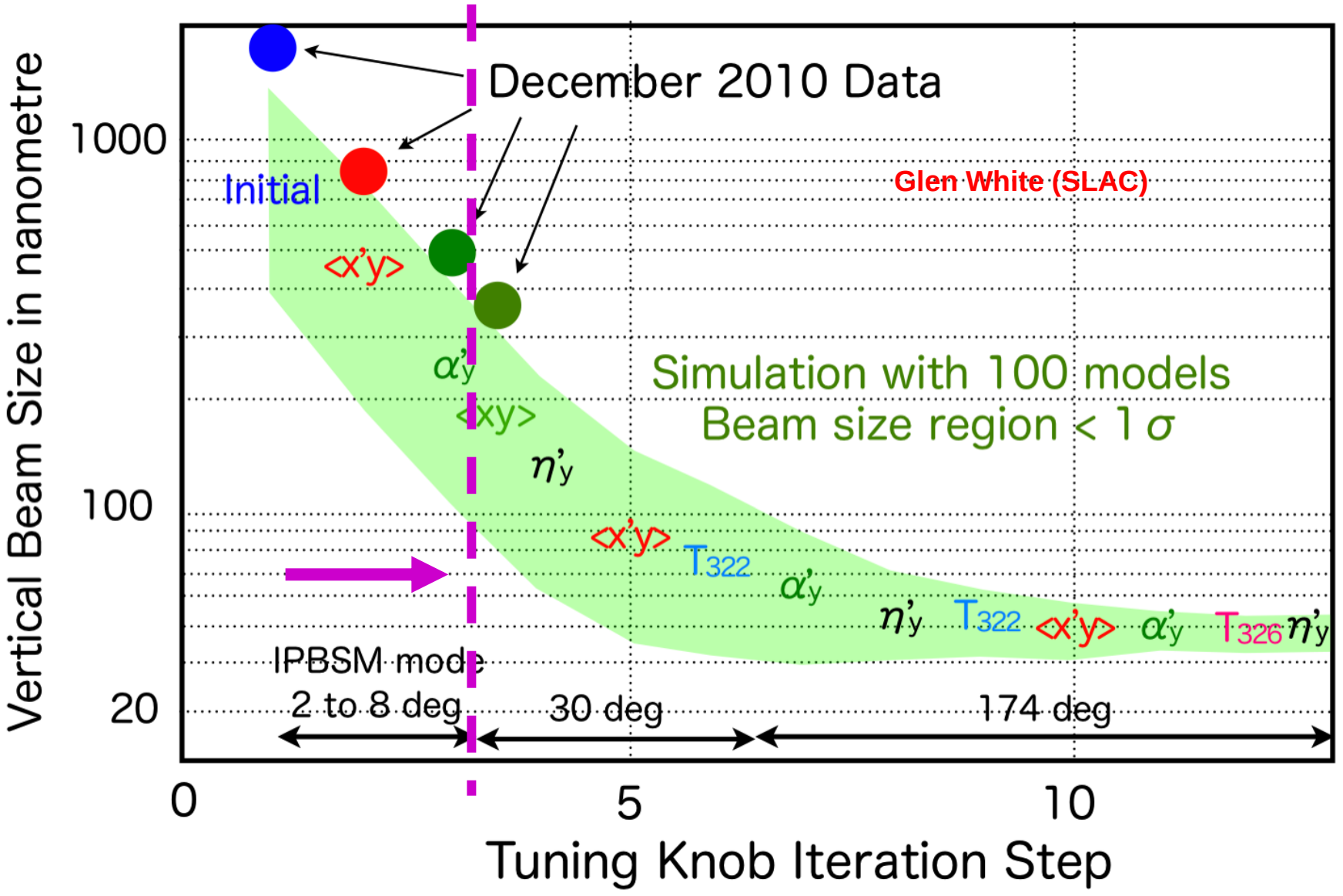
$\Delta\nu/\nu = 1.6 \times 10^{-7}$

Laser intensity = 2.8×10^{13} W/cm^2

$a_0 = 1.7 \times 10^{-4}$



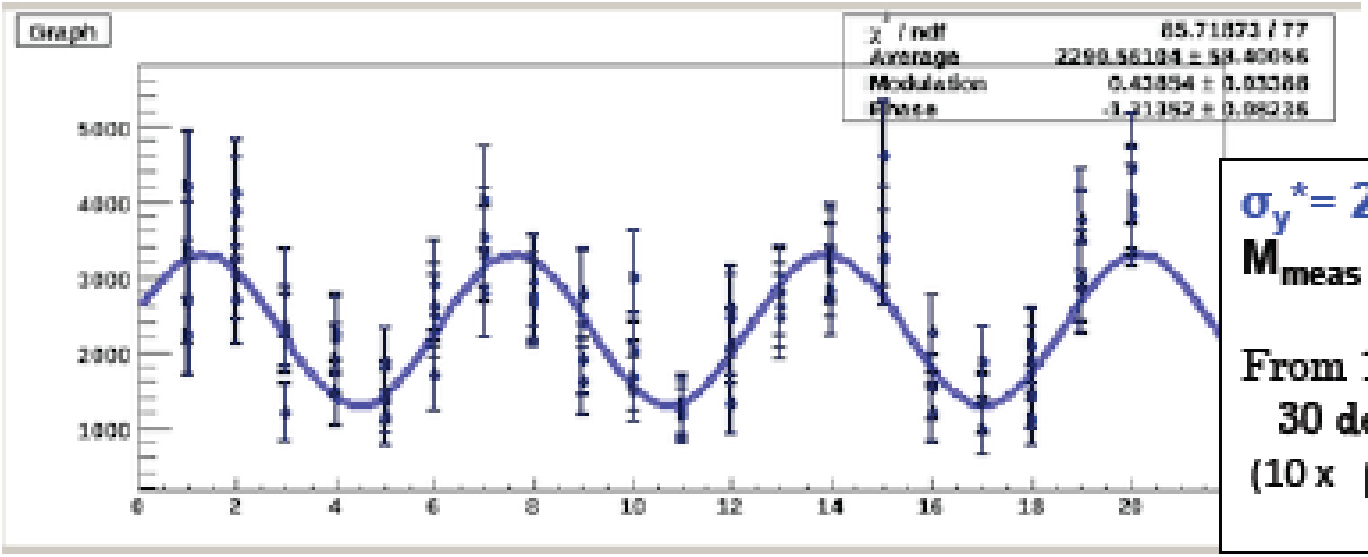
Tuning the ATF2 vertical beam size



Commissioning of 30 deg mode

Jacqueline Yan (Tokyo)

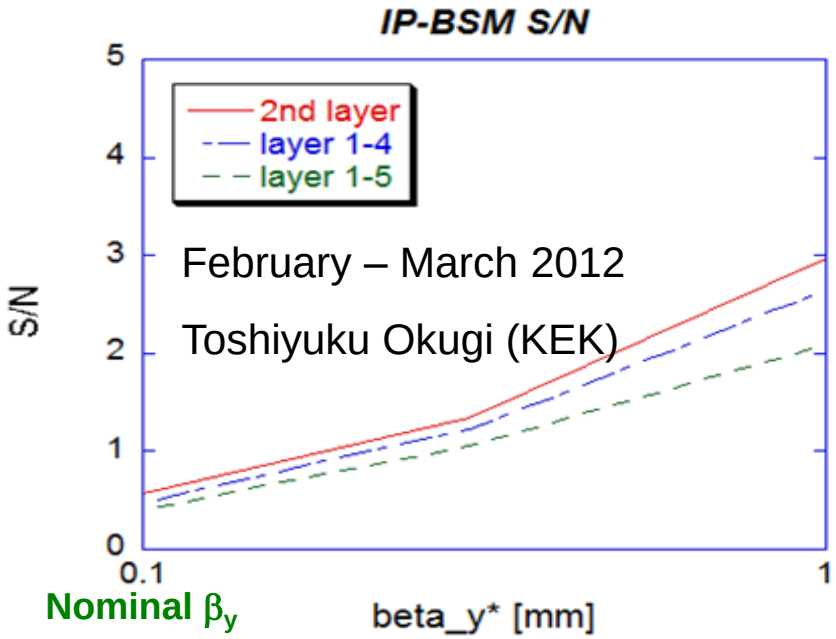
February 2012



$\sigma_y^* = 201 \pm 4.4$ (stat.) nm

$M_{meas} = 0.429 \pm 0.012$ (stat.)

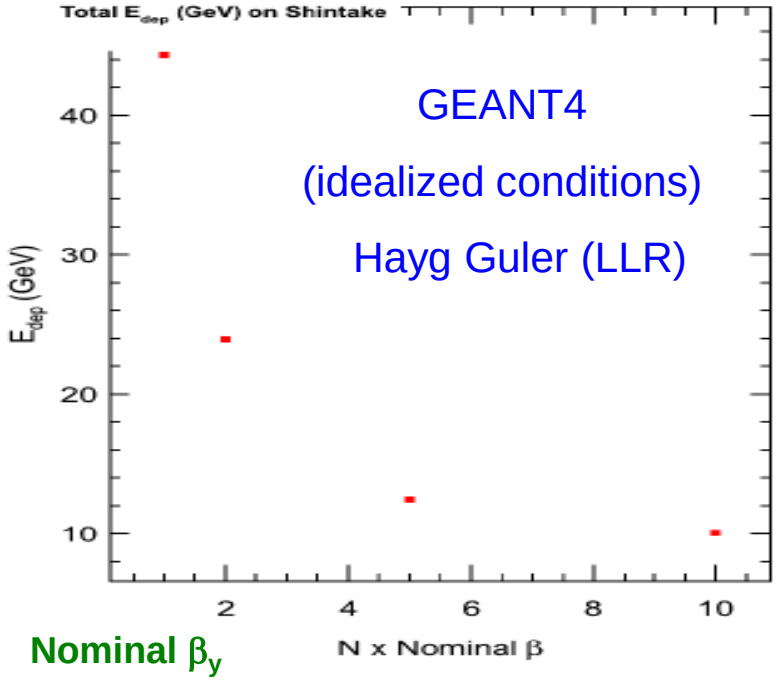
From 10 stable consecutive scans
30 deg, Feb 17, 2012
(10 x β_x^*, 10 x β_y^* optics)



February – March 2012

Toshiyuku Okugi (KEK)

Nominal β_y



GEANT4

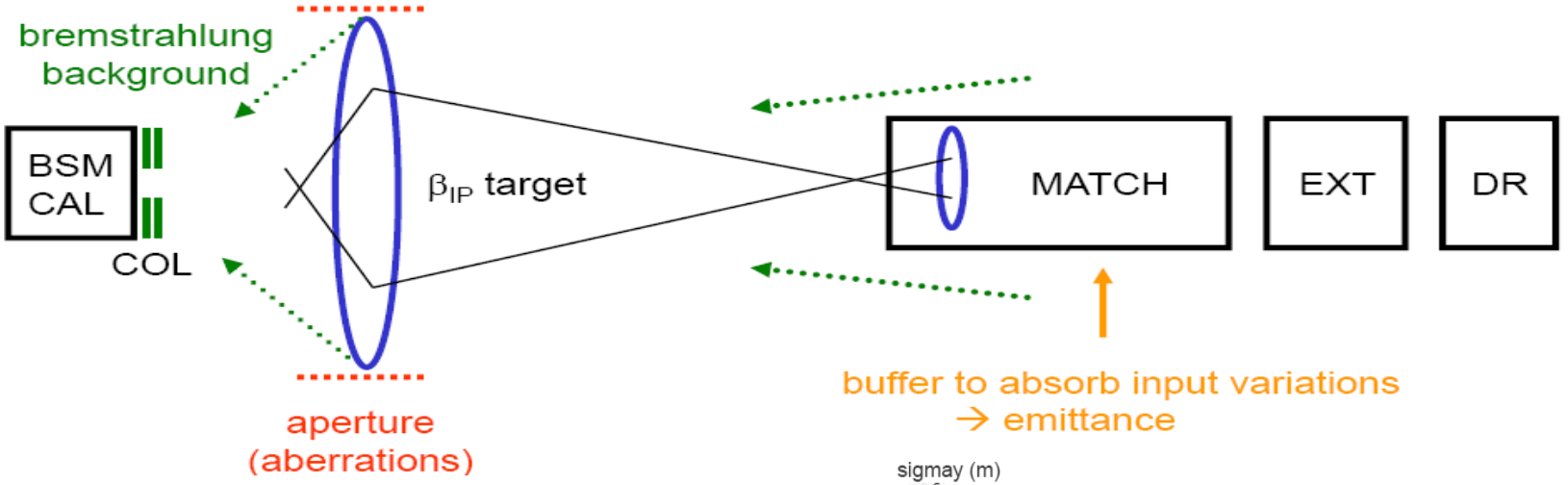
(idealized conditions)

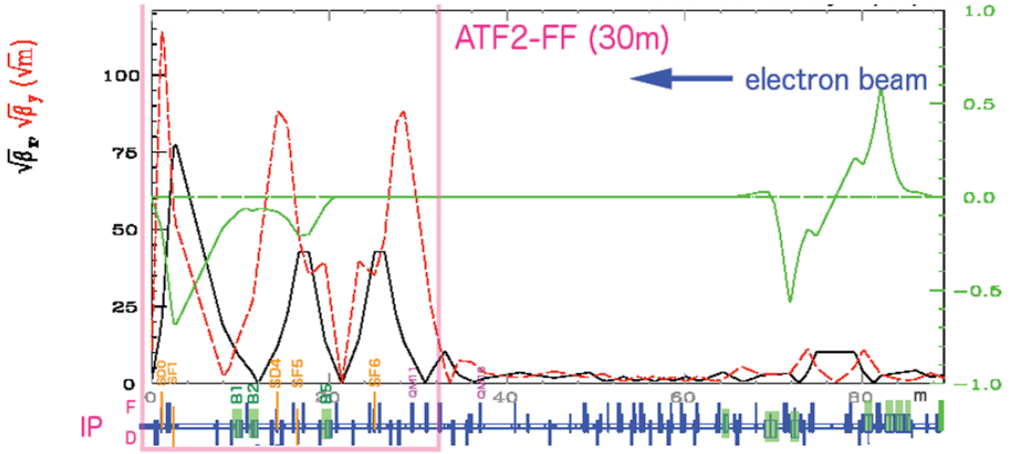
Hayg Guler (LLR)

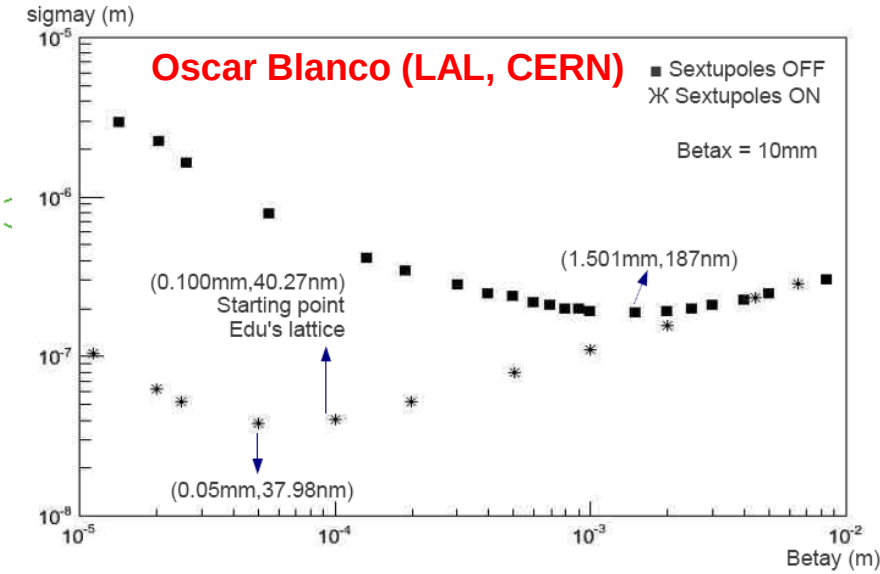
Nominal β_y

Commissioning → gradual $\beta_{x,y}$* (demagnification) reduction paced by

beam tuning | instrumentation (BSM / other) | background study





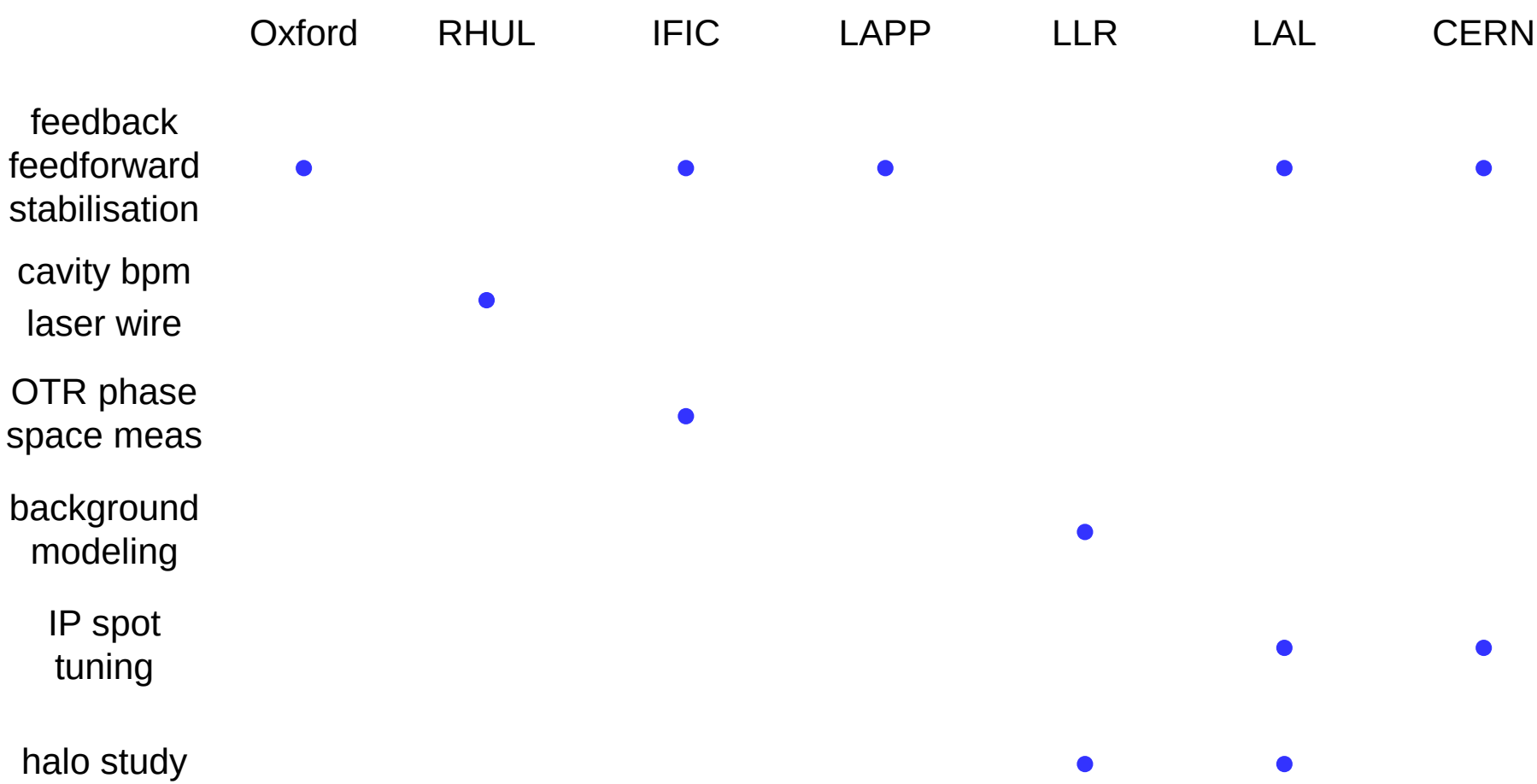


New strategy for "Goal 1" small beam size achievement

Multiple team R&D efforts ➔

1. **train 12 "operators" in March – June 2012** ***(9 weeks)***
2. **100% dedicated run in October-December 2012** ***(8 weeks)***

European contributions (ATF2)



New European projects (ATF2)

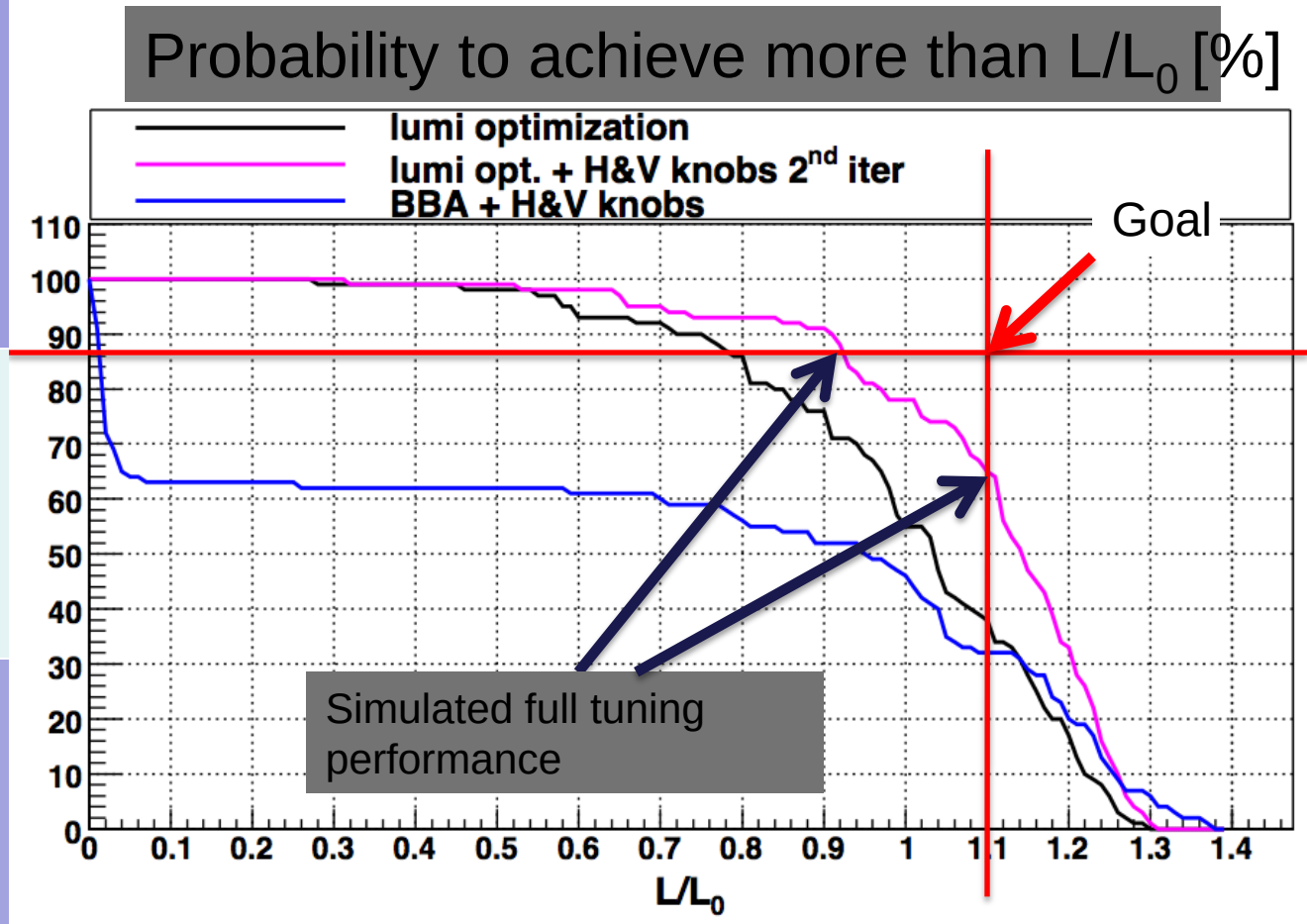
- Sensors to correct GM effects on ATF2 beam orbit data (fluctuation analysis), already bought at LAPP and will be shipped (with CERN & LAL)
- Ultra-low beta to push beam size down below 37 nm, new QD0/QF1 design, tiny (skew) multipoles, permanent or hybrid technology, will also pursue multipole mitigation in other magnets by swapping based on ordering (CERN,…)
- CLIC DR kicker specs not OK for ATF, but new design (IFIC, CIEMAT) may be possible (rise time, flat top, pulse length, stability, physical length, kick angle)
- Measure beam halo and «Shintake» Compton recoil electrons (→ **prepare for non-linear QED studies**) after the BDUMP magnets (LAL)
- Collimation for ATF2 ? (IFIC ??, CERN ??)

CLIC BDS tuning is sophisticated…

Main design issues
- chromaticity
- non-linear effects
- synchrotron radiation
- tuning
- stability

- Design is OK
- Imperfection mitigation comes close to target ($L \geq 110\% L_0$, probability 90%)

- But design is complex
- Convergence of tuning procedure is slow in simulations $O(10^4)$ iterations
- Very sensitive to dynamic effects
- Requires very advanced instrumentation and component design



Realism needs to be tested

→ ATF2 still far from this level

Concluding comments

- ATF2 is making good strong progress in 2012, after recovering from the earthquake
- The 30 degree mode of “Shintake” monitor is now validated → vertical beam size ≤ 200 nm

- Several BDS challenges need attention, for validation and further development
- Essential → expert training will be required, continuously…

- **ATF2/3** continues to serve a real technical purpose → should be supported (also relevant test for global international collaboration)
- **“CLIC 0” initiative**, if extended to address BDS, would be a significant and interesting step, which should then be evaluated globally