ATF2

status and start of commissioning

Andrei Seryi, SLAC

for the ATF2 team

May 8, 2009

ATF2 team

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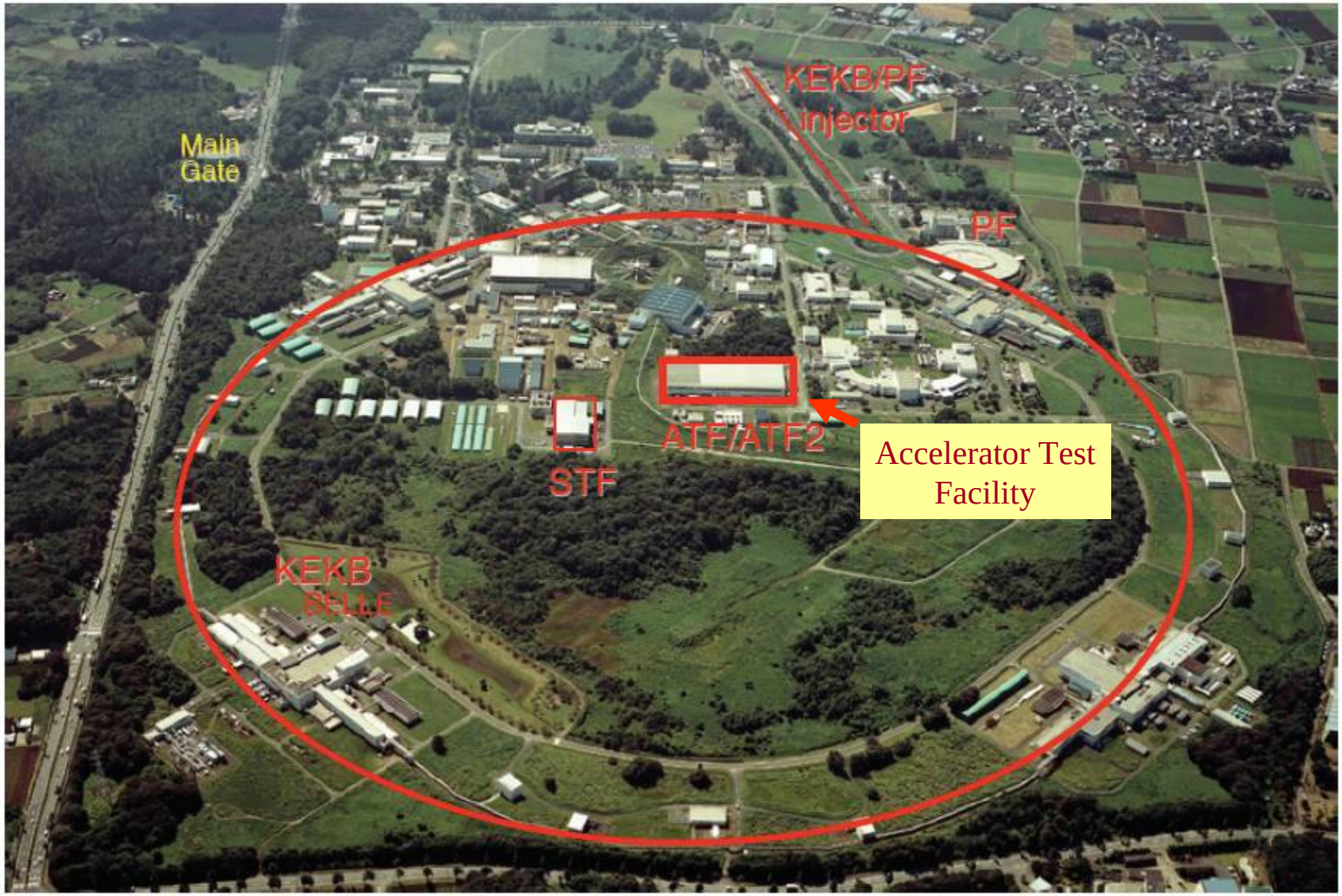
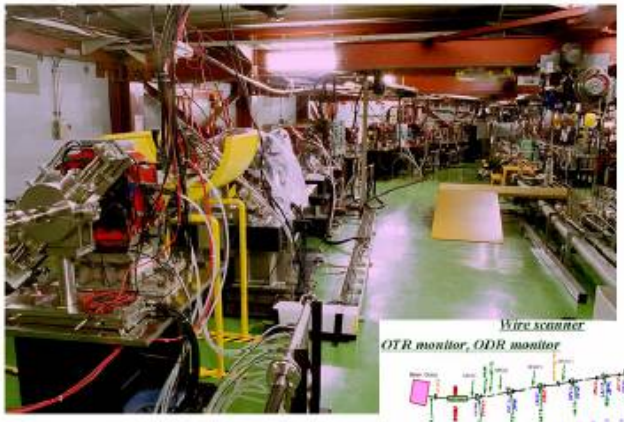
and colleagues who unintentionally missed from the list

Plan of the talk

- History and goals
- Organization
- Schedule and construction
- Highlights of recent beam runs
- Near term plans
- Longer term outlook

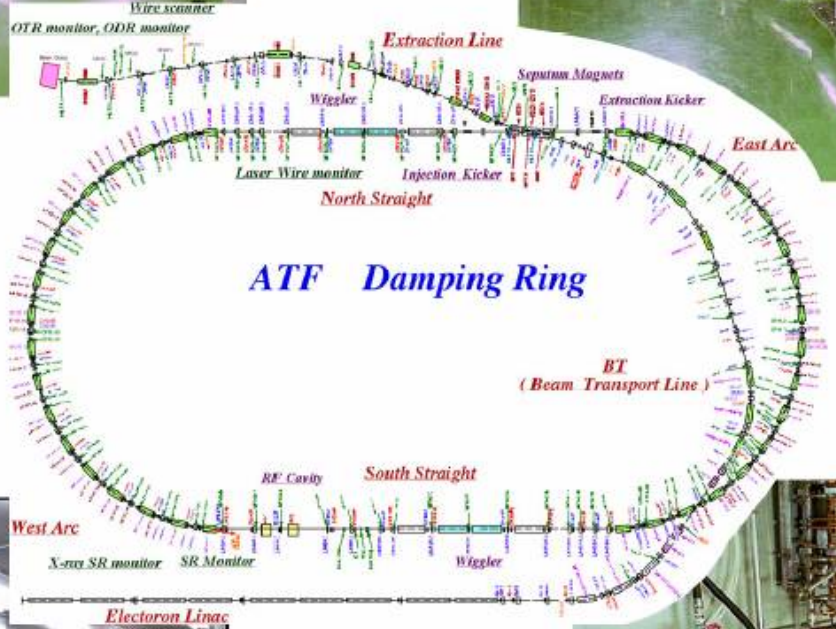

Main Gate
KEKB/PF injector
PF
ATF/ATF2
STF
KEKB
BELLE
Accelerator Test Facility

ATF and ATF2



Extraction Line

Damping Ring



Control Room

Linac

Accelerator Test Facility, KEK

1997-2008

Extraction line :utilization of low emittance beam
beam instrmentation, collimator damage

Cavity BPM
nanometer res.

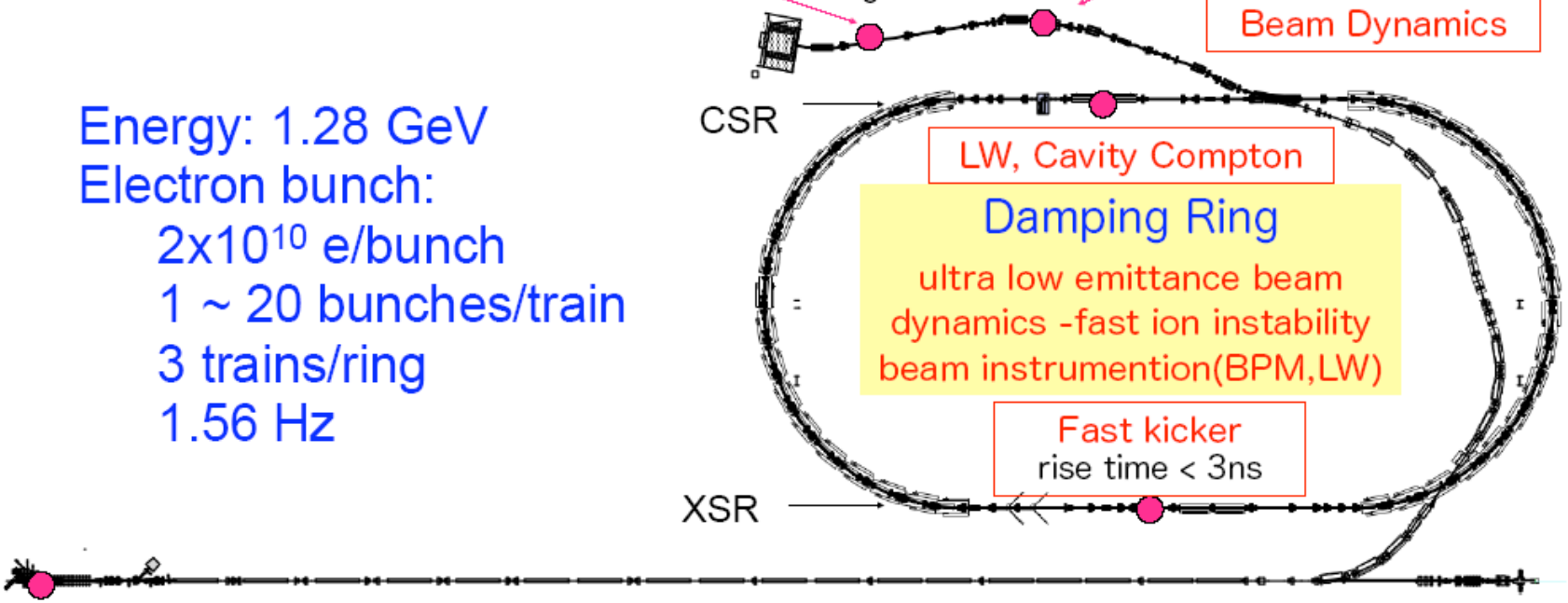
FONT
fast feedback (ns)

Pulsed Laser Wire Scanner
for beam size monitor (μm)

ODR, OTR
single shot meas.

Beam Dynamics

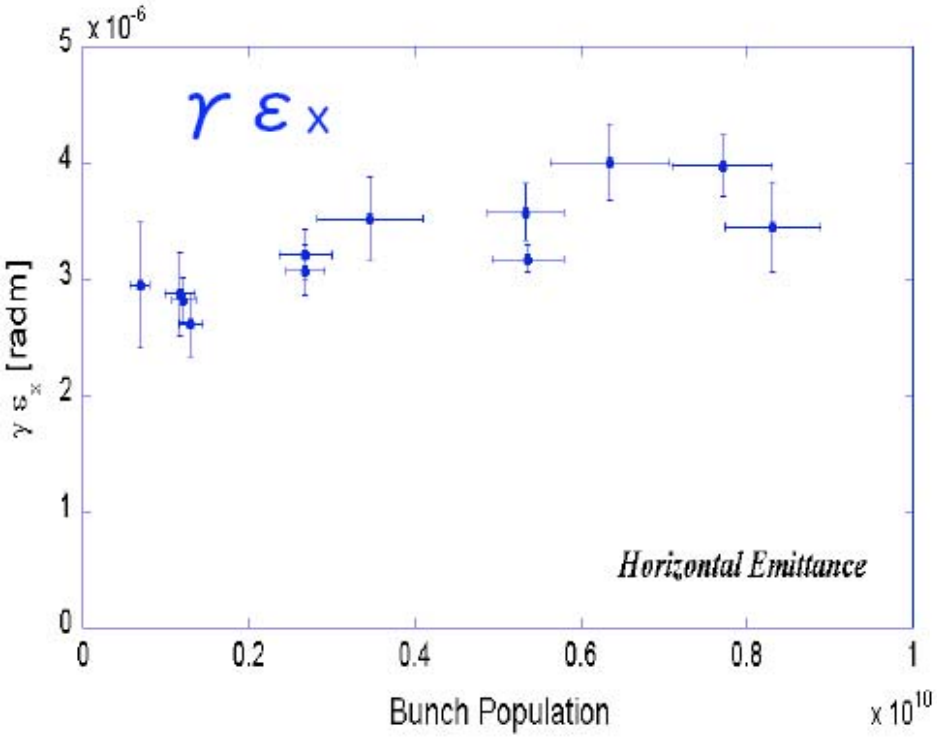
Energy: 1.28 GeV
Electron bunch:
- 2×10^{10} e/bunch
- 1 ~ 20 bunches/train
- 3 trains/ring
- 1.56 Hz

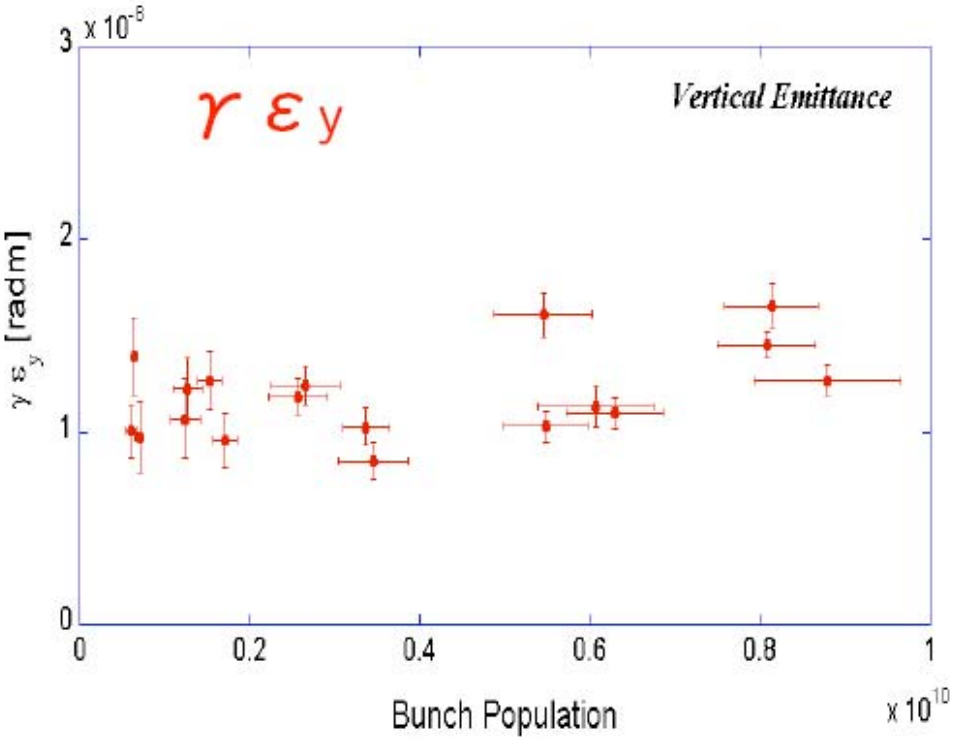


RF Gun
multi-bunch beam

S-band Linac (70m)
multi-bunch acceleration

Low emittance in ATF





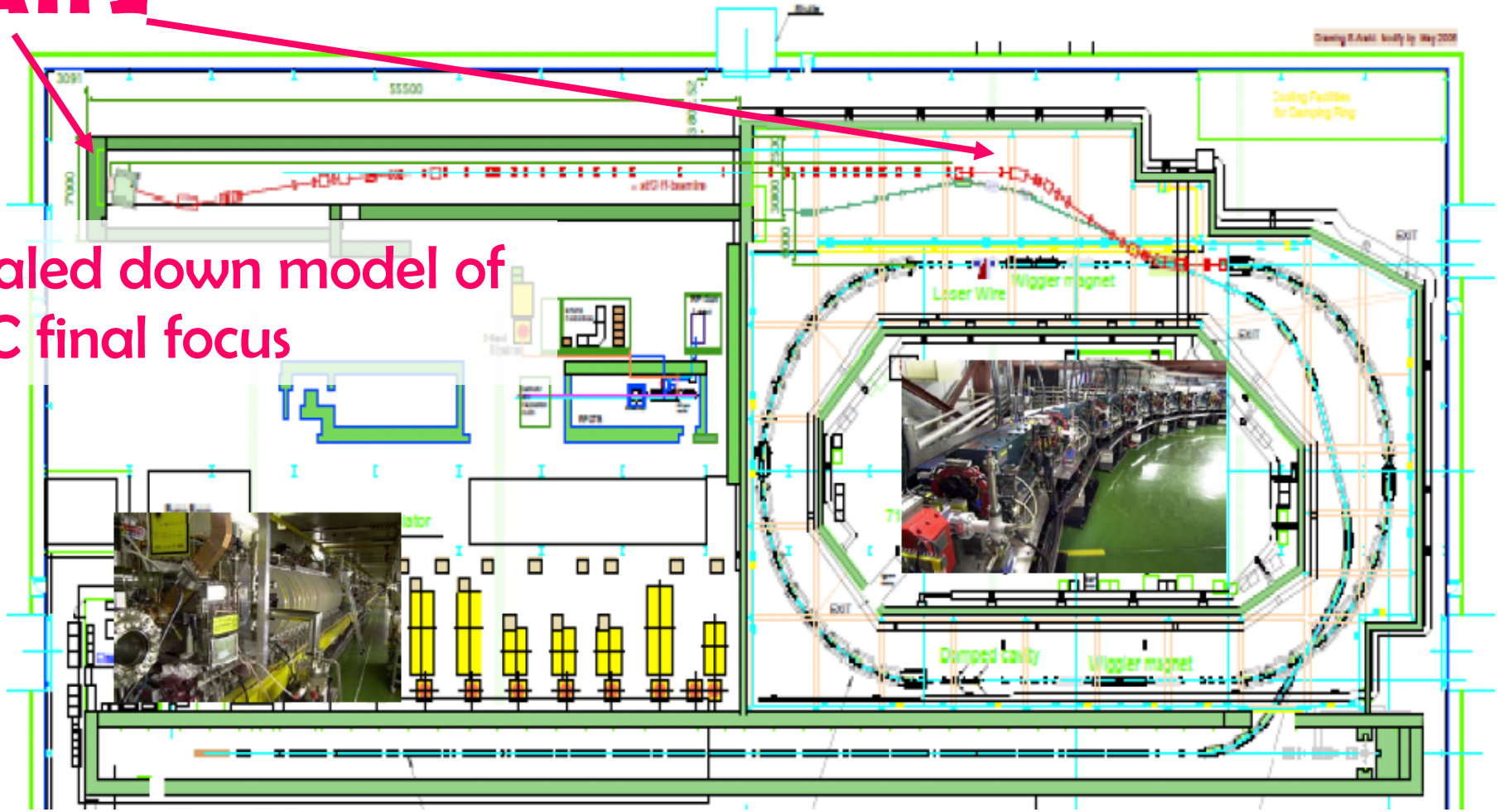
- Best measurements of emittance in ATF DR:
  - the ε_y=4pm is the best achieved value at low intensity and it becomes 1.5 times at the intensity of 1 x 10^10/bunch [Y.Honda et al., PRL 92 (2004) 054802]
- Very recent preliminary vertical emittance:
  - the ε_y=5pm (about 10% error) which was measured by Laser Wire in DR
  - thus, the best conditions are reproducible.

ATF
Accelerator Test Facility

at KEK

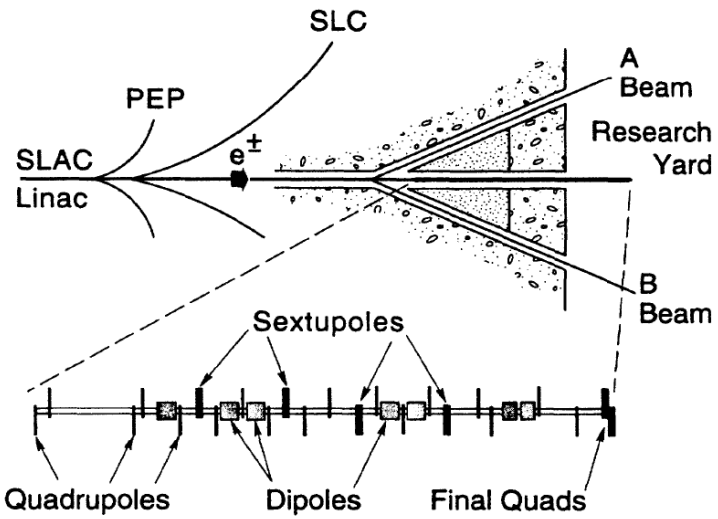
ATF2

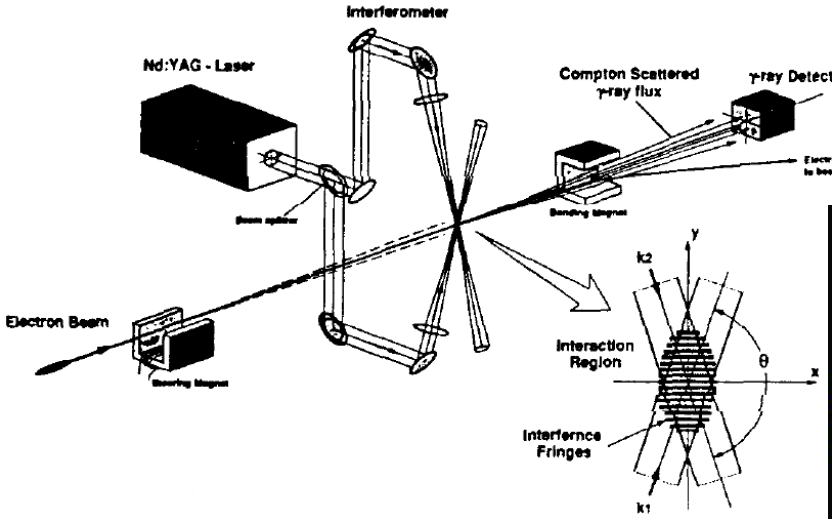
Scaled down model of
ILC final focus

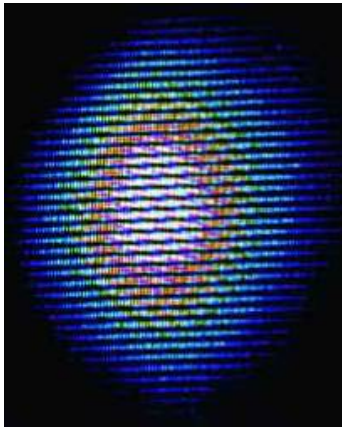


Final Focus Test Beam – optics with traditional **non-local** chromaticity compensation

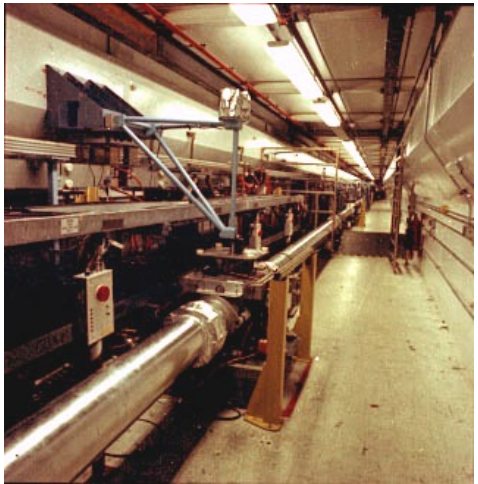
~1990-1995

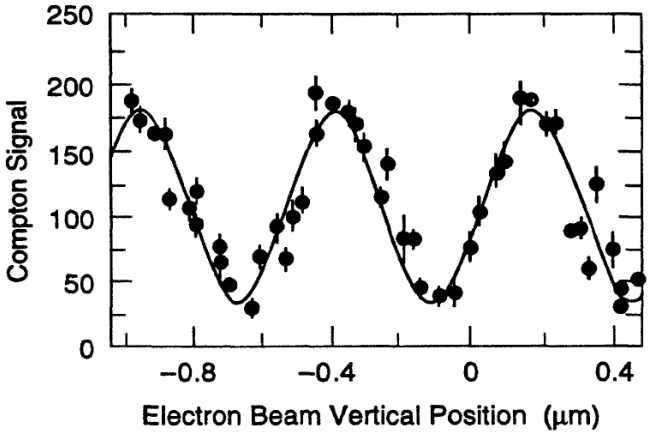






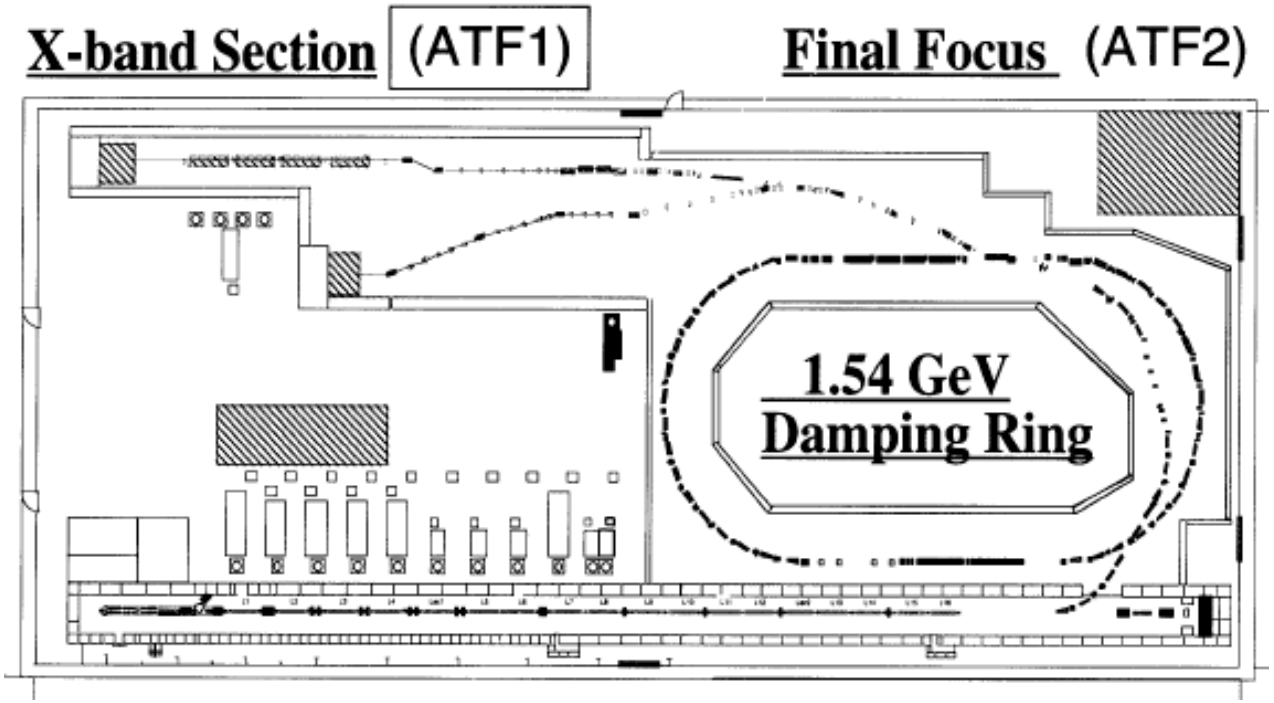
Achieved ~70nm
vertical beam size





ATF2

- The idea of **final focus with local chromatic correction** suggested in ~2000, and allowed, in particular, shortening FF of linear collider considerably
- The suggestion of a new test facility at ATF, to prototype the **final focus with local chromatic correction**, was considered in **2002** at Nanobeam workshop in Lausanne



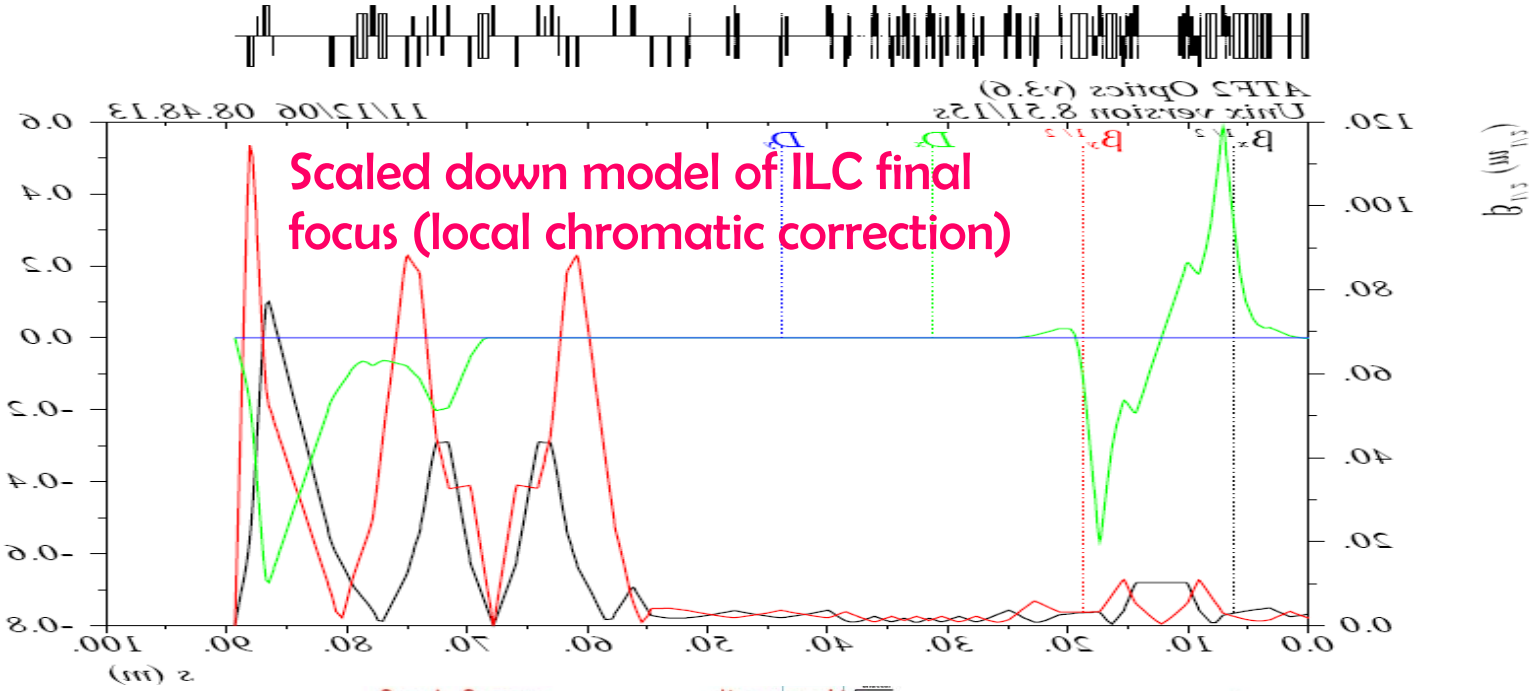
Early scheme as presented by
Junji Urakawa at Nanobeam 2002

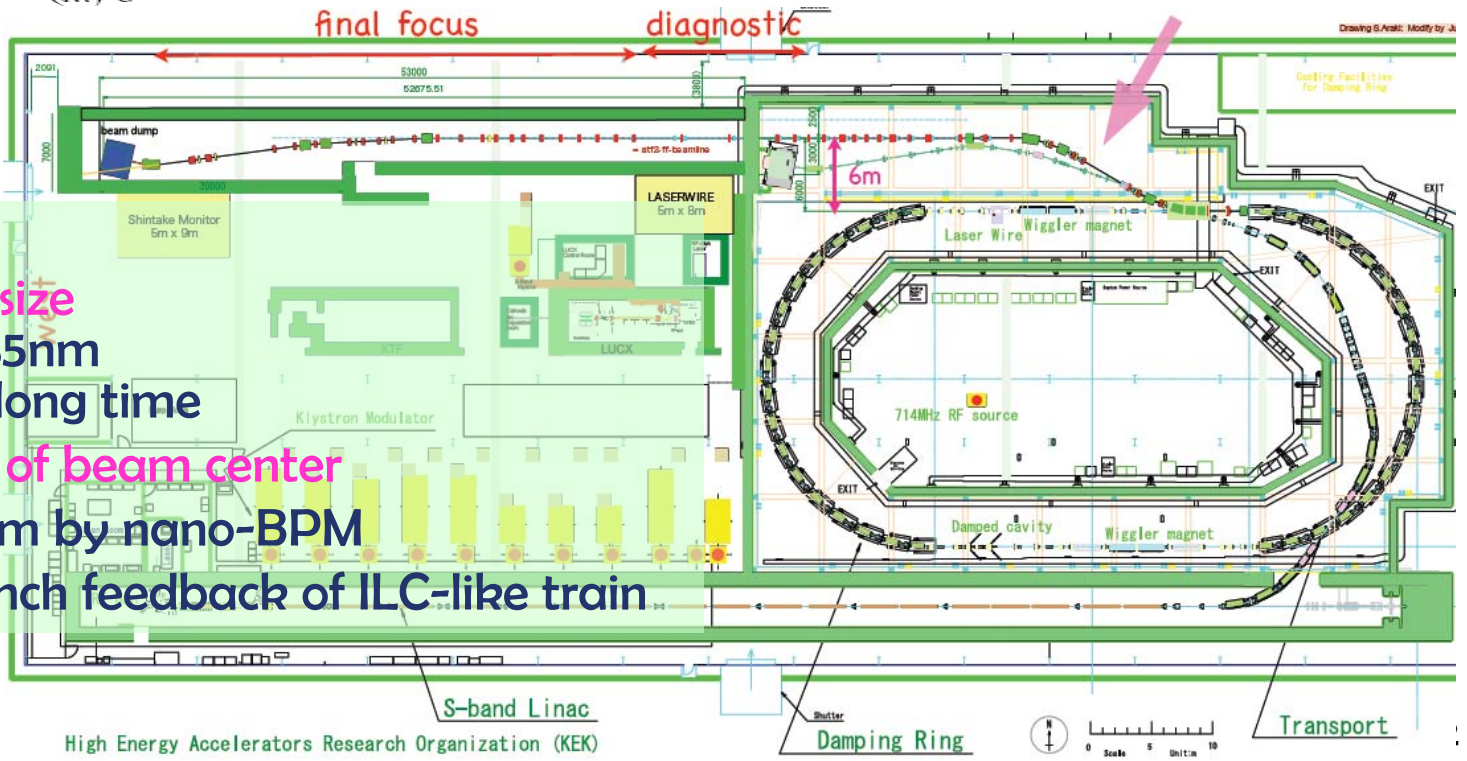
ATF2 major milestones

- September 2002, Nanobeam workshop, Lausanne
  - idea of new Final Focus test facility at ATF
- January 2005, SLAC, first ATF2 workshop
  - compared two optics versions, selected ILC-like design
  - stated the need to document the Proposal
- May 2005, ATF2 mtg at KEK
  - collaboration organization & MOU, task sharing, 1st version of schedule (commissioning start range: 02.2007-02.2008)
- August 2005
  - ATF2 Proposal, Vol.1 (technical description) released
- February 2006, SLAC, 1st ATF2 Project Meeting
  - ATF2 Proposal, Vol.2 (organization, cost & contributions) released
- May 2006, KEK, 2nd ATF2 Project Meeting …
  - detailed design & role sharing
- … May 2008, BINP Novosibirsk, 6th ATF2 Project Meeting
  - Review of construction status and commissioning readiness
- Dec 2008, KEK, 7th ATF2 Project Meeting
  - Focused on review of commissioning readiness, organization & planning

ATF2 Proposal: 110 authors, 25 institutions

ATF2 – model of ILC BDS

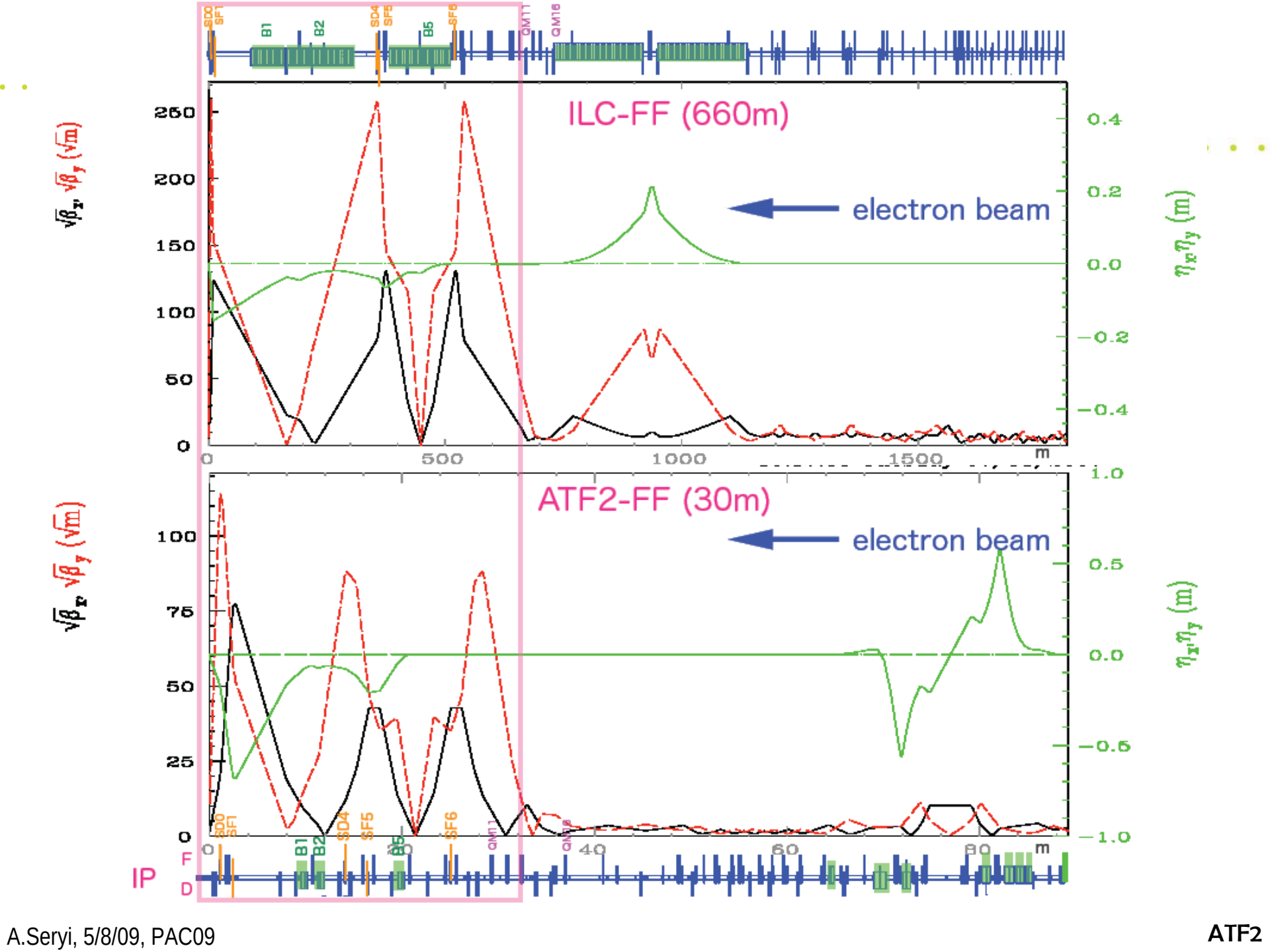




ATF2 goals

(A) Small beam size
- Obtain σ_y ~ 35nm
- Maintain for long time

(B) Stabilization of beam center
- Down to < 2nm by nano-BPM
- Bunch-to-bunch feedback of ILC-like train

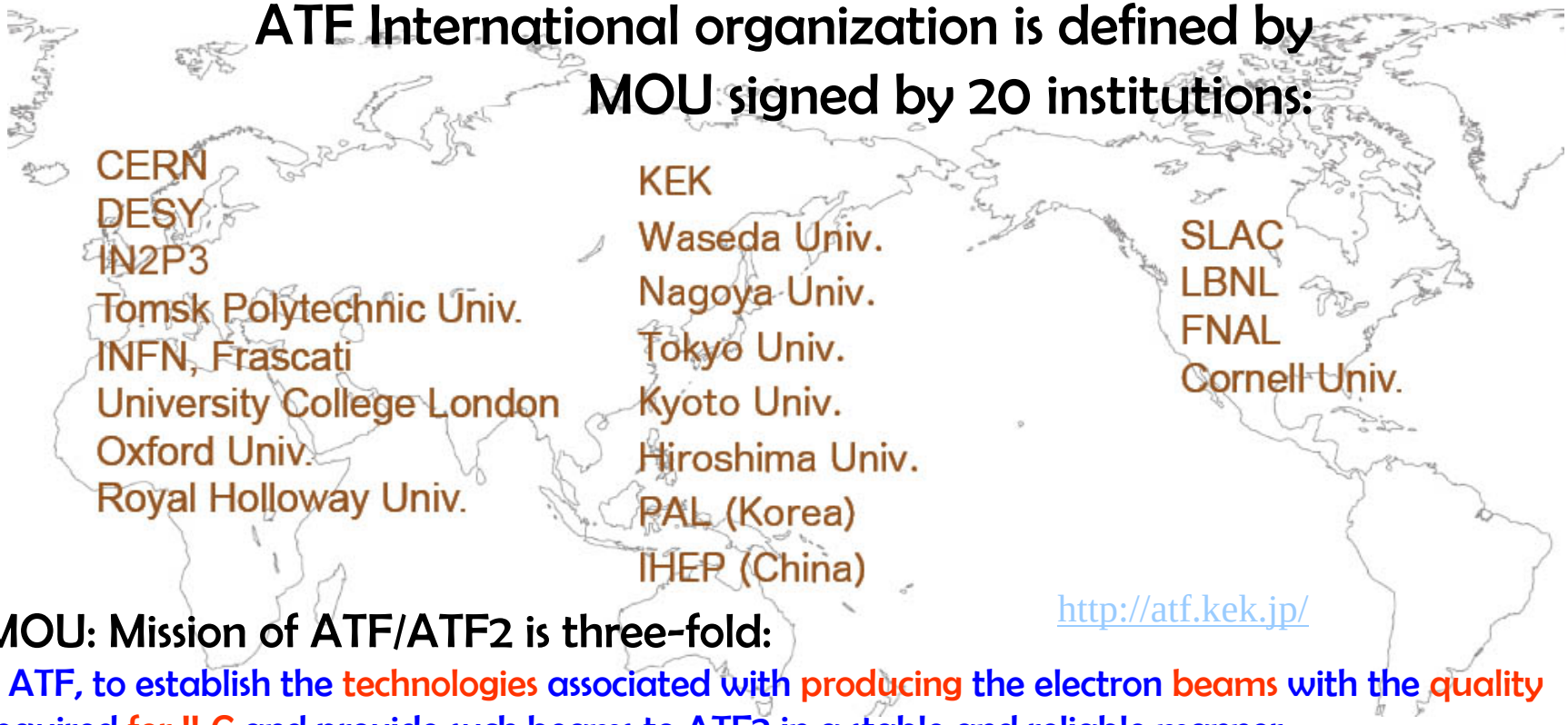

ILC-FF (660m)
electron beam
ATF2-FF (30m)
electron beam
IP
F
D
m

ATF2 & ILC parameters

Parameters	**ATF2**	**ILC**
Beam Energy, GeV	1.3	250
L*, m	1	3.5-4.2
$\gamma\varepsilon_{x/y}$, m*rad	3E-6 / 3E-8	1E-5 / 4E-8
IP $\beta_{x/y}$, mm	4 / 0.1	21 / 0.4
IP η', rad	0.14	0.094
σ_E, %	~0.1	~0.1
Chromaticity	~1E4	~1E4
$n_{bunches}$	1-3 (goal A)	~3000
$n_{bunches}$	3-30 (goal B)	~3000
N_{bunch}	1-2E10	2E10
IP σ_y, nm	37	5

ATF International Collaboration

ATF International organization is defined by MOU signed by 20 institutions:



http://atf.kek.jp/

MOU: Mission of ATF/ATF2 is three-fold:

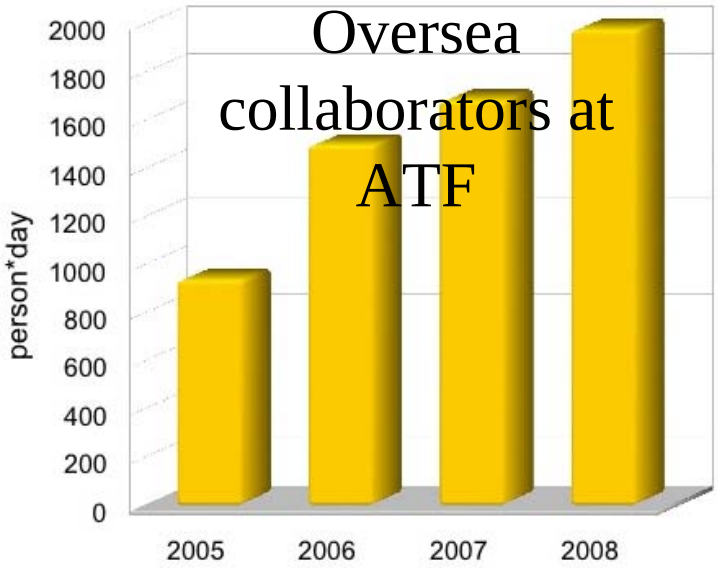
- ATF, to establish the technologies associated with producing the electron beams with the quality required for ILC and provide such beams to ATF2 in a stable and reliable manner.
- ATF2, to use the beams extracted from ATF at a test final focus beamline which is similar to what is envisaged at ILC. The goal is to demonstrate the beam focusing technologies that are consistent with ILC requirements. For this purpose, ATF2 aims to focus the beam down to a few tens of nm (rms) with a beam centroid stability within a few nm for a prolonged period of time.
- Both the ATF and ATF2, to serve the mission of providing the young scientists and engineers with training opportunities of participating in R&D programs for advanced accelerator technologies.

ATF International Collaboration

CERN
DESY
IN2P3
Tomsk Polytechnic Univ.
INFN, Frascati
University College London
Oxford Univ.
Royal Holloway Univ.

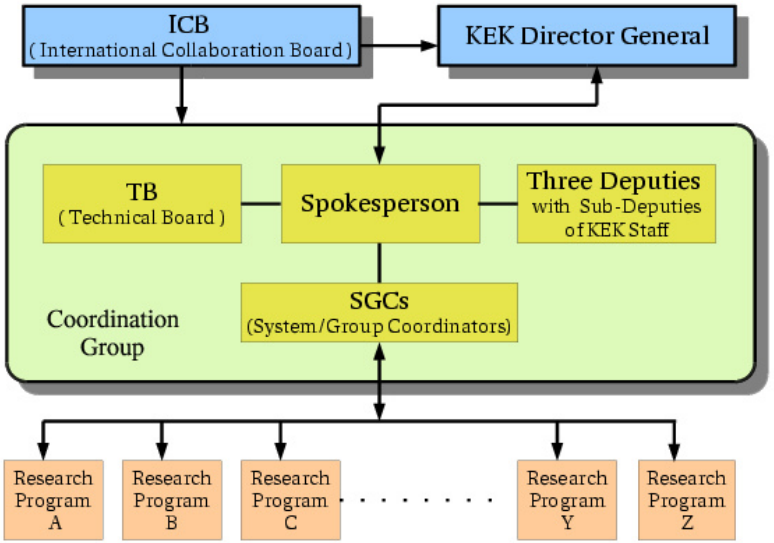
KEK
Waseda Univ.
Nagoya Univ.
Tokyo Univ.
Kyoto Univ.
Hiroshima Univ.
PAL (Korea)
IHEP (C...

SLAC
LBNL
FNAL
Cornell Univ.



ATF2 project meeting, 15-18 December 2008, KEK

ATF International Collaboration



ICB: decision making body for executive matters related to the ATF collaboration (chair: Ewan Paterson, SLAC)

Spokesperson: direct and coordinate the work required at ATF/ATF2 in accordance with the ATF Annual Activity Plan, report the progress to ICB and the progress and the matters related to KEK budget to director of KEK (Junji Urakawa, KEK)

TB: assist the Spokesperson in formulating the ATF Annual Activity Plan, including the budget and beamtime allocation and assist the ICB in assessing the scientific progress (co-chairs: A.Wolski, CI, E.Elsen, DESY)

Three Spokesperson's Deputies with for areas of:

- Beam operation:

Shigeru Kuroda KEK

- Hardware maintenance:

Nobuhiro Terunuma KEK

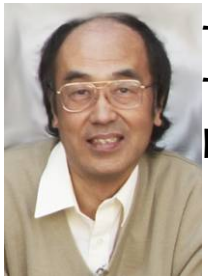
- Design, construction & commissioning of ATF2:

Andrei Seryi SLAC

Sub-Deputies at KEK:

Toshiyuki Okugi KEK

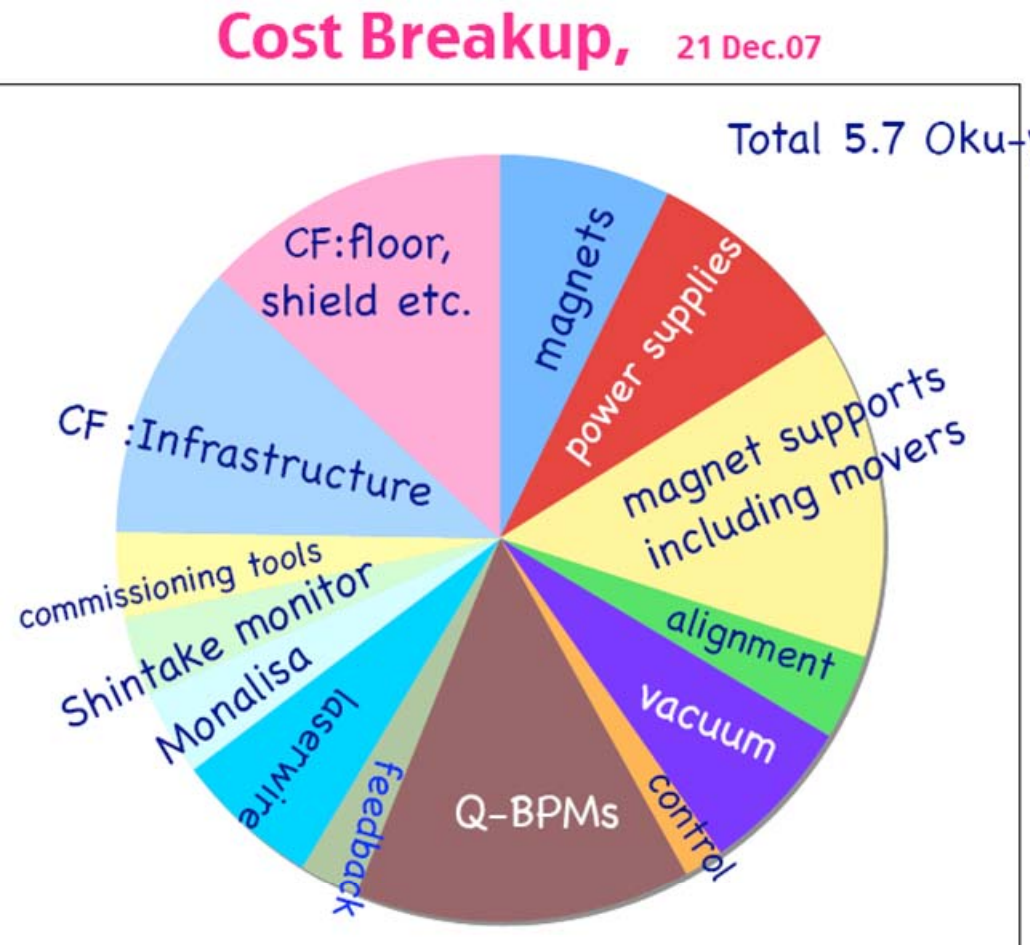
Takashi Naito KEK



Toshiaki Tauchi KEK

Philip Bambade LAL/KEK acting, pending ICB approval

ATF2 cost

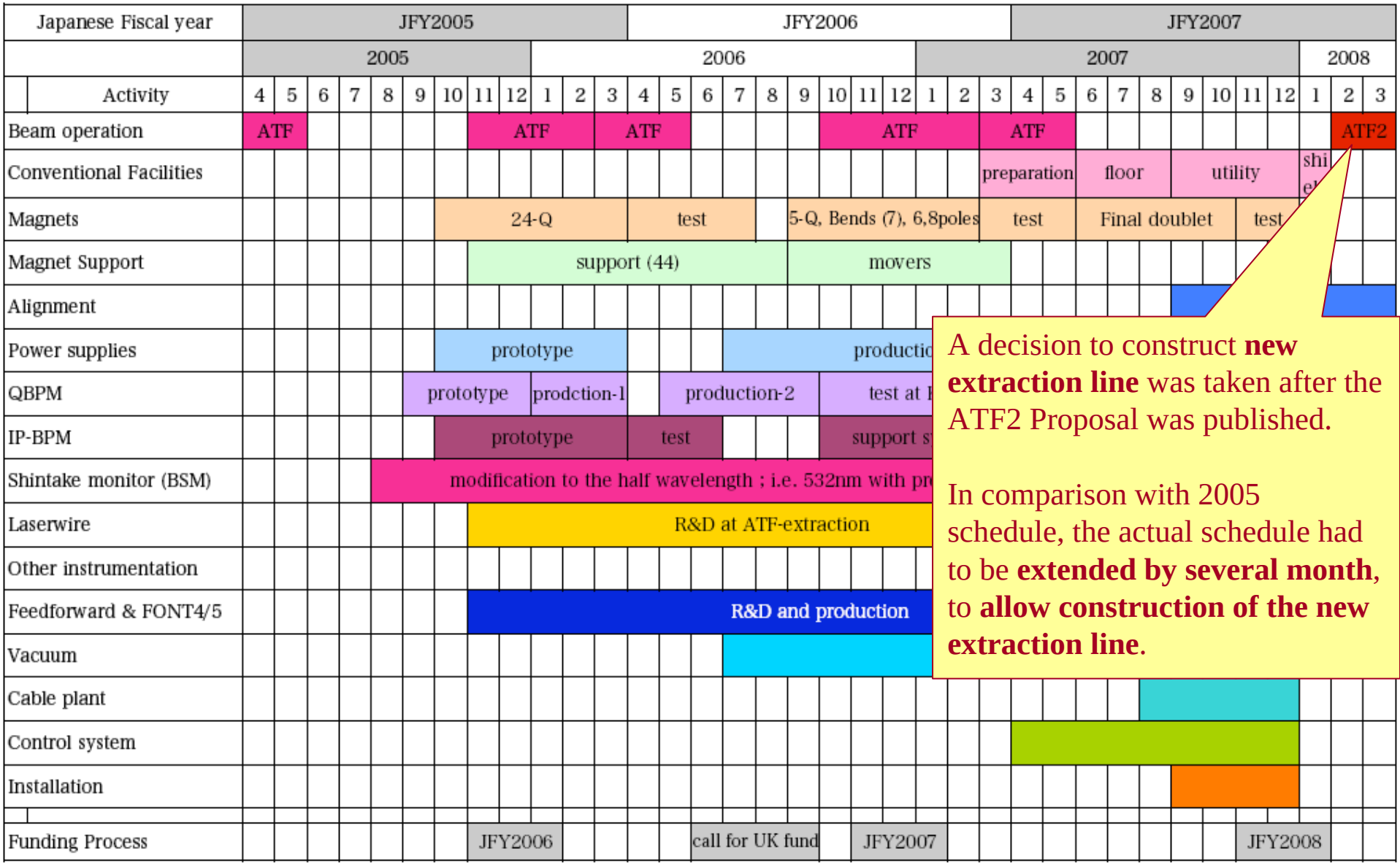


Constructed as ILC model, with in-kind contribution from partners and host country providing civil construction

Cost distribution of the components normalized by the total cost, where the in-kind ones are also included

Cost as seen at the end of 2005 (from ATF2 Proposal, Volume 2) was 5.2 Oku-yen

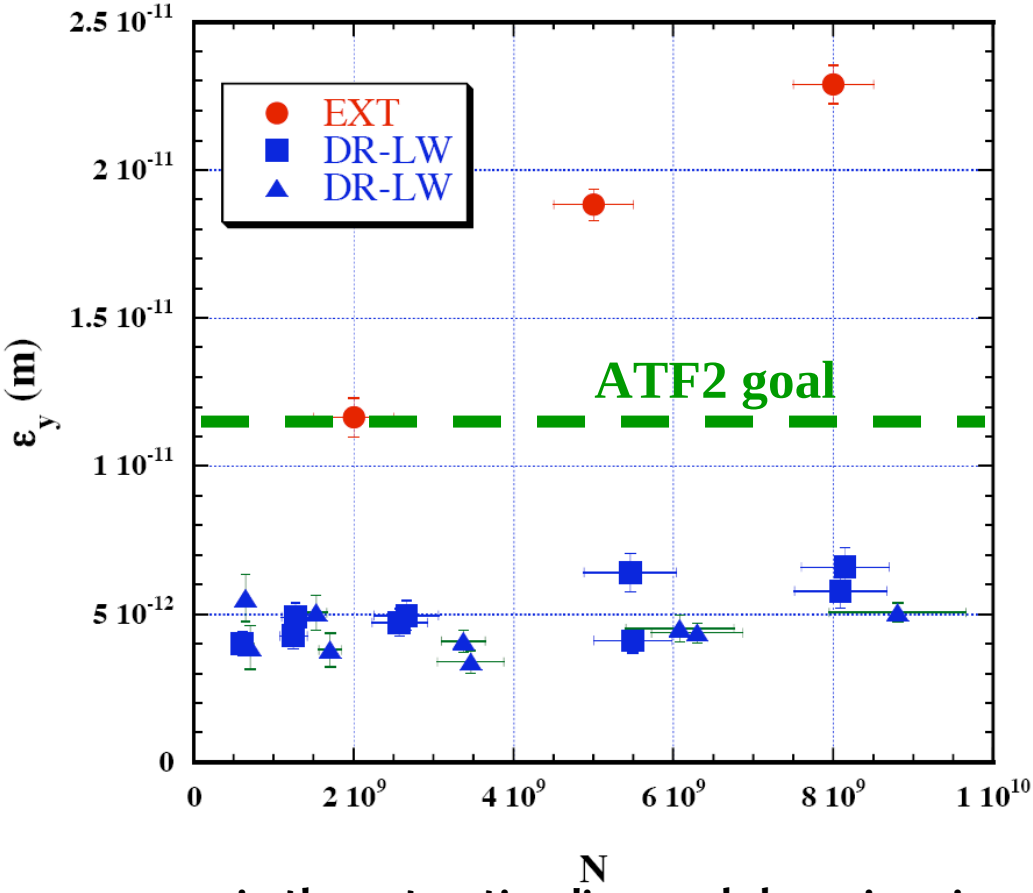
The 2007 cost is ~5.7Oku-yen, partly due to increased scope (additional devices & new Extraction line)



Outline of ATF2 schedule, as seen at end of 2005 (from ATF2 Proposal, Volume 2)

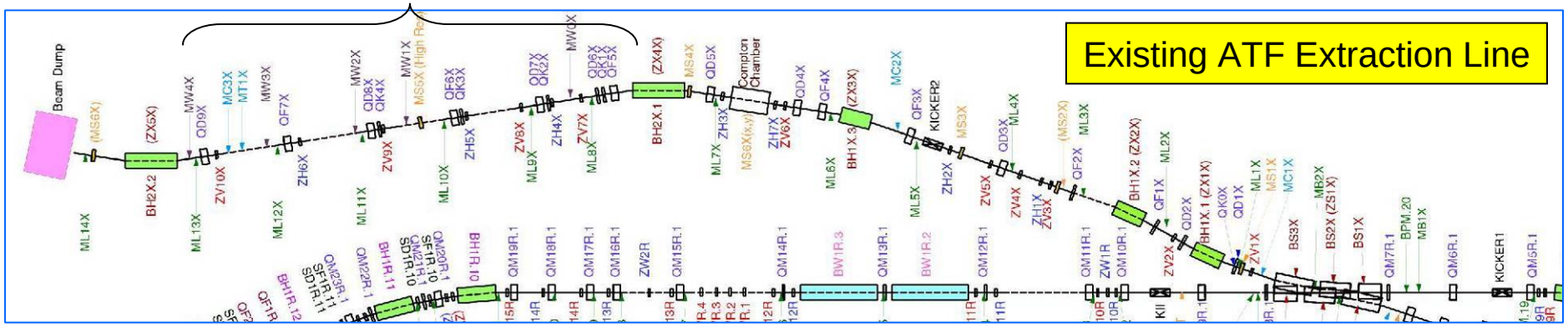
Extraction line

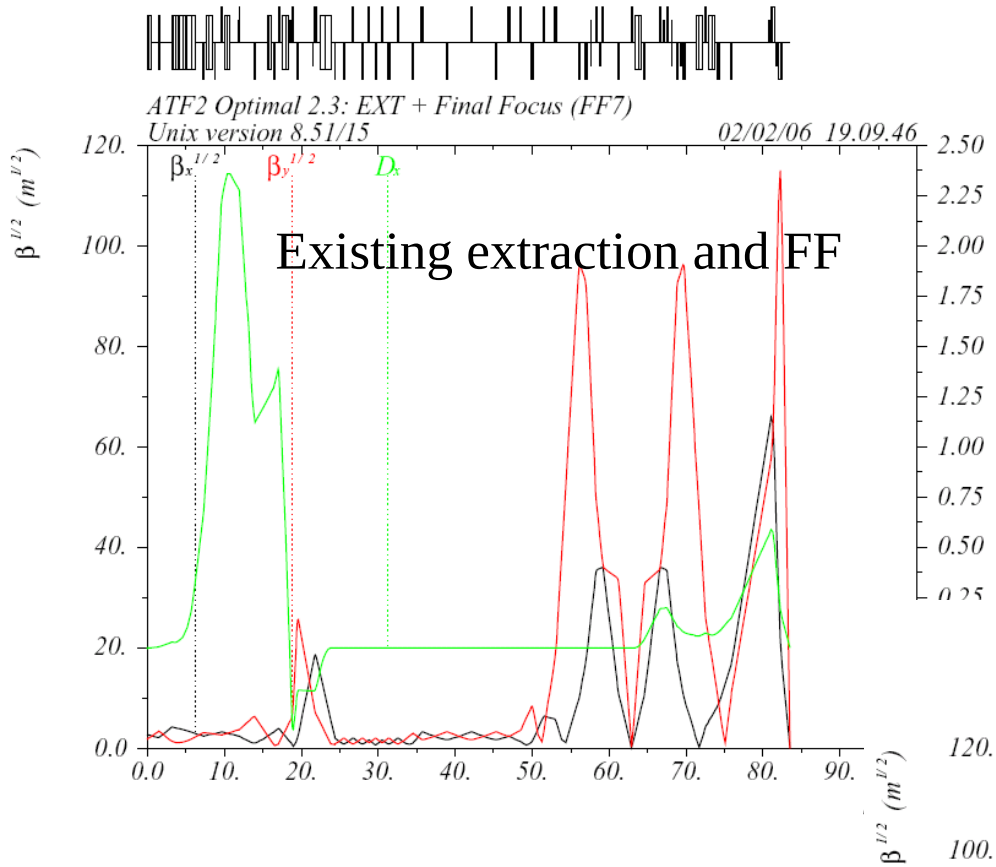
- Optics of existing extraction line not suitable for beam diagnostics and coupling correction
- Large dispersion (~2m) is one of the sources of ε growth
- It was redesigned and has been rebuilt

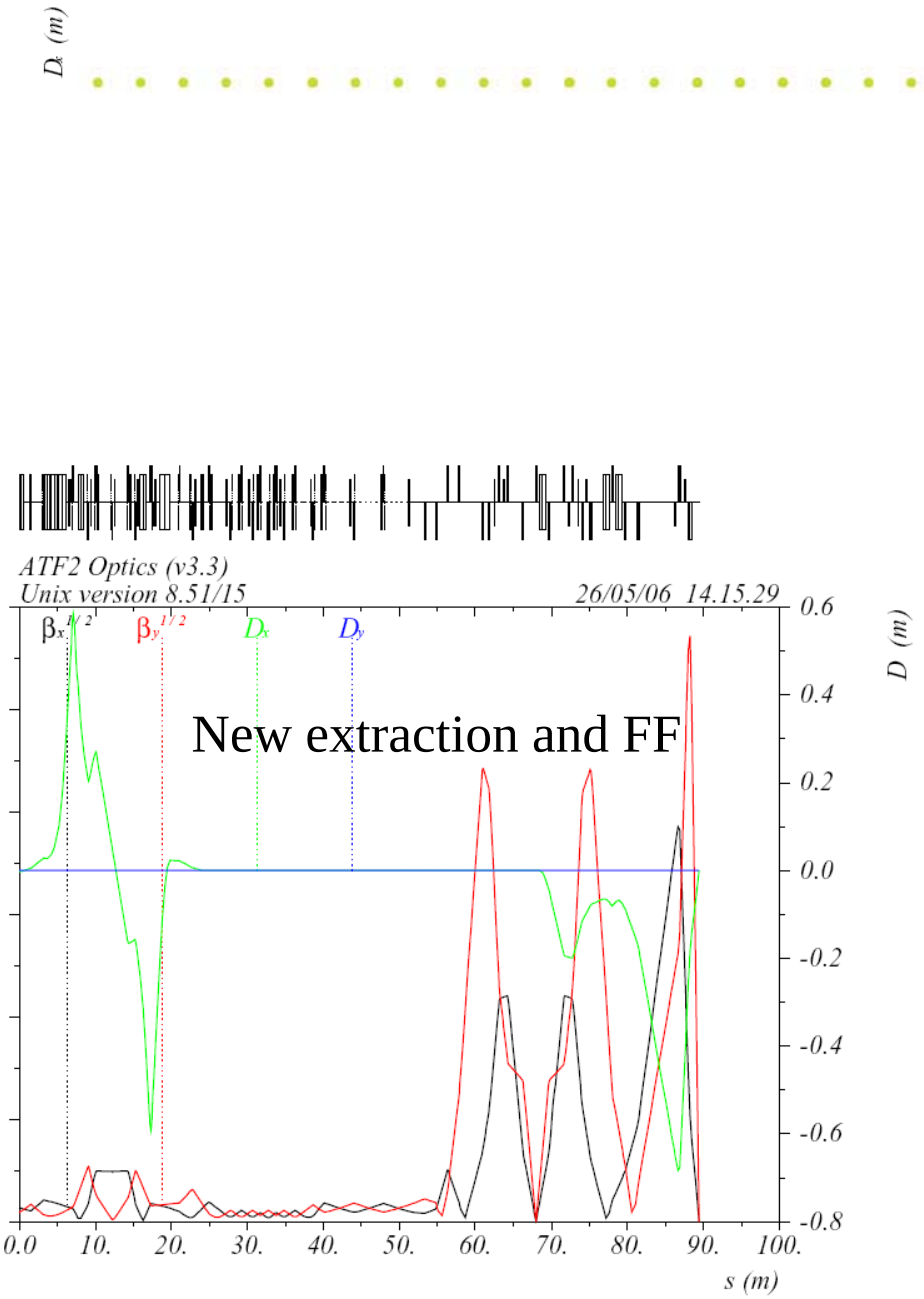


ε_y in the extraction line and damping ring

Coupling Correction / Emittance Diagnostics

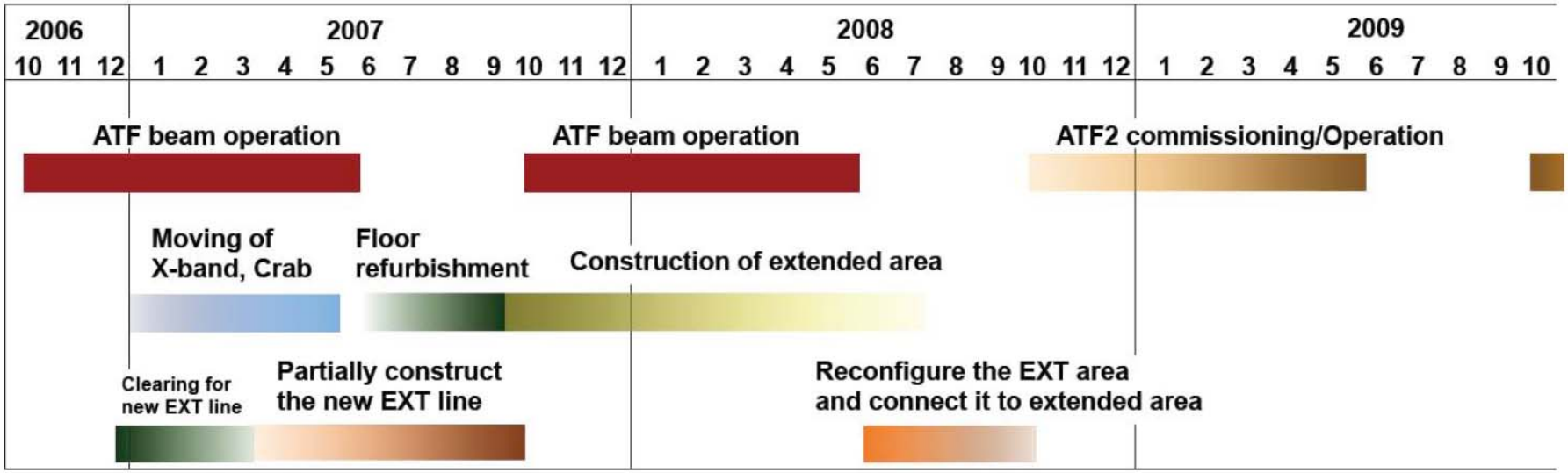






New Extraction:
Reduced dispersion from
2.5m to 0.6m

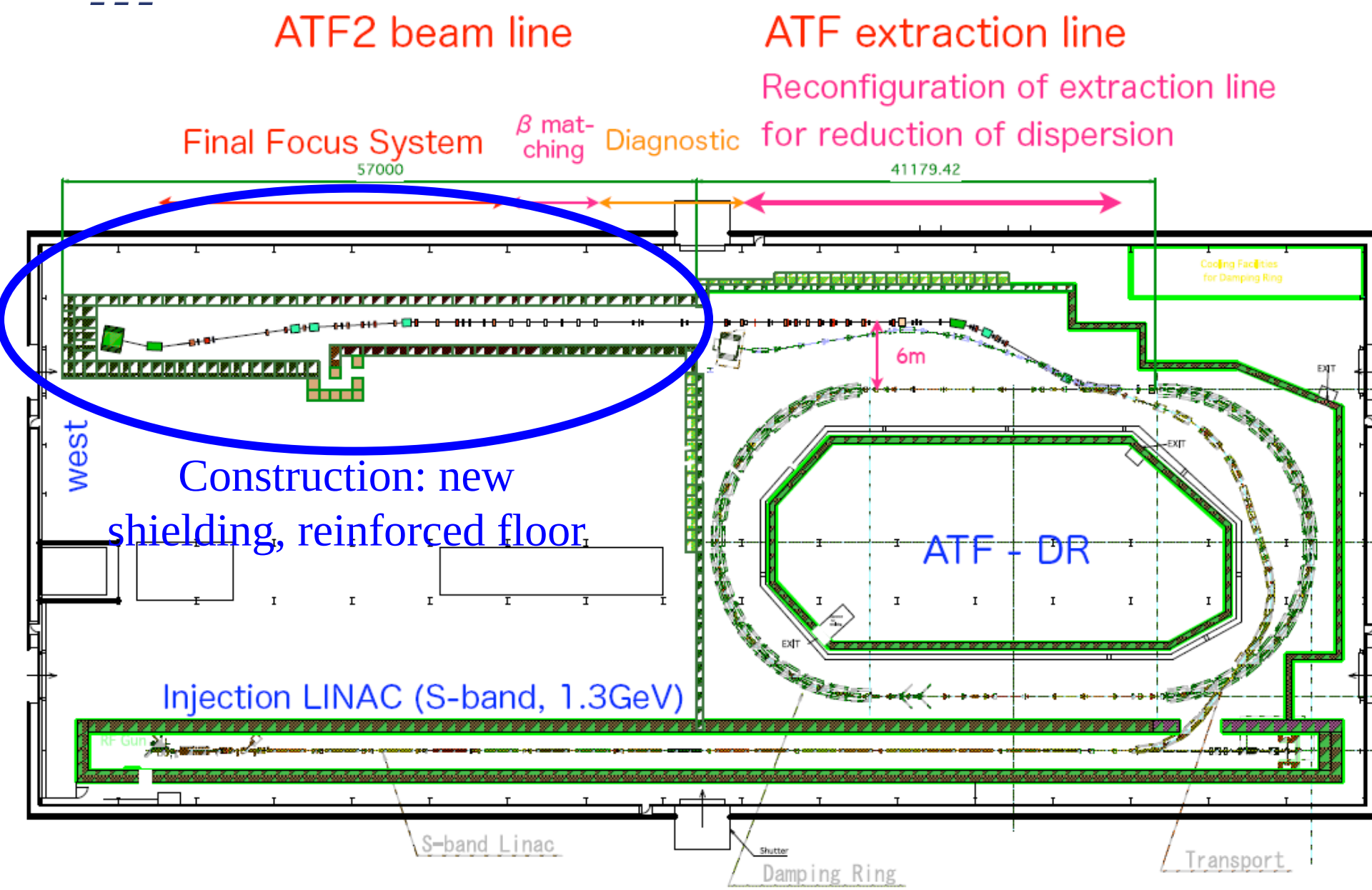
ATF2 schedule



- **Construction of the extended shield area for final focus system can be done during the ATF beam operation.**
- Partial construction beside the current EXT line in shutdown week will release the work load for reconfiguration of the EXT line in summer of 2008.
- **ATF2 beam will come in October, 2008.**

This slide was shown in this way ~2 years ago. The beam came in December 2008.

Layout & civil construction



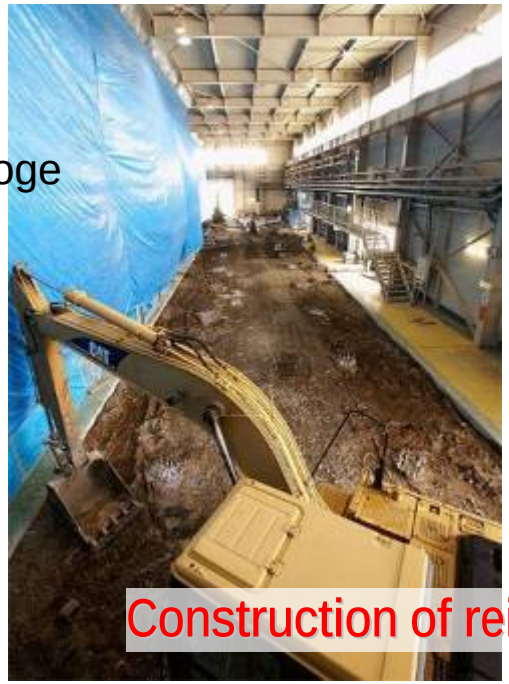
ATF2 construction in 2007

August – December

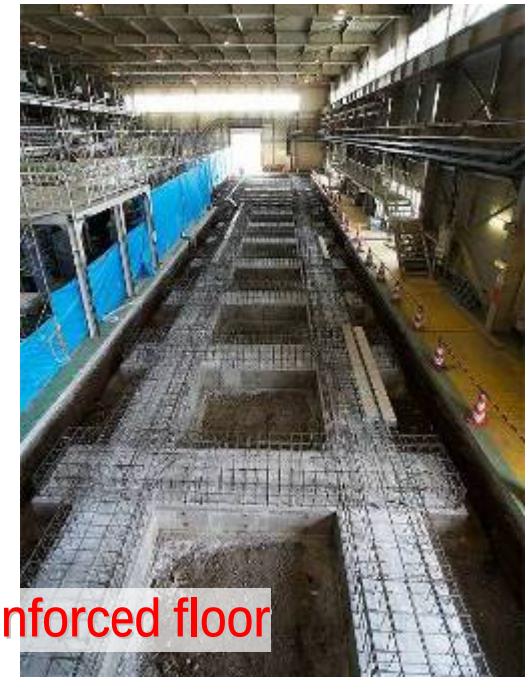
"Assembly hall" before construction

"Assembly hall" emptied for construction

Photos:
Nobu Toge



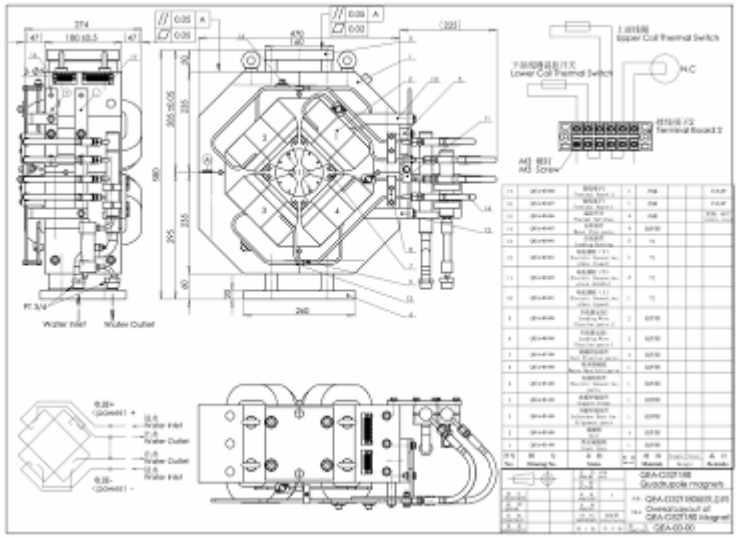
Construction of reinforced floor



Construction of shielding

Power Supplies and Magnet system

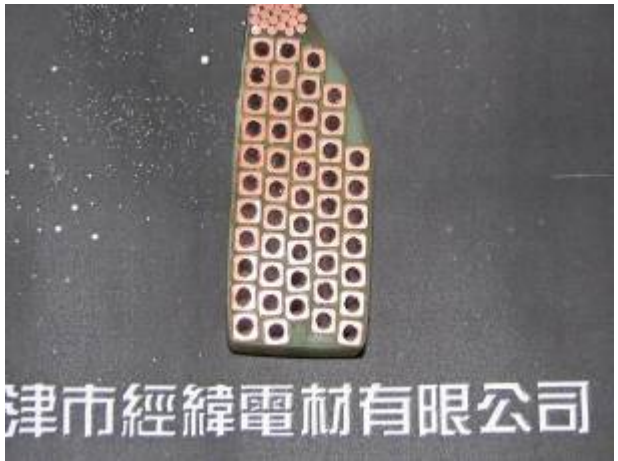
High Availability Power Supplies installed, connected and tested at ATF2

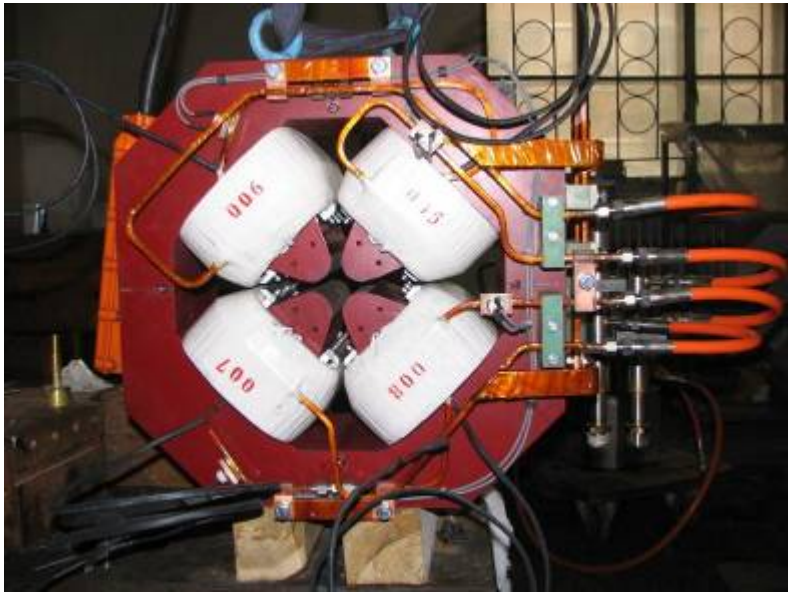


C.Spencer (SLAC) at IHEP, Beijing Dec 2005

Beamline quads: SLAC / IHEP / KEK design, QC / production, measurements / measurements & installation

A.Seryi, 5/8/09, PAC09





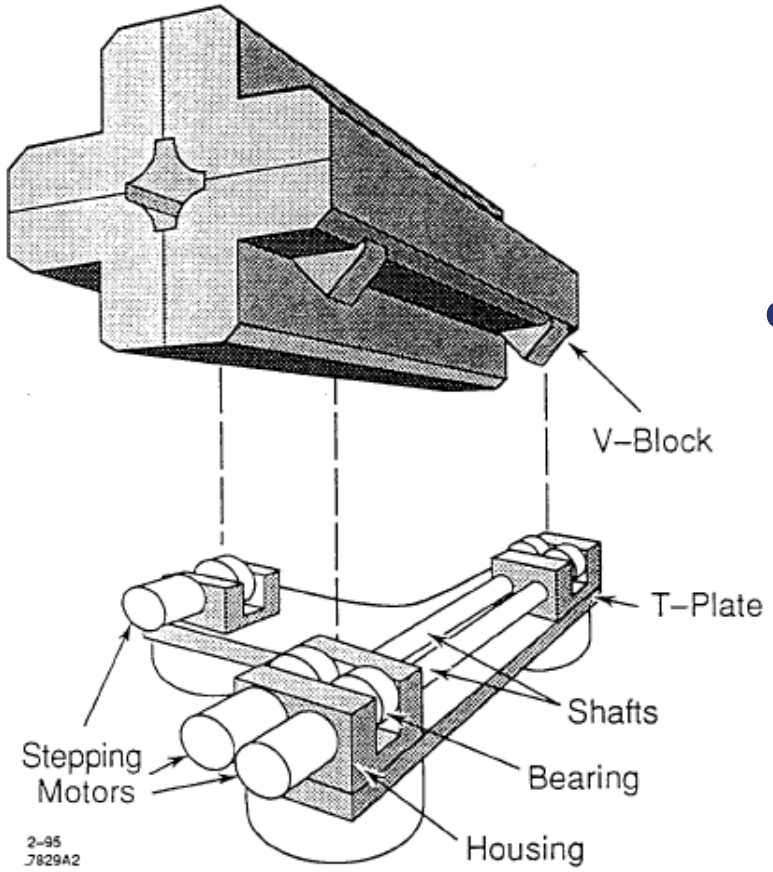
First ATF2 quad, Jan 2006

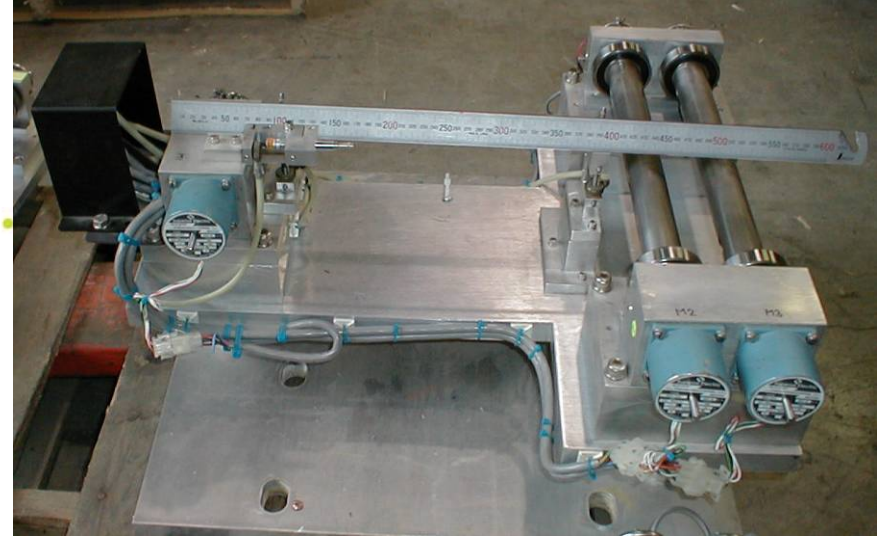
ATF2 construction – January 2008

The last regular quadrupole is going to the destination

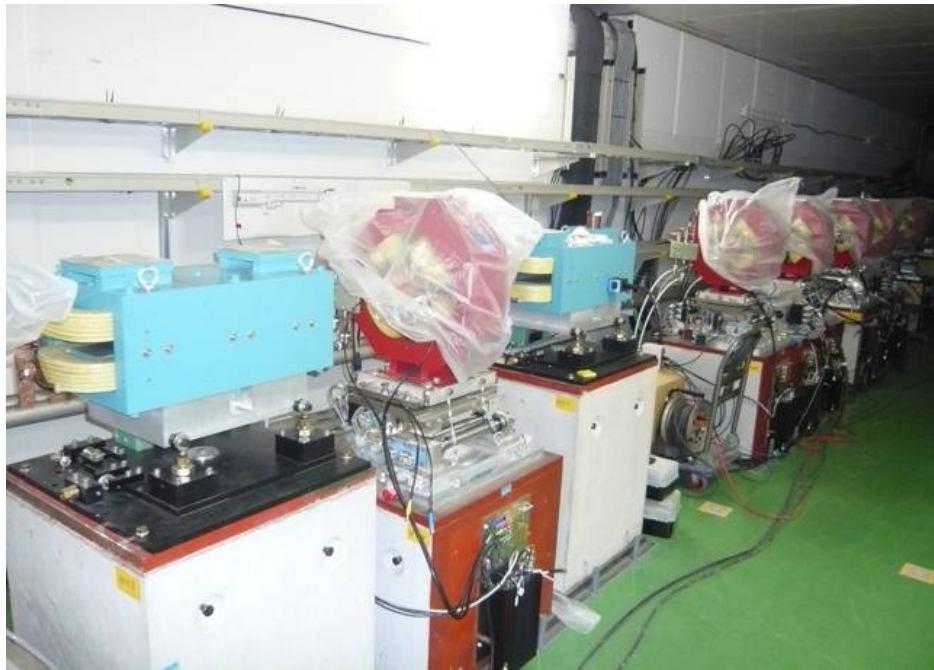
~20 sets of supports, movers & quads installed in January 08. R.Sugahara et al

Beamline movers



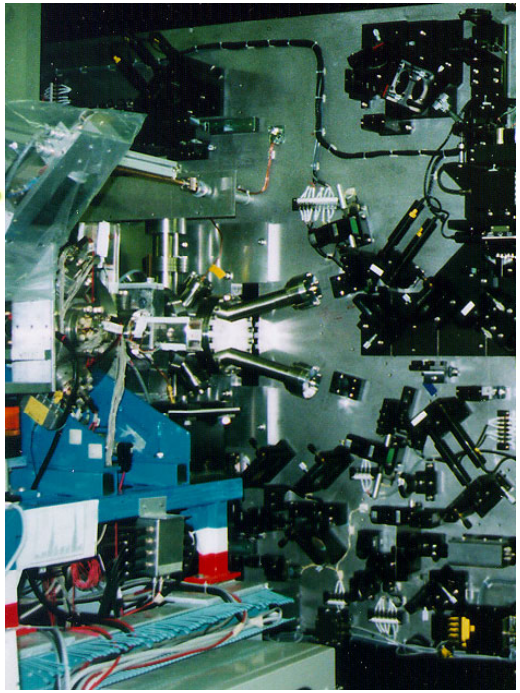


- FFTB cam movers were refurbished and used for all magnets of ATF2 (except bends)

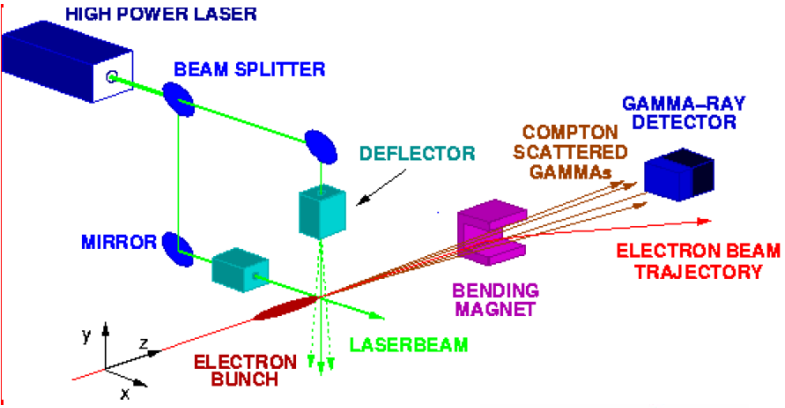


Advanced beam instrumentation at ATF2

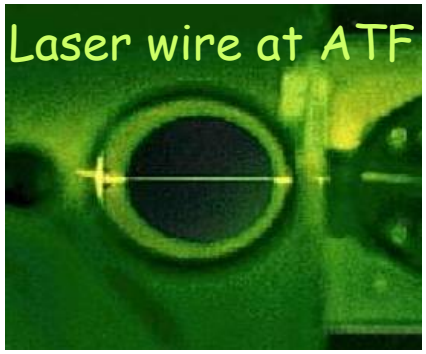
- BSM to confirm 35nm beam size
- nano-BPM at IP to see the nm stability
- Laser-wire to tune the beam
- Cavity BPMs to measure the orbit
- Movers, active stabilization, alignment system
- Intratrain feedback, Kickers to produce ILC-like train

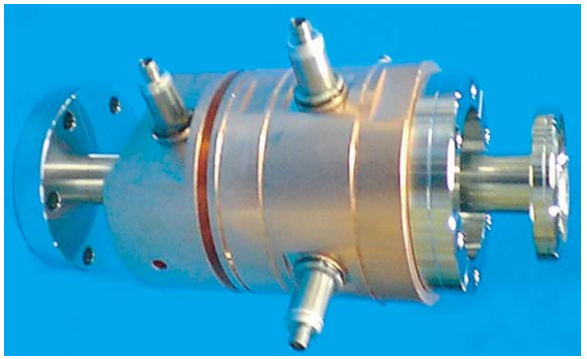


IP Beam-size monitor (BSM) (Tokyo U./KEK, SLAC, UK)

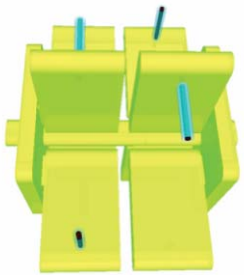


Laser-wire beam-size Monitor (UK group)





C & S band Cavity BPMs, for use with Q/S magnets with 100nm resolution (PAL, SLAC, KEK)



Cavity BPMs with 2nm resolution, for use at the IP (KEK)

Magnets and Instrumentation at ATF2

22 Quadrupoles(Q), 5 Sextupoles(S), 3 Bends(B) in downstream of QM16

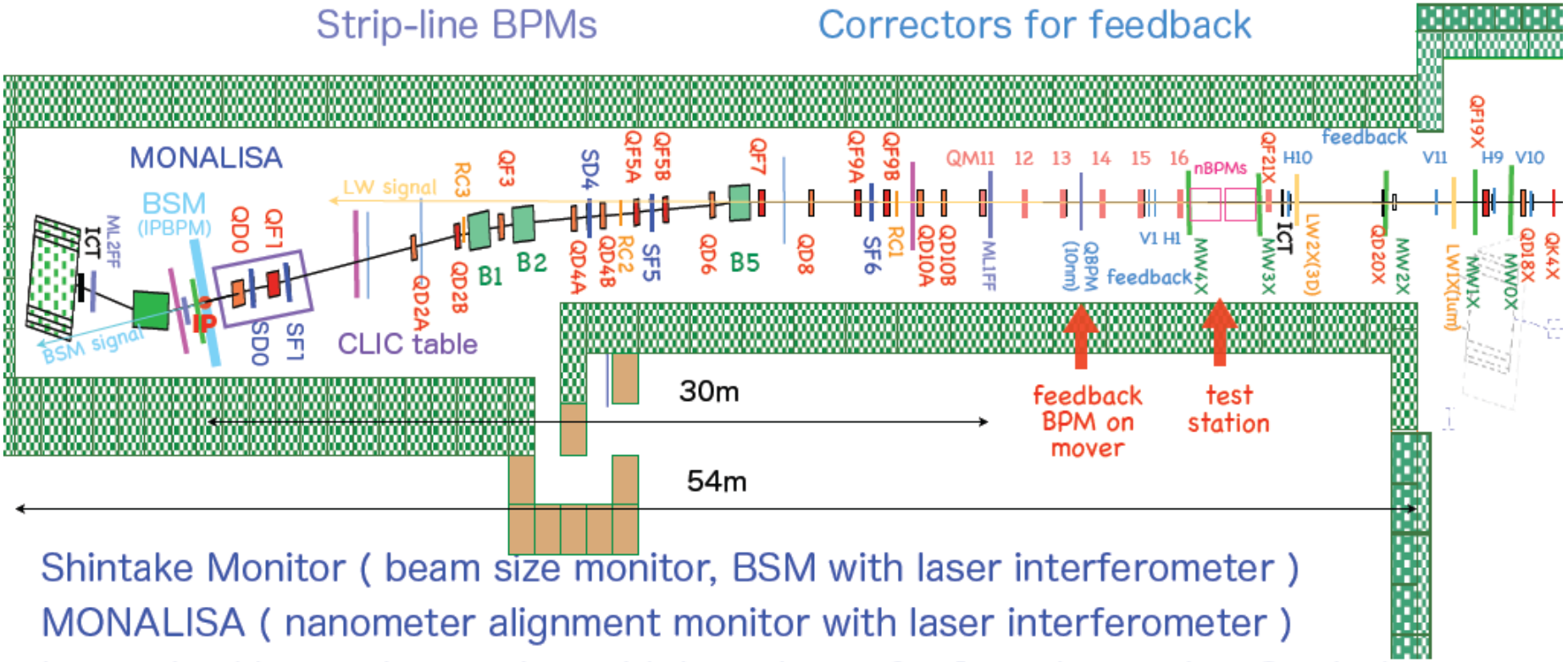
All Q- and S-magnets have cavity-type beam position monitors(QBPM, 100nm)

3 Screen Monitors

5 Wire Scanners, Laserwires

Strip-line BPMs

Correctors for feedback



Shintake Monitor (beam size monitor, BSM with laser interferometer)

MONALISA (nanometer alignment monitor with laser interferometer)

Laserwire (beam size monitor with laser beam for 1μm beam size, 3 axies)

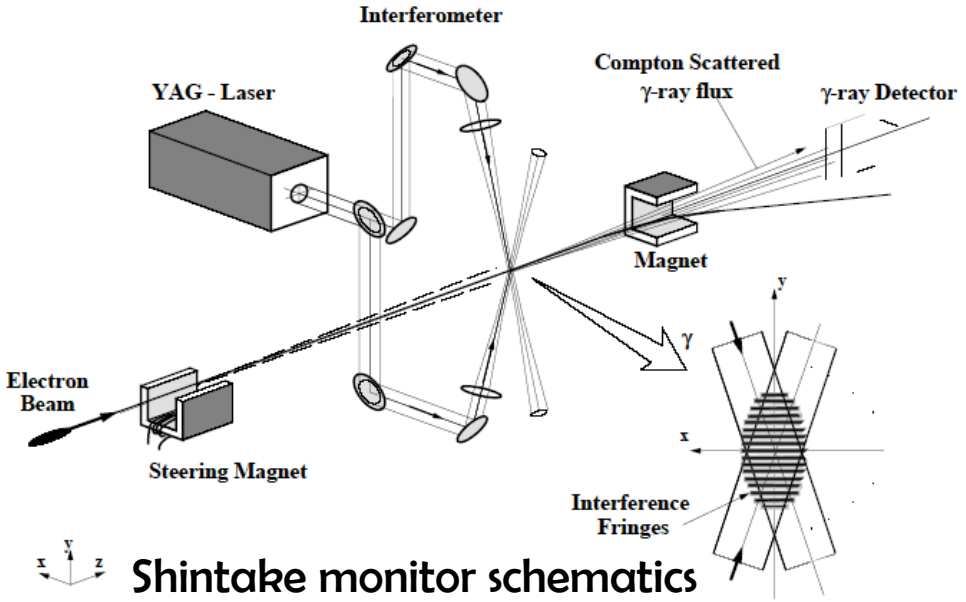
IP intra-train feedback system with latency of less than 150ns (FONT)

Magnet movers for Beam Based Alignment (BBA)

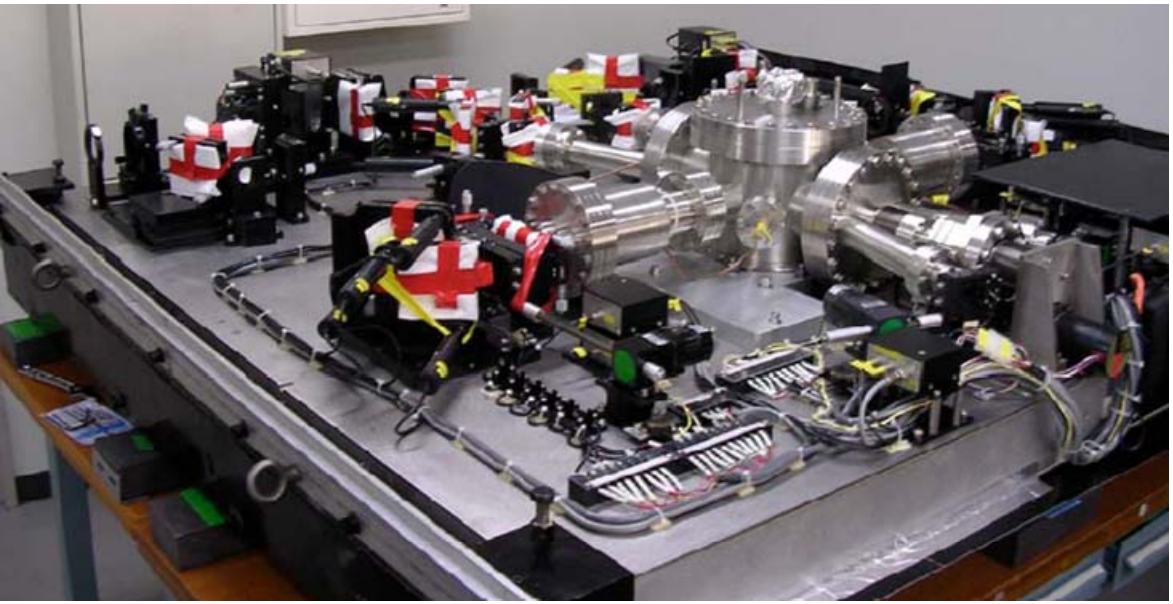
High Available Power Supply (HA-PS) system for magnets

IP Beam Size monitor

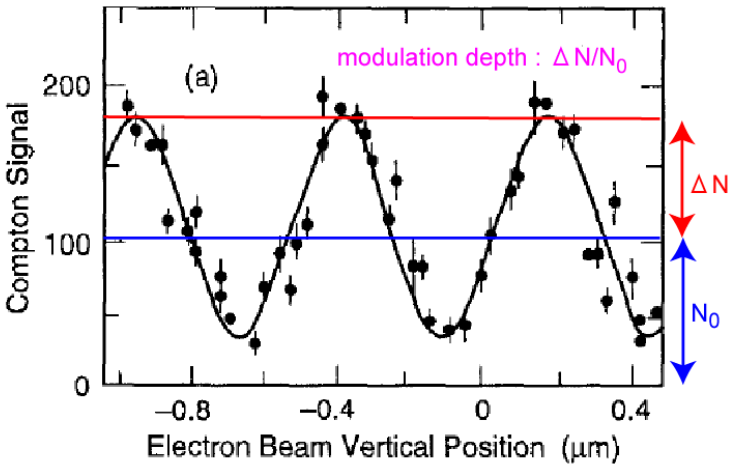
- Improved with respect to FFTB Shintake BSM
  - 1064nm=>532nm



Shintake monitor schematics



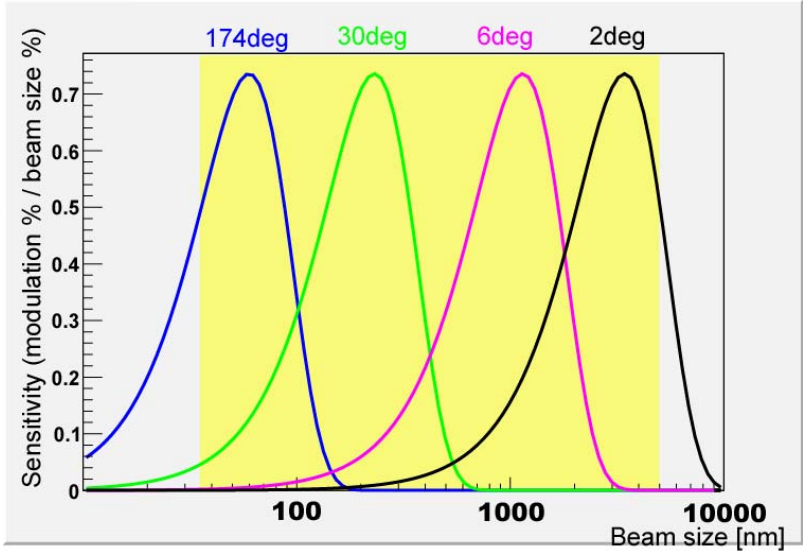
Jul 2005: BSM arrived to Univ. of Tokyo

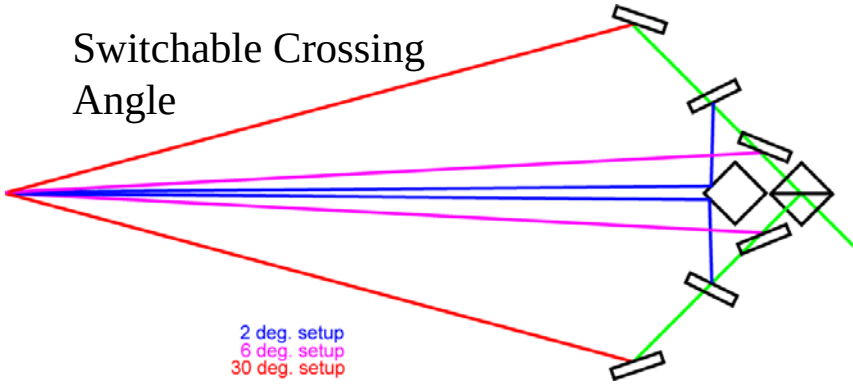


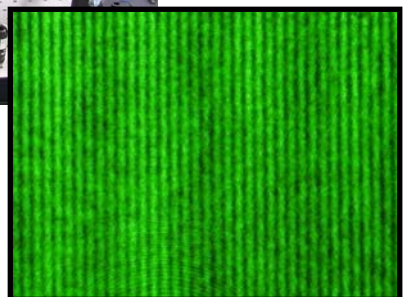
FFTB sample : σ_y = 70 nm

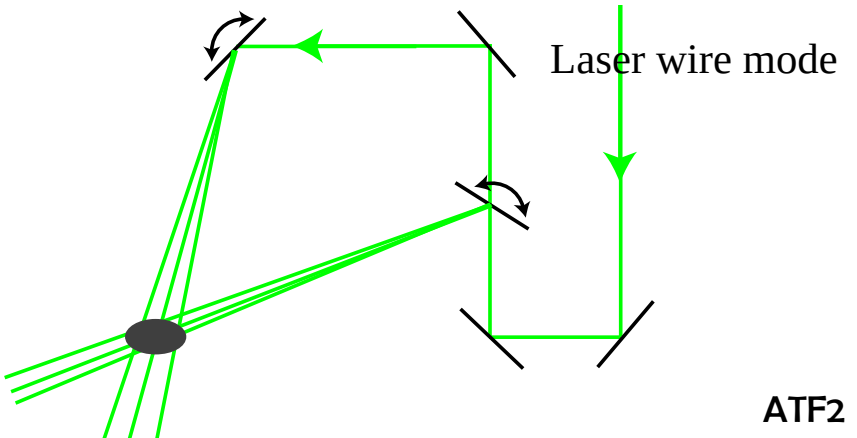
BSM in Tokyo Univ.

- New optical table & laser
- New crossing angles for wider range
  - σ_y: 37nm up to a few μm
- sx measurement by laser wire
  - σ_x beam size is 2.8μm, too large for interferometer => laser wire mode





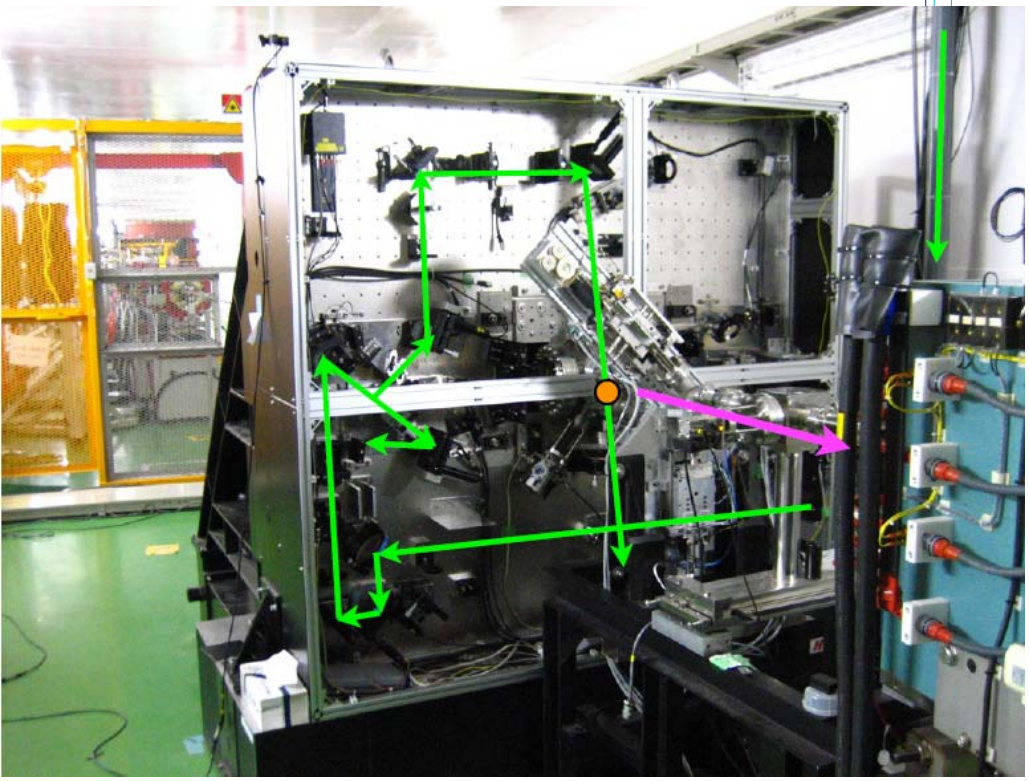


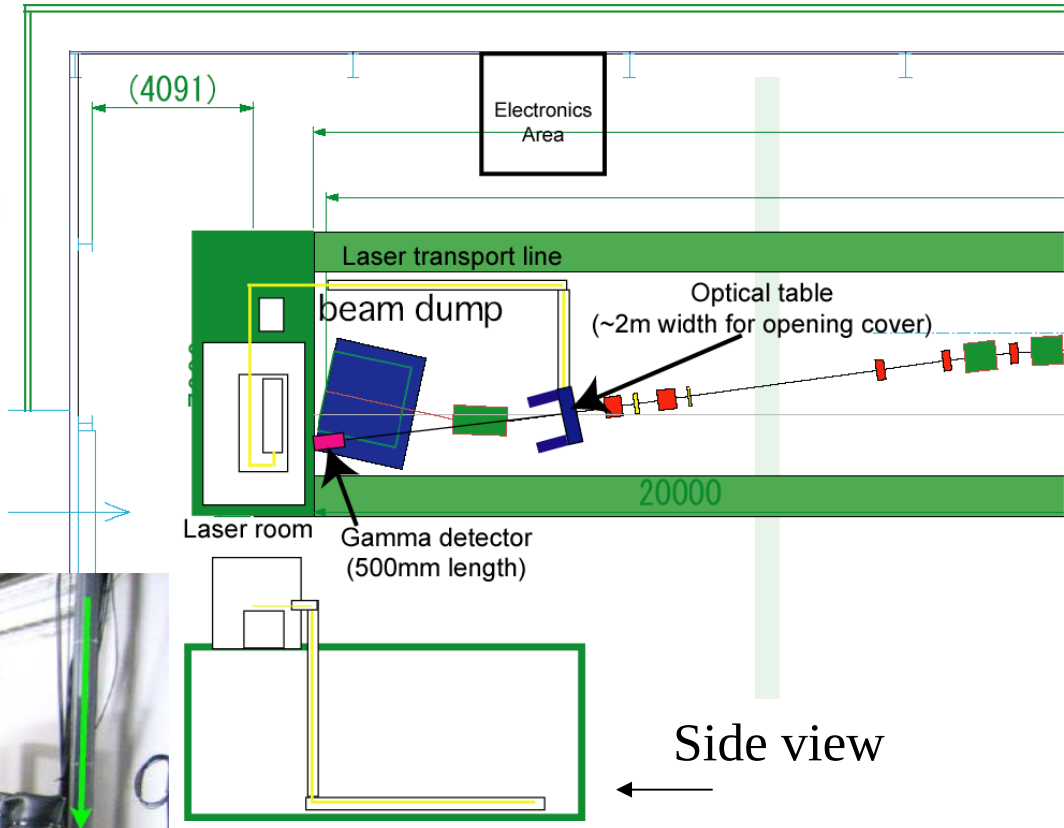


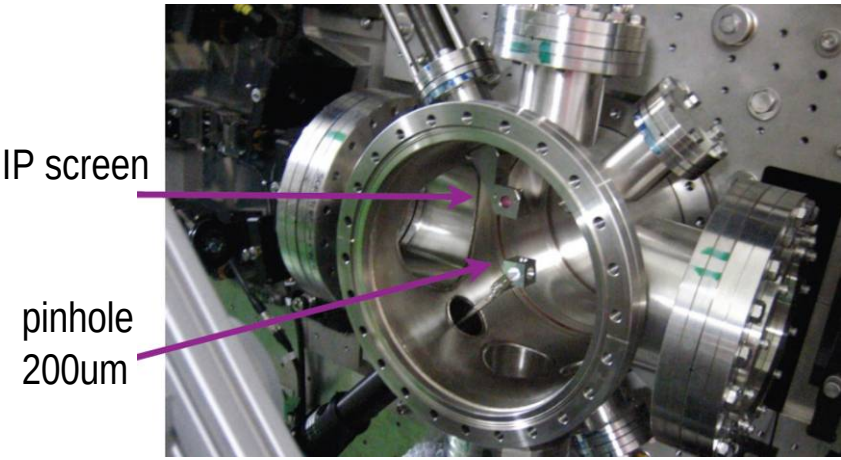
Beam Size Monitor

Tokyo Univ.

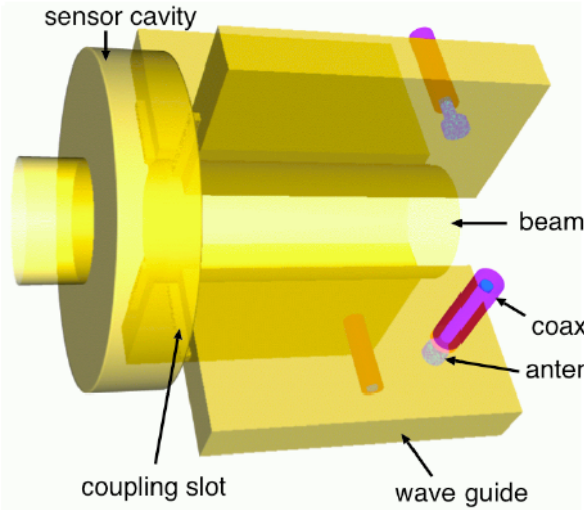
Shintake monitor Interferometer table on the ATF2 beam line



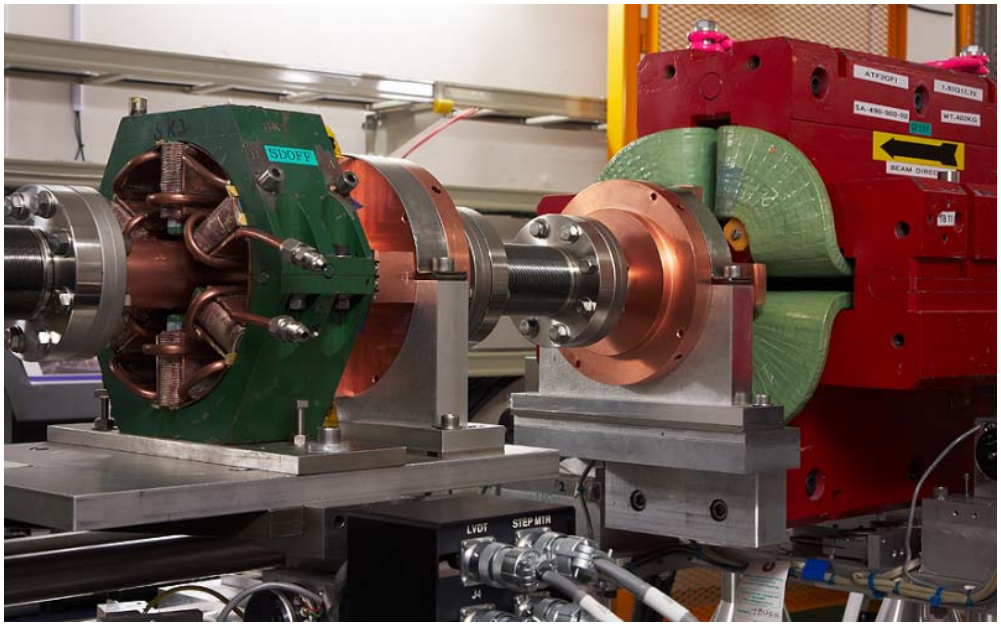




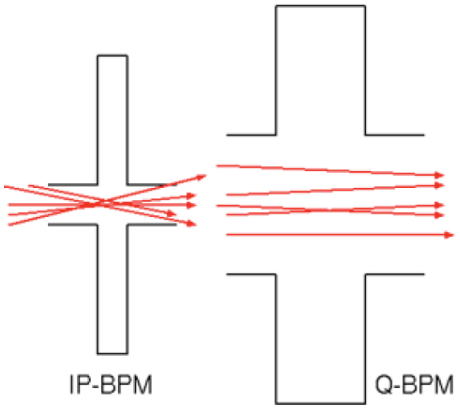
C & S band Cavity BPMs

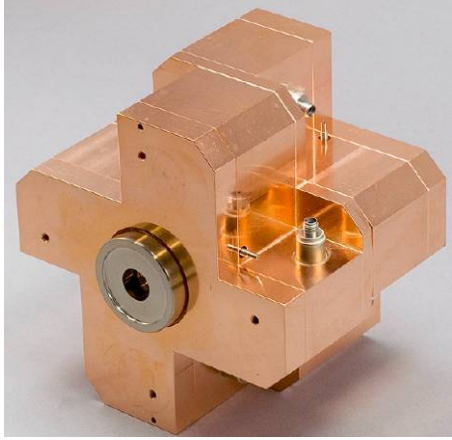


C-band dipole mode
Reference cavity
Downmix to ~25MHz
Digitize at ~100Ms/s, ~14 bit
Sub 100 nanometer resolution
Large dynamic range >500um



IP BPM

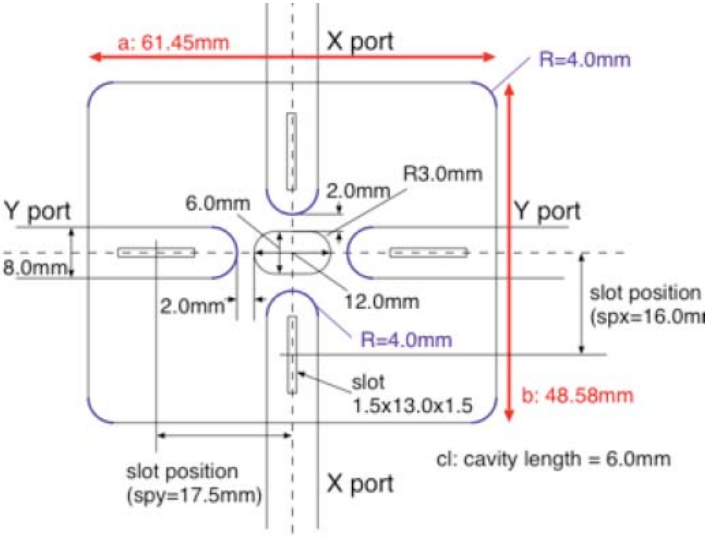


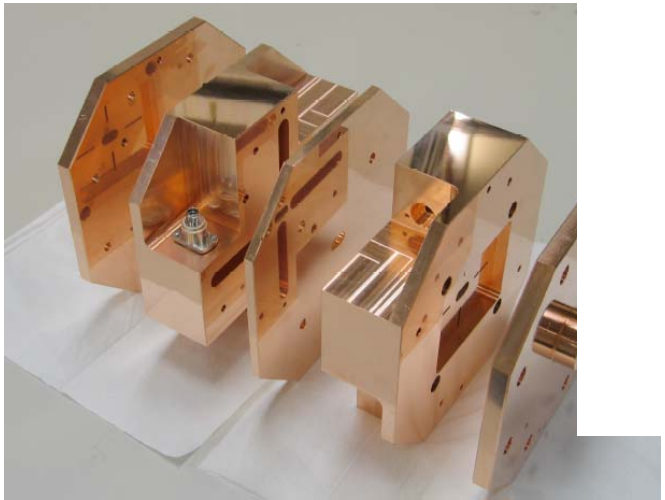


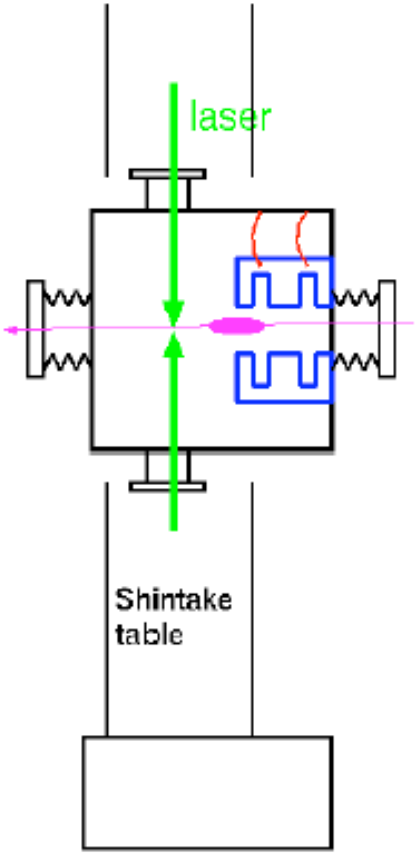
- Creates a reference at IP instead of opposite colliding beam
- => Need ~2nm resolution
- Challenge: ~100μrad angles at IP
- => Thin gap, small aperture, x-y separation

6.426 GHz (Y) and 5.712 GHz (X)

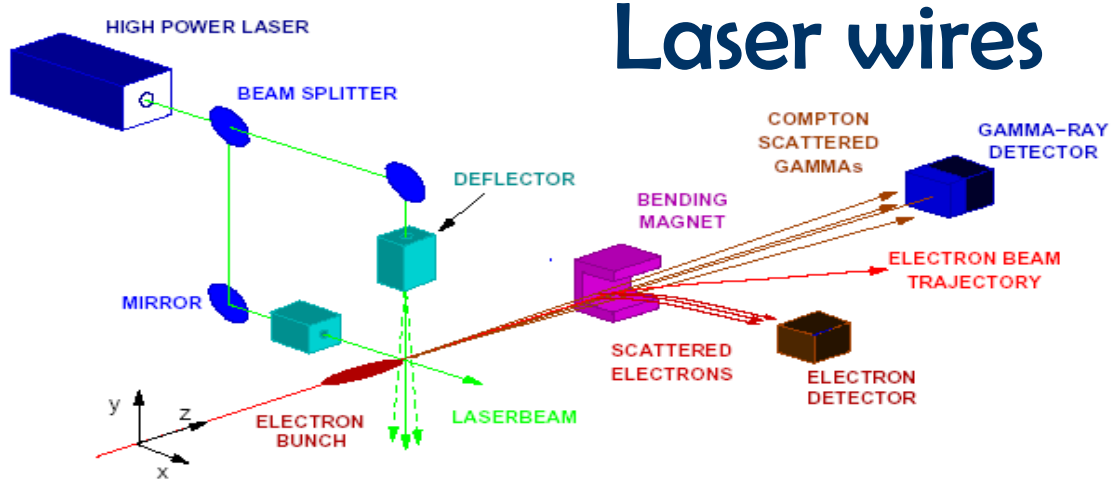
So far achieved resolution 8.7nm, dynamic range ~5 micron

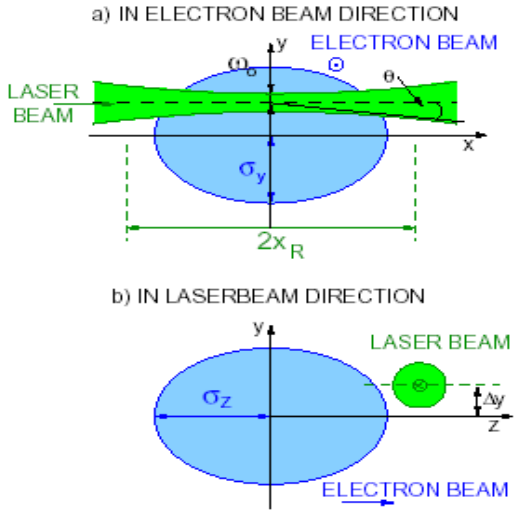




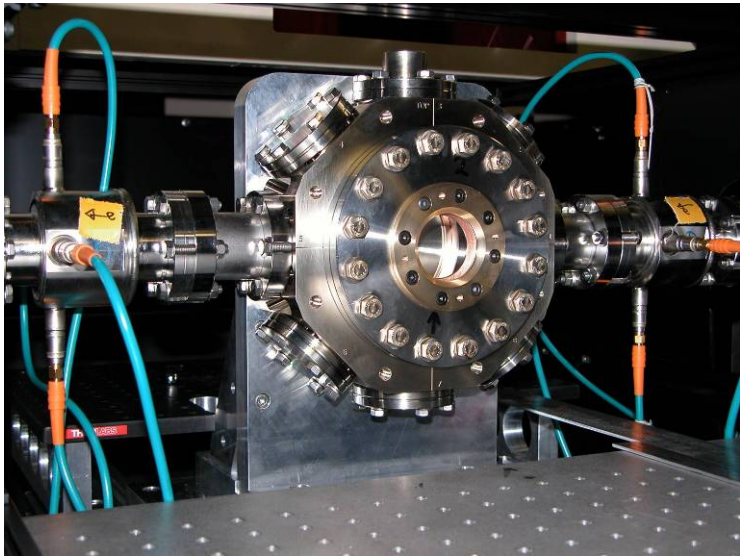


Laser wires



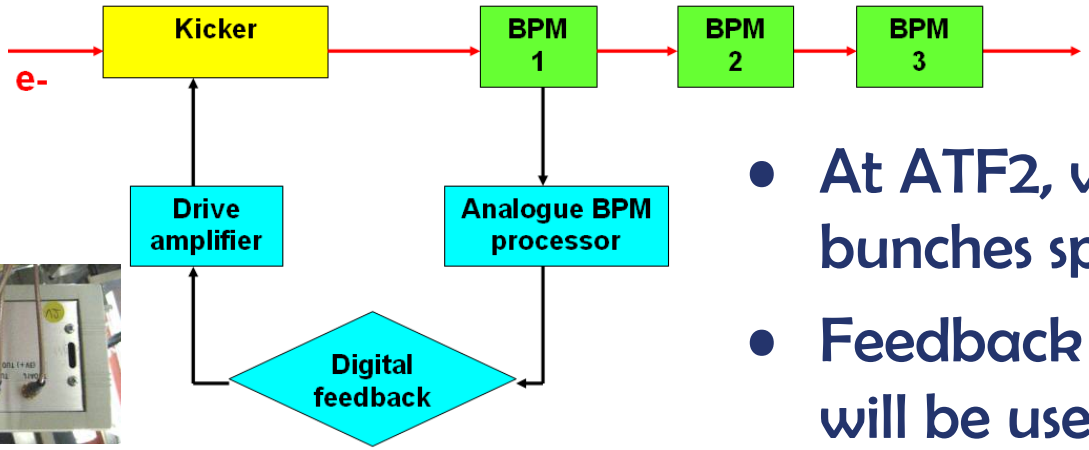


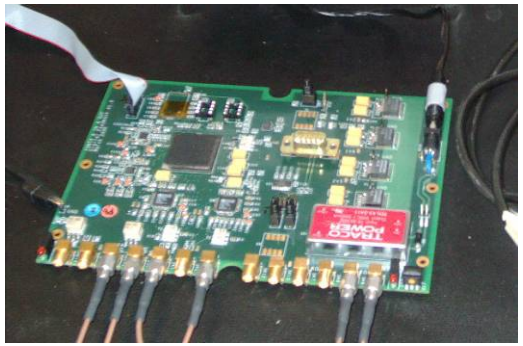
- Goal: non-destructive diagnostics for ILC
- (ATF2 to be tuned with carbon wires)
- Studies in ATF extraction line
- Aim to measure 1 μm spot beam
- Aim at 150ns intra-train scan
- Located at ATF2 in a place with ~μm spot
- Presently achieved minimum beam size measurement of 2.9 ± 0.15 μm



Laser wire chamber at ATF, Oxford

Fast feedback (FONT)



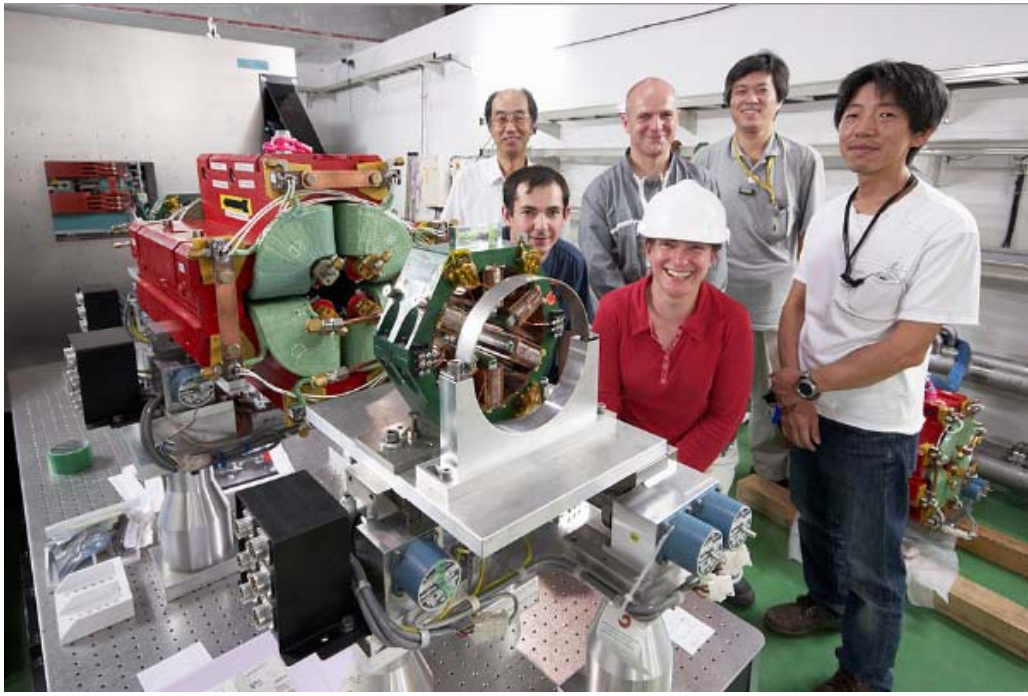


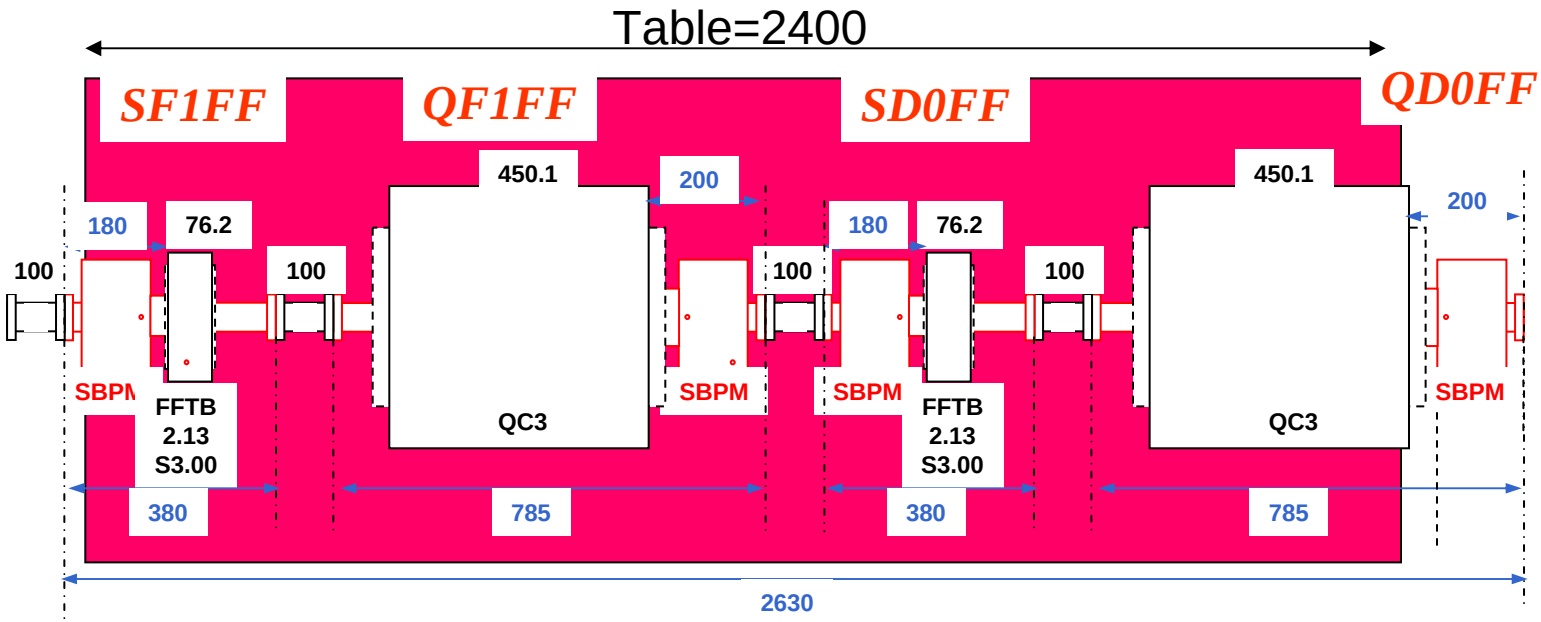
- At ATF2, will have ~20 bunches spaced with 150ns
- Feedback and feedforward will be used to straighten the train
- FONT4: latency estimate
  - Irreducible latency: 14ns
  - Electronics latency: 118ns
  - Total latency: 132ns

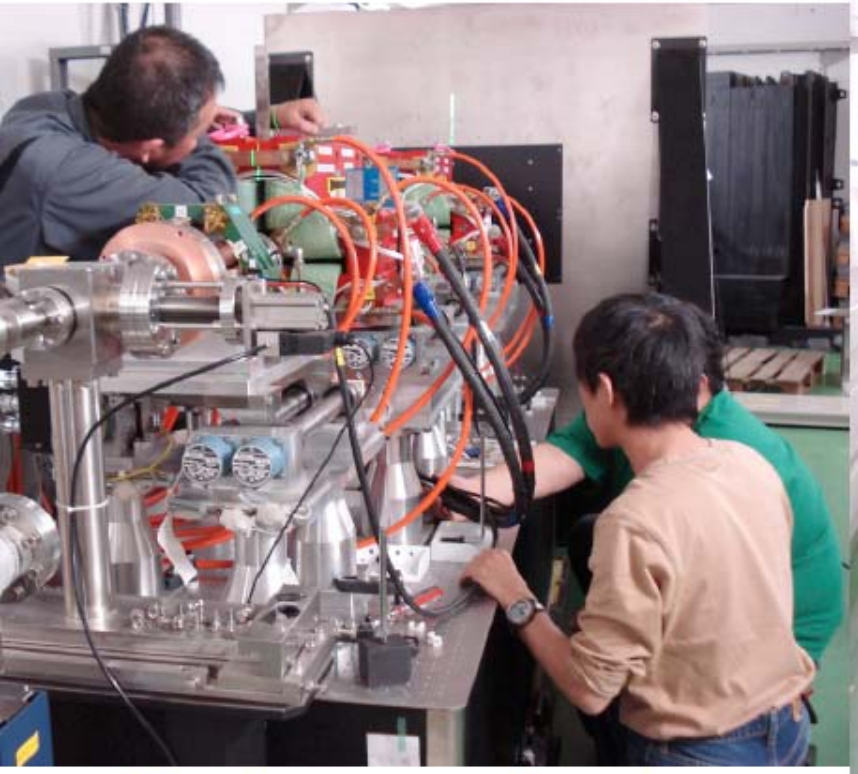
FONT – Feedback On Nanosecond Time scale
the group initially developed analog feedbacks with ~25ns latency.
Developments for ATF – digital, FONT4

FD integration

Stability study and integration of Final Doublet at LAPP, Annecy







FD alignment after the
Radiation Inspection ,
11 December, 2008

Organization of ATF2 Commissioning

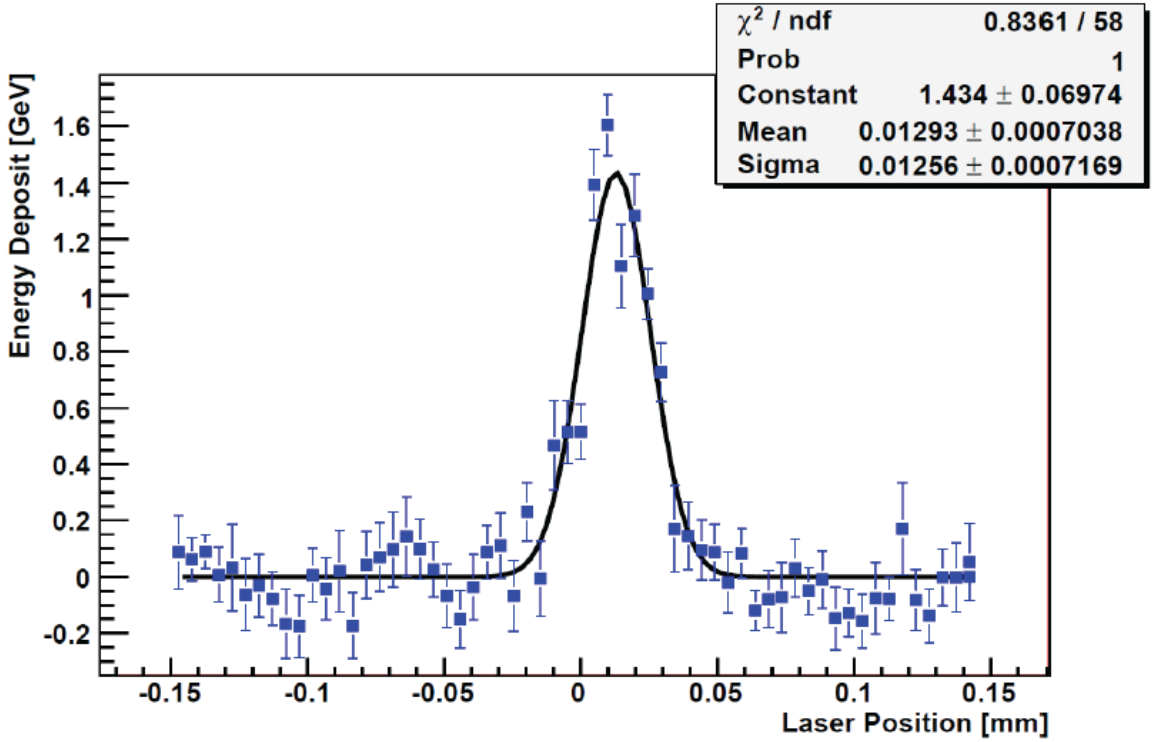
- Organization of commissioning was major focus of 7th ATF2 project meeting on Dec 2008
- Aim to achieve reliable observation of design beam size by end of 2010
- Overall principles
  - Integration of commissioning efforts for the whole collaboration
  - Importance of longer term plan, intermediate milestones (goals of each run) and detailed schedules of each run
  - Move from doing a collection of individual R&D tasks to focus on a common goal
  - Dedicate 50% of time to ATF2 programs
- Global milestones and detailed schedule developed internally by the ATF collaboration

Highlights of recent runs

- December 2008 pilot run
  - large IP beta optics, semi-ballistic trajectory
  - Establish beam to beam dump, minimize losses, Radiation inspection
  - First tests of hardware and tuning software (FS)
  - BSM commissioning & background characterization
- Jan 2009
  - Continue hardware commissioning & fast kicker study
  - Replace QM7 to one with larger aperture (possible source of EXT ε growth)
- Feb-Mar 2009
  - Large (8cm beta*), all magnets ON
  - Continue hardware commissioning
  - Commission laser wire mode of BSM
  - Tuning tools (EXT disp./coupling corr., IP scans, β/η & ε determ, BBA)
- Current April 2009 run
  - Optics verification for ~1um beam (large, 1cm β*) / IP wire scanners
  - Commission interferometer mode of BSM

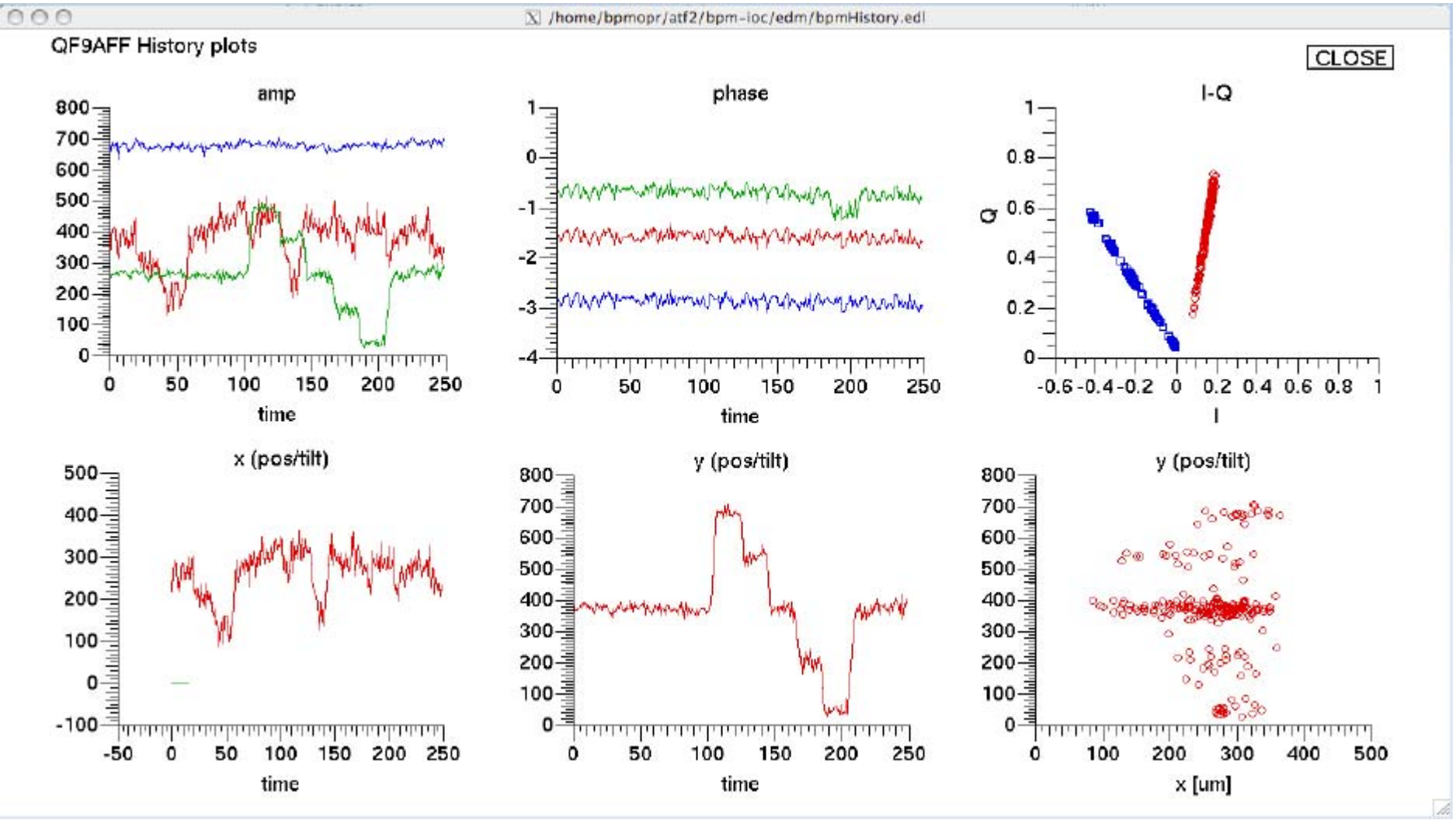
Feb-Mar run highlights

BSM Compton signal in LW mode



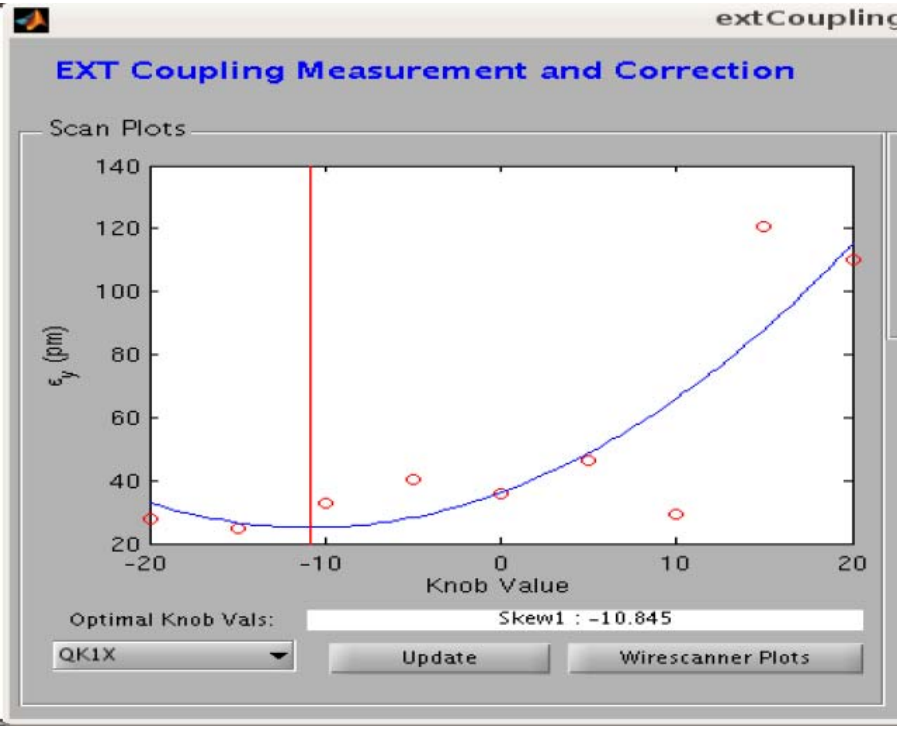
Convoluted size of 13microns was measured

Mover & corrector based automated calibration of BPMs



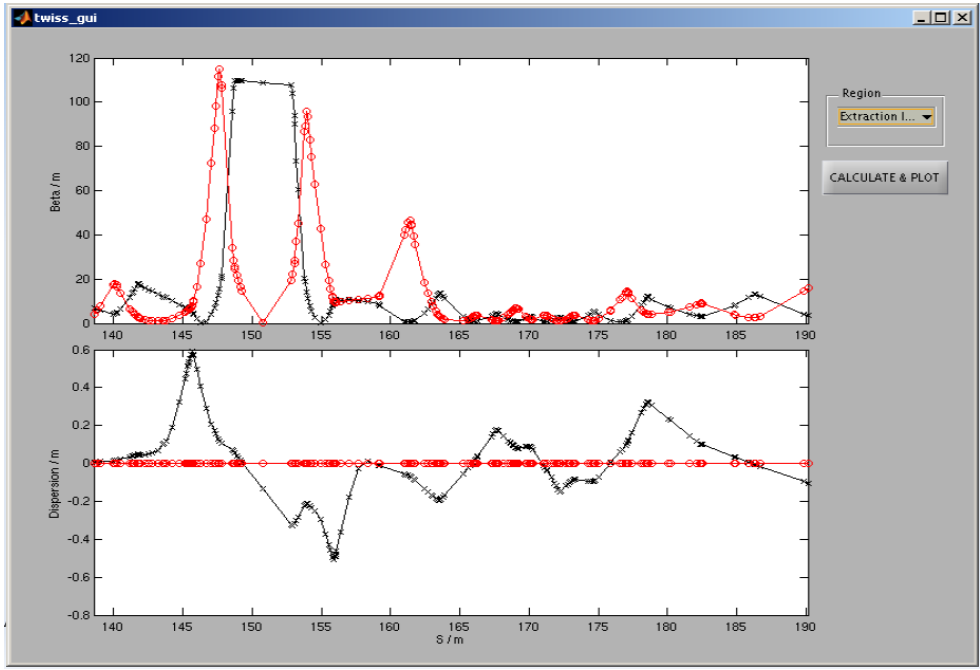
Feb-Mar & Apr run highlights

EXT coupling correction



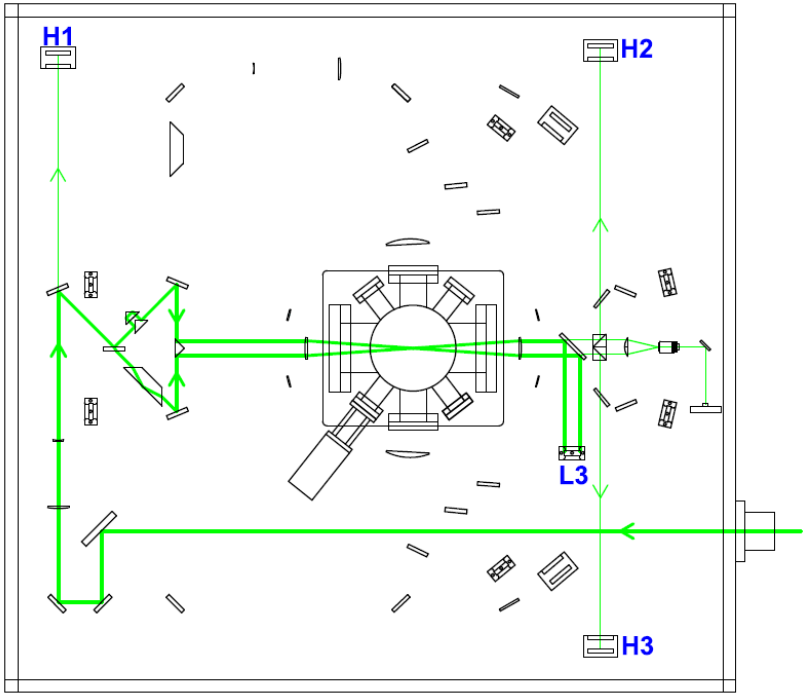
- Vertical emittance scans using 2 available skew quads
- Emittance measurement using 5 vertical wire scanners

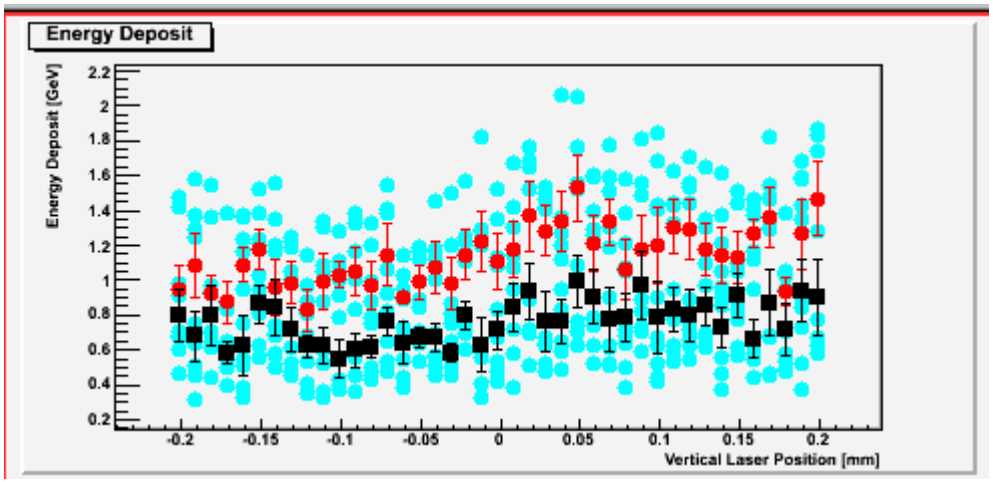
Optics tools



- Can verify and correct optics
- DR to EXT well matched, BMAGy~1.04

Highlights of April run





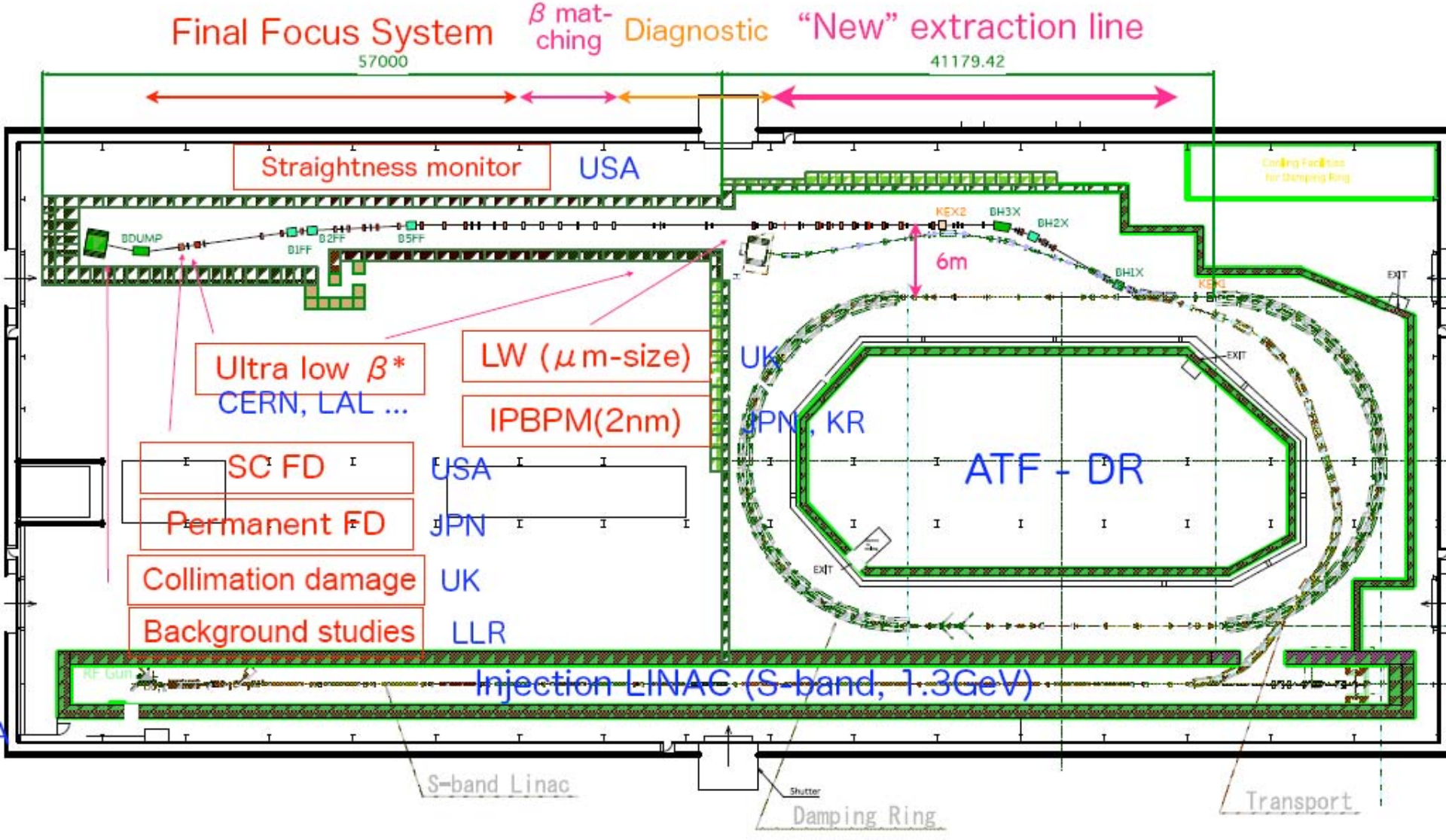
- BSM: 8 deg mode
- Can observe the signal from the start
- Continue working on laser and optics, to achieve beam size and see it by BSM

Long term plans

- As discussed at 7th ATF2 project mtg
- Long term plans
  - Stabilization to nm beam position, Monalisa
  - smaller beta*
  - SC FD
- Much longer Term Plans after ~2012, very tentative
  - Optional Photon facility ; 2015 – 2019
    - laser and optical cavities for photon linear collider
    - generation of photon beam
  - "Strong QED" experiments with Laser
    - Non-linear QED with Laser intensity of > 10^{22} W/cm^2
    - Unruh radiation study

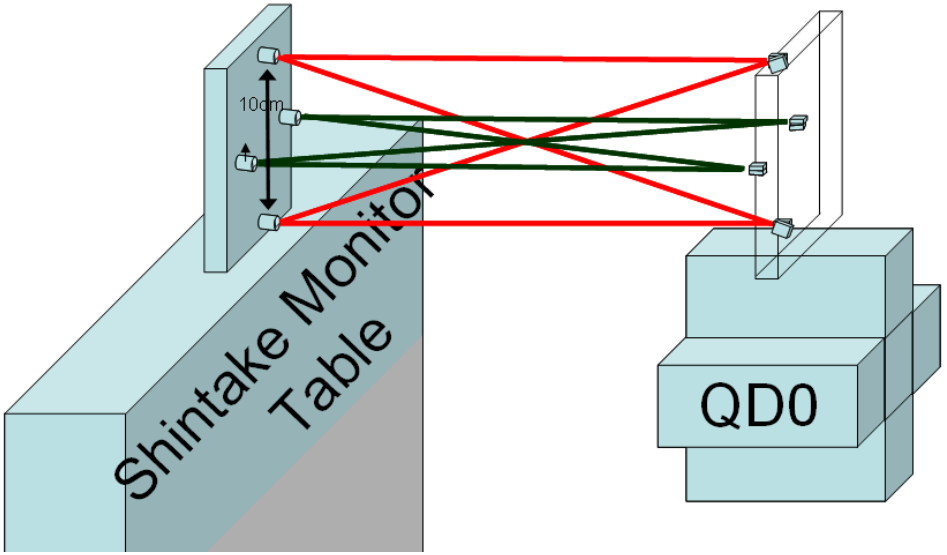
ATF2 beam line and planned/proposed R&Ds

2008 - 2010 - 2012 - 2014



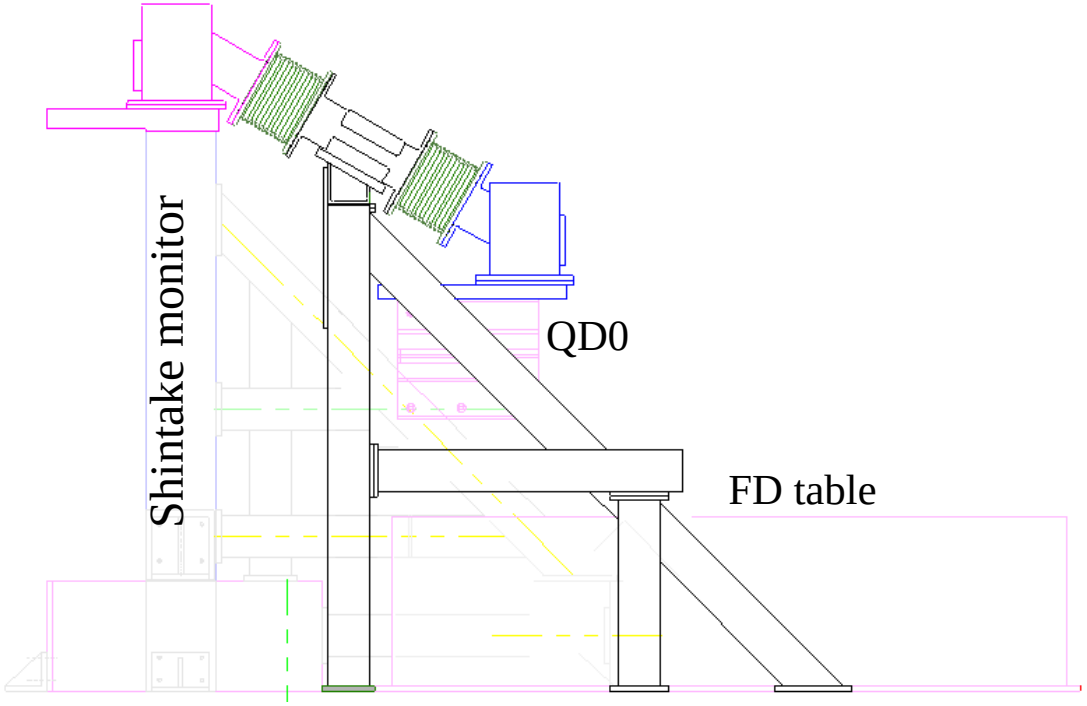
IP Interferometer

Monitoring Alignment &
Stabilisation with high Accuracy

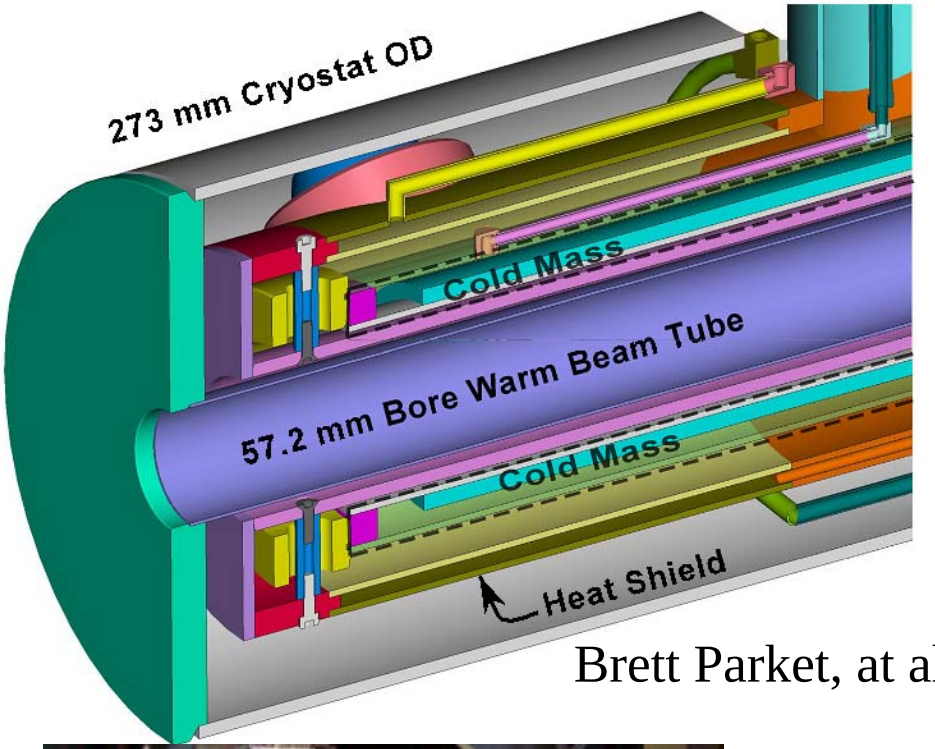


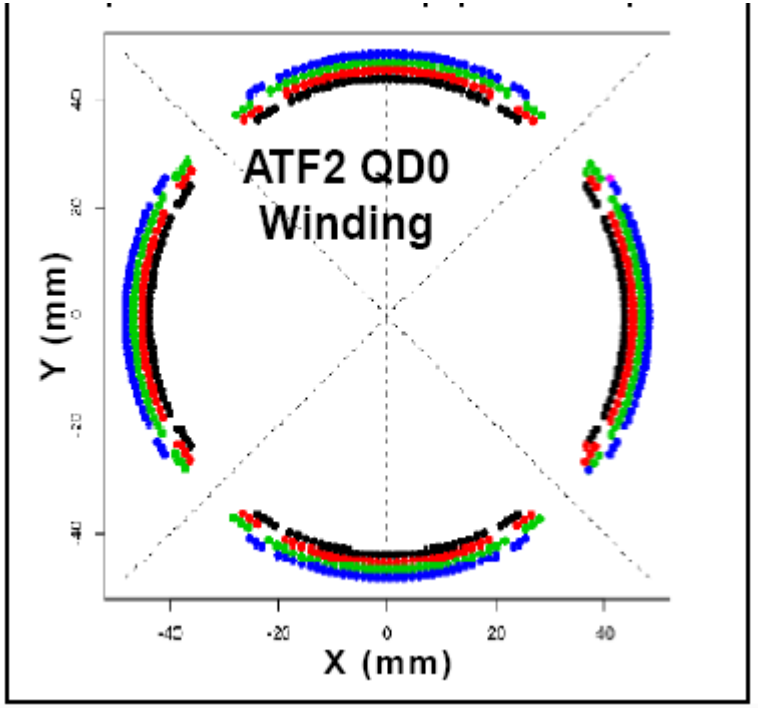
MONALISA Oxford

- MONALISA: measures 6D position of two objects separated by several meters with a precision of nanometres using interferometers
- Expect resolution: σ_y:10nm, distance: 1nm
- Use FFI and FSI (Fixed Frequency and Frequency Scanning Interferometry)
- Measure position of FD with respect to Shintake monitor

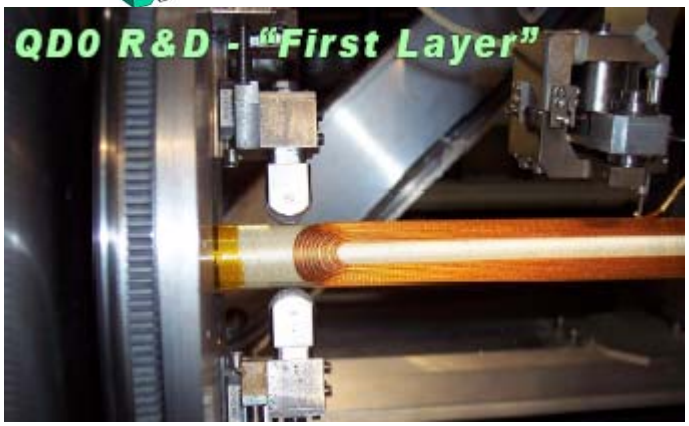


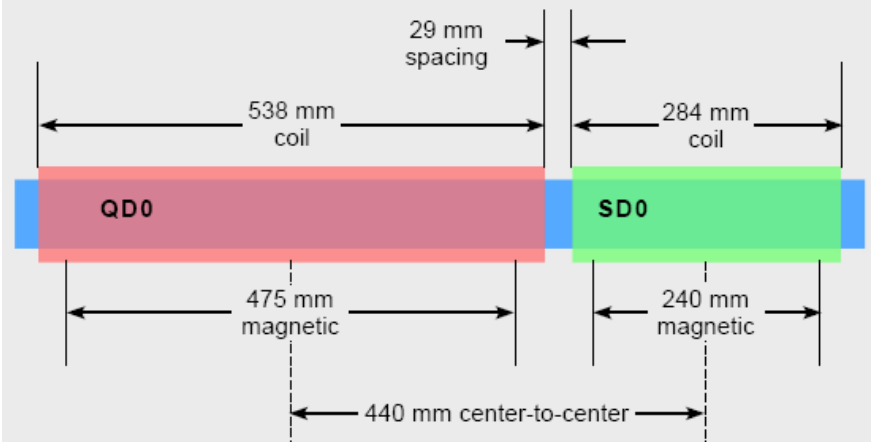
SC Final Doublet for ATF2



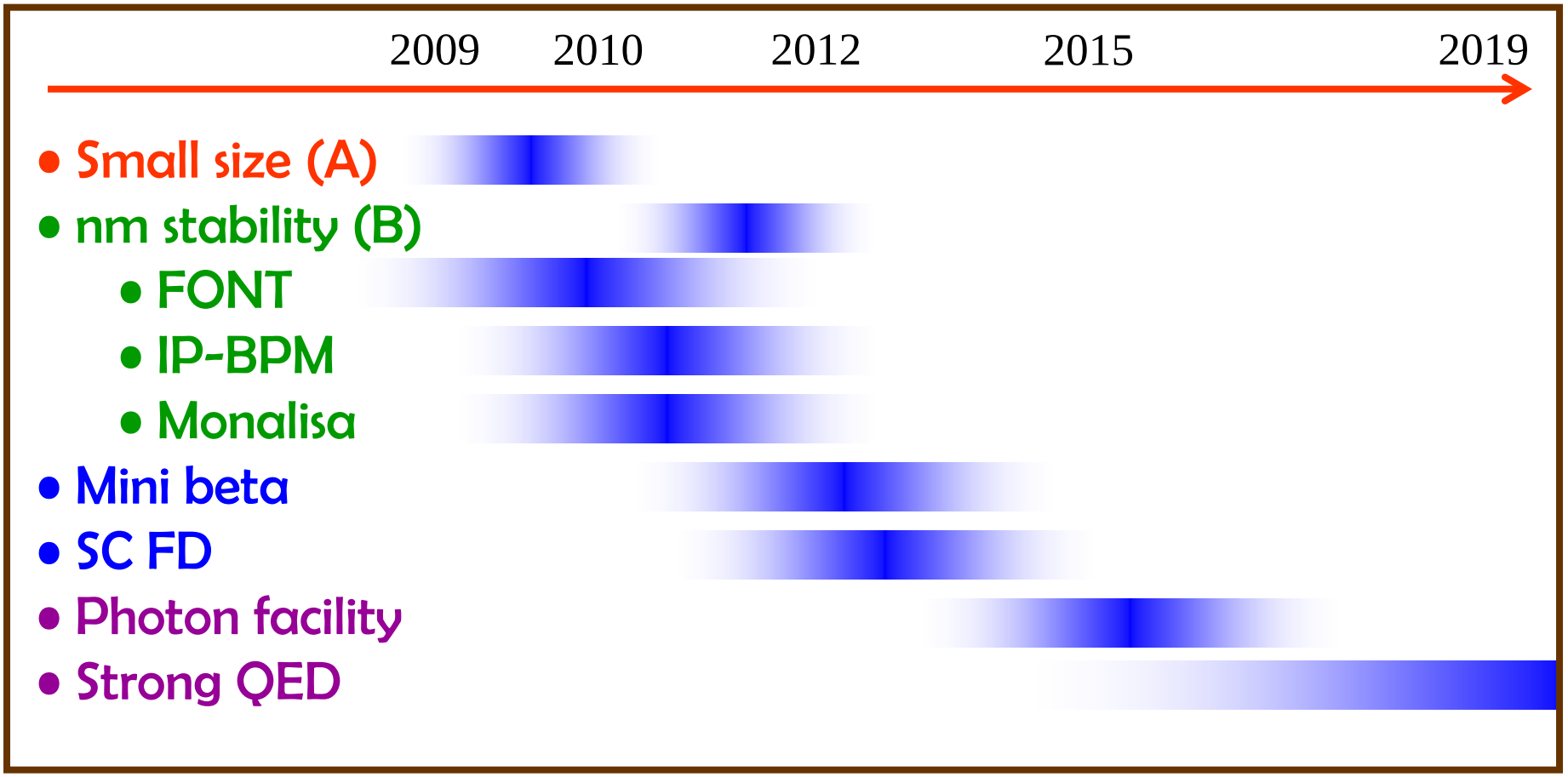


Brett Parket, at al, BNL





ATF2 Outlook



Conclusion

- ATF collaboration has completed construction of ATF2 facility and has started its commissioning
- ATF collaboration is streamlining organization of commissioning to match the challenge and the timescale
- Hardware for the second goal of ATF2 is being developed
- Looking into the future, planning upgrade of ATF2
- Tentative long term plans are being developed