# Multi-Optical Transition Radiation System for ATF2

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# Contents

-Motivation and Objectives
-Multi-OTR system
  - Current OTR monitor
  - New OTR design
-Optics and location for the new OTRs
-Actual status and planning

# Motivation and Objectives

-This system will be a valuable tool for measuring beam sizes and emittances from the Damping Ring.

-With an optical resolution of about 2um an original OTR design demonstrated the ability to measure a 5.5um beam size in one beam pulse and to take many fast measurements.

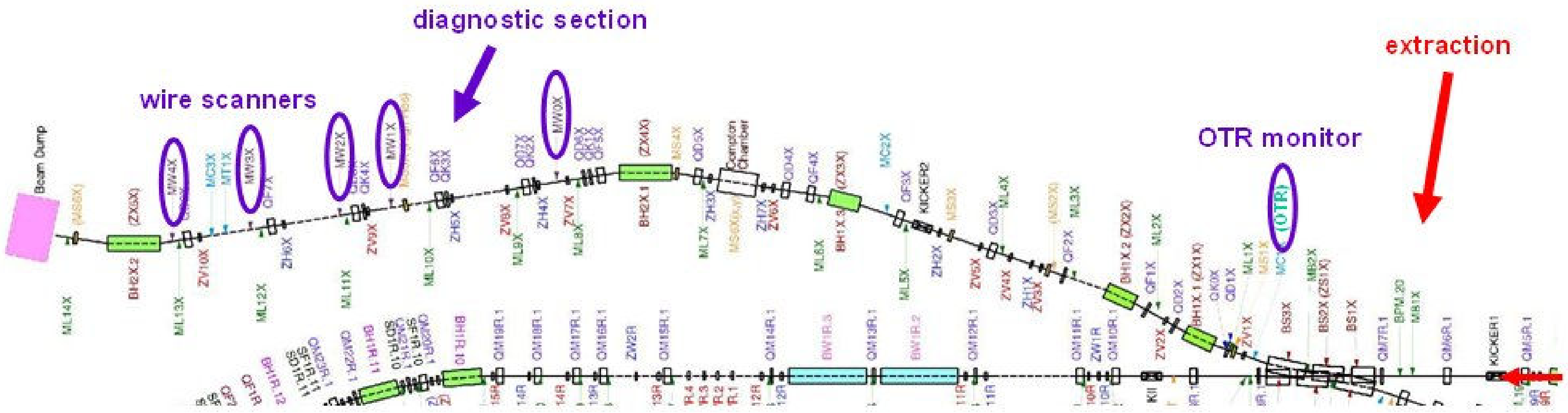
-This gives the OTR the ability to measure the beam emittance with high statistics, giving a low error and a good understanding of emittance jitter.

-Furthermore the near by wire scanners will be a definitive test of the OTR as a beam emittance diagnostic device.

# New Multi-OTR System

**In the diagnostic section of the ATF EXT line 5 wire scanners are located to allow emittance measurements (with 10 um tungsten and 7 um carbon wires)**

**- Requires many machine pulses, slow measurements**
**- Resolution: less than 2 um in X and 0.3 um in Y**




**PROPOSAL: Multi OTR System (4 units)**

**(collaboration involving SLAC and IFIC, with the KEK support):**

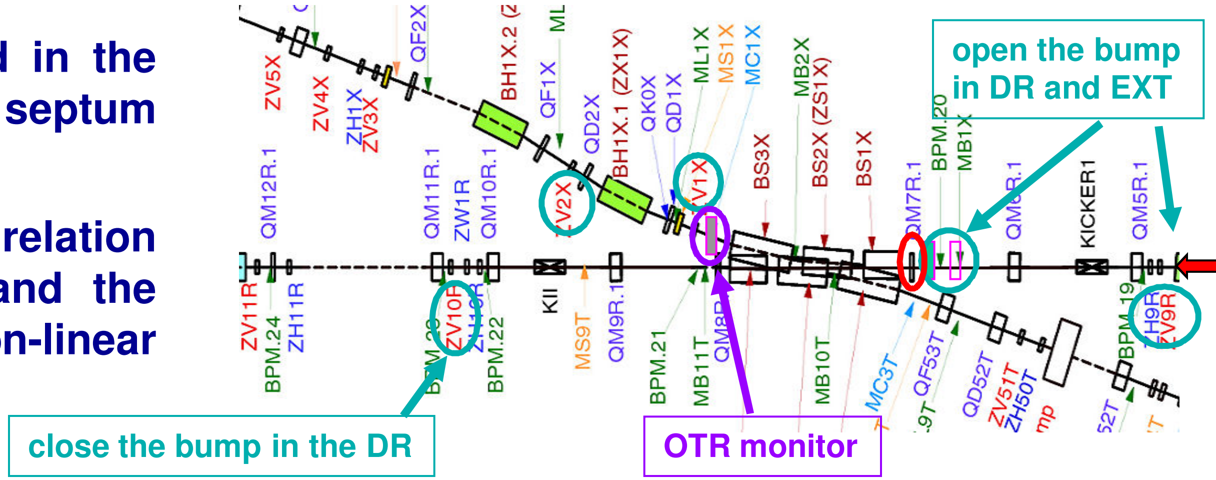
**beam dynamics studies, design, construction, and characterization including associated electronics**

**- horizontal and vertical beam size measurement in one beam pulse with 2um resolution**
**- OTR's placed close to the wire scanners: definitive test of OTR as emittance diagnostic device.**

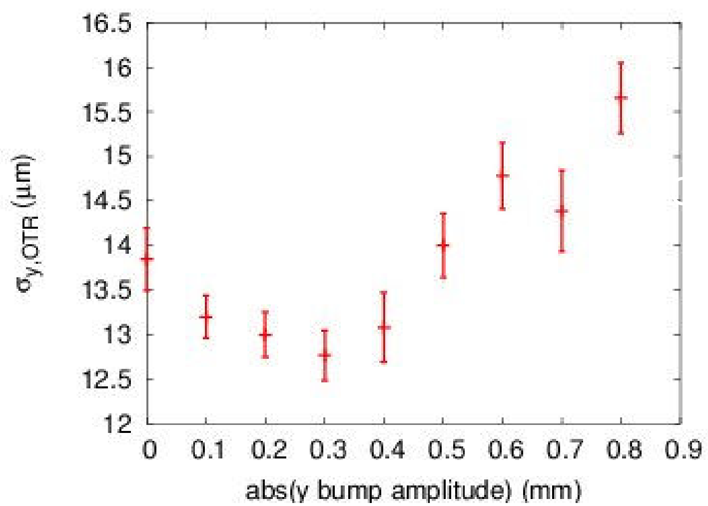
# Existing OTR monitor (OTR1X)

**The OTR1X monitor is installed in the ATF2 EXT line after the septum magnets.**

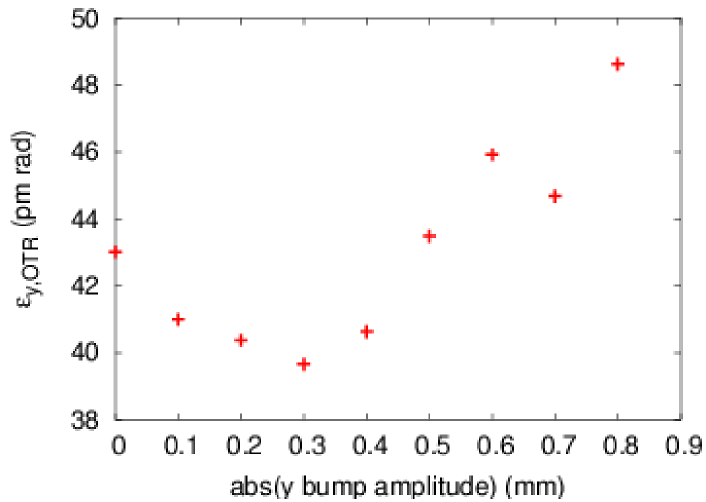
**It has been used to study the relation between the beam trajectory and the emittance growth due to non-linear fields in the extraction process**



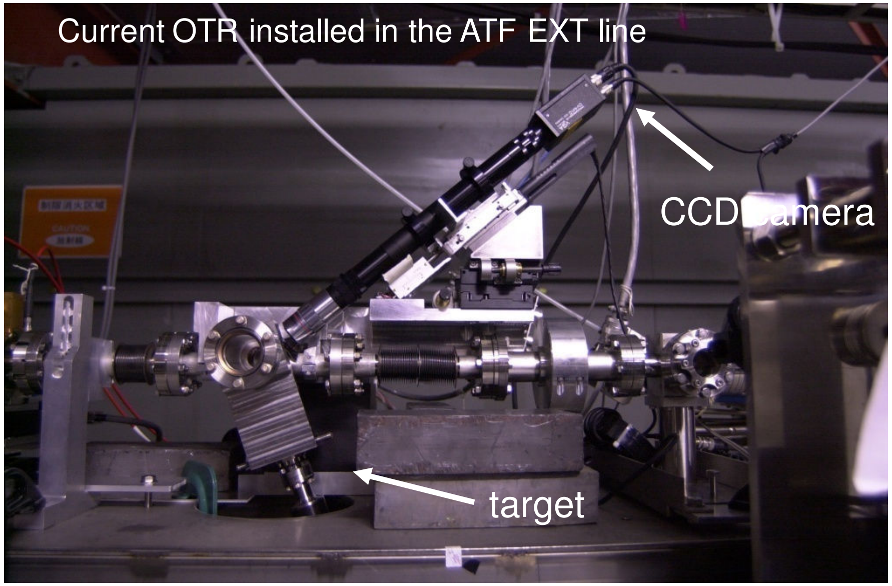

Measured beam sizes on 19th Dec'07

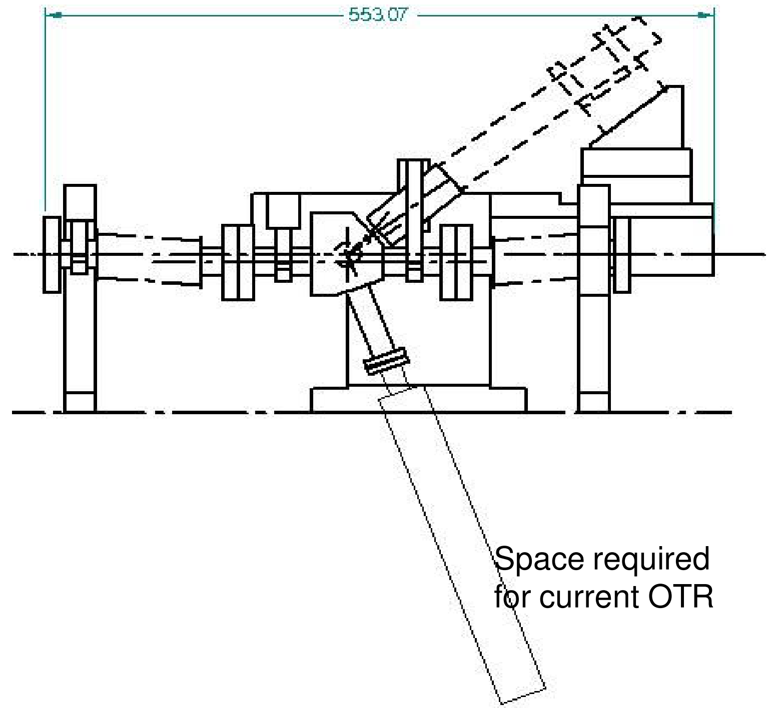



Inferred emittances from modeled ß-functions and dispersions



# Current OTR setup



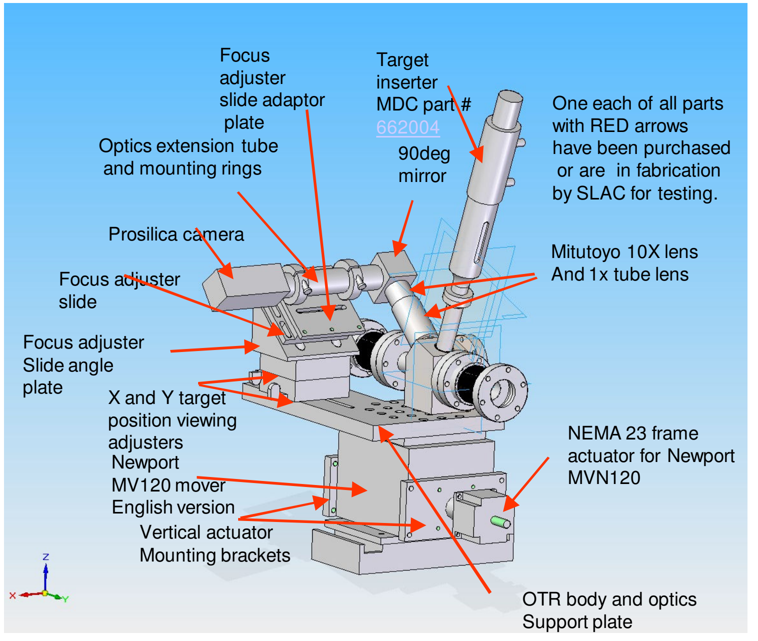



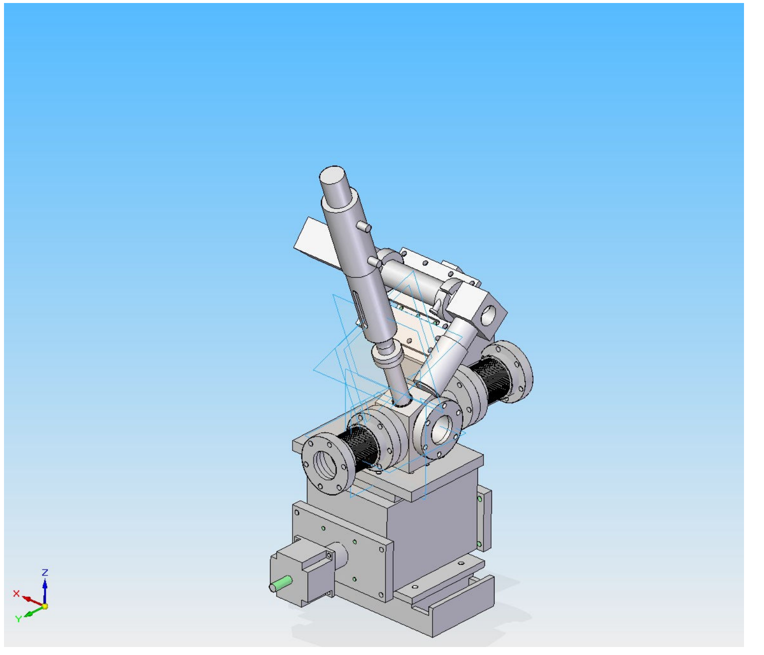

- **The OTR1X was an evolved design rather than a optimized one. New parts were added to the existing OTR to add functionality. Instead of making new design they were added bit by bit. As a result the OTR1X is a patchwork of parts and takes up a lot of beam line space.**

- **Existing OTR targets were rather thick, about 0.5mm of copper, beryllium or glassy carbon. This caused radiation darkening of the glass lens and camera damage.**

- **The camera CCD was not parallel to the target. This meant that the beam spot was in focus on only a small portion of the target. If the beam moved, the image had to be refocused.**

# New OTR monitor design



**New OTRs will have same controls and motion capabilities as current OTR with the following improvements:**

- Target actuator relocated to the top (no interference with the girder) and smaller design → greater flexibility in the OTR placement

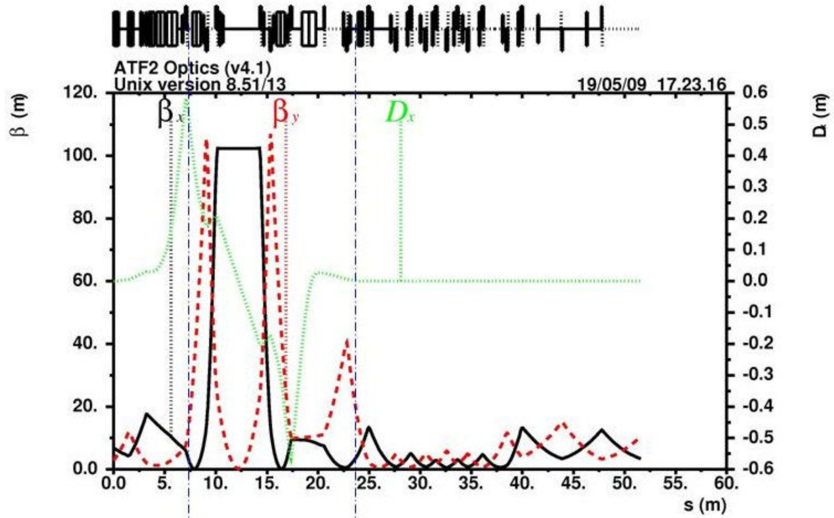
- Thinner target → reduce lens radiation darkening

- CCD camera parallel to the target. This will put the entire target into focus and reduce the need to adjust focus during normal operation → greater depth of field.

- 12 bit camera for more dynamic range with smaller pixel size for more resolution.

- The extreme thinness of the aluminum's 1200 Angstroms will reduce the power deposition in the aluminum and coupled to larger beam spot sizes should eliminate target damage problems.

# Optics and location for the new OTR's

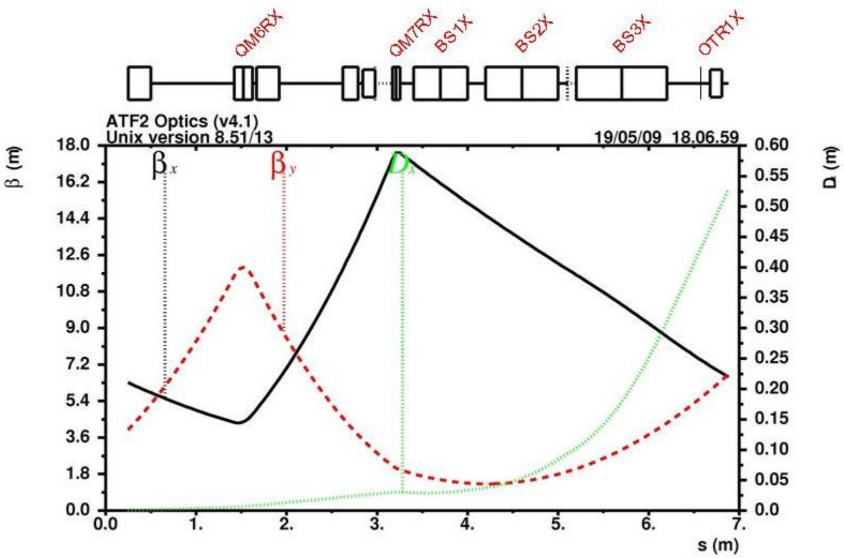



Shared with DR

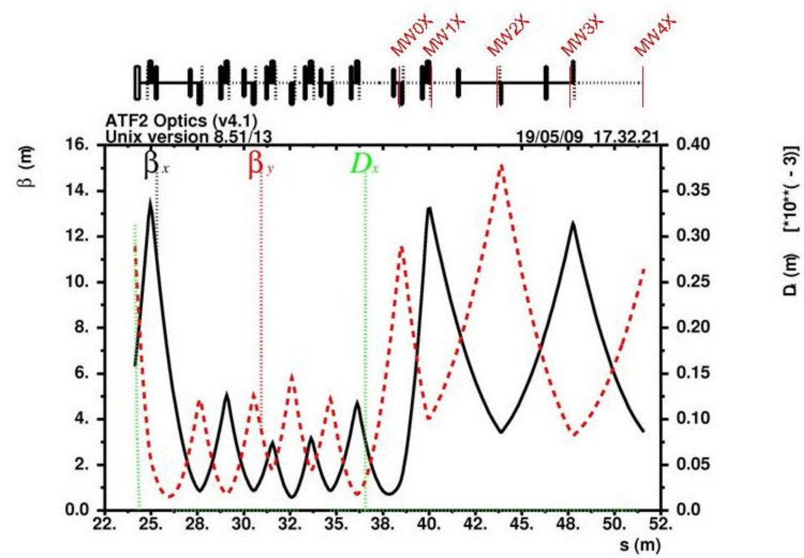
Matching section

Diagnostic section

(Dx=D'x=0)




Shared with DR




Diagnostic section (Dx=D'x=0)

# Optics and location for the new OTR's

## MAD Twiss parameters and beam size calculations for OTR1X and MW0X-MW4X of the ATF EXT line optics (V4.1)

| | OTR1X_old | Start EXT | OTR1X | MW0X | MW1X | MW2X | MW3X | MW4X |
|---|---|---|---|---|---|---|---|---|
| $\varepsilon_x$ [nm.rad] | 2.0 | | | | | | | |
| $\varepsilon_y$ [pm.rad] | 12 | | | | | | | |
| $\sigma_E$ | 8.00 x$10^{-4}$ | | | | | | | |
| $\beta_x$ [m] | 8.267 | 6.853 | 7.392 | 3.282 | 12.122 | 3.824 | 11.412 | 3.758 |
| $\beta_y$ [m] | 5.227 | 2.941 | 5.617 | 9.271 | 4.496 | 13.790 | 3.527 | 9.702 |
| $D_x$ [m] | 0.389 | 0.000 | 0.436 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $D_y$ [m] | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $\mu_x$ [$2\pi$] | 0.114 | 0.000 | 0.122 | 2.875 | 2.905 | 2.983 | 3.103 | 3.184 |
| $\Delta\mu_x$ [$2\pi$] | | 0.000 | | 2.752 | 0.030 | 0.078 | 0.120 | 0.080 |
| $\mu_y$ [$2\pi$] | 0.356 | 0.0000 | 0.366 | 2.142 | 2.184 | 2.251 | 2.363 | 2.455 |
| $\Delta\mu_y$ [$2\pi$] | | 0.0000 | | 1.775 | 0.042 | 0.067 | 0.112 | 0.092 |
| $\sigma_x$ [$\mu$m] | 439.78 | 117.07 | 470.10 | 81.02 | 155.71 | 87.45 | 151.08 | 86.69 |
| $\sigma_y$ [$\mu$m] | 7.85 | 5.89 | 8.14 | 10.46 | 7.28 | 12.75 | 6.45 | 10.70 |

**The four OTR's have to be as close as possible to the wire scanners in order to have similar conditions.**

# Optics and location for the new OTR's

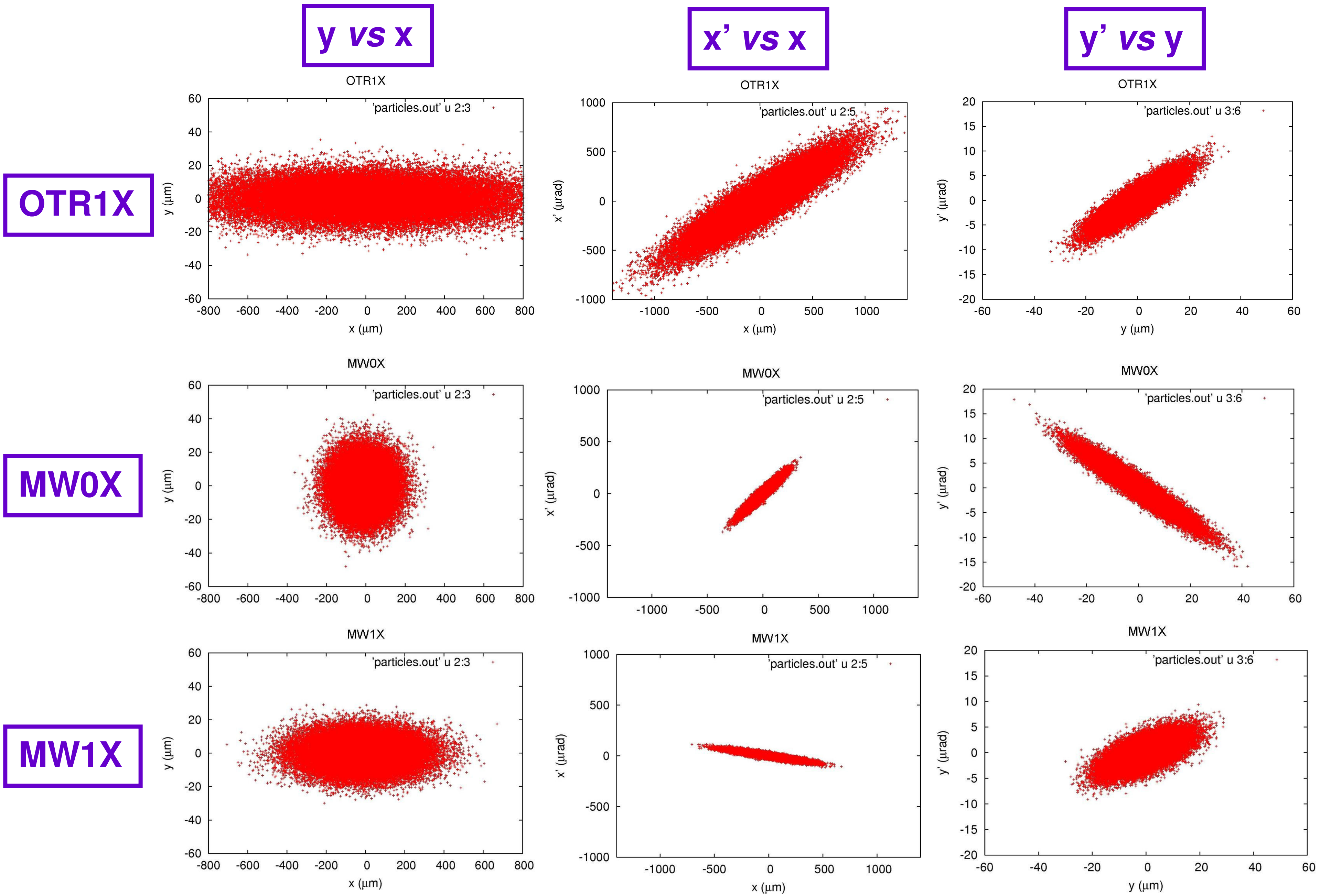
**Beam sizes, ß-functions and emittances for OTR1X and MW0X-MW4X of the ATF EXT line optics calculated from tracking simulations using PLACET and MAD programs.**

| | OTR1X_old | OTR1X | MW0X | MW1X | MW2X | MW3X | MW4X |
|---|---|---|---|---|---|---|---|
| $\sigma_x$ [$\mu$m] | | | 81.73 | 157.06 | 88.00 | 151.31 | 86.87 |
| $\sigma_y$ [$\mu$m] | 7.24 | 8.13 | 10.57 | 7.36 | 12.83 | 6.44 | 10.69 |
| $\varepsilon_x$ [nm.rad] | | | 2.02 | 2.02 | 2.02 | 2.02 | 2.02 |
| $\varepsilon_y$ [pm.rad] | 1.18 | 1.18 | 1.19 | 1.19 | 1.19 | 1.19 | 1.19 |
| $\beta_x$ [m] | | | 3.305 | 12.212 | 3.834 | 11.131 | 3.735 |
| $\beta_y$ [m] | 4.435 | 5.588 | 9.398 | 4.551 | 13.841 | 3.484 | 9.603 |

**Input parameters:**
**50.000 particles**
**x, y and E Gaussian distribution**

**Spot sizes estimated for the new OTR locations are a bit larger than the spots that damaged the cooper target in the original OTR tests → no target damage expected**

# Beam plots



y vs x
x’ vs x
y’ vs y
OTR1X
MW0X
MW1X
OTR1X
MW0X
MW1X
'particles.out' u 2:3
'particles.out' u 2:5
'particles.out' u 3:6
x (μm)
y (μm)
x' (μrad)
y' (μrad)

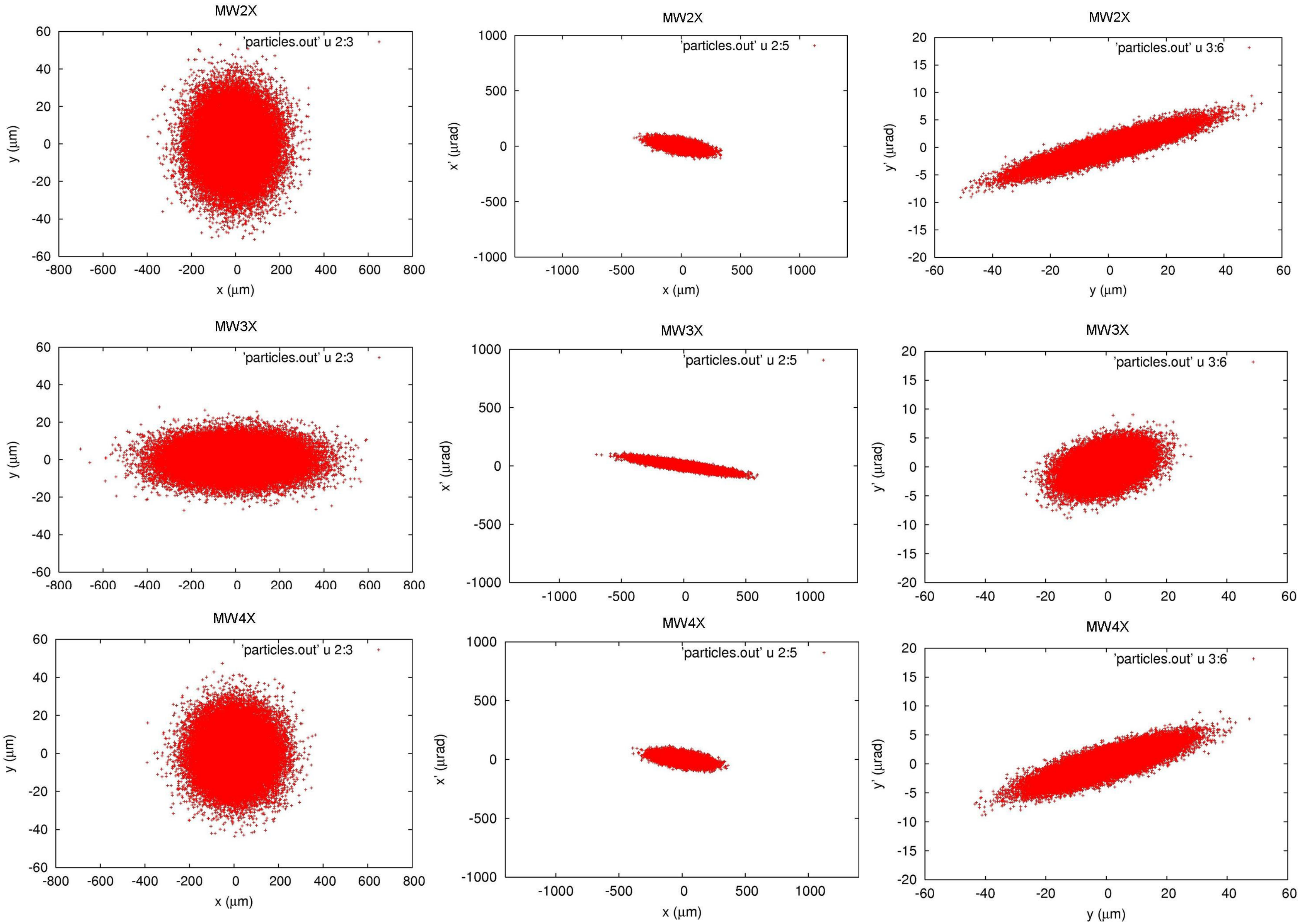
# Beam plots

**y vs x** | **x’ vs x** | **y’ vs y**

**MW2X**

**MW3X**

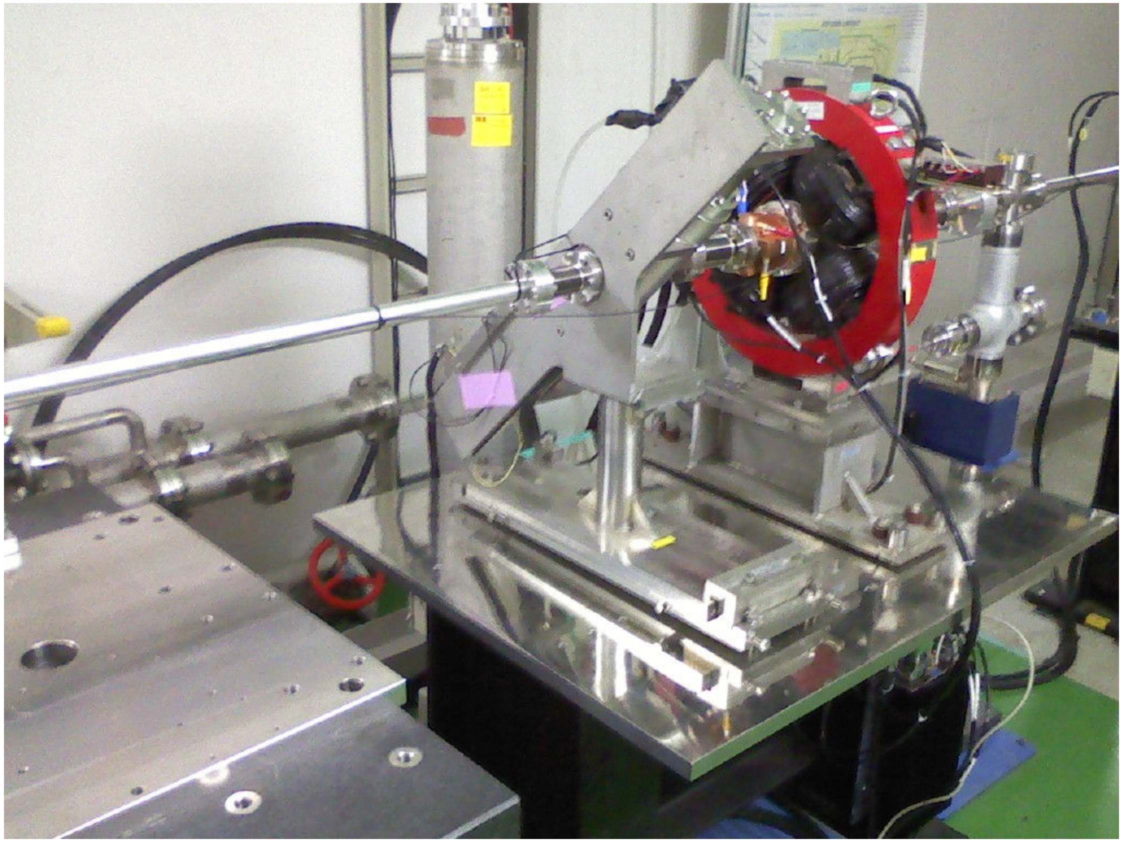
**MW4X**



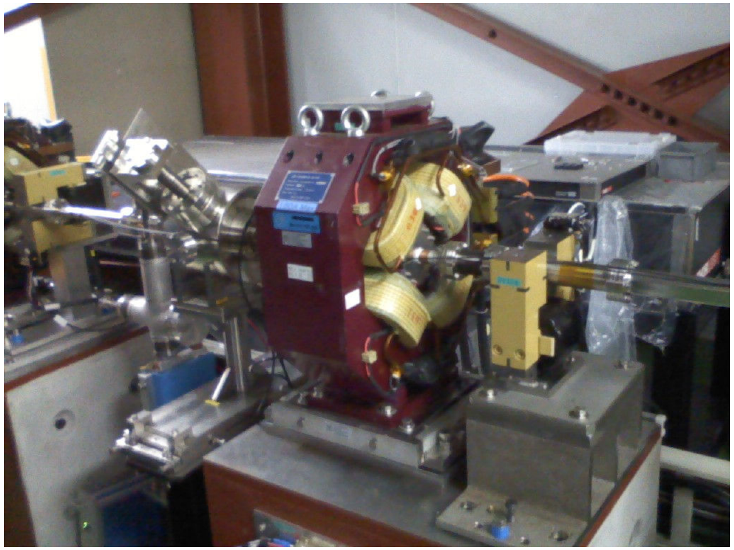
# Proposed locations for the new OTR's

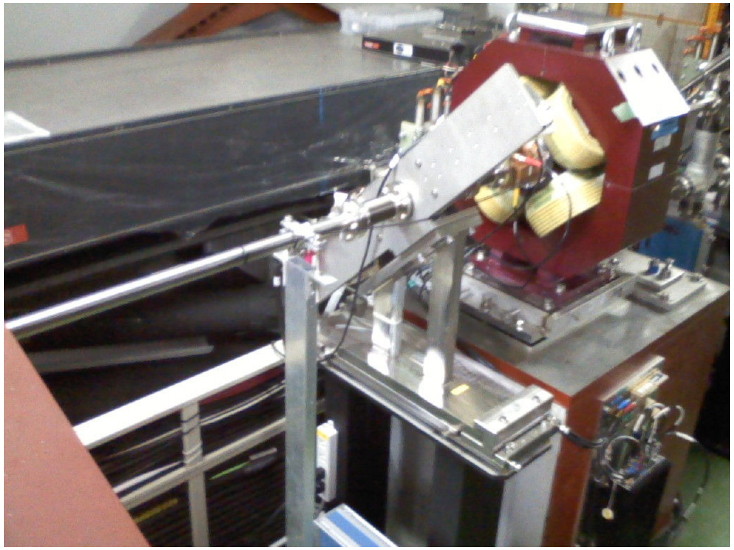
**During October 09 some locations have been identified.**

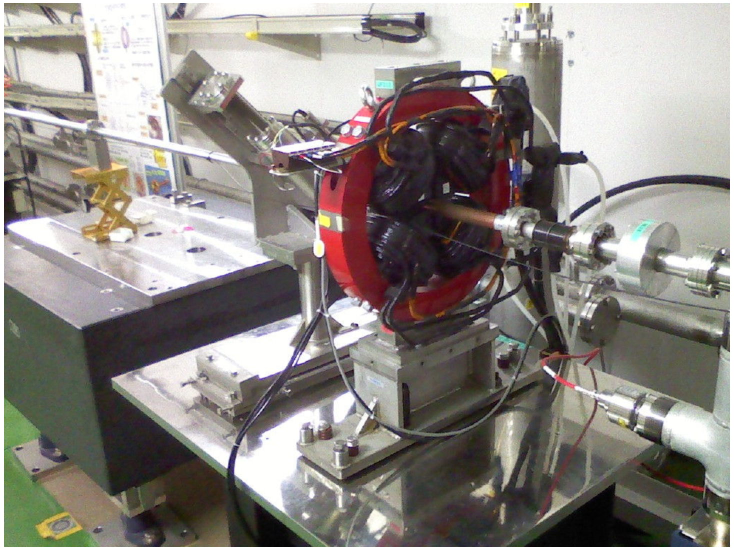
**A length of about 300 mm will be needed with the new OTR design.**

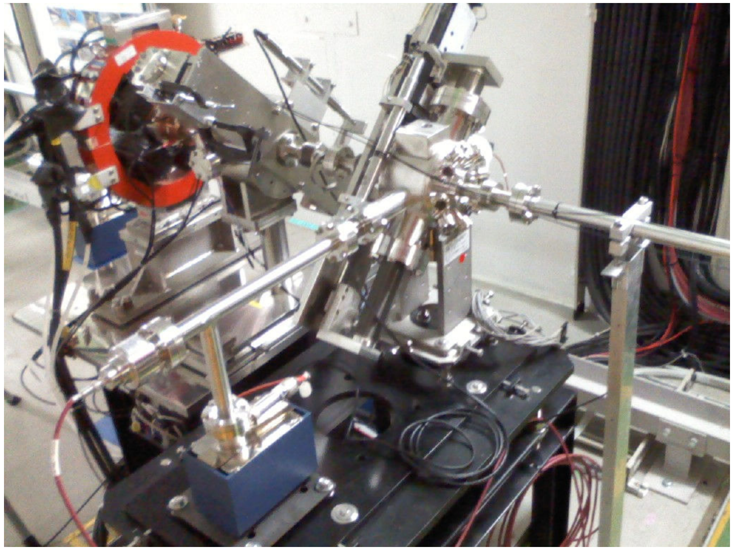


# Proposed locations for the new OTR's









# Actual status: optics design

**At SLAC we setup 90 degrees test optics**

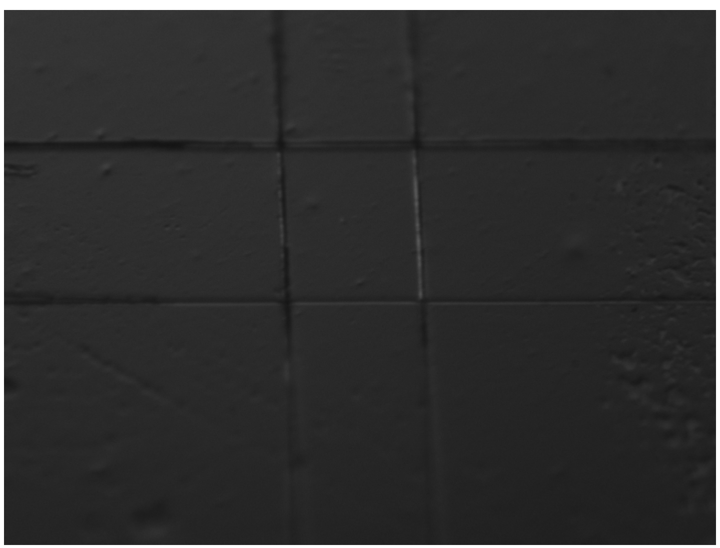
-**Confirmed 2um resolution**

-**Still need to check on optical performance with CCD tilted to match target angle**

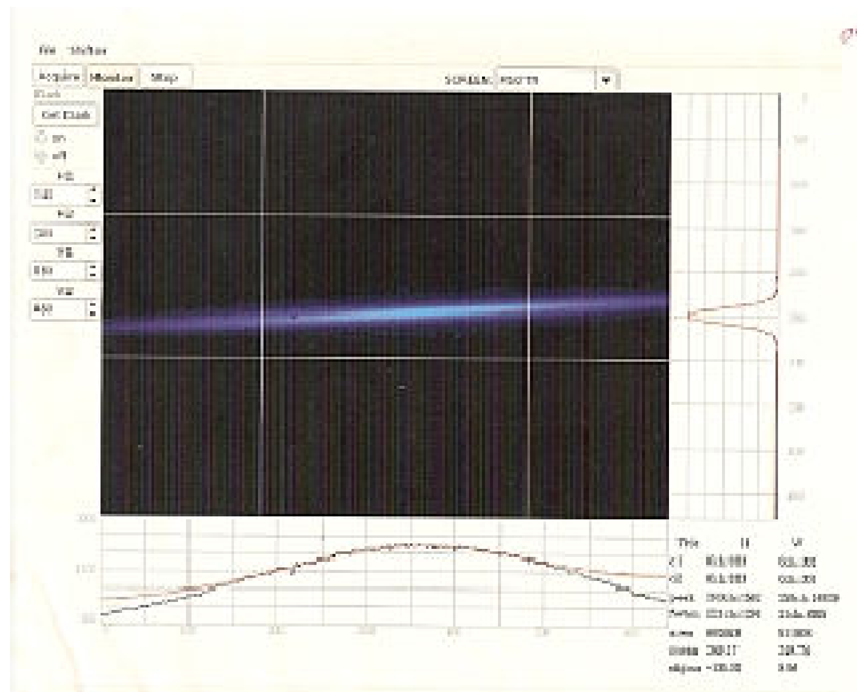
**- New Prosilica camera has slightly better performance than existing OTR camera. Pixel size is 3.75um/pixel almost a factor two improvement in resolution**

# Actual status: optics design

**During November 09 at KEK  the current OTR was updated with a new mylar target (aluminum coated nitrocellulose) and target actuator.**
**Calibration and tests with beam were also performed with success**
**-Confirmed ample light from new 2um targets**
**- Not enough current for a destruction test**
**-Observed greatly reduced radiation from target when inserted. This will mean: less browning of he lenses and longer camera life.**



Mylar target with calibration marks



Beam spot measurement with OTR

# Actual status: movers

**First tests of new movers configuration were made at SLAC**

- **Horizontal mover design finished purchasing underway**

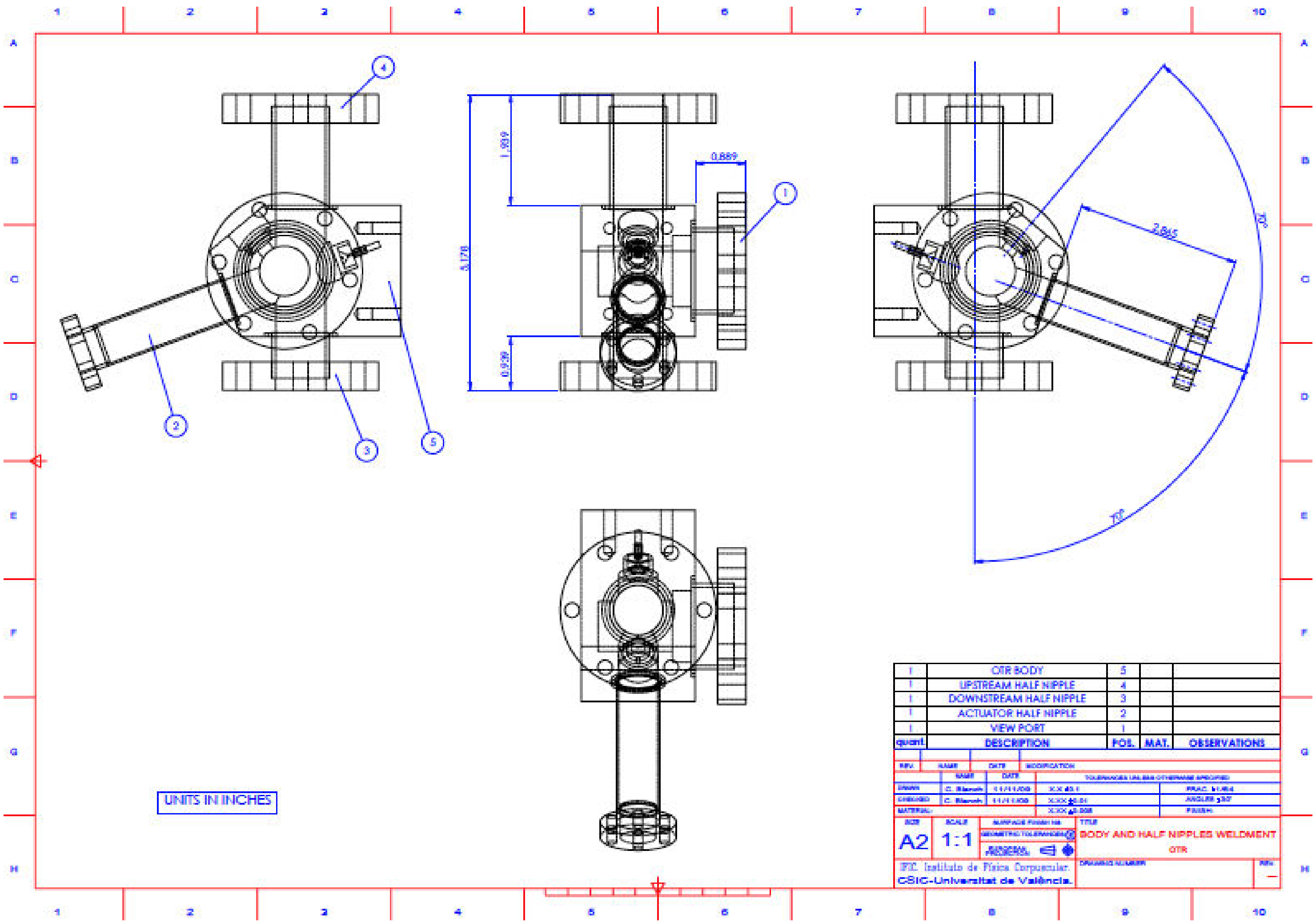
- **Vertical mover; same as existing OTR purchasing underway**

- **Focus mover same as existing OTR purchasing underway**

- **Control and read back of mover position will be done through EPICS compatible Newport 8 channel XPS chassis. One chassis and 8 driver cards purchased. One more chassis and card still required.**

# Actual status: main body fabrication

**Main body, flanges and tubes drafts for the new OTR design has been finished at SLAC/IFIC.** **The production is underway at IFIC.**



# Planning: Hardware

- OTR main fabrication
  - OTR body and optical windows parts
  - Fabricate and weld flanges on tubes and tubes to OTR body
  - Fabricate and weld bellows and flanges
  - Fabricate OTR moving system adaptors

- Assembly and test with movers

# Planning: software and simulations

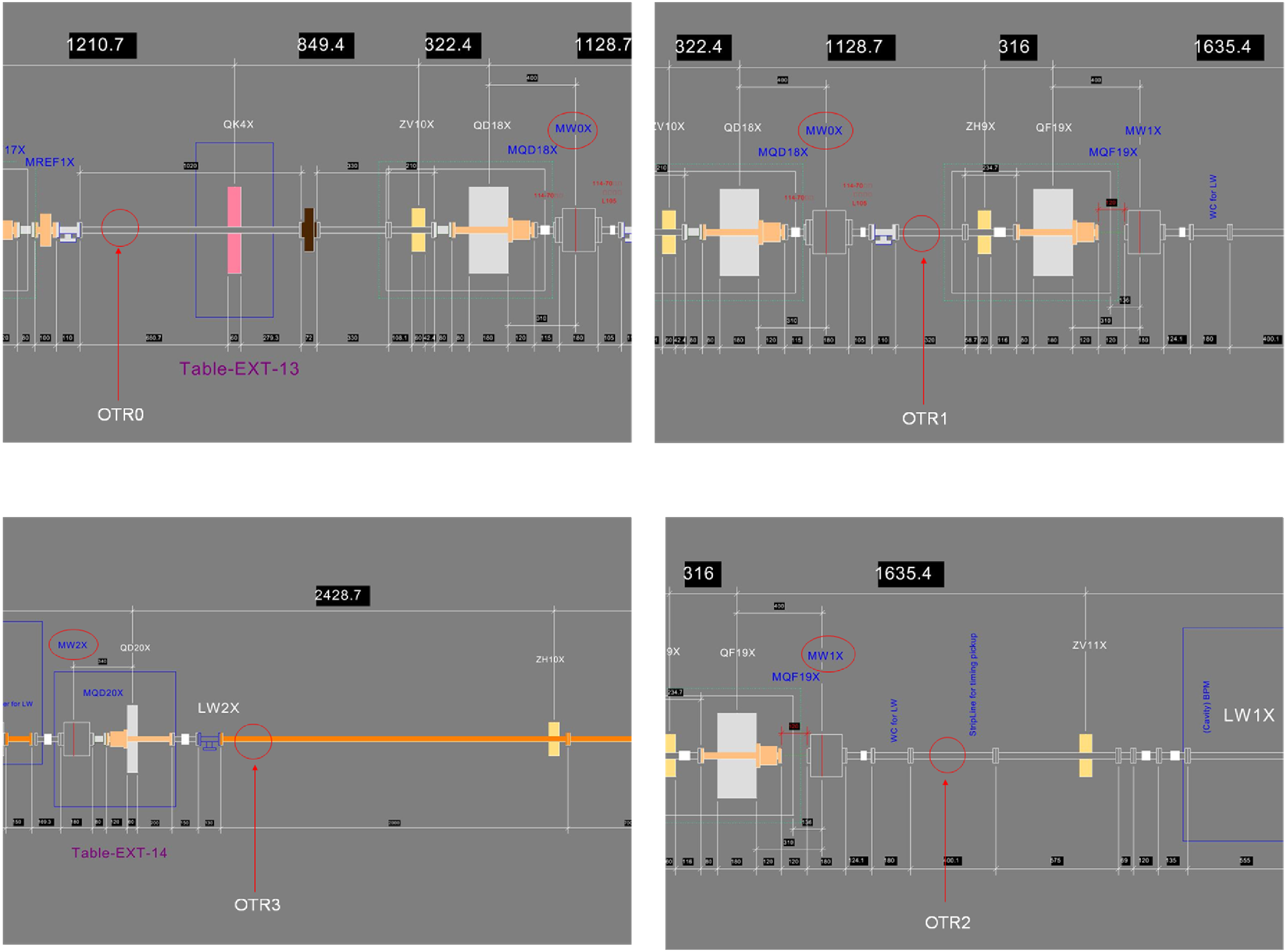
- Control software
  - Low-levels drivers
  - EPICS drivers and Data Base
  - High-level interface
  - Hardware protection

- Analysis software
  - 2D Gaussian filter, taking CCD image and generating beam matrix data
  - Beam finder and tracker

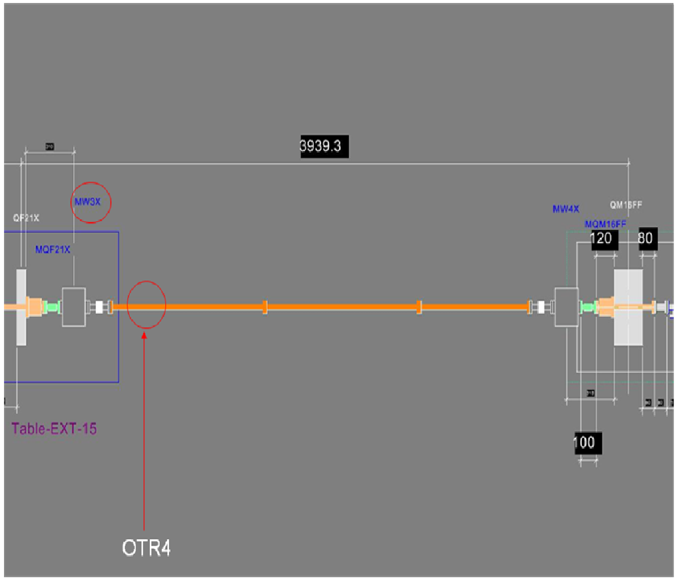
- Realistic optics and beam dynamics simulations

# Planning:tentative schedule

| | Jan | | | | | Feb | | | | Mar | | | | | Apr | | | | May | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Week # (2010)** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| **Main body construction** | | | | | | | | | | | | | | | | | | | | |
| **Movers assembly and setup** | | | | | | | | | | | | | | | | | | | | |
| **Test of movers (at IFIC/SLAC)** | | | | | | | | | | | | | | | | | | | | |
| **Control software development** | | | | | | | | | | | | | | | | | | | | |
| **Analysis software development** | | | | | | | | | | | | | | | | | | | | |
| **Beam Dynamics simulations** | | | | | | | | | | | | | | | | | | | | |
| **Installation** | | | | | | | | | | | | | | | | | | | | |



1210.7
849.4
322.4
1128.7
QK4X
ZV10X
QD18X
MW0X
MREF1X
MQD18X
Table-EXT-13
OTR0
322.4
1128.7
316
1635.4
QD18X
MW0X
ZH9X
QF19X
MW1X
MQD18X
MQF19X
WC for LW
OTR1
2428.7
MW2X
QD20X
MQD20X
LW2X
ZH10X
Table-EXT-14
OTR3
316
1635.4
QF19X
MW1X
MQF19X
WC for LW
StripLine for timing pickup
ZV11X
(Cavity) BPM
LW1X
OTR2


3939.3
MW3X
QF21X
MQF21X
MW4X
QM16FF
MQM16FF
120
80
100
Table-EXT-15
OTR4