THE ATF IP-BSM SYSTEM

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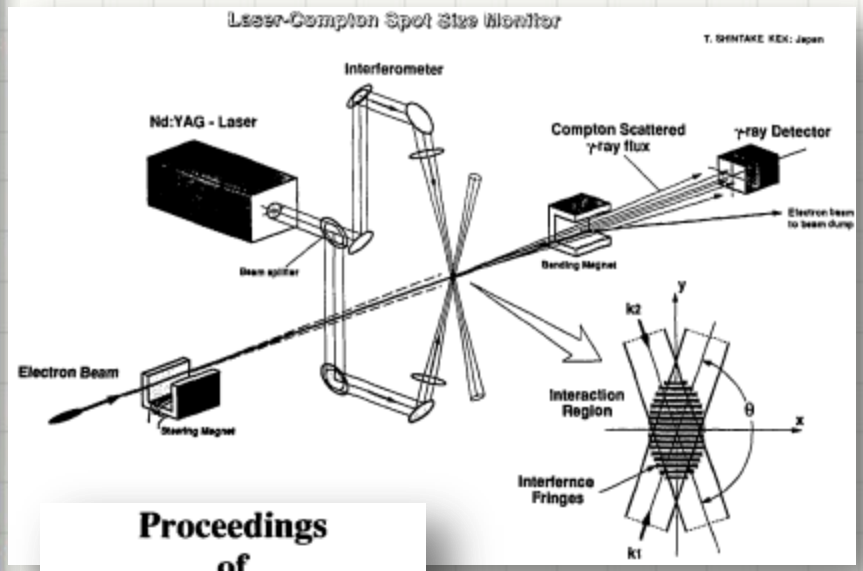
12 May 2022.

Outline

- ATF IPBSM overview
- Various quality degrading effects explanation
- ATF IPBSM improvements since 2020
- Recent results
- Summary and plans

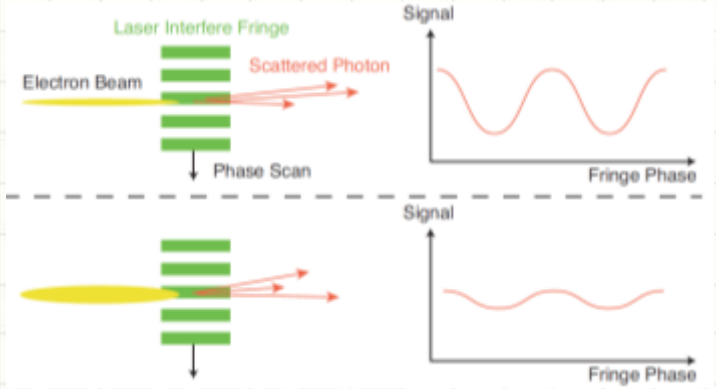
IPBSM principle

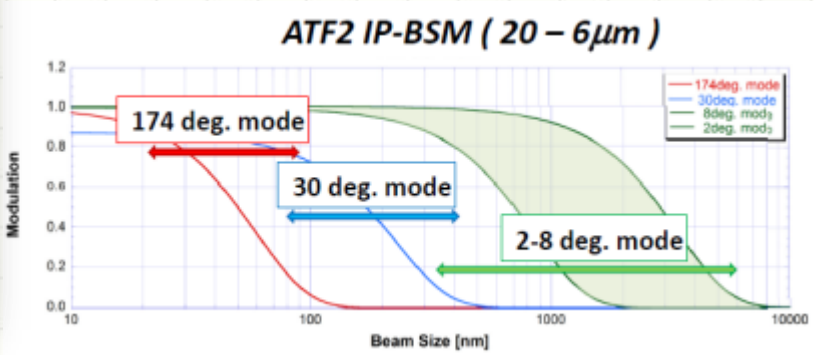


Proceedings of the Third Workshop on Japan Linear Collider (JLC)

KEK, Febrary 18 - 20, 1992

Original name:
"Laser-Compton Spot Size Monitor"





- **Establish the ILC final focus method with same optics and comparable beamline tolerances**
- ATF2 Goal : **37** nm → ILC **6** nm
  - Achieved **44** nm (2014)
  - obtained a good repeatability

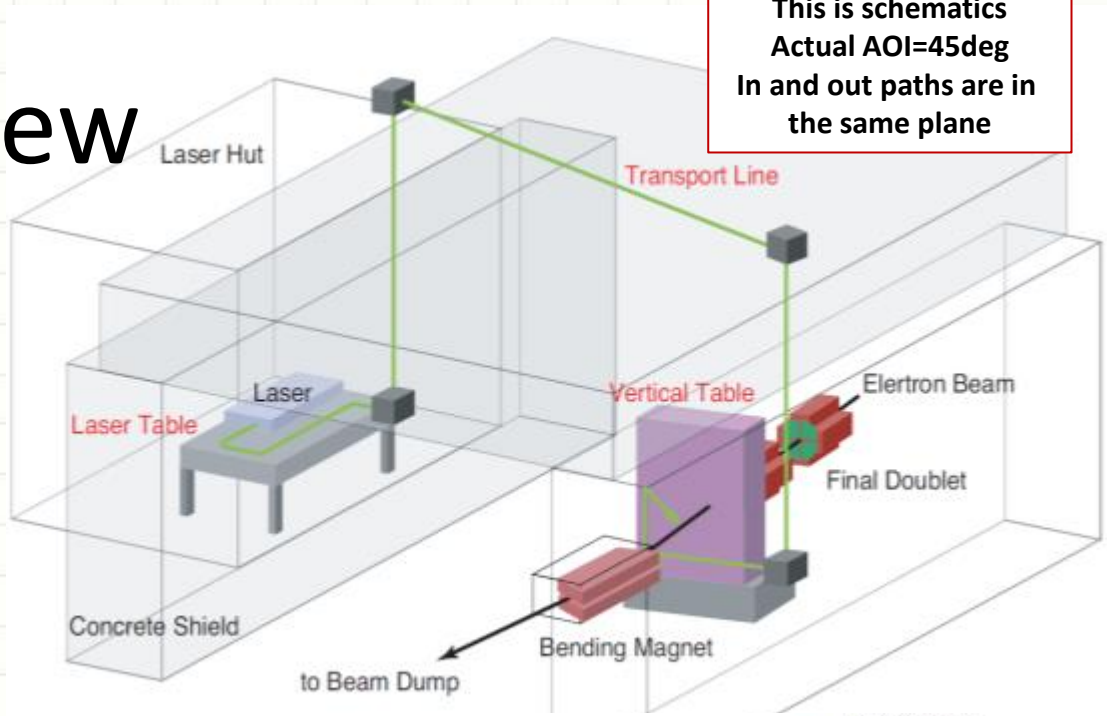
IP-BSM overview

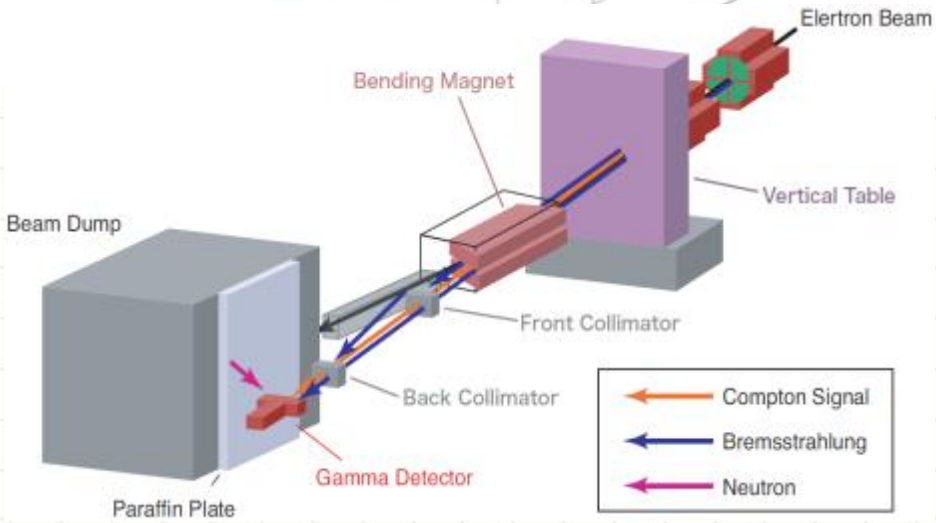
IP-BSM is not just a laser

IP-BSM consists of:

- Nd:YAG Laser
- Laser Transport Line (LTL)
- Vertical table (laser FF-IP)
- Detection line:
  - Collimator
  - Detectors
- DAQ
- Timing system
- Software

This is schematics
Actual AOI=45deg
In and out paths are in the same plane





Spectra-Physics Quanta-Ray PRO 350

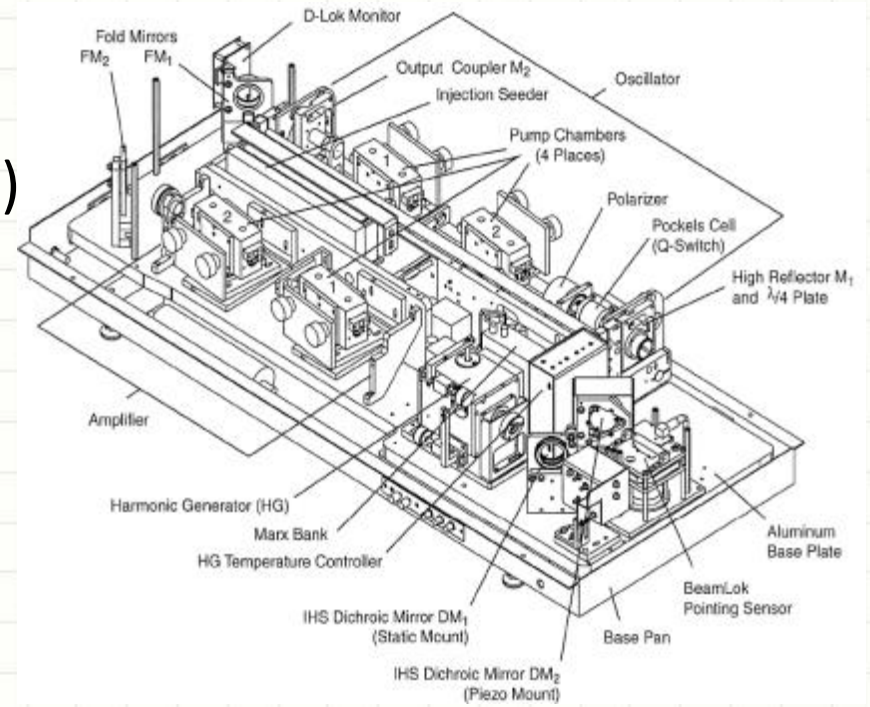
Right now it is discontinued

Company specs:

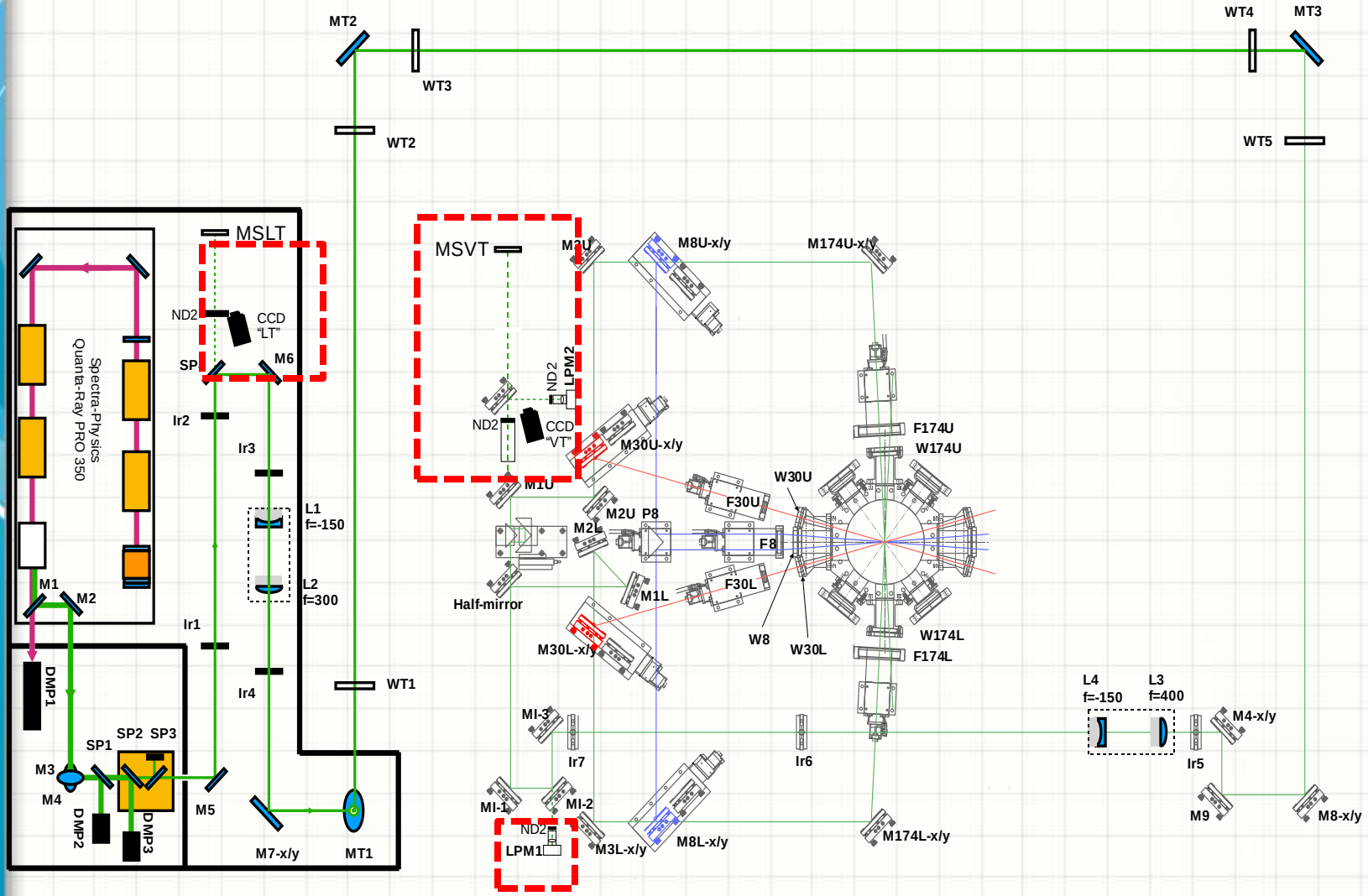
- Type: Nd:YAG Q-switched
- E_{532nm} = **1.4 J** +/- 3%
- Pulse = **8ns** +/- <0.5ns (FWHM)
- Rep. rate = 6.24 Hz
- M2 ~ 1.8 – 2.2 (vs tuning)

Requires regular actions:

- Cleaning
- Tuning
- Flash lamps replacement

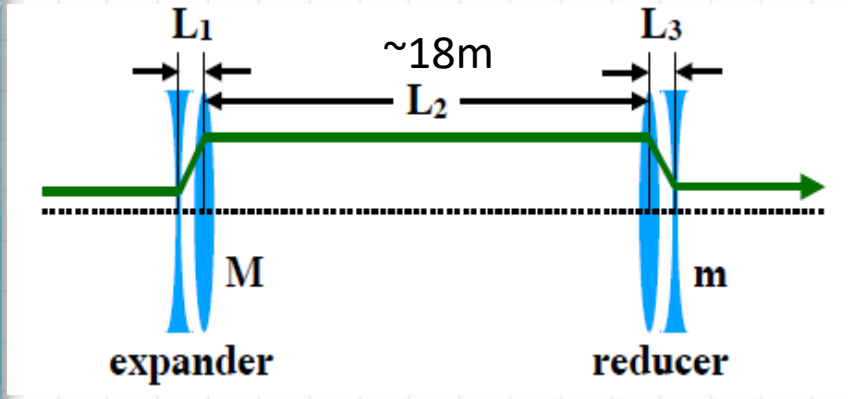


IP-BSM overview (recent details)

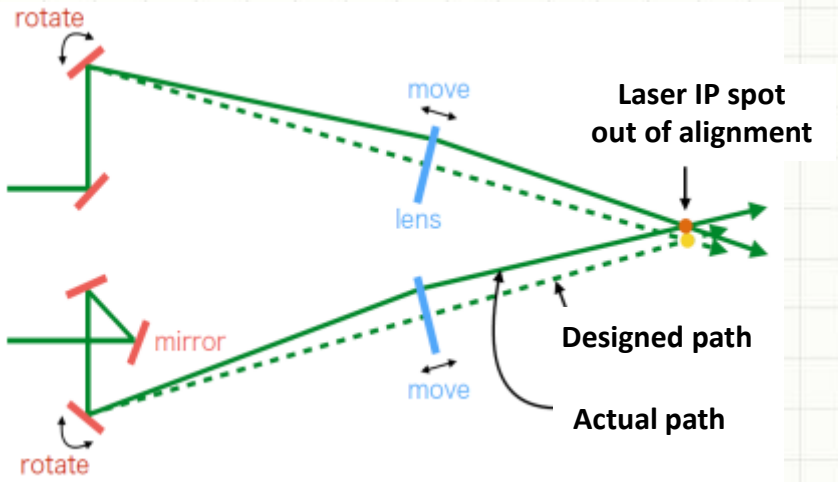


Laser beam misalignment effects

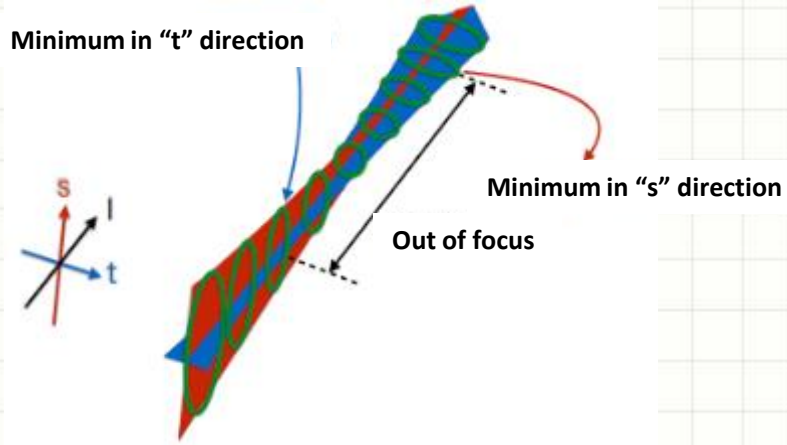
Existing laser transport line



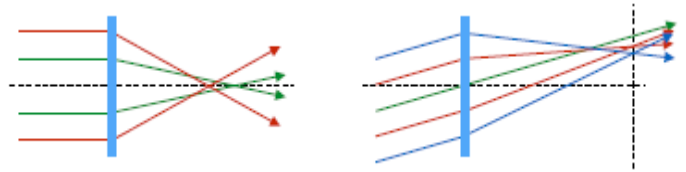
Not perfect laser path tuning result in aberrated profile at IP



Example of a strong astigmatism



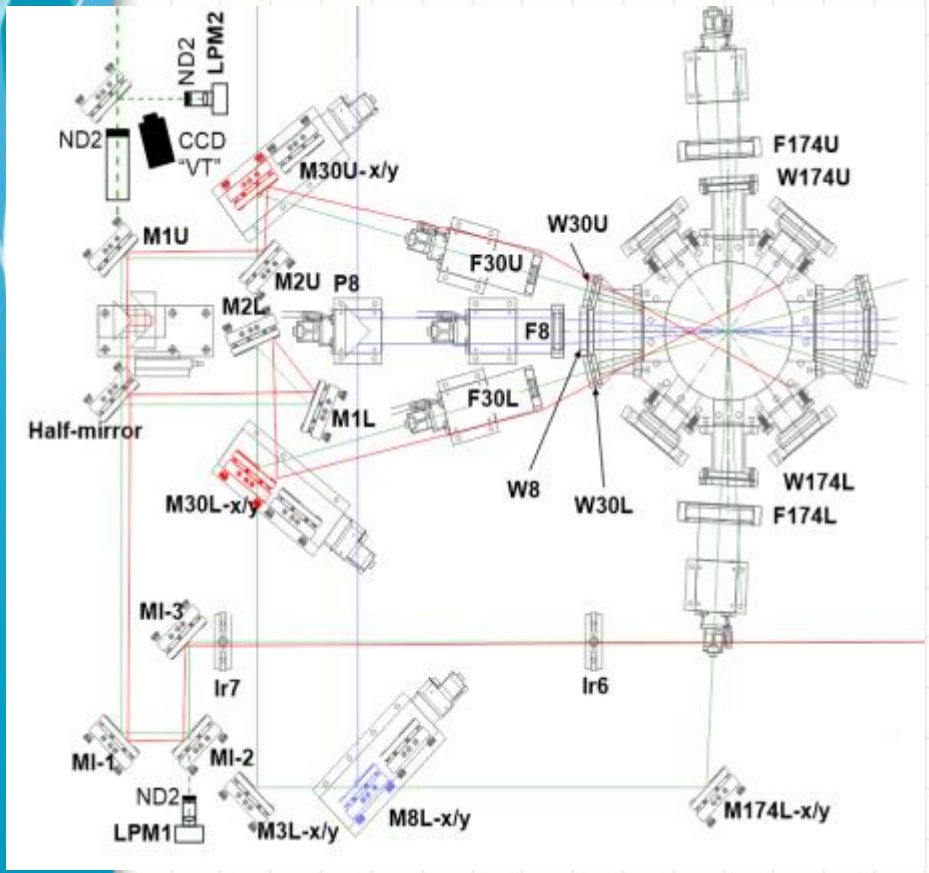
Types of aberrations we experience



Chromatic

Coma

Laser beam jitter effect



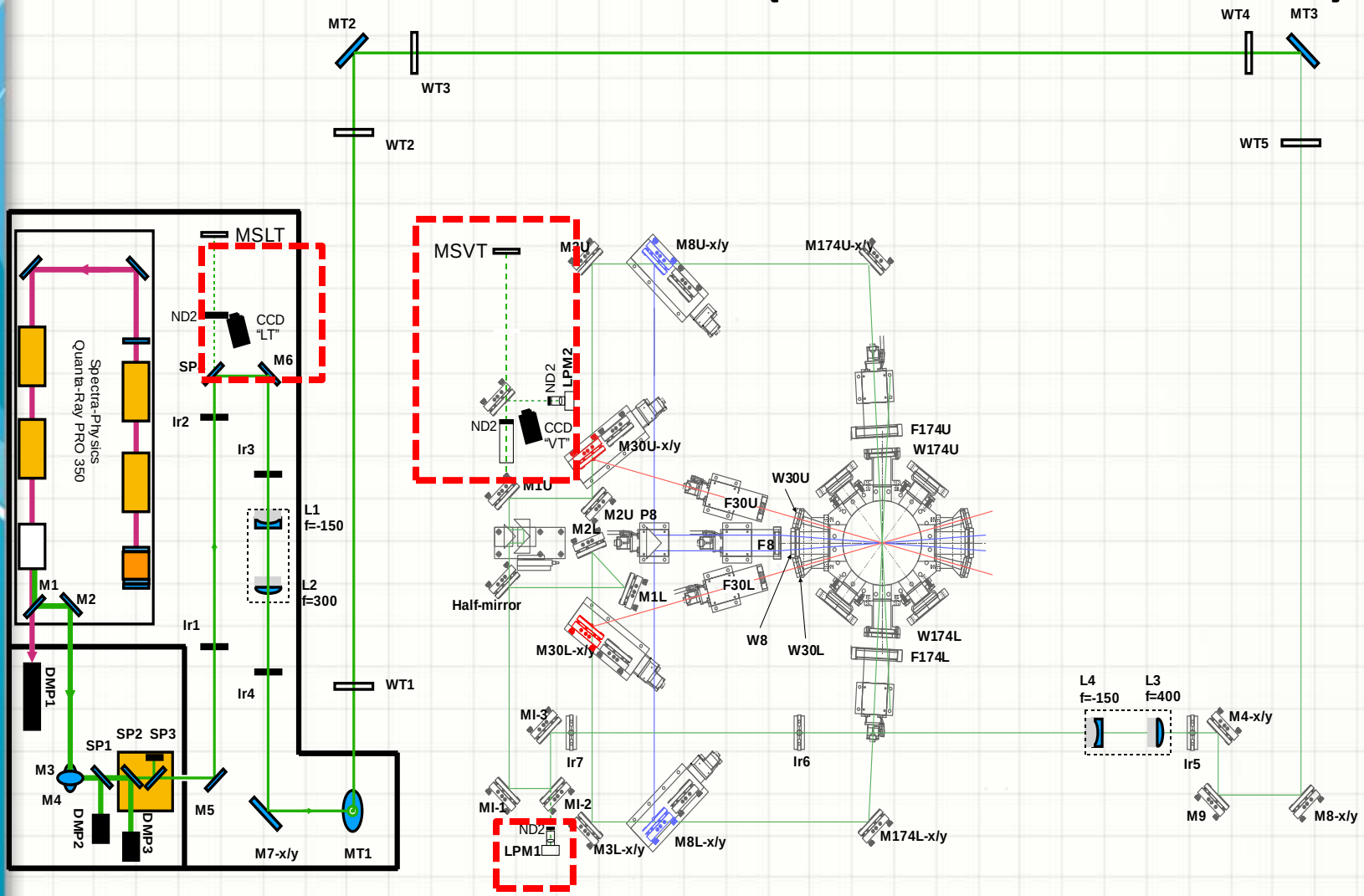
Change in input beam angle (left-hand side in the Vtable plane) leads to:

- Opposite laser beams displacement
- i.e. increasing of the crossing angle
- i.e. shifting of the IP
- i.e. changing of the delay between upper and lower path

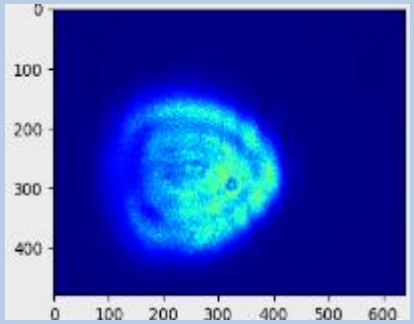
Improvements since 2020

- Laser table support
  - Partially rebuilt
  - Insulated (better temp.- & vibro- insulation)
- Laser table enclosure
  - Totally rebuilt (better temp.- & vibro- insulation)
- Laser transport line: MT2, MT3
  - Total rebuilt (fixed mirror holders, solid frame)
- Expander-reducer
  - A new alignment procedure is established (back-reflectors, Shearing interferometer)
  - Expansion/reduction factors were optimized
- Vtable input periscope: M4, M8, M9
  - Mirror support was totally rebuilt
- Vtable
  - Solid laser beam references
  - New alignment protocol (back-reflectors)
  - Laser position sensors
  - Laser profile CCD camera

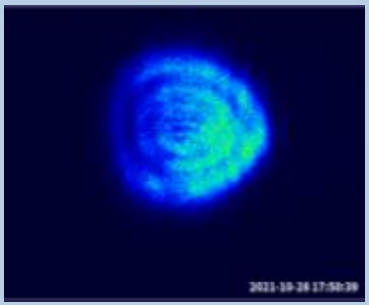
IP-BSM overview (recent details)



Laser beam profile

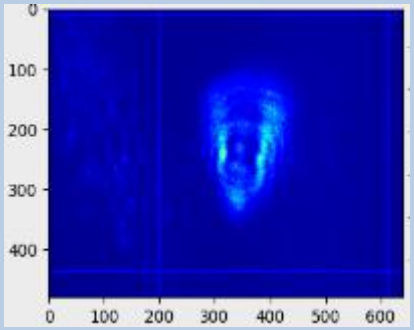


Laser hut

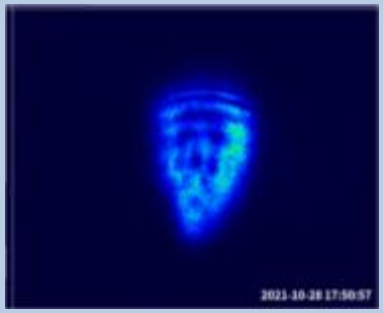


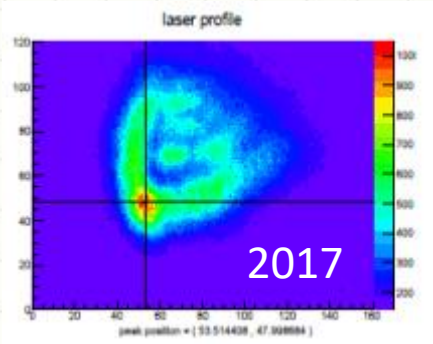
21 June 2021

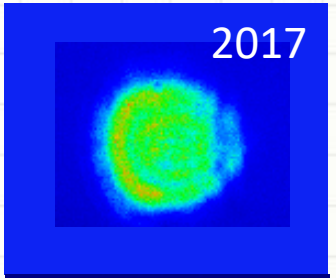
29 October 2021

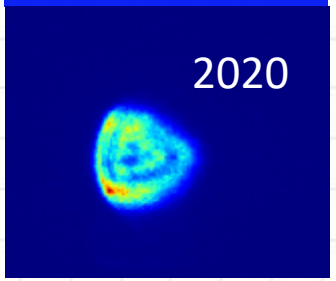


Vertical table





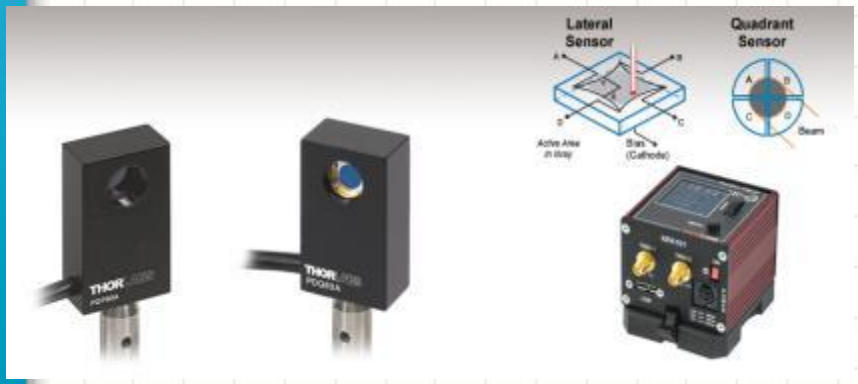




Profile was not the same time to time

Laser beam position sensors

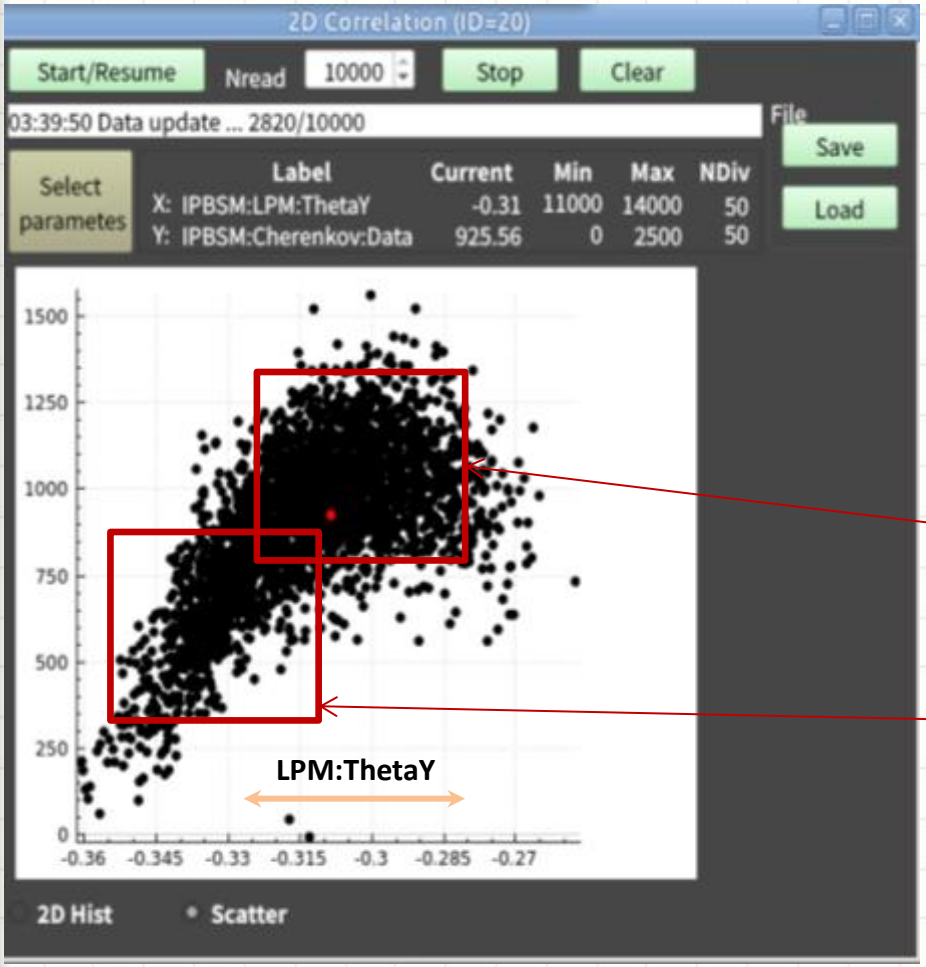
- Introduction of the Lateral Effect Position Sensors.
- Monitor shot-by-shot angular jitter at Vtable:
  - PDP90A + KPA101
  - Long cables -> CAMAC ADC
- Correlation was found
- Software event filter under the test



- Signals X,Y depends on laser beam position and laser intensity.
- Signals SUM depends only on intensity.
- Signal outputs:
  - X1,Y1,SUM1; X2,Y2,SUM2
- Calculated values:
  - $X_i norm = X_i/SUM_i$
  - $Y_i norm = Y_i/SUM_i$
  - $ThetaX = X_2 norm - X_1 norm$
  - $ThetaY = Y_2 norm - Y_1 norm$

Laser beam jitter effect

February 2022 (before LTL upgrade)



Cherenkov signal

- A clear correlation of Cherenkov signal with ThetaY was found.
- At the same time there is no correlation with ThetaX and X_i

Now both the tail and the peak spread become significantly smaller due to LTL upgrade

Stability measurements summary

This data measured with CCD cameras

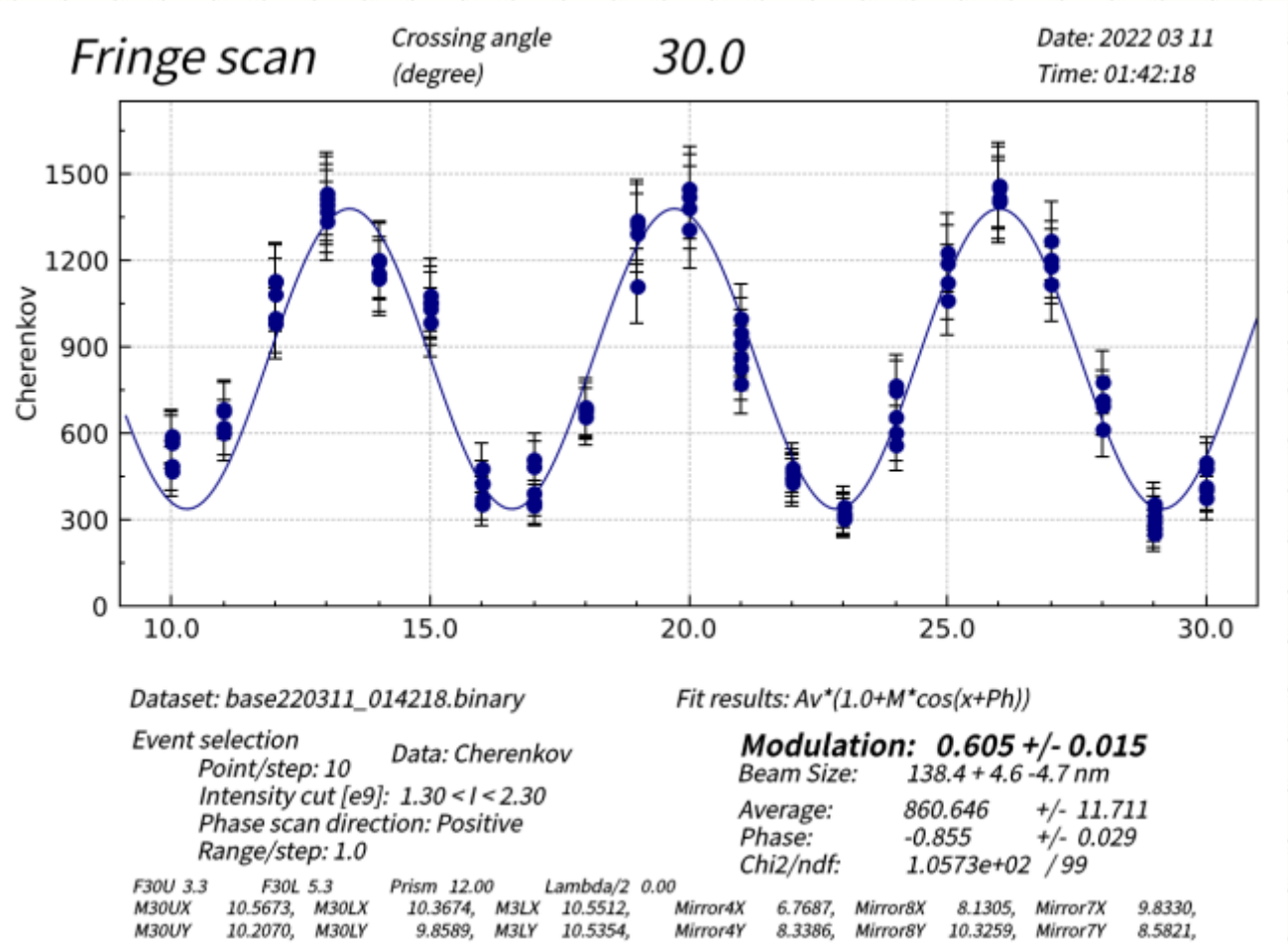
Parameter	June 2020	21 June 2021	25 June 2021	29 Oct. 2021
RMS Pointing stability, um @ laser table	H 39.1 / 7.8 V 29.2 / 7.3	H 26.7 / 4.1 V 20.0 / 3.5	H 22.8 / 1.1 V 25.8 / 2.3	H 13.2 / 0.31 V 14.3 / 0.54
Beam width stability, um @ laser table	H 2801 / 9.3 V 3179 / 9.0	H 3041 / 10.2 V 3322 / 14.4	H 2968 / 4.28 V 3291 / 15.7	H 2705 / 9.3 V 3075 / 9.0
RMS Pointing stability, um @ vertical table	H 69.1 / 13.0 V 63.3 / 10.2	H 37.6 / 3.9 V 86.6 / 9.4	H 49.0 / 4.7 V 78.8 / 9.2	H 34.4 / 1.27 V 50.2 / 4.24
Beam width stability, um @ vertical table	H 2948 / 33.8 V 3134 / 39.8	H 2273 / 21.8 V 3003 / 23.2	H 2087 / 21.0 V 2639 / 29.0	H 2174 / 21.8 V 3016 / 23.2

- Almost 2 times stability improvement is observed
- A new alignment protocol is under development

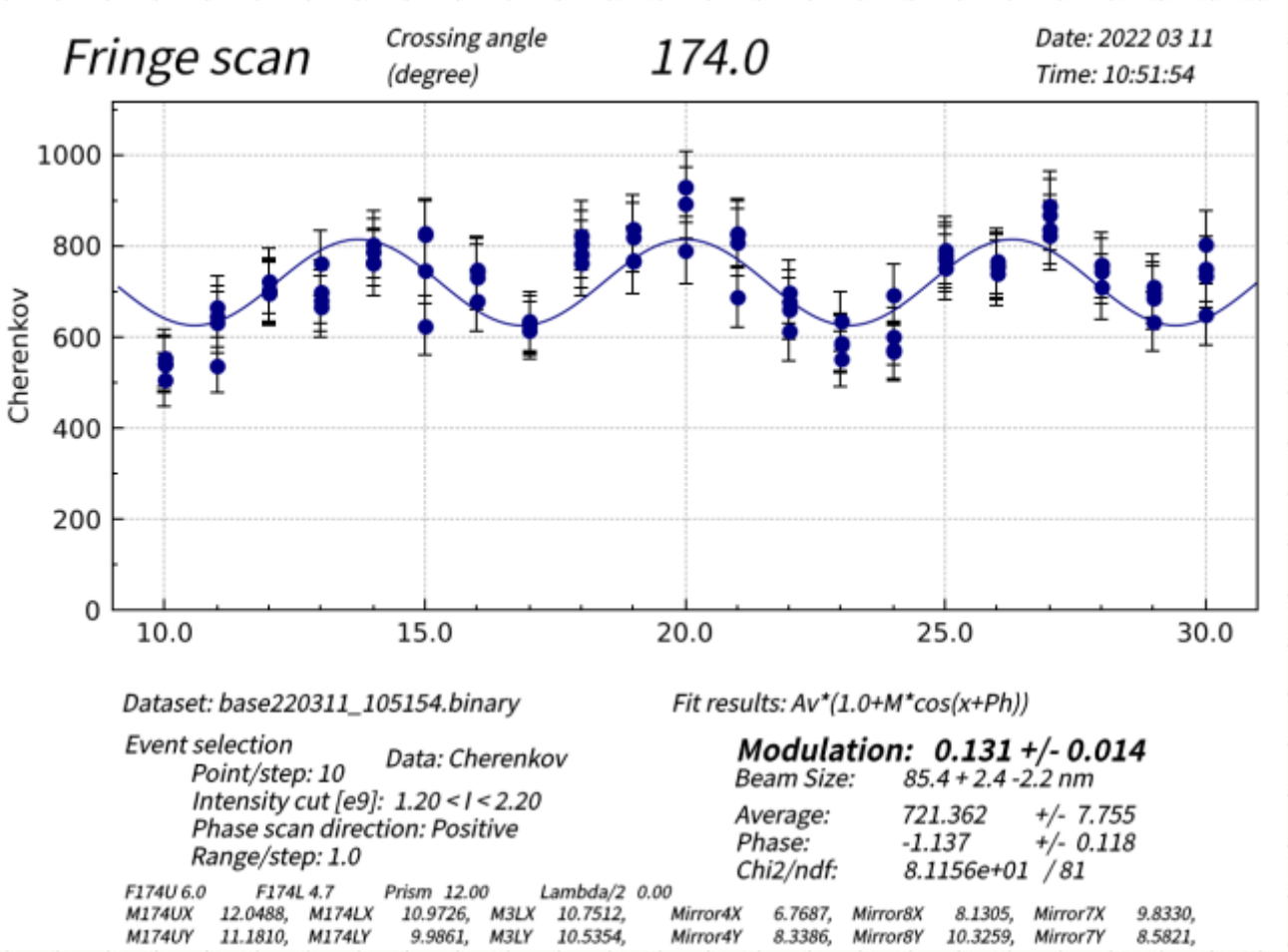
Stability measurements with LPMs

	Absolute angle, arb.units	rms spread
LPM2	**Ynorm**	**ΔYnorm**
Before LTL upgrd	0.030	0.002
After LTL upgrd	0.020	0.002
Laser table insul.	0.0217	0.0004
Laser hut insul.	0.0251	0.0001
MT8 support load	0.0244	0.0011

Typical 30deg. fringe scan



Typical 174 deg. fringe scan



What we will do next

- Energy stability:
  - Pulse-by-pulse normalization will be improved.
- Pointing stability:
  - Studied, understood, improved.
  - mid- and long-term (hours and days) can be corrected by mirrors.
  - On-line position monitoring is established.
  - Simulation of the laser beam propagation to IP still pending.
- LTL and FF tuning
  - New protocol is established
  - Global realignment was done (next week it will be verified with e-beam).
- Laser Mode stability:
  - Laser tuning and thermal stabilization.
- Fringe stability:
  - Will be improved via laser beam jitter reduction.


Thank you for your attention