Profile monitors, Injection Matching monitor, BSRT & BSRA

Stephane Bart Pedersen, Andrea Boccardi, Enrico Bravin, Gerard Burtin, Stephane Burger, Bernd Dehning, Jonathan Emery, Alan Fisher, Ana Guerrero, Jan Koopman, ***Thibaut Lefevre***, Aurelie Rabiller, Federico Roncarolo

LHC OP days - 19th of January 2010 – Evian

Outline

- **BTV**
  - Performances of the system
  - Dump lines / BTVDD
- **Injection Matching Monitor**
  - Fast camera on BTVM
  - Availability / Mode of operation / Experience from SPS
- **Synchrotron Light : BSRT / BSRA**
  - Performances obtained last year
  - What to expect for higher beam energies
  - Automatic operation with pre-defined table
  - BSRT Matching Monitor

LHC/BTV performance

LHC BTV Camera infos

CCD SANYO	All BTVs except ↓	
CIDTEC 8726-DX3 (3Mrads)		**BTVST.A4L2.B1, BTVSI.A5L2.B1, BTVST.A4R8.B2, BTVSI.A5R8.B2**
CIDTEC 8712-DM (1Mrads)		**BTVD.683458.B1, BTVD.623458.B2, BTSE.A4L6.B1, BTVSE.A4R6.B2**
SIRA (5Mrads)		**BTVDD.689339.B1, BTVDD.629339.B2 (camera permanently on !)**

Sensitivity RAD camera ~ 10x lower compared to CCDs

Optimized measurement with BTV system

NO LIGHTS or Background Substraction or Both

If saturation (flag on the application)

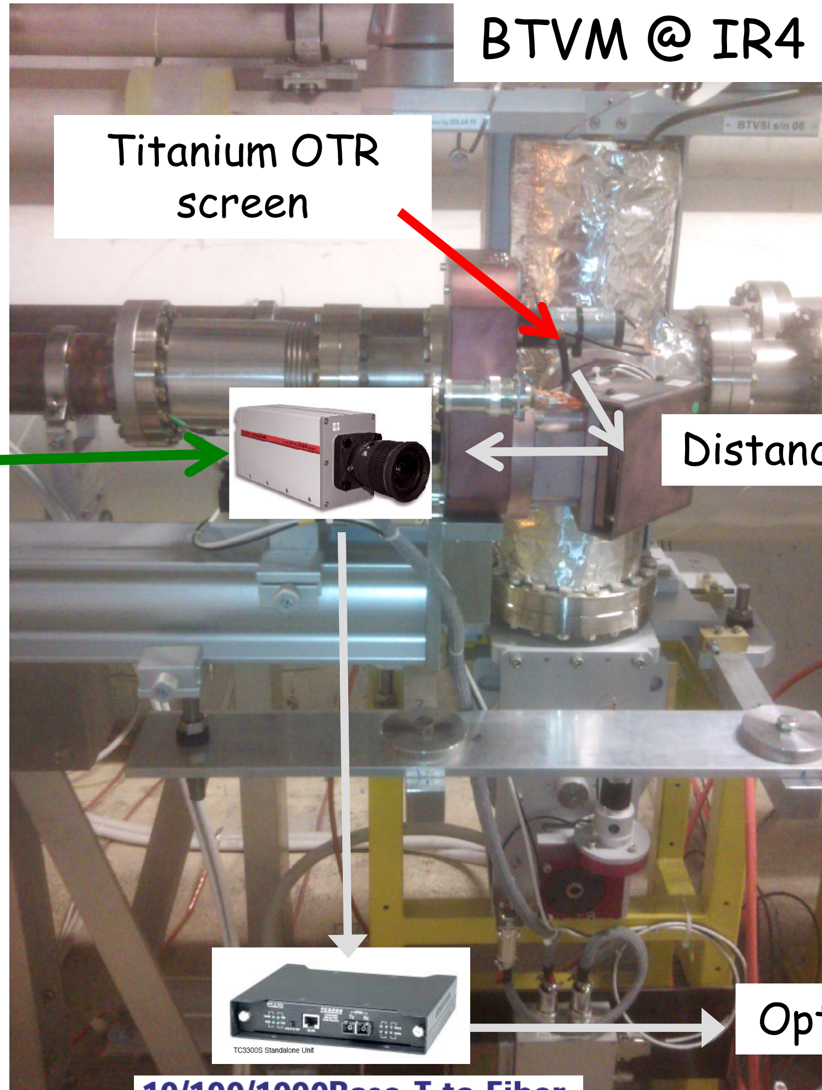
1/ Reduce gain
2/ Use filters
3/ Change screen

What can we expect to see

Using the CCD camera	Al2O3	->	all beams (saturation!)
	OTR	->	all beams
Using the CIDTEC camera	Al2O3	->	all beams (saturation?)
	OTR	->	beams above a few 10^{10} p

Courtesy of S.Burger

Injection Matching monitor

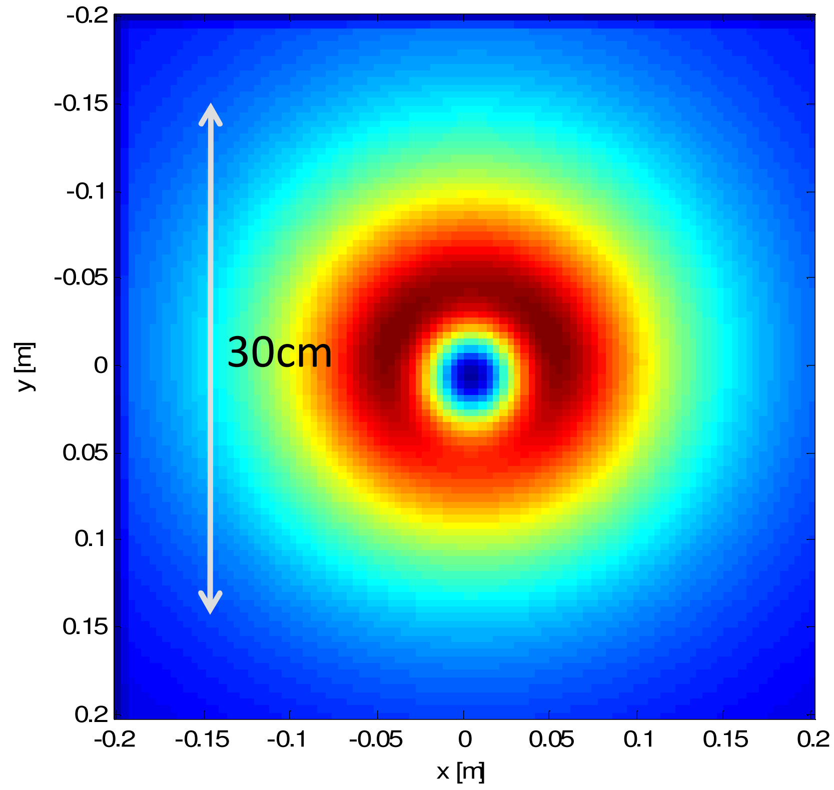


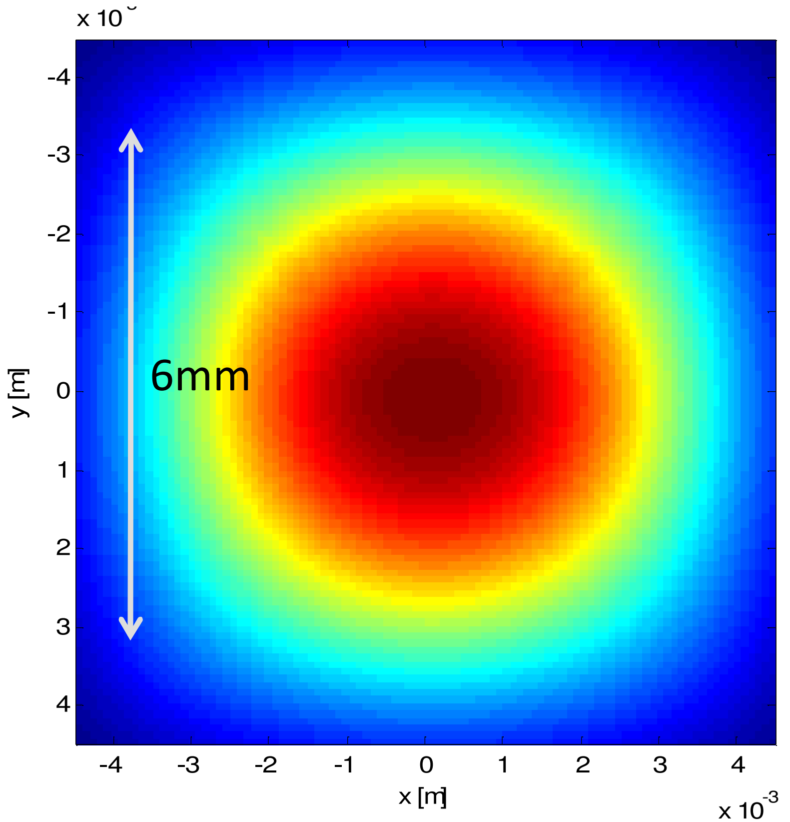
Injection Matching monitor

- Worked on the SPS with 1E11 protons @ 26GeV

- **@450 GeV on the BTVM, the system should work with 1E10 protons**

(Factor 2 more for the increase in Beam Energy (~ ln(γ)), Factor 10 more from the angular divergence (1/γ) and Factor 2 less from the reflectivity of the screen)



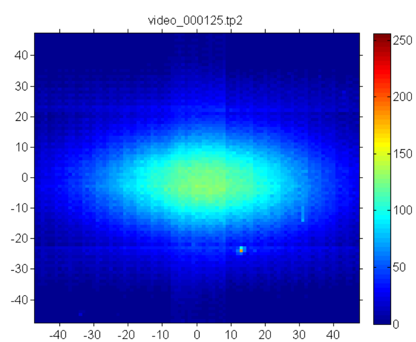


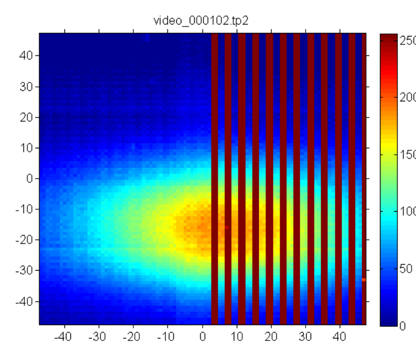
Injection Matching monitor

Frame Rates	Pixels
1000Fps	1504 x 1128
2000 fps	1056 x 792
5000 fps	640 x 480
10'000 fps	**416 x 320**
20'000 fps	**256 x 192**
30'000 fps	192 x 152
50'000 fps	96 x 72

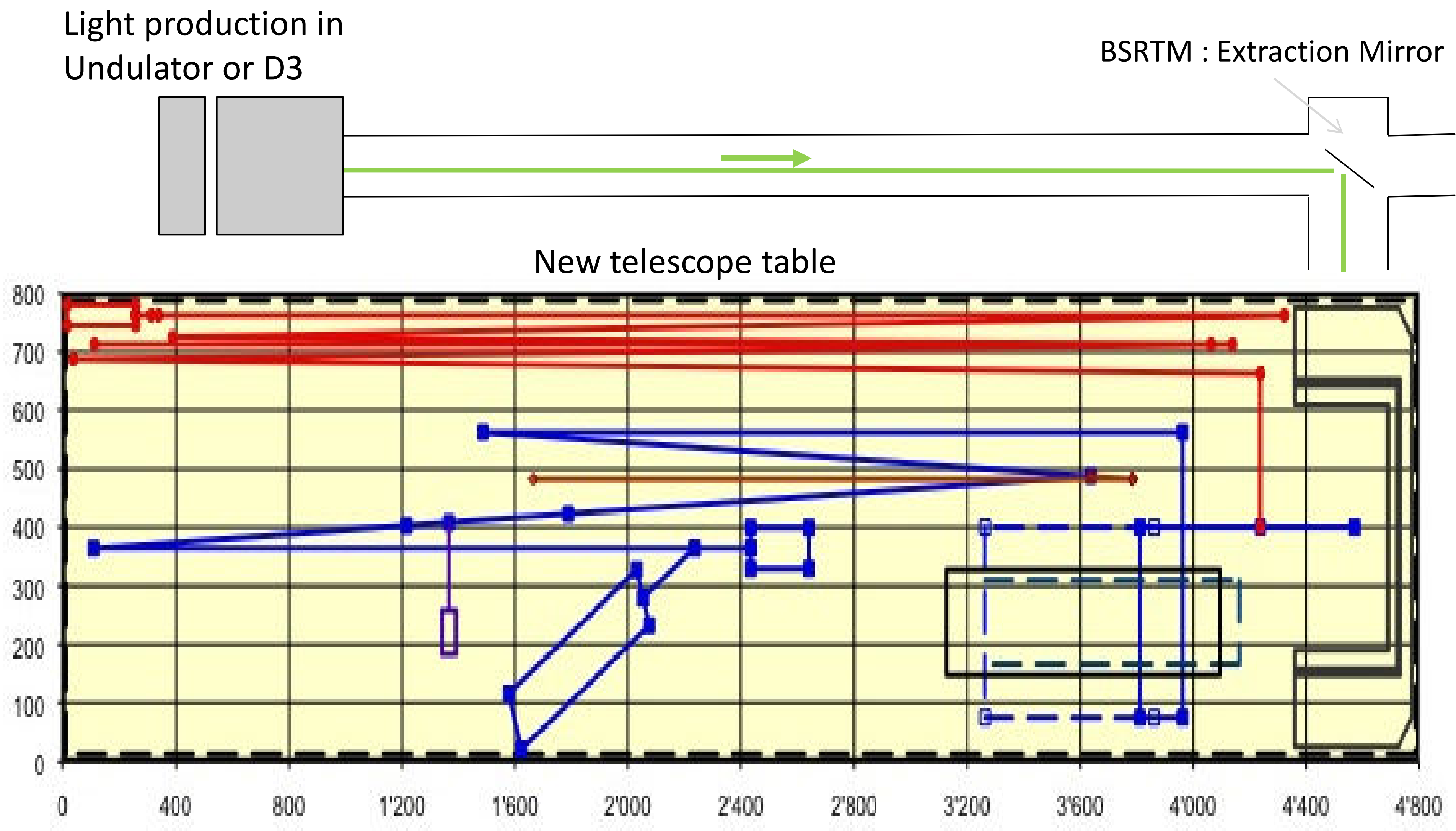
- Camera not Radiation hard and relatively expensive (70kCHF): Available on demand and Require an 2hours access to the tunnel to be installed

- During tests on the SPS, the camera was perturbed (radiation) and required to be reset from time to time



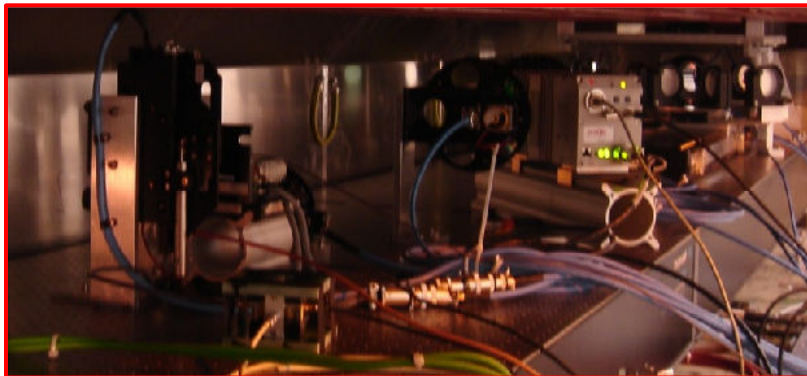


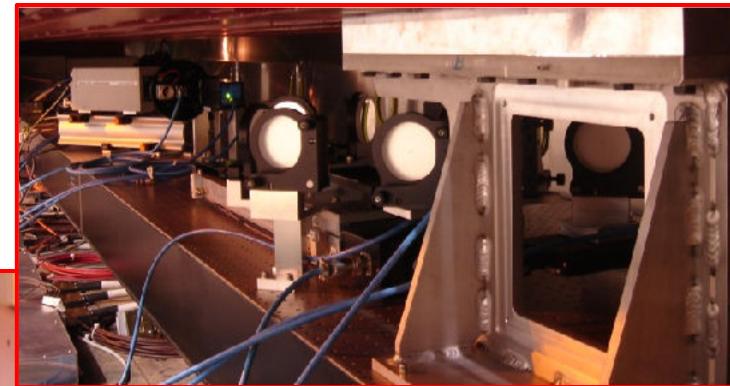
Synchrotron Light monitor: BSR

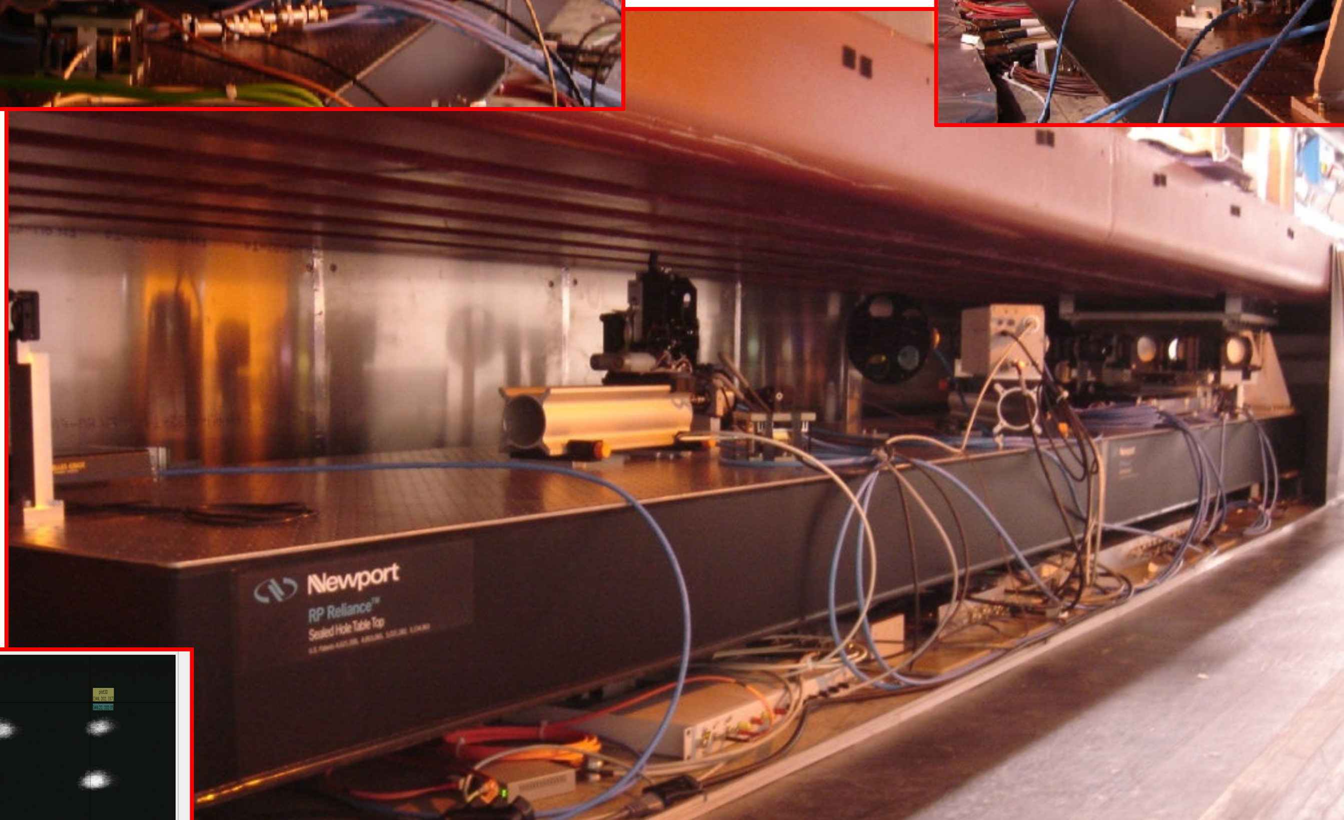


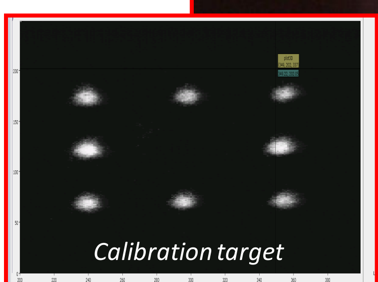
Light source tracking system, Imaging system, Slow and Fast cameras, Abort Gap monitor, Calibration line

Synchrotron Light monitor: BSR







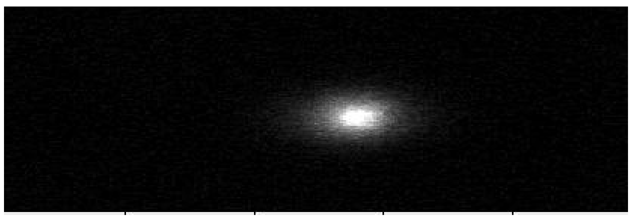


Calibration target

Performances BSRT/BSRA : run 2009

Both systems have been tested and worked well on both beams

- Mechanical & Optical alignments are almost perfect
- Slow Cameras and Abort Gap monitors worked as expected
- Measured light intensities agree within 10-20% compared to expectations



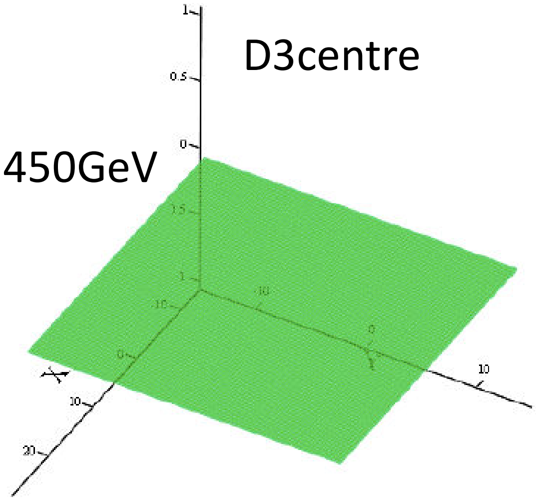
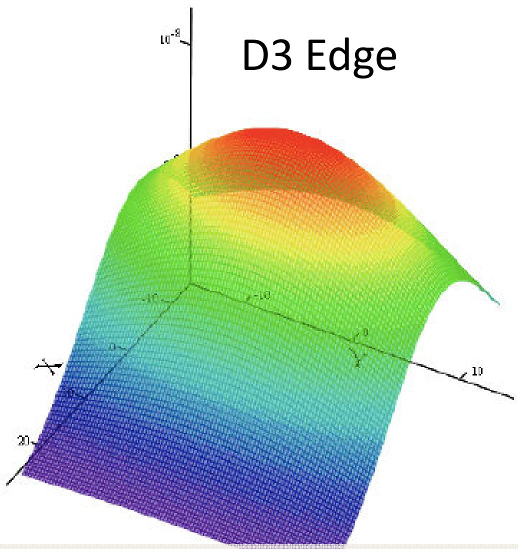
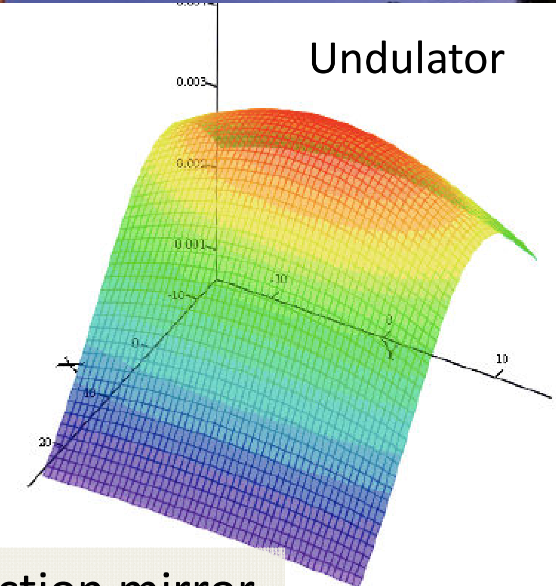
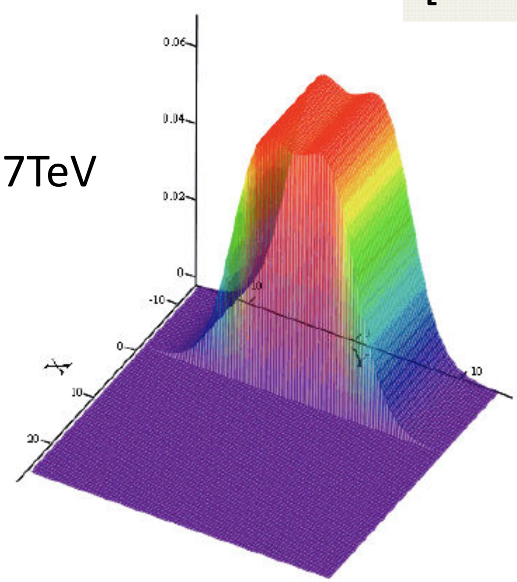
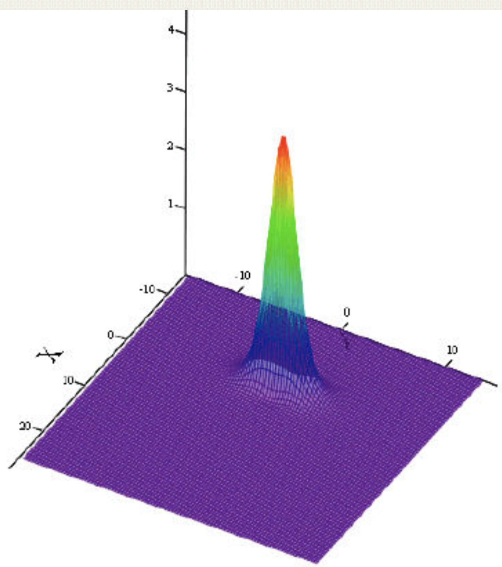
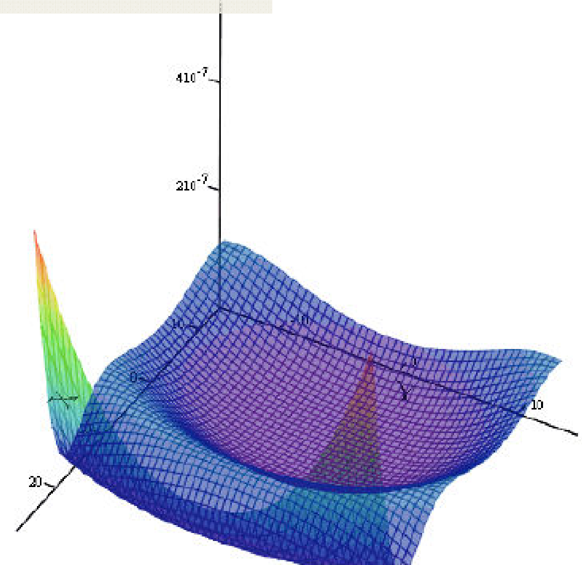
Beam 2 – 4 bunches - @450GeV (voltage 1000volts – OD1)
Undulator on @ 400A (nominal 450A - >20% more photons)

Beam 1 – 4 bunches - @1.18TeV (voltage 1500volts – OD0)
Undulator off

5E9 protons bunch seen by the BSRA
@450GeV – Undulator on @400A – HV@2550 volts – Gain 7E3
@1.18TeV – Undulator off – HV@2990 Volts – Gain 2E5

Maximum gain @ 3350 Volts (Gain1E6)
- Sensitivity x140 ~ 3E7 protons@ 450GeV
- Sensitivity x5 ~ 1E9 protons@ 1.18TeV

Estimates of Light intensities

	D3centre	D3 Edge	Undulator
450GeV			
7TeV			

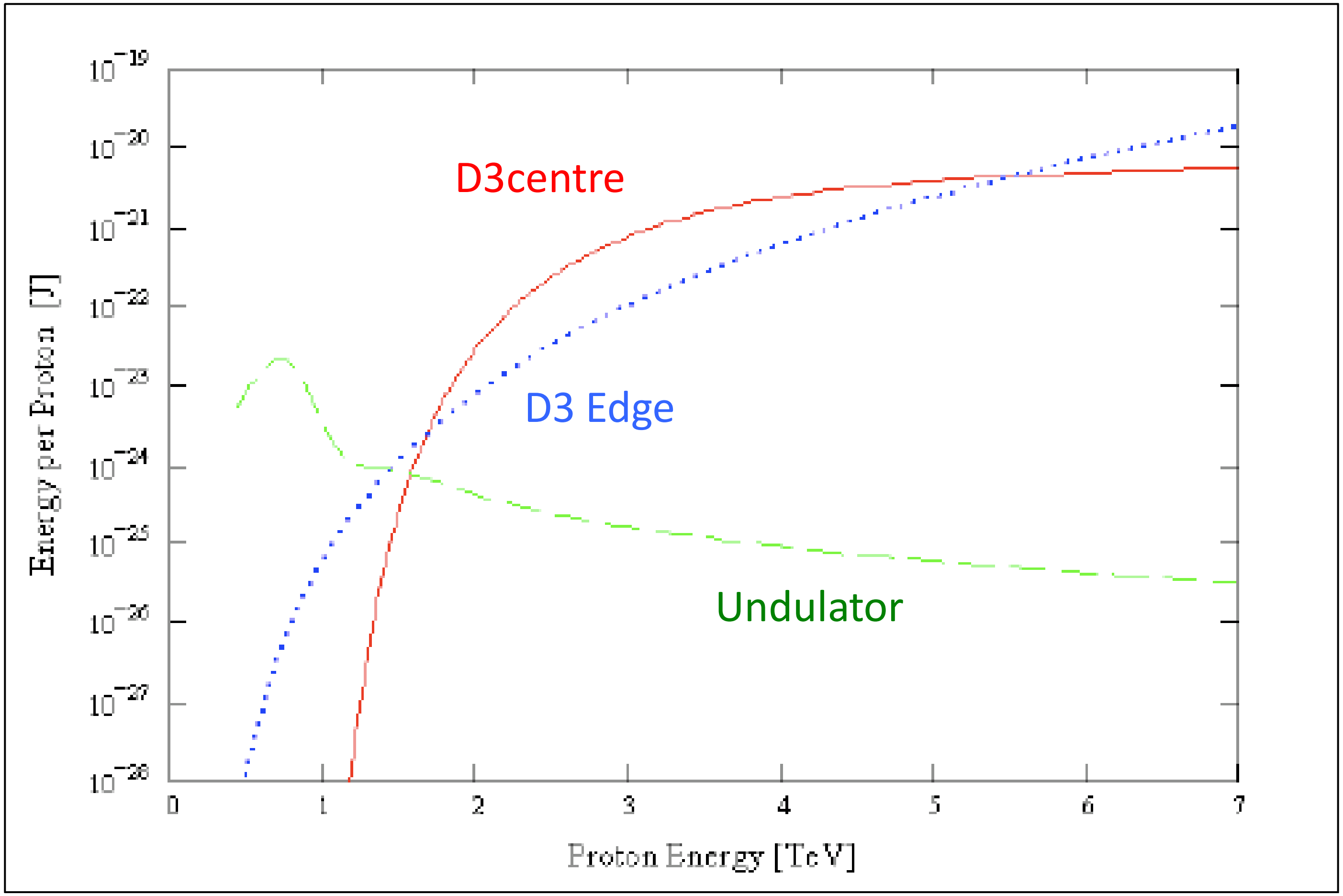
[200,900]nm Radiation on the extraction mirror

Courtesy of A. Fisher

Need the undulator 'on' for low beam energies

Estimates of Light intensities

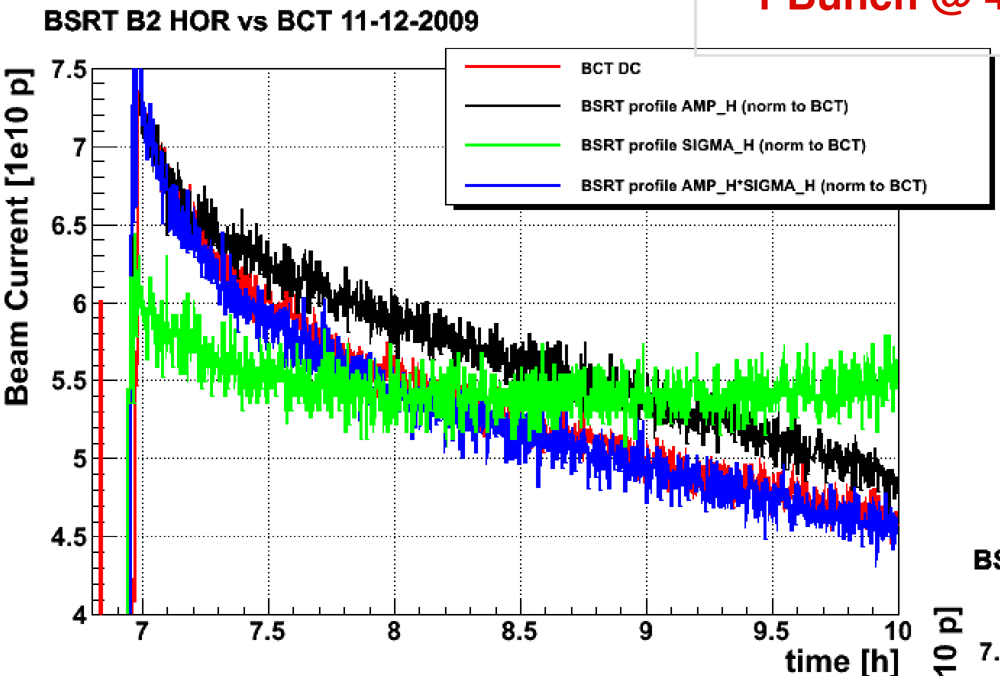
Radiated energy per proton collected by the extraction mirror –[200 – 900] nm.



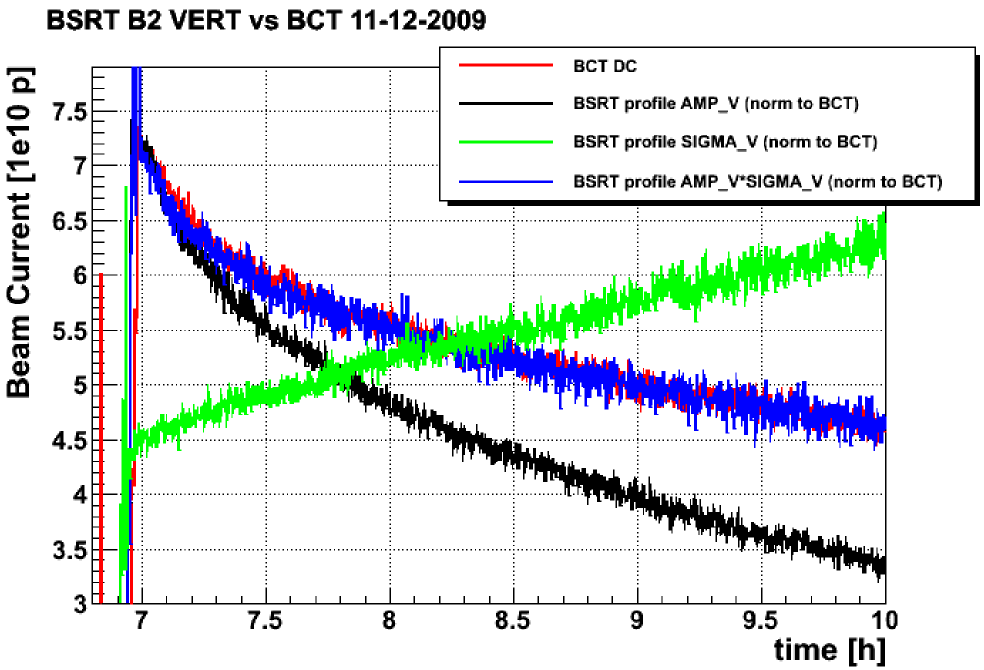
Courtesy of A. Fisher

BSRT compared to BCT

1 Bunch @ 450 GeV



HORIZONTAL
Sigma (green) rather cosntant, but
sigma*ampl (BLUE) tracks very well BCT (RED)



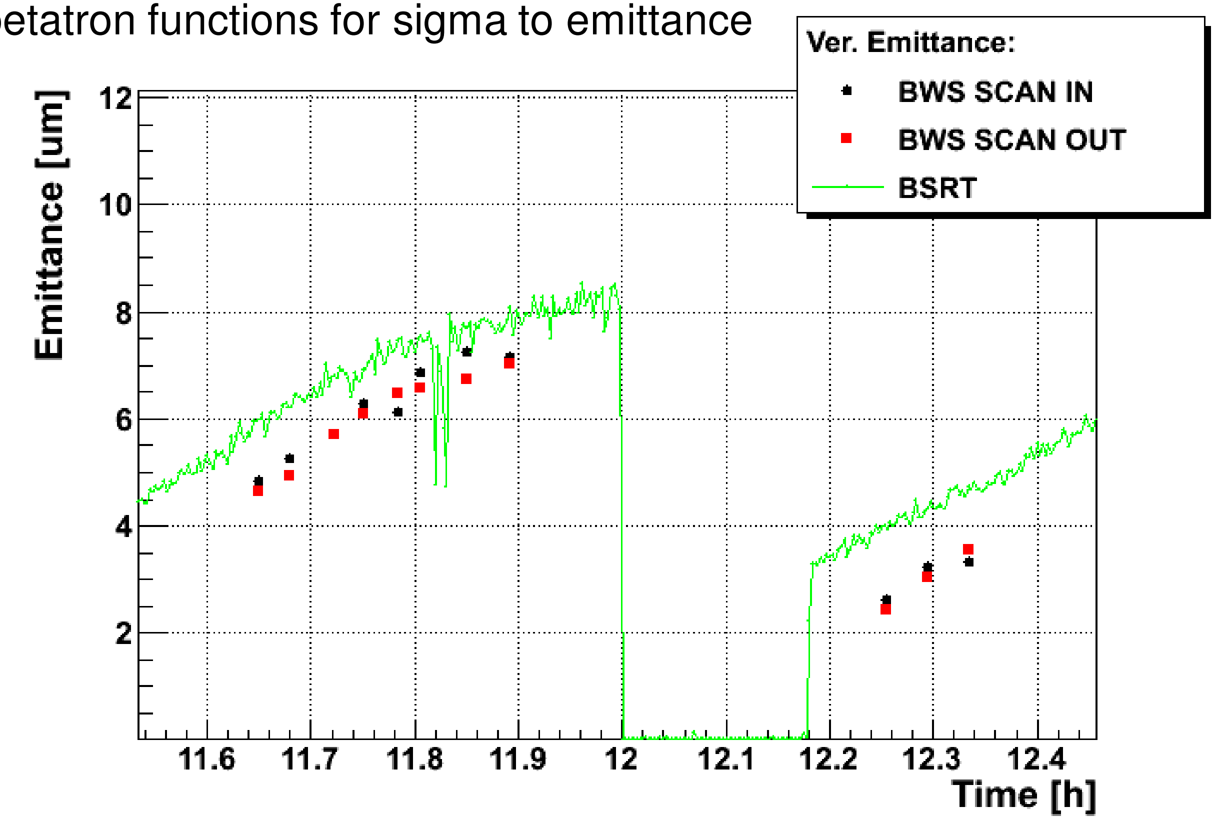
VERTICAL
Sigma blow-up (green) but sigma*ampl
(BLUE) tracks very well BCT (RED)

Courtesy of F. Roncarolo

BSRT compared to Wire Scanner

16 Dec 09, 450 GeV 1 bunch, Beam 2 : Normalized emittance as measured by WS and BSRT

-Using nominal betatron functions for sigma to emittance



- Excellent agreement in terms of emittance variation during the fill
- ~20 % systematic difference on normalized emittance

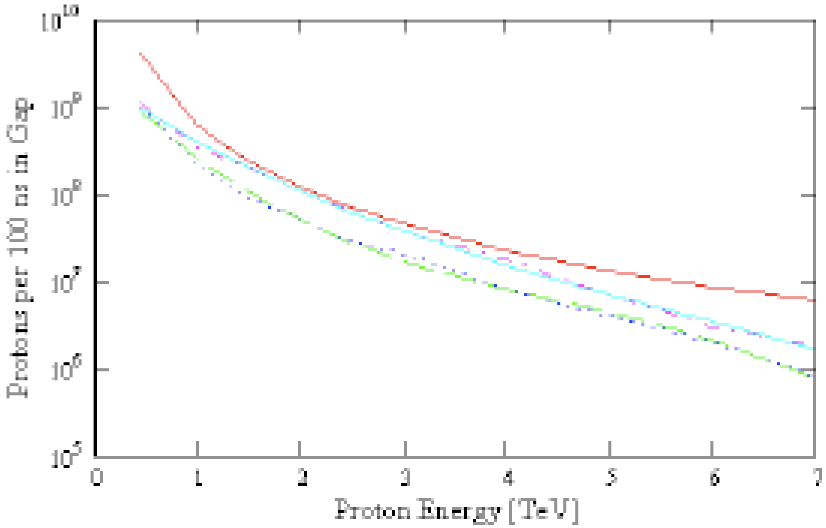
Source of uncertainty:

-Beta functions
-WS calibration
-WS and BSRT fitting to be checked
-BSRT optics uncertainties (aberration, PSF, etc...)
-BSRT proper settings (gains, filters, attenuators)

Courtesy of F. Roncarolo

Automatic Operation with pre-defined tables

BSRA works with the highest possible signal to noise ratio, we would change the PMT HV with beam energies

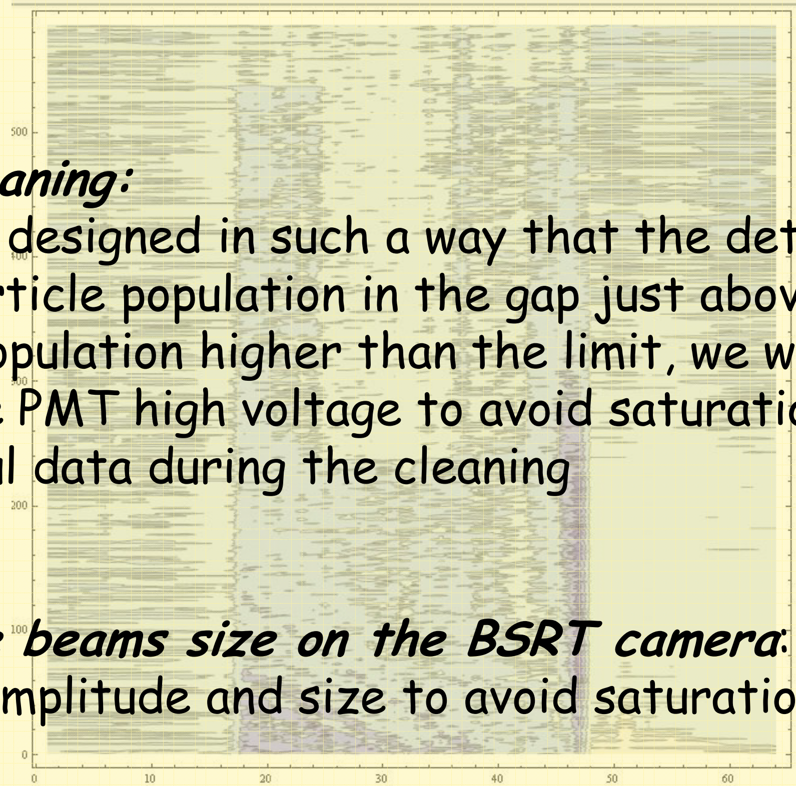


Energy [TeV]	PMT voltage [V]	Quench limit [p / 100ns]	Total intensity [pC / 100ns]
0.45	2883	1.10E+09	60.00
1.00	3351	3.00E+08	12.28
1.50	3351	1.00E+08	20.65
2.00	2891	8.00E+07	60.00
2.50	2666	5.00E+07	60.00
3.00	2600	3.00E+07	60.00
3.50	2587	1.20E+07	60.00
4.00	2580	9.00E+06	60.00
5.00	2619	5.00E+06	60.00
6.00	2668	2.00E+06	60.00
7.00	2656	1.10E+06	60.00

Following changes in beam current and beam energy, the light intensity sent to the cameras (two filters wheel and gain-integration of the intensified camera), the focalisation (2 motors) and the position/aperture of the slits (2 motors) must be adjusted in order to provide optimum performances

Operation with Feedback

In addition to the automatic operation using pre-calibrated table in MCS/LSA, There will be a need to add a feedback on both BSRA & BSRT to avoid saturation and provide useful/relevant data sets under any beam conditions



- ***Abort Gap cleaning:***
  The system is designed in such a way that the detector would saturate for particle population in the gap just above the limit
  For protons population higher than the limit, we would have to feedback on the PMT high voltage to avoid saturation and continue to provide useful data during the cleaning

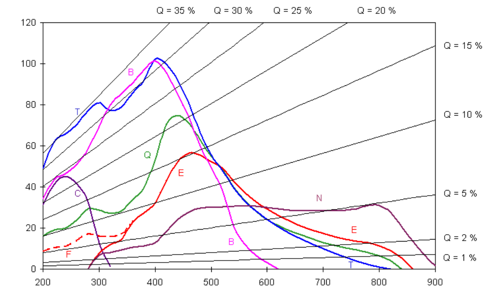
- ***Change of the beams size on the BSRT camera***: a feedback on the H&V beam amplitude and size to avoid saturation or weak pictures

Matching monitor with BSRT

HG

HIGH SPEED HIGH-G 100K/LE

Sensor design:	0,35 µm
Pixel size:	12 x 12 µm
Fill factor:	45%
Dynamic range:	60+ dB



Fast Image intensifier
Bialkali Photocathode (B) with a P47 phosphor

- Fast Camera installed permanently in the BSR telescope for turn by turn profile measurements (to be commissioned)

- Need to be intensified (optical fiber coupling under realization at the moment) in order to be sensitive to 1E10-1E11 protons @ injection energy

- In addition, the intensifier is gated and can provide bunch by bunch images

Conclusions

- **BTVs and Wire scanners** works quite reliably – still few bugs to be fixed

- **Matching monitor** as an 'on-demand' device for MD's
  - Ready to try on the BTVM
  - Implemented permanently on the BSRT hopefully later during the year

- **Synchrotron Light Monitors**
  - Systems worked basically as designed - Need the Undulator 'on'

    Deeper analysis of performances on going

  - Cross calibration with respect to Fast BCTs and Wire scanners
    - Spatial Resolution will decrease for higher beam energies – Cross check with Wire Scanners and optimization will take some time.

    - Detection threshold and operational table must be carefully extracted for several beam energy (to confirm predictions)

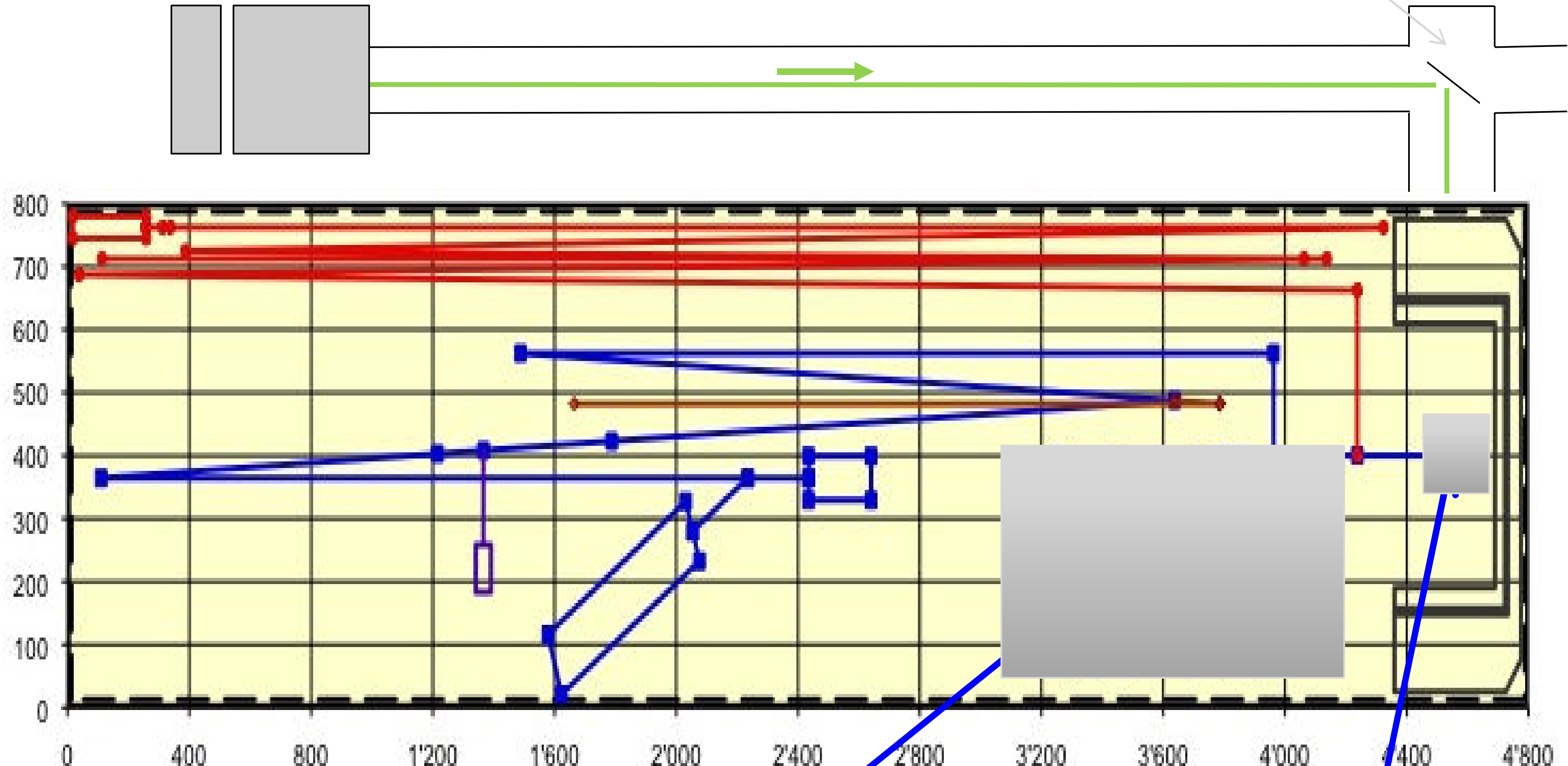
  - **Plans for this year**: Automatic Operation, Feedback, turn by turn and bunch by bunch measurements, test on a Longitudinal Density Monitor (50ps time resolution)


Thanks for your attention

Source Tracking System

Light production in
Undulator or D3

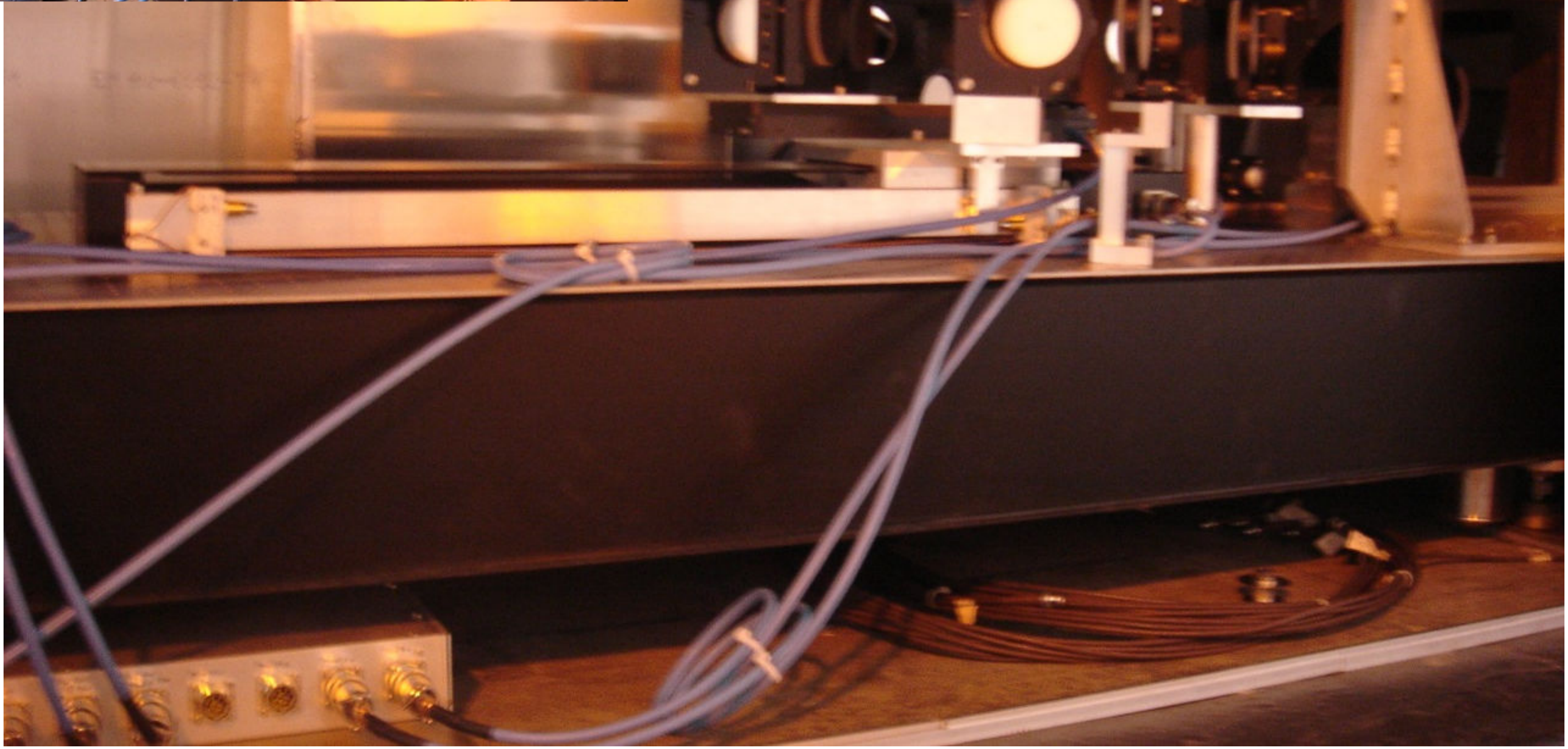
BSRTM : Extraction Mirror



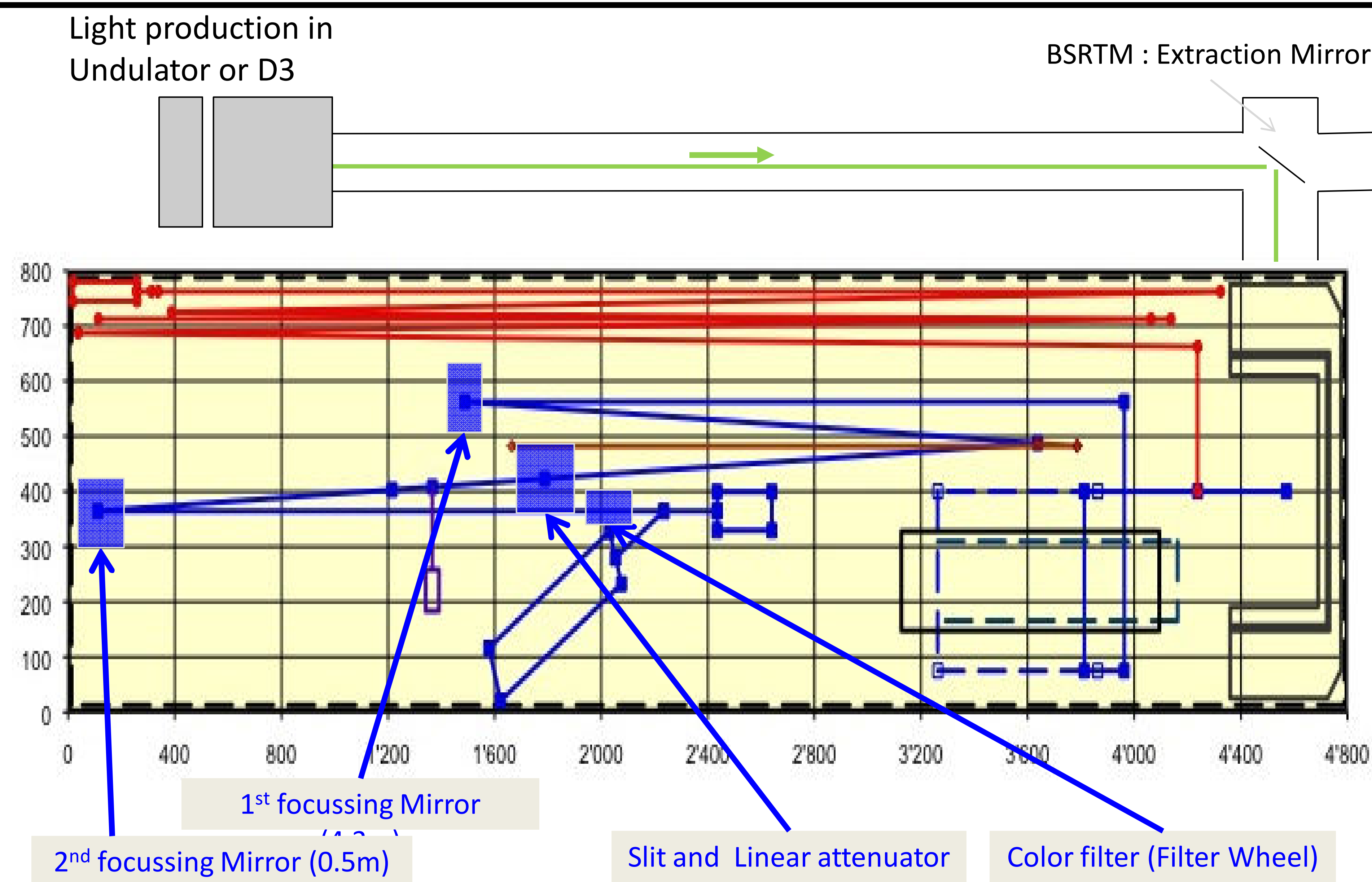
Two Translation stages (60cm & 15cm long) and 8 mirrors to control the position of the object plane over a distance bigger than 2.5 m

Control of H & V tilt angles of 1st mirror

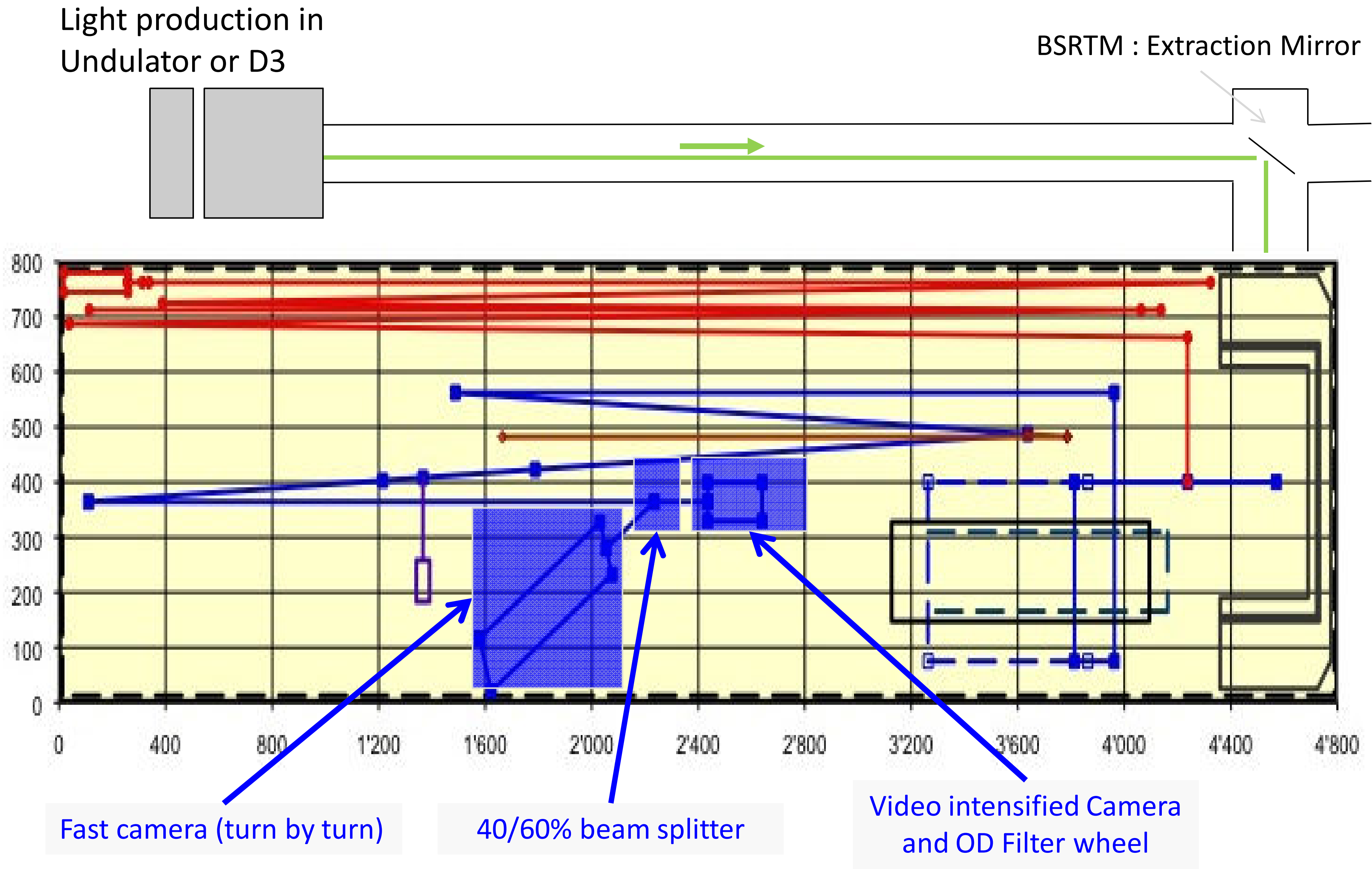
Source Tracking System



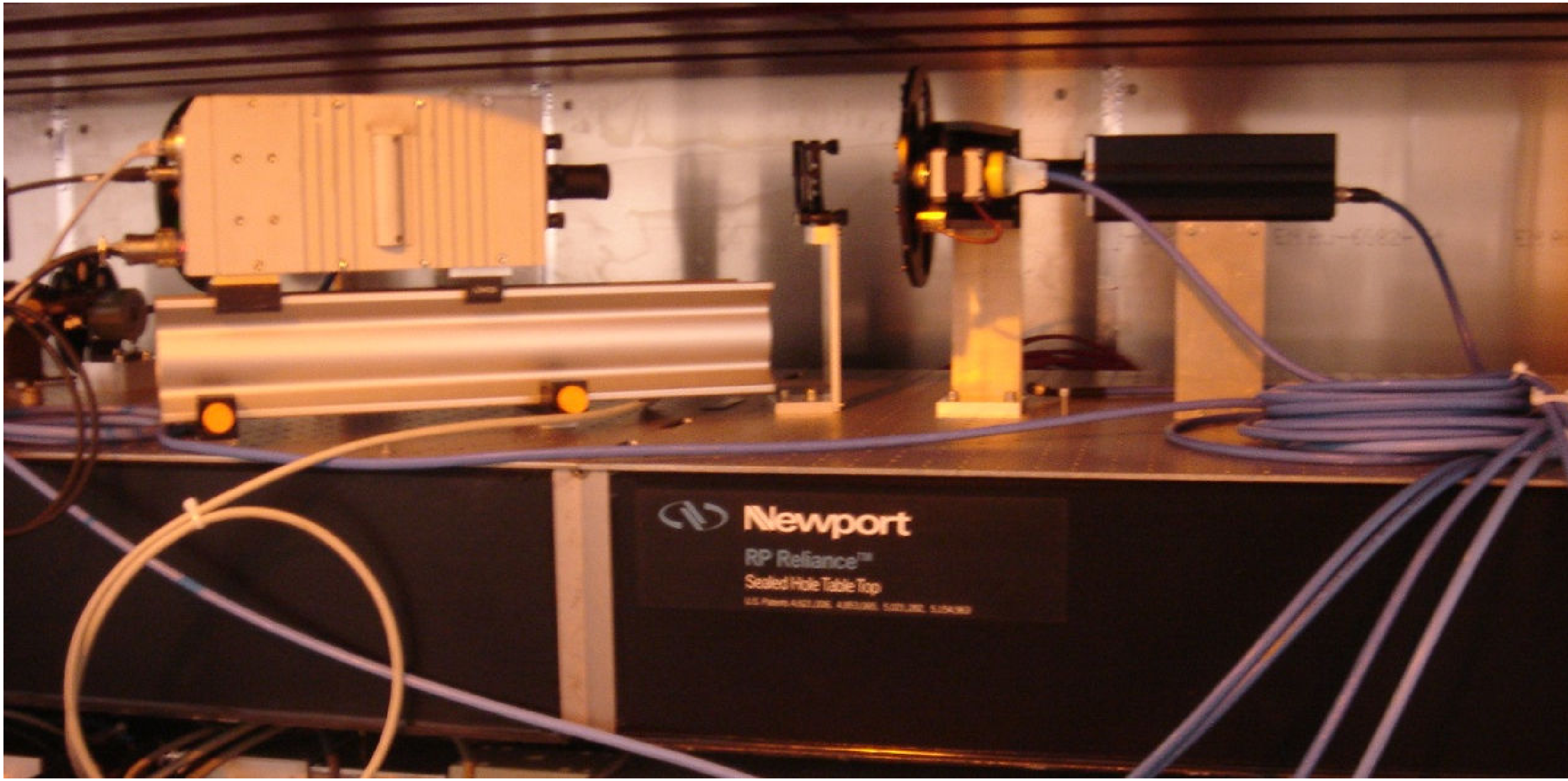
Imaging system



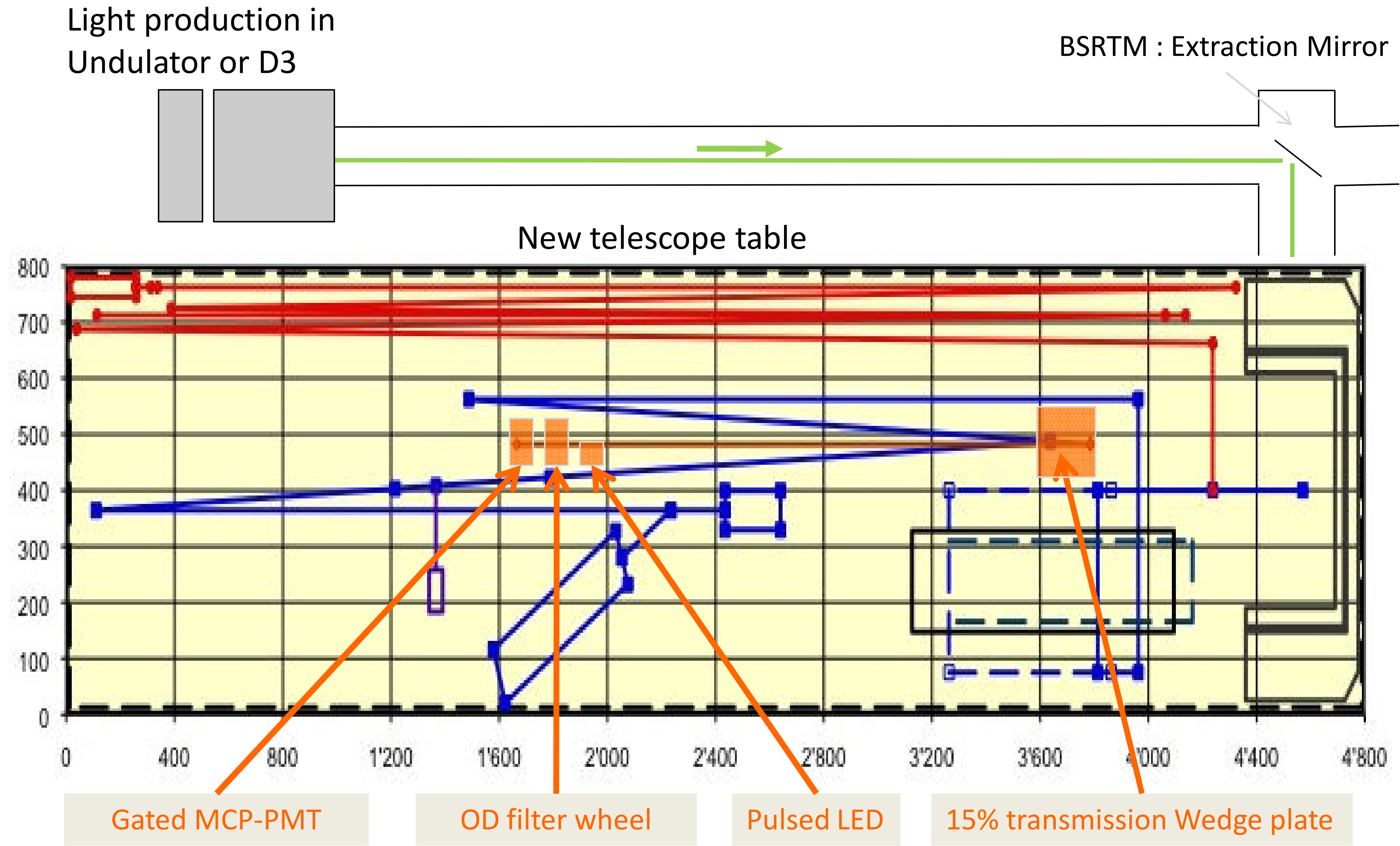
Slow and Fast Cameras



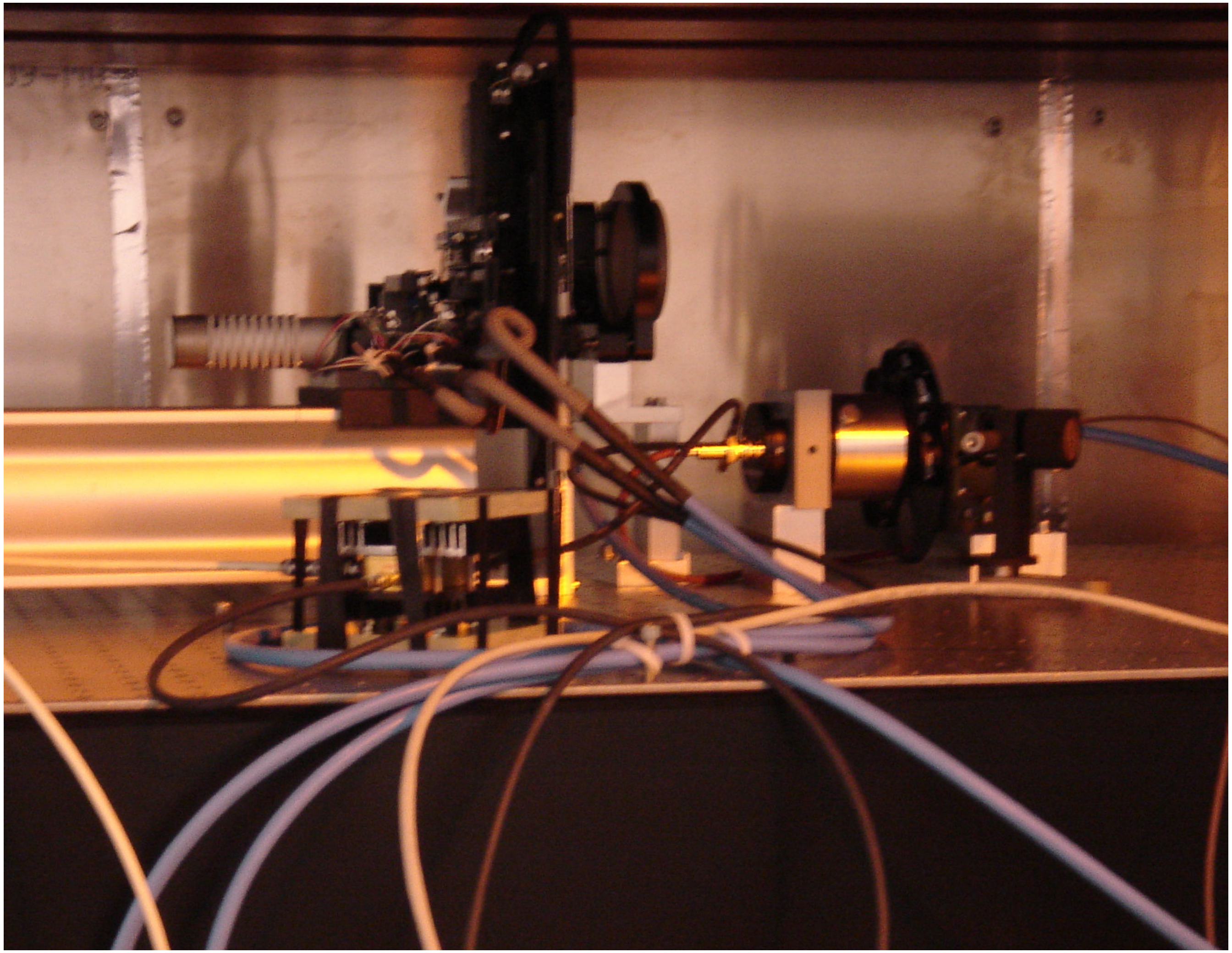
Slow and Fast Cameras



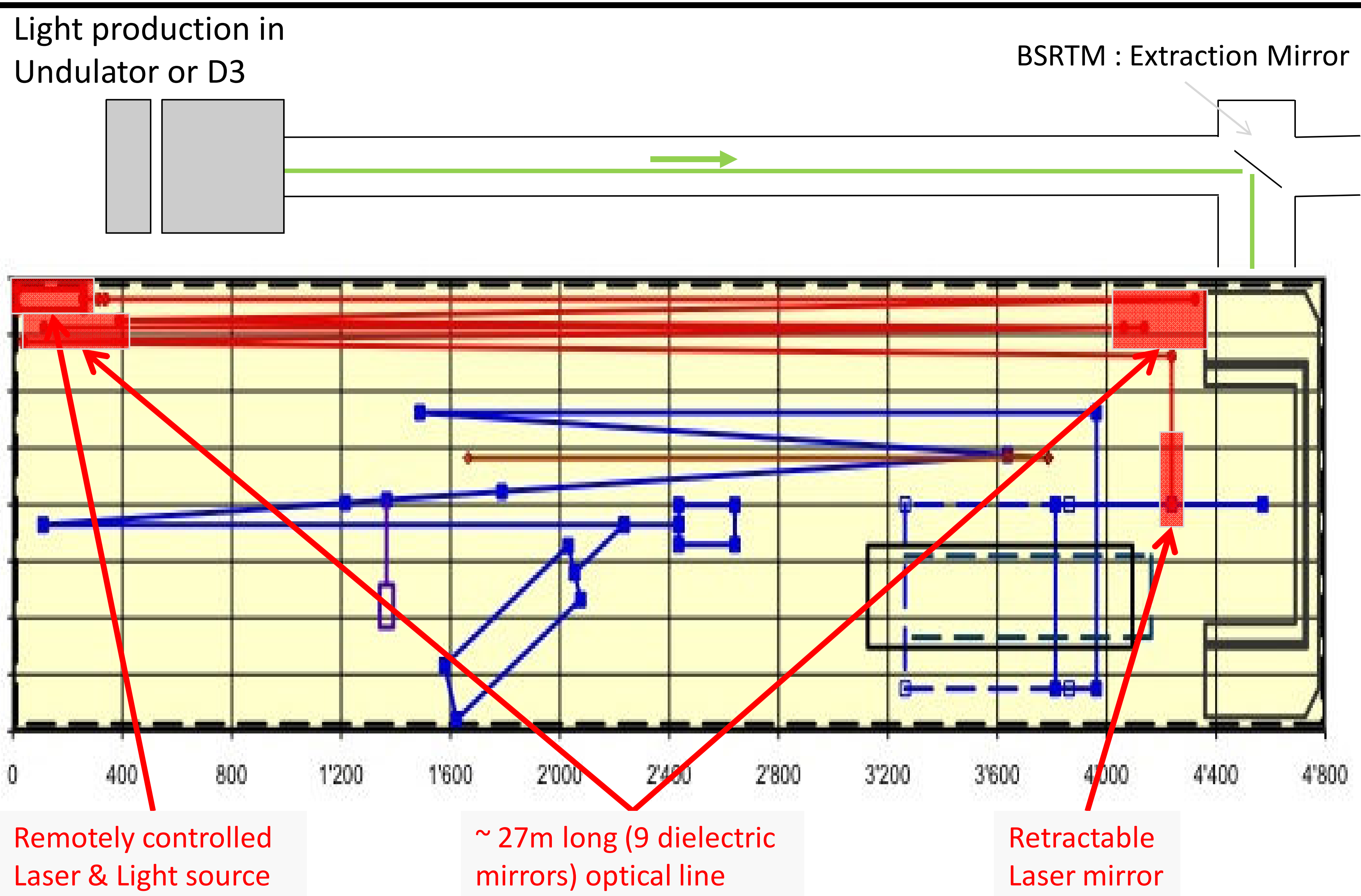
Abort Gap Monitoring System (BSRA)



Abort Gap Monitoring System (BSRA)



Calibration line

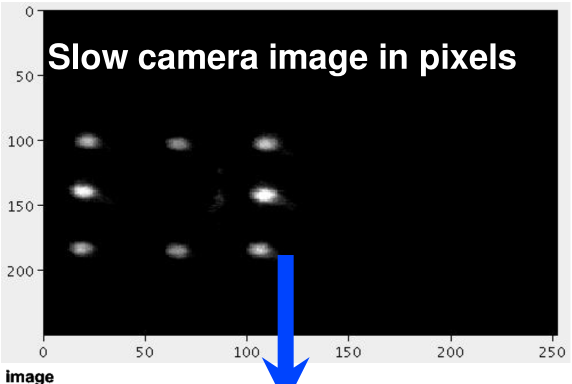


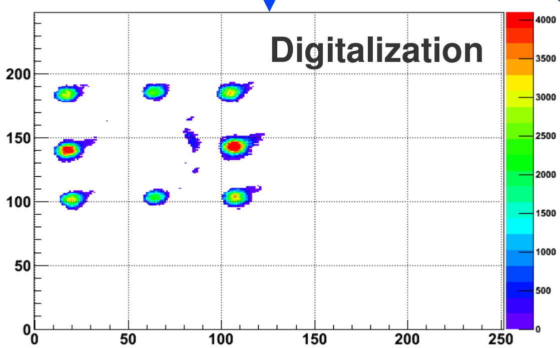
Controls

- ***All motors (24) powered via MIDI interface controlled by a Linux PC (one PC for both system). Potentiometers read-out on ADC channels – BSRTM position read-out on resolver***
- ***Alignement lasers and Fast cameras power supplies are remotely controlled (Relay and TTL output)***
- ***Slow cameras and the light power supplies for the calibration target are controlled via the CERN standard BTV card. Gain of the intensifier and the CCD shutter are controlled by DAC and TTL outputs***
- ***Fast cameras are directly connected to the network and read by a linux server***
- ***Triggers for the fast cameras are provided by the BOBR card (turn by turn)***
- ***BSRA signals is acquired by the mezzanine card***
- ***Triggers for the BSRA and the Pulsed LED are also provided by the mezzanine card***
- ***BSRTA is interlocked to the BIS***

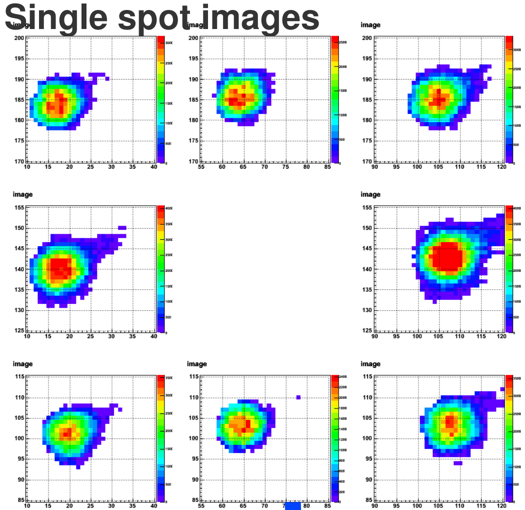
Performances BSRT/BSRA : run 2009

BSRT Calibration via reference target image

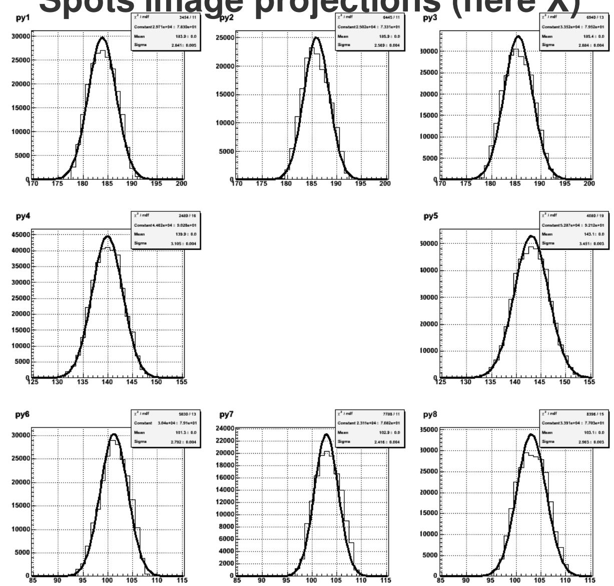




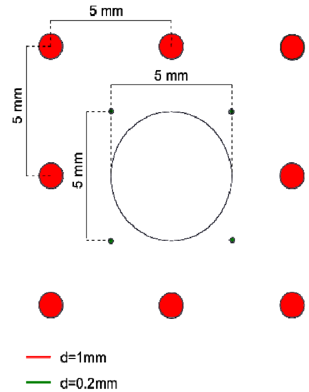
Single spot images



Spots image projections (here X)



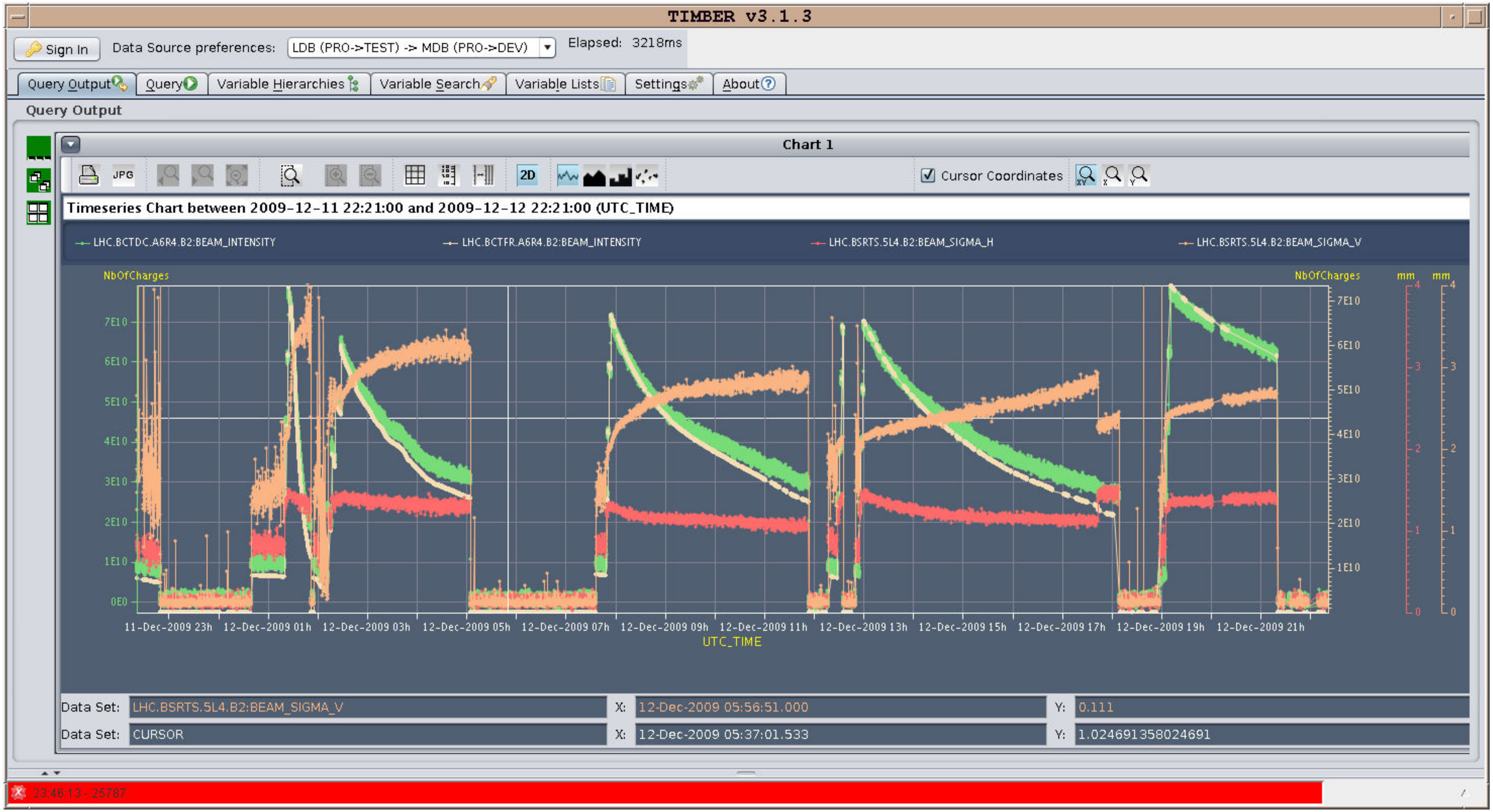
Calibration Target



Calibration Factor pixel / mm

Courtesy of F. Roncarolo

Performances BSRT/BSRA : run 2009



Fast BCT with BSRT amplitudes& sigmas during stable beams operations

Performances BSRT/BSRA : run 2009

BSRA & Fast BCT during the Ramp up to 1.18TeV