Summary of BDS/MDI

Philip Bambade

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On behalf of BDS/MDI working group convenors and speakers:

L.Gatignon (CERN), R. Tomas (CERN), G. White (SLAC), T.Tauchi (KEK)
K. Büsser (DESY), M. Oriunno (SLAC), N. Terunuma (KEK), A. Faus-Golfe (IFIC),
K. Kubo (KEK), E. Marin (SLAC), J. Snuverink (CERN), S. Liu (LAL), J. Yan (Tokyo),
P. Burrows (Oxford), Aryshev (KEK), Y. Levinsen (CERN), H. Garcia Morales (CERN),
M. Modena (CERN), H. Mainaud Durand (CERN), J. Allibe (LAPP), L. Deacon (CERN)

ECFA-LC2013 Workshop **DESY, 27-31 May 2013**

BDS/MDI Sessions & Talks (1)

28/6 9.00-10.30 (joint with detector integration)
- CLIC MDI status report, Lau Gatignon
- ILD MDI status report, Karsten Büsser
- SID MDI status report, Marco Oriunno

MDI

28/6 11.00-13.00 (joint with injector systems and with luminosity performance)
- CLIC BDS overview, Rogelio Tomas
- ILC BDS overview, Toshiaki Tauchi
- Status and update plan of the ATF DR, Nobuhiro Terunuma
- Turn-by-turn optics measurements in the ATF DR, Yves Rénier
- Extraction kicker for the CLIC damping ring, Carolina Belver Aguilar

BDS

DR

28/6 14.00-16.00 (joint with luminosity performance)
- CLIC RTML collimation systems and beam stabilisation, Robert Apsimon
- Tests of dispersion-free steering at FACET, Andrea Latina
- On-line dispersion free steering, Jürgen Pfingster

Tuning & algorithms

28/6 16.30-18.00 (joint with luminosity performance)
- OTR application to the RTML at ILC and CLIC, Angeles Faus-Golfe
- Discussion of common paths for ILC/CLIC FFS & BDS designs, Rogelio Tomas

Joint ILC & CLIC

BDS/MDI Sessions & Talks (2)

29/6 9.00-10.30 **ATF2 Day (open)**
- ATF2 continuous run in May, Kiyoshi Kubo
- Status of ATF2 lattices: from nominal to ultra-low β*, Eduardo Marin
- Wakefield effect, Jochem Snuverink

29/6 11.00-13.00 **ATF2 Day (open)**
- Beam halo, Shan Liu
- IP BSM, Jacqueline Yan
- Feedback in final focus and at IP, Phil Burrows
- ATF2 prospects, Glen White

ATF/ATF2

29/6 14.00-15.30 **ATF2 Day (Technical Board, open)**
- LW-OTR status, Alexander Aryshev
- CLIC kicker, Angeles Faus-Golfe
- Collimation/halo, Angeles Faus-Golfe
- CERN contribution, Rogelio Tomas
- Cavity Compton, Fabian Zomer
- Discussion: strategy for goals 1 and 2
  - →Plans for the summer, Nobuhiro Terunuma

29/6 16.30-18.00 **ATF2 Day (International Collaboration Board)**
- Report of ATF2 review, Rogelio Tomas (open)
- Discussion: future collaboration (closed)

BDS/MDI Sessions & Talks (3)

30/6 11.00-13.00 (joint with luminosity performance)
- Solenoids, Yngve Levinsen
- ILC & CLIC FFS optimisation and limitations, Hector Garcia Morales
- Two-beam tuning, Jochem Snuverink

CLIC (& ILC) FFS optimisation + tuning

30/6 14.30-16.00 (joint with detector integration and luminosity performance)
- CLIC QD0 field quality requirements, Yngve Levinsen
- CLIC QD0 and other BDS and post-collision line magnets, Michele Modena
- CLIC QD0 and BDS pre-alignment, Hélène Mainaud Durand
- CLIC QD0 stabilisation, Julie Allibe

CLIC magnets and stabilisation

30/6 16.30-18.00 (joint with detector integration and luminosity performance)
- CLIC post-collision line status, Lawrence Deacon

CLIC Post-collision line

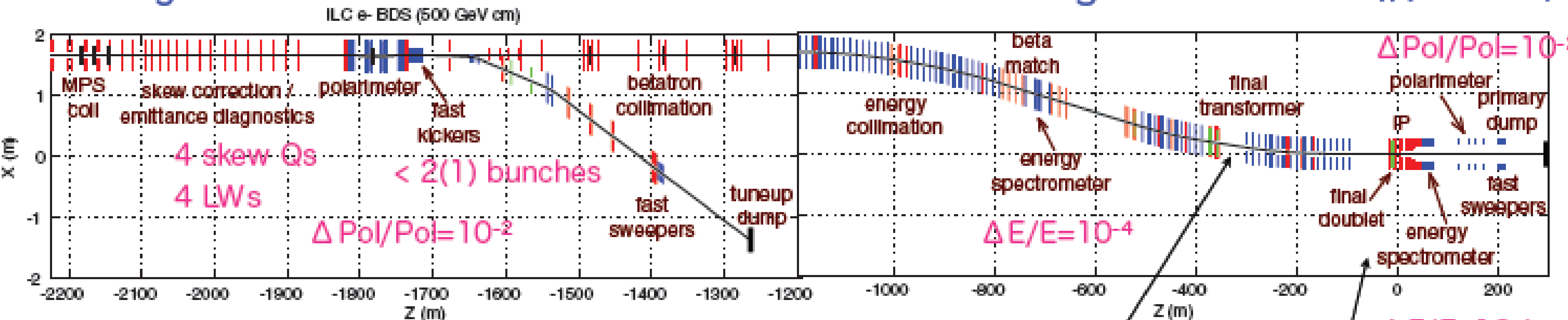
- *Sorry, cannot include material from every speaker…*
- *ATF2 already covered in Monday plenary by Kubo-san*

ILC BDS, E_{cm} =500GeV

to accommodate the upgrade to 1TeV center-of-mass energy

electron beam →

Diagnostics Collimation Matching Final Focus IR EXT& Dump



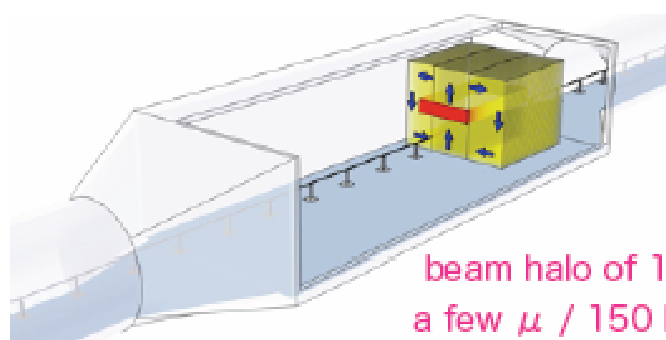
$\Delta E/E=10^{-4}$

5m-long magnetized muon shield(1.5T)

σ_x=474nm
σ_y=5.9nm
Horizontal crossing angle =14mr

$\Delta \varepsilon_x$<1% at chicanes of polarimeter and energy spectrometer

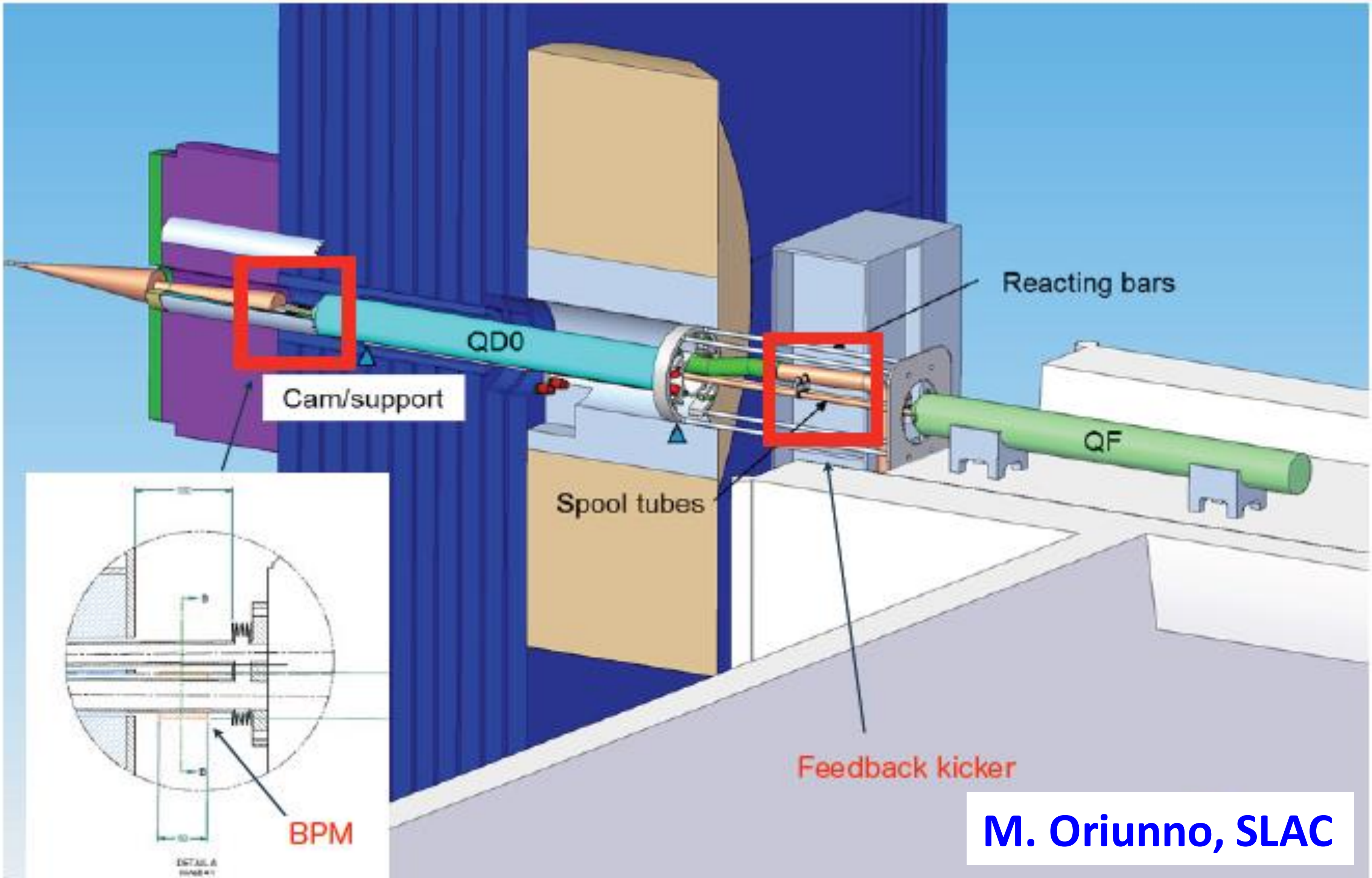
$\Delta \varepsilon_x$<0.5(1)% in bends at E_{cm}=0.5 (1) TeV



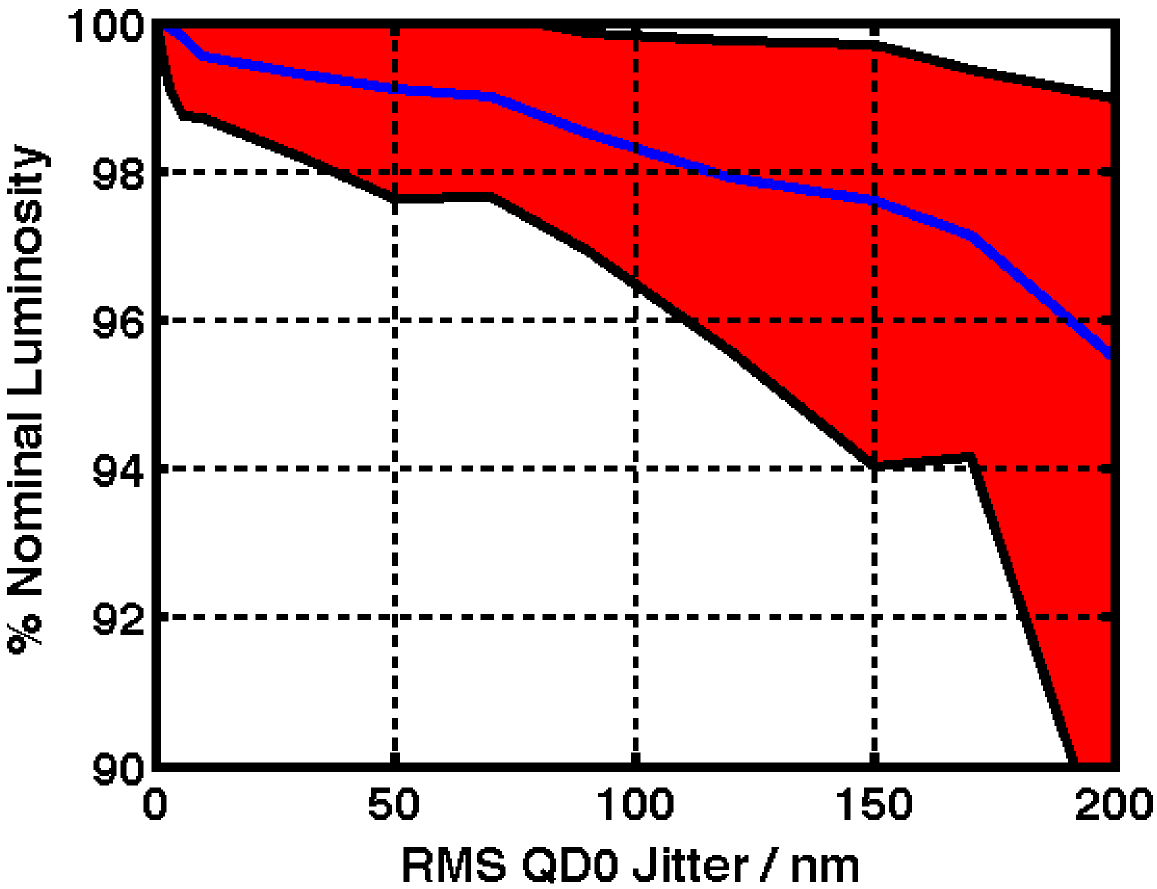
beam halo of 10^{-5} hit the collimators
a few μ / 150 bunches at IP

T. Tauchi, KEK

Final Doublet Region (SiD)

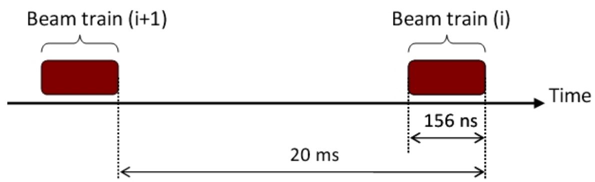


Luminosity Loss vs. QD0 Jitter



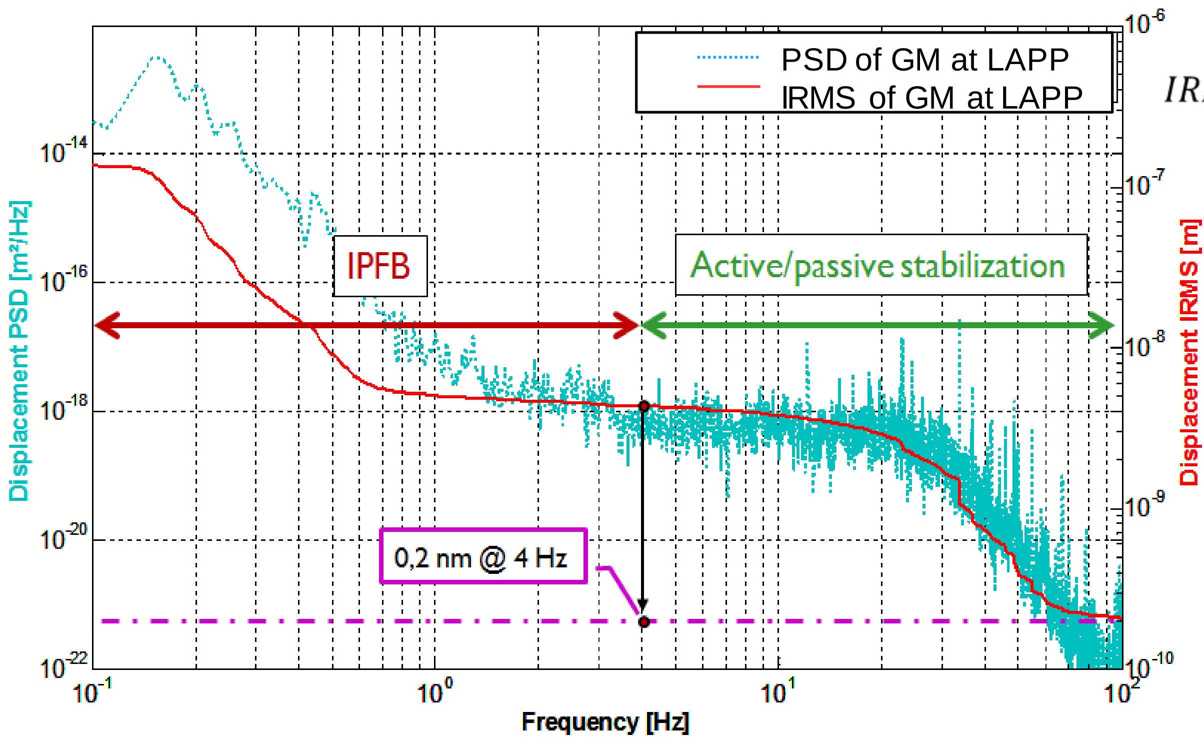
- Data shown gives % nominal luminosity for different levels of uncorrelated QD0 jitter.
  - 100 pulses simulated per jitter cases with FFB
  - Mean, 10% & 90% CL results shown for each jitter point from 100 pulse simulations
- **Tolerance to keep luminosity loss <1% is <50nm RMS QD0 jitter.**

Stabilization strategy: ground motion



Sample frequency = 50 Hz

Beam trajectory feedback only efficient at very low frequency

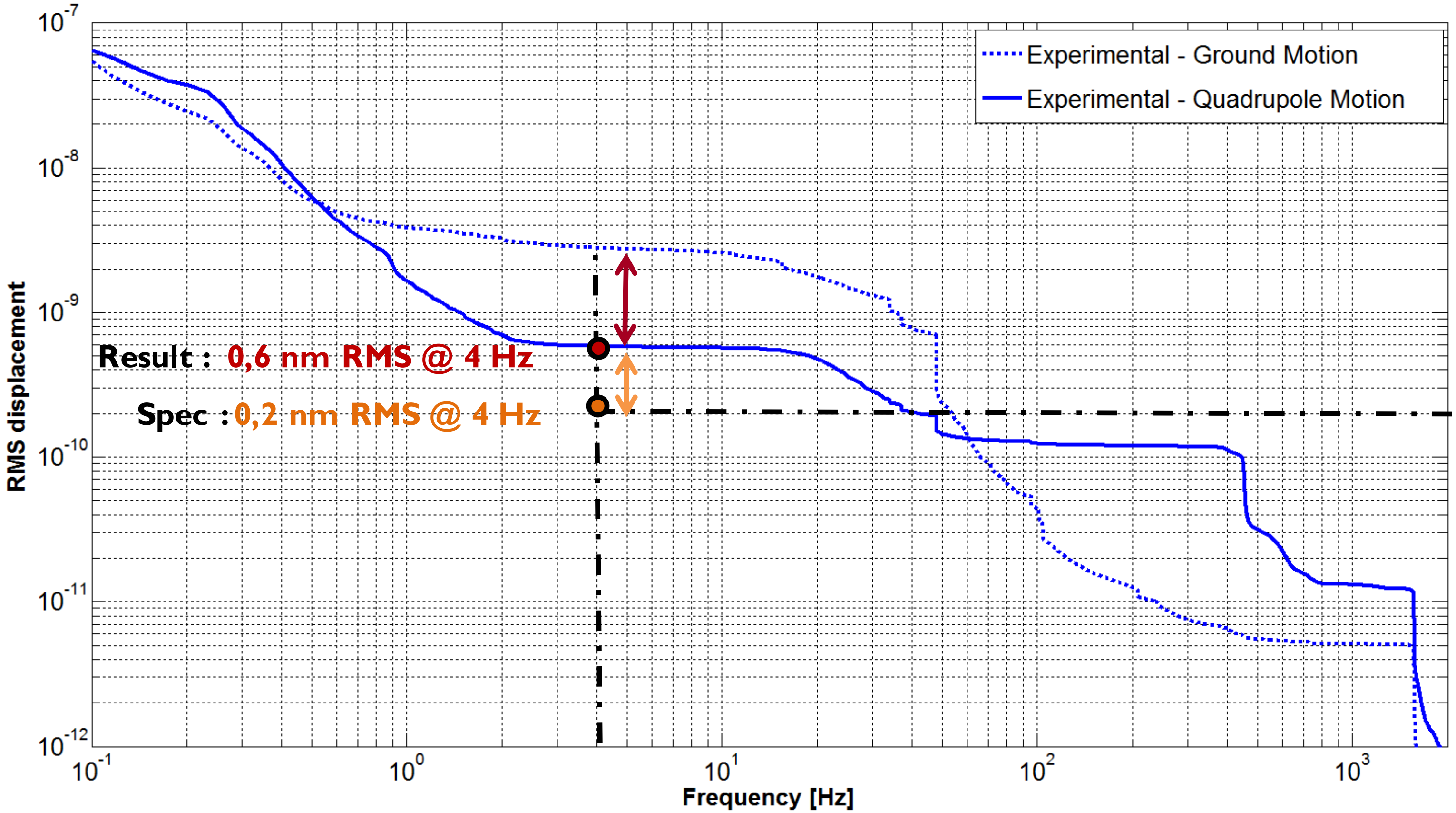


$$IRMS(k) = \sqrt{\int_f^{\infty} PSD(k)df}$$

At the IP (mechanical stabilization + beam feedback) we aim **0,2nm at 0,1Hz**

J. Allibe, LAPP

Active stabilization : results



Balik et al, "Active control of a subnanometer isolator", JIMMSS. (accepted)

Dedicated sensor in development at LAPP

- **<u>1st prototype :</u> developed for process demonstration**
  - Dimensions 250 x 250 x 110 mm
  - Promising GM measurement performances
  - tunable bandwidth (<1Hz to >100Hz)

Patent is in progress, G. Deleglise, J. Allibe, G. Balik & J.P. Baud

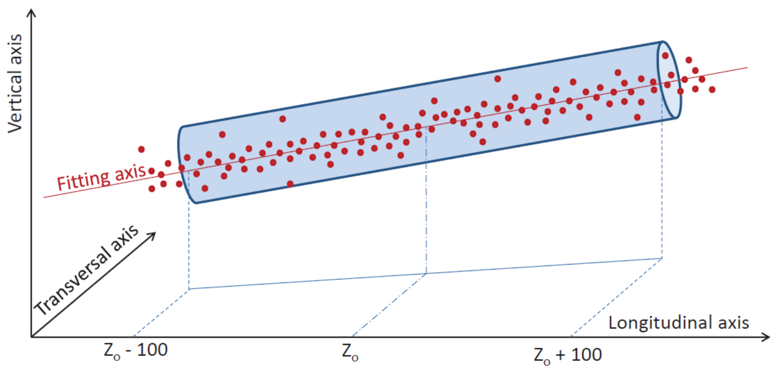
- **<u>2nd version :</u> miniaturized and optimized for control**
  - Dimensions 100 x 100 x 100 mm
  - Performances equivalent
  - Adapted transfer function
  - First tests in control encouraging

- **<u>Next Step :</u> Evaluation of the suitability for CLIC stabilizations in collaboration with CERN**
  - Further development and optimization
  - Robustness, reproducibility
  - Cost …

Pre-alignment requirements in CLIC BDS and final focus

H. Mainaud Durand, CERN

Determination of the position of each component of the BDS

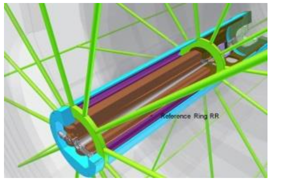


The zero of each component will be included in a cylinder with a radius of a few microns:

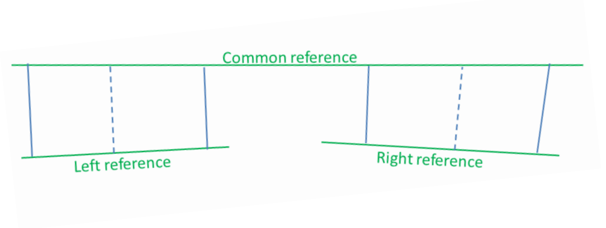
➔10 µm for BDS and final focus components

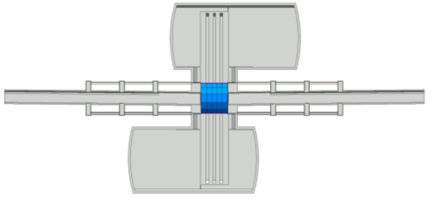
PACMAN

Special case of final focus area: left side w.r.t. right side



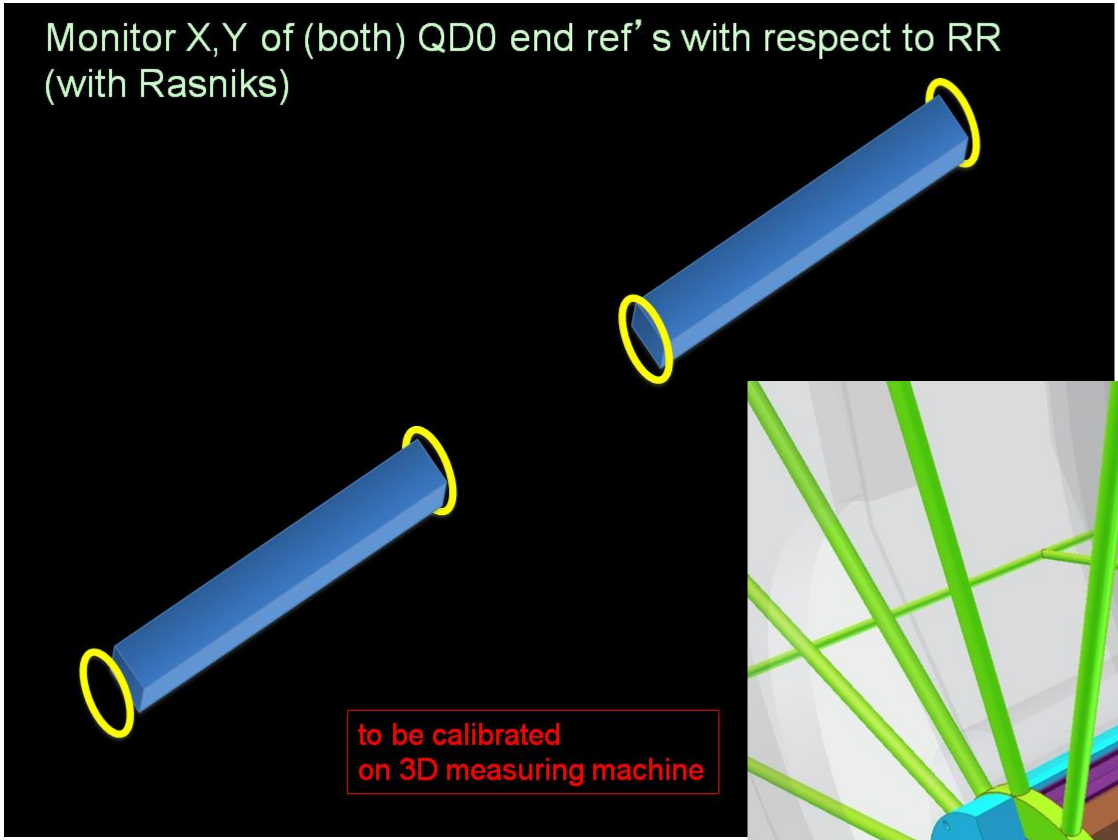
- ✓ Monitoring of the position of left QD0 / right QDO within ± 5 µm rms
- ✓ Determination of left reference line w.r.t right reference line : within ± 0.1 mm rms
- ✓ Monitoring of left reference line w.r.t right reference line : within a few microns

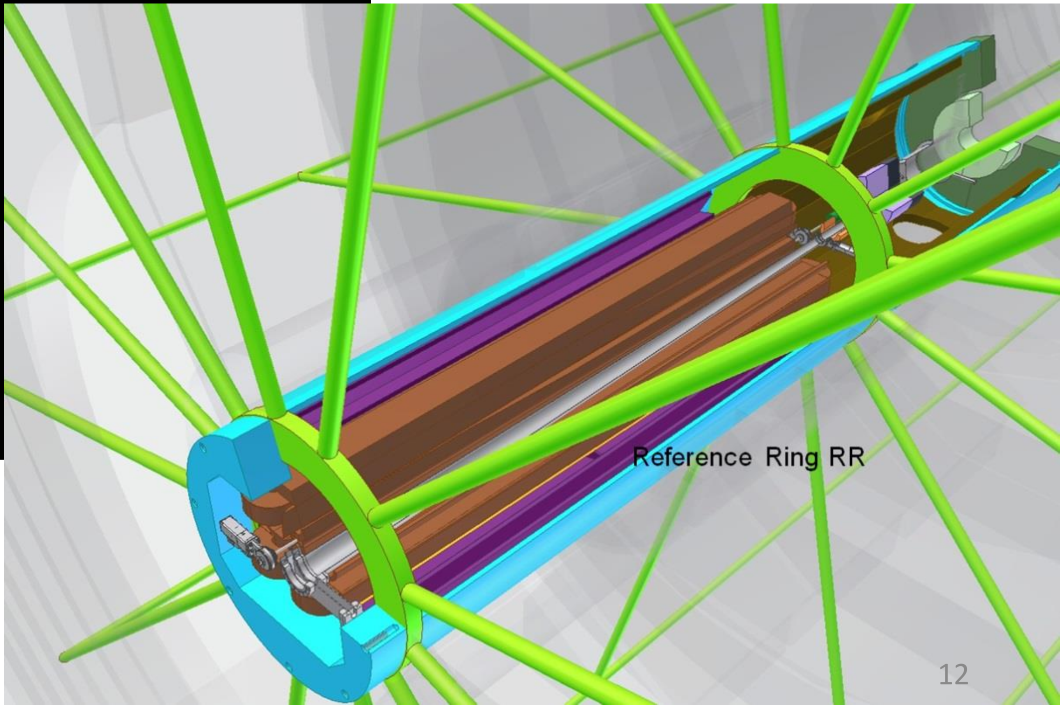


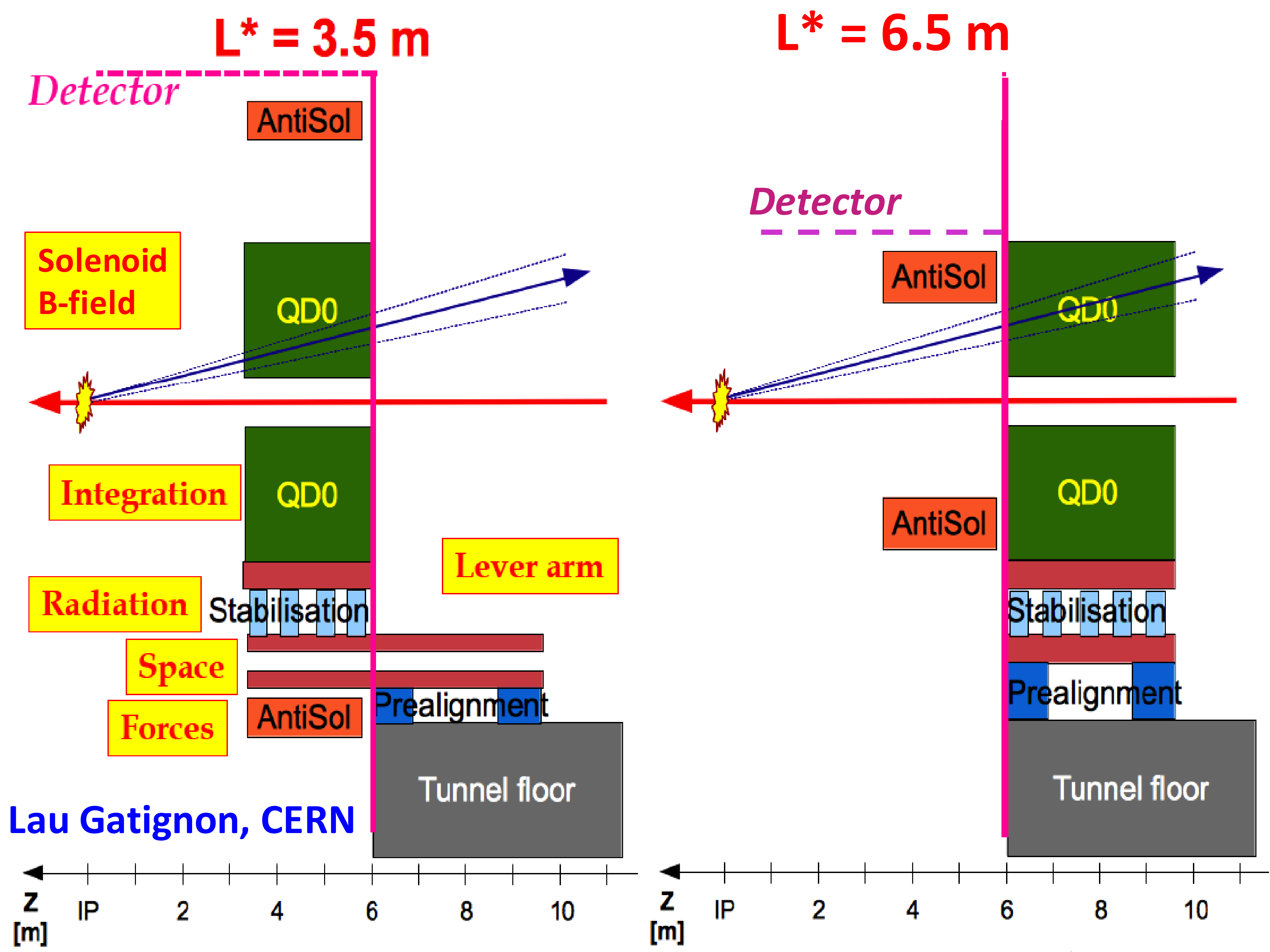


Monitoring of QD0

- ✓ **Reference Rings are mounted around the QD0s**
- ✓ **Two rings per QD0, for 4 wheels with zerodur spokes**



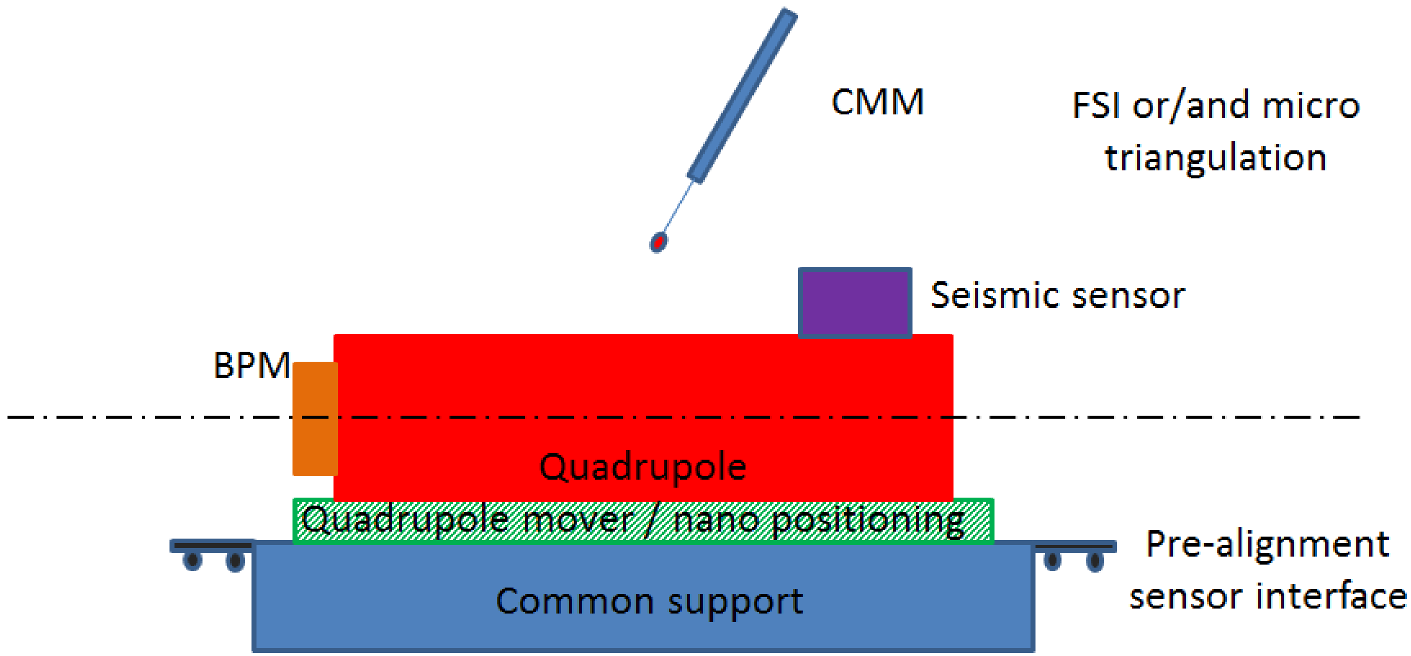



L* = 3.5 m
Detector
AntiSol
Solenoid
B-field
QD0
QD0
Integration
Lever arm
Radiation
Stabilisation
Space
Forces
AntiSol
Prealignment
Tunnel floor
Lau Gatignon, CERN
Z
[m]
IP
2
4
6
8
10
L* = 6.5 m
Detector
AntiSol
QD0
AntiSol
QD0
Stabilisation
Prealignment
Tunnel floor
Z
[m]
IP
2
4
6
8
10

PACMAN project:

H. Mainaud Durand, CERN

Propose and develop an alternative solution integrating all the alignment steps and technologies at the same time and location (CMM machine)



Technologies concerned:

Beam Instrumentation	Metrology	Micrometric alignment	Nano positioning	Magnetic measurements	Ultra high precision engineering

Marie Curie Initial Training Network (ITN):

Innovative Doctoral Program

CERN as host institution

15 associated partners

Start date (TBC): 1/09/2013

Duration: 4 years

Web site: http://cern.ch/pacman

Opening of applications: mid June 2013

10 PhD will start at CERN from 2014

Cranfield University	GB
ETH Zürich	CH
LAPP	FR
SYMME	FR
University of Sannio	IT
IFIC / FESIC	ES
Delft University of Technology	NL

DMP	ES
ELTOS	IT
ETALON	DE
METROLAB	CH
SIGMAPHI	FR

Hexagon Metrology	DE
National Instruments	HU
TNO	NL

ILC-BDS/FF Optics

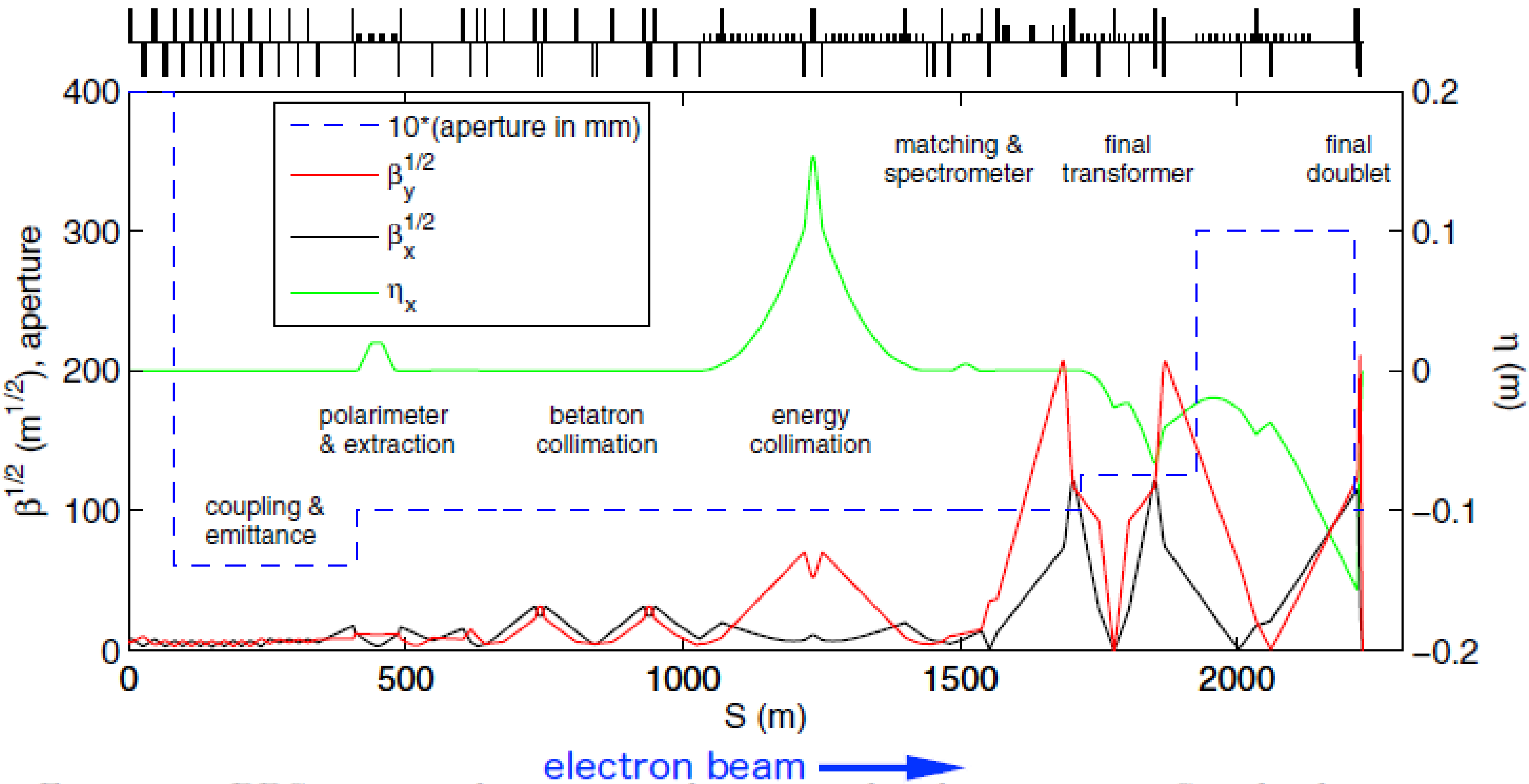


Figure 8.3. BDS optics, subsystems and vacuum chamber aperture; S is the distance measured from the entrance.

T. Tauchi

CLIC and ILC final focus system: optimisation and limitations

H. Garcia Morales
R. Tomas

1. Introduction
   - Final Focus Systems
2. CLIC 500 GeV optimization
   - CLIC 500 GeV FFS CDR
   - CLIC 500 GeV re-optimization
   - Reducing β^*
3. CLIC FFS as ILC FFS
   - CLIC as ILC FFS
   - Tolerances
4. Traveling focus studies for ILC and CLIC
5. Conclusions

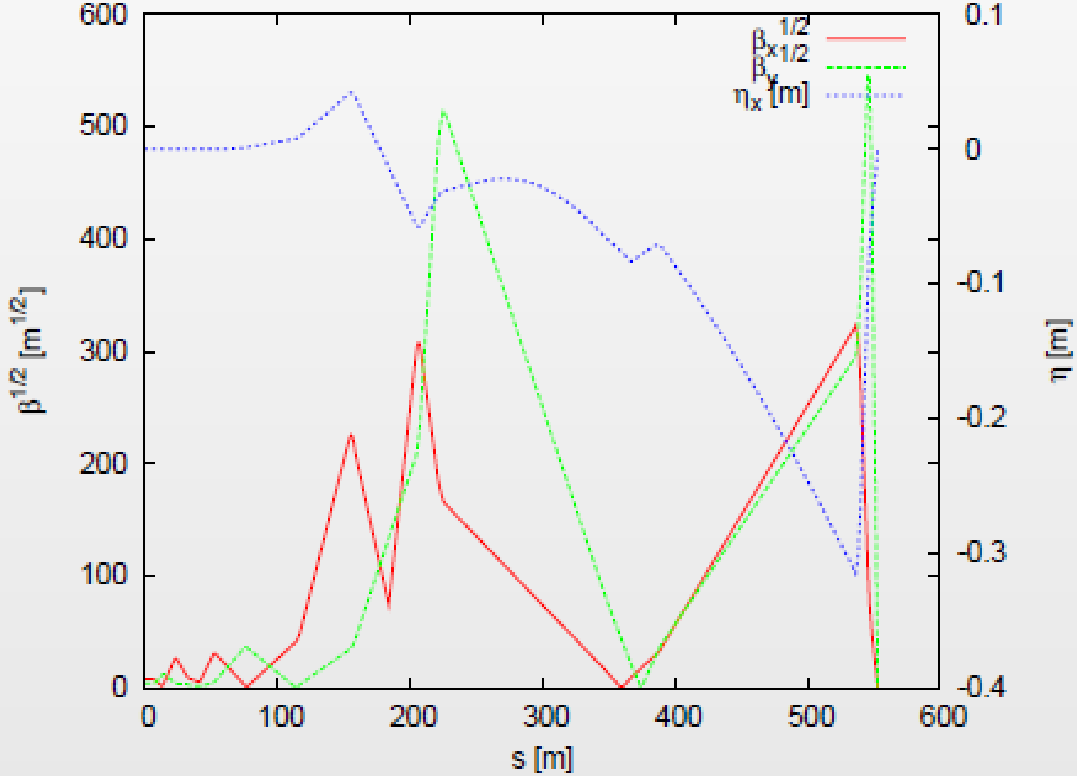
CLIC and ILC parameters

Parameter	Units	CLIC500[2]	ILC500[3]
Beam energy E_0	GeV	250	250
Bunches per beam n_b		354	1314
$e^{\pm}$ per bunch N	10^9	6.8	20
Repetition rate f_{rep}	Hz	50	5
Hor. emittance ϵ_x^N	μm	2.4	10.0
Vert. emittance ϵ_y^N	nm	25	35
Hor. beta β_x	mm	8.0	11.0
Vert. beta β_y	mm	0.1	0.48
Hor. beam size σ_x^*	nm	200	474
Vert. beam size σ_y^*	nm	2.26	6.0
Bunch length σ_z	μm	72	300
Energy spread δ_E	%	1.0	0.125
Luminosity $\mathcal{L}_T$	$10^{34} \cdot \text{cm}^{-2}\text{s}^{-1}$	2.3	1.47

[2] CLIC Conceptual Design Report, 2012
[3] ILC Technical Design Report, 2012

CLIC 500 GeV FFS CDR

The lattice with CDR parameters fulfills the luminosity requirements but with no margin of error.



Placet+GuineaPig

$$\beta_x^* = 8\text{mm}$$

$$\beta_y^* = 0.1\text{mm}$$

$$\sigma_x^* = 210.4\,\text{nm}$$

$$\sigma_y^* = 2.51\,\text{nm}$$

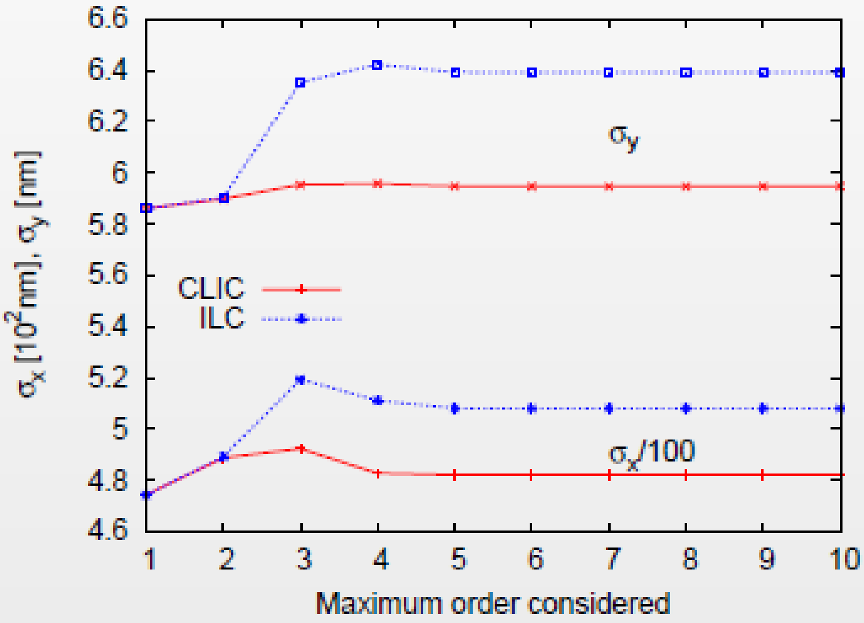
$$\mathcal{L}_T = 2.31\,\text{s}^{-1}\text{cm}^{-2}$$

$$\mathcal{L}_{1\%} = 1.40\,\text{s}^{-1}\text{cm}^{-2}$$

$$\Upsilon = 0.61$$

CLIC 500 GeV FFS-based as ILC FFS

We consider the option to use CLIC 500 GeV FFS lattice with ILC parameters at the IP for ILC beam.



Placet+GuineaPig

Parameter	ILC	CLIC-based
Length [m]	735	553
β_x^*/β_y^* [mm]	11/0.48	11/0.48
σ_x^{core} [nm]	499.3	483.7
σ_y^{core} [nm]	6.03	5.89
$\mathcal{L}_T$ [10^{34} cm^{-2}s^{-1}]	1.39	1.47
$\mathcal{L}_{1\%}$ [10^{34} cm^{-2}s^{-1}]	0.86	0.89

CLIC-based FFS lattice presents a similar performance in terms of beam sizes and luminosity at the IP. For a realistic implementation we should consider some other details. This shows we may move to a common concept.

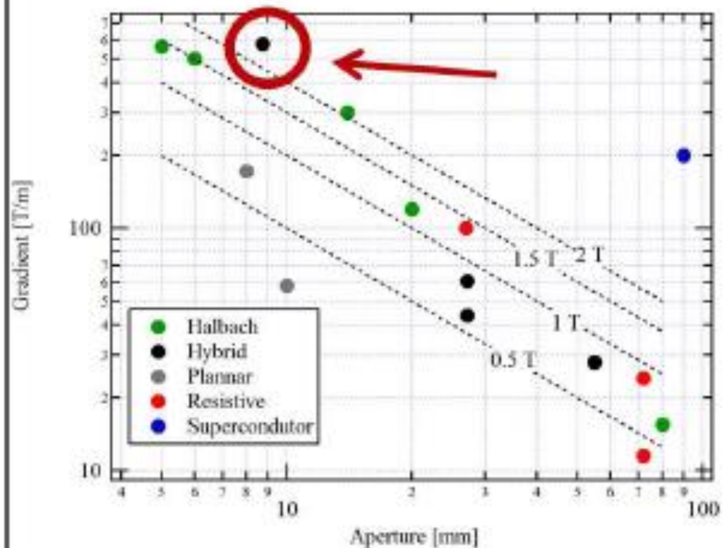
ESRF

State of the art

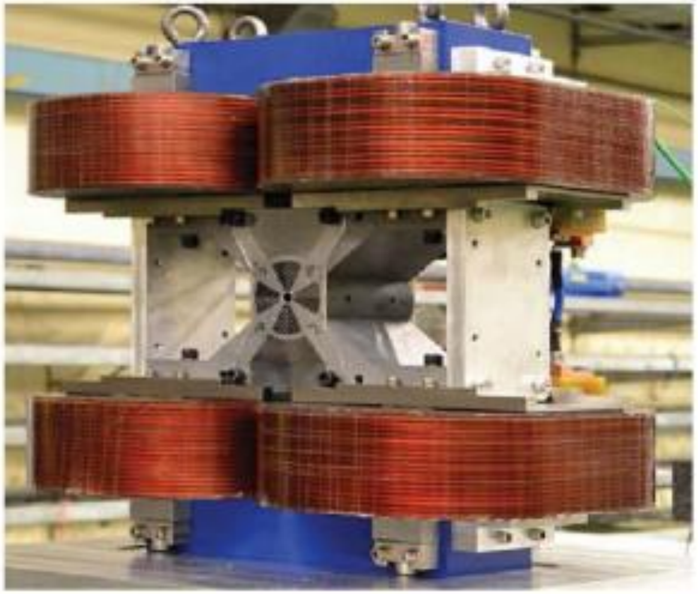
A light for Science

CLIC final focusing

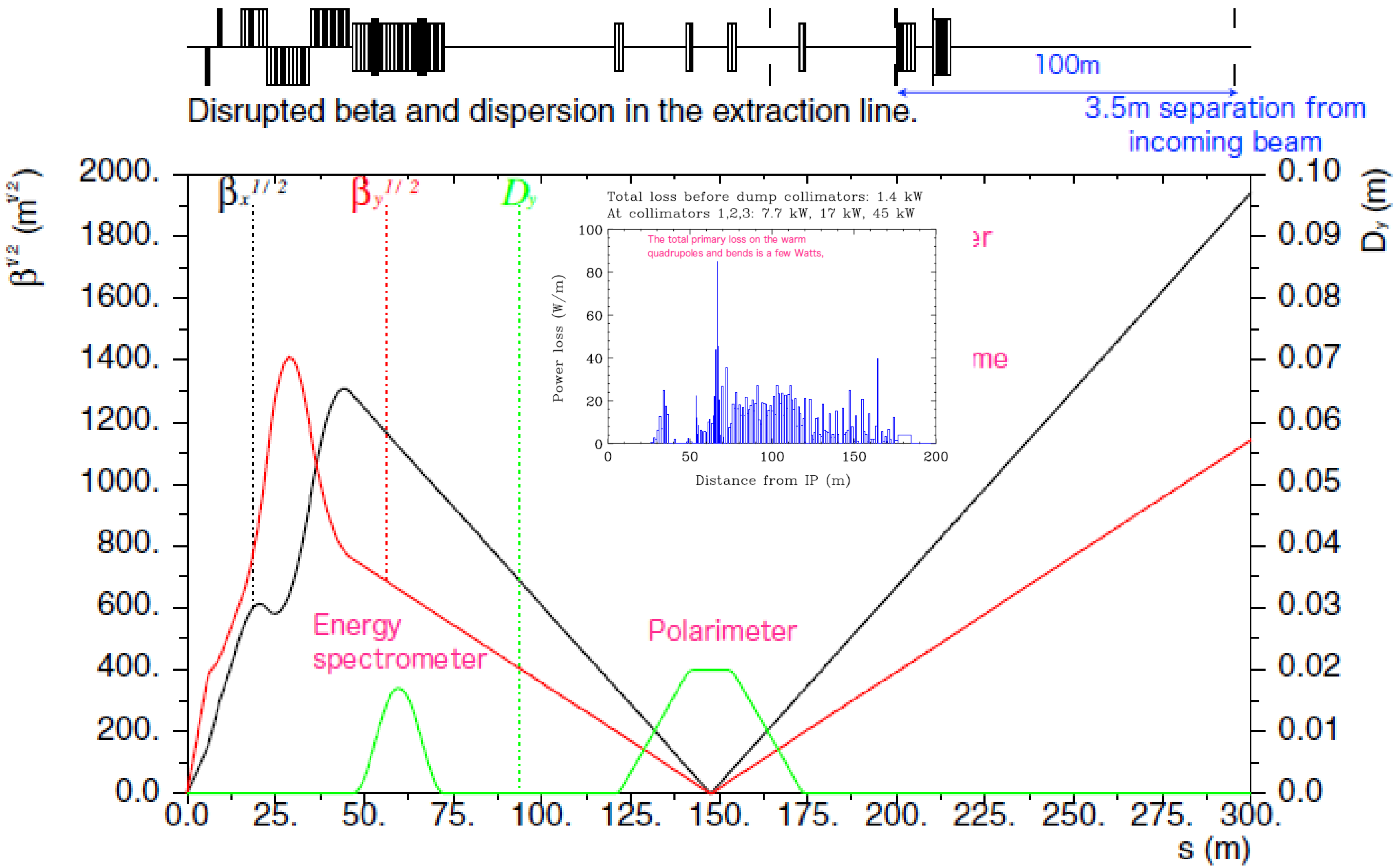
- Iron dominated, Coils + PM
- Gradient 525 T/m
- Aperture 8.25 mm
- Tuning range 80 %



M. Modena, CERN, IPAC 2012



ILC-BDS/EXT Optics

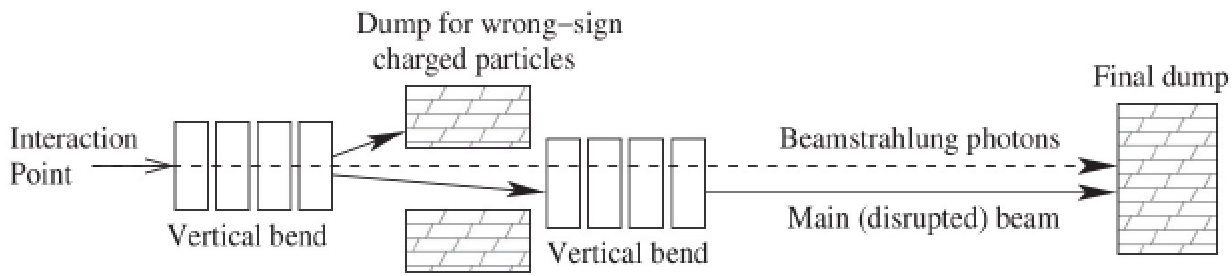


electron beam →

3cm circle by raster kickers
in a 15cm radius dump window

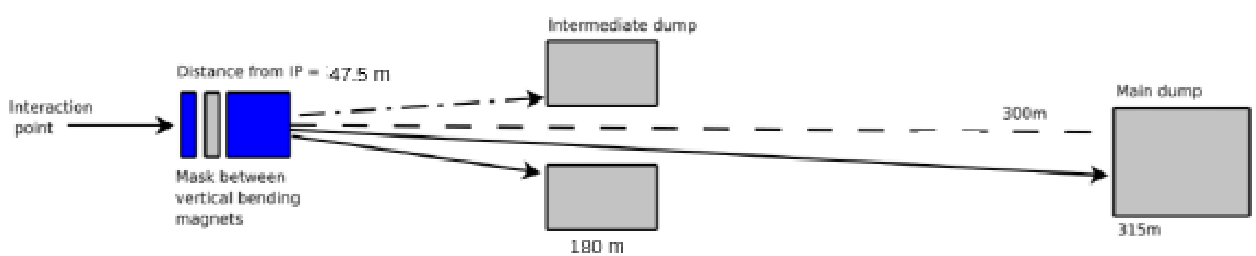
T. Tauchi, KEK

New post-collision line design for CLIC ➔ improves performances



A. Ferrari et al.

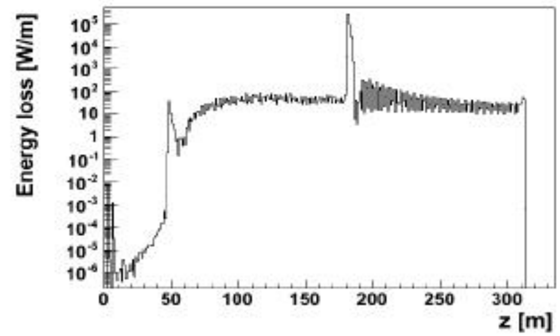
New layout

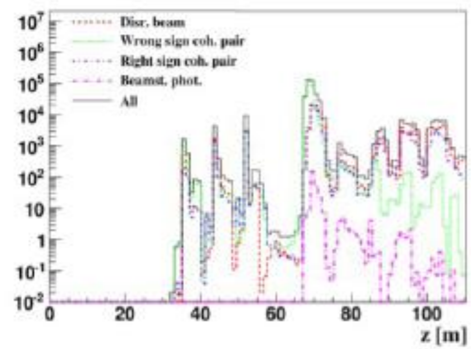


L. Deacon, CERN

Fewer beam losses with new layout !

- Beam losses in new layout (top) are small, less than ~100 W/m
- CDR baseline design (bottom): ~kW/m losses

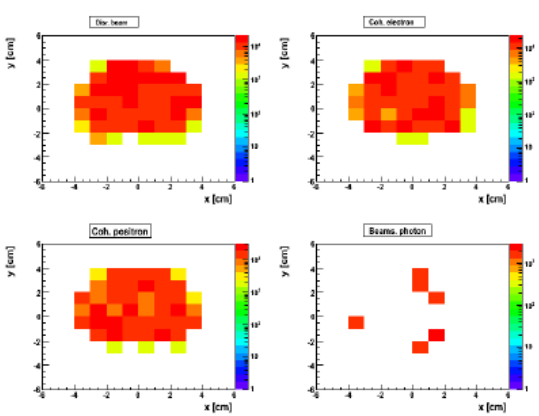




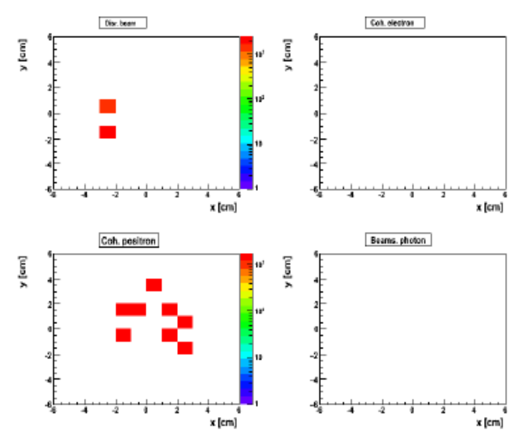
L. Deacon, CERN

And less photon and neutron backscattering…

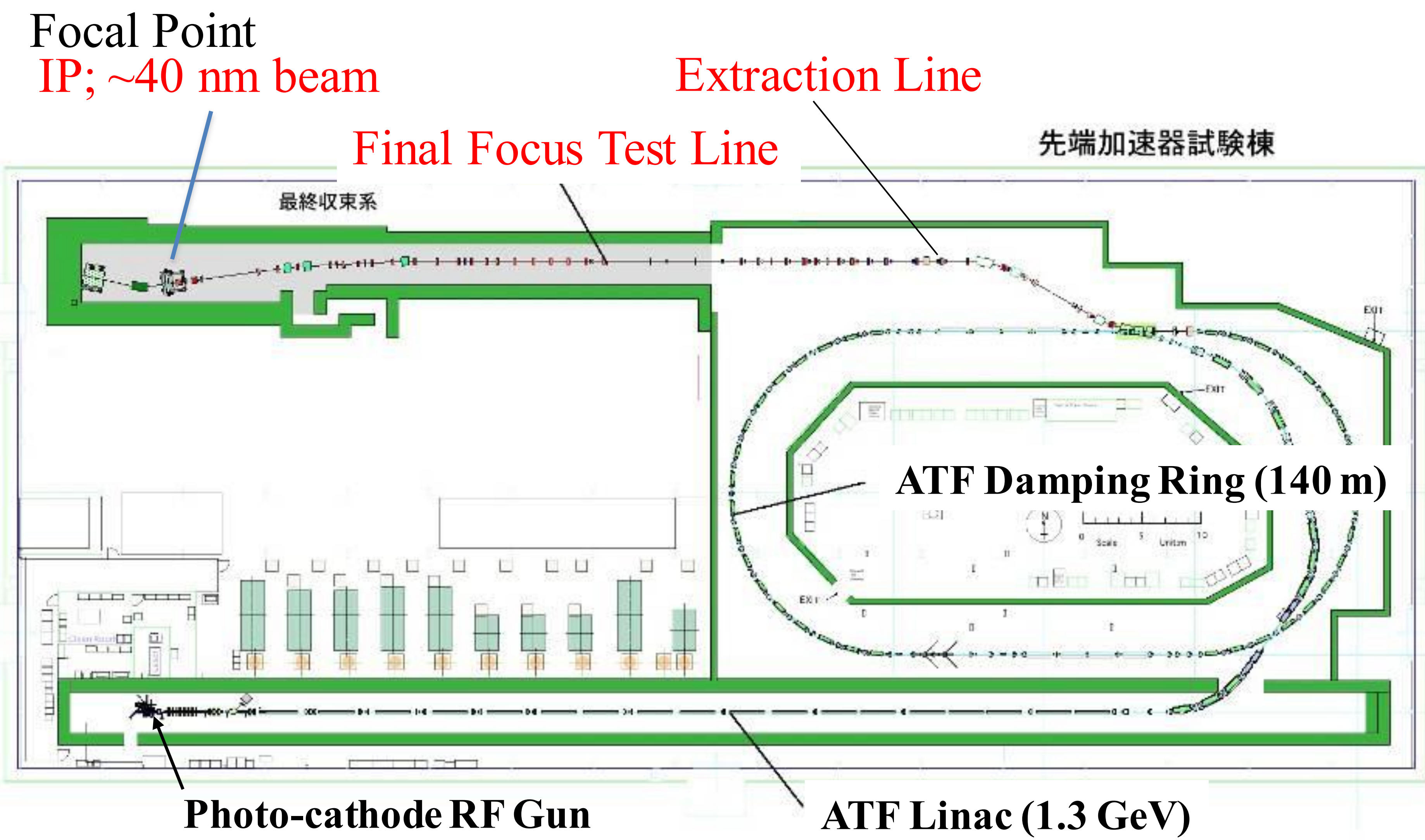
- Right: back scattered photons per m^2 at the detector
- By beam type
- $\sim 10^4$ per m^2 (fewer than in CDR version)



- Right: back scattered neutrons per m^2 at the detector
- By beam type
- $<10^3$ per m^2 (fewer than in CDR version)

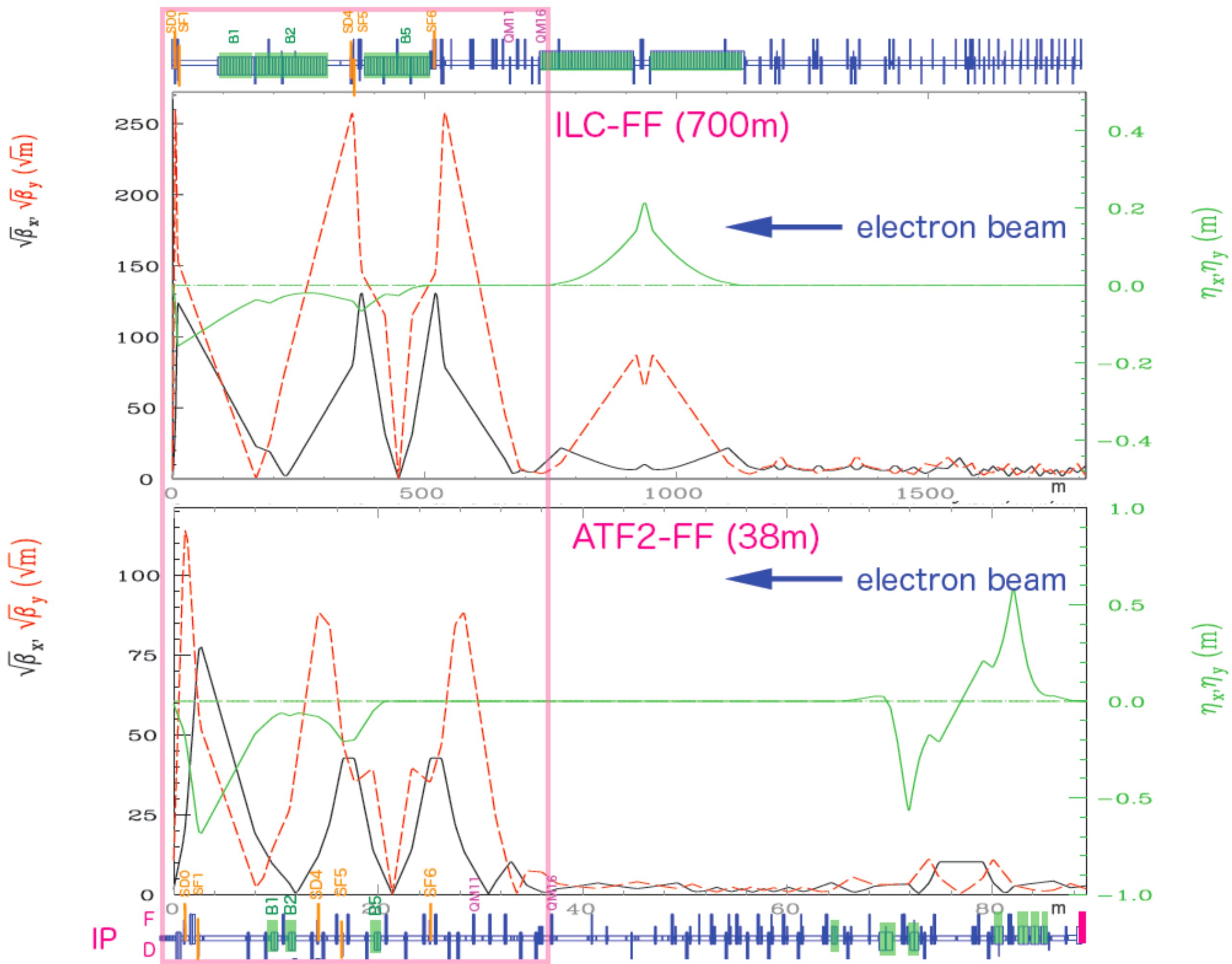


Accelerator Test Facility (ATF) at KEK



K. Kubo, CERN

Scale Test of ILC FFS Optics



- Scaled design of ILC local-chromaticity correction style optics.
- Same chromaticity as ILC optics.
- At lower beam energy, this corresponds to goal ~37nm IP vertical beam waist.

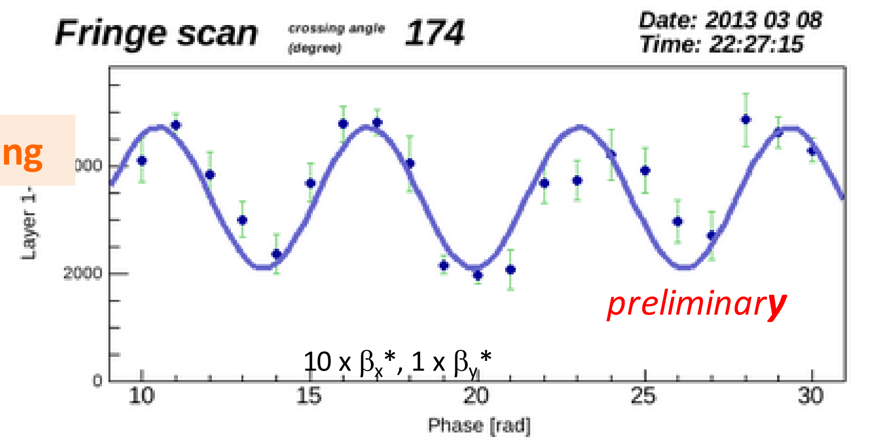
G. White, SLAC

Beam time status in 2013 Spring

Stable IPBSM performance → major role in beam tuning

measured M over continuous **reiteration of linear /nonlinear@ tuning knobs @** 174° mode

dedicated data for error studies under analysis



Fit results: Av*(1.0+M*cos(x+Ph))

Modulation: 0.385 +/- 0.025

Beam Size: 58.4 + 2.0 -1.9 nm

174° mode "consistency scan"

measure M vs time

after all conditions optimized

2013/03 /14

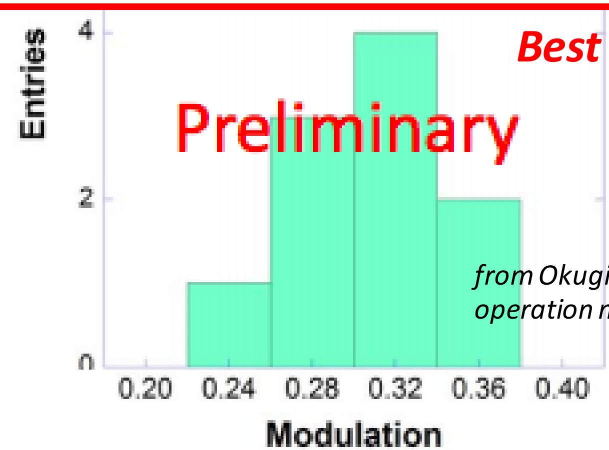
after IP-BSM roll alignment

after IP-BSM pitch alignment

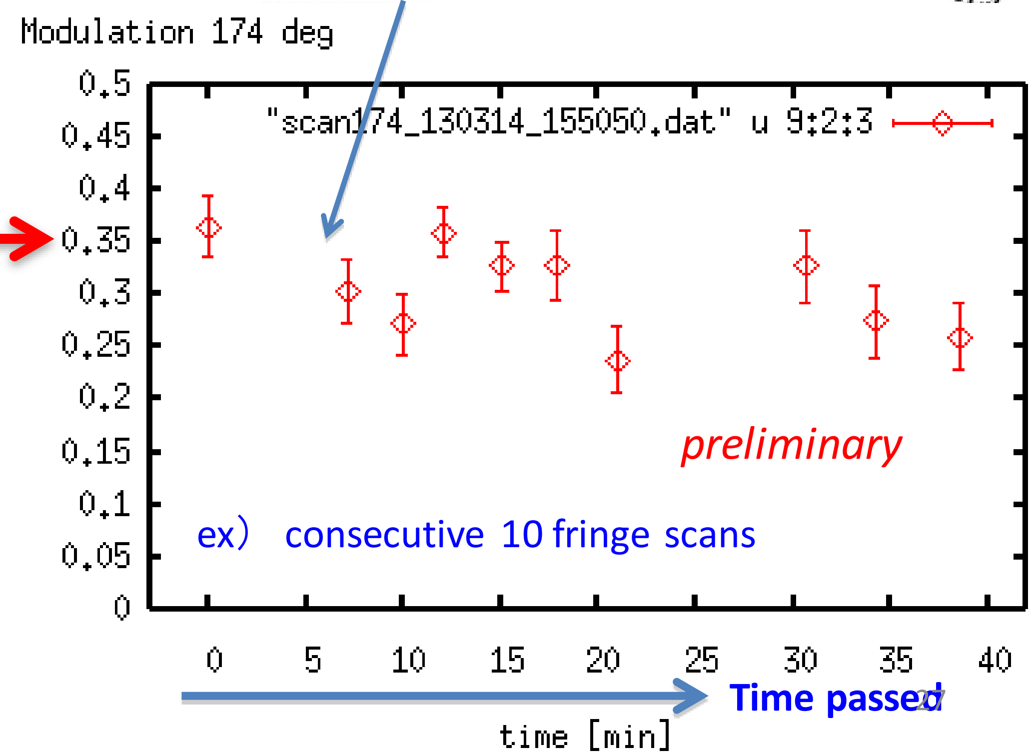
M ~ 0.306 ± 0.043 (RMS)

correspond to σy ~ 65 nm

Best record



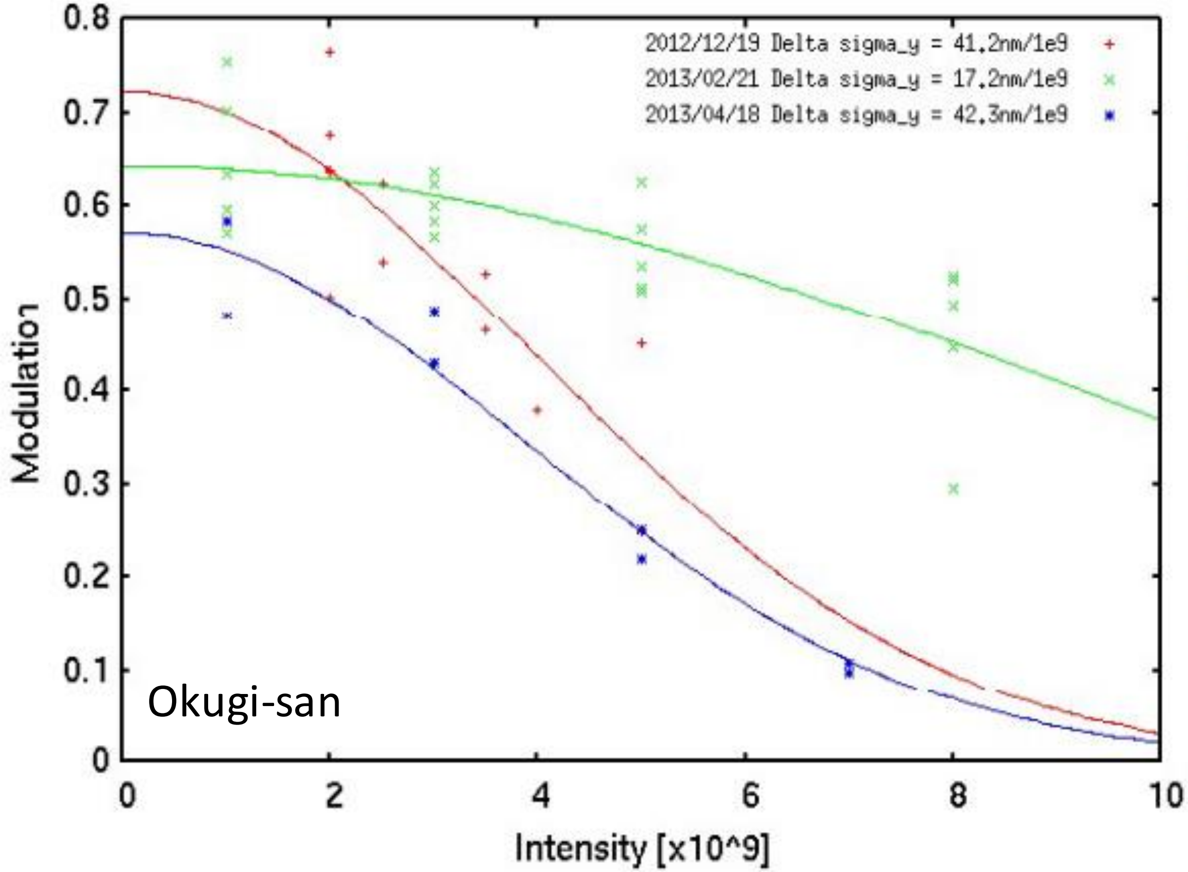
from Okugi-san's Fri operation meeting slides



J. Yan, Univ. of Tokyo

Wakefields

- December 2012 ~70 nm beam size was achieved, but only at very low intensity.
- Strong intensity dependence on beam size.

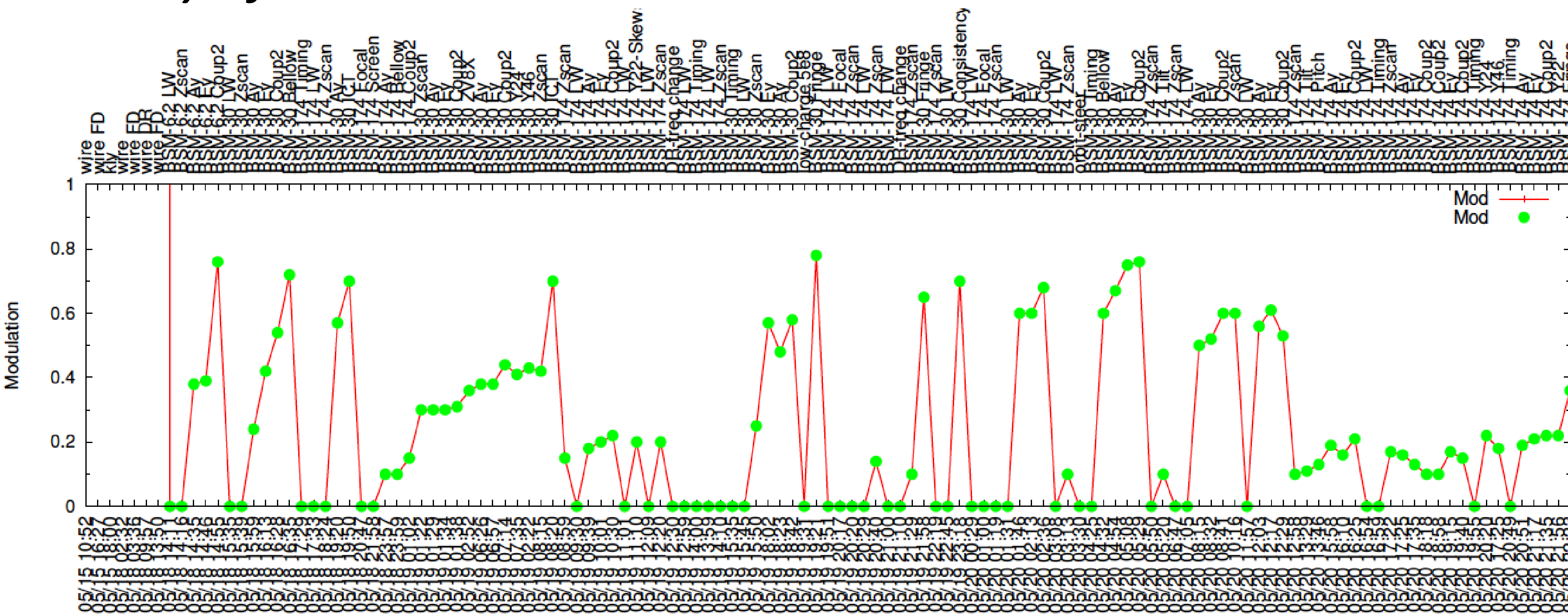


Red ; 2012 Dec.
Green ; 2013 Feb.
Blue ; 2013 Apr.

J. Snuverink, JAI-RHUL

History of IP-BSM modulation during May 2013 operation

courtesy of Edu Marin



1. Measured intensity dependance imply that wakefields cannot explain present beam size ~ 65 nm (if scaled linearly)
2. Confirm stability at IP (expect < 15 nm from vibration vibration + input jitter) → **Goal 2**
3. Non-linear tuning knobs have small effect (consistent with small influence from higher order aberrations and multipoles for this level of beam size)
4. Work to confirm small IP-BSM instrumental systematics (influence of fringe tilt,…)

Discussion on common paths for ILC&CLIC BDS systems

R. Tomas, CERN + input from discussion

- Lattice repository
- Different energies: 350 GeV (CLIC), 250-500 (ILC)
  → choice of common value for comparisons
- Different crossing angles: 18-20 mrad (CLIC), 14 (ILC)
- Crab cavity phase tolerance
- FFS optics design: can be common ?
- QD0 technology: permanent/hybrid versus SC
- Polarimetry & energy spectrometry: upstream / downstream ?
- Collimation & beam dumps
- FFS tuning: simulation & experimental work
  → **major learning from ATF2**
- Instrumentation and feedback
- MDI issues (push-pull, QD0/QF1 alignment,…)

→ propose joint meeting at LCWS-2013 following discussions via phone conferences and e-mails