

Status of UK ILC Beam Delivery System R&D

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**Linear Collider
Accelerator + Beam Delivery Collaboration
(LC-ABD)**

LC-ABD Collaboration

- Birmingham
- Cambridge
- Durham
- Liverpool
- Oxford
- Royal Holloway
- Daresbury Lab.
- Bristol
- Dundee (*was Abertay*)
- Lancaster
- Manchester
- Queen Mary
- University College London
- Rutherford-Appleton Lab.

Grahame Blair (PI), Philip Burrows (PM)

- 80 collaborators: faculty, staff, research associates, technical staff, graduate students **(23 new posts)**

www.astec.ac.uk/lc-abd/

Project Overview

1. Lattice design and beam simulations (**Angal-Kalinin**)
2. Advanced beam diagnostics (**Blair**)
3. Alignment and survey (**Reichold**)
4. Final focus luminosity stabilisation and spectrometry (**Burrows**)
5. e⁺ undulator, crab cavity system, wakefields/collimators (**Poole**)

Underpinning infrastructure support (CCLRC):

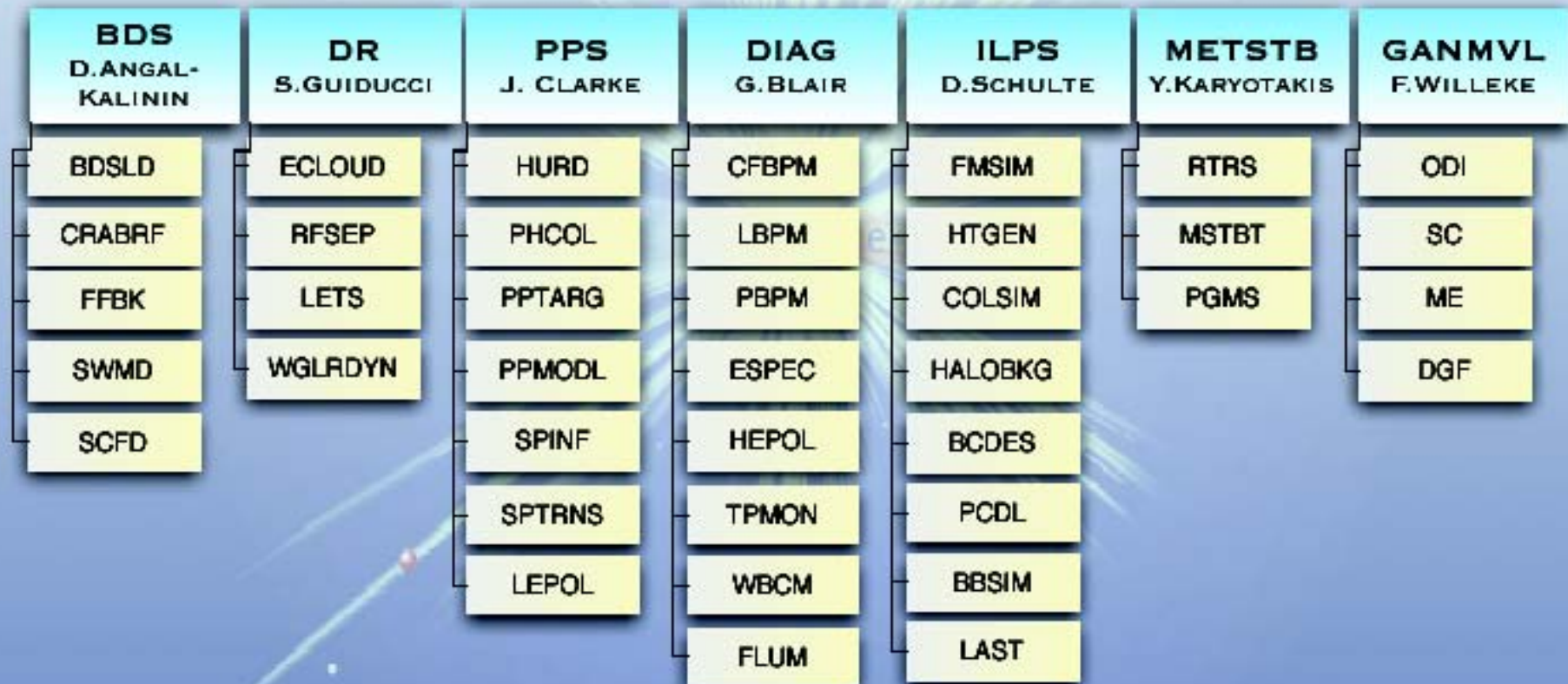
**vacuum, RF, magnets, diagnostics, control, electronics, DAQ ...
(SRS, ISIS, Diamond, ERLP ... accelerators)**



Subdivision of Work Packages

EUROTeV WORK PACKAGES & TASKS

(EXCEPT MNGMNT)



1.1 BDS Lattice Design

(Daresbury, Liverpool, RHUL; Saclay, Orsay, BNL, SLAC)

Aim: develop core group with underpinning expertise in optical design and simulation of beam delivery system, including:

- interaction region (IR),**
- extraction lines**

and lead in global design of BDS

Design: Final focus

Collimation optics

Beam diagnostics section

Machine protection

Provision for two IRs

Crossing angle issues

Extraction: Highly disrupted beams

Transport to beam dumps

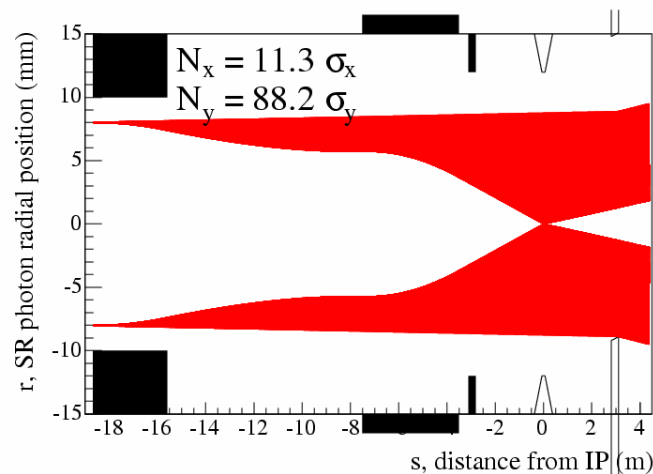
Beam sizes at beam dumps

Diagnostics

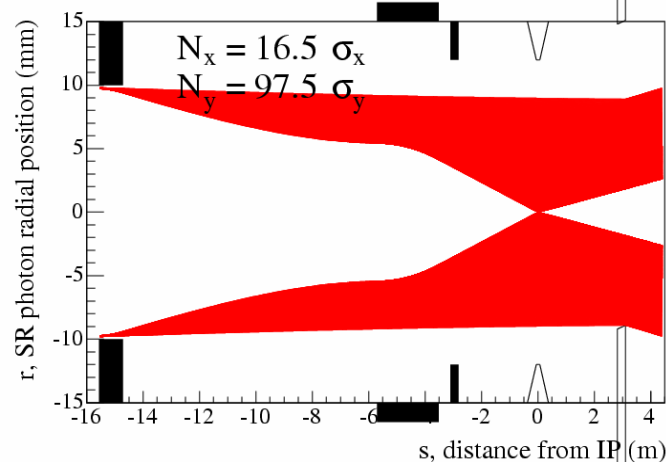
Beam dumps

Incoming beams: collimation depths

2 mrad

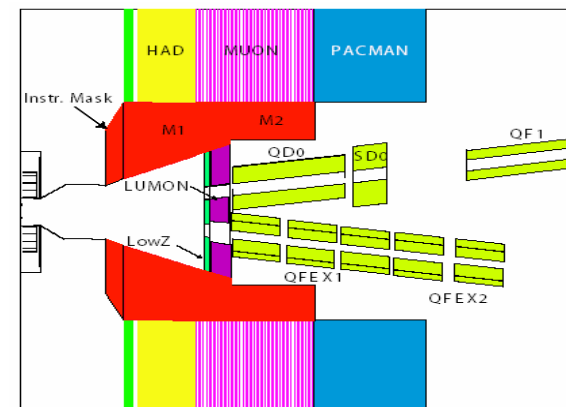


Long doublet

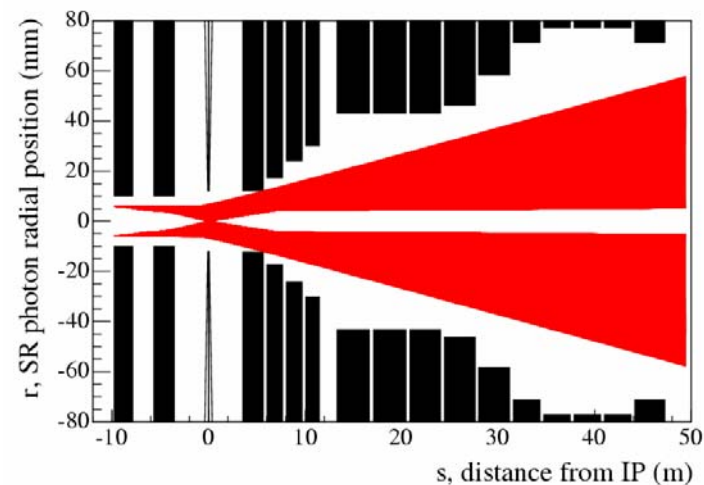


Philip Burrows Short doublet

20 mrad



http://www.slac.stanford.edu/xorg/lcd/ipbi/lcws05/maruyama_backgrounds.ppt

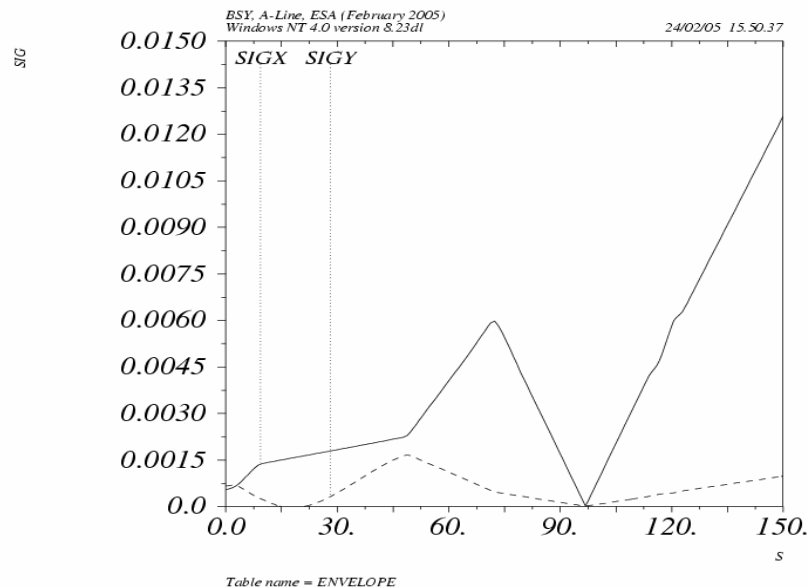


F. Jackson's talk – BDIR workshop

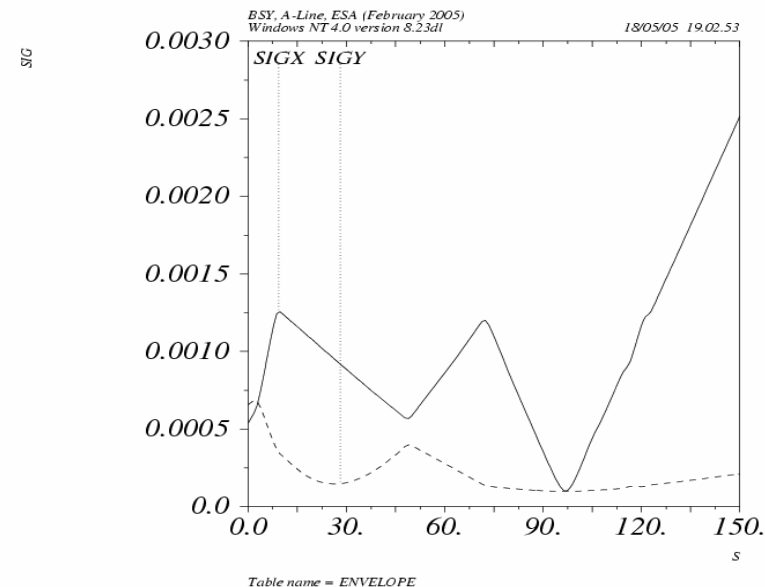
ESA : Optics for collimation wake field studies

Requirements on beam spot-size

- 100 μm (vertical) for the wakefield and BPM experiments
- < 20 μm (vertical and horizontal) for the material damage tests



100 μm waist at collimator wakefield box

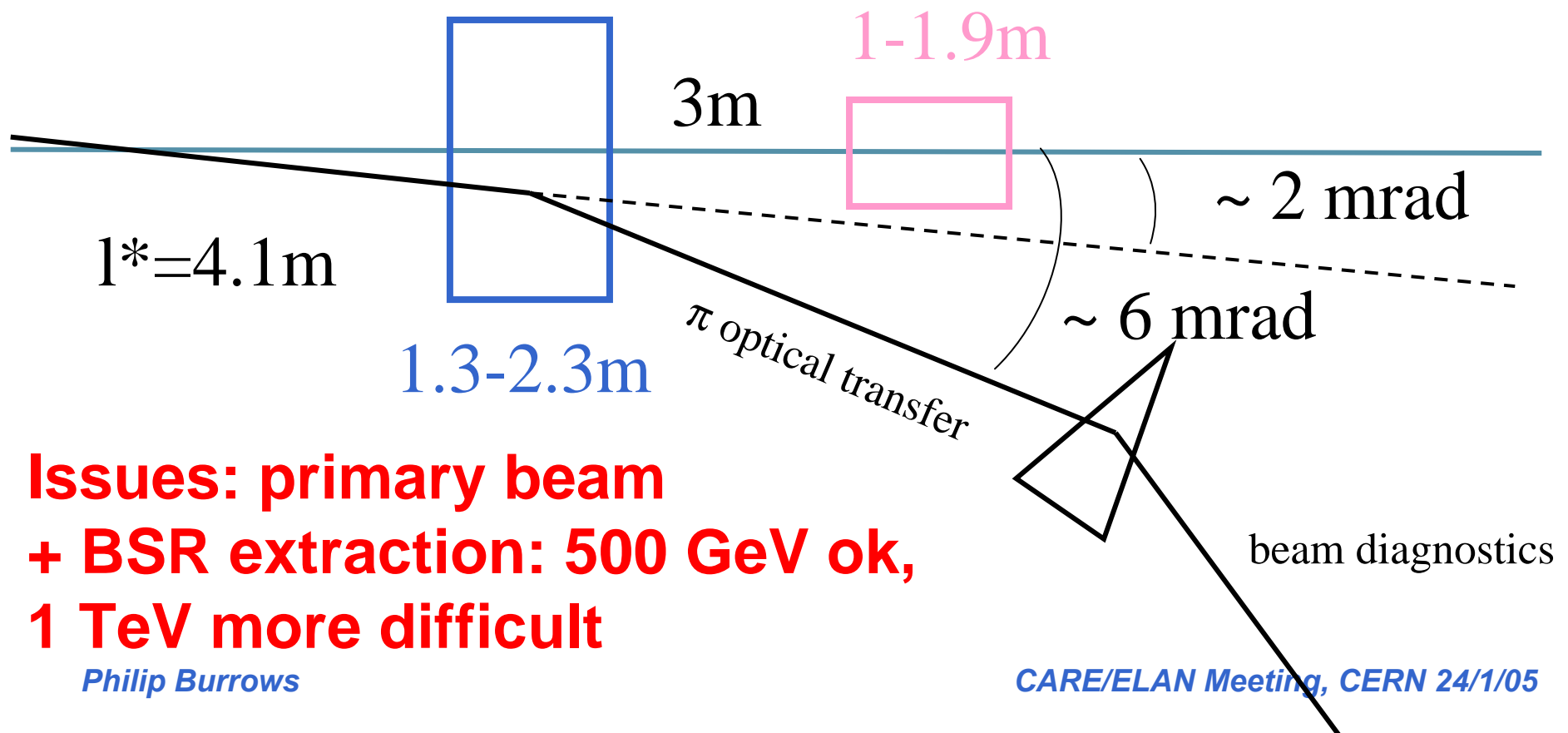


20 μm waist at collimator wakefield box

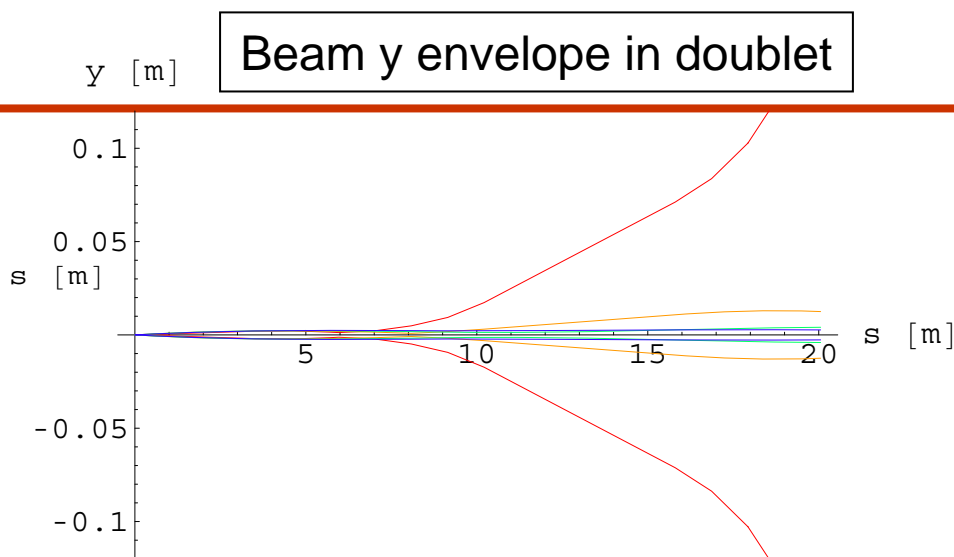
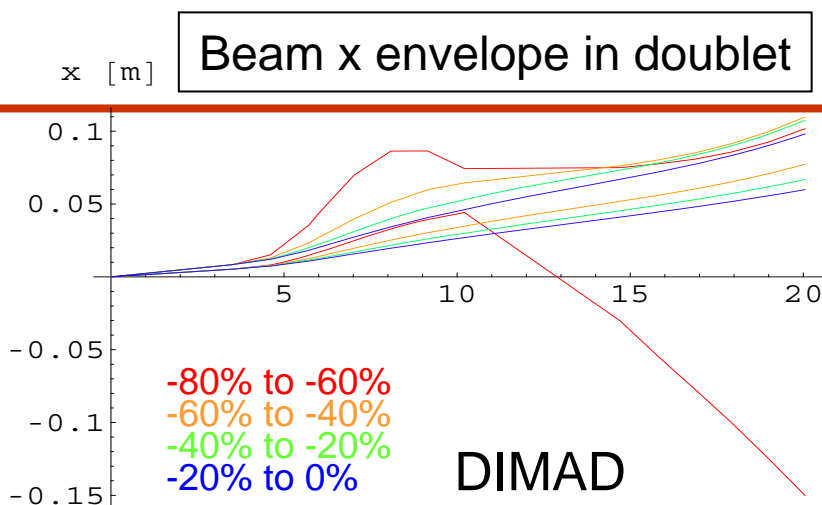
2mrad Xing angle: schematic

SC QD ($r = 35\text{mm}$)
214-228 T/m

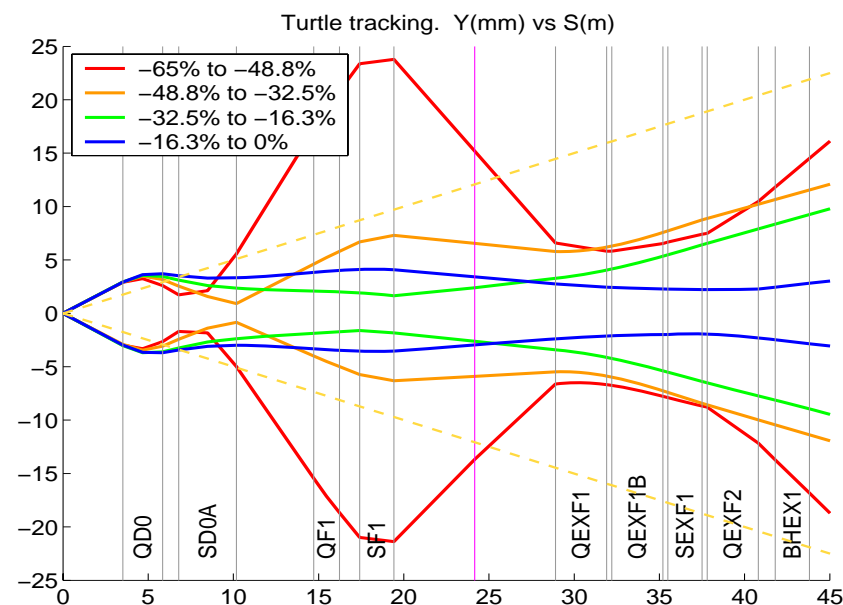
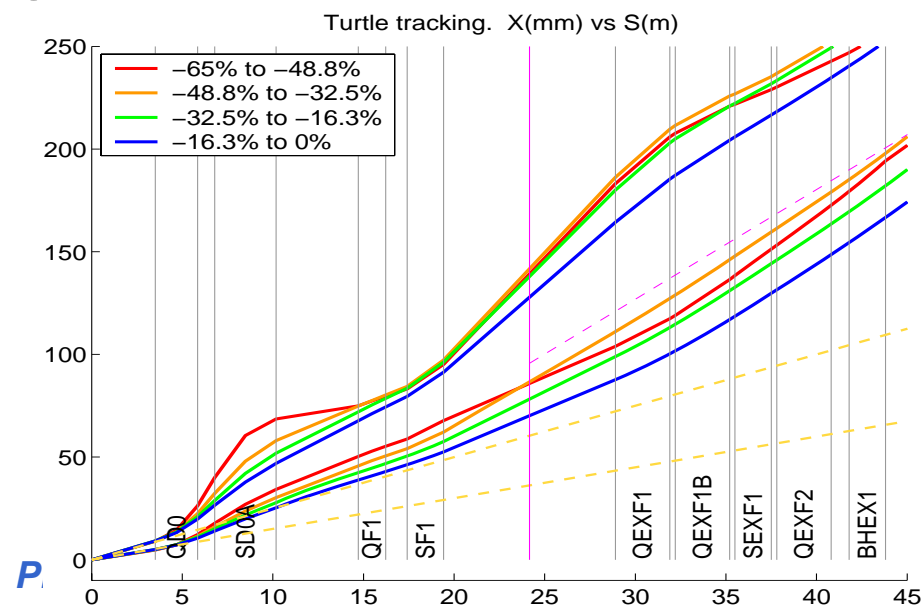
warm QF ($r \sim 10\text{mm}$)
140-153 T/m



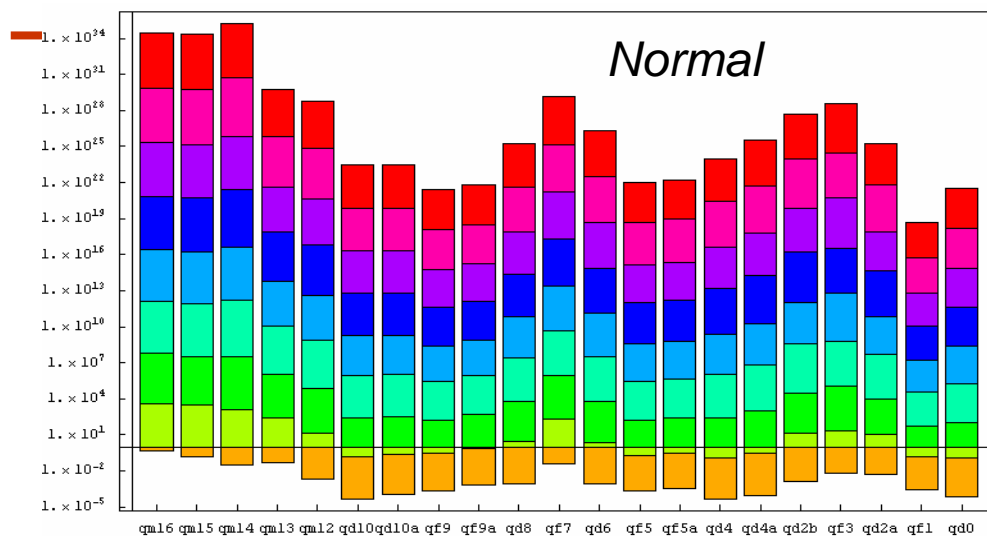
Tracking of disrupted beam through the extraction line



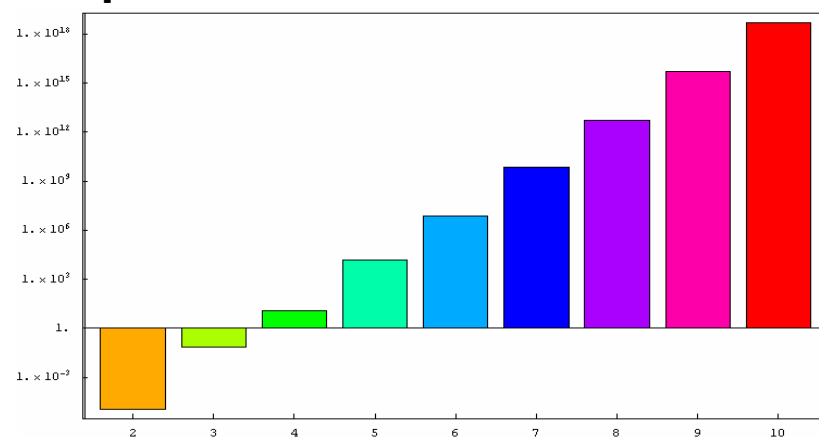
TURTLE



ATF2 : Tolerances and Tuning Knobs



Field Tolerances – Individual Quads Multipole Errors



Field Tolerances – All Quads Multipole Errors

Simulations of orbit correction and tuning procedure to define the estimations of jitter, fast and slow errors for magnet position, roll, field errors.

Tolerances defined as an rms error that leads to a 2% increase in beam size or a 15% change in position; whichever leads to a tighter tolerance.

J. Jones's talk – BDIR workshop

ATF2 proposal : Section 3.2

CARP ELAN meeting, CERN 24/1/05

1. 2 Beam Transport Simulations and Backgrounds

(Daresbury, Manchester, QMUL, RHUL; CERN, DESY, SLAC...)

Aim: develop core group with underpinning expertise in beam transport, background production and transport within integrated 'start to end' simulation framework:

linac -> BDS -> IP -> extraction line -> beam dumps

Critical issues:

ground motion + facilities noise modelling

**design of feedback systems for collision stabilisation
(also task 4.1)**

wakefield modelling (also task 5.3)

**beam halo production + tracking, location of diagnostics
(also task 2.1)**

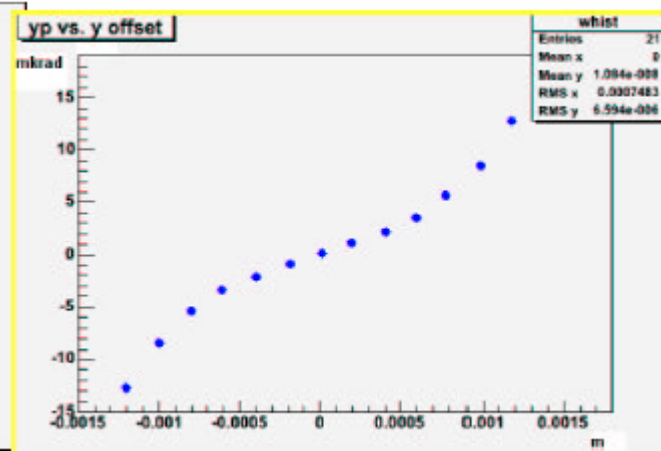
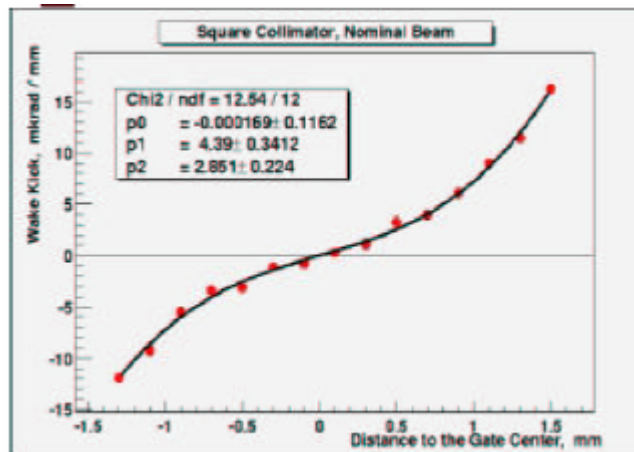
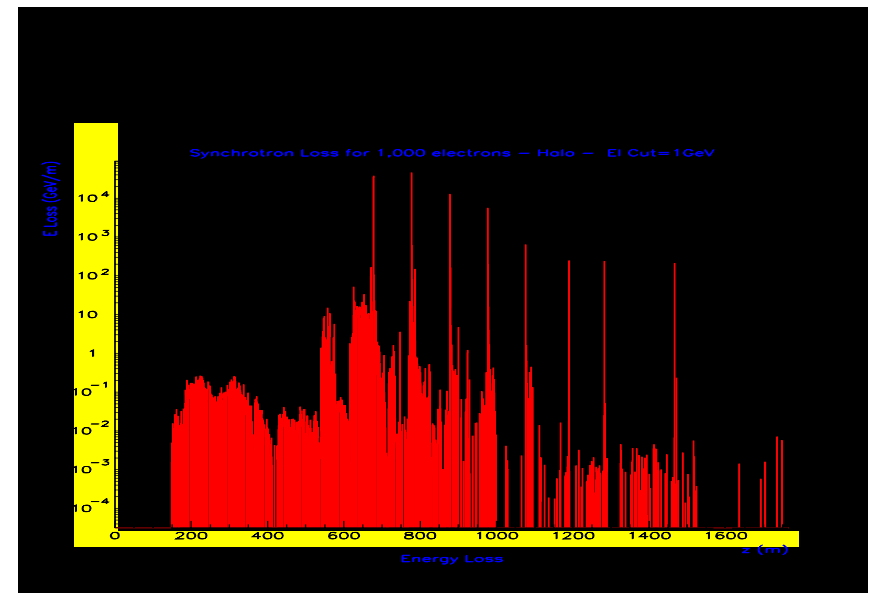
IR background modelling (also task 4.1)

Beam and halo tracking

QMUL high-
throughput
GRID cluster:
track 600 ILC
bunch
crossings:
0.5M cpuhrs!



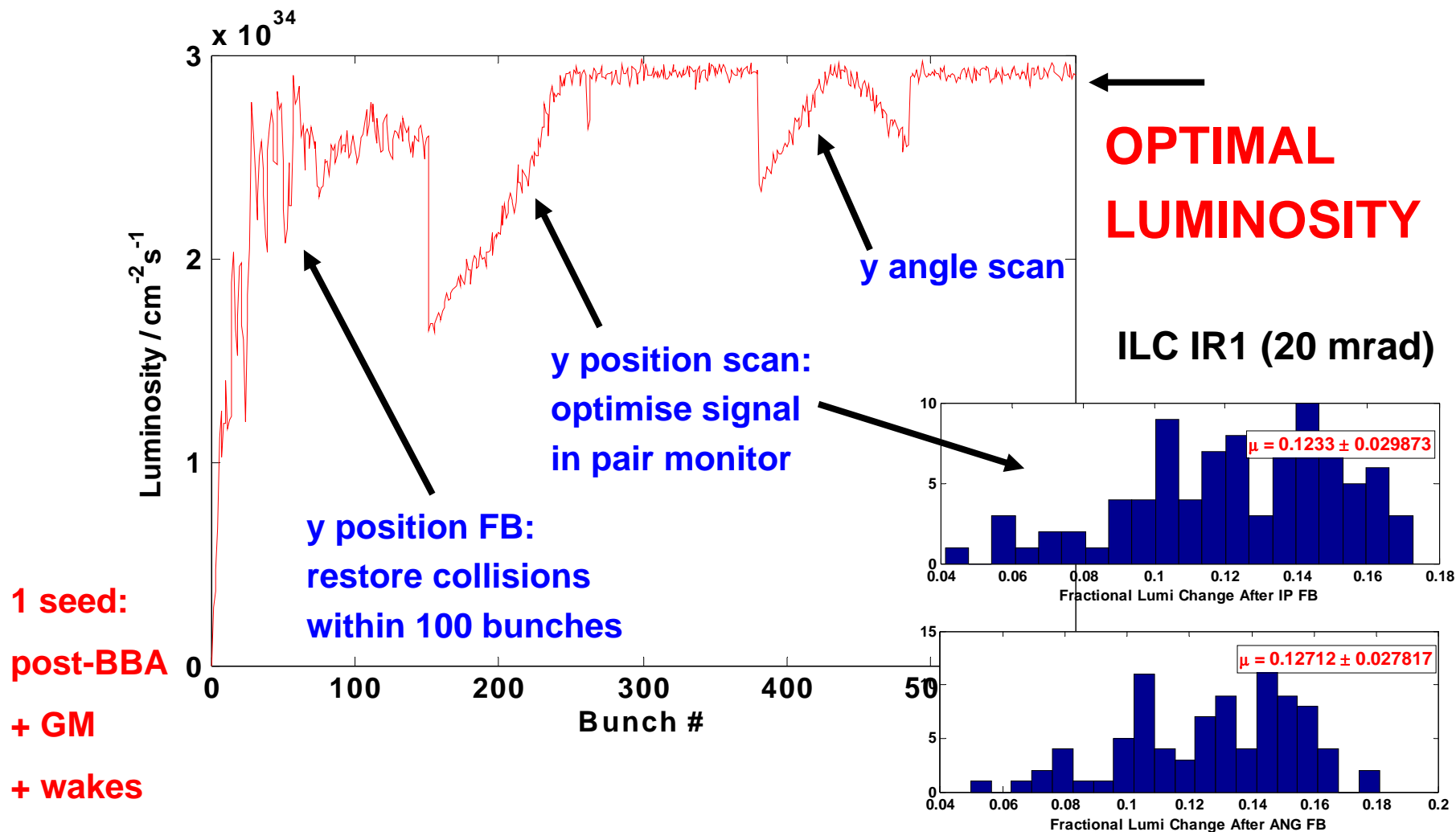
Halo energy deposition in BDS:



Wakefield kick angle
(MERLIN) up to
5th order

'ELAN Meeting, CERN 24/1/05

Intra-train feedback performance



ELAN BDYN beam transport code repository and collision simulation results database

<http://hepwww.ph.qmul.ac.uk/~white/accodes/codedeb.htm>



A table of available accelerator codes is shown below, click on the name of the code for detailed information and links to that code. A key describing the column headers is provided below the main table.

Please [email](#) with updates/revisions or suggestions.

Code	CV	OS	SA	SC	BB	BD	SP	PL
GUINEA-PIG	1.3	W,U	Y	C	Y	-	Y	-
CAIN	2.1e	W?,U	Y	F77	Y	-	Y	-
MERLIN / MATMERLIN	2.2	W,U	Y	C++	-	R	-	-
LIAR / MATLIAR	2.3	W,U	Y	F90	-	S,R	-	-
PLACET	0.81	U	Y	C	-	S	-	-
MAD(8.X)	X2.0	W,U	Y	C,F77&90	-	R	-	-
DIMAD	2.9	W,U	Y	F90	-	R	-	-
TRANSPORT	1.6	U,O	Y	F77	-	T	-	-
TURTLE	1.6	U	Y	F77	-	T	-	-
BDSIM	?	U	?	C++,GEANT4	-	R	Y	-
BRAHMS	?	U	?	F77,GEANT3	-	R	Y	-

Key:

- **CV**: Current production version.
- **OS**: Supported Operating System(s), **W**= MS Windows (NT,2000,XP), **U**= Unix / Linux, **O**=other (e.g. VMS, MacOS).
- **SA**: Source code Available? (**Y/N**). **\$**= Binaries only available at a cost.
- **SC**: Programming language of Source Code.
- **BB**: Code is used to simulate Beam-Beam interactions.
- **BD**: Beam Dynamics incorporated. **S**= slice tracking, **R**=ray tracing, **T**=Transport matrix calculation only.
- **SP**: Code can model secondary particle production and tracking.
- **PL**: Code is of type used for laser-plasma accelerator models.

<http://hepwww.ph.qmul.ac.uk/lcdata/>

LC Simulation Data Repository - Microsoft Internet Explorer

Address: <http://hepwww.ph.qmul.ac.uk/lcdata/pl+nm+gp.php>

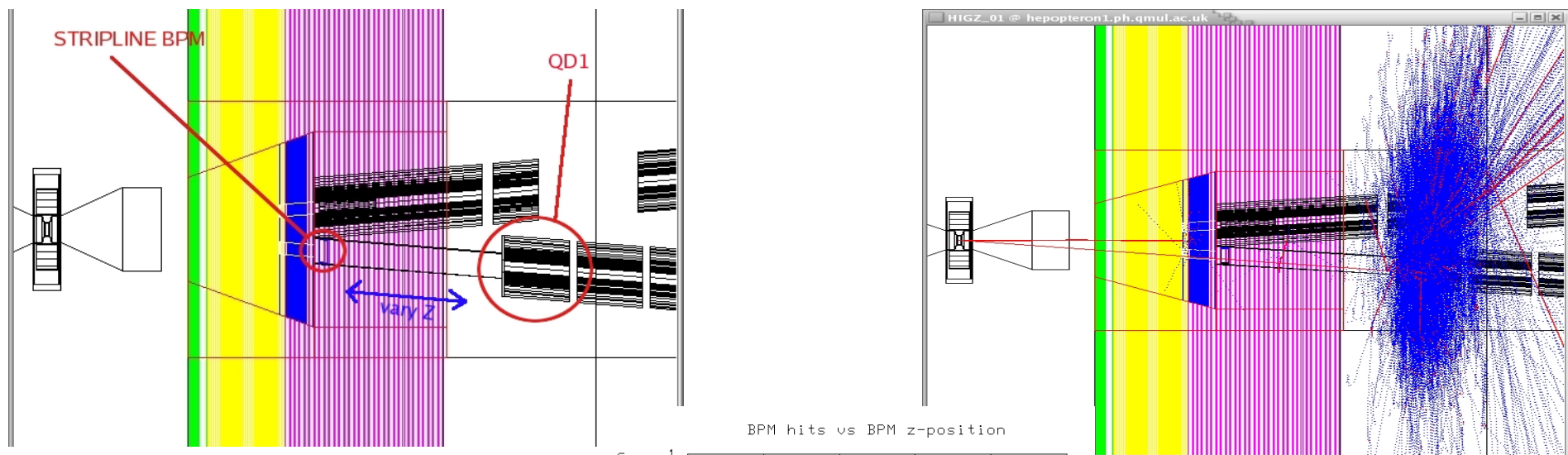
hadwgt	10000
jetwgt	10000
jitter	0
pairs_ratio	1
RALFILE	1

Choose data files to download for above choices: ([see here for details about files](#) or click on file description links).

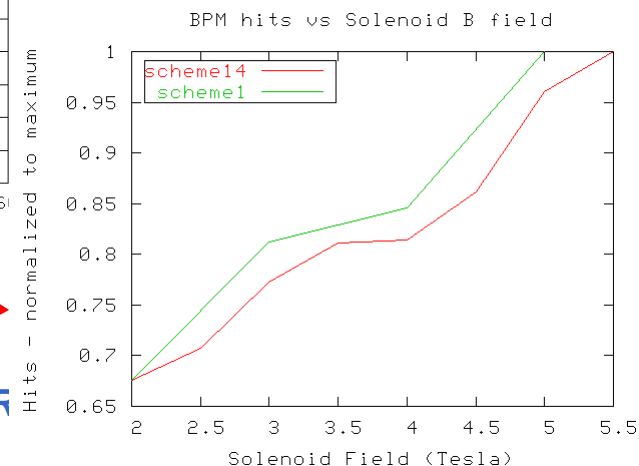
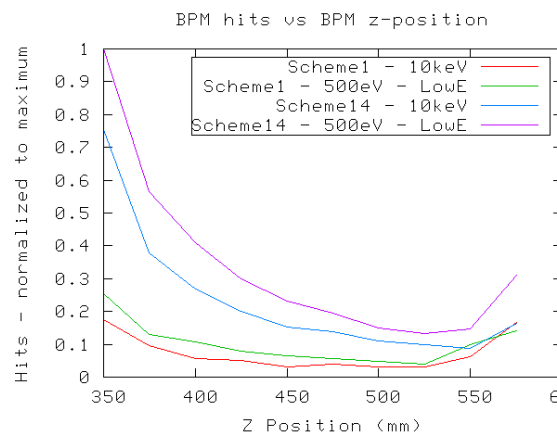
All files are zipped. Each zipped file contains one file per bunch that the simulation was run for. If a particular file is available for download, click on check mark in second column to start downloading.

File Description	File Download if Available
Beam at exit of Linac (PLACET) (e-)	X
Beam at exit of Linac (PLACET) (e+)	X
e- beam at IP pre-collision	X
e+ beam at IP pre-collision	X
e- beam at IP post-collision	X
e+ beam at IP post-collision	X
Background e+e- pairs	X
Background photons	X
Background hadrons	X
Minijets	X
Luminosity files	X
Simulation workspace variables	X
GUINEA-PIG input/output files	X

Background Environment for FB BPM (20 mrad)



Investigated:
 BPM z location
 EXT1 position
 Azimuthal effects
 L* + Detector B-field



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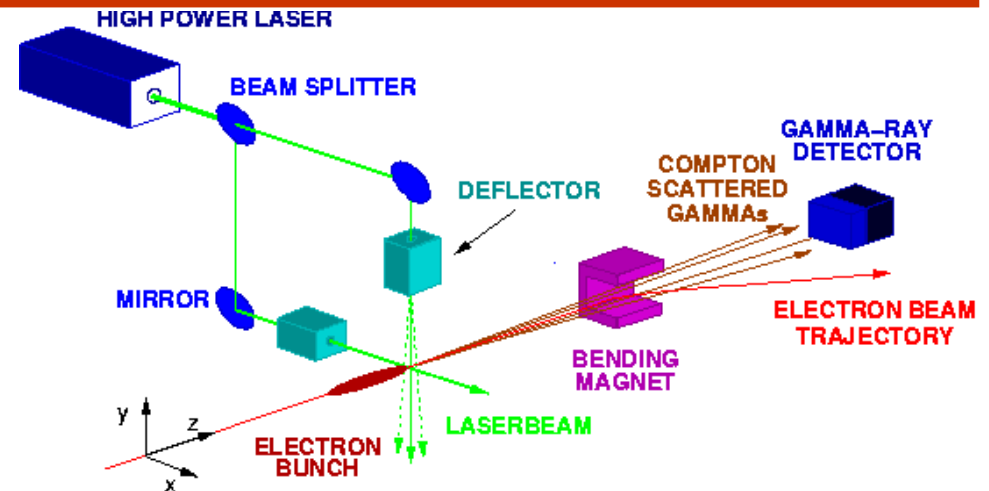
CAR

2. Advanced Beam Diagnostics

2.1 Laserwire (RHUL, Oxford, UCL; DESY, KEK, Kyoto, SLAC):

Ongoing collaboration on PETRA laserwire project
UK building laser scanning system (multidirection)
Simulations: halo backgrounds, diagnostics layout

Planning with KEK laserwire system for ATF extraction line



2.2 Bunch longitudinal profile (Dundee, DL, Oxford; FELIX, SLAC):

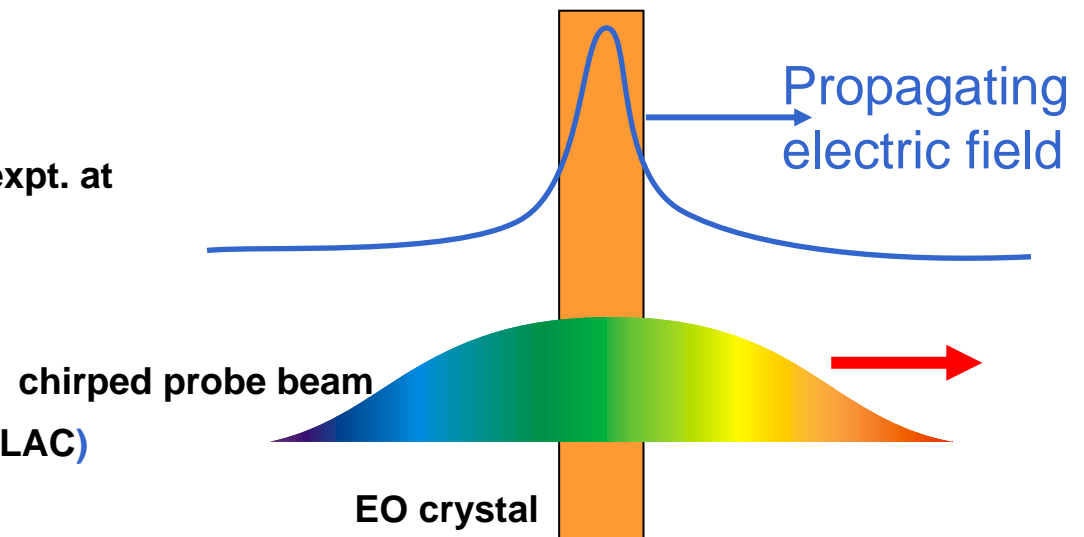
Very successful electro-optic bunch length expt. at FELIX

R&D on Smith-Purcell radiation bunch profile at FELIX

2.3 Polarisation (Durham, Liverpool; DESY, SLAC)

Spin transport code development

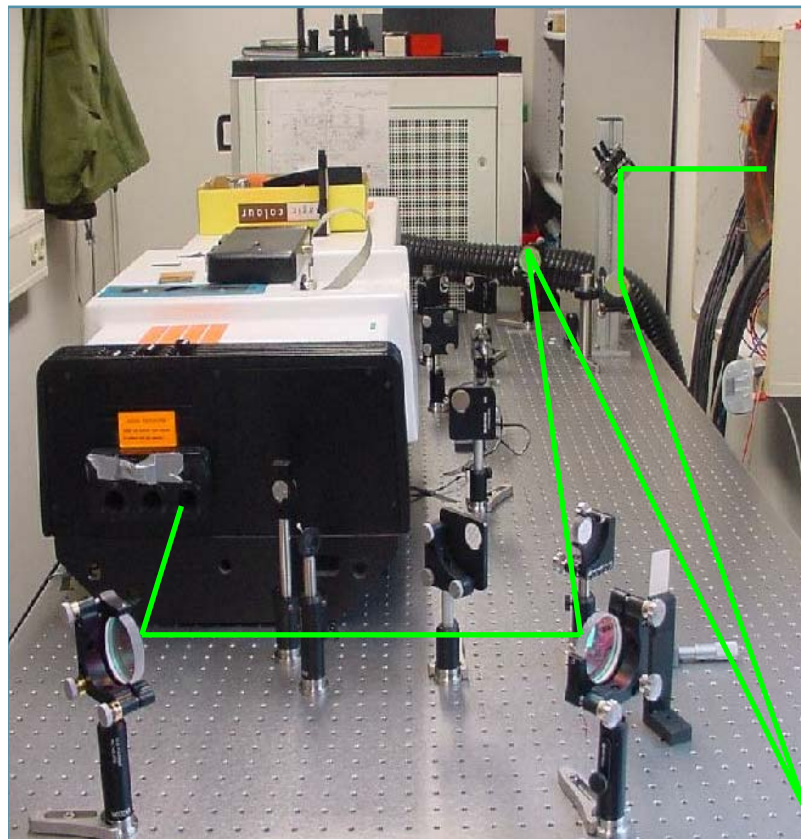
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CARE/ELAN Meeting, CERN 24/1/05

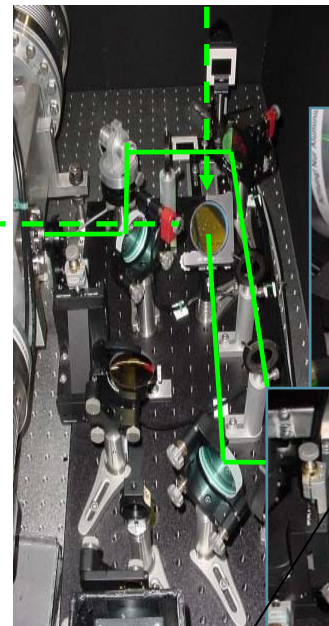
2.1 Laserwire: Current PETRA 1d-system

Built & shipped to DESY in 2003

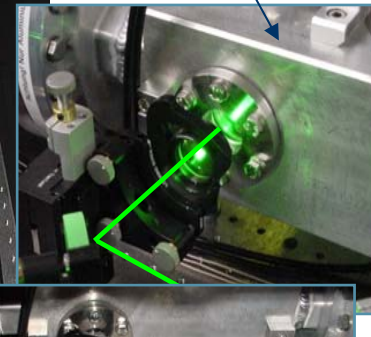


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In tunnel

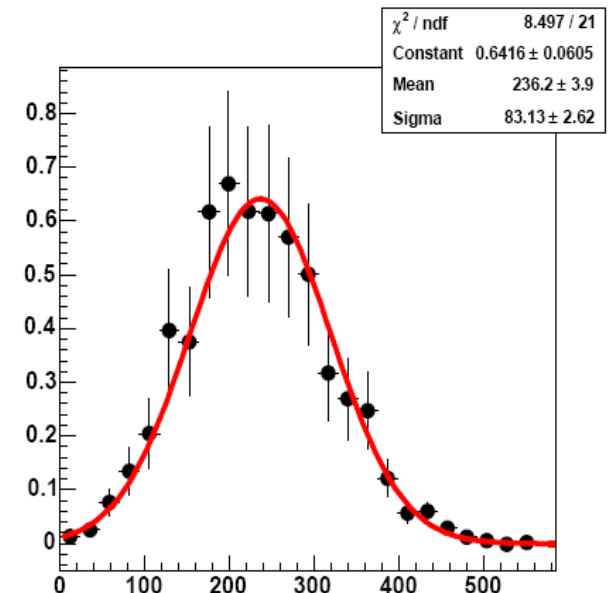


Vacuum chamber



Lens: LAP ($f=125\text{ mm}$)

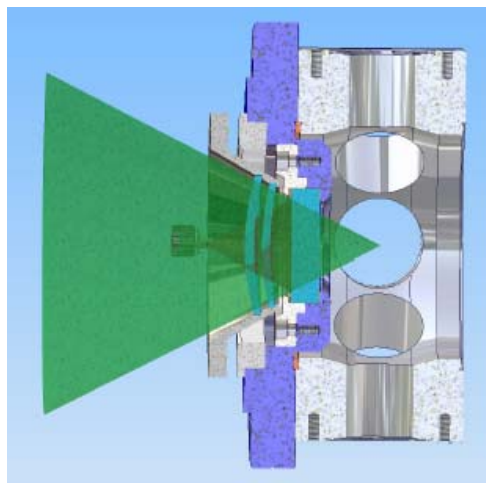
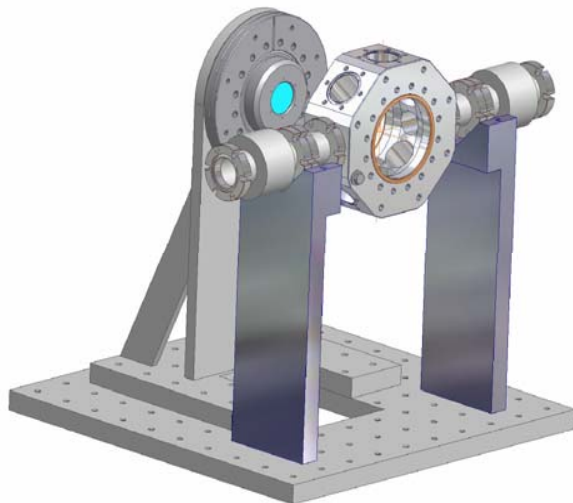
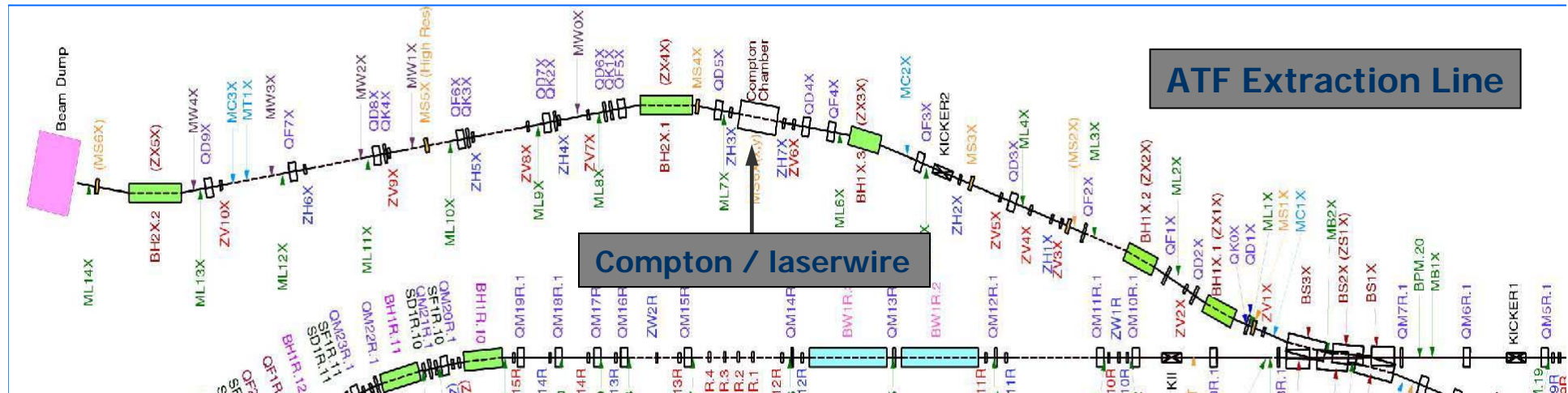
Scanner



CA

Laser-wire at ATF/ATF2

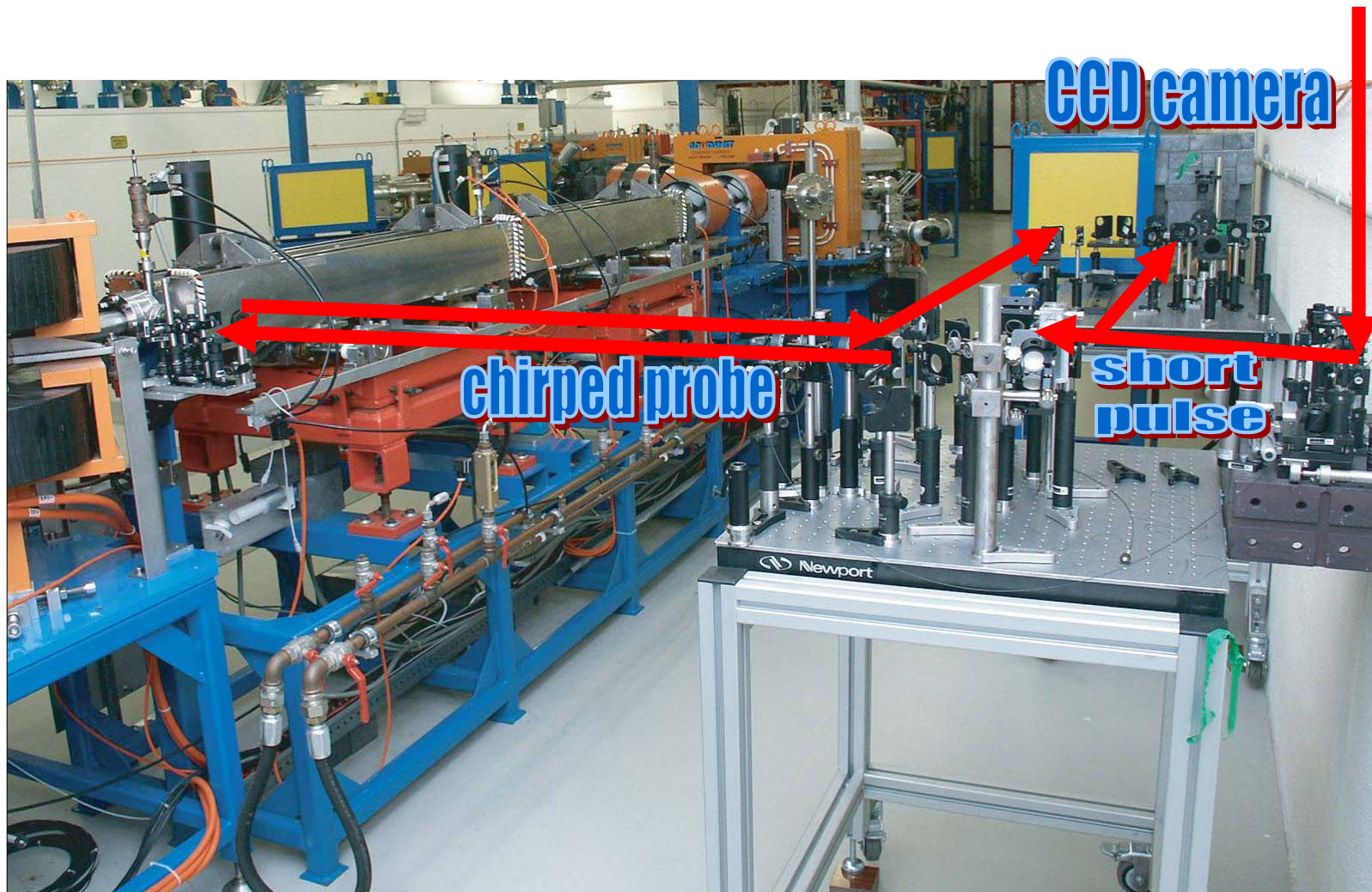
Purpose : Measure micron-scale electron spot sizes
($\sigma_y = 1 \mu\text{m}$ & $\sigma_x = 10 - 100 \mu\text{m}$)



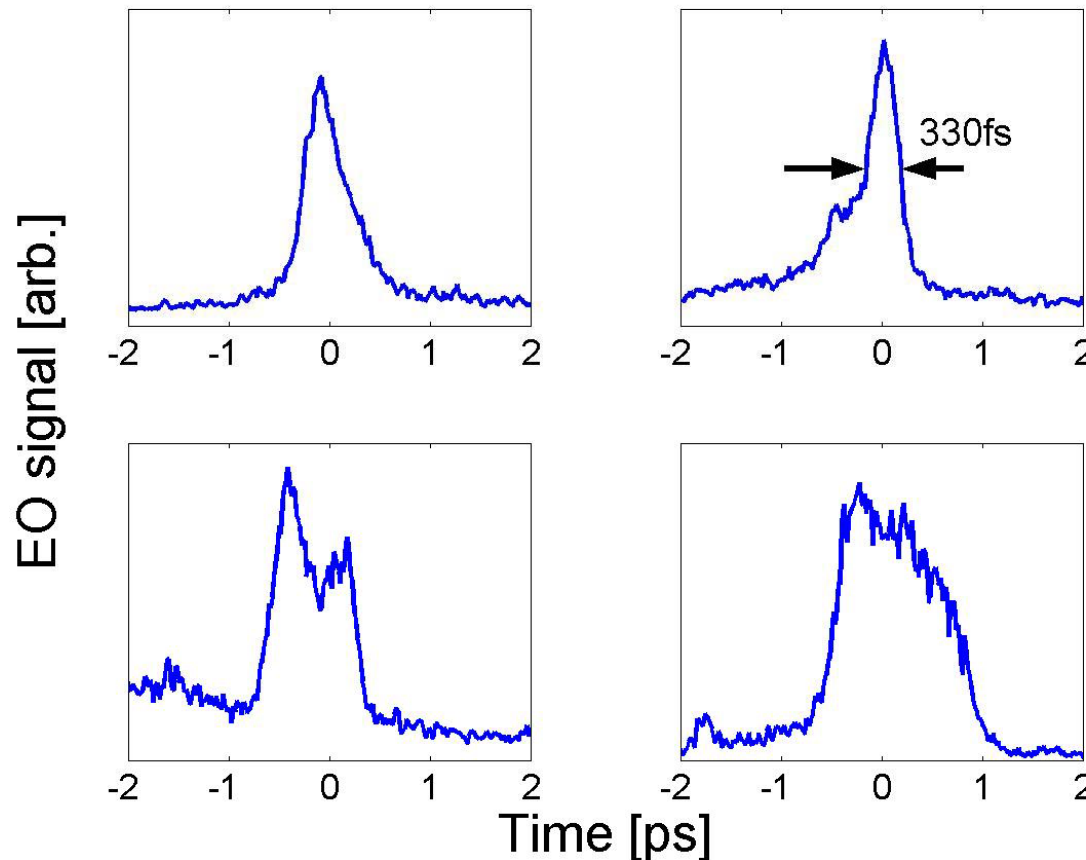
**Installation started
October 2005
First beam tests
December**

CARE/ELAN Meeting, CERN 24/1/05

2.2 Bunch z-profile measurement: EO technique (DL, Dundee, FELIX, SLAC)



Bunch z-profile measurements



Bunch profile modified by changing the buncher and accelerator phase.

Aim: < 200fs resolution, tests at FELIX + SLAC/ESA

2.2 Bunch z profile measurement: Smith-Purcell technique (Oxford, FELIX)

Array of 11 far-infrared pyroelectric detectors: simultaneous detection of the radiated power over a wide range of wavelengths.

Runs at FELIX November 04, January 05

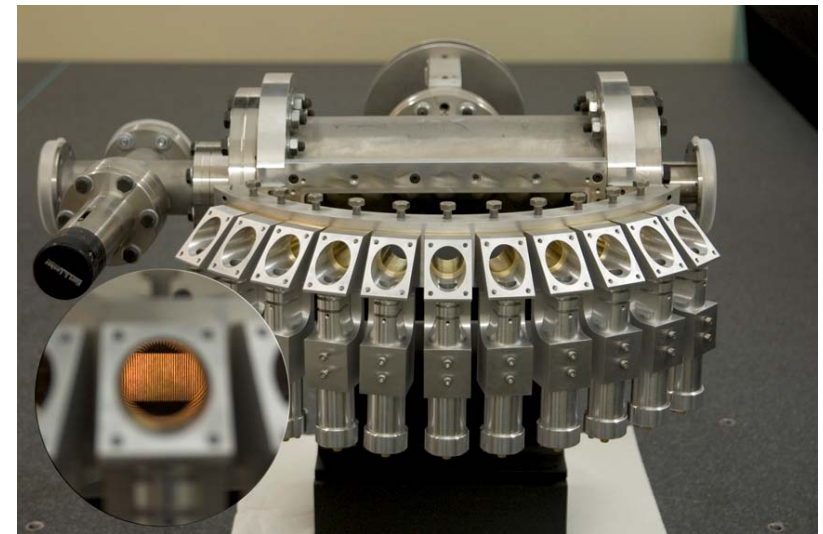
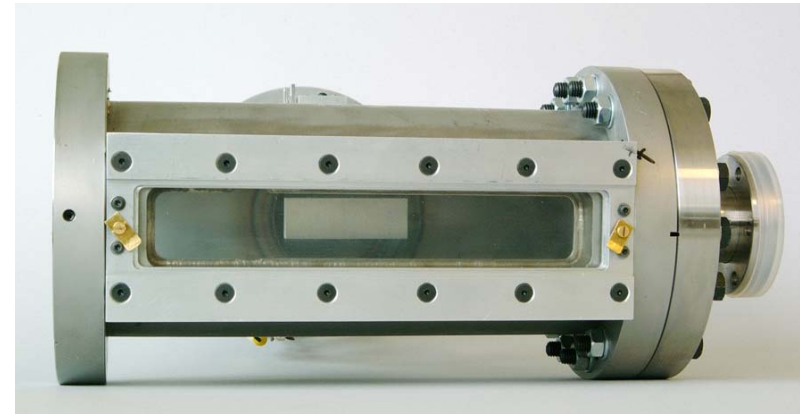
Pyroelectric detector + electronics worked well; background issues (upstream diffraction radiation?)

Grating carousel for backgrounds study

Winston cone light collection, better filtering

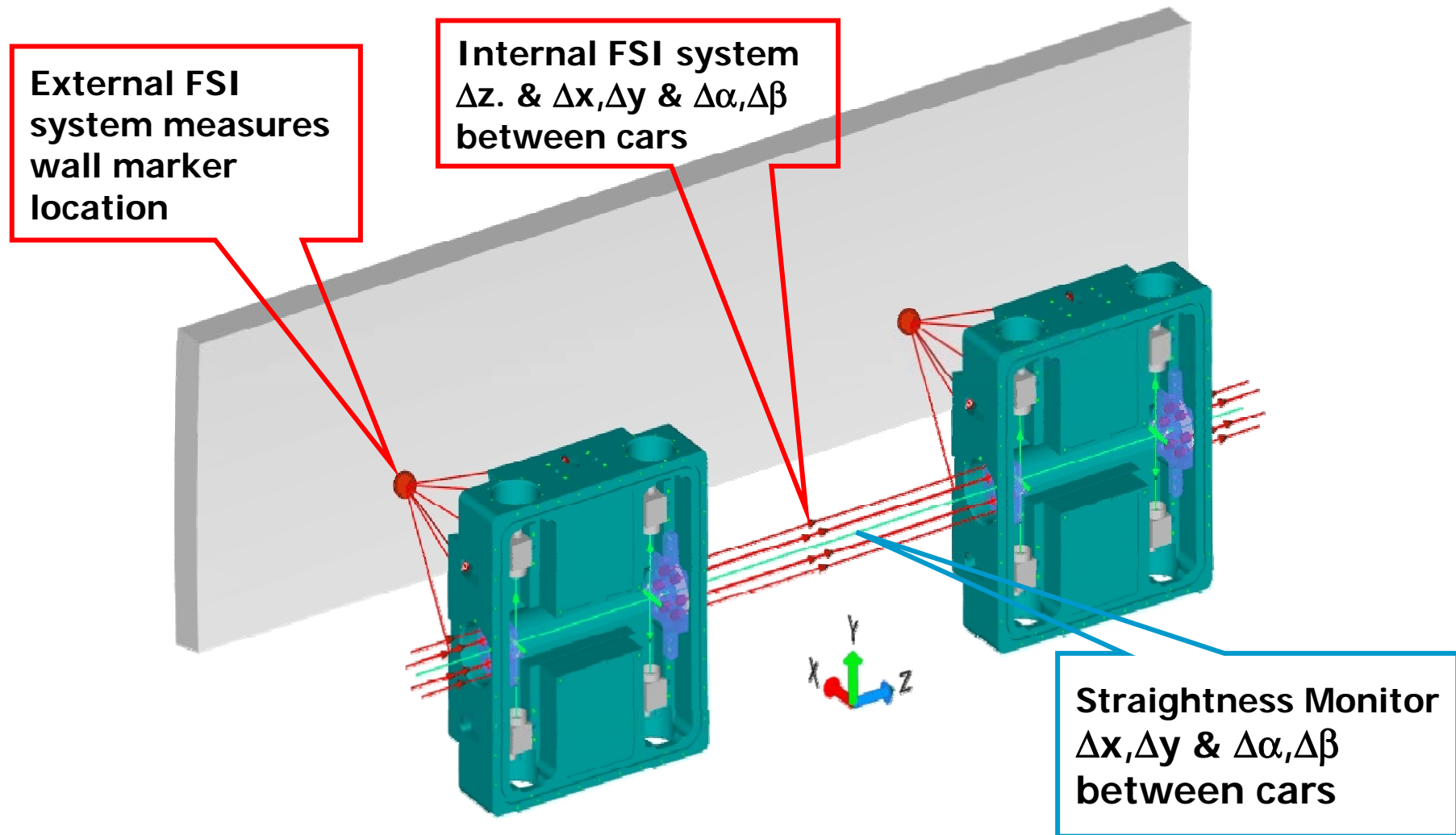
Further beam tests at FELIX + SLAC/ESA

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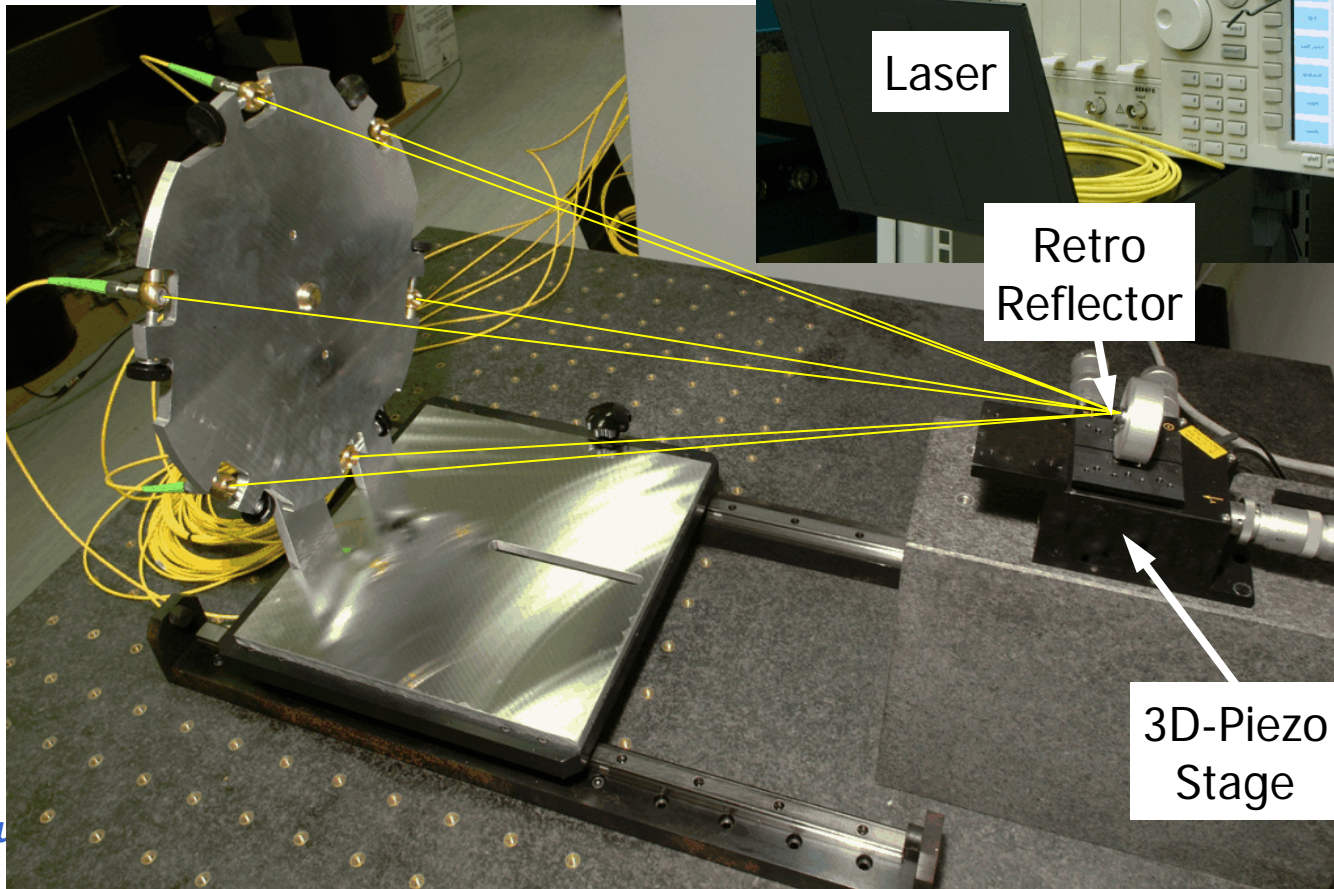
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3. Alignment and Survey (LiCAS) (Oxford, DESY, Warsaw)

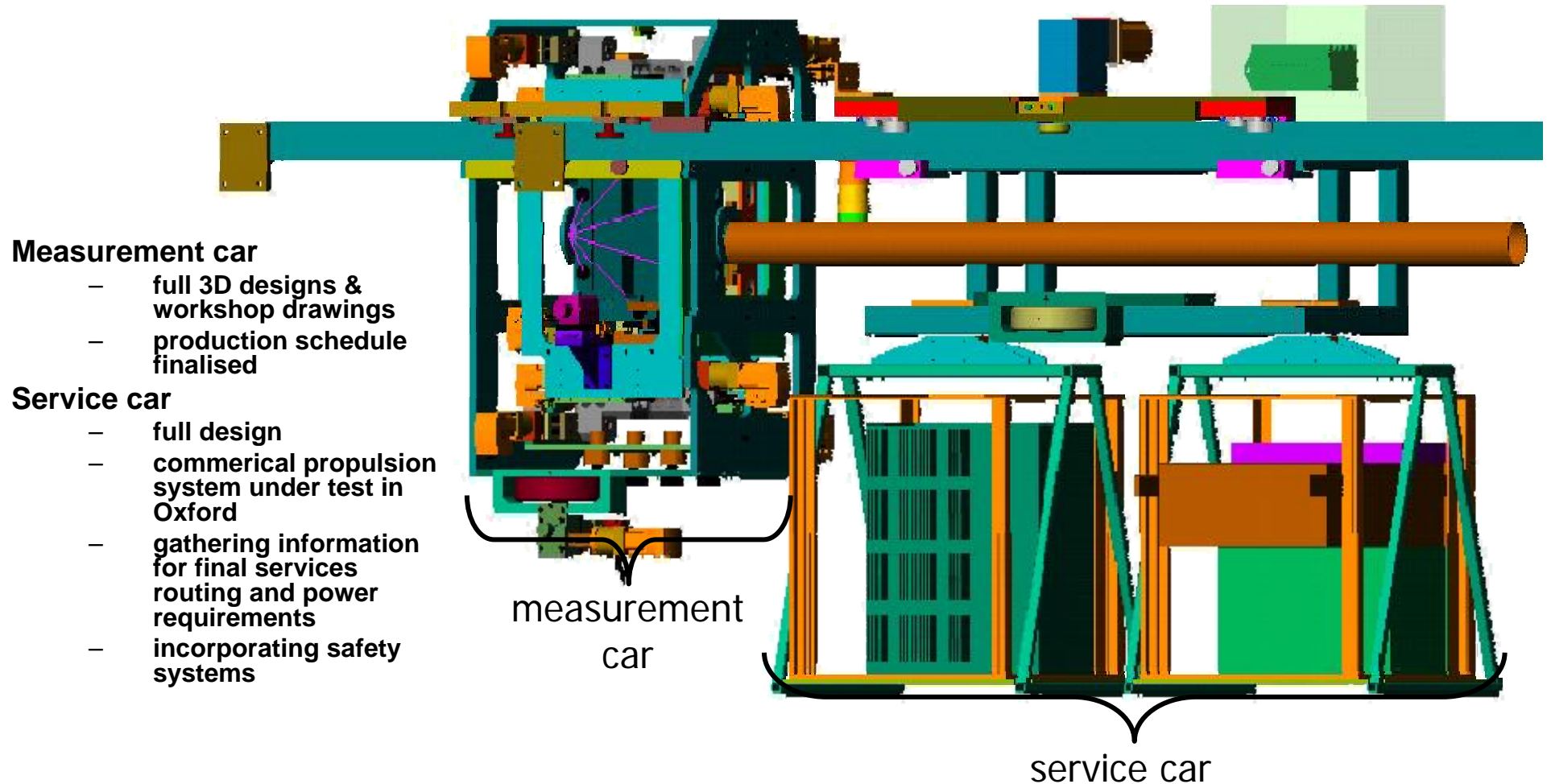


FSI Prototype

Short 6-line FSI system for 3D wall marker measurement works without collimation optics



Rapid Tunnel Reference Surveyor Mechanics



Tunnel preparation

60m long service tunnel at DESY

tunnel tests showed walls stable enough

installing high speed WLAN

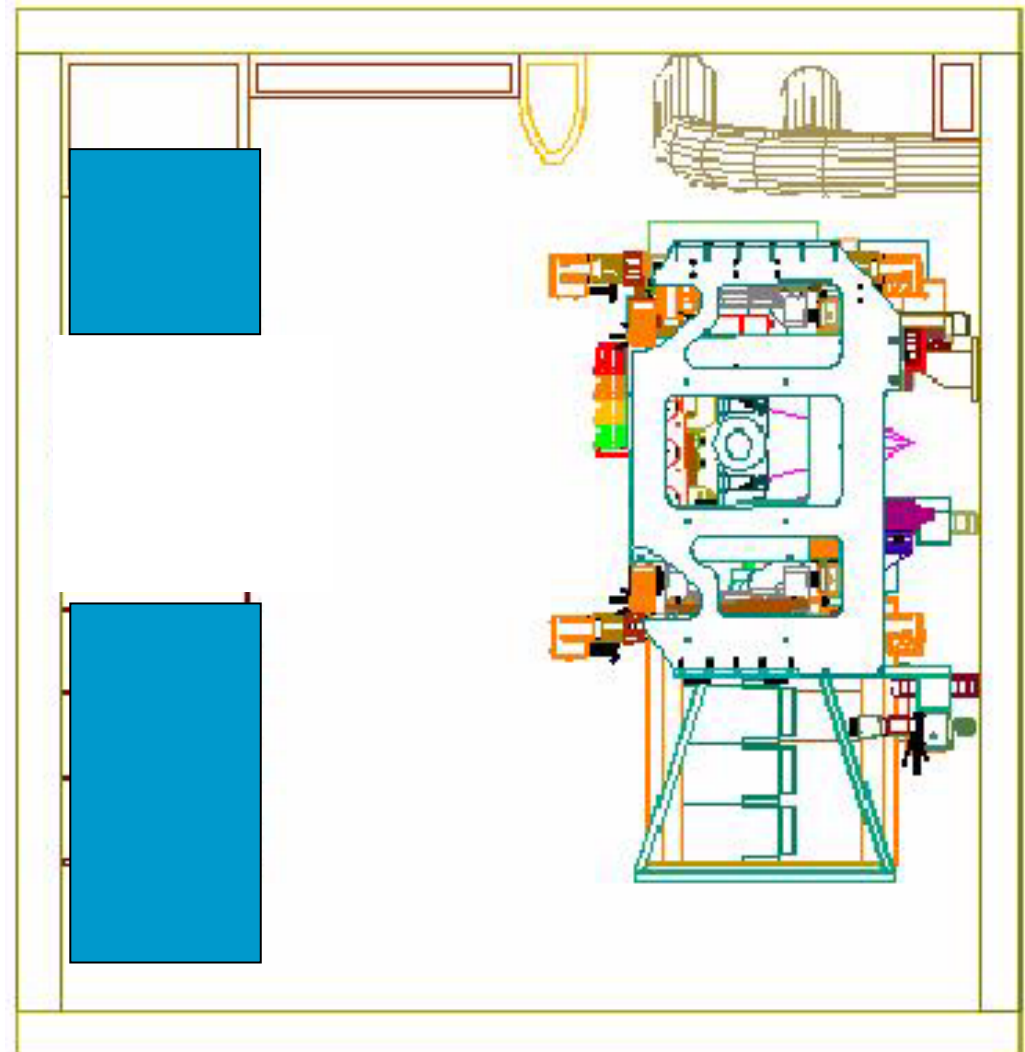
installing more interlocks and safety measures

ready for use well before RTRS prototype

Intend to deploy at XFEL



P

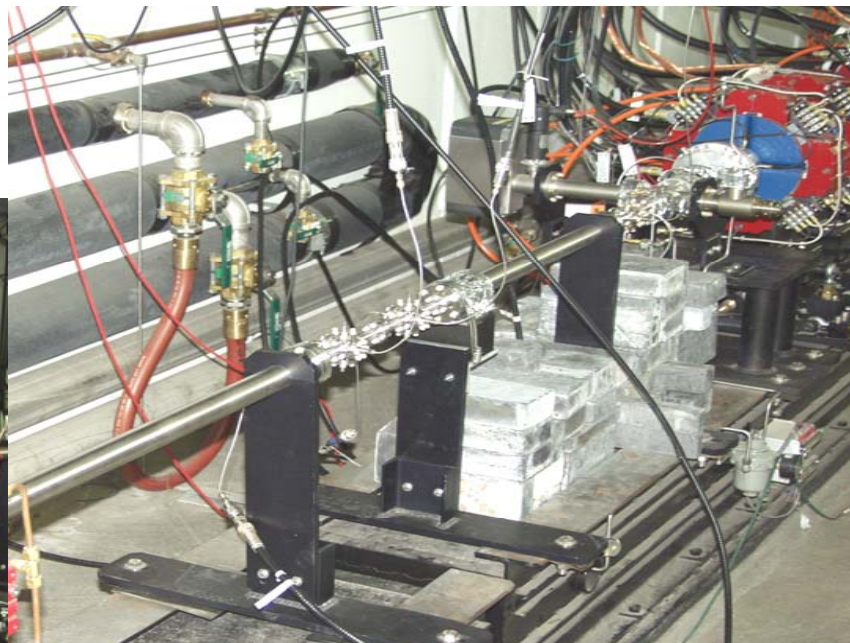
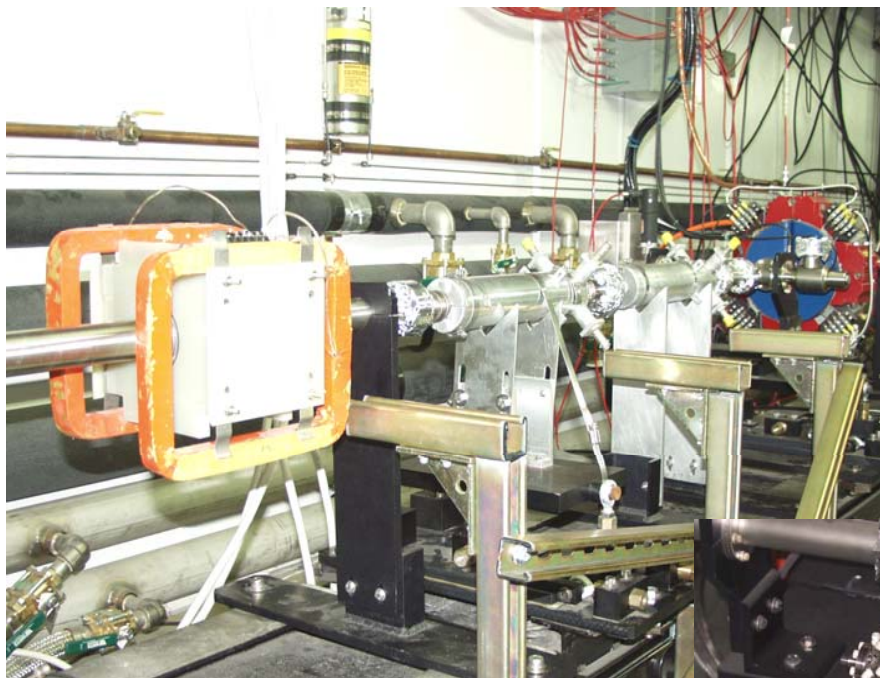


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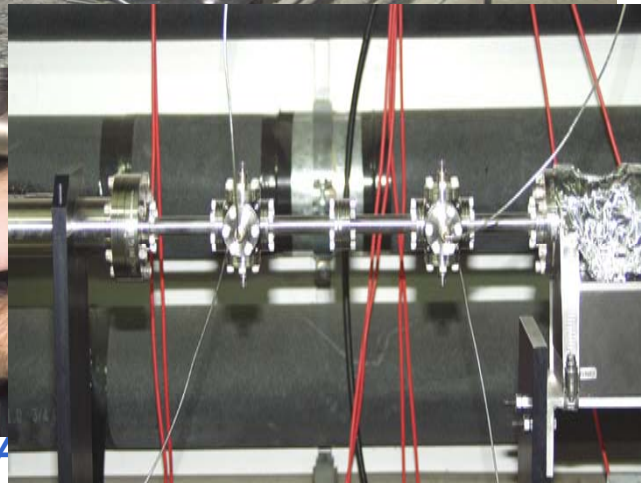
4.1 Development of beam-based FB system hardware (Daresbury, Oxford, QMUL, KEK, Kyoto, SLAC)

SLAC/NLCTA

Dipole and kickers



New BPMs



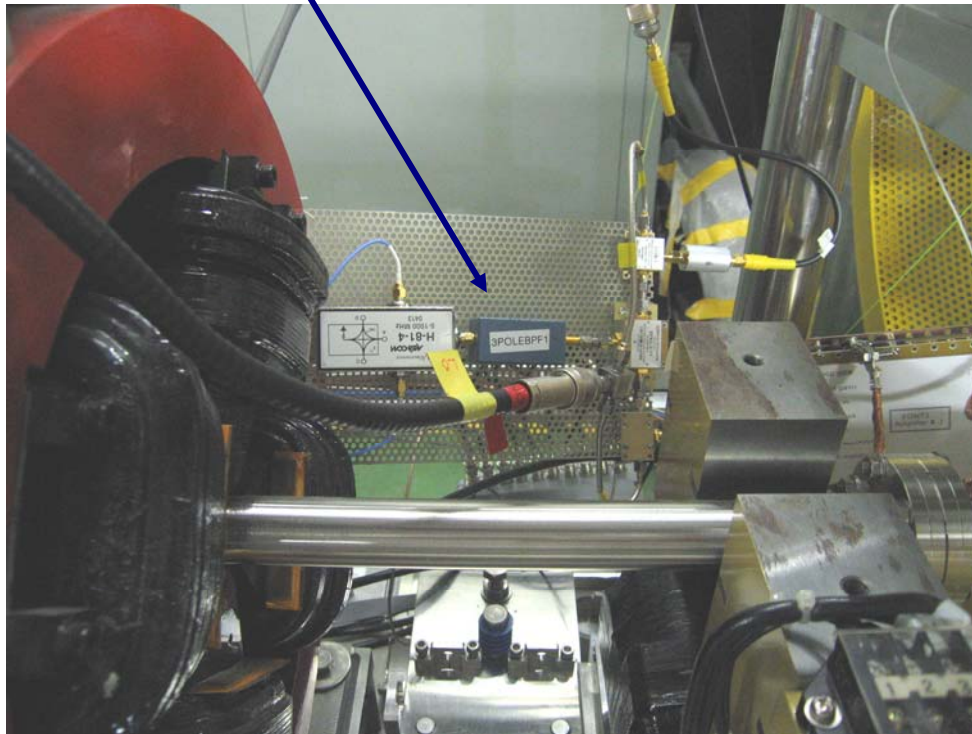
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CA

FONT3: beamline installation at KEK ATF

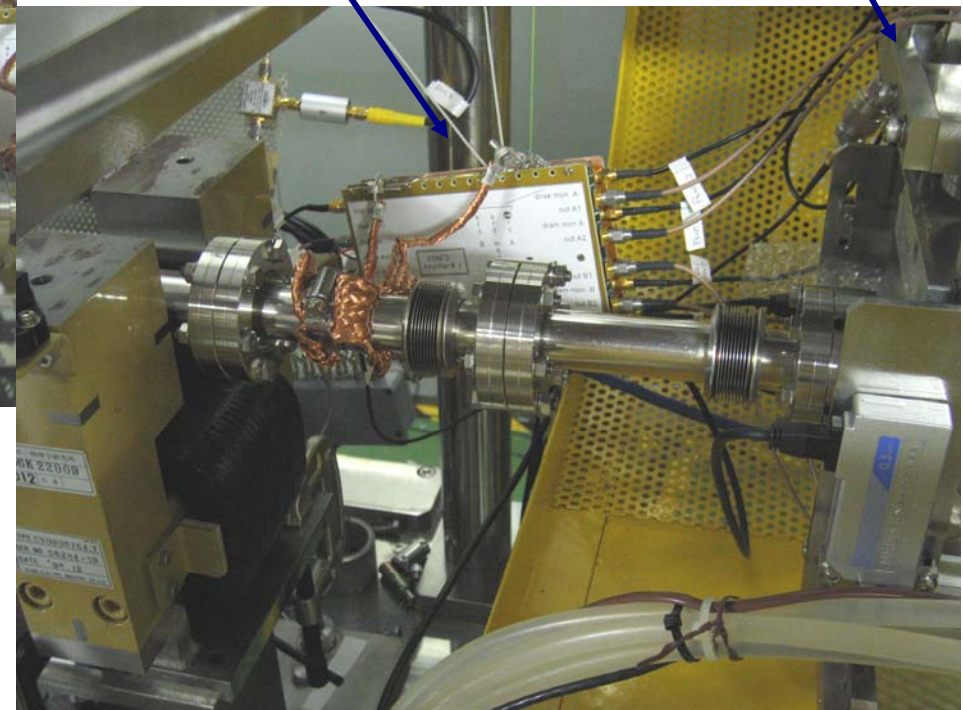
(1.3 GeV 56ns-long train @ 2.8ns spacing)

BPM processor board

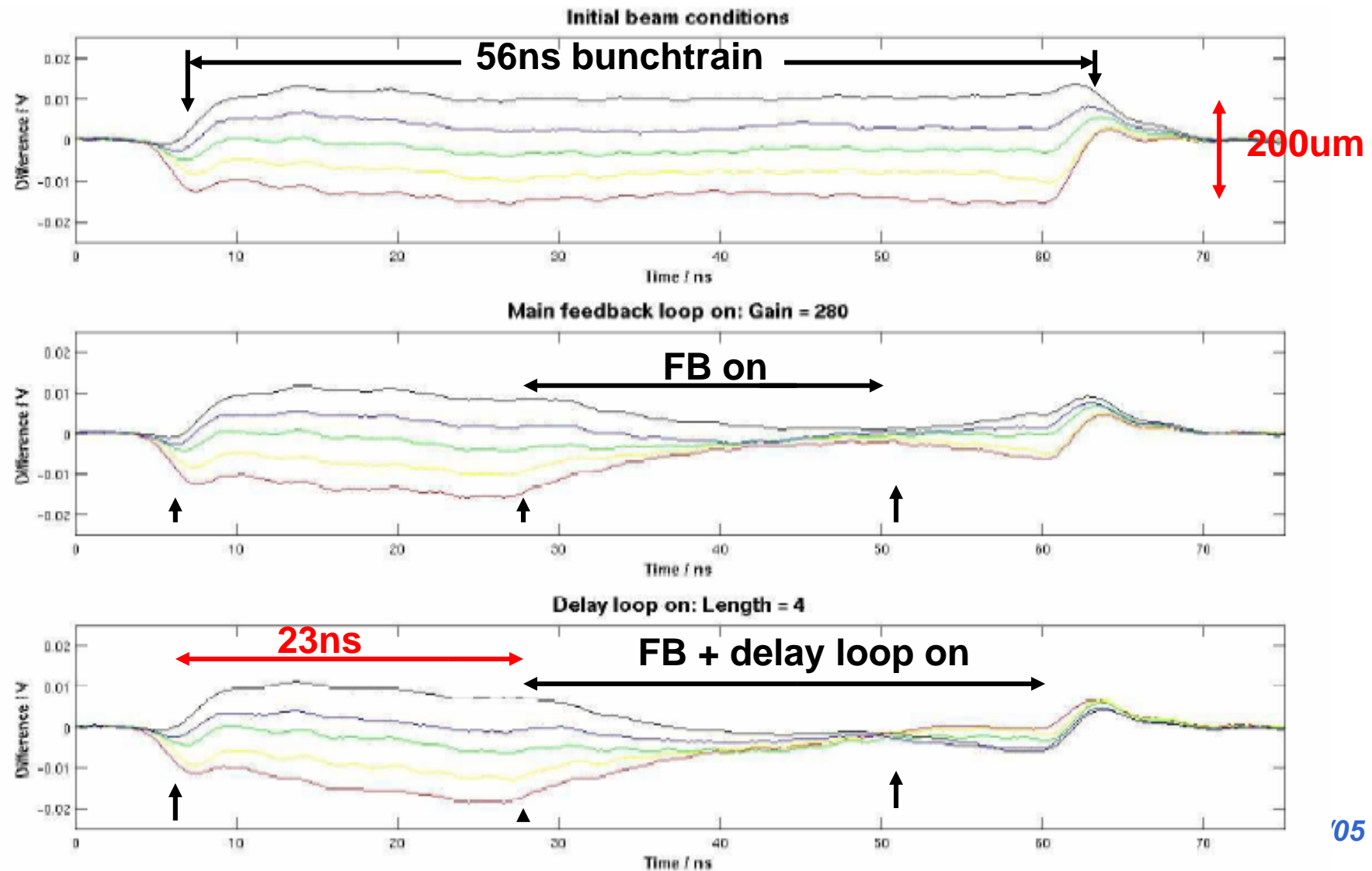


Amplifier/FB board

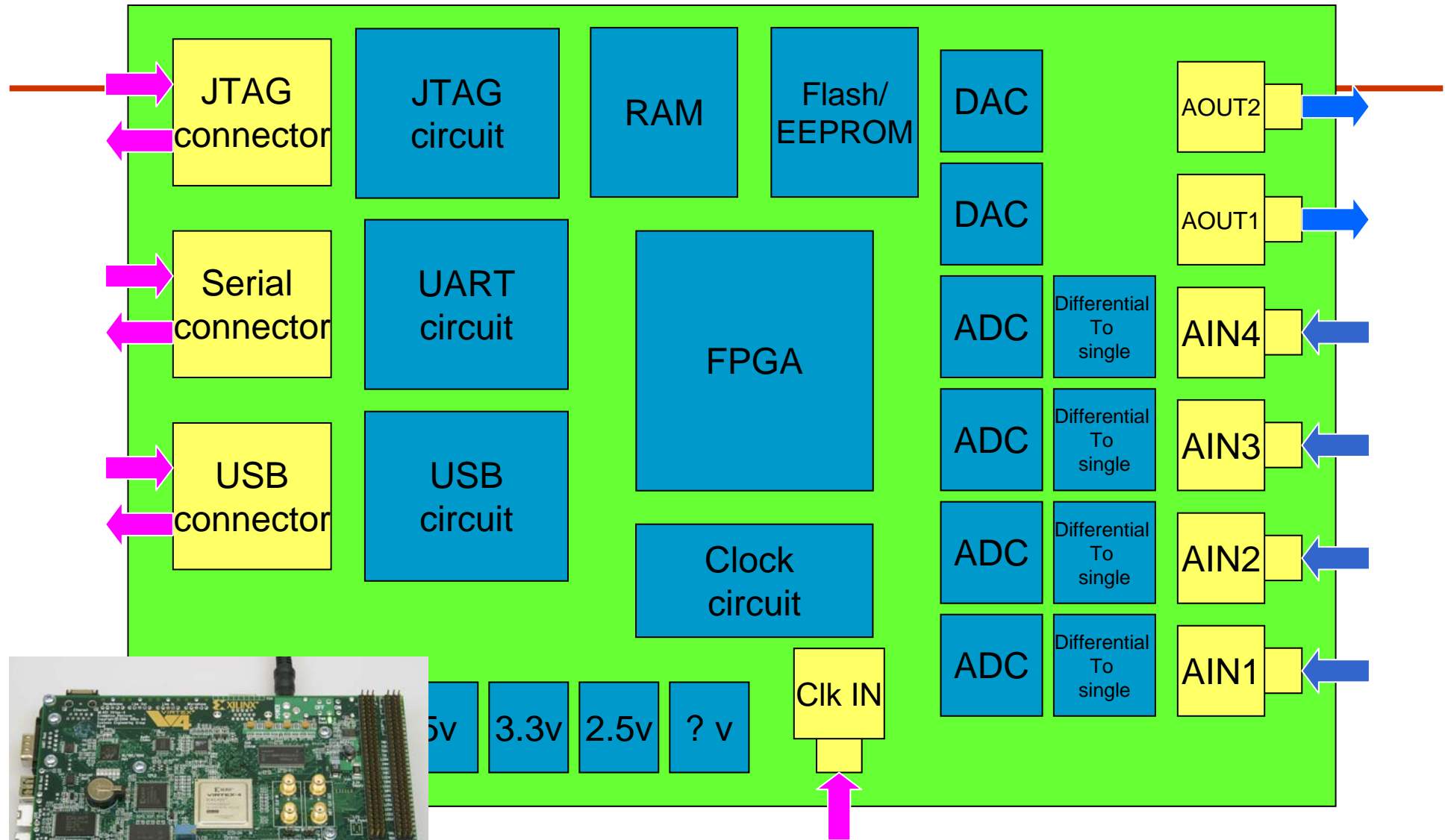
FEATHER
kicker



FONT3: Results (June 3 2005): Delay-loop feedback w. latency 23 ns



FONT4: Digital FB Processor Module



Latency goal 100ns

4.2 BPM/Spectrometry

(Daresbury, Cambridge, UCL, KEK, LBNL, LLNL, Notre Dame, Oregon, SLAC)

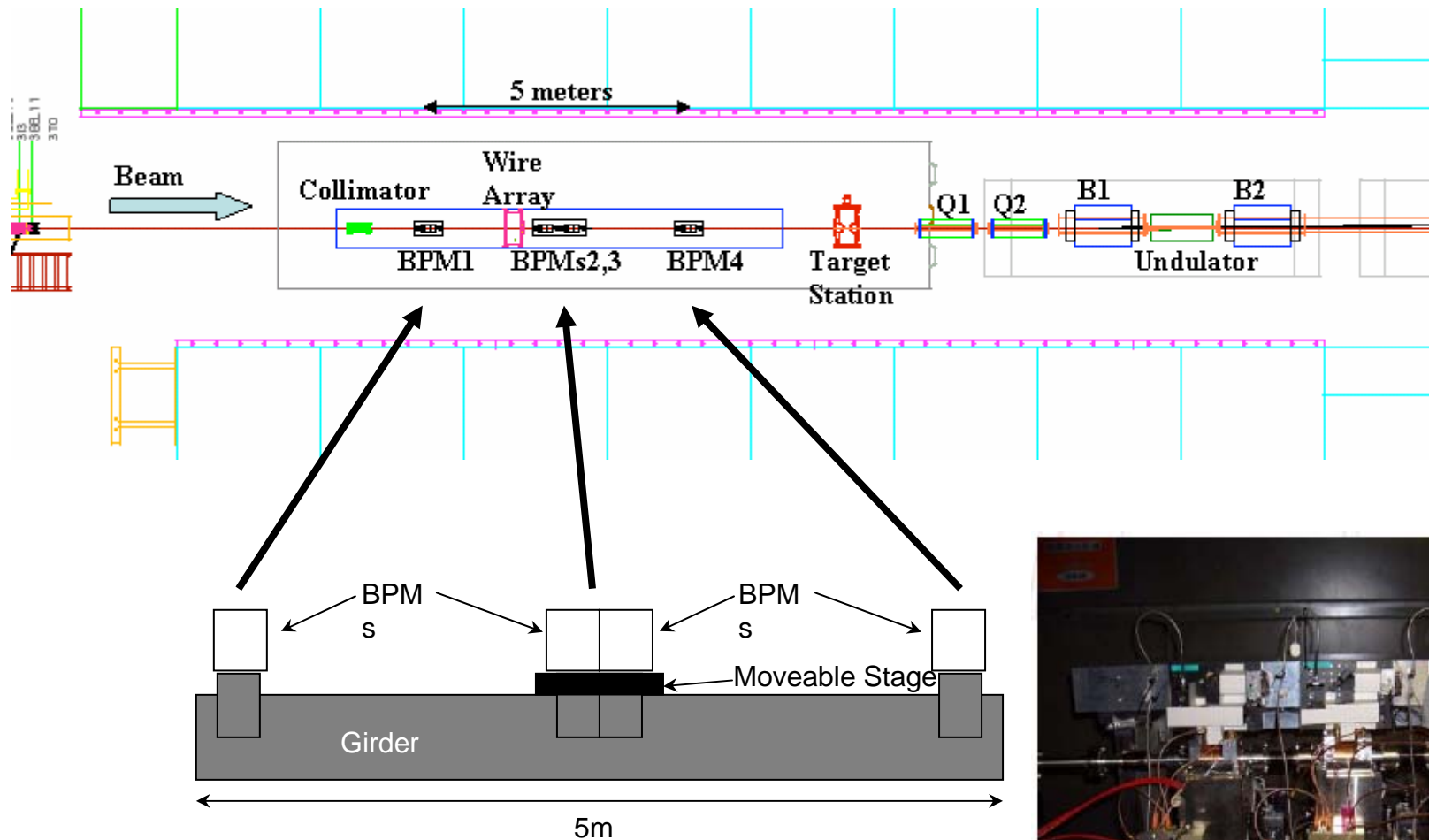
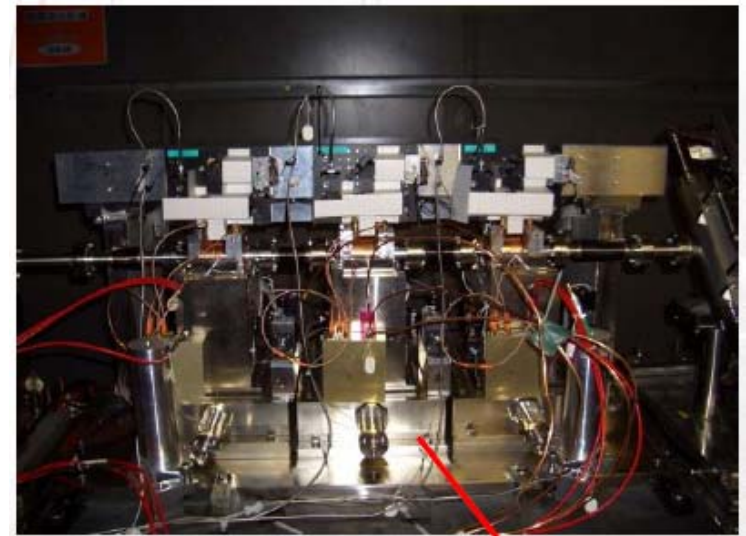


Figure 1. Sketch of the BPM girder and BPM locations.

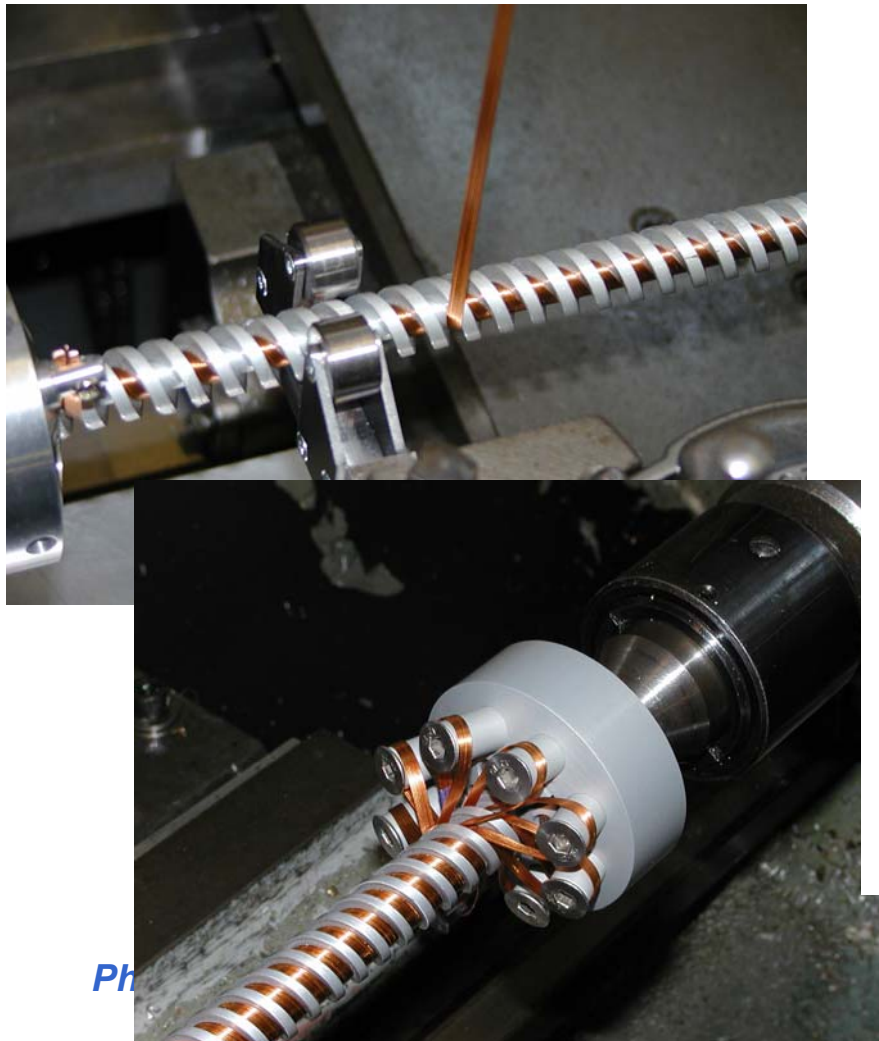
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5.1 Polarised positron source undulator

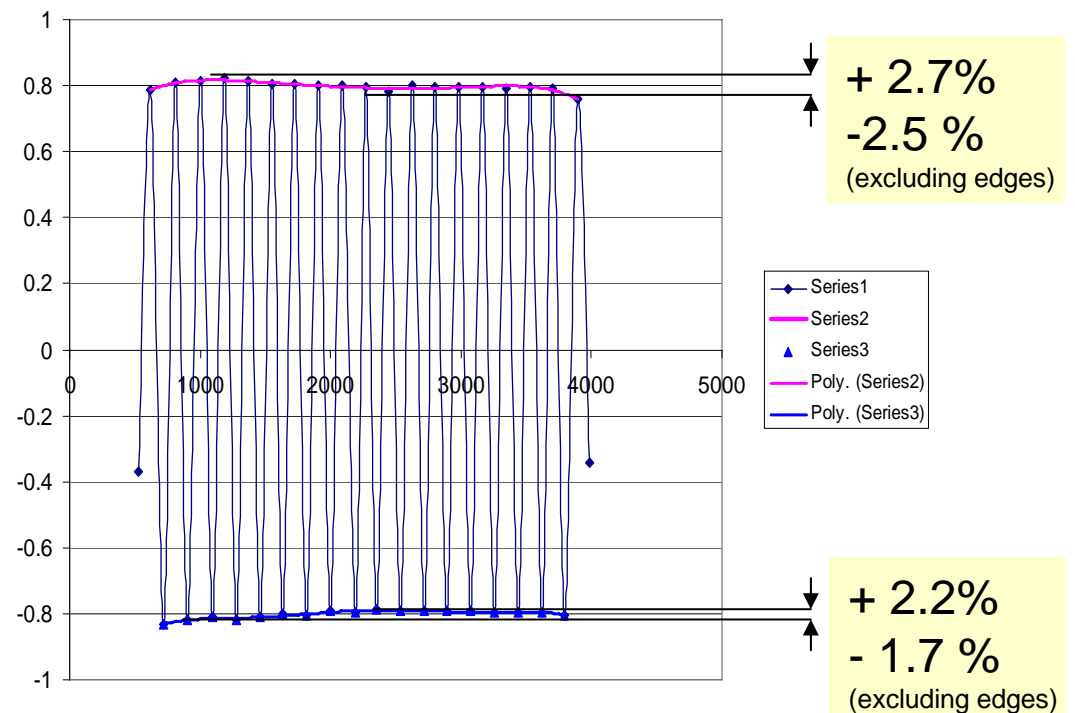
(Daresbury, Liverpool, RAL, DESY, SLAC et al)

Winding of superconducting prototype

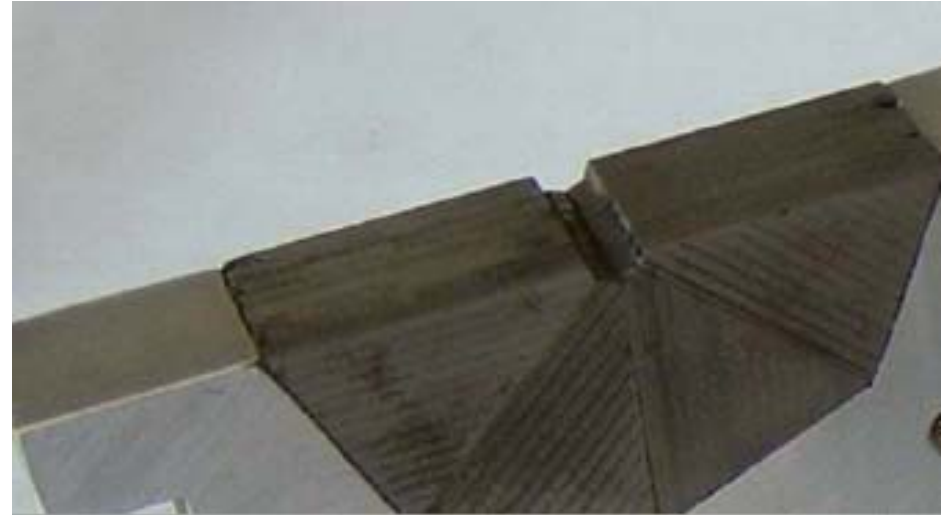
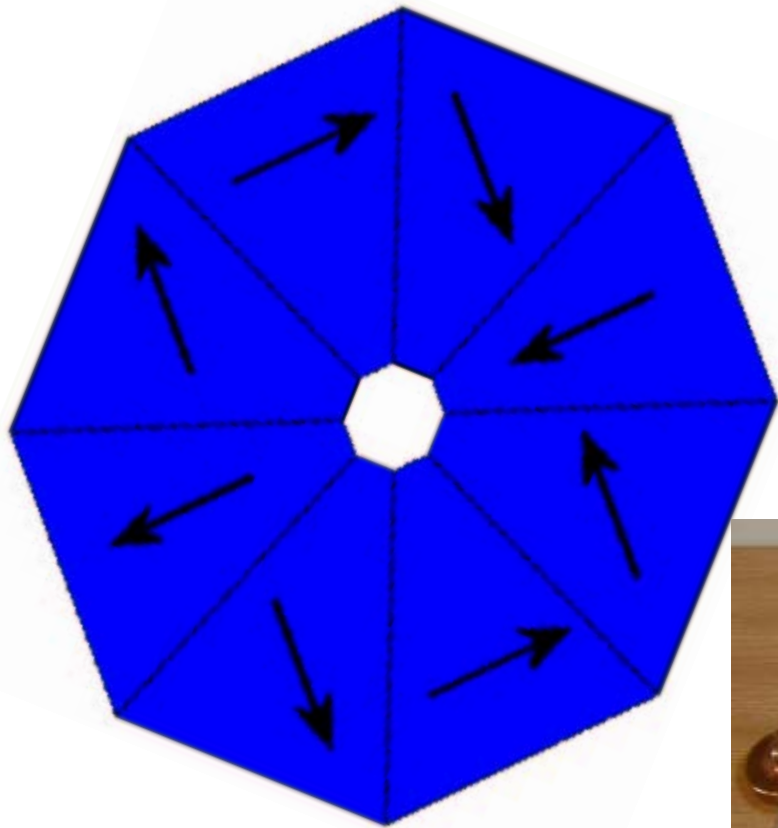


Cold tests at RAL:

Peak analysis

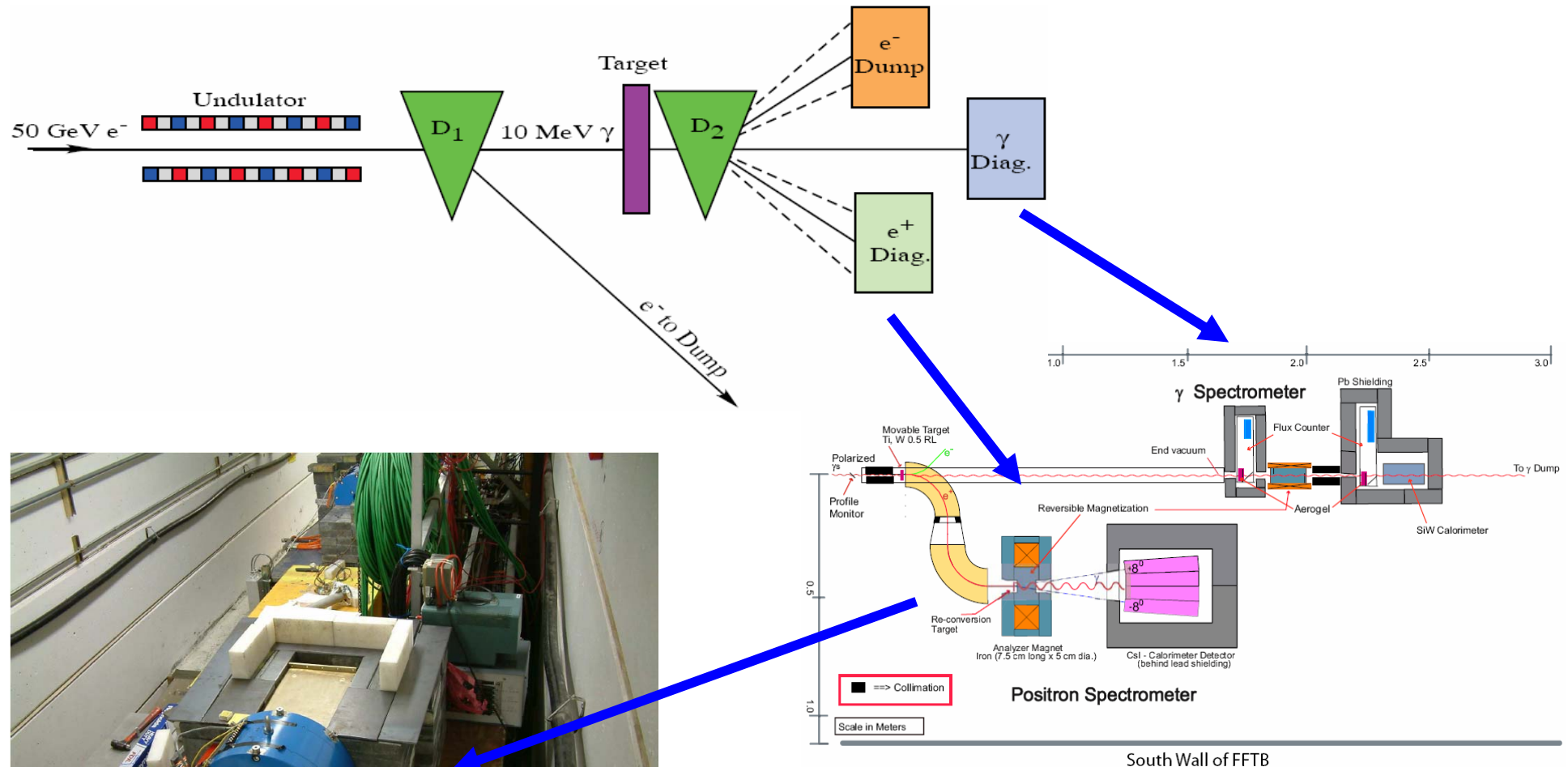


Novel PPM Design: Magnet Block Assemblies



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E166: First data, second run September 2005

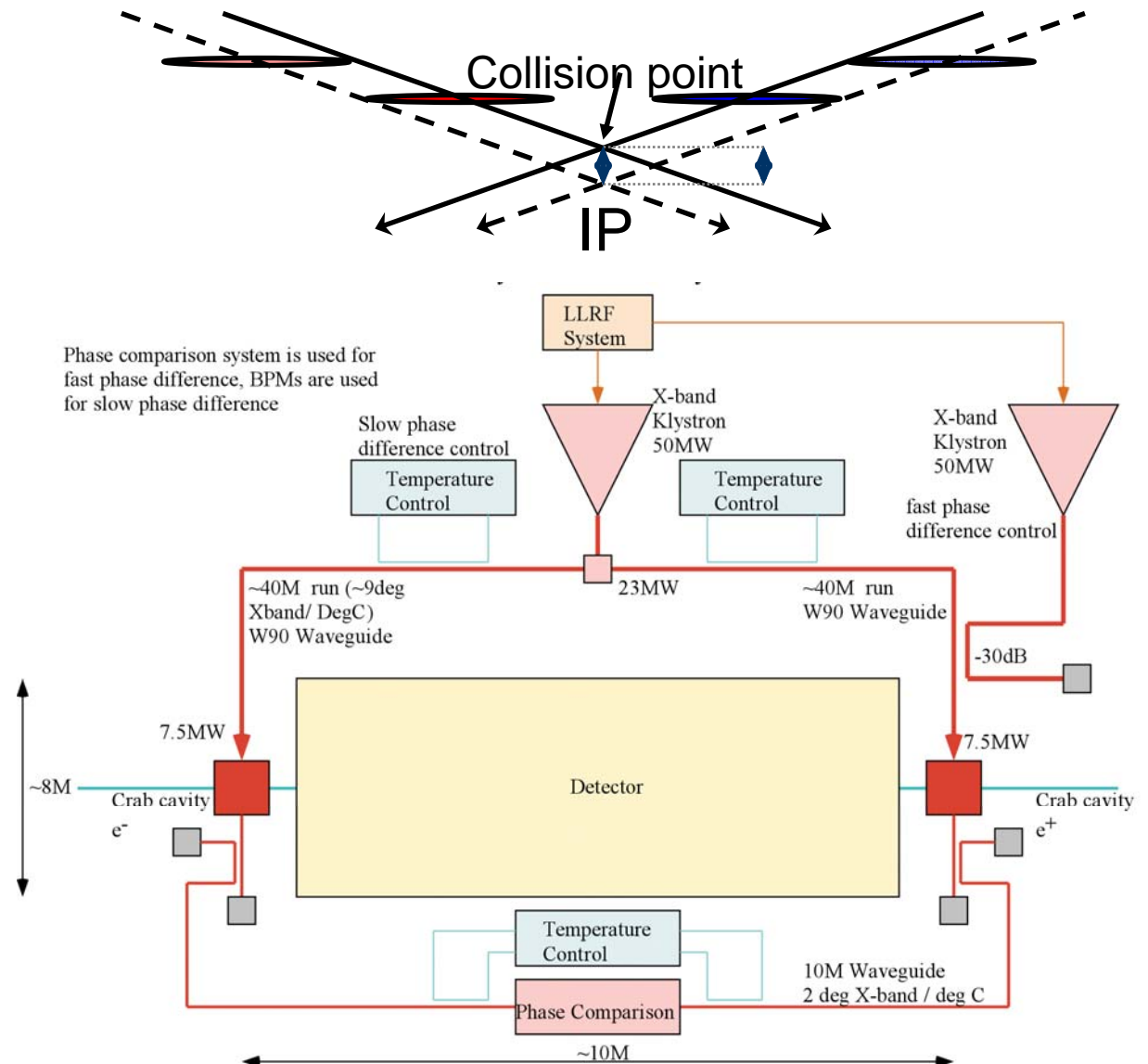


Pol. e^+ signal observed!

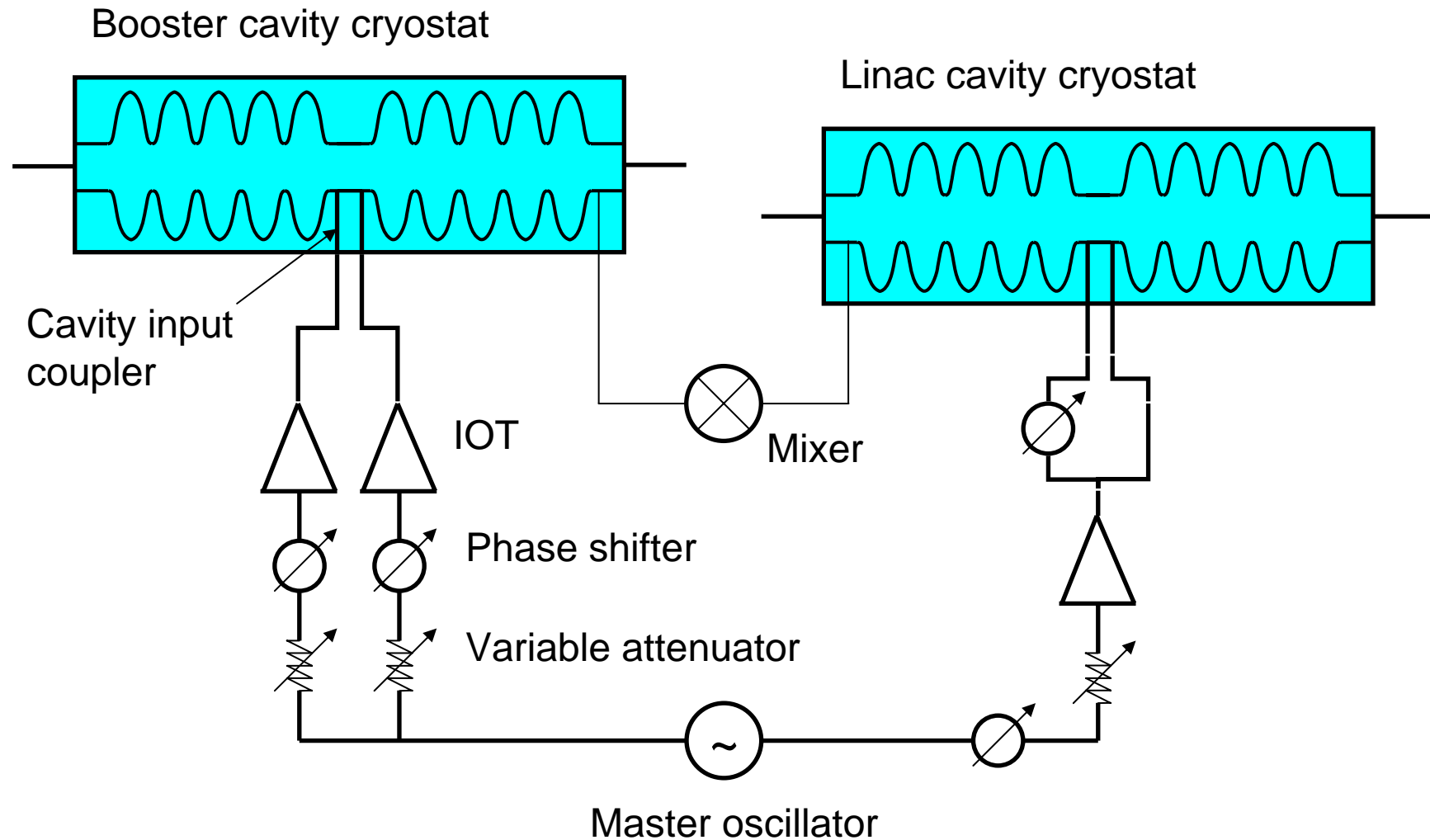
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5.2 Crab Cavity System

(Daresbury, Lancaster, Cornell, FNAL, SLAC)

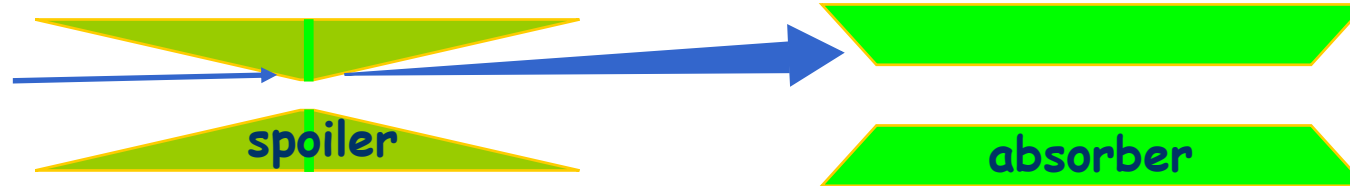


ERLP Phase Experiments

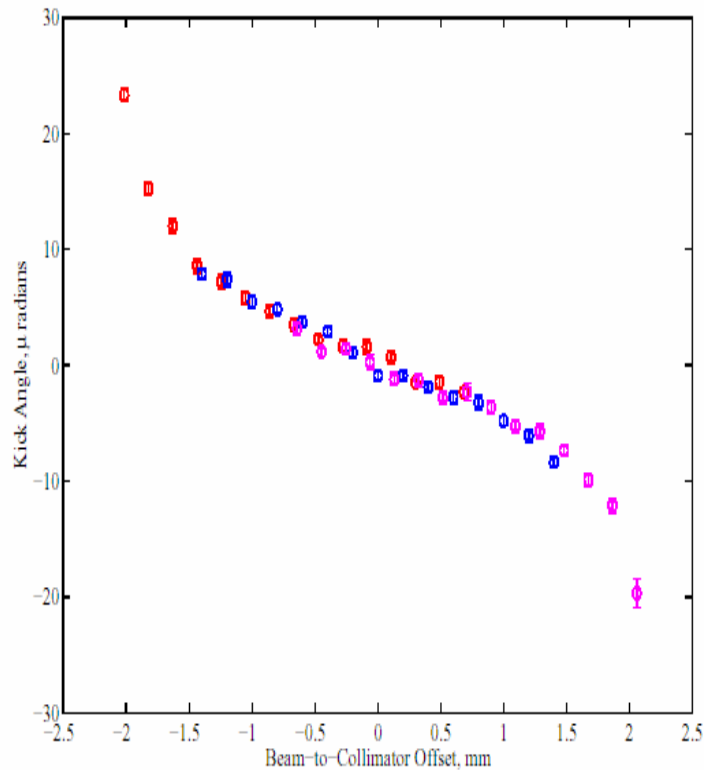


5. 3 Collimator Design

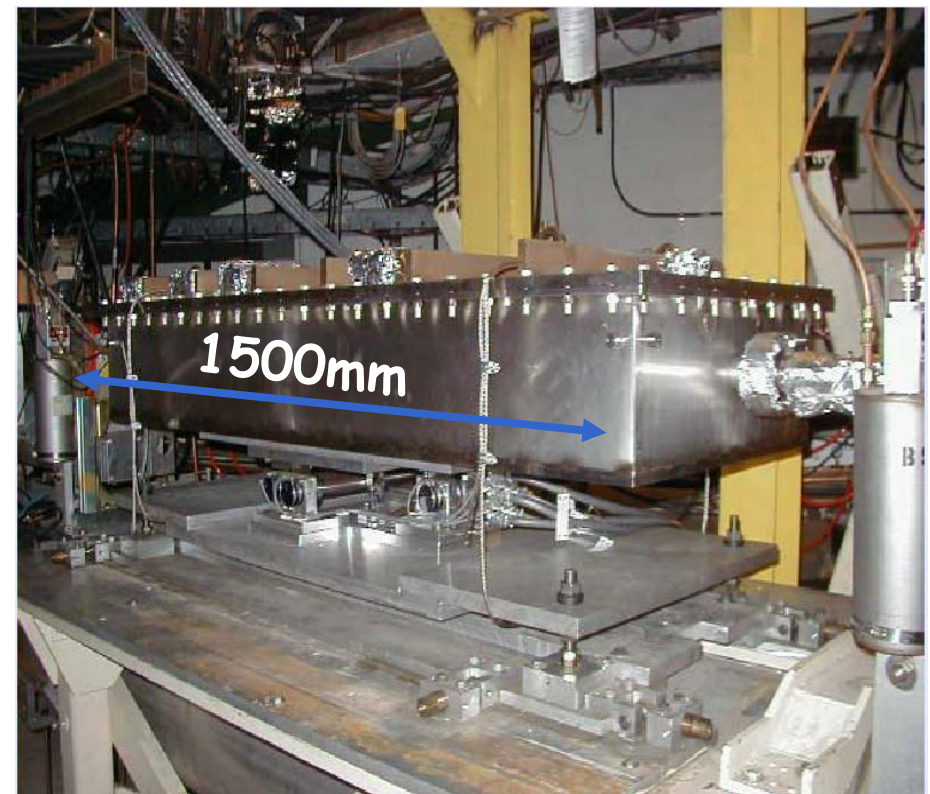
(Birmingham/RAL, Daresbury, Lancaster, SLAC)



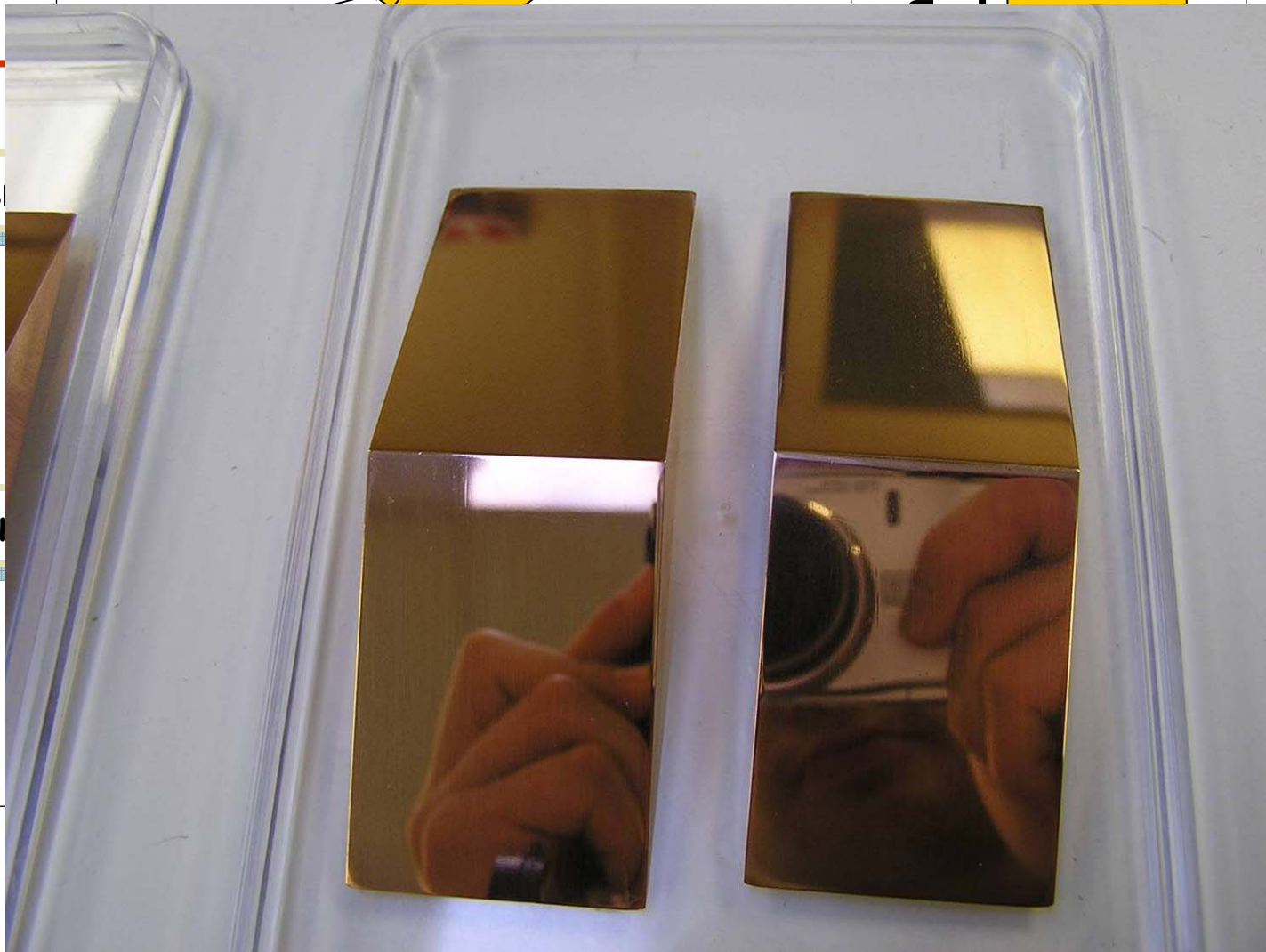
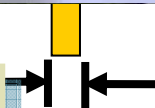



Modelling of wakefields:



Experimental tests in SLAC A-line:



Slot	Side view	Beam view	
			$\alpha=324\text{mrad}$ $r=2.0\text{mm}$
1			
2			$\alpha=324\text{mrad}$ $r=1.4\text{mm}$
3			$\alpha=324\text{mrad}$ $r=1.4\text{mm}$
4			$\alpha=\pi/2\text{rad}$ $r=4.0\text{mm}$
			
cf. same r, tapered		7mm	CARE/ELAN Meeting, CERN 24/1/05

7mm

LC-ABD Programme at ILC Test Facilities

ATF/ATF2:

- Laserwire system
- Intra-train FB system (+ FF ring-extraction)
- FF alignment system (StaFF – Eurotev)
- NanoBPM tests (for energy spectrometry)
- Lattice design, BPM design, tuning knobs, stability, operations

SLAC/ESA:

- E166 polarised positron system tests
- T468 collimator wakefield tests
- T466 prototype energy spectrometer tests
- Feedback BPM tests in background environment