Light Source Diagnostics

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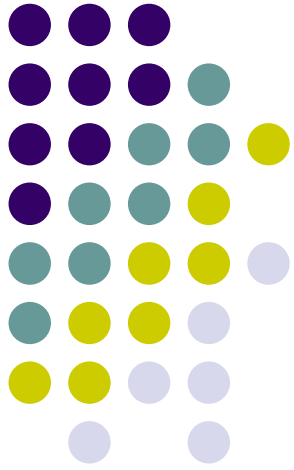


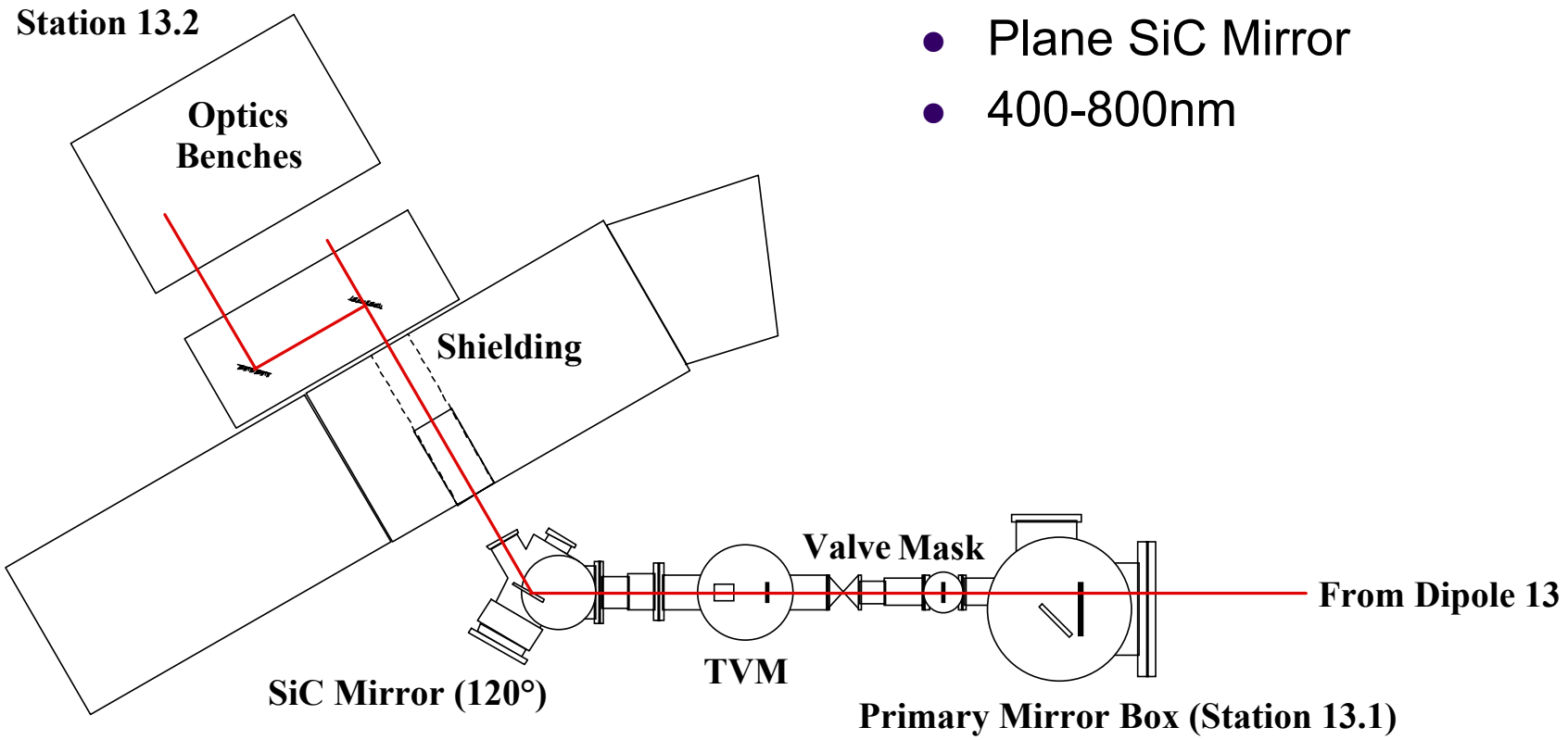
This Talk

- Not a review of light source diagnostics
  - Good summaries at EPAC/PAC/DIPAC, etc.
    - J.Safranek (ICALHEPS'99)
    - J.Clarke (EPAC'94)
    - R.Hettel

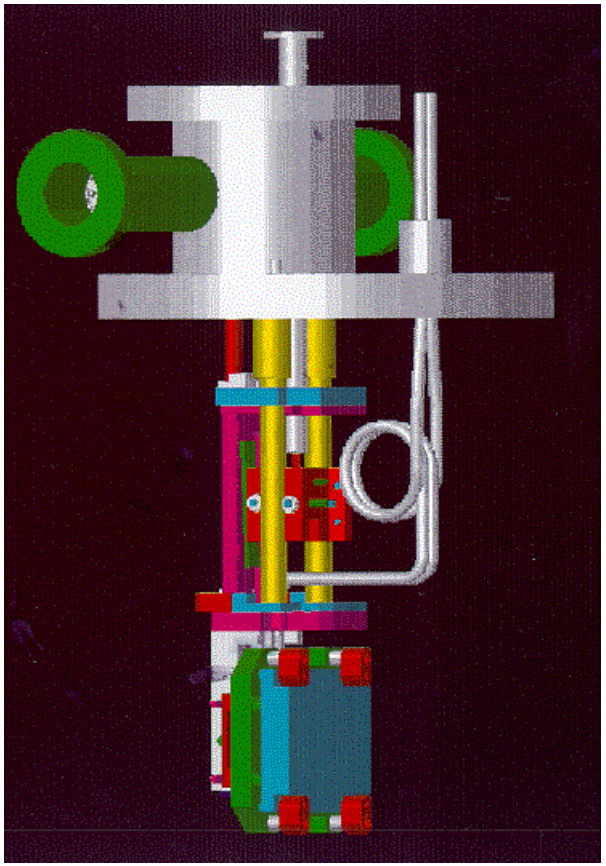
- Instead: a collection of various thoughts on diagnostics

Optical Diagnostic Layout (SRS)

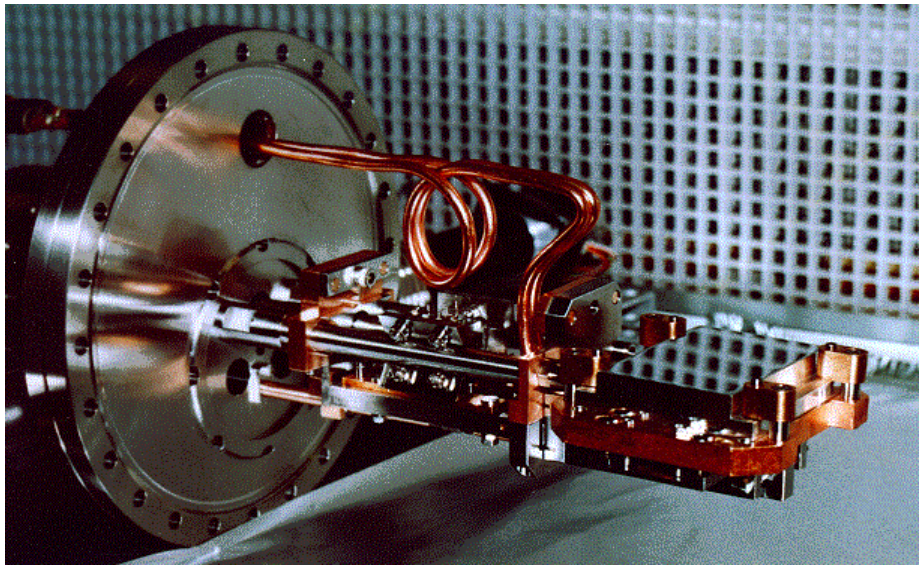
- Dipole source - 5mrad
- Plane SiC Mirror
- 400-800nm



Main Mirror (Optical)



SRS diagnostic
beamline mirror



Visible/uv wavelengths
Resolution limit ~100 um

2nd-generation spot sizes ~100-1000 um
3rd-generation spot size ~10-100 um

Cope with heat loads by thermocouple and moving mirror

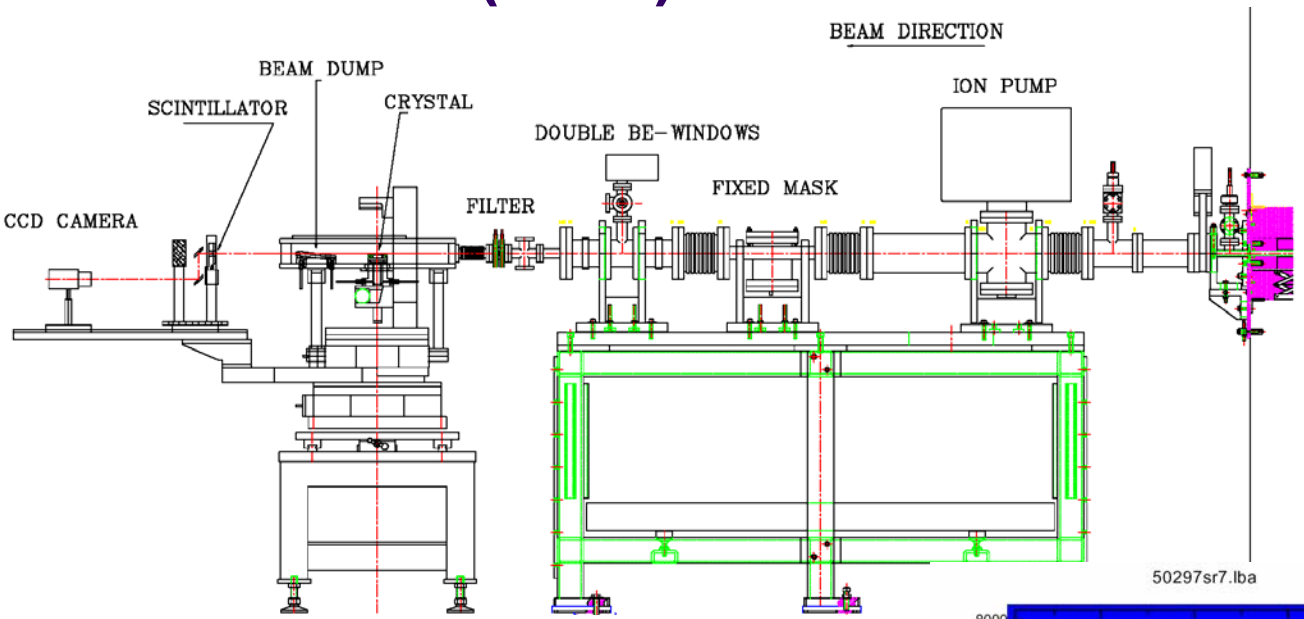
Very good for basic diagnostics and commissioning

Simple Installed SR Monitor

CLS Booster

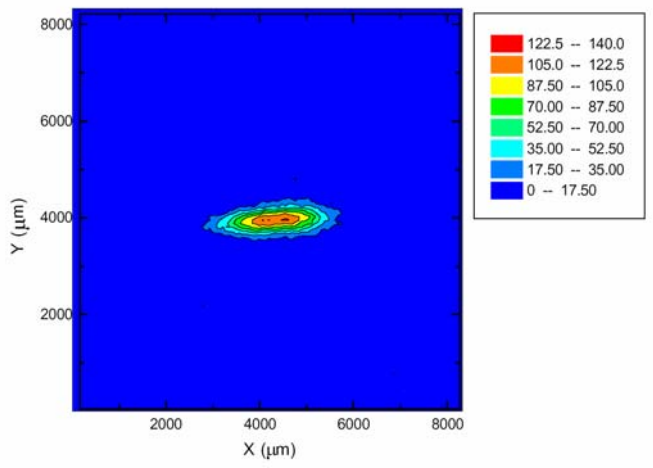
- Simple, cheap
- No excuse for not having one!

Pinhole Camera (APS)



Measurement (65 mA stored current)

X-ray beam size $(\Sigma_x \times \Sigma_y)$	674×164 $(\mu m)^2$
Partial emittance $(\varepsilon_x \times \varepsilon y_y)$	6.4×0.24 (nm·rad)
Total emittance (ε)	6.6 ± 0.6 (nm·rad)
Vertical coupling (χ)	0.037 ± 0.004
e-beam size $(\sigma_x \times \sigma_y)$	300×50 $(\mu m)^2$
e-beam divergence $(\sigma'_x \times \sigma'_y)$	21×4.9 $(\mu rad)^2$

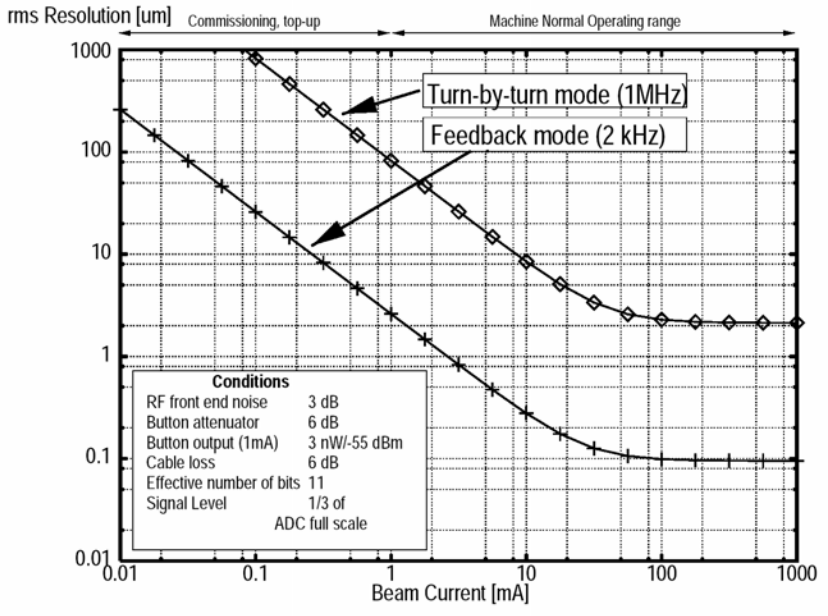


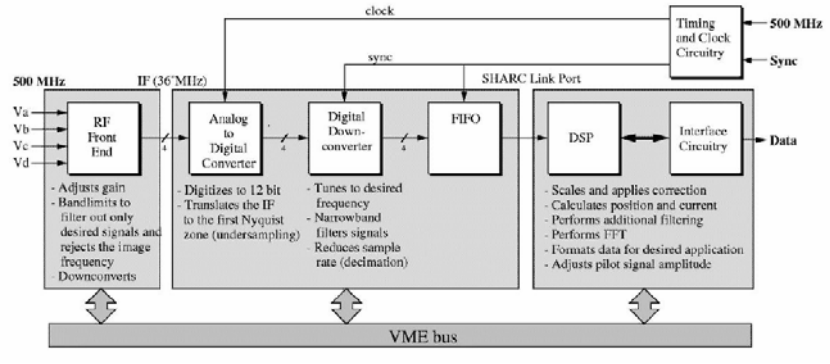
$CdWO_4$ Scintillator imaged onto CCD

EBPM Resolution

- um resolution or better possible from EBPMs
- Depends upon current and required bandwidth
- Can have thermal effects (e.g. ~50 um at ALS)

- However, this is not the whole story…





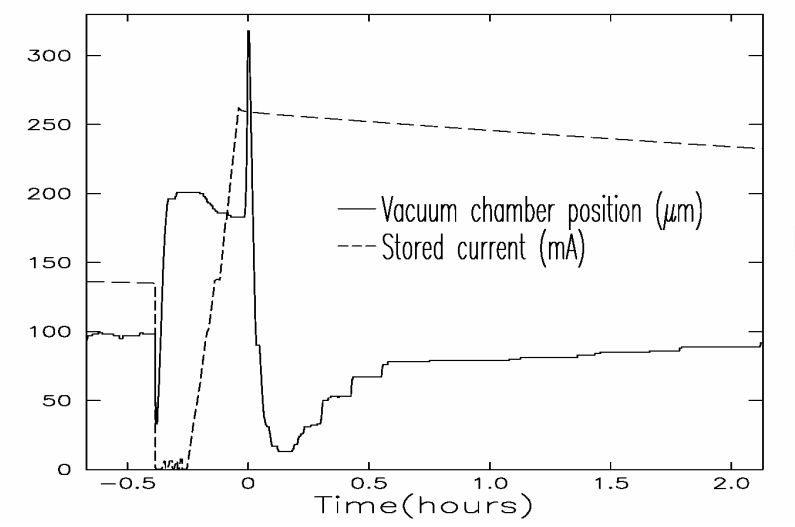
Swiss Light Source digital BPM

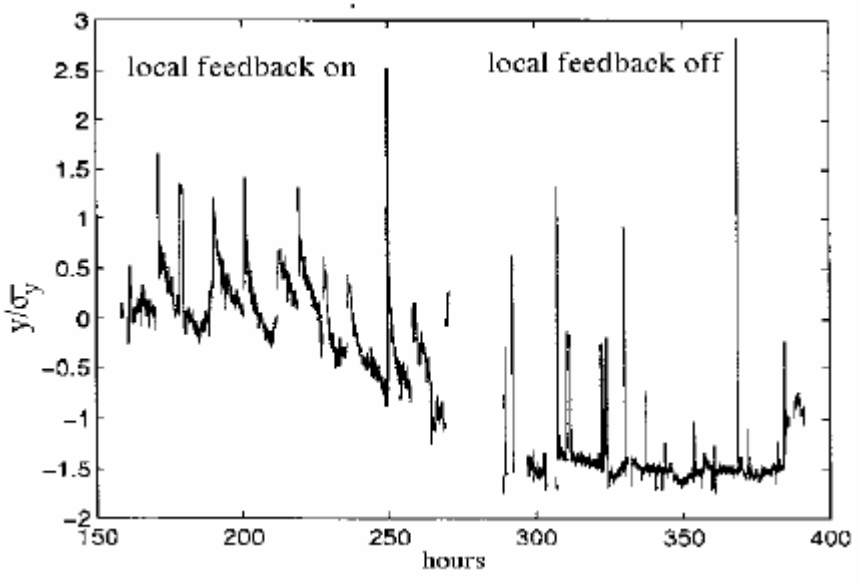
BPM Mounts

CLS EBPM fixed directly to girder

- 2nd-generation sources have BPMs fixed only to vessel (or none at all!)
- Get large movements….

BPM Movement





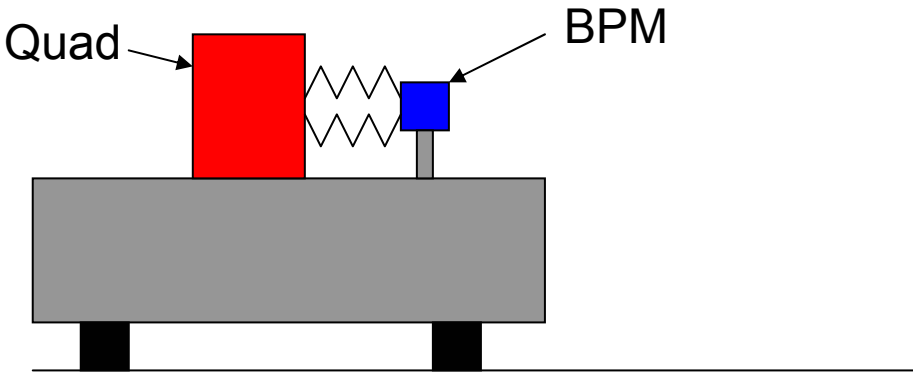
NSLS BPM Motion

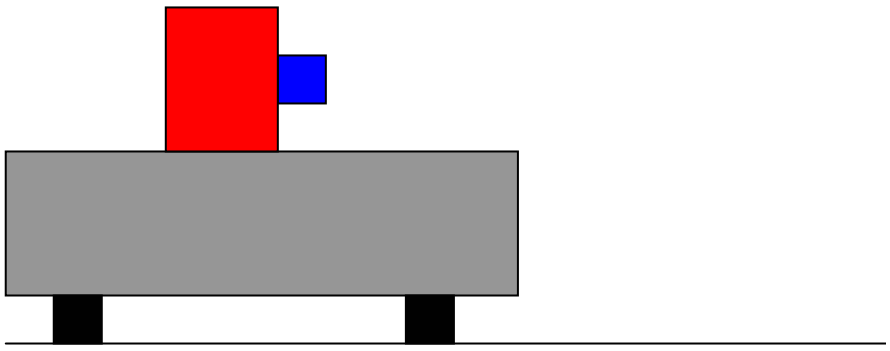
ESRF Feedback

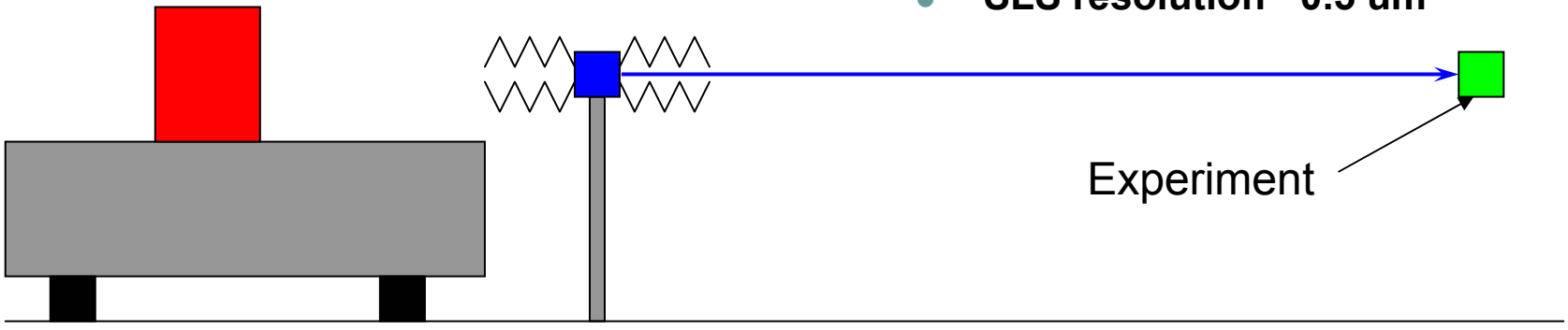
Also seen at other sources
SRS, ALS…

Caused by heating, pressure from other components etc.

BPM Mounting Methods



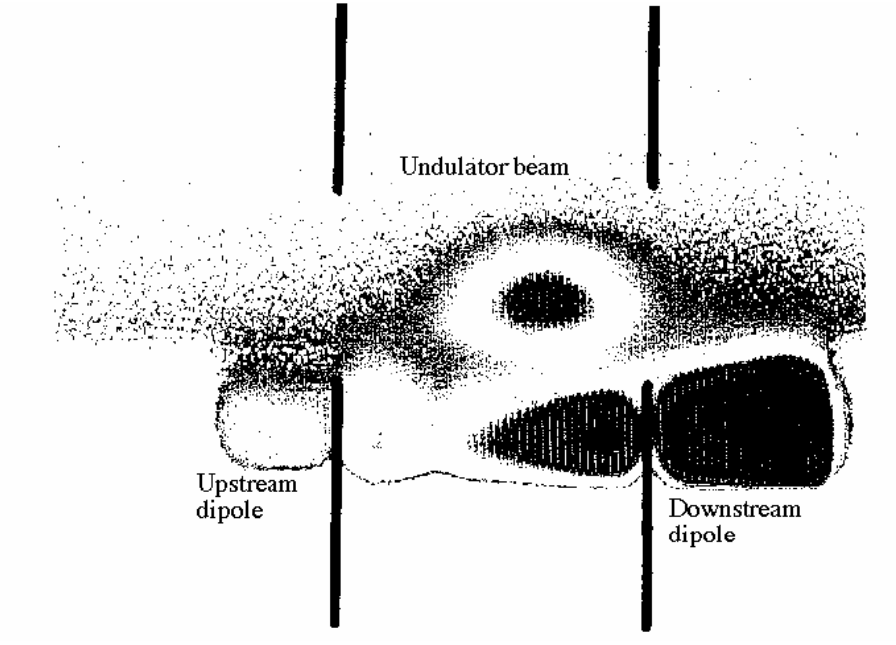




- The ground moves too:
  - ALS vertical >100um
  - DIAMOND >100um expected seasonal (water content in 14m chalk/clay)
  - SLS ~1mm seasonal change in C
- Magnet mount design can give lateral creep:
  - ESRF (damping mounts)
  - SRS >1mm! (frame mount + ageing floor)
- Survey errors (20-50 um typical on girder)
- Can add linear encoders
  - SLS resolution ~0.5 um

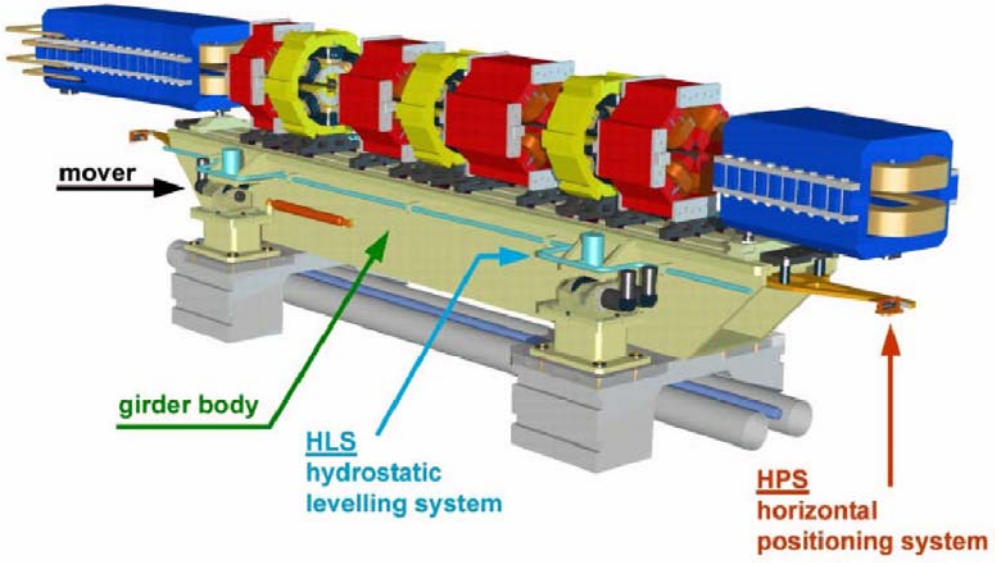
Photon BPMs also have problems

- Tungsten Vane Monitors
  - see edge of beam
  - can't avoid dipole radiation
  - sensitive to beam size
  - changes with undulator gap
- Can 'map' response with motion
- Developing energy-resolved TVM using hemispheric analysers



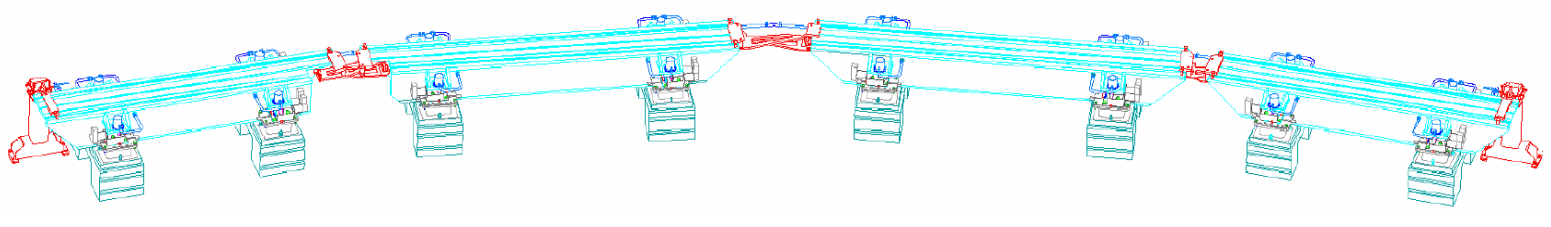
Light seen by ESRF TVM

Girder Alignment (SLS)

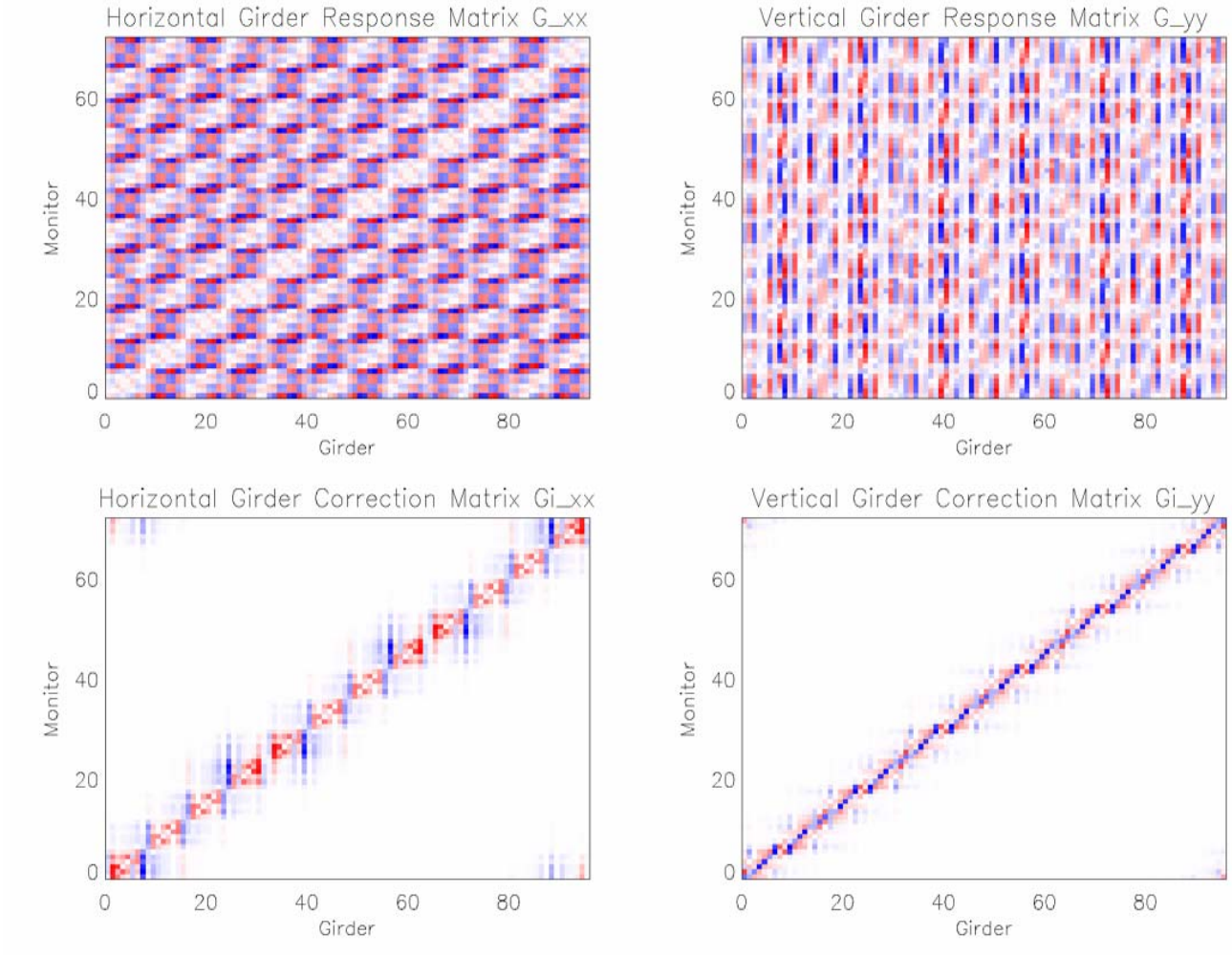


- 5-point support with roller cams:
- >1mm in 5 deg. of freedom
- Software can automate movements
- Will also be used in DIAMOND

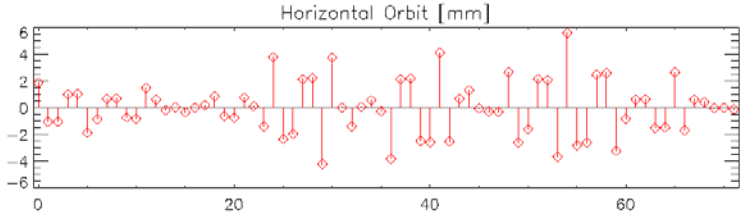
Translation [mm]	short	long	Rotation [mrad]	short	long
Sway u	1.41	1.41	Pitch χ	1.41	1.01
Heave v	1.41	1.41	Yaw η	1.41	1.01
Surge w	-	-	Roll σ	1.49	1.49

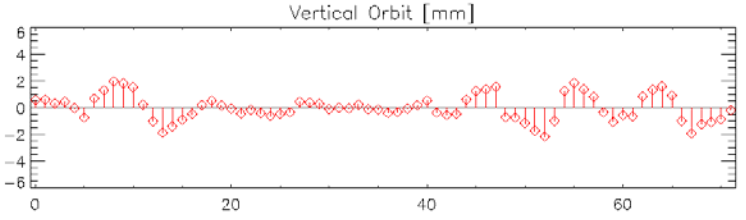


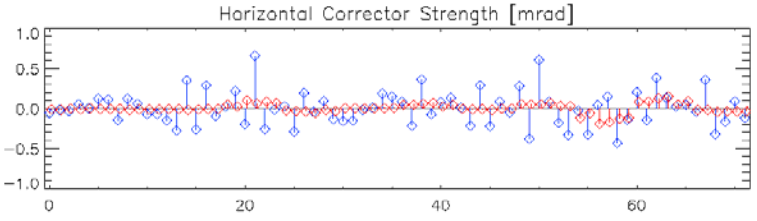
Girder ‘Response’ Matrices (SLS)

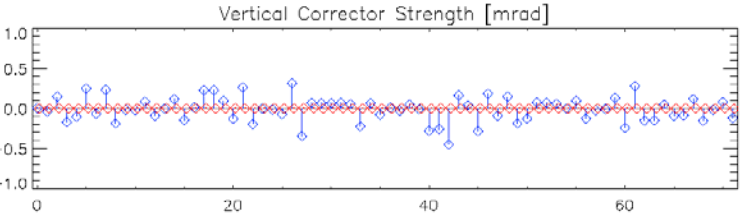


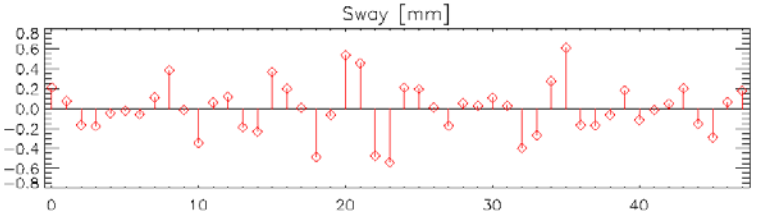
Orbit Correction Using Girders

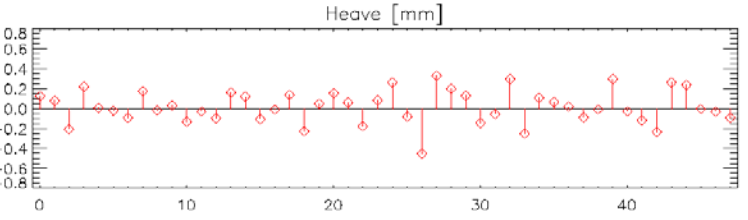


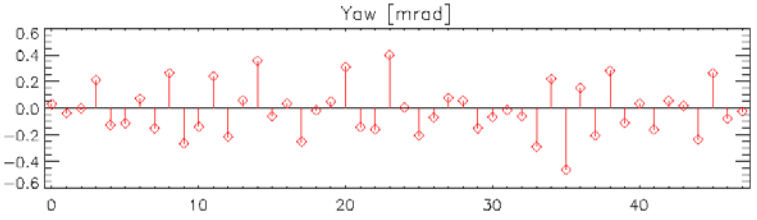


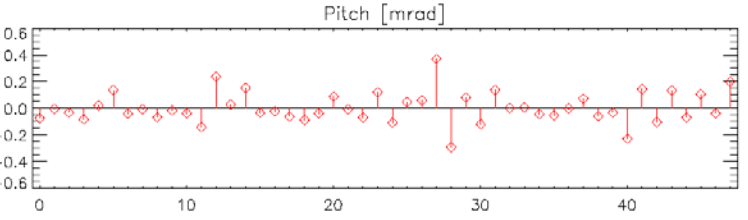










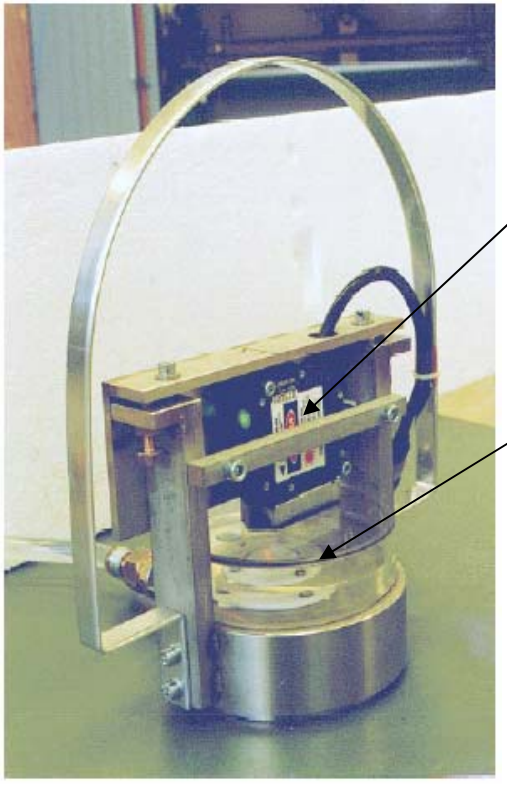


Only theory so far…

Hydrostatic Levelling Systems

ESRF (Electronic)

Problems with contamination mould etc. in water



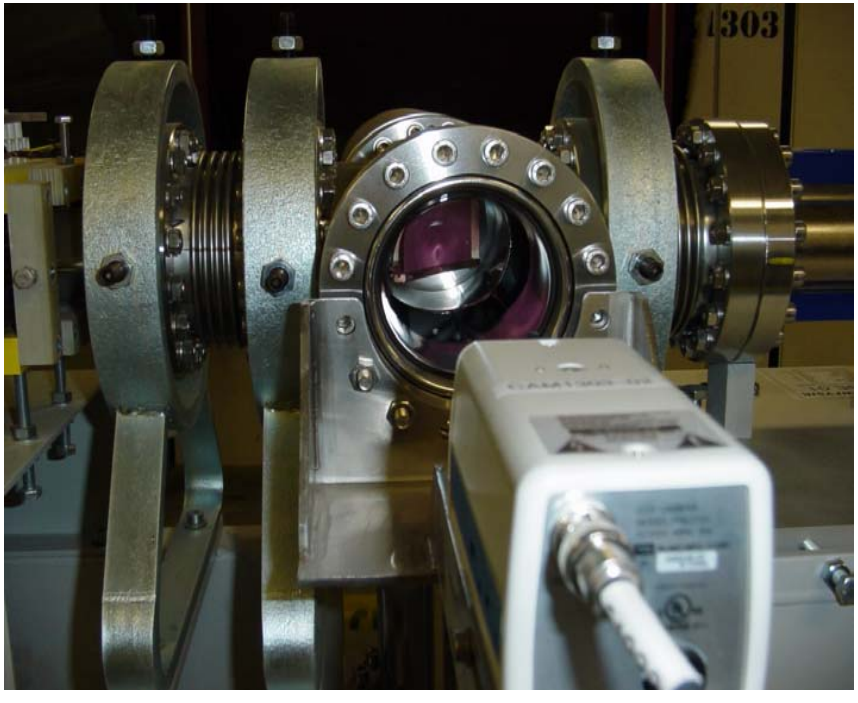
MAX-II (Optical) ~um resolution

Building and Accelerometer Mounts

Jointed floor to stop wind on building shell affecting storage ring (CLS)
(300 mm slab on thick glacial till)

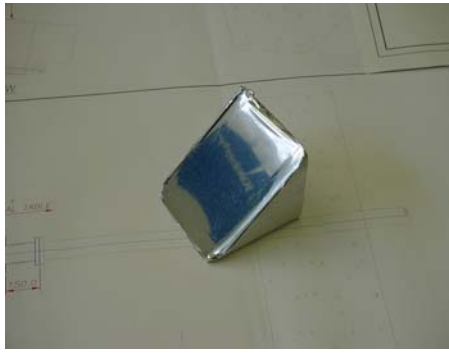
Accelerometer Mounts to measure transmission of vibration across joint
Not tried yet…

OTR Screens



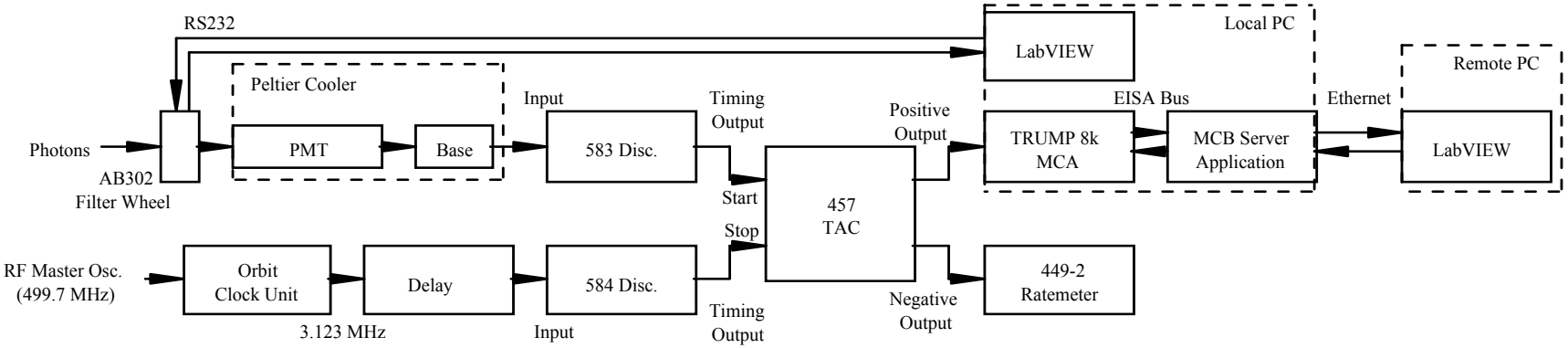
Installed monitor (CLS Transfer Line)

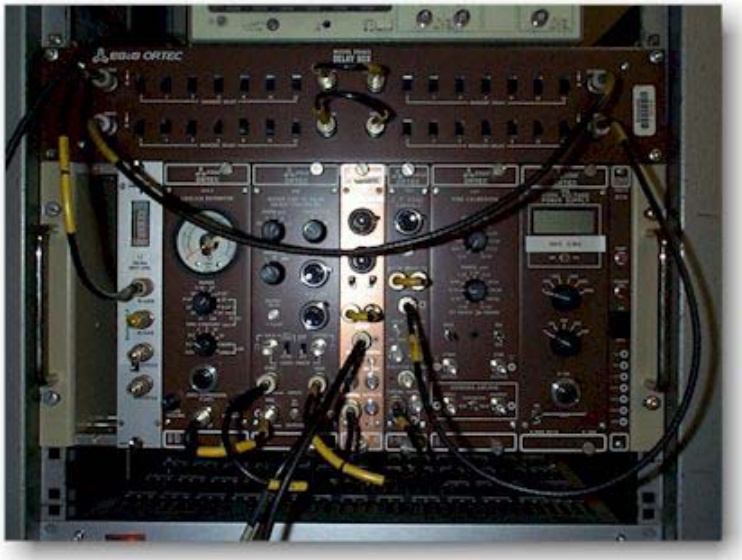
Screen – Al on Mylar



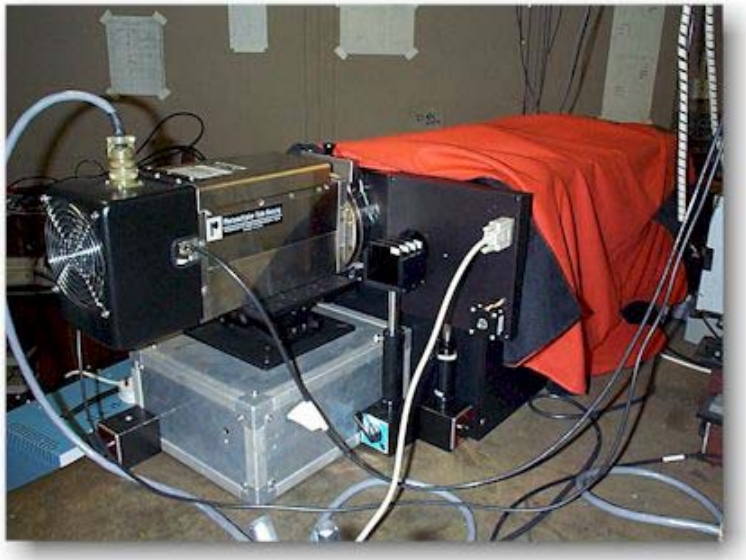
- Linear
- Fast response (sometimes too fast!)
- Narrow viewing angle can be a problem – roughen surface?
- Can combine with fluorescent screens

Photon Counting to Measure Bunch Filling Pattern



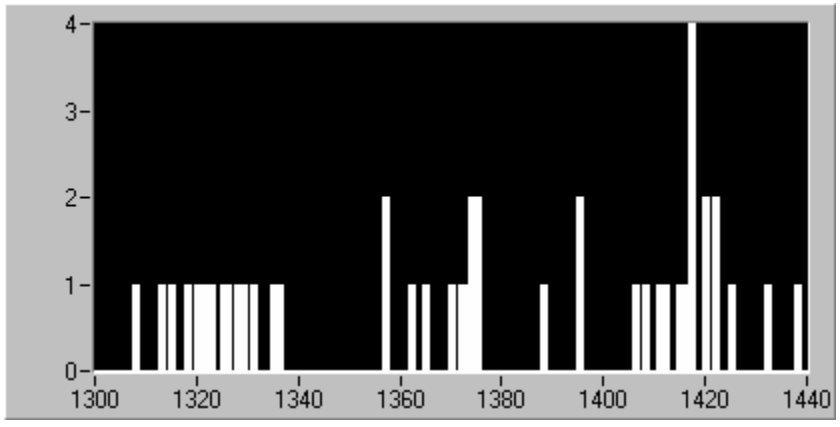


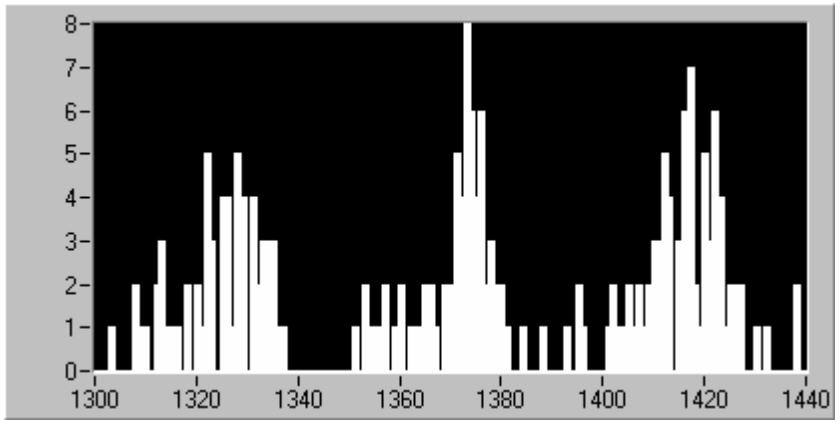
Single NIM Crate

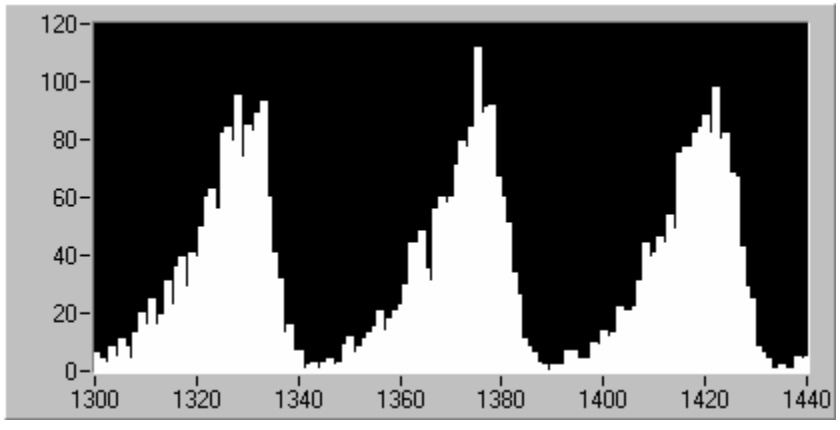


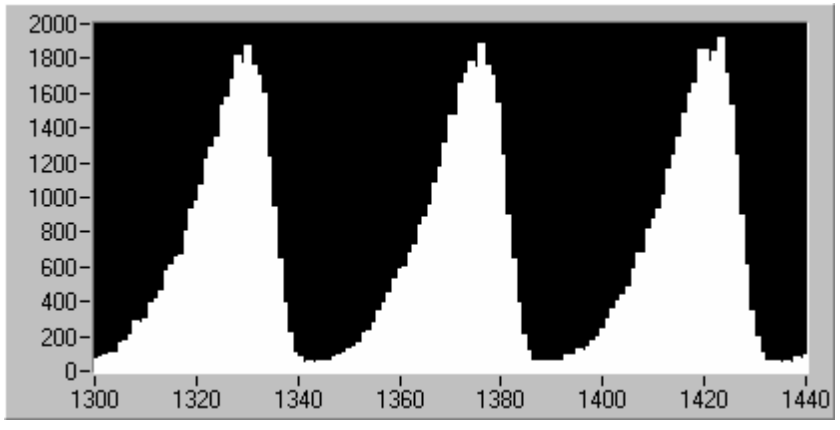
+Detector Optics

How Photon Counting Works





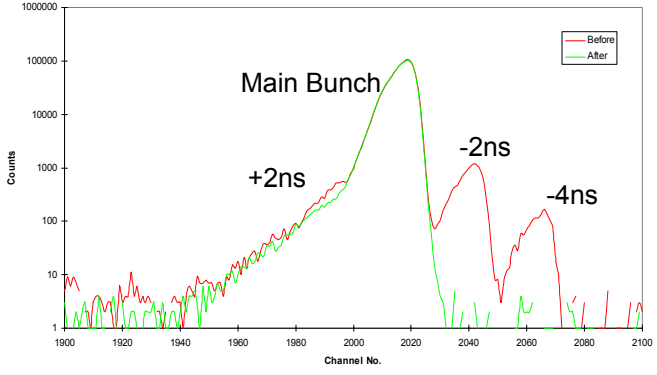




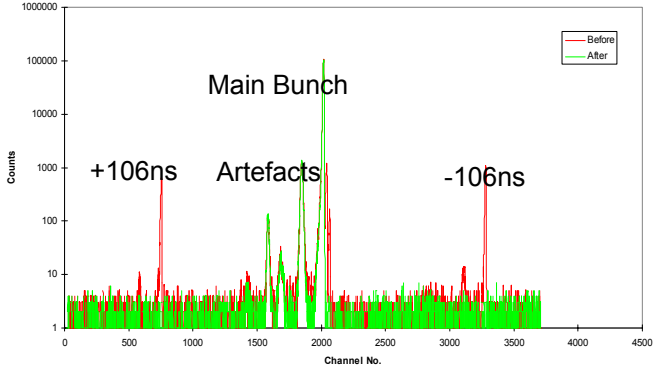
Takes around 60s to build good statistics
No good for single shot or in damping ring!

Cleaning Bunches by Resonant Excitation

Set frequency to vertical tune of parasitic bunches (~10 kHz above main bunch)
(SRS, ~20 mA main bunch current at 2GeV)



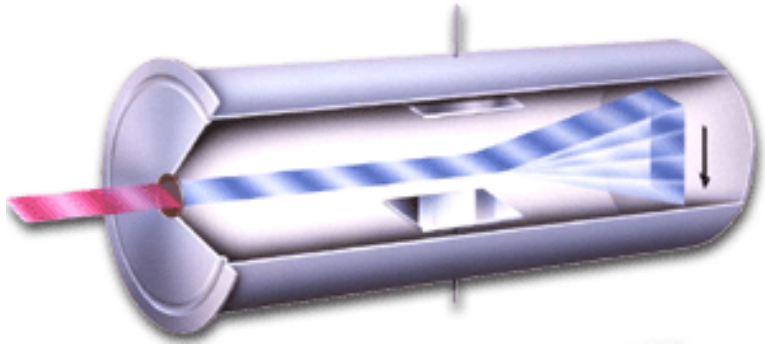
Removal of Neighbouring Bunches (+2ns, -2ns and -4ns)

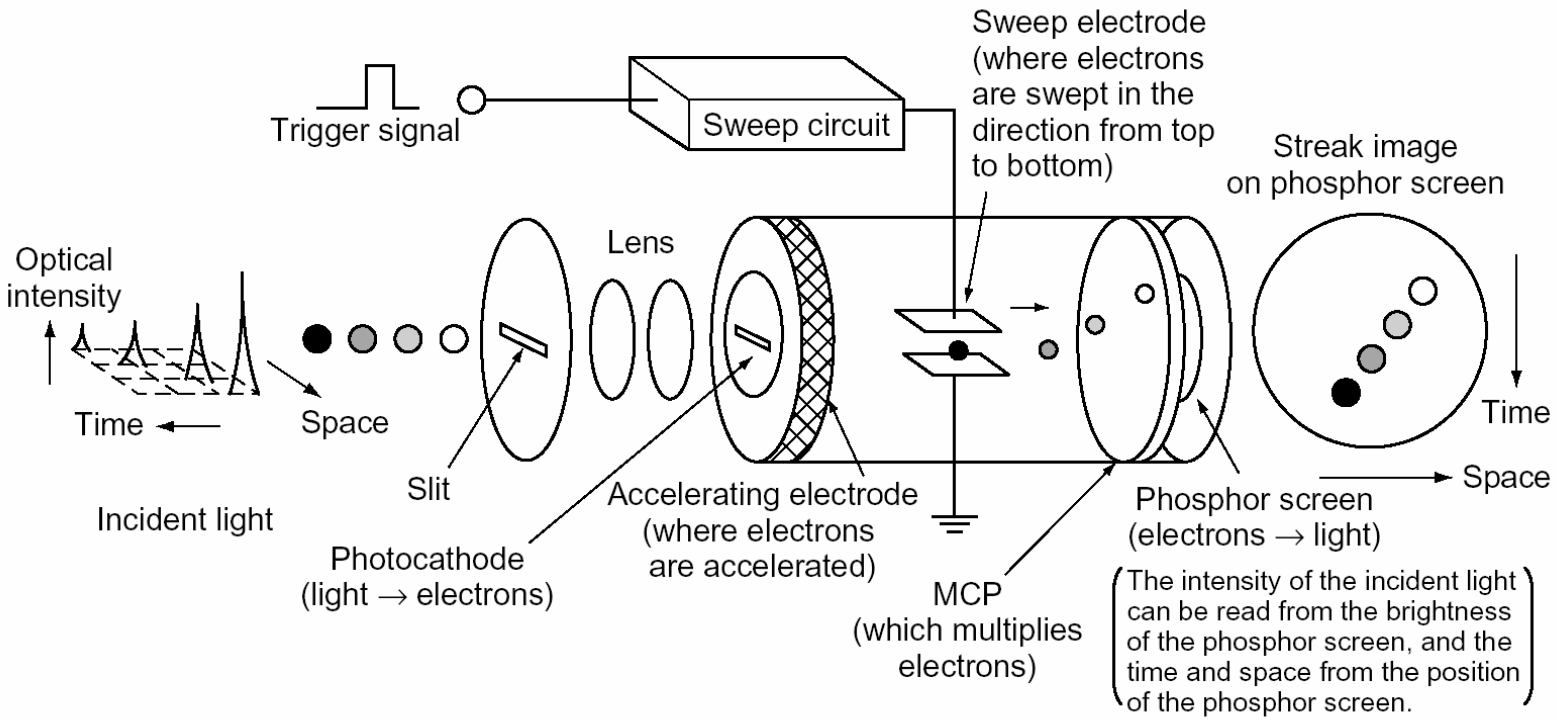


Removal of +106ns and -106ns contamination

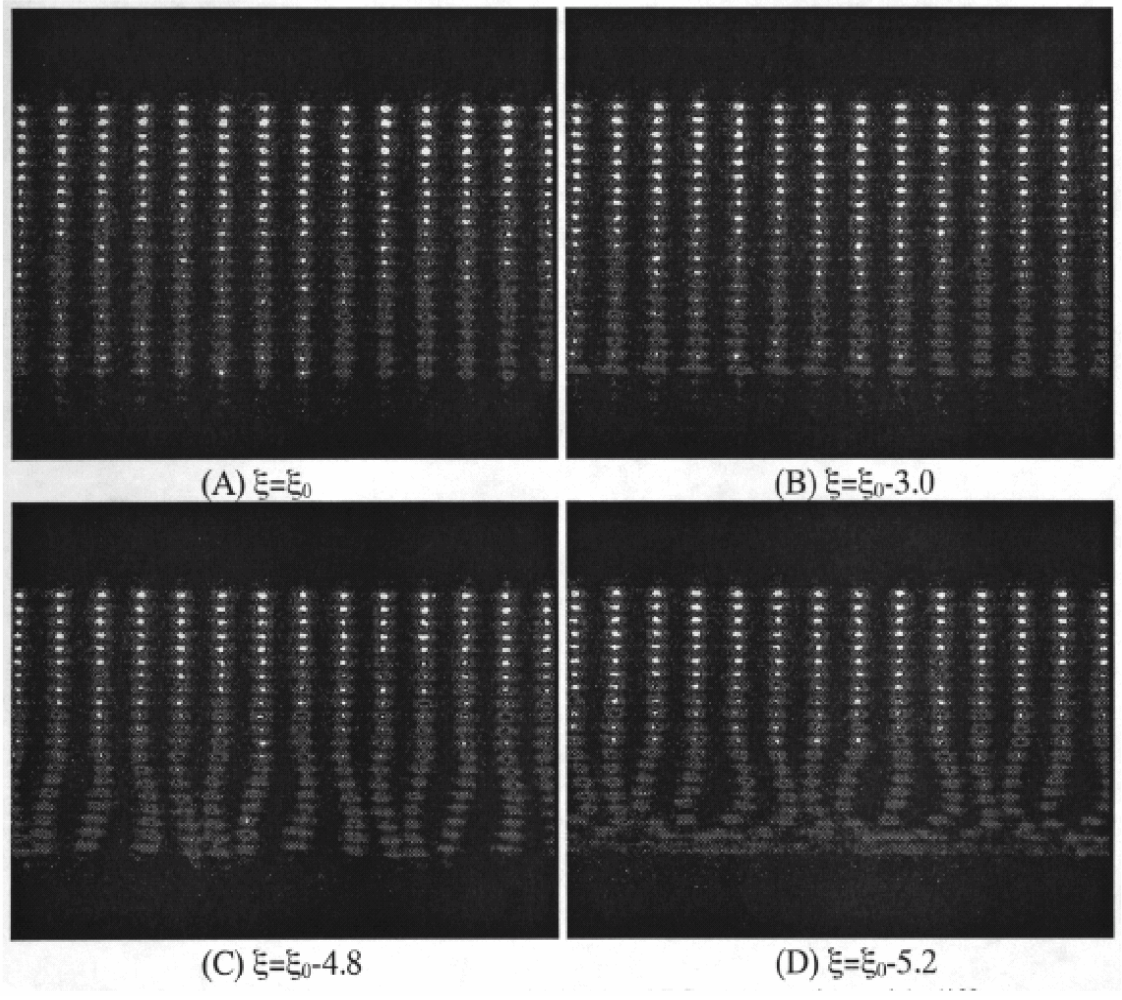
Streak Camera

2 ps resolution (500 fs at ESRF)
Signal to noise (contrast ratio) around $1:10^3$
cf. streaking electron beam down to 20fs
About 200,000 dollars/euros…





Typical Results (APS Multibunch)



Decoherence After Kick (APS)