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ISIS

Introduction to ISIS

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Rutherford Appleton Laboratory / STFC

First DITANET School on Beam Diagnostic Techniques
30 March – 3 April 2009

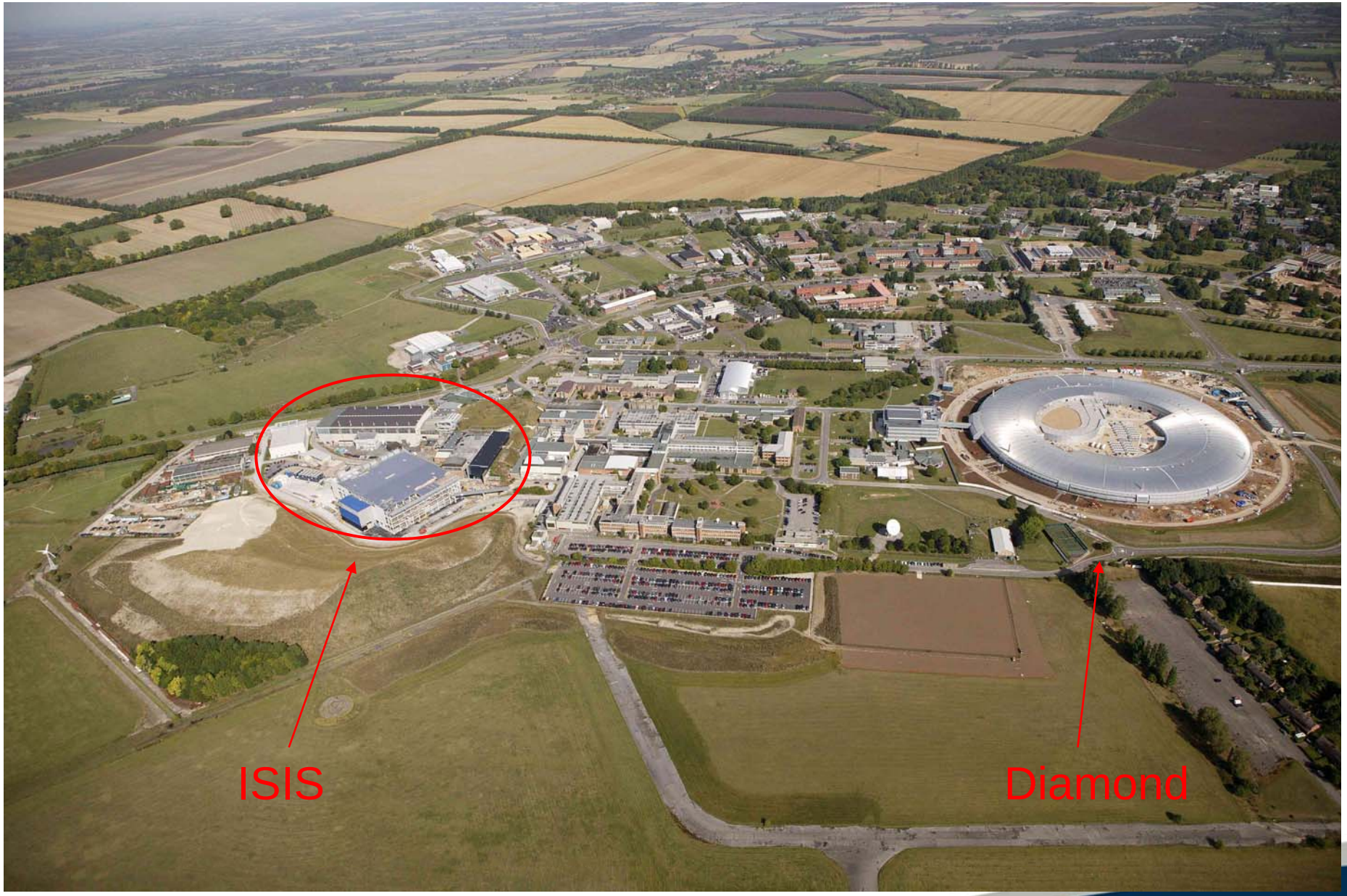
ISIS — world's most productive spallation neutron facility

0.2 MW, 800 MeV proton synchrotron, two target stations

User facility — 2000 scientists, national + international

Neutrons and muons
Structure and dynamics of condensed matter
From atoms to very large molecules

First Target Station 1984 — 20 instruments
Second Target Station 2008 — 7–20 instruments
Expect to go on to >2020
~£35M/year, ~350 staff



Rutherford Appleton Laboratory, looking north

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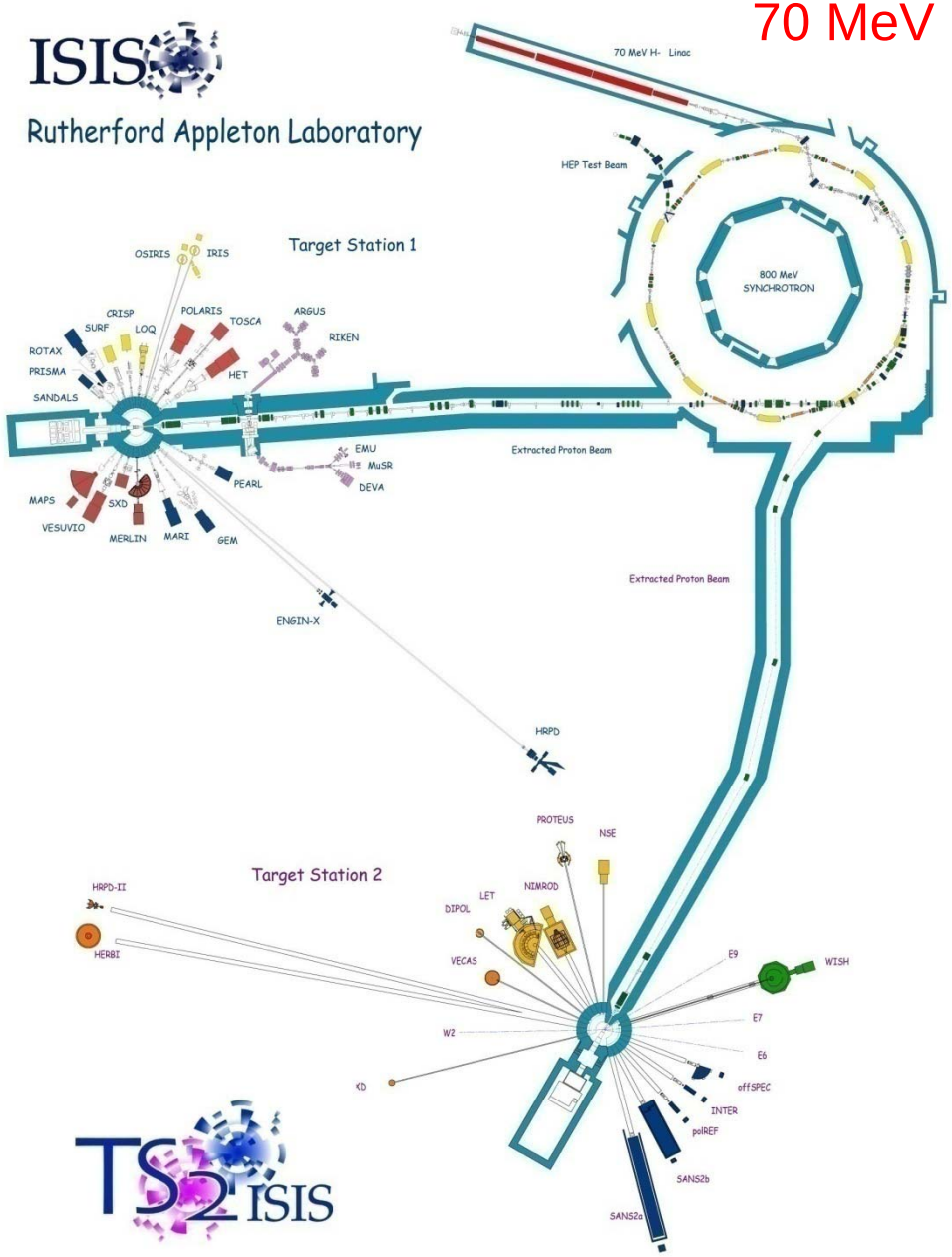
Rutherford Appleton Laboratory, looking north-east

70 MeV H^- linac



TS-1

800 MeV proton synchrotron

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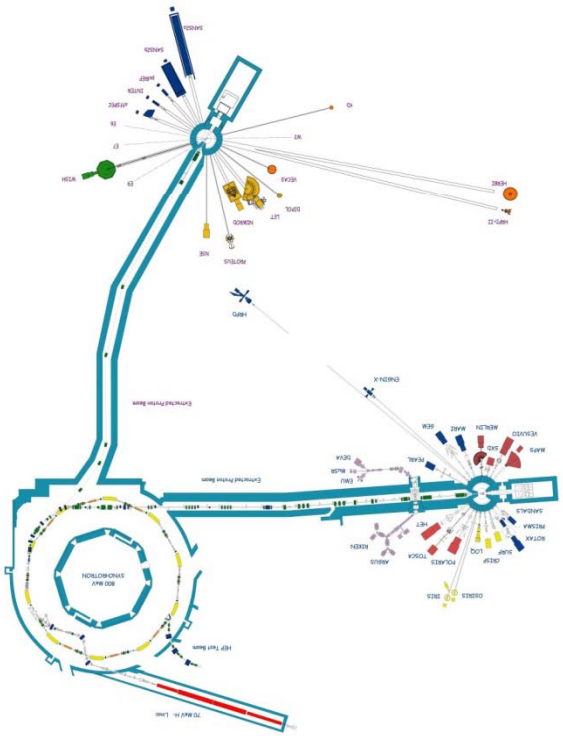

ISIS from air

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View down north side of ISIS 70 MeV H^- linac

Superperiods 9, 0 and 1 of the ISIS 800 MeV synchrotron

ISIS TS-1 experimental hall

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ISIS TS-2 experimental hall

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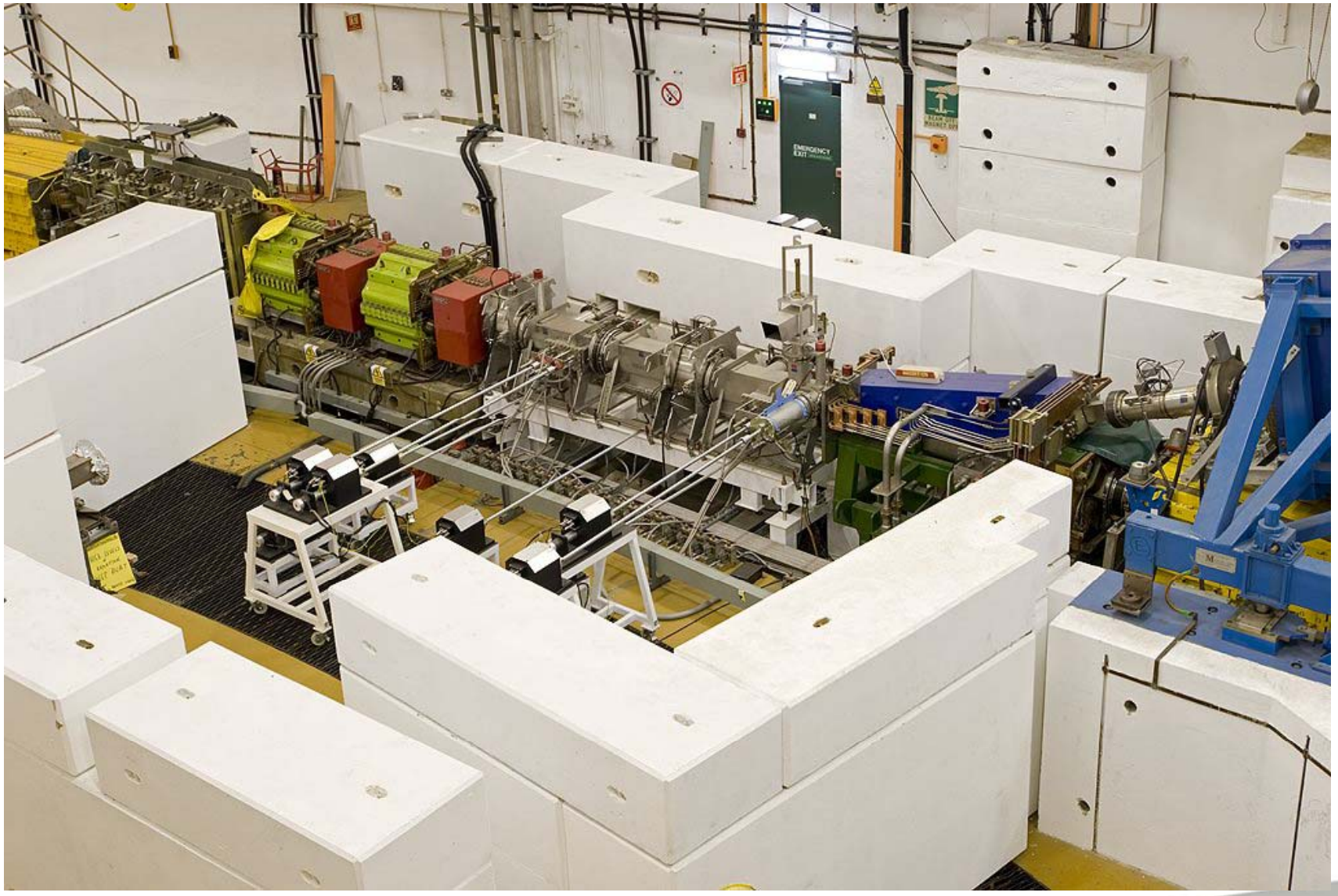
Operating ISIS

- Beam losses
  - Concentrated at one place — on collectors
  - Imperative to keep beam losses low (~1 W/m)
  - ISIS: ~1 kW lost, 163 m circumference, ~6 W/m
  - ISIS only ~0.2 MW, but ×2 beam losses would make life very difficult (2–3 mSv annual dose limit)
- Comprehensive beam diagnostics to trip beam if excessive beam losses occur



Synchrotron collector straight

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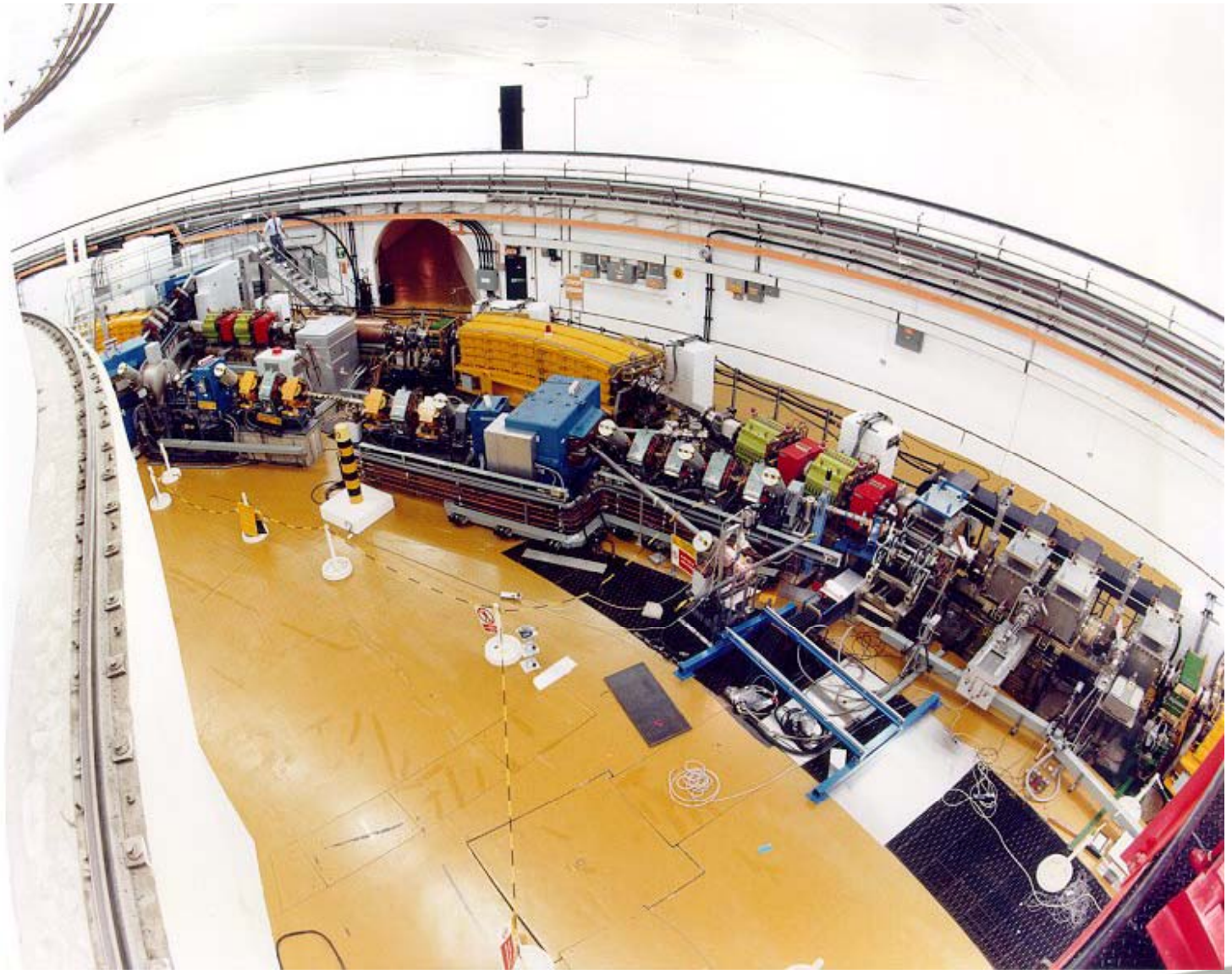

Beam loss monitors alongside synchrotron beam line

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ISIS Accelerator R&D Programme

Two main R&D activities

- Front ends of high power proton accelerators
  - Front End Test Stand — Alan Letchford
- High current rings
  - Facilitated by experimental programmes on ISIS synchrotron — Steve Payne

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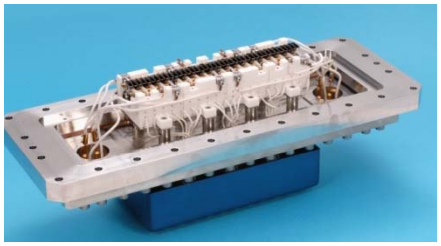
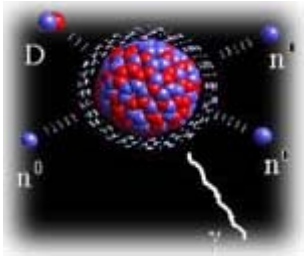
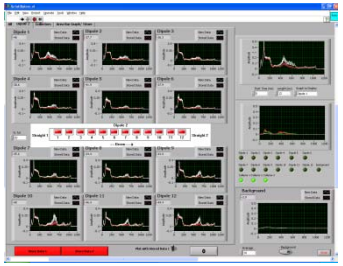
Overview of Beam Diagnostic Systems at ISIS

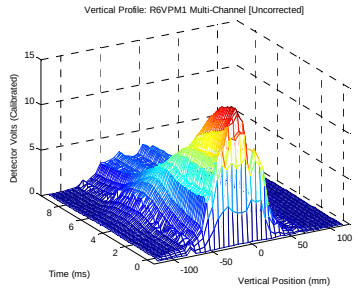






Steve Payne

with acknowledgment
to all members of the
ISIS Diagnostics Section
and accelerator physics



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Contents

1. Summary slide of ISIS diagnostic systems
2. Beam Loss Systems (argon gas ionisation, scintillator)
3. Beam Intensity diagnostics
4. Transverse Beam Profile Monitors
5. Beam Position Monitors
6. ‘pulsed’ diagnostics

…followed by FET diagnostics and MICE

Short Summary of ISIS diagnostics

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In the order of 250 individual pieces of individual diagnostic devices spread between the injector, accelerator ring and beam lines to Target 1 and 2.

Wide dynamic range – beam intensity varies 10^{10} – 10^{13} ppp (machine physics studies (using chopped / diluted beam) – normal running)

Beam Protection System – Intensity Toroids, 3 bad pulses, Beam loss Monitors (BLM's), 20 bad pulses (trip levels i.e. 'bad pulses' different for different parts of machine)

A lot of the diagnostic hardware still original (>25 years old!)

Development programme to upgrade existing hardware (e.g. BLM's) – and build new hardware (e.g. fast profile monitors)

Upgrade programme for electronics (obsolete 1980's components) and for to computer (PC based) DAQ systems

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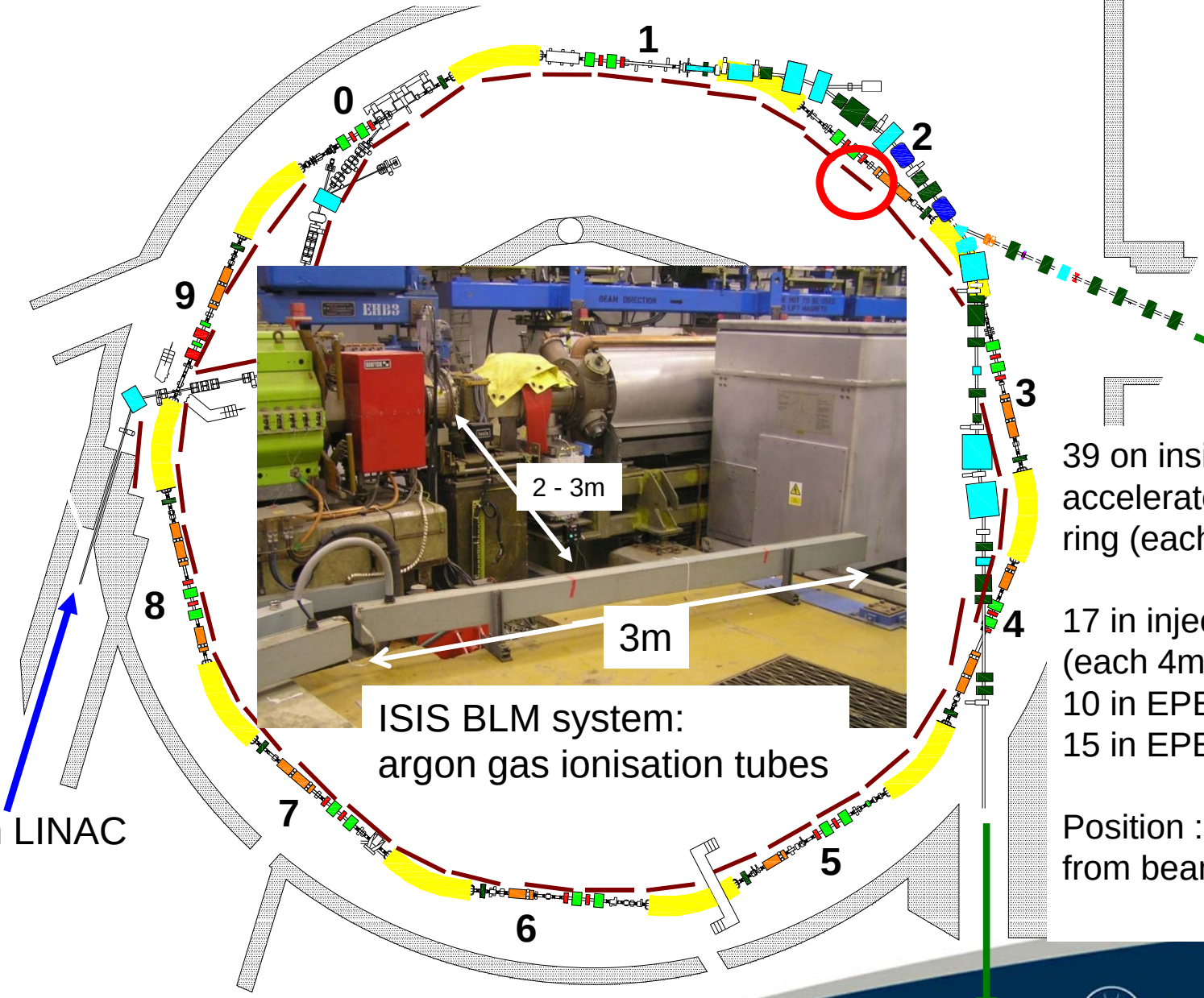
ISIS Diagnostics – Beam Loss Monitors

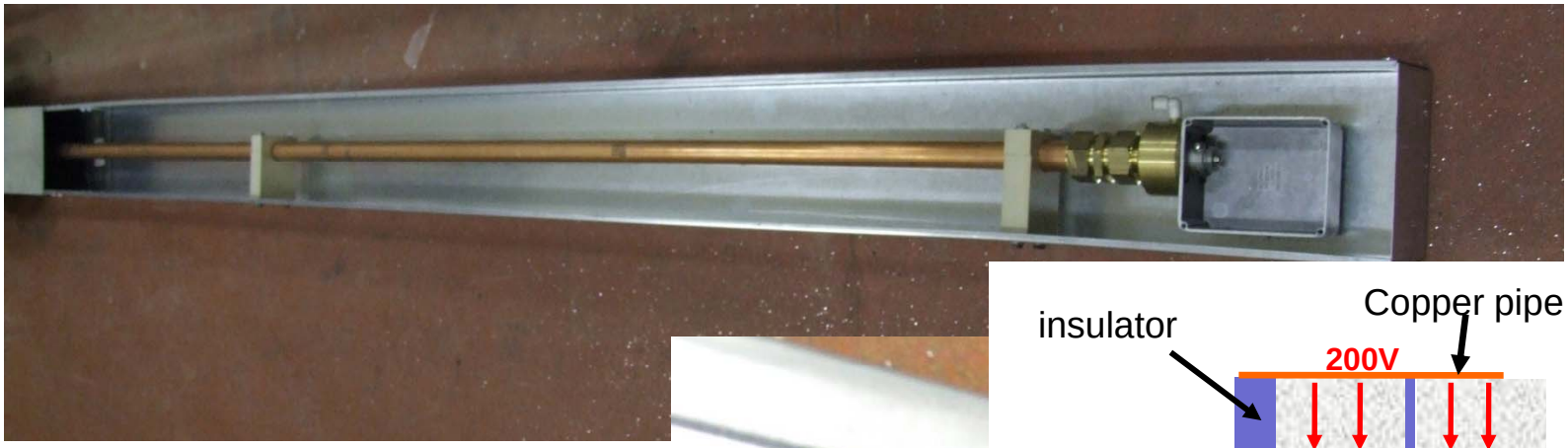


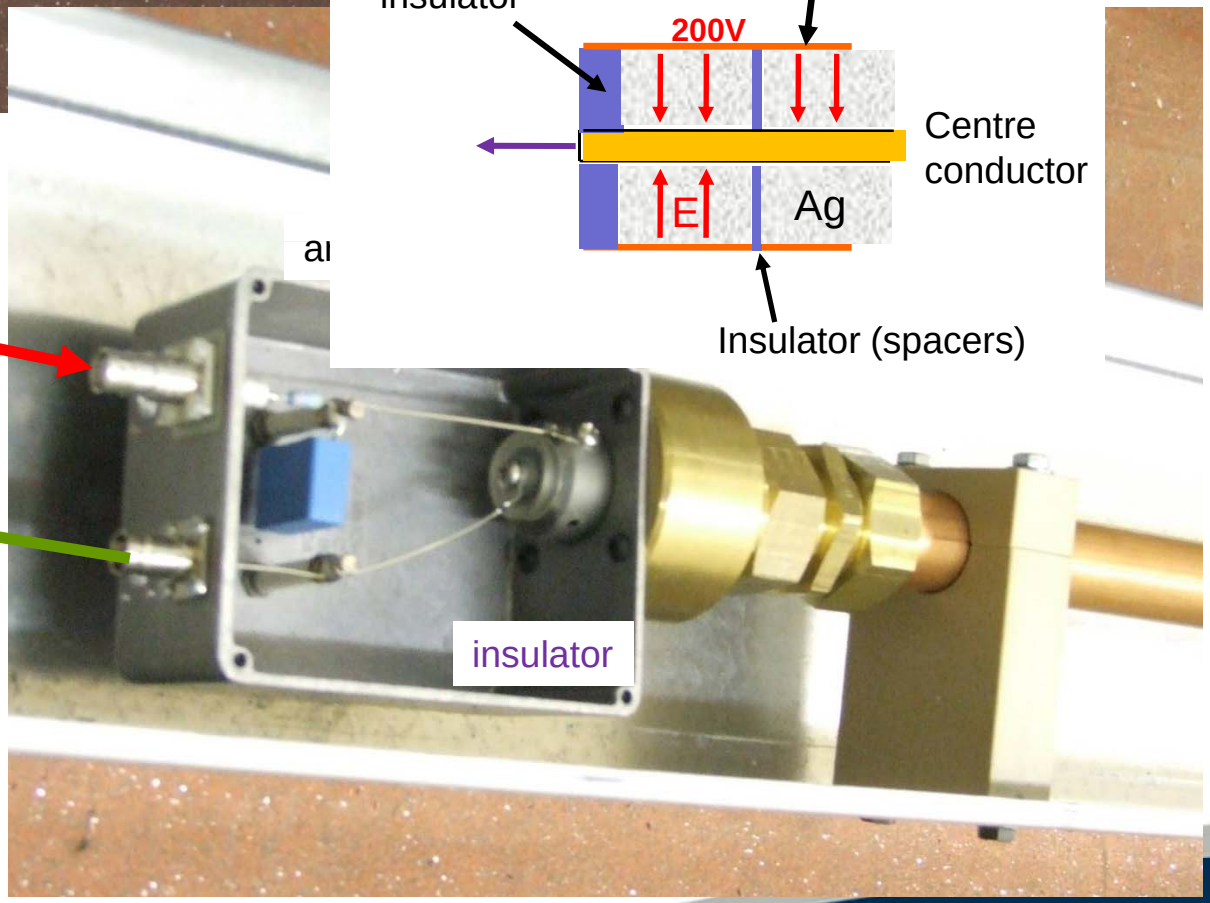
39 on inside of accelerator ring (each 3m long)

17 in injector / Linac (each 4m long)
10 in EPB 1 (4m long)
15 in EPB 2 (4m long)

Position : 2-3 metres from beam axis

EPB = Beam line to target





28mm copper tubing carries 200V (field: 10-20V/mm to centre conductor)

Signal taken from centre conductor

BLM Specification:
Argon gas (bottle supplied)
Gas volume = 0.6 litre
Gas pressure = 4 psi

Trip sequence…
20 consecutive pulses above preset trip level (ring and EPB1)
5 consecutive pulses on EPB2

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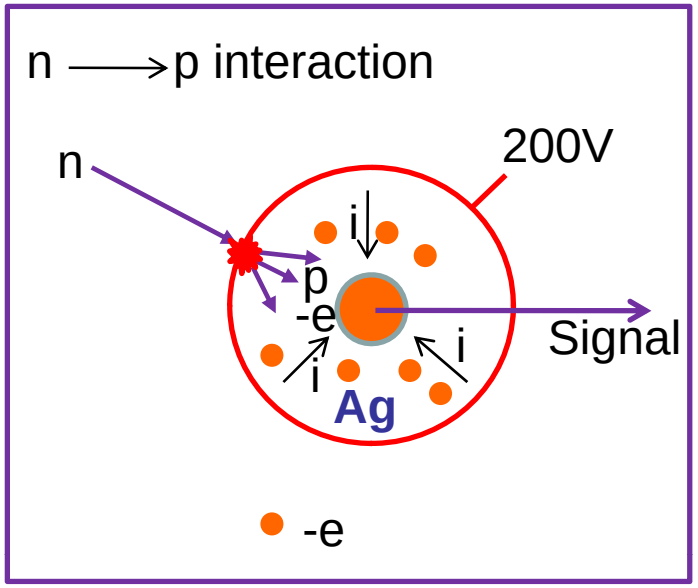
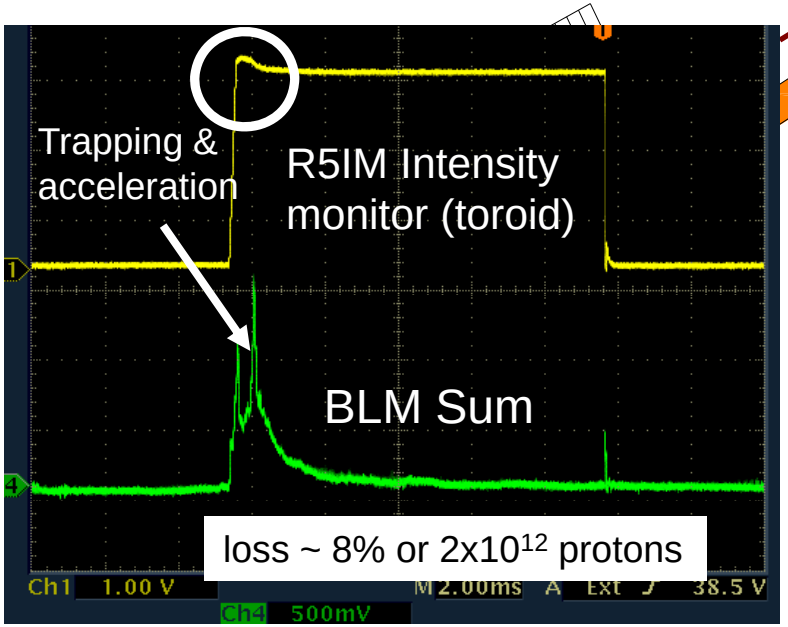


Stage 2:Evaporation neutrons



BLM

R5IM intensity Monitor (straight 5 part of tour)

Two stage process:
Stage 1: p – n interaction at vacuum vessel . High energy forward cascade neutrons (which BLM's do not see)

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•BLM's keep losses, and machine activation low during start ups and normal running (allowing access machine quickly during shutdowns. They offer:

•Good time (10us) and spatial resolution (3m) for locating loss

•No loss of performance with time (replenished argon – bottle fed, purged yearly)…just the odd gas leak to deal with!

• Ionisation tubes not calibrated (but have same gas volume and pressure) – electronics calibrated with test signal.

also …Scintillator Beam Loss diagnostic ‘inside’ Dipole 2

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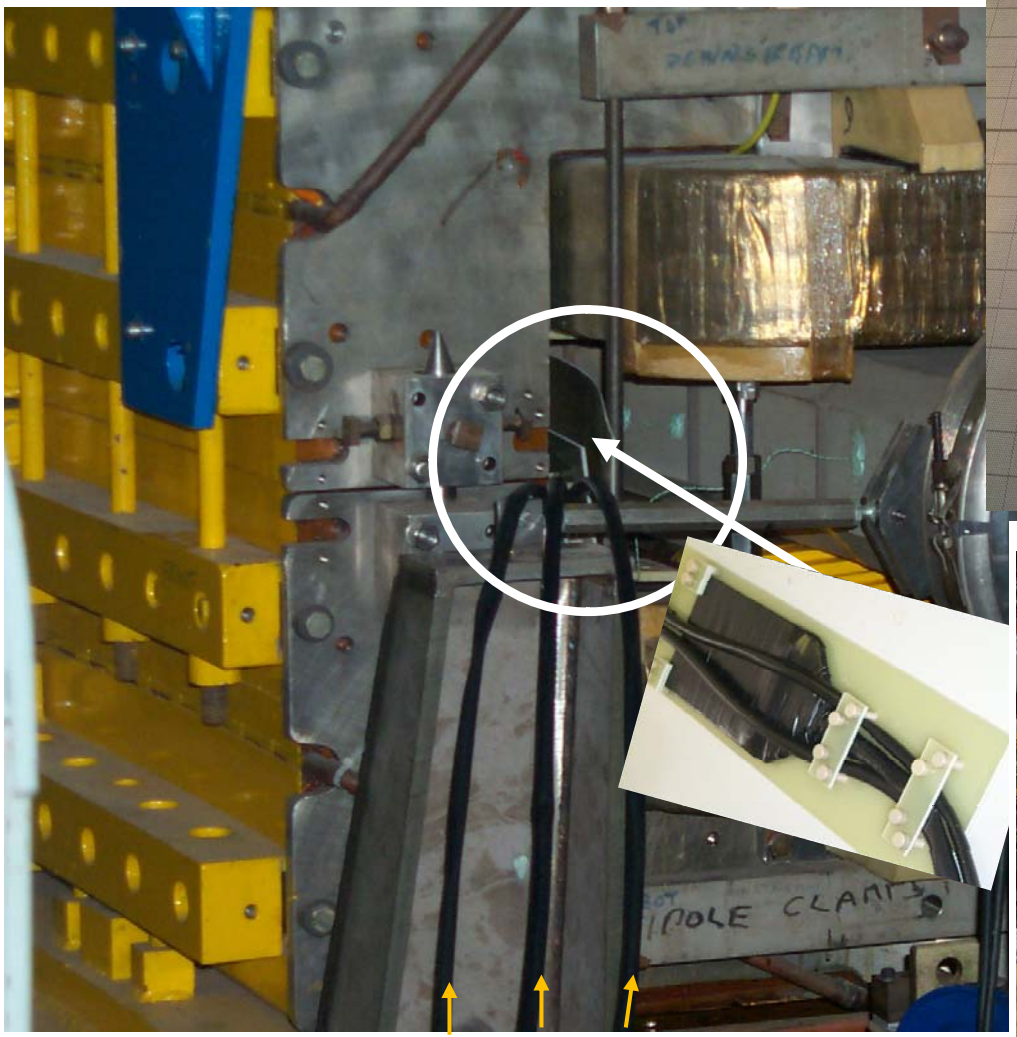
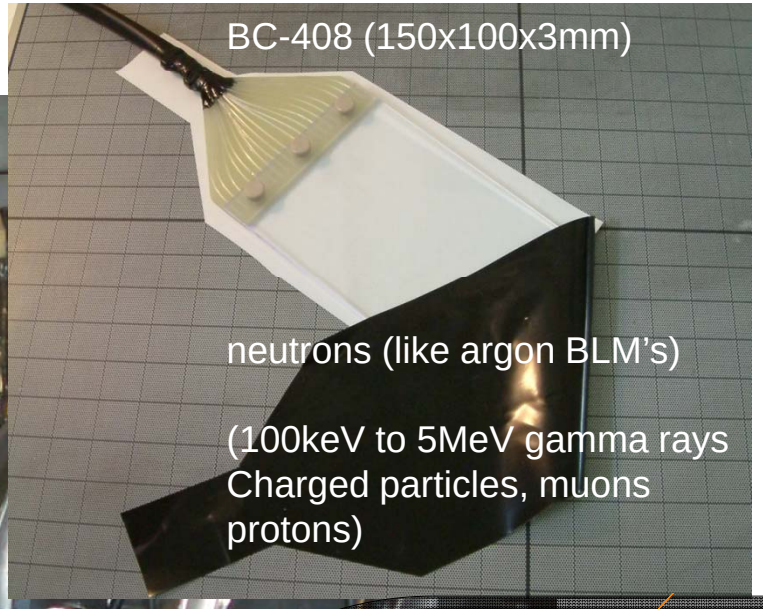
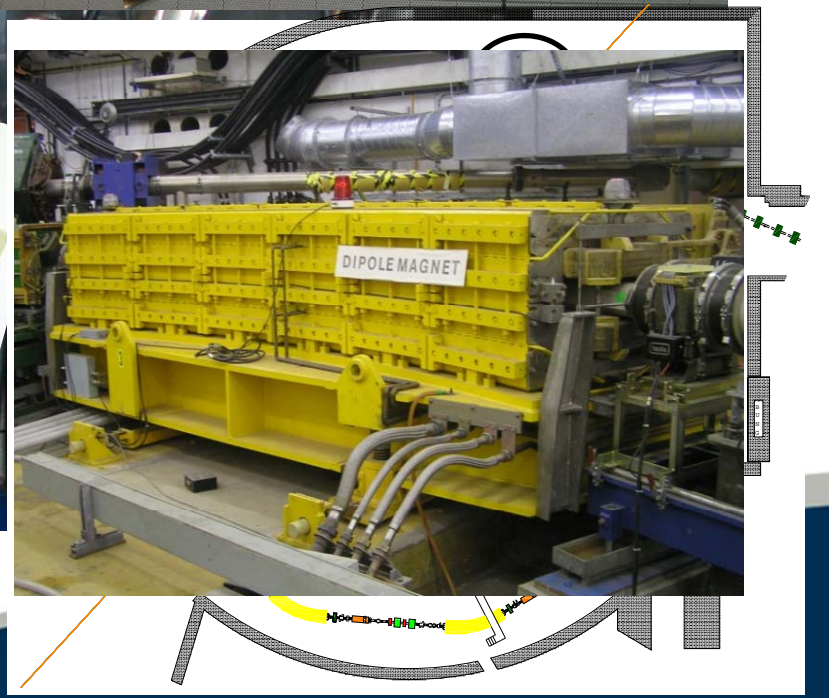


Optical Fibre bundles

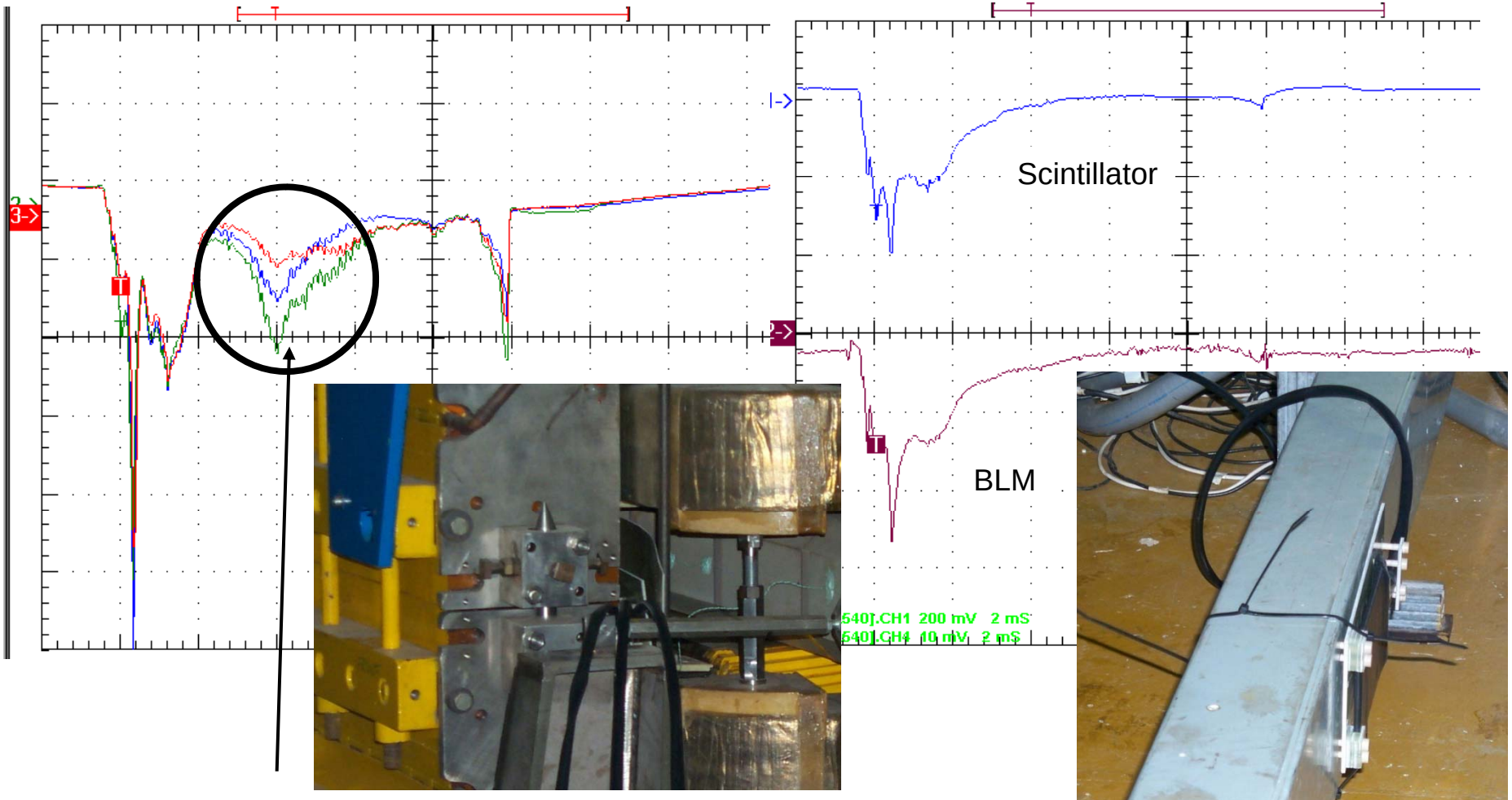


neutrons (like argon BLM’s)

(100keV to 5MeV gamma rays
Charged particles, muons
protons)

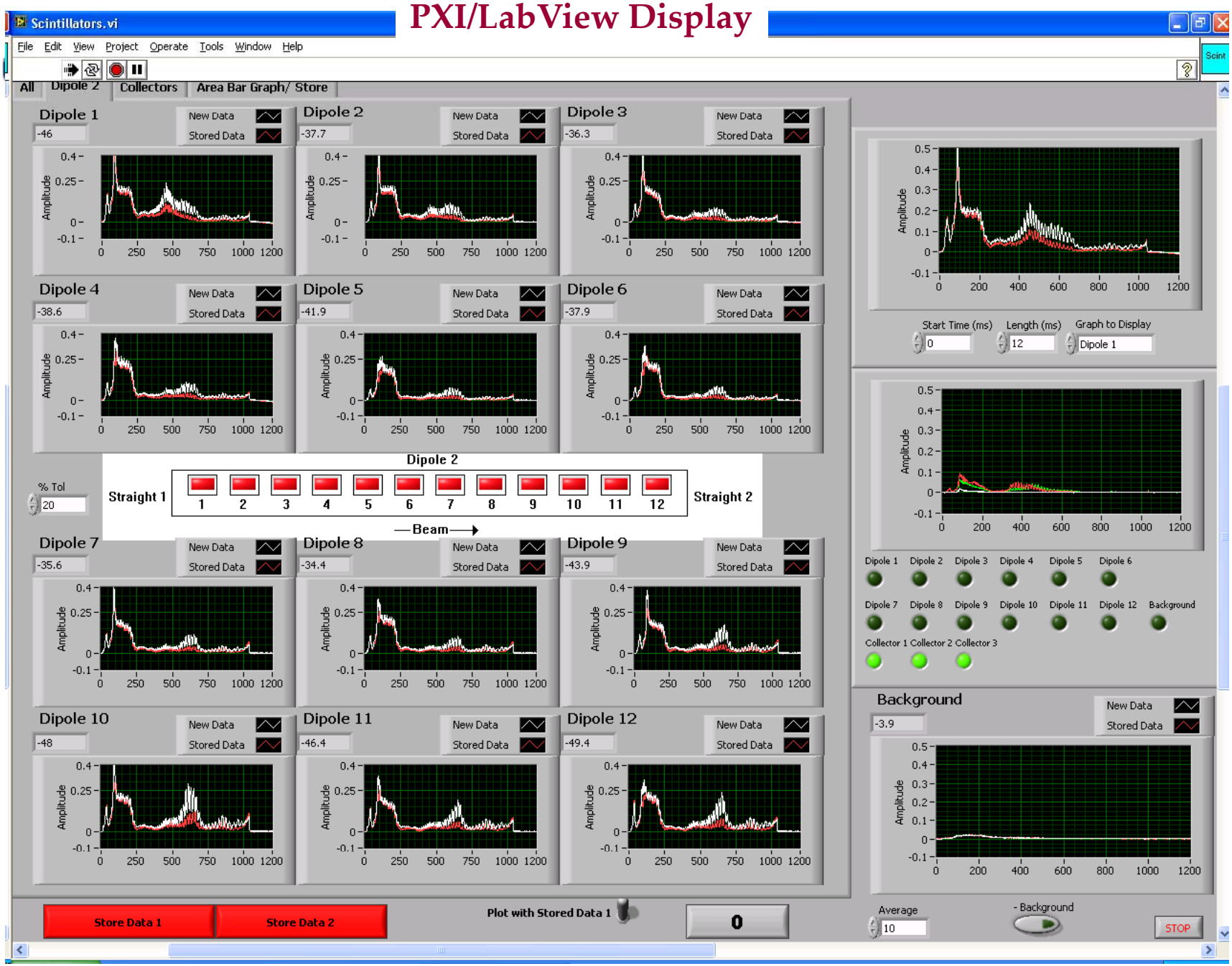


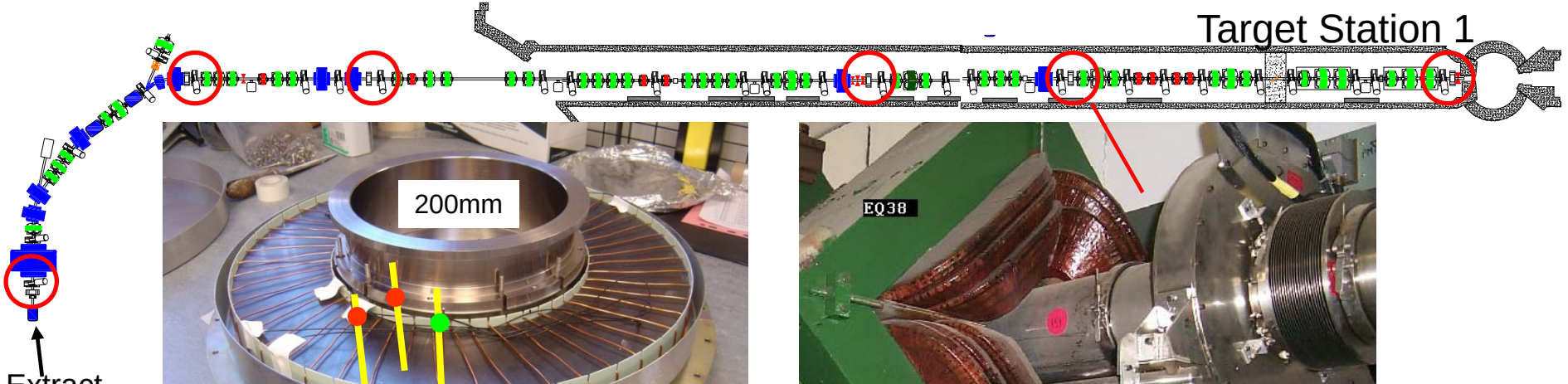
scintillator beam loss diagnostic



Loss not detectable with argon BLM due to shielding effect of dipole body

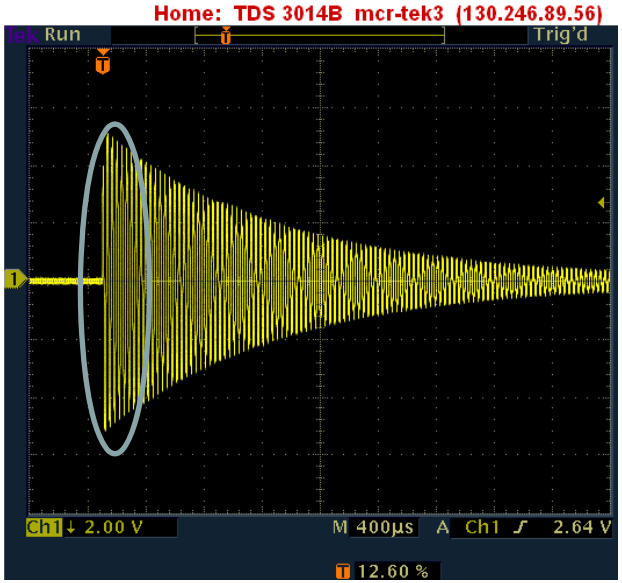
PXI/LabView Display

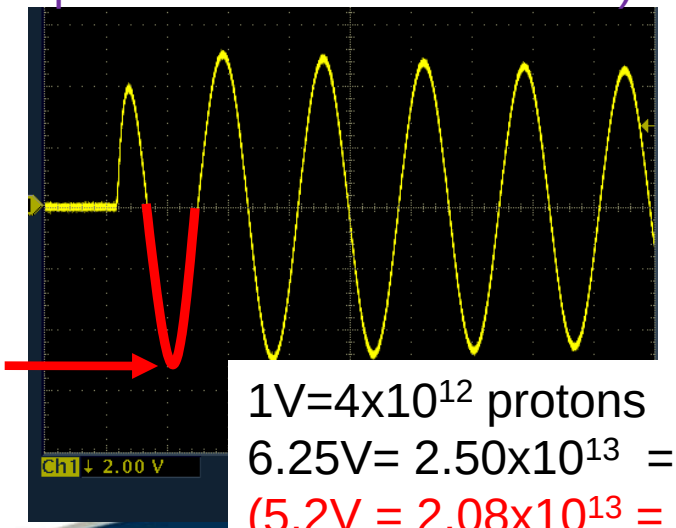


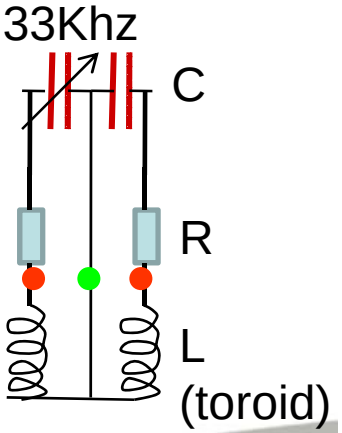


ISIS Beam Intensity (toroid) monitors - EPB

6 toroids in EPB1 , 5 in EPB2 (trip beam after 3 consecutive bad pulses – faster than BLM's)





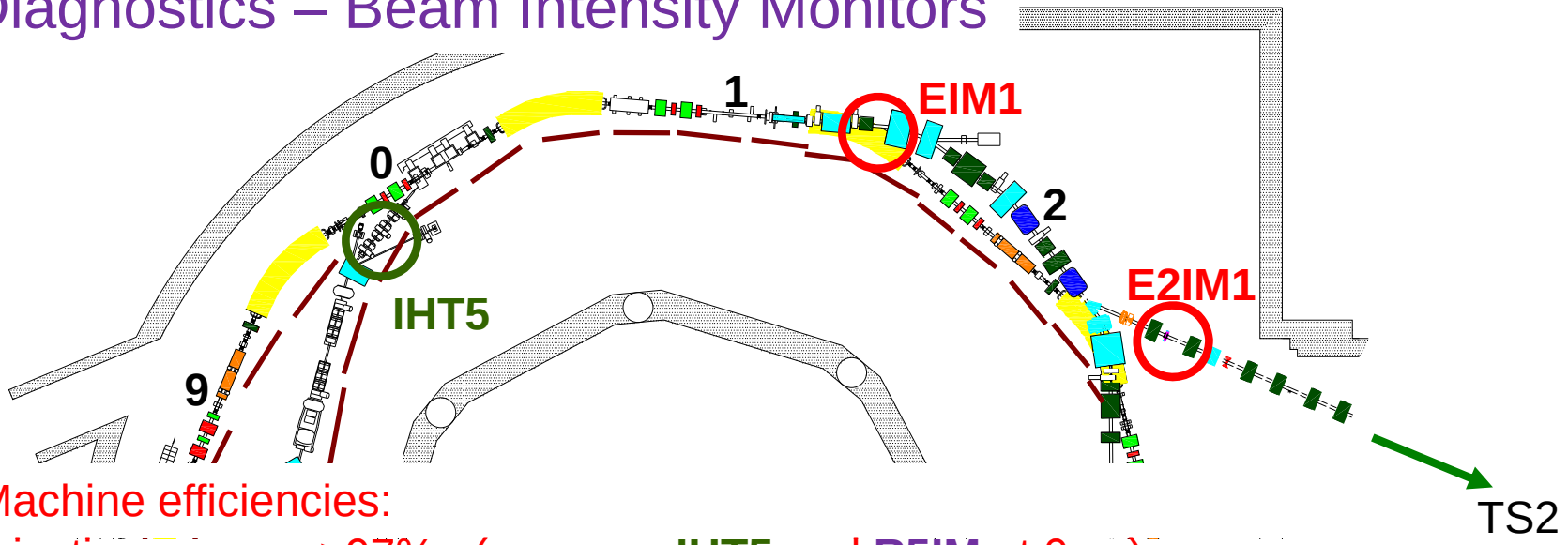


1V=4x10^{12} protons

6.25V= 2.50x10^{13} = 200uA at target

(5.2V = 2.08x10^{13} = 166uA)

ISIS Diagnostics – Beam Intensity Monitors



Machine efficiencies:

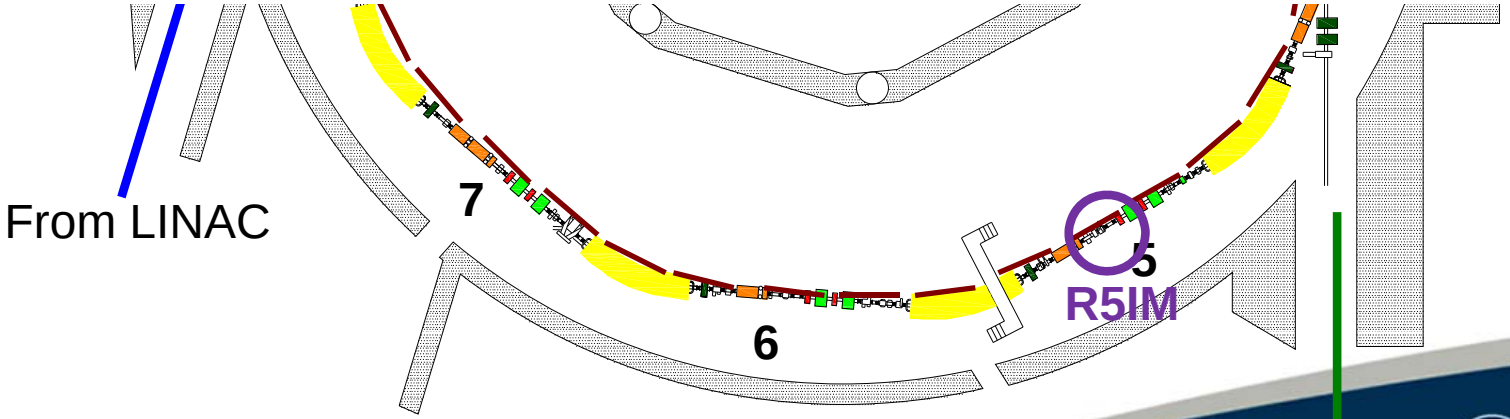
Injection =>97% (compare **IHT5** and **R5IM** at 0ms)

Trapping =>94% (0 to 2.5ms in acceleration cycle **R5IM**)

Acceleration =>95% (2.5 to 9.5 ms in acceleration cycle, **R5IM**)

Extraction TS1 =>99% (9.5ms acceleration cycle **R5IM, EIM1**

Extraction TS2 =>99% (9.5ms acceleration cycle **EIM1, E2IM1**



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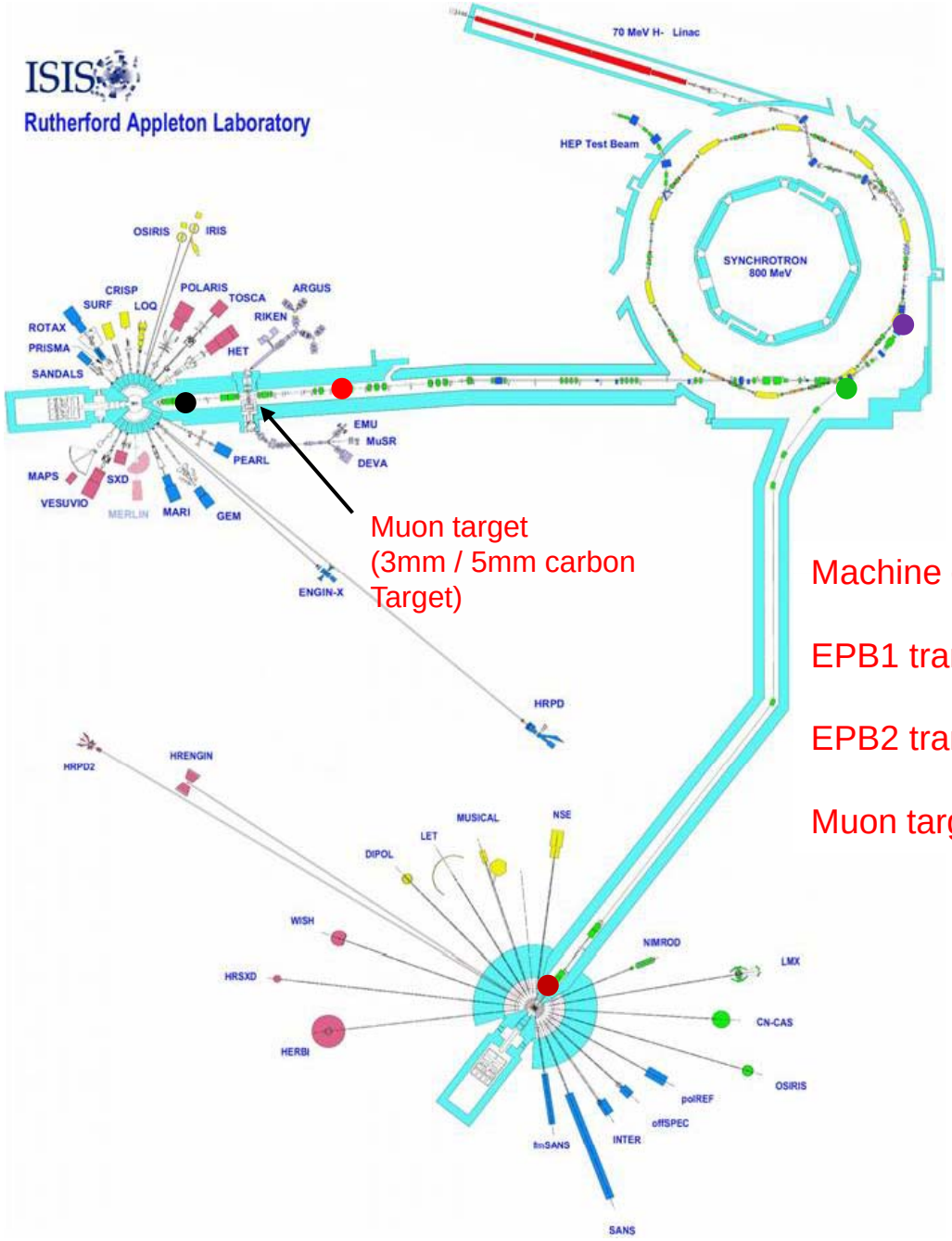

Machine efficiencies:

EPB1 transmission >99% (compare EIM1 ● and EIM5 ●)

EPB2 transmission >99% (compare E2IM1 and E2IM5 ●)

Muon target loss <6% (compare EIM5 and EIM6)

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Transverse Beam Profiles

- Wire ‘harp’ monitors (beam line to target 1 and 2)
- Moving wire type (injector beam line)
- gas ionisation profile monitors (accelerator ring)

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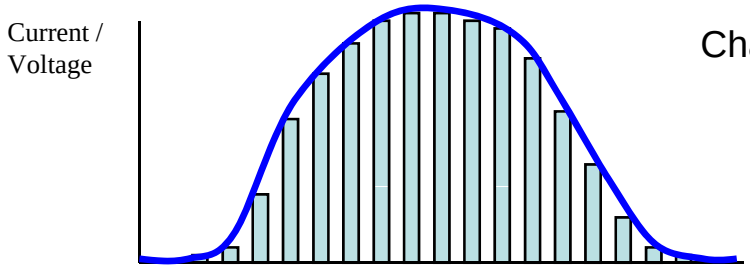
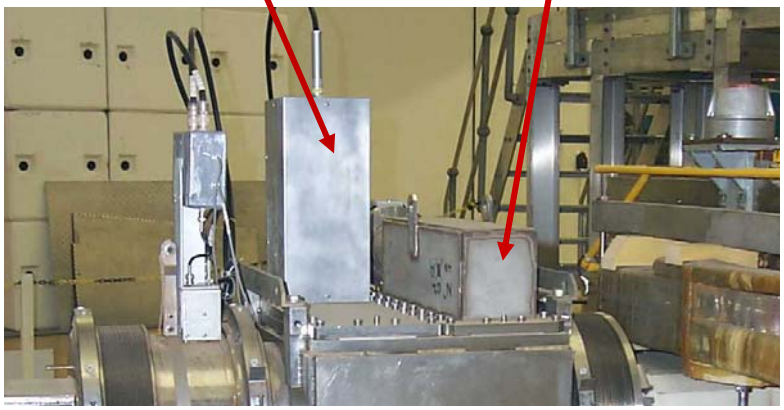
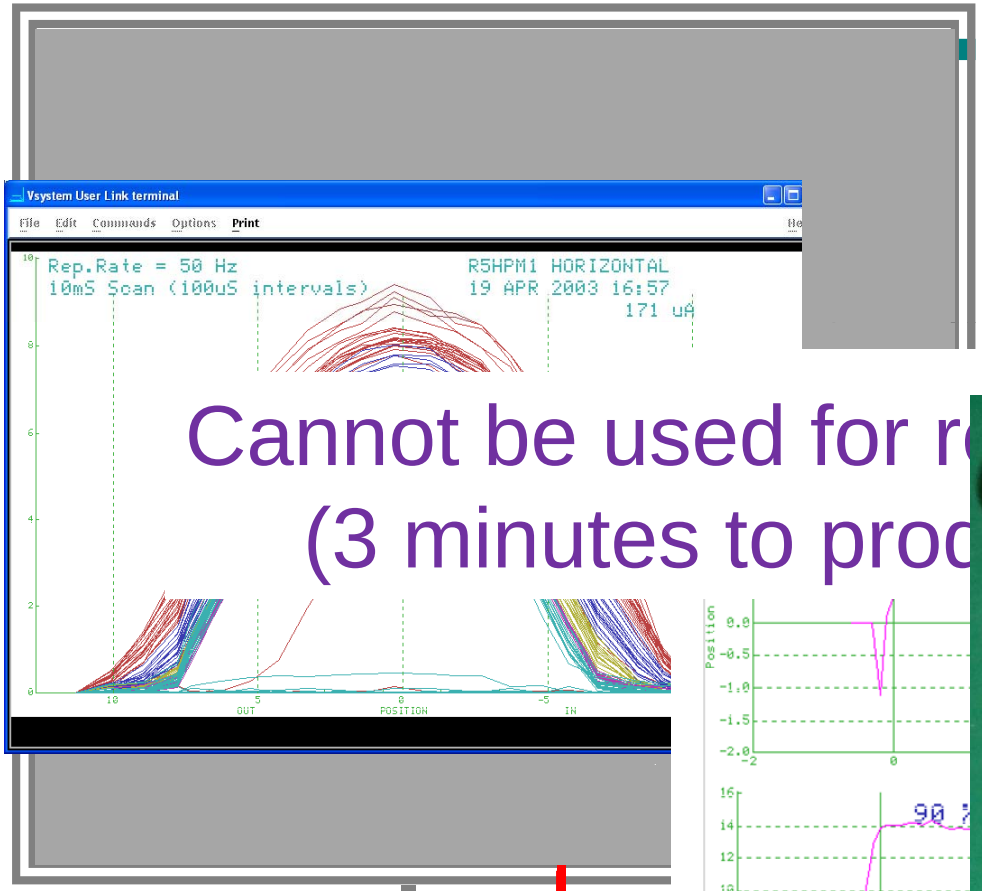


Channeltron output 0-2uA

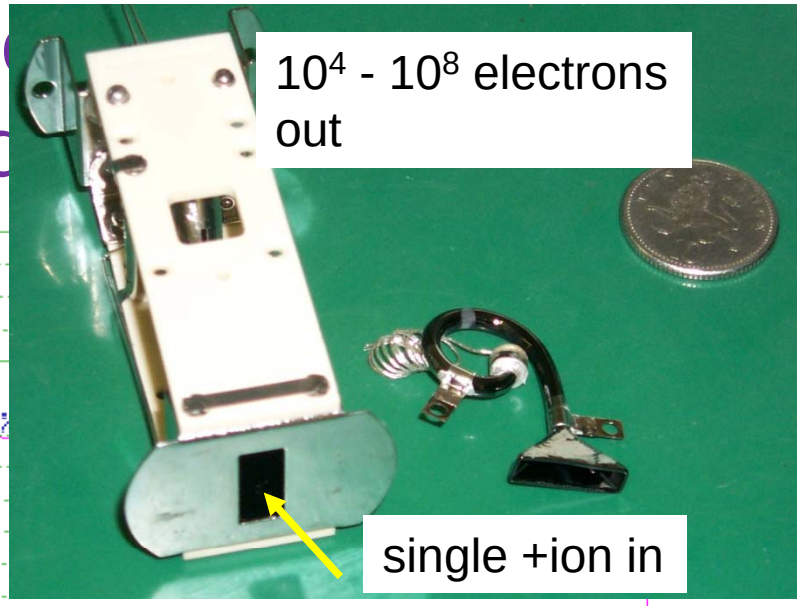
High voltage towers

Motor drive + channeltron

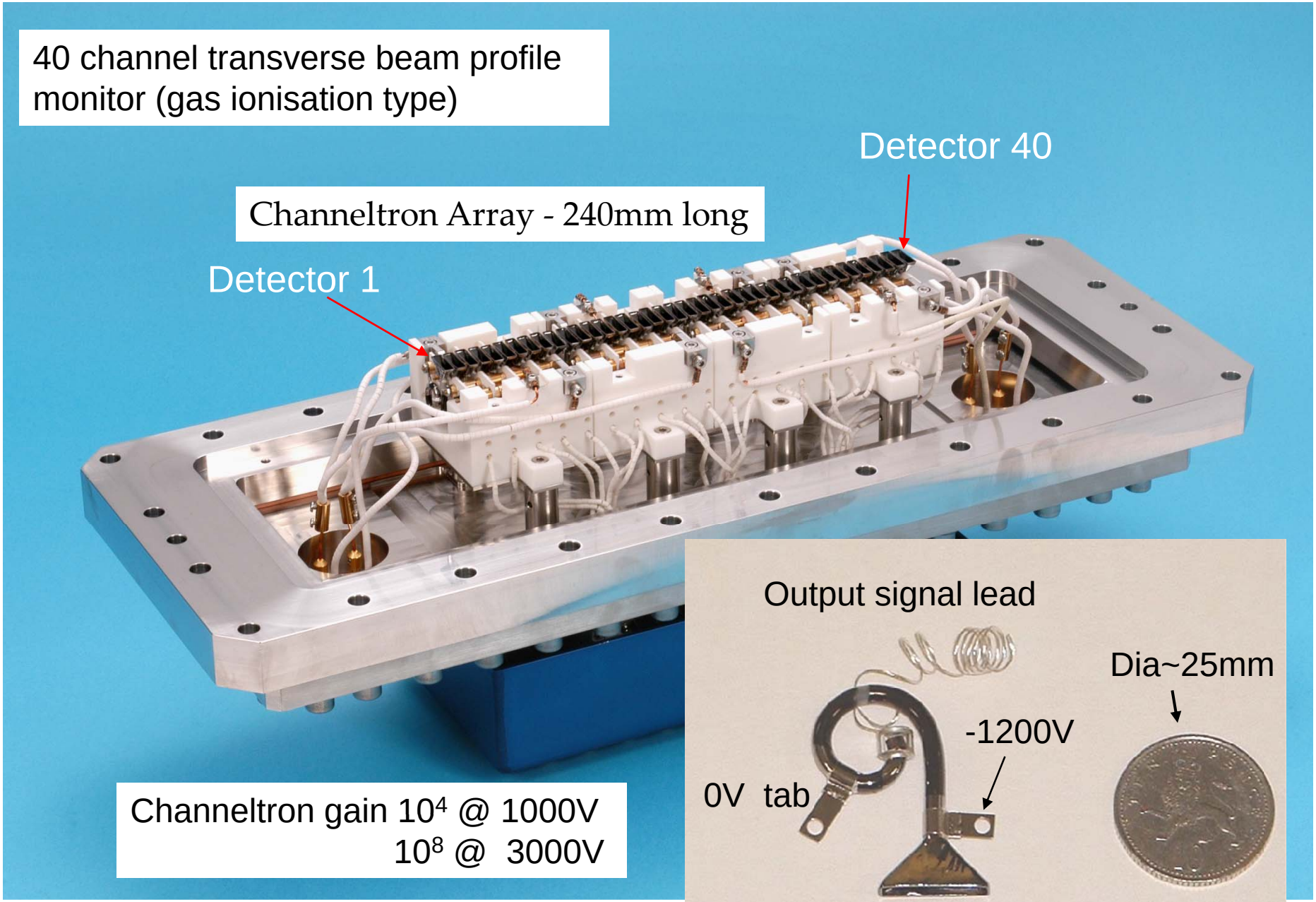




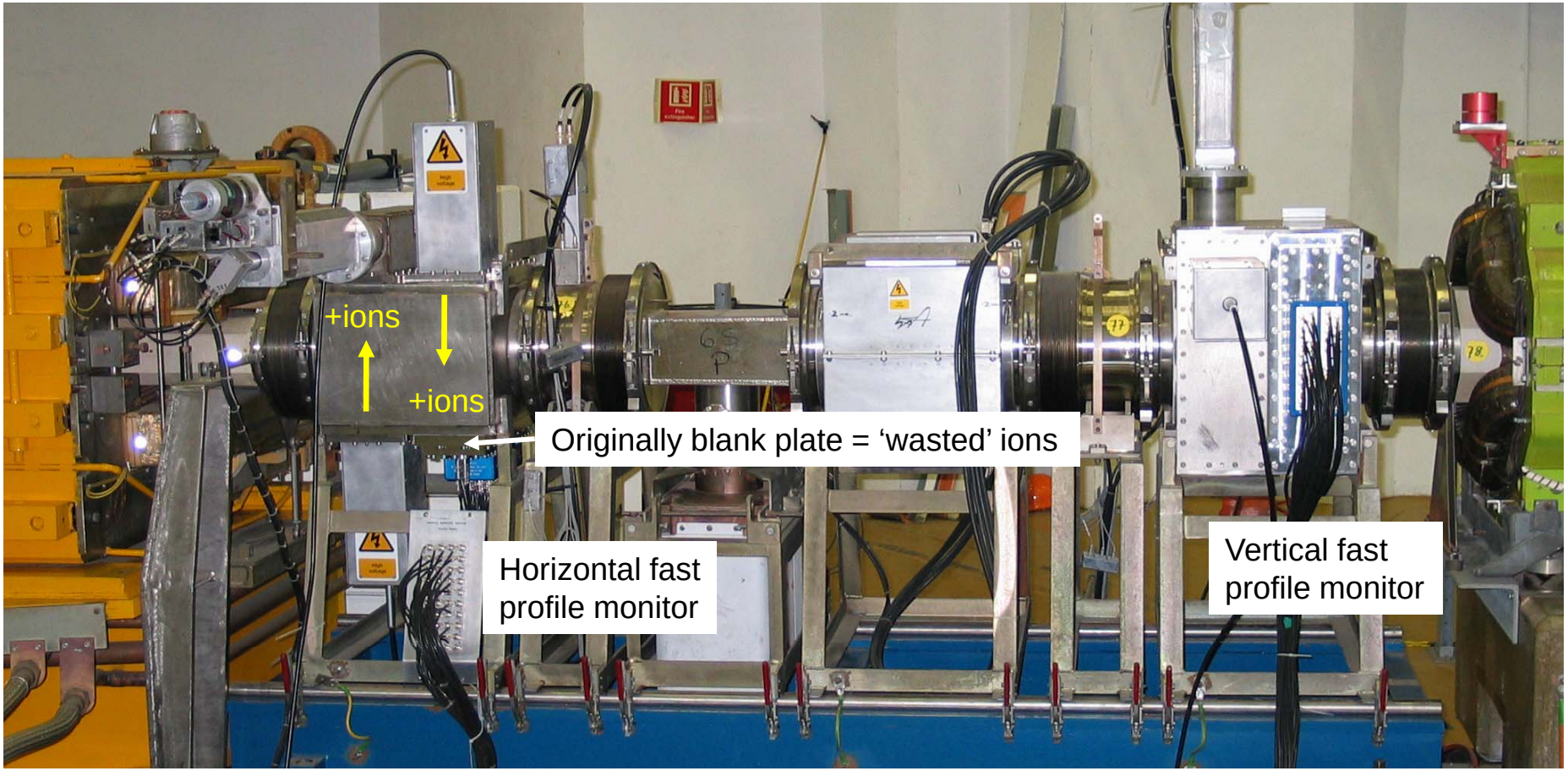
Cannot be used for r
(3 minutes to proc



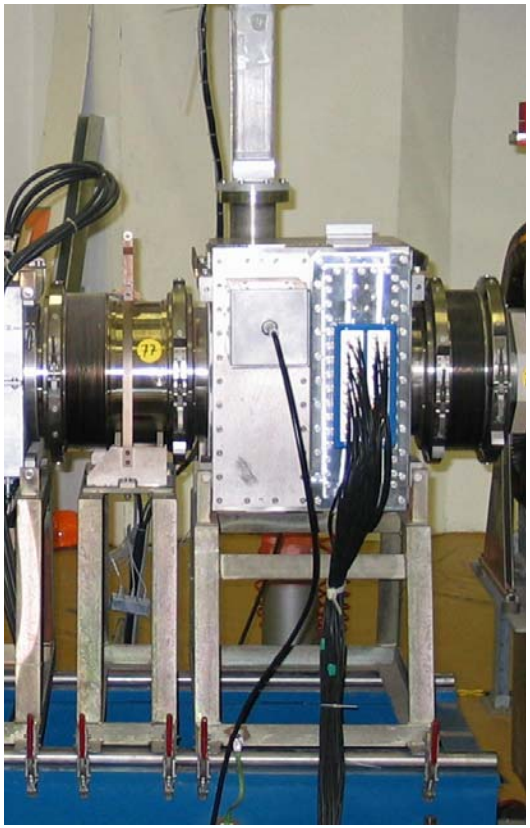
40 channel transverse beam profile monitor (gas ionisation type)



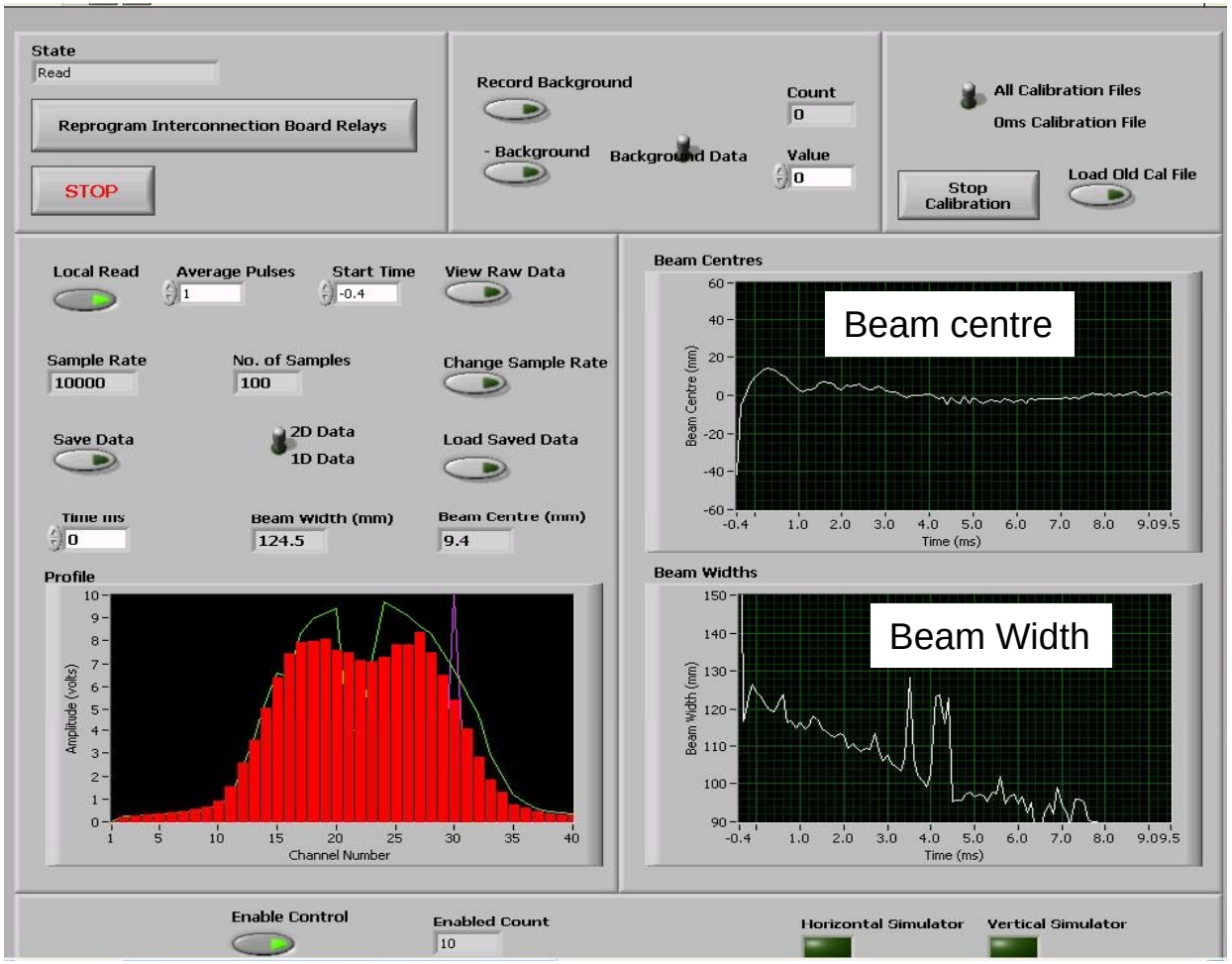
Channeltron gain 10^4 @ 1000V
10^8 @ 3000V



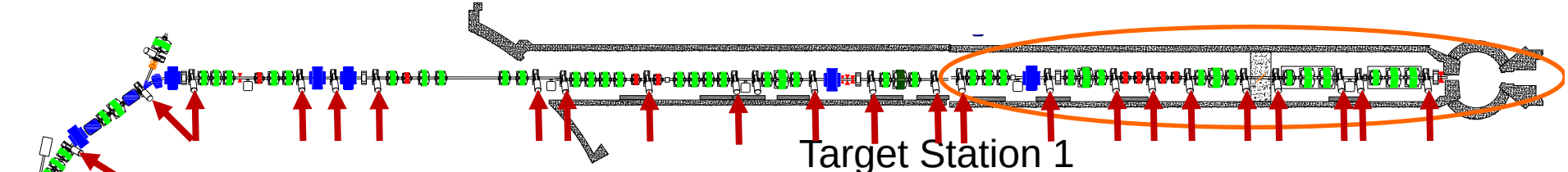
Horizontal and vertical multi-channel profile monitors in Straight 6



Vertical IPM in Straight 5

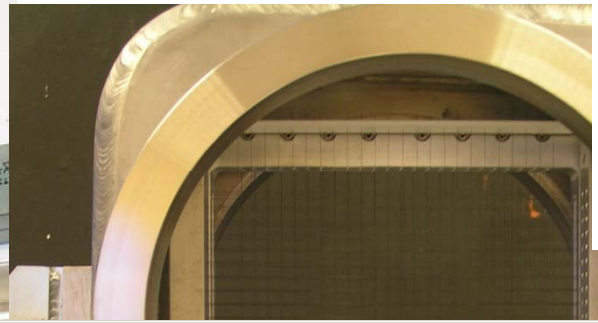


Fast profile monitors will be used to:
(real time) Study beam injection and painting
Transverse space charge effects



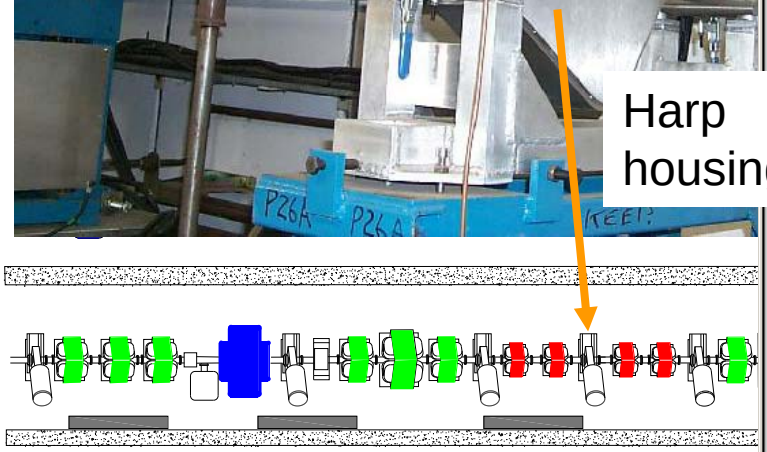
Extract septum

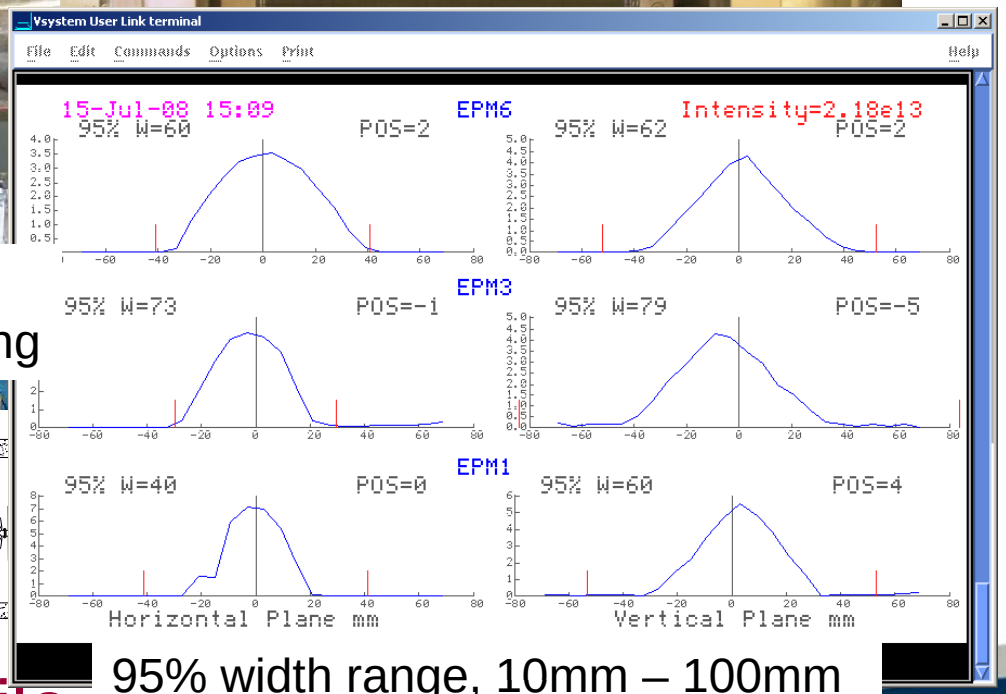
Pneumatic drive



24 x 24 wires silicon carbide (0.1mm diameter) 6mm/ 10 spacing

Harp housing





95% width range, 10mm – 100mm

ISIS Harp transverse profile monitors

(26 TS1, 34 TS2- used at beam rate of 1.6Hz only)

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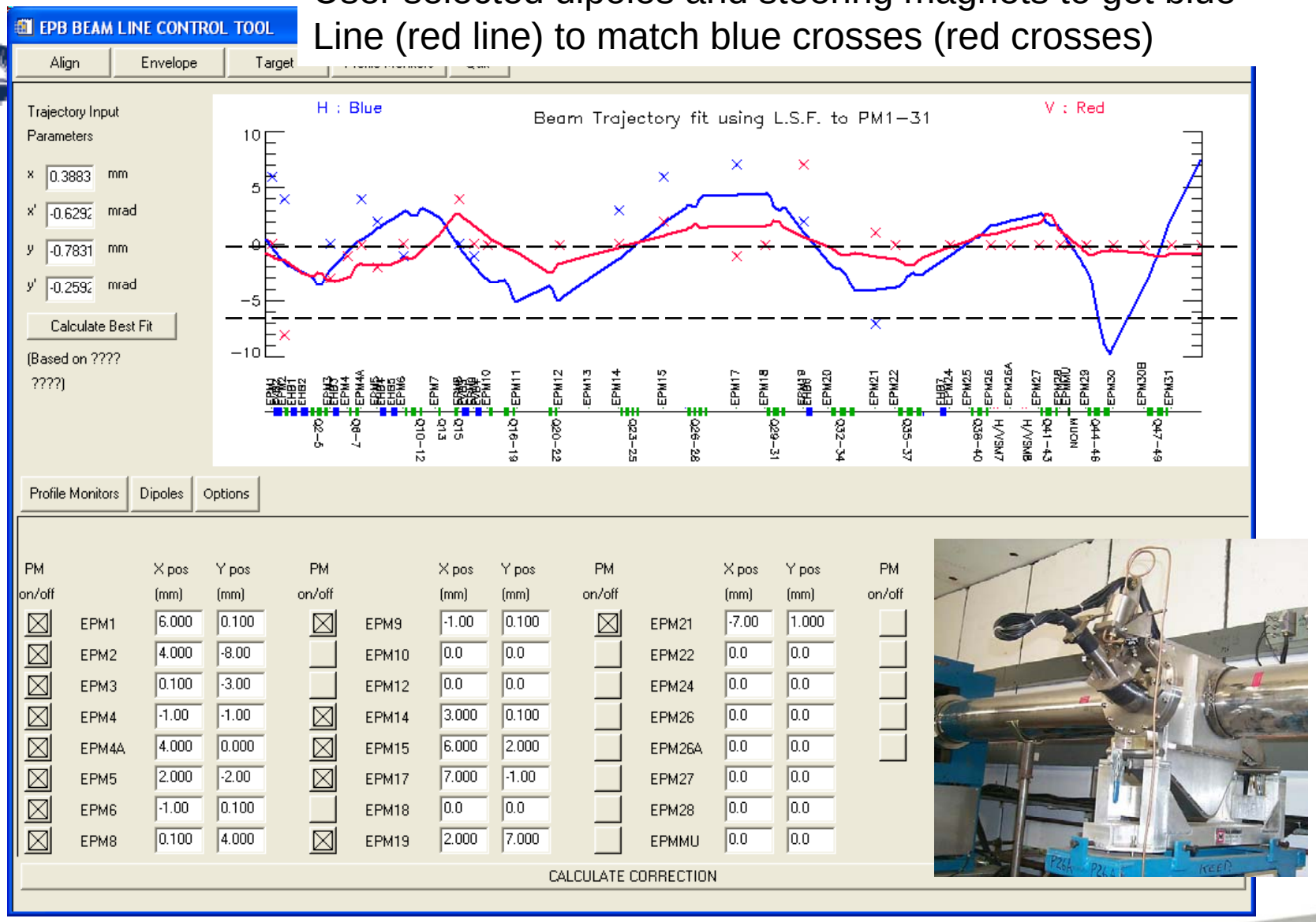
User selected dipoles and steering magnets to get blue Line (red line) to match blue crosses (red crosses)



EPB Correction Tool – suggests changes to Dipoles and steering magnets to Improve EPB trajectory

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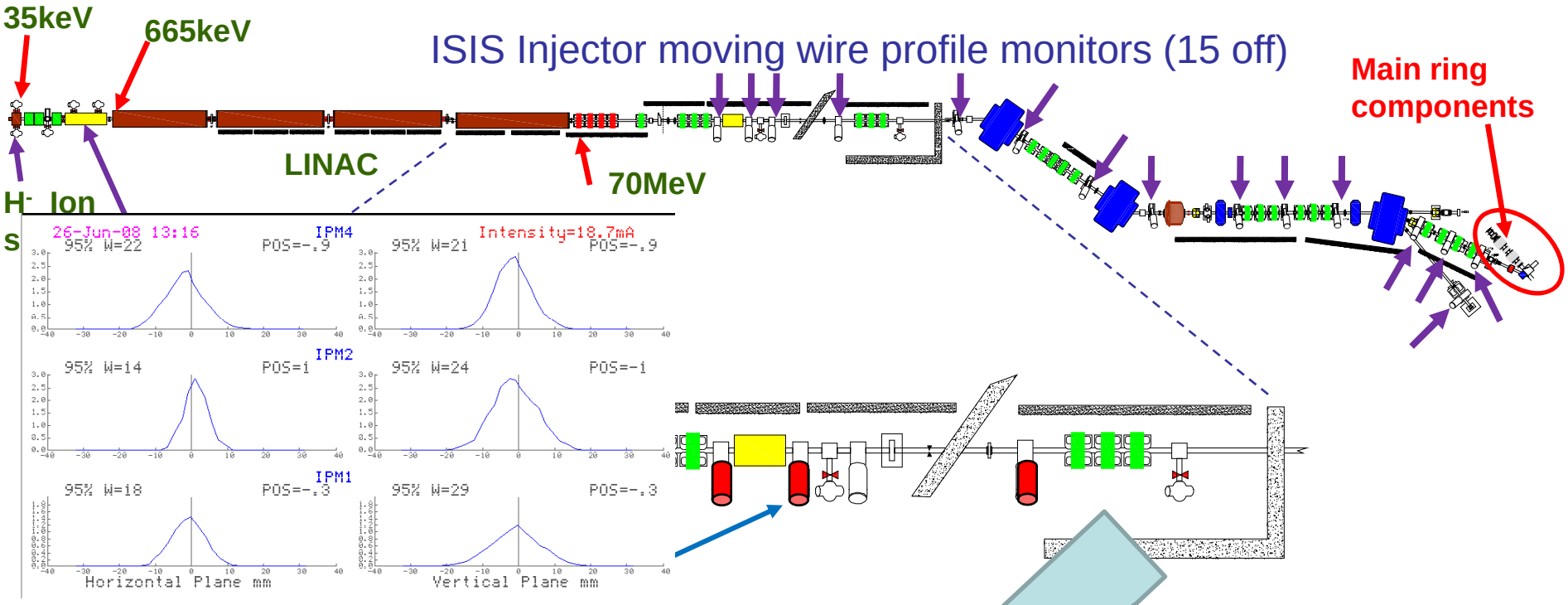
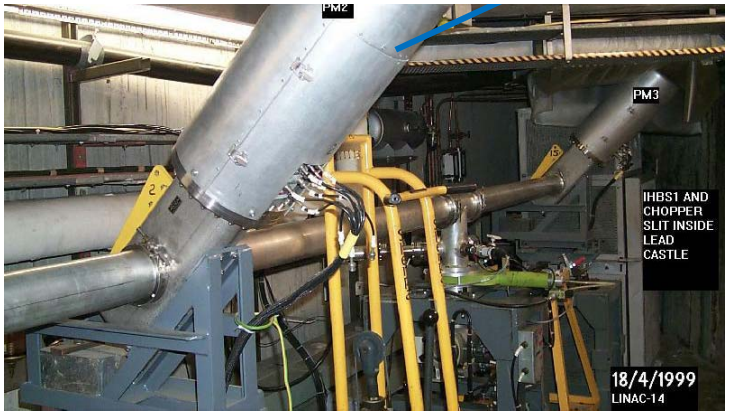
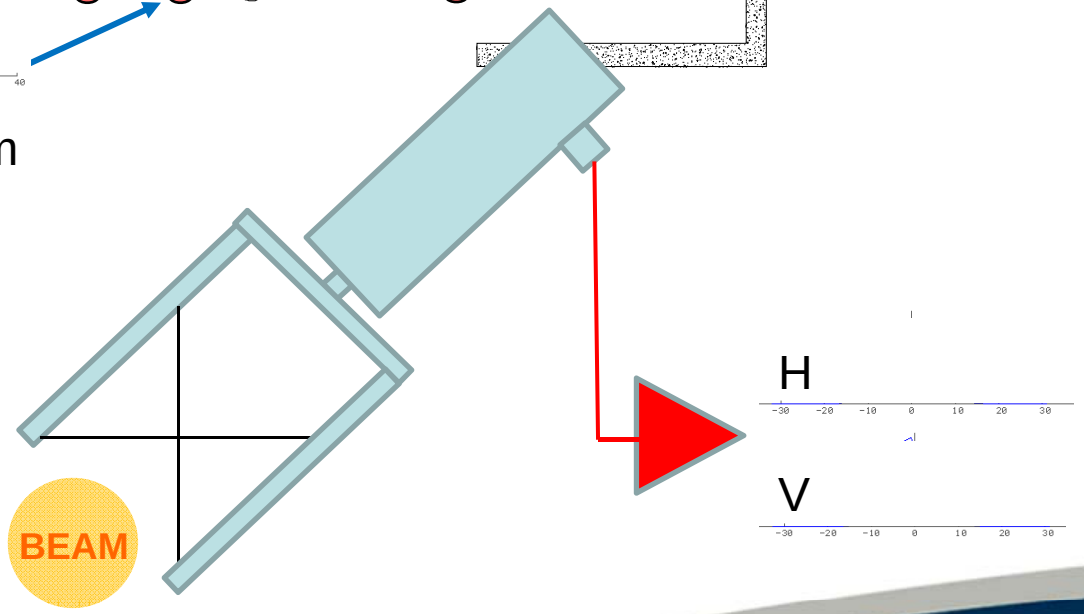
ISIS Injector moving wire profile monitors (15 off)



95% width range, ~12mm – 30mm





Only operates at 1.6Hz (base rate)
50Hz monitor under design

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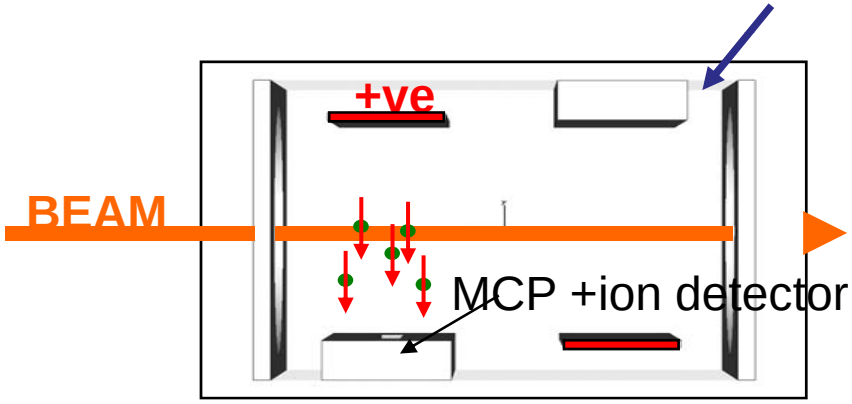
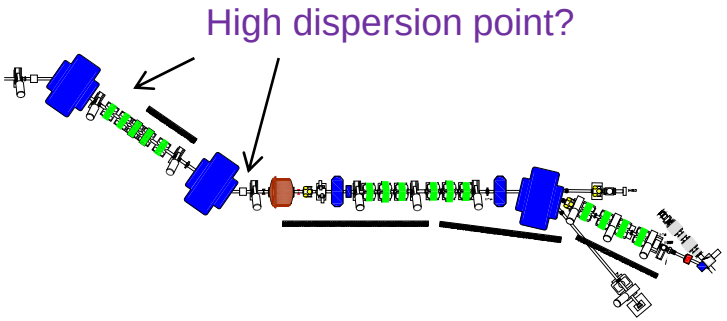
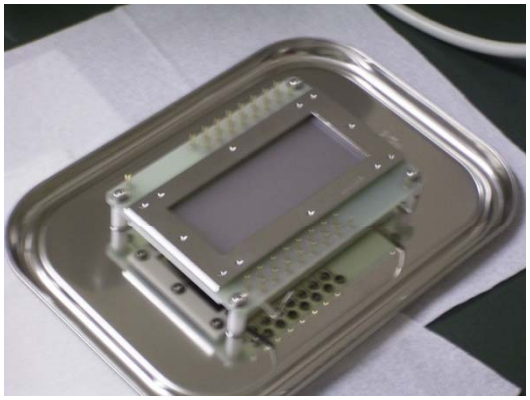
Plus side – Good profile to carry machine Tuning and machine studies, but…

Down side – very slow ~4 minutes (and only at 1.6Hz).

Looking at ‘ring profile’ style solution for a ‘50Hz’ monitor using micro channel plates

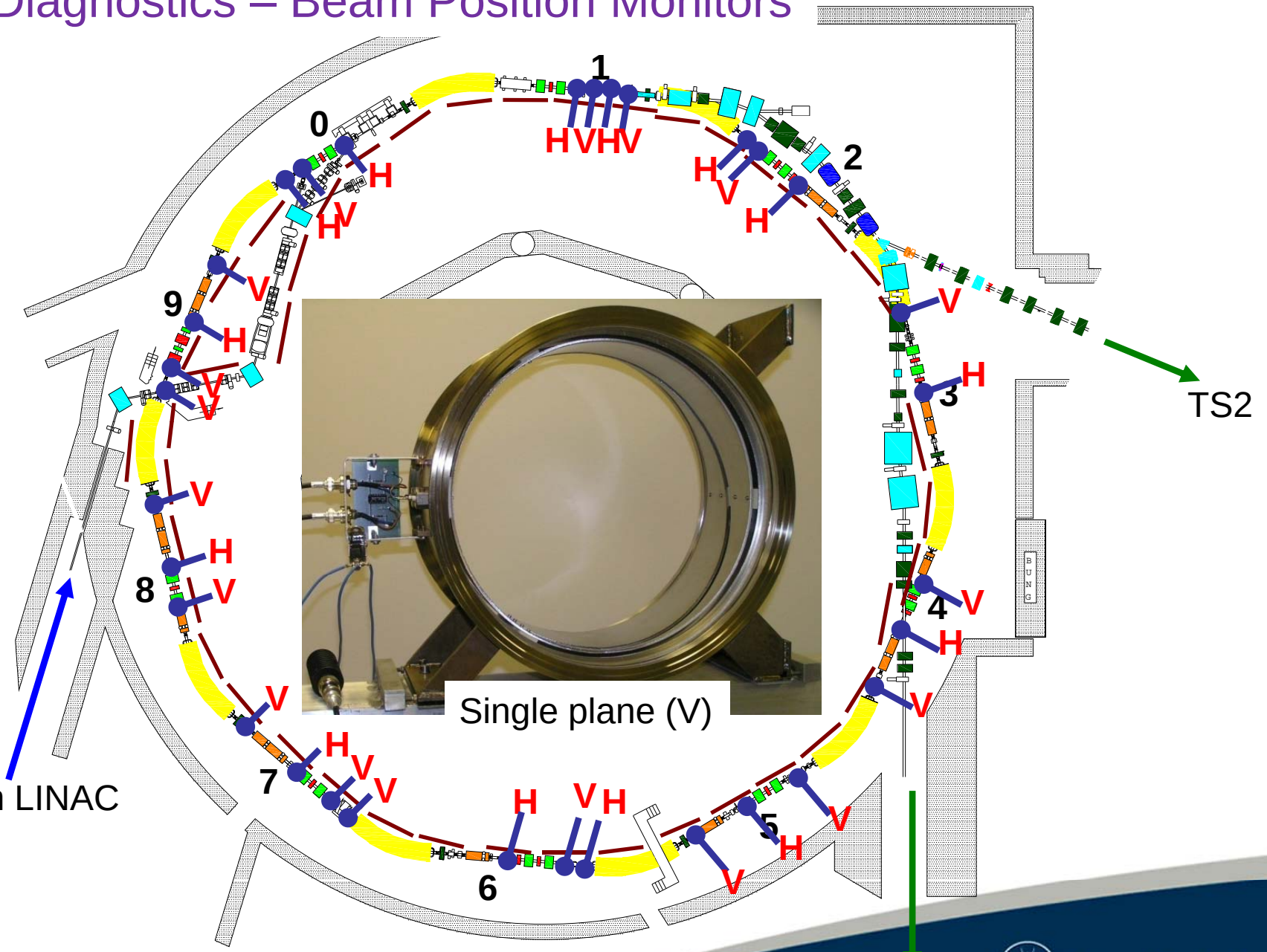






32 channel MCP (88mm active width)

ISIS Diagnostics – Beam Position Monitors



EPB = Beam line to target

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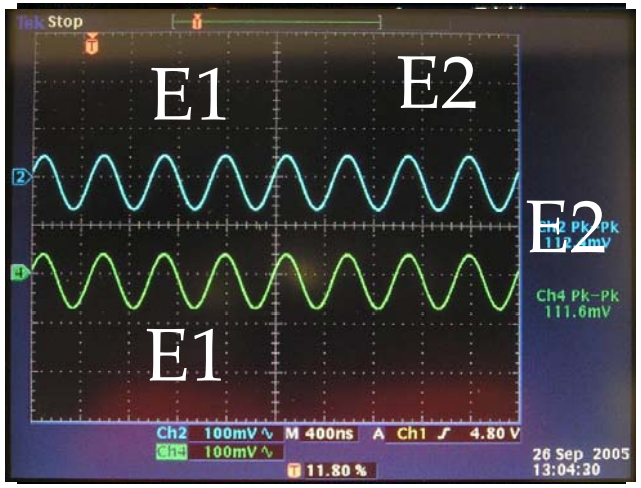
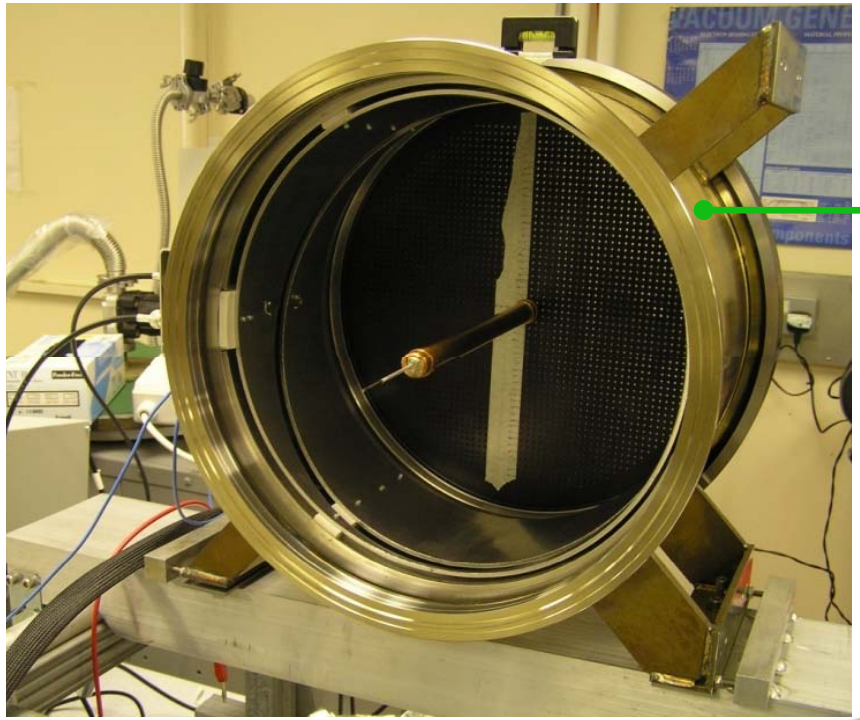
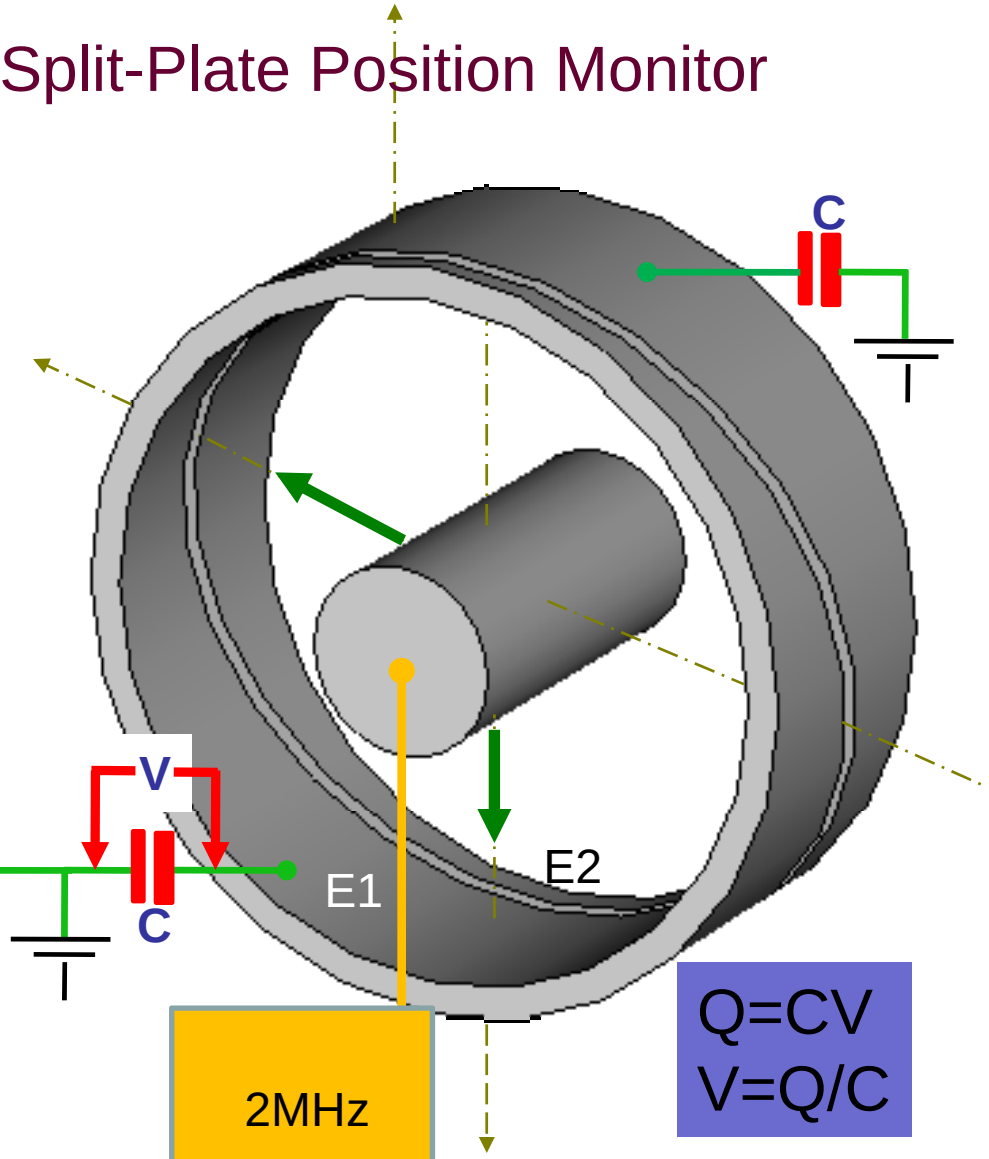
ISIS Split-Plate Position Monitor







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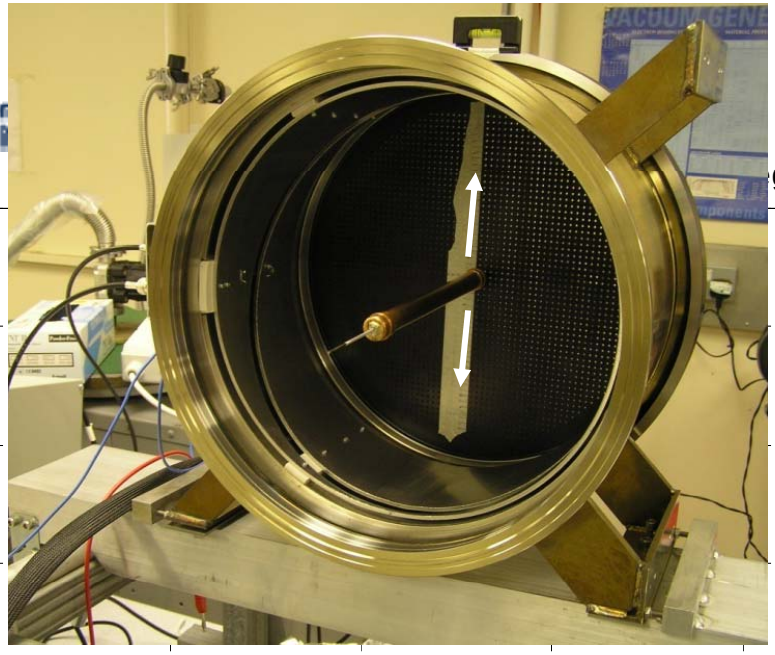

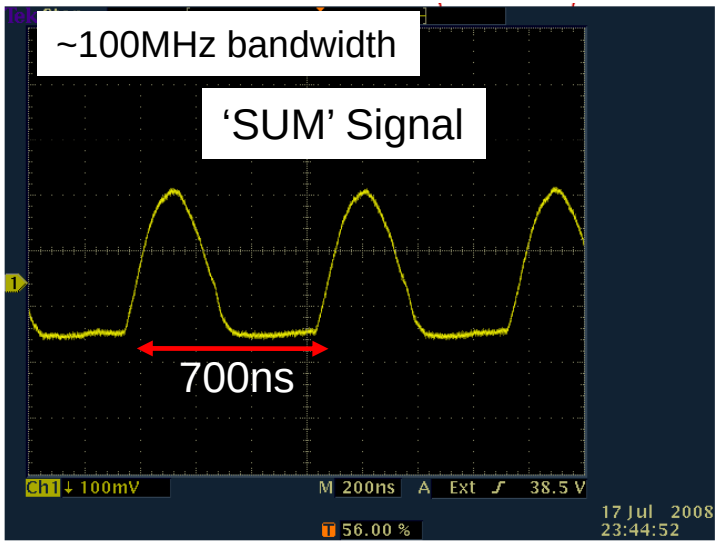

Slope = 1/k

k=105.8 = Calibration Factor

$$\frac{E_1 - E_2}{E_1 + E_2} * k = \text{Beam Position}$$

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‘pulsed’ Diagnostics (‘two machines’)

Can operate ISIS on Normal or Experimental settings (at 1.6Hz)

Parameters that can be varied:

• Horizontal Steering	beam steering
• Vertical Steering	beam steering
• Q values	beam focussing
• Harmonic Q values	beam focussing
• Vertical sweeper	injection painting
• radial demand	RF (beam centre)
• frequency trim	RF (beam centre)
• RF Gap volts	RF (beam capture)
• Phase switch	RF (anti-phasing)

Allows one pulse in *n (=32, 64, 128)* to ‘see’ a different machine set up – Restricts beam loss while trying to achieve the best set up.

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Groups A and B - tour route… ISIS then Diamond

Ziad Abou Haidar	Begona Femandez Martinez
Marc Alvarez	Peter Forck
Christiane Andre	Arnaldo Galbiati
Savyora Artikova	Tino Giacomini
Lucy Attwood	Aurelie Goldblatt
Thomas Aumeyr	Joachim Gomez
Santiago Bernal	Marcos Aurelio Gonzalez Alvarez
Douglas Bett	Janusz Harasimowicz
Alessio Bocci	Nicole Hiller
Enrico Bravin	Angela Intermite
Benjamin Cheymol	Lee Jones
Christian Eckardt	Nirav Yashvantray Joshi
Jan Egberts	Matthias Justus

If surname first letter > J
then : Diamond - ISIS
else ISIS - Diamond

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Groups C and D – Tour route … Diamond then ISIS

Caglar Kaya
Michel Kireef Covo
Felix Laux
Thibaut Lefevre
Konstantin Lekomtsev
Lili Ma
Paul Morby
Felix Mueller
Carsten Muller
Raquel Munoz
Maja Olvegard
Dominika Posadzv
Massimiliano Putigano
Marion Ripert
Georg Schepers
Joachim Schreiner
Udrea Serban
Michael Traeger
Beata Walasek-Hohne
Carsten Welsch
Marc Wenksat
Helmut Wiedemann
Tim Winkelmann
Kay Wittenburg

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