

Recent Status of Linac Facility at Osaka University

A.Saeki

Prof. S.Tagawa group: (Beam Material Science)

S.Seki, T.Kozawa, K.Kobayashi, K.Okamoto, A.Saeki

Prof. G.Isoyama group: (Accelerator Science)

R.Kato, Y.Honda, S.Kashiwagi, N.Kimura

Prof. T.Majima group: (Molecular Excitation Chemistry)

M.Fujitsuka, N.Ichinose, S.Tojo, K.Kawai

Prof. Y.Yoshida group: (Beam Science for Nanofabrication)

J.Yang

Technician:

S.Suemine, T.Yamamoto

Outline

1. Recent renewal of linac facility
2. S-band photocathod RF-gun linac
3. Pulse radiolysis

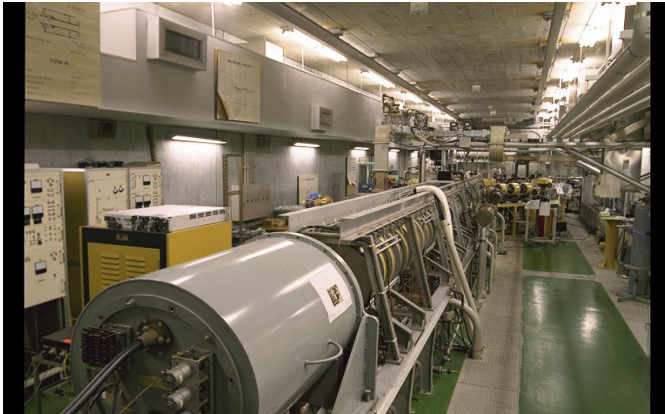
1. Recent renewal of linac facility

Prof. G.Isoyama group:

R.Kato, Y.Honda, S.Kashiwagi

Technician:

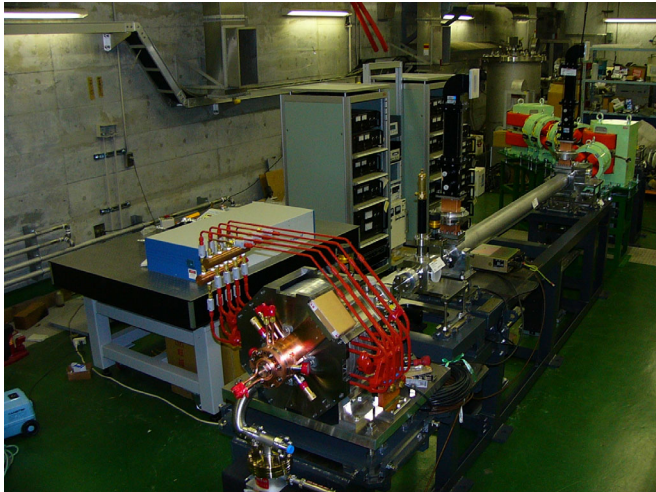
S.Suemine, T.Yamamoto



■ 38 MeV, L-band linac



■ 150 MeV, S-band linac



■ 30 MeV, S-band photocathod RF-gun linac

Used for

Pulse radiolysis

FEL, SASE

Positronium Annihilation Lifetime Spectroscopy

- RF system
 - Klystron
 - Pulse modulator for the klystron
 - Wave guide system
 - Three amplifiers for the sub-harmonic buncher system
 - Master oscillator
- Magnet system
 - Power supplies for the Helmholtz coils, the bending magnets, the quadrupole magnets, steering coils.
- Computer control system
- Timing system
- Facility
 - Interlock system for radiation safety
 - High precision cooling water system ($< \pm 0.03^{\circ} \text{C}$)
 - High precision air conditioner for the klystron room
 - AVR for the AC200V line for the klystron modulator

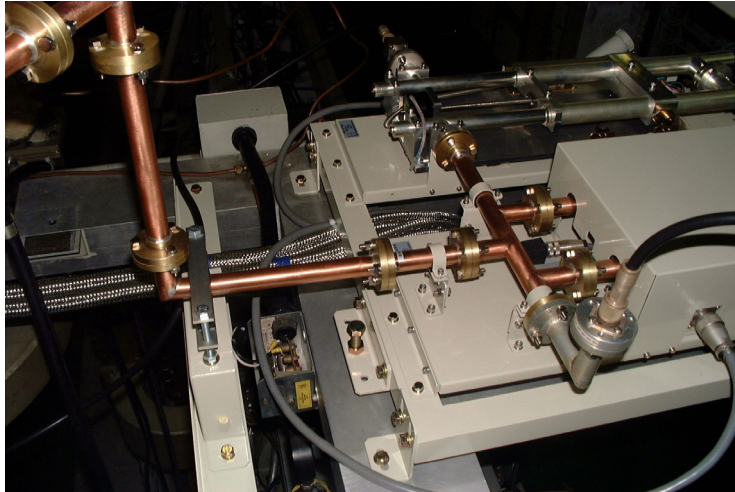
- Previous system
 - 5 MW klystron (Toshiba, E3775A) for the prebuncher and the buncher
 - 20 MW klystron (Thomson, TV-2022A) for the acceleration tube.
- New system
 - 30 MW klystron (Thales, TV-2022E) for the all.



Pulse Modulator for Klystron

- $V_{\max} = 295 \text{ kV}$, $I_{\max} = 275 \text{ A}$
- Pulse Width $4 \mu\text{s} / 8 \mu\text{s}$
 - Long pulse mode for FEL
 - 2 modes changeable by remote control.
- Flatness of the flat top $< 0.2 \%$ ($< 0.1 \%$)
- Pulse-to-pulse fluctuations $< 0.1 \%$ ($< 0.05 \%$)
- Repetition
 - 60 pps for the short pulse mode
 - 30 pps for the long pulse mode
- Inverter type HV generator
 - Stable and efficient
- Thyatron Switch
 - To be replaced with SSD
- Remote control using FL-net.



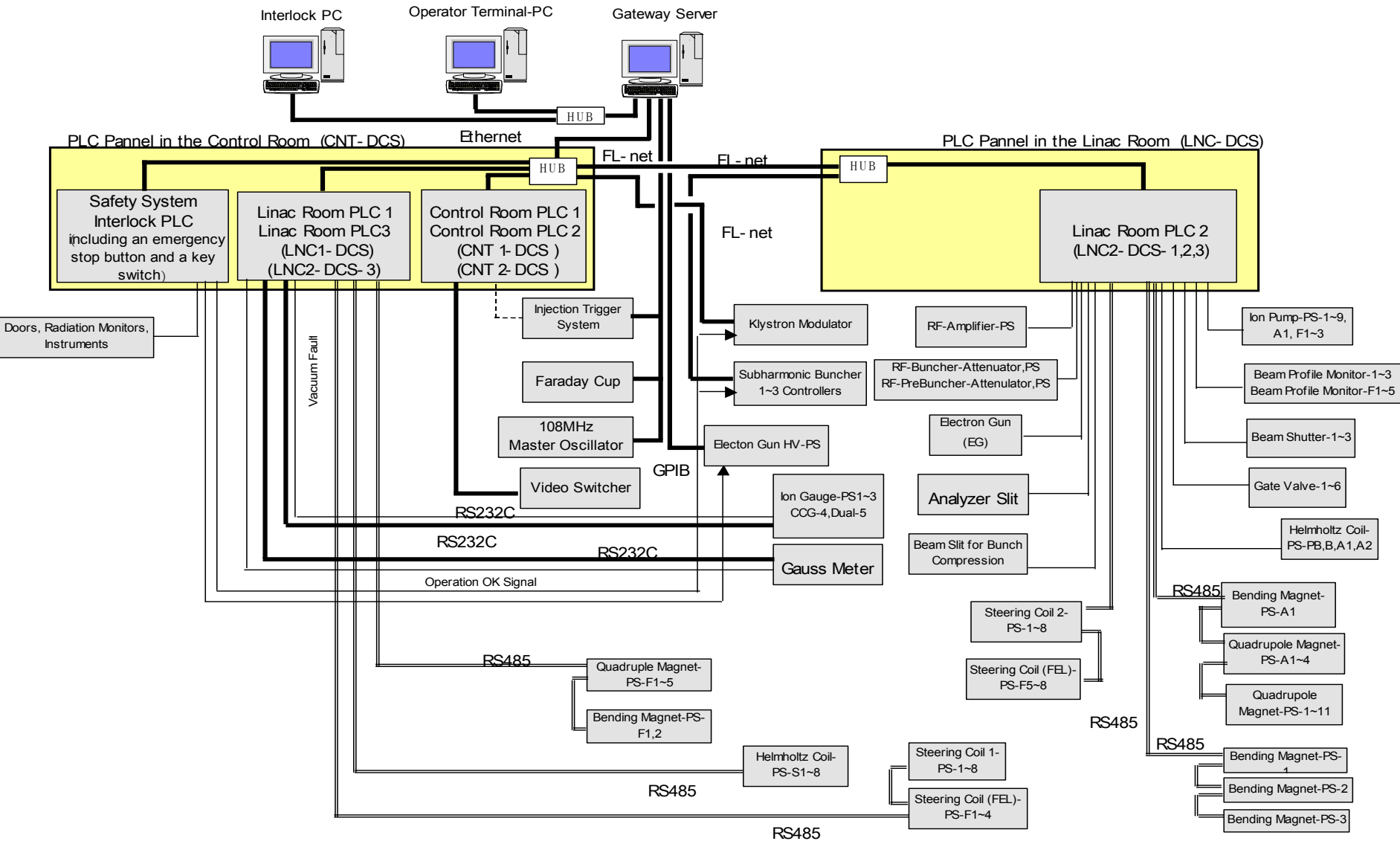


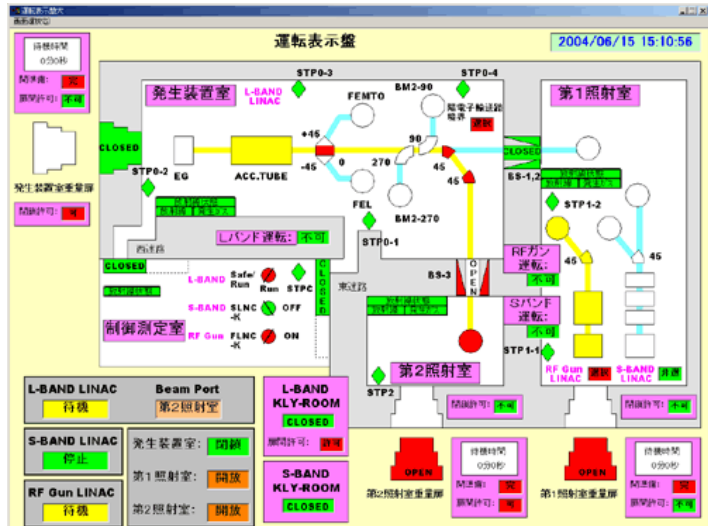
PRS10 Rubidium Frequency Standard

- **Ultra Low phase noise (<-130 dBc/Hz at 10 Hz)**
- **Time-tags or phase-locks to a 1 pps input**
- **72 hour stratum 1 level holdover**
- **RS232 for diagnostics, control and calibration**
- **Long lamp life and established reliability**
- **Low cost (\$1495, Quantity 1, U.S. list)**



The PRS10 is an ultra-low phase noise 10 MHz rubidium disciplined crystal oscillator. The device fulfills a variety of communication, syn-





All parameters are automatically saved, so that they can be restored in the next operation.

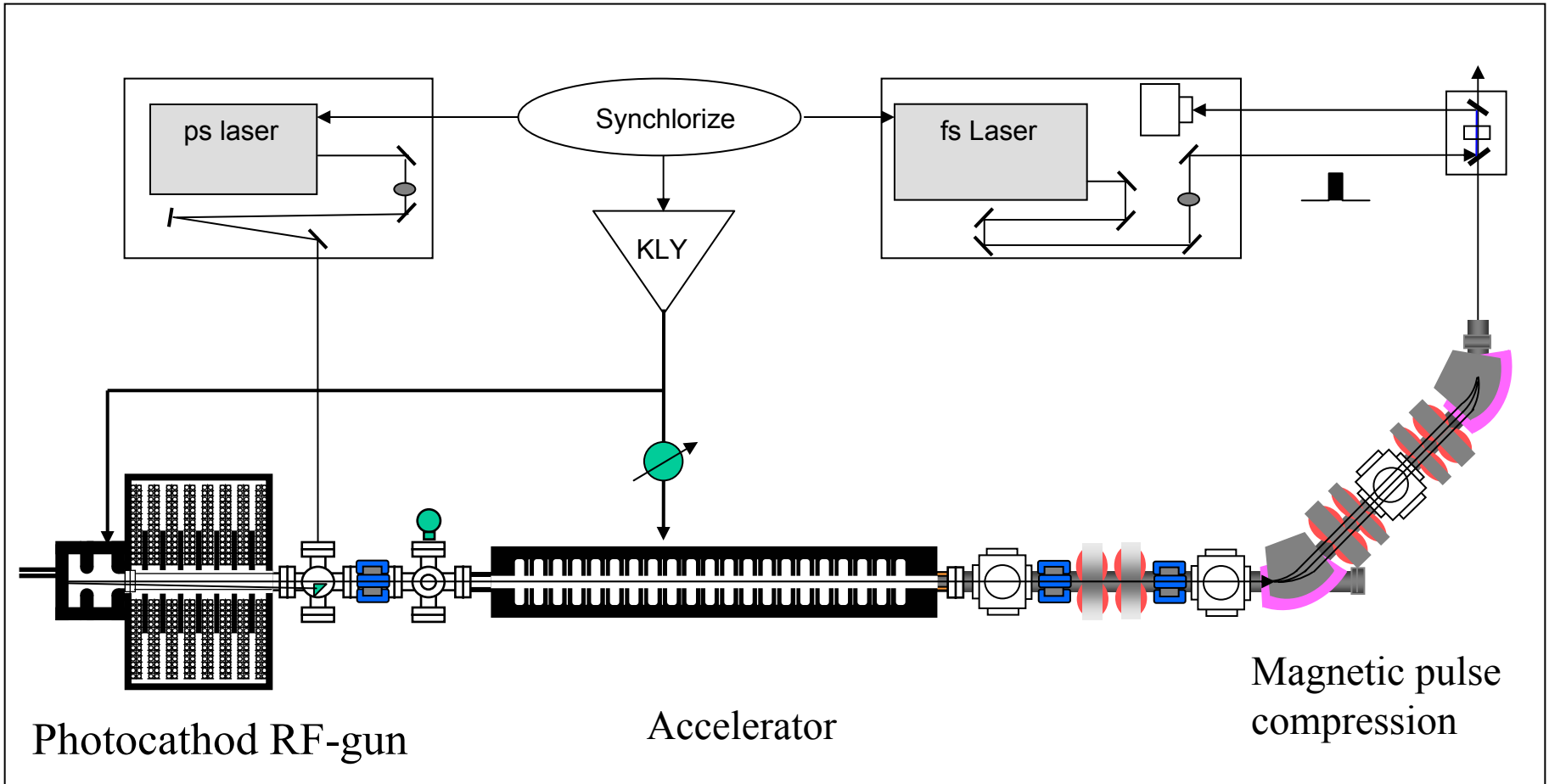
2. S-band photocathod RF-gun linac

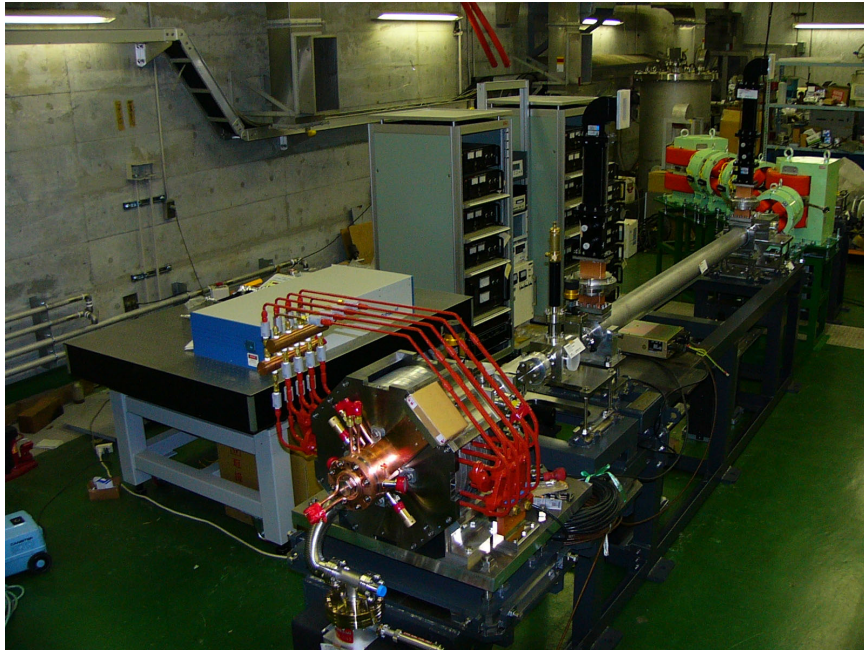
Prof. Y.Yoshida group:

J.Yang

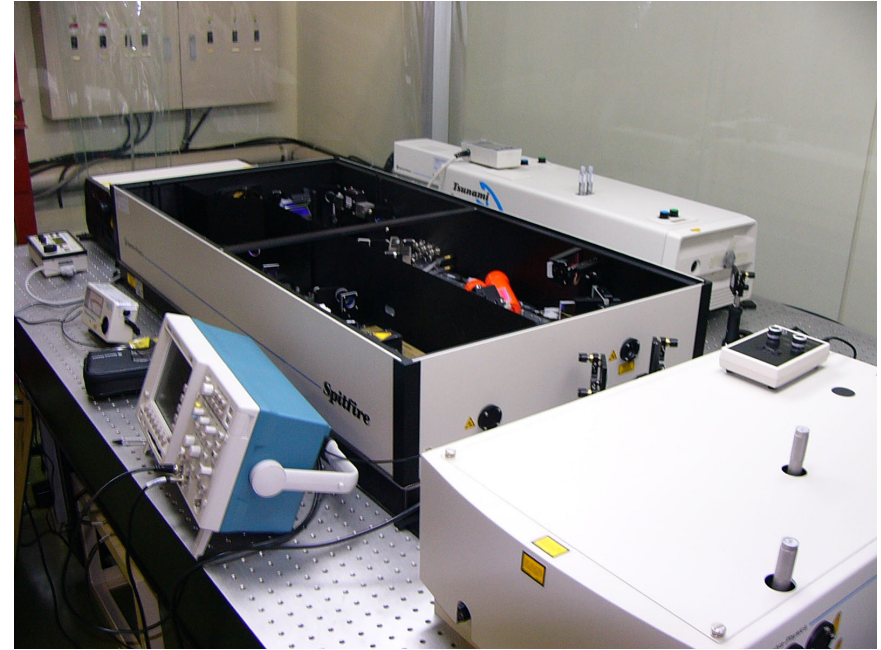
Prof. S.Tagawa group:

T.Kozawa





Linac



fs laser



ps laser

3. Pulse radiolysis

Prof. S.Tagawa group:

S.Seki, T.Kozawa, K.Kobayashi, K.Okamoto, A.Saeki

Prof. Y.Yoshida group:

Prof. T.Majima group:

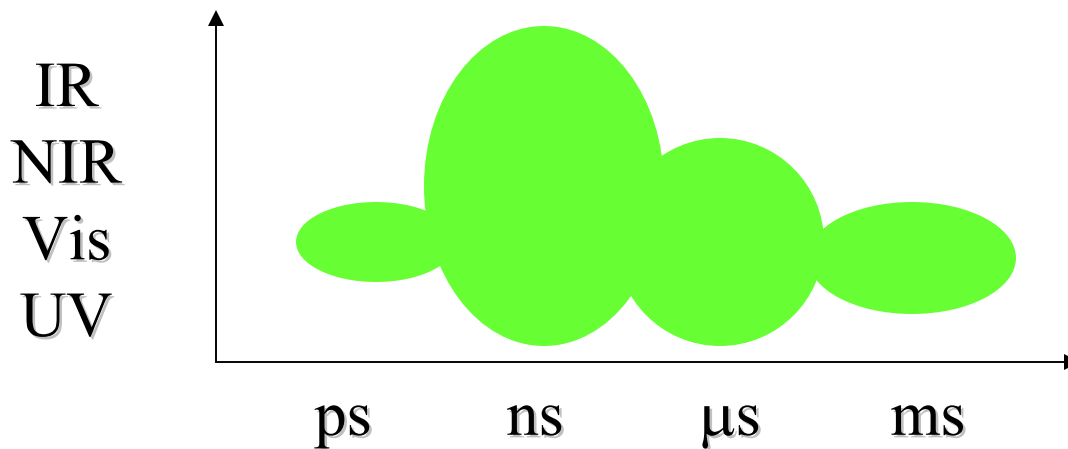
M.Fujitsuka, N.Ichinose, S.Tojo, K.Kawai

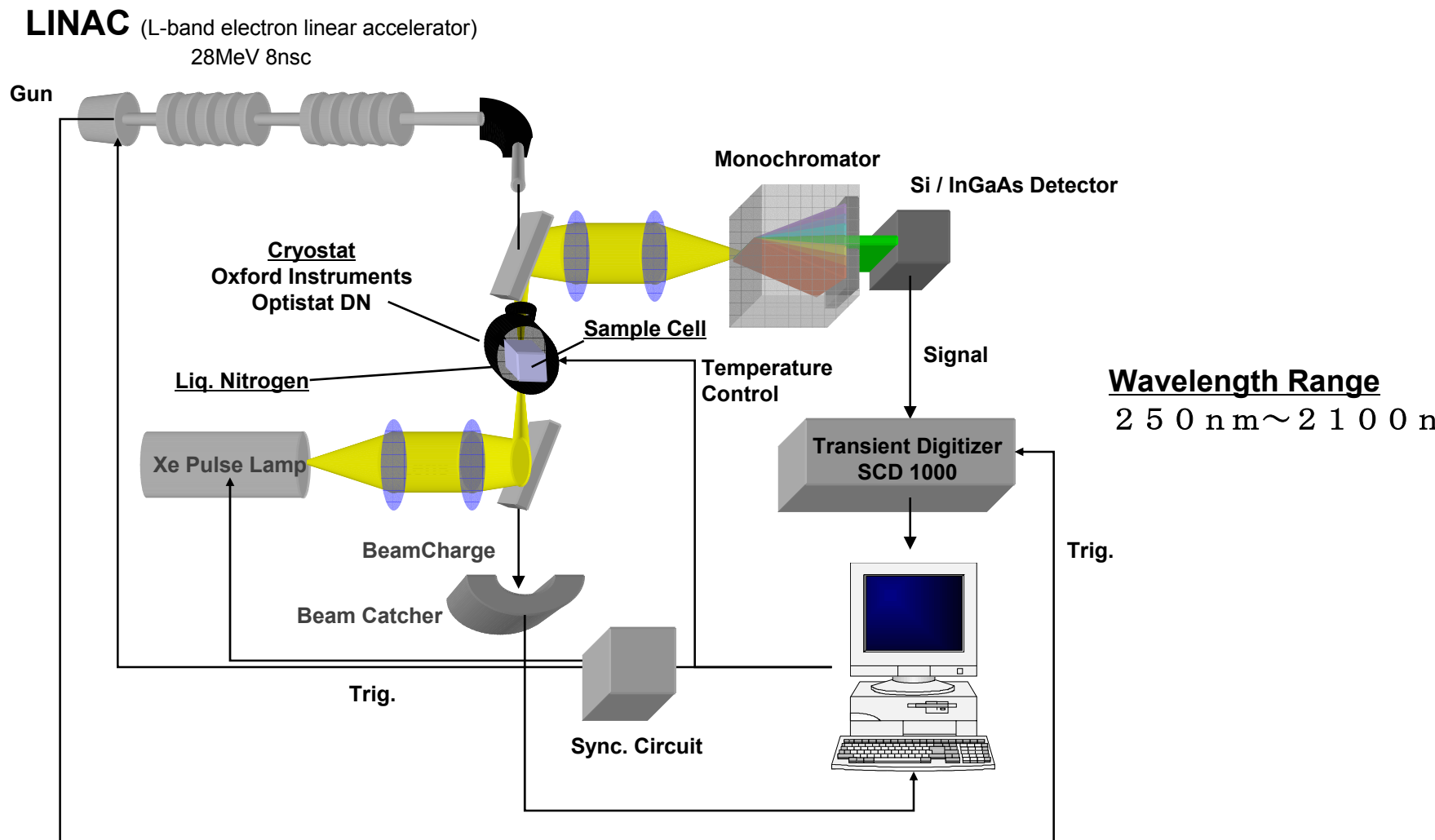
ns system

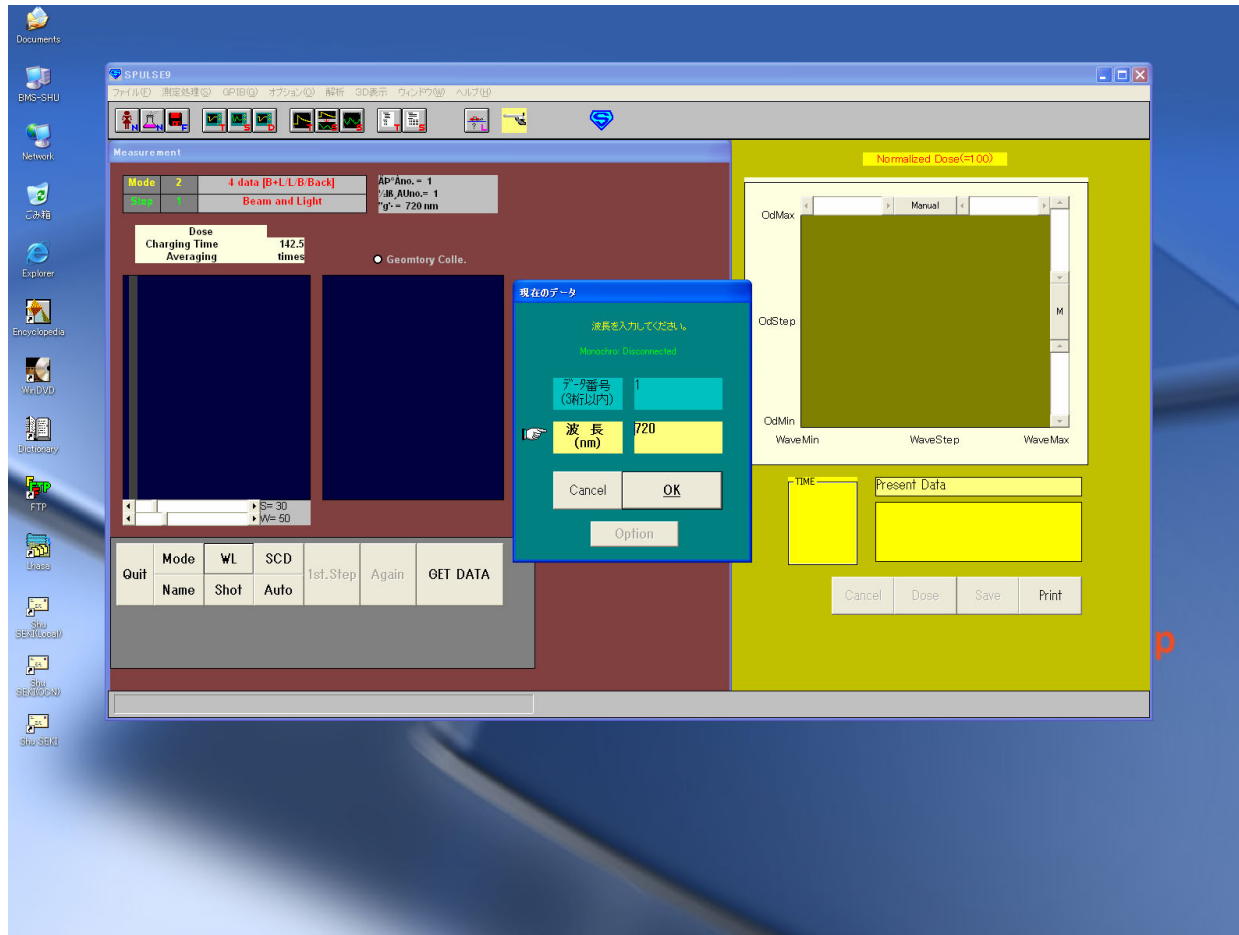
UV, Vis 1994
NIR, 1995
Low-temp, NIR, Vis, 1997
IR, 1998
UV, Vis, ns-ms, 2001

ps system (stroboscopic)

Laser-linac synchronized, 1995
Vis, 1998
Pulse compression, 1998
Jitter compensation, 1999
Improvement of S/N ratio, 2001

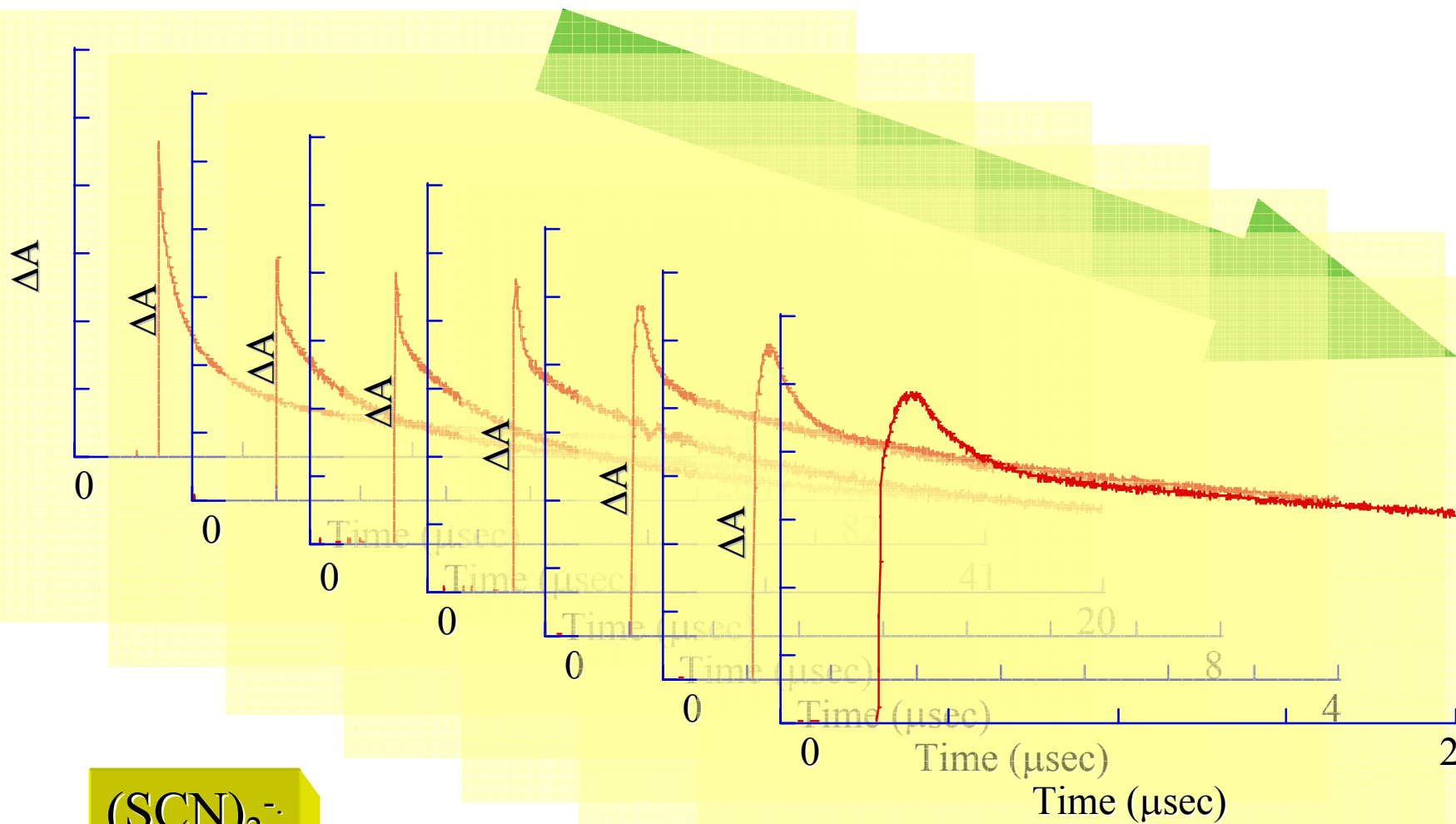




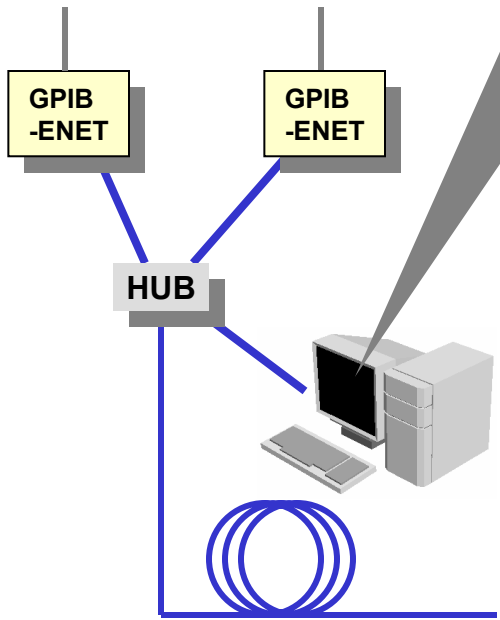


in Visual Basic

A kinetic trace in wide dynamic range can be measured on one pulse irradiation



Streak Camera etc Oscilloscope etc



Two software windows from the 'Subpicosecond TP' application. The left window shows a plot of 'Vertical: O.D. [arb. Unit]' vs 'Horizontal: Wavelength [nm]'. The right window shows a similar plot. A context menu is open over the left plot, listing options like 'TDS', 'Phase Shifter', 'Switch', 'Streak Lens', 'Streak WVT', 'Streak Position Monitor', 'Streak WVT', and 'Position Monitor'.

A control panel for 'Subpicosecond Pulse Radiolysis - Fundamental'. It features a list of numerical values, buttons for 'EXIT', 'SmallK<<', 'CLEAR', 'Repeat 49/50 Ave:49', 'Beam Noise', 'Laser Noise', 'Noise', 'Average', 'Step', 'Repeat', 'Streak Range' (with radio buttons for 20ps, 50ps, 100ps, 200ps, 500ps), 'AUTO SET', 'MEASURE', 'SAVE', 'PRINT', 'O.D. Dialog', 'Get Osc', and a 'File' field containing '100mMC-C14eDod2.txt'.

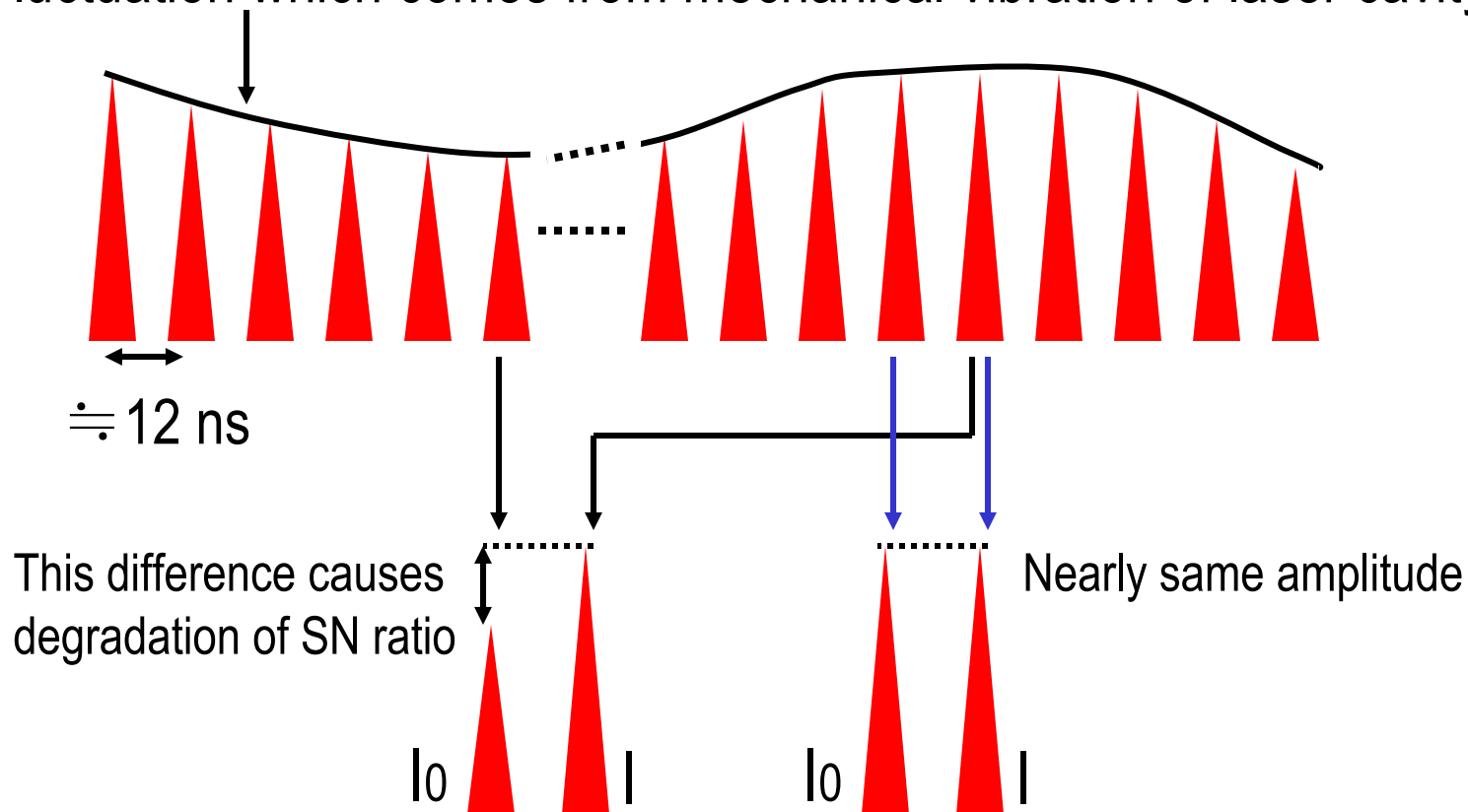
A control window for 'Streak WVT'. It contains a central display area, 'EXIT' and 'CLEAR' buttons, a 'Back Ground' button, 'GET' button, and timing controls for 'TIMING-1' (133 ms) and 'TIMING-2' (1 ms). There are also checkboxes for '補助 Laser' and 'Beam'.

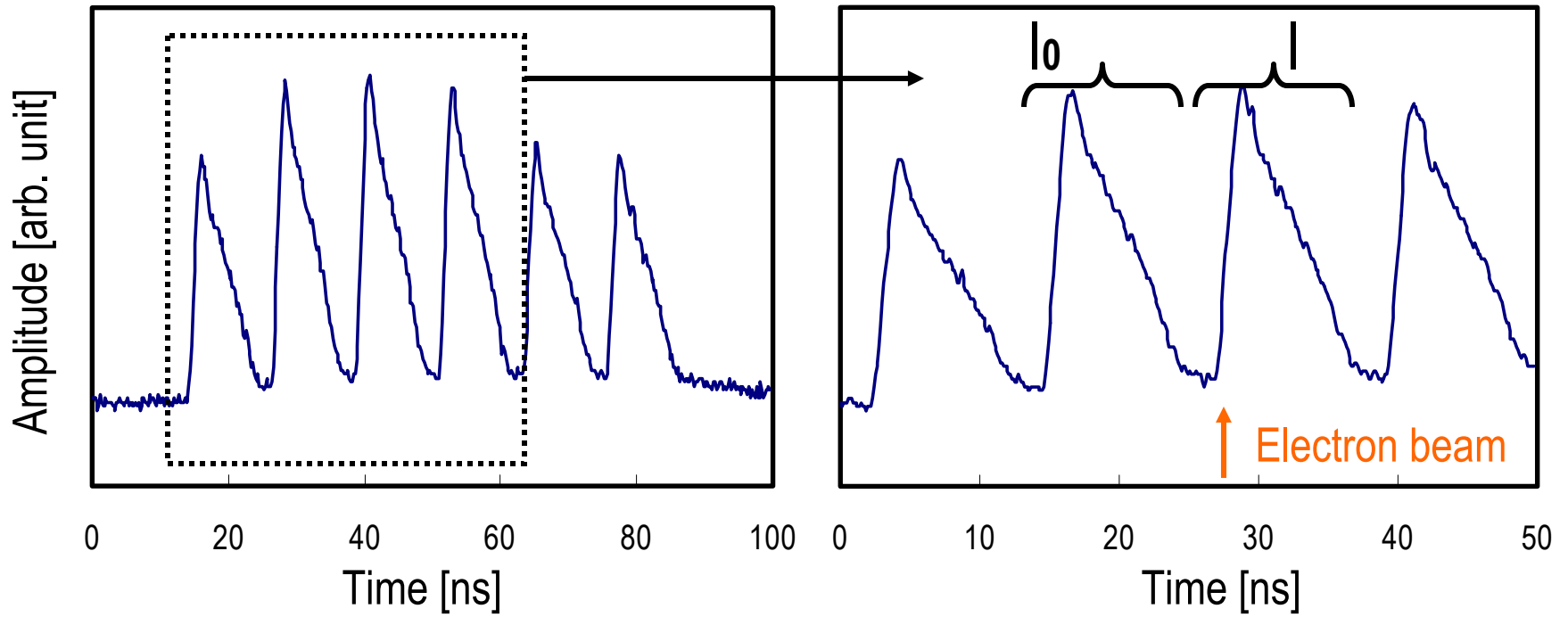
A blue control panel with two sections for 'Axis 1' and 'Axis 2'. Each section has a digital display showing '00000 pulse', 'Go to Start' and 'Go to MO' buttons, and a 'Reset' button. There are also 'Move' buttons and a 'Speed' control. The 'Axis 2' section also has a 'Resolution' control showing '0000 μm'. There are 'Ensemble' and 'Resolution' labels on the right.

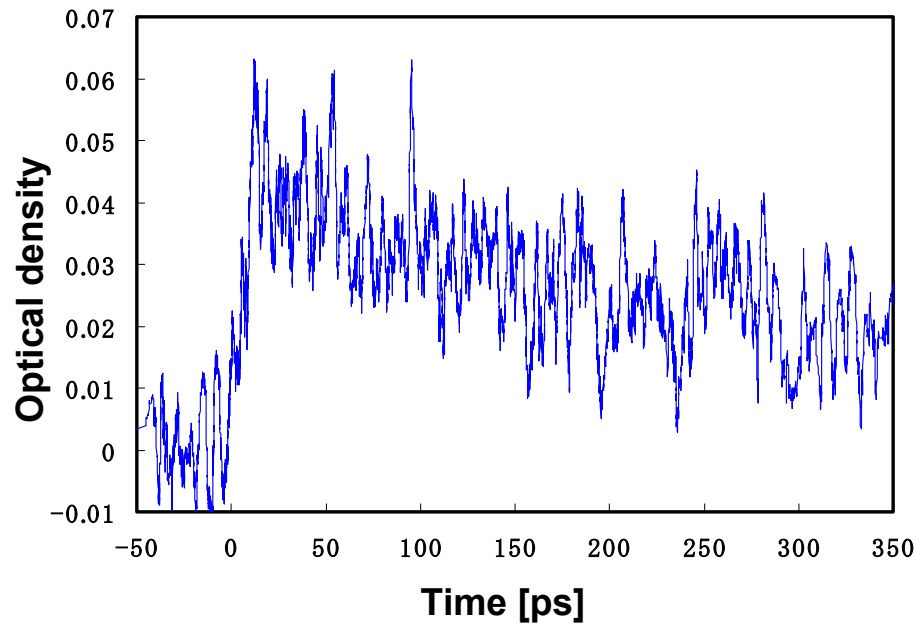
A control panel for a 'HAMAMATSU Femtosecond Streak Camera'. It features a circular 'shutter' control, a digital display for 'Streak Time(ps/10mm)' showing '500', and another display for 'I.I. Gain' showing '01'. There are 'Focus' and 'Open' buttons, and a 'Gate' control set to 'Normal'. An 'Exit' button is at the bottom.

⋮
etc

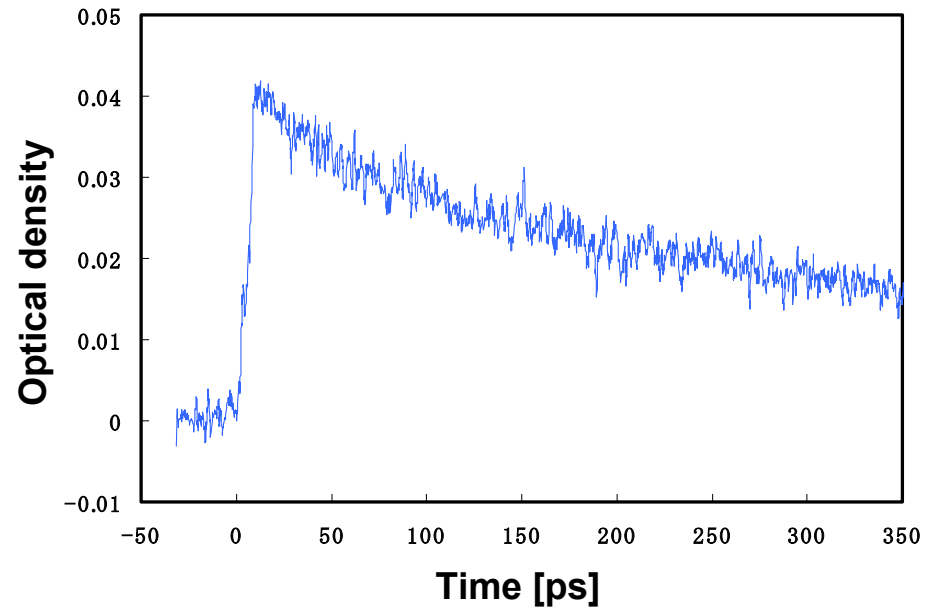
Fluctuation which comes from mechanical vibration of laser cavity etc.







Before improvement



After improvement

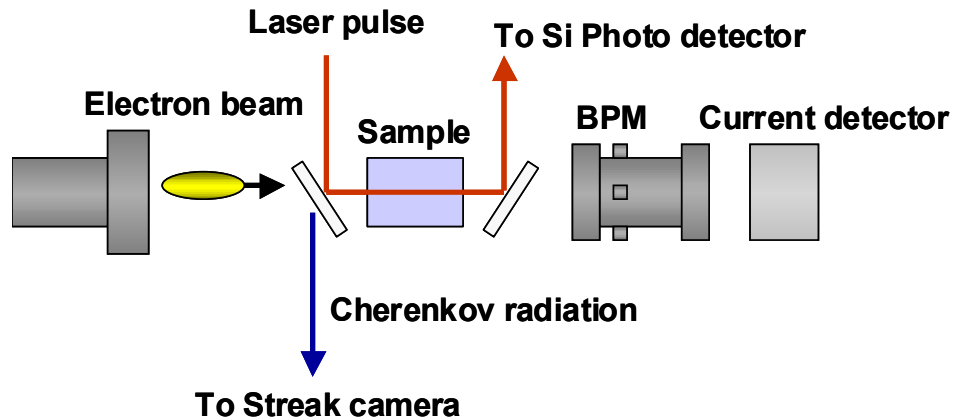
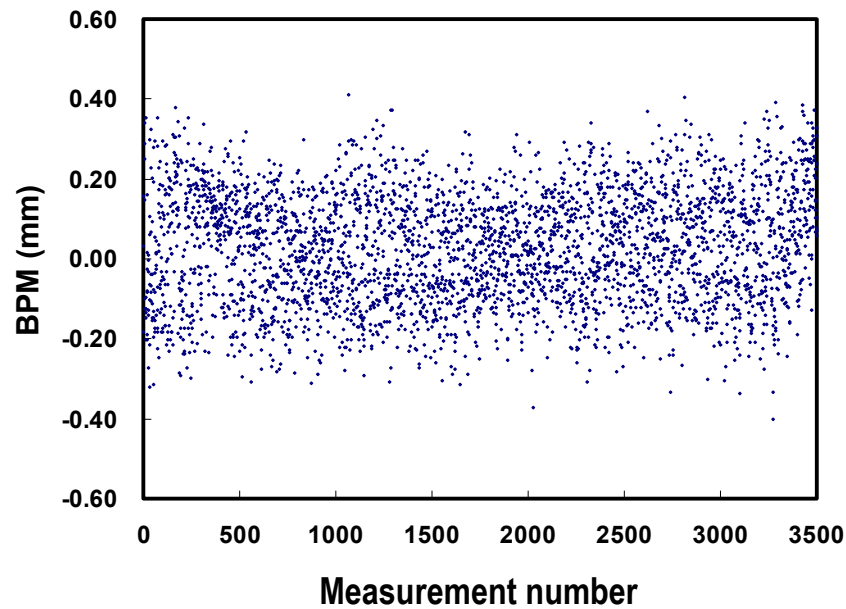
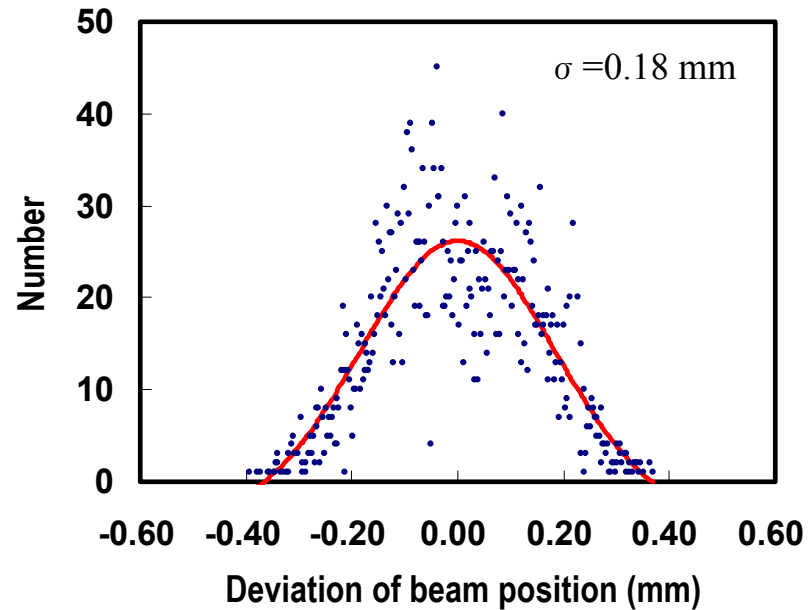


Diagram of BPM calibration experiment

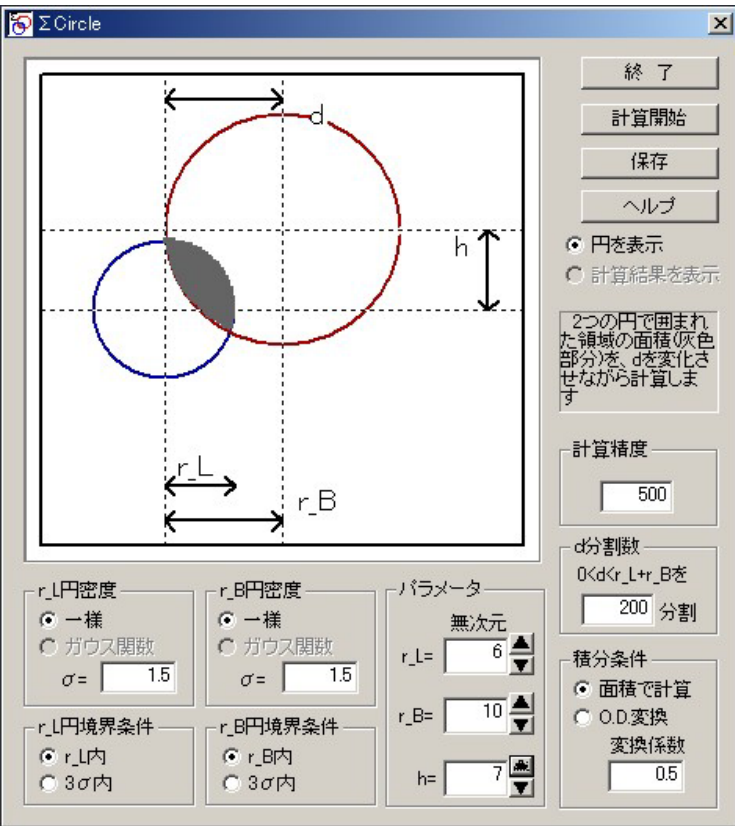


Beam position calculated by pickup voltage and $a_1=8.52$



Deviation of beam position and Gauss fitting

Calc. about effect of beam position on O.D.



<Algorithm of BPM calibration>

$$[\text{Optical Density}]_i = \log \frac{I_0}{I^i}$$

$$I_0 = \sum_{n=0, f_i(x_n, y_n) \leq 0}^{\text{mesh_num}} g_L(x_n, y_n)$$

$$I^i = \sum_{n=0, f_i(x_n, y_n) \leq 0, f_B(x_n, y_n) > 0}^{\text{mesh_num}} g_L(x_n, y_n) + \sum_{n=0, f_i(x_n, y_n) \leq 0, f_B(x_n, y_n) \leq 0}^{\text{mesh_num}} g_L(x_n, y_n) \times \exp\{-\alpha g_B(x_n, y_n)\}$$

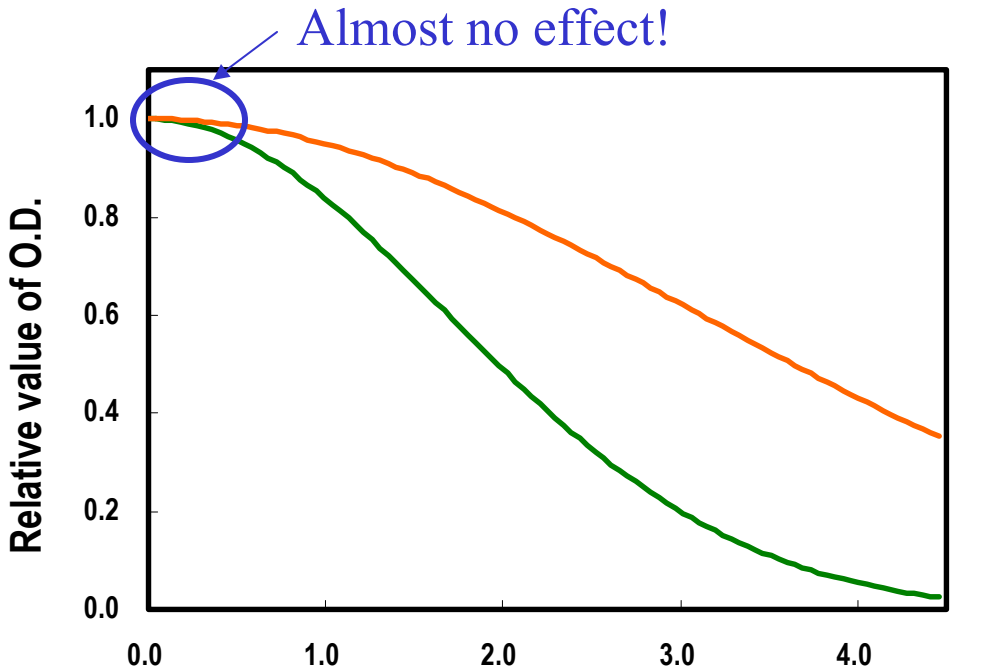
$$g_L(x_n, y_n) = \frac{1}{\sigma_L \sqrt{2\pi}} \exp\left(-\frac{x_n^2 + y_n^2}{2\sigma_L^2}\right) \quad (\text{Gauss Function})$$

$$g_B(x_n, y_n) = \frac{1}{\sigma_B \sqrt{2\pi}} \exp\left(-\frac{(x_n - d_i)^2 + (y_n - h)^2}{2\sigma_B^2}\right) \quad (\text{Gauss Function})$$

Calculation result of BPM

Simulation parameter

	σ L (mm)	σ B (mm)	h (mm)	σ L boundary condition	σ B boundary condition
Parameter1	1.5	1.5	0.0	radius 1.5 mm	radius 3σ mm
Parameter2	1.5	3.0	0.0	radius 1.5 mm	radius 3σ mm



d v.s. Relative value of O.D.
 — parameter1, — parameter2

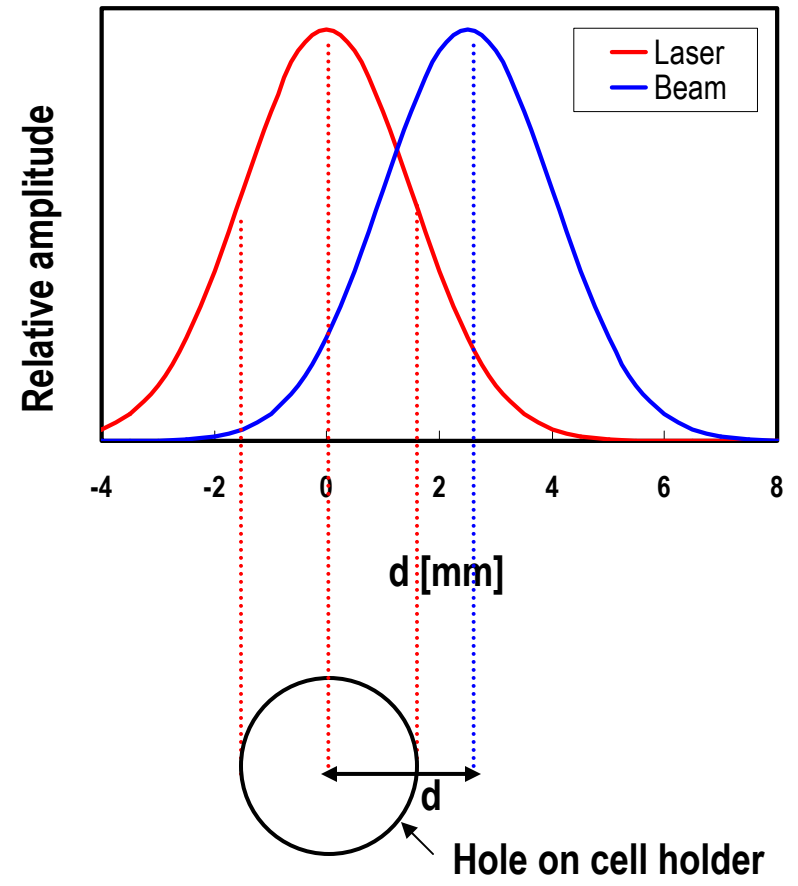


Image of position correlation between laser and beam

- L-band linac was renewed and the renewal was completed in May 2004.
- It will become a powerful tool for establishing bases of nanotechnology.
- The nanosecond & picosecond pulse radiolysis have been developed.
- The available wavelength of these system will expand and cover the range from UV to IR.