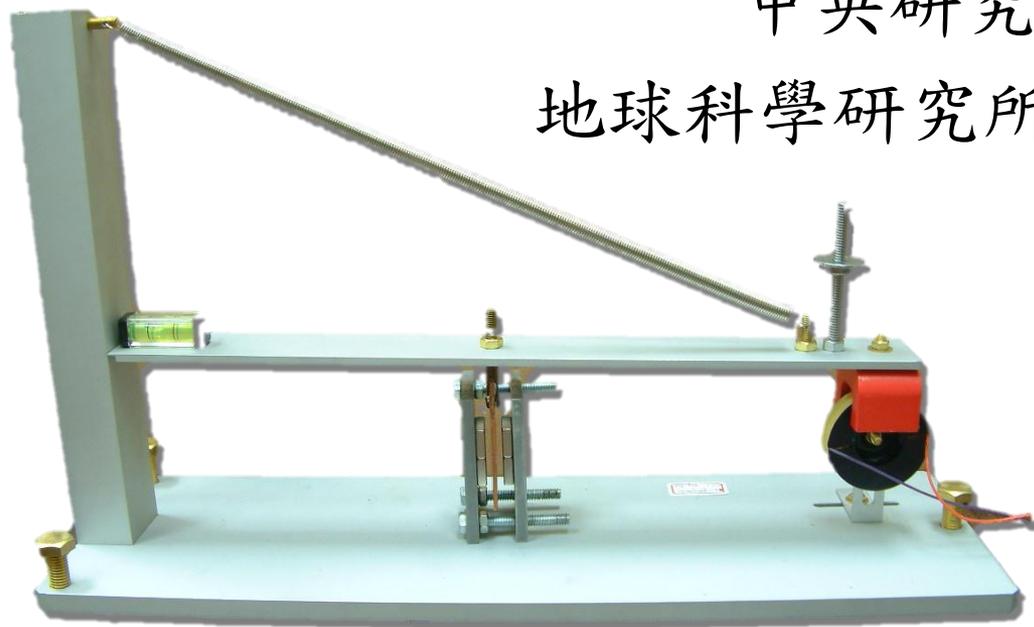


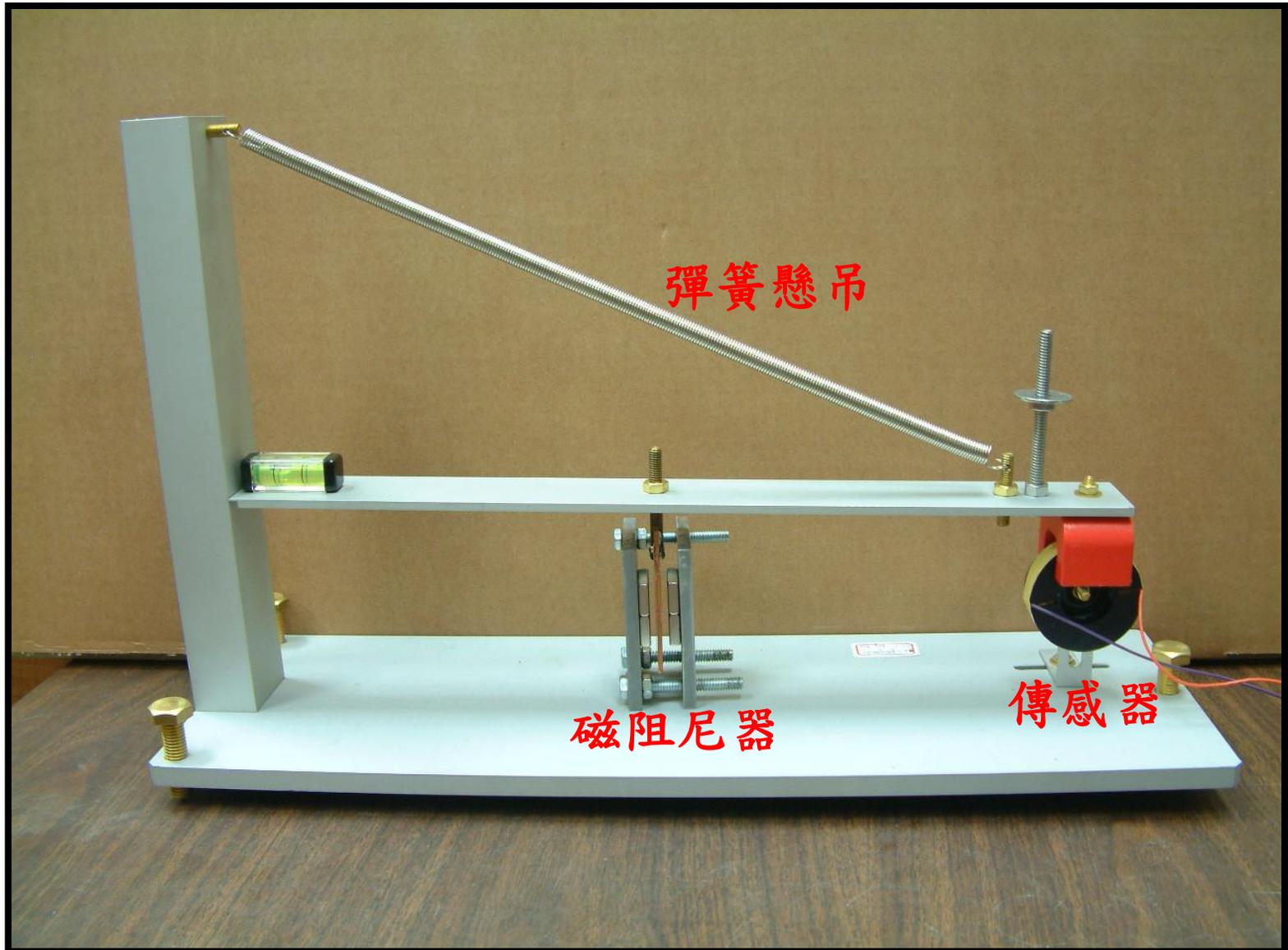


自己動手做 AS-1 地震儀

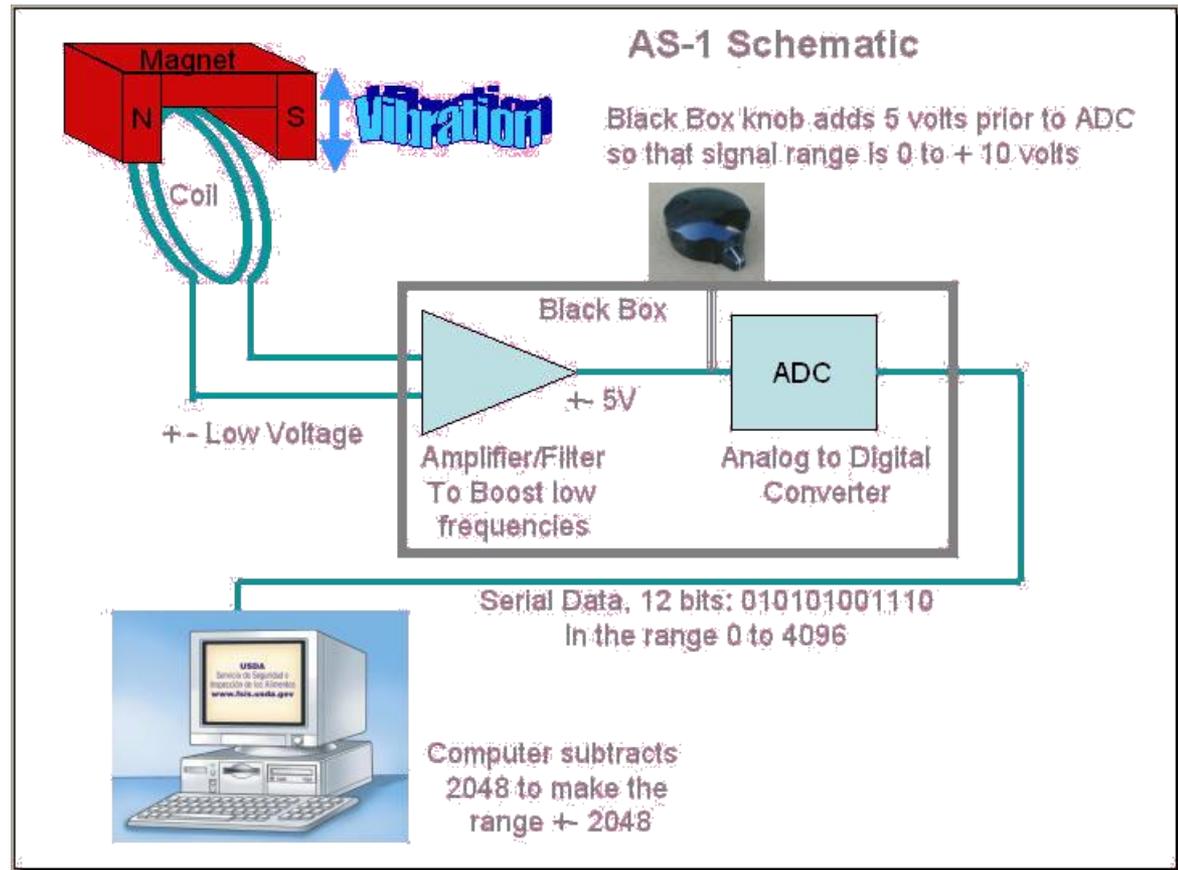
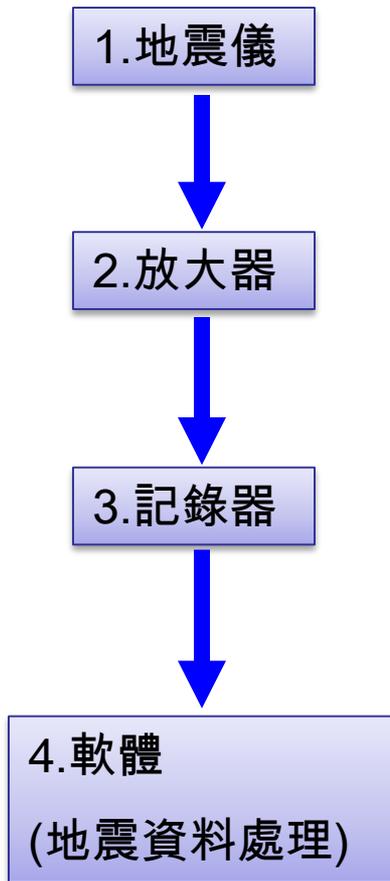
中央研究院
地球科學研究所 電子室



AS-1地震儀照片

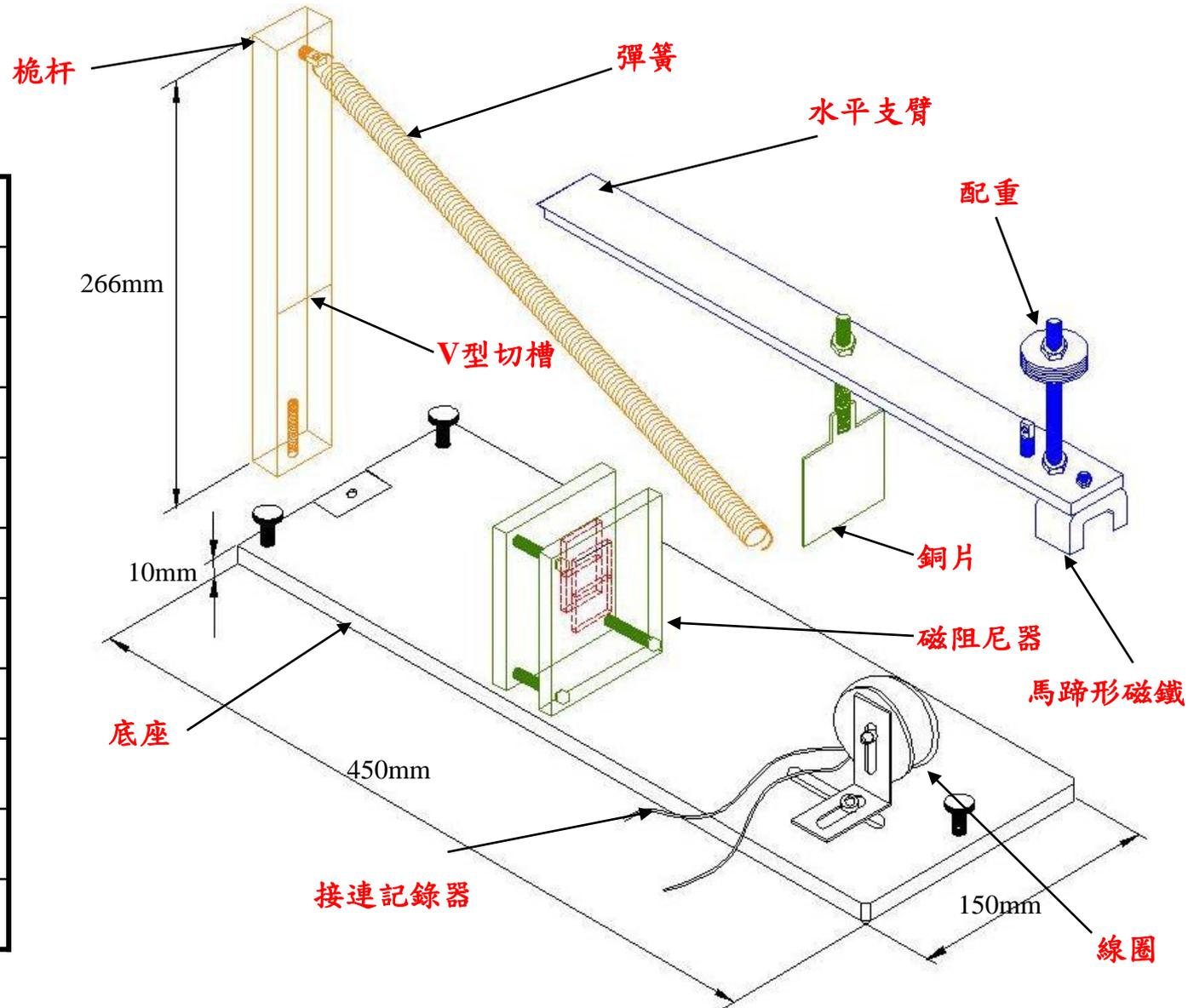


AS-1地震紀錄系統架構圖



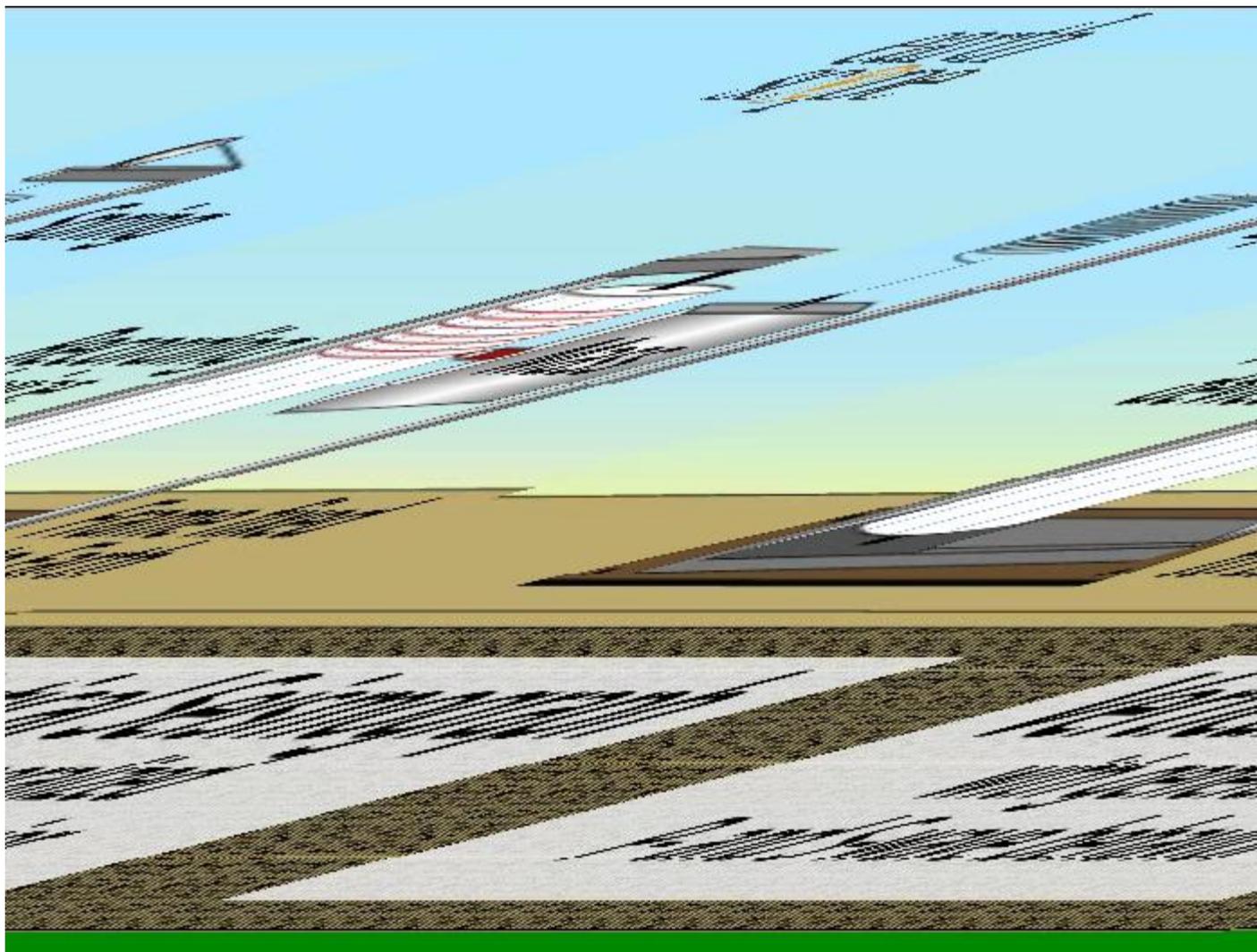
地震儀機械構造

AS1之主要零件	
1	底座
2	桅杆
3	線圈
4	彈簧
5	水平支臂
6	銅片
7	馬蹄形磁鐵
8	配重
9	磁阻尼器
10	其他 (螺絲)



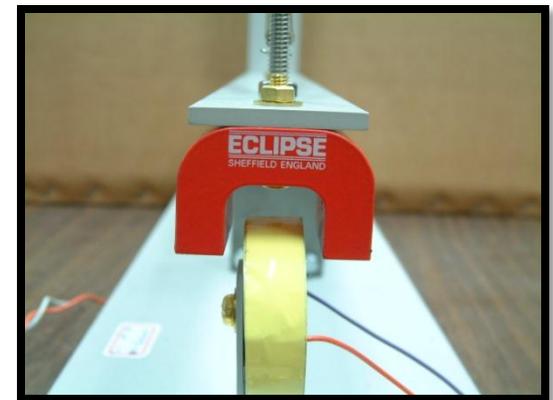
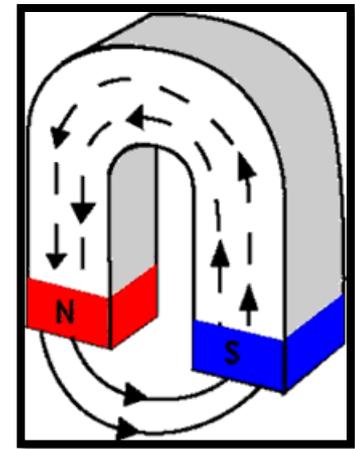
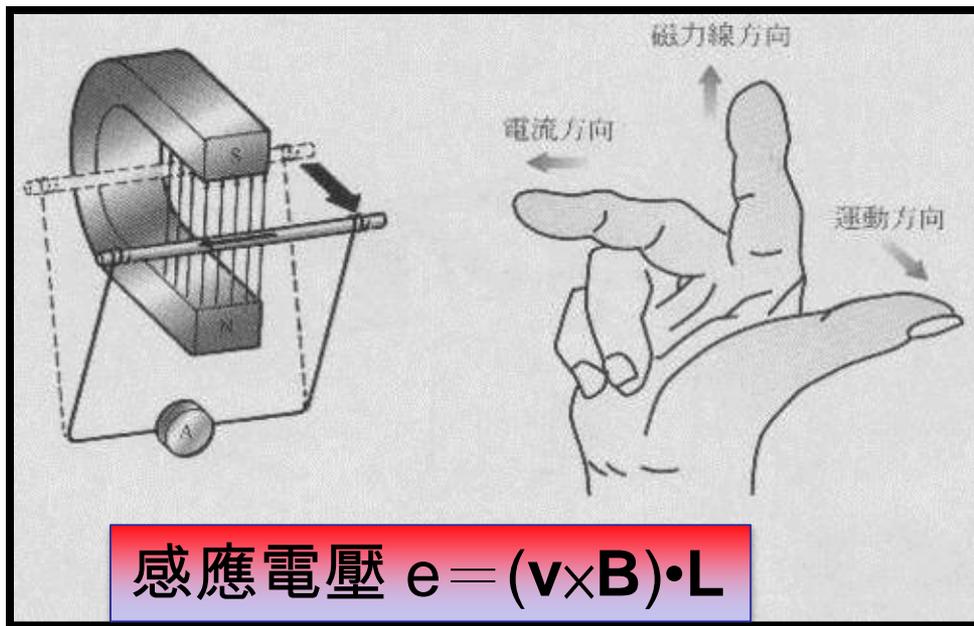
地震儀的原理

地震發生時，地震儀的框架及滾紙跟著地面震動，但是**質量塊**因為**慣性作用**而**保持不動**，因此能夠在滾紙上，紀錄地面的震動！



轉換器（法拉第定律的應用）

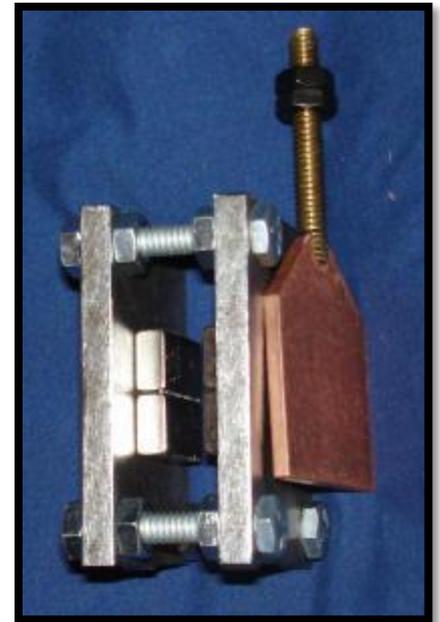
- 馬蹄形磁鐵（鋁鎳鈷合金磁鐵）



將滾紙更換成磁鐵與線圈，其相對運動可以轉換為電壓輸出

磁阻尼器 (冷次定律的應用)

- 釹鐵硼磁鐵(NdFeB)
 - 目前磁力最強的磁鐵
 - 電磁煞車也是此技術的應用
- 地震儀需要有抑制質量塊運動的機制！
- 銅片在磁場中運動時，因為銅片上磁通量的改變，進而產生感應電流及磁場，來抵抗銅片的運動，而產生阻力！！



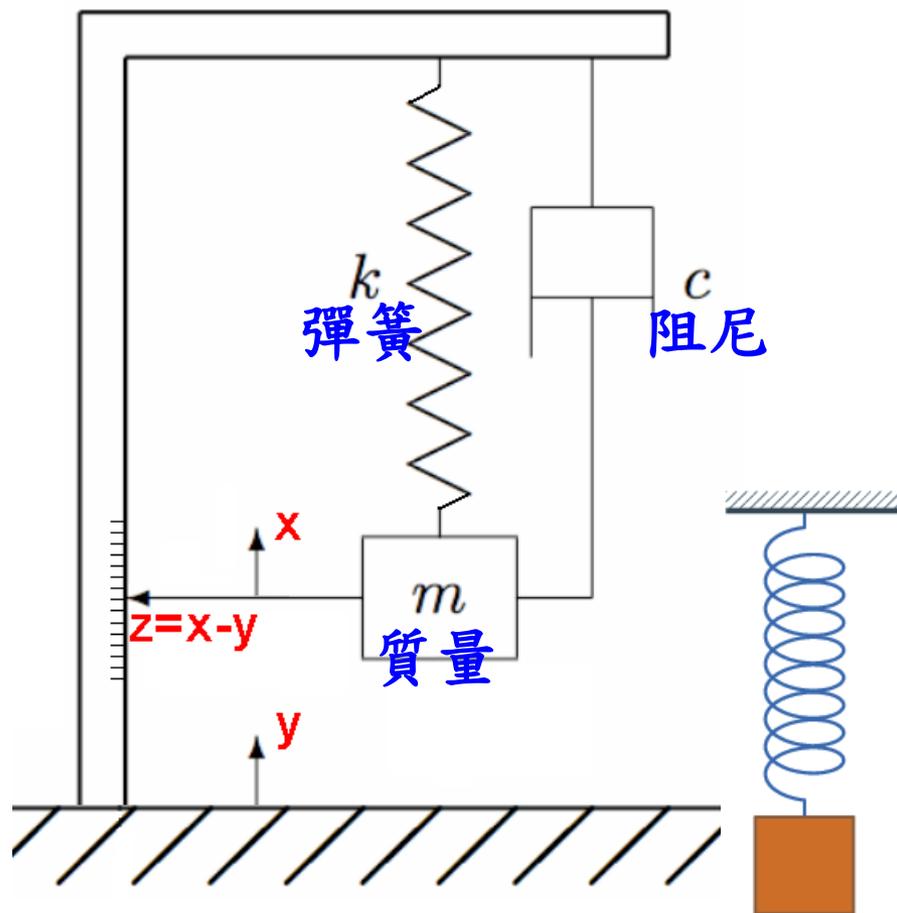
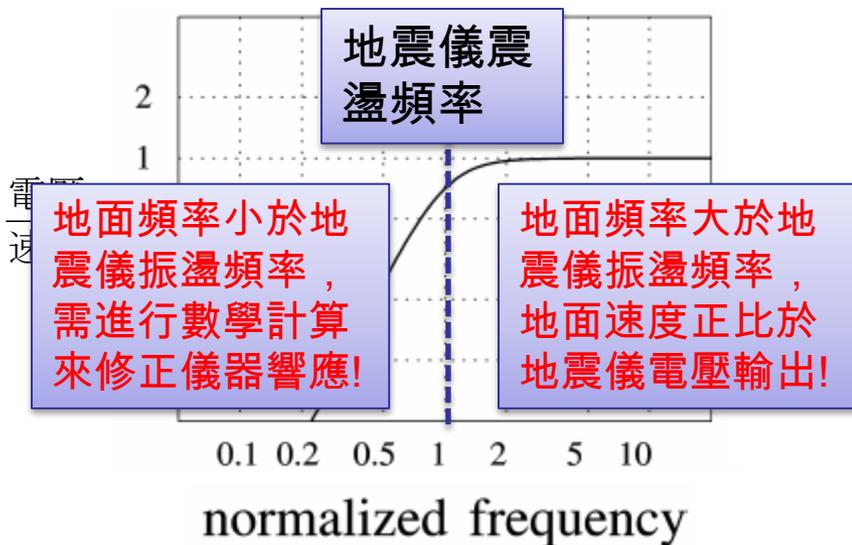
地震儀的分析

地震儀的動態分析

將**彈簧**、**阻尼**以及**質量**利用數學式子來描述...

$$T(s) = \frac{s^2}{s^2 + 2\xi\omega_n s + \omega_n^2}$$

地震儀可以用**自然振盪週期** ω_n 以及**阻尼比** ξ 來描述其響應!

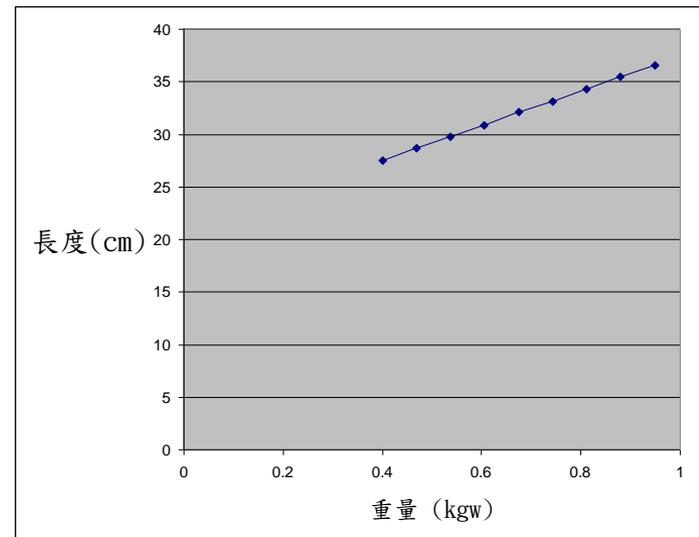


地震儀的檢驗

彈簧常數



懸掛不同重量的法碼，
並記錄其伸長量，來計
算彈簧常數



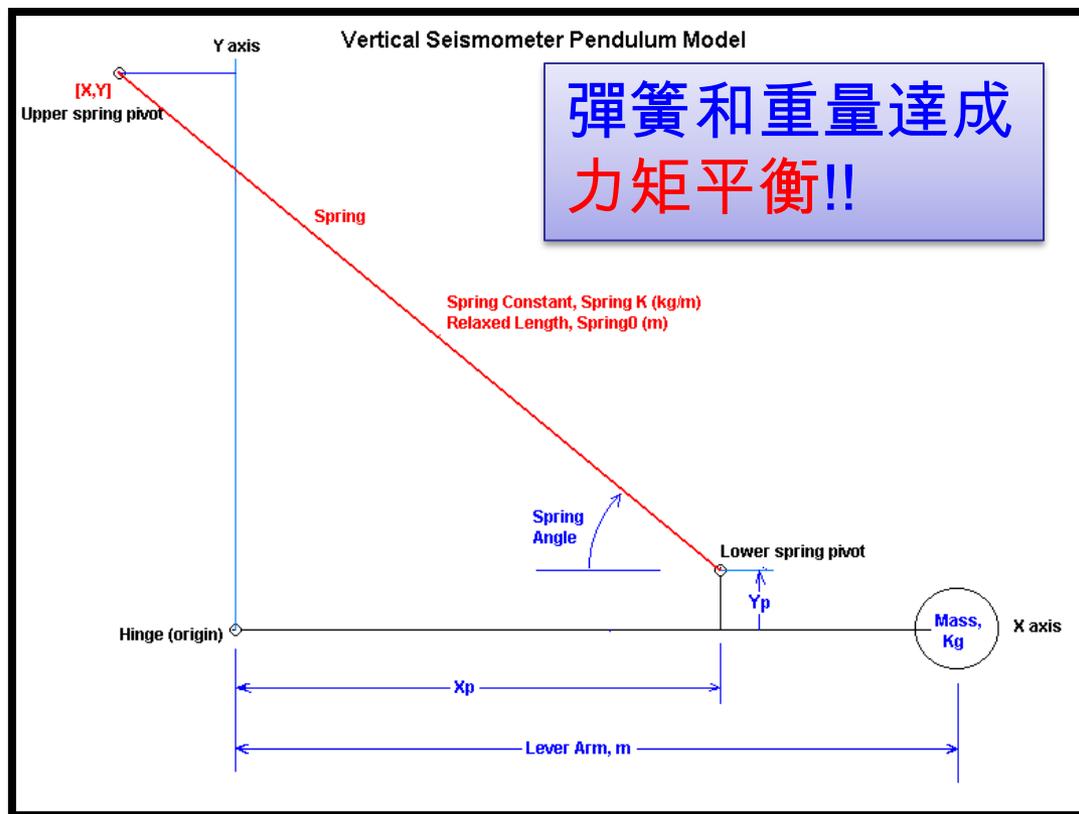
彈簧常數為8.04 kg/m

質體重量、彈簧常數的驗證

AS1 dimensions:		
X=	0.014	m
Y=	0.157	m
Xp=	0.333	m
Yp=	0.018	m
m=	0.286	m
等效重量=	0.481	kg

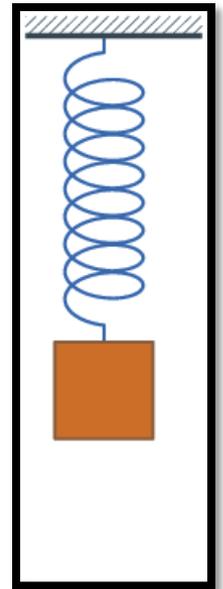
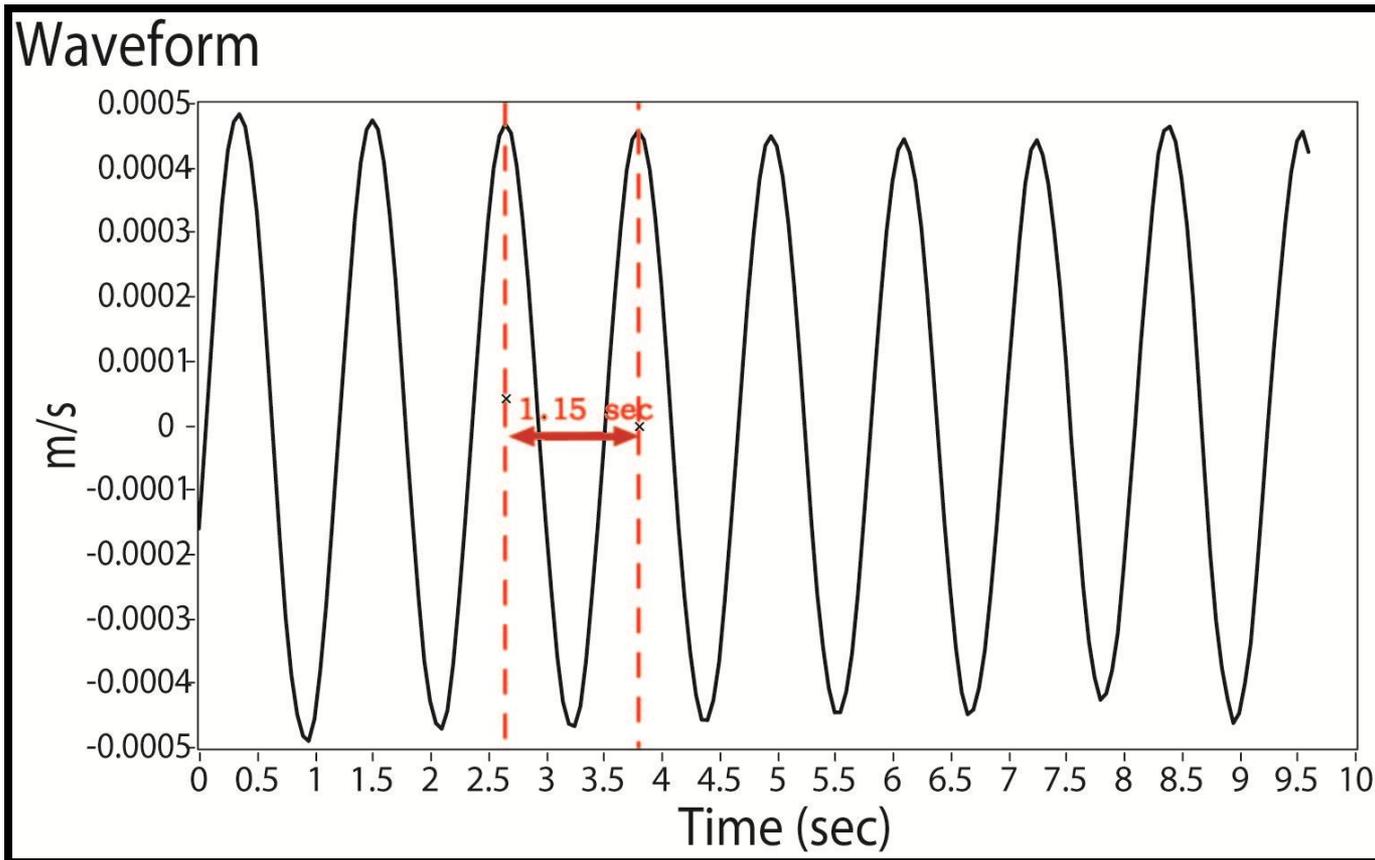
透過機構的尺寸、重量及彈簧常數，可計算出地震儀的自然振盪週期！

彈簧長度	0.348	m
彈簧張力	1.063	kg
彈簧角度	23.54	degrees
彈簧張力在垂直的分量	0.42	kg
等效彈簧常數	18.76	Kg/m
彈簧力矩	0.141	kg-m
重量力矩	0.138	kg-m
自然振盪週期	1.01	sec



Courtesy of Jeff Batten

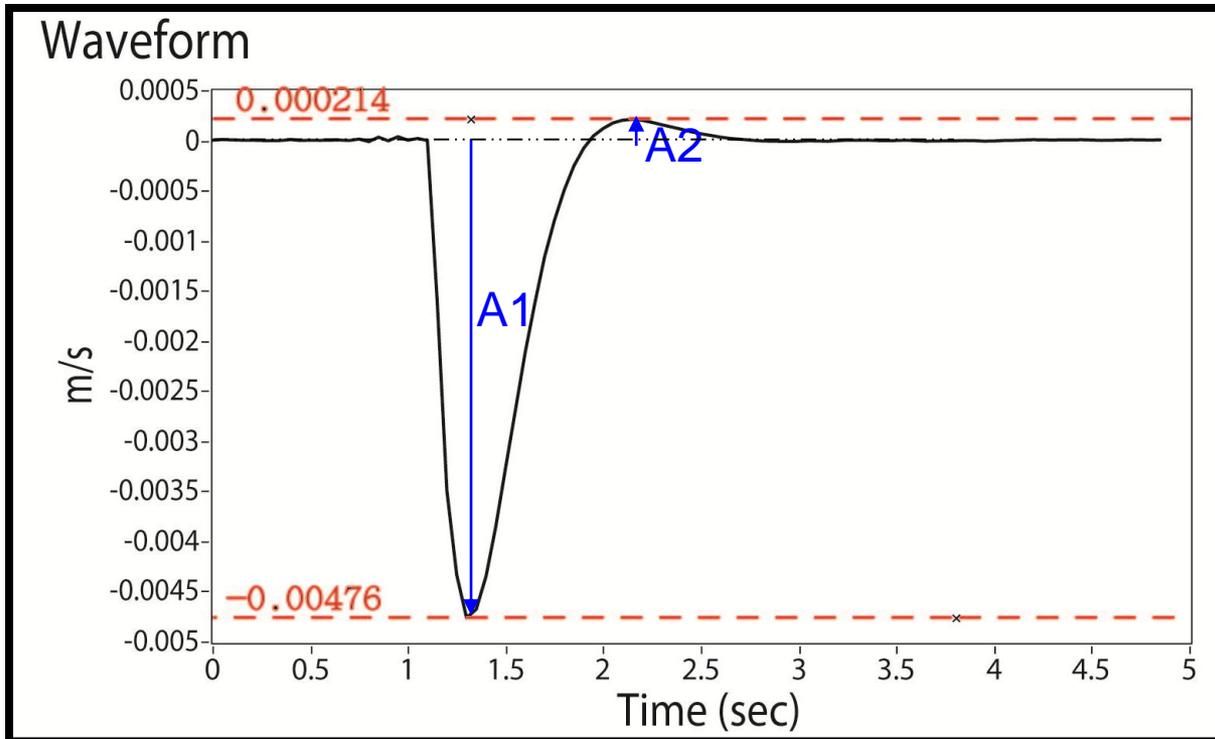
實際地震儀檢驗~自然週期



將磁阻尼移除，讓支臂與彈簧呈現自然振盪！

此檢驗的自然週期為1.15秒 (0.869 Hz)

實際地震儀檢驗~阻尼比



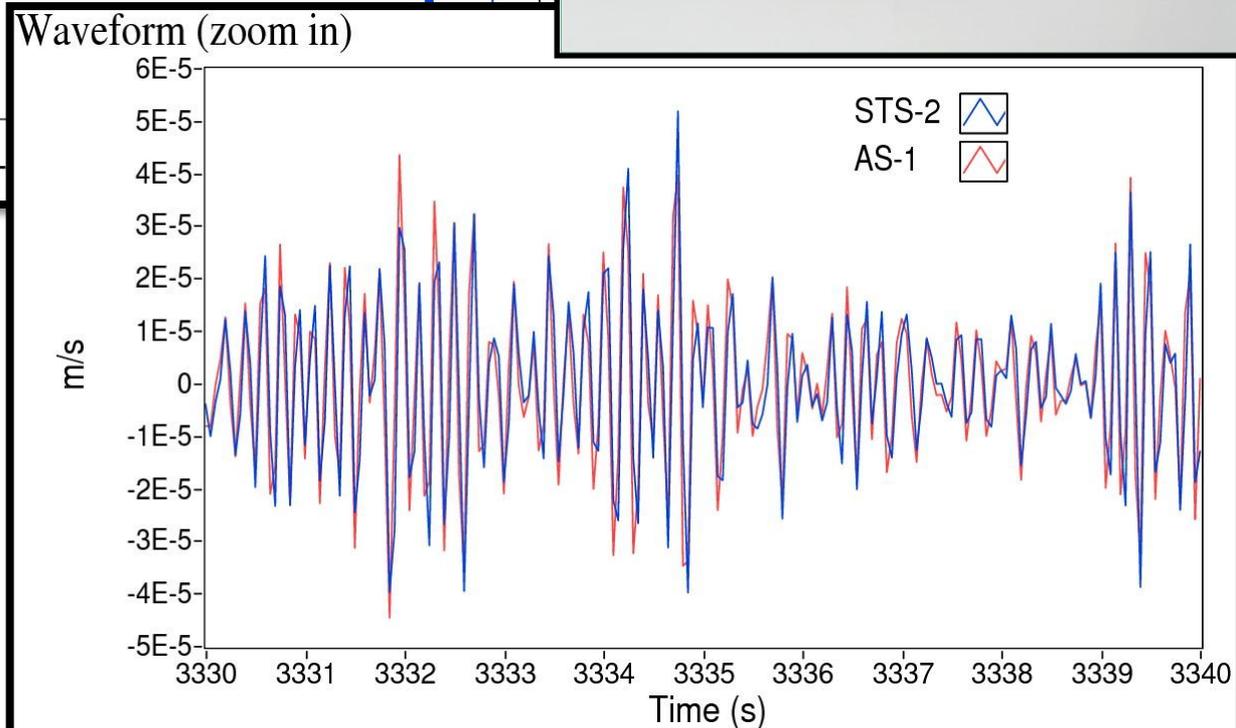
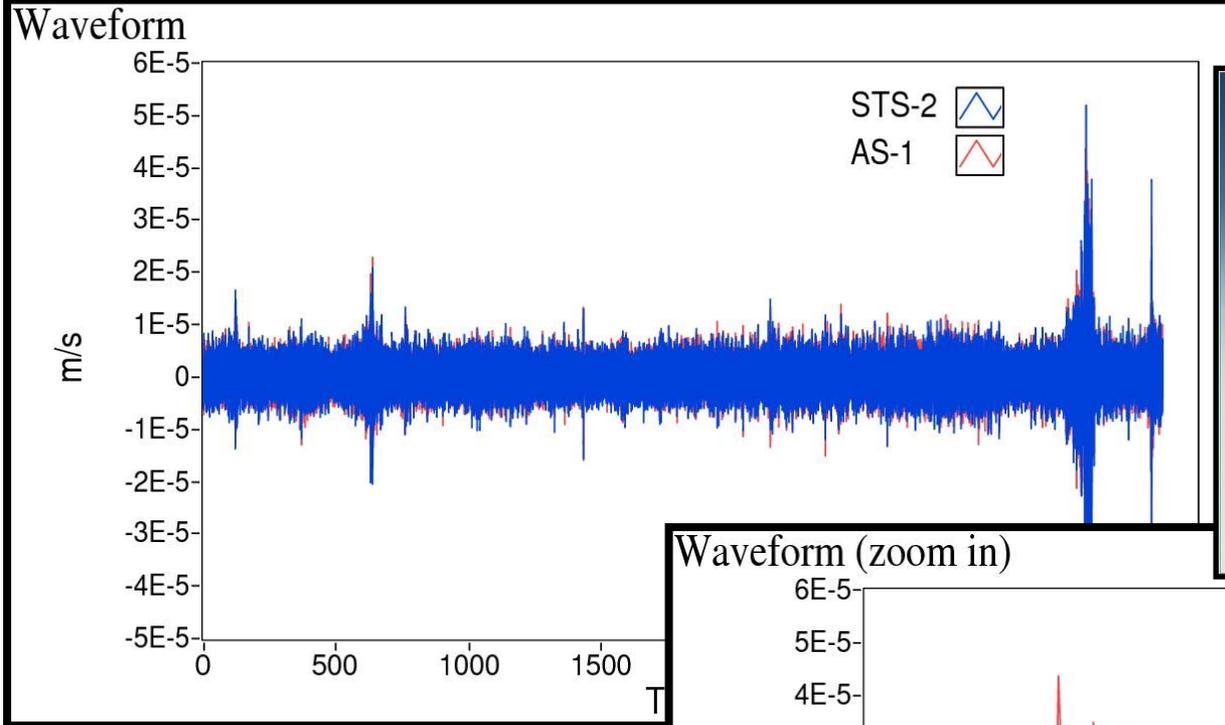
放回阻尼器，猛然拉起放置在橫樑的物體，讓支臂產生下動、上動、最後回復到水平位置。



$$\ln\left(\frac{A_1}{A_2}\right) = \frac{\pi\xi}{\sqrt{1-\xi^2}}$$
$$\xi = \frac{1}{\sqrt{1 + \left(\frac{\pi}{\ln\left(\frac{A_1}{A_2}\right)}\right)^2}}$$

此檢驗的阻尼比 ζ 為
0.702

與商用地震儀的比較(1)



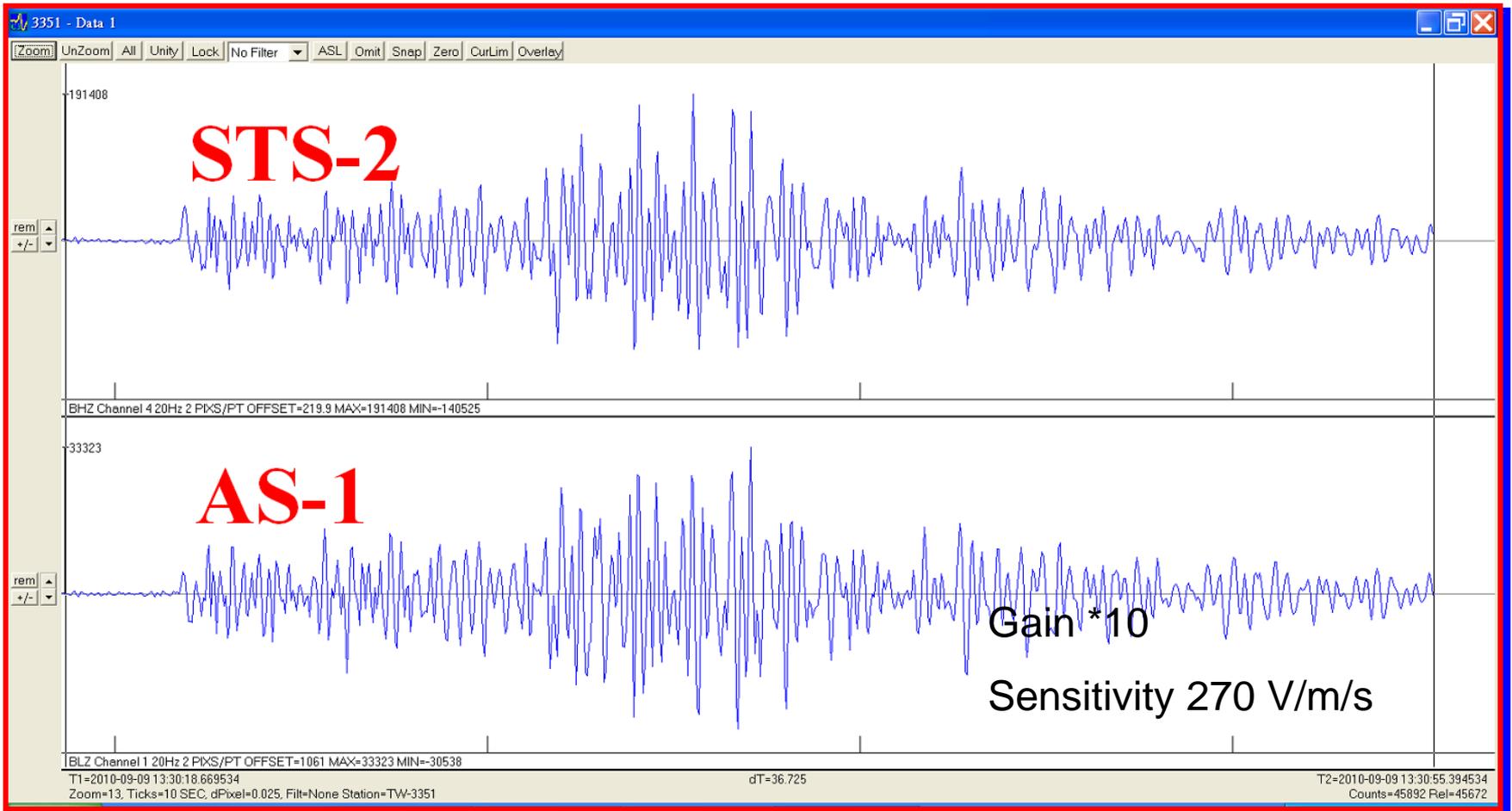
地球所

背景雜訊紀錄

與商用地震儀的比較(2)

(20100909 UTC 13:30 N24.46, E121.86, depth 23.3, ML 4.4)(南澳)

地震紀錄



記錄器及軟體

記錄器



\$29 (NTD 1000)

Product Highlights

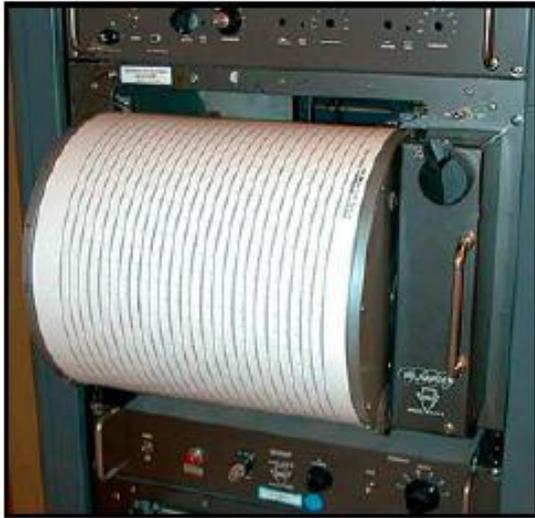
- Low-cost, Compact USB Data Acquisition Starter Kit
- Four ± 10 V Differential Analog Inputs
- 10-bit Resolution
- Up to 240 Hz Sample Rate

軟體

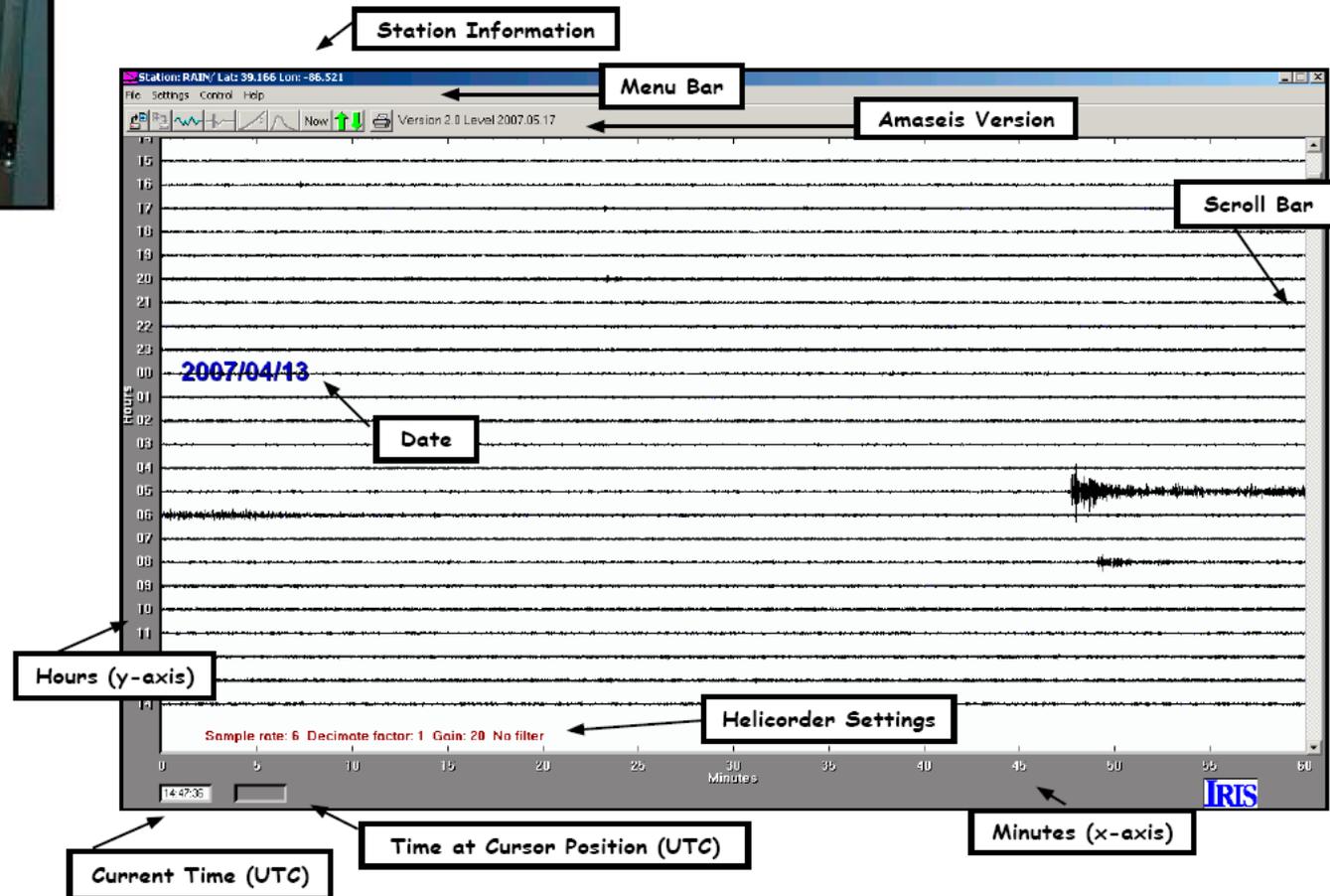
AmaSeis (written by Dr. Alan Jones, SUNY, Binghamton)

- 記錄AS-1地震儀的資料
- 觀察、即時呈現、儲存、濾波、分析和解釋地震圖

傳統鼓輪式記錄器



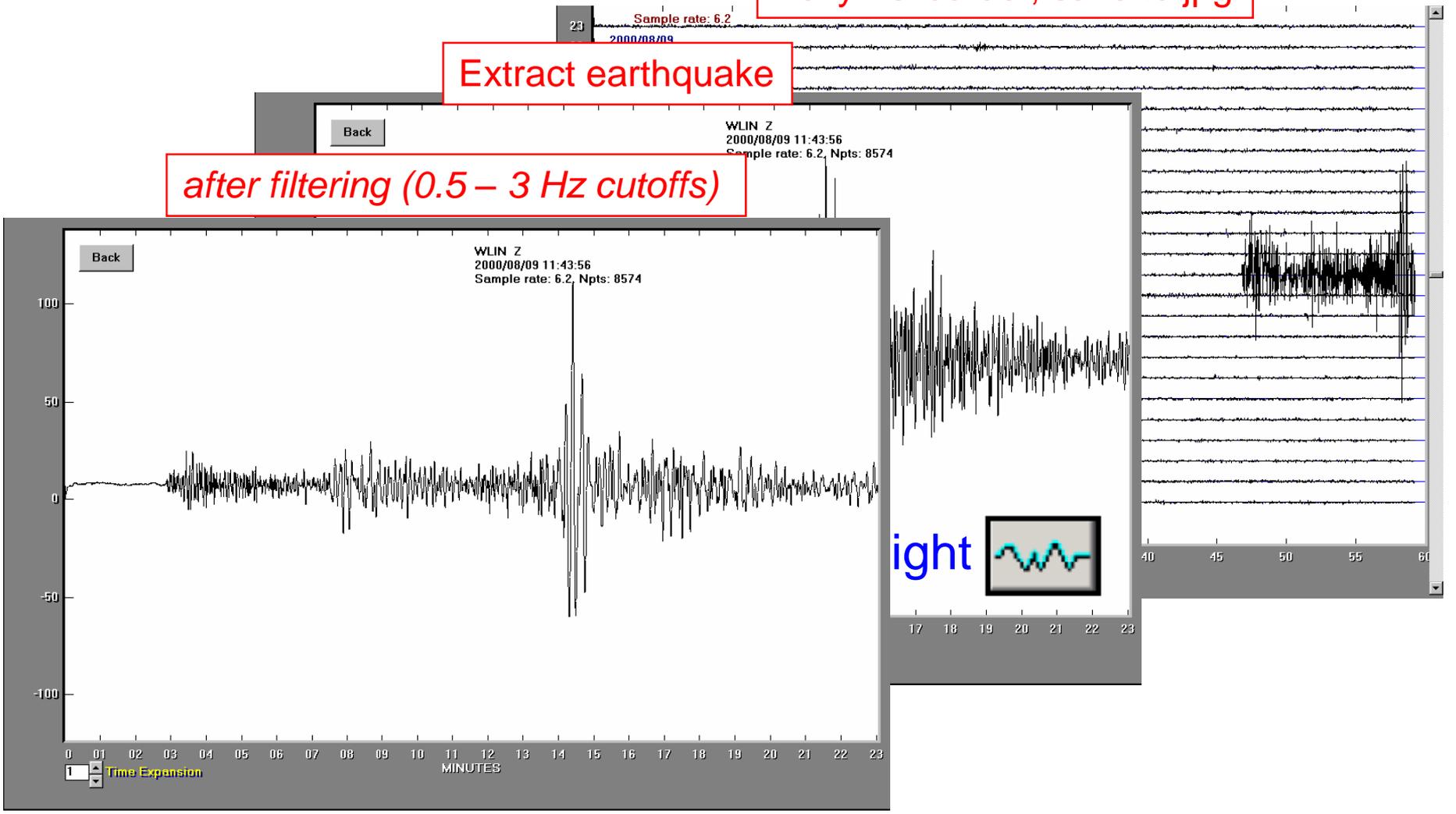
AmaSeis 介面



Daily helicorder, save to jpg

Extract earthquake

after filtering (0.5 – 3 Hz cutoffs)

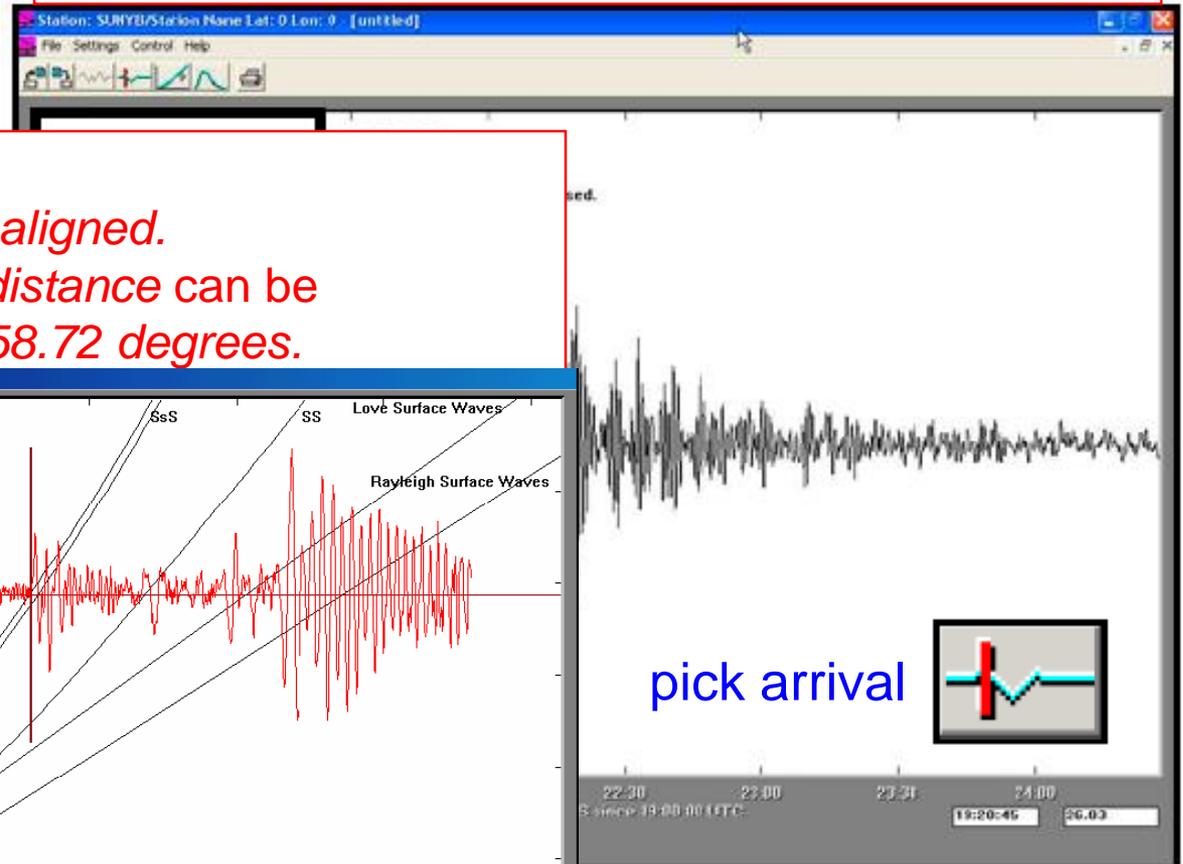
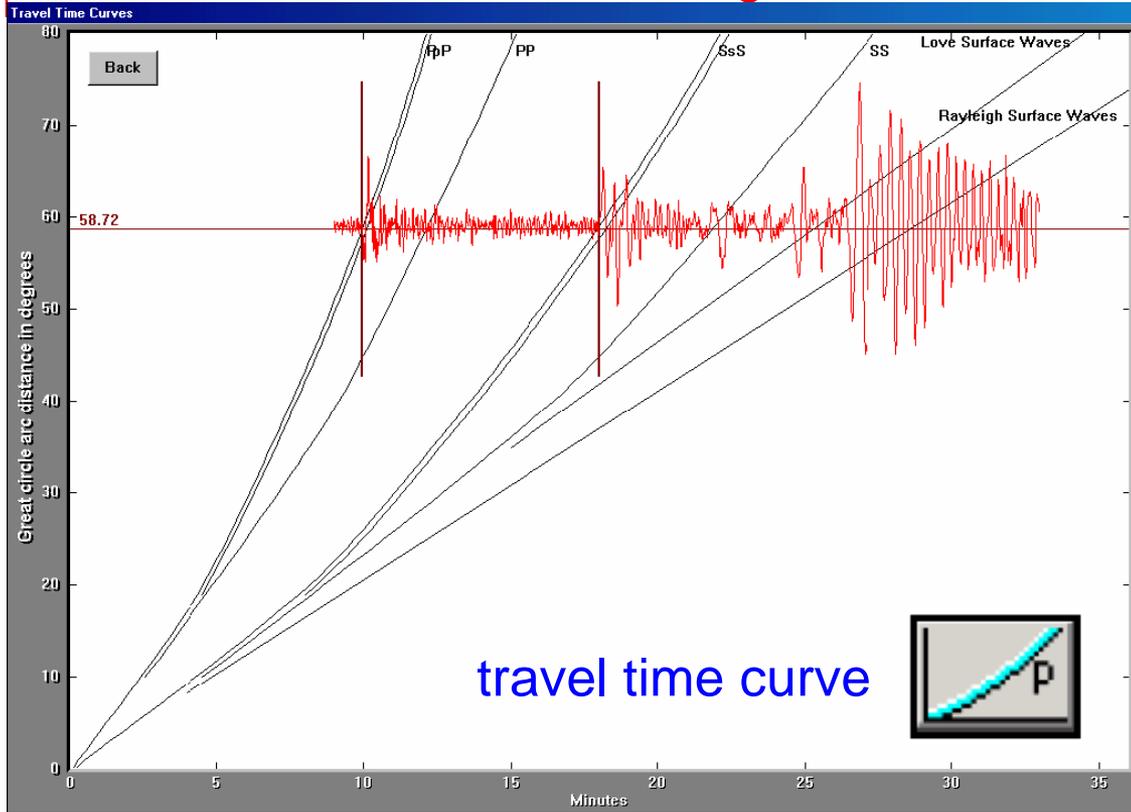


P and S arrival times (vertical red lines) are picked

travel time curve tool

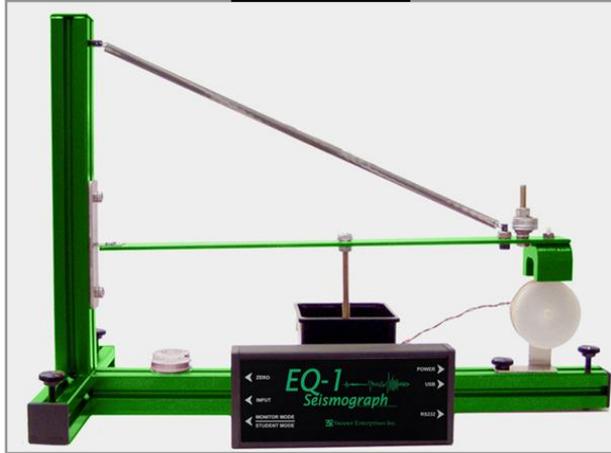
P and S arrival times are aligned.

The epicenter-to-station distance can be determined, in this case 58.72 degrees.

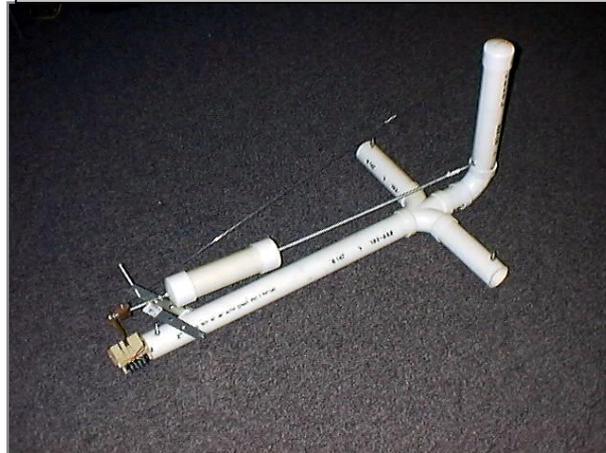


其它的設計

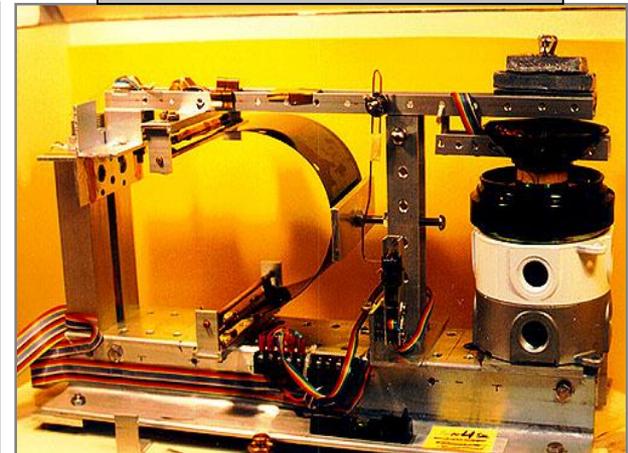
EQ-1



Mid America Earthquake Center



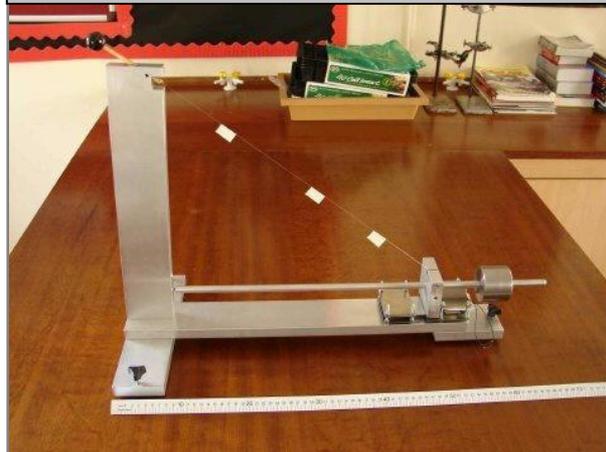
St. Louis University



Sep



Chris Chapman's Lehman Design



Lehman Seismometer



網路上的資源

- IRIS (Incorporated Research Institutions for Seismology)
<http://www.iris.edu/hq/sis> <http://www.iris.edu/hq/>
- Sinet <http://www.scieds.com/spinet/>
- 詳細的介紹AS-1 <http://www.jclahr.com/science/psn/as1/>
- 檢驗 <http://quake.eas.gatech.edu/calib/CalReptAS-1.htm>
http://jclahr.com/science/psn/as1/as1_lift/index.html
- 地震規模計算
<http://web.ics.purdue.edu/~braile/edumod/as1mag/as1mag3.htm>

謝謝各位的參觀與指教!

