Strong-Field QED

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Adrianfest

Rochester, NY

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http://puhep1.princeton.edu/~mcdonald/e144/adrianfest.ps

ΜΕΛΙΣΣΙΝΟΥ

Melissinoi in the USA

www.switchboard.com

A C	177 Whitewood Ln, Rochester, NY 14618	(716)473-119
Adrian C	4619 Chasum Hts, Canandaigua, NY 14424	(716)229-2923
Ana	2529 71st St, Flushing, NY 11370	(718)457-5064
Cecilia M	52 Vista Ln, Levittown, NY 11756	
Dominique and George	2345 Blue Bonnet Blvd, Houston, TX 77030	(713)667-8744
Doris and George	1653 Carriage Brooke Dr, West Palm Beach, FL 33414	(561)798-6123
E and Robert	309 Springwood Ct NE, Vienna, VA 22180	(703)242-0111
Elda	3457 82nd St, Flushing, NY 11372	(718)533-8075
Emmanuel G MD	2345 Blue Bonnet Blvd, Houston, TX 77030	(713)667-3828
G	9 Brandywine Dr, Matawan, NJ 07747	
George	3222 152nd St, Flushing, NY 11354	(718)939-1612
Iorgos George		
Istoria	238 Pheasant Cv, Canonsburg, PA 15317	(724)746-9053
James T	12387 Coronado Dr, Spring Hill, FL 34609	(352)686-1423
John	Los Angeles, CA 90001	(323)937-0980
John	2223 74th St, Flushing, NY 11370	(718)932-7338
Konstantinos	3162 29th St, Long Island City, NY 11106	(718)267-0454
Mario	1625 Commonwealth Ave, Brighton, MA 02135	(617)787-8109
Nicki	1902 Center St, Moundsville, WV 26041	(304)845-7017
Nicholas	Kirkland, WA 98033	(425)825-0405
Nick	3415 86th St, Flushing, NY 11372	(718)898-7914
Robert	104 120th St, Ocean City, MD 21842	(410)723-0383

Nicki, nkm3@ovis.net, wrote: The Melissinos family that are my relatives are from the island of Chios. The 9 original Melissinos have passed away but there are many offspring in Greece. My father had 2 brothers and six sisters whose parents name were Nicholas and Kyriaki Melissinos. There is another Melissinos (Istoria) living around Canonsburg, PA who is somehow related. I have been in contact with Colleen Zouvelekis, patncol@enternet.com.au, in Australia who has an uncle by the name of Xenophon Melissinos, which also was my father's name.

Using Cerenkov Radiation to Measure Potassium in Fertilizer

A science fair project by Rebekah Rogers, age 12.

First place winner in the Forest Hills School Science Fair.

Florence, Alabama, March 19, 1996.

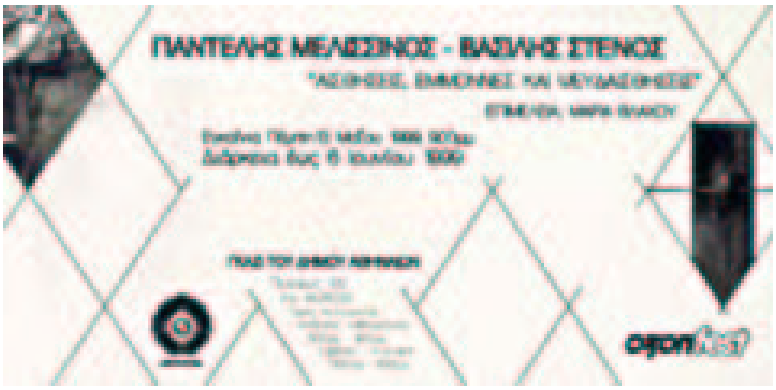
http://ourworld.compuserve.com/homepages/Bill_Rogers_AL/scifair.htm

Reference: Melissinos, Adrian C., *Experiments in Modern Physics* (Academic Press, 1966).

Melissinoi in Europe

–Alexandre Melissinos, http://www.cpod.com/monoweb/thomas/rva97/html/melissin.htm

Sensations, Obsessions and Illusions:



–Pantelis Melissinos, http://cheapart.lrf.gr/ennotice.htm

–Dr. Costas D. Melissinos, trademco@compulink.gr

"The famous Greek jet-ski rider Dr. Costas Melissinos will demonstrate his skills to friends and jet-ski enthusiasts some weekends this summer." http://www.tourhotel.gr/tourolympic/neo.htm

–Ch. Melissinos, MD, http//acropolis.conceptum.com.gr/erasmus/med_meet.htm

–Iason Melissinos, 30 Eolou str., 17561 Paleo Faliro

–Sakis Melissinos, http://surf.to/Sakis (Helsingborg, Sweden)

–Th. Zahariadis Melissinos, http://www.swt.iao.fhg.de/eurorim/guidelines/siig3/index.htm

The Sandal-making Poet of Athens

"Take away the Glories and the Honors
The granite palaces of this vain world
And only give me the smile of Pain
The tear of Joy and I will erect
A thousand palaces in me in which to live."

–Stavros Melissinos, known among sandal-makers as "The Poet"

(and among poets as "the sandal-maker").

89 Pondrossou Street in Monistiraki, Athens

http://www.athensguide.com/poet.html

The Melissinoi are the Bee People

Heraldic Insignia: gules, 3 bells sable, six bees 1, 2, 2, 1

http://www.heraldica.org/topics/national/byzantin.htm

Heraldry is a programming language still functional after 800 years!

http://www.blazons.com

Adrian's Initiation into the Melissinos Clan

The Battling Bees of Byzantium.

1212 First large-scale colonization of Crete by the Venetians.

1217-1219 The Skordilides and Melissinos Revolution. These Cretan Lords had great support from the people and managed to dominate the whole of West Crete. The Duke of Crete, Domenico Deifino, was forced to give them land and priveleges.

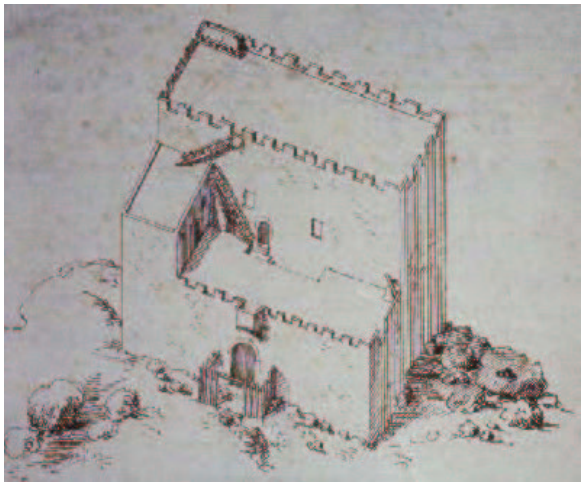
1222 The second batch of Venetian colonizers arrived in Crete and grabbed even more land. The noble Melissinos family considered that they had suffered damage and rose in revolution for the second time (not on its own, of course, but with the support of the people!). The Duke of Crete, Paolo Corino, came to a compromise with them and granted them new privileges.

1228-1236 The more you have, the more you want, and the greedy Melissinos again incited the Skordilides family and two other noble Cretan families (the Dracontopoulos and Arkoleos families) to revolution. The Venetian Duke was again unable to face them and, without much delay, he granted new priveleges and feudal lands to the Cretan nobles in an attempt to avoid total defeat.

–Stephanos Psimenos, *Unexplored Crete* (Road Editions, Ltd, Athens, 1996), pp. 38-39.

(Among these privileges was the coat of arms shown previously.)

See also, http://www.sfakia-crete.com/sfakia-crete/history.html



Melissos of Samos

Student of Parmenides.

Admiral of Samian navy, defeated Pericles 441 BC.

"Nor is anything empty. For what is empty is nothing.
What is nothing cannot be."

"Accordingly, being was not generated, nor will it be destroyed;
so it always was and always will be."

http://history.hanover.edu/texts/presoc/melissos.htm

http://www.utm.edu/research/iep/text/presoc/presoc.htm

[Adrian gave up a promising career in the Greek navy to become a physicist.]

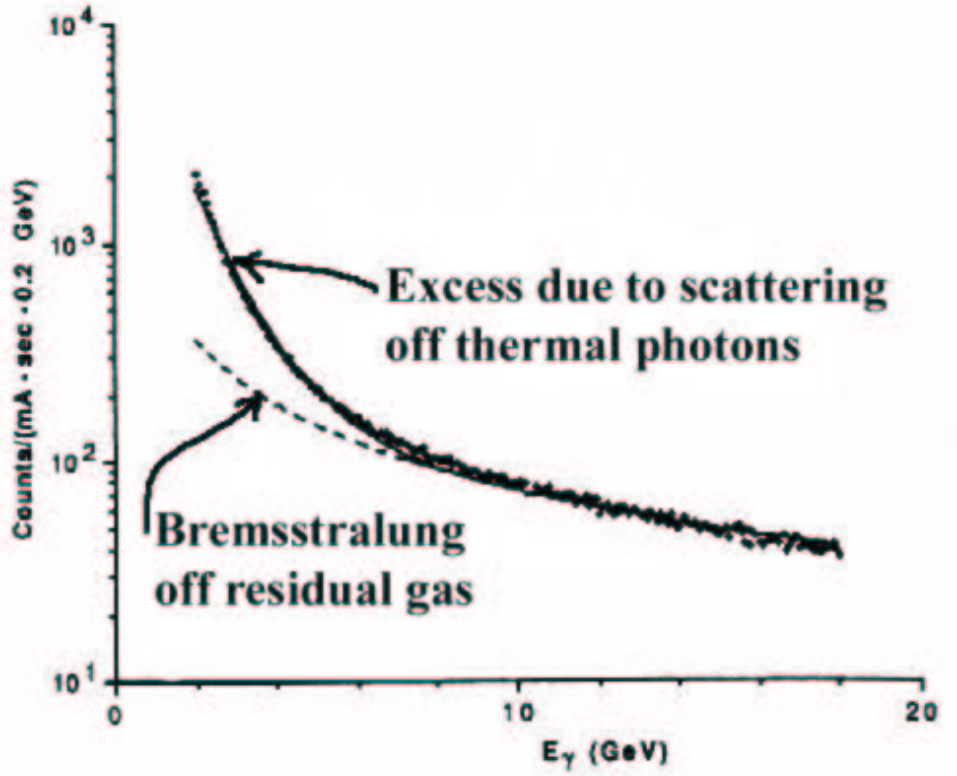
Scattering of High Energy Electrons Off Thermal Photons

B. Dehning, A.C. Melissinos *et al.*, Phys. Lett. **B249**, 145 (1990).

The vacuum inside a box at room temperature contains black-body radiation of temperature $T = 300\text{K}$ ($E \approx 1/40$ eV).

A high-energy electron beam, such as that at LEP with $\gamma \approx 10^5$, can Compton scatter off these black-body photons, yielding photons of energy $E' \approx 4\gamma^2 E \approx 1$ GeV.

Apparatus: LEP + lead glass block



Sonoluminescence

In 1850, the Navier-Stokes equation was the "theory of everything", but it doesn't predict sonoluminescence. [Erber]

[Sonoluminescence is what makes nitroglycerine explode.]

- Schwinger (1992): a bubble is an electromagnetic cavity; an imploding bubble will radiate away the changing, trapped zero-point energy.
- Liberati (1998): Imploding bubble $\Rightarrow$ rapidly changing index $\Rightarrow$ associated radiation.

  This relates to an earlier idea:
- Yablonovitch (1989): An accelerating boundary across which the index of refraction changes is a possible realization of the Hawking-Unruh effect, leading to conversion of QED vacuum fluctuations into real photons.

The Hawking-Unruh Effect

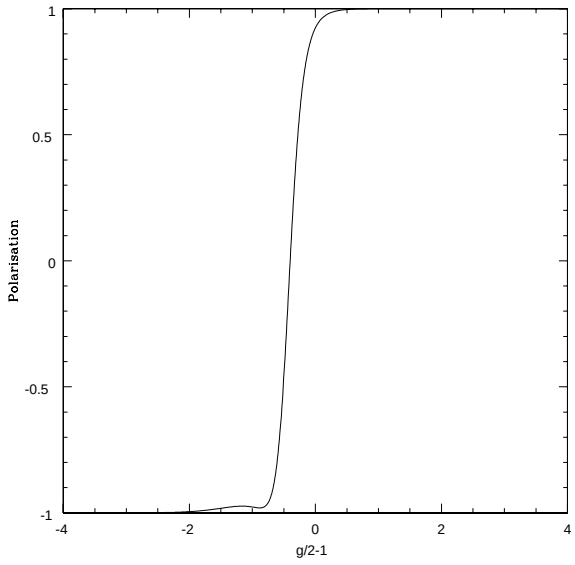
Hawking (1974): An observer outside a black hole experiences a bath of thermal radiation of temperature $T = \dfrac{\hbar g}{2\pi c k}$,

where g is the local acceleration due to gravity.

Unruh (1976): According to the equivalence principle an accelerated observer in a gravity-free region should also experience a thermal bath with: $T = \dfrac{\hbar a}{2\pi c k}$,

where a is the acceleration of the observer as measured in his instantaneous rest frame.

Bell (1983), Leinaas (1998), Unruh (1998): Incomplete polarization of electrons in a storage ring is explained in detail by Hawking-Unruh excitation.



Strong-Field QED

For high acceleration, need strong electromagnetic field.

Strongest macroscopic electromagnetic fields are in lasers.

Tabletop teraWatt lasers can be focused to $> 10^{19}$ W/cm^2.

$\Rightarrow$ Electric fields > 100 GeV/cm.

[Photon number density $> 10^{27}$/cm^3.]

(Nonperturbative) physics described by two dimensionless measures of field strength:

$$\eta = \frac{e\sqrt{\langle A_\mu A^\mu \rangle}}{mc^2} = \frac{eE_{\rm rms}}{m\omega_0 c} = \frac{eE_{\rm rms}\lambda_0}{mc^2},$$

governs the importance of multiple photons in the initial state, and characterizes the "mass shift": $\overline{m} = m\sqrt{1+\eta^2}$. [Kibble, 1996]

$$\Upsilon = \frac{\sqrt{\langle (F^{\mu\nu}p_\nu)^2 \rangle}}{mc^2 E_{\rm crit}} = \frac{2p_0}{mc^2}\frac{E_{\rm rms}}{E_{\rm crit}} = \frac{2p_0}{mc^2}\frac{\lambda_C}{\lambda_0}\eta,$$

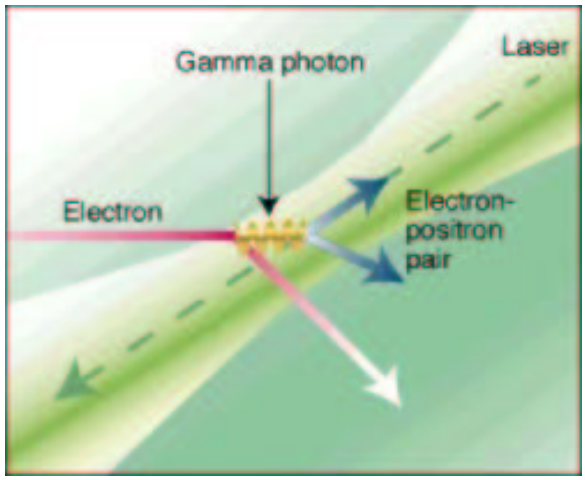
governs the importance of "spontaneous" pair creation, where $E_{\rm crit} = m^2c^3/e\hbar = mc^2/e\lambda_C = 1.3 \times 10^{16}$ V/cm.

Where to Find Critical Fields

- The magnetic field at the surface of a neutron star approaches the critical field $B_{\rm crit} = 4.4 \times 10^{13}$ Gauss.
- During heavy-ion collisions where $Z_{\rm total} = 2Z > 1/\alpha$, the critical field can be exceeded and e^+e^- production is expected.

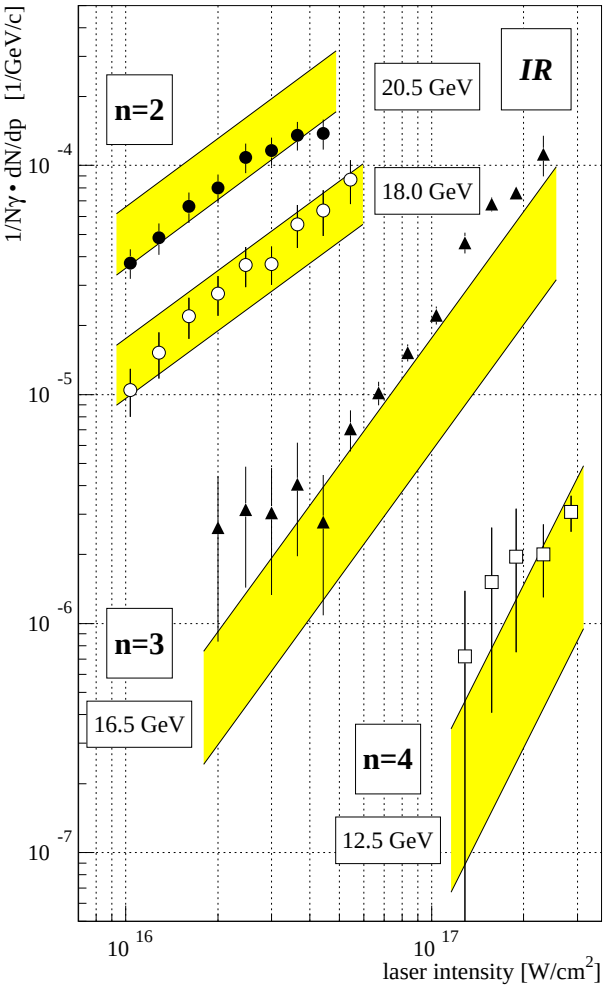
$$E_{\rm max} \approx \frac{2Ze}{\lambda_C^2} = 2Z\alpha E_{\rm crit}.$$

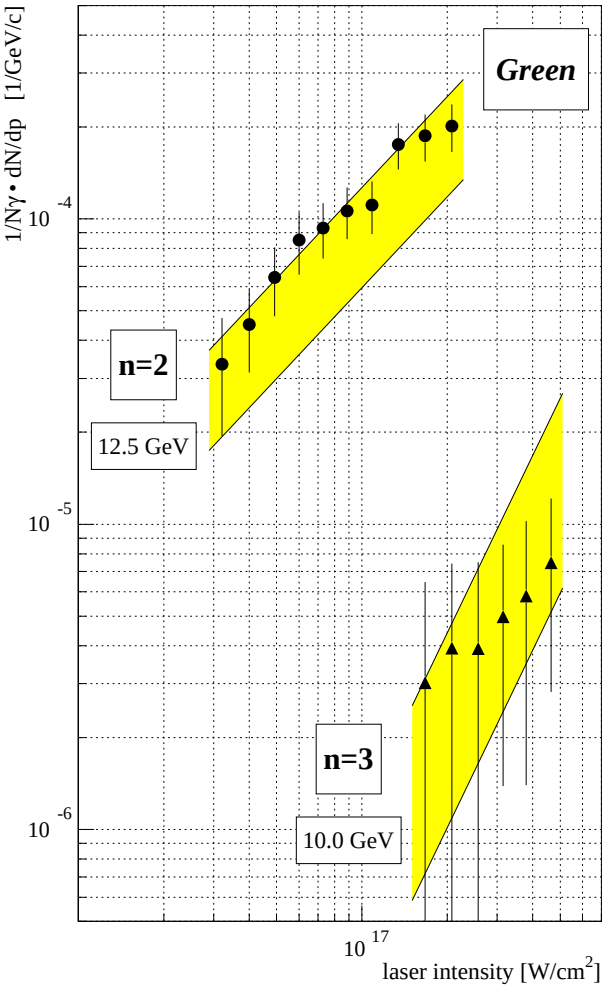
- Pomeranchuk (1939): The earth's magnetic field appears to be critical strength as seen by a cosmic-ray electron with 10^{19} eV.
- The electric field of a bunch at a future linear collider approaches the critical field in the frame of the oncoming bunch.
- The electric field of a focused teraWatt laser appears critical to a counterpropagating 50-GeV electron.



Physics at High η: Nonlinear Compton Scattering

$e + n\omega_0 \rightarrow e' + \omega$ [Bula *et al.*, 1996]





Normalized to total scattered photon rate

$\Rightarrow$ Rate(order n) $\propto I^{n-1}$.

Theory based on Volkov states of Dirac electron in a plane wave [Reiss (1962), Nikishov & Ritus (1964), Narozhny (1965)].

The Mass-Shift Effect

Toward the experimental observation of Nonlinear effects in Laser-Electron beam scattering

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Faculty of Science, Hiroshima University, Higashi-Hiroshima, 739-8526, Japan

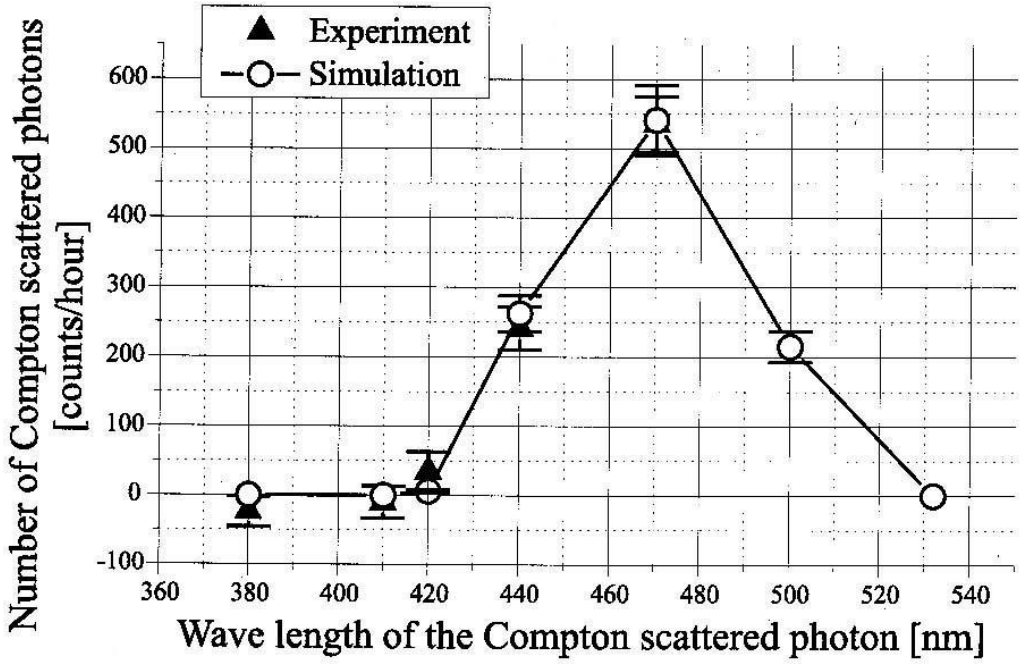
Ichita Endo, Tohru Takahashi

Graduate School of Advanced Sciences of Matter, Hiroshima University, Higashi-Hiroshima, 739-8526, Japan

Toshiaki Tauchi

High Energy Accelerator Research Organization (KEK), 1-1 Oho, Tsukuba, Ibaraki 305-0801 Japan

(August 6, 1999)



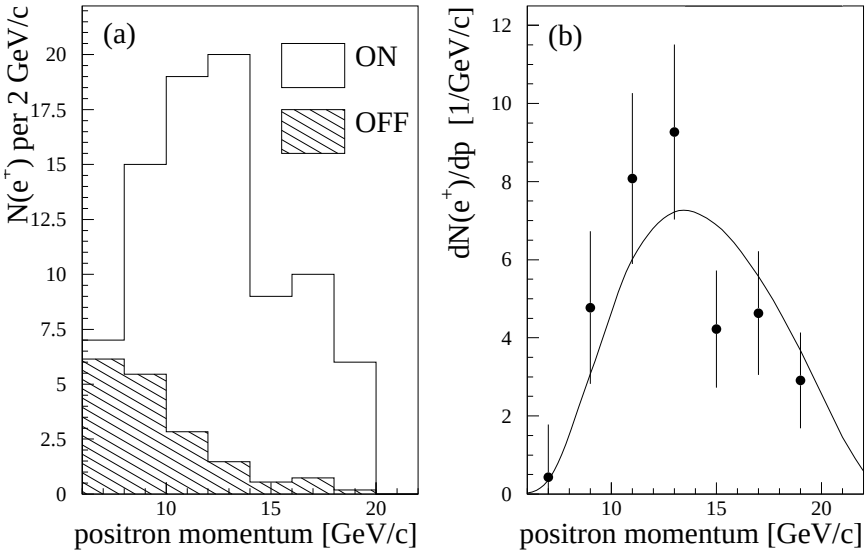
$\overline{m} = m\sqrt{1+\eta^2} \Rightarrow \lambda' = (1+\eta^2/2)\lambda/2.$

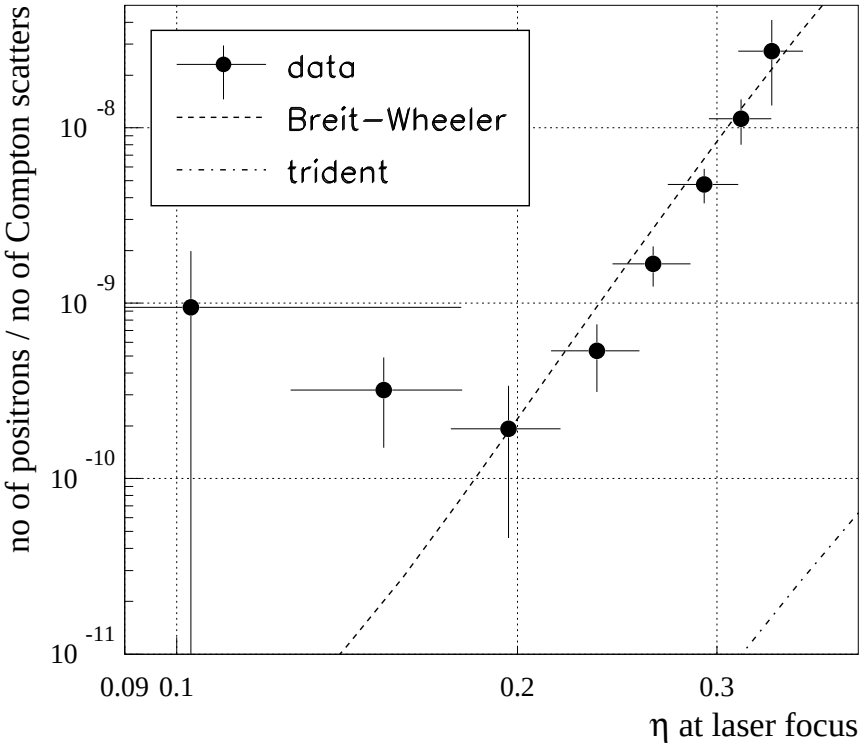
$\lambda = 800$ nm, $\eta = 0.6$ in this experiment.

Physics at High Υ: Pair Creation by Light

Two step process: $e + \omega_0 \rightarrow e' + \omega$, then $\omega + n\omega_0 \rightarrow e^+e^-$.

106 ± 14 signal positrons. [Burke *et al.*, 1997]





Rate $\propto \eta^{2n}$ where $n = 5.1 \pm 0.2$ (stat.) $^{+0.5}_{-0.8}$ (syst.)

$\Rightarrow$ 5 laser photons (process is below threshold for 1 photon).

Strong Field Pair Creation as Barrier Penetration

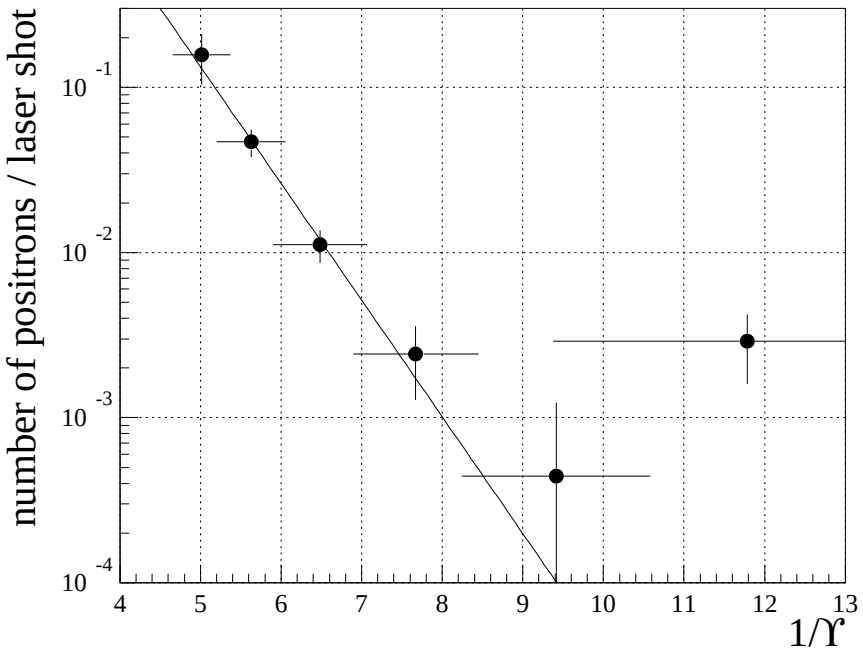
For a virtual e^+e^- pair to materialize in a field E the electron and positron must separate by distance d sufficient to extract energy $2mc^2$ from the field:

$$eEd = 2mc^2.$$

The probability of a separation d arising as a quantum fluctuation is related to penetration through a barrier of thickness d:

$$P \propto \exp\left(-\frac{d}{\lambda_C}\right) = \exp\left(-\frac{2m^2c^3}{e\hbar E}\right) = \exp\left(-\frac{2E_{\rm crit}}{E}\right) = \exp\left(-\frac{2}{\Upsilon}\right).$$

[Sauter (1931), Heisenberg and Euler (1936), Schwinger (1951)]



$R_{e^+} \propto \exp[(-1.8 \pm 0.2\,(\text{stat.}) \pm 0.2\,(\text{syst.}))/\Upsilon].$

The E-144 Collaboration:

Front: Glenn Horton-Smith, Theo Kotseroglou, Wolfram Ragg, Steve Boege

Back: Kostya Shmakov, Dave Meyerhofer, Charlie Bamber, Bill Bugg, Uli Haug,

Achim Weidemann, Dieter Walz, Dave Burke, Jim Spencer, Christian Bula,

Kirk McDonald, Adrian Melissinos

Not Shown: Clive Field, Steve Berridge, Eric Prebys, Thomas Koffas, Dave Reis

A Muon Storage Ring for Neutrino Production

The University of Rochester
Rochester 20, N.Y.

1960

Department of Physics

It is proposed to build a strong focusing ring to contain μ-mesons in a given momentum band for several π-meson lifetimes and then eject them.

Orbit radius 1.9 m
Mean radius 2.2 m

Aperture width 7 cm
Aperture height 4 cm

Maximum field 13 Kg.

Field index $n_1 - n_2 = n \simeq 15$

Betatron osc freq. $Q_r = 2.25$
$Q_z = 1.75$

Rotation frequency $\simeq$ 22 Mc /sec

Weight Fe 10 tons Cu 2 tons

Sectors: 4 each double
Focusing order: 1/2F D 1/2F

At the Cosmotron, a fairly well focused π-beam of 10^7/pulse could be obtained for a $\Delta p/p \simeq 20\%$. Assuming that for such a beam the capture efficiency is 50%, the μ-meson beam becomes

2.2×10^4/pulse with $\Delta p/p = 10\%$

At the AGS one could expect a fairly well focused beam of π's 2×10^8 so that under the same considerations the μ-mesons are 4.4×10^5/pulse with $\Delta p/p = 10\%$

The cost is estimated to less than $100,000.

If all this does not seem too unreasonable I will proceed to calculate orbits.

Is the Cost Too High?

A price tag of \$100k seems low, but the ring stored only 10^5 μ/s.

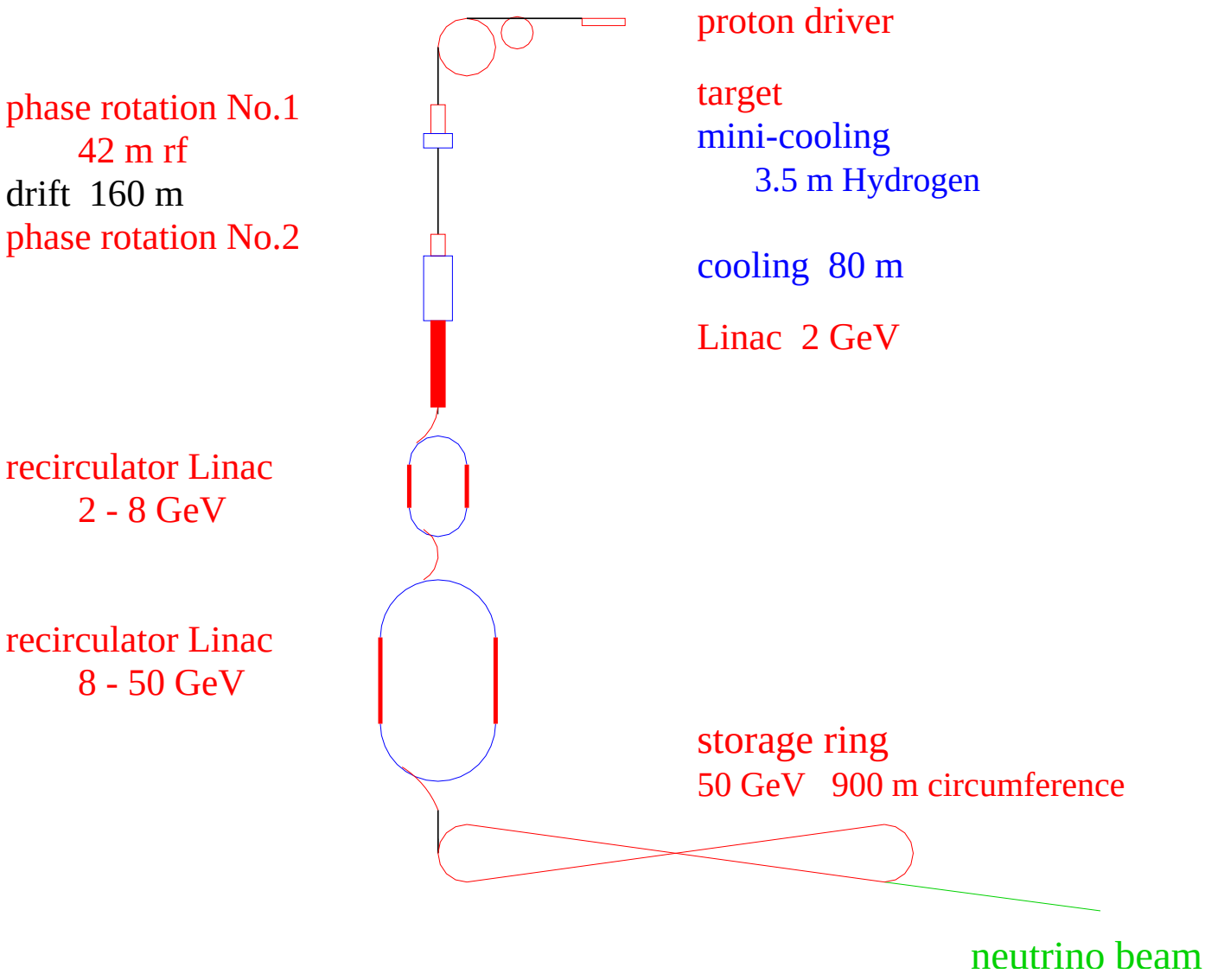
$\Rightarrow$ \$1 per μ/s stored.

We are now considering a facility to store 10^{14} μ/s, at a cost of roughly \$1B.

$\Rightarrow$ \$0.00001 per μ/s stored.

To have been this cost effective, Adrian's ring should have cost \$1.00!

A Neutrino Factory based on a Muon Storage Ring

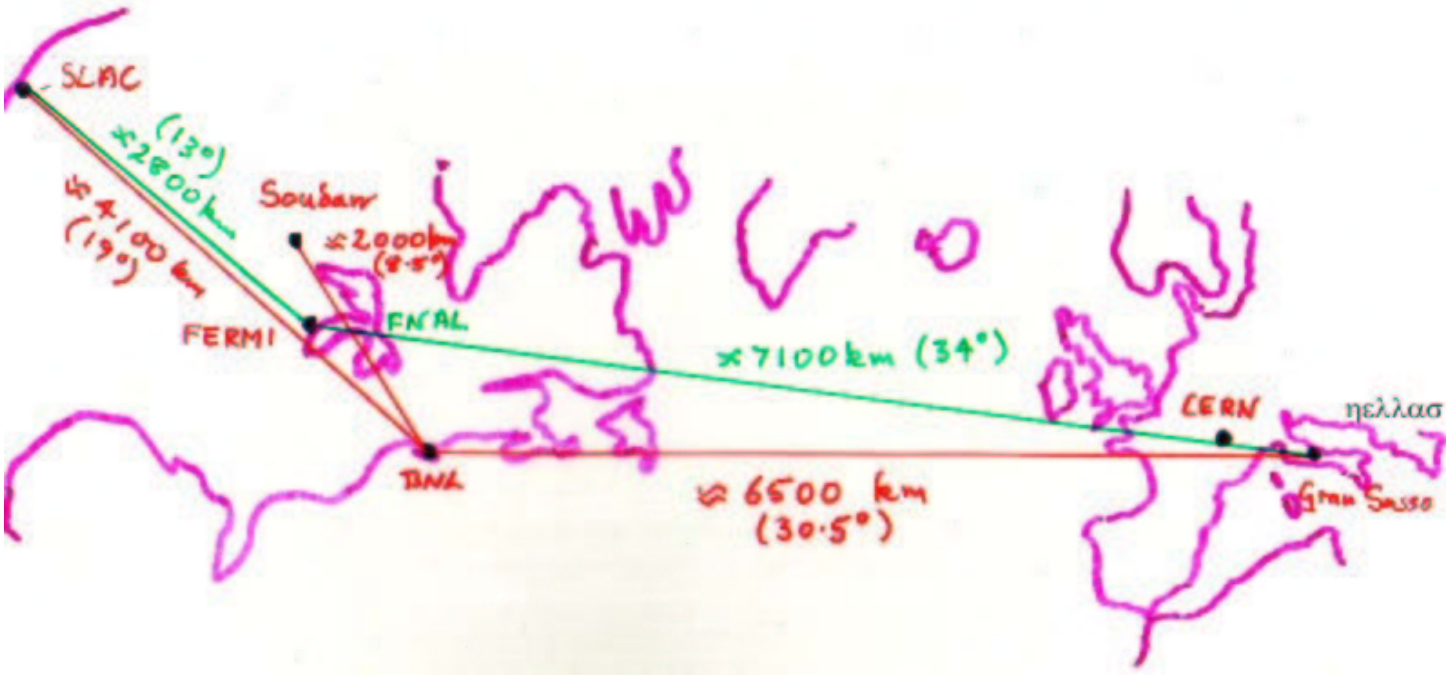


http://pubweb.bnl.gov/palmer/nu/params.ps

Also is a front end for a muon collider.

http://www.cap.bnl.gov/mumu/status_report.html

A Neutrino Factory is a Global Facility



A host lab contains the muon storage ring and a small, near detector.

Two larger detectors located elsewhere, one on the same, and the second on another continent.

Future Workshops: http://cap.bnl.gov/mumu/table_workshop.html