Possible Retrosignaling with
Array of n x m Delayed Choice Quantum Erasers, without coincidence counter

Thomas Goßmann, Kassel, Dec2020

A article on retrocorrelation experiment, Kim/Yu/Kulik/Shih/Scully 1999,
based on article by Drühl/Scully 1982

B discussion of experiment, slight chance in setup; n x m array such that one gets distinguishable signal noises at t=4 depending on decision “all beamsplitters on / all off“ at t=20, which is one future bit.

The work shall now be finished, by showing it to physicists in Munich, to get the missing functions out of the text, then get all technical details into calculation (like photon loss percentages), then I can actually calculate the maxima spectra of the two different signal noises.

A Retrocorrelation

A Delayed Choice Quantum Eraser

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This paper reports a "delayed choice quantum eraser" experiment proposed by Scully and Drühl in 1982. The experimental results demonstrated the possibility of simultaneously observing both particle-like and wave-like behavior of a quantum via quantum entanglement. The which-path or both-path information of a quantum can be erased or marked by its entangled twin even after the registration of the quantum.

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Complementarity, perhaps the most basic principle of quantum mechanics, distinguishes the world of quantum phenomena from the realm of classical physics. Quantum mechanically, one can never expect to measure both precise position and momentum of a quantum at the same time. It is prohibited. We say that the quantum observables "position" and "momentum" are "complementary" because the precise knowledge of the position (momentum) implies that all possible outcomes of measuring the momentum (position) are equally probable. In 1927, Niels Bohr illustrated complementarity with "wave-like" and "particle-like" attributes of a quantum mechanical object [1]. Since then, complementarity is often superficially identified with "wave-particle duality of matter". Over the years the two-slit interference experiment has been emphasized as a good example of the enforcement of complementarity. Feynman, discussing the two-slit experiment, noted that this wave-particle dual behavior contains the basic mystery of quantum mechanics [2]. The actual mechanisms that enforce complementarity vary from one experimental situation to another. In the two-slit experiment, the common "wisdom" is that the position-momentum uncertainty relation $\delta x \delta p \geq \frac{\hbar}{2}$ makes it impossible to determine which slit the photon (or electron) passes through without at the same time disturbing the photon (or electron) enough to destroy the interference pattern. However, it has been proven [3] that under certain circumstances this common interpretation may not be true. In 1982, Scully and Drühl found a way around this position-momentum uncertainty obstacle and proposed a quantum eraser to obtain which-path or particle-like information without scattering or otherwise introducing large uncontrolled phase factors to disturb the interference. To be sure the interference pattern disappears when which-path information is obtained. But it reappears when we erase (quantum erasure) the which-path information [3,4]. Since 1982, quantum eraser behavior has been reported in several experiments [5]; however, the original scheme has not been fully demonstrated.

One proposed quantum eraser experiment very close to the 1982 proposal is illustrated in Fig.1. Two atoms labeled by A and B are excited by a laser pulse. A pair of entangled photons, photon 1 and photon 2, is then emitted from either atom A or atom B by atomic cascade decay. Photon 1, propagating to the right, is registered by a photon counting detector D_0, which can be scanned by a step motor along its x-axis for the observation of interference fringes. Photon 2, propagating to the left, is injected into a beamsplitter. If the pair is generated in atom A, photon 2 will follow the A path meeting BSA with 50% chance of being reflected or transmitted. If the pair is generated in atom B, photon 2 will follow the B path meeting BSB with 50% chance of being reflected or transmitted. Under the 50% chance of being transmitted by either BSA or BSB, photon 2 is detected by either detector D_3 or D_4. The registration of D_3 or D_4 provides which-path information (path A or path B) of photon 2 and in turn provides which-path information of photon 1 because of the entanglement nature of the two-photon state of atomic cascade decay. Given a reflection at either BSA or BSB photon 2 will continue to follow its A path or B path to meet another 50-50 beamsplitter BS and then be detected by either detector D_1 or D_2, which are placed at the output ports of the beamsplitter BS. The triggering of detectors D_1 or D_2 erases the which-path information. So that either the absence of the interference or the restoration of the interference can be arranged via an appropriately contrived photon correlation study. The

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experiment is designed in such a way that L_0, the optical distance between atoms A, B and detector D_0, is much shorter than L_i, which is the optical distance between atoms A, B and detectors D_1, D_2, D_3, and D_4, respectively. So that D_0 will be triggered much earlier by photon 1. After the registration of photon 1, we look at these "delayed" detection events of D_1, D_2, D_3, and D_4 which have constant time delays, $\tau_i \simeq (L_i - L_0)/c$, relative to the triggering time of D_0. It is easy to see these "joint detection" events must have resulted from the same photon pair. It was predicted that the "joint detection" counting rate R_{01} (joint detection rate between D_0 and D_1) and R_{02} will show interference pattern when detector D_0 is scanned along its x-axis. This reflects the wave property (both-path) of photon 1. However, no interference will be observed in the "joint detection" counting rate R_{03} and R_{04} when detector D_0 is scanned along its x-axis. This is clearly expected because we now have indicated the particle property (which-path) of photon 1. It is important to emphasize that all four "joint detection" rates R_{01}, R_{02}, R_{03}, and R_{04} are recorded at the same time during one scanning of D_0 along its y-axis. That is, in the present experiment we "see" both wave (interference) and which-path (particle-like) with the same apparatus.

We wish to report a realization of the above quantum eraser experiment. The schematic diagram of the experimental setup is shown in Fig.2. Instead of atomic cascade decay, spontaneous parametric down conversion (SPDC) is used to prepare the entangled two-photon state. SPDC is a spontaneous nonlinear optical process from which a pair of signal-idler photons is generated when a pump laser beam is incident onto a nonlinear optical crystal [6]. In this experiment, the $351.1nm$ Argon ion pump laser beam is divided by a double-slit and incident onto a type-II phase matching [7] nonlinear optical crystal BBO ($\beta - BaB_2O_4$) at two regions A and B. A pair of $702.2nm$ orthogonally polarized signal-idler photon is generated either from A or B region. The width of the SPDC region is about $0.3mm$ and the distance between the center of A and B is about $0.7mm$. A Glen-Thompson prism is used to split the orthogonally polarized signal and idler. The signal photon (photon 1, either from A or B) passes a lens LS to meet detector D_0, which is placed on the Fourier transform plane (focal plane for collimated light beam) of the lens. The use of lens LS is to achieve the "far field" condition, but still keep a short distance between the slit and the detector D_0. Detector D_0 can be scanned along its x-axis by a step motor. The idler photon (photon 2) is sent to an interferometer with equal-path optical arms. The interferometer includes a prism PS, two 50-50 beamsplitters BSA, BSB, two reflecting mirrors M_A, M_B, and a 50-50 beamsplitter BS. Detectors D_1 and D_2 are placed at the two output ports of the BS, respectively, for erasing the which-path information. The triggering of detectors D_3 and D_4 provide which-path information of the idler (photon 2) and in turn provide which-path information of the signal (photon 1). The electronic output pulses of detectors D_1, D_2, D_3, and D_4 are sent to coincidence circuits with the output pulse of detector D_0, respectively, for the counting of "joint detection" rates R_{01}, R_{02}, R_{03}, and R_{04}. In this experiment the optical delay $(L_i - L_0)$ is chosen to be $\simeq 2.5m$, where L_0 is the optical distance between the output surface of BBO and detector D_0, and L_i is the optical distance between the output surface of the BBO and detectors D_1, D_2, D_3, and D_4, respectively. This means that any information one can learn from photon 2 must be at least $8ns$ later than what one has learned from the registration of photon 1. Compared to the $1ns$ response time of the detectors, $2.5m$ delay is good enough for a "delayed erasure".

Figs.3, 4, and 5 report the experimental results, which are all consistent with prediction. Figs.3 and 4 show the "joint detection" rates R_{01} and R_{02} against the x coordinates of detector D_0. It is clear we have observed the standard Young's double-slit interference pattern. However, there is a π phase shift between the two interference fringes. The π phase shift is explained as follows. Fig.5 reports a typical R_{03} (R_{04}), "joint detection" counting rate between D_0 and "which-path" D_3 (D_4), against the x coordinates of detector D_0. An absence of interference is clearly demonstrated. There is no significant difference between the curves of R_{03} and R_{04} except the small shift of the center.

To explain the experimental results, a standard quantum mechanical calculation is presented in the following. The "joint detection" counting rate, R_{0i}, of detector D_0 and detector D_j, on the time interval T, is given by the Glauber formula [8]:

$$\begin{aligned} R_{0j} &\propto \frac{1}{T}\int_0^T \int_0^T dT_0 dT_j \langle \Psi | E_0^{(-)} E_j^{(-)} E_j^{(+)} E_0^{(+)} | \Psi \rangle \\ &= \frac{1}{T}\int_0^T \int_0^T dT_0 dT_j |\langle 0 | E_j^{(+)} E_0^{(+)} | \Psi \rangle|^2, \end{aligned} \quad (1)$$

where T_0 is the detection time of D_0, T_j is the detection time of D_j($j = 1, 2, 3, 4$) and $E_{0,j}^{(\pm)}$ are positive and negative-frequency components of the field at detectors D_0 and D_j, respectively. $|\Psi\rangle$ is the entangled state of SPDC,

$$|\Psi\rangle = \sum_{s,i} C(\mathbf{k}_s, \mathbf{k}_i)\ a_s^\dagger(\omega(\mathbf{k}_s))\ a_i^\dagger(\omega(\mathbf{k}_i))|0\rangle, \quad (2)$$

where $C(\mathbf{k}_s, \mathbf{k}_i) = \delta(\omega_s + \omega_i - \omega_p)\delta(\mathbf{k}_s + \mathbf{k}_i - \mathbf{k}_p)$, for the SPDC in which ω_j and $\mathbf{k_j}$ ($j = s, i, p$) are the frequency and wavevectors of the signal (s), idler (i), and pump (p), respectively, ω_p and $\mathbf{k}_p$ can be considered as constants, a single mode laser line is used for pump and $a_s^\dagger$ and $a_i^\dagger$ are creation operators for signal and idler photons, respectively. For the case of two scattering atoms, see ref. [3], and in the case of cascade radiation, see ref. [9], $C(\mathbf{k}_s, \mathbf{k}_i)$ has a similar structure but without the momentum delta function. The δ functions in eq.(2) are the results of approximations for an infinite size SPDC crystal and for infinite interaction time. We introduce the two-dimensional function $\Psi(t_0, t_j)$ as in eq.(1),

$$\Psi(t_0, t_j) \equiv \langle 0| E_j^{(+)} E_0^{(+)} |\Psi\rangle. \quad (3)$$

$\Psi(t_0, t_j)$ is the joint count probability amplitude ("wavefunction" for short), where $t_0 \equiv T_0 - L_0/c$, $t_j \equiv T_j - L_j/c, j = 1, 2, 3, 4$, L_0 (L_j) is the optical distance between the output point on the BBO crystal and D_0 (D_j). It is straightforward to see that the four "wavefunctions" $\Psi(t_0, t_j)$, correspond to four different "joint detection" measurements, having the following different forms:

$$\Psi(t_0, t_1) = A(t_0, t_1^A) + A(t_0, t_1^B),$$
$$\Psi(t_0, t_2) = A(t_0, t_2^A) - A(t_0, t_2^B), \quad (4)$$
$$\Psi(t_0, t_3) = A(t_0, t_3^A), \quad \Psi(t_0, t_4) = A(t_0, t_4^B), \quad (5)$$

where as in Fig.1 the upper index of t (A or B) labels the scattering crystal (A or B region) and the lower index of t indicates different detectors. The different sign between the two amplitudes $\Psi(t_0, t_1)$ and $\Psi(t_0, t_2)$ is caused by the transmission-reflection unitary transformation of the beamsplitter BS, see Fig.1 and Fig.2. It is also straightforward to calculate each of the $A(t_i, t_j)$ [10]. To simplify the calculations, we consider the longitudinal integral only and write the two-photon state in terms of the integral of k_e and k_o:

$$|\Psi\rangle = A_0' \int dk_e \int dk_o \; \delta(\omega_e + \omega_o - \omega_p) \times \Phi(\Delta_k L) a_{k_e}^\dagger a_{k_o}^\dagger |0\rangle, \quad (6)$$

where a type-II phase matching crystal with finite length of L is assumed. $\Phi(\Delta_k L)$ is a sinc-like function, $\Phi(\Delta_k L) = (e^{i(\Delta_k L)} - 1)/i(\Delta_k L)$. Using eqs. (3) and (6) we find,

$$A(t_i, t_j) = A_0 \int dk_e \int dk_o \delta(\omega_e + \omega_o - \omega_p) \times \Phi(\Delta_k L) f_i(\omega_e) f_j(\omega_o) e^{-i(\omega_e t_1^e + \omega_o t_2^o)}, \quad (7)$$

where $f_{i,j}(\omega)$, is the spectral transmission function of an assumed filter placed in front of the k_{th} detector and is assumed Gaussian to simplify the calculation. To complete the integral, we define $\omega_e = \Omega_e + \nu$ and $\omega_o = \Omega_o - \nu$, where Ω_e and Ω_o are the center frequencies of the SPDC, $\Omega_e + \Omega_o = \Omega_p$ and ν is a small tuning frequency, so that $\omega_e + \omega_o = \Omega_p$ still holds. Consequently, we can expand k_e and k_o around $K_e(\Omega_e)$ and $K_o(\Omega_o)$ to first order in ν:

$$k_e = K_e + \nu \left.\frac{d\omega_e}{dk_e}\right|_{\Omega_e} = K_e + \frac{\nu}{u_e},$$
$$k_o = K_o - \nu \left.\frac{d\omega_o}{dk_o}\right|_{\Omega_o} = K_o - \frac{\nu}{u_o}, \quad (8)$$

where u_e and u_o are recognized as the group velocities of the e-ray and o-ray at frequencies Ω_e and Ω_o, respectively. Completing the integral, the biphoton wavepacket of type-II SPDC is thus:

$$A(t_i, t_j) = A_0 \Pi(t_i - t_j) e^{-i\Omega_i t_i} e^{-i\Omega_j t_j}, \quad (9)$$

where we have dropped the e, o indices. The shape of $\Pi(t_1 - t_2)$ is determined by the bandwidth of the spectral filters and the parameter DL of the SPDC crystal, where $D \equiv 1/u_o - 1/u_e$. If the filters are removed or have large enough bandwidth, we have a rectangular pulse function $\Pi(t_1 - t_2)$.

$$\Pi(t_0 - t_j) = \begin{cases} 1 & \text{if } 0 \le t_0 - t_j \le DL, \\ 0 & \text{otherwise.} \end{cases}$$

It is easy to find that the two amplitudes in $\Psi(t_0, t_1)$ and $\Psi(t_0, t_2)$ are indistinguishable (overlap in both $t_0 - t_j$ and $t_0 + t_j$), respectively, so that interference is expected in both the coincidence counting rates, R_{01} and R_{02}; however, with a π phase shift due to the different sign,

$$R_{01} \propto \cos^2(x\pi d/\lambda f), \quad \text{and} \quad R_{02} \propto \sin^2(x\pi d/\lambda f).$$

If we consider "slit" A and B both have finite width (not infinitely narrow), an integral is necessary to sum all possible amplitudes along slit A and slit B. We will have a standard interference-diffraction pattern for R_{01} and R_{02},

$$R_{01} \propto \text{sinc}^2(x\pi a/\lambda f) \cos^2(x\pi d/\lambda f),$$
$$R_{02} \propto \text{sinc}^2(x\pi a/\lambda f) \sin^2(x\pi d/\lambda f), \quad (10)$$

where a is the width of the slit A and B (equal width), d is the distance between the center of slit A and B, $\lambda = \lambda_s = \lambda_i$ is the wavelength of the signal and idler, and f is the focal length of lens LS. We have also applied the "far field approximation" for the signal and equal optical distance of the interferometer for the idler. After considering the finite size of the detectors and the divergence of the pump beam for further integrals, the interference visibility is reduced to the level close to the observation.

For the "joint detection" R_{03} and R_{04}, it is seen that the "wavefunction" in eq.(5) (which clearly provides "which-path" information) has only one amplitude and no interference is expected.

In conclusion, we have realized a quantum eraser experiment of the type proposed in ref. [3]. The experimental results demonstrate the possibility of observing both particle-like and wave-like behavior of a light quantum via quantum mechanical entanglement. The which-path or both-path information of a quantum can be erased or marked by its entangled twin even after the registration of the quantum.

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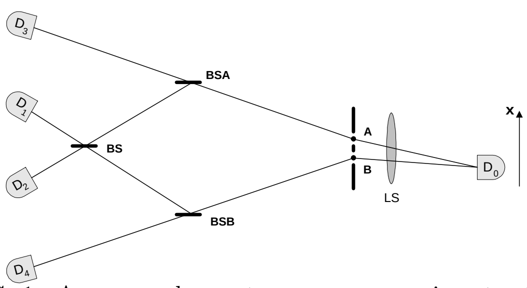


FIG. 1. A proposed quantum eraser experiment. A pair of entangled photons is emitted from either atom A or atom B by atomic cascade decay. "Clicks" at D_3 or D_4 provide which-path information and "clicks" at D_1 or D_2 erase the which-path information.

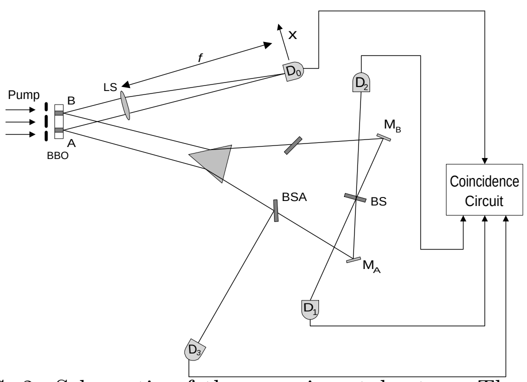


FIG. 2. Schematic of the experimental setup. The pump laser beam of SPDC is divided by a double-slit and incident onto a BBO crystal at two regions A and B. A pair of signal-idler photons is generated either from A or B region. The detection time of the signal photon is $8ns$ earlier than that of the idler.

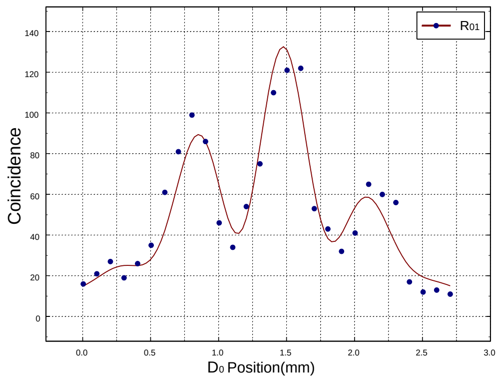


FIG. 3. R_{01} ("joint detection" rate between detectors D_0 and D_1) against the x coordinates of detector D_0. A standard Young's double-slit interference pattern is observed.

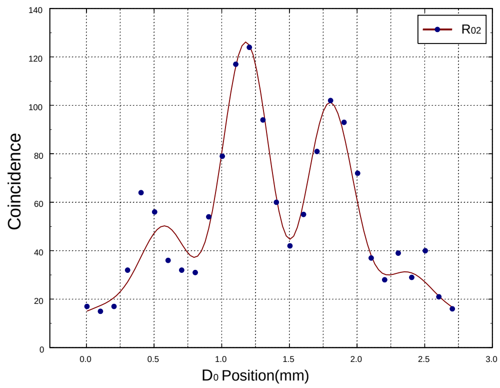


FIG. 4. R_{02} ("joint detection" rate between detectors D_0 and D_2) Note, there is a π phase shift compare to R_{01} shown in Fig.3

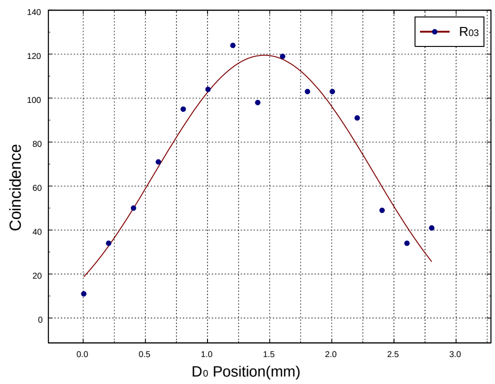


FIG. 5. R_{03} ("joint detection" rate between detectors D_0 and D_3). An absence of interference is clearly demonstrated.

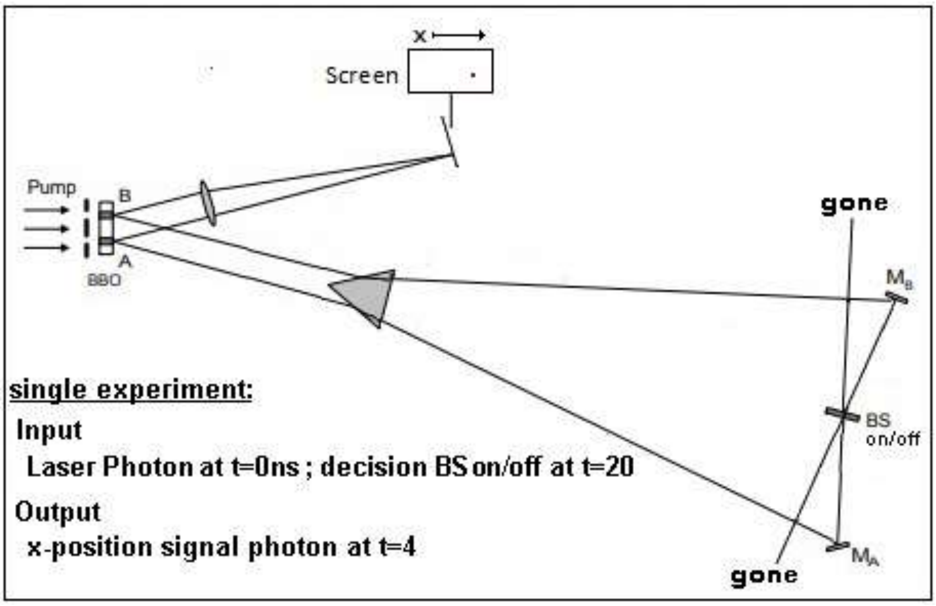
B From Retrocorrelation to Retrosignaling with n x m Delayed Choices ?

1. Description of above Retrocorrelation effect:

A photon hits a measuring screen, the x-coordinate arises randomly on base of a circumstance-dependent probability distribution, in the following called dice.
Which dice is used, is decided later, by means of a switch and a
further coincidence at an entangled photon (reflection/passage at 50:50 beam splitter).
On base of the photon impact one cannot recognize which dice is used.
That the earlier location randomness at the screen causes the later 50:50 randomness is considered to be excluded.
So the dice is actually formed in the future.
However, no information is supposed to flow into the past, it is "only a correlation".
For special groups of photons, however, this was not proved as far as I know, and there are still speculations about the information flow.

2. From Retrocorrelation to Retrosignaling

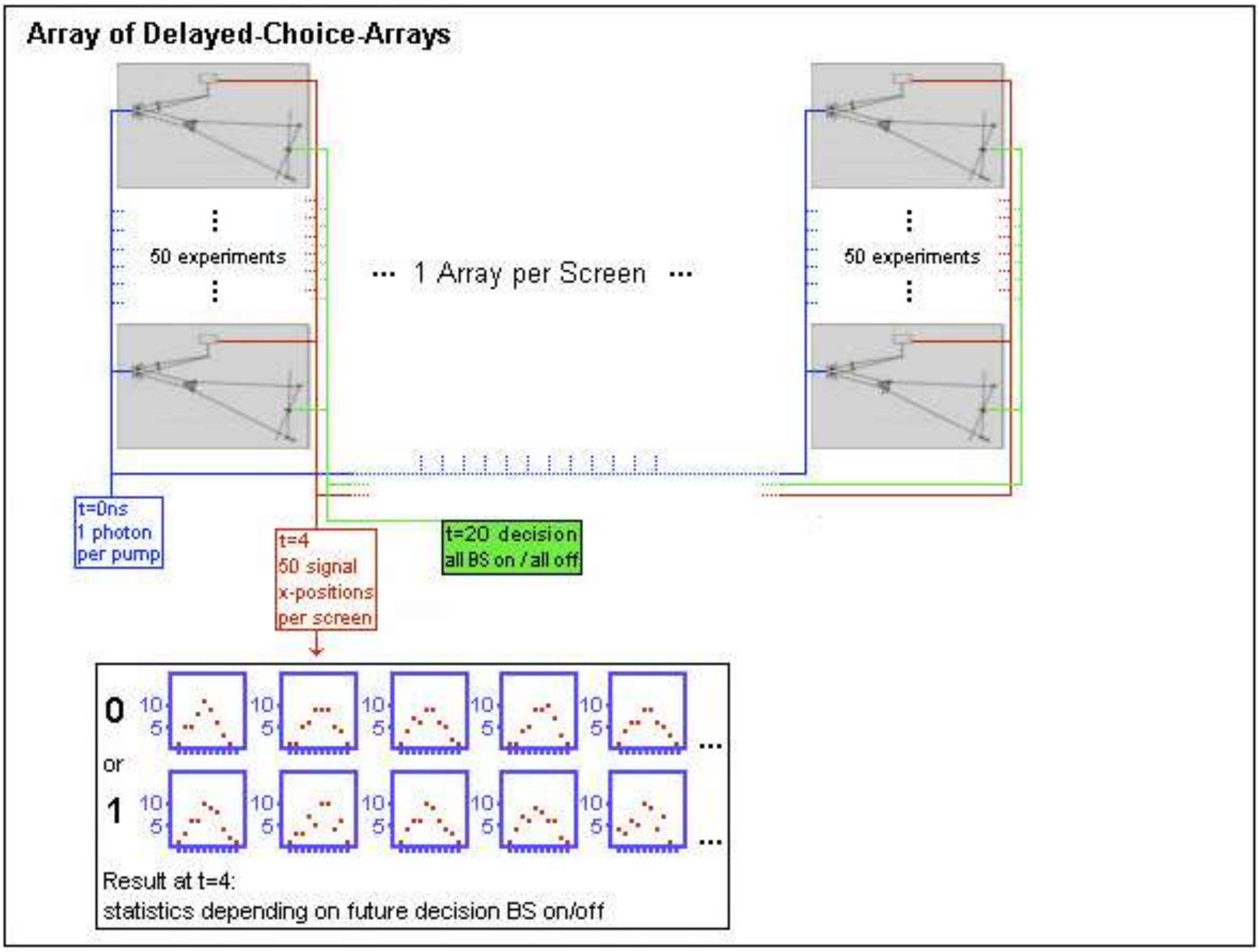
In order to clarify this partially or finally, I suggest the following set-up:



slightly modificated experiment from Kim...Scully 2000 "Delayed Choice Quantum Eraser"
BSoff:=100%passage as if no BS in place

The photon paths are not qualitatively different from the original setup:
If BSoff, photons going up have influence on signal like D4-photons, down D3,
if BSon, up is like D2, down likeD1.
So I use the signal dices from Kim...Scully.

50n simultaneous experiments without coincidence counters (m=50):



-- 50 signal photons from 50 Delayed choice quantum erasers hit one screen. n such arrays deliver a noisy signal at t=4, but if the noise is distinctly different depending on the BS-position at t=20, then one bit was sent into the past.

The dice of a signal photon x-coordinate depends on the path of the idler photon.
$f_i(x):=R_{0i}(x)$ (article, expectation curve, not measurement curve or interpolation curve)
For BSon and idler up dice is f_1, down f_2, off up f_3, off down f_4.
For a screen, when BSon, the dice is

(I) $P_{on}(d,m) = d/m\ f_1 + (m-d)/m\ f_2$, with d=number of up-idlers, m number of signal photons
(The screen expectation looks as if every single signal photon has this expectation, though they have different expectations due to their idlers.)

The signal curves Pon(d,m), or p'(x,d) in picture, are as follows; half of them with more than 1 maximum:
(The focal length of the signal lense is assumed f=0.7m, which fits to the mm-scale on the x-axes in their FIG.3-5; D1 is idler up, D2 down)

Probability curves for signal screens, depending on idler ratio D1/D2

BSon, m=50 photons/screen

$f_1(x)=(\sin(1917.34x)\cos(4473.8x)/(1917.34x))^2$ -- probability p´ if all idlers hit D1, d:=[D1]=50

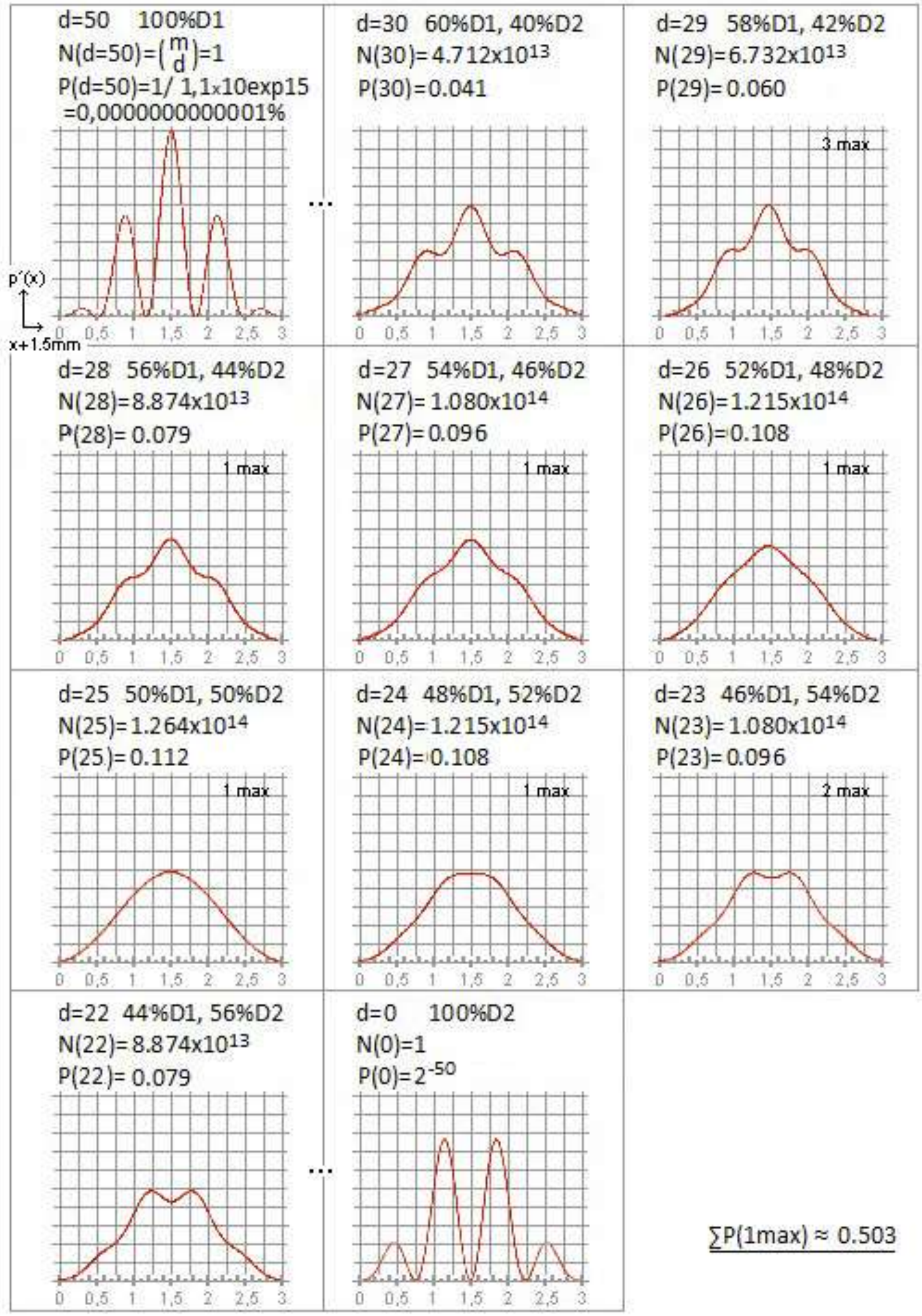
$f_2(x)=(\sin(1917.34x)\sin(4473.8x)/(1917.34x))^2$ -- p´(x) if d=0

$p'(x,d)=1/50*(df_1(x)+(50-d)f_2(x))$ -- probability curve for signal screen with d D1-idlers

N(d) := number of variations with d D1-idlers among the 2^{50} possible idler variations

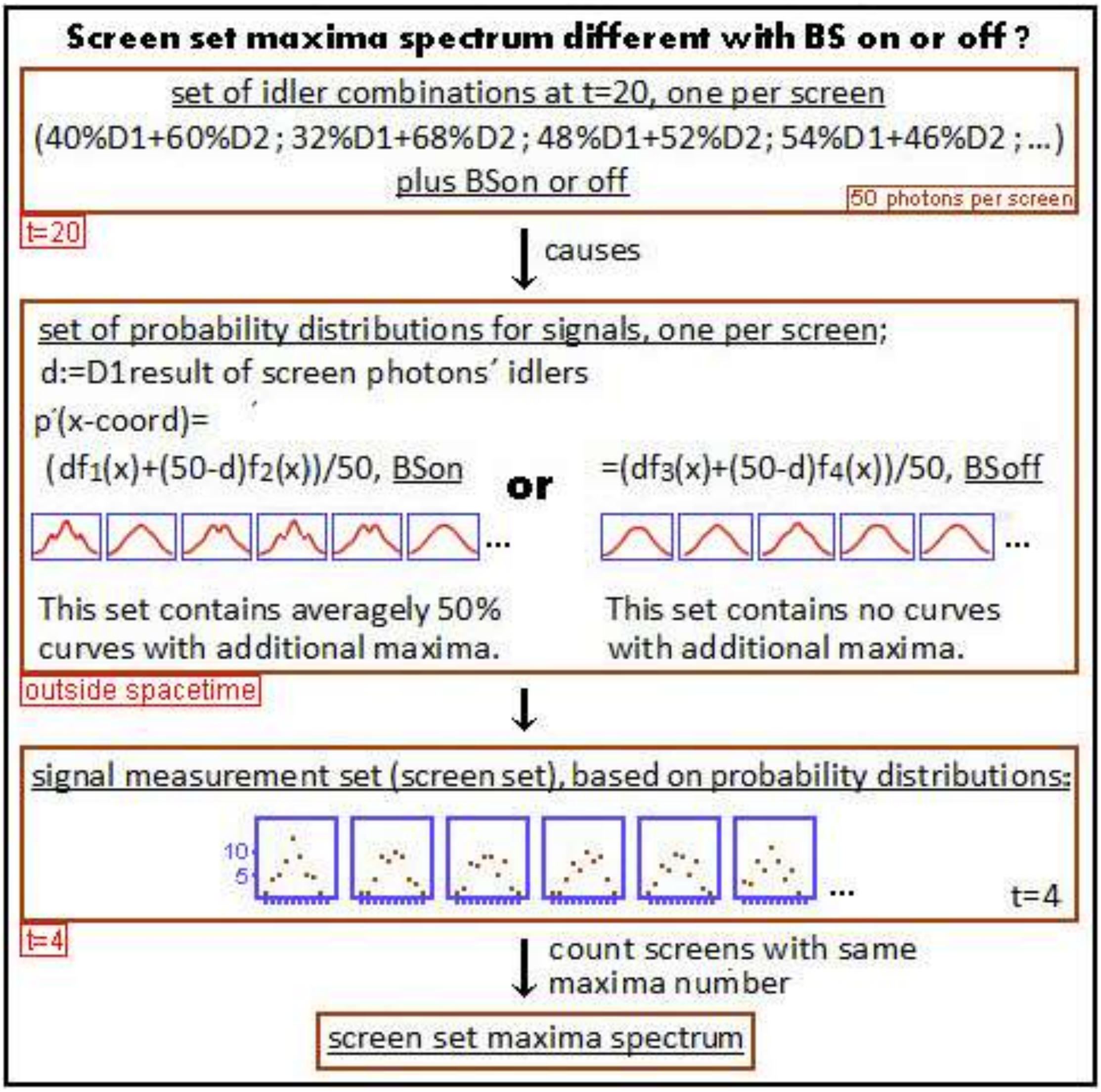
$P(d) := N(d)/2^{50}$ probability of idler variations with d D1-idlers

$[-1.5 \text{ to } 1.5\text{mm}]\int c\,p'(x)dx \approx 0.99$



$\sum P(1max) \approx 0.503$

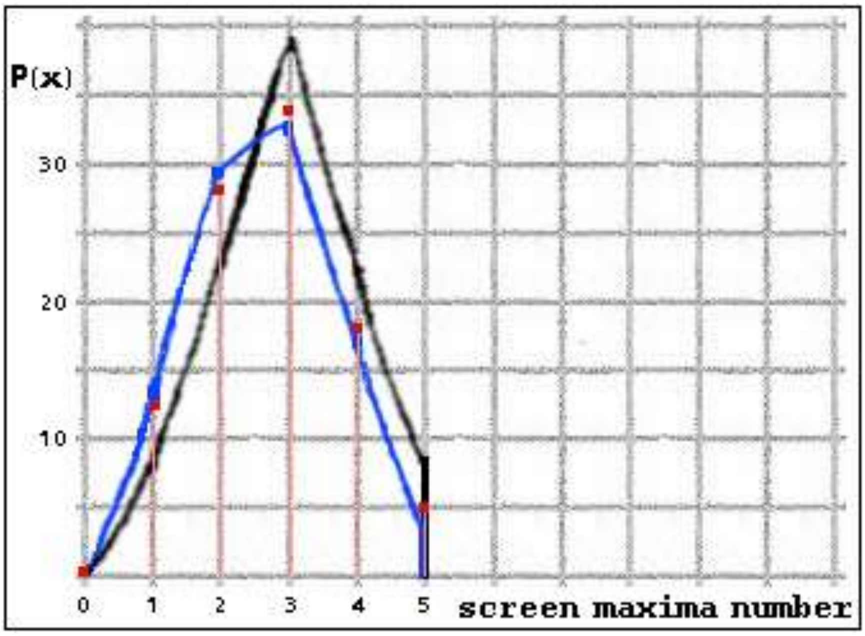
With BSoff, there are only signal curves (dices) with one maximum.
A screen measurement-graph set based on a Bson-dice set should have more maxima on average than with BSoff-dice:



For more than m=50 signal photons, the probability curves are better approached, but the percentage of screens with more than 1 maximum in probability curve decreases fast.

With different, clear-shaped maxima expectation curves, one can distinguish if the noise at t=4 comes from BSon or off at t=20:
In case of 10 (equal) measurement intervalls, there are between 0 and 5 maxima in the measurement curve. (depends on definition, two equal values as max)

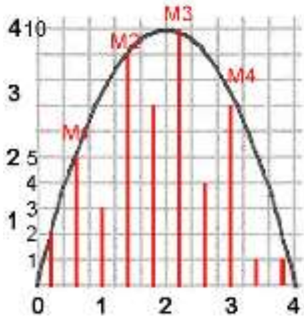
black- maxima expectation curve for very high n if BSon, blue off. (ficticious)



Red dots = maxima-spektrum for a measurement with n screens;
n high, so blue curve is recognised with 99,x% security. (one future bit)

Mathematical problem:
From a probability distribution, and a number of measurement intervalls, I don´t see how many maxima the measurement curve has:

Example $P(x) = -x^2+4x$, m=50 events, I=10 intervalls



red – measurement set with 4 maxima

$$P(interval):= 3/32 \, I \int_{x1}^{x2} P(x)dx \, I$$

$\Sigma P(interval)=1=100\%$

So is there a formula/algorithm, where I put in P,m,I, which then says “with x%probab. a measurement curve (bar chart) has 0 max, with y% 1 max,..., 5 max“ ?
Couldn't find one, so I have to do it by foot. (Calculate all combinations)

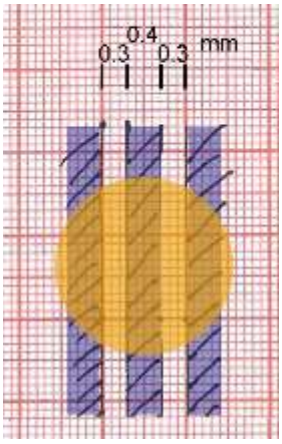
$M_i(d)$:= bar chart Probability over maxima number for one screen, d idlers up, 50-d idlers down
i=0 for BSoff, 1 for on (for i=1 the possible x-location probability curves are shown above)
MS_i := bar chart Probability over maxima number for random set of 50-photon-screens (= Maxima spectrum expectation; = probability for measurement set in picture, “screen set maxima spectrum“)
(blue and black bar curve above)

The bar charts can be added according to their occurence probability:

(II) $MS_i = [d=0 to 50]\Sigma M_i(d)(m \text{ over } d)/2exp50$ (Addition lemma)

(bar charts can be added because the underlying screen probability curves are not added, which would change the expectation of number of maxima. Just the probabilities to find maxima are added.)

– To actually do an Delayed Choice Array without coincidence counters, the equipment must be very good (especially if you want tenthousands single experiments on a chip).
Every Photon must be under control.
Maybe higher-energy photons are possible.
Noise sources preventing a sharp maxima spectrum expectation:
N1) The first problem besides a stable source is the double slit. Not all photons pass:



blue- sheet with slits   yellow- ca.99%light cone
If here the passing rate is about equal to the rate of the cross-sectional areas inside the light cone, about 65% of the photons get stuck in the sheet.
But that´s no problem: If a sheet detects a photon impact, a new one can be sent within a nanosecond without disturbing the statistics. So it´s possible that exactly 50 photons per screen (=array of 50 single experiments) go through the 50 doubleslits. This might take some ns, so longer light paths are necessary. To increase the choice delay time, slow photon medium would be helpful if very transparent. Then one could switch BS by hand, in contradiction to effect or not.

N2) Next comes two regions on a splitting crystal which splits the photon into entangled half-energy photons (signal and idler). Depending on which slit the photon went through, one of the regions emits a signal/idler pair.
The standard interpretation is that the photon has gone through both slits (or neither slit if you see it as localized particle) if no proof can exist that it has gone through a distinct slit.
So at the crystal, there´s a superposition of two events: “Region A emits“ and “Region B emits“.
The superposition stays intact/unsolved if there can exist no proof through which slit the photon has gone (BSon). That means, it is then undefined what classically happened in Region A or B. If a photon was emitted from one region (or not) is neither true nor false.
The size of the regions brings a little indefiniteness to the probability curves, and blurrs the maxima expectation graph.

And some photons might get stuck.
Maybe missing photons on the screen can be replaced. (Counting photon impacts, doing missing runs long before idlers reach BS.)

N3) Lenses, mirrors, measurement devices are not 100% exact too.
Hopefully this all sums up to less than one photon failure in 50 photons (per screen).
I try to figure out technical details, then calculate not-to-blurry maxima expectation.

-- missing functions f_3, f_4 (expectation curves R_{03},R_{04} in article):

(III) $f_3 + f_4 = f_1 + f_2 =(\sin(1917.34x)/(1917.34x))^2$
(else one screen is enough do detect effect difference from BSon/off.)

No explicit calculation of R_{03}, R_{04} in the text.
From

$$\Psi(t_0,t_1) = A(t_0,t_1^A) + A(t_0,t_1^B)$$
$$\Psi(t_0,t_2) = A(t_0,t_2^A) - A(t_0,t_2^B)$$

follows

$$R_{01} \propto \mathrm{sinc}^2(x\pi a/\lambda f)\cos^2(x\pi d/\lambda f)$$
$$R_{02} \propto \mathrm{sinc}^2(x\pi a/\lambda f)\sin^2(x\pi d/\lambda f)$$

From

$$\Psi(t_0,t_3) = A(t_0,t_3^A), \quad \Psi(t_0,t_4) = A(t_0,t_4^B)$$

follows
$R_{03,4}$ = ?
which are standard distributions with only one maximum.
(can´t do calculation at the moment)

In the article, the graph R_{03} doesn't fit the other graphs, it was taken from another run.
The measuring intervals are different from $R_{01,2}$ though in the text they emphasize how important it is that all measurements are done in one run, and there are about 20% less photons.
This doesn't mess with their task, it was just about proving there's no interference.
But it hinders the statistical analysis of parallel runs without coincidence counters, maybe intentionally.

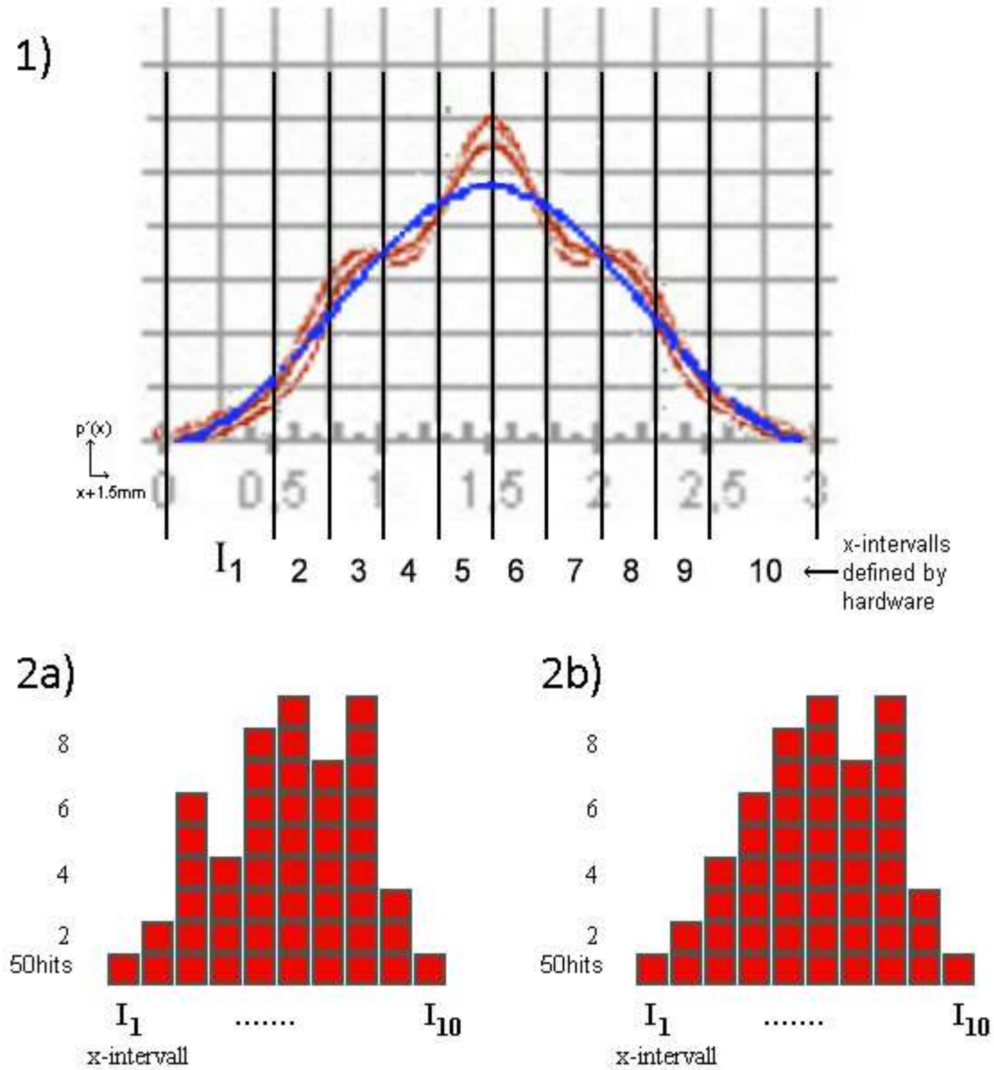
– The fastest way to accomplish sending a bit into the past is obviously combining a few retrocorrelation experiments, on one screen, with the new fundamental force "Peoch79", as Princeton failed to do, see other publication "Draft Articles on Retrocausality".
The new force changes wave functions, or measurement outcomes, and is called „intent".
I still offer to replace the chicks in Peoch79 by small electric devices, which would make research easier. (good chances for success)

The decision to not switch BSoff though it was predicted by its effect, causes some sort of time paradox, especially if lots of action is attached to the signal. Like lots of machines, programs etc start and then the cause for the start is removed!?

– In the 1990s, there was an effort by bureaucrats, scientists, activists etc to disclose secret stuff in order to support evolution of mankind, like politics, ufos, psychology, energy, Dr. Greer, and such. (NSA, Army etc sponsor of article)
Even SpA. Scully of X-files might have been named after one of the authors, who took part in both publications, 1982 and 1999. Because it's the “spookiest“ effect. (spooky squared compared to the entanglement Einstein called spooky)
Then some detail-disclosure followed (Wikileaks), and now allegedly Qanon, which is sort of continuation of disclosure, or half shit and half not wrong, or complete BS, or all in one, didn´t look at.

Update Jan2021

-- Free Choice of measurement intervalls possible.
Intervalls can be adjusted to screen probability curves such that screen set maxima expectation is more clearly distinct depending on BSon/off.



1) red: screen probability d=28,29,30; BSon
(31% of all screen expectations in infinite random set)
blue: typical BSoff-expectation (for all d without additional maxima)

2a,b) measurement result.
The result a (3max) ist more likely than b (2max) when BSon, which contributes to greater maxima expectation when BSon, because with BSoff b is more likely than a.
To have an overview and draw maxima expectation spectra, one has to go through all
((10+50-1)over 50) = 62,828,356,305 possible measurement sets for each d.
Some PCs will do it I think. (Excel maybe)

I=10 number of measurement intervalls (hardware)

I_1,..,I_{10} measurement intervalls (hardware)

[I_i] := number of photon hits in intervall (measurement)

S_{Ei} := {...p'(x,d,i)...}   infinite random set of 50-photon screen probability curves, i=0,1 for BSoff/on, m=50 photons/screen, n number of parallel screens very high (to infinite)

The set has 51 distinct elements (d=0,...,50), with occurence probability N(d)/2^{50} , see picture.

p'(x)= d/50 f1(x) +(1-d/50)f2(x) or f3/4 for i=0

S_{Mi} := {...D(I,d,i)...}   infinite random set of 50-photon measurement results: all distributions "50photons on intervalls I", with occurence prob N(p'(x,d,i)).

Concentrating on I_3 ,I_4, trying to avoid complicated max expectancy calculations:

In S_{M1}, is the probability of finding a screen result with [x3]>[x4] bigger than in S_{M0} ?

That would be a sufficient criterion to detect BSon/off (t=20) at t=4.

– I´m not sure if from f1+f2 = f3+f4 follows $P_{SM0}([I3]>[I4]) = P_{SM1}([I3]>[I4])$.

The occurence probability for each of the 62,828,356,305 distinct 50-photon measurement results D in S_M is obviously

$P(D) = (d=0to50)\Sigma\ N(d)/2^{50}\ N(d,D)$
with N(d,D) as occurence probability of D if p'=d/50 f1+(50-d)/50 f2 (f3,4 if BSoff)

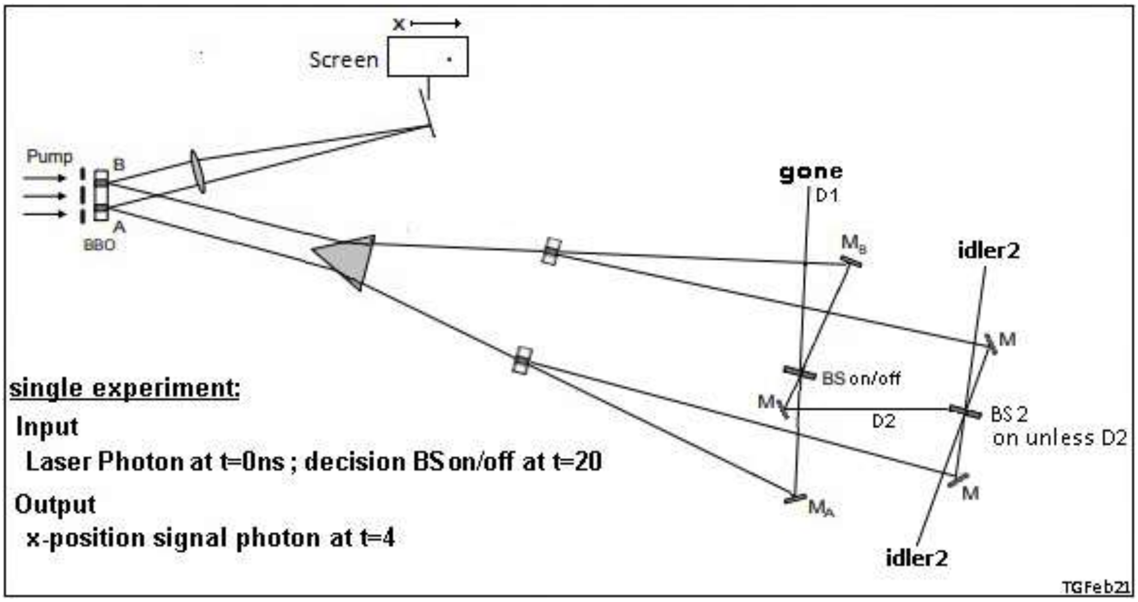
And, it's still possible that the blue and black max expect curves (bar charts) are identical, if the BSoff-curves have lots of flat parts which balance the additional max in BSon, in terms of max expectation. Though it does not look like it, as I wrote to statistics prof a year ago.
That means noises at t=4 are not distinguishable, and the partly answer to the initial question is: No retrosignaling via max expectation.
No answer by prof, no tips about max expect calculation. Maybe one department has theorems on max expectations, like information theory, military, pattern detection, not yet found.

Obviously proven so far:
1. My new physics term **"interference from the future"** for a property of physical reality, is valid. If delayed choices arrays run parallel and for one screen most idlers happen to go one way (BSon), this incident causes the screen result in the past to show interference. (minimum hundreds parallel photons per screen, so one can clearly see the interference expectation curve in the measurement result).
But: if you see a causeless interference on the screen, this does not prove there is an idler-incident ($P<2^{-100}$) and BSon in the future. It could also be a screen incident.
Then with trillions parallel screen arrays, shouldn´t there be more interference with BSon? Screen based interference (incidental, fake-interference) with both BSon/off, and wave-function caused interference additionally when BSon.
Suspectedly there´s a tricky no-answer, no time yet to study.
2. If there exists a force "**intent**" which has outside-spacetime influence on wave function or measurement results, QM says you can use it to **retrosignal** bits into the past.

Also in this context:
Reports about two bunches of electrons, which send properties via entanglement seemed serious, but I doubt if they´re able to transmit a single superluminal bit, or if yes I suspect they used 4d-QM with intent, outcome manipulation etc. (Setup and maths not yet seen.)

Array of delayed choice quantum erasers with extra delay

In this setup, if correct, the idler goes through a second BBO before meeting the beamsplitter. The idler1 then meets the BS where its which-way information is destroyed (BSon).
But idler2 still has ww-info. If idler1 goes down (D2 in Kim...Scully), it switches BS2 off, so there´s ww-info at idler2 and hence no signal interference. If idler1 goes up (D1), BS2 is not switched off, all ww-info lost, signal interference.



I suspect here is
combined signal prob when BSon unequal combined sign prob when BSoff:
f1+f2≠f3+f4 , which makes retrosignaling easy (all on one screen, less precision).
Let´s see:

In order to have RT not refuted by standard QM, the signal curves in case idler1 up (D1) must only depend on idler2 (if up, f3 on screen, if down f4), combined signal prob equal. That is, the latter incident at BS2 overrides any influence from incident BS1.
Can´t calculate yet.