From:	Nam, Sae Woo (Fed)
To:	Migdall, Alan L. Dr. (Fed); Slattery, Oliver T. (Fed)
Cc:	Polyakov, Sergey V. (Fed); Miller, Carl A. (Fed); Battou, Abdella (Fed); Ma, Lijun (Fed); Boisvert, Ronald F. (Fed); Tang, Xiao (Assoc); Marakkarakath Vadakkepurayil, Jabir (IntlAssoc); Sergey Polyakov
Subject:	Re: version for submission to ITL...
Date:	Tuesday, August 27, 2019 10:58:35 AM
Attachments:	IMS_2021-v2_Ollie_AM_SN.docx

Hi all,
I just made a couple of small comments. Also, I think we should pitch this earlier for FY2020 unless there is a reason to wait until FY 2021.

Cheers,
SaeWoo

From: Alan Migdall <alan.migdall@nist.gov>
Date: Tuesday, August 27, 2019 at 8:02 AM
To: "Slattery, Oliver T. (Fed)" <oliver.slattery@nist.gov>
Cc: Sergey Polyakov <sergey.polyakov@nist.gov>, "Miller, Carl A. (Fed)" <carl.miller@nist.gov>, Sae Nam <saewoo.nam@nist.gov>, "Battou, Abdella (Fed)" <abdella.battou@nist.gov>, "Ma, Lijun (Fed)" <lijun.ma@nist.gov>, "Boisvert, Ronald F. (Fed)" <boisvert@nist.gov>, "Tang, Xiao (Fed)" <xiao.tang@nist.gov>, "Marakkarakath Vadakkepurayil, Jabir (IntlAssoc)" <jabir.marakkarakathvadakkepurayil@nist.gov>, Sergey Polyakov <polyakov.sergey@gmail.com>
Subject: Re: version for submission to ITL...

I edited the first page, which I think is the latest version.
I included a comment about the challenge of photon counting detection speeds being much lower than classical comm detectors. I think we should make some mention of that and how it is not a show stopper.

Alan

From: "Slattery, Oliver T. (Fed)" <oliver.slattery@nist.gov>
Date: Tuesday, August 27, 2019 at 12:48 AM
To: "Slattery, Oliver T. (Fed)" <oliver.slattery@nist.gov>
Cc: "Polyakov, Sergey V. (Fed)" <sergey.polyakov@nist.gov>, "Miller, Carl A. (Fed)" <carl.miller@nist.gov>, "Nam, Sae Woo (Fed)" <saewoo.nam@nist.gov>, "Battou, Abdella (Fed)" <abdella.battou@nist.gov>, "Ma, Lijun (Fed)" <lijun.ma@nist.gov>, "Boisvert, Ronald F. (Fed)" <boisvert@nist.gov>, "Tang, Xiao (Fed)" <xiao.tang@nist.gov>, "Migdall, Alan L. Dr. (Fed)" <alan.migdall@nist.gov>, "Marakkarakath Vadakkepurayil, Jabir (IntlAssoc)" <jabir.marakkarakathvadakkepurayil@nist.gov>, Sergey Polyakov <polyakov.sergey@gmail.com>

Subject: RE: version for submission to ITL...

Hi:

So I had a go at this as attached. The cleaned up 1-page effort is on top and the partially edited older version (with notes from last week's meeting) is in the pages that follow. I tried to incorporate these ideas into the 1-pager text. We should add champions as appropriate (each group should do their own I guess).

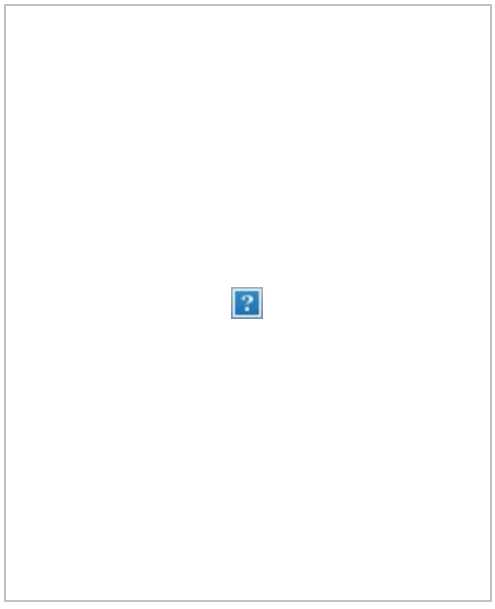
Thanks
Ollie S.

From: Sergey Polyakov <polyakov.sergey@gmail.com>
Sent: Tuesday, August 20, 2019 9:28 PM
To: Migdall, Alan L. Dr. (Fed) <alan.migdall@nist.gov>
Cc: Slattery, Oliver T. (Fed) <oliver.slattery@nist.gov>; Polyakov, Sergey V. (Fed) <sergey.polyakov@nist.gov>; Miller, Carl A. (Fed) <carl.miller@nist.gov>; Nam, Sae Woo (Fed) <saewoo.nam@nist.gov>; Battou, Abdella (Fed) <abdella.battou@nist.gov>; Ma, Lijun (Fed) <lijun.ma@nist.gov>; Boisvert, Ronald F. (Fed) <boisvert@nist.gov>
Subject: Re: version for submission to ITL...

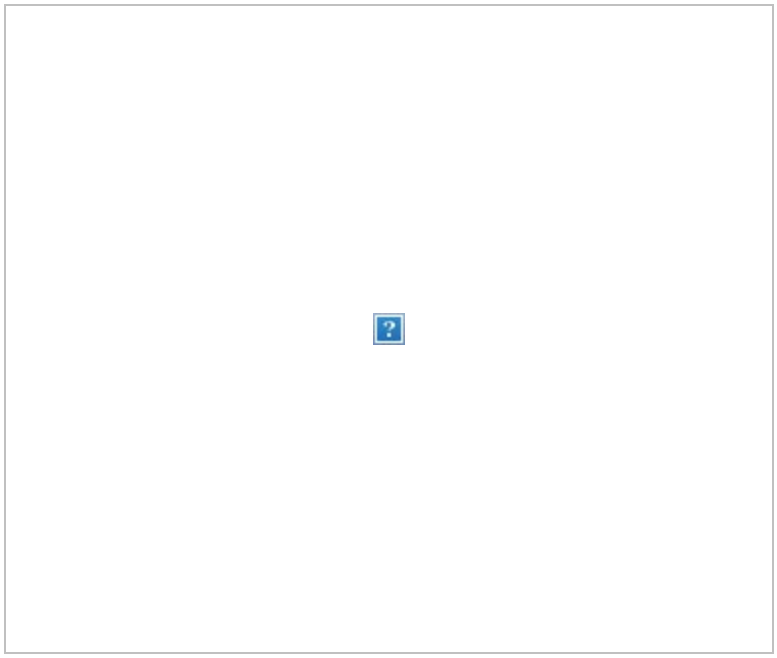
Cool, thanks!

Maybe we could take some of the wording from these publications and enhance our one-pager.

On Tue, Aug 20, 2019, 3:31 PM Migdall, Alan L. Dr. (Fed) <alan.migdall@nist.gov> wrote:

> Maybe useful graphics/data
>
> https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4733922/
>
> 

optical comm roadmap
Has graph (Fig 1) rolling over showing classical mode capacities are saturating
https://iopscience.iop.org/article/10.1088/2040-8978/18/6/063002/pdf



Growth of IOT
https://www.ericsson.com/en/mobility-report/internet-of-things-forecast

From: "Slattery, Oliver T. (Fed)" <oliver.slattery@nist.gov>
Date: Tuesday, August 20, 2019 at 2:03 PM
To: Sergey Polyakov <polyakov.sergey@gmail.com>
Cc: "Polyakov, Sergey V. (Fed)" <sergey.polyakov@nist.gov>, "Miller, Carl A. (Fed)" <carl.miller@nist.gov>, "Nam, Sae Woo (Fed)" <saewoo.nam@nist.gov>, "Battou, Abdella (Fed)" <abdella.battou@nist.gov>, "Migdall, Alan L. Dr. (Fed)" <alan.migdall@nist.gov>, "Ma, Lijun (Fed)" <lijun.ma@nist.gov>, "Boisvert, Ronald F. (Fed)" <boisvert@nist.gov>
Subject: RE: version for submission to ITL...

OK, no problem.

Thanks

Ollie S

From: Sergey Polyakov <polyakov.sergey@gmail.com>
Sent: Tuesday, August 20, 2019 1:59 PM
To: Slattery, Oliver T. (Fed) <oliver.slattery@nist.gov>
Cc: Polyakov, Sergey V. (Fed) <sergey.polyakov@nist.gov>; Miller, Carl A. (Fed) <carl.miller@nist.gov>; Nam, Sae Woo (Fed) <saewoo.nam@nist.gov>; Battou, Abdella (Fed) <abdella.battou@nist.gov>; Migdall, Alan L. Dr. (Fed) <alan.migdall@nist.gov>; Ma, Lijun (Fed) <lijun.ma@nist.gov>; Boisvert, Ronald F. (Fed) <boisvert@nist.gov>
Subject: Re: version for submission to ITL...

Im running a bit late with the previous meeting. See you soon. I'll be there at 2:10 or earlier.

On Fri, Mar 22, 2019, 5:35 PM Slattery, Oliver T. (Fed) <oliver.slattery@nist.gov> wrote:

> Hi Guys,
>
> attached is the submitting version. I suggest it is 98.01% ready – so exceeding our target.
>
> Abdella, please go ahead and submit.
>
> Thanks
> Ollie S.
>
> ---
>
> **From:** Polyakov, Sergey V. (Fed) <spoly@nist.gov>
> **Sent:** Friday, March 22, 2019 4:42 PM
> **To:** Slattery, Oliver T. (Fed) <oliver.slattery@nist.gov>; Miller, Carl A. (Fed) <carl.miller@nist.gov>; Polyakov, Sergey V. (Fed) <sergey.polyakov@nist.gov>; Nam, Sae Woo (Fed) <saewoo.nam@nist.gov>; Battou, Abdella (Fed) <abdella.battou@nist.gov>; Migdall, Alan L. Dr. (Fed) <alan.migdall@nist.gov>; Polyakov, Sergey V. <polyakov.sergey@gmail.com>; Ma, Lijun (Fed) <lijun.ma@nist.gov>; Boisvert, Ronald F. (Fed) <boisvert@nist.gov>
> **Subject:** Re: Latest updates
>
> Oliver:
>
> A reference for classical decoding with a known error estimate is any reference to "turbo code".
>
> https://en.wikipedia.org/wiki/Turbo_code
>
> If you need a more prestigious reference, it would be nearly any textbook on communication, Abdella could probably give you a textbook reference without thinking too long. For me, I would need to dig up a bit.
>
> A reference for quantum memory for state discrimination could be
>
> https://arxiv.org/abs/quant-ph/0608014

Best,

Sergey.

On 3/22/2019 2:45 PM, Slattery, Oliver T. (Fed) wrote:

> Room b345 – next door to where we were yesterday.
>
> Thanks
> Ollie S.
>
> ---
>
> **From:** Slattery, Oliver T. (Fed)
> **Sent:** Friday, March 22, 2019 2:03 PM
> **To:** Miller, Carl A. (Fed) <carl.miller@nist.gov>; Polyakov, Sergey V. (Fed) <sergey.polyakov@nist.gov>; Nam, Sae Woo (Fed) <saewoo.nam@nist.gov>; Polyakov, Sergey V. (Fed) <sergey.polyakov@nist.gov>; Battou, Abdella (Fed) <abdella.battou@nist.gov>; Migdall, Alan L. Dr. (Fed) <alan.migdall@nist.gov>; Polyakov, Sergey V. <polyakov.sergey@gmail.com>; Ma, Lijun (Fed) <lijun.ma@nist.gov>; Boisvert, Ronald F. (Fed) <boisvert@nist.gov>
> **Subject:** Latest updates
>
> So, the main changes in this version is answering SaeWoos comments; wording for the footnote, and reworking some other text pieces.
>
> To do:
> Budget,
> Add final two refs
> Consider Go/No Go 'measurables'.
>
> Thanks
> Ollie S.
>
> ---
>
> **From:** Miller, Carl A. (Fed)
> **Sent:** Friday, March 22, 2019 1:33 PM
> **To:** Polyakov, Sergey V. (Fed) <sergey.polyakov@nist.gov>; Nam, Sae Woo (Fed) <saewoo.nam@nist.gov>; Slattery, Oliver T. (Fed) <oliver.slattery@nist.gov>; Polyakov, Sergey V. (Fed) <sergey.polyakov@nist.gov>; Battou, Abdella (Fed) <abdella.battou@nist.gov>; Migdall, Alan L. Dr. (Fed) <alan.migdall@nist.gov>; Polyakov, Sergey V. <polyakov.sergey@gmail.com>; Ma, Lijun (Fed) <lijun.ma@nist.gov>; Boisvert, Ronald F. (Fed) <boisvert@nist.gov>
> **Subject:** Re: Budget
>
> Hi all –
>
> For the budget: It would be great if we can include money for me to support a

grad student at QuICS (who could do some related theory work). I've had good success with this before – my student Honghao Fu worked on theory related to the NIST randomness beacon (a former IMS project) and he co-authored two important papers. The cost to support him was about $75k a year, I think. (I don't know if this kind of thing is already covered under "NIST associates.")

I unfortunately can't make the meeting because I'm at QuICS, but I can answer questions over e-mail. Thanks for all your work!

-Carl

———

Carl A. Miller
Mathematician, Computer Security Division
National Institute of Standards and Technology
Gaithersburg, MD

From: "Polyakov, Sergey V. (Fed)" <spoly@nist.gov>
Date: Thursday, March 21, 2019 at 5:21 PM
To: Sae Woo Nam <saewoo.nam@nist.gov>, "Slattery, Oliver T. (Fed)" <oliver.slattery@nist.gov>, "Polyakov, Sergey V. (Fed)" <sergey.polyakov@nist.gov>, "Battou, Abdella (Fed)" <abdella.battou@nist.gov>, "Migdall, Alan L. Dr. (Fed)" <alan.migdall@nist.gov>, "Polyakov, Sergey V." <polyakov.sergey@gmail.com>, "Ma, Lijun (Fed)" <lijun.ma@nist.gov>, "Miller, Carl A. (Fed)" <carl.miller@nist.gov>, "Boisvert, Ronald F. (Fed)" <boisvert@nist.gov>
Subject: Budget

All:

Please find my first stub at budget. I tried to keep it under $1M for STRS, and, hopefully, it is realistic.

I saw that some other successful IMS proposals aim for even more money ($1.2M in strs PLUS IE), for instance CTL's quantum networking. So we might want some guidance on this from the ITL management.

One issue I see already. First, It seems that PML gets the lion share of IE money. This may be looked down upon by the ITL folks. If there is a way to rewrite this on a later stage, maybe we should pit this IE under 771 or 772 for now?

For the more experienced folks: this is my first carefully thought of IMS budget. If something seems unfair in the budget, chances are that I miscalculated something, and it was not intentional. Feel free to correct.

Thanks,

Sergey.

On 3/21/2019 3:05 PM, Nam, Sae Woo (Fed) wrote:

> I can't be there…
>
> Regarding:
> fundamental bounds are known already for most of these combinations. Perhaps, we wanted to work on understanding "practical" bounds..
>
> My thoughts:
> Yes, fundamentals are known… I think they need explaining clearly to naïve audience.
>
> SaeWoo
>
> ---
>
> **From:** "Slattery, Oliver T. (Fed)" <oliver.slattery@nist.gov>
> **Date:** Thursday, March 21, 2019 at 9:29 AM
> **To:** Sergey Polyakov <sergey.polyakov@nist.gov>, "Battou, Abdella (Fed)" <abdella.battou@nist.gov>, Sergey Polyakov <sergey.polyakov@nist.gov>, Sae Nam <saewoo.nam@nist.gov>, Alan Migdall <alan.migdall@nist.gov>, "Polyakov, Sergey V." <polyakov.sergey@gmail.com>, "Ma, Lijun (Fed)" <lijun.ma@nist.gov>, "Miller, Carl A. (Fed)" <carl.miller@nist.gov>, "Boisvert, Ronald F. (Fed)" <boisvert@nist.gov>
> **Subject:** RE: Rough draft of a 4-pager
>
> Room 222/B341 from 2:30-3:30 this afternoon.
>
> Whoever is available, please let us know so that we do not wait to get started. I assume there is a phone there but I will check.
>
> Thanks
> Ollie S.
>
> ---
>
> **From:** Polyakov, Sergey V. (Fed) <spoly@nist.gov>

Sent: Thursday, March 21, 2019 11:14 AM
To: Battou, Abdella (Fed) <abdella.battou@nist.gov>; Polyakov, Sergey V. (Fed) <sergey.polyakov@nist.gov>; Nam, Sae Woo (Fed) <saewoo.nam@nist.gov>; Slattery, Oliver T. (Fed) <oliver.slattery@nist.gov>; Migdall, Alan L. Dr. (Fed) <alan.migdall@nist.gov>; Polyakov, Sergey V. <polyakov.sergey@gmail.com>; Ma, Lijun (Fed) <lijun.ma@nist.gov>; Miller, Carl A. (Fed) <carl.miller@nist.gov>; Boisvert, Ronald F. (Fed) <boisvert@nist.gov>
Subject: Re: Rough draft of a 4-pager

Abdella: Sae Woo's formula is a correct statement of Shannon capacity. At issue is where N comes from. In our case with a noiseless channel, N is noise due to classical measurement - aka shot noise.

On 3/21/2019 11:09 AM, Battou, Abdella (Fed) wrote:

> I believe he is referring to the Nyquist capacity :
> C = 2B*log2M M number of symbols.
>
> ---
>
> **From:** Polyakov, Sergey V. (Fed) <spoly@nist.gov>
> **Sent:** Thursday, March 21, 2019 11:07 AM
> **To:** Nam, Sae Woo (Fed) <saewoo.nam@nist.gov>; Slattery, Oliver T. (Fed) <oliver.slattery@nist.gov>; Polyakov, Sergey V. (Fed) <sergey.polyakov@nist.gov>; Migdall, Alan L. Dr. (Fed) <alan.migdall@nist.gov>; Polyakov, Sergey V. <polyakov.sergey@gmail.com>; Battou, Abdella (Fed) <abdella.battou@nist.gov>; Ma, Lijun (Fed) <lijun.ma@nist.gov>; Miller, Carl A. (Fed) <carl.miller@nist.gov>; Boisvert, Ronald F. (Fed) <boisvert@nist.gov>
> **Subject:** Re: Rough draft of a 4-pager
>
> Sae Woo, than you for your comments!
>
> > I don't understand how there is a bound to the Shannon channel capacity in a "noiseless" channel. I am not sure what was trying to be stated.

I agree, we need to say that all the noise comes from the otherwise ideal classical measurement (i.e. shot noise).

> <2ns recovery time for the superconducting detectors may not be possible. But, I am fine with going for this.

I thought that if the short nanowire is placed onto a waveguide, this could result in very short deadtimes, but maybe it is too naive.

> It is too late now, but if we go further, I think we should consider restructuring the explanation by looking at the different scenarios for transmitter, channel, and receiver. Each of those could be quantum or classical, so there are 8 combinations. Understanding the fundamental limit for each scenario would be useful (the purpose of this IMS).

We have stated that there are "several" combinations where transmitter/channel/receiver can be independently classical or quantum, giving several scenarios to go with. We also implied that we will chose the quantum/classical layout that works best for our link. Given that there was this thought behind writing, It will be easy to emphasize that understanding of limits would be useful. I am not sure what do you mean by "fundamental". I thought that theoretical fundamental bounds are known already for most of these combinations. Perhaps, we wanted to work on understanding "practical" bounds?

Please comment.

Sergey.

SaeWoo

From: "Slattery, Oliver T. (Fed)" <oliver.slattery@nist.gov>
Date: Wednesday, March 20, 2019 at 9:58 PM
To: Sergey Polyakov <sergey.polyakov@nist.gov>, Alan Migdall <alan.migdall@nist.gov>, "Polyakov, Sergey V." <polyakov.sergey@gmail.com>, "Battou, Abdella (Fed)" <abdella.battou@nist.gov>, "Ma, Lijun (Fed)" <lijun.ma@nist.gov>, "Miller, Carl A. (Fed)" <carl.miller@nist.gov>, Sae Nam <saewoo.nam@nist.gov>, "Boisvert, Ronald F. (Fed)" <boisvert@nist.gov>
Subject: RE: Rough draft of a 4-pager

Hi All,
Attached is the latest version of the 4-page proposal. The editing was getting very unwieldy so I cleaned it up – but if you need to compare with the previous version, those edits/notes are included at the end of the document.

To do:

- Any further editing (we have about 3 lines available over the total first three pages and nothing on the last page). If we add any more content, I suggest we use it to further emphasize the high risk.
- Update the last few references – I

can do that tomorrow.

- Finalize the footnote as per our discussion today – it is tricky wording to keep it concise and clear and I am not able to think about it now. I can discuss with Sergey in the morning.
- Money and resources – it is a hard task, but we can build on the beginning we had this morning.

Thanks
Ollie S.

From: Polyakov, Sergey V. (Fed) <spoly@nist.gov>
Sent: Wednesday, March 20, 2019 6:00 PM
To: Slattery, Oliver T. (Fed) <oliver.slattery@nist.gov>; Migdall, Alan L. Dr. (Fed) <alan.migdall@nist.gov>; Polyakov, Sergey V. <polyakov.sergey@gmail.com>; Battou, Abdella (Fed) <abdella.battou@nist.gov>; Ma, Lijun (Fed) <lijun.ma@nist.gov>; Miller, Carl A. (Fed) <carl.miller@nist.gov>; Nam, Sae Woo (Fed) <saewoo.nam@nist.gov>
Subject: Re: Rough draft of a 4-pager

All:

Here is a new picture, and a go/no go, high risk tables. I am not sure if we should use the high risk table though.

Sergey.

On 3/20/2019 12:45 PM, Polyakov, Sergey V. (Fed) wrote:

> Sae Woo,
>
> We wonder if you are OK with the text about detector

improvement in the technical plan. For reference, I copied it to the bottom of this email. Also, how much money would you need to work on your part?

Oliver is currently going through the text to make it read better after we spent 2.5 hours on sentence-to-sentence sharpening the proposal. We hope to come up with a fresh, nearly final 4-page proposal by tomorrow. If you have time to go through the raw 4-pager, and want to change/influence the general direction of the document, please let it be known now. Otherwise, feel free to comment until the deadline (Friday COB).

Thanks,

Sergey.

Development of fast superconducting detectors. The superconducting nanowire detector technology developed by NIST is mature enough to support most proof-of-principle experiments. To aid deployment of this quantum technology beyond proof of principle, high photon detection rates and fast processing times are required. We will develop low-latency (<1ns), low jitter (<10ps), low dead-time (<2ns) detectors with near-unity

detection efficiency. We will also investigate integrated receivers with manipulation and detection of the optical signal on a single chip. This effort will increase data rates of quantum-enabled links towards the state-of-the-art classical links [MALD(1] and aid in adopting quantum technology in practical communications.

On 3/20/2019 9:42 AM, Slattery, Oliver T. (Fed) wrote:

> 222/ A216 at 10 am.
>
> Thanks
> Ollie S.
>
> ---
>
> **From:** Slattery, Oliver T. (Fed)
> **Sent:** Wednesday, March 20, 2019 12:35 AM
> **To:** Migdall, Alan L. Dr. (Fed) <alan.migdall@nist.gov>; Polyakov, Sergey V. (Fed) <sergey.polyakov@nist.gov>; Battou, Abdella (Fed) <abdella.battou@nist.gov>; Ma, Lijun (Fed) <lijun.ma@nist.gov>; Miller, Carl A. (Fed) <carl.miller@nist.gov>;

Nam, Sae Woo (Fed) <saewoo.nam@nist.gov>; Slattery, Oliver T. (Fed) <oliver.slattery@nist.gov>
Subject: Re: Rough draft of a 4-pager

I am attaching my first round of edits and comments. I started with Alan's edited version. Looking forward to the meeting tomorrow. I will try to arrange a room for an hour or an hour and a half in the morning.

thanks
Ollie S.

From: Migdall, Alan L. Dr. (Fed)
Sent: Tuesday, March 19, 2019 6:45 PM
To: Polyakov, Sergey V. (Fed); Battou, Abdella (Fed); Slattery, Oliver T. (Fed);

Ma, Lijun (Fed); Miller, Carl A. (Fed); Nam, Sae Woo (Fed)
Subject: Re: Rough draft of a 4-pager

My edits and comments are attached.

Alan

On 3/19/19, 10:49 AM, "Polyakov, Sergey V. (Fed)" <spoly@nist.gov> wrote:

> Dear all,
>
> attached is a first (very rough) draft of the 4-pager. It would be great
> if you provide detailed comments. Last time, Oliver was very effective
> in translating my text to a more readable, more high-level text. If
> Oliver or someone else wants to take upon this task, I am available all
> day today to

meet/help. In the meantime, I will make a better graphics for Fig 1, showing graphically our go/no go and desired "green"

communications region.

We probably should have a meeting tomorrow morning (10AM EST) to discuss all proposed edits and finalize the draft.

Sergey.

--

Dr. Sergey Polyakov,

Physicist,
Quantum Measurement Division, Physics Measurement Laboratory,
National Institute of Standards and Technology
and
Adjunct Associate

Professor,
Department
of Physics,
University of
Maryland,
College Park

Ph.: 301-975-
8473
Fax: 301-990-
1350

--
Dr. Sergey Polyakov,

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Quantum Measurement Division, Physics
Measurement Laboratory,
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Technology
and
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Ph.: 301-975-8473
Fax: 301-990-1350

Program Chair: Conference on Lasers and
Electro-Optics (CLEO 2019)
San Jose, CA, USA May 5 - 10.
www.cleoconference.org

--
Dr. Sergey Polyakov,

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Quantum Measurement Division, Physics Measurement
Laboratory,
National Institute of Standards and Technology
and
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Department of Physics,
University of Maryland, College Park

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Dr. Sergey Polyakov,

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Program Chair: Conference on Lasers and Electro-Optics (CLEO 2019)
San Jose, CA, USA May 5 - 10.
www.cleoconference.org