# Questionnaire for the evaluation of DTS, Jan. 2020

# (Version 6. Dez 2020)

**Guiding questions for reviewers**

**Goals**

* How would you rate the **objectives** of the program/topic with regard to scientific relevance and leadership? Which pressing societal or scientific challenges does it address?
* How would you evaluate its **strategic focus**? Is it innovative and is the approach unique?
* How would you evaluate its **contribution to the Helmholtz mission**, its strategies in transferring knowledge and technologies as well as for the development of talents and careers, including diversity management?
* How would you evaluate its **alignment** with the strategy of the research field?

Diese Fragen an die Gutachter sind hier in direkte Fragen der Reviewer an uns umformuliert:

**Q1: What is the strategic focus of DTS?**

**Q2: Why did you choose this focus?**

**Q3: In which respect is the DTS focus innovative and the approach unique?**

**Q4: Does DTS contribute to the Helmholtz mission and why?**

**Q5: Do MT and DTS have an effective strategy for technology and knowledge transfer?**

**Q6: How do you support young talent and promote scientific carriers?**

**Q7: Is DTS aligned with the strategy of the research field?**

**Work programme**

* How would you rate the proposed **work plan** with respect to the objectives? How coherent is the research concept/approach on the respective level? Are important aspects missing?
* How are the key competences of the **partners** integrated with regard to complementarity? How do they benefit from **collaboration**?
* How would you evaluate the **organizational structure** and the management? Does it provide tools for ideas, innovation, flexibility and agility?

**Q8: How do you make sure that milestones are reached?**

**Q9: Your milestones are rather generic and there are not too many. Why is this?**

**Q10: Which center contributes with how many people to the milestones?**

**Q11: Why do you focus on semiconductor and superconducting detectors rather than gas detectors, ToF or calorimetry for example?**

**Q12: Can you adapt your research to changing needs over the time of PoF-IV? How would this work?**

**Q13: Give examples of how you collaborate between centers? What is the added value of joining forces across centers in DTS?**

**Q14: Did you coordinate your milestones with the other Matter programs?**

**Q15: How do you provide incentives for innovation?**

**Q16: Do you have the flexibility to start seed-corn activities beyond the main research reactions in your proposal?**

**Q17: Gravitational waves seem to be a major hot new topic? Are you working on this? Why not?**

**Competences and resources**

* Based on the scientific evaluation, the program proposal and the oral presentations, how would you rate the overall **scientific quality** of the planned program/topic and the expertise of its scientists with regard to (i) potential for international leadership and groundbreaking research; (ii) competence of the partners; (iii) feasibility of the work program?
* How would you assess the **resources planned for each topic** with respect to the scope of the program/ topic?

**Q18: Please give examples of PIs with international leadership and visibility?**

**Q19: What are your most important national and international partners?**

**Q20: Who are your most important competitors?**

**Q21: How would you react to a reduction of funding in PoF-IV?**

**Q22: Could you provide a break-down of your resources by subtopic or work packages?**

**Q23: Why did you not yet acquire young investigator groups?**

**Impact and risks**

* How would you rate the potential **impact** of the program with regard to the research field, its technologies and its societal context? Does it contain elements serving as a nucleus for establishing new research areas? How would you rate the balance between groundbreaking and long-term research?
* What are major strengths and potential weaknesses?
* What are the opportunities, risks, and showstoppers?

**Q24: What are your main strengths? What are your weaknesses?**

**Q25: Which elements of your R&D will have most impact?**

**Q26: How much of your research is “blue sky” research?**

**Q27: How do you promote TT?**

**Q28: What are your main TT contributions?**

**ST1:**

Sensors / LGAD

**Advantage of LGAD over thin pixels?**

??? for less severe radiation environments one gets more charge in thin devices

**Do you have a demonstrator chip that can cope with such fast signals?**

I guess yes, but you know better, Michele

**But LGADs with fine pitch or small pixels have very low fill factor?**

Trench-isolation and AC readout will be explored

**What is the medical application you aim for?**

Monitoring of therapeutic beams

Potentially also fast, high-res. detectors for PET scanners

**What can you do better than the collaborators in RD50?**

We aim for applications and do not stop at R&D; we can integrate the whole system including sensor, readout and DAQ

**ST2:**

## Silicon photonics

**Competitors / partners?**

To the best of our knowledge we don‘t have competitors. CERN is working on a comparable project partnered with the KIT in the projects SiPh4HEP and SiPhoSpace.

**What is about the university groups that presented transfer rates of several Tb/s?**

IPQ is (still) using Silicon organic hybrid SOH that degrades within months.

It has not been tested for radiation hardness.

**Manufacturer / Fabs?**

Institut für Halbleiterphysik Frankfurt Oder GmbH

IMS, Stuttgart

IMEC, Belgium

Global Foundaries

And several others…

**Has additional funding been requested?**

Yes, but has not been successful; further proposals are planned

**What is the man power in the project up to now?**

The project has been started 6 years ago, with one scientist and 3 PhD students, two of them have already finished.

**Why silicon photonics? Nobody uses silicon photonics already.**

Silicon is known to be very stable against radiation induced damages and emerging damages can be annealed. Secondly silicon photonics has similar processes as CMOS and both can be monolithically integrated. Third the high refractive index of silicon allows compact photonic circuits. Furthermore silicon is a very cheap platform compared to other materials used in optoelectronics like indium phosphide or lithium niobate.

**How is radiation hardness reached?**

Investigations from CERN showed that it’s enough to make the electrical contacting of the pn-junction inside the waveguide, the so-called ‘slabs’, a little thicker. If degradation advanced too much, the modulators can be annealed by driving a few milliamperes in forward direction through the pn-junctions for about one minute.

**Silicon pn-modulators are inefficient. Why use them?**

That is correct, but these modulators also proved already that they are very stable and reliable and they can be made radiation hard with just minor changes to conventional modulators.

Other silicon based modulators introduce organic materials, which make the modulators much more efficient, but these organic materials are currently still susceptible to environmental conditions like oxygen, humidity, and light, and degrade within several weeks.

**Why an own driver (ASIC)? Can‘t you buy one?**

There are modulator drivers for single modulators available, but they are unsuitable for multi-channel setups like our WDM system, because they employ a rather large footprint and are not really power efficient (approx. 25%). The additionally required control circuitry for powering and power cycling adds further complexity. And at least for particle physics applications, their radiation hardness is questionable.

**Why a new system at all? Why not speed up conventional transmitters?**

Conventional transmitters use directly modulated VCSELs inside the detector volume. The expected particle flux in the CMS detector for the HL-LHC will destroy VCSELs within 1-2 months in the tracker region as per CERN investigations. No solution to enhance their lifetime is known yet.

Additionally the data rate for a single VCSEL is limited and it‘s very difficult to combine the light output of several VCSELs to one glass fiber to reduce the amount of fibers. Therefore each VCSEL has its own fiber and several are combined into a stiff and awkward fiber ribbon.

Even when combining the light output of several VCSELs, just a very coarse WDM scheme can be used due to wavelength variations while modulating the lasers (called ‚chirp‘).

**What is the difference to optical components in telecommunication industry? (e.g. Finisar)**

Telecom components still use Lithium Niobate for Mach-Zehnder modulators, which makes them very large (in the cm-range). Other used materials are Gallium Arsenide and Indium Phosphide, which are well suited, but also expensive. Furthermore we opt for a monolithic integration of read-out-chips, drivers, and electrooptic/photonic components, which is not possible/affordable with these materials.

**How many channels can be transferred via a single line? Can the detectors deliver this high rates? Several terabits/s on a single fiber? Where all these data should come from?**

Sensor modules become finer and finer pixelated and physicist don’t want to just know, if a pixel was hit but also when exactly and which energy was deposited. Further due to higher luminosities more pixels are hit and with higher rates. All this multiplies up to a huge increase in required data transport capabilities.

And current systems throw away many data before transmitting them. Avoiding that would enable more sophisticated trigger structures or track finding algorithms for higher resolution physics.

We think we can build systems with up to 64 wavelength channels and drive them with 40 Gbaud (Symbols/second) each. Each symbol can contain up three bits through Amplitude shift keying with 8 levels. All this adds up to 7.6 Tbit/s. And this is still way below the transmission capacities shown and used in telecom industry.

**Power consumption in the front-end?**

**Is the signal with -20dB too small?**

The signal can easily amplified using an optical amplifier (EDFA: Erbium Doped Fiber Amplifier). This is common use in telecom industry and the respective amplifiers are cheap and reliable.

On the other hand there are still many optimizations possible and under development. For example we lose about 9dB just for the fiber-chip-coupling, which can be lowered by optimized coupling methods to just 1dB.

**Are all major effects understood/included in the simulations?**

We think so, but also minor effects hold suprises…

**Segmented modulators versus fast DACs in the front-end?**

It’s not jet clear if it’s better to build simple drivers with just two output levels and let the DA-conversion be made optically or build a DAC and a linear driver, which converts the analog output of the DAC to a proportional output of the driver. We think that we can build the simple drivers more efficiently, but to investigate this is a topic of the PoF-period.

**Why ring modulators?**

Ring modulators are known to be difficult to control, but they promise much more compact and efficient WDM transceiver units, where the size of the photonic chip is merely defined by the size of the bond pads and the optical fiber couplers.

Ring modulators are very susceptible to fabrication tolearances, but this can be compensated by a tight temperature control, required anyway to tune and keep the ring at its resonance wavelength. Additionally recent investigations showed that the resonance can be made less sharp, reducing the efficiency but loosening the requirements for temperature control.

**What are potential application fields? Can the setup be used in XFEL?**

DESY, CERN, GSI, …??? The system might be used in all future detectors with a demand for a very high bandwidth data transmission, where directly modulated VCSELs (Vertical Cavity Surface Emitting Lasers) are not suitable anymore

**When can the first devices been used?**

The first demonstrator system will be operational within this year, but for a fully functional system for data taking several issues have still to be solved. For example more compact and efficient drivers, housing of the photonic chips and protecting their fiber-to-chip coupling, working point control of the modulators, stabilization of the filter characteristics of the multiplexers and demultiplexers, and so on… / approximately mid term

**How much does it cost?**

That‘s hard to specify in this early stage, but a projected 4-channel, 160 Gbit/s transmitter chip with a footprint of 4x1.5 mm² would cost about 800 €/chip using Europractice MPW runs. Additionally the driver, control electronics and packaging is required. Outside the detector volume commertial-off-the-shelf components like DFB lasers (Distributed FeedBack) and standard SFP+ or QSFP modules will be used.

Readout of cryogenic detectors

## Terabit DAQ systems

**Can we handle Terabit readout?**

Likely yes. In last 10 years throughput raised by 10 times.

200 Gbit/s Ethernet is already commercially available.

But what we do with data acquired at this rate?

**Can we handle it alone?**

No, co-operation with HPC centers is crucial as significant computational and storage resources are required

Doing it at scale makes it financially viable, reduce power consumption

Also, complexity of the data processing software increases. The only way forward is co-operation with HPC centers and possibly industry.

**How can we prepare?**

Make readout more compatible with HPC infrastructures

Improve scalability of our readout systems with intelligent data flow management

Rely on virtualization platforms making software ready for novel HPC environments

**What is different to existing data center (e.g. at DESY or CERN)?**

Electronics Packaging and micro channel cooling

**ST3:**

## Beam diagnostics

**Why are these devices not commercially available? What are the key technologies that make KAPTURE/KAYLPSO unique?**

**Do we plan to commercialize the devices?**

**Who is using KAPTURE/KALYPSO?**

**KAPTURE and KALYPSO exist since the beginning of PoF-3 – is there still room for improvements?**

**How to handle the enormous data rates?**