

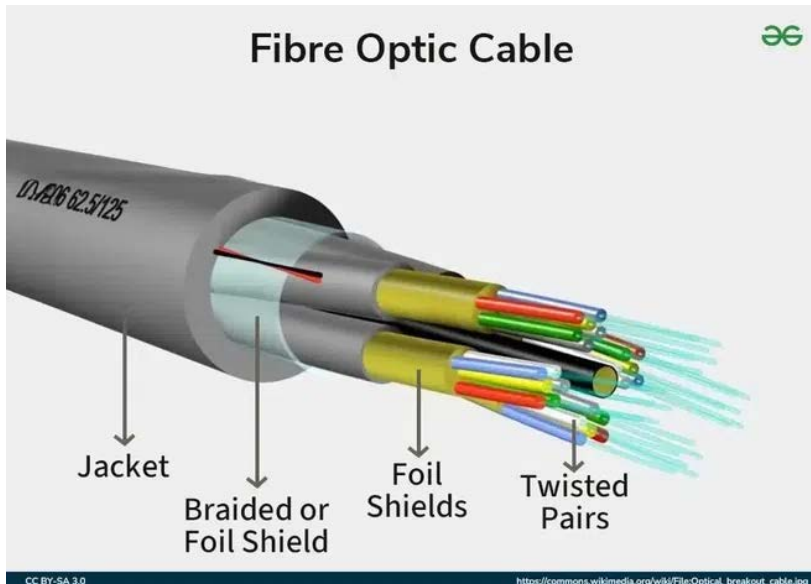


# Fiberinfrastrukturens alternative anvendelser

- QKD
- Sensing
- Tids- og frekvensdistribution

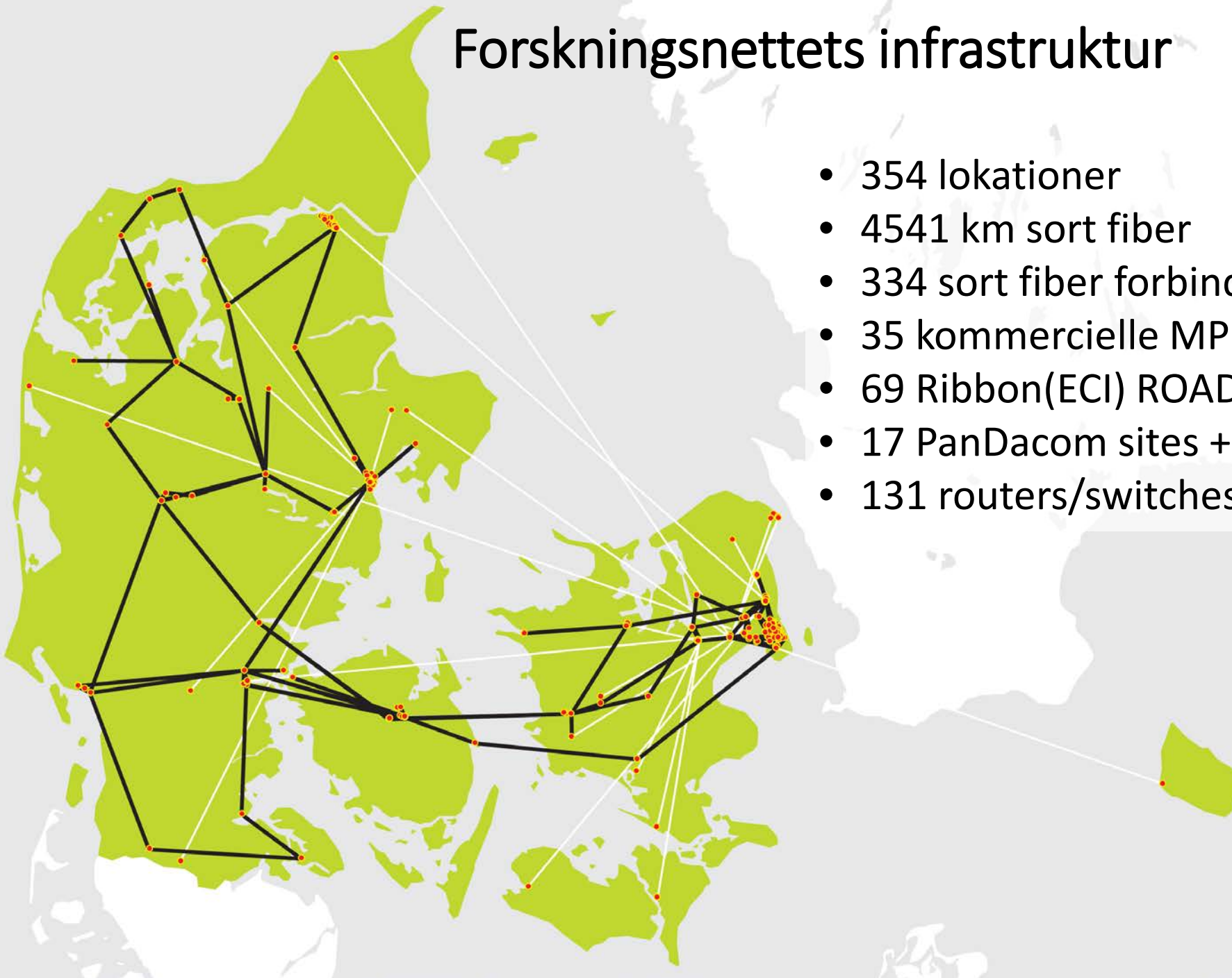
# Sorte fibre

- Lyslederfiberpar som vi lejer af fiberejerne
- Vi installerer og driver selv udstyret for enderne af fiberstrækningen
- På de fleste strækninger kører vi WDM (kaldet "farver"), så vi kan have mange forbindelser i en enkelt fiber



# Forskningsnettets infrastruktur

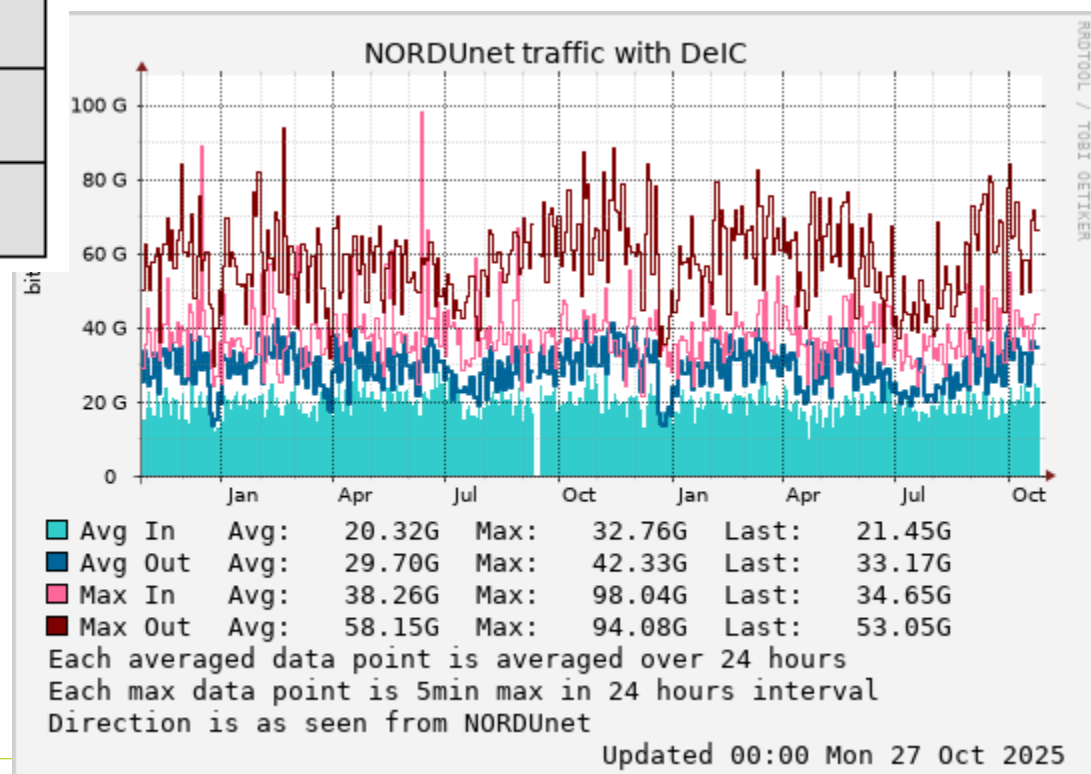
- 354 lokationer
- 4541 km sort fiber
- 334 sort fiber forbindelser
- 35 kommercielle MPLS-forbindelser
- 69 Ribbon(ECI) ROADM chassis
- 17 PanDacom sites + en del passiv WDM
- 131 routers/switches



# Vi leverer 500 forbindelser



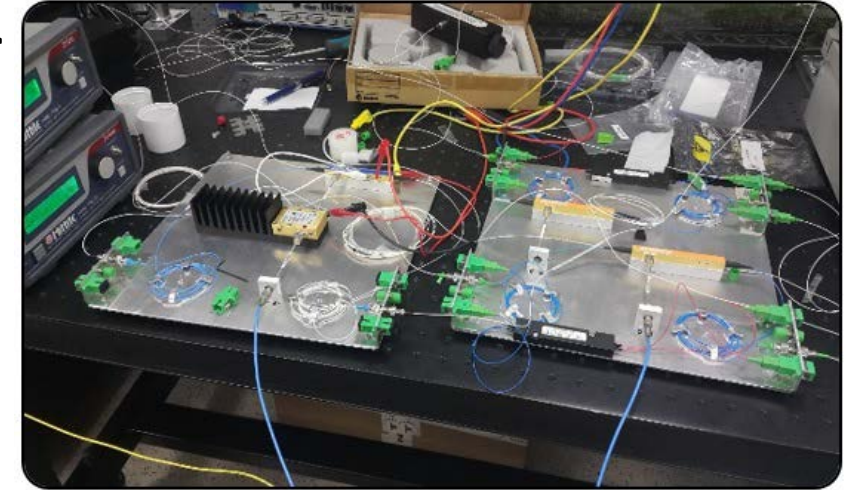
| Type   | n/a | 0.1 G | 0.5 G | 1 G | 2 G | 10 G | 40 G | 100 G | 200 G | Total |
|--------|-----|-------|-------|-----|-----|------|------|-------|-------|-------|
| Core   | 0   | 7     | 0     | 10  | 0   | 57   | 8    | 19    | 0     | 101   |
| Cust   | 4   | 0     | 0     | 48  | 0   | 119  | 0    | 11    | 0     | 182   |
| Intern | 27  | 1     | 1     | 30  | 1   | 131  | 0    | 11    | 1     | 203   |
| n/a    | 0   | 0     | 0     | 5   | 0   | 6    | 0    | 0     | 0     | 11    |
|        | 1   | 0     | 0     | 1   | 0   | 1    | 0    | 0     | 0     | 3     |
| Total  | 32  | 8     | 1     | 94  | 1   | 314  | 8    | 41    | 1     | 500   |



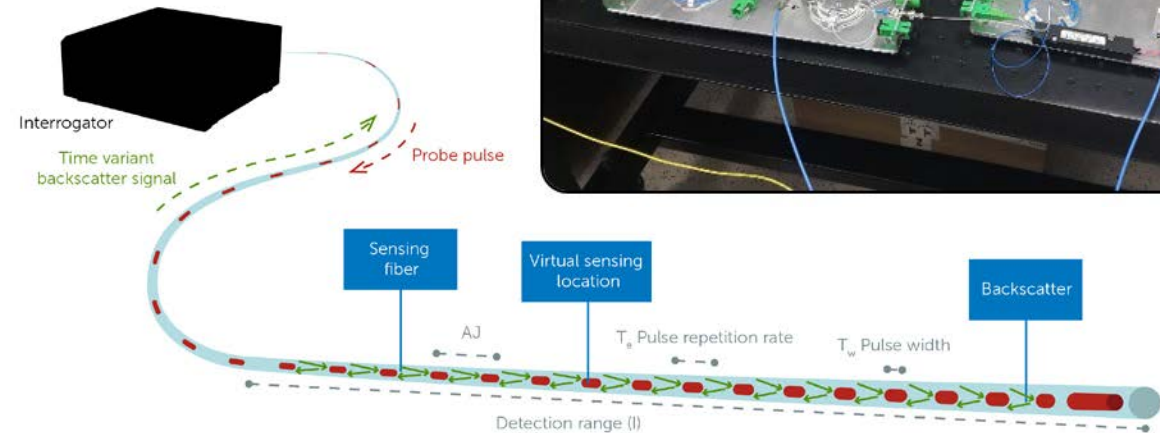


# Andre anvendelser af de sorte fibre end IP-trafik

- Test-bed for udvikling af kommunikationsudstyr

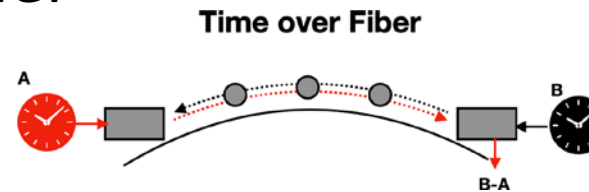


- Sensing (DAS, SOP mv)



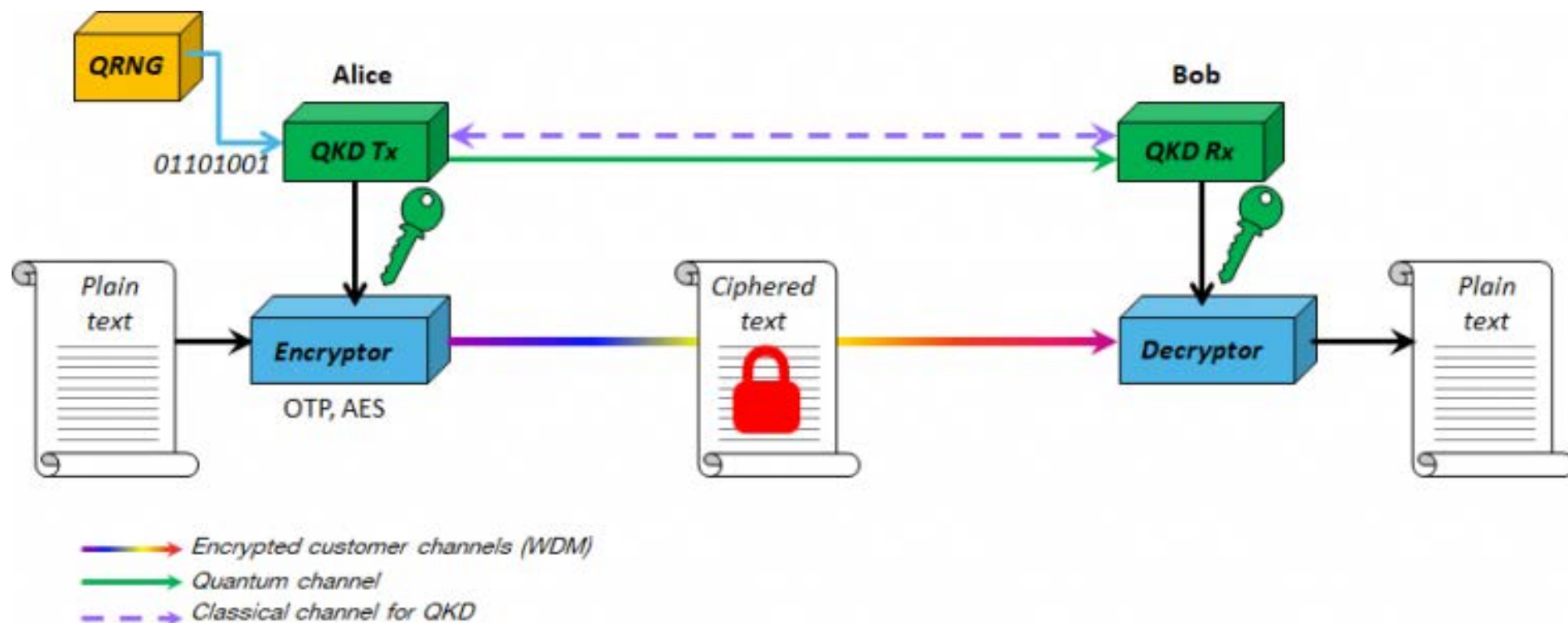
- Distribution af tids- og frekvenssignaler

- QKD (Quantum Key Distribution)



# QKD – Quantum Key Distribution

- Fotoner/signaler sendes afsted med en bestemt kvantetilstand (squeezed light)
- Hvis tilstanden er bevaret ved modtageren, kan man regne med at der ikke har været aflytning
- Båndbredden på 1-2kbit/s bliver brugt til at sende krypteringsnøgler
- Kvantesignalet skal i udgangspunktet være alene i den sorte fiber



# Motivationen for QKD

- Når kvantecomputerne kommer, kan de (formodentlig) bryde nogle af de krypteringsalgoritmer vi baserer os på i dag
- Det vil betyde at vi ikke længere kan have tillid til (nogle af) de ting i vores samfund som baserer sig på kryptering, såsom blockchain, kryptovaluta og sikker kommunikation
- QKD er den "kvante-sikre" metode til sikker kommunikation
- "Kvante-sikre" krypteringsalgoritmer er kun det lige indtil de bliver brudt
- QKD baserer sig på et fysisk princip
- En indsats nu sikrer vores parathed og udvikling af en industri på dette område

An abstract background with a dark blue field, scattered with small green and blue dots and thin, glowing green lines that suggest a network or quantum circuit.

What is the Cryptocalypse?  
When is it coming?

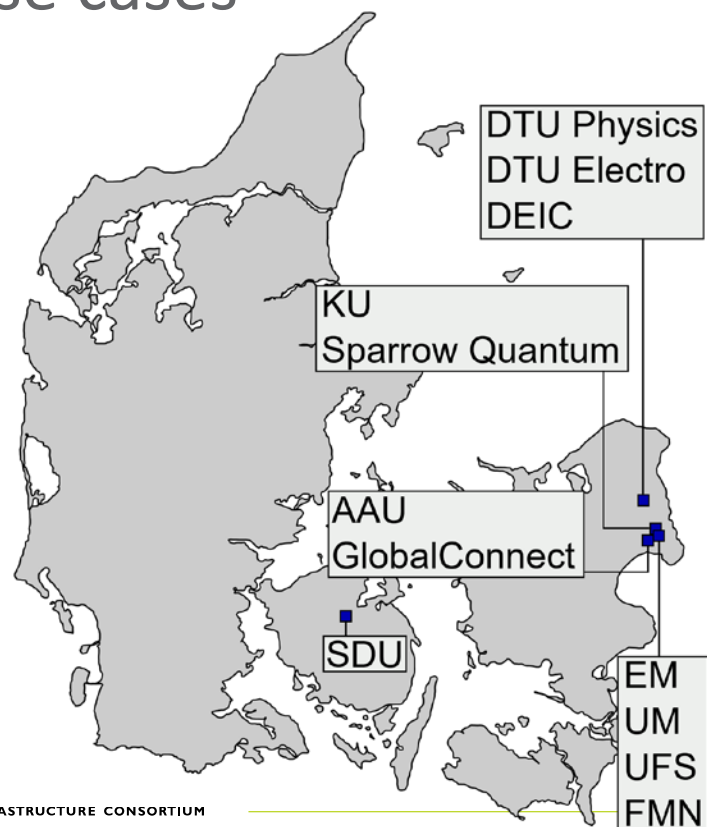
A solid red rectangular background. On the far right edge, a small portion of a person's face is visible, looking towards the left.

**Ready for  
Cryptocalypse?**

*Quantum Computing and Cybersecurity: Cryptocalypse or  
Overhype?*

# Første skridt: EuroQCI

- "Øer" af nationale projekter
- Det danske projekt hedder QCI.dk (2023-2025)
- Use cases



DECLARATION ON A  
**QUANTUM COMMUNICATION  
INFRASTRUCTURE**  
FOR THE EU

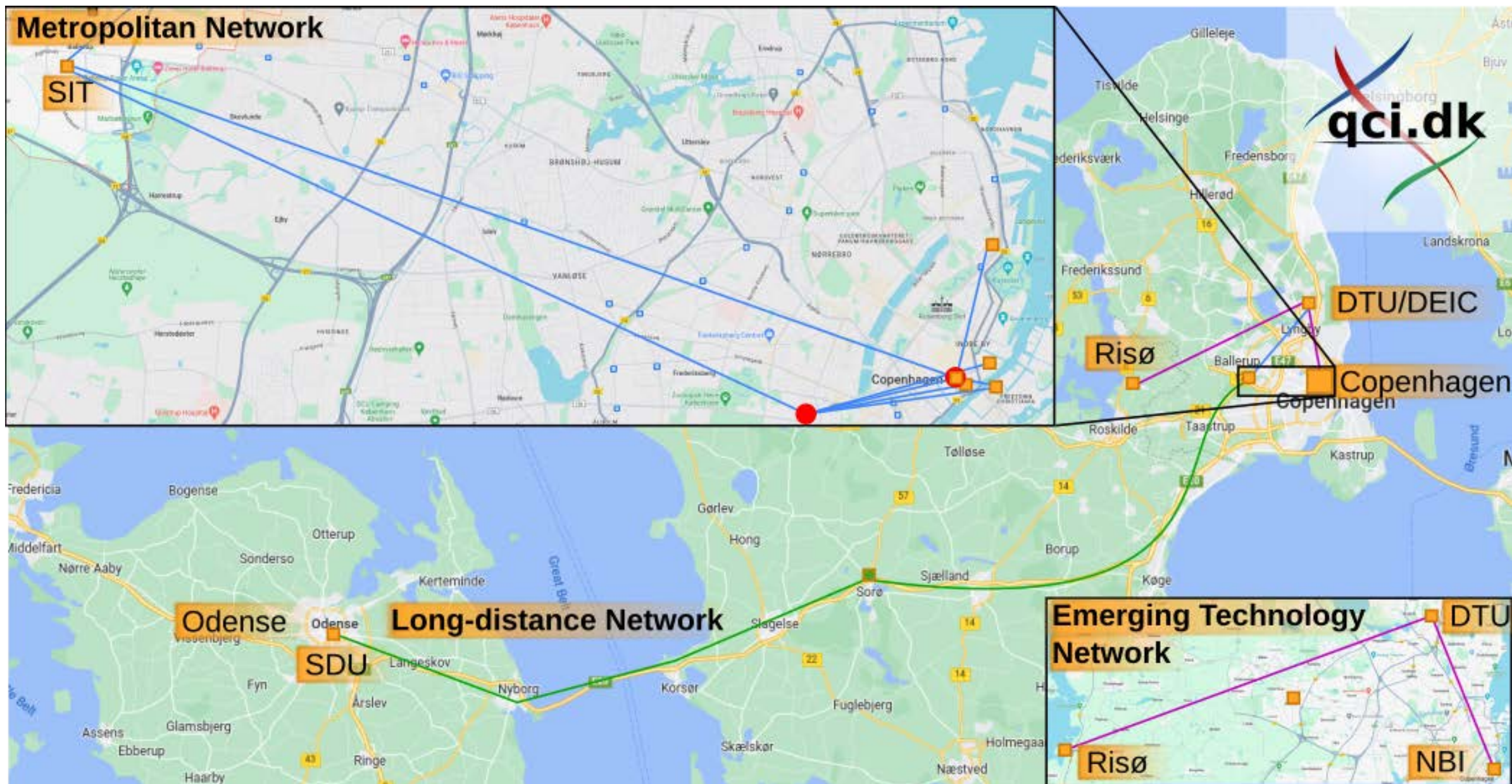
## All 27 EU Member States

have signed a declaration agreeing to work together to explore how to build a quantum communication infrastructure (QCI) across Europe, boosting European capabilities in quantum technologies, cybersecurity and industrial competitiveness.

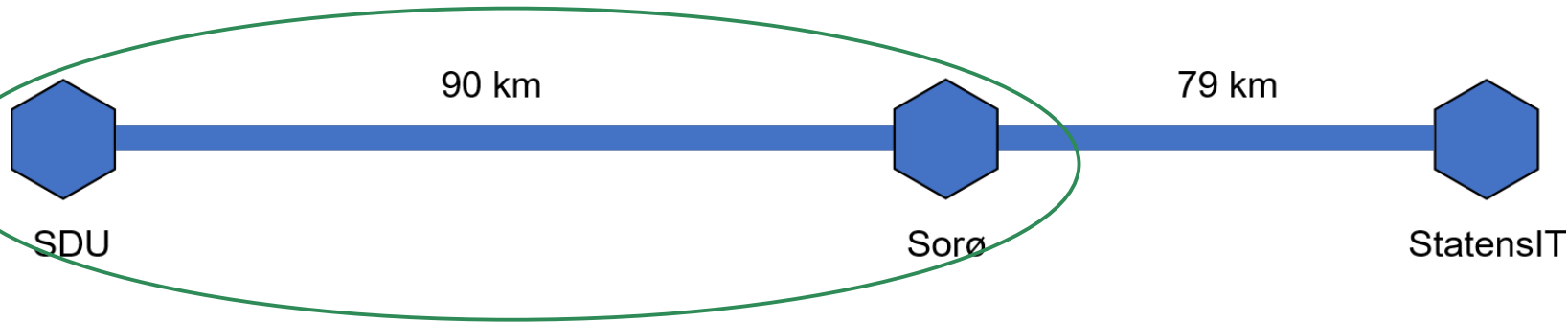
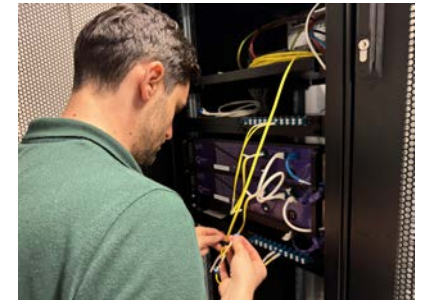
@FutureTechEU #EuroQCI



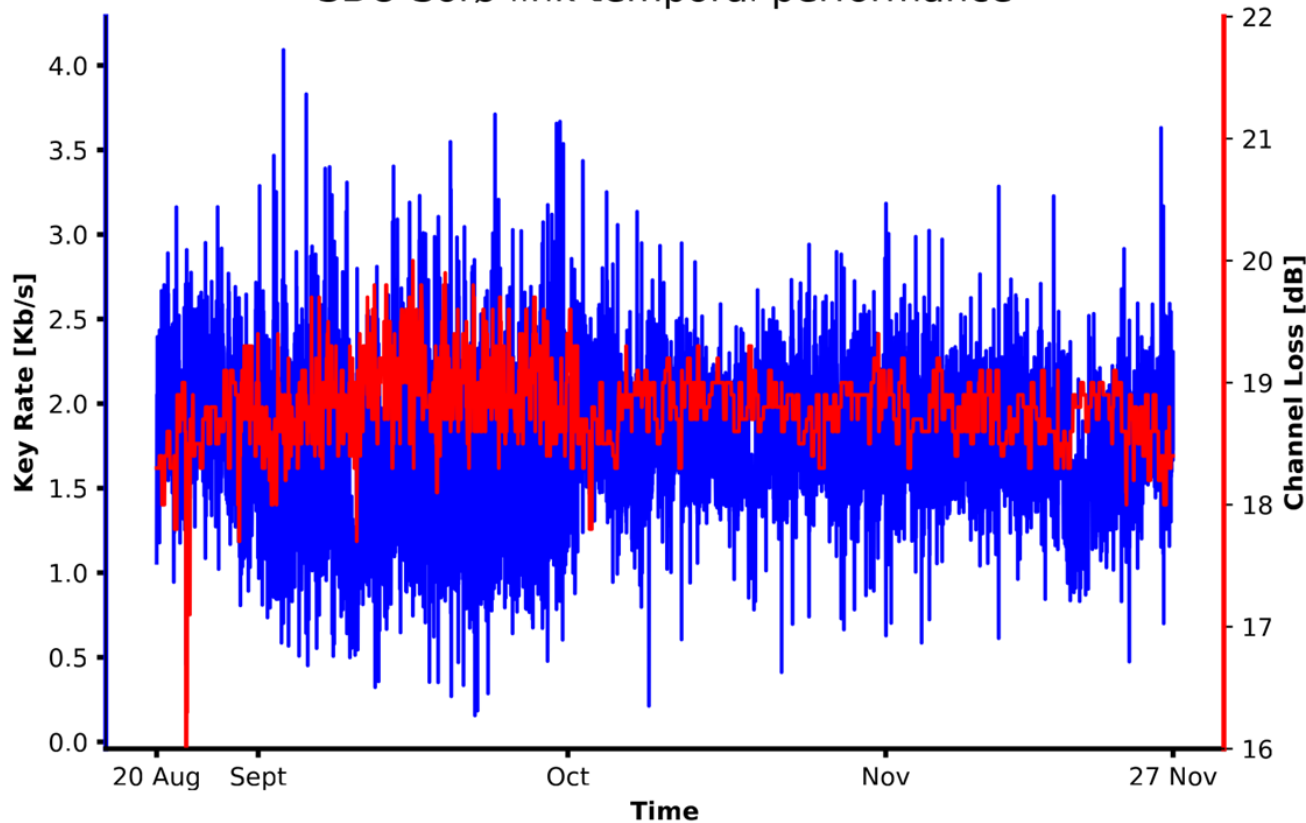




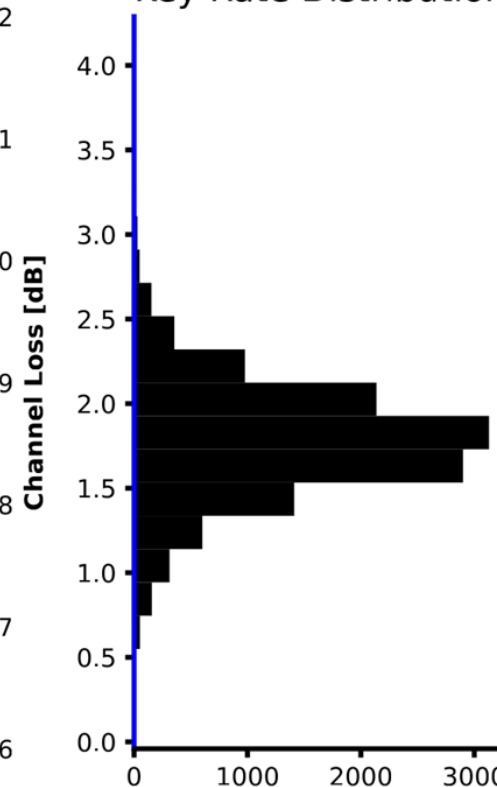
# First Link: Up and Running



SDU-Sorø link temporal performance

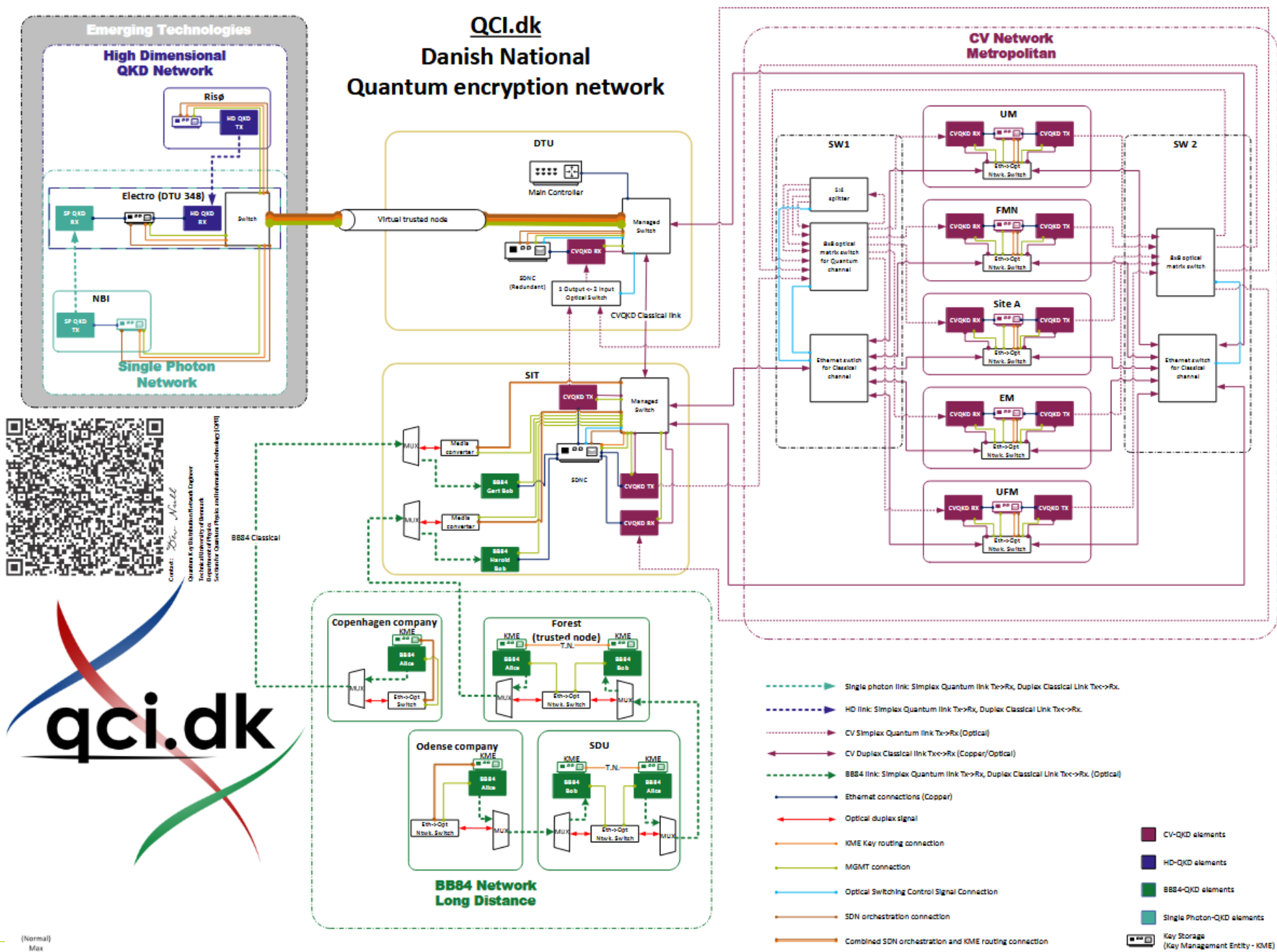


Key Rate Distribution





# Diagram af hele QCI.dk infrastrukturen



# EuroQCI

- Øer af nationale projekter
- Nu skal de sammenkobles i en række "cross-border" projekter
- Forskningsnettet leder et Dansk-Svensk-Polsk projekt, kaldet QCI.dk-CB
- Ansøgning til EU: 10 MEUR
- Vil realisere en "halv Østersø-ring"

DECLARATION ON A  
**QUANTUM COMMUNICATION  
INFRASTRUCTURE**  
FOR THE EU

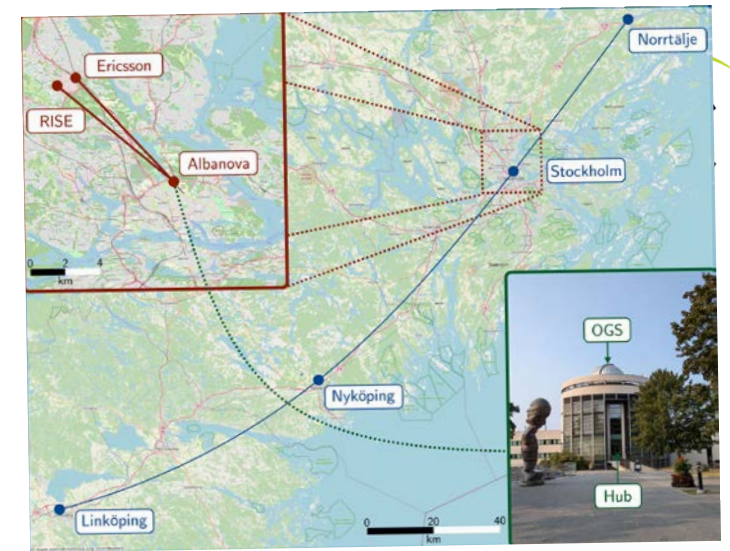
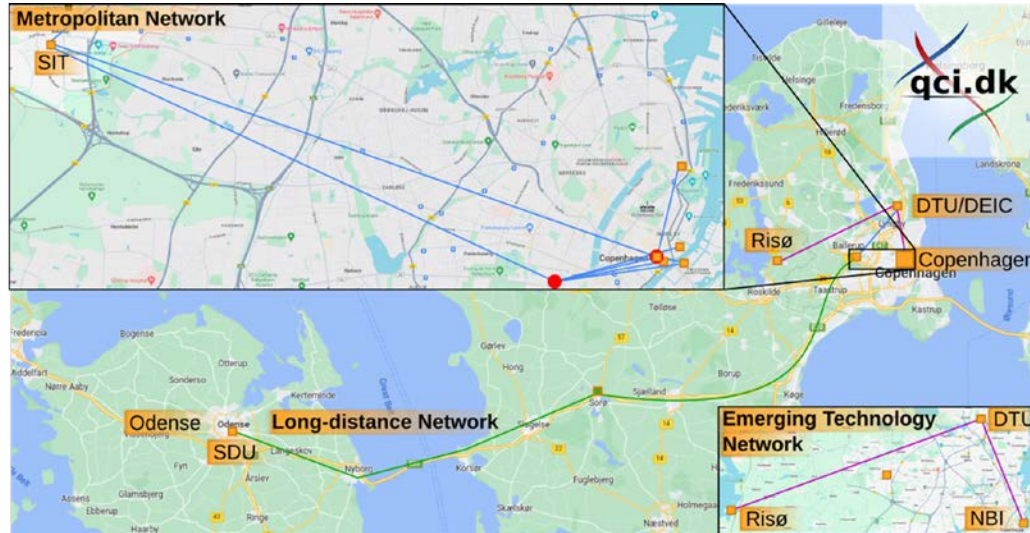
## All 27 EU Member States

have signed a declaration agreeing to work together to explore how to build a quantum communication infrastructure (QCI) across Europe, boosting European capabilities in quantum technologies, cybersecurity and industrial competitiveness.

@FutureTechEU #EuroQCI



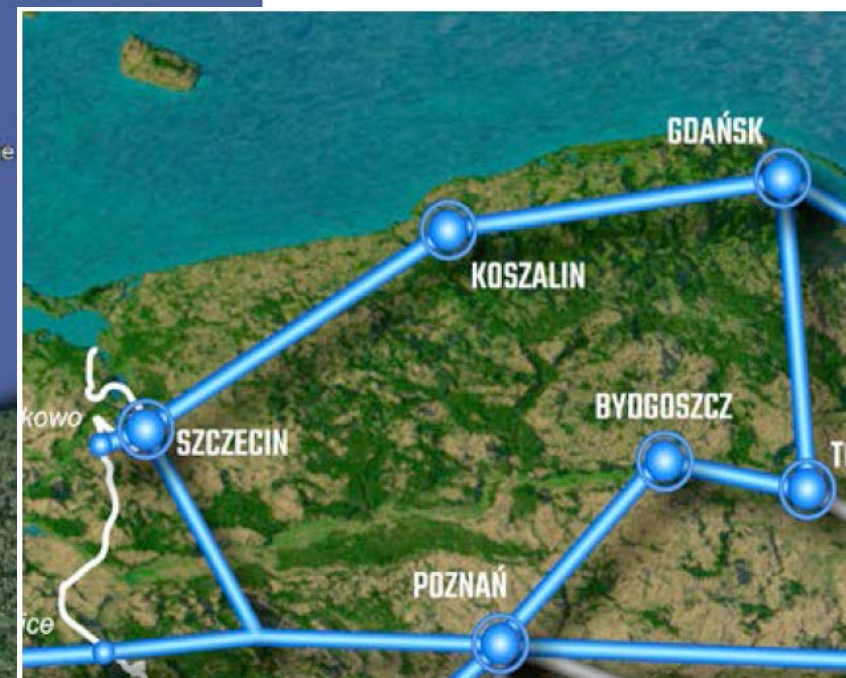
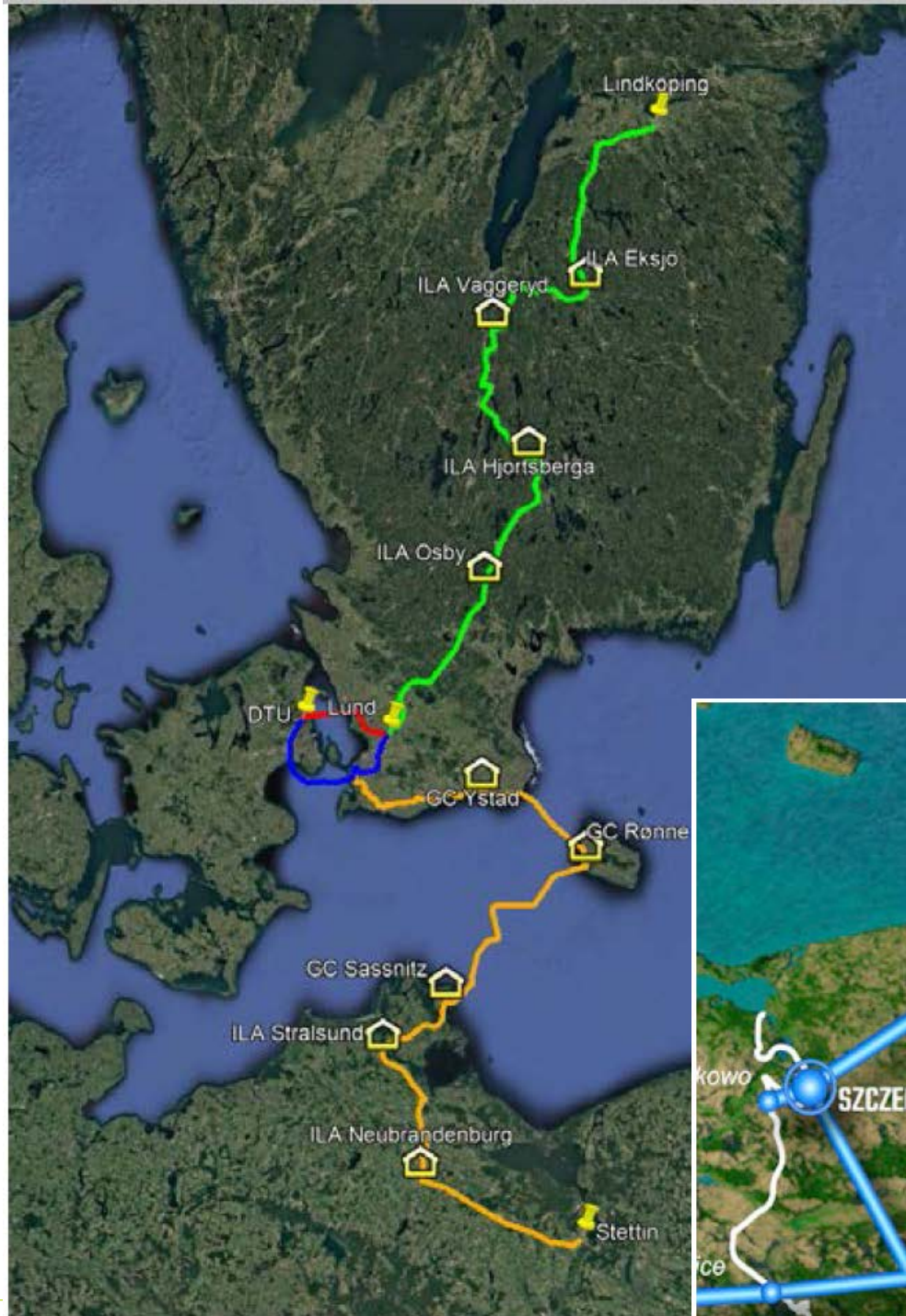
# QCI.dk-CB vil forbinde de nationale QCIs





# QCI.dk-CB

- 1240 km “ny” sort fiber
- 840 km fiber i PIONIER
- 4 eller 5 CB forbindelser
- Ca. 20 sæt QKD udstyr
- >1kbit/s
- 10 MEUR
- 3,5 år fra 2026
- Ansøgning sendt 27/3
- Aftale forventes underskrevet i november



# Partnerne i QCI.dk-CB



| Partner       | Relevance in the project                                            | Roles in the project                                                       |
|---------------|---------------------------------------------------------------------|----------------------------------------------------------------------------|
| DTU-DeiC      | The Danish NREN, part of Danish NatQCI                              | Management, Operations of large fibre-based infrastructures                |
| DTU-Physics   | Leading the Danish NatQCI, experience with QCI equipment            | Equipment procurement and configuration                                    |
| PCSS          | The Polish NREN, part of the Polish NatQCI.                         | Management of Polish part                                                  |
| KUT           | Regional network operator in the Polish NREN and NatQCI             | Deployment and operation of Polish part                                    |
| SUNET         | The Swedish NREN                                                    | Operations of large fibre-based infrastructures, liaison to Swedish NatQCI |
| ESS           | Use cases and natural hub in the topology                           | Important new use-cases                                                    |
| GlobalConnect | Unique experience in trans-national infrastructures and cable owner | Consultancy, use cases, expertise on fiber infrastructures                 |

# 42 måneder



| QCI.dk-CB Timetable |                                                            | 2026 |     |     |     |     |     |     |     |     |     |     |     | 2027 |     |     |     |     |     |     |     |     |     |     |     | 2028 |     |     |     |     |     |     |     |     |     |     |     | 2029 |     |     |     |     |     |      |
|---------------------|------------------------------------------------------------|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|-----|-----|-----|-----|-----|------|
|                     |                                                            | Jan  | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan  | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan  | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan  | Feb | Mar | Apr | May | Jun |      |
|                     |                                                            | 1    | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  | 11  | 12  | 13   | 14  | 15  | 16  | 17  | 18  | 19  | 20  | 21  | 22  | 23  | 24  | 25   | 26  | 27  | 28  | 29  | 30  | 31  | 32  | 33  | 34  | 35  | 36  | 37   | 38  | 39  | 40  | 41  | 42  |      |
| WP1                 | Project management, coordination and quality assurance     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |      |
| T1.1                | Administrative project management                          |      | MS1 |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |      |
| T1.2                | Cross border cooperation coordination                      |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |      |
| T1.3                | Technical coordination and risk management                 |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |      |
| T1.4                | Reporting                                                  |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     | MS2 |      |
| WP2                 | Design, deployment and operation of the QCI infrastructure |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |      |
| T2.1                | Preliminary design of the QCI infrastructure               |      |     |     |     |     |     |     |     |     |     | MS3 |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |      |
| T2.2                | Procurement of fiber and housing                           |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     | MS4 |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |      |
| T2.3                | Procurement and preparation of QCI equipment               |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     | MS5 |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |      |
| T2.4                | Deployment of QCI infrastructure                           |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     | MS6 |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |      |
| T2.5                | Operation of the QCI infrastructure                        |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |      |
| T2.6                | Performance evaluation                                     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |      |
| WP3                 | Interoperability with the connecting QCIs                  |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |      |
| T3.1                | Establishing common technical practices                    |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     | MS7 |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |      |
| T3.2                | Pre-installation trials                                    |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |      |
| T3.3                | Facilitating and monitoring use cases                      |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |      |
| WP4                 | Dissemination and outreach                                 |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |      |
| T4.1                | Website                                                    |      |     |     | MS8 |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |      |
| T4.2                | News, updates and documentation                            |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |      |
| T4.3                | Document sharing, internal communications, events          |      |     |     | MS9 |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |      |
| T4.4                | Coordination with other QCIs                               |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |      |
| WP5                 | Plan for the sustainability and continuation               |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |      |
| T5.1                | Desk-top study (the catalogue)                             |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |      |
| T5.2                | Engage with relevant stakeholders                          |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |      |
| T5.3                | Reporting (The Roadmap report)                             |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     | MS11 |

# QCI er for hele samfundet – ikke blot til forskning



- Nogle use cases kommer fra forskningen (ESS)
- Men de fleste er faktisk ikke relateret til forskning
- Denne QCI er for hele samfundet
- Kan bruges til at kryptere forskningstrafik
- Men kan bruges til at kryptere data på hvilket som helst netværk – når blot endepunkterne ligger "tæt" på QCI-nettets lokationer
- Vi hjælper altså hele Europa med at blive klar til "kryptokalypsen"



# Hvis du vil...



- Vide mere
- Deltage
- Hjælpe med at finde anvendelser af QKD

Så tag fat i os (eller en af de andre deltagende organisationer)

# Hvordan kan disse anvendelser eksistere sammen?

- QKD kræver – i udgangspunktet – at signalet er alene i fiberen
- Men QKD bruger kun den ene fiber i fiberparret
- Den anden kan man så køre WDM på og have en række anvendelser samtidig:
  - Almindelig trafik
  - Overvågning og styring af enhederne
  - Sensing
  - Tids- og frekvensdistribution
- Selvom QKD måske ikke er højt på din dagsorden – endnu – er der gode grunde til at interessere sig for den udvikling af infrastrukturen, som det fører med sig



# Tak

- Questions and comments

*Martin Bech*

*[martin.bech@deic.dk](mailto:martin.bech@deic.dk)*

*21760625*

*DeiC Netdrift*

*[netdrift@deic.dk](mailto:netdrift@deic.dk)*

*35 888 222*

*[www.deic.dk](http://www.deic.dk)*

*[serviceinfo.dk](http://serviceinfo.dk)*



# Backup slides





# Distribution of time og frequency signals

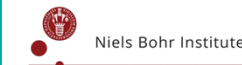


- Foreløbigt projektnavn SYNC-DK
- Ansøgning i februar til NFC (Nationalt Forsvarsteknologisk Center): 1,8 MDKK
- Ansøgning til Innovationsfonden i marts: 21,3 MDKK
- Distribution af White Rabbit og analoge signaler ( $10^{-18}$ )
- DFM(Hørsholm)-DTU(Lyngby)-NBI-AU i første omgang
- Many applications:
  - Time service independent of GNSS jamming
  - Spectroscopy
  - Geodesy
  - Location of jammers
  - Localisation of everything independent of GNSS

## IFD Grand Solutions 2025

Consortium Meeting

06/02/2025



Innovationsfonden  
**Grand Solutions**