KM3NeT:power distribution and control for a star-like sea-floor network

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for KM3NeT PPM work package H

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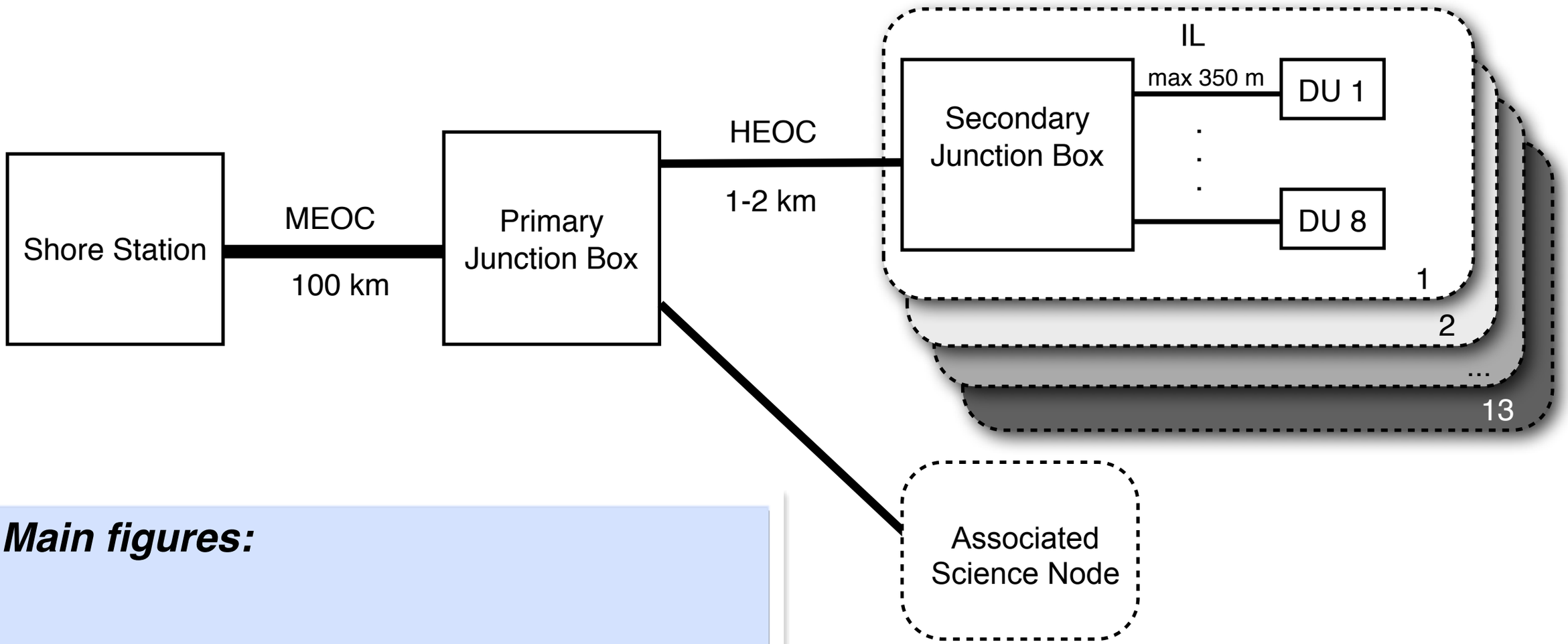
Talk Outline

- KM3NeT Seabed Star-like Network for a building block:
  - Input Data and Main Components
  - Electro-Optical Cable Specifications
  - Power System and Calculation Results
- Primary and Secondary Junction Boxes: Block Diagrams & Power scheme
- Medium Voltage Converter
- KM3NeT - IT

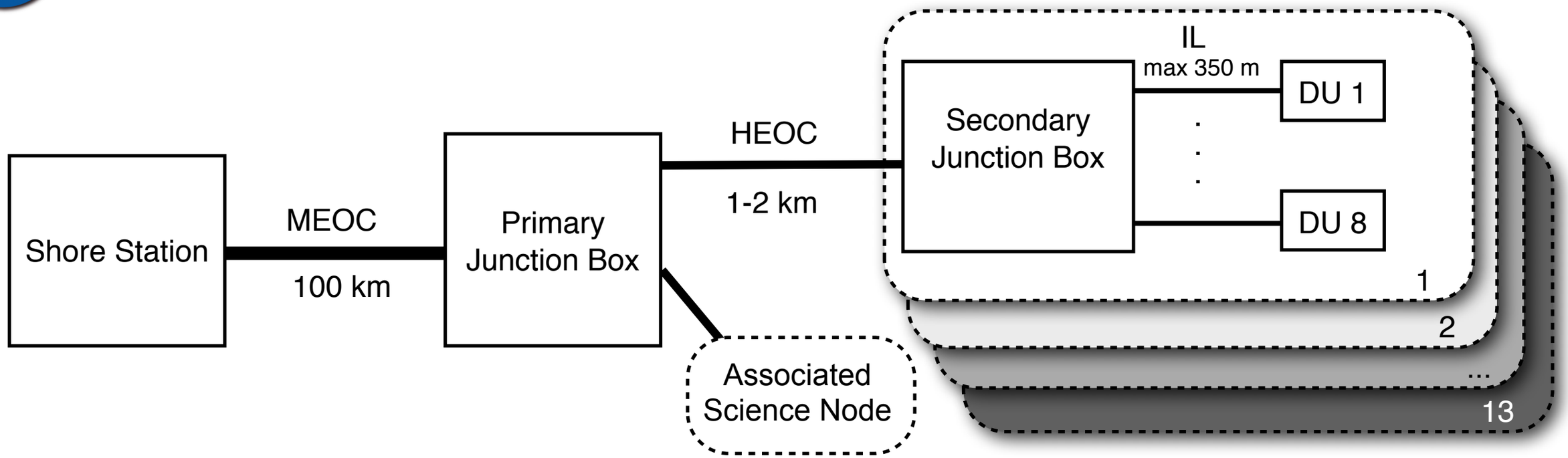
Star Detector Layout: Main Components



Main figures:

- 104 Detection Units
- 8 DUs per Secondary Junction Box
- 13 Secondary Junction Boxes
- 1 Associated Science Node (ASN)
- 1 Primary Junction Box

Star Detector Layout: Power System



✓**ON SHORE** :

- **Power Feeding Equipment (PFE)** :
  - delivers power to the submarine apparatus
  - Voltage Converter: 400Vac 3 phase / 10 kVdc

✓ **OFF SHORE** :

- **Main Electro Optical Cable (MEOC)**:
  - transmits power and communication
- **Primary Junction Box (PJB)**:
  - steps down the voltage from 10 kVdc to 400 Vdc
  - distribute power and communication to the secondary nodes

✓ **OFF SHORE** :

- **Secondary Junction Boxes (SJB)**:
  - distribute power and communication to 8 DUs
- **Cables (HEOC & IL)**:
  - connects electro-optically the PJB to the SJB and each JB to 8 DUs

Star-like Network Layout: Power System

✓ **DC POWER NETWORK:**

- **Transmission** Power System (from the shore station to the PJB) : **DC monopolar @ 10 kV**
  - the MEOC copper conductor is energized at -10 KV
  - positive electrode on shore
  - negative electrode off-shore

- **Distribution** Power System (from the PJB to the DU) : **DC bipolar @ 400 V**

POWER INVENTORY for a BUILDING BLOCK (104 DUs)

COMPONENT	*POWER / COMPONENT*	*POWER/ BUILDING BLOCK*
DU local control	360 W	37,44 kW
SJB internal load	100 W	1,3 kW
PJB internal load	300 W	0,3 kW
Associated Science	10 kW	10 kW
		49,04 kW

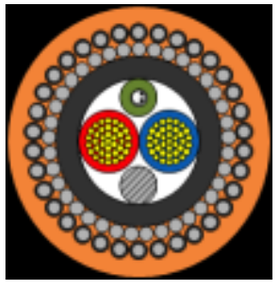
Star Detector Layout: cable specifications

CABLE	ROUTE	LENGHT	COPPER WIRES	QTY	QTY/km
MEOC MAIN ELECTRO OPTICAL CABLE	shore - PJB	100 km	1 copper conductor 1,5 Ω/km	1	100 km
HEOC HORIZONTAL ELECTRO OPTICAL CABLE	PJB - SJB	1000-2000 m	2 x 16 mm^2	14	20 km
IL INTERLINK CABLE	SJB - DU	100-350 m	2 x 16 mm^2	104	25 km
VEOC VERTICAL ELECTRO OPTICAL CABLE	DU backbone (2 VEOC per DU)	880 m	2 x 18 AWG	208	200 km

MEOC

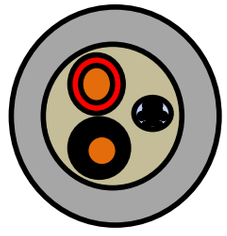
Alcatel·Lucent exans Draka

HEOC & IL



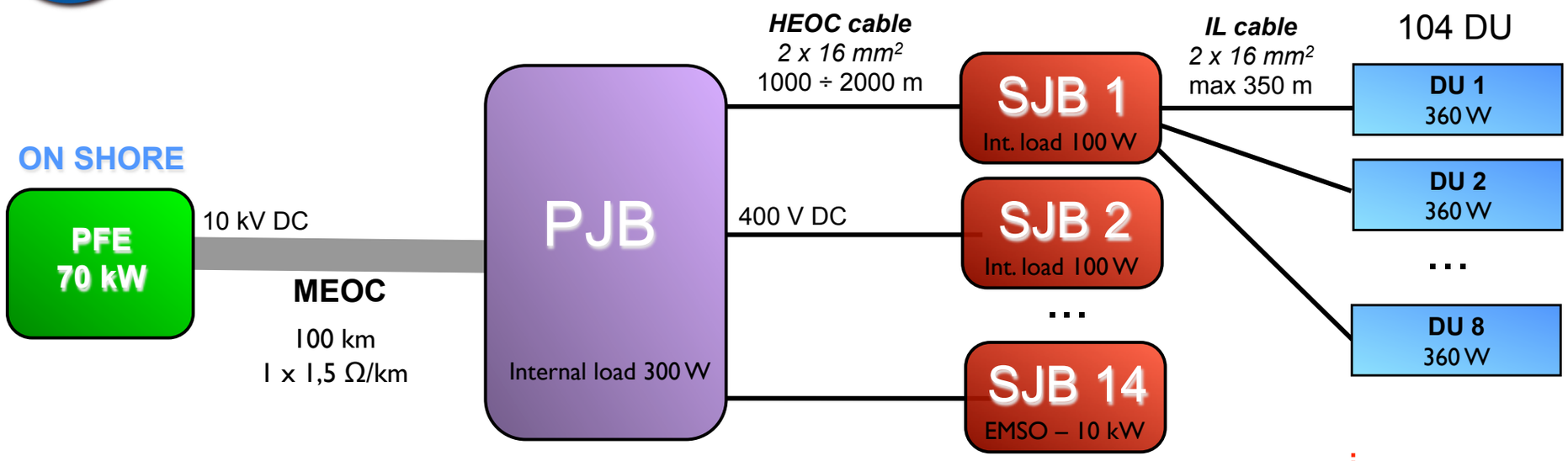
exans

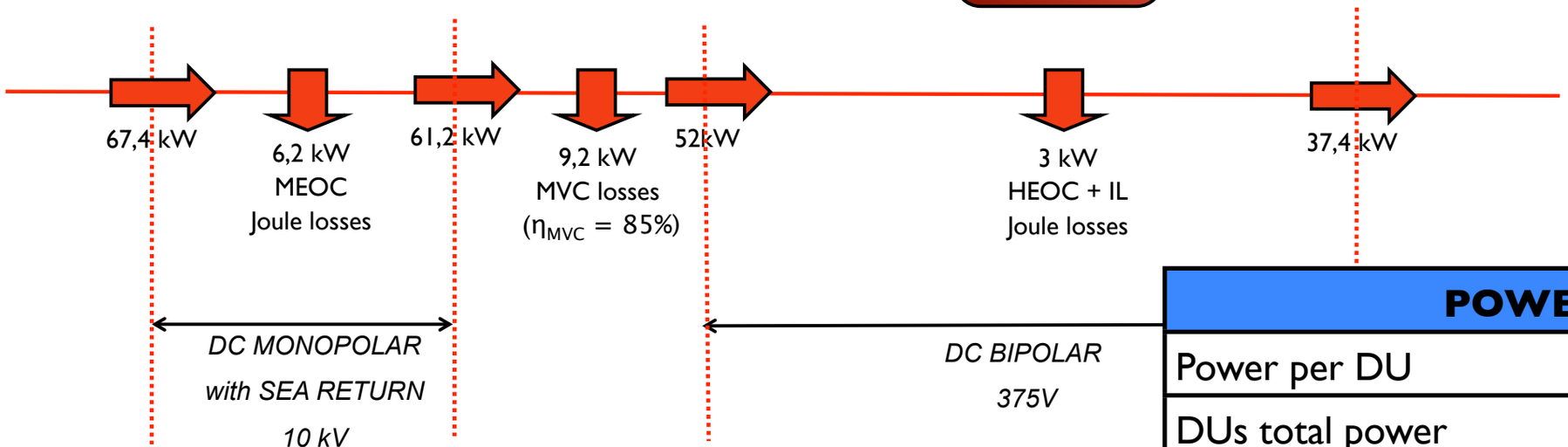
VEOC



NIKHEF

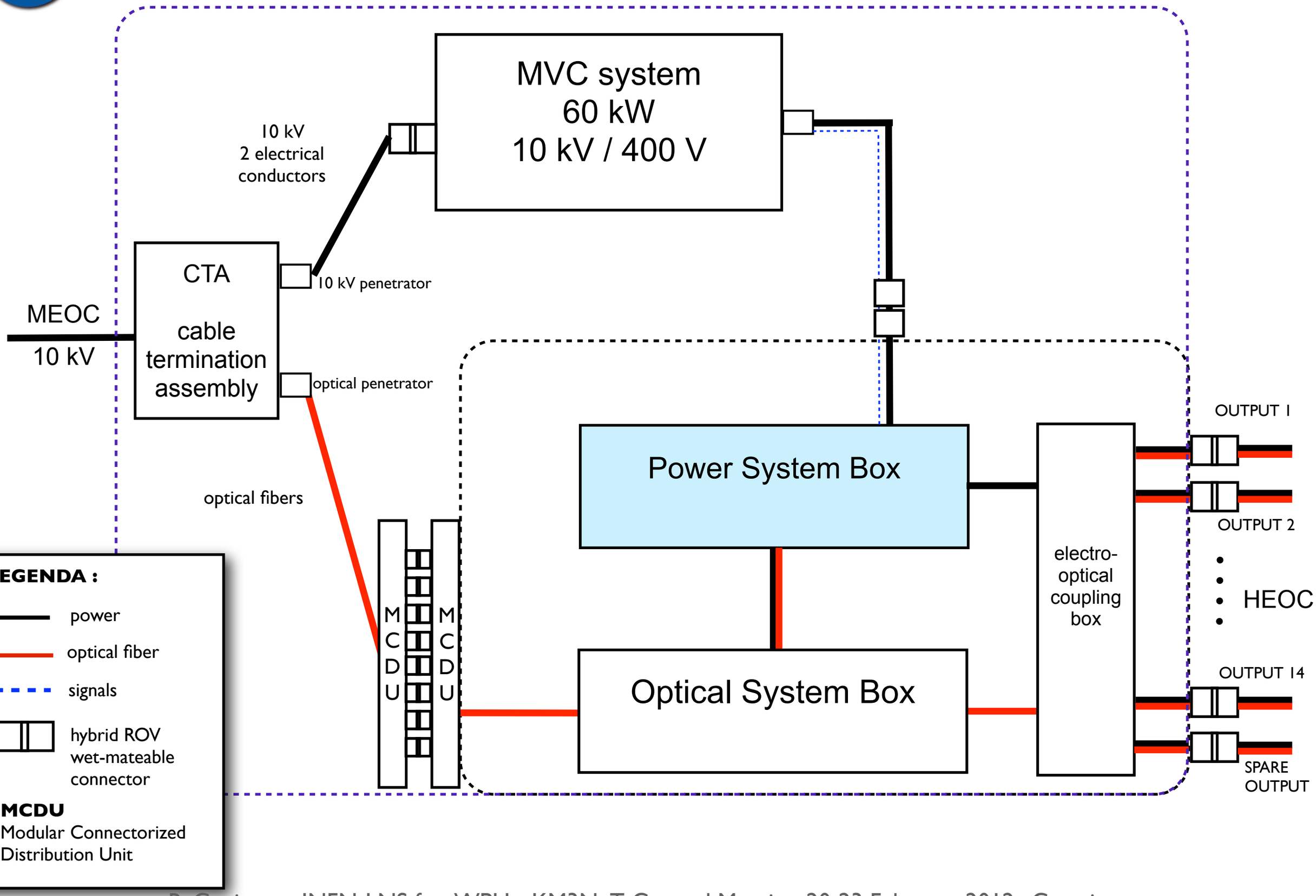
Star-like Network Layout: Calculation Results



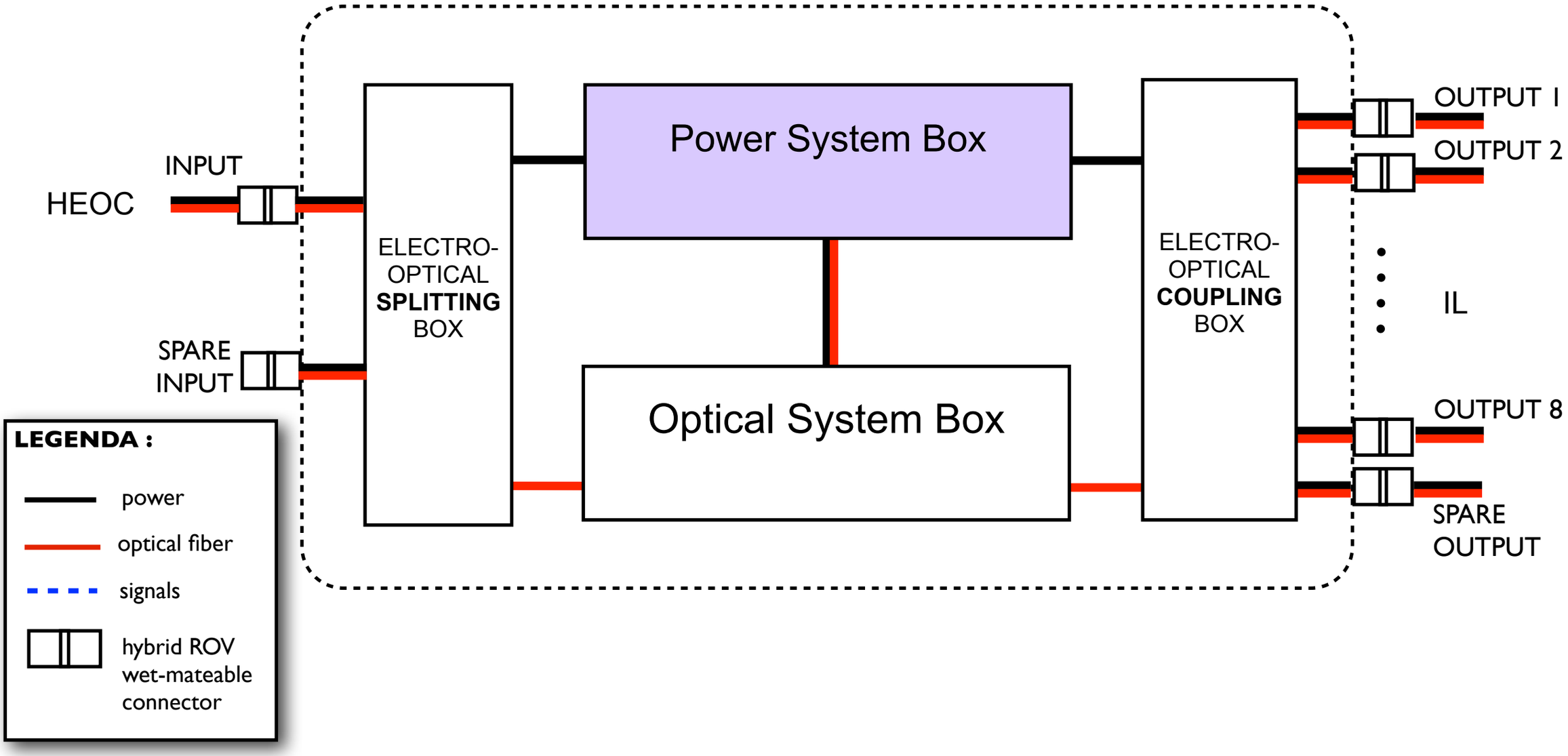


POWER BUDGET	
Power per DU	360 W
DUs total power	37,4 kW
Associated Science (EMSO)	10 kW
HEOC+IL Joule losses (~6%)	3 kW
Internal loads PJB+SJBs	1,6 kW
MVC joule losses (η= 85%)	9,2 kW
MEOC losses	6,2 kW
TOTAL POWER LOSSES	**27%**
POWER ON SHORE	**67,4 kW**

Primary Junction Box: block scheme



Secondary Junction Box: block scheme



PJB - Power System Box

MVC System

Optical System Box

Electro-Optical Coupling Box

375 V

400 V

INPUT _MVC

Power and slow control from MVC

2

R 1

R 7

R 13

R 14

A

OUTPUT_ SJB1

OUTPUT_ SJB7

OUTPUT_ SJB13

OUTPUT_ ASN

power and conveyed waves slow control

V

T

P

H

LV output

power

Power supply 375V/ LV

Conveyed waves to/from SJBs

CAN Bus RS 485/232 Ethernet I2C

Ground Fault Monitor

Analog & Digital I/O

Tx/Rx Copper

Tx/Rx

Tx/Rx f.o.

µC

f.o. to/from shore

slow control

f.o. to/from SJBs

LEGENDA :

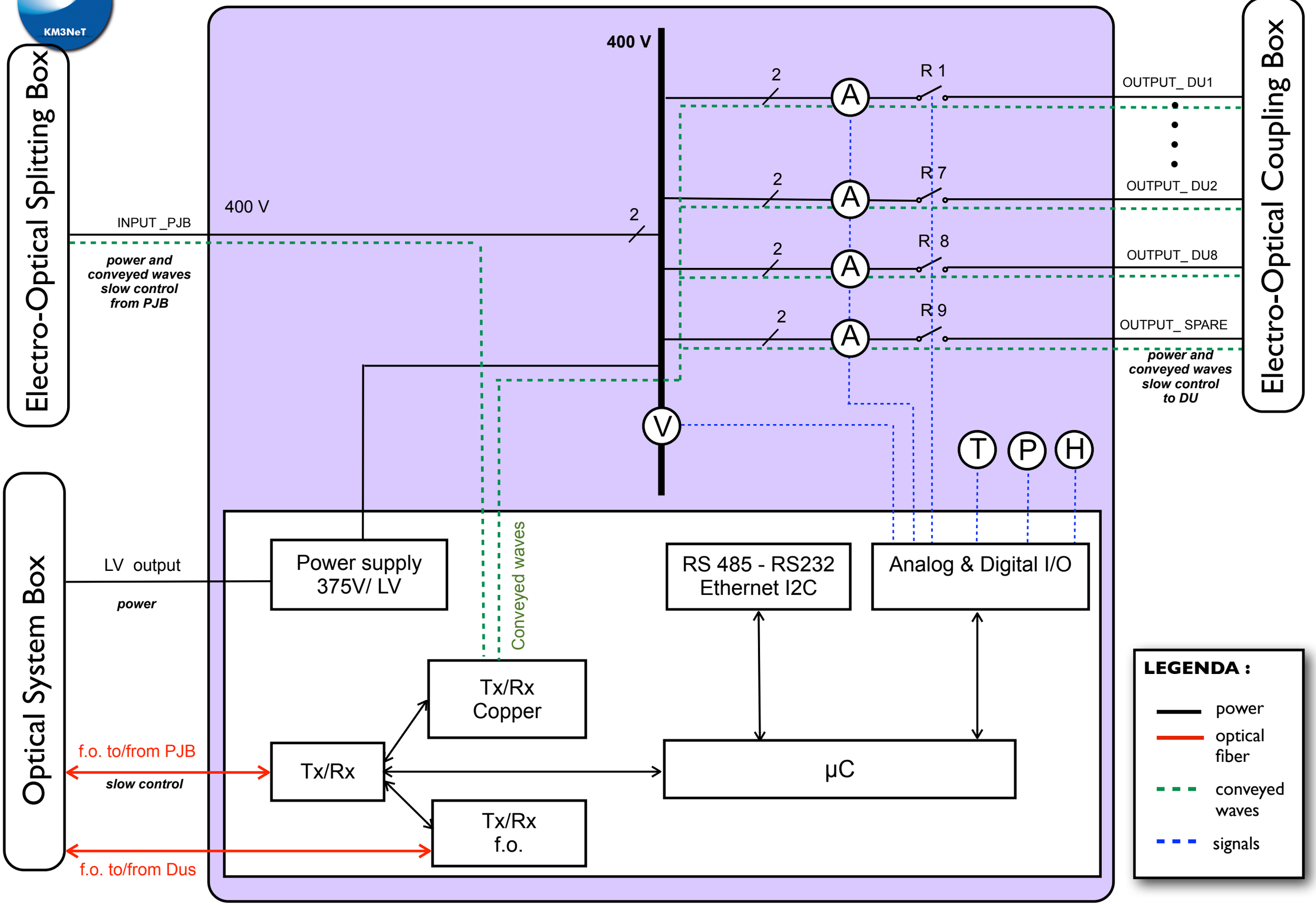
power

optical fiber

conveyed waves

signals

SJB - Power System Box



Medium Voltage Converter:

Alcatel produced a 10 kW, 10kV / 400 V Medium Voltage Converter for submarine application for two projects :

- NEMO: 2 pieces, 1 deployed and working
- NEPTUNE: 6 pieces, 5 deployed and working

As per Alcatel communication they have discontinued MVC product line.

The Alcatel MVC main features:

DC Input Voltage : 5,7kV - 10 kV

DC Output Voltage: 375 V

Power: 10 kW

Input shut down voltage: 5,2 kV

Efficiency @ 10 kV, full load : 87%

Voltage undershoot (10% to 90% step up) @ 10kV: 40 V

Voltage overshoot (90% to 10% step down) @ 10kV: 43 V

Output Ripple Voltage (rms @ 100 kHz) < 1,5 V

Medium Voltage Converter

An activity of market inquiry finalized to find a new supplier it is on going.

Companies contacted:

✓ PBF, OceanWorks, Bruker, Heinzinger,L-3 MariPro

- ***PFB*** is a power supply producer, it is interested and It did a feasibility study of a 10 kW/400V

- ***OceanWorks*** worked for NEPTUNE and VENUS (Node) and has an experience with subsea cabled network. It is ‘’interested in the development of a 10 kW - 10kV/400V solution in a single stage with firm fixed price and performance guarantees’’.

- ***L-3 MariPro*** has experience with subsea cabled network, worked for NEPTUNE. It is working for the Regional Scale Nodes (RSN) of the Ocean Observatories Initiative (OOI). It is producing seven MVC, 10 kW unit (10kV/375V) for the RSN.

KM3NeT-IT: Network Capacity

Present Status

PFE: 50 kW
MVC: 10 kW (85% eff.)
MEOC: 20 optical fibers

DU power: 360 W
JB power: 200 W
Cable Joule losses: 4%

→ 20 DUs (DU number only limited by MVC)

MVC upgrade to remove power limitation

PFE: 50 kW
MVC: 2 x 10 kW (85% eff.)
MEOC: 20 optical fibers

DU power: 360 W
JB power: 200 W
Cable Joule losses: 4%

→ 32 DUs (DU number limited by fibers
2 DUs per readout fiber)

DU power increase scenario

PFE: 50 kW
MVC: 2 x 10 kW (85% eff.)
MEOC: 20 optical fibers

DU power: 450 W
JB power: 200 W
Cable Joule losses: 10%

→ 32 DUs (DU number limited by MVC
and by fibers:
2 DUs per readout fiber)

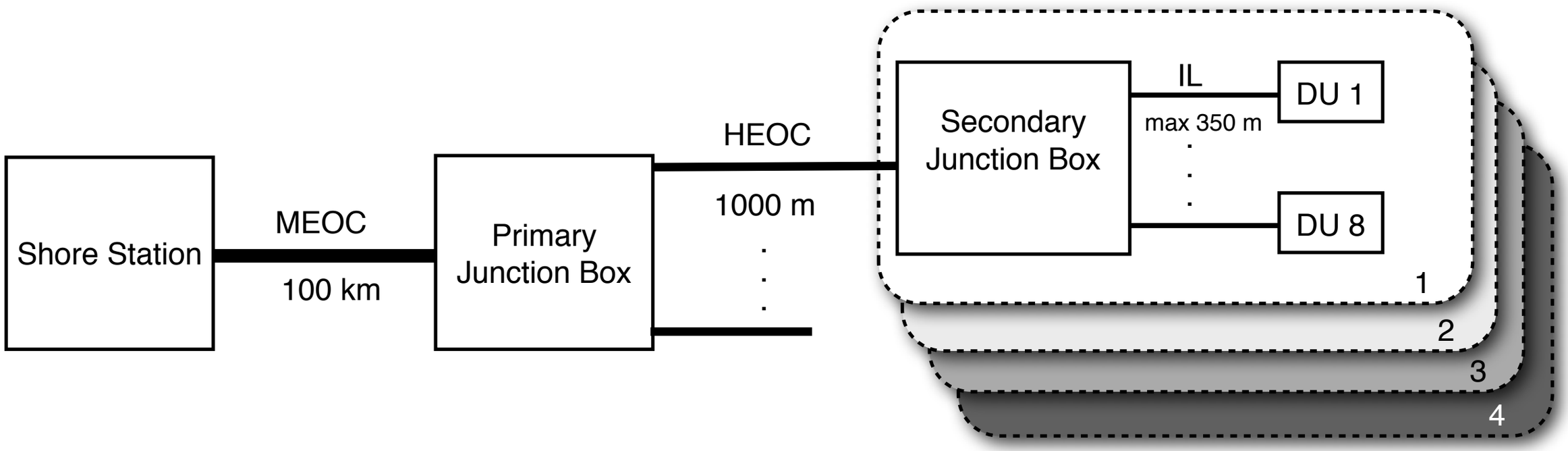
Improved fiber capacity scenario
(50 % - 3 DUs per readout fiber)

PFE: 50 kW
MVC: 3 x 10 kW (85% eff.)
MEOC: 20 optical fibers

DU power: 450 W
JB power: 200 W
Cable Joule losses: 10%

→ 48 DUs

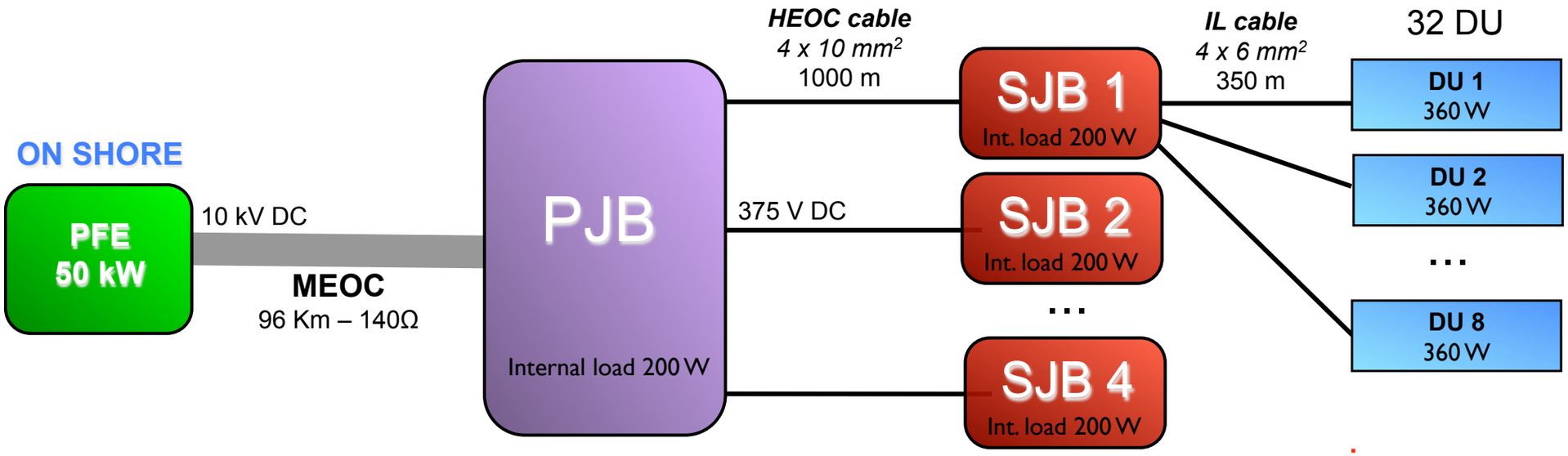
KM3NeT-IT: Seabed Network

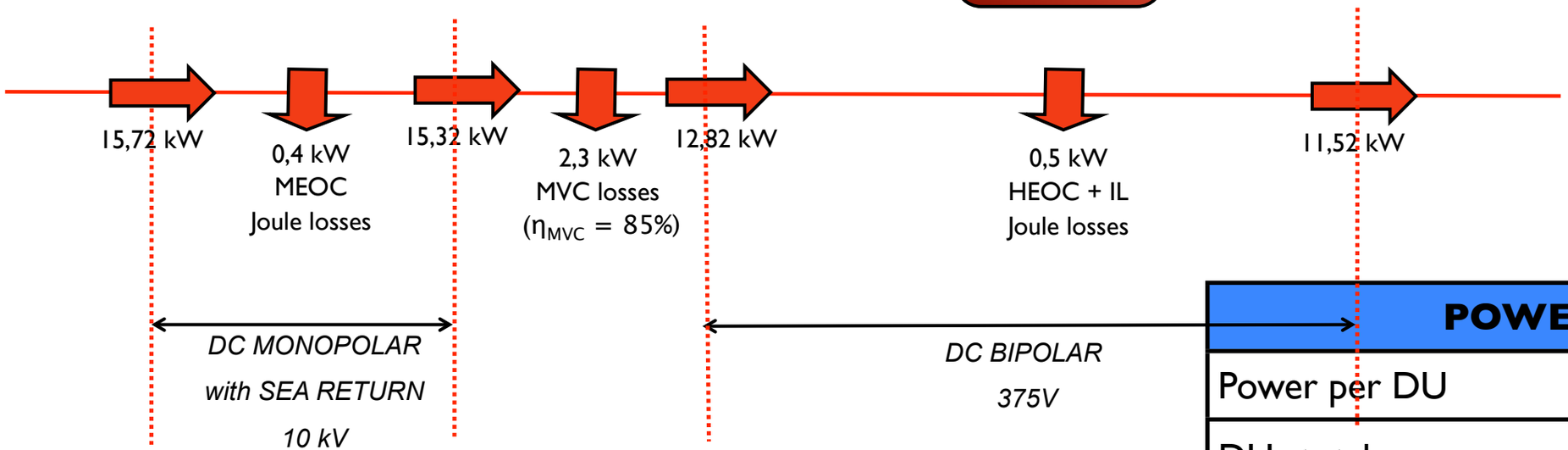


Main figures:

32 Detection Units
8 DU per Secondary Junction Box
4 Secondary Junction Boxes
1 Primary Junction Box

KM3NeT-IT: Calculation Results





POWER BUDGET	
Power per DU	360 W
DUs total power	11,52 kW
HEOC+IL Joule losses (~4%)	0,5 kW
Internal loads PJB+SJBs	1 kW
MVC joule losses (η= 85%)	2,3 kW
MEOC losses	0,4 kW
TOTAL POWER LOSSES	**27%**
POWER ON SHORE	**15,7 kW**

Conclusions

- Achievements:
    - Preliminary power inventory and power calculation results
    - Preliminary design of power distribution and its slow control data routing
    - Cables specifications - defined
    - Contacts with cable suppliers (Alcatel, Nexans, Draka, JDR) and cable terminations - on going
    - MVC specification - defined
    - Contacts with MVC development companies - on going

As soon as the final DU power inventory will be available

- Next Steps:
    - Network final power consuption,
    - Network final power distribution design (included cables and electrical connectors)
    - MVC procurement

Thank you for your attention