



Status of Active RadMon Technologies for the LHC

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TID and Φ Measurements



Build-up of charge in MOSFETs SiO₂ gate (TID)

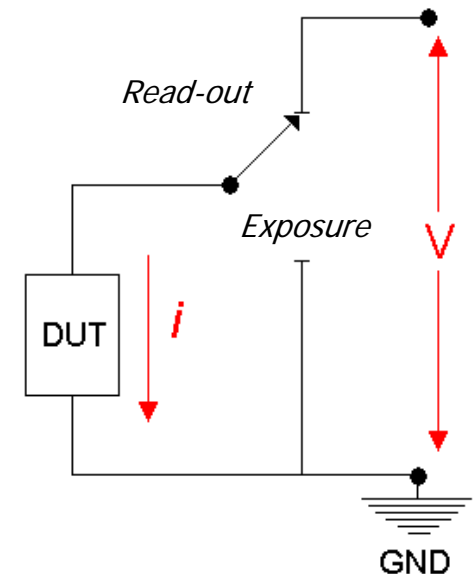
- Exposure in “zero bias” mode → 2-wires only readout;
- Long distance, **slow speed** readout;
- Readout at ZTC: if T ~ constant, **correction is not needed**.

RadFETs

Bulk damage in high ρ Si-base (Φ_{eq})

- Current source needed → 2-wires readout (FWD);
- Long distance, **fast pulse** readout (FWD);
- Bias needed if I_L measured (REVERSE);
- Temperature sensitive → **correction is needed**.

p-i-n diodes





Remind



All presented active devices are also

PASSIVE dosimeters

- Easy and fast readout with “simple equipment” (Source + Multimeter)
 - Basically measurement of resistivity!
- Good reproducibility;
- Readout doesn't erase dosimetric information compared to e.g. TLD

RadFETs Selection Procedure



Response to single radiation
Room Temp. Annealing

Sensitivity to fast neutrons at Φ_{LHC}

not studied before:

Risk of "early saturation" for
intermediate oxide thicknesses.

SiO₂ "quality" evaluation
(Isochronal Annealing)

Response at Low Dose-
Rate in Mixed Environment

Monitoring of the PS-T7

primary zone since

August 2004.

Devices packaging options

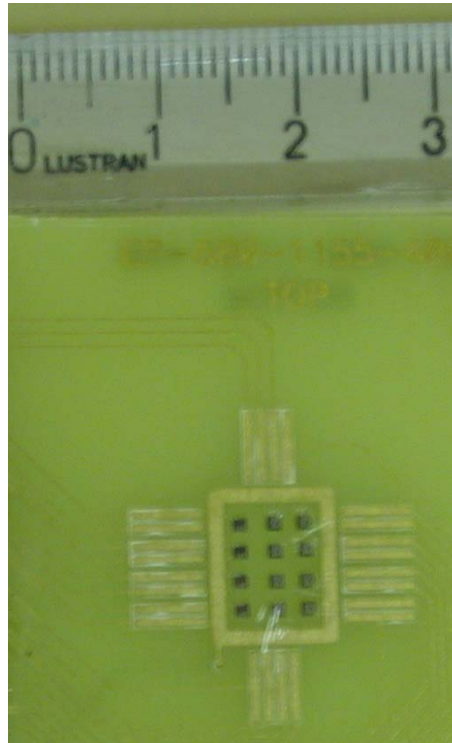
Actually **Two** devices
suitable for CERN purposes !

Crucial constraint in neutron
based radiation environments.

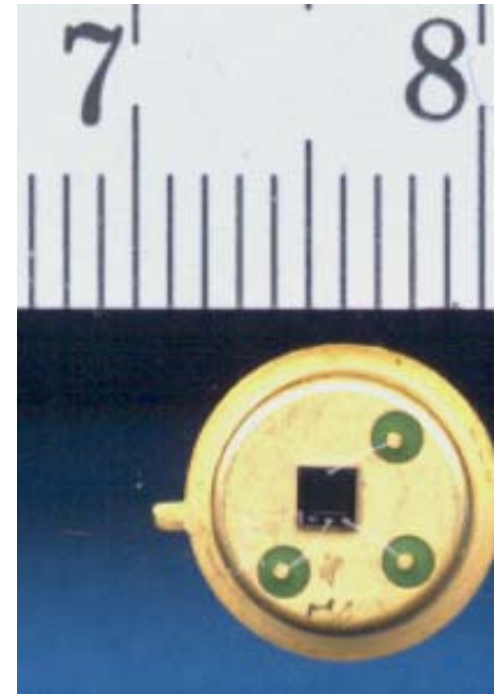
RadFETs



Thick Oxide
(CNRS-LAAS, France)



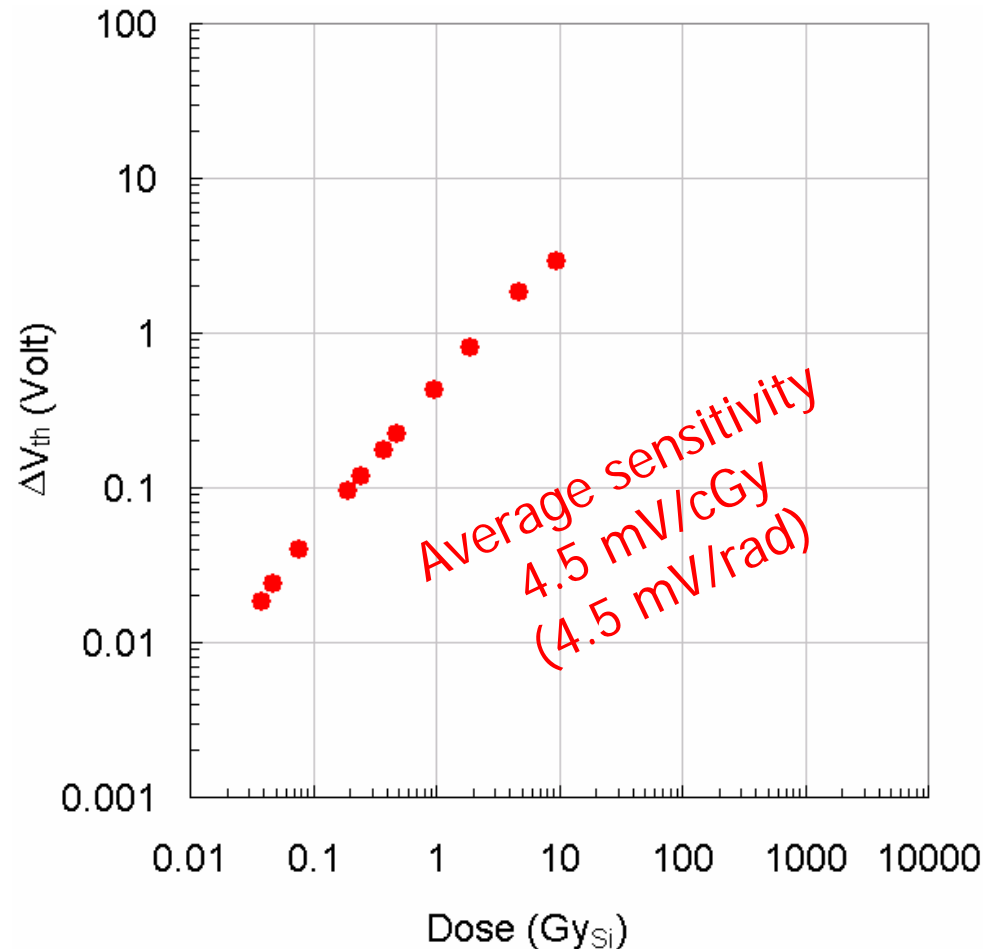
Thin Oxide
(R.E.M., England)



Thick Oxide RadFET (1)



1. $t_{\text{ox}} = 1.6 \mu\text{m}$, $A = 0.35 \text{ mm}^2$;
2. Ideal Range: $< \text{mGy}_{\text{Si}} - 10 \text{ Gy}_{\text{Si}}$;
3. Tested in Hadron radiation fields up to 10^{12} cm^{-2} ($1 \text{ MeV}_{\text{eq}}$);
4. Operational ZTC $i_{\text{ds}} \sim 100 \mu\text{A}$;
5. Fading $< 8 \%$ after 1000 h at RT;



Thick Oxide RadFET (2)

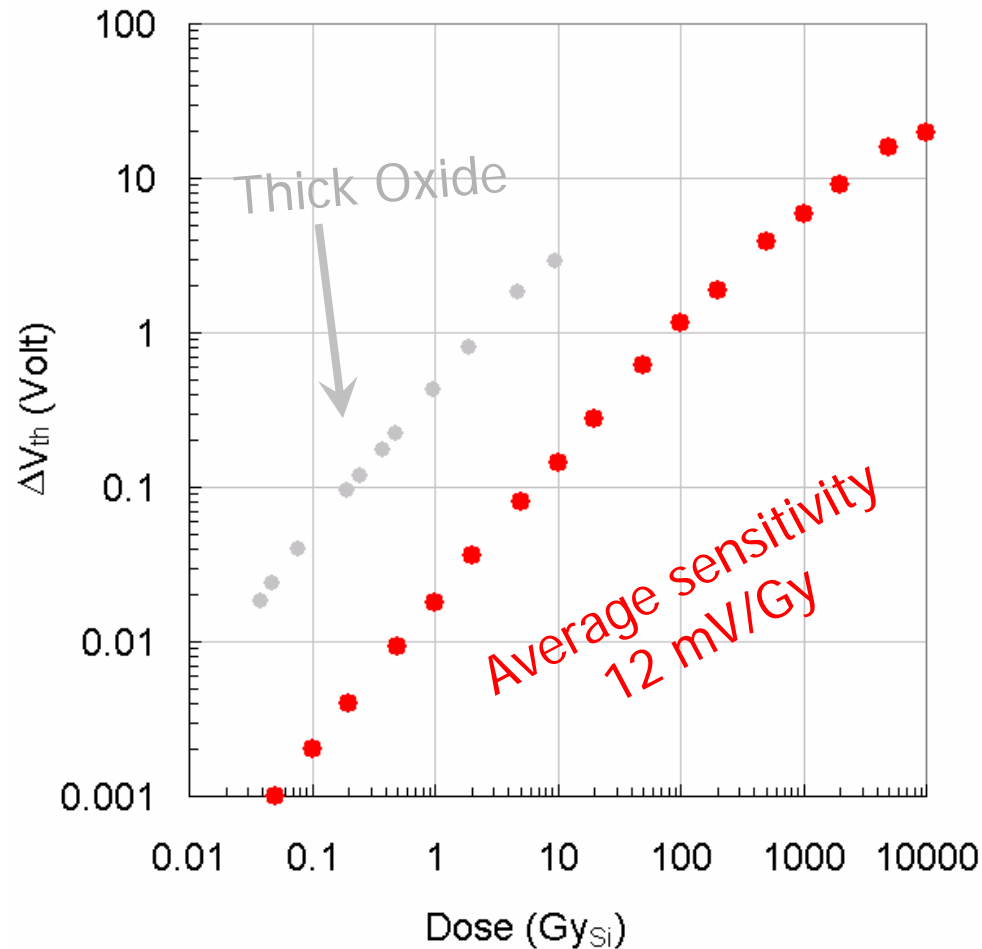


6. Fits almost totally the RadMon requirements of:
 - EXP. Infrastructures;
 - EXP. outer detectors (i.e. CMS MUON, ATLAS outside ID, etc ..);
 - Some LHC-machine locations
7. Supplied packaging:
 - **Standard** → Kovar TO-5 4 pins;
 - bare-die chip (~ 2 mm²).
8. Cost: ~ **70 CHF / MOS** (selection & characterization included);
9. Quotation based on a order of 100 pieces.

Thin Oxide RadFET (1)



1. $t_{\text{ox}} = 0.25 \mu\text{m}$, $A = 0.02 \text{ mm}^2$;
2. Ideal Range: $1 \text{ cGy}_{\text{Si}} - 10 \text{ kGy}_{\text{Si}}$;
3. Tested in Hadron radiation fields up to several 10^{14} cm^{-2} ($1 \text{ MeV}_{\text{eq}}$);
4. Operational ZTC $i_{\text{ds}} \sim 160 \mu\text{A}$;
5. Fading $< 2 \%$ after more than 200 h at RT;

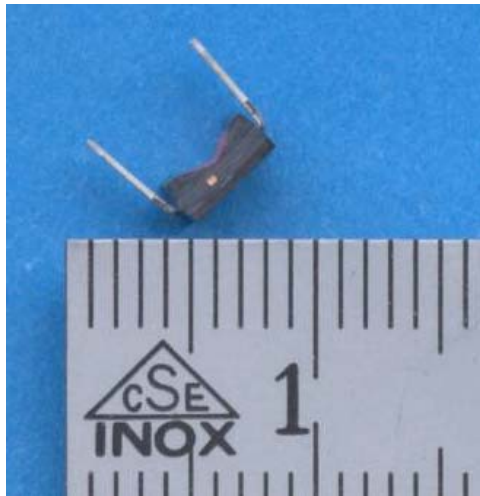


Thin Oxide RadFET (2)



6. Fits requirements for the RadMon monitoring inside detectors;
7. Supplied packaging:
 - **Standard** → bare-die chip (1 mm²);
 - CERN optimized Kapton/light-PCB/ceramic micro-carriers;
 - **Kovar TO-5: Successfully assembled at the PH Bond-Lab.**
8. Costs:
 - Dies: ~ **150 CHF / MOS** (if 400 pcs. ordered) ;
 - Assembly on special carriers increases price about 15-30% .
9. Price **strongly depending** on number of ordered pieces.

$p-i-n$ diodes

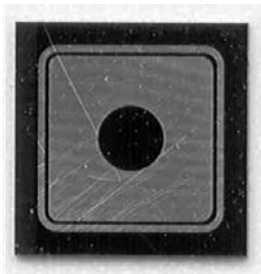
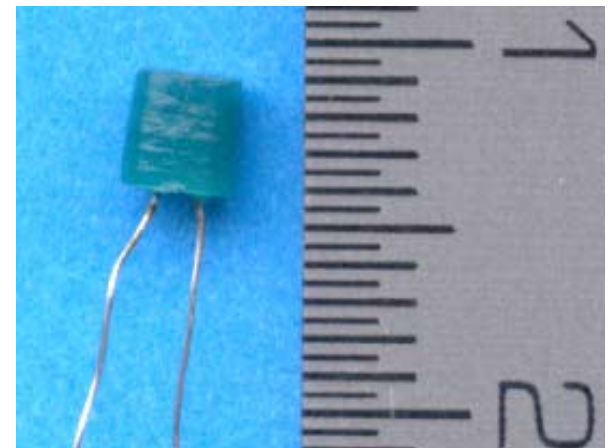


BPW34F



CMRP

(Centre for Medical Radiation Physics,
Australia)



PAD Detectors

Commercial BPW diodes



1. With actual 1 mA fast pulse:

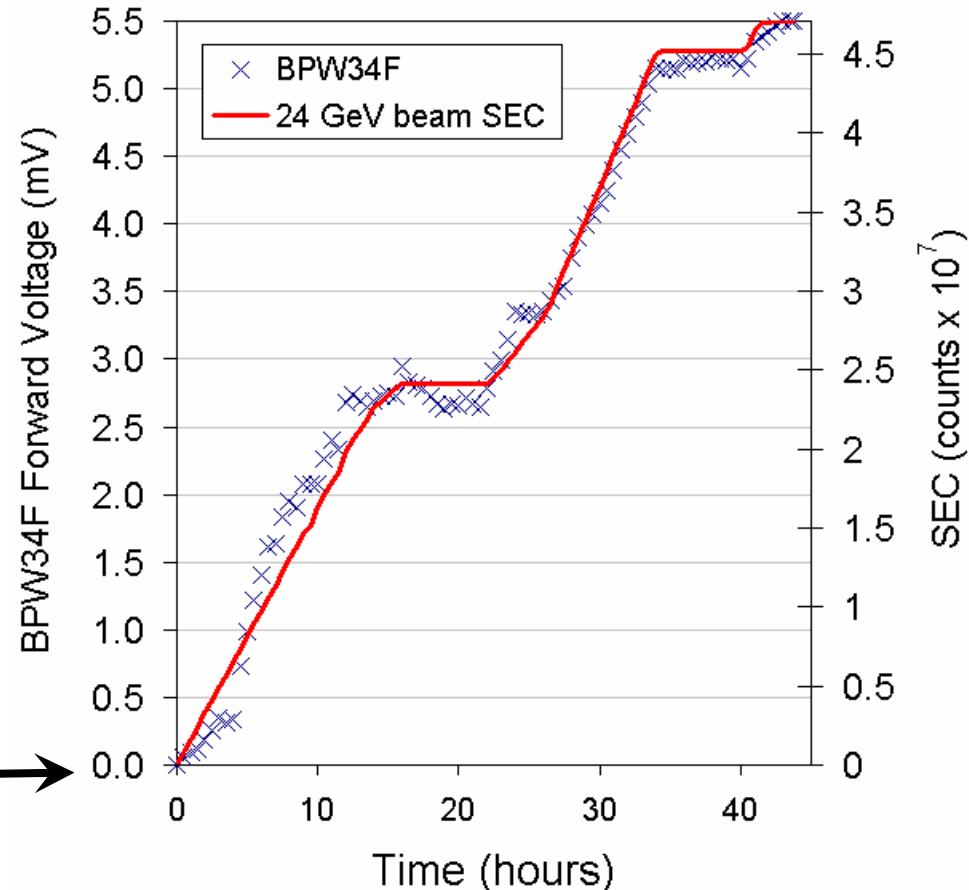
- Sensitivity $\sim 5 \times 10^9 \text{ cm}^{-2} \text{ mV}^{-1}$
- Operation range:
 $10^{12} \text{ cm}^{-2} \rightarrow 4 \times 10^{14} \text{ cm}^{-2}$

2. Sens. improvement under study:

- Optimize readout protocol;
- Applying **low** pre-irradiation. →

3. No availability problems (COTS).

4. Cost: **< 5 CHF / pcs.**



*Diode placed 1.40 mt. from proton beam
(raw data)*

CMRP Diodes



1. With 1 mA pulsed :

- Excellent resolution:

Sensitivity $\sim 2 \times 10^8 \text{ cm}^{-2} \text{ mV}^{-1}$

- Operation up to $2 \times 10^{12} \text{ cm}^{-2}$

2. Availability: Only one producer.

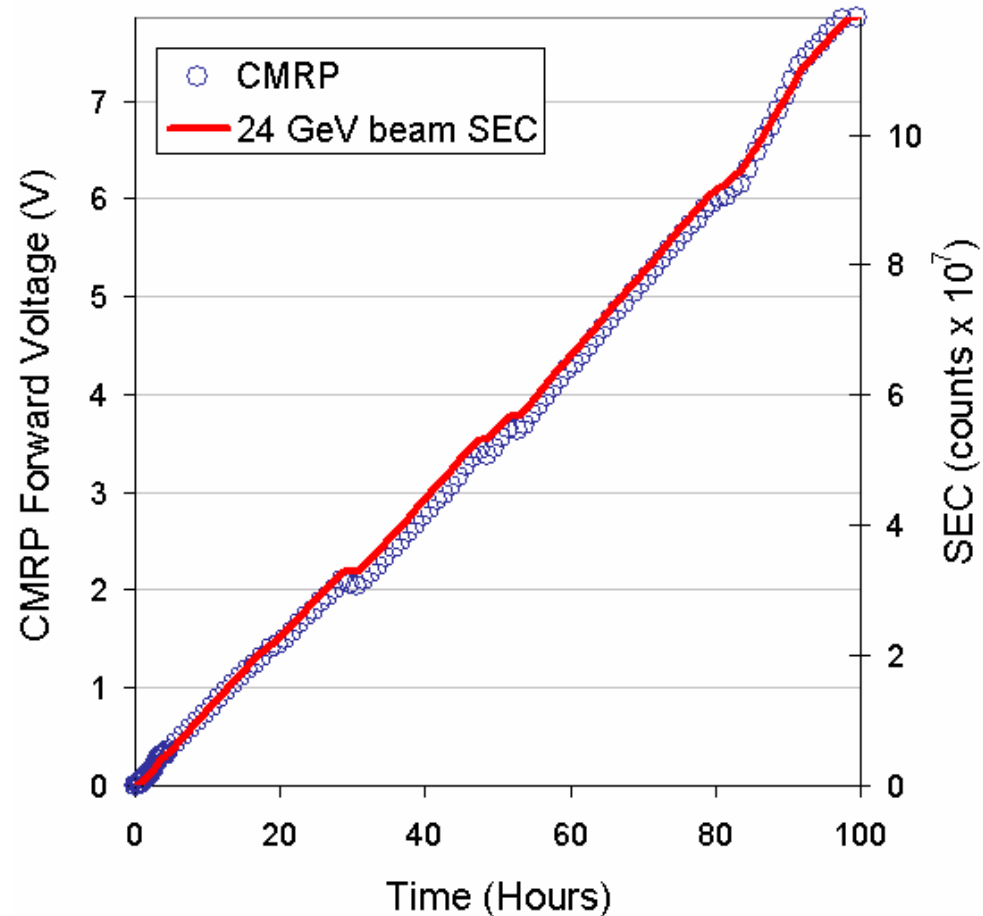
3. Present offer under negotiation :

- Price estimate: **200 CHF/pcs.**

- Minimum order is 100 pcs;

- Present Packaging:

mounted on polyimide film $2 \times 5 \text{ mm}^2$

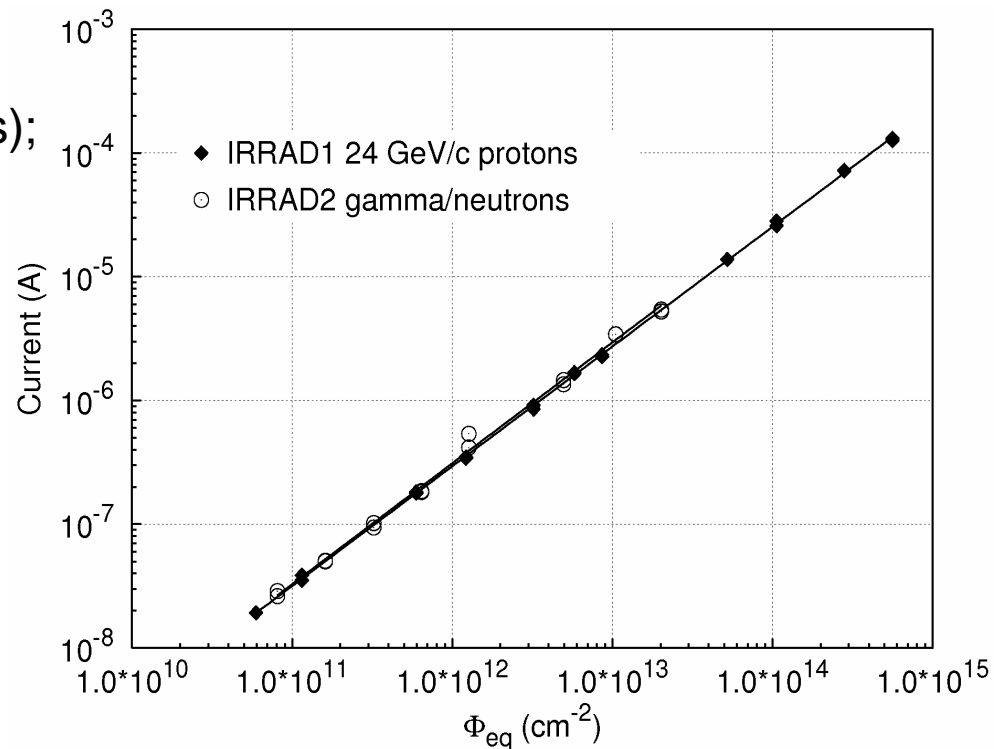


Diode placed 1.40 mt. from proton beam

PAD Detectors



1. Reading leakage current under full depletion (50 to some hundred Volts);
2. Very wide fluence range;
3. Very precise if used as passive dosimeters;
4. Complex annealing behaviour if used as active dosimeters;
5. Quotation for price requested:
 - Estimate: **45 CHF / pcs.** (packaging included)
 - 25 CHF / pcs. unpacked



*ST Microelectronic, Italy
PAD detectors 0.25 μ m
Off-line characterization*

Summary / Conclusions



Thick Oxides RadFETs / BPW diodes:

- No availability problems (off the shelf);
- Exact price estimate.

Thin Oxides RadFETs / CMRP diodes / PAD Detectors:

- Production for CERN is practically “on-demand”;
- Price estimate and minimum quantities can still vary.

Important to remember:

- Measurement reproducibility → devices belonging to the **same batch**.
- We need time to **calibrate all** the different batches!
- All these active devices are also **PASSIVE dosimeters**.

→ *Type and number of devices needed has to be finalized soon!*