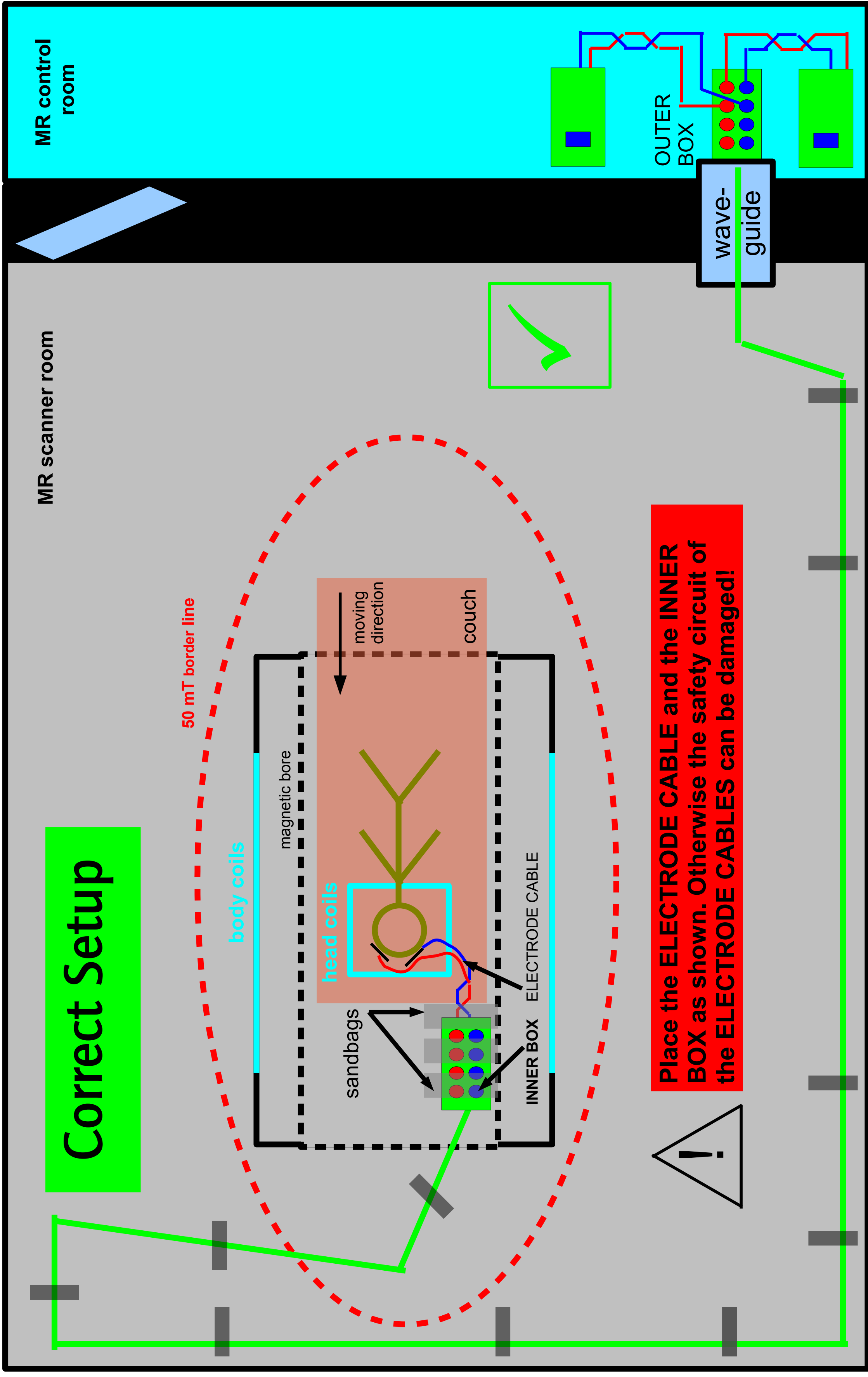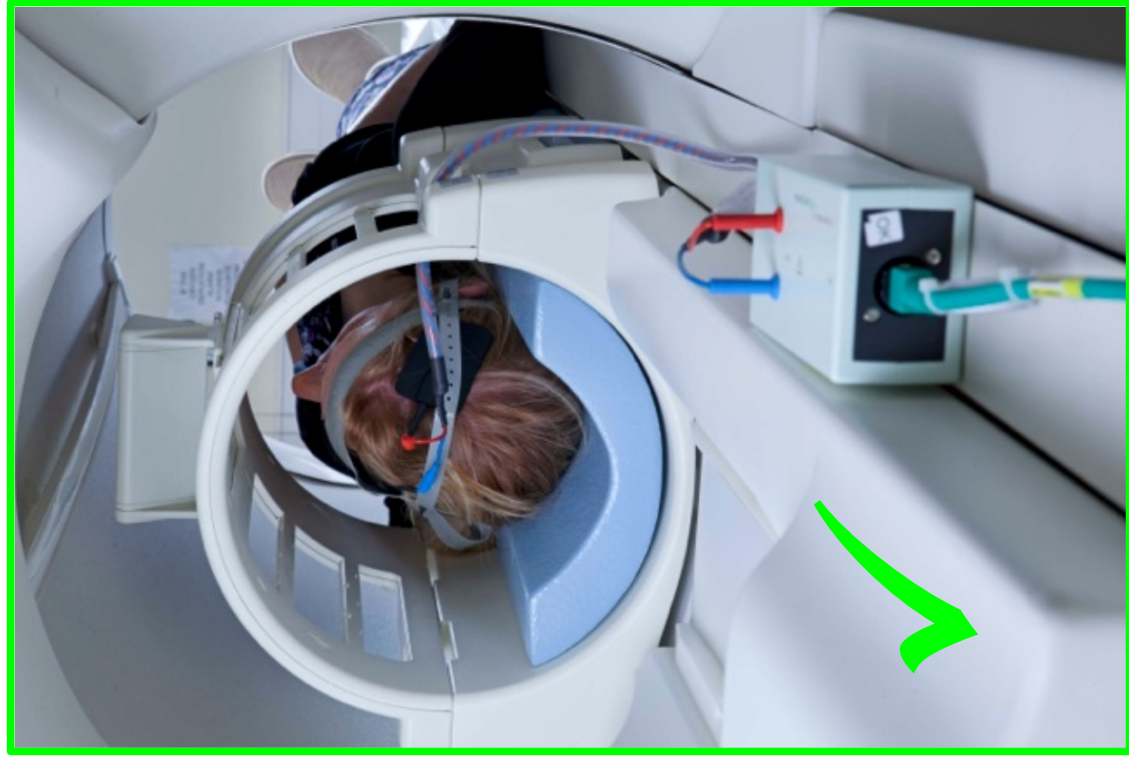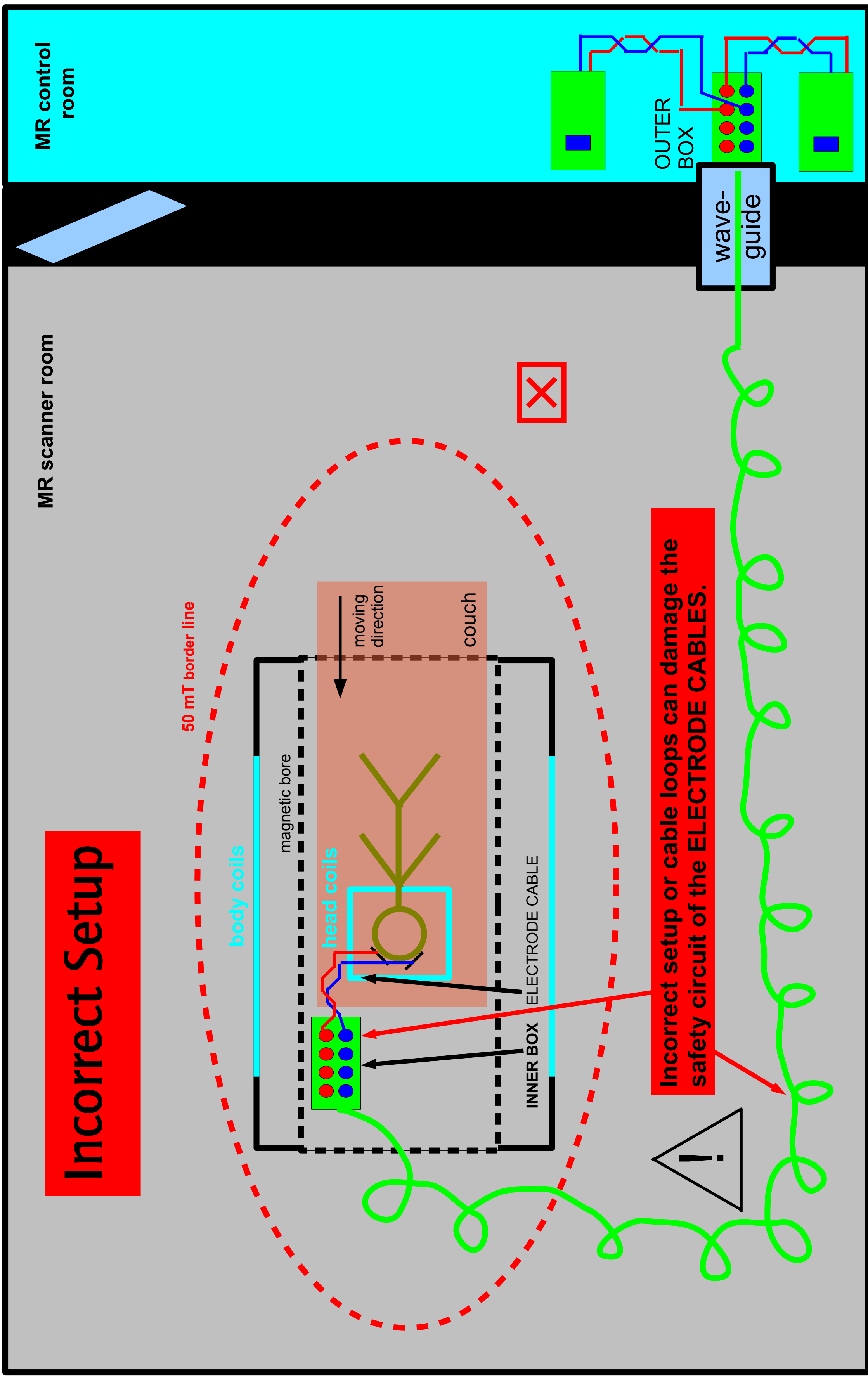# DC-STIMULATOR MR – Application Note

Dual-channel transcranial electrical stimulation (tES) during functional MRI

– Recommendations –

Correct Setup

MR control room

MR scanner room

OUTER BOX

wave-guide

INNER BOX

ELECTRODE CABLE

50 mT border line

body coils

magnetic bore

head coils

moving direction

couch

sandbags

Place the ELECTRODE CABLE and the INNER BOX as shown. Otherwise the safety circuit of the ELECTRODE CABLES can be damaged!

!

MR control room

MR scanner room

OUTER
BOX

wave-
guide

Incorrect Setup

50 mT border line

body coils

magnetic bore

head coils

moving
direction

couch

ELECTRODE CABLE

INNER BOX

Incorrect setup or cable loops can damage the safety circuit of the ELECTRODE CABLES.
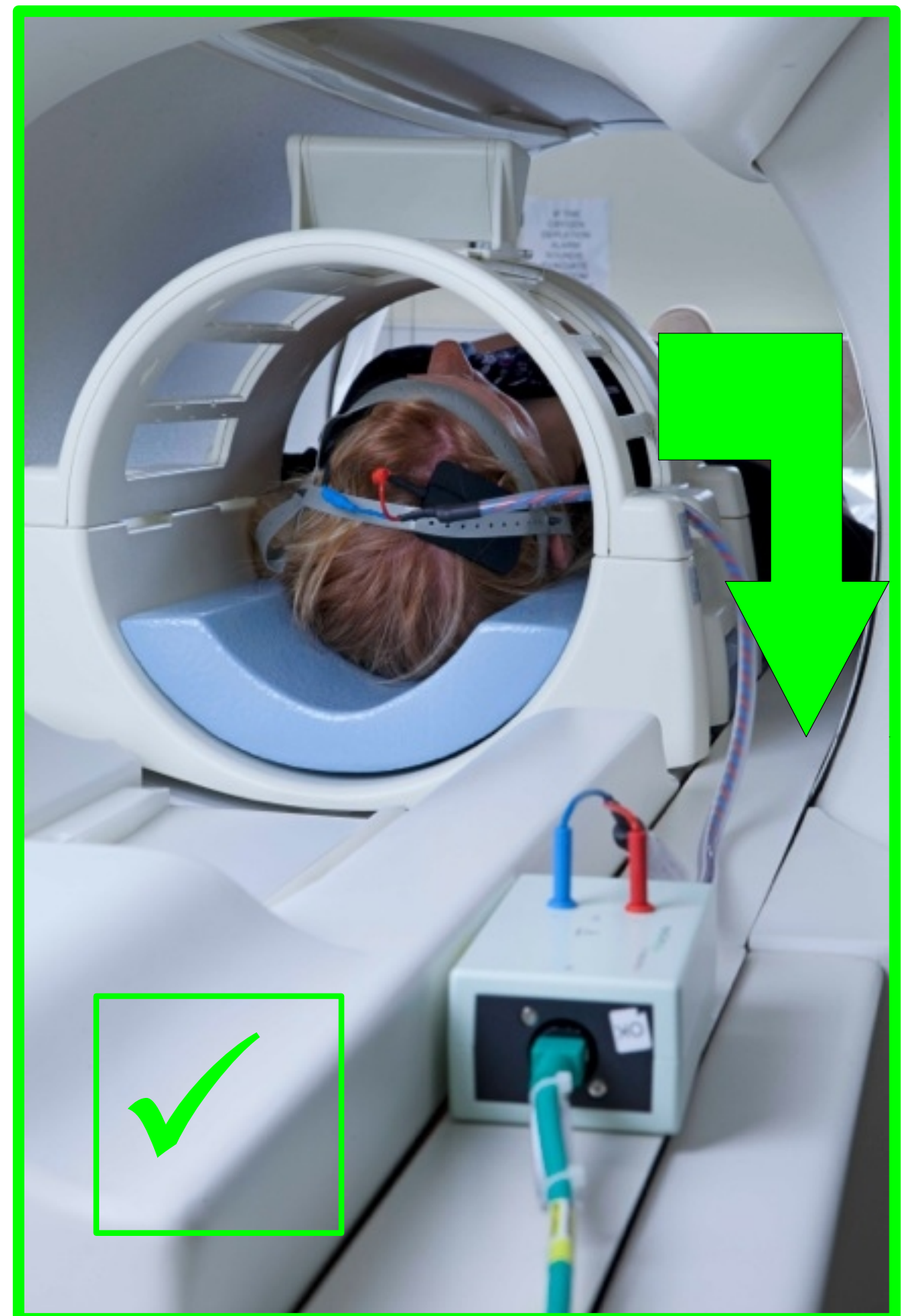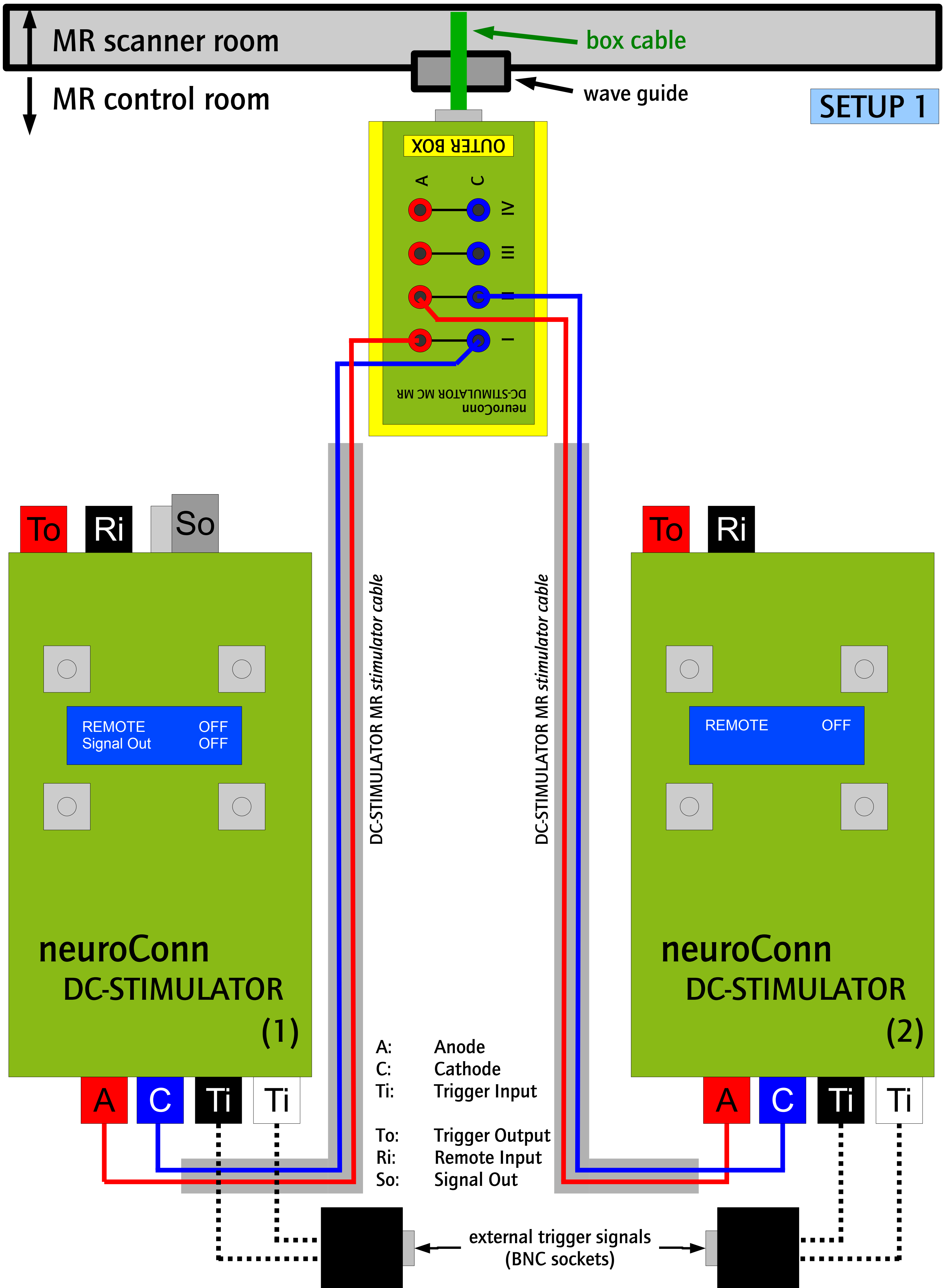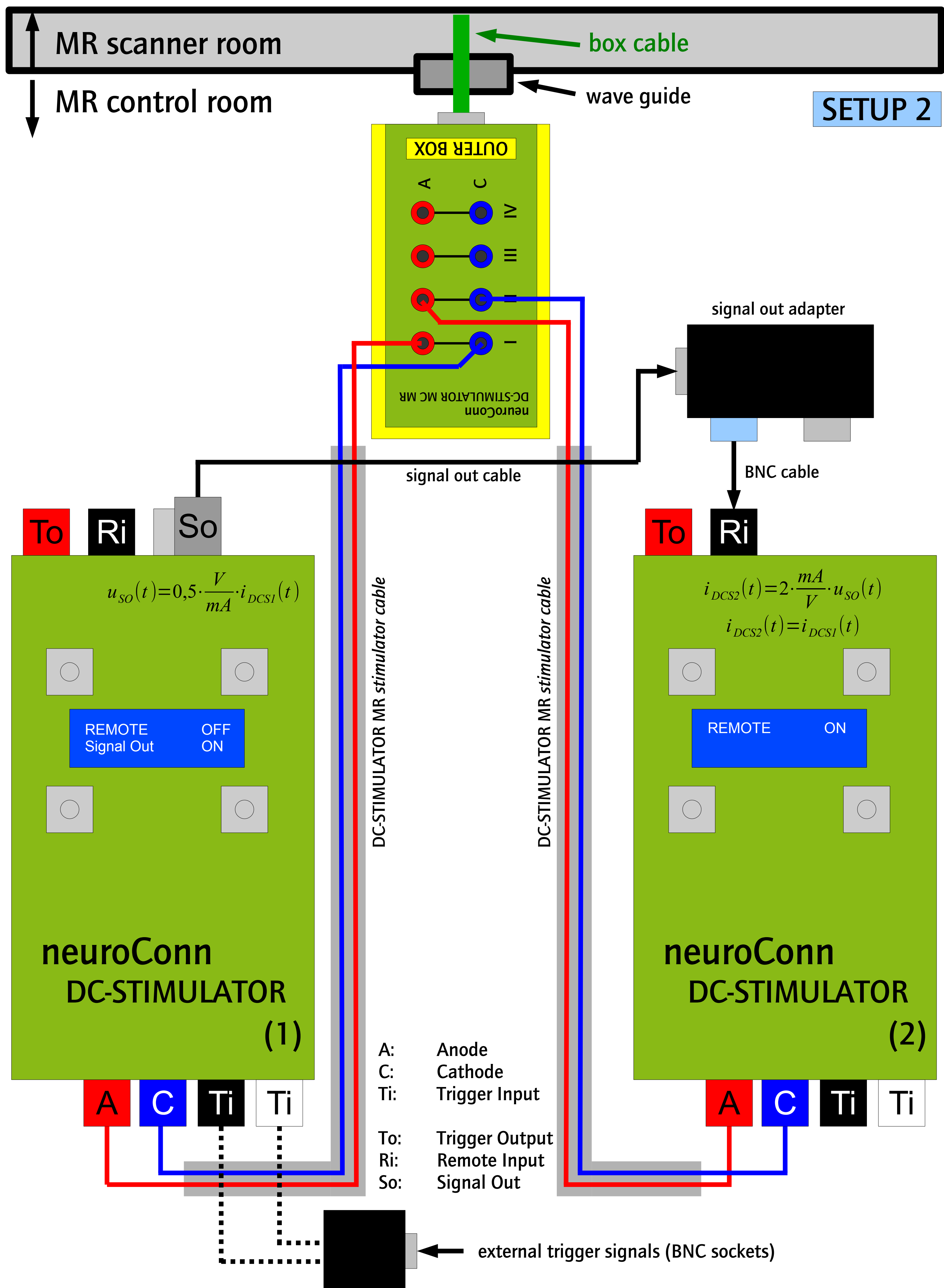
Incorrect Setup

Correct Setup

- The cable outlet <u>MUST</u> be on placed correctly. Otherwise the safety circuit of the electrode cable can be damaged.
- The DC-STIMULATOR MR was designed for fMRI sequences (EPI). We recommend to remove the ELECTRODE CABLE from the patient during anatomical sequences. Rubber electrodes can be left on patient's head.
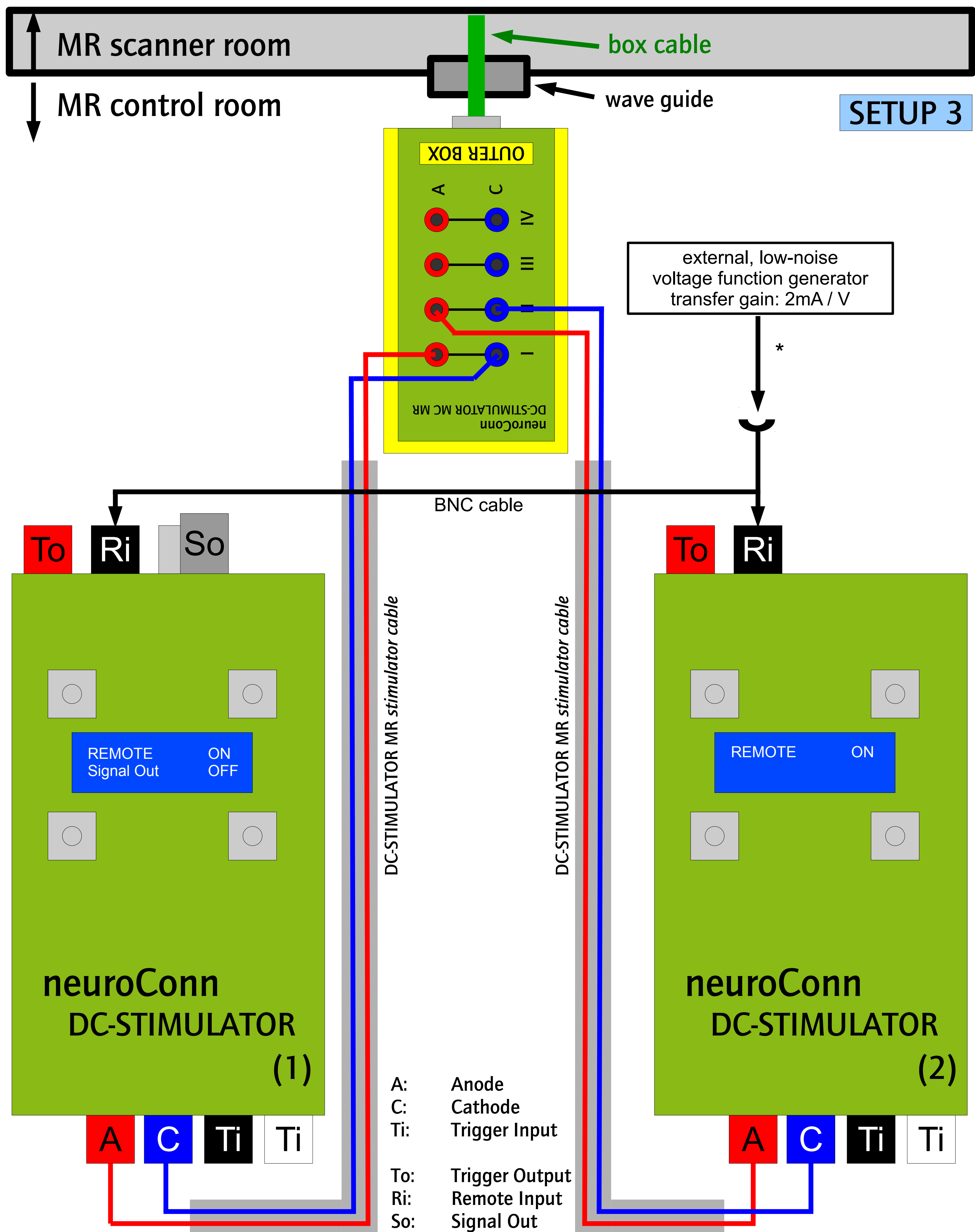
MR scanner room

MR control room

box cable

wave guide

SETUP 1

OUTER BOX

A   C

IV

III

II

I

neuroConn
DC-STIMULATOR MC MR

To   Ri   So

REMOTE   OFF
Signal Out   OFF

DC-STIMULATOR MR *stimulator cable*

DC-STIMULATOR MR *stimulator cable*

neuroConn
DC-STIMULATOR
(1)

To   Ri

REMOTE   OFF

neuroConn
DC-STIMULATOR
(2)

A   C   Ti   Ti

A   C   Ti   Ti

A: Anode
C: Cathode
Ti: Trigger Input

To: Trigger Output
Ri: Remote Input
So: Signal Out

external trigger signals
(BNC sockets)

Setup 1	
waveforms	waveforms from DC-Stimulator (tDCS, sinus, sinus (hw), sinus (w), pulse, noise, noise LF, noise HF)
channel waveforms:	different or common waveforms for channel I and channel II
operating modes:	DC-Stimulator 1 (left): REMOTE OFF, Signal Out: OFF DC-Stimulator 2 (right): REMOTE OFF
start trigger:	usable, common or different trigger events for DC-Stimulator 1 and 2 trigger modes: disabled, single or repetitive
impedance check:	Channel I: double check (voltage and current), automatic stop if impedance exceeds limits, short acoustic warning, SAFE-STOP Channel II: double check (voltage and current), automatic stop if impedance exceeds limits, short acoustic warning, SAFE-STOP
clock drift:	existing
transfer gain:	–
phase delay:	–
stimulation time:	approximately 8 hours

Setup 2	
waveforms	waveforms from DC-Stimulator (tDCS, sinus, sinus (hw), sinus (w), pulse, noise, noise LF, noise HF)
channel waveforms:	common waveform for channel I and II
operating modes:	DC-Stimulator 1 (left): REMOTE OFF, Signal Out: ON DC-Stimulator 2 (right): REMOTE ON
start trigger:	usable, trigger events only for DC-Stimulator 1 trigger modes: disabled, single or repetitive
impedance check:	Channel I: double check (voltage and current), automatic stop if impedance exceeds limits, short acoustic warning, <u>SAFE-STOP</u> Channel II: simple overload check (voltage), permanent acoustic warning, no automatic stop if impedance exceeds limits, <u>no SAFE-STOP</u> ⚠ <u>The user is responsible for stimulation stop.</u>
clock drift:	NO
transfer gain:	$i_{DCS1}(t) = i_{DCS2}(t)$
phase delay:	small between channel I and channel II
stimulation time:	approximately 6 – 8 hours

MR scanner room

MR control room

box cable

wave guide

SETUP 3

OUTER BOX

A C

IV

III

II

I

neuroConn
DC-STIMULATOR MC MR

external, low-noise
voltage function generator
transfer gain: 2mA / V

*

BNC cable

To Ri So

To Ri

DC-STIMULATOR MR *stimulator cable*

DC-STIMULATOR MR *stimulator cable*

REMOTE   ON
Signal Out   OFF

REMOTE   ON

neuroConn
DC-STIMULATOR
(1)

neuroConn
DC-STIMULATOR
(2)

A C Ti Ti

A C Ti Ti

A: Anode
C: Cathode
Ti: Trigger Input

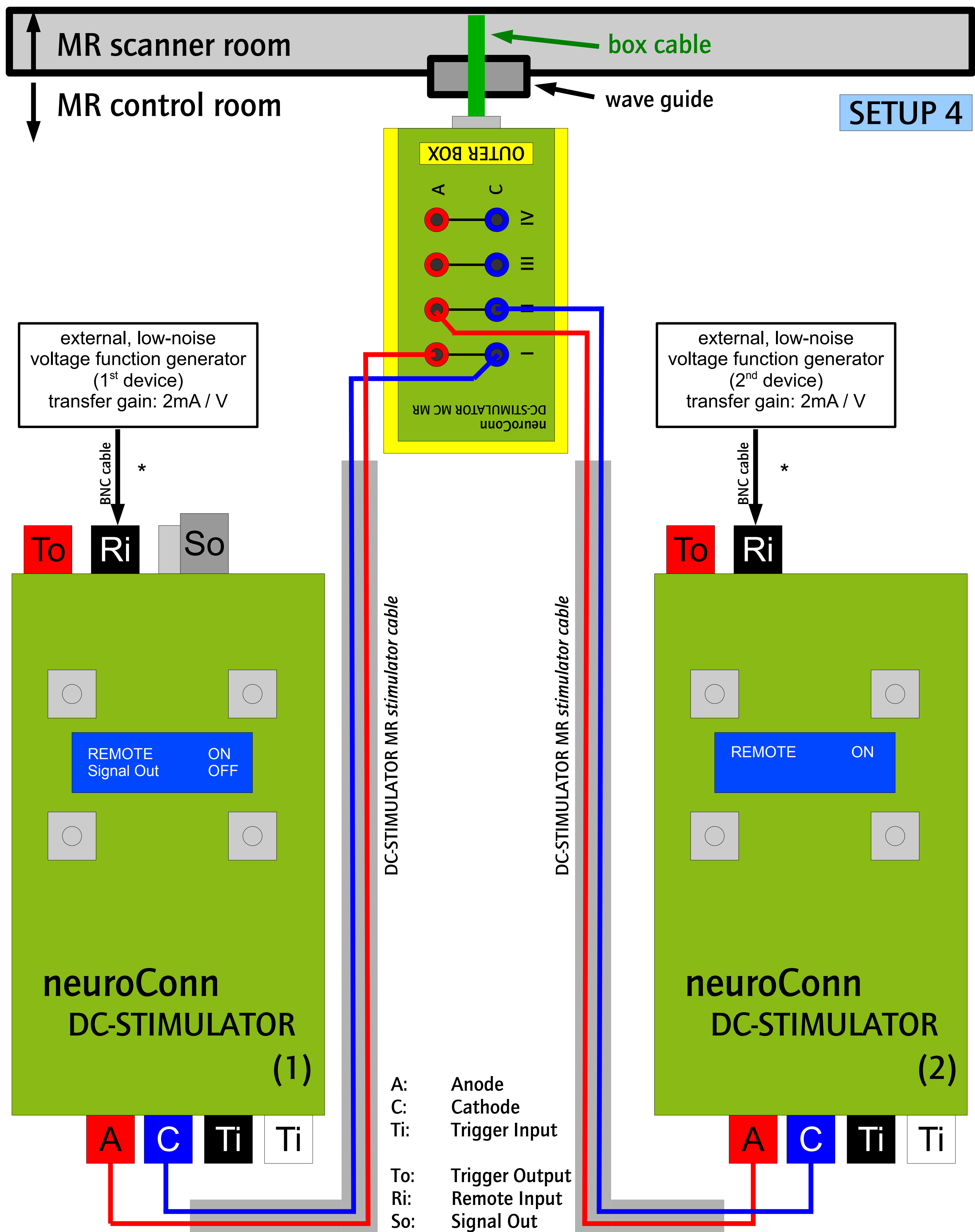To: Trigger Output
Ri: Remote Input
So: Signal Out

* If necessary, use the neuroConn's DC-STIMULATOR filter cable (BNC) to increase signal-to-noise-ratio.
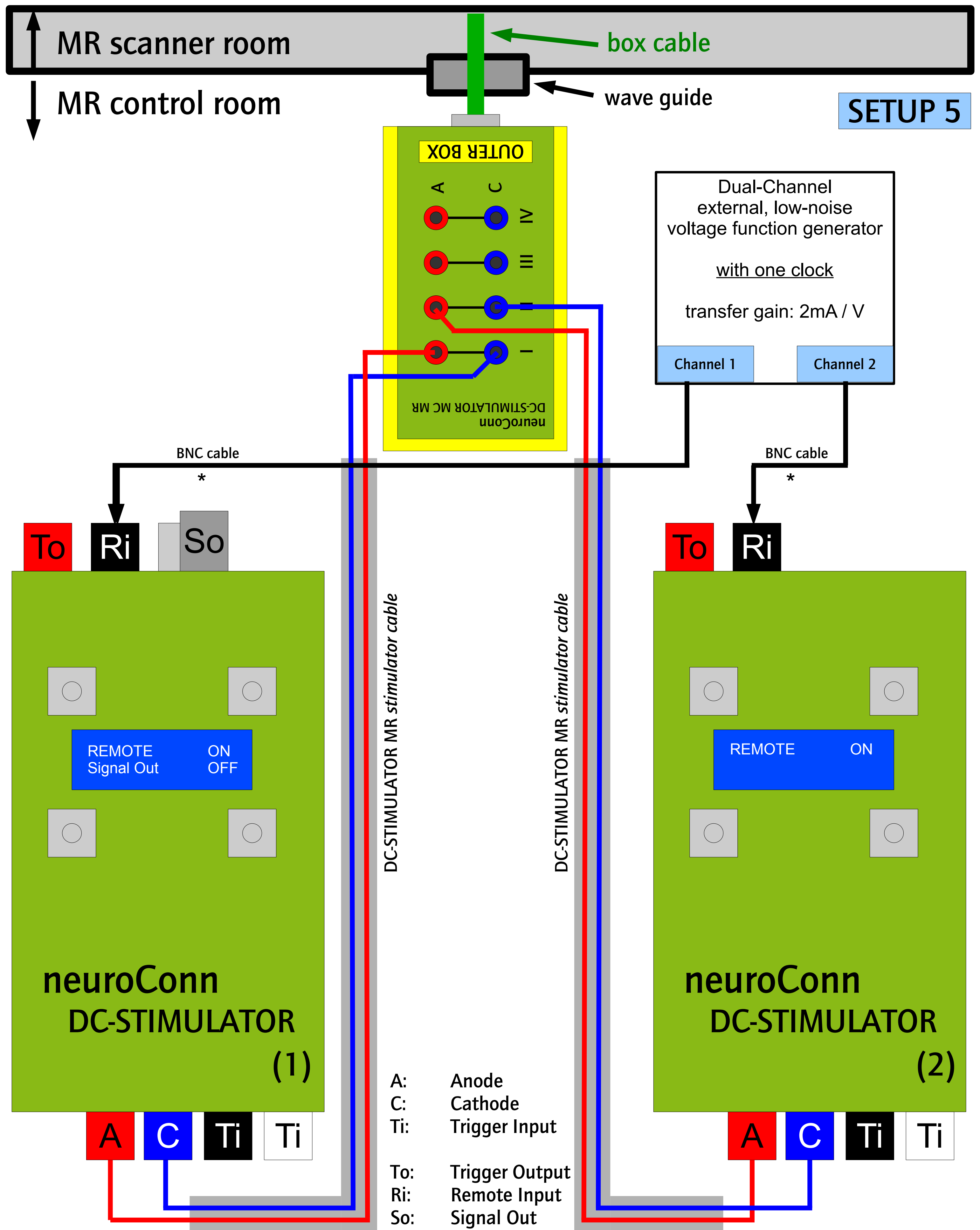
Setup 3	
waveforms	external waveform from low-noise voltage generator
channel waveforms:	common waveform for channel I and II
operating modes:	DC-Stimulator 1 (left): REMOTE ON, Signal Out: OFF DC-Stimulator 2 (right): REMOTE ON
start trigger:	not usable start trigger should be connected to external voltage generator
impedance check:	Channel I: simple overload check (voltage), permanent acoustic warning, no automatic stop if impedance exceeds limits, no SAFE-STOP ⚠ The user is responsible for stimulation stop. Channel II: simple overload check (voltage), permanent acoustic warning, no automatic stop if impedance exceeds limits, no SAFE-STOP ⚠ The user is responsible for stimulation stop.
clock drift:	NO
transfer gain:	2 mA / V
phase delay:	NO
stimulation time:	approximately 6 – 8 hours

MR scanner room

MR control room

box cable

wave guide

SETUP 4

OUTER BOX

A   C

IV

III

II

I

neuroConn
DC-STIMULATOR MC MR

external, low-noise
voltage function generator
(1st device)
transfer gain: 2mA / V

external, low-noise
voltage function generator
(2nd device)
transfer gain: 2mA / V

BNC cable   *

BNC cable   *

To   Ri   So

To   Ri

DC-STIMULATOR MR *stimulator cable*

DC-STIMULATOR MR *stimulator cable*

REMOTE   ON
Signal Out   OFF

REMOTE   ON

neuroConn
DC-STIMULATOR
(1)

neuroConn
DC-STIMULATOR
(2)

A   C   Ti   Ti

A   C   Ti   Ti

A: Anode
C: Cathode
Ti: Trigger Input

To: Trigger Output
Ri: Remote Input
So: Signal Out

* If necessary, use the neuroConn's DC-STIMULATOR filter cable (BNC) to increase signal-to-noise-ratio.

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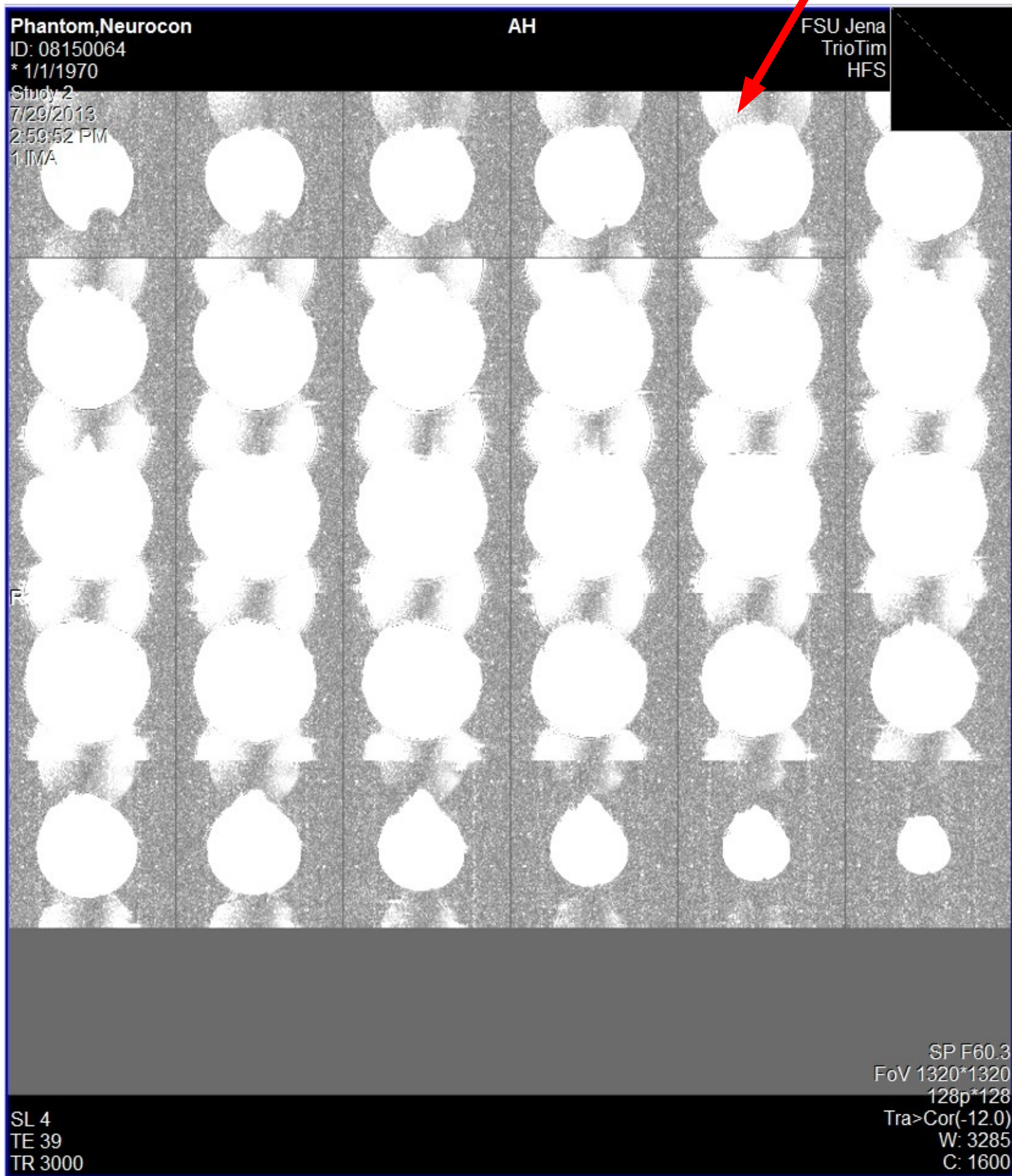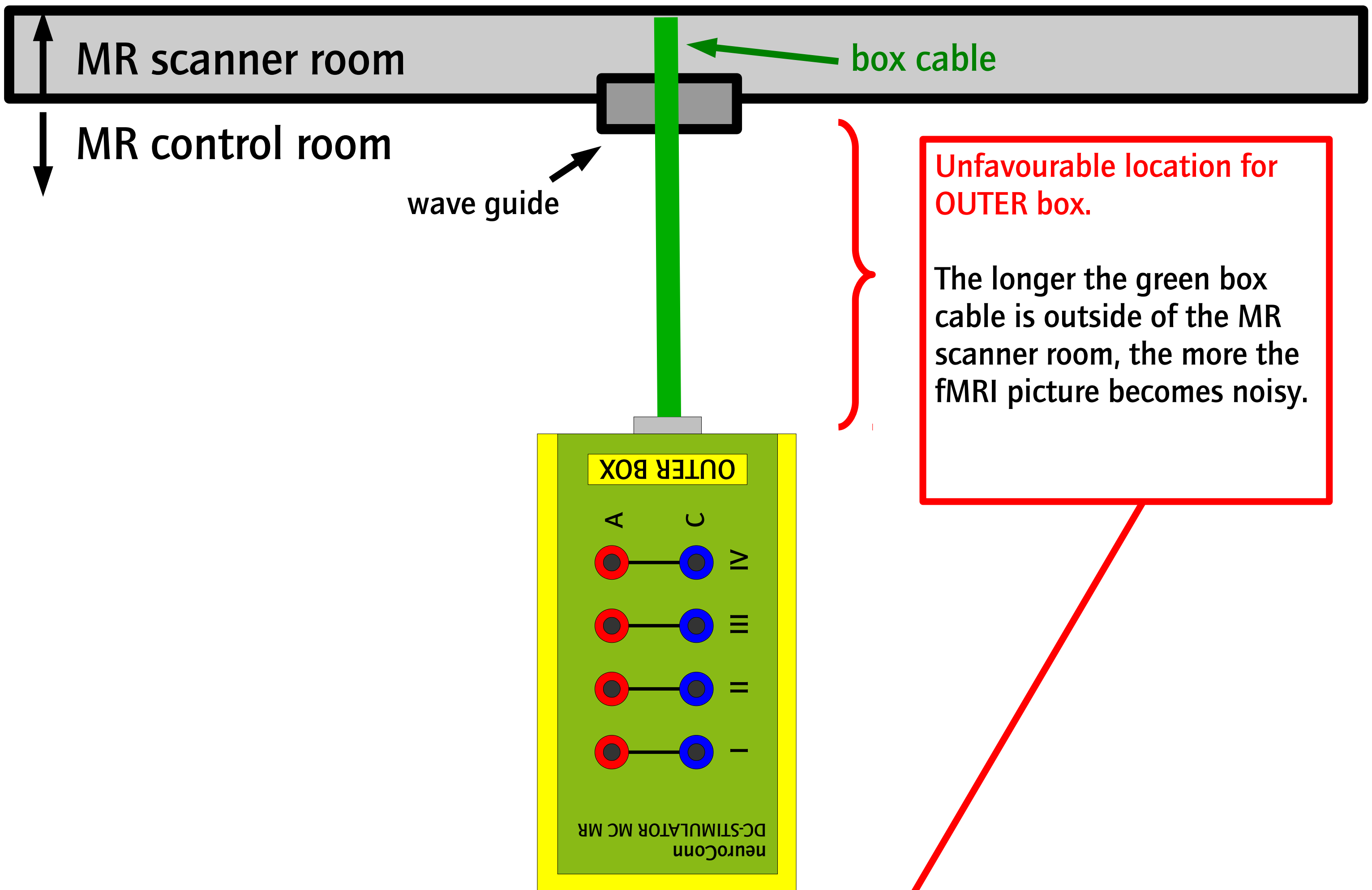
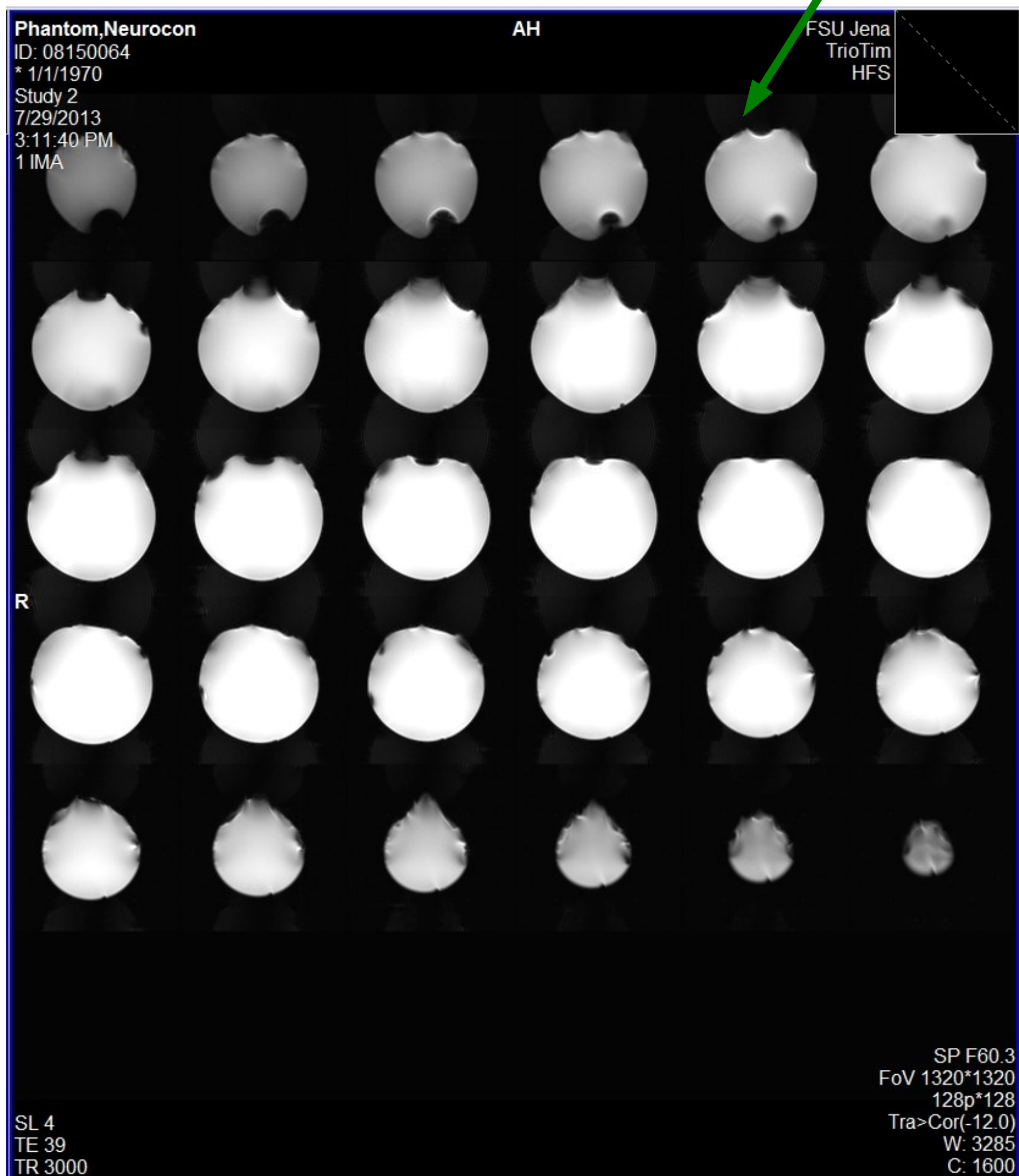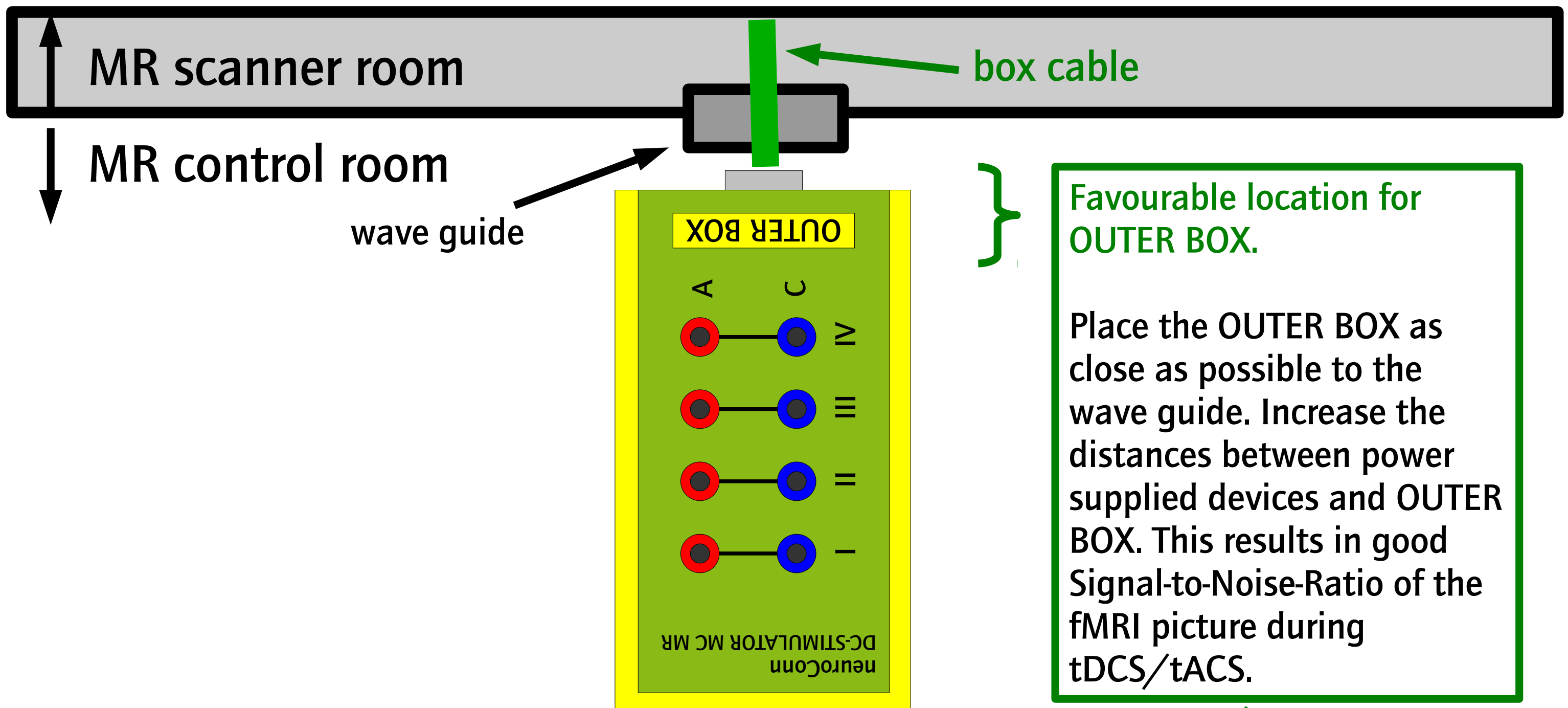| Setup 4	
waveforms	external waveform from low-noise voltage generator
channel waveforms:	common or different waveforms for channel I and II
operating modes:	DC-Stimulator 1 (left): REMOTE ON, Signal Out: OFF DC-Stimulator 2 (right): REMOTE ON
start trigger:	not usable <u>start trigger should be connected to external voltage generator</u>
impedance check:	Channel I: simple overload check (voltage), acoustic warning, no automatic stop if impedance exceeds limits, <u>no SAFE-STOP</u> ⚠ <u>The user is responsible for stimulation stop.</u> Channel II: simple overload check (voltage), acoustic warning, no automatic stop if impedance exceeds limits, <u>no SAFE-STOP</u> ⚠ <u>The user is responsible for stimulation stop.</u>
clock drift:	existing with two waveform generators, not-existing with dual-channel waveform generators
transfer gain:	2 mA / V
phase delay:	depending on waveform generators
stimulation time:	approximately 6 – 8 hours

MR scanner room

MR control room

box cable

wave guide

SETUP 5

OUTER BOX

A   C

IV

III

II

I

neuroConn
DC-STIMULATOR MC MR

Dual-Channel
external, low-noise
voltage function generator

with one clock

transfer gain: 2mA / V

Channel 1   Channel 2

BNC cable

*

BNC cable

*

To   Ri   So

To   Ri

REMOTE   ON
Signal Out   OFF

REMOTE   ON

DC-STIMULATOR MR *stimulator cable*

DC-STIMULATOR MR *stimulator cable*

neuroConn
DC-STIMULATOR
(1)

neuroConn
DC-STIMULATOR
(2)

A: Anode
C: Cathode
Ti: Trigger Input

To: Trigger Output
Ri: Remote Input
So: Signal Out

A   C   Ti   Ti

A   C   Ti   Ti

* If necessary, use the neuroConn's DC-STIMULATOR filter cable (BNC) to increase signal-to-noise-ratio.

Setup 5	
waveforms	external waveform from low-noise voltage generator
channel waveforms:	common or different waveforms for channel I and II
operating modes:	DC-Stimulator 1 (left): REMOTE ON, Signal Out: OFF DC-Stimulator 2 (right): REMOTE ON
start trigger:	not usable start trigger should be connected to external voltage generator
impedance check:	Channel I: simple overload check (voltage), acoustic warning, no automatic stop if impedance exceeds limits, no SAFE-STOP ⚠ The user is responsible for stimulation stop. Channel II: simple overload check (voltage), acoustic warning, no automatic stop if impedance exceeds limits, no SAFE-STOP ⚠ The user is responsible for stimulation stop.
clock drift:	not-existing with dual-channel waveform generators (derived from one clock)
transfer gain:	2 mA / V
phase delay:	depending on waveform generators
stimulation time:	approximately 6 – 8 hours

MR scanner room

box cable

MR control room

wave guide

Unfavourable location for OUTER box.

The longer the green box cable is outside of the MR scanner room, the more the fMRI picture becomes noisy.

OUTER BOX

A   C

IV

III

II

I

neuroConn DC-STIMULATOR MC MR

Phantom,Neurocon
ID: 08150064
* 1/1/1970
Study 2
7/29/2013
2:59:52 PM
1 IMA

AH

FSU Jena
TrioTim
HFS

R

SP F60.3
FoV 1320*1320
128p*128
Tra>Cor(-12.0)
W: 3285
C: 1600

SL 4
TE 39
TR 3000

MR scanner room

MR control room

box cable

wave guide

OUTER BOX

neuroConn DC-STIMULATOR MC MR

A   C

IV

III

II

I

Phantom,Neurocon
ID: 08150064
* 1/1/1970
Study 2
7/29/2013
3:11:40 PM
1 IMA

AH

FSU Jena
TrioTim
HFS

R

SP F60.3
FoV 1320*1320
128p*128
Tra>Cor(-12.0)
W: 3285
C: 1600

SL 4
TE 39
TR 3000

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