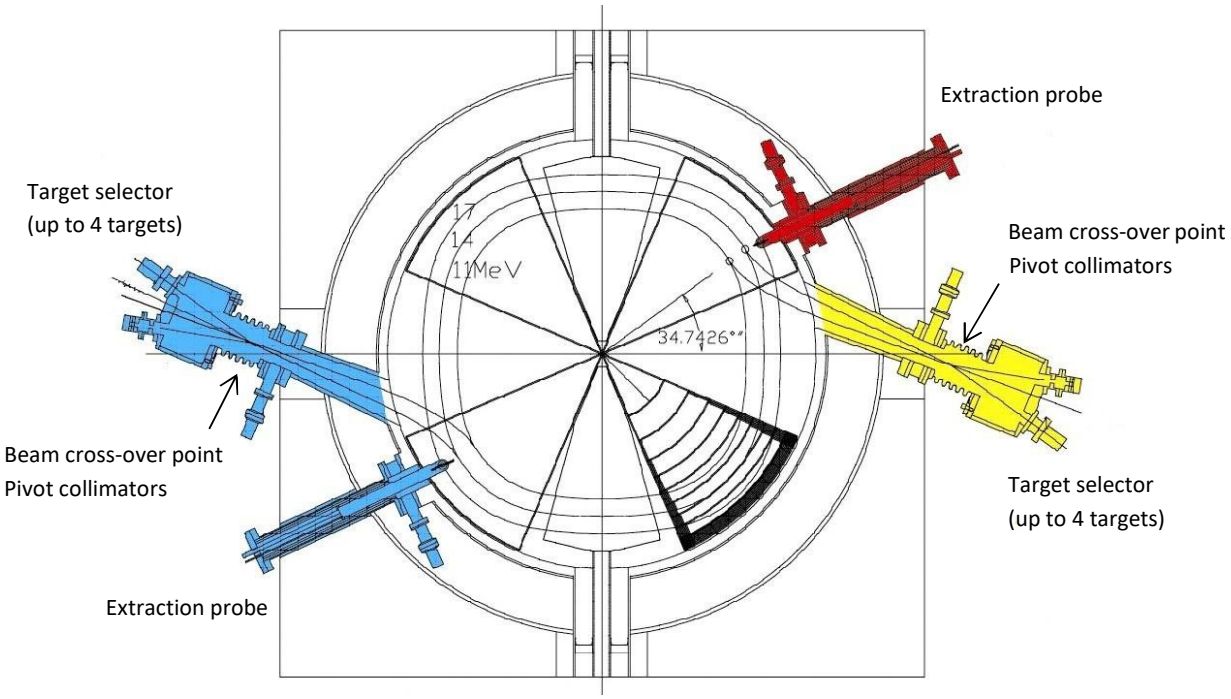
Beam extraction and target irradiation on the TR-19 cyclotron

1.9 nr.

T he TR-19 cyclotron is equipped with two beam extractors, 180º apart, so that two beams can be extracted simultaneously. Extraction is achieved by stripping of the electrons off the hydrogen ions using a thin-film pyrolytic carbon foil.



Each extractor can be moved radially to intercept beam of different energy, 14 MeV to 19 MeV, and divert stripped H^+ to the extraction ports. The tip of the extractor moves azimuthally to compensate for the change of the extracted beam angleand steers beam through a set of graphite collimators at the cross-over point in the target selector. Extractors move independently and precisely, allowing extraction of beams with beam currents variable in ratios from 1:99 to 50:50 at a full range of variable energy of 14 MeV to 19 MeV. The nominal energy of the two extracted beam must be the same.

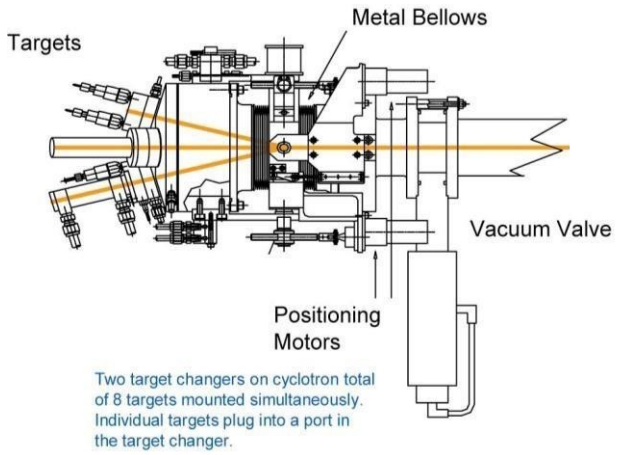
Multi-position target selector:

Each of the two external beamports on the TR-19 has a multi-position target selector. There are two models of target selectors available; with 3 or 4 target ports. The three-port selector is more suitable for custom targets or multiple, bulkier, targets (solid target), while the four-port selector can accommodate more conventional targets, such as C-11 gas or F-18 water targets. The target selector allows the cyclotron Operator to select one of four different targets on each of the beamports to be irradiated at any particular moment, permitting the Operator to select between eight different targets. The multi-position target selector and target assembly permits the use of liquid, solid and gas targets.

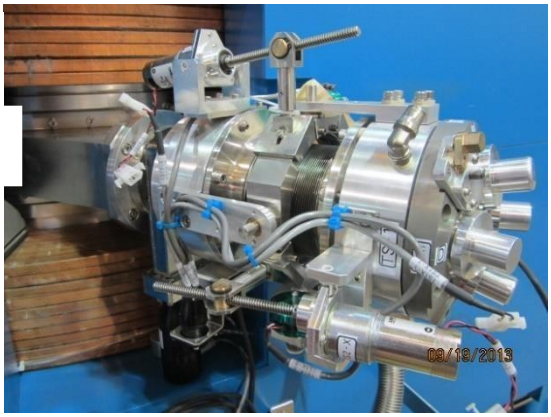
The multi-position target selectors are made primarily from aluminum and with a minimum of stainless-steel to minimize neutron activation. The target selector consists of a pivoting vacuum box with target mounting flanges on the periphery. The target selectors are complete with pivot frame, stainless-steel bellows, electro-mechanical operating mechanisms, read-backs for target position, current reading connector and a vacuum roughing port.

3.1;3.6 nr The positioning of targets by the multi-position target selector can be done either automatically by the Computer Control System, or by the Operator. The Computer Control System provides real-time control and monitoring of the targets and the target selector, including position and beam current on the target. Each target port is equipped with four-segment graphite collimators with beam current pick-up for each segment.

By pivoting target selector in two directions and maintaining required spill-ratio on each collimator segment system maintains a real time beam-target alignment. The TR-19 target selector is rated for 150 μA beam current continuous operation.



Two target changers on cyclotron total of 8 targets mounted simultaneously. Individual targets plug into a port in the target changer.

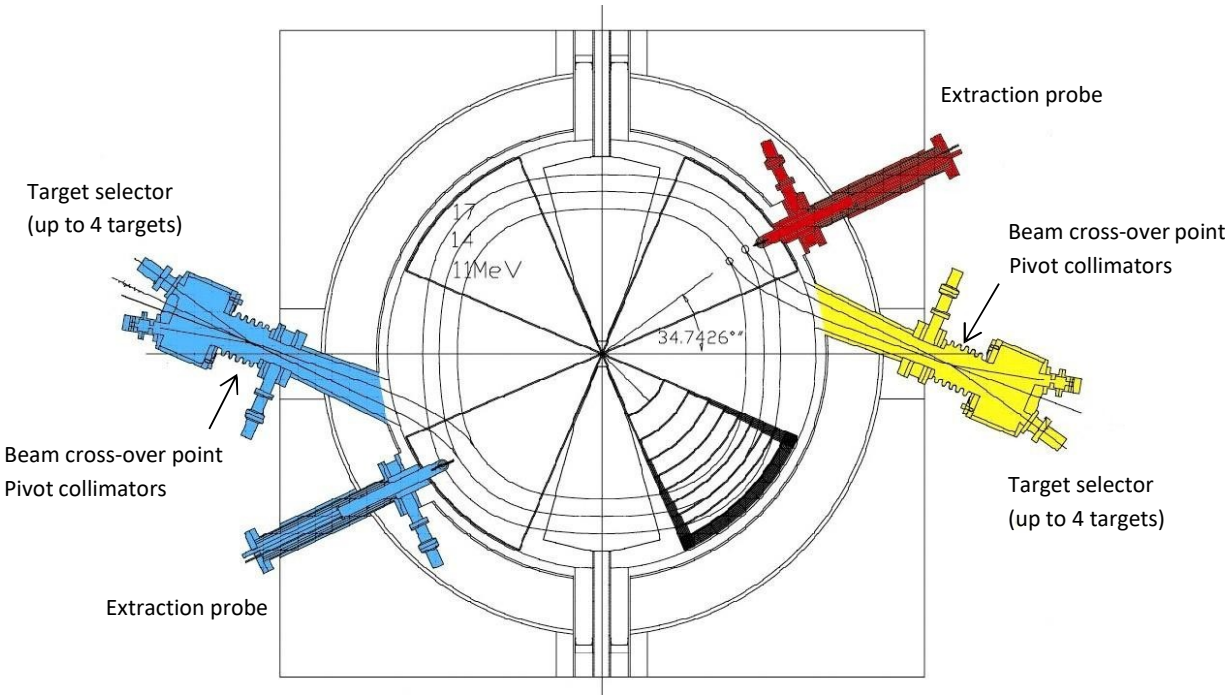


Each multi-position target selector and beamport can be isolated from the main vacuum tank by a vacuum isolation gate valve. The vacuum isolation valve allows the targets to be changed or maintenance to be done on the targets and target selectors without affecting the high vacuum in the main tank.

All multi-position target selector parameters are displayed in real-time by the Computer Control System. The Computer Control System provides the Operator with a Graphical User Interface which is easy to operate and user friendly. 3.1;3.6 nr

Beam extraction and target irradiation on the TR-19 cyclotron

1.9 nr. TR-19 ciklotronas turi du spindulių ištraukiklius, vienas nuo kito nutolusius 180º, kad būtų galima vienu metu ištraukti du spindulius. Extraction is achieved by stripping of the electrons off the hydrogen ions using a thin-film pyrolytic carbon foil.



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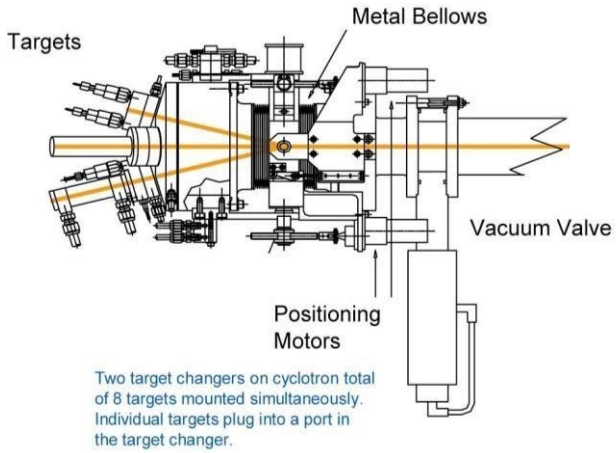
Multi-position target selector:

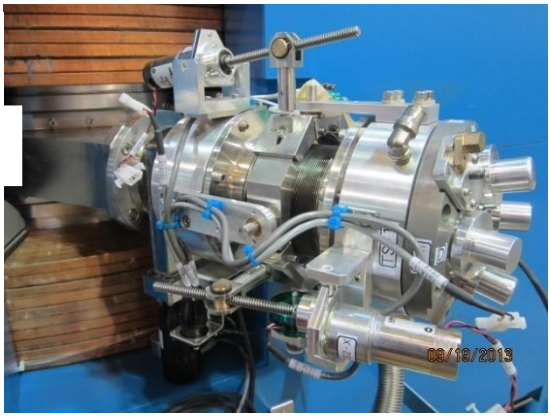
Each of the two external beamports on the TR-19 has a multi-position target selector. There are two models of target selectors available; with 3 or 4 target ports. The three-port selector is more suitable for custom targets or multiple, bulkier, targets (solid target), while the four-port selector can accommodate more conventional targets, such as C-11 gas or F-18 water targets. The target selector allows the cyclotron Operator to select one of four different targets on each of the beamports to be irradiated at any particular moment, permitting the Operator to select between eight different targets. The multi-position target selector and target assembly permits the use of liquid, solid and gas targets.

The multi-position target selectors are made primarily from aluminum and with a minimum of stainless-steel to minimize neutron activation. The target selector consists of a pivoting vacuum box with target mounting flanges on the periphery. The target selectors are complete with pivot frame, stainless-steel bellows, electro-mechanical operating mechanisms, read-backs for target position, current reading connector and a vacuum roughing port.

3.1;3.6 nr

Taikinių padėties nustatymą naudojant kelių padėčių taikinio parinktuvą gali automatiškai atlikti kompiuterio valdymo sistema arba operatorius. Kompiuterio valdymo sistema leidžia realiu laiku valdyti ir stebėti taikinius bei taikinio parinktuvą, įskaitant buvimo vietą ir spindulio srovę taikinyje. Kiekviename tiksliniame prievade yra įrengti keturių segmentų grafito kolimatoriai su kiekvieno segmento spindulio srovės imtuvu. By pivoting target selector in two directions and maintaining required spill-ratio on each collimator segment system maintains a real time beam-target alignment. The TR-19 target selector is rated for 150 μA beam current continuous operation.





3.1;3.6 nr.

Each multi-position target selector and beamport can be isolated from the main vacuum tank by a vacuum isolation gate valve. The vacuum isolation valve allows the targets to be changed or maintenance to be done on the targets and target selectors without affecting the high vacuum in the main tank.

Kompiuterio valdymo sistema realiu laiku rodo visus kelių padėčių taikinio parinktuvo parametrus. Kompiuterio valdymo sistema suteikia operatoriui grafinę vartotojo sąsają, kuri yra lengvai valdoma ir patogi vartotojui.

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.

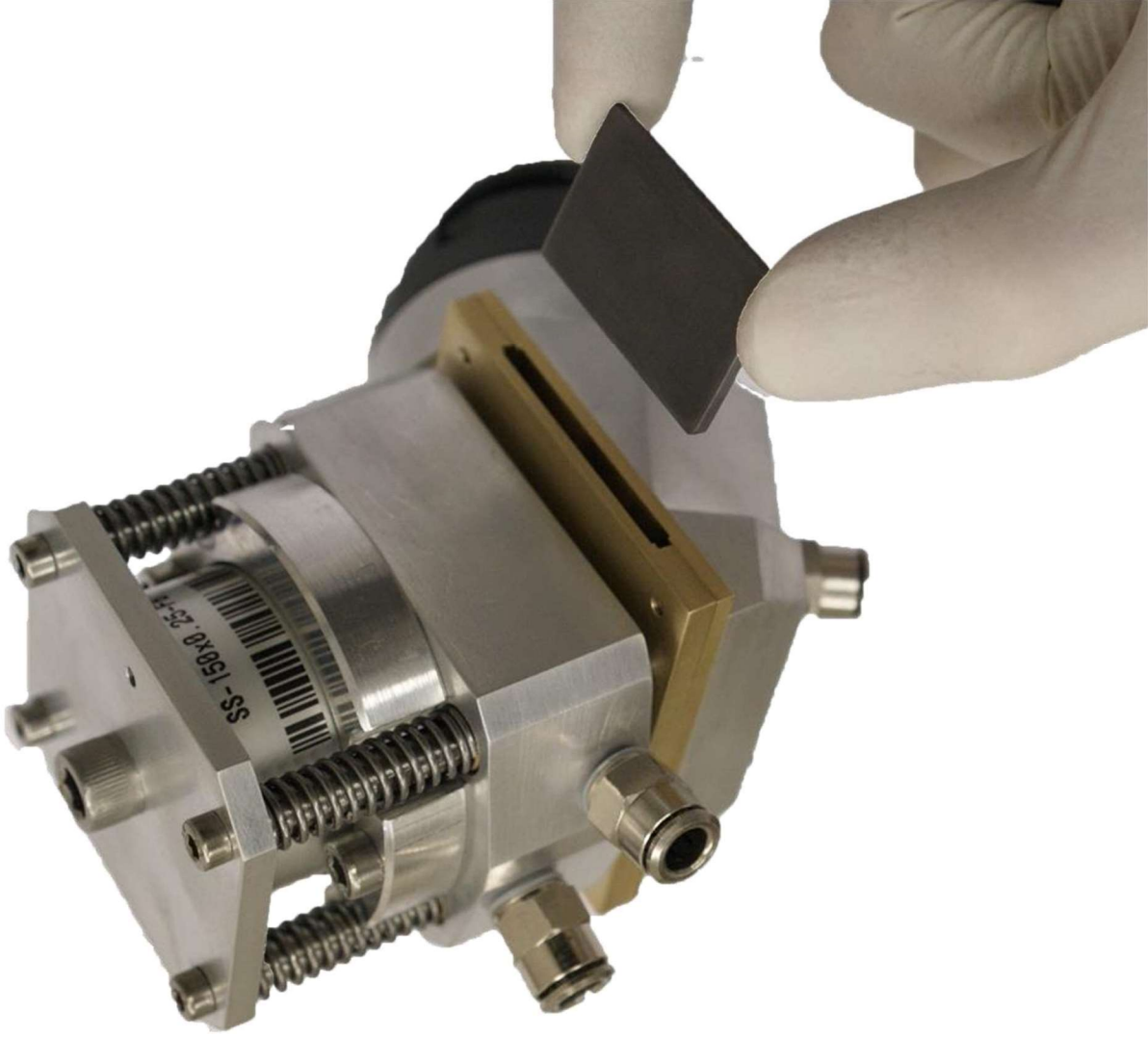
Vertėja
Translator / Переводчик
Goda Remeikaitė

AirV vertimų biuras

Šv. Stepono 7/Raugyklos g. 4A,
LT-01139, Vilnius
Tel./faks.: +370 5 2122496, +370 5 2310179
Mob. tel. +370 612 73093
El. paštas vilnius@airv.lt

Savanorių pr. 204/Taikos pr. 2,
LT-50187, Kaunas
Tel./faks.: +370 37 313455, 313258
Mob. tel. +370 650 51544
El. paštas kaunas@airv.lt

Taikos pr. 29,
LT-91145, Klaipėda
Tel./faks. +370 46 210588
Mob. tel. +370 650 58996
El. paštas klaipeda@airv.lt

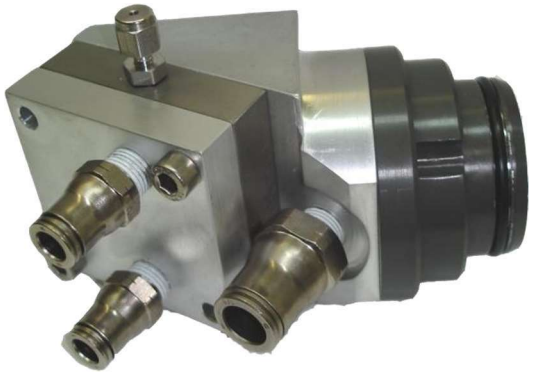


ADVANCED CYCLOTRON SYSTEMS

Outperforming the field

^{18}F - target and transfer system

1.3 nr.



^{18}F - target 5.1 nr.

TARGET TECHNICAL SPECIFICATIONS

Target made of aluminum and niobium
Havar window foil

4 nr. papildomai

Small Target (SMT):
Volume: 1.8 mL
Operating current: 55-65 µA
Max Current: 80 µA

Standard Target (STT):
Volume: 2.5 mL
Operating current: 70-80 µA
Max Current: 100 µA

Large target (LT):
Volume: 4.0 mL
Operating current: 80-100 µA
Max Current: 150 µA

Cooling: water, 3-6 lpm & helium, 50-100 slpm

Nuclear reaction: ^{18}O(p,n)^{18}F
Target material: ^{18}O-water, >97% enrichment
Target product: $^{18}F^-$

Yield (dua irradiatior	SMT (Ci)	STT (Ci	LT (C
1 h typical	8	10	13
1 h ma	10	12	16
2 h typica	14	17	24
2 h max			

3.1-3.3 papildomai

^{18}F- transfer system

^{18}F/^{13}N LIQUID TRANSFER SYSTEM

The same systems is used to transfer $^{18}F^-$ or $^{13}NH_4OH$

2 papildomai

Features:

Pressure monitoring
Air actuated rotary valves
Uses syringes for target loading
Uses He or N_2 gas for irradiated water bolus delivery

Dimensions:

Syringe panel: 56 x 32 x 10 cm
4-Valve transfer box: 41 x 30 x 10 cm or
Two transfer boxes: each 30 x 25 x 10 cm
Transfer box is mounted inside the vault, close to the target

Weight: 6 kg

Connections:

Quick connect and Swagelok fittings
Requires compressed air supply for valve operation

Process control options:

Integrated with cyclotron control system
Integrated with chemistry control system

1.3;5.1 nr.

^{13}N - target and transfer system

^{13}N - standard target

^{13}N – large target

TARGET TECHNICAL SPECIFICATIONS

Target made of aluminum (standard) or aluminum and niobium (large)
Havar window foil

Standard Target (STT): 4 nr. papildomai

Volume: 1.8 mL
Operating current: ~35 µA
Max Current: 40 µA

Large Target (LT):

Volume: 2.5 mL
Operating current: ~80 µA
Max Current: 100 µA

Cooling: water, 3-5 lpm & helium, 50-100 slpm
Nuclear reaction: $^{16}O(p,\alpha)^{13}N$
Target material: 3-7 mmol EtOH in water
Target product: $^{13}NH_4OH$

Yield (EOB)	STT (mCi)	LT (mCi)
20 min irradiation	300 3.7 papildomai	1000

1.3;5.1 nr.

^{11}C - target and transfer system

^{11}C - target

TARGET TECHNICAL SPECIFICATIONS

Target made of aluminum
Havar window foil

$^{11}CO_2$-Target: 5.1nr.

Volume: 58 mL
Length: 187 mm
Start Diameter: 12 mm
End Diameter: 26 mm
Operating current: 30-40 µA
Max Current: 50 µA

$^{11}CH_4$-Target: 5.1nr.

Volume: 94 mL
Length: 187 mm
Diameter: 25.4 mm
Operating current: 30-40 µA
Max Current: 50 µA

Cooling: water, 3-5 lpm & helium, 50-100 slpm

Nuclear reaction: $^{14}N(p,\alpha)^{11}C$
Target material: (2-5% H_2/N_2) / (0.1-0.5% O_2/N_2)
Target product: $^{11}CH_4$ / $^{11}CO_2$

Target	Yield (EOB) 30 min irradiation /Ci
$^{11}CO_2$	4.0
$^{11}CH_4$	1.5

3.4-3.5 papildomai

Typical specific activity: 2-20 Ci/µmol

^{11}C and ^{15}O (continuous production) transfer systems

Target transfer system features:
Pressure monitoring
High pressure valves and flow regulators
RF shielded
Uses helium gas for target purging and transfer of product to the hotcell
2 nr. papildomas

Dimensions:
Transfer box: 30 x 25 x 10 cm
Mounts inside the vault, close to the target

Weight:
5 kg

Connections:
Standard Swagelok fittings
Requires compressed air supply for valve operation

Process control options:
Integrated with cyclotron control system
Integrated with chemistry control system

1.3 nr.

^{15}O - target and transfer system

^{15}O – target 5.1nr.

TARGET TECHNICAL SPECIFICATIONS

Target made of aluminum
Havar window foil

Volume: 26 mL
Length: 138 mm
Diameter: 15.5 mm
Operating current: 20-25 µA
Max Current: 25 µA

Process:
Irradiation time continuous
Process time continuous

Cooling: water, 3-5 lpm & helium, 50-100 slpm

Nuclear reactions: $^{15}N(p,n)^{15}O$
Target material: $^{15}N_2/O_2$(<1%) gas mixture
Target product: $[^{15}O]O_2$ gas

Yi eld: ≥ 3 GBq/min at the transfer system exit

3.8 papildomai

Manual loading of the target disk in the target holder; pneumatic release of target into lead container

Target materials:
^{64}Ni, ^{68}Zn, ^{76}Se,^{89}Y,
^{123}Te, ^{124}Te, ^{111}Cd, ^{100}Mo

Target Preparation:
Electroplating
Deposition
Melting
High Pressure Pelletization
Electrophoresis

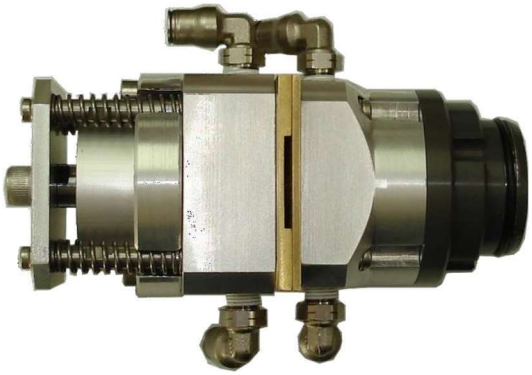
Solid targets 6.1 nr.

30° solid target holder for solid target

TARGET TECHNICAL SPECIFICATIONS

Operating current: 40-90 µA
Max Current: 100 µA

Target plate size: 24 mm x 40 mm x 2 mm
Effective target size: 10.5 mm x 20.5 mm ellipse



90° solid target holder for solid targets

TARGET TECHNICAL SPECIFICATIONS

Operating current: 20-70 µA
Max current: 80 µA

Target disk size: Ø 24 mm x 2 mm
Effective target size: Ø 10 mm

Manual loading of the target disk in the target holder; pneumatic release of target into lead container

Automated pneumatic transfer system is available from a 3rd party supplier

Target products:

^{64}Cu, ^{67}Ga, ^{68}Ga, ^{76}Br, ^{89}Zr

^{123}I, ^{124}I, ^{111}In, ^{99m}Tc

Target Processing:

Extraction by distillation Acid dissolution
Basic dissolution Evaporation
Ion exchange purification

1.3;5.1 nr.

Solution target for ^{68}Gaproduction

3.6 nr.

Irradiation time	^{68}Ga**, GBq
30 min	3
1 h	5
2 h	8

TARGET TECHNICAL SPECIFICATIONS

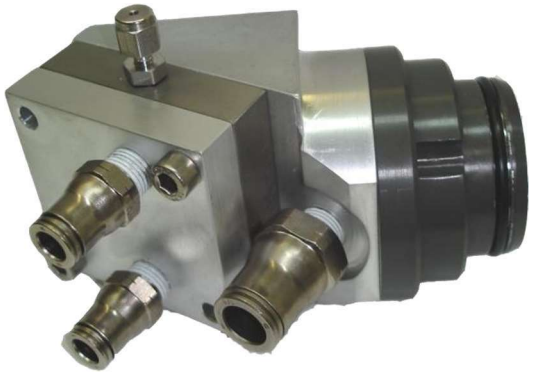
Target made of aluminum and niobium Havar window foil

Volume: 4 mL
Operating current: 20-35 µA
Max Current: 40 µA

Nuclear reaction:

^{18}F - taikinio ir perdavimo sistema

1.3 nr.



^{18}F - target 5.1 nr.

TARGET TECHNICAL SPECIFICATIONS

Target made of aluminum and niobium
Havar window foil

Small Target (SMT):
Volume: 1.8 mL
Operating current: 55-65 µA
Max Current: 80 µA

Standard Target (STT):
Volume: 2.5 mL
Operating current: 70-80 µA
Max Current: 100 µA

Large target (LT):
Volume: 4.0 mL
Operating current: 80-100 µA
Max Current: 150 µA

Cooling: water, 3-6 lpm & helium, 50-100 slpm

Nuclear reaction: $^{18}O(p,n)^{18}F$
Target material: ^{18}O-water, >97% enrichment
Target product: $^{18}F^-$

I šeiga (dvigubas švitinimas)	SMT (Ci)	STT (Ci)	LT (Ci)
1 val. tipiškai	8	10	13
1 val. maksimaliai	10	12	16
2 val. tipiškai	14	17	24
2 val. maksimaliai	18	20	30

^{18}F- transfer system

$^{18}F/^{13}N$ SKYSČIŲ PERDAVIMO SISTEMA

Tos pačios sistemos yra naudojamos perduoti $^{18}F^-$ arba $^{13}NH_4OH$

Features:

Pressure monitoring
Air actuated rotary valves
Uses syringes for target loading
Uses He or N_2 gas for irradiated water bolus delivery

Dimensions:

Syringe panel: 56 x 32 x 10 cm
4-Valve transfer box: 41 x 30 x 10 cm or
Two transfer boxes: each 30 x 25 x 10 cm
Transfer box is mounted inside the vault, close to the target

Weight: 6 kg

Connections:

Quick connect and Swagelok fittings
Requires compressed air supply for valve operation

Process control options:

Integrated with cyclotron control system
Integrated with chemistry control system

1.3;5.1 nr.

^{13}N - taikinio ir perdavimo sistema

^{13}N - standard target

^{13}N – large target

TARGET TECHNICAL SPECIFICATIONS

Target made of aluminum (standard) or
aluminum and niobium (large)
Havar window foil

Standard Target (STT):

Volume: 1.8 mL
Operating current: ~35 µA
Max Current: 40 µA

Large Target (LT):

Volume: 2.5 mL
Operating current: ~80 µA
Max Current: 100 µA

Cooling: water, 3-5 lpm & helium, 50-100 slpm
Nuclear reaction: $^{16}O(p,\alpha)^{13}N$
Target material: 3-7 mmol EtOH in water
Target product: $^{13}NH_4OH$

Yield (EOB)	STT (mCi)	LT (mCi)
20 min irradiation	300	1000

1.3;5.1 nr.

^{11}C - taikinio ir perdavimo sistema

^{11}C - target

TARGET TECHNICAL SPECIFICATIONS

Target made of aluminum
Havar window foil

$^{11}CO_2$-taikinys: 5.1nr.

Volume: 58 mL
Length: 187 mm
Start Diameter: 12 mm
End Diameter: 26 mm
Operating current: 30-40 µA
Max Current: 50 µA

$^{11}CH_4$-taikinys: 5.1nr.

Volume: 94 mL
Length: 187 mm
Diameter: 25.4 mm
Operating current: 30-40 µA
Max Current: 50 µA

Cooling: water, 3-5 lpm & helium, 50-100 slpm

Nuclear reaction: $^{14}N(p,\alpha)^{11}C$
Target material: (2-5% H_2/N_2) / (0.1-0.5% O_2/N_2)
Target product: $^{11}CH_4$ / $^{11}CO_2$

Target	Yield (EOB) 30 min irradiation /Ci
$^{11}CO_2$	4.0
$^{11}CH_4$	1.5

Typical specific activity: 2-20 Ci/µmol

^{11}C ir ^{15}O (nepertraukiamos gamybos) perdavimo sistemos

Target transfer system features:
Pressure monitoring
High pressure valves and flow regulators
RF shielded
Naudoja helio dujas tiksliniam valymui ir produkto pernešimui į kaitinimo elementą

Dimensions:
Transfer box: 30 x 25 x 10 cm
Mounts inside the vault, close to the target

Weight:
5 kg

Connections:
Standard Swagelok fittings
Requires compressed air supply for valve operation

Process control options:
Integrated with cyclotron control system
Integrated with chemistry control system

1.3 nr.

^{15}O - taikinio ir perdavimo sistema

^{15}O – target 5.1nr.

TARGET TECHNICAL SPECIFICATIONS

Target made of aluminum
Havar window foil

Volume: 26 mL
Length: 138 mm
Diameter: 15.5 mm
Operating current: 20-25 µA
Max Current: 25 µA

Process:
Irradiation time continuous
Process time continuous

Cooling: water, 3-5 lpm & helium, 50-100 slpm

Nuclear reactions: $^{15}N(p,n)^{15}O$
Target material: $^{15}N_2/O_2$(<1%) gas mixture
Target product: $[^{15}O]O_2$ gas

Yield: ≥ 3 GBq/min at the transfer system exit

Manual loading of the target disk in the target holder; pneumatic release of target into lead container

Target materials:
^{64}Ni, ^{68}Zn, ^{76}Se,^{89}Y,
^{123}Te, ^{124}Te, ^{111}Cd, ^{100}Mo

Target Preparation:
Electroplating
Deposition
Melting
High Pressure Pelletization
Electrophoresis

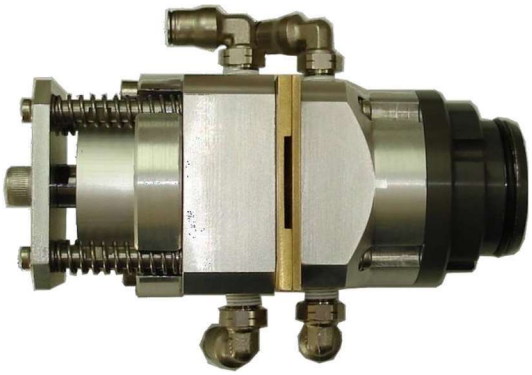
Kieti taikiniai 6.1 nr.

30° solid target holder for solid target

TARGET TECHNICAL SPECIFICATIONS

Operating current: 40-90 µA
Max Current: 100 µA

Target plate size: 24 mm x 40 mm x 2 mm
Effective target size: 10.5 mm x 20.5 mm ellipse



90° solid target holder for solid targets

TARGET TECHNICAL SPECIFICATIONS

Operating current: 20-70 µA
Max current: 80 µA

Target disk size: Ø 24 mm x 2 mm
Effective target size: Ø 10 mm

Manual loading of the target disk in the target holder;
pneumatic release of target into lead container

Automated pneumatic transfer system is available
from a 3rd party supplier

Target products:

^{64}Cu, ^{67}Ga, ^{68}Ga, ^{76}Br, ^{89}Zr

^{123}I, ^{124}I, ^{111}In, ^{99m}Tc

Target Processing:

Extraction by distillation
Acid dissolution
Basic dissolution
Evaporation
Ion exchange purification

1.3;5.1 nr.

Tikslinės ^{68}Gagamybos sprendimas

TARGET TECHNICAL SPECIFICATIONS

Target made of aluminum and niobium
Havar window foil

Volume: 4 mL
Operating current: 20-35 µA
Max Current: 40 µA

Nuclear reaction:

$^{68}Zn(p,n)^{68}Ga$

Target material:

^{68}Zn nitrate solution, >99% enrichment

Target product:

^{68}Ga nitrate solution

Irradiation time	^{68}Ga**, GBq
30 min	3
1 h	5
2 h	8

^{68}Ga TRANSFER SYSTEM

Is based on $^{18}F^-$ transfer system. It uses He or N2 gas push gas for product delivery to the processing hotcell

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Vertimo tikrumą ir atitiktį originaliam tekstui liudiju.

UAB "AIRV" VILNIAUS SKYRIUS

Vertėja
Translator / Переводчик
Goda Remeikaitė

AirV vertimų biuras

Šv. Stepono 7/Raugyklos g. 4A,
LT-01139, Vilnius
Tel./faks.: +370 5 2122496, +370 5 2310179
Mob. tel. +370 612 73093
El. paštas vilnius@airv.lt

Savanorių pr. 204/Taikos pr. 2,
LT-50187, Kaunas
Tel./faks.: +370 37 313455, 313258
Mob. tel. +370 650 51544
El. paštas kaunas@airv.lt

Taikos pr. 29,
LT-91145, Klaipėda
Tel./faks. +370 46 210588
Mob. tel. +370 650 58996
El. paštas klaipeda@airv.lt

#150 - 7280 River Road
Richmond, British Columbia
V6X 1X5 Canada

phone 604.276.1493
toll-free 1.877.270.1493
fax 604.278.7230

Technical Specifications Sheet

Model	Switch Yard System	**Reference**	TGT-SWITCHYARD
Manufacturer	Advanced Cyclotron Systems Inc. (ACSI)	**Revision date**	2014-03-27

Description 5.4;5.5;5.6 nr.;

The Switch Yard System is designed for directing irradiated target material, liguid or gas, from targets (up to four) mounted on the cyclotron to different hot cells (up to six) in the customer's radiopharmaceutial production lab.

ACSI
EXPERIENCE. INGENUITY. PERFORMANCE.

#150 - 7280 River Road
Richmond, British Columbia
V6X 1X5 Canada

phone 604.276.1493
toll-free 1.877.270.1493
fax 604.278.7230

Dimensions:	
	30 x 25 x 10 cm

Weight:	
	4 kg

Features:	
	Mounts inside of vault Facilitates radioisotope delivery to several different hot cells 5.5;5.6 nr.

Connections:	
	Swagelok, Vici and IDEX 1/16” or 1/8” fittings Requires compressed air supply for valve operation

Process control options:	
	Intergrated with cyclotron control system

ACSI
EXPERIENCE. INGENUITY. PERFORMANCE.

#150 - 7280 River Road
Richmond, British Columbia
V6X 1X5 Canada

phone 604.276.1493
toll-free 1.877.270.1493
fax 604.278.7230

Technical Specifications Sheet

Model	Switch Yard System	**Reference**	TGT-SWITCHYARD
Manufacturer	Advanced Cyclotron Systems Inc. (ACSI)	**Revision date**	2014-03-27

Aprašymas 5.4;5.5;5.6 nr.;
Sistema „Switch Yard“ skirta nukreipti švitintą tikslinę medžiagą, skystį ar dujas nuo taikinių (iki keturių), pritvirtintų ant ciklotrono, iki skirtingų karštųjų kamerų (iki šešių) kliento radiofarmacijos gamybos laboratorijoje.

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V6X 1X5 Canada

phone 604.276.1493
toll-free 1.877.270.1493
fax 604.278.7230

Dimensions:	
	30 x 25 x 10 cm

Weight:	
	4 kg

Features:	
	Mounts inside of vault Palengvina radioaktyviųjų izotopų tiekimą į keletą skirtingų karštųjų kamerų 5.5;5.6 nr.

Connections:	
	Swagelok, Vici and IDEX 1/16” or 1/8” fittings Requires compressed air supply for valve operation

Process control options:	
	Intergrated with cyclotron control system

Vertimas atliktas vertimų biure „AIRV“, į. k. 134819573, Raugyklos g. 4ª / Šv. Stepono g. 7, Vilnius.
Vertimo tikrumą ir atitiktį originaliam tekstui liudiju.
.

Vertėja
Translator / Переводчик
Goda Remeikaitė

AirV vertimų biuras

Šv. Stepono 7/Raugyklos g. 4A,
LT-01139, Vilnius
Tel./faks.: +370 5 2122496, +370 5 2310179
Mob. tel. +370 612 73093
El. paštas vilnius@airv.lt

Savanorių pr. 204/Taikos pr. 2,
LT-50187, Kaunas
Tel./faks.: +370 37 313455, 313258
Mob. tel. +370 650 51544
El. paštas kaunas@airv.lt

Taikos pr. 29,
LT-91145, Klaipėda
Tel./faks. +370 46 210588
Mob. tel. +370 650 58996
El. paštas klaipeda@airv.lt

ADVANCED
CYCLOTRON SYSTEMS, INC.

TR-19 CYCLOTRON

The TR-19 Cyclotron is the most advanced PET cyclotron system currently available. The design and technologies that are incorporated in the system are highly evolved, and reflect the principle design philosophies of maximum yield, ease of operation, low operating costs and minimum radiation exposure.

The technological and scientific expertise to develop and build such an exceptional cyclotron comes from a technology transfer agreement between the Cyclotron Group at TRIUMF (Canada's National Laboratory for Particle and Nuclear Physics) and Ebco Industries, an Advanced Cyclotron Systems affiliated company.

TECHNOLOGY:

- Variable energy: 14 – 19 MeV proton beam
- Models: 150 µA, 200 µA and 300 µA proton

1.2 nr.
1.7 nr.
1 papildomas

- Deuteron acceleration capability (optional): up to 9 MeV deuteron energy. Deuteron option has limited, 150 µA, proton current
- Upgradeable in factory and on-site
- Modular: No need to open the main vacuum tank for maintenance of the ion source, extraction probes and targets
- Customizable beamlines

The design and capabilities of the TR-19 cyclotron, as well as a variety of targetry and beamlines allow for production of the entire range of PET isotopes, such as ^{18}F, ^{11}C, ^{13}N, ^{15}O, ^{89}Zr, etc, as well as some SPECT isotopes, such as ^{99m}Tc.

The TR-19's outstanding production capability and unique features have made this cyclotron the accelerator of choice for many leading research institutes and radiopharmaceutical distribution centers around the world.

TECHNICAL SPECIFICATIONS

1.2 nr.

The TR-19 is a variable energy, strong focusing, isochronous cyclotron with a main magnet designed for the acceleration of negatively charged hydrogen ions (H^-) to a maximum energy of 19 MeV, and capabilities of accelerating negatively charged deuterium ions (D^-) to a maximum energy of 9 MeV, when equipped with the deuteron option.

TR-19 TECHNICAL SPECIFICATIONS

Beam energy (Variable 1.2; 1.5;1.8 nr.

Minimum:	**14 MeV Proton operation, 7 MeV Deuteron operation**
Maximum:	**19 MeV Proton operation, 9 MeV Deuteron operation**

EXTRACTED CURRENTS

Total extracted current: protons available to 300 µA

Total extracted current: deuterons available to 50 µA

MAGNET

Orientation:	**Vertical**
Geometry:	**4 Sectors (closed)**
Hill angle:	**Variable 45º**
Average induction:	**1.2 Tesla**
Opening for access:	**1.0 m**

RF SYSTEM

Number of dees:	**2 (45º)**
Dee voltage:	**50 kV**
RF frequency:	**73 and 37 MHz**
Power required: 18 kW	
Energy per rev:	**200 keV**

ION SOURCE (External)

Type:	**H- multicusp**
Output current:	**3 mA (nominal), 4 mA (maximum)**
Bias voltage:	**25 - 30 kV**

VACUUM SYSTEM

Operating pressure:	**< 2 x 10^{-6} Torr**
Cryopumps:	**one 4,000 l/s (H_2O) each**

CONTROL SYSTEM 2;3;5.2 nr. **(Automated, Computer Controlled)**

Computer system:	**PC Windows based**
Controllers:	**Allen-Bradley Industrial PLC Modules**
Interface:	**Graphical User Interface**

ION SOURCE:

The TR-19 cyclotron uses a state of the art, high brightness, low emittance, external multi-cusp ion source that can provide H- beam current in excess of 4000 μA.

The extraction lenses show a unique configuration complete with plasma filter optimized for negative hydrogen ion extraction. The center electrode and inflector display a proprietary design, optimized for maximum beam transmission.

The Ion Source and Injection System, including all beam and magnet currents, component voltages, hydrogen gas flow and pressure, and temperature sensor readings, are monitored in real-time by the computerized Control System.

TR-19 ION SOURCE:

- External Multi-cusp ion source with current up to 4 mA.
- Very high brightness and high transmission.
- Ion source beam stop for diagnostics and safety.

RF SYSTEM:

The TR-19 Radio-Frequency (RF) system incorporates special and unique design features that make it the most compact cyclotron RF system in the world. The custom and proprietary technology of the RF System was developed for the TR series of cyclotrons by the TRIUMF RF Group, which has been designing, building and operating high powered RF systems for over 40 years.

The RF system on the TR-19 is an 18 kW, 73 MHz system. It is very stable and was specially designed with ease of operation and maintenance in mind. Proprietary to Advanced Cyclotron Systems are the special shape of the Dees which serve to reduce the capacitive losses due to edge effects, impedance and the attenuation interaction between the Dees and the Dee liners. The Dees geometry is optimized for a high quality factor, Q, and low power losses. The nominal Dee voltage is 50 kV. The Dees and Dee stems are water cooled as is the RF amplifier using flow and temperature controlled de-ionized water.

RF SYSTEM:

- 50 kV, 73 or 37 MHz, fourth or second harmonic operation
- 45º Dees for maximum beam stability and efficient transfer of RF power to beam power
- Interlocked with the computerized Control System to permit real-time control of the RF amplitude, frequency and phase.
- Fully automated, user friendly Graphical User Interface. Can also be operated in manual, local, as well as remote mode.

BEAM EXTRACTION:

The variable energy capability of the TR-19 is possible because of the specially designed extraction system, which allows the cyclotron operator to precisely control the radial position of the extraction probe arm and foil in the TR-19, and hence the energy of the extracted ions.

The accelerated ions are extracted by stripping off the two electrons from the negative hydrogen (H-) ions by passing the ions through a thin carbon foil. The resulting positive (H+) ion beam bends in the opposite direction in the magnetic field and exits the magnet.

1.9 nr. The TR-19 cyclotron is equipped with two beam extraction probes, 180° apart, so that two beams can be extracted simultaneously, with a total extracted current of up to 300 µA. The extraction probes can be inserted and retracted from the main vacuum tank without affecting the main vacuum system.

EXTRACTION PROBES:

- Standard extraction probe: Single carbon foil
- Optional extraction probe: Carousel type. Multiple foils per carousel
- Less than 1 minute for foil change
- Easy maintenance without affecting cyclotron vacuum
- Radial and azimuthal adjustments allow selection of varying beam energy

VACUUM SYSTEM:

The TR-19 vacuum system is designed around clean, state-of-the-art high efficiency cryopumps. The high vacuum possible by using cryopumps permits exceptional beam stability, very low beam degradation and minimal neutron activation and residual radiation due to beam scatter by contaminants within the vacuum tank.

Another key feature of the vacuum system is its modularized design that permits the different sub-systems on the cyclotron to be isolated from the main vacuum tank. Maintenance on the extraction probes, beamlines, targets, ion source and injection system can be done while the main tank remains at high vacuum. This eliminates the need to vent the vacuum tank during maintenance, avoids the start-up delay due to system pump down, and allows the main tank to reach better vacuum levels.

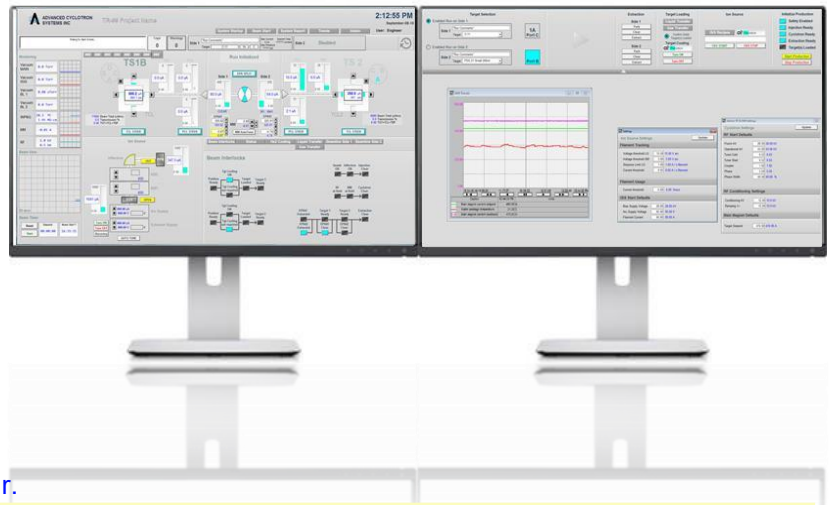
- Gate valves used to isolate all maintenance components including ion source, extraction probes, beamlines, and targets.
- Over 90% beam transmission inside the vacuum tank.
- High vacuum better than 2 x 10^{-6} Torr is easily maintained.

TR-19 CYCLOTRON

:

CONTROL SYSTEM

The TR-19 Control System offers reliability and easy of use. A Microsoft Windows based graphical user interface allows Operators to control the TR-19 in automated, semi-automated and manual modes. An industrial PLC system achieves rapid and reliable responses while also guiding the Operator's action.



The user interface runs on standard office grade computer equipment and is expandable to four monitors. Multiple terminals at different parts of the facility can control the cyclotron over an Ethernet connection. System can be setup that only one control computer will control cyclotron fully or partially with all other computers locked. While information about cyclotron operation can be visually displayed on the locked computers that can not be used to execute any operations.

Reliable

- Zero maintenance industrial PLC system
- Hard-wired safety devices in series with software checks provide critical redundancy

Automated

Well thought out automation allows machine operation from a supervisory level. Examples of TR-19 automation include:

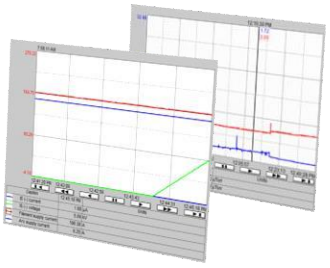
- Automatic machine start-up
- Automated vacuum pump-down and venting
- Beam tuning. Optimization of Ion Source and other cyclotron operating parameters
- Selection of beam energy and current.
- Target selection and target loading.
- Transfer of the irradiated material to selected hotcell for processing

Real-time

System parameters are monitored in real-time. Data-logging allows long term trends to be retrieved and analyzed.

Key features are:

- Complete device monitoring (Current, Voltage, pressure, power, etc.)
- Variable data logging for six months, one year or more.
- Alarms and warnings about anormal operating conditions
- Alarm and Activity logging
- Configurable user security privileges allow different levels of control
- Electronic PDF system run reports
- Email Notifications of alarm and system status



SAFETY:

3.2 nr.

Safety has been designed into every TR-19 sub-system reducing risks during operation and maintenance. During normal use of the cyclotron, the operator is never required to enter the cyclotron vault, manually operate valves, fill traps and targets, clean or fill systems, or to monitor system operation or to perform any other actions.
Special considerations have been made in the design of the TR-19 to minimize residual radiation and to decrease potential expose of the service personnel. With the installation of optional local shielding cyclotron operator receives no dose during servicing of any cyclotron subsystem except targets.

- All components on the cyclotron are easily removable for inspection and maintenance, and just as easily replaced.

access to any High Voltage or High Power areas is guarded by redundant mechanisms including limit switches and passive grounding contacts.

unless it can verify that all accessible areas are secure.

3.1;3.5;3.6 nr.

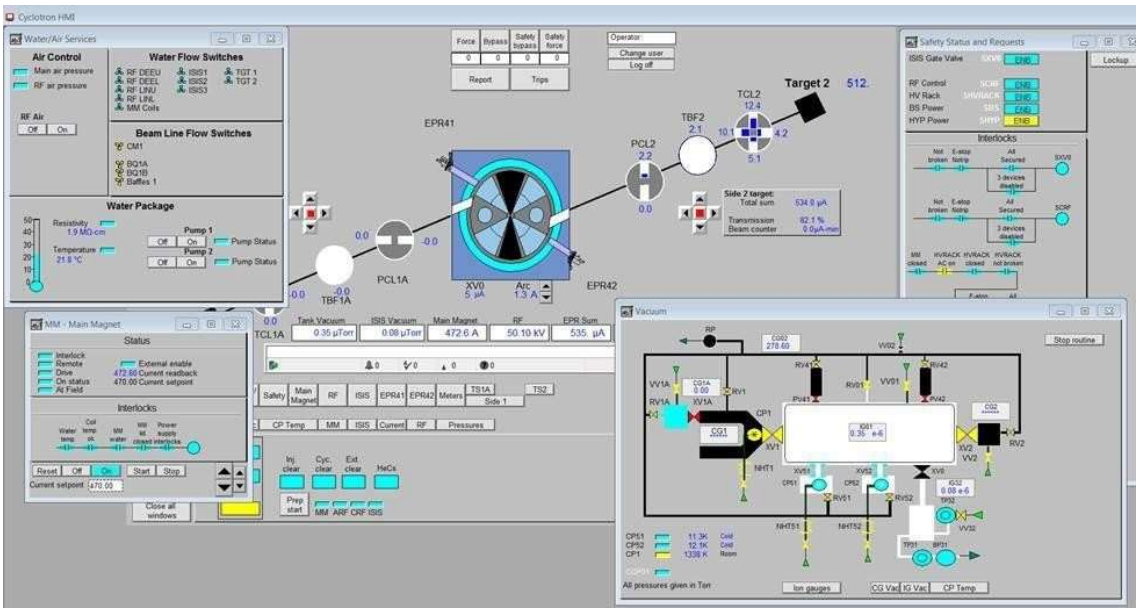
Some key elements of the safety systems which can be integrated into your radiopharmaceutical facility safety procedures:

- Last-Person-Out vault securing system.
- Light beacons and Alarm Horns for signaling risks to Operators.
- Hardwired emergency trip circuit activated by push buttons around the vault, cabinet room, and operator workstation.
- Built-in capabilities of the user interface, including alarm and activity logging, aid in safety auditing.

3.1;3.5;3.6 nr.

The Control System grants the operator full visibility of critical safety signals. During automated operation, the operator has the flexibility to disable those devices required for beam creation or which produce high voltage, if required.

5.2 nr.



TARGETRY AND BEAM LINES:

4.1 nr.

The TR-19 cyclotron can be provided with one or two multi-position target selector, a proprietary design of ACSI. The target selector is designed to allow three or four targets to be mounted on each of the external beamports of the cyclotron or at the end of a beamline. The multi-position target selectors permit extremely precise and rapid target positioning during irradiation.

Multi-port target selector (up to 150 µA of beam current)

Each multi-position target selector can be isolated from the main vacuum tank by a vacuum isolation gate valve, which allows the targets to be changed or maintenance to be done on the targets and target selectors without affecting the high vacuum in the main tank.

The positioning of targets can be done either automatically by the Computer Control System, or it can be done by the Operator. The Computer Control System provides real-time control and monitoring of the targets and the target selector, including position and amount of beam current on the target.

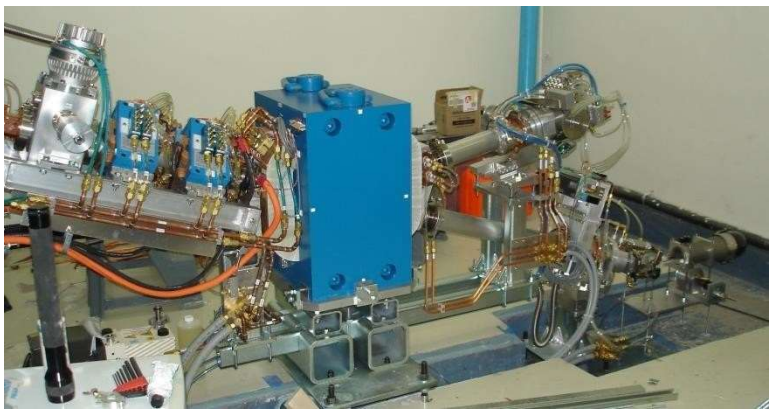
TARGETS 6.1 nr.

Liquid, gas and solid targets, for the production of the entire range of PET isotopes, as well as some SPECT isotopes, are available for installation on the TR-19 cyclotron.

The targets are designed to allow rapid attachment and removal from the multi-position target selector. The target bodies are water cooled to remove the heat produced by the beam current absorbed by the target bodies.

BEAMLINES

Beamlines can be installed on the beamports of the TR-19 cyclotron. Several configurations are available. The beamlines are fully instrumented and are controlled from the cyclotron control console.



SHIELDING:

The TR-19 is available in self-shielded, unshielded and local shielding configurations.

Self-shielded cyclotrons allow for installation in a room with standard walls, eliminating the need for a cyclotron bunker.

Un-shielded cyclotrons must be installed in a bunker with thick concrete walls.

The residual activity in the targets could cause the cyclotron operator to receive a high radiation dose during routine maintenance of the cyclotron.

ACSI's **local shielding** around the targets allows the operator to perform routine maintenance on the ion source and extraction probes, without radiation exposure.

The cyclotron vault walls will not get activated, which allows for lower decommissioning costs.

There is more room for the operator to move around the cyclotron to perform repairs and maintenance (compared with a self-shielded cyclotron).

There are additional savings on concrete (compared to un-shielded) or shielding costs (compared to self-shielded) cyclotrons.

ADVANCED CYCLOTRON SYSTEMS, INC.

TR-19 CYCLOTRON

The TR-19 Cyclotron is the most advanced PET cyclotron system currently available. Dizainas ir technologijos, kurios yra integruotos į sistemą, yra patobulintos ir atspindi pagrindines projektavimo filosofijas – maksimalią išeigą, paprastą eksploatavimą, mažas eksploatavimo išlaidas ir minimalų radiacijos poveikį.

The technological and scientific expertise to develop and build such an exceptional cyclotron comes from a technology transfer agreement between the Cyclotron Group at TRIUMF (Canada's National Laboratory for Particle and Nuclear Physics) and Ebco Industries, an Advanced Cyclotron Systems affiliated company.

TECHNOLOGY:

- Kintama energija: 14–19 MeV protonų spindulys
- Modeliai: 150 µA, 200 µA ir 300 µA protonai
- Deuteron acceleration capability (optional): up to 9 MeV deuteron energy. Deuteron option has limited, 150 µA, proton current
- Upgradeable in factory and on-site
- Modular: No need to open the main vacuum tank for maintenance of the ion source, extraction probes and targets
- Customizable beamlines

1.2 nr.

1.7 nr.

1.7 nr.

The design and capabilities of the TR-19 cyclotron, as well as a variety of targetry and beamlines allow for production of the entire range of PET isotopes, such as ^{18}F, ^{11}C, ^{13}N, ^{15}O, ^{89}Zr, etc, as well as some SPECT isotopes, such as ^{99m}Tc.

The TR-19's outstanding production capability and unique features have made this cyclotron the accelerator of choice for many leading research institutes and radiopharmaceutical distribution centers around the world.

TECHNICAL SPECIFICATIONS

1.2 nr.

TR-19 yra kintamos energijos stipriai sufokusuotas izochroninis ciklotronas su pagrindiniu magnetu, skirtu neigiamai įkrautiems vandenilio jonams (H-) pagreitinti iki maksimalios 19 MeV energijos, ir turintis galimybę pagreitinti neigiamai įkrautus deuterio jonus (D-) iki maksimalios 9 MeV energijos, kai yra deuterono parinktis.

TR-19 TECHNICAL SPECIFICATIONS

SPINDULIO ENERGIJA (Kintama energija) 1.2; 1.5;1.8 nr.

Minimali:	**14 MeV protonų veikimas, 7 MeV Deuteron**
operation Maksimali:	**19 MeV protonų veikimas, 9 MeV Deuteron**
operation	

EXTRACTED CURRENTS

Total extracted current: protons available to 300 µA

Total extracted current: deuterons available to 50 µA

MAGNET

Orientation:	**Vertical**
Geometry:	**4 Sectors (closed)**
Hill angle:	**Variable 45º**
Average induction:	**1.2 Tesla**
Opening for access:	**1.0 m**

RF SYSTEM

Number of dees:	**2 (45º)**
Dee voltage:	**50 kV**
RF frequency:	**73 and 37 MHz**
Power required: 18 kW	
Energy per rev:	**200 keV**

ION SOURCE (External)

Type:	**H- multicusp**
Output current:	**3 mA (nominal), 4 mA (maximum)**
Bias voltage:	**25 - 30 kV**

VACUUM SYSTEM

Operating pressure:	**< 2 x 10^{-6} Torr**
Cryopumps:	**one 4,000 l/s (H_2O) each**

VALDYMO SISTEMA 2;3;5.2 nr. **(automatizuota, valdoma kompiuteriu)**

Kompiuterio sistema:	**„PC Windows“ pagrindu**
Valdikliai:	**„Allen-Bradley Industrial PLC“ moduliai**
Sąsaja:	**Grafinė vartotojo sąsaja**

ION SOURCE:

The TR-19 cyclotron uses a state of the art, high brightness, low emittance, external multi-cusp ion source that can provide H- beam current in excess of 4000 μA.

The extraction lenses show a unique configuration complete with plasma filter optimized for negative hydrogen ion extraction. The center electrode and inflector display a proprietary design, optimized for maximum beam transmission.

The Ion Source and Injection System, including all beam and magnet currents, component voltages, hydrogen gas flow and pressure, and temperature sensor readings, are monitored in real-time by the computerized Control System.

TR-19 ION SOURCE:

- External Multi-cusp ion source with current up to 4 mA.
- Very high brightness and high transmission.
- Ion source beam stop for diagnostics and safety.

RF SYSTEM:

The TR-19 Radio-Frequency (RF) system incorporates special and unique design features that make it the most compact cyclotron RF system in the world. The custom and proprietary technology of the RF System was developed for the TR series of cyclotrons by the TRIUMF RF Group, which has been designing, building and operating high powered RF systems for over 40 years.

The RF system on the TR-19 is an 18 kW, 73 MHz system. It is very stable and was specially designed with ease of operation and maintenance in mind. Proprietary to Advanced Cyclotron Systems are the special shape of the Dees which serve to reduce the capacitive losses due to edge effects, impedance and the attenuation interaction between the Dees and the Dee liners. The Dees geometry is optimized for a high quality factor, Q, and low power losses. The nominal Dee voltage is 50 kV. The Dees and Dee stems are water cooled as is the RF amplifier using flow and temperature controlled de-ionized water.

RF SYSTEM:

- 50 kV, 73 or 37 MHz, fourth or second harmonic operation
- 45º Dees for maximum beam stability and efficient transfer of RF power to beam power
- Interlocked with the computerized Control System to permit real-time control of the RF amplitude, frequency and phase.
- Fully automated, user friendly Graphical User Interface. Can also be operated in manual, local, as well as remote mode.

BEAM EXTRACTION:

The variable energy capability of the TR-19 is possible because of the specially designed extraction system, which allows the cyclotron operator to precisely control the radial position of the extraction probe arm and foil in the TR-19, and hence the energy of the extracted ions.

The accelerated ions are extracted by stripping off the two electrons from the negative hydrogen (H-) ions by passing the ions through a thin carbon foil. The resulting positive (H+) ion beam bends in the opposite direction in the magnetic field and exits the magnet.

1.9 nr. TR-19 ciklotronas turi du spindulio ištraukimo zondus, esančius vienas nuo kito 180° kampu, kad vienu metu būtų galima ištraukti du spindulius, kurių bendra ištraukiama srovė yra iki 300 µA. The extraction probes can be inserted and retracted from the main vacuum tank without affecting the main vacuum system.

EXTRACTION PROBES:

- Standard extraction probe: Single carbon foil
- Optional extraction probe: Carousel type. Multiple foils per carousel
- Less than 1 minute for foil change
- Easy maintenance without affecting cyclotron vacuum
- Radial and azimuthal adjustments allow selection of varying beam energy

VACUUM SYSTEM:

The TR-19 vacuum system is designed around clean, state-of-the-art high efficiency cryopumps. The high vacuum possible by using cryopumps permits exceptional beam stability, very low beam degradation and minimal neutron activation and residual radiation due to beam scatter by contaminants within the vacuum tank.

Another key feature of the vacuum system is its modularized design that permits the different sub-systems on the cyclotron to be isolated from the main vacuum tank. Maintenance on the extraction probes, beamlines, targets, ion source and injection system can be done while the main tank remains at high vacuum. This eliminates the need to vent the vacuum tank during maintenance, avoids the start-up delay due to system pump down, and allows the main tank to reach better vacuum levels.

- Gate valves used to isolate all maintenance components including ion source, extraction probes, beamlines, and targets.
- Over 90% beam transmission inside the vacuum tank.
- High vacuum better than 2 x 10^{-6} Torr is easily maintained.

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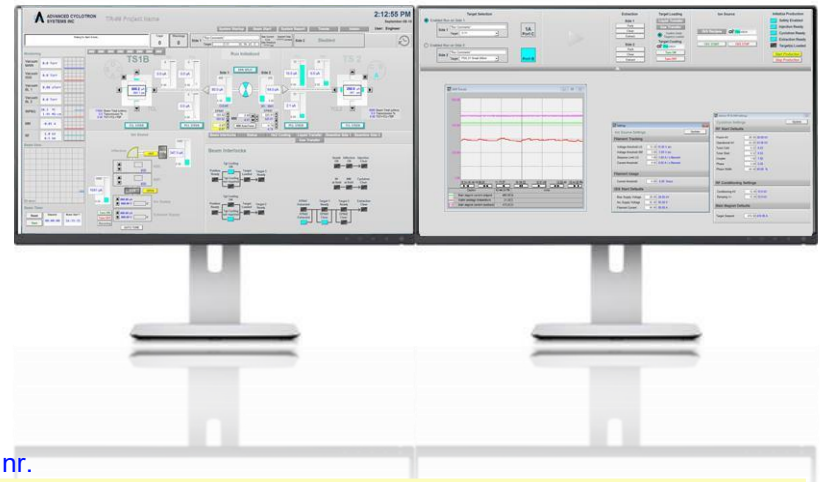


CONTROL SYSTEM

TR-19 valdymo sistema siūlo patikimumu

1.6;3.4

pagrįstą grafinę vartotojo sąsają, leidžiančią operatoriams valdyti TR-19 automatiniu, pusiau automatiniu ir rankiniu režimu. An industrial PLC system achieves rapid and reliable responses while also guiding the Operator's action.

2.1;2.2; 3.3;3.4;3.5 nr.

Vartotojo sąsaja veikia standartinėje biuro kompiuterių įrangoje ir yra išplėsta iki keturių monitorių. Keli terminalai skirtingose objekto vietose gali valdyti ciklotroną su „Ethernet" jungtimi. Sistemą galima nustatyti taip, kad tik vienas valdymo kompiuteris visiškai ar iš dalies valdytų ciklotroną, kai visi kiti kompiuteriai yra užrakinti. Tačiau informacija apie ciklotrono veikimą gali būti vizualiai rodoma užrakintuose kompiuteriuose, kurių negalima naudoti jokioms operacijoms atlikti.

Reliable

- Zero maintenance industrial PLC system
- Hard-wired safety devices in series with software checks provide critical redundancy

1.6;3.1 nr.

Gerai apgalvota automatika leidžia valdyti mašiną nuo priežiūros lygio. TR-19 automatikos pavyzdžiai:

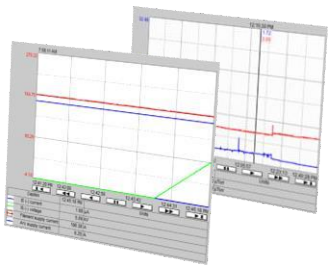
- Automatinis mašinos paleidimas.
- Automatizuotas vakuuminis išsiurbimas ir išleidimas.
- Spindulio derinimas. Jonų šaltinio ir kitų ciklotrono veikimo parametrų optimizavimas.
- Spindulio energijos ir srovės pasirinkimas.
- Taikinio pasirinkimas ir taikinio pakrovimas.
- Apšvitintos medžiagos perkėlimas į pasirinktą kaitinimo elementą perdirbti.

3.1;3.5;3.6 nr.

Sistemos parametrai stebimi realiuoju laiku. Duomenų registravimas leidžia gauti ir išanalizuoti ilgalaikes tendencijas.

Pagrindinės savybės:

- Visapusiškas prietaiso stebėjimas (srovė, įtampa, slėgis, galia ir kt.).
- Kintamų duomenų registravimas šešis mėnesius, vienerius metus ar ilgiau.
- Aliarmai ir įspėjimai apie neįprastas eksploatavimo sąlygas.
- Signalizacijos ir veiklos registravimas.
- Konfigūruojamos vartotojo saugos privilegijos leidžia kontroliuoti skirtingus lygius.
- Elektroninės PDF sistemos rengiamos ataskaitos.
- El. pašto pranešimai apie aliarmą ir sistemos būseną.



SAUGUMAS:.

3.2 nr.

Kiekviename TR-19 posistemyje buvo suprojektuotos saugos priemonės, mažinančios riziką eksploatacijos ir priežiūros metu. Įprastai naudojant ciklotroną, operatoriui niekada nereikia įeiti į ciklotrono skliautą, rankiniu būdu valdyti vožtuvus, užpildyti spąstus ir taikinius, valyti ar užpildyti sistemas, stebėti sistemos veikimą ar atlikti kitus veiksmus.

Projektuojant TR-19 buvo atsižvelgiama į tai, kad būtų sumažinta likutinė radiacija ir sumažintas aptarnaujančio personalo potencialas. Įdiegus pasirenkamą vietinį ekraną, ciklotrono operatorius, aptarnaudamas bet kurį ciklotrono posistemį, išskyrus taikinius, negauna dozės.

- Visi ciklotrono komponentai yra lengvai nuimami patikrinimui ir priežiūrai ir lygiai taip pat lengvai keičiami.
- prieigą prie bet kurios aukštos įtampos ar didelės galios zonos saugo rezerviniai mechanizmai, įskaitant galinius jungiklius ir pasyvius įžeminimo kontaktus.
- Sukurta personalo saugai, saugos sistema neleidžia ciklotronui gaminti spindulį, nebent ji galėtų patikrinti, ar visos prieinamos vietos yra saugios.

3.1;3.5;3.6 nr.

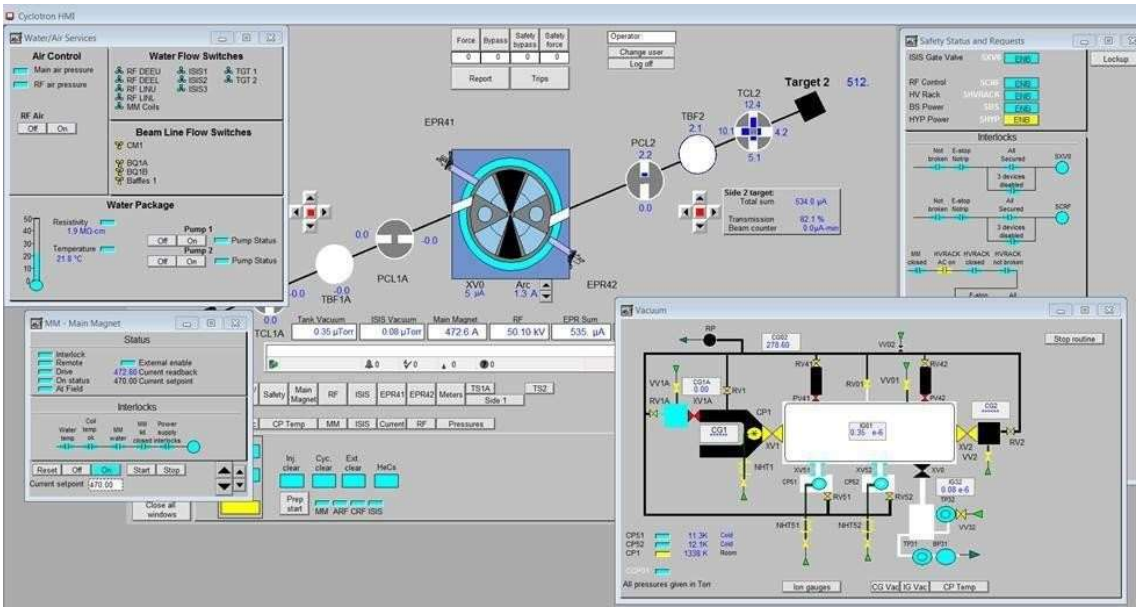
Keletas pagrindinių saugos sistemų elementų, kuriuos galima integruoti į jūsų radiofarmacijos įrenginių saugos procedūras:

- Skliautų tvirtinimo sistema „Last-Person-Out“.
- Šviesos švyturiai ir pavojaus signalai, signalizuojantys apie pavojų operatoriams.
- Laidinė avarinio išjungimo grandinė, aktyvuojama mygtukais aplink skliautą, kabineto patalpą ir operatoriaus darbo vietą.
- Integruotos vartotojo sąsajos galimybės, įskaitant aliarmo ir veiklos registravimą, padeda atlikti saugos auditą.

3.1;3.5;3.6 nr.

Valdymo sistema suteikia operatoriui visišką kritinių saugos signalų matomumą. Automatinio veikimo metu operatorius gali lanksčiai išjungti tuos įrenginius, kurie reikalingi spinduliui sukurti arba kurie, jei reikia, sukuria aukštą įtampą.

5.2 nr.



TARGETRY AND BEAM LINES:

4.1 nr.

TR-19 ciklotronas gali turėti vieną ar du kelių padėčių taikinių parinktuvus, patentuotą ACSI dizainą. Taikinių parinktuvas yra suprojektuotas taip, kad būtų galima pritvirtinti tris ar keturis taikinius ant kiekvieno iš išorinių ciklotrono spindulių prievadų arba ties pluošto linijos galu. Kelių padėčių taikinių parinktuvai leidžia ypač tiksliai ir greitai nustatyti taikinį švitinimo metu.

Multi-port target selector (up to 150 µA of beam current)

Each multi-position target selector can be isolated from the main vacuum tank by a vacuum isolation gate valve, which allows the targets to be changed or maintenance to be done on the targets and target selectors without affecting the high vacuum in the main tank.

The positioning of targets can be done either automatically by the Computer Control System, or it can be done by the Operator. The Computer Control System provides real-time control and monitoring of the targets and the target selector, including position and amount of beam current on the target.

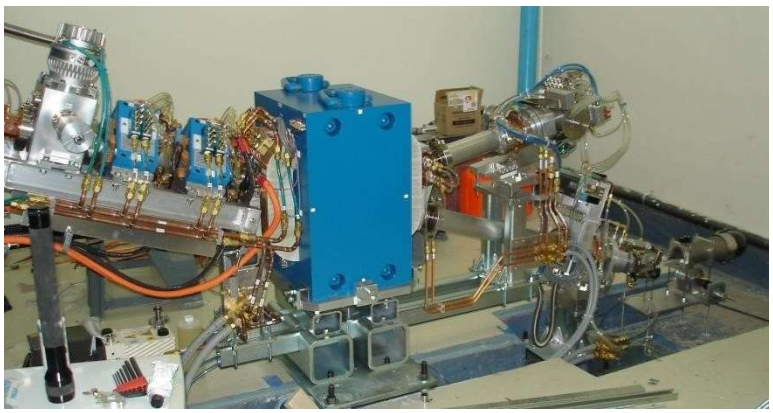
TAIKINIAI 6.1 nr.

Į TR-19 ciklotroną galima montuoti skysčių, dujų ir kietus taikinius, skirtus visam PET izotopų diapazonui gaminti, taip pat kai kuriuos SPECT izotopus.

The targets are designed to allow rapid attachment and removal from the multi-position target selector. The target bodies are water cooled to remove the heat produced by the beam current absorbed by the target bodies.

BEAMLINES

Beamlines can be installed on the beamports of the TR-19 cyclotron. Several configurations are available. The beamlines are fully instrumented and are controlled from the cyclotron control console.



SHIELDING:

The TR-19 is available in self-shielded, unshielded and local shielding configurations.

Self-shielded cyclotrons allow for installation in a room with standard walls, eliminating the need for a cyclotron bunker.

Un-shielded cyclotrons must be installed in a bunker with thick concrete walls.

The residual activity in the targets could cause the cyclotron operator to receive a high radiation dose during routine maintenance of the cyclotron.

ACSI's **local shielding** around the targets allows the operator to perform routine maintenance on the ion source and extraction probes, without radiation exposure.

The cyclotron vault walls will not get activated, which allows for lower decommissioning costs.

There is more room for the operator to move around the cyclotron to perform repairs and maintenance (compared with a self-shielded cyclotron).

There are additional savings on concrete (compared to un-shielded) or shielding costs (compared to self-shielded) cyclotrons.

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Vertėja
Translator / Переводчик
Goda Remeikaitė

AirV vertimų biuras

Šv. Stepono 7/Raugyklos g. 4A,
LT-01139, Vilnius
Tel./faks.: +370 5 2122496, +370 5 2310179
Mob. tel. +370 612 73093
El. paštas vilnius@airv.lt

Savanorių pr. 204/Taikos pr. 2,
LT-50187, Kaunas
Tel./faks.: +370 37 313455, 313258
Mob. tel. +370 650 51544
El. paštas kaunas@airv.lt

Taikos pr. 29,
LT-91145, Klaipėda
Tel./faks. +370 46 210588
Mob. tel. +370 650 58996
El. paštas klaipeda@airv.lt