Transnational Access - WP10 Proton, heavy ion and alternative beams and irradiation

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RADNEXT Kick Off Meeting – 19-21 May 2021
https://indico.cern.ch/event/983095/
https://indico.cern.ch/event/1029314/

cnes

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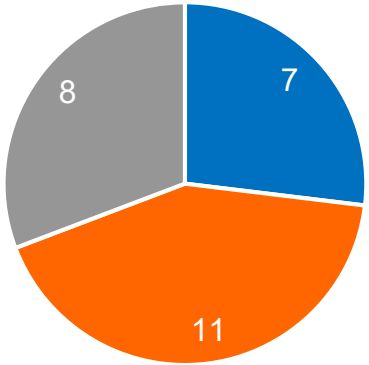
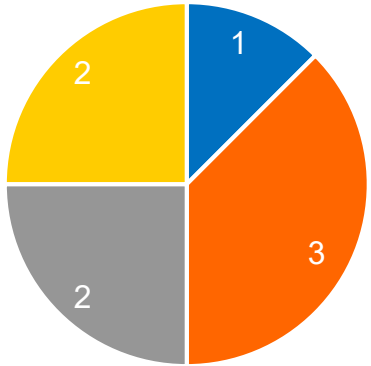
WP10: big variety of facilities

Beam type



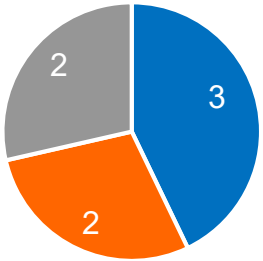
- Heavy ions
- Protons
- Other

Other beams



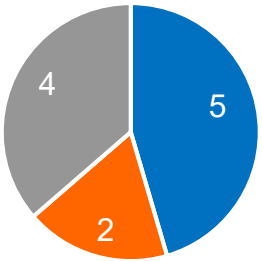
- Pulsed Xrays
- Pulsed laser & secondaries
- Electrons from LINAC
- e- & pions from cyclotron

Heavy ions Energy (MeV/u)



- E > 30
- 10 < E < 30
- E < 10

Protons Energy (MeV)

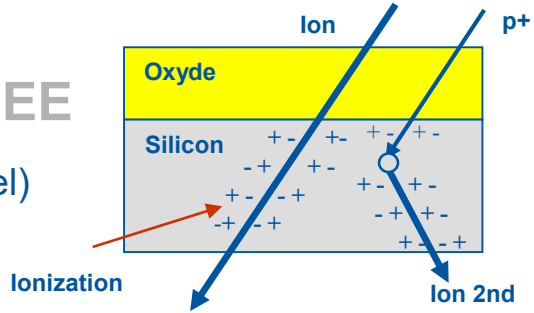


- up to >180
- Up to ~60
- Limited to <35

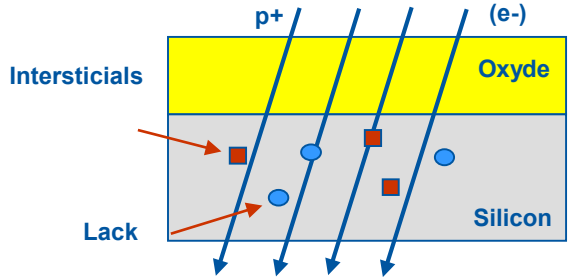
What kind of test with these facilities

- **Heavy ions:**
  - Single Event Effects (fault injection at component or system level)
  - Sensitive area localization (µprobe)
- **Protons:**
  - Single Event Effects
  - Displacement damage dose
  - DDD combined with Total Ionising Dose
- **Pulsed Xrays and laser:**
  - Single Event Effects
  - Sensitive area Localization
- **Electrons:**
  - Total Ionizing dose
  - Single Event Effects (<45nm)

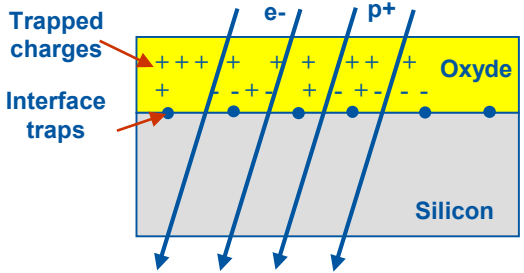
SEE



DDD



TID



Test standards

Standard	Title	SEE	DDE
ESCC-22500	Guidelines for Displacement Damage Irradiation testing		X
ESCC 25100	Single Event Effects test method and guidelines	X	
MIL-STD 750-E Method 1080.1	Test Method Standard -Test Methods for Semiconductor devices - Single Event Burnout and Single Event Gate Rupture Test	MOSFETS Heavy ions	
EIA JESD57A	Test Procedures for the Measurement of Single-Event Effects in Semiconductor Devices from Heavy Ion Irradiation	Heavy ions	

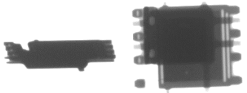
Heavy ion facilities

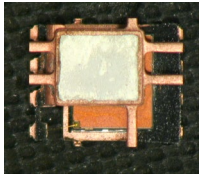
Heavy ion Facility	Energy (MeV/u)	Ion Species	Beam delivered in	Beam size (cm^2)	Flux ($s^{-1}cm^{-2}$)	Machine type	Country
CERN-CHARM-Ions	6 000	1/y (Pb)	Air		1E6 - 1E7	Synchrotron	Switzerland
GSI-SIS-18	150 - 1000	H to U	Air	Ø 0,5 - 2	1E3 - 1E9	Synchrotron	Germany
GANIL	5 - 95	C to U	Air	0,2 - 4	1E2 – 1E5	Cyclotron	France
RUG-KVI-CART	30	O to Xe	Air	3x3	1E2 - 1E5	Cyclotron	The Netherlands
JYU-RADEF	9,3 - 22	N to Au	Air & Vacuum	4x4	1 - 1E6	Cyclotron	Finland
UCL-HIF	9	C to Xe	Vacuum	Ø 2,5	20 – 1,5E4	Cyclotron	Belgium
GSI UNILAC µprobe	3,6 – 8,6	C to U	Vacuum	*	1 – 1E3	LINAC	Germany

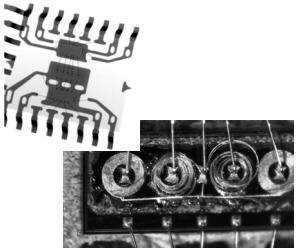
*: Irradiation field size 300x500µm²
Ion positionning accuracy 1µm

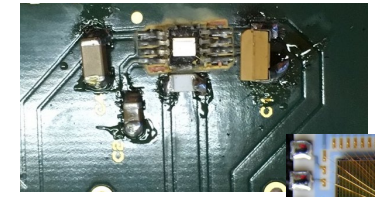
Limitations with heavy ion beams

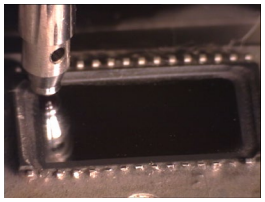
- De-capsulated samples for better LET and range control
  - Sample preparation may be complex
  - Sometimes impossible

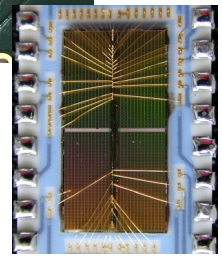




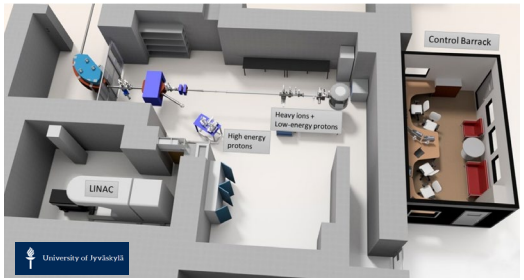








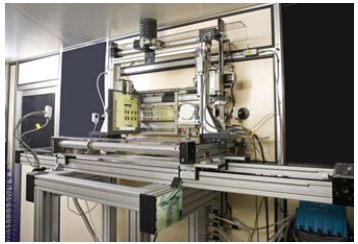
- Feedthrough connectors if test into vacuum chamber
- Distance to DUT when test in air

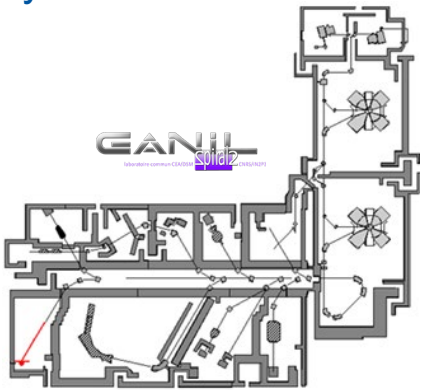


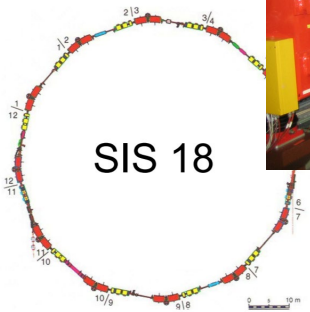
Heavy ion very high energy facilities

Heavy ion Facility	Energy (MeV/u)	Ion Species	Beam delivered in	Beam size (cm^2)	Flux ($s^{-1}cm^{-2}$)	Machine type	Country
CERN-CHARM-Ions	6 000	1/y (Pb)	Air		1E6 - 1E7	Synchrotron	Switzerland
GSI-SIS-18	150 - 1000	H to U	Air	Ø 0,5 - 2	1E3 - 1E9	Synchrotron	Germany
GANIL	5 - 95	C to U	Air	0,2 - 4	1E2 – 1E5	Cyclotron	France

- Complex machines usually dedicated to science
- Beam available in air
- Very high range
- Activation of samples







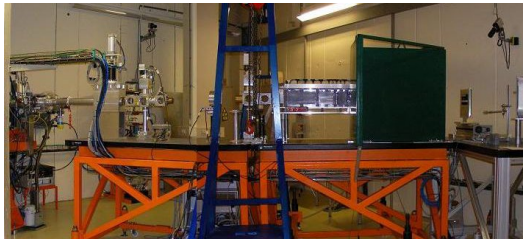
GSI Helmholtzzentrum für Schwerionenforschung GmbH

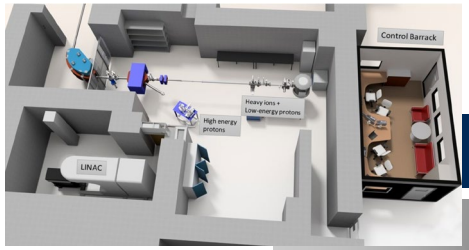
Heavy ion medium energy facilities

Heavy ion Facility	Energy (MeV/u)	Ion Species	Beam delivered in	Beam size (cm^2)	Flux ($s^{-1}cm^{-2}$)	Machine type	Country
RUG-KVI-CART	30	O to Xe	Air	3x3	1E2 - 1E5	Cyclotron	The Netherlands
JYU-RADEF	9,3 - 22	N to Au	Air & Vacuum	4x4	1 - 1E6	Cyclotron	Finland

- Beam possible in air
- Ion cocktail
- Possible activation of samples

KVI





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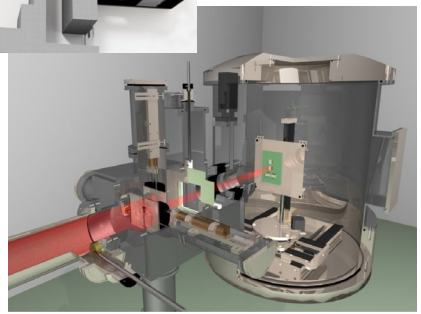
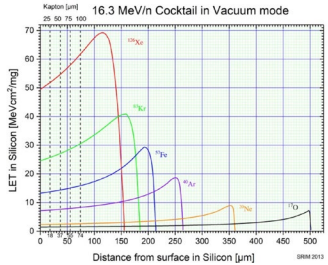
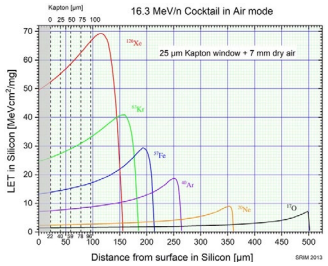


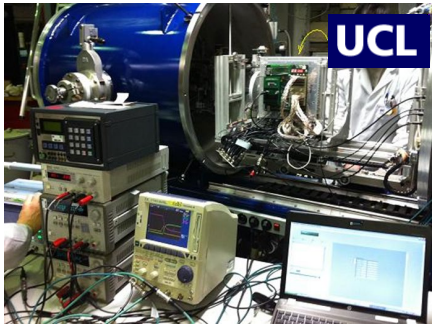


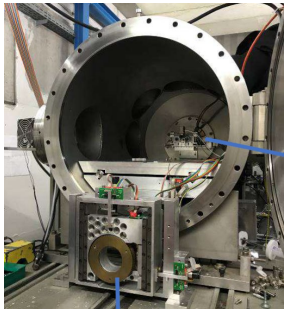


Heavy ion lower energy facilities

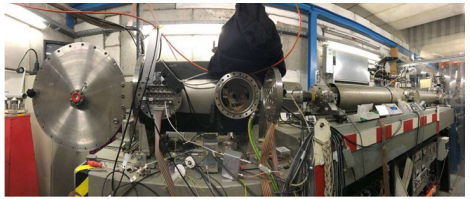
Heavy ion Facility	Energy (MeV/u)	Ion Species	Beam delivered in	Beam size (cm^2)	Flux ($s^{-1}cm^{-2}$)	Machine type	Country
UCL-HIF	9	C to Xe	Vacuum	Ø 2,5	20 – 1,5E4	Cyclotron	Belgium
GSI UNILAC µprobe	3,6 – 8,6	C to U	Vacuum	*	1 – 1E3	LINAC	Germany

- Beam in vacuum
- Ion cocktail
- Limited range





GSI

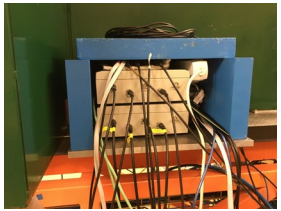


Proton facilities

Proton Facility	Energy (MeV)	Beam delivered in	Beam size (cm^2)	Flux ($s^{-1}cm^{-2}$)	Machine type	Country
CERN IRRAD/CHARM	24000	Air				
GSI-SIS18	4500	Air				
TRIUMF BL1B	350, 480	Air	3x3 to 7,5x7,5	1E2 - 4E7	Cyclotron	Canada
PSI-PIF	6 - 230	Air	Ø 0,5 -10	1E2 – 1E9	Cyclotron	Switzerland
RUG-KVI-CART	30-190	Air	2x2 – 10x10	1E4 - E9	Cyclotron	The Netherlands
UCL-LIF	10 - 62	Air or Vacuum	Ø 1,5 - 8	5E3 – 2E8	Cyclotron	Belgium
JYU-RADEF	0,4 - 55	Air or Vacuum	Ø 1 -10	1E2 – 1E9	Cyclotron	Finland
HZDR-DRACO	Few 10				PW Pulsed Laser	Germany
CLPU-VEGA	10				PW Pulsed Laser	Spain
USE-CNA-NEC	0,6 - 6	Vacuum	Ø 0,5 -1,5	1E4-1E13	VdG Tandem Pelletron	Spain
USE-CNA-IBA	18	Air & Vacuum	Ø 0,75 – 8	1E7 – 1E12	Cyclotron	Spain

Limitations with proton beams

- Distance DUT – Test system – Operator
  - ➢ Shielding is sometimes mandatory



- Significant accumulated dose

$$TID_{(Si)} = 1.6 \times 10^{-5}. \Phi. LET_{(Si)}$$

- Activation of samples when E>10MeV

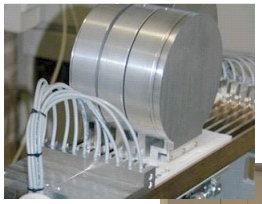
- Sample must be de-capsulated when E<30MeV

High energy proton facilities

Proton Facility	Energy (MeV)	Beam delivered in	Beam size (cm^2)	Flux ($s^{-1}cm^{-2}$)	Machine type	Country
CERN IRRAD/CHARM	24000	Air				
GSI-SIS18	4500	Air				
TRIUMF BL1B	350, 480	Air	3x3 to 7,5x7,5	1E2 - 4E7	Cyclotron	Canada
PSI-PIF	6 - 230	Air	Ø 0,5 -10	1E2 – 1E9	Cyclotron	Switzerland
RUG-KVI-CART	30-190	Air	2x2 – 10x10	1E4 - E9	Cyclotron	The Netherlands

- Beam available in air
- Energy selection with degraders
- Distance to DUT >>10m
- Activation of samples

➢ SEE injection at component or system level



Medium energy proton facilities

Proton Facility	Energy (MeV)	Beam delivered in	Beam size (cm^2)	Flux ($s^{-1}cm^{-2}$)	Machine type	Country
UCL-LIF	10 - 62	Air or Vacuum	Ø 1,5 - 8	5E3 – 2E8	Cyclotron	Belgium
JYU-RADEF	0,4 - 55	Air or Vacuum	Ø 1 -10	1E2 – 1E9	Cyclotron	Finland

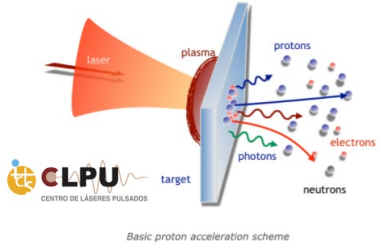
- Beam available in air or vacuum
- Energy selection with degraders
- Reasonable distance to DUT
- Limited activation of samples

➢ Displacement damage dose effects

Low energy proton facilities

Proton Facility	Energy (MeV)	Beam delivered in	Beam size (cm^2)	Flux ($s^{-1}cm^{-2}$)	Machine type	Country
HZDR-DRACO	Few 10				PW Pulsed Laser	Germany
CLPU-VEGA	10				PW Pulsed Laser	Spain
USE-CNA-NEC	0,6 - 6	Vacuum	Ø 0,5 -1,5	1E4-1E13	VdG Tandem Pelletron	Spain
USE-CNA-IBA	18	Air & Vacuum	Ø 0,75 – 8	1E7 – 1E12	Cyclotron	Spain

- Reasonable distance to DUT
- No or limited activation of samples



Basic proton acceleration scheme

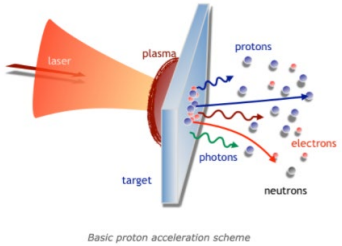
- Displacement damage dose
- Direct ionization SEE injection at component level

Other facilities

Facility	Beam type	Energy (MeV)	Beam delivered in	Beam size (cm^2)	Pulse duration	Flux ($s^{-1}cm^{-2}$)	Machine type	Country
ESRF_ID09	Pulsed X-Rays	1 to 30E-3	Air		~100ps		Synchrotron	France
CLPU-VEGA	Photons		Air & Vacuum	10µm	30 fs		800nm PW Pulsed Laser	Spain
CLPU-LWFA	Electrons	100-500						
CLPU-betatron	X-Rays	Few keV						
HZDR-ELBE							LINAC	Germany
HZDR-gELBE	Electrons	→ 18	Vacuum				Bremsstralung	
HZDR-eELBE	Electrons	→ 31	Air	Ø few 0,1 to 3	1-5ps			
PSI							Cyclotron	Switzerland
	Electrons	15-115						
	Pions	50-350						

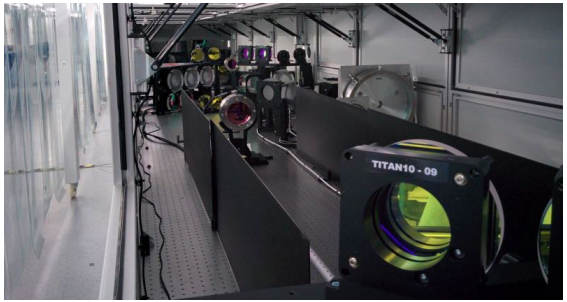
Other facilities

- Pulsed laser:
  - Direct beam
  - Secondary e-, X-rays, p+.



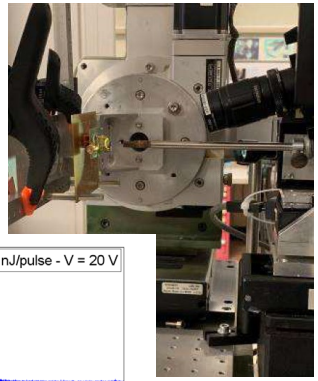
Basic proton acceleration scheme

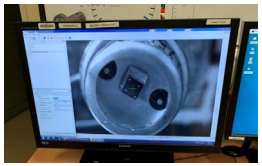
CLPU
CENTRO DE LÁSERES PULSADOS

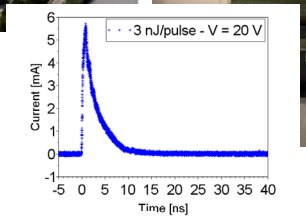


- Pulsed X-Rays

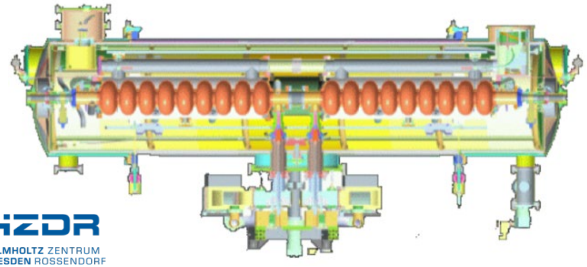
ESRF





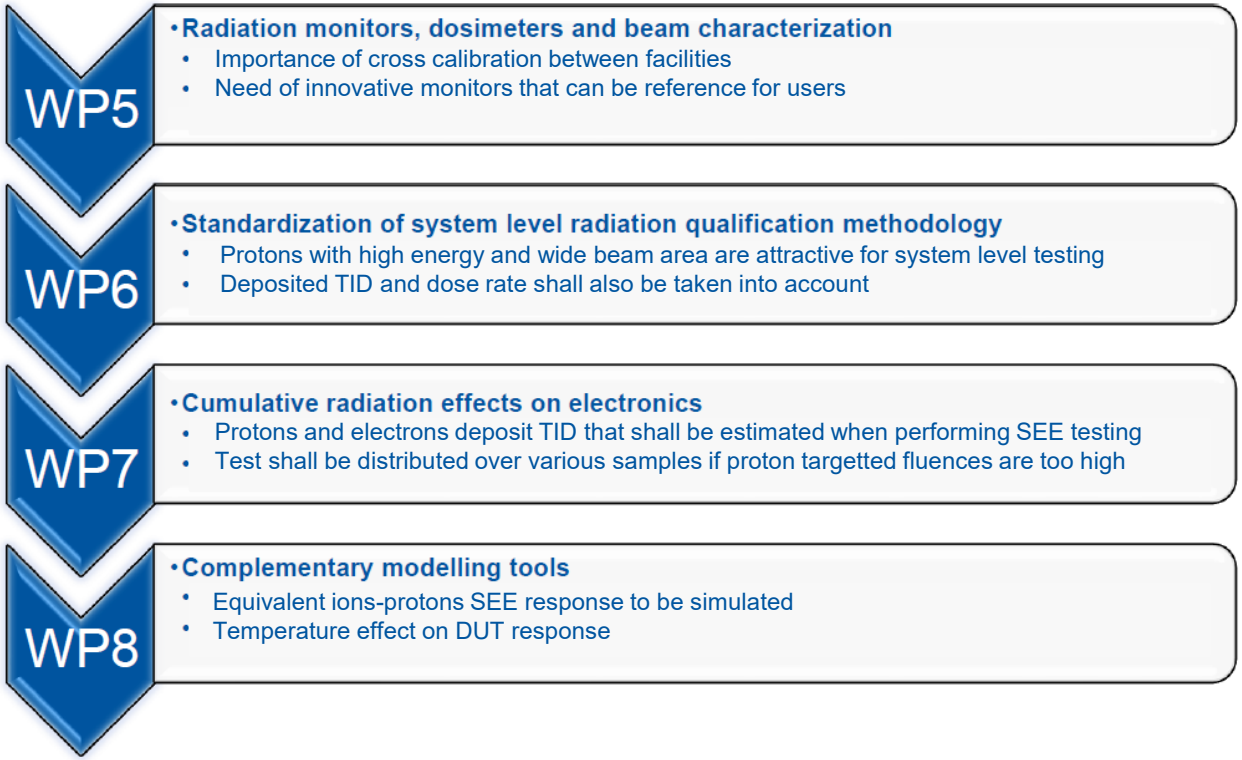


- Electron Linear accelerators



HZDR
HELMHOLTZ ZENTRUM DRESDEN ROSSENDORF

WP10: Relationships with Joint Research activities (Non-TA) WPs



Transnational Access

Description of work

- Users will be given **access to RADNEXT through TA**. The access to the facilities and information of various facilities are made more readily available to all.
- Help will be provided for the **selection of suitable facility** and proper beams for user's research needs.
- An ad-hoc **User Selection Panel** (USP) will be established at the beginning of the project. The USP will thoroughly evaluate the proposals according to its scientific excellence, impact on the radiation effects community, and implementation description and feasibility.

See WP03/NA-2 presentation

Thanks for your attention!

Source: AGOR / KVI-CART