11th Beam Telescopes and Test Beams Workshop

17th - 21st April 2023
Hamburg, Germany

General Facts

- Number of participants: 78 registrations (17 remote participants)
- Three different hands-on tutorials (Allpix Squared, Corryvreckan, Test-Beam)
- Guided DESY and lab tours
- Career counseling and Career path session
- Four lectures
- And a plethora of talks from the community …

Lectures

- Silicon sensor technologies for vertex and tracking detectors at future e^+e^- colliders - ***Dominik Dannheim***
- From Sensor to Detector - with some Obstacles - ***Ingrid-Maria Gregor***
- Experiments and detectors in photon science - ***David Pennicard***
- Tracking in particle detectors - ***Nicholas Styles***

Silicon sensor technologies for vertex and tracking detectors at future e+e- colliders - Dominik Dannheim (Monday)

Vertex/tracking detector concepts

Collider	ILC		CLIC	FCC-ee			CEPC	
Detector Concept	SiD	ILD	CLICdet	CLD	FCC-ee IDEA	Noble LAr/LKr	CEPC baseline	CEPC IDEA
B-field [T]	5	4	4	2	2	2	3	2
Vertex inner radius [mm]	14	14	31	17 → 12	17 → 12	17 → 12	16	16
Tracker out. radius [m]	1.25	1.8	1.5	2.2	2.0	2.0	1.81	2.05
Vertex	Si-pixel	Si-pixel	Si-pixel	Si-pixel	Si-pixel	Si-pixel	Si-pixel	Si-pixel
Tracker	Si-strips	TPC/ Si-strips	Si-pixel	Si-pixel	DC/ Si-strips	DC/Si-strips or Si-pixel	TPC/Si-strips or Si-strips	DC/ Si-strips
	arXiv:1306.6329		arXiv:1812.07337	arXiv:1911.12230	doi.org/10.1140/epjst/e2019-900045-4		arXiv:1811.10545	

Silicon sensor technologies for vertex and tracking detectors at future e+e- colliders - Dominik Dannheim (Monday)

- Detector physics requirements in Higgs Factory: similar in all collider concepts
  - High-energy Linear-Collider: more focus on asymptotic position resolution
  - High-luminosity low-energy Circular-Collider: more focus on material budget and particle ID
- Experimental constraints on vertex/tracker:

Main experimental constraints in **linear lepton colliders**:
- Significant rates of beam-induced backgrounds (incoherent e^+e^- pairs, $\gamma\gamma \rightarrow$ hadrons):
  - Constrains layout, granularity, impacts physics
- Backgrounds concentrated in very short bunch trains

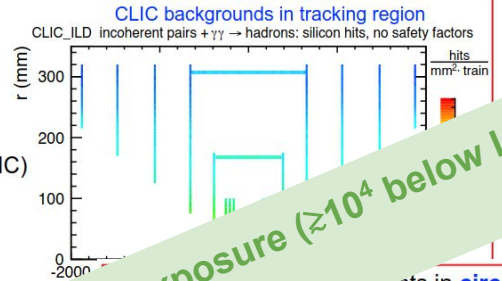
→ High instantaneous hit rates (up to 6 GHz/cm² @ 3 TeV CLIC)

→ Time-stamping: few ns @ 3 TeV CLIC, ~1-10 µs @ ILC

→ Fast detector signals / frontend

- Low duty cycle: ~20-200 ms gaps between bunch trains

→ trigger-less readout, pulsed powering



Moderate radiation exposure (≳10^4 below LHC run 1!) for all lepton-collider proposals

…ints in **circular lepton colliders**:

…g angle of beams, focusing quadrupoles inside det. volume

…ted to ~2 Tesla

…gh rate of physics events (up to 100 kHz, bunch spacing down to 30 ns)

→ Integration time <~1 µs required for occupancy and pile-up (30 ns @ Z-pole)

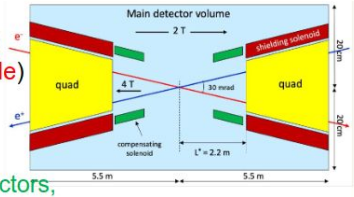
→ Fast detector frontend and DAQ

- Main backgr.: synchrotron radiation (reduced by shielding), incoh. pairs
- Continuous collisions (100% duty cycle)

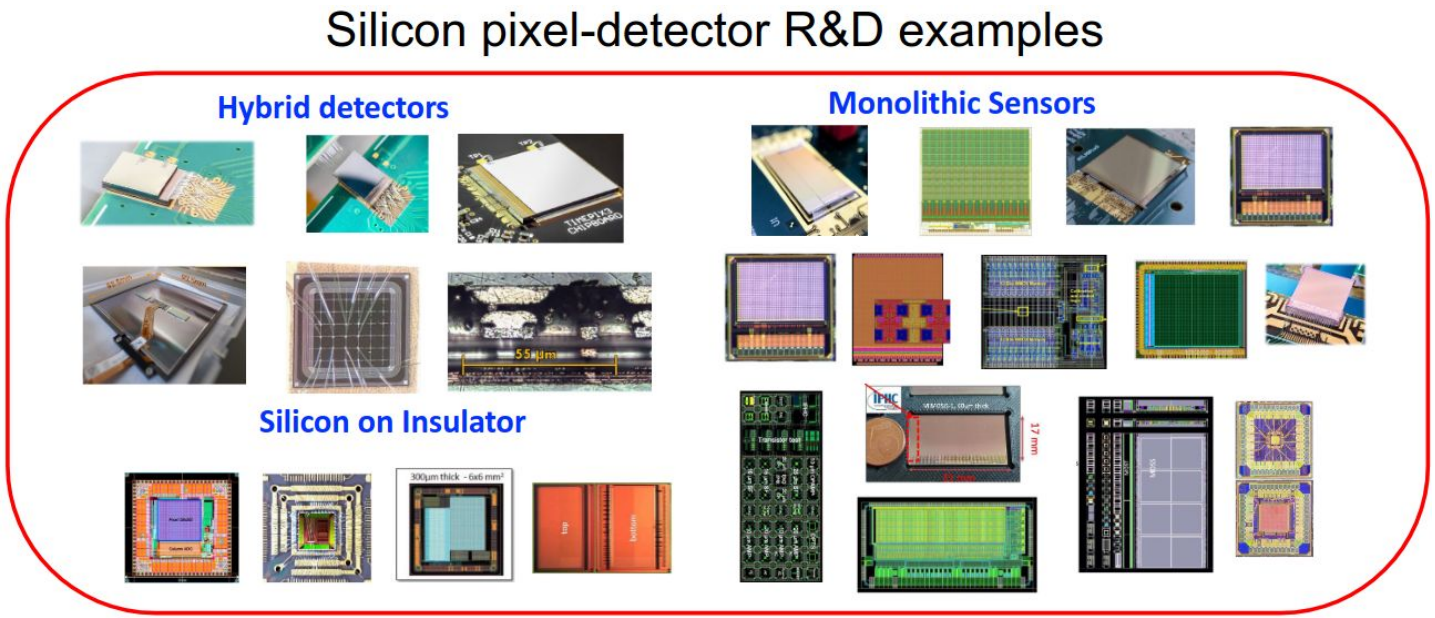
→ Beam-induced backgrounds more spaced out, less severe impact on detectors,

→ Pulsed powering not possible

FCC-ee detector region

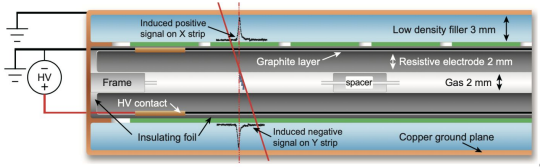


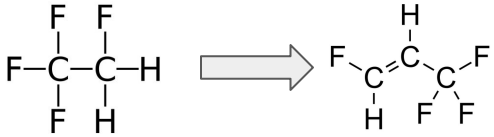
Silicon sensor technologies for vertex and tracking detectors at future e+e- colliders - Dominik Dannheim (Monday)

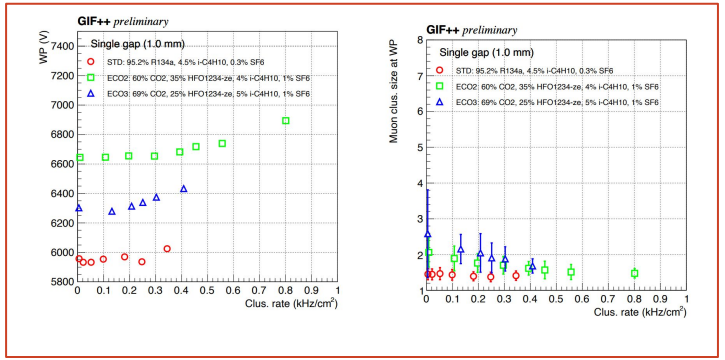


Tests of Resistive Plate Chambers with ecological gas mixture at GIF++ facility – Giuliana Galati (Tuesday)

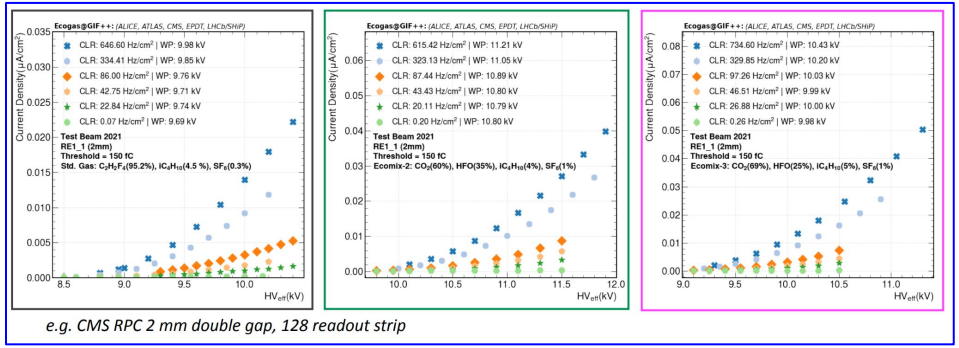
https://indico.cern.ch/event/1232761/contributions/5320967/







- Three mixture tested with several ABS with 6 chambers:
  - Std: 95.2% $C_2H_2F_4$ / 4.5% iC_4H_{10} / 0.3% SF_6
  - Eco2: 60% CO_2 / 35% HFO / 4% iC_4H_{10} / 1% SF_6
  - Eco3: 69% CO_2 / 25% HFO / 5% iC_4H_{10} / 1% SF_6



Constant cluster rate and decreasing cluster size

Higher currents for eco-gases

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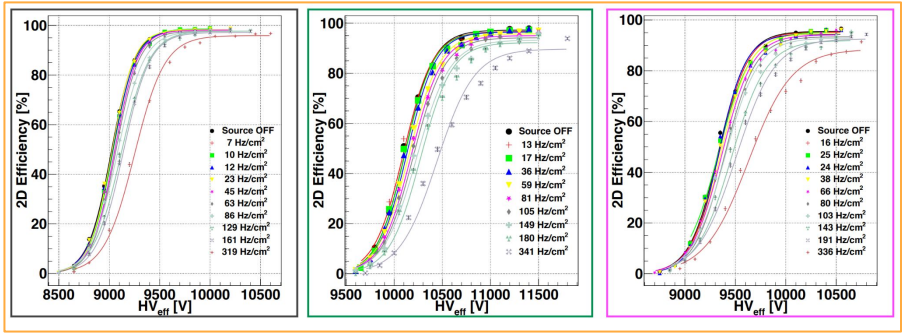
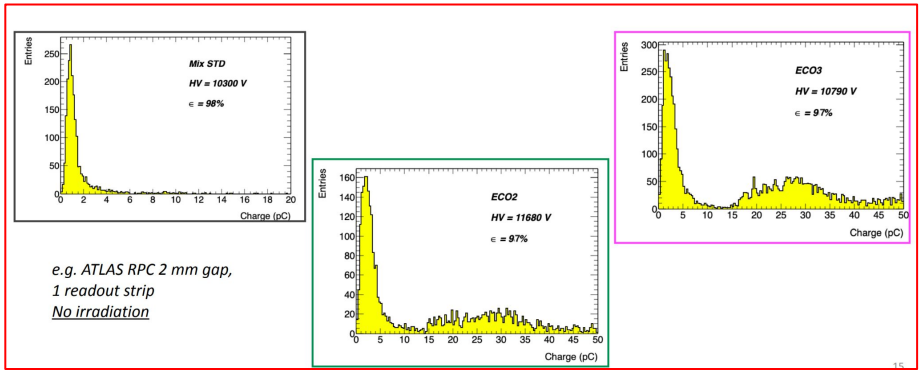


Comparable efficiency and WP



e.g. ATLAS RPC 2 mm gap,
1 readout strip
No irradiation

Second peak in Eco-gas due to multiple avalanches

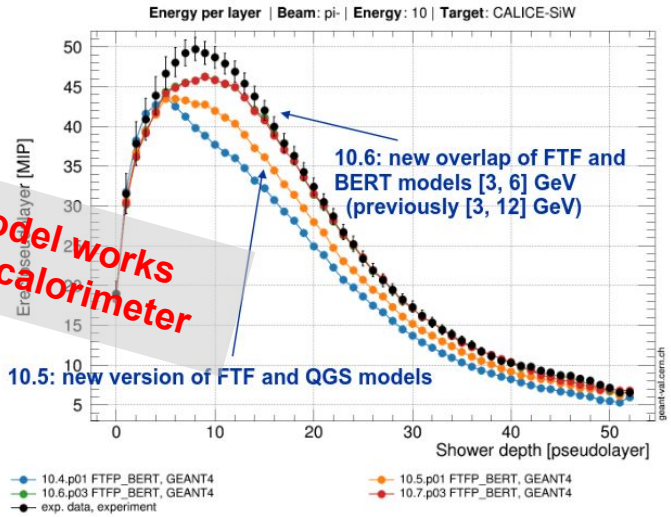
Geant4 validation on test-beam calorimetry data (Wednesday)

https://indico.cern.ch/event/1232761/contributions/5320333/

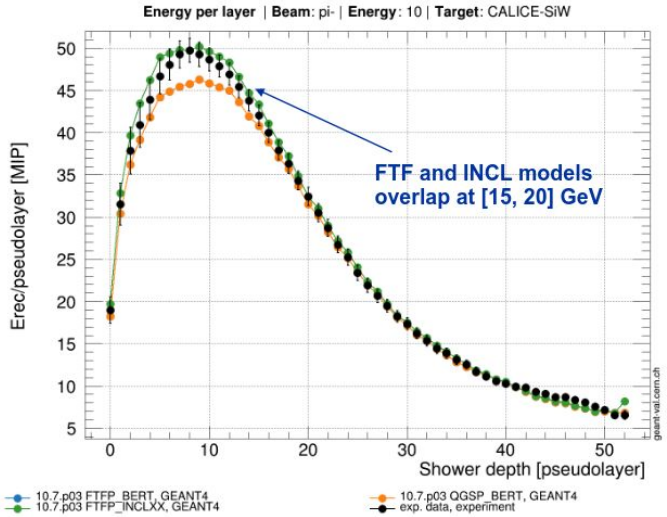
CALICE SiW: longitudinal energy distributions

10 GeV π^-, exp. data from NIM A794

Experimental INCL model works well with CALICE SiW calorimeter



FTFP_BERT Physics List regression testing 2017-2020



Physics Lists comparison - Geant4.10.7.p03

Geant4 validation on test-beam calorimetry data (Wednesday)

https://indico.cern.ch/event/1232761/contributions/5320333/

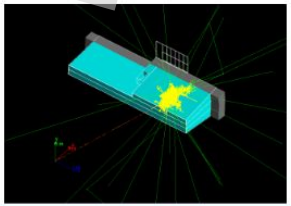
Hadronic resolution - FTFP_BERT (2017-2021)

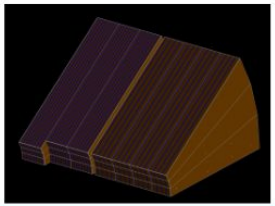
- ATLAS TileCal FTFP_BERT regression testing:
  - π^+ response fluctuations in good agreement with data for G4 10.4.
  - We observe a constant reduction of the response fluctuations from 10.4 to 10.5 to 10.6. Currently FTFP_BERT is $\simeq 20\,\%$ off w.r.t. ATLAS.
- ATLAS HEC FTFP_BERT regressione testing:
  - Geant4 validation study on the ATLAS HEC shows the same pattern.

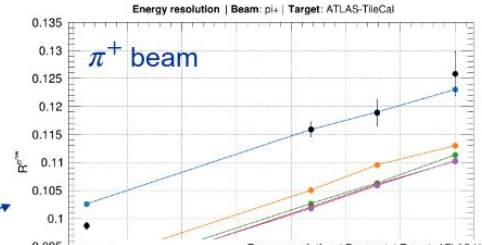
Pion response fluctuations ~20% lower in Geant4 than in testbeam

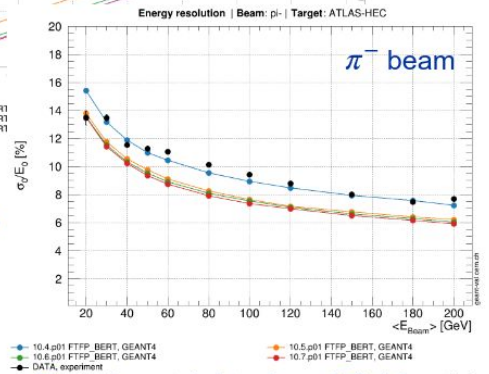
TileCal

HEC









Experimental data from ATLAS article

Monolith - Picosecond time stamping capabilities in fully monolithic highly-granular pixel sensor (Thursday)

https://indico.cern.ch/event/1232761/contributions/5321956/

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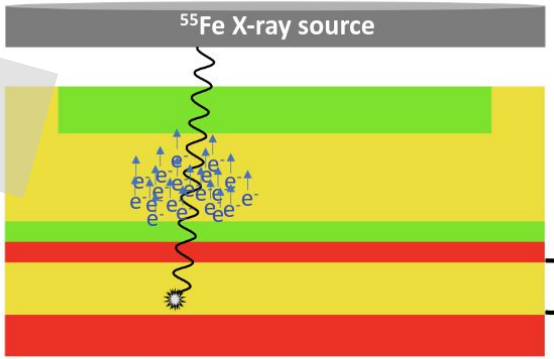
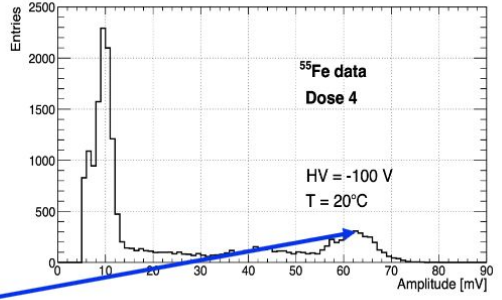
Département de physique nucléaire et corpusculaire

PicoAD Gain characterization

Sensor in fast SiGe BiCMOS process with gain layer

- Gain measured via point-like charge deposition inside the sensor of 5.9 KeV X-ray photons from ^{55}Fe





Ref: https://iopscience.iop.org/article/10.1088/1748-0221/17/10/P10032

Monolith - Picosecond time stamping capabilities in fully monolithic highly-granular pixel sensor (Thursday)

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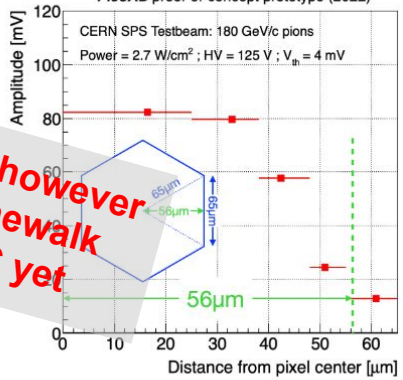
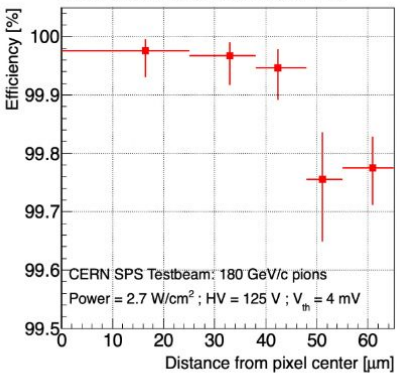
Position with the pixel

~13ps achieved in prototype, however only with oscilloscope and timewalk correction, no picosecond TDC yet

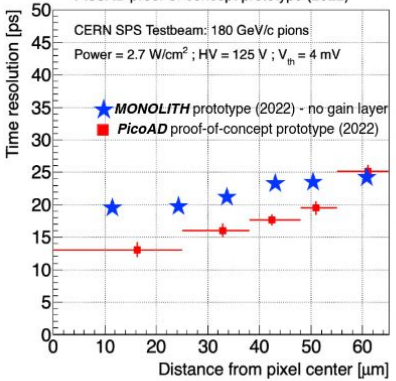
Signal amplitude MPV



Efficiency



Time resolution



Best PicoAD © prototype time resolution: (13.2 ± 0.8) ps within **25 µm** from **pixel center**
2022 prototype with no gain layer **less dependent** on position within pixel

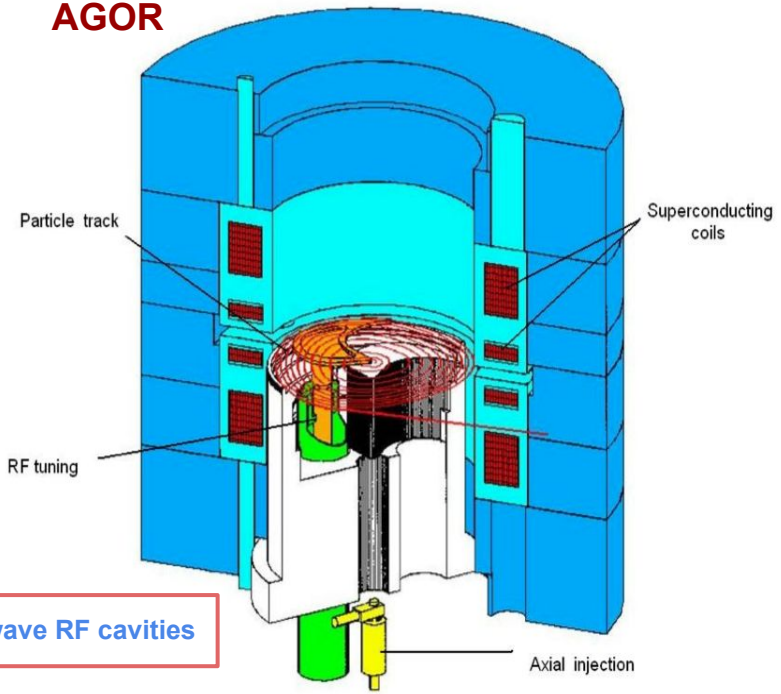
https://indico.cern.ch/event/1232761/contributions/5321962/

*The New **PA**rticle **T**herapy **RE**search **C**enter (PARTREC) at the UMC Groningen – Alexander Gerbershagen (Friday)*

- Until 2013: mainly nuclear physics
- Superconducting AVF Cyclotron
- RF operating range: 24 - 62 MHz
- Acceleration of light and heavy ions
- beams up to 190 MeV, 90 MeV/nc.

Focusing particles to the plane of acceleration by magnetic field variation

AGOR



3 halfwave RF cavities

https://indico.cern.ch/event/1232761/contributions/5321962/

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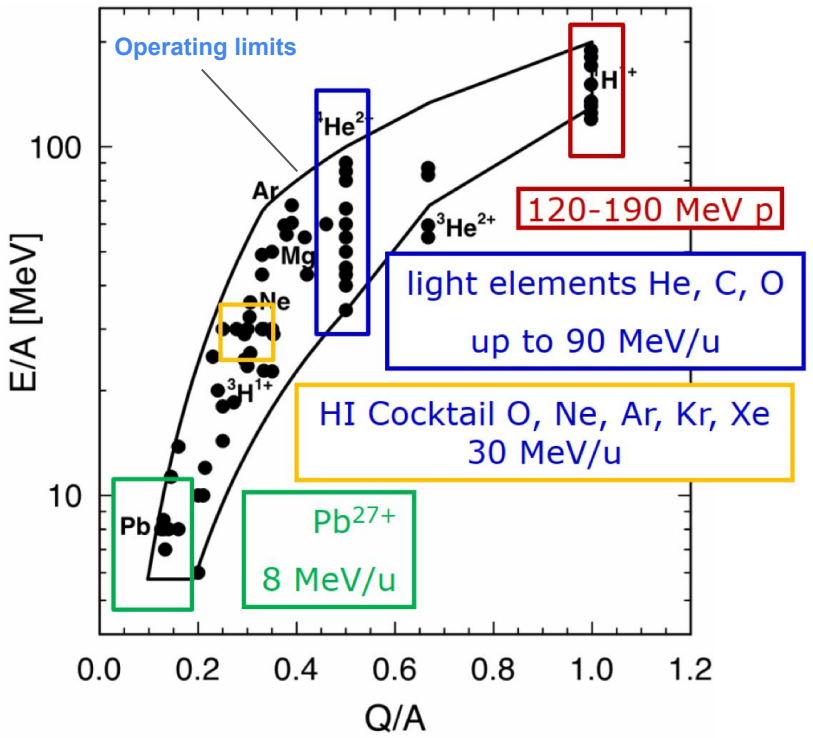
- beams up to 190 MeV, 90 MeV/nc.

Many available beam types!

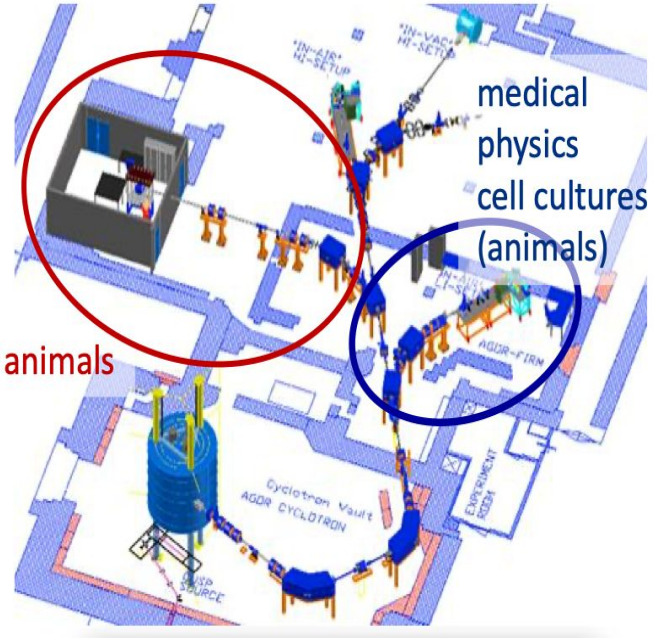
Attainable Particles/s:
Protons > e13
Ions < e11



https://indico.cern.ch/event/1232761/contributions/5321962/

*The New **PA**rticle **T**herapy **RE**search **C**enter (PARTREC) at the UMC Groningen – Alexander Gerbershagen (Friday)*

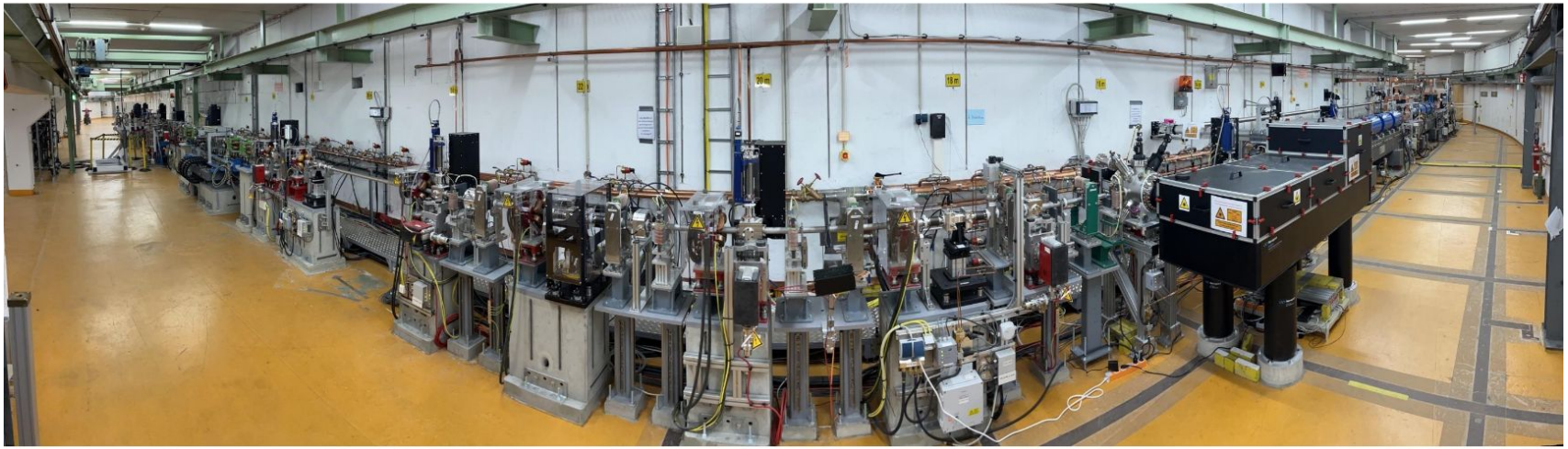
- Exchange with treatment facility GPTC
- Infrastructure for Biomedical Research
- Upcoming:
  - New 3D X-ray beamline
  - Bioluminescence imaging
  - Pencil beam scanning
  - High-dose rates (> 1000 Gy/s)



ARES Linac @ SINBAD - Florian Burkart

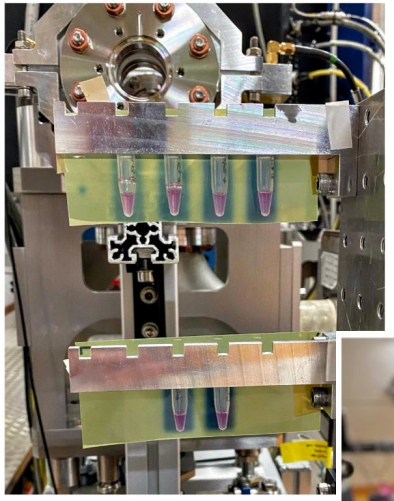
In operation since 2020

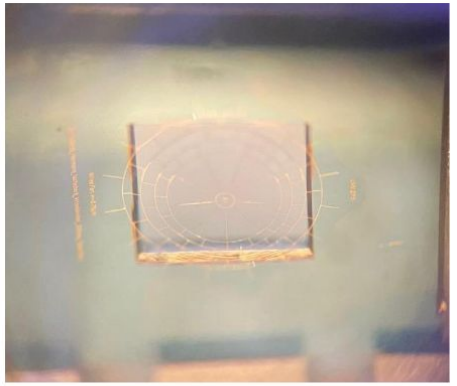
- Normal conducting 160 MeV electron linac for the production of **ultra-short electron bunches**



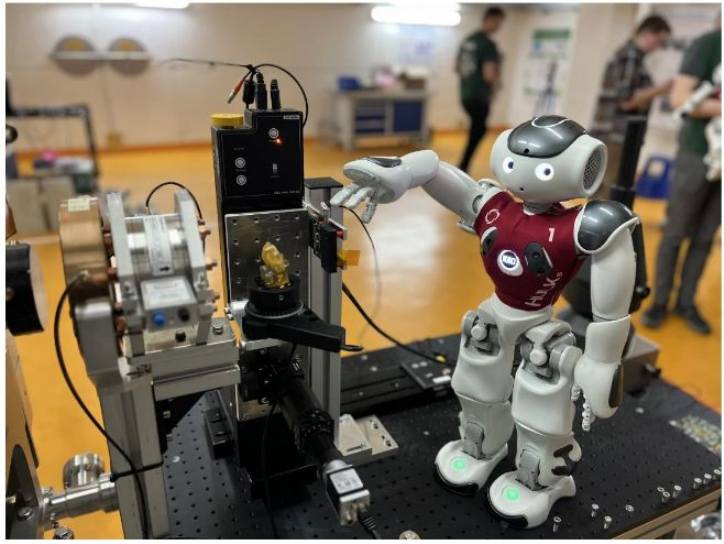
ARES Linac @ SINBAD - Florian Burkart

- R&D platform
  - Accelerator components
  - Detectors
  - Beam controls & diagnostics
- Medical research
  - Novel cancer treatment
  - VHEE experiments with living cells
- Automation, machine learning, robotics
- Electron CT experiments





Micro-wirescanner
1 micron thick gold wires

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