PROTON IRRADIATION FACILITY

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- **Two major changes in 2000**
- **Radiation effects in electronics**
- **Simulation of proton space environment**
- **Source of mono-energetic proton beams**
- **Calibration of particle detectors**
- **Operates since 1992**
- **User friendly and commonly available**

MAIN FEATURES REMINDER

Energy range:
50-300 MeV (9-60 MeV LI) - PKC2
6-71 MeV - NEB

Maximum beam flux:
10^5-10^8 p/sec/cm^2 - PKC2
10^9 p/sec/cm^2 - NEB

Beam profiles:
Gaussian $\sigma \cong 6$ cm or flat - PKC2
Flat $\phi \cong 6.0$ cm - NEB

Irradiation takes place in air

Sample mounting frame attached on XY table (can be rotated)

Sample test board as in SEU-Brookhaven and HIF-Brussel

Automated Data Acquisition System

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OPERATION in 2000 - SUMMARY

- **Irradiation period extend … … … … … 2 Feb - 15 Dec**
- **Number of experiments … … … … … . 42**
- **Participating research groups … … . 15**
- **Days with beam … … … … … … … … … 71 (+6)**
- **Beam blocks total … … … … … … … … 36 (+6)**
  (HE-PKC2 - 22, LE-NEB - 14, γ-source - 6+ !)
- **Beam shifts … … … … … … … … … … … 89½ (+ 6-½ +…)**
- **Setup shifts … … … … … … … … … … … ca. 28**

PSI Selected Experimental Facilities

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Accelerator Facilities
C Cockcroft-Walton
I2 Injector 2
R 590 MeV Ring Cyclotron
I1 Injector 1

Beam Transport Lines
P Proton Channel

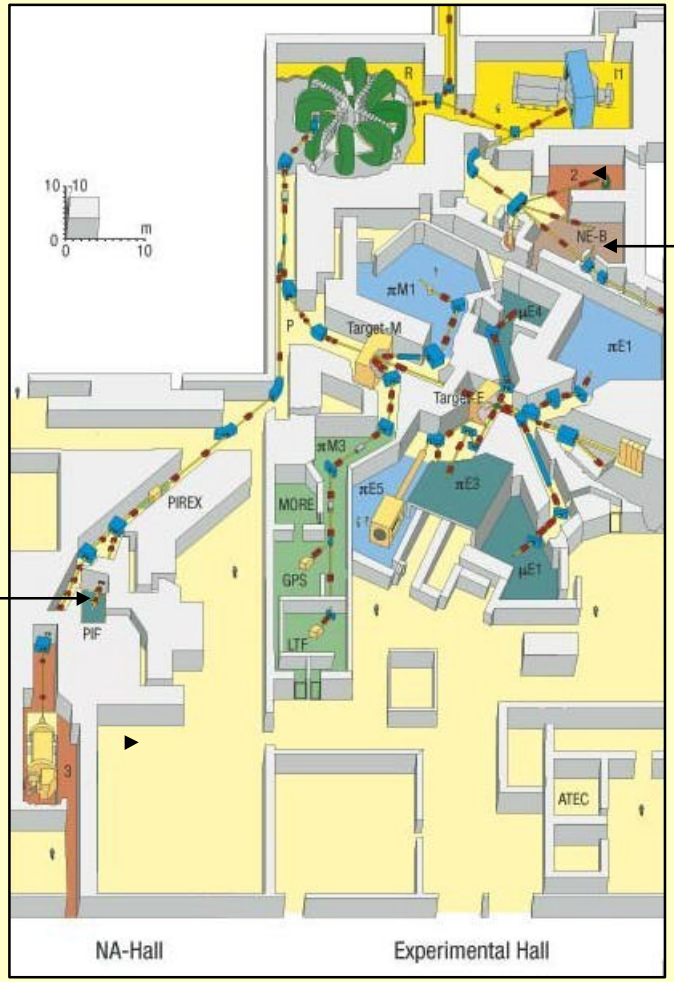
Neutron Spallation Source
S Neutron Spallation Source SINQ
L Target-Storage Pit

Medicine
1 Isotope Production IP2
2 Eye Treatment OPTIS
3 Proton Therapy Gantry

Nuclear Physics and Radiochemistry

Particle Physics

Solid State Physics and Materials Science



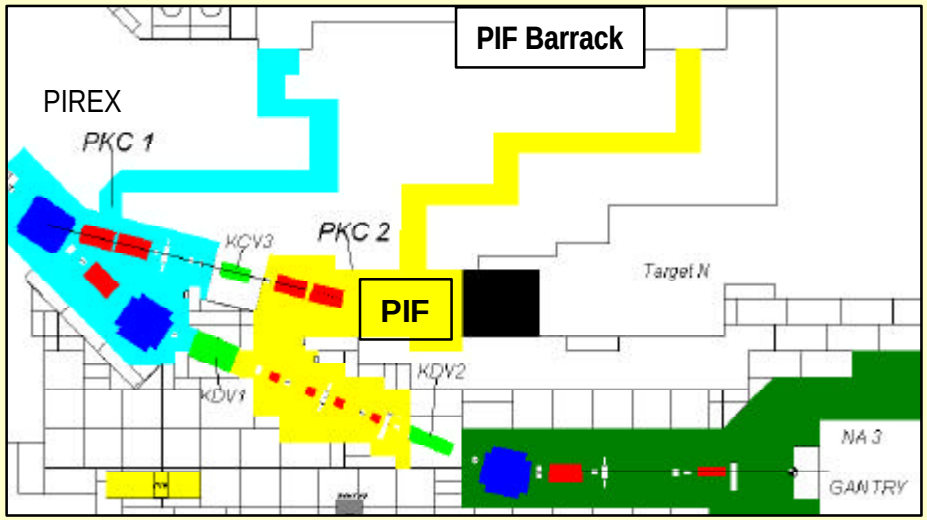
Old PIF OPTIS

PIF Station NEB
Low Energies

PIF Station PKC2
High Energies

Old PIF NA2

PKC2 Hall with PIF



New Experimental Sites

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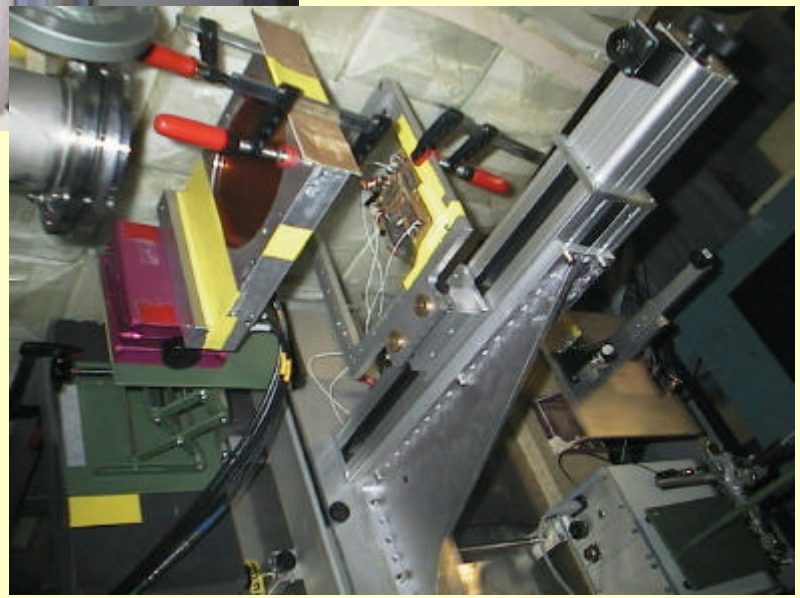
PKC2 XY-table, Laser and Beam Dump

PKC2 IC and Degrader

Portable !

NE-B IC, Frame and Laser



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PIF USERS in 2000

- ESA / ESTEC, EU
- PSI, Villigen
- ETH, Zürich
- University of Bern
- ABB Semiconductors, Lenzburg
- Contraves Space, Zürich
- CERN, Genf
- HIREX, France
- TRAD, France
- ALCATEL, France and Norway
- ASTRIUM, France and Germany
- SAAB Ericson Space, Sweden
- GSFC / Uni Berkeley, USA
- Marconi Applied Technologies, UK

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ESA EXPERIMENTS at PIF in 2000

WORK ORDER 15

- **Proton irradiation of THOMSON photodiodes and MIPAD photodiodes**
- **Proton irradiation of SAW filters**
- **Proton irradiation of non-linear crystals**
- **Proton irradiation of various laser diodes**

WORK ORDER 16

- **Proton irradiation of ACTEL FPGA - RT54SX16**
- **Proton irradiation of various Optocouplers types**
- **Proton irradiation of SIEMENS LabTop**
- **Proton irradiation of various SRAM types**

PIF EXPERIMENTS BY OTHER USERS

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- IREM radiation monitor calibration for INTEGRAL
- SREM calibration for PROBA and ROSETTA
- Radiation damage of various CCDs
- Activation measurement of Ta, Ti, Cu, W, and Al
- Radiation effects in power MOSFETs
- Radiation damage in novel solar cell technologies
- Dose effects in power supplies for CMS muon chamber and calorimeter
- Proton test of video-chain electronics (compressor and emitter)
- SEU characterisation of various electronic devices
- Proton test of Space Robotronic Controller
- Proton irradiation of AD Converter
- Gamma/electron tests of SREMs

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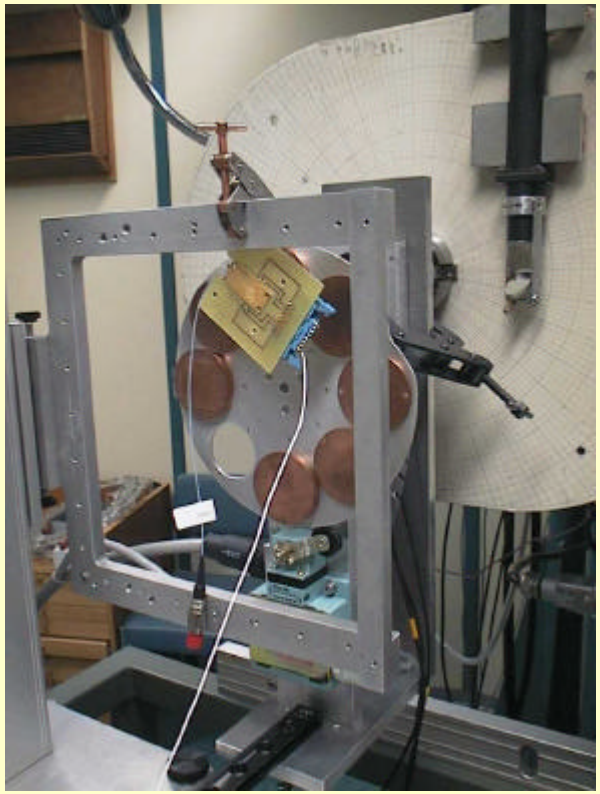
Proton Irradiation of THOMSON and MIPAD photodiodes (ESA ESTEC)



Irradiation setup in PIF OPTIS facility

DUTs -

12 THOMSON photodiodes with various epitaxial layers,
6 THOMSON photodiode arrays
2 MIPAS photodiodes
1 MIPAS laser diode

Setup -

Several samples irradiated simultaneously if possible.
Devices unbiased, grounded, facing beam.

Exposures -

Two campaigns performed.

Energy: 6 and 30 MeV

Fluency: from 10^{7} to 10^{12} p/cm^{2}

Fluxes: from 10^{6} up to $5 \cdot 10^{8}$ p/cm^{2}

Analysis -

Performed by ESA-ESTEC

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Calibration of SREM Batch (CSAG - ESA - PSI)

Standard Radiation Environment Monitor

SREM – developed in partnership: ESA, PSI and Contraves Space AG.
Monitors for PROBA and ROSETTA satellites manufactured
by Contraves AG, calibrated by PSI and delivered to ESA.

Setup

Example see Photo

Procedure -

I Short Functional Test, ^{60}Co and Cosmic Ray check
II Low energy response at 0°
II-a Thresholds determination
III Detector area measurement
IV Dead-time determination
V Full response calibration/set of energies and angles

Analysis -

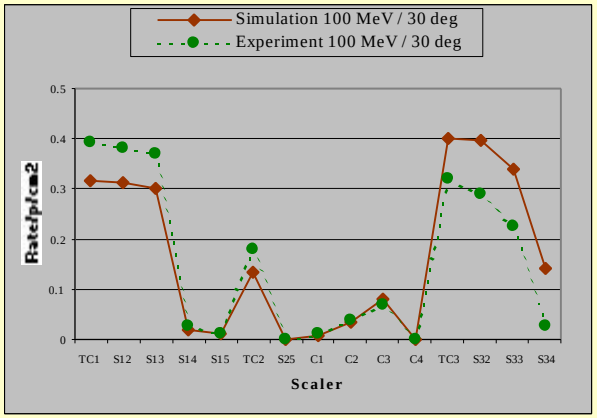
Simulations done for exactly the same energies as in experiment.
Angular positions changed for the whole set of proton incidence angles.

Conclusions -

Two tested SREMs meet their specifications.

Agreement experiment-simulations in general very good.

PROBA SREM mounted on PIF-PKC2 XY-table



Experiment and Modeling - comparison

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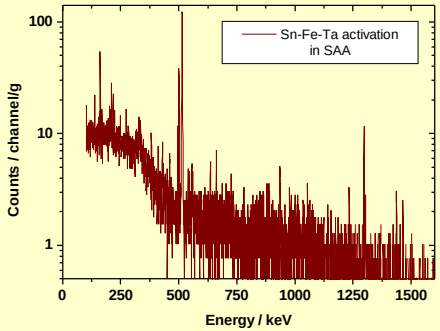
Background Studies for HESSI Project - SAA Induced Radioactivity (PSI - GSFC - UCB)

HESSI	- High Energy Solar Spectroscopic Imager
Launch	- 28 March 2001
Activation	- mostly metals surrounding Ge-spectrometer
Radiation	- predominantly protons in SAA

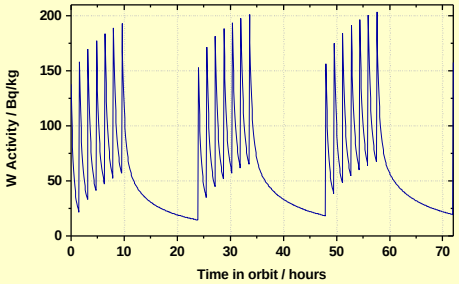


Gamma spectrum from Sn-Fe-Ta (1g) exposed to SAA proton spectrum. F=5.8•10^{10} p/cm^2 - 100 days in orbit;

Irradiated elements - Al, Ti, Cu, W and graded-Z shield plates: Sn-Fe-Ta (20x10x2 mm^3)

Exposures - Single energies: 50, 100, 200 MeV, SAA spectrum: 30-300 MeV in 8 bins

Analysis - Sn-Fe-Ta : 40 gamma ray lines found from 18 radioisotopes with $T_{1/2}$ from 8 min to 2 days. Total activity after SAA exposure test A=147 Bq/g



Activity changes during the flight - activation gain during SAA passing

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Proton Radiation Hardness Characterization of Solar Cells - (ETHZ-PSI)

Irradiated elements -

Solar cells in blocks of 12,

Al shielding to determine energy

Setup and Exposures -

Energy: 0, 5, 10, 15 MeV (all at once using degraders)

Fluency: 10^{11}, 10^{12}, 10^{13} p/cm2

4 cells exposed to single energy and fluency

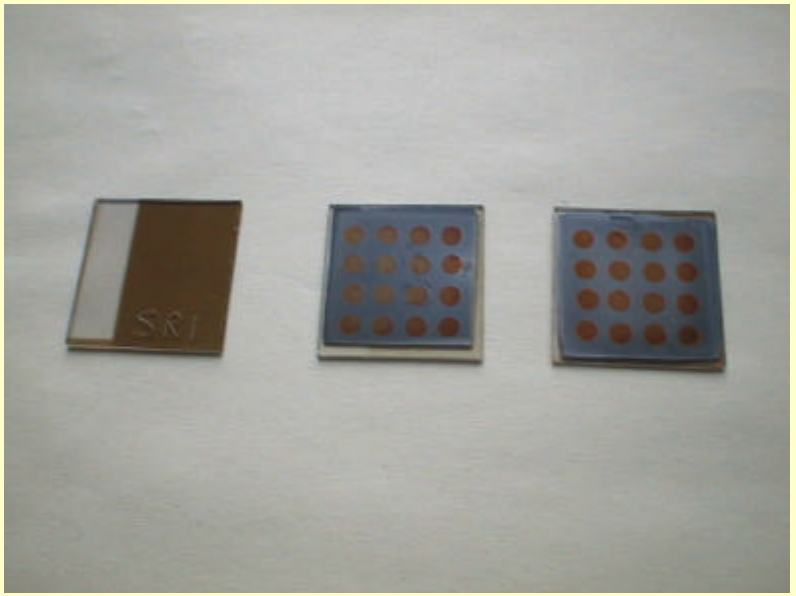
Analysis -

Done by ETH Zurich;

Results -

Preliminary data promising (TBP),

New measurements are planned



Solar Cells manufactured by ETHZ

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PSI / PIF Operation 2001

- Low energy (Injector 1) production - 1 March
- 1st PIF NEB / OPTIS week - 12 March
- High energy (Inj. 2, Ring) production - 2 May
- PIF PKC2 / Proton Therapy operation - 14 May

- Low energy area - Collimators, cables, full XY automation
- High energy area - New controllers, software, analysis SW

- Specification and design of new irradiation area / PROSCAN

- First irradiation reserved: PSI, ETHZ, Contraves Space, ESA

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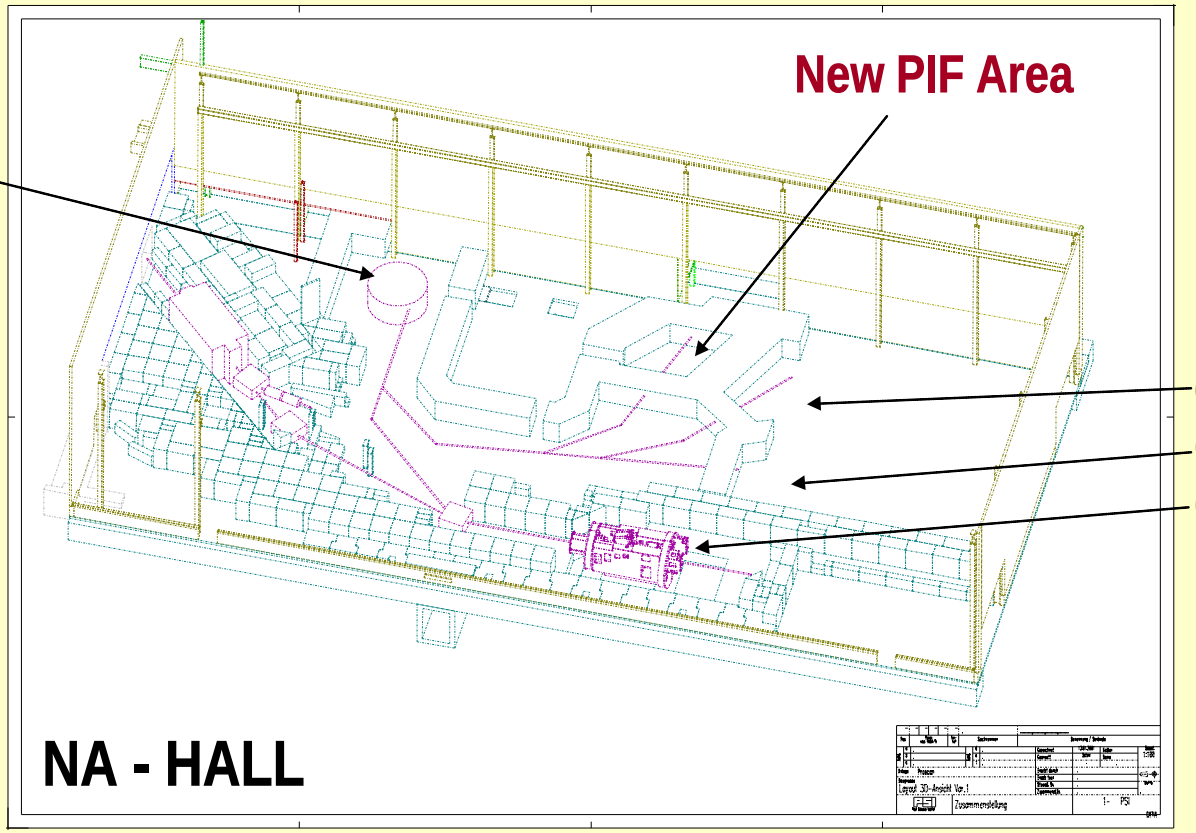
New Biomedical Cyclotron Project - PROSCAN



Biomedical Facilities
OPTIS
GANTRY 2
GANTRY 1 (existing)

PAUL SCHERRER INSTITUT

PROSCAN

Master Schedule

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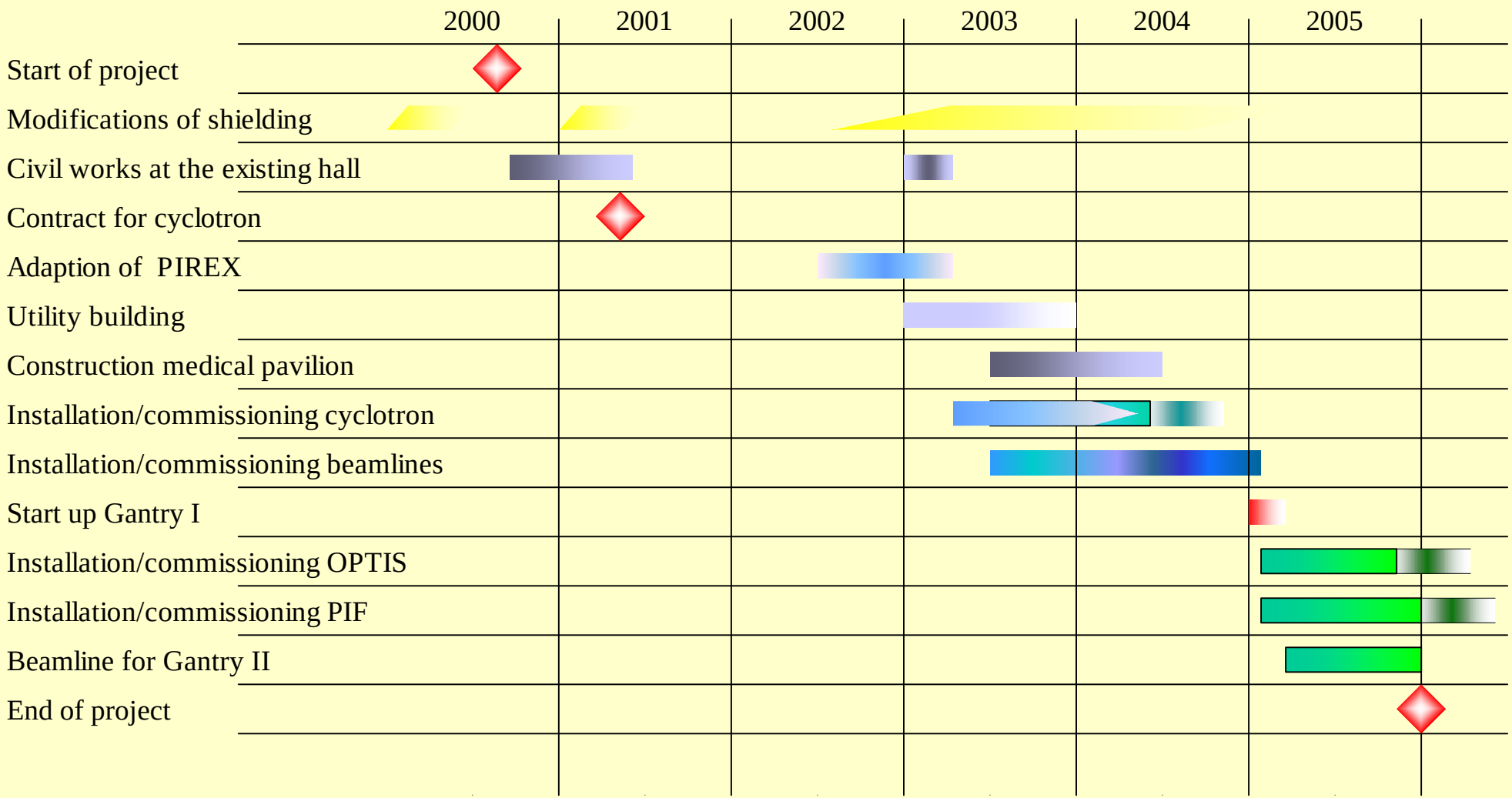

LABORATORY FOR ASTROPHYSICS

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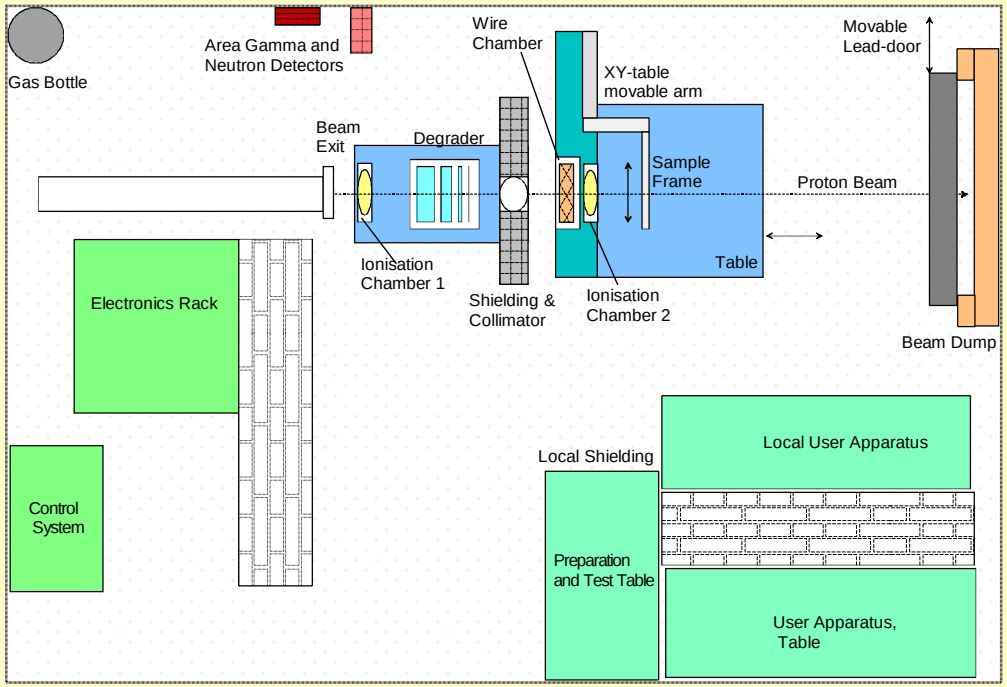
PROSCAN PIF Specifications:



Draft 0 of PIF area in PROSCAN

- Cyclotron Energy - 250 MeV
- Intensity in PIF area - 10 nA
- PIF Energies: 250 and 70 MeV
- Achromatic Beam
- Sweeper X and Y Magnets
- Vacuum System
- Water Supply
- He Recovery System
- Small Crane
- Network, Cables Infrastructure etc.
- Space and Biomedicine Utilization