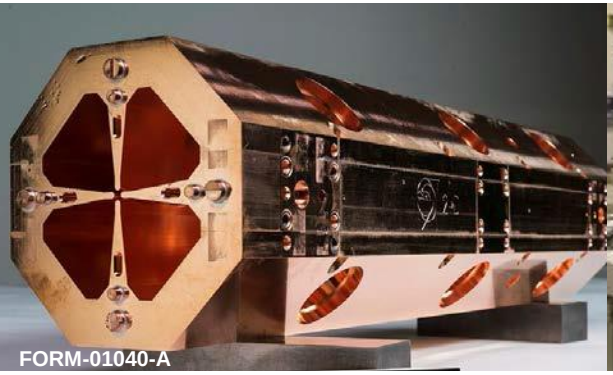
17th of MAY 2018

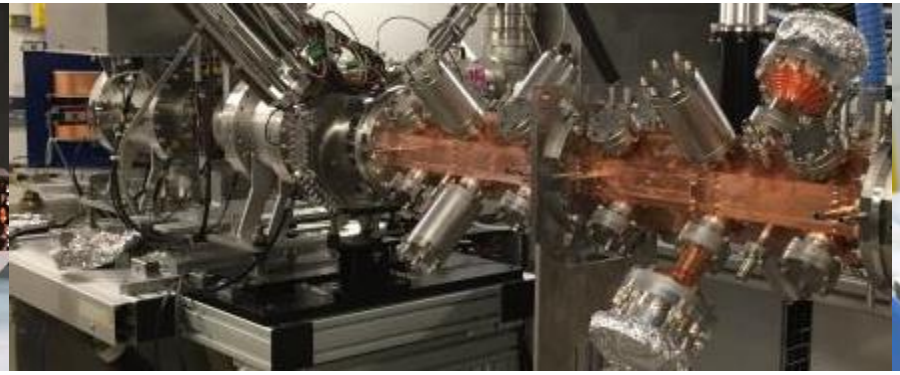
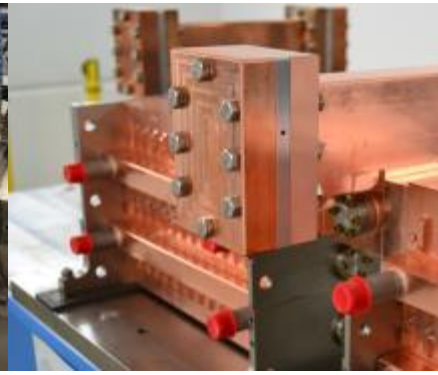
Libera WORKSHOP 2018

ADAM
an ADVANCED ONCOTHERAPY company

LIGHT PROTON THERAPY PROJECT

Yevgeniy Ivanisenko on behalf of ADAM team



CERN spin-off

AVO-ADAM

- **Advanced Oncotherapy (AVO) is a public company**
- **ADAM is R&D center of AVO**
- **~ 100 employees**
  - about **50 people** in accelerator R&D from **15+ countries** contributing their research lab and industry experience
- **Offices in UK, Switzerland and USA**

www.avoplc.com

www.adam-geneva.com

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Current Opportunities

Accelerator Physicist Beam Dynamics (Geneva)

Health and Safety Engineer (maternity cover contract) Geneva

Installation Engineer (UK)

LabVIEW RT Engineer (Geneva)

LabVIEW Software Engineer (Geneva)

Medical Physicist (Geneva initially)

PLC Software Engineer (Geneva)

Project Engineer (UK)

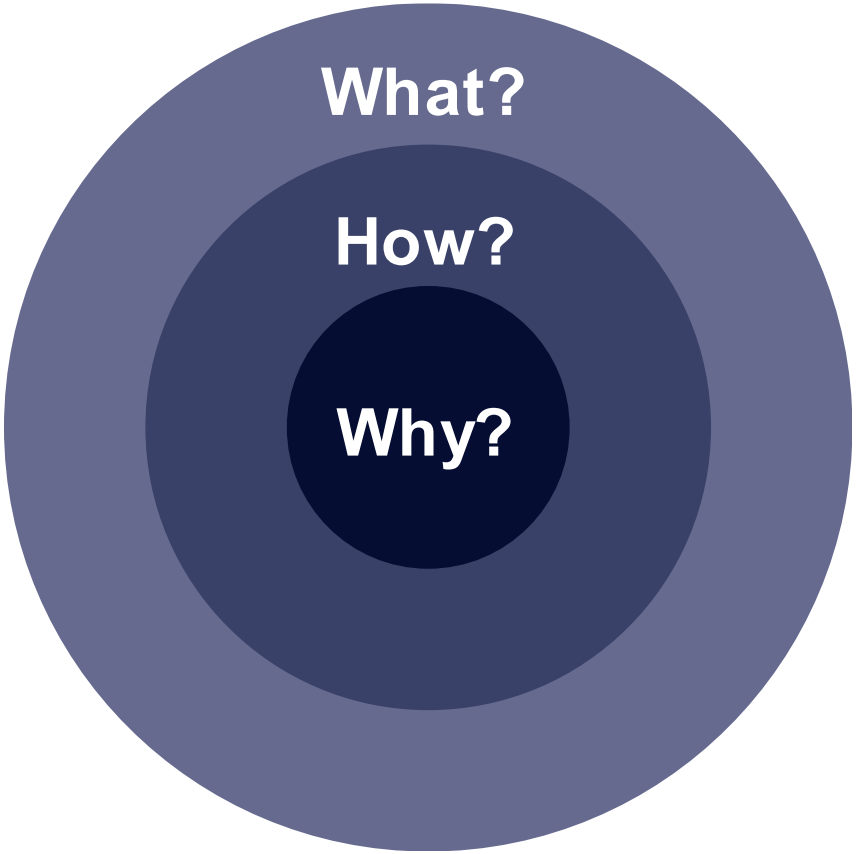
SCADA System Engineer (Geneva)

Senior Installation and Service Engineer (UK)

Site Support Engineer (UK)

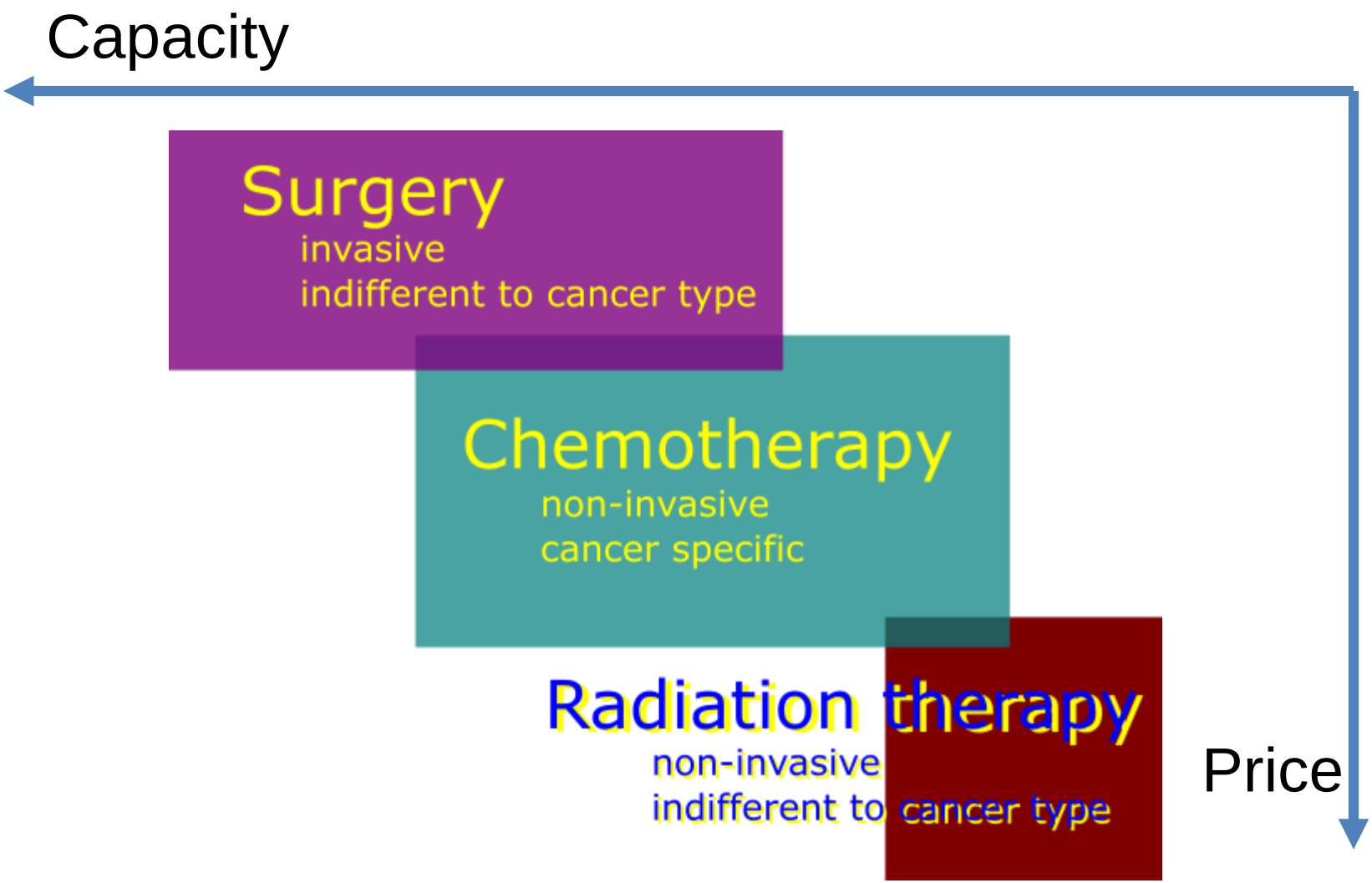
System Administrator (Geneva)

CONCEPTUAL INNOVATION



- **Why … (mission)**
  … to care?
  … to change?
  …
- **How … (direction)**
  … can be achieved?
  … can impact?
  ...
- **What … (objective)**
  … needs to be done?
  … will be the outcome?
  …

CANCER TREATMENT

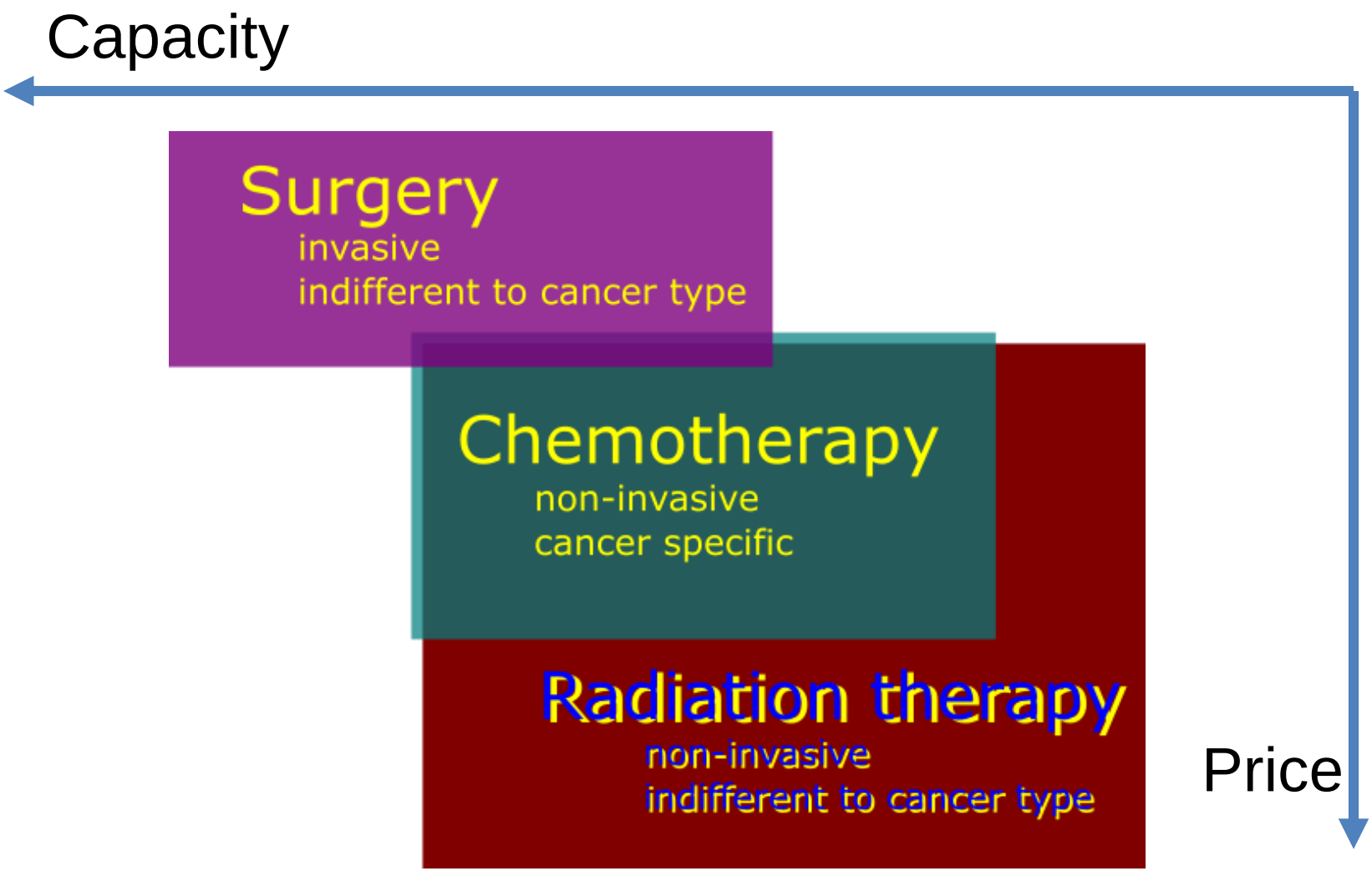


RT CANCER TREATMENT

- **Growing number of cancer cases in our aging society with a heavy industrial impact on environment**

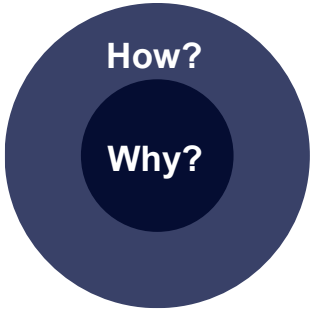
- **More affordable RT**
- **More accessible RT**

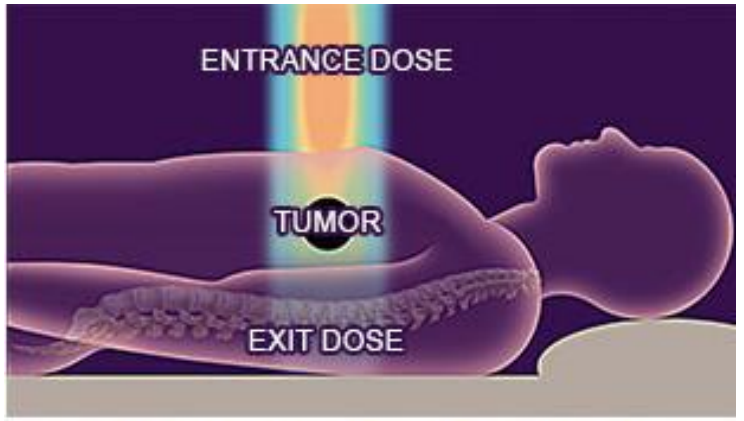
RT OUTREACH


Capacity
Surgery
invasive
indifferent to cancer type
Chemotherapy
non-invasive
cancer specific
Radiation therapy
non-invasive
indifferent to cancer type
Price

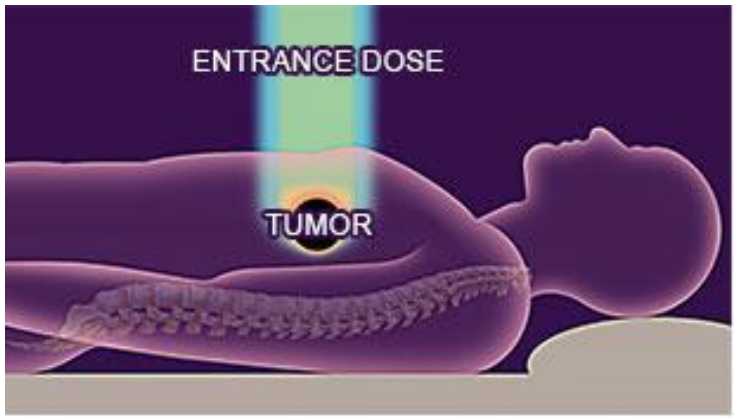
RADIATION THERAPY

- **RT**
  - –Proton VS Photon
- **PT advantage**
  - –Accuracy
    - Less toxicity
    - Less chance of secondary tumors

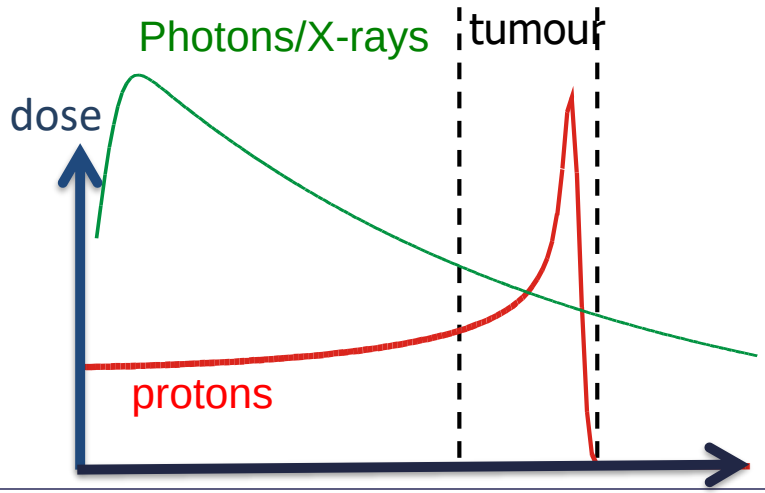




CONVENTIONAL RADIATION THERAPY:
Deposits most energy before target

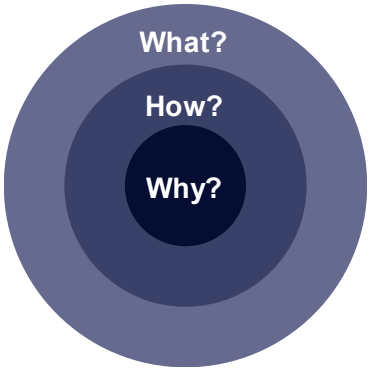


TARGETED PROTON THERAPY:
Deposits most energy on target

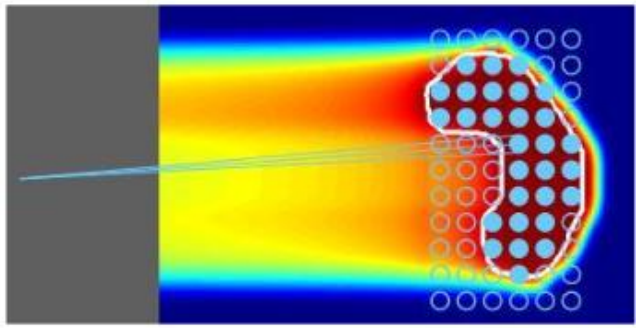


NEXT GENERATION PT

- **Small emittance**
  - –Pin point targeting w/o masks and degraders
    - Less induced secondary radiation
    - Less shielding
    - Less radioactive materials



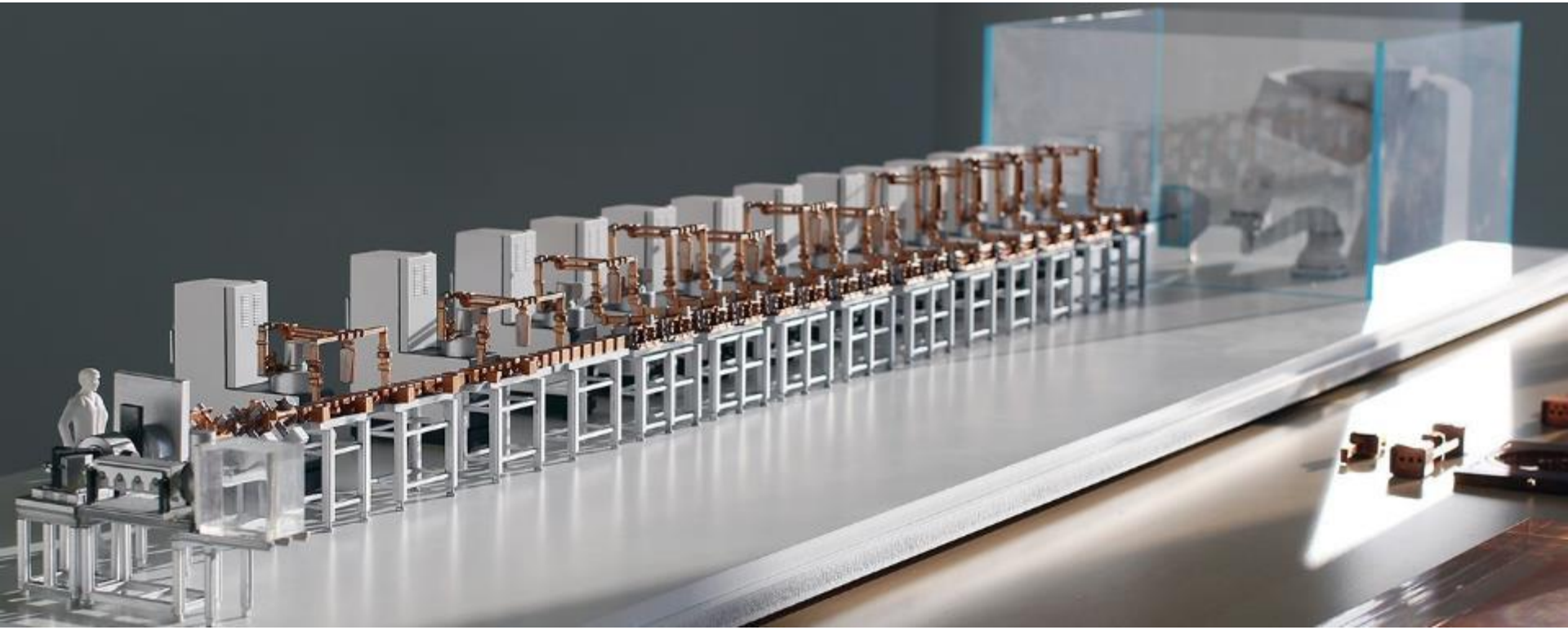
- **Energy / charge variation at high repetition rate**
  - –Raster painting (X,Y,Z) of the tumor volume
  - –Real time image guided adaptive treatment



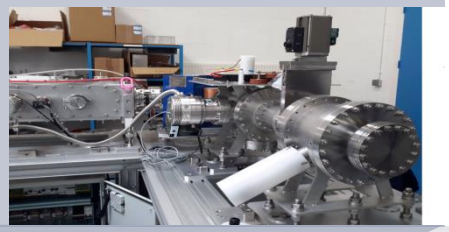
LIGHT DESIGN PARAMETERS

- **Linac Image Guided Hardron Therapy**
  - Proton accelerator up to 230 MeV
  - Energy and charge modulated beam at 200 Hz
  - Normalized emittance < 1 mm mrad

LiGHT
Linac for Image Guided Hadron Therapy

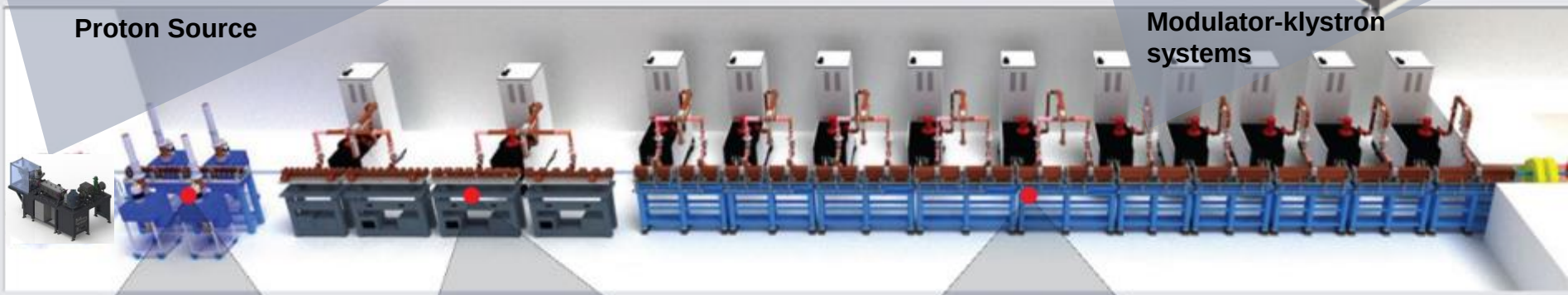


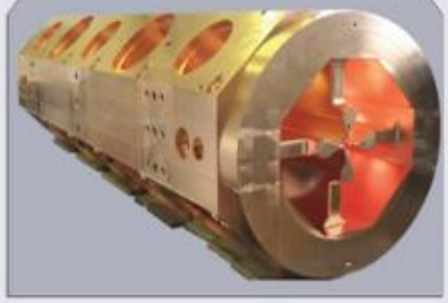
LINAC OVERVIEW



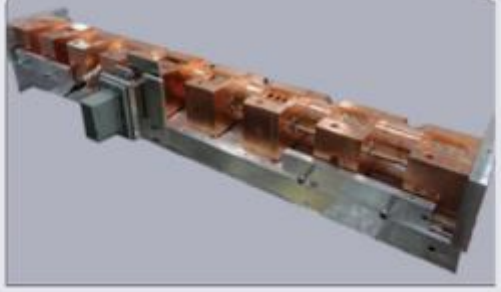
Proton Source

Modulator-klystron systems

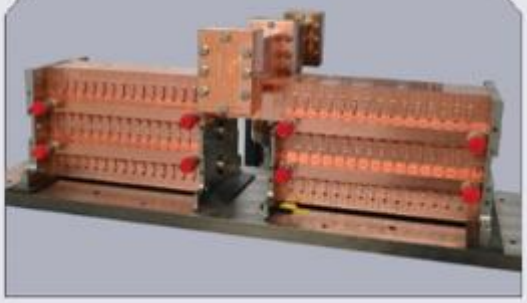




Radio Frequency Quadrupole (RFQ)



Side Coupled Drift Tube Linac (SCDTL)



Coupled Cavity Linac (CCL)

HISTORICAL INSIGHT WITH PROSPECTIVE

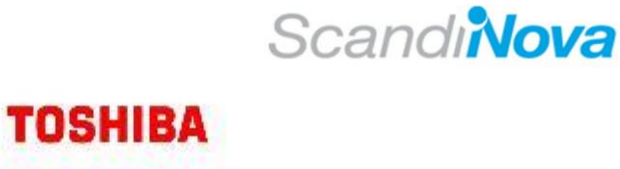
- **1993 TERA** foundation started developing proton therapy linear accelerator
- **2003** First accelerating structure test
- **2007 ADAM**, **a CERN spin-off company**, was found to commercialize a proton linac based on TERA and CERN technologies
- **2013 ADAM** is acquired by **Advanced Oncotherapy** (AVO) to bring a linac based medical solution on the market
- **2020** First patient at Harley Street

HARLEY STREET

Harley Street, London, the First Site Housing LIGHT

Access, Comfort, and Affordability for Patients

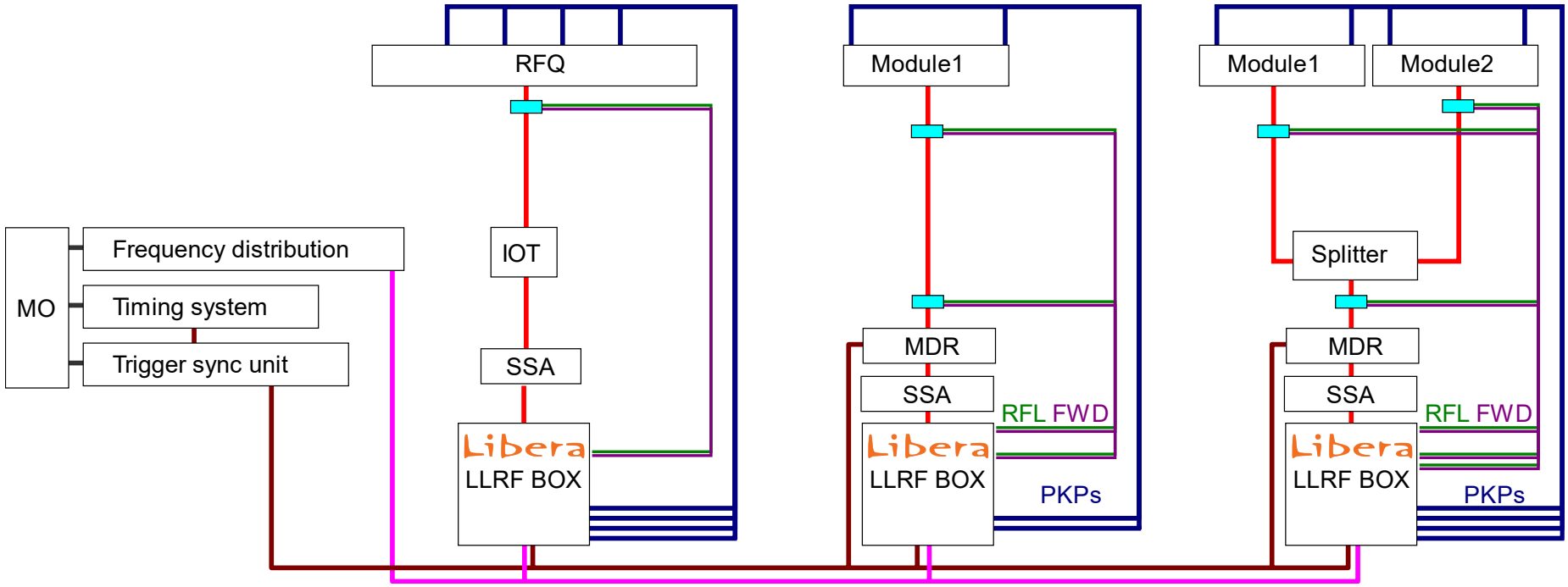
R&D AND INDUSTRIAL PARTNERSHIP



LIBERA INSTRUMENTS FOR LIGHT

LIGHT LLRF SYSTEM

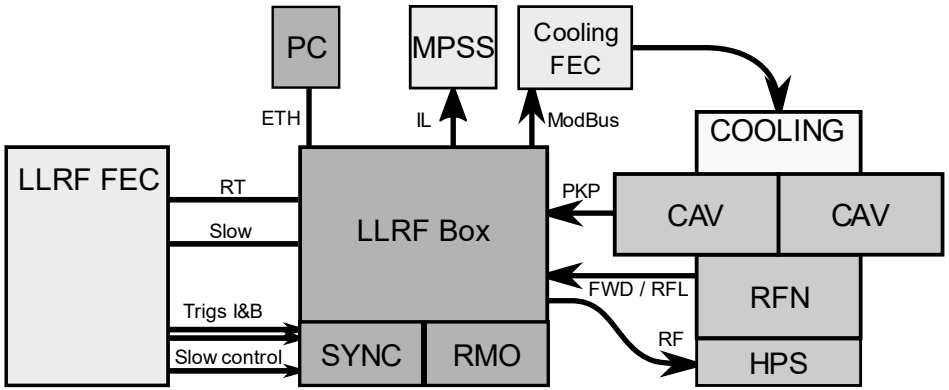
- **13 Libera LLRF units**



LLRF SPECIFICATION

- **Two frequencies**
  - RFQ at 750 MHz
  - SCDTLs and CCLs at 3 GHz
- **Pulse structure**
  - 5 us long RF pulse, arbitrary shape
  - 200 Hz
- **Slow cooling feedback**
  - Based on decay analysis
- **Adaptive feedforward (AFF)**
  - 0.15 deg RMS
  - 0.15 % RMS

- **Control system integration**
  - Real-time interface for pulse-to-pulse settings
  - Slow interface for non-critical data exchange
  - Interlock
  - Siemens PLC interface for the cooling loop (RS-485)



LLRF PROJECT STATUS

- **System requirements are defined**
- **Contract is signed**
- **Project in two phases:**
  - Phase one: hardware validation with two LLRF boxes and a sync box
    - *By the end of 2018*
  - Phase two: full system
    - *By the end of Q1 2019*

LIBERA SPARK BPM SYSTEM

- **Beam is pulsed (typ. for 2us every 5ms)**
  - triggered acquisition, important to set in the Spark correct trigger delay, threshold and number of samples

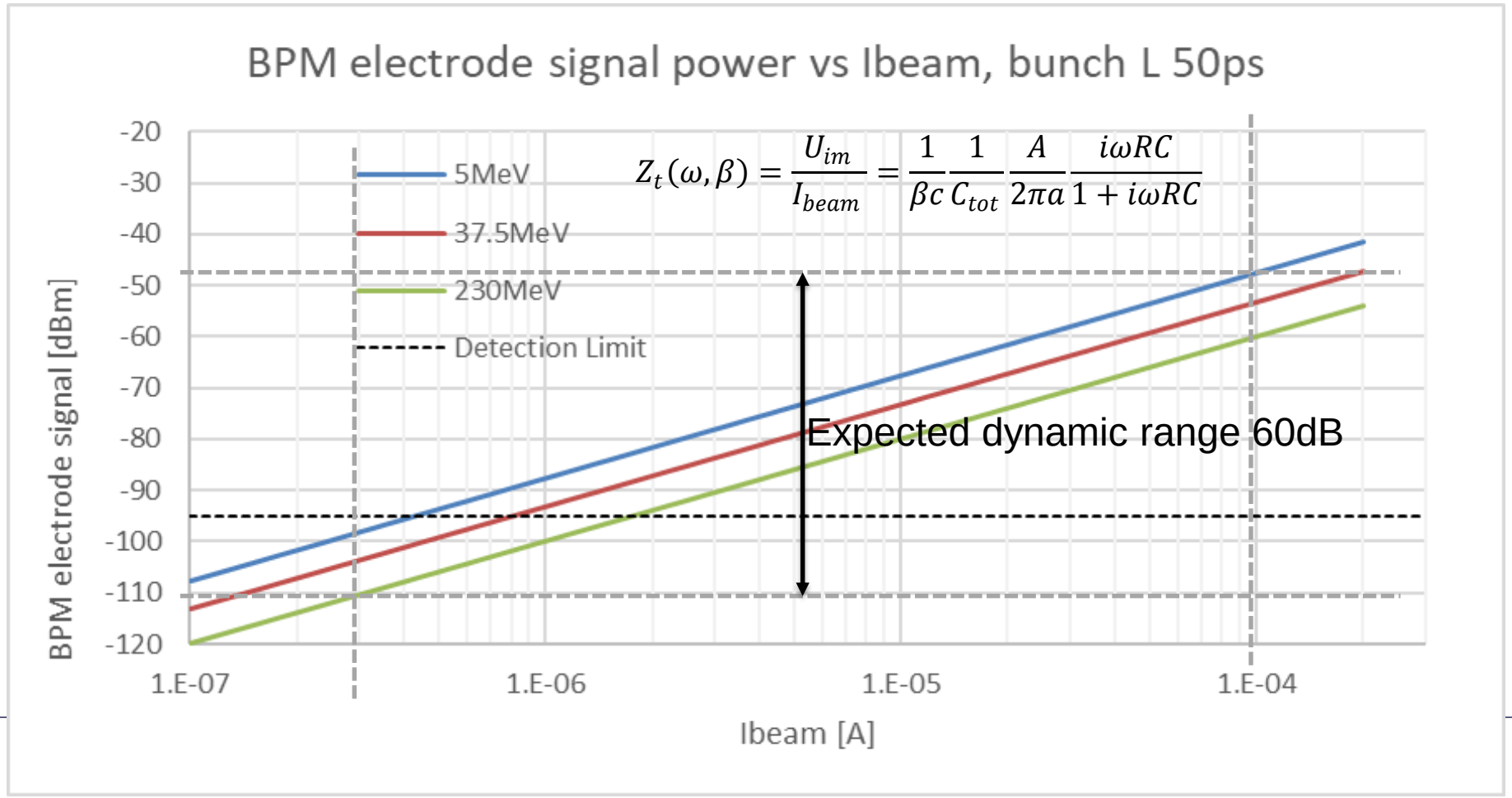
- **<x>, <y> of each beam pulse (max 200 Hz → 5ms rep rate!)**
  - Standard Spark interface not deterministic, fast interface (FPGA based) under development/test

- **Biggest challenge: BPM signals extremely weak and huge dynamic range 60dB (it can be from pulse to pulse) as a combination of**
  - Beam energy range from 5MeV up to 230MeV
  - Beam pulse current 0.3uA up to 100uA depending on treatment planning

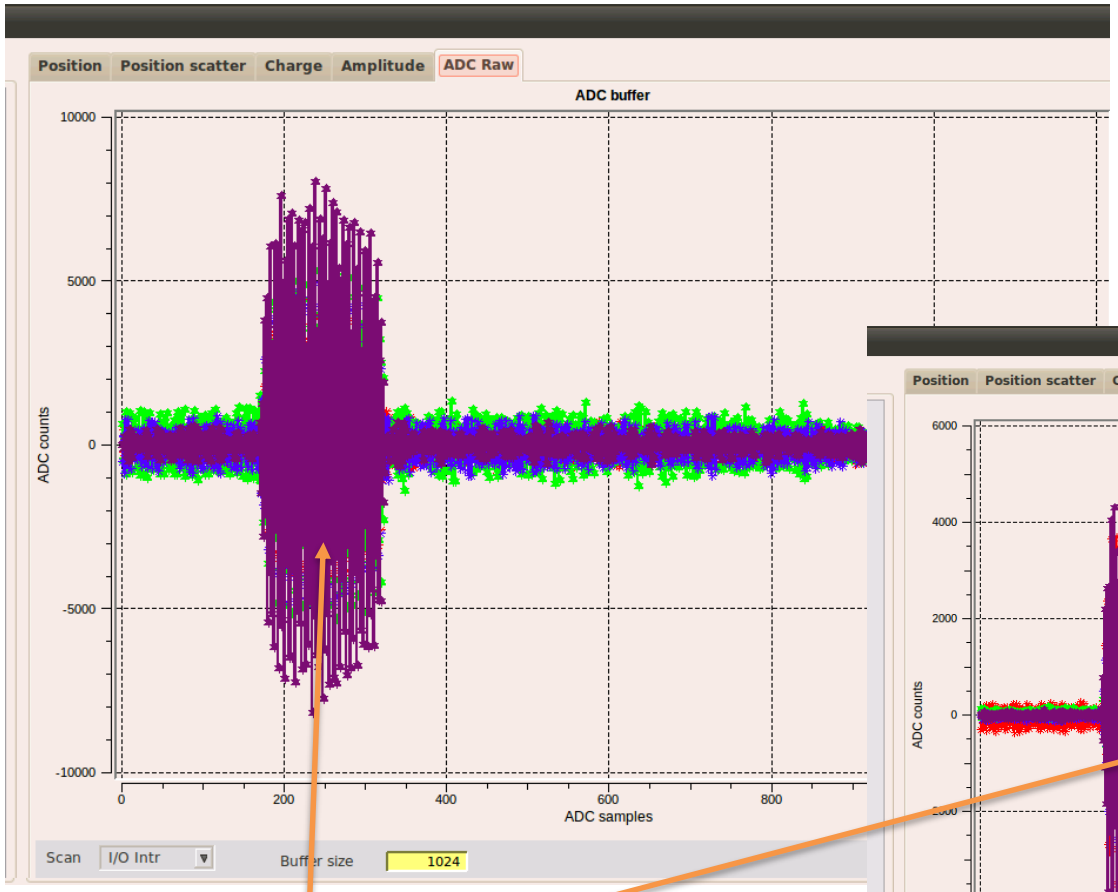
- **BPM system should always guarantee a resolution better than 50um**
  - fast gain setting in the electronics and/or Spark HL internal attenuators

More on BPM signal dynamic range

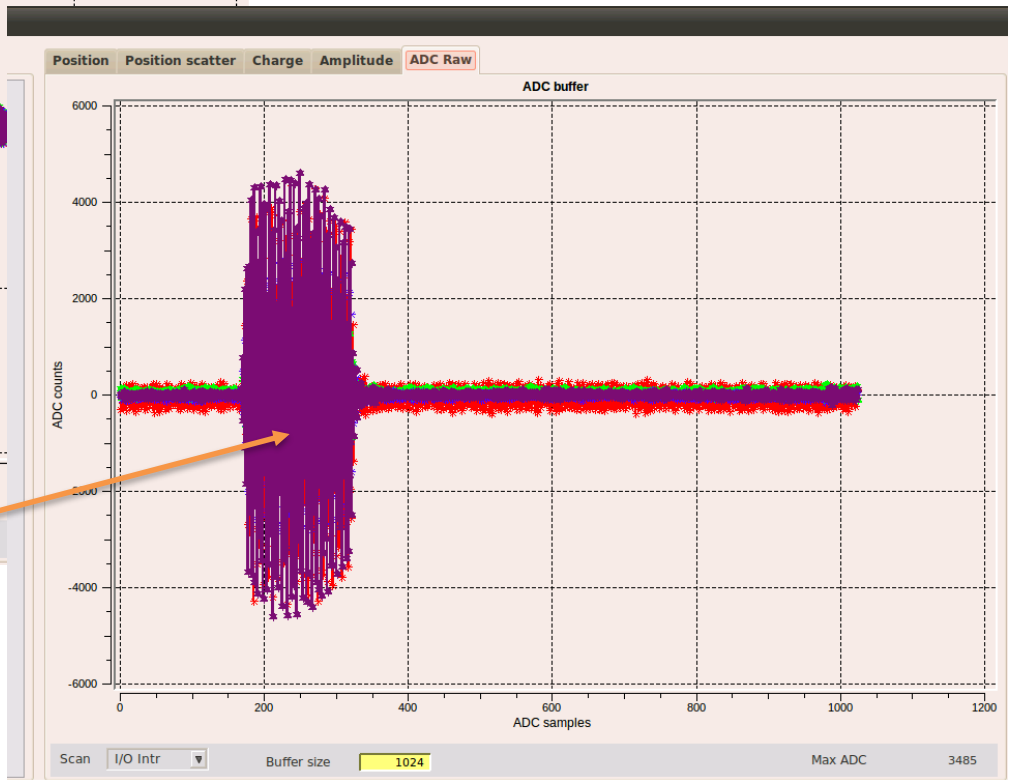
- **Current detection limit is -95dBm in the lab**
  - corresponds to ~1uA at 7.5MeV
  - different low-noise preamplifiers are in test to push the limit down



2 BPMs with different preamplifiers

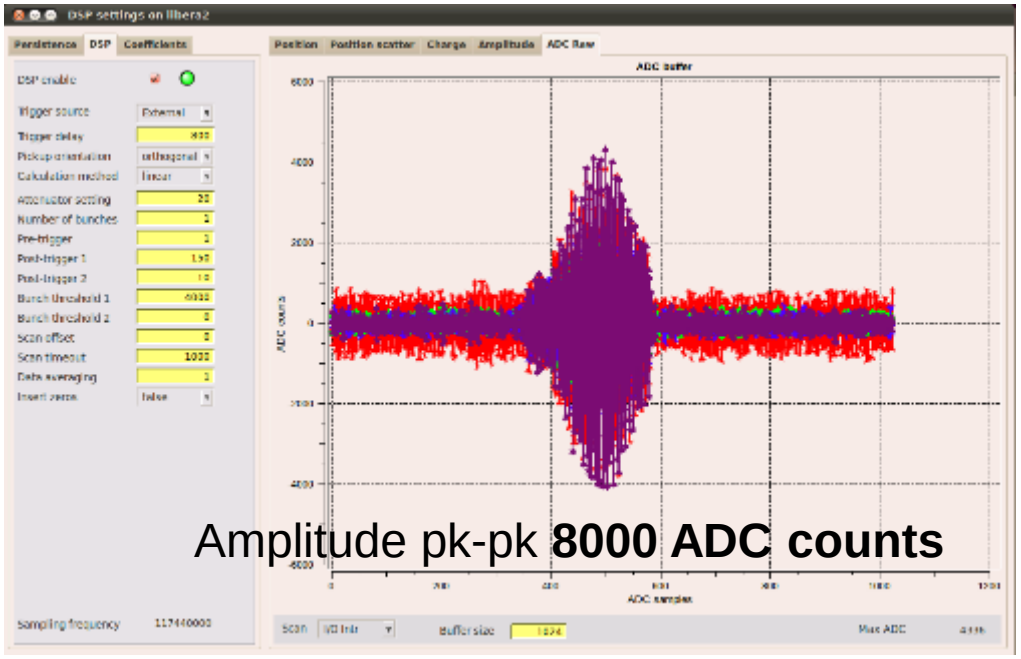


Noise level is different, beam position resolution is the same

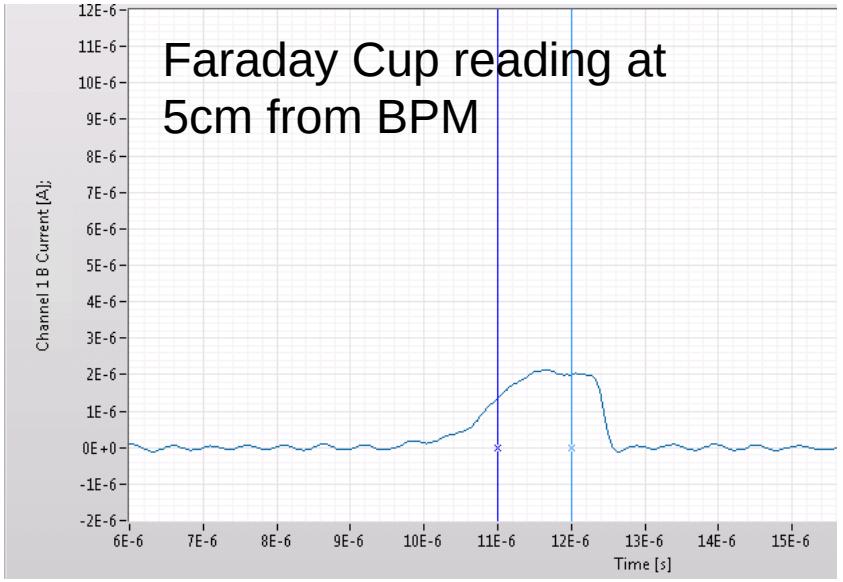


Beam @16MeV, 7uA

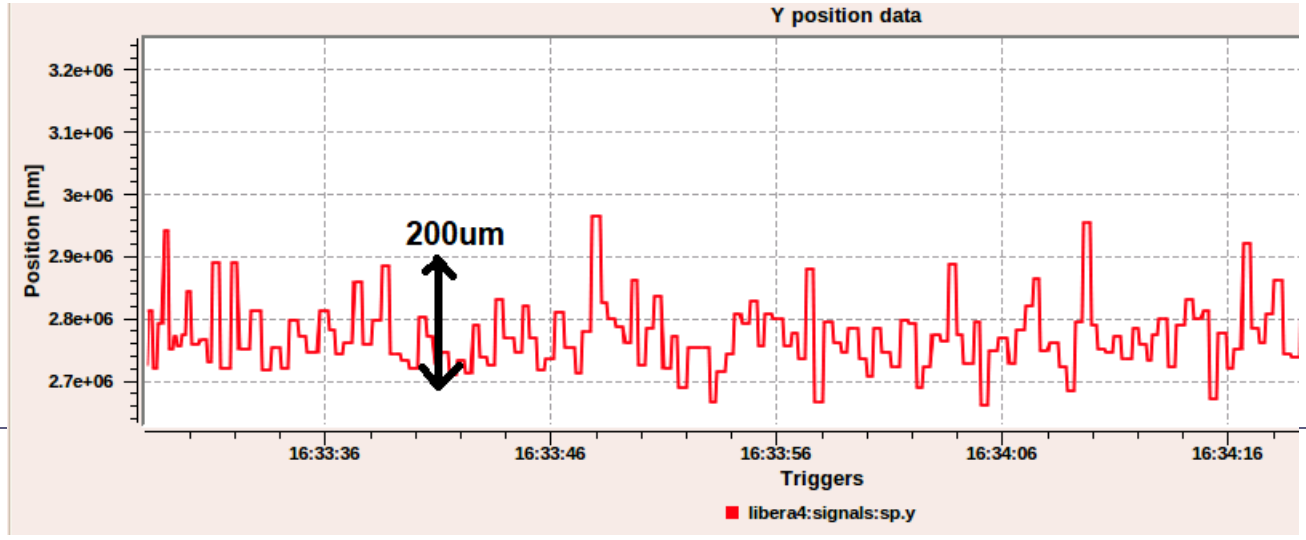
Resolution: 2uA beam at 16MeV



Amplitude pk-pk **8000 ADC counts**



2uA pulse current, 1.5us



THANK YOU!