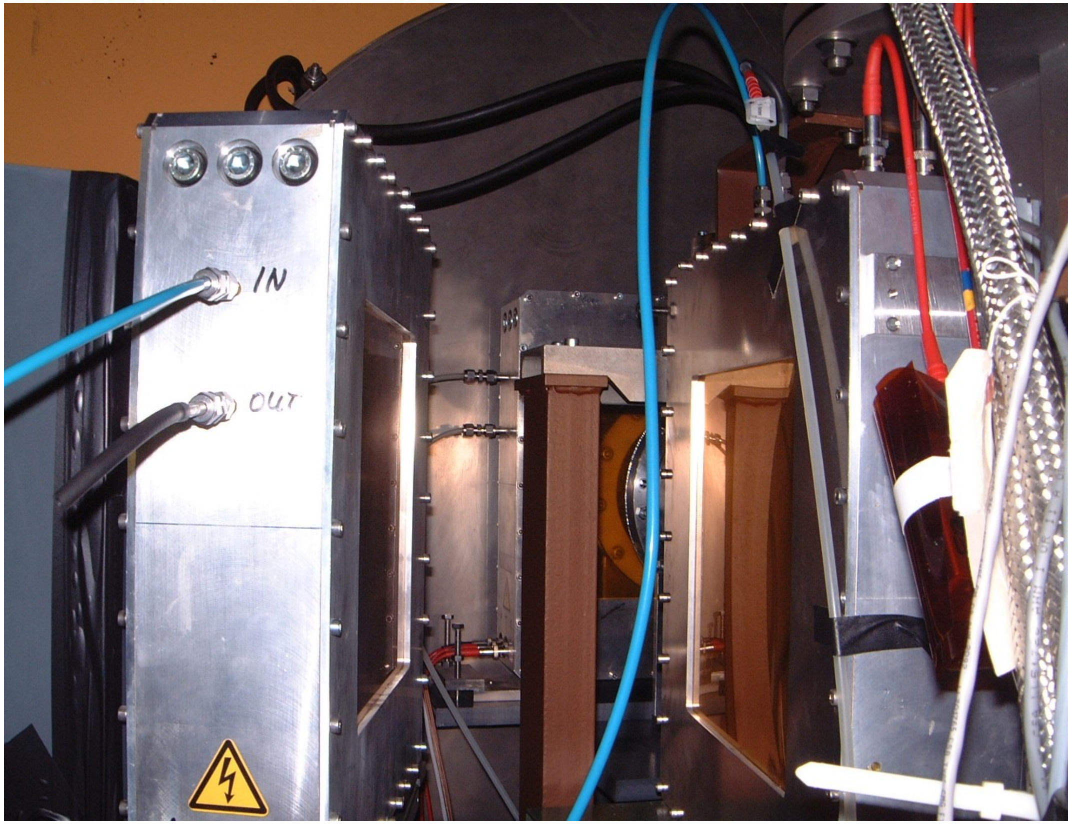
Hunting Tools Beyond the Driplines

Performing large-scale nuclear physics experiments



Håkan Johansson, Subatomic Physics, Chalmers, Göteborg, 2010-02-10

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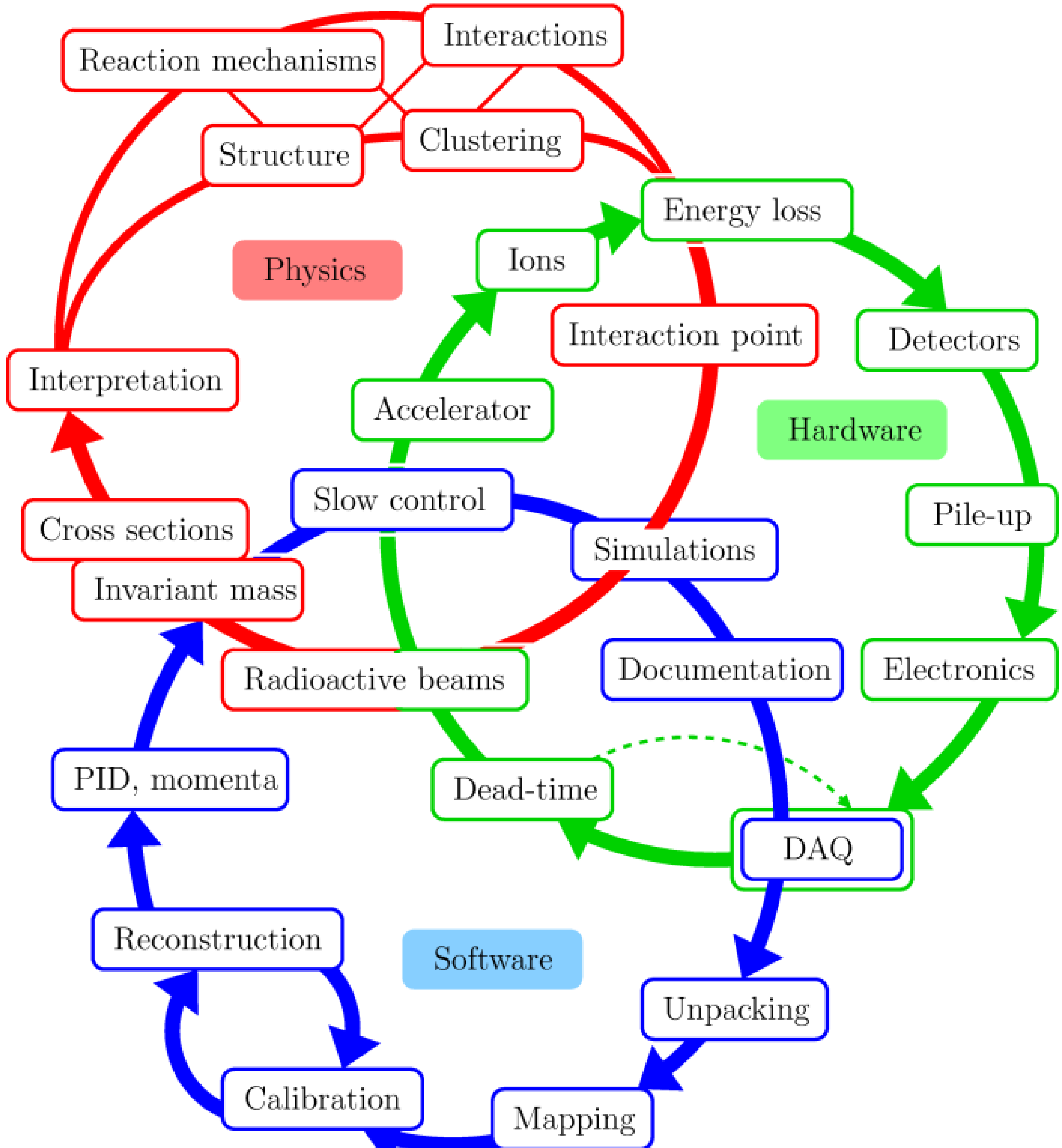
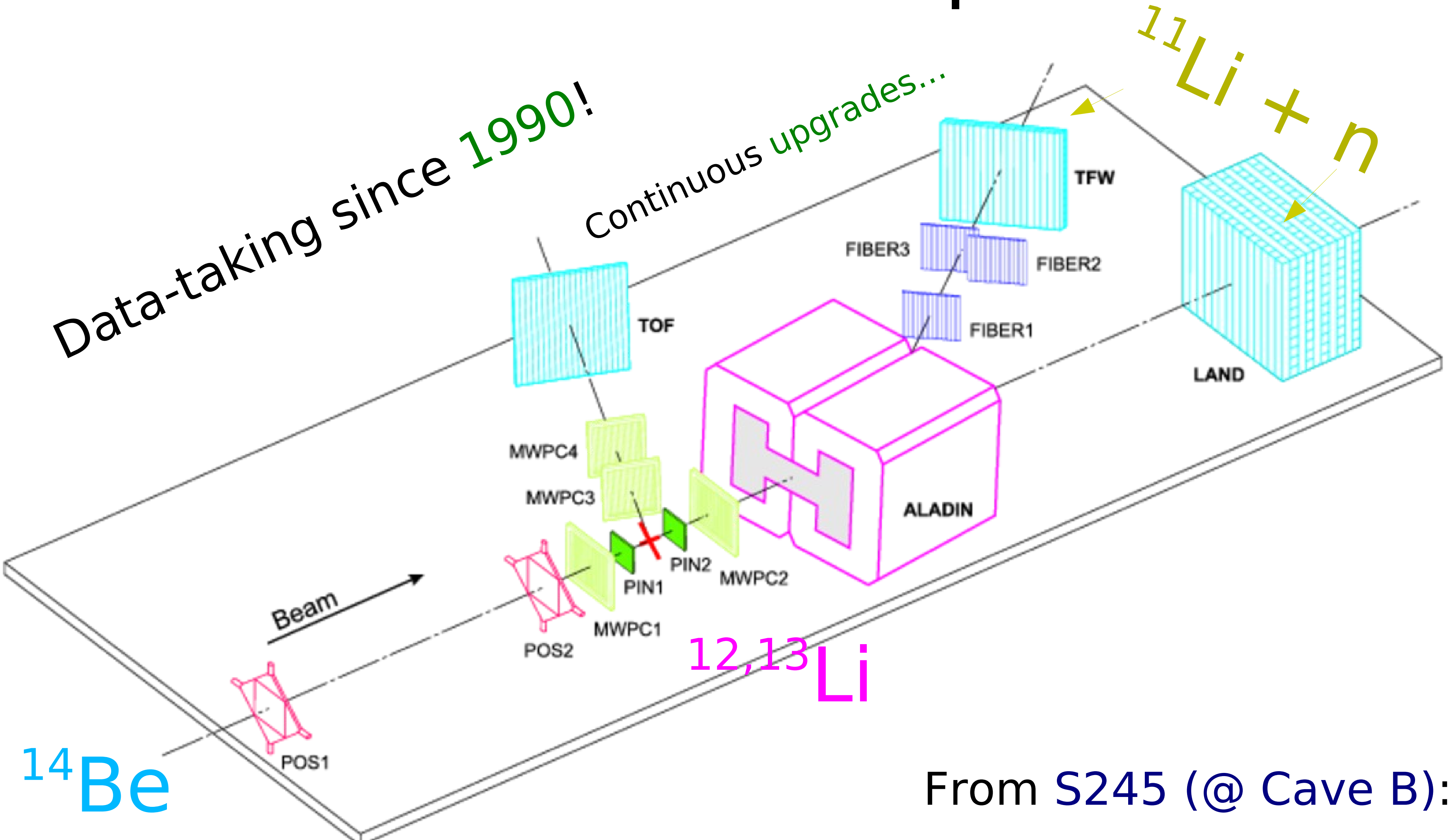


ALADiN-LAND setup → R^3B

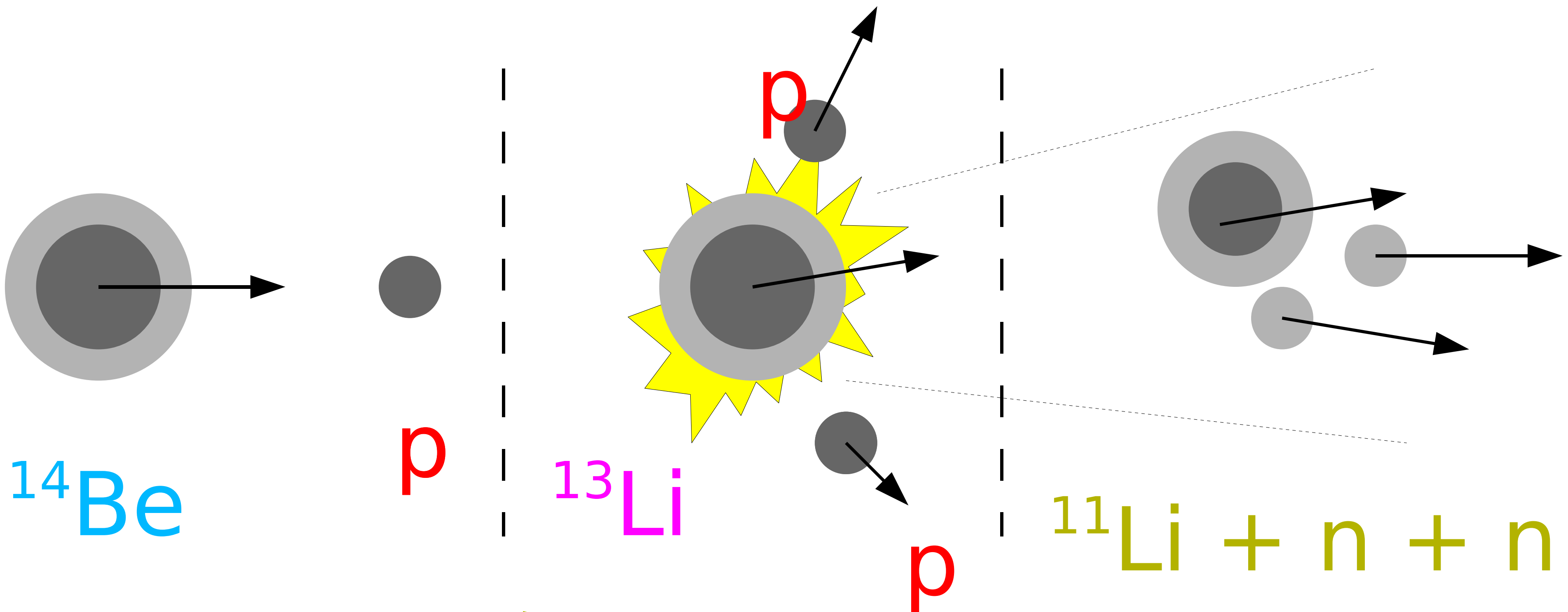


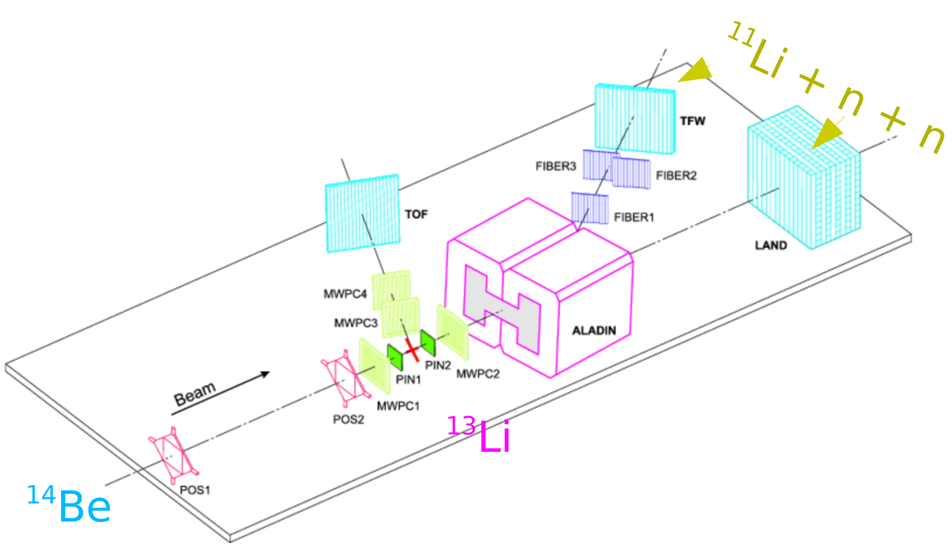
From S245 (@ Cave B):

Lithium isotopes beyond the drip line

Yu. Aksyutina, H.T. Johansson, et. al.
Physics Letters B, Vol 666 (2008) pp. 430-434

Unbound systems via invariant mass

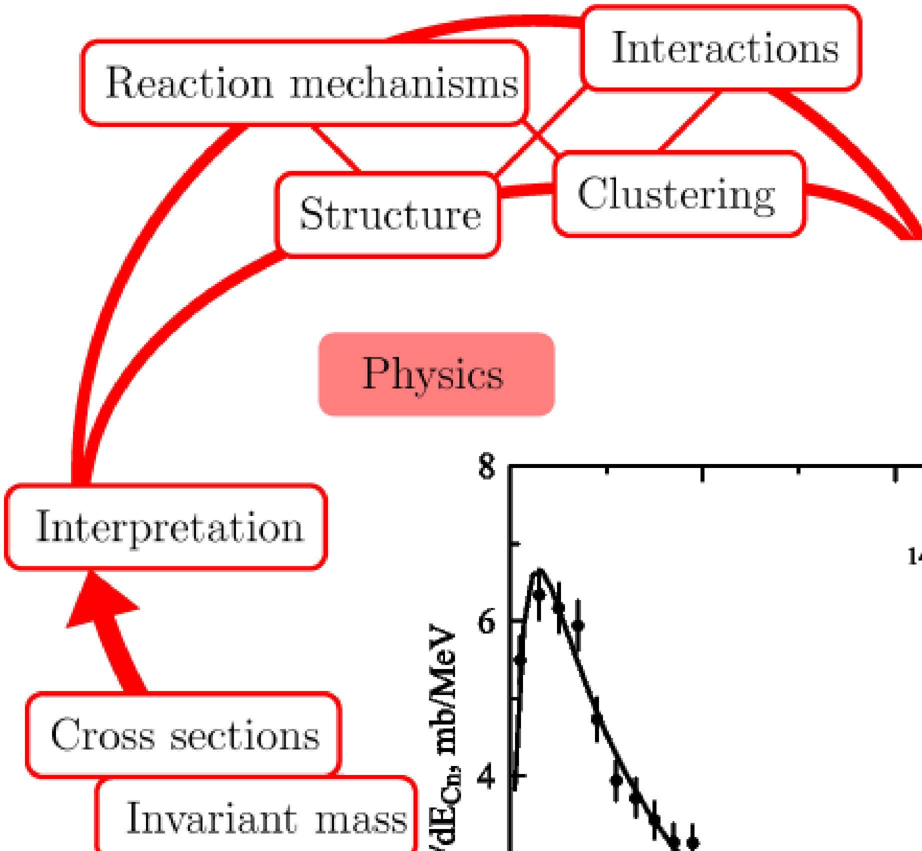


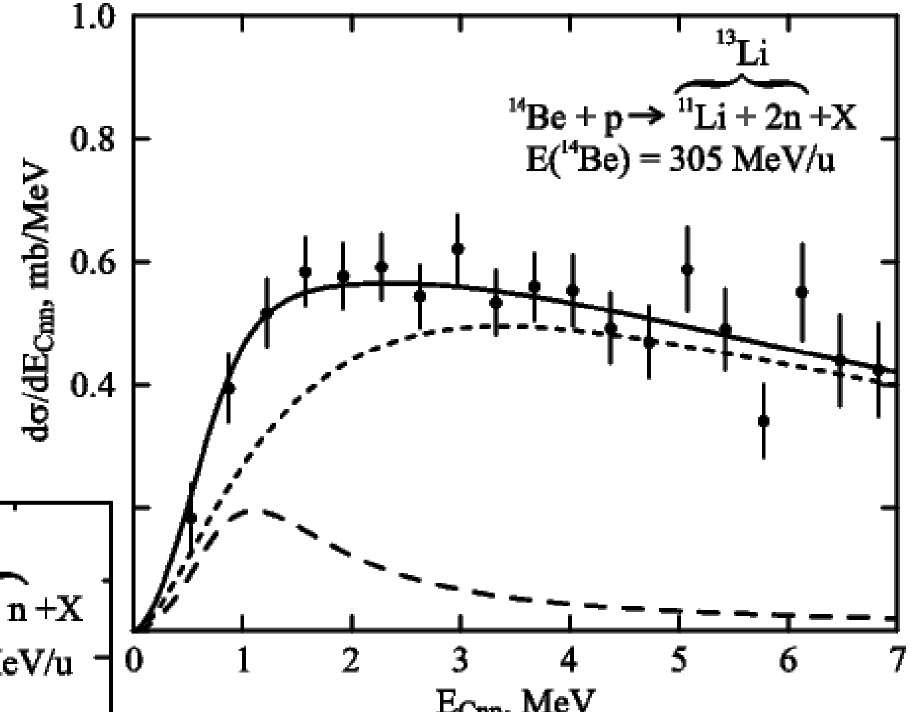


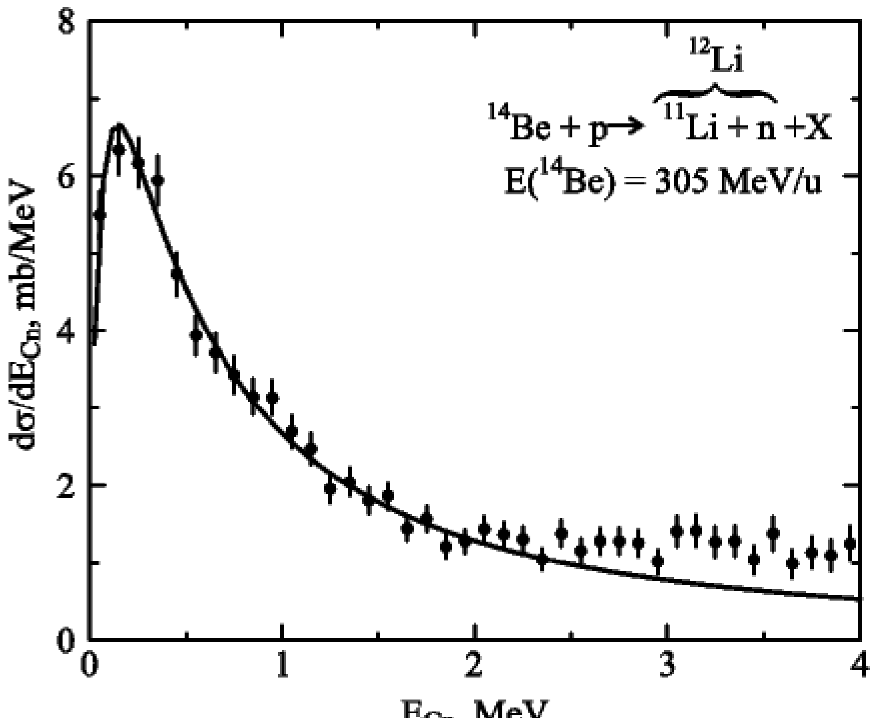
$$\mathbf{p}_{^{13}\mathrm{Li}} = \mathbf{p}_{^{11}\mathrm{Li}} + \mathbf{p}_{n} + \mathbf{p}_{n}$$

$$-\mathbf{p}_{^{13}\mathrm{Li}}^{\;2} = \mathbf{m}_{^{13}\mathrm{Li}}^{\;2}$$

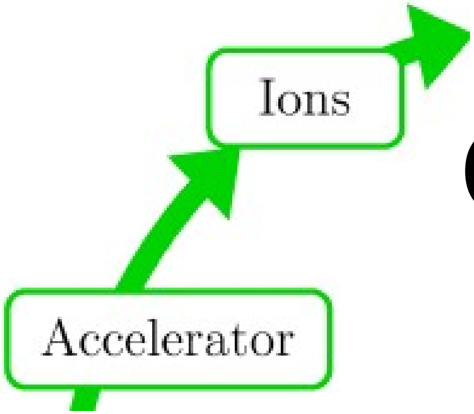
The unbound ^{12,13}Li observed for the first time





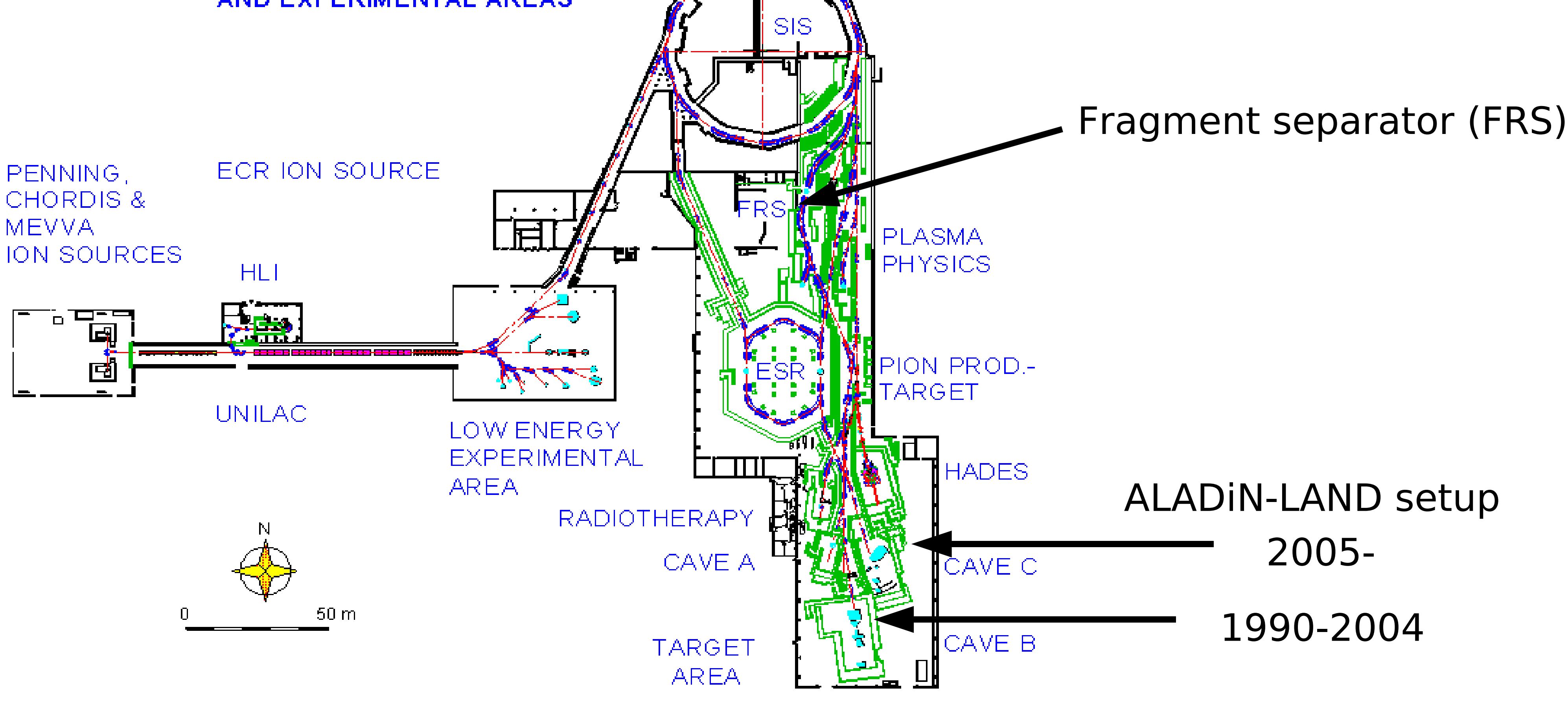


Invariant mass spectra

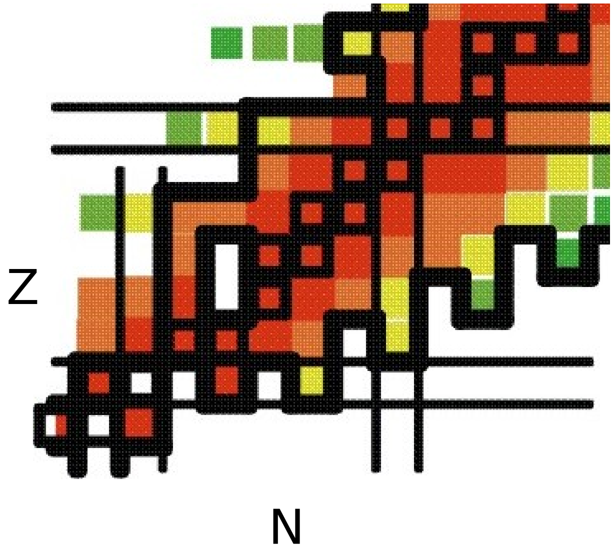


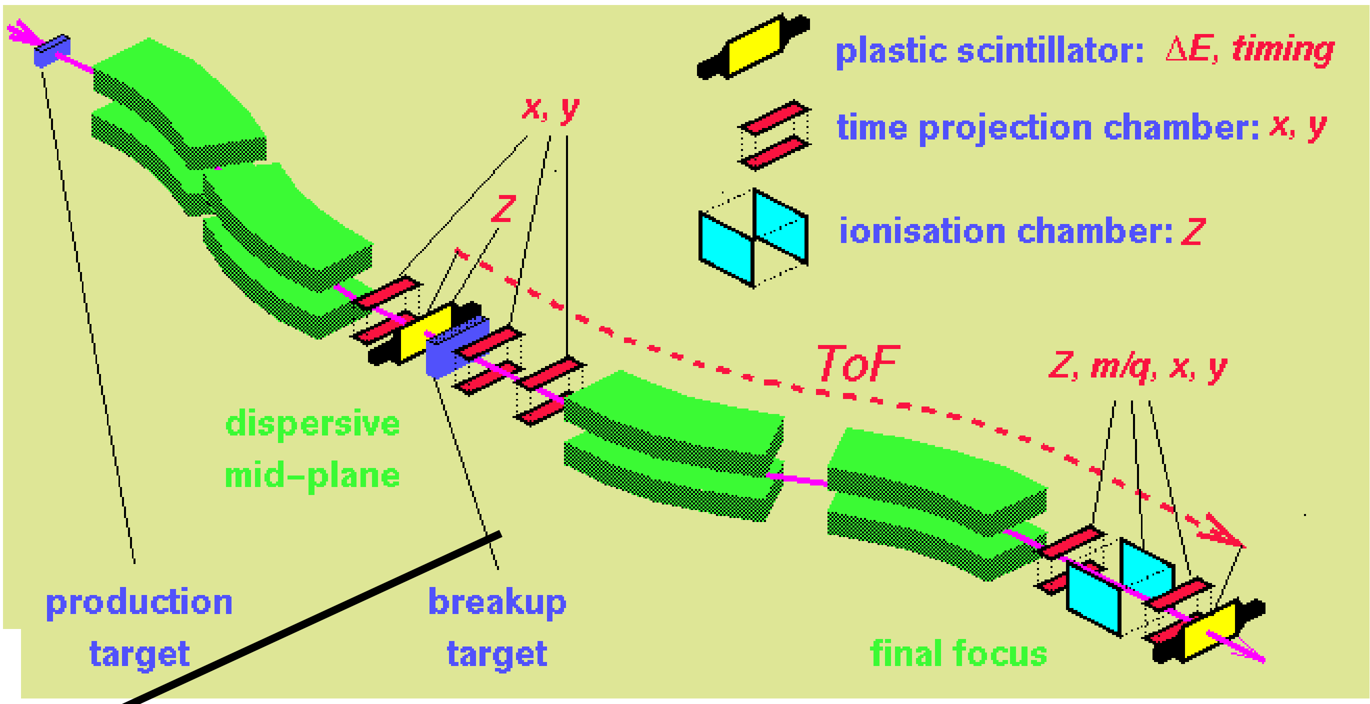
GSI (Darmstadt, Germany)

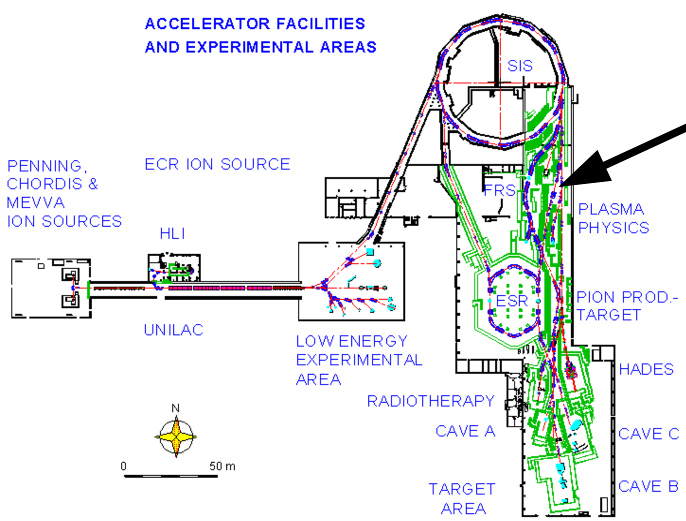
Gesellschaft für
Schwerionenforschung mbH



Exotic isotope production & selection





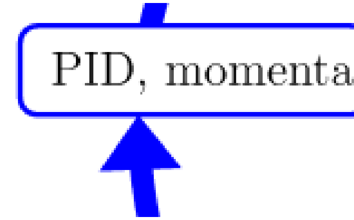


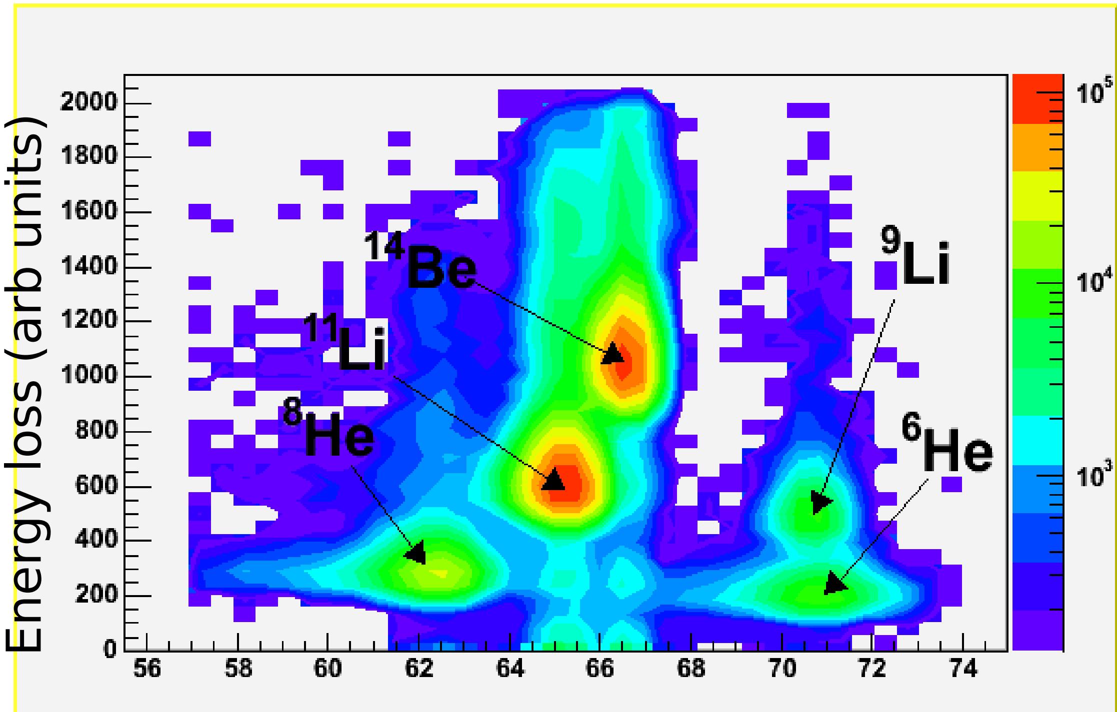
Fragment separator

Experimental apparatus

Radioactive beams

Incoming beam identification



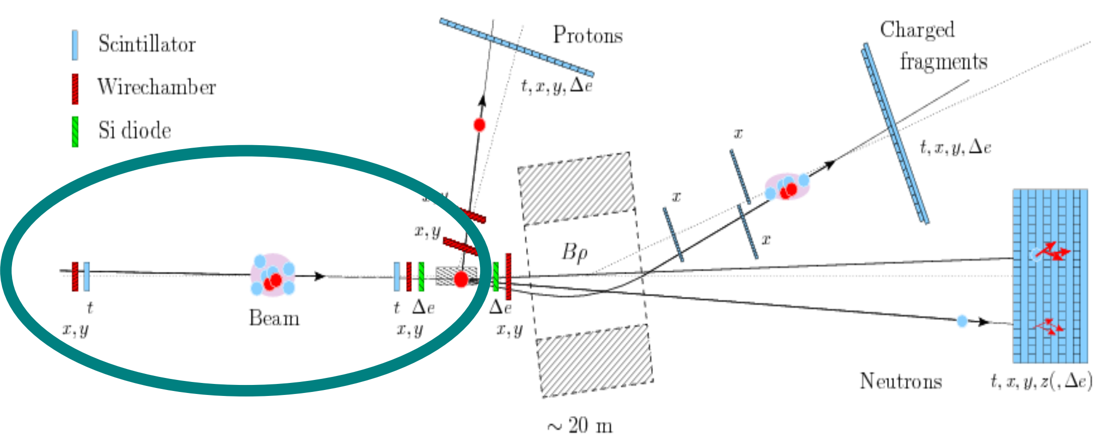


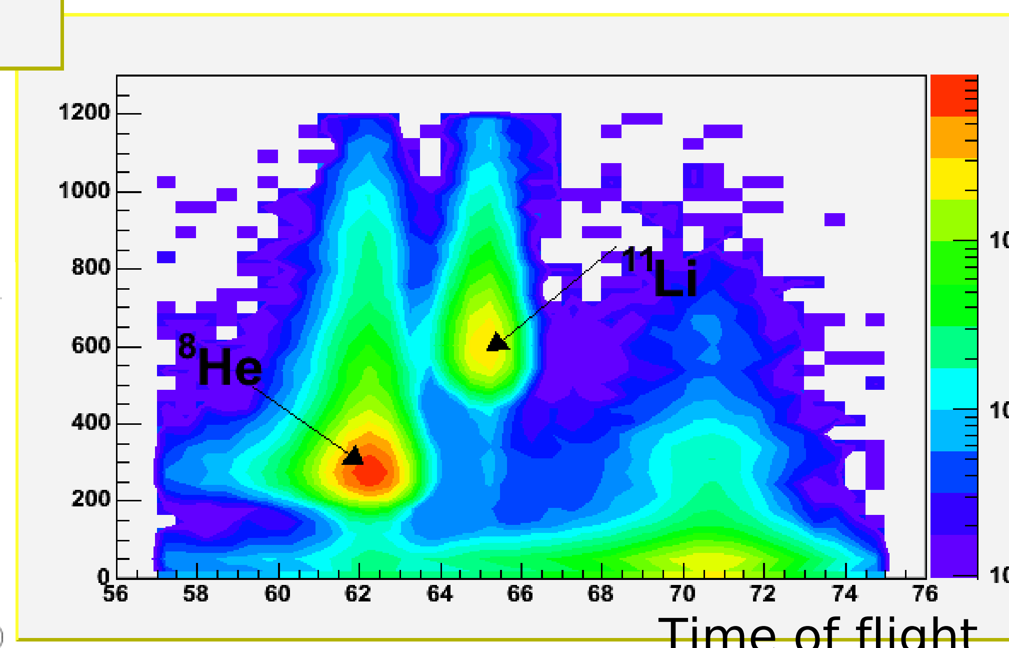
Time of flight

Ion charge (Z) from energy loss.

Ion mass (A), from A/Z, from velocity (time-of-flight).

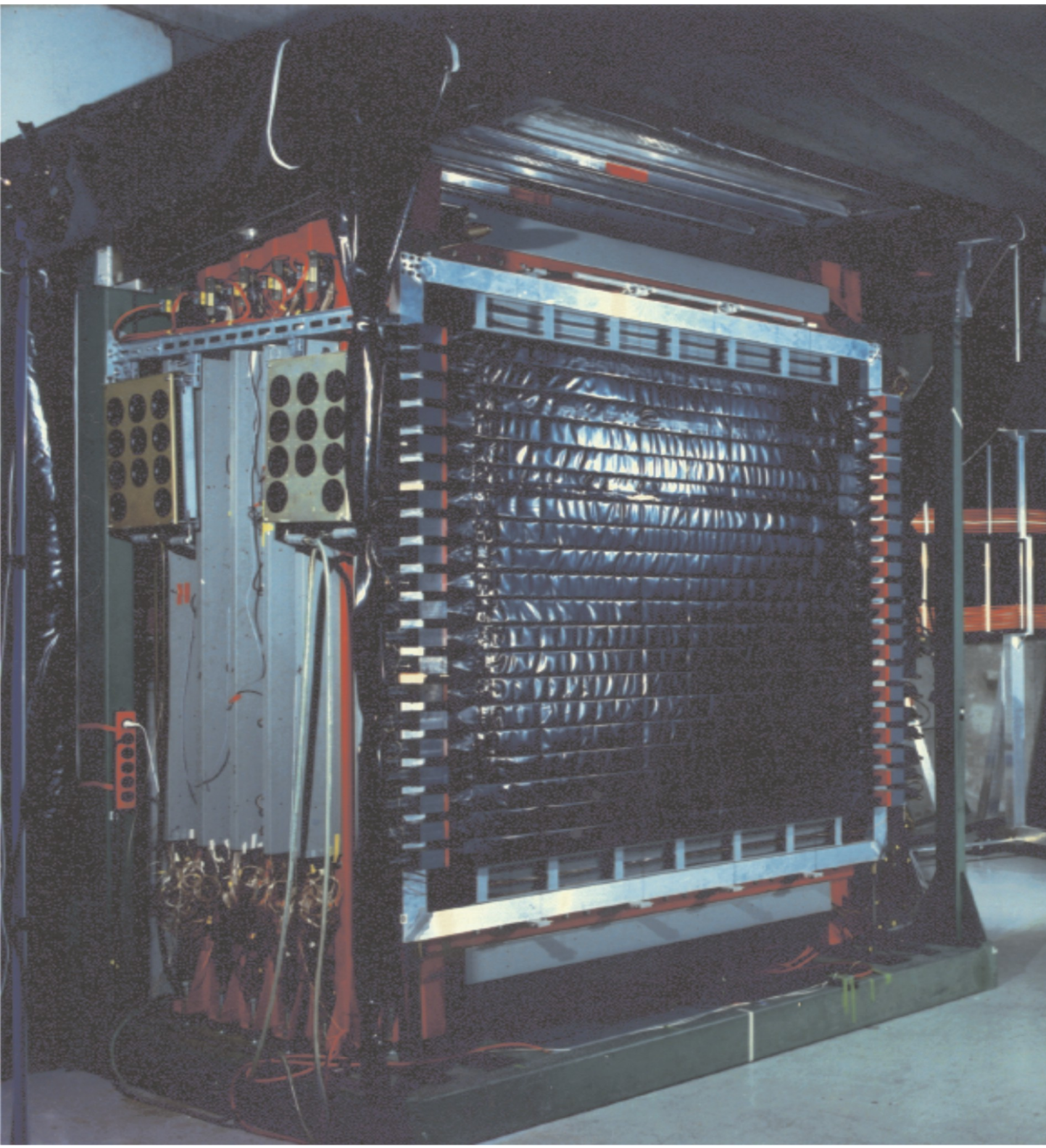
Ions surviving the fragment separator selection have velocity depending on their A/Z.





LAND - Large area neutron detector

Detectors

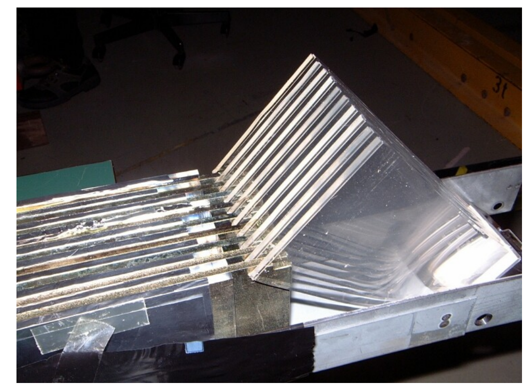


Volume: 2x2x1 m^3

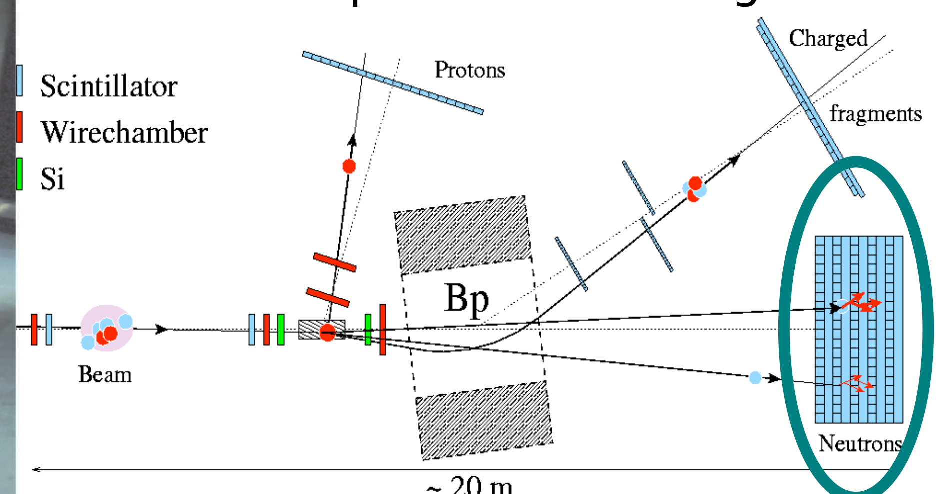
10x20 paddles

sandwiched: iron converter and scintillator

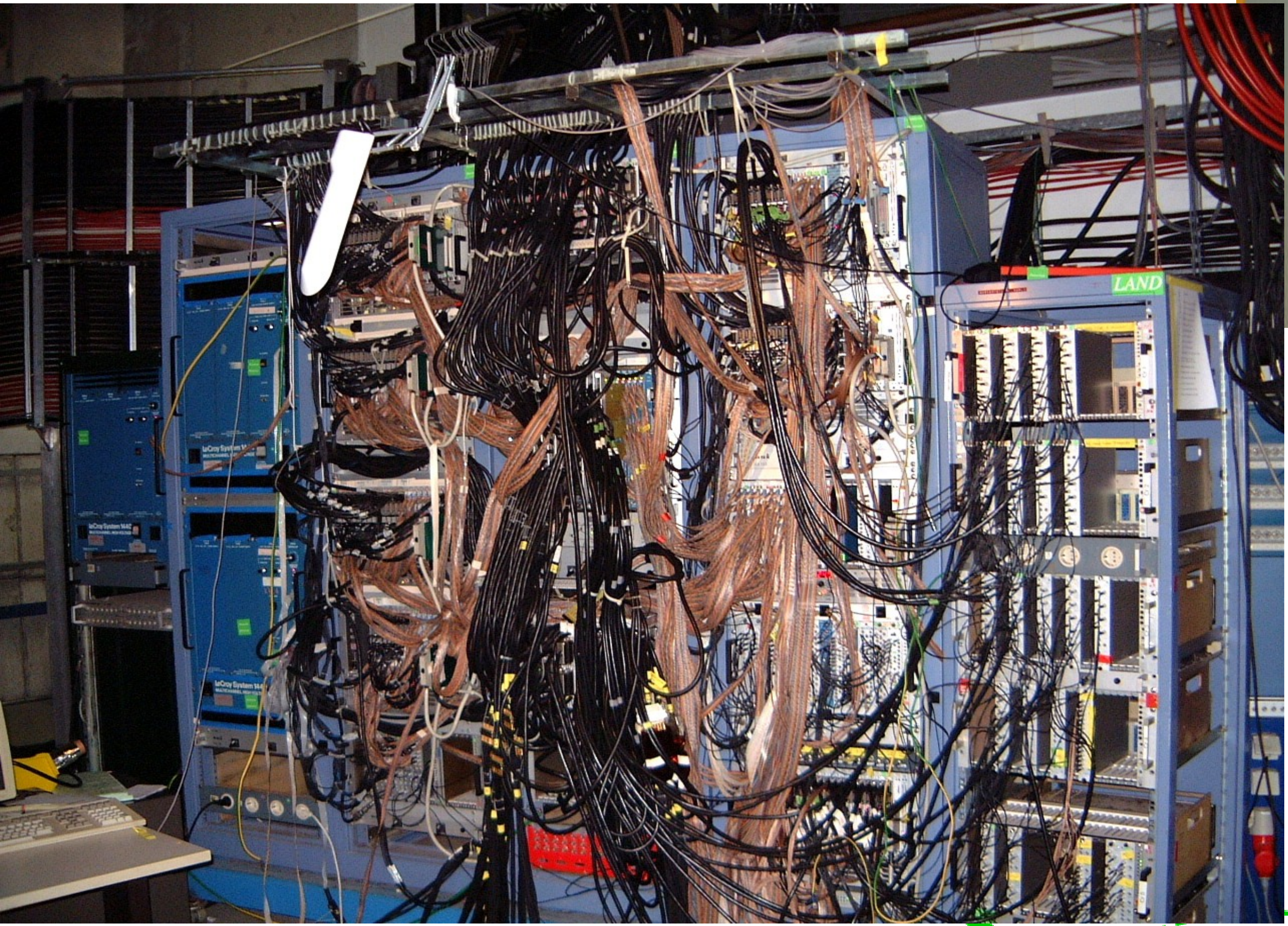
2 PMTs per paddle

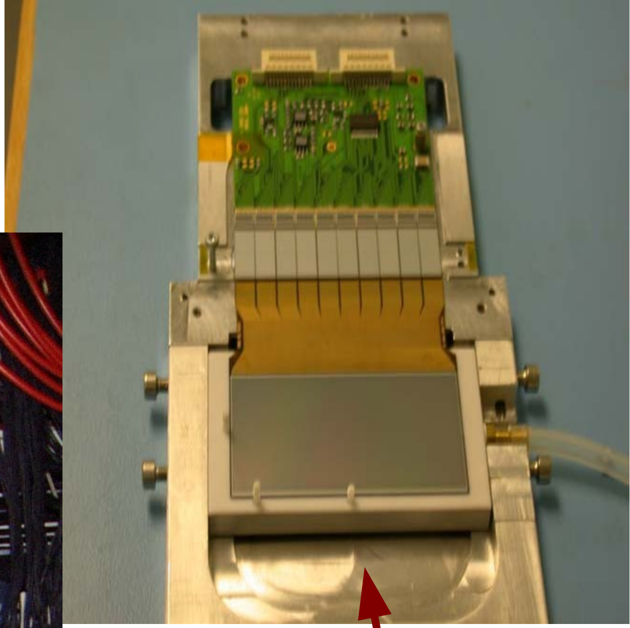


Time + amplitude → 800 signals

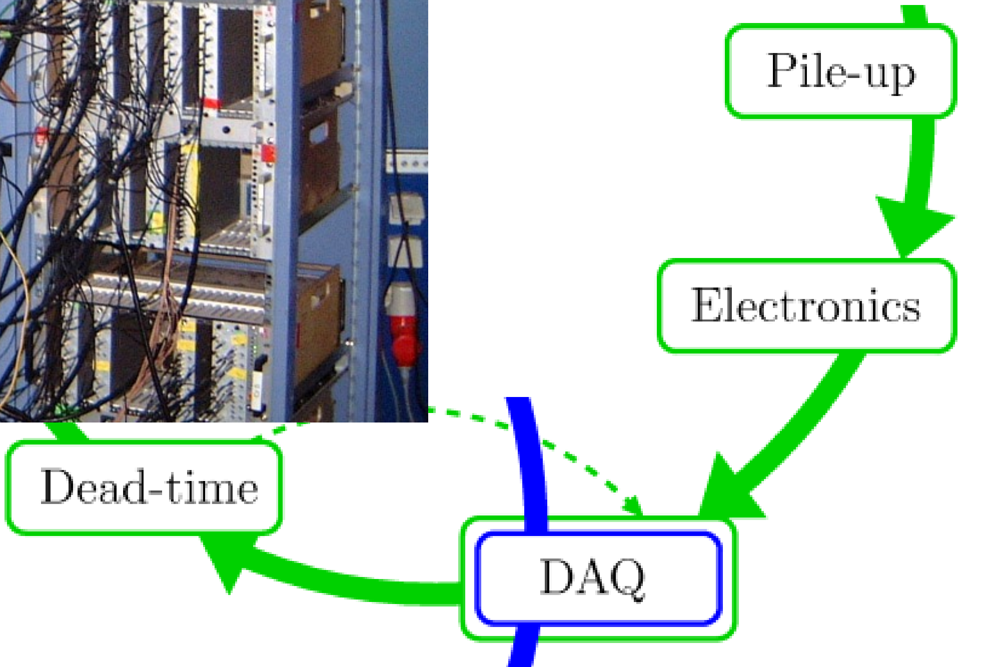


800+ signals



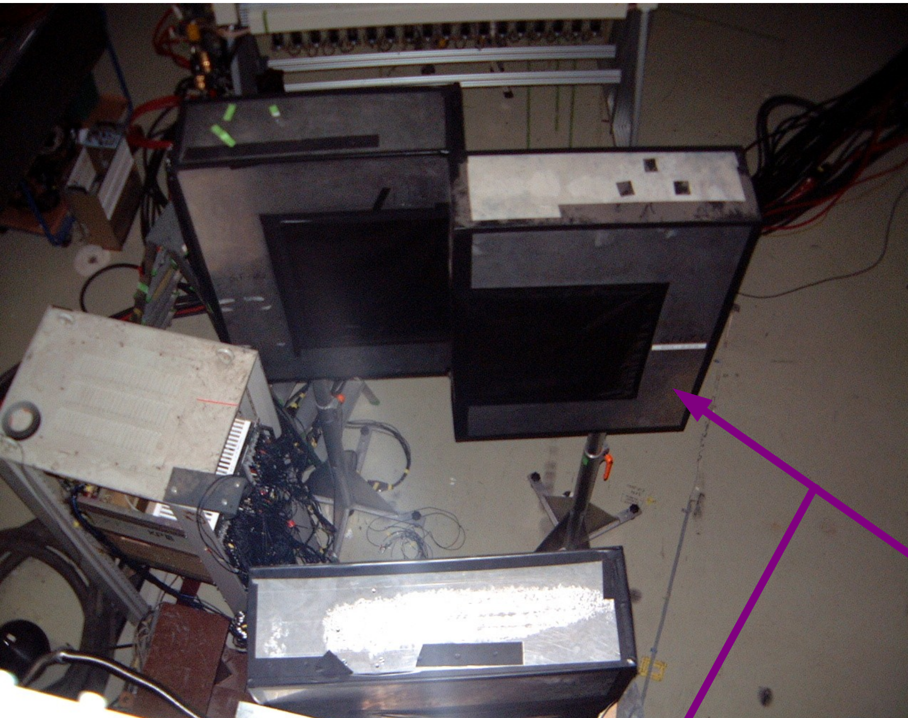


1024 channels
(7x4 cm^2 Si)



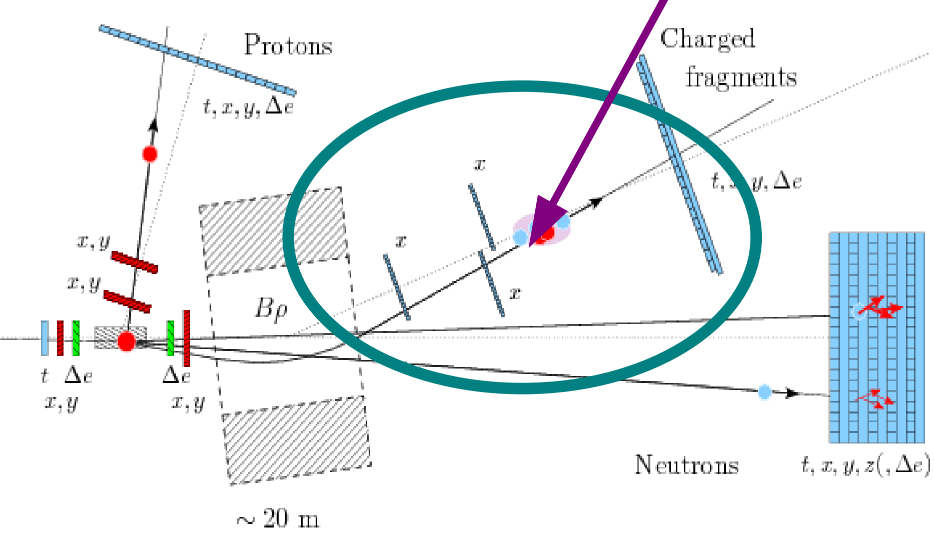
GFI – Großer Fiber Detektor

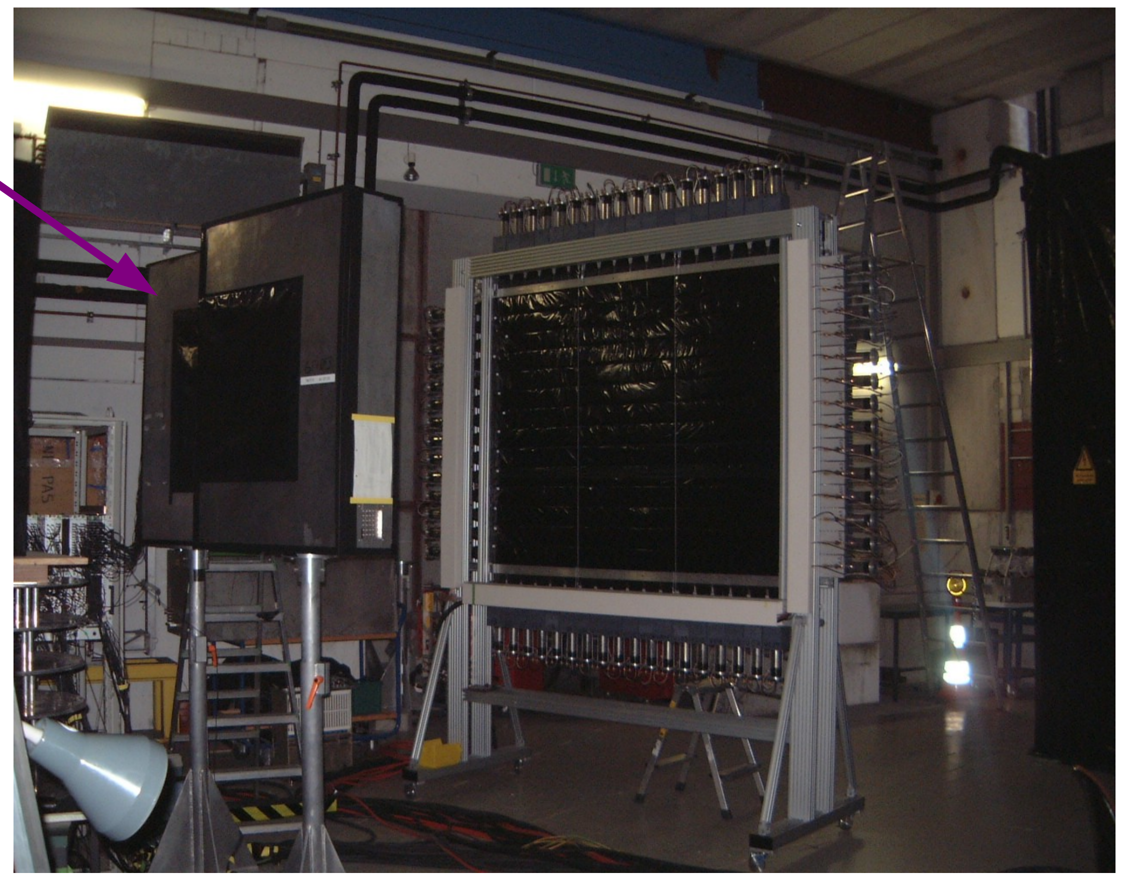
Large scintillating fibre detectors



500 scintillating fibres per detector

Coupled with lightguides to a position-sensitive photomultiplier (PSPM)





500 scintillating fibres (1.05 mm pitch) → 34(!) read-out channels

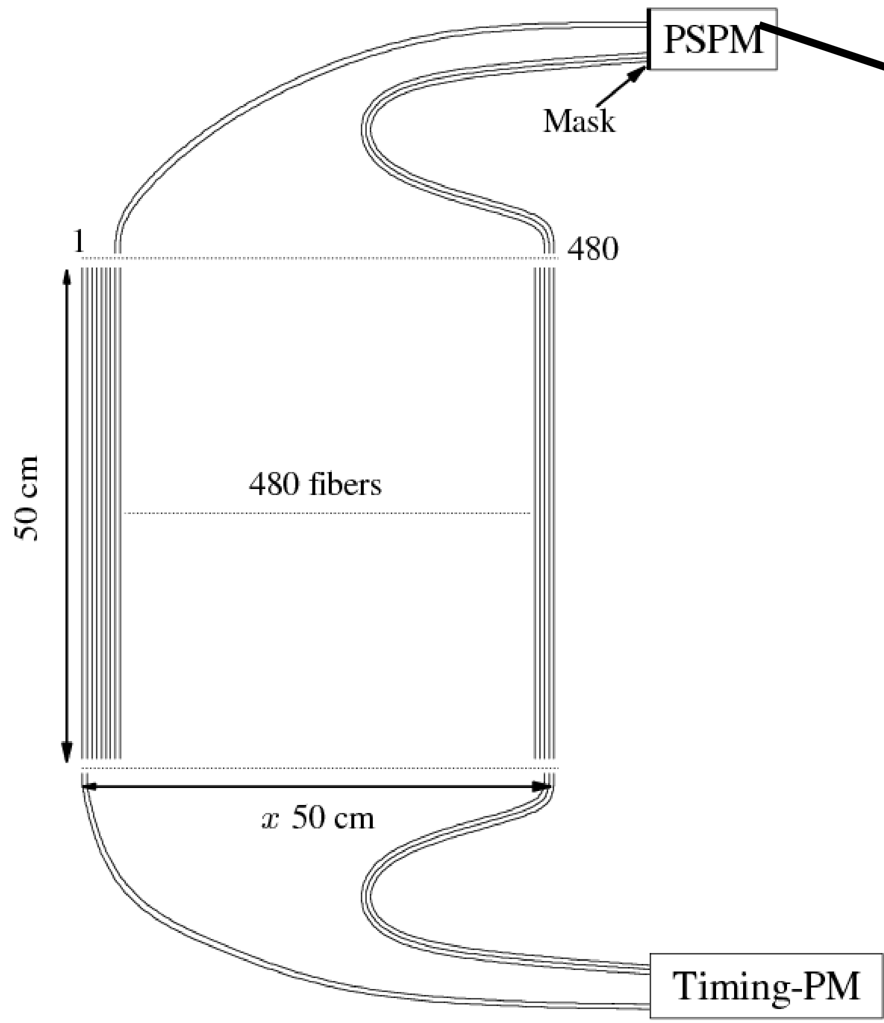


Fig. 1. Schematic view of a scintillating fibre detector.

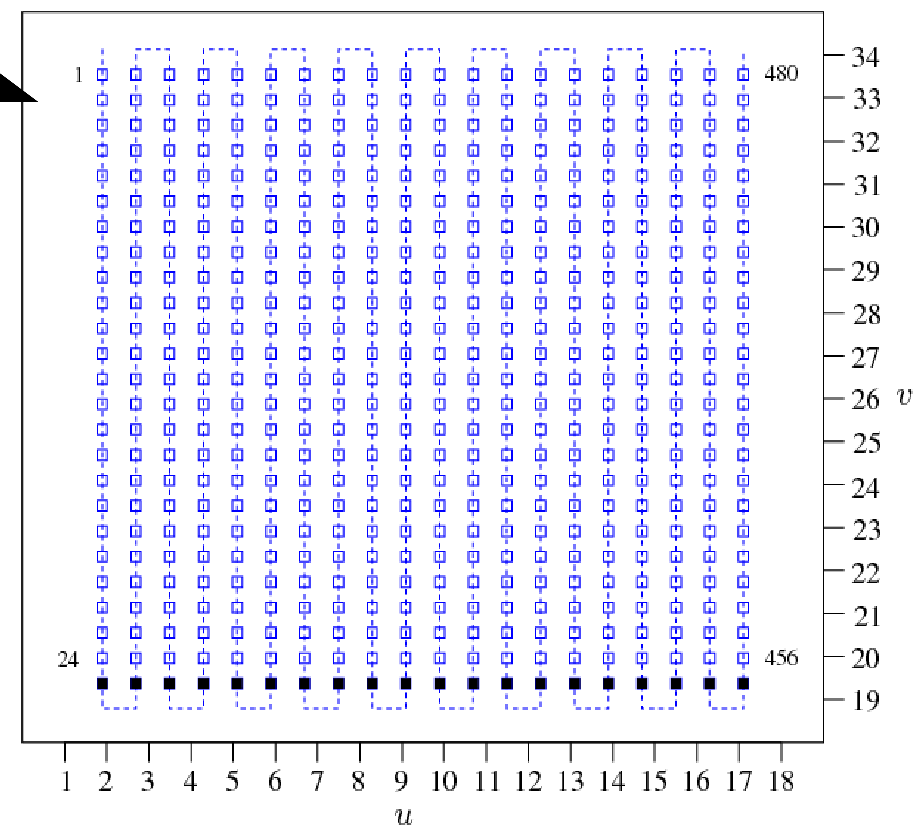
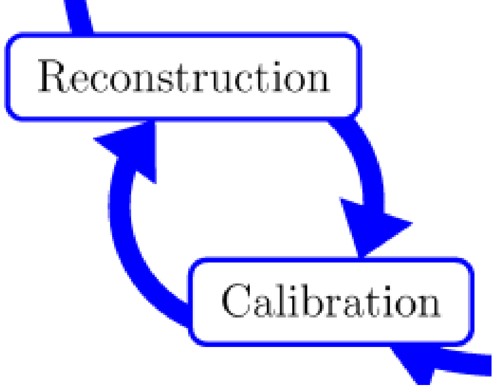


Fig. 2. Mask for fixing one end of the scintillating fibres to the position-sensitive photomultiplier (PSPM). Dark squares indicate unused holes. The dotted line indicates the meander-like ordering of the fibres. The relative position of the anode wires of the PSPM are indicated as well.

Determining the hit fibre



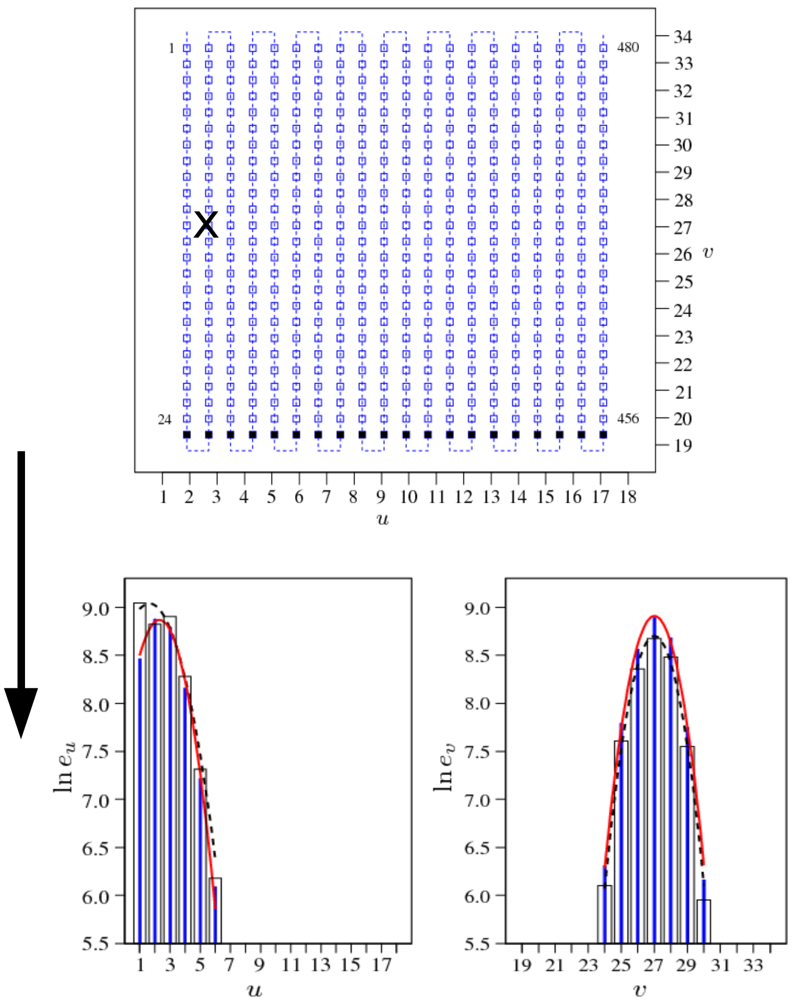


Fig. 3. Typical distributions of charge in the anode wires. The open and the filled (blue) vertical bars represent the natural logarithm of the signal heights recorded in the corresponding wire in a arbitrary unit before and after gain matching, respectively. The dotted and the continuous (red) lines are parabola fits before and after gain matching, respectively.

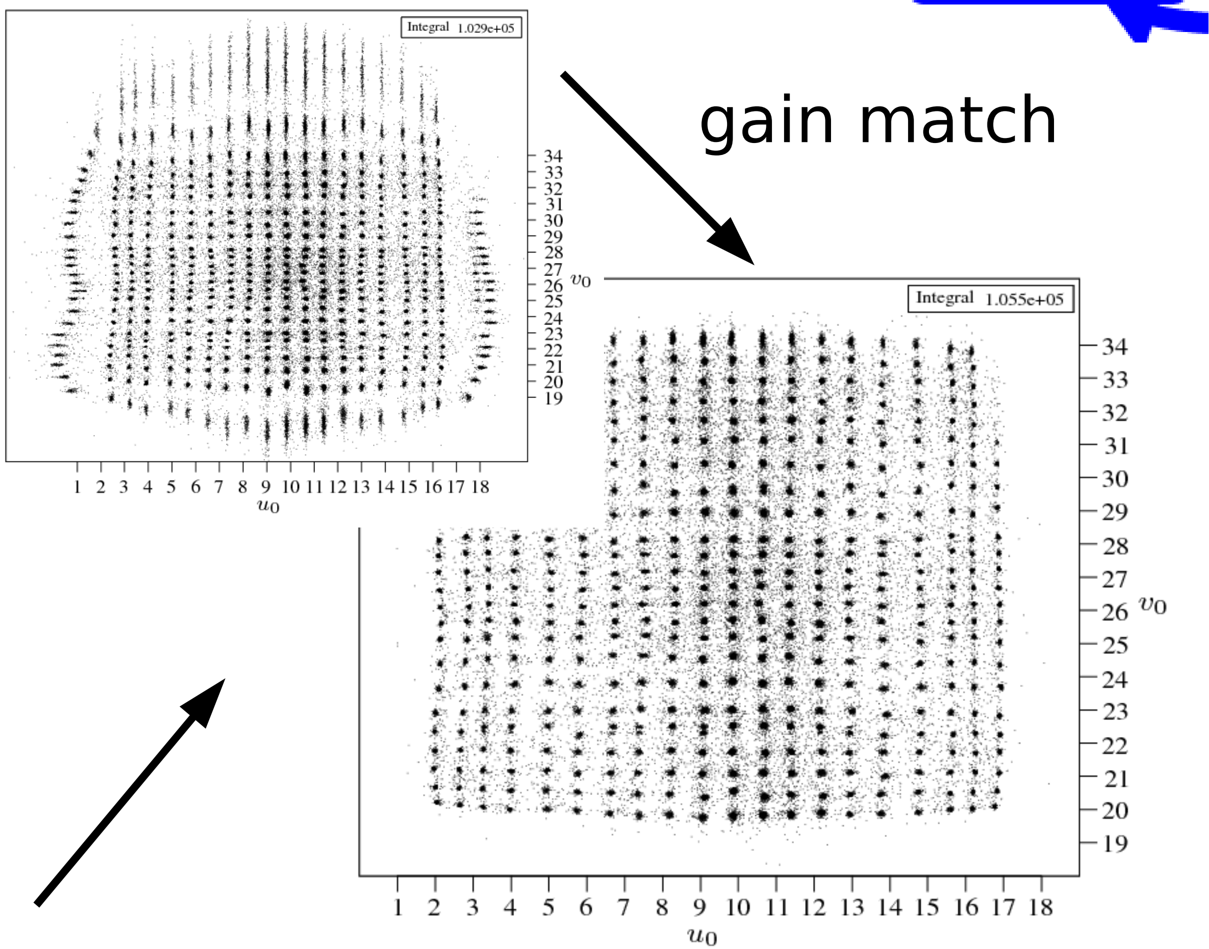


Fig. 4. Reconstructed image of the fibre mask before (top) and after (bottom) gain matching using a ^{58}Ni beam of 650A MeV. Each cluster of dots corresponds to a fibre. The increased number of accepted hits (Integral) in the gain matched panel is discussed in the text.

(PSPM) resolution depends on the deposited energy (ion Z)

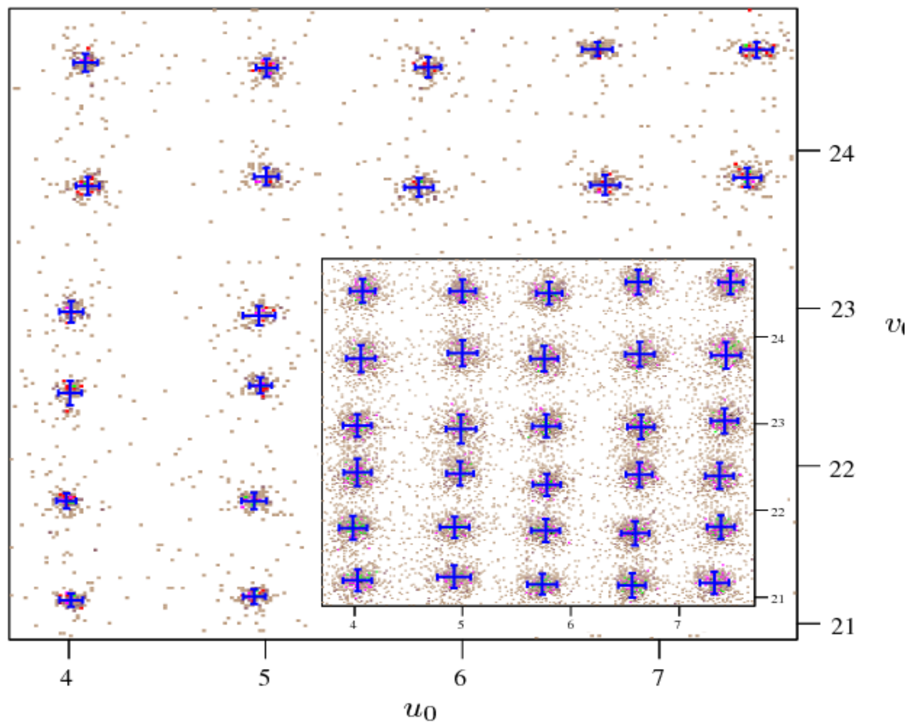


Fig. 5. Part of the 2-dimensional (u_0, v_0) histogram, with 1000×1000 bins, used to find the mean position and width of the clusters for a 650 A MeV ^{58}Ni beam. The mean positions of the clusters are indicated by crosses. The extents of the crosses correspond to the widths (FWHM) of the clusters. Inset shows the same plot for a 400 A MeV ^{12}C beam.

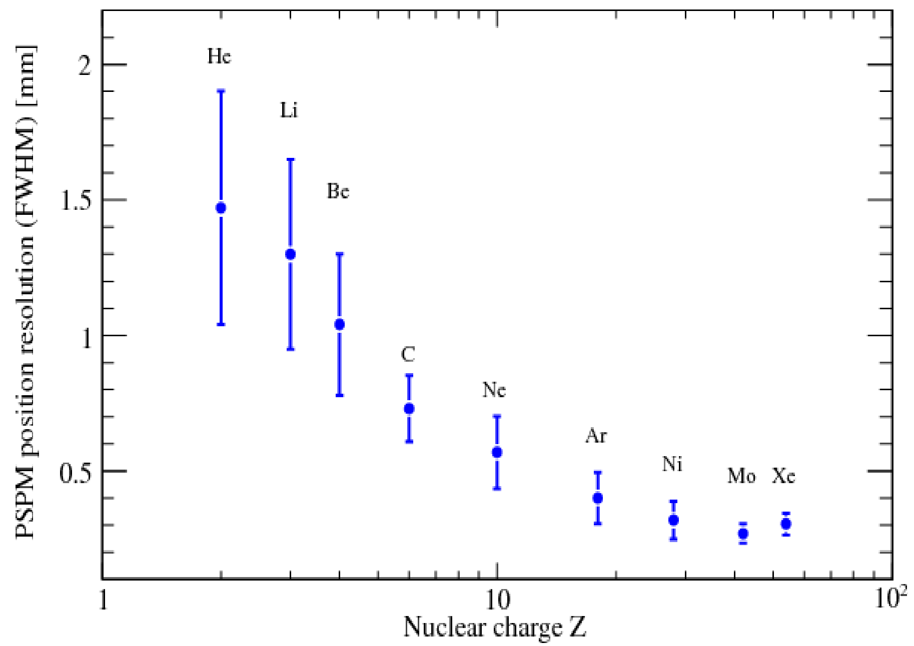


Fig. 6. Position resolution of a PSPM for projectiles of different charges corresponding to different amounts of light produced in the scintillating fibres. The error bars indicate the variation of the resolution over the area of the photocathode. The distance between two fibres is 3.0 mm in u and 2.2 mm in v.

Resolution (S287, Ni ions)

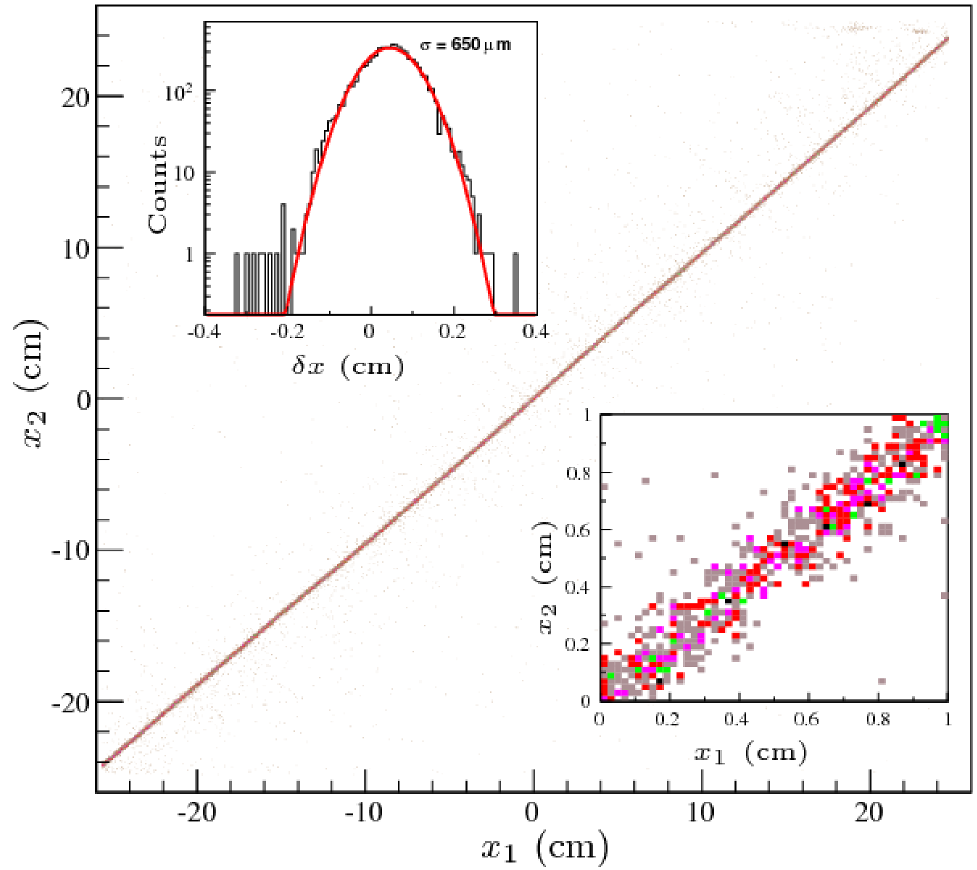
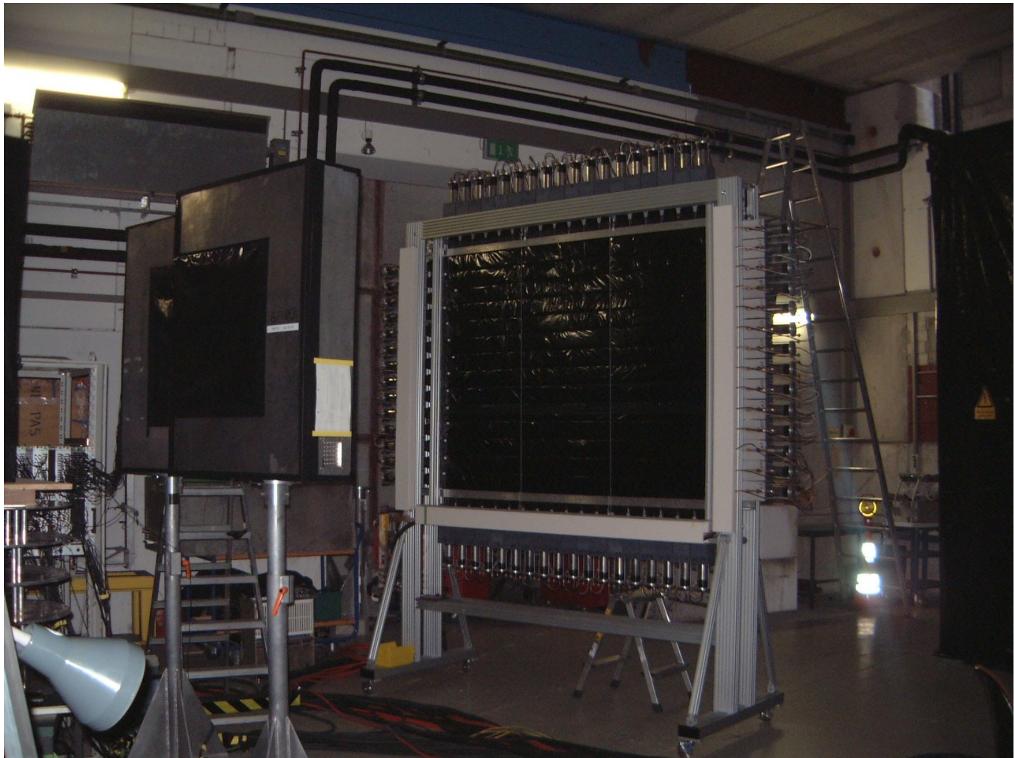
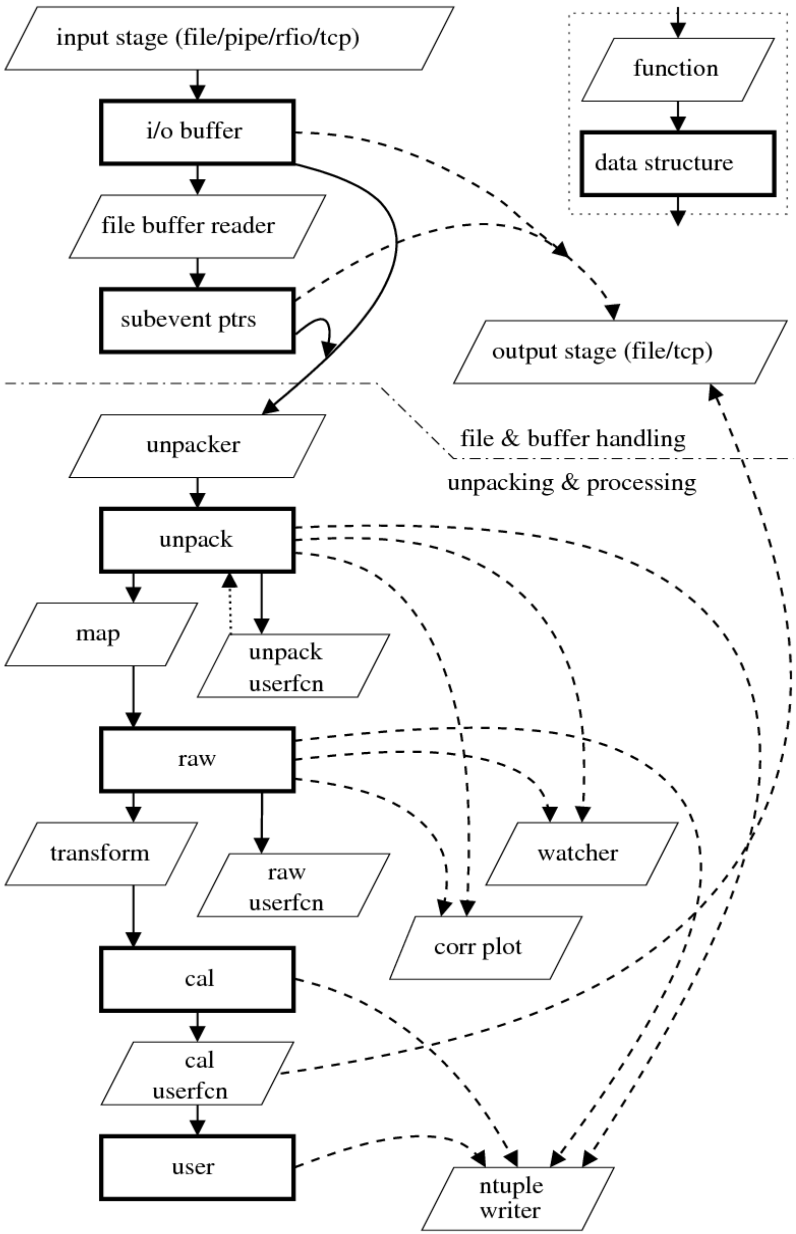


Fig. 8. The reconstructed position correlation between two fibre detectors, ∼40 cm apart, for a 650 A MeV ^{58}Ni beam. Inset (bottom) shows a (magnified) part of the same plot corresponding to ∼10 fibres. Inset (top) shows the difference between the position interpolated from two fibre detectors and the measured position in a third fibre detector along with a Gaussian fit.

x_{GFI1} - x_{GFI2}



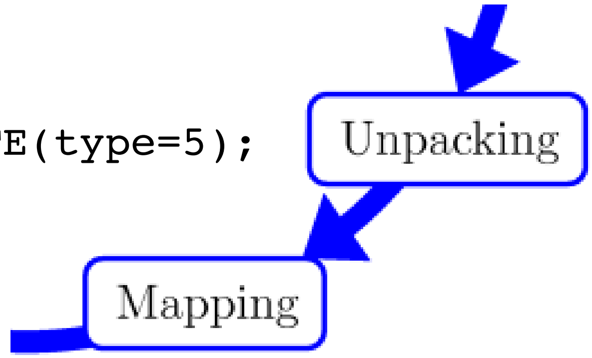
UCESB – unpack & check every single bit



'Quick-n-dirty' generic unpacking and data 'quality' monitor

Unpack code generation from C structure-like specification:

```
SUPER_TDC(slot)
{
  UINT32 value;
}
SUBEVENT(ONE_CRATE)
{
  tdc1 = SUPER_TDC(slot=5);
  tdc2 = SUPER_TDC(slot=6);
}
EVENT
{
  crate1 = ONE_CRATE(type=5);
}
```



Module .spec structure

```
VME_CAEN_V775(geom,crate)
{
  MEMBER(DATA12_OVERFLOW data[32] ZERO_SUPPRESS);

  UINT32 header NOENCODE {
      8_13:  count;
      16_23: crate = MATCH(crate);
      24_26: 0b010;
      27_31: geom = MATCH(geom);
  }
  list(0<=index<header.count) {
      UINT32 ch_data NOENCODE {
          0_11:  value;

          12:    overflow;
          13:    underflow;
          14:    valid;

          16_20: channel;

          24_26: 0b000;
          27_31: geom = CHECK(geom);

          ENCODE(data[channel],(value=value,overflow=overflow));
      }
  }
  UINT32 eob {
      0_23:  event_number;
      24_26: 0b100;
      27_31: geom = CHECK(geom);
  }
}
```

CAEN V775 (TDC) data format:

Header

31 - 27	26-24	23 - 16		13 - 8	
geom	0 1 0	crate		count	

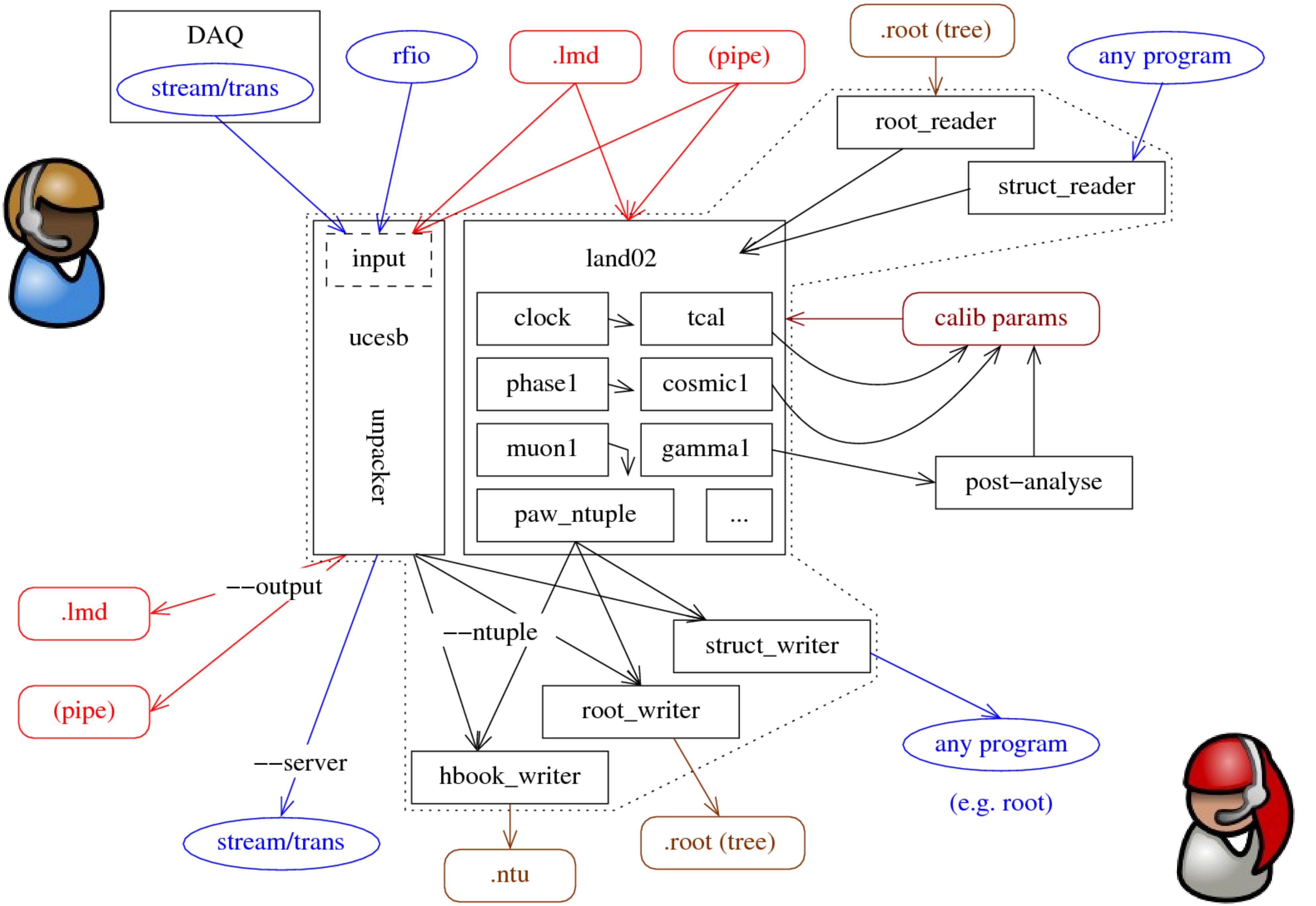
Data word

31 - 27	26-24		20 - 16		14	13	12	11 - 0
geom	0 0 0		channel		V	U	O	value

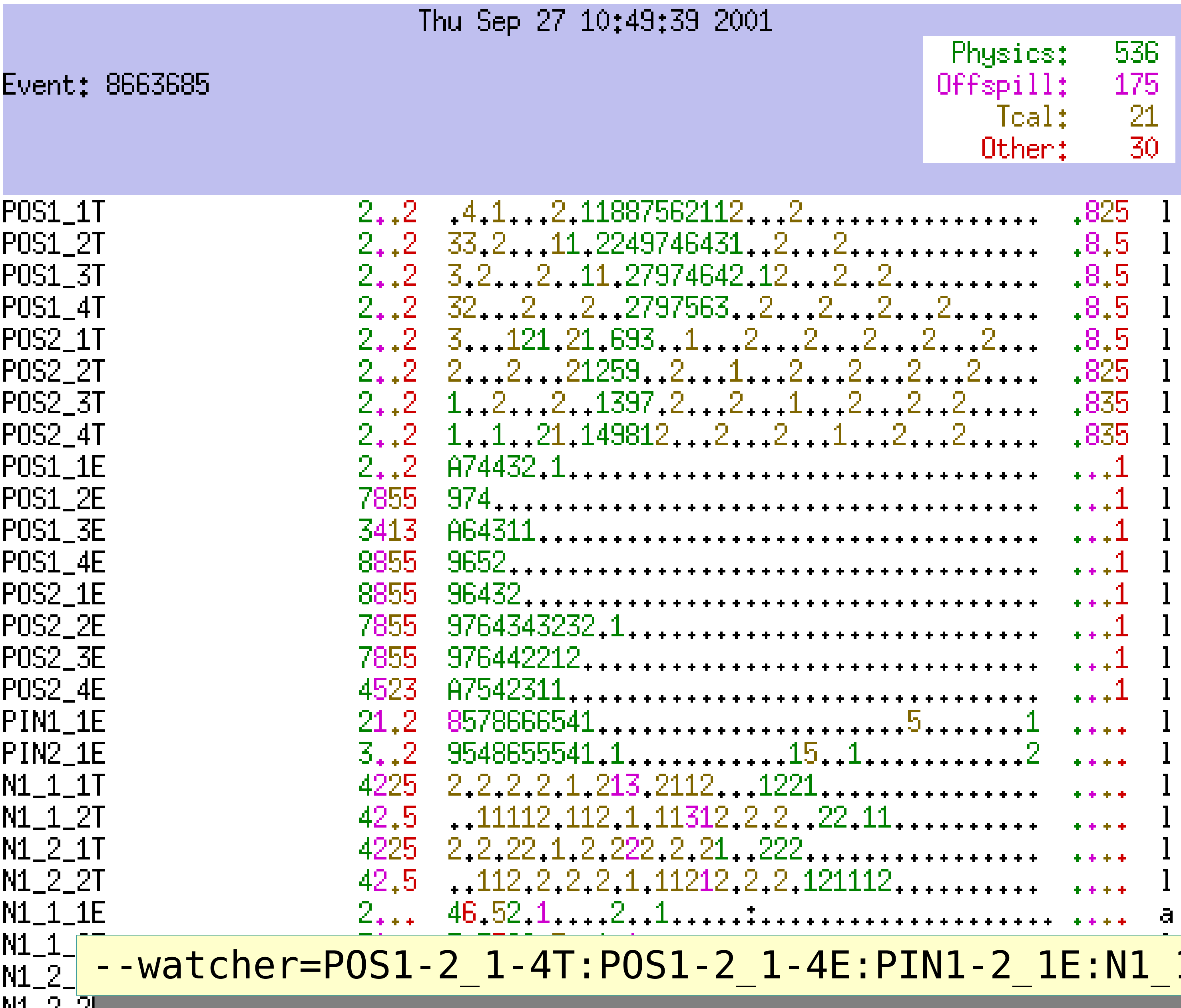
End marker

31 - 27	26-24	23 - 0
geom	1 0 0	event_number

ucesb/(land02) interaction



Watcher – the DAQscope



`--watcher=POS1-2_1-4T:POS1-2_1-4E:PIN1-2_1E:N1_1-2_1-2T:N1_1-2_1-2E`

Each line is a histogram for one raw channel

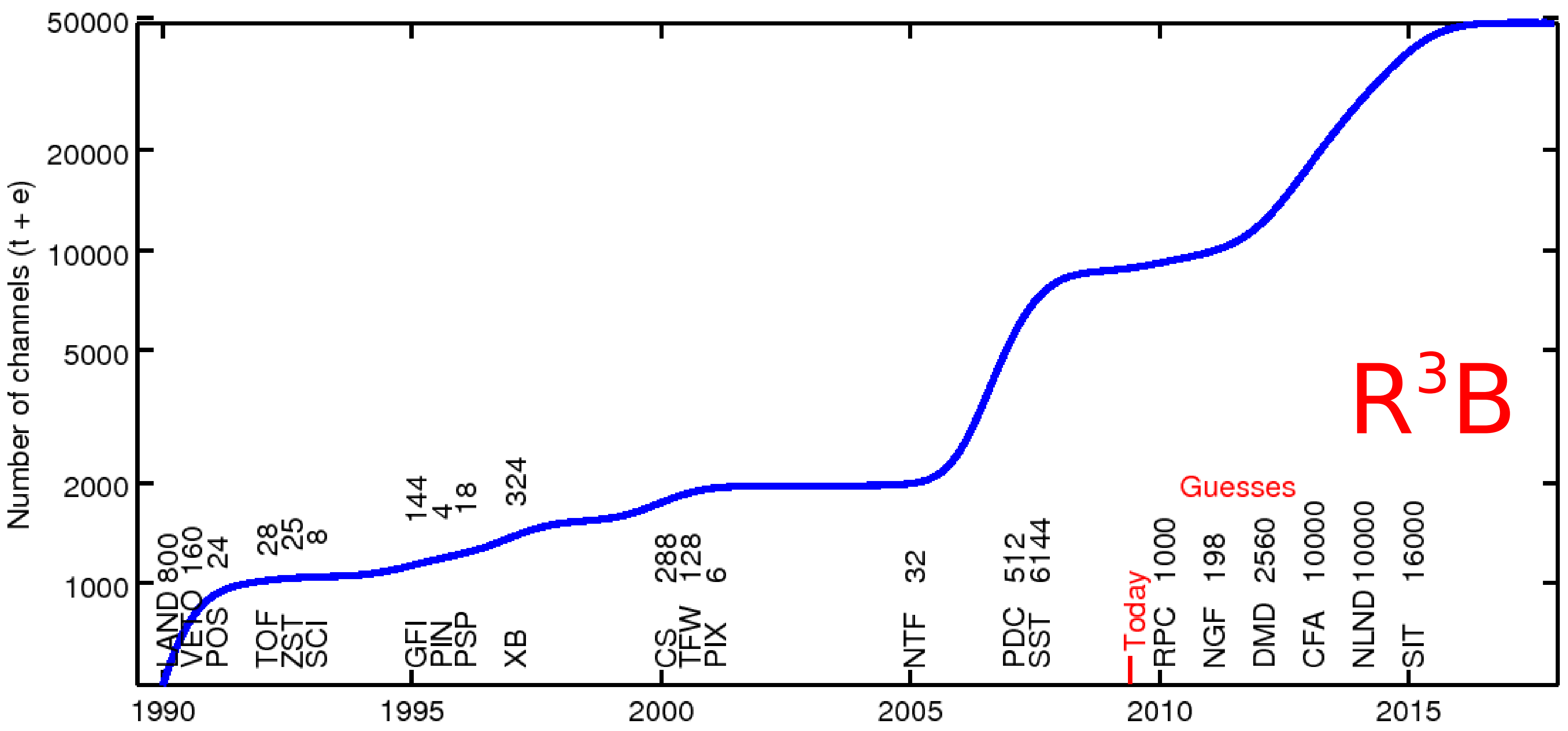
Values are $\log_2$ of bin content

Stored zeros and overflow

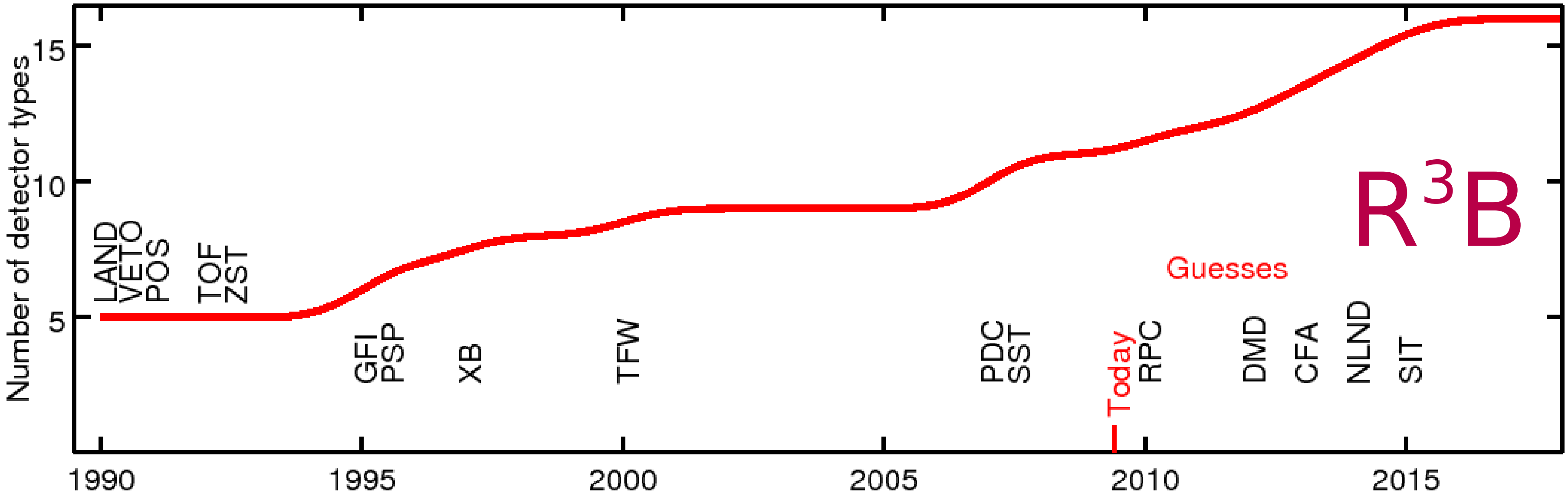
Colour by most contributing trigger type

Spill synchronized

ALADiN-LAND History I – channel counts



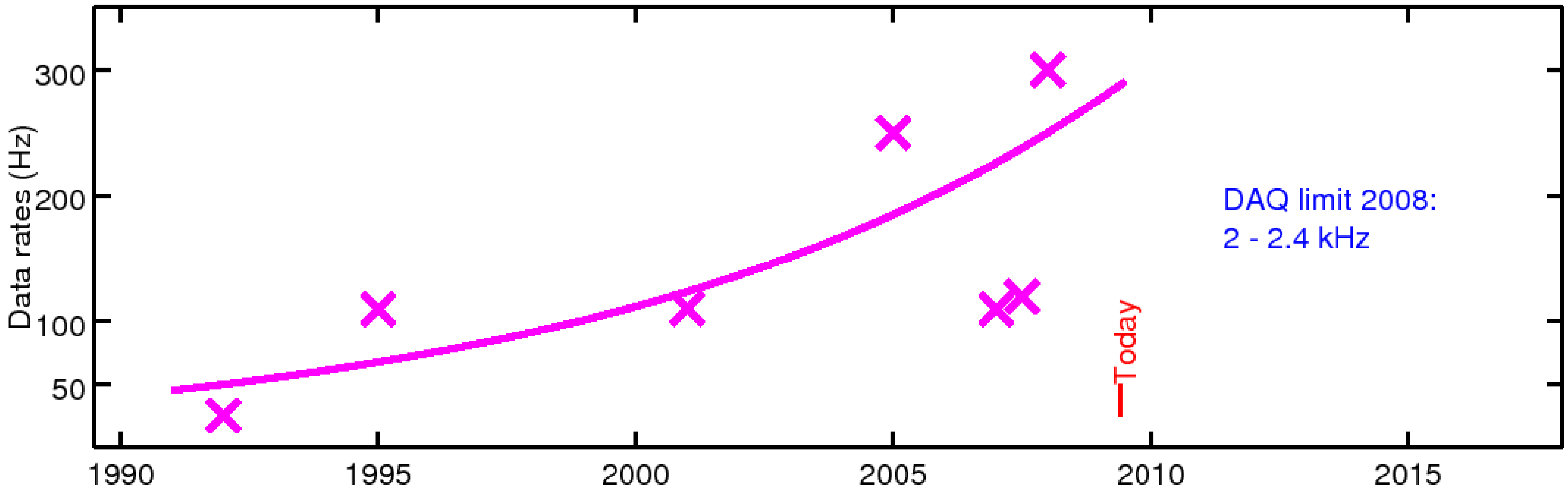
ALADiN-LAND History II – detector types



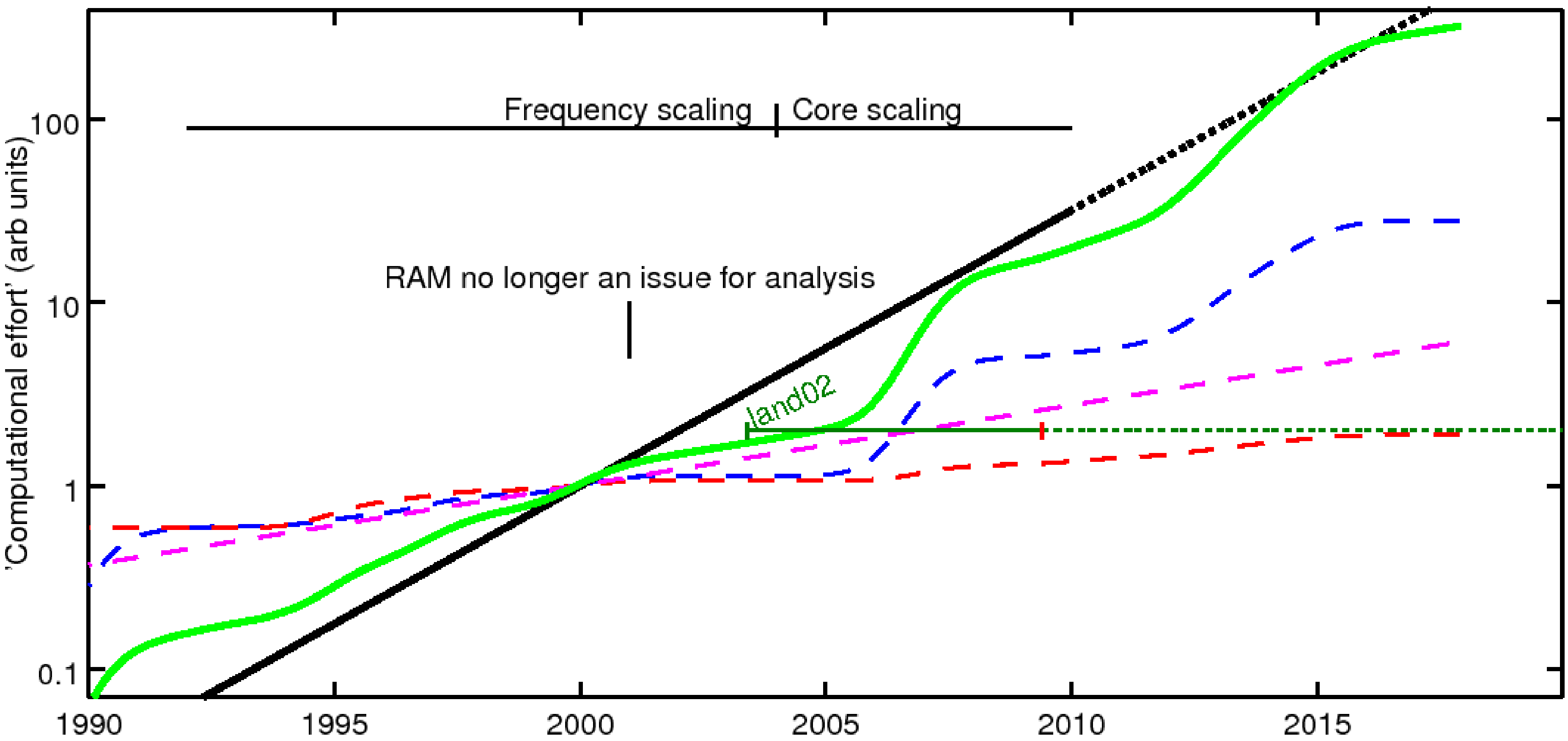
Each detector *type* requires routines for

- Calibration
- Reconstruction

ALADiN-LAND History III – data rates



Growing with Moore's law

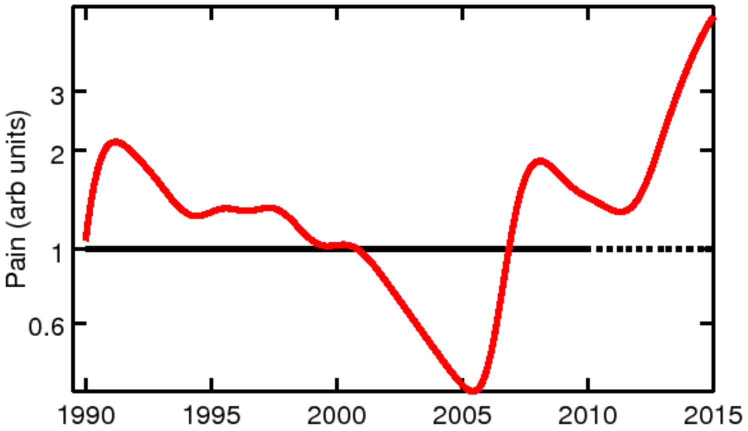


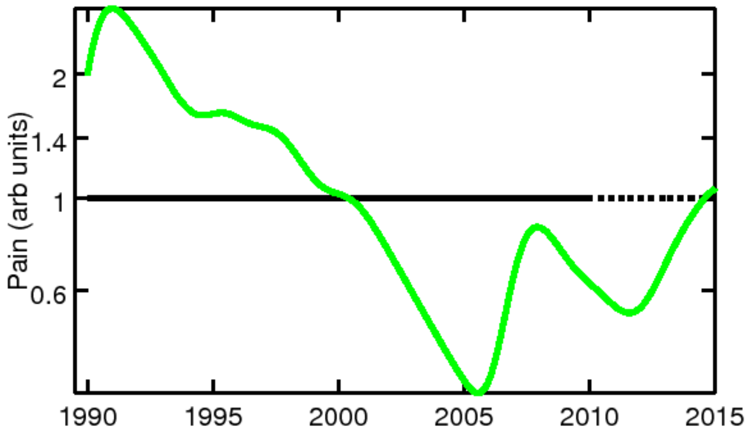
'Easy' scaling valid under assumption of efficient use of computers (i.e. adequate software)

Software is an **issue**

- Capable calibration methods and routines?
- Efficient reconstruction?
- Slow control params?

*sqrt(#ch)





Improvements in computer hardware can handle the increase in data sizes

Unless the software(s) fulfil the requirements of the complex setup, then **no** amount of computing hardware will **help** to extract the *correct data*!

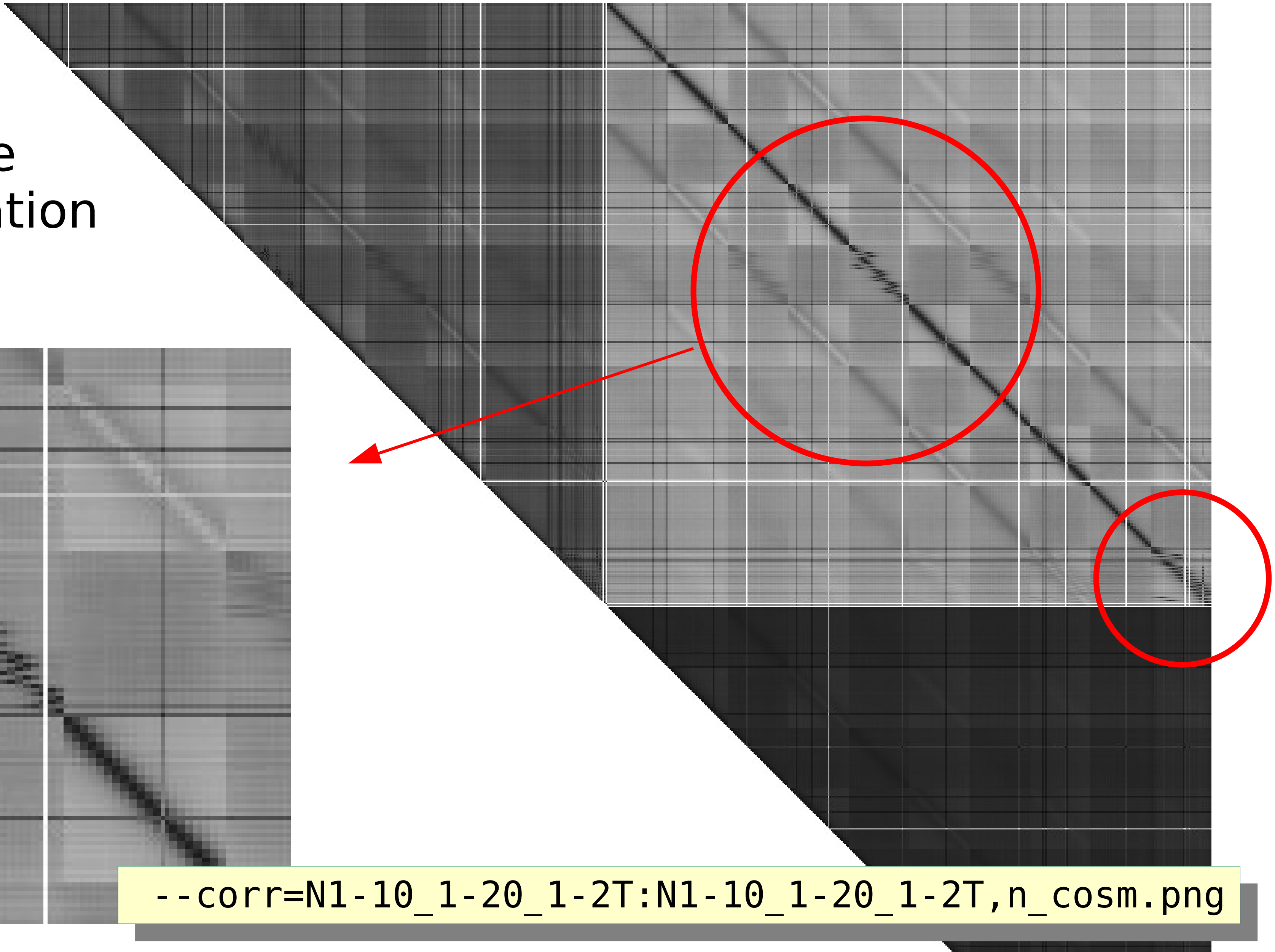
Finale!

Thank you!

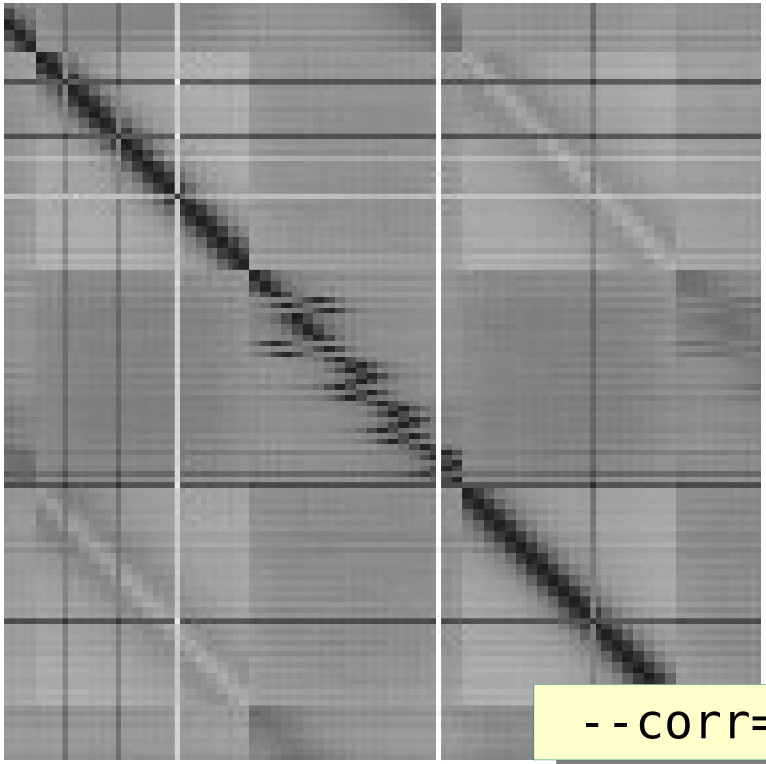
A whole lot of FUN!

Next: For discussion

Quickly finding LAND cable mismap

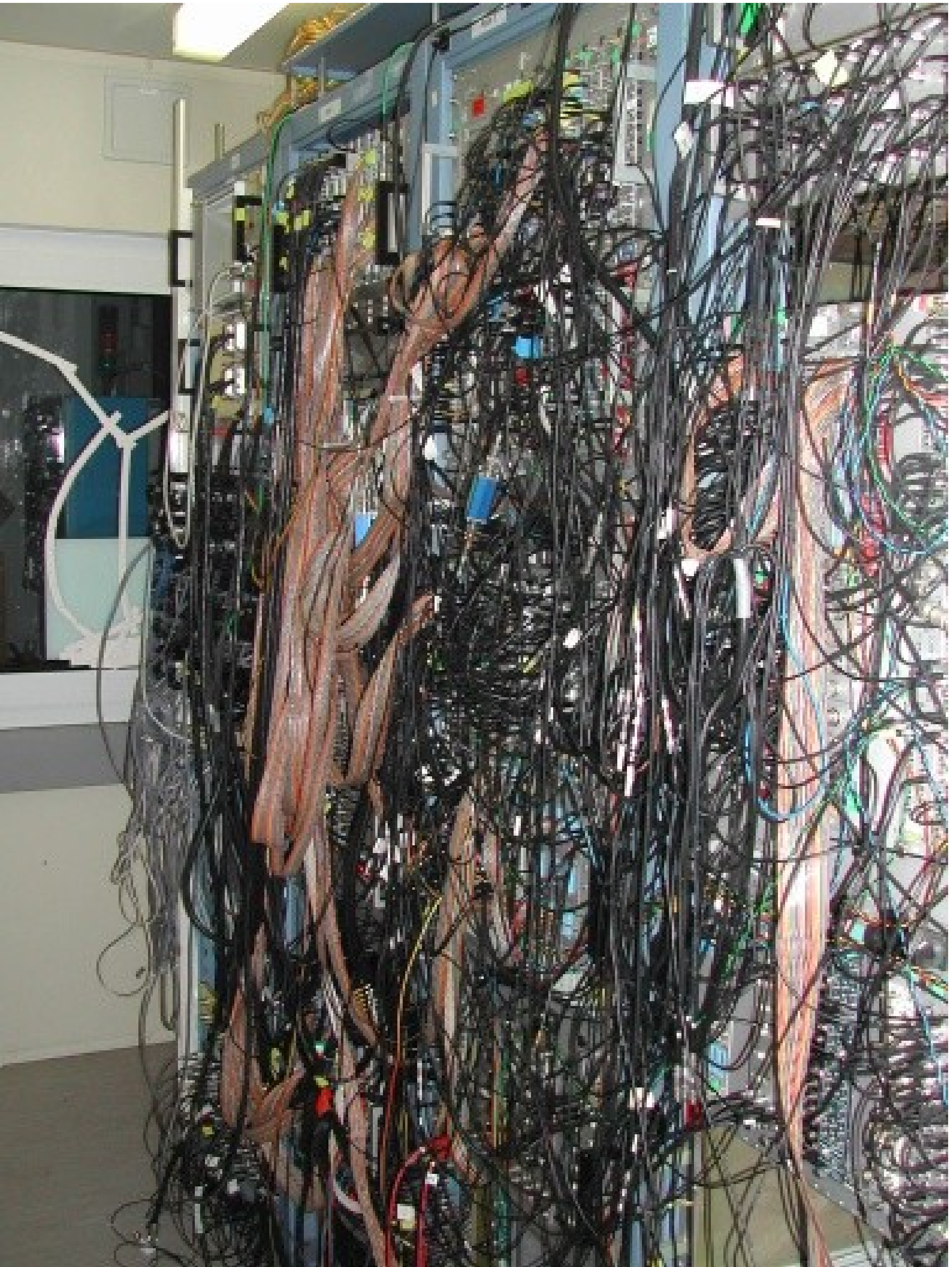


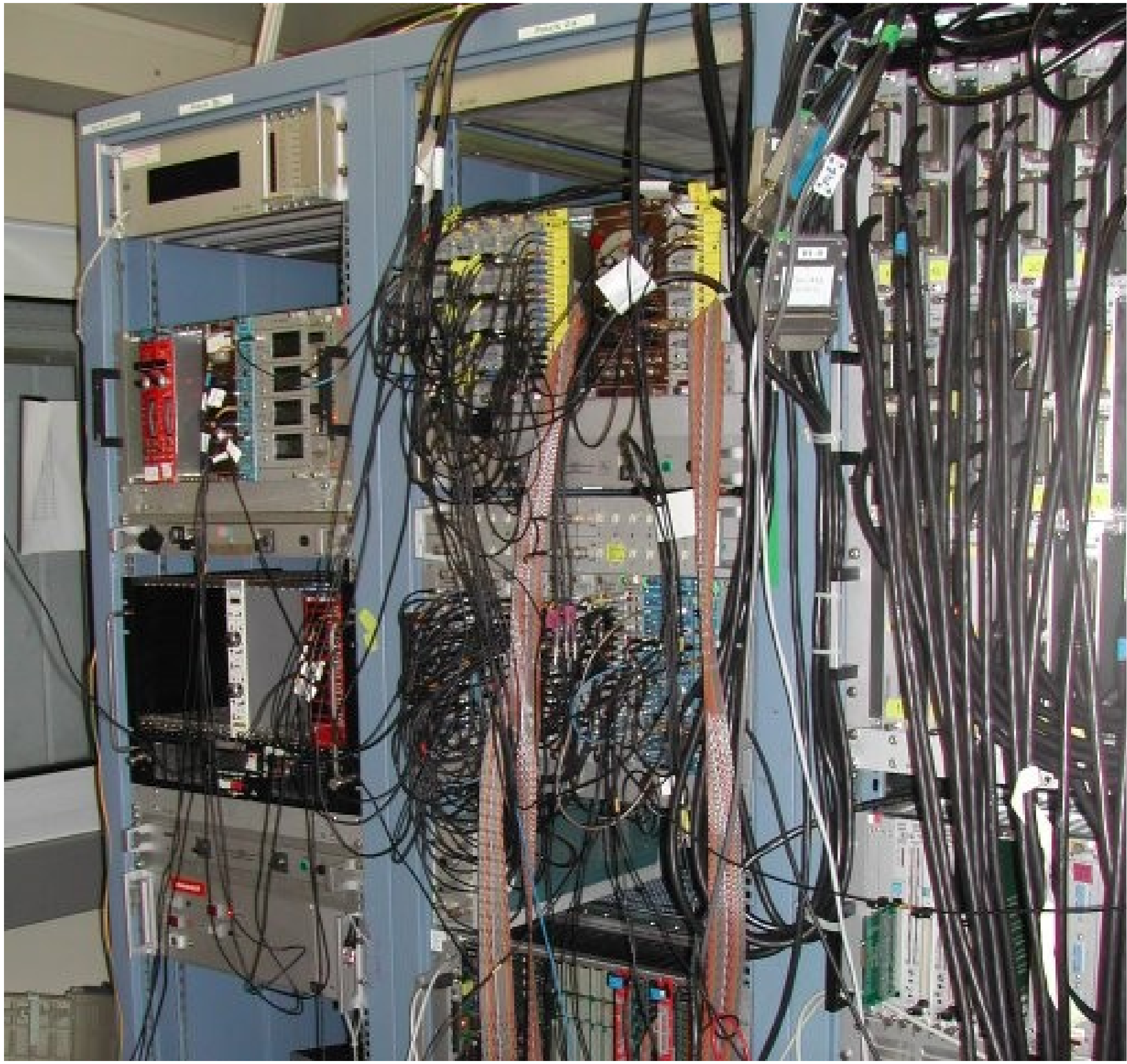
8-fold cable documentation problem



`--corr=N1-10_1-20_1-2T:N1-10_1-20_1-2T,n_cosm.png`

Just a few cables...





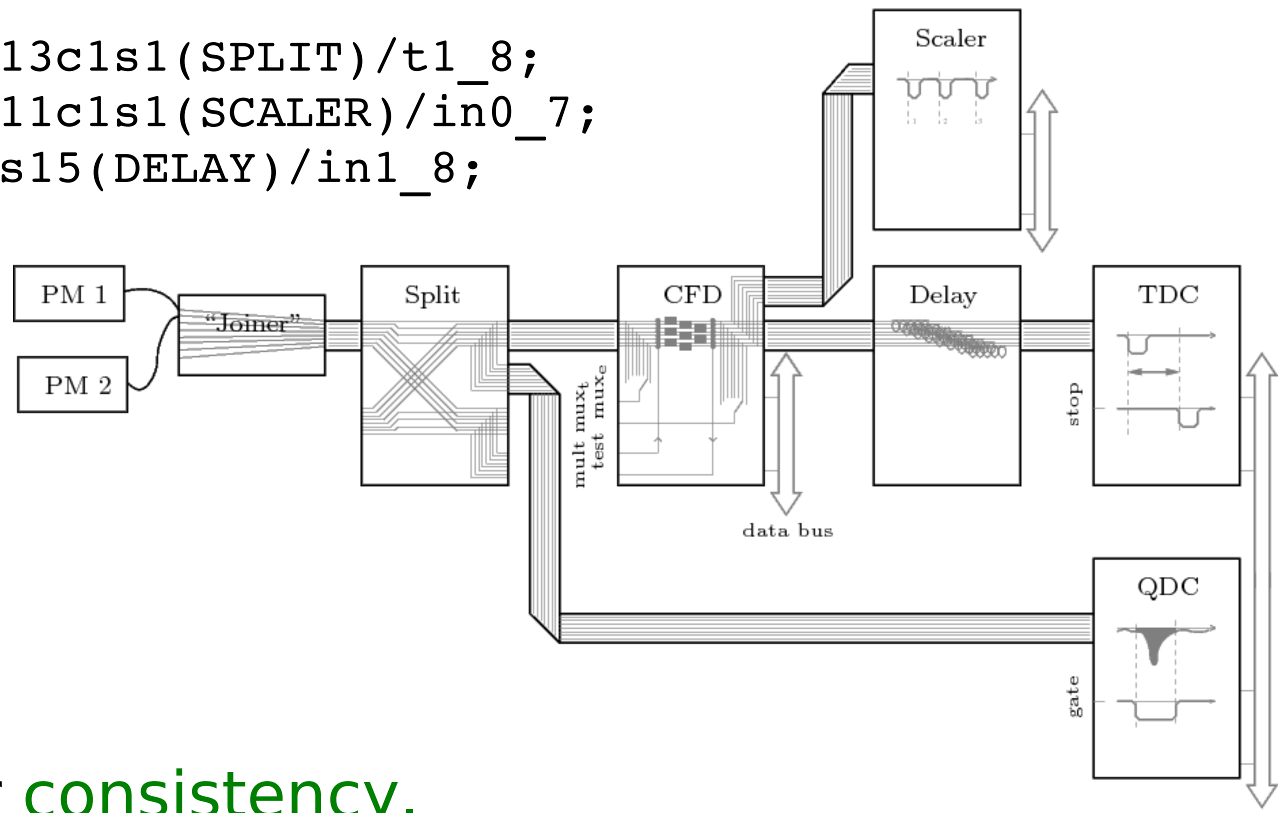
Solution / workaround ----------->

Support tool: cable documentation


```
CF8103(r12c2s1)
{
  SERIAL("LCF6343");  // Comments

 in1_8: "N11 CFTN1" <- , r13c1s1(SPLIT)/t1_8;
 th1_8: "1/1"       -> , r11c1s1(SCALER)/in0_7;
 tb1_8: "CR2 SL1"   -> , .s15(DELAY)/in1_8;

 m:            .c11s3/in1;
 test:         .s23/out1;
 mux_tb:       .s22/in1a;
 mux_e:        .s22/in5a;
 mux_mon: .s22/in9a;
}
```



C-like text format.

Parsed and checked for consistency.
(Every cable documented twice – at both ends.)

Checker generates tables for unpacking and slow-control.