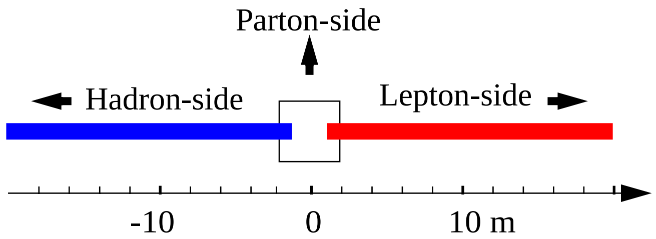
Toy Model of a Detector for EIC



PLAN:

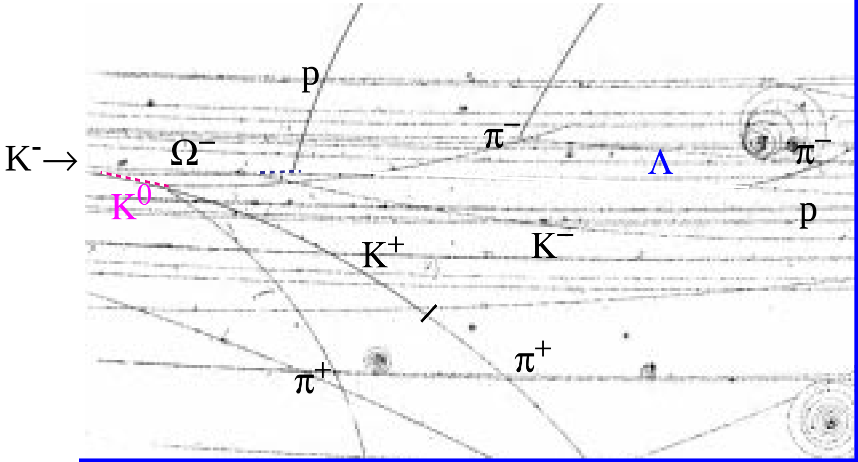
Revisit our toy model (cf. Whitepaper March 2001) in the context of interaction regions design.

"Strong interaction between detector and accelerator will be needed"

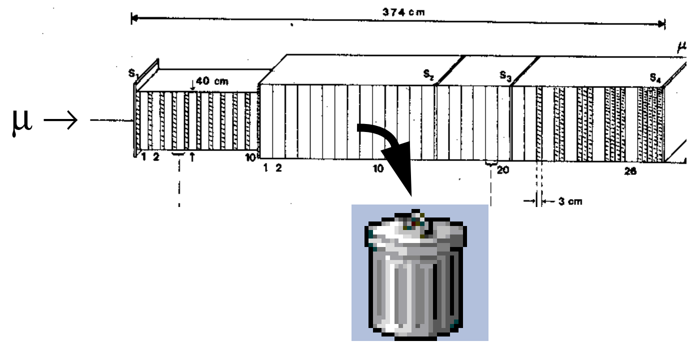
G. Hoffstaetter (Snowmass 2001)

TRANSPARENT versus OPAQUE TARGET

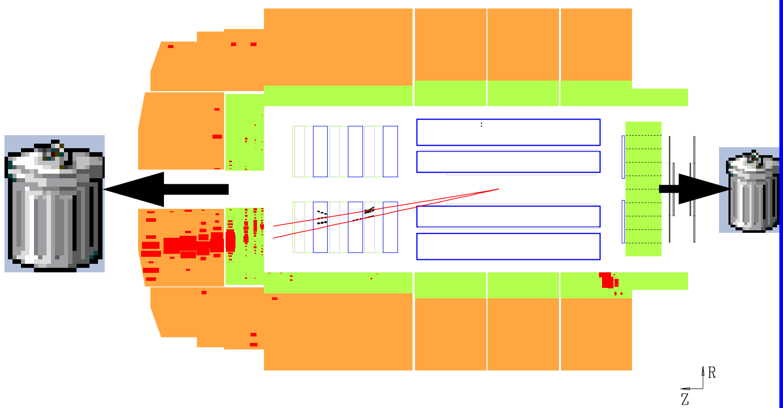
2 m HBC 1968



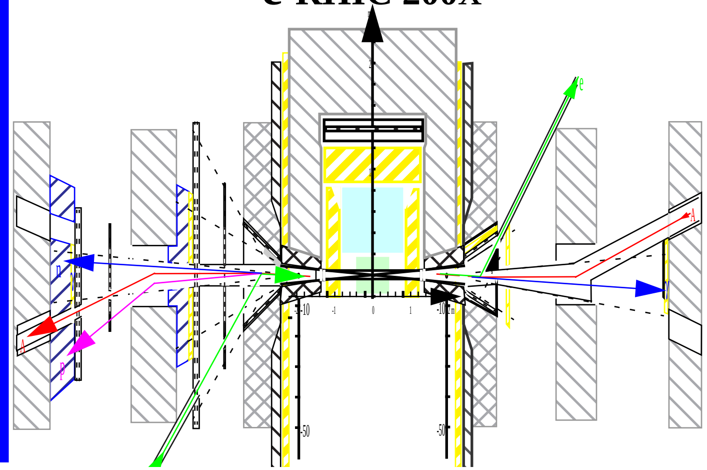
EMC 1980



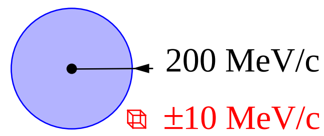
HERA1 1992



e-RHIC 200X



General



<u>Toy model goals</u>:

- 4 π acceptance for a complete final state identification
- “spectroscopic resolution” resolution for target remnants and jets

<u>Machine requirements</u>:

- beam divergence and crossing angle
- reasonable luminosity and backgrounds
- “active beam pipes”, “active collimators” and “skew vacuum chambers”

<u>Near beam detector requirements</u>:

- rates, background rejection, resolution (spacal, SiO_2-fibers,...)
- special designs? (active beam pipes)

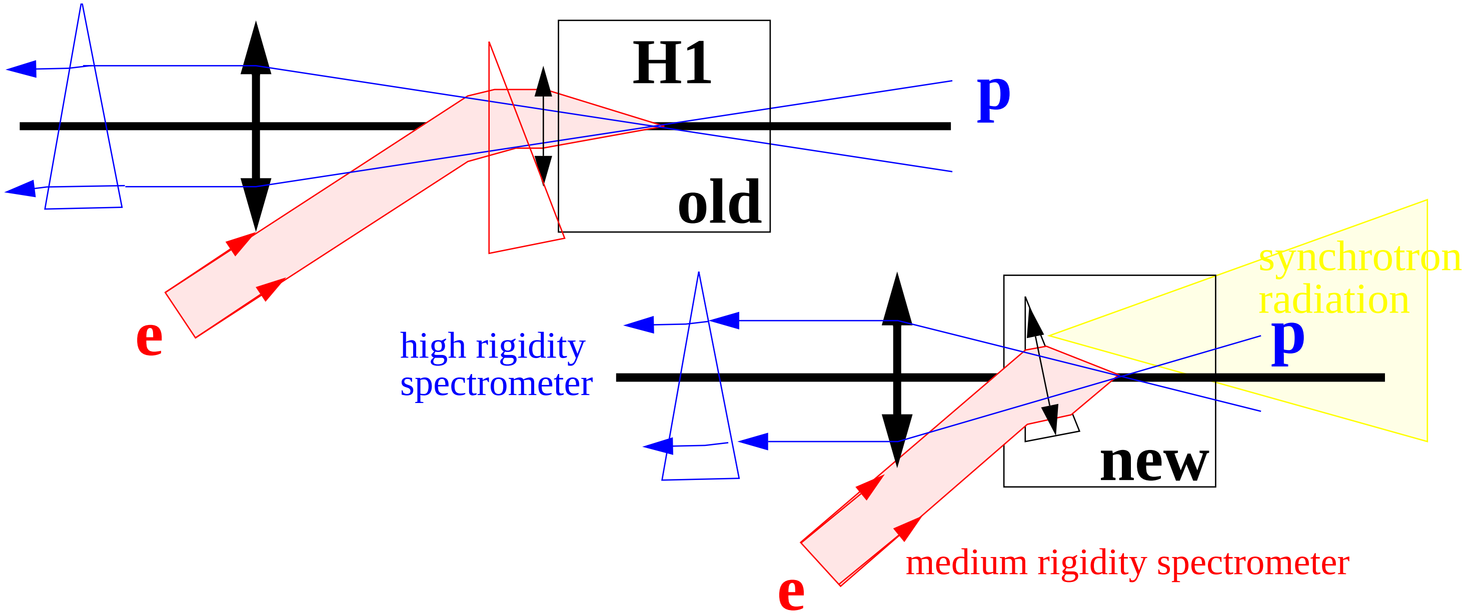
C<u>ompatibility of near beam detectors with other goals</u>:

- p-A, A-A, polarization, high luminosity...

Machine Requirements

In-beam spectrometers

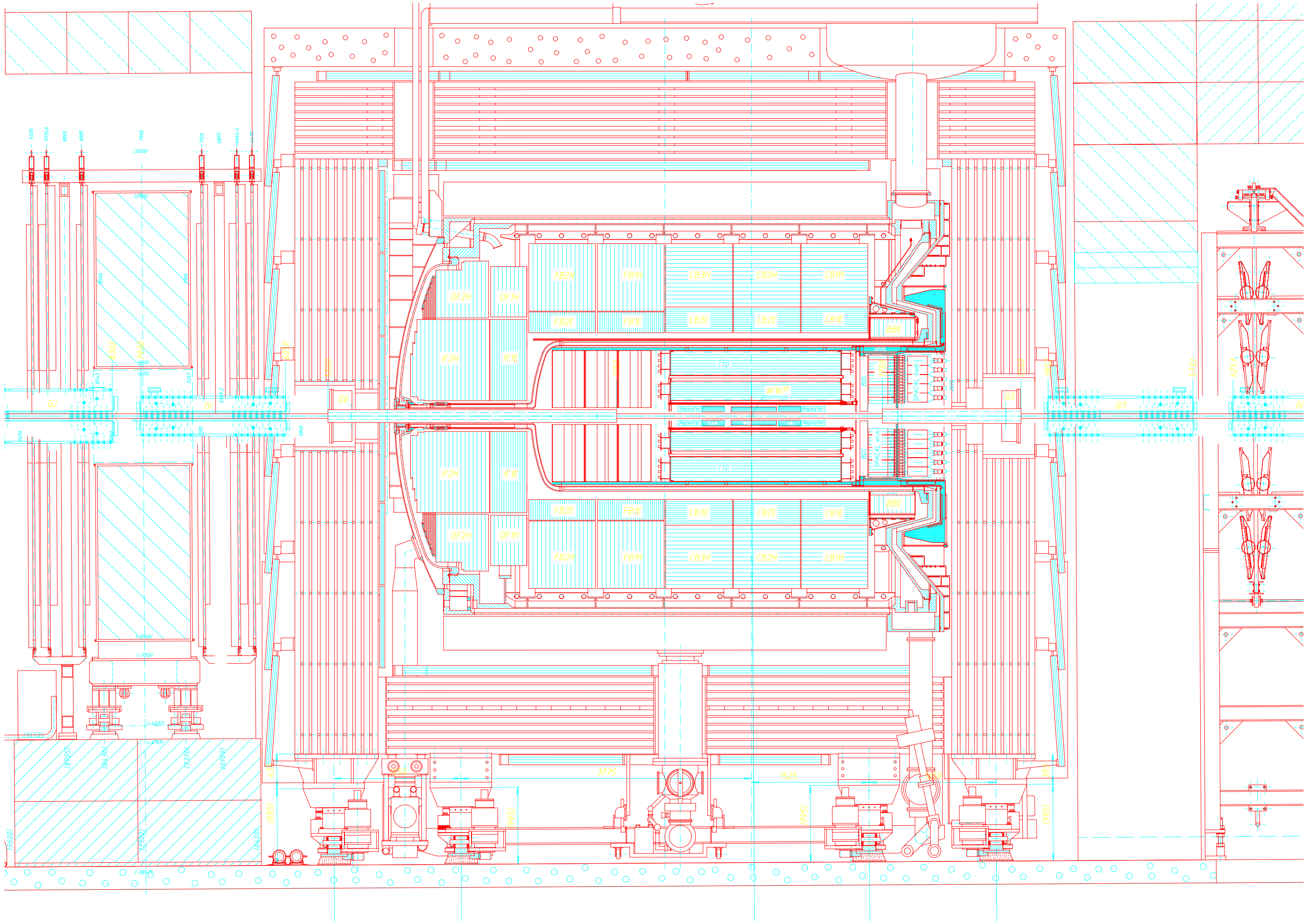
Novel feature of the toy model? It comes from the HERA hi-lumi upgrade[1]:



(“*magnets inside detector - detector inside magnets*” G.H. ibid.)

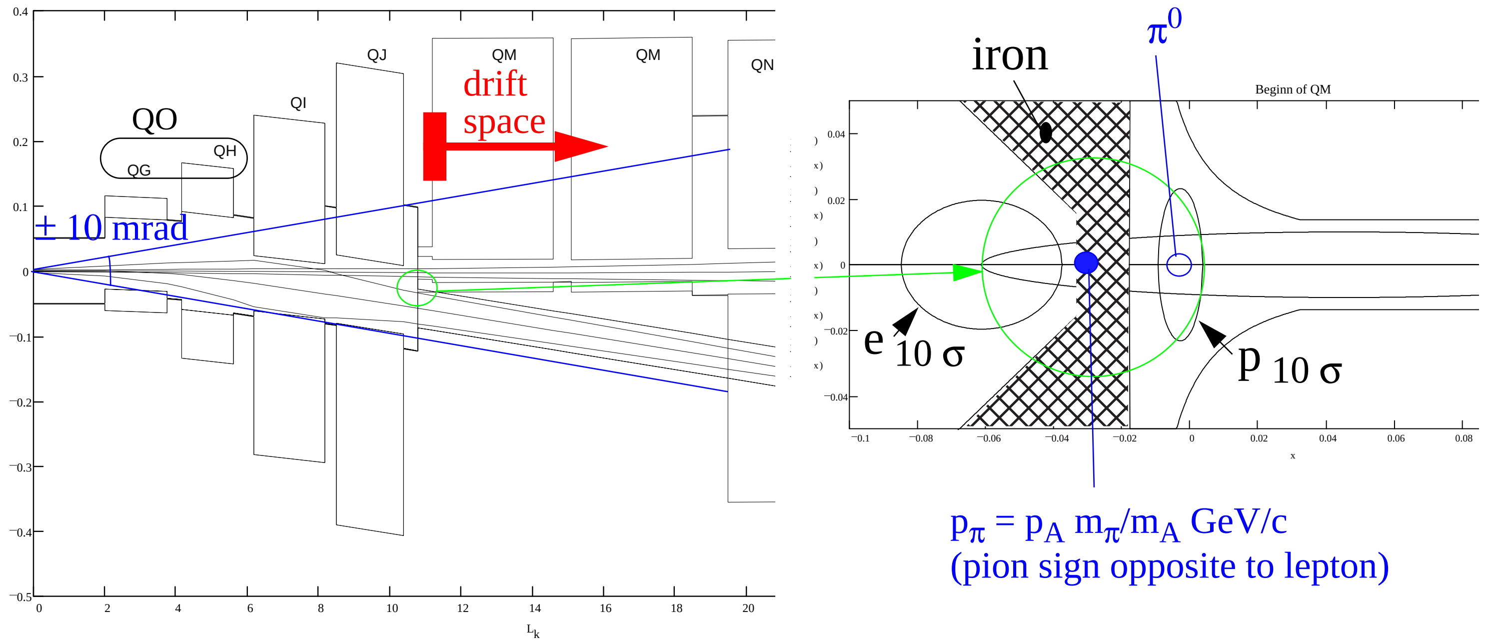
1. cf. “Evolution of HERA detectors towards e A physics”, E.B., Physics with HERA as eA collider workshop, DESY 25/05/99

Magnets inside detector ...



Spectrometer design parameters:

- aperture of medium and of high rigidity spectrometers
- length of drift space between spectrometers
- $\int$ B dl (fixed by beam optics)
- beam divergence (as low as possible)



Detector Requirements

Hadron-side

-main functions (left to right):

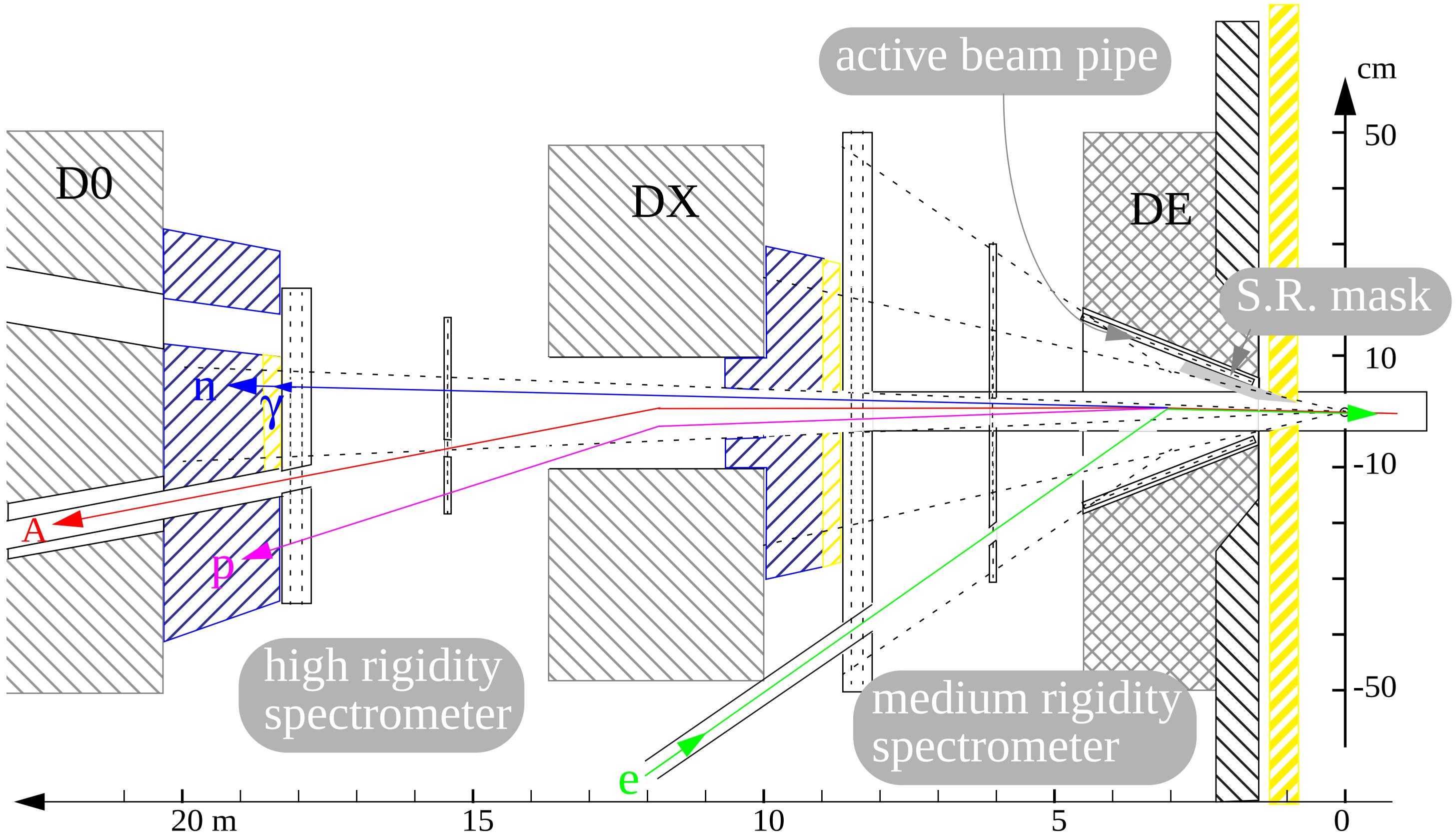
Roman pots (not on plan): diffractive scattering on beam (or same rigidity ion)

High rigidity spectrometer: EM calo for nuclear $\gamma(\pi^0)$; hadron calo for measuring evaporation neutrons and identificating p^+& ions; tracking for measuring evaporation p^+& ions

Medium rigidity spectrometer: EM calo for π^0s; hadron calo for measuring wounded neutrons and identificating ions&wounded p; tracking for measuring nuclear $\pi^\pm$, wounded p^+ and ions

Rapidity gap π-tagger: close the acceptance for charged particles emitted in the DIS process and tags diffractive events

Toy model ~hadron-side~:



-both spectrometer trackers using MWPC and drift chambers (or μstrips) at center.

-scintillating fiber calo for medium and high rigidity calorimeters (plastic or SiO_2?)

-scintillating fiber tracker ("active beam pipe") for rapidity gap π−tagger

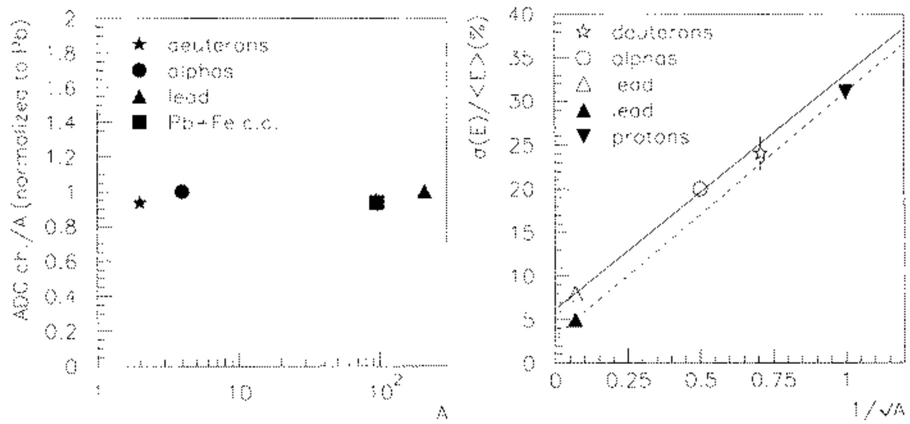
Detector details

High Rigidity Spectrometer question: plastic or SiO_2 fibers?

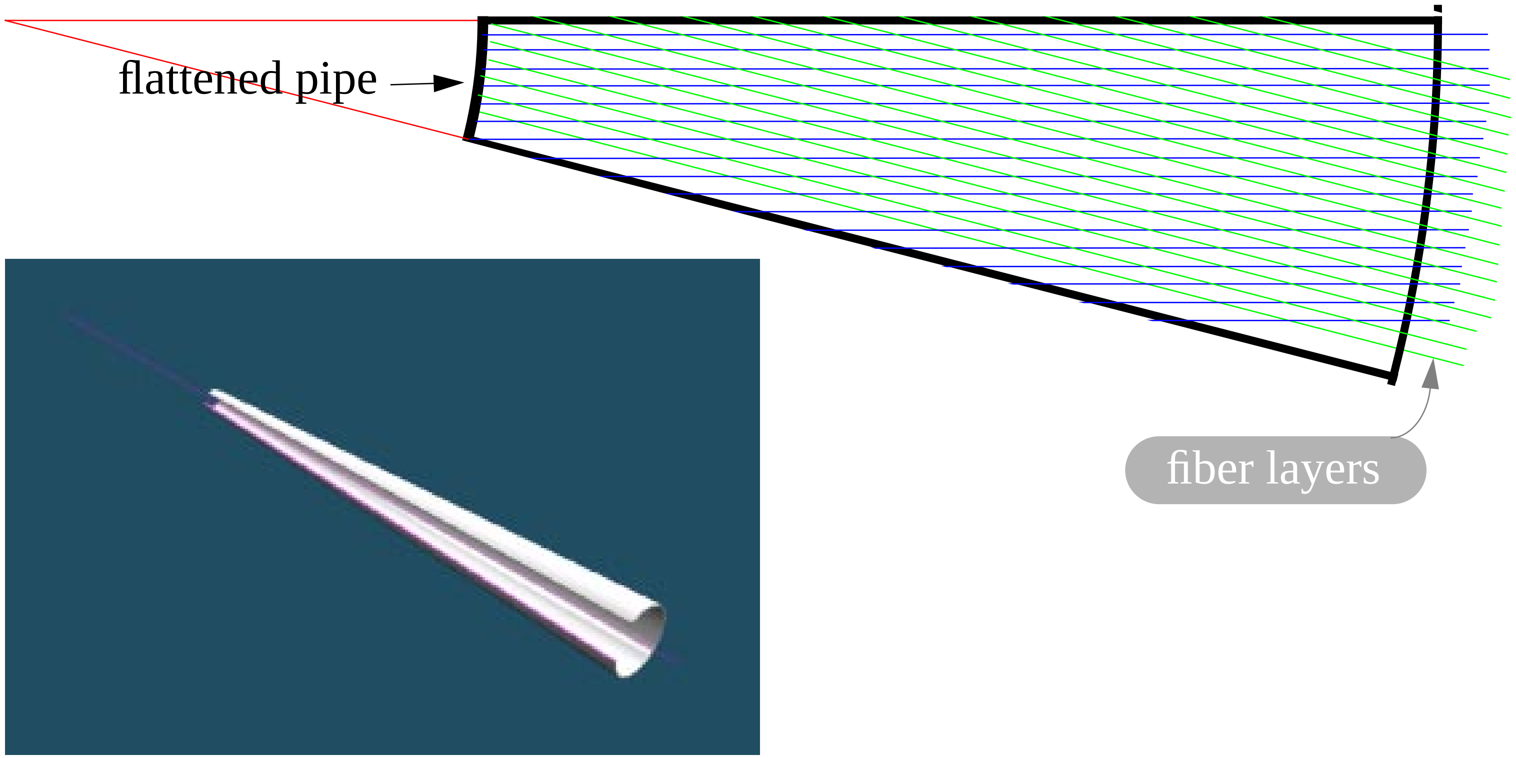
- Plastic has better energy resolution, is cheaper and easier to build. Spacal type hadronic resolution (30%/√E) is needed for spectator-neutron identification (D beam), but with a more radiation resistant design than former H1 FNC.
- SiO2 is radiation hard and gives highest spatial resolution. Needed for heavy ions (backed by dE/dx measurement?).

SiO_2 fiber in NA50

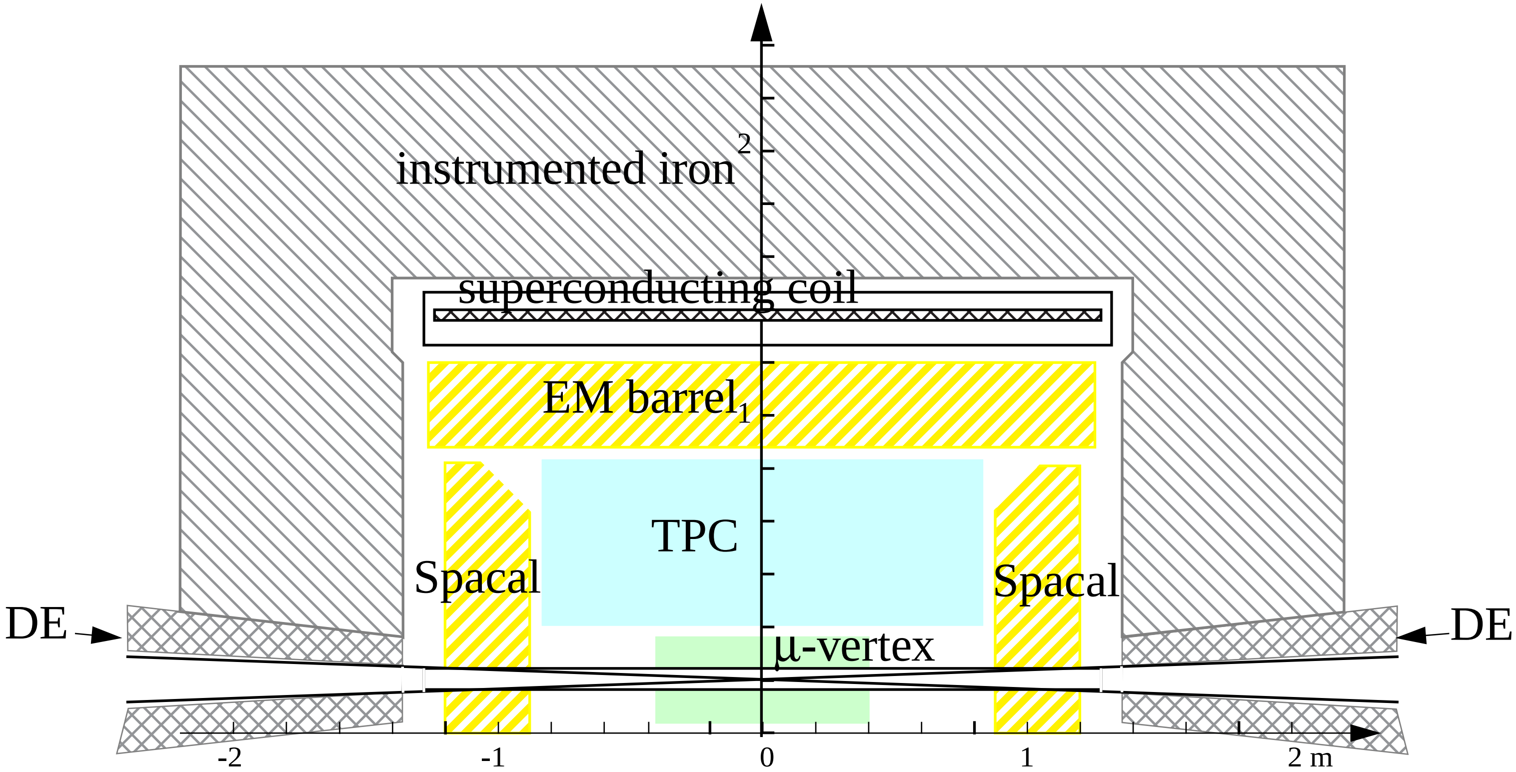
Arnaldi et al NIM A411 (1998) 1



active beam pipe:

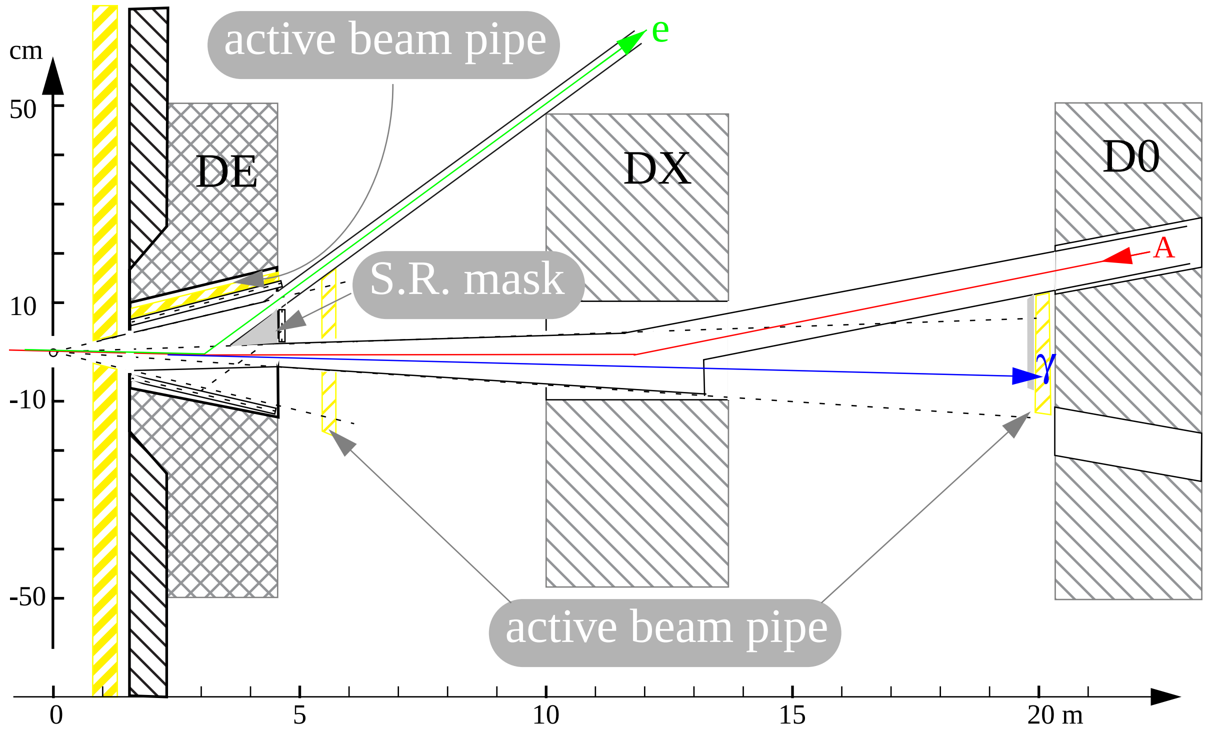


Toy model ~parton-side~ (good jet analysis, but not very high luminosities):



- Barrel is TPC backed by gas EM calorimeter inside magnet (=ℵ/2^3)
- Both endcaps are Spacal (=H1)
- μ–vertex provides small angle tracking

Toy model ~lepton-side~ (left to right):

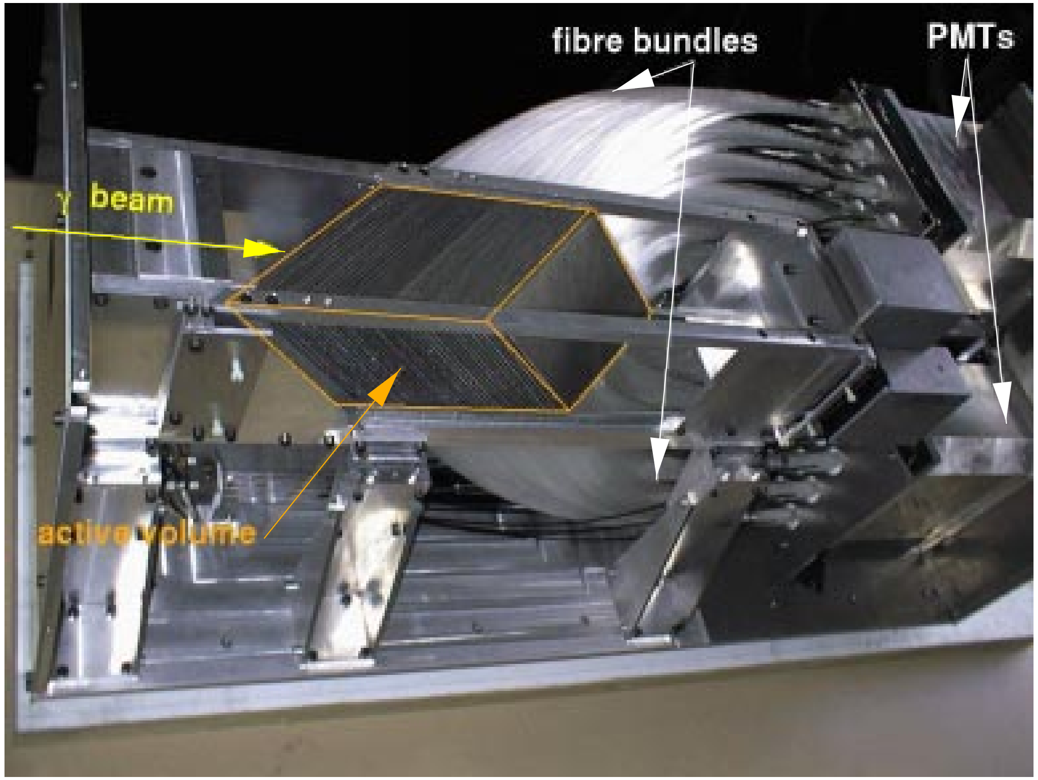


electron tagger: tracker measure e⁻ up to 10 GeV(photoproduction or DIS tagging) and closes acceptance for π's; backing EM calo confirms e- tagging.

γ tagger: measure Bethe-Heitler spectrum and tags initial bremhstrahlung; receives copious synchrotron radiation.

Toy Model:

- active beam pipe for electron tagger backed by Spacal on electron side
- quartz fiber calorimeter for γ tagger (takes up to a few γ per bunch cross)



Arnd E. SPECKA, Ecole Polytechnique, France specka@poly.in2p3.fr

Properties of new H1 SiO_2 fiber luminometer (thanks to A.Specka for the plots!).

ENERGY RESPONSE

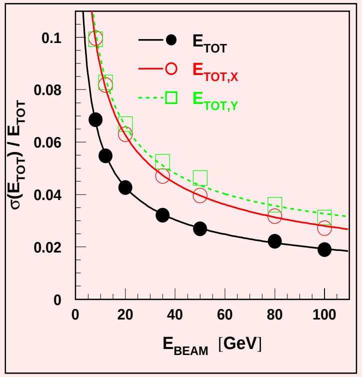
Resolution: (electrons)

- constant term compatible with 0
- stochastic term 19%/$\sqrt{E[GeV]}$

  sampling fluctuations: 16%/$\sqrt{E[GeV]}$

  photostatistics: 9%/$\sqrt{E[GeV]}$

Linearity: better than 1%

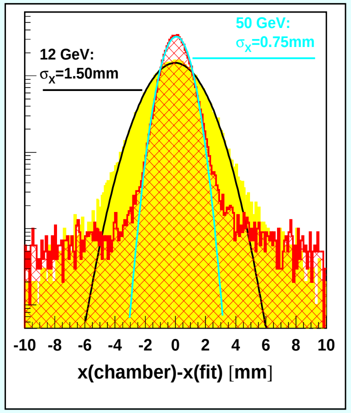


For earlier work on this type of detector see P.Gorodetzky et al NIM A361 (1995) 161-179

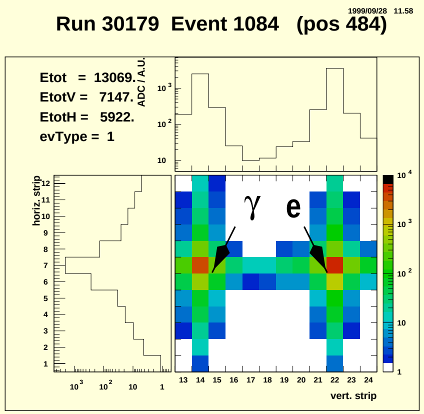
POSITION RECONSTRUCTION

Granularity: 10 mm

Resolution: 5 mm/$\sqrt{E[GeV]}$



BREMSSTRAHLUNG EVENTS: SEPARATION OF e AND γ



Summary of Toy Model Parameters

detectors	**type**	$\delta\alpha x \delta\beta$	**precision**	**char.**	**granularity**
central tracker	TPC	$10^{-3}x10^{-3}$	σ/p=0.5%p	? X0	
μ_vertex	Si	$10^{-3}x10^{-3}$		.02 X0	15x15μm
Barrel EM	Gas	$10^{-2}x10^{-2}$	σ/E=18%/✓E	X0=1.7cm	3.5x3.5cm
endcap EM	Spacal 2÷1	$3.10^{-3}x3.10^{-3}$	σ/E=7%/✓E	X0=.84cm	4x4cm
had calo	Inst.iron		σ/E=90%/✓E	4.5 λ	20x20cm
spectro track1	DC	$10^{-3}x10^{-3}$	σ/p=.02%p	0.2 X0	5x5mm
spectro track2	MWPC(1mm)	$10^{-3}x10^{-3}$	σ/p=.05%p	0.2 X0	1x1mm
spectro calo$_{EM}$	Spacal 4÷1	$2.10^{-4}x2.10^{-4}$ [a]	σ/E=9.5%/✓E	X0=.7cm	3x3cm
spectro calo$_{had}$	Spacal 4÷1	$4.10^{-4}x4.10^{-4}$	σ/E=30%/✓E	7 λ	3x3cm
e&π-taggers	sci.fiber	$2.10^{-2}x10^{-1}$	σ/E=1&5%	.3 X0	0.5x2cm
e-tag calo	Spacal 2÷1		σ/E=7%/✓E	X0=.84cm	2x300cm
γ-tagger	W/SiO_2 fiber	$10^{-4}x10^{-4}$	σ/E=20%/✓E	X0=.5cm	2x2 cm

a. overestimated for high rigidity spectro

Background Rates

H1 background rates applied to the Toy model:

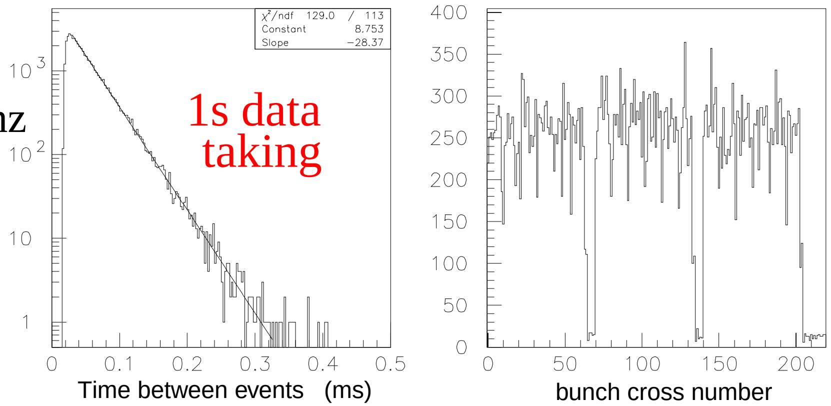
- proton induced background around $3.x10^{-3}$ for a $5x10^{10}$ p/bunch for all detectors, <1.5x10-3 for a single detector
- e^{+} induced background 10^{-3} for $2.5x5x10^{10}$ e/bunch (not predictive for e_RHIC)

H1 1997

OR of 4 near-beam calorimeters: 28khz

luminosity around $5x10^{30}$ cm^{-2} s^{-1}

(from E.B. et al, LPNHE 2001-10)



Performances of Spacal timing calorimeter[1]:

- timing accuracy: 0.1 ns/√E, timing resolution: 30 ns
consequences for the toy model --->clean pileup rejection with < 1% loss

1- The electronics of the H1 lead/scintillating-fibre calorimeters, NIM A 426 (1999) 518-537